The China Connection: A Glimpse of Collaborative Research Between China and Oregon State University

by
Kimberly Kenny

A PROJECT

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degree of

Honors Baccalaureate of Science in Biology (Honors Associate)
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Presented March 5, 2015
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AN ABSTRACT OF THE THESIS OF

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China's global influence in the realm of science and technology (S&T) has increased dramatically in recent times. China and the United States are now each other's main partner in scientific collaboration. As a major research university, OSU is one of the institutions with a large stake in this international collaboration. The purpose of this thesis is to investigate the scientific collaborations conducted between OSU and China as well as the S&T between two countries that will have a simultaneously cooperative and antagonistic relationship in future decades. A literature review was conducted. Both American and Chinese professors, students, and administrative staff were interviewed. The results are a compilation of research and experience that have found China's scientific structure to be fundamentally different from that of the U.S. and OSU, and one that is undergoing rapid change. China is publishing more scientific papers, graduating more students in STEM fields, conducting more collaborations both in-country and internationally, funding more S&T through government channels, and is paying its scientists more. The majority of OSU-China scientific collaborations involve an exchange of "big data" sets on the Chinese side for analysis of this big data and professional training on the OSU side.

Key Words: Science & Technology (S&T), Chinese Academy of Sciences (CAS), Ministry of Science and Technology (MOST), National Natural Science Foundation of China (NSFC)

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I understand that my project will become part of the permanent collection of Oregon State University, University Honors College. My signature below authorizes release of my project to any reader upon request.

Kimberly Kenny, Author

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I have learned so much from doing this thesis and I am immensely grateful to all the people who helped me along the way. I am very aware that I still have much to learn in the way of writing and research and I feel lucky to have had this opportunity to practice both. I will learn from my mistakes and shortcomings in this thesis and carry those lessons on into my graduate studies.

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Preface

I have been fascinated with China ever since I first visited the Middle Kingdom in 2003 when I was twelve years old. I was fascinated because it was so completely different from anything I had ever known. I didn't understand anything that was happening and that ignorance frustrated me. People openly stared at me and took my picture - one inescapable discomfort. There were cranes and construction everywhere. Ceaseless noise and suffocating, pushing, homogeneous crowds. The traffic was like a ballet rehearsal, with the incessant beeps serving as the barking commands of a dance instructor, the darting cabs and tour buses and private cars swerving in close proximity to each other in a closely choreographed maze of movement. Lines on the street were guidelines, not rules anyone strictly followed. I was less terrified by my impending doom as we passed a car and drove toward an oncoming truck than I was amazed and entranced by how it could all possibly work. Everyone smoked cigarettes. People spit in public and no one seemed to think it was impolite. Dinners included incredible amounts of drinking, endless toasts, and generous words of affirmed friendship. Smog made my eyes water. I received as many gifts as I did on Christmas. So much formality. Touring through warehouses and showrooms like cattle on parade, for pearls, jade, silk, tea. Squat toilets without running water or toilet paper. Being cramped in any sort of public transportation. Appalled at the apparently normal practice of people cutting me in line. Things I didn't want to eat but ate anyway to be polite. Bartering, learning to cut the price by at least half before chipping it lower. Being keenly followed by shop assistants instead of idly looking without interruption. A mall on a Wednesday morning was more crowded than I'd ever seen a mall during the height of the holiday season in the U.S. Cheap, fake designer purses that I bought excitedly thinking I'd be the coolest girl in seventh grade. Driving from a big city through a shanty town to another big city. Poverty. Beggars. Steamed dumplings, hot water, confusion. A language I couldn't imagine I'd ever begin to grasp.

These were my first impressions of China. Each day was long and yet too short at the same time; every night I fervently recorded the experiences in my journal until I could no longer keep my eyes open. I loved it. Nearly everything I knew about Western culture - about my white, Catholic, sheltered, upper middle class, midwest American upbringing - was turned on its head here. I had never been so out of my element and I wanted to take on the challenge of figuring out why.

Eleven years, six visits, and four years of language study later, I am still hooked on China, and I know how naive I was in thinking I could ever fully understand it. I could have felt this way because China was the first developing nation to which I had ever traveled, but I think it is something more than that. With increasing populations, climbing economies, and mounting carbon emissions as a result of development, the global prominence of countries in the Asian sphere will only become more pronounced in the coming decades. China's role in this future cannot be overstated. And it is a future intimately intertwined with that of the United States. The U.S. and China engage in extensive trade partnerships; many of China's young minds come to the U.S. for higher education; American researchers collaborate with their Chinese counterparts; both governments have recognized the importance of nurturing their diplomatic relations as the U.S. makes its "pivot to Asia."

As an undergraduate majoring in biology and pursuing an International Degree with an interest in science writing and China, this thesis was one of the only ways for me to combine all of those diverse aspects of my college career. I hope to follow my passions for science, international studies, science writing, and China toward a career that will involve all of them. This thesis is a kind of practice run at accomplishing that.

What kind of collaborative research is being done between China and the US, and more specifically between China and OSU? Who are the big names in Chinese-U.S. research? What defines China's science culture and how does it differ from the American science culture? What has China's science been like in the past and how does that compare to what it is today? What does a new American scientist beginning collaborations with China need to know? What does our future with China look like? Why does the United States seem to be so afraid of China - should we be afraid; how can we combat this fear? How can the U.S. work to better promote cultural and scientific understanding between the two nations? These are the questions that drove the research behind this thesis.

As with any thesis, there are many shortcomings and gaps in knowledge, which I would like to acknowledge here. Obviously there are far too many questions listed in the previous paragraph to answer in one dissertation, let alone an undergraduate thesis. Still, I would like to try to make a start. I realize I have a limited number of Chinese sources throughout this thesis, which I truly regret. I have interviewed Chinese undergraduate, graduate, Ph.D., and post-doc students, along with the Chinese OSU INTO instructor (Jennifer Wang) and two Chinese instructors, but my thesis would have been hugely improved by the inclusion of Chinese scientists working in China. I also realize I cannot encompass everyone at OSU who has had some connection to China, but I have highlighted some of the researchers I have found to be the most involved with Chinese collaborative research. Also missing is adequate female representation. The issue of male-female equality in Chinese collaborations is something I address briefly but would like, as with many other issues, to investigate in more depth. I could devote another year to investigate collaborative work with the Chinese, but because my time is limited I had to force myself to stop researching and "come up for air", as Nick Houtman would say, so that I can get something done on paper and synthesize my thoughts.

I would also like to make a note here about cultural sensitivity. I realize that my perspective is limited and influenced by my own experiences. I have great respect for China and the Chinese; nothing I write here is intended to slander them or belittle their scientific capability. The views expressed here that are not attributed specifically to interviewees or cited are my own. As a Westerner and an American, I inevitably have a Western and American perspective; still I try to maintain as much cultural relativism as possible. It is my firm belief that a thesis should be an avenue to express opinions, even if those opinions are controversial or supported by a mere year of research. I am of course willing to recognize any shortcomings in my analysis and hear any conflicting opinions readers may have.

My hope is that this will read as an educational manual about China's scientific community and the history of its collaborations with the U.S. and OSU more specifically, and also as a kind of guidebook for an American scientist going to China with no idea as to what he is getting himself into. I hope you will learn something about China and gain a deeper appreciation for the importance of U.S.-China scientific collaborations.

Introduction

How has science been done in China in the past?

For fourteen centuries China outstripped the West in terms of science and technology. I will repeat the common acknowledgments of the “four great inventions”: gunpowder (in the ninth century), the compass (adapted to navigation in the tenth century), papermaking (second century), and the printing press (block-printing in the eighth century and moveable type-printing in the eleventh); all were developed first in China (Elman, 2005; Kolesnikov-Jessop, 2005; Kostoff et al., 2007). The mechanical clock was also developed in China (by the monk and mathematician I-Hsing, along with his collaborator Liang Ling-Tsan) in 725; in Europe it was developed more than 500 years later around 1280 by a nameless artisan (Needham, 1945). For nearly 2,000 years the Chinese were the keenest observers of astronomy in the world; modern astronomers still reference Chinese records of early astronomical history today. The steam engine was in all respects completed in China about 500 years before Newcomen and Watt were credited with developing it in the West in the eighteenth century (Needham, 1945).

China’s early scientific accomplishments are more than a list of “beat-ya-to-it” inventions. China was thriving scientifically at a time when much of the rest of the world was in the darkness of the Middle Ages, and other empires outside of Europe could not come close to the higher level of development in the Middle Kingdom. Gavin Menzies argues in his 2002 book, *1421: The Year China Discovered America*, that Admiral Zheng He beat Columbus to the punch by 71 years. This claim, however, and claims he makes in his second book, *1434: The Year a Magnificent Chinese Fleet Sailed to Italy and Ignited the Renaissance,* published in 2008, are controversial and largely dismissed by the academic community. We do know that Zheng He was a great naval explorer, even if it is uncertain just how far he explored, and that he lived in a time when China was a great and sprawling empire capable of endorsing such expeditions.

Records of Chinese history began in the early Shang dynasty. The Imperial Encyclopedia (Gujin Tushu Jicheng) recorded for the first time most of China's scientific developments. It was written during the Qing dynasty under emperors Kangxi and Yongzheng, begun in 1700 and completed in 1725. Throughout China's approximately seventeen centuries of history, science has been run by the government and for the government. The Middle Kingdom has had a long line of dynasties stretching back to 1600 B.C. and ending at the beginning of the twentieth century with the fall of the Qing dynasty. Throughout China's dynastic cycles, the direction and purpose of science was decided by the emperor, as was his authority according to the Mandate of Heaven.

After the Hongxi emperor of the Ming dynasty came to power in 1424, China began a policy of isolationism that lasted hundreds of years. This contributed to the large shock China was to receive from the colonizing powers and their seemingly sudden superior scientific and technological capabilities beginning in the eighteenth century.

The Needham Question

It seems strange that the nation that developed gunpowder centuries before the Western world would fall so far behind the West in modern times. How is it that such a powerful empire came to be so scientifically and technologically outdone by Western colonizing powers beginning in the eighteenth century? This is a question British scholar Joseph Needham spent his career in China answering. His works culminated in *Science and Civilization in China*, a series of books first published in 1954 and ending in 2008.

"Our original question was: why had modern science originated only in Western Europe soon after the Renaissance? We soon came to realize that there was an even more intriguing question behind that, namely, why had China been more successful than Europe in gaining scientific knowledge and applying it for human benefit for fourteen previous centuries?" Needham wrote in 1945 in *Chinese Science*.

This came to be known as "Needham's Grand Question" or "The Needham Question." Some people thought Chinese script inhibited scientific thought (Needham and Wang, 2004). Some Chinese scholars (Yingqui Liu and Chunjiang Liu among them) thought it was a lack of property rights. They also point out that any new discoveries were sequestered by the government for its own use; they blame a state control that was too stifling. Needham agreed with the latter portion of this theory, and added that ingenuity was diverted away from scientific endeavors, while public dispute and competition were inhibited. Civil service was also the surest way to a prosperous life; scientists did not have as many incentives to pursue anything too radically different from a career in the government. Needham also noted the attitudes toward science and the West during the Ming and Qing dynasties as main causes of its apparent scientific downfall; both dynasties focused more on the arts and history and shunned scientific disciplines. A final answer to The Needham Question is the enormous amount of external and internal conflict China has experienced in the past 300 years, barely allowing it to come up for air let alone focus major resources on scientific progress.

Needham found that when he pointed out China's scientific accomplishments to Western colleagues in the 1950s, they fell on deaf ears - the works of science and technology had long symbolized a kind of Western superiority for Western scientists, and they were loath to give this up (Needham & Wang, 2004). Some scholars say Needham exaggerated Chinese technological achievements and that he assumes Chinese origin for too many things. Other critics of Needham place great emphasis on his intellectual love of communism. Needham was blacklisted by the U.S. government well into the 1970s for this reason.

Needham began his work investigating Chinese science after WWII, a momentous world event that propelled development and science and technology (S&T) across the globe. He worked with a Chinese woman named Lu Gwei-djen, whom he married after his first wife, Dorothy, died. Together they, and other authors both Chinese and Western, wrote most of the installments of *Science and Civilization in China*. Needham was originally a biochemist. He was fluent in Chinese, traveled China extensively (sending any medical books he could find back home to Britain via diplomatic channels), and became well acquainted with such high ranking officials as Zhou Enlai. Needham passed away in

1995. The *Science and Civilization in China* project is still underway at the Needham Research Institute. Needham also established the Society for Anglo-Chinese Understanding (SACU), which is also still functioning today, seeking “to promote understanding and advance the education of the UK public in all aspects of China and the Chinese People.”

Many Western scientists pushed their cultural predispositions upon their early Chinese collaborators. Needham thought the idea of the Chinese adopting Western science, along with all of its cultural norms, was “sheer nonsense” (Needham, 1945). He did not like to think of modern science as inherently Western and separate from “Chinese science.” He thought, rather, that “science is one and indivisible. The differences are essentially sociological - what you do science for, whether for the benefit of the people as a whole, or for the private profit of great industrial enterprises, or for the development of fiendish forms of modern warfare; in a word, your motive” (Needham, 1945). This debate of sorts - whether the world has a singular science or there are different sciences for different cultures - continues today.

Needham thought the West had much to learn from China in how we regard and practice science, something I would like to strongly second. Needham remembers feeling frustrated by the black and white, right and wrong, nature of Western science - something he called the “A or not-A disjunction” - and he remembers feeling surprisingly relieved when he would so often hear his Chinese colleagues answer his questions with: “well, it’s partially both and it’s not really either; it depends on the nature of the whole” (Needham, 1945). Chinese society has avoided this type of rigid Western thought, instead adopting a way of thought epitomized by the Taoist idea of yin and yang; neither force is ever absolutely dominant for more than a moment, "for immediately its power began to fail and it was slowly but surely replaced by its partner, and so the whole thing happened over and over again" (Needham, 1945). The Chinese can teach the West to be much more open-minded, Needham wrote. This difference in perceiving the world still exists today between Western and Chinese science cultures.

Michael Polanyi, a Hungarian-British chemist and social scientist, began a discussion about "science for science's sake," which is decidedly not the norm in China today, though it is a major component of American science (Nye, 2011). Scientists in the U.S. are encouraged to pursue their eclectic curiosities much more than their Chinese counterparts, encouraged to seek out knowledge without a state-mandated goal such as national defense (though of course American scientists pursue this as well).

This may be shifting in the American science culture of today, however, as there has been an increased public call for applied science. J. Britt Holbrook and Robert Frodeman are not alone in expressing the American sentiment: "What return do taxpayers get for their investment in scientific and engineering research?" (Holbrook and Frodeman, 2012). With many right-wing politicians questioning the validity of the National Science Foundation (NSF) and criticizing studies such as the now-infamous "shrimp on a treadmill" study, the so-called science for science's sake may become more science for society's sake. The two are not necessarily mutually exclusive, of course; a scientist can explore his curiosities for the sake of advancing knowledge and in doing so also benefit mankind. Neither is wholly the "correct way" to do science; there should be a mix of both. Still, the American public and current political atmosphere seem to demand more obviously practical objectives behind research. In contrast, the majority of Chinese science has seemingly always been a practical means to an end, be it national defense, infrastructural improvements, energy generation, or international recognition. Some of these differences can be better explained by author Donald Stokes' classification of different types of research, known more colloquially as Pasteur's Quadrant. The quadrant that carries Pasteur's namesake involves use-inspired basic research, while basic research is exemplified by Niels Bohr, and applied research by Thomas Edison. Each quadrant has its own strengths and limitations, much like the tendencies in American and Chinese science.

When did collaborative scientific work with China begin and what it like?

Much of Western science came to China via missionaries, most notably during the Ming and Qing dynasties. The first wave of missionaries were the Jesuits. Together with their Chinese counterparts, the Jesuit missionaries published works on mathematics and calendric science in 1669 under emperor Khang-Hsi (Schneider, 2011). One of the most notable Jesuit missionaries during this period is Matteo Ricci, an Italian mathematician and scientist who enjoyed success largely due to his acceptance of Confucian dress and philosophies (Shigeru & Sivin, 1973). Ricci was the first Westerner to be invited into the Forbidden City in 1601. Despite these successes, the Jesuits were largely unsuccessful in their aims of proselytization and their scientific influence was likewise minimal. One important reason for this was the Chinese rites controversy, during which the Pope declared that Chinese Christians who practiced ancestor worship were not in fact

Christians; after much debate the Kangxi emperor had many Jesuit priests expelled from China or persecuted. Nevertheless, these missionaries set a precedent of scientific exchange between the West and China that would be picked up again about one hundred years later.

The second, more influential, wave of missionaries who brought western science to China were the Protestants during the Qing Dynasty. Not surprisingly and like their Jesuit predecessors, these missionaries tried to include plenty of religious baggage in their scientific teachings, but the Chinese for their part tacitly sought to take the science without the religion (Elman, 2005). Notably, the Jesuits and the Protestants both withheld certain current scientific information from the Chinese largely because of religious reasons; the Jesuits refrained from informing the Chinese about Copernicus and the Protestants refrained from telling the Chinese about Darwin, until they could no longer avoid the necessity, but both came decades late (Elman, 2005).

When the Chinese began losing major conflicts with the Europeans and Japanese in the mid- and late-seventeenth through eighteenth centuries, they realized they desperately needed to catch up technologically, and needed scientific education to do this. There was consequently a high demand for western science. This was also a period during which many Chinese students went to the West for a scientific education, some of them funded by the government. Many of the partnerships between United States universities and some of the universities within China that still exist today were founded during this period. Contrary to popular belief, China did in fact have superior ships technologically during the First Sino-Japanese War from 1894 to 1895, but Japan was superior in naval leadership, ship maneuverability, and the availability of explosive shells (Chun, 2005). The loss of the First Sino-Japanese War in particular shook China to its core. Similarly, the British victories in the Opium Wars from 1839-1842 and 1856-1860 humiliated China and brought them to the realization of how badly they needed to learn from the West if they wanted to combat western imperialism. This change in attitude and increasing demand for western science was documented by John Fryer.

The British Protestant missionary named John Fryer observed from within as China absorbed major scientific knowledge from the West. He loved learning about China from childhood and spent most of his life there. He played a crucial role in translating western works to Chinese and in giving the Chinese names for certain fields of science (Chun, 2005). He worked with Chinese translators and scientists to compile his analects of Chinese and western medicine. Fryer, along with many other Protestant missionaries, helped establish “arsenals” in China during the Self-Strengthening Movement that aimed to improve China’s military might (Yu, 2013). Fryer edited China’s first scientific journals, which were in Shanghai and then Beijing (Chun, 2005). Interestingly, all of the first scientific journals in China carried the religious overtones of the Protestant missionaries who began them and who seemed feverishly bent on bringing God and science as an inseparable whole to the East.

Crucially, Fryer helped create essay contests for Chinese citizens who wanted to work for the government (which was a very popular occupational path) that required them to write about science. This was important because it got many more Chinese interested in science and exposed them to western science. Questions were created in conjunction with the

Chinese government, and carried nationalistic overtones. Some of the questions were: "In the sciences, China and the West are different; use Chinese language to critique Western learning," "Substantiate in detail the theory that Western methods all originate from China," and "Prove in detail that Western science studies mainly were based on theories of China's pre-Han masters." (Chun, 2005).

External and Internal Pressures

China has suffered great losses at the hands of colonial and military powers in the past three hundred years. It has also undergone a massive political upheaval with the ending of the Qing dynasty and the creation of the People's Republic of China in 1911. Russia, France, Great Britain, and Germany all sought to carve out chunks of China for themselves during the past two centuries. China fought off and succumbed to Japanese invasions. These external forces were and continue to be major sources of embarrassment and shame for the Chinese, sentiments that in no small part contribute to China's determination to make its overdue ascent onto the world stage. Much of this progress depends on S&T advancements. China also experienced its own terrible civil war between Chiang Kai-shek's Kuomintang and Mao Zedong's Chinese Communist Party (CCP) from about 1927 to 1949. Mao Zedong's CCP came to power on October 1, 1949, but this did not end China's internal conflicts. The Great Leap Forward and The Cultural Revolution, in particular, resulted in the deaths of millions of Chinese and the disenfranchisement of scientists and academics.

All of these events have been significant barriers to China's S&T advancement in recent centuries. Both external and internal pressures have stifled China's scientific growth. However, in the past forty years - no matter how atrocious the human rights abuses of the CCP and the other weaknesses it may have - China has enjoyed a relative period of stability long enough to make significant scientific advancements that are bringing it to the forefront of international science today.

There are certain aspects of Chinese history that are inescapably intertwined with its scientific development, or lack thereof, and deserve at least the briefest of mentions here.

The Sino-French War (1884-1885) saw the French take control of parts of Vietnam that had previously been controlled by China. The First Sino-Japanese War (1894-1895) saw Japan win control over part of Korea previously controlled by China. It revealed China's modest adoptions of Western technology were no match for Japan's Meiji Restoration and naval combative skill. The 1898 100 Days' Reform during the Qing dynasty was a response to the recent French victory and an attempt to Westernize China so as to combat foreign powers. It was a failed cultural, political, and educational reform movement. Begun by the young Guangxu Emperor, it was ended in a conservative coup led by the more traditionally-minded Empress Dowager Cixi (1835-1908).

The First Opium War (1839-1842) saw Britain in conflict with China over trade, particularly opium, the disastrous drug that gave the conflict its name and continues to wreak havoc in China and other parts of Asia today. The British East India Company wanted more access to Chinese markets and began making great sums of money from

Chinese opium addicts, whereas previously the British were the ones doing most of the buying (of silk, tea, and porcelain) from the Chinese. The Chinese government under the Daoguang Emperor of the Qing dynasty, alarmed by such profit losses and unfair trading practices, ordered that opium be confiscated and its import controlled. The British, for their part, objected to the seizure of their goods and launched a resounding naval attack. This resulted in the Treaty of Nanking in 1842, one of several devastating embarrassments for the Chinese; it granted the opening of five treaty ports for Britain and the control of Hong Kong was given to Britain (this control ended in 1997). The Second Opium War (1856-1860) was much the same story, this time including French imperialist powers. It further opened China to trade with Britain and France and resulted in China's paying reparations to European powers.

An important early development between China and the U.S. was the Open Door Policy. Created in 1899 and 1900, it ensured equal trade privileges between China, the U.S., Great Britain, Germany, France, Italy, Japan, and Russia. It was a component of China's international trade subjugation but also sought to hold China together in the face of imperialism (Needham, 1945). It was a cornerstone of American foreign policy with China for more than 40 years.

One of the important events within China was the Self Strengthening Movement (1861-1895). It was launched during the Qing dynasty in response to the recent embarrassing losses to foreign powers. Chinese government officials, appalled by the apparent military superiority of Western powers, launched a campaign of social reform as well as economic and military modernization, during which the Qing dynasty adopted much of Western

S&T. The Tongzhi Restoration (1860-1874) was in large part a response to the Self-Strengthening Movement and sought to restore traditional order in China and the Qing dynasty. It was designed by the formidable Empress Dowager Cixi. The Taiping Rebellion (1850-1864) further contributed to the internal instability of China. It was a civil war in southern China that partially coincided with the Second Opium War. It was one of the deadliest military conflicts in history, with a death toll of at least 20 million (Schneider, 2011). Hong Xiuqian was rebelling against the Qing dynasty and sought certain social reforms. The rebellion was eventually crushed with the aid of British and French forces.

There was much internal resentment toward the Qing dynasty, and much of this resentment culminated in Sun Yat-sen's creation of the Republic of China in 1911, a government that was only officially displaced with Mao's ascent in 1949. The last emperor of China, Aisin-Gioro Puyi, known more commonly as simply Puyi, led a fascinating and tumultuous life - he became an emperor while still an infant, was forced to abdicate, was emperor again, forced yet again to abdicate, and was used as a puppet emperor by the Japanese.

By the end of the Chinese Civil War (1927-1949), Mao took control of modern China and the Kuomintang moved to present-day Taiwan, establishing a democratic government there whose recognition (or lack thereof) has been a major source of sour feelings between China and the West. In the midst of the civil war, from 1931-1945, Chiang Kai-shek and Mao Zedong had to work together against a common enemy that occupied China: the Japanese. The Japanese occupation was another blow to China's pride and is still one of the main reasons for antagonism between the two countries. Occupation was a result of losses during the Second Sino-Japanese War (1937-1945). The Nanjing Massacre, in which approximately 300,000 Chinese civilians were slaughtered by Japanese forces, occurred at the beginning of this war during a blood-filled December in 1937. The Japanese government has yet to apologize and a powerful museum and memorial of the event has been erected in Nanjing, China.

On October 1, 1949, Mao announced from Beijing that the civil war was over and that the CCP had control of China. So began a communist reign that lasted until his death in 1976. One of his most memorable legacies is the Great Leap Forward. China launched the Great Leap Forward in 1958. Peoples communes were created from the previous cooperatives, but agricultural production declined. Backyard steel furnaces sprung up across the country, as everyone was expected to contribute to industrialization but often did not have the means. Production quotas were unrealistic and people began turning in fake numbers for their outputs, or pretending to be burning steel in their backyards when actually they were burning household furniture. 14 to 26 million people are thought to have died because of famine and disease during the Great Leap Forward between 1959-1961. S&T development was significantly halted during this time, but also improved by leaps and bounds due largely to a partnership with the Soviet Union.

China's scientific and technological collaborations with the Soviet Union deserve significant attention. Throughout their relationship, China relied heavily on the Soviet Union for scientific and technological support. There is no way China would have been able to progress as quickly as it did without this monumental support (Suttmeier, 1980).

Beginning in 1950, thousands of Soviet scientists, technicians, and advisors went to China to help the country develop. In 1957 they helped with China's nuclear program.

A significant scientific mishap was the Chinese following of the Soviet scientist Trofim Lysenko on his theories of genetics while the west looked on in shock (Suttmeier, 1980). The Chinese, however, did not continue to blindly accept Lysenkoism for long; although they had a close scientific relationship with the Soviets, they did not agree on everything (Suttmeier, 1980). The Soviets, who had been so important in helping China industrialize, split from China in 1959 and withdrew all of their support. China was determined to progress without the Soviets, but it was an impediment to their development and science programs nonetheless.

Mao began the Great Proletarian Cultural Revolution, or simply the Cultural Revolution, in 1966. Thousands of intellectuals - scientists among them - were "re-educated" by being relocated to rural farming areas to be used for labor. Again the advancement of science in China was derailed. The young Red Guards were Mao's watchdogs throughout the country. Mao became obsessed with the obliteration of old thought, customs, and habits. The years of the Cultural Revolution, from 1966 to 1976, seriously disrupted education and postgraduate training (Cao and Suttmeier, 2001). The Cultural Revolution saw the CCP decimated through purges. There were disruptions in education and scientific progress. It is thought that during the Great Leap Forward and Cultural Revolution, Mao effectively killed more people than Hitler and Stalin combined. There were also major disasters during this time; the Huang He flooded seven times and a major earthquake killed about 470,000 people in Tangshan. If the Mandate of Heaven were still to be believed, these were signs that it had been lost by the current ruler.

Mao died in 1976. A power struggle followed, and Deng Xiaoping eventually emerged from the fray. He himself had been purged twice during the Cultural Revolution. Deng began a period of reform and economic liberalization. He is largely responsible for leading China into its current state as an economic and scientific powerhouse. In 1988 Deng pronounced that "science and technology is the primary productive force." By the time Deng was looking for a new generation of scientists to help with the modernization of China, an entire cohort was missing from Mao-era purges and policies. S&T was one of the Four Modernizations Deng, along with Zhou Enlai, launched in China: agriculture, national defense, industry, and S&T.

The changes China has undergone in the past 50 years alone, not to mention its dynastic altercations in the past fourteen centuries, are simply remarkable. It has gone from being largely dominated by imperialist powers to flexing its own muscles among those countries that used to be its greatest antagonists. Only at the beginning of the 21st century has China's scientific community truly been able to thrive.

Meanwhile, in the United States

While China has approximately seventeen centuries of history, the United States of America has fewer than three hundred years. Our two parallel and yet extremely different paths have led to the S&T collaboration we have today. The Enlightenment that had so greatly affected Europe came with immigrants to the U.S. From our countries founding in 1776, the importance of S&T was already recognized. The 1776 U.S. Declaration of Independence states that the U.S. Constitution gives Congress the power "to promote the progress of science and useful arts by securing for limited times to authors and inventors the exclusive right to their respective writings and discoveries." Patent rights, intellectual property, and individual freedoms were emphasized; this is a major difference between the emergence of modern science in China and the U.S. One similarity in the development of modern science in the two countries is the use of S&T for national defense. While China was reeling from the Opium Wars, the United States was a young country in the throes of the American Civil War (1861-1865).

While the U.S. hardly emerged unscathed from WWII, it was one of the only industrial nations after the conclusion of WWII whose homeland had not been directly affected by war, and as a consequence the U.S. became an international leader in S&T. The development of "big science" saw big government money being poured into S&T in the U.S. This continued into the Cold War and space race. One of the differences between the development of modern science in the U.S. and China was the prominence of originally foreign scientists and inventors in the U.S. after WWII; Alexander Graham Bell, for example was Scottish; Enrico Fermi was Italian; Albert Einstein was German.

How is science currently done in China?

The China of today is a vast country with staggering geographic, biological, demographic, and ethnic diversity. It is a nation of approximately 1.4 billion people, with deserts, rainforests, grasslands, city sophisticates, and rural subsistence living. China now has 22 provinces, 5 autonomous regions (giving a nod to non-Han peoples), 4 central government-controlled municipalities (Beijing, Tianjin, Shanghai, and Chongqing), and 2 special administrative regions (Hong Kong and Macau). It is dangerous to make generalizations about all of China, as there are undoubtedly myriad exceptions to the rule. The conclusions in this thesis are based on personal experience, a literature review, and many interviews with both Americans and Chinese.

According to the Library of Congress China Country Study, “in a speech to the National Science Conference in March 1978, then-Vice Premier Deng Xiaoping declared: "The crux of the Four Modernizations is the mastery of modern science and technology. Without the high-speed development of science and technology, it is impossible to develop the national economy at a high speed" (Qui, 2014). For more than a century China's leaders have called for rapid development of S&T and “science policy has played a greater role in national politics in China than in many other countries.” (Library of Congress Country Study, 2014). Yet “the development of science and technology has been uneven, and significant achievements in some fields are matched by low levels in others…the character of Chinese science also reflects concentration of resources in a few key fields and institutions, often with military applications. In more politically radical periods - such as the Great Leap Forward (1958-60) and the Cultural Revolution (1966-76) - efforts were made to expand the ranks of scientists and technicians by sharply reducing education and certification standards.” (Library of Congress Country Study, 2014).

The science of China today is defined by rapid change. In the past twenty years alone, there have been more scientific publications (Wang et al., 2012; Wang, 1993; the Editors, 2010; Schneider, 2011; Rasgotra, 2013; Qiu, 2014; Morrison, 2014; Lu, 2010; Larson, 2014; Friedman, 2014); there have been more graduates at all education levels in STEM. fields; more students have studied STEM fields in the West, especially in the U.S.; there has been more government funding for both research and development (R&D) and S&T; there has been more international collaboration in STEM fields; there has been more scientific collaboration within China; more advanced labs are being erected within China. All of these things are widely recognized by the international scientific community. It is astounding not just the change China has undergone in these ways, but how quickly that change has happened. It is something to be admired and keenly aware of.

Hierarchy & Autocracy

As it has been for centuries of dynastic rule, China's science today largely emanates from the state. The Chinese governmental structure, in contrast to the American governmental structure, is hierarchical. Many of the top science agencies in China are overseen by the State Council along with a handful of the ministries including the Ministry of Environmental Protection (MEP), the Ministry of Industry and Information Technology (MIIT), and the Ministry of Water Resources (MWR).

Three of the most important and best funded scientific organizations in China are the Chinese Academy of Sciences (CAS), the Ministry of Science and Technology (MOST, formerly the State Science and Technology Commission), and the National Natural

Science Foundation of China (NSFC). All are headquartered in the capital city of Beijing. Many of the top universities in China are also located in Beijing, including Tsinghua University and Peking University. It is a pattern seen repeatedly in the Chinese scientific structure; funding, collaborations, and major institutions and centers emanate from Beijing. The number one producer of scientific literature in China is unquestionably the Chinese Academy of Sciences (CAS). CAS was created in 1949, the same year as the current government of China (CAS, 2015). CAS has launched an incentive program called the Thousand Talents Program, which helps fund Chinese scientists under the age of 55 working both full-time and part-time as well as a Distinguished Young Scholars program for Chinese scientists under 40 (CAS, 2015). In 1994 China set up the Distinguished Young Scientist Programme to support promising Chinese scientists under the age of 45.

The advantage to such heavy government investment is that much of the work gets done quickly and certain areas of science can advance quickly. The disadvantage is that creativity is reduced because science is more often used in the directed sense - as a means to an end, hardly ever “for science’s sake.”

In Chinese universities, there are two parallel systems of administration. One is the academic administration system, similar to that in the U.S. The second is the Communist Party. There is a Community Party Deputy who sits next to the Dean. There is another deputy who sits next to the Provost. And yet another one who sits next to the President. Everything must be approved by both the Communist Party representative and the university academic official. That slows things down and doubles the number of people faculty need to network with. Colleagues spend an enormous amount of time just going around and chatting with people to build guanxi, which can loosely be translated as relationships or connections.

“It relates to the old debate between democracy and autocracy,” Brett Tyler, a professor in the department of botany and plant pathology and director of the Center for Genome Research and Biocomputing, said, “Democracy can take forever to get things done, while autocracies just get it done. When the Chinese decide they want to get something done, such as invest in a technology or invest in a certain field, they will focus on that and dump a lot of money in that, and they’re not held back by people saying “Oh that’s not fair.” Democracy isn’t always good at getting things done quickly and efficiently. Autocracy can be extremely effective in getting things done, but overall governance might not be good.”

One sociological study conducted by Anderson et al. in 2010 used “gravity mapping” and the Science Citation Index (SCI) to show the linkages between China’s scientists in different cities. Unlike the “polycentric” U.S. - meaning the U.S. has many geographically varied spheres of scientific influence, in Palo Alto, Atlanta, and D.C., for example - China is “monocentric”; the center of Chinese science is unequivocally Beijing (Anderson et al., 2010). There are more scientists, more universities, and more research institutes in Beijing than in any other location in China (Anderson et al., 2010). In western countries like Europe and the U.S., the number of collaborations generally decreases as a function of geographic distance, but in China this simply is not so - it seems the only truly important factor is how well connected a Chinese scientist is with

Beijing (Anderson et al., 2010). No matter its distance from the capital city, any major Chinese scientific endeavor is somehow linked to Beijing. The paper also hypothesized superior infrastructure may be partially the cause of this, but it most certainly mostly due to the political structure of Beijing and the hierarchical structure of Chinese society (Anderson et al., 2010).

There are no specialized, remote Chinese college towns like there in the U.S. (Anderson et al, 2010). Chinese universities are in Chinese cities. Almost all have central urban locations, though “university districts” which are still in the city are emerging. Another interesting finding is that science does not increase in Chinese cities according to how developed the cities are, as it seems to do in Europe and the U.S. In the U.S., you would expect to find big science endeavors within any well-developed city. But in China, some well-developed cities are focused more on industrialization (in accordance with Beijing’s goals) and have little to no scientific influence (Anderson et al., 2010).

There is plenty of hype in the west about China rising to the top of the scientific world, with the number of publications and graduating students repeatedly - almost hysterically - held up as evidence by western sources. China’s publication of science related articles has had an annual exponential growth rate of 20% for the past three decades (Wang et al., 2012; Wang, 1993; the Editors, 2010; Schneider, 2011; Rasgotra, 2013; Qiu, 2014; Morrison, 2014; Lu, 2010; Larson, 2014; Friedman, 2014). Yes, the world should consider China a bigger player on the world scientific stage and respect the Chinese greatly for this, but the U.S. should not act so fearful and paranoid about this ascent. We should reflect on the quality of that ascent. It is true China is publishing many papers and graduating many students, but the high quantity does not necessarily mean high quality. And by what means are the Chinese reaching these ends of increased numbers? We should ask similar questions of any apparent trends in American scientific development; a simple increase in numbers does not always mean a greater contribution.

First, the increased number of Chinese STEM graduates will be addressed. Chinese labs tend to have many more graduate students than American labs, though interestingly not more undergraduates nor Ph.D. students nor post-doctoral students. Many of these graduates that are cited as such heavy evidence in western reports of China's scientific ascent may not have their sights set on scientific careers that translate into the progression of Chinese science, however. This is also an issue in the U.S.; many graduates in STEM fields do not go on to STEM careers. It may be that the proportion of students seeking careers outside the realm of science is higher in China. A degree and a publication can tend to be important factors in order for Chinese graduates to be competitive when moving on to work for the government, a career still coveted as a stable line of work in China.

Second, the increased number of Chinese publications will be addressed. Not all of the Chinese scientific publications are of the quality generally accepted by the international community, however. Again, this is also sometimes the case in the U.S. as well, but it seems to be more prevalent in China. The same pressures on professors to publish that exist here in the U.S. exist also in China, but it seems to a larger extent. Their relationships, reputations, careers, and livelihoods depend on it more so than they do for American scientists. A 2006 Science article explains: "To earn a master's degree, students at many universities must be first author of at least one SCI paper, and Ph.D. students need two. Many institutions hand out cash rewards - hundreds of dollars, scaled by the journal's reputation - for publishing a SCI paper. The combination of pressure and incentives has nurtured an environment that's rife with simultaneous or serial duplicate manuscript submissions, self-plagiarized cookie-cutter papers, individual and institutional honorary authorship, and outright plagiarism" (Xin, 2006).

There have been multiple big name reports of corrupt behavior within the Chinese academic system. According to the 2006 Science article, in the "scientific Wild East, an unprecedented number of researchers stand accused of cheating - from fudging resumes to fabricating data - to gain fame or plum positions" (Xin, 2006).

Scientific collaboration patterns reflect political resource allocation decisions, more so in China than in the U.S. In 1980, China focused its scientific endeavors mainly on multi-disciplinary science, medicine, and life sciences; by 2005, the government shifted its scientific focus to materials science, chemistry, and physics (Schneider, 2011). China's strengths in science include material science, physics, some hi-tech ventures, genetics, and the harboring of "big data," while it's weaknesses are a lacking investment in basic research, the life sciences, and social and psychological research (Schneider, 2011; Qiu, 2014). According to a 2007 paper published in Technological Forecasting & Social Change, "compared to the USA, the bulk of China's articles focus on the physical and engineering sciences, while the USA articles (compared to China) focus on medical, social, and psychological sciences" (Kostoff, 2007). Advances in hi-tech areas have been keys to the economic development of China, something that has ensured the tenuous stability of the CCP. The differences in focus between China and the U.S. are striking; China tend to emphasize the sciences that underpin defense and commercial needs, while the U.S. has a greater focus on research that will solve medical, psychological, and social problems. The 2007 reports predicts this gap will widen in the future (Kostoff, 2007).

Lack of Autonomy

Chinese scientists have long lacked autonomy from the government and this is still an issue hotly debated in China today. During Mao's time, CAS went before the CCP and demanded more freedoms in a statement that outlined their suggestions for improvement (Library of Congress Country Study, 2014). They were summarily "re-educated" (exiled and stripped of any influence) in rural China. Historically, it has been difficult for scientists to criticize the government. It remains difficult today. Another issue is scientists do not generally seem to have the freedom to simply investigate whimsical curiosities nor propose a research investigation simply because that investigation tackles a novel question; novel is not necessarily a good thing in Chinese proposals.

The Beijing Genomics Institute (BGI) is one example of the presence in China of "big data" and the impressive ability of the Chinese government to quickly fund certain scientific ventures it deems advantageous. The BGI facility in Shenzhen, China has the largest facility for genome sequencing in the world as well as a sizeable gene bank, a "bio-Google." It also has the largest pig cloning facility in the world, producing about 500 pig clones per year (Source: BBC News, 2014, http://www.bbc.com/news/science-environment-25576718). In 2010 the China Development Bank gave BGI a $1.58 billion line of credit (Shane, 2010). BGI has also published 18 research papers in Science and Nature since its establishment in 2007 2007 (Frank, 2011).

Both the U.S. and China complain of a brain drain. China is trying hard to get its scientists to return to China for work as well as trying to entice foreign scientists to come to China to work, with some success (LaFraniere, 2010). Other articles highlight the influx of Chinese scientists to the U.S. (Shane, 2010; Freifelderin, 2015; Holden, 2014; Kahn, 2011). The exchange of scientists between the two countries has increased.

Freedom of information is another hot topic when it comes to the differences in American and Chinese science culture. This conflict in China is exemplified by the recent disagreements with Google and the more recent government crackdown on VPNs. One New York Times article described how frustrating this can be for Chinese scientists, hypothesizing that perhaps they will return to the U.S. after having observed the differences in freedom of information access. (Wong, 2015).

The Chinese are known in the scientific world for their possession of big data sets. With more than 1.3 billion people, China has the capability to generate mass quantities of data on a relatively homogenous population. Scientific studies like those published in the infamous 2005 “China Study,” which used large Chinese data sets to investigate the effects of diet on weight loss and long term health, demonstrate this capability. Some Chinese scientists feel bitter about this big data role they feel they have come to take on, feeling they are used as “cheap labor” and as simple data sources by the scientific community without enough recognition or leadership opportunities. In some ways, China is still reeling from the embarrassments it suffered during the nineteenth and twentieth centuries. This plays a role in China's science culture and consciousness; there is a sense of needing to prove themselves on the world stage.

"There is criticism that our main role is to supply raw data, such as patient samples and cheap labor, and our foreign collaborators provide the idea, lead the project, and get most of the credit," said Mu-ming Poo, Chair of the Institute of Neurosciences at the Chinese Academy of Sciences in Shanghai during a 2014 forum from the National Science Review, which reads slightly like a staged play directed to American audiences to deliver somewhat subtle messages about how the Chinese would like to collaborate.

"Most Chinese researchers are willing to pay the 'tuition' at the beginning," said Jianwei Pan, a physicist at the Chinese University of Science and Technology at the Chinese Academy of Sciences in Hefei, in reference to Chinese big data exchanges with American collaborators. "Even though we have a lot of unique data, we may not have the experience or perspective to make the most out of them. But things will change after we learn from the experience of international collaboration and begin to develop our own ideas. This is a stage China will have to go through."

The forum highlighted this quote from Tandong Yao, a glaciologist of the Institute of Tibetan Plateau Research in the Chinese Academy of Sciences in Beijing: "We've passed the stage of merely providing cheap labor or passively following other countries in major international endeavors."

“If an institute invests a lot of money and human resources to collect patients’ data, how would it be willing to give them away lightly? This is a problem in big-data science. If China has a top-down policy to support such data collection and integration, we may have an advantage in this kind of international collaboration,” said Xuetao Cao, an immunologist and president of the Chinese Academy of Medical Sciences in Beijing.

“This provides rich resources of genetic materials and disease types, which our foreign colleagues are extremely interested in. Large-scale national epidemiology studies are areas China could lead in international collaboration,” said Cao.

Chinese scientists have just as difficult of a time, if not more difficulty, in collaborating with each other as Americans do collaborating with Chinese colleagues. “As evaluation systems in China don't value the contribution from researchers who are not first or corresponding authors, it's more difficult to attribute credit when several Chinese labs work together. And a strange consequence is that it's very difficult to get Chinese researchers to work together even if it's more beneficial to Chinese science,” said Jianwei Pan in the forum, a Quantum physicist of the Chinese University of Science and Technology at the Chinese Academy of Sciences in Hefei.

Science has been and will continue to be a competitive endeavor, despite its spirit of cooperation for the advancement of human knowledge. It is collaborative within certain boundaries; at the end of the day, both in the U.S. and even more so in China, it can be a quite a cutthroat enterprise.

Chinese culture tends to emphasize modesty and courtesy, while the American scientific community can sometimes have a he-who-yells-loudest-about-himself-wins feel. This can be a disadvantage for Chinese scientists on the international stage. A Chinese scientist has yet to win a Nobel Prize (though ethnic Chinese living in the U.S. have won the award), something that seriously irks them and Chinese scholar Cong Cao calls the Chinese "Nobel Prize Complex."

One particularly interesting piece in the New York Times published in 2010 offered the opinions of a handful of Chinese and American scholars on the issue of the scientific rise of China, which are summarized briefly here. Gordon G. Chang, author of *The Coming Collapse of China*, believes China's hierarchical, Beijing-centered structure smothers creativity and prevents the advancement of social sciences and soft disciplines. Furthermore, Beijing's oversensitivity to science that goes against the party line (such as wide swaths of biology that do not promote the occasional dubious racial theory) prevents much of the natural sciences from progressing. According to Cong Cao, author of *China's Scientific Elite* and who is referenced multiple times in this thesis, "the pressure for visible outcomes [such as quick and numerous publications] encourages academic fraud and corruption." John Kao, chairman and founder of the Institute for Large Scale Innovation, states that China is producing too large a quantity of science without enough quality and that the government is following "an industrial nostalgia rather than an ethos for innovation." Vivek Wadhwa, the director of research at the Center for Entrepreneurship and Research Commercialization at Duke University, cautions "anti-immigrant policies in the U.S. and a booming economy in China are causing highly skilled workers [and scientists] to go home." Jonathan Moreno, a senior fellow at the Center for American Progress, pushes for the U.S. to further emphasize scientific exchange through personal relationships with Chinese scientists. Gang Xiao, director of the Center for Nanoscience and Soft Matter at Brown University, says the Chinese government is adaptable to new ideas, but that rigid hierarchies and limits on the amount of information Chinese scientists have access to are the biggest obstacles (The Editors, 2010).

What do both parties have to gain from scientific collaboration?

Nations collaborate in order to accumulate knowledge and create a better global understanding of the world, to solve shared problems, and to strengthen relations in other spheres. There is great benefit to be had for both the U.S. and China in scientific collaboration. S&T are essential for both countries in facing new security and economic challenges, many of which the two countries share. There is a cooperative and yet antagonistic relationship between the two.

According to Francisco Marmolejo, Tertiary Education Coordinator of the Human Development Network at The World Bank, "between 2025 and 2050, half the world's population will speak Mandarin Chinese and the other half will speak either English or Spanish, with English as the predominant second language." China as an international presence and the Chinese as a people are not going to go away any time soon.

Though governments around the world seek international scientific cooperation, these motivations are inevitably laced with the desire to enhance national capabilities independent of global capabilities. A 2014 report for the U.S.-China Economic and Security Review Commission highlights this tension between “science and technology nationalism” and “science and technology globalism” (Simon, 2014). According to this report, China and the U.S. are now each other’s main partners in scientific collaborators.

How is collaborative science between China and the U.S. currently done?

Former U.S. President Richard Nixon’s landmark 1972 visit to China formalized new diplomatic relations with China. It ended 25 years of a stubborn silent treatment between the U.S. and the recently formed People’s Republic. The visit allowed the two nations to - at least temporarily - set aside the awkward question of recognizing Taiwan, which had long been a sore point for the Chinese government in Beijing. Another crucial objective was deferring the Soviet Union’s sphere of Communist influence. A permanent U.S. trade mission was also established. This had the inevitable consequence of increasing scientific collaborations between the two countries that had long been rivals - especially in the area of aerospace - for much of the Cold War. Subsequent U.S. presidents continued diplomatic relations and visits to the PRC, with various ups and downs, most notably the change in relations after the fall of the Soviet Union in 1991 and the mistrust and tensions created by the Tiananmen Square Massacre in 1989. From the beginning of U.S. relations with the PRC, attitudes have been characterized by a hesitant cooperation, a notion of being simultaneously close friends and close enemies.

During a speech in Shanghai in 1972, Nixon declared, "This was the week that changed the world, as what we have said in that Communiqué is not nearly as important as what we will do in the years ahead to build a bridge across 16,000 miles and 22 years of hostilities which have divided us in the past. And what we have said today is that we shall build that bridge" (Kahn, 2011).

On January 31, 1979, U.S. President Jimmy Carter and Deng Xiaoping signed the U.S.-China Agreement on Cooperation in Science and Technology (S&T). The Agreement, which was renewed most recently in 2011 and is in effect to this day, has advanced cooperative research in fisheries, earth and atmospheric sciences, basic research in physics and chemistry, a variety of energy-related areas, agriculture, civil industrial technology, geology, health, and disaster research. This government-to-government relationship consists of about 30 agency-to-agency protocols and more than 40 active sub-agreements (Library of Congress Country Study, 2014).

In 2002, the U.S. and China signed a protocol for joint cooperation in agriculture science and technology between the Chinese Ministry of Science and Technology and the USDA's Agricultural Research Service in agricultural biotechnology, natural resource management, dairy production, food safety, agricultural products processing, water-saving agricultural technology, and bioenergy (Library of Congress Country Study, 2014). In October of 2010, the EPA and China's MEP signed a Memorandum of Understanding on Scientific and Technical Cooperation in the Field of Environment, supporting collaborative efforts to address air pollution, water pollution, pollution from persistent organic pollutants and other toxic substances, hazardous and solid waste, and the development, implementation, and enforcement of environmental law (EPA, 2015). Many initiatives have emerged with China through the Strategic and Economic Dialogue

(S&ED). One of the most notable agreements in recent history is the creation of the U.S.-China Clean Energy Research Center (CERC) in November 2009 between U.S. President Barack Obama and then Chinese President Hu Jintao, renewed in November 2014 by Obama and current Chinese President Xi Jinping.

America's scientific relations with China most certainly extend beyond the spheres of the two countries' governments. There are now collaborations between companies, universities, professional societies, NGOs, and various people-to-people contacts. There have been major congressional mandates constraining the China-related activities of the U.S. Office of Science and Technology Policy (OSTP) (Pentland, 2011). The report purports the "overall health of U.S. science - especially university-based basic science - should be a matter of concern" (Simon, 2014).

What is notably different about the U.S.-China scientific relations compared with U.S. scientific relations with other countries is the huge presence of Chinese professional diaspora within the U.S. The flow of Chinese scientists to the U.S. and vice versa has only increased in the past three decades (Simon, 2014; Chu, 2013; Council on Foreign Relations, 2013). The report's executive summary concludes with, "In sum, the U.S.-China S&T relationship has become a complex, multifaceted pattern of engagement, particularly as China brings new capabilities, new wealth, and a strong sense of strategy to its S&T interactions with the United States" (Simon, 2014).

The Chinese Presence in Oregon

It is interesting to note that while China was undergoing its own development, there was a significant community of Chinese immigrants already in Oregon. Most Chinese immigrants came to Oregon from California during the Gold Rush in the mid-1800s (Oregon Multicultural Archives of OSU, 2014). Most of these people were from Guangzhou in Guangdong Province, near Hong Kong, and were young males (Oregon Multicultural Archives of OSU, 2014; The Oregon Historical Society, 2014). Chinese immigrants in Oregon faced significant challenges, including discrimination and anti-immigration laws at both the national and state levels. In 1859 the Oregon Constitution explicitly forbid any non-resident from China to own mining claims or real estate. At the national level, the 1882 Chinese Exclusion Act prohibited Chinese laborers from entering the U.S; subsequent legislation had the same effect. These were repealed in 1943 when China and the U.S. became allies in WWII.

Despite their disenfranchisement, the first Chinese people in Oregon made significant contributions to the states developing economy and landscape. They worked as miners, canners, railroad workers, farmers, ranch hands, and businessmen (Oregon Multicultural Archives of OSU, 2014). A tragic part of the Chinese history in Oregon is the 1887 Snake River Massacre, in which 34 Chinese miners were robbed and murdered by a white gang, the members of which never faced punishment and whose descendants still live in the area around Hells Canyon in eastern Oregon. Some of the murderers were from prominent families, whose descendants withheld certain incriminating documentation even a century later when author R. Gregory Nokes conducted research for his 2009 book

Massacred for Gold: The Chinese in Hells Canyon (Oregon Multicultural Archives of OSU, 2014; Natalia Fernandez, 2015).

Some of the Chinese history in Oregon was recently discovered in a collection of disinterment documents. These are available from an online archive made possible by collaboration between the Oregon Multicultural Archives (OMA) of OSU, the Chinese Consolidated Benevolent Association (CCBA), the Northwest News Network, and Portland State University Library's Special Collections. These documents showed one of several disinterment shipments that were made from Oregon to the Tung Wah Hospital in Hong Kong for redistribution among families in China (Source: Fernandez and Paschild, 2013). Sending the deceased's remains home to China was common practice in Oregon up until the last documented shipment in 1949 (the year Mao Zedong and the CCP took control of China). Shipments were arranged by the CCBA, an association that still exists today to serve the Chinese community in Oregon (Source: Fernandez and Paschild, 2013).

What is the History of Chinese Collaboration at OSU?

Today there is still a large Chinese presence in Oregon. This has resulted in a significant presence of Chinese students in Oregon public high schools, which in turn affects the Chinese population at OSU. According to a 2011-2012 OSU report on the university's diversity goals (the most recent available), 4.9% of the 26% of students of color at Oregon public high schools are Asian or Pacific Islander. This is the largest minority group after Hispanic. According to the same report, 7.2% of undergraduates at OSU are

Asian or Pacific Islander. According to the 2013-2014 Common Data Set at OSU, Asian and Pacific Islander undergraduates number 1,507 out of a total 27,925 students.

Much of the Chinese presence on the OSU campus is due to international students earning degrees at OSU. The INTO Program offers a pathway for these students, both at the undergraduate and graduate levels. According to the Fall Term 2014 International Student Enrollment Report, Chinese students are by far the largest group of international students. 1,772 of the 3,957 international students in Fall Term 2014 were Chinese, while 595 were Saudi Arabian (there are also South Koreans, Indians, Indonesians, Iranians, Taiwanese, Omanians, Japanese, and Brazilian students, in decreasing amounts). According to the 2012-2013 International Student Exit Survey Report, 29% of international students at OSU were part of a Master's program, 21% did an exchange program, 20% pursued Bachelor's degrees, 16% went through INTO OSU, and 14% did Doctorate programs. The majority of international students by a wide margin choose to study business or engineering (OSU Fall Term 2014 International Student Enrollment Report, 2014). The majority of international students are male (OSU Fall Term 2014 International Student Enrollment Report, 2014). Most students are on an F Visa, though this number may increase after President Obama's recent agreement with China to allow more Visa for 5 or 10 year periods to Chinese applicants (OSU Fall Term 2014 International Student Enrollment Report, 2014; Freifelderin, 2015). Interestingly, the top student sponsor is the Saudi Arabian Cultural Mission, while none of the listed student sponsor organizations were Chinese.

As a land-, sea-, space-, and sun-grant institution, OSU is a major player in research conducted in the state, and indeed around the world. According to the 2015-2016 International Student booklet, OSU received $263 million in research funding during the 2012-2013 fiscal year. It would be an interesting undertaking in a further study to learn what proportion of this funding involved collaborative work with Chinese scientists.

Oregon State University Researchers with Chinese Collaborations

There are many researchers at OSU who have collaborations with China, both on the Corvallis campus as well as part of the extended campus. In Corvallis, it seems there are professors in every department who have some connection to China, though it would take much more time and resources to identify every one of them. Dave King, Associate Provost of the OSU Extended Campus, first went to China in 1987 when he produced a PBS film about Inner Mongolia. In 2007 he led a project with the American Distance Education Consortium (ADEC) and the Central Agricultural Broadcasting and Television School (CABTS) which is part of the China Ministry of Agriculture to “develop collaborative, bi-lingual, cross-cultural online learning modules” (American Distance Education Consortium, 2014). Since September 2011, ADEC and OSU representatives have met in China twice and in the U.S. twice to improve their programs. The initial target audience was the 900 million Chinese farmers for whom CABTS provides training (American Distance Education Consortium, 2014). This is one example of the large impact parts of OSU, only one university in the United States, are currently having on China.

In the electrical engineering department, Patrick Chiang has had continuing semiconductor design collaborations with Chinese scientists at Fudan University ever since his 2006 NSF post-doctoral research fellowship at Tsinghua University in Beijing. In the College of Business, Zhaohui Wu has worked on sustainable supply chains with Chinese companies and the Chinese State Environmental Agency. In the College of Liberal Arts, Hua-Yu Li has worked with Chinese fellow political scientists to evaluate the Soviet impact on China. In the Department of Fisheries and Wildlife, Dan Roby worked with Chinese scientists to help establish a new breeding colony for the endangered Chinese crested tern. These are just a few examples of the wide array of Chinese collaborations done at OSU.

To better understand how scientific collaboration in particular is conducted between China and OSU, I sought out a group of researchers who have such endeavors with Chinese colleagues. I also interviewed both American and Chinese students from most of the labs of the people described below as well as both American and Chinese students unassociated with these labs.

I have taken an in-depth look at the work of the following five OSU researchers who conduct collaborations with Chinese scientists: Brett Tyler, David Hannaway, Bryan Tilt, Aaron Wolf, and Thomas Sharpton. I have also spoken with OSU scientists Desiree Tullos, who has done collaborative Chinese work with Tilt and Wolf. Each is at a different stage in the development of his or her Chinese connections and each represents a different scientific field - plant pathogen genomics, crop and soil science, anthropology and sustainable development, water science and policy, and microbiome ecology, respectively. They have had varying levels of success in sharing data, gaining expertise, and co-authoring publications, three of the goals many researchers have in beginning collaborations with China. I will briefly outline their work and connections to China below.

Brett Tyler

Brett Tyler is a professor in the department of botany and plant pathology at OSU, the director of the Center for Genome Research and Biocomputing (CGRB), and someone who has enjoyed great collaborative success with China. His office is decorated with tokens of this success - Chinese paintings hang from the wall; above a crimson couch there is a tac board with various collaborative publications pinned to it; across from that couch are four Chinese awards sitting open on a bookcase shelf. One of these is the Friendship Award of China, the highest civic award for non-Chinese scientists bestowed upon him by the Chinese government in 2013. It was the resulting publicity that had originally led me to the stoic Australian man.

Tyler's collaborations mostly focus on how to combat plant diseases affecting the soybean and potato so that food production can be improved and food security ensured around the world. China is particularly interested in combating plant disease because they are dependent on food imports; if a future conflict led to a cessation of food imports from the West, China would struggle. In an attempt to become self-sufficient, China has invested 10 billion USD in GMO food and is currently the world's leading producer of potatoes. According to Tyler, plant diseases destroy about ten percent of the world's agriculture production. If you could distribute that food properly, says Tyler, you could in one fell swoop solve most of the world's hunger problems. The world's population is continuing to double; one figure Tyler cited shows that in the next 30 years we need to produce more food than has ever been produced by the entirety of mankind up to this date. We are in a battle against time to prevent food shortages and starvation. The U.S. and China therefore have a vested interest in food production as a form of global security, and a vested interest in working together.

His first fruitful Chinese connection was with a friend of a friend - a man who was a post-doc in his lab at Virginia Tech. This friend, named Wang Yuanchao, was from the post-doc's undergraduate days when he was starting up a lab in Nanjing, China. Tyler invited Wang to his lab for three months to learn techniques. In 2004, Tyler visited China for a week. In 2005, another Chinese former post-doc got a position as a professor at a university in Yanling, China and in 2007 Tyler visited him there.

"Things snowballed from there," Tyler said. Now, Tyler is at no shortage for Chinese collaborations; in fact he has to turn many collaboration requests away since so many Chinese scientists are now chomping at the bit trying to secure work with him. In Tyler's lab there are currently two Chinese Ph.D. students, two Chinese post-docs, and one visiting Chinese student.

Tyler has been to China more than fifteen times. He has collaborations with Nanjing Agricultural University, Shandong Agricultural University, Anhui Agricultural University, Yangzhou Agricultural University, Northwest Agricultural and Forestry

University, Tsinghua University, and the Beijing Genome Institute. Outside of work, Tyler has traveled to Kunming, Lijiang, Zhongdian, and Tibet.

David Hannaway

Just down Campus Way from Tyler's office is a man who began collaborating with China twenty years before Tyler. David Hannaway, a professor in the department of crop and soil science and director of the forage program at OSU, made his first Chinese contacts in 1982 when two Chinese scientists - Hu Shing Tsung (who went by Peter) and Gao Liangzhi - came to work with him as visiting scholars. Hannaway came to collaborate extensively with Peter, who was a faculty member at China Agricultural University in Beijing. The two worked on a project that ten years later resulted in publication of the book Forage Resources of China and continued collaborations for 30 years. With Gao Liangzhi, Hannaway worked on developing an alfalfa crop simulation model. Their collaboration continues to the present.

Over the course of 32 years, Hannaway has travelled to China more than 60 times and visited nearly all provinces and their capital cities, agricultural universities, and animal husbandry bureaus. He has hosted Chinese undergraduate, graduate, and Ph.D. students. His current work with Chinese colleagues mostly involves defining Chinese climate and soil conditions to encourage the growth of plants that best serve the needs of foraging species like cows and sheep.

“Grain is expensive,” explains Pete Berry, a Ph.D. student working under Hannaway. “The cheapest way to feed your livestock is to have them graze pastures. If you can increase the forage for them to eat, you can save a lot of money.” China, like the U.S., wants to find the best way to produce quality meat and milk cheaply.

Better growth of certain forage plant species will in theory lead to higher quality meat and dairy products while addressing the huge environmental problems that have arisen from mismanagement of the land in China. There is a certain dichotomy between China’s intense desire for these improvements paired with its equally intense reluctance to release climate and soil data essential to these improvements; if Brett Tyler is an example of data sharing ease, David Hannaway certainly has had challenges in obtaining the data necessary for his work.

Bryan Tilt

Hannaway is not alone in his struggles to gain access to quality Chinese data. Bryan Tilt has also had his fair share of difficulties in this realm. As I asked about Chinese collaboration around OSU, I was repeatedly directed to Tilt, an associate professor in the anthropology department who speaks fluent Chinese, the result of more than a decade of language study and time spent living in China. He first learned how difficult it can be to acquire data in China during his graduate studies, when he was interested in industrial pollution. Anything related to the environment is a bit touchy in China and Tilt had trouble finding anyone willing to give him meaningful information for his studies.

“I’ve never *not* had restrictions on what I can do,” Tilt told me. “One of these days I’m going to work on a totally benign topic.”

The breakthrough in getting better access to information came in the form of a personal connection, this time a Chinese collaborator of his graduate school advisor. This was Li Yongxiang in Chengdu, Sichuan. Tilt’s research has been concentrated in the southwest area of China ever since, with his collaborative connections branching off from Professor Li.

Tilt usually goes to China at least once a year. His first trip to China was for a study abroad program in Harbin, in the cold northeast region closely neighboring Russia. Tilt also lived in China during a sabbatical and on a Fulbright Fellowship with his wife and two children for two years. He and his wife spent a total of about a year doing field work in villages in Sichuan. His primary Chinese interest is how the Chinese pursue economic growth while managing to “dodge the complete destruction of their environment.” He currently has a graduate and Ph.D. student from China working under him. More specifically and most recently, Tilt has worked on understanding the impacts of dams in China, conducting a seven-year study on the Three Parallel Rivers - the Nu (also known as the Salween), Lancang (Mekong), and Jinsha (Yangtze) - that have their headwaters in China. He teamed up with two other OSU researchers from different departments to do this: Desiree Tullos, an ecological engineer, and Aaron Wolf, a geosciences professor with a specialty in transboundary water issues and conflict resolution.

Aaron Wolf

The name Wolf suits him, with his diplomat's mastery of looking at an interviewer with unflinching finality when he has decided a question has been answered in full, even if that answer was only one sentence in length. "How does the saying go?" Tullos mused when I brought up her collaboration with Wolf. "That man could sell a red popsicle to a girl in a white dress." A professor in and department chair of geosciences, Wolf makes frequent trips around the world to conduct negotiations surrounding water issues; last year he worked in 24 different countries. His work with China has involved the joint dam project mentioned above, negotiation training, and his creation of the game-changing Transboundary Freshwater Dispute Database (TFDD).

"If you write on international rivers," Ph.D. student Jacob Peterson-Perlman, who works under Wolf, told me, "you call Aaron first."

The TFDD contains all the documented interactions surrounding water in the past one hundred years from the 276 international river basins that exist in the world (though that number is rising as more basins are documented). Former United Nations Secretary General Boutros Boutros-Ghali declared that the next world wars would be over water, and almost everyone in the field agreed, except for Wolf, who decided to take a closer look at the data. The data showed there has only been one war that was fought over water, and it was between the city states of Lagash and Uma in Mesopotamia four thousand years ago. Furthermore, analysis of the TFDD revealed that two thirds of the documented water cases were cooperative while only about one third were antagonistic (of that one third about two thirds of them involved Israel and its Palestinian neighbors), and none of that one third involved war. Wolf is quick to note that not all cooperation is good and not all conflict is bad, however, but points out that certainly the next world wars have not been over water.

“Almost all the rivers in Asia cross international boundaries and have headwaters in China,” Wolf said. 1.5 billion people rely on the water that originates in China, according to Wolf. It is a huge player in building dams and in water resources around the world, so naturally he has had many interactions with Chinese scientists and government officials. He has been involved in training workshops at Yunnan University that have helped the Chinese refine their approach to how their waters are viewed by the rest of the world, since so many of the world’s international players look upon China’s role in dams and water management negatively. For example, the Chinese No vote in the landmark 1997 U.N. Convention on water rights is often referenced as a reason for this attitude (China has yet to vote Yes.)

Wolf has also conducted formal research with He Daming at Yunnan University on the impacts of dams and international law. Both professors have invited each other to their respective universities. Another one of Wolf’s Chinese collaborators is Wang Zhijian, who is currently working in an office down the hall from Wolf as a guest post-doc and is using the TFDD daily. Wolf has hosted post-docs from China and has been to China for a week at a time over the course of five years. He seeks to help China “take its position in the world in a way that they’re comfortable enough to work multilaterally with other countries.”

Thomas Sharpton

For Thomas Sharpton, it was a chance meeting at a bioinformatics conference at OSU that resulted in his first professional Chinese connection. Of the five scientists interviewed, Sharpton is the newest when it comes to collaborations with China. He has only recently begun a collaboration with a female researcher in Nanjing, with the hope that she will come to the U.S. on a fellowship and they will begin working on publications together. Sharpton made his first trip to China this fall. His work concerns how the microbiome - the organisms that live on and inside mammals - influence mammal physiology. He hopes to better understand what microorganisms are living inside the intestines of certain livestock, like pigs, and how these microorganisms are related to the size and horticultural status of the pig. The idea is that if you can figure out what microbiome lives inside a healthy, fat, productive pig, then you can take action to reproduce those conditions for other pigs and get more yield out of your livestock. This is important because China is interested in developing the most productive livestock to better feed its people.

“This could change the nature of farming. No longer are you just harvesting animals; you’re harvesting the microbiomes in those animals,” Sharpton said.

The analysis of the microbiome is what you call “big data science.” You need lots of information to comprehensively analyze who is living on us and what they are doing. Most Chinese scientists, for their part, have multitudes of data but do not have the machinery and expertise to analyze it, nor an easy ability to publish their results in

English. Sharpton's lab, on the other hand, does not have the sheer amount of data that China has to offer but has the computing capacity and expertise. This is a common situation that preps both parties for partnership in the realm of U.S.-China scientific collaboration. The Chinese scientists walk away with the training they need, American scientists have access to more data, and both parties scientific journal publications.

"The Beijing Genomics Institute in general and China in particular have done a very good job of positioning themselves to be producers of big data. They have one of the most advanced sequencing facilities on the planet," Sharpton explains. The Beijing Genomics Institute is one of the largest genome databases in the world. China has produced landmark manuscripts in the microbiome field, particularly concerning the human microbiome. (A group of researchers in the BGI worked in collaboration with the European version of the human microbiome project - MetaHIT - and demonstrated differences in organisms between healthy and unhealthy individuals, and that within the group of healthy individuals there can be different types of healthy microbiomes. Perhaps at future cocktail parties we will be asking new acquaintances their biome types in place of inquires about their astrological signs.)

OSU has a fantastic computing center of its own, what Sharpton considers "a crown jewel at OSU": the CGRB, of which the previously mentioned Brett Tyler is the director. That is part of the reason why Chinese scientists are so interested in collaborating with OSU; at many of their institutions they lack access to anything like the BGI or CGRB.

Key Issues

The following key issues were topics that came up in most of the interviews as important aspects of a collaborative relationship with China, and more specifically a scientific collaborative relationship. Again, it is important to highlight the diversity within China and that any generalizations will inevitably have exceptions.

“I saw such a small fraction of the country. It’s similar to the U.S. - you can’t go to California and assume you’ve seen the whole country,” said Pete Berry after his first trip to China this summer, “There are so many small cultures within the U.S. and it’s the same way with China. Just talking about the food - everything changes with the region. So it’s hard to generalize.”

I will attempt here to address the cultural topics that were most prevalent in my readings and interviews with both Chinese and American scientists and students: relationships (or guanxi), the idea of face (or mianzi), “the Chinese yes,” dinner time etiquette, hosting and gift giving, living and working in China, data sharing, and creating win-win situations. My hope is that an American scientist who has little prior knowledge about China would, by reading this, be much better prepared to face the cultural issues he will inevitably face when working with the Chinese.

Having Guanxi and Giving Mianzi

"The buzzword is of course guanxi," Tilt tells me. Guanxi - pronounced like the "guan" of "iguana" and xi as in "she is stunning" - is translated roughly to relationships or connections, but that hardly does the term justice. "It's all about your guanxi. Usually you have to rely on someone else's guanxi," Tilt explains further.

You can gain guanxi by helping out a friend with his homework or taking him out to dinner. Later, when you need help, that friend is obligated to accommodate. Sometimes I imagine a Grand Guanxi Bank of Relations popping up like a familiar elephant in the room whenever two Chinese friends have an exchange. Buying a gift or doing a favor for a friend is a deposit in that friend's guanxi bank, and on a rainy day you can rely on the bank to return your investment in the form of a gift or favor to you. You can also make transfers or loans with your guanxi; if someone you know needs a place to stay in Beijing, you can transfer your guanxi to this person visiting Beijing by calling up your friend and saying you need a favor. We do this in the United States as well, but not to as great of an extent. Guanxi extends throughout all areas of Chinese society, from friendships to government to education to science.

"In China, if you're real friends, you know very private information about your friend, and you have to support him; you have to agree with him," my former Chinese host sister, Wu Siyu, told me. She is completing her undergraduate degree in Business and Economics at Miami University in Ohio. I lived with her and her parents in Nanning in 2009 for two weeks during a high school exchange. My strongest memories of her involve late nights she devoted to homework (her strongest memories of me, she told me later, were the large portions of food I ate). It was the first time I saw firsthand how hard Chinese students work; Siyu would attend school five days a week, take night and weekend classes, and stay up into the early hours of the morning finishing homework almost every day. Her case is not an isolated one; the large population creates an environment of intense competition for Chinese students who hope to succeed by out-working their peers.

In the U.S. we honor our friendships, to a point. But if we disagree with our friends, we will more than likely tell them so directly and we hardly ever feel obligated to blindly back our friends the way many Chinese people do. This is because a good Chinese friendship is steeped so heavily in guanxi bank investments. It is also one of the reasons, Jennifer Wang tells me, Chinese students sometimes are more tempted to help each other cheat.

“Students don’t want to break up the friendship. The support of the group is so important to them that they don’t want to give it up even for cheating,” says Wang, who is the INTO OSU Chinese student advisor. Refuse to help a Chinese friend cheat, and you may not get help when you need it. Not all Chinese students cheat, of course; Siyu is vehemently against her Chinese peers cheating and has helped her professors at Miami University devise ways to prevent it.

This is also related to the Chinese idea of face, or mianzi (pronounced like me, in, and zuh - imagine Arnold Schwarzenegger yelling “get *me in zuh* choppa!”). “Students are afraid to speak up in class because they think if they're not correct in front of the class then they'll lose face. They say 'I can lose my grade, but I cannot lose my face,'" Wang explained to me. By denying your friend help on his test, not only would you lose some of the guanxi you had built up with him, you would make him lose face.

"In China you don't speak straightforward or speak a lot about something, because we care a lot about what people think of us. We don't want to lose face. Americans care but not as much. Chinese people want to be in a group; they don't want to be different. In America when you're unique it's OK," said Siyu.

"One can 'diu mianzi' (lose face) or 'gei mianzi' (give face)," explains Tilt. "But you have to have face to begin with. You have face by being in a position of authority. Someone can lose face if another undercuts their authority, contradicts them, or shows disrespect. If someone is a social superior or equal you need to acknowledge their expertise, and in a very public setting. Doing it publicly in China is very important. Finding ways of recognizing your partners is really crucial...the fact that it's scripted and perfected doesn't mean that it's any less important or any less heart felt."

Li Xiaoyue, one of Tyler's Chinese Ph.D. students, has blacked out drunk in the name of giving face to a community whose trust she was trying to earn. Xiaoyue wanted to film a traditional Yi - one of the many minority groups in China - new years ceremony. Before she was allowed to begin the ceremony, however, she had to take three shots of baijiu, a very strong Chinese liquor. She had no choice but to drink it. She blacked out, didn't get the filming, and had to wait another year to return and try film the ceremony again.

It is valuable for American scientists to understand guanxi and mianzi because it will help them better understand why their Chinese counterparts act the way they do and help them to know what is appropriate in certain situations.

Wolf described a team building exercise he has conducted with both western and Chinese professionals that clearly shows this cultural difference. He asked everyone in the room to partner up and get ready to arm wrestle. On the word go, the westerners without fail immediately start trying to beat each other and slap their partners hands to the table. In the Chinese meeting rooms, however, upon the word go the arm wrestlers both freeze and do nothing. Neither arm wrestler wants to win because he doesn't want to make his colleague lose face.

Marco Clark, a former graduate student working under Bryan Tilt who has spent two years living in China, described it like this: "People in China think about the 'we.' Whatever you do reflects on your family, your friends, whatever community you're a part of. So it's a pretty strong motivator to do the right thing. But in the U.S. what you do only really reflects on you and we're taught to be individuals."

Over the phone with my grandfather, Bill Humm, who has conducted business in China since 1990 and been to China more than 100 times, he tells me before I can even ask my first question: "The number one thing is personal relationships. Then reputation." Grandpa Bill worked in industrial refrigeration at a time when refrigeration was a novelty to a China newly opened to American business. His guanxi is the reason I was able to go to China for the first time. His Chinese business associates arranged a three-week tour of China as a thank you to my grandfather for all of his years of business and I was allowed to come along. Now retired, he tells me the key to his success was his company's use of Chinese agents or secondary agents in country; the European companies he knew tried to begin business in China directly and were not nearly as successful.

"If you want to do research in China and you're not a Chinese person," Jacob Peterson-Perlman, a Ph.D. candidate working with Aaron Wolf, tells me, "you have to find a scholar like Wang here," gesturing to his Chinese associate who also works with Wolf, Zhijian Wang, "who can sponsor you and vouch for your work. Otherwise they're very non-trusting of outside people, of outside researchers."

Wang adds: "And if you're Chinese, you feel you should protect some Chinese national interest in the area where you work. It's hard to find a balance." But, Wang explains, if you are working with someone Chinese you can be seen as contributing to Chinese national interest instead of plundering Chinese information.

"In the U.S., if you don't know the person, you can just send him an email. In China, if you send that email, probably you won't get a reply. Someone high up has to introduce you," Yang Xiumei, a Chinese graduate student working under Hannaway, said. There is a hierarchy that people are constantly aware of. You know on which tier you sit and who your equals and superiors are. Due respect must be given to superiors and it is hard for someone lower on the ladder to just randomly reach up and talk to their higher up like they might in the U.S.

Building guanxi takes continuous work, and is almost like another occupation in and of itself. Many of the Chinese people I spoke with complained that sometimes they spend more time taking their collaborators out to dinner than they spend doing actual work. If someone important stops by your office, you drop everything to talk and build guanxi.

“In America, we have five minutes talk time, we sit and we talk, and then it’s done. But in China it’s not like that. We have dinner and talk about other things. In the whole two hours time maybe just two minutes we talk about the specific things. Because once we’ve already established the relationship we can talk about things more easily,” says Wang.

“In America, when you want to talk, you’ll send me an email to make appointment. In China, sometimes we don’t do this - just call them and say do you have time today and then talk. Sometimes we don’t make appointments earlier,” Xiumei echoes Wang. The upshot is that if you need to talk about something, Xiumei tells me, you can just quickly send your coworker a text to see if he’s free or just go talk to him without having to worry about making an appointment.

Similarly, if someone senior calls and asks you to put together a presentation for them by tomorrow, you do it, even if you have a proposal due at midnight, lectures to prepare, and papers to grade. Maintaining that relationship by putting together a presentation is more important than losing sleep and having to rearrange your schedule at the drop of a hat.

Wang again: “It’s normal for an American to refuse something. But in China they usually accept but maybe they truly cannot do that. They won’t say directly no but may give a reason why they can’t.”

Chinese scientists tend to really want to get to know the person they are going into a collaborative relationship with. Unlike in the U.S., where topics of religion, politics, and personal matters are generally avoided, the Chinese will often probe American collaborators. You can expect to be asked personal, awkward questions.

“I get comments and questions that would be unexpected for most westerners at work all the time,” Erin McCarthy, a recent Georgetown graduate working at a real estate office in Shanghai, tells me. “They ask direct questions about your weight, your appearance, do you have a boyfriend? You don’t want to reject it because you need to keep the guanxi. But you can work around it and answer vaguely if you feel uncomfortable.”

The Chinese “Yes”

One of my thesis procrastination techniques became watching YouTube videos about China. One of these videos I found was made by two young American men, Tim Nybo and Nick Ramil, who had gone to China to make it big in the business world and call themselves “the elevator life,” because why climb the corporate ladder when you can take the proverbial elevator? They have since created an eBook on starting a business in the Middle Kingdom. In one of their videos, they describe what they call “the Chinese yes.”

This is what my friends and I studying Chinese in Suzhou last summer had referred to as "the Chinese no."

It is my experience that often times Chinese people will find the most roundabout way to tell you no, or, more commonly, they will just tell you yes when what they really mean is no. It goes back to saving face and saving guanxi. Admitting an inability to do something would mean losing face. Saying no might indicate to a friend or collaborative partner that you do not care about them and you are not real friends, and that would lose you some guanxi. So they say yes. Then when the time comes to deliver, they make an excuse about why it cannot happen. So "the elevator life" tells us you have to be really sure you are getting a real yes, to really hammer home the details and ask them repeatedly, and if you sense there is a no in there, give them a diplomatically safe out to say no without actually saying no and losing face.

"I am American and we tend to want to be very direct. And that just doesn't work in China," said Tilt.

It is not only my experience. One female researcher at OSU got extremely frustrated with this when she worked in Beijing for a year in 2005 on her own. "China is a really frustrating place to work," she told me, "People promise things and don't deliver on them."

Wolf had an experience with the Chinese "no" during one of his collaborating sessions in the Mekong Delta. One of the Asian parties repeatedly said flat out no's to every proposal during negotiations. Later, Wolf was able to discern that they were just saying no because they did not know how to do what was being asked of them, they were feeling insecure, and did not want to admit to the whole community that they did not know how to do it. So the western delegation went back and said things like “We’re trying to figure this out together,” and “Can *we* do this?” instead of “Can you do this? And if you can’t it’s your fault.” The Asian party wanted to feel like part of a larger community, not just a group being taken advantage of. These are important lessons to learn from in any type of collaboration with the Chinese.

Dinner Etiquette

As a researcher going to China, it is important to understand that you will be taken out to dinner and that this will mostly not be a time for business, but a time for relationship building. If a Chinese person asks you out to dinner, then they plan to pay for your meal.

A good strategy if a Chinese person is not getting back to you or following through on his part of the deal is inviting him out to dinner. More than likely he will follow his cultural norm to say yes because if he said no it would be impolite, he would lose guanxi, and lose face. So he says yes, you do not talk about business at the table, then at the end you set up a time for you to meet and he is obliged to meet with you.

“The structure of hierarchy is written into the fabric of life in China,” says Tilt. All the way down to where you sit around the table is totally scripted. The way you toast people over drinks is totally scripted.

There is a certain hierarchy displayed at Chinese dinners. There is a symbology to where you sit around the table, when you eat, and how you clink glasses with your neighbors. At Chinese dinners, the most senior people eat first. The most senior people also sit in the seat where they can see the door. The next most senior person sits next to him and then people are arranged according to hierarchy after that. There are different words in Chinese for these different spots around the table. When you make a toast in China, as you will be expected to do if it is a dinner with collaborators, you make sure your glass hits the other person's glass accordingly - if you are lower ranked, you hit the glass below the other person's, if you are equals then you clink glasses at the same level.

During Pete Berry's first trip to China this summer, he saw there was a toast happening and raised his glass to join, as we would in the U.S. But the two Chinese men told him to sit down and wait his turn, that it was not a group toast at this time. Often at Chinese dinners, you move around the table toasting individuals so that everyone can be recognized, and then often there will be a group toast. It is taboo to put your chopsticks straight down into rice during dinner. At fancy dinners you want to keep your left hand below the table and use your right hand to eat with your chopsticks. As in most countries, you do not tip in China. There is often some amount of food that is left at the table, because the idea is often to show your guest that you have the means to provide more than enough food; if all the food got eaten then you might seem cheap.

"Work relationships in China are also personal relationships. You're expected to take an interest in people, go out to eat, go out drinking." Tilt said. He is not a big drinker but often found himself in situations where he would have to drink socially. This was the experience of most of the American interviewees.

Kai Tao, a Chinese Ph.D. student at OSU, says he was warned against how asking to take someone out to dinner can be misinterpreted as bribery and over-flattery in the U.S. He also once tried to pay off the meter maid sticking a ticket to his car but soon realized things do not work like that here.

This can be frustrating to Americans, who may see this relationship building time as frivolous and time that could have been spent working on the collaborative project. A female researcher at OSU echoed this sentiment: “I just want to get work done; I don’t want to go to a dinner where we spend thousands of dollars on these meals that just never end.”

Dinner situations vary, of course. On Tyler’s most recent trip to China, the students of a new collaborator took him out to dinner. These situations are much less formal than when fellow professors go out to dinner with each other. The young students were curious about culture and science in America and peppered Tyler were questions. At dinners hosted by Chinese professors, Tyler said his colleagues spent about 70% of their time speaking Chinese. But when having dinner with students, almost the entire dialogue was in English. Tyler’s position as the eldest and most senior at the table was still recognized and due respect given.

Hosting & Gift Giving

Something commonly observed by the researchers I talked to was that they would often see their collaborators on the phone as they arranged last minute events for a tour, planning as they went. A common trade is to invite a Western scientist to come speak at a Chinese scientist's university; while you are there, you can expect to be asked this many times. It gives face not only to your collaborator but also to the school he works at to have a westerner giving a lecture.

The most respectful way to give and receive gifts in China is with two hands. Gifts are not opened in front of others unless you are specifically asked to do so. There is a symbology behind many of the gifts given in China. Clocks, for example, are generally a big no-no. If you gift a clock to someone, he will think you are counting the days until his death and you wish him ill. Gifting a green hat symbolizes the receivers significant other is being unfaithful. Umbrellas are not given because of the way the word "umbrella" sounds in Chinese. It is also slightly taboo to gift something with a "Made In China" label, a mistake Wolf made when he was hosting Chinese collaborators at OSU.

Generally Chinese hosts will pay for everything during your stay, from food to accommodation to transportation. One Chinese interviewee lamented that American hosts generally do not pick visiting scholars up from the airport and go the extra mile to ensure the entirety of the trip is comfortable; "a visitor is more independent here," he told me.

"It's one of the cultural disconnects. I can't possibly offer the same level of hospitality when they come here. So it's awkward," Tyler says.

Living and Working in China

When Kai Tao was at university in China, power wouldn't be available after 11pm. The university would shut it down, Kai says, in order to get the students to go to bed and keep them from playing video games. In the summer he would be without air conditioning. That wouldn't happen here, he says - people would talk about their human rights and it would be a problem. Most universities in China don't have air conditioning. People use a lot of energy in the U.S., Kai says, using the MU we are sitting in as an example - the building maintains the same temperature for 24 hours throughout the whole year. Maybe in the future China will be like the U.S. is now, Kai muses. In terms of family life, Kai would prefer to live here. You get more time with your family, Kai says. In China, you have to spend your nights having dinners to network and put a lot of effort into that and less effort into family. For his career, Kai would prefer China because he could have more choices or opportunities than in the U.S. He is still deciding though.

Many Chinese scientists are focused mainly on their work and children are often taken care of by the grandparents. Americans tend to make more of a concerted attempt to keep family and work time separate. The work-life balance is different in China, says Tilt. Tilt experienced this when observing working families in Beijing as well as when he hosted a female Chinese scientist. When a Chinese colleague visited Tilt in Corvallis, she marveled at how Tilt and his wife both worked, both took care of the kids, both cooked dinner, both made lunches. Professionals in China, in contrast, rely heavily on grandma and grandpa. This Chinese woman's child lived with his grandparents a few blocks away. The vast majority of her attention was on her work. That would be very unusual here in the U.S. Tilt enjoys coaching soccer and striking that work-life balance. But part of him thinks it'd be nice to have more intergenerational support.

Tilt works with people, so he has had to go through an institutional review board (IRB). He has to make sure he's not exposing people in his studies to undue levels of risk, which can often happen in the case of China. Most of that on the China side has to be handled by the people he collaborates with. He has to get an "F Visa." Tilt has to get this via a letter from a Chinese institution, with the "red stamp of approval." Other scientists have gone on a tourist visa and not even sought the approval of the Chinese government, knowing they would be stopped in their tracks if they did.

"You need some kind of invitation letter to take to whatever study community you're working with, for example from a Yunnan provincial organization. Otherwise local leaders will ask who you are. When you get there you have to go to the local leaders first and ask for permission; in doing so you are giving them some face," said Tilt.

"Almost everything I do is encumbered by restrictions," Tilt continued. "Usually not at the level of people saying 'Oh you can't ask this kind of question,' although that has happened. It's usually up to the collaborators on how to deal with it - they're the ones who can push back." Tilt has the policy of differing to Chinese collaborators.

What frustrates Tilt about working with China? The “implicit quid pro quo” of the guanxi dynamic. Trying to keep track of that and figure out the right thing to do. He gets tired of the politically sensitive stuff.

“Driving is a time of prayer and fasting,” said Berry, “In the US we have this idea of order and structure. In the US, when you’re standing in a line it is wrong for someone to cut you. In China - there are 1.3 billion people, it’s survival of the fittest - you have to be pushy.”

Gender Equality

Both of Tyler’s new collaborators are from China Agricultural University in Beijing. One is a woman named Hmong who works on fungicides in order to make soybean plants more resistant. She is Tyler’s first female collaboration. Theoretically, under the communist party females are equal. But the expectations at home are very different - females are still expected to take care of families. Tyler has noticed that Hmong is “definitely more self-effacing,” has a very warm personality, and is very touchy-feely in an almost un-Chinese sense.

As the only woman in the dam project team from OSU, Tullos felt some difference between the way she was treated versus how the men were treated. Although she was the P.I., their (mostly male) Chinese collaborators would defer to Wolf during discussions and would give him the seat of honor at dinners.

“In America the boss is just a boss. But in China, the boss is the *boss*,” Jennifer Wang says. This means as an employee or subordinate you do things outside of work for your boss that they ask of you. (For example, one of my Chinese friends who I worked with during my internship in Hainan had to take care of his boss’s dog and clean his boss’s toilet and it was totally normal.) Having a superior-subordinate relationship extends outside the workplace and into the rest of your life; if you ran into your boss at the grocery store you wouldn’t think of yourselves as equals buying groceries; you would still treat the man picking out tomatoes next to you like your superior. Another of my procrastination techniques became watching Chinese television shows. A common phrase used would be to affirm individuals’ places in society; characters would repeat “the king is the king; the empress is the empress.”

Data Sharing

“I think it’s difficult, because in China we don’t share the data,” one Chinese student told me. “Nobody wants to do this - share his results or his experience with others - because sometimes it means I do my work and maybe sometimes you steal my life, my stuff! In China, my work includes modeling climate, soils, and plants. I need to get this data from the soil people, from the climate people. But sometimes the data is not free. I need to buy or through personal relationship - guanxi. Sometimes they think it is impossible, so they don’t share. I think this is a bad thing.”

While one OSU professor did research in China, she found that what was a state secret was open to interpretation. “Any data they wanted ended up being a state secret.

Sometimes they got some data secretly but weren't allowed to say where their source was from. I got some data digging through almanacs, through modeling. All of it seemed very secretive, a very closed environment. It's really hard to do any quality research and make any real recommendations when everything is considered a secret."

"It's not if they would share the data, it's if it could be published," Berry says. "There was one group that had amazing climate data, and what they would do is give that data to the government. There's not a sort of published open forum deal for them…They all admit that it doesn't happen but I don't know what they're waiting for."

In contrast, Tyler tells me: "I've had no situation ever when I was concerned about sharing data."

Tyler does feel, however, that one of his collaborators wants to collaborate but is "holding his most precious results close to his chest." Maybe he feels, hypothesizes Tyler, that Tyler will take his results and leave him alone and he won't have any bargaining chips to keep Tyler there.

Here, people are more open about data sharing than in China, Tyler says. But in future, he thinks China will put more effort into and be more open about data sharing since it is so important for the science.

Creating Win-Win Situations

“One key to success is creating win-win situations. You need to be in a position where everyone feels like they’re getting something they want. No one feels they’re getting used or exploited,” Tilt said.

The main things Chinese scientists seem to want are generally: help with translating and editing so as to publish in English-speaking scientific journals; technical training in the U.S.; use of U.S. advanced equipment. The main things the Americans want are generally: access to large swaths of data.

Our Future with China

It is inevitable that our future and that of China’s will be closely related. I like collecting predictions about China’s future, as I think it is so incredibly difficult to predict.

Kai Tao’s perspective: he thinks relations with the U.S. will be “better and better, more important, and closer and closer. I think we will be a great country like US in the future.” Americans can also have more opportunities in China, he said, because China is still a developing country. With more Chinese people coming to the U.S., and more opportunities for the U.S. to invest in China, there can be a “win-win to both countries.” China still has many issues to confront as it develops; Kai Tao describes the unrest in China, particularly in Hong Kong, Tibet, and Xinjiang, and lack of freedoms as “hard and complicated.” It is impossible for China to have democracy, he said, because China wants to stay stable and needs more time to develop. “If they let Hong Kong do it, other places might have a similar request - so they can’t allow Hong Kong. Xinjiang and Tibet have historic problems. The Chinese government put a lot of money and effort into those areas to help people there to develop. We need understanding from the U.S. People in the U.S. in the 60s also had lots of social problems. So China needs more time. Some of these things are not fair to us. We need more time and more chance to cooperate with the U.S. You have a lot of experience and advanced technologies, so we can work together and solve these problems.”

Feng Yu’s perspective: “I don’t think Chinese people know much about the States. That’s why it’s very good for people to communicate with each other and visit both countries.” Development in China cannot be inhibited either, he said. Perhaps the American government does not want China to become powerful because they do not want to have a competitor, he said. “The U.S. government wants to encompass China. All around China, the border countries are American allies - this is a big issue between the two countries. American people of course want their country to be number one, be the strongest nation in the world, feel threatened by strong neighbors. But I think now it is not the Cold War.”

Tilt’s perspective: “Chinese colleagues have the same pressures as American researchers - they need to be publishing, teaching, doing research. The United States education system is at a higher level than that in China, but China is catching up very quickly, while we in the U.S. are stagnating in terms of investing money in higher education. China’s central government is pumping money into higher education. And yet a lot of Chinese institutions lag behind in training and they really want access to cutting edge theory and methods."

Xiaoyue Li's perspective: She is not that positive about tension between the environment and economic development. "Economic development is based on the land and the people who don't have the power to defend it. But the local community can't share the benefit of the economic development."

Marco Clark's perspective: They're going to ruin their environment to the point where it so badly affects healthcare…In terms of the relationship with the US., we're already incredibly bound by economics. China is slowly growing as a consumer of things. There will be an interesting point when the Chinese are consuming more of what the U.S. makes when they reach our standard of living. Right now we can buy things in China because it's so cheap. At some point they'll have the cheap stuff made outside of China. They'll go more into technology and bigger industry."

Pete Berry's perspective: "It's a third world country becoming a first world country as fast as it can, and it's leaving a lot of people behind. So I don't know what the Chinese people are going to do. Obviously there are a lot of riots and a lot of issues that the younger people have."

Ignorance on Both Sides

To many Chinese, the idea of America is encapsulated in New York City, Washington D.C., Atlanta, Disneyland, and Hollywood movies. To many Americans, much of China is "red," communist, socialist, controlled by the government and lacking in freedoms for its people. These are concepts that are a result of ignorance on both sides.

Tyler's perspective: "There's somewhat of a tendency in the U.S. to find fault with the Chinese, because people are slightly nervous about the Chinese and they want to reassure themselves that they are not a threat, when in fact they are, as a nation which is rapidly approaching the point where they'll rival or perhaps even surpass the U.S. in science and technology. I think they're some considerable distance away from that, but if their economy continues to be strong and doesn't implode and if they continue to have social and political stability, then I think they could easily in 50 years' time surpass the U.S., if not sooner. But the question as to whether they can maintain the stability in the face of all the pressures remains to be seen."

That being said, Tyler adds "I think that they will find a path. The Chinese leadership are very focused on stability and the Chinese people are very focused on stability, so I think they'll find a way. And they've proven so far very adept at maintaining stability while cautiously, though never-the-less with skill, making progress, reforming the economy. They've already done a fantastic job with the economy. Now they have pollution, corruption, and the political process needs to be reformed."

Both American and Chinese interviewees acknowledged their own misconceptions and assumptions. One of these is that the Chinese are oppressed by a terrible totalitarian government and that the people desperately yearn for freedom. Another is the huge economic imbalance between extremely wealthy people at the top and all these peasants at the bottom. There are examples of abuse of power, extremely corrupt officials, and definitely the Chinese people complain about corruption, but it is not a dominating influence on peoples lives.

"For me, it's totally different from what I saw in the movies," Tao said, "People in the U.S. have a fancy or exciting life, but actually people here are very peaceful and focus on families."

"People think we don't have freedoms - don't have Facebook or twitter or Google or YouTube. I think this isn't a big deal. The reason they shut this down is because of Tibet and Xinjiang - they don't want these videos to be broadcasted, don't want rebels organized," Yu said. "The government is working on these problems, but hopefully in the future we will be more open. I know it is frustrating to not be able to work on internet."

The Next Generation

One of the biggest factors in how collaborative S&T between China and the U.S., and more specifically at OSU, will be done in the future is the changing perspectives of the next generation, many of whom are coming to the U.S. to study science and taking those experiences back with them to China.

In their 2001 study, Cao and Suttmeier explain, “The health of the scientific research enterprise in any country is critically dependent upon young scientists. In most fields, the period of greatest creativity and productivity comes early in a career. Young scientists hold together the generational structure of a country’s scientific community by linking the established scientific elite with a rising generation of graduate students.”

Xiaoyue Li, one of Tilt’s Chinese Ph.D. students, came here in August of 2012. She did her undergraduate studies in China. For her graduate dissertation, she worked with the Yi ethnic minority group in southwest China, work she is continuing for her Ph.D. dissertation. The biggest part that bothers her is the food. Much like the American “freshman fifteen,” Xiaoyue gained about 20 pounds in 2 months. Every single Chinese student interviewed in this thesis named food as the most difficult cultural adjustment and thing they missed most about China.

The communication between people here is also very different, she said. She was very shy the first term she was here, and did not want to interact with other students. She tended to just listen and not talk. “In China it was quite different,” she said, “We listen to the lecturer and we take notes and listen, not much interaction with the professor. But here it was discussion classes with everyone talking and I didn’t feel quite comfortable with that.”

The education system

It seems to be the general perception that Chinese students tend to be more book-smart while American students are more independent thinkers. Chinese students tend to be able to memorize large amount of information, while American students can be creative. Chinese students are taught to sit in lecture and absorb what the teacher says as fact. American students are taught to question everything and work in groups. Chinese students are almost always well-behaved and teachers in China hold a position of high status. These differences in education and outlook inevitably have an effect on how the next generation processes information and conducts science.

Jennifer Wang taught at a school in China that sought to help Chinese students get admitted at top American universities. Class structure was different from the traditional Chinese classroom setting; most teachers were westerners, the International Baccalaureate (IB) curriculum was adopted, students were told to ask questions and be critical of their teachers. Wang found herself having to coach the parents more than the children to help them adjust to this difference. Many Chinese parents believed it was "a waste of time" to have their children doing anything but listen to teachers during classes. Wang soon convinced them that this was the way to be accepted into top American universities after high school; western schools used more critical thinking than rote memorization and a substantial portion of class time was used for discussion. The fact that many more Chinese parents want their children to go to school abroad will result in a shift in learning styles for these children and perhaps a shift in how the generation as a whole processes scientific information.

“People here learn more and have a larger knowledge background. People here have more flexibility in what they study. In China, you can’t choose; most of your courses are required. Especially for biologists, who need very systematic knowledge. But people who study here or in Europe who are in China now take what they learn and apply it to the Chinese system to change it. The dean of this college [where she worked] was previously a professor in the U.S., and is now doing reforms and improving systems to be like the U.S. People here are more open and prefer more collaborations with others. Americans always sit around a table and talk about topics, then finally make decisions together,” Wang said.

The one-child policy

Children of the one-child policy era are often called “Little Emperors.” The one-child policy has produced a materially and educationally privileged generation among the elite; two parents and four grandparents can spend all their attention and resources on a single child. This creates a great deal of pressure for that child to succeed and to represent the family well. It has “fundamentally changed the psychology of a generation.” These children are also expected to care for their elderly family members, as is tradition in Chinese culture. However, China also has an aging population lacking a large group of grandchildren who might pay to support them according to proper filial piety. By some estimates, China has more than 185 million citizens over the age of 60, accounting for approximately 12 percent of China’s population. This aging population is struggling to receive the care and support it enjoyed during previous decades.

As a result of the one-child policy, many women feel they have lost sovereignty over their bodies; the state officially has control over their reproductive organs. “Women are controlled,” said one Chinese woman interviewed in a Thomas Reuters report, “they have to go to hospital frequently to check if they are pregnant or something. If they already have a child and they still get pregnant, the child will be killed”. Despite its strong enforcement, there are many who do not follow the one-child policy, both in the countryside and in China’s more metropolitan areas. There are many loopholes in China, if one is rich and well-connected. Pay enough money, have enough friends in the government, and you can have a second child. If you depend on farming for sustenance and need more children to help tend the land, the government allows rural families to have more children; the official state policy is that rural residents can have a second child if the first was a girl. But if you are not authorized to have a second child and the Chinese government finds out, the consequences can be disastrous for that child and his or her family. China’s “hidden children” are those born out of quota, who “face a life of limitations without an official ID,” if they are not abandoned or sold to human traffickers first.

It should be acknowledged that there are some positives to the policy: the Chinese government claims 400 million births have been prevented, possibly preventing the worsening of social, environmental, and economic pressures in China. China’s life expectancy has increased. China is also currently easing it’s stance on the one-child policy slightly; parents who are both the only child in their families are allowed to have a second child. Still, many believe this easing of the policy may be too late; the juggernaut of the demographic shift cannot be halted quickly or easily.

Arguably the most impactful consequences of the one-child policy is the gender gap between men and women in modern day China. The sex ratio, the numerical ratio between men and women in a population, is severely skewed in the Middle Kingdom. Health authorities call this gender imbalance the “most serious in the world”.

“But nowadays maybe some young guys - one child, the family just focuses on this one guy - they feel they have the right to say no, they can say no more like Americans. But when we had siblings there was limited food and you have to think of others. This is also a cultural things with the Confucius - you give things to older people, have hierarchy, give attention to these things,” said Wang.

Tao, when asked about the one-child policy, said he thought population “wouldn’t be a problem in China in the future and that China is still in control of the population.”

“We sacrifice a lot to the world,” he said, in having only one child. “People here have brothers and sisters and are very lucky; the feeling is totally different.” Tao is an only child, but would prefer to have a brother or sister. He does feel there is a lot of pressure on him to succeed. His parents and grandparents on both sides “put all their love in one child, so that’s maybe the reason why Chinese people sometimes are more selfish than Americans. They grew up in this environment - they don’t know how to share.”

Brain Drain?

Where do Chinese students want to go after the U.S.? Before he left China, Tao told his friends when he finished his Ph.D., he would go back to China, but now he is not so sure. One advantage he sees to staying is that people here have time after work, while in China, "almost all students work from 9am to 10pm or 11pm and also work on the weekends."

"People have more of their own time to have their life here in the U.S. In China they pay less attention to family and life - maybe one problem in China, they want to accelerate their research but ignore their family life or self development. With professors here, you can talk to them whenever you want. But in China teachers are always "higher" - you have to show them any respect you can. Here relationships with fellow students are very simple. Here you need to schedule a time. But in China, you just call him/her, go outside and just talk. In China, you have a big group dinner together and have lots of activities. Here it's more simple; people meet in a coffee shop," he said.

Many Chinese students are grappling with weighing similar advantages and disadvantages to living and working in China versus in the U.S. It is not always an easy decision.

Concluding Remarks

Chinese science as a whole is becoming a greater presence on the world stage and will continue to increase this presence in the decades to come. It is widely agreed by the global scientific community that China is graduating more students in STEM fields, both at home and abroad; China is publishing more papers in scientific journals; the Chinese government is devoting more money to R&D and S&T; China is increasing its international scientific collaborations; more Chinese people are beginning jobs in STEM fields; and average pay for Chinese scientists is increasing. All of these trends are impressive not only because of increasing numbers but also because these numbers are increasing so rapidly and in the face of the formidable hurdles any developing country confronts. According to the 2014 University of Michigan and Peking University collaborative study in the journal of the Proceedings of the National Academy of Sciences, there are four reasons China appears to be "overtaking" the United States in S&T: 1) China has a large population and human capital base, 2) China's labor market favors academic meritocracy, 3) there is a large diaspora of Chinese origin scientists, and 4) China has a centralized government willing to invest in science. These are all important considerations, but I do not believe China is "overtaking" the U.S. in S&T or that the U.S. should be so mortally terrified of this possibility. The American media often portrays China's scientific rise as a wholly negative thing and as a disastrous event for the U.S.; the U.S. should keep the positives of this rise in perspective. The U.S. should find ways to collaborate more with China and develop more cultural understanding. I predict that in the future, the quality of research, graduates, and publications will increase in China, and China will become less and less dependent on foreign collaborations, though foreign collaborations will increase. China will reach for less "low hanging fruit" and instead seek out more of the American-esque "science for science's sake." Both of our nations need each other to thrive in the future; we should continue building partnerships and trying to understand one another.

There are many future directions this research could take. I would love to create a network of all the people at OSU who have Chinese collaborations so that more OSU scientists could be aware of the Chinese collaborations their colleagues do. In this way perhaps resources could be pooled for various China trips and more collaborative connections made within OSU. I would also love to better understand what research with China is being done at other universities across the U.S. Who has the most collaborations? What particular fields best suit particular universities? What are OSU's strengths compared to other universities? Finally, I would be interested in finding a way to be more culturally sensitive when analyzing Chinese science. I am inevitably going to carry my cultural biases as a westerner and American with me as I learn about China; I would like to learn more techniques to ensure I remain culturally sensitive while appropriately critical.

China is a beautiful, dynamic, complex nation that will undoubtedly have a huge impact on the world, not least in the realm of S&T. China's increased scientific collaborations with the U.S. will lead to further developments in scientific collaboration at OSU. I am thrilled to be able to observe China's development in S&T, its continuing relations with the U.S., and the ways in which that affects scientific collaboration here at OSU.

A Final List of Advice

For American Scientists	For Chinese Scientists
● Be open ● Learn Chinese ● Show your appreciation in a public setting ● Be aware of table culture; prepare to drink large amounts of alcohol ● Create win-win situations ● Expect questions that may seem exceedingly personal ● Be aware that plans may change/things may be requested of you at the last minute ● Do not overcommit to collaboration	• Be open • Learn English • Understand that criticism is encouraged • Learn to be more independent • Understand that American professors expect questions, discussions, and group projects • Try to care less about what other people might think of you • Be aware that you will probably have to email to set up an appointment • Expect direct communication

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