Points Critical:
Russia, Ireland, and Science at the Boundary

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ABSTRACT

This essay compares the way in which Russia and Ireland have defined themselves since the mid-nineteenth century as scientific nations (or not) by following the careers of D. I. Mendeleev (1834–1907) and Thomas Andrews (1813–85), both of whom were involved in the discovery of the "critical point" boundary between liquids and gases. Mendeleev and Andrews deployed their critical-point research in a similar fashion to integrate science into the national identity for their respective countries, a strategy that proved far more successful for Mendeleev than for Andrews.

INTRODUCTION

What could possibly be learned about science by discussing Russia and Ireland together? One could easily compile a list of dissimilarities between Europe's largest country and one of its smallest that would make the endeavor appear distinctly unworthwhile. I wish, however, to point to ways in which they can be usefully and fruitfully compared for a specific time period (the nineteenth century) and in a specific area of cultural development (science).[1] In that period, elite laboratory science had a small but noteworthy penetration into both Russia and Ireland, and in both places it was associated with a particular quasi-foreign stratum: either Russo-Germans or German-educated Russians, and the Anglo-Irish Protestant Ascendancy, respectively. By comparing the two, we can better understand the relationship of national identity to science in some of the "later emerging" nations of Europe—that is, those countries that developed nationalist movements after patterns of industrialization and national self-identification had already congealed into fairly standard forms in England, France, and the German states. In the particular case of Russian and Irish scientists, we can see how nearly identical professional strategies yielded

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[1] My approach here is inspired by the stimulating comparison of twentieth-century political culture in Italy and Japan offered in Richard J. Samuels, *Machiavelli's Children: Leaders and Their Legacies in Italy and Japan* (Ithaca, N.Y., 2003).

very different results. For instance, how did the career of a specific scientist come to be marked as positive or negative in specific national contexts? As it happened, in the Russian context, the career of the scientist was built up into a source of national pride and aspiration beginning in the late nineteenth century, while in Ireland the same period marked its decline in prestige. Comparing the parallel (and somewhat related) developments in both contexts will help illuminate how certain scientists became icons for national identity, while others were deliberately written out of the national pantheon, irrelevant in large part *because* their primary personal identities were as scientists.

One common strategy of considering a broader context for the scientific endeavor has been to situate historical narratives in a nation-state context. For some concerns—the formation of educational institutions, state-funding patterns, questions of citizenship—this is a very fruitful approach. For the question of "national identity," however, it proves more problematic.[2] This term bears two distinct but related meanings. First is the notion that individual scientists approach the study of nature in ways strongly correlated with a frame of mind set by their national origins. Taken to absurd extremes, the result replicates naïve (and chauvinist) cultural essentialism. Consider my favorite example:

> If the average quality of the German scientist is heavy thoroughness, that of the Frenchman clearness and lucidity of thought combined with an impulse to treat science as art, that of the British extraordinary positivity and that of the American an ability to combine specialization with mass production, then the distinctive character of the Russian may be seen in the restlessness of his spirit and the striving to embrace a wide field of knowledge, to find answers to questions which are ever present in his thoughts and which once raised may not be lightly put aside, but must be settled the one way or the other, if only for the satisfaction of his own soul.[3]

No historian of science today would endorse this view without reservation. But similar tropes find their way into a wide variety of mainstream accounts and remain popular among scientists. One way of getting away from this kind of reductionism is to approach national identity in its second sense: as the identity of a larger collective, a rhetorical device for public figures (including scientists) in specific nations to define the political and economic contours of their nation-state as being "scientific." That is, the nation as a whole comes to acquire the identity as being a "scientific nation," without our having to project that political strategy—for it *is* a political strategy—into the minds of its citizens.

Such professions of scientific national identity are historically situated in space and time, a point that can be illustrated most effectively through comparison.[4] The historical scholarship on Ireland—and even more so on science in Ireland—is riddled with brief as well as extended comparisons. The most common comparator is Canada,

[2] An exception, specific to the case of Irish mathematics in the early nineteenth century, is David Andrew Attis, "The Social Contexts of W. R. Hamilton's Prediction of Conical Refraction," in *Science and Society in Ireland: The Social Context of Science and Technology in Ireland, 1800–1950*, ed. Peter J. Bowler and Nicholas Whyte (Belfast, 1997), 19–35.

[3] Alexander Petrunkevitch, "Russia's Contribution to Science," *Transactions of the Connecticut Academy of Sciences* 23 (1920): 211–41, on 222.

[4] Maurice Crosland, "History of Science in a National Context," *British Journal for the History of Science* 10 (1977): 95–113, 111.

either in toto or just the individual case of Quebec,[5] followed by the obvious comparisons to other British colonies, such as India, New Zealand, Australia, and colonial America.[6] Historians interested in the economics of colonialism have considered Ireland in relation to the more obviously "colonial" cases of Africa and Asia.[7] A smaller subset compares Ireland with other "late-emerging" nations on the Continent (Italy, Spain, Portugal),[8] and one sociologist of science has noted some intriguing parallels with another recently independent, formerly colonized, northern European country, Finland.[9] Given all of this frantic comparison with the Irish case, it would be surprising if Russia were left out. In fact it has not been, although the comparisons have remained on the level of economics and rebellions. (Both countries experienced shocks to their peasant populations in midcentury, with the disastrous famine in Ireland in 1846 and the emancipation of the serfs in Russia in 1861, and subsequently suffered a wave of political terrorism by the Fenians and the Populists, respectively.)[10]

This essay explores both the fruitfulness and the limits of extending the Ireland-Russia comparison to the history of science. There are a large number of ways this

[5] John Wilson Foster, "Strains in Irish Intellectual Life," in *On Intellectuals and Intellectual Life in Ireland: International, Comparative, and Historical Contexts*, ed. Liam O'Dowd (Belfast, 1996), 71–97, 84; Richard A. Jarrell, "Colonialism and the Truncation of Science in Ireland and French Canada during the Nineteenth Century," *HSTC Bulletin* 5 (1981): 140–57; Jarrell, "Differential National Development and Science in the Nineteenth Century: The Problems of Quebec and Ireland," in *Scientific Colonialism: A Cross-Cultural Comparison*, ed. Nathan Reingold and Marc Rothenberg (Washington, D.C., 1987), 323–50.

[6] Richard A. Jarrell, "Technical Education and Colonialism in Ireland in the Nineteenth Century," in *Prometheus's Fire: A History of Scientific and Technological Education in Ireland*, ed. Norman McMillan (Dublin, 2000), 170–86; and Tony Ballantyne, "The Sinews of Empire: Ireland, India, and the Construction of British Colonial Knowledge," in *Was Ireland a Colony? Economics, Politics, and Culture in Nineteenth-Century Ireland*, ed. Terrence McDonough (Dublin, 2005), 145–61.

[7] Liam Kennedy, *Colonialism, Religion, and Nationalism in Ireland* (Belfast, 1996), 169–71. Kennedy concludes that Ireland should not be compared with other colonies but with western European countries. This, of course, merely continues the tradition of thinking of Ireland juxtaposed with another place. Opposed to Kennedy on the issue of "colonialism" as a category for Ireland are: Terry Eagleton, "Afterword: Ireland and Colonialism," in McDonough, *Was Ireland a Colony?* (cit. n. 6), 326–33; and the very influential Michael Hechter, *Internal Colonialism: The Celtic Fringe in British National Development* (1975; New Brunswick, N.J., 1999).

Much of the discussion of science in a colonial framework has centered on the classic model of "colonial science" as provided by George Basalla, "The Spread of Western Science," *Science*, N.S. 156, no. 3775, 5 May 1967, 611–22, which explicitly names Russia as effectively "colonial" with respect to science on 613. Basalla has been criticized from all sides for oversimplification and lack of a clear mechanism. For two examples, see Ian Inkster, "Scientific Enterprise and the Colonial 'Model': Observations on Australian Experience in Historical Context," *Social Studies of Science* 15 (1985): 677–704; and V. V. Krishna, "The Colonial 'Model' and the Emergence of National Science in India: 1876–1920," in *Science and Empires: Historical Studies about Scientific Development and European Expansion*, ed. Patrick Petitjean, Catherine Jami, and Anne Marie Moulin (Dordrecht, Netherlands, 1992), 57–72. This relates to whether one can truly consider Irish science to be "colonial." See, e.g., Steven Yearley, "Colonial Science and Dependent Development: The Case of the Irish Experience," *Sociological Review* 37 (1989): 308–31; Richard A. Jarrell, "The Department of Science and Art and Control of Irish Science, 1853–1905," *Irish Historical Studies* 23 (1983): 330–47; and Roy MacLeod, "On Science and Colonialism," in Bowler and Whyte, *Science and Society in Ireland* (cit. n. 2), 1–17.

[8] Dorinda Outram, "Negating the Natural: Or Why Historians Deny Irish Science," *Irish Review*, no. 1 (June 1986): 45–49, 48–49.

[9] Yearley, "Colonial Science and Dependent Development" (cit. n. 7), 327

[10] Eoin MacWhite, "Ireland in Russian Eyes under the Tsars," *Australian National University Historical Journal* 1 (1965–66): 5–13; and Derek Offord, "Political Terrorism in Russia in the 1880s: The Fenian Lesson," *Irish Slavonic Studies*, no. 5 (1984): 27–31.

could be done, and I have selected a very small example as my starting point: the priority dispute over the discovery of the liquid-gas critical point between Dmitrii Ivanovich Mendeleev (1834–1907) and Thomas Andrews (1813–85). This was a particularly one-sided priority dispute: in 1870 Mendeleev, having read Andrews's article on the critical point published in 1869, claimed to have discovered the phenomenon a decade earlier, a claim to which Andrews never responded. (This silence on Andrews's part is in itself significant.) The priority dispute is slightly technical, and I explore it in some detail because it teases apart a distinction between conflict among international chemists within their discipline (resolved largely in terms of the generations of chemists) and the presentation of a style of science to one's immediate national interlocutors (the nationalist importance of showing one's science as fundamentally *non*national). In addition, the specificity and clarity of the issues eliminate any consideration of radical incommensurability between these two rather different national contexts.

Then I show how that original context for both research projects (Heidelberg for Mendeleev, midcentury Belfast for Andrews) and the scientists' subsequent careers illuminate the role of the science of this period in the construction of national identities. I will develop the Irish case more extensively than the Russian one not just because the latter is better treated in recent historiography (especially in terms of the identification of the Soviet Union as a scientific state) but also because the Irish case represents a counterintuitive instance where scientific self-identification *failed* to take root in the national self-concept.[11] As a result, the circumstances by which Irish nationalism came to exclude Andrews from iconic status demand greater explication.

WHO DISCOVERED THE CRITICAL POINT, AND WHO CARES?

Mendeleev saw threats to his scientific status everywhere, and his career was studded with efforts to establish priority for his most noted work, the periodic system of chemical elements, against all claimants (but especially from German chemist Julius Lothar Meyer).[12] The first serious priority dispute he engaged in petered out quickly, yet in many ways it set the pattern for the more famous disputes that followed. Mendeleev in 1870 nicely presented his vision of the substance of the "critical point," and by working forward from Mendeleev to Andrews, we can see how the concept had been repackaged by Mendeleev to lend credence to his priority claim.

Mendeleev's 1870 article in *Poggendorff's Annalen* on the critical point highlights two tropes common to all of Mendeleev's priority claims (and not his alone): first, he claimed that he was not really interested in priority and recognized the value of the *data* being offered by his opponent, if not the opponent's *originality* or *interpretation*; and that the two of them were talking about the same effect—in this case, what Andrews called "the critical point" (Mendeleev cited it in English), and Mendeleev's own "absolute boiling point" (*absolute Siedetemperatur* [Ger.], *temperatura*

[11] See, e.g., the essays included in Michael D. Gordin, Karl Hall, and Alexei B. Kojevnikov, eds., *Intelligentsia Science*, *Osiris* 23 (2008), and references therein.

[12] The literature on this priority dispute is voluminous. For an introduction, see J. W. van Spronsen, *The Periodic System of Chemical Elements: A History of the First Hundred Years* (Amsterdam, 1969); and Eric R. Scerri, *The Periodic Table: Its Story and Its Significance* (Oxford, 2007).

absoliutnogo kipeniia [Rus.]).[13] What exactly is this phenomenon? As Mendeleev paraphrased Andrews, it is "a critical temperature [that] exists for all bodies, so that by a higher temperature vapour will not condense—and thus presents as a gas—while by a lower temperature the same would under a certain pressure become condensed, and thus be a true vapour."[14]

Mendeleev argued that Andrews drew the wrong conclusions from this effect, and for the wrong reasons, because Andrews insisted on confusing what Mendeleev saw as a clear line between liquids and gases:

> From the above [quotation], as well as in many other places in Andrews's article, the impression could easily be formed as if the transition of a gas into a liquid at a defined temperature were less clear and sharp than under usual conditions. The incorrectness of such a conclusion, so far as the absence of a clear difference between gases and liquids in Andrews's article, compels me to make some comments on this situation, all the more as similar investigations were undertaken by me about 10 years ago.[15]

Interestingly, it is precisely this blurring of the boundary that makes Andrews's work seem so original today and what makes the critical point of liquids so important.

The question then is why Mendeleev did not see this blurring as either correct or significant. He ignored the question because he believed the importance of the "absolute boiling point" was to generate natural "laws," thus introducing more bright lines in nature, not erasing those already recognized. This interest in finding laws stemmed directly from the origins of Mendeleev's research on this topic in organic chemistry: "So one would probably find for hydrocarbons C^nH^{2n+2} a regularity [*Gesetzmäßigkeit*] between the change in the absolute boiling point and its composition, in that these temperatures for the liquid homologues C^6H^{14}, C^7H^{16}, are either measured directly or are derived from their coefficients of cohesion."[16] At the time Mendeleev made his claim for priority, he was indeed shifting away from the study of periodicity and toward state-funded research—an innovation Mendeleev encouraged as part of a vision of Russia as a scientific nation—on the compressibility of gases, a project that would eventually end in shambles in 1880.[17] One function of Mendeleev's prior-

[13] D. Mendelejeff, "Bemerkungen zu den Untersuchungen von Andrews über die Compressibität [sic] der Kohlensäure," *Poggendorff's Annalen der Physik und Chemie* 141 (1870): 618–26, 622–23. Mendeleev would continue to insist on the identity of these concepts and his priority in them into the twentieth century. In the seventh edition of his textbook *The Principles of Chemistry*, published in 1903, Mendeleev included a long footnote that recounted many of the same arguments as this 1870 piece and concluded: "Obviously, it [the critical point] is identical with the absolute boiling temperature." Mendeleev, *Osnovy khimii*, 7th ed. (1903), reproduced in Mendeleev, *Sochineniia* (Leningrad, 1947), 5:291n29.

[14] Mendelejeff, "Bemerkungen zu den Untersuchungen von Andrews" (cit. n. 13), 618. On the predecessors that Andrews does cite, see Duane H. D. Rollder, "Thilorier and the First Solidification of a 'Permanent' Gas (1835)," *Isis* 43 (1952): 109–13; and Yorgos Goudaroulis, "Searching for a Name: The Development of the Concept of the Critical Point (1822–1869)," *Revue d'histoire des sciences* 47, nos. 3/4 (1994): 353–79.

[15] Mendelejeff, "Bemerkungen zu den Untersuchungen von Andrews" (cit. n. 13), 619.

[16] Ibid., 623. Today these formulas would be written with subscripts, but Mendeleev characteristically preferred superscripts (as did many of his contemporaries).

[17] This gas research is detailed in Michael D. Gordin, *A Well-Ordered Thing: Dmitrii Mendeleev and the Shadow of the Periodic Table* (New York, 2004), chap. 3. Mendeleev specifically invoked both Regnault and Mariotte's law of the temperature-volume relationship in his priority article: Mendelejeff, "Bemerkungen zu den Untersuchungen von Andrews" (cit. n. 13), 625.

ity claim, therefore, was to characterize his new path of research as no departure at all but rather continuity from his earlier work; another was to carve out a reputation for himself as a leading European chemist. Both of these conditions, as we shall see, were intimately linked to the context of St. Petersburg in the late 1860s.

As far as priority disputes go, this one had no legs. Andrews never bothered to respond publicly to Mendeleev's position. This has nothing to do with prejudice against the claims of a Petersburger. Early in his career, in the 1840s, Andrews did engage in a priority dispute with St. Petersburg academician Hermann Hess over thermochemistry.[18] Even more important than national identity for priority claims, in this case, was one's professional stage: earlier in one's career it is more vital to stake such claims to build a reputation—a strategy both Andrews and Mendeleev deployed at the equivalent point in their own careers. Andrews did not see the criticisms as serious enough to answer and likely interpreted the Russian's experiments as being fundamentally about a different question. Nobody else seemed to take Mendeleev's claim seriously, either. It has very rarely been addressed in the chemical or historical literature, and the few glancing references to it leave no doubt as to where the priority belongs: "to Andrews and to him alone."[19]

The question is less why Andrews did not respond—such claims of priority were ubiquitous in this period and were rarely answered unless taken up by a third party—than why Mendeleev chose to make the claim when this research had lain fallow for a decade. Why did he initiate the dispute at all? First, because he was at an early stage of his career. Second, because he had much to gain in confronting an established (and, even better in the Russian context, *foreign*) scientist and little to lose, even in the case of complete silence on his opponent's part (which was in fact the case). But this was not simply a case of jockeying for prestige. For Mendeleev, there was a deep philosophical interest in the effect of the absolute boiling temperature, an interest he felt Andrews had ignored in his articles. The Petersburger was interested in the critical point as a locus for finding natural laws between organic homologues. This interest emerged directly out of his research on the absolute boiling temperature, conducted in his apartment laboratory while on a two-year state-funded postgraduate fellowship during 1859–61 spent mostly in Heidelberg. This research on organic liquids occupied essentially the entirety of his time abroad, and he published on it widely and in several languages (although not English).[20] In these delicate experiments, Mendeleev took an array of very pure liquid hydrocarbon homologues and studied their capil-

[18] Thomas Andrews, "On the Thermal Changes Accompanying Basic Substitutions," *Philosophical Transactions of the Royal Society of London*, pt. 1 (1844), 21, reproduced in Andrews, *The Scientific Papers of the Late Thomas Andrews*, ed. P. G. Tait and A. Crum Brown (London, 1889), 107.

[19] A. C[rum] B[rown], "Obituary Notices of Fellows Deceased," *Proceedings of the Royal Society of London* 41 (1886): i–xv, on xv.

[20] These are gathered, in Russian translation, in Mendeleev, *Sochineniia* (cit. n. 13). The original French and German articles are: "Notiz über die Ausdehnung homologer Flüssigkeiten," *Annalen der Chemie und Pharmacie* 114, no. 2 (1860): 165–9; "Sur la cohésion de quelques liquides et sur le rôle de la cohésion moléculaire dans les réactions chimiques des corps," *Comptes Rendus* 51 (1860): 97–99; "Sur la cohésion moléculaire de quelques liquides organiques," *Comptes Rendus* 50 (1860): 52–54; "Ueber die Molecularcohäsion einiger organischen Flüssigkeiten," *Zeitschrift für Chemie und Pharmacie* 3 (1860): 49–52; "Ueber die Ausdehnung homologer Flüssigkeiten," ibid., 397; "Ueber die Cohäsion einiger Flüssigkeiten, und über die Rolle, welche die Molecularcohäsion bei den chemischen Reactionen der Körper spielt," ibid., 481–84; and "Ueber die Ausdehnung und das specifische Gewicht der Flüssigkeiten beim Erwärmen über ihren Siedepunkt," *Zeitschrift für Chemie und Pharmacie* 4 (1861): 33–37.

lary rise in narrow tubes. Capillarity was his proxy for measuring the "cohesiveness" of the various fluids. The original idea, therefore, had absolutely nothing to do with the transition between gas and liquid; it was concerned exclusively with a property belonging to liquids.[21] (Nonetheless, capillarity is a very good way to find the critical point of various liquids.)[22]

Mendeleev's goal here was always to find microphysical laws concerning the forces that held liquids together and thus the forces that drove chemical reactions. Of course, he did not receive perfect results: "This law, however, is not completely exact, but only approximate—as are all laws known to date in physical chemistry."[23] Yet Mendeleev was convinced that eventually he would find the kind of regularity that would provide a connection between the microphysical (cohesion) and the macrophysical (capillarity):

> Selecting cohesion of liquids as the subject of my researches, I indeed supposed that it would be subject to such a law. Continuing the investigations of this subject, I have in mind above all a collection of data. The measure of the cohesion of bodies, doubtless, is a property more characteristic than, for example, the boiling point, and we have to date very little data about it. As a consequence, probably, one will discover the dependence between cohesion and many other physical properties, such as specific weight, expansion, heat capacity, latent heat, etc. With the development of molecular mechanics the measure of cohesion should enter as a necessary data for the resolution of a majority of questions.[24]

From his position in Belfast, Thomas Andrews had long established a reputation in thermochemistry, but his most famous work, that of the critical point, was an original departure for him in the 1860s, rather late in his career.[25] After a period of some silence in the 1860s, Andrews chose to deliver his findings in the distinguished Bakerian Lecture of 1869. With a decided emphasis on the transition between states and not either gases or liquids, he titled it "On the Continuity of the Gaseous and Liquid

[21] Mendeleev, "Chastichnoe stseplenie nekotorykh zhidkikh organicheskikh soedinenii," *Khimicheskii zhurnal N. Sokolova i A. Engel'gardta* 3 (1860): 81–97, reproduced in Mendeleev, *Sochineniia* (cit. n. 13), 12. Mendeleev was also interested in thermodynamic questions such as latent heat, but he made it clear that these were secondary issues: Mendeleev, "Sur la cohésion de quelques liquides et sur le rôle de la cohésion" (cit. 20), 99; Mendeleev, "Ueber die Ausdehnung und das specifische Gewicht der Flüssigkeiten" (cit. n. 20), 33.

[22] J. Livingston, R. Morgan, and Reston Stevenson, "The Weight of a Falling Drop and the Laws of Tate: The Determination of the Molecular Weights and Critical Temperatures of Liquids by the Aid of Drop Weights," *Journal of the American Chemical Society* 30 (1908): 360–76; Eric Higgins, "The Temperature Coefficient of the Weight of a Falling Drop as a Means of Estimating the Molecular Weight and the Critical Temperature of a Liquid" (PhD diss., Columbia Univ., 1908); and Eldred H. Chimowitz, *Introduction to Critical Phenomena in Fluids* (New York, 2005), 290–92.

[23] Mendeleev, "Chastichnoe stseplenie nekotorykh zhidkikh organicheskikh soedinenii [II]," *Khimicheskii zhurnal N. Sokolova i A. Engel'gardta*, 1 (1860): 145–70, reproduced in Mendeleev, *Sochineniia* (cit. n. 13), 30.

[24] Ibid., 32. This obsession with finding laws of nature runs like a scarlet thread throughout Mendeleev's career; the periodic system case is only the most obvious, prolonged, and successful example. See Gordin, *A Well-Ordered Thing* (cit. n. 17), chap. 7.

[25] For secondary studies of Andrews's work on the critical point, see: J. S. Rowlinson, "The Work of Thomas Andrews and James Thomson on the Liquefaction of Gases," *Notes and Records of the Royal Society of London* 57 (2003): 143–59; Rowlinson, "Thomas Andrews and the Critical Point," *Nature* 224, 8 Nov. 1969, 541–43; Allan A. Mills, "The Critical Transition between the Liquid and Gaseous Conditions of Matter," *Endeavour* 19, no. 2 (1995): 69–75; H. Mackle, "Thomas Andrews, Calorimetrist," *Nature* 224, no. 5219, 8 Nov. 1969, 543–44; and Cyril Domb, *The Critical Point: A Historical Introduction to the Modern Theory of Critical Phenomena* (London, 1996).

States of Matter." This lecture may never have been delivered, and if it was, very few people attended, as most of Andrews's more illustrious peers were in London that day attending the first Faraday Lecture at the Royal Institution (Andrews's close friend Michael Faraday had died two years earlier), delivered by the French chemist Jean-Baptiste Dumas and chaired by English chemist Alexander Williamson. Andrews, typically, declined to leave Belfast.[26] It is clear from the discussion in the published article based on the ostensible lecture, however, that he approached the phenomenon from the gaseous side and then worked his way back to the liquid, increasing the pressure on a sample in a thin capillary tube. In the paper, Andrews strongly emphasized the *physical* (rather than chemical) properties of the phase transition, mostly measured on carbonic acid (carbon dioxide). Even "transition" puts it a bit strongly because Andrews contended there was no real boundary at all:

> The answer to the foregoing question, according to what appears to me to be the true interpretation of the experiments already described, is to be found in the close and intimate relations which subsist between the gaseous and liquid states of matter. The ordinary gaseous and ordinary liquid states are, in short, only widely separated forms of the same condition of matter, and may be made to pass into one another by a series of gradations so gentle that the passage shall nowhere present any interruption or breach of continuity. From carbonic acid as a perfect gas to carbonic acid as a perfect liquid, the transition we have seen may be accomplished by a continuous process, and the gas and liquid are only distant stages of a long series of continuous physical changes.[27]

In fact, he explicitly excluded the very microphysical speculations Mendeleev was so keen on illuminating with his organic homologues, although he did recognize that his findings implied strong intermolecular forces.[28] So Andrews defined the "critical point" as the temperature above which it was impossible to condense a gas into a liquid, no matter how high the pressure; in other words, the critical point marked an *absolute* phase transition. Below that point, any substance could exist in either or both states simultaneously. The critical point of carbon dioxide was 31°C, of ether 200°C.

Much as in the case of Antoine Lavoisier's "oxygen" and Joseph Priestley's "dephlogisticated air," it should be clear that in this case the two scientists were not looking at (or for) "the same" effect: Andrews sought clarity of concepts at the expense of blurriness in the phenomena before him; Mendeleev wanted rigorous laws of natural phenomena but remained vague about categories such as "cohesion." Andrews worked with gases, whereas Mendeleev's interest lay only in the liquids. And, finally, Mendeleev cared about the microphysical features of the actual substance, while Andrews was interested in macroscopic, indeed thermodynamic, qualities. In what follows, I explore how these divergent approaches to what we now consider to be a single phenomenon were deeply embedded in professional choices made by the two scientists, and how those choices then shaped the readiness with which later Russians could unflinchingly adopt Mendeleev the scientist as a "Russian" icon, while the parallel choices by Andrews led to his being excluded from claims to "Irishness" in the twentieth century.

[26] Rowlinson, "Work of Thomas Andrews and James Thomson" (cit. n. 25), 146.

[27] Thomas Andrews, "On the Continuity of the Gaseous and Liquid States of Matter: The Bakerian Lecture," *Philosophical Transactions*, pt. 2 (1869), 575, reproduced in Andrews, *Scientific Papers of the Late Thomas Andrews* (cit. n. 18), 315. As he further articulated it, the transition was not only continuous but also symmetrical with respect to direction. See Andrews, "On the Gaseous and Liquid States of Matter," *Royal Institution of Great Britain*, 2 June 1871, reproduced in Andrews, *Scientific Papers of the Late Thomas Andrews*, 343.

[28] Andrews, "On the Continuity of the Gaseous and Liquid States of Matter" (cit. n. 27), 315.

INVENTING THE SCIENTIST'S ROLE IN PETERSBURG AND BELFAST

Andrews and Mendeleev came from and lived in two very different contexts, but they employed almost identical strategies and drew on very similar resources to establish their critical point/absolute boiling temperature research in their respective sites. Mendeleev situated this research from the start of his career as part of an ambitious program of pure science designed to secure him a position in the sparse academic environment of Petersburg. Andrews deployed similar moves to validate a position as a public intellectual in a troubled emerging nation. For Mendeleev, the purpose was both professionally and politically to point himself toward the future; for Andrews, it was to salvage some continuity with the past. By looking at these strategies as parallel yet divergent, I argue that we can see much of what gets attributed to "national character" in the sciences as the effects of a rather standard strategy in different contexts.

Mendeleev's case was doubly unusual: He was a scientist from a scientifically underrepresented country, and he performed his research not from his home base of Petersburg but in Heidelberg.[29] Mendeleev ended up in Heidelberg after the end of a long train of events initiated by Russia's loss of the Crimean War (1854–56). After the defeat, the government of the new tsar, Alexander II, began a series of reforms designed to bolster the fiscal and military stability of the Russian Empire. Although today these so-called Great Reforms are often (retrospectively) viewed as liberalizing measures—especially the 1861 emancipation of the serfs—they are more accurately seen as conservative efforts to avert unrest.[30] The development of the industrial sector of the economy was one of the prime targets of these reforms. To facilitate this in the late 1850s, a series of talented young Russian specialists in fields such as law, medicine, and the sciences were sent on state-subsidized two- or three-year trips (*komandirovki*) to Europe (and primarily to the German universities) to learn new techniques, acquire new research materials, and in general be trained in the structures and practices of a modern research university. The architects of the program, which lasted for about a decade, hoped to reimport these students so that technical education in the empire could be modernized.[31] Science was part of Russia's reorientation for the future.

Mendeleev was among the first cohort of such students who had just finished their Russian "candidate" or "master's" degrees, and he elected, along with a sizable cadre

[29] See M. D. Mendeleeva, "Novye materialy o zhizni i tvorchestve D. I. Mendeleeva v nachale 60-kh godov," *Nauchnoe Nasledstvo* 2 (1951): 85–94. On his capillarity work while there, see V. P. Veinberg, "Raboty D. I. Mendeleeva po kapilliarnosti i temperature absoliutnago kipeniia," in *Trudy Pervago Mendeleevskogo s"ezda po obshchei i prikladnoi khimii, sostoiavshagosia v S.-Peterburge 20-go po 30-go dekabria 1907 g.*, ed. V. E. Tishchenko (St. Petersburg, 1909), 89–106.

[30] W. Bruce Lincoln, *The Great Reforms: Autocracy, Bureaucracy, and the Politics of Change in Imperial Russia* (DeKalb, Ill., 1990); and Alfred J. Rieber, "Alexander II: A Revisionist View," *Journal of Modern History* 43 (1971): 42–58.

[31] Michael D. Gordin, "The Heidelberg Circle: German Inflections on the Professionalization of Russian Chemistry in the 1860s," in Gordin, Hall, and Kojevnikov, *Intelligentsia Science* (cit. n. 11), 23–49.

of Russian chemists, to spend his time in Heidelberg. Most of these Russians hoped initially to work with Robert Wilhelm Bunsen but eventually congregated instead in the organic chemistry laboratory of privatdozent Emil Erlenmeyer.[32] Mendeleev was not one of the Russians in Erlenmeyer's laboratory; he set up his own in his apartment where he conducted all of his capillarity research. He had been sent abroad in early 1859 for a two-year fellowship from the physical-mathematical faculty of St. Petersburg University (where he had begun his graduate work), with the possibility of a renewal for a third year. He attempted to parlay his findings on "absolute boiling temperature" into an extension for a third year.

Mendeleev's claim began as such things often did in Imperial Russia: with a petition. In a draft of his request to the physical-mathematical faculty for a further year abroad, composed on December 18, 1860, Mendeleev extolled his work on capillarity:

> But the largest part of my time in my stay abroad was dedicated to studies on that special field which connects chemistry with physics and mechanics. Convinced of the identity of the forces of chemical affinity and the force of cohesion and confident that a possibly full solution of questions on the causes of chemical reactions could not be done without knowledge of the magnitude of molecular cohesion, I chose as my specialty this very poorly worked out area.[33]

Note that he made no reference to the absolute boiling point here (or to the rather obvious practical implications for the liquefaction of gases, to which Andrews's work was almost instantly applied). Instead, he focused on highly ambitious potential theoretical insights. Or, as he wrote in a separate request to the petitioner of the St. Petersburg educational region, his hope was to partially efface the boundary between chemistry and physics: "The brilliance of purely chemical discoveries made contemporary chemistry a completely specialized science, tearing it away from physics and mechanics, but doubtless there should come a time when chemical affinity will be seen as a mechanical phenomenon, similar to how it has already come time for us to consider light and heat to be such phenomena."[34]

Mendeleev's move reflected a combination of factors: his own considerable ambition; his conviction that chemistry should grow closer to physics; and his sense of what would *work*, what would lead to an extension of his stay. Mendeleev believed—based on the surrounding environment in Heidelberg and in western European chemistry more generally, as well as on his sense of the aspirations of the Russian chemical community back home—that careful laboratory studies at the forefront of risky and speculative areas of physical chemistry would be precisely the kind of work the

[32] On why Heidelberg and why Erlenmeyer, see ibid. (Coincidentally, Andrews also spent the summer of 1854 in Heidelberg, working with Bunsen. P. G. Tait and A. Crum Brown, "Memoir," in Andrews, *Scientific Papers of the Late Thomas Andrews* (cit. n. 18): ix–lxii, xxvii.) The Russian higher educational system had three tiers: the "candidate," which roughly corresponds to an advanced undergraduate degree; the "master's," roughly equivalent to the degree of the same name in the West and which enabled a scholar to teach at the university level for a fixed period of time; and the "doctoral," roughly equivalent to a German *Habilitation*. Mendeleev earned his master's in 1858 but received his doctorate in 1864, after he returned from Heidelberg.

[33] Reproduced in M. N. Mladentsev and V. E. Tishchenko, *Dmitrii Ivanovich Mendeleev: Ego zhizn' i deiatel'nost'* (Moscow, 1938), 1:223.

[34] Reproduced in ibid., 226. The implication with respect to light as mechanical concerned the luminiferous ether.

modernizing state would encourage. Science, in this framing, was not yet a feature of *national* identity; it was intrinsically cosmopolitan. Since the established social position of the scientist was still rare in Russia, Mendeleev cast himself as international, thus drawing on other features of Russia's rather inclusive political culture. That is, he thought he should make a case to the Russians that he was a European chemist, reflecting their own European identifications, and that they should bankroll his further development along these lines.

They apparently did not agree. Mendeleev's friend and fellow chemist N. P. Il'in, who spied for him on the academic politics back home, wrote on February 22, 1860 (upon publication of Mendeleev's first major article on capillarity):

> At the faculty meeting or the university council [dean of the physical-mathematical faculty Heinrich Friedrich Emil] Lenz, on the communication to him of this work or he himself read it in the C.R. [*Comptes Rendus*], said, that for this, in order to do this, what you are doing now, it was not especially necessary to travel abroad, one could do that here as well; where this wind blows from, I do not know, but obviously your work is not understood as having the significance you would like them to ascribe to it.[35]

Mendeleev's mentor Aleksandr Voskresenskii seconded this in a letter on March 19, 1860: "[I]t wouldn't hurt to present something else, something purely chemical."[36] Mendeleev was required to return to Petersburg in February 1861.

In short, he had miscalculated: he had assumed that what Petersburg really wanted was evidence that what was happening with their scientists was no different from what was happening with their counterparts in the West. Instead, Lenz and his colleagues wanted evidence that the students were taking unique advantage of their stay abroad to do work not possible back home. Mendeleev's strategy had been to show that work back home was of the same kind (although of a different degree) as that in Heidelberg; his superiors disagreed. And, indeed, in the 1850s and early 1860s, Russian chemists were in general underfunded, overworked, and poorly organized.[37] There was no reason for locals to think that they were doing the same kind of work as their foreign peers—yet. The identity of "scientific" was not yet inherently included within "Russia." There are two points to take away from this: First, that Mendeleev's priority claim in 1870 was not only an attempt to set up his new gas research but also a retrospective justification of his Heidelberg research and a rebuke to his local colleagues. Second, that a plea for universal and pure science was not what his local context demanded in 1860. By the time of his priority claim a decade later, however, when Mendeleev reiterated the importance of his capillarity work, the situation was rather different. The Russian Chemical Society was founded in November 1868, providing a professional structure for chemists in the imperial capital, and Mendeleev had already begun to receive some attention for his periodic system of chemical elements—another research project that was cosmopolitan, not specifically Russian. With a professional community and local academic power

[35] Reproduced in ibid., 237.

[36] Reproduced in ibid.

[37] On the parlous state of Russian chemistry in this period, see Nathan M. Brooks, "The Formation of a Community of Chemists in Russia: 1700–1870" (PhD diss., Columbia Univ., 1989); V. V. Kozlov, *Vsesoiuznoe khimicheskoe obshchestvo imeni D. I. Mendeleeva, 1868–1968* (Moscow, 1971); and Iu. I. Solov'ev, *Istoriia khimii v Rossii: Nauchnye tsentry i osnovnye napravleniia issledovanii* (Moscow, 1985).

(he became professor of general chemistry at St. Petersburg University in 1867) to back him, he could successfully make the claim that Russian science competed on an international level for fundamental laws of nature.[38] He was well on the way to becoming an icon for Russian science precisely *because* his science was not specifically local.

For his part, Thomas Andrews deployed moves similar to those of Mendeleev and achieved completely opposite results—in both the short and long terms. That is, in the 1860s he turned claims of pure science into local credibility; and after his death, these very claims *excluded* him from the status of national icon for Ireland. Andrews belonged to the generation of chemists immediately preceding Mendeleev's, and he spent almost the entirety of his career happily ensconced in the relative backwater of Belfast. He had been born at 3 Donegall Square in Belfast on December 19, 1813, the eldest of six children of a noted linen merchant. Like many aspiring Belfast Protestants (he was Church of England and Ireland, not Presbyterian), he studied at the only local establishment to provide advanced education, the Belfast Academical Institution, but he left it in 1828 to study chemistry at the University of Glasgow with Thomas Thomson. By age fifteen, he had published his first scientific paper, "On the Action of the Blowpipe on Flame." Yet he remained on the move, studying in Paris at the laboratory of J.-B. Dumas, which he enjoyed enormously before returning to the British Isles to complete his education as a physician, earning a diploma from the Royal College of Surgeons of Edinburgh on April 25, 1835, and on August 1 that same year received his MD from Edinburgh. Somewhat unusual for his generation and origin, he had no deep interest in medicine but had undertaken a medical education since it was the best way for an Irishman to learn something about chemistry. In 1835, he received several jobs offers to teach chemistry in London and Dublin, but he turned them all down to practice medicine in Belfast. In 1842, he married a Scotswoman, Jane Hardie, and in 1845 began his career at the newly founded Queen's College in Belfast, where he remained until his death.

Andrews led a disciplined life. He was a man of Spartan qualities: he had an early breakfast and ate nothing until his late dinner after a full day of work. He lectured each day from Monday to Friday at 3 pm and had an exam each week; he taught practical chemistry each day to medical students for one term; and he presided over experimental work in his own lab, which was open from 9 am to 3 pm every day (and on Saturdays 9–12).[39] His laboratory research before discovering the critical point consisted of several peaks: he performed important work on the blood of cholera patients, showing a depletion of water and therefore that death was caused by dehydration; and he determined the composition of ozone (that it consisted solely of oxygen). Over the course of this provincial career, he attained a series of high honors: fellow of the Royal Society in 1849, president of the Chemistry Section of the British Association in 1852 and 1871 (declined to serve again in 1880 due to poor health), president of the British Association itself in 1876, and offered a knighthood in 1880

[38] See Gordin, *A Well-Ordered Thing* (cit. n. 17), chaps. 2 and 7, for the growth of Mendeleev's ambitions with respect to laws of nature.

[39] Students who performed exceptionally well on a special exam were allowed to work in the laboratory free of charge; others had to pay a fee of ten pounds for six months or thirteen pounds for the college session. T. W. Moody and J. C. Beckett, *Queen's, Belfast, 1845–1949: The History of a University*, 2 vols. (New York, 1959), 1:162.

(again declined because of illness).[40] Through his entire later career, he rarely budged from Belfast.

Belfast proved to be a rather interesting context. Although it only officially became a city in 1888 (after Andrews's death), it was clearly one of the more dynamic urban areas in mostly rural Ireland throughout the nineteenth century. A provincial town of 13,000 people in 1782, it experienced explosive growth in the following decades, with a population 50,000 by 1831 and 350,000 by 1901. This growth was fueled by linen, the trade of the Andrews family. By 1870, 99 percent of Irish linen was shipped from the port of Belfast, and 21,000 of the 50,000 industrial and commercial workers in the city labored in some aspect of the textiles trade, which experienced extraordinary growth during the "cotton famine" caused by the American Civil War.[41] Along with this demographic and economic growth, Belfast began to develop more of an autonomous cultural life, independent of the massive influence of Dublin, becoming (according to some lights) a "Northern Athens." Thus, despite disadvantages such as the lack of a local scientific instruments trade, Andrews was able to develop a formidable chemical laboratory at Queen's College, Belfast.[42]

The college and Andrews grew in prominence together and fed off each other. In 1845, just before the Great Potato Famine reconfigured Irish politics, the island was in the throes of the repeal movement headed by Daniel O'Connell. The goal of the movement was to repeal the 1801 Act of Union that had disbanded Irish self-governance and fully incorporated it into Britain. One contributing issue, with increasing traction in the regions outside Dublin, was the very limited state of higher education at home in Ireland. For the most part, only two serious institutions existed: Trinity College Dublin, the flagship of Irish education, which was closed to Catholics until Catholic Emancipation; and Maynooth College, a state-subsidized Catholic college to train priests, thus preventing an outflow of seminarians to France during decades of turbulent politics across the English Channel. In partial response to worries that Ireland was losing all of its best intellectual talent to Britain or to the Continent—and not least to dampen Protestant support for repeal—the Queen's College

[40] These biographical details are culled from: Tait and Crum Brown, "Memoir" (cit. n. 32); Henry Riddell, "Dr. Thomas Andrews: The Great Chemist and Physicist," *Proceedings of Belfast Natural History and Philosophical Society* (1920–21), 107–35; Crum Brown, "Obituary Notices of Fellows Deceased" (cit. n. 19), xi–xv; "Thomas Andrews," *Journal of the Chemical Society* 49 (1886): 342–44; and "Thomas Andrews, F.R.S.," *Nature* 33, 17 Dec. 1885, 157–59.

[41] Emily Boyle, "'Linenopolis': The Rise of the Textile Industry," in *Belfast: The Making of the City, 1800–1914*, ed. J. C. Beckett et al. (Belfast, 1983), 41–55; W. A. Maguire, *Belfast* (Staffordshire, UK, 1993), 59; and W. H. Crawford, *The Impact of the Domestic Linen Industry in Ulster* (Belfast, 2005). On the substitution of other fabrics for American cotton, see Sven Beckert, "Emancipation and Empire: Reconstructing the Worldwide Web of Cotton Production in the Age of the American Civil War," *American Historical Review* 109 (2004): 1405–38. On the growth and development of the city's infrastructure as the Ulster linen trade shifted from its rural origins to a seat in Belfast, see: Philip Ollerenshaw, "Industry, 1820–1914," in *An Economic History of Ulster, 1820–1940*, ed. Liam Kennedy and Philip Ollerenshaw (Manchester, UK, 1985), 62–108, 66; Helena C. G. Chesney, "Enlightenment and Education," in *Nature in Ireland: A Scientific and Cultural History,* ed. John Wilson Foster (Dublin, 1997), 367–86, 376; Raymond Gillespie, *Early Belfast: The Origins and Growth of an Ulster Town to 1750* (Belfast, 2007); Stephen Royle, "The Growth and Decline of an Industrial City: Belfast from 1750," in *Irish Cities*, ed. Howard B. Clarke (Dublin, 1995), 28–40; and Gerard James Slater, "Belfast Politics, 1798–1868" (PhD diss., New Univ. of Ulster, 1982).

[42] John Hewitt, "'The Northern Athens' and After," in Beckett et al., *Belfast* (cit. n. 41), 71–82; Peter Brooke, "Religion and Secular Thought, 1800–1875," in ibid., 111–28, 123; and J. E. Burnett and A. D. Morrison-Low, "Irish Provincial Instrument Making," in *"Vulgar and Mechanick": The Scientific Instrument Trade in Ireland, 1650–1921* (Dublin, 1989), 71–88.

system was established in 1845 to create three explicitly nondenominational colleges in Belfast, Cork, and Galway, each headed by a president and vice president to coordinate the development before they opened officially to students in 1849.[43] The vice president of Queen's College Belfast (QCB) was Thomas Andrews.

The fear of students emigrating was real. At the very moment that the Russian Empire was initiating its own effort to encourage study abroad for the present in order to minimize its necessity in the future, Ireland was facing a real hemorrhage of its young scholars. Before midcentury in Ireland, a significant number of students would travel abroad for at least part of their education, especially if they were Catholic (and thus had limited options for higher education at home). In these cases, the students would seek out universities in Rome, Paris, and other Continental Catholic cities. This experience on the Continent directly shaped the patterns of Irish science in terms of topics studied, structure of scholarship, and so on, upon their return.[44] Although not comprehensive, demographic data on Irish scientists in the nineteenth century is highly suggestive. Among scientists working in Ireland, 25 percent were born in Britain, 8 percent on the Continent, and 3 percent elsewhere. Of those born in Ireland, or to Irish parents temporarily abroad at the moment of birth, 36 percent were wholly or partially educated in Britain. Only 12 percent of them were educated on the Continent—although it has to be said that for many of these latter the decision to study abroad depended more upon whether one was a chemist than whether one was Catholic. Chemists experienced a tremendous pull to go to the Continent—and here Andrews was no exception.[45] Yet he himself insisted that even this limited leakage of students abroad had to stop: "The country which depends unduly on the stranger for the education of its skilled men, or neglects in its highest places this primary duty, may expect to find the demand for such skill gradually to pass away and along with it the industry for which it was wanted."[46] The Russians would have agreed.

Andrews's 1867 pamphlet on the Queen's College system, *Studium Generale: A Chapter of Contemporary History*, one of his two major publications on public policy issues,[47] was a clearheaded and vigorous defense of the nondenominational, decentralized structure of the Queen's University system against the University of London, Maynooth, and the newly established Catholic University in Dublin.[48] (The Queen's University administered the degrees, but the examinations were given at each of the three colleges.) In many ways, QCB was the most successful of the Queen's Colleges; it was the only one not incorporated into the National Universities of Ireland (NUI) in 1908, and it exists to this day.[49] Unabashedly pro-Irish, Andrews insisted that differences in performance were not due to any particular defect with the Irish students. Test results were "at least strongly in favour of the truth of my position, that the mental culture of the graduates of the universities of Ireland is, on the whole, not inferior to the mental culture of the graduates of the University of London."[50] Part of the success, in retrospect, can be seen to be Andrews's vigorous advocacy of a medical school for QCB (not intended in the original 1845 plans) and his effective administration in building up a strong science curriculum.[51]

But the real target of Andrews's pamphlet was not the chauvinists in England who would decry the quality of the Irish schools but the Catholics at home who blasted the Queen's University system as the "Godless Colleges" and tried to dissuade Catholics from attending them. This, he felt, was unworthy of the scientific tradition of great Catholics such as Blaise Pascal, Alessandro Volta, and even Galileo Galilei.[52] Catholics could also be scientific, and so could a Catholic Ireland, maintained Andrews. Yet, at the same time that they tried to prevent Catholics from studying alongside Protestants, Irish prelates made an effort to control the content of the curriculum in the recently established Catholic University to the point of harming free inquiry, in Andrews's presentation, and certainly had the effect of diminishing Catholic representation in science (and thus reinforcing the Protestant Ascendancy).[53] QCB was, in fact, a success in being nondenominational, despite the fact that its first two presi-

[43] Kevin B. Nowlan, *The Politics of Repeal: A Study in the Relations between Great Britain and Ireland, 1841–50* (London, 1965), 174. On the general history of Irish higher education in this period, see T. W. Moody, "The Irish University Question of the Nineteenth Century," *History* 43 (1958): 90–109; W. G. Scaife, "Technical Education and the Application of Technology in Ireland, 1800–1950," in Bowler and Whyte, *Science and Society in Ireland* (cit. n. 2), 85–100; Richard A. Jarrell, "Some Aspects of the Evolution of Agricultural and Technical Education in Nineteenth-Century Ireland," in ibid., 101–17. On the repeal movement's relationship with revolutionary Fenianism after the Potato Famine, and the role of Irish nationalism more broadly, see Brian Jenkins, *Irish Nationalism and the British State: From Repeal to Revolutionary Nationalism* (Montreal, 2006).

[44] Chesney, "Enlightenment and Education" (cit. n. 41), 371, 383.

[45] James Bennett, "Science and Science Policy in Ireland in the Mid-Nineteenth Century," in Bowler and Whyte, *Science and Society in Ireland* (cit. n. 2), 37–47, 37–38. Justus von Liebig, in particular, had a tremendous influence on science pedagogy in nineteenth-century Ireland, as discussed in Enda Leaney, "Science and Conflict in Nineteenth-Century Ireland," in *Culture, Place and Identity*, ed. Neil Garnham and Keith Jeffery (Dublin, 2005), 66–77, 67.

[46] Andrews, "Presidential Address," delivered at the Glasgow meeting of the BAAS, 6 Sept. 1876, reproduced in Andrews, *Scientific Papers of the Late Thomas Andrews* (cit. n. 18), 414.

[47] I exclude for the purposes of this essay Andrews's brief venture into alcohol policy. In 1867, he was president of the Education Section of the Social Science Association, which had a meeting in Belfast that year. He presented a paper called "Suggestions for Checking the Hurtful Use of Alcoholic Beverages by the Working Classes," displaying an interest in alcohol policy that eerily shadows Mendeleev's. (See Gordin, *A Well-Ordered Thing* [cit. n. 17], 165.) Andrews wanted to regulate the sale of hard liquor, advocating a system in which publicans had to offer food and that no pub could serve beverages stronger than 17 percent alcohol, the strength of sherry, eventually creeping down to the burgundy standard of 12 percent. Tait and Crum Brown, "Memoir" (cit. n. 32), xliv–xlv.

[48] Thomas Andrews, *Studium Generale: A Chapter of Contemporary History* (London, 1867), 29, 33–34.

[49] On QCB in post–World War II Northern Ireland, see L. A. Clarkson, *A University in Troubled Times: Queen's Belfast, 1945–2000* (Dublin, 2004). On Queen's College, Cork, see John A. Murphy, *The College: A History of Queen's/University College Cork, 1845–1995* (Cork, 1995).

[50] Andrews, *Studium Generale* (cit. n. 48), 21.

[51] On medicine, see Arthur Deane, ed., *The Belfast Natural History and Philosophical Society: Centenary Volume, 1821–1921* (Belfast, 1924), 63. On medical education in Andrews's Ireland, see Peter Froggatt, "Competing Philosophies: The 'Preparatory' Medical Schools of the Royal Belfast Academical Institution and the Catholic University of Ireland, 1835–1909," in *Medicine, Disease and the State in Ireland, 1650–1940*, ed. Greta Jones and Elizabeth Malcolm (Cork, Ireland, 1999), 59–84. The faculty insisted on the development of the medical school, which built on the lately established (1835) medical school at the Belfast Academical Institution and its central urban location. Moody and Beckett, *Queen's, Belfast* (cit. n. 39), 1:xlvii, 44, 86. On chemistry, see: Cecil L. Wilson, "Schools of Chemistry in Great Britain and Ireland—XXIX: The Queen's University of Belfast," *Journal of the Royal Institute of Chemistry* 81 (1957): 16–29.

[52] Andrews, *Studium Generale* (cit. n. 48), 63, 84–85.

[53] G. T. Wrixon, "Irish Science and Technology: The Changing Role of the Universities," *Irish Review*, nos. 17–18 (Winter 1995): 118–26, 119. For more on the church's objections, see Moody and Beckett, *Queen's, Belfast* (cit. n. 39), 1:277. On the identification of science with the Protestant Ascendancy, see David Andrew Attis, "The Ascendancy of Mathematics: Mathematics and Irish Society from Cromwell to the Celtic Tiger" (PhD diss., Princeton Univ., 2000); Gordon L. Herries Davies, "Irish Thought in Science," in *The Irish Mind: Exploring Intellectual Traditions*, ed. Richard Kearney (Dublin, 1985), 294–310, 305; James A. Bennett, *Church, State, and Astronomy in Ireland: 200 Years of Armagh Observatory* (Belfast, 1990), 56–57; and Terry Eagleton, *Scholars and Rebels in Nineteenth-Century Ireland* (Oxford, 1999).

dents, Pooley Shuldam Henry and Josias Leslie Porter, were Presbyterian ministers, and Andrews, as a long-serving vice president, was a devout Church of Ireland man.[54] For Andrews, being nondenominational was more than a convenient political pose. In a stance analogous to Mendeleev's in his very different context, Andrews insisted on a position of pure science—religious tests were irrelevant to the pursuit of pure knowledge—as a way of minimizing otherwise inevitable strife.[55]

Andrews's conciliatory defense of a scientific Ireland that links its past with its present was even more evident in his *Second Chapter of Contemporary History,* intervening in a much more explosive issue of public policy: the disestablishment of the minority Church of England and Ireland, undoing an aspect of the Act of Union that had grown increasingly unpopular on the island due to the tithe paying required of Catholic farmers. Andrews, unlike many of his ascendancy peers, favored disestablishment. He offered his value-neutral scientific pose here to present an account of Irish ecclesiastical history that demanded removal of the Church of Ireland's privileges, which "must, in his opinion, be eventually settled, if discontent and turbulence are to be banished from the soil of Ireland, and the inhabitants of the British Islands knit into a compact and United people."[56]

The main target of this pamphlet was again the clergy, the same group Andrews had lambasted in the *Studium Generale* for warping the charter of the Catholic University. The clergy was the opposite of what Andrews thought an elite should be to shepherd its people into peaceful coexistence; he offered, implicitly, a vision of a scientific priesthood that through its very nondenominational impartiality would be better suited to govern the hodgepodge of faiths on the island.[57] This was so because the Catholic priesthood fundamentally misunderstood Ireland; it was simply not a Catholic country:

> The people of Ireland is an expression frequently employed to describe the Roman Catholics alone, and Ireland is often spoken of as a Catholic country. In number, the Catholics greatly exceed all the other inhabitants, but their preponderance is only numerical; and to ignore the powerful Protestant minority, which forms the great majority among the classes of higher intelligence, and has succeeded in planting on Irish soil the flourishing industry of Ulster, is altogether inexcusable. No greater mistake can be made than to consider Ireland to be a Catholic country, in the same sense in which France is a Catholic, or England a Protestant country.[58]

[54] Brooke, "Religion and Secular Thought" (cit. n. 42), 113; and Moody, "Irish University Question" (cit. n. 43), 99.

[55] This notion that value blindness in science would covertly work in favor of nonsectarianism and thus union was common in many contexts in nineteenth-century Ireland. See the interesting analysis of roving lecturers in Enda Leaney, "Missionaries of Science: Provincial Lectures in Nineteenth-Century Ireland," *Irish Historical Studies* 34 (May 2005): 266–88.

[56] Thomas Andrews, *The Church in Ireland: A Second Chapter of Contemporary History* (London, 1869), 2. For a recent discussion of the surrounding issues, see Oliver P. Rafferty, *The Catholic Church and the Protestant State: Nineteenth-Century Irish Realities* (Dublin, 2008). On the creation of the Church of Ireland, see Alan Ford, "Dependent or Independent? The Church of Ireland and Its Colonial Context, 1536–1649," *Seventeenth Century* 10 (1995): 163–87.

[57] Edward Brynn, *The Church of Ireland in the Age of Catholic Emancipation* (New York, 1982). The famine had a disproportionate impact on Catholics, however, and so the numbers became (slightly) less lopsided for the rest of the century. In 1861, the number of Catholics had fallen by 30 percent since 1834, while those of Anglicans and Presbyterians had only fallen by 19 percent each. This meant Ireland's population was 77.7 percent Catholic, with Anglicans at 12 percent and Presbyterians at 9 percent. By 1901, the figures were Catholics at 74.2 percent, Anglicans at 13 percent, and Presbyterians at 9.9 percent. Sean Connolly, *Religion and Society in Nineteenth-Century Ireland* (Dublin, 1985).

The solution was not to privilege Catholics over Protestants but to avoid privileging any religion. He advocated disestablishment of the Church of England and Ireland and the allocation of its endowment and tithes among the various churches proportionately by population, to be revised periodically to account for demographic fluxes (say, every twenty-five to fifty years).[59] As a scientist, he took a fundamentally conservative stance, in the sense of only undertaking radical change in times of crisis and in general advocating small and incremental changes. In this case, the same applied: "To overturn a great national institution is always an operation of danger, and should never be attempted, except on the strongest grounds of necessity."[60] As an impartial scientist, he was also the right person to be able to tell when that moment of crisis had come.

Andrews was on the side of the victors here, although it is uncertain how much impact his second pamphlet had. The Church of Ireland was disestablished in 1869. Ironically, although Andrews may have supported the policy, the consequences worked against all of his arguments in its favor: it did not serve to promote union; in fact, it even weakened the support for science that the Protestants had provided. The union weakened in part because disestablishment meant ipso facto the relative strengthening of the Catholic Church, which after the famine had become a rallying point for national identity, coupled with a general intensification of the bureaucratic and authoritarian tendencies in the church of this period.[61] Retrospectively speaking, this was Andrews's final victory, for the rest of his project—a unified notion of Irishness that was nonsectarian and embedded as an equal partner in the British Isles—was obliterated with the coming of independence for the Republic of Ireland in 1921. What followed was not just the obliteration of Andrews's vision for a nonsectarian Ireland but the erasure of Andrews as an "Irish scientist" in a "scientific Ireland."

CONCLUSION: THE MAKING AND UNMAKING OF ICONS

The divergence between Mendeleev's and Andrews's views of the critical point did not prevent the possibility of mutual intelligibility, and their strategies of defining themselves as both national and cosmopolitan scientists proved to some extent fruitful for both in their lifetimes. After their deaths, however, their fates in national memory took radically different paths. Mendeleev came to be seen as quintessentially Russian, in a sense somewhat unmoored from his own self-identification as a Russian *scientist*; while Andrews was written out of Ireland's identity altogether.

Andrews's nineteenth-century peers widely considered him to be an *Irish* scientist, and he considered himself this way as well, a situation not atypical for the sizable minority of non-Presbyterian Protestants who would by the 1890s be known as the

[58] Andrews, *Church in Ireland* (cit. n. 56), 31.

[59] Ibid., 56.

[60] Ibid., 38. On the connection between this Burkean conservatism and science, see Gordin, *A Well-Ordered Thing* (cit. n. 17), chap. 1.

[61] Thomas A. Boylan and Terrence McDonough, "Dependency and Modernization: Perspectives from the Irish Nineteenth Century," in *Ideology and Ireland in the Nineteenth Century*, ed. Tadhg Foley and Seán Ryder (Dublin, 1998), 113–29, 125.

Anglo-Irish or (due to their predominant position in almost every sphere of public life) the Protestant Ascendancy.[62] There is today a growing historiography on the position of science in Irish history, which is mostly excellent (outside of a few instances of special pleading or tokenism), but it tends to focus almost exclusively on developments in Dublin—the cultural as well as the administrative capital of nineteenth-century Ireland—and more generally in places that ended up in the Irish Free State after 1922.[63] That is to say, almost all of the scholarship on science in Ireland excludes Belfast, and it is Belfast where Andrews staked his claim.[64] It was relatively unproblematic in the nineteenth century to be a scientist and Irish *and* British. After 1922, the triangulation became much more difficult.

To some extent, the eclipse of Andrews had a great deal to do with who he was—an Anglo-Irish Protestant—but perhaps even more so it had to do with his profession as a scientist. A historical puzzle remains as to why Irish nationalism, when it emerged, identified itself specifically with an ultramontane Catholicism and not with the state-building potential of science and technology—as, for example, anticolonialism and nationalism in India did.[65] The fear of an antiscientific free Ireland pushed several leading Irish scientists to advocate retaining the union for as long as possible—not least because a rupture with England might damage scientific ties to their peers in

[62] On this point, see the classic study by J. C. Beckett, *The Anglo-Irish Tradition* (London, 1976), 96. Andrews is identified as specifically "Irish" in almost all of the obituaries, but see, especially, Tait and Crum Brown's preface in Andrews, *Scientific Papers of the Late Thomas Andrews* (cit. n. 18), iii. On the conceptual ambiguity of who counts as an "Irish scientist," see Frank A. J. L. James, "George Gabriel Stokes and William Thomson: Biographical Attitudes towards Their Irish Origins," in *Science in Ireland, 1800–1930: Tradition and Reform*, ed. John R. Nudds, Norman McMillan, Denis L. Weaire, and Susan M. P. McKenna Lawlor (Dublin, 1988), 75–82, 76.

[63] See, e.g.: Attis, "Ascendancy of Mathematics (cit. n. 53); David Berman, "Enlightenment and Counter-Enlightenment in Irish Philosophy," *Archiv für Geschichte der Philosophie* 64 (1982): 148–65; Outram, "Negating the Natural" (cit. n. 8); Seán Mac Cartáin, "Technical Education in Ireland 1870–1899," in McMillan, *Prometheus's Fire* (cit. n. 6), 188–210; McMillan, "Ireland and the Reform of the Politics and Government of British Science and Education," in ibid., 481–524; McMillan, "Mathematical, Scientific and Engineering Reform before the Twentieth Century in Dublin University," in ibid., 138–69; McMillan, "The Transmogrification of the Colonial Tradition of Mathematics, Science and Engineering," in ibid., 74–105; McMillan, "Organisation and Achievements of Irish Astronomy in the Nineteenth Century—Evidence for a 'Network,'" *Irish Astronomical Journal* 19 (March and Sept. 1990): 101–18; Sean Lysaght, "Themes in the Irish History of Science," *Irish Review*, no. 19 (Spring/Summer 1996): 87–97; A. D. Morrison-Low, "The Trade in Scientific Instruments in Dublin, 1830–1921," in Burnett and Morrison-Low, "*Vulgar and Mechanick*" (cit. n. 42), 39–69; Herries Davies, "Irish Thought in Science" (cit. n. 53), 294–310; John Wilson Foster, "Natural Science and Irish Culture," *Éire-Ireland* 26 (1991): 92–103; Foster, *Nature in Ireland* (cit. n. 41); Foster, "Out of Ireland: Naturalists Abroad," in ibid., 308–65; Desmond Clarke, "An Outline of the History of Science in Ireland," *Studies* 62 (1973): 287–302; Ronald Cox, ed., *Engineering Ireland* (Cork, 2006); Nicholas Whyte, "'Lords of Ether and of Light': The Irish Astronomical Tradition of the Nineteenth Century," *Irish Review*, nos. 17–18 (Winter 1995): 127–41; Whyte, *Science, Colonialism, and Ireland* (Cork, 1999); Roy Johnston, "Science and Technology in Irish National Culture," *Crane Bag* 7, no. 2 (1983): 58–63; James Bennett, "Why the History of Science Matters in Ireland," in *Science and Irish Culture*, ed. David Andrew Attis (Dublin, 2004), 1:1–14; Brian B. Kelham, "The Royal College of Science for Ireland (1867–1926)," *Studies* (Autumn 1967): 297–309; and Enda Leaney, "Phrenology in Nineteenth-Century Ireland," *New Hibernia Review* 10 (2006): 24–42.

[64] Noteworthy exceptions to the silence on what would later become Northern Ireland include: Deane, *Belfast Natural History and Philosophical Society* (cit. n. 51); John Wilson Foster, "Natural History, Science, and Irish Culture," *Irish Review*, no. 9 (Autumn 1990): 61–69; and Ruth Bayles, "Understanding Local Science: The Belfast Natural History Society in the Mid-Nineteenth Century," in Attis, *Science and Irish Culture* (cit. n. 63), 139–69.

[65] Gyan Prakash, *Another Reason: Science and the Imagination of Modern India* (Princeton, N.J., 1999); and Deepak Kumar, *Science and the Raj: 1857–1905* (New York, 1995).

Britain.[66] After the disestablishment for which Andrews had argued so forcefully, his fellow Protestants were disempowered both institutionally and symbolically. Once the union had eliminated Ireland's parliament, the Church of Ireland became the most important symbol of corporate identity for Irish Anglicans. With the church's status diminished, many influential Protestants shifted toward the Gaelic-centered cultural revival, which vaunted the folklore and superstition that rationalists such as Andrews had sought to minimize. Cultural dominance came to replace ecclesiastical dominance.[67] In this frame of reference, after disestablishment, it was difficult in some circles (especially Ascendancy ones) to be both Irish and a scientist—science being tagged as *English*. And after 1922, Andrews's heirs could not even count him as a scientist who worked in Ireland, for the very simple reason that the place he had lived and worked was no longer *defined* as Ireland: it was British Northern Ireland and part of the United Kingdom. For this reason most post–Free State commentators on Andrews find themselves in the unenviable position of engaging in sometimes torturous pleading for his inclusion as an Irish icon.[68]

The contrast with Mendeleev could hardly be starker. Even during his lifetime Mendeleev came to represent the incarnation of "the scientist" as public intellectual—with his opinions on capital punishment, local politics, and the state of the world taken quite seriously. Much of this was the result of his careful self-fashioning, but it was also an indication that the program Mendeleev had pushed for—to have scientists be considered as exemplars of Russianness, not as foreign to it (and not as transplanted Europeans)—was quite successful.[69] To some extent, this success relied on developments beyond Mendeleev's direct control: the establishment of multiple professional communities of scientists following the foundation of the Russian Chemical Society in 1868; the industrialization of the Russian economy demanding more up-to-date (and simply *more*) technical experts on a par with those in central and western Europe; and the extensive travel by Russians across the Continent, which tended to give Russians a more European frame of reference for their local icons. But the manner in which Mendeleev as an *individual* was appropriated as a tool for Russian self-identification was also intimately connected with his rejection by the St.

[66] Greta Jones, "Scientists against Home Rule," in *Defenders of the Union: A Survey of British and Irish Unionism since 1801*, ed. D. George Boyce and Alan O'Day (London, 2001), 188–208.

[67] Beckett, *Anglo-Irish Tradition* (cit. n. 62), 104; and James H. Murphy, *Ireland: A Social, Cultural, and Literary History, 1791–1891* (Dublin, 2003), 69. On the Cultural Revival as reducing the influence of scientific thinking, see: Foster, "Natural Science and Irish Culture" (cit. n. 63), 95; Foster, "Natural History in Modern Irish Culture," in Bowler and Whyte, *Science and Society in Ireland* (cit. n. 2), 119–33, 127; Patrick Carroll, *Science, Culture, and Modern State Formation* (Berkeley, Calif., 2006), 169; Thomas Duddy, *A History of Irish Thought* (London, 2002), xiv; Sean Lysaght, "Science and the Cultural Revival: 1863–1916," in Bowler and Whyte, *Science and Society in Ireland* (cit. n. 2), 153–65; Sinéad Garrigan Mattar, *Primitivism, Science, and the Irish Revival* (Oxford, 2004); Oliver Macdonagh, *States of Mind: A Study of Anglo-Irish Conflict, 1780–1980* (London, 1983), 105; and Timothy G. McMahon, *Grand Opportunity: The Gaelic Revival and Irish Society, 1893–1910* (Syracuse, N.Y., 2008). For arguments against this position, see Whyte, *Science, Colonialism, and Ireland* (cit. n. 63), 169–70.

[68] See, e.g.: William J. Davis, "Thomas Andrews," in *Some People and Places in Irish Science and Technology*, ed. Charles Mollan, William J. Davis, and Brendan Finucane (Dublin, 1985), 46–47; Davis, "In Praise of Irish Chemists: Some Notable Nineteenth-Century Chemists," *Proceedings of the Royal Irish Academy* 77B, no. 18 (1977): 309–16; D. Thornburn Burns, "Thomas Andrews, 1813–1885," in *Physicists of Ireland: Passion and Precision*, ed. Mark McCartney and Andrew Whitaker (Bristol, 2003), 77–84; and Wilbert Garvin and Des O'Rawe, *Northern Ireland Scientists and Inventors* (Belfast, 1993), 14–17.

[69] Gordin, *A Well-Ordered Thing* (cit. n. 17), chap. 9.

Petersburg Academy of Sciences for the chair of technology in November 1880.[70] Blaming this incident on the so-called German party in the academy (many of whom, despite the name, were Russian-born, and some of whom were ethnically Russian) promoted Mendeleev as quintessentially *Russian*, despite the fact that foreign scientists were the ones buttressing his credentials and his own career began with capillarity research conducted in the German town of Heidelberg! In a similar fashion, Ivan Pavlov survived his transit across the Russian Revolution to achieve new heights of fame in Stalinist Russia precisely because the Soviet state wanted to define itself as "scientific," and Pavlov was a living icon who could serve for this end.[71] No matter that Pavlov and Mendeleev were both conservative and decidedly anti-Marxist; their pasts could be airbrushed when politically convenient. It was just this kind of inclusive impulse that was lacking on the part of Irish public intellectuals with respect to Andrews's legacy.

We have come a long way from an 1870 article claiming priority in an obscure dispute over credit for discovery of the critical point. I now must return to answer the question implied by the posing of this essay: What do we learn from the juxtaposition of Andrews and Mendeleev—and Ireland and Russia—that we would not have learned by looking at them separately? The first answer is that for all of their divergences (in age, nationality, language, specialization, reputation, and so on), Andrews and Mendeleev employed very similar strategies in arguing for a place for elite laboratory science in a modernizing, late-emerging nation-state. For both of them, the scientist's position was to advocate conservative reforms focused on stability and to bolster those positions precisely by insisting on the neutrality and universality of their science.[72] Because of the specific circumstances of Ireland's and Russia's histories, the effects of almost identical research and professional strategies was, in the case of Andrews, to minimize the importance of national identity—with lasting consequences for his status as an Irish scientist and for Ireland as a scientific nation—and, for Mendeleev, to intensify it.

The parallels between them extend further and tell us something about the common origins of the rampant national identification of scientists across Europe in the second half of the nineteenth century. The most common biographical experience shared by the two men was extensive education in Continental chemistry laboratories. The difference, however, was where they went: Germany or France. Perhaps a further investigation of the two models of Continental education and how they spread to different contexts can deepen our understanding of how very similar patterns seem to appear in such different peripheries of Europe (and beyond).

Finally, there is an interesting contrast between the positions of national identity in science in both countries that indicates a deeper anxiety about the rise or decline of science in fin-de-siècle Europe. Both Ireland and Russia present themselves in today's imaginary as folksy, peasant, traditional cultures, saturated with alcohol, music, and artistic creativity. But both also produced first-rate science, a fact somehow eclipsed in present discourse. In the case of Russia, the eclipse is a partial result of the sheer incandescence of the artistic developments of the late nineteenth century,

[70] Ibid., 138–41.

[71] Daniel P. Todes, "Pavlov and the Bolsheviks," *Studies in History and Philosophy of the Life Sciences* 17 (1995): 379–418.

[72] I draw here on the classic discussion in Joseph Ben-David, *The Scientist's Role in Society: A Comparative Study* (1971; repr., Chicago, 1984), 125.

as well as the tremendous identification of science and technology with the Soviet regime that succeeded that period. For Ireland, the question of how and why (and whether) science declined as home rule agitation increased has been a topic of extensive historical inquiry.[73]

The point is not so much about why we *now* might perceive those national identities as "scientific" or not but about what historical actors thought *then*. Mendeleev was fairly confident that Russian science would continue to reach higher and higher triumphs, while Andrews had to contend with the possibility that the great age of British (and Irish) science was approaching an end.[74] This indicates one of the central contrasts between the two men: Andrews directed his attention toward the past (the system of education, the established church), defended through historical inquiry; Mendeleev's public efforts (tariff reform, educational transformation, military modernization) were pointed to the future, defended through predictions based on economics. Mendeleev spoke to the future, and the future was kinder to him. Andrews remains rooted in the past, lauded as the historically significant discoverer of the critical point, yet forsaken as a national icon.

[73] Herries Davies, "Irish Thought in Science" (cit. n. 53), 306–9; Greta Jones, "Catholicism, Nationalism and Science," *Irish Review*, no. 20 (June 1997): 47–61; Whyte, "Lords of Ether and of Light" (cit n. 63), 136; and Morrison-Low, "Trade in Scientific Instruments in Dublin" (cit. n. 63), 63.

[74] Andrews, for what it's worth, did not believe that science was declining in the British Isles generally, or Ireland specifically. Andrews, "Presidential Address" (cit. n. 46), 409.