The Era of Living Intelligence

Navigating the technology supercycle powering the next wave of innovation

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The Next Wave of Innovation

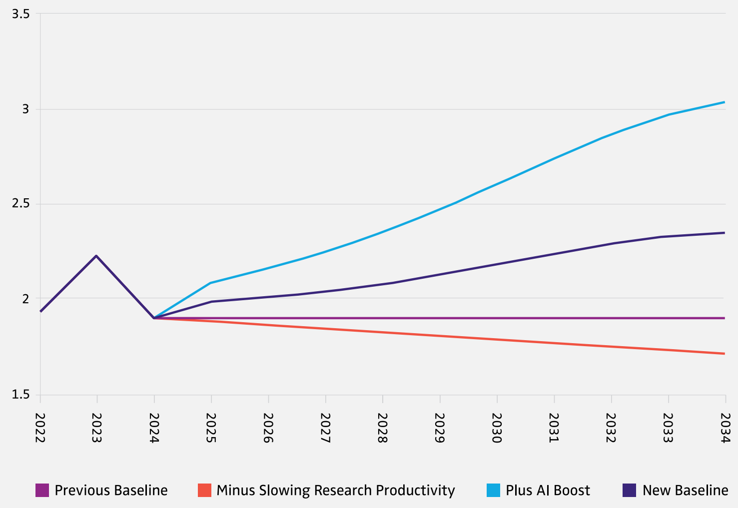
Recently, something very unusual happened with productivity: In August 2024, the U.S. Bureau of Labor Statistics reported 2.7% productivity growth[1] on a year-over-year basis, well above the average of 1.5% over the last decade and Europe's 1% growth rate. ''The difference [with compounding] is just enormous after 40 years in terms of incomes and living standards,'' said Federal Reserve Chair Jerome Powell shortly before the report's release.

Economists have attributed the steady rise in productivity to inflation, labor shortages, falling pay, layoffs, and automation. Speculation has also focused on the effect of generative AI, with some experts projecting major productivity gains over the next decade, based on promising experiments in augmenting human agents in industries like call centers. As a partial result of surging productivity, the incremental increase in GDP in the U.S. by 2030 could be significant, due to factors like the augmentation of human intelligence, increased innovation, and the substitution of machines for labor. *(See Figure 1.)*

Future Today Institute has a theory that may explain what's happening. We call it the *technology supercycle*. In economic terms, a supercycle refers to a sustained period of strong economic expansion in terms of GDP, asset prices, employment, and demand for goods and services. The last long boom that resembles the current boom began in 1982 and lasted until 2001, with some temporary hiccups along the way.

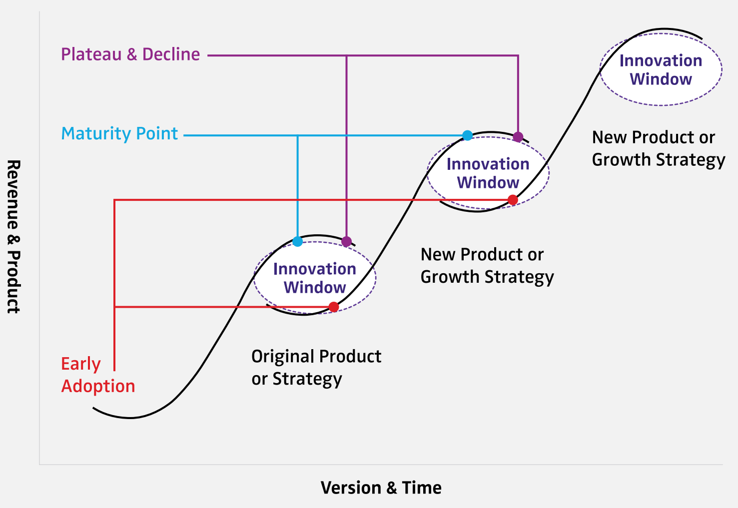
The standard explanation of growth during these periods focuses on S-curves—patterns of rapid growth and increased profits as an industry, product, or business model evolves and eventually reaches maturity and declines. *(See Figure 2.)*

Figure 1
Incremental GDP Growth Scenarios Resulting from AI in the U.S.



Source: Goldman Sachs Research

Figure 2
The S-curve Effect of Technology Adoption



Source: Abdelkader Mazouz, Loay Alnaji, Riadh Jeljeli & Fayez Al-Shdaifat.

1 U.S. Bureau of Labor Statistics, Second Quarter 2024, Revised

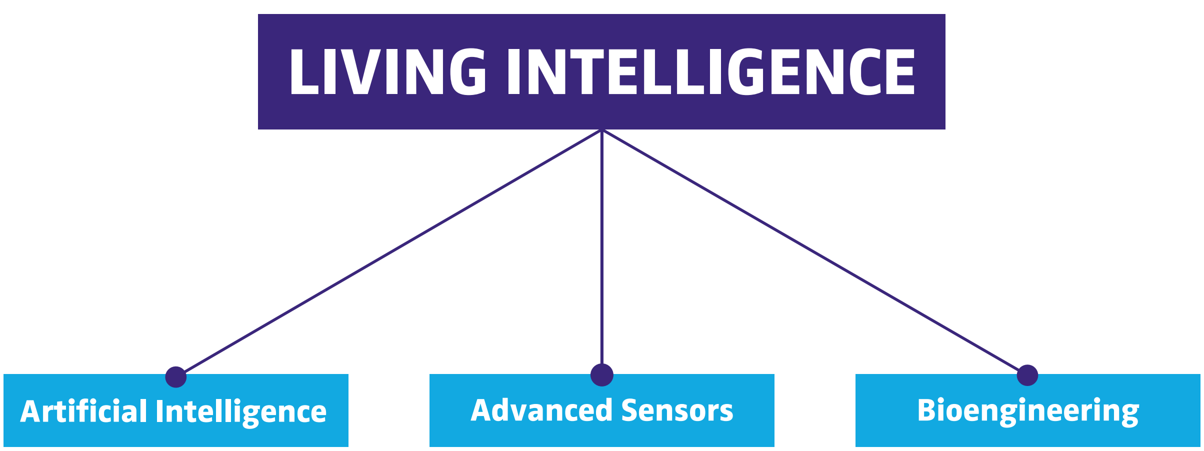
But this theory is inadequate to describe what's currently happening. In the past, general-purpose technologies (GPTs) like steam power and electricity had far-reaching applications across various sectors of the economy and society, leading to widespread changes in productivity and social structures. These technologies ultimately enabled new developments and industries beyond their original purpose.

Unlike previous cycles of technological advancement, which were more linear, our research shows that this supercycle is exponential in nature. We now see evidence that we're entering a liminal period between profound disruption and hypergrowth as the result of an intersection of not one but three general-purpose technologies: artificial intelligence, advanced sensors, and bioengineering. The hallmark of this emerging technology supercycle is the convergence of critical technologies that will reshape the world in profound and unpredictable ways.

The interaction and intersection of these technologies will create compounding effects, pushing the world into a new phase of technological disruption. As a result, economic models, workforce structures, and geopolitical power dynamics will not be disrupted; they will transform at a foundational level. New technologies and their convergence will fundamentally reshape entire sectors, such as health care, finance, energy, and transportation. This transformation will lead to the collapse of older systems and the rise of new structures.

The interaction and intersection of these technologies will create compounding effects, pushing the world into a new phase of technological disruption.

The convergence of these three general-purpose technologies results in a powerful new force we call *living intelligence*. Living intelligence is composed of overlapping strands of technology, each flashing bright red signals of a fundamental economic and societal shift.



The Foundation: Artificial Intelligence

Reasoning, learning, and self-improvement systems form the technical foundation of the shift.

AI represents the next era of computing, and it's embedded in everything we do. AI operates around the clock and never needs to rest. It is the ''everything engine'' that powers the technology supercycle.

Machine learning (ML), deep learning (DL), and generative AI (genAI) are interconnected fields within artificial intelligence. ML is a broad area where algorithms learn from data to make predictions or decisions without explicit programming, covering techniques like supervised and unsupervised learning. DL is a specialized subset of ML that uses multi-layered neural networks to automatically learn complex patterns from large datasets, to perform tasks such as image recognition and natural language processing. GenAI, in turn, is an application of deep learning that focuses on creating new content and concepts by learning patterns from existing data. Models like generative pre-trained transformers and generative adversarial networks use DL to generate novel outputs.

Google's latest innovation, NotebookLM, leverages its advanced AI capabilities to serve as a comprehensive personal research assistant, transforming the way users interact with their own data. Users upload various file types—including PDFs, Word documents, and even audio or websites—into custom-built databases, which are then processed using Gemini, Google's AI model, allowing for dynamic interaction with the content through conversational queries. This interactive approach facilitates deeper engagement with the material, supporting use cases such as generating study guides, summaries, and even podcasts.

One of the standout features of NotebookLM is its capacity to manage and synthesize vast amounts of information across multiple documents simultaneously, a critical differentiator in the AI landscape. Unlike traditional AI models that require retraining on specific datasets, NotebookLM focuses on leveraging the model's context window—effectively its short-term memory—to enhance accuracy without necessitating long-term retention of user data. This ensures lower hallucination rates, improved contextual responses, and users' heightened control over their information.

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AI is also speeding up new materials development. Running experiments often requires tiny, me-thodical tweaks to measurements, materials, and inputs. Graduate students might spend hundreds of tedious hours repeatedly making small adjustments until they find a solution—a waste of their time and brainpower. Unlike graduate students, AI doesn't have to sleep. Google DeepMind's AI program GNoME (named after its ability to graph networks for materials exploration) has significantly expanded the universe of stable materials for building things like batteries, microchips, and solar panels. These deep learning models generate billions of potentially usable structures. The top candidates are then filtered through GNoME models, which predict their stability based solely on chemical formulas.

The tool has identified 421,000 new, potentially stable crystals from a vast set of 2.2 million material structures, and more than 700 have already been created and tested in labs. This breakthrough, published in Nature[2], demonstrates AI's capacity to enhance our understanding of materials free from the constraints of the human mind.

Beyond testing hypotheses, AI is also accelerating scientific experimentation. Many researchers are using "self-driving labs"—automated robotic platforms enhanced with AI. One example is Emerald Cloud Lab, a research facility that conducts experiments without a researcher having to set foot in a physical lab space. Using AI, the lab can autonomously handle everything from method design to instrument operation to data acquisition and analysis. A 2023 study published in Nature showed how a self-operating lab successfully produced 41 new substances over 17 days of nonstop work.

But AI itself is morphing rapidly. AI models are getting smaller and can be increasingly located on the edge. Compute costs for training large language models (LLMs) have been doubling every nine months[3] since 2016. At the same time, the physical computing needed to produce the desired quality of results is halving every eight months. AI is becoming more efficient, but the cost to train increasingly powerful models is rising rapidly, even as hardware advances reduce the computational burden to some extent.

In response, lightweight and energy-efficient small language models (SLMs) that feature fewer parameters and more focused datasets have emerged. SLMs can be as much as 29 times less expensive as LLMs that consume vast amounts of compute and energy resources, researchers at the University of Michigan estimate. Dozens of SLMs now exist, and the number is growing rapidly. They are powering innovative new uses of AI on edge devices.

AI is becoming more efficient, but the cost to train increasingly powerful models is rising rapidly, even as hardware advances reduce the computational burden.

2 https://www.nature.com/articles/s41586-023-06735-9
3 https://epochai.org/trends

INDUSTRY SPOTLIGHT

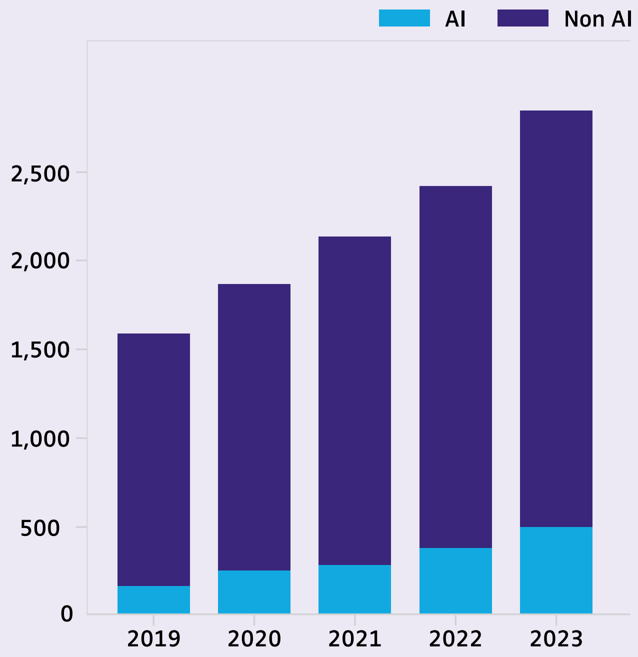
AI in Drug Discovery

The pharmaceutical industry has been one of the earliest adopters of computer technology and is now rapidly integrating AI into drug discovery. The traditional method used can be prohibitively expensive and time-consuming: it can cost as much as $2.6 billion and take 13.5 years to get from idea to an approved drug. Part of the expense has to do with the high attrition of potential drug candidates. Nearly 80% fail due to efficacy, toxicity, or simply because the body doesn't distribute, absorb, or metabolize the drug as it should.

New drug discovery proved a smart target for AI, and research is accelerating. In 2019, one in 10 scientific journal papers were about AI in drug development; in 2024, it's one in five. *(See Figure 3.)* Researchers are now working on everything from hit identification (predicting drug-target interactions, which can reduce the cost and time to experimental validation) to lead identification (designing and optimizing ingredient combinations to yield desired properties). Such activity shows just how much AI is powering the convergence of general purpose technologies across adjacent fields.

By applying advanced algorithms to harness vast datasets—from genomics to clinical trials—AI enables more targeted identification of promising candidates and illuminates their interactions with disease pathways. This streamlines the overall R&D process, boosting productivity and success rates while lowering costs and expanding treatment options for previously untreatable diseases. The gap between data-intensive computational labs and traditional wet labs is closing, with AI-designed molecules already advancing to clinical trials.

Figure 3
AI-Related Research Articles About Drug Development



Source: Future Today Institute research and analysis.

Consider these recent advances:

Medical Devices

Increasingly, AI is being incorporated into medical devices, and is speeding up radiology processes and handling delicate surgeries. In radiology, AI tools like those used in portable ultrasound devices enable faster cardiac issue diagnoses, making complex echocardiography machines unnecessary in some cases. The technology is being put to use in Tel Aviv at the Sheba Medical Center, where researchers have developed a portable ultrasound probe paired with a computer tablet and integrated it with a computer vision tool to diagnose cardiac issues in minutes. Images are uploaded to a secure cloud, where they are compared to a large corpus of existing scans, and an analysis is sent back to the doctor in near-real time. AI is also coming to the surgical suite. Today, surgeons can perform robotic-assisted minimally invasive procedures by controlling a da Vinci surgical robot, whose arms are equipped with surgical instruments and a camera. Researchers from the University of California at Berkeley, Google, and Intel have used videos of surgeons to train an algorithm to suture with precision, which suggests that it's likely AI will soon usher in new levels of autonomy.

Protein Folding

AlphaFold is an AI tool that predicts the structure of proteins and has outperformed an estimated 100 teams in a biennial protein-structure prediction challenge that has long vexed biologists. In a December 2023 update, Isomorphic Labs and DeepMind released an improved AlphaFold model that predicts protein structures with greater accuracy and models interactions with additional molecules like ligands. AlphaFold has predicted the shapes of nearly every protein in the human body, as well as hundreds of thousands of other proteins found in 20 of the most widely studied organisms, including yeast, fruit flies, and mice. And most recently, in May 2024, the team introduced AlphaFold 3, a new model that not only predicts the structure of proteins but also nearly all elements of biological life like DNA, RNA, ligands, and their interactions.

AI-First Drug Development

Scientists at Ludwig-Maximilians-Universität München developed an AI model that predicts where molecules can be chemically altered, enabling more efficient, sustainable synthesis. A University of Cambridge team created a platform that automates experiments, then uses AI to forecast chemical reactions. Until recently, this trial-and-error process was slow and inefficient. Major pharmaceutical leaders such as Johnson & Johnson, Novartis, and AstraZeneca have already forged partnerships with AI startups to tap into deep learning's unmatched speed and pattern recognition capabilities for parsing large volumes of data. While AI cannot yet replace lab science, it significantly accelerates prediction, design, and validation to streamline timelines.

Generative Antibody Design

An antibody is a protein that protects an organism from harmful substances and disease. In 2023, researchers from Absci Corp. showed how a generative AI model was able to design multiple novel antibodies that bind to the HER2 receptor more tightly than previously known therapies. Researchers removed data about antibodies that would cause the model to simply imitate the structure of known antibodies that work well. The resulting designs weren't already known to exist and received a high score on "naturalness," which meant they would generate a strong immune response. Using generative AI to design novel antibodies that function at the same level—or even better—than what the body produces marks a promising step toward reducing the speed and cost of therapeutic antibody development.

In-Silico Trials

These digital experiments use computer simulations rather than human subjects to test new drugs and therapies. They use AI to create "digital twins" that mimic human biology and disease in order to improve the drug development process. By running thousands of virtual trials, researchers can quickly and affordably predict how a drug might perform in human patients. For example, a company called Novadiscovery used AI to accurately forecast the results of a Phase 3 clinical trial. In-silico trials may one day replace up to half of human testing, and regulators are looking at how to include these virtual results in the approval process.

The Data: Advanced Sensors

Data from everywhere trains AI in real time, amplifying the shift toward AI.

If AI is the everything engine, that engine is going to need data. The next general-purpose technology involves advanced sensors: a network of interconnected devices that communicates and exchanges data to facilitate and fuel the advancement of artificial intelligence.

Our research shows a coming Cambrian explosion due to billions and billions of sensors that are always on, and will be increasingly on (and perhaps inside of) us.

Sensors are already everywhere, being put to use in multiple industries. Agricultural machinery manufacturer John Deere uses smart sensors to monitor soil conditions, crop health, and equipment performance. Sensors also allow tractors to apply precise levels of crop fertilizer. The data collected from these sensors feeds into algorithms that optimize farming practices, improving crop yields and resource efficiency. As sensor technology advances, AI systems drive greater innovations in sustainable agriculture.

Precision agriculture technology company Sentera makes drones equipped with smart sensors that capture high-resolution images and data on crop growth and health. Aerial data helps bioengineers identify and understand the genetic traits that contribute to optimal growth under various environmental conditions, leading to the development of bioengineered crops that can better adapt to changing climates and pest pressures, thereby improving agricultural productivity and sustainability.

Environmental technology company Airly uses sensors and AI for real-time air quality monitoring. Airly operates a vast network of advanced electrochemical sensors and laser particle counters to measure gases (carbon monoxide, nitrogen dioxide, ozone, sulfur dioxide) and environmental conditions like pressure, temperature, and humidity. The city of Warsaw, Poland, installed 165 devices to track air quality in the city and, ultimately, to help improve public health. The data revealed sources of pollution locally, and further analysis resulted in recommendations for how to make improvements.

Xylem, a water technology company, developed a new type of water meter that leverages advanced sensors and AI to manage the challenges of water distribution in densely populated settings. The meters continuously measure water flow and provide granular data on consumption patterns; they can also identify anomalies in water flow, like drops in pressure or irregular usage patterns, that typically result from a leak. Xylem's AI system also includes predictive analytics for maintenance. Rather than reacting to a burst pipe or a system failure, the sensors and AI tools can preempt an emergency by sending alerts to utility managers.

As engineered biology has improved, it has enabled new types of biological sensors that can be worn and ingested. Their purpose: to send and receive data in realtime. Tiny machines, called nanobots, can monitor patient health in realtime after being injected into the bloodstream. Acting as internal surveillance systems, nanobots can detect changes in environmental stimuli and conditions, allowing for continuous health monitoring and early diagnosis of potential health issues.

Nanobots also offer precise disease detection and diagnosis at the molecular level by interacting directly with cells and cellular machinery. For example, bladder cancer is among the most common cancers globally, especially among men. While current treatments offer good survival rates, nearly half of all tumors recur within five years, necessitating continuous monitoring. Researchers from the Institute for Bioengineering of Catalonia and CIC biomaGUNE have developed urea-powered nanobots that carry radionuclides that reduced bladder tumors in mice by 90%. The approach could lead to more effective treatments and potentially reduce patient hospitalization time.

Certain neurological disorders are best treated using neurostimulation, but traditional electrode-based stimulation devices can accidentally cause immune responses. Canan Dagdeviren, a professor at the MIT Media Lab, is leading a team that developed an implantable piezoelectric ultrasound stimulator, which is a novel sensor that can deliver ultrasonic, focused pressures to modulate neuronal activity. Her team also created a piezoelectric system—basically a soft, thin, sensor-filled device—that can be twisted, wrapped and implanted into the body. Yet another system uses a piezoelectric crystal and a honeycomb-shaped patch that can be worn comfortably over the breast for deep tissue scanning and imaging.

AbbVie Inc. patented subcutaneously administered treatments for advanced Parkinson's disease, and Life Patch International developed personal diagnostic devices featuring microfluidic circuits for transdermal testing. Medtronic's advancements in smart glucose sensors, which provide real-time monitoring of blood sugar levels, enable the development of more responsive and adaptive bioengineered insulin pumps that can automatically adjust dosages based on the data from the body, improving diabetes management and patient outcomes. Abbott, a medical device manufacturer, created its CardioMEMS HF System, which relies on smart sensors implanted in the pulmonary artery to remotely monitor the vital signs of patients with heart failure. Real-time data from these sensors led to the creation of bioengineered human organs and tissues that can better respond to conditions in the body.

Smart sensors now capture not only internal biological metrics but also data on behaviors, actions, and expressions in our environments. As sensor technology advances, the volume and quality of collected data grows, fueling continuous improvements in AI models. This feedback loop enables AI to capture more complex and previously inaccessible data types. Companies like Viso.ai provide emotion recognition and sentiment analysis, helping retailers gauge customer behavior, detect interest, and anticipate purchasing intent, enabling timely interventions.

As AI systems increasingly demand diverse data types, especially sensory and visual inputs, large language models must incorporate these inputs into their training or risk hitting performance ceilings. This challenge arises for two key reasons: the depletion of high-quality training data and growing legal concerns. Currently, much of AI's training data comes from online sources like Wikipedia, Reddit, and books. However, as legal actions emerge over the misuse of copyrighted and proprietary information, the pool of available data is shrinking. At the same time, AI systems are ravenous for more complex data types, such as sensory and visual inputs, meaning large language models will face diminishing returns if they continue to rely solely on text-based data. To maintain their effectiveness, these models will need to evolve and integrate new data types and sources. Companies have realized that they need to invent new devices in order to acquire even more data to train AI.

Sensors Are Improving Alongside AI

Our research shows that the number of earnings reports from public companies based in the U.S. and Europe mentioning AI and the internet of things (IoT) together grew 61% since Q3 2022. Patent filings for sensor technology as well as the number of large IoT-related deals within the pharmaceutical industry grew significantly from 2021 to 2022, although growth was followed by a period of decline before stabilizing at a higher level.

Advanced sensors have evolved quickly, thanks in part to AI. They are becoming increasingly sophisticated, miniaturized, and integrated into our daily lives—to the point where they are largely invisible to us now. Sensors are tucked inside of devices in our homes, embedded in our utilities, attached to manufacturing plants and beyond, monitoring and measuring various parameters around us, often without our awareness.

Microelectronics and nanotechnology have now dramatically reduced the size of sensors and unlocked more specializations. The average smartphone has between 18 and 25 sensors (and counting), each designed for a specific use: to detect motion, to understand positioning, to sense the environment and to detect a user's individual biometrics. Modern cars include light sensors, which automatically turn on the car's lights when it's dark outside. The food you eat likely passed through a dozen or more sensors to detect pathogens, measure the moisture content, control the rate of liquid ingredients during mixing and dispensing, assess quality, measure acidity or alkalinity, and monitor pressure levels during packaging and sterilization.

With improvements in AI, modern sensors are more capable of detecting minute changes with a high rate of accuracy and reporting anomalies. Part of wider networks, advanced sensors collect data from a vast array of sources, which are processed and analyzed with AI, and can enable real-time decision-making—but these networks can also learn to self-improve through reinforcement learning with human feedback.

Advanced Sensors Will Propel AI Beyond Large Language Models to Large Action Models

In the near future, companies like Apple or Google will embed smart sensors in devices to continuously collect and analyze personal data, such as health metrics, location data, and information about daily habits. All this data will be used to create highly individualized profiles that link to personal language and action models, tailored specifically to each user's needs and preferences. Personalized AI will deliver customized experiences, decisions, and information, making interactions with technology more intuitive and responsive to individual lifestyles. *(See "New Data Sources Are Coming," p. 13.)*

The integration of such real-time data from a multitude of sources will enable a new class of AI systems beyond today's large language models (LLMs): large action models (LAMs). If LLMs predict what to say next, LAMs predict what should be done next, breaking down complex tasks into smaller pieces. Unlike LLMs that primarily generate content, LAMs are optimized for task execution, enabling them to make real-time decisions based on specific commands. LAMs use a constellation of sensors everywhere, all around us, collecting multiple streams of data at once from wearables, extended reality devices, the internet of things, the home of things, smart cars, smart offices, and smart apartments. As LAMs become more embedded in our environments, they will operate seamlessly, often without users' direct engagement.

The foundational innovations driving this tech supercycle will fade from view, delivering ambient, real-time solutions tailored to user needs without requiring direct engagement. As these systems evolve, they will lead to the creation of more advanced personal models designed to anticipate our needs without conscious input.

Meanwhile, personal large action models, or PLAMs, will eventually interact with different systems, learn from large datasets, and adapt to changing business needs. PLAMs will improve our digital, virtual, and physical experiences by streamlining decision-making, managing tasks, negotiating deals, and anticipating our needs based on behavioral data. They won't need conscious input. These autonomous agents will personalize recommendations, optimize purchases, and communicate with other trusted agents, allowing seamless transactions—all while maintaining a user's privacy and preferences, since PLAMs, by definition, have access to all of the user data on personal devices.

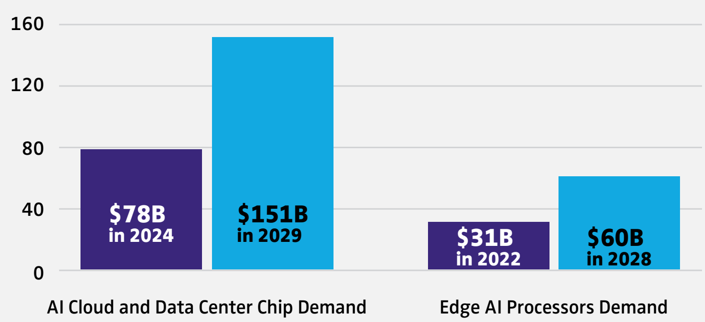
While people will have PLAMs, corporations will likewise have one or more corporate large action models (CLAMs), and digital-forward governments will have government large action models (GLAMs). All of these models will interact with varying degrees of success.

In addition, these models offer new alternatives to secure transactions. We anticipate some version of personal large action model authentication (or PLAM Auth) that will securely manage user data and facilitate transactions across platforms, offering more nuanced data-sharing rules than existing frameworks like OAuth and SSO. PLAM Auth would be a brand-new standard that fundamentally transforms the way different platforms, realities, sensor-enabled devices, and applications provide secure access to user data across digital, virtual, and physical environments. They would seamlessly and automatically adapt the authentication process to a user's behavior without manual interactions and ensure only necessary data is shared for personalized transactions. As users navigate increasingly complex, data-rich environments, PLAM Auth optimizes security while interactions are seamless across platforms.

We don't know if this is exactly what the future holds, but these developments indicate that sensors will have an enormous influence on how we interact with the world.

Figure 4

Tech Industry Forecast: Devices and Storage Market Size



Sources: IoT Analytics, Omdia, Future Today Institute.

There were **16.6 billion connected devices** in operation at the **end of 2023.**

The number of IoT connected devices should double, to **37.5 billion** within the **next seven years.**

FUTURE CASES

New Data Sources Are Coming

The integration of sensors and wearable devices will redefine the landscape of data collection and use. Beyond smartwatches and phones, some next-generation sensors include:

- **Wearable chemical sensors, which track sweat composition and detect hydration and electrolyte levels.**
- **Ultrasonic level sensors, which measure fluid levels in industrial settings in realtime.**
- **Vineyard sensors, which monitor water availability, sunlight, and soil moisture to optimize irrigation and the health of grape crops.**

In the future, the volume of data available for analysis will expand exponentially, offering unprecedented insights into consumer behavior and environmental interactions. The challenge for organizations won't simply lie in data collection, but also in the sophisticated parsing and interpretation of this deluge of data. Increasingly advanced algorithms and analytical frameworks will be required.

As AI models grow in complexity, alternative computing architectures like neurosymbolic AI, processing-in-memory technology, and specialized AI chips for on-device processing could offer significant advantages in terms of efficiency, speed, and privacy.

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AI at the Edge Unlocks New Data Sources

Smart devices like phones lack the memory and computing power required to fine-tune AI models with user data over time. This limitation means personal information must be transmitted to the cloud for updating, an energy-intensive process that risks compromising data privacy. Now, advances like PockEngine enable efficient on-device learning without offloading data. Developed through an MIT and IBM collaboration, PockEngine is a training model that selectively identifies the specific parts of an otherwise enormous model to update locally based on a user's unique inputs. This enables devices to continuously capture and process new, real-time data streams—such as voice modulation, user habits, and environmental changes—without the need for constant connectivity to external servers.

By focusing only on essential model parameters and preprocessing computations, PockEngine maximizes energy and data efficiency while creating personalized deep-learning models. As a result, previously inaccessible data types—like fine-grained behavioral patterns, micro-expressions, or environmental context—can now be captured and incorporated into personalized AI models directly on the device. For instance, AI assistants can continuously adapt to a user's accent or typing patterns without relying on constant cloud connectivity. Tests show that PockEngine can fine-tune complex models up to 15 times faster than alternatives, all while maintaining or boosting accuracy.

As AI models grow in complexity, alternative computing architectures like neurosymbolic AI, processing-in-memory technology, and specialized AI chips for on-device processing could offer significant advantages in terms of efficiency, speed, and privacy.

Small Language Models Untap Personal Data

While large language models with billions or trillions of parameters have demonstrated impressive capabilities, smaller AI models may be better suited to edge-based use cases. Although less broadly capable, specialized mini-models bring benefits like faster inference, lower compute requirements, and easier integration into edge devices. For mobile and embedded uses, massive cloud-based LLMs are often impractical due to their substantial size and latency. More compact models in the millions or single-digit billions of parameters, however, could potentially run efficiently on smartphones and IoT devices. This means that previously untapped, real-time data sources, such as in-home user preferences, appliance behaviors, or localized voice commands, can be captured and processed on-site.

Eventually, your washing machine could be equipped with a compact language model, and you could tell it you're washing a mixed load and are concerned about a sweater washing in overly warm water, without requiring internet connectivity to operate. By capturing and responding to this specific, real-time input locally, these models open new possibilities for personalized interaction with devices. SLMs could empower voice assistants, smart home automation, and beyond, reducing the dependency of devices on cloud-based services.

The Evolution: Bioengineering

Computing crosses the human-machine interface, deepening the shifts toward ubiquitous AI and sensors.

Bioengineering involves using engineering techniques to build biological systems and products, while generative biology (genBio) uses data, computation, and AI to predict or create new biological insights. Soon, genBio will serve as an input to computationally generate new biological components, such as proteins, genes, or even entire organisms, by simulating and predicting how biological elements behave and interact.

This convergence of AI and biology is increasingly part of the conversation: in the latter half of 2024, it was a frequent topic during analyst and investor days, as well as in public presentations. At Goldman Sachs Communacopia + Technology Conference, Microsoft's Chief Technology Officer Kevin Scott explained that the technology convergence would "make some discoveries over the intervening years that bridge the gap between what we're doing and what biology knows how to do." NVIDIA CEO Jensen Huang calls "digital biology" the "next amazing revolution for AI."

Companies like Ginkgo Bioworks use genBio to design and create custom enzymes that can be applied in industrial processes. For example, generative algorithms help engineer enzymes that break down complex molecules, such as plastics or other pollutants. EvolutionaryScale is another startup using genBio to make "biology programmable." Its ESM3 platform uses "chain of thought prompting" to design emGFP, a novel version of fluorescent proteins responsible for the bold colors of jellyfish and corals. The company says it would have taken nature 500 years to evolve a protein it created in a flash.

We're getting closer to understanding the secrets of the genome with AI advances targeted at genBio. An AI model called Evo is able to discern patterns in the notoriously long, complex strands of DNA that challenge current approaches, enabling modeling at the whole-genome level, kind of like ChatGPT, but instead for organisms. Evo uses the language of biology—DNA, RNA, and proteins—to make predictions, enabling the design of everything from molecules to full genomes. It even allows scientists to generate novel CRISPR systems for genome editing.

Figure 5

Number of Novel Materials Discovered Through Generative Biology Tools.

LAB OR COMPANY	DISCOVERY
Pacific Northwest National Laboratory in partnership with Microsoft	32 million new candidate materials to accelerate the search for more efficient rechargeable battery material.
Johns Hopkins Applied Physics Lab	1+ million candidate materials and 200 samples designed for national security needs.
Materials Nexus	100 million rare-earth-free material compositions and one new rare-earth-free permanent magnet.
Massachusetts Institute of Technology	50 novel microstructure composites that balance stiffness and toughness efficiently.
DeepMind	2.2 million new crystals, including 421,000 stable materials that could power future technologies.

Source: Future Today Institute analysis.

Bioengineering has the potential to help us transcend silicon-based computing systems. For example, in 2021 a group of scientists at Shanghai Jiao Tong University in China created a programmable DNA computer capable of running billions of circuits. Rather than relying on traditional silicon microchip-based frameworks, DNA computers operate using the very molecules that have been nature's medium for storing life's blueprints for eons. After all, biology has a code—ACTG—not unlike binary code (1s and 0s) in conventional computing.

One key advantage of programmable DNA is its remarkable data storage density, theoretically allowing storage of up to one exabyte of data per cubic millimeter. It has the ability to fit trillions of DNA molecules in a drop of water, enabling massive parallel computations while consuming minimal energy. To be fair, this new DNA computer takes hours to perform simple computations and won't replace regular computers anytime soon. But the research does hold promise for certain biomedical applications. For example, a DNA machine could detect specific genes and respond with a DNA strand that triggers biological reactions, which could prove useful in environmental monitoring or disease treatment. What's next: cajoling DNA to perform complex algorithms and disease diagnosis.

As bioengineering, and genBio along with it matures, we will have access to new therapeutics, new ways to manage climate change, and new ways to deal with the global food shortage.

> *As bioengineering, and genBio along with it matures, we will have access to new therapeutics, new ways to manage climate change, and new ways to deal with the global food storage.*

Most strikingly, advances in the three general-purpose technologies that make up living intelligence could help alleviate the widespread AI chip shortage. Sometime in the next decade, these technologies will work alongside another game-changing technology, organoid intelligence (OI). OI uses lab-grown tissues, such as brain cells and stem cells, to create biological computers that mimic the structure and function of the human brain. The technique has the potential to outperform silicon-based systems for processing-intensive AI tasks.

An organoid is basically a tiny replica of tissue that functions like an organ of the body. Basically, scientists start with a special type of "blank" stem cell. They put these cells in a gelatinous mixture and start adding molecules to nudge it to become heart cells, brain cells, or whatever they want to grow.

In 2021, researchers at Cortical Labs in Melbourne, Australia, made a miniature organoid brain that worked like a computer. They called it DishBrain, attached it to some electrodes, and taught it how to play the 1980s video game Pong. DishBrain is made of about 1 million live human and mouse brain cells grown on a microelectric array that can receive electrical signals. The signals tell the neurons where the Pong ball is located, and the cells respond. The more the system plays, the more it improves.

Cortical Labs is now developing a new kind of software, a biological intelligence operating system, which would allow anyone with basic coding skills to program their own DishBrains. Additional demonstrations of new, simple forms of neural networks made from biology are coming soon. Already in late 2023, a biocomputing system made of living brain cells learned to recognize the voice of one person out of a set of 240 audio clips of different people pronouncing Japanese vowel sounds. The clips were sent to the organoids as sequences of signals arranged in spatial patterns.

Scientists are in the process of building biological circuits, made of synthetic DNA, and the software that operates them. A program called DNAr, developed at the Federal University of Mato Grosso do Sul in Brazil, simulates chemical reactions, while another called DNAr-Logic enables scientists to design circuits. A high-level description of a logical circuit is then converted into a chemical-reaction network, which can be synthesized into DNA strands. Dramatically speeding up the design process for biological circuits could drastically reduce the time it takes to discover health care treatments and new drugs.

Organoids are not being developed just for research purposes—they already have commercial applications. The Swiss company FinalSpark offers cloud-based computing services using real organoids through its Neuroplatform: a system of 16 organoids housed in microfluidic incubators, maintained at body temperature (37°C), that has been operating continuously for more than four years. These organoids can transmit and receive electrical signals, learn, and perform tasks via electrical stimulation. Users can also deploy chemical stimulation, such as dopamine release, to "reward" the organoids. Designed for biocomputing and wetware computing research, the platform features a Python-based API for interaction with the organoids. FinalSpark claims its system could be up to a million times more energy-efficient than traditional computers.

Why bother inventing technology that sounds like it was inspired by a dystopian sci-fi novel? The top five U.S. companies that collectively spent the most on AI in 2023 ran up a bill for $105 billion. With expected usage rates rising, that bill could balloon to $187 billion in the next three years. The power demands from data centers will grow as the technology supercycle intensifies. By 2030, power demand is likely to grow 160%.

As businesses, governments, the research community, and consumers alike demand more applications, we'll need more energy-intensive computers and networks to crunch all that data. One hope is that biological computing might be able to perform all of those kinds of tasks using a fraction of the resources required of a traditional computer.

FUTURE CASES

Generative Biology Is the Next Big Disruption After Generative AI

What if it were possible to generate novel protein therapeutics using new AI-friendly computational tools, without having to discover them through trial and error? That's the promise of generative biology.

For example, Boston-based startup Generate Biomedicines trained an AI to invent proteins with structures that, as far as we know, don't exist anywhere in nature. Inspired by DALL-E 2, the powerful text-to-image AI system from OpenAI, Generate's platform asks users to describe the shape, size, and function of a protein they'd like to see. It then uses diffusion modeling to generate a structure with the right amino acids folded correctly to meet the description.

Our understanding of the genome, along with fundamental molecular and network mechanisms, is now being enhanced with similarly innovative tools that allow us to interact with, examine, and manipulate biological systems in new ways:

Spatial Biology + AI

Spatial biology is a burgeoning field that hopes to gain a deeper understanding of the human body using computer modeling and generative AI. Spatial biology uses data at the cellular and molecular level to map the intricate architecture of cells, allowing for a much more comprehensive view of cellular interactions at the atomic level. Increasingly, spatial biology will produce complex data, and companies will need advanced algorithms to help mine it for insights. Just as the super-high-resolution images from the James Webb Space Telescope are changing our understanding of the universe, the technological advancements, improved automation, and sophisticated data analysis capabilities researchers gain from spatial biology will transform our understanding of life. For example, spatial biology used in diagnostics and treatment development could usher in a new era of precision medicine.

Bioprinting Electronics

In a groundbreaking development that blurs the lines between biology and technology, researchers at UK-based Lancaster University successfully 3D-printed glowing shapes inside nematode worms, demonstrating the potential to embed electronics directly within living organisms. The team used a photonic 3D printer and a special ink that shapes and activates materials within an organism. By feeding this ink to nematode worms, the team was able to create intricate conductive circuits in the form of stars and squares. This technique points to the potential for improving traditional electronic implants, such as pacemakers and bionic ears, which have transformed medical treatments but come with their own set of challenges, including infection risks and maintenance difficulties. The Lancaster University team's work is part of a growing trend in bioprinting electronic implants and computer-brain interfaces, which could replace the medical devices we use today.

Bioprinting and Tissue Engineering

Organ donations face critical shortages, and until now, the only path to organ transplantation involved matching with a donor, making sure the recipient's immune response doesn't reject the organ, and mitigating the risk of infection. An emerging solution is organ bioprinting, which uses stem cell technology to fabricate organs tailored to the recipient's cellular profile and could reduce the risk of rejection. Researchers at Stanford University are growing human organs inside bioreactors, which provide a biologically active environment where cells, tissues, or microorganisms can be grown or maintained under controlled conditions. The team plans to grow all the cell types needed to produce a human heart inside the bioreactor and eventually feed the cells into a bioprinter to fabricate a fully functional human heart. By some estimates, bioreactors could produce needed cells by the billions, and eventually print a heart every two weeks. This year, printed human hearts will be transplanted into live pigs to see if they can keep the animals alive. Meanwhile, scientists at Harvard University's Wyss Institute have developed a new 3D bioprinting technique for tissue. This method creates thick, vascularized tissues using living human cells and a special silicone mold to shape and support tissue on a chip.

Fabricating Organoids

It's difficult and dangerous for scientists to study how living human tissue responds to viruses, medications, or other stimuli, because brain or heart tissue can't be removed from a living person. In December 2023, scientists at Weill Cornell Medicine used an organoid model to identify a new pancreatic cancer treatment. A month later, scientists at the Princess Máxima Center for Pediatric Oncology in the Netherlands successfully grew tiny brain organoids in a dish from human fetal brain tissue. The tiny blobs of tissue could also be reprogrammed to have certain diseases, in order to study developmental disorders or brain cancers. Scientists are already experimenting with transplantation: In separate experiments, researchers at Stanford and the University of Pennsylvania successfully transplanted human brain organoids into damaged rat brains. The organoid made connections to the rest of the brain and responded to flashing light stimuli. Experiments like these raise both complex ethical concerns and, perhaps, fears of a day when super rats that can process information as well as humans emerge.

Organ-on-a-Chip Systems

Picture something like a computer chip, but with a transparent circuit board, that's connected to a biological system pumping a blood substitute through tiny blobs of tissue. Organ-on-a-chip systems (OoCs) are synthetic organs made of three-dimensional microfluidic cell culture technology that promotes organ functions, processes, and physiological responses. Researchers in South Korea developed an artificial nervous system that can simulate a conscious response to external stimuli. It includes an artificial neuron circuit, which acts like a brain, a photodiode that converts light into electrical signals, and a transistor that acts as a synapse. All these components are connected to a robotic hand. Think of this as "wetware" rather than computer hardware. This type of a system could help people with certain neurological conditions regain control of their limbs and could eventually be worn or even embedded. Emulate, a company that makes OoCs, tested 870 human liver chips across a set of 27 drugs with known toxicity issues—and the chips did a better job of predicting drug safety than the usual methods of studying drug interactions.

The Era of Living Intelligence

The signs of the convergence of AI, advanced sensors, and generative biology are coming into focus. Although the signals may be subtle, they can be seen in investment, patents, and R&D spending. While spending alone does not guarantee innovation, a key indicator of success will be the revenue these investments are poised to generate in the near future as the technologies mature and begin to scale. As revenues are realized, these signals will become far more pronounced. For now, we rely on the subtler data points from investments and early research.

This convergence is already driving a significant shift in venture capital and corporate spending. Companies like EvolutionaryScale, which raised $142 million from AWS and NVIDIA's venture arm, highlight the growing integration of AI into biotech. These advancements span various fields, from drug discovery to environmental remediation, showcasing how the cross-pollination of technologies is accelerating breakthroughs. Generative biology, powered by AI, is expected to generate efficiencies in life sciences, further underscoring this convergence.

The impact of the convergence extends across industries—from materials science to connected devices to health care. For instance, CuspAI raised $30 million to develop AI for materials science, reflecting the increasing overlap between AI and traditional fields like chemistry. In the health care sector, Sword Health, which specializes in musculoskeletal care, secured $340 million in funding for AI and connected sensors technology, showcasing the rapid growth of AI-powered health care.

The convergence also encompasses computing technologies, particularly in edge computing and neuro-symbolic AI. Companies like Symbolica AI, which raised $33 million in 2024, highlight the growing importance of sensor-driven data and AI processing at the edge. IDC forecasts edge spending to reach $232 billion by 2024, with sectors like health care, energy, and materials science reaping the benefits as they transform operational models and innovation cycles.

These investments are not isolated developments; they are part of a broader technological convergence that is ushering in a new era defined by living intelligence.

In this era, as breakthroughs in AI enhance the capabilities of sensors and biotechnologies, a self-reinforcing cycle of innovation will emerge. This triad of technologies will create a flywheel effect, where each advancement fuels new discoveries and applications, accelerating the overall pace of innovation.

These investments are not isolated developments; they are part of a broader technological convergence that is ushering a new era defined by living intelligence.

As the era of living intelligence unfolds, it will create new markets and value for consumers. The flywheel effect will drive increased consumer spending, which in turn will attract more investment. This influx of funding will bring in top talent, spurring further innovation. As this cycle continues, consumers will derive greater value from new technologies, driving even more spending, thereby perpetuating the cycle.

The flywheel effect between technological advancement, capital attraction, and talent acquisition accelerates the pace of innovation, fostering a bioeconomy that transforms industries and overall value creation.

This growth in demand will also attract more investment, as investors follow the emerging revenue streams. Network effects, where the value of a product or service increases as more users adopt it, are particularly strong in technology-driven industries. Bioengineering startups, for example, are leveraging advanced sensors to monitor biological processes in real time, leading to cost efficiencies and breakthroughs in areas like CRISPR-based therapies. This convergence is creating an ecosystem where every innovation strengthens the entire network, attracting more investors as scalable, data-driven solutions expand exponentially.

In parallel, the global sensor market is enabling the collection of unprecedented amounts of data in sectors like health care and agriculture. These sensors feed vast amounts of real-time information into AI systems, which in turn deliver predictive analytics and insights. This feedback loop continuously improves AI systems as sensor networks expand, allowing bioengineering firms to optimize processes and outcomes. Investment firms are diversifying portfolios to capitalize on this convergence, betting on the synergies between AI, bioengineering, and sensor technologies to generate exponential returns. For example, AI-driven bioengineering combined with wearable sensors is enabling real-time health monitoring, projected to exceed $87 billion by 2026. Early investors can expect significant long-term gains from this convergence.

These advancements don't just improve productivity; they elevate the quality of output, creating even more compelling products and services. This continuous innovation loop attracts more consumer spending, which in turn signals greater potential returns for investors, ensuring that funding flows back into the system. The flywheel effect between technological advancement, capital attraction, and talent acquisition accelerates the pace of innovation, fostering a bioeconomy that transforms industries and enhances overall value creation.

We're already seeing the signs of convergence in living intelligence technologies across several leading-edge industries. Early adoption is happening most intensively in industries like pharmaceuticals, medical products, health care, space, construction and engineering, consumer packaged goods, and agriculture. But applications are coming to other industries soon, creating novel "white spaces" of opportunity in industries like financial services. As additional industries jump on board, innovation will disperse much more broadly, fueling additional flywheel effects.

How Living Intelligence Convergence Works in Practice

We see five characteristics of converged living intelligence technologies that make them different from technologies that came before. The following chart illustrates key shifts in synergies, flexibility, scale, innovation, and transformation before and after convergence.

Living intelligence is a force of tremendous change. With that change comes unprecedented opportunity. Organizations that make the leap toward the future happening everywhere around us will harness that opportunity for exponential growth.

#	Characteristic	BEFORE CONVERGENCE		AFTER CONVERGENCE
1	**SYNERGIES** Converged technologies are more than the sum of their parts. They create new value through the integration of previously distinct technologies, leading to exponential benefits.	Technologies operate in silos, with value delivered narrowly in isolated functions or industries.	**SYNERGIES**	Technologies become seamlessly integrated, and the resulting synergies unlock new capabilities, efficiencies, and value creation.
2	**FLEXIBILITY** Converged technologies are designed to adapt and evolve more easily with changing customer needs, business environments, and tech advancements.	Individual technologies require specific use cases or rigidly defined environments in which to operate.	**FLEXIBILITY**	Organizations enjoy greater flexibility in deployment and customization.
3	**SCALE** Converged technologies can be scaled with more impact and often at lower incremental costs.	Scaling individual technologies results in higher costs with less efficiency.	**SCALE**	Network effects compound value, while new platforms allow for faster scaling at lower costs.
4	**INNOVATION** Converged technologies accelerate innovation cycles and can reduce the time it takes for new products and services to enter the market as enthusiasm, funding, and shared infrastructure increase.	Siloed development translates into longer innovation cycles and lengthy integrations.	**INNOVATION**	Rapid experimentation and iteration allow for faster prototyping and scaling.
5	**TRANSFORMATION** Converged technologies have the power to disrupt entire end-to-end value chains, because they lead to new solutions that were previously unachievable.	Incremental innovation is limited to improving efficiencies or expanding features of existing products.	**TRANSFORMATION**	Radical innovation disrupts markets, creates new value chains, and redefines industries.

A Call to Action

People living today are experiencing momentous change—what we call the *great transition*. Society is going to look very different once the transition is complete. New capabilities and mindsets will be required to make the leap.

Are you thinking broadly enough about the potential impact of living intelligence?

Future Today Institute's research suggests that the convergence of AI, advanced sensors, and bioengineering could revolutionize industries, not only automating about half of today's business activities much sooner than previously projected, but also ushering in new products, services, and entire fields. Living intelligence combines the cognitive power of AI, real-time data capture from advanced sensors, and innovations in bioengineering to reshape the future of work, redefining tasks, roles, and responsibilities across various sectors. It will also shift how and where value is created. For that reason, executive leaders should consider how their business models might be profoundly disrupted or potentially enhanced.

What are the organizational implications of living intelligence?

Rather than passively exploring potential use cases, leaders should adopt a proactive, strategic approach. They need to assess how AI, sensor data, and bioengineering can converge to deliver immediate value and prepare for long-term applications. As convergence evolves, companies will need to undertake a new digital transformation. This process should include the creation of a long-term strategy, an expanded value network map, and a comprehensive execution plan. Which business functions stand to benefit the most from this convergence now, and which could be transformed in the next six to 12 months? Leaders that anticipate developments and use strategic foresight to plan for growth will gain a competitive advantage.

What is the impact of living intelligence on the organization's value network?

Where are the opportunities for innovation and growth? What might threaten the organization's ability to thrive? What are the downstream risks to partners or customers? Understanding how living intelligence fits into an existing value network can significantly enhance an organization's innovation and value generation capacity through faster identification of growth opportunities, stronger partnerships, and a more resilient network, capable of adapting to disruptions. As a result, companies can improve customer satisfaction, reduce operational costs, and drive long-term value creation across the entire value chain. Prioritizing this transformation positions businesses to outperform competitors in a rapidly evolving landscape.

Does the organization have the right talent and risk management systems in place?

Leaders must evaluate their talent strategy to ensure they have access to multidisciplinary expertise in AI, bioengineering, and sensor technologies. Furthermore, as the adoption of living intelligence expands, they must establish robust oversight structures to manage potential ethical risks, such as data privacy and algorithmic bias, that arise from the integration of biological data and AI.

How to prepare your organization for the great transition.

Although living intelligence may seem like a futuristic idea, forward-thinking CEOs and business leaders cannot afford to wait. The rapid pace of advancement in these technologies demands immediate action to remain competitive. By taking the following steps with urgency, leaders can capture early advantages and stay ahead of industry disruptions.

1. Demystify living intelligence for the entire organization.

Senior leaders should familiarize themselves with the intricacies of living intelligence—how AI, sensor data, and bioengineering interplay—to confidently lead and educate the workforce. This will involve fostering a culture of innovation and transparency, especially in addressing any concerns around the ethical implications of bio-sensor data integration or the potential for AI-driven automation to displace jobs.

2. Develop pragmatic scenarios for disruption and new value generation.

Leaders should develop scenarios for using and scaling living intelligence technologies, processes, and products. Companies must use strategic foresight to understand how the evolving living intelligence ecosystem could have an impact on their existing products and processes. Prioritize monitoring, acting, and agile decision-making in order to adapt to the convergence. As convergence evolves, companies will need to undertake a new digital transformation, which should include the creation of a new vision for the organization, a long-term strategy, an expanded value network map, and a comprehensive execution plan.

3. Identify two or three high-impact use cases—and just get started.

Leaders should pinpoint specific use cases where living intelligence can make the most significant impact, whether it's revolutionizing supply chain management with real-time sensor data, using AI to enhance patient outcomes in health care, or applying bioengineering to optimize product development. By choosing pilots with the greatest potential for scalability, leaders can accelerate the adoption of living intelligence and begin integrating these technologies into everyday workflows.

4. Commit to developing the necessary roles, skills, and capabilities.

The convergence of AI, advanced sensors, and bioengineering will demand a new set of skills across the organization. Leaders must prioritize reskilling and upskilling initiatives to prepare employees to work effectively alongside these technologies. Additionally, they should continuously assess their evolving talent needs as new applications of living intelligence emerge.

5. Monitor regulatory shifts and be prepared for policy uncertainty.

The convergence will spark myriad innovations and demand unprecedented agility from companies, especially given the current patchwork regulatory approach. Leaders must empower their organizations to experiment with new products and processes, and ensure that they shape their own futures rather than being compelled to adapt to external innovations or react to regulatory shifts.

Living intelligence is a force of tremendous change. With that change comes unprecedented disruption and opportunity. Organizations that make the leap toward the future happening everywhere around us will harness that opportunity for exponential growth.

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As founder and CEO of the Future Today Institute (FTI), Amy pioneered a unique quantitative modeling approach and data-driven foresight methodology that identifies signals of change and emerging patterns very early. Using that information, Amy and her colleagues identify white spaces, opportunities, and threats early enough for action. They develop predictive scenarios, along with executable strategy, for businesses worldwide. In addition, Amy is regularly asked to advise policymakers in the White House, Congress, U.S. regulatory agencies, the European Union and United Nations. In 2023, Amy was recognized as the #4 most influential management thinker in the world by Thinkers50, a biannual ranking of global business thinkers. With research specializations in both AI and synthetic biology, Amy is the author of four books which have been translated into 19 languages. She developed and teaches the Strategic Foresight Course at NYU Stern School of Business.

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Methodology

Our research combines in-depth qualitative and quantitative analysis to assess how artificial intelligence, bioengineering, and advanced sensors are being integrated into business and daily life. We gathered data from a variety of sources, including patent filings, scientific publications, investment rounds, macroeconomic indicators, and online search trends. Using our proprietary system, we identified patterns and grouped data into nodes, which were then evaluated through standardized metrics. This approach enabled us to track technological advancements and their economic impact across sectors and geographies.

We focused on key metrics such as market capitalization and investments, productivity gains, and employment shifts to understand the broader economic implications. Investment data from 2019 to the present was analyzed to track funding in AI, bioengineering, and advanced sensors, while productivity metrics evaluated how these technologies have improved efficiency across industries. Employment trends were examined to quantify the creation of new jobs directly linked to these technologies, and their contribution to GDP was modeled across major economies including the U.S., China, and the EU.

While our methodology is rigorous, there are inherent limitations due to data availability and external factors. Some datasets, particularly those related to investment rounds or employment, may have lags or regional biases. Additionally, the rapidly evolving nature of AI, bioengineering, and advanced sensors means that certain trends might shift abruptly, necessitating continuous monitoring and adjustments to our models.

About Future Today Institute

Future Today Institute is a management consulting company specializing in strategic foresight, a data-driven practice for developing plausible future scenarios. As organizations worldwide grapple with an increasingly volatile and uncertain business climate, FTI provides clarity through long-term strategic planning. Its team of subject matter experts combines best-in-class trends and technology research with actionable strategies to generate business impact. In the two decades since its founding, FTI has become the preeminent foresight consultancy to Fortune 500 companies, major governments, and other global organizations—empowering leaders to make better decisions about the future, today.

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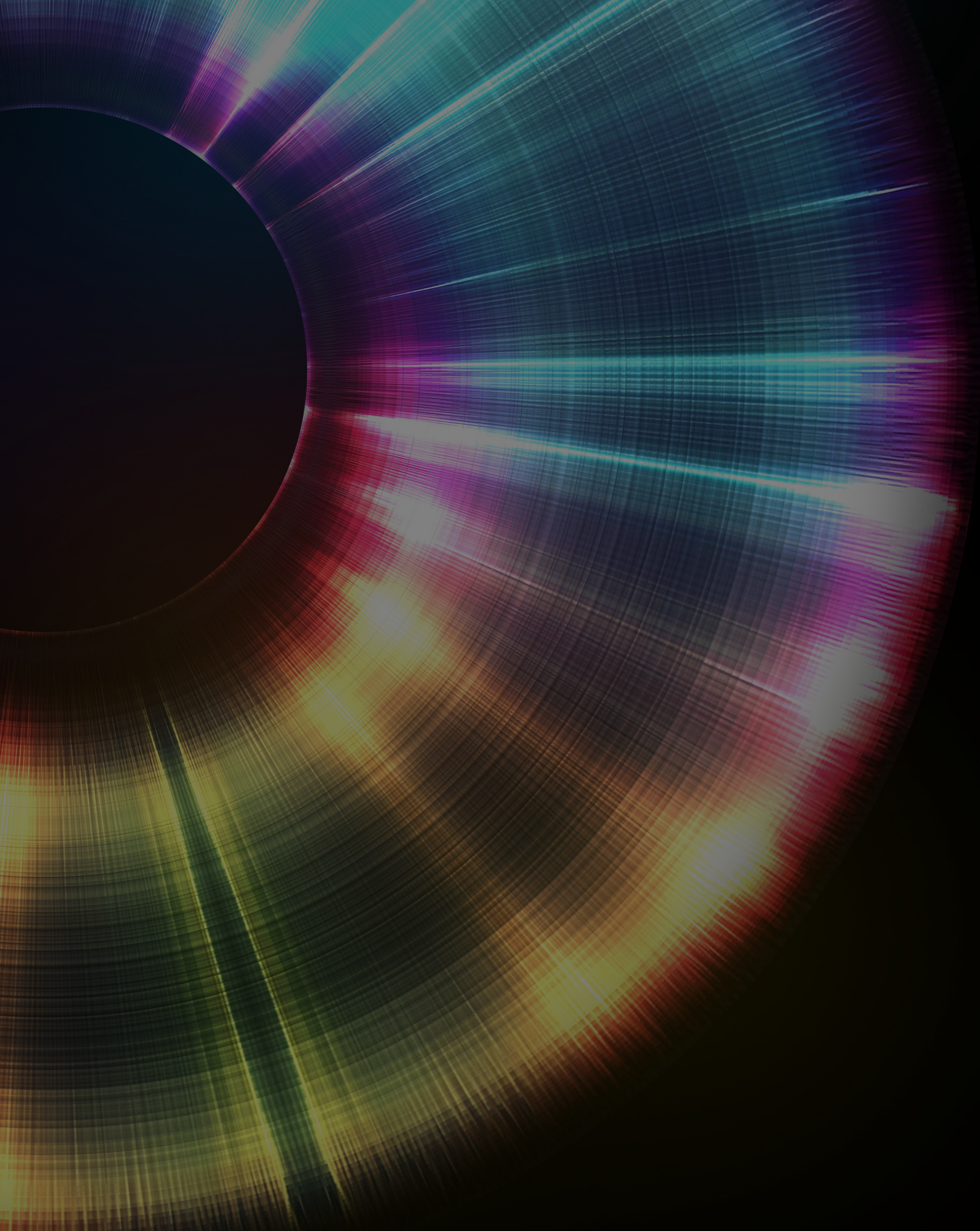

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