Next Generation CROs

Differentiated technologies today that will pay-off tomorrow

October, 2020

Advisors | MEHTA PARTNERS

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Executive summary

- Global drug discovery R&D outsourcing is estimated to grow at a CAGR of 12% to reach $18B in 2025 from a current base of ~$10B
- Biopharma is riding on the wave of innovative technologies, from AI-driven discovery to real-world evidence platforms, from protein therapeutics to RNA modalities, from gene therapy to cell therapy, from precision medicine to companion diagnostics, etc.
- To cater to biopharma's evolving needs, a differentiated approach wherein CROs fully integrate as an extension of biopharma's R&D team, while offering advanced services, will yield long term relationships for sustainable growth
- It is timely for the CROs to consider a strategy anchored around some of the next generation, early stage technologies that will help differentiate among the peers and drive the growth in the coming years.
    - A handful of large (PPD, Charles River, etc.) and mid-size/small CROs (Crown Bio, Porton, etc.) are already investing in next generation early stage technologies from industry and academia
- MP group, with its >30 years of experience in Global Biopharma/CRO space, has identified several below-the radar opportunities and can catalyze your initiative to build a future-proof strategy for success

Differentiated technologies discussed in the report

Artificial Intelligence

- Proven cases in hit identification and lead optimization, off-target toxicity predictions, biomarker establishment are already gaining traction within the biopharma stakeholders
    - Partnerships between virtual discovery AI start-ups and experimental CROs with differentiated offerings will lead to a one-stop shop solution for potential clients

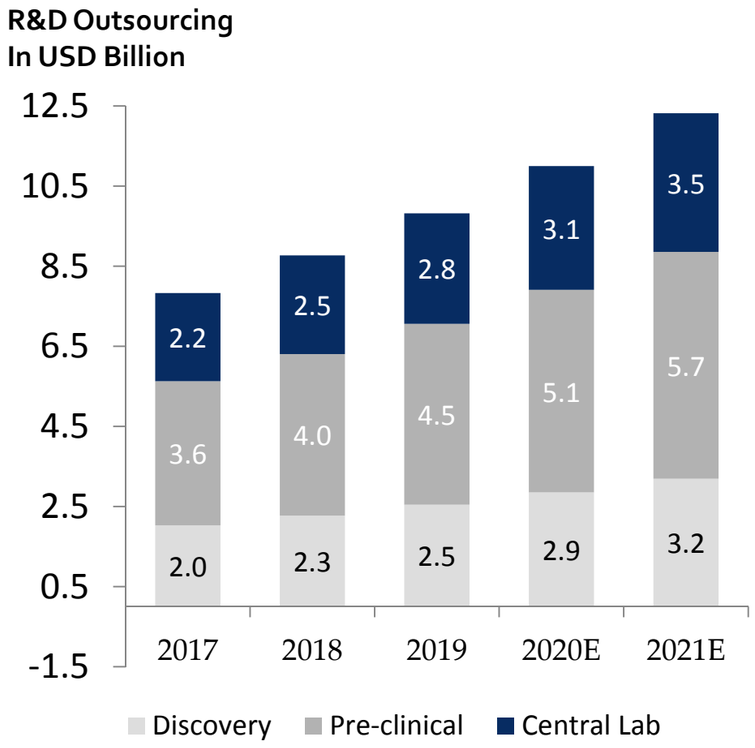
Biologics formulation technologies

- Companies are exploring differentiating technologies to either overcome the challenges associated with protein formulation or for life cycle management of their blockbuster molecules
    - CROs offering innovative-differentiated technologies for biologics will rise to the increasing need

Organ-on-a chip/3D Bioprinting

- Several big pharmas have adopted organ-on a chip and 3D Bio-printed tissues/models, owing to its potential to replacing animal testing for tox studies
    - CROs with select and validated technologies of disease/tissue specific models will gain competitive advantage

Global drug discovery R&D outsourcing was $8B in 2017 and is estimated to grow at a CAGR of 12% to reach ~$18B in 2025



Outsourcing Landscape

- Pharma cos often outsource discovery research functions to independent services providers to optimize cost structure and avoid the need to maintain redundant development capabilities globally
- Key drivers are -
  - **Rising costs of therapeutic development**: With rising costs of development (up nearly 14x since the 1970s) and commercialization of new therapeutics, it is financially impractical for companies to maintain redundant development teams and facilities, and biopharmaceutical companies are increasingly reliant on CROs to optimize fixed overhead costs and shorten the development timeline
  - **Increasing number of small and virtual biotechs:** Emerging biotechnology companies often lack infrastructure and leverage CRO expertise to complete necessary development processes instead of building in-house capabilities
  - **Focus on internal efficiencies**: Pharma cos are focusing on strengthening core capabilities and therefore, outsource several aspects of drug discovery and development process
- The overall R&D discovery expenditure is estimated to be $10 billion, with 25% penetration of outsourcing, while the preclinical R&D market is estimated to be $15 billion, and 30% penetrated by outsourcing

Source: IMS, Company reports, Citeline, FDA, MP Advisors

Today's stronger bio-pharma R&D environment is likely to fuel growth to pre-clinical drug discovery outsourcing space

- Biopharma R&D activity significantly improved over the last decade
  - Global biopharma R&D spending continues to steadily increase to ~$186B in 2019
    - Small- to mid-size biopharma R&D spending is growing 3-4x faster than top 20 global biopharma
  - FDA drug approvals and preclinical pipelines have significantly increased
    - Driven by rare/orphan disease and oncology research
    - 48 drug approvals in 2019
- Biopharma industry has moved beyond the significant patent cliff in 2012-2016
  - Believe there is less patent risk today

- Biotech industry is larger and better funded than a decade ago
  - Companies with active R&D pipelines have doubled
- In addition to pharma partnering, biotech is benefiting from a robust funding environment from capital markets/IPOs and VCs
  - 2018: Second-highest year for biotech funding on record after 2015
  - 2019: Exceeded 2018 investments
- Multiple sources of biotech funding provide balanced access to capital
  - Biotechs are estimated to have at least three years of cash on hand today due to broad-based investment in the sector
- Biotechs have limited internal infrastructure; rely on outsourcing to early-stage CROs like as flexible and efficient R&D partners

Average FDA Drug Approvals per Year	
22 2005-09	**40** 2015-19

Pre-clinical pipeline	
5100 2009	8500 2019

Sales at Risk Due to Patent Expiration	
28% 2012-16	18% 2018-22

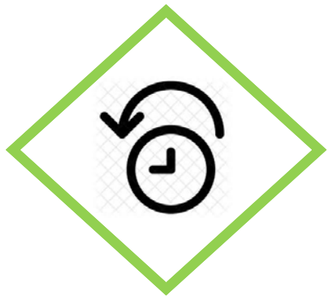
Companies with Active Biopharma R&D Pipeline	
1,965 2008	**~4000** 2018

Biotech Funding (Capital Markets/VCs)	
$94B 2005-09	**~$250B** 2013-18

Source: FDA.gov, industry reports, Citeline/Pharma Projects, Evaluate Pharma, MP Advisors

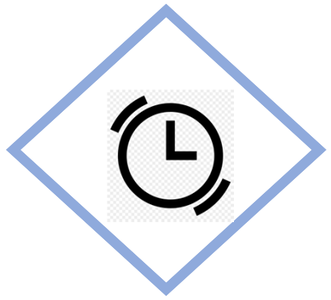
Biopharma is audacious on innovative technologies

It is timely for CROs to build a strategy anchored around innovative offerings and carve a niche



The Past

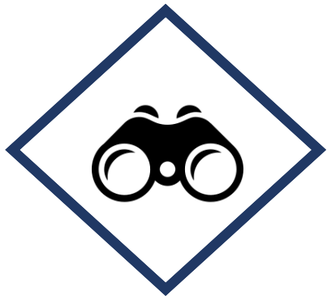
Historically, CROs have grown by building the scales for the services that pharma cos and biotechs wanted to outsource due to a number of reasons, from reducing the overheads, to cost-effective operations, to downsizing the headcount for effective management, etc.



The Present

Currently, operational efficiency, large scales and past experience have been the key value propositions, with relatively lesser focus on differentiated offerings, of course with a few exceptions.

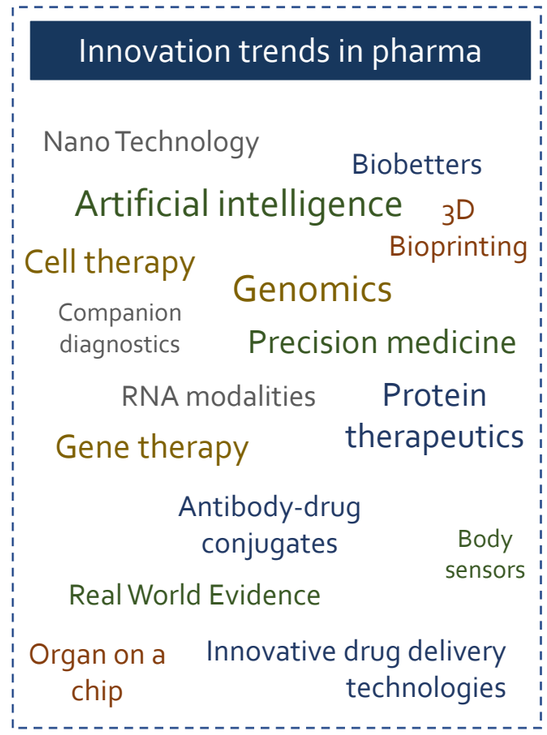
CROs are seldom the preferred partners for differentiated technologies/solution



The Future

An opportunity for CROs to create a niche and fully integrate as an extension of Biopharma's R&D team.

Anticipate biopharma's R&D needs and adopt innovative technologies, creating market differentiation that will potentially yield long-term sustainable client relationship



Next generation CROs

Adoption of innovative technologies will lead to the evolution of next generation CROs and their services

It is timely to adopt technologies that are in early stage and explore partnerships to create a win-win ecosystem

- Start-ups will benefit from the broader client exposure of the CROs and gain attraction from the industry & CROs will benefit from adopting cutting edge technologies to expand their services and portfolio, leading to increased clientele and revenue
- Only a handful of large (PPD, Charles River, etc.) and mid-size/small CROs (Crown Bio, Porton, etc.) are already ahead in the race as they are investing in next generation early stage technologies from industry and academia

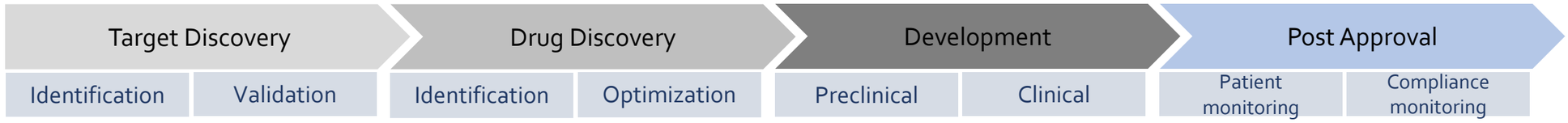
A few of these technologies are now at the verge of maturity and have started to gain interest from pharma companies. **3 such technologies and the related industrial landscape have been covered in this report:**

1. **Artificial Intelligence in Drug Discovery:** The potential of hit identification and lead optimization within months will create heavy reliance on AI-based platforms for early stage discovery
   - Partnerships between virtual discovery AI start-ups and experimental CROs with differentiated offerings will lead to one-stop shops for early stage discovery companies
2. **Biologics Drug Development**: Differentiating formulations of biologics will allow companies to extend patent life of their blockbuster molecules and retain the market share
   - Small molecule formulation CROs will have to upgrade their offerings to cater to the increasing needs of the biologics market
3. **Microphysiological Systems and 3D-Bioprinting:** Advanced toxicity predictions using AI followed by screening on MPS/3D models will replace animal testing
   - CROs having selected advanced technologies and disease/tissue specific models will gain competitive advantage

1 Artificial Intelligence and Drug Discovery

Applications of AI in drug discovery and development

AI-enabled solutions are emerging as a crucial tool for transforming drug discovery R&D, as it promises to cut down time as well as cost of new drug development, while reducing the risks of failure.



- Extract knowledge from literature to generate insights on possible hidden variables that may be important
- Identify competitive whitespace
- Generate novel target ideas by understating underlying disease mechanisms
- Identify a polypharmacology/Multi-target approach
- Validate targets using various computational models

- Analyze data sets, form hypotheses and generate drug candidates
- Analyze data from patient samples in both healthy and diseased states to generate novel biomarkers and therapeutic targets
- Repurpose currently approved drugs to rapidly identify new indications
- Conduct experimental biology at scale by testing 1000+ of compounds on 100+ of cellular disease models simultaneously
- Predict 3D structures of protein targets
- Predict binding affinity, ADMET and other pharmacological properties of molecules

- 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
- Automate matching patients to clinical trials through personal medical records and genetic analysis
- Improve pathology and sub-group analysis
- Improve patient monitoring and compliance in real-world settings

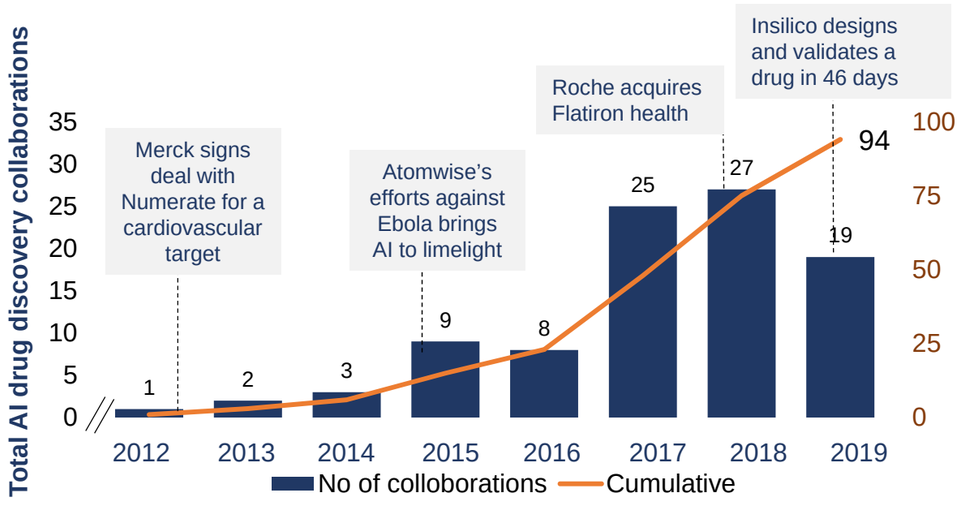
Source: Secondary Research, MP Analysis

Adoption of AI in pharma and CROs is increasing

AI R&D market is expected to cross USD $20 billion by 2025

45+ **Pharma companies and CROs** partnering with one or more AI based start ups

Global pharma: Adoption of AI has been the highest in the US, followed by the UK
Japanese pharma: Adoption is increasing among large pharma companies
Indian pharma: Adoption is low, with only a few companies exploring AI



Source: Secondary Research, MP Analysis

100+ **Deals spanning** a wide variety of applications

Majority of the deals are concentrated in early discovery, including target identification, validation and hit/lead discovery

Large CROs are investing and partnering with start ups to offer AI solutions for lead identification and advanced clinical trial solutions, creating a one-stop shops for Big pharma companies

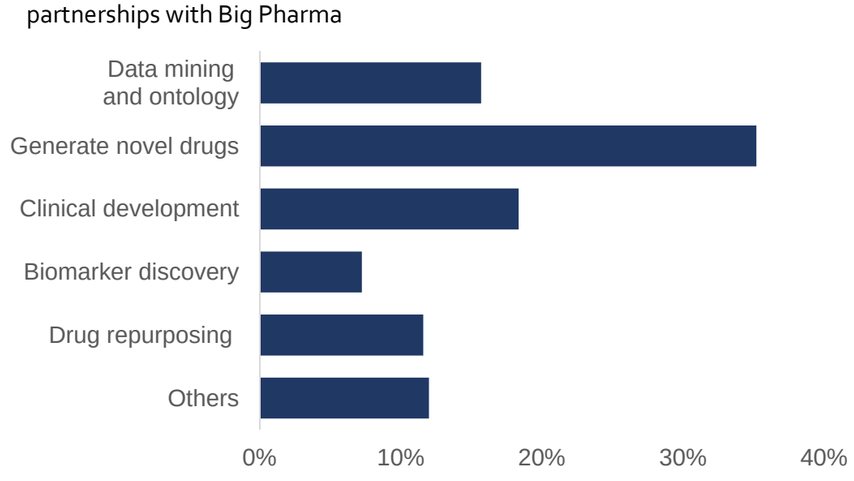
~50% of the AI-based companies focus on early stage drug discovery

Promising results already seen in oncology, infectious disease & neurology space

AI drug discovery companies by segment

Only a handful of companies have internal development programs, while majority of the companies work on a license-based model offering their software/AI platforms as a service, with high amount of flexibility

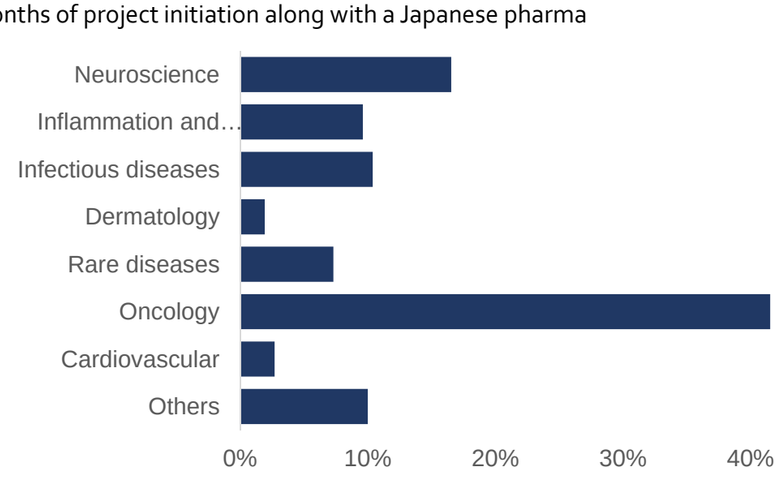
While most have capabilities specific to a vertical within the drug discovery or development value chain, A few of these companies have capabilities across all the functions. Some of these companies have already inked broad partnerships with Big Pharma



Pipeline of drugs using AI

Among 116 drug candidates identified using AI platforms at different stages (eg: ADMET prediction, sub-population identification) in development, several compounds focusing on Oncology, Neurology and Infectious Disease are in the late stage development. Results of completely AI driven and designed programs have also been recently reported

For e.g. Exscientia announced registration of a phase I trial for first completely AI-designed drug for obsessive compulsive disorder within 12 months of project initiation along with a Japanese pharma



Source: BenchSci, MP Analysis

Indicative

Strategic partnership with an early stage AI company: A mutually-benefiting relationship for long term success

Partnering with an early stage company will create a win-win ecosystem

- CROs will be able to gain exposure to cutting edge AI platforms with minimal investments and get a first-hand experience of the ability of these platforms to improve R&D efficiency with an opportunity to evolve the platform specific to the CROs needs
- Start-ups will be able to generate experimental proof-of-concept and validation of insights from the platform, as well as gain visibility to cater to a broader client portfolio

Atomwise-Charles River Laboratories
A commercial agreement to expand the services

Atomwise: An AI driven virtual screening platform that can predict binding of small molecule to proteins
Charles River: A fully integrated drug discovery CRO

Deal : CRO will offers its clients access to Atomwise's artificial intelligence (AI).
It will provide CRLs clients with the opportunity to efficiently screen billions, and evaluate thousands, of compounds to optimize potency, selectivity, and toxicity during hit and lead identification before committing resources to assays or syntheses.

As a result, clients are offered a one-stop-shop solution for drug discovery solution, while offering an opportunity to significantly improve R&D efficiencies and drug discovery timelines

VantAI – TaraBiosystems
A symbiotic relationship

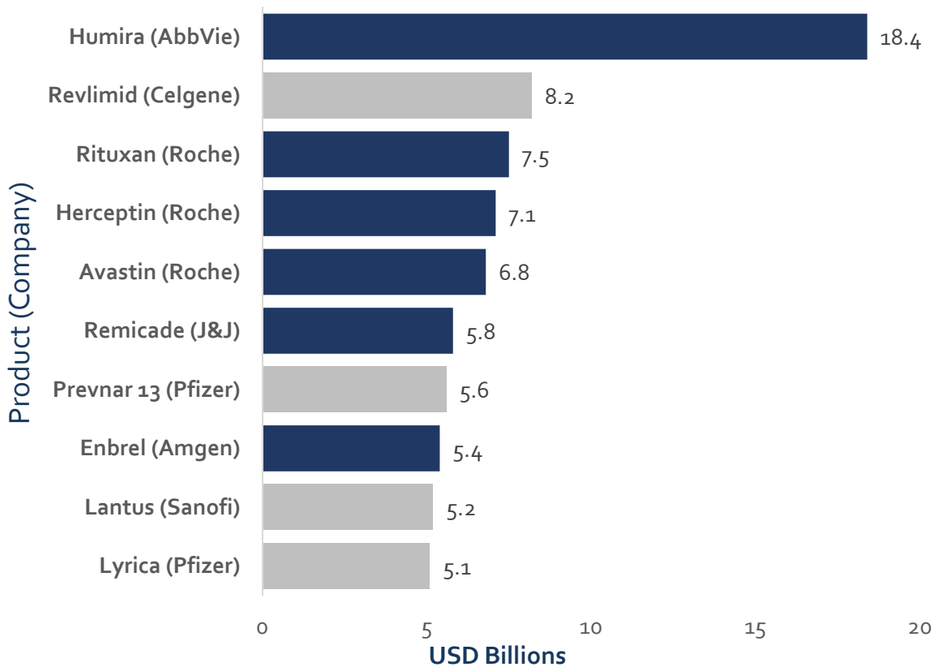
VantAI: An AI driven platform to predict toxicity of drugs, design and optimize new drugs
TaraBiosystems: An organ-on-a-chip company providing drug toxicity screening services and models

Deal: TARA, with its state-of-the-art in vitro human biology models, will leverage VantAI's computational capabilities to identify and develop new therapies to fight cardiac disease in-return provide proof-of-concept data to VantAI to improve their platform

Tight coupling of VantAI's in silico technology and TARA's in vitro human biology creates a high-throughput feedback loop for identifying and optimizing potential drug candidates for internal pipeline and for the clients.

2 Biologics Drug Development

Biologics market is huge and growing



Top 10 products by global sales - 2018 (monoclonal antibodies/fusion proteins highlighted in blue); Lantus is an insulin and Prevnar 13 is a vaccine

- Biologics 2019 sales worldwide are estimated at ~$250B, and expected to double by 2025
- Six of top-10 products by sales are biologics
- With a history of just three decades, biologics space is still evolving, and the coming decade will witness rapid maturation and transformation
- While the currently marketed drugs largely focus on three therapy areas (oncology, immunology and diabetes), ~25% of the pipeline targets other indication, including asthma and COPD, HIV, Parkinson's, and pain
- Within biologics, monoclonal antibodies, fusion proteins, and antibody drug conjugates hold a majority of the market share, and will continue to dominate in the coming decade.

Delivery of biologics faces major limitations…

- Each dose consists of high doses, and thus needs high volume of 10 to 100 ml
  - Such large volumes require intravenous (IV) administration, with patient tethered to infusion set-up
  - Such IV can take a long time to infuse, often in a hospital or a clinic, and several times a week
  - Subcutaneous (SC) administration will be much more convenient for patients, while saving cost associated with hospitalization, for which the ideal volume is <2mL
- Few current formulation technologies offer a customized solution
  - Halozyme, Reform Biologics, Excelse Bio, etc.
  - High cost
  - Their use of non-GRAS (Generally Recognized As Safe) excipients can add new toxicity issues

Market Opportunity – Protein Formulation Technology

A multi-billion dollar industry in making with at least few thousand protein biologics in development pipeline,

The biopharma pipeline consists of ~17000 distinct biologic products at various stages of development; 30-40% are potential candidates for high concentration protein formulation technologies.

- ~8000 of these products are protein-based biologics
- ~200 molecules are in Phase 3 or pending approval and likely to hit the market in the next two years
- ~800 and ~900 molecules are in Phase 2 and 1 respectively that will reach the market in 4 – 8 years
- ~6000 products in pre-clinical stage of development. Many others remain undisclosed
- **Early stage molecules, which are majority of the pipeline, are the ideal candidates for these platforms as the formulation development for such molecules can be done upfront**

Key areas of opportunity

Formulation of products in developmental phase	High concentration formulation of marketed products	Potential new applications
• Preclinical and phase 1/IND molecules are the key targets • Oncology products have the highest need of high concentration formulation (50% of the development pipeline)	• ~130 protein based biologics marketed to-date • Lifecycle extension to delay biosimilars threat • Formulation development for biosimilars/biobetters	• Decrease the dosing frequency by increasing the concentration especially in autoimmune space (~700 molecules in development) • Ophthalmic delivery of biologics (~300 molecules in development)

Leading biologics originators are developing in-house solutions, but larger set of cos would still benefit from such a technology

Competitive Landscape – Biologics Formulation Technologies

Parameters	Halozyme	Alteogen	Bhami Research Lab	Reform Biologics	Excelse Bio	Arecor	Arsia Therapeutics
Technology Principle	**Enzyme based technology to temporarily clear space under the skin and increase absorption of injected drugs**		**Viscosity Reducing excipients to formulate high concentration biologics**				
Lead Compound	Hyaluronidase (Approved drug)	Hyaluronidase	Nicotinic Acid + Tryptophan – GRAS ingredient	Caffeine	Amino Acids	Oligomers of ethyleneimine	Camphorsulfonic acid derivatives
Amount Of Excipient Needed	75 to 150 USP units	N/A	16 mg (HGG Conc. 270 mg) – 75% Reduction in Viscosity	22 mg (BGG Conc. 280 mg/mL) – 37% Reduction in Viscosity	No standardized protocol established yet	0.2 mg/mL to about 5 mg/mL	93 mg (BGG Conc. 260 mg) – 44% Reduction in Viscosity
Viscosity Reduction	Viscosity is not an issue since large volume can be injected	Viscosity is not an issue since large volume can be injected	Works on all the tested proteins	Works on a limited number of tested proteins	Works on a limited number of tested proteins	N/A	Works on a limited number of tested proteins
Stability	Stable for 2 years at 4°C	Higher thermal stability as compared to wild type human hyaluronidase	6 months at 4 and 25°C. Further studies on-going	No stability data available	No long term stability data available	6 months at 40°C	100 days at 4°C and 7 days at RT.
Toxicity	Thrombosis or hypersensitivity reaction during injection	Lower risk of toxicity shown as compared to wild type human hyaluronidase	No toxicity. These excipients are extensively used in parenteral formulation	Serious toxicity was seen blood concentration of ≥ 50 mg/L	No toxicological data available	Higher the size of oligomer, higher the cytotoxic effect	Toxicology data available with limited CSA derivates
Available For Partnership	Yes	Yes	Yes	Yes	Yes	Yes	No
Ophthalmic Use	No	No	Yes	No	No	No	No

3 Micro-physiological Systems and 3D Bioprinting

Microphysiological Systems (MPS) – Organ on a Chip

Improving clinical predictability of in vitro studies

Background

- Drug development witnesses high failure rate largely due to poor translation between 2D in-vitro > in vivo > clinical data
  - ~90% of the drugs validated in pre-clinical studies fail during the clinical development
  - Depending on the stage at which it fails, there is immense cost and time burden associated with such failures
- Therefore, physiologically relevant in vitro models with better predictability can potentially save tremendous amount of time and cost
  - Such models can potentially reduce, if not eliminate, the requirement of animal studies, where the translation to clinical response has anyway been poor; often times, 3D culture models used do not adequately represent human biology

MPS

- MPS attempts to model physiological and mechanical functions of a human organ
- MPS are developed by integration of several areas of research:
  - Microfluidics
  - Microfabrication
  - Tissue Engineering
  - Cell Biology and Physiology

Applications

- MPS can largely be used in the following areas
  - Safety Testing (Toxicology)
  - Efficacy Testing
  - Modeling diseases for better understanding of the mechanism
  - High throughput screening
  - Precision medicine

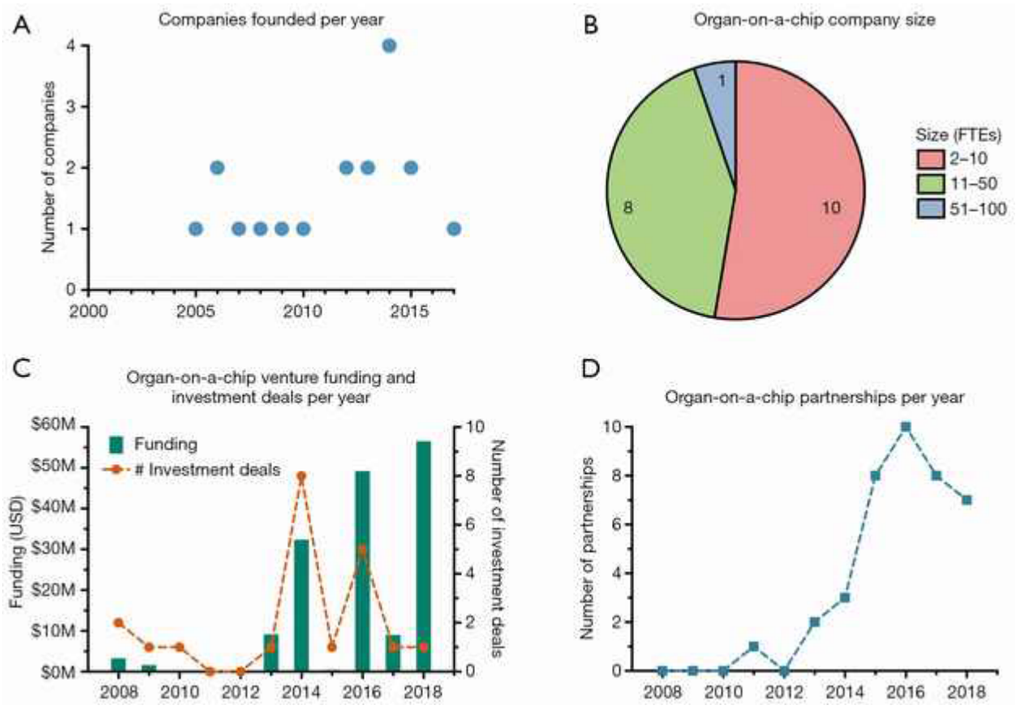
Market Overview

Indicative

MPS has the potential to save cost as well as cost in drug development, while avoiding failures

- The MPS market is likely to increase from a low base of ~$30m in 2018 to ~$150m in 2025 at a CAGR of ~25%
- 1-2 companies focusing on MPS founded every year between 2015-2018. Of those companies, most of the companies have FTEs either between 2-10 or 11-50
- Only a handful of companies have started making notable progress, with players like TissUse and Mimetas now realizing recurring revenues
- There has been a fluctuation in the number of funding deals with relatively modest quantum of investment
  - MPS focused companies have obtained ~$100m in funding between 2008-2018, with about 20 deals
- An increase in the number of industry partnerships between 2012-2016 however, a declining trend is observed in the last 3 years
- In addition to the companies, MPS models are also being developed by academic labs

Key Statistics



Note: Each of these points can be discussed in greater detail. The statistics are only based on publicly available information

Market Overview

Most technologies are at a proof-of-concept stage – A key reason for the low revenue base

- Most of the available technologies are still at a 'proof-of-concept' stage, leading to limited use
  - The industry expects a scaled-up models with validated processes and outcomes
  - Currently, no models are accepted by the USFDA or any other regulators
  - MPS often have concerns regarding reproducibility as well as automation
  - Moreover, MPS often has challenges integrating to the existing workflow and equipment

As MPS industry matures, will CROs start getting involved?

- CROs are the preferred contractors of pharma cos for safety and efficacy testing
- While CRO's exposure to MPS is minimal, strong validation data is likely to generate interest

Early stage of MPS space offers an opportunity for CROs to cultivate and develop select few technologies

Note: Each of these points can be discussed in greater detail

3D Bioprinting: The latest advancement for toxicity prediction

A reproducible and scalable fabrication strategy providing precise 3D control compared to conventional microfluidic tissue fabrication methods

Background

Bioink: The biomaterial solution used in bioprinting of living cells is referred to as 'bioink'. In bioprinting processes. There are four main types of bioink materials utilized including hydrogels, microcarriers, cell aggregates, and decellularized matrix components. Cell aggregate-based bioink materials can be further classified into three: tissue spheroids, cell pellet, and tissue strands

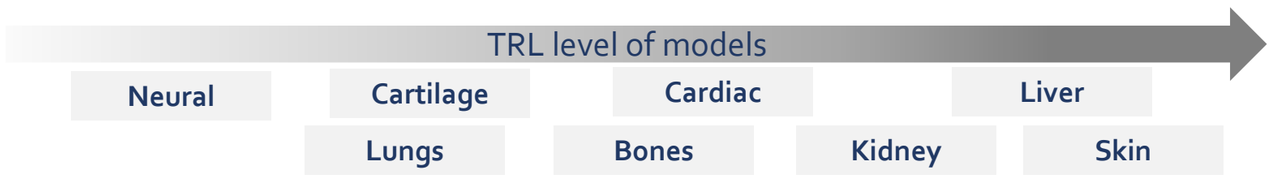
MRI/TEM images are used to computationally model the tissues, which are then 'Bioprinted' using bioink and specialized 3D printers

Advantages

Enables high throughput fabrication of anatomically precise patterning of cells and tissue constructs according to the medical image data obtained from patients and can also be personalized by taking patients cells

Allows fabrication of porous structures with controlled architecture, with ability to coculture multiple cell types locally

Has the ability to integrate vascularization within engineered tissues to mimic the form and function of native tissues in the body



Use of 3D Bioprinting in Drug Discovery and Cosmetics Testing Expected to Reach $500 Million by 2027[1]

Some providers sell 3D printers and relevant Bio-inks, some provide services and a few have licensed or partnered their technologies

Source: Company reports, MP Analysis, [1] smart-tech analysis

Case Study

Organovo – An early stage technology gaining traction

Organovo has demonstrated proof of concept in its 3D printed liver and kidney models. Additional partnerships going on for skin and other models

Background - Based in San Diego, CA, Organovo Holdings was founded in 2007 with a focus on generation 3D tissues for drug discovery applications and printing 3D organs

Funding to date: $43.7 million; **Business model**: Partnerships to develop specific models

Technology - Utilize primary human cells to produce in vivo-like physiology most relevant for drug testing and therapeutic applications, many of the input cells sourced through its subsidiary, Samsara Science. The bio-ink building blocks are then dispensed from a bioprinter, using a layer-by-layer approach that is scaled for the target output. Proprietary biogels may be incorporated for temporary support or as filler to create channels or void spaces within tissues to mimic features of native tissue.

Early Highlights– Presented data demonstrating retention of key liver functions in bioprinted tissues for up to 40 days and additional data demonstrating that its 3D liver tissues exhibit dose-dependent responses to acetaminophen, a known liver toxicant, and that the toxic effects can be assessed using both standard screening assays and histopathological assessment of the treated tissue

Select deals

Year	Partner	Deal type	Comments
2015	Merck	Partnership	Merck gained access to Organovo's exVive3D bioprinted human liver tissue and included developing other tissue models using Organovo's NovoGen bioprinting platform
2015	L'oreal	Partnership	development, validation and commercial supply of skin tissue. L'Oreal will fund the first two phases, and if the skin tissue develop is being used for skincare products, the firm will have exclusive rights to the skin tissue
2016	Roche	Partnership	3D bioprinted human liver tissues used detect significant dose-dependent toxicity of trovafloxacin at clinically relevant doses, compared to levofloxacin, a structurally related, but non-toxic compound. The hepatotoxic potential of trovafloxacin was not originally identified by traditional preclinical tests including animal studies
2019	Viscient Biosciences	Alliance Sister company	expand upon Organovo's current service portfolio for compound screening in disease models, which aids the drug discovery work of the company's customers. Viscient is targeting early discovery work for non-alcoholic fatty liver disease (NAFLD) and non-alcoholic steatohepatitis (NASH)
2019	CSL Behring Australia	Collaboration	To develop bioprinted tissue based treatments for kidney diseases

Source: Company reports, MP Analysis

MP Group can catalyze your initiative

With over 3 decades of diverse experience and integrated perspective in domestic and global BioPharma/CRO space, and deep understanding of upcoming technologies, MP Group has the capabilities to help you

MP Team will be happy to be an extension of the management team and help with one or more of the below initiatives:

- Asses the internal capabilities and identify the key business segments that can benefit in short term and long term by adopting these new technologies
- Leverage MP's global network to identify potential below-the-radar opportunities for partnering or investment, unique to the vision of the company, in the shortlisted areas of interest
- Develop a robust opportunity assessment framework with the desired criteria and evaluate the relevant opportunities against the framework
- Prepare a detailed business case for each of the shortlisted opportunities and approach the potential partners — jointly or individually, as appropriate
    - Assist in the discussions, partnership/deal structure, negotiations in consummating the partnership
- Technical due diligence to investigate the technologies best suited for the need

THANK YOU.

We invite you to write to us -

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Competitive landscape- Selected AI companies

Indicative

Name	Year Founded	Location	AI experts/ total employees	Funding $m	Applications	Pharma /*CRO* Partners
Atomwise	2012	US	0.20	51.3	Uses Deep Learning Neural Networks to help discover new medicines.	Monsanto, Merck, Pfizer, Abbvie, Lilly, *CRL**
Insilico Medicine	2014	US	0.35	51.0	Predicts pharmacological properties of drugs and identify novel biomarkers with focus on aging and related diseases	GSK, Beijing Tide pharma, A2A pharma
XtalPi	2014	US	0.10	67.5	Predicts crystalized form of drug and understands its safety, stability, and efficacy	Pfizer *
Exscientia	2012	UK	0.15	43.0	Processes drug discovery data and generates potential drug candidates; takes one-quarter of the time as compared to traditional approaches.	Janssen, GSK, Sanofi, Evotech, Sunovion pharma
TwoXAR	2014	US	0.22	14.3	Screens compound libraries for efficacy; identify new targets and drugs from a public library	Santen pharma, Ono pharma, SK biopharma
Numerate	2007	US	0.25	65.0	Predicts PK/PD of a potential drug, with a focus on neurodegeneration, cardiovascular disease, and oncology	Takeda, Boehringer Ingelheim, Merck
Numedii	2008	US	0.2	3.5*	Identifies connections between drugs and diseases at a systems level to identify new drugs	Allergan, Astellas, Aptalis
Cyclica	2013	Canada	0.27	7.0	Considers the polypharmacology, pharmacokinetics, and structural pharmacogenomics of molecules for minimizing off-target interactions	Merck, Bayer *
Recursion pharmaceuticals	2013	US	0.13	226	Identifies new indications for many known drugs and predict efficacy	Takeda, Sanofi *
Schrodinger AI	2016	US	0.10	193	Ideate, optimize, and analyze drug candidates. Evaluate chemical compounds in silico ahead of synthesis and assay	Sun pharma, Bayer, WuXi Apptech, ono pharma

Majority of the companies are in the early stage therefore, the precise revenue and market share may not be available

***other undisclosed partners**

Competitive Landscape: MPS (1/4)

Indicative

Company	Year Founded	Location	PE Investor	Funding ($m)	Application	Pharma Partners
Barcelona Liver Bioservices	2017	Spain	-	-	Liver Diseases: Obtaining pre-clinical data in partial and non-physiological experimental models, EXOLIVER®, RODENT MODELS, LIVER CELLS, TISSUES, ORGAN ON A CHIP	IDIBAPS, Caixa impulse Conatus Pharma, Gilead, Ready Cell, Brudy Lab, Gattx,
BiomimX	2017	Italy	-	-	Generation of predictive models of human organs and pathologies, Heart, Precision Organ Model. uBeat technology allows to apply a controlled, uniform and uniaxial strain to 3D cell constructs within a micro scaled platform BIOMIMX'S HEART-ON-CHIP: Allows for the generation and culturing of miniaturized 3D cell culture models BIOMIMX SRL: designed as drug screening tools.	EIT Health
BI/OND	2017	Netherlands	-	-	Offers platforms for complex 3D tissues (organoids, ex vivo tissue, spheroids, micro tissues) cultivation as well as tissue-tissue interface models, Chip for Ex Vivo Tissues, Organoids, Micro tissue, Chip for tissue-tissue interface models and The Plate model.	InforMed, EIT Health, NOW, Health-Holland, Tudelft, ECSEL, Yes Delft, STW, Nanonextnl, hDMT
4Design Biosciences	2015	USA	-	-	Vascularized micro-organ (VMO) platform chips: Chemical library drug screening, Drug ADME and toxicity testing, Optimization of combination drug therapies, Personalized medicine, Vascular Pathology, etc.	-
Ananda Devices	2015	Canada	-	-	Predective Human Models, Microfluidic devices made of biocompatible silicone, organ-on-a-chip technology	-
AIM Biotech	2012	Singapore	DRAPER VC, MirXES Innov	-	3D versus 2D cell culture: Microfluidic devices for cell culture	Fisher Scientific, Tebu-Bio

Competitive Landscape: MPS (2/4)

Indicative

Company	Year Founded	Location	PE Investor	Funding ($m)	Application	Pharma Partners
Charles Stark Draper Laboratory (Draper)	1932	USA	-	-	BIOMIMETICS: Predict the effects of drugs on multiple-organ systems in humans using human tissue. EVIDENT: Microfluidics help preclinical researchers to pinpoint effective immunotherapies for cancer PREDICT96: Make preclinical testing for drug development more predictive	Tec starts, Greentown Labs, Masschallenge, Massachusetts Eye and Ear Infirmary
Aspect Biosystems	2013	Canada	Pallasite Ventures, Panagaea Ventures, Innovate BC, Endure Capital, Reolentless Prusuit, UCB seed Fund	25.0	Microfluidic bioprinter, Microfluidic printheads, Customizable biomaterials, Tissue therapeutics, Musculoskeletal Injuries & disorders, Metabolic disorders, Cell Biology, 3D printing.	GSK, JSR Corporation, Depuy Synthes,Merck
CN Bio Innovations	2009	UK	CITIC Securities	11.5	Predictive Human Models, Microfluidic devices made of biocompatible silicone, organ-on-a-chip technology	Zyoxel,AstraZeneca, Ionis Pharma, , Bristol-Myers Squibb, Alnylam, Benitec, Tianjin Weikal Bioeng
Allevi	2014	USA	-	3.6	Bio Ink for Liver, Heart, Bone, Cartilage, Kidney, Nervous Systems, Skin, Vascularization, Lung, Brain Bio Printer: Allevi 1, Allevi2, Allevi3	-
AxoSim	2014	USA	-	3.5	Nerve-on-a-Chip ® technology, D Mini-Brain technology	-

Competitive Landscape: MPS (3/4)

Indicative

Company	Year Founded	Location	PE Investor	Funding ($m)	Application	Pharma Partners
CorSolutions	2007	USA		2.7	Fluid Delivery Control: Flow Rate versus Pressure 3D Cell Culture: Human Umbilical Vein Endothelial Cells are seeded onto optically transparent flow cells and subjected to shear stress using precision pumping; cells align in the direction of the flow. Stop Flow: Using the PneuWave software's preset flow rates, the user can quickly change flow rates to easily manipulate particles or cells	-
Creo Bioscience	2013	Japan	Nissei Capital	0.89	On-demand of Body on a Chip technology, drug discovery/diagnosis technology, and microfluidic device type cell culture device.	
BeOnChip	2016	Spain	EASME, Executive Agency for SMEs	0.077	BE-GRADIENT: Allows to perform cell cultures under chemical gradients BE-TRANSFLOW: Allows a combination of a 2D-3D organized coculture E-FLOW does in vitro simulation of physiological environments involving flow and shear stress. Long-term 2D or 3D experiments in two independent channels under flow conditions, BE-DOUBLEFLOW: Allows a combination of a 2D-3D organized coculture with the possibility of establishing flows with or without cells over the epithelium.	-
AlveoliX	2015	Switzerland	Venture Kick, Eurostar	0.003	Organs-on-Chip Technologies, Lung-on-Chip Model, Lung-on-Chip Technology, Lung-on-chip for inhalation toxicology	Israel Institute of Technology, ARTORG Centre, Helmholtz Institute Saarland
Mimetas	2013	Netherlands	NA	29.5	**OrganoPlate®**: The OrganoPlate® is a microfluidic 3D cell culture plate, supporting up to 96 tissue models on a single plate	Hubrecht Organoid Technology, Roche, Molecular Devices Corp, Galapagos NV

Competitive Landscape: MPS (4/4)

Indicative

Below are some of the other key companies with a focus on microphysiological systems and 3D Bioprinting. MP Group is actively tracking majority of these companies

- MPS
- 3D Bioprinting

Company Names		
Curiochips	INTENZE Products	StemoniX
Denz Bio-Medical	Iontox	Stratec Consumables
Elveflow	Javelin Biotech	Sun Bioscience
Emulate	Jiksak Bioengineering	Syneos Health
EpiSkin	Kirkstall	Synvivo
ESA	MicroBrain Biotech	Tara Biosystems
Fluigent	Microfluidic ChipShop	Tebu-bio
Hesperos	Micronit	TissUse
Hurel Corporation	MiniFAB	WYSS Institute
imec	NeoFluidics	Xona Microfluidics
InSphero	Nortis	Organovo
Cyfuse Biomedical	EnvisionTEC GmbH	Poietis
Aspect Biosystems	Regenovo Biotechnology	Cellink
Stratasys	Allevi	FUJIFILM Wako Automation