The Bell Labs X "Project":
A Vision for Reinventing Corporate Research Labs

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There is increasing recognition that the nation's research ecosystem requires change, particularly in the face of intensifying global competition (McNutt, 2024). In the meantime, a powerful research model that, in the 20th century, helped create the science and technology foundation for our 21st century world sits dormant. That model is *corporate research labs*: labs whose research is inspired by real-world use and real-world problem-rich environments *and* that advance knowledge on behalf of broader society. Here, we outline a vision for re-establishing this model in a 21st century form. We refer to the model as "Bell Labs Xs," to signify that there would be many of them, all emulating the essential magic of corporate research labs such as the iconic Bell Labs of the 20th century, yet evolving in an "X-like" manner. These Bell Labs Xs would harness industry to create public, not just private, goods, and could, we believe, revitalize US leadership in science and technology and US economic prosperity for the 21st century and beyond.

Deficiencies in Our Current Research Ecosystem

Most research in the US is, in this early portion of the 21st century, performed by two categories of institutions—mission institutions (which we define broadly to include public or private institutions with real-world use mandates) and academic institutions. Both fill important niches in the nation's research ecosystem, but neither fills, in their current instantiations, the missing niche that is, we believe, necessary to revitalize the nation's research productivity.

Consider mission institutions, again defining these broadly. If public, they are institutions with government-mandated missions such as national security. If private and for-profit, they are corporations with corporation-mandated missions to serve particular markets and customers. If private and not-for-profit, they include foundations serving founder-mandated missions such as global health, as well as the focused-research organizations (FROs) (Marblestone et al., 2022) that have emerged recently to tackle non-commercial but societally beneficial challenges that benefit from a "block-funded single-organization" approach. A common denominator of all these institutions is that they have pressing mission mandates to meet, on time and on budget. Such mandates are of course not a bad thing. It is their single-minded focus on mission and cost that has made US mission institutions, both public and private, so productive and internationally competitive. But this single-minded focus leaves on the table research, including fundamental scientific understanding, that might not have immediate impact on the mission institution's mandate but could have profound broader societal impact. Occasionally, a mission institution will have a funding stream sufficient to allow for flexibility, such as Google's dominance of the search market allowing it to fund research like Deep Mind's that does not contribute to Google's short-

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term profits but benefits all of society. Such funding streams along with the necessary public-mindedness are rare, though, and not a generalizable solution to research at the national scale.

Consider academic institutions, by which we mean mostly universities whose primary purpose is to educate, but also include research institutes that are either closely affiliated with universities or have adopted similar operating models. A common denominator of these institutions is intellectual freedom—the freedom of researchers within these institutions to choose the source of inspiration for their research, and to pivot their research as they explore and find the new and surprising. Such academic research, often distant from real-world use, can be extremely forward looking and impactful, as was Einstein's research. But, precisely because such research is often distant from real-world use, it is also often prone to the valley of death that separates it from real-world impact as well as often to the echo chamber of "expert" peer review in which publications and citations, not real-world impact, are the metrics of success. To mitigate this, funders of academic research increasingly encourage some tie to real-world use. But, without intimate involvement from mission institutions, the ties are distant and sometimes even disingenuous.

Our Vision: The Bell Labs Xs "Project"

These deficiencies in America's current research ecosystem might be thought to be without solution. But these deficiencies were much less present in the 20th century, widely viewed as the golden age of US innovation. During the 20th century, corporate research labs—including but by no means limited to Bell Labs, General Electric, IBM, Dupont, HP, and Xerox PARC—were powerful contributors to scientific and technological advance. Perhaps unlike any other research institution before or after, Bell Labs was iconic (Gertner, 2013; Noll, 2015). Scientists and engineers affiliated with Bell Labs gave us radio astronomy, the transistor, information theory, and the laser. They won 12 Nobel Prizes and 5 Turing Awards (illustrated in the Table below)—the first to Clinton Davisson in 1937 for research done in the 1920s on the wave nature of matter and the most recent to John Hopfield in 2024 for research done in the 1980s on artificial neural networks.

	Accomplishment	Researcher(s)	Year(s)	Award(s)
1	Wave nature of matter	Clinton J Davisson	1920s	Nobel Prize in Physics (1937)
2	Transistor & transistor effect	John Bardeen / Walter Brattain / William Shockley	1940s	Nobel Prize in Physics (1956)
3	Information theory	Claude Shannon	1940s	Turing Award (1966)
4	Error-correcting codes	Richard Hamming	1950s	Turing Award (1968)
5	Laser	Charles Townes / Arthur Schawlow	1950s	Nobel Prize in Physics (1964)
6	Charge-coupled device (CCD)	Willard S Boyle / George E Smith	1960s	Nobel Prize in Physics (2009)
7	Cosmic microwave background	Arno A Penzias / Robert W Wilson	1960s	Nobel Prize in Physics (1978)
8	Electronic structure of materials	Philip W Anderson	1960s-1970s	Nobel Prize in Physics (1977)
9	Compiler design	Alfred Aho / Jeffrey Ullman	1970s	Turing Award (2020)
10	Development of Unix & C	Ken Thompson / Dennis Ritchie	1970s	Turing Award (1983)
11	Optical tweezers	Arthur Ashkin	1980s	Nobel Prize in Physics (2018)
12	Quantum dots	Louis Brus	1980s	Nobel Prize in Chemistry (2023)
13	Laser cooling	Steven Chu	1980s	Nobel Prize in Physics (1997)
14	Fractional quantum Hall effect	Horst Störmer / Daniel Tsui / Art Gossard*	1980s	Nobel Prize in Physics (1998)
15	Deep learning	Yann LeCun	1980s-1990s	Turing Award (2018)
16	Fluorescence microscopy	Eric Betzig	1990s-2000s	Nobel Prize in Chemistry (2014)
17	Artificial neural networks	John Hopfield	1980s	Nobel Prize in Physics (2024)
		*Core contributor but not Nobel Prize winner		

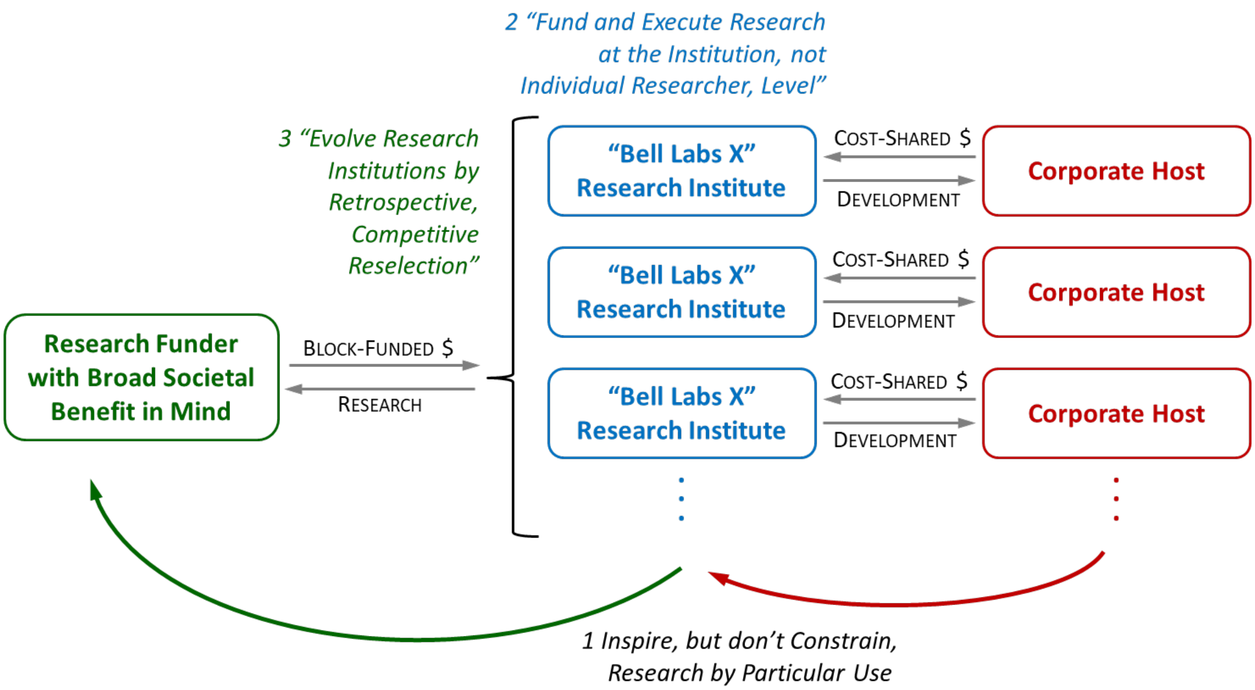
Our vision, our solution to these deficiencies, is the *re-establishing* of corporate research labs, drawing upon best practices from Bell Labs and its sister labs but reimagined in a 21st century form. At a very high level, our vision is depicted in the Figure below as a network of what we call "Bell Labs Xs" with three key funding/organizational features:

(1) Each Bell Labs X would be a public-private partnership: hosted and cost-shared by a corporation so as to springboard off of its real-world technologies and problem-rich use environment, but with majority government and/or philanthropic funding to support knowledge advance on behalf of broader human society.

(2) Each Bell Labs X would be block funded and thus have the freedom to organize itself, at the level of the research institution and all subunit levels, towards the full and undiluted purpose of research (Perry et al., 2016).

(3) Each Bell Lab X would compete with others within a larger Bell Labs Xs network, with those producing the greatest benefit to broader human society being reselected for continuation, and those producing the least benefit not being reselected.

To see why these three funding/organizational features are key, we describe in the remainder of this working paper how they follow from three guiding principles (Tsao, 2024) that we believe are necessary to re-establish the essential magic of Bell Labs in a 21st century form.



Guiding Principle 1: Inspire, but don't Constrain, Research by Particular Use

The first guiding principle stems from a powerful three-stage research "rubric" that, time and again, was executed by Bell Labs and its researchers.

In the first stage, "inspire research by particular use," a real-world space of uses and potential uses defines concrete problems that capture the imagination of researchers. The real world is the ultimate source of all knowledge (Anderson, 1990), and concrete real-world problems can be powerful inspirations for deep and fundamental research. For example, it was Claude Shannon's exposure in his early Bell Labs career to problems of intense real-world interest—cryptography during World War II and communications in the presence of noise post World War II—that inspired his breakthroughs in information theory (Soni & Goodman, 2017).

In the second stage, "seek, and pivot to, surprise," researchers, in their explorations of real-world problems, are encouraged to seek surprise (Tsao et al., 2019) and, when they find it, to pivot to it. This is a reflection of Alexander Graham Bell's famous words, taken seriously at Bell Labs: "Leave the beaten track occasionally and dive into the woods. Every time you do so you will be certain to find something that you have never seen before. Follow it up, explore all around it, and before you know it, you will have something worth thinking about to occupy your mind." The surprise is sometimes external to the researcher, as in Karl Jansky's unexpected discovery of radio emissions from the Milky Way; but the surprise is sometimes internal to the researcher, as in Claude Shannon's unexpected idea to treat information as a quantifiable and manipulable entity independent of its physical medium.

In the third stage, "don't constrain research by particular use," researchers, having sought and pivoted to surprise, don't constrain their research to the original use that inspired them, but explore spillover and broader societal uses (Arora et al., 2019). This is extremely important because surprise, by definition, can't be anticipated; and, all the more, the uses that the surprise leads to can't be anticipated. Of course, the new knowledge *might* benefit the original use, and this certainly counts as success. But spillover into broader societal benefit counts as the more important success, just as Claude Shannon's revolutionizing of not just communications, but the entire field of information science, was his most important success.

This three-stage research rubric is powerful but contains within it an inherent tension. Corporations are the home of real-world use and real-world problem inspiration, but are not the usual home of altruistic broader societal benefit. Bell Labs' altruism was enabled by of its culture of public service and by its monopoly profits that allowed for such public service. In the 21st century, altruistic corporations are rare hence require a new model. That model, we believe, is a public-private partnership of a particular and innovative type. Corporations would host and cost share each Bell Labs X, and in so doing "donate" their real-world use and real-world problem-rich environment. Government agencies and/or philanthropies with broader societal benefit in mind would provide majority funding to support Bell Labs X knowledge advances that benefit larger human society.

This Bell Labs X research model would thus transcend Vannevar Bush's "linear model" in which academia builds society's store of science and technology, then industry puts that store to work commercially. Instead, industry would *also* play a major role in building society's store of science and technology. The relationship between industry and the nation's science and technology enterprise would be flipped or at least rebalanced. Instead of asking what the nation's public-goods store of science and technology can do for industry, we would also be asking what industry can do for the nation's public-goods store of science and technology.

Guiding Principle 2: Fund and Execute Research at the Institution, not Individual Researcher, Level

The second guiding principle stems from two empirical observations. The first observation is that virtually all goods and services whose production processes are not straightforward, and that require collective action on the part of multiple individuals, are produced by institutions with appropriate governance and leadership structure and incentives. Such collective action requires institutional leaders who use hard-earned, tacit, boots-on-the-ground contextual knowledge to orchestrate and nurture employees and other resources. The second observation is that research that produces scientific and technological knowledge is no more straightforward than the production of other goods and services. If anything, research, with its enormous uncertainties and necessary real-time opportunism, is less straightforward. Thus, research all the more requires institutions that can flexibly and in real time orchestrate and nurture human and other resources.

To operationalize this, we envision each Bell Labs X being block funded as a research institution, with leadership allocating funds internally as it believes would best serve the orchestration and nurturing of research. What do we mean by the orchestration and nurturing of research? Borrowing from recent thinking on the nature and nurture of research (Narayanamurti & Odumosu, 2016; Narayanamurti & Tsao, 2021), we outline a few overarching aspects, even as we recognize that each Bell Labs X must tailor its orchestration and nurturing to its particular circumstances and knowledge domain.

<u>Organization</u>: Research is a highly specialized and challenging activity, one that is devoted to seeking surprise and the overturning of conventional wisdom. It requires an organization that is aligned—from leadership to middle management to in-the-trenches researchers to support staff—around the collective purpose of research (Currall et al., 2014). Moreover, because research is culturally very different from development (Bown, 1953), each Bell Labs X, with its focus on research, must be organizationally insulated from its host corporation's much larger development activity—even if it must not be intellectually isolated from that development activity.

<u>Culture</u>: Asking people to explore and seek surprise means asking them to take on an uncertain, risky, and exceedingly difficult assignment, and this requires immersion in a culture exquisitely supportive of such exploration. Because no one can anticipate where surprise will be, exploration must be holistic—spanning the full symbiosis between science and technology, between question-finding and answer-finding, and between research and development. And because overturning conventional wisdom can be uncomfortable, a culture of informed contrariness is required.

<u>People</u>: People are the beating heart of research—they must be cultivated and developed but also held accountable to high standards. There is the empathy and care associated with recruiting, hiring and mentoring. There is the leader's deft touch that navigates those situations when

researchers need guidance or collaboration versus those when researchers are best left alone. And there is the letting go of researchers when their fit to the organization has run its course.

Guiding Principle 3: Evolve Research Institutions by Retrospective, Competitive Reselection

The first two guiding principles are necessary but not sufficient for Bell Labs Xs as a network to be optimally productive in the long run. To guarantee such productivity, competition is necessary (Crawford, 2023). Although, as discussed just above, there is much we know about how research institutions should be organized to maximize research productivity, there is also much we do not know (Phillips, 2023). Thus, to continually ratchet up its research productivity as a network, those Bell Lab Xs that are more successful should be continued while those that are less successful should be discontinued.

In other words, we envision a network of Bell Labs Xs that is subject to retrospective competitive reselection. At the end of some reasonable time frame, perhaps ten years or so, the individual Bell Labs Xs would be evaluated according to how well they have created the kind of knowledge that society desires from this research model: knowledge that is maximally disruptive (has changed the way we think and/or do), *and* that has the greatest potential for broad benefit to society. This criteria echoes the Nobel Prize criteria except that it is more neutral with respect to whether the new knowledge has a science or technology flavor, rather than the Nobel Prize's historical emphasis on science.

Most importantly, even though there must also be an initial competition that is prospective (for deciding which Bell Labs Xs would be accepted into the network at the outset), the more important competition would be retrospective (i.e., based on track records of merit). From the point of view of the philanthropist or government agency providing majority funding, retrospective evaluation of research already done is much easier and more accurate then prospective evaluation of research proposed to be done. From the point of view of researchers and research leadership, retrospective evaluation unlocks so-called "permissionless innovation" (Thierer, 2016)—their freedom to allocate time and resources in real time without asking for pre-approval (through, e.g., proposals).

Next Steps

America stands at a critical moment. There is increasing recognition that our current research ecosystem requires change and even reconceptualization, particularly in the face of intensifying global competition. Here, we have proposed a vision for a new hybridized research model, Bell Labs Xs, that would revive the essential magic of 20th century corporate research labs such as the iconic Bell Labs but in a 21st century form. This "new old" research vision would, we believe, profoundly revitalize America's science and technology and single-handedly assure its leadership for decades to come. The knowledge domains these Bell Labs Xs advance could span as wide a range as that of the corporations that serve our human needs—from energy to information to health to education to finance to agriculture and beyond.

We welcome ideas for next steps. Because Bell Labs Xs would be public-private partnerships, we especially invite research leaders from corporations and policymakers/funders from government and philanthropy to debate how the partnerships could be best structured for mutual benefit. Because Bell Labs Xs is a new research model, we also invite the applied metaresearch (Nielsen & Qiu, 2022) community to debate and perhaps quantify its underlying assumptions. We wish foremost to build a community to improve and ultimately implement the vision.

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