4
Drawing the Line between Pure and Applied Physics

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The name "International Union of Pure and Applied Physics" (IUPAP) might appear cumbersome to the modern eye. Wouldn't an International Union of Physics be inclusive enough? Why saddle the name with a wordy and redundant distinction like "Pure and Applied"? This essay probes that question and shows that we can learn much about the circumstances in which IUPAP emerged, the issues it was constituted to address, and its evolving mission by considering how the organization navigated the fraught, but nevertheless potent distinction between pure and applied physics.

This aspect of IUPAP's identity calls out for historical contextualization in no small part because the pure/applied distinction is itself a strictly historical one. Although physicists still refer to "applied physics"—*Physical Review Applied*, established in 2014, is one of the newer additions to the American Physical Society's family of journals—"pure physics" is no longer the preferred nomenclature. Since the mid-20th century, physicists have gravitated toward less morally freighted terms like "basic" or "fundamental" to cover the provinces of physics that "pure" would once have named.[1] Understanding why the "PA" appeared in IUPAP, and with what consequences, requires probing the historical background that explains how those categories would have been understood when IUPAP was founded in 1922.

The Prehistory of Pure Science

References to "pure science" in English began to appear more frequently in the mid-19th century, but they did not at that time approximate the meaning that would predominate in the early 20th century. The notion of pure science that shaped the establishment of the institutions of physics such as IUPAP instead had its roots in the late-19th century and reflected Victorian debates about the role of science in society. Tracing that shift shows the contours of the intellectual, social, and political contexts in which IUPAP emerged.

William Whewell, the 19th-century polymath, was always careful with his words. He coined quite a few of the terms scientists still use, including "anode," "cathode,"

[1] This analysis will focus largely on the Anglo-American world, but IUPAP is not a monolingual organization, and so it is worth noting a similar drop-off in the use of the French "*physique pure*" in favour of "*physique fondamentale*" during the second half of the 20th century.

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"ion," and, indeed, the word "scientist" itself.[2] When it fell from Whewell's pen, "pure science" referred to areas of inquiry that could be advanced a priori, without reference to the fickle empirical realm. And so, he referred to the science of motion as pure because it "does not depend upon observed facts, but upon the Idea of motion."[3] Here, the *pure* were opposed not to the *applied*, but to the *inductive* sciences. Pure, or deductive sciences could be apprehended from first principles; inductive sciences could progress only via empirical access to the external world. The distinction was key to Whewell's classification of the sciences.[4]

In the late 19th century, the significance of "pure" when attached to science shifted meaning and began to take on a clear moral valence. A passion for pure science was a distinguishing feature of the X Club, a group of Victorian thinkers who advocated the pursuit of "science, pure and free," by which they meant that it was both superior to mere technical work and unfettered by the strictures of religious dogma.[5] Their more prominent members, including John Tyndall and Thomas Henry Huxley, used their platform to advocate for the pursuit of science for its own sake, by practitioners who were pure insofar as the advance of science itself was their only animating motive.

This view coalesced in the 1870s and 1880s. In 1870, inaugurating University College London's new Faculty of Science, the chemist and fellow-traveler of the X Club Alexander Williamson delivered "[a] Plea for Pure Science," calling on the government to support scientific investigations conceived without a practical aim.[6] When Tyndall undertook a lecture tour of the United States in late 1872 and early 1873, the leitmotif of his lectures was the necessity of cultivating pure science if the United States aspired to advance its national fortunes and win the regard of the international scientific community.[7] Tyndall echoed Alexis de Tocqueville's observation that the American character included a preoccupation with the practical and profitable over the abstract and arcane. He contrasted pure not with empirical, inductive science, but rather with science pursued for the sake of profit or glory—purity, for Tyndall, resided not in the nature of the phenomena, but in the heart of the investigator.

By the 1880s, Huxley too became a vocal public advocate for the moral and practical superiority of pure science. Physicists such as William Thomson and Peter Guthrie Tait, ideological opponents of the X Club, had cultivated a close connection between physics and industry and made great hay in the era of burgeoning steam and telegraph infrastructure. Huxley perceived danger in linking the pursuit of science to the pursuit

[2] On Whewell, see: Laura Snyder, *Reforming Philosophy: Victorian Debates on Science and Society* (Chicago: University of Chicago Press, 2006); Richard Yeo, *Defining Science: William Whewell, Natural Knowledge, and Public Debate in Early Victorian Britain* (Cambridge: Cambridge University Press, 1993).

[3] William Whewell, *Aphorisms Concerning Ideas, Science, and the Language of Science* (London: Harrison & Company, 1840), 8.

[4] Raphaël Sandoz, "Whewell on the Classification of the Sciences," *Studies in History and Philosophy of Science* 60 (2016): 48–54.

[5] Thomas Archer Hirst, quoted in Ruth Barton, *The X Club: Power and Authority in Victorian Science* (Chicago: University of Chicago Press, 2018), 227.

[6] Alexander W. Williamson, *A Plea for Pure Science* (London: Taylor and Francis, 1870). See also, Graeme Gooday, "Vague and Artificial: The Historically Elusive Distinction between Pure and Applied Science," *Isis* 103, no. 3 (2012): 546–4.

[7] Michael D. Barton, Joseph D. Martin, and Gregory Radick, eds., *The Correspondence of John Tyndall*, vol. 13, *June 1872–September 1873* (Pittsburgh: University of Pittsburgh Press, 2024).

of profit and sought in particular to deny that applied science had any independent existence—it was *merely* the application of pure science.[8]

In 1883, across the Atlantic, the physicist Henry Rowland, an experimentalist who had earned an international reputation for his precision diffraction gratings, made his own plea for pure science to the American Association for the Advancement of Science. Like Tyndall, and de Tocqueville before him, Rowland observed the hard-headed pragmatism that ran through American culture and warned that "those who wish to pursue pure science in our own country must be prepared to face public opinion in a manner which requires much moral courage."[9] In 1899, at the first meeting of the American Physical Society, which he represented as its inaugural President, Rowland reiterated his message: "He who makes two blades of grass grow where one grew before is the benefactor of mankind; but he who obscurely worked to find the laws of such growth is the intellectual superior as well as the greater benefactor of the two."[10] Rowland's vision of pure science exerted a long-lasting influence on the character of the American Physical Society, the principal institution of American physics.[11]

Both Huxley and Rowland might have been expected to develop more nuanced positions on the basis of their own knowledge and practice. Whatever his disdain for the theologically minded North British physicists like Thomson and Tait, Huxley witnessed thermodynamics and electromagnetism blossom in the wake of the successes of steam engines and telegraphy.[12] Moreover, as a bullish Darwinian, he was aware that artificial breeding techniques inspired Charles Darwin, and not the other way around. Rowland, for his part, came from the American tinkerer tradition, cutting his teeth on electrical components and railway engineering before turning to physics. As an experimentalist, he held that the theory–experiment distinction did not map onto the pure–applied distinction—experimental investigations could be pure as well—but he would have been aware of the extent to which successful experiment relied on the resources of industry. Huxley's and Rowland's views make most sense, then, when viewed as aspirational rather than descriptive.

These joint efforts thus constituted an organized campaign to create a new category of pure science, positioned prior to applied science and engineering, both in the sense that it was intellectually worthier, but also in the sense that abstract knowledge must, by either necessity or by robust contingency, come chronologically before its practical application. Between Whewell in the early 1900s and the X Club and Rowland later in the century, the key intervening factor was the rapid growth of engineering and industry as sources of profit, and thus of influence and authority, especially in industrializing Britain. The new category of pure science was itself engineered to secure the social standing of the scientist. As science became a profession, the nobility of

8 Gooday, "Vague and Artificial."

9 Henry A. Rowland, "A Plea for Pure Science," *Science* 2, no. 29 (1883): 242–50, on 242. See also Paul Lucier, "The Origins of Pure and Applied Science in Gilded Age America," *Isis* 103, no. 3 (2012): 527–36.

10 Henry A. Rowland, "The Highest Aim of the Physicist," *Science* 10, no. 258 (1899): 825–33, on 826.

11 See Joseph D. Martin, *Solid State Insurrection: How the Science of Substance Made American Physics Matter* (Pittsburgh: University of Pittsburgh Press, 2018), esp. ch. 1.

12 This latter proposition is not borne out by the historical record. See, e.g., Bruce J. Hunt, *Pursuing Power and Light: Technology and Physics from James Watt to Albert Einstein* (Baltimore: Johns Hopkins University Press, 2010).

the undertaking determined the status of that profession, and casting pure science as morally superior to engineering and applied science was a way to ensure that its comparatively unprofitable undertakings would still be able to command cultural capital.

The natural opposite of "pure" is not "applied," but "impure." That fact could not have been lost on the turn-of-the-century advocates of pure science, nor on their contemporaries with applied interests. As the 20th century dawned, the relationship between pure and applied sciences was, by design, oppositional and antagonistic.

The Rise of Applied Science

"Applied science," like "pure science," became a more common term in the 1870s and 1880s. To apprehend its meaning, it is important to note that through much of the 19th century, "science" was a generic term that could be applied to just about any area of specialist knowledge or skill. Understood in this way, "applied science" did not mean "science, which is then applied," but something much more like "the specialised practical arts." On this understanding, applied science was science in its own right, not something apart from it.

When Huxley and his contemporaries emphasized the contrast between pure and applied science, and insisted that the former preceded the latter, they were subtly but consequentially shifting the meaning of "applied science," attempting to transform it into "the uses of science." This represents a considerably narrower understanding of "science," which, by the 1880s, no longer referred to *any* systematized knowledge or knowhow, but rather became restricted to the natural sciences (with a sometimes-grudging acknowledgment of the human sciences as well).

Rowland in the United States, like Huxley in Britain, had thrown down a gauntlet. American engineers responded by embracing the term "applied science," but interpreting it differently. Applied science was distinct from the mechanical arts by virtue of holding greater professional standing, deserving of a place in university curricula and of its own professional societies. But it was also not a science itself, and so should remain independent from the growing, professionalizing scientific disciplines, where it was in any event held in low esteem. This balancing act, as Ronald Kline describes, led American engineers into a devil's bargain, in which they gained the professional recognition increasingly afforded to scientists by adopting Rowland's assumption about the linear relationship between science and technology.[13]

World War I represented a crucial juncture in the relationship between pure and applied science. Disruption of trade with Europe heightened the need in the United States for the cultivation of domestic industrial know-how, and the need to apply science to develop it. Likewise in Britain, France, and Germany, scientists were mobilized for their technical expertise in a way they had not

[13] Ronald Kline, "Construing 'Technology' as 'Applied Science': Public Rhetoric of Scientists and Engineers in the United States, 1880–1945," *Isis* 86, no. 2 (1995): 194–221.

been in previous conflicts.[14] Whereas previously, "pure science" and "applied science" had been used rhetorically to police the boundaries between emerging professional communities, war work increased the stock of "pure and applied science" as a collective noun, emphasizing the interdependence of abstract and practical investigations.

After the war, applied scientists enjoyed much-enhanced social capital. Although physics remained a little-known profession, chemists parlayed their wartime work on poison gas into public visibility and policy influence.[15] In a remarkable inversion, defenders of pure science sought to borrow the newfound prestige of applied science. The American biologist, John M. Coulter, maintained: "[t]he public has begun to recognize the fact that pure and applied science are not mutually exclusive fields of activity, but complementary, and therefore public support for pure science has been growing, and *as a consequence of the practical achievements of pure science in connection with the war*, it bids fair to enter upon its own public estimation and support."[16]

One result, especially in the United States, was rapid growth in the number of professional scientists who identified as applied physicists. The meeting at which the American Physical Society (APS) was founded in 1899 had just 36 attendees. In 1902 it had 144 members, and only four from industry. But by the end of World War I, about a quarter of the APS's growing membership hailed from industry. These applied physicists, alienated by the APS with its strong emphasis on abstract investigations, clamored for professional representation.[17] More physicists were beginning to hang their identity on applications, and unbashfully so.

The institutional situation was somewhat better for applied physicists in Britain, who were amply represented in the Physical Society of London. British physics also had a long and proud tradition of close connections with industry. But the war was likewise a watershed moment, convincing the government that it needed to invest more heavily in applied science, even over the objections of the still-powerful Huxley acolytes that pure science was the wellspring of all that could be applied, and risked neglect.[18]

At the dawn of the interwar period, the relationship between pure and applied science was an intensely current topic in the Anglo-American world. That relationship was also in flux. The course of world events had inspired many to rethink the value hierarchy that had defined the relationship since the two terms began to be used in conjunction. At the same time, the champions of pure science had succeeded to a large extent in making the case that applied science could not simply forge ahead on its own, as was evident when IUPAP met in Chicago in 1933, alongside the Chicago World's Fair, which adopted the motto, "Science Finds, Industry Applies,

[14] Arne Schirrmacher, "Sounds and Repercussions of War: Mobilization, Invention and Conversion of First World War Science in Britain, France and Germany," *History and Technology* 32, no. 3 (2016): 269–92.

[15] Hugh R. Slotten, "Humane Chemistry or Scientific Barbarism?: American Responses to World War I Poison Gas, 1915–1930," *The Journal of American History* 77, no. 2 (1990): 476–98.

[16] John M. Coulter, "The Role of Science in Modern Civilization," *Transactions of the Illinois State Academy of Science* 11 (1918): 19–28, on 22. My emphasis.

[17] Martin, *Solid State Insurrection*, 20–7.

[18] Stathis Arapostathis and Graeme Gooday, "Electrical Technoscience and Physics in Transition, 1880–1920," *Studies in History and Philosophy of Science Part A* 44, no. 2 (2013): 202–11.

Man Conforms." The coordination of pure and applied science had been a necessity of war, and the link would have to be maintained to make science an engine of peace.

International Union, National Agendas

IUPAP itself emerged from a family of responses to World War I, coordinated by the International Research Council (IRC). Scientific exchange was conceptualized as a tool for healing the wounds of war and promoting international comity.[19] The IRC quickly formed international unions for geodesy and geophysics, astronomy, and chemistry. These institutions recognized the increasingly international nature of scientific practice, sought to strengthen the bonds between scientists in disparate nations, and aimed to implement greater standardization in the practice of science and in the language of scientific exchange.

It was the chemists who first insisted on adding "pure and applied" to the name of their union in 1919, and so IUPAP, when it formed in 1922, followed the lead of the International Union of Pure and Applied Chemistry (IUPAC).[20] Industrial chemists had long been a powerful constituency in the chemistry community and the name ensured that their interests were enshrined in the name of the union. The name of IUPAP is thus notable for two reasons: it similarly recognized the importance of applied physics, and it reinforced the parallelism with the other major branch of the physical sciences.

The first IUPAP General Assembly, which met in 1923 with representatives from thirteen countries, among whom the diversity of expertise reflected the ambition to instill unity among physicists with a variety of interests.[21] But the lack of discussion of the pure and applied components of physics at these meetings make evident the extent to which the distinction was, to a large extent, an Anglophone imposition; the French minutes of early meetings routinely lapsing into referring to the body as *l'Union Internationale de Physique*, indicating a certain superfluity of *pure et appliquée* in the Francophone world by the 1920s. Indeed, the journal *Journal de Physique Théorique et Appliquée*, founded in 1872, changed its name to *Journal de Physique et le Radium* in 1920 after a merger with *Le Radium*.

The pure/applied distinction might have been a potent one in Britain and the United States, but its potency reflected the internal professional politics of those national scientific communities rather than a global consensus around those categories. Categories like pure and applied science, that is, were primarily national in character. Bernadette Bensaude-Vincent has shown no category representing an

[19] See the chapter by Fauque and Fox in this volume.

[20] Frank Greenaway, *Science International: A History of the International Council of Scientific Unions* (Cambridge: Cambridge University Press, 1996), 50.

[21] Belgium, Denmark, Spain, the United States, France, Great Britain, Italy, Japan, Norway, the Netherlands, Sweden, Switzerland, and Czechoslovakia sent scientific representatives. Canada, Poland, and South Africa were also members, but sent no representatives. In the wake of World War I, Germany was excluded.

appropriate cognate to "applied science" ever stabilized in France.[22] In Japanese, the word "pure" was rendered differently for IUPAP than it was for the IUPAC.[23] Germany had a tradition in *reine und angewandte Mathematik*, but its physical counterpart, *reine und angewandte Physik* appeared comparatively rarely.

The union forged between pure and applied science, as represented in IUPAP's name, that is, was more important for physics within particular national contexts than it was for physics internationally. In national-level scientific communities, these categories mediated the support and esteem certain types of research received. At first glance, the inclusion of this distinction in the name of an international organization seems to indicate the upward pressure those national tensions exerted on the international stage. But little evidence suggests that IUPAP concerned itself explicitly with addressing the tensions between pure and applied physics in its early years. The divisions that consumed its attention were the national ones, and it sought modes of scientific exchange that could bridge those divides, with its purity or applicability a secondary concern.

What should we make of IUPAP's cumbersome name in light of this? The General Assembly's early discussions suggest that navigating the pure/applied distinction played little role in either framing or executing its mission.[24] The name is, however, indicative of the broader context that led to its emergence. The very existence of an international body that explicitly linked pure and applied physics put them on the same footing and reinforced the connection between them. IUPAP made a statement that applied physics *was* physics. By electing William Bragg as its first President, it bestowed international leadership upon an individual who held the regard of both acolytes of abstraction and practically minded practitioners. For applied physicists, that provided a measure of prestige that they sometimes felt they lacked within their national communities. For pure physicists, it reinforced the necessity of pursuing and supporting abstract research alongside practical research. IUPAP's name, that is, reflected an emerging consensus that the abstract and practical branches of physics were necessarily linked.

Pure and Applied Physics in Practice

If IUPAP's name signaled parity between pure and applied physics in the eyes of the international community, its practices nevertheless reflected the relative disciplinary dominance of pure physicists through the middle decades of the 20th century. It also reflected the comparative ease of sharing abstract research across national boundaries.

[22] Bernadette Bensaude-Vincent, "At the Boundary between Science and Industrial Practices: Applied Science, Arts, and Technique in France," *Science Museum Group Journal* 13 (Spring, 2020): 201309.

[23] I thank Kenji Ito for this observation.

[24] "Union Internationale de Physique Pure & Appliquée, Assemblée Générale Constitutive, Paris—Décembre 1923"; "Union Internationale de Physique Pure & Appliquée, Deuxiéme Assemblée Générale, Bruxelles—7 Julliet 1925;" "Union Internationale de Physique Pure & Appliquée, Troisiéme Assemblée Générale, Bruxelles—10 et 11 Julliet, 1931," series B2aa, vol. 1, folder A "General Reports, 1923–1960," IUPAP, Gothenburg Secretariat, (hereafter IUPAP Gothenburg), Center for the History of Science, Royal Swedish Academy of Science.

IUPAP was born into a world wounded by war, and not long into its existence another global conflict loomed, which saw charter members Japan and Italy pitted against most of the others. In that context, amid awareness that physics could be readily applied to the causes of war, IUPAP's internationalization efforts were more easily directed toward non-applied subjects. In its early decades, it concerned itself especially with questions of scientific notation and nomenclature. Metrology, for instance, occupied a sweet spot between pure and applied physics—salient enough to problems of interest to nations, such as trade and mapping, to garner widespread interest, but abstract enough to be understood as pure. IUPAP, which was led by representatives of the classical physics tradition, also engaged little with the burgeoning field of quantum mechanics, which in any event would have been difficult to pursue seriously without including German physicists.

World War II significantly reordered the international physics community. Following the intellectual migration from Europe and massive government investment, the balance of global power shifted to the United States. The US government was newly enthusiastic about federal physics funding and, in the wake of the success of the Manhattan Project, many other nations were of a similar mind. Nuclear physics, an abstruse pursuit in the 1930s, became the iconic representation of the power of the pure, once applied. IUPAP's role coordinating the pure and applied branches of physics took on new meaning in the post-war world.

Two circumstances would prompt a fuller-scale re-evaluation of the proper relationship between abstract and practical approaches to physics within IUPAP. The first of these was the expansion of the organization's membership. Just twenty nations had joined before World War II. By the end of the 1960s, that number had doubled. The new membership transformed IUPAP into a more thoroughly global organization. Sixteen of the first twenty member states were in Europe or North America, the exceptions being charter members Japan and South Africa, Australia (joined 1925), and China (joined 1934, left 1949, re-joined 1984). The addition of countries like India (1948), Argentina and Brazil (1951), Israel and Pakistan (1951), the Soviet Union (1957), and the Koreas (1969) meant that, at the dawn of the 1970s, the interests of the member states reflected not just countries with established scientific infrastructure, but those who aspired to build it as well.

As a 1978 report on physics in Pakistan put it "basic science—even the segments necessary for 'applicable' physics—is a frightful luxury for a poor country."[25] The perception within IUPAP was that nations seeking to gain coequal membership in the international scientific community after World War II often lacked both the resources and the inclination to launch major programs in fundamental physics. They recognized the abstract virtue of scientific engagement as a source of international prestige, but they more often than not sought to combine it with proximate material benefit to their domestic societies and economies. Crucially, this was not a universal characteristic of IUPAP's new members. In Brazil, for instance, the development of infrastructure for fundamental research held at least as much importance as support

[25] Untitled Report on Physics in Pakistan, 1978, series E11, vol. 2, folder 08 "Council meeting Stockholm 1978," IUPAP Gothenburg.

for applied work.[26] Nevertheless, the perception that it was true for *some* nations spurred efforts to increase activity in support of applied physics, the systematic neglect of which became a recurring topic of discussion.

In 1981, IUPAP addressed this issue through the formation of a Commission on Physics for Development.[27] Existing commissions tended to support conferences that represented the latest developments in specialized fields, and these activities catered best to physicists from nations that were industrialized, not those that were industrializing. The commission addressed the perceived "need for developing countries to be able to send their scientists to m[e]etings where matters of a more general nature were discussed."[28]

Conferences organized under the auspices of this commission focused more squarely on applied issues—energy, environment, and industry among them. The first of these, held in Trieste in 1984, took as one of its key objectives "to identify and define priority fields of physics which are most important for the technological and industrial development of third world countries."[29] The action the conference identified also focused on applied aims, including establishing "regional experimental and applied physics research centers in selected developing Countries" and "the establishment and maintenance of one or more international centers in experimental and applied physics."[30] The Commission on Physics for Development, though, remained a comparatively small element of IUPAP's activities. It played a role in making IUPAP membership a more attractive proposition for developing countries. Its direct engagement in applied questions, though, did little to overcome the impression elsewhere in the Union that applied interest remained underemphasized.

Awareness of the relative paucity of applied physics in the IUPAP program had been present for some time. In 1972, IUPAP President Robert F. Bacher's speech to the fourteenth General Assembly noted ruefully: "Our main activities have been in sponsoring research conferences on the latest work on the forefront of the various fields of pure physics. This is not of primary interest to the developing nations and there is no reason why it should be." Bacher, himself a nuclear physicist, Manhattan Project veteran, and former provost of Caltech suggested that IUPAP would have to take applied considerations into account more explicitly, for instance in its education programs, to generate interest in the developing world.[31] As IUPAP pursued an expansion strategy that would add thirteen new members before the end of the century, these concerns became increasingly relevant.

[26] Cássio Leite Vieira and Antonio Augusto Passos Videira, "Carried by History: Cesar Lattes, Nuclear Emulsions, and the Discovery of the Pi-Meson," *Physics in Perspective* 16, no. 1 (2014): 3–36.

[27] International Union of Pure and Applied Physics, minute of the Executive Committee meeting held in Paris, August 29, and September 3, 1981, series E11, vol. 3, folder 09 "Council meeting Paris 1981," IUPAP Gothenburg.

[28] Larkin Kerwin, letter to Mary Beth Stearns, March 22, 1978, series E12, vol. 1, folder 06 "General Assembly Stockholm 1978," IUPAP Gothenburg.

[29] Luciano Bertocci, memo to IUPAP International Advisory Committee, August 11, 1983, series E11, vol. 4, folder 03 "Council meeting Ottawa 1983," IUPAP Gothenburg.

[30] Daniele Sette "On the International Support to Physics in Developing Countries," series E11, vol. 6, folder 11 "Council meeting Quebec 1989," IUPAP Gothenburg.

[31] Robert F. Bacher, Presidential address at the XlVth General Assembly, Washington, September 1972, Appendix VI in *Report on the XIVth General Assembly, Washington, DC, 1972*, IUPAP-17, series B2aa, vol. 2, folder A "General Reports, 1969–1987," IUPAP Gothenburg.

The second factor that prompted new discussions of the pure–applied relationship within IUPAP was the changing fortunes of applied physics in the United States and Western Europe. Applied physicists became more assertive in the 1970s and 1980s. Within the APS, new divisions dedicated to computational physics, materials, and lasers were established. The breakup of the Bell System in 1984 was a blow to industrial physics research, but the diaspora of physicists with industrial experience into universities further softened the academic/industrial divide that had been so acute two or three decades earlier.

New institutions emerged to advocate for the needs of applied physicists. As solid-state physicists with fundamental interests restyled themselves as condensed matter physicists, the interdisciplinary field of materials research gained traction. The Materials Research Society was established in 1973, in no small part because of the efforts of the Indian-born American physicist Rustum Roy, who advocated fiercely for increased emphasis on applied, rather than basic research as the wellspring of advances in both science and technology.[32]

IUPAP could hardly ignore these developments. In 1976, it organized a conference in Dublin on the topic of physics in industry, which drew eighty-five contributions from physicists representing twenty-two countries.[33] The lively nature of the conference inspired then IUPAP President Clifford Charles Butler, an English physicist then serving as President of the Nuffield Foundation, to commit to a greater role for industrial topics in future IUPAP meetings.[34]

It took some time, however, before deeds would align more closely with words. Through the 1980s, concern about overemphasis on the pure portion of the organization's mission cropped up more frequently in internal communications. The British materials scientist Cyril Hilsum worried in October 1983 that "IUPAP is intended to support applied physics as well as pure physics, yet the overwhelming majority of our conferences are on pure physics."[35] His was not an isolated view. IUPAP President Allan Bromley acknowledged in January 1985 that "the Union over the years has tended to forget the fact that it bears responsibility for applied as well as so-called pure physics."[36]

By the mid-1980s, IUPAP began to take concrete action to alter the balance that had theretofore tilted in favor of pure physics. A resolution adopted at the October 1, 1985 Executive Committee meeting in Oslo ensured that "at least one of the Chairman and Vice-Chairman of each Commission shall be drawn from the industrial physics world."[37] This did increase industrial representation within IUPAP and

[32] Joseph D. Martin, "What's in a Name Change?: Solid State Physics, Condensed Matter Physics, and Materials Science," *Physics in Perspective* 17, no. 1 (2015): 3–32.

[33] E. O'Mongain and C. P. O'Toole, eds., *Physics in Industry* (Oxford: Pergamon, 1976).

[34] Frank E. Jamerson, "Physics in Industry," *Physics Today* 30, no. 10 (1977): 71–2.

[35] Cyril Hilsum, letter to Jan Nilsson, Associate Secretary General IUPAP, October 12, 1983, series E11, vol. 4, folder 15 "Council Meeting Oslo 1985," IUPAP Gothenburg.

[36] D. Allan Bromley, letter to John Bardeen, Conyers Herring, Hendrik Casimir, and Frederick Seitz, January 24, 1985, series E11, vol. 5, folder 15 "Council Meeting Oslo 1985," IUPAP Gothenburg.

[37] "Minutes: Oslo meeting, September 30–October 1, 1985 Norwegian Academy of Science, Oslo, Norway," Appendix F, series A1, vol. 1, folder E "Minutes from Council Meetings 1972–1999," IUPAP Gothenburg.

bring more contributors from applied spheres into meetings, but with, as one report put it, "uneven success."[38]

Throughout the 1980s and 1990s, the role of industrial physics in the Union, and strategies for increasing its involvement, was a perennial topic of discussion within the governance structure. Various working groups were formed to discuss the issue, and to think about how to navigate the cultural difference between the largely academic physicists who thought of research and collaboration on the scale of decades, and industrial researchers who, once the previously academic-style research laboratories like Bell were shuttered, increasingly planned on the scale of years, if not months.

But despite several suggestions that IUPAP required a commission—a primary subdivision of IUPAP charged with supporting conferences—dedicated to industrial physics, one was never established. The Union instead attempted to better integrate researchers with applied interests into the existing topical commissions, most notably the Commission on Semiconductors, established in 1951. The commission supported a variety of international meetings, including the prominent series of International Conferences on the Physics of Semiconductors. The series predated the commission, originating in a 1950 meeting in Reading, England, at which William Shockley presented his work on the junction transistor, and remained an important forum for exchange between academic and industrial researchers.[39]

Nevertheless, the primacy of a pure-physics perspective within IUPAP had consequences for the commissions. In 1978, the Union governance floated a proposal to merge the commissions dedicated to semiconductors, magnetism, and solid-state physics to create a new commission on condensed matter physics. Such a move would have mirrored activity in organizations like the APS, which in 1978 renamed its Division of Solid State Physics the Division of Condensed Matter Physics, in part to keep up with the new, and increasingly non-solid cutting-edge of the field, but also because of concerted efforts to emphasize the intellectual contributions of the field over the industrial.[40]

Pushback came from, among others, Mary Beth Stearns, a solid-state physicist then a principal scientist at the Ford Motor Company and a member of the Commission on Magnetism. Stearns observed that semiconductor physics, magnetism, and solid-state physics collectively produced over 28% of doctorates in physics in the United States. Since each commission had limited representation in the IUPAP governance structure, merging these commissions would systematically underrepresent those areas' interests relative to fields like particle physics (14.8% of doctorates), nuclear physics (3.8%) and space science (3.7%). "The present and proposed distribution of commissions is not representative of the physics community," Sterns concluded. "[t]he executive committee's amalgamations … would make the representation worse—not

[38] "International Union of Pure and Applied Physics Minutes, Meeting of the Executive Council, September 1996," series A1, vol. 1, folder E "Minutes from Council Meetings 1972–1999," IUPAP Gothenburg.

[39] Leo Esaki, "Highlights in Semiconductor Device Development," *Journal of Research of the National Institute of Standards and Technology* 86, no. 6 (1981): 565–70.

[40] Joseph D. Martin, "What's in a Name Change?"

better."[41] Larkin Kerwin, then Secretary General, circulated Sterns's letter to the IUPAP Executive Committee. The merger never took place, and instead the Solid-State Commission was renamed the Commission on Structure and Dynamics of Condensed Matter in 1981.[42]

Stearn's observation about the proportionality of representation on the IUPAP Executive Committee highlights another mechanism that conspired to ensure the underemphasis of applied physics. In principle, commissions were responsible for both the pure and applied dimensions of their subjects. Subjects with large applied components tended to be populous, but were most commonly represented on the Executive Committee by academic physicists, and those subjects more oriented toward basic research were both smaller, and so overrepresented relative to the size of their communities within IUPAP, and inclined to neglect potential applied dimensions of their fields altogether.

In 1985, Bromley raised the question of "whether IUPAP should take some further aggressive action to establish closer ties with physics related industries." He outlined two competing schools of thought within IUPAP:

> In one, the emphasis is on retaining the unity of science, and the recognition of the great importance of keeping the pure and applied aspects of any of our subfields in close communications. There are obvious benefits, not only within the science itself but also in terms of making the science understandable and attractive to all those taxpayers who inevitably end up supporting it. The other branch argues that the pure and applied sections of our disciplines have already pulled so far apart that it is a futile hope to even consider bridging the gaps between them. This group argues that what we should do is to establish a whole new set of Commissions charged specifically with the health and well-being of the applied sections of physics.[43]

Not for the first time, the question arose of how to fit practical research into the structure of institutions organized around topical divisions based on a taxonomy that privileged the categories of abstract research.

The IUPAP Secretary General, Jan Nilsson, circulated Bromley's query to the leadership of the commissions. Responses generally agreed that IUPAP should do more to respond to the needs of applied and industrial researchers. "I think that IUPAP should live up to its name," Hiroshi Kamimura of the Commission on Semiconductors put it.[44] Representatives of areas that enjoyed a close relationship between abstract and practical researchers, though, tended to share the sentiment articulated by Per Christian Hemmer, of the Commission on Thermodynamics that "no really meaningful distinction can be drawn between pure and applied physics," and to favor measures to increase IUPAP's attention to applied matters, but to disfavor radical restructuring

[41] Mary Beth Stearns to Larkin Kerwin, February 20, 1978, series E12, vol. 1, folder 06 "General Assembly Stockholm 1978," IUPAP Gothenburg.

[42] Executive Committee meeting minutes, August 29, and September 3, 1981 (ref. 27).

[43] Jan S. Nilsson, memo to Chairmen and Secretaries, IUPAP International Commissions, April 2, 1985, series E11, vol. 5, folder 08 "Council Meeting Oslo 1985," IUPAP Gothenburg.

[44] Hiroshi Kamimura to Jan S. Nilsson, August 16, 1985, series E11, vol. 5, folder 08 "Council Meeting Oslo 1985," IUPAP Gothenburg.

of the organization.[45] Treating applied physics separately, they felt, would enforce a division between basic and applied interests that they did not regard as reflecting their fields.[46] Representatives from the commissions dedicated to particle physics, mathematical physics, astrophysics, and cosmic rays, evidently not regarding the issue as one of interest to their membership, neglected to reply.

The consequence was to continue with the status quo, so far as the structure of commissions was concerned, but to encourage the practice adopted in 1985 of nominating members from industry, or with applied expertise, to leadership positions and to encourage IUPAP-sponsored meetings to recruit more speakers with applied interests. Structurally, the factors that favored non-applied research within the organization remained in place. Nor did contextual factors, in an era of increasing international economic competitiveness, work in favor of IUPAP's effort on this front. Such factors would continue to limit efforts to support applied topics into the 21st century. As the council noted in 2001, while lamenting the decline of industrial participation in IUPAP activities, "many industrialists were unwilling to share their newest research with others fearing the commercial competition."[47]

The three-decade saga of applied industrial physics and its relationship to IUPAP's mission reveals much about the wider international community of physicists in the late-20th century. Abstract, fundamental physics of the type pursued in large accelerators and telescopes was highly visible during this period, and proved a particularly potent medium for scientific exchange.[48] But as the Cold War cooled, and then fizzled, military pressures were replaced by economic ones. Intellectual property regimes became barriers as significant as military secrecy regimes to international exchange of knowledge. Just as IUPAP had struggled in the early 20th century to build meaningful exchange around applied research in the context of widespread militarism, it faced similar challenge in the late 20th century in the face of widespread mercantilism.

Conclusion

Historians of science and technology have of late sought to deconstruct the distinction, however it is expressed, between pure, basic, or fundamental research on one hand and applied, practical, technologically oriented research on the other. So-called pure pursuits have never been independent of the needs, desires, and values

[45] Per Christian Hemmer to Jan S. Nilsson, August 5, 1985, series E11, vol. 5, folder 08 "Council Meeting Oslo 1985," IUPAP Gothenburg.

[46] Pierre Aigrain to Jan S. Nilsson, August 29, 1985, series E11, vol. 5, folder 08 "Council Meeting Oslo 1985," IUPAP Gothenburg.

[47] Minutes, IUPAP Council and Commission Chairs Meeting, September 28–29, 2001, Mexico City, Mexico, series A1, vol. 1, folder C "Minutes of the IUPAP Council & Commission Chairs Meeting," IUPAP Gothenburg.

[48] Joseph D. Martin, "Prestige Asymmetry in American Physics: Aspirations, Applications, and the Purloined Letter Effect," *Science in Context* 30, no. 4 (2017): 475–506; Joseph D. Martin, "Word and Image in Popular Science," in *Where Words and Image Meet*, ed. Florence Grant and Ludmilla Jordanova (London: Bloomsbury, 2024).

of the pursuers and their supporters.[49] Applied research often opened avenues into fundamental insight.[50] Historians have nevertheless pointed out that, however murky the lines were in practice, the distinction itself had considerable rhetorical power, and considerable practical stakes.[51] The way in which "pure and applied" physics were navigated within IUPAP reinforces that point.

IUPAP is an object lesson in the relationship between aspiration and reality. Like the other international unions established in the wake of World War I, IUPAP sought *unity*. It sought international unity, but, as the name suggests, it also sought an elusive unity among the various branches of physics, and particularly among those who ferret out physical principles and those who put them to work.

Both forms of unity, however, proved difficult to cultivate. The world was rocked by war, both hot and cold, in the decades following IUPAP's establishment. Physicists played key roles in both. And IUPAP was little more successful than other organizations at combatting the centrifugal forces—such as divergent incentives, cultural differences, and competing priorities—that pulled academic and industrial researchers, and so often basic and applied researchers, away from each other on the institutional level, even as the practice of physics saw them become increasingly intertwined.

[49] Steven Shapin, *Never Pure: Historical Studies of Science as If It Was Produced by People with Bodies, Situated in Time, Space, Culture, and Society, and Struggling for Credibility and Authority* (Baltimore: Johns Hopkins University Press, 2010).

[50] Joan Bromberg, "Device Physics vis-à-vis Fundamental Physics in Cold War America: The Case of Quantum Optics," *Isis* 97 (2006): 237–59.

[51] Mario Daniels and John Krige, "Beyond the Reach of Regulation?: 'Basic' and 'Applied' Research in the Early Cold War United States," *Technology and Culture* 59, no. 2 (2018): 226–50.