

THE 2018 NOBEL LAUREATES AND FOREIGN-BORN SCHOLARS IN THE U.S. HIGHER EDUCATION SYSTEM

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“Science and education are borderless.”

Karin Olofsdotter, Ambassador of Sweden to the United States

Executive Summary

Each year, the Nobel Prize is awarded to outstanding individuals in the fields of Economics, Physics, Medicine or Physiology, Chemistry, Literature, and Peace. Unlike in prior years, in 2018, none of the American winners were foreign-born individuals who immigrated to the United States or who were working at a U.S. institution at the time they won. But the United States did play an important role in their formation; nine of the twelve 2018 Nobel Laureates were either students, teachers, or research fellows at U.S. institutions of higher education at some point in their lives, even if they were not born in the United States. Three of the 2018 Nobel Laureates were foreign-born academics who spent considerable time at U.S. institutions. Originally from Canada, Dr. Donna Strickland was on staff at Princeton University and at the Lawrence Livermore National Laboratory after earning her doctoral degree at the University of Rochester. Her fellow 2018 Laureate in Physics, French-born Dr. Gerard Mourou, was also at the University of Rochester. Finally, Japanese-born immunologist Dr. Tasuku Honjo was a visiting fellow at the Carnegie Institution of Washington and then the U.S. National Institutes of Health for seven years, and was later elected to the U.S. National Academy of Sciences as a foreign associate.

Their stories are the stories of dozens of foreign-born Nobel Prize Laureates and other gifted scientists who came to the United States to follow their dreams of knowledge and of genuine contribution to the wellbeing of humankind.

Key Findings

Foreign-born individuals who immigrated to the United States have historically represented an important share of Nobel Prize winners. In 2018, nine of 12 Nobel Prize winners were affiliated with U.S. institutions of higher education at some point in their lives. Of these nine, three are foreign-born individuals who studied and worked in the United States.

U.S. institutions of higher learning have provided the world's best scientists and researchers with the human and physical resources and research environments necessary to reach the highest echelons of scientific discovery and innovation.

Constant international travel and international collaboration are characteristics of highly-skilled individuals and is the nature of advanced science.

Foreign-born individuals receive a large share of the PhDs granted by U.S. universities, particularly in the Science, Technology, Engineering, and Math (STEM) fields. Foreign-born PhD recipients with temporary visas outnumbered U.S. citizens and permanent residents in the fields of engineering and mathematics, and computer sciences in 2016, according to data from the U.S. National Science Foundation's Survey of Earned Doctorates (SED).

Foreign-born individuals who hold a PhD represent large shares of workers in occupations in the Nobel Prize fields of physics, chemistry, medicine and economics. Overall, in the United States, 52.2 percent of workers in these occupations are foreign-born.

Changes to U.S. immigration policies and attitudes may negatively impact foreign scholars' ability to study, work, and conduct research in the United States. By restricting the admission of foreign nationals, the United States may be effectively closing the door on the next Nobel Prize winner and impeding important research and scientific discoveries. This means that future Donna Stricklands, Gerard Mourous, and Tasuku Honjos may not have the opportunity to study and conduct research in the United States.

Introduction

Each year, the Nobel Prize is awarded to outstanding individuals whose actions contribute to the benefit of humankind. Since 1901, the prizes have been given in the fields of Physics, Medicine or Physiology, Chemistry, Literature and Peace. In 1968 a sixth prize was added, the Sveriges Riksbank Prize in Economic Sciences. In past years, the Institute for Immigration Research (IIR) has looked at American Nobel Laureates who were immigrants* to this country. This year however, none of the American winners were foreign-born individuals who immigrated permanently to the United States or were at a U.S. institution at the time they received the award.

But the United States did play an important role in the intellectual development of the Nobel Laureate class of 2018; in fact, most of the 2018 Nobel Laureates were either students, teachers, or research fellows at U.S. institutions of higher education at some point in their lives, even if they were not born in the United States and did not immigrate here permanently. Six of the 2018 Nobel Laureates were originally from the United States and pursued their studies here. Three of the foreign-born Nobel Laureates spent time at U.S. institutions. Born in Canada, Dr. Donna Strickland was on staff at Princeton University and at the Lawrence Livermore National Laboratory, after earning her doctoral degree at the University of Rochester where she worked with her fellow 2018 Laureate in Physics, Professor Gerard Mourou. Dr. Mourou, who was also affiliated with the University of Michigan, was born in Albertville, France. The third such Laureate this year was the Japanese-born immunologist Dr. Tasuku Honjo, who shared this year's Nobel Prize in Physiology or Medicine with James P. Allison, an American-born immunologist at the University of Texas at Austin. A long-time collaborator of Professor Allison, from 1971 through 1977 Dr. Honjo was a visiting fellow at the Carnegie Institution of Washington and then the National Institute of Child Health and Human Development at the U.S. National Institutes of Health (NIH). Since 1992 Dr. Honjo has spent many years as an NIH Fogarty Scholar in Residence and, in 2001, was elected to the U.S. National Academy of Sciences as a foreign affiliate.

Their stories are the stories of dozens of foreign-born Nobel Prize Laureates and other top scientists who came to the United States to follow their dreams of knowledge and of genuine contribution to the wellbeing of humankind. As Karin Olofsdotter, current Ambassador of Sweden to the United States, mentioned in her opening remarks at the 2018 Symposium with American Nobel Laureates, "Science and education are borderless."

This realization that science and education are borderless has long been at the heart of the American education system and has shaped the advancement of science since the time of Thomas Jefferson and Benjamin Franklin. Today's higher education system thrives in the cultural, intellectual, and economic contributions of foreign-born students and faculty, just as the United States has benefitted from immigrants over the course of history.

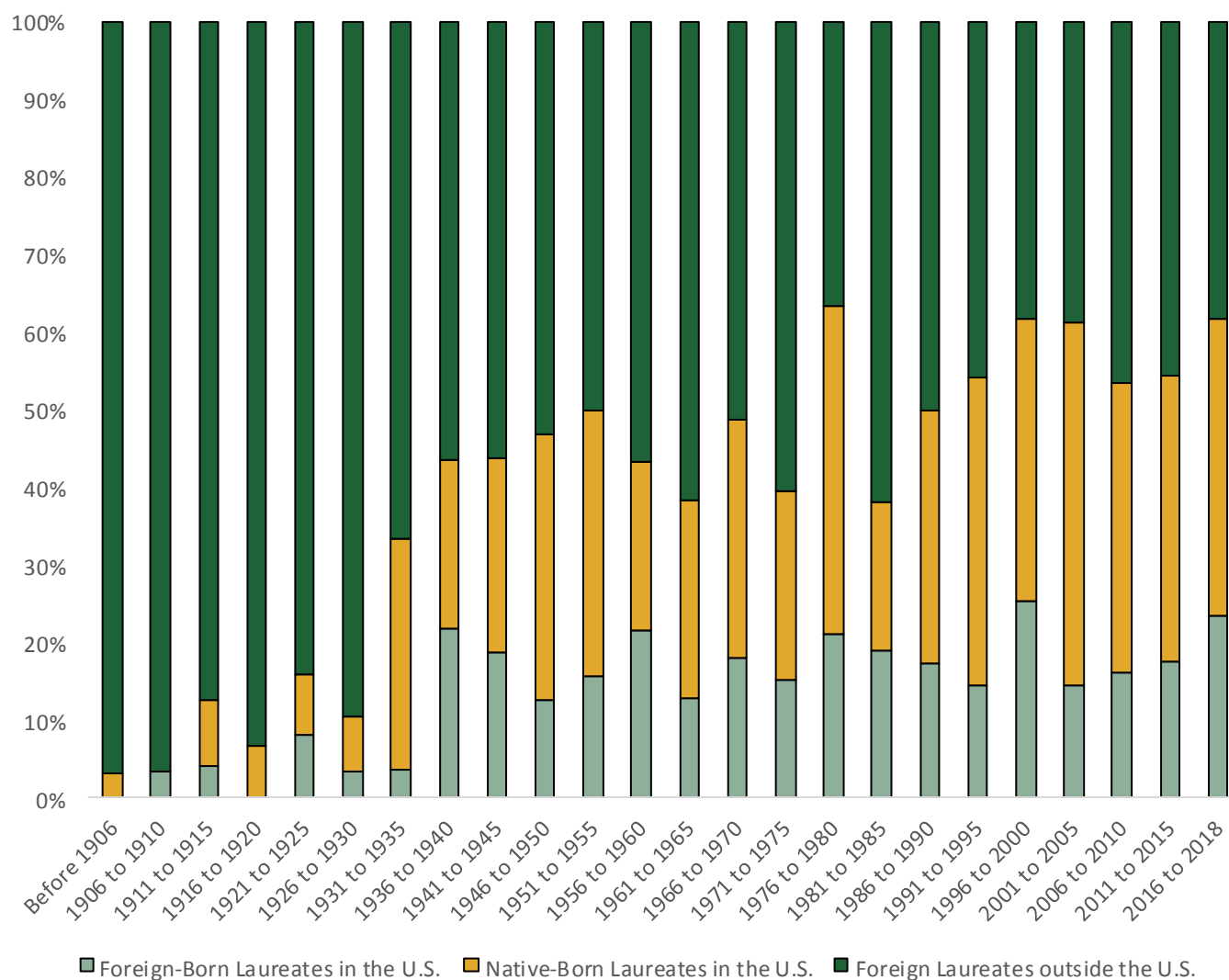
This study analyzes the role that U.S. institutions of higher education have played in the lives of the 2018 Nobel Laureates as well as countless others who have come to the United States to follow their dream of advanced knowledge and science. However, our findings also raise the question: is this dream threatened?

* Please note that the terms "immigrant" and "foreign-born" are used interchangeably throughout this report. Foreign-born refers to individuals who are not a U.S. citizen at birth or who were born outside the U.S., Puerto Rico or other U.S. territories and whose parents are not U.S. citizens. The foreign-born may include naturalized U.S. citizens, Legal Permanent Residents, temporary residents, refugees and asylees, and others. Native born includes those who are U.S. citizens at birth, those born in the United States, Puerto Rico, or other U.S. territories, and those born abroad to a parent who is a U.S. citizen.

Immigrant Nobel Prize Winners Throughout the Years

Beginning in the late 1930s, foreign-born individuals who immigrated to the United States and were in the United States when they received the Nobel Prize have historically represented an important share of U.S. Nobel Prize winners (see Figure 1). In 2017, for example, two of the eight Nobel Prize Laureates from the United States were foreign-born individuals. In 2018 however, none of the U.S. Nobel Laureates were foreign-born individuals who immigrated permanently to the United States or were at a U.S. institution at the time they received the award.

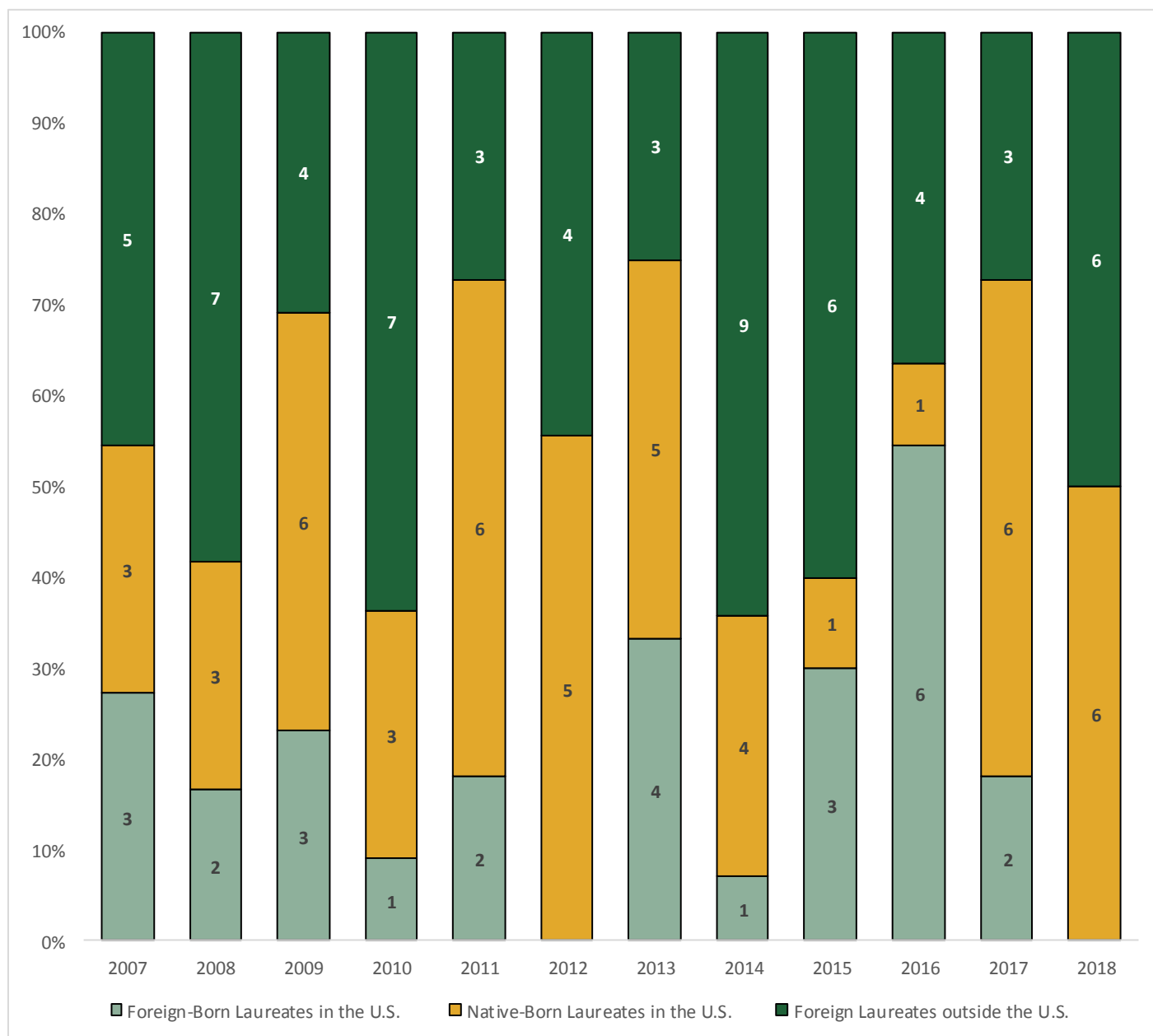
Figure 1. Percentage of U.S. Born and U.S. Immigrant Nobel Laureates Compared to Total Nobel Laureates, 1901-2018



Source: IIR Analysis of Nobel Prize Winners data 2018: All Nobel Prizes. NobelPrize.org. Nobel Media AB 2018. Accessed November 30, 2018. <https://www.nobelprize.org/prizes/lists/all-nobel-prizes/>

Figure 2 provides additional information about the winners in the last 12 years. In each year except 2012 and 2018, there were immigrants among the U.S. winners. In 2016, six of the seven winners from the United States were foreign born. In 2013, four of the nine U.S. winners were foreign-born, and two of the three non-U.S. winners were foreign-born individuals who, at some point in their lives, were associated with U.S. institutions of higher education.

Figure 2. U.S.-Born and Foreign-Born U.S. Nobel Laureates, 2007-2018



Source: IIR Analysis of Nobel Prize Winners data 2018: All Nobel Prizes. NobelPrize.org. Nobel Media AB 2018. Accessed November 30, 2018. <https://www.nobelprize.org/prizes/lists/all-nobel-prizes/>

The Foreign 2018 Nobel Prize Laureates and U.S. Institutions of Higher Education

In 2018, nine of the 12 Nobel Prize winners had ties to institutions of higher education in the United States, including three winners from other countries – Donna Strickland, Gerard Mourou and Tasuku Honjo. For those with U.S. ties, the physical and human resources found in these U.S. institutions were important to their research and helped them in their pursuit of the Nobel Prize (A biography of all other 2018 Nobel Prize Winners is found in Appendix A).

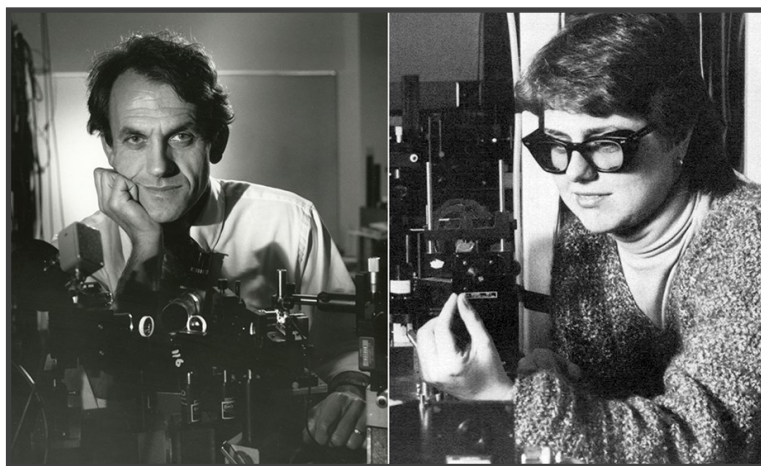
Nobel Prize in Physics

The Nobel Prize in Physics was awarded for groundbreaking inventions in the field of laser physics.¹ The award was split between three researchers: Canadian Donna Strickland, French Gerard Mourou, and American Arthur Ashkin.

Donna Theo Strickland was born in Guelph, Canada in 1959. She received her Bachelor of Engineering degree from McMaster University in Canada and a Masters' Degree and a PhD in Physics from the University of Rochester in New York. This is where she developed her research into Chirped Pulse Amplification (CPA) that led to her Nobel Prize alongside Gerard Mourou, who was her doctoral supervisor.² After receiving her PhD in 1989, she worked in the laser division of the Lawrence Livermore National Laboratory and at the Advanced Technology Center for Photonics and Opto-electronic Materials at Princeton University. She is now an Associate Professor in the Department of Physics and Astronomy at the University of Waterloo in Canada.³ Donna Strickland was the first woman in 55 years to win the Nobel Prize in Physics and the third woman in history after Maria Goeppert Mayer in 1963 and Marie Curie in 1903.

Gerard Albert Mourou was born in 1944 in Albertville, France. He received his Bachelor of Science Degree from the University of Grenoble, his Master of Science degree at the Ecole Polytechnique, and his PhD at the Pierre and Marie Curie University in 1973. After receiving his PhD, he became a professor at the University of Rochester in New York in 1977. There he met Donna Strickland. Their work in the Laboratory of Laser Energetics at the University of Rochester led to the creation of the CPA for which they were both awarded the Nobel Prize in Physics.⁴ Mourou later became A. D. Moore Distinguished University Professor Emeritus of Electrical Engineering and Applied Physics at the University of Michigan in 1990 and is currently a professor at the Ecole Polytechnique in France. At the University of Michigan, he founded the Center for Ultrafast Optical Science (CUOS), a National Science Foundation Center of Excellence.⁵

Dr. Gerard Mourou and Dr. Donna Strickland



Source: University of Rochester Newscenter, photos from 1987 and 1985, respectively.

Nobel Prize in Physiology or Medicine

The Nobel Prize in Physiology or Medicine was awarded jointly to Tasuku Honjo of Japan and American James P. Allison for their discovery of cancer therapy by inhibition of negative immune regulation.⁶

Tasuku Honjo was born in Japan in 1942. He earned his medical degree in 1966 and his PhD in Medical Chemistry in 1975, both at Kyoto University. From 1971 to 1974, he was a research fellow at the Carnegie Institution for Science, Baltimore. There he conducted research at the Brown Lab of the Department of Embryology. From 1974 to 1977, he researched immunology at the National Institute of Child Health and Human Development at the National Institutes of Health (NIH) in Bethesda, Maryland. During this time, he was also a faculty member at Tokyo University. In 1992 he also joined the NIH Fogarty International Center as a scholar. His research and work led to the identification of the Programmed Cell Death Protein (PD-1).⁷ Thanks to his research, treatments have been developed to modulate PD-1 proteins in immune cells to allow the immune system to attack certain cancers including lung cancer, renal cancer, melanoma, and lymphoma.⁸ This discovery, together with that of the CTLA-4 T-cell protein by American James P. Allison, has led to cancer treatments that have been effective against certain types of cancer.⁹ Dr. Honjo is currently a professor at the Kyoto University Department of Immunology and Genomic Medicine. He is an honorary member of the American Association of Immunologists.

Dr. Tasuku Honjo and His Students at Kyoto University after Hearing That He Was Awarded the Nobel Prize



Source: The Nobel Prize official website gallery – Tasuku Honjo, Kyoto University

Figure 3. 2018 Nobel Prize Laureates and U.S. Institutions of Higher Education

Name	Nobel Prize	Nationality	Involved with U.S. Higher Education Institution?	U.S. Higher Education Institutions
Donna Strickland	Physics	Canadian	Yes	University of Rochester, Princeton University
Gerard Mourou	Physics	French	Yes	University of Rochester, University of Michigan
Tasuku Honjo	Medicine	Japanese	Yes	Carnegie Institute for Science
Arthur Ashkin	Physics	American	Yes	Columbia University, Cornell University
James P. Allison	Medicine	American	Yes	University of Texas, University of California-Berkeley
Frances H. Arnold	Chemistry	American	Yes	Princeton University, University of California-Berkeley, California Institute of Technology (Caltech)
George P. Smith	Chemistry	American	Yes	Haverford College, Harvard University, University of Missouri, University of Wisconsin, Duke University
William D. Nordhaus	Economic Sciences	American	Yes	Yale University, Massachusetts Institute of Technology (MIT)
Paul M. Romer	Economic Sciences	American	Yes	University of Chicago, Massachusetts Institute of Technology (MIT), Stanford University, University of California-Berkeley, University of Rochester, Queen's University, New York University
Sir Gregory P. Winter	Chemistry	British	No	
Nadia Murad	Peace	Iraqi	No	
Denis Mukwege	Peace	Congolese	No	Honorary PhD from Harvard University

Source: IIR Analysis of the Biographies of the 2018 Nobel Prize Laureates.

Figure 3 summarizes each of the 2018 Nobel Prize Laureates' affiliations with U.S. institutions of higher education. Nine of the Nobel Prize winners in 2018 had either studied or taught at colleges and universities in the United States at some point in their careers.

Universities in the United States are highly-ranked internationally. Currently, according to the Times Higher Education World University Rankings, seven of the top ten universities in the world are located in the United States.¹⁰ It is notable that six of the 2018 Nobel Prize Laureates were associated with six of these leading U.S. universities. In other words, U.S. institutions of higher learning have provided the world's best scientists and researchers with the human and physical resources and research environment necessary to reach the pinnacle of scientific advancement.

Some of them, such as Dr. Tasuku Honjo, travelled constantly between their country of origin and the United States over the course of their careers. In fact, constant travel and international collaboration are characteristic of these highly-skilled individuals and are the nature of advanced science.

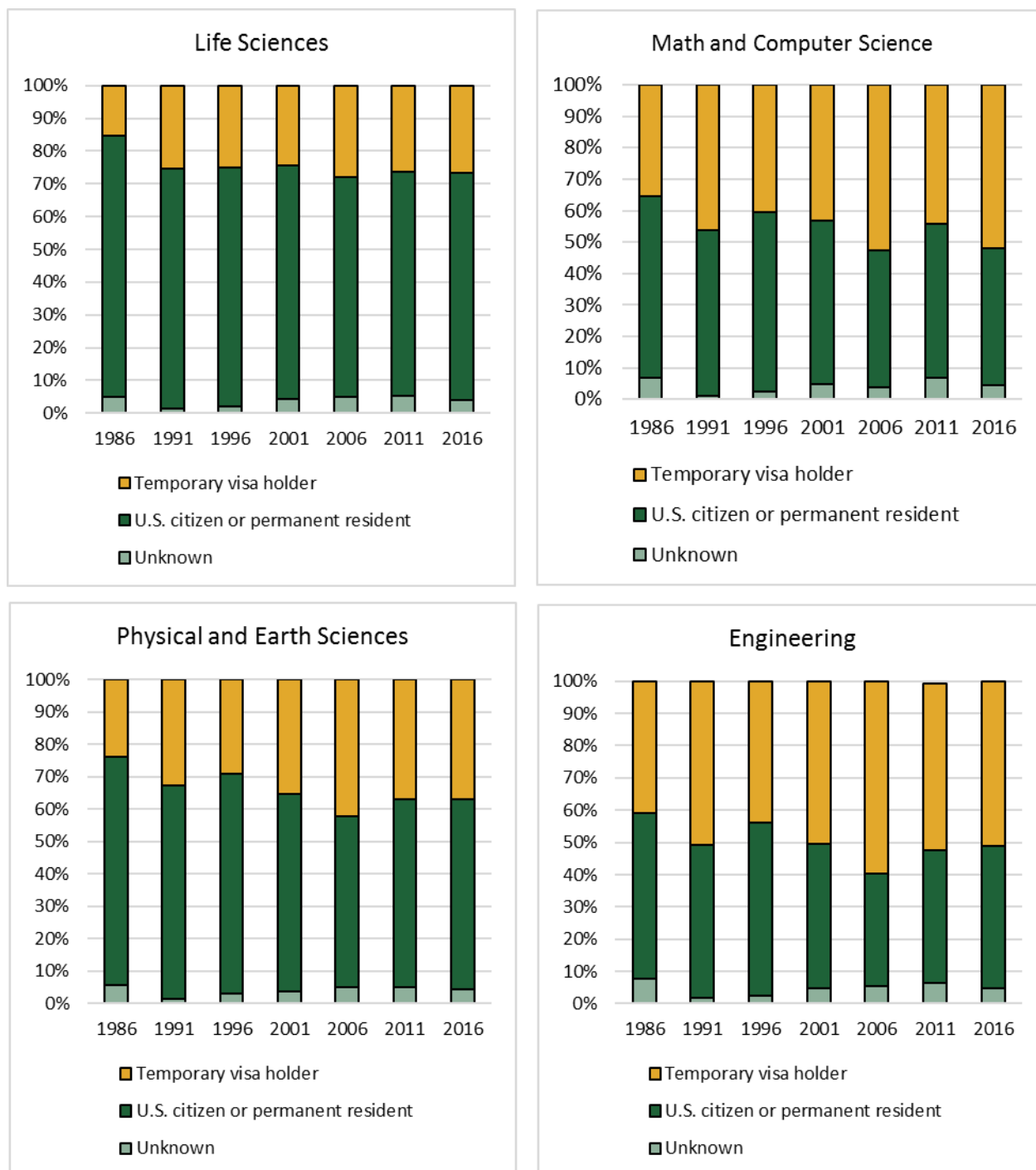
In response to a question about how international collaboration has advanced her career, Frances H. Arnold, winner of the 2018 Nobel Prize in Chemistry, stated, "... evolution teaches you that if you are not diverse, you go extinct."¹¹ Dr. Arnold was interested in international relations at one point in her life and is a good example of the deep connection between diplomacy and science. Scientific expertise is important to diplomats as they craft agreements on global issues. In 1984, U.S. Secretary of State George Shultz wrote, "The revolution in communications, energy, environmental sciences and other aspects of science and technology has...imparted an importance to [science and technology] considerations in foreign affairs undreamed of a generation ago."¹² Science also has a need for diplomacy to pool necessary resources, organize international exchanges and conferences, and draw international attention to critical issues of international importance.¹³ The international language of science and scientific discovery helps to bring nations together.

Trends in Temporary Visa Holder PhD Recipients in the United States

Nobel Laureates, potential Nobel Prize winners, and leading scientists more generally tend to have doctoral degrees, and doctoral degrees from the United States are highly valued in the international community. Approximately 31 percent of PhD holders in the United States in 2015 were foreign-born, according to a 2017 study from the Brookings Institution.¹⁴ 2018 Nobel Laureate Donna Strickland is an example of an international student who came to the United States and became a PhD recipient in Physics. Foreign-born students have taken many paths to arrive in the United States. Some arrived as children or as refugees, some have temporary work authorization, while others have lawful permanent residency or have become naturalized U.S. citizens. Many of the foreign-born PhD students in the U.S. are international students who are here on temporary nonimmigrant visas, such as F-1 student visas or J-1 scholar visas. The Nobel Prize recipients in the fields of Physics, Medicine, Physiology, and Chemistry typically hold doctoral degrees in science, technology, engineering, and mathematics (STEM) fields.

To allow us to view trends over time, Figure 4 shows STEM PhD recipients in the United States disaggregated by citizenship status, for the past thirty years.¹⁵ Data limitations will not allow us to look at all the foreign-born in a single category because foreign-born naturalized citizens and foreign-born green card holders are combined with U.S. citizens, a limitation that necessarily leads to an underestimate of foreign-born STEM PhD recipients.

Figure 4. STEM Field PhD Recipients: U.S. Citizens, Permanent Residents, and Temporary Visa Holders 1986-2016



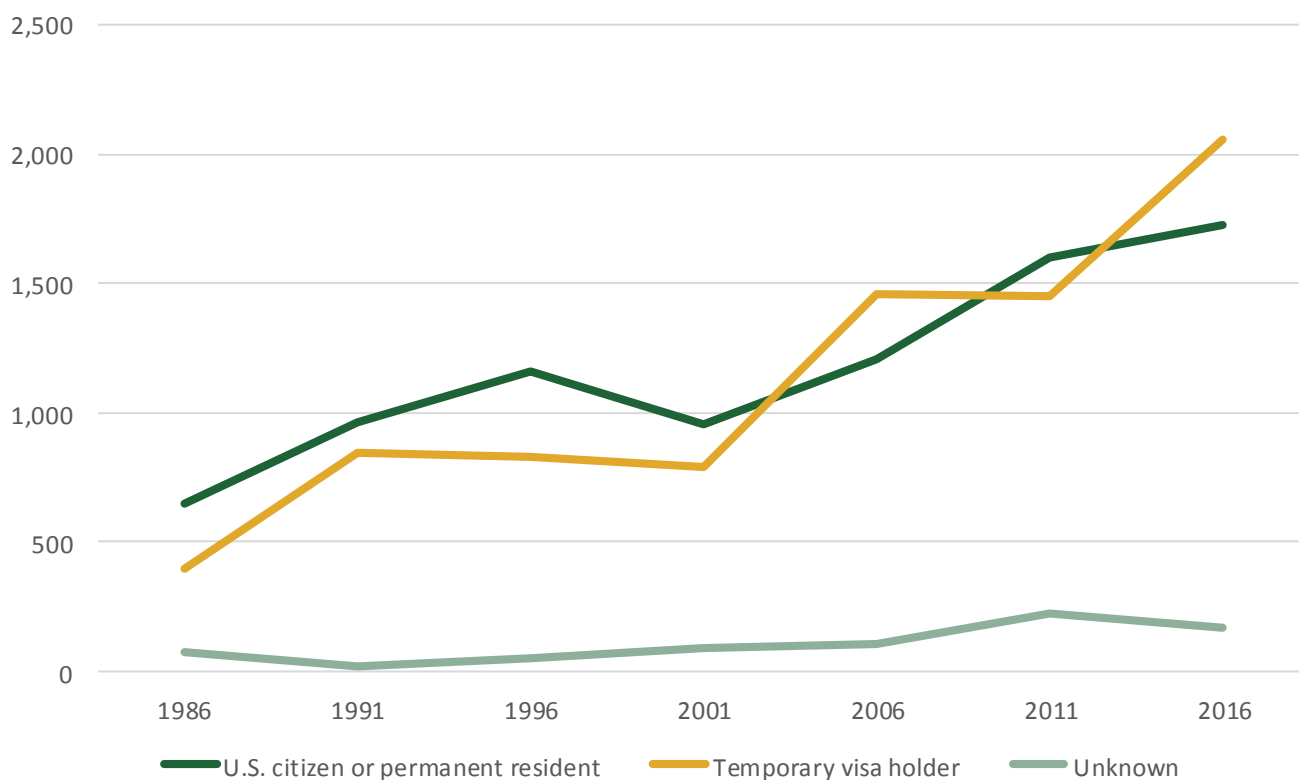
Source: National Science Foundation: National Center for Science and Engineering Statistics (NCSES). 2018. Survey of Earned Doctorates. Doctorate recipients, by broad field of study and citizenship status: Selected years, 1986–2016
<https://www.nsf.gov/statistics/2018/nsf18304/data.cfm>

Mathematics and computer science, engineering, life sciences, and physical and earth sciences are the four areas with the largest percentages of earned doctorates who are temporary visa holders. There are smaller shares of PhD recipients in psychology and social sciences, education, and humanities and arts who were temporary visa holders. Overall, there are higher percentages of temporary visa holder PhD recipients in the STEM fields than in non-STEM fields.

The two STEM fields in which temporary visa holders outnumber and represent a higher percentage of PhD recipients than U.S. citizens and permanent residents are mathematics and computer science, and engineering.

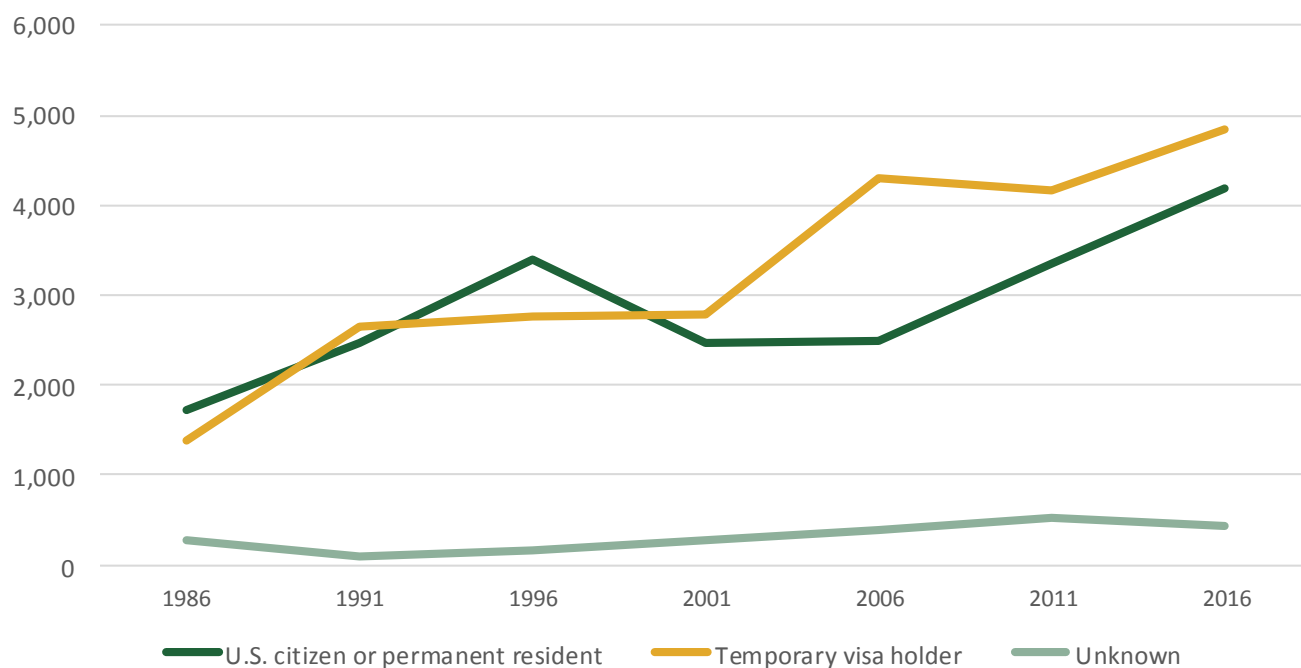
In the field of mathematics and computer sciences, PhDs who were temporary visa holders outnumbered U.S. citizens and permanent residents in the years 2006 and 2016. The number of temporary visa holders with PhDs remained close to the number of U.S. citizen and permanent residents in the field of mathematics and computer sciences between 1986 and 2001 (see Figure 5). In the field of engineering, temporary visa holders outnumbered U.S. citizens or permanent residents in 1991 and from 2001 to 2016 (See Figure 6).¹⁶

Figure 5. Mathematics and Computer Sciences Doctorate Recipients by Broad Field of Study and Citizenship Status 1986-2016



Source: National Science Foundation: National Center for Science and Engineering Statistics (NCSES). 2018. Survey of Earned Doctorates. Doctorate recipients, by broad field of study and citizenship status: Selected years, 1986–2016 <https://www.nsf.gov/statistics/2018/nsf18304/data.cfm>

**Figure 6. Engineering Doctorate Recipients
by Broad Field of Study and Citizenship Status 1986-2016**



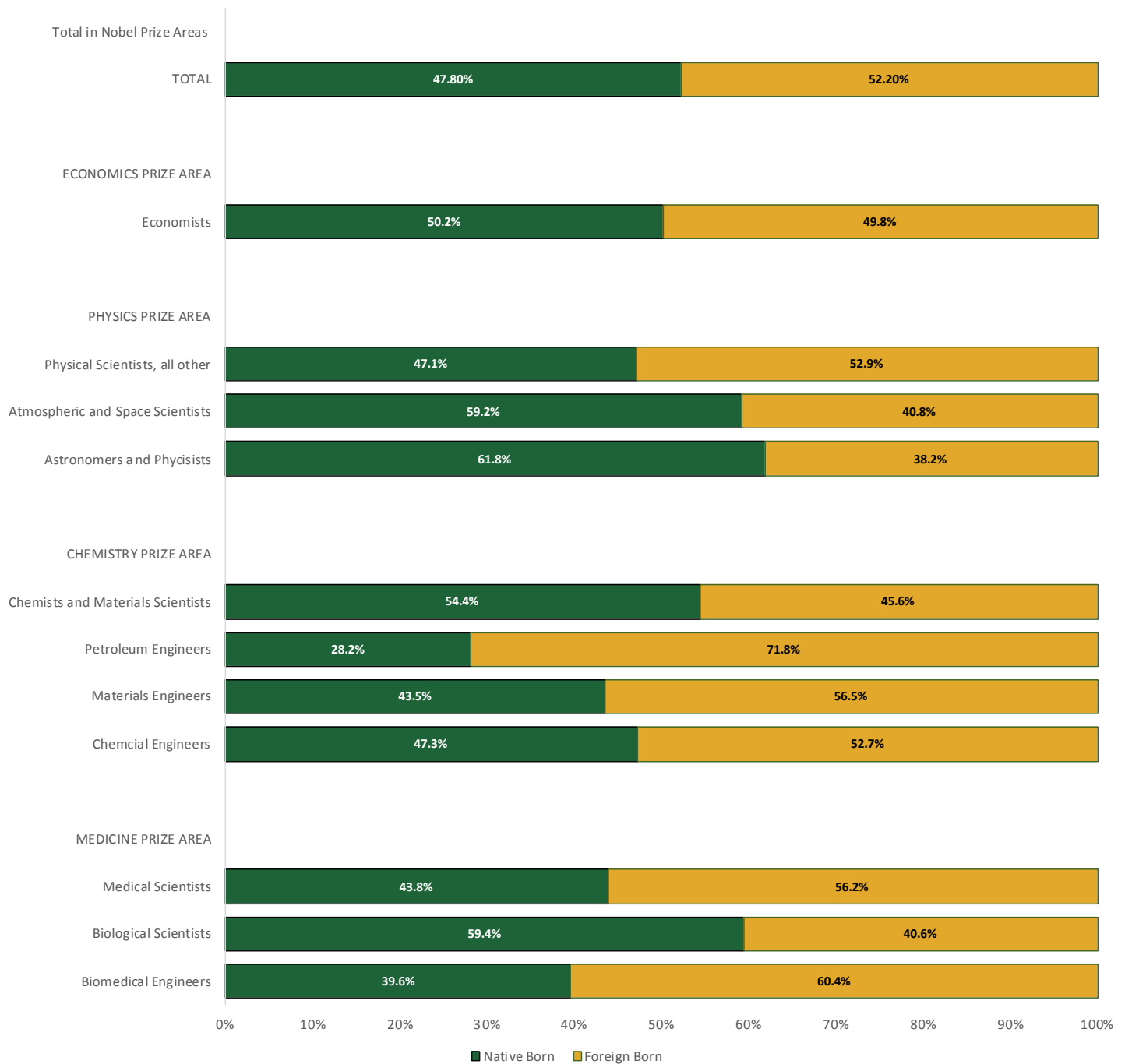
Source: National Science Foundation: National Center for Science and Engineering Statistics (NCSES). 2018. Survey of Earned Doctorates. Doctorate recipients, by broad field of study and citizenship status: Selected years, 1986–2016 <https://www.nsf.gov/statistics/2018/nsf18304/data.cfm>

Foreign-Born Individuals Working in Nobel Prize-Related STEM Occupations in the United States

Highly-skilled immigrants who receive doctoral degrees may eventually go on to become postdoctoral research fellows or obtain other jobs in the United States. For example, Dr. Tasuku Honjo received his PhD from Kyoto University in Japan and then came to the United States and became a research fellow. Others may come to the United States to pursue teaching jobs, such as Dr. Gerard Mourou who, after receiving his PhD in France, became a professor at the University of Rochester. Others who receive their PhDs either abroad or in the United States obtain jobs in the STEM fields. In this section we look at the share of immigrants with doctoral degrees within Nobel Prize-related occupations. Not only are some of these individuals potential Nobel Prize winners, but just as importantly, many are a crucial component of the United States' STEM workforce.

Figure 7 illustrates the prevalence of foreign-born, highly-skilled individuals in various occupations in the United States. Between 38 percent and 72 percent of individuals working in Nobel-related STEM occupations are foreign-born, depending on the occupation. Overall, more than half (52.2 percent) of all people in these occupations are foreign-born. The occupations in which foreign-born individuals outnumber the native born are petroleum engineers (71.8 percent), biomedical engineers (60.4 percent), materials engineers (56.5 percent), medical scientists (56.2 percent), all other physical scientists (52.9 percent), and chemical engineers (52.7 percent).

Figure 7. Foreign-Born and Native-Born Individuals in Nobel Prize-Related Occupations in the United States, Age 25+ with PhDs. 2012-2016*



*Nobel prizes in Literature and Peace are excluded.

Source: IIR Analysis of American Community Survey (IPUMS-USA: University of Minnesota) 2012-2016 five-year estimates.

Recent Changes to Immigration Policy and the Decrease in International Graduate and Undergraduate Student Enrollment in the United States

Recent changes to U.S. immigration policies could impact international scholars' ability to study, research, and work in the United States. By restricting the admission of foreign nationals, the United States may be effectively closing the door on the next Nobel Prize winner, and impeding important research and scientific discoveries. This means that future Donna Stricklands, Gerard Mourous, and Tasuku Honjos may not have the opportunity to study and conduct research here.

For example, a 2017 executive order severely restricts the ability of nationals from seven countries – Iran, Libya, North Korea, Somalia, Syria, Venezuela, and Yemen – to enter the U.S. as either an immigrant (permanent admission) or nonimmigrant (temporary admission).¹⁷ This means that many individuals from these countries may not be able to study, work, or conduct research in the United States.¹⁸ Currently, there are approximately 14,000 individuals from these countries working as postsecondary teachers in the United States.¹⁹

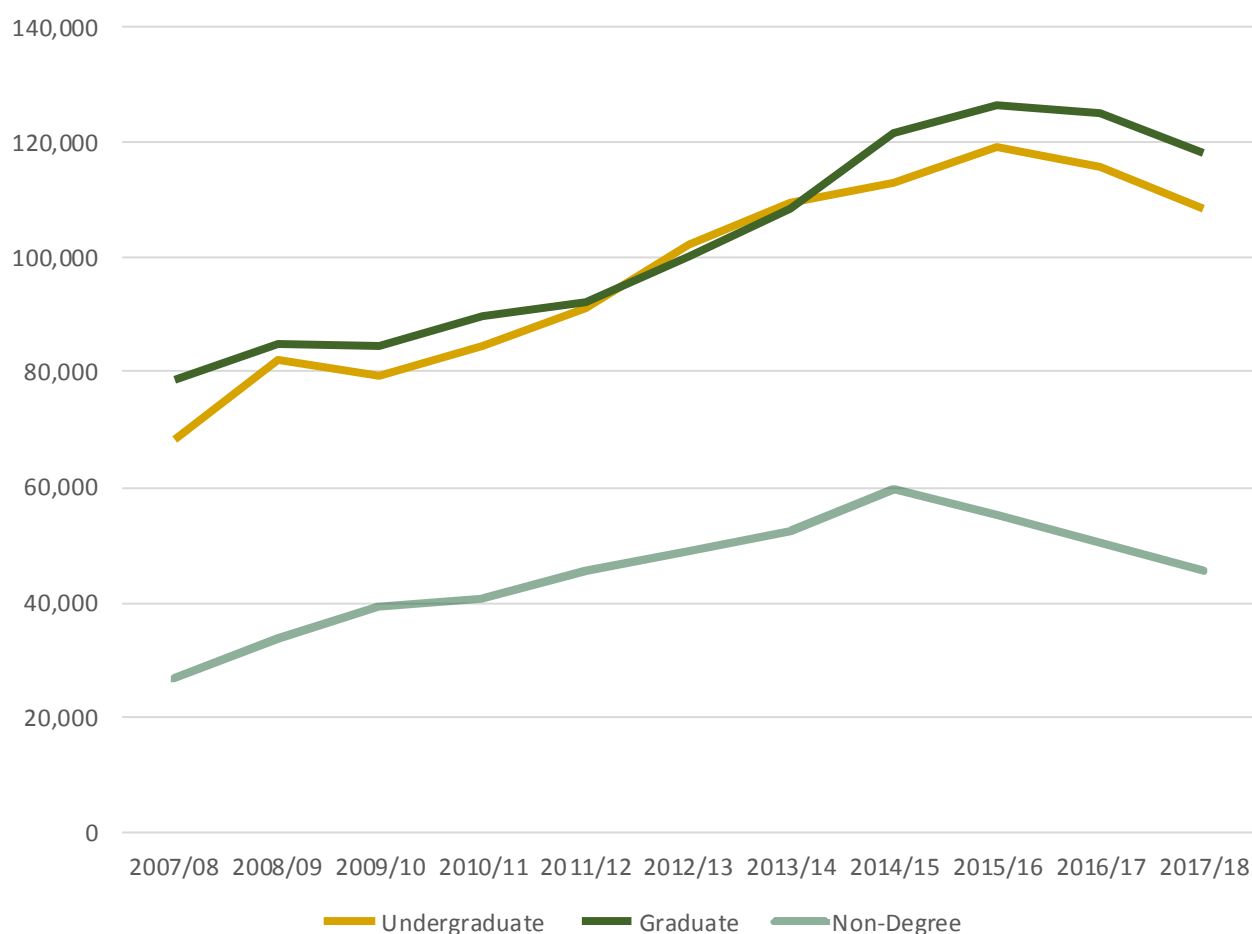
There have been other important changes affecting international students. As of August 9, 2018, students may begin to accumulate unlawful presence immediately after their student visas expire if they fail to maintain lawful status, making them more vulnerable to being barred from reentry in the future.²⁰ Furthermore, changes to Optional Practical Training (OPT) are likely to affect international scholars. OPT is an option that allows certain foreign students at U.S. universities to work after graduation by providing temporary employment that is related to a student's major area of study. Eligible students can receive up to 12 months of OPT employment authorization (36 months for STEM fields) before or after completing their academic studies.²¹ In early 2018, the government restricted the type of employer for whom a student with OPT can work, thus limiting opportunities in the United States.²² The Trump administration has also signaled that it may restrict J-1 cultural exchange programs, particularly those that allow the beneficiaries to work in the United States. While no details have been provided, it is possible that international professors and scholars could be restricted from entry. Other policy changes have created new barriers to legal immigration and have slowed and reduced admissions to the United States.²³

Taken together, the administration's adversarial stance on immigration results in the United States being viewed as a less welcoming, less desirable destination for highly-skilled and highly-motivated foreign nationals seeking an ideal location to receive an education and conduct their research. This is problematic in a global marketplace where multiple countries are competing for the "best and brightest" students and researchers. In response to the proposed international student rule, NAFSA: Association of International Educators wrote, "This proposal is yet another policy which makes the United States less attractive to talented international students, scholars, and exchange visitors and undoubtedly will encourage them to look elsewhere to do their groundbreaking research and build diplomatic ties."²⁴

It appears that international enrollments in U.S. universities may already be on the decline. Even though there has been an increase in overall PhD recipients between 2001 and 2016 for both U.S. citizens/permanent residents as well as temporary visa holders, there has been a decline in the stock of total new international student enrollment between 2016 and 2018 for both undergraduate and graduate students. Taken together these two trends may be seen as a pipeline issue: increasing numbers of graduates reflect earlier increases in new enrollments. In the future however, decreasing new enrollments today are likely to lead to decreasing numbers of graduates tomorrow.

According to data from the Institute for International Education (IIE), between the 2015/2016 and 2016/2017 academic years, international undergraduate and graduate student enrollments have declined 2.9 percent and 1.3 percent respectively. Even non-degree seeking student enrollments have decreased by 8.8 percent. This means that in the 2015/2016 to 2016/2017 period, the aggregate of these three categories experienced a 3.3 percent decline according to IIE Open Doors. Even more alarming is the fact that this decline doubled between 2016/2017 and 2017/2018 period (see Figure 8).

Figure 8. New International Graduate and Undergraduate Student Enrollment 2007-2018 (All Fields)



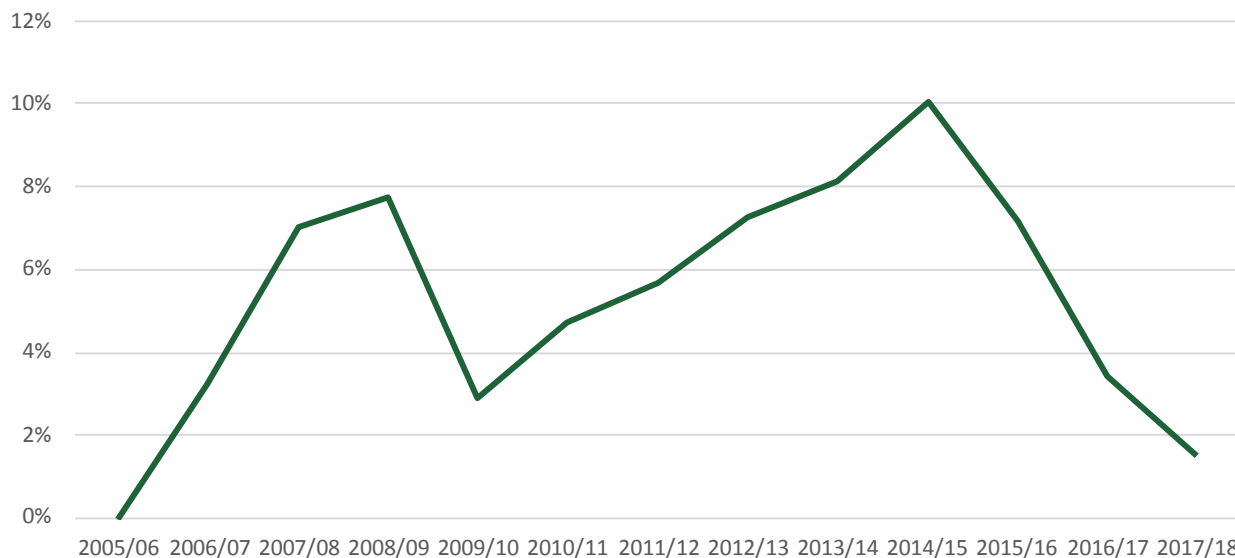
Source: Institute of International Education 2018. "International Student Enrollment Trends, 1948/49-2017/18." Open Doors Report on International Educational Exchange. Retrieved from <https://www.iie.org/Research-and-Insights/Open-Doors/Data/International-Students/Enrollment>

According to the latest information from IIE Open Doors, in the 2016/2017 to 2017/2018 period there has been an overall 6.6 percent decline in new international student enrollments in the three categories. New undergraduate enrollments fell by 6.3 percent, while new graduate and non-degree enrollments fell by 5.5 percent and 9.7 percent, respectively.

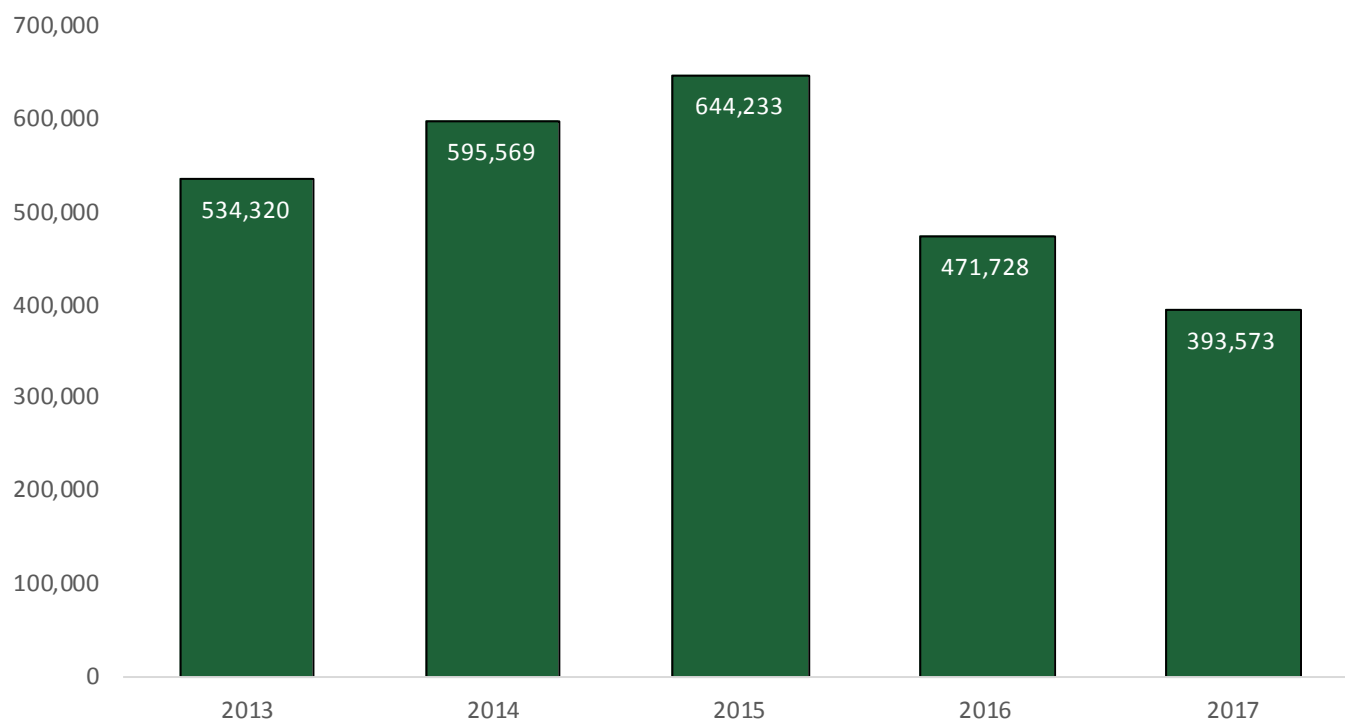
In addition, the Fall 2018 International Student Enrollment Hot Topics Survey of U.S. Higher Education, also conducted by IIE in coordination with the College Board and six other institutions, reports that the 540 institutions surveyed reported a 1.5 percent decrease in new enrollments between the 2017/2018 and 2018/2019 periods.²⁶ This data is from a smaller sample than the overall 2018-2019 IIE Open Doors report which will come out next year. However, this preliminary data suggests that for a third year period in a row, the decrease in new enrollments continues.

Even though the total *quantity* of international students has increased by 1.5 percent between the 2016/2017 and 2017/2018 periods, the size of the increase (of the annual percent change) has declined. In the 2013/2014 to 2014/2015 period there was a 10 percent increase, a 7.1 increase in the 2014/2015 to 2015/2016 period, a 3.4 percent increase in the 2015/2016 to 2016/2017 period and finally a 1.5 percent increase in the 2016/2017 to 2017/2018 period as can be seen in Figure 9.²⁷ If this trend in the reduction of the total annual percent change continues, the United States might have, for the first time since 2005, a net decrease in the absolute number of international students in the near future.

Figure 9. Annual Percent Change of International Students in U.S. Educational Institutions



Source: Institute of International Education 2018. "International Student Enrollment Trends, 1948/49-2017/18." Open Doors Report on International Educational Exchange. Retrieved from <https://www.iie.org/Research-and-Insights/Open-Doors/Data/International-Students/Enrollment>

Figure 10. F-1 Visas Issued 2013-2017

Source: ICEF Monitor. 2018. "US F-1 visas down nearly 17% in 2017."

Retrieved from monitor.icef.com/2018/03/us-f-1-visas-down-nearly-17-in-2017

The number of F-1 student visas issued also shows declines in the past two years. According to a study conducted by the International Consultants for Education and Fairs (ICEF) in March 2018, which uses data from the U.S. State Department, there has been a 17 percent decline in the number of F-1 visas issued in 2017 compared to 2016 (see Figure 10), coinciding with decreases in international student enrollments.²⁸ Overall, we see a decrease in F-1 visas and in international student enrollment across all categories for at least two years in a row.

All of this is particularly concerning when one takes into account the contributions to the economy that international students represent for the nation. Quite apart from their value to the nation as future scientists and researchers, particularly in the STEM fields, higher education is one area of the U.S. economy where there is a significant positive balance of trade. The U.S. Bureau of Economic Analysis place the export value of U.S. higher education, which is the direct cost of higher education paid by international students, at over \$35 billion in 2015. This pales in comparison to the just over \$5 billion that U.S. students are spending to study overseas. However, going beyond the direct costs of education and adding in cost-of-living expenses and taking out any U.S. based financial aid, the total value of education exports exceeds \$50 billion.²⁹ Calculated in terms of jobs, according to the NAFSA Association of International Educators, international students created a total of 155,381 direct jobs and 300,241 indirect jobs in 2017/2018 academic year.³⁰ Most of the direct jobs created are in the higher education and accommodation sectors.

Conclusion

Highly-skilled foreign-born individuals in the United States represent important shares of the STEM workforce. Many of them hold PhDs from U.S. colleges and universities. It is from this pool of highly-skilled STEM PhD recipients that many Nobel Prize winners have come. Both native-born and foreign-born Nobel Prize winners have benefited from U.S. institutions of higher education. A good share of the non-U.S. Nobel Prize winners in 2018 have spent time in the United States and were part of the U.S. higher education system at some point in their lives. It is clear that U.S. institutions of higher education play a critical formative role in the lives of the world's top scientists, including Donna Strickland, Gerard Mourou and Tasuku Honjo.

U.S. colleges and universities are not only important to potential Nobel Laureates. Highly-skilled immigrants who hold PhDs and work in STEM fields are a very important part of the overall United States workforce. They contribute to one of the most important drivers of the economy: technology, which translates into productivity. In fact, this year's Nobel Laureate in Economics, Paul M. Romer, modeled how knowledge about technology contributes to a nation's economy.³¹

However, certain changes to U.S. immigration policies and attitudes may negatively impact foreign scholars' ability to study, work, and conduct research in the United States. In fact, graduate, undergraduate, and non-degree international student enrollments decreased for the third year in a row. The number of F-1 student visas issued has also decreased sharply since 2016. These policy changes mean that the pool of potential foreign-born Nobel Laureates may be threatened. Because foreign-born workers make up important parts of the STEM workforce in the United States, current immigration policies do not only affect foreign-born, highly-skilled individuals, but also affect the United States' ability to create new technologies that drive our economy.

Appendix A: Additional 2018 Nobel Prize Laureates

Nobel Prize in Physics

Arthur Ashkin was born in the United States in 1922 to immigrant Jewish parents, Isadore and Anna Ashkin, who came from territories of what is now Ukraine. When they immigrated into the United States, they settled in New York where Arthur Ashkin was born. He received his Bachelor's degree in Physics from Columbia University and both his Master of Science degree and PhD from Cornell University. His studies at Cornell University focused on nuclear physics, but after receiving his PhD in 1952, he went to work for Bell Labs where he started laser research. He went on to publish many papers related to photorefractive and non-linear optics. In 1986 he invented optical tweezers, a way of using the radiation pressure of light to move very small physical objects such as bacteria and viruses.³² This invention led to his Nobel Prize in Physics in 2018. In 1992 he retired from Bell Labs.

Nobel Prize in Physiology or Medicine

James P. Allison was born in Alice, Texas in 1948. He received his Bachelor of Science in microbiology from the University of Texas in 1969. He received his Master of Science and PhD at the University of Texas in 1973. He was a faculty member at the University of California, Berkeley from 1985 to 2004. It was during his time that he studied the T-cell protein CTLA-4. He observed that this protein functions as a "brake" that slows down the immune function of T-Cells (immune cells). While other scientists saw this protein as a potential target to treat autoimmune diseases in which the immune system becomes over active, Allison focused on the inverse of this process, to take advantage of the increased activity of the immune system to actually attack cancer cells by inhibiting this protein from placing brakes on the immune system.³³ His development of an antibody that could block the CTLA-4 immune reduction function enabled the immune cells to increase their activity. In 1994 he and his team conducted research to test this hypothesis with good results.³⁴ This led to cancer treatments called *immune checkpoint therapy* which are able to inhibit these CTLA-4 and PD-1 proteins or "brakes" in immune cells and thus allow them to attack cancerous cells even in advanced stage cancers. Currently he is Professor at the MD Anderson Cancer Center at the University of Texas in Houston.³⁵

Nobel Prize in Chemistry

The Nobel Prize in Chemistry was split between Americans Frances H. Arnold and George P. Smith and British Sir Gregory P. Winter for the phage display of peptides and antibodies.³⁶

Frances H. Arnold was born in Edgewood, Pennsylvania in 1956. She studied at Princeton University where she received her Bachelor of Science degree in mechanical and aerospace engineering in 1979. She received her PhD from the University of California, Berkeley in 1985. Currently she is Linus Pauling Professor of Chemical Engineering, Bioengineering and Biochemistry at the California Institute of Technology (Caltech). Making use of the physical and human resources of her laboratory in Caltech, Frances Arnold discovered a way of making enzymes do novel functions³⁷ by directing their evolutive path.³⁸ Such novel functions allow for the production of certain pharmaceuticals and environmentally friendly ways of manufacturing chemical substances. These enzymes can also be used to produce renewable fuels.³⁹ She is the fifth woman to receive the Nobel Chemistry Prize.

George P. Smith was born in Connecticut in 1941. He received his Bachelor of Arts degree from Haverford College in 1963 and his PhD in bacteriology and immunology from Harvard University in 1970. In 1975 he joined the faculty of the College of Arts and Science in the University of Missouri. There he received tenure, was

promoted to associate professor in 1981 and to full professor in 1990.⁴⁰ While at Missouri, he conducted research into antibody diversity, the generation of repeated DNA sequences and combinatorial chemistry which led to the assembly of bacteriophages.⁴¹ In 1985 he studied for a year at Duke University where he conducted research focused on the use of directed evolution to create a method known as *phage display*.⁴¹ This method uses bacteriophages to generate new evolved proteins.⁴² He was also a postdoctoral fellow at the University of Wisconsin and is currently Curator's Distinguished Professor Emeritus of Biological Sciences at the University of Missouri.

Sir Gregory P. Winter was born in Leicester, United Kingdom in 1951. He spent his years as a youth in West Africa and later returned to England where he conducted Natural Sciences studies in the University of Cambridge. Here he received his degree in 1973. In 1976 he received a PhD from the Medical Research Council (MRC) Laboratory of Molecular Biology (LMB) in Cambridge in the United Kingdom.⁴³ His work led to human antibody focused treatments such as adalimumab (Humira).

Sveriges Riksbank Prize in Economic Sciences

The 2018 Prize in Economic Sciences was awarded to Americans William D. Nordhaus and Paul M. Romer for their work in integrating innovation and climate with economic growth.⁴⁴ Their work is innovative in the sense that it integrates climate change into macroeconomic analysis and also the market of ideas that lead to technological innovation.⁴⁶⁵

William D. Nordhaus was born in 1941 in Albuquerque, New Mexico. His grandfather, Max Nordhaus, immigrated from Germany in 1883. He studied at Yale University where he received his Bachelor of Arts degree in 1963 and his Master of Arts degree in 1873. During his junior year in college he went to Paris, France where he received a Certificat at the Institut d'Etudes Politiques. He received his PhD from the Massachusetts Institute of Technology (MIT) in 1967. Nordhaus' research led him to create an *integrated assessment model*, which is a quantitative model that addresses the dynamics between the economy and climate.⁴⁶ He is currently Sterling Professor of Economics at Yale University, is part of Yale's School of Forestry and Environmental Studies.⁴⁷

The prize was also awarded to **Paul M. Romer** for introducing knowledge as a driver for economic growth.⁴⁸ He was born in Denver, Colorado in 1955. He received his Bachelor of Science degree in Mathematics in 1977 and his Master of Arts in 1978, as well as his PhD in economics, from the University of Chicago in 1983. His work focused on the importance of ideas that generate technological change, which is widely considered to be primary driver of economic growth.⁴⁹ He also conducted studies at MIT and Queen's University.⁵⁰ He taught at Stanford University's Graduate School of Business, the University of California at Berkeley, and the University of Rochester.⁵¹ Currently he is a professor at the New York University Stern School of Business.

Nobel Peace Prize 2018

The Nobel Peace Prize was awarded jointly to Iraqi Nadia Murad and Congolese Denis Mukwege for their work in fighting the use of sexual violence as a weapon of war and armed conflict.⁵²

Nadia Murad was born in Iraq and is part of the Yazidi minority in this country. In 2014 The Islamic State attacked her village, targeting the Yazidi population. She was abducted and was repeatedly a victim of abuse.⁵³ After three months, she managed to escape and eventually emigrated to Germany where she now lives.

Denis Mukwege was born in 1955 in the Belgian Congo which is now the Democratic Republic of Congo. He has spent most of his life helping victims of sexual violence. He received his Doctor of Medicine Degree from the University of Burundi and his PhD from the Universite Libre de Bruxelles. He has received honorary degrees from six universities throughout the world including Harvard University.⁵⁴

Endnotes

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About the Institute for Immigration Research

The Institute for Immigration Research (IIR) is a multidisciplinary research institute at George Mason University. The IIR is dedicated to informing and refocusing the immigration conversation among academics, policymakers, and the public by producing and disseminating valid, reliable, and objective multidisciplinary academic research related to immigrants and immigration to the United States. Our faculty affiliates, graduate students, and partners are at the forefront of research examining the economic contributions of all immigrant in the United States, with an emphasis on immigrant entrepreneurs with high levels of education and skills. The IIR produces high quality, timely research and analysis intended to promote informed action.

The IIR was founded in 2012 through the generous donation of Ms. Diane Portnoy, educator and philanthropist and is a joint venture with The Immigrant Learning Center, Inc. (ILC) of Malden, Massachusetts.

The IIR is located on the campus of George Mason University in Fairfax, Virginia, outside the nation's capital, Washington, DC. Its strategic location allows the IIR to draw on unparalleled academic, government, and private resources to advance its mission in research, education, and professional opportunities for current and future scholars of immigration studies. Through conferences, workshops, lectures, and other events, the IIR is able to engage in community outreach with one of the most diverse populations in the United States.



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