Thematic Report on Chinese American Contributions: Science and Technology
Science and technology are cornerstones of the US economy. The nation’s leadership in scientific research and innovation has cemented its global economic and geopolitical leadership in the decades since World War II. Chinese American scientists and innovators have been an important driving force of these achievements. In an era of rapid scientific and technological evolution, they hold the promise to continue to make exceptional contributions that support the US economy and benefit society.
Overview

As of 2018, 15% of working Chinese Americans are employed in the occupations of life, physical and social sciences, computing and mathematics, and architecture and engineering—nearly three times as high as the percentage of Americans in general who work in these fields. Chinese Americans also have outsized representation in the pursuit of education in science and engineering. Between 1998 and 2018, more than 288,000 Chinese American students obtained bachelor’s degrees or above in science, technology, engineering and mathematics (STEM) subjects (Figure 1). STEM subjects made up 37% of all degrees awarded to Chinese Americans in this period; in comparison, only 21% of all degrees earned by Americans in general were in STEM subjects. Since 1998, the number of STEM degrees earned by Chinese Americans has increased notably, rising at a compound annual growth rate of 3.8%—one-quarter higher than the overall rate among US students (Figure 2).

As a result of their engagement in scientific research and technological development, Chinese Americans also have an outsized representation in professional societies that recognize and honor prominent scientists and innovators. One in 25 living members of both the National Academy of Engineering (NAE) and the National Academy of Sciences (NAS) is Chinese American. While active across different fields, Chinese American members of these societies have been particularly accomplished in physics, mathematics, biological and biomedical sciences, electronics, communications and information systems, mechanics and materials. As leaders in their fields, they have developed truly paradigm-shifting advances, ranging from groundbreaking developments in electronics and information systems, to breakthroughs in medicine, and feats of aerospace engineering.

The past century has seen remarkable increases in Chinese Americans’ contributions in science and technology, thanks in part to the repeal of major discriminatory laws and anti-immigration policies beginning in the 1940s and the growing number of Chinese people who came to study in the US in the postwar period—first from Taiwan and Hong Kong and later from mainland China—eventually becoming US citizens. The increasing integration of Chinese Americans into the US scientific community is evident in the growth in the number of Chinese Americans elected as members of NAE and NAS (Figure 3), following in the footsteps of figures including Chien-Shiung Wu, dubbed the “Queen of Nuclear Research” and “The First Lady of Physics,” who in the 1950s became one of the first elected Chinese NAS members.

Chinese American scientists and researchers have made substantial contributions across critical disciplinary fields and historical eras that have shaped today’s economic and industrial landscapes—ranging from the Space Age to the rise of the Digital Age and the Fourth Industrial Revolution.
Annual STEM education completion among Chinese Americans by degree level, 1998-2018

Sources: Department of Education, IPEDS Completions Survey; The Economist Intelligence Unit analysis.
Data includes both citizens and permanent residents.

Compound annual growth rates of education completion (Bachelor’s degree and above) by STEM Field\(^3\), 1998-2018

Sources: Department of Education, IPEDS Completions Survey; The Economist Intelligence Unit analysis.
Data includes both citizens and permanent residents.
The Space Age (1950s–present)

Amid a growing rivalry with the Soviet Union in the 1950s, the US government increased investment in science and technology to meet challenges at multiple frontiers, including space exploration. Since then, the US has not only claimed the victory in the so-called space race but established its preeminence in space, despite growing challenges from Russia and China. Space exploration has also fostered innovation and brought about breakthroughs in medicine, new materials and industrial techniques.\textsuperscript{11}

Chinese Americans have contributed to the US’s progress in space exploration from the beginning. During the 1960s, Wen Tsing Chow, an engineer, made groundbreaking advancements in the fields of computer-guided navigation and systems engineering, playing a key role in verifying the guidance equations and software implementation for NASA’s Gemini manned spaceflight program.\textsuperscript{12} Mr Chow’s pioneering use of photochemical circuitry enabled the miniaturization of computer components in guidance systems, which established the use of digital computers in missiles and spacecraft. Mr Chow’s work also paved the way for further microminiaturization, as is used in many technology products today.\textsuperscript{13}

In the 1960s-1970s, Chang-Lin Tien, a world-class mechanical engineer, helped to develop the insulating tiles for the space shuttle and was also an important contributor to the design of the rocket boosters used to catapult satellites into space in the Saturn space rockets.\textsuperscript{14} To date, Saturn V, which transported the Apollo 11 astronauts, remains as the only vehicle to transport human beings beyond low Earth orbit.\textsuperscript{15}
In addition to important engineering work on the ground, Chinese Americans have also made contributions in space. In 1985, Taylor Wang became the first person of Chinese descent to go into space as one of a seven-man crew on the Challenger space shuttle that undertook the first operational Spacelab mission, with the goal of conducting primary scientific experiments in space. The research conducted by Dr Wang and his fellow crewmembers would ultimately inform the creation of a permanent research lab orbiting the Earth.16 The crew completed 15 scientific investigations during a seven-day mission, establishing important precedents for experimental design in space.17 Following Dr Wang’s mission, four other Chinese American astronauts, Ed Lu, Leroy Chiao, Franklin Chang-Diaz and Kjell Lindgren, have undertaken space missions. Altogether, they spent 559 days (equivalent to nearly 19 months) in space.18

These prominent figures were only representatives of numerous Chinese American scientists and engineers working on basic and applied research to support space exploration. Today, one in 25 aerospace engineers in the US is Chinese American, and one in 20 aerospace engineers in the aerospace manufacturing industry is Chinese American.19 As the global space industry is projected to generate revenue of more than US$1 trillion by 2040—nearly triple the current level— their work and innovation will help to sustain the US’s position in this fast-growing market.20

The Digital Revolution (1960s–present)

Today, very few Americans can imagine life without mobile devices, computers or the internet. The digital world in which we live has been driven by breakthroughs in semiconductor and computing power made in the 1960s, the invention and evolution of the internet and personal computers in the 1970s-2000s, and the rise and proliferation of smart devices and social media since then.
Chinese American scientists and innovators, together with their peers, have made outsized contributions in these areas. Today, one in ten of NAE’s elected members in the field of electronics, communication and information is Chinese American. Two in 25 (7.8%) electrical and electronics engineers and materials engineers working in the manufacturing of computer, communications, and electronic components and parts are Chinese American.

The digital revolution would have been impossible without breakthroughs in semiconductor technology. Chih-Tang Sah was among the leading figures in the 1960s who drove breakthroughs in integrated circuit chips, enabling computing advances. In 1963, when working at Fairchild Semiconductor Corporation, Dr Sah invented the complementary metal-oxide-semiconductor (CMOS) device fabrication process with Frank Wanlass. Today, CMOS technology is used to manufacture more than 90% of integrated circuits, which have revolutionized the electronics industry, paving the way for mobile phones, computers, televisions, and the array of consumer electronics products that are integral parts of American life today.

Since Dr Sah’s influential work in the 1960s, a number of other Chinese American scientists and researchers have made notable accomplishments. The best-known examples among them include:

• Chenming Hu, whose seminal work on metal oxide semiconductor (MOS) reliability and device modeling has had an enormous impact on the continued scaling of electronic devices, enabling smaller yet more functional and higher-performance integrated circuits;

• Robert S Chau, who has played a key leadership role at Intel in advancing revolutionary changes in transistor technology that enable smaller, faster, and more energy-efficiency microprocessors; and

• Burn Jeng Lin, a leading figure in semiconductor manufacturing renowned for his contributions to lithographic manufacturing.

All three are recent winners of the Institute of Electrical and Electronics Engineers Jun-ichi Nishizawa Medal (in 2009, 2012 and 2013 respectively), in recognition of their outstanding contributions in semiconductor technology.

Since the internet became mainstream in the 1990s, Chinese Americans have been active in unleashing its potential to revolutionize the ways in which people live and work. In the San Francisco Bay Area, which encompasses Silicon Valley, about one in five software developers and computer and information research scientists is Chinese (both citizens and non-citizens), and one in ten is Chinese American.

Among the pioneers was Jerry Yang, who created Yahoo together with David Filo in 1994. Yahoo soon became the first popular online directory and search engine, inspiring many
to pursue similar success, including the founders of Google and Facebook. More recently, Steve Chen co-founded YouTube in 2005, which became the world's leading platform for online video sharing and viewing, revolutionizing the way that people consume media.

In 2011, Eric Yuan founded Zoom Video Communications, which has helped to reshape the way that people communicate in both their personal and professional lives. Zoom has played an important role in enabling social and business communications during the COVID-19 pandemic—in just the first quarter of 2020, Zoom witnessed its daily active user numbers balloon from 10m to more than 200m.28

As the world becomes increasingly digitalized, cybersecurity is more important than ever. According to the FBI, cybercrime cost US businesses and individuals US$3.5bn in 2019.29 To tackle this problem, some Chinese Americans are leading the way in development of and access to cybersecurity tools. Fortinet, a multi-billion-dollar firm led by Ken Xie, is a global leader in providing services to businesses, and, in the process, helping to combat the threat of hacking domestically and abroad.30

In addition, Mr Xie is a founding partner of the World Economic Forum (WEF) cybersecurity and digital trust platform, and has established the WEF’s Cybersecurity Learning Hub, an initiative that provides free education designed to address the global deficit in the cybersecurity workforce.31 With this work, Mr Xie is helping to build the relevant skills among future generations, ensuring that businesses and individuals in the US can defend against the growing threat of cybercrime and hacking.

The Fourth Industrial Revolution (2010s–present)

The so-called Fourth Industrial Revolution is a confluence of technological breakthroughs that have taken place in the past decade in fields including artificial intelligence (AI), robotics, the Internet of Things, biotechnology, 3-D printing and autonomous vehicles, among others.32 Together, these technologies hold the potential of disrupting every industry and transforming entire systems of production, management and governance. Whether the US can stay at the forefront of technological development as these technologies take hold will determine its global status in the coming decades.

Chinese American scientists and researchers have been at the heart of advancing these technologies. Working in AI and machine learning, Fei-Fei Li, a computer scientist and professor at Stanford University, has been described as bringing “humanity to AI.” Dr Li was elected by the NAE in 2020 in recognition of her contribution in “building large knowledge bases for machine learning and visual understanding.”33,34

Andrew Ng is another leading computer scientist in this area; Dr Ng founded and directed the Google Brain Deep Learning Project in the early 2010s. The AI and machine learning
technologies that Dr Li, Dr Ng and countless other researchers are developing have enormous implications for transforming economic activities and enhancing social wellness, including through fraud detection, drug development, and real-time monitoring of food production and energy infrastructure, among others.\(^3^5\)

In bioengineering, Yulun Wang invented the first FDA-approved surgical robot, a voice-controlled robotic arm that can hold and move a laparoscope (a tool used in keyhole surgery) for a surgeon.\(^3^6\) Dr Wang also developed the ZEUS robotic surgical system, which performed the world’s first trans-Atlantic surgery. His current research aims to integrate telemedicine interfaces with AI data, allowing physicians to virtually detect patient vital signs automatically and with greater precision. More broadly, telemedicine and virtual healthcare enable patients to communicate directly with doctors instead of visiting emergency rooms or hospitals, which greatly improves patient access and convenience while lowering costs for all involved parties.\(^3^7\)

As the advances constituting the Fourth Industrial Revolution unfold, Chinese American scientists and researchers will continue to play an important role in driving the US progress. As of 2018, an estimated one in 25 American graduates with a bachelor’s degree or above in disciplines that are core to Fourth Industrial Revolution technologies—including computer science, mathematics, biological and biomedical science, and engineering—is Chinese American.\(^3^8\)
Investigation of Chinese American scientists

Since the 1950s, scientists of Chinese descent working in the US have tended to be suspected of and even charged with spying for China. Some cases involved real espionage or fraud; in many other cases, however, charges against Chinese Americans suspected of intellectual property theft were later downgraded or dismissed. An analysis of 136 cases brought under the Economic Espionage Act between 1997 and 2015 found that 21% of Chinese and 22% of Asian defendants were ultimately not convicted of espionage or other major crimes, about twice the rate of defendants from other ethnic groups. The high rate of false accusation of Chinese American scientists has prompted widespread objections to FBI conduct.

The history of federal investigation into Chinese American scientists aligns with historical patterns of discrimination against Asian Americans, dating from the Chinese Exclusion Act of 1882 to the internment of Japanese Americans during World War II. During the Cold War, the FBI ran a program dedicated to surveilling Chinese scientists, including those who were US citizens. Documents obtained through the Freedom of Information Act show an early tendency within the US national security establishment to assume that major scientific advances in China were the product of theft by Chinese American researchers, logic that would inform cases for decades to come.

Perhaps one of the most notorious false accusations was a case involving Wen Ho Lee, a physicist at Los Alamos National Laboratory in New Mexico, in 1999. Dr Lee was charged
with sending US nuclear secrets to China and held in solitary confinement for nine months. Eventually, the case against Dr Lee unraveled, and in September 2000 he was acquitted of 58 of the 59 charges against him; he was later awarded US$1.6m in damages. The case prompted a congressional investigation and sparked a national conversation. Nonetheless, stereotyping, undue process and bad analysis endured, and Chinese American scientists continue to be investigated.

In recent decades, as China’s scientific knowledge and spending have grown, many American universities and agencies have encouraged collaboration between the two countries to facilitate public, shared access to innovative research and promote global scientific advancement. Regrettably, improper investigative procedures and ethnic stereotyping have led, too often, to hasty conclusions that information shared in the spirit of public collaboration constituted illegal espionage.

In May 2015, Dr Xiaoxing Xi, a Temple University physics professor and a naturalized American citizen, was arrested for allegedly spying for China, but was ultimately cleared of all charges. This case prompted more than 40 members of Congress, including Ted Lieu, Judy Chu, and Keith Ellison, to call on the US Attorney General to investigate whether race or ethnicity played a role in the accusations of espionage faced by Chinese American scientists.

Most recently, since 2018, the National Institutes of Health (NIH) has sent nearly 190 letters to more than 80 US institutions about individual scientists that it believes have broken NIH rules on research funding. The NIH’s requests have reportedly targeted scientists who are ethnically Chinese: 82% of all scientists investigated were of Asian ancestry—causing fears among Chinese American scientists about racial profiling and concerns among the broader community about its potential damage to US scientific leadership (there is more information on the NIH investigations in the Public Health report).

**Conclusion**

The world is evolving rapidly into the new industrial era while facing growing pressure from challenges ranging from climate change and resource scarcity to aging populations and increasing health risks. As such, scientific and technological innovation will remain central to American economic growth, national security interests and societal development. With their commitment to scientific research and innovative technologies, Chinese Americans can continue to make significant contributions as the US seeks to sustain and reinforce its competitiveness in the coming decades.
1 US Census Bureau, 2018 American Community Survey 1-year estimates, public use microdata sample (PUMS); The Economist Intelligence Unit analysis.
2 Including both citizens and permanent residents.
3 Including biological and biomedical sciences, computer and information sciences, engineering and engineering technologies, mathematics and statistics, physical sciences, psychology and agriculture-related sciences.
4 Department of Education, IPEDS Completions Survey; The Economist Intelligence Unit analysis. Data includes both citizens and permanent residents.
5 National Academy of Engineering member directory; National Academy of Sciences member directory; The Economist Intelligence Unit analysis based on typical Chinese family names.
6 National Academy of Engineering member directory; National Academy of Sciences member directory; The Economist Intelligence Unit analysis based on typical Chinese family names.
9 “Science” includes physical sciences, biological and biomedical sciences, psychology and agricultural-related sciences; “Technology” includes computer and information sciences; “Engineering” includes engineering and engineering technologies; “Mathematics” includes mathematics and statistics.
10 Including both living and deceased members.
13 “Mr. Wen Tsing Chow”
19 US Census Bureau, 2018 American Community Survey 5-year estimates, PUMS; The Economist Intelligence Unit analysis.
21 National Academy of Engineering membership directory; The Economist Intelligence Unit analysis.
22 US Census Bureau, 2018 American Community Survey 5-year estimates, PUMS, The Economist Intelligence Unit analysis.
27 US Census Bureau, 2018 American Community Survey 5-year estimates, PUMS, The Economist Intelligence Unit analysis.

34 “Professor Fei-Fei Li,” National Academy of Engineering, accessed August 18, 2020, https://nae.edu/224664/Professor-FeiFei-Li.


38 Department of Education, IPEDS Completions Survey; Economist Intelligence Unit estimates. Data includes both citizens and permanent residents.


43 Hvistendahl, “The FBI’s China Obsession.”


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