



**AI FOR
DRUG DISCOVERY,
BIOMARKER DEVELOPMENT
AND ADVANCED R&D
LANDSCAPE OVERVIEW
2018 / Q1**

**Companies - 80
Investors - 180
Corporations - 25
R&D Centers - 20**

AI for Drug Discovery, Biomarker Development and Advanced R&D Landscape Overview 2018 / Q1

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AI for Drug Discovery, Biomarker Development and Advanced R&D Landscape / 2018 Q1

Companies - 80
Investors - 180
Corporations - 25

SPECIALIZATION

Drug Discovery

Advanced R&D

Investors

AI Companies

Corporations



Biomarker Development



AI for Drug Discovery, Biomarker Development and Advanced R&D Landscape / 2018 Q1

USA

Companies - 80
Investors - 180
Corporations - 25

Regional
Position

Investors

AI Companies

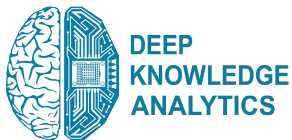
Corporations

UK

Other Regions

EU

Asia



Executive Summary

AI for Advanced R&D and Drug Discovery 2018 / Q1

In 2017 our analytical department released our inaugural report on the state of the AI for Drug Discovery industry, entitled AI for Drug Discovery Landscape Overview 2017, and in January 2018 we released AI for Drug Discovery, Biomarker Development and Advanced R&D 2017.

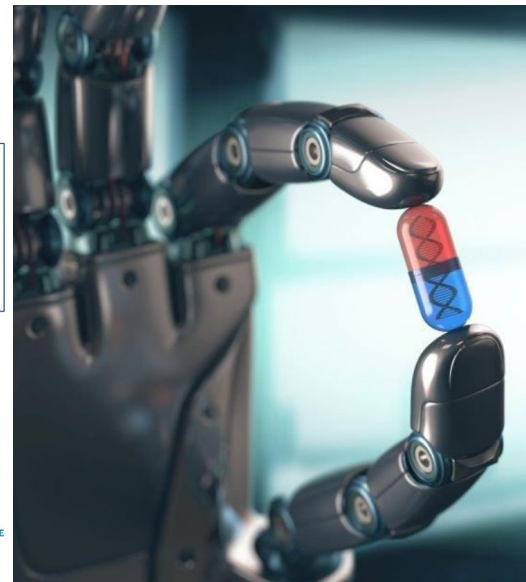
Now, nearing the end of the first financial quarter of 2018, the state of the field had advanced so rapidly, that we are compelled to release a second, updated edition, not one year later, but one quarter later.

The first quarter of 2018 saw major changes, significant investments, acquisitions, and the establishment of substantial joint ventures. This serves as a stark reminder of how fast the AI for drug discovery, biomarker development and advanced R&D sector is advancing.



**AI FOR DRUG DISCOVERY,
BIOMARKER DEVELOPMENT
AND ADVANCED R&D
LANDSCAPE OVERVIEW 2017**

www.dkv.global



**AI for Drug Discovery
Landscape Overview 2017**

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AI for Advanced R&D and Drug Discovery 2018 / Q1

- The report's Executive Summary charts the major trends and significant developments that have occurred in the industry during the first quarter of 2018.
- Chapter I gives a more comprehensive overview of the specific developments underlying and shaping the major trends outlined in the Executive Summary.
- Chapter II compares the top AI companies for drug discovery and advanced R&D side by side according to a variety of metrics including technology, assets and employees.
- Chapter III discusses the major occurrences happening in the BioPharma sector, and outlines how the entire BioPharma industry is now actively participating in the AI for drug discovery and biomarker development space via internal R&D, investment and acquisition, in contrast to 2017, during which time they remained skeptical of the disruptive impact of AI.
- Chapter IV details how IT & Tech Giants are continuing to enter the space; this was already a major trend in 2017, and it is continuing apace into 2018, remaining one of the strongest hallmarks of the subsector's exponential dynamic of development.
- Chapter V focuses specifically on the largest investments and joint ventures that were launched in the first quarter of 2018.

AI for Advanced R&D and Drug Discovery 2018 / Q1

- Chapter VI covers an emerging niche within the AI for drug discovery and advanced R&D subsector, namely, AI for Longevity, showing that Longevity is an increasingly prominent niche within the space, and one that has perhaps the most disruptive potential for BioPharma and healthcare in general.
- Chapter VII outlines the convergence of AI, Digital Medicine and Blockchain. The beginnings of this unifying trend could already be seen in 2017, but 2018 will mark the year in which the synergetic integration of AI with Digital Medicine and Blockchain becomes a major trend in the subsector, approaching the status of a standard industry hallmark that any serious company will need to begin implementing in order to stay competitive in the rapidly growing AI in healthcare industry.
- Chapter VIII serves as a short primer and introduction into deep learning, and its application to drug discovery and biomarker development.
- Chapter IX presents a comparative analysis of various leading players and companies in the AI for drug discovery industry, and which presents a classification system whereby different companies can be grouped into different classes and compared with one another.
- The report concludes with a detailed appendix profiling the top 80 companies, 20 leading R&D centers, AI leading 10 BioPharma giants, top 15 IT&Tech giants, and 180 investors in the AI for drug discovery and advanced R&D subsector.

AI for Advanced R&D and Drug Discovery 2018 / Q1

This extended second edition considers the industry landscape in greater depth than our previous reports, and provides updated profiles of the top companies, investors and influencers comprising the industry. Additionally, this report gives an in-depth analysis of the significant role that tech giants and IT corporations have started to play in the exponentially-advancing AI for drug discovery industry. IT giants already begun to venture into this sphere in order to reap the significant gains that are to be had in the years to come

BioPharma giants will need to commit significant resources (and perhaps even more importantly, significant will and the implementation of AI-focused strategies) to the acquisition of AI specialists and AI for drug discovery companies. However, several BioPharma giants have already begun to do just this, and might jump ahead of other BioPharma companies in the AI race.

One prime example of the major changes that have occurred in just the past several months is the current state of what we referred to in our previous reports as the **Big Gap**, i.e., the fact that throughout 2016 and 2017 IT giants recognized and supported AI for healthcare startups, in terms of both investment and acquisitions, while BioPharma lagged behind, still skeptical of the impact that AI could make upon drug discovery, biomarker development and other BioPharma niches. Our most recent analysis seems to indicate that this Big Gap is now to a large extent **neutralized**, and the BioPharma industry now has significant interest in AI, and belief in its ability to facilitate fundamental paradigm shifts in their traditional modes of operation. Some BioPharma companies have now become actively involved in the AI for drug discovery sector, while others still lag behind, skeptical of the sector's potential for impact and disruption, or finding themselves unable to acquire or implement these novel technologies in any relevant capacity.

All indications point to the conclusion that 2018 will mark the year that will test the strength, resolve and foresight of BioPharma as a whole. Those BioPharma companies that commit significant will and resources to acquiring strong AI specialists, technologies and acquisitions will flourish, and those that do not will stagnate, and by the time their profit margins force them to realize the disruptive potential of AI for drug discovery and other biomedical niches, they will have missed the boat, with the majority of talent, technology and companies having already been acquired by their competitors.

AI for Advanced R&D and Drug Discovery 2018 / Q1

Meanwhile, within that last financial quarter, Chinese IT and Tech giants, such as Alibaba, Baidu and TenCent, have made significant investments and acquisitions in the AI for Drug Discovery sector, showing that the number of IT giants committing to the sector is growing not just regionally but also globally.

At the same time, the lack of AI specialists that was alluded to in our previous reports is still present. The majority of talented AI specialists in general have been acquired by traditional IT giants and have been applied for purposes other than AI in healthcare, creating a lack of enough specialists to support the activities of AI for drug discovery companies.

And it is not just traditional BioPharma companies that are suffering from this lack of specialists; indeed, even companies specializing specifically in **AI for drug discovery are feeling the effects of this lack, as can be seen on page 29 of this report, which shows that on average, AI specialists make up only 19.7% of such companies staff.** One of the central aims of this report is to summarize this gap, and chart the possible ways forward in order to neutralize it.

Overall, the AI in healthcare and BioPharma subsector is growing at an exponential rate, both in terms of new companies, investments and acquisitions, and in terms of the extent with which it is disrupting the traditional modes of operation on BioPharma as a whole.

What is now a subsector and niche is poised to grow into perhaps the leading subsector in BioPharma in the next 2-3 years, one that will have the greatest transformational impact on the industry, and one that will distinguish the leaders of the industry from the stagnators.

By the end of 2018, we can predict that there will be intensive competition between the largest BioPharma companies and the largest IT and tech giants for the acquisition of new AI specialists, technologies and startups, in much the same way that 2014 – 2016 saw intense competition between IT-giants and Tech corporations to acquire the best AI assets and resources.

Chapter I

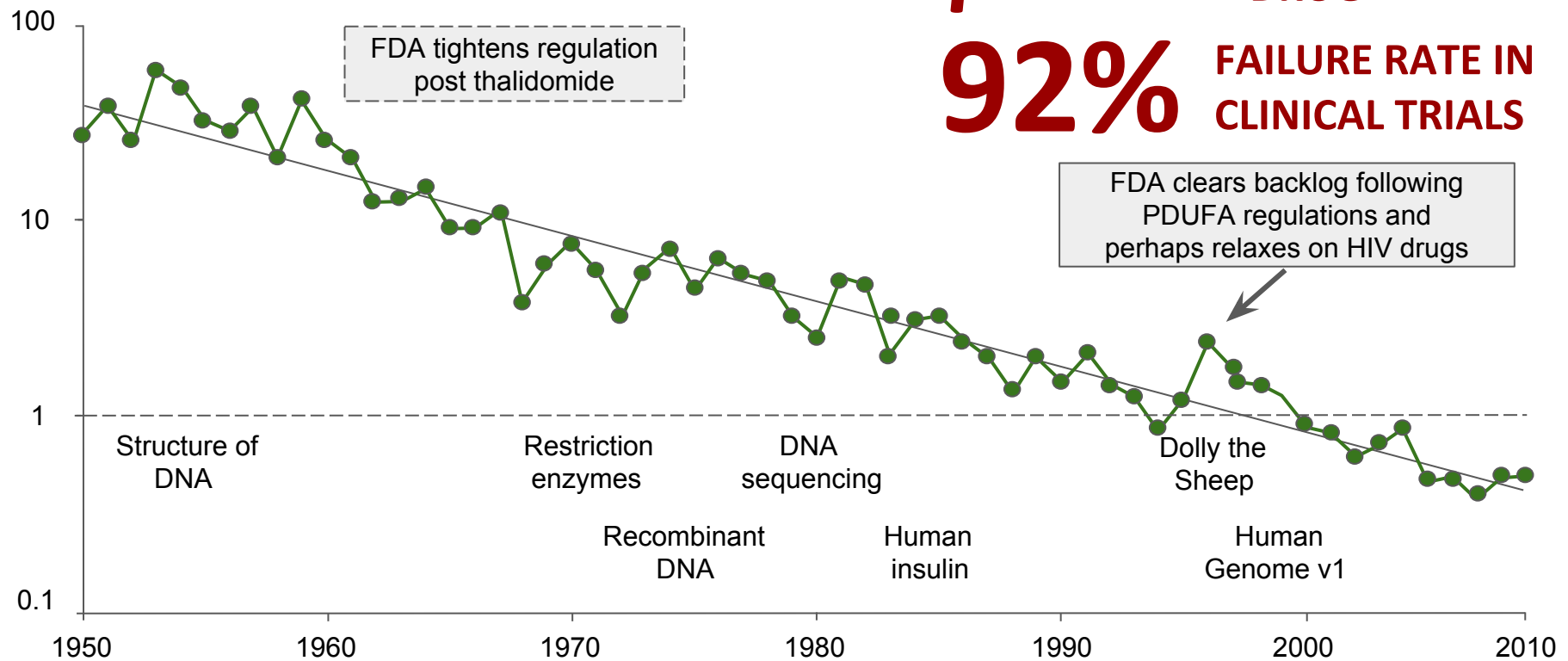
The State of AI in R&D and Drug Discovery Q1 2018

Pharma Efficiency is Declining Steadily

>\$2.6B TO DEVELOP ONE
DRUG

92% FAILURE RATE IN
CLINICAL TRIALS

NMEs per \$B R&D spent (inflation adjusted)



Bernstein Research: The Long View - R&D Productivity, 2010

46 NEW DRUGS launched in 2014

GLOBAL SALES:

>\$1 Trillion

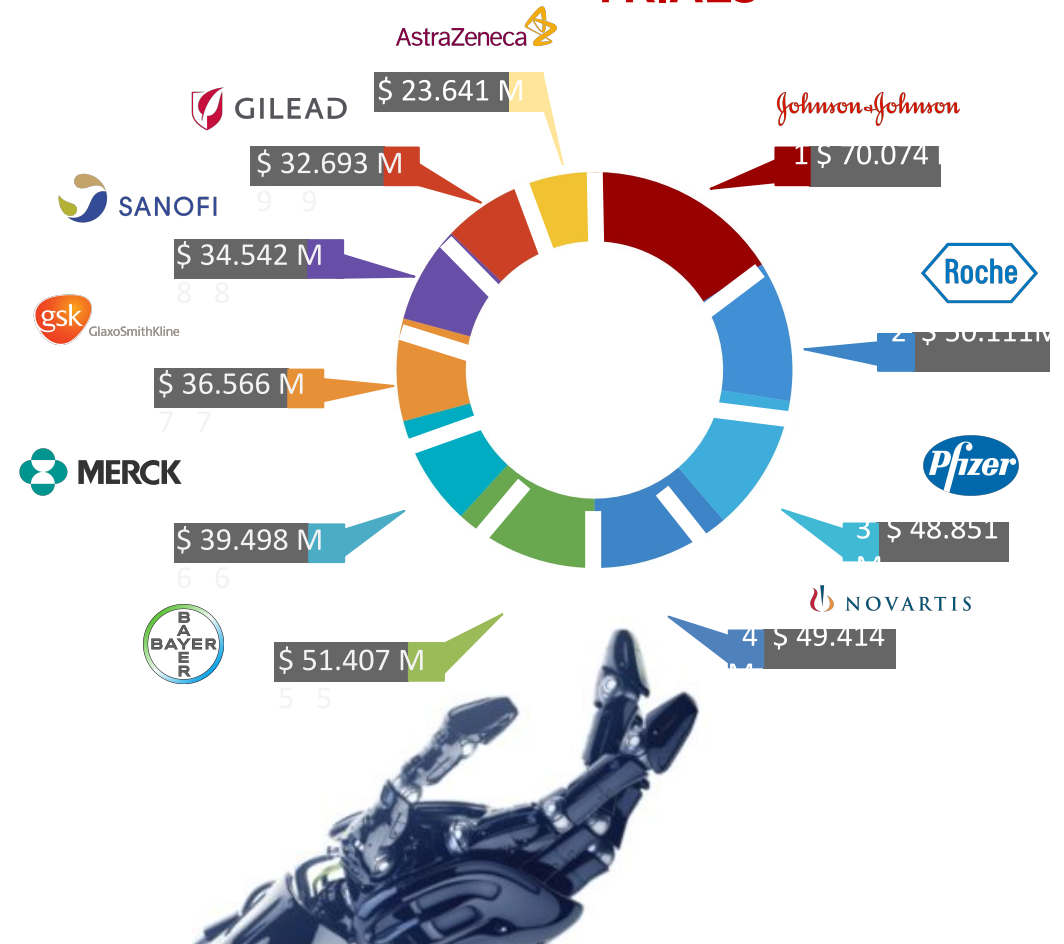
GLOBAL R&D:

>\$150 Billion



>\$2.6B TO DEVELOP ONE DRUG

92% FAILURE RATE IN CLINICAL TRIALS



AI and Drug Discovery

On average, it takes about a decade of research — and an expenditure of \$2.6 billion — to shepherd an experimental drug from lab to market. And because of concerns over safety and effectiveness, only about 5 percent of experimental drugs make it to market at all.

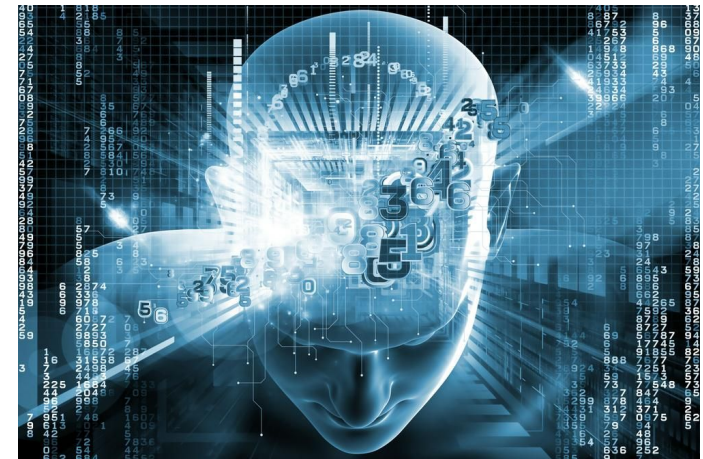
But drug makers and tech companies are investing billions of dollars in artificial intelligence with the hope that AI will make the drug discovery process faster and cheaper.

Microsoft Research Labs is investing in AI for drug design and pharmacology, which studies how drugs act in the body, and called the technology a “tremendous opportunity.” We have counted 10 pharmaceutical companies and 80 companies using AI for drug discovery. Benevolent.ai has used AI computer algorithms to explore new treatment options for amyotrophic lateral sclerosis, or ALS, a degenerative nervous system disease. AstraZeneca struck a partnership with BERG to use the latter’s A.I. platform to home in on promising biological targets and possible agents against neurological diseases such as Parkinson’s.

Healthcare will be the lead area of the Fourth Industrial Revolution and one of the major catalysts for change is going to be artificial intelligence (AI).

AI in health represents a collection of multiple technologies enabling machines to sense, comprehend, act and learn so they can perform administrative and clinical healthcare functions. Unlike legacy technologies that are only algorithms/tools that complement a human, health AI today can truly augment human activity.

AI has already found several areas in healthcare to revolutionize starting from the design of treatment plans through the assistance in repetitive jobs to medication management or drug creation. And it is only the beginning.



Source: <http://medicalfuturist.com/top-artificial-intelligence-companies-in-healthcare/>

The Rise of AI in Healthcare

I believe that AI is a sleeping giant for healthcare in general

Eric Horvitz,
director of Microsoft Research Labs
in Redmond, Washington



The number of startups entering the healthcare AI space has increased in recent years, with over 50 companies raising their first equity rounds since January 2015. Deals to healthcare-focused AI startups went up from less than 20 in 2012 to nearly 70 in 2016.

The field of AI for Healthcare has been actively growing since 2015. The market is primarily being driven by factors like the rise of personalized medicine in tests for clinical decision-making and big data in healthcare industry and the growing adoption of AI in genetics. Also, AI created real-time monitoring system, and healthcare wearables are playing a crucial role in digital healthcare monitoring.

A report published by The BMJ in 2016 noted that medical errors claim 250,000 lives each year, making it the third leading cause of death in the U.S. AI in healthcare and medicine could organize patient routes or treatment plans better, and also provide physicians with literally all the information they need to make a good decision.

“I have no doubt that sophisticated learning and AI algorithms will find a place in healthcare over the coming years,” Andy Schuetz, a senior data scientist at Sutter Health said. “I don’t know if it’s two years or ten — but it’s coming.”

UK Government Support for AI in Healthcare

The government's healthcare tsar, Sir John Bell, has told BBC News that AI could "save the NHS".

John Bell said that NHS patient records are uniquely suited for driving the development of powerful algorithms that could transform healthcare and seed an "entirely new industry" in AI-based diagnostics.

"What Google's doing in [other sectors], we've got an equivalent unique position in the health space," he said. "Most of the value is the data. The worst thing we could do is give it away for free."

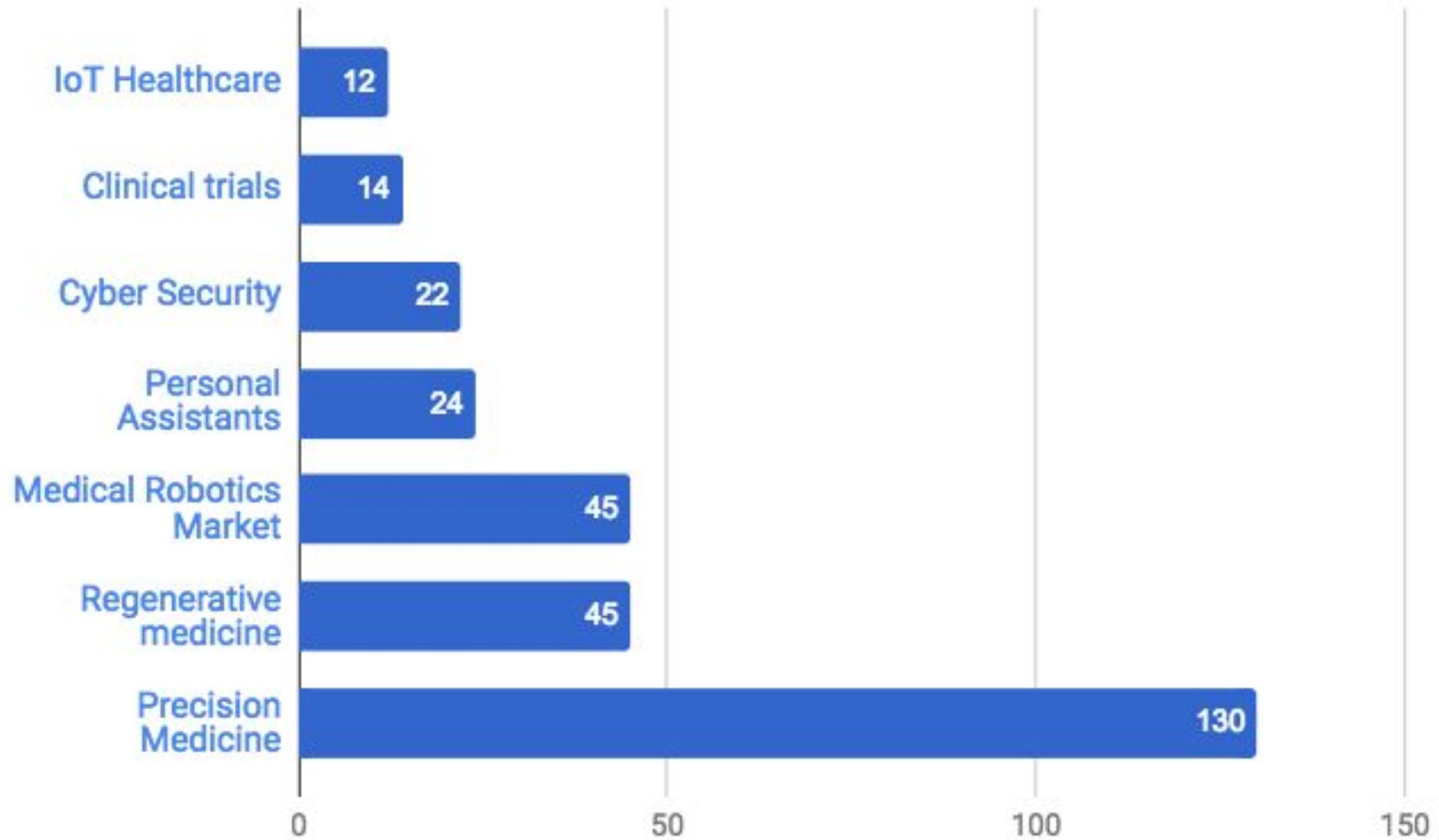
Researchers at an Oxford hospital have developed artificial intelligence (AI) that can diagnose scans for heart disease and lung cancer. The heart disease technology will start to be available to NHS hospitals for free this summer. "There is about £2.2bn spent on pathology services in the NHS. You may be able to reduce that by 50%. AI may be the thing that saves the NHS," he said.

The system will save billions of pounds by enabling the diseases to be picked up much earlier.

In January 2017, Stephen Metcalfe MP and Lord Clement-Jones CBE set up a new body: The All-Party Parliamentary Group on Artificial Intelligence, which aims to unpack the term, to gather evidence to better understand it, to assess its impact, and, ultimately, to empower decision-makers to make policies in the sphere. AARPG Group Officers also include Chris Green MP, The Right Reverend Doctor Steven Croft, Baroness Kramer, Lord Janvrin, Lord Broers, Lord Holmes of Richmond, Lord Willetts, Baroness McGregor-Smith, Mark Hendrick MP and Carol Monaghan MP. Without being too technical, the APPQ-AI is trying to understand how AI will impact the lives of UK citizens and organisations, and subsequently, whether and how it should be regulated. Bringing together government, business, and academia the body shares evidence and assist in setting an agenda for how the UK should address AI moving forward.



Global Healthcare AI Market Growth by 2025 In \$Billions



Source: Deep Knowledge Analytics

AI for Drug Discovery, Biomarker Development and Advanced R&D

- The global healthcare AI market is highly fragmented and is characterized by the presence of a large number of industry players.
- In this report we conducted specific analysis of the most crucial and important sectors of application AI in Healthcare:
 - Advanced R&D
 - Drug Discovery
 - in silico Clinical Trials
 - Diagnostics and Biomarker development
 - NeuroTech
 - Surgery
- We landscaped:
 - 80 leading AI companies working in these 5 sectors.
 - 180 investors that invested in these 40 startups.
 - 10 leading Pharma and IT-corporations exploring AI in Healthcare
- The broad field of AI in Healthcare has already experienced a significant rise during 2016, especially in the application of computer vision, text analysis and chatbot technologies. Since all these techniques were first developed in the IT-sector, it was possible to easily repurpose them for the healthcare sector.
- However, the segment of applying AI for advanced R&D is limited to companies and researchers with very high levels of expertise. This creates a specific scarcity for AI specialists in this niche.
- 2018 is expected to become the year in which AI will be recognized as the most powerful driver of progress in solving the crucial challenges in the most advanced sectors of science and R&D in the healthcare and Biotech industries.
- Applying AI for advanced R&D, biomarker development and for drug discovery will bring the most disruptive impact on the business model of the Pharma and entire Biotech industry.
- This is why the players from the AI for drug discovery market can become new game changers and significantly influence the capitalization of pharma companies.

The Broken Model of BioPharma

The efficiency of research and development (R&D), defined as the number of successfully approved drugs given the budget allocated to new drug development, has declined for decades.

The cost of drug discovery and subsequent development is a massive challenge in the pharmaceutical industry.

A typical drug can cost upwards of \$2.5 billion and a decade or more to identify and test a new drug candidate. Today, only about one in ten drugs that enter phase 1 clinical trials reaches patients.

Drug makers need to find a more efficient way of developing medicines. AI can speed up drug discovery, cut R&D costs, decrease failure rates in drug trials and eventually create better medicines.

What we have is an industry that is entering a vicious cycle of negative growth and terminal decline as its fundamental business model has run out of steam by the Law of Diminishing Returns: Diminishing R&D productivity and return on investment leads to diminishing growth in sales. Eventually, growth turns negative and sales start to contract. Decreasing sales then limits the amount of money available to invest back into R&D, which causes sales growth to decline even further. And so on, until the industry is gone altogether.

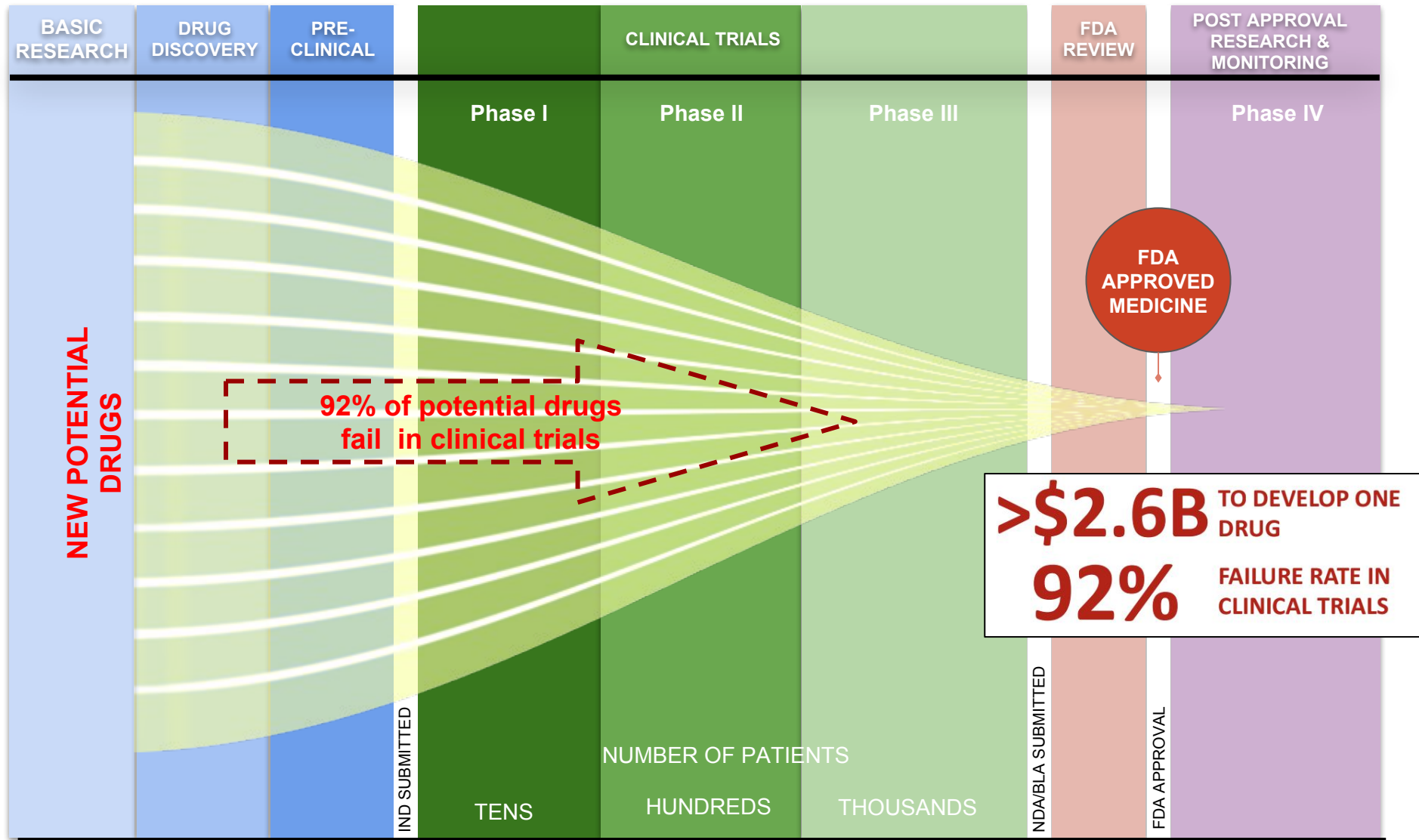
Pharma as we know it will shrink out of existence, and there is nothing we can do to stop it. The Pharma and Biopharma industries together will evolve into something quite different, most likely continuing the historic trend of increasing complexity towards more complex biological solutions to pressing healthcare problems, such as cell & gene therapy, tissue engineering and regenerative medicine.

Sources:

<https://www.linkedin.com/pulse/pharmas-broken-business-model-industry-brink-terminal-kelvin-stott/>
<https://www.drugtargetreview.com/news/29432/new-2018-role-artificial-intelligence-drug-discovery/>

The Biopharmaceutical R&D Process

GLOBAL SALES: >\$1 Trillion
GLOBAL R&D: >\$150 Billion



The Application of AI for Advanced R&D

Generate Novel Drug Candidates

- Analyze data sets, form hypotheses and generate novel insights
- Identify novel drug candidates
- Analyze data from patient samples in both healthy and diseased states to generate novel biomarkers and therapeutic targets
- Predict binding affinity and other pharmacological properties of molecules
- Allow filtering for drug-like properties of molecules
- Reduce complexity in protein design

Aggregate and Synthesize Information

- Extract knowledge from literature
- Generate insights from thousands of unrelated data sources
- Improve decision-making
- Eliminate blind spots in research
- Identify competitive whitespace

Repurpose Existing Drugs

- Rapidly identify new indications for many known drugs
- Match existing drugs with rare diseases
- Conduct experimental biology at scale by testing 1000+ of compounds on 100+ of cellular disease models in parallel
- Generate novel biomarkers and therapeutic targets

Design and Run Preclinical Experiments

- Reduce time, money, and uncertainty in planning experiments
- Decode open- and closed-access data on reagents and get actionable insights
- Automate selection, manipulation, and analysis of cells
- Expedite development of cell lines and automate manufacturing of cellular therapeutics
- Automate sample analysis with a robotic cloud laboratory

Clinical Trials

- Optimize clinical trial study design
- Transform diverse streams of biomedical and healthcare data into computer models representative of individual patients
- Deliver personalized medicine at scale, by revealing optimal health interventions for individual patients
- Analyze medical records to find patients for clinical trials
- Automate matching cancer patients to clinical trials through personal medical history and genetic analysis
- Improve pathology analysis
- Identify patients that would benefit from novel therapies

AI for Drug Discovery and Biomarker Development

- Applying AI for advanced R&D, biomarker development and drug discovery will bring the most disruptive impact on the business model of the Pharma and entire Biotech industry.
- Specific attention should be paid to those projects capable of applying Next Generation Artificial Intelligence techniques, Deep Learning and in particular GAN's (generative adversarial networks) and reinforcement learning for:
 - Drug Discovery and Drug Repurposing
 - Biomarker Development
 - Clinical Trials Predictors
 - Aging Research
 - AI Solutions in convergence with Blockchain
- The leading players in this specific niche can become new game changers for entire market and significantly influence the capitalization of pharma companies.



Source: <https://www.technologynetworks.com/drug-discovery/lists/4-toxicology-approaches-in-drug-discovery-294488>

Next Generation AI for Drug Discovery and Biomarker Development Convergence with Blockchain and Digital Medicine

- In 2018, even more extreme challengers and disruptors will arrive with the convergence of next generation AI, blockchain and precision medicine.
- Longgenesis is a revolutionary blockchain-based personalized medicine Data Marketplace platform built by Insilico Medicine and Bitfury that provides modular toolsets coupled with integrated advanced
- Artificial Intelligence systems to store, manage, and trade life data: social network data, health data and medical records.
- Longgenesis will redefine the relationships between healthcare companies and patients. By facilitating a fast and easy way to contribute or purchase data along with an integrated deep learning AI, enterprises can save much money on R&D while users will for the first time be compensated for their Life data efficiently and ethically.



AI in Healthcare and AI in Drug Discovery

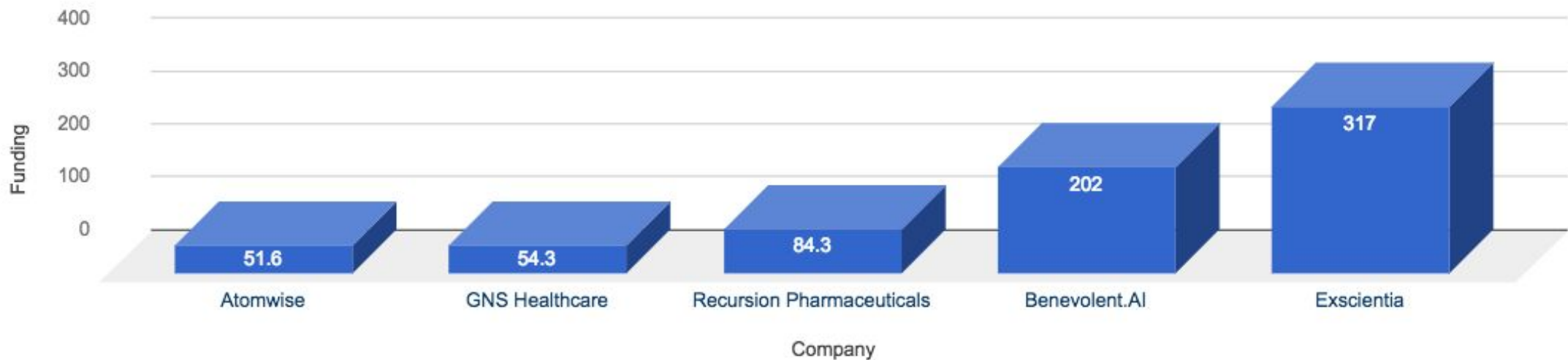
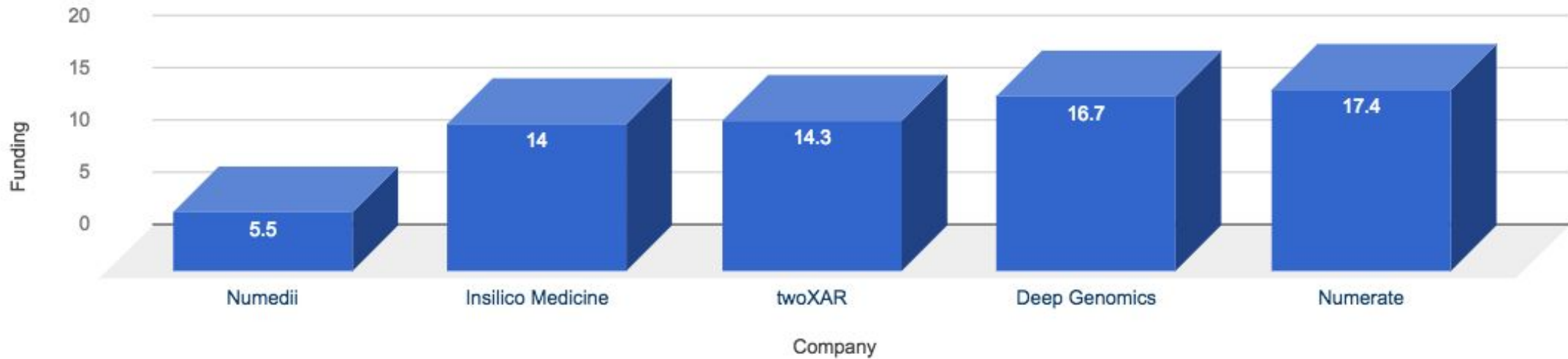
- Today, drug discovery is a trial-and-error process that eats up enormous amounts of research time. AI can significantly narrow the focus of researchers by rapidly assimilating and analyzing the information in public and proprietary databases.
- Beyond scanning health records to help providers identify chronically ill individuals who may be at risk of an adverse episode, AI can help clinicians take a more comprehensive approach for disease management, better coordinate care plans and help patients to better manage and comply with their long-term treatment programmes.
- The use of AI is enabling review and translation of mammograms 30 times faster with 99% accuracy, reducing the need for unnecessary biopsies.
- Researcher Frost & Sullivan said artificial intelligence systems will generate \$6.7 billion in global revenue from healthcare by 2021, compared with \$811 million in 2015.
- In 2018, even more extreme challengers and disruptors will arrive with the convergence of next generation AI, blockchain and precision medicine.
- The global healthcare AI market is highly fragmented and is characterized by the presence of large number of industry players, while the AI for drug discovery segment has a comparatively lower level of competition because this market segment only accepts companies with very high levels of expertise. There are more than 300 AI in Healthcare companies, but only 30 of them are capable of entering the AI in Drug Discovery sector.
- The breakthroughs in AI for drug discovery will change the R&D process of Bio Pharma, and it will make tremendous impact on whole biopharma industry.
- That is why the players from the AI for drug discovery market can become new game changers and significantly influence the capitalization of pharma companies.

Chapter II

Comparison of Leading AI Companies

Comparison of AI for Drug Discovery Companies

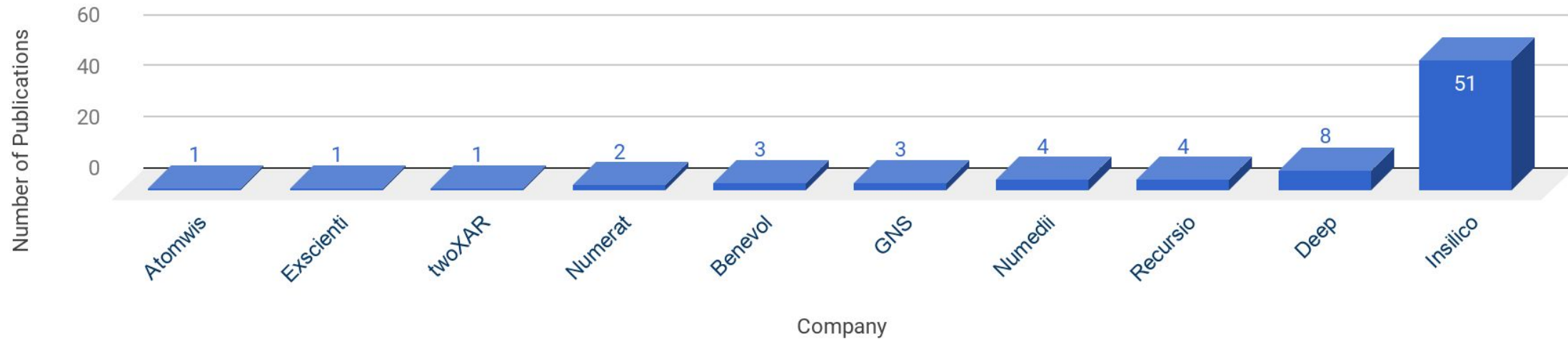
Funding*, \$m (*as of 1 April 2018*)



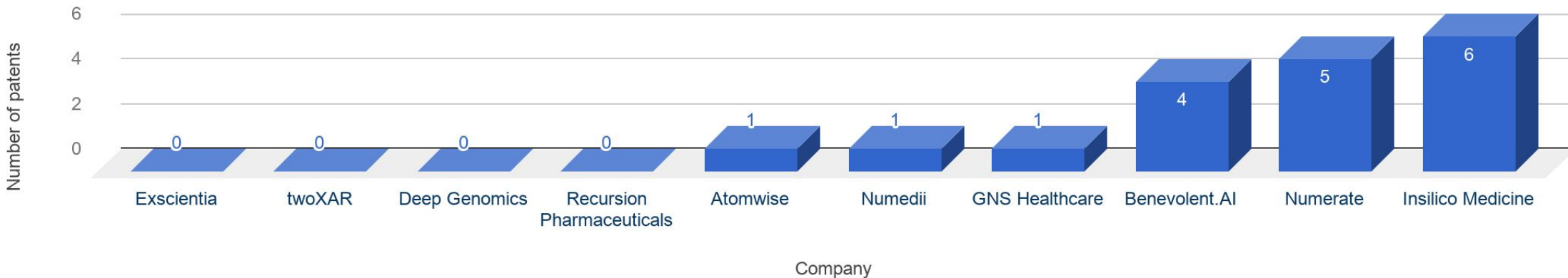
Comparison of AI for Drug Discovery Companies

(as of 1 April 2018)

Number of Publications (PubMed)

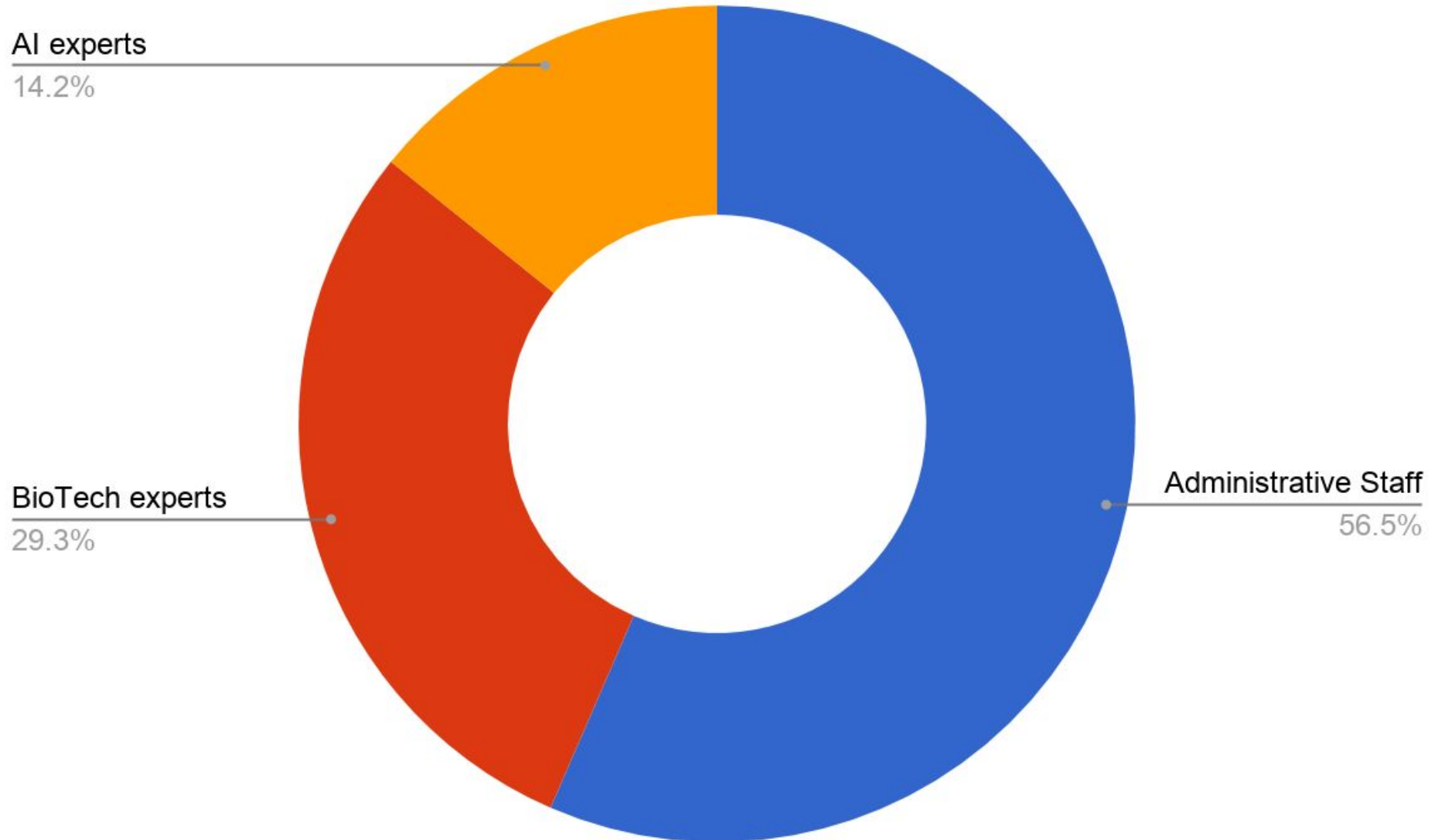


Number of Patents (Google Patents)



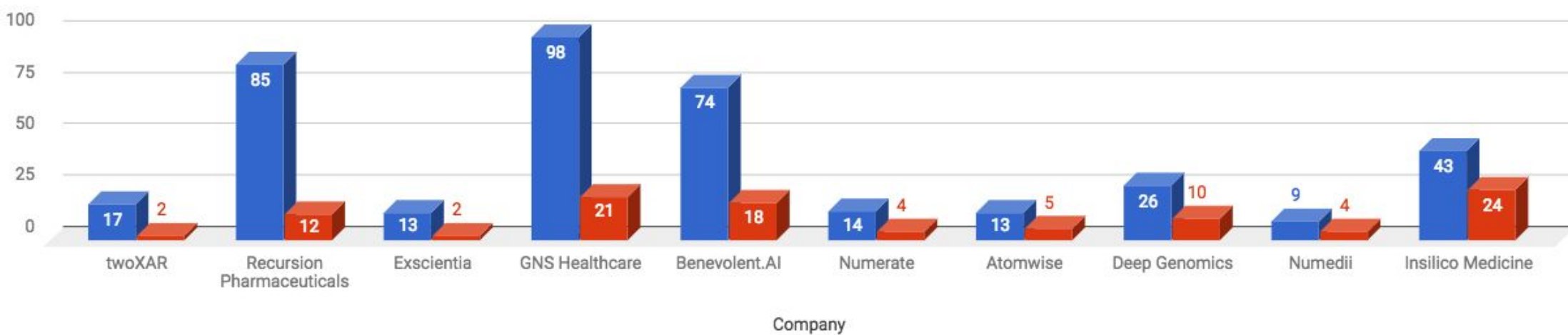
Ratio of Experts in HealthTech AI R&D Startups

AI experts vs BioTech experts vs Administrative Staff



Total Number of Employees / AI experts

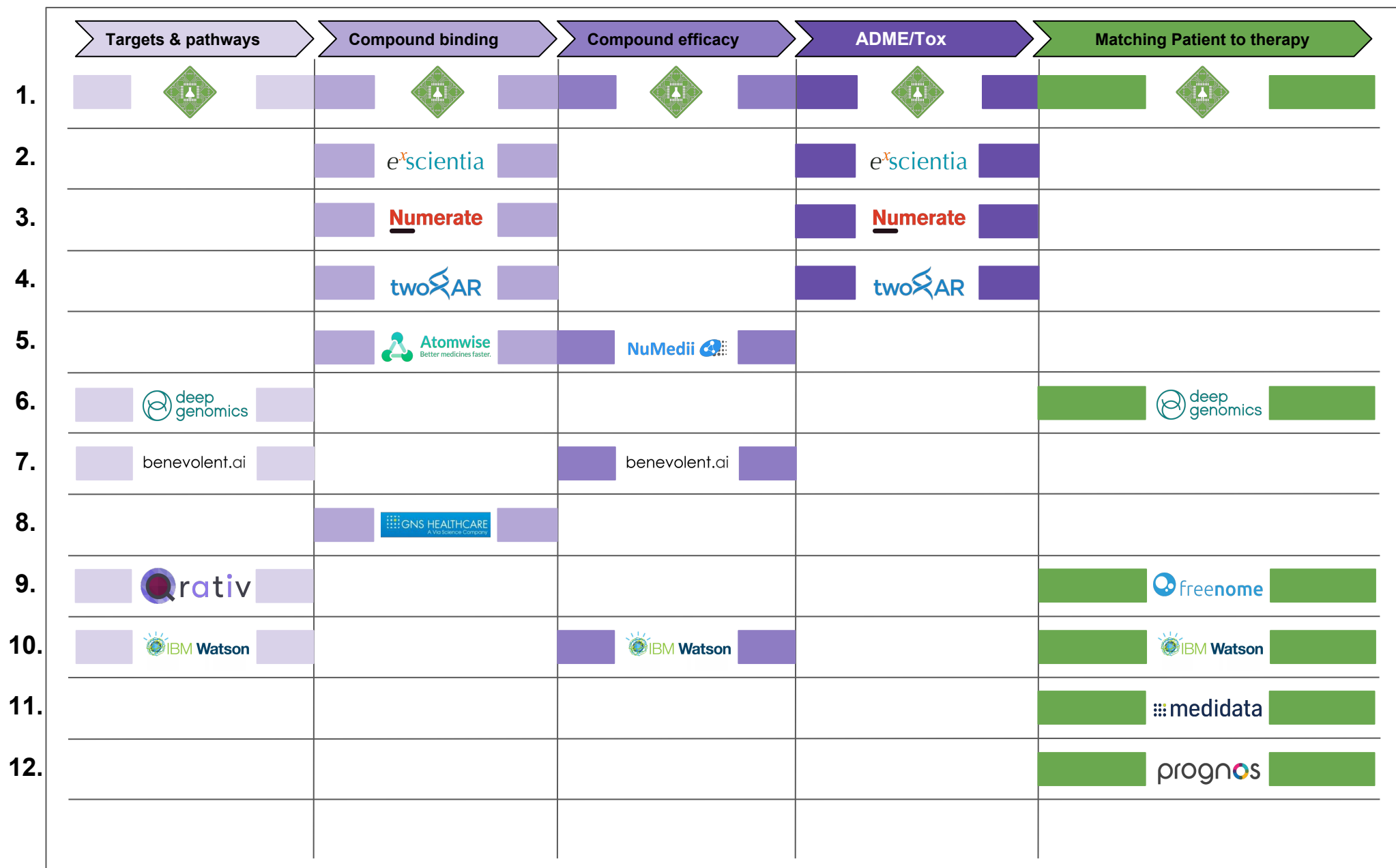
(as of 1 April 2018)



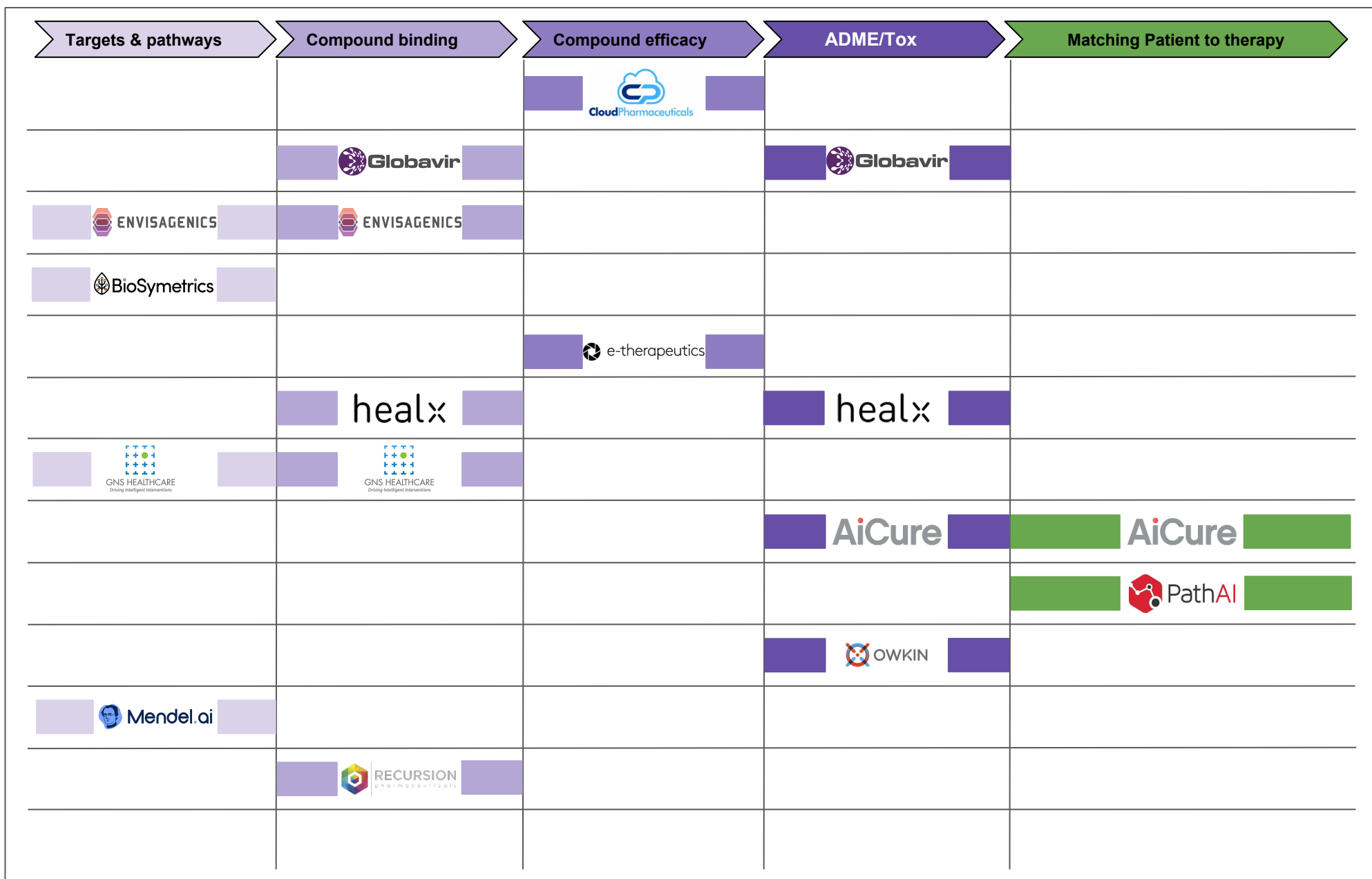
True AI companies The ratio: AI experts vs Total Number of Employees



Diversification of AI applications for R&D and Drug Discovery process



Diversification of AI applications for R&D and Drug Discovery process



Comparison of AI for Drug Discovery Companies

Company	Scientific publications covering AI for drug discovery	Number of AI experts in the team / total number of employees	Public talks on AI for drug discovery	Validation	Use GANs/RL
1. Atomwise	+	11/13	+	n/a	n/a
2. Cloud Pharmaceuticals	+	n/a	+	n/a	n/a
3. Benevolent.AI	+	18/74	+	n/a	n/a
4. Globavir	-	1/4	-	n/a	n/a
5. Envisagenics	-	n/a	+	n/a	n/a
6. Numerate	-	4/15	+	+	n/a
7. NuMedii	+	4/9	+	n/a	n/a
8. TwoXar	+	1/15	+	n/a	n/a
9. Exscientia	+	2/12	+	+	n/a
10. BioAge Labs	+	1/5	+	n/a	n/a
11. Insilico Medicine	+	24/43	+	+	+

Comparison of AI for Drug Discovery Companies

Company	Scientific publications covering AI for drug discovery	Number of AI experts in the team / total number of employees	Public talks on AI for drug discovery	Validation	Use GANs/RL
12.Cyclica	+	7/27	+	n/a	n/a
13.Deep Genomics	+	10/26	-	n/a	n/a
14.BioSymetrics	-	5/7	-	n/a	n/a
15.e-therapeutics	+	4/25	-	n/a	n/a
16.Healx	-	5/20	-	n/a	n/a
17.GNS Healthcare	+	21/98	-	n/a	n/a
18.AiCure	-	9/43	+	n/a	n/a
19.PathAI	-	13/37	-	n/a	n/a
20.Owkin	-	9/22	+	n/a	n/a
21.Mendel.ai	-	6/8	-	n/a	n/a

Diversification of the AI in R&D and Drug Discovery process



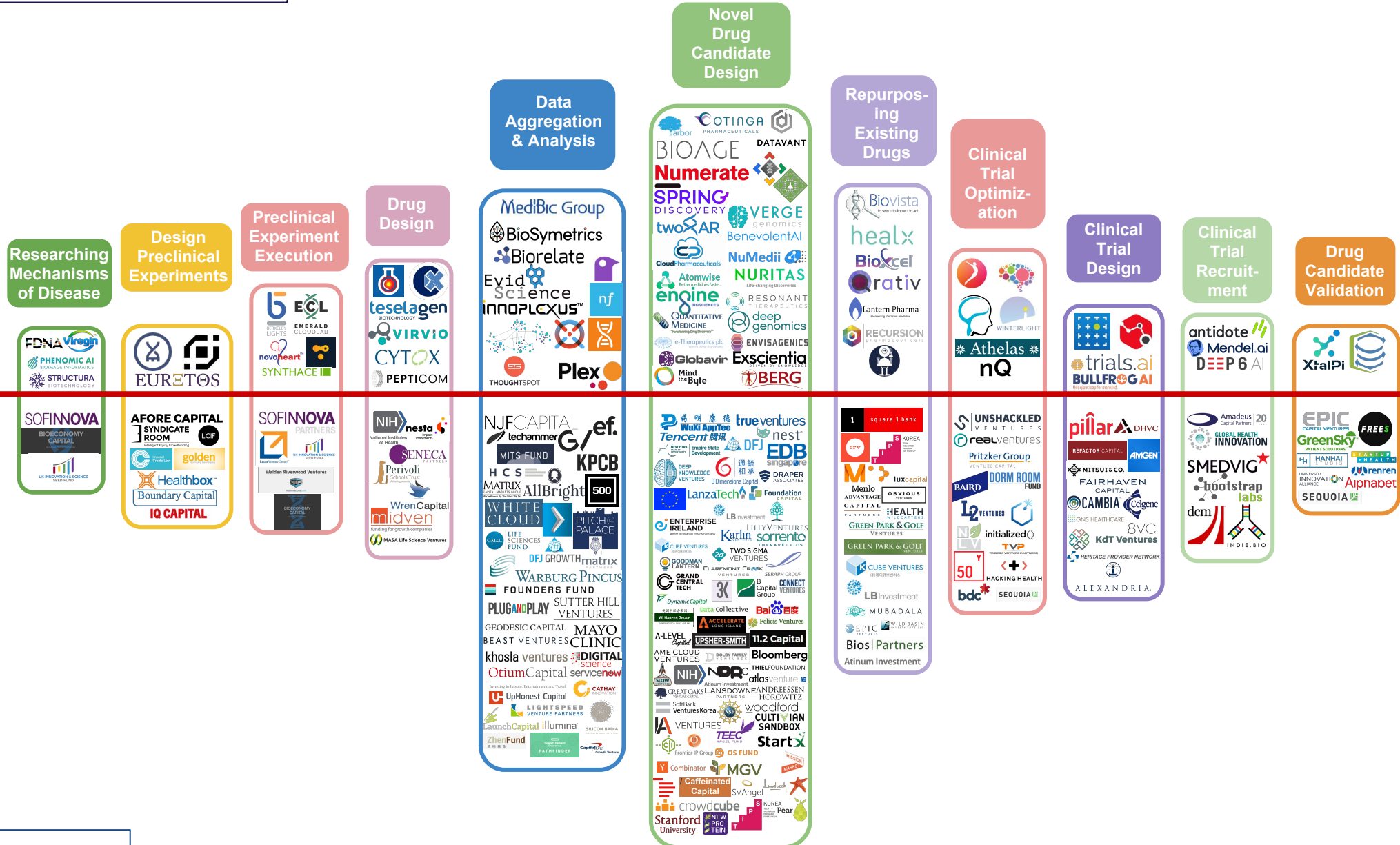
<p>These companies are mainly focused on understanding of mechanisms of disease and its evolution.</p>	<p>Organizations of this group are collecting and systematize information about patients, preclinical and clinical experiments and drugs.</p>	<p>AI startups, which are working on Drug Discovery field, are focused on repurpose of existing drugs, design on a new drugs, validation of drug candidates.</p>	<p>AI startups which are focused on trials: Design, Optimization and Run of preclinical trials.</p>	<p>These AI startups provide services on recruitment for clinical trials as well as support in publishing data.</p>

Diversification of AI in R&D and Drug Discovery process

Companies - 80
Investors - 180

Companies

Investors



Chapter III

BioPharma Transformation
from Scepticism
to active Cooperation

AI in BioPharma R&D: Pharma Companies Started to Close “The Big GAP”

- It will have a domino effect in the sense that Biopharma budgets are significantly related to spending on R&D and failures in clinical trials, meanwhile the breakthroughs in applying AI for drug discovery will have dramatic impact on not just Biopharma companies but all biotech startups and biotech VC funds. All of them will be disrupted.
- The major progress in these technologies is coming not from biotech side but from IT side.
- Due to the lack of AI specialists and promising AI & Drug Discovery startups, only a select few BigPharma players will emerge as the leaders of this trend.
- Meanwhile others, even with substantial budgets and the will to succeed in this area, will fail if they are even 1 year late to the race because all of the top AI specialists and AI in healthcare start-ups will have been acquired by then.
- The number of experts in the field of AI for drug discovery is insufficient to meet the demand of all big pharma companies, so only those few pharma companies and investors who will partner with the best AI for drug discovery companies in time will benefit from these collaborations and increase their capitalization accordingly.
- In the past six months a large number of deals and acquisitions are made between Big Pharma companies and AI startups.

BioPharma: The Road Forward

- Those Bio Pharma companies that will create strong AI for drug discovery divisions and that will succeed to acquire the best AI startups will become the leaders of the field as little as 3 to 5 years from now. Consider the acquisition of DeepMind by Google for \$0.5B in 2014. Those companies that will invest heavily in their AI for drug discovery departments will see their market capitalization skyrocket in coming years.
- Those Bio Pharma companies that do not accept AI will repeat the mistakes of Kodak, who were once the leader of their industry, but went to bankruptcy because they failed to embrace digital photography as the disruptive trend it was, even despite the fact that the digital camera was invented inside Kodak labs.
- If Bio Pharma would find the courage to spend 10% of their marketing budget on R&D in AI, they could blow IBM Watson out of the water by learning from their mistakes, reinventing themselves and coming one step closer to halting the looming threat of the Silver Tsunami. We see now that our forecasts in the previous version of the report were true. Big Pharma companies are now actively investing in and collaborating with the smaller companies from the AI for Advanced R&D industry.



BioPharma's Failure is Strategy, Not Capital

- The pharmaceutical industry has accumulated capital but remains conservative, bureaucratic and risk-averse in their investment strategy. As government budgets become ever more constrained, it is increasingly urgent that the roadblocks to medical advancement be eliminated.
- This may reflect the inefficiency and of the organizations themselves and capital intensive barriers to entry more than the intrinsic intractability of complex biological systems - indeed, the most successful drugs historically have been discovered serendipitously. In any case, the sector shows signs of sluggishness: twenty years ago, 20% of Swiss GDP was derived from pharmaceuticals — now it is down to 5.7% of GDP.
- Banks and Tech Giants are snapping up the bet AI specialists and startups and it is inevitable that pharma will require the same scarce technology and talent. Biopharma must recruit advanced deep learning teams (as Google did with Deep Mind).



Main acquisitions / big collaborations between big Pharma companies and AI startups

1. Pfizer announced in late 2016 a collaboration that will utilize IBM Watson for Drug Discovery. Pfizer is using IBM's AI technology on its immuno-oncology research, a strategy of using a body's immune system to help fight cancer.
2. Genentech, a member of the Roche Group announced in the summer of 2017 their collaboration with Cambridge, MA-based GNS Healthcare. This collaboration's first focus will be on oncology. Genentech plans to use the GNS REFS™ (Reverse Engineering and Forward Simulation) causal machine learning and simulation platform to find and validate potential new drug candidates. They will also look for genetic patient response markers that could lead to targeted therapies.
3. One of the largest by drug discovery collaborations and strategic leasing agreements in 2017 was between pharmaceutical maker Sanofi and artificial intelligence driven drug discovery company Exscientia. Exscientia is responsible for inventing new potential drugs while Sanofi will be responsible for making them, testing them, and bringing them to clinical trial.
4. Exscientia signed a deal with pharmaceutical company GlaxoSmithKline in July 2017. The drug maker is employing Exscientia to discover novel and selective small molecules for up to 10 disease-related targets.
5. Last year BenevolentAI reached a deal to license potential drugs from Johnson & Johnson. BenevolentAI licensed the right to develop, manufacture and commercialize a select number of novel clinical stage drug candidates from Johnson & Johnson.
6. AstraZeneca announced this year a partnership with Alibaba to apply technology including artificial intelligence to patient diagnosis and treatment.
7. Mitsubishi Tanabe Pharma partnered in 2017 with Hitachi to optimize clinical trial planning with AI. The pair wants to utilize AI technology such as natural language processing and deep learning to automate the process. The approach can shorten the time spent on information search and collection by about 70%.

Chapter IV

Tech Corporations and
IT-giants
Advanced AI in
Healthcare & Drug Discovery

Tech Giants and Drug Discovery

Tech Giants are more flexible with new technologies, moreover their revenue depends on cutting edge technologies, which they are using and implementing in their products. AI and machine learning technologies became a part of their technologies. These technologies are used in advanced R&D and drug discovery. In our opinion using advanced technologies by Tech Giants give them a huge advantage over BioPharma companies on drug discovery.

The interest and application of AI is relatively faster in healthcare and life sciences as many giant tech corporations like Google, Apple, IBM, Qualcomm, AT&T, GE, Amazon, and Microsoft have shown interest by investing, acquisitions and partnering with life sciences companies in this space. In the life sciences space, an enormous amount of data has been generated and the big data is getting bigger and bigger by minute from omics, biomarker research, drug discovery, clinical trials, smart pills and devices, manufacturing supply chain sensors, patient data and from commercial functions.

AI & Machine Learning are universal and can be used in various industries, and drug discovery is not an exemption.

Tech Giants are more flexible than BioPharma companies, they do have much more capabilities to implement new technologies in advanced R&D and drug discovery sectors. The future of the BioTech sector lies on their shoulders.

In addition to that, Facebook, Google, Amazon have other advantages, these companies do have access to billions of customers worldwide, who can be monitored and researched. Based on this information and developed biomarkers, the industry of drug discovery will make a step forward and would be more precise than ever.

In this section 10 Tech Giants and their involvement in advanced R&D and drug discovery were analysed. It's important to mention that every and each company has its own vision and the level of involvement differs from one company to another, however, overall, IT Giants are interested in advanced R&D and drug discovery sector.

Google, Apple, Alibaba and Amazon

Google - according to an article in Nature outlining the field, the firm's deep learning project, Google Brain, is growing its biosciences team, and industry watchers wouldn't be surprised to see them target drug discovery. Now, Google Brain is focused on 4 directions: Artificial-intelligence-devised encryption system; Image enhancement; Google Translate; Robotics. However, in a nearest future AI technologies which were developed by Google Brain can be applied to drug discovery industry.

Alibaba has a special division called **The ET Medical Brain**. It is a suite of AI solutions designed to ease the workload of medical personnel by using computers to act as virtual assistants for patients and in medical imaging, drug development and hospital management. Healthcare requires huge quantities of data to be processed from different sources. "AI allows computers to play a significant role in assisting decision-making, freeing medical personnel from complex repetitive tasks to focus on delivering quality care to patients," according to Alibaba Cloud. The company has focused some of their efforts on AI systems that can detect certain types of early stage cancers. Alibaba Health developed a diagnostic tool that uses imaging to make early diagnoses, while Alibaba Cloud is leveraging AI and visual computation technologies to detect cervical cancer and training machines to find lung cancer using high-resolution CT scans.

Recently, Alibaba teamed up with AstraZeneca to help expand the drug maker's market in China. Alibaba and AstraZeneca will work together to deliver smart health services driven by the Internet and AI. With these developments, it's clear that China's tech industry sees AI as a real solution to improve the country's healthcare.

Amazon has a program Biotech and Pharma in the Cloud Accelerate scientific discovery and enable operational efficiencies in the AWS Cloud. Data Lakes With the AWS cloud, developers, scientists and business users can store, process, and analyze data across previously siloed product and therapeutic teams. One of the main ideas on the program is to gain further insight and accelerate innovation for new drugs and treatments.

In 2016 **Apple** has found its first ever partnership with a drug company. British firm GlaxoSmithKline has announced it will be using ResearchKit (a medical platform designed to turn the iPhone into a diagnostic tool for clinical trials and studies) to conduct a medical study on rheumatoid arthritis. Apple seeks to form partnerships with medical companies and establish itself as a legitimate player in the health industry. Pharma companies are moving into a new area in drug R&D, by using Apple's ResearchKit platform to gather data from iPhone users to draw on when developing new drugs.

L'Oreal, Baidu, Tencent, Intel and Hitachi

Cosmetics brand **L'Oreal** has sworn not to test on animal, and in 2015 L'Oreal started using 3D printers that mimic human skin as a testing ground for new products. L'Oreal partnered in 2015 with bio-engineering firm Organovo, the latter of which both designs and creates "multicellular, dynamic, and functional human tissues for use in drug discovery and medical research," according to Allure. Together, they will craft tissue that is similar to human skin, which leads to faster, easier, and totally humane testing methods. Bin Chen Lab, together with Butte Lab and Hadley Lab, received in 2017 funds from L'Oreal to discover drugs for hyperpigmentation.

Chinese web giant **Baidu** pushed in 2017 further into the AI market with the acquisition of Raven Tech, a startup behind the 'Flow' digital assistant. Baidu is betting on AI and intends to lead its growth beyond virtual assistants to more niche areas where increasing computing power can analyse big data and make big decisions simple. One such area is medicine, where Baidu is looking to use artificial intelligence algorithms for drug discovery technology so it can significantly shorten the process.

In 2018 was announced that Medopad has teamed up with Chinese tech giant **Tencent** to develop artificial intelligence-enabled clinical decision support software and medical chatbots. The partnership will combine Tencent's data assets and AI technology with Medopad's mobile apps. As well in 2018 British pharmaceutical giant AstraZeneca has teamed up with Chinese technology powerhouses Alibaba and Tencent to deliver smart healthcare services through the use of artificial intelligence (AI) and the internet of things (IoT) in China. Tencent Holdings Ltd joined in 2018 Alphabet Inc's Google and Sequoia Capital China to a \$15 million B series funding round for Boston- and Shenzhen-based artificial intelligence (AI) pharmaceutical firm XtalPi Inc.

The **Intel** Xeon Scalable platform offers potent performance for all types of artificial intelligence (AI). Kyoto is one of many leading healthcare providers and research institutions that are working with Intel and using Intel artificial intelligence technology to tackle some of the biggest challenges in healthcare.

Mitsubishi Tanabe Pharma and **Hitachi** have become the latest companies attempting to use artificial intelligence (AI) to more efficiently develop drugs. The aim of the collaboration is to use Hitachi's advanced digital technology, including AI, to shorten the development period for new drugs and reduce development costs, while reducing the possibility of expensive trial failures.

IBM, Huawei, Samsung, NVIDIA, Microsoft

IBM created the Watson for Drug Discovery, which is a cloud-based, cognitive solution that analyzes scientific knowledge and data to reveal known and hidden connections that can help increase the likelihood of scientific breakthroughs. The platform allows researchers to generate new hypotheses with the help of dynamic visualizations, evidence-backed predictions and natural language processing trained in the life sciences domain. It is used for both new drug target identification and drug repurposing.

Huawei is Chinese Tech Giant, which is also involved in the race. Collaborating with established genomic data experts WuXi NextCODE and WuXi AppTec, Huawei created the platform, which is aiming to support the Precision Medicine Initiative taken up by the Chinese government, and link researchers across China through a secure nationwide network.

South Korean multinational conglomerate - Samsung is also focused on biotech and healthcare industry. **Samsung NeuroLogica**, the healthcare subsidiary of Samsung Electronics, is integrating its computed tomography (CT) and other imaging equipment with artificial intelligence (A.I.) clinical decision support technology developed by Israeli startup MedyMatch. So far, this Giant is not very close to advanced R&D and drug discovery, however, we can assume that the situation will be changed in following few years.

NVIDIA is implicitly involved in advanced R&D and drug discovery. This company produces hardware which is used by AI companies with are involved it advanced R&D and drug discovery process. For example, BenevolentBio's deep learning software, powered by the NVIDIA DGX-1 AI supercomputer, ingests and analyzes the information to find connections and propose drug candidates.

Microsoft - the last Tech Giant in our list - is also applies computer science expertise to enable data-driven healthcare, enhance wellness and accelerate progress in life sciences. Artificial intelligence, machine learning and exponential leaps in data availability and cloud computing fuel research initiatives to understand biology at molecular and cellular levels, guide the development of medical treatments and analyze data streams to detect health threats, predict disease outbreaks and counsel patients.

Nestle

Finally, **Nestlé** - which is not IT nor Tech Giant, but is highly involved in AI advanced R&D industry. It is known, that Nuritas, biotech company, which, combines artificial intelligence and genomics to discover and unlock natural Bioactive Peptides with extraordinary health benefits, wants to revolutionize the discovery of natural active ingredients that can support and improve human health. The company uses artificial intelligence (AI) to look closely at the foods we eat to find peptides that could provide extraordinary benefits. The biotech has joined forces with **Nestlé**, the world's largest food and beverage company, which will provide its expertise in the area of food and nutrition to validate the biotech's discoveries.

Conclusions: It's important to mention that every and each company has its own vision and the level of involvement differs from one company to another, however, overall, IT Giants are interested in advanced R&D and drug discovery sector.

Sources:

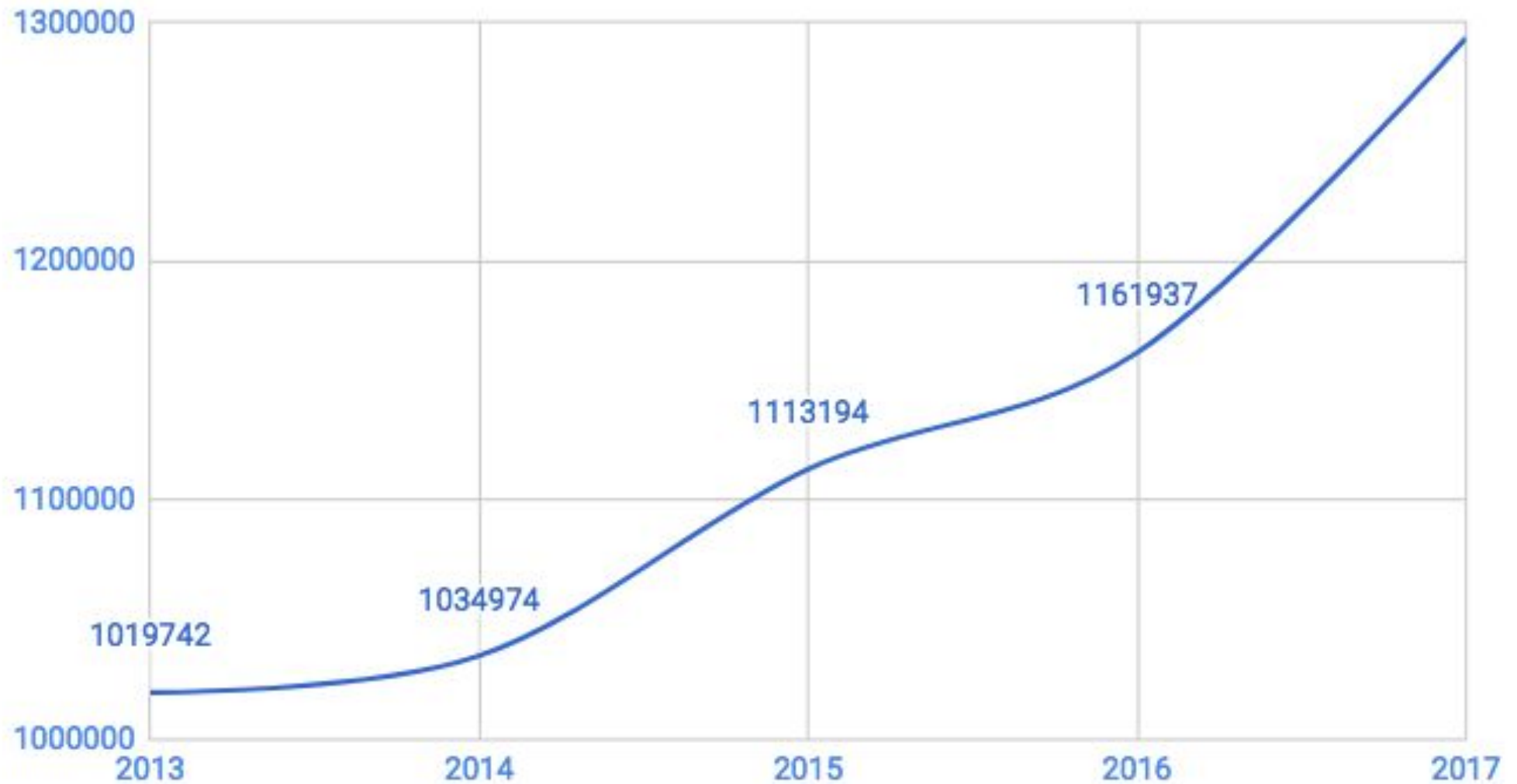
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Chapter V

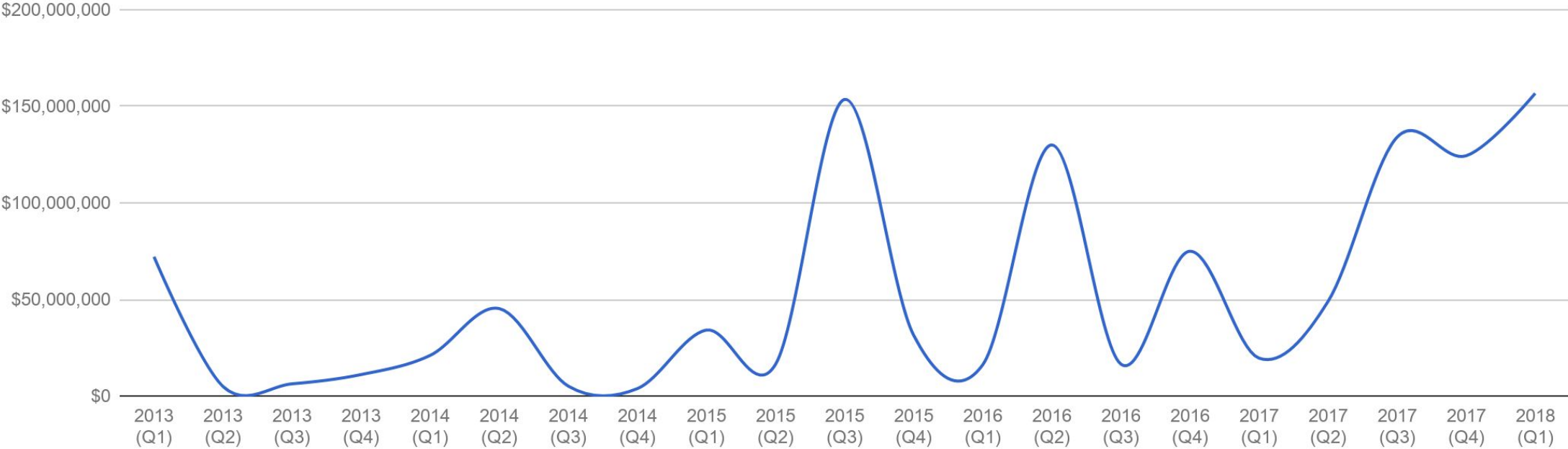
Investments and Joint Ventures

Combined Capitalization of 20 Tech and BioPharma Corporations

in millions \$



Investments in 80 AI Companies in R&D and Drug Discovery



Investments and industry capitalization

2013-2015. During these years the first scalable AI approaches for Drug Discovery and Advanced R&D were developed and several big industry players with talented strategic managers started doing pilot collaborations and small investments.

2016-2017. As the AI approach is new for science, many pilot projects failed and there was a lot of criticism towards the use of deep learning for Drug Discovery and Advanced R&D. Therefore, there were significant concerns regarding the scalability of such approach, and whether they could deliver truly disruptive results, above and beyond traditional R&D departments in BioPharma. By the beginning of 2017 first rather tangible results were achieved by a number of AI companies and new benchmark methods for the application of AI were established, and new collaborations between Pharma and AI startups yielded much better results. Since then the race for the acquisition of the best AI startups began.

2018. Now the capitalization of the industry is continuously growing. By 2019 the growth of the capitalization of the AI for Drug Discovery industry could increase from 5x to 10x. If there will be major breakthroughs, the growth leading up to 2020 could approach 20x or more.

Over the next several years, we can expect to see VC firms and subsidiary funds focused exclusively on the AI for drug discovery subsector, and funds that invest in a maximally-diverse number of AI for drug discovery companies so as to bet on the entire subsector, in such a way as to tie the performance of the fund to the performance of the entire sector rather than any individual company.








Conclusions:

1. Diversification. In 2015 and 2016, 26 and 22 investment rounds were conducted, in 2017 the number of investment rounds increased to 30. This increase can not be called significant, however, the amount of money raised in each investment round increased significantly.
2. Increased amount of investments. 2017 and 2018 showed significant growth of investments. Comparing to 2015 and 2016, when AI R&D startups raised \$231M and \$230M accordingly, 2017 showed significant growth to \$691M. In Q1 of 2018 AI R&D startups raised more than \$156M. Considering the various investment deals that occurred in April - May of 2018, we can expect that Q2 2018 will be substantial and that total investments at the end of 2018 could exceed \$1B.
3. Consistency. During 2013-2016 there was some growth in the amount of capital raised by the industry players, however the trend was not steady. In 2017-2018 we observed stable growth of the investments in the industry.

Invest & Short

- Financial entities like banks and hedge funds have become mathematical corporations, i.e. IT-firms driven by AI, but BioPharma have been less agile, with their executives preferring to avoid risk rather than embrace disruptive technologies and practices.
- BioPharma executives are wary of reducing net earnings by embarking on expensive IT-related R&D efforts. But by ignoring the increasing penetration of BioPharma by disruptive IT technologies like AI, they are failing to hedge long-term risk and return profiles properly, preferring to avoid short-term expenditures at the expense of setting themselves up for longer-term stagnation in the face of their less risk-averse competitors.
- Investors should invest in the AI in healthcare sector, and the AI for Drug Discovery sector in particular, because it will inevitably grow.
- The AI for Drug Discovery subsector, in particular has the potential to grow 10x-20x more than the broader AI in Healthcare sector, due to its leading position in terms of tangible results, and its extremely disruptive potential.
- Invest in the BioPharma giants who have already demonstrated an early commitment to embrace disruptive IT technologies like AI; noticing the early commitments to AI of Google and NVIDIA, who have now become AI giants, would have netted investors substantial gains.
- Invest in IT corporations who have allocated significant R&D efforts to AI in healthcare and AI for drug discovery, as they are likely to surpass many of the current BioPharma giants in the healthcare sector.
- Investors should short those BioPharma giants who have remained stick in their old ways, unwilling to show early commitment to AI disruptive IT technology R&D. They will fail in the way of Kodak and Yellow Cab, who were disrupted by digital photography and Uber.







AI R&D startups investments 2017 - 2018

AI startups	Investment description	Investor name
<p>Exscientia</p> 	<p>Sanofi invested 300 000 000\$ in 2017.</p> <p>Exscientia and Sanofi will develop bispecific small molecule drugs in the high interest area of metabolic disease, including diabetes. Exscientia will be responsible for compound design, while Sanofi will handle the chemistry synthesis, as well as further assays, preclinical experiments and subsequent trials.</p> <p>Evotec invested 17 000 000 \$ in 2017.</p> <p>Exscientia and Evotec have cooperated since early 2016 to advance small molecules, and bispecific small molecules in immuno-oncology. Through this investment, Evotec becomes the first strategic shareholder in the UK based company.</p>	<p>Sanofi</p>  <p>Sanofi is a healthcare company engaged in the research, development, manufacturing, and marketing of innovative therapeutic solutions. It covers areas such as diabetes solutions, human vaccines, innovative drugs, consumer healthcare, emerging markets, animal health.</p> <p>Evotec</p>  <p>Evotec is a drug discovery alliance and development partnership company focused on rapidly progressing innovative product approaches with leading pharmaceutical and biotechnology companies.</p>
<p>Antidote</p> 	<p>Merck Global Health Innovation Fund (GHI) invested £11 000 000 in 2017</p> <p>This funding will accelerate the development of new capabilities for its trial matching platform, including precision medicine and EHR-matching, as well as further global expansion.</p>	<p>Merck Global Health Innovation Fund</p>  <p>Merck GHI is evolving corporate healthcare venture capital globally by utilizing their healthcare ecosystem strategy.</p>
<p>Benevolent AI</p> 	<p>Woodford Investment Management invested \$115 000 000 in 2018</p> <p>The funding will be used to keep developing the drugs the company has discovered, along with potentially expanding BenevolentAI's technology to other fields including energy and agriculture.</p>	<p>Woodford Investment Management</p>  <p>The trust currently intends to conduct its affairs so that its securities can be recommended by IFAs to ordinary retail investors in accordance with the FCA's rules in relation to non-mainstream investment products and intends to continue to do so for the foreseeable future.</p>

AI R&D startups investments 2017 - 2018

AI startups	Investment description	Investor name
<p>GNS Healthcare</p> 	<p>Amgen Ventures invested \$6 000 000 in 2017</p> <p>The funds will be used to further develop the company's REFS causal machine learning and simulation platform -- as well as solutions across drug discovery and development, value-based drug solutions, and care management.</p>	<p>Amgen Ventures</p>  <p>The firm primarily invests in the biotechnology sector with a focus on discovering and developing human therapeutics with a focus on oncology, inflammation, hematology, nephrology, metabolic disorders, neuroscience, and cardiovascular therapeutics</p>
<p>AiCure</p> 	<p>Baird Capital invested \$15 000 000 in 2017</p> <p>The investment will accelerate commercial and engineering activities. AiCure is solving the lack of patient oversight and poor adherence to therapy, a \$500 billion problem in the US alone.</p>	<p>Baird</p>  <p>Baird Capital makes venture capital, growth equity, and private equity investments in strategically-targeted sectors around the world. Baird Capital is the direct private investment arm of Robert W. Baird & Co.</p>
<p>Insilico Medicine</p> 	<p>Deep Knowledge Ventures and Juvenescence Limited invested over \$10 000 000 in 2014-2017</p> <p>Insilico Medicine's primary expertise is in the many flavors of generative adversarial models, one-shot learning, reinforcement learning and meta-learning used to develop a portfolio of over 1,000 promising molecules targeting cancer and age-related diseases. Besides AI for drug discovery, the company is also extremely active in the niche of applying AI for drug repurposing and AI for aging biomarker discovery.</p>	<p>Deep Knowledge Ventures</p> <p>DKV lead by Dmitry Kaminskiy is an investment fund focused on early stage companies at the intersection of AI and precision medicine and Longevity.</p>   <p>Juvenescence Limited</p> <p>Juvenescence Limited is a VC firm focused exclusively on longevity startups, led by prominent British investor Jim Mellon.</p>

AI R&D startups investments 2017 - 2018

AI startups	Investor name	Investor name
<p>Atomwise</p> 	<p>Monsanto Growth Ventures (MGV) invested \$45 000 000 in 2018</p> <p>Atomwise's software analyzes simulations of molecules, reducing the time researchers need to spend synthesizing and testing compounds. The company says it currently screens more than 10 million compounds each day.</p>	<p>Monsanto Growth Ventures </p> <p>MGV is the venture capital group at Monsanto Company. Monsanto has a large footprint as a provider of technology-based solutions and agricultural products that improve farm productivity and food quality.</p>
<p>twoXAR</p> 	<p>SoftBank Ventures invested \$10 000 000 in 2018</p> <p>Using its proprietary AI-driven platform, twoXAR rapidly identifies drug candidates for in vivo testing in weeks rather than years and has demonstrated in vivo success rates significantly greater than those of traditional approaches across therapeutic areas including diseases such as liver cancer, rheumatoid arthritis, and type 2 diabetes. The funds will be used to run preliminary preclinical studies, advance current programs in their pipeline, and grow their diversified team.</p>	<p>SoftBank Ventures </p> <p>SoftBank envisions an AI-driven future and funds technologies that contribute to “the betterment of humanity.” SoftBank Ventures invest in applications of Artificial Intelligence across various industries, but “none is perhaps more ready for AI-driven transformation than biopharmaceutical research and development”.</p>
<p>ThoughtSpot</p> 	<p>Lightspeed Venture Partners invested \$60 000 000 in 2017</p> <p>ThoughtSpot's funding will help with the company's debut of a new artificial intelligence product, SpotIQ. With this technology, a computer asks thousands of questions on its own, making assumptions about what the user wants to know based on the user's profile and certain search terms. The search produces dozens of analyzed data sets in seconds.</p>	<p>Lightspeed Venture Partners </p> <p>Lightspeed Venture Partners is a venture capital firm that is engaged in the consumer, enterprise, technology, and cleantech markets. Lightspeed is an early stage venture capital firm focused on accelerating disruptive innovations and trends in the Enterprise and Consumer sectors.</p>

AI R&D startups investments 2017 - 2018

AI startups	Investor name	Investor name
<p>BioAge Labs</p> 	<p>Andreessen Horowitz invested \$10 900 000 in 2017</p> <p>The company intends to use the funds to build the team, refine and test its signatures of aging, and begin in vivo evaluation of drug candidates. BioAge Labs initially targets specific diseases where aging is causal. However, its ultimate goal is to combat the suffering and disability caused by all aging-related diseases, and to restore both the quality and quantity of life in old age.</p>	<p>Andreessen Horowitz ANDREESSEN HOROWITZ</p> <p>Andreessen Horowitz LLC is a venture capital firm specializing in investing in seed, start-ups, early, mid stage, growth, and late stage. It prefers to invest in business and technology sector with a focus on software, cloud computing, enterprise software and data-storage, software related biology, biotech, and medicine companies at the intersection of computer science and life sciences with a focus on digital therapeutics, cloud technology in biology, and computational medicine.</p>
<p>PathAI</p> 	<p>General Catalyst Partners invested \$11 000 000 in 2017</p> <p>PathAI, a Cambridge, MA-based company developing A.I. software aim at helping pathologists be more efficient and accurate in diagnosing disease. The startup will use the funds to build out its team and develop its artificial intelligence-based technology.</p>	<p>General Catalyst Partners </p> <p>General Catalyst Partners is a private equity and venture capital firm. The firm seeks to invest in technology with a focus on advanced materials, clean energy solutions, cyber security and biosecurity and more.</p>
<p>XtalPi</p> 	<p>Sequoia Capital China invested \$15 000 000 in 2018</p> <p>This funding will be used to develop new computational models built on big data generated from XtalPi's high-precision computing platform and to expand its business into adjacent areas along the pharmaceutical value chain. The investment will also support the construction of a prediction-driven research lab.</p>	<p>Sequoia Capital China </p> <p>Sequoia Capital China has an impressive and diverse portfolio comprising about 300 dynamic companies that deliver high returns on investment using differentiated technologies and innovative business models</p>

3 ways of cooperation

Investments in AI for Drug Discovery and R&D are growing, however, 21 Big Pharma companies are using different approach in getting AI for Drug Discovery and R&D specialist and ideas.

Awards / grants

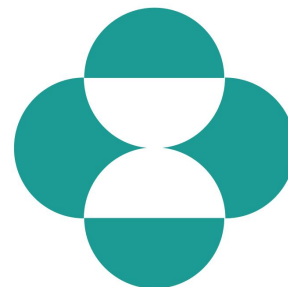
Collaboration

Acquisitions

Source: Deep Knowledge Analytics
Crounchbase.com

Awards / grants

- **Johnson & Johnson** Innovation and Janssen Research & Development launched the Artificial Intelligence for Drug Discovery QuickFire Challenge. Johnson & Johnson Innovation will award up to \$100,000 in grants, one year of JLABS residency & mentorship to the individuals or teams who submit the best ideas, technologies, or solutions that are using artificial intelligence to advance healthcare.
- **Novartis** provides funding opportunities for innovative, substantial-risk projects that have the potential to open up novel research directions and aim beyond incremental innovation and discovery. In this year's call, proposals in the field of artificial intelligence (AI) will be accepted, namely: AI in drug discovery, AI in clinical development and medical practice, AI and the patient. Grants are for a period of 18 months. A maximum of 15 projects will be funded, depending on the quality of the proposals as judged by the review committee.
- **Atomwise** Opened in 2017 Applications For Historic AI Drug Discovery Awards. Atomwise Inc. sought proposals from innovative university scientists to receive 72 potential medicines, generated specifically for their research by artificial intelligence. The Artificial Intelligence Molecular Screen (AIMS) program is designed to dramatically accelerate the race towards life-saving drugs by analyzing millions of compounds for each disease.
- **Merck**, a leading science and technology company, announced in 2017 recipients of €1 Million Grant at the fifth annual Grant for Multiple Sclerosis Innovation (GMSI) during the 7th Joint ECTRIMS-ACTRIMS Meeting in Paris, France.



MERCK

Collaborations

- **Genentech**, a member of the Roche Group, in the summer of 2017 announced their own collaboration with Cambridge, MA-based GNS Healthcare. GNS Healthcare's mission statement is to use the latest innovations in machine learning to turn biomedical data into solutions and treatments on cancer therapy.
- **Johnson & Johnson** and IBM announced in 2015 plans to collaborate around a new generation of intelligent virtual coaching solutions and applications designed to transform the patient experience and deliver improved health outcomes.
- **Janssen Research & Development**, LLC, another organization in the Johnson & Johnson family of companies, has been working with WinterLight Labs and their speech-based AI platform to analyze Janssen's growing collection of speech data acquired from ongoing clinical trials.
- Johnson & Johnson's medical device company, **Ethicon**, is collaborating with Google on this initiative which aims integrate data analytics capability into a digital surgery platform.
- Pharmaceutical giant **Pfizer** in late 2016 announced a collaboration that will utilize IBM Watson for Drug Discovery. Pfizer is using IBM's AI technology on its immuno-oncology research, a strategy of using a body's immune system to help fight cancer.
- **GlaxoSmithKline** is putting potentially \$43 million into Scottish artificial intelligence (AI) company Exscientia, which aims to use deep learning to develop new drugs. It also partnered with Insilico Medicine "after completing over 18 months of pilots". The terms were not disclosed.
- **AstraZeneca** teamed up in 2017 with US biology and technology company Berg to search for new drugs to treat Parkinson's Disease and other neurological disorders, using artificial intelligence.
- French pharma major **Sanofi** has signed a 250 million euro (\$273 million) research collaboration and licence option agreement in metabolic disease with Exscientia in 2017.

Acquisitions

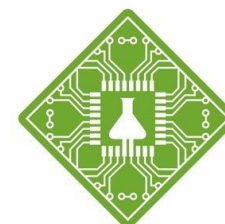
- **Johnson & Johnson** Medical Devices Companies, through French affiliate Apsis S.A.S., announced in 2018 the acquisition of Orthotaxy, a privately-held developer of software-enabled surgery technologies, including a differentiated robotic-assisted surgery solution. This proprietary technology is currently in early-stage development for total and partial knee replacement, and the Johnson & Johnson Medical Devices Companies plan to broaden its application for a range of orthopaedic surgery procedures. **Financial terms of the transaction will not be disclosed.**
- Pharma giant **Roche** in 2018 acquired Flatiron Health, developer of a cancer electronic health record software that collects and aggregates data from cancer patients, for \$2.1B.
- **Roche** acquired in 2017 Viewics, Inc, a laboratory business analytics platform. Under the terms of the agreement, Roche is acquiring all shares of the company. Financial details of the acquisition were not disclosed.
- AlphaCore Pharma, an Ann Arbor-based biotech company working on a drug to treat atherosclerosis, announced in 2013 that it has been acquired by MedImmune, the biologics division of the Delaware-based pharmaceutical giant **AstraZeneca**. The terms of the deal were not disclosed.
- **Astellas Pharma**, a Japanese pharmaceutical and biotechnology company, is acquiring in 2018 Seattle biotech Universal Cells. Astellas will pay up to \$102.5 million for Universal Cells in upfront and milestone payments, assuming the company hits certain benchmarks in developing its universal stem cell technology.
- **QIAGEN** announced in 2018 that entered into an agreement to acquire STAT-Dx, a privately-held company developing the next generation of multiplex diagnostics for one-step, fully integrated molecular analysis of common syndromes using a novel system based on real-time PCR technology and proven QIAGEN chemistries..

Most Promising Players

Bio Pharma



Startup

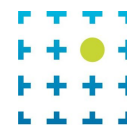


INSILICO MEDICINE

BenevolentAI



Atomwise
Better medicines faster.



GNS HEALTHCARE

Chapter VI

AI and Advanced R&D in Longevity Research

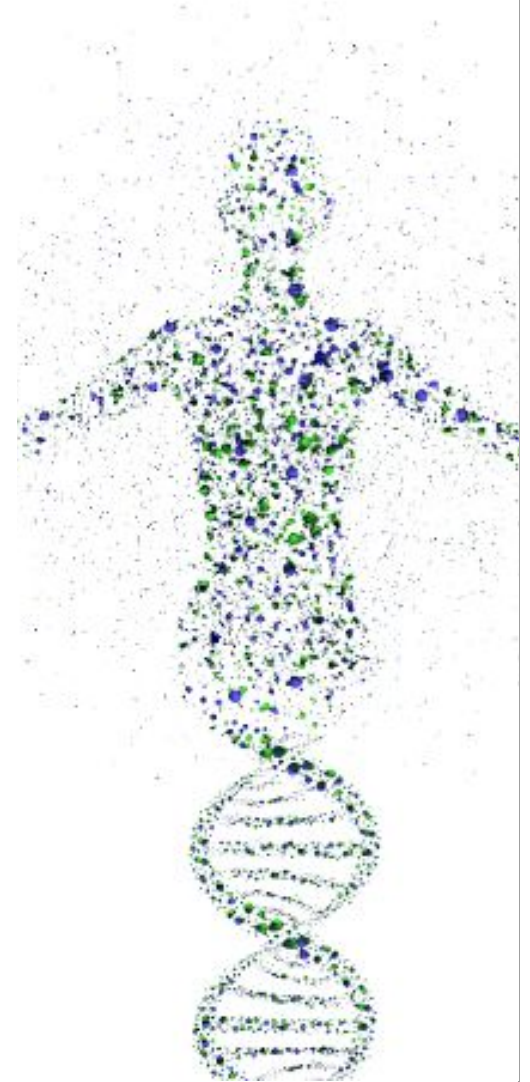
“ We have the means right now to live long enough to live forever. ”
~Ray Kurzweil

The following chapter describes the manner in which these technologies combine to form an industry.

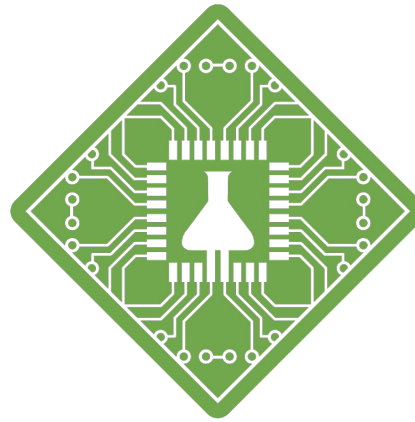
But any industry worthy of the Industrial Revolution title must have some form of automation or technological optimisation, and a system of finance behind it.

This chapters examines how AI and blockchain technology form the engine of the future industry, and touches upon some novel financial systems.

“I see a bright future for the biotechnology industry when it follows the path of the computer industry, the path that von Neumann failed to foresee, becoming small and domesticated rather than big and centralized. ” ~Freeman Dyson



AI companies in Longevity



Insilico Medicine



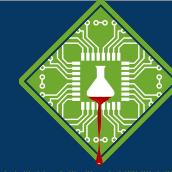
Atomwise
Better medicines faster.

Atomwise



BioAge

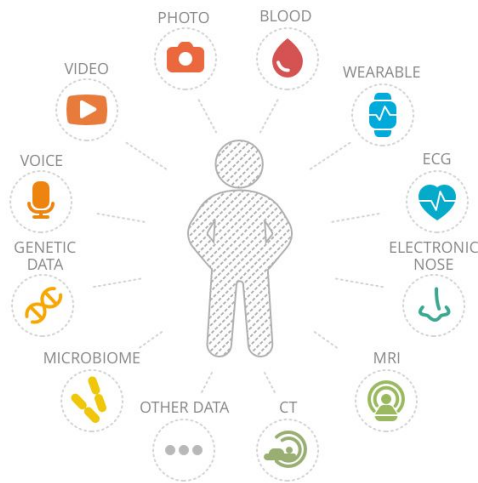
Insilico Medicine Aging.AI 2.0



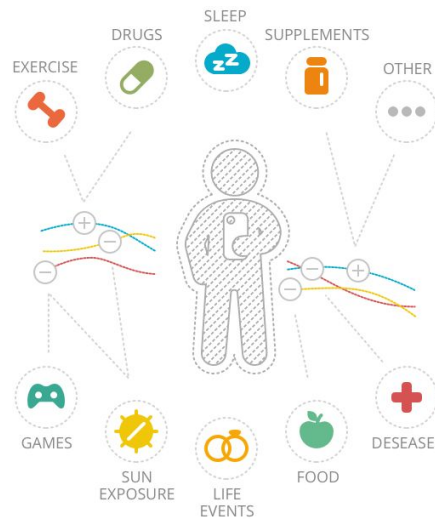
INSILICO MEDICINE

One of the most promising projects developed by Insilico Medicine is called Aging.AI 2.0, which is an AI-empowered platform integrating multiple predictors of clints age and used to track changes of health over time and optimize clints lifestyle.

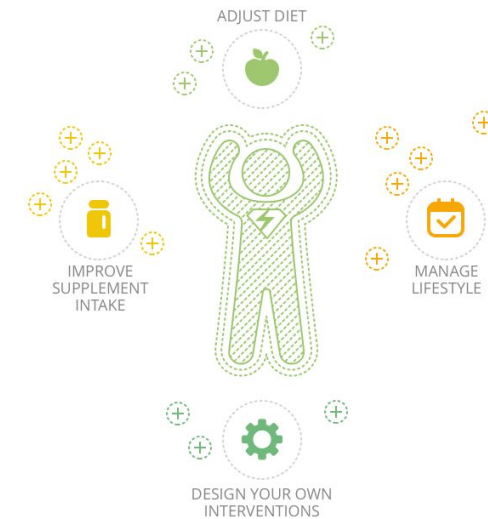
<http://young.ai/>



Track your age
at every level!

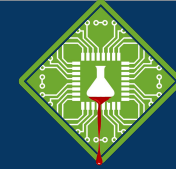


See what makes you
younger or older!



Stay young!

Insilico Medicine



INSILICO MEDICINE

Insilico Medicine's mission is to extend healthy longevity through innovative AI solutions for drug discovery and aging research. Insilico Medicine is committed to transforming the pharmaceutical industry with next-generation artificial intelligence. They are developing new tools for drug discovery and repurposing, biomarker development and pursuing novel strategies for rapid validation. Their projects combine advances in genomics, big-data analysis, deep learning and reinforcement learning.

Insilico Medicine and Biotime announced in 2016 the launch of a beta version of Embryonic.AI, an artificially intelligent system for analyzing the embryonic state of human cell samples using gene expression data.

Insilico established in 2017 a collaboration with GSK to discover novel biological targets and molecules. As a first stage of the collaboration, GSK will evaluate Insilico's technology in the identification of novel biological targets and pathways of interest to GSK.

In 2018 a collaboration occurred between Insilico Medicine and Juvenescence AI Limited, which is a drug development and artificial intelligence company focused on ageing and age-related diseases. Juvenescence AI combines advances in artificial intelligence with classical development expertise in order to prioritize and develop compounds from Insilico Medicine, Inc's end-to-end automated drug discovery pipeline through to clinical proof of concept.

By using AI and deep learning, the company can analyze how different compounds will affect certain cells, determine what drugs can be used to treat the symptoms, and any possible side effects that may occur.

Even though it's only been around a few years, Insilico has already been named by NVIDIA as one of the 5 top AI companies. With R & D resources spread out across the globe in the UK, Russia, and Belgium and a backing of \$14 million behind it

Sources: https://www.eurekalert.org/pub_releases/2017-08/imi-iec081417.php

<https://www.businesswire.com/news/home/20180205005024/en/Insilico-Medicine-Juvenescence-Announce-Drug-Candidate-Joint>



Atomwise is the creator of AtomNet, the first Deep Learning technology for novel small molecule discovery, characterized by its unprecedented speed, accuracy, and diversity.

Today, drug-resistant bacteria and pandemic viruses threaten to send us back to the time of plague and smallpox. Persistent, neglected diseases remain a dark spot on our collective conscience. And while we're all living longer, diseases of aging like Alzheimer's still have no cure. Atomwise has the unique ability to research hundreds of millions of potential medicines rapidly, making it fundamentally easier to tackle these big problems.

Atomwise's AtomNet platform uses structural information to predict binding between molecular targets and small molecules by processing millions of data points regarding successful and unsuccessful ligand-binding interactions. The company has more than 50 molecular discovery programs, including confidential projects with AbbVie Inc. and Merck & Co. Inc.

In April 2017, Atomwise started a program to motivate academic scientists to explore the drug-hunting potential of its technology. Researchers can apply to the company's Artificial Intelligence Molecular Screen (AIMS) awards program by identifying the disorder they hope to treat, and the disease-causing biomolecules they want to defeat with a drug. Successful applicants will receive 72 compounds that Atomwise predicts are most likely to work as that drug.

Atomwise has been partnering up with big pharmaceutical firms, biotechnology companies, and university research labs in an effort to speed up the discovery of new drug candidates for neurodegenerative diseases, cancer, and other disorders. In June, the startup also announced a collaboration with Monsanto to find compounds that might protect crops against pest infestations and diseases.

Source: <http://www.chematria.com/>
<http://www.4-traders.com/ABBVIE-12136589/news/AbbVie-AI-drug-discovery-company-Atomwise-raises-51M-series-A-26122374/>
<https://www.xconomy.com/san-francisco/2018/03/07/atomwise-raises-45m-to-grow-ai-driven-drug-discovery-business/>

BioAge is committed to contribute to and support the evidence-based medical approach to a healthy lifestyle, accomplished through diet, exercise, supplementation and the use of integrative medicine.

The overall aim of the proposed staff exchange programme is to build, extend and strengthen sustainable international collaborations between the partners so as to create a knowledge base for biomarker based research related to aging, sampling techniques in the elderly and biomonitoring studies.

BioAge develop biomarkers and drugs that impact human aging by coupling genomic data with machine learning. BioAge is building a platform that doesn't require waiting for its subjects to actually age. Instead, it wants to measure biological age using signals floating in a drop of blood.

BioAge Labs raised \$10.9M in Series A financing to accelerate drug discovery for aging in 2017. BioAge is betting on the power of high-throughput human data, coupled with innovative machine learning, to substantially accelerate drug discovery for aging. The company take a hybrid experimental and computational approach to identifying the molecular signatures that drive aging, working with multiple partners in academia and industry. The funding will enable BioAge to build their team, refine and test their signatures of aging, and begin in vivo evaluation of drug candidates. Their initial targets for drug development will be specific diseases where aging is causal; however, their ultimate goal is more ambitious—to combat the suffering and disability caused by all aging-related diseases, and to restore both the quality and quantity of life that is so often lacking in old age.

Sources: <https://medium.com/@BioAge/bioage-labs-raises-10-9m-in-series-a-financing-to-accelerate-drug-discovery-for-aging-31974fcb3229>
<http://bioage.com/about.html>
<https://a16z.com/2017/07/28/bioage/>

Biomarkers of Aging

While many anti-aging interventions have demonstrated life-extending or other geroprotective effects in model organisms, practical limitations continue to hamper translation to the clinic. One problem is that the evaluation of aging changes and possible anti-aging remedies requires a comprehensive set of robust biomarkers.

Large-scale longitudinal programs like MARK-AGE have been launched to analyze changes in multiple biomarkers during aging and correlation between biological and chronological age. Several “aging clocks” able to predict human chronological age using various biomarkers have already been proposed. Methylation-based markers such as epigenetic aging clocks are currently the most accurate, while transcriptomics and metabolomics have shown to be less so.

Recent studies show that biomarkers of age-related pathologies could be used to evaluate senescence modifications based on the connection between age-related pathologies at the signaling pathway level. However, most of these biomarkers are not representative of the health state of the entire organism or individual systems and are not easily measured or targeted with known interventions.

Machine learning (ML) techniques, such as support vector machines (SVM), are routinely used in biomarker development and rapid increases in labeled data are enabling deep neural networks (DNNs). Methods based on deep architectures have outperformed classical approaches not only in image analysis, but also in solving a wide range of genomics, transcriptomics and proteomics problems.

Using Artificial Intelligence (AI), **Insilico Medicine** has developed a system that measures the biological age using readings found in a common blood test. Insilico Medicine calls it the Aging Clock, and it is based on biomarkers of aging found in our blood chemistry. Insilico Medicine says its number-crunching has yielded the most precise measure of a person’s biological age. To develop their algorithm, the company used AI techniques to analyze the blood tests of an international group of 130,000 people.

Sources: <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4931851/>
<http://longevityfacts.com/ai-based-app-measures-bodys-aging-clock/>

Biomarkers of Aging

Vadim Gladyshev, Professor of Medicine at Brigham and Women's Hospital, Harvard Medical School:

"The use of the new tool to track human biological age may enable discovery of drugs and other interventions that target the fundamental process of aging, thereby delaying the onset of all chronic diseases at once, instead of targeting one disease at a time. The project has parallels with MouseAge, a tool for assessing biological age in mice, which we develop jointly with In Silico Medicine."

Insilico Medicine, Inc., a Baltimore-based company specializing in the application of artificial intelligence for drug discovery, biomarker development and aging research, announced in 2018 a publication of a research paper titled "Population-specific biomarkers of human aging: a big data study using South Korean, Canadian and Eastern-European patient populations" in The Journal of Gerontology. Insilico believe AI will transform biomarker development and drug discovery much sooner than most pharmaceutical companies and regulators expect.

In the paper, the authors present a novel deep-learning based hematological human aging clock, a biomarker that predicts the biological age of individual patients.

In 2017 the company announced the launch of the Beta 1.0 version of YOUNG.AI. The first version was publicly unveiled on September 12th, 2017 at the 4th Aging Research for Drug Discovery Forum and the Artificial Intelligence and Blockchain for Healthcare Forum in Basel, Switzerland, 11-13 of September. The beta 1.0 version features deep learned photographic and basic blood biochemistry-based predictors of age as well as the ability to track drug and supplement intake.

Sources:

https://www.eurekalert.org/pub_releases/2017-09/imi-ant091117.php

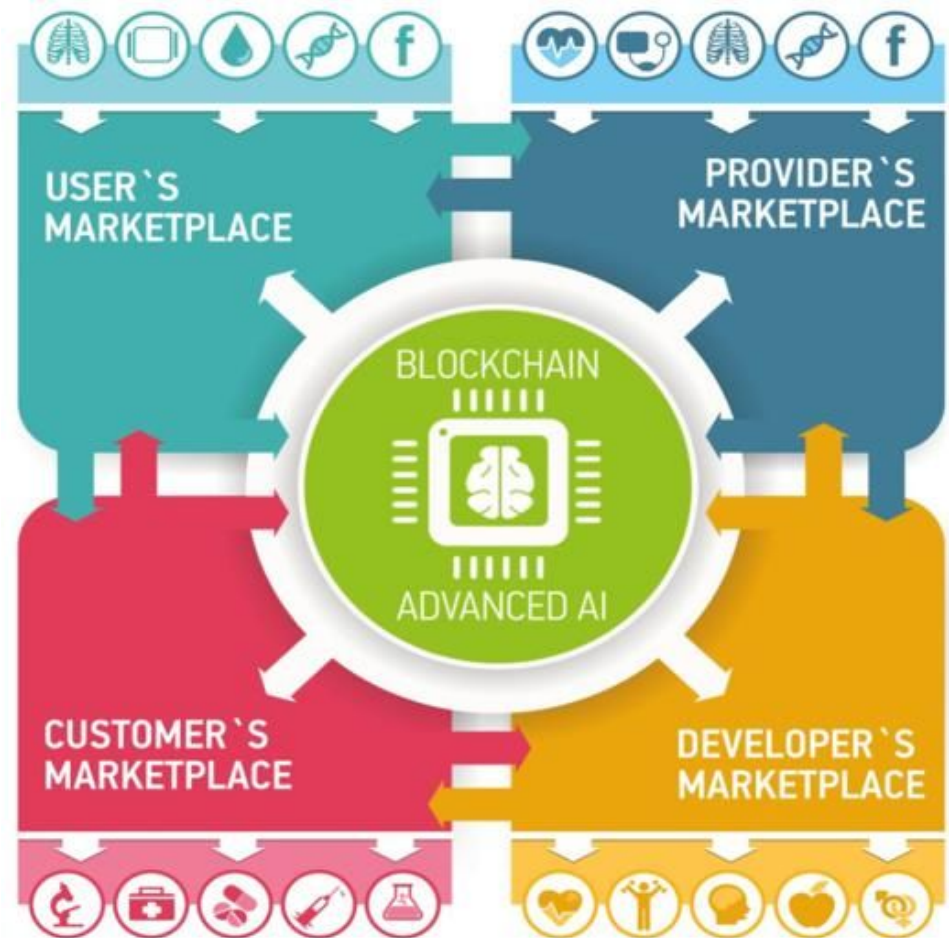
https://www.eurekalert.org/pub_releases/2018-01/imi-apd011118.php

Chapter VII

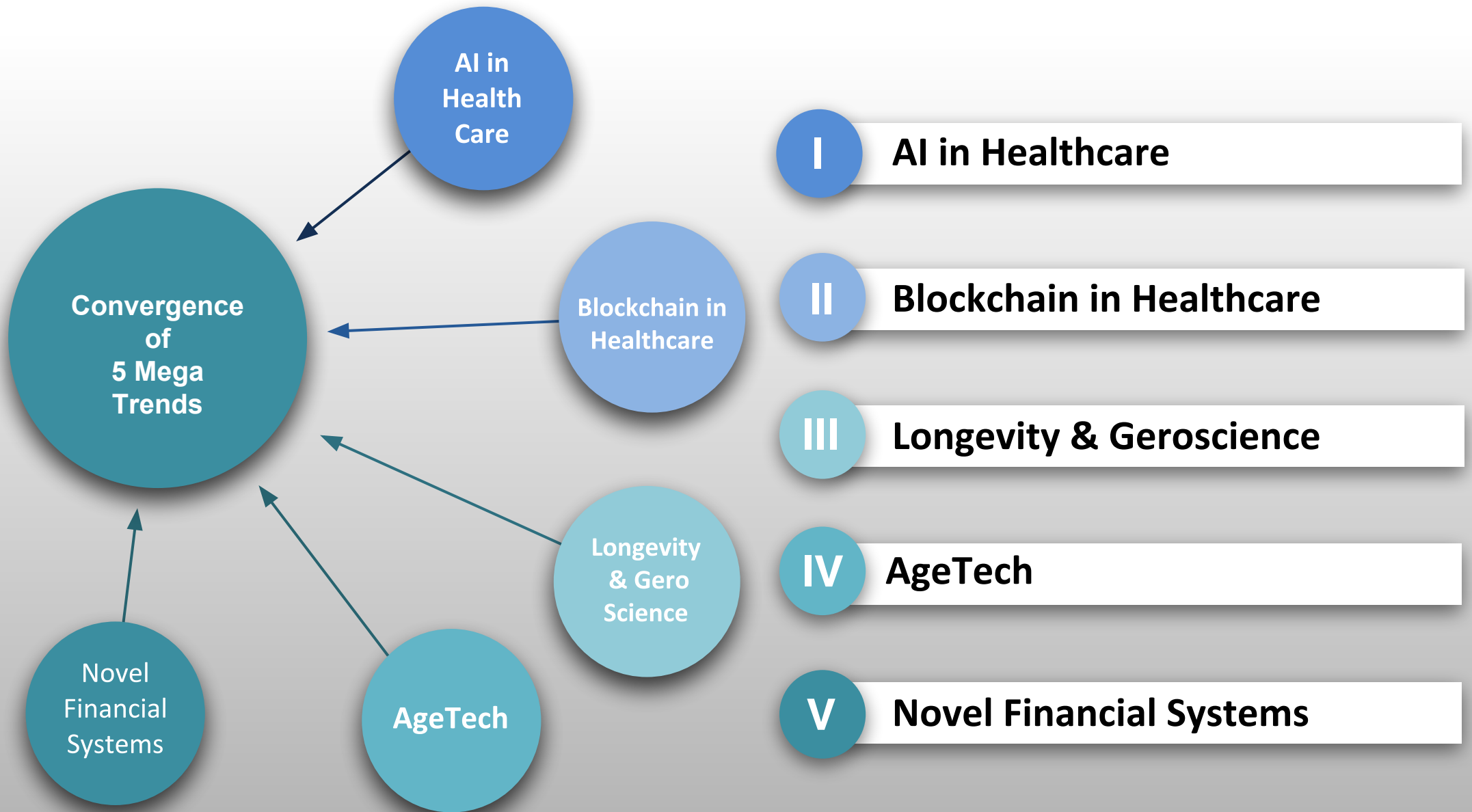
Next Generation AI for Drug Discovery
and Biomarker Development
Convergence with Blockchain and Digital Medicine

Next Generation AI for Drug Discovery and Biomarker Development Convergence with Blockchain and Digital Medicine

- In 2018, even more extreme challengers and disruptors will arrive with the convergence of next generation AI, blockchain and precision medicine.
- Longgenesis is a revolutionary blockchain-based personalized medicine Data Marketplace platform built by Insilico Medicine and Bitfury that provides modular toolsets coupled with integrated advanced.
- Artificial Intelligence systems to store, manage, and trade life data: social network data, health data and medical records.
- Longgenesis will redefine the relationships between healthcare companies and patients. By facilitating a fast and easy way to contribute or purchase data along with an integrated deep learning AI, enterprises can save much money on R&D while users will for the first time be compensated for their Life data efficiently and ethically.



5 Mega Trends to Disrupt the BioTech & BioMedicine Industries in the next 5 Years



Consequence: The Major Shift in the BioMedicine Industry

The emergence to the AI and Blockchain technologies in Biopharma and Biomedicine industry will start the rapid development of these technologies, the mass emergence of new startups and the fundamental changes in the world politics and economy

The window of opportunity to launch such technology startup will remain open for maximum 2 years from now. After that, the market will be full and these new nowadays technologies will be adapted by the large corporations and governments in the next 5 years

In this period, approximately to 2022, the pharma companies will openly embrace the AI and Blockchain technologies and will focus on their development instead of relying the 'old-school' technologies, which are in use nowadays.

2017

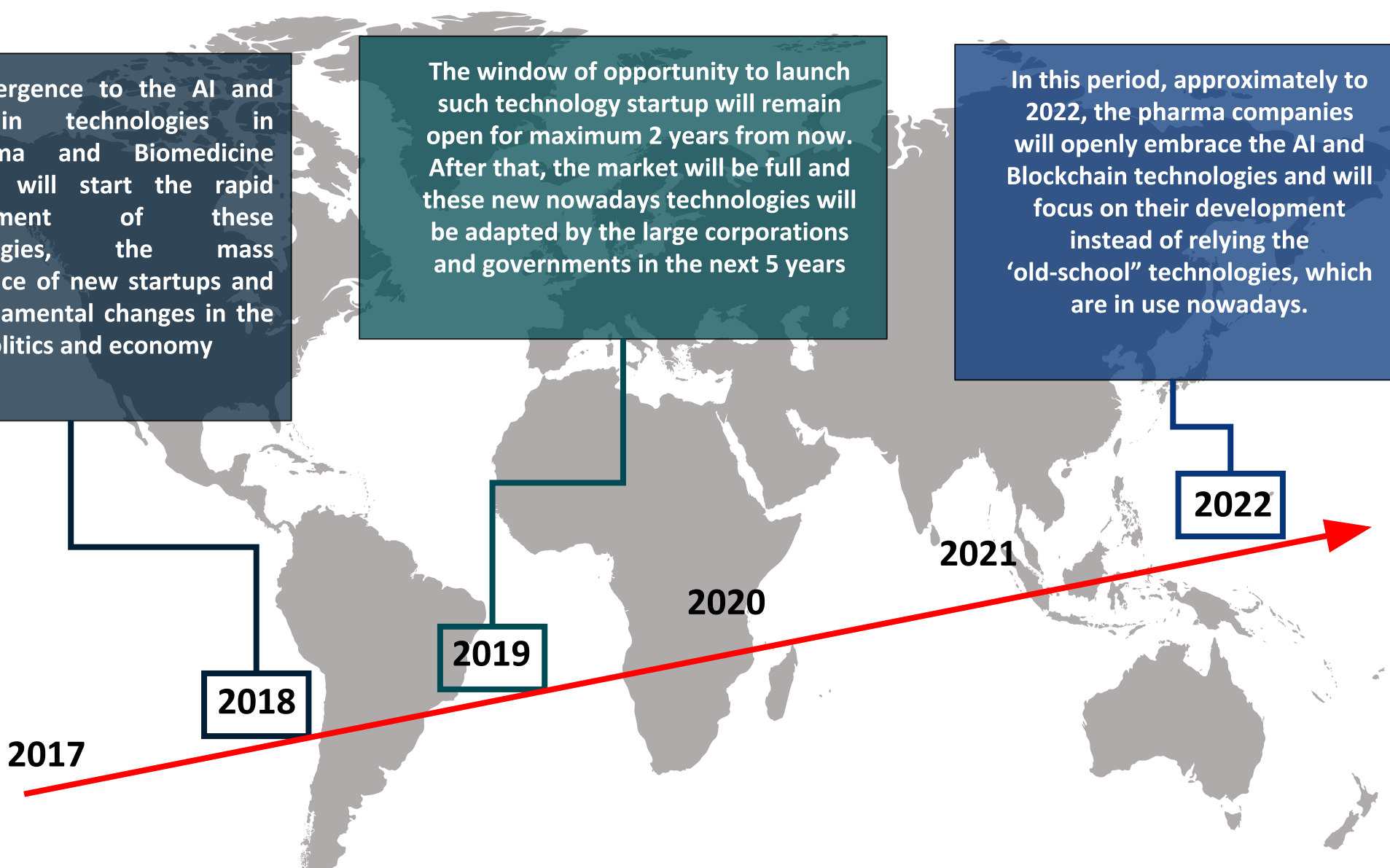
2018

2019

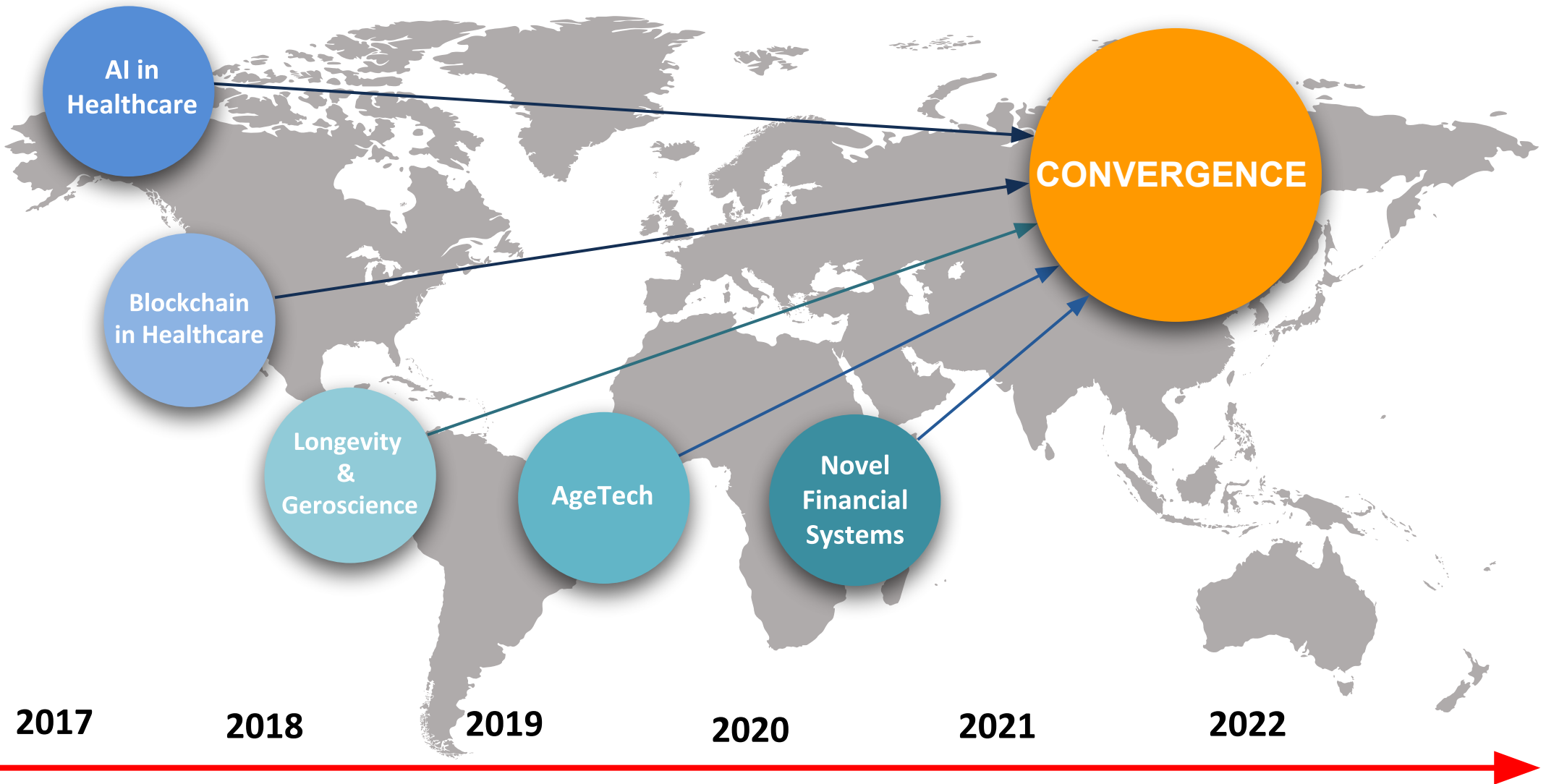
2020

2021

2022



Convergence of 5 Mega Trends



Convergence of Technological MegaTrends

5 Mega Trends to Disrupt the BioTech & Venture Capital Industry in 5 Years

Major Disruption on the Horizon

The BioPharma and BioMedicine industry is now on the edge of a major shift which will happen in 2018-2019.

There is clear evidence of this today, but due to the significant inertia pervading the BioPharma industry relating to the traditional business model of pharmaceutical companies and heavy government regulations, the capacity for the industry to translate novel trends into actual practice is significantly lacking.

We have major evidence for these emerging trends all around us, but for several specific reasons they are only recognized by a few top executives in the industry. Those executives that don't begin to recognize these trends and act accordingly will be responsible for colossal industry failures in the next 5 years.

The window of opportunity to board this departing train is 1, maximum 2 years from now and in the next 5 years the first pharma company to openly embrace AI at the C suite and board level focusing on their own development instead of relying on the "old-school" technology companies, will see its stock skyrocket.

Major Disruptive Trends:

- I. **AI in BioPharma and Healthcare**
- II. **Blockchain and Next Generation IT in Healthcare**
- III. **Longevity & Gero Science**
- IV. **Broken VC and BioPharma Business Model and Novel Financial Systems**
- V. **AgeTech**

Convergence of Technological MegaTrends

I. Artificial Intelligence

- AI in Healthcare is rising very fast. There have been several deals worth tens to hundreds of millions of dollars in just the past few months alone
- As this trend continues it will mostly be applied by existing IT giants, with the exception of areas such as electronic health records and digital pathology where these do not have access to the data
- These advances will occur much faster than even the most optimistic scenarios, outperforming even the speed of AI development demonstrated by the big IT giants of today - Google, Facebook, NVIDIA, Baidu, etc.
- The continuous development of software, the rise of the sharing economy, the distribution and processing power and AI, along with the convergence of all these niches causes transformation at a global scale making the right forecasting for healthcare and BioPharma in particular, needed, and where key players should switch from thinking of niche areas to a much more holistic and inclusive approach
- One of the most important patterns in this emerging area is AI in drug discovery, and it holds the greatest disruptive potential. It has begun to penetrate into Big Pharma's drug discovery departments at a rapid pace

II. Blockchain in Healthcare

- This will take the form of blockchain integration into healthcare governance systems, into telemedicine mobile apps for securing and transmitting personal medical information, and into systems for analyzing and optimizing healthcare business processes, among others
- The overarching trend will be blockchain as healthcare's backend
- Its speed of penetration is enormous and on the rise, and its speed of penetration into new fields that could benefit significantly from enhanced protection of data and enhanced logistical optimization, like the healthcare industry, is huge

Convergence of Technological MegaTrends

III. Longevity & Healthcare

- Longevity is another major trend, but is much more complicated than the above 2 trends
- With AI, this window of opportunity is very short. For longevity it is much longer - around 5 years
- The window of opportunity is longer for longevity, but its potential to disrupt the field is also much larger
- Because the window of opportunity is larger, there is much more time and opportunity for Pharma to begin activities within this emerging trend

IV. A Broken VC and BioPharma Business Model

- During recent years we have seen significant stagnation in the VC industry, not only in biotech but many other industries
- The industries most affected are those with big requirements for DeepTech, advanced R&D
- This stagnation is due to the outdated model of typical VC funds, which made sense 5-10 years ago, but not so much nowadays
- There is an emerging phenomenon already disrupting the typical VC industry, known as Initial Coin Offerings and Crypto Liquid Venture Funds, applying advances in blockchain and cryptocurrencies to create radically progressive and dynamic investment models
- VC funds, in the US in particular, are also beginning to recognize the disruptive potential of this new investment model
- These new investment models and instruments are in a sense like the merger of VC funds and Hedge Funds, with all their advantages and fewer of their disadvantages

Convergence of Technological MegaTrends

- VC funds sometimes have very high profits but very low liquidity. Hedge funds typically have lower profits but very high liquidity
- These new investment models have both - high profits and very high liquidity
- I predict that 2018 will be the threshold when many promising biotech startups will begin receiving substantial investments in the form of angel financing and crypto fundraising

V. AgeTech

- A fifth major trend will be what can be called AgeTech - the integration of FinTech and HealthTech
- Financial services designed for the aging demographic that integrates cutting-edge FinTech services with emerging geoscience and P3 (personalized, precision and preventive) medicine therapies to deliver optimized financial and healthcare services for elderly citizens
- The aging demographic is rising rapidly and will witness enormous growth over the next 20 years.
- AgeTech services will serve to extend the healthy, productive and functional years of elderly citizens' lives and will promote them to remain in or re-enter the workforce, enhancing their lives and the economy simultaneously

"It's vital that individuals and businesses recognize the tremendous potential of this longevity revolution. Our aging population could generate the most significant opportunity of our lifetime."²¹⁶

– Andy Sieg, Head of Merrill Lynch Wealth Management

-Milken Institute, Silver to Gold

Convergence of Technological MegaTrends

VI. Conclusions

- Keep an eye on these 5 rapidly emerging trends - AI in Healthcare and Drug Discovery, Blockchain in Healthcare, Geroscience and Longevity, AgeTech and Crypto Liquid Venture Funds.
- In 5 years these 5 areas will disrupt the BioMedicine and BioPharma industry nearly beyond recognition to what it is today as well as many other industries.
- It is well known that professionals are unable to see these trends on a grand scale, the real transformation will happen because of convergence between all these 5 trends in combination. This convergence will further influence the acceleration at an unforeseen rate that requires deep forecasting.
- The era of venture capital and unadaptable BioMedicine and BioPharma companies in this industry is coming to a close with ample opportunity for them to adapt or die making way for up and coming R&D groups and startups that take advantage of these new technologies and financing mechanisms.
- Development of the BioMedicine and BioPharma industries will be faster than anyone can imagine including the pessimists and optimists because of the convergence of these trends, the more the number of dimensions, the greater the acceleration as the industry leapfrogs into a new era.
- These megatrends will become much clearer in the next two years and we will make adjustments to these megatrends in 2018 when the picture becomes clearer and we can forecast the synergy between the rate of acceleration of these trends and of their convergence.

Digital Health

Digital health covers a broad range of applications and areas. This includes mobile health, health information technology, wearable devices, telehealth and telemedicine, and personalized medicine.

The digital and genomic revolutions in particular hold great potential for digital health: while it took 10 months to sequence a genome in 2007, today it takes as little as just one hour.

Digital health concerns itself with the following goals:

- Reducing inefficiencies and costs
- Increasing quality of care
- Improving access
- Making medicine more personalized

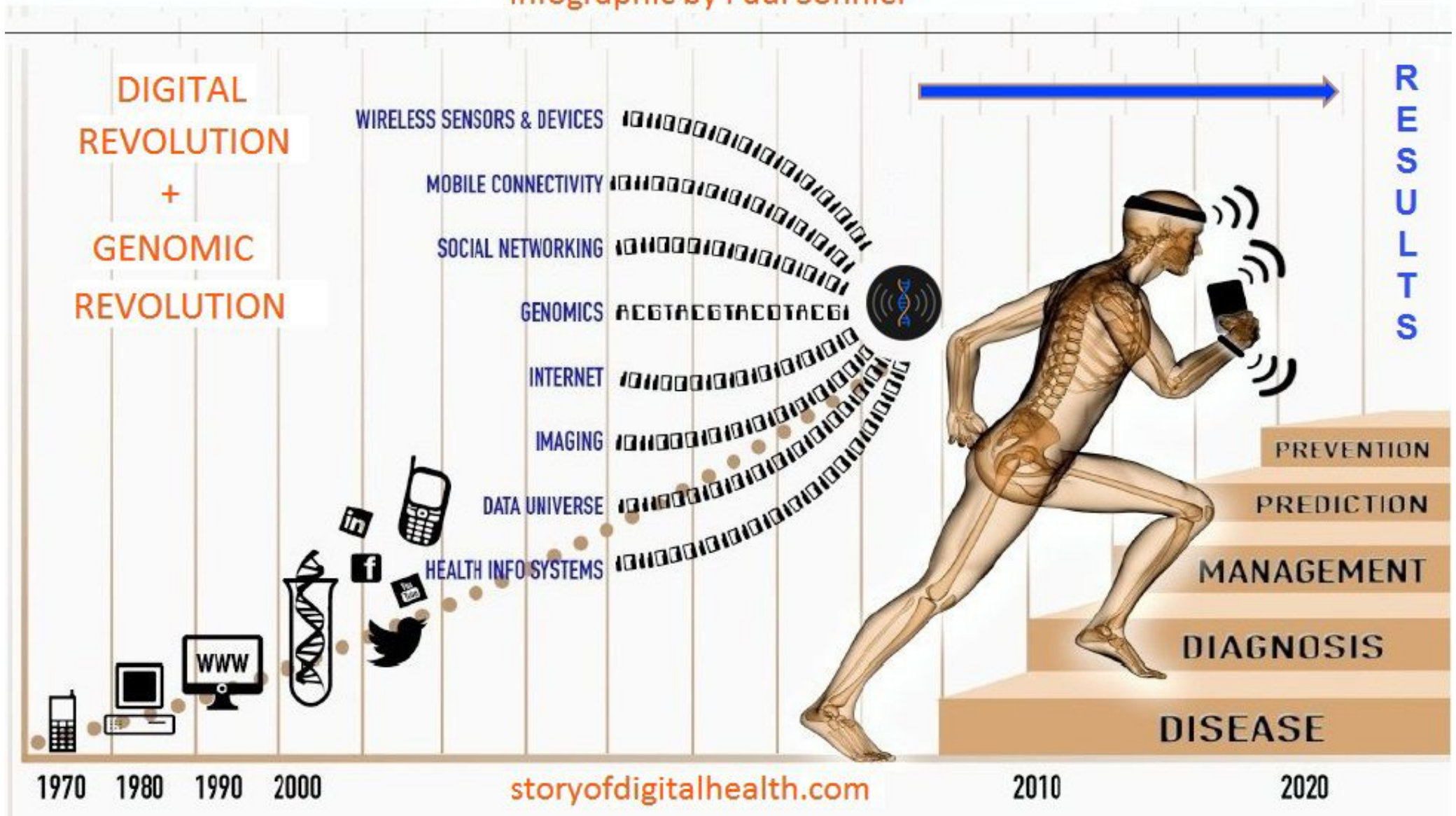
Over \$16 billion have been invested in 800+ digital health companies since 2014; \$3.5 billion in the first half of 2017 alone, but no unicorns so far. Healthcare is an old industry with traditional institutions that struggle to innovate; hence the high interest in investing in up and coming, innovative startups.

This means that digital health startups need early funding for a relatively extended period of time - compared to the average apps and platforms - before they can start reaping the benefits of their work in contrast to apps and platforms.

Data also represents another challenge for these companies. The metrics of success for healthcare companies are harder to come by and usually take a long time to come by.

THE DIGITAL HEALTH REVOLUTION

Infographic by Paul Sonnier

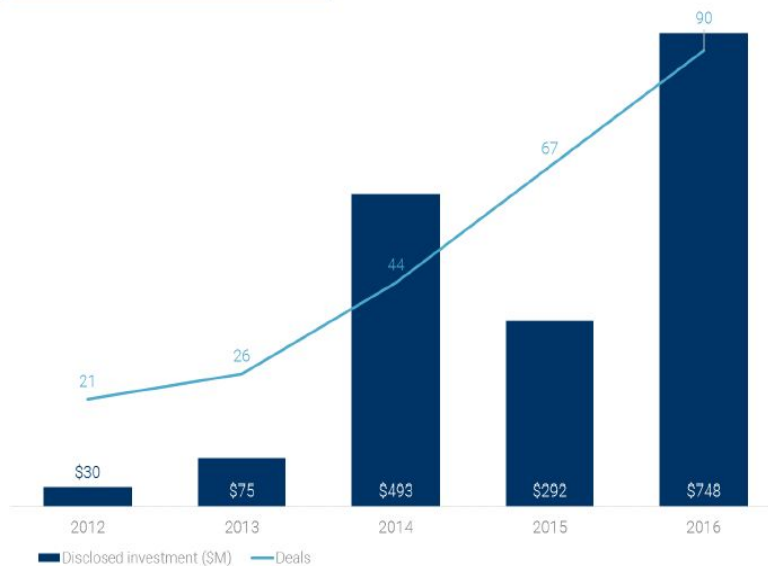


Artificial Intelligence

Much of the current commercial applications of AI concern what is known as weak artificial intelligence, aka narrow AI; think Google, Apple, or Amazon's personal assistants that use natural language processing to understand a query then do a relatively simple search, taking into consideration a few factors from your history and behavior. A truly artificially intelligent system is one that learns on its own, is capable of processing very large amounts of data and digging up associations, and imitates human behavior. We are just beginning to scratch the surface of AI in healthcare.

When talking about Artificial Intelligence in healthcare, more often than not, Big Data is the first topic that comes into discussion. Digital data is growing at an exponential rate - by 2020, the data created annually will reach 44 trillion gigabytes. Tech titans such as Google or IBM, are trying to tap the potential of patient data mining using their AI tech. It is worth noting that IDC predicts that the worldwide spend on AI and cognitive computing will reach \$46 billion by 2020.

ANNUAL FUNDING HISTORY



Alphabet, the parent company of Google, recently launched the Google Deepmind Health project. Deepmind Health is able to process hundreds of thousands of medical information entries within minutes. This will enable providers to provide better and faster health services. Google also aims to employ the same algorithms that power its search engine to genetic data in the hopes of understanding what makes people healthy.

IBM on its part, is using Watson technology to power WatsonPaths. The aim is to help physicians make informed and accurate decisions, faster, and to glean insights from electronic medical records.

AI in healthcare dominates all other industrial applications of AI in terms of equity deals, raising \$1.8B across 270 deals since 2012.

Artificial Intelligence

Real artificial intelligence is already being used to detect diseases. According to the American Cancer Society, a large number of mammograms yield false results - as much as half of healthy women are wrongly diagnosed with cancer. AI, on the other hand, is able to review and translate mammograms 30 times faster, and with a 99% accuracy rate.

This is possible because we are able to train algorithms to tell the difference between groups of pixels that represent cancer versus groups that don't. The algorithms constantly learn. Software is able to process millions of those images, or others, in a day.

Gartner predicts that by 2025, half of the population will rely on "virtual personal health assistants" powered by AI. These personal assistants would be cognizant of a user's unique medical conditions, history, and genetic makeup and able to incorporate them in its decision making. Automating primary care needs is also a great boon to the elderly demographic in particular, who typically lacks mobility. These assistants will help seniors remain independent for longer, and reduce the need for hospitalization or staying in nursing homes. Overall the progress of AI implementation in healthcare will carry great reduction in costs and time.



AI for instance will be able to accelerate drug development and make it more cost effective; by contrast, the costs of developing pharmaceuticals through clinical trials can reach billions of dollars and can take more than a decade.

Banks have embraced machine learning quickly, looking more like IT firms with each passing day, but the executives of pharma have been less agile. Top managers are avoiding risk rather than showing results. They don't want to be the executive who reduced earnings by engaging in advances IT capex. However, in neglecting disruptive technological risk, they are failing to hedge properly. The same is true of countries, including the United Kingdom.

Blockchain

We have already discussed the power and importance of Blockchain technology in creating trust in the ecosystem.

Trust to share health data, which is paramount to harnessing the power of biological science and research.

We also went over the value that blockchain can offer when it comes to logistical matters, such as maintaining and unifying health records, establishing a log of accountability and transparency, as well as fighting counterfeit drugs.

All of those advances are a great boon to the longevity industry.

But to delve deeper into the effects of blockchain on longevity, there has been accumulating evidence that suggests that aging is linked to genetic and epigenetic alterations.

Epigenetic, by definition, describes the study of changes in gene expression that do not involve changes to the underlying DNA sequence, instead arising from nongenetic influences on gene expression.

Given the reversible nature of epigenetic mechanisms, they provide promising avenues for therapeutics against age-related decline and disease.

Looking at epigenetic data, deep learning algorithms can predict the risk of a disease in time to prevent it.

However, ensuring security and privacy in transmitting and storing personal epigenetic profiles will require building a new and open data ecosystem.

Blockchain has the potential to do just that.

1 Health organizations direct information to the blockchain

Health organizations provide service two patients

Clinical data is tracked in existing Health IT systems

Standard data fields and a patients public ID are redirected to the blockchain via APIs



2 Transactions are completed and uniquely identified

Blockchain

Each transaction is stored on the blockchain, containing the patients public (non-identifiable) ID

Smart contract processes incoming transaction



3 Health organizations and institutions can directly query the blockchain

Blockchain

Health organizations and institutions submit their queries via APIs

Non-identifiable patient information (e.g. age, gender, illness) is viewable

Data can be analyzed to uncover new insights



4 Patients can share their identity with health organizations

The patients private key links their identity To blockchain data

The private key can be shared with new health organizations

With the key organizations can then uncover the patients data

Data remains non-identifiable to those without the key



Blockchain will enable secure and verifiable sensitive data storage and sharing, while allowing patients to choose to share their individual data with relevant parties such as doctors and researchers, as well as for clinics to access non-identifiable patient data through queries via APIs.

Each patient is assigned their **private key** to enable sharing of their data which remains unidentifiable to anyone from the outside without the key.

P3 medicine

Precision, preventive, and personalized medicine, also known as P3 medicine, represents the next evolutionary step from reactive disease care. In contrast to the latter, P3 covers three functions: the early detection of factors responsible for diseases (predictive), reducing the likelihood of diseases (preventive), and therapy that focuses uniquely on each patient (personalized).

P3 medicine is made possible thanks to the convergence of three trends:

One is the advances in systems medicine - a field of study that looks at the systems of the human body as part of an integrated whole that are affected by biochemical, physiological, and environment factors - particularly its increased ability to understand the complexity of diseases.

Two is our increased ability to collect, store, and analyze data.

And three, an ever easier access to information afforded to consumers about their own health data, leading to a rise in their active interest in managing their health.

The human genome is made up of about 25,000 genes, but some genes may not be fully expressed, some genes share multiple responsibilities, and each gene encodes multiple proteins, all of which produces very complex interactions. This is where supercomputers come in.

They are able to model biological networks and simulate the functioning of these networks to identify any perturbation, or disease, and the therapies most likely to 'fix' the network.

P3 medicine is much more effective than the medicine we know today. While the current status is marked by increasing healthcare costs, the promise of P3 is that it could lead to better health for consumers and an industry that is more efficient financially.

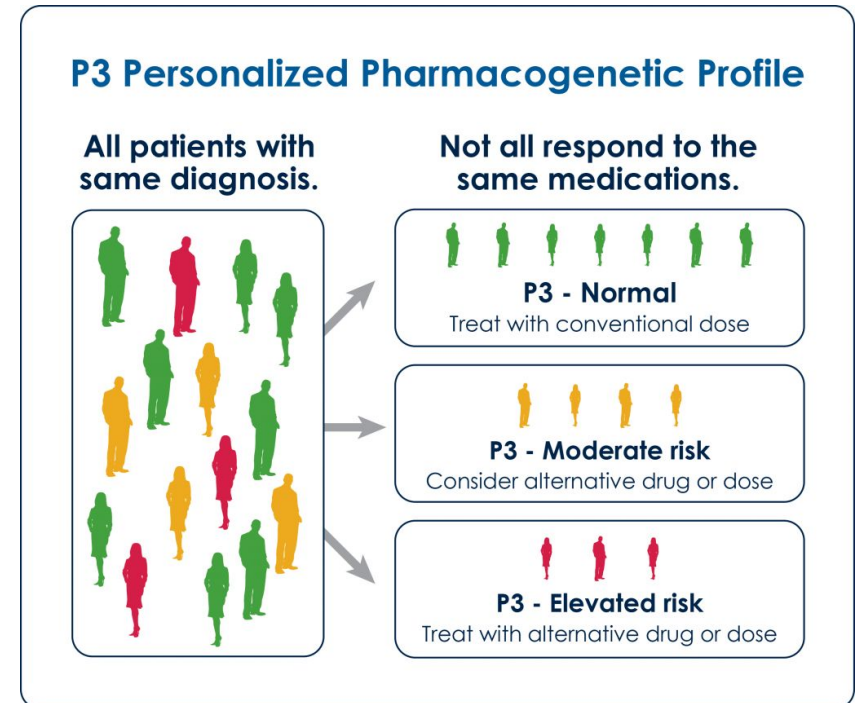
P3 medicine

Personalized medicine is an interdisciplinary field that is entering the market with a promise to revolutionize the industry. Personalized medicine can be defined as an approach in healthcare that creates therapies based on individual characteristics of the patients.

Personalized medicine is used in conjunction with the precision and preventive medicine to form the P3 Medicine. The core ideas of the P3 approach are:

- Take **personal** traits of the patient into the consideration
- **Predict** diseases before they do any substantial damage
- **Prevent** diseases when possible, rather than to treat them

P3 Medicine stands as a key enabler in the longevity technology framework that ties multiple innovations in a single industry,



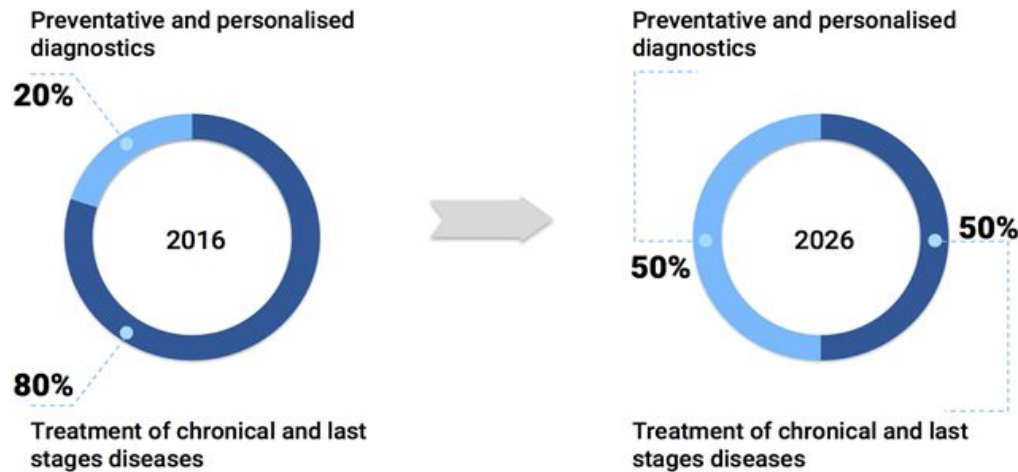
Source: <http://arcpointos.com/pharmacogenetics-testing/>

P3 Medicine mirrors another notable trend in modern healthcare, gene therapy. While the latter is using advancements in genetics and related fields in order to treat diseases by altering patient's genome, P3 looks to learn from one's genetics instead of altering it. This approach can be seen as a safer and less invasive one.

The strongest point of P3 medicine from the longevity perspective is the fact that it is **already being partially implemented** while having enormous potential for further development.

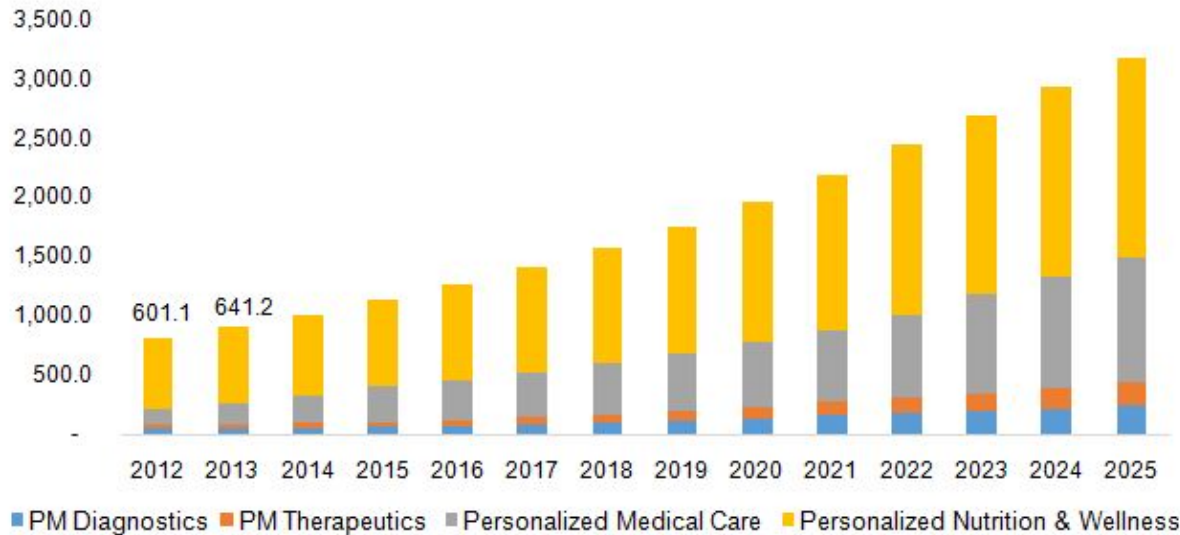
P3 market is expected to develop significantly over the course of the next ten years. This is because P3 Medicine is a complex structural change for the healthcare industry that heavily relies on other **emerging technologies** that are also expected to be fully developed in ten years.

P3 medicine



It is expected that personalized and preventive approach in treatment of chronic diseases will become the prevalent one by 2026.

The changes in healthcare systems together with emerging technologies will double the P3 medicine market by 2022, compared to 2012.



Source:
<https://www.grandviewresearch.com/industry-analysis/personalized-medicine-market>

AgeTech

“We need a seismic shift from collective responsibility for retirement to individual responsibility.”
~ Laurence D. Fink

AgeTech is the amalgamation of Fintech and Healthtech. Age-friendly banks use technology to attract and protect vulnerable older customers.

A person's financial decision-making ability peaks roughly in their mid-50s, and begins to deteriorate afterwards. Elderly people in general struggle with day-to-day banking activities, are more susceptible to poor investment choices and financial fraud; the average age of victims of mass-marketing scams is 75.

Barclays for instance uses voice recognition to help customers who have trouble with passwords. Other fintech solutions for the elderly focus on mobile technology: the devices currently found on the market aren't friendly to the elderly populations. A revolution in AgeTech then is very much dependant on the spread of mobile devices that are easy to use for old people. Only then will banks be able to unlock mobile banking for that demographic.

More significantly, algorithms are helping banks spot any alarming changes in behavior - such as spending patterns - which could signal trouble.

Managing people's money can shed light on their health

A much more intriguing pattern is emerging: banks are well placed to spot elderly individuals who are at risk. A decline in financial management skills can be an early sign of health problems, dementia for example. Banks will be able to refer a person to a doctor. In addition to spotting financial abuse, some banks are currently training their staff to spot dementia.



Commenting on the changing retirement landscape in a 2013 speech to NYU Stern MBA students entitled *Longevity in the Age of Twitter*, Laurence D. Fink, CEO of BlackRock and an NYU Trustee raised the spectre of the Silver Tsunami:

“When I was growing up, the U.S. was launching the Great Society, which sought to summon the resources of government to wipe out poverty. Today, the generation that came of age with the Great Society is headed for retirement and giving you a Grey Society – where we will need to summon up even greater resources just to meet their needs.”

Turning to the role of technology in managing senior finances:

*“ We need a seismic shift from collective responsibility for retirement to **individual** responsibility. ”*

By adapting to the changing biological reality of each individual’s as they age, the growth of AgeTech hands back to old people their former individual decision making capacity, putting the wisdom of individual life experience back behind the grey pound.

Objective forecasting for 2018 - 2022 (applying TRLs)

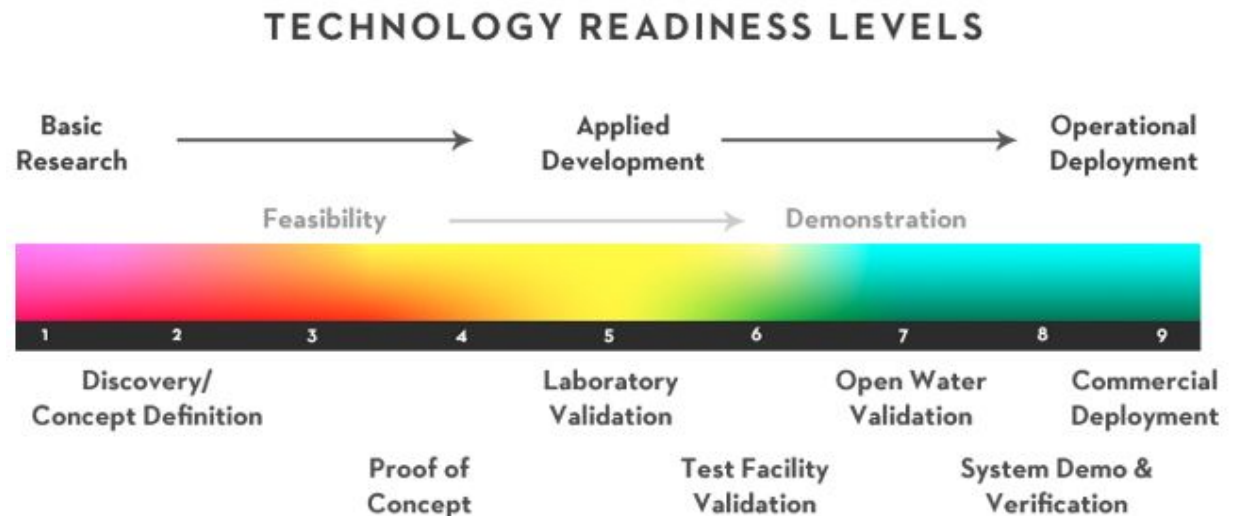
Technology readiness levels (TRLs) enable the gauging of the maturity of Critical Technology Elements (CTEs) determined during a Technology Readiness Assessment (TRA) that examines program concepts, technology requirements, and demonstrated technology capabilities.

TRL use a ranking 1 - 9, with 9 being the most mature technology, with specific TRL levels being assigned to specific technologies by a group of scientific experts familiar with each specific technology. The use of TRLs enables consistent, uniform discussions of technical maturity across different types of technology.

In the coming years, TRLs can underpin efforts to shed light on the most important technologies, but also those that are at present furthest away from their practical application; therefore enabling the right timing and focus to ensure the accomplishment of specific endpoints with regard to each emerging technology, and the interactions that are possible between technologies that are currently at different points on the TRL scale, but can be expected to merge in level over the coming few years.

Using TRLs can expedite progress in the coming 5 years by employing TRLs to provide an objective lens through which various technologies are viewed.

In the same way that using this scale has benefited the aerospace industry, it can bolster the efforts of the life sciences industry in the coming years.



Exponential acceleration of further progress

We have barely scratched the surface when it comes to the applications of technology in healthcare.

Technology grows exponentially: according to Moore's Law, computer processing speed doubles every 18 months. Although the healthcare industry is typically slow to progress, the growth driven by innovative tech should accelerate the progress exponentially.

Another factor enabling this acceleration is the growth of outside players: big and small companies looking to capitalize on gaps in the market will drive advances in diagnostics and treatments faster than traditional medical institutions. According Mary Meeker's latest report, venture capitalists in Silicon Valley are increasingly hiring bio experts to help guide their investments.

Artificial Intelligence, for instance, is expected to reach \$6.6 billion in 2021, at a compound annual growth rate of 42%. By 2020, it is expected that conditions such as cancer and diabetes will be diagnosed in minutes using cognitive systems. By 2025, AI systems are expected to be implemented in 90% of the U.S., and 60% of the global hospitals and insurance companies will have implemented AI systems, which will be able to deliver quality care to 70% of patients at a reduced cost.

Innovation in immunotherapy, such as checkpoint inhibitors - a type of drug that boosts the immune response against cancer cells - is growing at 139% CAGR. Scientists are still trying to nail down an algorithm for its effective use. Once realized, the market for checkpoint inhibitors could reach \$21.1 billion by 2020.

Now that the media hype dust has settled, 3D Printing for organ or tissue repair carries huge potential in healthcare. The 3D printing business for healthcare is expected to reach approximately \$6 billion in 2025.

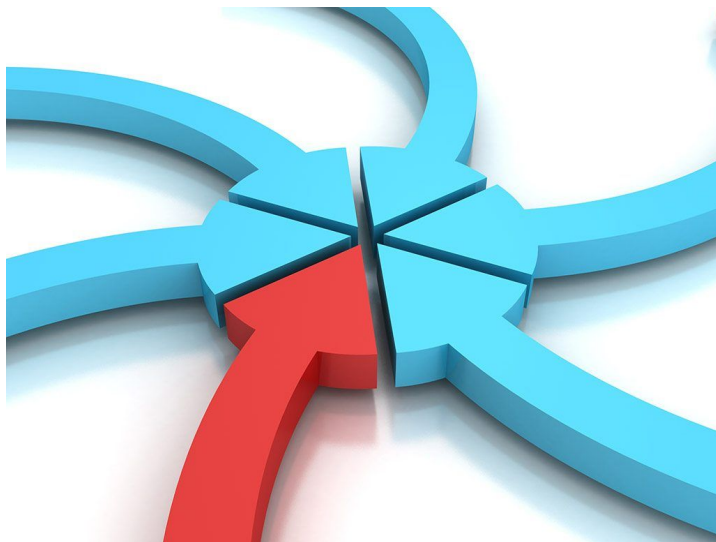
Conclusion

The whole will become bigger than the sum of its parts when the following 5 technology megatrends converge:

- AI in biomedicine
- The adoption of blockchain
- Progress in longevity and geroscience
- New financial systems and AgeTech.

These megatrends are going to converge **very fast** in the coming 5 years. Therefore the window for startups to enter this new market will be closing swiftly over the course of the next few years. By 2022, the big companies will openly begin to embrace these new trends, and leave behind the old technologies still in use at present, whereupon governments and financial institutions will adapt to work with the transformed industries.

“Given the increasing cost of drug discovery, development and clinical evaluation, it is clear that the clinical translation of geroprotective interventions will be increasingly led by the private sector, and by parties who have the resources to sustain the increasing financial burden of bringing truly effective longevity therapeutics to market.”



- Dmitry Kaminskiy, Managing Partner of Deep Knowledge Life Sciences



Chapter VIII

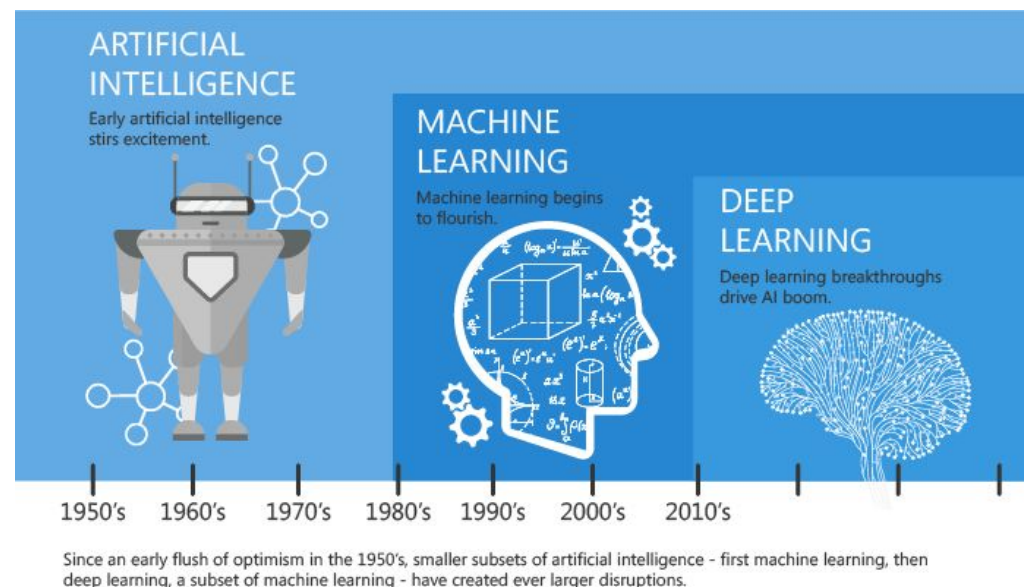
Deep Learning in Drug Discovery

Deep Learning in Drug Discovery

Deep learning is a subset of machine learning consisting of artificial neural networks, famous for its capacity to learn in an unsupervised manner by being “trained on” unstructured and/or unlabelled data.

Its distinction with respect to traditional machine learning can be best thought of as its depth - i.e., deep learning uses “deeper” layers of artificial neural networks which are layered on top of each other.

Machine learning has been in use for almost two decades in the process of drug discovery.



Since the inception of deep learning as a field, it has progressed by leaps and bounds, and has become famous in the public eye for replicating many functions which previously were once thought of as the exclusive domain of humans.

For instance, over the past few years deep learning algorithms have allowed computers to see, read, and write, in ways that are less error-prone than older, more traditional methods of AI, such as decision trees.

For instance, the use of deep learning algorithms trained to analyze and interpret medical images with an error rate of just 6%, which some experts claim to be less error-prone than human doctors. Deep learning has a place in a wide variety of healthcare niches, including medical image analysis, medical device data evaluation, sequencing data analysis, virtual drug screening, drug adherence analysis, drug efficacy analysis, metabolomic profiling, sequencing, molecule profiling, biomarker identification, and drug lead identification, virtual testing and optimization.

Source: https://www.rootsanalysis.com/reports/view_document/deep-learning-in-drug-discovery-and-diagnostics-2017-2035/156.htm

Deep Learning in Drug Discovery

Importantly, deep learning algorithms have shown substantial capacities in significantly reducing the time and cost required to bring a drug to market.

Bringing the average drug to market has been known to cost as much as \$2.5B over a period of 12 years, and deep learning algorithms have in some cases been shown to reduce the cost of bringing a drug to market by as much as 50%.

Some experts predict that the annual cost savings associated with the development and deployment of deep learning-based solutions to drug discovery could result in cost savings nearing \$100B, with nearly \$35B projected savings in the diagnostics niche alone.

One of the most ripe commercial opportunities for the picking with regards to deep learning for healthcare is the AI-supported diagnostic imaging subsector, due to the abundance of data available, as well as the consistency of how such data is organized across different databases.

One of the starkest examples of the power of deep learning is in AlphaGo, popularly known to have bet the world champion in the game Go in a remarkably short amount of time. By emulating the computational patterns of human thought in a much more naturalistic manner than, for example, traditional, brute-force decision trees, it required less computational steps in order to arrive at the decisions it needed to make, and managed to win 100 out of 100 games after training on Go data for just three days.

Remarkably, more than 55% of deep learning companies focusing on the image recognition sector are applying their efforts to diagnostic imaging. Of these 55%, a remarkable 78% focus on medical imaging. Meanwhile, out of all deep learning companies, 35% are focusing their efforts on drug discovery, and 57% of those 35% aim to provide deep learning based drug discovery platforms.

Source: <http://www.gbm.hsbc.com/solutions/global-research>



Deep Learning in Drug Discovery

Medical data can be used to build knowledge maps and then be applied to applications like AI-assisted diagnosis and diagnostic imaging. A good example of this is Watson, IBM's collection of artificial-intelligence technologies used to interpret, analyze and predict data patterns. Its global medical database includes 100m patient records, 30m images and 200m insurance records.

According to Chinabgao.com and other research institutes, 10-20% of Chinese hospital revenue comes from medical imaging, the visualisation of body parts, tissues, and organs for use in clinical diagnosis and treatment.

HSBC Research Report assume that by 2021 the charge for single-patient AI-assisted diagnosis reaches RMB3,000 and the number of diagnosis accounts for one in a thousand of the 3bn hospital visits, the size of this market size would be around RMB9bn. Industry Research Institute estimates that sales of medical robots can reach USD4.8bn by 2021 and the overall market of AI healthcare applications is likely to total RMB100bn within five years.

The current revenue model for image diagnosis and AI-assisted diagnosis is similar to that of traditional medical informatisation companies. They both generate revenue from selling software and hardware products and undertaking informatisation projects for hospitals. The application of AI technologies can increase the value of products by improving doctors' efficiency and diagnosis accuracy. Government investment in medical and healthcare generates most of the revenue.

Deep learning technology, together with cloud computing and big data, are expected to trigger a new round of technological innovation. Software companies are usually asset-light and they focus on continuous innovations and technological upgrades. Their real value lies in the quality of their research teams and the ability of the management to turn R&D into products and sales. AI drug discovery platforms have the potential to have a real impact on the pharmaceutical industry. Over just the past year, many of the big drug makers seriously examine the potential of the technology via numerous tests, official collaborations of different sizes, and licensing agreements.

Source: <https://www.techemergence.com/machine-learning-drug-discovery-applications-pfizer-roche-gsk/>

Deep Learning in Drug Discovery

Deep learning has been proven capable of achieving lower error rates in image and voice recognition and natural language processing compared to traditional machine learning algorithms.

Famous in the eyes of the public for things like self-driving cars, natural language processing and image/voice recognition, its impacts on the drug discovery process have only recently begun to accumulate.

So, if deep learning is supposed to be a closer approximation to the kinds of information processing occurring in the human brain, then how does it differ?

One of the starkest differences is that, whereas humans require relatively little data in order to extrapolate trends and patterns, deep learning algorithms are famous for their dependence on very little data.

Consider the example of a human seeing a pattern one time, and extrapolating it to other instances.

This, in deep learning, is referred to as one-shot learning. Research has shown that deep learning algorithms perform better when the datasets they are trained on are large.

While work on specific architectures that allow for deep learning-based classifiers and predictors to be built that operate according to one-shot and even zero-shot learning, for now, the performance deep learning algorithms are somewhat limited to the available size of the datasets used to train them.

Deep learning algorithms have proven highly effective in modeling the chemical reactions between candidate drugs and their molecular targets, through which they exert their mechanisms of action.

This has allowed researchers to hone in on a much more precise suite of candidate molecules in silico, prior to in vitro validation.

Source: <https://www.sciencedirect.com/science/article/pii/S1359644617303598>

Deep Learning in Drug Discovery

While much work in the real of deep learning for drug discovery is happening in the US, such as through the work of Insilico Medicine, a Baltimore-based AI for age-related drug discovery and biomarker development company, important work in this arena is also occurring abroad as well.

In the UK for example, researchers from Warwick's School of Engineering have developed a deep learning algorithm capable of predicting whether or not a candidate drug molecule will bind to its target protein with 99% accuracy.

Take, for instance, the case of Chuna, which recently launched a next-generation AI development plan which included such AI platforms as Baidu's self-driving car algorithms, AliCloud's "city brain", Tenecent's medical imaging algorithms and iFlytek's natural language processing algorithms.

The Chinese healthcare system is ripe for the development of deep learning algorithms, because China's network of hospitals and healthcare institutions generated vast swatches of data regularly, so much so that the digitisation, classification and processing of such data was baluated at RMB30b in 2016

Source: <https://www.sciencedaily.com/releases/2017/12/171214144442.htm>

Generative Adversarial Networks (GANs)

Case Study: Insilico Medicine

Generative Adversarial Networks is the main technology used by Insilico Medicine and it represents the "cutting edge" in artificial intelligence, where new new leads can be produced by the deep neural networks on demand.

A publication of a seminal paper demonstrating the application of generative adversarial autoencoders (AAEs) to generating new molecular fingerprints on demand was published in Oncotarget on 22nd of December, 2016 written by scientists from the Pharmaceutical Artificial Intelligence (pharma.AI) group of Insilico Medicine. The study represents the proof of concept for applying Generative Adversarial Networks (GANs) to drug discovery. The authors extended this model to generate new leads according to multiple requested characteristics and plan to launch a comprehensive GAN-based drug discovery engine producing promising therapeutic treatments to significantly accelerate pharmaceutical R&D and improve the success rates in clinical trials.

Alex Zhavoronkov, PhD, CEO of Insilico Medicine, Inc. :

"At Insilico Medicine we want to be the supplier of meaningful, high-value drug leads in many disease areas with high probability of passing the Phase I/II clinical trials. While this publication is a proof of concept and only generates the molecular fingerprints with the very basic molecular properties, internally we can now generate entire molecular structures according to a large number of parameters. These structures can be fed into our multi-modal drug discovery pipeline, which predicts therapeutic class, efficacy, side effects and many other parameters. Imagine an intelligent system, which one can instruct to produce a set of molecules with specified properties that kill certain cancer cells at a specified dose in a specific subset of the patient population, then predict the age-adjusted and specific biomarker-adjusted efficacy, predict the adverse effects and evaluate the probability of passing the human clinical trials. This is our big vision"

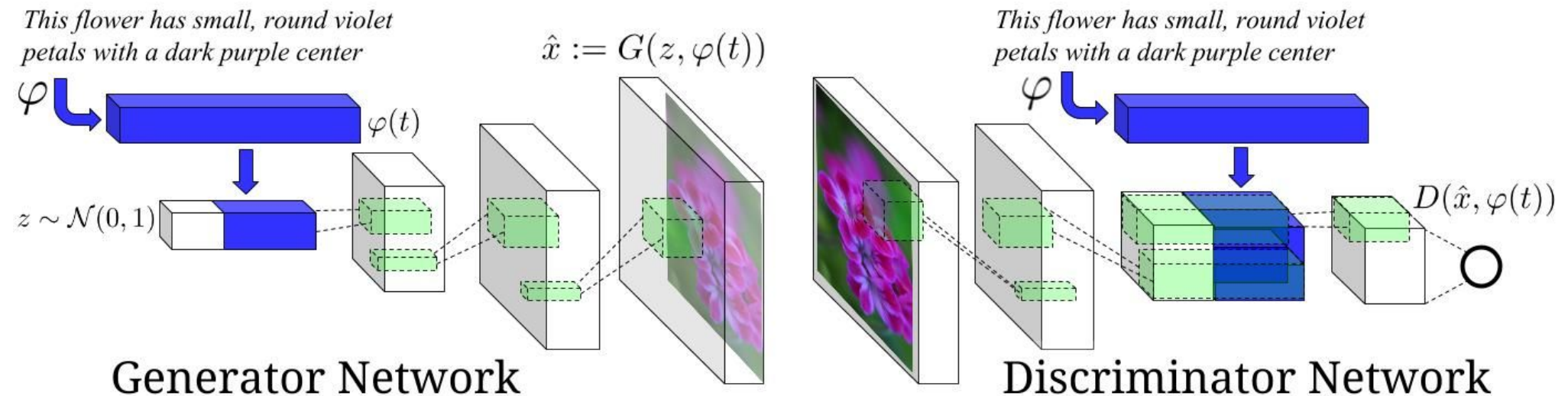
Source: <https://www.sciencedaily.com/releases/2017/12/171214144442.htm>
<http://www.oncotarget.com/index.php?journal=oncotarget&page=article&op=view&path%5B%5D=14073&path%5B%5D=44886>

Generative Adversarial Networks (GANs)

“Generative Adversarial Text to Image Synthesis” was written by Scott Reed, Zeynep Akata, Xinchun Yan, Lajanugen Logeswaran, Bernt Schiele, Honglak Lee, submitted on 17 May 2016 (v1), last revised 5 June 2016 (this version, v2).

“Automatic synthesis of realistic images from text would be interesting and useful, but current AI systems are still far from this goal. However, in recent years generic and powerful recurrent neural network architectures have been developed to learn discriminative text feature representations. Meanwhile, deep convolutional generative adversarial networks (GANs) have begun to generate highly compelling images of specific categories, such as faces, album covers, and room interiors. In this work, we develop a novel deep architecture and GAN formulation to effectively bridge these advances in text and image modeling, translating visual concepts from characters to pixels. We demonstrate the capability of our model to generate plausible images of birds and flowers from detailed text descriptions”.

This is the code for the ICML 2016 paper on text-to-image synthesis using conditional GANs. It can be used to train and sample from text-to-image models.



STRATEGIES FOR AI-POWERED DRUG DISCOVERY



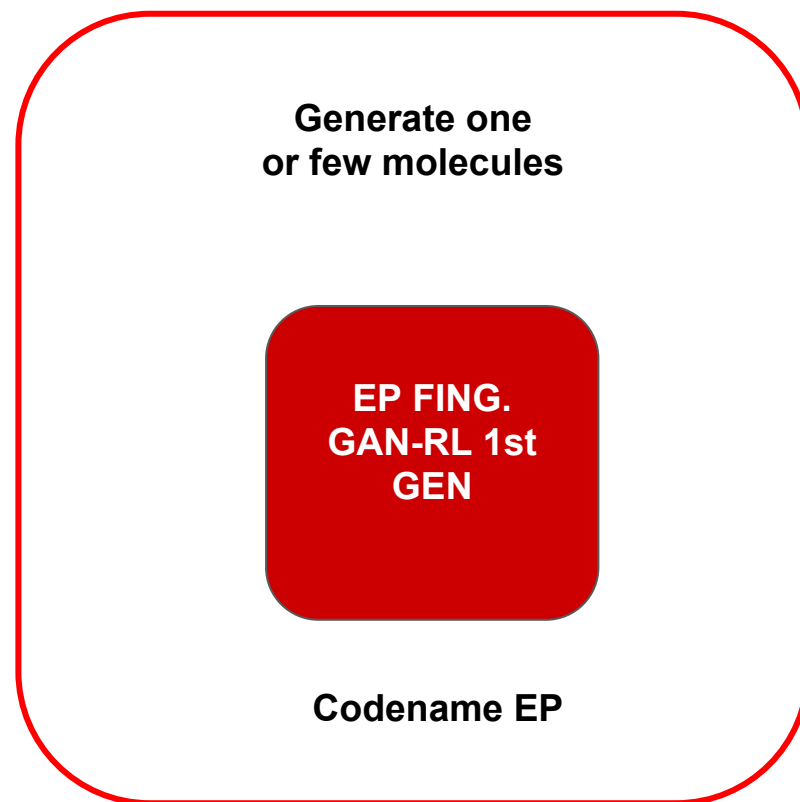
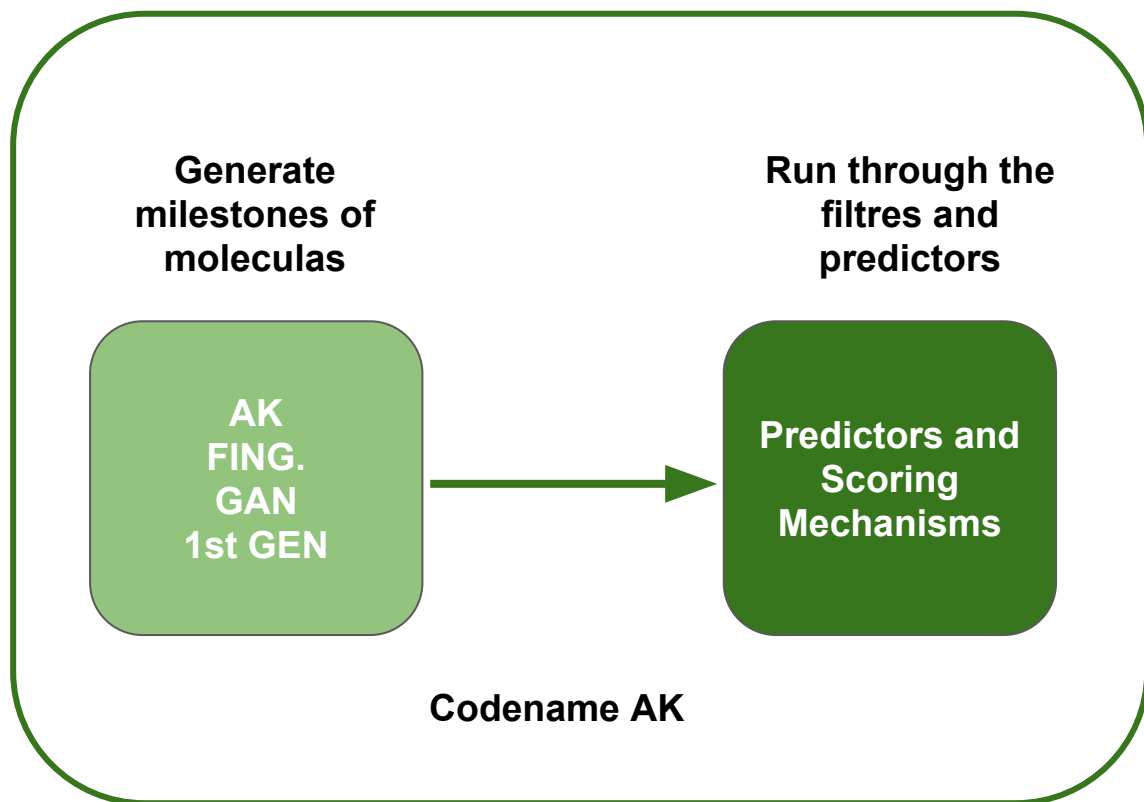
LOOKING FOR A NEEDLE IN A HAYSTACK



GENERATE PERFECT NEEDLES

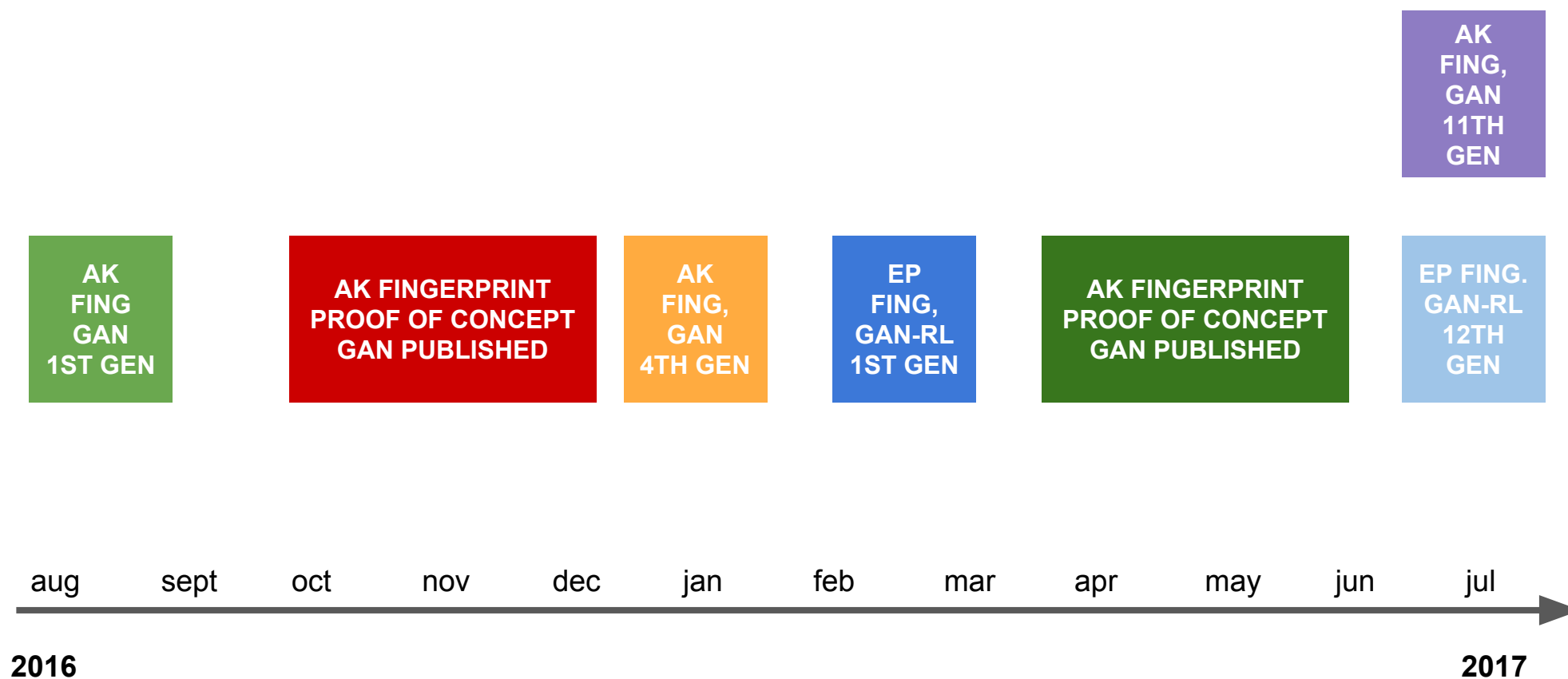
Generative Adversarial Networks (GANs)

Two main GAN directions



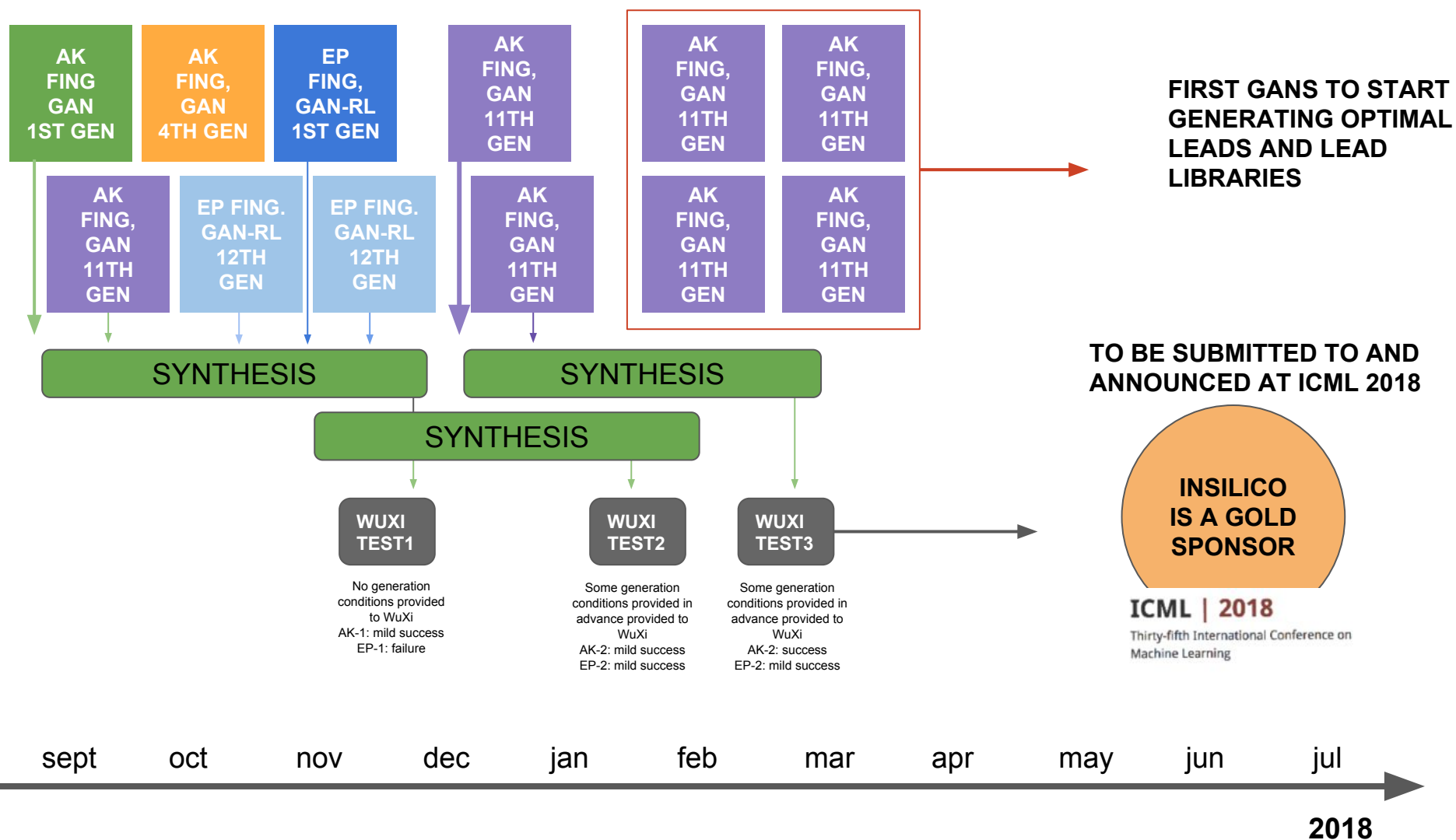
GANs

EVOLUTION OF TWO MAIN GAN APPROACHES GANs/GAN-RL AT INSILICO



GANs

EVOLUTION OF GANs/GAN-RL AT INSILICO



Chapter IX

Classification / Ratings of AI Algorithms
for Advanced R&D
and Drug Discovery Companies

AI in Drug discovery

Artificial Intelligence has become extremely popular these days, with many companies using the term in order to increase their perceived significance and to find investors. The AI industry is developing very fast, and companies and startups increasingly try to conceal the amount of AI specialists and the technologies they use in their activities. The AI market is very competitive, and thus companies are trying to secure their assets and trade secrets.

Thus, it is impossible to get inside companies' actual AI and Deep Learning algorithms to scrutinize the level of AI development and, moreover, the involvement of Machine Learning algorithms into, for instance, their Drug Discovery process. However, we believe that the level of AI development in one's company can be evaluated not only by "researching the code", but based on various forms of circumstantial evidence, such as:

1. Amount of AI specialists and their positions in the company;
2. Amount of articles and patents;
3. Visible AI application;
4. AI application of the AI product shows the flexibility of it and the ability of the IT team to apply

Each level is defined by a set of characteristics:

	Amount of AI specialists	Application of the AI	Visible AI application	Deep Learning
Level I	<5%	One niche	-	-
Level II	10%	1-2 niches	+	-
Level III	>15% Leading role in the company	More than 2 niches	+	+

Level I

As previously mentioned, the AI industry is developing at an extraordinary pace, and algorithms which were outstanding 5 month ago are now outdated. Based on our research the category “**Level I**” has following attributes:

1. Machine Learning algorithms are predominantly applied/used/focused on one niche;
2. The company has not disclosed any significant breakthroughs resulting from the application of AI technologies during the past 2 years;
3. The company has declared that they are using AI, but lack of actual evidence or application of Deep Learning;
4. The company possesses no patents or scientific articles related to AI publicly available for review;
5. AI specialists make up less than 5% of the company’s staff, or the company fails to publicly disclose AI specialists belonging to their core executive team.

1. Qrativ	9. Micar21	17. Novoheart	25. Brite Health	33. Plex Research
2. Arbor Biotechnologies	10. Nuritas	18. Synthace	26. Imagia	34. Sparrho
3. BioAge Labs	11. Reverie Labs	19. Transcriptic	27. nQ Medical	35. Structura Biotechnology
4. Cotinga Pharmaceuticals	12. Spring Discovery	20. AiCure	28. Virogin	36. ThoughtSpot
5. Datavant	13. Pepticom	21. Antidote	29. Biorelate	37. Cloud Pharmaceuticals
6. e-therapeutics	14. Virvio	22. Deep 6 AI	30. Innoplexus	38. Envisagenics
7. Engine Biosciences	15. Berkeley Lights	23. Mendel.ai	31. Lantern Pharma	39. Resonant Therapeutics
8. Globavir	16. Emerald Cloud Lab	24. Athelas	32. Owkin	40. BullFrog AI

II Level

Companies in this section are using Artificial Intelligence in order to

They can be found in all sectors from data collection to drug discovery.

1. These organizations are operating on one or two directions of Advanced R&D and Drug Discovery.
2. These companies do have their own **AI products**, which are used in order to one niche.
3. Average percentage of AI specialists employed by the company is 10% or above the total number of employees, or are part of the company's core executive team;
4. The company's patent list is available for the past 2 years.
5. The company's record of applying AI for Drug Discovery, R&D or other activities can be easily found and demonstrated.

1. BioSymetrics	6. BioXcel	11. Quantitative	16. PathAI	21. Healx
2. HelixAI	7. Recursion	Medicine	17. Trials.ai	22. Phenomic AI
3. Intellegens	Pharmaceuticals	12. Peptone	18. WinterLight	23. NuMedii
4. EvidScience	8. Deep Genomics	13. TeselaGen	Labs	24. Standigm
5. Biovista	9. exscientia	14. BenchSci	19. Euretos	25. sciNote
	10. Mind the Byte	15. GNS Healthcare	20. FDNA	

III Level

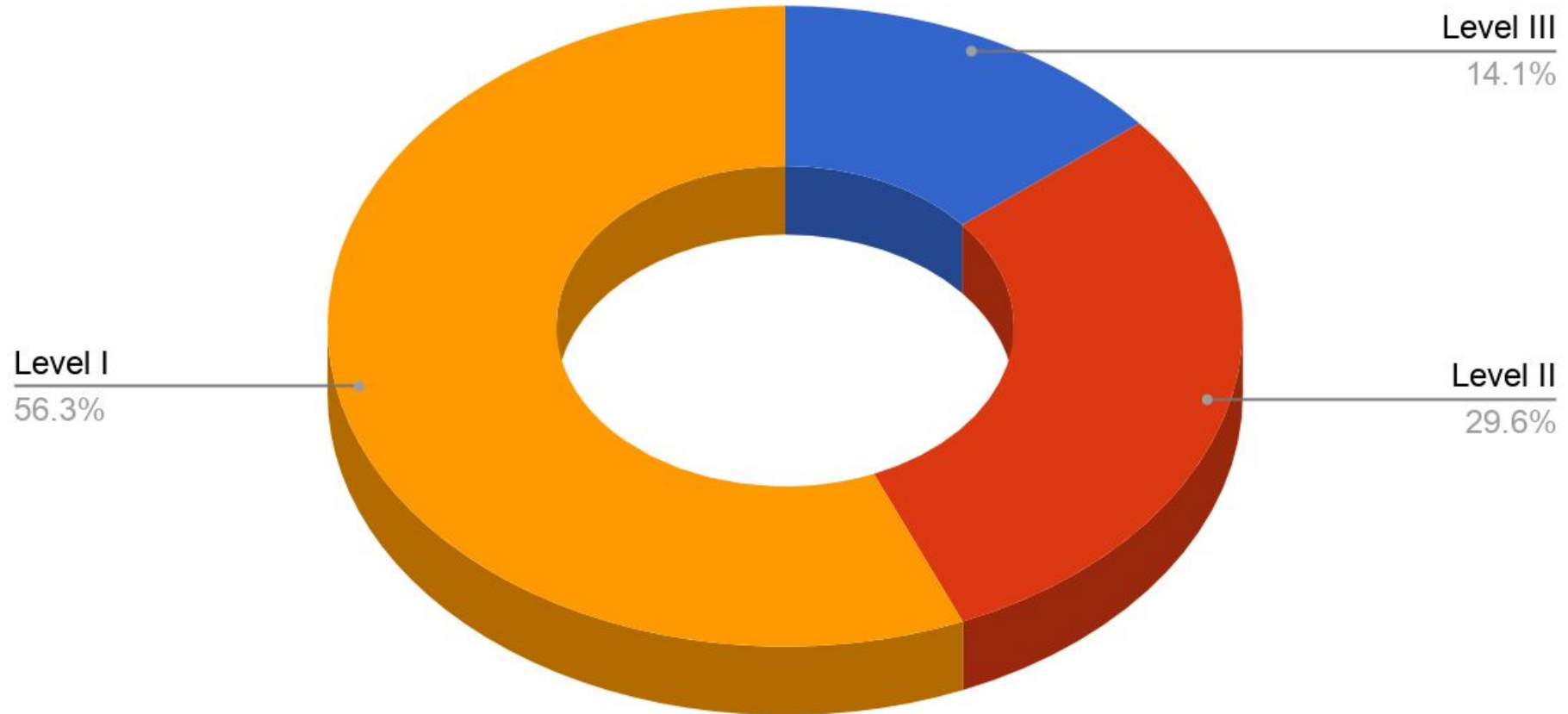
Companies within this category are among the leaders of the industry for AI for R&D and drug discovery. Their contributions have a more promising potential than AI companies.

The difference between Level III and Level II is subtle, but important. Companies within this class have the following characteristics:

1. The company has multiple directions of research and AI (i.e. more than 3)
2. The majority of the company's products are AI driven.
3. The company operates according to two or more directions of Advanced R&D and Drug Discovery, thus their product and IT team are flexible and are able to apply their technologies to various tasks.
4. AI specialists make up more than 15% of the company's team and hold key positions (i.e. director and/or executive-level positions) in the company.
5. The company promotes AI in their descriptive or promotional and marketing materials.

1. Insilico Medicine
2. Numerate
3. BenevolentAI
4. Cyclica
5. Desktop Genetics
6. TwoXAR
7. Verge Genomics
8. XtalPi
9. Atomwise
10. Berg

Types of AI in Advanced R&D and Drug Discovery Based on 80 companies








Appendix Profiles






80 companies Applying AI for Drug Discovery and Advanced R&D.....	114
20 Leading R&D centers.....	132
10 BioPharma Corporations Using Artificial Intelligence for Drug Discovery.....	141
15 Tech Corporations interested in advanced AI applications in Healthcare.....	145
180 Investors in AI for Drug Discovery.....	150






80 companies
Applying AI
for Drug Discovery
and Advanced R&D






80 companies Applying AI for Drug Discovery and Advanced R&D






- | | |
|-----------------------------|-------------------------------|
| 1. AccutarBio | 41. Insilico Medicine |
| 2. AiCure | 42. Intellegens |
| 3. Antidote | 43. Lantern Pharma |
| 4. Arbor Biotechnologies | 44. MediBIC Group |
| 5. Athelas | 45. Mendel.ai |
| 6. Atomwise | 46. Micar21 |
| 7. BenchSci | 47. Mind the Byte |
| 8. BenevolentAI | 48. nference |
| 9. Berg | 49. Novoheart |
| 10. Berkeley Lights | 50. nQ Medical |
| 11. BioAge Labs | 51. NuMedii |
| 12. Biorelate | 52. Numerate |
| 13. BioSymetrics | 53. Nuritas |
| 14. Biovista | 54. Owkin |
| 15. BioXcel | 55. PathAI |
| 16. Brite Health | 56. Pepticom |
| 17. BullFrog AI | 57. Peptone |
| 18. C4X discovery | 58. Phenomic AI |
| 19. Cloud Pharmaceuticals | 59. Plex Research |
| 20. Cotinga Pharmaceuticals | 60. Qrativ |
| 21. Cyclica | 61. Quantitative Medicine |
| 22. Cytex | 62. Recursion Pharmaceuticals |
| 23. Datavant | 63. Resonant Therapeutics |
| 24. Deep 6 AI | 64. Reverie Labs |
| 25. Deep Genomics | 65. sciNote |
| 26. Desktop Genetics | 66. Sparrho |
| 27. e-therapeutics | 67. Spring Discoveries |
| 28. Emerald Cloud Lab | 68. Standigm |
| 29. Engine Biosciences | 69. Structura Biotechnology |
| 30. Envisagenics | 70. Synthace |
| 31. Euretos | 71. TeselaGen |
| 32. EvidScience | 72. ThoughtSpot |
| 33. Exscientia | 73. Transcriptic |
| 34. FDNA | 74. Trials.ai |
| 35. Globavir | 75. TwoXAR |
| 36. GNS Healthcare | 76. Verge Genomics |
| 37. Healx | 77. Virogin |
| 38. HelixAI | 78. Virvio |
| 39. Imagia | 79. WinterLight Labs |
| 40. Innoplexus | 80. XtalPi |






Company	About	Website	Founded Year	Number of Employees	Country	Disclosed Funding, \$
1. AccutarBio 	AccutarBio employs artificial intelligence to revolutionize drug discovery.	https://www.accutarbio.com/	N/A	N/A	China	N/A
2. AiCure 	AiCure's intelligent medical assistant, IMA, leverages a visual recognition platform to monitor patient progress.	http://aicure.com/	2010	11-50	US	\$27,300,000
3. Antidote 	Antidote is accelerating the breakthroughs of new treatments by bridging the gap between medical research and the people who need them.	http://antidote.me/	2010	11-50	UK	\$27,700,000
4. Arbor Biotechnologies 	Arbor Biotechnologies is an early stage life sciences company pushing the boundaries of biodiscovery.	https://arbor.bio/	2016	2-10	US	\$12,200,000
5. Athelas 	Analyze cancer biomarkers in 60 seconds from a drop of blood using an at-home device slightly bigger than an Amazon Echo. Allows researchers to: Optimize oncology drug development with a biomarker monitoring platform and millions of patient datapoints.	http://athelas.com/	2016	N/A	US	\$3,620,000






Company	About	Website	Founded Year	Number of Employees	Country	Disclosed Funding, \$
6. Atomwise 	Atomwise develops artificial intelligence systems using powerful deep learning algorithms and supercomputers for drug discovery.	http://atomwise.com/	2012	1-10	US	\$51,570,000
7. BenchSci 	Decode open- and closed-access data on reagents such as antibodies and present published figures with actionable insights. Allows researchers to: Reduce time, money, and uncertainty in planning experiments.	http://benchsci.com/	2015	11-50	Canada	\$1,700,000
8. BenevolentAI 	A British company harnessing the power of AI to enhance and accelerate global scientific discovery	http://benevolent.ai/	2013	51-100	UK	\$87,000,000
9. Berg 	Analyze data from patient samples in both healthy and diseased states to generate novel biomarkers and therapeutic targets. Allows researchers to: Generate therapeutic targets from biological data in an unbiased way, and implement personalized medicine at scale.	http://berghealth.com/	2005	11-50	UK	\$1,300,000
10. Berkeley Lights 	BL is enabling cell by cell selection & manipulation to empower development, antibody discovery and engineering for personalized therapies.	http://berkeleylights.com/	2011	101-250	US	\$86,200,000






Company	About	Website	Founded Year	Number of Employees	Country	Disclosed Funding, \$
11. BioAge Labs 	Data with machine learning to measure human aging and accelerate drug discovery.	http://bioagelabs.com/	2015	N/A	US	\$10,900,000
12. Biorelate 	Create curated databases from the analysis of published scientific literature. Allows researchers to: Extract structured biological knowledge to power drug discovery applications.	http://biorelate.com/	2014	N/A	UK	\$140,000
13. BioSymetrics 	BioSymetrics is transforming the science of Massive Data analytics and prediction through its groundbreaking pre-processing.	http://biosymetrics.com/	N/A	N/A	US	N/A
14. Biovista 	Analyze data to find non-obvious, mechanism-of-action based associations between compounds, molecular targets, and diseases. Allows researchers to: Reposition late preclinical stage drugs in multiple sclerosis, mitochondrial diseases, oncology, epilepsy and chronic fatigue syndrome / myalgic encephalopathy.	http://biovista.com/	2005	N/A	US	N/A
15. BioXcel 	Find applications for existing approved drugs or clinically validated candidates. Allows researchers to: Develop a pipeline of product candidates in immuno-oncology, neuroscience, and rare diseases.	http://bioxcel.com/	2005	101-250	US	\$60,000,000






Company	About	Website	Founded Year	Number of Employees	Country	Disclosed Funding, \$
16. Brite Health  Brite Health	Analyze structured and unstructured clinical trial participant data. Allows researchers to: Reduce clinical trial dropout rates through personalized communication.	http://britehealth.co/	2015	1-10	US	\$240,000,000
17. BullFrog AI 	Using the bfLeap™ Artificial Intelligence platform, BullFrog AI specializes in helping pharmaceutical companies predict which patients will respond to therapies in development.	https://www.bullfrogai.com/	2017	2-10	US	N/A
18. C4X discovery 	C4X Discovery brings a new dimension to drug discovery. Using its unique NMR-based technique to determine 3D molecular.	https://www.c4xdiscovery.com/	2007	N/A	UK	N/A
19. Cloud Pharmaceuticals 	Cloud Pharmaceuticals is headquartered in Research Triangle Park, North Carolina.	http://cloudpharmaceuticals.com/	2014	11-50	US	\$1,497,000
20. Cotinga Pharmaceuticals 	Cotinga Pharmaceuticals is a biopharmaceutical company focused on developing treatments for a broad range of cancers by targeting the fundamental mechanisms driving cancer cell survival.	http://cotingapharma.com/	1999	N/A-	Canada	N/A






Company	About	Website	Founded Year	Number of Employees	Country	Disclosed Funding, \$
21.Cyclica 	Enhancing drug discovery by harnessing big data and predictive analytics; cloud-based, AI-assisted drug discovery	http://cyclicarx.com/	2013	11-50	Canada	\$7,100,000
22.Cytox 	Cytox is developing transformational prognostic technology that may contribute to the assessment of an individual's risk of developing	cytoxgroup.com	2004	1-10	UK	\$11,300,000
23.Datavant 	Datavant is an AI-driven initiative that aims to improve the design of clinical trials.	http://datavant.com/	N/A	N/A	US	N/A
24.Deep 6 AI 	Deep 6 AI finds patients for clinical trials in minutes, getting life-saving cures to people faster.	http://deep6.ai/	2015	11-50	US	N/A
25.Deep Genomics 	Deep Genomics is using artificial intelligence to build a new universe of life-saving genetic therapies.	http://deepgenomics.com/	2014	11-50	Canada	\$16,700,000






Company	About	Website	Founded Year	Number of Employees	Country	Disclosed Funding, \$
26.Desktop Genetics 	Determine biological variables influencing CRISPR guide design. Allows researchers to: Improve activity and reduce experimental bias in the selection of guides for CRISPR libraries.	http://desktopgenetics.com/	2012	11-50	UK	\$6,150,000
27.e-therapeutics 	eTherapeutics focuses on the discovery of cancer and degenerative diseases of the nervous system.	http://www.e-therapeutics.co.uk/	2003	11-50	UK	\$64,000,000
28.Emerald Cloud Lab 	Conduct experiments in an automated lab exactly as specified. Allows researchers to: Run experiments in a central lab from anywhere in the world.	http://emeraldcoudlab.com/	N/A	N/A	US	\$13,500,000
29.Engine Biosciences 	Engine Biosciences is a biotech company that applies machine learning to genomics for drug discovery.	http://enginebio.com/	N/A	1-10	US	\$10,000,000
30.Envisagenics 	Analyze RNA data from patients to identify new biomarkers and drug targets. Allows researchers to: Accelerate discovery of RNA therapeutics.	http://envisagenics.com/	2014	1-10	US	\$3,075,000






Company	About	Website	Founded Year	Number of Employees	Country	Disclosed Funding, \$
31.Euretos 	Euretos is a bioinformatics company providing a discovery platform for identification and validation of targets and biomarkers.	https://www.euretos.com/	2012	11-50	The Netherlands	N/A
32.EvidScience 	Build a database of therapy evidence. Allows researchers to: Quickly answer any comparative cost and outcome question.	http://evidscience.com/	N/A	N/A	US	\$500,000
33.Exscientia 	Exscientia is applying AI and big data processing to accelerate drug discovery and development	http://exscientia.co.uk/	N/A	11-50	UK	\$317,000,000
34.FDNA 	Genomic insights through computer vision, deep learning and artificial intelligence.	http://fdna.com/	2011	11-50	US	\$30,000,000
35.Globavir 	Generate novel insights and predictions from biological data, chemical data, and curated databases of approved drugs. Allows researchers to: Leverage existing data to develop therapies (currently focused on infectious disease diagnostics and treatments).	http://globavir.com/	2011	11-50	US	\$5,500,000






Company	About	Website	Founded Year	Number of Employees	Country	Disclosed Funding, \$
36.GNS Healthcare 	GNS Healthcare is a big data analytics company focuses on discovering what works in the healthcare industry and for whom.	http://gnshealthcare.com/	2000	101-250	US	\$48,750,000
37.Healx 	Healx is passionate about finding new therapeutic solutions for rare diseases.	http://healx.io/	2014	1-10	UK	\$1,950,000
38.HelixAI 	We're building a hands-free, voice-activated virtual assistant for the sciences.	http://askhelix.io/	2017	N/A	US	N/A
39.Imagia 	Analyze radiological images to produce clinically actionable information. Allows researchers to: Predict a patient's disease progression and treatment response, for clinical trial stratification and companion diagnostics.	http://imagia.com/	2015	11-50	Canada	N/A
40.Innoplexus 	Generate insights from billions of disparate data points from thousands of data sources. Allows researchers to: Improve decision-making by seeing information in context from biomedical data sources including publications, clinical trials, congresses, and theses.	http://innoplexus.com/	2011	101-250	Germany	\$3,000,000






Company	About	Website	Founded Year	Number of Employees	Country	Disclosed Funding, \$
41.Insilico Medicine 	InSilico Medicine is dedicated to finding novel solutions for cancer and age-related diseases using advances in genomics and big data.	http://insilicomedicine.com/	2014	11-50	US	\$14,000,000
42.Intellegens 	Learn underlying correlations in fragmented datasets with incomplete information. Allows researchers to: Estimate missing knowledge of how candidate drugs act on proteins, to aid design of new drug cocktails that activate proteins to cure disease.	http://intellegens.co.uk/	2017	1-10	US	N/A
43.Lantern Pharma 	Analyze genetic signals and molecular markers for patient response to drugs. Allows researchers to: Find clinical uses for validated cancer treatments whose development has been discontinued.	http://lanternpharma.com/	2013	11-50	US	\$5,530,000
44.MediBIC Group 	MediBIC is aiming to deliver a health care platform optimized for each individual.	http://www.medicbic.com/en/	N/A	N/A	Japan	\$7,100,000
45.Mendel.ai 	Mendel.ai automates matching cancer patients to clinical trials through personal medical history and genetic analysis.	http://mendel.ai/	2016	1-10	US	\$2,000,000






Company	About	Website	Founded Year	Number of Employees	Country	Disclosed Funding, \$
46.Micar21 	Micar21 is a biotechnology company provide Drug Discovery FASTER - using in silico and Artificial Intelligence	http://micar21.com/	2016	1-10	Bulgaria	N/A
47.Mind the Byte 	Analyze data in a SaaS-based bioinformatics platform for computational drug discovery. Allows researchers to: Leverage big data and machine learning for every stage of the drug discovery process, from target-identification to post-marketing activities, with no need for their own hardware infrastructure.	http://mindthebyte.com/	2011	1-10	Spain	\$630,000
48.Nference 	nference Artificial Intelligence AI technology (nferX) enables Knowledge Synthesis from unstructured text & structured biomedical databases.	http://nference.ai/	2013	51-100	US	\$3,000,000
49.Novoheart 	Make sense of data from testing drug candidates on their bioartificial human heart constructs. Allows researchers to: More accurately evaluate a drug candidate's cardiac safety and effectiveness.	http://novoheart.com/	1964	N/A	Canada	N/A
50.nQ Medical 	Find hidden health signals in data from personal devices such as laptops and smartphones. Allows researchers to: Optimize clinical trials for neurological diseases, including through better, faster identification of ideal study participants, less in-clinic observation, improved compliance, and earlier measure of drug impact.	http://nq-medical.com/	2017	1-10	UK	N/A






Company	About	Website	Founded Year	Number of Employees	Country	Disclosed Funding, \$
51. NuMedii 	NuMedii discovers and de-risks effective drugs by translating life sciences big data into therapies.	http://numedii.com/	2008	11-50	US	\$5,500,000
52. Numerate 	Numerate seeks to overcome major challenges in drug discovery by applying novel machine-learning algorithms, at cloud scale, to drug design.	http://numerate.com/	2007	11-50	US	\$8,200,000
53. Nuritas 	Predict the therapeutic potential of food-derived bioactive peptides. Allows researchers to: Cost-effectively develop highly targeted treatments for specific diseases from natural food sources.	http://nuritas.com/	2014	11-50	Ireland	\$28,320,000
54. Owkin 	Build intelligence from distributed datasets, including through privacy-safe transfer and federated learning. Allows researchers to: Overcome the problem of data-sharing in healthcare to automate diagnostics, predict treatment outcomes, and optimize clinical trials.	http://owkin.com/	2016	11-50	US	\$13,100,000
55. PathAI 	PathAI's goal is to improve cancer diagnosis using artificial intelligence.	http://pathai.com/	2016	11-50	US	\$15,200,000

Company	About	Website	Founded Year	Number of Employees	Country	Disclosed Funding, \$
56. Pepticom 	Design peptides based on a target's solved crystal structure. Allows researchers to: Speed development of peptide drugs, which have high selectivity and low toxicity.	http://pepticom.com/	2011	11-50	Israel	N/A
57. Peptone 	Accelerate protein lead optimization and design through knowledge- and physics-based artificial intelligence.	http://peptone.io/	2016	1-10	The Netherlands	N/A
58. Phenomic AI 	Analyze cell and tissue phenotypes in microscopy data. Allows researchers to: Rapidly and accurately profile single cells in microscopy images.	http://phenomic.ai/	N/A	N/A	Canada	N/A
59. Plex Research 	Plex Research is the Boston area start-up that's transforming the humble search bar into a drug discovery powerhouse.	http://plexresearch.com/	2017	N/A	US	N/A
60. Qrativ 	AI platform and clinical data and a remit to identify treatments for rare diseases.	http://qrativ.bio/	2017	11-50	US	\$8,300,000

Company	About	Website	Founded Year	Number of Employees	Country	Disclosed Funding, \$
61.Quantitative Medicine 	Quantitative Medicine is a medical platform that is used to construct, assess, validate, and deploy drug models.	http://qtmed.com/	2012	1-10	US	\$563,000
62.Recursion Pharmaceuticals 	Combining experimental biology, automation, and artificial intelligence to discover 100 treatments by 2025.	http://recursionpharma.com/	2013	51-100	US	\$84,430,000
63.Resonant Therapeutics 	Assess and prioritize a library of drug candidates derived from analyzing tumor microenvironments. Allows researchers to: Simultaneously discover novel targets and functional antibodies for cancer.	http://resonantrx.com/	N/A	N/A	US	\$1,959,800
64.Reverie Labs 	Reverie Labs optimizes potential medicines using machine learning.	https://www.reverielabs.com/	2017	2-10	US	N/A
65.sciNote 	Write a draft scientific manuscript based on provided data. Allows researchers to: Get a "head start" when writing a scientific manuscript to submit for publishing.	http://scinote.net/	N/A	N/A	US	N/A

Company	About	Website	Founded Year	Number of Employees	Country	Disclosed Funding, \$
66. Sparrho 	Sparrho is a personalised science research discovery platform allowing users to discover, curate and share over 60m research articles	http://sparrho.com/	2013	11-50	UK	\$3,000,000
67. Spring Discovery 	A Palo Alto, CA-based machine learning-based drug discovery platform.	www.springdisc.com/		N/A	US	\$4,300,000
68. Standigm 	Interpret how drug compounds would interact with people in the real world. Allows researchers to: Predict new indications for existing drugs (current focus).	http://standigm.com/	2015	1-10	South Korea	\$3,690,000
69. Structura Biotechnology 	Enable high-throughput structure discovery of proteins and molecular complexes from cryo-EM data. Allows researchers to: Discover and understand the detailed three-dimensional structure of important protein molecules, complexes, and drug targets.	http://structura.bio/	2016	N/A	Canada	N/A
70. Synthace 	Synthace uses open source technology to make process in biotechnology move faster.	http://synthace.com/	2011	11-50	UK	\$19,300,000

Company	About	Website	Founded Year	Number of Employees	Country	Disclosed Funding, \$
71. TeselaGen 	Make and modify DNA. Allows researchers to: Prototype and edit recombinant molecules for vaccines and biologic medicines.	http://teselagen.com/	2011	1-10	US	N/A
72. ThoughtSpot 	AI-driven Analytics for Humans. New breed of Relational Search Engine designed for data analytics.	http://thoughtspot.com/	2012	101-250	US	\$140,000,000
73. Transcriptic 	Transcriptic is a SaaS-based biotechnology company providing robotic solutions for biology labs.	http://transcriptic.com/	2012	11-50	US	\$26,620,000
74. Trials.ai 	Trials.ai leverages AI to manage clinical trials. We're focused on Study Design & Execution for Sponsors & CRO's & Sites.	http://trials.ai/	2015	1-10	US	N/A
75. TwoXAR 	Screen compound libraries for efficacy against a disease, identify new drug candidates from a public library, and identify biologic targets. Allows researchers to: Speed and reduce costs for drug discovery.	http://twoxar.com/	2014	11-50	US	\$14,300,000




Company	About	Website	Founded Year	Number of Employees	Country	Disclosed Funding, \$
76.Verge Genomics 	Map hundreds of genes that cause a disease, then find drugs that target all at once. Allows researchers to: Find cures for complex diseases—especially brain diseases—that involve a network of genes.	http://vergegenomics.com/	2015	11-50	US	\$4,000,000
77.Virogin 	Virogin Biotech is an early-stage R&D company in the field of oncology. We are focused on innovations in oncolytic viruses and immunotherapy.	https://ca.virogin.com/index.php	2015	1-10	China	N/A
78.Virvio 	Synthetic biology company developing designer mini-protein biotherapeutics.	http://virvio.com/	2015	N/A	US	\$209,000
79.WinterLight Labs 	Assess and monitor cognitive health by analyzing a short speech sample. Allows researchers to: Identify patients, screen patients, and evaluate response to therapy for clinical trials of mental health treatments.	http://winterlightlabs.com/	2015	1-10	Canada	\$500,000
80.XtalPi 	XtalPi is a U.S.-China biotech firm that uses artificial intelligence and computing to accelerate the development of new drugs.	http://xtalpi.com/	2014	51-100	US	\$20,309,000

20 Leading R&D centers



20 Leading R&D centers

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|---|---|
| 1. La Jolla Laboratories | 11. Babraham Research Campus |
| 2. Merck Exploratory Science Center (MESOC) | 12. Janssen Pharmaceutical Companies of Johnson & Johnson |
| 3. Roche Innovation Center Copenhagen | 13. Chinese Thoracic Oncology Group (CTONG) |
| 4. Sanofi Pasteur R&D Centre | 14. The Development Center for Biotechnology |
| 5. Johnson & Johnson Pharmaceutical Research and Development | 15. Korea Pharmaceutical and Bio-Pharma Manufacturers Association |
| 6. Centre for Drug Research and Development | 16. Pande Lab - Stanford University |
| 7. Warren Family Research Center for Drug Discovery and Development | 17. Center for Computational Health - IBM Research |
| 8. Ritsumeikan Research Center for Drug Discovery and Development Science | 18. The R&D Centre China LTD (RRDCC) |
| 9. Astellas Drug Discovery Research Centre | 19. China R&D Center (CRDC) - Pfizer |
| 10. Drug Discovery Oxford | 20. Merck Serono Pharmaceutical R&D Co., Ltd |




Research and Development Centers

Name	About	website	Country	Mission
<p>1. La Jolla Laboratories</p> 	<p>Pfizer is a research-based, global biopharmaceutical company. Pfizer is using IBM's AI technology on its immuno-oncology research, a strategy of using a body's immune system to help fight cancer. The campus includes dedicated facilities for pharmaceutical sciences, analytical chemistry, medicinal chemistry, X-ray crystallography, pharmacology, chromatography, drug safety evaluation, and pharmacokinetics, dynamics and metabolism. La Jolla's success is the ability to bring together new findings and technologies.</p>	<p>https://www.pfizer.com/science/research-development/centers/ca_la_jolla</p>	<p>California, USA</p>	<p>The scientists based in La Jolla focus on two areas of research and development: discovering and developing new medicines to treat many forms of cancer; and, discovering novel prophylactic and therapeutic vaccines for the prevention and treatment of significant human maladies (in the areas of cancer and central nervous system diseases).</p>
<p>2. Merck Exploratory Science Center (MESC)</p> 	<p>The Merck Exploratory Science Center (MESC) is focused on exploring the causes of some of the most challenging diseases. The MESC is made up of approximately 40 accomplished researchers with diverse scientific backgrounds but one common goal: to bring together biology, chemistry, technology and drug discovery under one roof to ultimately help MRL's global network of researchers to discover and develop new and innovative medicines and vaccines.</p>	<p>https://www.merck.com/about/featured-stories/cambridge-mrl.html</p>	<p>Massachusetts, USA</p>	<p>The company focuses on discovering and developing therapies to improve patients' lives and aims to explore emerging areas of disease biology to uncover new opportunities for drug discovery research.</p>
<p>3. Roche Innovation Center Copenhagen</p> 	<p>Roche Innovation Center Copenhagen is a leader in the rapidly emerging field of RNA-targeted drugs, where it is exploiting its proprietary Locked Nucleic Acid (LNA) platform to discover important novel medicines across multiple therapeutic areas. Roche Group plans to use the GNS REFS™ (Reverse Engineering and Forward Simulation) causal machine learning and simulation platform to find and validate potential new drug candidates.</p>	<p>http://www.roche.dk/</p>	<p>Danmark</p>	<p>RICC is investing in its drug discovery and technology platform, bringing together a multidisciplinary team of scientists with experience, talent and commitment to deliver broadly on the promise of RNA medicines.</p>




Research and Development Centers

Name	About	website	Country	Mission
<p>4. Sanofi Pasteur R&D Centre</p> 	<p>Sanofi Pasteur, the vaccine division of Sanofi, opened a new vaccine research and development centre in Canada. Sanofi Pasteur produces nearly one billion doses of vaccines per annum for about 20 infectious diseases. It is also developing vaccines targeting chlamydia, tuberculosis and pneumococcal. One of the largest drug discovery collaborations and strategic leasing agreements were announced this year between pharmaceutical maker Sanofi and artificial intelligence driven drug discovery company Exscientia.</p>	<p>http://www.sanofipasteur.ca/node/17302</p>	<p>Canada</p>	<p>The centre focuses mainly on the development of vaccines for cancer and paediatric ailments.</p>
<p>5. Johnson & Johnson Pharmaceutical Research and Development</p> 	<p>The Johnson & Johnson's businesses span across three sectors in China: consumer; pharmaceuticals; medical devices and diagnostics. The Asia division plans to invest in open innovation through more research partnerships and collaborative efforts that connect the medical and academic communities to its R&D centers. Johnson & Johnson reached a deal to BenevolentAI which has the right to develop, manufacture and commercialize a select number of novel clinical stage drug candidates from Johnson & Johnson.</p>	<p>https://jilabs.jnjinnovation.com/locations/jilabs-shanghai</p>	<p>China</p>	<p>The company's therapeutic areas include neuroscience, cardiovascular and metabolic disease, immunology, oncology and virology. A special focus will be placed on diseases with specific, high unmet needs in the region.</p>
<p>6. Centre for Drug Research and Development</p> 	<p>The Centre for Drug Research and Development is a global bridge that translates discoveries into innovative therapeutic products and improved health outcomes. CDRD has amassed strategic partnerships with over 50 affiliated universities and research institutes, 26 Canadian health sciences SMEs/entrepreneurs, six top global pharmaceutical companies, eight of the world's leading translational research centres, and three patient-focused foundations.</p>	<p>http://www.cdrd.ca/about/</p>	<p>Canada</p>	<p>CDRD is strategically focused on the following therapeutic areas, but will opportunistically support projects in any area given they meet the criteria above: Oncology (including immunotherapy/immunology), Anti-Infectives, Regenerative Medicine/Fibrosis, Neuroscience, Other Indications</p>



Research and Development Centers

Name	About	website	Country	Mission
<p>7. Warren Family Research Center for Drug Discovery and Development</p> 	<p>The Warren Family Research Center for Drug Discovery and Development is a collaborative program well aligned with the University's overarching Catholic mission through its focus on the discovery and development of new therapeutic leads for the treatment of unmet clinical needs in a number of areas including cancer, infectious diseases, and a number of rare diseases. The Center brings together chemical and biological expertise and technologies through partnerships with researchers within the University's biomedical research centers.</p>	<p>https://drugdiscovery.nd.edu/</p>	<p>USA</p>	<p>The mission of this premier drug discovery and development center is to organize the products and byproducts of past, current, and future chemical research to create the Notre Dame Chemical Compound Collection and to promote biological evaluation of these entities through internal collaborations and external partnerships.</p>
<p>8. Ritsumeikan Research Center for Drug Discovery and Development Science</p> 	<p>Research Center for Drug Discovery and Development Science conducts individual research in each of the fields of drug discovery and drug formulation technology. In addition, the Center conducts research and development activities through government-industry-academia partnerships, with an eye toward overall "drug manufacturing," from drug discovery to formulation.</p>	<p>http://en.ritsumei.ac.jp/research/organizations/research-center-drug-discovery/</p>	<p>Japan</p>	<p>The centre's focus is on two consortiums ("drug discovery" and "drug formulation") as their pillars.</p>
<p>9. Astellas Drug Discovery Research Centre</p> 	<p>Astellas Pharma is a global pharmaceutical company with a simple vision to produce exceptional medicines that change tomorrow for patients in need. Scientists strive to discover new chemical compounds with the potential to influence the biological processes that cause diseases. Astellas understands that new scientific discoveries combined with advances in technology are deepening our understanding of disease and creating an array of potential new medical solutions.</p>	<p>https://www.astellas.eu/rd/research-development/</p>	<p>Japan</p>	<p>Their vision is to be on the forefront of this changing healthcare environment, turning innovative science into valuable new treatment options for patients.</p>



Research and Development Centers

Name	About	website	Country	Mission
<p>10. Drug Discovery Oxford</p> 	<p>Oxford has all the necessary expertise on site to drive a drug discovery programme from target identification to preclinical candidate selection, and then on through all phases of clinical trials. This draws on key competencies from the Department of Chemistry, including a strong, broad-based and vigorous synthetic chemistry community with expertise in natural product synthesis, asymmetric synthesis and high-speed parallel assay synthesis, in silico modelling, screening and informatics, molecular imaging, radiochemistry, peptide and protein chemistry, carbohydrate chemistry, molecular biology, enzymology and proteomics.</p>	<p>http://drugdiscovery.chem.ox.ac.uk/</p>	<p>UK</p>	<p>The Drug Discovery showcases the University of Oxford's involvement in drug discovery and provides useful links to resources in this area. It looks at the wide range of disease areas that the researchers study, provides case studies of exciting new fundamental research, and explains the histories behind their most successful spin-outs.</p>
<p>11. Babraham Research Campus</p> 	<p>The Babraham Research Campus is considered to be one of the UK's leading campus' to support early-stage bioscience enterprise and is distinct in its co-location of bioscience companies with the Babraham Institute. World class research and business come together to promote innovation and strengthen links between academia and the commercial world. The Babraham Research Campus is managed and developed by Babraham Bioscience Technologies Ltd (BBT).</p>	<p>https://www.babraham.com/</p>	<p>UK</p>	<p>The aim is to create an environment where companies can focus on developing their science and building their business in a supportive and highly networked community, helping to create new medicines, jobs and growth, and maximising the impact of UK science.</p>
<p>12. Janssen Pharmaceutical Companies of Johnson & Johnson</p> 	<p>At Janssen Research & Development the biotherapeutics organization works to translate scientific discoveries into medicines that will continue to make significant contributions to human health. The strategy is to bring innovative, effective and safe treatments forward in six therapeutic areas: cardiovascular and metabolism, immunology, infectious diseases and vaccines, neuroscience, oncology, and pulmonary hypertension.</p>	<p>http://www.janssen.com/</p>	<p>United States</p>	<p>At Janssen, a key goal is developing and implementing new approaches to make the clinical trial process better and faster for all stakeholders: patients, trial sites/investigators and the healthcare industry at large.</p>




Research and Development Centers

Name	About	website	Country	Mission
<p>13.Chinese Thoracic Oncology Group (CTONG)</p> 	<p>This collaborative group is a research-based, non-profit academic group that is composed of medical units with certain chest tumor diagnosis and treatment capabilities in China and that promotes the development of chest prevention and treatment in China through multi-center clinical trials.</p>	<p>http://www.ctongonline.com/webhtml/Default.aspx</p>	<p>China</p>	<p>The goal of the collaboration group is to design and conduct multi-center clinical trials in the field of thoracic tumors, especially lung cancer research, to provide high-level evidence-based medical evidence for clinical practice of thoracic tumors, and to promote the standardization and modernization of thoracic tumor medical treatment and research activities in China. And internationalization, improve the diagnosis and treatment of thoracic cancer in China and its international status.</p>
<p>14.The Development Center for Biotechnology</p> 	<p>The Development Center for Biotechnology (abbreviation: Biotechnology Center, DCB) was founded in 1984 and is a non-profit organization established jointly by the government and the private sector. The Biotechnology Center, with its “best partner in the biotechnology industry”, has played the role of the “best in fostering” role in the value chain of the biotechnology and pharmaceutical industry in China. After the pre-clinical development and value-adding of innovative technologies or lead drugs through the Center, they are transferred to the third-biggest biotechnology and pharmaceutical manufacturer, and further commercialization of research and development results.</p>	<p>http://www.dcb.org.tw/home.php</p>	<p>Taiwan</p>	<p>The purpose of the Biotechnology Center is to cooperate with production, government, research, and research institutions, construct important environmental facilities required for the biotech and pharmaceutical industry, develop key biotechnologies, and cultivate professional talents to accelerate the development of China's biotechnology industry as the main task.</p>

Research and Development Centers

Name	About	website	Country	Mission
<p>15.Korea Pharmaceutical and Bio-Pharma Manufacturers Association</p> 	<p>The Korea Pharmaceutical and Bio-Pharma Manufacturers Association was founded in October 1945 with the name of Chosun Pharmaceutical Manufacturers Association at first, and as of 2015, it has 202 pharmaceutical companies as its members. The KPBMA is the largest pharmaceutical industry organization in Korea, with a membership that includes 175 domestic pharmaceutical firms and 27 multinational corporations. To achieve its goal of 'improving national healthcare through the sound development of the pharmaceutical industry,' it plays a variety of roles such as policy-supporting activities, educations, and supporting to member companies. Internationally, it cooperates with the international pharmaceutical organizations as a member of IFPMA (International Federation of Pharmaceutical Manufacturers & Associations) and WSMI (World Self-Medication Industry).</p>	<p>http://kpma.or.kr/english/index</p>	<p>South Korea</p>	<p>The goal is improving national healthcare through the sound development of the pharmaceutical industry</p>
<p>16.Pande Lab - Stanford University</p>	<p>Pande Lab use computer simulation, statistical mechanics, and Bayesian statistics to tackle challenging problems in chemical biology, biophysics, and biomedicine.</p>	<p>https://pande.stanford.edu/</p>	<p>Stanford</p>	<p>The goal is to push the limits of computational and theoretical methods and applying them to important problems in biophysics and biophysical chemistry.</p>
<p>17. Center for Computational Health - IBM Research</p> 	<p>The Center for Computational Health at IBM Research work on developing cutting-edge methodologies to derive insights from diverse sources of health data, to support use cases in personalized care delivery and management, real world evidence, health behavior modeling, cognitive health decision support, and translational informatics.</p>	<p>https://researcher.watson.ibm.com/researcher/view_group.php?id=6743</p>	<p>United States</p>	<p>The center pursue research in the application of data science to healthcare across the entire continuum from the health of individuals, to that of populations, to the healthcare system itself.</p>

Research and Development Centers






Name	About	website	Country	Mission
<p>18. The R&D Centre China LTD (RRDCC)</p> 	<p>The R&D Centre China LTD (RRDCC) was established in 2004 in Zhangjiang Hi-Tech Park in Shanghai as a pioneer in Pharmaceutical R&D in China. It is now a Roche Centre of Excellence contributing to the drug discovery in the areas of Oncology, Virology and Metabolic Diseases. The Development Centre is the first comprehensive Clinical Development Organisation in Asia Pacific (excluding Japan) of Roche. It is capable to design, conduct and analyse clinical studies to meet the registration needs – currently the only pharmaceutical company with this capability in China.</p>	<p>http://www.roche.com.cn/</p>	<p>China</p>	<p>The RRDCC is dedicated to develop new medicines for China and the rest of the world.</p>
<p>19. China R&D Center (CRDC) - Pfizer</p> 	<p>CRDC supports Pfizer's global biological and chemical pharmaceutical R&D programs across clinical development pipeline, and serves as an important hub of Pfizer global and Asia-Pacific R&D activities. As such, CRDC is an integral part of Pfizer's global R&D site network, providing support across many R&D disciplines, including clinical drug development, medical, regulatory and safety.</p>	<p>http://www.pfizer.com.cn/(S(syf5z355lzdweeigrwarzprw))/research/about_china_rd_center_en.aspx</p>	<p>China</p>	<p>CRDC's aspiration is to help accelerate China's transition to an innovative economy by catalyzing the upgrade of local R&D capabilities, systems, technologies/IP, and culture, to address unmet medical needs, and create a world-class biopharmaceutical R&D ecosystem for China, as part of the global R&D community.</p>
<p>20. Merck Serono Pharmaceutical R&D Co., Ltd</p> 	<p>As one of Merck Serono's four global R&D hubs, the R&D Beijing Hub will not only increase the level of China's Research and Development, but will also work closely with global R&D institutes, increase global product development efforts, and expand global R&D expertise and capability. This strategy has also become the company's key driver for further innovation, driving Merck Serono to achieve its ultimate mission of Living Science, Transforming Lives.</p>	<p>http://www.merck-china.com/en/company/beijing_merck_pharma_china/beijing_merck_pharma.html</p>	<p>China</p>	<p>The R&D Beijing Hub aims to stimulate innovation, introducing new products to Asia paralleling market timelines in the West, and leading research and development into new treatment solutions for critical diseases in Asia.</p>

10 BioPharma Corporations Using Artificial Intelligence for Drug Discovery





10 BioPharma Corporations Using Artificial Intelligence for Drug Discovery

1. Pfizer
2. Astrazeneca
3. Sanofi
4. Roche
5. GSK
6. Navartis
7. Illumina
8. Merck
9. Johnson & Johnson
10. Bayer

10 BioPharma Corporations and advanced AI in Healthcare

Name	About	website	Country	Practical applications and uses of AI
Pfizer 	<p>Pfizer is a research-based, global biopharmaceutical company. The Company applies science and its global resources to improve health and well-being at every stage of life. Pfizer develops and produces medicines and vaccines for a wide range of conditions.</p>	https://www.pfizer.com/	United States	<p>Pfizer announced in late 2016 a collaboration that will utilize IBM Watson for Drug Discovery. Pfizer is using IBM's AI technology on its immuno-oncology research, a strategy of using a body's immune system to help fight cancer.</p>
Astrazeneca 	<p>AstraZeneca is global innovation-driven biopharmaceutical company specialising in the discovery, development, manufacturing and marketing of prescription medicines that make a meaningful difference in healthcare.</p>	http://www.astrazeneca.com/	United Kingdom	<p>In February 2018, AstraZeneca announced a partnership with Alibaba to apply technology including artificial intelligence to patient diagnosis and treatment.</p>
Sanofi 	<p>Sanofi is a healthcare company engaged in the research, development, manufacturing, and marketing of innovative therapeutic solutions.</p>	http://m-en.sanofi.com/	France	<p>Sanofi - Exscientia partnership announced in May 2017, focuses on finding bispecific small molecule drugs for metabolic diseases such as diabetes and their comorbidities.</p>
Roche 	<p>Roche was one of the first companies to bring targeted treatments to patients. Roche Holding AG is the owner of F. Hoffmann-La Roche Ltd., a provider of in-vitro diagnostics and drugs for cancer and transplantation.</p>	http://www.roche.com/	Switzerland	<p>Genentech plans to use the GNS REFS™ causal machine learning and simulation platform to find and validate potential new drug candidates.</p>
GSK 	<p>GSK is a UK-based pharmaceutical and healthcare company focusing on research to develop and distribute treatments for HIV/AIDS, TB, and malaria.</p>	http://www.gsk.com/	United Kingdom	<p>GSK created an in-house artificial intelligence unit. And it has partnered with startups including Exscientia and Insilico Medicine.</p>

10 BioPharma Corporations and advanced AI in Healthcare




Name	About	website	Country	Practical applications and uses of AI
<p>Novartis</p> 	<p>Novartis is a global healthcare company based in Switzerland that provides solutions to address the evolving needs of patients worldwide. Their mission is to discover new ways to improve and extend people's lives.</p>	<p>http://www.novartis.com/</p>	<p>Switzerland</p>	<p>In January 2018, Novartis partnered with McKinsey's QuantumBlack to analyze clinical trial operations with machine learning.</p>
<p>Illumina</p> 	<p>Illumina has the goal to apply innovative technologies and revolutionary assays to the analysis of genetic variation and function, making studies possible that were not even imaginable just a few years ago.</p>	<p>https://www.illumina.com/</p>	<p>United States</p>	<p>Illumina uses big data techniques such as AI to process the sequencing information that comes into Illumina's cloud, and as a way to keep tabs on how its instruments are doing out in the field.</p>
<p>Merck</p> 	<p>Merck is a global healthcare leader working to help the world be well. Merck is known as MSD outside the United States and Canada. It is currently one of the world's seven largest pharmaceutical companies by market capitalization and revenue.</p>	<p>http://www.merck.com/</p>	<p>United States</p>	<p>Merck struck an early partnership with Numerate, announced in March 2012. The collaboration focuses on generating novel small molecule drug leads for an unnamed cardiovascular disease target.</p>
<p>Johnson & Johnson</p> 	<p>Johnson & Johnson engages in the research and development, manufacture, and sale of a range of products in the healthcare field.</p>	<p>http://www.jnj.com/</p>	<p>United States</p>	<p>In January 2018, Johnson & Johnson announced a partnership between Janssen and WinterLight Labs to try predicting dementia and neurodegenerative diseases from voice samples obtained through Janssen clinical trials.</p>
<p>Bayer</p> 	<p>Bayer is a global enterprise with core competencies in the fields of health care, nutrition and high-tech materials.</p>	<p>http://bayer.com/</p>	<p>Germany</p>	<p>There is evidence of Bayer's interest in AI in its 2016 Grants4Apps Accelerator.</p>

**15 Tech Corporations
interested in advanced AI
applications in Healthcare**






15 Tech Corporations interested in advanced AI applications in Healthcare

1. **Alibaba**
2. **Amazon**
3. **Apple**
4. **Google**
5. **Huawei**
6. **IBM**
7. **Microsoft**
8. **Nestle**
9. **Nvidia**
10. **Samsung Electronics**
11. **L'Oreal**
12. **Baidu**
13. **Tencent**
14. **Intel**
15. **Hitachi**




15 IT Corporations and advanced AI in Healthcare

Name	About	website	Country	Practical applications and uses of AI
<p>Alibaba</p> 	<p>Alibaba is a Chinese e-commerce company operating online marketplaces for both international and domestic China trade.</p>	<p>http://www.alibaba.com/</p>	<p>China</p>	<p>Alibaba is charting ways to push the application of AI in diagnostics and healthcare to make medical treatment more accessible, timely, and affordable. Alibaba Cloud is actively working on AI-powered solutions to tackle healthcare problems in China and globally</p>
<p>Amazon</p> 	<p>Amazon is an e-commerce retailer formed originally to provide consumers with products in two segments. It offers users with merchandise and content purchased for resale from vendors and those offered by third-party sellers.</p>	<p>http://amazon.com/</p>	<p>United States</p>	<p>Amazon Web Services and Merck announced a developer competition to that plans to harness artificial intelligence for diabetics.</p>
<p>Apple</p> 	<p>Apple is a multinational corporation that designs, manufactures, and markets consumer electronics, personal computers, and software.</p>	<p>http://www.apple.com/</p>	<p>United States</p>	<p>Lattice, the "dark data" startup Apple snapped up that have aspirations in the healthcare space.</p>
<p>Google</p> 	<p>Google is a multinational corporation that is specialized in internet-related services and products.</p>	<p>http://www.google.com/</p>	<p>United States</p>	<p>Google bought AI startup DeepMind in 2014 and has ended up focusing most of that company's energies in the healthcare space.</p>
<p>Huawei</p> 	<p>Huawei Technologies provides infrastructure application software and devices with wireline, wireless, and IP technologies.</p>	<p>http://huawei.com/</p>	<p>China</p>	<p>Huawei Technologies plan to develop processors optimized for artificial intelligence workloads, moves that will put them into competition with the likes of Intel, Google, Nvidia and Advanced Micro Devices.</p>

15 IT Corporations and advanced AI in Healthcare

Name	About	website	Country	Practical applications and uses of AI
IBM 	IBM is an IT technology and consulting firm providing computer hardware, software, and infrastructure and hosting services.	http://www.ibm.com/	United States	IBM developed machine learning models to analyze correlations between diseases and side effects commonly caused by the medications used to treat them.
Microsoft 	Microsoft is a software corporation that develops, manufactures, licenses, supports, and sells a range of software products and services.	http://www.microsoft.com/	United States	Microsoft's Project Hanover is using ML technologies in multiple initiatives, including a collaboration with the Knight Cancer Institute to develop AI technology for cancer precision treatment, with a current focus on developing an approach to personalize drug combinations for Acute Myeloid Leukemia (AML).
Nestle 	Nestle is a food and beverage company that provides its clients with cereals, bottled water, dairy, healthcare nutrition, and food services.	http://www.nestle.com/	Switzerland	The company uses artificial intelligence (AI) to look closely at the foods we eat to find peptides that could provide extraordinary benefits.
Nvidia 	Nvidia manufactures integrated circuits for use in motherboard chip-sets, graphic processing units, and game consoles.	http://www.nvidia.com/	United States	GE Healthcare and graphics firm NVIDIA combined artificial intelligence with imaging devices, accelerating the speed at which healthcare data can be processed.
Samsung Electronics 	Samsung Electronics is a South Korean multinational electronics company engaged in consumer electronics, information technology and mobile communications, and device solutions businesses worldwide.	http://www.samsung.com/us	South Korea	Samsung wants to add artificial intelligence to stroke diagnosis in ambulances.

15 IT Corporations and advanced AI in Healthcare

Name	About	website	Country	Practical applications and uses of AI
L'Oreal 	<p>L'Oréal manufactures and sells cosmetic products for women and men worldwide. It is the world's largest cosmetics company and has developed activities in the field concentrating on hair colour, skin care, sun protection, make-up, perfume and hair care.</p>	http://www.loreal.fr/	France	<p>L'Oreal partnered in 2015 with bio-engineering firm Organovo, of which both designs and creates "multicellular, dynamic, and functional human tissues for use in drug discovery and medical research".</p>
Baidu 	<p>Baidu is a Chinese multinational technology company specializing in Internet-related services and products, and artificial intelligence, headquartered at the Baidu Campus in Beijing's Haidian District. It is one of the largest internet companies.</p>	http://www.baidu.com/	China	<p>Baidu is looking to use artificial intelligence algorithms for drug discovery technology so it can significantly shorten the process of analysing big data and make big decisions simple.</p>
Tencent 	<p>Tencent Holdings Limited is a Chinese multinational investment holding conglomerate whose subsidiaries specialize in various Internet-related services and products, entertainment, AI and technology both in China and globally.</p>	https://www.tencent.com/en-us/	China	<p>In 2018 was announced that Medopad has teamed up with Tencent to develop artificial intelligence enabling clinical decision support software and medical chatbots.</p>
Intel 	<p>Intel is the world's second largest and second highest valued semiconductor chip makers based on revenue after being overtaken by Samsung and is the inventor of the x86 series of microprocessors, the processors found in most personal computers. Intel supplies processors for computer system manufacturers such as Apple, Lenovo, HP, and Dell.</p>	http://www.intel.com/	United States	<p>Kyoto University Graduate School of Medicine, one of Asia's leading research-oriented institutions, has chosen Intel® Xeon® Scalable processors to power its clinical genome analysis cluster and its molecular simulation cluster.</p>
Hitachi 	<p>Hitachi is engaged in the manufacture and sale of electronic and electrical products worldwide. Hitachi is a highly diversified company that operates eleven business segments.</p>	http://www.hitachi.com/	Japan	<p>Mitsubishi and Hitachi joined its forces to use AI to hasten drug R&D. Using Hitachi's advanced digital technology, to shorten the development period for news drugs.</p>

180 Investors AI for Drug Discovery

180 Investors AI for Drug Discovery

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|------------------------------------|-----------------------------------|--------------------------------|
| 1. 11.2 Capital | 31. Capital One Growth Ventures | 61. Fifty Years |
| 2. 500 Startups | 32. Cathay Innovation | 62. Foundation Capital |
| 3. 6 Dimensions Capital | 33. Celgene | 63. Founders Fund |
| 4. 8VC | 34. Claremont Creek Ventures | 64. FREES FUND |
| 5. A-Level Capital | 35. CLI Ventures | 65. Frontier IP Group plc |
| 6. Accelerate Long Island | 36. Connect Ventures | 66. General Catalyst |
| 7. Advantage Capital | 37. Crowdcube | 67. Geodesic Capital |
| 8. Afore Capital | 38. CRV | 68. GM&C Life Sciences Fund |
| 9. Alexandria Real Estate Equities | 39. Cultivian Sandbox Ventures | 69. Golden Venture Partners |
| 10. AllBright | 40. Danhua Capital | 70. Goodman Capital |
| 11. Alphabet | 41. Data Collective | 71. GPG Ventures |
| 12. Amadeus Capital Partners | 42. DCM Ventures | 72. Grand Central Tech |
| 13. AME Cloud Ventures | 43. Deep Knowledge Ventures | 73. Grand Challenges Canada |
| 14. Amgen Ventures | 44. DFJ Growth | 74. Great Oaks Venture Capital |
| 15. Andreessen Horowitz | 45. Digital Science | 75. GreenSky Capital |
| 16. ARCH Venture Partners | 46. Dolby Family Ventures | 76. GV |
| 17. Atlas Venture | 47. Dorm Room Fund | 77. Hacking Health Accelerator |
| 18. B Capital Group | 48. Draper Associates | 78. Hanhai Studio |
| 19. Baidu Ventures | 49. Draper Fisher Jurvetson (DFJ) | 79. Health Wildcatters |
| 20. Baird Capital | 50. Dynamk Capital | 80. Healthbox |
| 21. BDC Venture Capital | 51. EDBI | 81. Heritage Provider Network |
| 22. Beast Ventures | 52. Empire State Development | 82. Hewlett Packard Pathfinder |
| 23. Bioeconomy Capital | 53. Enterprise Ireland | 83. IA Ventures |
| 24. Biomatics Capital Partners | 54. Entrepreneur First | 84. Illumina |
| 25. Bios Partners | 55. EPIC Capital | 85. Index Ventures |
| 26. Bloomberg Beta | 56. EPIC Ventures | 86. Indie Bio |
| 27. BootstrapLabs | 57. European Union | 87. Initialized Capital |
| 28. Boundary Capital Partners LLP | 58. Fairhaven Capital Partners | 88. IQ Capital Partners LLP |
| 29. Caffeinated Capital | 59. Faridan | 89. K Cube Ventures |
| 30. Cambia Health Solutions | 60. Felicis Ventures | 90. Karlin Ventures |

180 Investors AI for Drug Discovery











91.	KdT Ventures	121.	New Protein Capital	151.	Square 1 Bank
92.	Khosla Ventures	122.	NJF Capital	152.	Stanford University Venture Fund
93.	Kleiner Perkins Caufield & Byers	123.	Novatio Ventures	153.	StartUp Health
94.	Lansdowne Partners	124.	Obvious Ventures	154.	StartX
95.	Lanza Tech Ventures	125.	Octopus Ventures	155.	Sutter Hill Ventures
96.	LaunchCapital	126.	OS Fund	156.	SV Angel
97.	LB Investment	127.	Otium Capital	157.	SyndicateRoom
98.	Lightspeed Venture Partners	128.	Pear Ventures	158.	Techammer
99.	Lilly Ventures	129.	Perivoli Innovations	159.	TEEC Angel Fund
100.	Liquid2 Ventures	130.	Pillar Companies	160.	Tencent Holdings
101.	London Co-Investment Fund	131.	Pitch@Palace	161.	The Thiel Foundation
102.	Lucas Venture Group	132.	Plug and Play	162.	Third Kind Venture Capital
103.	Lundbeck	133.	Pritzker Group Venture Capital	163.	TIPS
104.	Lux Capital	134.	Real Ventures	164.	Tribeca Venture Partners
105.	Masa Life Science Fund	135.	Refactor Capital	165.	True Ventures
106.	Matrix Partners	136.	Renren Inc.	166.	Two Sigma Ventures
107.	Mayo Clinic	137.	Rough Draft Ventures	167.	UK Innovation & Science Seed Fund
108.	Menlo Ventures	138.	Seneca Partners	168.	Uni-Innovate Group
109.	Merck Global Health Innovation Fund	139.	Sequoia Capital	169.	Unshackled Ventures
110.	Mission and Market	140.	Sequoia Capital China	170.	Upsher Smith Laboratories
111.	MITS Fund	141.	Seraph Group	171.	Walden Riverwood Ventures
112.	Mitsui & Co	142.	ServiceNow	172.	Warburg Pincus
113.	Monsanto Growth Ventures (MGV)	143.	Silicon Badia	173.	White Cloud Capital
114.	Mubadala Investment Company	144.	Silicon Valley Bank	174.	WI Harper Group
115.	National Institutes of Health	145.	Slow Ventures	175.	Wild Basin Investments
116.	National Science Foundation	146.	Smedvig Capital	176.	Woodford Investment Management
117.	NDRC	147.	Sofinnova Partners	177.	Wren Capital
118.	Nest.Bio Ventures	148.	Softbank Ventures Korea	178.	Wuxi Venture Capital Group Co Ltd
119.	Nesta Ventures	149.	Sorrento Therapeutics	179.	Y Combinator
120.	New Leaf Venture Partners	150.	SOSV	180.	ZhenFund










Company	About	website	Founded Year	Number of Employees	Country	Invested in
1. 11.2 Capital 	11.2 Capital is an early stage venture capital fund that invests in breakthrough technologies in software, hardware, and healthcare.	http://www.112capital.com	2013	2-10	United States	Deep Genomics 
2. 500 Startups 	500 Startups is a global venture capital seed fund with a network of startup programs headquartered in Silicon Valley with over \$350M in committed capital across 4 main funds and 13 micro funds.	https://500.co/	2010	51-200	United States	Transcriptic 
3. 6 Dimensions Capital 	6 Dimensions Capital is a healthcare focused investment firms with an in-depth focus and extensive coverage across China and the US.	http://6dimensioncapital.com/en/home/	2017	11-50	China	Engine Biosciences 
4. 8VC 	8VC seeks to enable industry transformation. In a wave of creative destruction, they believe emerging platforms will replace the decades old technology infrastructure behind many industries, promoting greater innovation and global prosperity.	http://www.8vc.com/	2015	11-50	United States	PathAI 
5. A-Level Capital 	A-Level Capital, LLC is a student-led venture capital fund based in Baltimore, Maryland. Our firm invests in Johns Hopkins University student and young alumni founded companies. Please visit our website, alevelcapital.com to learn more and/or apply for start-up funding.	http://www.alevelcapital.com/	2015	11-50	United States	

Company	About	website	Founded Year	Number of Employees	Country	Invested in
6. Accelerate Long Island 	ACCELERATE LONG ISLAND is a unique collaboration among Long Island's world class research institutions and its business community to commercialize research and create an entrepreneurial ecosystem.	http://www.accelerati.org/	2011	1-10	United States	Envisagenics 
7. Advantage Capital 	Advantage Capital provides equity and debt financing to established and emerging companies located in communities underserved by conventional sources of capital.	http://www.advantagecap.com/	1992	51-200	United States	Recursion Pharmaceuticals 
8. Afore Capital 	Afore Capital is a venture fund that focuses on pre-seed stage exclusively and is based in the San Francisco Bay Area.	http://afore.vc/	2016	2-10	United States	BenchSci 
9. Alexandria Real Estate Equities 	Alexandria Real Estate Equities, Inc. is an urban office REIT uniquely focused on collaborative life science and technology campuses in AAA innovation cluster locations.	http://www.are.com/	1994	251-500	United States	GNS Healthcare 
10. AllBright 	AllBright is a unique funding, education and support network designed to provide the support and finance needed for female-led leaders to thrive.	https://www.allbrightcollective.com/	2016	2-10	United Kingdom	Sparrho 





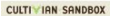

Company	About	website	Founded Year	Number of Employees	Country	Invested in
11. Alphabet 	Alphabet Inc. is the holding company for Google and several Google entities, including Google X, Google Ventures, Google Capital, Calico, and its Life Sciences efforts.	https://abc.xyz/	2015	10001+	United States	XtalPi 
12. Amadeus Capital Partners 	Amadeus Capital is a global technology investor that invests in technology companies at all stages, from seed to venture buyout; we also buy stakes from other investors or founders, to ensure that companies and entrepreneurs have the runway they need to succeed.	https://www.amadeuscapital.com/	1997	11-50	United Kingdom	Antidote 
13. AME Cloud Ventures 	AME Cloud Ventures invests in seed to later-stage tech companies that build infrastructure and value chains around data.	http://www.amecloudventures.com/	2012	11-50	United States	Atomwise 
14. Amgen Ventures 	Amgen Ventures is a California-based investment firm focused on early- and late-stage biotechnology companies.	http://www.amgen.com/	2004	n/a	United States	GNS Healthcare 
15. Andreessen Horowitz 	Andreessen Horowitz is a Silicon Valley-based venture capital firm with \$2.7 billion under management. They invest from seed to growth.	https://a16z.com/	2009	101-250	United States	BioAge Labs 

Company	About	website	Founded Year	Number of Employees	Country	Invested in
16. ARCH Venture Partners 	ARCH invests primarily in companies co-founded with leading scientists and entrepreneurs, concentrating on bringing to market innovations	re.comrchventu	1986	11-50	United States	Arbor Biotechnologies 
17. Atlas Venture 	Atlas Venture creates and invests in biotech startup companies in the U.S. with seed and early stage venture investments.	https://atlasventure.com	1980	1-10	United States	Numerate 
18. B Capital Group 	B Capital Group backs brash entrepreneurs building the next generation of groundbreaking technology companies.	https://www.bcapgroup.com/	2015	11-50	United States	Atomwise 
19. Baidu Ventures 	Baidu Ventures aims to back artificial intelligence, virtual reality, and augmented reality projects.	http://bv.ai/	2016	11-50	China	Atomwise 
20. Baird Capital 	Baird Capital makes venture capital, growth equity, and private equity investments in strategically-targeted sectors around the world.	http://bairdcapital.com/	1919	101-250	United States	AiCure 

Company	About	website	Founded Year	Number of Employees	Country	Invested in
21. BDC Venture Capital 	BDC Venture Capital is a venture capital investment firm investing directly in Canadian tech companies.	https://www.bdc.ca/en/bdc-capital/venture-capital/about-us/pages/default.aspx	1975	2-10	Canada	Imagia 
22. Beast Ventures 	Beast Ventures invests in seed stage technology companies in the United States and European Neighbourhood.	http://www.beast.vc/	2015	2-10	United Kingdom	Sparrho 
23. Bioeconomy Capital 	Bioeconomy Capital is a venture capital firm specializing in early stage. It seeks to invest in industrial biotechnology, which includes materials, chemicals, and enzymes. It primarily invest in technologies that enable biological engineering and production; and companies that use those technologies to produce goods and services.	http://www.bioeconomycapital.com/	n/a	2-10	United States	Synthace 
24. Biomatics Capital Partners 	Biomatics Capital Partners is a Seattle-based healthcare and life sciences venture firm.	https://www.biomaticscapital.com/	2016	2-10	United States	AiCure 
25. Bios Partners 	Bios Partners Is A Venture Capital Firm Based In Dallas/Ft. Worth Focused On Investment In Innovative Early-Stage And Growth-Stage Biotech And Medical Device Companies.	http://biospartners.com	n/a	1-10	United States	Lantern Pharma 

Company	About	website	Founded Year	Number of Employees	Country	Invested in
26. Bloomberg Beta 	Bloomberg Beta is an early-stage venture fund backed by Bloomberg that invests in startups making work better, focusing on machine learning.	https://github.com/Bloomberg-Beta/Manual	2013	2-10	United States	Deep Genomics 
27. BootstrapLabs 	BootstrapLabs is a leading Venture Capital firm based in Silicon Valley and focused on Applied Artificial Intelligence.	https://bootstraplabs.com/	2008	1-10	United States	Mendel.ai 
28. Boundary Capital Partners LLP 	Boundary Capital is a venture capital company focusing on early stage growth companies, primarily in the technology space.	http://www.boundarycapital.com/	2009	1-10	United Kingdom	Desktop Genetics 
29. Caffeinated Capital 	We are an early-stage venture capital firm based in San Francisco, California. We partner with unbreakable founders innovating in the biggest markets.	http://caffeinatedcapital.com/	2009	2-10	United States	BioAge Labs 
30. Cambia Health Solutions 	Cambia Health Solutions, headquartered in Portland, Oregon, is dedicated to transforming health care. We are a family of over 20 companies that work together to make the health care system more economically sustainable and efficient for people and their families.	https://www.cambiahealth.com/	1996	5001-10000	United States	GNS Healthcare 

Company	About	website	Founded Year	Number of Employees	Country	Invested in
31. Capital One Growth Ventures 	Capital One Growth Ventures is an investment firm focused big data technologies, payments, security, and financial technologies.	https://growthventures.capitalone.com/	2014	2-10	United States	ThoughtSpot 
32. Cathay Innovation 	Cathay Innovation is the global venture capital fund supporting digital entrepreneurs by bridging USA, Europe and China simultaneously.	http://www.cathayinnovation.com/	2015	11-50	United States	OWKIN 
33. Celgene 	Celgene discovers, develops and commercializes innovative therapies to treat cancer and immune-inflammatory-related diseases.	http://www.celgene.com/	1986	10001+	United States	GNS Healthcare 
34. Claremont Creek Ventures 	Claremont Creek Ventures, a seed- and early-stage venture capital firm, invests in various industries, including healthcare and energy.	https://claremontcreek.com/	2005	11-50	United States	NuMedii 
35. CLI Ventures 	CLI Ventures typically invests at early to late stages of companies in the U.S. and China.	http://www.cli.ventures/	2010	101-250	United States	twoXAR 

Company	About	website	Founded Year	Number of Employees	Country	Invested in
36. Connect Ventures 	Connect Ventures is a venture capital firm specialized in investments in seed, startup, series A, and early-stage companies.	http://www.connectventures.co/	2012		United Kingdom	Berg 
37. Crowdcube 	Crowdcube enables individuals to invest or loan in small companies in return for equity or an annual return.	https://www.crowdcube.com/	2010	101-250	United Kingdom	Mind the Byte 
38. CRV 	CRV has been a leading investor in early-stage technology companies for almost half a century, backing nearly 400 startups in its history.	https://www.crv.com/	1970	11-50	United States	Recursion Pharmaceuticals 
39. Cultivian Sandbox Ventures 	Cultivian Sandbox is a venture capital firm focused on building next-generation disruptive agriculture and food technology companies capable of generating superior returns.	http://cultiviansbx.com/	2008	1-10	United States	Nuritas 
40. Danhua Capital 	DHVC (Danhua Capital) is a California-based venture capital fund investing primarily in early-stage technology companies.	http://danhuacap.com/	2013	11-50	United States	PathAI 

Company	About	website	Founded Year	Number of Employees	Country	Invested in
41. Data Collective 	Data Collective invests in entrepreneurs building big data, deep compute, and IT infrastructure companies.	https://www.dcvc.com/	2011	11-50	United States	Atomwise 
42. DCM Ventures 	DCM Ventures assists entrepreneurs building world-class companies that will ultimately change how institutions and people use and live with technology.	https://www.dcm.com/	1996	1-10	United States	Mendel.ai 
43. Deep Knowledge Ventures 	Deep Knowledge Ventures is a Hong Kong based venture capital fund management company.	http://dkv.global/	2014	11-50	Hong Kong	Insilico Medicine 
44. DFJ Growth 	DFJ Growth is a late-stage global venture capital firm that provides capital to companies in seed-, early-, and growth-stages.	http://www.dfj.com/	2006	51-200	United States	Helix 
45. Digital Science 	Digital Science is a technology company serving the needs of scientific research. They provide software that makes the research process simpler and more efficient so that everyone can work smart and discover more.	https://www.digital-science.com/	2010	251-500	United Kingdom	Transcriptic 

Company	About	website	Founded Year	Number of Employees	Country	Invested in
46. Dolby Family Ventures 	Dolby Family Ventures is an early stage venture firm focused on building great technology companies.	http://www.dolbyventures.com/	2014	2-10	United States	Atomwise 
47. Dorm Room Fund 	Dorm Room Fund is the strongest community of entrepreneurial students in the nation.	https://dormroomfund.com/	2012	11-50	United States	Athelas 
48. Draper Associates 	Draper Associates, founded in 1985, is a seed-stage venture capital firm that encourages entrepreneurs to drive their businesses to greatness, to transform industries with new technologies, and to build platforms for extraordinary growth, jobs, and wealth creation.	http://www.draper.vc/	1985	11-50	United States	Atomwise 
49. Draper Fisher Jurvetson (DFJ) 	Draper Fisher Jurvetson is a California-based venture capital firm that funds companies in seed, early, and growth stages.	http://www.dfj.com/	1985	101-250	United States	Atomwise 
50. Dynamk Capital 	Life Science Venture Fund. Dynamk Capital is focused on identifying innovative companies with disruptive tools, technologies and services in the life sciences sector.	http://www.dynamk.vc/	2016	2-10	United States	Envisagenics 


Company	About	website	Founded Year	Number of Employees	Country	Invested in
51. EDBI 	EDBI is a Singapore-based global fund with investments in the knowledge and innovation-intensive sectors.	https://www.edbi.com/	1991	11-50	Singapore	Engine Biosciences 
52. Empire State Development 	Empire State Development (ESD) is New York's chief economic development agency. The mission of ESD is to promote a vigorous and growing economy, encourage the creation of new job and economic opportunities, increase revenues to the State and its municipalities, and achieve stable and diversified local economies	https://esd.ny.gov/	1968	101-250	United States	Envisagenics 
53. Enterprise Ireland 	Enterprise Ireland is the government agency responsible for the development and promotion of the indigenous business sector.	https://enterprise-ireland.com/en/	1998	501-1000	Ireland	Nuritas 
54. Entrepreneur First 	EF is a London-based company builder that invests in individuals “pre-team, pre-idea” to help create new technology startups.	https://www.joinef.com/	2011	1-10	United Kingdom	Sparrho 
55. EPIC Capital 	Epic Capital is a boutique investment firm focused on Canadian small- and mid-cap securities.	http://epiccapitalmanagement.ca/epic-healthcare-funds-lp-i/	2000	11-50	Canada	Cyclica 

Company	About	website	Founded Year	Number of Employees	Country	Invested in
56. EPIC Ventures 	EPIC Ventures is an investment company working with driven entrepreneurs to build successful and lasting companies.	http://www.epicvc.com/	1994	11-50	United States	Recursion Pharmaceuticals 
57. European Union 	The European Union occasionally makes investments.	http://europa.eu/	1993	10001+	-	Nuritas 
58. Fairhaven Capital Partners 	Fairhaven Capital (previously TD Capital) is a Cambridge, MA based venture capital firm investing in early stage technology startups.	http://fairhavencapital.com/	2001	1-10	United States	PathAI 
59. Faridan  faridan	Game changing science and technology are the heart of Faridan's investment strategy. Cross-disciplinary teams are the soul of their investment strategy. Upgrading human health is Faridan's end goal.	http://www.faridan.com/		11-50	United States	Arbor Biotechnologies 
60. Felicis Ventures 	Felicis Ventures is a boutique VC firm that backs iconic companies reinventing existing markets and creating frontier technologies.	https://www.felicis.com/	2006	11-50	United States	BioAge Labs 

Company	About	website	Founded Year	Number of Employees	Country	Invested in
61. Fifty Years 	Fifty Years is an early stage VC fund backing entrepreneurs solving the world's biggest problems.	http://www.fifty.vc/	2015	1-10	United States	Athelas 
62. Foundation Capital 	Foundation Capital is a venture capital firm made up of former entrepreneurs who set out to create the firm they wanted as founders.	http://foundationcapital.com/	1995	11-50	United States	Numerate 
63. Founders Fund 	Founders Fund is a San Francisco based venture capital firm investing in companies building revolutionary technologies.	https://foundersfund.com/	2005	11-50	United States	Transcriptic 
64. FREES FUND 	FREES FUND is a venture capital firm that provides both early and growth stage investment to technology startups in both China and the U.S.	https://www.freesvc.com/	2015	51-200	China	XtalPi 
65. Frontier IP Group plc 	Frontier IP specialises in the commercialisation of Intellectual Property (IP). Frontier IP establishes partnerships with individual universities and research institutions to assist with their spin-out and licensing activities and help maximise the commercial value of technologies emerging from their research programmes.	http://www.frontierip.co.uk/	2009	1-10	United Kingdom	Exscientia 

Company	About	website	Founded Year	Number of Employees	Country	Invested in
66. General Catalyst 	General Catalyst is a venture capital firm that makes early-stage and growth equity investments.	http://generalcatalyst.com/	2000	11-50	United States	ThoughtSpot 
67. Geodesic Capital 	Geodesic Capital is a Silicon Valley venture capital firm that provides late stage funding to enterprise and consumer technology companies	http://www.geodesiccap.com/	2005	11-50	United States	ThoughtSpot 
68. GM&C Life Sciences Fund 	GM&C Life Sciences Fund is a provider of venture capital funds to entrepreneurs operating in the life sciences area.	http://www.gmc-lifesciencesfund.com/	2015	1-10	United Kingdom	Biorelate 
69. Golden Venture Partners 	Golden Venture Partners is a seed-stage venture capital fund based in Toronto.	http://goldenvp.com/	2011	1-10	Canada	BenchSci 
70. Goodman Capital 	Private investment firm investing in technology and biotech companies across USA and Asia from early-stage to pre-IPO	http://www.goodman-capital.com/	2013	1-10	Singapore	Engine Biosciences 

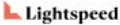
Company	About	website	Founded Year	Number of Employees	Country	Invested in
71. GPG Ventures 	Green Park & Golf, built on over 50 years of operational and financial experience, seeks investment opportunities that offer above-market	http://gpgventures.com/index.html	2011	1-10	United States	Lantern Pharma 
72. Grand Central Tech 	Grand Central Tech is a New York-based startup accelerator specialized in seed-stage and non-equity assistance investments.	https://grandcentraltech.com/	2014	1-10	United States	Envisagenics 
73. Grand Challenges Canada 	Grand Challenges Canada is dedicated to supporting bold ideas with big impact in global health.	http://www.grandchallenges.ca/	2010	11-50	Canada	Atomwise 
74. Great Oaks Venture Capital 	Great Oaks is an early stage venture investment firm founded by Andrew Boszhardt, Jr.	http://www.greatoaksvc.com/	2005	11-50	United States	Verge Genomics 
75. GreenSky Capital 	GreenSky Capital is a boutique corporate finance advisory firm based in Toronto, delivering customized financial solutions to small and medium sized businesses.	https://www.greenskycapital.com/	2008	1-10	Canada	Cyclica 

Company	About	website	Founded Year	Number of Employees	Country	Invested in
76. GV 	<p>Launched as Google Ventures in 2009, GV is the venture capital arm of Alphabet, Inc. They've invested in more than 300 companies that push the edge of what's possible. In the fields of life science, healthcare, artificial intelligence, robotics, transportation, cyber security, and agriculture</p>	http://www.gv.com/	2008	101-250	United States	TranscripTic 
77. Hacking Health Accelerator 	<p>Hacking Health accelerator exist to accelerate companies working in digital health</p>	http://www.hhaaccelerator.com/	2015	1-10	Canada	Imagia 
78. Hanhai Studio 	<p>Hanhai Studio is a cross-border business accelerator specializing in bridging opportunities between the US and China. Our focus lies in the entertainment and technology industries.</p>	http://hanhaistudio.com/	2015	1-10	United States	Cyclica 
79. Health Wildcatters 	<p>Health Wildcatters is a mentor-driven seed accelerator focused on improving healthcare by supporting entrepreneurs and healthcare startups.</p>	https://www.healthwildcatters.com/	2013	1-10	United States	Lantern Pharma 
80. Healthbox 	<p>Healthbox is a an innovation consulting and fund management services firm, helping organization build and sustain innovation strategies.</p>	http://healthbox.com/	2010	11-50	United States	Desktop Genetics 

Company	About	website	Founded Year	Number of Employees	Country	Invested in
81. Heritage Provider Network 	Heritage Provider Network (HPN) is a limited Knox-Keene licensed organization.	http://heritageprovider.network.com/	1996	5001-10000	United States	GNS Healthcare 
82. Hewlett Packard Pathfinder 	Hewlett Packard Pathfinder provides expansion stage capital and exceptional support to top-tier enterprise technology start-ups	https://www.hewlettpackardpathfinder.com/	2014	11-50	United States	ThoughtSpot 
83. IA Ventures 	IA Ventures is a venture capital firm that specializes in seed-stage and early-stage investments in the fintech sector.	http://www.iaventures.com/	2009	1-10	United States	Verge Genomics 
84. Illumina 	Illumina applies innovative technologies and revolutionary assays to the analysis of genetic variation and function.	https://www.illumina.com/	1998	5001-10000	United States	Helix 
85. Index Ventures 	Index Ventures is a multi-stage international venture capital firm that backs the best and most ambitious entrepreneurs.	http://www.indexventures.com/firm	1996	51-200	United Kingdom	Berg 









Company	About	website	Founded Year	Number of Employees	Country	Invested in
86. Indie Bio 	IndieBio is the largest biotech startup accelerator.	https://indiebio.co/	2014	1-10	United States	Mendel.ai 
87. Initialized Capital 	Initialized Capital is early stage VC firm focused on helping software engineers, designers and product people with their first seed checks	http://initialized.com/	2011	11-50	United States	Athelas 
88. IQ Capital Partners LLP 	IQ Capital Partners is a venture capital firm that invests up to £5m in early and growth stage deep tech companies.	http://iqcapital.vc/	2006	2-10	United Kingdom	Desktop Genetics 
89. K Cube Ventures 	A venture capital firm that provides funding and management services for startups and young entrepreneurs primarily in Korea.	http://www.kcubeventures.co.kr/	2012	11-50	South Korea	Standigm 
90. Karlin Ventures 	Karlin Ventures, a California-based early-stage venture capital fund, invests in software, e-commerce, and advertising technology companies.	http://karlinvc.com/	2013	11-50	United States	Verge Genomics 

Company	About	website	Founded Year	Number of Employees	Country	Invested in
91. KdT Ventures 	KdT Ventures is a new age seed stage venture firm, with a focus on the intersection of technology and science.	http://www.kdtyc.com/	2017	2-10	United States	PathAI 
92. Khosla Ventures 	Khosla Ventures is a venture capital firm that focuses on environmentally friendly tech, internet, computing, mobile, and silicon tech.	https://www.khoslaventures.com/	2004	11-50	United States	ThoughtSpot 
93. Kleiner Perkins Caufield & Byers 	Kleiner Perkins Caufield & Byers invests globally in internet start ups and operate an informational website filled with technology news.	http://www.kpcb.com/	1972	11-50	United States	Helix 
94. Lansdowne Partners 	Lansdowne Partners manages assets for a diversified client base that includes some of the world's largest and most sophisticated investors.	https://www.lansdownepartners.com/	1998	101-250	United Kingdom	BenevolentAI 
95. Lanza Tech Ventures 	Lanza Tech Ventures is a venture capital firm specializing in investments in early-stage companies.	http://lanzatechventures.com/	2001	2-10	United States	Numerate 








Company	About	website	Founded Year	Number of Employees	Country	Invested in
96. LaunchCapital 	LaunchCapital was founded in January 2008 with a mission to help entrepreneurs gain quick access to seed capital and mentorship.	https://launchcapital.com/	2008	11-50	United States	Helix 
97. LB Investment 	LB Investment is a private equity and venture capital firm focused on investments in healthcare industry.	http://lbinvestment.com/	1996	11-50	South Korea	Standigm 
98. Lightspeed Venture Partners 	Lightspeed Venture Partners is a venture capital firm that is engaged in the consumer, enterprise, technology, and cleantech markets.	http://lsvp.com/	2000	11-50	United States	ThoughtSpot 
99. Lilly Ventures 	Lilly Ventures has its roots in the scientific tradition of Eli Lilly and Company. Our investment philosophy drives us to seek great companies with compelling life science innovations.	http://lillyventures.com/	2001	2-10	United States	Numerate 
100. Liquid2 Ventures 	Liquid2 Ventures provides technology startups with seed stage investments and is based in San Francisco, California.	http://liquid2.vc/	2015	2-10	United States	Athelas 

Company	About	website	Founded Year	Number of Employees	Country	Invested in
101. London Co-Investment Fund 	London Co-Investment Fund is a venture firm that invests in high growth tech, science, and digital startups in London.	http://lcif.co/	2014	n/a	United Kingdom	Desktop Genetics 
102. Lucas Venture Group 	Lucas Venture Group is a venture capital firm investing in robotics, networking, software analytics/big data and cyber security.	http://www.luca.svg.com/	1985	2-10	United States	Berkeley Lights 
103. Lundbeck 	Lundbeck is a pharmaceutical company that develops products to treat people with psychiatric and neurological disorders.	http://www.lundbeck.com/global	2000	5001-10000	Denmark	BenevolentAI benevolent.ai
104. Lux Capital 	VC based in NYC and Menlo Park investing in counter-conventional, early-stage science and tech ventures, with \$1.4B AUM across 5 funds.	https://www.luxcapital.com/	2000	11-50	United States	Recursion Pharmaceuticals 
105. Masa Life Science Fund 	Masa Life Science Fund is a venture capital fund focused on investments in private, high-growth biotechnology, and life sciences companies.	http://www.mlsvfund.com/	n/a	2-10	United States	Cytos 

Company	About	website	Founded Year	Number of Employees	Country	Invested in
106. Matrix Partners 	Matrix Partners is a California-based venture capital firm focused on seed- and early-stage investments.	https://www.matrixpartners.com/	1977	11-50	United States	nference nference
107. Mayo Clinic 	Mayo Clinic offers medical care services in various specialties, including diabetes and endocrinology, gastroenterology, gynecology, cancer, neurology and neurosurgery, orthopedics, pulmonology, rheumatology, nephrology, urology, and cardiology and heart surgery.	https://www.mayoclinic.org/	1919	10001+	United States	Helix 
108. Menlo Ventures 	Menlo Ventures is a venture capital firm providing capital for seed through growth technology companies in the consumer and other sectors.	https://www.menlovc.com/	1976	11-50	United States	Recursion Pharmaceuticals 
109. Merck Global Health Innovation Fund 	Merck Global Health Innovation Fund (Merck GHI) is evolving corporate healthcare venture capital globally by utilizing their healthcare ecosystem strategy. This investment strategy connects innovative companies with complementary technologies to develop integrated healthcare solutions.	http://merckghifund.com/	2010	2-10	United States	Antidote 
110. Mission and Market 	Mission and Market is a micro-venture capital firm focused on seed investments in many areas, including big data, software-powered biotech.	https://angel.com/mission-and-market	2014	1-10	United States	Atomwise 










Company	About	website	Founded Year	Number of Employees	Country	Invested in
111. MITS Fund 	MITS Fund is a multi-stage investment fund that supports entrepreneurs in building new companies.	http://www.mitsfund.com/	n/a	1-10	United States	Transcrip ^{tic} 
112. Mitsui & Co 	Mitsui & Co., is a general trading and investment company, with interests in Iron & Steel Products.	http://www.mitsui.com/jp/en/index.html	1947	10001+	Japan	GNS Healthcare 
113. Monsanto Growth Ventures (MGV) 	Monsanto Growth Ventures, a venture capital group, offers technology-based solutions and agricultural products to improve farm productivity.	https://monsanto.com/company/monsanto-growth-ventures/	2012	10001+	United States	Atomwise 
114. Mubadala Investment Company 	Mubadala Investment Company is a UAE-based strategic investment fund.	https://www.mubadala.com/	2002	501-1000	United Arab Emirates	Recursion Pharmaceuticals 
115. National Institutes of Health 	National Institutes of Health is a biomedical research facility in the United States that focuses on biomedical and health-related research.	https://www.nih.gov/	1887	10001+	United States	Envisagenics 

Company	About	website	Founded Year	Number of Employees	Country	Invested in
116. National Science Foundation 	The National Science Foundation (NSF) is an independent federal agency created by the U.S. Congress in 1950.	https://www.nsf.gov/	1950	1001-5000	United States	Cloud Pharmaceuticals 
117. NDRC 	NDRC is a business that transforms entrepreneurial teams and ideas into startups with early investment and research help.	http://www.ndrc.ie/	2008	11-50	Ireland	Nuritas 
118. Nest.Bio Ventures 	Nest.Bio Ventures takes a deep science, cross-border approach to translating breakthrough science into revolutionary companies.	https://nest.bio/	2016	2-10	United States	Engine Biosciences 
119. Nesta Ventures 	Nesta Investments is a venture capital arm of NESTA specializing in direct and fund of fund investments.	https://www.nesta.org.uk/project/venture-investment	1998	2-10	United Kingdom	Cytox 
120. New Leaf Venture Partners 	New Leaf Venture Partners is a New York-based venture capital firm focused on investments in healthcare technology companies.	http://www.nlvp.artners.com/	2005	11-50	United States	AiCure 

Company	About	website	Founded Year	Number of Employees	Country	Invested in
121. New Protein Capital 	New Protein Capital is a Singapore-based investment company, investing in innovative solutions to address the food and feed challenges.	http://visviresnewprotein.com/	2014	1-10	Singapore	Nuritas 
122. NJF Capital 	NJF Capital is an investment firm that has supported innovative technology-based businesses across the world.	https://njfcapital.com/	n/a	2-10	United Kingdom	Owkin 
123. Novatio Ventures 	Based in Toronto, Boston and Hong Kong, we focus on the global development of innovations arising from Canada, China, South Korea, and other markets that we believe represent a significant source of opportunities for outsized value creation.	http://www.novatioventures.com/	2015	2-10	Canada	WinterLight Labs 
124. Obvious Ventures 	Obvious Ventures brings experience, capital, and focus to startups combining profit and purpose for a better world.	https://obvious.com/	2014	11-50	United States	Recursion Pharmaceuticals 
125. Octopus Ventures 	Octopus is a multi stage European venture capital investor backing talented teams with the potential to build big businesses.	https://www.octopusventures.com/	1999	11-50	United Kingdom	e-therapeutics 






Company	About	website	Founded Year	Number of Employees	Country	Invested in
126. OS Fund 	Investing in entrepreneurs, inventors and scientists who aim to benefit humanity by rewriting the operating systems of life.	https://osfund.co/	2014	1-10	United States	Atomwise 
127. Otium Capital 	Otium is an early stage European venture capital fund.	https://otium.fr/	2015	2-10	France	Owkin 
128. Pear Ventures 	Pear, formerly known as Pejman Mar Ventures, is an early stage venture fund founded by Pejman and Mar.	https://www.pe.ar.vc/	2013	2-10	United States	BioAge Labs 
129. Perivoli Innovations 	Perivoli Innovations aim is to allocate the profits from successful investments in new technologies to The Perivoli Schools Trust which focuses on improving nursery school education in sub-Saharan Africa.	http://perivoliinnovations.com/	2016	n/a	United Kingdom	Cytox 
130. Pillar Companies 	We've been involved in building startups for many years. we want to create the next generation of big, important, lasting technology companies.	https://pillar.vc/	2016	2-10	United States	PathAI 

Company	About	website	Founded Year	Number of Employees	Country	Invested in
131. Pitch@Palace 	Pitch@Palace focuses on the benefits for entrepreneurs, as they take no stake in the participants and impose no restrictions.	http://pitchatpalace.com/	2014	1-10	United Kingdom	Sparrho 
132. Plug and Play 	Plug and Play is a seed and early-stage investment firm focusing on technology start-ups.	http://plugandplaytechcenter.com/	2006	51-200	United States	Owkin 
133. Pritzker Group Venture Capital 	Pritzker Group Venture Capital is a trusted partner helping entrepreneurs build market-leading technology companies	http://www.pritzkergroup.com/venture-capital/	1996	51-200	United States	AiCure 
134. Real Ventures 	Real is an early-stage venture capital firm that backs entrepreneurs and builds the ecosystems in which they thrive.	https://realventures.com/	2007	11-50	Canada	Imagia 
135. Refactor Capital 	Seed fund co-founded by David Lee of SV Angel and Zal Bilimoria of a16z.	https://www.refactor.com/	2016	2-10	United States	PathAI 

Company	About	website	Founded Year	Number of Employees	Country	Invested in
136. Renren Inc. 	Renren.com is an online social network service that offers an extensive interactive communication platform for Chinese users.	http://renren-in.com/zh/	2002	1001-5000	China	XtalPi 
137. Rough Draft Ventures 	Rough Draft Ventures is a student-led team that funds technology-focused university entrepreneurs in Boston, Massachusetts.	roughdraft.vc	2012	11-50	United States	Reverie Labs 
138. Seneca Partners 	Seneca Partners is a middle market focused investment banking and private investing firm.	http://senecapartners.com/	2010	1-10	United States	Cytos 
139. Sequoia Capital 	Sequoia is a VC firm focused on energy, financial, enterprise, healthcare, internet, and mobile startups.	https://www.sequoiacap.com/	1972	51-200	United States	Athelas 
140. Sequoia Capital China  红杉资本	Sequoia Capital China is a VC firm focused on seed stage, mid stage, late stage, and growth investments in the fintech sector.	https://www.sequoiacap.com/china/en/	2005	11-50	China	XtalPi 

Company	About	website	Founded Year	Number of Employees	Country	Invested in
141. Seraph Group 	Seraph Group is an angel investor that invests between \$50,000 and \$1,000,000 in early-stage startups.	https://www.seraphgroup.net/	2005	1-10	United States	NuMedii 
142. ServiceNow 	ServiceNow provides cloud-based solutions that define, structure, manage, and automate services for enterprise operations.	https://www.servicenow.com/	2004	10001-5000	United States	ThoughtSpot 
143. Silicon Badia 	Silicon Badia is a venture capital firm that invests in technology companies globally.	https://www.siliconbadia.com/	2012	1-10	Jordan	Transcriptic 
144. Silicon Valley Bank 	Silicon Valley Bank works with technology, life science, cleantech, venture capital, private equity, and premium wine businesses.	https://www.svb.com/	1983	11-50	United States	Transcriptic 
145. Slow Ventures 	Slow Ventures invests in companies central to the technology industry and those on the edges of science, society, and culture.	http://www.slow.co/	2009	1-10	United States	Verge Genomics 

Company	About	website	Founded Year	Number of Employees	Country	Invested in
146. Smedvig Capital 	Smedvig Capital is a growth capital firm that invests in U.K & Nordic based businesses, with a focus on those that are technology enabled.	http://www.smedvigcapital.com/	1996	11-50	United Kingdom	Antidote 
147. Sofinnova Partners 	Sofinnova Partners is an independent venture capital firm based in Paris, France.	http://www.sofinnova.fr/	1972	11-50	France	Synthace 
148. Softbank Ventures Korea 	Softbank Ventures Korea is a Seoul-based venture capital firm that specializes in IT startup investment and corporate restructuring.	http://www.softbank.co.kr/	2000	11-50	South Korea	TwoXAR 
149. Sorrento Therapeutics 	Sorrento Therapeutics is focused on the development of proprietary drug therapeutics for addressing unmet medical needs.	http://sorrentotherapeutics.com/	2006	101-250	United States	Globavir 
150. SOSV 	SOSV is a venture capital firm that operates startup accelerators.	https://sosv.com/	1995	51-100	United States	Mendel.ai 

Company	About	website	Founded Year	Number of Employees	Country	Invested in
151. Square 1 Bank 	Square 1 Bank is a full-service commercial bank that provides financial services to entrepreneurs and venture capitalists.	https://www.square1bank.com/	2005	251-500	United States	Recursion Pharmaceuticals 
152. Stanford University Venture Fund 	As the entrepreneurship center in Stanford's School of Engineering, the Stanford Technology Ventures Program delivers courses and extracurricular programs to Stanford students, creates scholarly research on high-impact technology ventures, and produces a large and growing collection of online content and experiences for people around the world.	http://stvp.stanford.edu/	n/a	51-200	United States	Globavir 
153. StartUp Health 	StartUp Health is organizing and supporting a global army of Health Transformers to improve the health & wellbeing of everyone in the world	https://www.startuphealth.com/	2011	11-50	United States	Cyclica 
154. StartX 	StartX is an educational non-profit that helps Stanford's top entrepreneurs.	https://startx.com/	2009	11-50	United States	TwoXAR 
155. Sutter Hill Ventures 	Sutter Hill Ventures has financed technology-based start-ups and assisted entrepreneurs in building market-leading companies since 1962.	https://www.shv.com/	1962	11-50	United States	Helix 

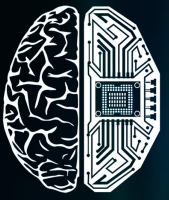
Company	About	website	Founded Year	Number of Employees	Country	Invested in
156. SV Angel 	SV Angel is a San Francisco-based angel firm that helps startups with business development, financing, M&A, and other strategic advice.	https://svangel.com/	2009	1-10	United States	Envisagenics 
157. SyndicateRoom 	SyndicateRoom connects ambitious investors with the country's most trailblazing companies.	https://www.syndicatoroom.com/	2012	11-50	United Kingdom	Desktop Genetics 
158. Techammer 	Angel investments of Jeff Hammerbacher and Halle Tecco. Over 80 angel investments since 2008, including 13 exits.	https://angel.co/techammer	2007	2-10	United States	Transcriptic 
159. TEEC Angel Fund 	TEEC Angel Fund provides seed and early stage venture investments and is based in California.	http://www.tsvcap.com/	2010	11-50	United States	NuMedii 
160. Tencent Holdings 	Tencent is a Chinese internet service portal offering value-added internet, mobile, telecom, and online advertising services.	https://www.tencent.com/en-us/	1998	10001+	China	Atomwise 

Company	About	website	Founded Year	Number of Employees	Country	Invested in
161. The Thiel Foundation 	We support science, technology, and long-term thinking about the future.	http://www.thielfoundation.org/	2006	2-10	United States	Envisagenics 
162. Third Kind Venture Capital 	Third Kind Venture Capital is a New York-based venture capital fund focused on early-stage investments.	http://www.3kvc.com/	2010	n/a	United States	Envisagenics 
163. TIPS 	TIPS creates the best odds for success through Financial investment, in addition to tested and proven mentoring and business incubation by some of the most successful angel investors.	http://www.jointips.or.kr/about_en.php	n/a	n/a	Korea	Standigm 
164. Tribeca Venture Partners 	TVP is an early-stage venture capital firm that partners with world class entrepreneurs in the NYC area leveraging emerging technologies.	http://tribecavp.com/	2011	1-10	United States	AiCure 
165. True Ventures 	True Ventures is a Silicon Valley-based venture capital firm that invests in early-stage technology startups.	https://trueventures.com/	2006	11-50	United States	Deep Genomics 

Company	About	website	Founded Year	Number of Employees	Country	Invested in
166. Two Sigma Ventures 	Two Sigma Ventures invests in companies run by highly driven people with potentially world-changing ideas.	http://twosigmaventures.com/	2012	11-50	United States	Verge Genomics 
167. UK Innovation & Science Seed Fund 	UK Innovation & Science Seed Fund, an early-stage venture capital fund, offers investment.	https://ukinnovationscienceseedfund.co.uk/	2002	11-50	United Kingdom	Synthace 
168. Uni-Innovate Group 	Uni-Innovation Group is devoted to provide complete incubation services, venture capital funds for high tech startups. In addition to this, it provides companies consultation on the Chinese market entry, and providing accurate and meticulous services for Chinese enterprises to search, purchase or merge advanced technologies overseas.	http://uniinnovategroup.com/	2011	51-200	Canada	Cyclica 
169. Unshackled Ventures 	Unshackled Ventures is an early stage venture capital fund created in 2014 to support foreign-born entrepreneurs.	http://www.unshackledvc.com/	2014	1-10	United States	Brite Health 
170. Upsher Smith Laboratories 	A partner in healthcare, striving to deliver high-value, high-quality therapies and solutions that measurably improve individuals' lives.	http://www.upsher-smith.com/	1919	501-1000	United States	BenevolentAI 

Company	About	website	Founded Year	Number of Employees	Country	Invested in
171. Walden Riverwood Ventures 	Walden Riverwood Ventures is a venture capital firm specializing in early stage investments.	http://www.wrvcapital.com/	2013	2-10	United States	Berkeley Lights 
172. Warburg Pincus 	Warburg Pincus LLC is a global private equity firm focused on growth investing.	http://www.warburgpincus.com/	1966	251-500	United States	Helix 
173. White Cloud Capital 	White Cloud Capital offers strategic growth and venture capital for seed and early stage business ventures.	http://www.whcloud.com/	2007	1-10	United Kingdom	Sparrho 
174. WI Harper Group 	WI Harper Group is a venture capital firm that focuses on early and expansion investments in Mainland China, Taiwan and Silicon Valley.	https://wiharper.com/	1993	11-50	United States	Engine Biosciences 
175. Wild Basin Investments 	Wild Basin Investments, LLC is a closely held investment firm located in Austin, Texas with a strong portfolio emphasis in early stage	https://wildbasininv.com/	2007	2-10	United States	Recursion Pharmaceuticals 

Company	About	website	Founded Year	Number of Employees	Country	Invested in
176. Woodford Investment Management 	Our business is grounded in the belief that core principles are essential to how we manage money and behave as a business.	https://woodfordfunds.com/	2014	11-50	United Kingdom	BenevolentAI 
177. Wren Capital 	Wren Capital LLP is a new seed capital investment fund based in London, UK.	https://www.wrencapital.co.uk/	2010	1-10	United Kingdom	CvtoX 
178. Wuxi Venture Capital Group Co Ltd 	Wuxi Venture Capital Group Co., Ltd. operates venture capital investment businesses. The Company invests in software development, new materials, new energy, and other industries. Wuxi Venture Capital Group Co. serves customers in China.	http://www.wxvcg.com/	2000	10001+	China	Insilico Medicine 
179. Y Combinator 	Y Combinator is a startup accelerator based in Mountain View, California.	http://www.ycombinator.com/	2005	11-50	United States	Atomwise 
180. ZhenFund 	ZhenFund invests in TMT, Healthcare, and Education among other sectors.	http://www.zhenfund.com/	2011	1-10	China	Transcriptic 



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