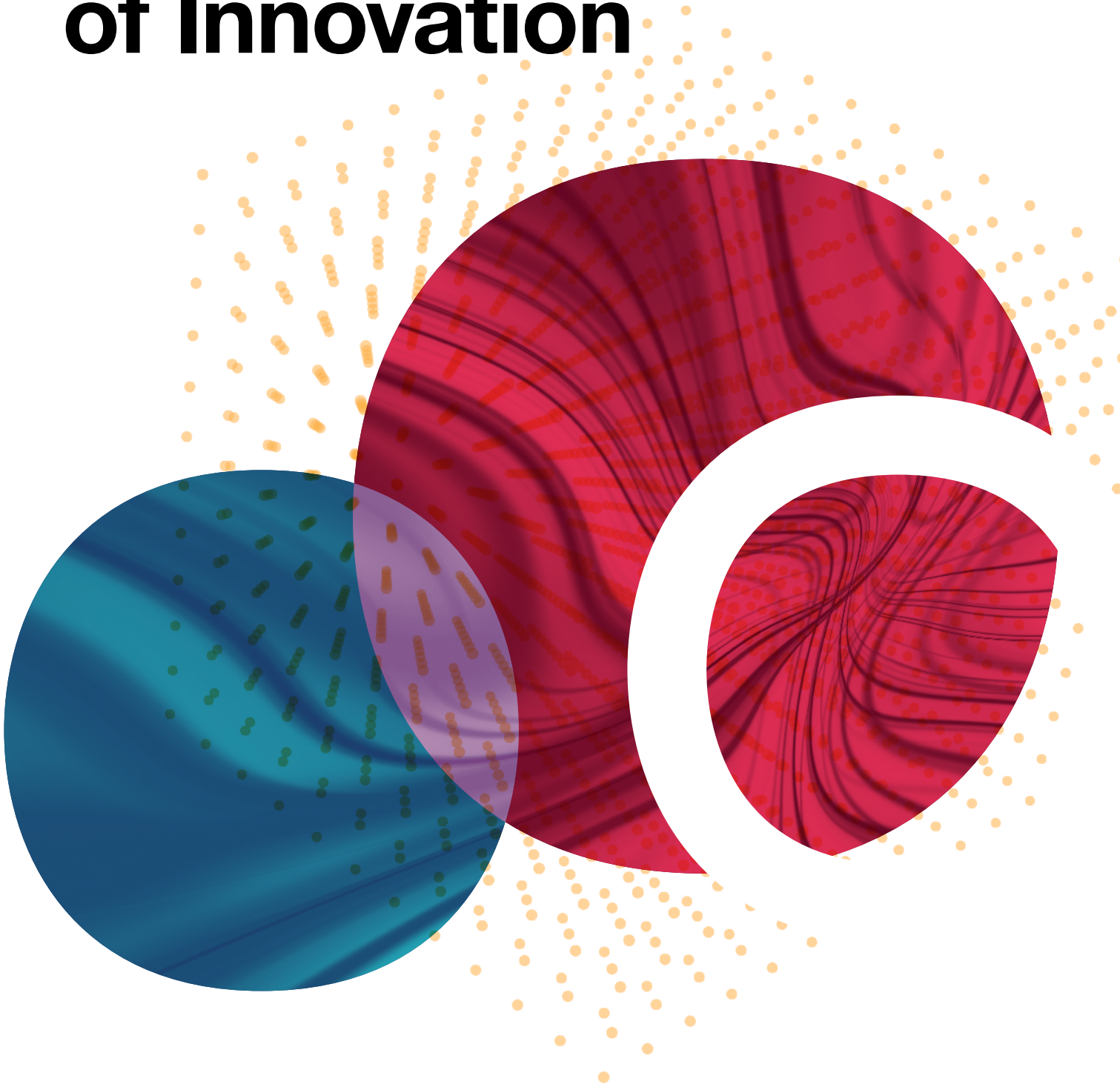
World Intellectual Property Report 2022
Executive Summary

The Direction of Innovation



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What economists define as the "direction of innovation" – the theme of this report – is the combination or sum of all the decisions individuals, firms, universities and governments make on which technological opportunities to pursue at any one time.

It is not only a question of how much economies invest in new ideas. The allocation of human and financial resources to different innovation activities can set the direction of innovation of communities, countries and even the world for decades to come.

The short-term direction of innovation and its implications are relatively easy to anticipate and coordinate. For example, to face the COVID-19 pandemic, governments and companies successfully redirected innovation investment towards the discovery, approval and mass-production of vaccines, achieving the objective in record time. Vaccines drastically reduced the number of deaths and helped the global economy to recover from the pandemic-provoked slump of 2020.

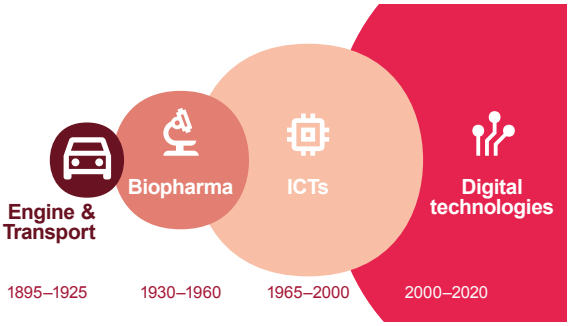
The long-term impact of the direction of innovation – in terms of both the returns or profits to companies and the benefits, or lack of them, to society – is less predictable. For example, it is difficult to predict which of the technological innovations limiting climate change will prove most effective.

Innovation has increased exponentially over the past 100 years, with very different technological catalysts

Over the last century, innovation decisions have cumulated in shifting technological trajectories. Technologies related to combustion engines, transport and other mechanical machines dominated the innovation landscape in the early decades of the past century. Biopharma technologies boomed thanks to pharmaceuticals in the 1930s and to biotechnologies since the 1990s. And in the final decades of the 20th century, there was a big shift towards information and communication technologies (ICTs) and semiconductors, which accounted for a quarter of all patents in the 30 years between 1990 and 2010. This increase in ICT patent share was mostly at the expense of "traditional," mechanical machine technologies.

Diverse technologies have driven innovation growth over the past 100 years

Figure 1 Top growing technological fields in patent filings, 1895-2020



Today, the direction of innovation is at a crossroads where promising new technologies are booming

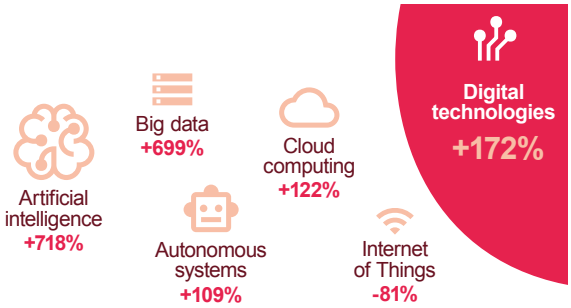
As we enter the third decade of the 21st century, new and powerful forces are driving the direction of innovation in fields such as science, technology and medicine.

Digitalization is changing the world. A wave of digitalized general-purpose technologies includes artificial intelligence (AI), predictive technologies, highly sophisticated automation and big data. Digital general-purpose technologies are transforming industries by bringing in new innovators, structures, practices and values. These technologies give rise to new industries, such as the Internet of Things.

Digitalization has the potential to spur economic growth, but risks exacerbating inequalities. AI, automation and other digital general-purpose technologies can spur economic growth when they generate innovation that complements and enhances human productivity. But they risk worsening economic inequality when innovation simply replaces people. They will make certain occupations obsolete and give rise to new ones that require different sets of skills. While they may create leapfrogging opportunities for some less-developed economies, others may miss out due to a lack of large capital investments and the high-skilled labor force necessary for these technologies to thrive.

Digital-related innovation has grown 172% faster than all patents in the past five years

Figure 2 Growth of technologies as percent of total patents average growth, 2016-2020



The COVID-19 vaccine success is an innovation model to build on. The COVID-19 pandemic generated and, in part, accelerated demand for new technologies to combat it. The COVID-19 crisis prompted responses to find solutions urgently from all actors in the innovation ecosystem – governments, the private sector, research institutions and universities, international communities, non-governmental organizations (NGOs), including philanthropic foundations.

The scale of the pandemic and the fact that it affected a large share of the global population created an important incentive for the private sector. In addition, several governments gave significant financial support to the private sector, including for clinical trials and for vaccine developers with promising vaccine candidates to build large-scale manufacturing capacity.

Moreover, the special emergency authorization and coordination efforts provided by relevant national and international government agencies allowed for a faster deployment of the vaccines worldwide.

The successful public–private collaboration in quickly identifying and developing COVID-19 vaccine candidates shows how policies can be useful in redirecting innovation efforts toward a common goal.

COVID-19 vaccine development has had an impact on medical research and practice. The success of the mRNA vaccine platform for COVID-19 has provided strong evidence that the technology works well and could have applications for other diseases. This could also signal the beginning a new golden era for vaccine development, similar to the one during the Second World War.

The COVID-19 crisis has also changed medical practice by accelerating the adoption of digital technologies. Many changes were already underway, but the pandemic highlighted the urgency to "go digital" and created opportunities to introduce operational improvements, such as virtual medical consultations.

But the fast deployment of COVID-19 vaccines and the wide adoption of underlying biotechnology tools are not without challenges in the short term. Creating and rolling out the vaccines using the new technology required a highly skilled labor force and well-equipped research labs. Moreover, the speed of COVID-19 vaccine development and medical trials came at the expense of delaying the approval of other medicines in the pipeline. In addition, the focus on vaccines and treatments to fight COVID-19 pandemic may hurt other lines of medical research for a number of years.

Societies' demands for innovation can change in the blink of an eye, especially when confronted by crises

Sometimes, large and unexpected systemic changes – such as new breakthrough technologies, epidemiological crises or wars – shake the preferences and priorities of the ecosystems' stakeholders. Governments and policymakers are usually called on to act in the face of priority-changing shocks.

For instance, as a direct result of the Second World War, the U.S. Government mobilized civilian science to address wartime needs by creating and funding public research organizations, for example, the U.S. National Institute of Health (NIH). More than seven decades later, many of the medical innovations developed during that period are now part of standard hospital practice.

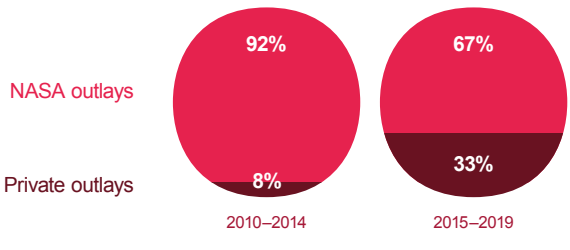
The Second World War created the demand for new technological solutions to problems such as treating wounded soldiers and reducing mortality rates. During the war, the U.S. Government allocated a large sum of money to its research and development (R&D) budget, almost 100 times what it had been investing in science in prior years. This concerted surge in public effort aided and supported the mass production of penicillin, the development of blood substitutes and the creation and production of vaccines, along with research on hormones and numerous other medical breakthroughs. This opened avenues for further research and medical improvements that reached far into the future. Penicillin research efforts were the precursor of antibiotics' development by pharmaceutical companies during the post-war decades.

Similarly, the Cold War led to an expansion in U.S. federally funded R&D into new domains, such as its mission to the Moon. In 1957, the Soviet Union became the first country to launch a satellite into low-Earth orbit. The U.S. responded in 1961 with a program to put a man on the Moon within a decade. Great political commitment, a large budget and scientific and engineering technical ability saw the goal achieved in October 1969.

By the end of the 20th century, U.S. "mission-oriented" R&D funding into space programs had led to the development of telecommunications satellite technologies and eventually fueled commercial involvement in space activities. Advanced industrial economies have become increasingly dependent on space systems for their information technology, remote sensing imagery, PNT (position, navigation and timing) data and other applications. A new space race between the U.S. and China may trigger innovative – and unpredictable – technologies in the decades to come.

Space innovation: government funding paved the way for new technologies and industries

Figure 3 Space funding by NASA and U.S. private investors, 2010–2019



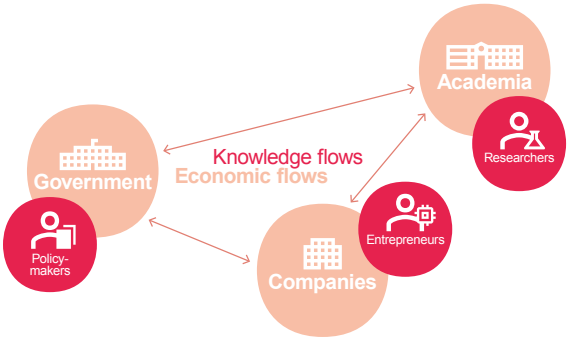
The direction of innovation is not decided single-handedly; it is the result of the dynamic interaction of multiple decisions by entrepreneurs, researchers, consumers and policy makers

The direction of innovation is constantly changing. It is influenced by the choices and interactions of public and private stakeholders looking to benefit from innovation. It is this innovation ecosystem that sets the direction of innovation. Curiosity guides researchers to explore new scientific fields and engineers to experiment with new technologies. Companies, entrepreneurs and governments alike identify innovation opportunities based on predictions of potential private and social returns.

Private stakeholders seize innovation opportunities more quickly when the expected returns are both foreseeable and easy to capture in monetary terms. They are also drawn to short-term innovation projects where the risks of failure are lower. But longer-term, riskier opportunities frequently hold the greatest potential for positive social returns.

Innovation ecosystems set the direction of innovation for decades to come

Figure 4 Conceptual summary of interactions between innovation ecosystem stakeholders



Governments must promote both the social and private returns of innovation. They often do this by centralizing activities and resources for innovations which affect the public good – goods or services freely available to all, such as national defense or pandemic prevention. They can also be the main source of demand for innovative technologies. Governments will design policies to influence the provision of public goods related to health, security or education.

Much of the direction of innovation is set by the knowledge gained by industries through their operating experience or their supply chains. Knowledge and innovation flows across fields and industries provide scientists, engineers and entrepreneurs with strong incentives to move to new fields and industries, applying the technologies they already master, rearranging the allocation of resources and ultimately affecting the direction of innovation.

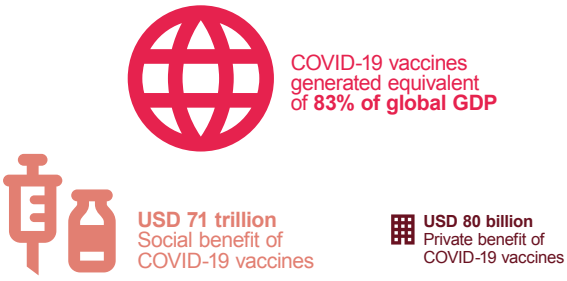
Public and private motivations to innovate are not necessarily aligned, but they can be leveraged for the common good

Social and private returns of technologies steer innovation. Innovations can have a transformative effect – for better or for worse – on the environment, public health, local communities, or on specific demographics, to name just a few examples. These are the social returns of innovation. If a technology is environmentally friendly, it will bring socioeconomic benefits to the wider community; conversely, a cheaper but more polluting new technology may have a negative socioeconomic impact.

The social returns of innovation can differ substantially from the private returns reaped by commercially-driven innovators, as manifested by the development of COVID-19 vaccines. Our research estimates that the social benefit of vaccine innovation amounts to USD 70.5 trillion globally, exceeding its private benefit by a factor of 887. This large social benefit reflects the value of saved lives, avoided health impairments and the lifting of lockdown measures, which far outweighs the revenues generated by vaccine manufacturers.

Public–private innovation is vital to leverage the common good

Figure 5 Estimates of social and private benefits of COVID-19 vaccine development



Innovation needs differ around the world

The ability of developing economies to either generate new technological solutions or absorb existing solutions in order to address their specific socioeconomic needs depends on their local innovation ecosystems and how connected they are to global innovation networks.

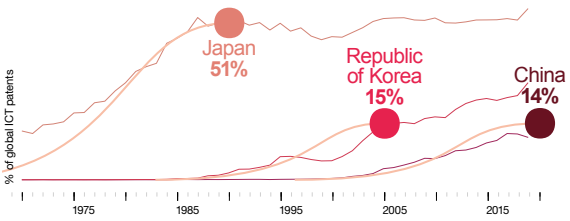
In some cases, usually those economies in the middle-income bracket, innovation ecosystems may unblock unprecedented innovative ability by leveraging scientific capacity, technological capital and skilled labor to narrow the technological gap between them and the most advanced economies.

In the case of the IT industry in East Asia, for example, Japan, the Republic of Korea and China managed to fully integrate into the global economy as core and active participants in international value chains. Their respective industrial policies facilitated their jump into cutting edge IT in just a few decades. The 1980s saw the East Asians enter the markets for PCs (personal computers), VCRs (videocassette recorders), audio cassette players and telecom equipment. In the 1990s came memory chips and wireless cell phones, and the 2000s brought various digital products, including digital TVs, wireless telecommunication systems and smart phones.

The development of all East Asian economies has common elements. These include economic catch-up, the fast technological progress of private firms and industries, and government policies to reduce the risks involved for firms in entering new industries.

New technological opportunities can spur economic development

Figure 6 Share of global ICT patent technologies, selected East Asian economies, 1970-2020



In other cases, market and non-market participants may have insufficient local innovative capacity either to identify, assimilate and learn from new technologies developed elsewhere, or else generate the innovations themselves. Low purchasing power may make it difficult to access global innovation to serve their needs. Basic infrastructure, such as roads, electricity or medical care, and important institutions, such as an effective financial sector, may be poor or non-existent, rendering some foreign technologies less suitable. Innovation may then need to be low-skilled, generally small in scale and targeted at specific communities or regions.

In all cases, the needs of the country come first, as innovation happens differently in different parts of the world. Innovation imported from abroad has to be usable in the importing country. Leapfrogging can only happen when this is taken into account. More importantly, innovation does not have to be cutting-edge to be socially valuable.

Technologies to address major challenges, such as climate change, are greatly needed

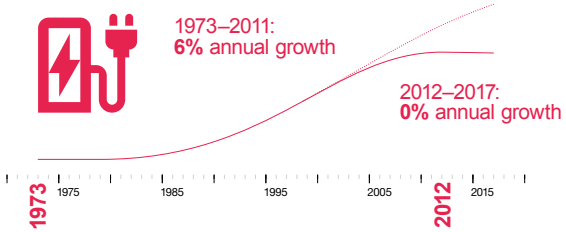
The future direction of innovation will depend on international and multilateral policies to address "grand challenges," such as access to education and health and climate-change mitigation.

The successful public–private collaboration in quickly identifying COVID-19 vaccine candidates shows how mission-oriented policies can be useful in generating important changes. Similar to the wartime efforts during the 1940s, these collaborations relied on existing science and technologies, proving that they work and ensuring the swift and large-scale production and deployment of vaccines.

Can "mission-oriented" policies be used to address the major and complex social, environmental and economic challenges that face the world? Policies based on centralized decision-making and the concentration of resources on one specific goal were very useful in the case of NASA's space program to reach the Moon and of COVID-19 vaccine development. But even mission-oriented policies may not be enough. Some observers see government policies as just one element of any solution, which will also require the efforts of all stakeholders of the innovation ecosystem, including consumers.

Clean technologies boomed after oil price shock, but it might not be enough...

Figure 7 Growth of global environmental related technologies, 1973-2017



Deepening commitments to sustainability at public, private and even consumer levels is changing how businesses conduct activities such as shifting to renewable energy or adopting climate-change mitigation technologies to reduce their carbon footprint. By using subsidies, regulations and standards to promote environmental technologies, governments are helping mitigate some of the risks and uncertainties associated

with investing in new, relatively untested alternative energy technologies.

Innovation in low-carbon emission technologies, especially in the energy sector, has grown in the first two decades of the 21st century and seen with a sharp increase in related patenting. This is also the case of enabling technologies, such as batteries, hydrogen and smart grids.

However, technologies that are at the early stages of development – basic or applied research stages – tend to be riskier and so require public funding to mitigate these risks. Carbon-removal technologies, for example, are expensive to build and maintain.

In addition, perception of the risks associated with global warming changes gradually. The incentive for private stakeholders to invest in developing clean technologies relies on such predicted demand.

Can policy help in shaping the direction of innovation?

Public policy can shape the direction of innovation in several ways:

Scientific and technological discovery-stimulating policies are most needed when innovation uncertainty and risk are greatest. For instance, governments use direct purchases regularly to assist the development of defense and aerospace technologies.

Risk-mitigating policies are likely to be most effective in the early phases of development after an initial discovery. R&D subsidies, soft loans and R&D tax incentives are typical risk-mitigating policy instruments.

Early-adoption policies aim not only at reducing innovation risk but also at increasing the number of companies using a given technology. Governments can step in to boost production of a given technology and by so doing ensure sufficient scale is achieved for it to be profitable.

Governments can also reduce risk or incentivize adoption indirectly by inducing consumption of goods and services containing a desired innovation. They can provide subsidies to producers to keep prices down or to consumers to encourage them to buy. They can influence adoption through publicly-funded education programs to cut the cost and increase the availability of skilled labor and to promote entrepreneurship in selected fields.

Regulation of digital technologies – including how access to data is governed – plays an important role in sustaining a competitive marketplace that promotes and rewards innovation. As digital technologies evolve at a fast pace, many governments around the world are currently considering adapting their regulatory toolbox.

The world's grand challenges – addressing climate change, reducing inequality, ensuring food security, preventing pandemics – are public goods, and the private sector on its own is unlikely to allocate enough innovation resources to resolve them. Nor can climate change be addressed by private and public-sector efforts within individual economies. It is only through a multi-stakeholder, internationally coordinated effort that we will be able to solve these global challenges.

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