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Science and Technology Cooperation between China and Leading Nations

—How Do the USA, Europe, etc., View China's Science and Technology, and How Do They Cooperate?—

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Introduction

This report summarizes how leading nations of Europe and North America view the state of China's science and technology, and how they are pursuing science and technology cooperation with China.

During the summer of 2014, we members of the CRDS Overseas Research Unit visited and interviewed personnel involved with science and technology at various countries' embassies in Beijing. Most of the content below resulted from those interviews.

The words of the people we interviewed are not directly quoted herein. The first reason is that we were unable to bring recording devices into the embassies and so on where we performed the interviews, so it would be difficult to ensure accurate quotation. Moreover, the interviews did not consist of us just listening to people talk; they were discussions. The content below is the result of analysis of those discussions. Furthermore, the interviews were all conducted in English, so translating them into Japanese for this Japanese report might lead to some discrepancies. In practice, of course, the interview contents are the heart of this report.

The names and titles (as of the time of the interview) of the persons interviewed are as follows.

○USA

Robert G. Ivy; DOE Director, US Embassy

Helena W. Fu; DOE Deputy Director—Clean Energy, US Embassy

Callan Ordoyne; Scientific & Technical Affairs Officer, US Embassy

Joanna I. Lewis: Assistant Professor, Georgetown University

○Germany

Julia M. Kundermann; First Counsellor Science and Technology, German Embassy

Baiyu Zhang; Scientific Assistant, German Embassy

Hui He; Devision of Science and Technology, German Embassy

Han Xiaoding; Chief Representative, Fraunhofer Representative Office Beijing

He Hong; Chief Representative, Helmholtz Association, Representative Office Beijing

○UK

Karen Maddocks; First Secretary, British Embassy Beijing

Katy Fu; Senior Science & Innovation Officer, British Embassy Beijing

○France

Norbert Paluch; Counsellor, French Embassy Beijing

Antoine Myard; Director, Bureau of CNRS in Beijing, French Embassy Beijing

○Italy

Plinio Innocenzi; Science and Technology Counsellor, Embassy of Italy Beijing

○EU

Philippe Vialatte; Head of Science, Technology and Environment Section, Delegation of the European Union to China

Alexandra Lehmann; Attache of Science, Technology and Environment Section, Delegation of the European Union to China

○Australia

Sean Starmer; Counsellor, Science & Industry, Australian Embassy

Wang Chan; Senior Reserch and Program Officer, Science & Industry, Australian Embassy

Materials discussing science and technology cooperation between each country and China are appended at the end of each chapter as background information. Those materials can be considered supplements to the interviews and discussions held at the embassies and so on.

A simple summary of this report is as follows.

First, as for how leading nations of Europe and North America view the state of Chinese science and technology, there is no much difference among them. Each country is amazed at the way China has leapt forward in recent years, especially since entering the 21st century. Until about 10 years ago, China's research and development expenditure was meagre, and its facilities and equipment were not up-to-date. Although large research staffs were employed, few personnel received adequate training, and outstanding Chinese human resources were left in Europe, the USA, Japan, and so on. That changed dramatically with economic development. Today, China is second in the world in research and development expenditure measured in purchasing parity, having passed Japan and trailing only the USA. In terms of research personnel as well, an increase in the number of posts in China and the spread of policies to lure personnel from overseas have led many researchers studying or working abroad to return to China. Indeed, the number of researchers has passed the USA to rise to first in the world. China's facilities, equipment, experimental apparatuses, and so on are not inferior to those of Europe, the USA, Japan, etc., they are the most up-to-date and advanced in the world.

If, however, one asks if China has achieved commensurate results, the S&T-related personnel of each of the countries were united in the view that it has not. China passed through eras of chaos, with foreign invasions, internal disorder, and so forth, and research and development on science and technology in a calm atmosphere really only began no more than about 40 years ago after the Cultural Revolution ended. It is therefore conceivable that the cultural foundation for fostering science and technology is insufficient and is a contributing factor to less than adequate results.

China As for whether science and technology cooperation with China is necessary, each country has clear ideas, and none of them rejects cooperation itself. They differ, however, on the forms that cooperation should take.

The USA is currently China's biggest cooperation partner. In the case of the USA, not just the government, but also the private sector, universities, and so on undertake cooperation for their own purposes with a relatively high degree of freedom. Private-sector companies have their eyes on China's enormous markets or see China as a major source of research personnel. Universities actively pursue cooperation with China to secure international students and to enhance their own research potential. Such activities make for a large volume of cooperative relationships both in the USA and in China. Networks with developed countries in Europe, such as the UK and Germany, had been most important to US science and technology, but today it appears that ties with China just as close. The US government, on the other hand, limits cooperation mainly to certain sectors because of national security concerns. Partly because of the idea that China aims to become a military power, cooperation on technology related to nuclear weapons or to space development, for example, is clearly prohibited. Government cooperation with China prioritizes measures against global warming, for instance.

Germany is also enthusiastic about cooperation with China. It was one of the first developed countries to expand such cooperation. German industry, especially the automobile industry, pushed cooperation with its eye on the gigantic Chinese market, and research organizations such as the Fraunhofer Society actively pursued research cooperation with China. Human exchanges are also flourishing. Personnel who studied and performed research in Germany are making marks in government and academia. A representative example is Wan Gang, the current Minister of Science and Technology. After studying at a German university, he worked for Audi before returning to China. A characteristic topic for cooperation now being pursued is water treatment in places such as Qingdao.

The UK has some of the world's leading technical research universities. Although China sends a considerable number of students to that country, cooperation has not made sufficient progress, and the UK's presence in the manufacturing industries that support China's economy is weak. In recent years, however, the UK has become aware of the importance of China's science and technology potential and size. It aims to expand cooperation through steps such as the creation of the Newton Fund, a funding mechanism for science and technology cooperation with developing nations including India.

Although to a lesser extent than Germany, France has been one of the leading European nations pursuing cooperation with China. It is gradually building a record of cooperation in fields where it is strong, such as life science and ICT.

Italy has relatively lower science and technology potential itself, so it has not expanded overall cooperation to the extent that other European nations have. Still, as the level of China's science and technology has risen, Italy has pursued cooperation in Big Science fields such as particle physics and in the design sector that is one of its strengths.

The EU also emphasizes science and technology cooperation with China. Always based on the state of cooperation by leading nations such as the UK, Germany, and France, it is expanding cooperation with Horizon 2020, the successor to the 7th Framework Program, as an important tool. Cooperation with China is often difficult for small and medium nations like those of Northern and Eastern Europe to accomplish on their own, so EU cooperation serves as an important facilitator of such initiatives.

Australia is also expanding cooperation with China. Utilizing the advantage of being part of the English-speaking world, it had long actively sought to bring in Chinese students. With the development of China's science and technology level, it has also been working to expand research cooperation.

Japan had a record of accepting Chinese students and researchers mainly at universities, and that heritage continues today. In recent years, however, factors such as the increasing closeness of Chinese cooperation with leading nations of Europe and North America and political friction between Japan and China have diminished Japan's position as a partner in science and technology cooperation. It is necessary to rethink strategy on Japan-China science and technology cooperation in light of cooperation between China and leading nations of Europe and North America as discussed in this report.

Chapter 1 USA

1. View of current situation

China's science and technology has two aspects. Its science is world-class, but the country lacks experience in the application of science. It is taking on the challenge of industrial application, but not systematically, so success is lacking. In the USA, there are many leading senior scientists, and they guide application of science is based on their experience. Chinese scientists, however, are remarkably young, and there is no generation that can guide the application of science.

China is still in a developmental stage in terms of its scientific decision-making systems and systems that are burdensome for scientists. In 20 or 30 years, China will likely have experienced people who can apply science splendidly. If reforms are carried out, the future should be even better.

2. Basic policy on cooperation

China is developing rapidly and increasing its economic and political presence. Chinese markets in particular have rapidly grown large, making China an important partner. Cooperation with China benefits the USA. Furthermore, cooperation with China is essential in order to control carbon dioxide emissions on a global scale as a measure against climate change.

China has a much larger workforce to inject into joint science and technology research, so it can collect enormous amounts of experimental data. However, one must take care regarding the openness and transparency of data.

3. Framework for cooperation

In 1979, the USA signed an agreement on science and technology cooperation that covered all S&T fields, including nuclear power. On the US side, it was signed by the heard of the OSTP (presidential science advisor). More than 100 MOUs in various individual fields have been signed under that umbrella.

In response to China's growing science and technology prowess, the relationship is moving towards an equal partnership. The two countries are building a relationship in which they obtain mutual benefit through a joint funding system in which the USA funds US institutions and China funds Chinese ones.

4. Categories emphasized in cooperation

To the government as a whole, fields that accord with US policy, such as the climate change sector, have high priority. Furthermore, each agency and institution has its own priority fields.

Cooperation with China is restricted in some fields. For example, Congress is cautious regarding cooperation on space, and there are limits to NASA's cooperation with China. However, the government allows cooperation with China in fields such as managing collisions with space debris. In the nuclear power field, civilian and military programs are strictly divided, so cooperation with Chinese civilian programs is possible.

5. Specific examples of cooperation

Cooperation with China is advanced in the energy field. The US Department of Energy (DOE) and China's Ministry of Ministry of Science and Technology (MOST) launched the Clean Energy Research Center in 2009. It is a virtual center that performs joint research in three fields: clean coal, clean cars, and energy-efficient buildings. This cooperation has accomplished great results, and the center will perform a review for the Secretary of Energy (head of the DOE) in July 2014.

The Renewable Energy Partnership Program, which also began in 2009, is another example of success. This program, led by the US and the Chinese National Energy Bureau (NEB), is a forum for US-Chinese dialog on all fields of clean energy. It sets themes every year and encourages collaboration among corporations. Themes it has covered include market access and shale gas development.

6. Issues in cooperation

Handling of intellectual property rights (IPR), which are privately owned in the USA but belong to the state in China, and transparency in the handling of research data are issues. The latter issue in particular leads to the problem of data from joint research not being shared. In China, scientific data is often kept undisclosed because it is considered sensitive. Rather than a cultural gap, it is more that the two countries' political and economic systems are different.

Background information: "**Directions and Implications of Science, Technology, & Innovation in China**"

This material is remarks by Denis Simon, a Vice Provost at Arizona State University, to PCAST, an advisory council to the US Executive Office of the President, on 9 May 2014. It is quoted from the following website.
https://www.whitehouse.gov/sites/default/files/microsites/ostp/PCAST/pcast_may_2014_transcript_5.9.pdf

Thank you, it's a great pleasure to be here and I want to thank PCAST for having the vision to take a closer look at what is going on in China in the innovation space and also to look at the broader implications in terms of the United States and our relationship with China as we look forward. The issues surrounding China have both something to do with our bilateral relationship, but I also would argue they are a part of a larger change in the international landscape, and that as we look at China we ought to think more broadly also about the implications with our relationships with other countries as the international S&T landscape begins to change.

Just to give you a little bit of perspective. In July, 2012, the Chinese held a major domestic conference on their innovation policy, they had been faced with a bunch of problems and they organized this meeting right before they had a leadership change, which is usually unusual for them to do that. But they called this special conference and at the closing session they made this statement. They said that China missed the first industrial revolution, it only caught the tail end of the second industrial revolution because of the cultural revolution. And now we're in the forefront of a third industrial revolution, which as far as China is concerned presents a rare strategic opportunity. The Chinese see both life sciences and clean energy are likely to be the two major building block technologies going forward into the 21st century, and they see these technologies as areas where they must make progress in order to keep pace with the international frontier, but also in order to help transition their economy to the next level as well. Similarly, right after the global financial crisis, Wen Jiabao, the former premier of China, was talking to the Chinese Academy of Sciences and he also made the following statement: Faced with the current international financial crisis, various countries are competing with each other to capture the science and technology commanding heights. The whole world will enter an unprecedented era of intensified innovation and industrial revitalization.

I think these are two very, very important perspectives. Because they give us a sense of the determination and the national political will that is now being put together in China in order to look at how China can catapult itself into the ranks of the advanced industrialized countries. And also again transition its economy from the manufacturing oriented or low end manufacturing oriented economy that drove most of its economy for the last 30 years, and moving into the era of China becoming a so-called knowledge economy. So what I want to do is talk a little bit about some of the things going on internally, but most importantly to talk about the external implications for what seems to be going on in terms of how China is reconfiguring and repositioning its international activity as a now more important country in the international science and technology space. So we see that the China now has shifted from a country that was once oriented in the direction of self-reliance to a policy that we've all heard about, a policy called indigenous innovation, in which China now wants their economy driven much more by the weight of innovation. Some 30 to 40 percent of growth is to be derived from this new knowledge economy, or what China calls high tech industry. And as those of us who have been reading about China understand, a lot of this is about changing the whole calculation of where growth will come from in China by virtue of many of the problems that Chinese have encountered.

Kelly (Next Speaker) will talk about the environmental issues and the energy issues, in a little bit. But the last one, last couple of bullets here are very, very important. The one, Chinese perception about the growing protectionism in the international economy with respect to technology, a sense that with all of the pressure they're getting about IP protection et cetera that this may not be as an open era coming forward as they've seen over the last 30 years. Second, their concerns about national security, and we see with the increase in the Chinese military budget, and particularly the budget for advanced technology in the military sector, that this is also a concern of the Chinese, particularly after watching the American deployment of so-called smart weapons in the two gulf wars, the Chinese are very, very concerned about their ability to keep pace with U.S. defense technology. And finally, and I would argue perhaps maybe even more important than all, and that is the lethargic performance of their own R&D system.

Over the last half a dozen years we've seen the Chinese substantially increase their spending in R&D by over 20 percent per year. It has made China now the number two spender in R&D in the world, and yet for all of the input that now China has more money, more people, and more infrastructure than they've ever had before and Chinese leaders are unhappy or anxious about the fact that they haven't gotten a big bang for their buck. So I think in contrast to a lot of people who see sort of a more arrogant China, I would argue that the Chinese are extremely apprehensive about what's going on. After putting all this effort in, they're not getting the results they wanted. So China has put in place basically what I would call a strategic innovation triangle, it's built basically on 3 legs.

A 15 year medium and long-term science and technology plan that they have now just gone through their first midterm evaluation. I was one of 12 international experts asked to sit in that evaluation, it was a very, very interesting process in which we critiqued a lot of the things going on, and that's the first time they've had such an open process for this kind of plan. That's joined by a medium and long-term plan for education, and a medium and long-term plan for talent. So resonating with some of the discussion that we had this morning about workforce preparation, et cetera, the Chinese are very, very much concerned that they will have sufficient number of high quality, talented individuals to staff this new knowledge economy as the economy goes forward. It may seem like an irony, given the fact that China graduates so many students every year, but actually the reality on the ground is that China may have a talent shortage, not a talent surplus. And this is something that they are trying to deal with. So we've seen the system go from what we would call then a system characterized by a high degree of resource shortage to what I would call a high degree of resource abundance.

If you would have asked me in the 1980s what's the problem with the Chinese S&T system, I would have said not enough money, not enough people, very poor infrastructure. We look at the system in 2014, we would say more than enough money, more than enough people in some respects, and more than enough infrastructure, particularly 2010, 2011, these big investments in R&D went into modernizing the entire S&T infrastructure and we can see that in terms of the spending, again growing twice as fast as the economy. And that's why China today is now achieved over 2 percent of GDP on R&D spending. So it's something that we didn't expect to happen as quickly as it has, but now when you have a system of resource abundance or seeming resource abundance, the system operates in a very different way than it had been over the last 20 or 30 years. So the expectations are, this is from Battelle's work, that if the Chinese keep growing at the same rate in terms of their R&D spending, sometime around 2023 they will surpass both the United States and the EU in terms of their annual R&D spending.

But one of the things that we know is that money doesn't guarantee innovation. And that's the problem the Chinese are facing now. They're trying to figure out what it is about the culture of their innovation system and the management of that system that is not yielding the results that they had anticipated. This all came to the surface in July 2011, again former premier Wen Jiabao in Chaussure, a communist party journal that gets published, it is a journal in which Chinese officials sometimes write, and Wen Jiabao presented a rather scathing criticism of the entire R&D system. And in this article he more or less said that the Chinese system is not prepared to meet the requirements of the economy, nor is it able to meet the requirements that are needed to sustain China to become a competitive force in the world economy in the years ahead. So coming from the Premier at the time using this kind of vehicle was a major statement that indicated just the severity of the problems. I tracked the movement of Chinese officials traveling around the country. We can see them constantly making speeches admonishing different localities, different institutions, they've got to improve their innovation performance. So this is something that's going on now on a regular basis. Now, this all translates into a different set of policies now for China on the international stage.

We thought that with China's push towards indigenous innovation it was actually going to perhaps become a more closed economy. And I think we made a bad judgment. I think that what we will have seen if we would have looked more closely is that the move towards indigenous innovation was perfectly aligned with what China was doing on the other side of the equation in terms of repositioning itself to further utilize its international science and technology engagement to further push ahead its economy and further drive it to become a more innovation oriented kind of economic system. So in 2012 there was a very interesting report in Koji Raboue, the science and technology daily, in which they talked about basically now three major shifts that China is now engaged in, in terms of its transition and thinking about how to conduct its international science and technology affairs. First, a shift from sort of going at it alone to now a more full-fledged kind of science and technology diplomacy. Second, on the road from what they call tracking and catching up to now more and more peer, or more and more parity based kind of cooperation. And third from being a so-called passive collaborator, now towards looking for relationships that are much more equal balanced more mutually beneficial and more win-win. So these are all designed to change the equation for how China relates to its both bilateral partners and also its engagement in the multilateral system of international S&T affairs.

So we can see now that over the last 20 or 30 years China has built a major infrastructure in terms of utilizing its international S&T relationships for global engagement. And if you look at this, this is sort of a piece of all the different segments in which bilateral government-to-government collaboration has become an increasingly smaller part of this kind of international presence, and private sector, university-to-university, think tank-to-think tank all sorts of other kinds of collaborative mechanisms now have become much more the mainstay of China's international S&T relations. So even though we look at the bilateral S&T relationship as an important part of this, the reality is that our relationship with China has outgrown what the government is doing. And if we look more closely, our corporate to corporate ties is also becoming more and more expanded. So by early 2013 China now had established not just diplomatic relationships but in this case science and technology cooperation relations with 150 countries, it has over 100 international intergovernmental S&T agreements, it has now about 140 S&T diplomats in 70 institutions and 47 different countries. Its presence now is expanding widely. It is now becoming much more engaged in what the Chinese have called a format of science and technology diplomacy, not in just sort of dabbling in the international S&T system. And that also has implications not only for Chinese central government, but also for local governments at the provincial and municipal level as well. So what we've seen is we've seen also devolution of authority going to municipal and provincial governments now, encouraging them directly to get engaged with their counterparts, through state to state, province to province relationships.

These are all starting to again build and grow, particularly in terms of money availability. So these are just sort of some documentation and sort of growth in the budget for international science and technology cooperation at the central government level, particularly during 2010 and 2012, as I said, in the post financial crisis as part of their stimulus. Those two years are what we call booster years. But it's been growing steadily all the way up until this year, and we can see that in the same way in terms of international S&T cooperation projects. They've also been growing both projects going abroad and also projects coming into China. Now, all of this story seems very, very good. China is becoming more globally engaged, it's spending more money on its R&D system, and everything seems to be in pretty good shape for the Chinese.

In fact, if you look at China's high tech exports, you would say in fact China is indeed making the transition to this knowledge economy. High tech exports have been growing particularly over the last half dozen years very, very rapidly. And one would think that hey, you know, the Chinese are really on the road to success here. Who makes those high tech exports? In many cases as much as 80 percent are actually contributed by foreign investment companies, and about 66 percent as of last year were coming from joint venture companies and wholly owned companies. So what we've started to see is we haven't seen a change in the derivation of where the technologies are coming from that support these high tech exports. For the most part they continue to be owned by foreign entities. This is a great disappointment to Chinese leaders, who want more and more of the intellectual capital, or intellectual property, to be coming from their own domestic sources. They continue to be coming from foreign sources. And many of the things evaluated as coming from the Chinese side continues to be low value added. The best case that's been advertised recently was the case of the iPhone in which the Chinese get some 3 or 4 percent of the total value added versus the bulk of the revenue which accrues to Apple and a number of Apple suppliers in Japan and other places. So these are major problems, the way the Chinese see it. The problem looks even worse in a World Bank report that came out in 2012 using some 2009 data. They indicated that China had an IPR deficit in balance of payments of some $10 billion while the United States had a surplus of over $64 billion. So you can see what's getting Chinese officials apprehensive and nervous, they don't see a shifting of the tides in terms of the reality of where their technology position is.

In fact, according to that World Bank report it says that using the Thomson Reuters survey of Chinese patent data, many of you know that China's patent data indicates rapid increases in the source of patents coming out of China, it says only about one fifth of the patent professionals believe that Chinese patents are of high quality. A smaller percentage than any other country in the world included in their survey.

So there's some interesting sort of disconnecting. More money, more people, more equipment, not getting the bang for the buck. This means that engagement in international S&T affairs become even more and more important because it means if a domestic system is not producing the value, China has to plug in somewhere else to ensure a more steady flow into their knowledge bank coming from abroad, and therefore international S&T cooperation now is becoming even more important. Over the last decade there have been two major conferences now, and this process has started going forward. In 2006 there was the national foreign scientific knowledge affairs conference in which the former minister Xu Guanhua oversaw the discussion or the beginning of discussion, about is China actually getting yield from these science and technology relationships on a bilateral and multilateral level.

And they discussed now five major shifts, and this what we see today actually being played out. Again, the move from general cooperation to now cooperation that's focused on the needs or specific needs of this medium and long term plan. And in fact, in the evaluation process that I was engaged in there's one whole group now focused simply on is science and technology cooperation actually yielding benefit for the goals and objectives of the medium and long-term plan. Second, from project collaboration to integrating collaboration, and project talent and R&D. So what they want to make sure is that there's training, there's actual knowledge generation, and that these projects are actually yielding some results. Third, they want to make sure from sort of a technology import orientation that they are both going abroad, as well as bringing things into China. So you could see more and more activity now going on in the United States, more and more companies being set up, more and more think tanks being set up, more and more sort of listening posts on science and technology now being set up around the United States and Europe, et cetera, to bring knowledge back into China. Fourth, from just general cooperation driven by the government, to cooperation driven by more players, as I suggested before, and then finally, the fifth one, from bottom up to sort of top-down now.

Much more guidance from the center about the types of projects that China ought to be engaged in, in terms of international cooperation. So we look at the bottom here, I think it's very instructive. China will change its position of working for other bosses, i.e., foreigners, as typified in the past cooperative activities through establishing dedicated funds through national S&T cooperation, supporting major S&T cooperation projects, raising China's position in international S&T cooperation, making China's participation in such cooperation on an equal footing, and realizing results, sharing and earning reciprocal benefits. So this all indicates again a different kind of posture. And then again in August 2011 I would make the argument that this was sort of the follow-through from those admonitions. And we began to see actually some very, very concrete activities coming out. On the bottom you'll see minister Wan Gang with Madam Liu Yandong who is really the vice premier who is in charge of international science and technology affairs, sort of indicating they are very much concerned about these particular areas. Wan Gang at that meeting talked about a number of tasks, and just in the interest of time, most important, strengthening the level and design for scientific knowledge and cooperation between governments, and also making sure that China now enhances its role in major international S&T affairs. So what we've seen is China going from sort of a bystander on the side to now becoming much more active. And also, shifting its thinking, creating a whole series of new kind of platforms for collaboration, and also striking some new initiatives. Particularly in the case of the United States, something like CERC. Where CERC is seen by Minister Wan Gang as not only a pet project of his, but also presenting a new kind of model. So after 30 years of science and technology cooperation with China on a bilateral basis between U.S. and China, the Chinese are beginning to suggest that maybe it's time for some innovation in the relationship. Maybe it's time to revitalize and alter the basis of the relationship, because the global context has changed, and the relationship between the United States and China has changed, and also China's own S&T capabilities have changed.

And so we've seen the seeds of a kind of a new game starting to be played. We see this also in terms of China's international presence more broadly in terms of international S&T organizations. China is involved in now some 20 or 30 major international S&T projects like ITER, for example, and it's starting to increase that effort to becoming much more engaged. In a recent discussion we had in Beijing, Chinese talked about bringing some major S&T organizations to China so that they'd set up their headquarters in China, and also enhancing their influence and their voice in the international S&T organizations in which they belong. And we're starting to see now training activities going on within the Chinese bureaucracy to basically create senior officials who can assume positions of leadership in these major international organizations. So we're starting to see a sea change come about. Now, along with this, of course, if you're going to ramp up and you're going to engage in more activity, you're going to run into problems if you're not prepared. And in some ways the aspiration is moving faster than the ability to deliver. And of course, that's always a problem, there's a disconnect, China's aspiration always moves somewhat faster than the ability of the system to deliver in reality. But what we've got now is we've got a recognition of those problems, we've got an understanding of those problems, and now there's a major new reform underfoot in China not only to fix the innovation system but also in this case to begin to fix the international S&T cooperation system particularly in terms of personnel development, in order to be able to staff people across these international S&T organizations.

Now, the last thing that I want to talk about, that is China's foreign R&D in China, which I think is a major area of growth that some people probably will find surprising. Right now at the end of the 2013 there were some almost 1,400 foreign R&D centers that had been set up by foreign corporations in China. This is something, given China's ITR problems, most people figured would not happen. But major companies, some sitting around this table, some of the strongest ones, GE is a very good example, are not simply using these R&D centers to adapt products to Chinese markets. No, it's not Campbell soup saying do we want sweet or sour soup for the Chinese market, it is our companies now that are actually creating new innovation that is serving the global marketplace. And this is change that again is happening very, very quickly. A lot of return Chinese who would think twice perhaps about perhaps going back to China are now going back to work for foreign multinationals in their R&D headquarters in China. And so in some ways the Chinese are talking about what they're calling now an internal brain drain. These people, maybe they're not staying abroad, but when they go back they're going back into the foreign sector, they're not going to work for the Chinese Academy of Sciences. What the consequences of this foreign R&D will be is very interesting. A lot of impacts right now are intangible on the soft science side: training, technology transfers, standards. But what they can potentially bring is something called brain circulation. Most Chinese, there's a saying I'd rather be the head of the chicken than the tail of the ox. So a lot of these individuals will work for big companies for a while, and then they will go out and they will become the next wave of technologically entrepreneurship in China. This is similar to what happened in Taiwan in the late 70s, early 80s, and is likely to happen in China. And so this is perhaps maybe one of the saving graces for China, that these R&D establishments will turn into valuable training ground for the foreign presence in China. So where does this all take us? So we have a very interesting transition going on.

China, 1980 was a marginally involved peripheral player in the global economy. It had limited participation. It was self-reliant in its orientation, and it basically was outside of the western S&T system. In 2014 we see a much more engaged China, a proactive or increasingly proactive stakeholder. One that's become now a favored site for foreign R&D activity, and has become a transnational collaborator. China now in terms of international collaboration on articles, on citations, on international projects, is becoming one of the major players now in science and technology affairs. So what's out there? If we look at particularly the international problems, again, we can see that not everything is working well, but we can see that this transition is becoming much more part or ingrained in what the Chinese are thinking about how they will play their role in the future. And in particular, the Chinese are thinking about how are they going to position their economy in the years ahead. This is a section from the Chinese Academy of Sciences, Science and Technology Roadmap 2050. And if you look near the bottom it sort of says that China must do this kind of long-term forecasting if it is going to have the ability to position itself in science and technology affairs so we can make the right investments and make the right choices. And this kind of foresighted anticipation of where the global economy is going, this is something that the Chinese consider essential in order to make sure that they're not off somewhere in left field. That's also why life sciences, clean energy, new materials, et cetera, are all high priorities for the Chinese. Remember, China is not a small little country, it is a continental sized economy. Continental sized economies have ambitions and aspirations that are different than small countries, and therefore China, whether it's nationalism, culturalism or just big power status, China is interested in restoring its place in the international economy. We can see this in terms of collaboration. This is Chinese science and technology ties in terms of research co-authorship. The good news is that the United States continues to be China's primary partner in terms of research collaboration, by far. And this is just some recent data over the last let's say six, seven years that we can see this really big increase in the role of the United States. So U.S. relationship with China continues to be China's most important S&T relationship but I would make the argument that we're not leveraging it enough. We're not being innovative and creative enough in terms of thinking about how do we utilize that relationship.

Even in the areas of nanotechnology these relationships are beginning to pay off. The Chinese collaboration is growing, Chinese authors now account for some 21 percent of the over 800,000 SCI indexed articles that are published globally. The Chinese share has increased to some 27 percent, and the U.S. coauthors are by far the leading collaborators with Chinese authors. And we would find this in many fields. If we look at the international college, some of the work done by Caroline Wagner at Ohio State, we see this kind of collaborative relationship with United States as the principal partner gives the United States a huge leverage. So where does this all take us. It's clear I think we've entered a key transition point in China's international science and technology relations. China is becoming more assertive, more proactive, more determined, and it's tying science and technology to its diplomacy. One can witness China in Africa as a very good example of the Chinese starting to go use science and technology as a tool to enhance their relationships with African countries. There's an effort to improve the performance of the system, and it's also an effort to raise the visibility and the image of China in both global and regional affairs. I think these all suggest that we're going to see a much more active China in international science and technology affairs. It doesn't necessarily mean it will be an adversarial relationship with the United States, but it also means that it will be a much more proactive relationship, and we're likely to bump heads with the Chinese more and more unless we figure out a way how to work collaboratively. I can think of no global international S&T problem that will not require close U.S.-China S&T cooperation. That being the reality I think we need to begin to think of how do we now take advantage of our understanding of this transition in Chinese S&T relationships abroad and how we utilize that to change the game to the next level in terms of our bilateral relationship.

Thank you very much.

Chapter 2 Germany

1. View of current situation

China's science and technology are succeeding in many fields, and indeed reaching the leading edge in some. China aims for innovation through science and technology, it is swift and ambitious, and it is achieving brilliant results.

The speed of change in the research and development system is not that fast. Moreover, action is piecemeal, and a more strategic approach would be better. Basic science is weak. Universities and research institutions need structural reform and internationalization. In Germany, half the Max Planck research leaders, for example, are foreign nationals, and the USA maintains its research prowess by gathering outstanding scientists from other countries.

The level of science and technology varies by field. Fields where China has reached the leading edge include IT, wireless networks, and smartphone manufacturing. China is also very advanced in supercomputers and space development, but not so much in materials science. System engineering is going well in space-related fields, but China lacks the ability to develop an automobile industry on its own.

2. Basic policy on cooperation

Germany's basic thinking on promoting international cooperation is to exchange culture, technology, science, etc., after thorough dialog with other countries that share this planet. Science and technology in particular belong to the whole world, without political barriers.

German industry is among the most powerful in the world, but maintaining that strength will require ongoing effort. Cooperation with China is an important part of that effort, and it needs to be cooperation that fuses each country's best and brings about breakthroughs.

3. Framework for cooperation

There is a bilateral cooperation agreement at the national level, with a committee meeting annually. In 2014, the meeting will be held in Germany in October. As will be discussed below, cooperation proceeds with MOUs that have been signed in various fields under the agreement.

Cooperation with China began with personnel exchanges with the Chinese Academy of Sciences (CAS). During the 1980s, around 600–700 Chinese were accepted at Fraunhofer Institutes. Even today, there are some people accepted from CAS, local governments, and so on. Acceptance of doctoral students, exchanges of other students and researchers, and provision of postdoctoral fellowships (15-month) are carried out. Because the two countries' funding schemes and evaluation systems differ, joint funding is not easy. However, there is public recruiting for fields such as water and computational biology.

In the past, the German and Chinese governments served as producers for joint research cooperation between the two countries' research institutions, but today that type of activity is limited. Seminars and other joint events are also held, but they are not large in number.

The mainstay of today's cooperation activities is contract research in which German research institutions provide research services to Chinese clients. Funding comes from the Chinese clients. Japan rarely outsources applied research through such contracts for research cooperation, but outsourcing of applied research is commonplace for Germany. China is rich in diversity, and its markets are enormous. India has those same characteristics, but it remains a future market.

4. Categories emphasized in cooperation

Cooperation works well in fields that do not compete with domestic German industries. For example, development of a method to test the authenticity of cashmere (specifically, DNA testing) being carried out in Beijing is no problem, because Germany has no domestic cashmere industry or market. Additionally, cooperation with China in fields that can contribute to German domestic industry is also important. On the other hand, there are fields in which Germany is reluctant to cooperate. It is dubious about cooperation in high-tech fields related to competitiveness in specific industries, such as development of new automobile engines. Furthermore, cooperation in fields that would compete with German manufacturing industries, solar panels for example, would increase the competitiveness of rivals. Moreover, legal aspects of Chinese intellectual property rights are in a developmental stage, unlike the situation with the USA or Japan, so caution is necessary.

Bearing such points in mind, MOUs starting in 2011 were signed in seven fields. Joint committees meet every two years, and cooperation has begun under this secure framework.

i) Vocational training
ii) Clean Water Innovation Center in Shanghai
iii) Water treatment
iv) IT and future cities
v) Life science
vi) LEDs
vii) Partnership program for high school students

5. Specific examples of cooperation

We will introduce specific examples from the above seven fields.

First, in vocational training, for German automakers and other corporations to develop business in China, the presence of skilled technicians is indispensable, but education and training there is not sufficient. China as a society values learning and parents want to send their only child into higher education and a white-collar job rather than having them trained to work in a factory as a skilled technician.

In German vocational training cooperation with China, for 30 years the German Chamber of Commerce and Industry has supported automakers and machinery manufacturers in a corporate-led program, and local governments have provided training. Underlying this is the German culture of industry taking responsibility for worker quality. Vocational training cooperation in China was very much welcomed, but it did not manage to change Chinese thinking. Today, vocational training has developed, and in cooperation with China, students can receive it at four centers in Chongqing, Shanghai, Qingdao, and Tianjin. The German side provides the curriculum and faculty training in Germany, while China provides the buildings and the instructors.

Bilateral cooperation in the water treatment field is also important. Today, there is top-down, strategic development in places such as Qingdao, Shandong Province; Taihu Lake in Wuxi, Jiangsu Province, Dianchi Lake in Kunming, Yunnan Province, and Chaohu Lake in Hefei, Anhui Province, covering broad areas of water treatment including water supply, wastewater treatment, and water purification.

In April 2014, a 30,000-m^2 water treatment facility was completed in Qingdao with funding from the Bundesministerium für Bildung und Forschung (BMBF, Federal Ministry for Education and Research). The grounds include a hotel, a park, models of infrastructure and water treatment facilities, and an exhibition of German technology. German researchers contributed to the construction along with researchers from Shanghai Jiao Tong University and Qingdao Technical College. In the future, the plan is for Qingdao and private-sector corporations to put up funds for further construction of facilities.

6. Issues in cooperation

Germany and China have many cultural differences and troubles that accompany them, but the situation is rapidly improving. Fist, communication in English has become possible. Efforts to discuss and solve problems are noted. On the other hand, the problem remains that transparency is not ensured because funding is not open to the foreign partner. In joint research, the extent of coverage of research costs differs. The German side bears costs that the Chinese side should be handling, such as infrastructure and utilities, so there is an imbalance in the provision of funding.

When cooperating with China, nonpayment of usage fees for intellectual property rights was a problem in the past, but today there is no special difficulty. China's high-speed railway technology is criticized as essentially a copy combining Japanese, German, and French technology. Indeed, only Siemens and Kawasaki Heavy Industries had technology for 350-kph railways, but copying of its technology was a small problem to Germany. Opening China's rail market was more important. The German high-speed rail market is small. It is also necessary to consider that China has also added some technical development. However, if China enters markets such as the UK, it will impact Siemens' profits.

Background information: "**Die deutsch-chinesische Zusammenarbeit in Wissenschaft und Technologie als erfolgreiches Beispiel für den internationalen wissenschaftlichtechnologischen Austausch**"

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http://www.kas.de/upload/dokumente/2014/06/Politik_WuF_82.pdf

(Original in German)

The Sino-German collaboration in the area of science and technology as a successful example of the exchange of scientific and technological knowledge between nations

Wan Gang

In 2014, the diplomatic relations between Germany and China will have existed for 42 years. The Chinese philosopher Confucius once said: "you have no more delusions about yourself at 40" (si shi bu huo). The current Sino-German relationship finds itself in exactly this phase of "clarity". For 42 years, the relations between Germany and China have steadfastly withstood the challenges of international vicissitudes and the associated change, and have developed in a stable fashion. In recent years particularly, this relationship has entered into a broad-based, extremely active and successful phase, in which both sides have come to appreciate each other as important strategic partners. The good relationships and close collaboration between the two countries are the result of a long-standing friendship between the two nations and their joint efforts. Within the context of this collaboration, China has learned much in the areas of future-oriented technologies and management from Germany and, at the same time, offered a broadly diversified market that has been favorable for German economic growth and thereby supported the German economy. When looking at the historic origins of the bilateral relations, their current status and their future development, one can only conclude that collaboration in the area of science and technology has played a key role in strengthening Sino-German relations and will continue to do so in the future.

Germany and China – countries with a long and fruitful tradition of scientific and technological collaboration

Towards the end of the 19th century, the Chinese government started to make funds available so that Chinese students could study in Germany and also created a government-supported bilateral exchange program. In 1907, China founded the "Shanghai

German Medical School" with assistance from Germany. This school subsequently expanded to become the “Shanghai German School of Medicine and Engineering" before ultimately evolving into today's highly reputable Tongji University. At the beginning of the 20th century, China started to understand Germany increasingly better and Kant, Hegel, Nietzsche, Marx and Engels established themselves as leading German intellectuals in the eyes of the Chinese; to such an extent, in fact, that their thinking has profoundly influenced China's development. Many of the entrepreneurs of modern China spent time studying in Germany and Europe. Germany became an important point of contact where China was able to encounter and learn from the modern Western knowledge culture in the 20th century.

After the reform and opening up of China, the Sino-German collaboration in science and technology played a significant role in China's rapid emergence as an economic power.

While they may be an accident of history, some evident parallels between the Sino-German collaboration in science and technology and a number of significant historical events in the Chinese development process provide food for thought.

One of these events occurred in 1972. In that year, China breached the Iron Curtain that existed during the Cold War and initiated diplomatic relations with the Federal Republic of Germany and the United States of America. This was a historic moment of great importance, as the West accepted China's approaches and China opened up further to the West. The same year marked the start of a more intensive and constructive phase in the collaboration between Germany and China in the area of science and technology. The Chinese Academy of Sciences invited the Max Planck Society to visit, thereby opening the door to cooperation and the exchange of scientists and engineers between the two countries. The governments of both countries started to send trade delegations. Initial contacts between individuals gradually developed into concrete collaboration on projects.

Further convergence occurred in 1978. In that year, China decided to implement a policy of reform and openness and defined four modernization goals, namely the modernization of agriculture, industry, defense and science & technology. This was the start of a period of double-digit economic growth in China, which was to continue for more than 30 years. And, in the same year, a delegation from the Federal Ministry for Research and Technology visited Beijing. During this visit, discussions started on reaching an intergovernmental agreement regarding collaboration in the area of science and technology. Thanks to the support of the former Chinese Vice Premier and Chairman of the State Science Commission, Fang Yi, and support from the German side, both countries signed the "Intergovernmental Agreement between the Federal Republic of Germany and the People's Republic of China on Scientific and Technological Cooperation" on 9 October 1978. This agreement was one of the first cooperation agreements to be signed by Germany and China. The agreement on economic cooperation was signed a year later and the agreement on cultural cooperation came into effect two years later. The agreement took the common interests of both sides into account to the greatest possible extent and created a firm base for future collaboration between Germany and China:

–It laid the foundations for wide-ranging cooperation in many areas. It touched on many aspects; for example, it involved government departments and supported research institutes and universities, but also businesses and social organizations and also encouraged international collaboration and exchanges between scientists at a personal level. The range of bilateral cooperation included basic research, applied research and technical development.

–Because the legal statuses and organizational structures were not fully comparable between the two countries and countless different categories existed, provision was made for a number of different forms of cooperation. These included support for scientists staying in the other country while conducting research, jointly organized academic conferences and joint research activities that were supported by the government or by businesses.

Thanks to the impetus provided by the intergovernmental agreement, the cooperation in science and technology developed extremely rapidly and resulted in many successes. A large number of outstandingly talented scientists came to the fore. For example:

−Qiu Fazu, a member of the Chinese Academy of the Sciences, received the Grand Cross of Merit of the Federal Republic of Germany;

−The former Minister of Science and Technology, Zhu Lilan, who also received the Grand Cross of Merit of the Federal Republic of Germany;

−Chen Jia‘er, a member of the Chinese Academy of the Sciences, received the Grand Cross of Merit of the Federal Republic of Germany;

−Xu Kuangdi, a member of the Chinese Academy of Engineering Sciences, received the Sino-German Friendship Award;

−The former rector of Tongji University, Wu Qidi;

−The former president of the Chinese Academy of the Sciences, Lu Yongxiang;

−And the German Professor Peter Gruss (Biology), who received the Chinese Award for International Cooperation in Science and Technology,

−Andreas Dress (Mathematics) and

−Albert Börner (Astrophysics).

The Sino-German cooperation in the area of science and technology focuses particularly on promoting young talented people - a focus which has led to very special experiences for me personally. Following my admission to Tongji University in 1978, I later went to Germany to further my studies and ended up staying in Germany for a further 15 years. First, I completed my Ph.D. at the University of Clausal, an achievement for which I would particularly like to thank my academic mentor, Professor Dr. Peter Dietz, who not only guided me with a firm hand and very intensively through my research work, but also made great efforts to help me personally with matters of everyday life and introduced me to the inner circle of local Sino-German cultural life. His application-oriented and practical style greatly influenced me in my later work. After I graduated, I was fortunate to be able to work for Audi for 10 years where I participated in developing various models and managed multiple major scientific and technological projects and priority programs. In Germany, I was privileged to personally experience how hugely significant scientific and technological innovations are for rapid economic growth and see how the federal government intensively encouraged scientific and technological innovation. During this truly unforgettable period of my life, I developed the deep emotional bond with my German friends, which was and still is an inexhaustible driving force in my efforts to further advance the scientific and technological cooperation between Germany and China.

The scientific and technological collaboration between Germany and China in its mature and stable phase

The scientific and technological collaboration between our two countries deepened at the beginning of the 21st century and became more clearly defined in terms of its function. Today, that collaboration has reached a mature and highly successful phase. Three of the five signed joint statements ensuing from the first round of Sino-German government consultations (2011) originate from the science and technology sector. During the second round of Sino-German government consultations (2012), the content of more than half of the intergovernmental agreements was related to science and technology. Our scientific and technological collaboration has greatly advanced Sino-German relations - in fact, one could even say overall Sino-European relations - and has now taken on institutionalized, differentiated and diversified forms:

1. The intensive exchange between the leaders of both countries has created a solid foundation for bilateral cooperation. In recent years, the leaders of both countries have remained in close contact with each other, thereby strengthening trust between the countries at a strategic level. The former German Chancellor, Schröder, visited China on six occasions during his period in office. Similarly, the current German Chancellor, Merkel, has also visited China on six occasions to date. The former Prime Minister of China, Wen Jiabao, visited Germany on six occasions during his period in office and, in 2011, inaugurated the first round of the regular Sino-German government consultations at the head of a party of 13

ministers. Shortly after the current Chinese government came to power, the Prime Minister of the State Council, Li Keqiang, started his first tour of foreign visits in Germany. This reflects the new government's strong desire to continue the good relations with Germany. In fact, in the context of China's external contacts, the most intensive exchanges at political level take place with Germany. The dialogue and exchange with Germany are not only extremely intense, but also highly successful. All of this promotes a continuing strong development of the scientific and technological cooperation between Germany and China.

2. Due to the close level of involvement at different levels, the cooperation is now developing in a "pragmatic" direction. The bilateral scientific and technological collaboration is now not only being promoted by the competent government departments of both countries, but is also receiving support from other economic agencies, industrial organizations, businesses and foundations. According to preliminary information, the German and Chinese leaders of the government departments responsible for science and technology have already met on more than twenty occasions since the start of the current century. Leading figures from the Chinese Ministry of Science and Technology (MOST), like Zhu Lilan, Liu Yanhua, Li Xueyong and Shang Yong, and Minister Bulmahn, State Secretary Dudenhausen and Minister Schavan of the Federal Ministry of Education and Research (Bundesministerium für Bildung und Forschung/BMBF) regularly visit the other country. After taking office as the Minister of MOST in 2007, I personally visited Germany on a regular basis and maintained good contacts with the Federal Ministry of Research, the Federal Ministry of Transport, the Federal Ministry of Economics and the Federal Ministry of the Environment. Close relations have developed between the government departments of both countries through intensive exchange. Electric mobility is a good example of this: on the Chinese side, the Ministry of Industry and Information Technology, the Ministry of Science and Technology, the National Development and Reform Committee, the Ministry of Finance and the State Committee for Standardization have participated in the developments in this area together with the German Federal Ministry of Economics, the Federal Ministry of Transport, the Federal Ministry of Research and the Federal Ministry of the Environment. These representatives of both countries have held countless events and symposia on standards and infrastructure and organised demonstration projects, thereby creating a solid foundation for good cooperation.

3. The mechanisms of bilateral cooperation have become more sophisticated and differentiated. The efforts of both sides have led to the creation of a series of stable mechanisms that will expire at different times. The official framework provides the overall design for cooperation

and ensures coordination and promotion. This is implemented primarily by the joint Committee for Scientific and Technological Cooperation, whose chairperson in each country holds the office of a Vice Minister or higher. The committees meet alternately in China and Germany and have done so on 22 occasions to date. Currently, the main forms of cooperation are joint projects,"2+2 Projects", joint laboratories, groups of junior scientists and research institutes. In addition to the committee mechanism, other highly effective collaborations exist, particularly those between the Chinese Academy of Sciences and the Max Planck Society, and between the National Natural Science Foundation of China (NSFC) and the German Research Foundation (Deutsche Forschungsgemeinschaft/DFG). The Sino-German Centre for Research Promotion (CDZ), a joint initiative of the NSFC and DFG, promotes cooperation between universities, scientific research institutes and the next generation of scientists of both countries in a multi modal manner and has been accepted by the majority of scientists on both sides.

4. Collaboration takes place in equal partnership and for the mutual advantage and profit of both parties. In reflection of the continuing strengthening of China's research capabilities, the bilateral cooperation has gradually evolved from a one-sided learning process to research and development collaborations on an equal footing, and the focus of cooperation has simultaneously moved towards jointly tackling a wide range of issues as opposed to simply exchanging scientists. The collaboration in the areas of electric mobility, climate change, sustainable development and life sciences has moved up to a new level, in which not only research and teaching, but also commercial applicability play an important role. Both sides stress the paramount importance of exploiting research results by actively involving businesses. The following examples illustrate the extent to which our collaboration is based on equal partnership and mutual advantage and profit:

    a. Cooperation in the area of innovation policy: In order to strengthen consultation on innovation policy between Germany and China, both sides initiated a dialogue on innovation policy by convening the first Sino-German Innovation Forum in 2011. In 2012, Germany accepted China's invitation to participate in the Pujiang Innovation Forum in Shanghai. Germany organized the second Sino-German Innovation Forum in Berlin. For more than two years, both sides have researched and communicated more intensively on issues such as innovation policy, research investments, administrative frameworks, sector development and developing human resources. The associated outcomes have been actively implemented by official decree and are achieving good results. The third Sino-German Innovation Forum is scheduled to take place in China.

b. Cooperation in the area of electric mobility: Germany and China have jointly set up the Electric Mobility Research and Development Platform and founded the Sino-German Research Centre for Electric Mobility. Within this context, 15 focal universities of applied sciences and scientific research institutions, and 19 businesses from both countries, have collaborated in projects such as that for developing a "lightweight electric car". Numerous successes have been already been achieved in this area. China is actively driving forward the "10 Cities, 1000 Vehicles" project. Collaboration agreements for this project have been signed with Nordrhein-Westfalen, Bremen and Hamburg and a platform has been created for the purpose of interactively demonstrating cars originating from both countries. The prototype of a fuel cell powered vehicle with four-wheel-drive, which has been jointly developed and manufactured by both sides, was presented during the international automotive exhibition in Shanghai in April 2013. China will provide a smaller, fully electric passenger vehicle for demonstration purposes at the International Building Exhibition (IBA) in Hamburg and a fully electric bus built in China has already been deployed on one of Hamburg's regular bus services.

c. Cooperation in the area of life sciences: During the second round of Sino-German government consultations in 2012, the Chinese Ministry of Science and Technology and the Federal Ministry for Education and Research officially opened the Sino-German Innovation Platform for Life Sciences in Beijing and organized a Sino-German symposium on cooperation in the area of life sciences. The associated coordination office and advisory committee of experts have already been set up. Both sides are intensifying the research and development cooperation between researchers, teachers and producers that are active in priority areas such as biomedicine, biopharmaceuticals and novel biomaterials and provide joint support for innovation projects.

d. Cooperation in the area of "Clean Water": In 2012, both countries initiated the Sino-German research and development program called "Clean Water". A collaboration has started between the major Chinese scientific and technological special project called ''pollution control and rehabilitation of surface waters" and the German project called ''international partnerships for sustainable climate protection and environmental technologies and services" (CLI- ENT). In March 2013, both sides decided to set up a Sino-German Innovation Centre for "Clean Water" in Shanghai's

Zhang Jiang Hi-Tech Park in order to organize joint research and development activities and initiatives for marketing research results in collaboration with German and Chinese research institutes, technology parks and businesses. Cooperation with industry plays an important role in this context. These measures have led to the creation of a long-standing platform for innovative cooperation between Germany and China in the area of "Clean Water".

e. The cooperation in the field of semiconductor lighting technology: In 2012, Germany and China signed the "Joint declaration of cooperation in the area of LED technology between the Ministry of Science and Technology of the People's Republic of China and the Ministry for Education and Research of the Federal Republic of Germany". This marked the start of joint research and development projects in the areas of control and test measurement, the influence of light on living beings and their health, the evaluation of LED demonstration projects, off-grid lighting, standardization of LED products, recycling LED products and the collection of LED products during their entire life-cycle. This also includes the cooperation between the Chinese "10 cities, 10,000 lights" project (applicability and demonstration project: cities lit using semiconductor technology) and the German "communes in a new light" competition.

f. The Sino-German collaboration at Tongji University: this university has a special place within the framework of Sino-German cooperation. In order to jointly train up talented young people, Tongji University has set up joint education facilities, namely the Sino-German University College (CDHK), the Sino-German University of Applied Sciences (CDHAW) and the Sino-German Institute for Vocational Education (CDIBB). Numerous other institutes at Tongji University nurture close relations with well-known German universities in the area of human resources. With regard to research, Tongji University has set up numerous joint research and development units with German universities, extramural research institutions and corporations. The Institute of Solid State Physics is one of these research units and has already enjoyed the support of the German and Chinese governments for some considerable time. Platforms for cooperation have been created in collaboration with German corporations, for example the VW-Tongji Institute for Automotive Research, the center for academic exchange in science and research and the joint automotive laboratory.

These examples are just a few facets of the scientific and technological cooperation between Germany and China. Very close and effective collaborations exist in terms of both education and research, and also commercial applicability. They form the basis for the successful economic and technological development of the two countries.

Further measures designed to extend the success of the Sino-German cooperation in science and technology into the future

Against the backdrop of today's progressive scientific and technological revolution and the global changes in industry, the Sino-German cooperation in science and technology appropriately responds to the major trend of global development while continuing to promote the common interests of both sides. The 30 year long process of reforming and opening up China has led to successes that have attracted the world's attention. In spite of these huge successes, China continues to face major challenges in terms of resources and the environment. China accordingly applies an innovation-driven development strategy, strongly emphasizes the quality and efficiency of economic growth and aspires in this way to achieve an upgraded version of the Chinese economy. That will require scientific and technological innovation. Both in the form of the products of China's own powers of innovation and imported future technologies. Germany is highly developed in the area of science and technology and has access to cutting-edge technologies and good management skills in numerous areas, such as industrial manufacturing, the energy sector and environmental conservation. We hope that China can learn from this. At the same time, China strongly promotes industrialization, the creation of an IT infrastructure, expanding the infrastructure in urban areas and modernizing agriculture. Each year, ten million people move from rural areas to the cities in China. The resulting economic, social, cultural and civic growth will generate tremendous economic demand and create new markets. Germany can also benefit from these emerging market opportunities in China. The Sino-German cooperation has proved its value and sets an example for Sino-European collaboration. The two countries are each other's largest trading partners in the European Union and Asia Pacific region. When considering the future of this bilateral cooperation, we have the following hopes:

1. The hope that both sides will continue to strengthen the exchange of scientists further. People are the starting point for all innovations and the basis of all cooperation. An intensive exchange of scientists is a prerequisite for good collaboration. During the past 30 years, tens of thousands of Chinese have studied and worked in Germany. In 2012, approximately 30,000 Chinese exchange students were resident in Germany and more than 5,400 German students were present in China. Each of them is a bridge in the friendship between China and Germany. I am overjoyed to see how the exchange programs for young scientists and partner groups that have been set up by the Max Planck Society and the Chinese Academy of Sciences are actively developing talent by helping young people with

their education. At present, there are already more than 30 of these Sino-German partner groups in which a number of promising young people are rapidly reaching maturity. I hope that both sides will continue to deepen this mechanism for exchanging scientists, expand the types of exchange opportunity and refine the exchange platforms further in order to jointly train even more highly productive and talented people.

2. The hope that both sides will continue to strengthen the cooperation in the area of basic research. Basic research is the source of innovation; it is an indispensable driving force for long-term development. Germany and China are both successful countries in the area of basic research and each have broad-based subject offers and extensive and varied areas of collaboration. I hope that both sides will give basic research even greater attention, particularly in the newly formed crossover subjects. I hope that they will jointly create new organization models for innovative research, jointly promote the creation of major experimental platforms, jointly participate in key international programs and major projects and further deepen their open collaboration.

3. The hope that both sides will strengthen their technological cooperation, particularly in respect of improving the population's living standards, and in the areas of energy and environmental conservation. A close cooperation between Germany and China that exploits the two countries' respective strengths will be helpful and useful to both China, in its efforts to restructure its economy and upgrade its industries, and to Germany in its efforts to improve the international competitiveness of its businesses and expand its global markets. China wants to strengthen the collaboration with Germany in the following technological areas: modern manufacturing industry, transport, the chemical industry, new materials, biomedicine and the aerospace sector. Due to the increasingly high incomes enjoyed by the Chinese population, China's needs relating to an improvement in general living conditions and environmental conservation will clearly grow. This will lead to major opportunities for Sino-German cooperation in the area of sustainable development.

4. The hope that both sides will continue to promote cooperation between businesses, particularly in the small and medium-sized enterprise segment (SME). Businesses are the key players in effectively applying technological innovations. Within that envelope, the SME sector is a powerful innovative force. While focusing heavily on cooperation with large German multinational corporations, China also encourages cooperation between small and medium-sized enterprises on both sides. China supports cooperative initiatives between German and Chinese businesses in the SME sector so that they can capitalize on

their complementary strengths in the areas of funding, technology, staff and marketing and jointly stimulate growth. I hope that both countries will make even greater efforts to promote cooperation between their business sectors by implementing political measures, creating platforms and releasing market forces so that this cooperation can grow further in equal partnership and to the benefit of both parties.

5. The hope that the scientific and technological cooperation between Germany and China will continue to act as a powerful force in strengthening the scientific and technological cooperation between Europe and China. Germany is a key member of the European Union and plays a crucial role within Europe as a united entity. China has signed an agreement on scientific and technological cooperation with the European Union and set up a Sino-European dialogue mechanism to promote collaboration in the area of innovation. I hope that the Sino-German cooperation in science and technology can be an even more effective force in bringing about Sino-European cooperation in order to create a win-win situation in the areas of innovation strategy, human resources, technology and marketing research results.

If we look back into the past, both Germany and China have shown great confidence in each other and continuously supported and furthered their cooperative initiatives. As a result, they have achieved immense successes. If we look into the future, new challenges are certain to arise again and again as China continues to modernize and Germany continues to develop. China will not change its strategic position regarding the Sino-German cooperation, nor its guidelines and political measures in respect of cooperation for mutual benefit, nor its confidence and resolve in respect of the friendship between Germany and China in the long term. Let us join hands and work together on implementing the “updated version” of the Sino-German cooperation in science and technology and on further improving the living conditions on our planet.

Chapter 3 UK

1. View of current situation

Chinese science and technology are outstanding in several specific areas. At the highest levels, they differ little from the level of the UK. Chinese R&D covers all fields with enormous investment. On the other hand, it is problematic that China is not creating innovation well.

2. Basic policy on cooperation

Science and technology cooperation with China is performed with the objectives of further stretching areas where the UK excels, expanding UK industrial profits, and forming sustainable networks.

3. Framework for cooperation

The UK and China signed a science and technology agreement in 1978. A joint commission meets every two years. UK-Chinese cooperation is reviewed there. MOUs on separate fields, such as space and innovation, are signed under that umbrella.

The UK established the Newton Fund as a cooperation program for emerging nations. Funding for cooperation with China was set up in December 2013. This funding goes one-third each to joint research (stem cell research, sustainable manufacturing, synthetic biology) performed by UK research councils (RCs), construction of joint industrial centers, and support for researcher exchanges.

4. Categories emphasized in cooperation

Promising fields for cooperation with China are 1) life science, especially stem cell research, synthetic biology, and other biology, 2) space development including satellite manufacturing, 3) advanced materials and their application, 4) research on land and air pollution accompanying urbanization, 5) food, water, and agriculture, 6) energy, especially shale gas, renewable energy, and green energy, and 7) the creative manufacturing industries that are the UK's specialty.

5. Specific examples of cooperation

Twenty private-sector companies and universities participate in the Sustainable Manufacturing Program, which finds business partners and has achieved tie-ups with 500 Chinese partners. In addition, the Technology Partner Initiative has realized £45 million in business from a £100,000 investment. In the future, these initiatives may be integrated into the Newton Fund's construction of joint industrial centers program.

6. Issues in cooperation

It is necessary to understand that the UK and China have different standards, regulations, and legal environments.

A recent example is that during implementation discussions with the Newton Fund, China's Ministry of Science and Technology (MOST) stated that it would contribute £100 million over five years, but those involved were bewildered to find that MOST does not have those funds.

Background information: "**China's Absorptive State: Research, innovation and the prospects for China-UK collaboration**"

This material is an executive summary of a report published by the UK think tank Nesta in 2013. It is quoted from the following website.
http://www.nesta.org.uk/publications/chinas-absorptive-state-innovation-and-research-china

China's Absorptive State: Research, innovation and the prospects for China-UK collaboration

Ten key findings

1. China is an absorptive state, increasingly adept at attracting and profiting from global knowledge and networks. China's growing innovation system has succeeded in combining rapidly improving home–grown capabilities and infrastructure with foreign technologies and knowledge to build the world's fastest supercomputer, send astronauts into space and pioneer the Beidou Satellite Navigation System. These examples suggest that what China's President Xi Jinping terms "innovation with Chinese characteristics" will not be a straightforward path from imported to home– grown innovation, but a messier process in which the lines between Chinese and non–Chinese ideas, technologies and capabilities are harder to draw. Characterising China as an absorptive state helps us to understand its current phase of development: that the systemic conditions for research and innovation have reached a stage where ideas can be effectively absorbed and exploited, with increasingly dense and targeted networks to enable this. But it also helps us assess the prospects for future development: absorption will remain a core strand of national research and innovation policy, and Chinese firms' impressive ability to rapidly absorb and re–innovate, while adding novelty and value to ideas and technologies in the process, is crucial to understanding their competitiveness.

2. Accelerating the shift to a more innovative economy remains a core priority of China's new leadership, yet equally important is a new focus on quality, efficiency and evaluation. A policy focus since the early 1990s on investment and growth has propelled China into the top ranks of global innovation, but the process has been inefficient and these policies are now being complemented by a growing focus on efficiency, quality, coordination and evaluation. This trajectory of reform is likely to be consolidated in the 2016 13th Five Year Plan.

3. The exceptional growth trajectory of China's research base continues, but has not yet been matched by similar leaps in quality. Growth in output is pervasive throughout the system, both in large fields such as engineering and in newer fields such as biomaterials, which grew 15–fold in the last decade. Impact remains below world average in most areas, but is close to that benchmark in a number of fields, including engineering and mathematics, and consistently above average in agriculture. The strengths of established research economies like the UK are relatively stable from year to year, while China's are changing at an unprecedented rate. This requires a cautious approach to interpreting strengths and weaknesses. Spikes of excellence and pools of mediocrity can be hidden among the averages.

4. Research and innovation is still highly concentrated on China's east coast, but diverse models of innovation are visible among east coast hotspots. While some second tier inland cities such as Chengdu and Wuhan have benefited from government and multinational investment in innovation, well over two–thirds of all patents were granted to applicants on the east coast in 2011. In addition, the east coast accounted for over 60 per cent of China's publication output. Yet among the eastern hotspots of Beijing, Shanghai and Guangzhou, there are contrasting innovation models. While the central government sets the overall policy context, targets and evaluation metrics, there is a considerable degree of autonomy in how to deliver on these goals in different places, leading to experimentation through different interpretations of national policies.

5. Over the last five years, an expanding tier of Chinese multinationals have become visible in global rankings of firm–level innovation. Both Baidu and Tencent appear in the top 50 of Forbes' list of most innovative companies and ZTE applied for more PCT patents than any other company in the world in 2012. China has benefited considerably from the fragmentation and modularisation of global production, which has allowed its enterprises to specialise within particular niches of product and service value chains. Businesses are responsible for almost three–quarters of China's R&D spend, but progress towards an enterprise–led innovation system has been inhibited by the slow pace of reform in state–owned enterprises.

6. Previously regarded as a weakness, the quality and speed of China's capacity for incremental re–innovation is now an important competitive asset. Sophisticated manufacturing networks excel in absorbing, adapting, prototyping and market testing new products and technologies at speed. 'Shanzhai' methods of production previously referred only to substandard imitation, but as former shanzhai companies have developed disruptive products, this method of innovation is of growing international interest as a distinctive way of adding value. These approaches are not only prevalent in manufacturing, but also in the digital and creative industries.

7. After three decades of rapid economic growth, debate in China is intensifying about how to direct innovation towards social and environmental goals. Environmental and health concerns are prompting a sharper focus on low–carbon and sustainable innovation and the government is investing heavily in low–carbon cities, renewable energy and energy efficiency programs. A more proactive and vocal civil society is at the forefront of growing calls for social innovation. More demanding Chinese consumers are driving new types of user–driven innovation, a process which will intensify as domestic consumption takes over from investment as the main driver of China's economic growth.

8. Our new analysis shows that in 2011, the UK overtook Japan to become second only to the US in the number of its joint research publications with China. The UK has increased its share of China's collaborative activity while other EU countries have declined. This is an encouraging sign but a weak predictor of future performance, owing to the speed of change within the Chinese system. For any country seeking to collaborate with China, ensuring a density and diversity of connections will be crucial, spanning the academic, research, commercial, trade and cultural spheres.

9. There is no perfect formula for high impact collaborations with China. There is very little evidence available on the effectiveness and economic impact of different models of support for international innovation collaboration. Each county's strengths and modes of engagement are unique, and while it is important to monitor and benchmark the UK's performance against that of other countries, and learn from other countries' experiences, the transfer of 'best practices' in collaboration is rarely straightforward. For instance the US and German approaches to collaborating with China are frequently held up as models for the UK to emulate. However, the UK's economy and military might is substantially different from that of the US and its manufacturing base contrasts with the one which forms the foundation of the Sino-German relationship.

10. The greatest 'China risk' for innovative companies is focussing too heavily on downside risks, and missing out on the opportunities that China presents. Hawkish perspectives on Chinese innovation highlight the 'dark side' of China's absorptive state: international flows of ideas and technology resulting from IP theft, forced technology transfer and hacking. But innovative firms recognise that without some risk, there is little reward. Intellectual property is only as valuable as one's capacity to exploit it and stay ahead of the competition. The increasingly absorptive Chinese system brings both risks and opportunities for businesses, universities and others seeking

to work with and in China. These risks need to be managed with care, but they should not be over–emphasised to the extent that they eclipse a far greater risk – that of failing to participate fully and benefit from the next phase of China's growth.

Recommendations

1. The UK should develop a new five–year strategy for China–UK collaboration in research and innovation. Work towards this strategy should begin now, but 2016 would be the ideal time to publish it, to take account of new policies in China's 13th FYP, and the 2015 post–election Spending Review in the UK. The strategy should encompass the full breadth of potential innovation links between the two systems, from research through to the commercialisation, demonstration and scaling phases of new technologies. Some programs should envisage a horizon of decades rather than years, and this strategy should be fully embedded in a long–term plan for innovation–led economic growth in the UK. Stable long-term investments and incentives should help experimental approaches to collaboration flourish. On the UK side, this process will require the active involvement of the Technology Strategy Board and a wide range of industrial and business partners in addition to BIS and RCUK.

2. The UK should develop more sophisticated methods and metrics for identifying China–UK innovation opportunities and for evaluating impact. The strategy should look beyond readily measurable research performance and patenting data to understand China's evolving specialisms. It should explore how UK companies can better engage with China's strengths in developing, iterating and scaling technologies. The UK should develop approaches to supporting ecosystems of collaboration rather than individual companies. The UK's 'eight great technologies' should form the basis of a mapping exercise to determine specific China–UK complementarities, which should feed into the five–year strategy. Bibliometric data should be used to expand and diversify research collaborations, by developing a real–time data resource for UK researchers, identifying the range of Chinese universities where they can find relevant capacity and competence. One of the strengths of UK innovation policy is the high degree of openness and debate about the effectiveness of different approaches. Much equivalent debate and analysis takes place on the Chinese side, but is often difficult to access online. The UK government should encourage Chinese counterparts to promote access to data and analysis on innovation policy in the same way the UK has on the gov.uk website.

3. Expand the China–UK innovation policy dialogue to include a new bilateral expert group, able to undertake in–depth analysis to inform ministerial meetings. China and the UK should expand their existing innovation policy dialogue to establish a group of Chinese and UK experts in

research, innovation and industrial policy, able to explore themes relevant to collaboration and provide input and advice to official discussions. This group could analyse emerging policies and what they mean for each country, evaluate programs and methods used to support collaboration, and assess Chinese and UK strengths and weaknesses for areas of complementarity. Crucially, the work of the group should be published, to inform public debate on UK–China collaboration. Focused analysis could also be undertaken under priority themes spanning research and innovation, for example:

• Ageing and healthcare: Both countries face the challenge of caring for an expanding elderly population with a dwindling workforce. Innovations in health technology, and systemic approaches to transformation could be explored.

• Smart and sustainable cities: China has been investing heavily in smart and eco–cities, and efforts have been made to match Chinese demand to UK strengths in design, construction and big data. But this is an area that can only grow in importance given the pace of urbanisation in China and Chinese excellence in
materials science and engineering.

• Creative industries: China is now making significant investments in cultural institutions and creative industries, and is a huge potential market for the UK. Creative industries are an area of great strength for UK innovation and there are considerable unexploited opportunities for collaboration.

4. Further boost the UK's presence and capacity in China to coordinate innovation diplomacy and collaboration for greatest economic and social impact. The UK needs to invest further to ensure it can sustain the full range of activities required for an effective approach to innovation diplomacy that will unlock long–term economic opportunities for the UK. This will require brokers and intermediaries capable of supporting a full spectrum of relationships. They should recognise when to support individual or supply chain–based collaborative efforts and when to shift attention to transforming the macro policy environment. They also need to ensure better coordination between UK partners in China. As the global innovation system develops, the UK should design more targeted policies to increase its own capacity to absorb, develop and exploit knowledge as well as to generate it. The proposed expert group should work closely with UK representatives on the ground to gather data and identify opportunities and draw lessons from effective practices

Chapter 4 France

1. View of current situation

China has developed with unbelievable speed, and the atmosphere for R&D fields has changed dramatically. There has been enormous investment in science and technology, with laboratory buildings and other facilities developing rapidly. The French National Center for Scientific Research (CNRS) is the largest research institution in Europe, yet it is no match for the Chinese Academy of Sciences (CAS). Furthermore, many young researchers are active and have accumulated much knowledge. One must bear this situation in mind when cooperating with China. Other countries are also seeking cooperation with China. The level of research has risen greatly, and the volume of output is impressive.

The quality, however, is not as great as the quantity. Internationalization also remains insufficient. China is not accustomed to management of complex international cooperation, but it is improving by learning the American style. As for technology, patents concerning basic matters are few; applied matters are the mainstay. However, this situation will likely change quickly.

The strengths of Chinese science and technology are their quickness to change direction and immediately tackle new topics, their state-of-the-art facilities and equipment, and the youth of the principal investigators (PIs) that they are able to attract from all over the world.

On the other hand, issues that remain unchanged from 15 years ago are that science, technology, and innovation are separate from education, management of research labs and offices is weak, and originality in research is low.

Regarding the first issue, there are examples in clinical research where universities and hospitals are unable to collaborate. They should both share knowledge and become more innovative. In research management, there are no research leaders or bosses to set the direction of research. Each lab performs independent research without affiliation. Big personalities are needed to organize research and set its direction. Research also tends to lack originality. Returnees from overseas copy and repeat the research done in other countries in the past rather than opening up new fields. This is another adverse effect of not having research leaders and each PI doing separate research.

In individual fields, in space development, China launches 20 satellites per year. It is also advancing manned space development. It skillfully applies Soviet technology. Chinese space technology characteristically progresses by accumulating incremental improvements. It is not innovative.

China's materials science is world-class. Its overall science, however, is not better than Japan's or Europe's. Its applied science is poor. It is unlikely to produce many Nobel laureates for a while.

2. Basic policy on cooperation

Like other countries, France's basis for cooperation with China is building an equal partnership and jointly tackling shared global issues.

There are three benefits to cooperation with China.

First, research that cannot be done by France alone can be performed jointly. Examples include Earth science, atmospheric and climate science, and space science. Mathematics is another field where both countries are strong, so the benefits of cooperation are great.

Second, research that cannot be done by France can be performed jointly. Examples include research on Oriental studies, archaeology, Chinese history, and Chinese language.

Third, France has a history of educating Chinese personnel since the 1920s. Continuing to train Chinese researchers is meaningful as retained history. Deng Xiaoping and Zhou Enlai both studied in France.

3. Framework for cooperation

France has signed five agreements with China.

The first was an agreement on science and technology cooperation signed in 1978. The 13th joint committee met in France in 2011. The 14th is to meet in China in 2014.

The second was an agreement on space signed in 1997. Cooperation on space with China should be further pursued. France has already signed two MOUs on satellite cooperation and provided onboard equipment for two satellites.

The third was an agreement on infectious disease prevention signed in 2004, the year after SARS became rampant.

The fourth was a cooperation agreement on traditional medicine in 2007. There are still some doubts about the scientificness and effectiveness of traditional medicine, but the cooperation is proceeding.

Finally, the two countries signed an agreement on innovation dialog in 2013. Unlike the others, this agreement focused on soft activities such as exchanging information on innovation and examining innovation systems. It is not a framework for implementing specific cooperation.

Meanwhile, France's representative research institution, CNRS, has exchanged 10–15 MOUs with Chinese research institutions. The moist important are on cooperative relationships with CAS and NSFC.

4. Categories emphasized in cooperation

As discussed above, France has signed five agreements with China. They can be considered the priority fields.

In addition, the 2011 Sino-French committee on science and technology cooperation held in 2011 based on the agreement on science and technology cooperation identified the following six fields as priority fields.

i) Sustainable development, biodiversity, water treatment,

ii) Green technology

iii) Energy,

iv) Biotechnology, including measures against infectious disease

v) Information security

vi) Advanced materials

However, based on reflection that there are too many priority fields, the next committee meeting will consider reducing them to three.

5. Specific examples of cooperation

France and China are developing cooperation by establishing joint laboratories. Joint laboratories are defined as performing student and researcher exchanges, holding joint seminars, and submitting joint papers, regardless of whether there is a physical laboratory. There are currently 56 joint laboratories all across China. In the future, they are to be reduced to 50.

The laboratory operated by the Pasteur Institute in Shanghai in cooperation with CAS has reportedly produced superb results. Financially, the French Ministry of Foreign Affairs shoulders some of its personnel costs, but basically it operates through support from the Shanghai municipal government and competitive Chinese funds. There are some, however, who say it is not a success. This is because the Pasteur Institute uses a franchise system, so it is not a joint laboratory, and almost all the researchers are Chinese, so their articles are written in Chinese, and the output is of little use to France.

The joint green chemistry laboratory LIAMA (Laboratoire Sino-Européen d'Informatique, d'Automatique et de Mathématiques Appliquées: China, Sino-European Laboratory in Computer Science, Automation and Applied Mathematics), established in Shanghai in 1997, is also noted as a successful example. It is a newer laboratory, but it performs research with the participation of private-sector corporations and area universities. It produces many PhDs, publishing about 10 dissertations annually. Its vigorous research activities produce wonderful results.

A joint mathematics laboratory established by France's CNRS and Fudan University is also producing outstanding results. France is proud to have the second highest number of Fields medalists in the world after the USA, and China is also strong in mathematics.

6. Issues in cooperation

In the process of cooperation to date, there has never been a problem with the handling of patents. MOUs on cooperation and so on are thoroughly reviewed by security and legal experts, so there are no problems.

French high-tech corporations, on the other hand, have suffered issues with intellectual property rights. The stability of intellectual property rights is not guaranteed inside China. In Europe, the USA, Japan, etc., all the rules are clear, and one need only follow them when applying. In China, however, the system is unclear, and its operation may change depending on the interpretation of the person handling it at that particular moment.

There is currently no sense that political interference or influence is a problem for research cooperation. Much cooperation came to a stop at the time of the Tiananmen Square incident in 1989. The French government suspended grants to Chinese exchange students, but that now belongs to the past. The year 2014 will mark the 50^{th} anniversary of the beginning of cooperation, so the French government is enthusiastic about promoting cooperation. However, although there is an MOU with the Chinese Academy of Social Sciences, cooperation is very politicized and implementation has been accompanied with difficulty.

Background information: "**Renforcer la coopération scientifique et technologique avec la Chine**"

This material is a report published by the French Ministry of Higher Education and Research in 2011. It is quoted and tentatively translated from the following website.

http://media.enseignementsup-recherche.gouv.fr/file/Travaux_rapports/30/9/renforcercooperationchine_191309.pd

(Original in French)

Strengthen scientific and technological cooperation with China

In 2010, the Groupe de Concertation Transversal "International" (GCTI) - international cross-functional consultation group, responsible for implementing the international part of the National Strategy for Research and Innovation (SNRI) , completed a study on Franco-Chinese scientific and technological cooperation: the French point of view . This diagnostic has led to the development of a strategic direction plan for the attention of those involved in French research (ministries, agencies, alliances, bodies, institutions of higher education and research, competitiveness clusters, companies, etc.). At the end of this strategic exercise, a monitoring committee including ministries, alliances, agencies and qualified personalities was established.

China is quickly evolving from the status of "workshop of the world" to that of "laboratory of the world". It the second quarter of 2010, it became the second economic power in the world in terms of GDP. It is likely that it will in 15 to 20 years be the first scientific nation before the United States. With a growth of 173% between 2001 and 2007, it rose from 7th to 2nd global rank in terms of the number of scientific publications. The filings of patents and utility models have also been multiplied by 6 between 2000 and 2009. Its research capacity (budget, equipment, human resources) is increasing in power. The 12th five-year plan (2011-2015) is making scientific development and the basis of socio-economic development of China.

The strengthening of its capabilities and the quality of its scientific production make China more and more attractive in terms of research. It is thus becoming an essential partner to respond to major scientific , socio-economic and environmental challenges (preservation of the environment, climate change, sustainable agriculture, ageing of the population, etc.).

France, by signing an intergovernmental agreement on 21st October 1978, followed by many sector and inter-agency agreements, is one of the first European nations to have engaged in a policy of cooperation with China in the field of science and technology. **This cooperation must**

now be strengthened and revitalized. Those involved in French research are invited to look at Chinese research which is strongly progressing.

Consultation - Coordination - Promotion

Number of French people involved in public research (organizations, institutions of higher education and research) or private research (competitiveness clusters, enterprises) are already present in China. They are invited to cooperate and work together to ensure that the action of France in China is coordinated. It will thus gain in visibility and coherence. In France, the Ministry of Higher Education and Research will regularly endeavour to gather public figures in Franco-Chinese scientific and technological cooperation (ministries, alliances, agencies) to strengthen the coordination of actions and to make each of them a mutual sharing of experience.

Those involved in French research (agencies, universities, major educational institutions) and businesses are invited to exploit all the potential of China and not to concentrate only on the clusters of Beijing and Shanghai.

Programming - financing

The Alliances, whose purpose is increasing performance, the visibility, the international influence and highlighting French research in their field, will take the recommendations - themes, but also cross-functional - of the strategic orientation plan in their respective road maps into account.

The different French financing programs, from financing of mobility to the financing of projects, will be made consistent and put into permanent service of themes Identified as being high-priority.

The National Research Agency (ANR) will strengthen joint programs that it has implemented with the funding agencies in China on the basis of reciprocity.

The French researchers are also invited to use the European programs (collaborative projects of 7FP, Marie Curie Actions, the European Research Council) existing to collaborate with their Chinese partners, the Ministry of Higher Education and Research ensuring articulation between national action the and European action within the Strategic Forum for the International Scientific and Technological Cooperation (SFIC).

France will also strengthen its cooperation with China in the framework of multilateral programs launched by the international organizations to respond to global challenges.

Partnerships

The French researchers are invited to prepare the envisaged cooperation well at all levels - scientific, technological, political, hierarchical, legal, organizational, financial, economic, etc. and approach persons or institutions having the experience of cooperation with China.

French companies established in China are invited to approach joint structures for research and French training avenues present in China, and vice versa.

Companies could also strengthen their positioning by organizing scientific events (seminars, symposia, etc.), by participating in Franco-Chinese working groups (themes, standardisation, etc.).

Mobility

The mobility of French researchers in China, particularly doctoral students and post-doctoral students, is strongly encouraged:

- French researchers are invited to seize the opportunities offered by Chinese research and Chinese funding bodies.
- This mobility must be accompanied at all levels (administrative formalities, housing, language and cultural awareness, enhancement of mobility in one's career, etc.) by their establishment of guardianship.

It is recommended that institutions of higher education and research should supervise the mobility of students and Chinese researchers that they welcome. The welcome of Chinese researchers in France (housing, transport, administrative approaches - scientific visa, social coverage, etc. -, learning French, etc.) will have to be improved.

Research organizations and institutions of higher education and research would have every interest in organizing better monitoring of Chinese researchers who have worked in their French laboratories so that they can rely on relays of confidence in their cooperation with China.

During the joint scientific and technical commission of 30th May 2011 (Paris), France and China have decided to strengthen their scientific and technological cooperation on topics which correspond with the priorities of the National Strategy for Research and Innovation:

- sustainable development, biodiversity and water management
- chemistry and green technologies
- energies
- life sciences including infectious diseases and emerging diseases
- sciences and technologies of information and intelligent cities
- advanced materials.

Bilateral seminars will be organized for each of these themes in the years to come.

Chapter 5 Italy

1. View of current situation

China is at the same level as Japan and Europe in some fields. In a few particular areas, they are at the world's top level. For example, Peking University's graphene research is at a level comparable to that of MIT in the USA, among the best in the world. However, the quality of the professors at a single university will vary.

China has undoubtedly become a science and technology leader, particularly in making huge investments in Big Science areas in which the USA no longer engages. For example, China plans to construct the world's largest "boson factory," even larger than CERN, and the world's largest synchrotron. Within 10 years, most of the world's biggest research facilities, including space and astronomical observation will probably be in China.

Chinese research and development expenditure is 2.1% of GDP, €20,000 million per year. In light of low personnel costs, that amounts to about three times as much, €50,000 million per year. Compared with the Horizon 2020 program's expenditure of €80,000 million over seven years for the entire EU, the scale of China's investment is extremely large.

There are issues, however. First, the research and development mechanism is extremely complicated, and the management system is poor. Redundant investment is common, and there is no coordination. They compete with each other rather than cooperating. The Ministry of Science and Technology (MOST) has no research and development implementation function and does not plan. Twenty years ago, Japan had the same flaw, but it has improved in recent years.

Control by the Communist Party is the weak point of Chinese universities. Control of the CAS is light, but universities are tightly controlled.

The research funding allocation process is extremely opaque and without clear explanation. Outstanding personnel who have studied abroad and know the open systems of the USA and Europe are disappointed by China and leave again shortly after returning.

Research is very top-down, and researchers are constantly asked to respond to the needs of corporations and the military. Therefore, the attitude of emphasizing new ideas and discoveries is weak.

2. Basic policy on cooperation

Italy's basic stance on cooperation with China is that small cooperation with a distant country is inefficient, so it will cooperate in fields with large projects and little technology transfer. Cooperation in fields with shared social significance is considered basic.

3. Framework for cooperation

Based on a science and technology cooperation agreement, there is an annual consultation between MOST and the Italian government.

Italian Ministry of Foreign Affairs has organized an expert group led by the Minister of Foreign Affairs, the "Strategic Table in S&T with China." It meets three or four times per year.

4. Categories emphasized in cooperation

Cooperation in Big Science fields is emphasized, with 70-80% of cooperation in high-energy physics.

Cooperation on space has also begun recently. Specifically, it is Earth observation from satellites in order to predict earthquakes. It involves observing special elementary particles that appear before earthquakes combined with various types of data about the earth's surface and using that to predict the occurrence of earthquakes. It is cooperation that combines China's strengths in technology for Earth observation via satellite and Big Data analysis with Italy's knowledge of high-energy physics.

5. Specific examples of cooperation

Interesting initiatives include the above-discussed cooperation in the space field, a facility in Tibet for observing the generation of elementary particles using cosmic rays, the "JUNO" neutrino observation project in Daya Bay and Guangzhou (CAS Institute of High Energy Physics for China and National Institute of Nuclear Physics for Italy), and the national biological experimental facility near the Shanghai Synchrotron Radiation Facility. Two Italian institutions are actively engaging in cooperation with China. They are the National Institute of Nuclear Physics and the University of Rome.

6. Issues in cooperation

There is the well-known problem of patent law requiring that in invention completed in China must be claimed there first, but that is a matter for the EU to negotiate. Instead, one must exercise caution concerning dual use issues. On the other hand, when the cooperation is for science, there are no restrictions even on space fields. Italy is even considering cooperating on China's space station plan.

Background information: Section concerning Italy in "**Report of the EU Representative in Beijing**"

This material is from the section about Italy in the April 2014 report of the Science, Technology and Environment Section of the European Union Delegation to China and Mongolia on EU cooperation with China on science and technology. It is quoted from the following website.
http://eeas.europa.eu/delegations/china/documents/eu_china/research_innovation/tour2015/italy2.pdf

The report is organized according to categories such as Cooperation Framework, Priorities, Joint research structures, and Innovation-related activities.

Report of the EU Representative in Beijing

INFORMATION ON BILATERAL AGREEMENTS

The Executive Program on Scientific and Technological Cooperation between Italy and China for the years 2013-2015 is actually in course. The Program includes 31 projects in 6 main fields: Applied Basic Science (Chemistry, Mathematics and Physics): Energy and Environment: Space and aeronautics; Information Communication Technology; Nanotechnology and Advanced Materials; Technologies Applied to Cultural Heritage.

A. The CNR (Consiglio Nazionale delle Ricerche) has various agreements with Chinese Institutions.
   1. Agreement CNR – Chinese Academy of Agricultural Sciences (CAAS)
      Annual call for joint research projects
   2. Agreement CNR – Chinese Academy of Forestry (CAF)
      Annual call for joint research projects
   3. Agreement CNR – Chinese Academy of Sciences (CAS)
      Annual call for joint research projects

B. The Istituto Nazionale di Fisica Nucleare (INFN, National Institute of Nuclear Physics) has several agreements with Chinese Institutions with joint and annual calls.
   1. Memorandum of Understanding between INFN and Institute of High Energy Physics (IHEP) of CAS and establishment of a Joint Laboratory (June 2012)
   2. General Framework Agreement between CAS and INFN, June 2011
      Exchange of researchers: senior and junior. 20 + 20 three months scholarships
   3. Agreement with the China Institute of Atomic Energy (CIAE) and INFN (December 2009)

Five scholarships per year to Chinese researchers to work at Laboratori Nazionali di Legnaro ed i Laboratori Nazionali del Sud.

C. On September 2013 an Agreement on the participation of Italy to the China Seismo-Satellite (CSES) program for the study of earthquakes from the space has been signed by the Italian Space Agency and the China National Space Administration; Italy will realize two payloads in the first CSES satellite.

D. On November 2013 an Agreement between the Italian Space Agency and the Ministry of Science and Technology of China (MOST) for the realization of a 3D moon mapping project has been signed. The project is reserved to University students of both sides.

E. January 2014. A technical agreement has been signed between Italian Institute of Nuclear Physics and CNSA for realization for the payloads for CSES satellite.

PRIORITY FIELDS OF CO-OPERATION

Applied Basic Science (Chemistry, Mathematics and Physics): Energy and Environment: Space and aeronautics; Information Communication Technology; Nanotechnology and Advanced Materials; Technologies Applied to Cultural Heritage.

JOINT INSTITUTES

Several Joint laboratories have been activated in the recent years in different fields with Chinese Universities and the Chinese Academy of Sciences. More than 350 agreements have been signed between Italian and Chinese Universities for collaboration in education and research.

SINO-ITALIAN COOPERATION PROGRAM FOR ENVIRONMENT PROTECTION

In the year 2000 the Italian Ministry for the Environment, Land and Sea (IMELS) launched the Sino-Italian Cooperation Program for Environmental Protection together with the State Environmental Protection Administration of China (SEPA). The goal was to help China to improve her environment, support her sustainable development and promote the cooperation between enterprises of the two countries. In the following years, the Italian side has expanded the cooperation to other Chinese government bodies and academic institutions, Universities, Chinese Academy of Social Sciences (CASS), the Ministry of Science and Technology (MOST), the People's Government of Beijing Municipality, the Shanghai and Tianjin Municipality, the National Development and Reform Commission (NDRC) of China, the Ministry of Water Resources (MWR) and the State Forestry Administration (SFA).

IMELS has implemented more than 200 projects in China in collaboration with the Chinese Government departments, universities, research institutes and enterprises. Through pilot projects, cooperative research and environmental protection capacity building, it covered a number of fields in the sustainable development. (1) Energy Efficiency, Clean Energy & Renewable Energy; (2) Assist China to implement international conventions about the environment; (3) Air Monitoring; (4) Urban Sustainable Development & Eco-building; (5) Waste Recycle; (6) Sustainable Transportation; (7) Integrated Management on Water Resources; (8) Eco Conservation & Sand Control; (9) Sustainable Agriculture; (10) Capacity Building for Environmental Protection.

The total value of the projects developed so far or currently on-going is of 350 million euros. IMELS has co-financed these projects with 185 million euros, either through direct contribution to the Chinese partnering entities or through the Trust Funds established in the World Bank and other Multilateral Funds. Other co-financing has been granted by the Chinese institutions and Italian companies involved in the program, the United Nations, the Global Environmental Facility, the Word Bank and the Multilateral Fund for the Montreal Protocol on the Protection of the Ozone Layer, with at least 165 million euros.

INNOVATION-RELATED ACTIVITIES

The Innovation Dialogue between Italy and China is well established within a structured framework of agreements and joint centres between the Ministry of Science and Technology of China and the Ministry of Education, Research and University of Italy. Three different centres have been activated in China:

1. Sino-Italian Innovation Centre for Technology Transfer, Beijing China.
   Managing partners: China-Beijing Municipal Science and Technology Office (MOST), Italy- University of Bergamo, Fondazione Citta' della Scienza of Napoli
2. Sino-Italian Centre for e-government, Shenzhen, China
   Managing partners: China-MOST, Italy – Politecnico di Torino
3. Sino – Italian Centre for design, Shanghai, China
   Managing partners: China – Tongji University, Italy – Politecnico di Milano

TRILATERAL OR MULTILATERAL JOINT INITIATIVES

Multilateral initiatives are under the frame of European Union. The EC2 center is part of an important multilateral project on environment which is managed by the Politecnico di Torino. Italian research groups participate also to the INCO-LAB EU program.

Chapter 6 EU (European Community)

1. View of current situation

China's science and technology prowess should be looked at on a time axis of approximately 35 years after the Cultural Revolution. When one considers that it started a zero following the Cultural Revolution, its development is truly fantastic. The fact that China's previous leader, Hu Jintao, was a graduate of an engineering department at Tsinghua University is very characteristic of China's strong belief in and promotion of science. China's science and technology level will someday surpass that of Japan and Europe, but the question is when.

On the other hand, on the negative side for China are the occurrence of environmental problems, social inequality, and low transparency. Those are things that we developed nations experienced in the past. Issues that should be solved include incorporating open-minded perspectives into the education system, making systems open through system reform, and promoting transparency in processes.

Additionally, China's research funding generates much waste, and the allocation of research and development expenditure is not transparent. It is necessary to increase the mobility of science and technology personnel, open research labs to non-Chinese, and encourage cooperation with the next generation of young researchers.

As for innovation, the environment (e.g., intellectual property, standards, access to information related to procurement and credit) China prepares for corporations from the EU is considered inadequate. The EU considers it necessary to build venues for discussion of improving that environment.

2. Basic policy on cooperation

EU sees China as an equal partner and considers strengthening cooperative relations to be important.

3. Framework for cooperation

The EU's framework for research cooperation with China is Horizon 2020 and a strategic approach to specific domains. In addition, there are programs related to human resources mobility (Marie Curie program, etc.).

Horizon 2020 is the successor to FP7 (the Seventh Framework Program). Through the end of FP7, the BRICS nations, including China, were considered developing nations, but Horizon 2020 sees the BRICS nations as industrialized, so cooperation with the EU is now premised on joint expenditure. This is because of rules permitting some contributions of research funds to developing nations, but prohibiting contributions to industrialized countries. Not limited to cooperation with China, cooperation under Horizon 2020 is to be carried out based on the four principles of transparency, joint financing, strategic approach, and give-and-take.

Aside from that, there is cooperation through a strategic approach. First, the EU worked out domains from which it would benefit from cooperation with china in terms of markets, technology, and social issues. It identified four areas: sustainable urbanization, food, agriculture and bio science, ICT, and aviation. Next for each domain, it brought in Chinese experts to discuss means of cooperation and so forth. China has international open cooperation schemes funded by the NSFC, MOST, and so on, and it was decided to utilize them.

4. Categories emphasized in cooperation

The above-discussed four areas of sustainable urbanization, food, agriculture and bio science, ICT, and aviation are considered priority fields.

5. Specific examples of cooperation

One interesting example to introduce is the IMMUNOCAN project in Shanghai. It is a joint institute of Fudan University and the French company bioMérieux that works on cancer markers. Through funding from the EU, it promotes participation by researchers from the EU. Researchers from Germany, Denmark, and Italy thus worked at a joint institute in Shanghai, expanding cooperative relations. In addition to China's IMMUNOCAN, this type of cooperation establishing a joint institute also exists in Brazil and Russia.

6. Issues in cooperation

In order to reach mutual understanding, it is extremely important to take time for discussion. Regarding the issues with intellectual property rights (IPR) that are commonly discussed, understanding has recently been gradually increasing and they have ceased to be an obstacle. Furthermore, China's one-party political system does not prevent the EU from cooperating with china on science and technology.

7. Background information: "**ROADMAP FOR COOPERATION BETWEEN CHINA AND THE EUROPEAN UNION**"

This material is the section on China from a report from the European Commission to the European Parliament and the European Council published in September 2014. It is quoted and tentatively translated from the following website.

http://media.education.gouv.fr/file/Cooperation_Internationale/10/8/SWD_Roadmaps_(st13219-ad01.en14)_350108.pdf

The same document summarizes strategy towards nine countries (Japan, USA, Canada, China, South Korea, India, Brazil, Russia, and South Africa) and two regions (one comprising six Eastern European nations including Ukraine and the other 10 countries around the Southern Mediterranean, including Israel and Tunisia).

ROADMAP FOR COOPERATION BETWEEN CHINA AND THE EUROPEAN UNION

1. CHINA AS A PARTNER OF THE EU

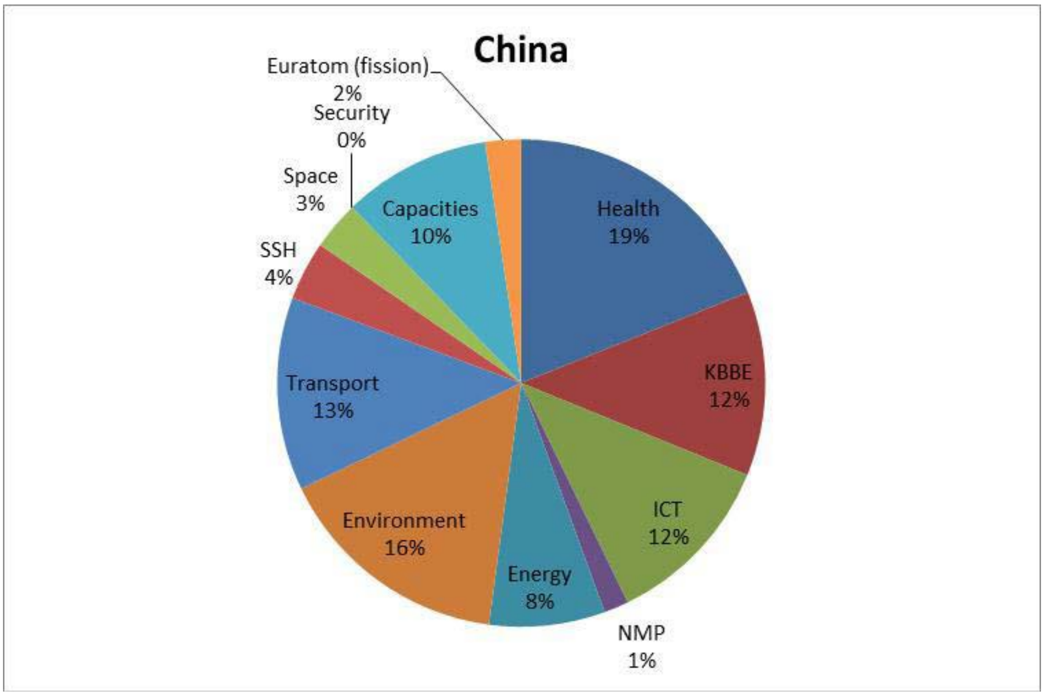
Relations between the EU and China have developed fast since diplomatic ties were established in 1975. In particular, the creation of the EU-China Comprehensive Strategic Partnership in 2003 has deepened and broadened cooperation in a wide range of areas, and the EU and China have become highly interdependent as a result. At the 16th EU-China Summit of 21 November 2013, both sides jointly adopted the EU-China 2020 Strategic Agenda for Cooperation and inaugurated the first High Level Innovation Cooperation Dialogue. The two sides will implement the Strategic Agenda for Cooperation through their annual Summit, which provides strategic guidance to their relationship, through the three pillars directly underpinning the Summit (the annual High Level Strategic Dialogue, the annual High Level Economic and Trade Dialogue, and the bi-annual People-to-People Dialogue) and through their regular meetings of counterparts and their broad range of sectorial dialogues.

EU-China scientific cooperation is governed by a Science & Technology Cooperation Agreement signed in December 1999 and renewed for the second time in November 2009. The Agreement is implemented through a Joint Steering Committee. The last meeting was held in Brussels in June 2014. In addition, an Agreement between the European Atomic Energy Community (Euratom) and the Government of the People's Republic of China for R&D Cooperation in the Peaceful Uses of Nuclear Energy (R&D PUNE) is in place since August 2008. China and Euratom are participating in an inter-governmental multilateral agreement on fission-related research, are partners of the ITER multilateral cooperation project on fusion research and participate, within the Generation IV international Forum, in the research and development activities of the Sodium Fast Reactor and the Very-High Temperature Reactor.

The performance of the Chinese research and innovation system has improved noticeably over the past decades. China is now a major player in terms of funding and human resources for research and development (R&D). China ranks first in terms of R&D staff with 2.5 million researchers. Its GERD has more than doubled in just five years (2005-10). R&D expenditure as a percentage of GDP reached 1.98 % in 2012 with a target of 2.2% of GDP by 2015 (12^{th} Five-Year Plan) and 2.5% by 2020 (15-year Medium to Long-Term Science and Technology Development Plan). The business sector accounts for 72% of GERD (1.30% of GDP). However, performance in terms of patenting remains relatively limited (fifth place in 2012 regarding applications under the Patent Cooperation Treaty), and also in terms of knowledge intensive services and high-technology manufacturing industries.

2. COOPERATION BETWEEN CHINA AND THE EU ON RESEARCH AND INNOVATION: STATE OF PLAY

As of February 2014, Chinese entities participated 334 times in FP7 signed grant agreements, receiving a total EU contribution of EUR 32.9 million. The distribution of the Chinese participation (by total cost of Chinese participants) over the different FP7 sub-programs is shown below.



KBBE:Knowledge-Based Bio-Economy

NMP:Nanosciences, Nanotechnologies, Materials and New Production Technologies

SSH:Socio-economic Sciences and the Humanities

Research cooperation with China is also taking place in the framework of the Euratom-fission program with two projects worth EUR 1.2 million, and within ITER on fusion research with 49 on-going collaborative activities involving 11 European entities and 13 Chinese research institutions. 3,845 Chinese researchers have been funded through the Marie Curie Actions (2007-2013) and Chinese institutions have participated in 315 projects. There is an on-going FP7 project, the Bilat Dragon Star to support the policy dialogue with China.

China has been targeted as an important partner for cooperation in the first Horizon 2020 work program (2014-15), with topics encouraging cooperation with Chinese researchers in areas such as Food, Agriculture and Biotechnology, Water, Energy, Information and Communications Technologies, Nanotechnology, Space and Polar research. Furthermore, in the Euratom Work Program (2014-2015) fusion and fission topics include cooperation with China. The European Commission's Joint Research Centre is pursuing cooperation with China on the topics of air quality, disaster management, remote sensing and land management in line with the overall S&T priorities identified at the latest EU-China Summit and Innovation Cooperation Dialogue. Work is also on-going to strengthen the synergies between the EU's cooperation with China and the activities of the Member States (MS). Within the Strategic Forum for International Cooperation (SFIC), the Commission and the Member States have been working on the identification of common challenges and priorities to be pursued with and vis-à-vis China.

The network of EU Member States Science Counsellors in China has produced a series of documents regarding IPR issues, setting up of joint research structures and an overview of EU MS activities. Research and Innovation features high on the agenda of the EU-China Summits. A strong cooperation with China on research and innovation is one of the milestones of overall EU China relations and contributes to reaching the objectives of the EU's external policies. With the High Level Dialogue on Innovation Cooperation the two sides are committed to enhance their mutual understanding of their respective innovation policies and systems, to promote predictable, transparent and effective framework conditions related to innovation and to develop joint and coordinated actions for the development and deployment of innovative solutions. Framework conditions for cooperation in research and innovation with China have been improving over the last few years, e.g. in adopting international standards and in IP protection and enforcement where China has come a long way in the last decade. However, there is still substantial room for improvement in infrastructures, the legal environment and practices related to IPR, standards, procurement and other framework conditions.

3. COOPERATION BETWEEN CHINA AND THE EU ON RESEARCH AND INNOVATION: PRIORITIES FOR THE FUTURE

In the framework of the policy dialogue with China the following areas have been identified
as priorities for EU-China cooperation:

– Food, Agriculture and Biotechnology

Cooperation in these areas addresses important common challenges such as food security, food safety and healthy diets, animal health, sustainable agriculture and the development of a low-carbon economy. Given the economic weight of China, even small moves to more sustainability in primary production and processing can lead to substantial global benefits for the environment and climate. The opportunity to export sustainable solutions and scale-up the potential of the Chinese market will enhance European innovation and competiveness. China is also the world's largest aquaculture producer and marine related challenges are important for both Europe and China, making these further areas with potential for future cooperation.
Cooperation in this area has been moving towards a strategic partnership, with the signature of a Letter of Intent between the European Commission and the Chinese Academy of Agricultural Sciences (CAAS). This new initiative will ensure concrete substantial and balanced joint research and innovation cooperation activities on selected priorities of common interest to be supported.

– Sustainable Urbanisation

Urbanisation of societies is an issue of crucial importance both for Europe and China, and it features high on the political agenda of both sides. Research and innovation are recognized components of the EU-China Sustainable Urbanisation Partnership as they play a key role in addressing the challenges urbanisation creates. Cooperation opportunities will be pursued in areas such as sustainable urban and peri-urban planning, green transport, clean technology, air quality, sustainable urban energy and disaster management. Effective links with the Joint Programming Initiative Urban Europe will be sought.

– Aviation

China is a large and growing market for the aeronautics industry and has developed state-of-the-art aeronautics technologies. Cooperation through collaborative research projects under FP7 allowed issues of common interest linked to global environment and safety issues to be tackled. Building on existing policy dialogue and past cooperation, intense preparatory work has been done in developing future joint initiatives on aviation. In consultation with EU and Chinese industry, stakeholders' priorities of common interest are being identified in areas such as environmental aspects of aviation, flow control, advanced materials, numerical simulation and validation methods, and efficient air transport. Cooperation in these areas will be sought through joint and coordinated EU China calls for collaborative research and innovation projects.

– Environment

The global dimension of Environment and Climate make them a priority for cooperation with China. The areas of water challenges, water for sustainable development and links between environment and urbanisation are considered as particularly important. China has considerable research capacity in this domain, and mutually beneficial cooperation opportunities can be found, particularly in the larger context of urbanisation issues. The
importance of EU-China cooperation in the area of water is further underscored by the launch of the China-Europe Water Platform (CEWP) in March 2012 – a Member States' initiative to be implemented within the framework of the EU Water Initiative (EUWI) and China's framework of cooperation with Europe in the water sector.

– ICT

Rapidly increasing wireless-traffic and applications pose challenges for both Europe and China. International collaborative research in the next 5 to 10 years will be key to developing the next generation of telecommunications. Cooperation involving industry and research institutes on information and communication technology will be enhanced through existing and further mechanisms. Key topics such as the next generation of network and communications infrastructure (5G), smart cities and internet of things will be explored.

– Energy

Cooperation on coal-related technologies such as clean coal and carbon capture and storage (CCS) will continue being supported under Horizon 2020. In addition, EU-China cooperation opportunities are also being explored on renewable energy including in the fields of concentrated solar power and energy storage (batteries).

– Nuclear energy

Euratom and China are increasing exchanges and cooperation on nuclear safety emergency response, nuclear fuel cycle, nuclear waste management and nuclear security. Also the strengthening of international non-proliferation regimes and related export control arrangements, as well as fighting against smuggling of nuclear material are matters for further potential cooperation. Education and training programs oriented to
post-doc and PhDs and safety of super critical water reactors (SCWR) are being pursued further.

Euratom is also strengthening cooperation in the multilateral framework of the ITER project and building up a strategic bilateral partnership on fusion energy research. Furthermore, Euratom foresees bilateral cooperation at the Joint European Torus facility (JET) in support to ITER, where Chinese researchers are contributing in the field of diagnostics. Cooperation on fusion research with China, in particular on JET and on the China Fusion Engineering Testing Reactor (CFETR), will be pursued through regular policy dialogue under the RD-PUNE agreement.

– Health

In addition to the above, health research is an area where the EU and China have a lot togain from closer cooperation. There is a strong tradition of cooperation on health both in the context of the EU Research Framework Programs and in multilateral initiatives aimed at addressing global health challenges. These are in particular the International Cancer Genome Consortium (ICGC22), the International Rare Diseases Research

Consortium (IRDiRC23) and the Global Alliance for Chronic Diseases (GACD24). China has expressed interest in joining the Global Research Collaboration for Infectious Disease Preparedness (GloPID-R), on which the EU is currently working. There is scope for reinforcing cooperation with China on global health through Horizon 2020 and in international multi-partner research initiative such as, for example, the International Human Epigenome Consortium (IHEC25) or the Initiative for Traumatic Brain Injury Research (InTBIR).

-Materials

Coordinated call (which was decided with the National Science Foundation of China) resulted in three jointly financed projects in biomaterials, started in 2013. The outcome of the projects will be used to assess further cooperation opportunities.

-Industrial innovation

Substantial progress has been made in developing a framework for cooperation to promote closer collaboration in mutual economic and strategic interest between EU and Chinese industrial clusters of businesses, researchers and innovators. EU-China research and innovation cooperation is also to be strengthened by supporting the EU-China mobility of researchers and strengthening people-to-people contacts, from both the public and private sectors, in strategic research and innovation areas. This will be pursued through the Marie Skłodowska-Curie actions under Horizon 2020, the Erasmus + program and the new initiative "EU-China Research and Innovation partnership" supporting mobility of EU researchers and innovators to China. To cope with the growth of on-line collaboration between European and Chinese researchers the e-infrastructure link capacity between the two regions should be strengthened in the future, possibly through a long term arrangement.

Chapter 7 Australia

1. View of current situation

Australia has been cooperating with China since the 1980s, but the growth of China's science and technology during the past 5 or 10 years has been remarkable. On the input side, research and development investment has grown by 22–25% per year, while the numbers of papers and patent applications have soared on the output side. Additionally, many Chinese students have enrolled in Australian universities. There are now about 100,000 Chinese undergraduates enrolled. The number of Chinese with doctorates in Australia has also increased recently.

Some in Australia point to concerns such as a lack of creativity, vague funding mechanisms, and a research system that pressures researchers to publish often. Even so, not cooperating with rapidly developing China is not an option.

2. Basic policy on cooperation

A benefit of cooperation with China is supplementation of Australia's small population of only 23 or 24 million. For example, Australia can tie into Shanghai's hospital network with its many cases for clinical research, and the size of China's markets is also very attractive. Additionally, in the marine research field, China has eight times Australia's prowess in marine research and exploration. It could quickly survey the broad area of Western Australia.

In terms of quality of research personnel as well, the number of outstanding Chinese researchers is increasing. Looking at a span of 10 or 20 years, quality will likely catch up with the numerical superiority.

3. Framework for cooperation

As for forms of cooperation, the overwhelming majority is bottom-up cooperation that occurs naturally without government involvement, but there is also funding for small-scale joint research carried out by government in a top-down manner. The first three-year cooperation period is just ending, with a total budget of 9 million Australian dollars. Funding in the amount of 10 million Australian dollars over four years is about to begin. A wide range of fields are covered, including biotechnology, energy, and agriculture.

In bilateral cooperation, Australia prioritizes China and India. Under a policy set by the new Cabinet that took office last September, the budget for international cooperation is to shrink. The budgets of Australia's funding intuitions such as the Australian Research Council (ARC) and the National Health and Medical Research Council (NHMRC) are about 1,000 million Australian dollars, while the budget that can be allocated to international cooperation is about 10 million

Australian dollars. Consequently, cooperation must concentrate on China and India rather than on developed countries.

4. Categories emphasized in cooperation

Priority fields for cooperation are shared concerns of the two countries, such as are water management, agricultural productivity in dry environments, reduction of coal use (energy conversion), steel and power production, and subtropical diseases.

5. Specific examples of cooperation

Australia's Commonwealth Scientific and Industrial Research Organization (CSIRO) cooperates closely with CAS.

Additionally, an undergraduate exchange program between Monash University (a Victoria State university headquartered in the Melbourne suburb of Clayton) and Southeast University (a university located in Nanjing, Jiangsu) is worthy of notice. It is a new cooperation program that just began in October 2013.

6. Issues in cooperation

Even if there are cultural differences with China, the large number of people of Chinese descent living in Australia should be able to fill in the blanks. In fact, 7% of employees at CSIRO speak Chinese. There are strong human ties with China, and that naturally builds bridges.

No problems concerning intellectual property rights are seen. They are considered to be properly protected.

Background information: "**Partners in influence: How Australia and China relate through science**"

This material is from materials accompanying a speech by the Australian government's Chief Scientist, Professor Ian Chubb, at Australian National University, Canberra, in August 2013. It is quoted from the following website.

http://www.chiefscientist.gov.au/wp-content/uploads/Australia-China-speech.pdf

Partners in influence: How Australia and China relate through science

Thank you for the invitation to deliver the 2013 Australian Centre on China in the World (CIW) lecture. My topic tonight is Partners in influence: How Australia and China relate through science. I hope to do the topic justice – and I don't want to make it appear simple. It is not. It involves human beings with all their foibles working across cultures, languages and over distances. But it will be worth it in the end; good science will have, must have, a serious influence on our future; and it is likely to have more when it involves science based largely on international collaboration. As I go along, I do hope to persuade you that the relationship will benefit from some strategic forethought both to build on and to get the best out of what is a truly strong foundation.

But first, let me say that it is a pleasure to be here – and even more of a pleasure to see how the Centre has developed. I well remember the days of negotiating the arrangements with Officials and the Prime Minister's Office. It was probably not the most difficult negotiation of my life - since both the Prime Minister and I wanted it to happen – but not everybody sang from the same sheet. It was an important issue for us – by that I mean Australia, not just the ANU. I also remember Prime Minister Rudd's concept – it was to be a place that studied China and its place in the world. It wasn't about China per se – but about China in context. This gave the Centre a focus and highlighted the depth – to understand China and its role in the world, you had to understand China – and understand it well. So we were expected to build capacity to learn as much about China as we could - and to contextualise it to contemporary times. Accordingly it was expected to be a Centre that drew together experts from other places in Australia and internationally, not just ANU. I am pleased to see that is happening, too. It seems that some of my former senior academic colleagues may have put the dummy back where it belongs having spat it out – driven as we say by the well-known syndrome called self-interest. Before I get lost in reminiscences, let me get on with the main game and turn to the China-Australia relationship.

In the past few decades, China and Australia have become increasingly important to each other – the bonds have got tighter. Not a surprise, really. There is now a substantial Chinese presence in Australia. Mandarin, for example, is now the second most widely spoken language in Australia after English, and the people who speak it are not all products of the Australian education system. In the four decades since formal diplomatic relations began, China has not only become Australia's largest trading partner, but also our most significant single education partner, and a growing research partner. The last point in particular represents a scientific engagement that began even before diplomatic relations were established (I'll talk a little about this point later). Australia and China now share a strong and highly productive relationship in science that has been built over more than 50 years.

I didn't visit China before diplomatic relations were established. I first went there in 1987. It was clear even then the importance that China put on science and research – on international connections widely, and with Australia, too – as its pathway to a better future. The universities in China in those days were not in good shape – but the determination to improve was palpable. I remember going into a dingy, dusty and dirty building in 1987 with a long dimly-lit corridor packed floor to ceiling with boxes of PCs. They said that they had been commissioned to develop word-processing in Chinese. As it happened I was back a few months later. That task was well in hand. The building was in better shape but still old and shabby. We were shown a room with a small(ish) but powerful main-frame computer behind glass walls – it was a gift from a Japanese company. They were going to use it to network the campus. A year or so after that they had a bigger computer (a bigger gift). They had a bigger plan - to network the province. They'd done more than that not long afterwards. I visited a few years ago I went back to the same place. I was with an Australian colleague and we were shown a number of machines making, as I recall, computer components. They were in separate and very clean rooms in a modern building with hatted, masked and overalled staff and students working them. I asked about equipment like that in Australia – and was told that we had one in the country – they had half a dozen or so in one corridor in one university. Now, after more than 25 visits, I have seen a change that is staggering: people, resources, facilities and infrastructure that is at least first class and in fact infrastructure that is probably setting the world standard; only the determination to improve is still as palpable as it was all those years ago.

Such change, and such determination, is admirable – but can be disconcerting. In the US, for example, much has been made of the proportion of the Chinese graduating class in a year that comprises scientists, technologists, engineers and mathematicians. As a percentage, it is around three-times that of the US (and roughly the same multiple of ours). This disparity was doubtless one of the reasons to cause President Obama to say in 2011: the countries which out-educate us today will out-compete us tomorrow. He had already said in 2010: ...leadership tomorrow depends on how we educate our students today. The US response has been to plan for 1,000,000 more science graduates within the decade (a 33per cent increase) and an increase in funding to develop more (and better) science teachers in schools; all within a 5-year strategic plan for science education. Of course, the US is concerned about retaining a pre-eminent position. We can't sensibly do that in all fields: but we can do that in those that we choose to prosecute – and I'll come back to this need for alignment, focus and scale a little later.

Our relationship with China is important – to us, and I think I can presume to the Chinese, given the recent growth. Let me be clear: they have more people than us (hardly breaking news) more universities than us (not news either) and they are developing capacity at a pace that will take them way beyond us soon (seeing is believing) and maybe even beyond the current big players; but while we can't do everything because we are relatively small, we have some comparative advantages and strengths that are compatible with their needs and aspirations. And we have been there in partnership with them for a long time – so we know how to work with them.

For us, persistent linkages with a potential scientific super-power are important. To be in a longstanding, trusting and culturally aware partnership is a key. Under those circumstances we can together mould and share the basis for our relationship, and that is a better and more secure place for us both than a fly-by opportunistic purely mercantile arrangement. Our scientific relationship with China is not like that. It has prospered because each of us brings, and has brought, scientific capacity of quality, and a need, to the relationship, based on quite different intellectual traditions that come together in exciting ways to create new knowledge. We have been doing it for a long time now, and it is growing not stagnating. Science and scientists have helped us relate, country to country, in an enduring way.

The relationship has also been scientifically productive. It has given rise to many exciting discoveries, innovative new products and strategic new relationships. These include the development of the first electricity generating plants to capture carbon dioxide for storage so contributing to world-leading research on reducing carbon pollution from coal-fired power stations; clinical trials of potential treatments for diabetes and pre-diabetes conditions; the discovery of biological control agents that have the potential to improve China's national wheat harvest by up to 10 per cent. And it is not just academic researcher to academic researcher. It includes academics working with industry. The Baosteel-Australia Joint Research and Development Centre is a world-first joint venture between the Chinese steel company and four Australian universities – the University of Queensland, the University of NSW, Monash University and the University of Wollongong. The collaboration is designed to ensure a more holistic approach to research in order to drive innovation and develop new products.

When we think about another plank in our relationship, education, the connection is also strong. In 2012, Chinese students accounted for around 30 per cent of all international student enrolments in Australia and 40 per cent of all international enrolments in higher education. Australia places great value on the contribution our Chinese students make to our institutions and to our communities, a value well beyond simple economics. The presence of so many smart young Chinese in Australia helps us to learn about China, and them to learn about Australia. An Australian of my age, who was in our education system when I was, saw the students here under the Colombo Plan close up and personal. We saw the importance of the 'learning' that comes from sharing a class-room, a tutorial group or a bench in the practical class with students from other cultures. And we made some enduring friendships along the way. It didn't hurt either for us to branch out from the staples of lamb chops and mashed potato, or Chiko Rolls, to food with real and variable taste - and spice. All are long-term legacies I continue to enjoy.

Today's generation of young people will see a different world from the world I saw at their age. But it won't be the insular even insulated world of my parent's generation that changed slowly with mine and which is now changing at a breathtaking pace. If the world is to be a better one, then barriers to comprehensive social, economic and cultural understanding need to be minimised. As far as I am concerned, that will come about, in part at least, if young people are educated together so that they learn about each other while they study physics, or chemistry or even economics.

It is fair to say, I think, that we have seen what can be achieved through international relationships. And China and Australia are now solid partners aspiring for a better future: both are deeply committed to the generation of knowledge and its use, and education, that will combine to deliver improved economic, social and environmental outcomes for all. From early individual contacts in the 1960s, and I will talk about some of these later, China and Australia have become prolific partners in scientific publications, with a wide range of institutions involved and the full spectrum of the sciences.

It is clear that science is a universal 'language' and it isn't even political, although we have seen how it can be politicised. But it is the issues that draw us together; it is the issues that encourage Australia and China to collaborate. The shared 'language' makes it possible.

But why does that collaboration matter? Why does international science collaboration matter? I think it is important to note that scientific collaboration is part of a much broader international effort. It is also important to note that many of the problems that confront us in Australia are global in character: issues related to climate are not uniquely Australian problems; nor are pandemics; antibiotic resistant microbes; influenza; food; security both for citizens and nations, to name just a few. No one country can find the way to solve, or manage, or mitigate any of these huge problems on their own. We cannot, for example, face down bird-flu without working seriously with neighbours to our north. We can't do on our own all there is to do about antibiotic resistance given our propensity to travel and to be travelled to. How could we, to paraphrase Jane Lubchenco from NOAA: manage the unavoidable and avoid the unmanageable without a concerted and coordinated international effort?

It is I think a self-evident that science (indeed STEM) will be at the core of many of the solutions to the big problems facing humanity. It will be science that finds the new antibiotic, or a new way to treat microbial infections. It will be science that is at the heart of approaches to feed the people of the planet; and science will help us understand the climate, and the environment. It will be science that has a big part to play in finding the ways of managing the unavoidable and avoiding the unmanageable. I don't argue that science (or STEM) will be there on its own; but it will be a constant. And I can't possibly argue that it will be Australia on its own; but I will and do argue that Australia as part of a globally connected STEM will help define the pathways we need to take; and we will be there because we earned a place. Because we are there, we will make our contribution to worldwide prosperity and global security. Science (STEM) plays an important role in building partnerships between countries that can be sustained. As I said, it is not political, it is universal and the problems are large and many are global – or at least cross international borders.

It seems to me that it would be a pity if we do not use to the maximum extent possible the linkages around the world that have been built by scientists: sharing a curiosity, sharing knowledge, sharing infrastructure along with a focus on matters where the benefits will be shared. Using the linkages to influence outcomes.

To understand the links better, and to work out how to use them better, the Prime Minister's Science, Engineering and Innovation Council has sought (and funded) a project from the Australian Council of Learned Academies (ACOLA) called Asia Literacy-beyond language. It will include consideration of science in diplomacy - or science of as a part of diplomacy. The report will be released next year.

The point really is simple: Australian science has been internationally networked from the time we got truly serious about it –from 1946 onwards. And it was networked because it had to be. We did not produce our first PhD graduate until 1948, so when ANU was established a fair bit of its early budget was spent either recruiting from overseas or sending people overseas to get the qualification to bring research expertise into the country. Many of those links were sustained over the years – primarily though not exclusively with the UK and the US. While the output from these links has grown in recent times, there has also been substantial growth with researchers in many countries in our region.

I think Australia learnt a lesson back then – one that I hope is not forgotten. Until we did research on a reasonable scale in Australia, until our universities were expected to engage in the search for knowledge, until we became a contributor to the world's bank of knowledge, we were outside the tent relying on others to tell us what we needed to know. Whether or not they did that is one thing; but as part of post-war reconstruction, it was a clear resolve of the leadership at the time that we should not find ourselves in that situation again. Contribute, therefore get to sit at the table where important knowledge is exchanged and important decisions are made. Offer knowledge to draw benefit from the work of others might have been a suitable mantra for the time. It still is.

We have seen change. Some 35 per cent of articles published in international journals in 2008 are now internationally co-authored. Twelve years ago, that figure was 25 per cent3. The proportion of internationally co-authored publications from Australian science has risen from 25per cent in 1996 to 45per cent in 2009. International collaboration has grown faster than domestic-only research in countries like Australia, the UK and Switzerland.

For China, the proportion has remained at around 25per cent, although this a constant proportion of a much larger volume - from fewer than 3,500 papers to over 30,000 during the period 1996-2009. Australian papers co-authored with Chinese colleagues has risen from 4 per cent to 14 per cent during that time.

The message is clear: STEM activities in any country with aspirations for the future will be internationalised at their core; and global presence is essential, not an optional add-on.

The relationship with China began on an individual, sporadic basis. For example, Professor Wilbur "Chris" Christiansen, a radio astronomer at the University of Sydney, visited China in 1963 as a guest of the Chinese Academy of Sciences (CAS). After the success of that visit, a number of delegations were organised: the Australian Academy of Science sent a delegation to China, a reciprocal delegation was received in Australia, and a group of Australian scientists attended the 1964 Peking Symposium. This period also saw the beginning of temporary researcher exchanges. Two Chinese astronomers visited Australia for six months, and Professor Christiansen spent a sabbatical year in China in 1966, assisting with the construction of a radio telescope based on his previous work. Like many worthwhile relationships, what began as ad hoc meetings and arrangements have moved towards a more formal, mutually beneficial union. The relationship continues today. For example Chinese and Australian engineers and scientists are collaborating on the technology for both Australia's part of the SKA radio telescope in Western Australia and China's new FAST telescope to be built in southwest China. What's happening in radio astronomy is also happening in other fields. And the pace of change is unnerving for some – and an opportunity for us.

China is moving up the global ladder in terms of the number of research publications. It has overtaken the United Kingdom as the second-ranked country in scientific publication output and on current trends will probably overtake the United States by the end of the decade - if those trends continue.

China is also collaborating more with other nations, and even more so with Australia. Between 1995 and 2010, Australia-China collaboration grew faster than China's overall collaboration with the world, and faster than China's collaboration with the USA. There are now 885 formal university-to-university partnership agreements in place to support exchange and cooperation between Australia and China – 72 per cent more agreements than a decade ago – a situation that for the first time outnumbers US-Australian agreements. Some 2000 or so Australian students travelled to China to study in 2011 – and 3 universities (VU, UTS and Monash) have established joint campuses in China. In several fields of research—such as mathematics, engineering and chemistry—China is now Australia's leading partner in collaboration. And it is the second-top source in agricultural and veterinary science and immunology. But there's more!　Joint publications with China in more than half the subject areas examined have an average citation impact higher than that for all Australian publications in the subject area.

The China / Australia science relationship has been based on mutual benefit – surely the right way to go. How do we identify areas where we want to work together, put the processes in place, share know-how, and both get benefit?　As it happens, Australia and China appear to have complementary research foci. And we do share some research priorities. We both have concerns related to: (but by no means confined to) issues like adapting to changing climatic conditions, meeting the healthcare needs of ageing populations, the environment, energy and food security and future economic directions to build and sustain prosperity. Elaborating on what I said earlier.

We need two approaches to our international collaboration: one approach is to align with shared challenges so that we can ensure focus and scale; the second is to ensure that individual researchers can participate in projects with colleagues that might arise because of shared curiosity and the like. An example of the first approach is the Joint Research Centres program (or JRC as I will call them). These are virtual centres that link Australian and Chinese research institutions conducting a portfolio of research-related activities in a specified field of research.

The JRC for Energy will develop advanced energy technologies for improved energy security and reduced CO_2 emissions from both countries. The JRC for Light Metals will develop revolutionary light-weight alloys and advanced manufacturing processes that will ultimately lead to greener, cheaper transport systems.

The JRC for Wheat Improvement aims to achieve major technical advancements in grain quality for wheat improvement. The JRC for Minerals, Metallurgy and Materials (the 3-M Centre) aims to facilitate Australia-China collaboration for excellence in minerals, metallurgy and materials. The JRC for River Basin Management aims to increase water productivity, food security and economic returns while protecting water ecosystems. The ANSTO-SINAP Joint Materials Research Centre Development will develop materials that will lead to zero-carbon emission technology for power generation and hydrogen fuel production. These Joint Research Centres were announced during the visit to Australia last year by then State Councillor and now Vice-Premier Madam Liu Yandong.

Examples of the second approach, really a hybrid of the two approaches I mentioned, are the visits planned and supported by the Australia-China Science and Research Fund. By next year it will have supported over 80 Australian research groups to travel to China; two groups of mid-career researchers to China (and two groups to Australia); one knowledge exchange symposium; and two Australia-China Science Academies Symposia (one in Australia, one in China). All of this is good. All of this is worthwhile. But all of this will not be enough for either country. What we need to do – both nations - is ensure we have sufficient alignment, focus and scale in order to increase the level and impact of China-Australia collaboration. To get more influence from the partnership.

China has already acted in order to prepare for a future more dependent on Science and Technology (S&T). This important partner of Australia is continuing to develop its capacity in S&T to provide a strong knowledge base to secure a prosperous future for its citizens. China took action in 2006, by adopting a new Science and Technology development goal to 2020 covering agriculture, industry, high-tech and the generation of new ideas. It adjusted its Science and Technology (S&T) strategies to align them better with the overall national strategy and the goals for economic and social development. Those strategies sum up the contribution of science and technology thus:

*the advancement of S&T is the radical motive of social and economic development;

*scientific innovation will accelerate the transformation of economic development, which is the first priority of the national strategy;

*S&T are not only about knowledge and skills, but are also closely related to the national culture and spirit. The scientific spirit and qualities of a nation determine the future and vitality of the nation.

What these statements indicate to me is that there is an understanding in China about what the consequences are of not taking strategic action now. The development of China and the role of science, technology and innovation is not being left to chance. It says to me that one of our most strategically important collaborative partners is taking urgent and planned steps to improve their skill and knowledge base in any or all of STEM.

Australia could also choose to be strategic. Like China we could plan to equip our education system to prepare the increasingly STEM-dependent workforce of tomorrow. We could plan to ensure a steady flow of new ideas. We could plan to align research and innovation with areas of comparative advantage and national need. We could plan to strengthen international alliances.

I recently laid out the case for such a strategy in a position paper which is available on the Chief Scientist website. It proposes many key actions, one of which is the establishment of an Asian-Area Research Zone. This makes sense. As I have said, many of the challenges that confront Australia are shared with neighbours like China. It is obvious that the solutions to those challenges must also be shared. Sometimes on a bilateral basis and sometimes multi-laterally. Of course an Asian-Area Research Zone is one of many key actions contained in the position paper. It is important that none of them are read in isolation.

That's the point of having a strategy to guide Australia's STEM enterprise -education, research, innovation, and influence – and it must be done in its entirety. Australia can build capacity if we commit to a strategy. This becomes even more important when we hear that the resources boom is coming off the boil. Our relationship with China will enter a new and different phase. We will need to start now to work out how to build from the base that has been constructed by all these people over all these years

And if we have a strategy, as China does, we can be partners in influence: changing the way we do what we do and how we think about the important issues that we need to be concerned about. We can find a way to manage the unavoidable and avoid the unmanageable. We can help find the solutions we need. And together we can influence how the world thinks on important scientific matters.

It seems to me that it would be a pity if we do not use to the maximum extent possible the linkages around the world that have been formed by scientists: sharing a curiosity, sharing knowledge, sharing infrastructure along with a focus on matters where the benefits will be shared. And that with China is surely what we want – a real and effective partnership between friends and colleagues – a partnership of influence.

Thank you.