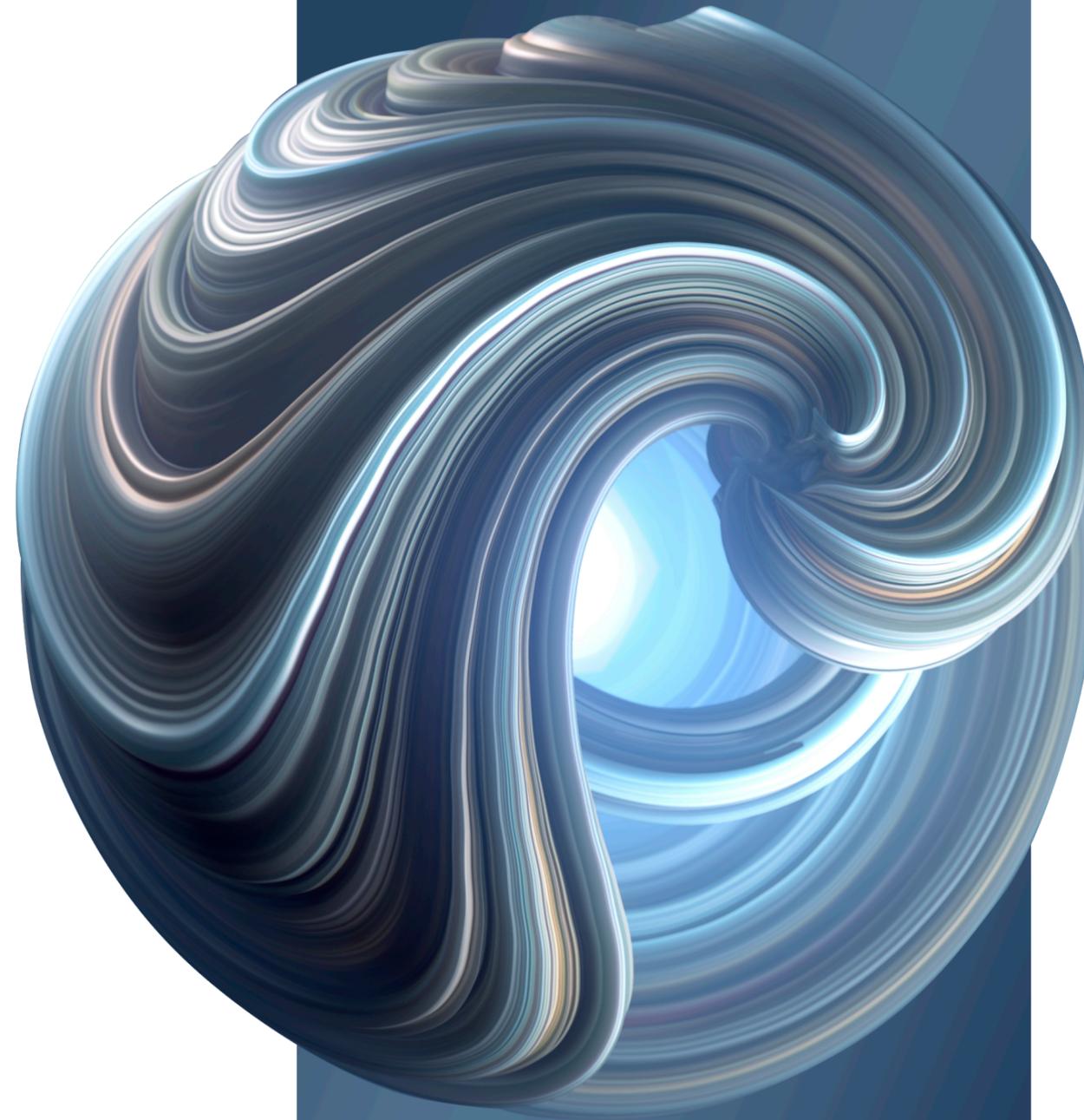




**Technology**  
in the **21st century**  
Innovation trends since 2000

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## Introduction: The global patent landscape

The Intellectual Property (IP) sector has time and again demonstrated its resilient and propitious nature, even under the harshest of circumstances. In 2021, around 3.4 million patent applications were filed worldwide, a 3.6% increase on the previous year. That is according to the [World Intellectual Property Indicators \(WIPI\) report](#), which tracks applications filed directly with national and regional offices as well as PCT applications. Such growth testifies to the continuing pace of innovation and the importance of the patent system despite global setbacks caused by the COVID-19 pandemic and consequent business disruption.

In this report, we look at what is driving this increase by analyzing trends in eight prominent technology sectors in the period 2000-2020: automotive, biotechnology, energy, entertainment, IT / communication, medical devices, pharmaceuticals and space exploration.

We have identified certain key terms for each sector and tracked their popularity in published patents using worldwide patent database statistics. Based on this snapshot of how specific technologies have developed over the past two decades, we look at what is propelling change and speculate about future developments. The data compiled by Dennemeyer is based on specially tailored searches of publicly available patent data.

According to the most recent WIPI report, the number of patent applications filed worldwide has soared from 1.87 million in 2007 to 3.4 million in 2021. Applications grew each year, except for 2009 and 2019, when slight declines occurred (3.8% and 3.0%, respectively). Though year-on-year percentages may appear relatively low, the cumulative result is a pronounced acceleration in patenting activity: It took 15 years for worldwide patent applications to double from approximately one million in 1995 to around two million in 2010, but only a further six years to surpass three million in 2016.

As the WIPI report makes clear, much of this expansion is fueled by Asia: The region accounted for 67.6% of global patent applications in 2021, compared to 54.6% just 10 years earlier. In the most recent year, China accounted for 69% of applications in the region, though significant growth was also recorded in the Republic of Korea, India and Singapore.

Our study sheds further light on these geographical trends, including in which sectors they are most apparent. We also look at some of the major national players in each category based on the number of patents granted and highlight some unexpected findings in the data. The evaluation seeks to identify not just developments in technology and innovation but also what the data tells us about patterns in commercialization, licensing and litigation.

## Methodology

### Data collection

The data in this report has been compiled by Dennemeyer. We started by identifying eight industry sectors that have seen notable innovation in the past 20 years: automotive, biotechnology, energy, entertainment, IT / communication, medical devices, pharmaceuticals and space exploration. Next, recommended keywords were generated using the PatBase "Thesaurus" tool, and from this compilation, the most relevant were selected. We then performed semantic searches using these keywords in patent applications filed between 2000 and 2020. In all, 23 distinct queries were run for each selected technology sector.

The results were sorted by year of application. For a more granular interpretation, we further inspected the output for the owners of each patent and patent family. (This is an imperfect exercise as applications are sometimes filed under the names of subsidiary companies or holding companies.)

Note that, as patent applications are typically published 18 months after filing, the years 2021 and 2022 have been largely omitted from the analysis due to insufficient data available at the time of writing.

### Analysis

In examining the broader trends since 2000, the data is based on applications rather than grants. This is the case because over longer stretches of time, grants can give a misleading impression of the interest within a specific technology, as many untracked factors may influence the granting process (e.g., payment requirements). Additionally, poor-quality and / or bad-faith applications are assumed to be a scarcity among the top filing companies on account of the legal expertise at their disposal and the fact that such actions would only be detrimental to their patenting strategies.

By concentrating on trends between 2000 and 2020, we aim to unearth and explain longer-term movements in patent and innovation cycles in the eight sectors mentioned. While these do not cover every field of business, they shed light on some of the most dynamic and impactful areas of the world economy and the technologies that will likely steer the course of the next few years.

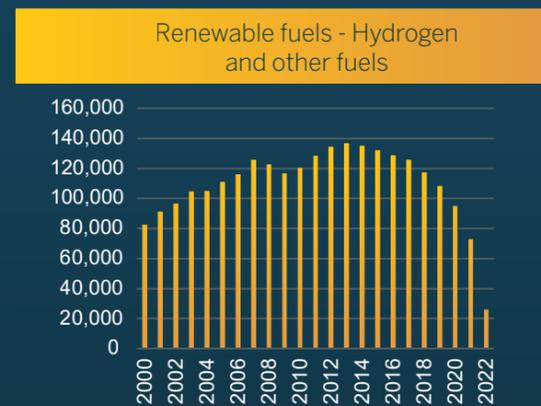
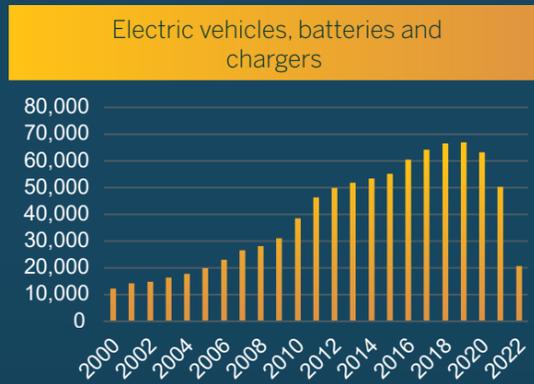
Tracking granted patents comes into its own in a narrower inspection of more recent trends. However, examining the top patent filing and holding companies over each year of the period would yield little benefit for our assessment. While such information befits a study of corporate history, the surfeit of data here would only cloud the picture of directed patenting activity. As such, when we speak about individual companies, the data pertains to patents granted between 2017 and 2022. This is to ensure the analysis remains pertinent to developing, ongoing and maturing innovation trends.



# Automotive

**The automotive industry** is going through a revolution. New means of propulsion, notably electric and hydrogen power, are set to replace petrol and diesel as the standards. This is the most significant change to transportation in the last 100 years, but it is not the only one. New technologies are being developed for all aspects of the automotive experience, from safety to entertainment, remote monitoring and even autonomous driving.

The investment in electric vehicles is evident from Dennemeyer's collected patent data, with the number of applications increasing every year from 12,235 in the year 2000 to 66,978 in 2019. The number fell slightly to 63,158 in 2020 – perhaps an indication that the technology is maturing and that innovation is already reaching the market.



Top 10 patent holders - Electric vehicles, batteries and chargers			
Assignee	Families	Applications	Grants
Ford Global Tech LLC	779	2303	740
Toyota Motor Co. Ltd.	777	1869	657
Hyundai Motor Co. Ltd.	973	2242	521
KIA Motors Corp.	753	1643	462
Apple Inc.	85	576	335
BYD Co. Ltd.	567	1076	291
Honda Motor Co. Ltd.	528	1326	277
Nissan Motor	556	820	270
Porsche AG	312	675	196
Jaguar Land Rover Ltd.	104	410	179

Top 10 patent holders - Renewable fuels - Hydrogen and other fuels			
Assignee	Families	Applications	Grants
Toyota Motor Co. Ltd.	1633	4268	1706
Ford Global Tech LLC	1260	3893	1541
Hyundai Motor Co. Ltd.	1720	4111	986
GEN Electric	742	2483	984
KIA Motors Corp.	1367	3138	883
Honda Motor Co. Ltd.	1185	2860	671
Nissan Motor	398	1164	439
Boeing Co.	262	953	423
Bosch GmbH Robert	2745	5249	387
Weichai Power Co. Ltd.	977	1050	385

Top 10 patent holders - Self-driving technology			
Assignee	Families	Applications	Grants
Google Inc.	1367	3138	883
Waymo LLC	30	389	143
Ehuri Corp.	1	19	14
Okeeffe James Thomas	1		14
Ordos CityPudu Tech Co. Ltd.	14	14	13
Obshchestvo S Ogranichennoy Otvetstvennostyu Yandeks Bepilotnye Tekh	9	9	9
Huai Xiaoning	1	12	8
Metarail Inc.	1	12	8
Clements Sigmund Lindsay	1	8	8
Nanjing Shilaier Automobile Electronic Co. Ltd.	8	8	7

These findings are consistent with other reports on electric vehicle technology, such as that published jointly by the [European Patent Office \(EPO\)](#) and [International Energy Agency \(IEA\)](#) in September 2020. One of the major findings of this study was that patenting activity in electricity storage had grown at an annual rate of 14% from 2005 to 2018, a pace "four times faster than the average of all technology fields."

Unsurprisingly, this surge in development was driven by advances in rechargeable lithium-ion batteries such as those used in electric vehicles.

Compared to electric vehicles, research in hydrogen fuel technology has progressed in fits and starts.

A recent report by the [World Intellectual Property Organization \(WIPO\)](#) on hydrogen fuel cells identified three waves of research and development: one in the mid-1980s, another around 2005 and a current period, beginning around 2016.

According to the Dennemeyer data, applications for hydrogen and other renewable fuels and fuel cells increased each year from 2000, peaking at 124,892 in 2007. The numbers then dropped in 2008 and 2009 before another period of growth from 2010 to 2013, when there was a new peak of 136,254 applications. However, it has fallen each year steadily since then, and in 2020 there were just 94,218 applications.

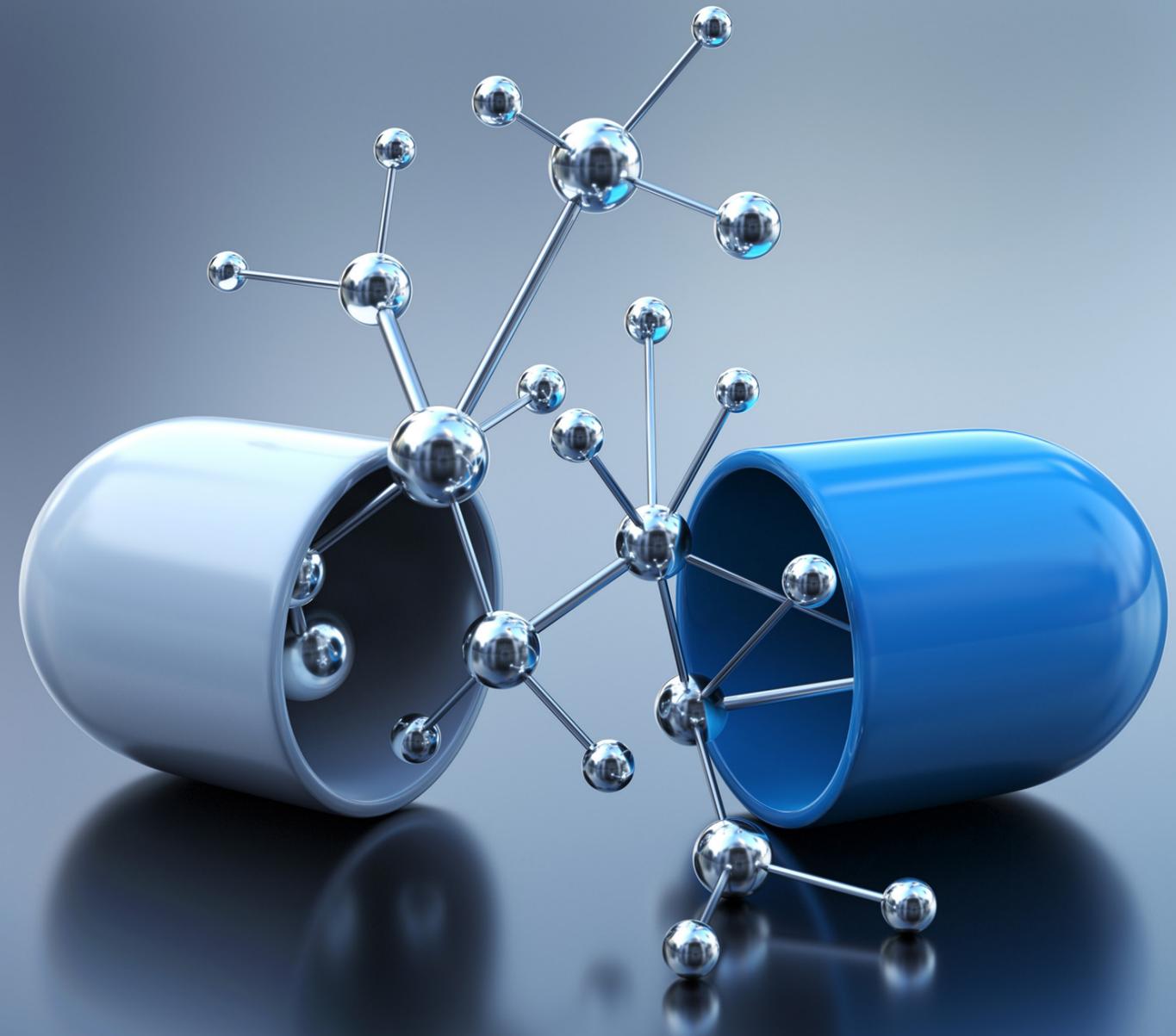
Given the renewed focus on environmental concerns and the need for alternative means of energy generation that overcome the shortcomings of battery-powered vehicles, it is likely that we will see evidence of the third phase of hydrogen research over the next few years. Generating electricity via onboard hydrogen power cells holds advantages over storage options where the latter would be prohibitively large or heavy, as in the cases of aviation and marine transport.



Of course, patents are only one weapon in researchers' armory, and this is one sector where other IP rights are likely to play an important role. For example, design rights protect the shape of vehicles and other characteristics, including potential features that make them more environmentally friendly. In the EU, [several changes to the rules](#) governing industrial design rights have recently been proposed. If accepted, these would have substantial implications for automotive companies, particularly regarding the availability of spare parts.

Another emerging field, though one that is yet to deliver on its potential, is self-driving technology. Here, the total number of patent applications captured in the Denemeyer data is relatively small – though it has grown spectacularly from just a handful to over 500 each year since 2016. While this jump likely reflects the investment in this area from a wide range of companies, it may be that the number of patent applications does not fully illustrate all the innovation that is taking place. Many improvements may be protected in other, less immediately discernable ways (for example, as patents for sensors or image processing), as trade secrets or as open-source software.

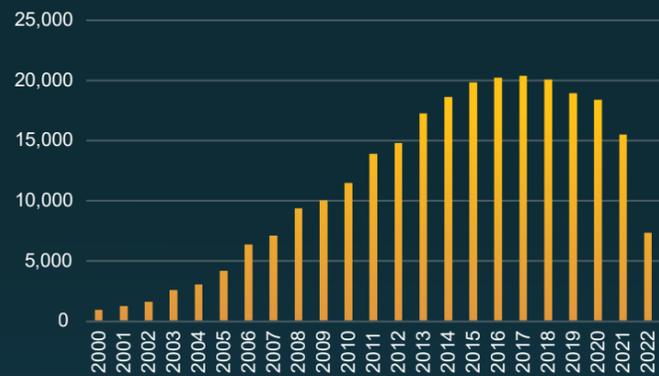
A further observation is the names that appear among holders of patent families for self-driving technology. The leading companies for electric vehicles and renewable fuels are nearly all established automotive companies such as Ford, Hyundai, Toyota, KIA and Honda. (Aerospace giant Boeing and the multi-sector Bosch also feature prominently.) By contrast, the leading patentees in self-driving technology are either new entrants or technology corporations, the top five companies being Google, Waymo, Eturi Corp., Ordos City PUDU Tech Co. and Yandex.



# Pharmaceuticals

The pharmaceutical industry is indicating a shift toward the development of complex, better-targeted drugs using genetic marking and so-called "big data." This is evident in the focus on precision medicine (sometimes called personalized medicine) and the use of platform technologies in diagnostics. These methods of collating and interpreting massive amounts of clinical data often involve various forms of artificial intelligence (AI), such as deep learning.

### Precision (personalized) medicine



### Platform technologies, e.g., for diagnostics



### Pharmaceuticals

The number of annual applications relating to personalized medicine grew over **2,000%** from just **899 in 2000** to **20,312 in 2017**

Court decisions may affect diagnostic patents more acutely than most other specialisms.

### Top 10 patent holders - Platform technologies, e.g., for diagnostics

Assignee	Families	Applications	Grants
Bayer AG	3	103	64
Canon Inc.	25	77	45
Philips Koninkll NV	25	140	44
Novartis AG	2	80	35
Angioadvancements LLC	1	56	35
Seqirus UK Ltd.	2	50	31
Google Inc.	7	59	30
Samsung Electronics Co. Ltd.	7	39	30
Natera Inc.	5	78	28
Chinese Univ. of Hong Kong	4	88	28

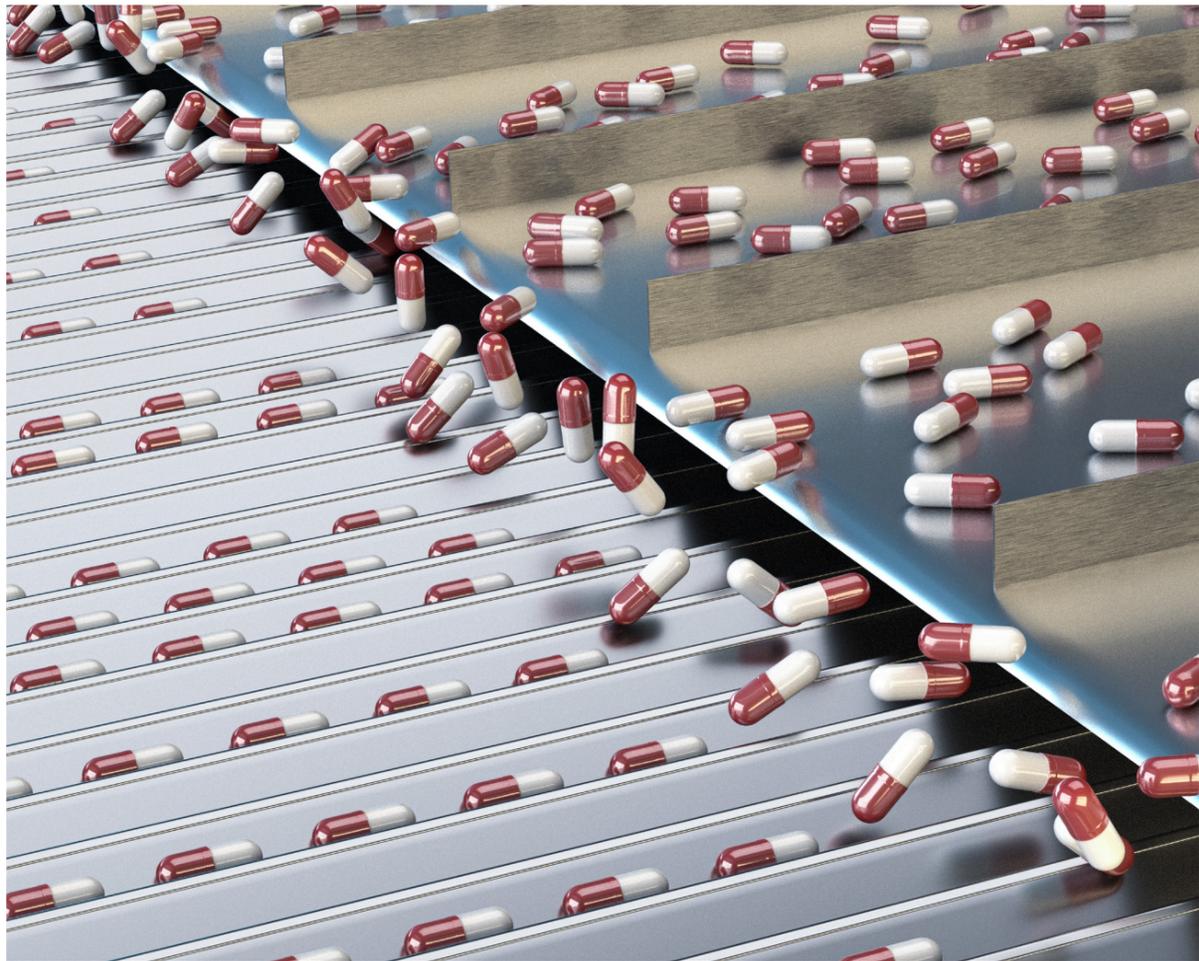
### Top 10 patent holders - Precision (personalized) medicine

Assignee	Families	Applications	Grants
Hoffmann La Roche	159	743	135
Univ. California	121	485	131
Regeneron Pharma	6	258	114
Celgene Corp.	19	287	97
Ventana Med Syst Inc.	50	286	93
Critical Care Diagnostics Inc.	6	159	92
Novartis AG	23	283	80
Astute Medical Inc.	26	287	76
Biomarin Pharm Inc.	4	121	68
Genentech Inc.	39	453	66

The growth in patent applications relating to personalized medicine was extraordinary in the first 15 years of this century, according to Dennemeyer's research. Filings increased yearly from 2000 to 2017 before falling back slightly. To demonstrate how dramatic this upswell was, the number of annual applications grew over 2,000% from just 899 in 2000 to 20,312 in 2017.

The transition in platform technologies (such as diagnostics) is not as pronounced, perhaps because these tools are harder to identify and track. There were 1,818 applications in 2000, hitting a high-water mark of 3,954 in 2014. Though annual numbers do not display any marked long-term patterns, they have consistently held above 2,500 since 2002.

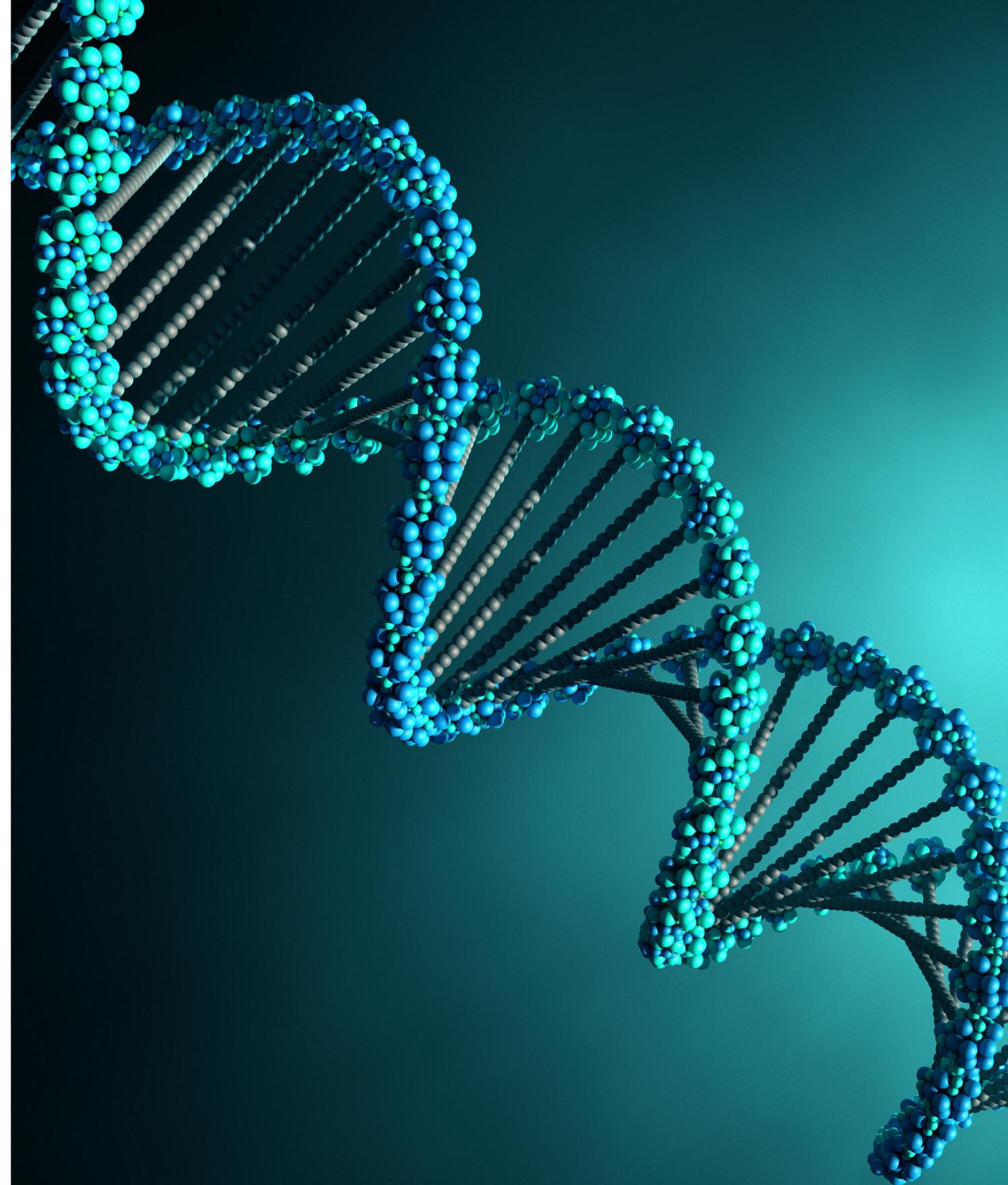




Applications for such technologies may also be more acutely affected by court decisions than most other specialisms. In the United States, for example, diagnostic patents were addressed by the U.S. Supreme Court judgments in the *Bilski* (2010), *Mayo v Prometheus* (2012) and *Myriad* (2013) cases. The last was also the subject of a High Court of Australia judgment in 2015. Though the disputed diagnostic and process claims in each of the named cases were deemed patent ineligible, it is worth noting that applicants in the pharmaceutical field have the sophistication and resources to adapt their filing strategies in response to these and similar decisions.

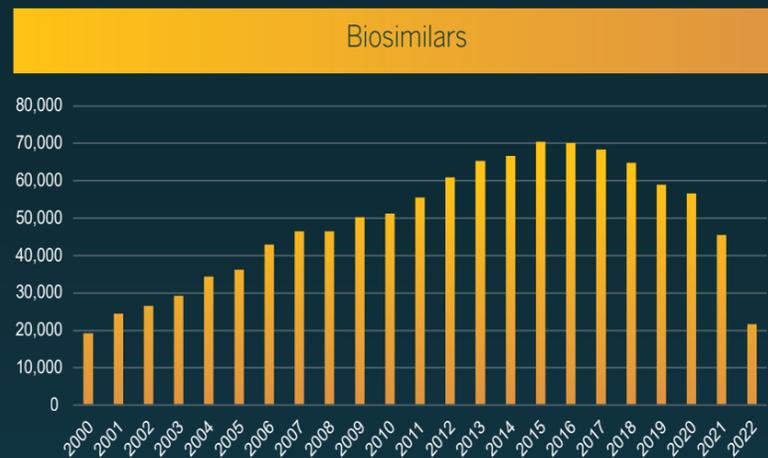
Regarding granted patents for platform technologies, it is unsurprising that leading pharmaceutical company Bayer tops the rankings, with competitor Novartis also making a strong showing. In addition to these traditional players in the healthcare field, electronics manufacturers Canon and Philips are very active, neatly encapsulating the crossover of medicine and digital technology.

Another trend likely to be transformative in the next few years is the use of AI in pharmaceutical research. In future reports, it will be curious to see whether this becomes evident in patent applications or if organizations will rely on other forms of IP, such as copyrights and trade secrets, to protect this investment.



# Biotechnology

**Biological medicines**, or those whose active substances are derived from biological sources, e.g., insulin products, are the cornerstone of various treatments. Hence, the emergence of a class of biological medicines referred to as "biosimilars" was probably the biggest trend in biotechnology in the first part of the 21st century. These products are highly similar to other biological medicines already approved and sold – the so-called "reference medicine" – and are permissible after the patent and other market protections for the original have expired.



With several blockbuster biologicals coming off patent in the 2010s, the market for biosimilars grew significantly: McKinsey *estimated* the market grew 56% a year between 2015 and 2020 when it reached \$15 billion USD. It is projected to reach \$30 billion USD by 2025 and then double to \$60 billion USD by 2030.

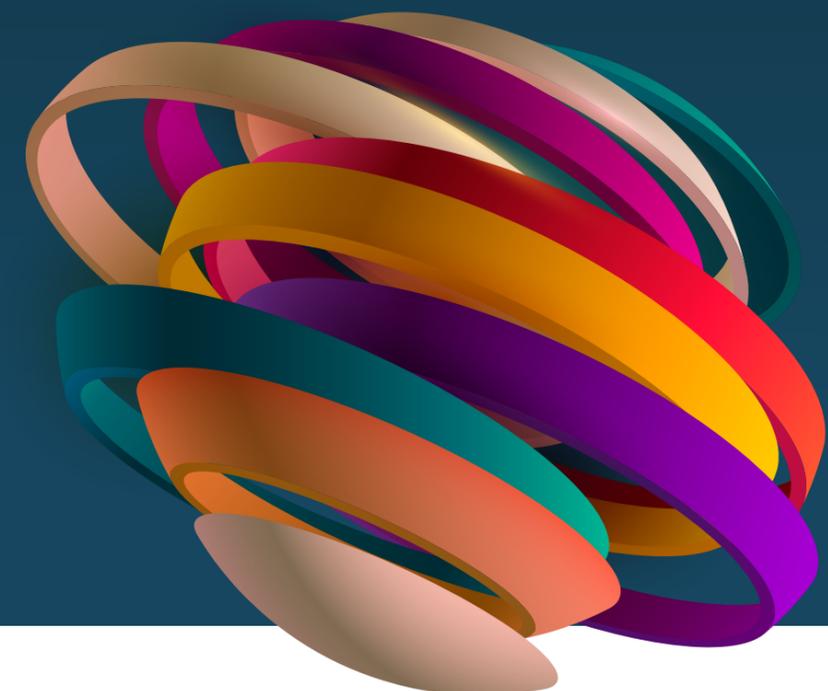
Top 10 patent holders - Biosimilars			
Assignee	Families	Applications	Grants
Novartis AG	303	7477	3065
Genetech Inc.	182	3691	1265
Immatics Biotechnologies GmbH	54	3002	1182
Hoffmann LA Roche	160	1792	578
Regeneron Pharma	56	1153	365
Abbvie Inc.	56	1148	350
Pfizer	36	756	324
Univ. Pennsylvania	47	745	314
Amgen Inc.	75	858	306
Squibb Bristol Myers Co.	42	679	282

## Biotechnology

Biosimilars were probably the biggest trend in biotechnology in the first part of the 21st century.

The first marketing authorization for a biosimilar in Europe was granted in 2006, and the first in the United States occurred nine years later. Given the amount of money involved, it is not surprising that there has also been extensive (and expensive) litigation over biosimilars, notably regarding the recently concluded patent protection for AbbVie's drug Humira, an antibody used to treat a number of conditions, including psoriasis and arthritis.

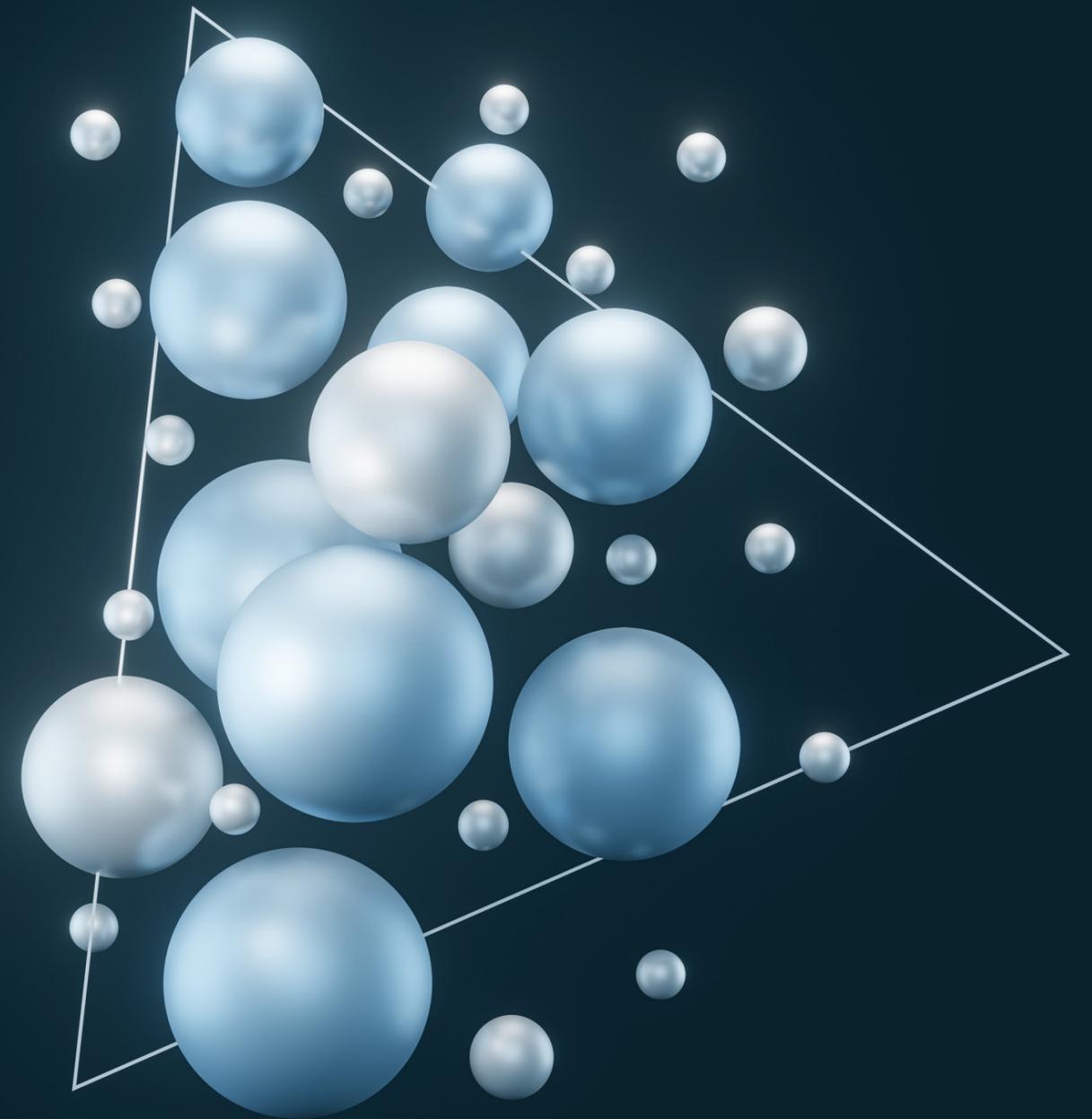
The Denemeyer data shows that patent applications regarding biosimilars increased steadily from 18,932 in 2000 to 70,096 in 2015 – before declining slightly in the following five years. This might suggest that critical research was conducted in the early part of the century, and excitement has now scaled back. Patents in the biotech field, as in pharmaceuticals, are vital to protecting valuable products and can also be extended in some instances – so even if the number of filings has declined in recent years, they are likely to remain important until well into the 2030s.





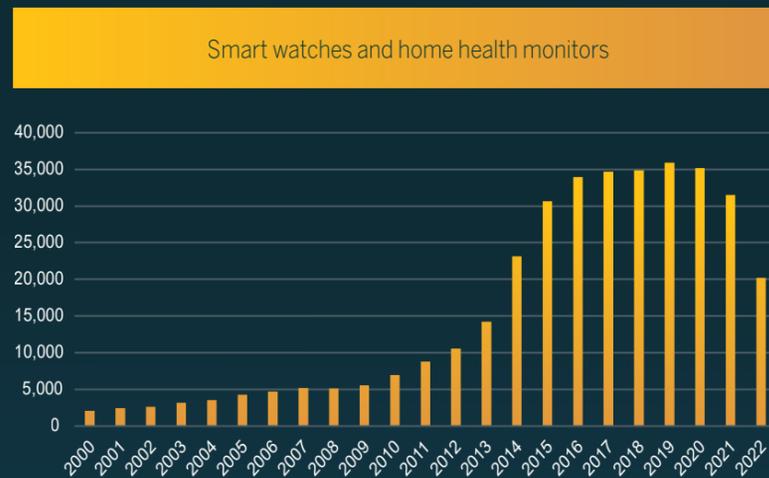
The most extensive portfolio in this area belongs to Novartis (3,065 granted patents), followed by Genentech, Immatics Biotechnologies, Hoffman-La Roche and Regeneron Pharmaceuticals. Unlike other fields of technology discussed in this report, the leading patent owners are nearly all U.S. or European entities: This is a notable area where Chinese innovation has not yet impacted the data.

Biotech continues to be an exceptionally innovative sector, with daily announcements about new applications in human health, agriculture and other areas. With the potential of technologies such as CRISPR-cas9 genome editing and CAR T-cell therapy beginning to emerge, it will be interesting to see what trends take hold over the next few years.



# Medical devices / equipment

At the moment, one of the standout fields of innovation concerns devices such as **smart watches, home health monitors and personal fitness trackers**. Our research highlights the pace of invention in this area: Patent applications in this category increased almost every year from 2000 (2,170 applications) to 2019 (36,011 applications). Though there was a slight decline in 2020, applications for these technologies have consistently been over 30,000 applications since 2015.



As in other technology areas, the upward trend slipped in 2008, when R&D spending was cut and consumer demand dipped due to the financial crisis.

Top 10 patent holders - Smart watches and home health monitors

Assignee	Families	Applications	Grants
Apple Inc.	365	3496	2671
Samsung Electronics Co. Ltd.	475	2510	1223
Huawei Technologies Co. Ltd.	512	1525	866
Google Inc.	244	1223	631
Beijing Baidu Network Information Technology Co. Ltd.	569	579	579
Qualcomm Inc.	352	1860	552
Fitbit Inc.	66	532	444
Guangdong Oppo Mobile Telecommunications Corp. Ltd.	94	749	429
Beijing Xiaomi Mobile Software Co. Ltd.	295	478	399
Guangdong Xiaotiancai Technology Co. Ltd.	623	665	359

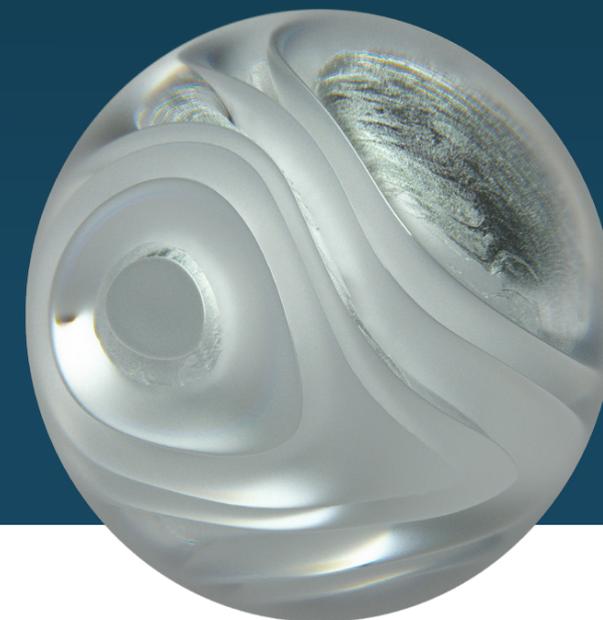
## Medical devices / equipment

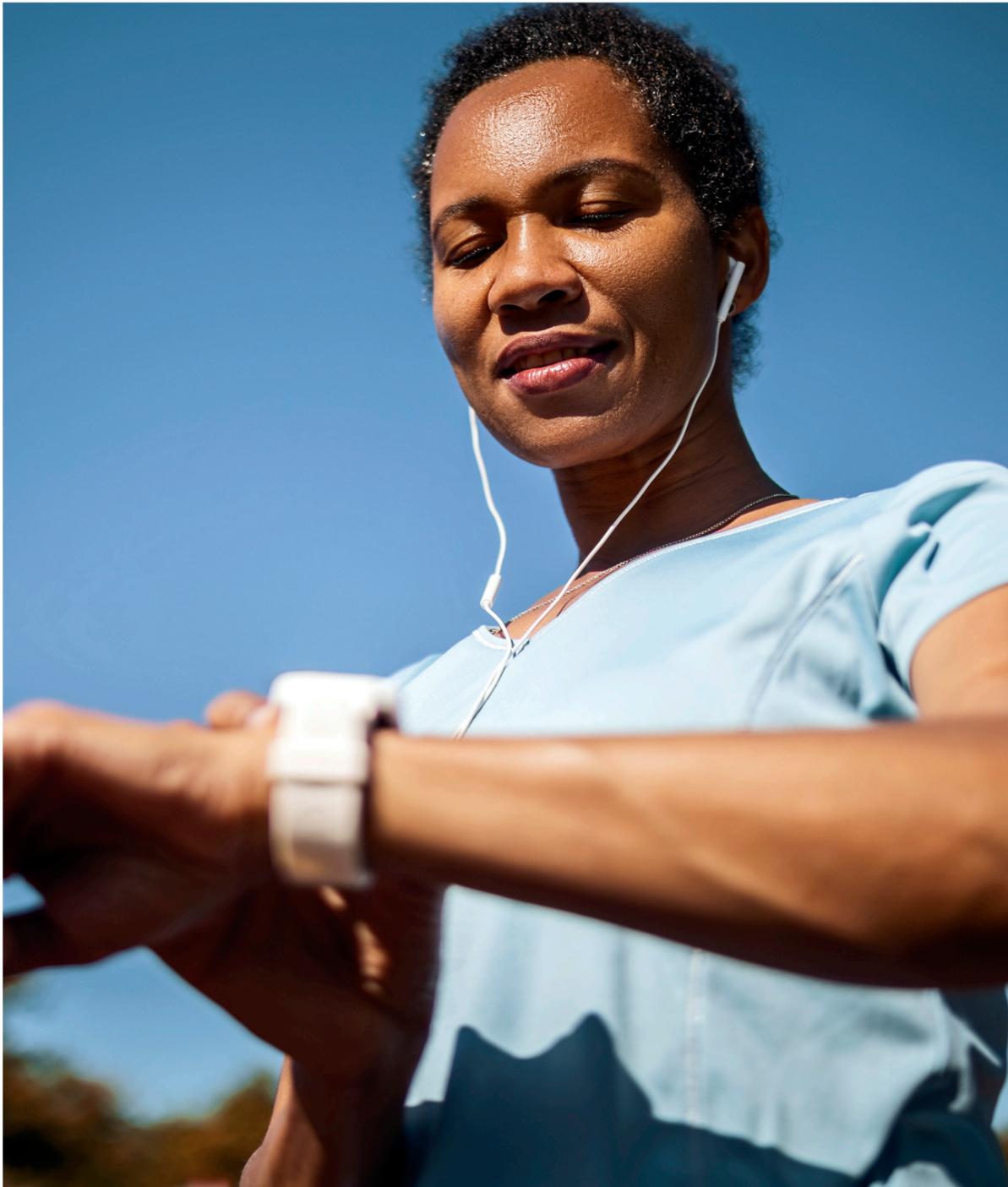
In recent years, tech companies have invested heavily in developing smart watches and amassing a formidable portfolio of patents. While this can be seen as a sign of progress for the industry, it has also raised serious questions about personal data protection and national security.

While the growth of this sector is undeniable, there has been much speculation about which companies will rise to the top: Will it be healthcare / medical device developers or electronics companies? Our research suggests the latter: Apple leads the way with 2,671 patent grants, followed by Samsung Electronics (1,223), Huawei Technologies (866) and Google (631).

All the remaining organizations in the top 10 are based in China except for Fitbit, a consumer electronics and fitness company, and Qualcomm, which are headquartered in the United States.

With an aging world population and the attendant pressures on health systems, an increase in the use of remote health monitoring is widely anticipated. One report by [Grand View Research](#) predicts that the global wearable medical device market will grow by 28.1% annually between 2022 and 2030. One of the effects of the COVID-19 pandemic was a greater awareness of health data and the value of tracking such information among the ill and the apparently well. Apps already help people monitor fitness, fertility and other data – and there is scope for them to do much more.





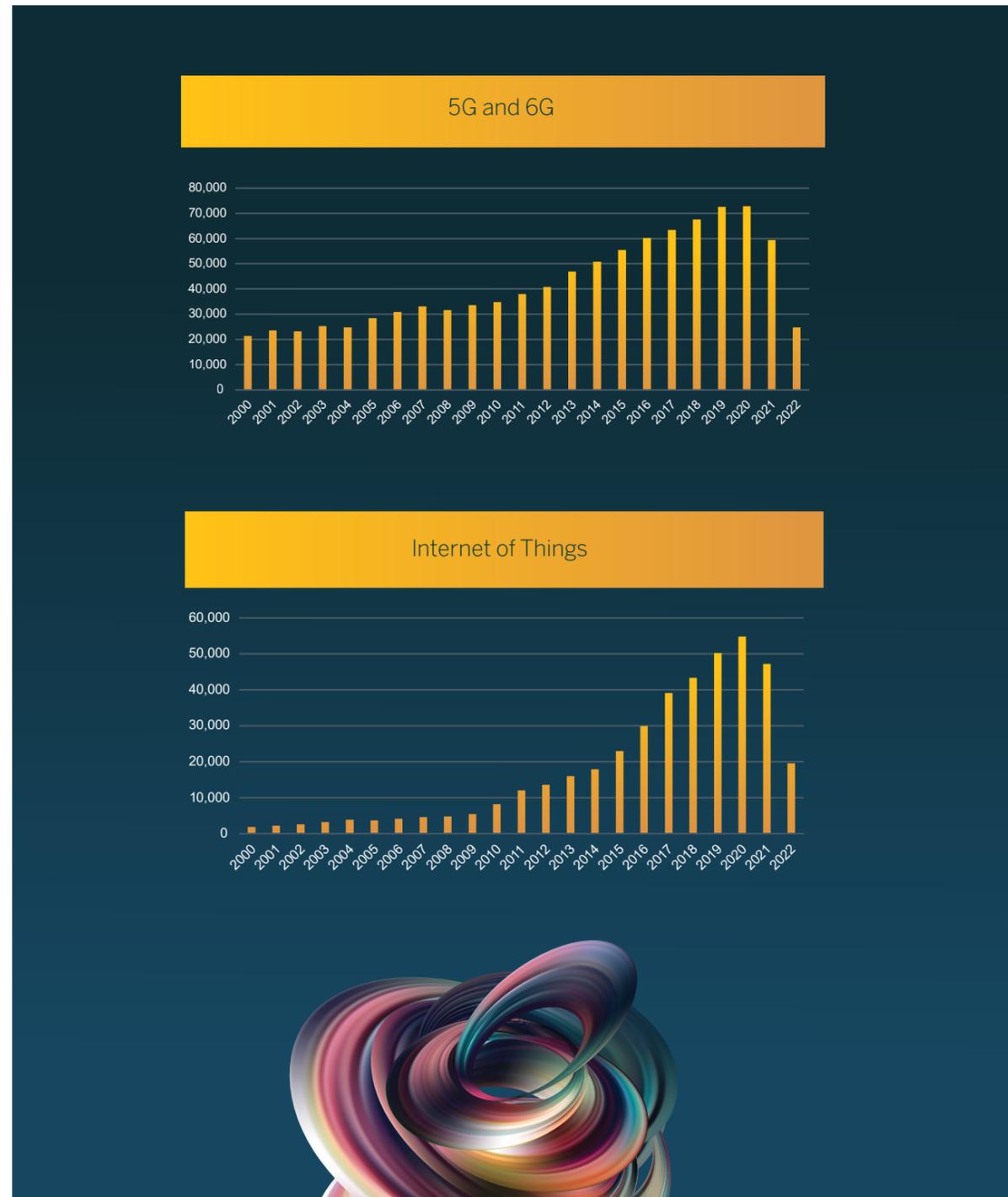
However, this is also a highly regulated area. Healthcare companies are familiar with such considerations, but tech companies tend to operate in disruptive environments. As it is the latter group that holds many of the patents in this field and given that there are also serious concerns about personal information and national security with foreign data controllers, there are still many IP questions to address for this technology to fulfill its potential.



# IT / Communication technology

The enormous progress made in **communications technologies** over the past two decades is reflected clearly in the patent application data.

Patent applications relating to 5G (rolled out in 2019) and 6G (yet to be standardized) more than tripled from 21,447 in 2000 to 73,007 in 2020. However, the overall growth during the two decades disguises a few dips, notably in 2008 when applications fell 4.15% (they grew the following year again). This may reflect the impact of the global financial crisis and resulting investment uncertainty on R&D spending.



Top 10 patent holders - 5G and 6G			
Assignee	Families	Applications	Grants
Samsung Electronics Co. Ltd.	2867	11520	2347
AT&T Intellectual Property	336	897	484
Ericsson Telefon AB LM	398	1448	389
Qualcomm Inc.	494	1745	380
Huawei Tech Co. Ltd.	628	2249	344
LG Electronics Inc.	859	1824	327
Guangdong Oppo Mobile Telecommunications Corp. Ltd.	286	1213	259
BASF SE	74	681	231
Apple Inc.	345	821	205
T Mobile USA Inc.	209	408	164

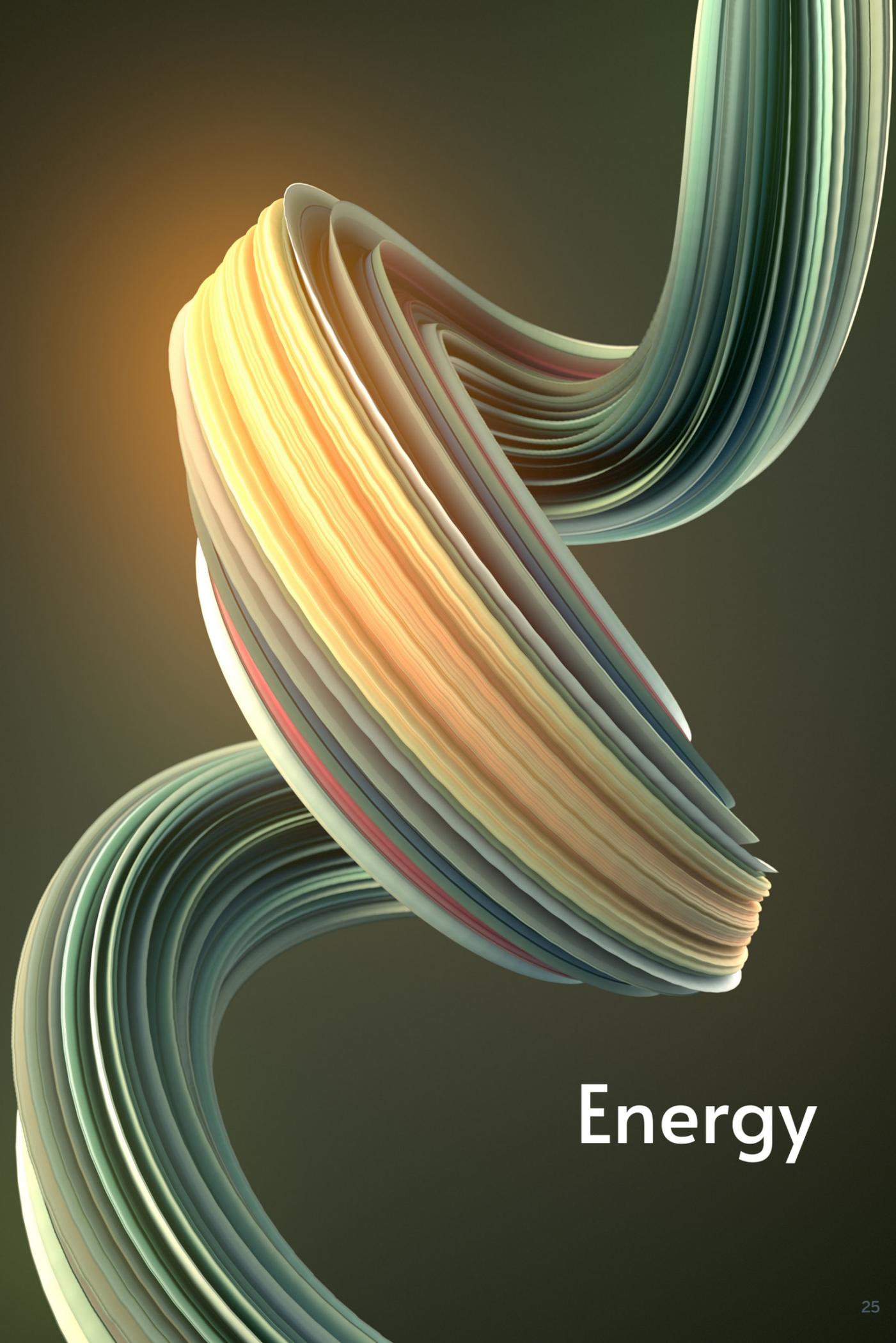
Top 10 patent holders - Internet of Things			
Assignee	Families	Applications	Grants
Samsung Electronics Co. Ltd.	1901	8203	1749
IBM	1091	1876	1211
Qualcomm Inc.	374	1614	435
Microsoft Technology Licensing LLC	327	1108	397
Ericsson Telefon AB LM	333	1182	360
Intel Corp.	321	1093	360
LG Electronics Inc.	275	810	240
Huawei Tech Co. Ltd.	481	1524	234
Amazon Tech Inc.	108	327	190
AT&T Intellectual Property	127	235	167

Applications relating to the Internet of Things have grown even faster, from just 1,653 in 2000 to 54,546 in 2020 – an increase of almost 3,200%. There was double-digit growth almost every year during this period. Only the year 2005 saw a slight decline (-5.11%). The most impressive growth came in 2010 (up 51.65%) and 2011 (up 49.27%), with another boom in 2015-17.

Though IT / communications is another of the fields in which the predominance of Asian patent holders is striking, actors in the United States still display robust innovation strategies. Samsung received by far the most patent grants for 5G and 6G technologies, with 2,347. Telecommunications companies AT&T and Ericsson are second and third, receiving 484 and 389. The Internet of Things presents a similar story: Samsung again tops the list (1,749 grants). IBM, Qualcomm and Microsoft follow, with Amazon Tech making an interesting appearance in ninth place.



Despite much hype, technologies incorporating the Internet of Things have yet to become commonplace – perhaps because the take-up of 5G devices has been slower than expected. Nevertheless, progress is being made, and the significant litigation surrounding the topic, especially over standard essential patents and FRAND licensing, indicates the crucial role patents will play. The difficult questions for courts to resolve include jurisdiction (anti-suit injunctions), evidence (the role of comparable licenses) and appropriate remedies (should injunctions be granted?). The issue of anti-suit injunctions is currently the subject of a [World Trade Organization \(WTO\) complaint](#) filed by the EU against China.



# Energy

Patent applications for **renewable energy** closely track investment in solar, wind and hydroelectric power, which has fluctuated significantly during the 21st century. There appear to be three main phases of development over the past 20+ years.

As might be expected, the search for alternatives to hydrocarbons impelled the first period of substantial growth in patent applications. There was double-digit growth almost every year from 2001 to 2011, when there were 89,731 applications. In 2008, the number of applications increased by over 30%.

Renewable energy generation - Solar, wind, hydro



However, the growth rate stalled in 2012, and the number of applications declined in 2013 and 2014. This was followed by a brief and smaller resurgence, which lasted from 2015 (the year of the Paris Agreement) to 2017. The comparatively slow growth perhaps reflects the gradual maturation of the industry.

Top 10 patent holders - Renewable energy generation - Solar, wind, hydro

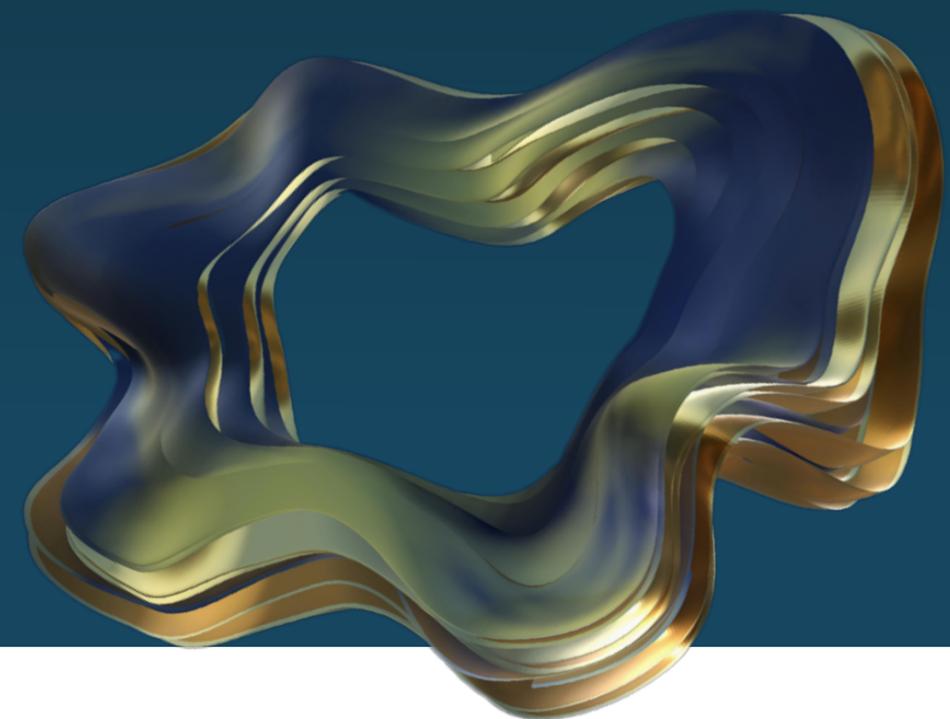
Assignee	Families	Applications	Grants
Vestas Wind SYS AS	906	2660	875
General Electric	616	1996	752
State Grid Corp. China	2696	2758	630
Wobben Properties GmbH	435	2692	596
Siemens Gamesa Renewable Energy AS	722	2213	562
Sunpower Corp.	169	1184	499
LG Electronics Inc.	374	1329	364
Power Huadong Engineering Corp Ltd.	529	560	313
Beijing Hanergy Photovoltaic Invest Co. Ltd.	402	422	313
Beijing Boyang Dingrong PV Tech Co. Ltd.	500	519	310

## Energy

Companies from China, the United States and Europe dominate patent ownership for renewable energy.

There was a slight fall over the next two years before 2020 marked the beginning of a third rise, with 88,197 applications. This is likely to continue during the 2020s, given the passage of the Inflation Reduction Act in the United States, the implementation of the [European Green Deal](#) and many other measures to promote sustainability worldwide: Preliminary data from 2021 suggests a further slight increase is likely.

Energy companies from China and Europe dominate patent grants in these areas, but as is often the case, North America cannot be discounted. Vestas Wind Systems in Denmark received 875, followed by General Electric in the United States (752) and China's State Grid Corp. (630).





This will be one of the most exciting areas to watch over the next few years, given the critical importance of sustainable energy and the key role that innovation has to play in helping to deliver net zero carbon emissions. Technologies of this kind have the potential to transform industries, including transport, agriculture and manufacturing. Still, careful licensing solutions will be required to ensure the dissemination of IP-protected technologies, especially in emerging markets, and balance compensation for researchers with fair access. Alongside patents, other incentives, such as the [Earthshot Prize](#), may also have a role to play.

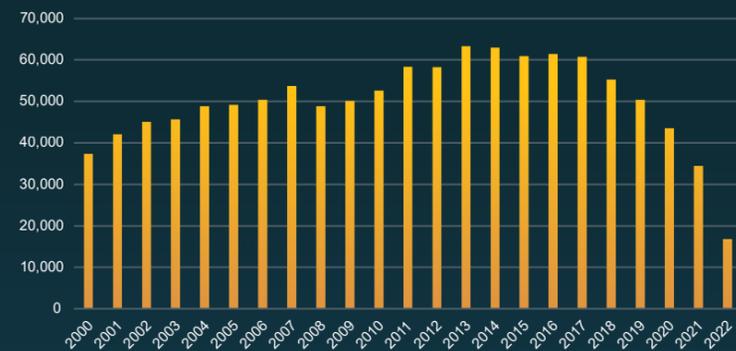


# Entertainment

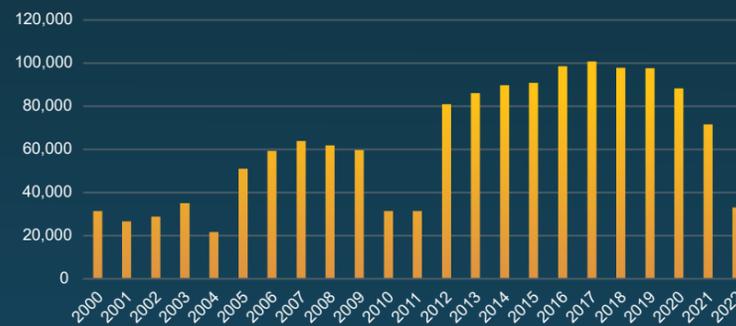
**Non-fungible tokens (NFTs) and the Metaverse** have only recently entered the public consciousness, thanks to some high-profile adopters and significant media coverage. But the data suggests that companies have been building patent portfolios in these areas for a long time.

As far back as 2000, there were 37,323 applications with terms relevant to NFTs and the Metaverse. The number increased each year to 2007, when it reached 53,680. Filings peaked at 63,211 in 2013 before beginning to decline. In 2020, there were 43,497 applications, and early indications suggest there may be a similar number in 2021 and 2022.

NFTs and the Metaverse



Virtual reality, augmented reality



## Entertainment

Technology companies have been building patent portfolios relating to non-fungible tokens (NFTs) and the Metaverse for a long time.

Top 10 patent holders - NFTs and the Metaverse

Assignee	Families	Applications	Grants
Meta Platforms Inc.	173	2359	1052
Sony Corp.	90	989	454
Huawei Tech Co. Ltd.	186	967	311
Samsung Electronics Co. Ltd.	164	846	310
IBM	194	465	300
Intel Corp.	162	811	281
Dolby INT AB	12	431	228
Commissariat Energie Atomique	143	434	191
Fraunhofer GES Forschung	77	427	180
LG Electronics Inc.	32	428	178

Top 10 patent holders - Virtual reality, augmented reality

Assignee	Families	Applications	Grants
Apple Inc	632	3877	1936
Samsung Electronics Co. Ltd.	1158	5417	1783
Qualcomm Inc.	599	3714	1186
Google LLC	542	2304	998
Microsoft Technology Licensing LLC	623	2455	965
Magic Leap Inc.	441	2994	912
Sonos Inc.	124	1242	727
IBM	557	952	635
AT&T Intellectual Property	290	796	635
LG Electronics Inc.	782	2333	625

By contrast, applications for virtual and augmented reality have fluctuated enormously. To illustrate, between 2003 and 2004, they fell 37.9%, while in the following year, they rose 134.86%. After a few years of relative consistency, they fell 47.53% in 2010 but rebounded 157.57% in 2012. Since then, applications have been between roughly 80,000 and 100,000 a year. This compares with 20,000 to 40,000 in the period from 2000 to 2004.

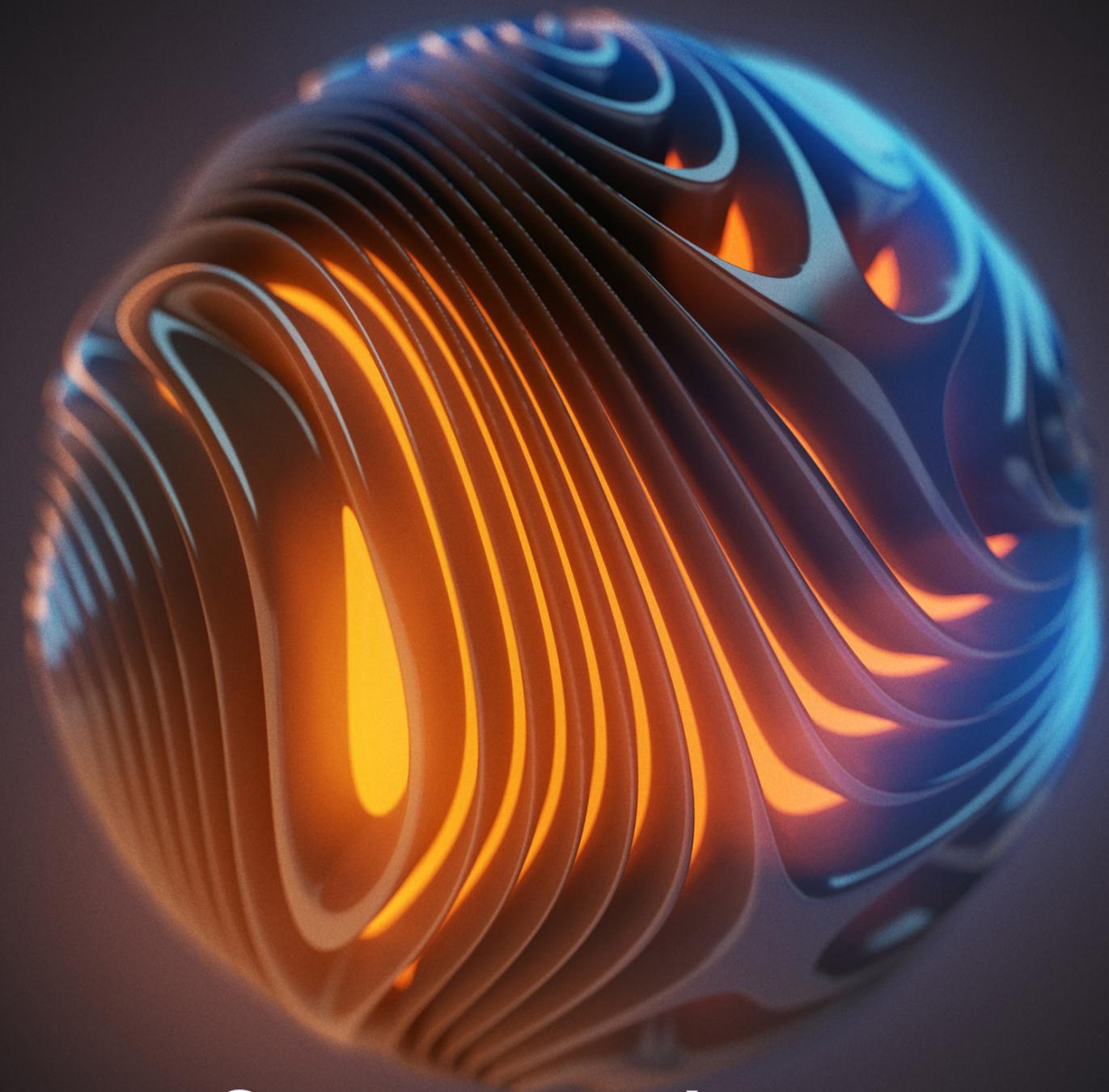
It is hard to explain these vacillating trends in patent filings. Perhaps investors' interest is simply fickle regarding such technologies compared to more long-term, sure-fire investments such as healthcare or energy. It may also be the case that many applicants file speculative applications in these areas to ensure they have protection if and when a market develops. Perhaps another contributory factor is that merger and acquisition activity, though frequent, is highly unpredictable in the entertainment sector.

Clearly, established technology and social media companies dominate filings. For virtual reality / augmented reality, the top 10 patentees based on the number of patent grants are Apple, Samsung, Qualcomm, Google, Microsoft, Magic Leap, Sonos, IBM, AT&T and LG Electronics. Applications for NFTs / the Metaverse are led by Meta (formerly Facebook), Sony, Huawei, Samsung and IBM. With 191 granted patents, a surprising appearance is made by the Commissariat à l'énergie atomique et aux énergies alternatives, the French Alternative Energies and Atomic Energy Commission.



If the hype around NFTs and the Metaverse is justified, then many of the technologies patented over the past decade will likely have significant value in the next few years. That could lead to some intense negotiations and litigation as new products and services are developed. We have already seen trademark disputes over NFTs in cases between Hermès and Mason Rothschild (recently ruling in favor of Hermès), Nike-StockX and Juventus-Blockeras.

With the development of new technologies and online environments where social activity and sales will occur, we will probably see further disputes over copyrights, trademarks and patent rights, among other issues. Such cases will undoubtedly raise burning questions about the scope of protection, jurisdiction and the balance between monopoly rights and fair or permitted uses. Judges will certainly have their work cut out.

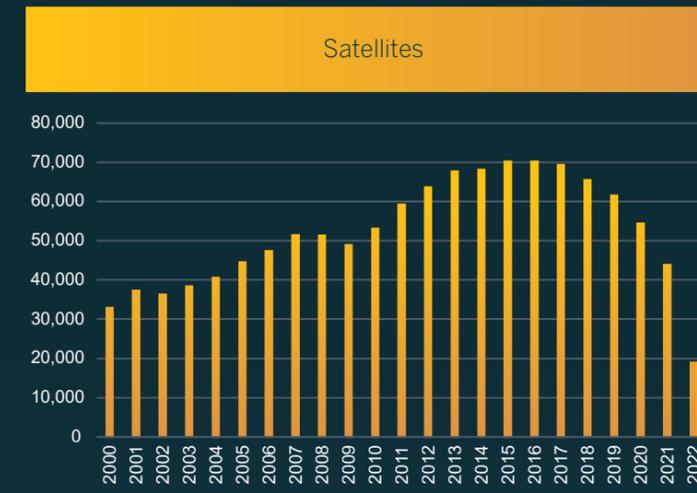


# Space exploration

The rocket renaissance has been one of the most thrilling developments of the past few years. Entrepreneurs such as Elon Musk (SpaceX), Jeff Bezos (Blue Origin) and Richard Branson (Virgin Galactic) have spearheaded this new space race, but many other organizations – both public and private – are investing heavily.

According to [Nasdaq](#), Bank of America predicted that the space economy will be worth \$1.4 trillion USD by 2030. (By comparison, it was estimated at \$469 billion USD in 2021.) The so-called new space sector already comprises more than 10,000 companies providing services such as travel into space, satellite operations, defense, data analytics and even asteroid mining.

This field is as expansive as it gets, but the Dennemeyer analysis focused on three areas: **habitation technologies, rockets and satellites**. Remarkably, the trends in these three areas are very different.



Patent applications for habitation technologies have been comparatively low measured against other space-based inventions, and highly variable at that. From a low point of just a single application in 2013 to a peak of 56 in 2017, longer-term human forays beyond the Earth do not seem to be a priority line of research at this time.

By contrast, applications relating to satellites increased somewhat steadily from 33,312 in 2000 to a peak of 70,613 in 2016. They have since dropped slightly, with 54,792 applications in 2020.

**Space exploration**  
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Top 10 patent holders - Habitation technologies			
Assignee	Families	Applications	Grants
Boeing Co.	4	17	9
UhcsProperty SA	1	22	9
Emulate Inc.	1	9	3
Earthdaily Canada Holdings Corp.	1	11	3
Nanoracks LLC	1	4	3
Vinci Construction	2	4	2
Publichnoe Aktsionernoe Obshchestvo Raketno Kosmicheskaya Korporatsiya Enegiya Imeni SP Koroleva	2	2	2
Airbus Defence and Space SAS	1	4	2
Victor Duran Serrandell	1	1	2
Federalnoe Gosudarstvennoe Byudzhethnoe Obrazovatelnoe Uchrezhdenie Vysshego Obrazovaniya Moskovskij	1	1	1

Between these two sector extremes, the number of applications relating to rockets totals a few thousand each year. However, the overall trend is upward: In the first decade of this century, there were about 2,000 applications each year, but following a boom of over 30% in 2010, there were consistently 3,000 to 4,000 filings each year from 2011 to 2020.

### Top 10 patent holders - Satellites

Assignee	Families	Applications	Grants
Qualcomm Inc.	785	3248	890
Apple Inc.	175	930	523
IBM	342	665	516
AT&T Intellectual Property	199	575	489
Viasat Inc.	105	960	466
Samsung Electronics Co. Ltd.	275	1210	408
Intel Corp.	225	995	399
Google Inc.	118	802	390
Boeing Co.	219	895	384
State Farm Mutual Automobile Insurance Co.	40	435	358

### Top 10 patent holders - Rockets

Assignee	Families	Applications	Grants
Land Space Tech Corp. Ltd.	336	360	171
ArianeGroup SAS	48	115	63
Boeing Co.	34	127	62
Beijing i-Space Tech Co. Ltd.	120	121	53
Aktsionernoe Obshchestvo Voenno Promyshlennaya Korporatsiya Nauchno Proizvodstvennoe Obedinenie Mash	41	41	41
Arkema France	16	132	40
Publichnoe Aktsionernoe Obshchestvo Raketno Kosmicheskaya Korporatsiya Enegiya Imeni SP Koroleva	38	38	38
Aktsionernoe Obshchestvo Konst Byuro Khimavtomatiki	38	38	38
Rossiyskaya Federatsiya OT Imeni Kotoroj Vystupaet Mini Oborony Rossijskoj Federatsii	35	35	35
Beijing Xingji RongyaoTech Co. Ltd.	96	101	34

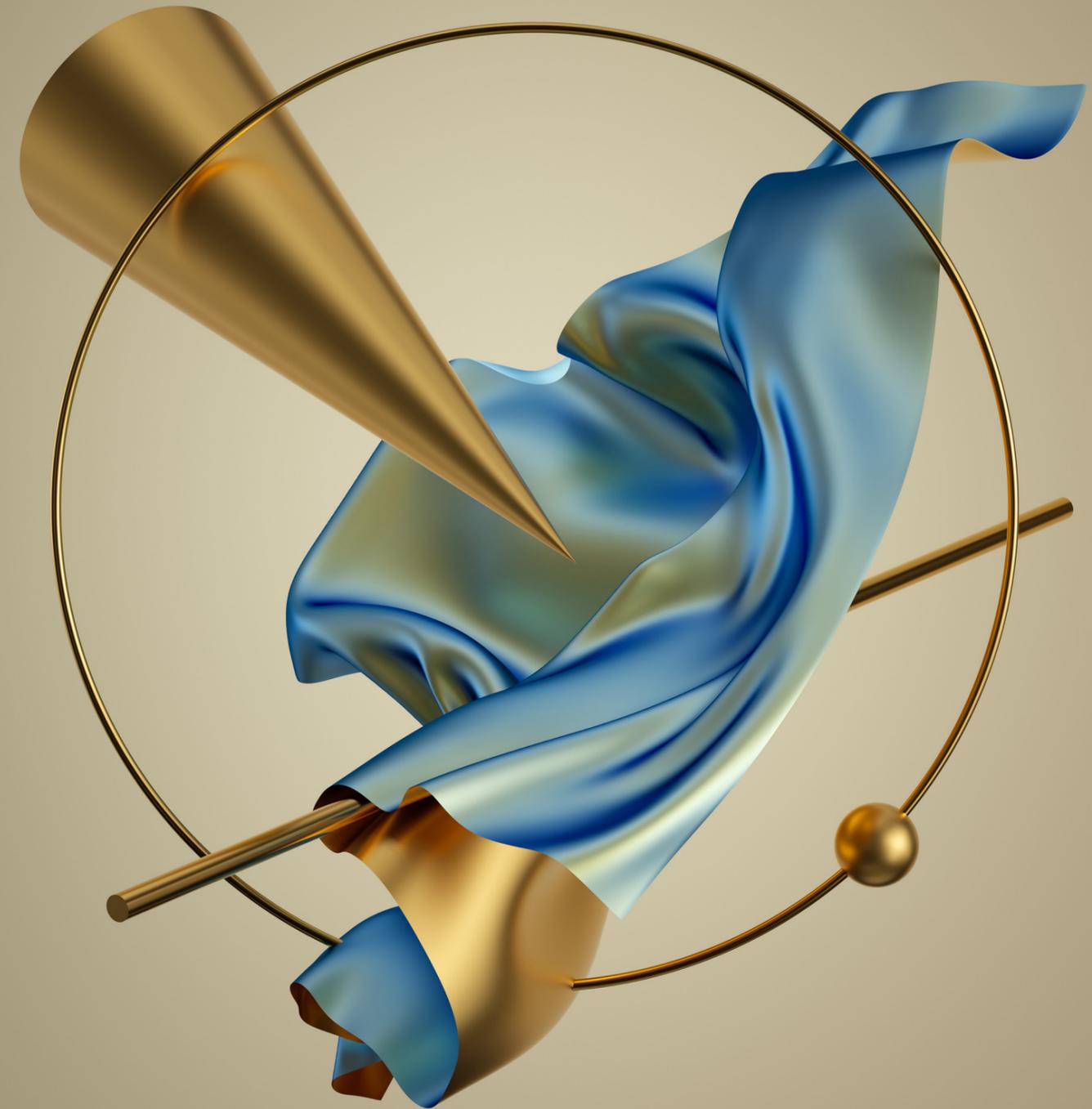
The data on patent ownership in this sector is fascinating, as it demonstrates the diverse range of companies investing in space technology: from Chinese research institutions to U.S. telecommunications companies.

For example, most of the major players in satellites are electronics and communications enterprises such as Qualcomm, Apple, IBM, AT&T and Viasat, though Boeing has a strong presence in the sector. Interestingly, State Farm Mutual Automobile Insurance Co. comes in at number 10, reflecting their focus on satellite tracking of vehicles.

Meanwhile, in rockets, the solid performance of Chinese organizations continues in the top four recipients of patent grants: LandSpace Tech Corp., ArianeGroup, Boeing and Beijing i-Space Tech. Outside of China, France and the United States, several Russian organizations claim their places as notable innovators.

Predictably, the size of portfolios is minimal in habitation technologies, with even the top companies having only a handful of patents. Here, Boeing leads the way, though Russian aerospace company S. P. Korolev Rocket and Space Corporation and the German-headquartered Airbus Defence and Space are also active.

The disparate pattern of IP ownership suggests this is an industry ripe for consolidation. However, special political and legal considerations apply to space given its potential military and strategic importance and the need for international cooperation (as in the International Space Station). The next few years will determine what influence the enormous growth of innovation in China (as well as other countries such as India) will have on the status quo.



# Conclusion

This report has isolated some of the most pertinent and telling patenting trends from the first 20 years of the 21st century. While the ever-evolving reality of the technologies examined and the vagaries of the markets they inhabit mean it is not always easy or helpful to pin down the state of each sector, some directions are clear.

For example, the data demonstrates the ongoing internationalization of patenting activity. A similar report published 20 years ago would have been dominated by U.S., European and Japanese names. But in many of the fields covered in this report, Chinese companies stand out – and this will likely continue to be the case given the country's investment in innovation. In future years, we may also see the rise to prominence of organizations in India, Brazil and other emerging markets.

Having said that, it is also possible that there will be a shift back toward the west. For one, 2023 will see the launch of the Unitary Patent and Unified Patent Court, which aim to streamline patent protection, licensing and litigation in the EU. Time will tell if these initiatives encourage patenting in the EU by reducing some of the complexity of IP protection and providing a harmonized enforcement system. It also remains to be seen if anything comes of [legislative proposals](#) to make the U.S. patent system more attractive to applicants, particularly in the IT and telecom sectors. If passed, the Patent Examination and Quality Improvement Act of 2022 would enjoin the Comptroller General of the United States to report on ways "to improve the patent examination process at, and the overall quality of patents issued by" the United States Patent and Trademark Office. Intriguingly, this would include an evaluation of the need and nature of defining metrics for "patent quality."

Another trend is the development of new industry sectors. We see this most plainly in the boom in patent applications relating to renewable energy and smart watches / home health monitors – a product category that did not exist 20 years ago. In both cases, it is possible to note how innovation leads and reflects social change. That is to say, technology enables us to travel more cleanly and independently manage our lifestyles while also responding to widespread concern about the environment and the interest in living more healthily.

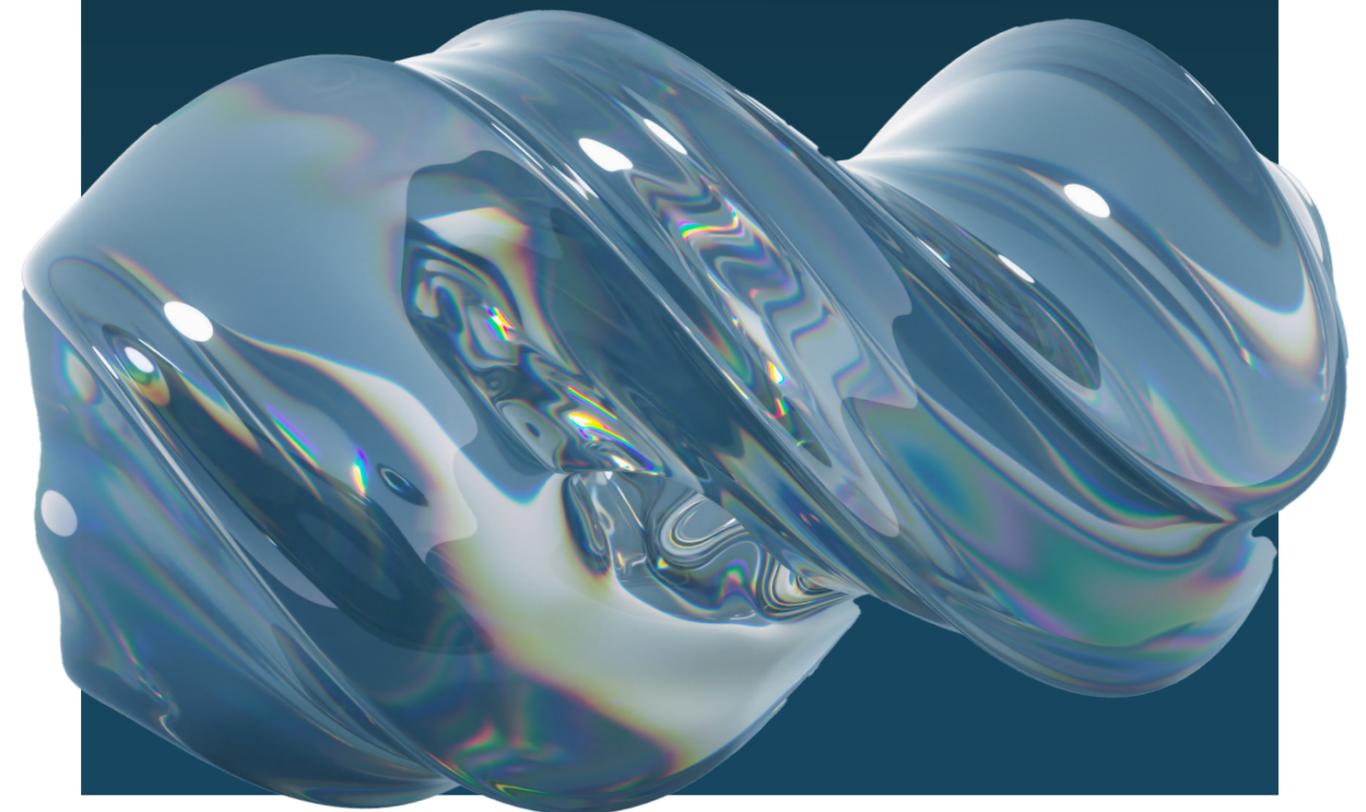
As average lifespans worldwide continue to extend, applying additional pressure on our cities, infrastructure and healthcare systems, we will likely see more innovation relating to remote monitoring, caregiving, accessibility and sustainable living in the next decade. Resolving disputes on licensing and standards will become even more pressing, and calls for mandatory arbitration or other means of dispute resolution may become louder.

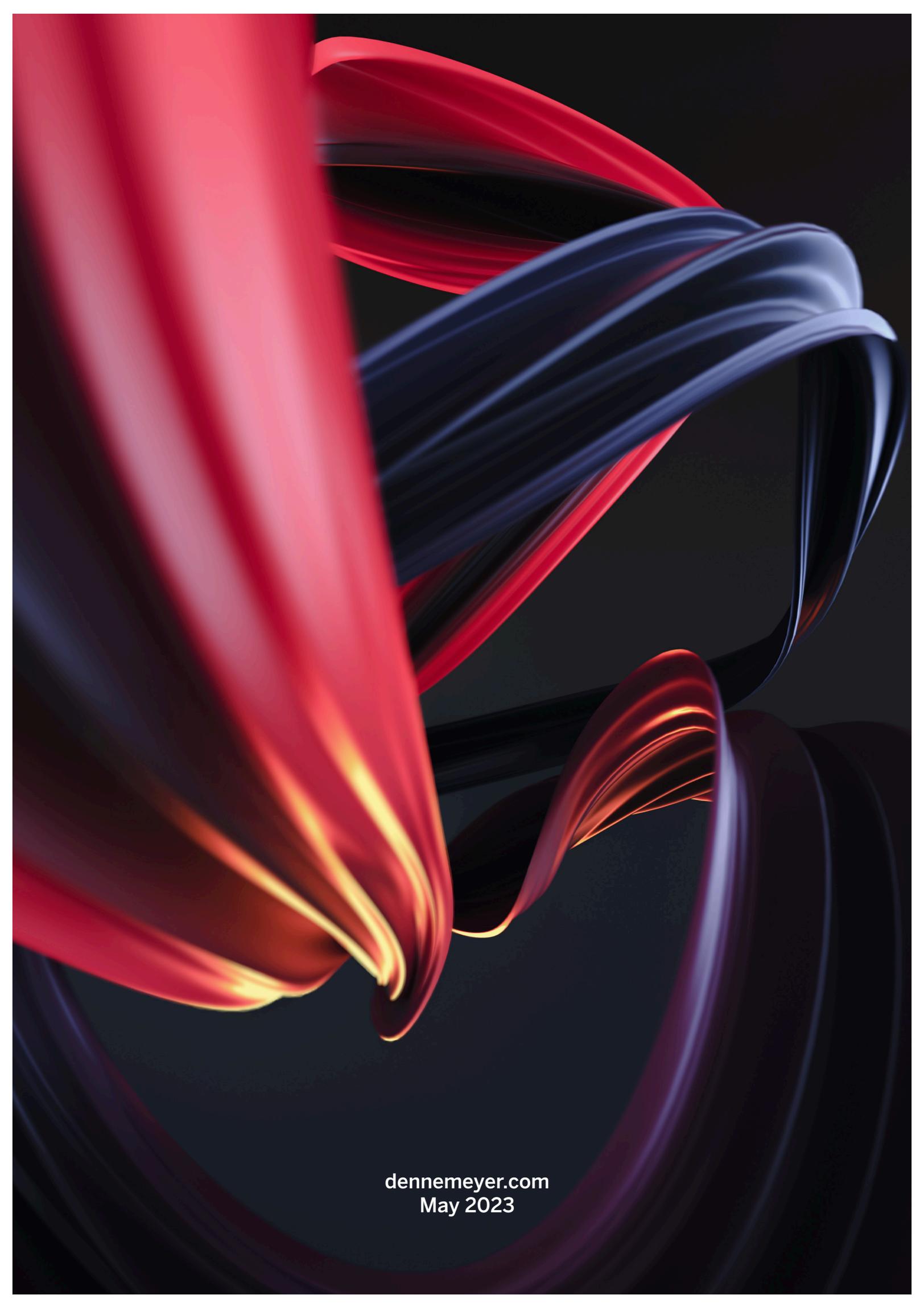
Reflecting many other areas of innovation, much of this enterprise is likely to involve robotics and AI – two of the biggest areas of current research that cut across sector boundaries. While there will remain questions about what is patentable and the scope of protections, there is little doubt that these technologies will shake up the patent system in the coming years. Indeed, there is already a stirring debate about whether an AI can be named as the inventor of a patent, an issue that various jurisdictional courts have tackled in the "DABUS" cases.

AI will also have an impact in other respects, for example, in facilitating searching of prior art and even perhaps analyses of what is obvious / novel. We may have to re-think terms such as "person having ordinary skill in the art," given the importance of computers in primary research. With patent applications' technical complexity on the rise, AI may be deployed more and more by patent offices, applicants and IP professionals to manage workloads. The input of non-human actors could even be used to predict the outcomes of patent conflicts and maybe (one day) even decide them.

While patents will be vital in this new environment, sophisticated IP managers will have a range of tools in their armory, including registered and unregistered IP rights. Data will play an increasing role, and new business models will emerge, requiring trade secrets, copyrights, designs and even trademarks to protect them from every angle. To strengthen a portfolio, patent specialists will need to recognize how these neighboring IP protections can be overlapped and complemented.

This report provides a snapshot of the range and extent of innovation in pivotal sectors over the past two decades as well as technologies that will shape business and society in the coming years. Patents are at once an indicator and an enabler of technological progress, and their horizons never cease to expand. We look forward to exploring those new frontiers in future reports.





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