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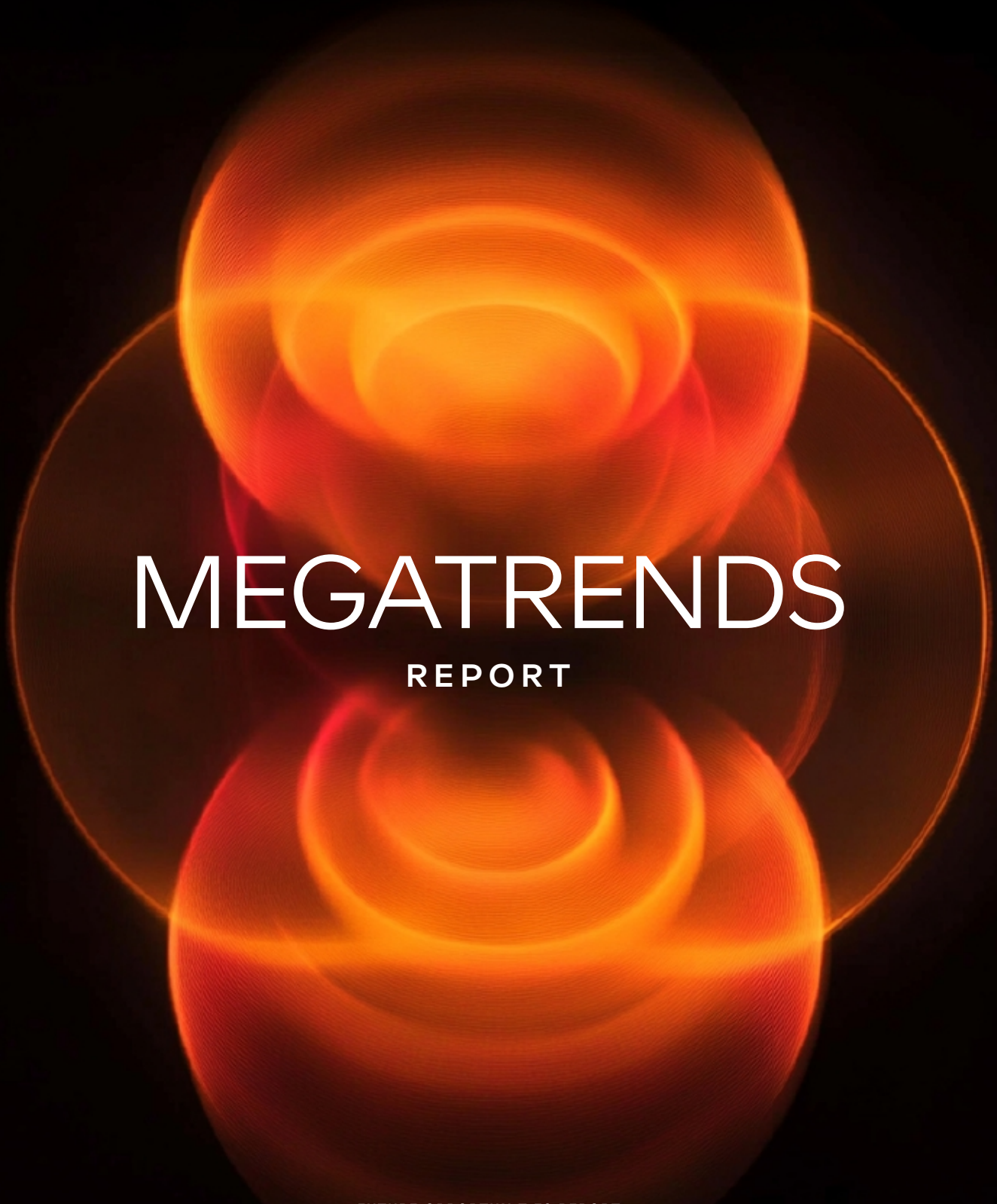

MEGATRENDS
REPORT

FUTURE OPPORTUNITIES REPORT

THE GLOBAL 50

2025

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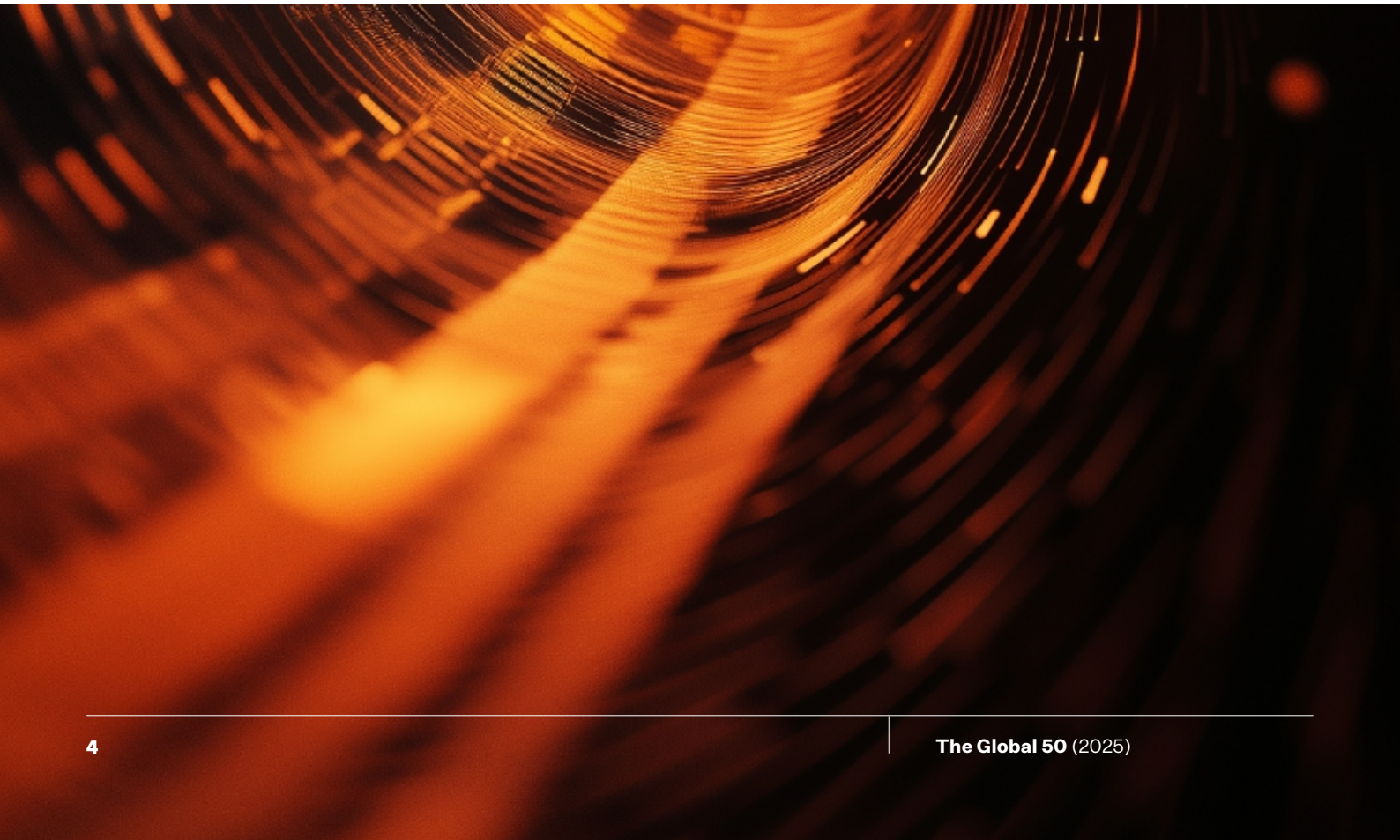
Contents

Introduction

Our understanding of progress will continue to evolve.

We will need to reflect on and adapt to what we think meaningful progress looks like. However, as the world moves towards more complexity, and in an era of quantum shifts, change is happening very quickly, making foresight both increasingly more challenging and more important.

In its fourth edition, The Global 50 continues to focus on the future through the lens of growth, prosperity and well-being. Megatrends are one of the key pillars of our view of the future, and as research-led thematic paths relevant for a decade or so, megatrends are interrelated and both shape, and are shaped by, day-to-day signals across all aspects of work and life.



Navigating the Megatrends

The nature of megatrends is that they are dynamic and may evolve, especially when they intersect with uncertainties. Approaching The Global 50 from a strategic foresight perspective is about exploring and monitoring signals, trends, disruptions, megatrends, and scenarios to extract insights. It is also about translating these insights into actionable decisions and policies.

Using the megatrends, organisations can establish a starting set of signals or areas of review to scan the environment and explore scenarios relevant to their specific sector or domain or objectives. The megatrends can also be used to stress-test strategies and support future-oriented impact evaluations. While assumptions and uncertainties shape our long view of the future, the megatrends provide guidance for the near- to medium-term outlook.

Readers can develop or inform strategies and initiatives that focus on the future, benefitting from the opportunities and mitigating associated risks relevant to their strategic vision and mission. This can be part of their strategic, operational or risk management plans.
Each megatrend includes a brief summary along with keywords readers may use to search for related signals. In addition, for each megatrend we have included signals of what might gain momentum in 2025 and three areas of future opportunity that may be relevant over the next decade. The megatrends are as a result of an annual metareview alongside on-going monitoring of relevant signals.

This is an extract of the megatrends section of The Global 50 (2025).

To access the complete report, and other Global 50 related reports, please visit the Dubai Future Foundation website.

dubaifuture.ae/the-global-50

MEGATREND 1

Materials Revolution

KEYWORDS

Biomimetic Materials
Biomimicry
Clean Energy
Critical Minerals
Magnets
Quantum Communication
Quantum Computing
Quantum Materials
Rare Earth Elements
Superconductors

Materials are fundamental to all products, foods, medicines and drinks that we consume on a daily basis. Driven by extensive progress in advanced machine intelligence, nanotechnology and materials science, as well as interdisciplinary research and innovation, new opportunities are arising in the use of materials in almost all industrial, technological and consumer sectors.

THREE THINGS TO LOOK OUT FOR IN 2025

TRANSPARENT WOOD

Biodegradable, natural wood can be processed into a transparent wood composite with a honeycomb structure, which is stronger than glass and plexiglass. Transparent wood insulates five times better than glass, enhancing building efficiency.[1] However, its environmental impact will need to be assessed and improved before widespread adoption.

COOLING CERAMICS

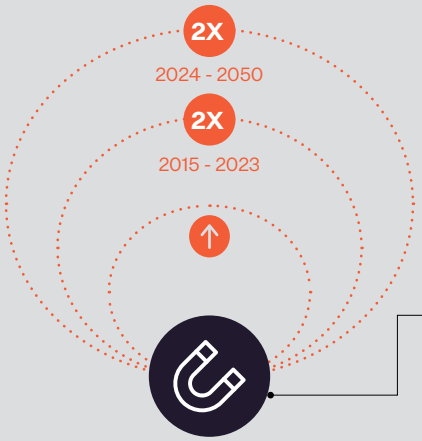
Cooling ceramic is durable and made with an alumina coating that resists ultraviolet degradation and withstands temperatures above 1,000°C.[2] With 99.6% solar reflectivity, it is energy-efficient and offers potential for numerous cooling applications.[3] It could serve as a new type of roof shingle.

BIOFILTRATION

Smart biological filters coated with enzymes have been seen to remove 97% of toxic bisphenol A and 94% of pesticides from water using special proteins that block, trap and break down harmful chemicals.[4] These filters can be reused multiple times and have applications in bioreactors, water treatment, in food processing and as biosensors.

AREAS OF FUTURE OPPORTUNITY

PERMANENT MAGNETS



Permanent magnets – as rare earth elements – contribute to efforts towards the clean energy transition and to reaching net zero.[5] Permanent magnets convert energy from turning wind turbines into electricity.[6] Permanent magnets in electric vehicles convert energy from batteries into torque in motors[7] and can save 20–40% of energy versus non-magnet motors.[8] In fusion energy power plants, strong magnetic fields can regulate plasma at temperatures higher than the Sun's core.[9] Magnets are also used in healthcare (e.g. magnetic resonance imaging (MRI),[10] transcranial magnetic stimulation[11]) and consumer electronics.[12] Eighty-five per cent of magnet mining is concentrated in China.[13]

However, the demand for permanent magnets doubled between 2015 and 2023[14] and is expected to nearly double between 2024 and 2050.[15] To meet this demand, alternative materials will be needed. For example, researchers are exploring rare-earth-free permanent magnets, such as those using iron nitride (FeN), as long as – in the case of electric vehicles – motor performance is maintained.[16] Using artificial intelligence (AI), King's College London has developed an iron-based superconducting magnet, which could be a significant breakthrough in creating cost-effective MRI machines.[17]

BIOMIMETIC MATERIALS

Biomimetic materials are materials that are made by humans but inspired by nature, either in their properties or how they function.[18] Biomimetics is currently contributing to advances in various fields, including science, engineering and medicine.[19] Nature – resilient over billions of years[20] – offers efficient and sustainable approaches to the challenges we face.

From wind turbine blades inspired by the tubercles (bumps) on humpback whale fins, which reduce drag by 32%,[21] to the Namib Desert beetle's hydrophilic shell inspiring materials used in fog harvesting in arid regions,[22,23] innovations inspired by nature can generate considerable economic benefits[24] up to $1.6 trillion by 2030.[25]

QUANTUM MATERIALS

$2 trillion

in global economic value by 2035

Quantum materials have unique properties that are integral to advancing quantum technology.[26] Materials such as superconductors and semiconductor quantum dots (such as those made of silicon and germanium)[27] help stabilise quantum bits (qubits), enhancing quantum computing capabilities.[28] Similarly, materials such as spin qubits and diamond nitrogen-vacancy centres underpin quantum sensing technologies.[29]

Key players, such as Amazon Web Services, IBM and IonQ, are leading advances in this field, achieving significant progress in quantum error correction.[30] Advances in quantum communication are enabling ultra-secure networks resilient to cyber threats.[31]
The potential applications of quantum technologies span multiple sectors, including finance, healthcare and defence. These advances are not only poised to revolutionise industries but could also generate over $2 trillion in global economic value by 2035.[32]

MEGATREND 2

Boundless Multidimensional Data

KEYWORDS

Carbon Emissions
Cross-border Data Flows
Data Analytics
Data Latency
Data Storage
Digital Twins
IoT Connectivity
Multimodal AI
Real-Time Analytics

As technology advances – quantum computing, blockchain, the Internet of Things (IoT), edge computing, automation, digital realities, and more – data will become both more constant and more multidimensional. Data will become more available within, and for, governments, businesses and society, in larger volumes, and at greater speeds. Enhanced by 5G, 6G and uninterrupted connectivity through multiple networks, including satellites, access to real-time analytics and insights will improve. Solutions will be developed to minimise the environmental impacts of data capture, transmission and storage.

THREE THINGS TO LOOK OUT FOR IN 2025

EXPANDING CONNECTIVITY

In 2023, 97 million people accessed the internet for the first time. This brought the total number of people connected to the internet in 2024 to 5.35 billion – 66% of the global population.[33] The continuing roll-out of 5G,[34] efforts to improve the affordability of mobile internet connectivity, and increasing digital inclusion[35] are initiatives to watch.

DATA SOVEREIGNTY

Data sovereignty is evolving as cross-border data flows grow amid differing approaches to artificial intelligence (AI) regulation.[36] Countries and regions continue to evolve their own data protection laws for managing data throughout various stages of the data life cycle. Cloud computing and the IoT will add complexity to data sovereignty, pushing the demand for data localisation and storage,[37] while raising important questions about whether data can truly be sovereign anymore.

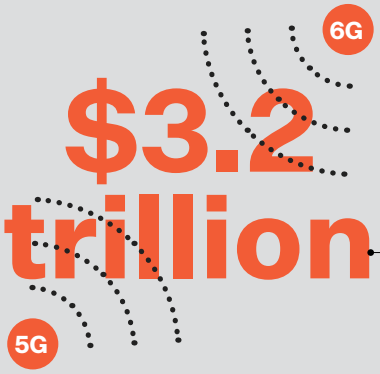
GREEN CONNECTIONS

Organisations that provide services over the internet will continue to take steps to reduce – or be expected to disclose – their environmental impact. For example, as video streaming makes up 65% of global data traffic, and total data traffic contributes 3.7% of global greenhouse gas emissions.[38] Netflix aims to reduce its emissions by half by 2030[9] and is investing in climate solutions to offset its remaining emissions.[39]

[9] From a 2019 baseline.

AREAS OF FUTURE OPPORTUNITY

PREPARING FOR 6G

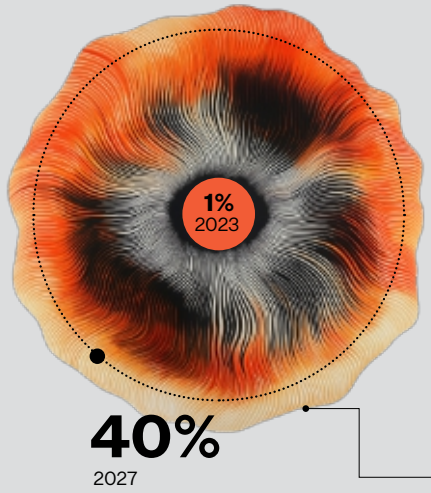


6G will have far-reaching impacts across sectors.[40] From enabling remote surgery and real-time health monitoring[41] to advanced automation and digital twins,[42] 6G will create new market opportunities across telecommunications, manufacturing and transportation.[43]

With low latency (i.e. quick response times),[44] 6G can theoretically increase speeds from 5G's peak data rate of 20 gigabits per second[45] to around a terabit (1,000 gigabits) per second.[46] It is also capable of handling up to 10 times more IoT-connected devices than 5G, with the total number of IoT devices expected to reach 500 billion devices by 2030.[47] 5G- and 6G-enabled activities combined are projected to create $3.2 trillion[h] in global growth by 2030.[48] The development of new optical components and transmission techniques will be critical for achieving the speeds that 6G promises.[49]

From curved light rays and metamaterials[50] to spiral plates that twist and stretch light beams,[51] reconfigurable intelligent surfaces are being developed to enhance signal propagation and networks and actively control electromagnetic waves to improve coverage and reduce energy consumption.[52]

MULTIMODAL EXPLAINABLE ARTIFICIAL INTELLIGENCE



Important decisions in healthcare and finance – for example, relating to diagnoses and treatment[53] and fraud detection[54] – may be made together with AI-based support systems using diverse (i.e. multimodal) data inputs, including text, images, audio and, one day, haptics. Multimodal AI will also impact other industries, including education, media, manufacturing, and consumer packaged goods.[55] Multimodal explainable AI (MXAI) focuses on explaining how, why and what AI delivers,[56] which is important for building trust in AI.[57]

With capabilities ranging from natural language processing and image processing to multi-input analysis and fast processing in real time,[58] MXAI is complex. Its complexity lies not just in its handling of data inputs but also in how those inputs are combined to produce an output. ChatGPT now accepts voice and image prompts,[59] foreshadowing how increasingly multimodal generative AI is likely to look in the future. While around 1% of AI use was multimodal in 2023, by 2027 the figure is expected to be 40%,[60] a significant jump that reflects potential rapid adoption of the technology.

SPORTS ARTIFICIAL INTELLIGENCE

Sports analytics has already had an impact, from improving the identification of talent through statistical modelling and coaching to performance optimisation, fan engagement, and refereeing.[61] Companies such as Catapult[62] and SportVU[63] are reinventing the sports industry with space for more opportunity in the future.[64]

At the 2024 Summer Olympics in Paris, NBC used AI to analyse 5,000 hours of coverage to deliver over 7 million combinations of daily recaps to fans in a personalised way.[65] The Paris Olympics also used AI to track and analyse athletes' performance, safeguard athletes from abuse on social media, provide multilingual and multi-format personalised content for both audiences and athletes, and optimise energy management through the use of digital twins to simulate energy requirements, as well as camera placement needs and accessibility issues.[66]

The value of AI in sports is set to reach nearly $30 billion by 2032, expanding at a compound annual growth rate of 30% from $2.2 billion in 2022.[67]

[h] Based on the EUR:USD exchange rate of 16 November 2024.

MEGATREND 3

Technological Vulnerabilities

KEYWORDS

Cross-border Security
Cyberbiosecurity
Cybercrime
Cyber-physical Threats
Data Breach
Identity Theft
Interoperability
Risk Mitigation
Security Protocols
Threat Detection

Together with technological advances in biotechnology and gene editing, precision agriculture, widespread digitalisation and automation, multimodal artificial intelligence (AI), and the spread of wearables and the Internet of Things (IoT), there inevitably arise new technological vulnerabilities and threats. Some become more severe, frequent and complex, crossing technological, industrial and geographical boundaries, and some, as with biotechnology, also cross biological boundaries. Cybercriminals are more organised, using AI to coordinate and perpetrate crimes. More innovative approaches to identifying, assessing and addressing vulnerabilities will be key.

THREE THINGS TO LOOK OUT FOR IN 2025 ↘

CYBERSECURITY A PRIORITY FOR LEADERS

CEOs are increasingly concerned about cybersecurity in the AI era, with nearly half of CEOs surveyed by the Oliver Wyman Forum ranking it as a top risk.[68] Industry data confirm the scale of this challenge. The Commonwealth Bank of Australia detects 85 million potential cyberfraud events daily,[69] with global average data breach costs of $4.88 million.[70]

BORDERLESS MISINFORMATION AND DISINFORMATION

Combating misinformation and disinformation will be a priority.[71] Whereas misinformation is unintentional, disinformation is meant to mislead.[72] Fifty-four per cent of those surveyed in the World Economic Forum Global Risks Perception Survey 2023–2024 said that dealing with misinformation and disinformation will require multistakeholder cooperation.[73] As global cooperation decreases and misinformation and disinformation are AI generated, the risk will only be higher, potentially deepening social and political divides.[74] This would be further complicated by reduced efforts and declining investments in content verification and fact-checking across organisations.[75]

TRUST THROUGH TRANSPARENCY

The demand for consumer protection in the digital economy[76] and in relation to public infrastructure[77] will continue to rise.[78] Robust user protection policies are a critical part of building public trust,[79] particularly in country-run digital systems such as payment platforms and data exchanges, and the millions – if not billions – of public digital records.[80] This will require transparency, public awareness, and public engagement.[81]

AREAS OF FUTURE OPPORTUNITY

INCORPORATING PSYCHOLOGY INTO CYBERSECURITY

Cybercrime significantly impacts victims[82] and their mental health.[83] For example, one survey found that 60% of fraud victims reported mental health struggles, with 55% experiencing anxiety, 48% depression, and 69% sleep problems.[84] In 2023, 349 million people were affected by data breaches, with 2.6 million fraud reports and over 1 million cases of identity theft, demonstrating the vast scale of cybersecurity challenges.[85]

While current barriers include leadership gaps, resource constraints, and the absence of widely accepted principles and standards, incorporating psychology into cybersecurity can deepen our understanding of why cyberattacks occur[86] and improve how we reduce cybersecurity threats. This can also enhance our mitigation strategies, encouraging interdisciplinary approaches and a focus on root behaviours.[87] Addressing these challenges can advance the integration of psychology within cybersecurity strategies.[88]

CYBERBIOSECURITY AWARENESS AND EDUCATION

Besides data privacy risks, there are two major threats unique to cyberbiosecurity. One is cyber-physical (i.e. sabotage of machines and equipment used in biological research, or theft of data) and the other is the creation of dangerous biological materials using digital information.[89] This is particularly relevant in biobanks[90] and other repositories of genetic samples and data where genetic information can be accessed and manipulated digitally, making it possible to create synthetic DNA and even reconstruct dangerous pathogens using published sequences.[91]

Awareness of cyberbiosecurity remains low around the world and some regions are less prepared than others, particularly the countries of Southeast Asia.[92] Irrespective of regulations, it is essential to raise awareness of cyberbiosecurity threats among biotechnology companies, research institutions, and policymakers through education and training, ensuring that researchers and practitioners from all relevant disciplines are involved.[93] One initiative to note is the Biological Security Research Centre at London Metropolitan University,[94] which established the International Biological Security Education Network in 2024.[95]

BALANCING INTEROPERABILITY WITH CYBERSECURITY

Cybersecurity is a global, cross-border challenge, and interoperability (the ability of systems to work together) can be both a challenge for, and a solution to, cybersecurity. As the world becomes more interconnected, particularly when it comes to data flows,[96] innovative approaches to cybersecurity are increasingly needed.

In 2023, the average time to identify and contain a breach was 258 days.[97] This time could be reduced by improving interoperability (often through common security standards and protocols), enhancing overall security and embracing collaborations between entities and nations.[98] For example, on an international scale, Estonia's cross-border electronic governance system X-Road is used in other countries (including several of the Nordics) to deliver security, services and economic benefits,[99] capturing both interoperability and cybersecurity benefits.

MEGATREND 4

Energy Boundaries

KEYWORDS

Carbon Neutrality
Catalysts
Clean Energy Mix
Electrolysers
Energy Storage
Game Theory
Hydrogen Production
Materials
Net Zero
Platinum

Energy has been at the heart of progress for thousands of years,[100] and energy-driven growth has been a major factor in economic progress.[101] Energy is imperative to everyday life. As we move towards new and alternative sources of clean energy, we will also need to focus on the key enablers that will make this possible. From novel materials and advanced machine intelligence to pushing the boundaries of the energy ecosystem between space and Earth, this megatrend is critical to growth, prosperity and well-being.

THREE THINGS TO LOOK OUT FOR IN 2025

FUNDING FOR ENERGY ACCESS

Sustainable Development Goal 7 aims to ensure that everybody has access to affordable and clean energy.[102] The World Bank and the African Development Bank have announced joint plans to bring electricity to 300 million people in Africa by 2030 through $30 billion in public sector investment and $9 billion in private sector investment.[103]

DRIVE FOR ENERGY SELF-SUFFICIENCY

Energy self-sufficiency is becoming even more important as technology advances, increasing the demand for energy.[104] Six Flags Magic Mountain amusement park in California is installing a new solar system that will offset 100% of the park's energy usage.[105] China will have the first onshore commercial small modular reactor (SMR) in 2025,[106] and technology companies Amazon[107] and Google[108] are both supporting their own SMR projects.

OPTIMISING THE BIOFUEL VALUE CHAIN

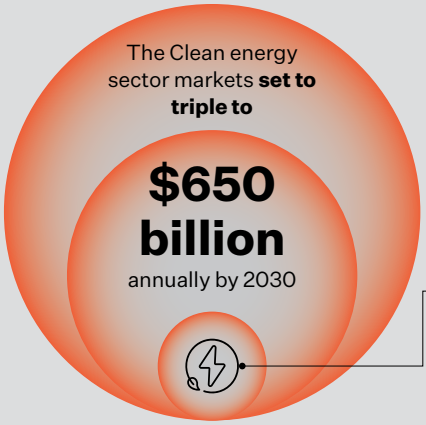
The worldwide biofuel market is expected to double between 2023 and 2033 to $243 billion.[109] While biofuels such as palm oil and sugarcane ethanol generally reduce emissions,[110] biodiesel production using palm oil farms in Indonesia and Malaysia can have 3 to 40 times higher greenhouse gas (GHG) emissions than diesel.[111] Redirection of agricultural products to biofuel production has led to challenges ensuring sufficient sustainable feedstock, leading to indirect environmental impacts.[112]

AREAS OF FUTURE OPPORTUNITY

GAME THEORY FOR THE GLOBAL PATH TO NET ZERO

The global net-zero economy is targeting carbon neutrality by 2050 and it is estimated that this will require approximately $275 trillion in capital spending, with an average annual investment of $9.2 trillion and reaching a peak of 8.8% of global gross domestic product between 2026 and 2030.[113] However, reaching this goal is not straightforward as many aspects come into play.

Game theory is a model for interactive decision-making where the outcomes depend on anticipating the strategies and associated decisions of others.[114] The use of game theory in relation to energy is not new; it has been used to model and optimise interactions between stakeholders within the complex energy system.[115] Applied to net zero, game theory can help – together with climate models – to influence interactions and decisions within multiple scenarios aiming towards net zero.[116]



ONSHORING THE MANUFACTURING OF CLEAN ENERGY TECHNOLOGIES

Clean technologies focus on reducing or eliminating pollutants or waste. From renewable energy, electric vehicles, and biofuels to advanced recycling and waste management systems, these technologies are redefining energy generation and transmission so that they help rather than harm the environment.[117]

Only four countries, along with the European Union (EU), are manufacturing 80–90% of the world's solar photovoltaic panels, wind turbines, batteries, electrolysers and heat pumps.[118] Australia, Chile and China account for more than 90% of global lithium production.[119] Others may start considering onshoring as a viable strategy through the clean energy transition.[120]

The clean energy sector presents an extraordinary growth opportunity, with markets set to triple to $650 billion annually by 2030 as nations fulfil their climate commitments. This expansion is driving strategic diversification of manufacturing capabilities and supply chain resilience across regions.[121] The sector promises to create 8 million new manufacturing jobs globally by 2030.[122]

HYDROGEN AND THE SEARCH FOR A PLATINUM ALTERNATIVE

While not the most significant, hydrogen is part of the future clean energy mix. In 2023, the use of hydrogen in new clean energy applications rose by 40% but still accounted for less than 1% of global hydrogen demand, which is expected to continue growing, driven by new applications in power and transport.[123] At the same time, by 2030, demand for low-emissions hydrogen is expected to reach only 10% of what is needed for net zero by 2050,[124] requiring significant advances in hydrogen fuel cells and infrastructure.[125]

Electrolysers, essential for hydrogen production, rely on materials such as platinum. In 2023, only 22% of installed capacity used the more efficient platinum-based proton exchange membranes,[126] a technology that has the potential to provide 11% of the global carbon dioxide emissions reductions required by the Paris Agreement by 2030.[127] However, platinum is hard to find.[128] While South Africa supplies over 70% of global platinum, its mining sector faces challenges, exacerbating future supply risks.[129] Promising alternative materials that maintain efficient energy conversion and storage capabilities include noble metal alloys, transition metals (e.g. nickel, cobalt), and carbon-based catalysts.[130]

MEGATREND 5

Evolving Ecosystems

KEYWORDS

Acoustics
Biodiversity
Climate Change
Internet of Underwater Things (IoUT)
Marine Conservation
Noise Reduction
Ocean Health
Regeneration
Sustainability
Wildlife

Driven by resource scarcity, climate change, and shifts in social values, environmental impact management will increasingly move towards a focus on ecosystems as opposed to the environmental impact of specific processes, products or services. Approaches will be more interdisciplinary, with a focus on future impact. They will also take into account both societal and environmental factors, with the primary goal of regenerating or conserving biological and ecological services and resources while providing for basic human needs.

THREE THINGS TO LOOK OUT FOR IN 2025

SUSTAINABILITY OF GENERATIVE ARTIFICIAL INTELLIGENCE (GENAI)

By 2026, over 80% of organisations will use GenAI in production settings, compared to less than 5% today.[131] While GenAI enables fast content creation (or recreation) across industries, its environmental impact is a growing concern. ChatGPT is thought to consume the same amount of energy as 33,000 average homes in the United States, and global water demand for cooling data centres used for AI may reach half the annual water consumption of the UK.[132] Mitigating these effects through advanced computer chips for energy-efficiency and the adoption of renewable energy sources will be important.[133]

INCREASED VOLUNTEERISM FOR THE ENVIRONMENT

Globally, 53% of people surveyed for the Peoples' Climate Vote 2024 were more concerned about climate change than they had been in the previous year.[134] In 2022, nearly 15% of people aged 15 and over volunteered at least once per month. As awareness of environmental risks and need for action increases,[135] environmental volunteering (e.g. tree planting, river clean-ups, and habitat restoration) may increase.[136]

CLIMATE TECH START-UPS IN AFRICA

Climate tech start-ups in Africa may be key to driving transformative change. Africa holds great potential for clean energy, responsible mineral extraction, ecosystem restoration, and – through climate tech start-ups – youth engagement.[137] Since 2019, African climate tech start-ups have raised over $3.4 billion, a number expected to rise given the need for $277 billion annually[138] to meet the Paris Agreement climate goals by 2030.[139]

AREAS OF FUTURE OPPORTUNITY

ALL THINGS REGENERATIVE

The concept of regeneration became increasingly popular in the 1990s in urban development as an innovative response to climate change looking beyond making buildings green.[140] Since then, regeneration has become the new sustainability.[141] While sustainability focuses on balancing human needs with environmental protection,[142] regeneration takes efforts further by focusing on restoring natural resources, enhancing biodiversity, and rejuvenating damaged ecosystems.[143]

As a result, the idea of regeneration has spread to other domains.[144] For example, in medicine, there is increasing recognition that the human body can heal itself.[145] In agriculture, farmers are rehabilitating the soil, respecting animal welfare, and building healthier communities while improving their yields.[146] Making efforts to restore and improve ecosystems in day-to-day living,[147] regenerative tourism, long-term community, and environmental enrichment are increasingly prioritised over immediate returns.[148]

ACOUSTIC ARTIFICIAL INTELLIGENCE FOR ECOSYSTEMS

AI with acoustics holds potential in understanding and improving marine, wildlife, urban and other ecosystems. Underwater sound travels further than visual signals or scents and is critical for marine life communication, migration and interaction with the environment.[149] AI has already been successfully used to monitor whale vocalisations, improving species detection and marine conservation strategies.[150]

Recent studies on AI and wildlife have focused on birds (48%) and mammals (22%),[151] but issues include insufficient datasets, high background noise, lack of standardisation, and complex sound classifications. While maintaining wildlife welfare and being aware of potential AI bias, AI may provide valuable real-time insights for conservation.[152]

AI is also helping to optimise room acoustics, urban noise monitoring, studio recordings, and speech clarity in educational environments.[153] From workplaces to healthcare, AI and acoustics can boost productivity and creativity, with Internet of Things (IoT) integration and advanced signal processing enhancing auditory experiences and immersive sound environments.[154]

INTERNET OF UNDERWATER THINGS (IoUT)

In 2021, the **IoT** was expected to unlock up to

$12.6 trillion

in value by 2030

In 2021, it was estimated that the IoT is expected to unlock up to $12.6 trillion in value by 2030 from applications in factories (26%), human health (10–14%), and others.[155] Achieving this will depend on advanced connectivity through 4G and 5G networks, as well as balancing affordability with interoperability, cybersecurity and deployment complexity.[156]

Oceans face critical pressures from climate change and unsustainable use of ocean resources, affecting ecosystems and human societies.[157] The United Nations Decade of Ocean Science for Sustainable Development (2021–2030)[158] promotes interdisciplinary research and global collaboration to improve the health of the oceans.[159] As interest in marine sciences increases and with devices that monitor and support applications underwater, the Internet of Underwater Things (IoUT) provides future opportunities for environmental monitoring, exploration, and disaster prevention.[160,161] Challenges related to harsh water conditions and data collection and transmission will need to be overcome.[162]

MEGATREND 6

Borderless World – Fluid Economies

KEYWORDS

AI Personhood
Cryptocurrency
Digital Assets
Education
Energy
Environment
Regulation
Stablecoin
Tokenisation
Water

Increasingly, unmediated transactions in finance, health, education, trade, services and even space lead to the blurring of jurisdictional boundaries, shifting liabilities and creating increased numbers of cross-border communities and networks. Advances in communications, computing, and advanced machine intelligence will accelerate a borderless world that will change the way we work, live and communicate.

THREE THINGS TO LOOK OUT FOR IN 2025

GLOBAL DATA ACCESS AND USER CONSENT FOR AI TRAINING

Spending on artificial intelligence (AI) is expected to rise to $632 billion by 2028.[163] Existing social media,[164,165] technology,[166] and network[167] platforms, which are global in nature, are turning to user data to train their own AI models. While some companies have denied or expressed no interest in doing this,[168] others are providing their users with updated user terms or the ability to opt out. The need for common global standards for data management and sharing may increase.[169]

CROSS-BORDER PHILANTHROPY FOR GLOBAL CHALLENGES

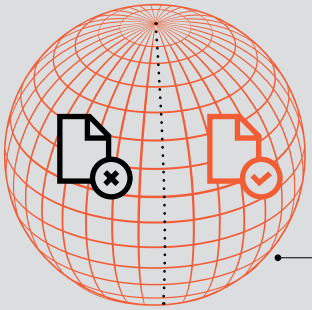
In 2022, 40 private philanthropies reported $11 billion in development support to the Organisation for Economic Co-operation and Development (OECD), although contributions have stagnated since 2021.[170] Reported in the 2023 Global Philanthropy Tracker, global cross-border philanthropy reached $70 billion across 47 high-income countries in 2020, representing 85% of global GDP.[171] While domestic philanthropy grows,[172] cross-border giving remains crucial for addressing natural disasters and global crises such as COVID-19.[173] However, barriers persist, including taxation issues, limited legal recognition for foreign foundations, and misaligned legal protections.[174]

INTELLECTUAL PROPERTY IN A BORDERLESS DIGITAL WORLD

AI, especially large language models and generative AI (GenAI), is trained primarily from public sources, including copyright-protected text, and visual and auditory works.[175] The growing outputs from GenAI will continue to raise questions about its role in the inventive process. The World Intellectual Property Organization runs multiple events and discussion forums on this topic,[176] and the Centre for the Fourth Industrial Revolution in the UAE has published a report touching on intellectual property, AI and the creative industries.[177]

AREAS OF FUTURE OPPORTUNITY

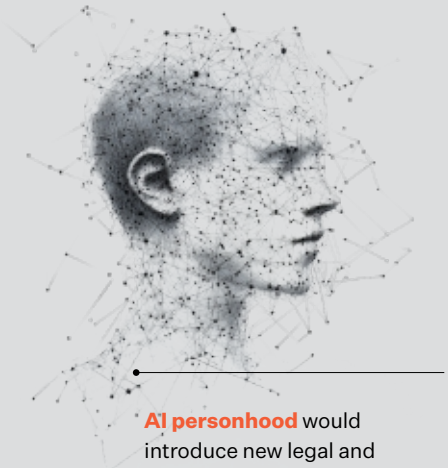
GLOBAL COOPERATION FOR CROSS-BORDER DIGITAL ASSET REGULATION



Overall tokenised market capitalisation, excluding Bitcoin and Tether, could hit approximately $2 trillion by 2030 due to the increased use of these currencies in mutual funds, bonds, exchange-traded notes, loans, securitisation, and alternative funds.[178]

However, digital assets lack a universal definition[179] despite the fact that two-thirds of 86 jurisdictions surveyed by the World Economic Forum already regulate or are planning to regulate digital assets.[180] These differences create regulatory challenges because a digital asset that is legal in one jurisdiction may be illegal in another. The Financial Stability Board[181] and the International Organization of Securities Commissions[182] are working on providing universal definitions,[183] and the Principles of the International Institute for the Unification of Private Law offer a framework connecting digital assets to existing legal structures.[184] However, gaps persist. The UAE is a leader in the Middle East and North Africa region in regulating digital assets. Several organisations have published regulatory frameworks, including Dubai's Virtual Assets Regulatory Authority,[185] Abu Dhabi Global Market,[186] the Dubai International Financial Centre,[187] and the Digital Assets Oasis in Ras Al-Khaimah.[188]

EXPLORING ARTIFICIAL INTELLIGENCE PERSONHOOD FOR LEGAL BOUNDARIES



AI personhood would introduce new legal and **ethical challenges about rights, responsibilities and accountability**

AI has the potential to add as much as $15.7 trillion to the worldwide economy by 2030.[189] As AI becomes ubiquitous, highly autonomous AI systems may eventually warrant legal status like corporate entities, particularly if impacting international decision-making and cross-border interactions.

Granting legal status to non-corporate entities is not a new issue; many have argued for legal rights for nature.[190] However, AI personhood would introduce new legal and ethical challenges about rights, responsibilities and accountability and would require a debate around whether AI entities fit into the existing (or future) legal structures.[191] Considering legal personhood for AI could raise critical questions about moral responsibility, economic efficiency, and legalities, especially as AI's capabilities continue to evolve. Giving AI legal personhood would mean it could face sanctions, fines and deactivation resulting from unlawful actions.[192] However, the perceived accelerated advances in AI make this a challenge,[193] and as an emerging concept it is an area of opportunity for coordination in the larger global context.[194]

TRANSDISCIPLINARY EDUCATION FOR GLOBAL INNOVATION

The next 10 years will see many environmental, societal, technological and economic global risks that cannot be solved by individual countries alone.[195] Between 2030 and 2040, global water and energy demands are expected to rise by 40% and 50%, respectively,[196] impacting food and water systems, economies and supply chain systems, and many other areas of work and life that could lead to increased global tensions.[197] Meanwhile, climate change is affecting global socio-economic systems, such as food, physical assets, infrastructure, natural capital, and migration,[198] triggering an interconnected set of social and environmental risks.[199]

In a borderless, interconnected world, addressing such complex cross-border and cross-sectoral issues requires a transdisciplinary approach. By combining insights from multiple fields, we can develop unique and innovative solutions that address both the technical challenges and the societal implications of emerging and future technologies. Universities and training institutions can promote transdisciplinary education programmes that combine law, technology, ethics, and international relations, encouraging cross-sector understanding and collaboration. These programmes can be co-developed by academic and industry leaders to ensure that they address practical, real-world challenges. Some institutions, such as the University of Twente in the Netherlands,[200] have already set up programmes that focus on transdisciplinary education, but more are needed.

MEGATREND 7

Digital Realities

KEYWORDS

Augmented/Virtual Reality Headsets
Digital Theatre
Immersive Experiences
Life Satisfaction
Performing Arts
Real–Virtual Divide
Self-esteem
Self-expansion
User Acceptance
Virtual Identities

Digital natives – those who have grown up with digital forms of entertainment, education and communications – will naturally usher in increasingly virtual worlds where many 'real-world' tasks and behaviours can be replicated and potentially even improved in 3D and 4D environments. The emergence and spread of 5G and 6G networks will enhance autonomous applications as they offer more reliable, cost-effective and secure high-speed connectivity that enables real-time analytics and decision-making. As quantum technologies, such as quantum computing, communications and sensors, become scalable and reliable, immersive experiences will start to feel like reality.

THREE THINGS TO LOOK OUT FOR IN 2025

METAVERSE CALLS

The metaverse, specifically virtual reality (VR), was expected to replace smartphones by 2035, but its widespread adoption has seen a series of challenges,[201] including the loss of $13.7 billion by Meta's Reality Labs in 2022,[202] cybersickness,[203] mental health problems caused by cyberbullying, identity theft, and financial exploitation,[204] as well as regulatory obstacles, cultural resistance, and security concerns.[205] However, considering the Dubai Metaverse Strategy,[206] South Korea's $177 million investment fund for the metaverse,[207] ongoing efforts by the World Economic Forum,[208] and Mohamed bin Zayed University of Artificial Intelligence's Metaverse Lab,[209] the metaverse may yet be widely adopted.

DIGITAL CONTACTLESS EXPERIENCES

Augmented reality (AR) adoption through smartphones, particularly given the spread of 5G,[210] shows promising growth.[211,212] There are now over 2,000 spatial apps for Apple Vision Pro,[213] and, as generative artificial intelligence (AI) continues to make it quicker and cheaper to build spatial environments and experiences,[214] examples such as IKEA's home visualisation tool, L'Oréal's ModiFace AR tool, and Google Maps Live View[215] may become increasingly common.

ARTIFICIAL INTELLIGENCE POWERING EXTENDED REALITY

AI is expected to contribute nearly $20 trillion (3.5%) of global gross domestic product by 2030.[216] Within extended reality, AI enables personalised interactions and manages data flows, driving user engagement.[217] With results showing 75% improved learning retention and 275% increased confidence in learned topics,[218] extended reality powered by AI may have the potential to increase engagement and collaboration.

AREAS OF FUTURE OPPORTUNITY

GROWING THE DIGITAL THEATRE

The **home entertainment and cinema markets** were worth

$100 billion

in 2023

The home entertainment and cinema markets continue to grow, with an estimated worth of $100 billion in 2023 and an expected increase of 8% annually between 2024 and 2030.[219] The impact of technology has also been transformative in drama and the arts. With technological advances, new forms of theatre have emerged that encourage viewers to actively participate and interact within narratives.[220] Some are calling for technology to be used for analysis of productions to document knowledge for use in drama education in the future.[221]

Many performing arts theatres, some of which had never previously offered digital broadcasts, made their performances available online during the COVID-19 pandemic.[222] For example, National Theatre at Home,[223] launched during the pandemic, attracted over 15 million viewers from 170 countries within just four months of launch.[224] Facing challenges bringing back audiences to pre-COVID levels,[225] digital realities can enhance access and enable distant audiences to attend live performances or feel like they are part of a live performance.

THE VIRTUAL–REAL SELF DIVIDE

The boundary between our real and virtual identities continues to be blurred. People may maintain multiple identities across various platforms, raising philosophical and ethical questions about what it means to be human and what physical existence or being present or conscious means.[226] Key questions include what information can be shared in the virtual self, how to ensure privacy, who is accountable for errors or decisions in the virtual life that may or may not impact real-life experiences, and how to balance regulation to promote both trust and freedom in the virtual world.[227]

How virtual and real identities influence each other remains a crucial area of research,[228] building on previous studies that have focused on the relationship between the actual and idealised self [229] and how they can enhance societal prosperity and well-being. For example, participating in virtual environments can have positive effects when virtual and real identities are aligned. However, it can also create the feeling of being disconnected if the virtual self is seen as superior, negatively impacting self-esteem and life satisfaction.[230]

EVOLVING ACCEPTANCE OF AUGMENTED/ VIRTUAL REALITY HEADSETS

Sales of AR/VR headsets have gone down by

40%

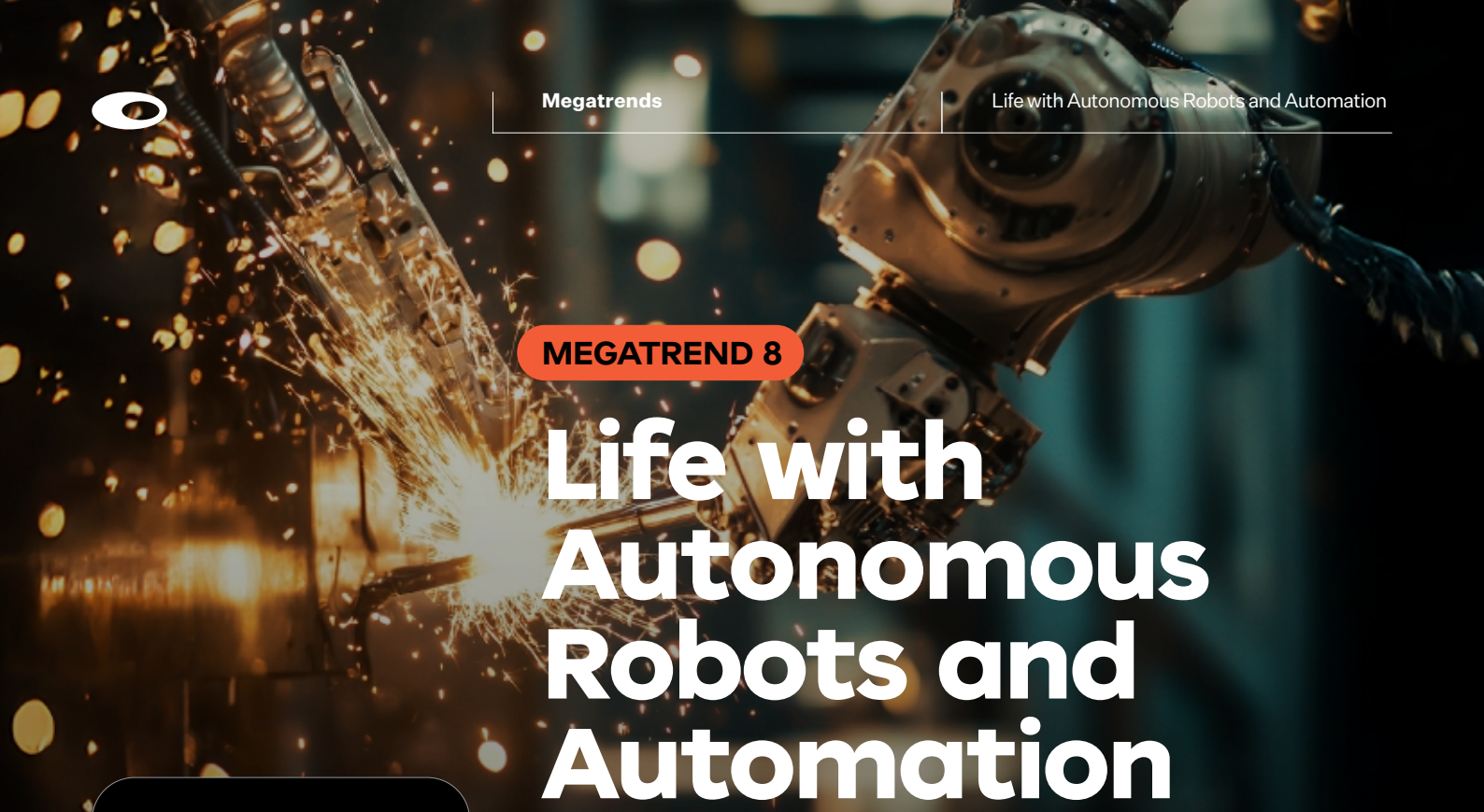
Start-up funding has dropped by

50%

Immersive experiences have expanded across disciplines and domains, mimicking real-life spaces, events and social interactions.[231] From health and climate to gaming and education, digital realities are increasingly enabled by AR/VR. However, despite a jump in popularity during the COVID-19 pandemic,[232] the growth of AR/VR-powered experiences remains uncertain and unpredictable.

While sales of AR/VR headsets have gone down by 40% since 2022, and start-up funding has dropped by 50%,[233] shipments of AR/VR headsets started to grow again in the third quarter of 2024 and are expected to rebound in 2025, with an expected compound annual growth rate (CAGR) of nearly 86% by 2028.[234] However, this optimistic outlook is not universal, as Apple has reduced its production of Apple Vision Pro.[235]

Despite efforts to make devices more user-friendly, AR/VR headsets continue to be considered experimental, with a focus on testing the functionality and viability of the technology.[236] Innovativeness, perceived benefits, and system quality are key to user acceptance, as are user-friendliness and potential societal impacts if more widely adopted.[237] There is an opportunity to develop new acceptance models based on standardisation and validation across applications and environments.[238]



MEGATREND 8

Life with Autonomous Robots and Automation

KEYWORDS

Additive Manufacturing
Biomimicry
Collaborative Robots (Cobots)
Drones
Humanoids
Human–Robot Interaction
Materials
Sea Drones
Soft Robotics
Trust

Driven by advances in mechanical engineering design, materials science, advanced machine intelligence, and advanced communication networks, robots will increasingly expand into other industries beyond the automotive, manufacturing, and supply chain logistics sectors. The use of robots[239] and automation[i] will provide greater opportunities for efficiency and innovation while presenting us with ethical and societal challenges around autonomy, decommissioning, and the future of work. The growing numbers of robot-to-robot, human-to-robot, and human-to-machine interactions will raise questions about intellectual property and robot rights.

THREE THINGS TO LOOK OUT FOR IN 2025

HUMANOID ROBOTS TO DISRUPT ALL ROBOTS

In 2023, there operated around 4.28 million robots in factories worldwide[240] and 4.31 million service robots in other industries, especially consumer service.[241] However, humanoid robots may disrupt both sectors. The global market for humanoid robots, which was $2.43 billion in 2023, is expected to reach $66 billion by 2032,[242] with application particularly in healthcare, manufacturing, and supply chain logistics.[243] RoboFab in Oregon, United States, is the first factory for humanoid robots.[244]

BREAKTHROUGHS IN ROBOT DEXTERITY

Robots are becoming more versatile due to configurational advances,[245] materials science, and sustainable robotics.[246] Generative artificial intelligence is expected to enable better sensing and adaptability in varied environments.[247] For example, Google's ALOHA Unleashed demonstrates advanced dexterity, carrying out complex tasks such as tying shoelaces and repairing other robots, while Google's DemoStart, also dexterous, uses simulation training to improve performance.[248]

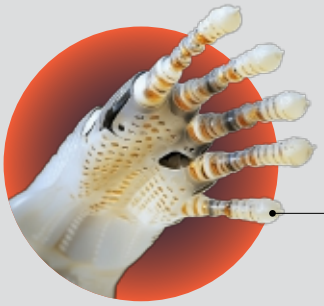
DRONE EVOLUTION

The capabilities of commercial drones are expected to expand, with a global sea drone market of nearly $20 billion[j] by 2030[249] and an electric vertical take-off and landing drone market of $160 billion by 2040.[250] China's first global certified air taxi, the EHang EH216-S, can carry two passengers,[251] and Dubai has started building a flying taxi station for up to 170,000 passengers annually.[252]

[i] Includes drones, software, autonomous cars, exoskeletons, unmanned ground vehicles, smart appliances, and so on. While there is no harmonised definition used across organisations, these types are all included in the definitions used by the International Organization for Standardization, the Institute of Electrical and Electronics Engineers, and ASTM International.

[j] Based on EUR:USD exchange rate 17 December 2024.

AREAS OF FUTURE OPPORTUNITY



BIOMIMICRY FOR SOFT ROBOTICS

Biomimicry draws inspiration from nature to enhance quality and functionality across domains and offer innovative solutions to global challenges. Soft robotics, a high-potential application of biomimicry, focuses on the development of adaptable robots made of materials that feel like biological tissue. Bionic multi-legged robots with flexible bodies outperform rigid robots in speed, stability, and terrain navigation,[253] and gecko-inspired robots can achieve an adhesion force of 180N, allowing them to climb and operate in microgravity environments.[254]

The development of bio-inspired soft robots requires several elements to be considered, including materials, actuation mechanisms, and design. Highly interrelated, as they are in biological systems,[255] bio-inspired soft robots are key in medical applications, where precision and reliability can be critical to the preservation of life.[256] Interdisciplinary collaboration between biologists and engineers will drive future innovation, deepening understanding of biological systems while advancing robotics capabilities to produce more sophisticated, versatile and lifelike robotic solutions.

BETTER UNDERSTANDING OF HUMAN–ROBOT INTERACTION

Robots are increasingly used in manufacturing, scientific research, agriculture, and food service. The development of larger numbers of collaborative robots (cobots) and humanoid robots signals a shift towards more adaptable robots that can work alongside humans in varied environments.

Trust in human–robot interaction is not just about reliability.

However, widespread adoption faces several obstacles. Safety concerns, regulatory requirements, the impact on jobs, and resource constraints make scalable adoption challenging.[257] Most importantly, there is the fundamental issue of trust,[258] especially as artificial intelligence (AI) becomes increasingly integrated with robotics.[259] Trust in human–robot interaction is not just about reliability. It is about humans intentionally depending on robots despite the inherent risks and vulnerabilities.[260] This relationship must be founded on positive impacts while acknowledging uncertainties, introducing an emotional dimension beyond technical reliability.[261] As the industry evolves, establishing trust between humans and robots will become crucial for successful integration. This challenge encompasses both technical reliability and the more complex emotional aspects of human–robot collaboration, setting the stage for future developments in the field.

BETTER MANUFACTURING MEASURED THROUGH ROBOT COLLABORATION

Evolving from rapid prototyping, additive manufacturing is distinct from traditional linear manufacturing. Similar to 3D printing, objects are built layer by layer,[262] enabling the manufacture of more complicated designs[263] and without retooling.[264] Materials, including polymers, metals, ceramics, sand and composites,[265] will be critical in scaling additive manufacturing.[266]

Cooperative robots[267] could be the catalyst for widespread adoption of additive manufacturing.[268] They could enhance printing capabilities, assist throughout the printing process, and enable real-time information capture and feedback beyond the limitations of single robotic systems.[269] Their effectiveness would rely on sophisticated planning, collision avoidance technology, and enhancement of the properties of relevant materials, augmented by AI and machine learning technologies.[270] Beyond technical capabilities, the key to success will lie in how the quality of the collaboration is assessed in real time.[271] In this way, the use of cooperative robots in additive manufacturing may reveal a new frontier in manufacturing innovation.

MEGATREND 9

Future Humanity

KEYWORDS

AI Dispute Resolution
Arts Education
Creative Economy
Cross-border Disputes
Digital Media
Generation Z
Legal Aid
Organisational Values
Study Tracks
Talent

With advanced machine intelligence, brain–computer interfaces, technological breakthroughs, advances in science and medicine, and an increasingly borderless world, people's understanding and expectations of self-realisation – including work, education and what it means to thrive – will shift. Personal development, how individuals and communities innovate and communicate, and new definitions of self-esteem, autonomy and stability will bring forth new ideas about parenting, care, love, belonging, inclusion and community. The traditional boundaries between self, society and institutions will evolve.

THREE THINGS TO LOOK OUT FOR IN 2025

WOMEN IN ARTIFICIAL INTELLIGENCE AND DATA SCIENCE

While data varies by source,[272] the share of women in AI engineering increased to approximately 35% in 2024,[273] and several initiatives aim to close this gap. For example, the international Women in Data Science project enables women to be fully represented and empowered in data science.[274] Similarly, Women in AI Benelux (Belgium, Netherlands and Luxembourg) focuses on empowering women to become AI and data experts and leaders,[275] while the UAE's Abdulla Al Ghurair Foundation has launched its own Women in AI programme.[276]

BRIDGING THE TECHNOLOGY-HUMAN GAP IN CUSTOMER SERVICE

In 2025, 85% of customer service leaders are expected to explore or pilot customer-facing conversational generative AI.[277] However, while technology is meant to enhance the customer digital experience, there is a growing disconnect[278] between businesses and customers, as technology alone is not improving customer loyalty.[279] Businesses will need to balance technological advancement[280] with authentic human connection.[281] Companies may look at strategically deploying technology as an enabler while prioritising relevance, genuine customer needs, and customers' ability to control the experience.[282]

ARTIFICIAL INTELLIGENCE AND HUMANITY – AN EVOLVING NARRATIVE

In a cross-disciplinary survey of experts in 68 countries in 2024, 34% expected to see a substantial acceleration in how AI would impact daily life and society within the next year.[283] As people's ways of communicating and connecting continue to change, reshaping relationships and social interactions,[284] AI will evolve to more increasingly reflect what is important to diverse human cultures, ethical frameworks, and region-specific approaches to ensure AI serves society's values and best interests.[285]

AREAS OF FUTURE OPPORTUNITY

The **creative economy** contributed

3.1%

of global GDP in 2022 and 2023

NEED FOR THE ARTS

Based on UNESCO data in 2022 and 2023, the creative economy generates $2.3 trillion annually, contributing 3.1% of global gross domestic product (GDP) and employing 6.2% of the global workforce.[286] This sector, encompassing both traditional arts and digital media,[287] is projected to reach 10% of global GDP by 2030.[288] Driven by digitalisation, this makes it one of the world's fastest growing sectors.[289] However, funding remains a challenge – heavily depending on traditional fundraising, grants and sponsorship, which are vulnerable to economic downturns – and is often overlooked in policy and investment discussions.[290] Besides funding, dropping enrolments in arts education is also a challenge.

Fundamental to the creative sector, arts education also supports the development of cross-disciplinary skills that can be used to address complex global challenges.[291] It plays an essential role in mental health, education and navigating social change,[292] and can enable a deeper understanding of life,[293] which will be especially valuable as society navigates the challenges of AI and other technological advances.[294]

The **global justice crisis** affects at least

5.1 billion

people

LAB FOR ONLINE DISPUTE RESOLUTION ACROSS LEGAL SYSTEMS

AI-powered dispute resolution shows promising potential for increasing access to justice globally. The global justice crisis affects at least 5.1 billion people around the world.[295] For example, in the United States, low-income Americans receive little to no legal help in 92% of civil cases.[296]

As mediators for dispute resolution,[297] large language models (LLMs) have demonstrated impressive capabilities, outperforming or matching human mediators in the selection of appropriate intervention types (62%) and creation of effective intervention messages (84%).[298] A cross-border online dispute resolution lab could further advance AI-enabled tools for handling disputes across jurisdictions and languages. The University of Cambridge has proposed standards for such an initiative, although there remain challenges related to bias, privacy and worldwide coverage.[299] Several innovative initiatives are already underway to pilot or roll out LLMs for legal aid. Suffolk University Law School and the American Arbitration Association have launched an online innovation clinic for dispute resolution in family law matters.[300] Other examples are the British Columbia Civil Resolution Tribunal, which handles small claims and motor vehicle disputes online,[301] and Queen's University Conflict Analytics Lab, which acts as an incubator for legal technology start-ups.[302]

Gen Z will represent

27%

of the workforce in 2025

UNDERSTANDING TALENT RETENTION

Meaningful work and job alignment are important factors in talent retention. However, alignment with organisational values plays a more significant role.[303] This alignment is crucial for Generation Z (Gen Z), who make up 25% of the global population and will represent 27% of the workforce in 2025.[304]

The concerns and preoccupations of this demographic – and others – present unique opportunities for organisations to reimagine workplace culture and retention strategies, particularly as Gen Z prioritise job security over frequent job changes.[305] However, assessing organisational value alignment – including corporate social values[306] – is not easy, particularly if an employee's level of self-knowledge is limited[307] and organisational values are unclear.[308] Along with clear organisational values[309] and ensuring genuine commitment to them,[310] this is best achieved from the hiring decisions that benefit both the organisation and the employee.[311] Organisations can adopt forward-looking strategies that include diverse hiring panels to reduce bias and ensure better cultural fit.[312] Prioritising alignment with values strengthens employee loyalty and positions companies as employers of choice contributing to a more productive workplace culture that meets the demands of an ever-changing job market.

MEGATREND 10

Advanced Health and Nutrition

KEYWORDS

Air Quality Epigenetics
Biochar
Carbon Sequestration
Genomic Data Diversity
Genomic Studies
Particulate Matter (PM)
Personalised/Precision Medicine
Soil Health
Sustainable Agriculture
Sustainable Development Goals (SDGs)

Progress in advanced machine intelligence, nano- and biotechnology, additive manufacturing, and the Internet of Things (IoT) will change our understanding and experience of health and nutrition. Driven by unprecedented developments and response to climate change, resource scarcity, and the desire for longevity, this megatrend will improve health across all age groups. It will reduce, if not eradicate, some communicable and non-communicable diseases and enhance the sustainable use of, and access to, water and food.

THREE THINGS TO LOOK OUT FOR IN 2025

THE GROWING CLIMATE–HEALTH LINK

Climate change is threatening health worldwide, pushing 132 million people into extreme poverty, including 44 million from the impacts of ill health.[313] In 2023, people experienced 50 more days per year of health-threatening temperatures, and 48% of global land faced extreme drought.[314] Food insecurity affects 151 million more people today compared with the levels seen between 1981 and 2010.[315]

HEALTHCARE SYSTEM BOTTLENECKS AROUND THE WORLD

Healthcare bottlenecks around the world vary from a lack of guidelines, supervision, training and cleanliness for women during childbirth in Pakistan[316] to the cost and voluntary nature of the private insurance system of the United States, which leaves millions of people uninsured.[317] Despite gaps in data,[318] overcrowding and long waiting times in emergency departments are already common in the OECD[319] and around the world,[320] as are access barriers for mental health care.[321]

MEAT TRADE ALONGSIDE REGULATORY, CLIMATE AND DEMOGRAPHIC SHIFTS

By 2033, the global meat trade is expected to grow by 12% driven by rising demand in sub-Saharan Africa and Asia.[322] Exports from North and South America are also expected to grow, accounting for just over half of global meat exports.[323] This is alongside the European Union's ban on food imports linked to deforestation,[324] growing concerns over the impact of meat production on the climate,[325] as well as ageing populations and changing consumer preferences in high-income countries.[326]

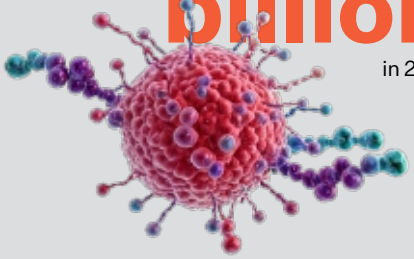
AREAS OF FUTURE OPPORTUNITY

AIR QUALITY EPIGENETICS

The **global epigenetics market** reached a value of

$14.6 billion

in 2023

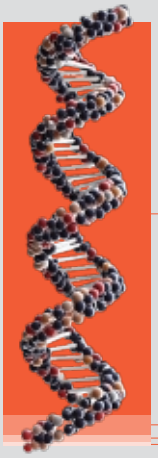


The environment influences epigenetics, which studies the processes that activate or deactivate specific genes, influencing not only individual health but also the health of future generations.[327]

Particulate matter (PM) in the air may include organic and inorganic compounds that have epigenetic effects linked to poor health. Current research on PM's epigenomic impact is limited, with future opportunities to identify biomarkers and develop interventions that could mitigate PM-related health risks, especially in vulnerable populations.[328]

The global epigenetics market reached a value of $14.6 billion in 2023 and is expected to increase by nearly 15% annually up to 2030.[329] Eight epigenetic therapies have been approved by the US Food and Drug Administration (FDA) and are currently on the market, with six being used to treat haematological malignancies and two approved for solid tumours.[330]

EXPANDING PRECISION MEDICINE THROUGH DIVERSE GENOMIC RESEARCH



Current genomic data in genomic studies come from

94.5% European ancestry

4% Asian

0.9% Hispanic and other

0.6% African

Precision/personalised medicine is transforming approaches to genetic diseases.[331] In 2023, precision medicines made up 38% of the FDA's new therapeutic drug approvals and over a quarter of all approvals since 2015.[332] While combined use of magnetic resonance imaging scans with genetic testing has improved diagnostics for neurological disorders such as cerebral palsy[333] and autism,[334] the impact of precision medicine has not been fully realised.[335]

For example, epilepsy affects 50 million people globally, with 80% living in low- or middle-income countries.[336] While 70% of people could be seizure-free with proper treatment – once diagnosed – 50% of cases have unknown causes.[337] Benefiting from personalised medicine in this case requires addressing current limitations, particularly in genomic data presentation. With nearly 94.5% of current genomic data in genomic studies coming from European ancestry, followed by nearly 4% Asian, 0.9% Hispanic and 0.6% African,[338] expanding research to include diverse populations is a future opportunity. From a growing emphasis on data sharing[339] across demographics and geographical regions to efforts to overcome cultural barriers[340] and stigma[341, 342] associated with genetic testing, these steps are crucial for developing more effective, targeted therapies and ensuring broader access to the benefits of precision medicine.

BIOCHAR FOR CROPS

With **biochar**, crop yields can increase by

10%

Biochar, a carbon-rich charcoal, is produced through pyrolysis of biomass at high temperatures (500°C).[343] A by-product of bioenergy production, which currently makes up 55% of global renewable energy and must grow by 8% annually until 2030 if net-zero targets by 2050 are to be met,[344] biochar as a future opportunity powers a circular approach to biomass.

Biochar offers multiple benefits, including enhanced soil health, improved water retention, and carbon sequestration.[345] Biochar can aid composting,[346] water filtration,[347] carbon capture,[348] and agricultural yields,[349] contributing to some of the Sustainable Development Goals (SDGs): SDG 6 (clean water), SDG 13 (carbon capture), and SDG 15 (soil health).[350] Its role in soil health is particularly significant for sustainable agriculture and climate mitigation strategies, as it enhances soil's structure, water retention, and microbial health while reducing acidity.[351] With biochar, crop yields can increase by 10%, as it enhances nutrient absorption and retention, deters pathogens and pests, and makes plants more resilient to environmental impacts.[352]

This research was undertaken by the Dubai Future Foundation's Dubai Future Institute. The Dubai Future Foundation produces insights and foresight reports using evidence-based analysis and imagination that enable stakeholders to anticipate and better navigate the future.

Our publications can be found at dubaifuture.ae/insights/

Bibliography

dubaifuture.ae/bibliography-global-50-2025

مؤسسة دبي للمستقبل
DUBAI FUTURE FOUNDATION

About The Dubai Future Foundation

Dubai Future Foundation aims to realise the vision of His Highness Sheikh Mohammed bin Rashid Al Maktoum, Vice President and Prime Minister of the UAE and Ruler of Dubai, for the future of Dubai and consolidate its global status as a leading city of the future. In partnership with its partners from government entities, international companies, startups and entrepreneurs in the UAE and around the world, Dubai Future Foundation drives joint efforts to collectively imagine, design and execute the future of Dubai.

Under the supervision and with the support of His Highness Sheikh Hamdan bin Mohammed bin Rashid Al Maktoum, Crown Prince of Dubai, Chairman of the Executive Council of Dubai and Chairman of the Board of Trustees of Dubai Future Foundation, DFF works on a three-pronged strategy: to imagine, design and execute the future. It does this through the development and launch of national and global programmes and initiatives, preparing plans and strategies for the future, issuing foresight reports and supporting innovative and qualitative projects. These contribute to positioning Dubai as a global capital for the development and adoption of the latest innovative solutions and practices to serve humanity.

Dubai Future Foundation focuses on identifying the most prominent challenges facing cities, communities and sectors in the future and transforming them into promising growth opportunities by collecting and analysing data, studying global trends and keeping pace with and preparing for rapid changes. It is also looking at future sectors, their integration and the reshaping of current industries.

Dubai Future Foundation oversees many pioneering projects and initiatives, such as the Museum of the Future, Area 2071, The Centre for the Fourth Industrial Revolution UAE, Dubai Future Accelerators, One Million Arab Coders, Dubai Future District, Dubai Future Solutions, Dubai Future Forum, Dubai Metaverse Assembly. Its many knowledge initiatives

and future design centres contribute to building specialised local talents for future requirements and empowering them with the necessary skills to contribute to the sustainable development of Dubai.

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Any Arabic translation of The Global 50 is solely for convenience. While efforts have been made to ensure accuracy, the English version shall prevail in case of any discrepancies or inconsistencies between the two translations.

References

* To improve searchability and scannability, we have not used 'Ibid.' in this year's edition.

1 Coleman, J. (2023) 'The Surprising Possibilities of See-Through Wood'. Smithsonian Magazine. 19 December. www.smithsonianmag.com/innovation/the-surprising-possibilities-of-see-through-wood-180983471/

2 City University of Hong Kong (2023) 'CityU revolutionary cooling ceramic enhances energy efficiency and combats global warming through its application in building construction'. 10 November. www.cityu.edu.hk/media/press-release/2023/11/10/cityu-revolutionary-cooling-ceramic-enhances-energy-efficiency-and-combats-global-warming-through-its-application-building-construction

3 City University of Hong Kong (2023) 'CityU revolutionary cooling ceramic enhances energy efficiency and combats global warming through its application in building construction'. 10 November. www.cityu.edu.hk/media/press-release/2023/11/10/cityu-revolutionary-cooling-ceramic-enhances-energy-efficiency-and-combats-global-warming-through-its-application-building-construction

4 Liu, G. et al. (2024) 'Biocatalytic membranes with crosslinked enzyme aggregates for micropollutant removal'. Chemical Engineering Journal, 479. https://doi.org/10.1016/j.cej.2023.147635

5 International Energy Agency (2022) 'The Role of Critical Minerals in Clean Energy Transitions: Executive summary'. March. www.iea.org/reports/the-role-of-critical-minerals-in-clean-energy-transitions/executive-summary

6 Vekasi, K. (2022) 'Wind Power, Politics, and Magnets'. Harvard University. 18 November. https://epicenter.wcfia.harvard.edu/blog/wind-power-politics-and-magnets

7 International Energy Agency (n.d.) 'The role of critical minerals in clean energy transitions: Critical Minerals'. www.iea.org/topics/critical-minerals (retrieved 3 January 2025)

8 International Energy Agency (2024) 'Global Critical Minerals Outlook 2024'. May. https://iea.blob.core.windows.net/assets/ee01701d-1d5c-4ba8-9df6-abeeac9de99a/GlobalCriticalMineralsOutlook2024.pdf

9 Chandler, D. (2021), 'MIT-designed project achieves major advance toward fusion energy'. Online. 2 Oct. https://news.mit.edu/2021/MIT-CFS-major-advance-toward-fusion-energy-0908

10 National Institute of Biomedical Imaging and Bioengineering (n.d.) 'Magnetic Resonance Imaging (MRI)'. www.nibib.nih.gov/science-education/science-topics/magnetic-resonance-imaging-mri (retrieved 3 January 2025)

11 Cleveland Clinic (2022) 'Transcranial Magentic Stimulation (TMS)'. 29 August. https://my.clevelandclinic.org/health/treatments/17827-transcranial-magnetic-stimulation-tms

12 Nayebossadri, S. et al (2024) 'Hydrogen-assisted recycling of Nd-Fe-B magnets from the end-of-life audio products'. Journal of Magnetism and Magnetic Materials, 603. https://doi.org/10.1016/j.jmmm.2024.172239

13 International Energy Agency (2024) 'Global Critical Minerals Outlook 2024'. May. https://iea.blob.core.windows.net/assets/ee01701d-1d5c-4ba8-9df6-abeeac9de99a/GlobalCriticalMineralsOutlook2024.pdf

14 International Energy Agency (2024) 'Global Critical Minerals Outlook 2024'. May. https://iea.blob.core.windows.net/assets/ee01701d-1d5c-4ba8-9df6-abeeac9de99a/GlobalCriticalMineralsOutlook2024.pdf

15 International Energy Agency (2024) 'Global Critical Minerals Outlook 2024'. May. https://iea.blob.core.windows.net/assets/ee01701d-1d5c-4ba8-9df6-abeeac9de99a/GlobalCriticalMineralsOutlook2024.pdf

16 Rallabandi, V., Ozpineci, B. and Kumar, P. (2024) 'How to Build EV Motors Without Rare Earth Elements Experimental motors use exotic materials and clever configurations'. Institute of Electrical and Electronics Engineers. 2 July. https://spectrum.ieee.org/ev-motor

17 King's College London (2024), 'Scientists create world's strongest iron-based superconducting magnet using AI'. Online. 4 Oct. https://www.kcl.ac.uk/news/scientists-create-worlds-strongest-iron-based-superconducting-magnet-using-ai

18 Science Direct (2009), 'Biomimetic Material'. Online. 3 Oct. https://www.sciencedirect.com/topics/engineering/biomimetic-material

19 Hwang, J. et al. (2015) 'Biomimetics: forecasting the future of science, engineering, and medicine'. International Journal of Nanomedicine, 10: 5701-5713 10.2147/IJN.S83642

20 Saunders, T. (2023) 'How old is Earth? Our world's surprising age, explained'. BBC Science Focus. 5 July. www.sciencefocus.com/planet-earth/how-old-is-the-earth

21 Hamilton, T. (2008), 'Whale-Inspired Wind Turbines'. Online. 4 Oct. https://www.technologyreview.com/2008/03/06/221447/whale-inspired-wind-turbines/

22 Yu, Z., et al. (2020), ' Namib desert beetle inspired special patterned fabric with programmable and gradient wettability for efficient fog harvesting'. Journal of Materials Science & Technology, 61. doi: https://doi.org/10.1016/j.jmst.2020.05.054

23 Casey, L. (2021), 'Conjuring water from thin Air – A beetle's guide to innovation'. Online. 4 Oct. https://www.sydney.edu.au/science/news-and-events/2021/01/22/conjuring-water-from-thin-air.html#:~:text=The%20beetles%20extract%20water%20from,harvest%20water%20from%20the%20air.

24 Ye, W., Tee, B.C.K. and Andal, S. (2024) 'Deep Tech Series Vol. 6: How Nature-Inspired Deep Tech is Shaping a Sustainable Future'. United Nations Development Programme. 16 October. www.undp.org/policy-centre/singapore/blog/deep-tech-series-vol-6-how-nature-inspired-deep-tech-shaping-sustainable-future

25 Lebdioui, A. (2022) 'Nature-inspired innovation policy: Biomimicry as a pathway to leverage biodiversity for economic development'. Ecological Economics, 202. https://doi.org/10.1016/j.ecolecon.2022.107585

26 Becher, C., et al. (2023), '2023 roadmap for materials for quantum technologies'. Materials for Quantum Technology, 3: 012501 10.1088/2633-4356/aca3f2

27 Becher, C., et al. (2023), '2023 roadmap for materials for quantum technologies'. Materials for Quantum Technology, 3: 012501 10.1088/2633-4356/aca3f2

28 Becher, C., et al. (2023), '2023 roadmap for materials for quantum technologies'. Materials for Quantum Technology, 3: 012501 10.1088/2633-4356/aca3f2

29 Bogobowicz, M. et al. (2024) 'Steady progress in approaching the quantum advantage'. McKinsey & Company. 24 April. www.mckinsey.com/capabilities/mckinsey-digital/our-insights/steady-progress-in-approaching-the-quantum-advantage#/

30 Bogobowicz, M. et al. (2024) 'Steady progress in approaching the quantum advantage'. McKinsey & Company. 24 April. www.mckinsey.com/capabilities/mckinsey-digital/our-insights/steady-progress-in-approaching-the-quantum-advantage#/

31 Bogobowicz, M. et al. (2024) 'Steady progress in approaching the quantum advantage'. McKinsey & Company. 24 April. www.mckinsey.com/capabilities/mckinsey-digital/our-insights/steady-progress-in-approaching-the-quantum-advantage#/

32 Bogobowicz, M. et al. (2024) 'Steady progress in approaching the quantum advantage'. McKinsey & Company. 24 April. www.mckinsey.com/capabilities/mckinsey-digital/our-insights/steady-progress-in-approaching-the-quantum-advantage#/

33 DataReportal (2024) 'Digital around the world'. https://datareportal.com/global-digital-overview (retrieved 15 January 2025)

34 Johnson, H. (2024) 'About 2.5 billion people lack internet access: How connectivity can unlock their potential'. World Economic Forum. 25 September. www.weforum.org/stories/2024/09/2-5-billion-people-lack-internet-access-how-connectivity-can-unlock-their-potential/

35 GSMA (2024) 'New GSMA report shows mobile internet connectivity continues to grow globally but barriers for 3.45 billion unconnected people remain'. 23 October. www.gsma.com/newsroom/press-release/new-gsma-report-shows-mobile-internet-connectivity-continues-to-grow-globally-but-barriers-for-3-45-billion-unconnected-people-remain/

36 Flinders, M. and Smalley, I. (2024) 'What is data sovereignty?'. International Business Machines (IBM). 3 June. www.ibm.com/think/topics/data-sovereignty

37 Chen, M. (2024) 'What is Data Sovereignty?'. Oracle Cloud Infrastructure (OCI). 2 May. www.oracle.com/ae/cloud/sovereign-cloud/data-sovereignty/

38 Afzal, S. et al. (2024) 'A Survey on Energy Consumption and Environmental Impact of Video Streaming'. Journal of the Association for Computing Machinery, 1(1). https://arxiv.org/pdf/2401.09854

39 Netflix (2023) 'Environmental Social Governance Report 2023'. https://s22.q4cdn.com/959853165/files/doc_downloads/2024/6/2023-Netflix-Environmental-Social-Governance-Report.pdf

40 Organization for Economic Co-operation and Development (2024) 'OECD Digital Economy Outlook 2024 (Volume 1): Embracing the Technology Frontier'. OECD Publishing. 14 May. https://doi.org/10.1787/45ba765d-en

41 Semaan, E. et al. (2024) '6G spectrum – enabling future mobile life beyond 2030'. Ericsson. May. www.ericsson.com/49ac9c/assets/local/reports-papers/white-papers/2024/6g-spectrum.pdf

42 Semaan, E., and et al. (2024), '6G spectrum – enabling future mobile life beyond 2030', Ericsson. Online. 8 Oct. https://www.ericsson.com/49ac9c/assets/local/reports-papers/white-papers/2024/6g-spectrum.pdf

43 Chafii, M. (2023) 'Twelve Scientific Challenges for 6G: Rethinking the Foundations of Communications Theory'. IEEE Communications Surveys & Tutorials, 25(2): 868-904. https://doi.org/10.1109/COMST.2023.3243918

44 Semaan, E., and et al. (2024), '6G spectrum – enabling future mobile life beyond 2030', Ericsson. Online. 8 Oct. https://www.ericsson.com/49ac9c/assets/local/reports-papers/white-papers/2024/6g-spectrum.pdf

45 Cisco (n.d.) 'What Are 5G Speeds?'. www.cisco.com/c/en/us/solutions/what-is-5g/what-are-5g-speeds.html (retrieved 3 January 2025)

46 De Luca, S. (2024) 'The path to 6G'. European Parliament. January. www.europarl.europa.eu/RegData/etudes/BRIE/2024/757633/EPRS_BRI(2024)757633_EN.pdf

47 De Luca, S. (2024) 'The path to 6G'. European Parliament. January. www.europarl.europa.eu/RegData/etudes/BRIE/2024/757633/EPRS_BRI(2024)757633_EN.pdf

48 De Luca, S. (2024) 'The path to 6G'. European Parliament. (2024), 'The path to 6G'. Online. 7 Oct. January. www.europarl.europa.eu/RegData/etudes/BRIE/2024/757633/EPRS_BRI(2024)757633_EN.pdf

49 Chafii, M. (2023) 'Twelve Scientific Challenges for 6G: Rethinking the Foundations of Communications Theory'. IEEE Communications Surveys & Tutorials, 25(2): 868-904. https://doi.org/10.1109/COMST.2023.3243918

50 Chafii, M. (2023) 'Twelve Scientific Challenges for 6G: Rethinking the Foundations of Communications Theory'. IEEE Communications Surveys & Tutorials, 25(2): 868-904. https://doi.org/10.1109/COMST.2023.3243918

51 Radivon, A. et al. (2024) 'Expanding THz Vortex Generation Functionality with Advanced Spiral Zone Plates Based on Single-Walled Carbon Nanotube Films'. Advanced Optical Materials, 12(17). https://doi.org/10.1002/adom.202303282

52 Rhode & Schwarz (n.d.) 'Reconfigurable intelligent surfaces (RIS)'. www.rohde-schwarz.com/se/solutions/wireless-communications-testing/wireless-standards/6g/reconfigurable-intelligent-surfaces-ris/reconfigurable-intelligent-surfaces-ris_257043.html (retrieved 3 January 2025)

53 Pahud de Mortanges, A. et al. (2024) 'Orchestrating explainable artificial intelligence for multimodal and longitudinal data in medical imaging'. npj Digital Medicine, 7. https://doi.org/10.1038/s41746-024-01190-w

54 Keskin, Ç. and Çiftçi, E. (2024) 'Multimodal AI'. PwC. 26 April. www.pwc.com.tr/en/multimodal-ai

55 McKinsey & Company (2023) 'What's the future of generative AI? An early view in 15 charts'. 25 August. www.mckinsey.com/featured-insights/mckinsey-explainers/whats-the-future-of-generative-ai-an-early-view-in-15-charts

56 Rodis, N. et al. (2024) 'Multimodal Explainable Artificial Intelligence: A Comprehensive Review of Methodological Advances and Future Research Directions'. IEEE Access, 12: 159794-159820. https://doi.org/10.1109/ACCESS.2024.3467062

57 Ali, S. et al. (2023) 'Explainable Artificial Intelligence (XAI): What we know and what is left to attain Trustworthy Artificial Intelligence'. Information Fusion, 99. https://doi.org/10.1016/j.inffus.2023.101805

58 Keskin, Ç. and Çiftçi, E. (2024) 'Multimodal AI'. PwC. 26 April. www.pwc.com.tr/en/multimodal-ai

59 OpenAI (2023) 'ChatGPT can now see, hear and speak'. 25 September. https://openai.com/index/chatgpt-can-now-see-hear-and-speak/

60 Gartner (2024) 'Gartner Predicts 40% of Generative AI Solutions Will Be Multimodal By 2027'. 9 September. www.gartner.com/en/newsroom/press-releases/2024-09-09-gartner-predicts-40-percent-of-generative-ai-solutions-will-be-multimodal-by-2027.

61 Johnson & Wales University (JWU) (2024) 'How Sports Analytics Enhances Performance and Efficiency'. 4 May. https://online.jwu.edu/blog/how-sports-analytics-enhances-efficiency-and-performance/

62 Catapult (n.d.) 'Our solutions'. www.catapult.com (retrieved 3 January 2025)

63 Stats Perform (n.d.) 'Optical Player Tracking'. www.statsperform.com/team-performance/basketball/optical-tracking/ (retrieved 3 January 2025)

64 PwC (n.d.) 'Sports Industry Outlook 2024: What's Next In Sports: 2025 outlook launching in January'. www.pwc.com/us/en/industries/tmt/library/sports-outlook-north-america.html (retrieved 3 January 2025)

65 PwC (n.d.) 'Artificial intelligence – The MVP for personalizing sports'. www.pwc.com/us/en/industries/tmt/library/artificial-intelligence-in-sports.html (retrieved 3 January 2025)

66 International Olympics Committee (2024) 'AI and tech innovations at Paris 2024: A game changer in sport'. 20 July. https://olympics.com/ioc/news/ai-and-tech-innovations-at-paris-2024-a-game-changer-in-sport

67 Allied Analytics LLP (2024) 'AI in Sports Market to Reach $29.7 Billion by 2032 at 30.1% CAGR: Allied Market Research'. Globe Newswire. 14 February. www.globenewswire.com/news-release/2024/02/14/2829174/0/en/AI-in-Sports-Market-to-Reach-29-7-Billion-by-2032-at-30-1-CAGR-Allied-Market-Research.html

68 Kreacic, A. et al. (2024) 'The New Growth Agenda'. Oliver Wyman Forum and New York Stock Exchange. www.oliverwymanforum.com/content/dam/oliver-wyman/ow-forum/Permacrisis/The_New_Growth_Agenda.pdf

69 Swiss Re Institute (2024) 'SONAR 2024: New emerging risk insights'. 12 June. www.swissre.com/institute/research/sonar/sonar2024.html

70 International Business Machines (IBM) (2024) 'Cost of a Data Breach Report 2024'. www.ibm.com/reports/data-breach

71 Igarape Institute (2023) 'Global Futures Bulletin: The global threat of disinformation and misinformation in Latin America and how to fight back'. November. https://igarape.org.br/wp-content/uploads/2023/11/Global-Futures-Bulletin-Disinformation.pdf

72 American Psychological Association (APA) (n.d.) 'Misinformation and disinformation'. www.apa.org/topics/journalism-facts/misinformation-disinformation (retrieved 3 January 2025)

73 Cavaciuti-Wishart, E. et al. (2024) 'Global Risks Report 2024: 19th Edition Insight Report'. World Economic Forum. January. https://www3.weforum.org/docs/WEF_The_Global_Risks_Report_2024.pdf

74 Cavaciuti-Wishart, E. et al. (2024) 'Global Risks Report 2024: 19th Edition Insight Report'. World Economic Forum. January. https://www3.weforum.org/docs/WEF_The_Global_Risks_Report_2024.pdf

75 Watt, N., Riedlinger, M. and Montaña-Niño, S. (2025) 'Meta is abandoning fact checking – this doesn't bode well for the fight against misinformation'. The Conversation. 8 January. https://theconversation.com/meta-is-abandoning-fact-checking-this-doesnt-bode-well-for-the-fight-against-misinformation-246878

76 Deloitte (2023) 'Consumer privacy: A business imperative in the digital age'. 3 December. www.deloitte.com/middle-east/en/our-thinking/mepov-magazine/securing-the-future/consumer-privacy.html

77 Sherman, J. (2024) 'Finding security in digital public infrastructure'. Atlantic Council. 21 October. www.atlanticcouncil.org/in-depth-research-reports/issue-brief/finding-security-in-digital-public-infrastructure/

78 Senbet, L. et al. (2024) 'Foresight Africa: Top priorities for the continent in 2024'. Brookings Institution. 26 January. www.brookings.edu/wp-content/uploads/2024/01/ForesightAfrica2024.pdf

79 Webb, A. et al (2024) '2024 Tech Trends Report'. Future Today Institute. https://futuretodayinstitute.com/wp-content/uploads/2024/03/TR2024_Full-Report_FINAL_LINKED.pdf

80 Sherman, J. (2024) 'Finding security in digital public infrastructure'. Atlantic Council. 21 October. www.atlanticcouncil.org/in-depth-research-reports/issue-brief/finding-security-in-digital-public-infrastructure/

81 Gille, F., Smith, S. and Mays, N. (2022) 'Evidence-based guiding principles to build public trust in personal data use in health systems'. Digital health, 2022(8). https://doi.org/10.1177/20552076221111947

82 Cheng, J. (2022) 'The Social and Psychological Consequences of Ransomware Attacks'. ISACA. 7 October. www.isaca.org/resources/news-and-trends/isaca-now-blog/2022/the-social-and-psychological-consequences-of-ransomware-attacks

83 Bada, M. and Nurse, J.R.C. (2020) 'The social and psychological impact of cyberattacks'. Emerging Cyber Threats and Cognitive Vulnerabilities: 73-92. www.researchgate.net/publication/338313135_The_social_and_psychological_impact_of_cyberattacks/link/5e86f53d-4585150839b96a08/download

84 Future Care Capital (2024) 'Three in five fraud victims go on to experience mental health problems'. 21 March. https://futurecarecapital.org.uk/latest/fraud-victims-experience-mental-health-problems/

85 St. John, M. (2024) 'Cybersecurity Stats: Facts And Figures You Should Know'. Forbes. 28 August. www.forbes.com/advisor/education/it-and-tech/cybersecurity-statistics/

86 Sarkar, G. and Shukla, S. (2023) 'Behavioural analysis of cybercrime: Paving the way for effective policing strategies'. Journal of Economic Criminology, 2. https://doi.org/10.1016/j.jeconc.2023.100034

87 Byrnes, F. (2020) 'The value of psychology and cognitive science in Cybersecurity'. International Business Machines (IBM). 9 March. www.ibm.com/blogs/ibm-anz/psychology-and-cybersecurity/

88 Haney, J.M., Cunningham IV, C. and Furman, S.M. (2024) 'Towards Integrating Human-Centered Cybersecurity, Research Into Practice: A Practitioner Survey'. National Institute of Standards and Technology. 26 February. www.ndss-symposium.org/wp-content/uploads/usec2024-13-paper.pdf

89 Fouad, N.S. (2024) 'Cyberbiosecurity in the new normal: Cyberbio risks, pre-emptive security, and the global governance of bioinformation'. European Journal of International Security, 9(4):553-573. https://doi.org/10.1017/eis.2024.19

90 Annaratone, L. et al. (2021) 'Basic principles of biobanking: from biological samples to precision medicine for patients'. Virchows Archiv: an international journal of pathology, 479(2): 233–246. https://doi.org/10.1007/s00428-021-03151-0

91 Fouad, N.S. (2024) 'Cyberbiosecurity in the new normal: Cyberbio risks, pre-emptive security, and the global governance of bioinformation'. European Journal of International Security, 9(4):553-573. https://doi.org/10.1017/eis.2024.19

92 Jeselyn and Trajano, J.C.I. (2024) 'CO24156 | Cyberbiosecurity: Adapting to Emerging Threats in the Biosecurity Landscape'. S. Rajaratnam School of International Studies (RSIS). 17 October. www.rsis.edu.sg/rsis-publication/rsis/cyberbiosecurity-adapting-to-emerging-threats-in-the-biosecurity-landscape/

93 Fouad, N.S. (2024) 'Cyberbiosecurity in the new normal: Cyberbio risks, pre-emptive security, and the global governance of bioinformation'. European Journal of International Security, 9(4): 553-573. https://doi.org/10.1017/eis.2024.19

94 London Metropolitan University (n.d.) 'Biological Security Research Centre'. www.londonmet.ac.uk/research/centres-groups-and-units/biological-security-research-centre/ (retrieved 3 January 2025)

95 London Metropolitan University (n.d.) 'International Biological Security Education Network'. https://ibsen.org.uk/ (retrieved 3 January 2025)

96 Altman, S.A. and Bastian, C.R. (2024) 'DHL Global connectedness report 2024: An in-depth analysis of the state of globalization'. DHL Group. February. www.doi.org/10.58153/7jt4h-p0738

97 International Business Machines (IBM) (2024) 'Cost of a Data Breach Report 2024'. www.ibm.com/reports/data-breach

98 Castellvi, S. (2024) 'Advancing global interoperability: The role of standardization in data spaces'. International Data Spaces Association. 5 April. https://internationaldataspaces.org/advancing-global-interoperability-the-role-of-standardization-in-data-spaces/

99 Hardy, A. (2024) 'Estonia's digital diplomacy: Nordic interoperability and the challenges of cross-border e-governance'. Internet Policy Review, 13(3): 1-31. https://doi.org/10.14763/2024.3.1785%0A

100 Smil, V. (2004) 'World History and Energy'. Encylopedia of Energy, 6. https://vaclavsmil.com/wp-content/uploads/2024/10/smil-article-2004world-history-energy.pdf

101 Instead Knowledge (2022) 'Bob Ayres at 90: Key Insights on Energy in the Economy'. 26 July. https://knowledge.insead.edu/responsibility/bob-ayres-90-key-insights-energy-economy

102 The Global Goals (n.d.) '7 Affordable and Clean Energy: Ensure access to affordable, reliable, sustainable and modern energy for all.' www.globalgoals.org/goals/7-affordable-and-clean-energy/ (retrieved 3 January 2025)

103 World Bank Group (2024) 'New Partnership Aims to Connect 300 Million to Electricity by 2030'. 17 April. www.worldbank.org/en/news/press-release/2024/04/17/new-partnership-aims-to-connect-300-million-to-electricity-by-2030

104 EY (2024) 'Tech Trends Series: EY India'. July. www.ey.com/content/dam/ey-unified-site/ey-com/en-in/services/technology/tech-trends-series/ey-india-tech-trends-series-july-2024-v1.pdf

105 Six Flags (2023) 'Six Flags Magic Mountain Breaks Ground on California's Largest Solar Energy Project'. 1 November. www.sixflags.com/six-flags-magic-mountain-breaks-ground-on-californias-largest-solar-energy-project

106 China Nucelar National Corporation (2024) 'Hainan Nuclear Power, IAEA sign a capacity-building execution deal over SMRs construction'. 8 November. https://en.cnnc.com.cn/2024-11/08/c_1043524.htm

107 Amazon (2024) 'Amazon signs agreements for innovative nuclear energy projects to address growing energy demands: New Small Modular Reactor agreements are part of Amazon's plan to transition to carbon-free energy'. 16 October. www.aboutamazon.com/news/sustainability/amazon-nuclear-small-modular-reactor-net-carbon-zero

108 Calma, J. (2024) 'Google inks nuclear deal for next-generation reactors'. The Verge. 15 October. www.theverge.com/2024/10/15/24270645/google-nuclear-energy-deal-small-modular-reactor-kaiross

109 Krutnik, M. et al. (2024) 'Global Energy Perspective 2023: Sustainable fuels outlook'. McKinsey & Company. 10 January. www.mckinsey.com/industries/oil-and-gas/our-insights/global-energy-perspective-2023-sustainable-fuels-outlook

110 Jeswani, H.K, Chilvers, A. and Azapagic, A. (2020) 'Environmental sustainability of biofuels: a review'. Proceedings of the Royal Society A: Mathematical, Physical and Engineering Sciences, 476(2243). https://doi.org/10.1098/rspa.2020.0351

111 Jeswani, H.K, Chilvers, A. and Azapagic, A. (2020) 'Environmental sustainability of biofuels: a review'. Proceedings of the Royal Society A: Mathematical, Physical and Engineering Sciences, 476(2243). https://doi.org/10.1098/rspa.2020.0351

112 Suzan, S. (2024) 'The advanced and waste biofuels paradox: Availability and sustainability of advanced and waste biofuels'. Transport and Environment. July. www.transportenvironment.org/uploads/files/202407_TE_advanced_biofuels_report-2.pdf

113 Krishnan, M. et al. (2022) 'The Net-zero transition: What it would cost, what it could bring'. McKinsey & Company. January. www.mckinsey.com/~/media/mckinsey/business%20functions/sustainability/our%20insights/the%20net%20zero%20transition%20what%20it%20would%20cost%20what%20it%20could%20bring/the-net-zero-transition-what-it-would-cost-and-what-it-could-bring-final.pdf

114 The American Experience Trust (n.d.) 'Game Theory Explained'. PBS. www.pbs.org/wgbh/americanexperience/features/nash-game/ (retrieved 3 January 2025)

115 Yarar, N. et al. (2024) 'A Comprehensive Review Based on the Game Theory with Energy Management and Trading'. Energies, 17(15). https://doi.org/10.3390/en17153749

116 Aviso, K.B. (2024) 'Use game theory for climate models that really help reach net zero goals'. Nature, 628(502). https://doi.org/10.1038/d41586-024-01083-8

117 Jain, H. (2024) 'From pollution to progress: Groundbreaking advances in clean technology unveiled'. Innovation and green development, 3(2). https://doi.org/10.1016/j.igd.2024.100143

118 International Energy Agency (2023) 'The State of Clean Technology Manufacturing: An Energy Technology Perspectives Special Briefing'. May. www.iea.org/reports/the-state-of-clean-technology-manufacturing/analysis

119 International Energy Agency (2023) 'The world is entering a new age of clean technology manufacturing, and countries' industrial strategies will be key to success'. 12 January. www.iea.org/news/the-world-is-entering-a-new-age-of-clean-technology-manufacturing-and-countries-industrial-strategies-will-be-key-to-success

120 International Energy Agency (2023) 'The world is entering a new age of clean technology manufacturing, and countries' industrial strategies will be key to success'. 12 January. www.iea.org/news/the-world-is-entering-a-new-age-of-clean-technology-manufacturing-and-countries-industrial-strategies-will-be-key-to-success

121 International Energy Agency (2023) 'The world is entering a new age of clean technology manufacturing, and countries' industrial strategies will be key to success'. 12 January. www.iea.org/news/the-world-is-entering-a-new-age-of-clean-technology-manufacturing-and-countries-industrial-strategies-will-be-key-to-success

122 International Energy Agency (2023) 'The world is entering a new age of clean technology manufacturing, and countries' industrial strategies will be key to success'. 12 January. www.iea.org/news/the-world-is-entering-a-new-age-of-clean-technology-manufacturing-and-countries-industrial-strategies-will-be-key-to-success

123 International Energy Agency (2024) 'Global Hydrogen Review 2024'. October. https://iea.blob.core.windows.net/assets/89c1e382-dc59-46ca-aa47-9f7d41531ab5/GlobalHydrogenReview2024.pdf

124 International Energy Agency (2024) 'Global Hydrogen Review 2024'. October. https://iea.blob.core.windows.net/assets/89c1e382-dc59-46ca-aa47-9f7d41531ab5/GlobalHydrogenReview2024.pdf

125 Gulli, C. et al. (2024) 'Global Energy Perspective 2023: Hydrogen outlook'. McKinsey & Company. 10 January. www.mckinsey.com/industries/oil-and-gas/our-insights/global-energy-perspective-2023-hydrogen-outlook

126 International Energy Agency (2024) 'Global Hydrogen Review 2024'. October. https://iea.blob.core.windows.net/assets/89c1e382-dc59-46ca-aa47-9f7d41531ab5/GlobalHydrogenReview2024.pdf

127 International Energy Forum (2023) 'Energy transition to trigger huge growth in platinum for hydrogen'. 4 September. www.ief.org/news/energy-transition-to-trigger-huge-growth-in-platinum-for-hydrogen

128 International Energy Forum (2023) 'Energy transition to trigger huge growth in platinum for hydrogen'. 4 September. www.ief.org/news/energy-transition-to-trigger-huge-growth-in-platinum-for-hydrogen

129 International Energy Forum (2023) 'Energy transition to trigger huge growth in platinum for hydrogen'. 4 September. www.ief.org/news/energy-transition-to-trigger-huge-growth-in-platinum-for-hydrogen

130 Kepenienė, V. and Tamašauskaitė-Tamašiūnaitė, L. (2024) 'Advanced Catalytic Materials for Renewable Energy Sources'. Catalysts, 14(8). https://doi.org/10.3390/catal14080497

131 Gartner (2023) 'Top 10 Strategic Technology Trends 2024'. 16 October. https://emt.gartnerweb.com/ngw/globalassets/en/publications/documents/2024-gartner-top-strategic-technology-trends-ebook.pdf

132 Crawford, K. (2024) 'Generative AI's environmental costs are soaring – and mostly secret'. Nature, 626. https://doi.org/10.1038/d41586-024-00478-x

133 Crawford, K. (2024) 'Generative AI's environmental costs are soaring – and mostly secret'. Nature, 626. https://doi.org/10.1038/d41586-024-00478-x

134 United Nations Development Programme (2024) 'The Peoples' Climate Vote 2024'. 20 June. www.undp.org/publications/peoples-climate-vote-2024

135 United Nations Development Programme (2024) 'The Peoples' Climate Vote 2024'. 20 June. www.undp.org/publications/peoples-climate-vote-2024

136 Sextus, C.P., Hytten, K.F. and Perry, P. (2024) 'A Systematic Review of Environmental Volunteer Motivations'. Society and Natural Resources, 37(11): 1591-1608. https://doi.org/10.1080/08941920.2024.2381202

137 Senbet, L. et al. (2024) 'Foresight Africa – Top priorities for the continent in 2024'. Brookings Institution. www.brookings.edu/wp-content/uploads/2024/01/ForesightAfrica2024.pdf

138 Mureithi, C. (2024) 'More money is going to African climate startups, but a huge funding gap remains'. Associated Press News. 2 May. https://apnews.com/article/africa-climate-tech-start-up-funding-462006ed8e3e28fe4eb9221dde174a11

139 African Development Bank Group (n.d.) 'Action plan on climate change'. www.afdb.org/en/topics-and-sectors/sectors/climate-change/action-plan-climate-change (retrieved 3 January 2025)

140 Dhanani, R. (2023) 'The History of Regenerative Sustainability'. The sustainable agency. 17 November. https://thesustainableagency.com/blog/the-history-of-regeneration-and-regenerative-sustainability/

141 Radjou, N. (2024) 'Regeneration: Why businesses are moving beyond sustainability and thinking about regrowth'. World Economic Forum. 6 June. www.weforum.org/stories/2024/06/businesses-are-moving-beyond-sustainability-welcome-to-the-age-of-regeneration/

142 Radjou, N. (2024) 'Regeneration: Why businesses are moving beyond sustainability and thinking about regrowth'. World Economic Forum. 6 June. www.weforum.org/stories/2024/06/businesses-are-moving-beyond-sustainability-welcome-to-the-age-of-regeneration/

143 Radjou, N. (2024) 'Regeneration: Why businesses are moving beyond sustainability and thinking about regrowth'. World Economic Forum. 6 June. www.weforum.org/stories/2024/06/businesses-are-moving-beyond-sustainability-welcome-to-the-age-of-regeneration/

144 Regenerative Living (n.d.) 'Practical skills to live on the planet as if we intend to stay'. www.regenerativeliving.online (retrieved 3 January 2025)

145 Mayo Clinic (n.d.) 'About regenerative medicine'. www.mayo.edu/research/centers-programs/center-regenerative-biotherapeutics/about/about-regenerative-medicine (retrieved 3 January 2025)

146 Regenerative Organic Alliance (n.d.) 'Why Regenerative Organic?'. https://regenorganic.org/why-regenerative-organic/ (retrieved 3 January 2025)

147 Regenerative Living (n.d.) 'Practical skills to live on the planet as if we intend to stay'. www.regenerativeliving.online (retrieved 3 January 2025)

148 Inversini, A. (2023) 'The rise of regenerative hospitality'. Journal of Tourism Futures, 10(1): 6-20. https://doi.org/10.1108/JTF-04-2023-0107

149 Whittaker, G.R., Peters, K. and van Opzeeland, I. (2024) 'Oceans sing, are you listening? Sounding out potentials for artistic audio engagements with science through the Polar Sounds project'. Marine Policy, 169. https://doi.org/10.1016/j.marpol.2024.106347

150 Starowicz, A. and Zielinski, M. (2024) 'Sustainable acoustics: The impact of AI on acoustics design and noise management'. Technical Sciences, 27: 193-209. https://doi.org/10.31648/ts.10297

151 Sharma, S., Sato, K. and Gautam, B.P. (2023) 'A Methodological Literature Review of Acoustic Wildlife Monitoring Using Artificial Intelligence Tools and Techniques'. Sustainability, 15(9). https://doi.org/10.3390/su15097128

152 Sharma, S., Sato, K. and Gautam, B.P. (2023) 'A Methodological Literature Review of Acoustic Wildlife Monitoring Using Artificial Intelligence Tools and Techniques'. Sustainability, 15(9). https://doi.org/10.3390/su15097128

153 Starowicz, A. and Zielinski, M. (2024) 'Sustainable acoustics: The impact of AI on acoustics design and noise management'. Technical Sciences, 27: 193-209. https://doi.org/10.31648/ts.10297

154 Starowicz, A. and Zielinski, M. (2024) 'Sustainable acoustics: The impact of AI on acoustics design and noise management'. Technical Sciences, 27: 193-209. https://doi.org/10.31648/ts.10297

155 Chui, M., Collins, M. and Patel, M. (2021) 'IoT value set to accelerate through 2030: Where and how to capture it'. McKinsey & Company. 9 November. www.mckinsey.com/capabilities/mckinsey-digital/our-insights/iot-value-set-to-accelerate-through-2030-where-and-how-to-capture-it

156 McKinsey & Company (2024) 'What is the Internet of Things (IoT)?'. 28 May. www.mckinsey.com/featured-insights/mckinsey-explainers/what-is-the-internet-of-things

157 World Ocean Initative (n.d.) 'Ocean Health'. https://impact.economist.com/ocean/ocean-health (retrieved 3 January 2025)

158 UNESCO (n.d.) 'United Nations Decade of Ocean Science for Sustainable Development (2021-2030): The science we need for the ocean we want'. www.unesco.org/en/decades/ocean-decade (retrieved 3 January 2025)

159 UNESCO (n.d.) 'United Nations Decade of Ocean Science for Sustainable Development (2021-2030): The science we need for the ocean we want'. www.unesco.org/en/decades/ocean-decade (retrieved 3 January 2025)

160 National Oceanography Centre (n.d.) 'Technology development'. https://noc.ac.uk/technology/technology-development (retrieved 3 January 2025).

161 Adam, N. et al. (2024) 'State-of-the-Art Security Schemes for the Internet of Underwater Things: A Holistic Survey'. IEEE Open Journal of the Communications Society, 5: 6561-6592. https://doi.org/10.1109/OJCOMS.2024.3474290

162 Adam, N. et al. (2024) 'State-of-the-Art Security Schemes for the Internet of Underwater Things: A Holistic Survey'. IEEE Open Journal of the Communications Society, 5: 6561-6592. https://doi.org/10.1109/OJCOMS.2024.3474290

163 International Data Cooperation (IDC) (2024) 'Worldwide Spending on Artificial Intelligence Forecast to Reach $632 Billion in 2028, According to a New IDC Spending Guide'. 19 August. www.idc.com/getdoc.jsp?containerId=prUS52530724

164 Tong, A., Wang, E. and Coulter, M. (2024) 'Exclusive: Reddit in AI content licensing deal with Google'. Reuters. 22 February. www.reuters.com/technology/reddit-ai-content-licensing-deal-with-google-sources-say-2024-02-22/

165 Duffy, C. (2024) 'Social media platforms are using what you create for artificial intelligence. Here's how to opt out'. CNN. 23 September. https://edition.cnn.com/2024/09/23/tech/social-media-ai-data-opt-out/index.html

166 Tong, A., Wang, E. and Coulter, M. (2024) 'Exclusive: Reddit in AI content licensing deal with Google'. Reuters. 22 February. www.reuters.com/technology/reddit-ai-content-licensing-deal-with-google-sources-say-2024-02-22/

167 Davis, W. (2024) 'LinkedIn is training AI models on your data'. The verge. 19 September. www.theverge.com/2024/9/18/24248471/linkedin-ai-training-user-accounts-data-opt-in

168 Ng, T. (2024) 'Adobe Says It Won't Train AI Using Artists' Work. Creatives Aren't Convinced'. Wired. 19 June. www.wired.com/story/adobe-says-it-wont-train-ai-using-artists-work-creatives-arent-convinced/

169 Bank for International Settlements (2024) 'Annual Economic Report'. 30 June. www.bis.org/publ/arpdf/ar2024e.pdf

170 Organisation for Economic Co-operation and Development (n.d.) 'Philanthropy'. www.oecd.org/en/topics/sub-issues/philanthropy.html (retrieved 15 January 2025)

171 Osili, U. et al. (2023) 'Global Philanthropy Tracker 2023'. The Indiana University Lilly Family School of Philanthropy. https://scholarworks.indianapolis.iu.edu/bitstreams/48715811-4c8a-4081-9baf-1ce66b21c9be/download

172 Organisation for Economic Co-operation and Development (n.d.) 'Philanthropy'. www.oecd.org/en/topics/sub-issues/philanthropy.html (retrieved 15 January 2025)

173 Osili, U. et al. (2023) 'Global Philanthropy Tracker 2023'. The Indiana University Lilly Family School of Philanthropy. https://scholarworks.indianapolis.iu.edu/bitstreams/48715811-4c8a-4081-9baf-1ce66b21c9be/download

174 Philanthropy Europe Association (2024) 'Obstacles to cross-border philanthropy are real and the time to remove them is now'. 23 May. https://philea.eu/obstacles-to-cross-border-philanthropy-are-real-and-the-time-to-remove-them-is-now/

175 World Intellectual Property Organization (WIPO) (n.d.) 'Artificial Intelligence and Intellectual Property'. www.wipo.int/about-ip/en/frontier_technologies/ai_and_ip.html (retrieved 6 January 2025)

176 World Intellectual Property Organization (WIPO) (n.d.) 'Artificial Intelligence and Intellectual Property'. www.wipo.int/about-ip/en/frontier_technologies/ai_and_ip.html (retrieved 6 January 2025)

177 UAE Centre for the Fourth Industrial Revolution (2024) 'Artificial Intelligence in Creative Industries: Guidelines for the Development, Regulation, and Use'. Dubai Future Foundation. October. www.dubaifuture.ae/wp-content/uploads/2024/10/AI-in-creative-industries-English.pdf

178 Banerjee, A. et al. (2024) 'From ripples to waves: The transformational power of tokenizing assets'. McKinsey & Company. 20 June. www.mckinsey.com/industries/financial-services/our-insights/from-ripples-to-waves-the-transformational-power-of-tokenizing-assets

179 Soukupová, J. (2024) 'Virtual Property, Digital Assets, Data, Digital Content and Others – an Analysis of the Fragmented Terminology'. Charles University in Prague Faculty of Law Research Paper No. 2024/I/2. http://dx.doi.org/10.2139/ssrn.4796480

180 Dej, S. and Waliczek, S. (2024) 'Digital Assets Regulation: Insights from Jurisdictional Approaches'. World Economic Forum. October. www3.weforum.org/docs/WEF_Digital_Assets_Regulation_2024.pdf

181 Financial Stability Board and the International Monetary Fund (2024) 'G20 Crypto-asset Policy Implementation Roadmap: Status report'. 22 October. www.fsb.org/uploads/P221024-3.pdf

182 The International Organization of Securities Commissions (2023) 'Policy Recommendations for Crypto and Digital Asset Markets: Final Report'. 16 November. www.iosco.org/library/pubdocs/pdf/IOSCOPD747.pdf

183 Lee, L. (2024) 'Examining the Legal Status of Digital Assets as Property: A Comparative Analysis of Jurisdictional Approaches'. Social Science Research Network. https://dx.doi.org/10.2139/ssrn.4807135

184 UNIDROIT (2023) 'UNIDROIT Principles On Digital Assets And Private Law'. www.unidroit.org/wp-content/uploads/2024/01/Principles-on-Digital-Assets-and-Private-Law-linked-1.pdf

185 Virtual Assets Regulatory Authority (VARA) (n.d.) 'Regulatory Framework'. https://rulebooks.vara.ae/ (retrieved 6 January 2025)

186 Abu Dhabi Global Market (ADGM) (n.d.) 'Digital Assets'. www.adgm.com/setting-up/digital-assets/overview (retrieved 6 January 2025)

187 Dubai International Financial Centre (DIFC) (2024) 'DIFC Announces Enactment of New Digital Assets Law, New Law of Security and Related Amendments to Select Legislation'. 13 March. www.difc.ae/whats-on/news/difc-announces-enactment-of-new-digital-assets-law---new-law-of-security-and-related-amendments

188 Sullivan, A. et al. (2024) 'Going Digital in the UK, US, and UAE: The Latest Digital Asset Developments'. Morgan Lewis. 12 September. www.morganlewis.com/pubs/2024/09/going-digital-in-the-uk-us-and-uae-the-latest-digital-asset-developments

189 Rao, A. and Verweiji, G. (2017) 'Sizing the prize: What's the real value of AI for your business and how can you capitalise?'. PwC. www.pwc.com/gx/en/issues/analytics/assets/pwc-ai-analysis-sizing-the-prize-report.pdf

190 Kahui, V. (2024) 'Granting legal 'personhood' to nature is a growing movement – can it stem biodiversity loss?'. The Conversation. 25 April. https://theconversation.com/granting-legal-personhood-to-nature-is-a-growing-movement-can-it-stem-biodiversity-loss-227336

191 Zaidan, E. and Ibrahim, I.A. (2024) 'AI Governance in a Complex and Rapidly Changing Regulatory Landscape: A Global Perspective'. Humanities and Social Sciences Communications, 11. https://doi.org/10.1057/s41599-024-03560-x

192 Kurki, V.A.J. (2019) '6 The Legal Personhood of Artificial Intelligences'. A theory of legal personhood, 175-190. https://doi.org/10.1093/oso/9780198844037.003.0007

193 Han, C. (2024) 'AI and Personhood: Where Do We Draw The Line?'. Duke Research blog. 5 November. https://researchblog.duke.edu/2024/11/05/ai-and-personhood-where-do-we-draw-the-line/

194 Zaidan, E. and Ibrahim, I.A. (2024) 'AI Governance in a Complex and Rapidly Changing Regulatory Landscape: A Global Perspective'. Humanities and Social Sciences Communications, 11. https://doi.org/10.1057/s41599-024-03560-x

195 Cavaciuti-Wishart, E. et al. (2024) 'Global Risks Report 2024: 19th Edition Insight Report'. World Economic Forum. January. www3.weforum.org/docs/WEF_The_Global_Risks_Report_2024.pdf

196 Cavaciuti-Wishart, E. et al. (2024) 'Global Risks Report 2024: 19th Edition Insight Report'. World Economic Forum. January. www3.weforum.org/docs/WEF_The_Global_Risks_Report_2024.pdf

197 McKinsey & Company (2020) 'McKinsey on Climate Change'. September. www.mckinsey.com/~/media/McKinsey/Business%20Functions/Sustainability/Our%20Insights/McKinsey%20on%20Climate%20Change/McKinsey-on-Climate%20Change-Report.pdf

198 McKinsey & Company (2020) 'McKinsey on Climate Change'. September. www.mckinsey.com/~/media/McKinsey/Business%20Functions/Sustainability/Our%20Insights/McKinsey%20on%20Climate%20Change/McKinsey-on-Climate%20Change-Report.pdf

199 Cavaciuti-Wishart, E. et al. (2024) 'Global Risks Report 2024: 19th Edition Insight Report'. World Economic Forum. January. www3.weforum.org/docs/WEF_The_Global_Risks_Report_2024.pdf

200 University of Twente (n.d.) 'Our courses'. www.utwente.nl/en/education/master/programmes/transdisciplinary-master-insert/courses/ (retrieved 6 January 2025)

201 Marr, B. (2023) 'A Short History Of The Metaverse'. Forbes. 9 December. www.forbes.com/sites/bernardmarr/2022/03/21/a-short-history-of-the-metaverse/

202 Vanian, J. and Levy, A (2023) 'Meta lost $13.7 billion on Reality Labs in 2022 as Zuckerberg's metaverse bet gets pricier'. CNBC. 1 February. www.cnbc.com/2023/02/01/meta-lost-13point7-billion-on-reality-labs-in-2022-after-metaverse-pivot.html

203 McArthur, V. and Teather, R.J. (2024) 'Why the metaverse isn't ready to be the future of work just yet'. The Conversation. 12 November. https://theconversation.com/why-the-metaverse-isnt-ready-to-be-the-future-of-work-just-yet-241882

204 Kumar, A. et al. (2024) 'Unveiling the dark and scary side of metaverse: an in-depth qualitative investigation'. Journal of Enterprise Information Management. https://doi.org/10.1108/JEIM-04-2024-0195

205 Ball, M. and Alaghband, M. (2022) 'The promise and peril of the metaverse'. McKinsey & Company. 29 March. www.mckinsey.com/capabilities/mckinsey-digital/our-insights/the-promise-and-peril-of-the-metaverse

206 Emirates News Agency-WAM (2022) 'Hamdan bin Mohammed launches Dubai Metaverse Strategy'. 18 July. www.wam.ae/en/details/1395303067141

207 Keane, J. (2022) 'South Korea is betting on the metaverse – and it could provide a blueprint for others'. CNBC. 30 May. www.cnbc.com/2022/05/30/south-koreas-investment-in-the-metaverse-could-provide-a-blueprint.html

208 World Economic Forum (n.d.) 'Defining and Building the Metaverse'. https://initiatives.weforum.org/defining-and-building-the-metaverse/home (retrieved 6 January 2025)

209 Mohamed Bin Zayed University of Artificial Intelligence (2023) 'The metaverse where reality is not only immersive but inferred'. 17 November. https://mbzuai.ac.ae/news/the-metaverse-where-reality-is-not-only-immersive-but-inferred/

210 Caglar, B. and Yao, H. (2024) 'Glasses half full? Three key trends shaping Augmented reality experiences in the US'. Ericsson. 5 September. www.ericsson.com/en/blog/2024/8/3-augmented-reality-trends-shaping-future-ar-us

211 Caglar, B. and Yao, H. (2024) 'Glasses half full? Three key trends shaping Augmented reality experiences in the US'. Ericsson. 5 September. www.ericsson.com/en/blog/2024/8/3-augmented-reality-trends-shaping-future-ar-us

212 Caglar, B. and Yao, H. (2024) 'Glasses half full? Three key trends shaping Augmented reality experiences in the US'. Ericsson. 5 September. www.ericsson.com/en/blog/2024/8/3-augmented-reality-trends-shaping-future-ar-us

213 Apple (2024) 'visionOS 2 brings new spatial computing experiences to Apple Vision Pro'. 10 June. www.apple.com/ae/newsroom/2024/06/visionos-2-brings-new-spatial-computing-experiences-to-apple-vision-pro/

214 Jansson, A. (2019) 'The mutual shaping of geomedia and gentrification: The case of alternative tourism apps'. Communication and the Public, 4(2). https://doi.org/10.1177/2057047319850197

215 Caglar, B. and Yao, H. (2024) 'Glasses half full? Three key trends shaping Augmented reality experiences in the US'. Ericsson. 5 September. www.ericsson.com/en/blog/2024/8/3-augmented-reality-trends-shaping-future-ar-us

216 International Data Corporation (IDC) (2024) 'IDC: Artificial Intelligence Will Contribute $19.9 Trillion to the Global Economy through 2030 and Drive 3.5% of Global GDP in 2030'. 17 September. www.idc.com/getdoc.jsp?containerId=prUS52600524

217 Institute of Electrical and Electronics Engineers (IEEE) (n.d.) 'The Role of Artificial Intelligence (AI) in the Metaverse'. https://metaversereality.ieee.org/publications/articles/the-role-of-artificial-intelligence-in-the-metaverse (retrieved 6 January 2025

218 Ivey, R. (2024) 'Is XR the unsung hero of the digital revolution?' World Economic Forum. 22 August. www.weforum.org/stories/2024/08/why-xr-is-key-to-unlocking-the-next-digital-revolution/

219 Grand View Research (n.d.) 'Movies And Entertainment Market Size, Share & Trends Analysis Report By Product (Movies, Music & Videos), By Region, And Segment Forecasts, 2024 – 2030'. www.grandviewresearch.com/industry-analysis/movies-entertainment-market (retrieved 6 January 2025)

220 Yuhui, T., Dawam, Z.A.M. and Zainal, S. (2024) 'Immersive Theatre: A Comprehensive Review and Future Direction'. Pakistan Journal of Life and Social Sciences, 22(2): 3767-3775. www.pjlss.edu.pk/pdf_files/2024_2/3767-3775.pdf

221 Mitsopoulou, E., Kyprianos, K. and Brattis, P. (2024) 'Documenting the ephemeral: An ontology for the performing arts'. Journal of Information Science. https://doi.org/10.1177/01655515241271052

222 Morgan, D. (2020) 'Performing arts online: Bringing theater to socially-distancing audiences'. CBS News. 30 March. www.cbsnews.com/news/coronavirus-performing-arts-online-bringing-theater-to-socially-distancing-audiences/

223 National Theatre at home (n.d.) 'National Theatre at home'. www.ntathome.com (retrieved 6 January 2024)

224 Thomas, S. (2020) 'National Theatre launch new global streaming service of shows'. London Theatre. 30 November. www.londontheatre.co.uk/theatre-news/news/national-theatre-launch-new-global-streaming-service-of-shows

225 Mannino, T. (2024) 'Performing arts sector faces change four years after pandemic start'. All Arts. 26 April. www.allarts.org/2024/04/new-york-city-performing-arts-pandemic/

226 Tripathi, R.L. (2024) 'Fragmented Selves: Identity, Consciousness and Reality in the Digital Age'. Open Access Journal of Data Science and Artificial Intelligence, 2(1). https://doi.org/10.23880/oajda-16000148

227 Treat, D. and Wallace, M. (2023) '3 urgent questions to ask as we navigate a new digital identity'. World Economic Forum. 28 September. www.weforum.org/stories/2023/09/3-urgent-questions-digital-identity/

228 Georgieva, I. (2011) 'The similarity between the virtual and the real self - how the virtual self can help the real self'. Studies in Health Technology and Informatics, 167(1): 20-5. www.researchgate.net/publication/51231098_The_similarity_between_the_virtual_and_the_real_self_-_how_the_virtual_self_can_help_the_real_self

229 Davis, T. (n.d.) 'Self-Concept: Definition, Examples, & Psychology Theories'. Berkeley Well-being Institute. www.berkeleywellbeing.com/self-concept.html (retrieved 6 January 2025)

230 Yang, S. et al. (2024) 'The Double-Edged Influence of Self-Expansion in the Metaverse: A Two-Wave Panel Assessment of Identity Perception, Self-Esteem, and Life Satisfaction'. Cyberpsychology, Behavior, and Social Networking, 27(1). https://doi.org/10.1089/cyber.2022.0400

231 Yang, S. et al. (2024) 'The Double-Edged Influence of Self-Expansion in the Metaverse: A Two-Wave Panel Assessment of Identity Perception, Self-Esteem, and Life Satisfaction'. Cyberpsychology, Behavior, and Social Networking, 27(1). https://doi.org/10.1089/cyber.2022.0400

232 Skandalis, A. (2020) 'Virtual reality has been boosted by coronavirus – here's how to avoid it leading us to dystopia'. The conversation. 23 June. https://theconversation.com/virtual-reality-has-been-boosted-by-coronavirus-heres-how-to-avoid-it-leading-us-to-dystopia-141073

233 Yee, L. et al. (2024) 'McKinsey Technology trends Outlook 2024'. McKinsey & Company. 16 July. www.mckinsey.com/capabilities/mckinsey-digital/our-insights/the-top-trends-in-tech#/

234 International Data Corporation (IDC) (2024) 'AR & VR Headsets Market Insights'. 18 December. www.idc.com/promo/arvr

235 Shakir, U. (2024) 'Apple reportedly cuts Vision Pro production due to low demand'. The verge. 23 April. www.theverge.com/2024/4/23/24138487/apple-vision-pro-cut-shipment-forecast-kuo-rumor

236 Yee, L. et al. (2024) 'McKinsey Technology trends Outlook 2024'. McKinsey & Company. 16 July. www.mckinsey.com/capabilities/mckinsey-digital/our-insights/the-top-trends-in-tech#/

237 Wen, X., Sotiriadis, M. and Shen, S. (2023) 'Determining the Key Drivers for the Acceptance and Usage of AR and VR in Cultural Heritage Monuments'. Sustainability, 15(5). https://doi.org/10.3390/su15054146

238 raser, S. and Böhm, S. (2024) 'A Systematic Literature Review on Technology Acceptance Research on Augmented Reality in the Field of Training and Education'. The Fifteenth International Conference on Advances in Human-oriented and Personalized Mechanisms, Technologies, and Services CENTRIC 2022. https://doi.org/10.48550/arXiv.2411.13946

239 Institute of Electrical and Electronics Engineers (IEEE) (n.d.) 'What is a robot?'. www.ieee-ras.org/images/Standards/meeting_june_2021/9-Robot-Term-Discussion.pdf (retrieved 6 January 2025)

240 International Federation of Robotics (IFR) (2024) 'World Robotics 2024'. September. https://ifr.org/img/worldrobotics/Press_Conference_2024.pdf

241 International Federation of Robotics (IFR) (2024) 'World Robotics 2024'. September. https://ifr.org/img/worldrobotics/Press_Conference_2024.pdf

242 Fortune Business Insights (2024) 'Humanoid Robot Market Size, Share & Industry Analysis, By Motion Type (Biped and Wheel Drive), By Component (Hardware and Software), By Application (Industrial, Household, and Services), and Regional Forecast, 2024-2032'. 16 December. www.fortunebusinessinsights.com/humanoid-robots-market-110188

243 Berruti, F., Lewandowski, D. and Tilley, J. (2024) 'The robot renaissance: How human-like machines are reshaping business'. McKinsey & Company. 22 March. www.mckinsey.com/capabilities/operations/our-insights/the-robot-renaissance-how-human-like-machines-are-reshaping-business#/

244 Agility Robotics (2023) 'Opening RoboFab: World's First Factory for Humanoid Robots'. 18 September. https://agilityrobotics.com/content/opening-robofab-worlds-first-factory-for-humanoid-robots

245 Knospler, J., Xue, W. and Trkov, M. (2024) 'Reconfigurable modular soft robots with modulating stiffness and versatile task capabilities'. Smart Materials and Structures, 33. https://doi.org/10.1088/1361-665X/ad4d35

246 Miao, W. and Bai, H. (2024) 'The new material science towards sustainable robotics'. Journal of Materials Chemistry C, 12(33). https://doi.org/10.1039/D4TC01868K

247 Berruti, F., Lewandowski, D. and Tilley, J. (2024) 'The robot renaissance: How human-like machines are reshaping business'. McKinsey & Company. 22 March. www.mckinsey.com/capabilities/operations/our-insights/the-robot-renaissance-how-human-like-machines-are-reshaping-business#/

248 DeepMind Robotics Team (2024) 'Our latest advances in robot dexterity'. Google DeepMind. 12 September. https://deepmind.google/discover/blog/advances-in-robot-dexterity/

249 Strategy& (2023) 'Above and below water drones market'. PwC. www.strategyand.pwc.com/it/en/assets/pdf/sea-drones-report.pdf

250 Ernest, N.S., González, J. and Arbery, M. (2022) 'Advanced air mobility: a disruptive force for incumbent transportation players'. Kearney. 1 July. www.kearney.com/industry/aerospace-defense/article/-/insights/advanced-air-mobility-a-disruptive-force-for-incumbent-transportation-players

251 EHang (2024) 'EH216-S Completes UAE's First Passenger-Carrying Demo Flight, Accompanied by Successful Demo Flights of EH216-L and EH216-F Pilotless eVTOLs in Abu Dhabi'. www.ehang.com/news/1083.html

252 Evans, T. (2024) 'Work starts on Dubai's first flying taxi station'. The National news. 12 November. www.thenationalnews.com/news/uae/2024/11/12/dubai-flying-taxis-vertiport/

253 Li, X. et al. (2024) 'Bionic Multi-Legged Robots with Flexible Bodies: Design, Motion, and Control'. Biomimetics, 9(10). https://doi.org/10.3390/biomimetics9100628

254 Yu, Z. et al. (2024) 'A Gecko-Inspired Robot Using Novel Variable-Stiffness Adhesive Paw Can Climb on Rough/Smooth Surfaces in Microgravity'. Advanced intelligent systems, 6(10). https://doi.org/10.1002/aisy.202400043

255 Zamanian, A.H. and Voltzow, J. (2024) 'Soft robots and soft bodies: biological insights into the structure and function of fluidic soft robots'. Bioinspiration and Biomimetics, 20. https://doi.org/10.1088/1748-3190/ad8b8d

256 Harvard Biodesign Lab (n.d.) 'Soft Robotics'. https://biodesign.seas.harvard.edu/soft-robotics (retrieved 6 January 2025)

257 Yee, L. et al. (2024) 'McKinsey Technology trends Outlook 2024'. McKinsey & Company. 16 July. www.mckinsey.com/capabilities/mckinsey-digital/our-insights/the-top-trends-in-tech

258 Yee, L. et al. (2024) 'McKinsey Technology trends Outlook 2024'. McKinsey & Company. 16 July. www.mckinsey.com/capabilities/mckinsey-digital/our-insights/the-top-trends-in-tech

259 Schäfer, A., Esterbauer, R. and Kubicek, B. (2024) 'Trusting robots: a relational trust definition based on human intentionality'. Humanities and Social Sciences Communications, 11. https://doi.org/10.1057/s41599-024-03897-3

260 Schäfer, A., Esterbauer, R. and Kubicek, B. (2024) 'Trusting robots: a relational trust definition based on human intentionality'. Humanities and Social Sciences Communications, 11. https://doi.org/10.1057/s41599-024-03897-3

261 Schäfer, A., Esterbauer, R. and Kubicek, B. (2024) 'Trusting robots: a relational trust definition based on human intentionality'. Humanities and Social Sciences Communications, 11. https://doi.org/10.1057/s41599-024-03897-3

262 Urhal, P. et al. (2019) 'Robot assisted additive manufacturing: A review'. Robotics and Computer-Integrated Manufacturing, 59: 335-345. https://doi.org/10.1016/j.rcim.2019.05.005

263 Linke, R. (2017) 'Additive manufacturing, explained'. MIT Sloan School of Management. 7 December. https://mitsloan.mit.edu/ideas-made-to-matter/additive-manufacturing-explained

264 Urhal, P. et al. (2019) 'Robot assisted additive manufacturing: A review'. Robotics and Computer-Integrated Manufacturing, 59: 335-345. https://doi.org/10.1016/j.rcim.2019.05.005

265 Additive Manufacturing (n.d.) 'What is additive manufacturing?'. www.additivemanufacturing.media/kc/what-is-additive-manufacturing/am-materials (retrieved 6 January 2025)

266 Zhou, K., Zhao, R.R. and Qi, H.J. (2024) 'Special Issue Editorial: Advanced Materials for Additive Manufacturing'. Advanced Materials, 36(34). https://doi.org/10.1002/adma.202410446

267 Alhijaily, A., Kilic, Z.M. and Bartolo, A.N.P. (2023) 'Teams of robots in additive manufacturing: a review'. Virtual and Physical Prototyping, 18(1). https://doi.org/10.1080/17452759.2022.2162929

268 Kharmanda, G. (2024) 'Identification of Uncertainty Cases in Robots with Focus on Additive Manufacturing Technology: A Mini Review'. Journal of Modern Industry and Manufacturing, 3(11). http://dx.doi.org/10.53964/jmim.2024011

269 Alhijaily, A., Kilic, Z.M. and Bartolo, A.N.P. (2022) 'Teams of robots in additive manufacturing: a review'. Virtual and Physical Prototyping, 18(1). https://doi.org/10.1080/17452759.2022.2162929

270 Alhijaily, A., Kilic, Z.M. and Bartolo, A.N.P. (2022) 'Teams of robots in additive manufacturing: a review'. Virtual and Physical Prototyping, 18(1). https://doi.org/10.1080/17452759.2022.2162929

271 Shukla, A. (2024) 'Performance Metrics for Collaborative Robots: A Literature Review'. engrXiv Engineering Archive. https://doi.org/10.31224/39649

272 Bandura, R. and McLean, M. (2024) 'Leveraging Digital Technologies to Advance Women's Economic Empowerment'. Center for Strategic and International Studies. 27 August. www.csis.org/analysis/leveraging-digital-technologies-advance-womens-economic-empowerment

273 Bandura, R. and McLean, M. (2024) 'Leveraging Digital Technologies to Advance Women's Economic Empowerment'. Center for Strategic and International Studies. 27 August. www.csis.org/analysis/leveraging-digital-technologies-advance-womens-economic-empowerment

274 Bandura, R. and McLean, M. (2024) 'Leveraging Digital Technologies to Advance Women's Economic Empowerment'. Center for Strategic and International Studies. 27 August. www.csis.org/analysis/leveraging-digital-technologies-advance-womens-economic-empowerment

275 Women in AI (n.d.) 'Changing the role of women in AI'. https://womeninai.nl (retrieved 6 January 2025)

276 Abdulla Al Ghurair Foundation (n.d.) 'Nomu Al Ghurair: Women in AI'. www.alghurairfoundation.org/program/women-in-ai/ (retrieved 6 January 2025)/

277 Gartner (2024) 'Gartner Survey Reveals 85% of Customer Service Leaders Will Explore or Pilot Customer-Facing Conversational GenAI in 2025'. 9 December. www.gartner.com/en/newsroom/press-releases/2024-12-09-gartner-survey-reveals-85-percent-of-customer-service-leaders-will-explore-or-pilot-customer-facing-conversational-genai-in-2025

278 Forrester (2024) 'Forrester's 2024 US Customer Experience Index: Brands' CX Quality Is At An All-Time Low'. 17 June. www.forrester.com/press-newsroom/forrester-2024-us-customer-experience-index/

279 Hyken, S. (2020) 'Ninety-Six Percent Of Customers Will Leave You For Bad Customer Service'. Forbes. 12 July. www.forbes.com/sites/shephyken/2020/07/12/ninety-six-percent-of-customers-will-leave-you-for-bad-customer-service/?sh=108a6d4a30f8

280 Forrester (n.d.) 'Forrester Decisions for Customer Experience'. www.forrester.com/research/customer-experience/ (retrieved 6 January 2025)

281 Curtis, M. et al. (2023) 'Accenture Life Trends 2024'. Accenture. www.accenture.com/content/dam/accenture/final/accenture-com/document-2/Accenture-Life-Trends-2024-Report.pdf

282 Leachman, L. and Scheibenreif, D. (2023) 'Using Technology to Create a Better Customer Experience'. Harvard Business Review. 17 March. https://hbr.org/2023/03/using-technology-to-create-a-better-customer-experience

283 United Nations (2024) 'Governing AI for Humanity: Final Report'. September. www.un.org/sites/un2.un.org/files/governing_ai_for_humanity_final_report_en.pdf

284 United Nations (2024) 'Governing AI for Humanity: Final Report'. September. www.un.org/sites/un2.un.org/files/governing_ai_for_humanity_final_report_en.pdf

285 Larsen, B. and Dignum, V. (2024) 'AI value alignment: How we can align artificial intelligence with human values'. World Economic Forum. 17 October. www.weforum.org/stories/2024/10/ai-value-alignment-how-we-can-align-artificial-intelligence-with-human-values/

286 United Nations (2024) 'Creative Economy Outlook 2024'. July. https://unctad.org/system/files/official-document/ditctsce2024d2_en.pdf

287 United Nations (2024) 'How digitalization is transforming the creative economy'. 11 July. https://unctad.org/news/how-digitalization-transforming-creative-economy

288 International Finance Corporation (IFC) (n.d.) 'Creative Industries'. www.ifc.org/en/what-we-do/sector-expertise/creative-industries (retrieved 6 January 2025)

289 International Finance Corporation (IFC) (n.d.) 'Creative Industries'. www.ifc.org/en/what-we-do/sector-expertise/creative-industries (retrieved 6 January 2025)

290 Global Leaders Institute for Arts Innovation (2024) 'Impact Investing for the Creative Economy: Purpose with profit'. www.globalleadersinstitute.org/blog-post/impact-investing-for-the-creative-economy-placing-purpose-alongside-profit/ (retrieved 6 January 2025)

291 Holley, T. (2024) 'By prioritising STEM over SHAPE in schools we poorly prepare students for a complex future'. LSE. 5 February. https://blogs.lse.ac.uk/impactofsocialsciences/2024/02/05/by-prioritising-stem-over-shape-in-schools-we-poorly-prepare-students-for-a-complex-future/

292 Shotwell, M. (2023) 'How Art Makes Us More Human: Why Being Creative is So Important in Life'. Cultivate Arts and Education. 6 March. www.cultivategrandrapids.org/post/how-art-makes-us-more-human-why-being-creative-is-so-important-in-life

293 Carr, D. (2024) 'Art and Life'. The journal of Aesthetic Education, 58(3): 1-19. https://muse.jhu.edu/article/935891

294 Kaimal, G. (2020) 'Nonverbal therapy helps people work through trauma and build resilience'. American Scientist, 108(4). www.americanscientist.org/article/how-art-can-heal

295 World Justice Project (2019) 'Global Insights on Access to Justice: Findings from the World Justice Project General Population Poll in 101 Countries'. https://worldjusticeproject.org/sites/default/files/documents/WJP-A2J-2019.pdf

296 Legal Services Corporation (2022) 'The Justice Gap: The Unmet Civil Legal Needs of Low-income Americans'. https://justicegap.lsc.gov/the-report/

297 Tan, J. et al. (2024) 'Robots in the Middle: Evaluating LLMs in Dispute Resolution'. arXiv. https://doi.org/10.48550/arXiv.2410.07053

298 Tan, J. et al. (2024) 'Robots in the Middle: Evaluating LLMs in Dispute Resolution'. arXiv. https://doi.org/10.48550/arXiv.2410.07053

299 Hörnle, J. (2009) 'Cross-border Internet Dispute Resolution'. https://assets.cambridge.org/97805218/96207/frontmatter/9780521896207_frontmatter.pdf

300 Suffolk University (2024) 'American Arbitration Association and Suffolk Law Launch Online Dispute Resolution Innovation Clinic'. 17 July. www.suffolk.edu/news-features/news/2024/07/18/22/06/aaa-suffolk-law-online-dispute-resolution-clinic

301 Civil Resolution Tribunal (n.d.) 'Civil Resolution Tribunal'. https://civilresolutionbc.ca (retrieved 6 January 2025)

302 Conflict Analytics (n.d.) 'All Rise, the AI Court is Now In Session: A new lab uses artificial intelligence to help individuals and businesses resolve their legal disputes'. Queen's University. https://conflictanalytics.queenslaw.ca/news/all-rise-the-ai-court-is-now-in-session

303 Basher, F. et al. (2024) 'Impact of job meaningfulness on employee retention: Antecedent and outcome of person-organization fit and person job fit'. Journal of Infrastructure, Policy and Development, 8(11). https://doi.org/10.24294/jipd.v8i11.7326

304 Oliver Wyman Forum (n.d.), 'What Business Needs To Know About The Generation Changing Everything'. Online. 6 Nov. www.oliverwymanforum.com/global-consumer-sentiment/a-gen-z.html

305 Ayoobzadeh, M. et al. (2024) 'A tale of two generations: a time-lag study of career expectations'. Personnel Review, 53(7): 1649-1665. https://doi.org/10.1108/PR-02-2022-0101

306 Holum, M. et al. (2024) 'Career preferences of business students in Norway and Poland: Factors explaining the choice between public and private sector'. The International Journal of Management Education, 22(3). https://doi.org/10.1016/j.ijme.2024.100997

307 Hale, J. (2024) 'When an Employee Thinks They're Awesome, but You Don't'. Crucial Learning. 8 May. https://cruciallearning.com/blog/when-an-employee-thinks-theyre-awesome-but-you-dont/

308 Sepah, C. (2017) 'Your Company Culture is Who You Hire, Fire, and Promote: Use the Performance-Values Matrix to build an Outstanding Culture'. Medium. 3 March. https://medium.com/s/company-culture/your-companys-culture-is-who-you-hire-fire-and-promote-c69f84902983

309 Giddis, C. (2024) 'Company culture is who you hire, fire, and promote'. Medium. 23 January. https://medium.com/the-daily-bugle/company-culture-is-who-you-hire-fire-and-promote-837d8e15cab1

310 Hong, D.J. (2024) 'Are We Attractive to You? A Study on Metaverse Recruitment and Organisational Attractiveness'. HAL open archive server. https://ideas.repec.org/p/hal/journl/hal-04589098.html

311 Tholen, G. (2023) 'Matching Candidates to Culture: How Assessments of Organisational Fit Shape the Hiring Process'. Work, Employment and Society, 38(3): 705-722. https://doi.org/10.1177/09500170231155294

312 Tholen, G. (2023) 'Matching Candidates to Culture: How Assessments of Organisational Fit Shape the Hiring Process'. Work, Employment and Society, 38(3): 705-722. https://doi.org/10.1177/09500170231155294

313 World Bank (2024) 'Health and Climate Change'. 16 November. www.worldbank.org/en/topic/health/brief/health-and-climate-change

314 Romanello, M. et al. (2024) 'The 2024 report of the Lancet Countdown on health and climate change: facing record-breaking threats from delayed action'. The Lancet, 404(10465): 1847-1896. www.thelancet.com/journals/lancet/article/PIIS0140-6736(24)01822-1/abstract?rss=yes

315 University College London (2024) 'Health threats of climate change reach record-breaking levels'. 30 October. www.ucl.ac.uk/news/2024/oct/health-threats-climate-change-reach-record-breaking-levels

316 Hameed, W. et al. (2022) 'Health system bottlenecks hindering provision of supportive and dignified maternity care in public health facilities'. PLOS global public health, 2(7). https://doi.org/10.1371/journal.pgph.0000550

317 Wager, E. and Cox, C. (2024) 'International Comparison of Health Systems'. KFF. 30 October. www.kff.org/health-policy-101-international-comparison-of-health-systems/

318 Linder, G. and Woitok, B.K. (2020) 'Emergency department overcrowding: Analysis and strategies to manage an international phenomenon'. Wiener klinische Wochenschrift, 133: 229-233. https://doi.org/10.1007/s00508-019-01596-7

319 Organisation for Economic Co-operation and Development (2020) 'Waiting Times for Health Services: Next in line'. OECD Health Policy Studies. 28 May. www.oecd.org/en/publications/waiting-times-for-health-services_242e3c8c-en/full-report/component-2.html#exec-summ-d1e61

320 Linder, G. and Woitok, B.K. (2020) 'Emergency department overcrowding: Analysis and strategies to manage an international phenomenon'. Wiener klinische Wochenschrift, 133: 229-233. https://doi.org/10.1007/s00508-019-01596-7

321 Cosio, D. and Deyman, A. (2024) 'Is Your Practice Suffering from Mental Health Care Gridlock?'. MedCentral. 10 June. www.medcentral.com/behavioral-mental/is-your-practice-suffering-from-mental-health-care-gridlock

322 Organisation for Economic Co-operation and Development and Food and Agricultural Organization of the United Nations (2024) 'OECD-FAO Agricultural Outlook 2024-2033'. 2 July. www.google.com/search?client=safari&rls=en&q=opECD-FAO+Agricultural+Outlook+2024-2033&ie=UTF-8&oe=UTF-8

323 Organisation for Economic Co-operation and Development and Food and Agricultural Organization of the United Nations (2024) 'OECD-FAO Agricultural Outlook 2024-2033'. 2 July. https://doi.org/10.1787/4c5d2cfb-en

324 Brown, A. (2024) 'Move to protect Australian beef industry from EU land clearing laws criticised by scientists'. The Guardian. 10 May. www.theguardian.com/australia-news/article/2024/may/10/move-to-protect-australian-beef-industry-from-eu-land-clearing-laws-criticised-by-scientists

325 Devitt, J. (2024) 'Small Reductions to Meat Production in Wealthier Countries May Help Fight Climate Change, New Analysis Concludes'. New York University. 4 November. www.nyu.edu/about/news-publications/news/2024/november/small-reductions-to-meat-production-in-wealthier-countries-may-h.html

326 Organisation for Economic Co-operation and Development and Food and Agricultural Organization of the United Nations (2021) 'OECD FAO Agricultural Outlook 2021 2030'. https://doi.org/10.1787/19428846-en

327 Klibaner-Schiff, E. et al. (2024) 'Environmental exposures influence multigenerational epigenetic transmission'. Clinical Epigenetics, 16. https://doi.org/10.1186/s13148-024-01762-3 3

328 Gavito-Covarrubias, D. et al. (2024) 'Epigenetic mechanisms of particulate matter exposure: air pollution and hazards on human health'. Frontiers in Genetics, 14. https://doi.org/10.3389/fgene.2023.1306600

329 Grand View Research (n.d.) 'Epigenetics Market Size, Share & Trends Analysis Report By Product (Reagents, Kits, Instruments), By Technology (DNA Methylation), By Application (Oncology), By End-use, By Region, And Segment Forecasts, 2024 – 2030'. www.grandviewresearch.com/industry-analysis/epigenetics-market# (retrieved 7 January 2025)

330 Feehley, T. et al. (2023) 'Drugging the epigenome in the age of precision medicine'. Clinical Epigenetics, 15. https://doi.org/10.1186/s13148-022-01419-z

331 Muharremi, G., Meçani, R. and Muka, T. (2023) 'The Buzz Surrounding Precision Medicine: The Imperative of Incorporating It into Evidence-Based Medical Practice'. Journal of Personalized Medicine, 14(1). https://doi.org/10.3390/jpm14010053

332 Personalized Medicine Coalition (2024) 'Personalized medicine at FDA: The scope & significance of progress in 2023'. www.personalizedmedicinecoalition.org/wp-content/uploads/2024/02/report-3.pdf

333 Horber, V. et al. (2021) 'The Role of Neuroimaging and Genetic Analysis in the Diagnosis of Children With Cerebral Palsy'. Frontiers in Neurology, 11. https://doi.org/10.3389/fneur.2020.628075

334 Nisar, S. and Haris, M. (2023) 'Neuroimaging genetics approaches to identify new biomarkers for the early diagnosis of autism spectrum disorder'. Molecular Psychiatry, 28: 4995-5008. https://doi.org/10.1038/s41380-023-02060-9

335 Peebles, I.S., Kinney, D.B. and Foster-Hanson, E. (2024) 'Systematic decision frameworks for the socially responsible use of precision medicine'. npj genomic medicine, 9. https://doi.org/10.1038/s41525-024-00433-9

336 World Health Organization (2024) 'Epilepsy'. 7 February. www.who.int/news-room/fact-sheets/detail/epilepsy

337 World Health Organization (2024) 'Epilepsy'. 7 February. www.who.int/news-room/fact-sheets/detail/epilepsy

338 Genome Wide Association Studies (GWAS) Diversity Monitor (2025) 'Total GWAS participants diversity'. 7 January. www.gwasdiversitymonitor.com

339 Gordon, T.M. (2024) 'Precision Medicine Has a Data Equity Problem'. Nonprofit Quarterly. 21 January. https://nonprofitquarterly.org/precision-medicine-has-a-data-equity-problem/

340 Columbia University Department of Psychiatry (2022) 'Cultural Barriers to Genetic Testing: To make tests clinically useful for non-European groups, we must focus on efforts to take their concerns into account'. 7 June. www.columbiapsychiatry.org/news/cultural-barriers-genetic-testing

341 Baynam, G., Gomez, R. and Jain, R. (2024) 'Stigma associated with genetic testing for rare diseases—causes and recommendations'. Frontiers in Genetics, 15. https://doi.org/10.3389/fgene.2024.1335768

342 Munung, N.S. et al. (2024) 'Perceptions and preferences for genetic testing for sickle cell disease or trait: a qualitative study in Cameroon, Ghana and Tanzania'. European Journal of Human Genetics, 32: 1307-1313. https://doi.org/10.1038/s41431-024-01553-7

343 Energy Information Administration (EIA) (2024) 'Biomass explained'. 30 July. www.eia.gov/energyexplained/biomass/

344 International Energy Agency (n.d.) 'Bioenergy'. www.iea.org/energy-system/renewables/bioenergy (retrieved 7 January 2025)

345 Rousseau, N. (2024) 'The Remarkable Growth of the Global Biochar Market: A Beacon of Environmental Progress'. Earth.Org. 4 April. https://earth.org/the-remarkable-growth-of-the-global-biochar-market/

346 Sanchez-Monedero, M.A. et al. (2018) 'Role of biochar as an additive in organic waste composting'. Bioresources Technology, 247: 1155-1164. https://doi.org/10.1016/j.biortech.2017.09.193

347 Li, R. et al. (2023) 'Porous Biochar Materials for Sustainable Water Treatment: Synthesis, Modification, and Application'. Water, 15(3). https://doi.org/10.3390/w150303955

348 Moya, B. (2023) 'Biochar is carbon removal's jack of all trades. Here's why'. World Economic Forum. 23 November. www.weforum.org/stories/2023/11/biochar-carbon-removals-jack-of-all-trades-for-immediate-climate-action/

349 Pandian, K. et al. (2024) 'Biochar – a sustainable soil conditioner for improving soil health, crop production and environment under changing climate: a review'. Frontiers in Soil Science, 4. https://doi.org/10.3389/fsoil.2024.1376159

350 Patro, A. et al. (2024) 'Recent approaches and advancement in biochar-based environmental sustainability: Is biochar fulfilling the sustainable development goals?'. iScience, 27(9). https://doi.org/10.1016/j.isci.2024.110812

351 Pandian, K. et al. (2024) 'Biochar – a sustainable soil conditioner for improving soil health, crop production and environment under changing climate: a review'. Frontiers in Soil Science, 4. https://doi.org/10.3389/fsoil.2024.1376159

352 Yadav, S.P.S. et al. (2023) 'Biochar application: A sustainable approach to improve soil health'. Journal of Agriculture and food Research, 11. https://doi.org/10.1016/j.jafr.2023.100498

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