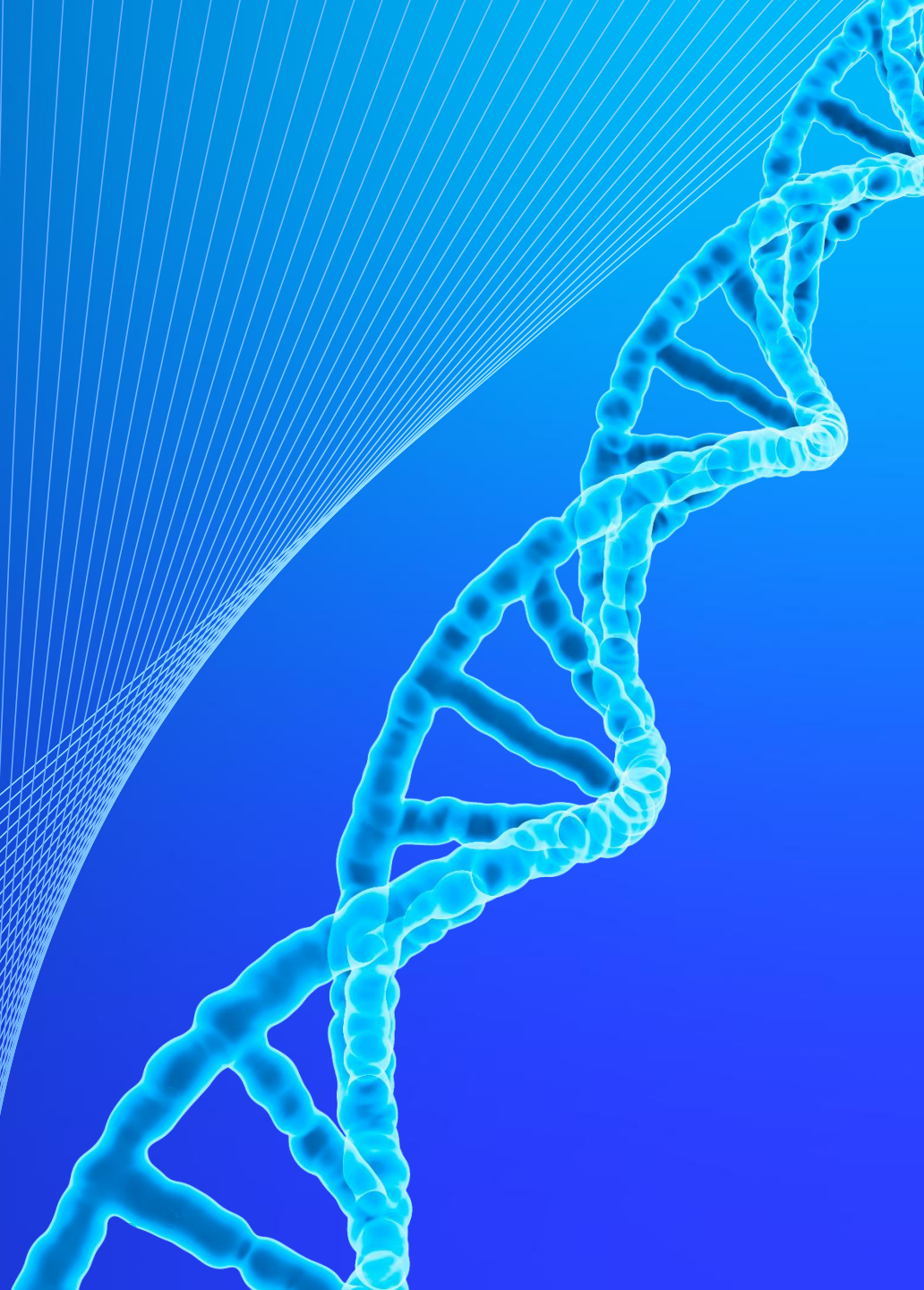
McKinsey & Company

AI: Hype or turning point for Biotech?

BioCentury-BayHelix East-West Biopharma Summit

October 2023



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What is the state of the

biotech industry today?

Value creation is becoming increasingly challenging for biopharma

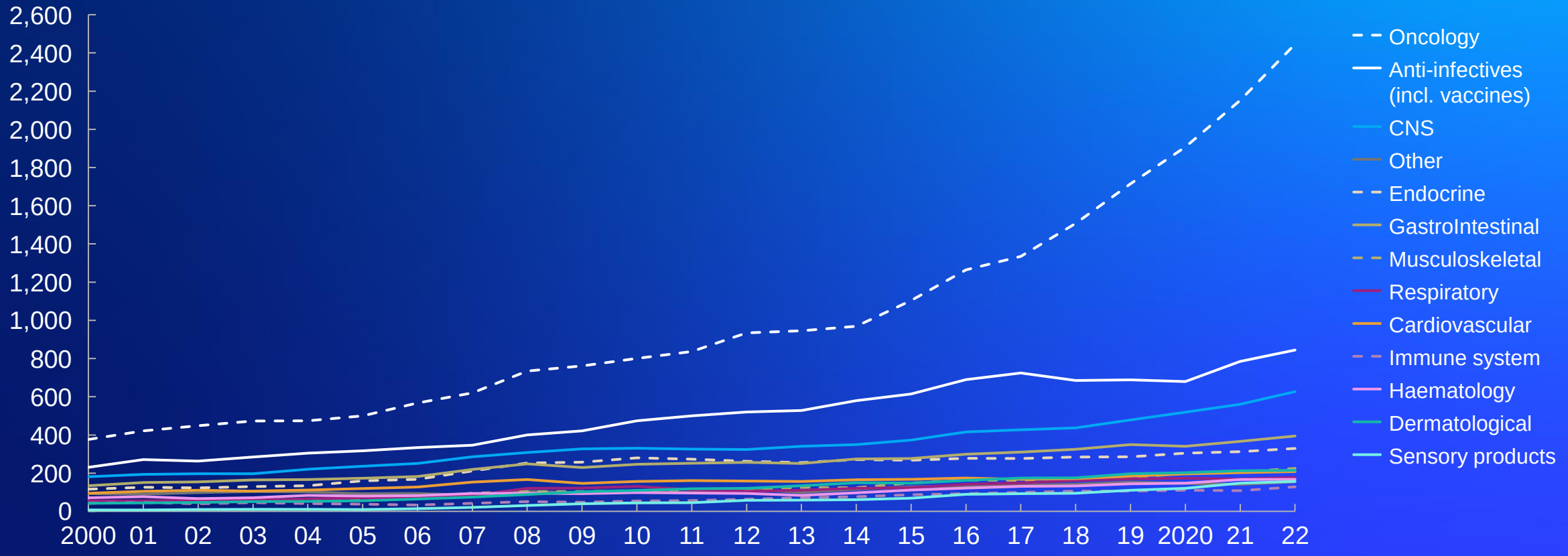
1: Increased competition, genericization and evolving regulations are compressing asset life cycles and increase pricing pressure

2: Consistently high cost of innovation amidst a landscape of tighter capital markets

1: The R&D pipeline is massively expanding, esp. in oncology…

Total number of compounds in clinical development (phase I-III)[1]

Number of compounds reported in trends data

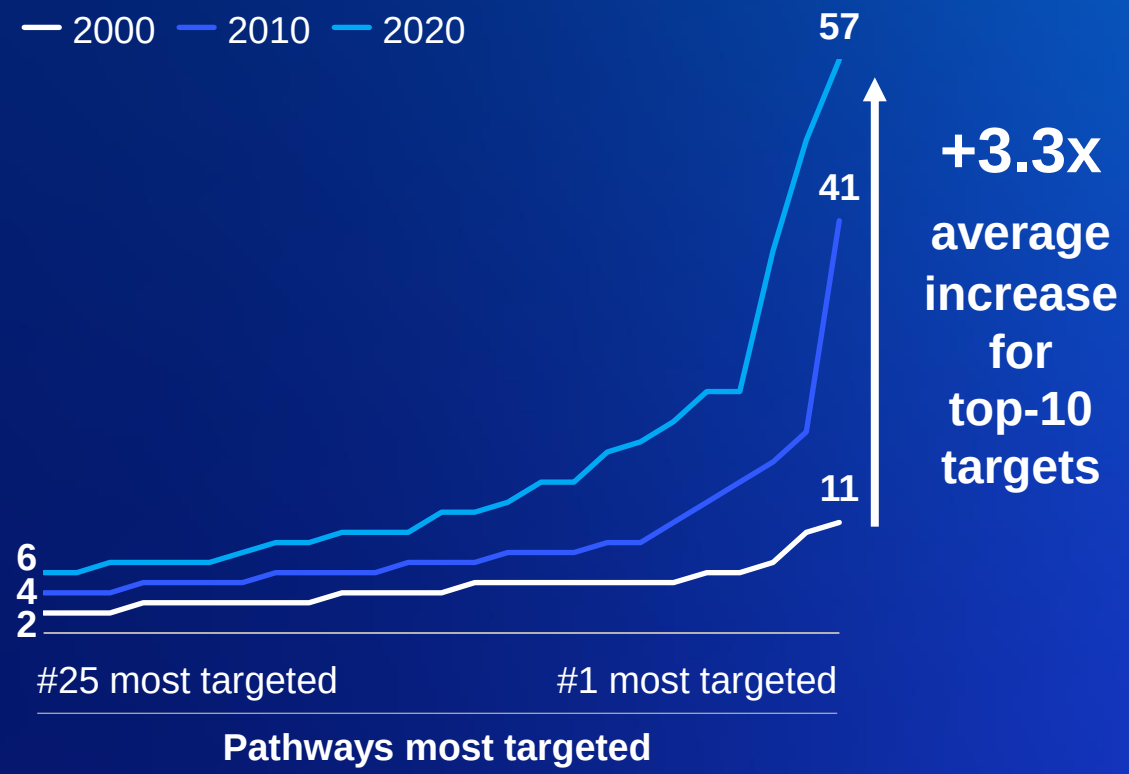


1. Excluding reformulations and biosimilars; Smallest TAs (GU, diagnostics and imaging, and other) are grouped as “Other”

Source: Pharmaprojects® 2023; McKinsey analysis

1: …but there is significant competition for the same promising targets

Global pipeline assets[1] per target, Number of assets



+3.3x
average increase for top-10 targets

Asia-Pacific
~6.6x

North America
~2.1x

Europe
~0.8x

Average increase in number of assets per target for the top 10 targets by region[2]

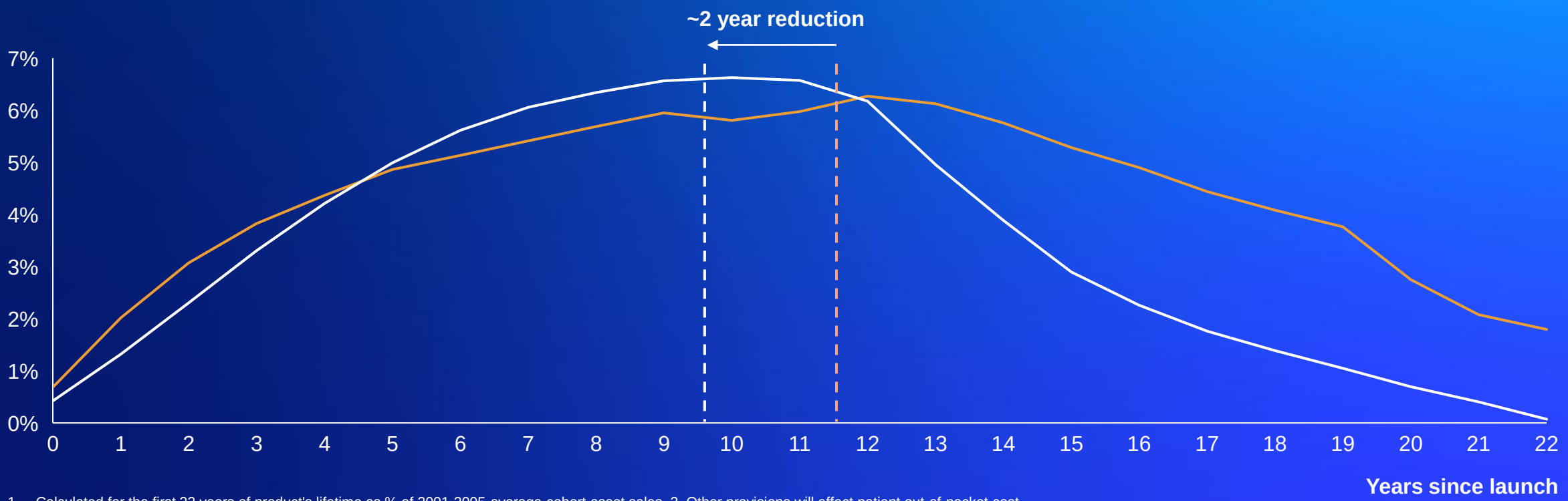
1. Analysis includes >250 companies in APAC, >150 companies in Europe, >250 companies in North America
2. Geographic region assigned based on originator's headquarters location

Source: Pharmaprojects I Informa, 2022

1: Lifecycles of pharma assets are already accelerating, with less time to capture the value of innovation

Time to 50% sales has decreased by ~2 years since 2000

Revenue distribution % of lifetime[1] sales for top 36 BioPharma marketed products by product launch period

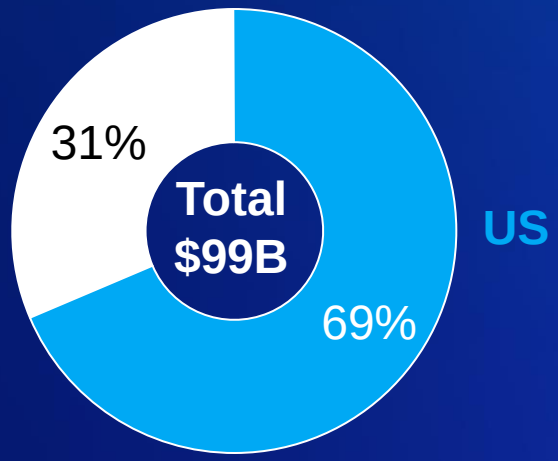


1. Calculated for the first 22 years of product's lifetime as % of 2001-2005 average cohort asset sales 2. Other provisions will affect patient out-of-pocket cost and inflation penalty

Source: Evaluate pharma, Press Search

1: Inflation Reduction Act (IRA) can further shorten life cycles and increase pricing pressures

Revenue for top 15 biotechs with global breakdown reported[1]



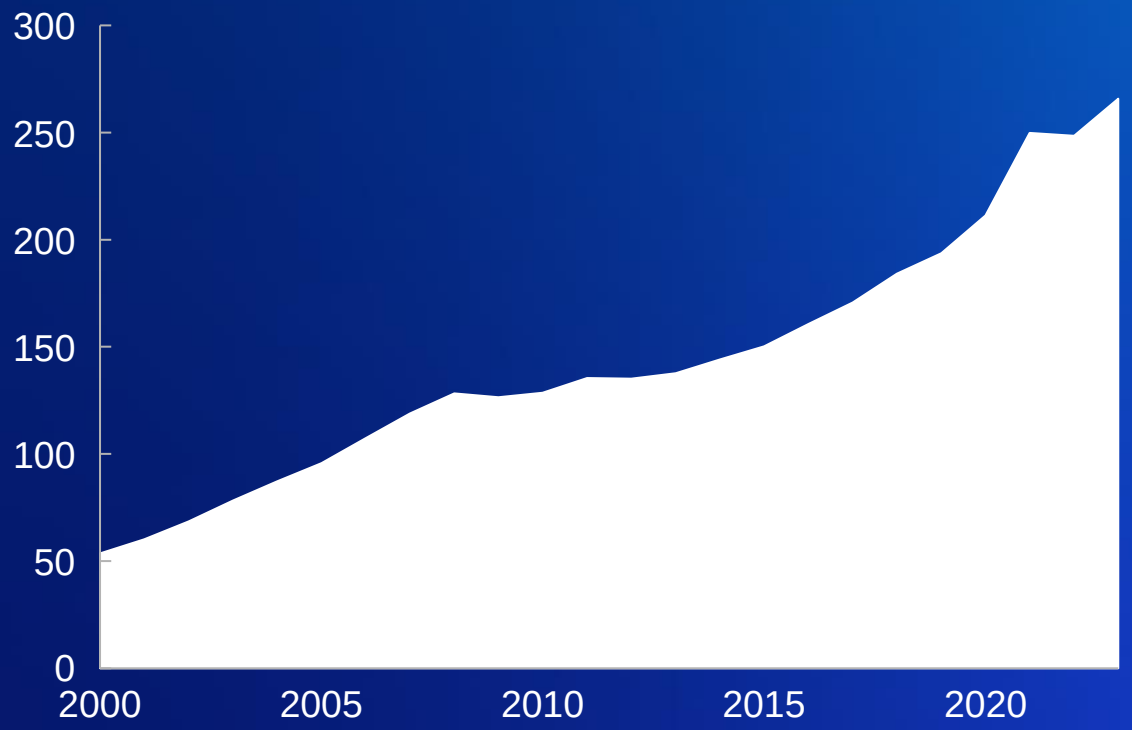
Changes		Potential Implications
2023		
Medicare inflationary rebates	›	Limits level of drug price increases year over year
2026		
Medicare drug price negotiation	›	Impacts blockbuster drugs with likely spillover effects on entire TAs
2027+		
Continuous increase in drugs subject to negotiation	›	Increases pricing pressure across the industry

1. Biotechs ranked by 2021 global revenue; includes top 15 biotechs that reported revenues by region in their 2021 SEC filings

Source: US Federal Law; expert interviews as of October 2022; company 10Ks

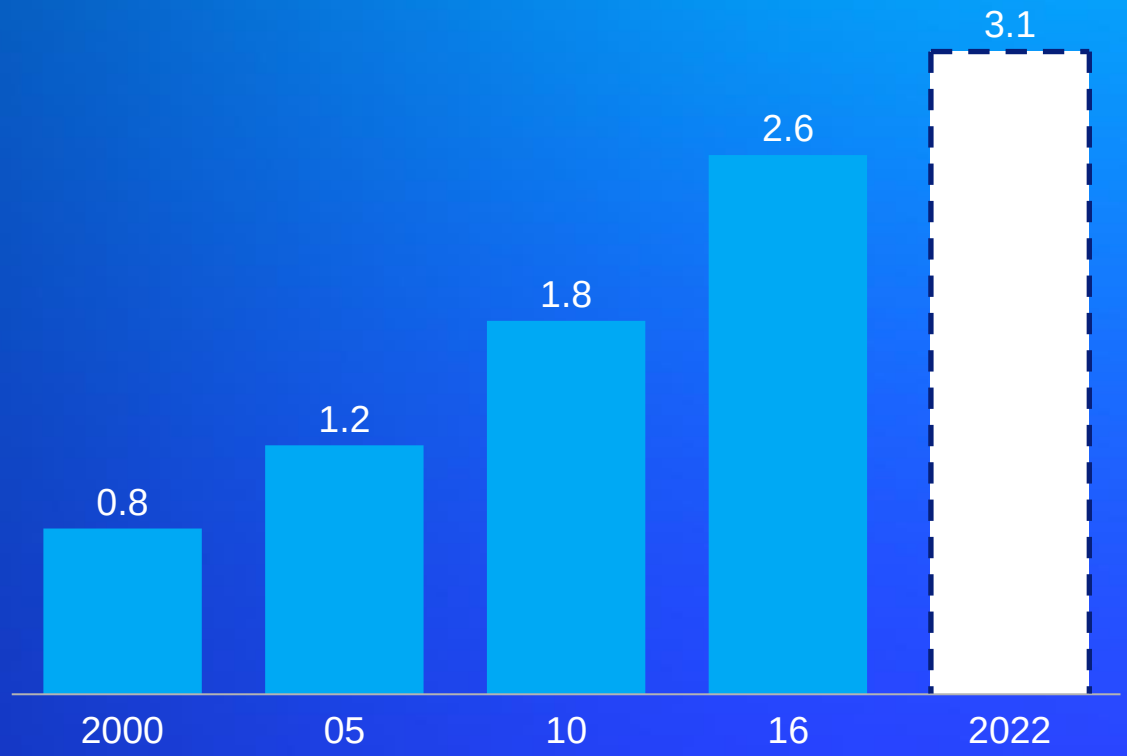
2: R&D spend is consistently increasing

Pharma R&D spend, 2000-23 ($B per year)



~$3.4T in cumulative R&D spend

Average cost per successful NME[1], 2000-22 ($B per year)

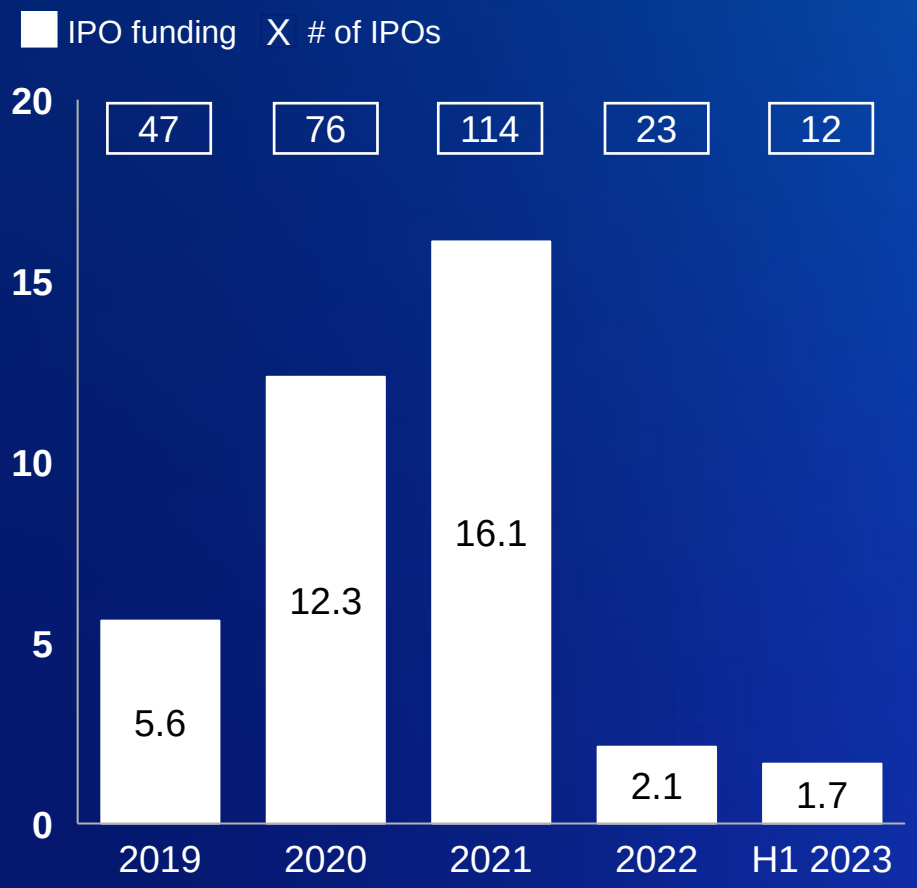


1. Based on latest available data from 2016 Tufts Institute study - 2022 figure represents inflation-adjusted estimate

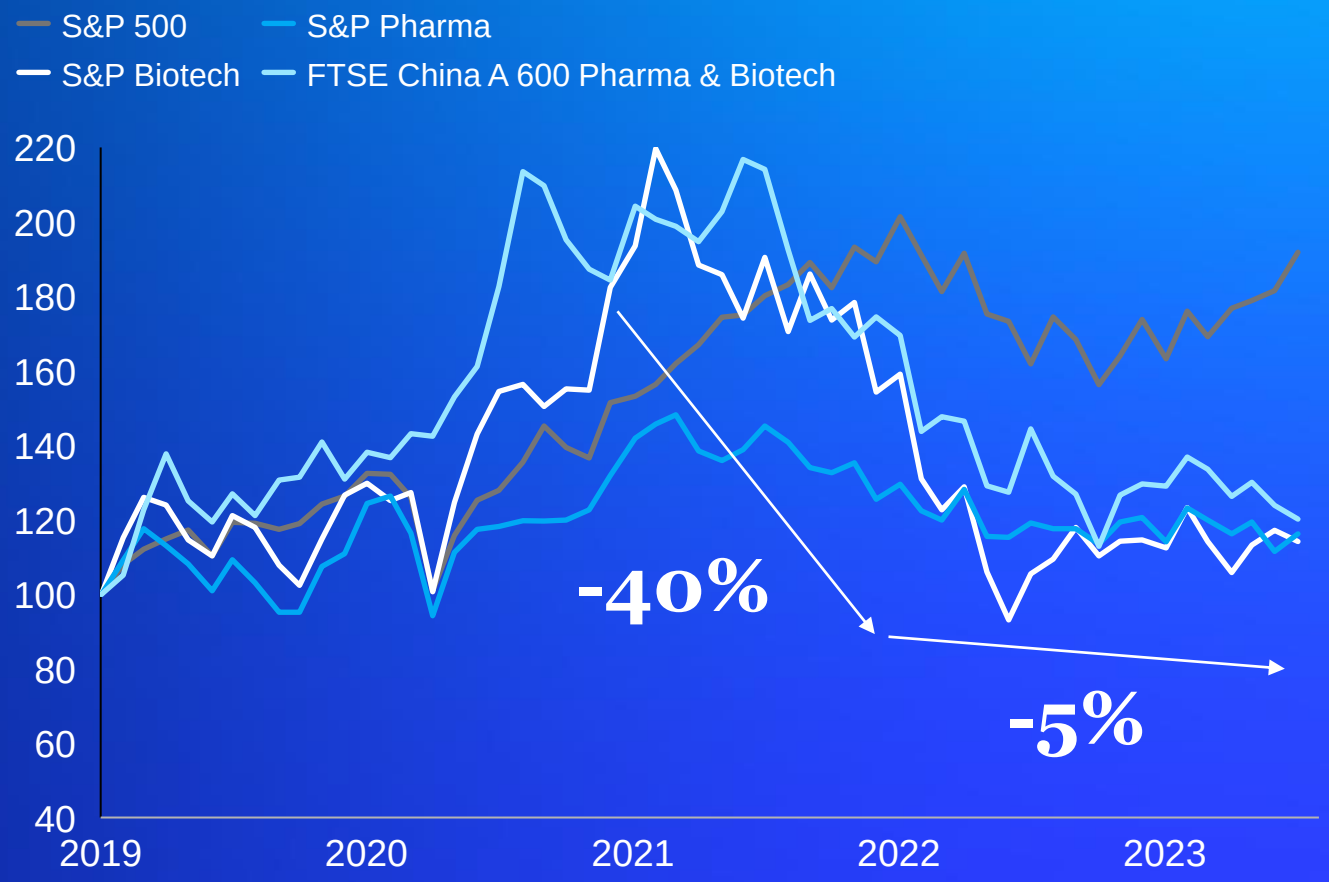
Source: Evaluate Pharma; Journal of Health Economics 2016; PharmaProjects,, CPI from US Bureau of Labor Statistics

2: Biotech funding and valuation landscape has stabilized, but at a significantly lower level than during the COVID pandemic

Biopharma IPO funding 2019-H1 2023,
Total investment, $USD Bn ; # of IPOs



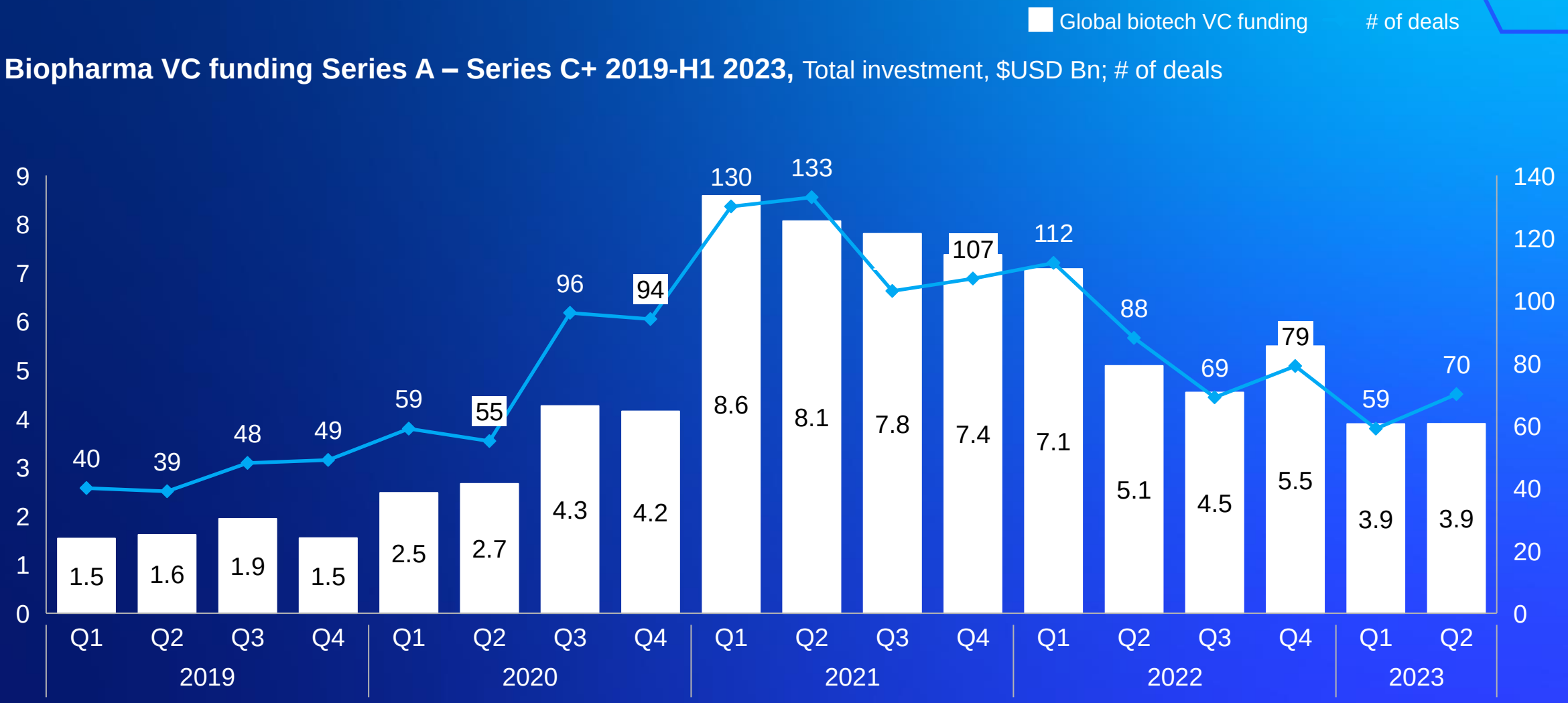
Performance of the S&P Biotech vs. major indices 2019-H1 2023,
Total gross return, index (Jan 2019 = 100)



Source: Pitchbook 2023 data; filtered for "Biotechnology" industry; Excludes contract and research services, industrial biotechnology and food/agriculture; Capital IQ; S&P500, S&P Pharmaceuticals Select Industry Index (SPSIPH), S&P Biotechnology Select Industry Index (SPSIBI); FTSE China A 600 Pharma & Biotech index - Investing.com

2: VC funding landscape remained strong in 2022/23 but a reversal to pre-pandemic norms may be underway

Biopharma VC funding Series A – Series C+ 2019-H1 2023, Total investment, $USD Bn; # of deals

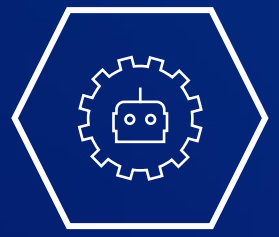


Source: Pitchbook 2023 data; filtered for "Biotechnology" industry; Excludes contract and research services, industrial biotechnology and food/agriculture

Can AI change the equation?

AI, platform technologies and focus on larger patient populations could fundamentally change the equation

Early promise of success



AI fundamentally transforms R&D incl. speed, cost and success rate

~25% acceleration,
2-3x PoS

Platforms increase NME productivity once passing proof of concept

100+ mRNA clinical and commercial assets in 2023,
63% increase from 2022

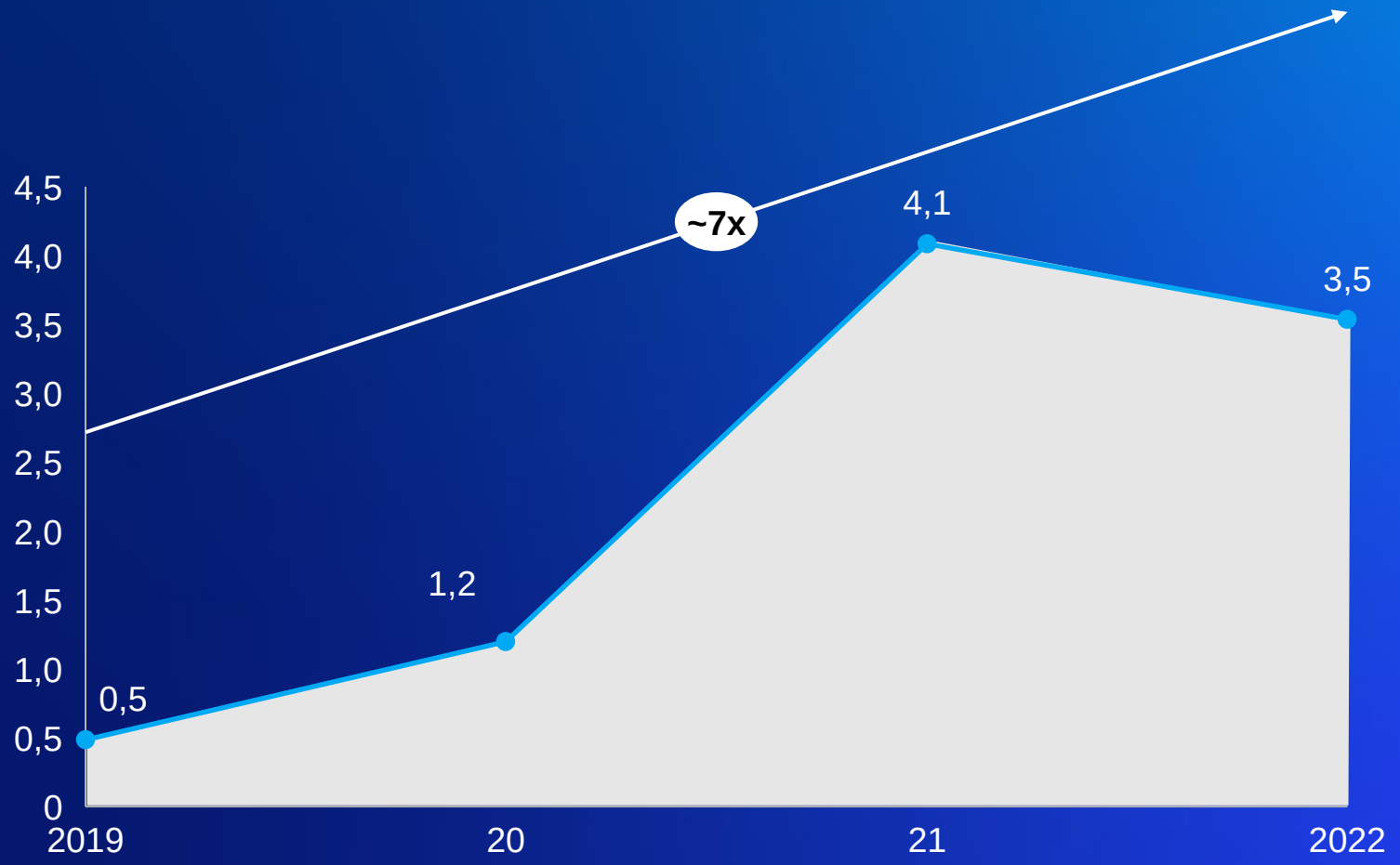
Larger patient populations increase addressable market and unmet need

~1 bn+ populations for obesity and COVID drugs

Source: Pharmaprojects , McKinsey case studies, WHO

Funding for AI has skyrocketed over the past years – even amongst overall tighter financial markets

VC funding for ML enabled drug discovery (in $ Bn)

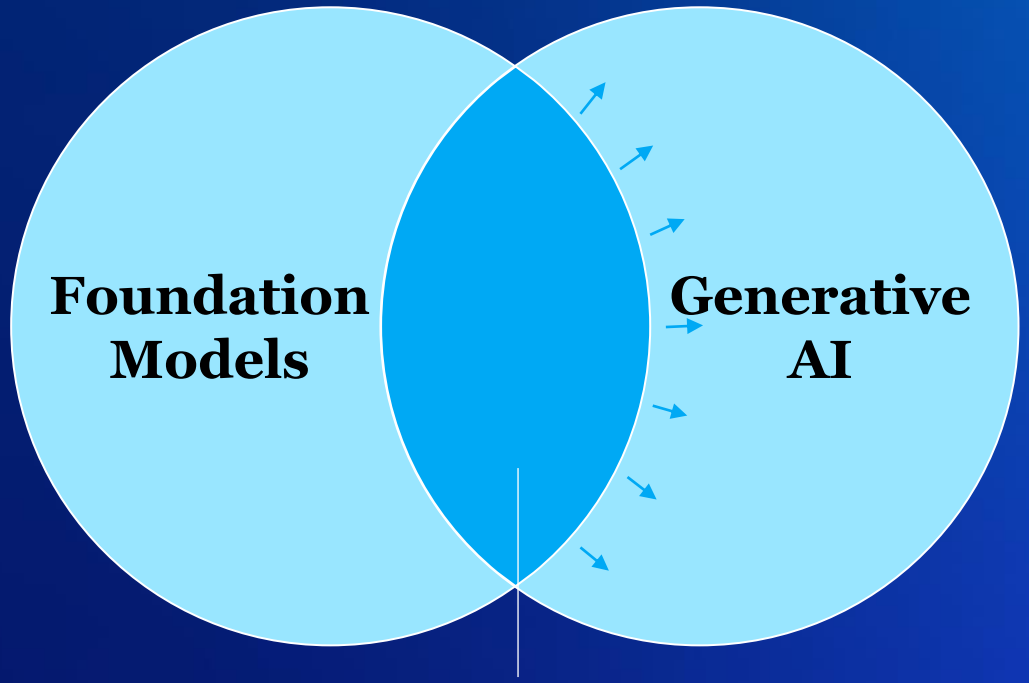


Comments

- VC funding for ML enabled drug discovery has increased 7x over the past 3 years – corresponding to 22% of overall VC funding (up from 12%)
- VCs are actively expanding their investments in AI even among overall decline in funding

Source: Deals >$10M in Series A-Series C+ in privately-held companies during 2019-2022; Filtered for "Biotechnology" industry; Excludes contract and research services, industrial biotechnology and food/agriculture

Foundation Models and GenAI are currently pushing the art of the possible across industries…



At the growing intersection of FM and Gen AI are exciting tools like ChatGPT, DALL-E, MidJourney and Stable Diffusion

FM

Foundation Models (FMs) are large deep learning models, pre-trained with attention mechanisms on massive datasets, adaptable to a wide variety of downstream tasks including content generation

Gen AI

Generative AI are methods to generate content using algorithms, typically using deep learning models such as GANs[1], VAEs[1] or FMs

1. GAN: Generational Adversarial Network, VAE: Variational Auto-Encoder

In biopharma R&D, AI can help to OPTIMIZE…

Research and preclinical studies through automation

Early clinical trials through adaptive trial design

Late-stage trials through E2E Control Tower

~20-30% Acceleration

Indirect contribution from prediction (e.g., the right patient population)

… and more importantly, foundation models can PREDICT

Successful targets and leads through in silico experimentation

High value indications through analyzing patient journeys

Patient populations through RCT simulation

~2-3x Probability of Success

AI can accelerate R&D...

Current approval timeline

5-7 years

Accelerated approval with AI

1-2 years

Preclinical development

~24-36 mos.

~10-20 mos.

~50%

Reduction in time

Early clinical (Phase I/II)

~24 mos.

~20-22 mos.

~10-20%

Reduction in time

Late clinical (Phase III/IV)

~32-40 mos.

~28-32 mos.

~10-20%

Reduction in time

Source: Press search, FDA guidance on clinical trial times, Pharmaceutical Technology, PubMed, McKinsey analysis

AI use cases across the R&D continuum

Preclinical development

Disease understanding → **Target identification** → **Lead identification**

Data-enabled digital twins

E2E automation

Early clinical (Phase I/II)

Trial design → **Population identification**

Clinical endpoint optimization

Location incidence / prevalence mapping

Late clinical (Phase III/IV)

Trial execution → **Safety & quality monitoring** → **Regulatory submissions**

Clinical control tower

AI/ML-enabled data quality control

Patient burden-based submission strategy

… and predict successful drug candidates (example lead ID)

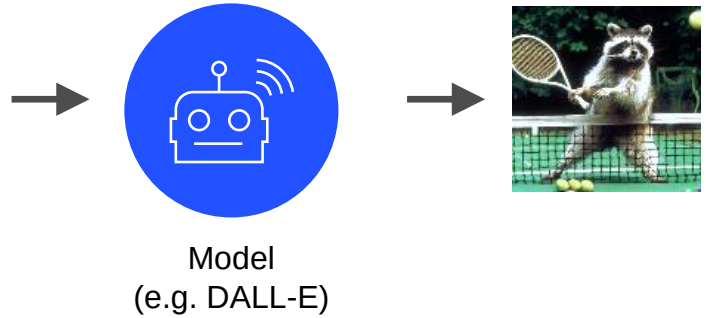
Illustrative example

Context

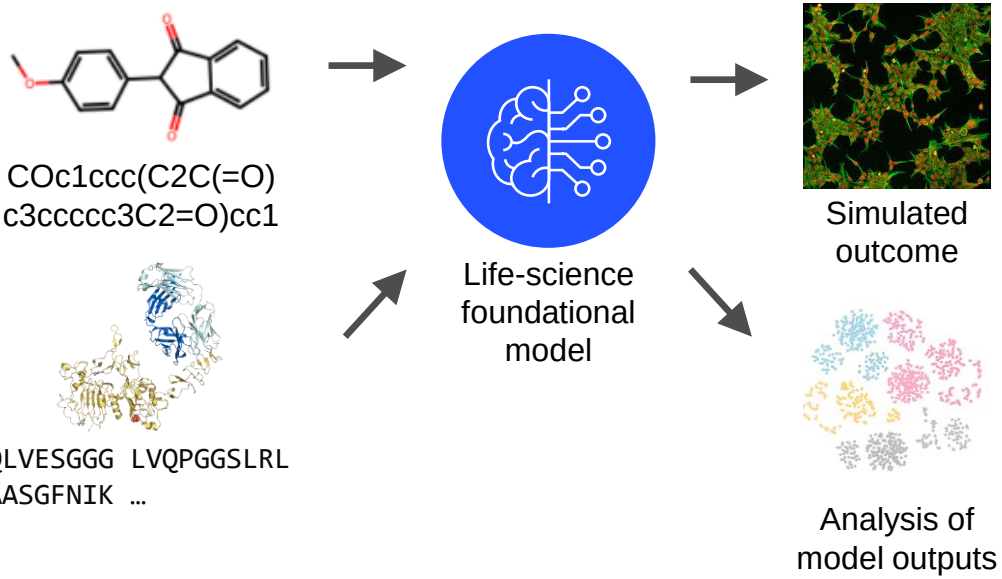
We can use foundational models (FM) to simulate the outcomes of experiments to accelerate drug discovery and improve quality of identified leads

Foundational models have been used for new image generation

"A raccoon playing tennis at Wimbledon in the 1990s"



Alternatively, these models can be used to simulate experimental outcomes for lead generation



With foundation models improved generation of leads is possible:

- **2-3x+ increase in POS** based on improved output quality from higher information capture
- **2x+[1] speed to reach first outcomes** using off-the-shelf models instead building from scratch

1. ~6-8weeks with of-the-shelf foundation models vs ~4-5 months with traditional deep learning

GenAI now creates additional value by actively generating content

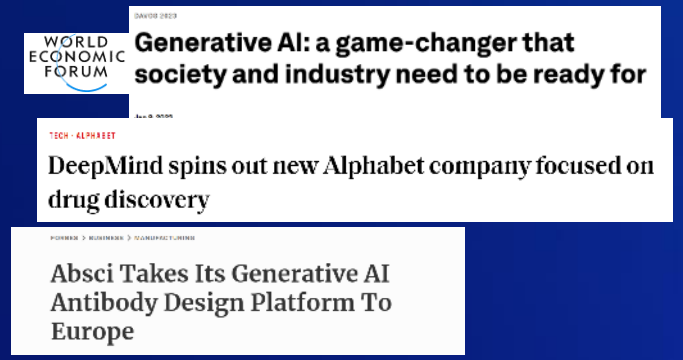
Insight generation	**Disease understanding** Comprehensive synthesis of relevant academic literature	**>30M** PubMED references summarized instantly
Engagement	**Trial management** Responsively generated insights on top questions (e.g., feasibility, performance)	**15-20%** reduction in trial timelines
Automation	**Regulatory/ Submission** Instantaneous generation of an entire CSR	**10-40%** reduction in medical writing workflow

Based on the broad impact GenAI can have, there is global excitement for advancing and adopting the technology

>$10B investment in one of the top players[1]

30%[2] increase in number and value of VC/PE deals in GenAI in LS since 2020 (from $1.8B to $2.1B)

8X growth in search for "Generative AI"[1] in 2022[3]



~80% of current AI research is focused on Generative AI today[4]

GenAI model developers partnering with PharmaCos to capture value across value chain

DeepMind OpenAI NVIDIA

Insilico Medicine

Developed a GenAI model to predict clinical trial success rates w/ 80+% accuracy

NOVARTIS

Partnered with Microsoft to leverage MoLeR for drug discovery and accelerate compound identification

insitro

Combine FMs and high-throughput biology to create predictive models for target identification and drug design

Exscientia

GenAI leveraged across all stages of R&D, with average time from target to candidate of ~13 months at 80% lower cost than industry average

1. Microsoft investing in OpenAI
2. Pitchbook search
3. Between Jan & peak Dec 2022 (pre holiday) based on Google Trends results
4. https://www.economist.com/interactive/briefing/2022/06/11/huge-foundation-models-are-turbo-charging-ai-progress, not specific to Life Sciences industry

GenAI can further speed up R&D - Faster, automated medical writing with leaner organization

What it is

- **CSR auto-drafting** informed by existing documents e.g., protocol and SAP
- **Routine TLF generation** using ADaM datasets
- **Auto-QC in-text TLFs** to reduce potential errors

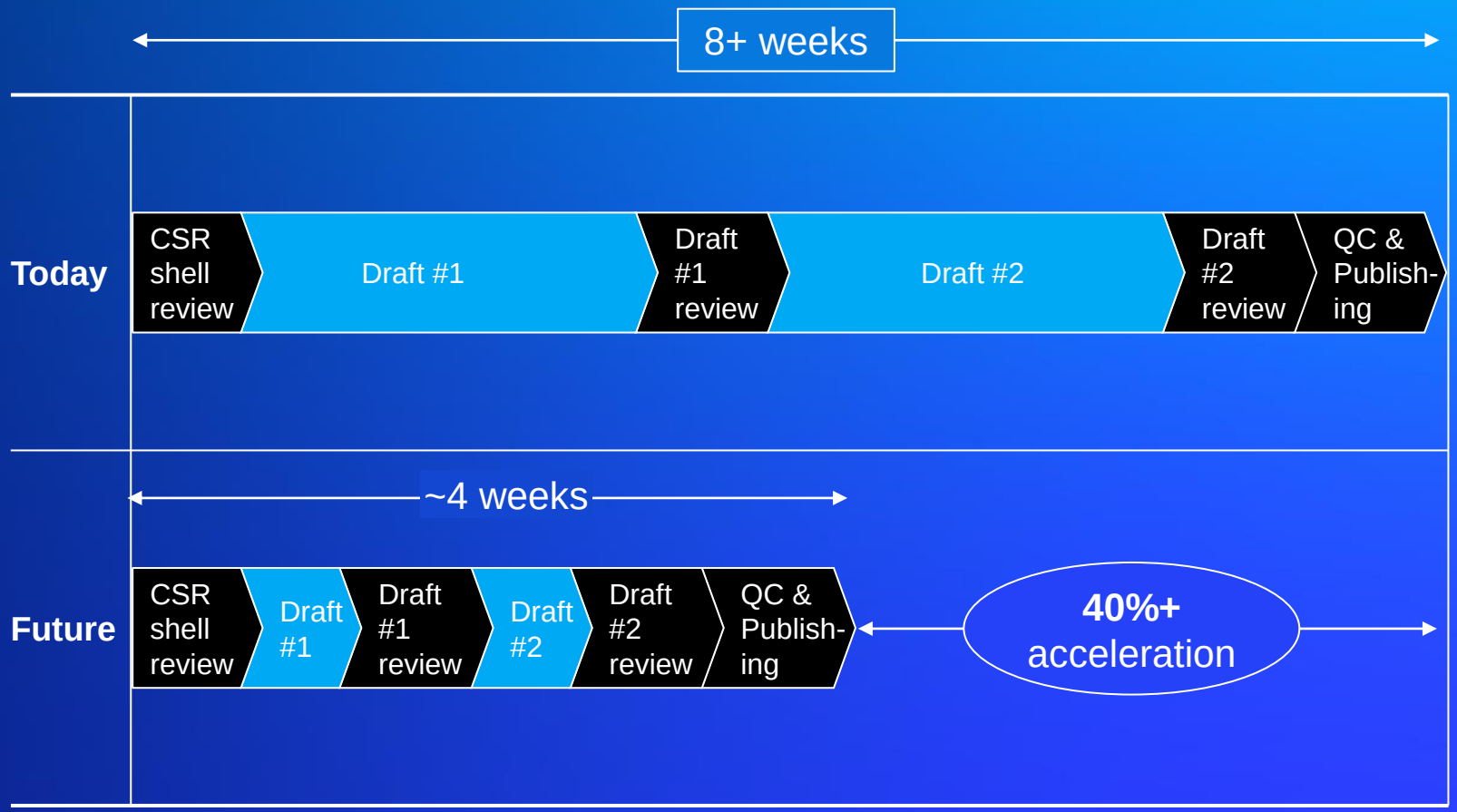
Impact

40% faster regulatory submission

50% more cost efficiency across regulatory organization

2x reduction in quality issues from automated QC

CSR auto-drafting could accelerate E2E CSR timeline by 40% or more

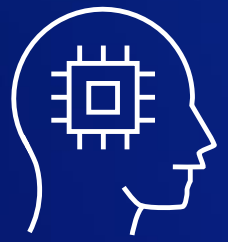


How can biotech companies differentiate and capture value through AI?

Key questions for biotech companies to differentiate and capture value through AI

1

In a world of ubiquitous access to AI, how will biotech differentiate?



2

Can AI move the needle on value creation for biotech companies?

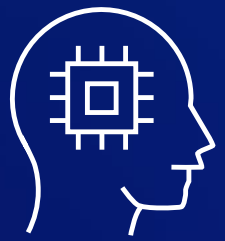
3

Will the next horizon of AI change the game?

Key questions for biotech companies to differentiate and capture value through AI (1/3)

1

In a world of ubiquitous access to AI, how will biotech differentiate?



Generalized AI models are becoming commoditized/ open source, differentiation will be achieved through:

- Multi-modal, fit-for-purpose datasets
- Combining AI with cutting edge biology and automation

1: Wide availability of open- and close-sourced AI models – but biotechs differentiate through cutting edge use cases

Non-exhaustive

Major tech players have established footholds with sophisticated products…

Gen AI Incumbents

Microsoft

OpenAI

Google DeepMind

stability.ai

Drug Discovery Models

MoLeR

AlphaFold

OpenBioML

…but value can be unlocked through specific use cases/ training models on proprietary datasets

Insilico Medicine

AlphaFold

ChatGPT

*Used **AlphaFold** to design novel oncology molecule*

*Leverages **ChatGPT** in **R&D discovery platform***

Exscientia

Leverages GenAI across all stages of Research

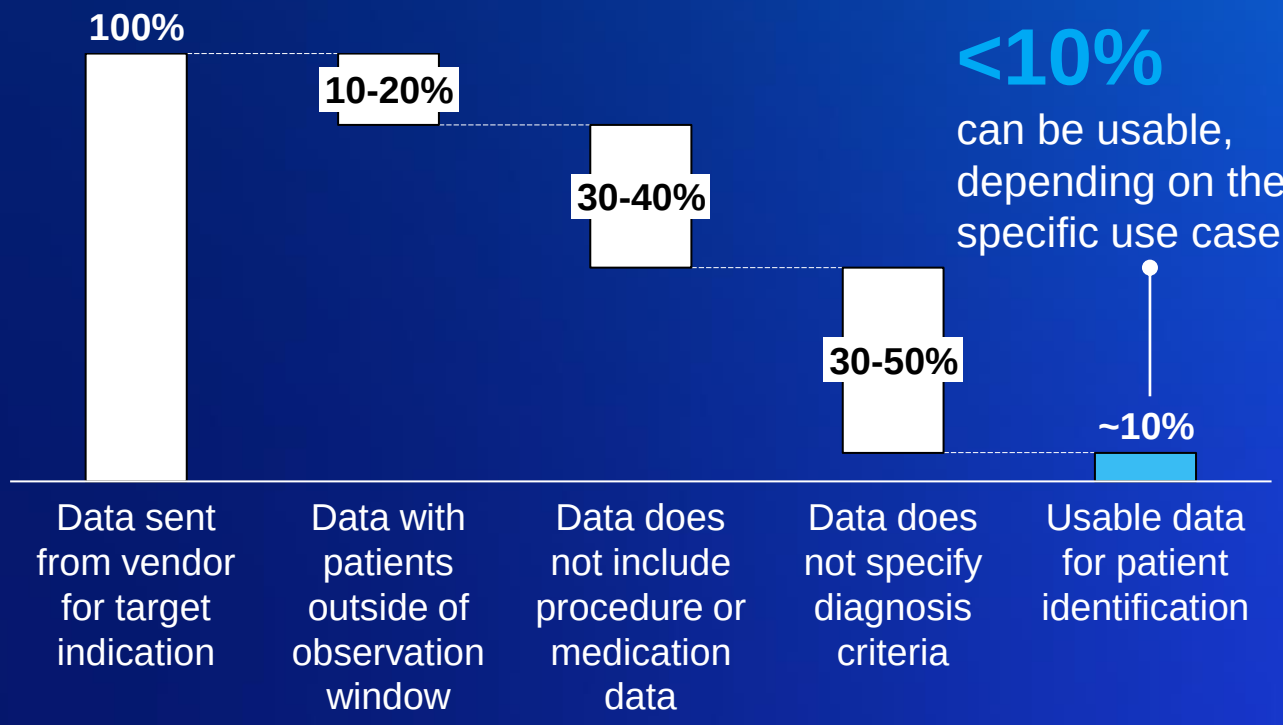
*Reduces time from target to candidate to **~13 months, at 80% lower cost** than industry average*

Source: Business Insider, Biopharma Trend, Royal Society of Chemistry, Forbes, GlobeNewswire, company websites

1: Creating and curating large, high-quality datasets is a challenge…

Existing datasets can be incomplete, missing segments of patient data

EMR data for target patient identification, Percent of data
Specific disease area, representative example



> **It is not feasible for individual biotechs to invest the time and capital into collecting data to create AI capabilities**
>
> – US biotech CEO

Source: Expert interviews as of November 2022; EMR data example with specific condition and 5+ years of observation

1… as well as managing data across borders

Hindering factors

Legal: Regional variation in legal & regulatory frameworks for personal data protection

Scientific: Non-representativeness of clinical data according to patient profiles in different regions of the world (e.g. inclusion criteria, evaluation criteria)

Methodological: Health authority rules requiring the sourcing of local data for the evaluation of marketing applications

Solutions

Data anonymization: Developing reliable, high-performance de-identify techniques meeting various international standards (while maintaining the finesse /usability of the data)

AI: Designing pan-regional research protocols (covering multiple populations), homogenous cohorts, matching systems for patients records & large-scale protocols, and 100% artificial clinical trials

1: Biotechs and pharma companies can join forces to create a superior data foundation for AI

Biotech companies are already contributing significantly to pharma portfolios:

58% of novel modalities in development pipeline sourced externally by top 20 pharmacos

2x more new launches driven by external vs. internal innovation

Key steps to access, combine and use data:

- **Access data** from development programs in partnerships
- **Create fit for purpose datasets** combining the data through a consortium
- **Keep proprietary data exclusive,** e.g., leveraging federated learning for AI models

~20% **improved prediction on small molecule properties already shown** through federated learning (MELLODDY) – larger impact expected on large molecules

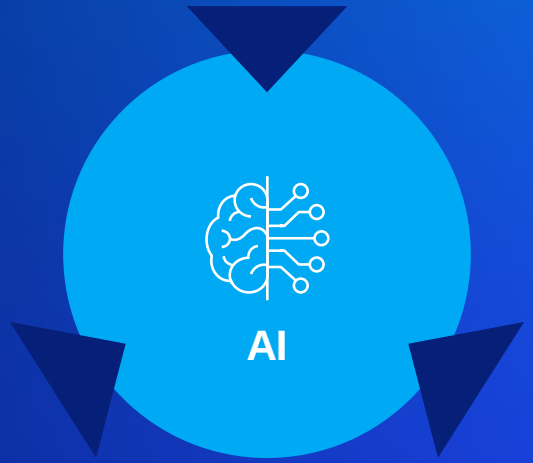
Source: https://www.nature.com/articles/d41586-023-02896-9, Evaluate October 2018 & February 2020; IQVIA Pharma Deals January 2021; PitchBook Data, Inc. (data has not been reviewed by PitchBook analysts); as of November 2021, https://www.melloddy.eu/

1: It takes more than AI to move the needle – particularly in drug discovery

Non-exhaustive

Idea generation

Constant stream of new, potentially breakthrough ideas – generated internally or through knowledge transfer



Laboratory hardware and automation

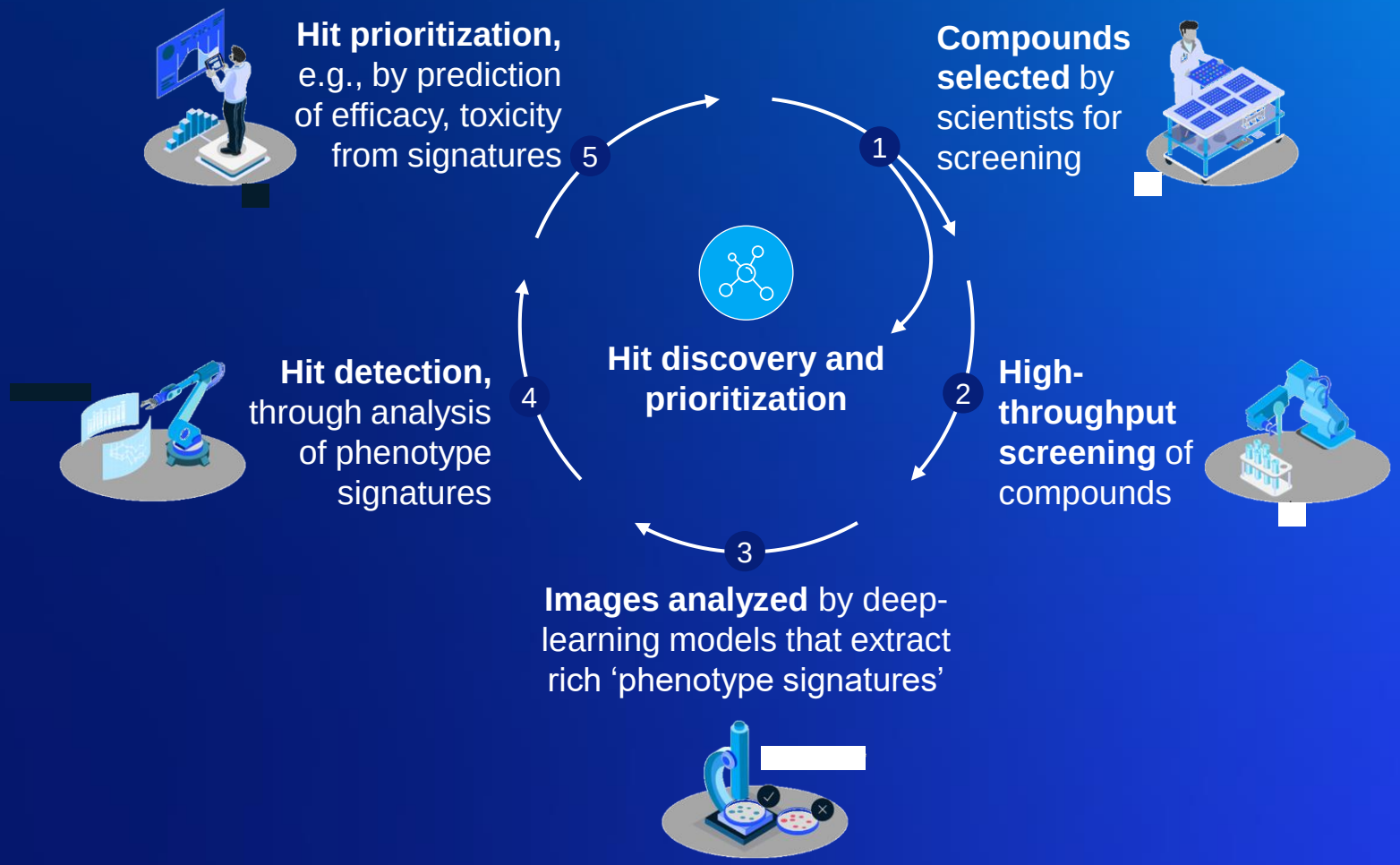
Digitized experimentation and data capture, e.g., automated microscopy and image analysis

Biological discovery platforms

Targeted delivery and DNA/ cell engineering, e.g., LNP, stem cells, DNA/ RNA editing

1: Closed-loop iteration between analytics and R&D is key to capturing AI impact and increase POS

Example Closed-Loop Research System (CLRS)



Key features of CLRS's

Create large, fit-for-purpose datasets (e.g., through targeted HT screening and automated imaging)

Embed AI in discovery: put advanced methods and models at heart of research decision making

Focus on impact: ensure analyses are tailored to most valuable questions shaping research programs

Become differentiating resources: self-learning models improve iteratively with integration of new data

Key questions for biotech companies to differentiate and capture value through AI (2/3)

2

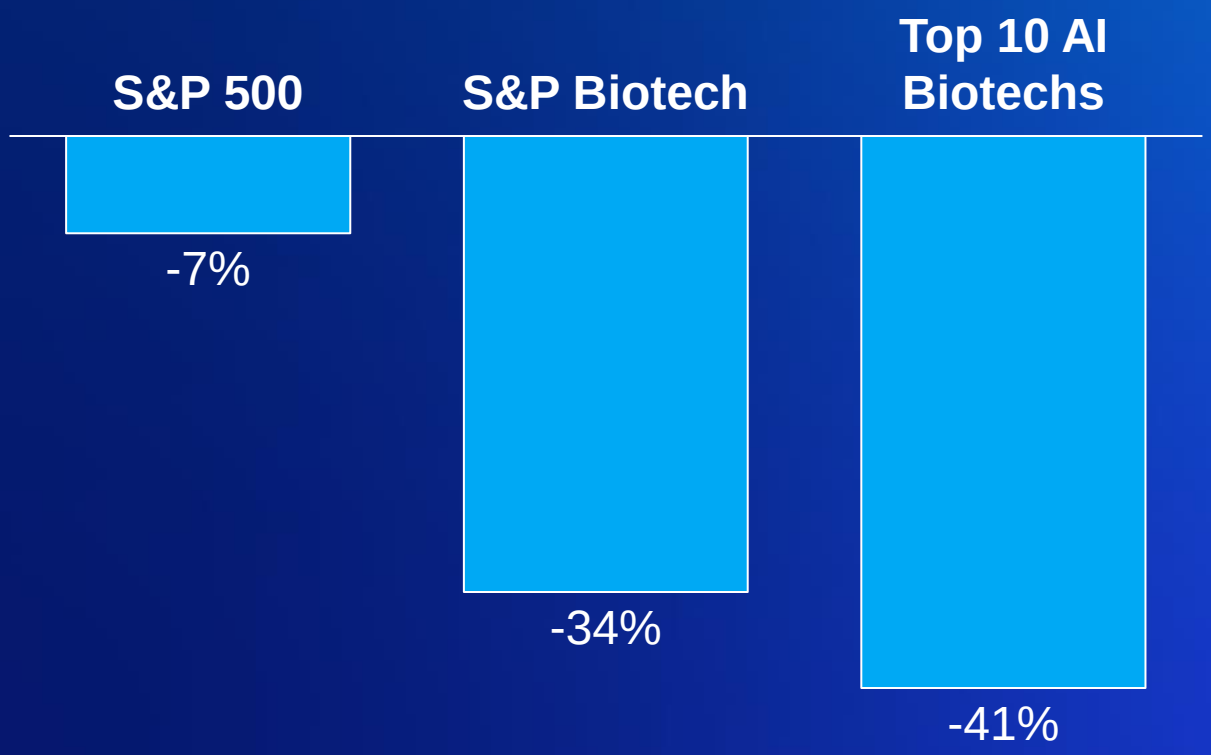
Can AI move the needle on value creation for biotech companies?

Valuations for AI biotechs have dropped even more than for biotech overall, indicating some disillusionment on the value creation through AI, at least in the near term

But AI companies can move the needle when they create strategic distance at key steps of the value chain (detailed ahead)

2: While biopharma has underperformed the S&P 500 overall, AI-driven biotechs have done even worse

Market cap index value decrease from 3Q21 to 2Q23



Potential reasons for the disillusionment

High resource need for accessing data and hardware/ automation

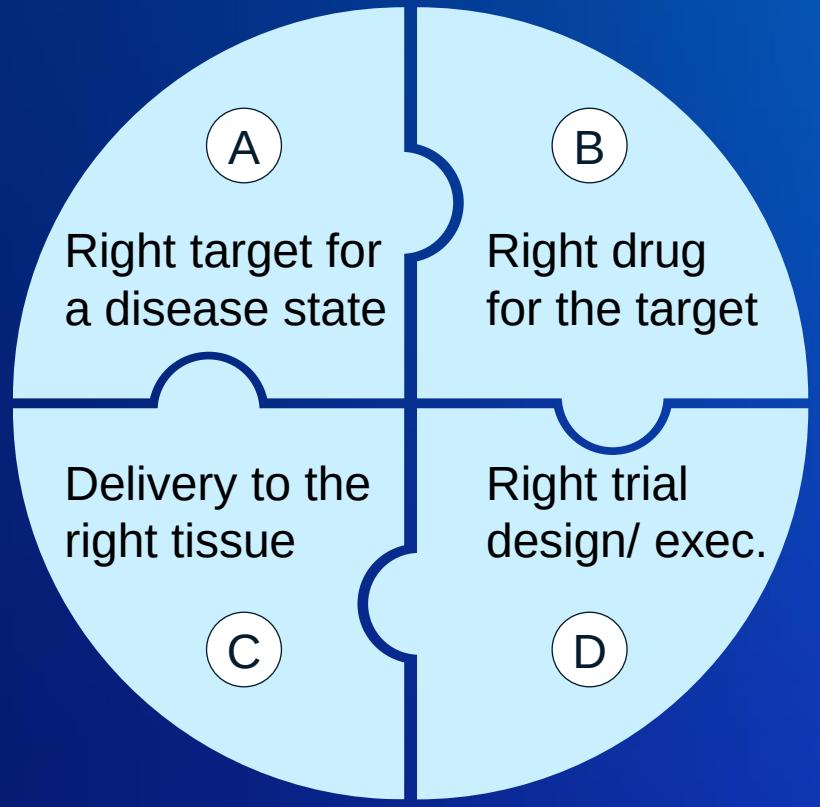
Longer timelines than expected for ROI in a high interest environment – few AI enabled assets have made it into the clinical pipeline

Persistent reliance on large pharma partners for clinical development diluting the value created

1. "Top 10 AI Biotechs" based on weighted average index of top 10 public AI-focused biotechs (by market cap) with IPO date by Q3 of 2021: Schrodinger, Recursion Pharmaceuticals, AbCellera Biologics, Relay Therapeutics, Exscientia, Erasca, SyntekaBio, Gritstone bio, Absci Corporation, and BioXcel Therapeutics

Source: S&P Dow Jones Indices (S&P 500, S&P Pharmaceuticals Select Industry Index [SPSIPH], S&P Biotechnology Select Industry Index [SPSIBI])

2: Going forward, how can AI companies shift the equation?



Biotech companies can specialize on individual factors to focus their resources (e.g., not all biotechs need their own Development engine)

Sources of strategic distance

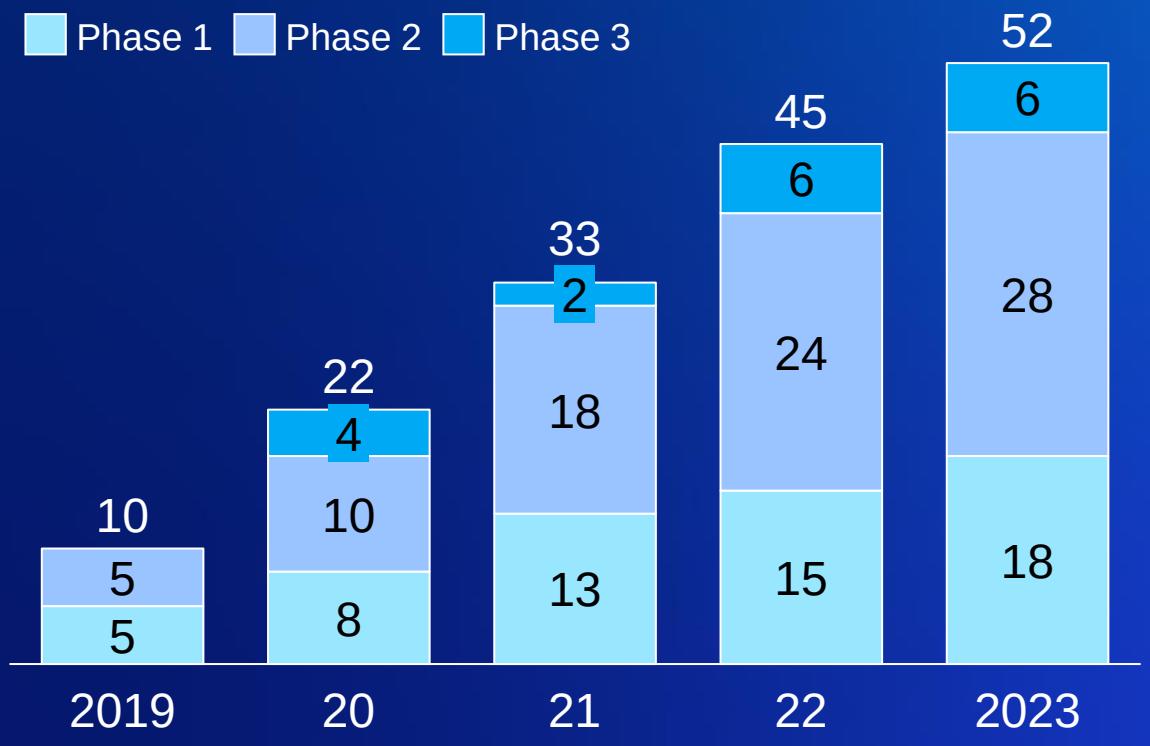
- **A** Linked -omics/ clinical datasets
  Causal AI models
- **B** HT[1] op and partnership model
  Proprietary datasets on molecular properties/ bioactivity
- **C** Precision delivery platforms targeting specific cell (state) across compartments (incl. CNS)
- **D** Clinical development engine incl. AI augmentation (detail follows)

1. High Throughput

2D: AI companies are ramping up their clinical trial activity to achieve clinical proof of concept for their assets

Illustrative Non-exhaustive

Number of clinical trials by top 20 AI biotechs, 2019-23[1]



Key concepts to consider when standing up a development engine

Use AI to **accelerate and reduce costs of trial operations** (e.g., trial design, site and population selection)

Select lead programs with **rapid proof of differentiation** (e.g., via biomarkers, early clinical readouts)

Optimize **development engine for high throughput** (e.g., by focusing on a limited number of high performing sites)

1. Top 20 AI-focused biotechs measured based on market cap (if public) and funding raised. Companies included: Tempus, Relay Therapeutics, Recursion Pharmaceuticals, Exscientia, XtalPi, Erasca, Generate Biomedicines, AbCellera, Schrodinger, Insitro, Nimbus Therapeutics, Valo Health, Gritstone bio, BenevolentAI, Absci, InSilico Medicine, PhenomeX, Owkin, BioXcel Therapeutics, and Adagene

Source: PitchBook, ClinicalTrials.gov

Key questions for biotech companies to differentiate and capture value through AI (3/3)

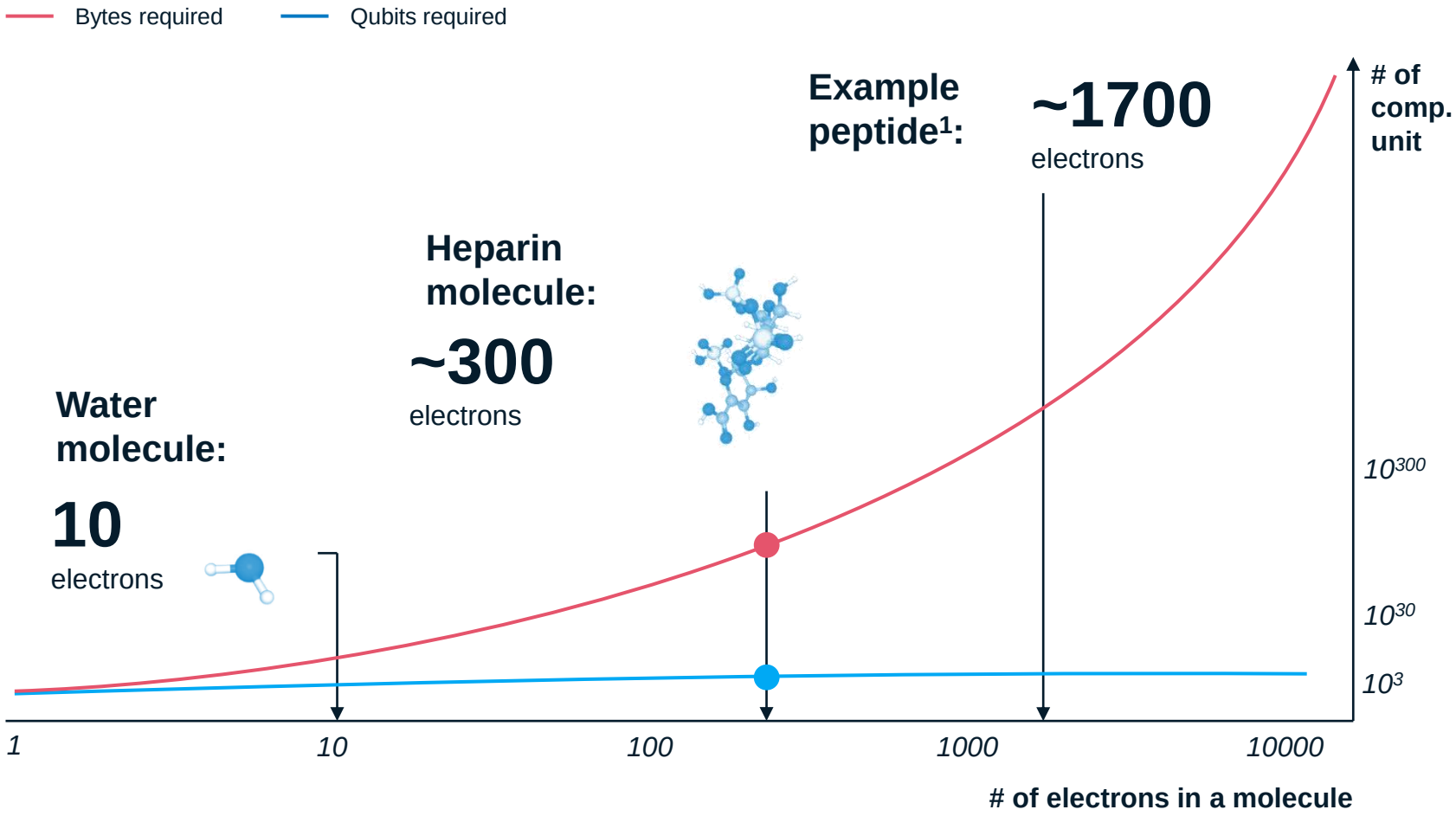
3

Will the next horizon of AI change the game?

We are seeing a new wave of innovation in Biotech AI that can re-shape the art of the possible:

- **Quantum Computing** can push the limits of understanding complexity of biological pathways and molecule interactions

3: Quantum computing can exponentially improve our ability to solve complex problems



1. Vasoactive intestinal peptide

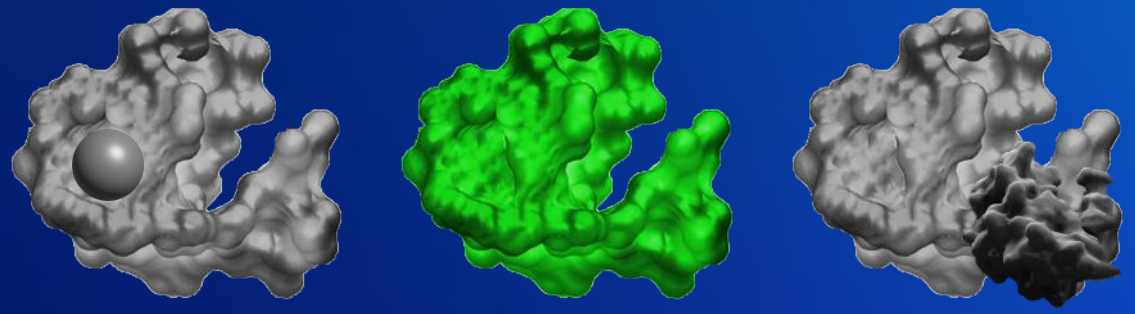
Source: McKinsey analysis

QC has massive potential for life science given many simulation type problems:

- Target ID based on interaction simulation on complex pathways
- Precise HIT/ lead ID based on dynamic and atom level structure prediction
- Synthesis pathways for drugs based on precise simulation of reaction mechanisms

3: Quantum computing can mean a breakthrough for drug discovery

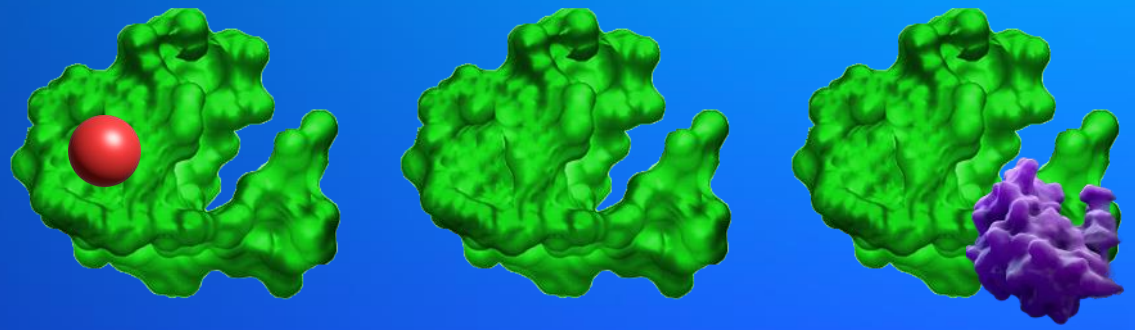
Current state: Computer-assisted drug discovery



Protein with ligand | Protein (without ligand) | Protein – protein interaction

Today, it is only possible to simulate a “snapshot” of the structure of a protein in specific states, limiting accuracy of target and drug selection

Future state: Quantum-enabled drug discovery



Protein with ligand | Protein (without ligand) | Protein – protein interaction

Quantum computing enables the simulation of the "whole movie" of all possible states of protein interactions, including down to the atomic level

3: Key questions – how will the Quantum Computing game shape up in biopharma?

Will incumbent large tech companies provide quantum computing services comparable to the cloud business or will they enter the drug discovery arena?

How will the value that quantum computing generates be split across large pharma, large tech and biotech?

How soon will quantum computing be adopted as a standard enabler of drug discovery?

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