Arthur D Little PRISM

The laboratory of the future

People-centric innovation in industrial R&D

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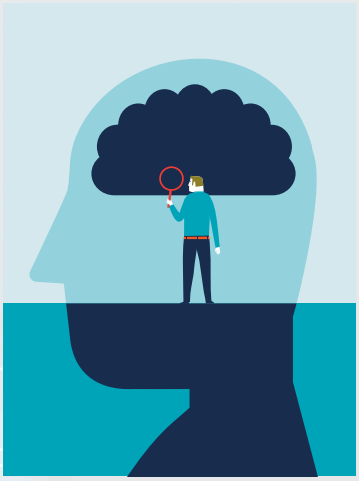
Industrial research and development has been transformed by factors such as globalization, specialization and open innovation. To meet growing challenges, R&D needs to change again to create the laboratory of the future, which will focus on putting people at the heart of innovation. We explore three next practices companies can implement now to position themselves for future R&D leadership.

It's hard to pinpoint when the world's first private research and development (R&D) laboratory came into existence. However, it was probably during the early days of the chemical industry in Germany after 1850, and swiftly followed by similar ventures from other leaders in the first industrial revolution, such as America, the UK and Belgium. Some of these pioneering industrial research labs remain innovation powerhouses even today, such as those of General Electric and DuPont in the US and Solvay in Belgium.



As industrial R&D has expanded and matured, so has the way it is managed. This is driven by three factors:

- Globalization demands that most large companies run their R&D using often dozens of labs all over the world. Even their most strategic technical competencies can now be distributed over several locations, close to wherever the best talent can be found or utilized. Chemicals giant BASF, for example, has around 70 labs globally, with three designated as the headquarters of their research divisions.

- Today's R&D organization is typically split between labs devoted to research and those focused on creation of products and services. Geoff Nicholson, former 3M executive and the "father of the post-it", said the former "turn money into knowledge", while the latter "turn knowledge back into money". This second phase often happens in smaller development labs or product houses sitting close to the target customer base. And as both talent and customer base have become more dispersed, so has the average company's R&D footprint. Consequently, India

and China in particular have seen a spectacular rise in the number and size of industrial R&D labs over the last two decades.

- Finally, the concept of open innovation is now prevalent in almost every industry sector, including those that used be hermetically sealed, such as aerospace and defense. As a result, research labs today are often tightly networked with local innovation partners. For example, Philips operates some of its medical technology R&D activities inside large hospitals.

In this article we argue that industrial R&D will continue to evolve significantly, demanding creation of what we would like to phrase as the "laboratory of the future". This "laboratory" (by which we mean the entire delivery engine of industrial R&D) will be driven by emerging needs to develop "mega-solutions" to meet the world's most pressing challenges: by convergence between industries, technologies and ecosystems, and because of the digital revolution, which is already changing the way R&D is being done, and by whom.

At the center of all these developments are people: how they learn, think, originate ideas, connect and deliver. All this means the laboratory of the future has to be designed principally from a human resource management perspective, which is not how most R&D organizations have traditionally evolved. The article will therefore review the fundamental HR challenges, the main factors for success, and examples to learn from, before outlining the key implications for innovation and HR executives in large industrial firms.

Our case for change

"People are our greatest asset" is probably the most overused sentence that CEOs utter. Clearly, that's because it is true, especially when it comes to companies whose prosperity depends on R&D and innovation. Yet, at the same time, HR in industrial companies is often seen "just" as a support function, rather than a key stakeholder in managing

their "greatest asset". Why do many companies outsource or offshore critical parts of HR support and rarely make vital topics such as digital transformation and ecosystem innovation strategic HR issues?

If this was ever an acceptable way of managing a company's greatest assets, it definitely won't enable a successful transition to the "laboratory of the future". Here is why:

1. **Attracting digital thinkers and doers:** Arguably led by the life sciences sector, leading players in all industries are now engaged in a wide variety of pilot projects and programs to make their innovation functions better, faster and smarter. And as how innovation gets done becomes increasingly digitalized, so does the need for researchers and developers to think and act "digital". But as we have shown in a recent report[1], major challenges remain – the most common of which are attracting, retaining and developing the right "digital thinkers and doers" and making them productive in an industrial R&D context. It's hard to be successful and happy as a digital native working in an analog environment optimized for the predictable and efficient evolution of physical products, when your added value and passion lie in high-speed software development. If "digital transformation" is as important as industry leaders say it is, this is truly a make-or-break obstacle to success.

2. **Diversifying team capabilities:** Companies that say they simply make products are becoming rare. Instead, businesses boast about delivering "solutions", based on their excellent customer understanding and even "intimacy". This is not (just) marketing speak. Across the industrial innovation landscape, the most promising opportunities are often about new formulations, smart applications and digitally enabled new business models, rather than new molecules or faster cars. But truly becoming a provider of solutions rather than of products

1. "Innovating in the digital age", Prism 2 2018

requires skills and capabilities that are not normally found in industry, such as design thinking, software development, customer empathy and consultative selling. The challenge is not only to recruit and develop these skills, but also to enable people with diverse experience, mind-sets and preferences to work together and be collectively successful. And this is not just about diversity for the sake of inclusiveness and fairness, but also because you can't be a successful solutions provider without employing the right mix of experiences, skill sets and mental models – and making them work together effectively.

3. **Excelling at both productivity and creativity:** The combination of the digital revolution and the world's thirst for new business models and breakthrough innovations requires many industrial companies to excel at two very different games at the same time. Firstly, they need to further optimize their cores, focusing on scale and productivity. Secondly, they must excel at disrupting their chosen markets through their (often newly found) leadership in speed and creativity. Textbooks used to say a company could only be good at one thing, but the success of Amazon, for example, shows that companies can, and should, be leaders in both "productivity" (e.g., in warehousing and logistics) and "creativity" (e.g., in constantly offering new cloud-based solutions). Leaders in industrial R&D will need to find ways to match this two-sided innovation firepower if they want to grab their fair share of next-generation solutions in markets such as mobility and the circular economy.

4. **Coping with fragmentation of critical knowledge and insight:** The largest and most attractive innovations will increasingly rely on companies' vast networks of ever-changing partnerships, as well as frequent acquisitions to provide quick access to new technologies, capabilities and ideas. Imagine running the innovation activities of a company active in security and safety solutions, for example. We estimate that there are over 5,000 companies active around the world in security alone, ranging from alarm systems to biometrics solutions and

cybersecurity software. Together, they are involved in over 500 M&A deals each year – 10 per company, on average. This implies that a company's accessible knowledge base may change vastly in just a few years – more quickly than the time to market of typical large innovation programs.

To add to this conundrum: if innovation and R&D thrive when people share, challenge and enrich their insight and ideas, will dispersion of innovation teams and ecosystems across markets and regions come at the expense of creativity, reliability and effectiveness? "Where's my water cooler?" quipped one R&D executive when we explained what her ideal global innovation team should look like. She meant certain parts of the innovation process relied on people's proximity, trust, and even camaraderie. This is obviously true for the "fuzzy front end" of idea generation and enrichment. But it also applies to downstream activities such as quality control and risk mitigation. The leading R&D labs of tomorrow will be those that have optimized this "everywhere-versus-somewhere" dilemma.

This transformation poses a significant challenge to research organizations: they are in the business of combining existing wisdom and new ideas into new, more valuable knowledge. But their repository of knowledge is changing and expanding quickly, with important information and expertise increasingly scattered and dynamic. As knowledge domains become more intertwined, monodisciplinary expertise won't get you very far. And traditional methods of making people learn (such as predefined courses) and acquire information (for example, a company's knowledge management system) require a serious makeover.

Three "next practices" for success

These challenges may sound particularly intractable to the average CTO, who feels they are already struggling to meet the requirements of today, let alone those of tomorrow. How can they work on "next practice" innovation, if just deploying current "best practices" is hard enough? Fortunately, there are already plenty of examples of promising tools and approaches that have shown their practical value to companies on their way to making their employees (much) more effective innovators.

While the final blueprint of the lab of the future is yet to be written, there are three "next practice" trends that we at ADL already apply with our clients today. (See Figure 1.)

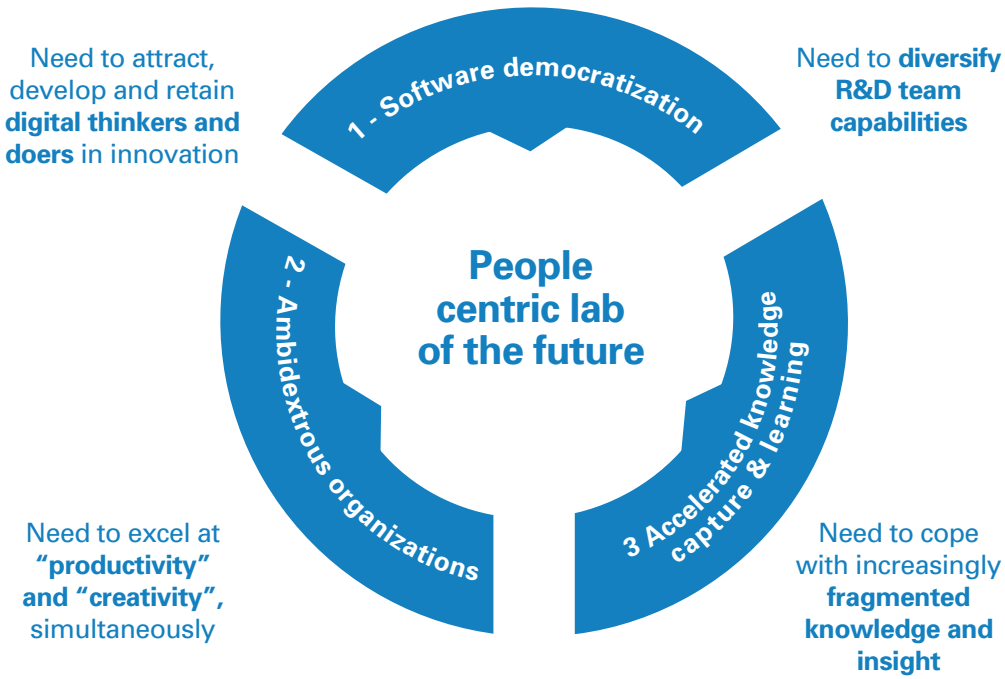


Figure 1: The trends that are shaping the people-centric lab of the future

1. Software democratization: When the CTO of a company active in a sector such as chemicals or advanced equipment says her lack of "digital thinkers and doers" is a major barrier to success (and many have mentioned this to us), she implies there is a chasm between digital natives/specialists and all others, often including herself. Thanks to a number of interesting developments, this chasm need not be as impassable as she thinks it is:

- Recent years have seen rapid expansion of the number and types of companies offering state-of-the-art software and analytics with easy-to-use interfaces. Are you interested in piloting artificial intelligence to identify non-obvious technology trends? Companies such as Quid and PoolParty can have the first results in a matter of days. Do you want to do advanced analytics on manufacturing or supply-chain data? Ask, for example, TrendMiner or Qlik.

- The availability of no- and low-code software allows non-specialists to do a fair deal of software development themselves, for instance, in workflow automation or creating functional prototypes of new software tools for their customers. This topic is further discussed elsewhere in this issue of Prism ("Unleashing innovation using low code/no code – The age of the 'citizen developer'").

- As we have outlined in our article "The human-to-technology language challenge"[2], organizations looking to acquire software used to have just two fundamental approaches – build or buy, both of which often brought their own problems and, even more commonly, costs. Using an approach we call "smart stitching", companies can split their end-to-end innovation processes into discrete elements which can each be delivered using standard or even open-source software. And because the elements that are truly bespoke are of limited complexity, the development of these components becomes a manageable and time-efficient exercise. These commodity and custom elements can then be "stitched" together into an end-to-end solution.

2. Prism 2 2017

We have found this approach to be particularly effective in creating a "just right" digital environment, and thereby in fostering broad user adoption of modern digital solutions. And as any R&D leader will tell you, this is a key challenge for automation initiatives among researchers and engineers, especially those that aim to bring about behavioral change.

2. Accelerated knowledge capture and learning: Trying to "know all that the company knows (or could know)" has been a somewhat elusive goal ever since knowledge management (KM) became an established discipline some 30 years ago. Some companies, such as Siemens and Schlumberger, have invested in building their own systems, while others rely on off-the-shelf software. But most KM solutions still have inherent flaws that will need to be overcome in the laboratory of the future. (See Box 1.)

Box 1 – Limitations of traditional KM systems

- Owners of relevant information are assumed to be posting and updating their experience and expertise. But few follow this "ideal behavior", and often the most valuable insight would be from or between people who have no idea that they should be sharing it.

- Almost invariably, information seekers are also assumed to be "active" – to know they need information and the KM system contains the solution. But people are often unaware of their knowledge gaps, or believe they have no time to spend on the system during their busy working days.

- Captured (documented) knowledge is assumed to be codified (tagged, categorized and compartmentalized), but such a repository will never reflect the company's full knowledge potential. And even when the system is able to search unstructured information, the retrievability of documentation is usually limited by imperfect search-query possibilities and siloed information repositories and formats.

This is where machine learning (ML), specifically the use of so-called knowledge graphs, comes in. Knowledge graphs can be constructed in a two-step process: firstly, by extracting semantical understanding from unstructured textual information using natural language processing (NLP) technologies, and secondly, mapping the extracted entities and their relationships onto a graph representation. This approach facilitates scalable representation of complex knowledge in digital form, as well as discovery of otherwise-elusive patterns and connections. These tools have grown mature in, for instance:

- Life sciences, in which they are used for tasks such as identifying new purposes for existing drugs based on millions of scientific articles and reports.

- Chemicals companies such as BASF, which apply these methods to accelerate and improve literature assessment and interpret vast amounts of product performance data to, for example, speed up selection of novel catalysts.

Applying ML and other advanced digital technology to a company's internal and external knowledge systems is rapidly changing the state of the art in industrial R&D knowledge management. We now can link even "passive" seekers and owners of insight and information (see Box 1) and offer a digitally optimized user experience (UX) that helps find non-obvious insight and can even "prod" people into actions they wouldn't otherwise consider taking. (See Figure 2.)

	Enablers		
Knowledge...	Triggers Prompts that initiate the transfer of information or catalyze learning activities	Technology Advanced (digital) technologies to support documentation, search, transfer and learning	UX Design attributes that make interfaces "easier to use than not to use"
...seekers	e.g., **predicting seeker's (future) learning** needs based on activity and network profiling (as example), and **prompting timely action**	e.g., recommending systems and chatbots based on **natural language processing (NLP)** that make suggestions to find "non-obvious" information	e.g., use of **adoption engineering** to make sure KM and learning solutions "go viral" and deliver behavioral change
...owners	e.g., **formal protocols** for debriefing projects at specific moments using prescribed formats	e.g., use of **speech recognition** tools to automate capture of knowledge from audio/video sources	e.g., use of **gamification** to stimulate engagement of owners in knowledge-transfer activities
...repositories	e.g., automated **keyword tagging** enables generation of "quick reference lists" for specific topics	e.g., use of **graph data technology** for discovery and extraction of topics and identification of hidden relationships within vast amounts of textual data	e.g., **data visualization** interfaces that make it easier to understand and prioritize information

Figure 2: Examples of accelerated knowledge capture and learning

3. Ambidextrous organizations: As we have shown previously[3], shaping "ambidextrous" organizations is hard and takes time. However, it can be done. For (large) research organizations, this means continuing to serve as productive "knowledge delivery engines" (traditional R&D), while also embracing active or even orchestrating roles in market-facing discovery (as Philips does inside academic hospitals), as well as running proof-of-principle pilots with local partners as part of their breakthrough innovation portfolios.

Insight for the executive

Companies claiming they are moving to digitally transform their entire ways of working are easy to find. And indeed, a majority of industrial companies have already shown impressive results from the rollout of "Industry 4.0" and similar principles, with more to come. It is therefore surprising to see that the very essence of most companies' competitive advantage – innovation – is barely addressed or not included

3. "Ambidextrous organizations – How to embrace disruption and create organizational advantage" – Prism 1 2018

at all in this great leap forward. If innovation leadership is about being the best at making their people learn, think, originate ideas, connect, and deliver new business value, companies must better understand what's keeping their people from leading in these areas and what "next practices" can be deployed to remove these hurdles.

The laboratory of the future is not "just" about using clever tools to simplify or improve specific tasks – such as in designing experiments or in analyzing patent databases. Deploying such tools is necessary to keep pace in the world of today, but they will almost certainly not be enough to meet the grand innovation challenges facing the company of tomorrow: how to encourage adoption of digital thinking by *everyone in everything* related to innovation; how to forge "multi-everything" teams (such as multi-skills, multi-experience and mental models) to design, develop and sell winning solutions in a converging world; and how to fill the widening information and learning brokerage gap, ensuring that people act and think based on the understanding and insight they *could* have, rather than have already.

The future path for innovation won't just happen. The challenges mentioned above are relevant today, and so are ways to address them. As we have outlined in this article, software democratization, accelerated knowledge capture and learning, and deployment of new organizational models based on ambidexterity are already being applied. They have the potential to drive a quantum leap in innovation effectiveness, speed and efficiency.

The key to success is to start and end the creation of the laboratory of the future with people, as well as to understand:

- What would make people perfect innovators in your company, today and tomorrow?
- What is keeping them from reaching this optimal level – as individuals, teams and organizations?
- How could you stitch the right combination of the "next practices" described in this article into an augmented innovation environment and experience that removes or minimizes such obstacles?
- How can you translate these findings into discrete, must-win battles within your digitalization journey and manage them for success?
- And finally, how can you ensure that this journey brings frequent and clear improvements in the user experience for everyone in your innovation community, rather than promising future advances and benefits that will never become concrete?

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