



Artificial intelligence and its expanding role across the biopharma landscape

An analysis of trends and developments that signal a biopharma model of the future

Contents

01 Introduction

02 Deal landscape analysis

A look back

| A look forward

| Types of deals

03 Deep dive on top 10 biopharma companies

04 Forward-looking AI-focused biopharma companies

05 Factors impacting ongoing adoption of AI in biopharma

06 Conclusion

07 How KPMG can help

Introduction

Artificial intelligence (AI) is already a well-established tool across biopharma. Since most AI adoption has been in research and development, as opposed to downstream commercial operations, there are still substantial opportunities for increased integration. In addition, organizations are actively exploring how to layer generative AI, including large language models (LLMs) like OpenAI's ChatGPT, on top of existing data and AI models to further bolster the drug discovery process and augment operations.

This paper provides an overview of key trends that demonstrate AI's staying power in the biopharma industry. These include top 10 biopharmas' investment strategies and adoption of AI to enhance existing capabilities or bolster pipeline activities. We evaluated the expanding landscape of biopharma company models, with an emphasis on AI-focused entities in the pharmaceutical and service spaces. Further, we seek to shed light on the pivotal factors affecting the acceptance and integration of these innovative paradigms by the wider biopharma community.

These analyses align with our hypothesis that AI-driven biopharma manufacturers and services companies will play a vital role in the industry for years to come.



Deal landscape analysis

1 A look back: Although AI is not new to the biopharma industry, widespread adoption took some time. Despite the prevalence in the 2010s of peer-reviewed papers on generative approaches and deep reinforcement learning as supplements to R&D activities,¹ there was still some skepticism about the viability of AI-focused biopharma service organizations.² As such, startups such as Insilico Medicine, BenevolentAI, and Exscientia founded in the nascent stages of artificial intelligence in drug discovery often struggled to secure funding from venture capitalists.

In part, early doubt stemmed from the fact that many AI companies didn't yet have a history of fruitful partnerships and successful drug discoveries. Questions regarding the reliability and accuracy of AI algorithms and outputs for identifying suitable drug candidates further exacerbated these concerns. Regulatory and compliance uncertainties also cast a shadow, with industry leaders wary about how AI methods would be regulated and whether controls would be mandated. As a result of these factors, until the end of the 2010s and early 2020s,³ companies often resorted to developing their own pipeline of AI-generated targets to demonstrate proofs of concept and establish credibility.

¹ "The cornucopia of meaningful leads: Applying deep adversarial autoencoders for new molecule development in oncology," Oncotarget, February 14, 2017; "druGAN: An Advanced Generative Adversarial Autoencoder Model for de Novo Generation of New Molecules with Desired Molecular Properties in Silico," Mol. Pharmaceutics, July 13, 2017; "A Deep Convolutional Neural Network for Bioactivity Prediction in Structure-based Drug Discovery," AtomNet, October 10, 2015; "Automated design of ligands to polypharmacological profiles," Nature, December 12, 2012.

² "Inside the nascent industry of AI-designed drugs," nature.com, June 1, 2023.

³ "Pharma backs off biotech acquisitions," Nat Biotechnol, November 3, 2022.

⁴ An AI-focused deal is classified as an agreement between two or more companies centered around an asset or capability leveraged through artificial intelligence.

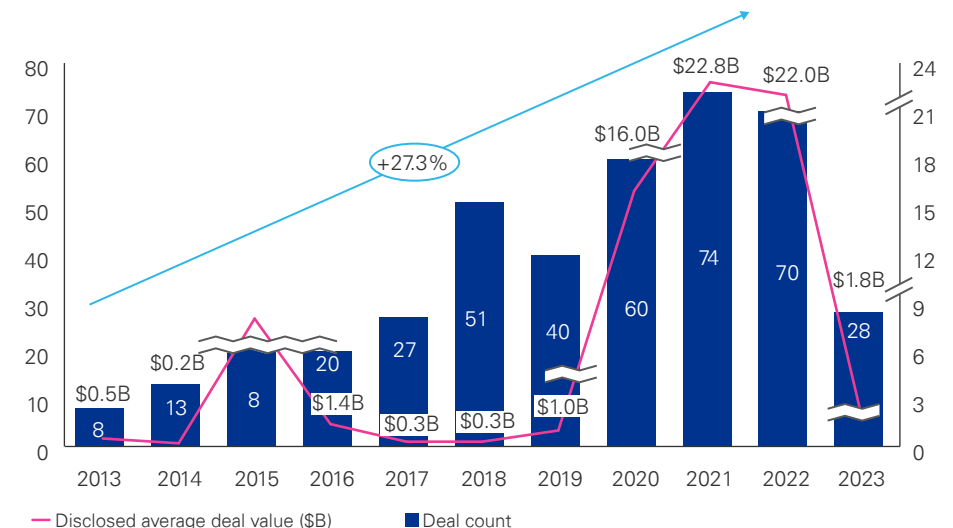
⁵ The M&A and partnership analysis in Exhibit 1 reflects biopharma companies across the following segments: large-cap biopharma (>=\$50 billion); mid-cap biopharma (\$1-\$50 billion); small-cap biopharma (<\$1 billion); private biopharma.

2 A look forward: Favorable market conditions, coupled with a growing confidence in the use of AI across biopharma, have led to a significant increase in AI-focused M&A and partnership deals, with a compounded annual growth rate of 27.3 percent from 2013 to 2022.⁴

It should be noted that geopolitical and economic factors drove a dip in AI-related deal volume during 2022. In response, pharmaceutical companies shifted toward lower-risk partnerships and asset acquisitions. At present, tighter credit market conditions and anticipated near-term valuation declines may continue to prompt a conservative approach to AI-focused deals for a time.

Despite these challenges, however, the upward trajectory of AI applications in biopharma is expected to continue⁴ (Exhibit 1).

Exhibit 1. Average number and value of M&A and partnership deals have risen over the last decade, but dropped during the economic downturn*⁵



*Data through June 2023

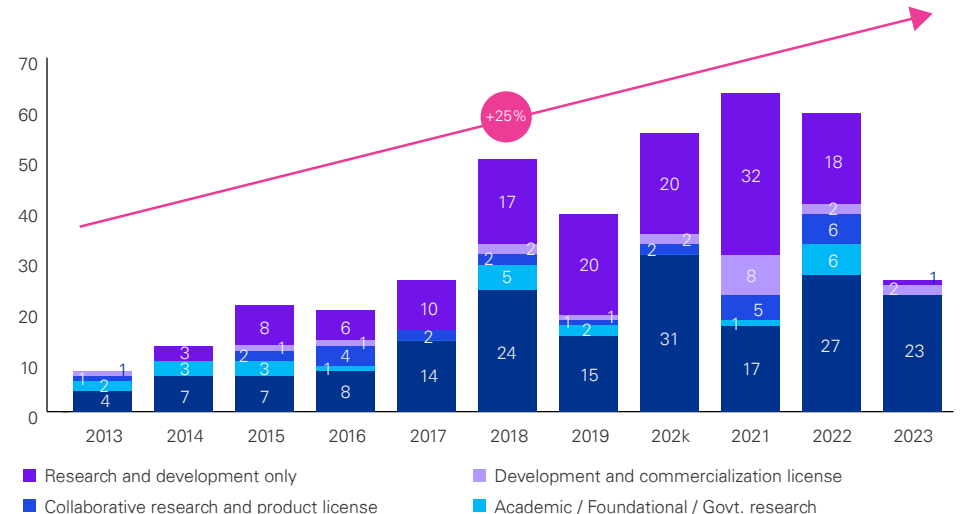
Source: MergerMarket, company websites

3

Types of deals: Over the past ten years, AI-related deals have predominantly focused on enhancing R&D (161 deals) and development and commercialization licensing (95 deals). These initial areas of focus reflect biopharma organizations' desire to improve efficiencies and realize value through AI-driven innovation.

Biopharma companies can increase R&D efficiency via multimodal data analyses. Methodologies such as this can help generate novel insights into disease mechanisms leading to faster predictions about entirely new drug targets and compounds that could interact with known medical targets. By contrast, the traditional target-based approach to drug discovery is much more time-consuming, involving high-throughput screening (HTS) of large libraries of compounds that must then be optimized through medicinal chemistry and evaluated for safety and efficacy. In other words, the typical timing of 2-3 years⁶ for small-molecule pre-clinical activities nomination to first subject can be significantly reduced using AI (Exhibit 2).

Exhibit 2. AI-related deals favor R&D, as well as development and commercialization*



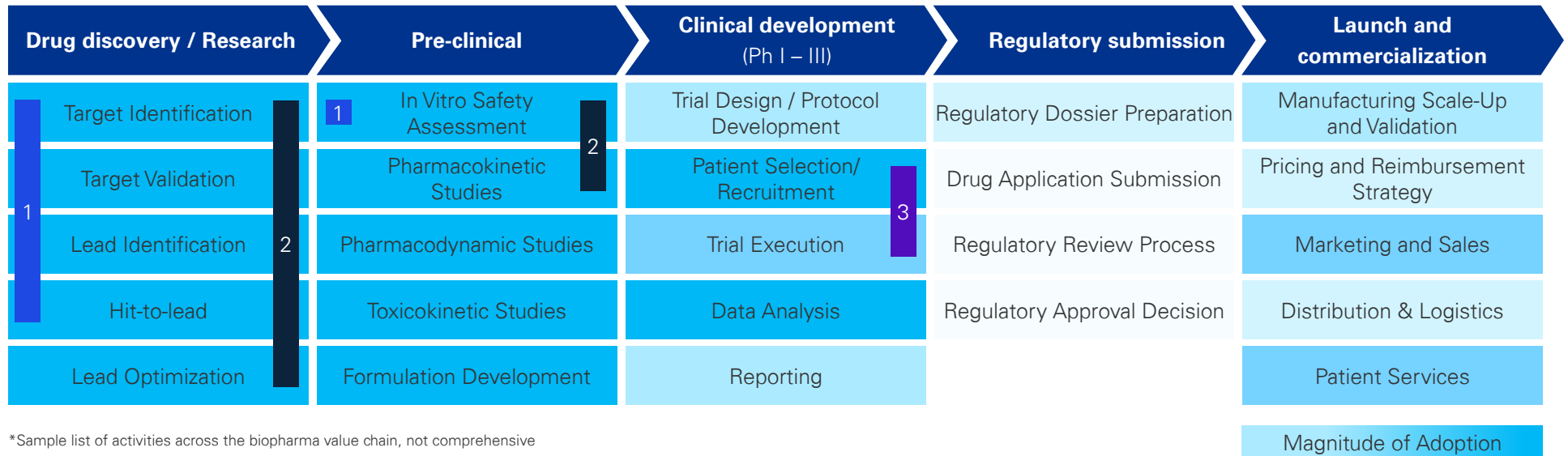
*Data through June 2023

Source: MergerMarket, company websites



⁶ "Drug discovery and development: introduction to the general public and patient groups" - Front. Drug Discov., 24 May 2023

Exhibit 3. AI adoption across the biopharma value chain*



*Sample list of activities across the biopharma value chain, not comprehensive
Source: MergerMarket, company websites, industry reports.

Directional summary of the breakdown of AI adoption across the biopharma value chain, highlighting the distribution of activities performed by companies described in the notable R&D deals below:

1 In January 2023, X-Chem, a global leader in DNA-encoded library (DEL) technology, entered a research partnership with Sironax.⁷ X-Chem utilized its DEL platform to bolster Sironax’s drug discovery pipeline, screening its unique DNA-encoded libraries against challenging neurodegenerative-disease targets to identify novel compounds.

2 In July 2022, Orion Biotechnology Canada and Peptilogics launched a strategic research collaboration to use AI for drug discovery targeting an historically undrugged G Protein-Coupled Receptor (GPCR) target.⁸ The partnership combined the capabilities of Peptilogics’ AI platform, Nautilus™, with Orion Biotechnology’s proprietary drug discovery platform, thereby harnessing their joint expertise in peptide design and engineering.

3 In September 2022, Brainomix partnered with Bridge Biotherapeutics to employ its AI-Powered e-ILD software for quantitative imaging biomarker analysis in a Phase 2 study of autotaxin inhibitor BBT-877 targeting Idiopathic Pulmonary Fibrosis (IPF).⁹ This collaboration was centered on an AI system, trained to process high-resolution chest CT data in patients with interstitial lung diseases, thereby aiding in the collection of high-quality imaging data that helped illuminate the relative efficacy of BBT-877.

⁷ “X Chem and Sironax Begin Neurodegenerative Disease Drug Discovery Research Partnership,” X-Chem, January 5, 2023.

⁸ “Orion biotechnology and peptilogics enter strategic research collaboration to enable AI_driven drug discovery against undrugged GPCR target,” Peptilogics, July 12, 2022.

⁹ “Brainomix and Bridge Biotherapeutics, Inc. Announce Partnership to Utilize Brainomix’ AI-Powered e-ILD Software for Automated Assessment of Idiopathic Pulmonary Fibrosis (IPF),” BioSpace, September 7, 2022.

Deep dive on top 10 biopharma companies

Overall, top 10 biopharma¹⁰ comprised 41.5 percent of AI-focused deals from 2013-2023, ultimately driving the growth trajectory of AI investment across the broader biopharma market. Pfizer, Roche, and AstraZeneca led the way with 28, 27, and 25 deals respectively over that period. In addition, AI deals as a percentage of total M&A and partnership deals grew at 24 percent compounded annually from 2013-2022.

Diving deeper into the deals, we categorized each based on whether they were capability or pipeline driven. Capability-focused deals involve investments focused on enhancing an activity or process along the value chain. Pipeline deals can be investments or collaborations focused on the identification and development of a pipeline asset or program.

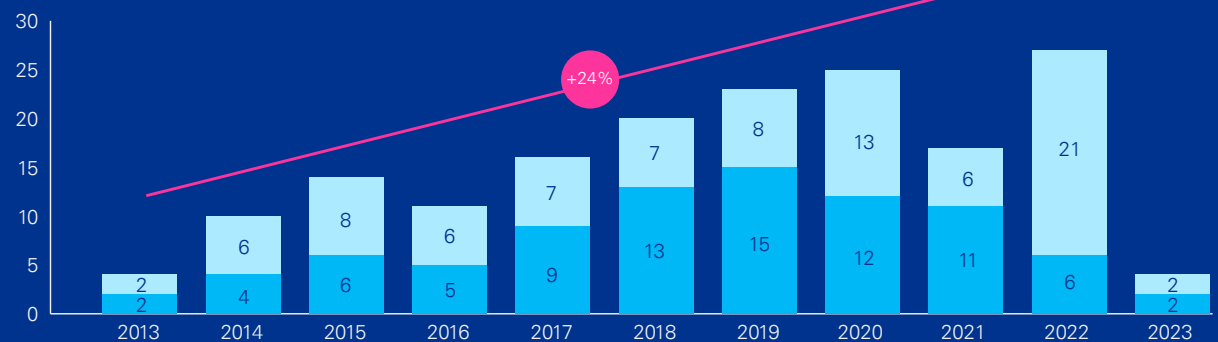
From 2013 to 2023, the top 10 biopharma companies engaged in a balanced distribution of capability and pipeline-focused activities. Between 2017 and 2021, there was a noticeably heavier investment in capabilities, reflecting a growing demand for technology advancements to bolster R&D processes. However, 2022 marked a distinct surge in pipeline deals, signaling increased confidence in AI's potential to enhance pipeline program success. Despite yearly fluctuations, the overall trend suggests an ever-increasing role for AI, and more recently, generative AI from both a capability and pipeline development perspective. (Exhibit 4).

Exhibit 4. The numbers and distribution of pipeline and capability deals across Top 10 biopharma companies*

Top-10 biopharma – AI focused M&A and partnerships deal analysis, 2013-2023



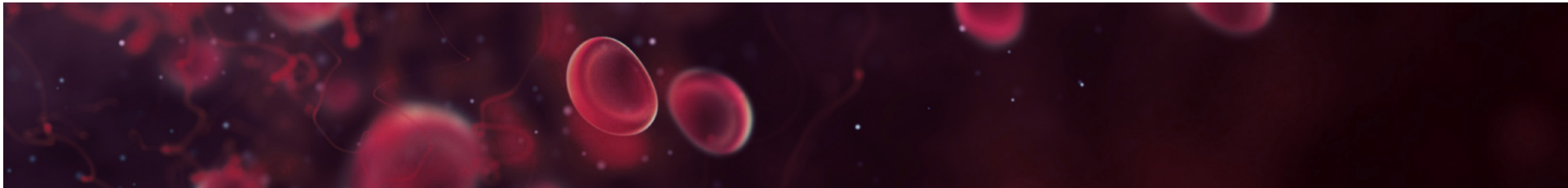
Top-10 biopharma – AI focused M&A and partnerships deal analysis, 2013-2023



*Data through June 2023

*Note: (1) Excluding blanks (2) YTD

¹⁰ Top 10 Biopharma companies by revenue are Pfizer, Johnson & Johnson, Roche, Merck, Abbvie, Novartis, Bristol Myers Squibb, Sanofi, AstraZeneca, and GlaxoSmithKline; Kevin Dunleavy, "The top 20 pharma companies by 2022 revenue," FiercePharma, April 18, 2023.



Notable capability-focused deals across top 10 biopharma include:

- Pfizer and Alex Therapeutics partnered to leverage the latter company's AI-powered digital therapeutics platform for personalized treatments, with an initial focus on a digital therapy for nicotine addiction (January 2022).¹¹
- Shape Therapeutics entered a research collaboration with Roche to advance gene therapy applications in neuroscience and rare diseases. Their work together utilizes Shape's AI-driven RNA technologies and AAV-based RNA editing technology (August 2021).¹²
- Emulate, Inc. and AstraZeneca announced a strategic agreement to develop and test Emulate's Organs-on-Chips technology in AstraZeneca's laboratories, aiming to accelerate the technology's development and potentially reduce animal testing in research (May 2018).¹³

Notable pipeline-driven deals across top 10 biopharma include:

- XtalPi collaborated with Janssen Pharmaceuticals, applying their AI-integrated Inclusive Digital Drug Discovery & Development (ID4) platform to streamlining the "Design-Make-Test-Analyze" cycle. The companies are focused on validating small-molecule hits for a Janssen-designated target (October 2022).¹⁴
- Evotec and Bristol Myers Squibb expanded their strategic protein degradation partnership to harness Evotec's AI-enabled EVOpanOmics screening capabilities and data analysis platform. The work is focused on selecting promising drug candidates from Bristol Myers Squibb's cereblon E3 ligase modulators library (May 2022).¹⁵
- Absci's collaboration with Merck employs Absci's AI-powered Integrated Drug Creation™ Platform and Bionic Protein™ technology to design enzymes specifically for Merck's biomanufacturing applications. The companies could potentially collaborate on up to three drug discovery targets (January 2022).¹⁶

In summary, the idea of leveraging AI across the biopharma sector has endured through initial skepticism and economic challenges. This is evidenced by the investment strategies of leading biopharma organizations, which are demonstrating a commitment to AI-fueled innovation across R&D and pipeline development. [See Appendix for a more comprehensive listing of AI-focused deals among Top 10 biopharma companies.]

¹¹ "Pfizer and Alex Therapeutics announce Strategic Commercial Partnership," Alex Therapeutics, January 31, 2022.

¹² "Shape Therapeutics enters into a strategic research collaboration with Roche to advance breakthrough AAV-based RNA editing technology for neuroscience and rare disease indications," Shape Therapeutics, August 24, 2021.

¹³ "Emulate, Inc. and AstraZeneca form strategic agreement to work side-by-side on Organs-on-Chips technology to improve prediction of human safety and efficacy of drug candidates," Emulate, May 16, 2018.

¹⁴ "XtalPi Announces Research Collaboration with Janssen," XtalPi, October 10, 2022.

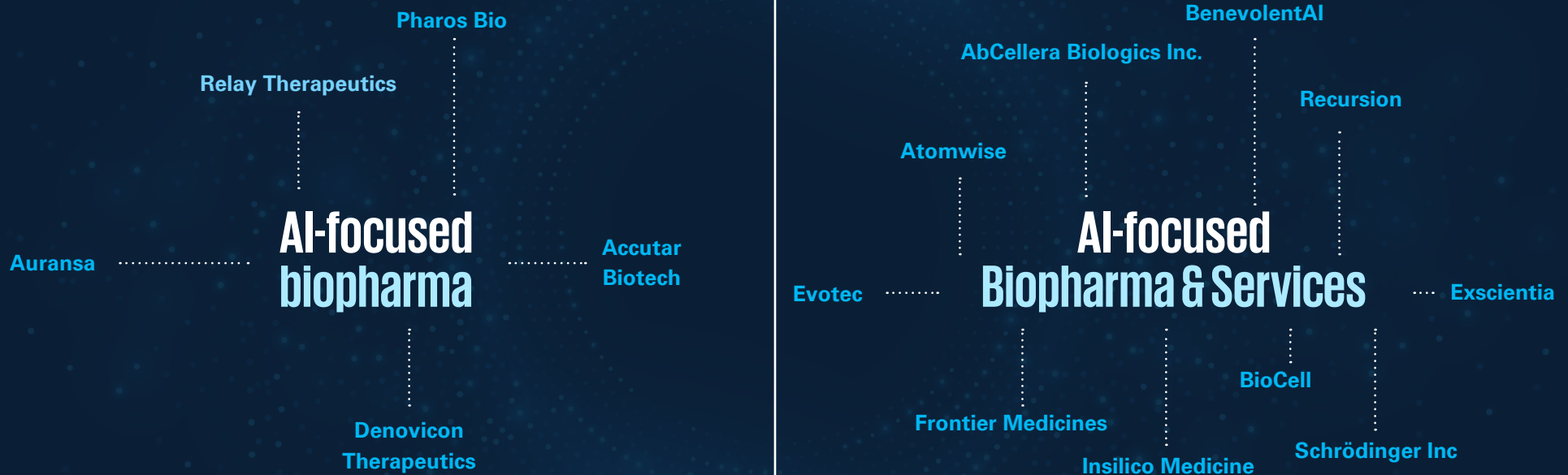
¹⁵ "Evotec and Bristol Myers Squibb extend and expand strategic partnership in protein degradation," Evotec, May 10, 2022.

¹⁶ "Absci Announces Research Collaboration with Merck," Absci, January 7, 2022.

Forward-looking AI-focused biopharma companies

Shifting our focus to the nuances of the biopharma landscape, the following analysis elucidates the rise and influence of AI-focused entities within the biopharma and services spaces. (Exhibit 5) Our deep-dive analysis will focus on AI-focused biopharma companies, where AI forms the crucial engine driving R&D and pipeline decisions, as well as AI-focused biopharma service organizations, which harness AI for pipeline decisions while also offering services to the broader industry. Alongside this detailed exploration, we share our insights on the pivotal factors influencing their sustained adoption and acceptance within the broader biopharma community.

Exhibit 5. Representative AI-focused biopharma companies*



*Sample list of AI-focused biopharma companies, not comprehensive

Example of an AI-focused biopharma company– Relay Therapeutics

Relay Therapeutics is characterized as a precision medicine company that works in the clinical stage of small-molecule therapeutic discovery, particularly within targeted oncology and genetic diseases.

The company integrates computational and experimental technologies via its Dynamo™ platform, which is rooted in the understanding of protein motion. As a self-proclaimed “new breed of biotech” enabled by AI and machine learning, Relay is creating a novel approach to drug discovery known as Motion-Based Drug Design®.

Some of the company’s work involves partnerships with top 10 biopharma companies, like their deal with Genentech focused on the development and commercialization of a drug for locally advanced or metastatic solid tumors. Relay supplements this activity through its partnership with D. E. Shaw Research, a computational biochemistry firm specializing in long timescale molecular dynamics simulations. Relay uses D. E. Shaw Research’s computational capabilities to analyze protein motion, with the aim of developing and commercializing targeted compounds.

Relay’s current AI-based capabilities include:

- Enhanced understanding of protein domains: AI-driven insights inform differentiated motion-based hypotheses on how best to modulate a protein’s behavior and identify potential novel allosteric binding sites.
- Accelerated hit identification: Proprietary tools like Relay’s DNA-encoded library platform “REL-DEL” enable the design of relevant activity-based screens, yielding a larger number of potential leads.
- Faster and enriched lead optimization: The Dynamo™ platform enables efficient prediction and design of compounds with enhanced potency, specificity, selectivity, and bioavailability, circumventing the need for the typical lengthy and expensive iterative wet laboratory approach.

Example of an AI-focused biopharma and services company– Insilco Medicine

Insilco Medicine is a private, clinical-stage biopharma firm harnessing AI to optimize drug discovery and development. The company has developed an entirely proprietary, AI-driven R&D platform, which not only facilitates its internal pipeline, but also serves other biopharma companies. In the past year, Insilco Medicine has nominated nine preclinical small-molecule candidates for approval using its AI-enhanced pipeline, with plans to expand to 15 candidates annually. They have been able to progress these candidates from preclinical stages to Phase I trials faster than the typical timing of 2-3 years for small-molecule pre-clinical activities.¹⁷

In addition, their AI-discovered and -designed treatment for idiopathic pulmonary fibrosis has produced promising Phase I results¹⁸ and is now nearing Phase II trials. Overall, Insilco is managing a total of 31 programs across 29 targets. One notable co-development is their agreement in immuno-oncology with Fosun to support its QPCTL program.

Insilco’s suite of drug-discovery tools includes PandaOmics, a natural language processing engine that evaluates target novelty and rare disease associations by analyzing multiple data sources such as patents, research publications, and clinical trial databases. Their active learning system, Chemistry42, utilizes 42 pre-trained generative algorithms to design drugs, evaluating key properties like druggability, selectivity, and potency. The performance of this system is enhanced and validated through strategic partnerships with industry leaders and the recent incorporation of ChatGPT to supplement the data integration capabilities of knowledge graphs.

Lastly, Insilco’s transformer-based AI platform, inClinico, integrates generative AI and analyzes data from over 55,600 Phase II trials spanning seven years. Authored by Insilco-affiliated researchers, the study revealed 79% accuracy in predicting the transition success from Phase II to Phase III clinical trials.¹⁹

¹⁷ “Drug discovery and development: introduction to the general public and patient groups,” *Frontiers in Drug Discovery*, May 24, 2023.

¹⁸ “Insilico Medicine announces positive topline results of the New Zealand Phase 1 trial of INS018_055, an AI-designed drug for an AI-discovered target,” *Insilico Medicine*, January 10, 2023.

¹⁹ Aliper, Alex, et al. “Prediction of Clinical Trials Outcomes Based on Target Choice and Clinical Trial Design with Multi-Modal Artificial Intelligence.” *Clinical Pharmacology and Therapeutics*.”

Factors impacting ongoing adoption of AI in biopharma

As we stand on the precipice of a potential shift in mindset across biopharma, it is critical to understand the role of generative AI and the forces driving its acceptance and integration across the value chain. While generative AI cannot solve all issues facing R&D, its incorporation into the drug development workflow can improve decision-making and efficiency, thereby creating immense value in the field. Key value-driving capabilities that will greatly influence generative AI's acceptance in biopharma years to come include:

Identification of novel compounds with enhanced characteristics

There are numerous theoretical benefits to identifying novel compounds – improved safety profiles, enhanced potency, specificity, selectivity, bioavailability, and more. Beyond product characteristics, developing patentable chemical matter within the well-characterized medicinal chemistry space is also paramount. Despite these possibilities, many of the initial generative AI-generated compounds to date have been less novel than hoped but still meaningful. For example, two AI-derived compounds from Exscientia currently in human trials are based on well-known chemical structures, targets, and mechanisms:

- DSP-1181: A Serotonin 5-HT_{1a} receptor agonist for obsessive-compulsive disorder (OCD) has been found, upon structural analysis, to have the same shaped molecules as haloperidol, a frequently used first-generation antipsychotic agent approved in 1967.²⁰
- EXS21546: An Adenosine A_{2a} receptor antagonist for several types of tumors has three structurally similar shapes, which are shared with other reported A_{2a} antagonists.²¹

Validated proof of improved timelines and cost efficiencies

Enhanced timelines and lower costs brought about by generative AI can significantly accelerate drug discovery and development in biopharma, leading to quicker market responsiveness and potential first-to-market advantages. An illustrative example is the speed at which Insilco was able to advance candidates to clinic, as discussed above.



²⁰ "AI drug discovery: assessing the first AI-designed drug candidates to go into human clinical trials," CAS, September 23, 2022.

²¹ "AI drug discovery: assessing the first AI-designed drug candidates to go into human clinical trials," CAS, September 23, 2022.

Meaningful success in clinic

Successful advancement of generative AI-led programs to approval will go a long way toward alleviating the still inherent doubt in some quarters of the industry. Theoretically, the ability to draw new insights from large complex datasets provides AI-focused biotechs with enhanced decision-making capabilities that should improve the probability of success. However, despite success in the nomination and initiation of clinical trials, to date AI-focused biopharma companies have not achieved revolutionary success beyond Phase II. Successful advancement of generative AI-led programs to approval will go a long way toward alleviating the still inherent doubt in some quarters of the industry. For instance, BenevolentAI's AI-designed atopic dermatitis candidate targeting tropomyosin receptor kinases, called BEN-2293, fell short in its Phase 2a trial, failing to demonstrate significant improvement over placebo.



Future View: Anticipated developments on the horizon

1

More advanced AI—Biopharma is adopting advanced AI technologies like Diffusion Generative Models²² to increase efficiency and precision in drug development. These models will be integrated with protein-folding techniques to achieve drug mechanism predictions, phenotypic screening, and drug target identification faster and at a lower cost.

2

Large language model (LLM) integration—LLMs like ChatGPT are increasingly being used by biotech companies to streamline data interactions and enhance accessibility. LLMs are repurposed as advanced search engines in biological science, facilitating the generation of potential new drug targets by interpreting DNA or protein sequences. Of course, privacy concerns and tool integration challenges will also need to be addressed.

3

Infrastructure upgrades that support adoption—Nvidia's BioNeMo Cloud²³ provides an infrastructure for pretrained AI models to streamline drug discovery. Adopted by several major companies, this platform integrates with Nvidia DGX Cloud for further customization.

²² "Speeding up drug discovery with diffusion generative models," MIT News, March 31, 2023.

²³ "Nvidia launches BioNeMo Cloud to accelerate drug discovery," drugdiscoverytrends.com, March 21, 2023.

Conclusion

Generative AI models offer significant potential for applications in drug development, yet their inherent limitations and ethical implications must not be overlooked. As probabilistic tools, they predict outcomes based on past data, which may not always be completely accurate, leading to unexpected results. This underscores the need for subject matter experts to thoroughly validate these models within the complex realm of drug development.

Further, despite substantial interest and investment in AI integration within biopharma, there remain notable opportunities for improvement. Key among these is the paucity of validated value claims, particularly a lack of transformative success in advanced clinical trials, which holds back full-fledged

confidence in AI's potential. To turn the tide, it may be more prudent to initially adopt a conservative strategy. This would involve using AI to enhance known compounds and increase understanding of familiar diseases and targets, rather than pushing the boundaries into lesser-explored areas with traditional targets. By focusing first on solidifying and demonstrating value in these well-understood areas, the biopharma industry will be well positioned to build a stronger foundation for AI's broader application and acceptance over time.

Looking to the future, as biopharma companies begin or accelerate their AI journeys, following are six key considerations to bear in mind:

- 1**
Align with AI-focused biotech companies: Given the pivotal role of AI-driven biotech companies in the industry today, biotech companies should look for ways to leverage their capabilities through strategic partnerships, acquisitions, or in-house development.
- 2**
Build integrated AI systems: AI isn't a one-size-fits-all solution. It is crucial to identify specific scientific and operational challenges and integrate AI into research systems to address these effectively.
- 3**
Co-create solutions with ecosystem partners: Rather than focusing solely on in-house development, emphasize co-creating solutions with ecosystem partners to scale capabilities and enhance innovation.
- 4**
Plan for incremental AI adoption: Develop a targeted AI roadmap, identifying high-value use cases aligned with specific discovery programs. Before investing in larger-scale tool or platform development, create proof-of-concept algorithms.
- 5**
Embrace change management: Prepare your organization for AI integration by implementing a change management strategy. Clearly articulate the benefits of AI, provide relevant training to AI users, and adapt job descriptions as AI gets woven into new R&D processes.
- 6**
Consider your broader technology stack: Maintain a well-designed tech stack that facilitates the quick adoption of AI advancements.

Appendix

Top 10 Biopharma/AI-focused deals, 2022-2023*

Licensor	Licensee	Date	Total deal value	Category	Deal comments
Abcellera Biologics Inc.	AbbVie	12/15/2022	Eligible for upfront payments and milestone payments	Pipeline	AbCellera partners with Abbvie to advance new antibody therapies leveraging AbCellera's antibody discovery and development engine to deliver optimized development candidates for up to five targets selected by AbbVie across multiple indications.
HotSpot Therapeutics Inc.	AbbVie	12/6/2022	\$295 million	Pipeline	Abbvie launches strategic collaboration with Hotspot Therapeutics to further expand immunology pipeline leveraging HotSpot's Smart Allosterity™ drug discovery platform for the development of the first and only small molecule IRF5 (interferon regulatory factor 5) inhibitor for the potential treatment of autoimmune diseases
C4XD Discovery Holdings plc	AstraZeneca	11/28/2022	\$402 million	Pipeline	C4XD signs exclusive global licence worth up to \$402 million with AstraZeneca for the development and commercialisation of NRF2 Activator programme
Thorne HealthTech Inc.	AstraZeneca	8/4/2022	Financial terms were not disclosed	Pipeline	Thorne HealthTech partners with AstraZeneca to research and develop novel disease applications for Astrazeneca's pipeline using Thorne's cloud-based AI disease discovery technology
Scorpion Therapeutics Inc.	AstraZeneca	1/13/2022	\$1.5 billion	Pipeline	Scorpion Therapeutics Enters Agreement with AstraZeneca to Discover, Develop and Commercialize Novel Cancer Treatments Against 'Undruggable' Targets
Charm Therapeutics	BMS	3/20/2023	Eligible for upfront payments and milestone payments	Capability	Charm Therapeutics announces collaboration with Bristol Myers Squibb to enable and accelerate small molecule drug discovery programs using Charm's DragonFold, its proprietary deep learning platform that identifies novel molecules through protein-ligand co-folding, to discover novel compounds.
Evisagenics	BMS	11/29/2022	Eligible for upfront payments and milestone payments	Pipeline	Envisagenics announces research collaboration with Bristol Myers Squibb to leverage Envisagenics' SpliceCore AI platform to identify alternative splicing derived targets for therapeutic development to expand Bristol Myers Squibb's vast oncology pipeline.
Evotec SE	BMS	5/10/2022	\$5 billion	Pipeline	Evotec SE has extended and expanded its partnership with Bristol Myers Squibb (NYSE:BMJ) in targeted protein degradation, originally signed in 2018, to building a molecular glue-based pipeline
Roche/PathAI	BMS	3/25/2022	Financial terms were not disclosed	Capability	Roche announces collaboration with PathAI and Bristol Myers Squibb to advance personalized healthcare through digital pathology solutions
Wave Life Sciences	GSK	12/13/2022	\$225 million	Pipeline	Wave Life Sciences and GSK announce collaboration to drive discovery and development of oligonucleotide therapeutics focusing on novel genetic targets
PathAI	GSK	4/5/2022	Financial terms were not disclosed	Capability	PathAI and GlaxoSmithKline sign multi-year agreement to accelerate research and drug development in oncology and non-alcoholic steatohepatitis (NASH) by leveraging PathAI's technologies in digital pathology including the use of PathAI's AIM-NASH tool
LifeMine Therapeutics Inc.	GSK	3/23/2022	\$70 million with potential royalties and milestone payments	Pipeline	LifeMine Therapeutics and GSK enter drug discovery and development alliance to identify novel product candidates to modulate difficult-to-drug targets across multiple disease areas utilizing Avatar-Rx, LifeMine's proprietary genomically-enabled drug discovery platform
XtalPi Inc.	J&J	10/27/2022	Financial terms were not disclosed	Pipeline	XtalPi announces research collaboration with Janssen to deliver chemical matter with validated binding affinities and desirable property profiles
PaigeAI	J&J	6/15/2022	Financial terms were not disclosed	Capability	Johnson & Johnson partners with Paige to develop and commercialize novel AI-based biomarker test for bladder cancer

Licensor	Licensee	Date	Total deal value	Category	Deal comments
Roivant Sciences Ltd.	J&J	4/13/2022	Financial terms were not disclosed	Pipeline	VantAI announces multi-year protein degrader discovery collaboration with Janssen, leveraging VantAI's geometric deep learning platform
TRex Bio	J&J	1/6/2022	Financial terms were not disclosed	Pipeline	TRexBio Announces Collaboration with Janssen to Discover Novel Targets for Immunology and Inflammation using TRexBio's proprietary Deep Biology platform
BigHat Biosciences Inc.	Merck	11/29/2022	Financial terms were not disclosed	Pipeline	BigHat Biosciences announces research collaboration with Merck. BigHat and Merck will collaborate to optimize up to three proteins by leveraging BigHat's platform to synthesize, express, purify, and characterize molecules
Ginkgo Biowork Holdings Inc.	Merck	10/11/2022	\$144 million	Capability	Ginkgo Bioworks announces collaboration with Merck to improve active pharmaceutical ingredient manufacturing
Orion Corp.	Merck	7/13/2022	\$290 million with potential milestone payments	Pipeline	Merck and Orion announce global collaboration for the development and commercialization of ODM-208, an investigational steroid synthesis inhibitor for the treatment of metastatic castration-resistant prostate cancer
AbSci LLC	Merck	1/7/2022	\$610 million	Pipeline	AbSci will deploy its Bionic Protein™ non-standard amino acid technology to produce enzymes tailored to Merck's biomanufacturing applications
Cleerly Inc.	Novartis	7/25/2022	\$192 million	Capability	A group of investors including Novartis acquired an undisclosed stake in Cleerly Inc, the local software-Medical Technology company engaged with AI-powered imaging solutions, through a Series C funding round. The consideration was \$192m.
Tempus Labs	Pfizer	2/28/2023	Financial terms were not disclosed	Pipeline	Tempus announces new strategic collaboration with Pfizer to advance oncology therapeutic development with the goal to more precisely gather insights that will inform novel drug discovery and development in oncology.
Roivant Sciences Ltd.	Pfizer	12/1/2022	Financial terms were not disclosed	Pipeline	Roivant and Pfizer form new Vant company focused on developing TL1A drug candidate for inflammatory and fibrotic diseases
Roivant Sciences Ltd.	Pfizer	6/28/2022	Financial terms were not disclosed	Pipeline	Roivant and Pfizer unveil Privoant Therapeutics and ongoing registrational studies for oral brepocitinib in dermatomyositis and lupus
Alex Therapeutics AB	Pfizer	1/31/2022	Financial terms were not disclosed	Capability	Pfizer and Alex Therapeutics announce a strategic commercial partnership to provide evidence-based digital therapeutics to patients, focusing in Germany
Astellas Pharma Inc.	Roche	3/28/2023	Financial terms were not disclosed	Capability	Astellas and Roche Diabetes Care Japan ink partnership agreement to develop and commercialize integrated diabetes self-management solution with BlueStar®
CytoReason Ltd.	Sanofi	1/23/2023	Financial terms were not disclosed	Pipeline	CytoReason to license its IBD disease model to Sanofi in expanded multiyear, multimillion dollar deal
Insilico Medicine Inc.	Sanofi	11/8/2022	\$1.2 billion	Pipeline	Insilico Medicine, a clinical stage AI driven drug discovery company, signs strategic research collaboration worth up to \$1.2 billion with Sanofi to advance drug development candidates
Atomwise Inc.	Sanofi	8/17/2022	~\$1 billion	Pipeline	Sanofi partners with Atomwise to develop and commercialize small molecule treatments for up to five targets using the AtomNet computational discovery technology with \$20m upfront payment
Aqemia	Sanofi	6/15/2022	Financial terms were not disclosed	Pipeline	Aqemia announces an extension of its first collaboration with Sanofi on AI and quantum physics-driven drug discovery in oncology
Exscientia plc	Sanofi	1/7/2022	\$5.2 billion	Pipeline	Exscientia and Sanofi establish strategic research collaboration to develop AI-driven pipeline of up to 15 novel small molecule candidates across oncology and immunology

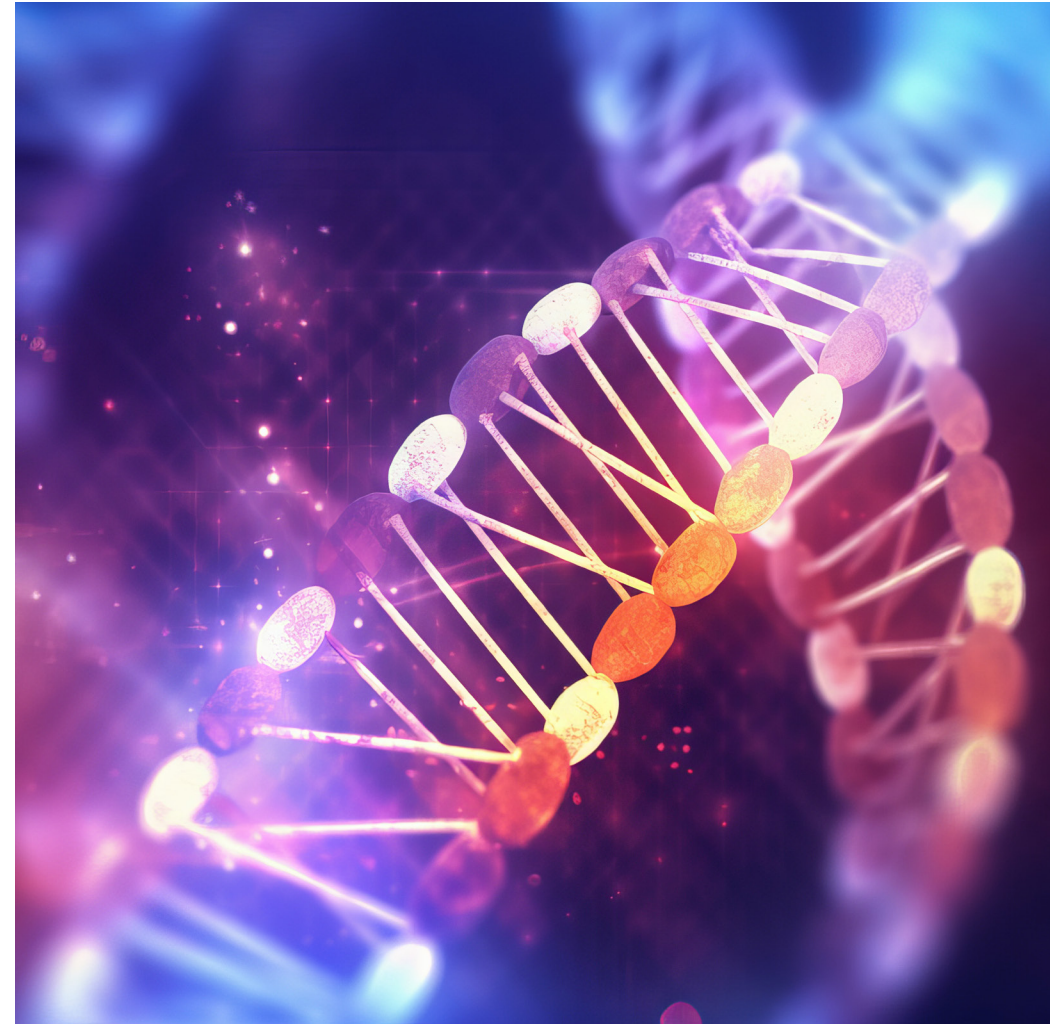
*Data through June 2023

Source: MergerMarket, company websites

How KPMG can help

Our firm is uniquely positioned to assist companies across the biopharma landscape, leveraging our strategic partnerships and insights into the dynamic generative AI market. Through the various services summarized below, we have helped guide clients in navigating the complex realm of drug development, identifying trends, assessing potential impacts, and developing strategies to capitalize on opportunities and threats driven by the emergence of generative AI.

- **Strategic Advisory** helps clients develop their overall generative AI strategy by identifying trends in the generative AI market, assessing how these trends could impact a client's business, and helping the client develop strategies to capitalize on these trends.
- **Deal Sourcing and Evaluation** to identify potential opportunities for acquisition or partnership within the generative AI market based on factors such as market position, technology portfolio, strategic fit, and potential return on investment.
- **Commercial Due Diligence** including the evaluation of a target company's market position, business model, customer relationships, and growth prospects.
- **Market and Competitive Intelligence** involves continuous monitoring of the generative AI market and providing clients with insights about market trends, competitor actions, regulatory changes, and other factors that could impact their businesses.
- **Integration Planning and Post-Merger Integration** happen after a deal is completed and involve helping a client integrate the acquired company or assets. This could involve identifying potential synergies, developing an integration plan, or helping manage the integration process.



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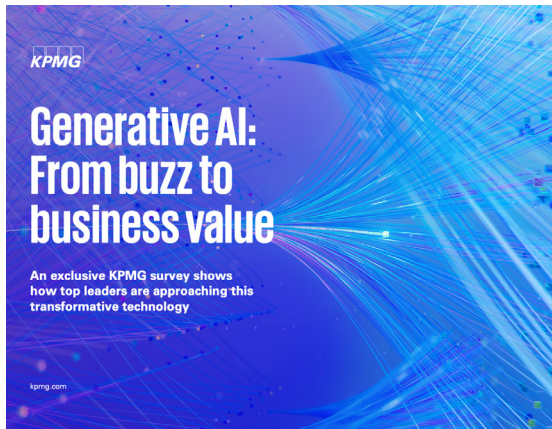
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Related thought leadership:



Learn how KPMG can help make your [generative AI implementation](#) successful, and explore how we can help you [adopt AI](#) in a safe, trustworthy, and ethical manner.

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