How chemicals R&D leaders can address disruption and keep innovating

Four key trends are impacting R&D organizations today. Leaders can break traditional paradigms and adapt to remain competitive.

EY Parthenon

Building a better working world

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In brief

- Interviewing R&D leaders in chemicals and related fields, the EY-Parthenon team noted four vital trends: digital technology, sustainability, new ways of working, and the talent gap.
- Leaders who can drive change and adopt new paradigms in the R&D function will continue to stay competitive; non-adapters will struggle or fail.
- As the natural center of innovation, R&D can take a leading role in guiding the transformations that are needed to address these disruptive forces.

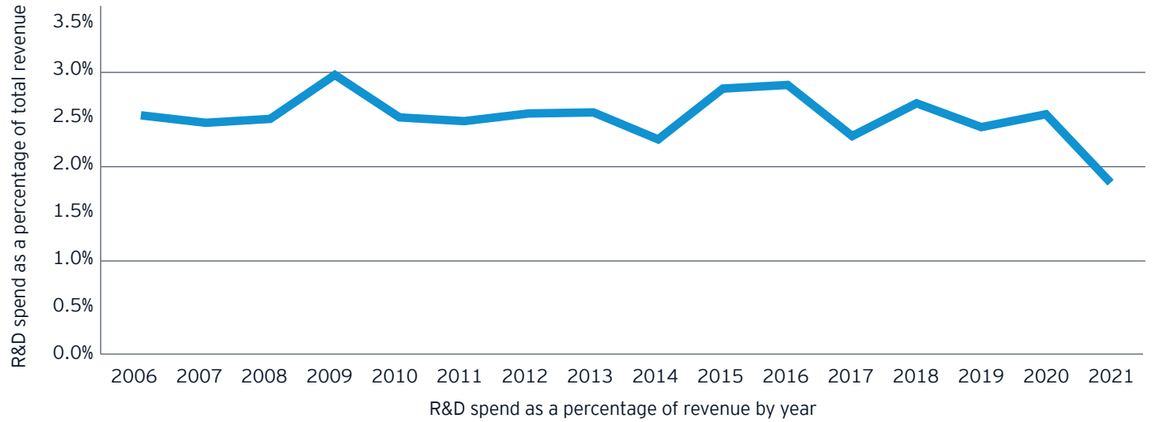
For chemicals companies contending with multiple disruptive forces, the time for innovation is now. As the natural headquarters of innovation for the organization, the research and development (R&D) function can benefit from evolving technologies while leading the enterprise as a spearhead of change.

Some of the challenges are not new but have become established trends that are continuing to develop. As we emerge from the pandemic and related turmoil, it is possible to identify successful strategies from companies' recent experience and look ahead to ways the R&D function can help the company navigate challenges to improve future competitiveness. Those that innovate successfully can grow with their customers and meet profitability and sustainability targets; those that cannot will struggle or fail.

This report examines four disruptive trends – digital technology, sustainability, new ways of working, and the talent gap – through interviews with R&D leaders in chemicals and adjacent sectors. EY-Parthenon teams spoke with executives at a diverse blend of small private firms and Fortune 50 publicly traded firms, specialty and commodity manufacturers, and companies that produce chemicals, materials, formulated and fabricated products, agricultural ingredients, and consumer products. All are US-based companies with global operations.

R&D remains a primary engine of innovation and profitable growth for companies in the chemicals and materials industry. R&D helps companies realize the right combination of product, service, application, and target market. Over the last 15 years, average R&D spending in the sector has generally remained steady at around 2.5% of revenue (Figure 1).

Figure 1: R&D spend as a percentage of revenue by year

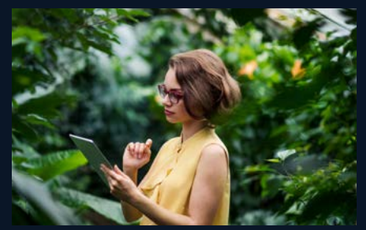


Source: Chemical & Engineering News, S&P Capital IQ.
Note: Data reflects averages for chemical companies out of the Chemical and Engineering News Global Top 50 that reported R&D spend, which varied between 26 and 34 companies each year.

Interviews with R&D leaders identified approaches to address disruptive trends that will continue to impact R&D functions — and their organizations — in the foreseeable future in these four areas:

Digital technology

- Technologies can help virtualize insights and minimize or accelerate physical lab activities.
- Data sharing can help break down functional silos and increase visibility, trust and collaboration across the enterprise.
- New collaboration patterns are needed to take full advantage of advanced modeling technologies that accelerate development.



Sustainability

- Customers rely on their suppliers to develop more sustainable products to help them improve their own sustainability profiles – "green" is no longer a niche.
- Process engineering can help companies execute more sustainable operations and drive both environmental and cost benefits.
- Incorporating sustainability metrics and decision criteria into project management processes will help push efforts further in the direction of sustainability and circularity.

Ways of working

- Certain activities can be performed remotely or flexibly, and others cannot. These need to be defined, and those who do not benefit from flexibility in their jobs will expect to be compensated accordingly.
- Performance management models in a flexible work environment must evolve from being based on presence or effort to being based on results and output.
- Location can be a talent limiter to some companies; "location-free" approaches can help attract previously inaccessible talent.

Talent gap

- Gen Z workers seek links between their work and a meaningful purpose. Linking company purpose to the career value proposition is important in attracting and retaining talent.
- With increasingly tighter talent pools, companies can seek creative, nontraditional means of attracting talent.
- Similarly, they can create new and interesting opportunities for R&D workers to continue to feel engaged and enriched by their experiences.

Chapter 1:

The power and potential of digital technology

Tools like automation, analytics and cloud can create an engine for innovation and competitiveness.

Digital technology is a disruptor that brings challenges but also significant opportunities for R&D organizations. After all, this is where the innovative magic happens, and R&D is in a position to benefit directly from powerful modern technologies, such as automation, data and analytics, and cloud.

Investment in digital transformation is being taken very seriously by some companies, especially larger firms, but not all. Some savvy companies are recognizing the need to stay at the forefront technologically, because technology supports innovation, and innovation helps create an engine that helps companies survive and thrive. And competitors these days can come from unexpected quarters. R&D leaders are realizing that after years of tinkering, the time is ripe to implement digital solutions in a major way within their organizations. "This digital thing is everything!" noted one executive. Accordingly, data science and modeling groups are growing rapidly within major R&D organizations. One executive noted that his firm's data science department tripled in headcount in the last three years.

We consider three key benefits of digital transformation that R&D organizations can prepare to exploit:

1. **Automated product development** – Digital tools are enabling insights that may be tedious or impossible for the human mind to develop, accelerating innovation and product development.
2. **Expanded interconnectivity** – As businesses, assets and people become increasingly networked and generate ever-increasing types and amounts of data, companies and their R&D organizations can integrate data from multiple platforms to exploit the information at hand.
3. **New patterns of collaboration** – Increased transparency and data integration will enable R&D organizations to break down silos within R&D and the broader enterprise. Companies can seek both internal and external partners to spur innovation. People with differing domain expertise (i.e., both data science/analytics and traditional sciences/engineering) will need to collaborate effectively.

Automated product development

One exciting area is the use of automation to help develop new molecules and formulations, saving many hours of manual work and even enabling things that cannot be done by humans at all. Several product development examples have been published. A multinational consumer goods company and Arzeda are combining physics-based protein design with deep learning, a type of artificial intelligence (AI), to improve existing enzymes or build new ones to function in consumer or industrial products. An example is a group of lipases that break down grease in dish detergents or promote saponification of oils and fats for soap production. In a melding of sustainability and digital initiatives, this example is part of The multinational consumer goods company's $1.2 billion plan to replace petroleum derivatives with 100% bio-based ingredients for cleaning products by 2030, up from 16% today.[1]

Chemical companies and those further downstream are not turning to technologies like AI only to develop new products but also to reduce the number of time-intensive, manual tasks performed in the laboratory. A global chemicals and materials company and Siemens have collaborated using next-generation computing to integrate virtual testing software for modeling and failure prediction with commonly used commercial finite element software packages to advance development of high-performance polymers and composites for auto and aerospace markets.[2] Food and other packaged goods manufacturers are working to virtualize physical development like packaging design and drop trials. "Packaging trials, flavor changes and small formulation changes could be done totally virtually within 4–5 years with the information we have," predicted one R&D head in the consumer goods sector.

Major R&D organizations have long been using physical lab automation for high-throughput screening and analysis. To step further into the future, some are exploring the self-driven R&D lab. In this quasi-autonomous laboratory, AI and robotics automate and control synthesis and validation in a closed cycle, leveraging machine learning for data analysis while maintaining a human interface so that scientists' knowledge can be incorporated.

Pilot programs at Kebotix with Johnson Matthey showed that robots could perform many of the traditional functions of researchers, but humans maintain ultimate control and set the design objective that the algorithm reduces to a numerical optimization.[3] While the self-driven R&D lab is not a reality yet, in part due to cost, chemical and adjacent sectors are potentially moving toward a new era in which AI-created insights direct scientific data collection and allow for rapid experimentation.

Expanded interconnectivity

Several executive interviewees cited efforts to integrate the growing volumes of data available from sales, manufacturing, supply chain, environmental health and safety, and R&D to provide improved visibility for their technical people. The goal is not necessarily to move to a single tool or platform, but firms are striving to integrate multiple tools into a single portal. "The integration creates cultural ripple effects – transparency you can't hide from. This allows us to have candid discussions, leading to increases in productivity we haven't seen before," noted the R&D head of a midsized specialties producer. R&D groups at smaller companies often struggle with justifying the investment in various digital technologies, because they cannot leverage the cost as well as larger organizations. The EY-Parthenon research did find, however, that some of these companies have taken steps to centralize data and even leverage systems from other functions to accelerate innovation.

The R&D head of a specialty materials formulator noted that his firm is using filters to screen lead-generation data from the customer relationship management system and identify product development opportunities proactively. The activity is spurring conversations with colleagues in marketing that may have otherwise been delayed or not held at all. Another executive cited his firm's efforts to engage with startups to cost-effectively access technology to promote data integration as well as project and portfolio management.

The value, of course, depends on the quality of data. After years of figuratively throwing their hands in the air and saying, "We have bad data," firms are beginning to cleanse and digitize disparate data sets to accelerate insight development and innovation. While this can be daunting for experimental data, firms can start with more standardized data sets like product and packaging specifications. External partners with AI technologies can help clean and harmonize disparate data sets.

[1] *Chemical & Engineering News website*, 07, 13 July 2021.

[2] "Siemens adds material modeling to Simcenter through acquisition of MultiMechanics," *Siemens website*, 15 December 2019.

[3] "Business Roundup," *Chemical & Engineering News website*, 19 August 2021.

New patterns of collaboration

Advanced analytics and AI technologies will not replace scientific experience and know-how, but people from digital and traditional scientific and engineering domains can adapt and work together. Inevitably, a portion of the traditional R&D population will be unable to do this, conceded one executive. As work and collaboration became increasingly virtual during the height of the pandemic, his organization experienced bottlenecks with individuals who were not digitally savvy enough to make the leap and chose to leave or retire early as the R&D organization accelerated its digital agenda.

As data and analytics become an integrated norm within R&D organizations, operating models will need to evolve. Larger R&D organizations are hiring data scientists in addition to traditional scientists and engineers. Because the technologists in these analytics groups often hold advanced degrees and are charged with innovating ways of helping the enterprise make better use of data, they are often housed within the R&D organization but serve the entire enterprise. This poses a challenge to R&D leaders, who need to make sure their technologists are equitably serving other functions, rather than solely supporting R&D.

Companies do not necessarily need to hire all of these new capabilities. Many are collaborating creatively with outside vendors or universities. A major coatings manufacturer is now using machine learning for color matching and color design, enabled through collaboration with universities to develop the required machine-learning code. "We clearly can't do this by ourselves. There are a lot of vendors. I talk to vendors nearly every day," noted another executive. Vendors range widely in size and services offered. Some firms have chosen to work with large single vendors to stretch their platforms as far as possible, while others hesitate to bet on one provider and thus engage many parties. R&D organizations need to collaborate with the IT function to develop reliable partnerships.

Analytics professionals do not usually speak "science," and traditional scientists and engineers are generally not well-versed in areas like cloud technologies and neural networks. This report addresses the related talent challenge below, and EY-Parthenon research showed that for the next few years, leaders will need to address the inefficiencies inherent in bringing previously unfamiliar capabilities and domain knowledge into their organizations.

Chapter 2:

Sustainability at the forefront

With the right metrics and approach, environmental challenges can become business opportunities.

The drive to greater sustainability — whether in the form of reduced carbon emissions, better water stewardship, or more circular products that stay out of the waste stream — is both an opportunity and a threat for chemical and materials manufacturers. In response to global accords such as the Paris Climate Agreement, some chemicals companies have pledged to reduce or reach net-zero emissions by 2030 or 2050.

Stakeholders, including investors, regulators and employees, are pressuring companies all along the value chain to act more sustainably. While the term "sustainability" is often interchangeable with "ESG" (environmental, social and governance), our report found the environmental pillar to be most relevant for chemical industry R&D organizations. The EY-Parthenon team examined sustainability through two primary lenses:

1. The development of products and services that enable customers to be more sustainable — for example:
   a. Products that are derived from renewable rather than conventional feedstocks like petroleum
   b. Products that enable circularity strategies such as recycling or composting
   c. New synthetic routes to natural products whose cultivation is environmentally intensive or has resulted in overharvesting
   d. Services that enable more targeted and efficient use of products, such as digital farming
2. The development of processes that enable chemical manufacturers to reduce their own environmental footprint — for example, processes that reduce:
   a. Energy usage and carbon emissions
   b. Other harmful emissions like volatile organic compounds (VOCs)
   c. Net water usage
   d. Net raw material usage

More sustainable offerings

Sustainability requirements complicate the economics of product development. Financial implications are still critical but can manifest in different ways. Some applications may command a price premium for a more sustainable product (e.g., compostable packaging used for niche, health-oriented packaged food brands), while other applications require at least cost neutrality, if not cost savings, because end customers are not expected to pay a higher price (e.g., packaging for mass market food brands).

While chemical and materials companies produce many products that support or enable sustainable applications (e.g., adhesives for solar panels, separator membranes for rechargeable batteries), markets now demand that traditional products are more sustainable from a product lifecycle perspective. The degree to which companies embrace a truly sustainable framework for innovation and product development varies by their target industries and often by company size. Smaller companies selling into niche B2B applications may focus only on making products safer — for example, by moving away from toxic additives. Going a step further, companies can help their direct customers to lower their environmental impact, such as through use of coatings that cure faster or at a lower temperature. Larger companies selling to consumer goods customers (B2B2C) will also need to focus on using more sustainable raw materials as well as whether their products end up being recycled or deposited in landfills.

While there are many frameworks for categorizing chemicals and materials, they can be split into three main categories for this discussion about sustainability. Thermoplastics such as polyolefins and PET are mechanically recyclable, and producers are increasingly incorporating post-consumer content into the resins they supply. However, many end products such as flexible film packaging are difficult to mechanically recycle economically, so companies are increasingly investing in various chemical recycling ("advanced recycling") technologies to break plastics back down to chemical building blocks that can be used to make the same resins from which they were recycled or other products.

> Stakeholders are pressuring companies all along the value chain to act more sustainably.

Thermoset materials such as polyurethanes and epoxies cannot be recycled the same way as thermoplastics and have historically ended up being downcycled or landfilled. While thermosets are generally geared to semi-durable and durable applications, circularity imperatives have driven several companies to develop ways of keeping these materials in the value chain and out of landfills. "It's not yet a profitable area, but we're willing to invest even if we just break even," noted an R&D leader from a major materials manufacturer.

Lastly, small molecules and performance chemicals such as surfactants, fertilizer and solvents, which cannot be readily recycled like plastics or other materials, also require a more sustainable lifecycle. However, chemical manufacturers need to be flexible as they develop new offerings. Some of their customers may require products that are bio-derived, biodegradable, and/or nontoxic. These categories are not mutually exclusive, but R&D organizations and their commercial counterparts need to plan appropriately and establish decision frameworks to serve customers who hold different views of what "sustainable" means.

Sustainability efforts can also increase the resiliency of companies' supply chains, which is of critical importance in today's business environment. The R&D leader of a major industrial coatings business mentioned that their organization had been significantly impacted by supply chain disruptions resulting from extreme weather events. By formulating bio-derived inputs rather than those derived from petroleum, the company has increased supply chain resiliency while reducing its environmental impact.

A typical complication is that a sustainability improvement in one dimension of a product or process may decrease performance in another. For example, chemical recycling technologies can help keep plastics out of landfills, but they also require more energy to run the recycling process, resulting in potentially higher emissions. Commercialization may also result in unintended consequences. To mitigate this risk, the R&D head of a global packaged food manufacturer cited the example of higher value, "flywheel" technologies that enable multiple benefits. For example, food companies would find very high value in a high-intensity sweetener that has the health benefits of lower sugar content, has a lower emissions footprint due to reduced volume to be shipped and is renewably sourced.

Sustainability in the process environment

In addition to the product portfolio, R&D organizations continue to focus on supporting their companies' operations from a sustainability standpoint. Historically, many efforts to reduce the environmental impact of operations simply fell under the category of general productivity improvement. These include efforts to reduce waste, energy consumption, number of process steps and other factors. Several executives cited the increased importance of these initiatives to their internal and external stakeholders, particularly in water usage, which has not always been a financially impactful aspect of operations.

Chemical producers and their downstream customers are doing more to reduce the environmental impact of their processes. For example, petrochemical producers such as Dow are now planning to sequester carbon emissions from their operations and employ autothermal reforming technology to convert off-gases such as methane to hydrogen used to heat crackers. Additionally, electrification of crackers and other production assets would enable producers to increase the share of renewables in their overall energy consumption.

Sustainability metrics in the innovation management process

To identify and meet sustainability goals, R&D organizations need to implement sustainability metrics in their development processes. Most executive interviewees noted that their innovation management processes, including stage-gate frameworks, are evolving or have already evolved to include sustainability metrics. These metrics are generally being tracked but are not yet being used as decision criteria to continue or cancel projects, though companies are moving in this direction. At a midsized specialties producer, the R&D head noted that they are deprioritizing development efforts lacking a positive sustainability profile and are targeting 70% of new product development to have a positive sustainability impact over the next five years.

Chapter 3:

Ways of working – labor models in today's R&D organization

Leaders are embracing flexible and remote working approaches – for some roles – to help attract and keep talent.

Like other functions that followed an in-person, on-site working model before the rise of COVID-19, R&D organizations had to scramble and adapt when the pandemic first started. Remote work and staggered shifts in the lab were the primary tactics employed.

More than three years later, many R&D groups have adopted a new model working forward, though this varies by company. Several key issues can be addressed:

1. What work needs to be done on-site? What work can (or should) be done remotely?
2. How much flexibility should be provided with regard to on-site work during conventional business hours? Who can have this flexibility? How should those who cannot have this flexibility be compensated?
3. How should performance be measured when managers no longer see their people in person as much as they used to?

With the adoption of digital collaboration tools, remote work is now feasible for many tasks, and companies have adopted flexible working models where possible. However, lab work still must be done on-site, and likely will for the foreseeable future. "There are some things that just can't be replicated remotely," explained one senior leader. "Hallway conversations in labs and at conferences are where the magic happens."

Companies have experimented successfully with a variety of creative approaches and levels of flexibility, such as enforcing core hours on certain days when team members are expected to be on-site.

With regard to which colleagues are afforded the opportunity to work remotely, "there seems to be a have/have-not gap," explained one leader. "Those who primarily work in the lab have limited ability to work remotely and are now showing more willingness to work in nontechnical functions. How do we compensate them for working in a job with less flexibility than other functions?" These are questions that tie into the discussion of talent acquisition and retention below. In any case, the pre-pandemic stigma around remote work has faded from most organizations.

The shift to flexible and remote work has been well-received by employees and embraced by leaders who have increasingly adopted output-based performance measurements, which has been the case across functions. "Attitude and results matter rather than working hours," commented the technology leader at a rubber fabricator. "Rather than setting company-wide policy, we leave it to managers to intervene when they notice drops in productivity: results, patent streams, publications, usage of lab equipment," explained an executive at a major materials manufacturer, "We're focusing more on the Y's than the X's. We've been pretty pleased so far. Output has stabilized. Will it work long-term? We're not sure yet."

Historically, many chemicals, materials, and other manufacturing companies have had challenges attracting talent in locations perceived to be less attractive, whether they be too rural, non-coastal, too cold, too hot, and so on. Remote work has enabled many people to relocate to more favorable locations, while allowing the company to retain them as employees. Some interviewees' firms are adopting a "location-free" approach to attract and retain talent. One executive acknowledged the company's location was not ideal for all candidates, so the company has allowed those who do not work in the lab, such as managers, to work from a different part of the country as long as they are willing to meet with their teams or leaders as needed and at their own expense. Time will tell how R&D organizations can strike the right balance between flexibility and structure.

Chapter 4:

Filling the talent gap

In the war for R&D talent, companies can win by recruiting through nontraditional channels and offering a differentiated work experience.

While the fight for talent has been a challenge for R&D organizations in most manufacturing sectors, executives highlighted various issues, which can be discussed in three categories:

1. The needs of today's workforce, especially millennials and Gen Z
2. Attracting talent
3. Retaining talent

The needs of today's workforce

Hiring and keeping the best people is harder nowadays, and even the biggest companies can no longer rely on household-name brand status to attract new hires. The younger generation of workers has different expectations from previous cohorts, and companies must not only articulate how their people help fulfill a meaningful purpose but also provide an enjoyable and rewarding experience. "I look around the table at leadership meetings, and I see a bunch of middle-aged men who are often dismissive of the needs of the millennial and Gen Z workforce," lamented the R&D leader at a midsized performance chemicals formulator. "Younger folks are very comfortable with moving to other companies. Our engagement survey revealed that our systems are antiquated. Our processes are difficult. Our career models seem to be constricting," he noted.

Clearly, the value proposition for today's scientists and engineers extends beyond doing interesting work at a large, established employer. "We need to create a baseline for the talent cohort we bring in," explained one industry executive. "That baseline is comprised of a focus on, first, wellbeing; second, cohesiveness, inclusion, and belonging; and finally, appreciation."

Attracting talent

Our executive interviews indicated that the ability to attract R&D talent varies by size of company, though even larger companies have challenges in certain areas. "Securing talent has not been a big issue for us," relayed an R&D leader from a major diversified chemical and materials producer. "What's really difficult is securing talent with dual domain knowledge [traditional science/engineering plus data/analytics]." The executive described how the company has started an internship program to attract chemistry, materials science, and chemical engineering PhD students who also have data analytics and modeling skills.

Another large company is pursuing talent from nontraditional backgrounds and channels. One example is OneTen, a US coalition whose mission is "to hire, promote, and advance one million Black individuals who do not have a four-year degree into family-sustaining careers over the next 10 years." OneTen helps employers use a "skills-first" approach rather than an approach based on academic credentials or pedigree. The executive indicated that putting employees sourced from OneTen through an apprenticeship program helps to build the skills they need to succeed in the lab, even without a four-year degree.

A coatings manufacturer is looking at revising its model for attracting and retaining technicians. Because technicians with college degrees carry a similar fully loaded cost as those without college degrees, many companies hired college graduates to fill technician roles. But the coatings manufacturer found that college-educated technicians frequently leave for higher-paying jobs at other companies or in completely different fields.

One of their US-based R&D leaders explained how they are exploring the European apprenticeship model to identify non-college bound talent early and build a candidate pool that has been engaged and groomed over time to fill the technician ranks.

Smaller companies, which often can't match the higher salaries paid by their larger peers, seem to struggle more. "The talent shortage is limiting R&D innovation in small and medium enterprises," explained the technology leader at a smaller compounding and fabrication company. "To attract talent, we need to provide a multiyear career growth plan, stability and flexibility."

Retaining talent

Talent retention is also critical, particularly when technical people are increasingly lured by large technology companies seeking to innovate new offerings in multiple industries. One interesting program example is a "marketplace" model, in which existing employees can apply for multi-month assignments outside their core area. During these rotational assignments, employees can build new skills, network in different groups and continue to feel engaged in what is a highly nonlinear alternative to career growth.

This model may be particularly attractive to technical staff who want to take an extended break from lab work and build their business acumen. The company benefits by retaining talent and diversifying its employees' experiences and skill sets. There is also a great opportunity to accommodate extended sick leaves and parental leaves by enabling the company to temporarily substitute employees on leave with those on temporary assignment.

How to position today's R&D organization for the future

The R&D environment is clearly as dynamic as any other function along the chemicals and materials value chain. EY-Parthenon offers the following summary thoughts on how leaders can best prepare for the future:

Digital technology

- Virtualize traditional lab testing where possible through AI and other modeling tools to skip or accelerate physical experimentation.
- Connect data across functions to enable R&D and other functions to see past silos and access an integrated view of the data.
- Invest in processes that promote collaboration, such as between data scientists and traditional scientists and engineers.

Sustainability

- Help customers become more sustainable by developing more sustainable products.
- Seek opportunities for process engineering groups to improve the sustainability profile of operations, including the exploration of game-changing approaches.
- Incorporate sustainability metrics into stage gate and related program management processes. Move beyond simply measuring; incorporate sustainability metrics into decision criteria.

Ways of working

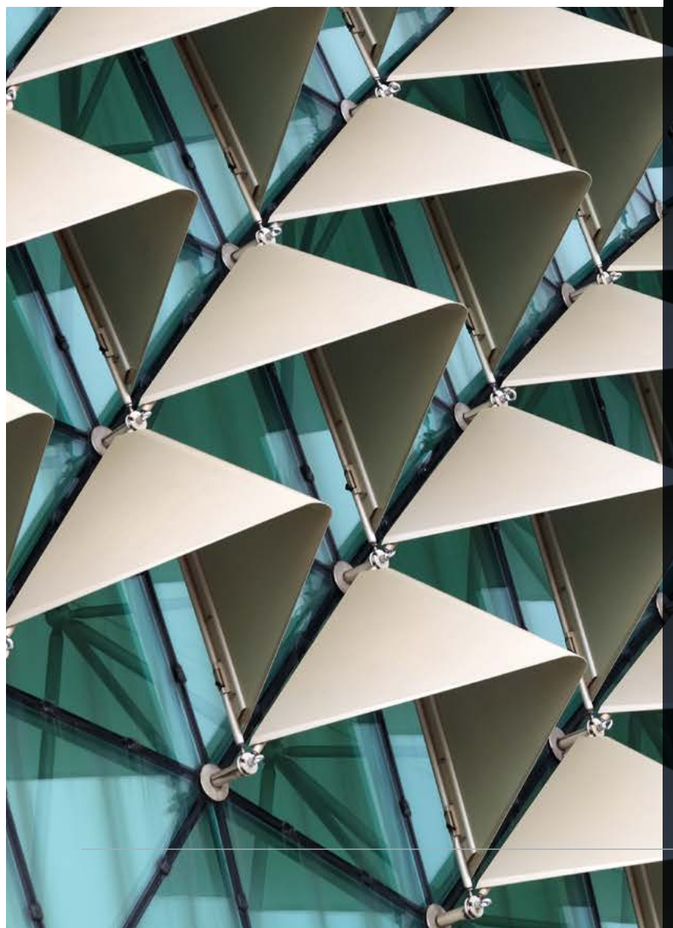
- Clarify what work can be done remotely or flexibly; determine the "haves and have-nots" of flexible work – and compensate the have-nots appropriately to retain them.
- Reconsider performance management models and revamp them to reward results and output rather than time physically spent in the lab.
- Consider "location-free" approaches to attracting talent, especially in locales perceived as unattractive.

Talent gap

- Link company purpose to the R&D career value proposition, but also strive to provide employee experiences that are individually enjoyable and rewarding.
- Seek creative, nontraditional means of attracting talent.
- Create new and interesting opportunities for R&D personnel to continue to engage them and enrich their experiences and development.

Summary

To stay competitive, R&D organizations can adapt to capitalize on key disruptions, such as digital technology, sustainability, new ways of working, and the talent gap. Through interviews with R&D leaders in chemicals and adjacent sectors, the EY-Parthenon team identified strategic approaches, from adoption of emerging technologies to new ways of attracting and managing employees, that companies can take to evolve and maintain competitiveness in the changing environment.



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