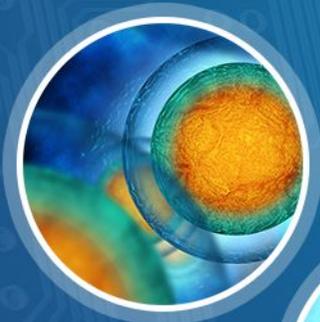


Enhanced Analysis of Most Promising AI-companies as the Best Investment Targets for AI-Pharma.Capital



Enhanced Analysis of Most Promising AI-companies as the Best Investment Targets for AI-Pharma.Capital Fund

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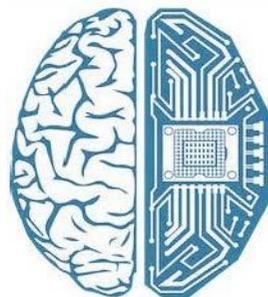
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Introduction

Inasmuch as efficiency of R&D in drug discovery of biopharma declines for many decades, applying AI is an obvious solution to this problem. It is expected to see the growth of AI for Drug Discovery sub-sector capitalization by 5-10 times by the end of 2020. Therefore, we can consider AI for Drug Discovery sector as a highly multifactorial phenomenon which is certain to involve a diverse range of companies.

In 2018, Deep Knowledge Analytics systematised this industry in a series of reports providing a comprehensive assessment of companies applying AI for Drug Discovery. “AI for Drug Discovery, Biomarker Development and Advanced R&D Landscape Overview” is a 100-page report, which identified the emerging industry trends, including some of the key initiatives, investment deals and M&A activity. In general, it contains an updated and expanded review and analysis of the declining R&D efficiency of pharmaceutical companies, outlining important drivers of change, both negative and positive, includes an updated and expanded list of the top AI in drug discovery and healthcare conferences, together with illustrative event analytics – a resource that would be useful both for planning activities, as well as making sense of the industry's top places to maintain constructive discussions on a broad range of AI topics.

The report profiled 150 companies applying AI for Drug Discovery & Advanced R&D. The report used infographics to illustrate where the companies stood in relation to each other. So, the aim of the report was to list these companies and, where applicable, to classify them according to application, industry segmentation, and regional location. Pharma companies are categorized according to industry segmentation (i.e. focusing on Drug Discovery, Biomarker Development, or Advanced R&D, respectively). Mentioned categorization can be seen on mind maps and infographics.



**DEEP
KNOWLEDGE
ANALYTICS
PHARMA DIVISION**

**AI for Drug Discovery, Biomarker Development and Advanced R&D
Companies Landscape
September 2019**

Companies - 150

Repurposing Existing Drugs

Preclinical Experiment Execution

Drug Design

Clinical Trial, Design, Optimization, Recruitment

Data Aggregation & Analysis

Design Proclinical Experiments

Researching Mechanisms of Disease

Introduction

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. In addition, 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 breakthroughs in AI for Drug Discovery will change the R&D process of BioPharma, and it will have a tremendous impact on whole BioPharma industry.

The following document offers a system of metrics for rating entities according to the variables that matter in the progress of the industry in coming years.

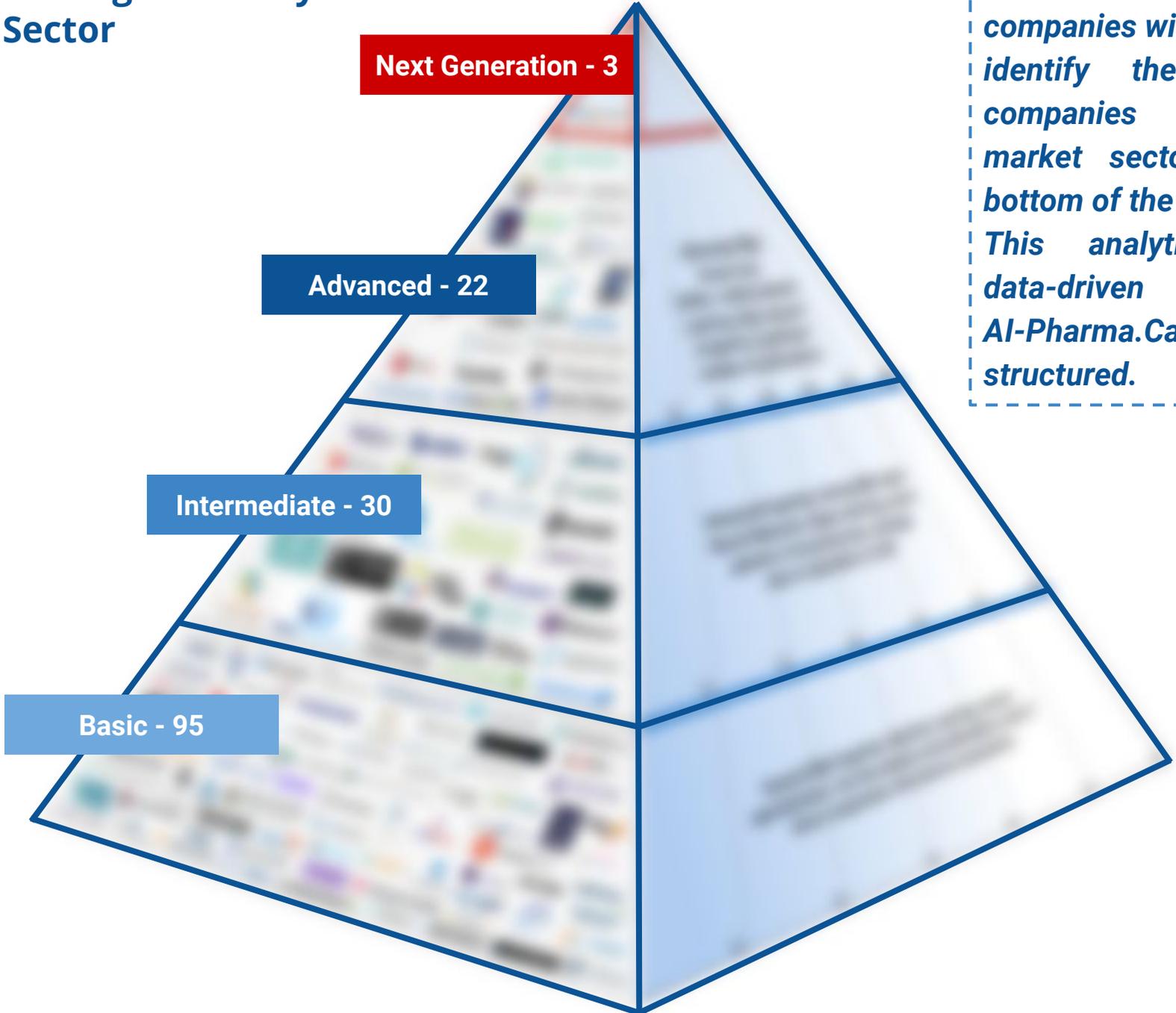
Despite the diverse nature of the industry, a practical assessment of its constituent companies is not impossible as it might appear.

The process begins by establishing some key metrics of a company: product type, IPO reaching, annual revenue, regulation of the company's product in the particular geographic area of activity and number of disease targets. These metrics have the most significant impact on the assessment of a company.

Metrics are divided into next categories - **general characteristics, science activity, financial position, marketing, targets of treatment, focus level (depth factor), product pipeline maturity, services, technologies, main activity, data type** - then drill down further to provide relevant insights.

Deep Knowledge Analytics believes that the methodology will serve as a useful long-term analytical tool, and continuing a source of confidence for investors following the industry.

Level of AI-Strength of 150 Companies in Drug Discovery Sector



DKA Pharma Division has developed a sophisticated multidimensional analytical framework to benchmark the full scope of companies within the global AI in Pharma, to identify the top-25 most promising companies distributed across distinct market sectors, revealing the untapped bottom of the AI in Pharma Industry iceberg. This analytical methodology is the data-driven foundation upon which AI-Pharma.Capital's 2020 target portfolio is structured.

Goal and Applications of the Analytical Report

This report aims to enhanced analysis of most promising AI-companies as the best investments targets for AI-Pharma Index Hedge Fund in order to enable investors, corporations and other industry participants to develop effective short and long-term strategies.

To understand development line of best companies applying AI in drug discovery, bioinformatics and biotechnology it is crucial to analyze their backgrounds, technical skill-sets, strengths, competencies and types of impact they have on the industry in general. Applying AI for Drug Discovery and cooperation with pharma AI companies may indicate the prospects for competitive advantage in the market and opportunities for further growth.

Particularly, analytical report estimates activities of 25 the most promising AI-companies as the best investments targets for AI-Pharma.Capita. Also, the report is supplemented with a qualitative analysis and comparison of the best 25 companies.

Key factors have combined to increase the capability of AI in particular: high number of AI-experts, cooperation with well-known companies,high level of funding, end-to-end clinical development, high publicity position, personalized medicine, use of unique technology.

The findings of the report can be used for:

- Developing the optimal portfolio for investing in AI for Drug Discovery, Bioinformatics and Biotechnology industry
- Gaining understanding of current pharma and tech markets opportunities and crucial threats
- Determining what has to be done in order to benefit from these tendencies and tackle particular issues.

With this analytical product AI-Pharma.Capital will have deep expertise on how their strategic agendas can be optimized and stabilized in order to benefit and choose the best attractive companies for investments in AI-Pharma industry.

Level of AI-Strength of 150 Companies in Drug Discovery Sector

Group	Patents	Publications	AI specialists	Cooperation with Pharma or Tech Corporations	Others
Advanced level	Average/high amount of patents, related to AI, ML technologies applicable to Drug Discovery.	Significant number of publications in peer-reviewed journals.	High ratio of AI specialists on staff.	Established partnerships or collaborations with one or more Pharma and Tech Corporations	High levels of participation at Drug Discovery / AI conferences, and high visibility in media.
Intermediate level	Companies have some patents in Drug Discovery	Some publications in peer-reviewed journals.	Average ratio AI specialists on staff.	Cooperation is possible.	ex-Parma or Tech company executives and/or specialists part of staff.
Basic level	Very few patents.	Very few publications in peer-reviewed journals.	Low ratio AI specialists on staff.	No direct cooperation.	Low levels of activity in the field.

General Methodology

Deep Knowledge Analytics uses detailed mathematical procedures to assign a weighting (or importance factor) to each of the dozens of metrics it applied to AI for Drug Discovery companies, and to combine them into a single calculated score out of 100, wherein each metric is taken into account in proportion to its overall level of importance, in order to arrive at a single adjusted organization ranking that takes into account all relevant variables including qualification of employees, collaborations, scientific activity, financial strengths, product maturity, and specific orientation to arrive at a single, summative ranking for each AI for Drug Discovery company.

- **Strength of its IP**
- **Level of advancement of its internal R&D**
- **Maturity of its product pipeline (indicating how close to market its products are)**
- **Scientific validation (whether it has human validation clinical trials completed or ongoing, whether it has in silico results, preclinical results in model organisms or just in vitro results)**
- **Experience of the scientific management team and the business management team**
- **Level of its advancement in terms of marketing and business development**
- **Therapeutic depth and breadth of its product pipeline**

All metrics are added together in accordance with their assigned weight factors (i.e., importance factors) in order to create a final AI in Pharma company score, thereby quantitatively ranking companies in accordance with their overall strength in the areas of science, technology and business development.

25 Leading Companies in AI for Drug Discovery Sector

1	Amgen
2	Novartis
3	Roche
4	Merck
5	AbbVie
6	Novo Nordisk
7	Boehringer Ingelheim
8	Sanofi
9	Regeneron
10	Moderna
11	Vertex Pharmaceuticals
12	Amgen
13	Novartis

14	Novartis
15	Roche
16	Novartis
17	Novartis
18	Novartis
19	Novartis
20	Novartis
21	Novartis
22	Novartis
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24	Novartis
25	Novartis

General Metrics

Before many of the subsequent metrics can be determined, it is necessary to establish some general characteristics of the company.

Region regulation (high/medium/low). The degree of regulation to which the company is subject, based on the jurisdiction. Typically this is high in Europe, low in Asia, and medium in America. This has some bearing on variables below concerning product pipeline.

Product type (dependent/Independent). Does the company provides some services in collaboration with other companies, or does it produces its products independently, without relying on others.

Stage of the business's life cycle (introduction/growth/maturity/decline). This is necessary in determining the extent of the company's impact in time.

Company type (profit/non-profit). Does a company make profits for one`s personal fulfillment or for serving the society.

Collaboration (numeric). The sum of revenue of the companies partnered with.

Top managers' qualification (high/medium/low). This is an education/training/experience level and is necessary when assessing CEO's and Board Member interviews, publications (+ education). High - well known scientists/doctors/economists/other experts ratio is 25% or higher among CEOs and Board members; Medium - well-known experts ratio is between 5% and 25%; Low - less than 5%.

AI-experts\employees ratio (numeric). AI-experts divided by all employees.

IT expenditures (numeric, currency). Capital expenditures or commitments relating to or arising out of the company's information technology infrastructure.

Publicly position.

Science Activity

Most of AI for Drug Discovery companies are engaged in scientific research. This is the basic process for the development of cutting edge technologies, which are vital for AI companies. Some are involved with data analysis research, some with translational research, some with the direct application of AI technologies.

It is comprised of the following variables:

Number of publications (numeric). The sum of the company's publications over the last 10 years.

Impact factor of publications (numeric). Weighted average of the impact factor of all journals they published in.

Number of licensed patents (numeric). The sum of the company's patents over the last 10 years.

Scientists\employees ratio (numeric). Scientist employees divided by all employees.

Number of collaborations with scientific establishments (numeric). The sum of Universities/Clinics/Laboratories the company is partnered with.

H-index (numeric). How many (n) publications of a company have n citations (maximal value of n). It indicates how significant the publications of a company are in the scientific world.

Grants (numeric, currency). The sum of the company's grants.

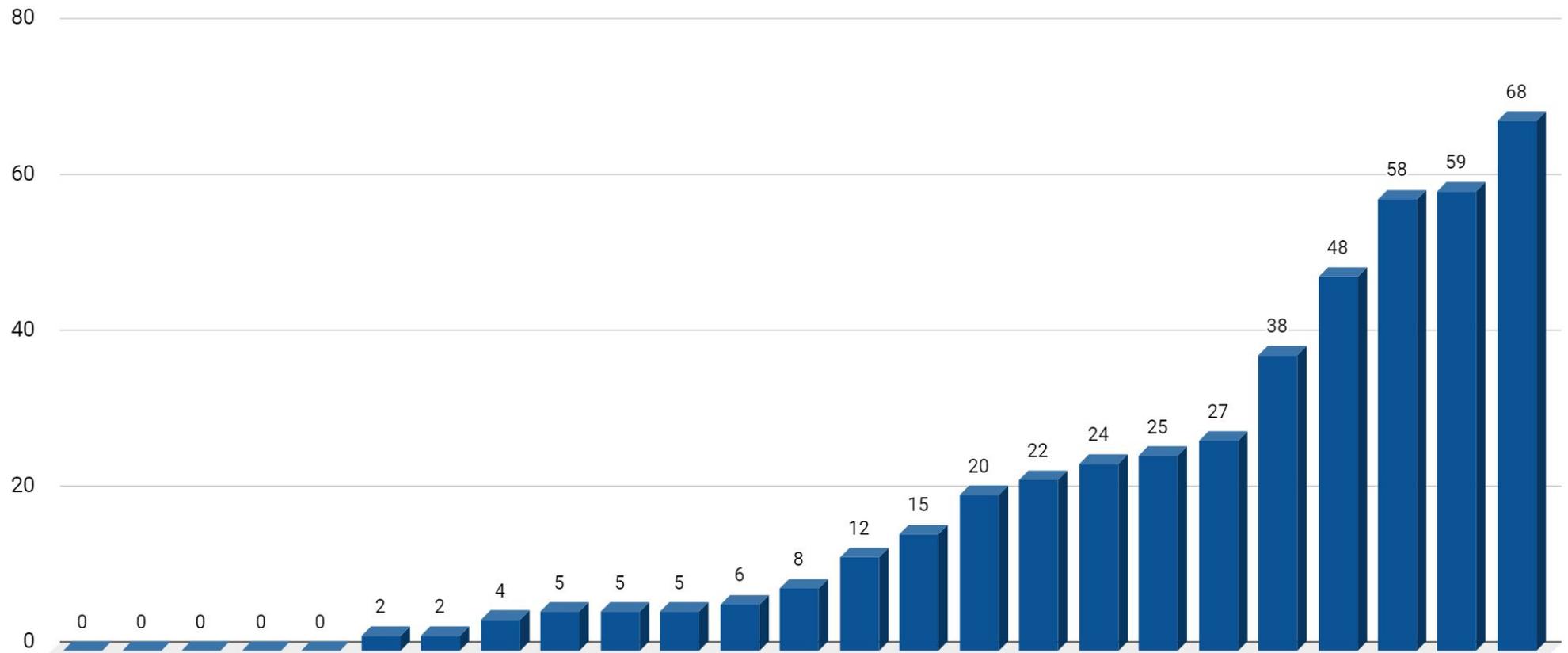
Participating in scientific conferences. Average number of conferences per year during the last 5 years.

Wet-lab testing (yes/no). If a company has laboratories equipped with appropriate plumbing, ventilation, and equipment to allow for hands-on scientific research and experimentation.

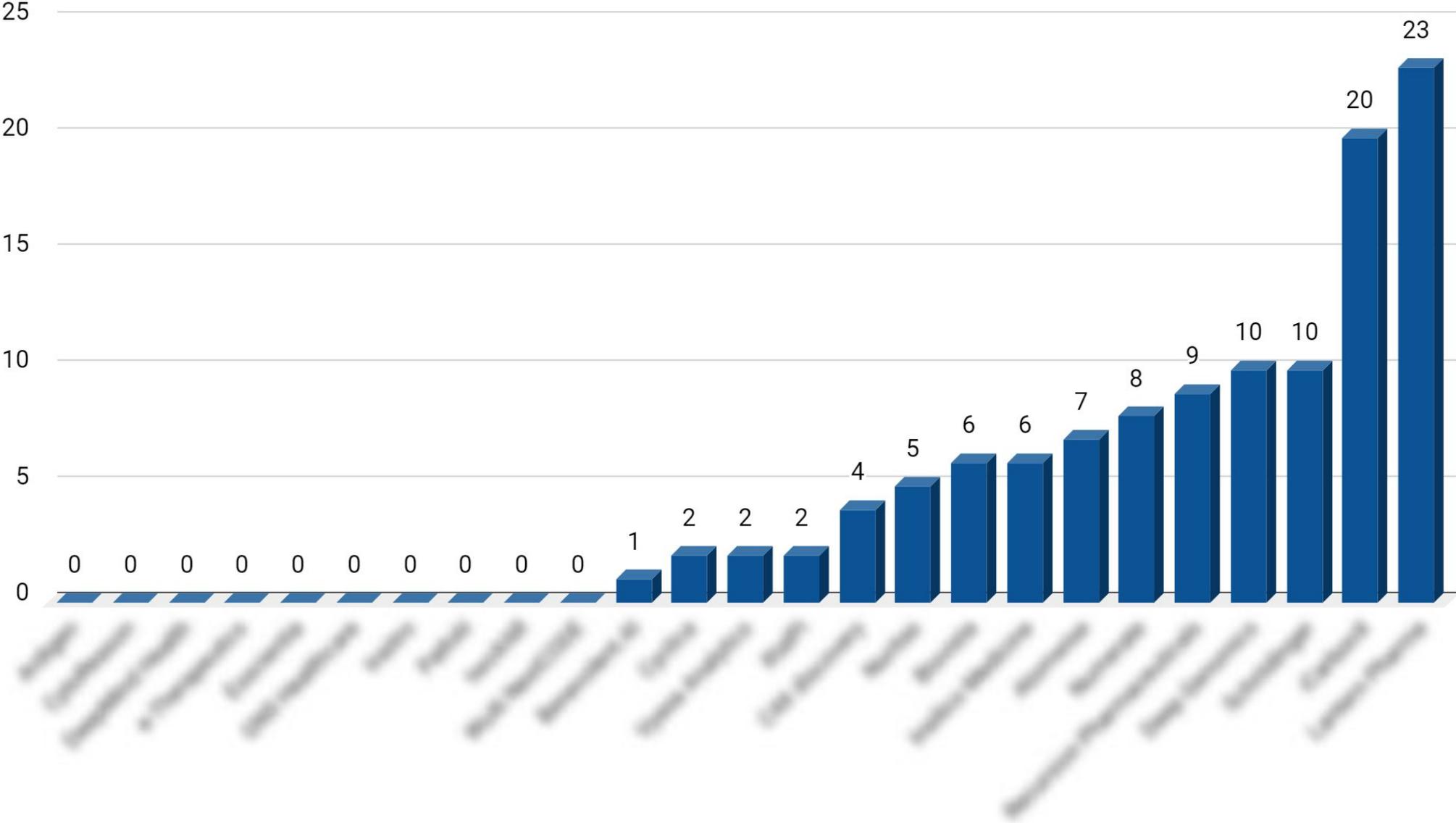
End-to-end clinical development (yes/no). If the full process of clinical trials is provided by a company, or some stages of the trials are processed outside the company.

Clinical trials. How many trials are ongoing and how many are successfully finished on humans/animals. On humans: finished +3, ongoing +2; on animals: finished +2, ongoing +1.

Number of Scientific Publications



Number of Patents



Financial Position

The company's financial position is one of the most important factors in analyzing an investment target. Financial position is the status of the assets, liabilities, and owners' equity of an organization. In the following list, the key points are highlighted and described. Here there are mostly presented relative figures and some well-known ratios.

Profitability -> ROA (numeric). An indicator of how profitable a company is relative to its total assets.

IPO (Numeric, currency). If a company done an IPO and the size of IPO of the company.

Series Funding Rounds (numeric). The number of Series Funding Rounds the company got after the first seed funding. The more additional rounds, the better, especially if the business is growing through outside investment.

Total funding amount (numeric, currency). Total funding amount raised across all funding rounds.

Annual revenue (numeric, currency). Shows if the products that the company sells have demand on the market.

Return on equity (numeric, currency). A measure of financial performance calculated by dividing net income by shareholders' equity. ROE represents how effectively management is using a company's assets to create profits.

Return on investment (numeric, currency). A performance measure used to evaluate the efficiency of an investment or to compare the efficiency of a number of different investments.

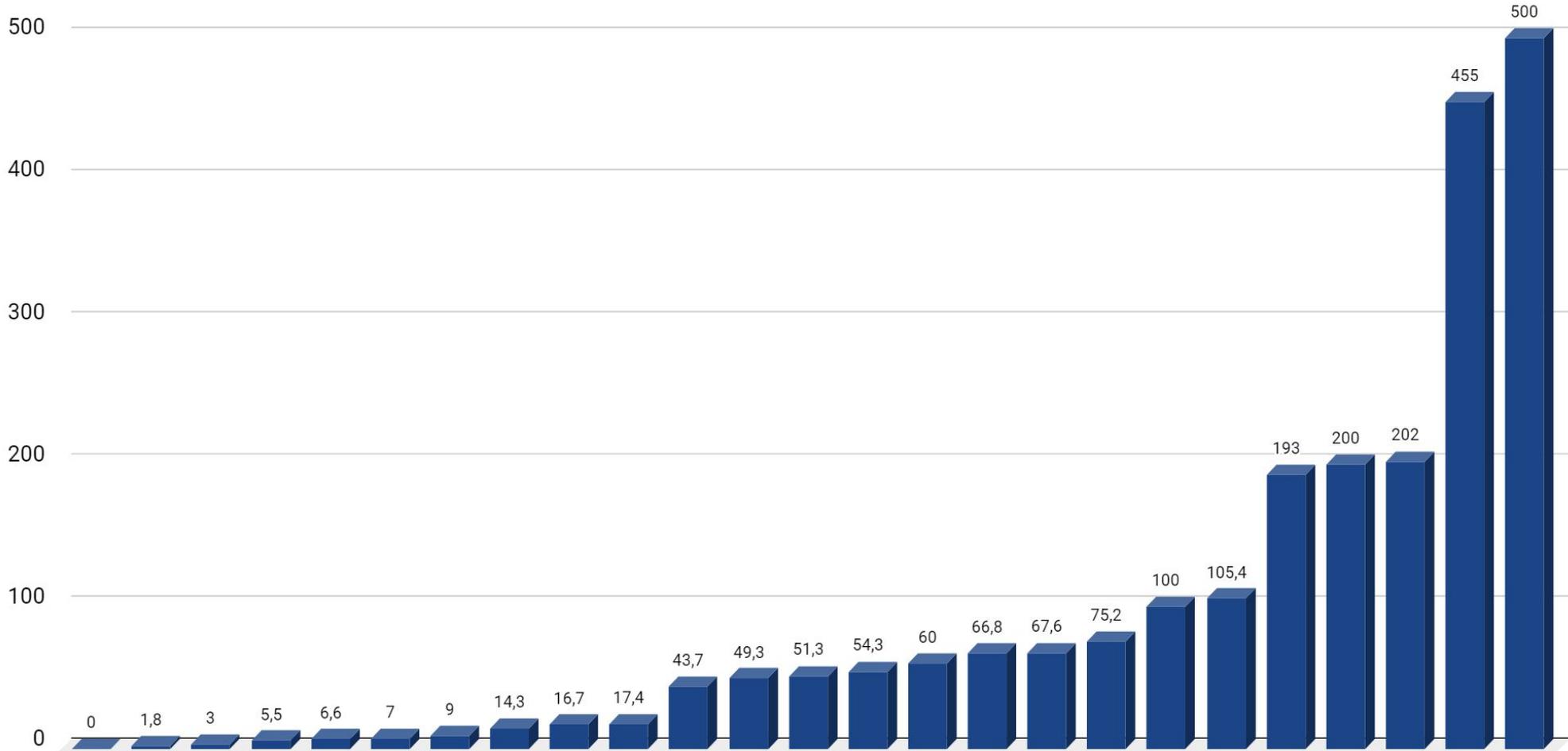
Ratio of funding to patents filed and grants (numeric, currency). How much funding is needed for the company to file a patent and to get a grant. It shows how efficiently the money is used.

Ratio of funding to clinical trials (numeric, ratio). How much funding the company requires to conduct a clinical trial.

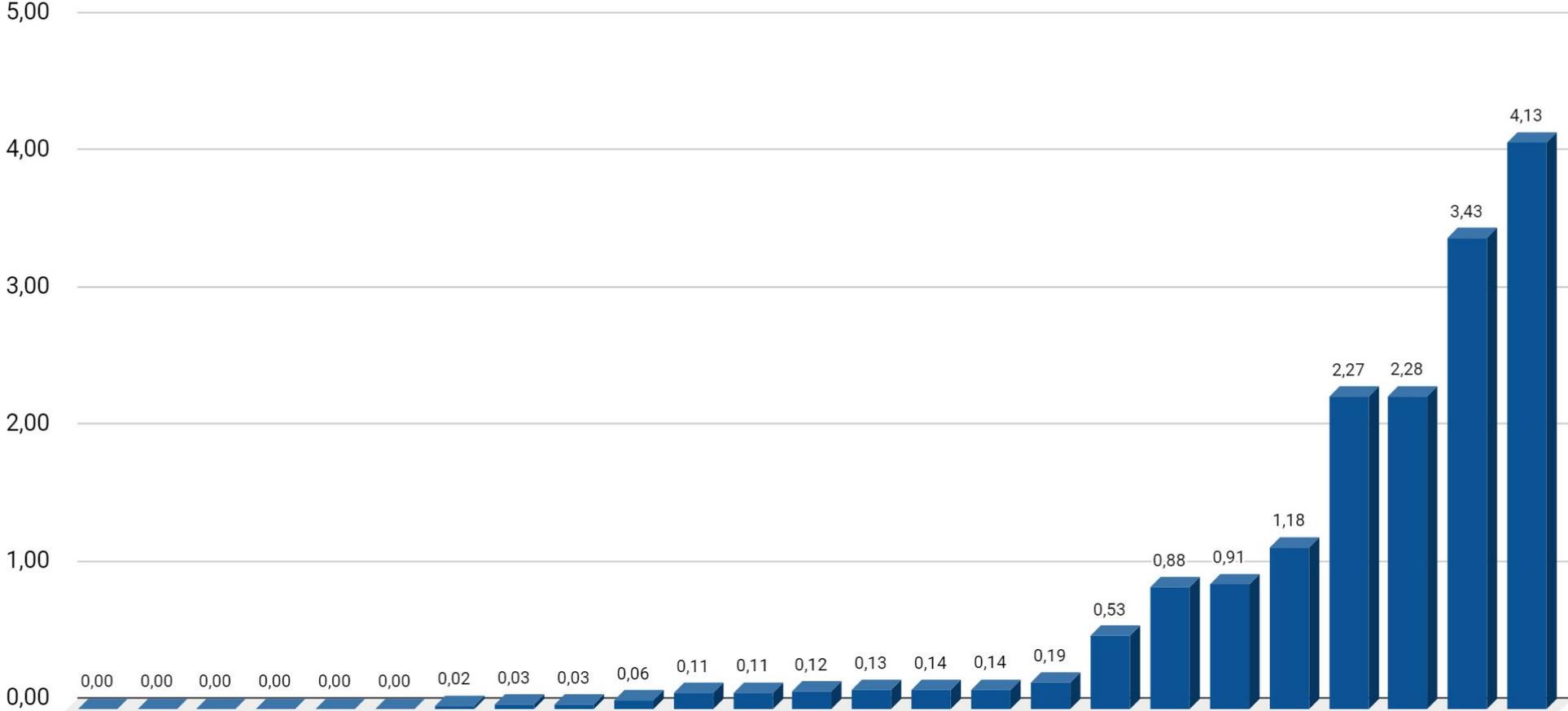
Number of investors (numeric). The sum of all the investors that invested in the company.

Number of subsidiary companies (numeric). The sum of all the subsidiary companies of the parent company.

Funding, in millions USD



Ratio of Scientific IP vs Funding



Focus level (Therapeutic Depth Factor)

Each strategy of Pharmacy and Healthcare industries process consists in creating and investigation of the impact of a product on a biological organization level or levels. This levels correlates with focus level (therapeutic depth factor). The more synthetic a company's product is in this regard, the higher its focus level, described as a depth factor. Usually, AI for Drug Discovery industry concentrates on the low therapeutic depth factors (e.g. Genomic or Biochemistry level) because of enormous complexity of processes in the higher levels like Organs or Tissue level.

For the focus level, the product shall be assigned one of 6 categories, each representing a particular therapeutic depth factor, listed below:

The Biochemistry Level (yes/no). Describes any research involving the small molecules that alter metabolic processes. Majority of AI for Drug Discovery companies develops small molecules, therefore work on this level.

Genomic (yes/no). Involving the artificial manipulation of natural molecular structures related to the expression of inheritance. This category includes DNA-RNA technology: gene therapy like CRISPR, gene silencing approach like siRNA.

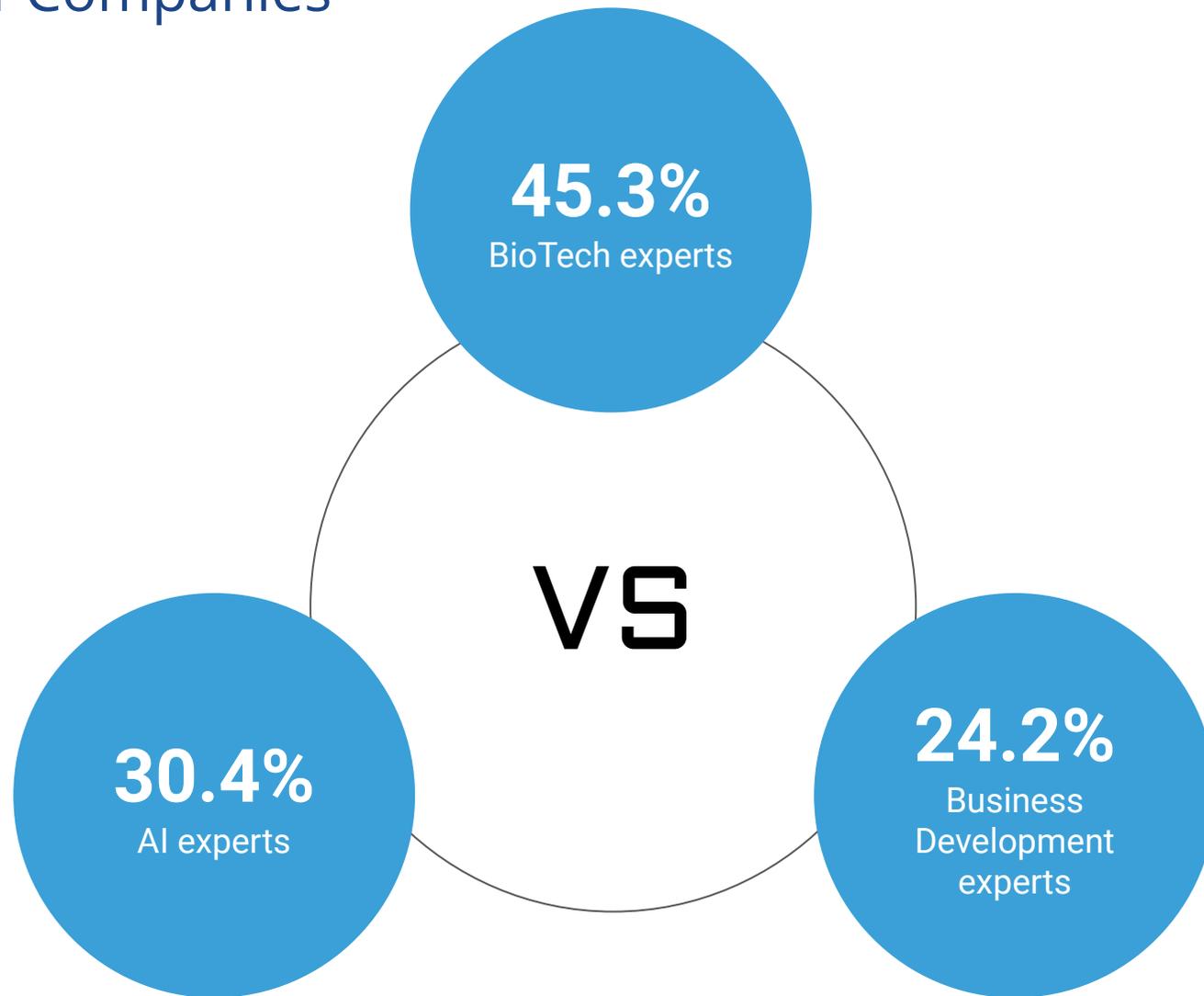
Proteins and cell signalling (yes/no). Individual protein studies, studying of cell signaling pathways and networks of protein-associated interactions such as protein-protein interaction, proteins-genes interactions.

Cellular (yes/no). Includes cell models, stem cells, regenerative medicine of human cells.

Tissue level (yes/no). This focus level represents a threshold at which interventions rely more on technological or engineering innovations than on basic research, which is generally considered sufficient in order to proceed with interventions at this level. This and the next level are the least popular among AI for Drug Discovery companies due to insufficient optimization of AI technologies to describe processes on these levels.

Organs (yes/no). Organoids studies, artificial organs development. At this focus level, even regenerative medicine is a supplementary technology.

AI experts vs BioTech experts vs Business Development experts In Top-25 AI-Companies



Most of the 150 AI-companies operating in the AI for Drug Discovery space on average have 15% of the stuff which can be considered as AI-experts. In the case of leading 25 AI-companies this bar raises up to 30% of the total amount of stuff. We might consider that the most balanced companies should be proportioned as 33% - AI experts, 45% Biotech experts, 24% - Business development specialists.

Technologies

Technologies are major drivers of advances in drug discovery. To identify promising drugs or biomarkers, create analysing platforms, and provide precious medical approach companies are using such technologies as machine learning, automation, nanofluidics, imaging, unique software and enhanced assay. Next metrics represent indicators of the variety of technologies which companies apply.

Use of unique technology (yes/no). Unique technologies allows companies to conduct research faster and at a lower cost, thereby reducing the number of in vitro tests and sending only the most promising drug/biomarker candidates to preclinical and clinical research. Companies which apply unique technologies are more competitive.

Artificial Intelligence (yes/no). AI is used to increase the performance. It is the best way to find the optimal solution for complex problems through emulating human respond behavior in pattern recognition and decision making.

Machine Learning (yes/no). It is used to increase the accuracy of the result through self-learning algorithms where the machine takes data and finds the solution based on it; in such tasks as assisted diagnosis, triage and prevention, clustering for the discovery of disease subtypes, and reducing medication errors via anomaly detection.

Bioinformatics (yes/no). Bioinformatic analysis can accelerate drug target identification and drug candidate screening and refinement, but also facilitate characterization of side effects and predict drug resistance. This growing importance lies also in the utility of bioinformatics tools to predict, analyze, or help interpret clinical and preclinical findings.

Deep Learning (yes/no). Companies which apply deep learning algorithms could be successful in genome interpretation and analysis of genetic variants, and other complex tasks that requires a combination of robust biological data and clinical knowledge.

Big Data (yes/no). There are key areas in pharmaceuticals where using Big Data plays a crucial role.

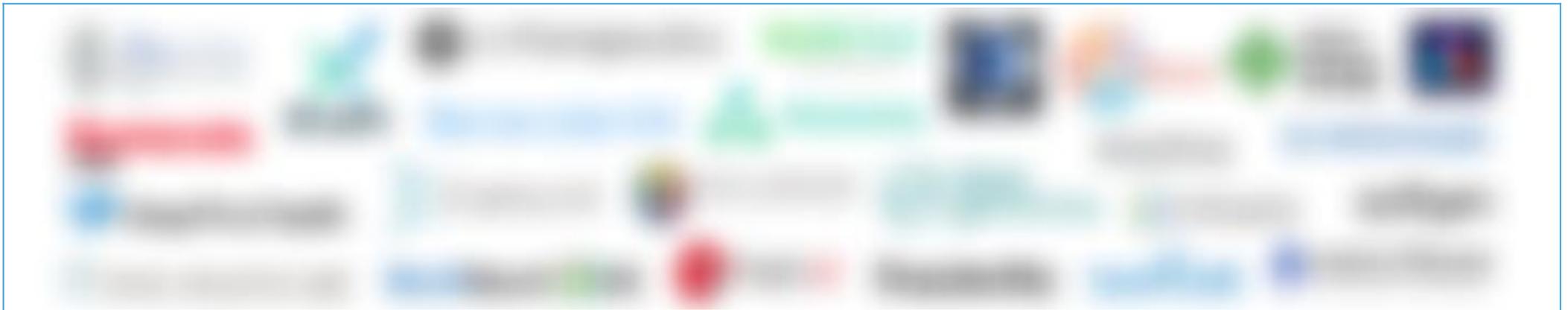
Cloud Computing (yes/no). Companies which apply cloud computing can leverage the cloud's real potential to accelerate drug discovery timelines.

Symbolic AI (yes/no). Novel methods that combine symbolic methods and statistical methods in Artificial Intelligence. It is an essential part of embeddings for analysis of biological and biomedical data.

“Advanced AI” Group

The companies in this section are active in the field of Drug Discovery and basic research. The following criteria have been used to attribute companies to the list of top 25 AI companies in Drug Discovery,

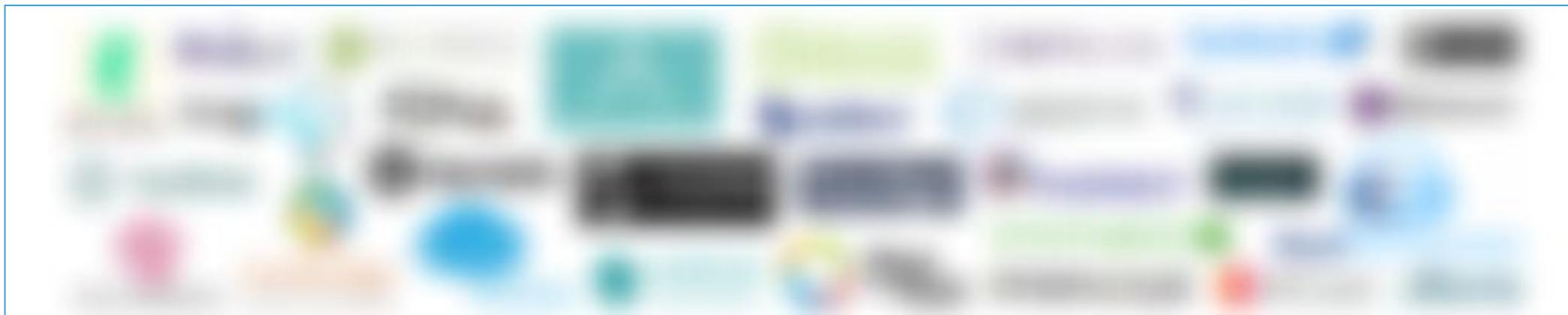
1. **Significant amount of patents and peer-reviewed articles in the domain of pharmaceutical research and AI technologies:** companies in this category are demonstrating significant advances in the application of AI to drug discovery tasks, which is reflected in a high number of research publications, public presentations and press-releases, patents. They usually have strong expertise both in drug discovery and development and in theoretical and practical aspects of AI technology.
2. **High ratio of AI specialists to other employees:** companies in this category typically have a decent number of employees with background in AI/ML/DL, which allows generating unique know-how and intellectual property. Importantly, these companies have strong interdisciplinary teams uniting AI and life science experts.
3. **Direct collaborations with some of the 30 Pharma and Tech Corporations:** an important indicator for a company to be included in this category is the availability of official research collaborations with some of the top 30 Pharma and Tech corporations, where they provide advanced know-how in AI-driven drug discovery.
4. **High level of AI tech promotion:** companies in this category are typically active presenters in high profile public events and forums; they appear in news and media regularly. They contribute significantly to promoting AI-driven approach to drug discovery and basic biology, educating the public by specific use cases, and establishing best AI adoption practises.



“Intermediate AI” Group

The companies in this group still have significant know how in the AI for drug discovery domain, they were chosen based on the following criteria:

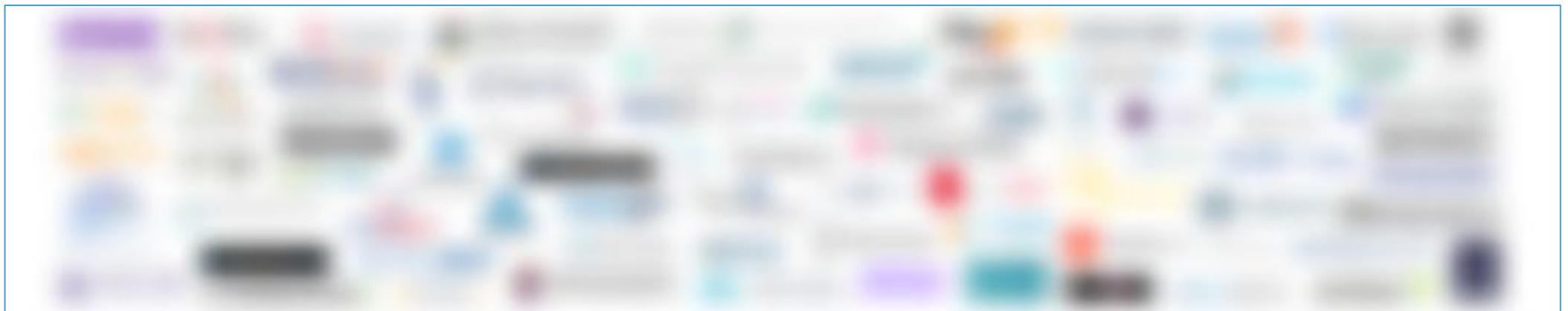
1. **Intermediate number of articles and patents:** their expertise is primarily in drug discovery or basic research, and they develop augmenting capacities in the AI-related technologies to boost core workflows.
2. **The ratio of AI specialist to other employees is average:** companies in this category typically have small-to-medium teams of AI experts collaborating with a core team of chemists/biologists.
3. **Direct collaborations with 30 Pharma and Tech Corporations:** companies in this category are supposed to have research collaborations with some of the 30 Pharma and Tech corporations, which is an indicator of a decent level of research capabilities.
4. **Average level of AI tech promotion:** companies in this list have a lower level of overall public presence and media coverage, compared to the “Advanced” Group. They participate in several top events regularly.



“Basic AI” Group

Companies in this group were chosen based on the following criteria:

1. **Low but non-zero number of research articles and patents:** these companies have a small number of research publications and/or patents covering only essential aspects of their technology. Typically, companies in this group are at the prototype or early validation stage of their technology/approach.
2. **The ratio of AI specialist to other employees is below average:** companies in “Basic” Group typically have a small number of AI-experts. They typically have early startup-like organizational structures, bootstrapping resources and human talent.
3. **Absence of officially announced collaborations with top 30 Pharma and Tech corporations:** companies in this list are typically in their early stage of development, and not yet established research ties with leading pharmaceutical or technological brands. Occasional companies in this list might just have entered in such collaborations lately, or are in the process of negotiation, though.
4. **Weak AI technology promotion:** companies in this list typically have small presence in media, public events and official forums. Their marketing teams are small, with the majority of resources allocated to developing core technological know-how.



Method of Final Company Score Calculation

To calculate the final score 4 types of values for each metric are applied:

- **“Raw value”** - the factual value of a metric (directly answers questions according to metric meaning). For quantitative value - number; for qualitative value - word (yes/no, high/medium/low, etc.)
- **“Metric value”** - the *row value* transferred into range [0.0-1.0]. For the quantitative value, it is defined with the formula: *row value* of a company divided by the maximal *row value* of the correspondent metric among all companies. For example, h-index of the X company equals to 5, when the highest h-index among all assessed companies is 20, subsequently, an h-index *metric value* of the X company: $5/20=0.25$. For qualitative value *metric value* is defined according to the meaning of *raw value*. For instance, if a *row value* is “high/yes” and the metric is favorable for a company (e.g. Top managers' qualification), correspondent *metric value* equals to 1.0. If such value is “low/no”, the *metric value* is 0.0. In contrast, if the metric is unfavorable for company (e.g. Region regulation), “high/yes” is equals to 0.0 and “low/no” - 1.0. Intermediary qualitative values, like “medium”, are in the range (0.0-1.0) (e.g. medium = 0.5).
- **“Weight factor”** - indicates how significant particular *metric value* compared to other *metric values* from other metrics. The factor is in the range [0.0-1.0]. If the metric is one of the most considerable among others (e.g Product type or Annual revenue), the *weight factor* for it is reaching 1.0. The least significant metrics (e.g. Events attended or if a company concentrates on Infectious diseases) have *weight factor* nearly 0.05-0.1.
- **“Final value”** - is the *metric value* multiplied by the *weight factor*. This comprehensive value takes into account the importance of a company's particular metric compared to other companies and to other metrics.

The final score of a company is the sum of all *final values* of all metrics.

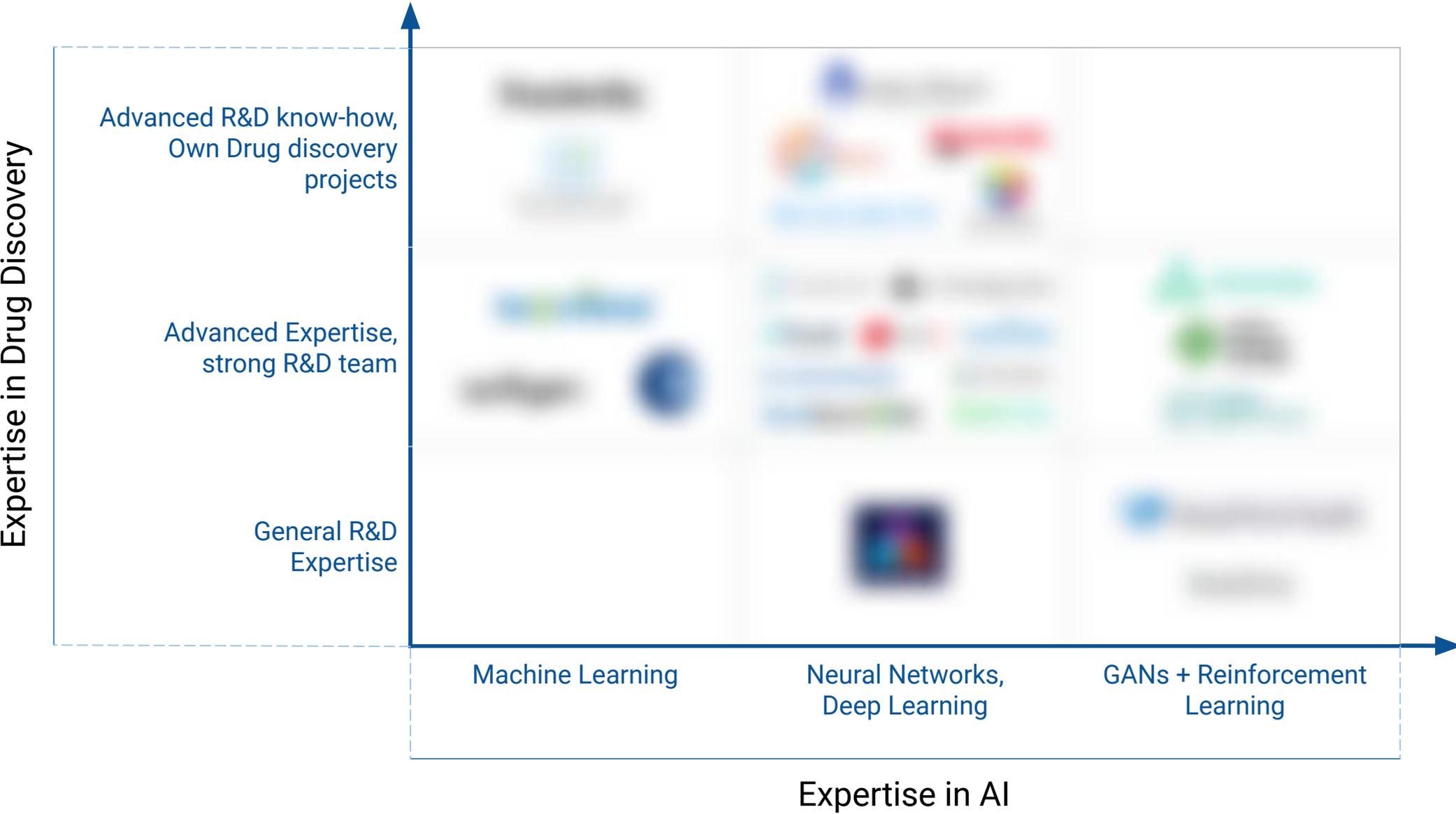
Comparison of Top-25 AI Companies: Level of Scientific Validation

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
Acugen	-	18/50	+	N/A
Atomix	+	6/37	+	N/A
Atomix AI	+	34/179	+	N/A
Avicenna	+	1/18	+	+
Cell Discovery	-	5/19	+	+
Cytiva	-	7/35	+	+
Cytosense	+	3/20	+	+
Deep Genomics	+	11/36	-	N/A
DeepMind Health	+	-	+	N/A
e-Therapeutics	+	5/20	+	N/A
Excelsior	+	4/37	+	+
Gen Healthcare	+	26/120	-	N/A
Genentech	-	22/117	+	N/A

Comparison of Top-25 AI Companies: Level of Scientific Validation

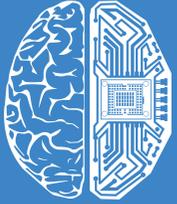
COMPANY	SCIENTIFIC PUBLICATIONS COVERING AI FOR DRUG DISCOVERY	NUMBER OF AI EXPERTS IN THE TEAM / TOTAL NUMBER OF EMPLOYEES	PUBLIC TALKS ON AI FOR DRUG DISCOVERY	VALIDATION
Amgen	+	16/47	+	+
Novartis	-	7/21	+	-
Roche	-	2/9	+	+
Novo Nordisk	-	4/16	+	+
AbbVie	-	4/55	+	+
Merck	+	14/80	+	+
Boehringer Ingelheim	+	14/135	+	+
Sanofi	+	37/400	+	-
Vertex	+	4/20	+	+
Moderna	-	3/10	+	-
Regeneron	+	13/218	+	+
Genentech	-	3/44	+	-

Comparison of Top-25 AI for Drug Discovery Companies Expertise in Drug Discovery R&D / AI



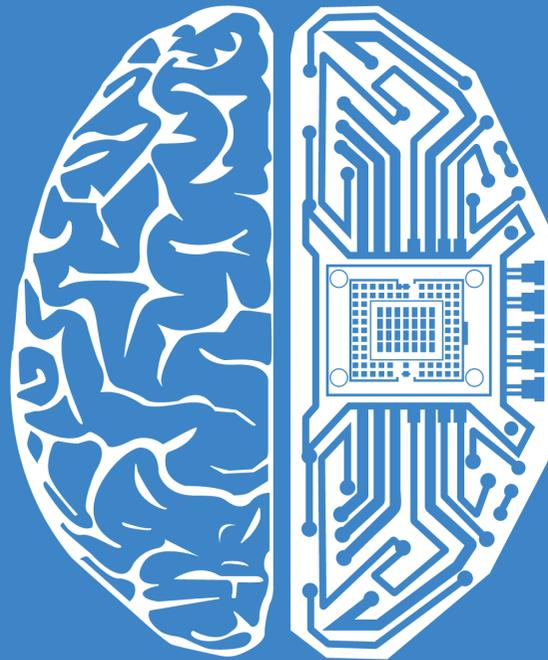
Classification of AI applications for R&D and Drug Discovery process

Hypothesis Knowledge Discovery	Target ID Biology	Compound Generation	Compound Binding	ADME Tox	Clinical Trials	Personalized Medicine	Real World Insights
				</			



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