It seems that the scientific research is quite distant from public's daily life——researchers wearing white coat adding some liquid to test tubes which produces some unpleasant smell and tumbling bubbles or sitting in front of the screen typing some code to put out a long roll of numbers difficult to understand. For a long run, it's the image of research and researcher in public's mind, and the public call them "nerd".

We FUDAN-China wants to depict a full image of research and researchers in China to the whole world. We are not nerds. We are a group of people devoted to build a bright future, and we are also lively human kind with our mood rather than robots without feelings(even some robots have motion nowadays). Besides that, we also have discussed some other issues in this article to exhibit a much more realistic and comprehensive truth to international readers.

The research of China and her researchers:

the story of Y.S.

"Just be casual", said Y.S. walking to us with smile on her face.

We meet with Y.S. in a restaurant next to our school, which is famous for its authentic western flavor. The idyllic western decoration and the spice-rich food make us seem to have forgotten the bustling and busy Shanghai outside the restaurant, to have forgotten the lab filled with the sound of the refrigerator.

Y.S., sitting across from us, wears a long pink dress with black long hair down around her shoulders. She always seems to be smiling. Looking at her, we can't help thinking of a famous figure Wang Xifeng in the classic Chinese classic *Dream of Red Mansions*. Wang Xifeng is a hot and mighty woman. Under her management, the complicated affairs of a big family are well-organized. Or she is just like the Chinese version Scarlett in the *Gone with the Wind*.

As a Ph.D. student majors in medicine at Fudan University, she is a normal researcher among all Chinese researchers. And from our perspective, she is also a microcosm of all Chinese researchers.

Uneven road to education

"For the idea that I hold so dear to my heart,I'd not regret a thousand times to die."

—— Qu Yuan, *Li Sao*, about 3000BC

Y.S. is from Hubei Province. One of China's mother rivers, the Yangtze River, passes through Hubei Province and gives birth to the long history of Hubei Province. More than 3,000 years ago, the Chu people who were known for their romance created a splendid Chu culture on this wonderful land. Qu Yuan, the first poet in Chinese history, also shared the same blood with Chu people. His patriotic sentiments and his persistence of his dreams touched Chinese people for generations. His masterpiece is still one of the compulsory content to Chinese students.

Today, Hubei is still an important node for inland navigation. Since the completion of the Three Gorges Dam, its status has become more prominent. Despite this, given China's huge differences between the east-coast cities and the inner cities, the educational resources of Hubei Province are still quite poor relatively. Wuhan University, ranked 257 in the QS World University Rankings® this year, is the only famous universities in the province.

Hubei witnessed the first 20 years of Y.S.. In China, if you ask kids under 10 what they want to be when they grow up, their answers probably would be “scientists”, although they don’t know what scientists do actually, and they don’t become a scientist when they get older. However, Y.S. hold on to it. In high school, she knew that she would become a researcher in the future. From that moment on, she has gotten prepared for the long road of scientific research.

Now, Y.S. has been on the road of higher education for a full nine years. By adding 12 years of primary and secondary education, Y.S. has been a student for 21 years, accounting for three-quarters of her age, and it’s twice the average level[1].

If you want to divide Y.S.'s education with a single point , it must be Gao Kao, the college entrance examination.

Gao Kao is a national general examination that every Chinese student has to take to win the entrance to a university. Gao Kao has always been being the most important examination in China. Not only for it is essential for thousands of students to change their destiny, but also it represents the country's emphasis on intellectuals and respect for knowledge.

However, such an important examination was forced to pause for nearly 10 years. Because of the disastrous 10-year Cultural Revolution in the 1960s and 1970s, the new born People’s Republic of China stopped Gao Kao as well as most academic research, which regretfully contribute to China missing the first decade of the new technological tide. In 1977, with Deng Xiaoping coming back into power, China’s new leaders announced the end of the Cultural Revolution and the resumption of Gao Kao. In the first 20 years since Gao Kao was resumed, due to the restrictions on higher education resources, the admission rate of the college entrance examination was very low, making college students really rare.

But things have changed in the new century, thanks to the enrichment of educational resources and changes in policies, the establishment of a large number of new universities and the expansion in enrollment of existing universities enable more students to receive higher education. And thus the average academic qualifications of Chinese have also increased significantly—— college students are not as rare as pandas any more. Looking at all kinds of recruitment information on the Internet in Shanghai, you may assume that China is full of undergraduate, postgraduate and even doctoral students. However, in fact, due to the uneven educational resources, till 2010, the proportion of the Chinese population who have received college education or above accounts for less than 9%.

[1] http://www.stats.gov.cn/ztjc/ztfx/ggkf40n/201809/t20180918_1623598.html

In order to enter the ideal university through Gao Kao, nearly 10 million students prepare for it one year or even more in advance. Even some parents calculates when their children will attend Gao Kao from the day they are born.

“It’s a single bridge”, it’s how many people who have experienced Gao Kao describe it. 9 years ago, Y.S. also walked over this bridge. Y.S.'s challenge was not very successful. She did not enter China's top universities but was enrolled to a less well-known university in Hubei Province to major in laboratory medicine. In her four-year study, she has never forgotten her initial ambition——she wants to be a researcher. To achieve that, she embarked on another wooden bridge.

In China, there are two main ways to obtain postgraduate’s degree qualifications: Bao Yan or Kao Yan. Bao Yan is a kind of method that is favored by undergraduate students mainly in that they could get the access according to their previous academic performance without attending examination. However, in most cases, it is the privilege of famous universities. It is quite difficult for schools Y.S. studying in.

Kao Yan is the choice of most people. Students taking part in the postgraduate entrance examinations are required to take the unified exam held each winter. Compared with Gao Kao, the postgraduate degree is even more difficult – because of its lower admission rate and higher demands of students' self-management ability.

For Y.S., this journey went smoothly – even though only four people achieved to climb to the higher level in her class– she was admitted to a college in Guiyang, Guizhou. Although the economy of Guizhou is not outstanding in China, with the development of the data economy and its rich herbal resources for TCM, Guizhou is becoming an emerging industry center with strong development potential.

After a three-year pharmaceutical studies, she spurred herself to pursuit higher goals, that she wanted to get a Ph.D.. Shanghai Medical College of Fudan University, the school Y.S. applied for, has a 90-year-old history and good reputation both at home and abroad. According to the rules she can only apply for one tutor in a same school. If she didn’t make it, she would lose the opportunity to be admitted.

Originally, Y.S. applied to another tutor, but since this tutor's enrollment quota was full, she turned to the current tutor. At the time of applying, a postgraduate classmate of Y.S. who also wanted to apply for doctoral degree had a discussion with Y.S. which school to apply for. Y.S.’s classmate would rather apply for a common school – hoping to increase the chances of admission. However, Y.S. wanted to study and develop herself in Shanghai: "There is no loss in anyway." After a written examination and an interview, Y.S. became the only two people to receive doctoral education.

Although Y.S. is always smiling when telling us her story, but in the view of us who have exoerienced similar trajectories, every step takes sweat, tears and even blood.

When it comes to her future plan, Y.S. assumes that she would go abroad to challenge herself and then spend two years or so accumulating experience. Finally, she would like to go back to China to find a job in college. When we asked whether her parents supported her choice, she says that they actually don't not know what scientific research was. The only thing they know is that she hardly go bake home and could live independently in Shanghai.

Each month, the subsidy issued by the school is more than 2,000 yuan (about 350 US dollars). It is impossible to rely on this to provide for her parents after covering her expense in Shanghai. For most people, living in Shanghai with $350 a month is not an easy task. Like any other metropolitans in USA like Los Angeles and New York, the rent the extremely high. Even the monthly rent of a single room of 20 m^2 is far exceeds the subsidy.

However, since most Chinese universities are of public interest (especially top universities), the cost of living in school is very low. The annual doctoral tuition of Fudan University is 10,000 yuan (about 1,500 US dollars), and accommodation costs 1200 yuan per year (about 175 US dollars), which is relatively low compared to universities in USA. And besides, a large number of doctoral students can get a scholarship nearly equivalent to tuition. Therefore, from a global perspective, the cost of receiving higher education in China is quite low, enabling Y.S. to continue her education without burdening her family much.

Y.S. has a compatriot sister. After finishing her undergraduate education, she is now engaged in human resources work in a company located in Guangdong Province whose GDP is highest in China's provincial administrative units. She has achieved independent living and could send some money to their parents now and then.

When we asked Y.S. whether she regretted it for more than a decade, she said: "Never. I made the choice and I really like my current state."

"It's a good question"

" You can enjoy a grander sight by climbing to a greater height "

——Wang Zhihuan, *Climbing the Guanque Buliding*, about 740 AD

Y.S.'s daily work starts around 9 am.

Read literatures, do experiments, write manuscripts... Everyday seems to be filled with taskes. As long as it is a weekday, Y.S. will appear in the lab timely. Y.S. doesn't have the habit of having meals regularly. In instead, there are always boxfull of snacks in her rest area to satisfy her hunger. A big box of snacks will be wiped out within a few days, then succeeded by a new box.

Although her diet is so unhealthy and irregular, we are always amazed at her fitness. Perhaps going to exercise every night is her secret. After bathing, she will return to the lab to continue her work. The eucalyptus trees outside the laboratory window have witnessed countless nights Y.S. working until the early hours of the morning.

Y.S. devotes almost 2/3 of the day into the experiment, making she familiar with various experimental protocol and operations. But despite that, Y.S. still sometimes gets confused about what she is doing and whether it make sense to the world. One problem we talked about in the interview plunged her into meditation - "It's a good question", she said.

"Whether in China or around the world, there is a large number of projects doing repetitive work. Are these necessary?"

In China, especially in those lower-level research institutions, there are many research groups (somehow we can call them the "bottom stratum" of research field) relying on repetitive work——the work that the peers have already done——in the hope of finding a little breakthrough. There is an appropriate idiom to describe this phenomenon——picking up others' wisdom from their mouth. This is also one of the reasons why China's research work has been criticized by international peers for lack in innovation or even described as "junk" for a long time. In this regard, many Chinese researchers have also recognized the existence of such problems. Nevertheless, due to all kinds of limitations in subjective and objective aspects, they can do little to help. For them, constant repetition is an important driving force for their projects to continue to receive financial support to sustain their project——of course, these repetitive tasks often put on a new look to make them different from the initial researches.

However, even for high-level research teams, repeating predecessors' work takes up a lot of research time, even though they don't aim to repeat what they already have, but only as a tool or for other goals.

The word "REPEAT" sounds simple, but actually, it's not. There are a lot of studies that stagnate in the phase of repeating without progress, wasting both experimental funds and time as well as making the researchers feel confused.

Then, does repetition make sense? If so, how?

It is universally acknowledged that repeatability is an essential feature of science, which means that we can get similar results under the required conditions of the original experiment. Therefore, repetition plays an important role in testing scientific research results and peer review.

Two years ago, Han Chunyu, a young scholar at Hebei University of Science and Technology in China, published an article named *DNA-guided genome editing using the Natronobacterium gregoryi Argonaute* in *Nature*. This article introduces a DNA-guided gene editing technique that is more promising than CRISPR-Cas9 commonly used currently. The publication of this article aroused widespread concern among researchers around the world. A shining research star seemed to be rising.

However, this myth was quickly shattered. Han's research results could not be repeated by most research institutions, which was likely to mean that Han was fraudulent, and this article was

retracted by Nature eventually. If there is no duplication, Han's academic misconduct might get away with it. It is the repetition that frightens those who intend to take academic fraud, and because of that, research field becomes almost the cleanest one among all walks of life.

In this way, repetition is indeed necessary, but not all research results will encounter such large-scale repetitive experiments. It's the "benefit" of those explosive theoretical or technological advances. There are considerable research results that may will not get such great attention, attempting some researchers to risk their reputation.

For researchers, repetition is also a complex issue. No researcher doesn't want to make a big breakthrough, but there is such a dilemma: if one wants to make great progress, it usually means less support from existing data and research as well as greater risk of failure, less opportunity of funding, and longer research time. Han's fraud may be the result of his giving up to these pressure. It is the same with students like Y.S., and one thing is even more important. If one wants to graduate successfully, he/she must publish an article (usually an IF >5 article) within a three years. Otherwise, they may face delays in graduation. This will drive graduate students like Y.S. to choose some research projects that are more conservative and easier to get results in such a relatively short time, so sometimes to repeat the work of others is a necessity.

However, if we look at it from another angle, a lot of repetitive work is the road to the maturation of researchers for us green hands. Newton said that he was standing on the shoulders of the giants (although his words were originally used to satirize the short Hooke). And we are growing step by step following the footprints of our predecessors to have a glance of things that have never been seen before. The difference is nothing more than the fact that some people could move forward while some people always spin in the same place without progress. Obviously, our excessive blame on them is not appropriate.

Theirs stage must be taken into consideration when assessing their work instead of measuring it with very high standards from the very beginning——which may put out their enthusiasm.

In fact, we iGEMers, as new comers to the research field, we are encountered with such choices in the iGEM competition. When we are using parts built by others, we are actually repeating the experiments that other teams have already done, especially using those not confirmed. And when watching wikis of other groups, we can also find out that the basic work of many groups is also repeating some literature or experiments of previous teams.

The STEP system designed by our team is based on the improvement and further research of a new technology called MESA. In our previous experiments, there are also a large amount of repeating work of MESA. In the beginning, due to the slow progress of repetition experiments, we often doubted ourselves whether it is meaningful to repeat it and even have a period of self-denial. But as we deepened our understanding of the repetition and the progress of the experiment afterwards, we gradually changed our mind.

Maybe Y.S.'s answer solved this problem very well: "Repetition is a fact, but actually every

repetition will be different. And when these difference accumulated, there may be a breakthrough. This question is common. One of my teachers once said: 'Repetition is necessary because the realm of personal knowledge still need improving. When your realm continues to expand, it may not be repetition from a higher perspective.'"

"For those of us who are new to scientific research, repetition may be boring or even meaningless, but we may come across breakthroughs in some corners. Moreover, scientific research itself has repeatability. The development is obtained by countless trial and repetition", Y.S. added.

As for our team, after repeating the predecessor's MESA many times, we encountered the problem of low response intensity. Through repetition and exploration of different conditions and past literatures, we gradually discovered that the recognition of receptors and ligands is the key to the overall system response intensity. Taking this opportunity, we tried to use Rosetta to calculate and analyze the interaction structure between the receptor and the ligand, so as to find a breakthrough by selecting a new ligand protein or modifying the existing protein.

Therefore, we can draw a conclusion that the repetition in scientific research is the major way for researchers to mature their scientific research techniques and develop their scientific thinking. We should support them to obtain the excellent experience of their predecessors. But we should also always encourage our researchers to boldly envisage, boldly practice, and propose more original and forward-looking results, and this is the future of science.

Will be better in the future

" I will mount a long wind and break the heavy waves someday, and then set off my sail to bridge the deep, deep sea"

——Li Bai, "Difficulties in Traveling", AD 744

Though occupied with her laboratory work, Y.S. is not a person immersing herself in her work completely.

She was on summer vacation when we were interviewing her. In China, doctoral students generally have vacations in the midwinter and midsummer, each lasting two weeks or so. However, Y.S. is not planning to go home during this holiday. Instead, she chooses to stay in Shanghai to look after the lab and find some part-time jobs to improve her life.

On weekdays, she often goes shopping with her labmates or classmates. And sometimes she also takes a short break watching TV sets in the rest area of laboratory. Recently, she was watching a legendary TV series backgrounded in the Qing Dynasty (about 1770) called *Story in Palace of Prolong Happiness* which describes how a woman becomes the most favored imperial concubine of the Chinese emperor Qianlong through her own efforts. This drama has reputation for its helping people releasing pressure.

Like what she did in her high school, Y.S. has already planned for her future. Y.S. says that she

would like to go to the United States to did her post-doc and after that she wants to get into a pharmaceutical company to accumulate some experience. But finally, she prefers to return to university—— "The work in universities is more stable than in enterprises. Of course, if I could do well in pharmaceutical companies, I won't. After all, it is quite difficult to work in universities now. Anyway, I will hold on to my initial goals."

In China, there are millions of students like Y.S. who are weaving their dreams with their own hands. Taking the biopharmaceutical industry that Y.S. working in for instance, China is becoming the world's largest biopharmaceutical market in the latest 10 years. According to the *Blue Book of China's Biomedical Industry Development*, China's biomedical industry is experiencing a explosive growth, with a compound annual growth rate of 16%, ranking first in the world. Simultaneously, Chinese government is promoting a national health plan such as "Healthy China 2030". It is foreseeable that China's pharmaceutical market will be a huge blue ocean in the near future.

However, in this huge blue ocean, Chinese local enterprises are embarrassed——China's scientific research strength is still very weak. In the field of biomedicine, the developed countries and regions such as the United States, Europe, and Japan occupy a dominant position, holding more than 90% of patents; the conversion rate of biomedical achievements in China moves in circles around 5%, which is far from that of developed countries. Although China is the world's largest exporter of APIs (Active Pharmaceutical Ingredients), due to at the lowest end of the industry chain, the profits Chinese companies are very meager.

Chinese people have always been believing in the concept of self-independence, and they want to change the status quo. They hope to obtain independence intelligent property right to break the monopoly and then reduce costs, making more Chinese citizens enjoy affordable and effective medical care.

The core of promoting research capabilities is talent. In order to catch up with the advanced level of personnel training, Chinese government is investing huge amounts of money in scientific research , which are used to both train local talents and introduce international researchers.

This year, the Ministry of Education of the People's Republic of China approved the establishment of the West Lake University in Zhejiang Province. West Lake University is located in Hangzhou, a rising city only two hours' drive from Shanghai. As a private university founded by the biologists such as Shi Yigong and several top Chinese scientists, the goal of West Lake University is to make itself a new peek of Higher education institutions of China in 20~30 years. West Lake Education Foundation hopes to raise at least 20 billion yuan (about 3 billion US dollars) in the next few years to fund the newly-born university.

Thanks to its rich resources and support, West Lake University is expected to become one of the top scientific research institutions in a short period of time and become comparable to other top universities and research institutions, which is unimaginable from the perspective of traditional scientific research institutions.

Due to the government's efforts to strengthen scientific research, China's scientific research level has developed by leaps and bounds. The *China Nature Index* released by *Nature* shows that, China's high-quality research output increased by 37% between 2012 and 2014 according to the weighted fractional count (WFC).

However, as even Sheldon is afraid to be referred as a nerd, the occupation researcher is not so attractive to Chinese. In the past 20 years, China's real estate industry has developed rapidly, making the price of commercial housing increase by more than ten times or even higher. The whole country was immersed in the frenzy of real estate at that time. Although this enthusiasm has cooled down, it is still far from completely regressing, drawing people in the impetuousness.

Nevertheless, the impetuous environment can't breed achievements of science. In nowadays China, research is not considered a high-reward career, and people who choose need to be courage enough to make up their mind.

At this moment, there are many researchers like Y.S. who are working hard on their own posts. Despite failures and confusion, they all believe that the future will be better.

One more thing

" when this love become a beautiful memory, what left with me is only a deep sorrow."

——Li Shangyin, *Jin Se*, about 840 AD

——"What is your most regretful thing?"
——"I shouldn’t refuse a confessions of a boy who I like when preparing for Kao Yan."
——"Why?"
——"At that time, I only wanted to focus on study and don’t want to be distracted. "
——"How is he now?"
——"Already got married and become a father."
——“Do you feel regretful?”
——“Never.”