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Transformation

Next Gen Tech: Breakthroughs that will transform the world

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Key takeaways

- Bank of America Institute's 'Next Gen Tech' series explores 30 breakthrough technologies across artificial intelligence (AI), computing, robots, communication, healthcare, energy and mobility, that are about to alter our lives. Join us as we discuss what's next on the tech horizon.
- It's easy to forget that the newest AI wave emerged largely within the last 15 months and remains early in development when compared to historical cycles of innovation. AI's newest wave represents a paradigm shift in corporate efficiency, productivity and global advancement in line with past disruptive technologies like the personal computer, internet and iPhone.
- And while AI underpins many of the technologies throughout this series, it's not just about the impact of AI itself so much as how it intertwines with other technologies. AI is now being leveraged as a tool for other innovations and it is this integration that will power the pace of global transformation.

This publication is part of Bank of America Institute's 'Next Gen Tech' series – focused on sharing 30 breakthrough technologies that will transform the world. Each week, we'll highlight one of seven categories (artificial intelligence, computing, robots, communication, healthcare, energy and transport), and share advancements within each, so stay tuned for more.

Innovation leads to transformation

The pace at which shifts in innovation are transforming businesses, and the world, is unprecedented. Between the exponential growth of data (doubling every two to three years), cheapening computing power, and the rise of a connected world (e.g., IoT (internet of things), mobile devices, social media), BofA Global Research believes that the fastest transformation in human history is ahead of us.

What's more, the commercialization of new technologies and breakthroughs will happen much faster than ever before and as a result, society is preparing for what is coming next, today. But let's start at the beginning.

The AI revolution

The first Industrial Revolution involved waterpower driving manufacturing. Advances in textiles brought about the first factories and in turn, cities expanded around them. The second wave involved rail, steam and steel advancements, while the third saw the emergence of electricity powering lights and telephone communication. Then, during the fourth wave, aviation revolutionized travel. Finally, the fifth, and most recent wave, saw the internet bring in a new frontier of globalization and information flow.[1]

As the innovation waves shorten, we may be nearing the sixth wave – one that embraces AI (artificial intelligence) and the digitization across IoT, robotics, drones and more, to create intelligent manufacturing systems that can operate with minimal human intervention. It also relates to cloud computing, collaborative robots and quantum computing. Industry 6.0 may seem futuristic, but with the advent of generative AI (genAI), the mass adoption of AI may happen much sooner than we think.

For a technology to be considered a general-purpose technology (GPT), there are three characteristics that should be exhibited: *pervasiveness* (the GPT should spread to most sectors), *improvement* (the GPT should get better over time and thereafter lower the cost to its users) and *innovation spawning* (the GPT should make it easier to innovate, create new products/processes).[2] AI can certainly tick these boxes.

The pervasiveness of AI is at an 'iPhone defining moment' in that there is an abundance of commercial use cases and it will likely catalyse a corporate efficiency and productivity evolution that touches every sector globally over the next five to 10 years, as discussed in AI evolution: Reality justifies the hype. In a survey conducted by McKinsey in August 2023, one-third of respondents indicated that their organizations were using generative AI regularly in at least one business function. In fact, 2023

[1] Visual Capitalist, Dorothy Neufeld
[2] Timothy F. Bresnahan and M. Trajtenberg, 1992, General purpose technologies: Engines of growth?

was a record year of investment in genAI; funding to the space was up 5x compared to the previous year – with equity funding topping $21 billion.[3] We have also witnessed the evolution of large language models (LLMs), and as investment increases, they will continue to advance, enabling more use cases and further innovation.

In our AI era

BofA Global Research sees three reasons why the exponential pace of global transformation – blistering as it already is – will move vertically from here, all powered by AI reaching mass adoption:

1) Tech-tanglement:

It's not just about the impact of AI itself but also how it intertwines with other technologies, e.g., robots, simulation and communications. As AI evolves, so will everything else. In this way, AI is the key engine that can enable the next wave of innovation. How? There are multiple channels, but to name a few:

- **AI could be embedded into existing products offering better capabilities**. For example, 5G advanced (5G mobile technology embedded with AI capabilities) could have 10x the mobile speed and a third of the latency and costs, compared with 5G. Using AI in grid management could help plan electricity requirements 12x faster than without AI.

- **AI is being leveraged as a tool (for other innovations)**. For instance, AI-enriched simulation for drug discovery and material breakthroughs. AI helped to discover 45x times more crystals ever known to man. Using AI in drug discovery enabled the finding of a candidate for liver cancer in just 30 days.

- **Create the required technology to enable the next generation of AI**. For example, to reach AGI (artificial general intelligence – a type of AI that can perform as well, or better than, humans on a wide range of cognitive tasks) we may need 'embodied AI' – giving a physical form to AI so that it can learn from a wider environment of data and teach itself to do tasks that it was not pre-programmed to do. This could involve putting AI into robot-like humanoids, drones, cobots (collaborative robots) and AVs (autonomous vehicles).

These connections and interactions of technologies create a feedback loop. As AI-enabled products offer better capabilities, as AI is used as a tool for fuelling more innovation and as it creates demand to improve existing technologies, our world becomes ever more infused in this AI era.

For example, over the past few years, LLMs have become larger, driving the need for more compute. But we may want to have LLMs running on end-devices rather than in the cloud, which opens up more opportunities for end-device/edge compute. In this way, we have AI fuelling innovation, fuelling AI, fuelling innovation, and on and on. While many AI-related tech developments have come to fruition over the past year, BofA Global Research believes that we could see more as this propagation continues to unfold, springboarding us on to the path of Industry 6.0.

2) Tech-scarcity:

We live in a world of demand for technology in order to address our world of scarcity. With growing innovation and improving economics, there is hope that we can leverage these new technologies to shift our world from one of scarcity to one of abundance. Examples of such scarcity include:

- **Scarcity in bandwidth:** We inhabit a world that generates 328 quintillion (million trillion) bytes of data every day[4] and data generation will only get faster from here as AI takes hold. In fact, an estimated 90% of all global data will be AI-generated by 2025.[5] And according to International Data Corporation (IDC), the amount of data created is projected to double every two to three years.[6]

- **Scarcity in compute:** The training of AI systems can be divided into two eras: the first era and the modern era. The first era of compute usage relied on limited computational resources and simple algorithms. The modern era, which began in c.2012, with the rise of deep learning and powerful hardware, allowed for the training of increasingly complex models with billions of parameters. Post-2018, the computing power increased 275x every two years compared to 8x previously.

- **Scarcity in healthcare:** The US has one of the most expensive health systems worldwide with spending totalling $4.3 trillion in 2021. Yet approximately 25% of US healthcare spend, or $1 trillion, is considered wasteful, and about one-quarter of that could be recovered through interventions. The largest source of healthcare system waste, roughly $266

[3] CB Insights
[4] Statista
[5] Europol Innovation Lab (2021). Facing Reality: Law Enforcement and the Challenge of Deepfakes.
[6] International Data Corporation (IDC)

billion, is administrative costs. Additionally, there is currently a global shortage of more than seven million health workers, which could rise to 13 million by 2035.[7] See Tough hiring tests healthcare's patients for more.

- **Scarcity in metals:** Transitioning the global economy to clean energy and transportation would require significant increases in critical minerals, many of which are relatively small commodity markets requiring additional mining capacity. This can be costly (with long lead times) and environmentally sensitive. Furthermore, their availability is often geographically concentrated, posing supply chain risks. In fact, more than 300 new mines would be required by 2035[8] for electric vehicle (EV) batteries and energy storage. However, despite much concern over the impacts from EV batteries, metal volumes for the electricity grid would be far higher – the total copper requirement could double between 2020 and 2040.[9]

3) Tech-onomy:

All of the investments in automation, AI and tech are reducing prices across the board and increasing returns. For example, while drive capacity has risen by more than 20,000x in the past 20 years, the price per gigabyte has fallen by >99%.

It's quite simple: improving economics speeds up innovation. One way of thinking about the economics behind innovation is the learning curve. This is the observation that costs decrease as the production of a technology increases. For every cumulative doubling of production, the cost per unit decreases by typically 20%. Increasing production gives engineers the opportunity to learn how to improve the process. This creates a positive feedback loop of increasing demand and falling prices. More technology gets deployed to satisfy demand, leading to falling prices. Then, these technologies become cost-effective in these new applications, feeding increased demand again.

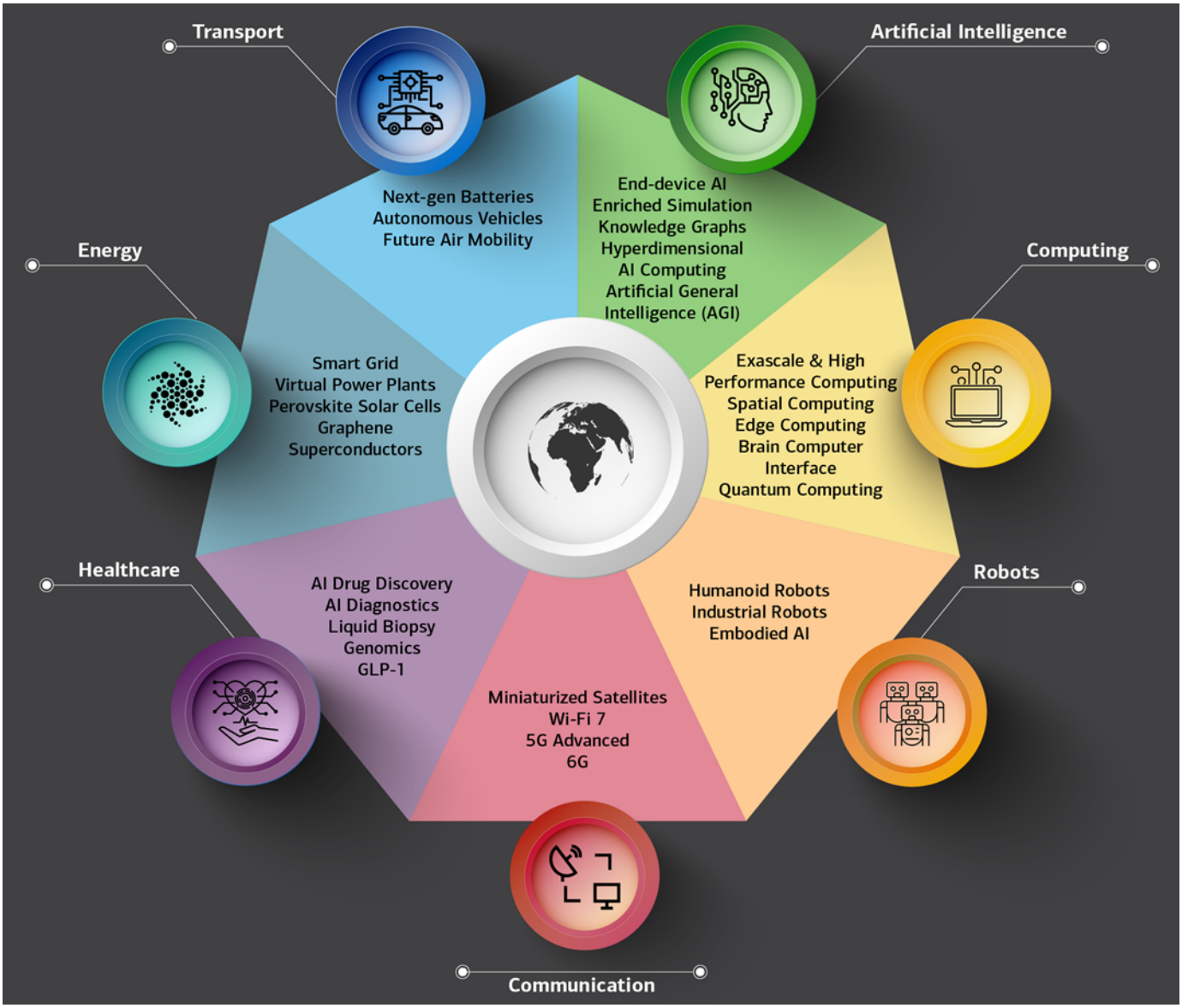
I want to break free: 30 breakthrough technologies

As the AI revolution picks up steam, it underpins the advancement of next generation technologies across categories including computing, robotics, communication, healthcare, energy and materials, future mobility, and of course, AI itself (Exhibit 1). Recently, BofA Global Research mapped out 30 breakthrough technologies that are about to alter our lives (Exhibit 2). Bank of America Institute's forthcoming series, Next Gen Tech, will dive into each of the aforementioned categories and the technologies within them.

It has been roughly a year and a half since the proliferation of large language models and generative AI, and so now seems a good time to ask: what comes next?

[7] World Health Organization (WHO)
[8] Benchmark Mineral Intelligence
[9] International Energy Agency (IEA)

Exhibit 1: Identified breakthroughs in AI, computing, robots, communication, healthcare, energy and transport
Illustrating breakthrough innovations across different sectors



Source: BofA Global Research

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Exhibit 2: What are the breakthrough innovations across different sectors?
Additional details on the 30 breakthroughs identified by BofA Global Research in AI, computing, robots, communication, healthcare, energy and transport

Theme	Breakthrough	What is it?
AI		
	End-device AI	Deployment of AI functions/models on local devices e.g., smartphones, autos, wearables
	Enriched Simulation	Using AI to accelerate the discovery process and identify the most viable simulations, speed up the creation of new molecules and bring down the cost to do so
	Knowledge Graphs	Knowledge graphs organize data from multiple sources, capture information and forge connections between them. The solution to hallucination, efficiency and neural networks capabilities
	Hyperdimensional AI Computing	Using high-dimensional vectors to represent information rather than the traditional binary system. It can capture more complex data patterns and allow computers to retain more memory
	Artificial General Intelligence (AGI)	A hypothetical AI agent, that will possess general cognitive abilities at, or above human level on a wide range of tasks and can solve tasks without being preprogramed to do so
Computing		
	Exascale Computing & HPC	Computational systems that use supercomputers and parallel computer clusters to solve advanced computation problems
	Spatial Computing	Computers that change human machine interaction by using AR/VR to blend the graphic interface for the user to take place in the real physical world
	Edge Computing	Distributed computing that processes data closer to the physical location of end devices compared with the cloud, which is located in data centers far away
	Brain Computer Interface	Brain waves of humans and animals directly interacting with the external world and vice versa
	Quantum Computing	Computing that leverages sub-atomic particles to store information and uses superpositions for complex calculations that would take a classical computer billion of years
Robots		
	Humanoid Robots	Humanoid robots assist humans and have a human-like form, mimicking human behavior and interactions
	Industrial Robots	Machines that can be automatically controlled or programmed to manipulate and move objects – they are a key enabler of the emerging Industrial Internet
	Embodied AI	Other embodied AI interfaces include service robots, autonomous vehicles, agricultural robots, drones, spatial computing/virtual reality etc.
Communication		
	Miniaturized Satellites	Micro and Nano satellites, which are low cost, small, lightweight satellites, mostly in Low Earth Orbit (LEO, up to 1,000km altitude)
	Wi-Fi 7	The next generation of Wi-Fi offering 5x more speed, leapfrog capacity and 75% drop in latency compared to previous Wi-Fi generation
	5G Advanced	The evolution of 5G mobile technology with embedded AI capabilities, offering 10x the mobile speed, a third of the latency and lower costs compared to current 5G
	6G	The revolution of mobile phone technology. The new generation which can offer 1Tbps speeds, close to zero latency and AI embedded capabilities
Healthcare		
	AI Drug Discovery	Using AI to escape the massive jump in medicine discoveries and inefficiencies. Reduce spend, time to market and personalization of drugs and treatments
	AI Diagnostics	AI has recently made huge advances in automatically diagnosing diseases, making diagnostics cheaper and more accessible
	Liquid Biopsy	Liquid biopsy is a "simple blood test" that can provide critical health information, especially for cancer
	Genomics	Genomics is the study of genes and their functions, and related techniques, whereas genetics is the study of heredity. Proteomics is roughly defined as large scale study of proteins

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Theme	Breakthrough	What is it?
	GLP-1	Glucagon-like peptide 1 (GLP-1) are hormones responsible for the "incretin effect" that makes you feel 'more full' and eat less
Energy		
	Smart Grid	Expanding, upgrading and digitalizing electricity grids to cope with the shifts in power supply and demand, increasing the share of global energy consumption to electricity
	Virtual Power Plants (VPP)	A VPP aggregates or controls a network of power generating or consuming assets to be used collectively to balance an electricity grid
	Perovskite Solar Cells	Next-gen materials with strong light absorption and electric charge properties to increase the conversion efficiency of solar cells
	Graphene	The thinnest and strongest material known to humans
	Superconductors	Materials that carry electrical currents with zero resistance
Transport		
	Next-Gen Batteries	Batteries with increasing capacity to store energy and recharge faster and cheaper, enabled by improving chemistry and material sciences
	Autonomous Vehicles	Technology that can assist or fully replace human driving, enabled by a combination of sensors and software
	Future Air Mobility	Aircraft & drones powered by electric propulsion that can take off and land vertically, Democratizing lower-cost/higher-frequency urban air travel for passenger and cargo transit.

Source: BofA Global Research

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