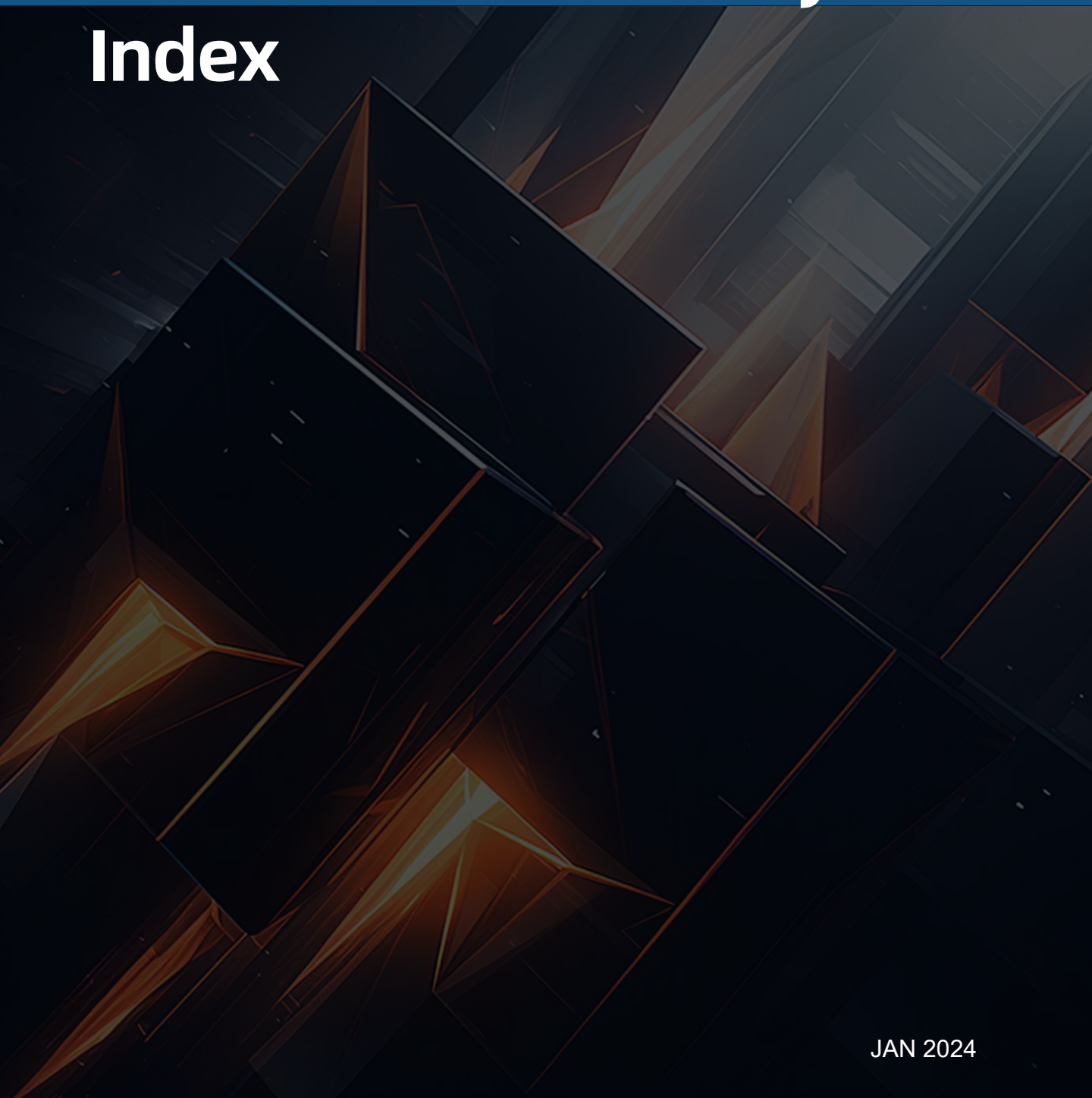
ICV TA&K
Technology Advisory
& Knowledgebase

2023

Global Future Industry Index



JAN 2024

PREFACE

The Global Future Industry Index (GFII) is a research initiative crafted by ICV TA&K, bolstered by support from esteemed organizations such as WIPO, OECD, and IRENA. This study, underpinned by rigorous secondary research, data collation from diverse institutions, and interviews with domain experts in biotechnology, green energy, and advanced information technologies, seeks to comprehensively assess the capabilities of over 20 countries and regions across future industry layout, development, innovation investment, and environmental sustainability.

Future industries, in this context, are defined as forward-looking and strategically significant sectors involving technology, innovation, and societal advancement. These industries encompass emerging technologies, inventive business models, and sectors with profound impacts on society, the economy, and the environment. Our research focuses on key domains such as artificial intelligence, biotechnology, green energy, humanoid robotics, high-performance computing, quantum information, neuroscience and neuromorphic intelligence, and advanced communications. The development of these fields significantly shapes industrial structures, employment dynamics, and global competitiveness.

Through the deployment of this index, our objective is to furnish invaluable insights to global decision-makers, business leaders, and investors concerning the performance and developmental trajectories of nations in the realm of future industries. We express our gratitude for the adept composition by the ICV TA&K team and acknowledge the pivotal role played by all experts involved in this research, contributing their time, insights, and specialized knowledge to the formulation of this index.

Research Team

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Acknowledgement

We are grateful to the institutions who offered us support, including but not limited to:

Special thanks to the organizations for their collaborations:

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Executive summary

Future industries emerge after major technological innovations, disrupting existing markets, shaping new demands, influencing policy-making, and redefining economic and social structures. When compared to strategic new industries, it more accurately represents the fresh direction of future technological and industrial advancement, and it assumes a pivotal, supporting, and leading role in economic and social transformations. In recent years, the future industry has become a new competitive frontier for major nations worldwide, and countries are actively charting their future industrial development.

1

2023 GFII Ranking Update:
The United States and China remain in the top two, with fluctuating rankings in multiple countries and the release of field champions.

Compared to the 2022 rankings, the overall rankings of the United States and China remain unchanged, remaining in the top two. The rankings of the United Kingdom, South Korea, Germany, and the Netherlands have all increased, while Switzerland, Japan, and Singapore have declined to some extent. Among them, the United States maintains a leading position in multiple fields, China ranks first in talent and education, Sweden ranks first in sustainability and environment, and Switzerland ranks first in international cooperation and trend adaptability.

2

2023 City Comprehensive Ranking:
Leading Cities in the Global Science and Technology Innovation Pattern and Diversified Competition.

The comprehensive ranking of cities reflects the comprehensive strength of future industries. In 2023, San Francisco remained at the top of the list, leading in fields such as AI. However, quantum information and deep space and deep sea need to be strengthened. London jumped to second place, standing out in neuroscience and neuromorphic intelligence and deep space and deep sea. Beijing, Munich, Boston, and other cities have strong technological innovation capabilities. The United States has the most cities on the list, followed closely by China. Each city has advantages in different fields, demonstrating the diversity of global innovation patterns.

3

2023 Technology Twin Stars Shine:
Breakthrough Progress in AI Large Models and Quantum Information.

As a hot topic in the technology industry in 2023, the AI industry and language models have achieved remarkable results. Open AI, Google, Microsoft, and other companies have successively launched their own large model products, promoting the establishment of the AI ecosystem and multimodal innovation. The quantum information industry also made breakthrough progress in 2023.

01
Executive summary

Superconducting quantum bit technology and quantum superfusion have become the technological trends in quantum computing. Quantum communication protocols and technologies, as well as quantum key distribution technology, have also been widely applied and promoted, providing more possibilities for the future development of quantum communication.

4

New Technology Trends in 2023: Accelerated Commercialization of Humanoid Robots and R&D Rush for Controllable Nuclear Fusion.

Since 2023, the popularity of the humanoid robots industry has continued to rise. With the continuous evolution of Tesla Optimus, it marks a breakthrough in a series of core technologies of humanoid robots, providing more possibilities for its commercialization. In terms of Controlled nuclear fusion, with its advantages of large energy release and sufficient raw material reserves, it is expected to become the optimal solution for nuclear energy. Governments and enterprises around the world have increased their investment in developing controllable nuclear fusion energy projects, constructing fusion energy test reactors, and promoting the research and commercialization of controllable nuclear fusion technology.

02

Introduction:Tech Evolution, Global Impact

02
Introduction:Tech Evolution, Global Impact

How do we define the future industry of 2023?

This report selects eight future industries based on the 2023 technology hotspots, comprehensive considerations of industrial technological innovation and trends, market demand and trends, sustainability, and environmental protection, government policies and regulations, social and cultural changes, and more. The selected industries are quantum information, deep space and deep sea, AI, controllable nuclear fusion, humanoid robots, neuroscience and neuromorphic intelligence, advanced connectivity, and biotechnology.

The future industries can be divided into two categories: one comprises advanced industries that are already present and will remain integral to various industrial economies in the long term, such as AI, advanced connectivity, and biotechnology. The other category consists of industries that are expected to grow into advanced industries within the next 10 to 15 years, including quantum information, deep space and deep sea, controlled nuclear fusion, humanoid robots, and neuroscience and neuromorphic intelligence.

Compared to the future industries released in 2022, this report has added AI, deep space and deep sea, controllable nuclear fusion, and neuroscience and neuromorphic intelligence, and removed the metaverse industry. The main reason for the adjustment is that in 2023, the concept of the metaverse has become less hyped, and companies such as Tencent, Microsoft, Meta, and ByteDance have announced adjustments to their metaverse-related businesses. Additionally, it is crucial to further improve the infrastructure for building networks and high-performance computing power. Whether it's broadband and computing power at the hardware level or AI, they are all frameworks for building the future metaverse, which may be the most essential aspect of the market.

02
Introduction:Tech Evolution, Global Impact

Methodology: The Global Future Industry Index in 2023

It's the second annual comparative ranking that provides dynamic updates and tracking of various sectors within the future industries each year. It comprehensively compares the layout and development of future industries, innovation investments, and environmental sustainability capabilities among over 20 countries and regions globally, collectively representing approximately 75% of the global GDP.

The index was developed through in-depth primary and secondary research processes. Secondary research involves continuous review of several hundred articles, research reports released by NGOs such as UNIDO & WIPO, government policy documents, and ongoing examination of scientific literature. Primary research includes nearly 30 in-depth interviews with experts from various fields globally, including quantum scientists, biological scientists, and professionals in various scientific and research domains, technology experts, government policymakers, non-governmental organization activists, as well as technology entrepreneurs and venture capitalists in various sectors of the future industries.

This research process informed an evaluation and selection of distinct sets of country-level data to become the indicators of the Future Industry Index; the 2023 edition now comprises 15 such indicators. The indicator datasets were turned into ranked scores in one of two ways. For quantitative metrics, such as growth rates or values, each data point for each country was scaled up or down using minimum-maximum normalization to develop a range of scores across all countries for that indicator. For data that was largely qualitative or nonstandard, a ranking categorization system was developed, and each country was assigned a score.

Once all 15 indicators were scored, they were organized into separate pillars.The data came from a wide range of latest publicly available sources. These include the International Monetary Fund (IMF), the International Renewable Energy Agency (IRENA), the Organization for Economic Co-operation and Development (OECD), the World Bank, the United Nations Food and Agriculture Association (FAO), the World Intellectual Property Organization (WIPO), and the National Institute of Standards and Technology (NIST),The International Federation of Robotics (IFR) etc. In some cases, ICV TA&K researchers expanded and refined existing datasets, conducting additional cross-comparative country-level research to fill in data gaps, or to create rankings out of nonstandard data.

This was done specifically for several indicators in the future industry policy pillar, including the Policy Pivot, and in a new indicator added to this year's index.

As in past editions, the structure of GFII 2023 is made up of five pillars:

Pillar 1

Innovation Ecosystem and Technological Capability - This pillar measures the overall environment and proficiency of a region or entity in fostering innovation within its ecosystem and its technological capabilities.

The indicators within this pillar include the following:

• R&D and Technology Investment: Evaluate the level of investment in research and technological innovation by countries or cities, including both government and corporate
R&D expenditures.

• Attraction and Cultivation of Tech Talent: Examine the ability to attract and cultivate high-level tech talent, including talent strategies employed by research institutions and businesses.

• Start-up Activity: Measure the number of start-ups, investment activities, and the presence and development of incubators, reflecting the vibrancy of the innovation ecosystem.

• Development of Innovation Ecosystem: Assess the construction and operation of technology parks, research centers, and technology innovation incubators to support innovative development.

• Construction of Digital Infrastructure: Evaluate investments in digital technologies such as 5G and the Internet of Things (IoT) by cities or countries to support the digital economy and technological applications.

Pillar 2

Industry Diversity and Emerging Industries: - This pillar assesses the diversity of industries within a region or entity and its readiness to embrace emerging sectors.

The indicators within this pillar include the following:

• Potential for Development in Emerging Industries: Assess the potential and innovation capabilities of future industries, including areas such as artificial intelligence, biotechnology, and new energy.

• Capability in Building Industrial Ecosystems: Evaluate the ability and level of countries or city clusters in building ecosystems for future industries.

• Industry Diversity: Evaluate the diversity of industrial structures in cities or countries, avoiding excessive reliance on a specific industry.

Pillar 3

Sustainability and Environment - This pillar measures the commitment and efforts of a region or entity in promoting sustainability and environmental conservation.

The indicators measure the following:

• Utilization of Renewable Energy: Examine progress in the utilization of renewable energy (solar, wind, etc.) by cities or countries.

• Environmental Policies and Ecological Protection: Evaluate government-issued environmental policies and ecological protection measures to ensure sustainable development.

Pillar 4

Talent and Education - This pillar measures the quality of human resources and educational initiatives within a region or entity.

The indicators measure the following:

• Cultivation of High-Tech Talent: Evaluate the quality and quantity of higher education institutions and tech training to ensure an adequate supply of high-quality talent.

• Innovative Education and Vocational Training: Examine innovative education and vocational training programs that match industry needs, enhancing the innovation and practical application skills of talents.

Pillar 5

International Collaboration and Adaptability to Trends - This pillar measures the extent to which a region or entity engages in global collaboration and adapts to emerging trends. This involves an analysis of partnerships, collaborations, and interactions with other nations or entities on an international scale.

The indicators measure the following:

• International Innovation Collaboration: Measure the level of innovation collaboration with other countries or cities, including research collaboration and technology exchange.

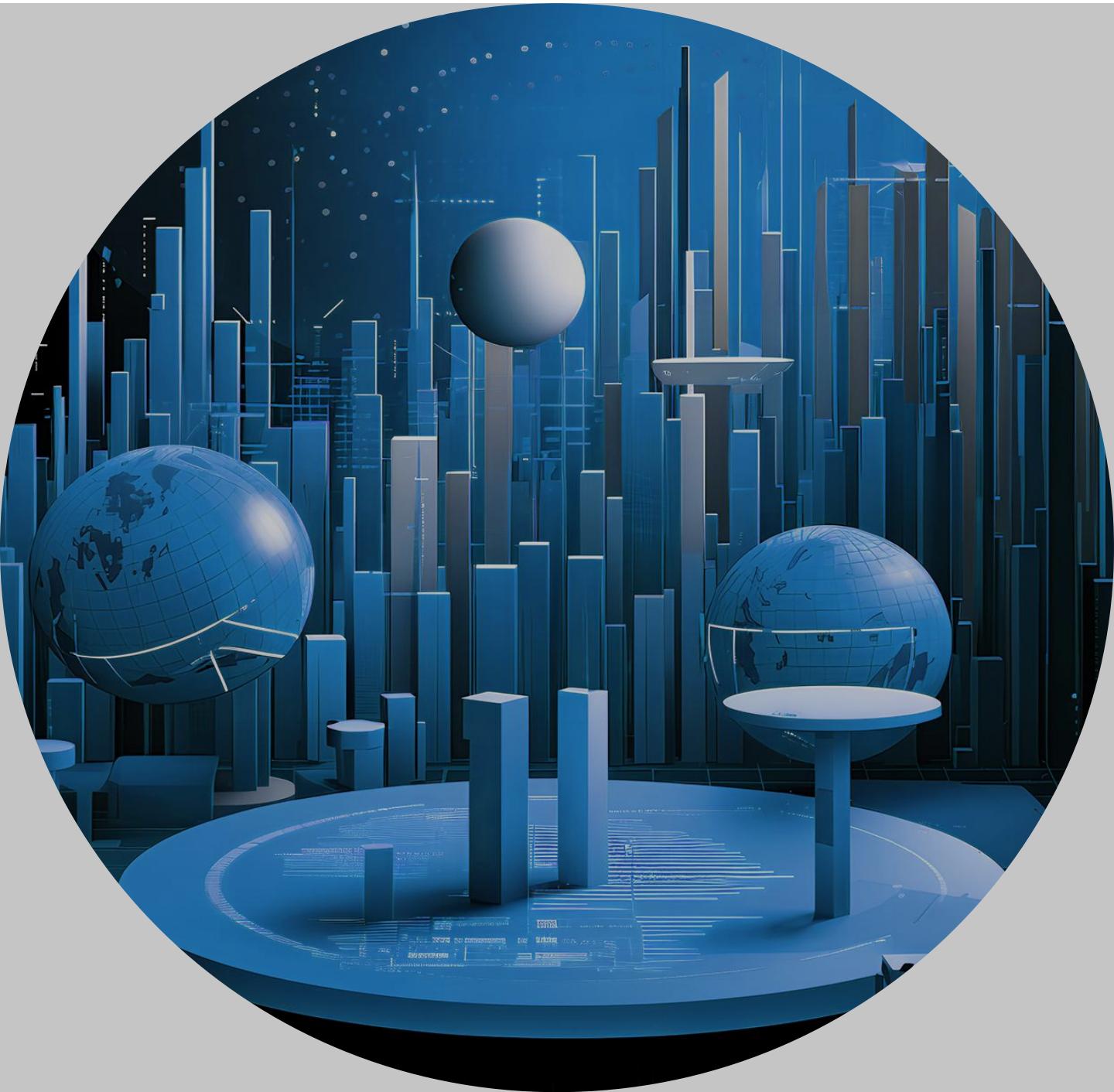
• Participation in International Industry Chains: Evaluate the degree of participation in international industry chains and global value chains to expand markets and strengthen international competitiveness.

• Adaptability to Future Industry Policies and Trends: Examine whether relevant policies contribute to adapting to future industry trends, including digital transformation and smart manufacturing.

03

Global Future Industries Assessment 2023:

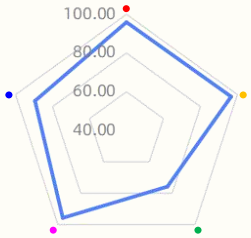
National Perspectives Ranking



Country	Overall				Innovation Ecosystem and Technological Capability		Industry Diversity and Emerging Industries		Sustainability and Environment		Talent and Education		International Collaboration and Adaptability to Trends	
	2023		2022	Score	Rank	Score	Rank	Score	Rank	Score	Rank	Score	Rank	Score
United States	1	—	1	91.71	1	95.91	1	96.62	15	75.79	2	95.73	3	89.50
China	2	—	2	88.55	8	84.60	2	96.44	14	76.15	1	97.15	6	86.29
United Kingdom	3	↑	5	88.54	3	88.07	3	87.54	5	87.18	3	94.30	7	85.40
South Korea	4	↑	8	87.44	2	89.05	7	85.58	3	93.59	6	88.79	12	81.31
Germany	5	↑	6	86.97	7	86.03	4	86.83	7	84.34	7	87.54	2	89.68
Switzerland	6	↓	3	86.04	4	87.10	13	76.86	10	82.56	4	92.70	1	89.85
Sweden	7			84.93	10	84.07	5	86.65	1	97.51	11	80.78	15	79.00
Netherlands	8	↑	10	83.91	5	86.83	11	77.57	4	89.68	13	79.00	4	87.18
France	9	—	9	83.78	11	81.67	10	82.02	5	87.18	9	82.38	5	87.01
Canada	10			82.99	12	80.95	6	85.94	15	75.79	5	89.14	11	81.84
Japan	11	↓	4	81.15	6	86.21	7	85.58	18	70.45	12	80.42	14	79.17
Singapore	12	↓	7	80.52	8	84.60	18	74.01	19	68.67	8	87.36	8	83.98
Denmark	13			79.32	16	75.79	17	74.37	2	95.02	14	73.12	10	83.09
Italy	14			78.09	14	76.59	9	83.98	13	77.22	17	69.21	9	83.62
Australia	15			77.36	14	76.59	16	75.61	17	75.44	10	82.20	16	76.68
Spain	16			74.88	17	72.50	14	76.33	11	78.28	18	69.03	13	79.71
Israel	17			74.39	13	79.80	19	71.88	8	83.98	19	68.32	19	69.03
India	18			73.79	18	71.34	11	77.57	12	77.93	15	72.41	18	71.34
Portugal	19			73.25	20	69.12	14	76.33	8	83.98	20	66.00	17	74.55
Russia	20			69.40	19	70.81	20	70.27	20	65.47	16	70.63	20	68.49

Note: As the 2022 evaluation only included 10 countries, the ranking changes for countries not listed are not displayed.

No.1 United States



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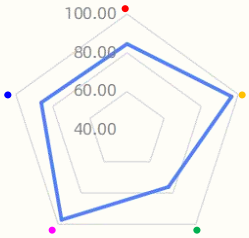

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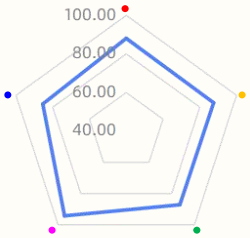

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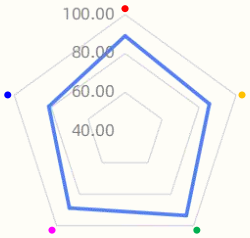

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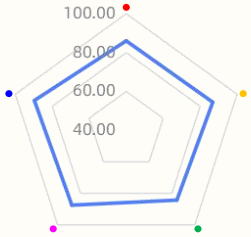

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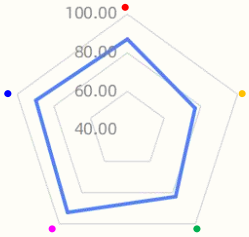

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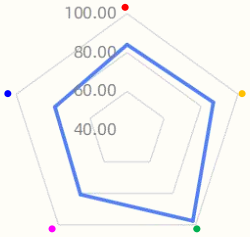

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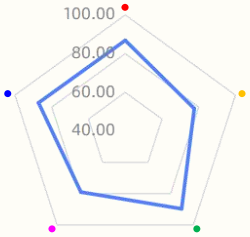

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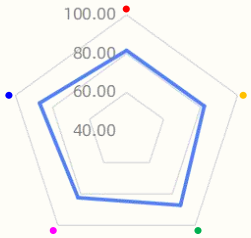

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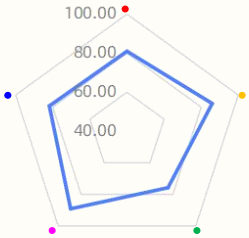

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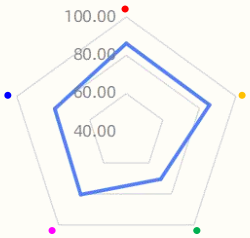

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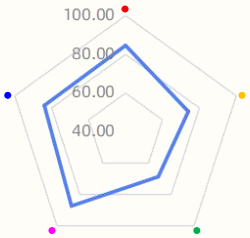

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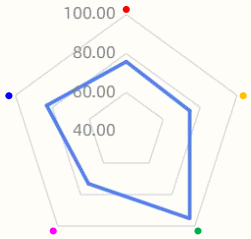

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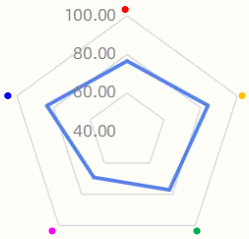

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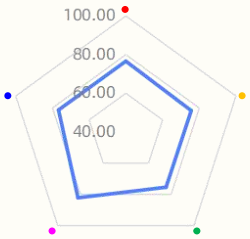

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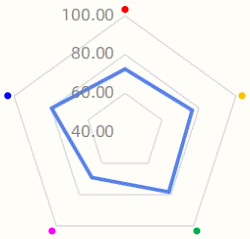

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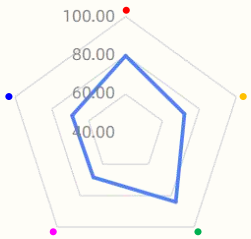

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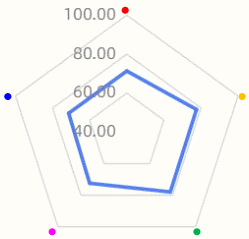

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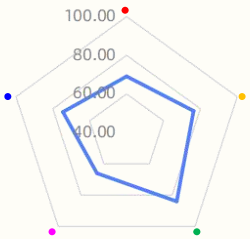

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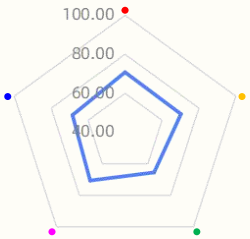
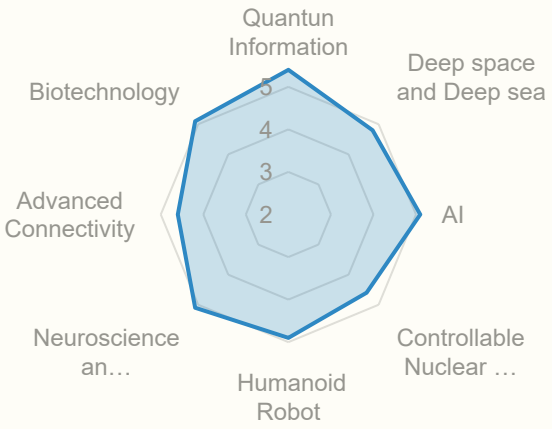


- Innovation Ecosystem and Technologzical Capability
- Industry Diversity and Emerging Industries
- Sustainability and Environment
- Talent and Education
- International Collaboration and Adaptability to Trends

03

Global Future Industries Assessment 2023: National Perspectives Ranking- by industry

No.1 United States



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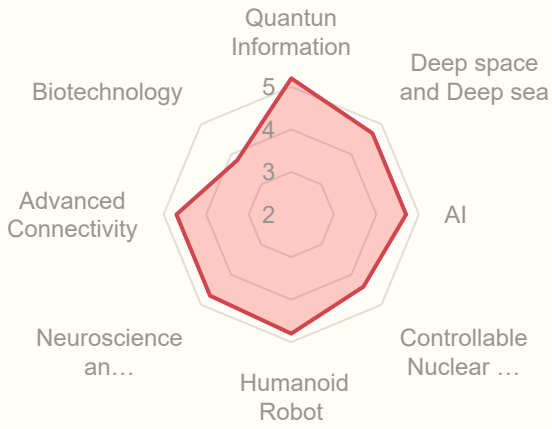

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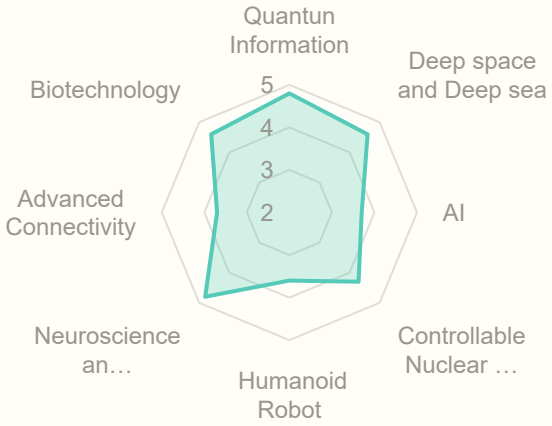

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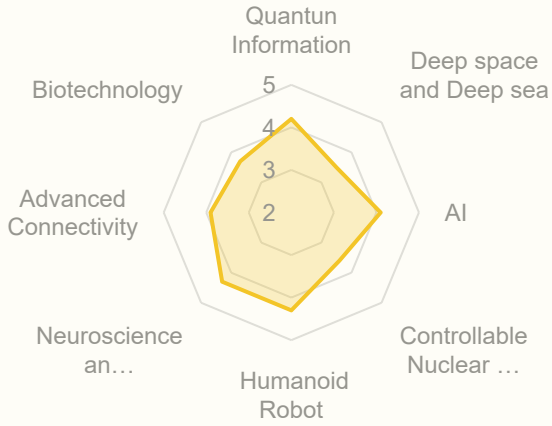

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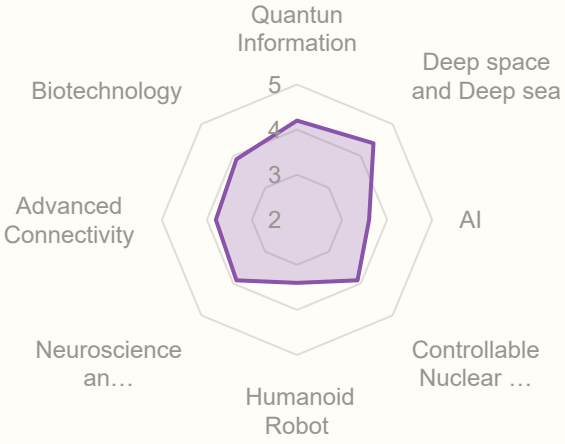

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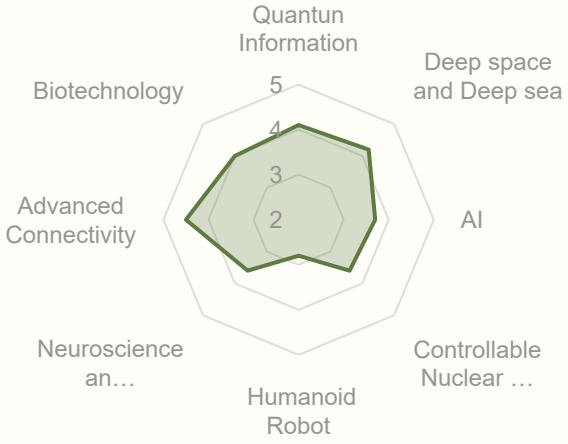
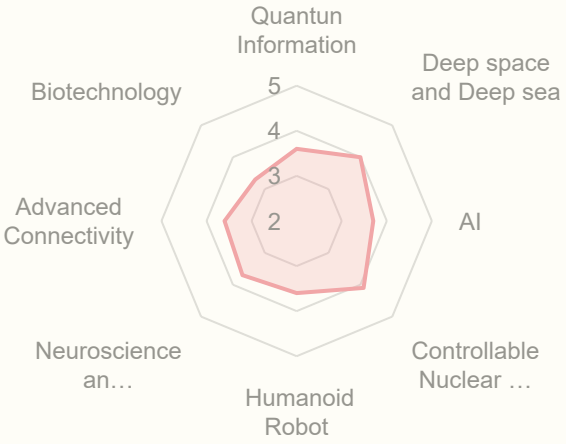


03

Global Future Industries Assessment 2023: National Perspectives Ranking- by industry

No.7 Sweden



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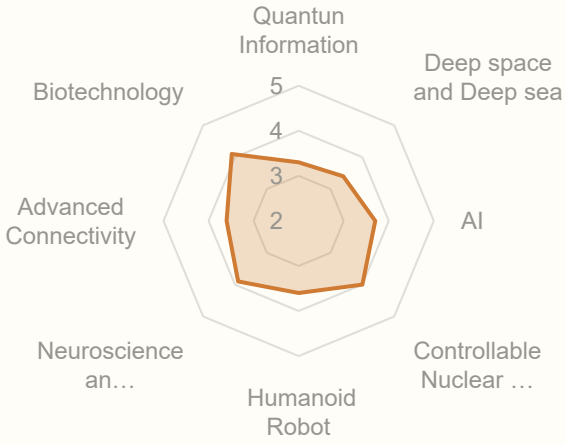

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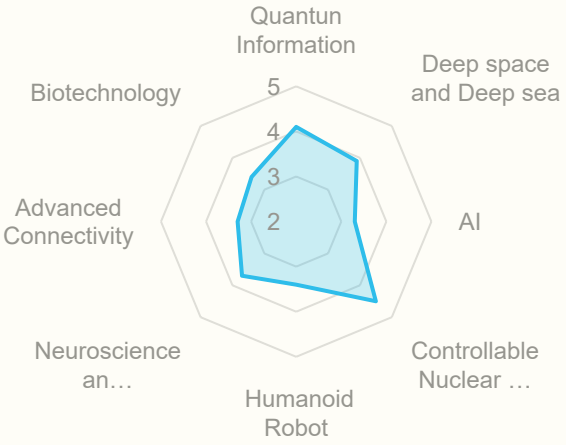

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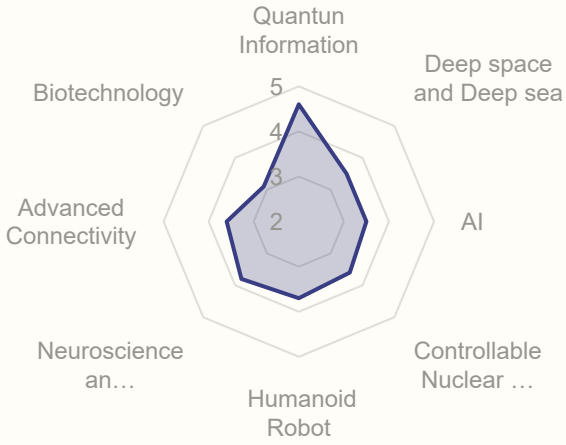

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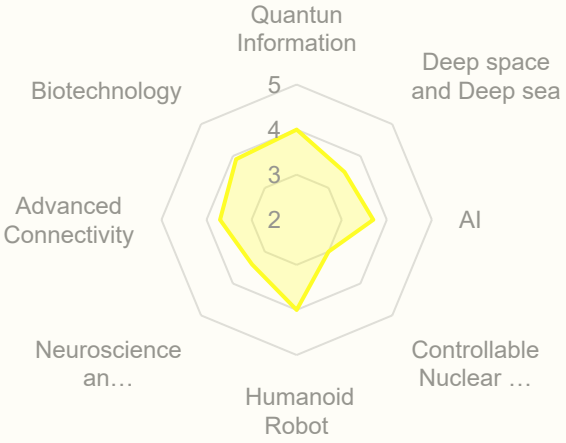

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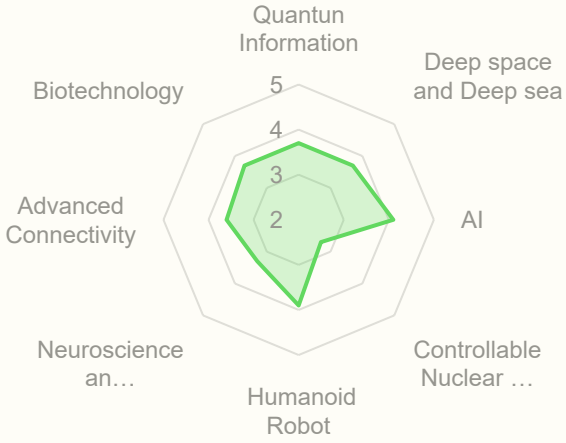

03

Global Future Industries Assessment 2023: National Perspectives Ranking- by industry

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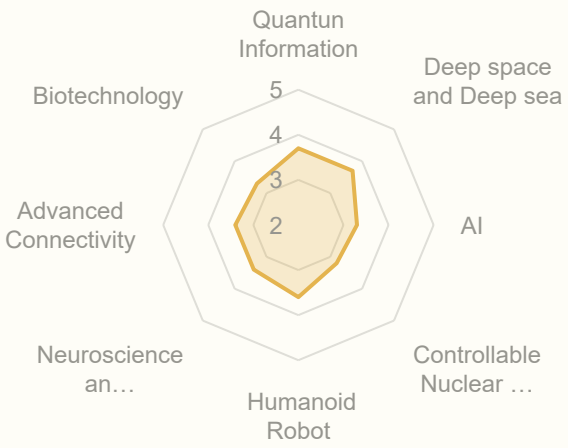

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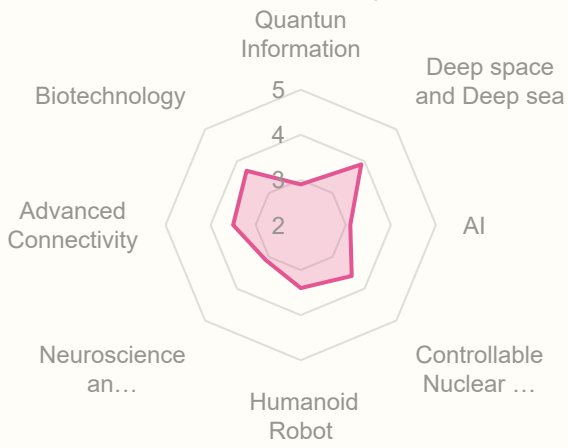

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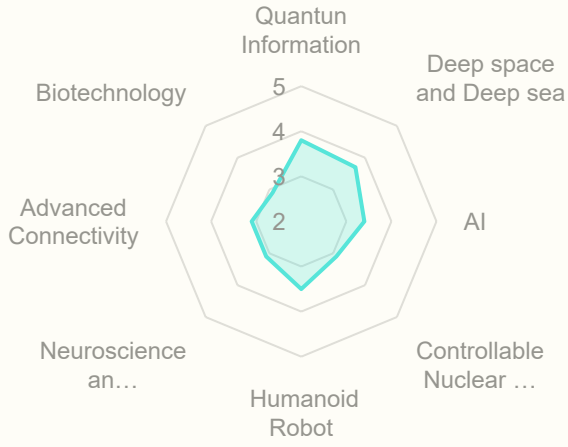

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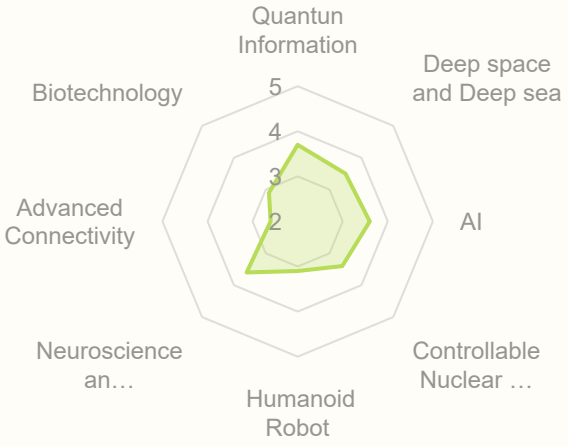

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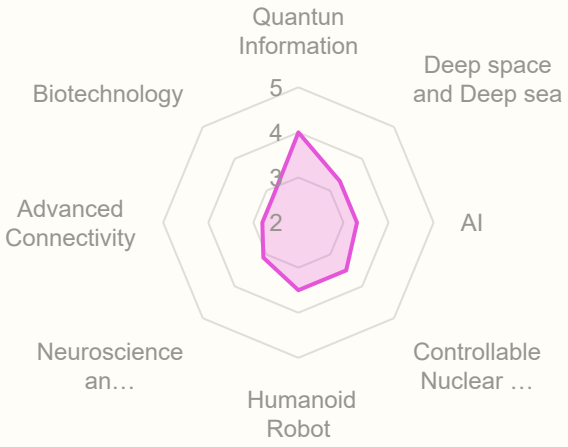

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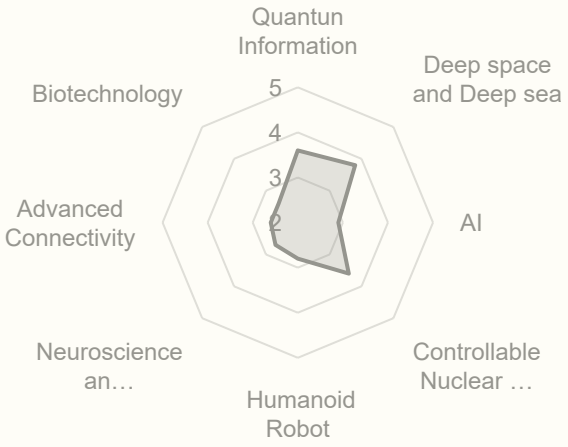
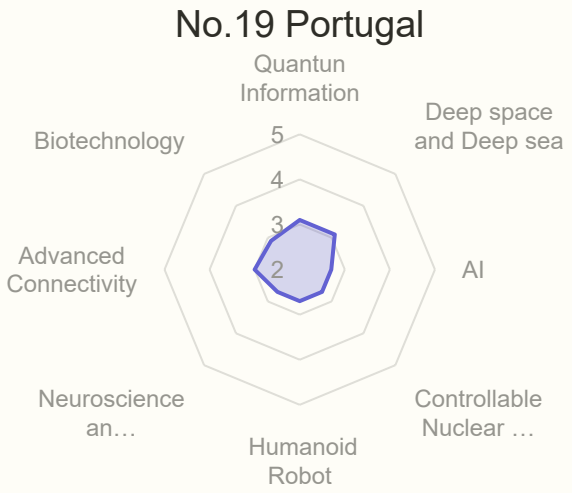


03
Global Future Industries Assessment 2023: National Perspectives Ranking- by industry



The Global Future Industry Institute (GFII) has identified 20 countries with the greatest technical innovation strength and potential for future industrial development. GFII evaluates candidate cities across five dimensions: innovation ecosystem and technological capability, industry diversity and emerging industries, sustainability, and environment, talent and education, and international collaboration and adaptability to trends.

For the 2nd consecutive year, the United States and China topped the GFII, with the United States remains the unrivaled leader in future industries and tops the charts in innovation ecosystem and technological capability, industry diversity and emerging industries.

China ranks second and outperforms the United States in talent and education (1st). The United Kingdom has improved significantly compared to last year and is ranked third overall this year, excelling in all dimensions.

Compared to 2022, South Korea (4th), Germany (5th) and Netherlands (8th) have all moved up the rankings in 2023 and consistently appear in the top ten, while Switzerland, Japan, and Singapore have all fallen in the rankings in 2023, ranking sixth, eleventh and twelfth respectively, with Switzerland ranking first in international collaboration and adaptability to trends. Sweden, leading in sustainability and environment (1st), enters the top ten. Canada, showing steady growth, ranks tenth.

03
Global Future Industries Assessment 2023: National Perspectives Ranking

Innovation Ecosystem and Technological Capability

Country	Innovation Ecosystem and Technological Capability		1.1 The Future Industry Index		1.2 Attraction and Cultivation of Tech Talent		1.3 Start-up Activity		1.4 Development of Innovation Ecosystem		1.5 Construction of Digital Infrastructure	
	Rank	*Score*	*Rank*	*Score*	*Rank*	*Score*	*Rank*	*Score*	*Rank*	*Score*	*Rank*	*Score*
United States	1	95.91	3	94.66	1	98.22	1	98.22	1	98.22	7	87.54
South Korea	2	89.05	2	96.44	12	78.64	14	75.08	2	96.44	1	98.22
United Kingdom	3	88.07	8	85.76	8	85.76	6	89.32	7	87.54	3	94.66
Switzerland	4	87.10	6	89.32	2	96.44	4	92.88	12	78.64	13	76.86
Netherlands	5	86.83	11	80.42	3	94.66	8	85.76	10	82.20	5	91.10
Japan	6	86.21	4	92.88	11	80.42	15	73.30	3	94.66	8	85.76
Germany	7	86.03	7	87.54	4	92.88	12	78.64	5	91.10	16	71.52
China	8	84.60	10	82.20	10	82.20	11	80.42	4	92.88	10	82.20
Singapore	8	84.60	12	78.64	5	91.10	3	94.66	17	69.74	2	96.44
Sweden	10	84.07	4	92.88	7	87.54	7	87.54	16	71.52	9	83.98
France	11	81.67	12	78.64	13	76.86	10	82.20	6	89.32	11	80.42
Canada	12	80.95	16	71.52	9	83.98	5	91.10	9	83.98	15	73.30
Israel	13	79.80	1	98.22	17	69.74	2	96.44	18	67.96	14	75.08
Italy	14	76.59	17	69.74	6	89.32	18	67.96	12	78.64	17	69.74
Australia	14	76.59	14	75.08	15	73.30	13	76.86	15	73.30	6	89.32
Denmark	16	75.79	9	83.98	14	75.08	19	66.18	20	64.40	3	94.66
Spain	17	72.50	18	67.96	16	71.52	17	69.74	14	75.08	12	78.64
India	18	71.34	20	64.40	20	64.40	9	83.98	11	80.42	20	64.40
Russia	19	70.81	19	66.18	19	66.18	20	64.40	8	85.76	19	66.18
Portugal	20	69.12	15	73.30	18	67.96	16	71.52	19	66.18	18	67.96

Innovation ecosystems and technological capabilities are pivotal indicators of a country's global competitiveness, encompassing R&D and technology investment, attraction and cultivation of tech talent, start-up activity, development of innovation ecosystem, and construction of digital infrastructure.

The United States and South Korea lead the ranking in this domain, with the United States ranking first in attracting and cultivating tech talent, start-up activity, and development of innovation ecosystem, and South Korea ranking first in digital infrastructure construction. As for the future industry index, Israel has the highest investment in research and technology. The United Kingdom, ranking third in innovation ecosystem development, demonstrates balanced progress among the top 20 countries.

In general, the United States, South Korea, and the United Kingdom are the top countries in this area.

03
Global Future Industries Assessment 2023: National Perspectives Ranking

Industry Diversity and Emerging Industries

Country	Industry Diversity and Emerging Industries		2.1 Potential for Development in Emerging Industries		2.2 Capability in Building Industrial Ecosystems		2.3 Industry Diversity	
	Rank	*Score*	*Rank*	*Score*	*Rank*	*Score*	*Rank*	*Score*
United States	1	96.62	1	98.22	1	98.22	4	92.88
China	2	96.44	2	96.44	2	96.44	2	96.44
United Kingdom	3	87.54	4	92.88	9	83.98	9	83.98
Germany	4	86.83	5	91.10	5	91.10	13	76.86
Sweden	5	86.65	9	83.98	8	85.76	5	91.10
Canada	6	85.94	7	87.54	10	82.20	7	87.54
Japan	7	85.58	3	94.66	11	80.42	12	78.64
South Korea	7	85.58	6	89.32	12	78.64	7	87.54
Italy	9	83.98	15	73.30	7	87.54	3	94.66
France	10	82.02	8	85.76	13	76.86	10	82.20
Netherlands	11	77.57	18	67.96	4	92.88	14	75.08
India	11	77.57	12	78.64	20	64.40	6	89.32
Switzerland	13	76.86	16	71.52	3	94.66	19	66.18
Portugal	14	76.33	19	66.18	18	67.96	1	98.22
Spain	14	76.33	10	82.20	16	71.52	15	73.30
Australia	16	75.61	11	80.42	15	73.30	16	71.52
Denmark	17	74.37	12	78.64	14	75.08	18	67.96
Singapore	18	74.01	17	69.74	6	89.32	20	64.40
Israel	19	71.88	14	75.08	17	69.74	17	69.74
Russia	20	70.27	20	64.40	19	66.18	10	82.20

Industrial diversity and emerging industries are vital for a country's economic resilience, aiding in cost control and stable development. This includes the potential for development in emerging industries, capability in building industrial ecosystems, and industry diversity.

From the results of the industry diversity and emerging industries ranking, the United States has a high potential for development in emerging industries such as AI, quantum, biotechnology and new energy, and is a leader in building industrial ecosystems. Despite Portugal's top rank in industry diversity, it falls behind in the other two aspects. China ranks second in all aspects within this domain, and the United Kingdom ranks third in industry diversity and emerging industries.

In general, the United States, China, and the United Kingdom are the top countries in this area.

03
Global Future Industries Assessment 2023: National Perspectives Ranking

Sustainability and Environment

Country	Sustainability and Environment		3.1 Utilization of Renewable Energy		3.2 Environmental Policies and Ecological Protection	
	Rank	Score	Rank	Score	Rank	Score
Sweden	1	97.51	1	98.22	2	96.44
Denmark	2	95.02	4	92.88	1	98.22
South Korea	3	93.59	2	96.44	6	89.32
Netherlands	4	89.68	5	91.10	7	87.54
United Kingdom	5	87.18	10	82.20	3	94.66
France	5	87.18	6	89.32	9	83.98
Germany	7	84.34	12	78.64	4	92.88
Israel	8	83.98	3	94.66	18	67.96
Portugal	8	83.98	7	87.54	12	78.64
Switzerland	10	82.56	9	83.98	11	80.42
Spain	11	78.28	15	73.30	8	85.76
India	12	77.93	8	85.76	19	66.18
Italy	13	77.22	18	67.96	5	91.10
China	14	76.15	11	80.42	17	69.74
United States	15	75.79	14	75.08	13	76.86
Canada	15	75.79	16	71.52	10	82.20
Australia	17	75.44	13	76.86	15	73.30
Japan	18	70.45	17	69.74	16	71.52
Singapore	19	68.67	20	64.40	14	75.08
Russia	20	65.47	19	66.18	20	64.40

This dimension evaluates countries' sustainability and environmental efforts, with a focus on the adoption of renewable energy, environmental policies, and ecological conservation.

Sweden and Denmark showcased robust performance in sustainability, with Sweden launching solar park initiatives (Sweden's declaration of plans to build a 90 MWp solar park along the runways of Hultsfred Airport) and Denmark implementing an increased carbon emissions tax. South Korea and Israel are noted for their use of renewable energy, while the United Kingdom and Germany are renowned for their environmental policies and ecological conservation efforts. Italy, despite its lag in renewable energy development, excels in environmental policy and protection.

In general, Sweden, Denmark, and South Korea are the top countries in this area.

03
Global Future Industries Assessment 2023: National Perspectives Ranking

Talent and Education

Country	Talent and Education		4.1 Cultivation of High-Tech Talent		4.2 Innovative Education and Vocational Training	
	Rank	Score	Rank	Score	Rank	Score
China	1	97.15	1	98.22	3	94.66
United States	2	95.73	3	94.66	1	98.22
United Kingdom	3	94.30	2	96.44	6	89.32
Switzerland	4	92.70	5	91.10	2	96.44
Canada	5	89.14	7	87.54	4	92.88
South Korea	6	88.79	6	89.32	7	87.54
Germany	7	87.54	4	92.88	14	75.08
Singapore	8	87.36	8	85.76	5	91.10
France	9	82.38	9	83.98	12	78.64
Australia	10	82.20	10	82.20	10	82.20
Sweden	11	80.78	12	78.64	8	85.76
Japan	12	80.42	11	80.42	11	80.42
Netherlands	13	79.00	13	76.86	9	83.98
Denmark	14	73.12	16	71.52	13	76.86
India	15	72.41	14	75.08	19	66.18
Russia	16	70.63	15	73.30	20	64.40
Italy	17	69.21	17	69.74	18	67.96
Spain	18	69.03	18	67.96	16	71.52
Israel	19	68.32	19	66.18	15	73.30
Portugal	20	66.00	20	64.40	17	69.74

This section focuses on evaluating the talent and education levels of various nations, including the development of high-tech talent, innovative education, and vocational training.

China and the United States exhibited notable achievements in talent and education indicators, partly due to the extensive collaboration between businesses and universities in research and development (R&D), as well as the top three universities in each country scoring highly in the QS World University Ranking. Additionally, the United Kingdom Switzerland, and Germany received excellent scores for their top three universities in the QS ranking. Canada and Singapore also demonstrated praiseworthy performance in university-industry (R&D) collaboration.

In general, China, the United States, and the United Kingdom are the leading countries in this section.

03
Global Future Industries Assessment 2023: National Perspectives Ranking

International Collaboration and Adaptability to Trends

Country	International Collaboration and Adaptability to Trends		5.1 International Innovation Collaboration		5.2 Participation in International Industry Chains		5.3 Adaptability to Future Industry Policies and Trends	
	Rank	Score	Rank	Score	Rank	Score	Rank	Score
Switzerland	1	89.85	7	87.54	6	89.32	2	96.44
Germany	2	89.68	3	94.66	9	83.98	8	85.76
United States	3	89.50	1	98.22	14	75.08	6	89.32
Netherlands	4	87.18	12	78.64	2	96.44	3	94.66
France	5	87.01	5	91.10	10	82.20	9	83.98
China	6	86.29	2	96.44	19	66.18	5	91.10
United Kingdom	7	85.40	4	92.88	12	78.64	13	76.86
Singapore	8	83.98	17	69.74	1	98.22	1	98.22
Italy	9	83.62	6	89.32	8	85.76	19	66.18
Denmark	10	83.09	15	73.30	4	92.88	4	92.88
Canada	11	81.84	8	85.76	16	71.52	7	87.54
South Korea	12	81.31	14	75.08	5	91.10	10	82.20
Spain	13	79.71	9	83.98	11	80.42	18	67.96
Japan	14	79.17	10	82.20	13	76.86	14	75.08
Sweden	15	79.00	13	76.86	7	87.54	16	71.52
Australia	16	76.68	11	80.42	18	67.96	11	80.42
Portugal	17	74.55	20	64.40	3	94.66	17	69.74
India	18	71.34	16	71.52	17	69.74	15	73.30
Israel	19	69.03	18	67.96	20	64.40	12	78.64
Russia	20	68.49	19	66.18	14	75.08	20	64.40

This section is dedicated to evaluating the capacity of different nations to collaborate internationally and adjust to global trends, with international innovation collaboration, participation in international industry chains, and adaptability to future industry policies and trends.

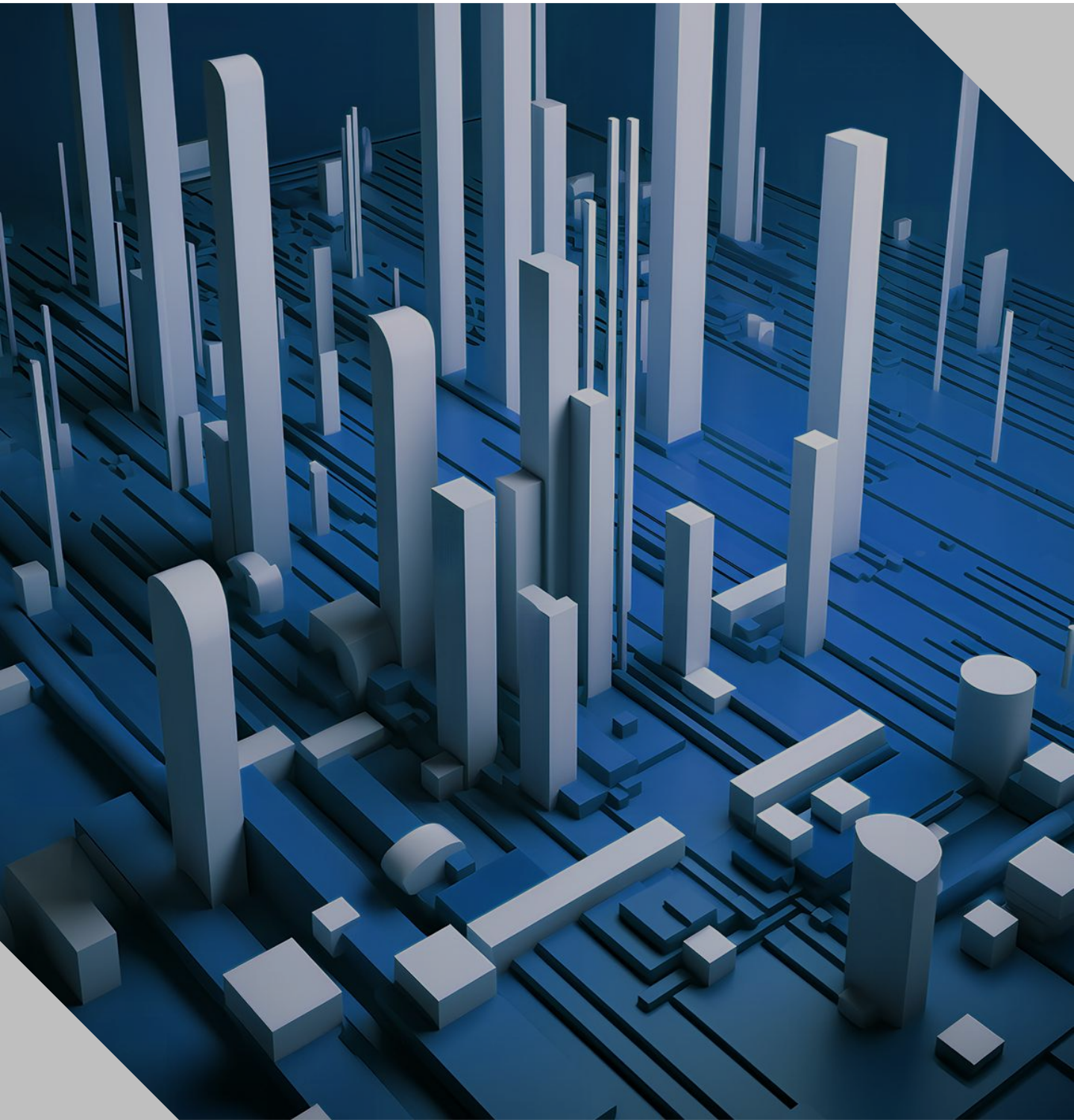
According to the Nature Index 2023, the United States, China, and Germany demonstrated excellence in international innovation cooperation. According to the 2023 Global Value Chain Development Report issued by the WTO, Singapore, the Netherlands, and Portugal are notable participants in the global value chain (GVC). Furthermore, Singapore, Switzerland, and the Netherlands have excelled in developing policies to address emerging industry trends, such as digital transformation and smart manufacturing.

In general, Switzerland, Germany, and the United States are the top countries in this part.

04

Global Future Industries Assessment 2023:

Future City 20



04
Global Future Industries Assessment 2023: Future City 20

The GFII selected 20 cities (clusters) with the most technical innovation strength and potential for future industrial development, and the GFII named them "Future City 20".

2023		*2022*	*City/MAs*	*Score*
1	—	1	San Francisco-San Jose	98.22
2	↑	8	London	96.44
3	↓	2	Beijing	94.66
4			Munich	92.88
5	—	5	Boston	91.10
6	↓	4	New York	89.32
6	—	6	Tokyo-Yokohama	89.32
8	↑	17	Los Angeles	85.76
9	↓	3	Guangdong-Hong Kong-Macao Greater Bay Area	83.98
9	↑	13	San Diego	83.98
11	—	11	Seoul	80.42
12	↑	18	Hefei	78.64
13			Berlin	76.86
14	↓	9	Seattle	75.08
14	↓	10	Paris	75.08
16			Pittsburgh	71.52
17	↓	7	Shanghai	69.74
17			Toronto	69.74
19	↓	14	Washington DC-Baltimore	66.18
20			Moscow	64.40

Note: refer to "Comprehensive analysis and ranking of future industries" for a detailed ranking of each industry segment

Future City 20 ranking considers factors such as quantum information, deep space and deep sea, AI, controllable nuclear fusion, humanoid robots, neuroscience and neuromorphic intelligence, advanced connectivity, and biotechnology, and objectively reflects the overall strength of the city/metropolitan area in these future industries.

San Francisco-San Jose, like in 2022, achieved the highest overall ranking. San Francisco has top-notch research institutions and a large number of innovative technology talents, leading the world in AI, humanoid robots, advanced connectivity, and more. However, San Francisco falls relatively short in quantum information and deep space and deep sea, and has not entered the top 5 cities in the world in these field.

London's ranking has significantly increased compared to 2022 and ranked second in 2023. London has outstanding advantages in neuroscience and neuromorphic intelligence, deep space and deep sea, and biotechnology, but needs to be strengthened in AI and humanoid robots.

Other cities with strong technological innovation capabilities include Beijing, Munich, Boston, and others. Among them, Beijing, ranking third, has balanced development across these fields, with notable innovations in advanced connectivity, neuroscience and neuromorphic intelligence. Munich has shown outstanding strength not only in biotechnology, but also in neuroscience and neuromorphic intelligence. Boston's advanced technological environment has attracted many companies from emerging industries, especially in neuroscience and neuromorphic intelligence, humanoid robots and biotechnology.

In this ranking, the United States stands out with the highest number of cities on the list, boasting a total of 8 cities. Following closely behind is China, with 4 cities making it into the top 20. Germany also has 2 cities on the list, which have a certain competitive advantage.

05

Comprehensive analysis and ranking of future industries

05
Comprehensive analysis and ranking of future industries

Quantum Information

Definition

Quantum information refers to a novel method of transmitting information based on the fundamental principles of quantum mechanics. It involves the calculation, encoding, and transmission of information using the coherent properties of quantum systems.Quantum information encompasses quantum computing, quantum measurement, and quantum communication. Among these fields, quantum computing is a branch of computing that focuses on developing computer technology based on principles of quantum theory. Quantum theory explains the behavior of energy and matter at the atomic and subatomic levels. Quantum technology will lead to breakthroughs in various industries, including aerospace, national defense, automotive, chemical, finance, and pharmaceuticals. Quantum information science encompasses quantum computing, precise quantum measurement, and quantum encryption.

Summary of Outstanding Achievements in 2023

a. Quantum computing has various approaches, with a primary focus on superconducting quantum computing

Currently, quantum computing is trending towards superconductivity, ion traps, and neutral atoms, with multiple technologies advancing simultaneously. Superconducting qubits play a crucial role in advancing quantum technology. On December 5, 2023, IBM released the next generation of superconducting quantum processor chips, IBM Condor and Heron. Among them, Condor has 1121 superconducting quantum bits, making it the first quantum chip with 1000 qubits. In addition, IBM announced plans to release the open-source quantum programming software Qiskit and the Qiskit-based framework "Qiskit Patterns" in February 2024. This will provide engineers with more intuitive and efficient development methods, making quantum computing development easier to access and popularize.

b. Quantum computing has reached a milestone moment

In December 2023, QuEra achieved 48 logical quantum bits and constructed 40 medium-sized error correction codes by controlling 280 physical bits. These codes can detect and correct any errors that may occur during entangled logic gate operations.

c. The fusion of Quantum computing and supercomputing has become a focal point of development

In March 2023, Nvidia released the DGX Quantum system, which integrates technologies like CUDA Quantum and H100 NVL. This system provides an acceleration platform for quantum classical hybrid computing, specifically designed for generative AI models such as GPT.

d. The security evaluation of algorithms in the field of post-quantum cryptography (PQC) becomes crucial

In 2023, a novel neural network training technique known as "Recursive Learning" was developed to execute side-channel attacks on the highest 5th order mask of the Crystal Kyber algorithm, which is one of the four anti-quantum

05
Comprehensive analysis and ranking of future industries

Quantum Information

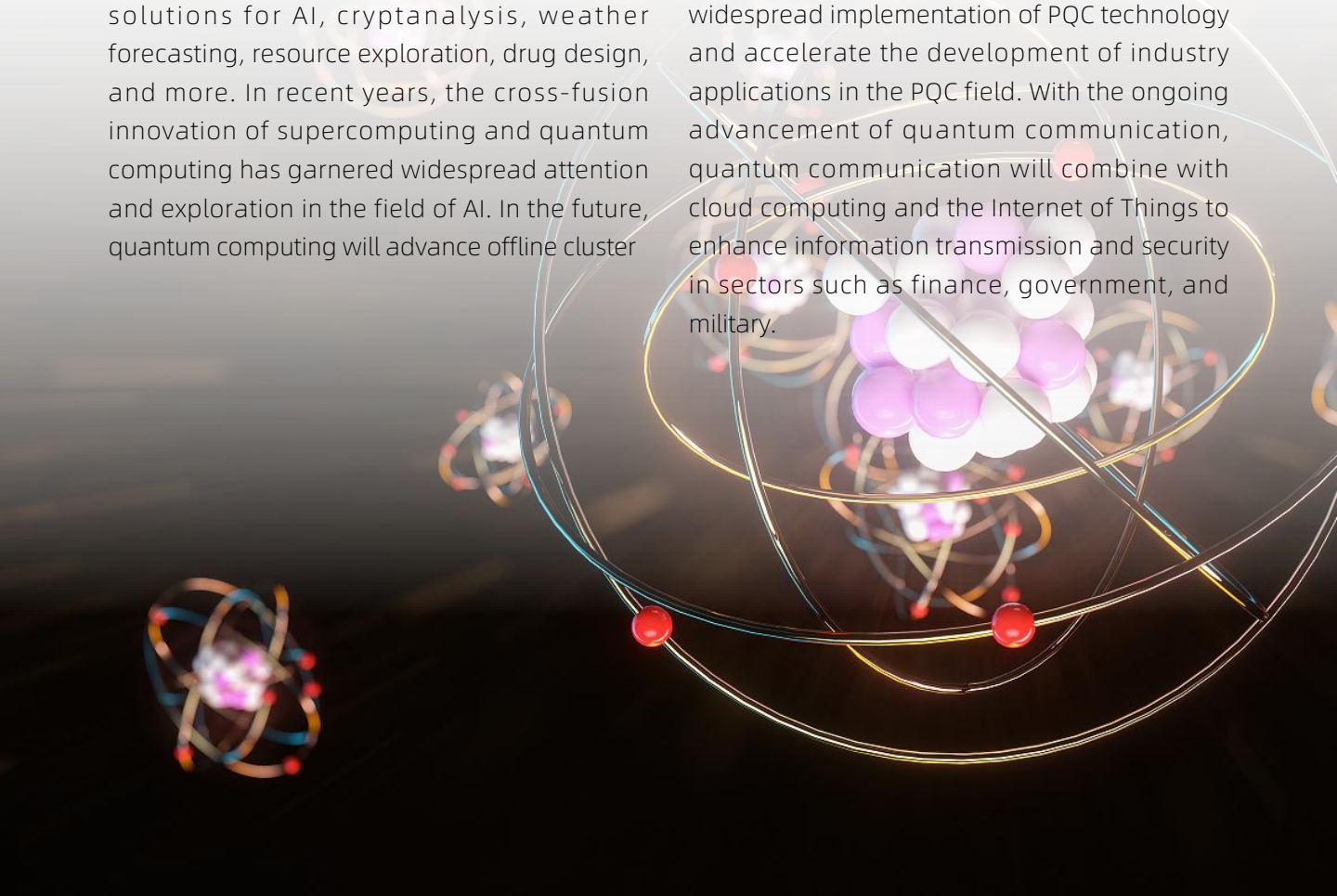
cryptography security algorithms recognized by NIST. This method involves cyclically rotating information and has demonstrated a probability of recovering message bits above 99%. This discovery indicates that neural networks can be used to crack NIST's PQC algorithm, emphasizing the importance of evaluating the security of PQC algorithms.

Future development trends

Currently, quantum information is rapidly advancing, and the pace of commercialization and industrialization is expected to accelerate in the future.

Firstly, quantum computing, with its powerful parallel computing capabilities, can offer solutions for AI, cryptanalysis, weather forecasting, resource exploration, drug design, and more. In recent years, the cross-fusion innovation of supercomputing and quantum computing has garnered widespread attention and exploration in the field of AI. In the future, quantum computing will advance offline cluster technology, connecting multiple quantum processors through a network to form a larger quantum system. This will enhance the performance of quantum computers and open up new possibilities for the trend of quantum superfusion.

Secondly, in the field of quantum communication, current research is focused on achieving quantum communication over longer distances and enhancing the efficiency and security of the process. With NIST's standardization work in the field of Post-Quantum Cryptography (PQC) advancing in the United States, PQC technology is on the verge of reaching its peak. This standardization process will establish a solid foundation for the widespread implementation of PQC technology and accelerate the development of industry applications in the PQC field. With the ongoing advancement of quantum communication, quantum communication will combine with cloud computing and the Internet of Things to enhance information transmission and security in sectors such as finance, government, and military.



City Ranking

Rank	City/ Metropolitan Area	Rank	City/ Metropolitan Area
1	Chicago	11	Paris
2	Hefei	12	Delft
3	Boulder - Denve	13	Tokyo-Yokohama
4	New York	14	Shanghai
5	Toronto - Waterloo	15	Zurich
6	Tel Aviv-Yafo	16	Sydney
7	Helsinki	17	Guangdong-Hong Kong-Macao Greater Bay Area
8	London-Oxford-Cambridge	18	Seoul
9	Munich-Stuttgart	19	San Francisco-San Jose
10	Beijing	20	Singapore

Quantum information, as an emerging field with substantial potential to transform technological paradigms in the future, has become a central focus of global science and technology strategic planning. The top five cities are Chicago, Hefei, Boulder-Denver, New York, and Toronto-Waterloo. In the top 20 rankings, American cities hold 4 positions, European cities hold 6 positions, and Asian cities hold 5 positions (including 4 Chinese cities).

In terms of industrial scale and quantum applications, the United States is currently at the forefront of global quantum information development, particularly in the field of quantum computing, where it maintains a leading advantage. Companies like Google, IBM, and Microsoft are making strides in research and developing quantum computing platforms. China's quantum information technology is leading the way in Asia, with major enterprises like Quantum CTek and CIQTEK. There are also some potential unicorn companies.

Enterprise ranking

Rank	Enterprise	Rank	Enterprise
1	IBM	11	PsiQuantum
2	Quantinuum	12	Pasqal
3	Google	13	SEEQC
4	QuantumCTek	14	IQM
5	Rigetti	15	Hyqubit
6	IonQ	16	QuantWare
7	Xanadu	17	ORCA Computing
8	D-wave	18	Quandela
9	CIOTEK	19	ColdQuanta
10	Argit	20	IQM Finland

05
Comprehensive analysis and ranking of future industries

Deep space and deep sea

Definition

The deep space industry encompasses a range of commercial activities utilizing deep space technology, such as space tourism, space mining, space manufacturing, and space science research. It is a high-tech, high-risk, and high-return industry that requires support and investment from various sectors, including government, enterprises, research institutions, and capital markets, for its development. The deep sea industry encompasses a range of commercial activities that utilize deep sea technology, such as deep-sea resource development, deep-sea scientific research, deep-sea equipment manufacturing, and deep-sea tourism. The development of the deep sea industry requires addressing numerous technical and commercial challenges, including equipment pressure resistance, deep sea communication, and energy supply. However, its development is of great significance for human understanding of the ocean, the development of marine resources, and the expansion of living space.

Summary of Outstanding Achievements in 2023

In 2023, the "Chinese Eye" experienced a period of remarkable breakthroughs. It discovered pulsar binary systems with orbital periods as short as 53 minutes, detected crucial evidence of nanohertz gravitational waves, and observed black hole "pulses" for the first time in the radio band. These findings have had a profound impact on the study of galaxy evolution and supermassive black holes, and have also introduced a new avenue for gravitational wave astrophysics.

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In August 2023, India became the first country to successfully achieve a soft landing of the lunar probe "Luna 3" at the South Pole of the Moon.

In September 2023, the South China Sea Institute of Oceanography, Chinese Academy of Sciences, achieved a breakthrough in electromagnetic exploration across the mid-ocean ridge.

In September 2023, NASA's first asteroid sampling and return mission, OSIRIS-REx (Pluto), successfully collected 250g of samples from a near-Earth asteroid called Bennu and returned to Earth. Preliminary analysis of the samples revealed that the asteroid contained high levels of carbon and water, which are the main components of life.

In October 2023, an international research team discovered the periodic precession of black hole jets in the M87 galaxy. This finding linked the dynamics of the M87 jet with the state of the supermassive black hole at the center of the galaxy, providing observational evidence for the existence of spin in the M87 black hole. This discovery is in line with Einstein's general theory of relativity's prediction that "if the black hole is in a rotating state, it will cause a reference frame drag effect."

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Comprehensive analysis and ranking of future industries

Deep space and deep sea

Future development trends

Environmental exploration and monitoring technology is increasingly taking center stage. By integrating ocean and space robotic exploration technologies, it is possible to conduct monitoring and surveillance of ecologically significant and sensitive habitats such as coral reefs, fishing grounds, deep sea seabed, and trenches, as well as retirement sites for oil and gas platforms. In the future, the technological integration of deep space and deep sea exploration will continue to advance, with the following main development trends:

a. Enhancing Robotic Hardware for Autonomous Missions through Bio-Inspired Designs and Advanced Sensing Systems

Bio-inspired shapes and materials, combined with compact and innovative sensor packages, are poised to advance robotic hardware into a realm of improved sensing capabilities. This development supports intelligent strategies for mission planning and knowledge acquisition. The enhanced design enhances the success of complex autonomous missions in unfamiliar terrains by optimizing energy efficiency and instrument control. Intelligent tools for data interpretation facilitate the acquisition of new insights derived from the analyzed environment.

b. AI-Powered Decision-Making for Enhanced Adaptability in Extreme Aqueous Environments

AI-driven decision-making represents a significant advancement in customizing the capabilities of individual platforms in challenging underwater environments. This autonomy will facilitate the execution of extended missions with minimal human involvement, dynamically managing mutual navigation, communication, and data collection. Furthermore, this adaptability creates opportunities for further improvements in behavior for collaborative missions.

c. Integrating Molecular and Imaging Approaches in AI-Empowered Robotic Platforms for Autonomous eDNA Sensor Data Collection

Advancements in ecological monitoring technologies involve integrating molecular and imaging techniques into AI-powered robotic platforms to efficiently extract information. The use of autonomous eDNA sensors in data collection is poised to revolutionize our understanding of marine biodiversity.

City Ranking

Rank	City/ Metropolitan Area	Rank	City/ Metropolitan Area
1	Houston	11	Luxembourg
2	San Diego	12	Marseille
3	London-Oxford-Cambridge	13	Hefei
4	Toulouse	14	Hyderabad
5	Moscow	15	Guangdong-Hong Kong-Macao Greater Bay Area
6	Beijing	16	San Francisco-San Jose
7	Tsukuba	17	Melbourne
8	Seattle	18	Vancouver
9	Munich	19	Pittsburgh
10	Los Angeles	20	Kita Kyushu

Deep space and deep sea exploration are two crucial high-tech fields that have not been fully explored on Earth. Through research and exploration of deep space and deep sea, we can promote scientific and technological progress, generating new ideas and directions for future technological development. Meanwhile, exploration of deep space and deep sea can foster the advancement of fields such as aerospace engineering, deep sea engineering, electronic information, and new materials.

More importantly, as resource consumption intensifies, environmental problems are becoming increasingly prominent.

Deep space and deep sea exploration can offer new resources and habitats for humanity, addressing resource shortages and environmental challenges.

Government agencies and private enterprises in the United States, Europe, China, and Japan are actively conducting deep space and deep sea exploration projects. In the realm of deep space exploration, it encompasses the United States' Mars exploration program, Europe's Mars Express, and China's Chang'e lunar exploration program. The deep sea exploration encompasses the United States' deep sea challenge program, Europe's Ocean Map program, and China's Jiaolong deep sea submersible.

Enterprise ranking

Rank	Enterprise	Rank	Enterprise
1	Ispace	11	CSSC
2	Blue Origin	12	Masten Space Systems
3	SpaceX	13	Airbus Defence and Space
4	SpaceForge	14	Space Pioneer
5	AstroForge	15	DORD
6	Starlink	16	Ocean Gate Expeditions
7	OrigeSpace	17	Mitsubishi Heavy Industries
8	Orbit Fab	18	Maxar
9	McDermott International	19	Deepwater corp
10	GE	20	Skyroot

After years of technological accumulation and research, the United States has emerged as a leader in this field. For example, Houston and San Diego in the United States are both globally renowned for their deep space and marine science research. The research institutions and enterprises in these cities have attracted a significant number of high-end talents and technological resources, which are crucial for the advancement of deep space and deep sea exploration industries. This support is instrumental in driving the development of these industries in the United States. From the ranking of the top 20 cities, it can also be seen that the United States holds 6 spots, with the highest number of cities on the list. Meanwhile, China and Japan have also achieved significant results in this field. In this ranking of the top 20 cities, they occupy 3 and 2 spots respectively.

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Comprehensive analysis and ranking of future industries

AI

Definition

AI is the theory and development of computer systems capable of performing tasks that traditionally relied on human intelligence, such as speech recognition, decision-making, and pattern recognition. AI is a broad term that includes various technologies such as machine learning, deep learning, and natural language processing.

The AI industry chain is typically divided into three layers: the basic layer, technical layer, and application layer. The foundational layer establishes the groundwork for the AI industry in areas such as networking, algorithms, hardware deployment, and data collection. The technical layer constructs a technological pathway that begins with simulating human intelligence-related features. The application layer integrates one or more types of basic AI application technologies, combining them to create software and hardware products or solutions customized to meet specific application scenario requirements.

Summary of Outstanding Achievements in 2023

The characteristics of the journey of transformation in AI are the advancement of open-source AI, license debates, and the emergence of powerful generative AI models.
The development of open-source AI has reached an unprecedented height, reshaping the framework and model pattern of AI. The release of PyTorch 2.0 has set a new industry standard and provided powerful tools for researchers and developers. Nvidia's Modulus and Colossal AI have been further enhanced based on the PyTorch framework, contributing to collaborative innovation in open source ecosystems. Technology giants Microsoft and Google have respectively achieved significant milestones by integrating ChatGPT into Bing and launching Budd.

However, the path of open source is not without controversy. Meta's release of Llama 2 as "open source" has sparked a debate about the definition of open source in AI. Although considered a significant contribution, the scale limitations in Llama 2 have raised doubts about its true openness, prompting discussions on whether it is necessary to redefine licensing models for the unique complexity of AI.

At the same time, 2023 witnessed the rise of advanced generative AI models, which have changed natural language processing and creative content generation. OpenAI's GPT-4 is a groundbreaking language model that redefines the capabilities of AI with outstanding performance in text-based applications such as creative writing, coding, and complex problem-solving.

Jina AI's 8K text embedding model and Mistral AI's Mistral 7B demonstrate the increasing proficiency of the AI community in processing large amounts of text data. These models highlight a trend towards more powerful and detailed AI models that are applicable to different fields.

However, the proliferation of generative AI models has raised ethical issues, including biases in AI generated content and the urgent need for transparency in AI development. As AI continues to integrate into various industries, the industry strives to ensure that its use is ethical and responsible.

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Comprehensive analysis and ranking of future industries

AI

Future development trends

In the field of AI, there are multiple key trends in technology, applications, and security:

a. Technical trends

- **Multimodal Models Driving Information Fusion**: One of the technological trends is the emergence of multimodal models, which expedite the fusion of diverse data, including text, images, and videos. This allows AI to develop a more comprehensive understanding of the real world and to adapt to complex and diverse interaction scenarios.
- **Embodied intelligence opens up new possibilities**: As an emerging technological trend, embodied intelligence allows intelligent agents to perceive the physical world through interaction with the environment and to understand and transform the objective world. This presents significant opportunities for the future advancement of AI.
- **The path to achieving universal AI is becoming clearer**: the widespread use of large models is laying the groundwork for the advancement of universal AI. Additionally, technologies like brain-computer interfaces are introducing new forms of human-computer interaction, signaling the gradual realization of universal AI.
- **Performance Improvement of Data-Driven Models**: The significance of data is growing, and high-quality data can boost the performance of AI models. The implementation of new technologies, such as vector databases, will further advance the progress of data management.
- **Intelligent computing centers are becoming essential infrastructure**: The AI transformation of data centers considers intelligent computing centers as crucial infrastructure, and cloud computing is evolving towards heterogeneous computing architectures centered on CPU+GPU/NPU. This evolution promotes the diversity and ecological development of AI chips.

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Comprehensive analysis and ranking of future industries

AI

b. Trends in application

- Large language models will serve as personal intelligent assistants: helping to create travel plans and perform other tasks, ushering in a new era of user interaction.
- A variety of models thrive in enterprise large models: Large models thrive in business-end applications, meeting the specific needs of enterprises and creating a tiered demand pattern.
- Lightweight large models drive end-to-end computing power: They help reduce application costs, promote the development of end-to-end computing power, and enable users to access AI services more economically, reliably, and safely.
- The profound impact of large-scale models on the labor market and scientific research: Large language models have profound and complex effects on the structure of the labor market and scientific research paradigms, reducing intellectual costs in cutting-edge technological research and enhancing research efficiency.

c. Trends in application

The balance between AI governance and interpretability is emphasized as the final trend, highlighting the need to balance AI governance with technological advancements. The rise of technologies like explainable AI has sparked controversy, and the need for regulation is becoming more prominent. Governments around the world are developing and implementing policies and regulations for AI to ensure its credibility and security.

City Ranking

Rank	City/ Metropolitan Area	Rank	City/ Metropolitan Area
1	San Francisco-San Jose	11	Seattle
2	Los Angeles	12	Shanghai
3	Pittsburgh	13	Guangdong-Hong Kong-Macao Greater Bay Area
4	New York	14	Helsinki
5	Boston	15	London-Oxford-Cambridge
6	Singapore	16	Tokyo-Yokohama
7	Seoul	17	Zurich
8	Munich	18	Sydney
9	Copenhagen	19	Hangzhou
10	Beijing	20	Luxembourg

It is evident from the rankings that the United States and China hold advantageous positions in the field of AI. Among them, the United States is a significant hub for AI, home to numerous technology giants and top research institutions, and has consistently maintained a leading position. From a ranking perspective, the United States holds six spots out of the top 20 cities, with all of the top five cities being American. Secondly, through national strategy and substantial investment, China has rapidly become a significant player in the global AI field, with four cities ranking in the top 20.

Enterprise ranking

Rank	Enterprise	Rank	Enterprise
1	Open AI	11	Advance Intelligence Group
2	Google	12	Huawei
3	Microsoft	13	ByteDance
4	Meta	14	Cohere
5	NVIDIA	15	Scale AI
6	Adobe	16	Quantexa
7	IBM	17	Runway
8	Canva	18	Naver
9	Baidu	19	Aleph Alpha
10	Databricks	20	Helsing

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Comprehensive analysis and ranking of future industries

Controllable Nuclear Fusion

Definition

Controllable nuclear fusion is a sustainable and controllable nuclear reaction, and a device for conducting such reactions is referred to as the "artificial sun". Controllable nuclear fusion, as a cutting-edge disruptive technology with significant potential, is currently recognized as one of the important solutions to ultimately address human energy challenges. Compared to nuclear fission, controllable nuclear fusion releases more energy, has abundant sources of raw materials, produces less radioactive waste, and is safer. It is a key direction for future energy development.

Summary of Outstanding Achievements in 2023

In August 2023, China's Circulation three successfully achieved high-constraint operation mode under a plasma current of 1 million amperes.

In October 2023, the world's largest and most advanced nuclear fusion reactor, JT-60SA, was successfully ignited. The tokamak facility, jointly constructed and operated by Japan and the European Union, was completed in 2020. In the same month, the National Ignition Facility (NIF) in the United States successfully achieved ignition twice, resulting in a controllable net energy gain for nuclear fusion. This allowed the energy generated by the fusion reaction to exceed the energy consumed during the process. At this point, American scientists have successfully increased the number of ignition attempts to four.

Future development trends

a. The development of high-temperature superconducting technology can shorten the construction period of Controllable nuclear fusion devices

Superconducting magnets are essential components of tokamak devices in magnetic confinement controlled nuclear fusion. They are used to create a magnetic field that confines fusion reactions. With the continuous advancement of superconducting technology, there is an expectation for the enhancement of the strength and stability of magnetic fields. The tokamak technology aims to miniaturize strong magnetic fields using high-temperature superconducting materials, with the expectation of significantly reducing the cost of fusion devices and shortening the technology iteration cycle.

b. The strategy of controlling high-temperature plasma through numerical simulation will become possible

In controllable nuclear fusion, it is essential to manage the behavior of high-temperature plasma to attain stable and efficient nuclear fusion reactions. This involves technologies related to plasma generation, heating, confinement, and control. With the advancement of computer science and numerical simulation technology, it is now possible to optimize the control strategy of plasma through numerical simulation.

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Comprehensive analysis and ranking of future industries

Controllable Nuclear Fusion

c. Nuclear energy (Controllable nuclear fusion) will serve as a cutting-edge climate solution

Nuclear energy, specifically controllable nuclear fusion, faces challenges in terms of public acceptance and economic competitiveness when compared to renewable energy and fossil fuel power generation. But it is the only reliable, dispatchable, physically and materially small, plug-and-play zero-carbon power generation solution.

d. The breakthrough of AI and diversified business models will further accelerate the pace of commercialization

The breakthrough in AI will have a significant impact on the development of the controllable nuclear fusion industry, potentially shortening its commercial development cycle.

Controllable nuclear fusion research involves complex physical processes and massive amounts of data. AI can be utilized to optimize experimental parameters and develop more precise models of plasma behavior. If a suitable AI model can be developed and provided with enough magnetic constraint control samples, along with strategy networks and value networks, it can quickly generate various plasma configuration schemes without the need for reprogramming, after mastering the training methods of the control system proficiently. This will significantly reduce the experimental process and the number of repeated experiments, helping scientists and engineers make better use of limited experimental resources to accelerate research on nuclear fusion.

City Ranking

Rank	City/ Metropolitan Area	Rank	City/ Metropolitan Area
1	Saint Paul de Vence	11	Paris
2	San Francisco-San Jose	12	Tokyo-Yokohama
3	Hefei	13	Los Angeles
4	Chiba	14	Liverpool
5	London-Oxford-Cambridge	15	Seoul
6	Munich	16	Sydney
7	Berlin	17	Amsterdam
8	Boston	18	New Delhi
9	Moscow	19	Taipei
10	Vancouver	20	Stockholm

Currently, more than 50 countries around the world are conducting research and construction on over 140 controllable nuclear fusion devices and have achieved a series of technological breakthroughs. Europe has a long-standing presence in this field, boasting advanced technology and the world's largest operational tokamak device. The Joint European Torus (JET), located at the Culham Centre for Fusion Energy in Oxfordshire, UK, is the only existing tokamak facility capable of operating with deuterium-tritium fuel mixtures. It is evident from the rankings that European cities hold 8 of the top 20. Secondly, the United States also maintains a global leading position in the use of nuclear energy and technology research and development, holding three spots in the top 20 city rankings. This has led to the emergence of many outstanding enterprises, including Commonwealth Fusion Systems. Furthermore, China has established a comprehensive presence in the nuclear energy sector, attaining global leadership. Hefei, China and Taiwan, China ranked third and 19th respectively in this ranking of the top 20 cities.

Enterprise ranking

Rank	Enterprise	Rank	Enterprise
1	Tokamak Energy	11	Trumpf
2	CNNC	12	HB11 Energy
3	Commonwealth Fusion Systems	13	Fusion Energy Institute
4	Renaissance Fusion	14	Proxima Fusion
5	TAE Technologies	15	NT-Tao
6	Helion Energy	16	Thales
7	Kyoto Fusioneering	17	Ex-Fusion
8	Zap Energy	18	STARTORUS Fusion
9	MarvelFusion	19	CTFusion
10	General Fusion	20	Eni

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Comprehensive analysis and ranking of future industries

Humanoid Robot

Definition

Humanoid robots, also known as biomimetic humans, are robots designed to mimic human appearance and behavior, especially those with bodies similar to humans. Humanoid robots require robust motion control capabilities, as well as advanced perception and computing abilities. Humanoid robots can adapt to various real-life scenarios, allowing them to shift from professional roles to multifunctional roles. This increases economies of scale and reduces costs.

Summary of Outstanding Achievements in 2023

The humanoid robots were deployed as prototypes in an environment where they collaborate with humans. The humanoid robots in the laboratory have been proven to handle complex tasks such as cooking, cleaning, folding clothes, welding, and brewing coffee. The development of humanoid robots with AI capabilities is rapidly advancing, to the point where robots can learn by observing human behavior.

In May 2023, Sanctuary AI (@TheSanctuaryAI) released the sixth generation humanoid robots, Phoenix, featuring a 20-degree-of-freedom robotic arm capable of performing precise operations similar to those of human hands, such as opening soft plastic bags. During the test, the robot completed 110 retail-related tasks in a store in Vancouver, including packaging goods, labeling, folding, and cleaning.

In October 2023, Amazon tested the humanoid robots Digit at its BFI1 operations center in Sumner. The robot was produced by AgilityRobotics. Digit is currently employed as a warehouse robot, tasked with recycling Amazon's distinctive yellow boxes. It is expected that the production capacity of Digit robots will reach 10,000 units per year by 2027.

In December 2023, Tesla released its latest version of the humanoid robots, Optimus Gen 2. The second-generation Optimus Gen 2 humanoid robots incorporates Tesla's self-developed actuators and sensors, improving its walking ability, perception, balance, and overall body control. This represents a further acceleration of the industrialization of humanoid robots.

Future development trends

a. Embodied intelligence enables Humanoid robots to transition from specialized to universal use

Before the development of large-scale models, humanoid robots were limited to specific scenarios and carried out actions based on pre-set instructions. With the advancement of large-scale models, humanoid robots are able to engage more deeply with the physical world through perception and limb interaction, facilitated by multimodal models. Now, they can perceive, learn, and adapt to the environment, becoming embodied intelligent robots that closely mimic human natural intelligence and are widely used in various scenarios. In the future, embodied intelligence will enable robots to interact, perceive, make decisions, and complete complex tasks more naturally within their environment.

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Humanoid Robot

b. A New Era of Human Machine Collaboration

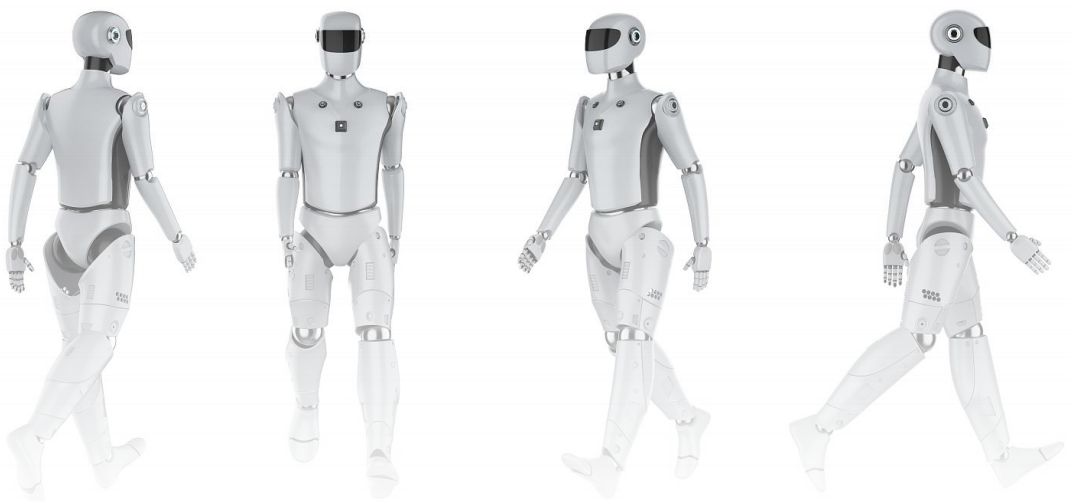
In the context of Industry 4.0 and intelligent factories, collaborative robots have been widely used in the manufacturing industry. The collaboration between bionic robots and humans is expected to become more common in the future. They will collaborate in the fields of production, healthcare, and services to capitalize on their respective strengths. This collaborative effort is expected to enhance efficiency, lower costs, and establish a safer working environment.

c. Widely applicable scenarios

With the continuous improvement of large-scale models and the advancement of sensor technology, the intelligence and mobility of humanoid robots are constantly increasing, approaching the capabilities of real humans. Tesla's foray into the humanoid robots industry is anticipated to substantially decrease manufacturing expenses. The application scenarios for humanoid robots are very extensive, including customer service, healthcare, education and training, home services, emergency rescue, and the entertainment industry. They can perform a variety of tasks in hotels, hospitals, schools, homes, disaster-stricken areas, and theme parks, offering guidance, services, performances, and other functions.

d. Data security challenges

With the growing use of biomimetic robots, there is an increasing need for data security. These challenges involve safeguarding sensitive information in robot systems and ensuring their secure operation. The data stored and transmitted, including design drawings, process parameters, production plans, and other confidential information of the enterprise, need to be properly protected. Manufacturers and users will face increasing data security challenges, necessitating comprehensive consideration of multiple aspects such as hardware, software, communication, and user privacy. This will require the development of stricter security strategies and measures to ensure that robot systems can effectively resist potential threats at all levels.



City Ranking

Rank	City/ Metropolitan Area	Rank	City/ Metropolitan Area
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2	Boston	12	Guangdong-Hong Kong-Macao Greater Bay Area
3	Pittsburgh	13	Toronto
4	New York	14	Seoul
5	Beijing	15	Munich
6	Los Angeles	16	Singapore
7	Paris	17	Zurich
8	Tokyo-Yokohama	18	Sydney
9	London-Oxford-Cambridge	19	Hangzhou
10	Seattle	20	Kyoto-Osaka-Kobe

As versatile, integrated, and intelligent robots, humanoid robots require robust motion control capabilities, as well as advanced perception and computing abilities. The technical challenge lies in replicating the processes of perception, cognition, decision-making, and execution as accurately as possible in various human scenarios. This involves utilizing state-of-the-art technologies in fields such as biomimetic perception and cognition, dynamic fusion technologies, artificial intelligence, big data cloud computing, and visual deep navigation.

At present, well-known humanoid robots include Tesla's "Optimus Prime", Boston Power's "Atlas", 1X Technology's EVE and NEO, and others. Due to high technological barriers, the primary participants in the humanoid robots industry are technology companies, and the United States holds a significant advantage in this field. Among the top five cities, the United States holds four positions, with a total of six American cities ranking in the top 20.

Enterprise/University ranking

Rank	Enterprise	Rank	Enterprise
1	Boston Dynamics	11	Agility Robotics
2	Tesla	12	Shadow Robot
3	Hanson Robotics	13	Pormobot
4	Apptronik	14	Segway-Ninebot
5	Sanctuary AI	15	Figure
6	Engineered Arts	16	1X Technologies
7	IntuitiveSurgical	17	Dataa Robotics
8	Beyond Imagination	18	Karlsruhe Institute of Technology
9	TOYOTA Robotics	19	Apptronik
10	Macco Robotics	20	Sanctuary

05
Comprehensive analysis and ranking of future industries

Neuroscience and Neuromorphic Intelligence

Definition

Neuroscience and neuromorphic intelligence, as two cutting-edge technological fields, are showing a new trend of mutual learning and deep integration, becoming a research hotspot in the international scientific community in recent years. Neuroscience provides important scientific basis and clinical guidance for the effective diagnosis and treatment of brain diseases through in-depth analysis of various brain functional neural foundations.

At the same time, the research results of neuroscience also provide inspiration and inspiration for brain like research. Neuromorphic intelligence is a machine intelligence inspired by the neural operation mechanism and cognitive behavior mechanism of the brain, using computational modeling as a means, and achieved through software and hardware collaboration. Neuromorphic intelligence has the characteristics of being brain like in information processing mechanisms, humanoid in cognitive behavior performance, and achieving or surpassing human intelligence levels.

With the vigorous advancement of a new round of technological revolution and industrial transformation, major economies around the world have increased their investment and research and development efforts in this field, actively laying out "brain plans", striving to reveal the life code and working mechanism of the human brain, leading the innovative development of cutting-edge technologies and future industries such as life sciences, medical health, biomimetic technology, AI, military security, etc.

Summary of Outstanding Achievements in 2023

In May 2023, Musk's subsidiary Neuralink was granted permission to conduct brain computer interface human trials, which is seen as a milestone in the commercialization of brain computer interface applications. Musk hopes that this technology can help visually impaired and mobility impaired individuals recover their vision and mobility. In the same month, the world's first non-human primate invasive brain computer interface test was successful in Beijing, China. The experiment achieved an invasive brain computer interface brain controlled robotic arm in the monkey brain, which is of great significance for promoting research in the field of neuroscience.

In July 2023, the brain like Computing Center of Tsinghua University in China proposed for the first time a dual brain driven cross paradigm heterogeneous fusion brain like computing architecture, achieving compatible integration of computer science oriented and neuroscience oriented intelligent computing models, providing a new solution and feasible path for the development of brain like computing. And further developed the world's first commercial heterogeneous fusion brain computing chip KA200 and HP series computing boards, providing a high-performance and efficient computing platform for mainstream AI application scenarios and brain science research.

In August 2023, Neurosoft, a Swiss company, successfully tested its flexible brain implant on a human body for the first time. Neurosoft's

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Comprehensive analysis and ranking of future industries

Neuroscience and Neuromorphic Intelligence

flexible brain implants have enormous potential to drive the development of brain analysis and stimulation fields. With further research and development, it is expected to play an important role in the treatment of various neurological diseases.

Future development trends

In the future, new imaging, neural monitoring and regulation technologies will promote the rapid development of various sub fields such as brain cognition, brain diseases, and neuromorphic intelligence. In addition, data governance and ethical safety supervision in the fields of neuroscience and neuromorphic intelligence will be increasingly valued.

a. The sub fields of Neuroscience and neuromorphic intelligence will continue to develop rapidly

In the field of cognitive research in the brain, efforts will be made to observe and analyze the encoding mechanisms of neural information at multiple levels, including brain regions, neural circuits, and neurons, in order to reveal how the brain performs its perceptual and cognitive functions. At the same time, the development process of the brain is also explored in the layer area of neurons and neural circuits.

For the research of brain diseases, we will focus on breakthroughs in several key areas in the future. The primary task is to analyze the pathogenesis of brain diseases throughout their entire lifecycle, striving to comprehensively explain the occurrence and development of diseases from multiple perspectives, including genes, brain networks, and individuals and populations. By establishing a disease trajectory model, the aim is to achieve early identification and prevention. At the same time, integrating in vitro experiments and clinical data, constructing predictive models, and using pluripotent stem cell technology to simulate the state of brain diseases provide a new perspective for disease research. Based on network level analysis of neuroimaging and advanced technologies such as brain computer interfaces, a perception intervention closed-loop control system for brain diseases is being constructed. In addition, searching for biomarkers with diagnostic and therapeutic value, establishing a quantitative evaluation system, will greatly improve the accuracy of diagnosis and treatment of brain diseases. The combination of AI and machine learning algorithms will bring revolutionary changes to the diagnosis and treatment of brain diseases.

In terms of neuromorphic intelligence, the future development trend will shift from "solely inspired by brain structure" to "inspired by both brain structure and function". In this process, "perceptual intelligence" and "cognitive intelligence" will collaborate to promote the transformation of intelligent technology from "specialized" to "universal". In the future, we will achieve deep integration of brain like structure and function, creating brain like intelligent products that mimic the brain at the structural level, approach the brain at the device level, and surpass the brain at the functional level.

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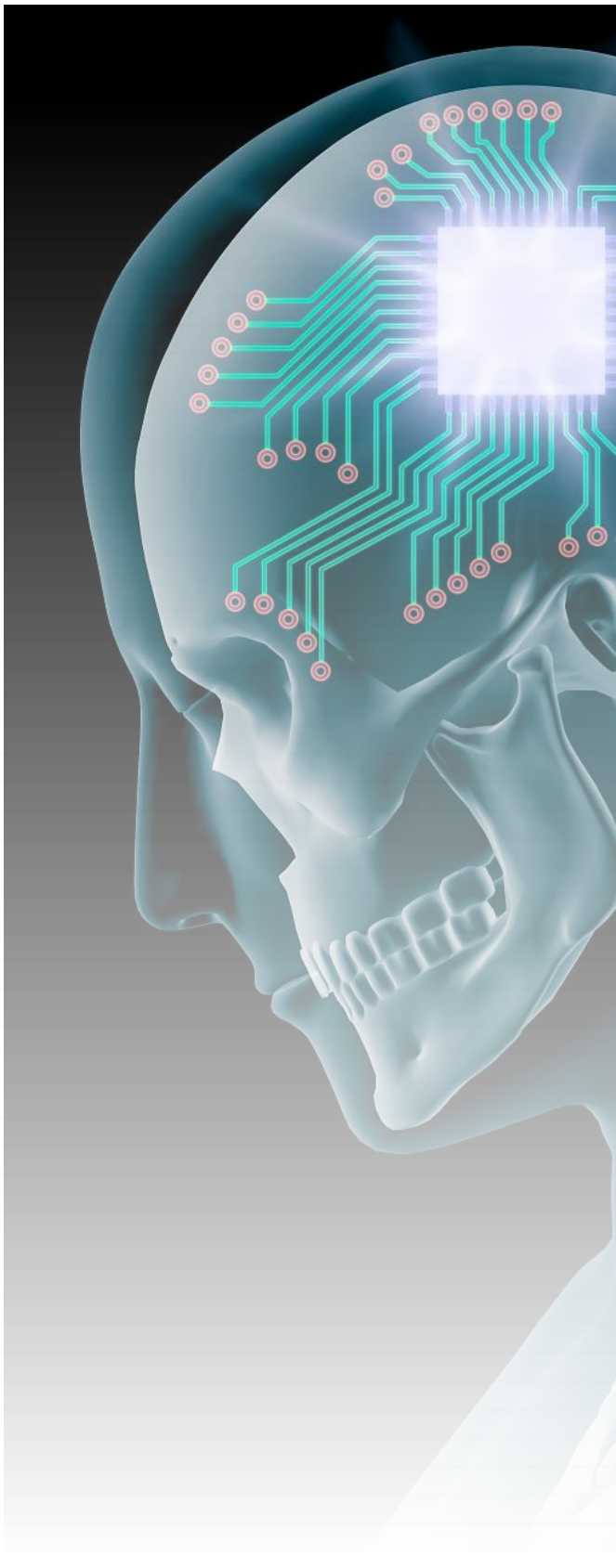
Comprehensive analysis and ranking of future industries

Neuroscience and Neuromorphic Intelligence

b. Data governance and ethical security supervision are receiving increasing attention

With the continuous advancement of neuroscience programs in various countries around the world, massive brain atlases and monitoring data have emerged. How to efficiently and safely utilize these data resources has become an urgent problem in the current field. This has also given rise to an urgent need for data governance. Looking ahead, the field of neuroscience will further increase its emphasis on data governance and strive to build a globally unified and coordinated data governance principle and framework. At the same time, neuroscience and neuromorphic intelligence technology, especially in the field of brain computer interfaces, also face many ethical and security challenges.

With the widespread application of brain like intelligent products, especially brain computer interfaces, ethical and security issues will become increasingly prominent. To address this challenge, countries must strengthen their regulatory efforts on ethical and safety issues, ensuring the harmonious development of technological innovation and social ethics.



City Ranking

Rank	City/ Metropolitan Area	Rank	City/ Metropolitan Area
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2	London	12	Kyoto-Osaka-Kobe
3	Beijing	13	Hangzhou
4	San Francisco-San Jose	14	Washington DC-Baltimore
5	Munich-Stuttgart	15	Guangdong-Hong Kong-Macao Greater Bay Area
6	Los Angeles	16	Seoul
7	Berlin	17	Amsterdam
8	New York	18	Toronto
9	Tokyo-Yokohama	19	Paris
10	Basel	20	Zurich

At present, based on the progress of global neuroscience and neuromorphic intelligence technology research. In terms of hardware, research institutions and related enterprises in various countries have successively developed various types of brain chips and brain like computers; In terms of software, research and development achievements such as algorithm frameworks and pulse neural networks have emerged. However, there are still deficiencies in the theoretical level of neuroscience, the technology of brain like computing systems is not yet mature, and brain like computing cannot fully simulate the diversity and variability characteristics of neurons. There is still a long way to go before it becomes mature.

The United States is one of the earliest countries in the world to consider neuromorphic intelligence as one of the major strategies for future development. It is also the country with the most mature brain science foundation and neuromorphic intelligence technology in the world, achieving an overall layout from basic theory to industrial application. Hardware layer advantage companies such as Intel and HP; Software layer advantage companies such as Numenta and Vicarious, as well as application layer companies represented by Neuralink, and other leading global companies in the field of neuromorphic intelligence, are mostly headquartered in the United States. Based on the ranking, the United States occupies five seats in the top 20 cities, occupying a dominant position in the industry.

Research on neuromorphic intelligence in China started relatively late compared to Europe and America, but has developed rapidly in recent years and gradually reached the international forefront level. At present, the research achievements in Chinese neuroscience and neuromorphic intelligence mainly include two aspects: the development of neuromorphic chips, the development of neuromorphic computers, and breakthroughs in neuromorphic computing theory. Overall, China is in the second tier of the neuroscience and neuromorphic intelligence industries, occupying four seats in the top 20 cities.

Enterprise ranking

Rank	Enterprise	Rank	Enterprise
1	Synchron	11	Inner Cosmos
2	Neuralink	12	NeuraMatrix
3	BrainCo	13	Neurotech
4	G-Therapeutics	14	NeuroXess
5	BrainUp Technology	15	Lifescapes
6	Synchron	16	NextMind
7	ClearPoint Neuro	17	FlowNeuroscience
8	Theranica	18	Neurcle
9	Cyberkinetics	19	Moshi
10	NeurosoftBioelectronics	20	MicroPort Neuro Tech

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Advanced Connectivity

Definition

Advanced connectivity is a fundamental component of social life. While 5G networks possess inherent flexibility, the evolution and transformation of society and the economy will present challenges that 5G networks may not be able to address. Therefore, it is necessary to transition to the 6G era to further expand connectivity capabilities.

With the development of new communication technologies in each generation, the focus of the network is constantly evolving. The focus of the 5G era is on connecting the Internet of Things and industrial automation systems, while the 6G era aims to integrate physical, digital, and human experiences. 6G is the organic integration of land mobile communication with high, medium, and low orbit satellites. It requires heterogeneous access to satellites, launch platforms, drones, ground cells, and other components to cater to different deployment scenarios and diverse business needs, achieving seamless global coverage and access for anyone, anywhere, and at any time. Among them, LEO broadband satellite Internet will become an integral part of 6G due to its wide coverage, high bandwidth, low delay, and lack of regional impact.

Summary of Outstanding Achievements in 2023

Satellite Internet has become the "commanding height" of the key industry in the space competition of large countries. It not only fills the significant gap in all-time, all-area, and all-space integrated communication, but is also a core "component" of building the next generation of 6G network technology. With significant progress in satellite launch and manufacturing technology, the communication network of ultra-low orbit giant satellites has garnered widespread attention from academia and industry, and non-terrestrial networks are widely regarded as an indispensable component of 6G networks.

In 2023, SpaceX successfully completed 98 launch missions. Among the 98 launches, 63 were satellite chain launches, accounting for 64.3%. A total of 1984 satellite chain launches were launched, and currently a total of 5650 satellite chain launches have been launched. With its record-breaking orbital launch achievements, SpaceX showcases to the world the endless possibilities and relentless pursuit of human space exploration.

China's two major LEO satellite Internet constellations, GW and G60, have applied for over 20,000 satellites. In July 2023, China successfully launched its first flat-panel type LEO broadband communication satellite, "Longjiang 3". This breakthrough satellite has mastered key technologies in LEO satellite ground high-speed communication and flat-panel satellite platforms, providing essential technical support for China's satellite Internet construction. Furthermore, several countries and enterprises are actively exploring more efficient satellite manufacturing and launch technologies to reduce costs and increase production capacity.

The European Union has established the 6G research and development group "HEXA-X", with 44 participating members including companies such as Nokia, Ericsson, Orange, Telekom Spain,

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Advanced Connectivity

and well-known universities like the University of Oulu in Finland. It is anticipated that by 2027, the European Union will invest approximately RMB 6.9 billion in the "6G Intelligence and Network Services" project, encompassing eight projects like HEXA-X, to research and develop the core technology of 6G, AI foundational technology, enhance service coverage, and network sustainability technology.

Future development trends

a. Deep Integration of 6G and AI: Implementing Collaborative Evolution of Networks and AI

One of the core features of future 6G mobile systems is network-intrinsic AI, which can be categorized into AI-enabled networks and networks enabled by AI. AI-empowered networks achieve end-to-end self-empowerment through air interface fusion, enhancing key metrics such as bandwidth, speed, and capacity. Networks enabled by AI achieve ubiquitous inclusiveness through mobile communication networks, leveraging the unique advantages of 6G to assist high-value scenarios, use cases, and businesses, ultimately realizing the overarching vision of "everything connected, digital twins".

b. Direct connection of Volkswagen mobile phones to satellites: fully leveraging the advantages of high and low orbit satellites, supporting diversified business scenarios

The integration of the earth and the sky achieves comprehensive integration between satellites and the ground. As a vital component of the satellite Internet, public mobile phone direct connection satellite services bring about genuine integration between the earth and the sky. With the evolution of technology and industry, it has been observed that high-orbit satellites suffer from limitations in terms of capacity, speed, and latency, whereas low-orbit satellites offer distinct advantages and have emerged as a key direction for future development. Furthermore, with the advancement of LEO technology and the maturing 3GPP NR NTN industry, mobile phone direct connections to LEO satellites based on 3GPP NTN technology are gradually becoming the new technological focus of satellite Internet.

c. Integration and interoperability of high and low orbit satellites: a key development direction for the future of satellite communication industry

In the realm of satellite communication, the convergence and interoperability of high and low orbit satellites are regarded as significant avenues for future development. High orbit satellites are renowned for their extensive coverage, long lifespan, stable signal, and straightforward networking attributes, whereas low orbit constellations are distinguished by their low latency, minimal link loss, high bandwidth, and cost-effectiveness, each with exceptional performance. By integrating high and low orbit satellites, the advantages of multiple orbits can be fully leveraged, providing flexibility and redundancy and thereby meeting the demands of future satellite communication.

d. The mutual empowerment and integration of satellites and clouds: becoming a future development trend

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Advanced Connectivity

In the future, close collaboration between satellite operators and cloud vendors will continue to intensify, leading to mutual technological and business empowerment. Currently, cooperation mainly focuses on reliable data transmission and satellite data processing. On one hand, the high-speed and low-latency satellite broadband provided by satellite operators offers a dependable communication channel for cloud resources. In the event of fiber optic disconnections and other network disruptions, satellite connections can serve as crucial network redundancy for cloud workloads, ensuring continuous access. On the other hand, ground-based cloud services provide robust technical support for satellite data processing. Additionally, the industry is actively promoting the research and development of processing-related technologies on satellites, with the long-term objective of directly enabling data sharing on satellites.

City Ranking

Rank	City/ Metropolitan Area	Rank	City/ Metropolitan Area
1	San Francisco-San Jose	11	Berlin
2	Beijing	12	Seattle-Tacoma-Bellevue
3	Guangdong-Hong Kong-Macao Greater Bay Area	13	New Delhi
4	San Diego	14	Paris
5	London-Oxford-Cambridge	15	Toronto
6	Seoul	16	Helsinki
7	Tokyo-Yokohama	17	Kyoto-Osaka-Kobe
8	Stockholm	18	Dallas-Fort Worth
9	Washington DC	19	Singapore
10	Suzhou-Wuxi-Changzhou	20	Bangalore

Currently, information and communication technology, particularly mobile communication technology, is thriving and has emerged as a significant driving force in accelerating the integration of the digital economy with the real economy. It continues to play a pivotal role in fostering global economic and social development, transforming industrial structures, and promoting technological iteration and innovation. On a global scale, 5G has entered a phase of widespread commercial deployment. According to data from the Global Mobile Suppliers Association, as of May 2023, 254 operators from 99 countries and regions around the world have launched commercial 5G network services. Simultaneously, with the evolution of mobile communication technology, 6G has become a focal point of global technological innovation. The top five cities in the advanced connectivity industry (MA) are San Francisco-San Jose, Beijing, Guangdong-Hong Kong-Macao Greater Bay Area, San Diego, and London-Oxford-Cambridge.

Enterprise ranking

Rank	Enterprise	Rank	Enterprise
1	HUAWEI	11	Verizon
2	Ericsson	12	Intel
3	NTT Docomo	13	Qualcomm
4	Samsung	14	NEC
5	Nokia	15	SK Telecom
6	SpaceX	16	China Satellite Network Grc
7	ZTE Connectivity	17	Orange
8	Starlink	18	Softbank
9	Viasat	19	China Telecom
10	HughesNet	20	BT

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Comprehensive analysis and ranking of future industries

Biotechnology

Definition

Biotechnology is a technology that applies the fundamental principles of biology, chemistry, and engineering to produce useful substances or provide certain services to humans using living organisms (including microorganisms, animal cells, and plant cells) or their components (organelles and enzymes). The core of biotechnology is genetic engineering centered around DNA recombination technology, which also encompasses fields such as microbial engineering, biochemical engineering, cell engineering, and biological products. As a rapidly advancing field, biotechnology is exerting profound impacts on our lives, and significant breakthroughs have been achieved in areas such as gene editing, synthetic biology, and biosensing technology.

Summary of Outstanding Achievements in 2023

a. Gene editing technology brings hope to diseases that are considered incurable

The approval of the Casgevy therapy based on CRISPR gene editing technology signifies the gradual transition of CRISPR gene editing tools from laboratory to clinical use in the treatment of sickle cell disease β. Significant breakthroughs have been achieved in the field of hereditary blood diseases such as thalassemia.

b. RNA technology is widely used in vaccine development, treatment of rare diseases, and optimization of medical applications

MSKCC in the United States has developed a novel personalized mRNA vaccine for the treatment of pancreatic ductal carcinoma, which has demonstrated promising safety and efficacy in phase I clinical research. Moderna has announced a collaboration with Merck to launch an mRNA-based skin cancer vaccine. The Institute of Microbiology at the Chinese Academy of Sciences has developed a monkeypox mRNA vaccine containing multiple antigens, and has optimized the manufacturing process of the multi-antigen mRNA vaccine.

c. AI enhances protein engineering and drives drug reuse

2023 is a pivotal year for biotechnology, marked by groundbreaking advancements in protein engineering, mainly driven by the integration of AI. Insilico Medicine, Adaptyv Bio, and other companies have developed generative AI models to explore protein sequences and structures through training on large datasets, generating artificial proteins that can be widely utilized in areas like disease treatment and plastic degradation. David Baker's protein design tool RoseTTAFold Diffusion, based on diffusion models, reimagines the structure and function of proteins.

Furthermore, AI has also discovered novel applications for the existing drug iMCD in treating rare diseases. This development represents a significant breakthrough, highlighting the potential of AI in identifying existing drugs and repurposing them for new therapeutic purposes. The University of Pennsylvania, the Kalman Disease Collaboration Network, Medidata, and Every Cure utilize AI algorithms to screen existing drugs, identifying

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Biotechnology

those that can be repurposed for rare diseases. This approach not only expedites the process of discovering treatment methods but also significantly reduces the financial costs associated with developing brand-new drugs from scratch.

Future development trends

The application and development prospects of biotechnology are accompanied by new breakthroughs in the life sciences. Modern biotechnology has been widely utilized in industries, agriculture and animal husbandry, medicine, environmental protection, and other fields. Nanobiology and PCR (polymerase chain reaction) technologies currently dominate biotechnology, while gene editing, CRISPR technology, and stem cell technology are seen as the future transformative forces, expediting disease treatment and research on genetically modified crops. Simultaneously, biotechnology is actively integrating AI and ML to accelerate the discovery and optimization of emerging technologies such as biomaterials, biological nanomaterials, biomass energy, and bioinformatics. Additionally, advancements in tissue engineering and bioprinting technology will lay the foundation for more effective and personalized treatment, enhancing the efficiency of biological testing and bioinformatics screening by creating high-precision 3D tissue models. In the future, the biotechnology industry will develop rapidly driven by technological innovation and cooperation models.

City Ranking

Rank	City/ Metropolitan Area	Rank	City/ Metropolitan Area
1	Boston	11	Tel Aviv
2	San Francisco-San Jose	12	Amsterdam
3	Geneva	13	Beijing
4	London-Oxford-Cambridge	14	Stockholm
5	Munich-Stuttgart	15	Berlin
6	San Diego	16	Copenhagen
7	Tokyo-Yokohama	17	Toronto-Burnaby
8	Zurich	18	Suzhou-Wuxi-Changzhou
9	Washington DC-Baltimore	19	Shanghai
10	New York	20	Singapore

The top five biotechnology industry hubs are Boston, San Francisco-San Jose, Geneva, London-Oxford-Cambridge, and Munich-Stuttgart. Among the top 20 cities, eight belong to Europe, six to the United States, and four to Asia. Overall, the United States leads the global biotechnology industry, boasting the world's most successful biotechnology companies and advanced technology. Compared to the United States, Europe and Asia have lower levels of biotechnology. In Europe, the biotechnology industry is mainly concentrated in countries such as Germany, the United Kingdom, the Netherlands, and Sweden. In Asia, it is mainly concentrated in countries such as Japan, China, and Singapore.

The Asian cities on the list are Tokyo-Yokohama, Beijing, Singapore, and Shanghai, ranking 7th, 13th, 19th, and 20th respectively.

Enterprise ranking

Rank	Enterprise	Rank	Enterprise
1	Novo Nordisk	11	Chugai Pharmaceuticals
2	Thermo Fisher Scientific	12	Biogen
3	Amgen	13	Lonza
4	CSL	14	Samsung Biologics
5	Gilead Sciences	15	Agilent Technologies
6	Vertex Pharmaceuticals	16	Seagen
7	Regeneron Pharmaceuticals	17	Illumina
8	Daiichi Sankyo	18	Jiangsu Hengrui Medicine
9	Moderna	19	Sun Pharmaceuticals
10	WuXi AppTec	20	Beigene

Conclusion

The future industry has become a focal point of competition among major powers, especially on a global scale, where the competition between developed countries and emerging economies for future industries is gradually intensifying. Numerous new concepts, technologies, and fields, including quantum technology, neuroscience, AI, unmanned technology, metamaterials, aerospace and ocean, are constantly emerging. In response to this trend, countries have formulated industrial policies, provided more resources and support, and established the future industry as the "main battlefield" for governments and enterprises to compete in.

The competition in the digital economy is becoming increasingly fierce, and AI has emerged as its core industry, particularly the application of large models, making it a critical area of industrial competition among major countries. In this field, seizing the first-mover advantage in AI technology and industry, and establishing technological and industrial barriers, will help to secure a commanding position in future international competition. Developed countries have built solid technological barriers and advantages through years of technological accumulation and continuous investment from international giants, and hold a leading position in the application and industrial landing of AI. With the continuous expansion of commercial applications, AI technology is expected to become the core driving force of the digital economy and enter an explosive development stage, leading to increasingly fierce competition in the AI industry.

Concurrently, the scale of green industries will continue to expand. As global carbon neutrality goals are gradually implemented and governments invest increasingly in green and low-carbon sectors, the global green industry is expected to further grow. The Ukrainian crisis has intensified pressure on Europe's energy structure transformation, prompting Europe and America to accelerate their comprehensive shift towards clean energy. Moving forward, the international energy industry will undergo structural changes, and nuclear energy is anticipated to become one of the main forms of energy in the future. To continue promoting the development of nuclear energy, various countries have formulated a series of incentive policies, including the "Future Roadmap of Nuclear Fusion Energy" released by the US Department of Energy, the "European Nuclear Fusion Research and Development Roadmap" of the EU, and Japan's "Nuclear Fusion Energy Plan". These policies will drive the advancement of the nuclear energy industry.

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