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Emerging Academic Scientists' Exclusionary Encounters with Commercialization Law, Policy, and Practice

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Academic laboratories are sites of not only great scientific but also social inquiry. Following Robert Merton's seminal work in the 1950s,[1] sociologists, anthropologists, historians, economists, and other scholars have set upon studying the internal dynamics of academic laboratories and the structures, institutions, and outside actors infiltrating, influencing, and complicating laboratory environments. While important to situate commercially-oriented research practices such as patenting within this broader range of influences that have and will continue to influence academic science,[2] the university's increasing embrace of the marketplace over the last forty or so years[3] has motivated many investigations of the academic lab.[4]

Today, commercializing academic science ranks high amongst government and institutional priorities.[5] There is an enduring optimism that the commercial potential of university research has yet to be tapped.[6] Others meanwhile contest this policy capture, charging that commercialization threatens free academic inquiry, appropriates public goods, and limits knowledge generation, sharing, and dissemination.[7]

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[1] See for example Robert K Merton, "Priorities in Scientific Discovery: A Chapter in the Sociology of Science" (1957) 22 Am Soc Rev 635.

[2] A standard response to those who express concerns about the commercialization of academic science is to ask whether the concerns in question are, in fact, more attributable to longstanding norms of competition and secrecy within academic science. Part of the empirical challenge, then, is to disentangle the various influences upon the behaviours and choices of academic scientists. See for example Wei Hong & John P Walsh "For Money or Glory? Commercialization, Competition, and Secrecy in the Entrepreneurial University" (2009) 50:1 Sociological Quarterly 145.

[3] While important examples of "academic entrepreneurialism" date back to the early twentieth century, it was not until the 1980s and 1990s that governments, research funding agencies, and academic institutions began promoting the commercialization of research in earnest. See Jocelyn Downie & Matthew Herder, "Reflections on the commercialization of research conducted in public institutions in Canada" (2007) 1:1 McGill JL & Health 23; and Charles Weiner, "Patenting and Academic Research: Historical Case Studies" (1987) 12:1 Sci Tech & Human Values 50.

[4] For recent summaries of these inquiries, see Frank T Rothaermel, Shanti D Agung & Lin Jiang, "University Entrepreneurship: A Taxonomy of the Literature" (2007) 16:4 Indust & Corp Change 691; see also Maria Theresa Larsen, "The Implications of Academic Enterprise for Public Science: An Overview of the Empirical Evidence" (2011) 40:1 Research Policy 6.

[5] See Industry Canada, *Mobilizing Science and Technology to Canada's Advantage: Progress Report 2009* (Ottawa: Public Works and Government Services Canada, 2009), online: www.ic.gc.ca/eic/site/ic1.nsf/eng/04715.html; Association of Universities and Colleges of Canada, *Partners in the business of innovation* (Ottawa: AUCC 2011); and Canadian Institutes of Health Research, *CIHR's Commercialization and Innovation Strategy* (Ottawa: Public Works and Government Services Canada, November 2005), online: www.cihr-irsc.gc.ca/e/30162.html.

[6] Nova Scotia, *Summary from the Report on the University System in Nova Scotia* (2010) online: www.gov.ns.ca/premier/publications/EducationReport-Summary.pdf.

[7] Jennifer Washburn, *University, Inc.: The Corporate Corruption of American Higher Education* (New York: Basic Books, 2005); Risa L Lieberwitz, "Confronting the Privatization and Commercialization of Academic Research: An Analysis of Social Implications at the Local, National, and Global Levels" (2005) 12:1 Ind J Global Legal Stud 109; Sheldon Krimsky, *Science in the Private Interest: Has the Lure of Profits Corrupted Biomedical Research?* (Lanham: Rowman & Littlefield, 2003).

Evidence about the impact of this emphasis on commercialization and the attendant growth of commercialization activities in the academic sphere has been gradually accumulating, especially in the United States,[8] and to a lesser extent in other countries like Canada. For example, one group of researchers has carried out a series of surveys of academic scientists since the early 1990s, highlighting withholding of data as an increasing concern.[9] However, the purpose of this chapter is not to describe the variety of concerns and existing empirical evidence surrounding commercialization laws, policies, and practices. Rather, the purpose is to identify and to begin to characterize a set of concerns flowing from emerging academic scientists' encounters with commercialization laws, policies, and practices. In the United States, Canada, and elsewhere there is a dearth of empirical evidence focused specifically upon this group; this gap in the empirical literature poses a significant concern.

More specifically, in this chapter I argue that "emerging scientists," which I define to include Masters and PhD students, postdoctoral fellows (PDFs), and research associates, merit empirical investigation for three intertwined reasons. The first reason is evidentiary: emerging scientists are increasingly likely to be exposed to commercialization given systematic increases in patenting and other commercialization practices;[10] however, there is little empirical knowledge as to whether and to what extent commercialization practices influence the choices, commitments, and scientific contributions of emerging researchers, or how their participation in such practices, in turn, shapes the commercialization process. Gathering empirical evidence about these relationships is therefore critical. The second reason to focus on emerging scientists is generational. The increasing prevalence of commercialization activity means that which was once exceptional is becoming routine. It is important to ask what is lost if and when the cognitive dissonance previously associated with commercialization disappears. Finally, the third reason stems from the position of emerging researchers generally and women emerging scientists more specifically. Just as exposure to commercialization activities is systematically increasing, gaining a foothold in academia is becoming a more costly, time-consuming, and competitive process than ever before,[11] during which aspiring academic scientists endure an "extended period of limited intellectual autonomy."[12] In this sense, emerging scientists are generally vulnerable, and it is necessary to gather evidence about how exposure to commercialization figures in this equation. Further, there is already empirical evidence showing that women scientists are marginalized from commercialization activities such as patenting and membership on

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8 See for example Rothaermel, above note 4.

9 David Blumenthal et al, "Withholding Research Results in Academic Life Science: Evidence From a National Survey of Faculty" (1997) 277:15 JAMA 1224; Eric G Campbell et al, "Data Withholding in Academic Genetics: Evidence From a National Survey" (2002) 287:4 JAMA 473; Darren E Zinner et al, "Participation Of Academic Scientists In Relationships With Industry" (2009) 28:6 Health Affairs 1814.

10 Downie & Herder, above note 3.

11 Paula Stephan & Jennifer Ma, "The Increased Frequency and Duration of the Postdoctorate Career Stage" (2005) 95:2 Am Econ Rev 71.

12 Francis Collins, "Scientists need a shorter path to research freedom" (2010) 467 Nature 635.

company advisory boards.[13] Thus, for normative reasons, it is important to decipher whether and in what ways exposures to commercialization disrupt, inspire, or otherwise shape the careers, commitments, and choices of emerging scientists generally and, in particular, emerging scientists who are women.

The chapter proceeds in three parts. In *Part A* I describe contextual changes related to commercialization in the academic realm as well as a range of commercialization activities—some formal and others less so—that emerging scientists are increasingly apt to be exposed to as they pursue scientific careers. In the process I survey the existing empirical evidence about emerging scientists and their predecessors, the current elites and established of academic science. In *Part B* I identify two "exclusionary encounters" that emerging scientists are likely to have with commercialization laws, policies, and practices. These encounters pertain to 1) inventorship of patentable discoveries, and 2) intellectual property ownership. By way of brief conclusion in *Part C* I set out one hypothesis (motivated by the two exclusionary encounters described in Part B) for future empirical inquiry.

The subtext of this chapter is to motivate further empirical inquiry into commercialization at Canadian academic institutions for few empirical studies of commercialization have been carried out in Canada to date. In the meantime I draw heavily from studies performed elsewhere, especially the United States (US). My analysis moreover aspires to interdisciplinarity insofar as it is constructed from literatures beyond the law, including economics, management, and social studies of science and technology, and the research hypothesis set out in the final part calls for approaches and research techniques outside traditional legal scholarship.

A. The Commercialization of Academic Science

1) Commercialization Infrastructure, Activity, and Governance

Since the 1970s there has been a marked growth in commercialization infrastructure and activity amongst academic institutions as well as government and institutional policies pertaining to commercialization.[14] In terms of infrastructure, the "technology transfer offices" (TTOs) now populating academia provide visible evidence of this larger trend. Located on or near university campuses, TTOs serve as "brokers on the boundary" between academic researchers and the private sector.[15] TTO personnel

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[13] Waverly W Ding, Fiona Murray & Toby E Stuart, "An Empirical Study of Gender Differences in Patenting among Academic Life Scientists" (2006) 313 Science 665; Waverly W Ding, Fiona Murray & Toby E Stuart, "From Bench to Board: Gender Differences in University Scientists' Participation in Commercial Science" *Harvard Business School* (2010), online: Harvard Business School http://hbswk.hbs.edu/item/6483.html; and Waverly Ding & Emily Choi, "Divergent Paths to Commercial Science: A Comparison of Scientists' Founding and Advising Activities" (2011) 40 Research Policy 69.

[14] Downie & Herder, above note 3; see also Janet Atkinson-Grosjean, *Public Science, Private Interests: Culture and Commerce in Canada's Networks of Centres of Excellence* (Toronto: University of Toronto Press, 2006).

[15] See Donald Fisher & Janet Atkinson-Grosjean, *"*Brokers on the Boundary: Academic-industry Liaison in Canadian Universities*"* (2002) 44 Higher Education 449.

make regular visits to researcher labs, encouraging scientists to communicate interesting findings to their office, cautioning against wider disclosure in order to preserve patenting opportunities,[16] and drumming up university-industry partnering possibilities.[17] While select academic institutions such as Stanford University, the Massachusetts Institute of Technology (MIT), and the University of Wisconsin created TTOs in the early twentieth century, a grand total of twenty-seven TTOs existed in the US before 1980.[18] But between 1983 and 1999 well over a hundred offices were created in the US.[19] In Canada, the first three TTOs were established during the 1970s at McGill University, L'Ecole Polytechnique, and Cape Breton University. Eleven "key" Canadian universities followed suit during the 1980s,[20] and surveys conducted during the 1990s and early 2000s showed a continuous rise in the number of TTOs, TTO personnel, and financial resources dedicated to commercialization.[21]

Today, essentially every major university engaged in scientific research in the US and Canada has some form of TTO, as do other institutions such as government laboratories, funding councils, private research institutions, and teaching hospitals. TTOs have, in turn, professionalized, forming umbrella organizations such as the Association of University Technology Managers (AUTM),[22] and the Alliance for Commercialization of Canadian Technologies (ACCT).[23] They have also formed networks,[24] and feed into public policy debates.[25]

The growth of commercialization infrastructure over the last forty years coincides with increases in a range of commercialization activities.[26] These activities take many

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16 This point in particular is stressed in a "Guide to Protecting Intellectual Property" prepared by the "Canadian University Intellectual Property Group (CUIPG)," which comprises the Directors of Intellectual Property/Industrial Licensing offices at the following Canadian universities: British Columbia, Alberta, Waterloo, Western Ontario, McMaster, Toronto, Queen's, Montreal, McGill and Laval. See Dalhousie University, Innovation and Industry Liaison, *A Guide to Protecting Intellectual Property*, online: http://innovation.dal.ca/researchers/intellectualproperty.php.

17 The practices and challenges of TTOs are detailed in numerous studies. See for example Fisher & Atkinson-Grosjean, above note 16; see also Richard A Jensen, Jerry G Thursby & Marie C Thursby, "Disclosure and Licensing of University Inventions: 'The Best We Can do With the S**t We Get to Work With'" (2003) 21:9 International Journal of Industrial Organization 1271.

18 Association of University Technology Managers, *AUTM U.S. Licensing Survey: FY 2005, Survey Summary* at 17, online: www.autm.net/FY_2005_Licensing_Survey/8930.htm

19 *Ibid.*

20 Fisher & Atkinson-Grosjean, above note 16.

21 For example, the number of new university-industry intellectual property licences and options executed by TTOs soared from 49 in 1991 to 544 in 2004. This increase (of 1,010.2 percent) is more than four times the increase in number of survey respondents, which rose from ten in 1991 to thirty four in 2004. See Association of University Technology Managers, *AUTM Canadian Licensing Survey: FY 2004, Survey Summary*, online: www.autm.net/FY_2004_Licensing_Survey/10193.htm; see also Downie & Herder, above note 3, for a discussion of these trends.

22 Association of University Technology Managers, online: www.autm.net/Home.htm.

23 Alliance for Commercialization of Canadian Technologies, online: www.acctcanada.ca/.

24 See for example Springboard Atlantic, online: www.springboardatlantic.ca/.

25 See Industry Canada, Advisory Council on Science & Technology, *Public Investments in University Research: Reaping the Benefits* (Ottawa: Industry Canada 1999).

26 David C Mowery et al, "The Growth of Patenting and Licensing by U.S. Universities: An Assessment of the Effects of the Bayh-Dole Act of 1980" (2001) 30:1 Research Policy 99; Downie &

forms but patent applications, patent grants, licensing agreements, research contracts with industry, and university spin-off companies are the most frequently tracked measures of commercialization.[27]

While the overall trends in the US and Canada are in the same direction, the level of commercialization observed at American academic institutions appears to significantly outpace that at their Canadian counterparts. For example, in fiscal year 2010 US-based respondents to the survey conducted by AUTM reported 12,281 total new patent applications whereas the corresponding figure for Canadian respondents was 928.[28] After accounting for differences in response rate (183 versus 40 in the US and Canada, respectively), US institutions file, on average, four times as many new patent applications per year as Canadian institutions (100:25 new patent applications per institution).However, relative to the amount of money allocated to academic research by federal governments in the US and Canada, these commercialization data points become more comparable. Again, using the most recent AUTM surveys as an example, per $100,000 in federal research expenditures, Canadian institutions file slightly more new patent applications (0.034) compared to those in the US (0.031).[29] In other words, in proportion to the respective public tax dollar investments in academic science, US and Canadian research centres currently appear to engage in roughly equal amounts of commercialization activity such as patenting.

Despite substantially increasing in recent years commercialization activities may still seem like relatively exceptional events, yet the foregoing measures of commercialization are under-inclusive.[30] To begin, certain commercialization activities are simply not tracked in surveys conducted by AUTM and others.[31] For example, there is no readily available data surrounding agreements signed by students and PDFs to "pre-assign" any intellectual property to their host institutions, "confidentiality agreements" signed by members of research teams, or participation by academic scientists on company advisory boards. There are also a variety of less formal moments in between discrete commercialization events such as filing a patent application that are designed to steer researchers toward commercialization. The internet is littered with "brown bag" lunch sessions put on by universities on the topic of commercialization, ostensibly, to "educate" researchers about the importance of vetting a presentation with the university's TTO before attending an academic conference. Otherwise, if the presentation happens to

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Herder, above note 3; and Matthew Herder, *The Rhetoric of Innovation* (LL.M Thesis, Dalhousie University, 2006).

[27] *Ibid*.

[28] Association of University Technology Managers, *U.S. Licensing Activity Survey Highlights: FY2010*, online: www.autm.net/FY_2010_Licensing_Survey/7008.htm.

[29] *Ibid*.

[30] Aldo Geuna & Alessandro Muscio, "The Governance of University Knowledge Transfer: A Critical Review of the Literature" (2009) 47:1 Minerva 93.

[31] Matthew Herder & Josephine Johnston, "Access Concerns and Business Models in Public-Sector Technology Transfer of Genetic Inventions" in E Richard Gold & Bartha M Knoppers, eds, *Biotechnology IP & Ethics* (Markham: LexisNexis Canada, 2009).

include any new research findings, the researcher risks running afoul of patent law's requirements of "novelty" and "non-obviousness."[32]

Finally, in addition to increases in commercialization infrastructure and activity (both formal and informal), there has been a proliferation of policy instruments tied to commercialization. This is perhaps especially true in Canada where, in distinction from the US, there is no legislation that establishes a uniform set of rules around intellectual property ownership and other commercialization issues for federally funded research.[33] Instead, using an array of policy instruments introduced by the federal government beginning as early as the 1960s and accelerating during the 1980s and 1990s, it can be argued that Canada has embraced patenting as a "policy tool" and technology transfer more generally to an even greater extent than the US.[34] From tax incentives, industry matched funding requirements, to "science to business" programs for budding scientists, the message from governments and funding agencies in Canada and the US is unequivocal: commercializing academic science is expected.[35] Setting out, in concrete terms, commercialization goals, plans, and milestones is in many cases now essential to securing research funding from public sources. Accordingly, research institutions have gradually implemented a slew of policies, which taken together, govern commercialization. These include invention disclosure policies, revenue sharing policies, joint venture policies, intellectual property ownership policies, conflicts of interest policies, and data and materials sharing policies.

The challenge is to discern what impact, if any, these governance mechanisms regarding, diverse exposures to, and forces in favour of commercialization have upon academic science. In the next section, I describe the empirical commercialization literature to date with a narrowing focus on emerging academic scientists.

2) Commercialization's Untold Intergenerational Impact?

The empirical literature surrounding the commercialization of academic science has several limitations. First, the literature is still maturing. A recent meta-analysis of the literature suggests the field lacks organization and methodological rigour.[36] Some settings, including Canadian academic institutions, have moreover been the subject of limited study to date.[37] Second, although varying in methodology and object of inquiry,

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[32] See CUIPG, above note 17.

[33] Some have recommended that legislation similar to that which is in place in the US be enacted in Canada, however. See Industry Canada, above note 26.

[34] Donald Fisher, Janet Atkinson-Grosjean & Dawn House, "Changes in Academy/Industry/State Relations in Canada: The Creation and Development of the Networks of Centres of Excellence" (2001) 39:3 Minerva 299; and E Richard Gold et al, "The Unexamined Assumptions of Intellectual Property: Adopting an Evaluative Approach to Patenting Biotechnological Innovation" (2004) 18 Pub Affairs Quarterly 299.

[35] Downie & Herder, above note 3; Creso M Sa & Jeffrey Litwin, "University-Industry Research Collaborations in Canada: The Role of Federal Policy Instruments" (2011) 38:6 Sci Public Policy 425.

[36] Rothaermel, above note 4 at 699–703.

[37] In the period since Downie & Herder, above note 3 was published (when we drew attention to the lack of empirical evidence regarding commercialization in Canada), only ten or so empirical studies have been completed. See for example Herder & Johnston, above note 32; Tania M Bubela & Timothy

an economic lens dominates empirical studies of commercialization. A robust conceptual framework, capable of assessing the normative implications of conflicting findings is lacking. Consider two investigations into the effects of patenting upon academic science. The first, a survey study, found one in nine researchers abandoned one research project every two years due to concerns about patents.[38] The second, a citation-based analysis, showed that "genetic researchers forego about one in ten research projects… through the causal negative impact of a gene patent grant."[39] The two findings are similar but whereas the authors of the survey study inferred that concerns related to academic patenting may be overstated, the authors of the citation analysis used their findings to support the claim that patents inhibited knowledge flows. Finally, there is a significant bias toward studying the formal instruments of commercialization such as patents, presumably because of the relative ease of measurement and, again, the economic orientation of those contributing to the literature. However, unpacking the effects of commercialization requires far greater attention to the "shifting reward structures, changing funding imperatives and normative pressures emerging among scientists themselves."[40] There is a need for greater qualitative study of commercialization laws, policies, and practices.

Despite these limitations, the empirical literature of academic commercialization contains a number of themes that are salient here. To begin, most knowledge exchange between academic institutions and the private sector happens separate from formalized intellectual property transactions. Acquiring information through more traditional means—whether by buying it off the shelf, reading publications, attending conference proceedings, or hiring graduate students—remains the dominant mode of public/private sector knowledge exchange.[41] Historically, this is not surprising given that attitudes toward commercialization have been mixed amongst faculty.[42] But even for the academic scientists on board with that agenda or working in the life sciences where industry

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Caulfield, "Role and Reality: Technology Transfer at Canadian Universities" (2010) 28:9 Trends in Biotechnology 447; Fiona A Miller, Carrie B Sanders & Pascale Lehoux, "Imagining Value, Imagining Users: Academic Technology Transfer for Health Innovation" (2009) 68:8 Social Science & Medicine 1481; CJ Murdoch & Timothy Caulfield, "Commercialization, Patenting and Genomics: Researcher Perspectives" (2009) 1:2 Genome Med 22; Kate Hoye & Fred Pries, "Repeat Commercializers,' the 'Habitual Entrepreneurs' of University-Industry Technology Transfer" (2009) 29:10 Technovation 682; Kate A Hoye, *University Intellectual Property Policies and University-Industry Technology Transfer in Canada* (PhD Thesis, University of Waterloo, 2006); and E Richard Gold & Julia Carbone, "Myriad Genetics: In the Eye of the Policy Storm" (2010) 12:4 Suppl Genetics in Medicine S39.

[38] John P Walsh, Wesley M Cohen & Charlene Cho, "Where Excludability Matters: Material Versus Intellectual Property in Academic Biomedical Research" (2007) 36 Research Policy 1184.

[39] Kenneth G Huang & Fiona E Murray, "Does Patent Strategy Shape the Long-Run Supply of Public Knowledge? Evidence from Human Genetics" (2009) 52:6 Acad Mgmt J 1193 at 1214.

[40] Steven Peter Vallas & Daniel Lee Kleinman, "Contradiction, Convergence and the Knowledge Economy: The Confluence of Academic and Commercial Biotechnology" (2008) 6:2 Socio-Econ Rev 283 at 291.

[41] W Cohen et al, "Industry and the Academy: Uneasy Partners in the Cause of Technological Advance" in Roger Noll, ed, *Challenges to the Research University* (Washington DC: Brookings Institution, 1998); Ajay Agrawal & Rebecca Henderson, "Putting Patents in Context: Exploring Knowledge Transfer from MIT" (2002) 48:1 Management Science 44.

[42] Henry Etzkowitz, "The Norms of Entrepreneurial Science: Cognitive Effects of the New University-Industry Linkages" (1998) 27:8 Research Policy 823 at 830.

relationships are more the norm,[43] the bulk of their forays into that world are nevertheless likely to occur "outside" of negotiations over intellectual property rights.[44] This underscores the importance of paying attention to less formal exposures to commercialization (e.g. brown bag lunch sessions) as discussed above.

Secondly, individuals and the relationships they form appear central to the commercialization process. "Star" academic scientists (and the networks they occupy) have been shown, in hindsight, to substantially explain patterns of technology diffusion and economic growth in a region.[45] Scientists are most likely to identify industry receptors for a given technology, not TTOs[46] and, without their continued participation, efforts by a university to generate revenues tend to falter.[47] In short, much of academic scientists' value to private sector players—in terms of their tacit knowledge, their prestige, and their networks of potential collaborators—escapes codification. Therefore keeping them engaged, potentially at the expense of their other obligations like teaching, mentoring, and grant writing, not to mention actual research,[48] is key from a commercialization point of view.

Finally, while maintaining an academic scientist's commitment as commercialization haphazardly unfolds is critical, the influence of the institutional and social contexts in which any academic researcher is embedded cannot be discounted. Context can shape an individual's openness to commercialization in the first place. If a researcher was educated at Stanford University, an early mover toward norms of academic entrepreneurialism, she or he is more likely to engage in commercialization.[49] Changes in institutional setting may also undo that very sort of imprinting: academic scientists have been shown to alter their patenting behaviour if it conflicts with the norms of a new institutional home.[50] Further, shaping can occur not just at the institutional level,

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43 Darren E Zinner et al, "Participation of Academic Scientists in Relationships with Industry" (2009) 28:6 Health Affairs 1814.

44 Riccardo Fini, Nicola Lacetera & Scott Shane, "Inside or Outside the IP System? Business Creation in Academia" (2010) 39:8 Research Policy 1060.

45 Lynne G Zucker & Michael R Darby, "Star Scientists and Institutional Transformation: Patterns of Invention and Innovation in the Formation of the Biotechnology Industry" (1996) 93:23 Proc Natl Acad Sci 12709; Lynne G Zucker, Michael R Darby & Marilynn B Brewer, "Intellectual Human Capital and the Birth of U.S. Biotechnology Enterprises" (1998) 88:1 Am Econ Rev 290.

46 Vivek Ramakrishnan , Jiwen Chen & Krishna Balakrishnan, "Effective Strategies for Marketing Biomedical Inventions: Lessons Learnt from NIH Licence Leads" (2005) 5:4 Journal of Medical Marketing 342; Jerry G Thursby, Richard Jensen & Marie C Thursby, "Objectives, Characteristics and Outcomes of University Licensing: A Survey of Major U.S. Universities" (2001) 26:1 J Tech Transfer 59; Christina Jansen & Harrison F Dillon, "Where do the Leads for Licences Come From?: Source Data from Six US Institutions" (2000) 14:3 Industry and Higher Education 150.

47 Ajay Agrawal, "Engaging the Inventor: Exploring Licensing Strategies for University Inventions and the Role of Latent Knowledge" (2006) 27:1 Strategic Management Journal 63; Richard Jensen & Marie Thursby, "Proofs and Prototypes for Sale: The Licensing of University Inventions" (2001) 91:1 Am Econ Rev 240.

48 Fini, above note 45 (document some of these trade-offs).

49 Janet Bercovitz & Maryann Feldman, "Academic Entrepreneurs: Organizational Change at the Individual Level" (2008) 19:1 Org Sci 69 at 81.

50 *Ibid* at 86.

but also inter-personally. If a postdoctoral fellow's supervisor engages in patenting (or not), then she or he is likely to do so (or not do so) later on.[51]

Therein lies part of the impetus for my claim that emerging academic scientists, as a group, merit more empirical attention. While there is a sizeable literature about members of the established academic research community that describes the factors that influence their attitudes about,[52] or willingness to participate in, commercialization,[53] how frequently they do so, and what that engagement tends to entail or result in,[54] comparatively little is known about emerging scientists' experiences of commercialization. Yet compared to their predecessors, emerging scientists will encounter commercialization far more frequently given the systematic rise in commercialization infrastructure, activity, and governance. It is safe to assume that fewer of today's supervisors were exposed to patenting when they began their academic careers.

The current commonality of commercialization also supports the focus on emerging academic scientists. Once, commercialization was the province of the scientific elite. Although different variables, including gender, research productivity, social networks, and employer influence continue to predict involvement in discrete commercialization activities such as advising versus founding a private firm,[55] participation in commercialization is on the whole now democratized.[56] It is not only the emerging scientists who attend Stanford or MIT who will encounter commercialization. More than that, though, commercialization is also being normalized. There is evidence of established academic scientists foisting commercialization-related tasks such as meeting with TTO representatives upon junior members of their laboratories, not just to avoid the work, but rather to safeguard their more traditional academic selves.[57] Perhaps this strategy mitigates the cognitive dissonance experienced by established academics when participating, distantly, in the commercialization process. But there is a need to assess how it informs the choices, commitments, and scientific contributions of the emerging scientists left to do the commercialization legwork.

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[51] Pierre Azoulay, Christopher Liu & Toby Stuart, "Social Influence Given (Partially) Deliberate Matching: Career Imprints in the Creation of Academic Entrepreneurs" (2009) 09-136 Harvard Bus Sch Entrepreneurial Mgmt, Working Paper, online: Social Science Research Network http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1410816.

[52] Pierre Azoulay, Waverly Ding & Toby Stuart, "The Determinants of Faculty Patenting Behavior: Demographics or Opportunities?" (2007) 63:4 J Econ Beh'r & Org 599 at 603; Etzkowitz, above note 43.

[53] Toby E Stuart & Waverly Ding, "When Do Scientists Become Entrepreneurs? The Social Structural Antecedents of Commercial Activity in the Academic Life Sciences" (2006) 112:1 Am J Soc 97.

[54] Jensen & Thursby, above note 48; Jason Owen-Smith & Walter W Powell, "To Patent or Not: Faculty Decisions and Institutional Success at Technology Transfer" (2001) 26:1-2 J Tech Transfer 99 at 113.

[55] Ding & Choi, above note 13.

[56] Stuart & Ding, above note 54 at 124.

[57] Sanjay Jain, Gerard George & Mark Maltarich, "Academics or Entrepreneurs? Investigating Role Identity Modification of University Scientists Involved in Commercialization Activity" (2009) 38:6 Research Policy 922 at 923.

Last, there are normative reasons to examine the situation of emerging scientists vis-à-vis commercialization. Doctoral students, PDFs, and research associates are vulnerable in various ways. The demands of pursuing a career in academic science today are extreme. Due to the sheer volume of knowledge in any given field of inquiry, original insights tend to require many more years of research than in the past.[58] Earning a PhD is necessary for legitimacy and can mean taking on a significant amount of financial debt. The more costly hardship, though, may be that few PhD graduates land a tenure-track position right away.[59] They instead face one, if not two, or three, meagrely paid "postdocs" before they can legitimately entertain going on the academic job market.[60] In the US and elsewhere, there is presently an oversupply of PhD graduates and PDFs.[61] Thus, many highly educated researchers will not secure posts in academic science. Conceivably, commercialization may open up new employment opportunities outside the confines of academe.

Training and job security challenges aside, it is unclear how gratifying the PDF experience usually proves to be. According to one survey, control over the various aspects of a research project is, more often than not, in the hands of the PDF's supervisor or shared between the two.[62] In part, this is the nature of the beast: research increasingly favours teams of scientists over the individual,[63] and junior scientists often are not yet in command of a team. But it is also a function of status and hierarchy dynamics in the lab environment. In some unknown proportion of cases, scientists will come to regard their time as postdocs as transformative learning experiences or, at the very least, as effective bridges to an academic appointment. For the remainder, the postdoc experience may be remembered as a time when they worked on research problems in which they had only a small personal stake or felt powerless to redefine. Whether and how various exposures to commercialization alter this equation is an open question with normative implications. Perhaps exposure to commercialization and, more specifically, introductions to members of the private sector, will be perceived as a way out of the confusion that an extended time at higher education institutions presently affords.[64] Does commercialization offer emerging scientists opportunities to exercise entrepreneurial autonomy?

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[58] Benjamin F Jones, "The Burden of Knowledge and the 'Death of the Renaissance Man': Is Innovation Getting Harder?" (2009) 76:1 Review of Economic Studies 283.

[59] Statistics Canada, *Graduates of doctoral programs—who are they and what are their post-degree plans?* (2005), online: www.statcan.gc.ca/pub/81-004-x/2005003/8611-eng.htm.

[60] Stephan & Ma, above note 11.

[61] David Cyranoski et al, "The PhD Factory" (2011) 472:7343 Nature 276; Mark C Taylor, "Reform the PhD System or Close it Down" (2011) 472:7343 Nature 261.

[62] Geoff Davis, "Doctors Without Orders" (2005) 93:3 American Scientist (supplement) online: Sigma XI http://postdoc.sigmaxi.org/results/.

[63] Stefan Wuchty, Benjamin F Jones & Brian Uzzi, "The Increasing Dominance of Teams in Production of Knowledge" (2007) 316:5827 Science 1036.

[64] Research has shown that PhD students and PDFs view employment in industry versus academia as fundamentally different. Michael Roach & Henry Sauermann, "A Taste for Science? PhD Scientists' Academic Orientation and Self-Selection into Research Careers in Industry" (2010) 39:3 Research Policy 422 (as commercialization blurs the boundary between these two employment contexts, there is a need to determine if emerging researchers' assessment of these two career paths has shifted; the extent to which it creates new opportunities or tensions within the laboratory environment; or, more fundamentally still, alters emerging health researchers' understanding of what research projects, collaborations, and interactions are more or less worthwhile).

Commercialization may also represent a new site of gender- and/or race-based inequality. Although the numbers of women participating in academic science are finally increasing,[65] deep-seated inequalities in academic science remain.[66] Commercialization may be an important contributor to these larger inequalities. Women academic scientists are presently far less likely than their male peers to become patent-holders, be named to private company advisory boards, or found a company of their own.[67] Will commercialization exacerbate or extend the gender gap in academic science for emerging scientists?

In sum, the lack of empirical evidence surrounding emerging academic scientists' commercialization related experiences, the increasingly prevalent, democratic, and routine nature of those experiences, and the normative implications of commercialization, should motivate further empirical inquiry. In the second part of this chapter, I identify two issues within commercialization law, policy, and practice that are worthy of empirical study.

B. Exclusionary Encounters with Commercialization

Although emerging academic researchers are increasingly apt to encounter commercialization laws, policies, and practices, I argue below that those encounters are likely to be experienced as moments of exclusion. Relative to more established academics, commercialization laws, policies, and practices, are apt to deny emerging researchers' 1) contributions to patented inventions, and 2) ownership interests in intellectual property more generally. I explore each in turn, guided by US and Canadian laws and policies given that they are most likely to govern commercialization efforts emanating from Canadian academic institutions.

1) Patent Inventorship

US and Canadian laws do not pretend that corporations can invent. When a patent application is filed, the human person(s) responsible for the claimed invention must be named.[68] Patent law accommodates multiple inventors, but the standard for "inventorship" and the consequences of misinforming the patent office as to the identity of the inventor(s) are similarly high in the US and Canada. Only those who conceive or contribute to the conception of the invention are proper inventors. Those who engage in verification, perhaps crucial to establishing an invention's utility, are not inventors if they do not contribute to the "inventive concept."[69] Misleading the patent office as to the

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[65] Statistics Canada, *Women in Science and Engineering* (2006) online: www41.statcan.ca/2006/0193/ceb0193_003-eng.htm.

[66] Corinne A Moss-Racusin et al, "Science Faculty's Subtle Gender Biases Favor Male Students" *Proceedings of the National Academy of Sciences* (2012), online: Proceedings of the National Academy of Sciences www.pnas.org/content/early/2012/09/14/1211286109.

[67] Ding, Murray & Stuart, above note 13; Ding & Choi, above note 13.

[68] 37 CFR § 1.41(a) (2005); 35 USC § 111 (2005).

[69] *Apotex v Wellcome Foundation Ltd*, 2002 SCC 77; *Weatherford Canada Ltd v Corlac Inc*, 2011 FCA 228.

identity of the inventor(s) can result in the patent being declared invalid. Thus, whether filing in the US or Canada, there is a strong incentive to adhere to the legal standard.

TTOs are often at pains to explain this to academic researchers yet a disconnect between the legal standard of inventorship and the social practice of science remains. This disconnect derives from fact that credit for work in the laboratory is allocated not simply based on who did what, but also each researcher's social standing. Empirical research has thus shown that social factors like occupying a position of seniority within a lab or enjoying an important reputation within a scientific field influence authorship on scientific publications and, to a lesser extent, patent inventorship.[70]

We can observe the disconnect between the legal standard of inventorship and the social practice of academic science in at least a couple of ways. The first is through "patent-paper pairs," in which the same core knowledge is disclosed in both a patent application and peer-reviewed publication.[71] Several quantitative studies have shown that the listed authors and inventors in a patent-paper pair are unlikely to match, with the former significantly outnumbering the latter.[72] Secondly, litigation reveals how this legal-social disconnect disproportionately affects emerging scientists. Where inventorship over an academic invention is at issue, the absence of graduate students, PDFs, and research associates named as inventors on a patent often animates the dispute.[73]

From an emerging scientist perspective, the outcomes of this litigation have been mixed. The first in this line of cases, *In re Katz*,[74] involved a Harvard University medical school professor whose patent application was rejected, in part, because of an article he had previously published with two graduate student co-authors. The Court of Customs and Patent Appeals overturned the rejection, concluding that "authorship of an article by itself does not raise a presumption of inventorship."[75] Therefore, an affidavit from the students disclaiming inventorship was not necessary; rather, the very fact that they were

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[70] Carolin Häussler & Henry Sauermann, "Credit Where Credit is Due? The Impact of Project Contributions and Social Factors on Authorship and Inventorship" (2012) Research Policy, online: Social Science Research Network http://ssrn.com/paper=1750240.

[71] Fiona Murray, "Innovation as Co-Evolution of Scientific and Technological Networks: Exploring Tissue Engineering" (2002) 31:8-9 Research Policy 1389 at 1392, citing Philippe Ducor, "Intellectual Property: Co-Authorship and -Inventorship" (2000) 289 Science 873.

[72] *Ibid*; Francesco Lissoni & Fabio Montobbio, "Inventorship and Authorship in Patent-Publication Pairs: an Enquiry into the Economics of Scientific Credit" (2008) 224 KITeS, online: http://econpapers.repec.org/paper/cricespri/wp224.htm; Martin Meyer & Sujit Bhattacharya, "Commonalities and Differences between Scholarly and Technical Collaboration: An Exploration of Co-Invention and Co-Authorship Analyses" (2004) 61:3 Scientometrics 443.

[73] For a review of the jurisprudence prior to 2006, see Sean B Seymore, "My Patent, Your Patent, or Our Patent? Inventorship Disputes Within Academic Research Groups" (2006) 16 Alb LJ Sci & Tech 125; see also *Falana v Kent State University*, 669 F (3d) 1349 (Fed Cir 2012); although the focus here is on inventorship, emerging scientists seem prone to not being named as an author as well. See *Johnson v Schmitz*, 119 F Supp 2d 90 (2000); Rochelle Cooper Dreyfuss, "Collaborative Research: Conflicts on Authorship, Ownership, and Accountability" (2000) 53 Vand L Rev 1162 at 1207.

[74] 687 F 2d 480 (CCPA 1982).

[75] *Ibid* at 455.

"working under the direction and supervision"[76] of the professor worked against any inference of joint inventorship.

Chou v University of Chicago[77] was, in contrast to *Katz*, a relative victory for emerging scientists. Chou worked a total of fourteen years for a professor of molecular genetics, first as a graduate student and then as a PDF. The professor, Dr. Roizman, enforced a policy of confidentiality; no laboratory work could be publicly disclosed without his say so, yet he assured Dr. Chou that she would be "fairly treated for the research which she conducted."[78] And, for some time, Chou and Roizman worked collaboratively, generating a number of research articles and patent applications in which they were named as joint inventors. On one occasion, however, without Chou's knowledge, Roizman filed a patent application based upon a series of research papers that listed Chou as the lead author. Roizman also founded a company to exploit the patented technology. Roizman later forced Chou to resign her position, and she sued in return, naming the university, Roizman, and his company as defendants. Overturning a lower court decision, the Federal Circuit ultimately held that one need not own an invention to meet the requirements of standing when inventorship is at issue, and legitimized a variety of tort claims against professors and universities, including fraudulent concealment, breach of contract, and breach of fiduciary duty.

Subsequent decisions in the US emphasize the fact-specific nature of academic inventorship disputes.[79] Relative to universities and established academics, though, emerging scientists are less well positioned to marshal facts and law to their advantage. Presumably, this partially explains why there are no reported decisions involving an academic scientist where inventorship was at issue in Canada.[80] However, there are also obvious risks to an emerging scientist's career in bringing such a suit such as destroying the very relationships upon which her or his future career depends. All of the US cases to date involved emerging scientists who had moved on from the supervisors and institutions that allegedly denied them inventorship.

If litigation is rare to non-existent, then, the more important empirical question is how do emerging researchers negotiate these exclusionary encounters, and what impact (if any) do they have upon their everyday experiences, laboratory interactions, and commitments. Before hypothesizing along these lines in Part C of this chapter, consider first one more type of exclusionary encounter.

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76 *Ibid* at 456.

77 254 F 3d 1347 (Fed Cir 2001).

78 See Seymore, above note 74 at 145, note 142.

79 In *University of West Virginia. v VanVoorhies*, 278 F 3d 1288 (Fed Cir 2002) (the emerging scientist was, unlike Dr. Chou, knowledgeable of patent law (Dr. VanVoorhies was, in fact, a registered patent agent) and intimately involved in patent-related decision-making. His claims against West Virginia University and a professor for, *inter alia*, breach of fiduciary duty thus failed).

80 There have, however, been other cases in Canada where ownership—as opposed to inventorship—and decision-making regarding the commercialization of an invention were at issue. See *O'Brien v University of Guelph*, [1996] OJ 4026; *Balanyk v University of Toronto*, [1999] OJ 2162; *Corporation de l'École polytechnique de Montréal v Fardad*, 2010 QCCA 992, [2010] QJ 4729.

2) Intellectual Property Ownership

Even if an emerging scientist is included as an inventor, she or he is unlikely to be an owner of the resulting patent or other intellectual property compared to an academic faculty member.[81] Originally, the common law principle was that employees, which captures established and emerging scientists alike, own any inventions made during the course of employment unless they were employed specifically for that purpose.[82] Until recently, US institutions believed that this general rule no longer applied in the context of federally funded research. However, in 2011 the US Supreme Court restored the common law principle, ruling that ownership vests in the inventor(s) absent an agreement otherwise, to be construed as a matter of state law.[83] In Canada, federal legislation is silent with respect to employee inventors and the common law has fluctuated, favouring employers and employees at different times in different provinces.[84] The main point here remains that emerging scientists appear more likely to be divested of ownership than their more senior colleagues.

This sort of exclusionary encounter can occur in two principal ways, either by operation of an express agreement such as a university's intellectual property policy or, depending on the circumstances surrounding employment, it can be implied.

Beginning with university policy, in Canada there exists a range of approaches to intellectual property ownership amongst academic institutions.[85] Of the twenty-three (23) universities ranked in the top 25 in terms of research funding[86] with intellectual property policies accessible online, the default rule is either the inventor(s) (13) or the institution (7) owns, with three exceptions of joint ownership. However, at eight of those 23 institutions the ownership interests of emerging scientists are not accounted for or are second class to those of faculty. In the former case, intellectual property ownership is determined by the faculty collective agreement, which does not extend to emerging scientists. In the remaining four institutions, emerging scientists' ownership interests are explicitly differentiated, in one way or another, from those of faculty. The University of Toronto collapses inventorship into ownership: if an emerging scientist arrived at the invention after being directed by a faculty member "specifically with the object of

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[81] This disassociation between the creator (or inventor) and owner of intellectual property is premised on a centuries old US court decision. See Catherine L Fisk, *Working Knowledge: Employee Innovation and the Rise of Corporate Intellectual Property, 1800-1930* (Chapel Hill: University of North Carolina Press, 2009) at 33 citing *Pennock v Dialogue*, 27 US 1 (1829).

[82] *Bloxam v Elsee* (1825) 1 Car & P 558; *United States v Dubilier Condenser Corp*, 289 US 178 (1933); *Comstock Canada v Electec Ltd*, [1991] FCJ 987.

[83] *Board of Trustees of the Leland Stanford Junior University v Roche Molecular Systems Inc*, 131 S Ct 2188 (2011).

[84] David Vaver, *Intellectual Property Law: Copyright, Patents, Trade-Marks*, 2d ed (Toronto: Irwin Law, 2011) at 366.

[85] Statistics Canada, *Survey of Intellectual Property Commercialization in the Higher Education Sector* (2010) online: www.statcan.gc.ca/cgi-bin/imdb/p2SV.pl?Function=getSurvey&SDDS=4222&lang=en&db=imdb&adm=8&dis=2.

[86] This list of universities is derived from Re$earch Infosource Inc, *Canada's Top 50 Research Universities 2009*, online: www.researchinfosource.com/media/2009Top50List.pdf.

making such an invention," then she or he is not the owner of that invention.[87] The other two institutions take a more blunt approach: whether under the specific direction of a supervisor or not, if any kind of employment relationship between the emerging scientist and the university exists (University of New Brunswick)[88] the emerging scientist has no ownership interest in any resulting patents or, it appears, must "pre-assign" the same to the university (University of Saskatchewan).[89]

There is no robust data about the prevalence of "pre-assignment" contracts in Canada or the US, but they are reported to be a common component of the PDF hiring process.[90] Thus, even where a university policy suggests otherwise or is silent on the issue, pre-assignment contracts can divest emerging scientists of their ownership interests in any intellectual property that results from their work.

Emerging scientists can also lose ownership by implication by virtue of the "employed to invent" common law exception to employee ownership. This exception has not yet been applied in the context of academic science in Canada,[91] and one notable commentator has suggested that academics are amongst the least likely to fit within this exception given that they are "usually hired to teach and research, not invent and patent."[92] However, others have noted that emerging scientists may be in a different position, "especially where the work in question is clearly directed towards commercial purposes or objectives, as opposed to 'pure' research."[93] The increasing policy emphasis placed upon commercialization highlighted in Part A above thus suggests that emerging scientists are today more apt to be seen as employees hired to invent than their supervisors, especially if they do not have other obligations of the more traditional academic such as teaching.

As with exclusions from patent inventorship, the frequency of emerging scientists' exclusions from intellectual property ownership, by operation of an express or implied arrangement is not presently known. In the final part of this chapter I briefly hypothesize one potential effect that such experiences—however (in)frequent—might have.

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87 University of Toronto, *Inventions Policy* (2007) s 3.3(a), online: www.governingcouncil.utoronto.ca/policies/invent.htm.

88 University of New Brunswick, Office of Research Services, *Guidelines on Intellectual Property Interests for Students Involved in Research at the University of New Brunswick*, (September 7, 2006) online: www.unb.ca/research/ors/indgovtserv/iptt/guidelines.php.

89 It is unclear whether the University of Saskatchewan requires PDFs to pre-assign any and all inventions to the university. However, a memorandum of understanding with language to that effect is provided as a template on the university's website. See University of Saskatchewan, "APPENDIX IV Memorandum of Agreement - Intellectual Property", online: www.usask.ca/hrd/investigators/appendixes_and_samples.php.

90 Seymore, above note 74 at 137, citing Dreyfuss, above note 74.

91 It has, however, been applied to an US-based academic scientists in a couple of cases. See *Speck v Northern Carolina Dairy Foundation Inc*, 319 SE (2d) 139 (1984); and, *Madey v Duke University*, 307 F (3d) 1351 (2002).

92 Vaver, above note 86 at 368.

93 Kevin LaRoche, Christine Collard & Jacqueline Chernys, "Appropriating Innovation: The Enforceability of University Intellectual Property Policies" (2007) 20:2 IPJ 135 at 261.

C. Conclusion: Future Research Questions

Emerging scientists' exclusionary encounters with commercialization can ground many hypotheses. I offer one by way of conclusion: that emerging scientists' who experience exclusion in some form, paradoxically, learn to prize that which they have been previously denied, i.e. participation in commercialization. This hypothesis derives from previous research in behavioural economics and cognitive psychology, which sheds some light on how individuals value what they own and what they create. Specifically, individuals tend to overvalue that which they already own (an "endowment effect"); and, the process of creating something, rather than simply owning it, heightens that tendency to overvalue (dubbed a "creativity effect").[94] Thus, conceivably, emerging scientists who experience exclusion will prize status as an inventor, or intellectually property ownership, more than someone else who is not similarly excluded from those experiences (a "prizing effect").

The challenge going forward is, of course, to develop an empirical research design capable of probing for this and other possible effects associated with emerging scientists' exclusionary encounters with commercialization. The purpose of this chapter was to argue that the intersection of emerging academic scientists and commercialization laws, policies, and practices provides a rich, and important locus of inquiry that has been under-studied and under-theorized to date.

[94] Christopher J Buccafusco & Christopher J Sprigman, "The Creativity Effect" (2011) 78:1 U Chicago L Rev 31.