

ANTICIPATING EMERGING SCIENCE - HUMAN AUGMENTATION

GESDA's perspective to the Human Augmentation Exhibition at the Swiss Pavilion, 2025 World Expo Osaka-Kansai, Japan

Overview

In the 21st century, scientific research has significantly deepened our understanding of biology while also developing a suite of radical new technologies. When combined, these create an emerging ability to enhance our brain power and productivity, change our experience of reality and our information-processing skills, alter our genome, give us extra years of healthy life and improve our bodies' ability to fight disease. This era of "human augmentation" has the potential to significantly improve human well-being, changing not just how individuals live, but how society functions. Below is an exploration of how global scientific experts anticipate some of the possible advances and their implications for us as individuals, society and the planet. See the note on GESDA's methodology at the end of this document for more details on the process behind this, and for how you can have your say too: it's important that everyone co-creates our possible futures together.

Emerging Science Trends in the field of Human Augmentation:

- 1) AI is everywhere:** we work with, and have our natural capabilities enhanced by AI, which will also become our collaborator and personal assistant.
- 2) We live in multiple realities:** improvements in augmented and virtual reality experiences mean that spending time in the real world becomes an option rather than a necessity.
- 3) Technology supercharges the brain:** interfaces that connect our minds to vast computing resources – and to other minds – change the way we live, work and relate.
- 4) Gene science brings longer, healthier lives:** we are no longer in thrall to inherited diseases, and tweaks to our immune systems and cell function enable us to live better and longer lives.

Anticipated emerging scientific trends in human augmentation – and what they mean for society

1) AI is everywhere

AI is already providing useful services, such as answering telephone calls and online queries, helping surgeons to make difficult medical decisions and even assisting with scientific discovery. But we are only at the beginning of what is possible. Within 5 years, GESDA's experts anticipate that AI agents will be providing daily assistance to humans in everyday activities. Within 10 years, AIs will be interacting with each other, establishing a new AI workforce that operates alongside humans in retail, social care and education – and perhaps many other sectors. This could be a period of time where most human jobs involve collaborating with AI agents.

The current proliferation of AI going on around us is unlikely to halt: in 25 years, humanity could enter the era of "ambient intelligence" in which every element of the human-made environment responds intelligently to us in an intuitive and almost undetectable way. By then, we will perhaps be used to

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things in our environment reacting to our presence and using their intelligence to adapt and respond to our needs. Machines might prepare our food and drink before we even ask for it, for example, or automatically scan our vital signs to catch sickness or disease before it manifests. Mobile AIs – intelligent robots, essentially – are also being developed. As they develop the ability to work with language, visual and other senses – and their mobility – these intelligent robots could develop a deeper understanding of the physical world and their place in it — something that may allow AI to develop a rudimentary sense of “self” and “other”.

Collaborative work with advanced AI that has some kind of understanding of humans may lead to better human decision-making processes. AIs might facilitate discussions that lead to improved governance, for instance. Recent breakthroughs have enabled sophisticated analysis of the way human conversations work and are opening up the prospect of AI agents working alongside humans in hybrid teams. These agents could act as a “shared brain” for the group and keep team dialogue flowing. They could ultimately act as moderators, steering group deliberations. Within 10 years, decisions in crucial areas like medicine and the criminal justice could be made by systems that combine individual human knowledge, collective human intelligence and AI supervision.

Advances in AI might even make it possible for artificial agents to become equal members in AI-human teams. AI could be used as an advocate-avatar for nature – for forests or ocean ecosystems, say – or to represent the interests of future generations. Organisations such as the IPCC and UN might eventually use human-plus-AI teams to aid cross-cultural negotiations.

2) We live in multiple realities

Humans have long sought to break free of the confines of the physical world. We have used fiction and cinema to create imaginary worlds, for example. More recently, videogames have established virtual worlds in which representations of ourselves can exist, act and interact.

Such ventures are only going to escalate in the future, as new technologies make it possible for these worlds to be more immersive, interactive and absorbing. As a result, we will struggle to find distinctions between “traditional” reality and all of the other realities in which we will live, work and socialise.

Advanced sensory experiences such as Augmented Reality (AR) have already begun to change the human experience in this way. AR will be developed primarily as a display replacement, with glasses that overlay simple information like navigation instructions, translations or diagnostics, or allow people to make video calls without a handheld device. However, in combination with data streams from the expanding “internet of things”, AR will create an intuitive new layer of information for workers.

In the next 5 years, “augmented reality” (AR) glasses will become good enough to allow widespread industrial and commercial use for those working in field operations: architects visiting a construction site, for example, will use AR glasses to compare progress against views of the finished project. Such applications are data-intensive and their use will therefore be in specialist tasks at first. However, research breakthroughs in data management will eventually enable broader consumer applications.

In 10 years, devices will likely become powerful enough to switch seamlessly between AR and VR, opening the gates to the metaverse. The boundary between traditional reality, AR and VR will become blurred as breakthroughs in graphics and audio enable complex virtual content.

It’s not just about what we can see. In 25 years we might be wearing multi-sense “haptic” interfaces that make both AR and VR experiences almost indistinguishable from reality in terms of what we see,

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hear and feel. When combined with advances in brain-machine interfaces, it may become possible to transmit visual and haptic information – including taste and smell – directly to the brain.

This might sound overwhelming, but this future is likely come with a personalised AI assistant, contained within the virtual reality, that continually tailors our experience to optimise all aspects of life. You might even have an AI “co-pilot” that see the world from your perspective, providing an always-on, highly personalised overlay of digital information and offering inputs to your daily decision-making.

3) Technology supercharges the brain

We are a species that has been shaped by our environment: humans have evolved in a multitude of ways to better handle the challenges and opportunities of new surroundings. However, science and technology has advanced to the point where we are able to alter and improve on biological capabilities for ourselves.

One route to this kind of change is through technologies that enhance the physical capabilities of the human brain. This might help people with incapacitating disorders of memory such as Alzheimer’s disease, but it could also read and alter the brain states of normal, healthy individuals. Within 5 years, neural enhancements that can read and decode brain signals, and respond by making decisions — often aided by AI — might enhance the depth and quality of sleep, or perhaps override, dampen or amplify an emotion. In 10 years we might see non-essential “cosmetic” augmentation of healthy brains become a growing trend: people might choose to add in senses such as the ability to “see” a magnetic field, for instance.

In some cases, patients with brain injuries might be able to work with an AI system to retrain their brain so that it returns to its pre-injured state – or just to improve their mind’s focus so that they can perform specific tasks better than is ordinarily possible. Cross-species research might lead to a way to augment human cognition with capabilities of other animals, such as the excellent short-term memory of a chimpanzee.

In 25 years, a combination of genetic engineering and implants will facilitate enhancement of intelligence in healthy individuals, or even allow memory-editing for therapeutic purposes.

4) Gene science brings longer, healthier lives

Many of our vulnerabilities to disease and ageing are written into the genome found in every one of our cells. Our genome determines our physical characteristics, including our immune system’s response to viral and other infections, and other threats to our health. New advances in genome editing are making it possible to identify and fix vulnerabilities in specific types of cells or to optimise the function of the immune system.

In 25 years a whole slew of possibilities may arise: we could be engineered to sleep less, to have children that don’t inherit our heritable diseases, and to resist the effects of radiation, environmental toxins and infectious diseases.

Once the opportunities are available, some people may opt for “bespoke” tailoring of their genome. They might seek genetic mutations that give them night vision, or a temporary change in eye colour. Some may even choose to change what they can eat by having genetic engineering that allows them to digest cellulose or extract nutrition from plastic.

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Gene technologies may also correct, slow down or even reverse processes linked to premature ageing, thus increasing our healthspan. DNA repair is coming over the horizon, making “genome maintenance” programmes an option within 10 years. On a 25 year timescale, we might be able to incorporate genes that bestow extreme longevity on other animal species into our own genome. It may also become possible to reverse the processes that cause our cells to show signs of ageing.

Looking ahead

A future in which humans are routinely augmented is looking inevitable. However, nothing about the age of the “augmented human” has been decided yet. All of the possible futures are still open, and we can all be involved in the processes that will steer us towards outcomes that improve human well-being and establish more inclusive societies. Working together, we can develop good governance to ensure that augmentation opportunities that improve health or cognitive capacity are available to everyone regardless of geography or economic circumstances. We can start helpful conversations that will ensure people always own the valuable intellectual property contained within their biological brains. We can help each other to stay safe in virtual worlds, keeping ourselves and our loved ones safe from political manipulation or commercial exploitation. We can make sure people have the right not to augment themselves – and to not lose out on any life opportunities because of that decision.

What next?

Citizens' perspectives are vital to GESDA's vision for helping to shape our possible futures because we believe **the future is a story written by all of us**. To assist with this, GESDA and EPFL have co-created “The Geneva Public Portal to Anticipation”. You can visit the installation onsite in Osaka or online at <https://gesda.global/publicportal/>.

Note on methodology

This document is the first in a series of three discussion briefings produced by the Geneva Science and Diplomacy Anticipator (GESDA) for the Osaka World Expo. The briefings draw on the contents of the 2024 GESDA Science Breakthrough Radar®, an extensive exploration of the thoughts and opinions of hundreds of scientists about their current research and anticipated futures of their fields at 5, 10 and 25 years from now.

Asia-based experts who contributed to the GESDA Radar include:

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Find out more at <https://radar.gesda.global> and <https://portal.gesda.global>

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