

2 ケンブリッジ研修生

Suicide and Mental Health

Kaori Takagi

The World Health Organization (WHO) defines health as a state of complete physical, mental and social well-being, not merely the absence of disease or infirmity. Since this basic policy took effect in 1948, the number of patients who have physical diseases has been decreasing. On the other hand, more people are suffering from mental illness these days. Mental illness can lead to suicide, and the suicide rate in Japan is by far the highest among developed countries. What brings about this problem? What can we do to save lives? I will study mental health and suicide prevention to find the answers.

1. Current Situation of Suicide in Japan

In Japan, 25,427 people killed themselves in 2014. The number of suicides had been more than 30,000 but it started to decrease in 2010. However, it is still high. There was a rapid increase in the suicide rate in 1998 but the exact reason has not yet been found.

Statistics show that the number of men who commit suicide is larger than that of women. Furthermore, as people get older, the risk of committing suicide becomes higher. People in their fifties tend to fall into the risk of suicide more easily, this is particularly common in Japan. Similarly, the unemployed also have a higher suicide risk.

a. Main Causes of Suicide

People commit suicide from various motives. One of the main reasons is worries about health. About half of the suicides in Japan happen for this reason. Those who have incurable diseases are often in danger of committing suicide. The second largest reason is economic and livelihood issues. The percentage of suicide for this reason has been increasing dramatically since 1997. Family issues, work-

related issues, love affairs and school related issues can cause suicide, too.

b. Special Issues of Suicide in Japan

Suicide connotes many problems. I will discuss three serious ones.

The first problem is that a large number of young people (under 40 year old) commit suicide every year in Japan. This situation is very serious even compared with other countries. Japan is the only country of the G7 nations where suicide is the leading cause of death in the 15-39 age groups. 6,581 young people killed themselves in 2014, this is about 26% of all suicides. In recent years, the total number of suicides has been decreasing, but suicide among younger generations has not changed greatly.

The second problem is that suicide attempt survivors often try to commit suicide again. About 15% of men and 30% of women who died by suicide in 2014 had a history of suicide attempts. People who have tried to hurt themselves have several times as high a risk of reoccurring episodes or further suicide attempts as those who have not.

The third problem is a misunderstanding of suicide. Many people say, "people take their own lives because they are weak," or "we cannot stop suicide." Even medical students have these opinions, but they are not true. Some countries and regions have been successful in suicide prevention.

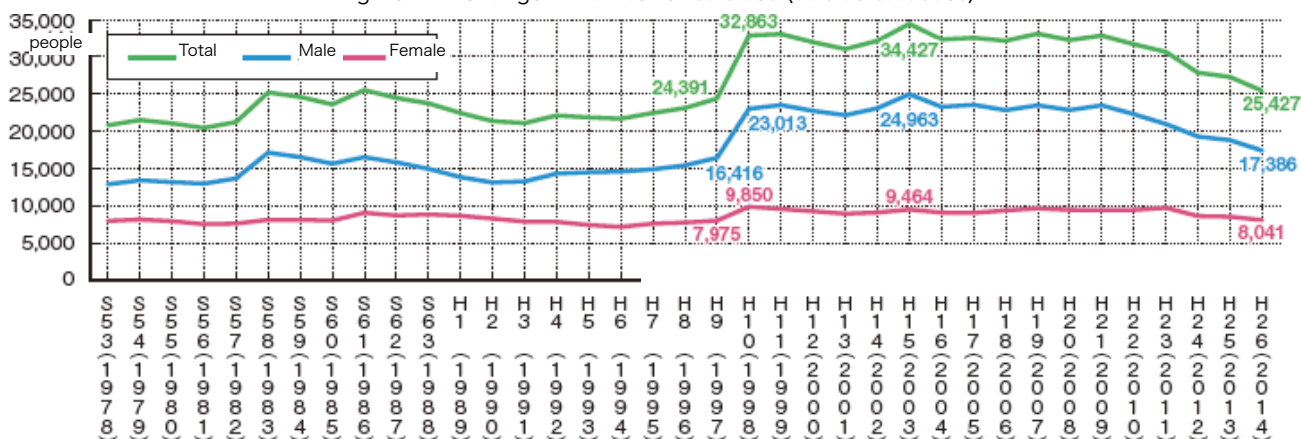
c. Prevention of Suicide

In order to reduce the number of suicides, some prevention activities have been practiced in Japan.

The Japanese government announced a law, "Basic Act on Suicide Prevention" in 2006 and a comprehensive suicide prevention policy has since been promoted. It emphasizes three fundamental principles: suicide is a death that people feel driven to in the end; suicide can be prevented; people thinking of suicide give off signals even as they hide their suffering.

Based on these ideas, the government, local authorities, communities, employers and citizens have made efforts in, for example, promoting the cultivation of gatekeepers in a

Figure 1 Change in number of suicides (suicide statistics)



資料：警察庁「自殺統計」より内閣府作成

variety of fields and disseminating correct knowledge about suicide and suicide-related events. Thanks to these activities, many lives have been saved.

2. Current Situation of Mental Illness in Japan

Mental illness often leads to suicide. It is said that about 80% of suicide victims had mental illnesses.

Mental illness is a severe mental disorder in which a person loses the ability to recognize reality or relate to others. The patients are not able to cope with the demands of everyday life. Symptoms include being paranoid, having false ideas about what is taking place or who one is, and seeing, hearing, or feeling things that are not there. Depression is a main mental illness. About 6% of people in Japan have mental problems. Women fall into depression more easily than men. Pregnant women, senior citizens, and people who have myocardial infarction, diabetes, and cancers also have a high risk of depression.

a. Symptoms of Depression

Depression can affect anyone. The symptoms are loss of interest and pleasure, sleep disorder, eating disorder and lack of concentration. Early treatment is important.

b. Causes of Depression

The patients do not always have clear reasons for feeling depressed, however, there are some notable causes.

One reason is genetic factors. Some scientist say that the risk of depression is heredity, but confirmation of this hypothesis has not been found yet. Another reason is psychological factors. People who are serious, methodical and perfectionists are considered easy to fall into depression. Excessive intake of medication and alcoholism

are also related to the risk of depression.

c. Treatment for Depression

There are three main treatments for depression.

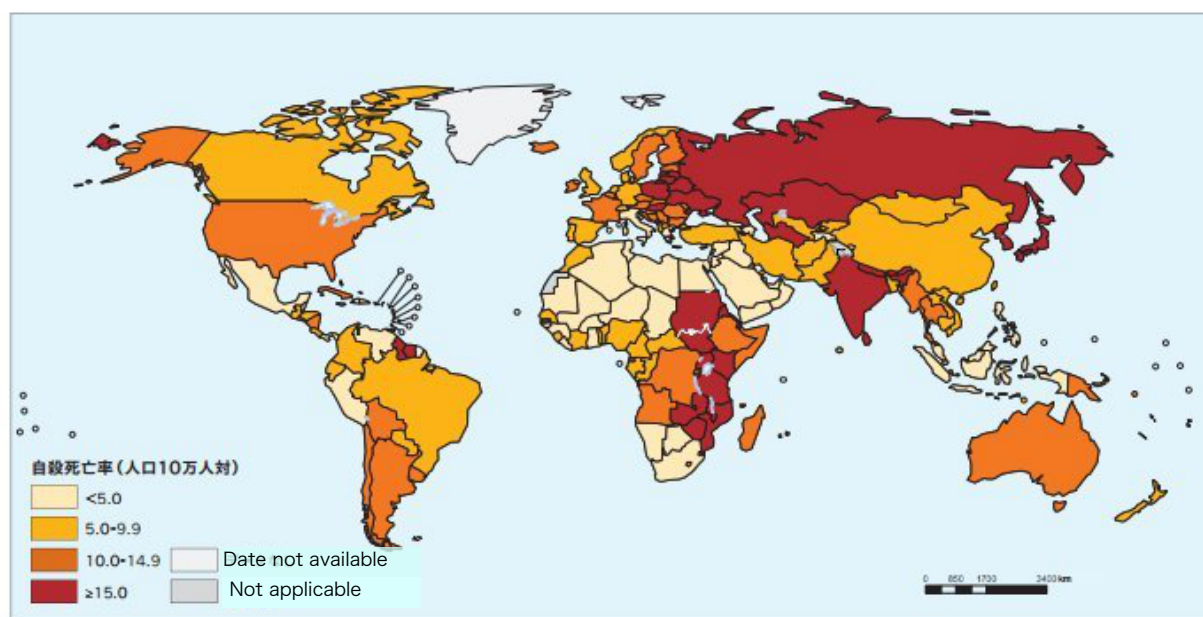
Psychological treatment means reducing stress by organizing thoughts and feelings. Patients reconsider whether their thoughts are twisted or not. They also learn how to control their mind. Having regular sleep and taking time to relax are effective, too. Another way to improve depression is medication. There are various types of medicine for depression, so doctors have to choose the best one for each patient. If the medicine's intake is stopped or reduced without the doctor's permission, it will not work well. Medicine must also be taken even after recovering from depression to prevent recurrences. However, some medicines have serious side effects and require careful use. Finally, there is social treatment. It is necessary to promote public awareness and understanding of mental health and mental illness. We should not try to cheer up the patients too much or repeatedly ask the cause of depression. Having an understanding and being aware of the signs of depression are the best ways to help promptly.

d. Difficulty of Depression Treatment

Depression is a difficult disease to cure because the patients will not see a doctor. While the number of depressives has been increasing greatly, the number of doctors are too few and they do not have enough time to see their patients. Furthermore, there is no infallible criterion to determine whether people have a mental illness or not in Japan, so doctors tend to prescribe antidepressants for their patients easily.

3. Current Situation of Suicide and Mental health in the

Figure 2 Suicide mortality (per 100,000 population)



World

The abundance of suicide is a serious problem all over the world.

Korea, Guyana, Lithuania and Sri Lanka are countries with a high risk of suicide. On the other hand, Ireland, Chile, and Thailand have lower risks. Generally, suicide increase in high latitude countries, this is because the hours of sunlight may affect people's mental states. In addition, cultural differences, such as religion and customs, have an influence on suicide rates. For example, many old people commit suicide in Hungary, because elderly persons are often regarded as worthless after their retirement. According to an anecdote, it is said that Hungarians have a mutant gene which may cause suicide. Islamic nations have lower risks of suicide, as Islam prohibits their believers from killing themselves.

Japan's suicide rate is high, but the morbidity rate of depression is low around the world. America, New Zealand, and France have large numbers of mental illness patients.

4. My Research in Britain

I had an interview with Elizabeth Fistein, a doctor in the Institute of Public Health at Cambridge University. She is a specialist in general adult psychiatry and rehabilitation psychiatry. I asked her several questions about suicide and mental health.

a. the Suicide Rate in Britain

While Japan had the seventeenth highest risk of suicide in the world, Britain was one hundred fifth in 2015. Japanese people have already started prevention activities like Britain. What makes the difference of the suicide rate between Britain and Japan?

According to Dr Fistein, primary care for mental illness is the most important. There are four main ways to encourage early treatment in Britain.

First, people can receive a high level of care from their GP, General Practitioner. The GP is a particular aspect of the medical system in Britain. There are many specialists in psychiatry in the hospitals and they will help patients who are suffering from mental illness promptly.

Second, there is an organization called NICE, National Institute for Health and Clinical Excellence in Britain. They are doing research on mental health and sharing new ideas with other institutions. GPs follow the guidelines established by NICE.

Third, the British government has been taking some measures at high risk spots of suicide. For example, a telephone box is set on a cliff and people who are attempting suicide can use it to speak to someone about the difficulties they are suffering. The Samaritans, an organization in Britain, operates a 24-hour service available every day of the year.



The author(l) with Dr Elizabeth Fistein(r), Institute of Public Health, Cambridge University, July 2016.

Lastly, many hospitals in Britain have taken some activities to prevent their patients from committing suicide. Ropes, cords or items with which inpatients can hang themselves are fixed with magnets. Also, staff members take care of their patients after they leave the hospital. They ask some social communities to cooperate in helping their patients return to normal life. This is because mental patients have a higher risk to commit suicide when they are getting better and have the energy to act.

b. the Suicide Problems of Young British People

Japan has a high risk of young people's suicide. 866 students killed themselves in 2014. Many of them commit suicide because of underachievement and finding a job is one of the biggest concerns of university students.

Students in Britain commit suicide because of pressure to get high scores on tests and the problem of bullying. Sometimes excessive news about suicide leads them to kill themselves. However, students' suicide is not as ordinary in Britain as it is in Japan.

c. School Counselors in Britain

Most Japanese schools have counselors for students, but most of them are temporary workers. Students feel uncomfortable talking with an unfamiliar counselor about their problems. However, every school in Britain has regular counselors and students can ask them for help any time. They can also receive counseling with GP. The GP works as a gatekeeper and plays an important part to prevent young people from suicide.

d. Suicide Problem in Scotland

Britain has the lowest suicide rate in Europe. However, talking about each area of Britain, more people in Scotland commit suicide than those in other areas.

The most reliable reasons are social and economic issues. There are some areas where poor people are living in Scotland. Most of the residents do not have any jobs and they sometimes have physical health problems, drug dependence and alcoholism. These lead people to have a

higher risk of depression and suicide.

In addition, the Scottish have too much fat in their daily diet and eating habits might have a bad influence on mental health. Some biological studies suggest the existence of unusual patterns in the Scottish gene information.

e. Workers' Depression and Suicide in Britain

Workers' depression is a serious problem for our society. 1,835 self-employed persons and 7,121 employees committed suicide in Japan in 2014. This brings Japanese society a large amount of economic loss.

The Japanese ministry of health, labor and welfare proposes the stress check test to companies with fifty or more employees once a year from December, 2015. On the other hand, there is no standardized program in Britain. However, companies prevent their employees from mental illness in another way.

Some big companies have occupational health departments and the employees can ask the doctors and nurses for help. Regular counselors check the mental health condition of the employees. Furthermore, the employees can take holidays from one to three weeks when they feel deep stress.

A meeting for mental patients is sometimes held at Cambridge University. All attendees have mental illnesses and they share their problems and how to cope with stress.

These trials are working well to prevent and cure mental illness. However, not every company and university in Britain is taking such prevention measures.

f. Prejudice against Mental Illness.

Japanese people sometimes think killing themselves is a good way to take responsibility for failure. This is a traditional way of thinking based on Japanese samurai history. Also, many Japanese feel uncomfortable going to mental hospitals because there is a kind of prejudice against mental illness. It is not only in Japan but also in Britain.

In order to propagate the right understanding, the British professional organization of mental illness is doing a large-scale public education campaign. You can find many advertisements which tell us how mental patients get over their problems on TV and in movies. It is also effective that celebrities talk about their mental illness openly.

In recent years, the number of suicides is much larger than that of traffic accident victims in Japan. The suicide rate shows how well the social welfare is working in the country. Many of us do not know the serious situation about suicide. Also, depression is often said to be like a cold, but it is not always true. The patients have indescribable pain. As a result, they sometimes choose death. Everyone has the possibility to fall into depression.

The government and some private organizations are taking this problem seriously and have started some prevention activities. However, they are not yet enough. We can learn from the U.K. policy.

Suicide and mental illness is a common issue for all of us. It may take a long time, however, it is entirely possible to get rid of death from suicide if everyone understands the importance of its prevention.

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The Application of Stem Cell Biology to Medical Care

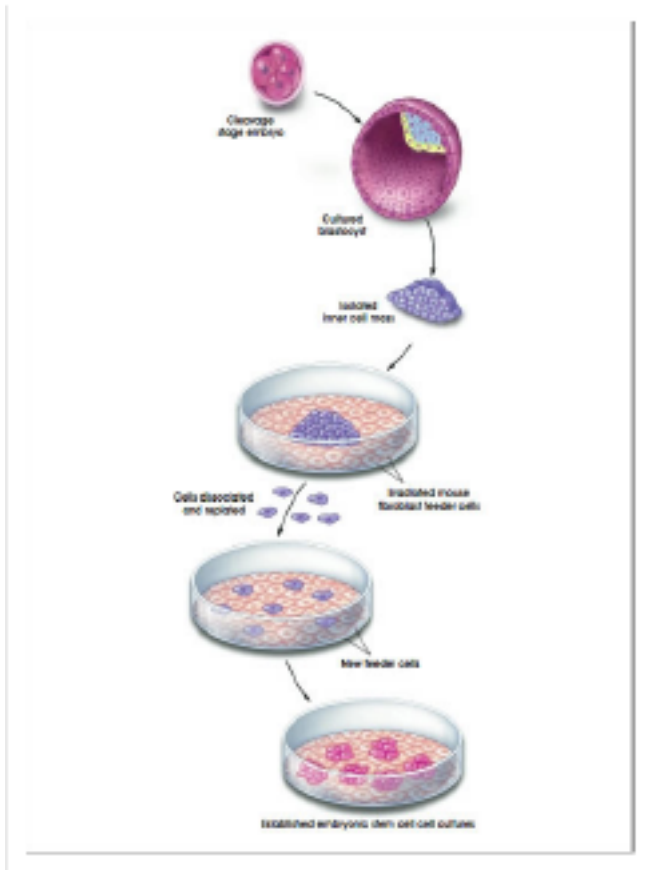
Umi Kiriyaama

>Introduction

Human bodies are made from fertilized eggs by the information in DNA. An embryo, the form that the fertilized egg repeated dividing has totipotency, the ability of a single cell to divide and produce all of the differentiated cells in an organism, and to produce the same cell. However the somatic cell which finished its differentiation doesn't have this ability. The stem cell is the cell which has totipotency for; the Embryonic Stem cell (ES cell) and induced Pluripotent Stem cell (iPS cell).^{*1} Regenerative medical study taking the advantage of this ability has been done all over the world, especially in Japan, the U.K. and the U.S. In the program me, Summer Camp 2016 in Cambridge I visited the lab where stem cell biology is studied, as well as a hospital, and asked some questions about regenerative medicine.

- >The method of making the ES and iPS cell
- >To differentiate the ES and iPS cell
- >The interview at the Gurdon Institute
- >The interview at Papworth Hospital
- >Conclusion

>The method of making the ES and iPS cell



The presentation from Dr. Steven Moor

The characteristic of the ES and iPS cell is that both of them can be made in vitro.

The ES cell

The ES cell was made for the first time by Martin Evans and Matthew Kaufman in the University of Cambridge genetics department in July for the first time, and Gail R. Martin of the University of California. The Anatomy department in San Francisco used the term "embryonic stem cells" in a paper published in December, 1981. In 1998, the researchers led by James Thomson of the University of Wisconsin-Madison developed a technology to isolate and culture human embryonic stem cells for the first time. (1) This papers were:

1. Put a somatic cell into a serum to stop it from dividing.
2. Put its nucleus into unfertilized egg without nucleus

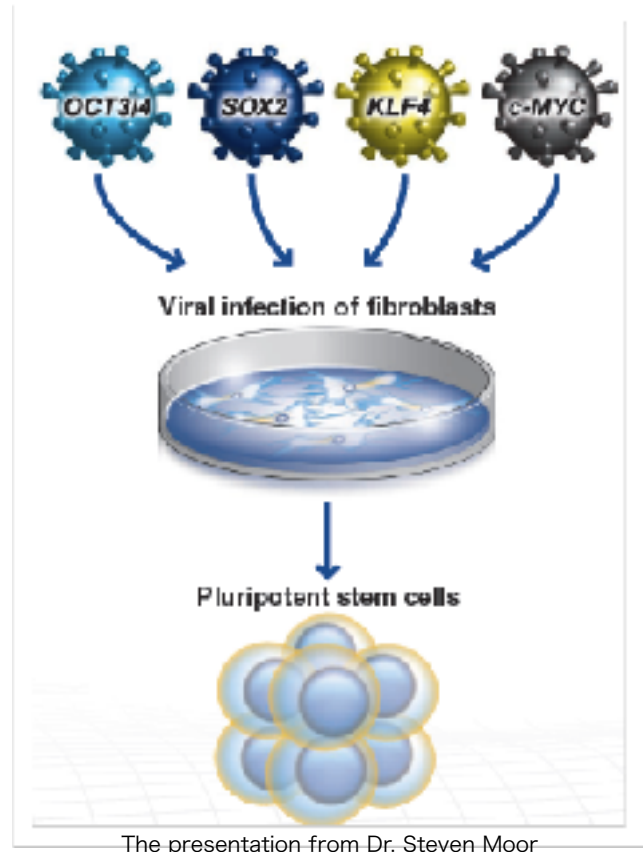
There are some ethical problems with the use of ES cells. ES cells are produced from unfertilized eggs, which could be a human in the future. Consequently some governments of developed countries think researchers are depriving the eggs of life. It is the single important problem whether or not the unfertilized eggs are regarded as a human being.

The iPS cell

Human iPS cells are published in the paper of Dr. Shinya Yamanaka, who won the Nobel Prize in physiology and medicine. The process for creating iPS cells is:

1. Inject four proteins, Oct3/4, Sox2, c-Myc and Klf4 called "Yamanaka factor" into somatic skin cell's nucleus.

The functions of the four proteins are below.



The presentation from Dr. Steven Moor

➤ Oct3/4

This is a protein that regulates the function of other genes. It is necessary to maintain the initialized state.* 2) It is called the transcription factor and activates the transcription of target genes in concert with Sox2. There is a network around the Oct3/4.*1)

➤ Sox2 (Sry related HMG box 2)

Sox2 works in cooperation with the Oct3/4 to control the appearance of a variety of downstream genes, there are large numbers of genes that are controlled by a master gene.*4) A master gene is the gene which adjusts the expression of a plurality of other genes that have a specific purpose.

➤ Klf4

This is a transcription factor. While it functions as a tumor suppressor for a variety of cancers, for other cancers, such as breast cancer, it functions as a cancer gene.*3)

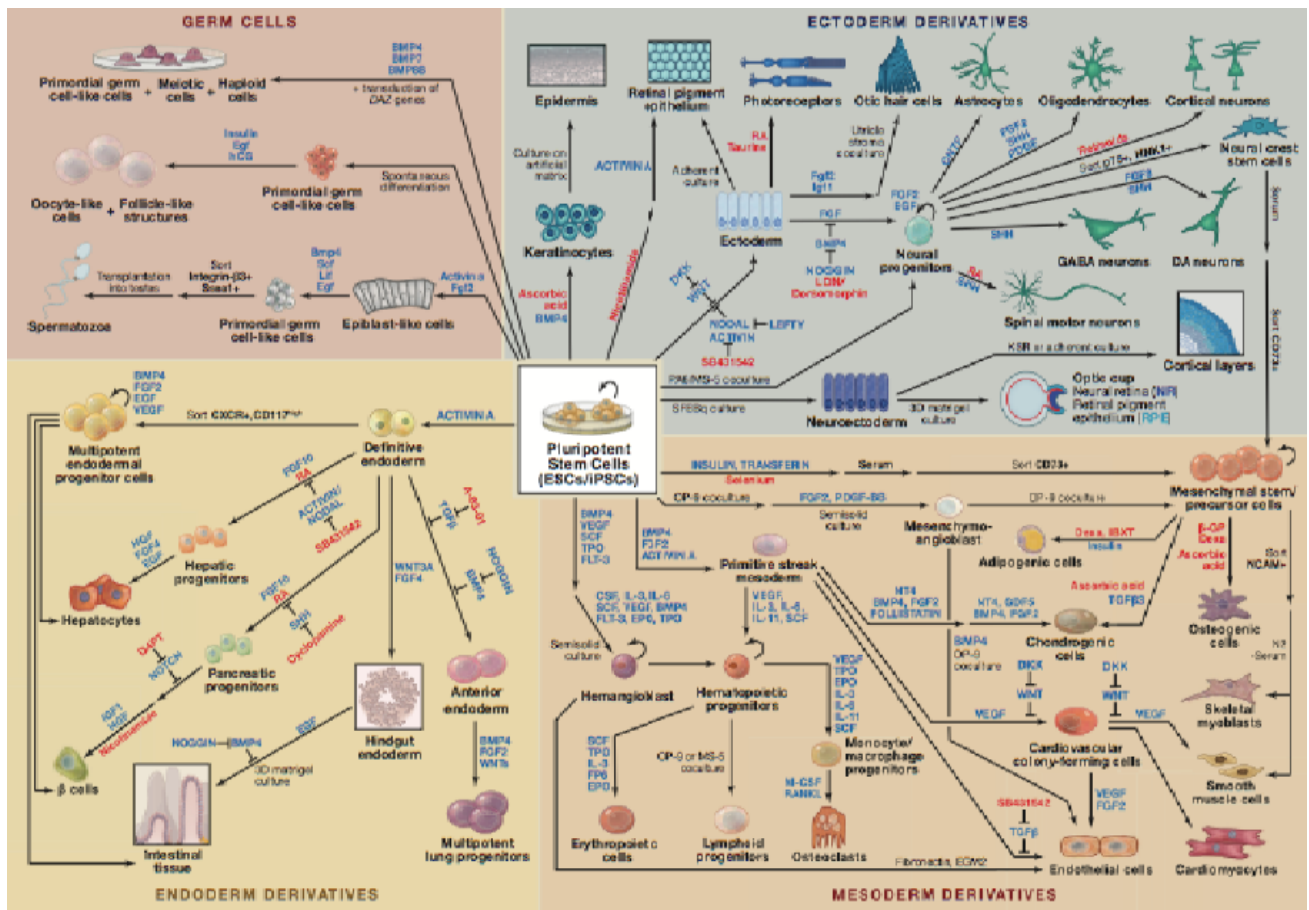
In initialization, the role of Klf4 induction is thought to activate the target gene of Oct3/4 and Sox2.*1)

➤ c-Myc *4)

This is a transcription factor, one of the cancer genes. It causes cancer, but it is necessary in order to create the iPS cells. It has become possible to make iPS cells without using c-Myc.*2)

According Dr. Nakagawa et al (2010), the most important points are below,

- While c-Myc contributes to increasing establishment efficiency of iPS cells, it acts on tumor formation. This is shown from the experimental results of the chimeric mice from iPS cells.
- It is found that L-Myc, one of the Myc family, induces iPS cells more efficiently than c-Myc. In experiments



Presentation from Dr. Steven Moor

with chimeric mice, they found that tumorigenesis hardly occurs with iPS cells produced using L-Myc.

- Using three factors of Oct3/4, Klf4, L-Myc, it is possible to produce a mouse iPS cells.

⇒ With these results, it is thought that the use of L-Myc and oncogenic variants of reduced c-Myc (W136E) will be considered effective to make iPS cells for clinical applications.

The iPS cell has no ethical issues because it can be created only from human somatic cells. However there are some challenges, such as the low probability of success.

➤ To differentiate the ES and iPS cell

Some particular proteins are needed in order to differentiate the ES and iPS cell. For example, A6/MS-5 coculture and Reb'nolds are used to make a stem cell cortical neuron in the graph below.

These proteins which have an effect on the stem cells are being looked for all around the world. The most comfortable environment for making large tissues is also studied. The technology to make large tissue from stem cells makes it possible to transplant an organ into a patient that has their own DNA.

➤ The interview at the Gurdon Institute

On 19th July 2016, I visited Dr Steven Moor, who is doing stem cell biology under Prof. Rick Livesey at the Gurdon Institute, and interviewed with him at 10:00. The Gurdon Institute is located a Tennis Court Street. It used to be the

cancer institute, but became the Gurdon Institute in of the achievements of Dr John Gurdon, who succeeded in making a clone animal of *Xenopus laevis* and won the Nobel prize with Dr. Shinya Yamanaka in 2012.

After I entered the building, I wrote the date, my name and the time I visited in the book. Then I received a sticker which was the pass.

First I listened to Dr Moor's presentation. He is doing research using neuron cells. To observe the cells of cerebral neocortex, he has investigated the evolution of the human brain and looked at diseases such as Down's syndrome and Alzheimer's. He is using actual human neuron cells differentiated from ES cells and iPS cells. These cells can differentiate to all kind of the brain cells. The ES and iPS cell enable experiments to be more close to a patient's brain.

Second I asked some questions I made in Japan.

Q. Should animal cloning be allowed?

A. Yes, but only for research.

Q. Which protein is needed to differentiate stem cells into neuron cells?

A. Two proteins, A6/MS-5 coculture and Reb'nolds and each has their own receptor. Now, studies have been to substitute the protein with an inexpensive drug.

In the end he took me to a lab tour. I went a room where he does experiments and I was showed some laboratory instruments and cells. Long-term cells are stored in containers, such as drums, containing liquid nitrogen. The other cells used immediately were stored in the vault which



This is the Gurdon Institute.



The sticker

is kept at the same 37 degrees as human body temperature. The cells which is to be used immediately have been stored in the vault which is kept at the same 37 degrees as human body temperature. I was showed the iPS cells and the neuron cells that have been differentiated into iPS cells. The synapse was able to be found in Zion system cells.

The cell was injected with a disinfectant solution carefully after being taken out and before being put away again. The disinfectant was sprayed more than five times.

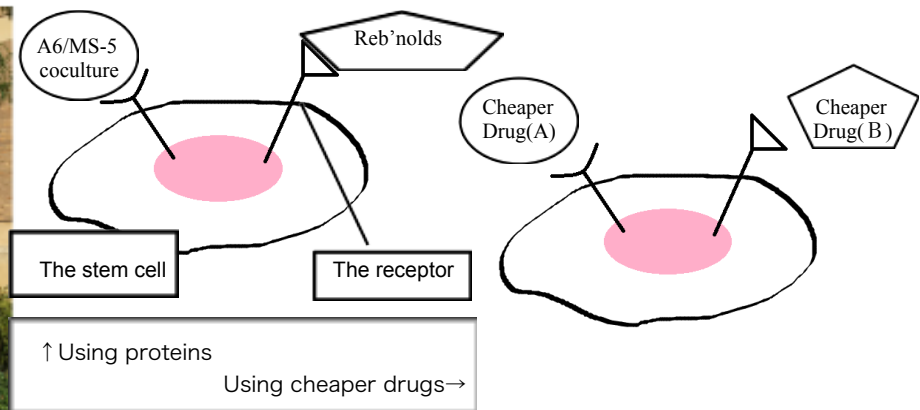
The interview finished around 11 o'clock.

>The interview at Papworth Hospital

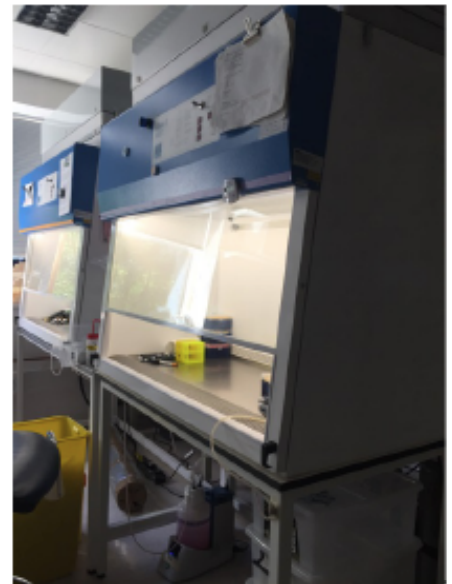
On the 22nd I visited Dr Sudarshan who is working at Papworth Hospital as a heart surgeon. She told me that the technique of coating artificial blood vessel with cardiac cells differentiated from stem cells has been studied in Japan. It has great expectations as a regenerative medicine for repairing the heart itself using the stem cell sheet.

>Conclusion

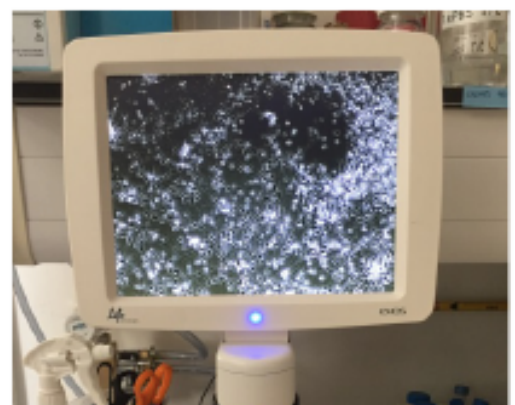
Stem cell biology has been out all around the world. The problem that iPS cells tend to be cancer cells is being solved by Japanese researchers. The proteins which are needed to differentiate stem cells have been mostly found. Preparation



iPS cells



Inside this box, the work such as putting protein is done. Inside this, the wind is blowing from the bottom to the top, to cut off the air from outside.



for the practical application is in place.

Molecular biology has been actively carried out in Cambridge; there are also a lot of great results. Stem cell research is an area of study that has the most sciin the world. Research into regenerative medicine using stem cells is underway all over the world.

The neuron cells differentiated from iPS cells.
The synapse is found

I want to study the application of stem cells to medical technology. Through participating in this program I have decided to do stem cell research in the future. By studying hard, I'd like to visit the Gurdon Institute as a biologist.

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iPS細胞はいつ患者に届くのか(塚崎朝子)

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(1)Wikipedia



* 1)iPS Trend

* 2) iPS細胞と'ズ' <http://xn--ips-di8h40n.biz/dic/30.html>

* 3) Sox2 is necessary for keeping the ES cell from differentiate

○Shinzi Masui

Sox2はマウスES細胞の未分化性維持に必須である

○升井 伸治, 丹羽 仁史 (理化学研究所CDB多能性幹細胞研究チーム)

* 4)"Promotion of Direct Reprogramming by Transformation-deficient Myc"

Masato Nakagawa, Nanako Takizawa, Megumi Narita, Tomoko Ichisaka and Shinya Yamanaka.

Black Holes at the Center of Galaxies

Taisei Sekimoto

Introduction

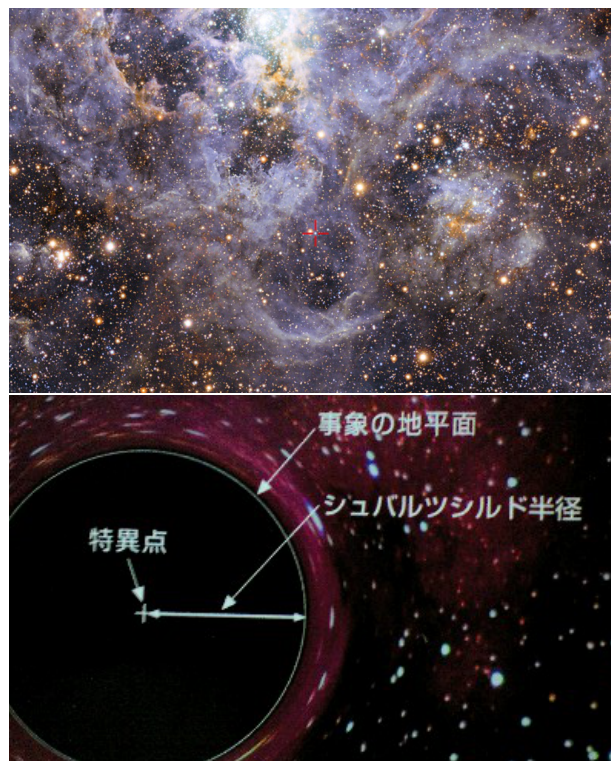
Currently, research into the universe has made progress all over the world. The universe is infinite and immeasurable and the Earth on which we are living is only a very tiny part of it. From the first space flight in 1961 to the Apollo 11 moon landing in 1969, many satellites have been



launched into space to help us with researching the universe. However more than 90 percent of the universe is still unknown. Black holes are one of nature's biggest mysteries. My interest in black holes led me to do this research.

What is a black hole?

A black hole is an object with a very strong gravitational pull from which even light cannot escape. The density and mass of a black hole is so high that matter is squeezed into a small



space. Matter from exploded planets is crushed by gravity and becomes black holes. This happens only in the case of planets with a mass more than 30 times that of our sun. Therefore black holes must be heavy, however they are invisible.

The Structure of Black Holes

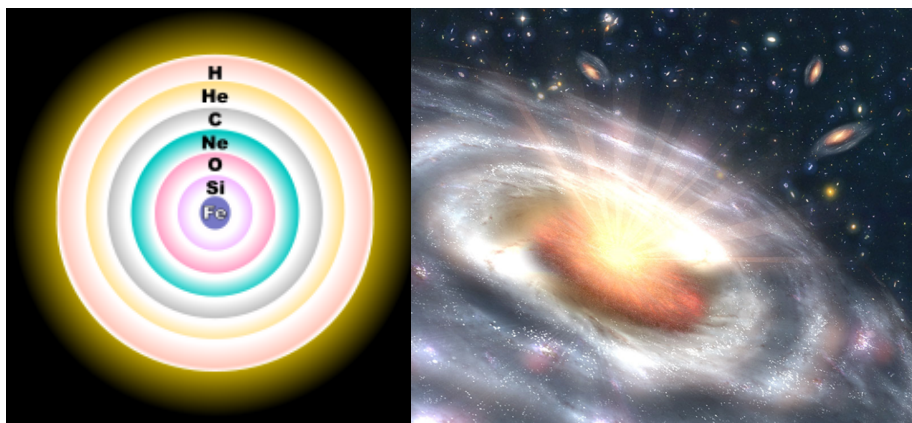
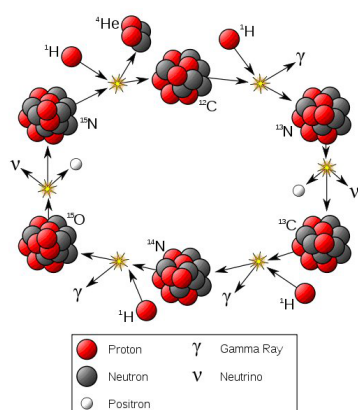
Black holes are assumed to be "event horizons" and a "singularity." Planets are condensed into a "singularity", retaining their mass. The "event horizon" is composed around the "singularity". The gravity of a black hole has an effect on only the inside of the "event horizon." Even light can not escape from this gravity.

A fixed star

A hundred-billion of stars are observed in the universe. The Earth is classified as a planet and it revolves around our star, the sun once a year. On the other hand, some stars appear to stay in the same positions, these are called "fixed stars." The sun is one such "fixed stars." We now know fixed stars are heavenly bodies outside the solar system. Even the nearest fixed star is four light years away from the Earth. By knowing that fixed stars are visible to the naked eye from the Earth, their brightness is at least the same as the sun's. It takes many millions of years for the light of fixed stars to reach the Earth and meet our eyes.

Evolution of fixed stars

Where does a fixed star's energy come from? We know that the main component of a fixed star is hydrogen. The energy is released when an atomic nucleus of hydrogen changes its shape. A new atomic nucleus is made when several other atomic nuclei combine in a "nuclear fusion reaction." This reaction does not occur just anywhere in a fixed star, but only in the center where there is both high



pressure and high temperature. Hydrogen changes to helium first and then it changes to carbon and oxygen. If the core shines only by residual heat caused from a nuclear fusion reaction, this is classified as a “white dwarf.”

How is a black hole made?

Once the hydrogen atom becomes iron, it stops emitting heat because of iron’s stable nature. As the density of iron becomes higher, so does its pressure. This pressure causes two reactions. One reaction is “electron capture.” This happens when a part of the electrons of iron cannot withstand the high pressure and it lodges itself into the atomic nuclei. This means some atoms change into other atoms.

Another reaction is “photolysis of iron.” This occurs when iron is exposed to gamma rays in space, causing it to decompose. Photolysis is the decomposition of materials under the influence of light. Photolysis is the opposite of nuclear fusion. As such a reaction progresses rapidly, the center of a star begins to collapse. The star explodes, and the atoms clash. Electrons and protons are compressed to form a neutron star. The pressure of the neutron star is so high that it is crushed, making a black hole.

A black hole at the center of the galaxy

There is a large black hole at the center of each galaxy. What does it do in the galaxy? Active galaxies emit huge amounts of energy from their centers. The source of this energy is a black hole which is dozens of times the mass of the sun. Inside a black hole, matter is rotating at high speeds. Black holes have very strong gravitational pulls and gravity is different depending on its proximity to the center. Therefore, rotating speeds are different between the inside and the outside. This generates enormous frictional heat.

How was it made?

We do not know how the large black holes at the center of the galaxies were made. There are three possible theories including my own.

1. Fixed stars which are dozens of times the mass of the sun exist from the beginning. They cause supernova explosions and create large black holes which are billions of times bigger than the sun. However, the largest fixed star

discovered is only three hundred times as massive as the sun, so this theory is believed to be less likely.

2. A black hole made by a supernova explosion absorbed stars and gases around it and grew over the years.

In February 2015, a team in Beijing found a black hole which is about twelve billion times as massive as the sun. This theory is also believed to be unlikely because the formation of a black hole of this size would take longer than the age of the universe.

3. Most black holes experience repeated collisions and unions. These can form huge black holes.

This theory is considered the most likely. Research teams in Massachusetts observed gravitational waves which traveled through space-time, by using “LIGO.” “LIGO” is the Laser Interferometer Gravitational-Wave Observatory, which is designed to open the field of gravitational-wave astrophysics. Gravitational waves are wave motions which travel through space-time and it can be observed that they come from united black holes and neutron stars.

Research into Black Holes in Cambridge

We do not know how the large black holes at the center of galaxies are formed. I have looked into this matter and did some research at Cambridge.

I visited the Kavli Institute of Cosmology to meet Dr. Kulkarni who majored in astrophysics. To deepen my knowledge about those theories, I asked him the following questions in Cambridge:

1. What phenomenon would occur if two large black holes with very different masses were to collide?

2. Given the sheer number of random variables, how likely is it that huge black holes were made by the union of many black holes?

3. Theoretically how long would it take for a large black hole 10 billion times as heavy as the sun to be formed?

4. How is a thin cloud of hydrogen condensed in the Milky Way to make large stars?

5. Can we actually witness the existence of black holes with modern technology?



Dr. Kulkarni told me as follows: When two large black holes collide, they will become a new black hole. The interesting aspect is that the mass of a new black hole would be smaller than the total mass of the two original black holes. This is because it emits gravitational waves and loses its masses. It does not emit light, but instead gravitational waves. Last year we finally detected gravitational waves which showed the union of ordinary black holes through LIGO (Laser Interferometer Gravitational Wave). Now scientists are trying to detect the union of large ones through LISA (Laser Interferometer Space Antenna).

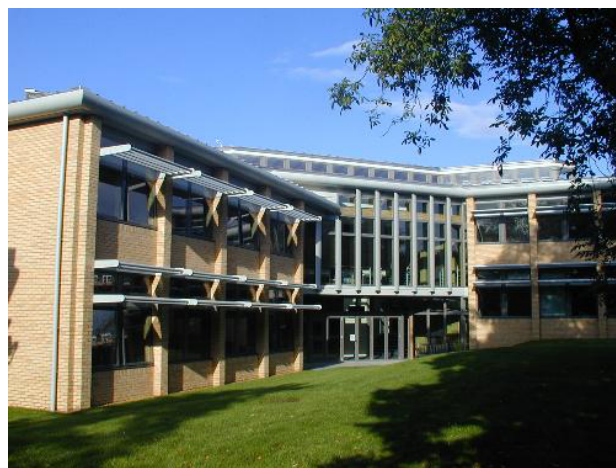
I thought that when the universe was young, hydrogen gasses condensed and then, exploded. This cycle was repeated and the core became larger and larger.

This is a process of forming large black holes. Large black holes absorb stars and gasses around them. They sometimes unite and grow over the years. This is the process to by which supermassive black holes are formed. I was glad to know that my expectation was similar to Dr. Kulkarni's theory.

Conclusion

Large black holes at the center of the galaxies were not formed just by the union of many black holes. It is assumed that condensation and explosion of hydrogen gasses had been repeated many times during the early stages of the universe and after that, they could gradually become supermassive black holes.

Before my visiting Cambridge, I had thought a very large black hole was formed by just only the union of many black



holes. However I found it took a long time to form a large one, so this theory was believed to be less likely. I also found the existence of black holes was evident because LIGO detected gravitational waves.

I learned it is very important to formulate a hypothesis and inspect it from various fields and angles. This is not only the case for black holes but also other fields. I could know well how the huge black hole were formed and become bigger in detail. My research in Cambridge gave me a wonderful experience and fueled my curiosity in space mysteries.

