Yggdrasil

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Visit our website with all the details and ideas about this project!
https://0919692122aaa.wixsite.com/yggdrasil-nasa-assc

Part I: Introduction

1.1: Executive Summary

***"Imagination is more important than knowledge. For knowledge is limited to all we now know and understand, while imagination embraces the entire world, and all there ever will be to know and understand."*, Albert Einstein.**

The Mother Earth is facing sets of serious problems, and as the time goes on, they tend to be more and more intense. For example, global warming, excessive population, lacking of natural resources due to the massive destruction of rainforests and jungles, ocean pollution…, these crisis make the Earth no longer a suitable place for us to live in. Ironically, the issues are mostly caused by humans, ourselves.

For the purpose of finding a new place for us to maintain our existence, and changing the strong possible destiny of the current apocalyptic situation facing humanity, we came up with the idea of Yggdrasil, a giant long-term living space with spiral structure which contains all that humanity needs. The physical structure, environmental systems, human factors, supporting systems as well as the operations were all fully considered and Yggdrasil was designed specifically for meeting humanity's physical and mental health. There are facilities that are made especially for some certain groups of people to fulfill our purposes of creating a community like Yggdrasil.

Yggdrasil should be a connection for all mankind, and that is one of the reasons why this name was taken from Norse mythology. The goal is to ***survive*** even after the Earth is no longer habitable. To achieve this, humans need to unite with each other without bias and distrust towards one another. Furthermore, to ***increase living quality*** and to ***ameliorate the disadvantages***, the following will be addressed:

Survival mechanism
- Artificial gravity
- Day and night regulation
- Water cycling
- Energy from the sun

Necessities
- Water
- Sunlight
- Nutrition
- Air
- Purveyance
- Medication
- Supplies

Entertainment
- Low-gravity areas
- Exercise areas

- Sound and light stimulation
- Humanities and art
- Library

Types of Government and Economy

- Capitalism
- Socialism
- THE THIRD WAY

In the end, more coherent and joint efforts are needed and our model proposed in this project is expected to make contributions toward this direction of the permanent survival of humanity. It is important to synthesize a great number of such studies across a wide range of contexts in order to build up a professional knowledge base to better inform all the opportunities and challenges in space settlement. What we suggest is that mutual collaborations and cooperations in various fields should be paid attention to. With the highest respect to our only planet, Earth, it is hopeful for us to find an appropriate home elsewhere in the future.

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1.2: Acknowledgements

Firstly, we would like to thank especially to NASA Ames Research Center, the National Space Society, and the San Jose State University for conducting this contest that enables high school students like us who are in love with the outer space, to create a new homeland for humans, a world beyond our imagination. Secondly, big thanks to Mr. Chung-Hsien Weng and Mr. Eion McPherson as our supervisors throughout the whole investigation and writing time. Because of their instructions on both the science and the English writing part, this project could be formed at the end.

To bring this to an end, we are grateful to all the researchers, scientists, economists, and sociologists who contributed to the related fields of this project, as well as the improvements of human society.

1.3: Why Yggdrasil?

Humanity is always trying to break through the many difficulties we are constantly facing, at the same time challenging both the knowns and unknowns. We almost can see the future of the Earth, or at least realize the earth is no longer an appropriate place for the humans to solely live upon. Extreme weather, severe pollution, arctic ice melting, the destruction of the ozone layer hole and so much more disasters made by human beings are all hurting the mother earth. If we do not want to be extinct, then finding a new home seems to be the only choice.

Although scientists have proven the possibility of founding a new habitation on other planets, like Mars, there are still endless problems need to be discussed. Under this condition, building a living place on the space track is no doubt a better choice, for the uncertainties is expectable and predictable.

That was how we got the idea of this name. The whole design for this space shelter is like a tree, including the trunk and the branches, meaning the cooperation between mankind, and the support for all the lives and hopes. With the sight of Yggdrasil, the tree symbolizes clean energy and sustainable development, which remind us of learning from our mistakes that the effects of excessive greenhouse gases on the environment. The CO2 emission, which is the main cause of global warming, reach the peak in 2018, as shown below.

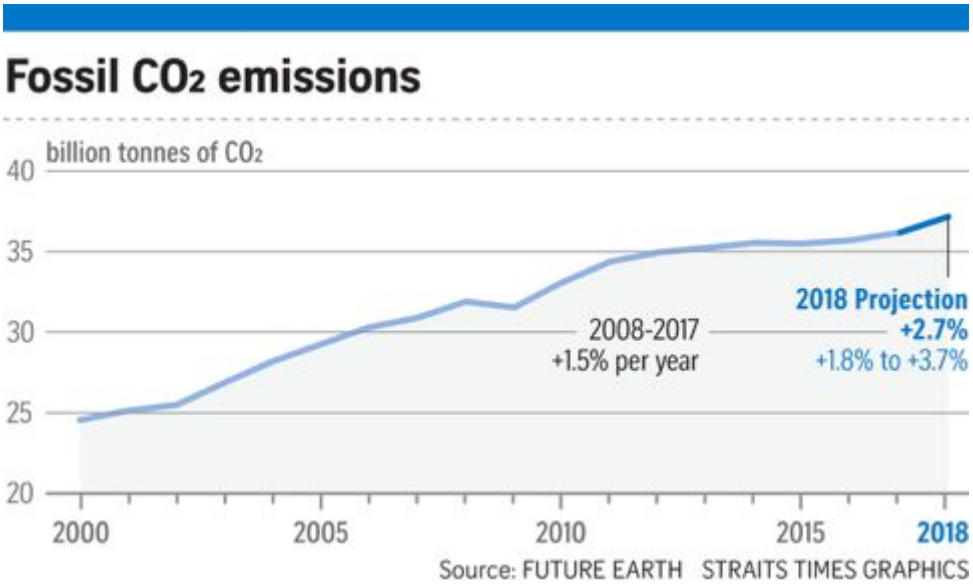


Figure 1, The amount of fossil CO2 emissions
https://www.straitstimes.com/world/study-global-co2-emissions-to-hit-record-in-2018

From the perspective of design and function, it is just like Yggdrasil, an immense mythical tree that connects the nine worlds in Norse cosmology. In the world of Norse cosmology, Yggdrasil is the center to the cosmos and considered very holy. The branches of it extend far into heavens, which represent our goal of founding a better world. This idea came in our minds as we were discussing the name of our project and the new home for humanity. We, the seven teammates were from different classes and we hardly knew each other before joining this contest, just like the different worlds in the Norse mythology. As we started digging into the mysteries of outer space, creating a world which is built exactly in a way that we desired, including our expectations for our current society, finding problems with our design, and then figure out ways to solve them. The result did not come easily though. During the process, sometimes we had conflicts over one issue and that really forced us to think back from the beginning, then present our ideas and the reasons behind it to the teammates. We all knew the contest is tough, and which demanded much time and effort. What we can be proud of is that we have done, how we overcame what we thought was impossible, and within it, we put in our dreams, and improvements that can be made in the existing system. The process of researching, writing, discussing, and decision making, transformed the whole project into an overwhelming experience.

It is now more than just pages of papers, instead, it is series of memories that we made together, and we hope we can pass this feeling on to all humans through the naming of Yggdrasil, uniting everyone as one.

1.4: Purpose and Mission Statement

- ***How did we come to take part in the NASA Space Settlement Contest?***

Seven high schoolers, seven brains, one dream. That was how we met in the first place and decided to do something different. We care about human's future and are fascinated by the possibilities of space settlement! Though we aren't the smartest, nor do we know everything, but we are brave enough to explore, to learn, and to top it all off, we are willing to take action!

Part II: Physical structure, Private Habitation Facilities (PHFs)

2.1: Location

- **The cycling orbit**

"The Cycler system alters the philosophy behind a Mars program. It makes possible the dream of regular flights to the Red Planet and a permanent human presence there. That's the only way we'll ever succeed in taking mankind's next giant leap: a subway-in-the-sky between our planet and our future second home." Buzz Aldrin – Popular Mechanics, December 2005.

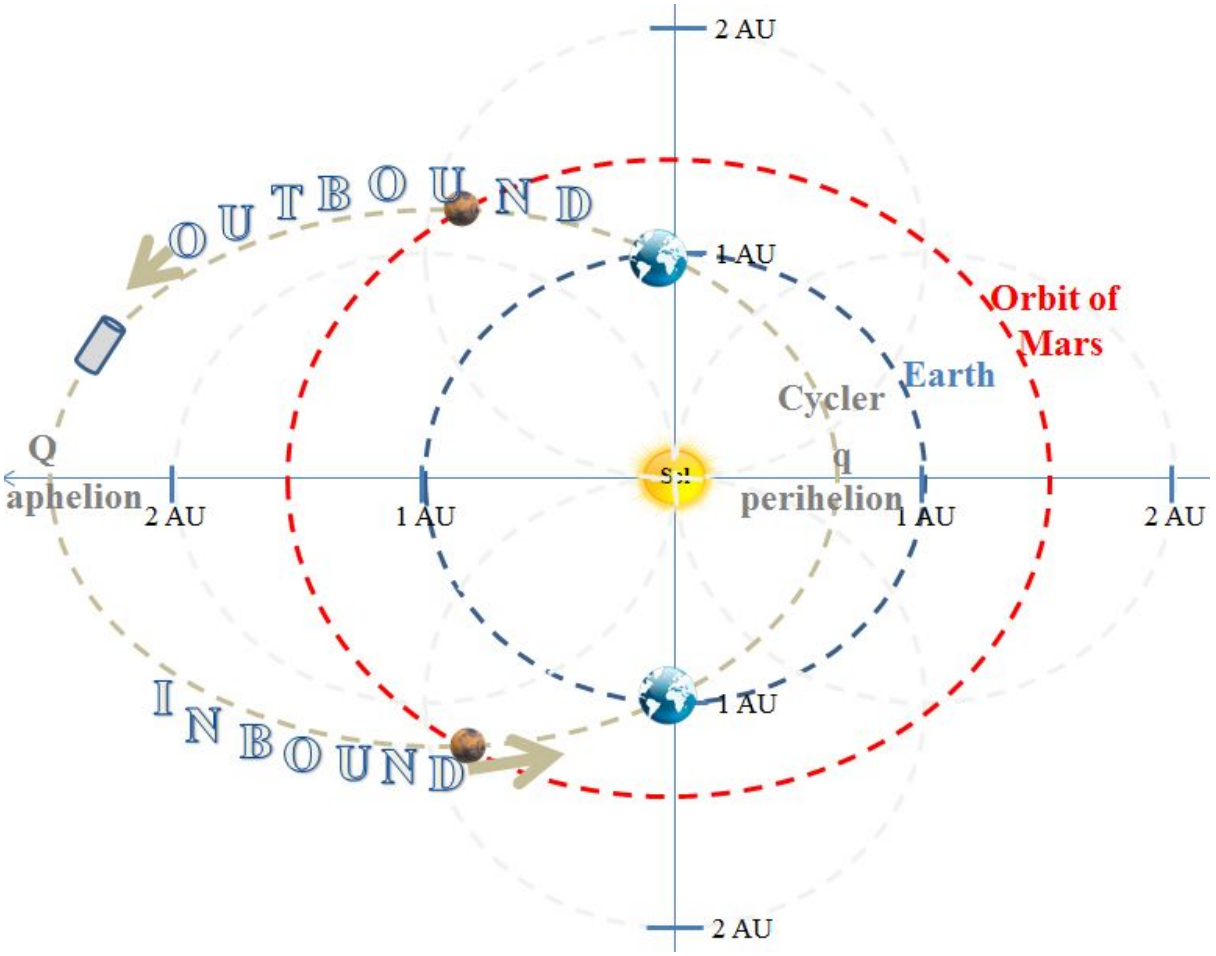


Figure 2, The Aldrin Cycler's trajectory

- https://3.bp.blogspot.com/-1NjQUwRBZJQ/Ucqr6a8LXgI/AAAAAAAACYA/5NLBk7ojXRs/s1600/CyclerOrb6.26.13.png

Aldrin improved his orbital rendezvous expertise and made it possible to travel to Mars and get supplies from Earth. He adapted the cycling orbit concept and applied it to human missions to Mars.

Aldrin estimated the positions and movements of the Earth and Mars exactly, which enables Yggdrasil to travel on the gravity-assist trajectories over and over again. The cycling system of Aldrin's system contributes to the lower requirement of fuel when it comes to traveling to Mars, and it needs only with an expected time around five and a half months to finish the journey from Earth to Mars. The slow rotation of the spacecraft is the feature of the Aldrin Cycler, and it is designed to create artificial gravity to prevent the danger of osteoporosis and muscle loss during long trips under a weightless state. Every time when the Aldrin Cycler's trajectory vacillates by the Earth, a smaller Earth-departing interceptor spacecraft departs crew and the goods to dock with the Cycler spacecraft. Finally, the Aldrin Cycler system provides a long-term way which can be reused to travel to Mars.

2.2: Structure

We have two spirals as living spaces, in which the outer ring has a radius of 12000m and the inner ring has a radius of 9000m. The rotation speed of the two spirals will be the same, which means that the artificial gravity generated by the outer ring will be heavier than the inner ring. We intend to let the elderly or those who have difficulty supporting their own bodies stay in the inner circle, which will alleviate their burden due to the fact that the gravity there will be less than 1G. All the structure mentioned above is shown as the following figure. We have designed a shelter for our long-term journey in space. It consists of a main trunk in the middle, holding up the community. With several ring-like tubes winding around, all of the detail designs and distribution based on these ”slides”. The main trunk is the headquarter of the whole structure, every transportation starts from here. In order to make sure the conveyance won't be obstructed, there will be elevators in different directions, not just only up and down. If you want to travel faster, space shuttle is also available. More than a transportation center, it is also a capital, the heart of this space shelter. As for the tubes surrounding it, they are all specialised for different purposes. For instance, food area, amusement park, library, residential area, government departments, etc.

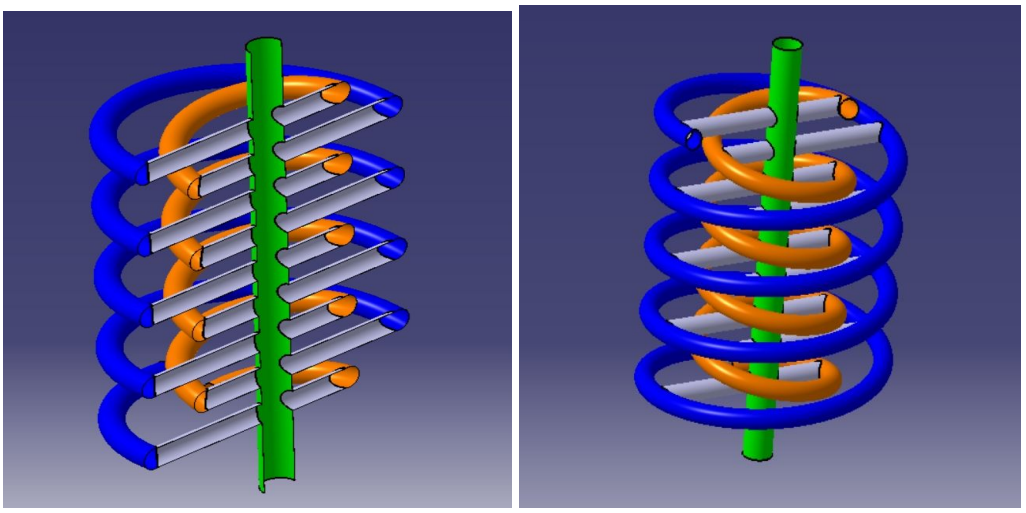


Figure 3,4, The outside structure of Yggdrasil (Longitudinal section)

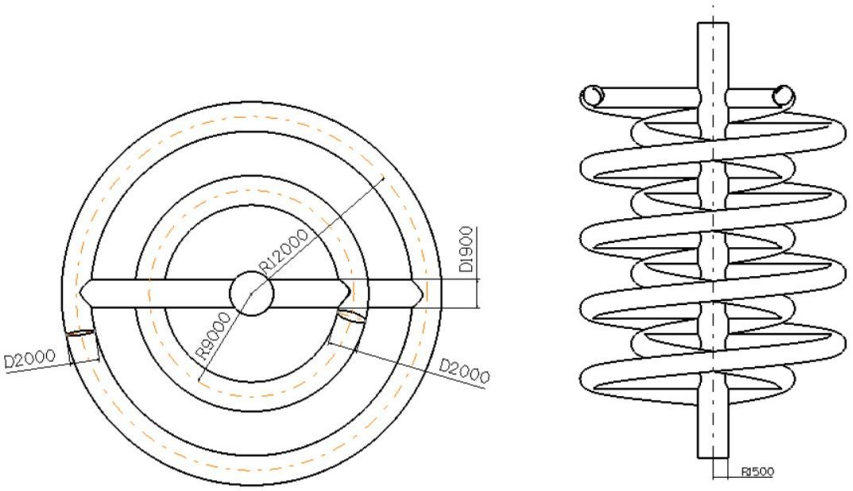


Figure 5,6, Carrier Main Structure and Interior Space Design

1. Carrier Main Structure:

   We intend to use the heat pipe as the main material for the outer shell of our spaceship. The heat pipe is a device that can quickly transfer heat energy from here to there. It is to add water or liquid such as ethanol to the hollow metal pipe to maintain the temperature. Due to the excellent thermal conductivity and a small amount of heat loss , heat pipe can adapt to the great temperature difference between the Earth and outer space. The heat pipe has the advantages of small mass, simple appearance, no moving parts, simple connection with other instruments, durable and reliable, and good sound insulation . In the weightless , its adaptability is amazing, and many people in the space engineering community pay attention to it. In the fall of 1965, Explorer 36, which was launched by NASA, had used heat pipes as heat transfer devices. We

think that installing solar panels on the outer casing of the spaceship can directly convert solar radiation into the energy needed inside the spacecraft. In this way, it not only solves the problem of space radiation, but also solves the problem of insufficient energy in the spaceship.

2. Interior Space Design:

At the forefront of the spacecraft is the cockpit, which contains a temporary rest area for driving, a bathroom, an instrument that controls the direction of the spacecraft and communicates with the personnel on the spacecraft. Immediately behind the cockpit is the office of the important crew like the energy management room, the waste disposal room, as shown in the following graph.

Figure 7, Inside the ring-like tubes(residential area)

- https://settlement.arc.nasa.gov/70sArt/AC75-1086-1f.jpeg

In this way, the crews can receive instructions in a timely and quick manner. With regards to public spaces, there are bars, restaurants, cinemas, electronic libraries, gyms, public toilets, small hospitals, etc.

2.3: Internal PHFs distribution

These public spaces are equipped with life-saving equipment in case of emergency. Next, it will be everyone's room (with their own bathroom equipment), the floor is squatable for storage, and the room of the important crew will be placed between the passenger's room if there is an emergency. It will be guaranteed if there is an emergency. At the end of the spacecraft the engines and fuel are placed, mainly

to supply the power needed for the entire spacecraft to move forward. There are pipelines delivering fuel, remotely operated from the bridge.

2.4: Internal cargo transportation

Since our space colonies use a rotary centrifugal force to obtain artificial gravity, the outer circle gets more gravity. Conversely, the inner ring gets less gravity force, because the innermost axis is at the center. Close to the center of the circle, the centrifugal force obtained is almost zero, and the cargo in the middle will be in a state of weightlessness. If you want to carry out the work of transporting the goods, first store the goods to the shaft cargo holds, making use of the characteristics of the weightless state, as long as the goods do not require gravity. The thrust allows our ship to travel a considerable distance, compared to mounting cargo on the outer ring. This method saves a lot of energy for goods that need to travel longer distances.

2.5: Artificial Gravity

Here is the calculation for manufacturing the speed required to be equal to the Earth's gravity.

the outer:

$R \times \omega^2 = 9.8\ m/s^2$

$R = 12000\ m$

$\omega = 0.029\ rad/s$

the inner:

∵The rotation speed of the two spirals are same

∴$\omega = 0.029\ rad/s$

$R = 9000\ m$

$g = r \times \omega^2 = 7.35\ m/s^2 = 0.75\ g$(Earth's gravity)

2.6: Propulsion

We use the Ion Propulsion engine, which has the advantage of reducing weight and solar energy for everyday use in spacecraft. The principle is to install a nuclear fission system inside the spacecraft to generate electricity, and then ionize the helium atoms to release electrons and eject positively charged ions. The disadvantage is that electrical neutrality and acceleration are very low. It takes weeks or months to reach the maximum speed, but the specific impulse of this type of engine is very large and can reach very fast speeds.

Part III: Environment Systems

- Day and night regulation

  The pineal gland is a conical region of the human brain that secretes serotonin derivative melatonin. This hormone emanates through the nerve cells of the lower nucleus of the hypothalamus. The working principle can adjust the day and night time difference and season conversion. Ancient Egypt, Descartes, and even today's Stanford University, the US government, and the former Soviet government have all been betting on the pineal gland to illustrate its importance in human functioning.

  Sunlight is the setting factor of the biological clock. In other words, it is the spring that starts the biological clock. Therefore, human beings have developed the principle of living in the "sunrise and sunset", which proves that day and night are complementary. In the space of non-earth environment, we must maintain a suitable light cycle to protect the health of crew and passengers.

  It is possible to manufacture day and night effects by using man-made fiber curtains with better shading. The man-made fiber curtains are easy to wash and have a hard texture. Durability is a major feature.

3.1: Water

Under the condition that human will stay in the outer space forever and not considering to come back to earth to get supplies, bringing water directly from earth to space is barely feasible due to the massive cost and low efficiency. To stay hydrated, the ideal way is to find water sources in the space and reuse it constantly.

Scientists claim that water is prevalent throughout the universe, or at least those parts we can explore. According to astronomical research, water can be found on comets, asteroids and some planets, although it is mostly in the form of ice, we can still collect it and use the system on the spacecraft to make it useful for the human consumption.

Water can also be recycled from urine, sweat, respiration and any other used water of the crew using a special technology called Water Recovery System (WRS), which is highly efficient, given that more than 85% of the waste can be recovered as water. To recycle the water, the waste will first be collected to a distillation assembly, where it then spins to create gravity that pulls the non-water material to its walls, therefore separates the water and the waste. Secondly, the assembly will be heated

up in order to evaporate water, those water vapor will then be condensed in the outer chamber to form distillate. After this process, the fresh water is pumped to a tank where all the recovered water gathers, then be pushed to a separator to isolate the odorous gas from the liquid.

The water then moves to a filter and goes through adsorbent and ion exchange media (a process which removes dissolved contaminants). Next, it is treated by a reactor at 131℃(267℉), the reason for it is to get rid of all the organics and microorganisms. Iodine is added into the recycled water for microbial control at the final step. Then the processed water is transported to a checkpoint, where clean water is stored for the crew to reuse, while contaminated water is sent back through the process again.

3.2: Food

Due to the lack of water resources in space, the planting method we use is drip irrigation. Although this method has higher initial cost, it can reduce the loss of fertilizer, nutrients and water. Because the amount of water is not much, it can also reduce the growth of weeds. The water is controlled by the output of each nozzle, and the uniformity of distribution is high. It also keeps the leaves dry and reduces the risk of disease, and the labor cost is lower than other irrigation methods. In the lighting of plants, we decided to use LED lighting, because only by adjusting the wavelength of the light, the growth of the plant can be controlled. When the light intensity reaches a certain peak, the green plants will perform photosynthesis to generate oxygen at the highest rate.

Wolffia Arrhiza, the source of protein we intend to use after boarding Yggdrasil is rootless, and it is the smallest plant on Earth. Furthermore, it has high nutritional value. The starch in it is as high as 50%, and the protein content is equivalent to that of soybeans, reaching 40%. In addition, the breeding speed is fast. Under its optimal growing condition, it doubles its number in forty-eight hours. It can also be used as source of nutrition for fish and other aquatic organisms.

Figure 8, Wolffia Arrhiza

https://www.foodnext.net/news/newsnation/paper/4739565650

Meat Resources

- Artificial meat culture

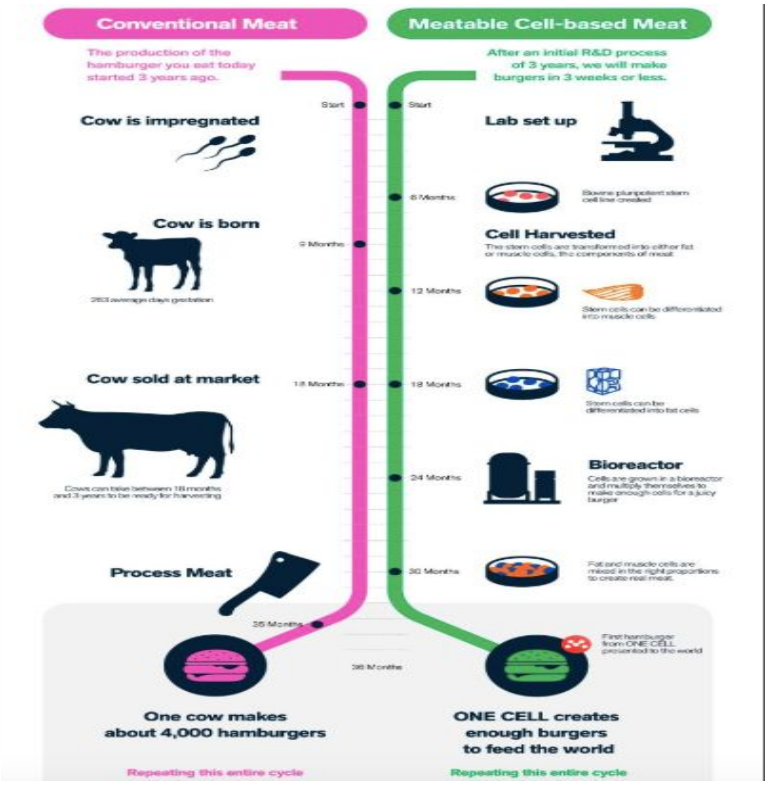
A Israeli startup Aleph Farms as well as Meatable from Netherlands have both successfully used bovine cells to produce a structurally complete artificial steak in the laboratory. This is the first meat that has been grown in vitro, and has the muscle texture of traditional meat. Many kinds of artificial meat produced are all derived from bovine embryos, which are fetal bovine serum (FBS) to replicate more animal cells. However, Meatable is a pluripotent stem cell that can be converted into any type of animal cell without serum, such as muscle and fat cells.

We will utilise the fetal bovine serum cells mentioned above to cultivate artificial meat, so that even if the livestock breeding program cannot be implemented, humans still have access to meat.

Animal Breeding

Because most animals are unable to bear the stresses of the spacecraft's ascent and descent and will suffer from high stress, we will use frozen egg technology to freeze the fertilized eggs of animals, thaw the eggs in space, and then use artificial uteruses and wombs to nurture the embryonic lifeforms through their fetal development. After the birth of the creature, we will produce biofeeds in the spacecraft to supply the bio-food source, a small amount of pasture and plants, and provide some moisture and dietary fiber.

Figure 9, The company Meatable's way of meat culturing



- https://cdn-a.william-reed.com/var/wrbm_gb_food_pharma/storage/images/media/images/meatable-graphics/8659298-1-eng-GB/meatable-graphics.jpg

3.3: Nutrition

Apart from water and air, we certainly need nutritions to keep our bodies working. As we all know, humans especially need a lot of different kinds of vitamins, like vitamin A, D, B, but how do we get these vitamins from?

1. Vitamin A

We mainly get vitamin A from cod liver oil, beef tallow, red and purple vegetables. We can plant those plants or raise the animals on our colony.

2. Vitamin D

Vitamin D from the other hand comes from cod liver oil, dairy products, fruit, and ultraviolet light. In space, we can take advantage of ultraviolet light the sun provides to illuminate our skin, so that the body can make vitamin D itself. Unarguably, vitamin D can be extracted directly from the certain plants and animals.

3. Vitamin B_3

In the light of the new experiments by researchers funded by NASA, vitamin B3 may be made on cold dust granule in space, and then be brought to the Earth by meteorites or comets. Vitamin B3 is used for the construction of nicotinamide adenine dinucleotide, called NAD for

short. NAD is vital to metabolism. This result supports the theory that the origin of life may rely on the supply of important molecules of biologically produced by space and brought to Earth by the impact of comets and meteors.

4. Vitamin B group

Group B refer to B1, B2, B3, B6, and B12. We derive them from meat, green vegetables, and quinces. We can extract group B from the mentioned ones above to make healthy food for our citizens.

5. Vitamin C

The greatest known vitamin C can be consumed through many things, for example, citrus and vegetables.

Food is one of the key factors in maintaining vitality. It allows our bodies to produce heat, and in this way, to have the energy for daily activities. Thus, how to find a food supply system that can sustain development in space has become the biggest problem here we're facing.

（1）Storage:

Current space foods are mainly canned and bagged. There are two reasons for this: First, because they are small in size, easy to carry, and do not take up space. Astronauts only need to heat them or add water when they eat. Second, because real cooking in weightlessness is a large potential risk due to fire, the foods that are carried are pre-cooked foods. Vacuum packaging reduces the chances of bacteria being present in the food. Additionally, the deliciousness of the food is also very important. This is not enough by cooking techniques and food technology. This means that there is a vast difference between the taste of space foods and Earth foods. This can be seen from the perspective of the eater.

（2）Taste:

The astronauts have just arrived in space and need a little time for the body to adapt. Because of the lack of gravity in space, the way in which body fluids flow will be different. It will flow from the core of the body and the limbs into the head in a way that has never been seen on Earth. It feels like hanging on the head and feet for a while, but doing so is still impossible to achieve in a zero gravity situation. Astronauts usually feel what they call "Charlie Brown face", that is, the face becomes swollen by excess fluid. It not only makes astronauts look silly but also causes a stuffy nose, making astronauts unable to taste the flavor of food. They

can taste the five basic flavors as well, but the aroma is greatly reduced, so the food is not delicious enough. Astronauts have repeatedly reported that eating in Earth's orbit is different in taste than on Earth. Usually they will say that the food in space is not tasty. This is because space meals reduce the amount of sodium. Ingesting high levels of salt in space can cause body water retention and other health problems. When the new ultra-low sodium food developed by Mattson is launched into space, the salt will be lowered to a lower level, meaning that the taste is lighter and the volatile molecules released by the salt is fewer. It is the most important that space food is healthy and delicious.

（3）Farming:

The space food will run out one day even though we will bring much to our space colony . At present, most of the scientific researchers of space food focus on how to package and flavor, and rarely study food systems that can be continuously developed in outer space. However, in space, the sustainability of food is not impossible. In the movie "The Martian", the marooned astronaut Mark Watney uses the water produced by the combustion of hydrogen and oxygen to grow potatoes. In addition to potatoes, soybeans, wheat, peanuts, dried beans, lettuce, spinach, tomatoes, herbs, carrots, cabbage, and rice are all plants that NASA believes will be the most promising for use in space in the future.

If we want to grow food in space, the necessary conditions for survival will be the same as on Earth, with sufficient sources of sunlight, gravity, air and water (this section will be detailed in other paragraphs of this article). Obviously, the challenges we face will be more complicated. This is because in space we have to overcome unique challenges and are not aided by advantages that are taken for granted on Earth. Planting food in outer space is not easy, but humans will not give up. We are working hard to move toward a greater, more daring goal.

3.4: Gas

Electrolysis of water is the primary way of oxygen synthesis. In this process, water is split into oxygen (O2) and hydrogen (H2). The oxygen is

emitted into a cabin which is a breathable air system, known as the Oxygen Generation System, while the explosive hydrogen is excluded and released outside of Yggdrasil. The crew can also get oxygen chemically from lighting up Solid Fuel Oxygen Generation (SFOG) canisters comprised of lithium perchlorate. Each of them provides the amount of oxygen that a crew needs for one day.

3.5: The Sun

All the nutrients, minerals and vitamins we ingest have their own unique energy absorption spectrum. The energy generated by the wavelength in the sun can penetrate the skin, enter and interact with various chemical substances and minerals in the body, assist in the synthesis of essential components and nutrients, and the decomposition of various types of waste excreted by the body. The ultraviolet light in natural sunlight is a necessary condition for the body to absorb calcium. At the same time, sunlight can also improve children's attention and improve muscle energy.

Ultraviolet A in the sun also helps lower blood pressure. Studies have shown that allowing the tester to be in the UVA lamp chamber can release nitrus oxide from the skin and relax the blood vessels for 30 to 50 minutes. Therefore, scientists have predicted that long-term absorption of UVA can lower blood pressure. Humans can get vitamin D from UVB through the sun, and the amount obtained is much more than 6 tablespoons of cod liver oil or 200 eggs. If the body lacks vitamin D, it will cause cartilage to weaken, so more sun exposure can reduce the occurrence of cartilage weakening.

Sunlight is also associated with serotonin, which affects human emotions. Experiments have shown that subjects who have less sun exposure have a serotonin and receptor combination that is two to three percent less, which in turn causes a depression. Therefore, more sun exposure can reduce the incidence of depression.Melatonin helps people fall asleep, and when the brain senses the sun, it stops secreting until 14 to 16 hours later. So the controlling of the sunlight time helps to adjust the physiological clock. According to our circular orbit, almost all of our tracks can be sun-baked, but the sunlight we receive on the ship is inversely proportional to the square of the distance, so there may be insufficient sunlight at the far end of the orbit. When the sun is not enough, we will replace the sun with LED lights.

RayVio's 293 nm UV LEDs produce vitamin D3 more efficiently than sunlight in skin samples. Dr. Holick, a professor of medicine, physiology and biophysics at Boston University School of Medicine, tested UV LEDs from different sources and wavelengths. RayVio's 293 nm LEDs have the potential to produce vitamin D3 in the shortest possible time, using target wavelengths. LEDs can cause specific biological

effects in humans to help treat and prevent chronic diseases. Without the protection of the atmosphere and the Fan Ai wheel, if it is directly exposed to the human body, the solar wind and cosmic rays will directly affect the human body, so we will close the whole cabin and set up UV lamps in the cabin to make the UV light Bright, so the body can supplement the sun needed.

3.6: Resource allocation

Jamal Meattle had delivered three green plants, Areca palm, Mother-in-Law's Tongue and money plant, can make the air we need aboard our ship. After watching the TED video of Meattle's speaking, we want to put the genes that they can make into the bacteria, so that the bacteria can make air. These kinds of bacteria will be kept by the state, and the proper amount of bacteria will be released in the colonies every day to fix the amount of air needed by people.

Figure 10, Indoor plant

- https://lifehacker.com/three-plants-that-give-you-better-indoor-air-5149643

2. Water resources

There are three types of water resources: domestic water, industrial water, and agricultural water. Domestic water will be delivered daily through each household's pipeline. It must be registered with the government before applying for water, avoiding the existence of the people who lack household registration.What's more,the government will limit the amount of water that households can apply to promote the concept of cherishing water resources. Industrial water is transported to various factories through pipelines.At the same time, it will also assess the amount of water required by each factory to limit the amount of water that can be applied by them. Part of the agricultural water is distributed to the farmer, and the rest is handed over to the state for watering street trees to create a green space colony.

TABLE 1
PREVALENCE OF UNDERNOURISHMENT IN THE WORLD, 2005–2017

	Prevalence of undernourishment (%)					
	2005	2010	2012	2014	2016	2017[1]
WORLD	**14.5**	**11.8**	**11.3**	**10.7**	**10.8**	**10.9**
AFRICA	**21.2**	**19.1**	**18.6**	**18.3**	**19.7**	**20.4**
Northern Africa	6.2	5.0	8.3	8.1	8.5	8.5
Sub-Saharan Africa	24.3	21.7	21.0	20.7	22.3	23.2
Eastern Africa	34.3	31.3	30.9	30.2	31.6	31.4
Middle Africa	32.4	27.8	26.0	24.2	25.7	26.1
Southern Africa	6.5	7.1	6.9	7.4	8.2	8.4
Western Africa	12.3	10.4	10.4	10.7	12.8	15.1
ASIA	**17.3**	**13.6**	**12.9**	**12.0**	**11.5**	**11.4**
Central Asia	11.1	7.3	6.2	5.9	6.0	6.2
Eastern Asia	14.1	11.2	9.9	8.8	8.5	8.5
South-eastern Asia	18.1	12.3	10.6	9.7	9.9	9.8
Southern Asia	21.5	17.2	17.1	16.1	15.1	14.8
Western Asia	9.4	8.6	9.5	10.4	11.1	11.3
Central Asia and Southern Asia	*21.1*	*16.8*	*16.7*	*15.7*	*14.7*	*14.5*
Eastern Asia and South-eastern Asia	*15.2*	*11.5*	*10.1*	*9.0*	*8.9*	*8.9*
Western Asia and Northern Africa	*8.0*	*7.1*	*8.9*	*9.3*	*9.9*	*10.0*
LATIN AMERICA AND THE CARIBBEAN	**9.1**	**6.8**	**6.4**	**6.2**	**6.1**	**6.1**
Caribbean	23.3	19.8	19.3	18.5	17.1	16.5
Latin America	8.1	5.9	5.4	5.3	5.3	5.4
Central America	8.4	7.2	7.2	6.8	6.3	6.2
South America	7.9	5.3	4.7	4.7	4.9	5.0
OCEANIA	**5.5**	**5.2**	**5.4**	**5.9**	**6.6**	**7.0**
NORTHERN AMERICA AND EUROPE	**< 2.5**	**< 2.5**	**< 2.5**	**< 2.5**	**< 2.5**	**< 2.5**

[1] Projected values.

Figure 11, Prevalence of undernourishment in the world

- http://www.fao.org/3/I9553EN/i9553en.pdf

3.Food supply

According to the World Food Program, about one in nine people in the world are still hungry when sleeping. In the light of the chart of Food and Agriculture Organization of the United Nations (FAO), the proportion of undernourished people (PoU) has been increasing year by year in South America and Africa. It is several times higher than North America and Europe. These show the problem of uneven distribution of food in the world, and we do not want this problem to occur in this space colony. It will ensure that all food is distributed evenly to supermarkets everywhere, and control the price of food , so that the poorer people can afford it, while also protecting the profit of farmers, and then through various safety tests to ensure the safety of food.The same policy applies to restaurants and every household in the space colony. There is an extra charge if you leave leftovers to encourage people not to waste food. Food banks will be set up everywhere. If residents have food that they accidentally buy, they can be placed there and sold to others at a low price, and the revenue will be classified as a national treasury.

4.Land

First, the land is allocated to the national residents by households, and then the land is distributed for state-owned enterprises, including entertainment places, schools, etc. The rest of the land can be regularly bidding by every resident or company. Besides, the land is freely traded except for state-owned land.

3.7: Medication

We will introduce common medicines when we board the ship. For example: acetaminophen and aspirin painkillers, stomach medicines, cold medicines, etc. Then set up the Pharmaceutical Research Institute and the Living Medicine Laboratory. The Institute of Medicine specializes in the development of new drugs, vaccines, and the side effects of new drugs on humans. The Living Medicine Laboratory is a small unit under the Pharmaceutical Research Institute. It is responsible for the side effects, genetic recombination, and continuous development of new drugs for chronic diseases.

- Health care

  Before leaving the earth, it is appropriate to produce medical equipment and order system to reduce the environmental pollution caused by mass production.

- Equipment

  We will bring some health checkups and some common medical equipment to the spaceship, and train the maintenance team on the ship and establish a medical equipment production line.The development of modern science makes life in space no longer a dream. We discussed the problems encountered in space and its scientific solutions.

- Patient placement

  Small hospitals and medical centers will be set up, and they are divided into emergency departments and wards. The emergency department is divided according to the severity of the patient's injury, and at least 5 doctors and 5 to 7 nurses are assigned in each district, and it is stipulated that it is not possible to cross the district, thus reducing some medical disputes for delayed treatment. Part of the ward is divided into divisions, and each department nurses are evenly distributed. There is no special reason for the hospital to be dispatched, so that the nurses in each ward can be balanced, and the uneven distribution of nurses can be improved.

- Medical personnel

  We will establish a medical teaching building on board to train various medical personnel. For example: pharmacists, doctors, physiotherapists, etc., and the main focus is on internships and basic introductory knowledge to nurture future medical talents.

3.8: Waste

The water can be recycled from urine, sweat, respiration and any other used water of the crew using a special technology called Water Recovery System (WRS), which is efficient that more than 85% of the waste can be recovered as water. To recycle the water, the waste will first be collected to a distillation assembly, where it then spins to create gravity that pulls the non-water material to its walls, therefore separates the water and the waste. Secondly, the assembly will be heated up in order to evaporate water, those water vapor will then be condensed in the outer chamber to form distillate. After this process, the fresh water is pumped to a tank where all the recovered water gathers, then be pushed to a separator to isolate the odorous gas from the liquid. The water then moves to a filter and goes through adsorbent and ion exchange media (a process which removes dissolved contaminants). Next, it is treated by a reactor at 131℃ (267℉), the reason for it is to get rid of all the organics and microorganisms. Iodine is added into the recycled water for microbial control at the final step. Then the processed water is transported to a checkpoint, where clean water is stored for the crew to reuse, while contaminated water is sent back through the process again.

3.9: Excretion

（1）Excretion

Excretion is divided into urine and feces. The process is the same as what was mentioned in subtopic 3.8. We will take some manure to compost for planting fruits and vegetables, and the rest will be decomposed by an insect called black otter. This insect can feed on livestock manure, and its body is also a high-value animal protein feed. After death, it can be eaten by animals raised on the spacecraft.

（2）Garbage Disposal

We intend to unify the containers into compostable plastics. This kind of plastic does not contain traditional plastics and become organic, carbon dioxide and water after decomposition by microorganisms.

（3）Corpse Treatment

We think of three methods for corpse processing: sealed storage, burial in space and frozen crushing. However, space journeys are long-term travels because the cosmic rays of space will cause the rot to accelerate, so the first method is less suitable. The second method is also an option, but the garbage or objects floating in space have other impacts. The danger of spacecraft, if the astronaut's body is abandoned in space, it is likely to float with the planet's orbit and hit a satellite or space station. Finally, we chose the third method "frozen crushing." The robotic arm will let the body float in the large sealed bag outside the cabin. After a few hours, the

body will be completely frozen, the robot arm will vibrate strongly, and the body inside the bag will become broken into powder. In this way, it will not only reduces the weight, but also makes the time of preservation longer.

Part IV: Human Factors

4.1: Governance

1. The Necessity of Having Government

In space economics, the first question we have to face is whether to establish a government, and to discuss the significance of having a government in space. After a long analysis, we have decided to set up a government. Because no matter what kind of economy we take, if there is no government in control, it will easily lead to economic collapse or inflation by some people on purpose. Second, if there is no government that regulates the people in the group, the society will become a mess and unable to operate smoothly.

2. Government system

a. Capitalism V.S. Socialism

In the twentieth century, how a government works or what principles it follows can lead to varied results, and it is those results that affect a nation's development and their process of improvement. Our team thinks that whether we adopt from Socialism or Capitalism, which are the two main doctrines that have been adapted throughout centuries and are still be using commonly among current times, will not fit the brand new world we try to create in space. In the light of this, we decided to combine the two and get the biggest advantages out of them. But since starting up a new government system is not an easy thing to do, we will have more Socialist policies than the other in the beginning years to keep the running in control, and when the time goes by, more Capitalist policies will join and may surpass the Socialist ones in number. However, it'll all result from how fast our new world grows or which direction it leads to. Super mysterious, but it is also excited to see it happen.

- Capitalism
  - We allow people to possess their own fortune and anything they bring with them from Earth home. That is the way we want to appeal them to go to space with and the way to show our respect, and win their trust.

- Socialism
  - We will control the amount of salary they get each month due to their workload and how much they contribute to society, since creating jobs for people is the first thing we have to deal with for our economic

development's good. Through this, we can encourage people to push our world's economy and development.

- ➢ We will put our daily routines into a healthy, fair, and flexible schedule for everyone on this spaceship to follow. How things work is definitely different up there in the space, included the influence on human bodies, we need to get people to adapt to the space life as soon as possible by scheduling routines for them. As for how long this will last is going to depend on the real situation once we for real put our huge project into action and make it come true.
- ➢ Our government should have more power on deciding vital things like waging wars on potential invaders if necessary, setting up rules to tax, deciding which laws to pass immediately, and so on. In order to quickly have this vast society under control. And again, this will be temporary. Our goal is to create a free and comfortable atmosphere for this brand new world.

b. Conclusion

Elon Musk, the founder of Tesla, vowed to conquer Mars in the next 30 years, and it is undeniable that the future of mankind is going to be developed in farther and greater space. But even if we already have advanced technology into outer space, there are still some social problems that must be solved. Therefore, the theme for this article will be space economy, which affects the whole in a most critical way.

To be honest, this is a brand new field to not only us, but also to every one who dares to dream big. There is very little information on the Internet, because the space missions currently are mainly focus on short-term. As for long-term space travel, even space colonization is the goal for all of us humanity to pursue. However, the length of time affects how we plan it, and the actual situation of the two is completely different. For example, things to consider about for short-term plans are not that comprehensive compares to the long-term one. The reason is clear and simple, it doesn't need it. It is just a small group of people living together, all the necessities don't have to be circulated through the transaction, because they are already well-prepared on the earth. But things will be far more complicated if we want to live in space for permanent.

The first problem encountered was the government system. What is the most ideal way for government to conduct in order to manage the people successfully? Is it possible to move the existing conditions on Earth directly into space? Capitalism and socialism are clearly the two basic choices we have. But when we try to imagine and project our vision to the entire space society, you will find that it is absolutely impossible to rely on any kind of system alone. For example, the four essential necessities, which are food, sunlight, air and water, are not free to sell on the market, because there are bound to be many people who cannot afford to buy them because of poverty, or are manipulated by the minded businessman. If there is no right to live, it

will lead to a riot of the poor, then the space system we work hard to built will be destroyed. Another example is real estate. The habitable land in space is very limited, It is as important as water. If there is no good distribution of land on average, where should the homeless people live? In addition to this, the government must ensure that everyone has a job to do. The space base is limited, which means we can not accommodate any useless. There are also some non-monetary measurable things, such as fertility, population control, and death, which are also issues that the government must control.

Therefore, we obviously have to make partial transfers and adjustments. The ideal result is that the government can guarantee that the people can maintain the basic living materials, but they do not give protection too much. According to each person's family background, economic situation, physical health, provide substantive equality, so that everyone can enjoy the same reasonable differential treatment, rather than the equity. Under such conditions, the open market will compete for other extravagant luxury materials, so that those who work hard will enjoy the rewards they deserve, and moderate freedom will not make society socially lazy. "The political system with the characteristics of space colonization" will be the perfect and ideal way to rule.

4.2: Civil Special Law

In the space, there must be many problems we never face before on earth. In order to set up an orderly society, we have to concern about every aspect of the new law we need in the space.

➪Legal Age:
The legal age in the space will be 18 years old. This is when we are ready for university and it’s time to be responsible for your actions.

➪Offenses of Escape:

In Yggdrasil, everyone is well distributed to different section, which means we won’t allow anyone who roams freely at strange time or is absent too long at work. If the police found out anyone who has tempted to escape for unreasonable purposes, they will be fined and warned for the first time. If he or she is recidivism, the hardest punishment is to be monitored closely to make sure her or she follows the schedule regularly for few months.

➪Penal Provisions:

People who commit stealing, bullying, harming, and so forth, will face with temporary imprisonment or fined for up to all salary of the month. We our team don't want to pressure people into doing things good, we prefer we can all create a brave new world where everyone can be nice to everyone.

➪Ban on mining:

We hope the resources near to our colony or even on it are for everyone to share, so we forbid any private mining activity. Our government will have rights to decide which parts of the space to explore.

➪ Last but not least, our " Space's Anthem, " " Space's Flag, " and " Space's Day" will be passed to represent our society formally. This is designed to bring everyone together as we our team strongly believe the saying, " United, we stand, decided, we fall."

"Space's Flag" will undoubtedly have our team's logo on it, unless the pattern is disliked by a majority of our citizens, which hopefully won't happen. For " Space's Day", it will be the day of the landing of the first group of people.

4.3: Education

As the saying goes, "Study changes life, knowledge changes fate." Education is extremely important and couldn't be neglected. We will set up a lifetime education system for any learner. We will also promote this, " Learning is for your own, not for others." To encourage people to desire for knowledges.

Grades:

a. Home-studying: 0~3 years old

At this stage of the life, it can be the most crucial part for the babies. Family life influences the formation of the baby's personality the most, so it is undoubtable that we can't substitute parents with school. We will give their parents appropriate measure of maternity leave, to let them have more time to accompany beside their babies. (Exclusive: If the parents want to go back to work before kindergarten, toddler school is also provided. But we still insist that the baby must be with their family for at least 2 years, therefore your child must be older than 2 if you want to sent him/her to the toddler school).

b. Kindergarten: 3~6 years old

After three years of staying at home, it's time for the children to start to learn how to interact with the society and people in the community. This will be the first time they learn how to makes friends with others and have a good time at school. We won't put any hard lesson in this stage yet, the main goal of coming to kindergarten is to have fun!!!

c. Elementary School: 6～12 years old

The traditional curriculum will start from here. Subjects like mathematics and English are required courses, others like physics, chemical, biography, earth science, history, geography, civic education will be classified into different levels. Every

students can choose the degree they want for each courses based on their interests. Art, sport, computer science, philosophy and more diversified classes are also provided for elective courses. Last but not least, in order to preserve the ethnic diversity, we persist that every students must learn their nation's mother language. In the other words, every single citizen in Yggdrasil can speak at least 2 kinds of languages. This not only decrease the barrier between different race, but also protect multiple cultures as well.

d. Middle School: 12~15 years old

The main spirit for this course is same as the elementary, but what differs to it is that everything will be harder and deeper. In addition to this, students will started to take an exclusive class for career exploration. According to the way we adapt to govern the spaceship, everyone must be at work. Therefore, we want to let the children choose their jobs in advance. First, there will be a lesson set to lead them to be familiar with all the jobs stage by stage. This lead them to their dream job closer and clearer.

e. High School: 15~18 years old

As the students have become more mature in this phase, it's time for them to enter the workforce. For the first year of the high school, there won't be big movement at this time. But for the second year, students are requested to find a job they want to do in the future, and they will actually follow a worker to work with him. If you ended up finding out that you aren't comfortable with doing that job, application must be submitted before half of the year. We want to make sure that every students can be at work immediately after graduation.

f. University: 18~22 years old

Future should be settle down at this time. Everyone will goes to the department related to the job. After finish four years of studying the last knowledge and technique, you can either choose to pursue the lore deeper in institute, or dive right into work directly.

g. Institute: 22~25 years old

This is specially set for those who desperately want to discover the epistemology to the extreme. Most of them are aim to become a research scholar or scientist in the future.

e. Life-time Learning club: 65 years old and more

It is never too old to learn! We encourage learning, because it promotes the development of civilization. The club welcome anyone who is retire and is ready to start a brand new stage of reading with friends around.

4.4 Economy

Economic policy

The issuance of a currency must be guaranteed, so that people are willing to believe in the value of the currency and use it. The value of the objects in space will be different from that on the earth. For example, minerals, the most direct way to obtain minerals on the earth is to dig from the ground. But in space, a stone is pulled back from the asteroid belt, and there are hundreds of tons of minerals inside, which makes the value of the mineral fall seriously, so what we want to bring to space may not be the most valuable on earth, we want to use the necessities in space, for instance, water, air, and food, as guarantee for the space currency. The government provides these three elements for survival, and they are used as money and will be saved in the card in the form of "points". People can ask those necessities from the government, thus receive entities.

The monthly quota allowance for each person is distributed, and a certain amount can only be taken for self-use and cannot be traded. For those who have a certain amount of stock, they are not allowed to allocate basic subsidies. Due to the importance of clean air, we will tax on people who produce excessive carbon dioxide or air pollution more heavily to achieve the internalization of external costs. As for water and food, we will discuss them separately. First of all, water, we will install pipelines to the households, people apply for the amount of water that they need, limiting clean water can only be provided by the government to ensure that it is not replaced. As for food, it is not possible to implement food monopoly because there are too many types of food. The government only provides the simplest type of food, which contains high quantity of nutrition and is easy to produce.

Economic risk

1. The people are dissatisfied with the monopoly system.However,businessmen and even politicians want to profit from it.
2. Although the water, food ,and air are government monopolies , it is inevitable that there will be a black market , which will result in a decrease in the value of the currency (the number of points in the card).
3. Everyone is unconditionally distributes the necessities of life each month.However,it may cause people not to engage in production work or unwilling to work hard, resulting in ineffective social division of labor. This distribution system has a counter-effect on the whole society because people who do not work can also receive the necessities of life, and the government can not abolish this distribution project to encourage initiatives in production. Otherwise, everyone can not be satisfied even the most basic survival, and it will certainly cause social unrest.
4. This type of currency will have the same value as food and water at first, but in the end, only water will have a higher value. This is because the food made by the government is the most basic, people only get them

when it is allocated. If people want to have diverse, delicious food, they have to spend extra money (points) on it. In addition to this, to control of water monopoly, inspecting is another cost of money, and there is a risk that the operation data will be hacked, but we can use cryptocurrency to solve this problem.

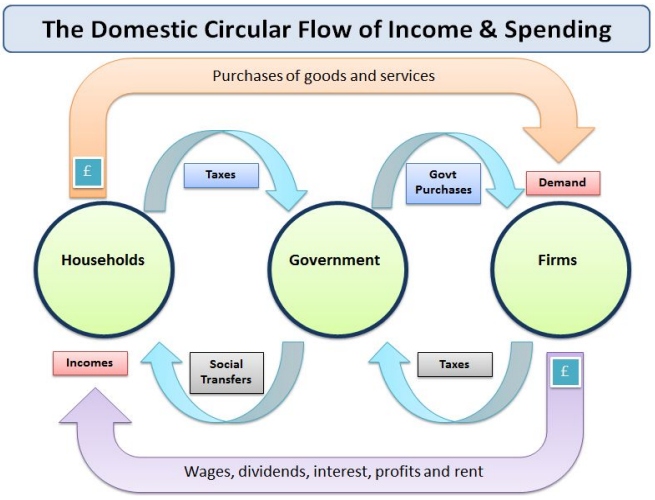


Figure 12, The domestic circular flow
http://abdpvtltd.com/economic-model-circular-flow-diagram/economic-model-circular-flow-diagram-lovely-understanding-the-circular-flow-of-in-e-and/

Economic Theories

Figure 13, William Nordhaus

https://www.sunoresearch.com.br/tudo-sobre/william-nordhaus/

- We adopt ideas from William D. Nordhaus and Paul M. Romer, who have won the 2018 Nobel Prize in Economics for their work in "climate, innovation, and economic growth.

1. Climate economics

William D. Nordhaus and Paul M. Romer proposed the “Net Economic Welfare Indicator”, which will always involve environmental pollution (negative externalities), domestic activities, and social obligations (positive externalities)

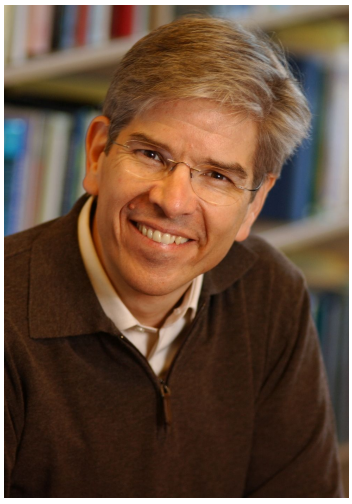
when calculating GDP (gross domestic product). Taking environmental pollution as an example, it is necessary to formulate the permissible standards for various pollutions. If the pollution exceeds the standard, it is necessary to list the expenses for improvement, and then deduct these funds from GDP.

2. What is an "economic externality"?

The "economic externalities" refers to the behavior of an economic entity that may benefit others (positive externalities) or damage (negative externalities), but the economic entity will not benefit or pay for it. In the June 2006 issue of the Proceedings of the National Academy of Sciences, Nordhaus gave an example in an interview: "In terms of technology, if a person invents a valuable new product, like the central processors, phones, or Windows, the inventors will certainly get some money back. But the real feedback is the consumer benefits, like the new product itself, or a lower price."

3. Applications in space

According to the two points above, in order to externalize negative externalities, we should increase the price of fossil fuels such as coal or increase taxes such as “fossil fuel tax”. Based on the law of supply and demand, when the price of fossil fuels increases, the demander will reduce the purchase amount because of the increase in cost, or the demander will find additional renewable energy in order to reduce the production cost. This method effectively reduces the amount of fossil fuel used, thereby reducing carbon emissions and environmental pollution.



- figure 14, Paul Michael Romer
https://zh.m.wikipedia.org/wiki/File:Paul_Romer_in_2005.jpg

1. The Theory of Endogenous Growth

Technology and economic research and development are the source of economic growth. Society can be divided into research departments, intermediate production departments and final production departments. All of the above are based on creativity and knowledge, and investment is the key to promoting growth.

2. Applications in the space

In addition to the two essential elements of capital and labor, the theory of internal growth is focused on the growth of internal independent money, so we can try to

improve investors' willingness to start the pace of development by setting discounts on distribution, dividends, and limited privileges. Of course, vigorous recruiting the talented as the source of innovation is also very important, and starting development requires a strong team (not necessarily the government).

4.5: Entertainment

1. Common room and library

There will be common rooms located everywhere in our colony. In this technologically advanced era, sadly, everyone used to communicate with other people through social media. However, we still have to do our best to learn social interaction. Lots of people are afraid of talking with "real" people. Hence, we can improve this by providing friendly areas for everyone to enjoy.

There is going to be a wide variety of categories of books in the library so citizens can read whatever they are interested in. We also provide e-books that contain several different subject fields, such as literature, science, art, philosophy...and so on. Everyone can learn new knowledge through reading, and be occupied without feeling bored or not knowing what to do to spare time. There is a coffee shop near beside it, you can get dessert whenever you like. Everyone can drink coffee or eat dessert while reading books. The open time for the common room and the library is 24 hours a day, 7 days a week. The coffee shop opens from 7a.m. to 9 p.m., 7 days a week.

2. Space tour

One of the most special activities here is space tourism. People can take on the space tour craft to visit other neighbourhoods or see the natural beauty of the outer space. We hope that the citizens who go on the space tour are able to see a world that doesn't look the same as the Earth. Don't worry about having no idea about the stars, planets, satellite, other neighbourhoods, or other celestial bodies in the space. There are some documents explaining those for the travelers. This tour is provided by SpaceX travel agency, whose staff are passionate and experienced in space tour. So, we ensure that every trip is substantial enough. Safety has already been concerned and we have proved it scientifically that it is absolutely no problem with this adventure.

3. Pub

If the citizens want to relax, going to the pub is a nice choice. People can have a drink and listen to live performing music there. We provide many kinds of wine, such as sparkling wine, red wine, whisky...and so on. There are also some drinks which don't contain alcohol, including cola, juice, mocktail, etc. As for music performances, we won't let the people down. We invite different singers everyday, and all of them are able to sing multi-style songs. A quick reminder: according to the law of Yggdrasil,

residents who are not yet 18 years old cannot have drinks that contain alcohol, and the bartenders are also not allowed to sell those drinks to the minors. If someone violates the law, he or she will get severe punishment.

4. Dining hall

It is a perfect place to hold a party or eat dinner. People can eat various foods from many countries, including America, China, Japan, Korea, Europe, and even aboriginal food. What's more, there are some events being held regularly, like Thanksgiving meal, Christmas party, New Year's countdown, reunion dinner of Chinese New Year. Friday is the most interesting day every week. We sincerely invite celebrities or residents who would like to perform on the show "Friday Night". There are different shows every week, and we will herald the coming of the show online. However, the seats are limited, so the people who want to eat or join the party need to reserve the seats.

5. Movie theater

We know that many people love to watch movies, so there is a movie theater in the colony. We play different kinds of movies everyday. We send the introduction and the trailers of the movies that will be played next week to everyone's email box. Therefore, people can know whether the movie they love will be played. However, the movie theaters in Yggdrasil are slightly different from what we had on Earth. The theaters on Earth are larger and can accomodate lots of people, but the theater here is not too big. The reason is that we put your comfort into consideration when we were designing the theatres. We thought by limiting the number of audience, it could improve your experience quality. Those people who have interest in watching movie must enter their name in advance.

6. Remembering Our Past Museum

History always reminds us the mistakes that we made and the significant innovations we created. Remembering Our Past Museum is for education purpose: to remember human's history on Earth where we are originated from. There are nine museums in our colony, and every museum exhibit different themes, including the geography of the Earth, the important inventions and discoveries, the history of every continent or country, the most influential people, the special culture, the beautiful sceneries, the endemic species, the special buildings, the languages used on Earth. Everyone can go to every museum in their free time. Additionally, there are some rules should be followed. First, nobody can touch the exhibits. Second, everyone should be quiet in the museums. Third, people are not allowed to eat food here. Last but not least, everybody is banned from rampaging in the museum.

7. Video game room

Many people love playing video games, so there is a video game room for everyone. There are various video games there, and we will update the games regularly. All the games are voted by everyone, which means that people can tell the government which game they want to play as well as they are tired of. However, video games that are too violent or those which contain improper information are not allowed to be given under the Citizenship Laws of Yggdrasil. Because of the space limitation, one room is not too big; it can only accommodate 80 people. What's more, due to the concern of physical and mental health, each person is allowed to use this room 3 hours maximum a day. When a person use it for 3 hours, the alarm beside the seat will ring and the game will be stopped automatically.

8. Night club

There are some nightclubs in our colony for those people who feel bored at night. People can dance and sing to the rhythmic music there. When the people are thirsty, we also offer some drinks. It is also a chance to make friends. We also hold special planning party irregularly and welcome the people who want to join it. The night clubs in the colony is only open on every Sunday from 10 p.m. to 2 a.m. Due to the Citizen Law of Yggdrasil and physical and mental health of the children, residents who are under the age of 18 are not allowed to go into the night club.

9. Gym

There are so many delicacies here, so everyone need to do some exercise in order to burn the calories. We provide everyone with complete facilities and enough water. Additionally, it is so great that there are some personal coaches who will help everyone reach the goals whether in losing weight, gaining muscles, or other achievements. Fitness and yoga classes are provided everyday at 6 a.m. to 7 a.m., 3 p.m. to 4 p.m., and 7 p.m. to 8 p.m. However, there are still some rules need to follow. First, each person may come here 90 minutes each time, 2 times a day maximum. Second, the people who use those facilities should be careful. Finally,the opening time for the gym is going to be 5:30 a.m. to 9:30 p.m., no one can ask for getting into the gym when it is closed.

Part V: Supporting Systems & Operations

5.1: Space Warfare

Space wars may sound too sci-fi, but this is still a possible thing. If there are two world wars on Earth, it is not surprising for us to launch wars on other planets. It is also expected that two wars from different planets will occur. We need to plan ahead and develop weapons that protect us. In addition, whether we are on Earth or in space, meteorites are a potential threat. We can't watch the countdown timer waiting for death, die in the same way as dinosaur died. That’s too sad. We can definitely find methods for prevention.

1. **Conflicts**

   Conflicts could take place in the space as well as on the earth, thus we do need some technologies to protect ourselves. Stealth hull and laser weaponry, form a strong and defensive system to not only deter the enemy but also make the society peaceful.

   To make hulls “invisible” for radars, non-metallic polymer material or radar-absorbing material will be applied on the surface of hulls. When the radar launches the probe wave to the surface of the stealth aircraft, most of the energy is transmitted by the non-metallic polymer material or absorbed by the radar absorbing material. In order to make the probe wave from the radar hit the stealth aircraft and allow the probe wave to return as far as possible along the original path, the scientist designed the shape of the stealth aircraft into a flat shape and reduced the surface area of the fuselage as much as possible.

   ”Light Amplification by Stimulated Emission of Radiation”, in short, laser, which has high accuracy. As soon as they reach the target, they can burn and disable it without creating debris fields in orbit. When one or more electrons are at a higher energy level, we call the atom in an excited state, and electron can shift through energy absorption or release between energy levels. There are three types of transition, and the laser is formed from one of them called stimulated emission, in which photon is released by photon injection of matter, and it induces electrons to transition from high energy level to low energy level. The photon released will be reflected back and forth by the mirrors at the ends of the laser medium, inducing more electrons
   Perform stimulated radiation to increase the intensity of the laser. One of the mirrors at both ends will reflect all the photons, the other mirror will reflect most of the photons and let the rest of the photons pass through; the photons passing through the mirror will constitute the laser we see.

2. **Meteorite defense**

   The simplest and most feasible method is a method similar to planetary billiards, using a space detector to send a component (or the probe itself) to the

planet. Then, the asteroid will be pushed away from the intended orbit to avoid collision with the hull.

Massimiliano Vasile of the University of Strathclyde proposed a proposal to detonate a nuclear bomb at a certain distance from the target. Like the principle of the laser method, the plan will evaporate the surface material of the planet to generate thrust and change the orbit of the planet. "If ablation [erosion] is used, this method is very energy efficient," he said.

Lasers and nuclear bombs can play a role close to the planet, and the material composition of the planet's surface will be a major factor, because the composition itself will determine the evaporation temperature, and the different planets will be different. Another problem is the broken stones that fly out. There are many asteroids that are actually a collection of loose stones. An impactor is not very effective for such objects. Gravity traction is more effective, Johnson points out that the adhesion between ingredients and matter is not important.

In addition to using the impactor method, scientists also use gravity – to place a large airship directly into the orbit of the planet and use the mutual attraction between the two objects to push it into a new orbit. The advantage of this method is that the spacecraft can be implemented near the planet. The orbit will become a "halo", a circular path centered on a point whose gravitational pull on the object is equivalent to the sun's gravitational effect on the planet.

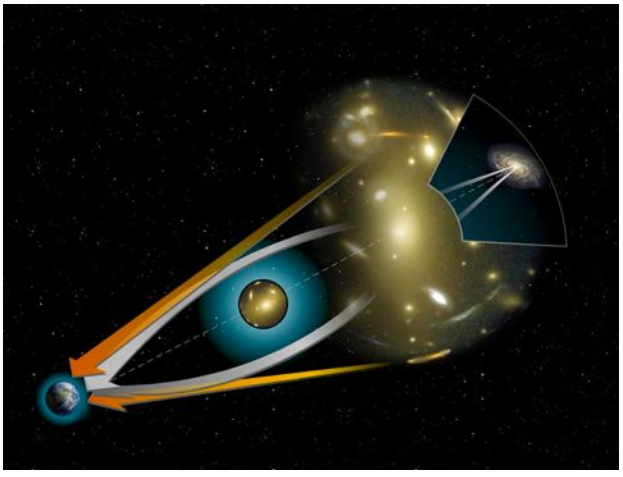


figure 15, Gravitational_lens
https://commons.wikimedia.org/wiki/File:Gravitational_lens-full.jpg

Human beings should have survived on earth, but for progress, to survive, we have to face all kinds of terrifying dangers from space, even stay with it. It’s not easy to face an unfriendly living environment, either for humans and enemies, but this is the price that must be paid to conquer the space.

5.2: Mars

Our orbit will travel through Earth and Mars. We can give supplies to the colonies as we pass through the Earth. Similarly, we can also use the resources on Mars. We take two basic things, water and soil. First, water, we have The possibility of liquid water on Mars, although there are some on Mars Solid water, but not the sci-fi movie set to warm Mars , but also It's just that today's technology can't be achieved. It's now certain that there is water on Mars to use. Then there is soil. The soil on Mars does have the nutrients needed for plants to survive on Mars. The soil on Mars actually has plants on Mars. The nutrients needed for survival, but also contains a substance, perchlorate, which, although toxic, is a component of rocket fuel that can be used to supplement the power required by the colonies.

5.3: Non-terrestrial Mining

The orbits of our colonies travel through the Earth and Mars, and after the orbit of Mars, close to the asteroid belt. We can consider mining asteroids to extract minerals. The minerals contained in an asteroid in outer space are quite amazing. The idea is that we can select an asteroid and then use a laser to get it out of his orbit. The principle of the laser is to use a beam to heat the surface of the rock, heating it to vaporize the rock itself, and then generating a movement after burning the gas. The thrust of the rock block brings it close to us and then goes to the top for mining, which saves the cost of transporting minerals to the colonies.

Part VI: Conclusion

Our spacecraft is double-stranded like DNA, with two spiral, tubular structures fixed by a long cylindrical column. It is expected to accommodate 500,000 people and

bypass the Aldrin Cycler's trajectory, and the orbit will pass through Earth and Mars periodically, which has the advantage of providing material replenishment and exploration opportunities. The heat pipe of the colony is used in Yggdrasil because its excellent thermal conductivity is suitable for adapting to the extreme temperature difference in space, and the outer layer is also covered with solar energy. The solar panels, which absorbs solar radiation while generating electricity, can solve both power and space radiation problems. The promotion part uses solar electric propulsion hybrid splits to advance the engine. The advantage is that the technology is mature and light, the initial speed is slow, but the operation in the later stage, we can have considerable speed. The artificial gravity part is made by rotation. We have two spiral tubes, which will produce two kinds of gravity with different sizes. The outer ring is exactly 1 times the earth gravity, and the inner ring is 0.75 times the earth gravity. We design the outer circle to give the average person a living activity, and the inner circle gives life to the elderly or people with reduced mobility, which can alleviate their difficulties. There is a connecting passage between the outer ring and the outer ring. It can be transported by elevator.

Because we have to live in a non-Earth environment, we must have a proper light cycle. We use man-made fiber curtains to create the difference between day and night, so that humans have a stable sleep. As for the water, Yggdrasil collects it on a planet or asteroid.We collects urine in the cabin and uses a water recovery system (WRS) to ensure that water is recycled and utilized to the maximum extent possible. In plant cultivation, we use drip irrigation and LED lighting because we can reduce labor costs and produce oxygen at the highest rate by controlling the nozzles and adjusting the wavelength of the light. Air makes plants produce naturally. In addition, we want to transplant the genes that plants can make oxygen into bacteria, so that bacteria can produce air to ensure the amount of air people need. Or a certain proportion of wastewater is distributed in the cabin to produce oxygen, and hydrogen, which is explosive, will be discharged outside the cabin.

In addition, the crew of the cabin will ignite SFOG to assist in the generation of oxygen. Land is uniformly distributed by the government and can be traded freely. The source of vitamins is taken from plants, meat, cold dust particles in space or by self-irradiation of sunlight, ensuring that the body does not lack vitamins in space. In the medical field, we will invite a group of medical-related industries and medicine manufacturers to pharmacy, sell medicine, see patients and impart relevant knowledge to the youth in the cabin to ensure that human medical care can continue to develop on Yggdrasil. As for the urine and the excreta, we intend to install a urine circulation machine on Yggdrasil, recover the water by centrifugal distillation, and further purify it into pure water that exceeds the drinking water standard of the earth.

The feces are part of the fertilizer for plant cultivation, and the rest are also can be broken down by insects.

The whole point for this part is to discuss the social issues in the space. First of all, the government system. We adapted both capitalism and the socialism at the same time. With the advantages of both, it is no doubt the best way to rule our home in the space. Second, is the civil special law. The extent law we have on Earth is nearly perfect for us, but there are still some questions we might face in the space. In order to built a safety society, we specially set up some laws for space. Next, is one of the most important thing, Education. Differ from Earth, we focus on job training. Last but not least, entertainment. It may be a long time for people living in our colony, so entertainments are necessary. There are various and extraordinary activities everyone can participate in. However, in order to protect the rights of the public, people must follow some rules when enjoying all of them. All in all, what we look forward to is make each citizen happy.

Finally, for some of our imaginations about space technology, we imagine that if there is a space war, we must have some defensive facilities on the colony, such as the hull material that can absorb radar, achieve invisible effects, and lasers, if The use of weapons in space, the laser is a good choice, its high precision, low launch cost, and not only can be used for attack, but also can be used to clean up the debris on the track, we imagine even can be used to move Asteroids, by heating the planet's surface with lasers, gasify and generate thrust that allows it to enter our projected orbit for mining. And Mars, although the idea of using greenhouse gases to warm Mars has recently proved unlikely, but we still believe that Mars has a lot of room to develop, like its soil contains toxic perchlorate, perchloric acid. Salt is actually a rocket fuel component that can be used. Mars' groundwater is also an important resource. Although it is not directly used, it is indeed a planet worth developing.

We believe that we can see a bright future at Yggdrasil because we are in the hope of making everyone experience a sense of elation. We cannot improve our past, but we can improve our future. Maybe we have done a vast number of terrible things to Earth and nearly led to the loss of our accommodation, but we can not only start new lives, but also discover ourselves at Yggdrasil.

Part VII: Appendix

Sitting in the spaceship, Catherine wonders what will be her first feeling upon seeing the “new home”. According to doctor Chiang, the new homeland for human is a place on the Aldrin Cycler’s trajectory and it is called Yggdrasil, which originates from ancient Norwegian and represents a spectacular, perfect world, and everyone is linked together by unity, it is not like the utopia created by the English writer Thomas More, nor is it the wonderland founded by Chinese poet Tao Yuan Ming’s pen, it is real and full of possibilities. For thousands of years, the mysterious universe has fascinated the humanity and the scientists have been trying to find a way to live in the outer space as a solution to the destruction of the Earth caused by all mankind.

Catherine glances back at the Earth one last time from the window of the spacecraft, the planet which was once vividly green with life is now a grey, lifeless…thing. You cannot even call it a sphere, since it is now full of holes, and is incomplete due to the atomic bombs that were dropped unscrupulously. Some part of it is still burning, with smoke continuously coming out from it. The Earth is glowing in the dark, but unlike a shooting star, it flickers irregularly like a dying creature gasping for breath, desperately yelling for help. “But it’s too late…… too late”, Catherine whispers, turning her head back to avoid the sight of the withering Earth.

“Welcome to Yggdrasil!”, Catherine, with her sleepy eyes, is woken up by the interruption of a sharp voice that comes from the horn above. But then she is suddenly wide awake, overwhelmed by curiosity, nervousness, and excitement as she walks out of the spacecraft.

A flat land opens up before her, and she gasps with astonishment. There are several giant spirals which consist main trunks in the middle, holding up the whole structure. A guiding robot appears at Catherine’s side and introduces himself to her as Mike, “Happy First Day in Yggdrasil, ma’am”, Mike says with a big, robotic smile(of course, he IS a robot), “ We are terrr...rific for your arrival! Welcome, welcome! First of all, let get into your most important need, shall we?” Mike goes on introducing Yggdrasil in pride excitedly. “There are nine neighbourhood in total. They’re all named after the nine realms from the Norse mythology. Oh, but don’t let the meanings behind the names bother you, ma’am, they have nothing to do with the mythology I can assure you.” At that, he winks (surprise! he even have… eyelids?) before continuing, “and here,” as he is speaking, Mike hands out a booklet with a big black title written: “RESIDENT GUIDE” to Catherine. He points at its cover where nine colours are present. “Each colour represents a neighbourhood. White: Niflheim, red: Muspelheim, gold: Asgard, green: Midgard, brown: Jotunheim, blue: Vanaheim, yellow: Alfheim, grey: Svartalfheim, and finally black: Helheim. Let me walk you through all the facilities in your assigned neighbourhood, which is Niflheim, and oh, almost forget this,” he gives Catherine a slip of paper. “This is your address, Number 256, North Peace Road, District 1, Niflheim, Yggdrasil.”

Catherine looks at the address and has no idea what it means. She turns to ask Mike, “Well, first things first, how do I get there?” Mike replies with a confidence that seems so human. He must be the newest version of AI technology, Catherine thinks for her fifth times since they’ve met. “Great question! See those ring-like tubes winding around the whole spiral? All of the detail designs and distributions are based on these ”slides”. The main trunk is the headquarter of the whole structure, every transportation starts from here. In order to make sure the conveyance won’t be obstructed, there will be elevators in different directions, not just only up and down. If you want to travel faster, space shuttle is also available to your service, ma’am. More than a transportation center, it is also a capital, the heart of this space shelter. As for the tubes surrounding it, they are all classified with different subjects. We have Food Paradise , Entertaining World, Book Universe, the Nine Realms(finally something sounds familiar, thought Catherine!), Life Care, Residential Service, etc”. “And also”, Mike starts again, “Everyone here has a unique resident number, you need it to buy your ever necessities, to enter your house, to go into a club, or to crank up your space automobile… literally EVERYTHING. And yours is 20011102, make up with your birth year and date” “Got it, thanks”, Catherine replies.

“Are you hungry? I suppose so, cause my sensor has sensed your blood sugar lower than usual and the glucagon is gonna fight the demon of hunger!” Mike says with a snap and a brisk laugh, and then he goes, “funny isn’t it?” “Well… seems like the humor system has not been uploaded yet… decrease the level of humor allowed, please” Catherine orders without any seriousness in her tone. Mike straights his body, “Appology, and yes ma’am. The level of humor has been decreased from 90% to 45%.” “Good. Now, take me to the… Heaven with Food…no, wait.... Foodie’s World…? ” “Is that humor my sensor is sensing? It’s Food Paradise, ma’am!” Mike smiles a little and presses the button on the elevator wall which the word F.P. is written on it. They go up to the 100th floor in a speed that is fast enough but impossibly comfortable at the same time, and then turn 25 degrees to the right and keep moving forward. ARRIVED, Catherine notices the words showed on the screen with a ding sound just above the door, which is opening and has just been closed for 30 seconds ago. Up came a huge, huge(HUGER than any fancy restaurant Catherine has ever seen before!) food court where many people are already in and having there meals. The unbelievable sight makes Catherine more thrilled about other places in Yggdrasil, though she would love to stay and taste everything, she only grabs a loaf of bread, the nearest food she can reach to, and says “Let’s continue the exploration, I can’t wait to see other places! Can I finish the bread on our way?” “Sure, ma’am”. They go into the elevator again.

For the rest of that day, Mike shows Catherine the entire Niflheim. There are more restaurants, shopping malls, markets, factories, residential area, parking lots(

now Mike uses those familiar names to explain these) for “space automobiles”(every resident will eventually get one once he/she passes the driving test and the register is approved), the life support system, leisure and entertainment venue, the educational area, and the city hall of Niflheim. He also walks her through all the basic laws in Yggdrasil, which gives her a bad headache.

Finally, the exploration is over. They go into the elevator one last time today and Mike enables the audio system by saying “Hey, Siri!” “Why still Siri, huh?” “Just got used to it on Earth, didn’t you? So the designers decided to keep using this as an access code to the audio system” “oh okay. So what are we gonna do now?” “Com’on, you gotta be kidding me. It functions as the Siri on Earth, ma’am. Don’t tell me you don’t know how to use it” “Alright, of course I got this. Go to Catherine Chiang’s room, resident number 20011102.”

Lying in her bed, Catherine is still stunned by all the things she saw today. “Human has always been dreaming about living in the outer space, and now we finally achieve this goal, which is amazing! I’m gonna try the movie theater tomorrow and then… I don’t know, I think I have fallen in love with all of these crazy things already…… ” There is a long pause, she falls asleep as silence conquers the room. The light in the bedroom automatically turned off, only the emergency exit light is still on. The colorful glowing dim light from the other eight neighborhoods which stand straight proudly like giants in the dark, comes in from the French window, indicates that the night life in Yggdrasil, has just begun.

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