DEEP TECH
DEEP DIVE

Presented in part with the 2021 DeepTechU venture conference

POLSKY Center for Entrepreneurship and Innovation
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DEFINING DEEP TECH

Deep tech is an interdisciplinary approach to solving fundamental issues – one that leverages several advanced technologies to reimagine what is possible.

What is deep tech? Defining a relatively nascent space is difficult as those involved grapple with finding a common language – this is an issue even in well-established industries. However, deep tech in particular poses a unique challenge because, despite its name, it is not about a technology per se, but about a different framing and approach, explains Ania Labno, managing director and partner at Boston Consulting Group (BCG).

"In essence, deep tech recognizes that the boundaries of science and critical need are enabling a reframing of what is possible," says Labno.

Echoing this sentiment, Jason Blumberg, CEO and managing director of the Chicago-based VC fund Energy Foundry, and an adjunct professor at the University of Chicago Booth School of Business, described deep tech as an approach that requires commercializing science-based innovation before building the business model.

This approach draws on those of several disciplines, including **advanced science, engineering, and design**, as well as the convergence of technologies, such as **matter and energy, computation and cognition, sensing and motion**.

As Labno further explained, the deep tech approach starts with a problem-orientation to solve fundamental issues. Additionally, it leverages the **Design – Build – Test – Learn** cycle, an iterative process which has become more cost effective as various prototyping tools have become more accessible.

According to BCG's research, **nearly all (96%) deep tech ventures use more than one advanced technology, using the best existing or emerging technologies to solve problems.** "They are shifting the innovation equation from bits alone (digital) to 'bits and atoms' (physical)," says Labno, adding that these ventures are building on digital transformation and the power of data and computation to develop mostly physical products – not software. Blumberg notes this is why deep tech generally evolves from the physical science and biological science research performed at institutions.

Deep tech ventures also are at the center of a deep interconnected ecosystem: "Because of the complexity of the task at hand and the deep scientific background needed, it is impossible for two people in a garage to come up with a meaningful innovation," says Labno.

A DEEP INTERCONNECTED ECOSYSTEM

In addition to a highly dynamic, distributed ecosystem, deep tech, as with all industries, requires the right mix of talent and a willingness to collaborate in order to exchange skills and resources.

"Most successful ecosystems include universities that play an important role in providing deep tech talent and IP, governments that invest in basic research and provide regulatory environment in which innovation can thrive, corporations that provide funding and technical know-how, as well as investors that provide both capital and commercial guidance and network," explains Labno.

Startups look to the ecosystem for help with market access (~60%), technical expertise (~40%), and business expertise and knowledge (~30%), according to a BCG survey.

The Midwest uniquely is anchored by world-class universities and research institutions, including Argonne National Laboratory and Fermi National Accelerator Laboratory, which are managed on behalf of the U.S. Department of Energy by the University of Chicago. The city and greater Chicago area also has the support of the local government, which recognizes that deep tech development will be a key driver of economic development.

"The Midwest is home to some of the world's premier efforts in materials science and engineering, sustainability, energy storage, and quantum information sciences, to name a few areas that are central to deep tech development," notes Juan de Pablo, UChicago Vice President for National Laboratories, Science Strategy, Innovation, and Global Initiatives.

"Finally there is a strong culture of innovation and support from local facilitators, incubators and accelerators that help guide the innovation to market," adds Labno. "The Midwest has a history of building things and tackling new challenges. Getting smarter about nature as a manufacturing partner and considering the implication of the new approach to employment will become ever more critical."

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DEVELOPMENT AND CHALLENGES

Total investments in deep tech quadrupled between 2016 and 2020 to reach $62 billion, according to BCG. "Deep tech is soaring," says Labno, noting that greater and greater portion of this investment is driven by private investors and companies with a long-term view on innovations.

Long-term is key in this conversation, as deep tech is a long-term bet. While deep tech offers significant advantages over current technologies, they require large sums of money and can take years or decades to reach the market.

Still, this bet is one private investors and venture capitalists are increasing willingly to take, as the payoff – solutions to some of society's biggest global challenges, the creation of entirely new markets, and disruption across myriad industries – is one worth taking.

In addition to growth in available capital, the barriers to enter deep tech are lowering, notes Labno: "Platform technologies such as computer-aided design on low-cost DNA synthesis allow innovators of today to enter spaces that would have been cost prohibitive just a few years ago. Technology begets technology and creates a virtuous cycle where we can innovate faster."

"The cost of launching a business is going down," echoed Blumberg, who notes that entrepreneurs are looking for alternatives to digital to find opportunities. "Low hanging digital fruit is hard to find, so today innovators need a 5-10x better technology to find opportunities," he says. Consequently, researchers are going back to the fundamentals as being a place where opportunity exists.

Also driving growth is an increase in government funding. "That R&D has converted to new innovation that can have a sizeable impact on society, and they are starting to come to market," adds Blumberg. However, it can take decades for a breakthrough to work through the system, because science doesn't move as quickly as people would hope, he notes. "Long time to return for deep tech technologies makes it challenging and require innovators to receive funding from a number of sources including public non-equity funding, accelerators, private funding as well as crowd-sourcing," adds Labno.

Consumers also are driving demand, says Blumberg, who notes that the public is often no longer content with current commodities, but are instead looking for new, better solutions. Notably, in cleantech, increasing calls to combat climate change are necessitating innovation. “People are paying attention,” says Blumberg.

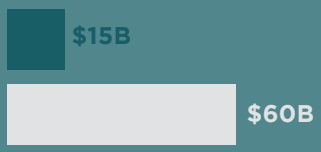
Still, as Labno explains, founders often struggle to tell a compelling narrative – including the potential and risks – about how a particular deep tech initiative will deliver on its promise.

“There are only a handful of funders who grasp the essence of deep tech ventures and have the frameworks to mitigate the science, market, timescale, and ethical risks associated with this form of venture,” she explains.

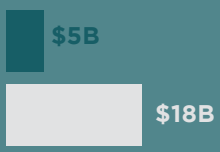
Funders, alternatively, focus on optionality rather than point solutions – focusing on risk mitigation as opposed to merely risk aversion.

“Additionally, the need to access diverse and often very unique talent can be challenging,” says Labno. “However, a vibrant and dynamic ecosystem, like the one we just mentioned, is crucial in addressing both of them.”

BY THE NUMBERS



According to BCG’s preliminary estimates, investment in deep tech start-ups and scale-ups more than quadrupled from **$15 billion in 2016 to more than $60 billion in 2020**



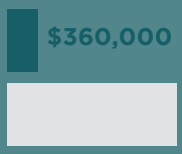
Similarly, the disclosed private investments in deep tech start-ups and scale-ups involving corporates among investors rose from **$5 billion in 2016 to $18 billion in 2020**

The average amount per private investment event rose from **$13 million in 2016 to $44 million in 2020**

89

The number of mergers and acquisitions of deep tech ventures peaked at **89 transactions in 2019**

The amount invested by “Smart Investors” (mutual funds with a proven track record) in deep tech increased from **$0.9 billion in 2016 to $5.2 billion in 2020**



When focusing on start-ups, the latest Hello Tomorrow survey confirmed an increase in amounts per investment event from **$360,000 to $2 million between 2016 and 2019**

Source: Deep Tech: The Great Wave of Innovation. *Deep Tech Strategy & Consulting I BCG*

IN THE LAB

// BOZHI TIAN

// JOHN ANDERSON

// AARON ESSER-KAHN

// NICK FEAMSTER

Lighting the Way for Minimally-Invasive Devices

Bozhi Tian has pioneered a new technique that harnesses the power of light to stimulate various cells and tissue – an approach that has a range of use cases. His lab is interested in probing the nanoscopic or molecular interface between the biological and inorganic systems, emphasizing novel material synthesis and device conception. The Polsky Center holds **several patents** related to this work, including a method for creating carbon-based bioelectronic devices and silicon nanomaterials for modulating cells. "There is a range of applications that you can envision for this type of system," **says Tian**.

The Future of Energy Storage: Bringing Batteries to the Molecular Scale

John Anderson is developing fundamentally new and disruptive materials to realize dramatic improvements in battery performance and cost. His research focuses on developing inorganic synthetic chemistry to solve problems relevant in nature, energy, and new materials.

A major goal of his research is to discover fundamentally new materials with what he described as "exciting and potentially paradigm-shifting properties for applications including energy storage." Recently, Anderson's team has discovered synthetic techniques to generate "unusual layered or lamellar structures of iron sulfide." The features of these structures, including redox (reduction-oxidation) characteristics, makes them an ideal candidate for batteries. Additionally, the material components are abundant and cost-effective.

Chemistry and Materials Science

Aaron Esser-Kahn's research meets at the intersection of biology, chemistry, and materials science – using tools from each discipline to address various unmet needs.

With this philosophy as a guide, his lab currently is focused on several projects. First, working toward microvascular thermal and gaseous exchange units, using knowledge derived from biology to replicate structures adapted for gas capture. In addition, they are developing materials for reprogramming the immune system. Specifically, they are creating polymer facades designed to rewire the immune system toward desired targets using tools from materials chemistry. The researchers also are working towards creating synthetic tissue scaffolds.

The Polsky Center has patented has patented a **sugar-peptide hybrid nano-formulation for multi-TLF agonists**, which improves therapeutic efficacy and reduces hematological toxicities, and NF-KB inhibitors that **selectively and locally limit inflammation and potentiate the protective response of adjuvants**.

Improving Network Operations and Internet Security

Nick Feamster makes the internet work better through his work designing and deploying network protocols and systems. He uses empirical network measurement and machine learning to understand and improve network performance, security, and privacy – and the results of this work often have policy implications. Deriving insights from network traffic, which can reveal insights into human behavior to help improve several aspects of the Internet, Feamster's lab develops data-driven systems for use in various applications.

ON THE MARKET

// ESYA LABS

// EVOZYNE

// PYXIS

// QUANTX

// SNAPGENE

Unique Organelle-Targeted Assays for Drug Discovery

Esya Labs is developing tools for the early, precise, and cost-effective detection of neurodegenerative diseases to support **drug discovery and personalized medicine efforts**. Cofounded by **Yamuna Krishnan**, the company's 10 commercially available sensors have several unique characteristics: the ability to measure two ions at the same time, quantify ion levels (versus simply detecting the presence of certain chemicals), and correct for pH-driven distortions of ion measurements. While the probes are typically targeted at lysosomes, applicability is broad and, with slight modifications, the technology also works with other organelles, such as the Golgi or mitochondria.

Synthetic Proteins Designed with Machine Learning

The **Evozyne** platform combines the principles of evolution with machine learning to create novel proteins with advanced functionality. The company was created based on the work of **Rama Ranganathan** and **Andrew Ferguson** and founded by Jeff Aronin of Paragon Biosciences, who serves as Evozyne's Chairman. The data-driven molecular engineering company has inked several strategic collaboration agreements since launching in 2019.

"It's really exciting to think about Evozyne as being a first major startup company to emerge directly on the principles of molecule engineering," **says Ranganathan**, who stresses the importance of bringing together disparate groups – not just biology, but computer science, physics, mathematics, and the humanities, to address some of society's biggest challenges.

Pyxis is a multi-platform company developing an innovative portfolio of biologics for patients with difficult-to-treat cancer. The company is focused on developing a new family of antibody-based immunotherapies derived from novel insights into the biology of the tumor microenvironment. Pyxis was founded by **Thomas Gajewski** and to date has raised $174 million and recently announced a worldwide licensing agreement with Pfizer.

The First FDA-Cleared Diagnostic AI Software

Developed In the lab of **Maryellen Giger**, **QuantX** in 2017 became the first FDA-cleared, machine-learning-driven system to aid in cancer diagnosis. QuantX is indicated for the assessment and characterization of breast abnormalities from MRI data in patients presenting for high-risk screening, diagnostic imaging workup, or evaluation of extent of known disease. The technology currently helps increase reader accuracy and improve overall radiologist performance during breast MRI exams and features a multi-modality image viewer and breast MRI biopsy module. In 2019, QuantX was named one of *TIME* magazine's inventions of the year and was bought by Paragon Biosciences, which founded Qlarity Imaging to further develop the system.

Bioinformatics Software to Enhance Research Workflows

SnapGene was founded by **Benjamin Glick** to help plan, visualize, and document molecular biology procedures and allow for the simulation of cloning. The desktop software is used in more than 65 countries, in virtually every major research institution, and in most of the largest pharmaceutical and biotech companies worldwide. The company was acquired by **GraphPad** Sofware in 2019.

Steven Neil Kaplan, Neubauer Family Distinguished Service Professor of Entrepreneurship and Finance, University of Chicago Booth School of Business and Kessenich E.P. Faculty Director of the Polsky Center for Entrepreneurship and Innovation

HOW VENTURE CAPITALISTS EVALUATE ENTREPRENEURS

A useful framework for evaluating companies and their chance of success can be captured in two acronyms: OUTSIDE-IMPACTS. OUTSIDE stands for: Opportunity (which incorporates IMPACTS), Uncertainty, Team, Strategy, Investment, Deal, and Exit.

Opportunity // Does the business idea create a positive expected value? To answer that requires evaluating its IMPACTS.

- **IDEA //** Can the founders explain the idea clearly and succinctly? Are they clear about what problem it solves? Have they established the "pain point"?
- **MARKET //** Is the target market large enough to support substantial growth or valuation? How large is the overall market and market segment the venture is targeting? Who are the key customers? How many are there and what will they spend? Is there solid support for these claims? Are there additional opportunities?
- **PROPRIETARY //** What exactly is proprietary about the idea? What is differentiating? Why and how will it make money? Is there a potential network effect? Does it have an advantage in terms of switching costs, execution, or technology? Are its advantages defensible?
- **ACCEPTANCE //** Who is the customer and will they accept or buy this new product or service and why? Why will the customers buy? What do they buy now and why? Why will they switch from their current product? How will the business reach customers and how quickly will it get customers? Can it acquire and retain customers and still make money?
- **COMPETITION //** Why won't the value be competed away? What will existing competitors do? What will other new entrants do? How will the entrepreneur respond?
- **TIME //** Why is this a good time to enter? Why hasn't the opportunity been taken already?
- **SPEED //** How quickly can it be implemented?

Uncertainty // Being aware of the uncertainties and keeping track of them is important. Many businesses fail because uncertainties turn out to be negatives. Companies, particularly startups, should always be trying to reduce the uncertainties, or move them in their direction. Managing risk means understanding the uncertainties involved in the venture and minimizing those that can be minimized.

TEAM // Can the management team implement the opportunity? How does their previous experience relate to the opportunity? Often, this analysis reveals that key elements of an effective management structure are missing, so it is worthwhile identifying what pieces are missing and how to fill them.

STRATEGY // Is the company's strategy consistent with the opportunity it is pursuing, the uncertainties surrounding that opportunity, and the management team it has in place?

INVESTMENT // Do forecasts and cash-flow requirements make sense, and are they reasonable? Many promising startups die by simply running out of money before they can prove they are viable.

DEAL // Even if the business idea looks solid, it is critical that the deal be well structured to secure investment. Does the structure provide appropriate incentives? Is the deal priced attractively? Does it provide or ensure appropriate governance? Does it help manage the uncertainties?

EXIT // Smart investors are focused on how to earn returns and how to cash out. It's important even at the onset to think about whether investors can exit the deal, and how, and whether that part of the deal is priced attractively.

Source: ***Chicago Booth Review.*** **"The Right Questions to Ask for Startup Success."**

Brad Tipp, Business Strategy Leader,
Higher Education Research at Microsoft

EXECUTIVE INSIGHT

The Polsky Center for Entrepreneurship and Innovation discusses with Brad Tipp the state of deep tech and the growth of data science – and how corporate partners, such as Microsoft, engage with the University and help faculty researchers advance their scientific knowledge.

What is driving the growth in data science and what are the challenges of meeting this demand?

Brad Tipp: The growth of data science is a consequence of both cloud computing and ubiquitous, and increasingly ambient, computing. When 3.5 billion people carry a smart phone and there are more than 30 billion Internet of things (IOT) devices, the sheer volume of data being collected is gargantuan. At the same time, the rise of cloud computing and the ability to near instantly deploy computing resources in order to analyze, find patterns, correlation, and causation means that the gating factor to do that become data scientists.

The challenge is that it is currently faster to collect data and deploy processing power than it is to educate and train people in the discipline of data science. The biggest challenge is to use data science in a way that doesn't just reinforce the views of the past in their deductions. Building ethical and diversity-respecting systems that genuinely reflect the 'real world' has the potential to bring greater equality, but if done badly will reinforce some existing myopic views.

What have been some of the most significant trends in the computer and data science space over the last five years?

Tipp: Democratization of 'big computing' through software as a service (SaaS), and the ramifications of it, is probably the single biggest trend in the last five years. Being able to easily stich together SaaS services of previously unaffordable scale and power from a single connected system has enabled data science to move at an exponential pace. With great power though comes great responsibility, as Spiderman would be told, and the challenge to use this data in the right way is now also democratized, meaning that in some cases the oversight and governance has been removed. Time will show that this will be a double-edged sword.

How do you see these evolving over the next five?

Tipp: At this time I can only see a continuing acceleration of the exponential curve that the industry is on. The total size of cloud native compute is still small compared to traditional compute, but this is changing rapidly. It is likely that the largest high performance computing-type systems are already cloud based assets, rather than the monolithic supercomputing 'devices.' The next phase is really joining the edge devices to SaaS services more, leading to a blended system of intelligence at both the edge and center of the mesh. The other evolution is the move to remove more of the stack from the solution, so researchers can work on their research and not on building an infrastructure to support it.

In what ways are new/emerging deep technologies helping researchers advance their scientific knowledge?

Tipp: Today, I see research still trying to just keep up with the opportunity that is already here. Machine learning and future AI work, at scale, will enable insights that today are unseen. There are other emerging technologies that will accelerate this, but the biggest challenge will be keeping the complexity below the surface, so that the domain expert can continue to focus on their domain expertise. If we can do this then I feel that research will go through an exponential explosion in the coming years, mirroring the capabilities that are already being offered in SaaS services in the cloud.

In what ways does Microsoft collaborate with universities? What is the importance of working with these institutions?

Tipp: Microsoft collaborates with universities at many levels. This is both an asset and can prove tricky. At the highest level, Microsoft and Microsoft Research work with individual labs and researchers on cutting edge work in areas like quantum computing, machine learning, computing language advances, cybersecurity, and zero trust systems, among other areas. At the same time, the company is using its collaboration software to enable researchers at any institution to work with their colleagues globally. We operate at almost every level of the technology stack, from the device to the data center and from services to run the institution, to services to write this document.

The important thing in all cases is to advance the research. Time to publication is our key measure of success. Whether that is our own work, or the work of any individual researcher writing a document or collaborating with a colleague at another university, or down the corridor.

DEEP TECH U

DeepTechU *is organized by the University of Chicago's Polsky Center for Entrepreneurship and Innovation and presented in collaboration with several partner universities, technology transfer offices, and national labs. For more information, visit* ***www.deeptechu.com****.*

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The Polsky Center for Entrepreneurship and Innovation applies world-class business expertise from the University of Chicago Booth School of Business to bring new ideas and breakthrough innovations to market. Home of the University's technology transfer office, the Polsky Center's dedicated team of professionals with deep technical expertise enabling technology commercialization perform market analysis, manage intellectual property, identify partners, and negotiate partnerships and licenses for discoveries and inventions developed by faculty, researchers, and staff. Learn more at **polsky.uchicago.edu** and follow updates on Twitter **@polskycenter**.

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THE UNIVERSITY OF CHICAGO

About the University of Chicago

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Microsoft

About Microsoft

Microsoft (Nasdaq "MSFT" @microsoft) enables digital transformation for the era of an intelligent cloud and an intelligent edge. Its mission is to empower every person and every organization on the planet to achieve more.