White Paper

Pharma R&D Annual Review 2024

Look back at key pipeline trends from the last 12 months so you can forecast success in 2024

CITELINE CLINICAL

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Welcome

Welcome to Pharmaprojects' 2024 review of trends in pharmaceutical R&D

Welcome to Pharmaprojects' 2024 review of trends in pharmaceutical R&D. For over 30 years now, I've been taking an annual look at the evolution of pharma R&D, and in this article I'll take the temperature of the industry at the start of 2024. We'll assess industry trends by examining the pipeline by company, therapeutic area, disease, target, and drug type, using data primarily from Pharmaprojects, part of the Citeline suite of products, which has been tracking global drug development since 1980. This report will be followed up by our annual supplement reviewing the New Active Substance (NAS) launches for the year just passed. But here, we'll examine how the pharma R&D climate is changing, look at where the pressure is rising and falling, and try to determine where the outlook is sunny and where storm clouds are gathering. Hopefully, it will help you to take the industry's temperature and forecast its outlook.

Regular readers of this report (which has been running since 1993, so is presented here in its 32nd edition) will know that, in recent years, I've threaded a different theme through each edition, to highlight points, to draw analogies, and to add a little character into what could otherwise be a rather lengthy narrative through a parade of statistics, charts, and tables — duller than a December day in Doncaster. Themes selected so far have included astronomy, movies, the natural world, music, food and drink, science fiction, travel, and, last year, literature. This year, as you may have guessed, I decided to hang my (rain) hat on something that affects us all every day: the weather, and the allied most important issue of our times, climate change.

Since our early cave-dwelling days, the activities of humans have been somewhat governed by the vagaries of the weather. We needed to know when conditions were best for hunting, and whether our crops would flourish or fail. The earliest attempts to predict the weather were largely unscientific and based on prophecy, astrology, or prayers to invisible weather gods. As with so many things, the ancient Greeks were the first to turn superstition into science, and in fact the term "meteorology" comes from the Greek meaning "the study of things high in the air." The acknowledged father of the science is Aristotle, who published a treatise on the subject as early as 350 BC. Of course, accurate instruments to measure weather-related phenomena only really came along with the Enlightenment, but weather forecasts were still notoriously unreliable, especially in countries like the UK where I am based, as little as 50 years ago. It was only with the growth of computing power, and with it, computer modeling algorithms, that forecasters were able to provide predictions with any measure of certainty. The key, as always, is data — and lots of it. My hope is that this report will fulfill the same function: it will provide enough information for you to determine which parts of the industry are likely to be basking in unbroken sunshine, and which are preparing for a period of unsettled conditions.

While our primary focus is naturally on the short term; i.e., whether we need to put on an extra jumper or to bring our umbrellas, the long-term trends are what exercise the minds of both climate scientists and pharma industry followers. In the past few decades, the topic of the weather has grown from being a parochial consideration to something threatening our very existence. But, in fact, the idea that our impact on the planet is changing it irrevocably has been around longer than you might think. It was at the end of the 19th century when scientists first predicted that changes in atmospheric carbon dioxide levels could substantially alter a planet's surface temperature through the greenhouse effect, and just prior to World War II when Guy Callendar connected carbon dioxide increases in Earth's own atmosphere to global warming. Particularly since the turn of the millennium, the evidence seems irrefutable that, unless action is taken and taken fast, we are building towards a threat to our continued existence. The pharma industry has of course weathered a more acute existential threat recently — the COVID-19 pandemic, which it helped to deliver us from — and has emerged to enjoy a moment in the sun. But both climate change and the coronavirus crisis are evidence of the fact that we need to identify — and act on — emerging trends very quickly. We have the data; it's what we do with it that counts.

Of course, changes in climate patterns predate humans and the transformational effect of the industrial revolution. Within the past million years, there have been at least eight cycles of ice ages and warmer periods, along with shorter cycles such as the Little Ice Age in the North Atlantic between the 16th and 19th centuries, which famously led to London's River Thames freezing over and the Victorian "Frost Fairs" held there. While climate is bound to have inherent variability, this change has been variously attributed to cyclical lows in solar radiation, heightened volcanic activity, changes in ocean circulation, and variations in Earth's orbit and axial tilt, so the human race hasn't always historically been behind climate change. It's clear now, however, that our effect extends far beyond such natural cycles, and is potentially sending our planet towards irreversible disaster, at least as far as life is concerned. It's theorized that other planets such as Mars have already been through this process, and that the dead planet we see today is potentially a spooky view into our own future.

The pharma industry, as we shall see, has been heating up for some time now, despite the mini-ice age which COVID presented. Within that overall trend, though, there are ever-shifting patterns, more complex than weather pressure charts. Drug development has its own areas of high and low pressure, its own fronts; in some places, it is experiencing headwinds, in others, the air is calm; and some therapeutics are most definitely hotter than others. In this report, we will present to you our meteorological map of pharmaceutical R&D as it is now, and compare that to our charts from a year ago, to get the best view of where things are warming up and where a deep depression may be setting in. We will also occasionally look further back to define longer-term trends; after all, you don't always just need to know whether it will rain tomorrow, you need to know whether to pack your sunscreen or your Wellington boots for your forthcoming holiday. In that sense, our pharma industry review will try to provide both a weather forecast and an insight into broader changes in the climate.

I hope this introduction has broken the ice and set you up to ride along the trade winds of data we have on today's pharma industry. So, take a rain check from whatever you're doing, find a place in the sun, and read on to find out where the industry is basking in unbroken sunshine, and where the outlook is more overcast. We won't try to boil the ocean, but we will provide a clear view to the horizon so that you can see which way the wind is blowing in drug R&D. We've cooked up a veritable storm of statistics and will help you to navigate any choppy waters they stir up. Hopefully, after reading this report, understanding drug R&D trends will be a breeze.

Introduction: Total Pipeline Size

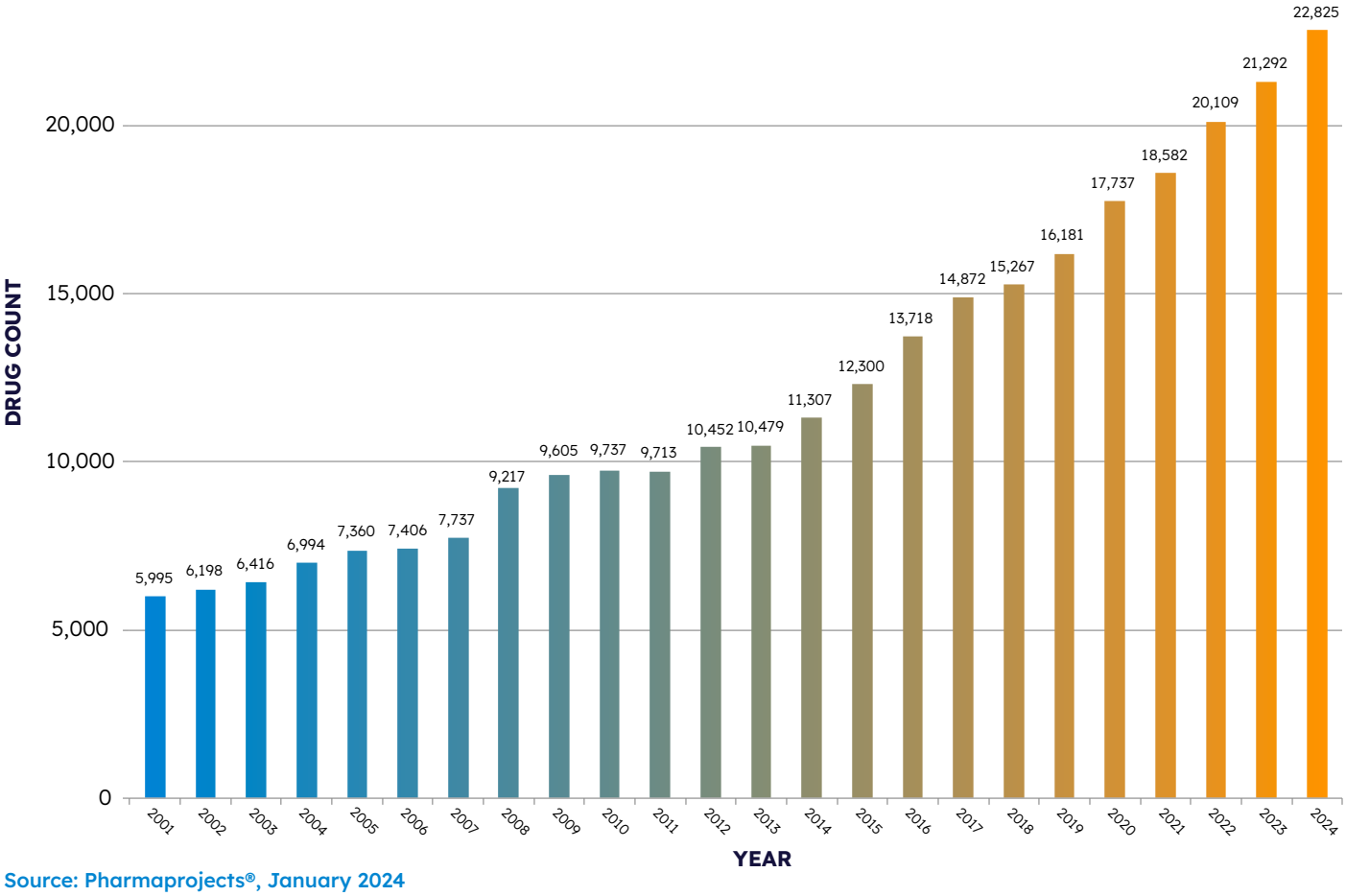
Pleasant outlook for pharma as things continue to heat up

As a foreword to this year's almanac, let's define the climate system in which our changing weather patterns analyses will take place, by looking at the total number of drugs currently in the R&D pipeline. All the analyses in this report will be focusing on this set of drugs, so it's worth starting off with a definition of what exactly we mean by the term "pipeline." Here, we are counting all drugs in development by pharmaceutical companies, from those at the preclinical stage, through the various stages of clinical testing and regulatory approval, and up to and including launch. Launched drugs are still counted, but only if they are still in development for additional indications or markets. Drugs whose development has been terminated, or is complete, are not included. All data were collected on Jan. 2, 2024.

Are things still heating up in pharma R&D, as well as the climate? Records for extremes of high temperature have repeatedly been broken in recent years. In the UK, the summer of 2022 saw the mercury peak at 40.3°C (104.5°F), while Australia hit its own record just a few months earlier, hitting a blistering 50.7°C (123.3°F). Perhaps surprisingly, the highest verifiable temperature humans have recorded globally thus far dates back over a century to July 1913, when the appropriately named Furnace Creek, California, recorded a face-melting 56.7°C (134°F). Globally, all 10 of the warmest years on record have occurred post-2000, with 2023 recently confirmed to be the warmest yet. It's now well documented that the overall trend for global temperatures is climbing at an alarmingly accelerating rate, with average global temperatures already having increased by about 1°C (1.7°F) since 1880, and projected to warm by 1.5°C (2.7°F) by 2050, and potentially by 2–4°C (3.6–7.2°F) by 2100.

We've also consistently seen increases in the number of drugs in development year-on-year — is "pharma warming" still occurring in 2024? Well, Figure 1 confirms that the overall pipeline size has again hit a new high, and the rate of expansion is on the up again. 2024's headline figure is 22,825 drugs, an expansion of 7.20% from last year's figure of 21,292. The rate of growth represents an increase from the previous year's 5.89%, which places the 2024 rate nicely in the middle of that rate and the year before (8.22%). It also places this year's rate pretty much dead on the average of the past five years, which is 7.14%. So it would seem that this year is at least right on trend.

Figure 1: Total R&D pipeline size by year, 2001—24



Source: Pharmaprojects®, January 2024

In real terms, the size of the pipeline has thus increased by 1,533 drugs, representing a bigger increase than the 1,183 seen during 2022–23, but almost exactly the same as the 1,527 uptick reported over 2021–22. But this doesn't tell the whole story. During 2023, a total of 5,428 drugs were added to the Pharmaprojects database, considerably more than the 5,082 added during the previous year. So how come the total pipeline size only grew by 1,533? The answer is that a total of 3,895 candidates left the active pipeline during the same period, a figure which again almost exactly matches the one from the previous year. This indicates that, once again, there has been considerable turnover within the pipeline in the course of a single year, but the amount of change has at least remained constant.

Let's look a little deeper into the types of drugs that entered the pipeline during 2023. By far the largest chunk of drugs fall into the oncology bucket, which provided 38.0% of all new candidates — interestingly, a little down from 2022's 40.7%. Neurologicals came in second, with 12.7%, also down from 13.5% the previous year. Taken together, these slight declines for the big hitters point to a slightly broader spread of candidates by therapeutic area joining drug companies' portfolios last year; as with weather, a mixed, balanced picture is healthier, rather than too much of one feature causing a flood or a drought somewhere else.

There might be some subtle shifts in wind direction this year, which are exemplified by a look at which companies added the most new drugs to the pipeline. This year, Pfizer tops the list with 32 new candidates, pushing Jiangsu Hengrui Pharmaceuticals into second place with 30. The leading Chinese firm topped the equivalent ranking last year, somewhat eclipsing the more traditional Western big pharmas. However, in terms of the location of development of 2023's new intake of drugs, there seems further evidence of China's continued advance. The US is still the pre-eminent territory this year, with 1,856 new candidates (up from 1,840), but China is closing the gap, with 1,627 neophyte drugs, up from 1,457 in 2022. The varying strengths of Eastern and Western trade winds is a subject we'll be returning to later in this report.

However, just as ever-warming temperatures might lead to nicer summers but have some potential downsides (droughts, forest fires, the total extinction of the human race, etc.), continuously increasing drug R&D pipeline sizes are not wholly a good thing. As we'll see shortly, the vast majority of the drugs in this number are not yet — and, in the majority of cases, will never be — launched. Thus, they are a cost to the industry, and a risk. Might the bloated pipeline reach a tipping point where it no longer becomes sustainable, in the same way that global warming might? Just as switching to renewable energy sources might save the planet, the way in which the industry renews itself and keeps progressing is by successfully launching new drugs, which earn revenue. We are still gathering and finessing data on NAS launches for 2023 as I write, but early indications are it's likely that, while it was a less successful year than 2021, which produced a record haul on 97 NAS launches, it surpassed 2022's 74 to become the second best year ever. Be sure to check out the forthcoming NAS Supplement for the final tally, and confirmation of whether the pharma industry is continuing to reap a sizable harvest, or whether drought conditions might be setting in.

Developing Systems: The 2024 Pipeline by Phase

Clinical development advances still face a stiff headwind

Weather, like new drugs, doesn't just appear fully formed — it develops. And, like a healthy human, it relies on many interrelated pieces working together to function. The large-scale structure of the Earth's atmospheric circulation systems, like the drug development process, remains fairly constant, but smaller-scale systems such as mid-latitude depressions or tropical convective cells occur chaotically and are impossible to predict accurately beyond around 10 days ahead.

Chaos theory plays a large part in climate modeling algorithms and unpredictability is innate, in much the same way as we cannot predict accurately whether a drug in preclinical development will make it through the development process. There are as many variables along the path to produce a successfully marketed drug versus a failed one as there are between a weather system developing into a hurricane versus a spell of light drizzle. In the pursuit of maximizing success in both fields, increases in computer power to better model such variables are an important step forward.

Drug development of course follows an orderly pattern, as candidates move from preclinical development, through the various phases of clinical trials, into registration, and (hopefully) finally onto the market. But just as the sun rising into a cloudless sky doesn't mean it will be fine all day, it might stay clear, or conditions might deteriorate; a drug can have a clear run to market but, more often than not, it will get lost in the fog and, before you know it, it's rain stopped play. Let's take a look at how the pipeline breaks down by phase of development, and try to determine whether the outlook is improving.

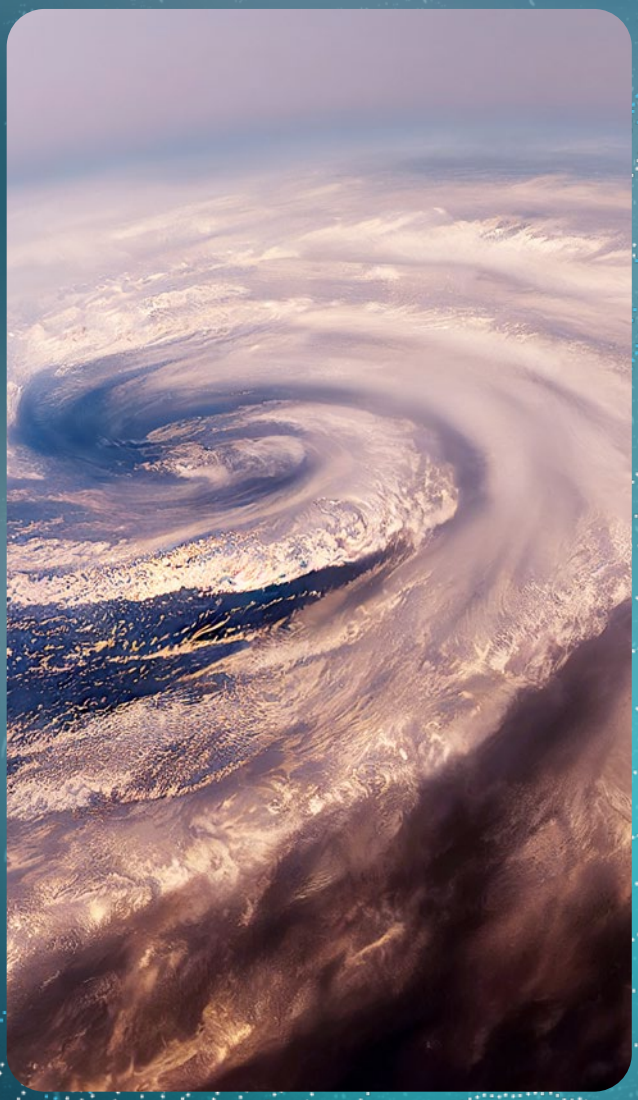
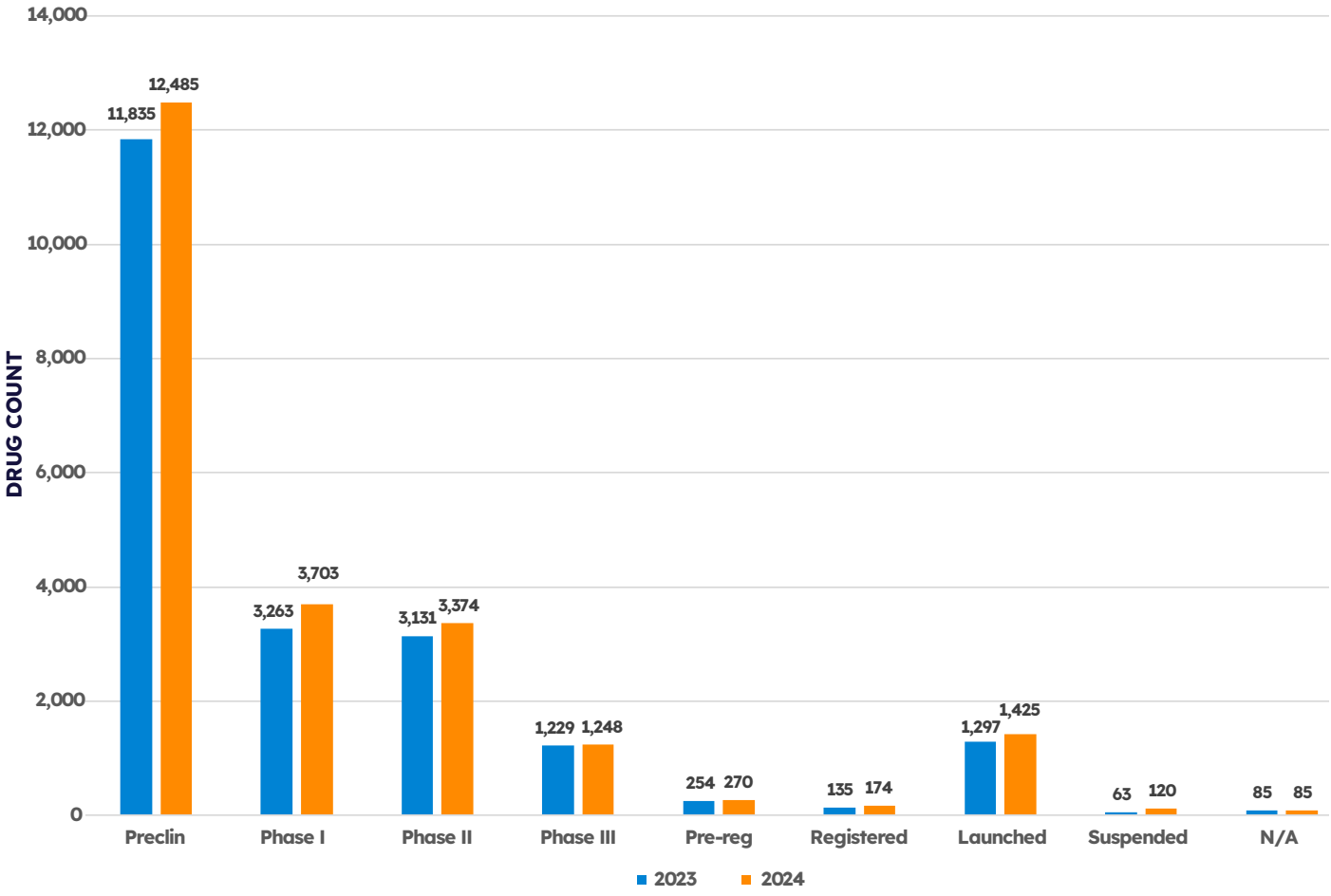


Figure 2: Pipeline by development phase, 2024 vs. 2023



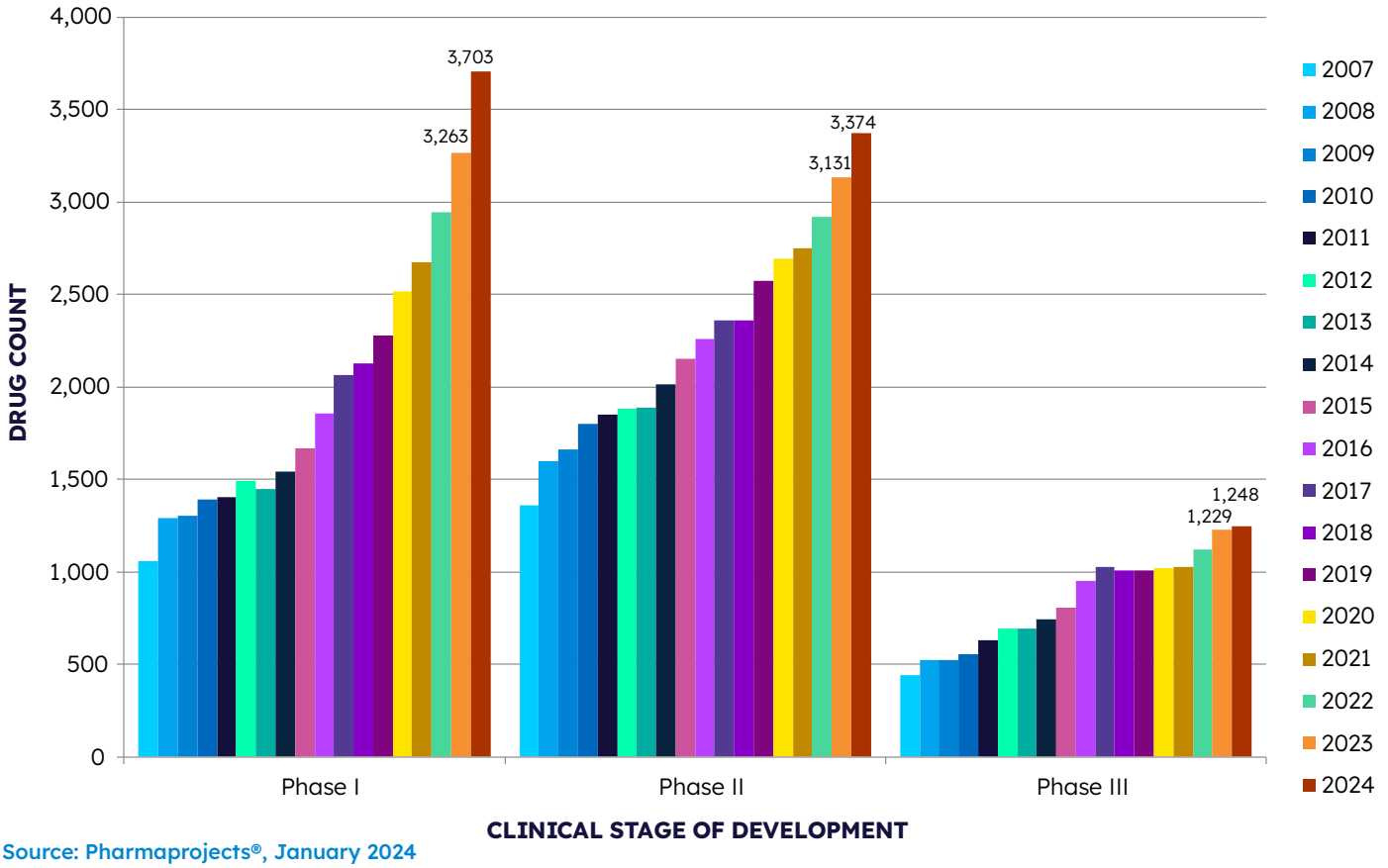
(N/A = not applicable and is applied to companion diagnostics prelaunch)

Source: Pharmaprojects®, January 2024

Figure 2 breaks down the 2024 pipeline by the drugs' current global statuses. Global status is the most advanced stage of development a drug has reached in any country, for any disease, and by any company, so each drug is counted only once here. You can immediately see that a considerable amount of the increase in pipeline size growth occurred by adding drugs at the preclinical stage, which posted a total up by 650. However, in percentage terms, this is a 5.5% increase; lower than the overall rate of increase in the pipeline as a whole, but higher than 2023's equivalent number of 4.3%. In percentage terms, it is the number of drugs in Phase I which has increased the most, rising by an impressive 13.5%, accelerating from the 10.7% increase reported last year. Rises at Phase II also showed a positive trend, with the number of drugs at that phase up by 7.8%, compared to 7.2% last year. Note that while the numbers in Phase I being higher than those in Phase II may at first seem counterintuitive, this is a function of these data being a snapshot in time. The fact that there are roughly the same numbers of drugs in Phase II as there are in Phase I in no way means that virtually all drugs undergoing Phase I then progress serenely to Phase II. There is considerable attrition between the two phases, but as Phase II development generally takes much longer, drugs pile up at the Phase II stage, so that at any one time, there are more drugs in Phase I than there are in Phase II.

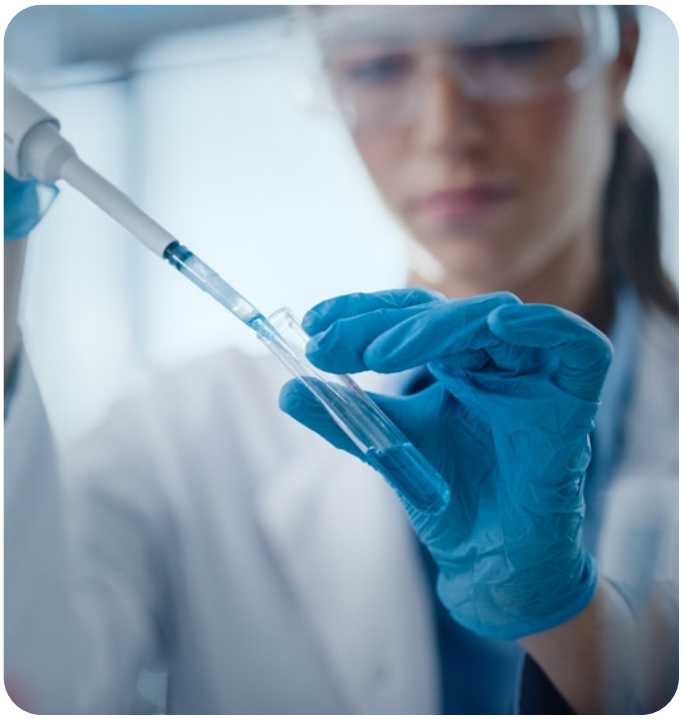
But there is cause for concern when we move to the Phase III number, which seems in contrast somewhat becalmed. It's wiser here to take a deeper dive into our historical records, as Figure 3 pulls out the numbers of drugs in the clinical development stages across a longer time period, going back to 2007. You can see here how the increases in Phase III numbers during the 2017–21 period failed to keep pace with equivalent rises seen in Phase I and II, indicating worsening attrition. But the sun had appeared to be breaking through the clouds here during 2022 and 2023, with Phase III numbers on the up again. This year's data indicate darkening skies again, which could be a cause for concern for the industry.

Figure 3: Clinical phase trends, 2007–24



Source: Pharmaprojects®, January 2024

It's undoubtedly true that if you are spending more on pushing more drugs through Phase I and Phase II trials, you want more drugs to make it into Phase III. However, there is a caveat to this. Phase III trials are by some measure the most expensive part of drug development, so it's only a good thing to have more drugs in Phase III if the industry is consequently able to bring more drugs to the market. Indeed, data from industry analysts such as Deloitte suggest that the year-on-year cost of developing drugs continues to rise, while return on investment is falling. This, like the ongoing rise in global temperatures, clearly cannot be sustainable.



Top Companies

Some enjoy a moment in the sun, but for others the future looks more hazy

Which companies in 2024 are enjoying extensive sunny periods, and which are undergoing a sudden cold snap? In this section, we'll take a look at the leading companies enjoying fair weather, plus the industry as a whole, which is composed not just of big fluffy clouds, but many tiny raindrops. Like the atmosphere, the pharma industry is composed of a number of distinct layers, and we'll be peering through the fog at each.

Table 1: Top 25 pharma companies by size of pipeline

POSITION 2024 (2023)	COMPANY	NO. OF DRUGS IN PIPELINE 2024 (2023)	NO. OF ORIGINATED DRUGS 2024 (2023)	TREND
1 (1)	Roche	218 (194)	125	↔
2 (5)	Pfizer	205 (171)	127	↑
3 (7)	AstraZeneca	166 (155)	103	↔
4 (10)	Eli Lilly	159 (135)	90	↑
5 (4)	Bristol-Myers Squibb	158 (175)	90	↓
6 (2)	Novartis	154 (191)	96	↓
7 (6)	Johnson & Johnson	150 (156)	81	↓
8 (13)	Jiangsu Hengrui Pharmaceuticals	147 (106)	138	↑↑
9 (8)	Merck & Co.	145 (151)	69	↓
10 (9)	Sanofi	142 (145)	79	↓
11 (11)	GlaxoSmithKline	138 (123)	70	↔
12 (3)	Takeda	130 (178)	50	↓
13 (12)	AbbVie	111 (122)	46	↓
14 (14)	Boehringer Ingelheim	111 (99)	80	↔
15 (27)	Sino Biopharmaceutical	103 (60)	84	↑↑
16 (15)	Bayer	91 (93)	61	↔
17 (24)	Shanghai Fosun Pharmaceutical (Group)	90 (64)	62	↑
18 (16)	Gilead Sciences	86 (86)	46	↔
19 (17)	Otsuka Holdings	85 (85)	45	↔
20 (20)	Eisai	81 (74)	46	↔
21 (18)	Amgen	79 (79)	47	↔
22 (26)	Astellas Pharma	78 (63)	40	↑
23 (19)	Novo Nordisk	76 (77)	53	↔
24 (23)	CSPC Pharmaceutical	73 (68)	60	↔
25 (21)	Regeneron	71 (73)	53	↔

Source: Pharmaprojects®, January 2024

The upper level of the atmosphere is the exosphere. At this rarified level, there's no weather as such, but the lower parts can host that most spectacular of atmospheric phenomena, the aurora. Shimmering on the upper echelons of the pharma industry are the Top 25 companies by pipeline size, which are listed in Table 1. Shining brightest for the second year in a row is the Swiss-based multinational Roche, which deposed its Basel-based neighbor Novartis last year. The latter slips notably this year with a pipeline which has considerably slimmed down. Taking the runner-up position this year is Pfizer, whose portfolio is about 20% bigger than it was this time last year, a fact which can largely be attributed to its completion of its acquisition of Seagen (the former Seattle Genetics) in December 2023. In a year which saw an unusual degree of turbulence in the upper atmosphere, it's just one of the significant changes in a top 10 which, in recent years, has exhibited a high level of stability. AstraZeneca hops up to number 3, having itself acquired a couple of small firms, Neogene Therapeutics and CinCor Pharma, while Eli Lilly shoots up from number 10 to number 4, having taken over Versanis Bio, DICE Therapeutics, and Sigilon Therapeutics during a particularly acquisitive year (it also subsumed POINT Biopharma, although that completed too late in the year to be included in the Jan. 2, 2024 data cut). Away from this year's top four, though, the rest of last year's top 10 all report pipelines of smaller size this year. While Bristol Myers Squibb and Johnson & Johnson steered clear of M&A activity during 2023, Novartis, Merck & Co., Sanofi, and most dramatically Takeda report smaller pipelines despite having acquired some (admittedly small) companies last year.

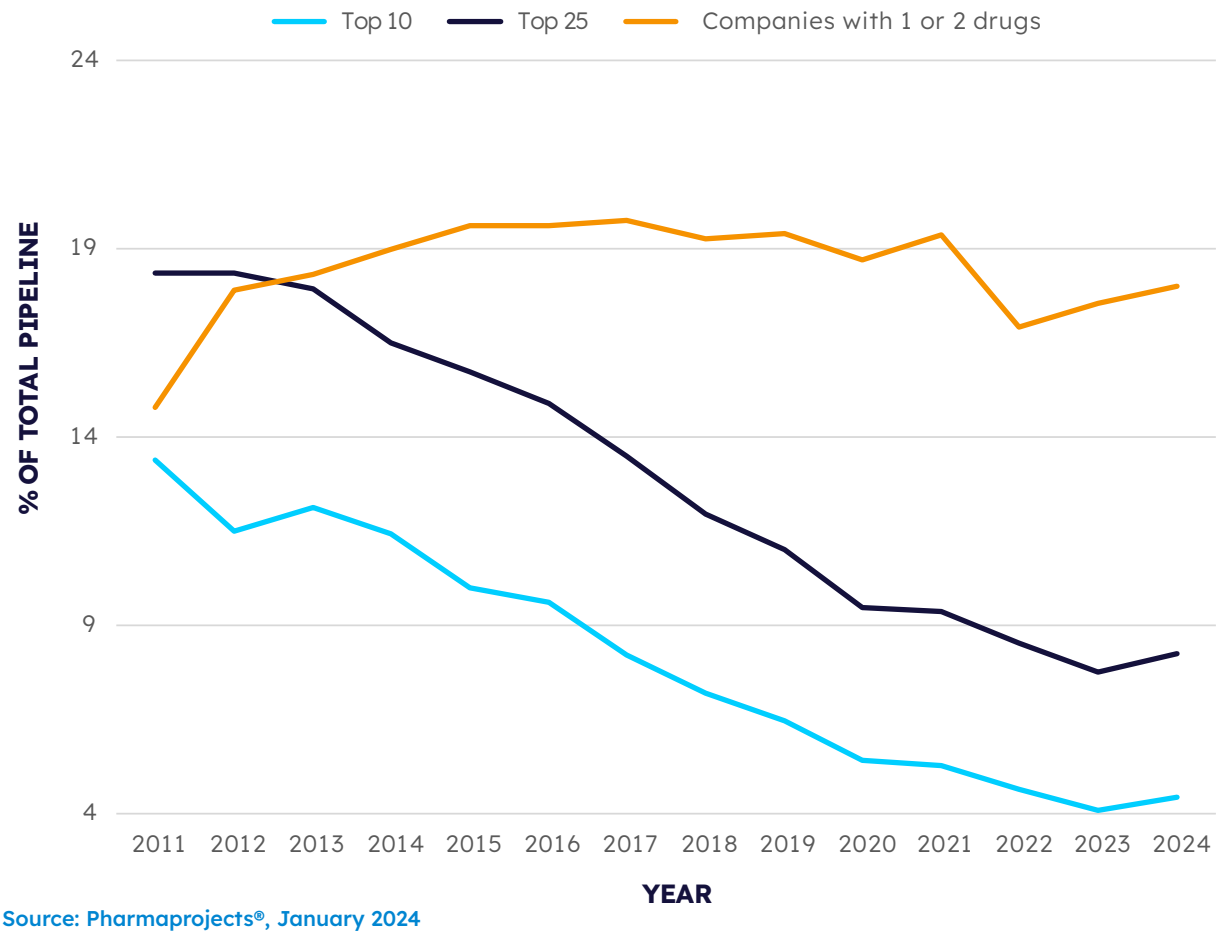
Most manufactured satellites orbit in the exosphere, and some of the larger and more reflective ones are sometimes visible from the Earth's surface as they catch the sunlight. Undoubtedly, one of the brightest "stars" in the pharma exosphere this year has to be Jiangsu Hengrui Pharmaceuticals. The company becomes the first ever Chinese firm to make it into the top 10 in terms of pipeline size, recording a 38.7% increase in its pipeline to burst into the upper firmament at number 8. It also has by some measure the biggest proportion of "homemade" drugs, with almost 94% of its drugs being self-originated. In fact, by this latter measure it is at number 1, having more drugs in the pipeline which it discovered itself than any other company, period. This is a landmark moment for the Chinese pharmaceutical industry, which, 20 years ago, had little to no homegrown pharma R&D focused on original compounds.

The next level of the atmosphere is the thermosphere, another rarified layer devoid of clouds and water vapor, but where you will find the International Space Station. Our next level, the companies numbering 11 to 25 by pipeline size, also has some interesting features in it, and again it's China that is lighting up the sky here. Sino Biopharmaceutical leapfrogs its compatriot Shanghai Fosun to become the country's second biggest R&D powerhouse, bursting into the upper echelons this year with a massive 72% increase in its pipeline size, all via organic growth. Similarly, Shanghai Fosun also reported decent growth with a 41% bigger R&D portfolio. These were by far the most significant changes in companies at this level; most other firms had pipelines of pretty similar sizes to last year.

With the possible exception of Pfizer's Seagen acquisition, our Top 25 is not really affected significantly by M&A activity through 2023. Overall, M&A activity across the industry appears to have slightly risen from last year's nadir, with 88 mergers and acquisitions reported by Pharmaprojects to have closed during 2023, slightly up from the 81 noted in 2022. There has now been a long period of calm weather after the stormy period of the late 1990s and early 2000s when tempestuous megamergers of pharmaceutical giants were commonplace. Like storms, these big mergers may have cleared the air, but many ultimately may have inflicted significant damage.

Most of the Earth's weather occurs in the lowest level of the atmosphere, the troposphere. Almost all clouds that are generated by weather are found here, with the exception of cumulonimbus thunder clouds, whose tops can rise into the lowest parts of the neighboring stratosphere. It's perhaps surprising how much activity occurs at the lowest level of the pharma industry too — at those companies that are only developing one or two drugs. This year, we are reporting 931 companies with only two drugs in their pipelines (up from 825 last year), and a huge 2,249 (up from 2,083) with just a single candidate. Just as it takes many tiny water droplets to make up a large cloud, taken together, these pharma minnows comprise a large part of the industry. Figure 4 shows that these minute, emerging companies produce just over 18% of the drugs in development, a slightly bigger slice than last year, but roughly the same percentage as 10 years ago. This is a larger tranche than either the Top 10 or the Top 25 companies. It's interesting to note, however, that this year seems to have witnessed a small reversal to the long-term trend whereby the biggest pharmaceutical firms were contributing smaller and smaller shares of drugs to the overall pipeline. The Top 10 are now providing 4.4% of drugs, up from 4.1%, while the Top 25 are delivering 8.2%, rising from 7.8%.

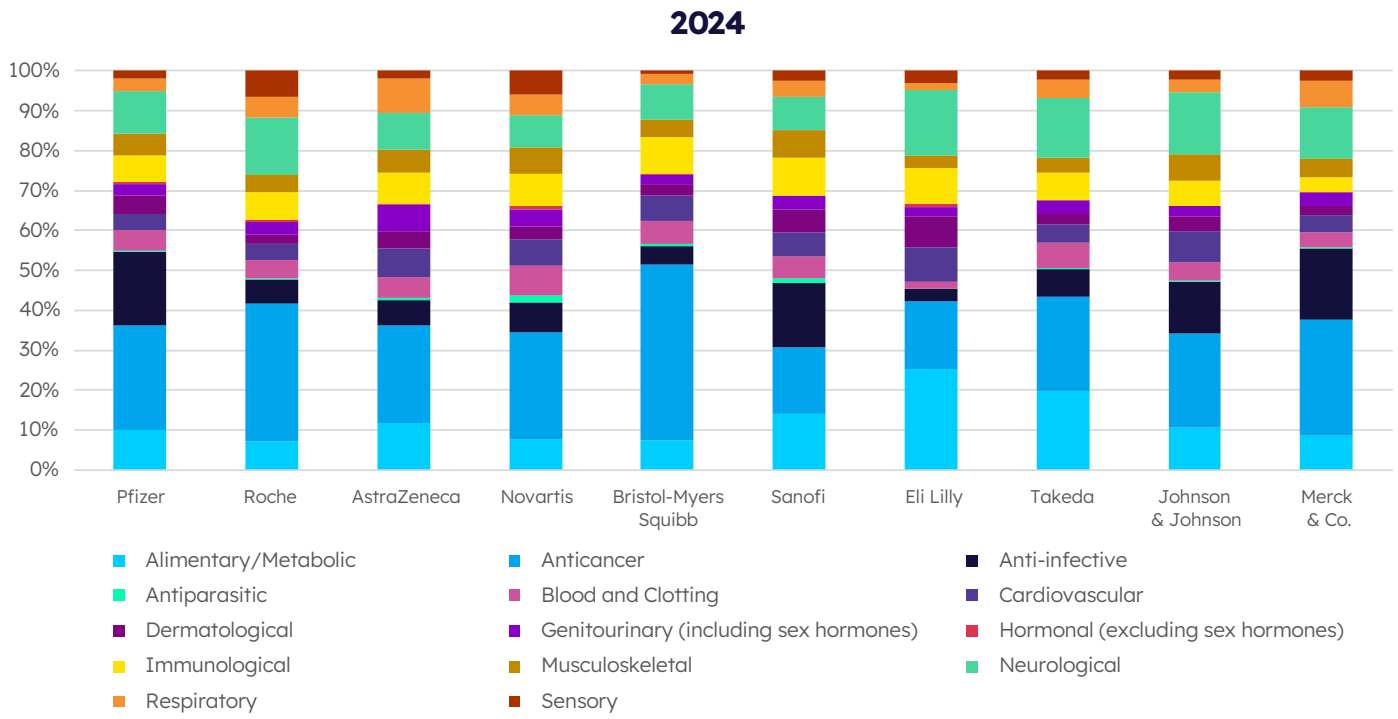
Figure 4: Share of the pipeline contributed by top 10 companies, top 25 companies, and companies with just one or two drugs, 2011—24



Source: Pharmaprojects®, January 2024

The Top 10 companies are continuing to display interests across a wide variety of therapeutic areas, as illustrated in Figure 5. In fact, the top five firms have drugs in development in every single one of the 14 therapeutic areas, while numbers 6 to 10 only miss out on one of the smaller areas each (antiparasitics for one, hormonal drugs for the other four). This indicates that, despite received wisdom suggesting that companies are refining their efforts to specialize in just a handful of disciplines, for the very largest companies at least, this simply isn't the case. There are some interesting diversifications within that, however, with Eli Lilly once again bucking the trend by being the only Top 10 company that doesn't have anticancers as its largest therapeutic focus (it instead prefers alimentary/metabolic drugs). Meanwhile, Bristol Myers Squibb is the company with the most skewed pipeline, with nearly 50% of its drugs having an oncology focus, whereas interest in other areas languishes at single-digit percentages. Sanofi almost matches its cancer portfolio size with that of its anti-infectives, with Pfizer and Merck & Co. also having sizable portfolios in that therapeutic area.

Figure 5: Disease focus areas of the Top 10 pharma companies



Source: Pharmaprojects®, January 2024

Rare diseases also continue to excite those at the helms of the biggest pharma beasts, with all the Top 10 companies featuring in our table of the 20 companies with the most drugs against rare diseases in their pipelines (Table 2). Novartis comes out on top by this measure, pushing Pfizer back into second place. Novartis has the second-highest proportion of its pipeline focused on rare diseases, its 53.6% being just edged out by Biogen's 53.7%. Elsewhere, only Bristol Myers Squibb also breaks the 50% barrier. At the other end of the scale, the company with the lowest percentage is the previously highlighted Chinese company Jiangsu Hengrui, with just 24.8%. Eli Lilly comes pretty close to that figure, with just 25.4% of its pipeline hitting rare diseases, further cementing the view that the company is something of an anomaly among the big hitters.

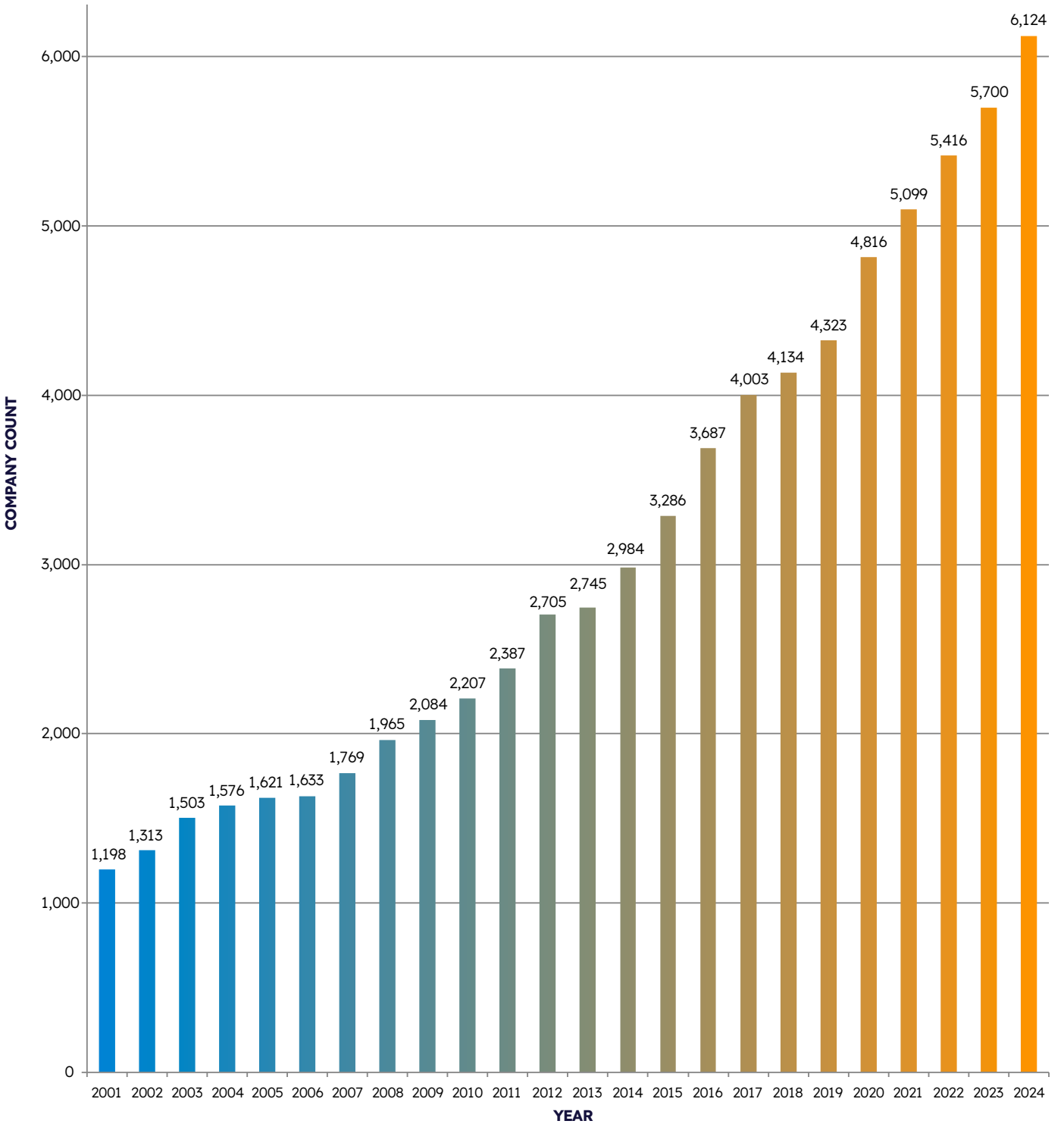
Table 2: Top 20 pharma companies with a rare disease focus

COMPANY	NUMBER OF DRUGS FOR RARE DISEASES	% OF PIPELINE
Novartis	118	53.6
Pfizer	112	40.1
Bristol-Myers Squibb	110	50.9
Roche	102	36.8
Sanofi	85	40.5
AstraZeneca	81	36.2
Takeda	80	39.8
Johnson & Johnson	71	37.0
GlaxoSmithKline	68	36.0
Merck & Co.	59	30.9
AbbVie	58	37.2
Amgen	52	46.8
Eli Lilly	51	25.4
Eisai	42	45.7
Bayer	40	34.2
Astellas Pharma	39	37.1
Jiangsu Hengrui Pharmaceuticals	37	24.8
Biogen	36	53.7
Otsuka Holdings	36	34.6
Sino Biopharmaceutical	36	34.3

Source: Pharmaprojects®, January 2024

The total number of companies involved in the pharma R&D ecosystem has now hit 6,124, as evidenced by Figure 6, continuing another upward trend. Unfortunately, a calculation error means that the equivalent figure for 2023 published last year was incorrect, so we have replaced this with an estimated total of 5,700. If accurate, this would give us a growth in the total number of companies developing drugs of 7.4%. Either way, it's clear that the sun continues to shine on the industry, with no shortage of new companies bubbling up in its sky. We can say that there were definitely more companies entering the fray during 2023, with 921 being added to our database, considerably more than the 809 discovered the previous year. This would suggest that around 500 companies were removed from our database over the past 12 months, either having been acquired, having folded, or, in the majority of cases, seemingly having become inactive. It's possible that, for some of these companies, while their current status is somewhat hazy, they will yet emerge from the mist and rejoin the active set for next year.

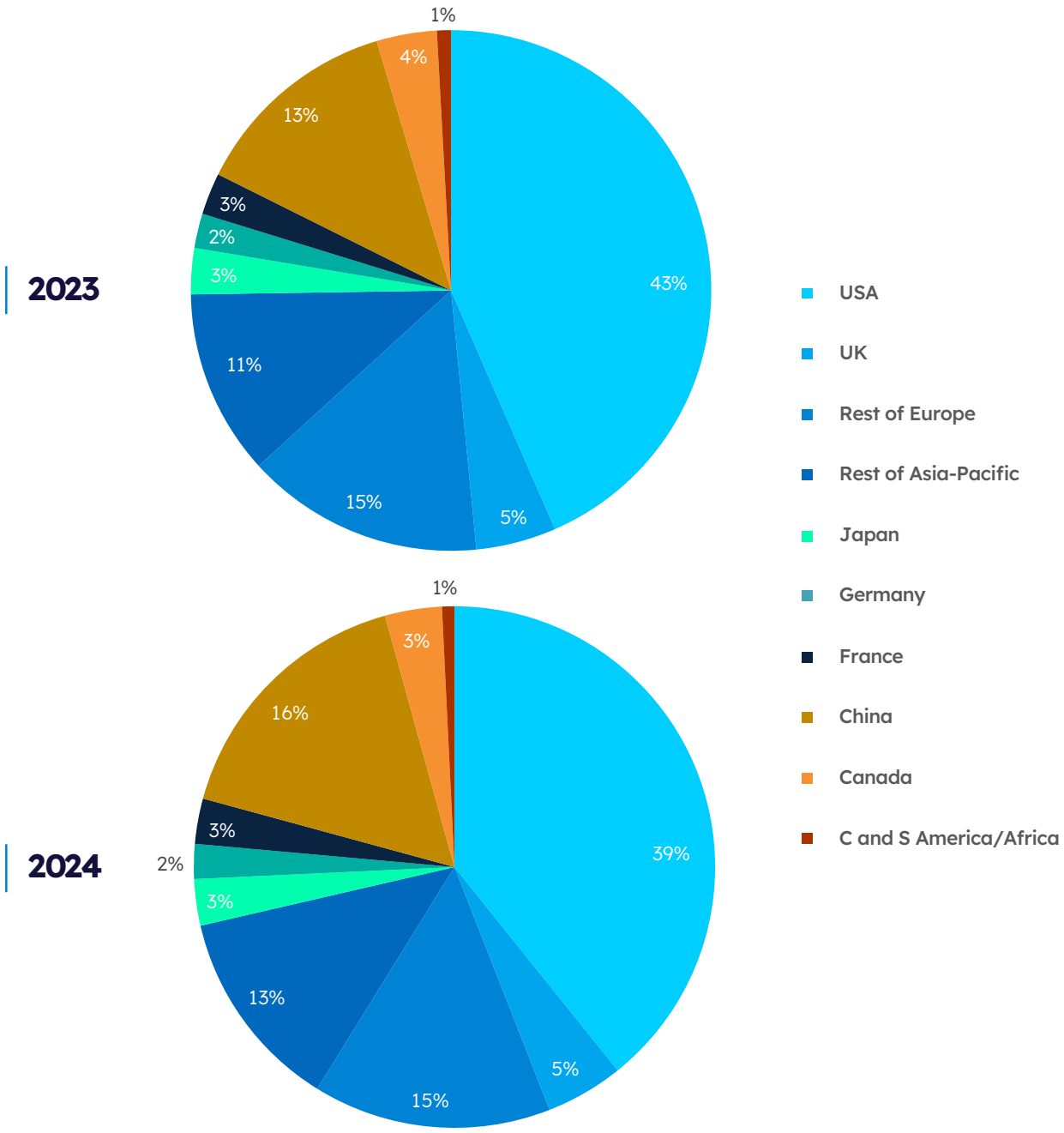
Figure 6: Total number of companies with active pipelines, 2001—24



*Estimated figure
Source: Pharmaprojects®, January 2024

Which way is the wind blowing in terms of geographies for drug development? Figure 7 suggests that the pharma pressure map indicates that the breeze is continuing to flow from west to east. We can see that, while 43% of all companies involved in pharma R&D a year ago were headquartered in the US, this figure has taken a significant dip in 2024 to 39%. Meanwhile, the proportion of China-based firms has increased once again, up from 13% to 16%. This represents an acceleration in the latter's growth, with 1,008 Chinese-headquartered companies reported this year, up from 808 last year and 792 the year before. Whereas last year we had suggested that growth in China might be slowing, in 2024, there appears to be a strengthening of the air currents in this direction from gentle to gusty.

Figure 7: Distribution of R&D companies by HQ country/region, 2023 and 2024



Source: Pharmaprojects®, January 2024

Similar trends can be observed in Table 3, which examines the locations where drug development is actually occurring. While the US still dominates, its presence is in decline. In all, 49.1% of all drugs in development have some US R&D activity; this is down from 51.1% last year, and falls below the 50% mark for the first time. Again, this ground has been ceded largely to China, which increases its share from 23.6% to 26.7%. Another Asian country, South Korea, has snuck into third place, pushing the UK into fourth. Note that the table only lists countries where 5% or more of drugs are in development. In total, our database reports active R&D in 162 countries this year.

The data for 2024 reinforce trends seen over a number of years in that R&D is experiencing an easterly airflow. This year, we have our first Chinese Top 10 pharma company, and the US losing its majority as the favored place for pharma R&D. Our forecast here is that such climactic changes are likely to continue for several years to come.

Table 3: Where is R&D actually occurring?

DRUG DEVELOPMENT COUNTRY	NUMBER OF DRUGS	% OF PIPELINE
USA	11,200	49.1
China	6,098	26.7
South Korea	3,233	14.2
UK	3,156	13.8
Germany	2,479	10.9
Canada	2,387	10.5
Australia	2,372	10.4
France	2,363	10.4
Spain	2,259	9.9
Japan	2,041	8.9
Netherlands	1,850	8.1
Italy	1,823	8.0
Belgium	1,783	7.8
Poland	1,724	7.6
Sweden	1,562	6.8
Denmark	1,536	6.7
Switzerland	1,504	6.6
Czech Republic	1,406	6.2
Hungary	1,398	6.1
Austria	1,369	6.0
Taiwan, China	1,362	6.0
Bulgaria	1,244	5.5
Finland	1,178	5.2
Portugal	1,174	5.1
Greece	1,171	5.1
Ireland	1,158	5.1
Romania	1,153	5.1
Israel	1,147	5.0
Norway	1,146	5.0

Source: Pharmaprojects®, January 2024

Therapies and Diseases
Cancer still taking R&D by storm

How many different types of weather are there?

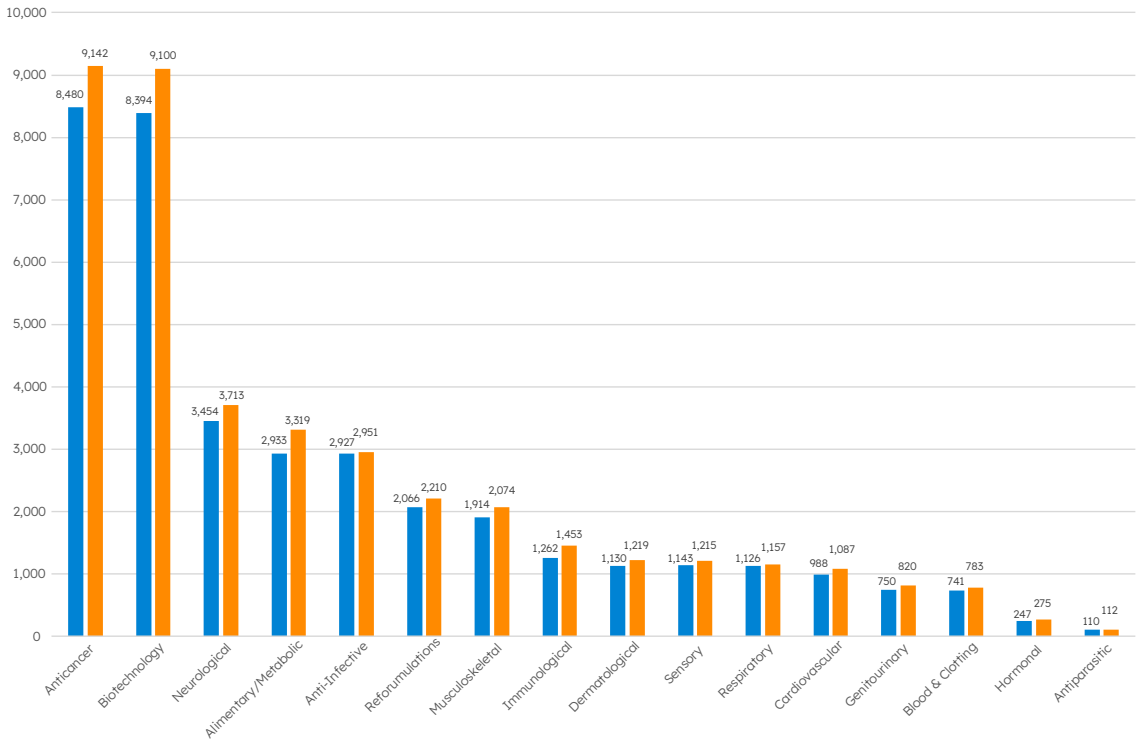
There doesn't seem to be an internationally agreed answer, and even in the various weather apps you probably have on your phone, there will probably be some discord. Try this for a basic list: sunny, partly cloudy, cloudy, drizzle, rain, stormy, foggy, windy, snowy. But, of course, many of these are not mutually exclusive. Similarly, drug development for disease types can cross multiple therapeutic areas, and we likewise assign them into a number of big buckets.

In this section, we move to looking at trends across the 14 major therapeutic area types for which drugs are under development. Just like with weather, there is no internationally agreed classification for therapeutic areas, with several ontologies such as ICD-10 and MeSH coexisting. Our own system has its origins in the EphMRA classification system, which itself is closely aligned with the well-known ATC code taxonomy.

However, over the years we have added both to the broad therapeutic areas and to the individual 250+ therapeutic categories to more closely reflect modern drug development.

We start our analysis in this area by looking at how numbers have changed year-on-year across those 14 therapeutic areas, along with the two additional classes that we created, biotechnology products and reformulations. This shows anticancer drugs reaching stratospheric levels again, with 9,142 drugs in development for oncology, up from 8,480 last year, an expansion of 7.8%, slightly ahead of the global pipeline expansion rate we reported earlier in this review. Neurologicals also marginally beat the average, with a 7.5% growth rate, but alimentary/metabolics put in a really impressive performance, swelling the pipeline by 13.1%. Meanwhile, growth in anti-infective R&D, which saw a boost during the COVID-19 pandemic but had since fallen to a below-average growth rate, has now almost stalled completely, increasing by a paltry 0.8% this year.

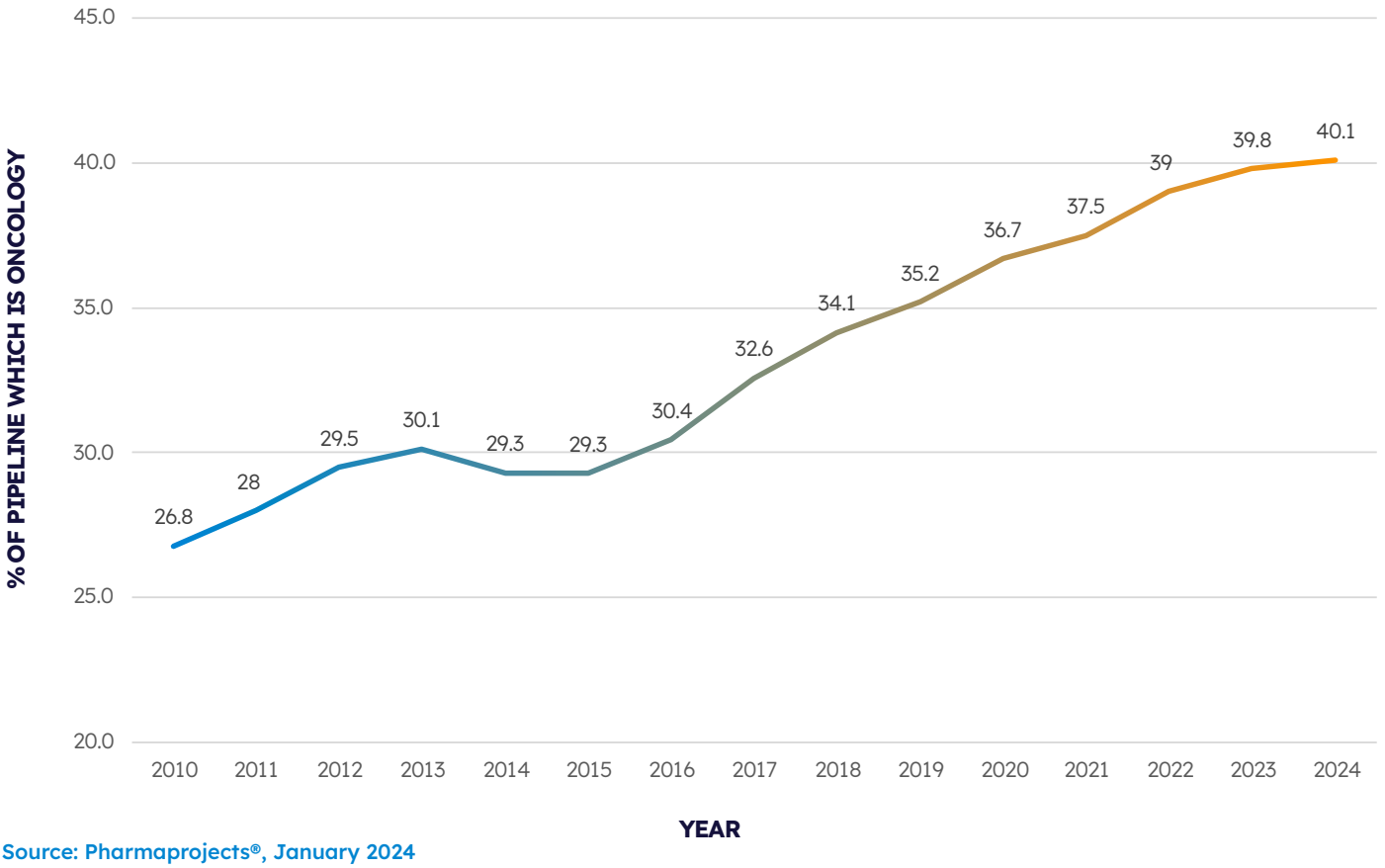
Figure 8: R&D pipeline by therapeutic area, 2023 and 2024



Source: Pharmaprojects®, January 2024

Oncology's above-average result has meant a further grab of its overall share of the pipeline, which Figure 9 shows. However, the rate at which its advance has slowed might be some comfort for the other therapeutic areas, which must be concerned to see their metaphorical polar ice caps continuing to recede.

Figure 9: Proportion of the pipeline in development for cancer, 2010—24



Source: Pharmaprojects®, January 2024

Table 4 zooms in on this analysis further, providing the Top 25 of the 243 individual therapeutic categories used to classify drugs in Pharmaprojects and the Citeline suite of products. Unsurprisingly, there are big boosts for the top two anticancer categories: anticancer, immunological (+8.2%); and anticancer, other (+8.6%). Gene therapy again comes in third, but there is further evidence of interest here peaking, with a growth rate of just 3.3% this year, down from 6.3% last year and 23.3% the year before. The Top 10 of this chart is once again pretty stable, as if an anticyclone has settled over therapeutic category changes, leading to a long period of calm weather.

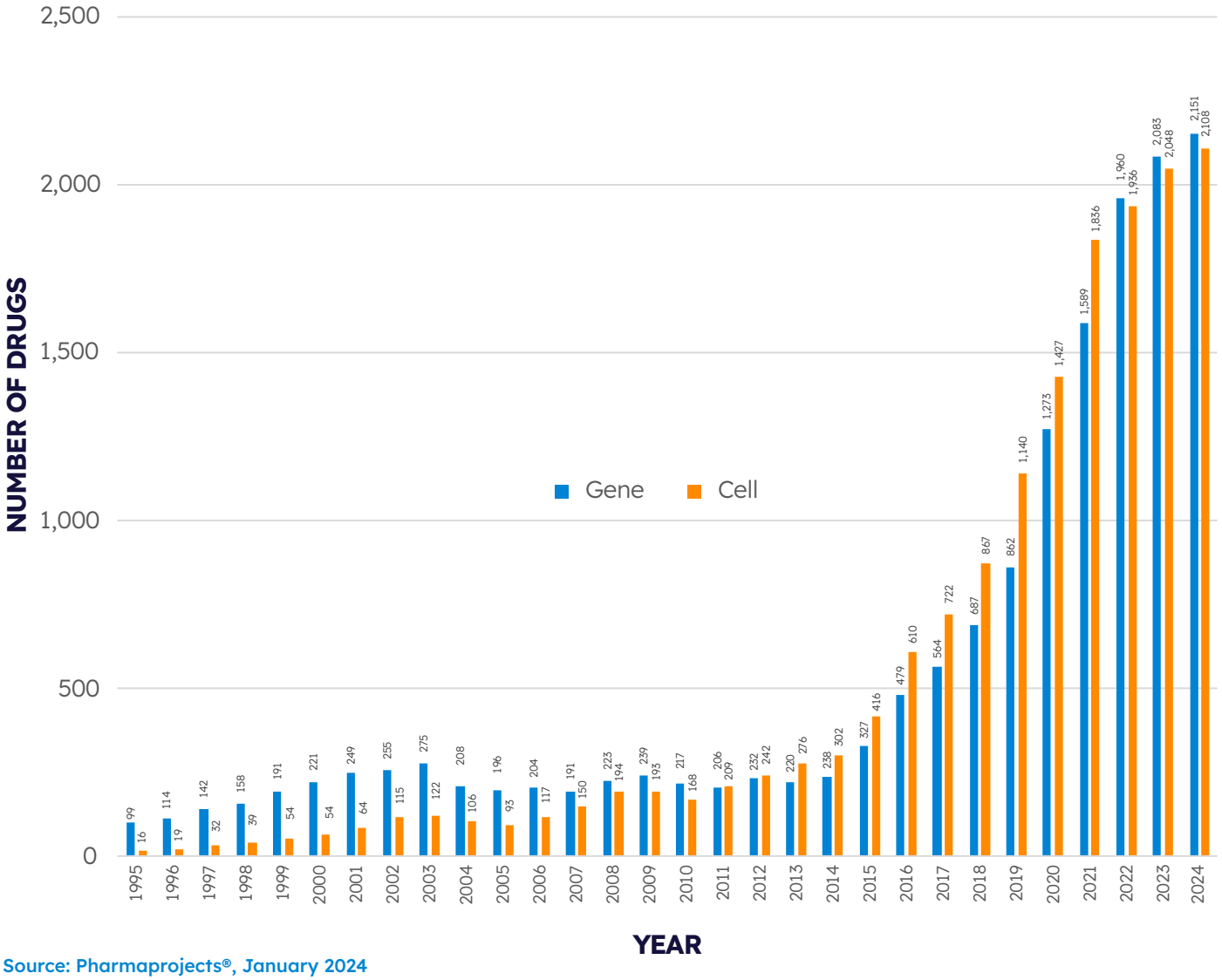
Table 4: Top therapeutic categories

POSITION 2024 (2023)	THERAPY	NUMBER OF ACTIVE COMPOUNDS 2024 (2023)	TREND
1 (1)	Anticancer, immunological	4,860 (4,492)	↑↑
2 (2)	Anticancer, other	3,935 (3,622)	↑↑
3 (3)	Gene therapy	2,151 (2,083)	↔
4 (4)	Monoclonal antibody, other	1,595 (1,395)	↑
5 (6)	Neurological	1,125 (1,045)	↔
6 (5)	Prophylactic vaccine, anti-infective	1,115 (1,064)	↔
7 (7)	Ophthalmological, other	1,054 (984)	↔
8 (8)	Antiviral, other	935 (983)	↓
9 (9)	Immunosuppressant	899 (797)	↑
10 (10)	Cellular therapy, chimaeric antigen receptor	795 (792)	↔
11 (11)	Antidiabetic	772 (747)	↔
12 (14)	Musculoskeletal	767 (677)	↑
13 (12)	Anti-inflammatory	747 (722)	↔
14 (13)	GI inflammatory/bowel disorders	740 (705)	↔
15 (15)	Cognition enhancer	702 (641)	↑
16 (17)	Monoclonal antibody, humanized	672 (624)	↑
17 (16)	Respiratory	654 (632)	↔
18 (18)	Cardiovascular	645 (599)	↑
19 (19)	Neuroprotective	632 (595)	↔
20 (20)	Hepatoprotective	618 (594)	↔
21 (21)	Dermatological	589 (559)	↔
22 (22)	Urological	578 (519)	↑
23 (24)	Antiparkinsonian	570 (516)	↑
24 (32)	Antibody-drug conjugate	551 (405)	↑↑
25 (23)	Analgesic, other	547 (517)	↔

Source: Pharmaprojects®, January 2024

Despite the fact that gene therapy and cell therapy growth appears from this table to be slowing, they both remain major drivers of drug development. Figure 10 shows this, but also reinforces the fact that their rates of expansion are slowing down from the frankly remarkable snowballing of R&D seen in the last decade. Of course, these two categorizations are not mutually exclusive; indeed, 1,192 drugs are classified as both — these are generally therapeutics whereby cells are removed from the body, genetically altered ex vivo, and then reintroduced to the patient (such as with CAR-T therapies). This means there are 959 gene therapies which are not also cell therapies; these will be primarily in vivo gene therapies, where genes are delivered in vivo to cells via a vector, or where genes are edited using newer, cutting-edge technologies (of which more later). This figure has grown from 886 last year. Cell therapies without a gene therapy component now stand at 916, up from 852.

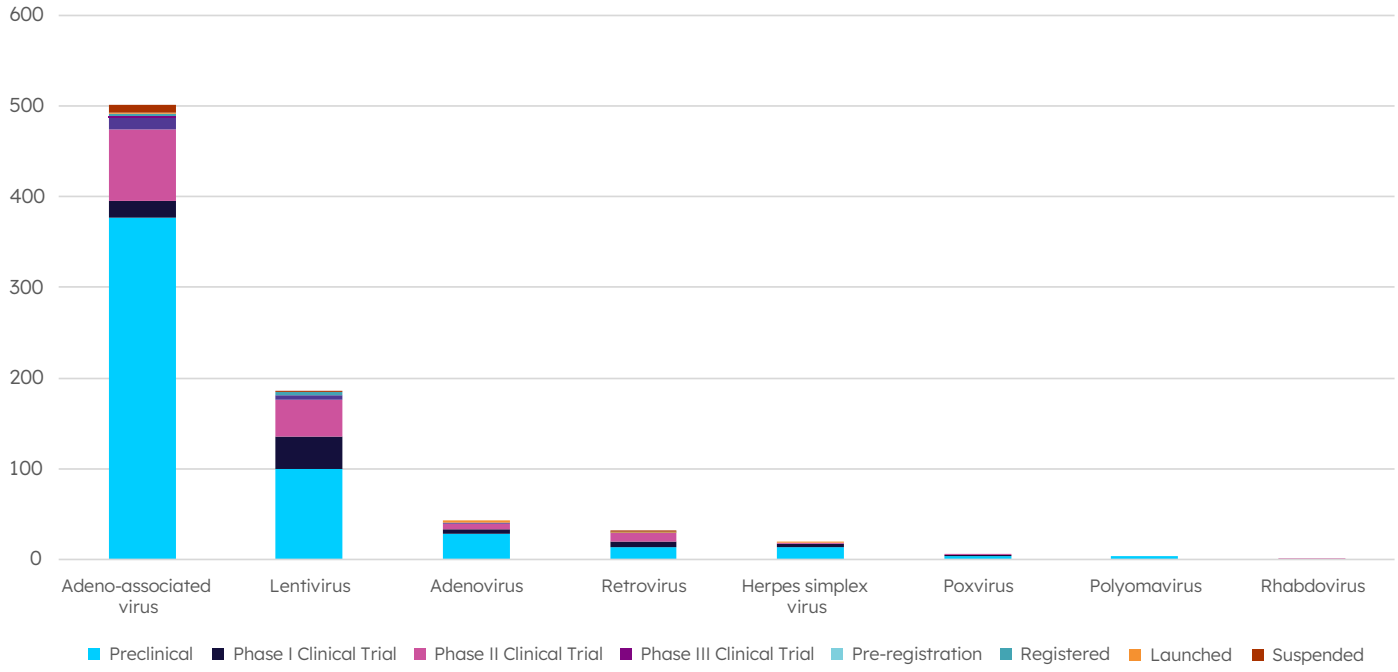
Figure 10: The ongoing rise of gene and cell therapies



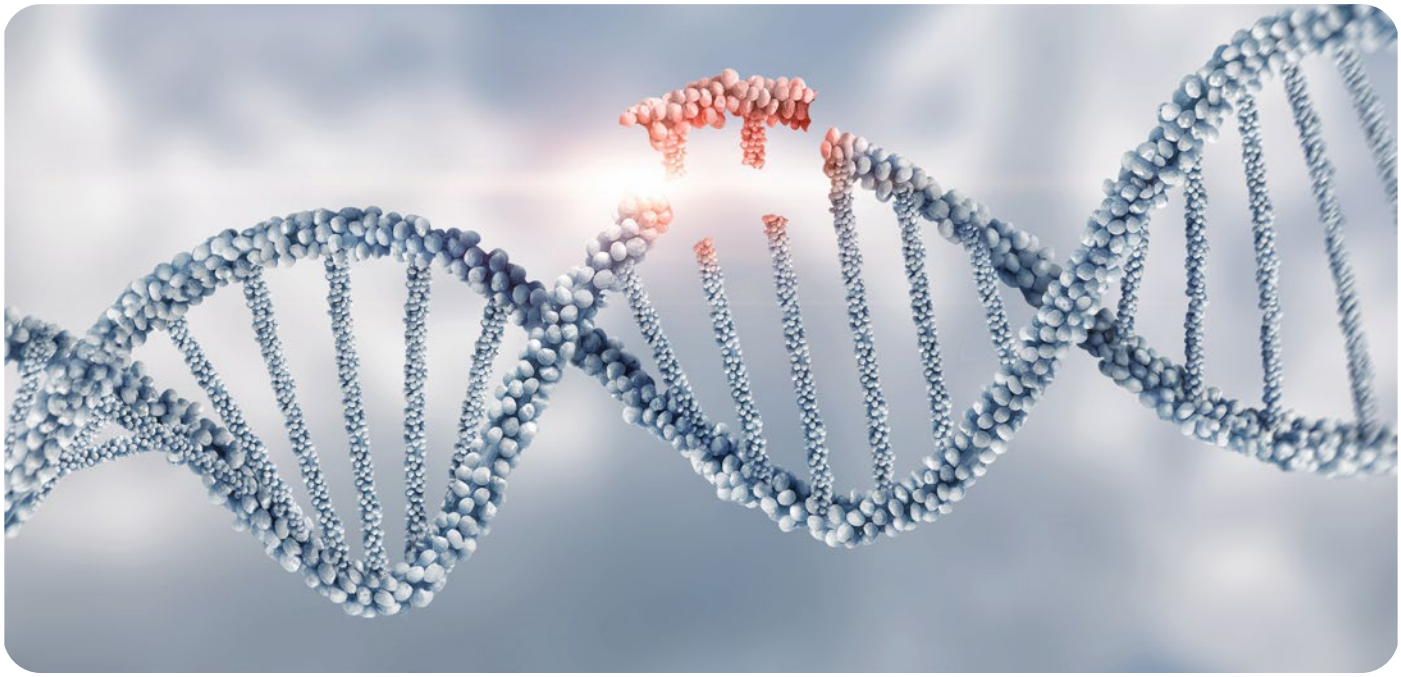
Source: Pharmaprojects®, January 2024

Within the umbrella term of gene therapy, a multitude of different technologies are covered, with one major variation being how the genetic change is introduced into cells. Whereas sometimes this is achieved via chemical methods or using plasmids, by far the most common method is to use a viral vector. The breakdown of the viral vector types is shown in Figure 11, which further breaks each down by global phase of development. You can see here that, by some measure, adeno-associated viral (AAV) vectors are both the most popular and the most mature. They account for just over 500 projects, including two of the six launched gene therapies using viral vectors. They also have significant numbers of drugs at Phase I, II, and III, although much of the work here is still at the preclinical stage of development. Lentiviruses come in second; this type of vector is more commonly used for ex vivo transfection of cells. Whereas the number of projects using AAV vectors has increased this year, lentivirus use is in decline, with 185 drugs this year, down from 241. The use of adenovirus took an even bigger tumble, falling from 109 to 43. AAV seems to be the weapon of choice.

Figure 11: Viral vectors used in gene therapies

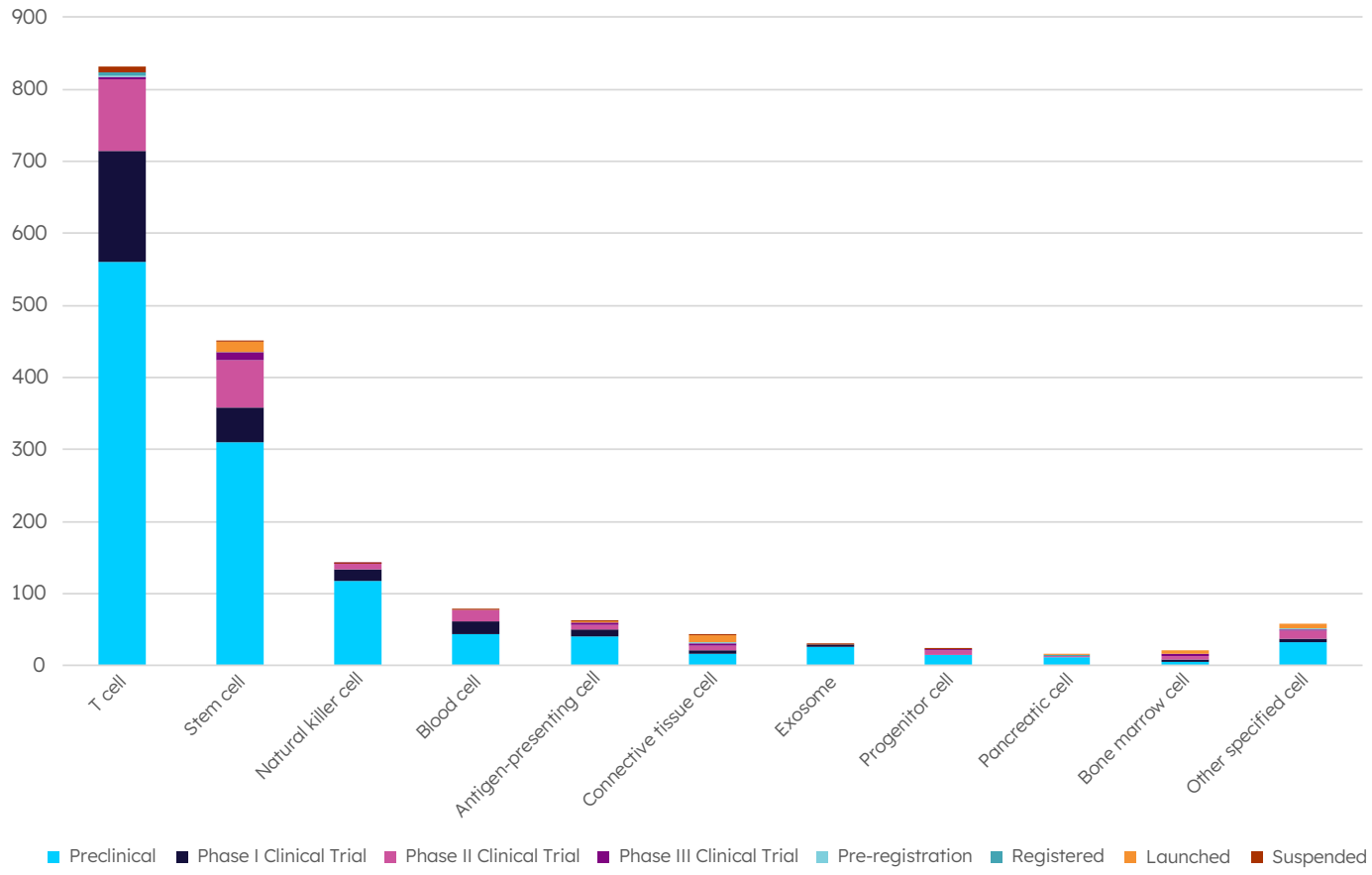


Source: Pharmaprojects®, January 2024



The types of cells used for cell therapy are considerably more diverse, with in total 24 different kinds of cells currently being employed. T cells remain the most popular, due to their predominance in the popular CAR-T-based therapeutics, although there are somewhat fewer this year. In contrast, the temperature is rising for stem cells, which have posted a modest increase, along with blood cells and antigen-presenting cells. Figure 12 has the details.

Figure 12: Cell types used in cell therapies



Source: Pharmaprojects®, January 2024

We now move to what is always one of the most interesting Top 25s — the individual diseases on which the pharmaceutical industry is focusing its attention most. These are listed in Table 5, where it should be noted that only specific diseases are listed; non-specific indications such as "Cancer, unspecified" have been removed from this analysis.

Table 5: Top 25 diseases/indications

POSITION 2024 (2023)	THERAPY	NUMBER OF ACTIVE COMPOUNDS 2024 (2023)	TREND
1 (1)	Cancer, breast	1,031 (965)	↑
2 (2)	Cancer, lung, non-small cell	1,010 (925)	↑↑
3 (3)	Cancer, colorectal	825 (741)	↑↑
4 (4)	Cancer, pancreatic	740 (675)	↑
5 (6)	Cancer, ovarian	625 (587)	↔
6 (5)	Cancer, brain	580 (539)	↑
7 (7)	Infection, coronavirus, novel coronavirus	580 (653)	↓
8 (8)	Cancer, prostate	576 (523)	↑
9 (9)	Alzheimer's disease	563 (529)	↔
10 (10)	Cancer, liver	501 (444)	↑
11 (11)	Diabetes, Type 2	498 (475)	↔
12 (14)	Cancer, leukaemia, acute myelogenous	497 (484)	↔
13 (12)	Cancer, melanoma	496 (476)	↔
14 (13)	Cancer, gastrointestinal, stomach	473 (449)	↔
15 (15)	Cancer, myeloma	459 (445)	↔
16 (17)	Parkinson's disease	457 (407)	↑
17 (16)	Arthritis, rheumatoid	449 (431)	↔
18 (18)	Cancer, head and neck	432 (408)	↔
19 (19)	Infection, coronavirus, novel coronavirus prophylaxis	425 (444)	↓
20 (20)	Cancer, lymphoma, non-Hodgkin's	419 (399)	↔
21 (21)	Non-alcoholic steatohepatitis	383 (369)	↔
22 (22)	Psoriasis	348 (337)	↔
23 (24)	Obesity	300 (230)	↑↑
24 (32)	Cancer, renal	299 (281)	↔
25 (23)	COVID-19 complications	285 (332)	↓

Source: Pharmaprojects®, January 2024

Breast cancer remains the hottest place on the temperature chart, with a pipeline that has warmed up by a further 6.8%, slightly below the overall expansion rate. As a result, it is in danger of being overtaken by second-placed non-small cell lung cancer, which itself advanced by 9.2%. Even more impressively, at number 3, the size of the colorectal cancer pipeline has risen by 11.3%. Tumors of the pancreas, the ovary, and the brain round off an all cancer top six this year. The incursion made into the top five by the novel coronavirus has now ended, with this indication dropping to number 7 with a pipeline that shrank by 11.2%. Nonetheless, with 580 drugs in

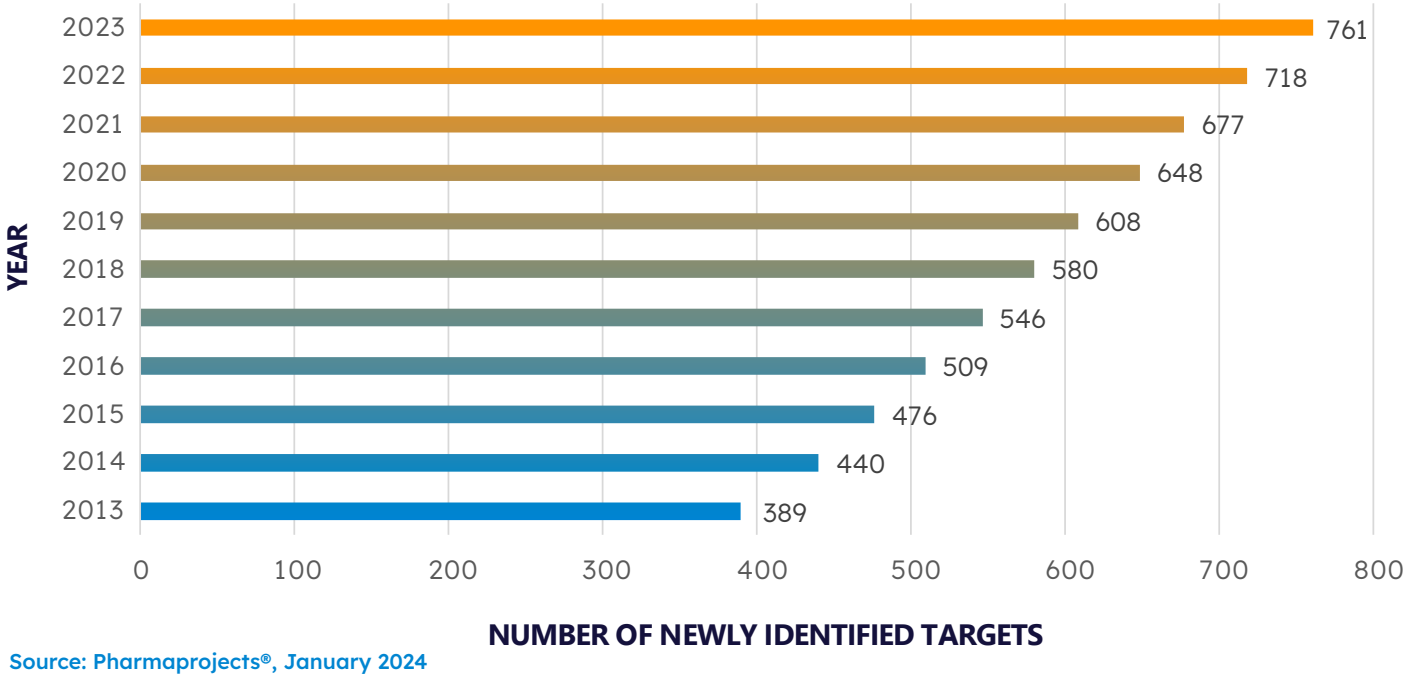
development against it, there is still significant effort being put into the ongoing battle with the virus, which thankfully has now become endemic rather than pandemic.

Elsewhere, that eternal tough nut to crack, Alzheimer's disease, remains as the only other non-oncology disease in the Top 10, which also sees a new entrant in the form of liver cancer, up a significant 12.8%. Further down in the Top 25, we see declines for two further COVID-19-related categories, those covering vaccines and complication therapies; but again, there is still considerable activity in both. Perhaps the most striking change in an otherwise fairly stable table is the 30% increase in the R&D of drugs to treat obesity. This is no doubt related to the success of Novo Nordisk's Wegovy (semaglutide), which was first launched for this additional indication in mid-2021, setting off a stampede for access that has led to supply issues. Note that this global picture masks some regional variations in the most popular disease targets for drug R&D, which we will look at later in this report.

While sunshine, cloudy skies, or rain showers are commonplace for most of us, there are some weather events which are thankfully rarer. 2023 saw a number of freak weather events across the globe: temperatures plunging to -28°C (-18.4°F) in Afghanistan, flooding in California and South Korea, heat-induced wildfires in Canada and Hawaii, and a record-breaking cyclone in Brazil. Climate change appears to increase the frequency of extreme weather, a concern for us all. For most of us, such catastrophic weather events can still be considered rare. But they nevertheless quite rightly grab our attention.

There is also a big focus on rare diseases in pharma R&D. Such syndromes may not affect many of us, but for those unfortunate enough to suffer from them, they can be similarly devastating. This, and the big paydays pharma can command for successfully developing drugs for orphan indications, means that rare diseases are a major focus for the pharmaceutical industry too. In Pharmaprojects, a rare disease is defined as one with a prevalence of 1 in 2,000 people in the EU, or affecting fewer than 200,000 people in the US (equivalent to around 1 in 1,600 people). Figure 13 demonstrates that the number of individual rare diseases being targeted by drug development continues to grow, hitting 761 by the end of 2023, with slightly more new additions to this pot over the course of that year than during the previous one.

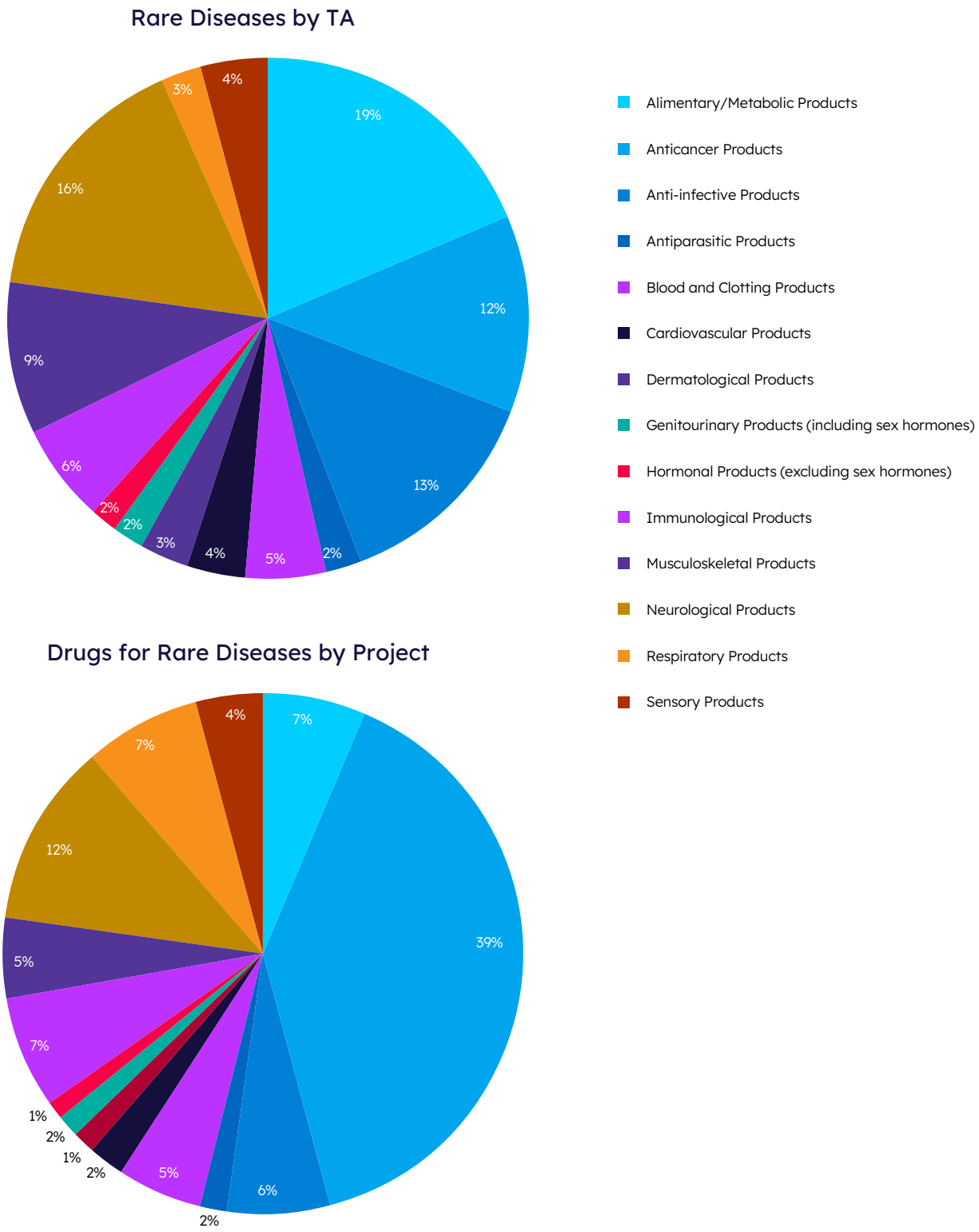
Figure 13: Number of rare diseases being targeted by pharma



Source: Pharmaprojects®, January 2024

In total, the number of drugs under development for rare diseases at the start of 2024 hit 7,191, up 7.6% from last year's 6,682, and representing 31.5% of all drugs in the pipeline, up a shade from 30.2% in 2023. As Figure 14 shows, the largest proportion of rare diseases, 19%, sit in the alimentary/metabolic area — this is not surprising, since there are many rare inherited genetic conditions that cause disorders of the metabolism. In contrast, cancer is only the fourth most common therapeutic area for rare diseases. Despite this, it still commands the most attention in terms of drugs under development, with 39% of all drugs in R&D for rare diseases being for a rare cancer. By this measure, alimentary/metabolic is pushed to joint third place, with a paltry 7% of the effort sitting there.

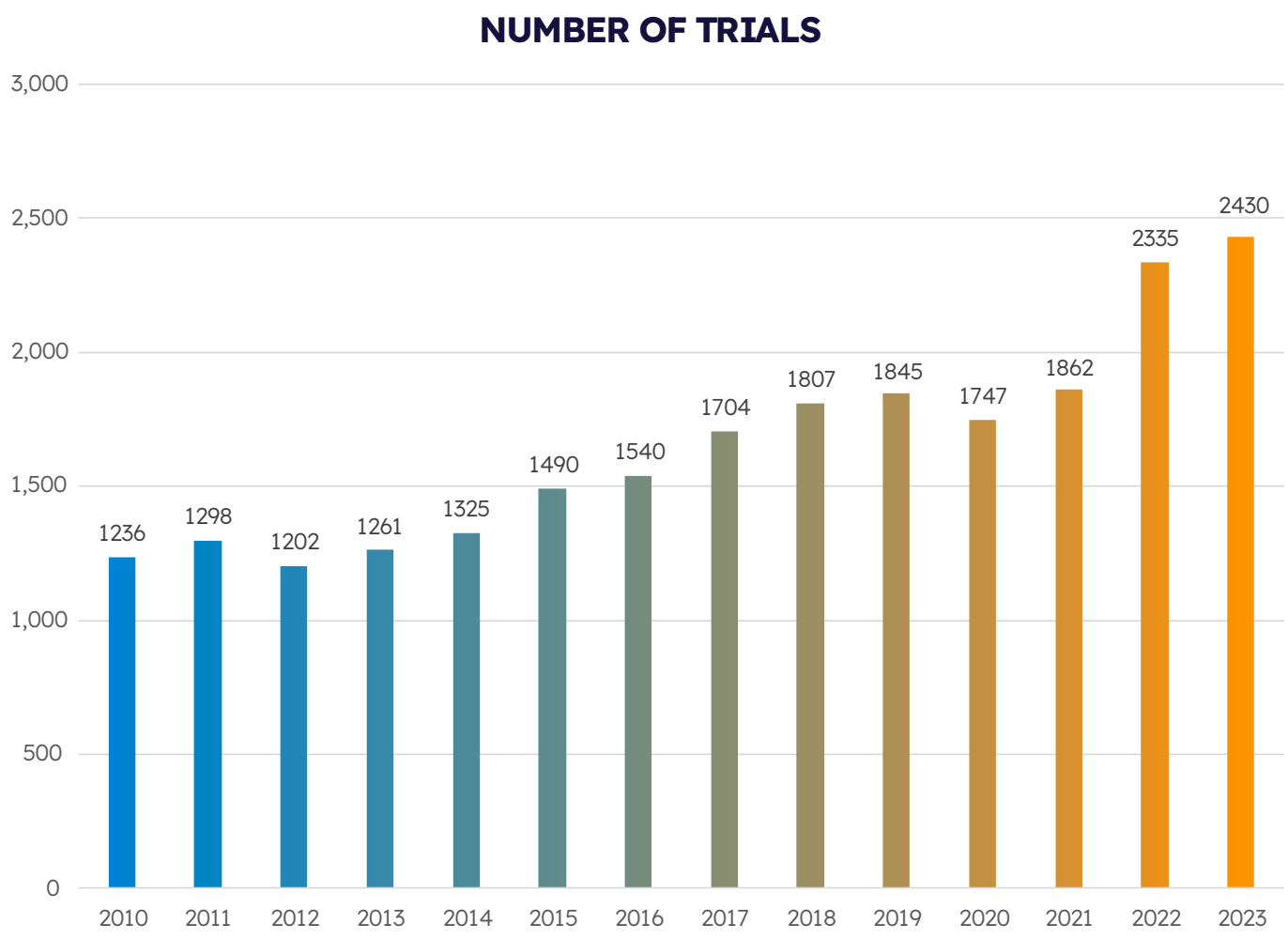
Figure 14: Rare diseases by therapeutic area, by number of diseases and number of drugs



Source: Pharmaprojects®, January 2024

Like all drug R&D, most of the rare disease work is at the preclinical stage, some of it at the cutting edge of development techniques. But there is considerable clinical activity too. Data from Trialtrove, another product in the Citeline suite that tracks individual clinical trials, shows that there were 2,430 clinical trial starts associated with rare disease-focused drugs during 2023 — up from 2022's figure, but by a somewhat lower percentage than in the previous 12 months (Figure 15).

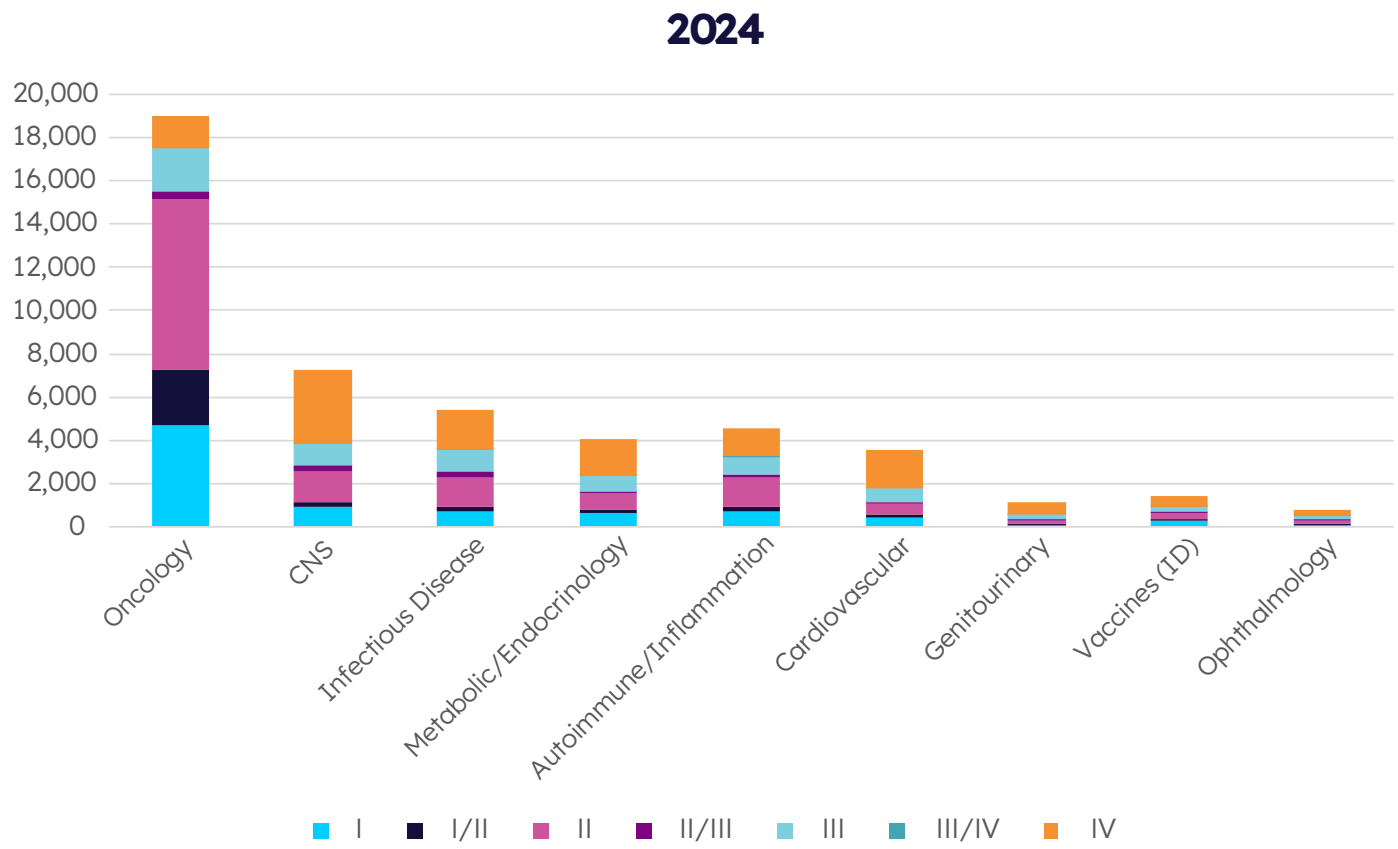
Figure 15: Industry-sponsored rare disease trials by start date, 2010—present



Source: Trialtrove®, January 2024

While we're on the subject of clinical trial statistics rather than drugs, let's take a look at all of the ongoing (open, closed, or temporarily closed) clinical trials reported by Trialtrove during 2023. Figure 16 breaks this down by trial phase and by therapeutic area (note that Trialtrove uses slightly different therapeutic areas from Pharmaprojects). The dominance of cancer is far more pronounced here, skewed by the fact that oncological candidates may often be tested in multiple clinical trials across different cancer types. There are 18,966 trials under way in cancer at the start of 2024, a 7.7% rise on 2023's figure, representing a slight slowdown in the growth rate from last year's 8.7%. CNS in second posted a similar growth rate of 7.6%. But infectious disease in third reported a decline of 3.1%, the strongest evidence yet that the spike caused by the COVID crisis is well and truly over (note that infectious disease vaccines was the only other therapeutic area to show a drop). Indeed, the number of novel coronavirus-related ongoing trials took a tumble this year, standing at 2,016, down from 2,384 last year.

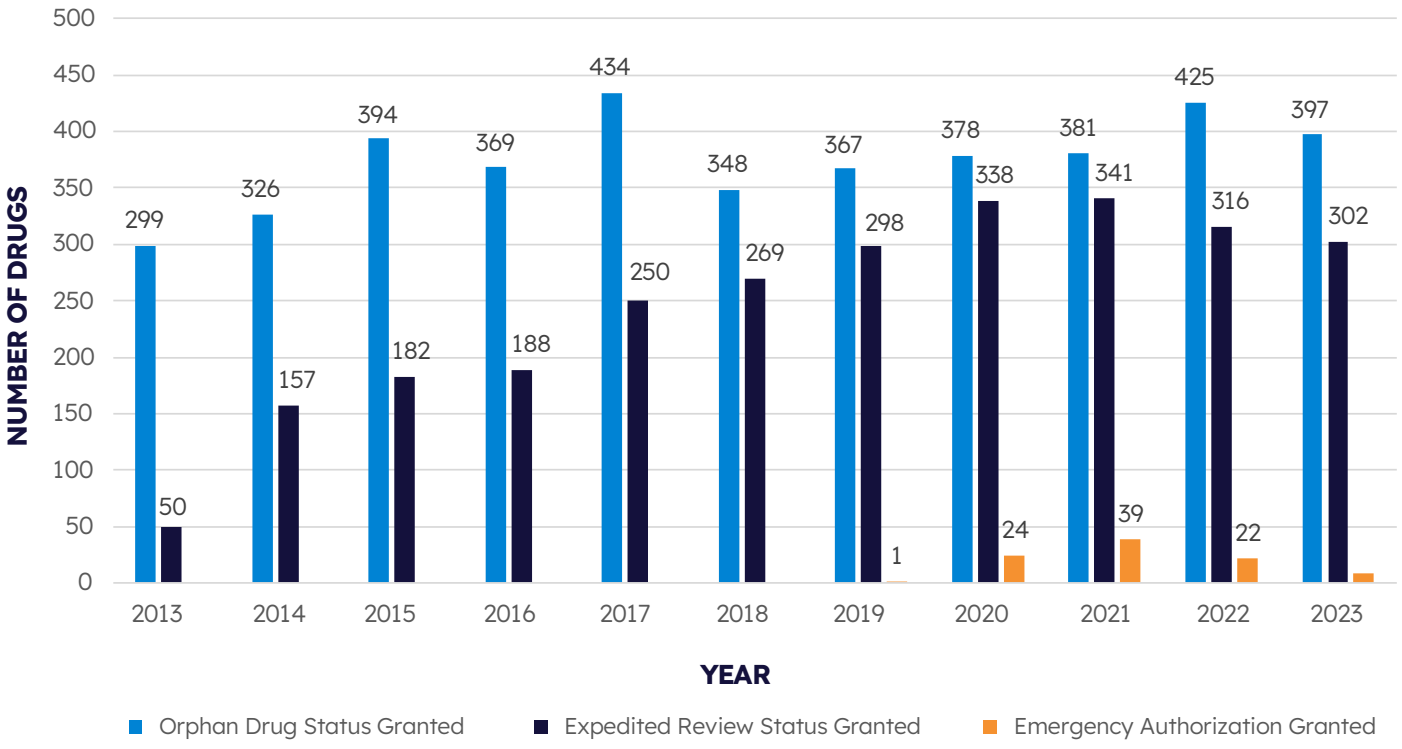
Figure 16: Ongoing clinical trials, by therapeutic area



Source: Trialtrove®, January 2024

The number of approvals of emergency authorization — a strategy which came to the fore during the pandemic — fell back too last year. Figures for this metric, shown in Figure 17, would seem to exactly track the course of the crisis. The amount of orphan drug and expedited review designations also dropped slightly in 2023.

Figure 17: Numbers of drugs receiving Orphan Drug status, Expedited Review designation*, and Emergency Authorization, 2013—23**



***Data for 2013 not complete as we only began systematically recording the dates of these events mid-year.**
****Emergency Authorizations only tracked from 2019.**

Source: Pharmaprojects®, January 2024

So, we seem to be entering a sunshine-after-the-rain period of drug development, as the clouds of COVID, if not exactly dissipating, appear to be scooting out to sea towards the horizon. And the horizons for drug R&D are still expanding; there are 1,514 individual diseases being targeted by active drug development this year, up from 1,452 a year ago. The pandemic actually accelerated progress in drug development in a number of areas, such as the use of mRNA-based vaccine technology. In that sense, the coronavirus-shaped cloud really does seem to have had a silver lining.

Regional Variations

Where the outlook seems to be brightest

While understanding changes in global climate is undoubtedly important, such data are not likely to be of much use in helping you to decide whether you can wear shorts tomorrow or whether you need to bring a woolly hat. So, new for this year's report, we are introducing several regional sub-analyses, looking at pipeline size growth rates, leading companies, and top diseases across a range of some of the largest pharmaceutical markets across the world. Is it sunny in China, but tipping it down across Europe?

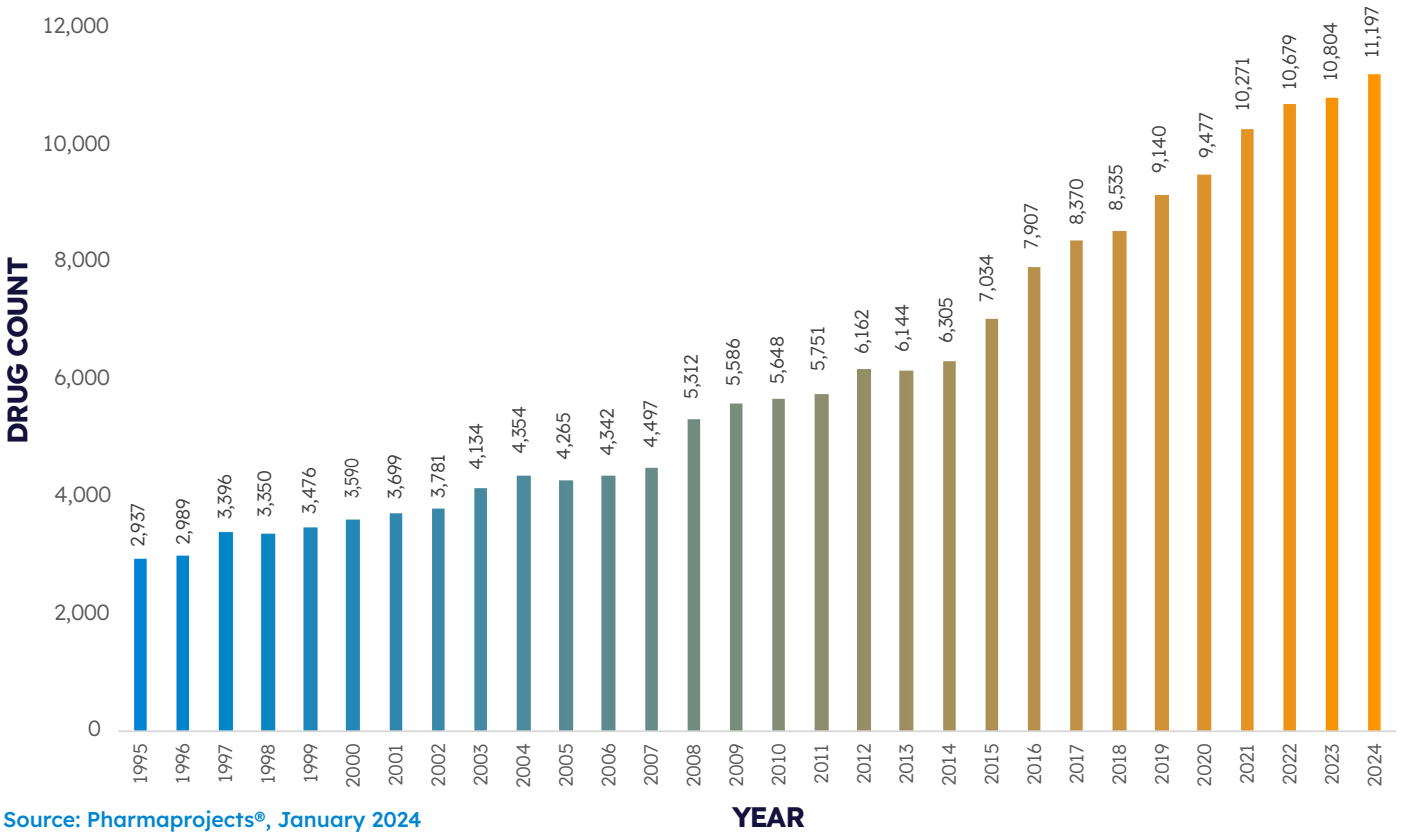
Let's find out...

United States

It seems prudent to start our regional analyses in the largest of the world's pharma markets, the US. The number of drugs in active development in the US has consistently grown since 1995, with an average pipeline increase of 284.8 drugs per year, corresponding to 4.8% year-on-year (YoY) growth. While the number of active pipeline drugs continues to increase in the US, the rate of growth has decelerated.

From 2023 to 2024, there was an increase of 393 active drugs in the US pipeline, equivalent to 3.6% YoY growth. This is around half the overall global pipeline growth rate of 7.3%. The US has historically been a powerhouse of drug development, but, as we have seen, has been ceding some ground in recent years. Since 2021, the US's annual pipeline growth rate has been well below the worldwide growth rate (2.9 percentage points [pp] lower in 2021–22, 4.4pp lower in 2022–23, and 3.7pp lower in 2023–24).

Figure 18: Total US R&D pipeline size, 1995—2024



Source: Pharmaprojects®, January 2024

As of January 2024, there were 2,609 companies developing drugs that are headquartered in the US. Of these, 39.9% were developing one drug, 83.5% were developing ≤5 drugs, and 96.6% were developing ≤10 drugs. The Top 10 companies are listed in Table 6, alongside the size of their pipelines.

(Note: data in this chapter were pulled at a slightly later date than the data used for Table 1, hence there may be minor differences in numbers.)

Table 6: Top 10 US—headquartered companies by size of pipeline

COMPANY	PIPELINE DRUGS
Pfizer	204
Johnson & Johnson	149
Eli Lilly	144
Merck & Co.	139
AbbVie	109
Bristol-Myers Squibb	106
Gilead Sciences	85
Amgen	76
Regeneron	74
Moderna	69

Source: Pharmaprojects®, January 2024

The Top 10 diseases in active development in the US are of course dominated by cancer indications, but here, non-small cell lung cancer tops the table, pushing breast cancer into second. Two non-cancer indications appear in the Top 10 disease list for the US: Alzheimer's disease (ranked sixth with 236 drugs in development, higher than globally) and the novel coronavirus (ranked ninth with 224 drugs in development, lower than globally). The Top 10 diseases in development in the US are nearly identical to the Top 10 worldwide list, the only exception being that acute myelogenous leukemia appears in the US Top 10, replacing liver cancer from the worldwide list.

Table 7: The US's Top 10 diseases for pipeline drugs

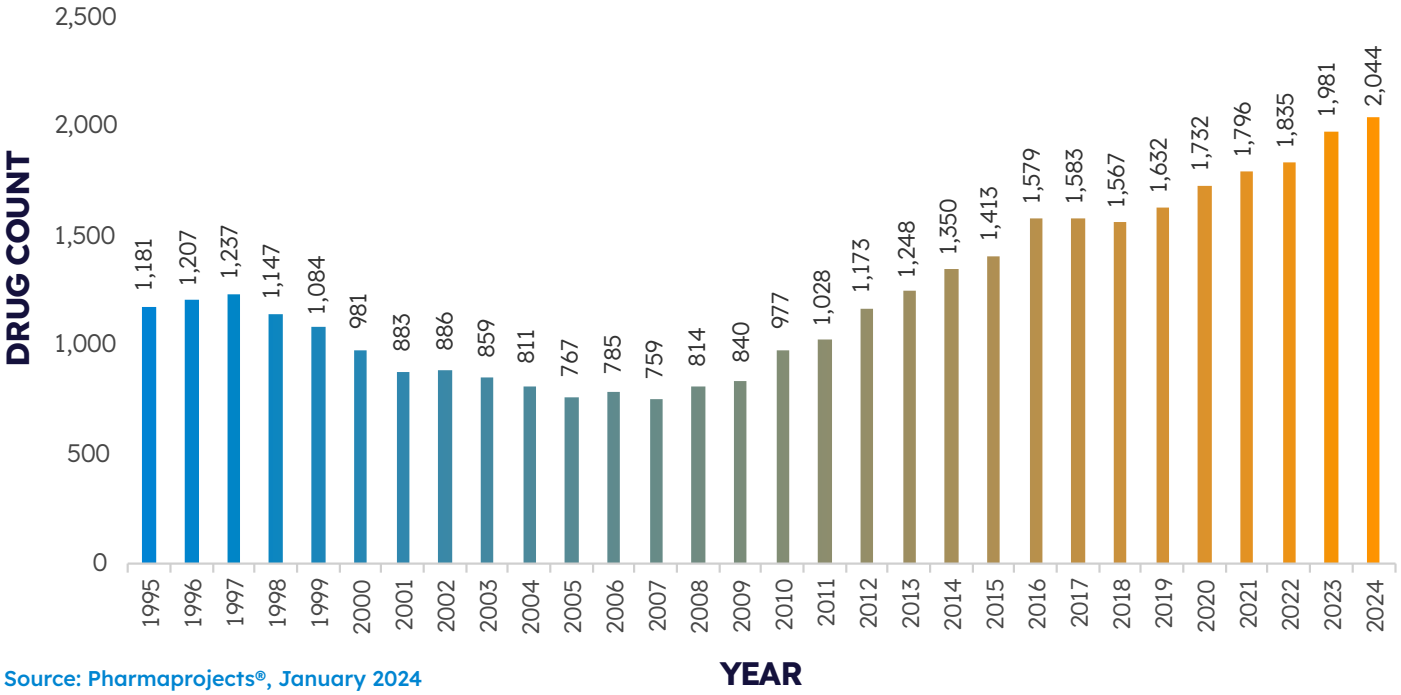
POSITION	DRUG DISEASE	PIPELINE DRUGS
1	Cancer, lung, non-small cell	414
2	Cancer, breast	356
3	Cancer, colorectal	287
4	Cancer, pancreatic	249
5	Cancer, ovarian	237
6	Alzheimer's disease	236
7	Cancer, brain	235
8	Cancer, prostate	225
9	Infection, coronavirus, novel coronavirus	224
10	Cancer, leukaemia, acute myelogenous	223

Source: Pharmaprojects®, January 2024

Japan

The size of Japan's R&D pipeline has steadily increased since 2007, following an overall decrease in pipeline size from 1995. The pipeline has increased by an average of 75.6 drugs per year since 2007, with a mean 6.1% YoY growth rate. From 2023 to 2024, the number of drugs in active R&D in Japan increased from 1,981 to 2,044, corresponding to a 3.2% growth rate. Based on these data, while the number of pipeline drugs continues to increase in Japan, the rate of growth has begun to decelerate. That said, since 2007, growth of Japan's pipeline has largely kept pace with the rest of the world. The average worldwide annual rate of pipeline growth since 2007 is 6.9%, only 0.8pp higher than in Japan.

Figure 19: Total Japan R&D pipeline size, 1995—2024



Source: Pharmaprojects®, January 2024

As of January 2024, there were 184 companies developing drugs that are headquartered in Japan. Of these, 35.3% were developing one drug, 63.6% were developing ≤5 drugs, and 83.7% were developing ≤10 drugs. The Top 10 Japanese companies are listed in Table 8, alongside the size of their pipelines.

Table 8: Top 10 Japan-headquartered companies by size of pipeline

COMPANY	PIPELINE DRUGS
Takeda	130
Astellas Pharma	74
Eisai	73
Daiichi Sankyo	55
Ono Pharmaceutical	50
Shionogi	48
Otsuka Pharmaceutical	34
Sosei Heptares	32
Taiho	32
Mitsubishi Tanabe Pharma	31

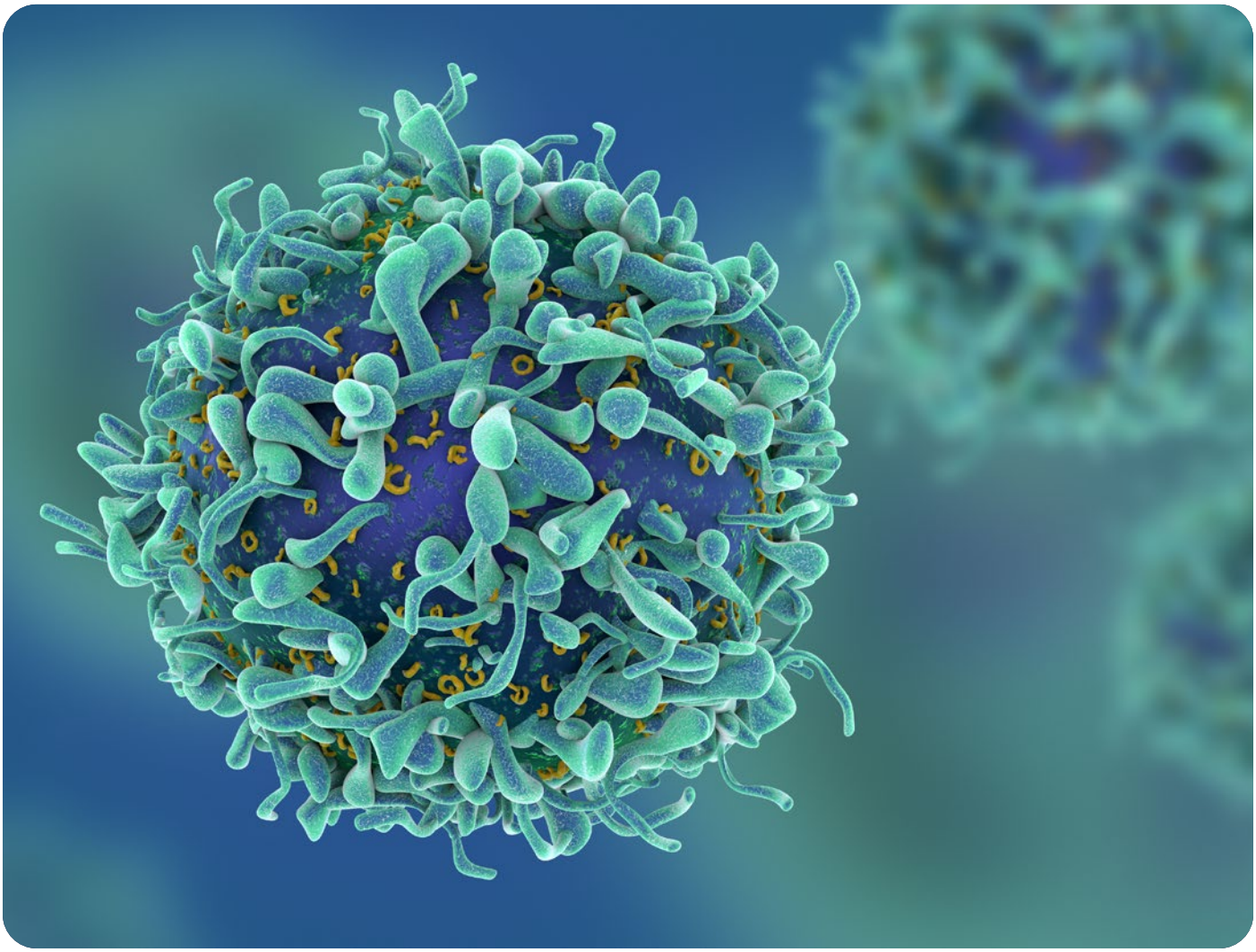
Source: Pharmaprojects®, January 2024

Cancer indications dominate Japan's Top 10 diseases in active development, taking seven out of the 10 spots. However, while all the cancer indications are solid forms in the worldwide Top 10 diseases (breast, non-small cell lung, colorectal, pancreatic, ovarian, brain, prostate, and liver), Japan's Top 10 list also includes the hematological cancers of non-Hodgkin's lymphoma and myeloma. The non-cancer indications included in Japan's Top 10 differ from both the worldwide list and that of the US, being type 2 diabetes, ulcerative colitis, and rheumatoid arthritis.

Table 9: Japan's Top 10 diseases for pipeline drugs

POSITION	DRUG DISEASE	PIPELINE DRUGS
1	Cancer, lung, non-small cell	97
2	Cancer, breast	56
3	Cancer, colorectal	53
4	Cancer, gastrointestinal, stomach	43
5	Diabetes, Type 2	40
6	Cancer, lymphoma, non-Hodgkin's	38
7	Cancer, pancreatic	34
8	Colitis, ulcerative	33
9	Arthritis, rheumatoid	32
10	Cancer, myeloma	31

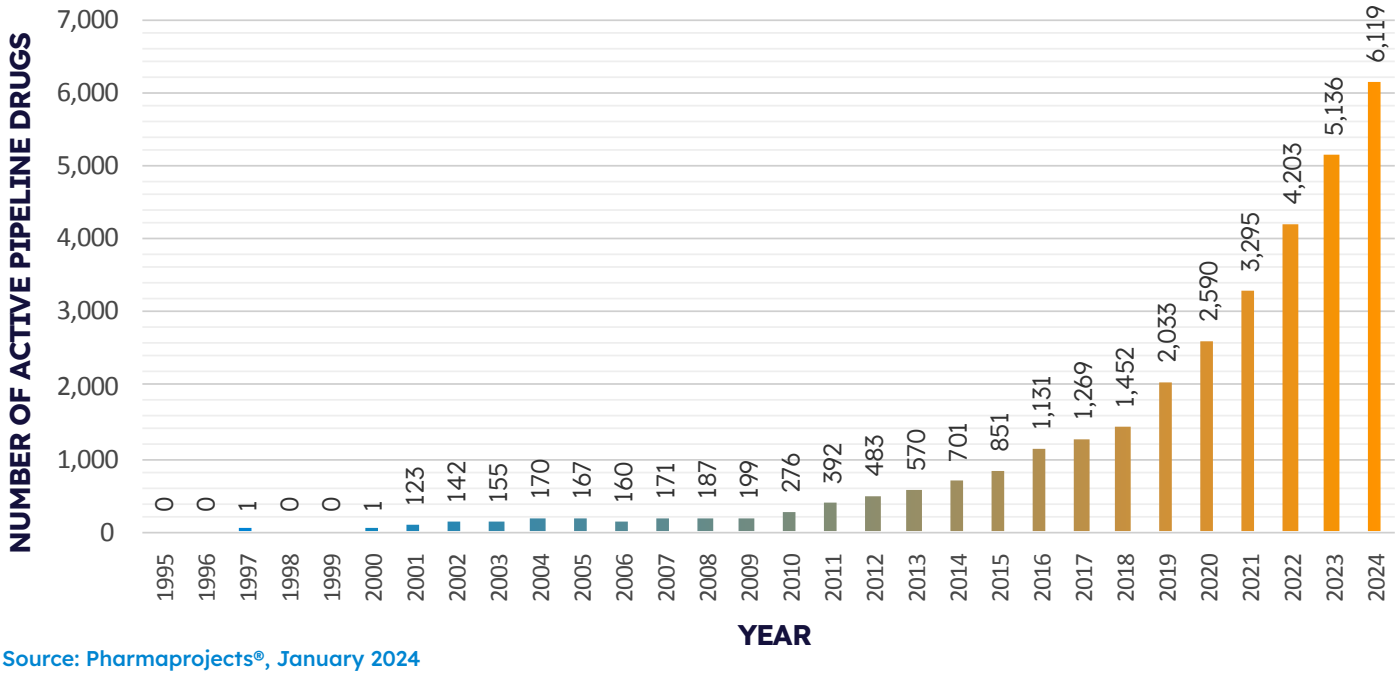
Source: Pharmaprojects®, January 2024



China

Although Chinese R&D companies only emerged into the pharmaceutical market in 1997, with one active drug in the market, they are currently responsible for developing 26.7% of globally active drugs, as we've seen, making China the second-largest developer of new drugs. This reflects the staggering growth China has gone through. The last five years have seen a boom for Chinese drug development with an increase of 200.9% since 2019, as shown in Figure 20, partly due to the surge of government investment in the pharmaceutical sector.

Figure 20: Total China R&D pipeline size, 1995—2024



Source: Pharmaprojects®, January 2024

There are a total of 1,270 pharmaceutical companies headquartered in China, which as previously noted is now a total that is second only to the US. The Top 10 companies in China can be seen in Table 10. From 2023 to 2024, the size of the active pipelines of nine of the Top 10 Chinese companies increased, reflecting the growth seen across the Chinese pharmaceutical sector.

Table 10: Top 10 China-headquartered companies by size of pipeline

COMPANY	PIPELINE DRUGS 2024
Jiangsu Hengrui Pharmaceuticals	147
Sino Biopharmaceutical	103
Shanghai Fosun Pharmaceutical (Group)	90
CSPC Pharmaceutical	73
BeiGene	58
Shanghai Junshi Biosciences	57
Shanghai Pharmaceuticals Holding	51
Innovent Biologics	50
Qilu Pharmaceutical	50
Huadong Medicine	44

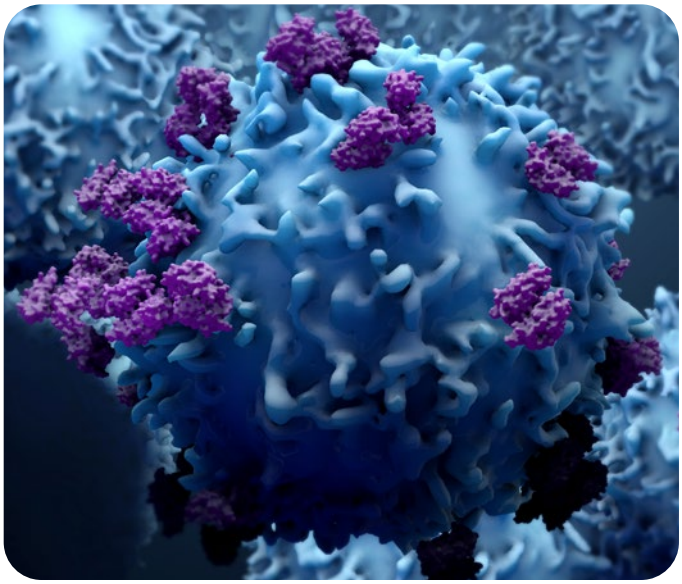
Source: Pharmaprojects®, January 2024

As shown in Table 11, nine out of the Top 10 diseases in China are forms of cancer, with the top three being non-small cell lung cancer, breast cancer, and gastrointestinal stomach cancer.

Table 11: China's Top 10 diseases for pipeline drugs

POSITION	DRUG DISEASE	NUMBER OF DRUGS
1	Cancer, lung, non-small cell	383
2	Cancer, breast	325
3	Cancer, gastrointestinal, stomach	227
4	Cancer, colorectal	218
5	Cancer, liver	207
6	Diabetes, Type 2	187
7	Cancer, pancreatic	169
8	Cancer, lymphoma, non-Hodgkin's	168
9	Cancer, myeloma	159
10	Cancer, leukaemia, acute myelogenous	141

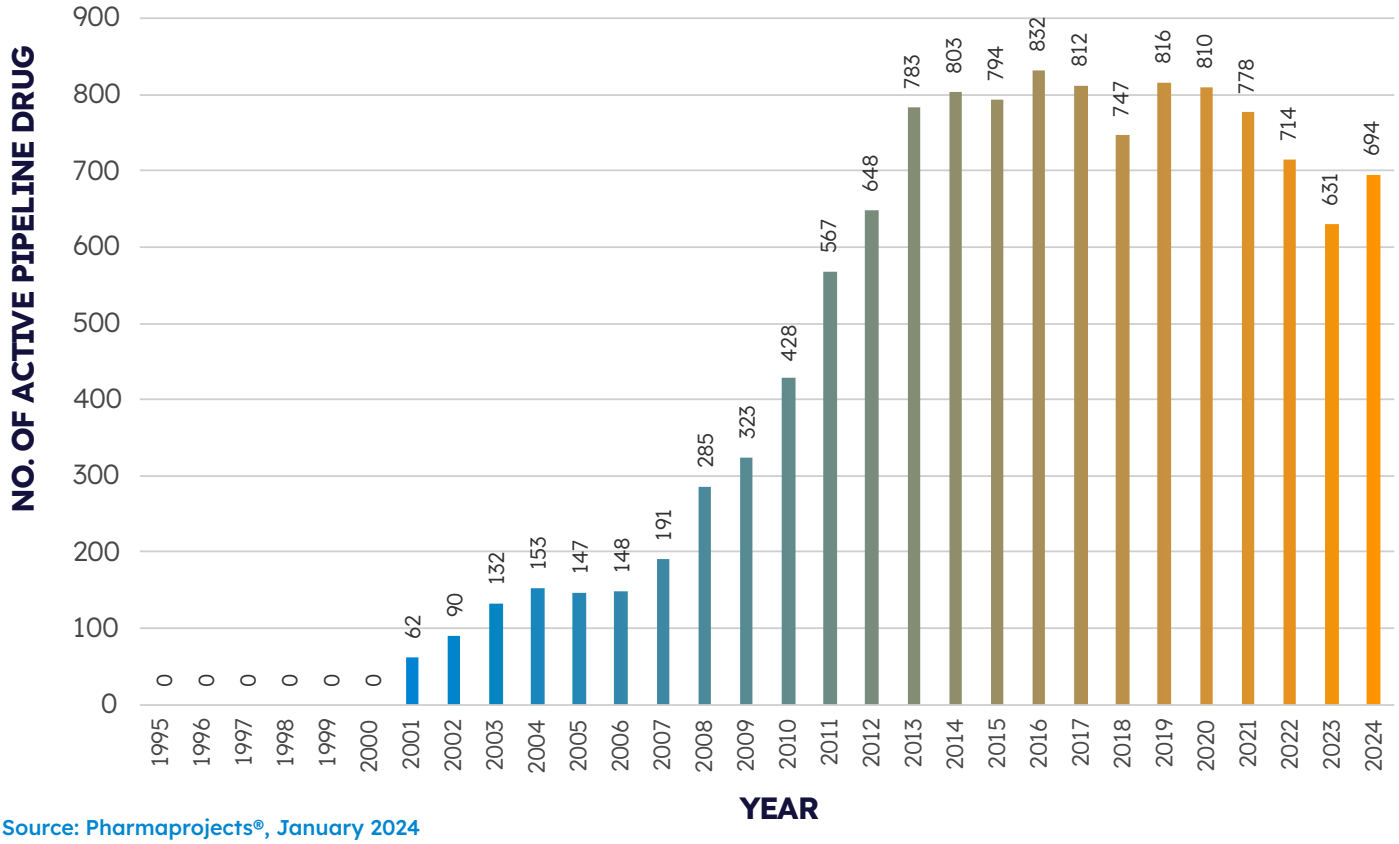
Source: Pharmaprojects®, January 2024



India

In India, active pipeline growth saw its steepest change from 2007 to 2013, across which there was a 309.9% increase in total active pipeline drugs. After 2013, the number of active drugs plateaued at around 800; however, since 2021, a steady decrease has been observed. There was an 18.9% decrease in the total number of active pipeline drugs observed from 2021 to 2023, as shown in Figure 21. But this year, that decline was almost completely reversed.

Figure 21: Total India R&D pipeline size, 1995—2024



Source: Pharmaprojects®, January 2024

In India, there are 120 pharmaceutical companies with their headquarters in that country, less than 10% of the total number of companies in China. Out of the Top 10 pharmaceutical companies in India shown in Table 12, seven saw a decrease in their total pipeline size this year.

Table 12: Top 10 India-headquartered companies by size of pipeline

COMPANY	NUMBER OF DRUGS
Dr. Reddy's Laboratories	36
Lupin	29
Sun Pharmaceutical Industries	21
Serum Institute of India	20
Zydus Lifesciences	19
Biocon	18
Cipla	13
Intas Pharmaceuticals	12
Suven Life Sciences	12
Bharat Biotech	11

Source: Pharmaprojects®, January 2024

Table 13 shows that India's top disease targets for R&D confound trends seen in other territories, with type 2 diabetes coming out on top. Breast cancer and non-small cell lung cancer are relegated to second and third place, respectively, here. They are two of only three cancer indications in India's Top 10, which has a wider variety of diseases across many therapeutic areas. These include metabolic and autoimmune indications, such as rheumatoid arthritis and psoriasis, as well as vaccines for diphtheria and tetanus.

Table 13: India's Top 10 diseases for pipeline drugs

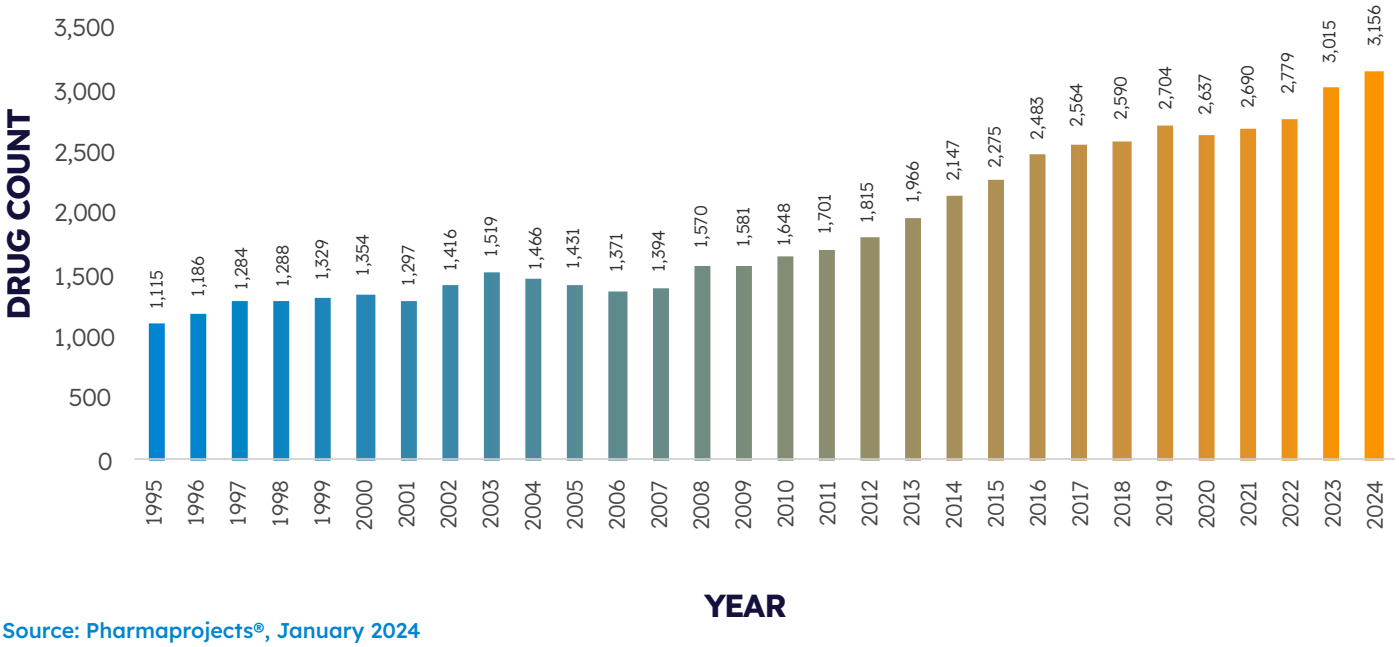
POSITION	DRUG DISEASE	NUMBER OF DRUGS
1	Diabetes, Type 2	175
2	Cancer, breast	143
3	Cancer, lung, non-small cell	105
4	Arthritis, rheumatoid	99
5	Cancer, colorectal	73
6	Infection, tetanus prophylaxis	61
7	Psoriasis	61
8	Infection, coronavirus, novel coronavirus	55
9	Infection, diphtheria prophylaxis	53
10	Pain, nociceptive, general	52

Source: Pharmaprojects®, January 2024

United Kingdom

In the UK at the start of 2024, there were 3,156 pipeline drugs, up from 3,015 in 2023. This 4.5% increase is less than the 7.8% growth rate seen from 2022 to 2023. There was a slight dip from 2019 to 2020; however, since 2020, drug development in the UK has been steadily increasing.

Figure 22: Total UK R&D pipeline size, 1995—2024



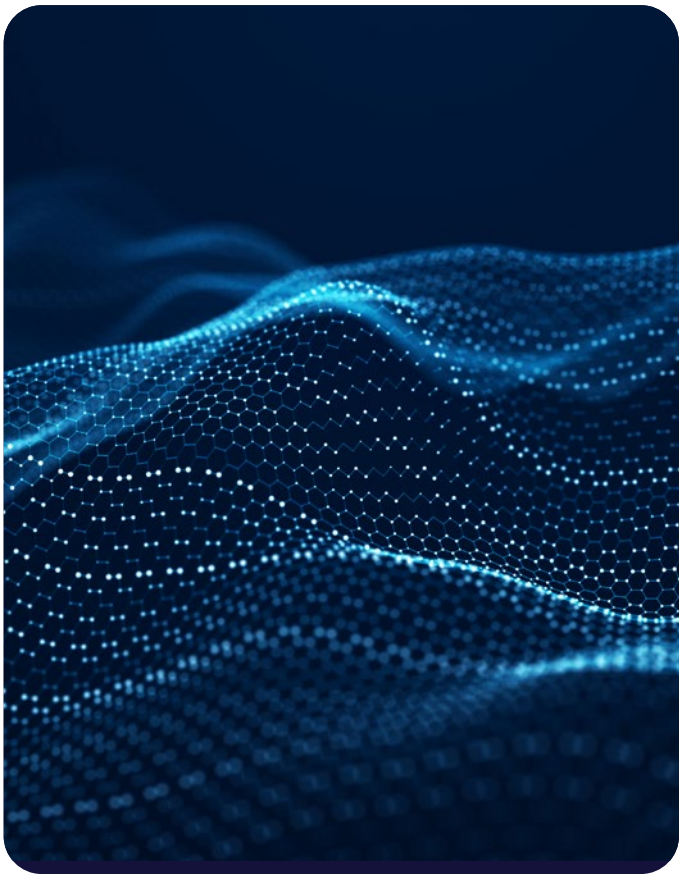
Source: Pharmaprojects®, January 2024

There are 321 companies developing drugs headquartered in the UK. The Top 10 UK companies are listed in Table 14, alongside the size of their pipelines. AstraZeneca and GSK dominate the UK pharma industry, with their closest competitors having pipeline sizes that are an order of magnitude less.

Table 14: Top 10 UK-headquartered companies by size of pipeline

COMPANY	NUMBER OF DRUGS
AstraZeneca	163
GlaxoSmithKline	128
Mundipharma International	20
Hikma Pharmaceuticals	19
Albumedix	17
Healx	15
ViiV Healthcare	14
Bicycle Therapeutics	13
PhoreMost	13
Oxford BioTherapeutics	12

Source: Pharmaprojects®, January 2024

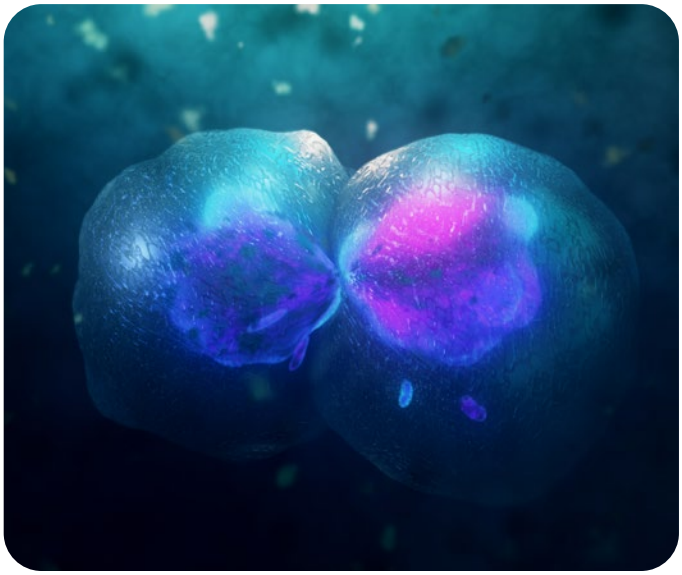


We have seen how the global pipeline is dominated by drugs in development for various cancer indications, and the data from early 2024 in the UK certainly reflect this, with the top seven of the Top 10 diseases falling into the oncology space. This pattern broadly falls in line with the global rankings; however, non-small cell lung cancer is the number 1 disease being targeted in the UK, whereas breast cancer is number 1 globally. Three non-cancer indications appear in the Top 10 disease list for the UK: type 2 diabetes (ranked eighth), Alzheimer's disease (ranked ninth), and novel coronavirus vaccines (ranked 10th).

Table 15: The UK's Top 10 diseases for pipeline drugs

POSITION	DRUG DISEASE	PIPELINE DRUGS
1	Cancer, lung, non-small cell	113
2	Cancer, breast	87
3	Cancer, colorectal	82
4	Cancer, prostate	63
5	Cancer, ovarian	57
6	Cancer, melanoma	52
7	Cancer, lymphoma, non-Hodgkin's	51
8	Diabetes, Type 2	51
9	Alzheimer's disease	49
10	Infection, coronavirus, novel coronavirus prophylaxis	48

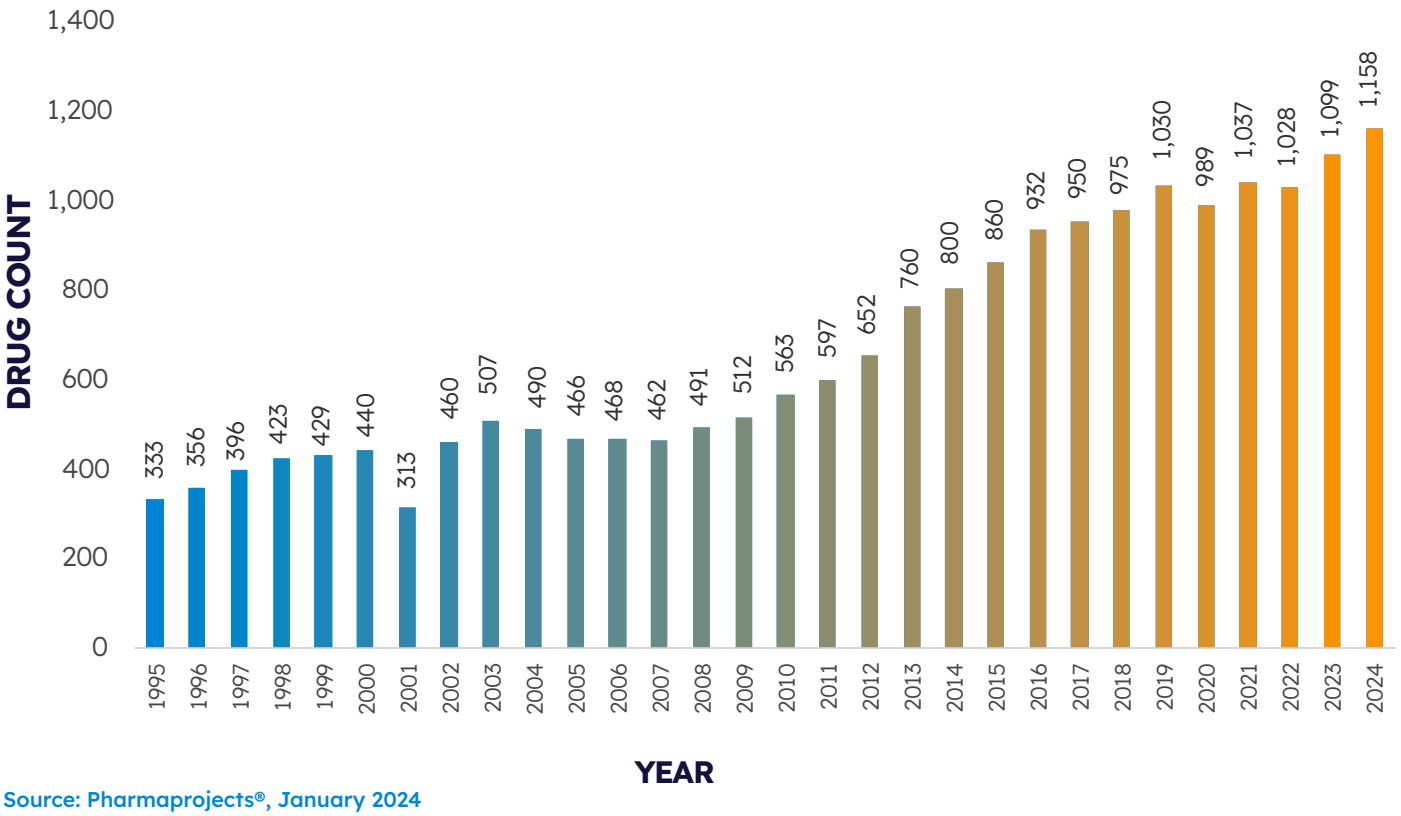
Source: Pharmaprojects®, January 2024



Ireland

Since 1995, there has been an overall increasing trend in the total pipeline size in Ireland. In terms of the most recent changes in pipeline size in Ireland, there are currently 1,158 pipeline drugs, which is up from 1,099 in 2023. However, this 5.4% increase is smaller than the 6.9% growth from 2022 to 2023.

Figure 23: Total Ireland R&D pipeline size, 1995—2024



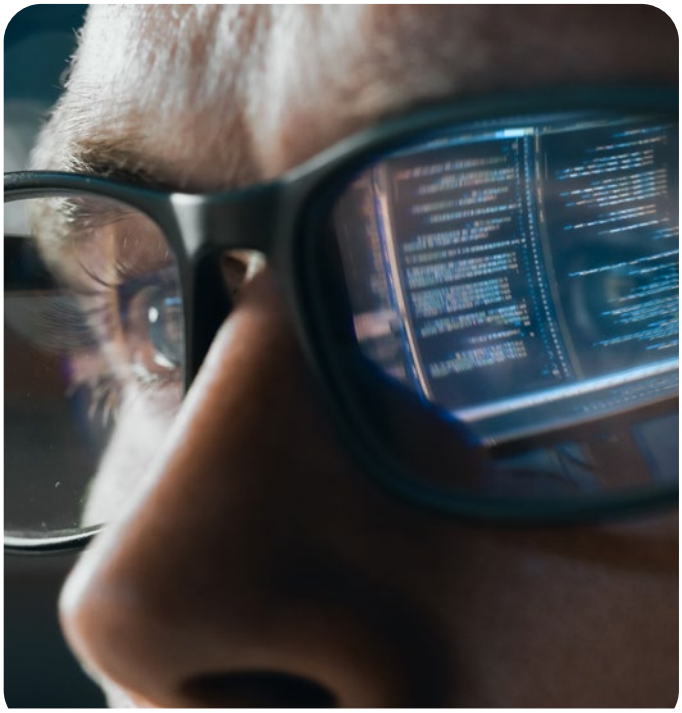
Source: Pharmaprojects®, January 2024

There are 40 companies developing drugs headquartered in Ireland. The top 10 Irish companies are listed in Table 16, alongside the size of their pipelines.

Table 16: Top 10 Ireland-headquartered companies by size of pipeline

COMPANY	PIPELINE DRUGS 2024
Jazz Pharmaceuticals	20
Alkermes	10
Mallinckrodt	9
Prothena	8
Perrigo	5
ONK Therapeutics	5
Shorla Pharma	4
GH Research	3
Inflection Biosciences	3
Orbsen Therapeutics	2

Source: Pharmaprojects®, January 2024



As we've seen, globally, the Top 10 diseases against which most drugs are in development are concentrated among cancer indications, but the data from early 2024 for Ireland show that this country is another that bucks the trend, with only four of the Top 10 diseases falling into the oncology space. While the top two diseases for Ireland are non-small cell lung cancer and breast cancer, the Top 10 indications in Ireland include a relatively higher number of metabolic and autoimmune indications, including type 2 diabetes, rheumatoid arthritis, juvenile arthritis, psoriatic arthritis, psoriasis, and ulcerative colitis.

Table 17: Ireland's Top 10 diseases for pipeline drugs

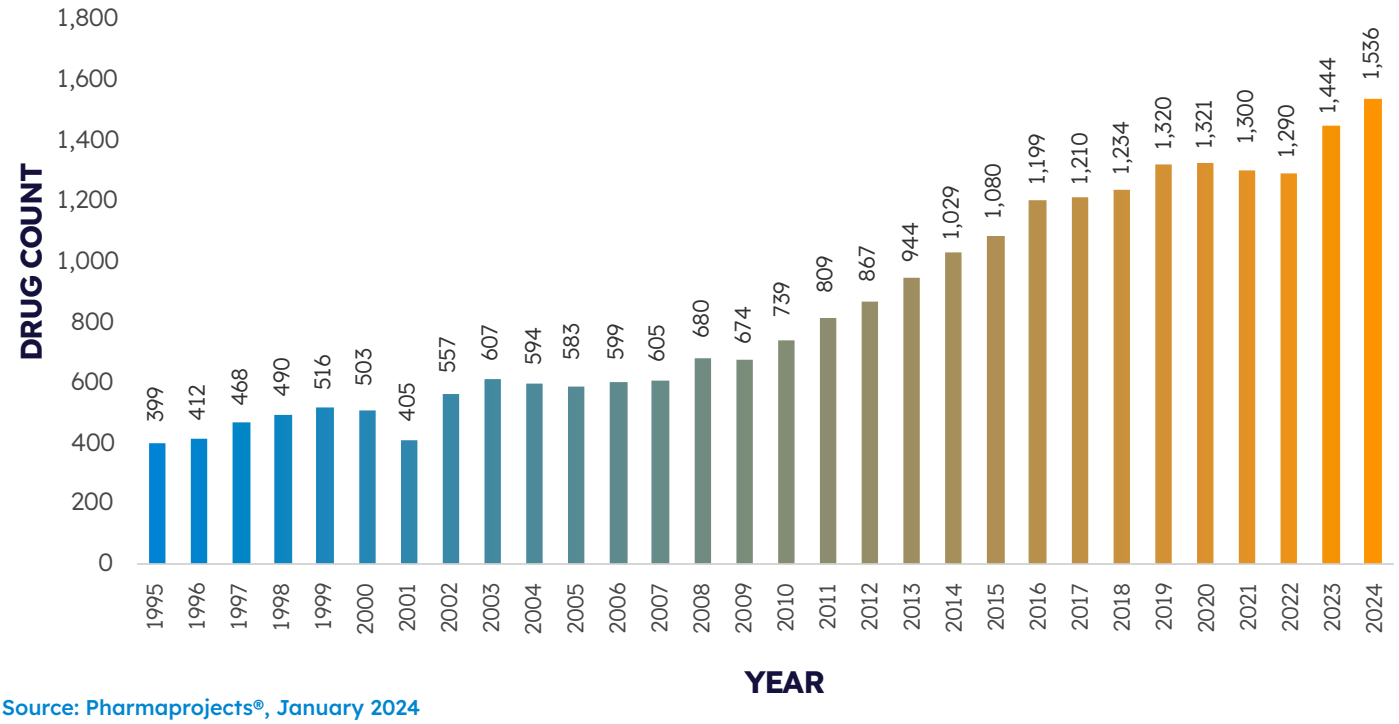
POSITION	DRUG DISEASE	PIPELINE DRUGS
1	Cancer, lung, non-small cell	51
2	Cancer, breast	44
3	Arthritis, rheumatoid	34
4	Diabetes, Type 2	32
5	Arthritis, psoriatic	31
6	Psoriasis	31
7	Cancer, colorectal	28
8	Colitis, ulcerative	27
9	Arthritis, juvenile	25
10	Cancer, renal	24

Source: Pharmaprojects®, January 2024

Denmark

In Denmark, there are currently 1,536 active drugs, which is up from 1,444 in 2023. This 6.4% increase is substantially less than the 11.9% YoY growth rate recorded from 2022 to 2023. The growth over the past year is slightly above the mean YoY growth rate in the country since 1996 (5.1%). In comparison, the progression of development in Denmark over the past year was slightly lower than the global growth rate of 7.2%. The last two years have stood out in the recent history of Denmark's drug development landscape as the country has had its two best years of growth since 2016.

Figure 24: Total Denmark R&D pipeline size, 1995—2024



Source: Pharmaprojects®, January 2024

Continued pharmaceutical development growth in Denmark is likely dependent on the 70 companies currently headquartered in the country, led by the Top 10 companies listed in Table 18. Novo Nordisk is head and shoulders above the rest, but there are a few other well-known companies based in the country, including Genmab, Lundbeck, and Leo Pharma.

Table 18: Top 10 Denmark-headquartered companies by size of pipeline

COMPANY	PIPELINE DRUGS
Novo Nordisk	68
Genmab	25
Lundbeck	16
Gubra	15
Bavarian Nordic	10
Leo Pharma	10
Zealand Pharma	10
Evaxion Biotech	8
ALK-Abello	7
Xellia Pharmaceuticals	7

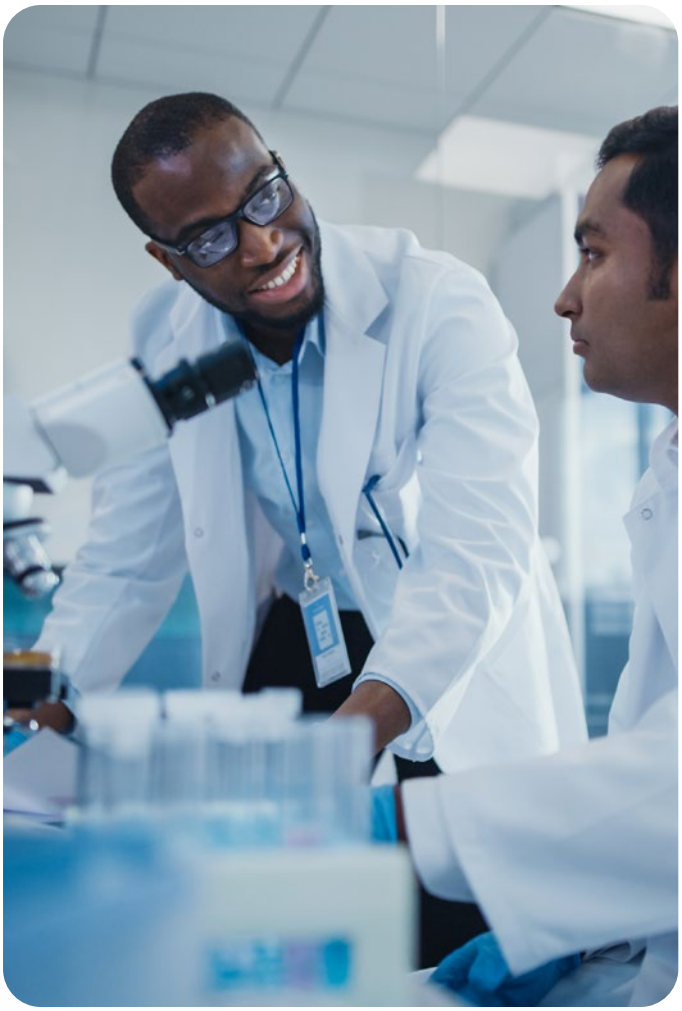
Source: Pharmaprojects®, January 2024

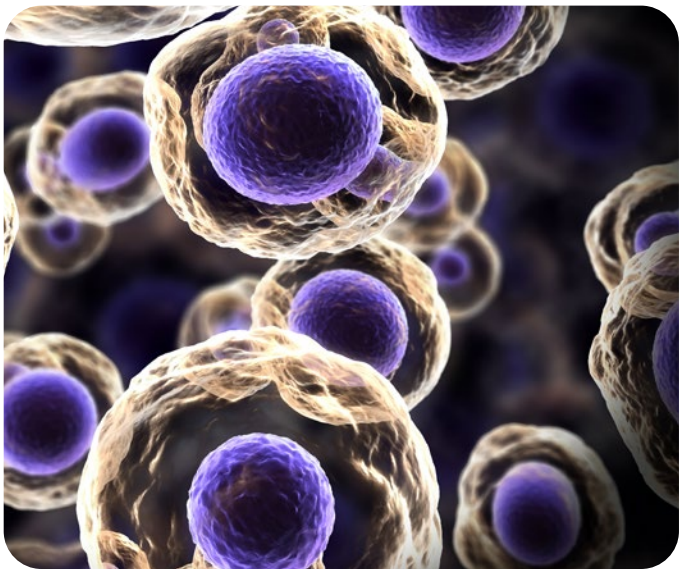
One would expect the vast majority of developmental therapies to be indicated for various forms of cancer or alimentary/metabolic diseases, and the data from early 2024 in Denmark confirm this, with seven of the Top 10 diseases falling into these spaces. With only four cancer indications, Denmark differs from the global rankings, where eight of the top 10 indications are cancer. The other two diseases of focus in the global landscape are Alzheimer's disease and novel coronavirus infection; however, out of the 589 indications under study in Denmark, Alzheimer's disease and novel coronavirus infection rank 34th and 55th, respectively.

Table 19: Denmark's Top 10 diseases for pipeline drugs

POSITION	DRUG DISEASE	NUMBER OF DRUGS
1	Cancer, lung, non-small cell	63
2	Cancer, breast	49
3	Cancer, colorectal	39
4	Diabetes, Type 2	38
5	Arthritis, rheumatoid	37
6	Psoriasis	32
7	Arthritis, psoriatic	31
8	Cancer, myeloma	30
9	Colitis, ulcerative	29
10	Crohn's disease	28

Source: Pharmaprojects®, January 2024

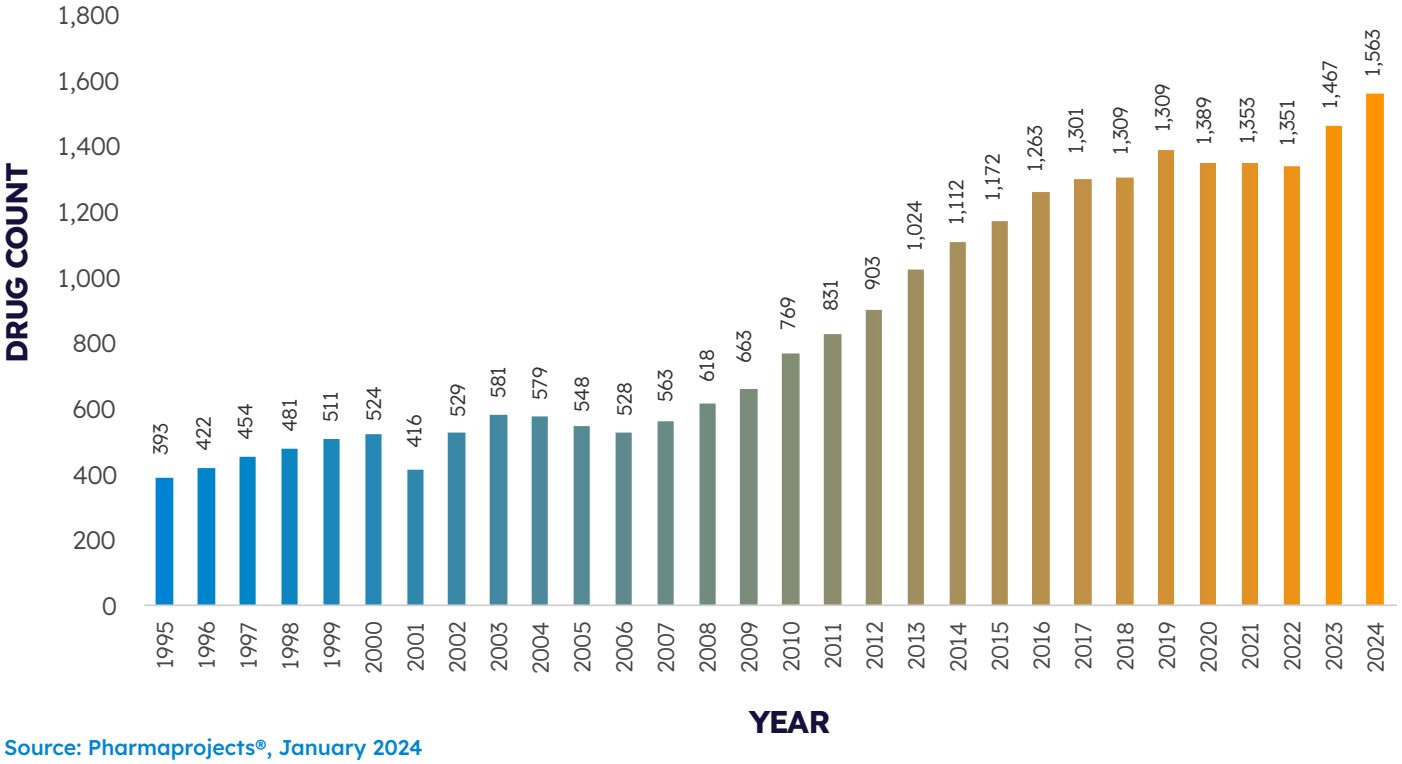




Sweden

From one Scandinavian country to another, we turn our focus to Sweden, which has similar development metrics to Denmark. In Sweden, there are currently 1,563 active drugs, which is up from 1,467 in 2023. This represents 6.5% YoY growth, which pales in comparison to the rate seen from 2022 to 2023, which was 9.2%. However, the past year's growth is still above the mean growth rate in Sweden since 1996 (5.2%), so drug development is clearly still growing in this market. Much like Denmark, the YoY growth rates seen in the past two years in Sweden are the country's highest since 2016.

Figure 25: Total Sweden R&D pipeline size, 1995—2024



Source: Pharmaprojects®, January 2024

Currently there are 136 companies headquartered in Sweden that are actively developing drugs. Table 20 shows the Top 10 of these companies and the number of drugs they have in their current pipeline. For Sweden to continue growing its pharmaceutical industry and remain productive in the global development landscape, the 10 companies below will need to continue their recent progress.

Table 20: Top 10 Sweden-headquartered companies by size of pipeline

COMPANY	PIPELINE DRUGS
Ribocure Pharmaceuticals	16
Anocca	15
Sobi	15
BioArctic	13
Medivir	9
Alligator Bioscience	8
Salipro Biotech	7
AlzeCure Pharma	6
BioInvent	6
Camurus	6

Source: Pharmaprojects®, January 2024

Sweden also lags in oncology development compared to globally, with only five cancer diseases in its Top 10. Interestingly, comparing the top pipeline indications between Denmark and Sweden shows that both countries heavily contribute to the development of therapies for arthritis and psoriasis, diseases that are at least 10 places lower in the global landscape. The Scandinavian countries appear to focus more on immunological diseases than many other countries around the world.

Table 21: Sweden's Top 10 diseases for pipeline drugs

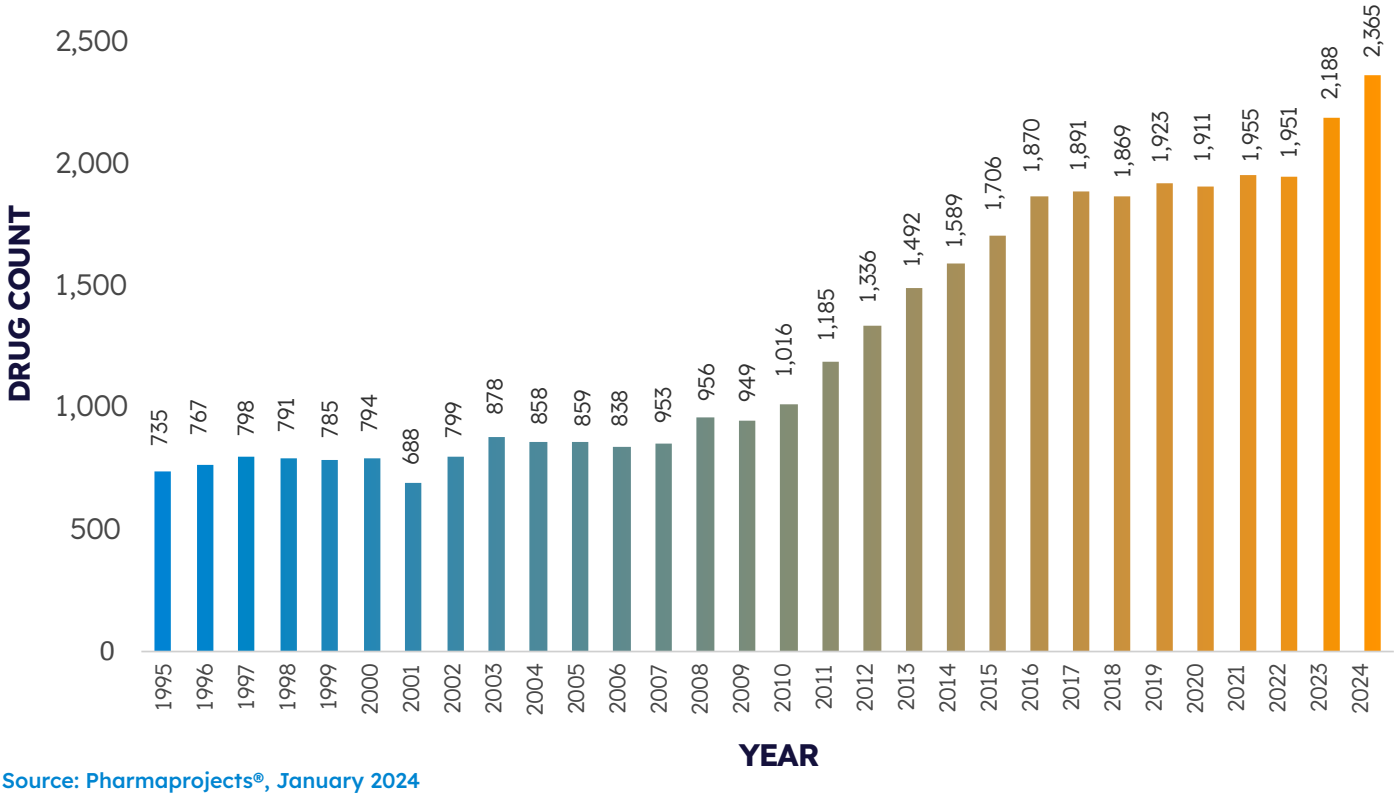
POSITION	DRUG DISEASE	PIPELINE DRUGS
1	Cancer, lung, non-small cell	62
2	Cancer, breast	50
3	Cancer, colorectal	40
4	Diabetes, Type 2	40
5	Arthritis, rheumatoid	38
6	Cancer, myeloma	35
7	Psoriasis	35
8	Arthritis, psoriatic	32
9	Alzheimer's disease	31
10	Cancer, prostate	30

Source: Pharmaprojects®, January 2024

France

We next move south to France, which dwarfs both Denmark and Sweden in the total number of drugs, while also besting both countries in YoY growth, with a rate of 8.1%. The most recent growth rate is down from 2022—23 (12.2%), but is also still above the global 2023—24 growth rate of 7.2%. The past year's growth is almost double the mean YoY growth rate since 1996 (4.3%), and is its second largest YoY metric since 2016.

Figure 26: France's R&D pipeline size, 1995—2024



Source: Pharmaprojects®, January 2024

With a large number of active drugs in the country, one would expect the companies headquartered in France to have large current pipelines, and that is what we can see in Table 22. With big companies like Sanofi and Ipsen leading the way, the development landscape in France looks to be in good hands for future years of continued growth.

Table 22: Top 10 France-headquartered companies by size of pipeline

COMPANY	PIPELINE DRUGS
Sanofi	130
Ipsen	38
Servier	32
TheraVectys	22
Pierre Fabre	18
Valneva	11
Innate Pharma	10
OSE Immunotherapeutics	10
Vectans Pharma	9
Xenothera	9

Source: Pharmaprojects®, January 2024

France's active pipeline is more comparable to the Top 10 targeted indications across the globe than those of many other countries, reporting nine out of the Top 10 diseases from the oncology space. Of the nine cancer indications, four are in both the French and global Top 10s: non-small cell lung cancer, breast cancer, colorectal cancer, and prostate cancer. As for the diseases that round out the global Top 10, Alzheimer's disease and novel coronavirus infection developmental drugs are not nearly as prevalent in France, with Alzheimer's disease placing 31st and novel coronavirus infection placing 37th.

Table 23: France's Top 10 diseases for pipeline drugs

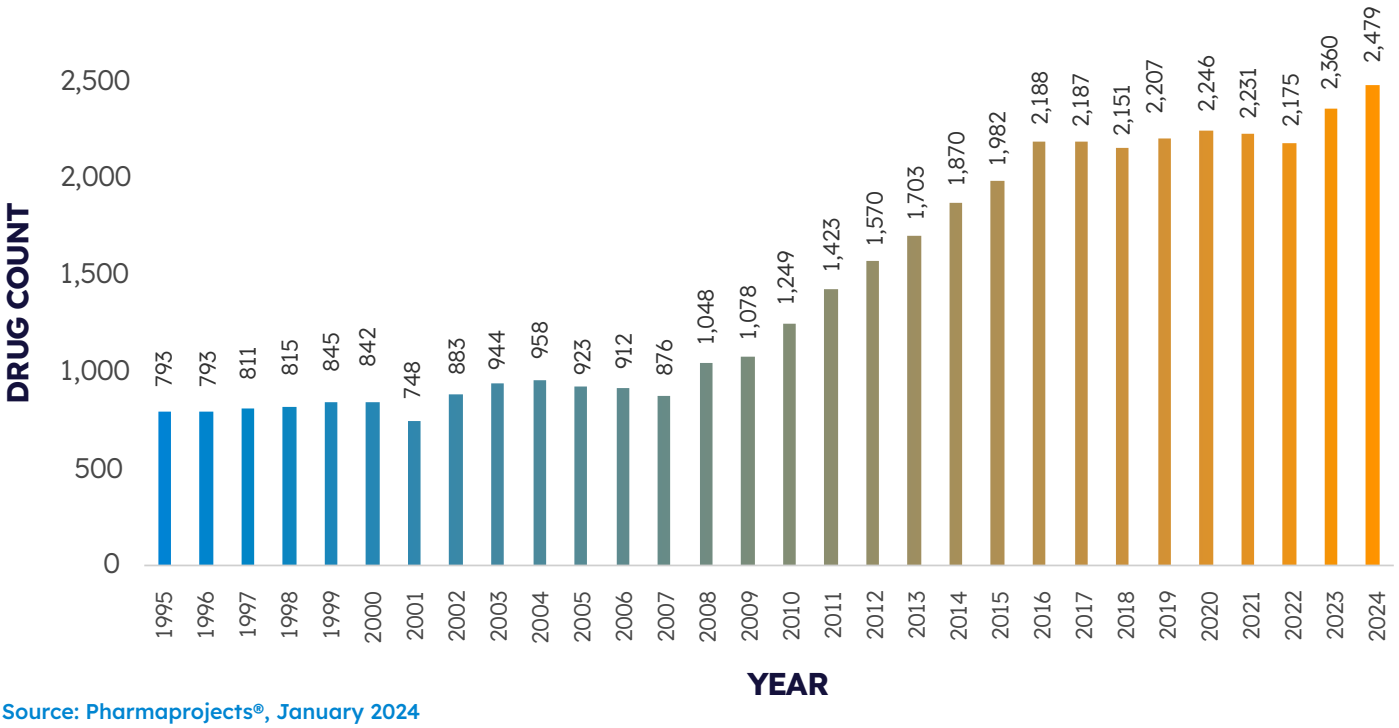
POSITION	DRUG DISEASE	PIPELINE DRUGS
1	Cancer, lung, non-small cell	134
2	Cancer, breast	89
3	Cancer, colorectal	69
4	Cancer, melanoma	58
5	Cancer, lymphoma, non-Hodgkin's	55
6	Cancer, leukaemia, acute myelogenous	54
7	Cancer, myeloma	46
8	Cancer, prostate	44
9	Cancer, renal	40
10	Colitis, ulcerative	38

Source: Pharmaprojects®, January 2024

Germany

Since 1995, there has been an overall increasing trend in the total pipeline size in Germany. In terms of the most recent changes in pipeline size, between 2023 and 2024 the total pipeline size in Germany rose, with a 5.0% increase in the number of active drugs.

Figure 27: Germany's R&D pipeline size, 1995—2024



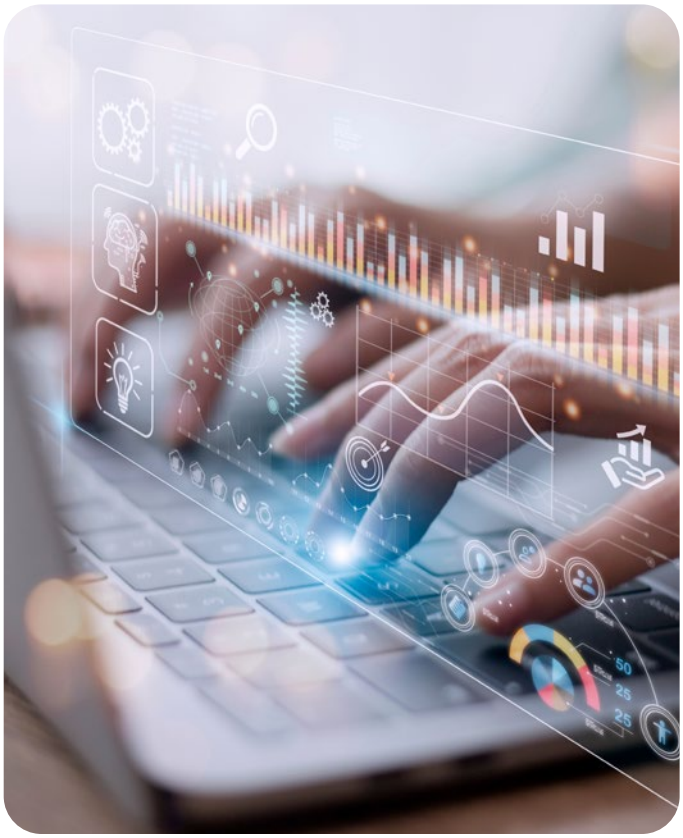
Source: Pharmaprojects®, January 2024

There are 143 companies headquartered in Germany. The top 10 companies are listed in Table 24, alongside the size of their pipelines.

Table 24: Top 10 Germany-headquartered companies by size of pipeline

COMPANY	PIPELINE DRUGS
Boehringer Ingelheim	103
Bayer	91
BioNTech	53
Evotec	49
Merck KGaA	36
CureVac	22
Grunenthal	12
Stada	11
Biotest	10
Medigene	10

Source: Pharmaprojects®, January 2024



The top three diseases in Germany are non-small cell lung cancer, breast cancer, and colorectal cancer, which are also the top three drug diseases globally. The Top 10 German indications also include a number of metabolic, dermatological, and autoimmune indications, such as type 2 diabetes, psoriasis, and rheumatoid arthritis.

Table 25: Germany's Top 10 diseases for pipeline drugs

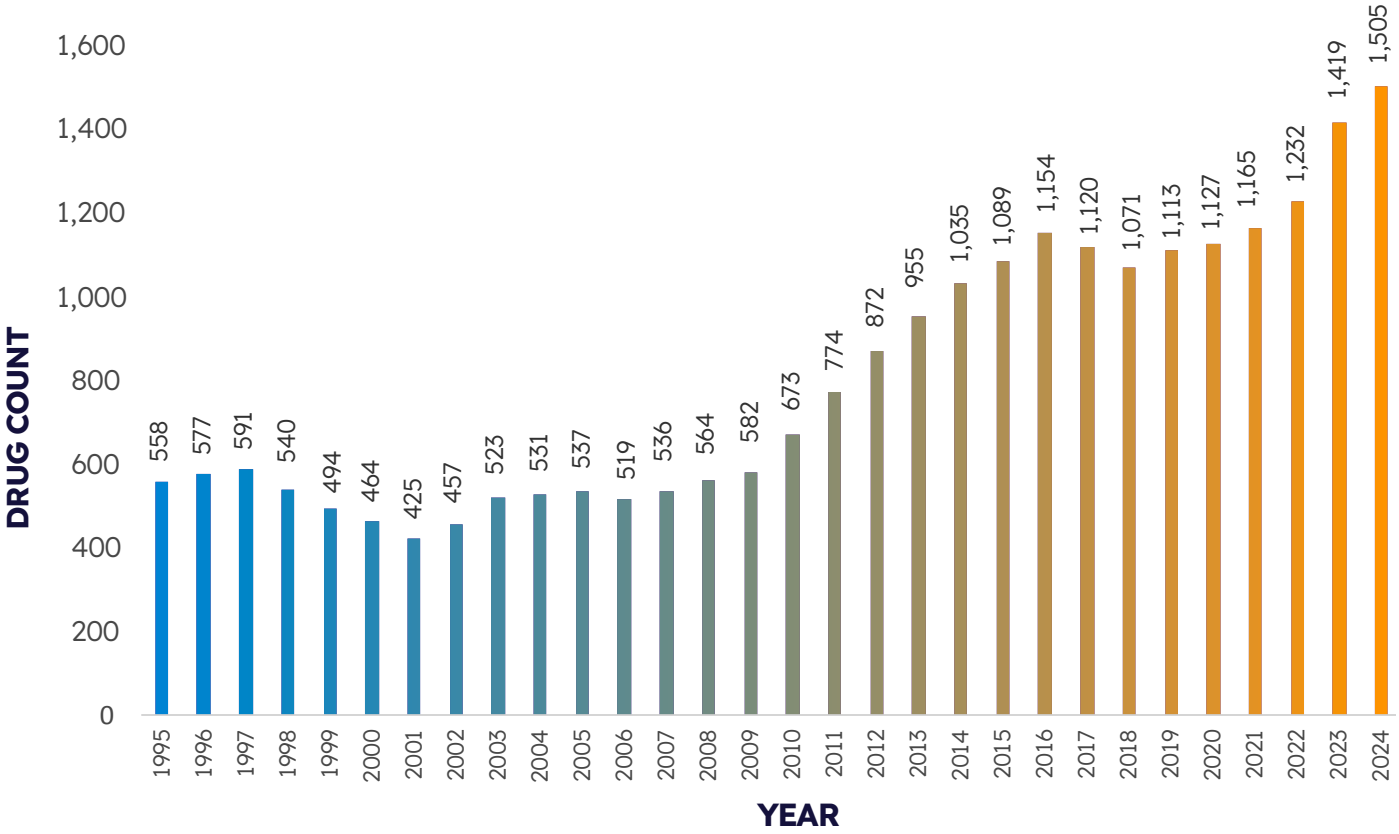
POSITION	DRUG DISEASE	PIPELINE DRUGS
1	Cancer, lung, non-small cell	109
2	Cancer, breast	71
3	Cancer, colorectal	60
4	Diabetes, Type 2	59
5	Psoriasis	46
6	Cancer, myeloma	44
7	Cancer, leukaemia, acute myelogenous	43
8	Arthritis, rheumatoid	41
9	Cancer, lymphoma, non-Hodgkin's	41
10	Cancer, melanoma	40

Source: Pharmaprojects®, January 2024

Switzerland

Since 1995, there has been an almost tripling of the total pipeline size in Switzerland. Between 2023 and 2024, the total pipeline size in Switzerland rose, with a 6.1% increase in the number of active drugs this year.

Figure 28: Switzerland's R&D pipeline size, 1995—2024



Source: Pharmaprojects®, January 2024

There are 188 companies headquartered in Switzerland. The Top 10 companies are listed in Table 26, alongside the size of their pipelines.

Table 26: Top 10 Switzerland-headquartered companies by size of pipeline

COMPANY	PIPELINE DRUGS
Roche	217
Novartis	153
Medicines for Malaria Venture	32
DNDi	29
CRISPR Therapeutics	23
Debiopharm	18
AC Immune	17
Sandoz	17
Light Chain Bioscience	14
Idorsia Pharmaceuticals	14

Source: Pharmaprojects®, January 2024

The top three diseases for Switzerland are non-small cell lung cancer, breast cancer, and colorectal cancer, which are also the top three drug diseases globally. As with the global pipeline, the Swiss pipeline is dominated by drugs in development for different cancer indications.

Table 27: Switzerland's Top 10 diseases for pipeline drugs

POSITION	DRUG DISEASE	NUMBER OF DRUGS
1	Cancer, lung, non-small cell	46
2	Cancer, breast	43
3	Cancer, colorectal	33
4	Cancer, melanoma	32
5	Cancer, brain	27
6	Alzheimer's disease	26
7	Cancer, myeloma	26
8	Diabetes, Type 2	23
9	Infection, malaria	21
10	Cancer, leukaemia, acute myelogenous	19

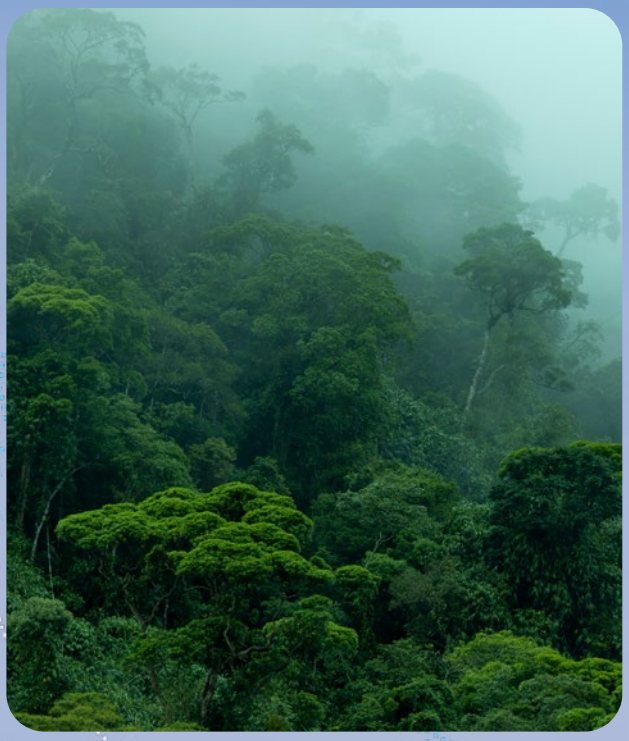
Source: Pharmaprojects®, January 2024

Mechanisms and Targets

Immuno-oncology makes hay while the sun shines

What makes weather work? The Earth's climate system is complex, but a small change to temperature, atmospheric pressure, cloud formation, wind, humidity, or rain patterns can have a significant effect on the development of weather systems. It is the interaction of all these different components, in an environment where chaos theory also plays its part, that produces our weather in all its infinite variety. Everything is very finely balanced, hence how an external force, for example human interventions such as the release of greenhouses gases into the atmosphere, can perturb the status quo, potentially irrevocably.

What makes drugs work is the subject of this section of our report, which looks at drugs' mechanisms of action and their targets. It's a similarly complex ecosystem. Just as we can model the weather to get predictions of the outcome of what's happening now, we can predict from drugs' mechanisms and targets what will happen when they are administered, but both are still incredibly inexact sciences. The whole point of the drug R&D process is to test hypotheses and gather evidence, so that we can have confidence in the outcome of taking a drug, just like we want to be able to trust our weather forecasts.



Beginning with mechanisms, Table 28 lists the current Top 25 mechanisms in Citeline's proprietary mechanism of action classification. It's important to note that this is hierarchical, one effect of which is to make the broader terms at the top of the hierarchy crop up most commonly. This is because, with over half of the pipeline still at the preclinical phase, where often full mechanistic information is yet unknown or undisclosed, there tend to be a lot of drugs where only a broad mechanistic class can be ascribed. As drugs move up through development stages, these general categorizations are often replaced by something more precise. There are also a number of "umbrella" terms, created to permit searching across mechanisms in certain broader categories. The immuno-oncology (IO) category is one such of these and is applied to drugs in the IO class even if more specific mechanistic information is also known, so that all IO drugs can be found in a single search. This is one of the reasons that it is applied to so many drugs. These caveats should be borne in mind when examining the Top 25 terms.

Table 28: Top 25 mechanisms of action (pharmacologies)

POSITION 2024 (2023)	MECHANISM OF ACTION	NUMBER OF DRUGS 2024 (2023)	% AT PR, R OR L	TREND
1 (1)	Immuno-oncology therapy	3,932 (3,393)	2.7	↑↑
2 (2)	Immunostimulant	1,812 (1,472)	10.3	↑
3 (3)	T cell stimulant	1,148 (1,091)	1.6	↔
4 (4)	Immune checkpoint inhibitor	986 (618)	4.0	↑↑
5 (5)	Gene expression inhibitor	354 (283)	1.7	↑
6 (15)	Immune checkpoint stimulant	303 (150)	1.3	↑↑
7 (7)	Protein degrader	292 (221)	1.0	↑
8 (6)	Genome editing	290 (274)	0.3	↔
9 (9)	Radiopharmaceutical	277 (192)	7.2	↑↑
10 (11)	Natural killer cell stimulant	223 (186)	0	↑
11 (10)	Angiogenesis inhibitor	192 (192)	28.1	↔
12 (8)	CD3 agonist	190 (198)	5.3	↓
13 (12)	PD-L1 antagonist	178 (181)	6.2	↓
14 (13)	Immunosuppressant	174 (179)	38.5	↓
15 (17)	Microbiome modulator, live microorganisms	167 (128)	1.2	↑
16 (14)	PD-1 antagonist	165 (152)	12.7	↔
17 (18)	Glucagon-like peptide 1 receptor agonist	156 (111)	5.8	↑
18 (16)	Vascular endothelial growth factor receptor antagonist	152 (142)	26.3	↔
19 (352)	Ubiquitin ligase E3 stimulant	125 (11)	0	↑↑
20 (21)	K-Ras inhibitor	108 (87)	2.8	↑
21 (31)	DNA topoisomerase I inhibitor	98 (67)	6.1	↑
22 (19)	Apoptosis stimulant	90 (103)	14.4	↓
23 (34)	Tubulin inhibitor	89 (62)	7.9	↑
24 (24)	DNA inhibitor	87 (82)	32.2	↔
25 (20)	ErbB-2 antagonist	87 (97)	20.7	↓

Abbreviations used in table: PR = pre-registration R = registered L = launched
Source: Pharmaprojects®, January 2024

This certainly helps to explain the table's number 1 category being IO therapy. There are now 3,932 drugs that fall into that bucket, meaning more than one in six of all drugs in development can be categorized in this way — a striking statistic considering how relatively new this technique, whereby the body's own immune system is trained to attack cancer cells, is. Further evidence of how the pharmaceutical industry is boldly placing a lot of faith in this strategy can be seen by looking at the column to the right of the number of drugs column in this table: the percentage of drugs using this strategy which have made it to the later stages (pre-registration, registered, or launched) of development. Only 2.7% of drugs in this category have made it this far, so the overwhelming majority of candidates are still in clinical or preclinical studies. As more products do progress, though, this is looking less like an enormous leap of faith and more like an exciting new front. With a remarkable 15.9% increase in candidates, this looks to be one area where it never rains but it pours.

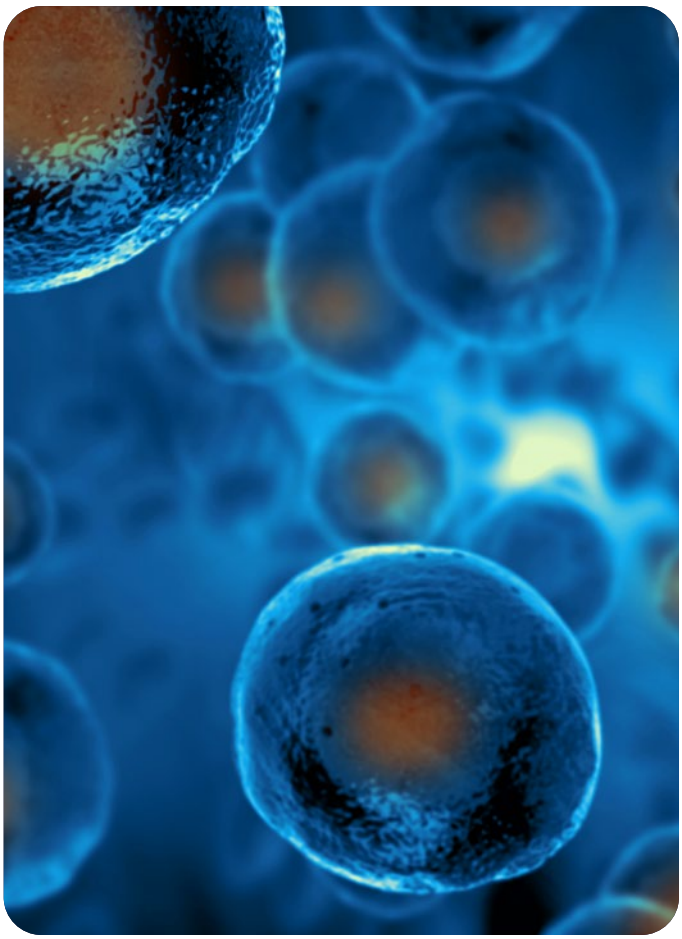
One of the subgroups of IO therapy, immune checkpoint inhibitors, reports a nothing less than stupendous 59.5% growth in pipeline size. This category embraces a plethora of different individual categories, including some which appear under their own right in the top 25, such as PD-L1 and PD-1 antagonists. Even more dramatically, the size of the pipeline of immune checkpoint stimulants has more than doubled. This can be partly accounted for by the fact that, during the course of last year, we created a new Target Family to encompass targets in this area, which led to a cleanup of the data and consequently more drugs being assigned this mechanism of action.

Two other broad IO categories involved in cell therapy, T cell stimulants and natural killer cell stimulants, feature, although their progress has somewhat stalled this year. Overall, the field of immuno-oncology is keenly represented, as it continues to have its moment in the sun.

The development of targeted protein degraders also saw a noticeable increase in 2023, with ubiquitin E3 ligase being the most popular target for these novel therapeutic agents. Keen observers will note an extraordinary rise in the number of ubiquitin ligase E3 stimulants in this year's Top 25, the explanation for which is twofold. First, there were a huge number of protein degraders (around 60) using this mechanism entering development over the past 12 months.

But there is also an internal reason for the stratospheric increase, as a review of such drugs led to us adding this mechanism to quite a few existing PROTAC drugs which didn't have this assigned before. But despite the ongoing interest in protein degradation and E3 ligase signaling, development remains firmly rooted at the preclinical to early clinical stage. To date, there are only six protein degrader drugs approved worldwide, with just two new launches in 2023. Another big increase within the Top 10 was in radiopharmaceuticals, which recorded a 44% rise, with imaging agents making up over half of this increase.

There was stagnation in the development of some of the more traditional anticancer cytotoxic drugs, such as DNA intercalators, tubulin binding agents, and angiogenesis inhibitors. This is perhaps indicative of the continued push towards targeted therapy as a mainstay, with little movement in this area since last year's report. One of the elders of targeted therapy, ErbB-2 antagonists, also took a hit, with the number of development candidates actually falling. Elsewhere, the continued rise of antibody-drug conjugates produced an increase in DNA topoisomerase I-targeting drug candidates, with TOP1 representing an attractive target for antibody-drug conjugate warheads.



Immuno-oncology makes its presence similarly felt in Table 29, where we look at the Top 25 individual protein targets which today's pipeline drugs are hitting. Here, there has been a change at the top, with CD3e, a target heavily used by CAR-T therapeutics, returning to the pole position. It deposes another IO-based target, PD-L1, down to number 3, while a more traditional anticancer target, Her2, moves up to number 2, so IO is not having everything its own way. Another IO-based target involved in CAR-T, CD19, also drops down the top five.

Table 29: Top 25 drug protein targets

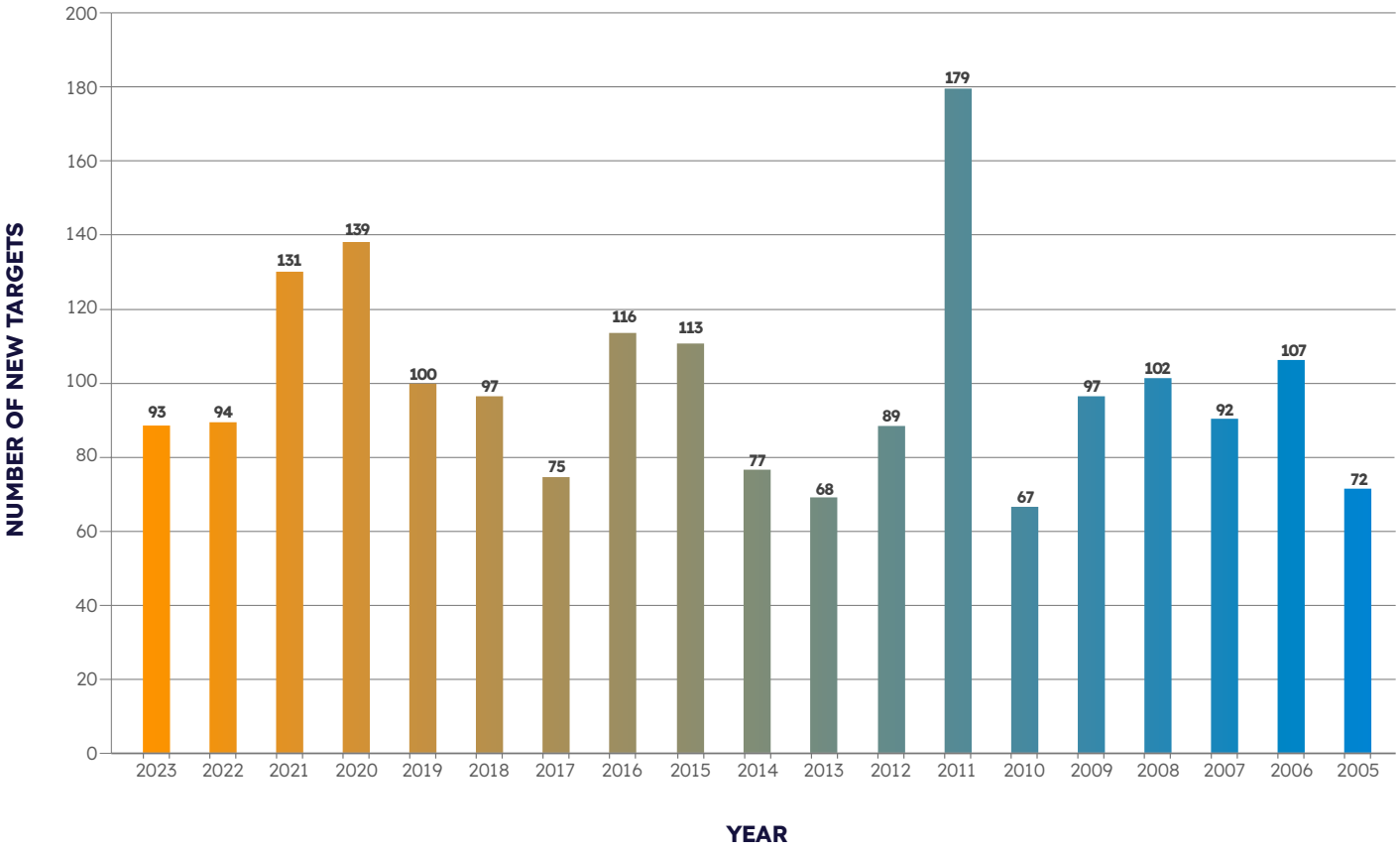
POSITION 2024 (2023)	TARGET	NUMBER OF DRUGS 2024 (2023)	TREND
1 (2)	CD3 epsilon subunit of T-cell receptor complex	223 (207)	↔
2 (4)	erb-b2 receptor tyrosine kinase 2 *[Her2]*	217 (187)	↔
3 (1)	CD274 molecule *[PD-L1]*	211 (210)	↔
4 (5)	epidermal growth factor receptor	205 (178)	↑
5 (3)	CD19 molecule	199 (194)	↔
6 (6)	programmed cell death 1 *[PD-1]*	194 (165)	↑
7 (8)	glucagon like peptide 1 receptor	169 (126)	↑
8 (7)	vascular endothelial growth factor A	168 (160)	↔
9 (9)	KRAS proto-oncogene, GTPase *[K-Ras]*	133 (118)	↔
10 (10)	5-hydroxytryptamine receptor 2A	127 (117)	↔
11 (11)	opioid receptor mu 1	104 (107)	↓
12 (12)	insulin receptor	97 (87)	↔
13 (14)	cannabinoid receptor 1	94 (86)	↔
14 (13)	TNF receptor superfamily member 17 *[BCMA]*	94 (87)	↔
15 (16)	nuclear receptor subfamily 3 group C member 1 *[glucocorticoid receptor]*	91 (84)	↔
16 (18)	membrane spanning 4-domains A1 *[CD20]*	90 (82)	↔
17 (16)	TNF receptor superfamily member 9 *[CD137]*	88 (84)	↔
18 (21)	claudin 18	87 (75)	↔
19 (15)	tumor necrosis factor	87 (86)	↔
20 (22)	androgen receptor	76 (75)	↔
21 (23)	transforming growth factor beta 1	76 (74)	↔
22 (19)	opioid receptor kappa 1	75 (80)	↓
23 (24)	CD47 molecule	74 (73)	↔
24 (26)	kinase insert domain receptor	73 (69)	↔
25 (25)	prostaglandin-endoperoxide synthase 2	72 (73)	↓

Note: NCBI names are used, except for additions in italics made by us for clarity.
Source: Pharmaprojects®, January 2024

Outside of the Top 10, the air is stiller this year, with few dramatic changes, aside from the continued decline of the opioid targets mu1 and kappa1. Conspicuous by its absence this year is the COVID-19 spike protein, which drops out of the upper echelons to number 31. It might have appeared in 2021's chart like a bolt from the blue, but its decline has been similarly lightning fast.

The lifeblood of the industry, though, has to be the continued identification of novel targets for drug development, showers of which are needed every year to prevent the drug development landscape rapidly becoming an arid desert. Figure 29 records that the number of newly identified drug targets in 2023 was very similar to that seen in 2022, at 93. This paints the year as another one very slightly below the par of 100 per year. The universe of targets for active drug development does continue to expand, however, with the total for 2024 hitting 2,035, up from 1,974 the year before, with a bigger increase than that seen from 2022 to 2023. We are clearly a long way still from there being nothing new under the sun.

Figure 29: Number of new drug protein targets identified by Pharmaprojects, by year



Source: Pharmaprojects®, January 2024

Famously, no two snowflakes are alike. While ways to treat diseases and targets for drug development will presumably not be similarly infinite, it seems likely that we may have barely scratched the surface of the myriad ways in which science may yet treat the burden of disease. Let's hope that the flurry of new targets identified, and new drugs produced, can turn into a blizzard.

Types of Pipeline Drugs

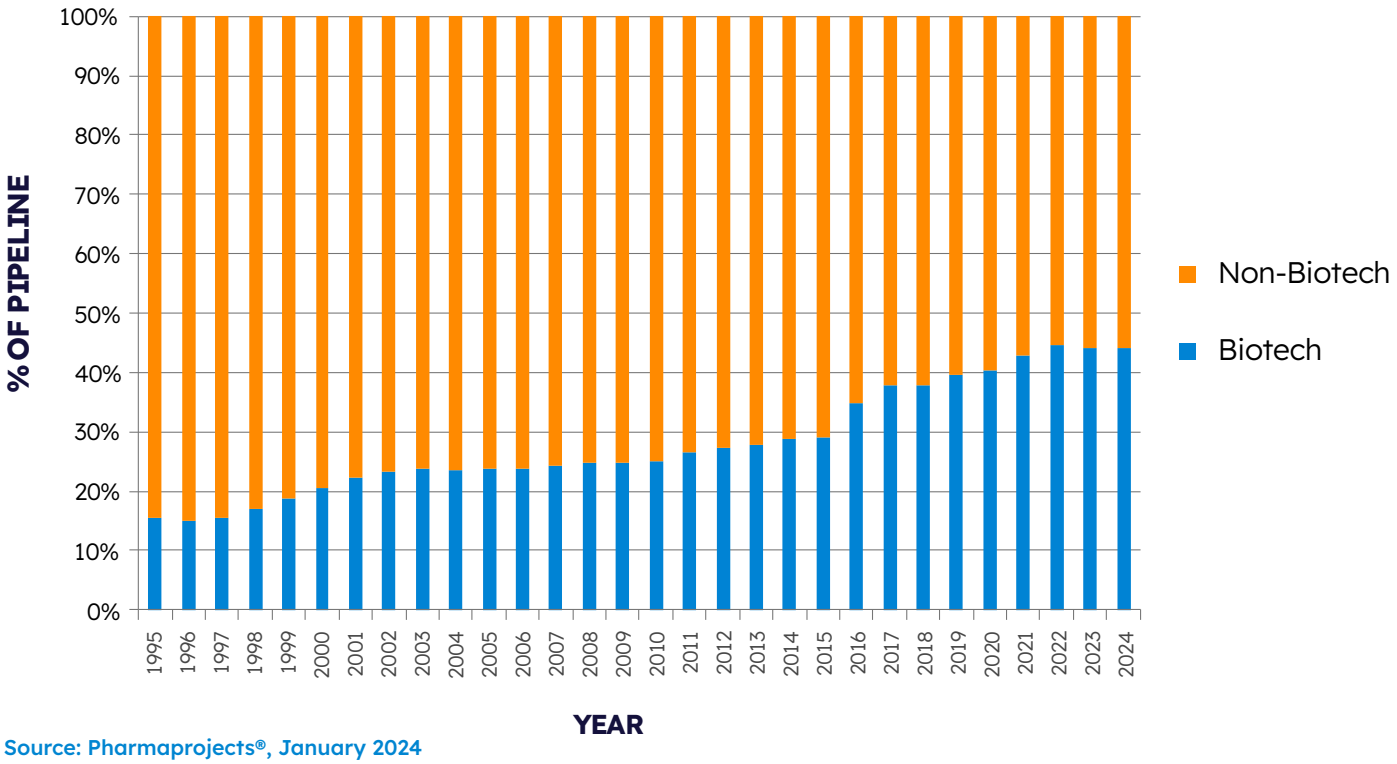
Is the continued move into biotech starting to meet a frosty reception?

Most experts believe that climate change is rapidly approaching an inflection point. If action is not taken now, we might reach the point of no return, whereby we lose the ability to control or reverse the changes happening to our world's weather. Last year, scientists from the British Antarctic Survey reported that ice melt in West Antarctica has accelerated and is now inevitable for the rest of the century, no matter by how much carbon emissions are cut. If this ice sheet is lost completely, it would raise global sea levels by five meters, leading to many coastal cities having to be abandoned. However, it is believed that if we act now, we can at least save the East Antarctic ice sheet, which has the potential to cause sea levels to rise by as much as 10 times that amount.

A change in pharma that also has seemed to be hitting a tipping point — although by no means a similarly negative trend — is the ongoing move away from traditional small molecule drug R&D to that based on biotechnological techniques. There were signs last year that this too might be hitting an inflection, and that the disappearance of large chunks of chemistry-based drug discovery might be slowing. This is one data point we will address in this last section of this year's report, which looks at the types of drugs under development.

Figure 30 therefore makes interesting reading. It now looks like there is clear evidence that the ongoing march into biotech has indeed plateaued. The overall proportion of biotech drugs this year stands at 44.2%, up just 0.2pp on last year, and still 0.5pp below where it was in 2022. It does appear that, after many years of biotechnology drugs taking an increasingly large slice of the pie, a set point might have been reached.

Figure 30: Biological vs. non-biological drugs as a percentage of the pipeline, 1995—2024



Source: Pharmaprojects®, January 2024

We can break this down further in Table 30, which gives data on the number of active drugs assigned to each of Citeline's individual drug type categories, referred to as origins as they indicate how the drug was originally produced. Here is further confirmation that predictions of the demise of the small molecule may well have been premature. Synthetic chemicals still top this chart, and in fact post a 5.1% increase on last year, although admittedly this is a smaller percentage increase than 2023's 7.8%. The next five categories provide some insight into the most common types of biotechnology-based candidates. This kicks off with antibodies at number 2, posting a heftier 11.1% rise in numbers, followed by four categories whose numbers report little change: recombinant proteins, autologous cell therapies, virally delivered nucleic acids, and heterologous cell therapies. Note that the origin classification is another hierarchical one, hence the category for cell therapies whose type is unknown appearing at number 7.

Table 30: Top 25 origins of pipeline drugs

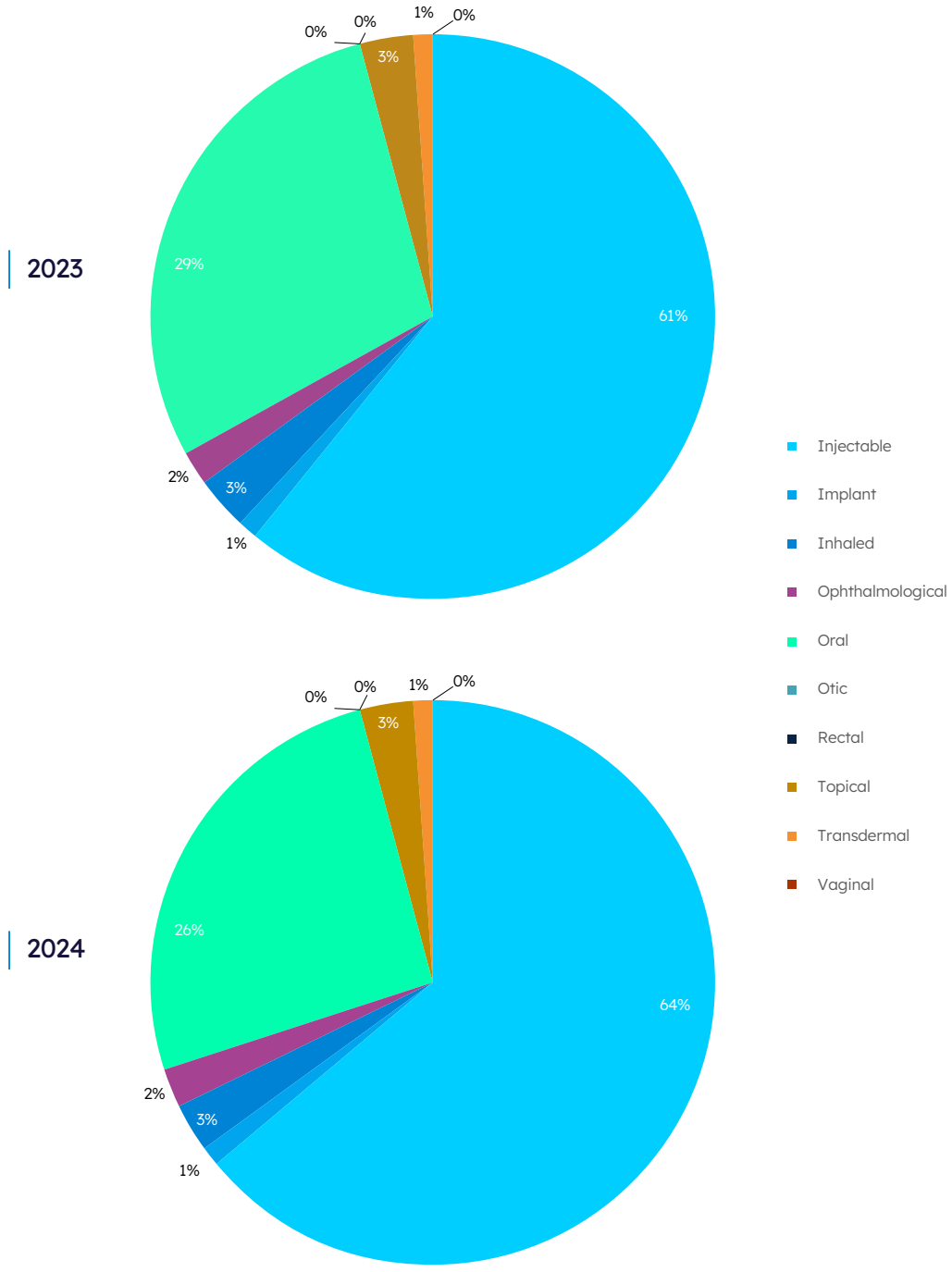
POSITION 2024 (2023)	ORIGIN	NO. OF DRUGS IN PIPE-LINE 2024 (2023)	TREND
1 (1)	Chemical, synthetic	10,831 (10,307)	↑
2 (2)	Biological, protein, antibody	3,038 (2,734)	↑
3 (3)	Biological, protein, recombinant	957 (932)	↔
4 (4)	Biological, cellular, autologous	722 (758)	↓
5 (6)	Biological, nucleic acid, viral vector	716 (677)	↔
6 (5)	Biological, cellular, heterologous	695 (687)	↔
7 (7)	Biological, cellular	688 (583)	↑↑
8 (8)	Chemical, synthetic, nucleic acid	612 (536)	↑
9 (10)	Biological, protein	558 (523)	↔
10 (9)	Biological, virus particles	535 (534)	↔
11 (11)	Biological, nucleic acid	493 (477)	↔
12 (12)	Chemical, synthetic, peptide	491 (461)	↔
13 (13)	Biological, other	392 (358)	↔
14 (14)	Biological, bacterial cells	339 (330)	↔
15 (15)	Biological, peptide	272 (254)	↔
16 (17)	Biological, nucleic acid, non-viral vector	266 (185)	↑
17 (19)	Biological	251 (164)	↑
18 (16)	Natural product, plant	218 (215)	↔
19 (18)	Biological, peptide, recombinant	176 (171)	↔
20 (21)	Natural product, fungal	58 (51)	↔
21 (20)	Chemical, semisynthetic	53 (57)	↔
22 (22)	Natural product, bacterial	46 (50)	↔
23 (23)	Natural product	38 (38)	↔
24 (25)	Chemical, synthetic, isomeric	21 (21)	↔
25 (24)	Natural product, animal	20 (22)	↔

Source: Pharmaprojects®, January 2024

In a table that, as usual, doesn't exhibit much structural change, there are a couple of increases for individual categories that are worth calling out. Nucleic acids produced by synthetic chemistry rise by 14.2% at number 8, while biologically produced nucleic acids delivered via non-viral means are up by an impressive 43.8% at number 16. It's also interesting to note how little natural product development contributes to the R&D pipeline now, with just 1.7% of current candidates being sourced this way.

Despite the stasis of this table, there is a bit of movement in the related metrics on drug delivery route, as evidenced in Figure 31. The proportion of drugs administered by injection is up a bit this year, with a concomitant fall in those delivered orally. Taken together, these delivery types cover 90% of all pipeline drugs, with topical and inhaled preparations constituting 3% each, and other routes even smaller percentages.

Figure 31: Pipeline by delivery route, 2023 and 2024



Source: Pharmaprojects®, January 2024

What's the Forecast for Pharma?

Plenty of rays of sunshine should hold off any storm clouds on the horizon

Since I began compiling this report at the beginning of January 2024, it's been officially confirmed that 2023 was the hottest year on record for planet Earth. The average land and ocean surface temperature during the year was 1.18°C (2.12°F) above the mean for the 20th century, making it the highest global temperature among all years in the US National Oceanographic and Atmospheric Administration's (NOAA's) climate records, which began in 1850. In doing so, it beat the next warmest year, 2016. More alarmingly, the 10 warmest years since 1850 have all occurred in the past decade. The NOAA estimates that the chances of 2024 being in the top five warmest years ever are 99%.

2023 was the "hottest" year for pharma R&D in terms of the number of drugs in development too, and I think we can make a similar prediction that 2024 is extremely likely to be even hotter still. The trend here, like the temperature, is heading inexorably upwards. But, just as climate change might mean a nice warm summer and a mild winter for some, but wildfires and floods for others, bigger drug pipelines are similarly a mixed blessing. They are signs that the industry is continuing to grow and that there is money available for investment, but as the vast majority of drugs will still fail, it could be said that ever-increasing amounts of capital are being spent for no return. While the last few years have seen some very encouraging signs in terms of the numbers of new drugs making it onto the market, 2023's data on this are still pending at the time of writing, and whether there is an overall upward trend is at this point moot. Certainly, the fact that a lower percentage of drugs in Phase II seem to be making it into Phase III must be a worrying statistic. Drug development will always be an inherently risky undertaking, but the chances of success ought to be getting better, not worse.

I reflected last year on how well the industry had done to not only just continue doing what it does during the COVID-19 pandemic, but also how it significantly contributed to society moving past it, and to use it as a springboard to supercharge advances. The use of mRNA vaccine technology comes to mind particularly here. To mix a range of weather-based idioms, the industry had been cooking up a storm of innovation for some time, and when the clouds of COVID gathered, and we were suddenly all snowed in, this definitely enabled us to see the sunshine after the rain sooner. Many countries around the world are now in the post-match analysis phase, holding scientists, administrators, and politicians alike to account for what we can learn so that we can handle the (inevitable) next pandemic better, as many parts of the world were woefully underprepared. We should all agree that pharma was a rare ray of sunshine here. It also emerged with its reputation enhanced, even if it is still not considered to be as pure as the driven snow.

Forecasting the fortunes of pharma can be as tricky as predicting next week's weather, as a COVID-style tempest can always wind up out of nowhere. However, we can certainly look at how external factors have the potential to blow things off course. I always make note of the global geopolitical outlook in my conclusion, as, just like how El Niño affects weather thousands of miles away, the pharma industry is always buffeted by world events, no matter how well it is insulated from their worst effects, like donning a duffel coat on a blustery day. Unfortunately, despite the sun peeping out as the clouds from COVID disperse, the outlook became grimmer during 2023. While the war in Ukraine grinds on further, it has been somewhat eclipsed by the ghastly events of the Israel-Gaza conflict that erupted in early October. At the time of writing, no resolution is in sight, with both sides entrenched in a whirlwind of horror. Thankfully, as yet, this hasn't expanded into a hurricane of regional conflict, although recent events in Yemen and across the Iran-Pakistan border are a chilling reminder that this remains a possibility. With the Middle East a major source of the world's oil, there is the potential that rising oil prices could again put the kibosh on a recovering economic picture. Maybe climate change isn't the only reason why we should be weaning ourselves off fossil fuels.

And as we go into another US election year, we can expect more instability in the political atmosphere, which is likely to be exacerbated by a bruising increase in the temperature of the rhetoric of the culture wars. The result of November's poll could seriously affect the direction of travel of the US in multiple fields, not least in respect of its relationship with China. We have seen in this report just how much China has emerged as a global player in pharma R&D, and it's not done yet. However, "business in China is going through a period of uncertainty," pointed out Helen Chen, Greater China managing partner and Asia healthcare sector head at L.E.K. Consulting, in an article of our sister publication Scrip. "Distractions are many," she continued, "a relatively low 5.5% GDP growth, political tensions with the US, pricing pressures and the hospital anti-corruption campaigns." Meanwhile, there is still the potential that out to sea, a storm could brew over control of the disputed territory of Taiwan.

All the above feeds into a funding environment for pharma that remains problematic. While this affects big pharma to a lesser degree, it could be a major source of disquiet for smaller biotech or start-up companies, which, as we have seen, are legion. "The funding environment for biopharma start-ups in 2024 is anticipated to be generally challenging," noted Koji Tamada, CEO of Japanese start-up Noile-Immune Biotech, also in Scrip. Michael Salako, investment director at UK life science venture capital company Start Codon, concurred: "Signs are that the funding environment for 2024 is generally going to be a difficult one," he said. "If the US Federal Reserve starts to reduce interest rates, this would enable capital to be moved out of risk-free money market funds and into potentially higher-yielding, riskier asset classes such as venture capital. However, this kind of change takes time to trickle down to those seeking funding. I'd expect any benefit from a change like this to only be felt by companies towards the end of 2024 or early in 2025," he stated.

What about the environment for deals? Another of our sister publications, Biomedtracker, recorded 2,218 pharma deals in 2023, including 1,237 financing deals. These numbers were down on their 2022 equivalents of 2,600 and 1,340, respectively, and continued an ongoing downward trend. But here, the mood from industry commentators was notably more optimistic. "I'm convinced that 2024 is the turning point for the biotech sector," said Cary Claiborne, CEO of Adial Pharmaceuticals, in Scrip. "Low valuations may initiate a flurry of acquisition activity, becoming an opportunity during the harsh conditions." Issei Tsukamoto, senior vice president, head of business development at Astellas Pharma, concurred, noting, "While many faced a challenging year in deal-making, there is good cause for optimism in 2024. M&A and financing activities in biotech sector are returning, and we can hope for a more 'normal' if not quite a 'boom' in activity."

One way to get a better sense of which way the wind is blowing is to look at industry output in terms of new drug launches. This is a topic we'll be diving into in more detail in the forthcoming companion volume to this report, the NAS Supplement, which reports on the full list of new active substances that made it onto the sunlit uplands of commercialization during the year just past. At the time of writing, mid-January 2024, there is still some work to do to finalize 2023's list (while drug approvals are usually widely reported, actual launches are less so, so our team undertakes major research to present you with a cast-iron list of products that genuinely received their actual market debut during the year). Looking at the figures it looks like 2023 has surpassed 2022's number. But check back in April to grab a copy of this report to be sure and to incorporate this missing piece of the jigsaw.

So, the pharmaceutical industry has entered 2024 snowed under by a plethora of new drug candidates but seems to continue to blow hot and cold during the clinical stages of development. Thus, it can't be said to be on cloud nine just yet. A continuing rising tide of new drug delivery to the market is vital if occasional sunny periods are to give way to there being not a cloud in the sky. As with climate change, whether it is pleasant tomorrow is largely immaterial — it's the longer-term trends that matter, and will be something we will continue to analyze. Come rain or shine, the Citeline Pharma R&D Review will be back next year to take the industry's temperature once again.

About the Author

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Ian Lloyd is the Senior Director of Pharmaprojects and Data Integration, overseeing the content and analyst services for our drug development solution. He supports clients in their drug pipeline data requirements and inquiries, providing insight into the best search strategies to answer their drug-related business questions and also identifying and analyzing trends in pharma R&D. For the past 32 years, he has authored the “Pharma Annual R&D Review” and its new active substances (NAS) launches supplement. This has become a must-have industry report for those seeking to identify the changing fortunes of drug R&D. Ian joined Pharmaprojects in 1987, when it was part of PJB Publications. It was acquired by Informa in 2003, and spun out to form Citeline, now part of the Norstella group, in 2022. He previously worked in molecular biology as a research assistant at the University of Bristol.

This reports also contains contributions from the following analysts in the Pharmaprojects team: Jonathan Stephens, Sydney Enokawa, Tollan Bell, Abdirazak Mohamed, JT Toebbe, and Arbesa Bela.