**2017 UIC RESEARCH PROJECT-KOREA**

**FINAL PAPER**

# Study on the Bacteria Habitation in Songdo Yonsei International Campus

**Bohyun Kim, Dabin Che, Na young Lee**

Underwood International College

Yonsei University

Table of Contents

## Abstract

Yonsei University International Campus (YIC) boasts a dynamic residential college. The members of the YIC community share learning and living experiences as well as bacteria. In this paper, the experiment of culturing bacteria from different places within YIC and the student survey for the bacteria hygiene awareness are discussed. The experiment was done in 10 different buildings and 9 different locations within the buildings. The ten buildings are Underwood Memorial Library (U), Vision Hall (VH), Libertas A (LA), Libertas B (LB), Veritas A (VA), Veritas B (VB), Veritas C (VC), Veritas D (VD), Dormitory 1 (D1), and Dormitory 2 (D2). The 9 locations were elevator buttons (E), surface of the desks (D), walls inside the washing machines (W), sitting surface of the toilets (T), display shelves in cooperative store (S), surface of the cafeteria tables (F), surface of the computer keyboards (C), fitness center (H), and the air (A). The result of the experiment indicates that the building with highest bacteria habitation at the time of our experiment was dormitory 2, followed up by dormitory 1 and the library (*Graph 3*). Also, it tells us that washing machine contains the most bacteria, followed up by the toilet and display shelves at the cooperative store (*Graph 5*). The result shows considerable accordance with the student expectations. However, there is no need to worry too much about the high levels of bacteria in the places mentioned. It might simply mean that many people have accessed he area. Washing hands with soap frequently is enough to prevent dangerous bacteria infection.


*Keywords:* Bacteria, Yonsei International Campus, hygiene

Study on the Bacteria Habitation in Songdo Yonsei International Campus

## Introduction

Yonsei University International Campus (YIC) at Songdo boasts a dynamic residential college. The members of the YIC community share learning and living experiences as well as bacteria. Bacteria are microorganisms that can pass from person to person virtually everywhere. The YIC may be a good dwelling environment for bacteria as many people interact with one another by pushing buttons and grabbing doors restlessly. With the hope of studying the environment we spend a lot of time in and providing useful information to the other people, we decided to run an experiment with the bacteria habitation at YIC. The experiment would have been more interesting and meaningful if we could identify each bacteria collected, but the instrument needed for the process of identification was too expensive. Therefore, compromising with our situation, we decided to culture bacteria from different places of our campus and analyze the colony created on the petri dish. Instead of identifying the bacteria, we compared the number of colonies.

At the end of the experiment, we ended up with colonies of different colors and shapes, which indicate the existence of various types of bacteria. This study was done so that the results would let us understand which location is more or less populated with bacteria and whether we should put more effort to sanitize our surroundings. Then, we ran a simple survey with the students. The survey have three types of questions. The answers to the questions that ask about the places the students have accessed the most is used to check whether the most accessed places contain the most bacteria. The answers to the questions that ask about the expectations of students of the places with the most bacteria would be compared to the data from the experiment to see if the two results match. The answers to the question about the best way of removing bacteria from hand would show the student awareness of hygiene.

Hopefully, by comparing the experiment and survey results and providing the information we gain from our study to the YIC community members, this research will enhance the public health awareness around YIC.

## Background

Before we discuss about our project, we would like to familiarize the readers to the basic concept of living organism and bacteria which is the subject of our research.

### Living Organism

Based on the relative complexity of their cells, all living organisms are broadly classified as either prokaryotes or eukaryotes (Vidyasagar). Prokaryotes are usually unicellular and absent of nucleus and other membrane bound organelles whereas eukaryotes are usually multicellular and present of those organelles ("Prokaryotes vs Eukaryotes"). Lysosomes, peroxisomes, microtubules, endoplasmic reticulum, Golgi apparatus, mitochondria, chloroplast are examples of the membrane bound organelles. The nucleus is an organelle at the core of the cell and contains the chromosomes, which are thread- like structures of DAN or genetic materials. Prokaryotes have nucleoid, a region where one circular chromosome is located, instead of a membrane bound nucleus. Prokaryotes perform cell divisions through binary fission, which is a process of duplicating chromosomes and dividing them up into two individual cells. This method is classified as asexual because there is no distinction of sex. One consequence of this asexual method of reproduction is that all organisms in a colony are genetically equal ("Cell Division"). Bacteria are classified as unicellular prokaryotes. Therefore, when they divide into two through binary fission, the number of organisms increases by two. When they are cultivated into colonies, each colony is derived from one bacterium.

**Examples of Bacteria**

Bacteria are minute microbes that vary widely in shape, size, mode of obtaining nutrition, and other survival requirements. There is virtually no habitat on earth, where bacteria are not present. Some of them can even survive in the least hospitable places like hot springs and radioactive wastes. Out of five nonillion bacteria on earth, a few of them are summarized in this paper (Sandhyarani). Unlike a misguided bias of general public, not all bacteria are detrimental for human beings and some bacteria are even utilized to benefit our health.

*Lactobacillus acidophilus*, found in dairy products, is an anaerobic bacterium that converts sugars and lactose into lactic acid. It can be added in food supplements for use in therapeutic intervention so it is considered as beneficial bacterium ("Lactobacillus Acidophilus").

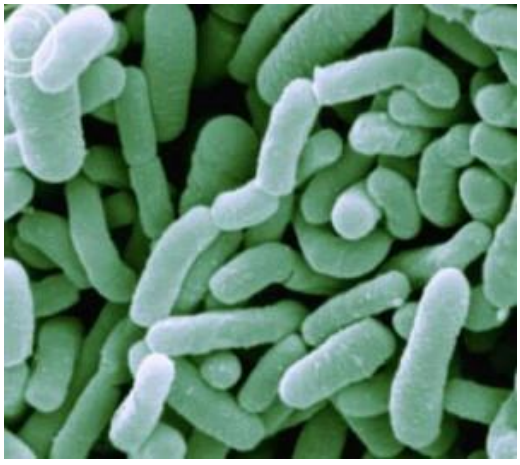


*Figure 1*. *Lactobacillus acidophilus* under microscope.

*Nitrogen-fixing bacterium* is another group of useful bacteria crucial for plant growth. It helps capturing nitrogen gas from atmosphere into soil and converting it into usable compounds for plants. Thanks to this bacterium, plants can supply themselves with the necessary compounds (D).

*Figure 2*. *Nitrogen-fixing bacterium* under microscope.

*Helicobacter pylori* is a type of bacteria that affects the digestive tract and causes medical symptoms. It is known for causing inflammation of stomach lining (stomach ulcer) and other digestive problems (PhD, C. P.).

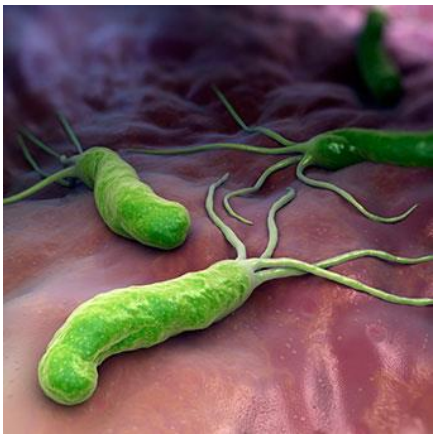


*Figure 3*. *Helicobacter pylori* under microscope.

## Pre-Lab

At first, we decided upon the locations at which we would collect the bacteria. We selected 10 different buildings: Libertas A, B, Veritas A, B, C, D, Dorm 1, 2, Vision Hall, and Underwood Memorial Library. Within those buildings, we selected 8 different locations: elevator buttons (the up and down buttons at the first floor of each building), surface of the desks, walls inside the washing machines, sitting surface of the toilets, display shelves in

cooperative store, surface of the cafeteria tables, surface of the computer keyboards, and fitness center. The most frequently used places were selected. In addition to the 8 locations, we had a measure of the air to represent the overall building. Not all the 8 locations are in each building. The information of which locations are used for each building is in *Table 1*. There are total 50 different locations. We performed 3 trials for precision and reliability of the data.

Table 1: Locations of Each Building (O: the location is in the building, X: the location is not in the building)

| | Underwood Memorial Library (U) | Vision Hall (VH) | Libertas A (LA) | Libertas B (LB) | Veritas A (VA) | Veritas B (VB) | Veritas C (VC) | Veritas D (VD) | Dorm 1 (D1) | Dorm 2 (D2) |
|---|---|---|---|---|---|---|---|---|---|---|
| Elevator (E) | O | O | O | O | O | O | O | O | O | O |
| Desk (D) | O | X | O | O | O | O | O | O | O | O |
| Washing machine (W) | X | X | X | X | X | X | X | X | O | O |
| Toilet (T) | O | O | O | O | O | O | O | O | O | O |
| Cooperative Store (S) | O | X | X | X | X | X | X | X | O | O |
| Cafeteria/ Food Court (F) | X | O | X | X | X | X | X | X | O | O |
| Computer Keyboard (C) | O | X | X | X | X | X | X | X | O | O |
| Air (A) | O | O | O | O | O | O | O | O | O | O |
| Fitness Center (H) | X | O | X | X | X | X | X | X | X | X |

We also decided to have 3 trials for each treatment. Before running the whole experiment using up 153 petri dish with agar culture medium, we did some test experiments to get an idea of how fast and how much bacteria would grow and to figure out the most adequate method to use when collecting bacteria. We have done three rounds of pre-lab.

**First Pre-Lab**

In the first pre-lab, we compared the three methods: exposing the culture medium to the air, leaving a finger print on the plate, and using a swab. With the swab, we diluted the sample by 1/500.

1. Prepare 3 petri dishes with the agar medium.
2. Leave one of the petri dish open in the air.
3. Soak a sterile cotton swab and rub the doorknob. Put the swab into a conical tube with 50 mL of distilled water.
4. Sterilize the glass spreader by heating with an alcohol lamp. Let it cool down.
5. Using a pipette, add 100nl of the diluted sample to the second dish. Rub the surface with a glass spreader.
6. When the surface is dried enough, close the 3rd dish and wrap it with Parafilm.
7. In another petri dish, lightly press your fingers on the agar medium. Close it and wrap it with Parafilm.
8. Cover the first petri dish and wrap it with Parafilm Keep all of the 3 petri dishes in an incubator for a day and see if any colonies are formed.

This was a rather spontaneous lab rather than a planned lab. Through this lab, we learned the procedure of this experiment from our professor. This first pre-lab, however, was done on the culture medium our advice professor provided us because it was before our culture mediums have arrived. He said that the agar medium was prepared with antibiotics long time ago, and therefore although most of them would be destroyed, some of them could be left in the medium. Probably because of this, we did not get any bacteria on the plates except for getting tiny colonies only on one of the finger prints.

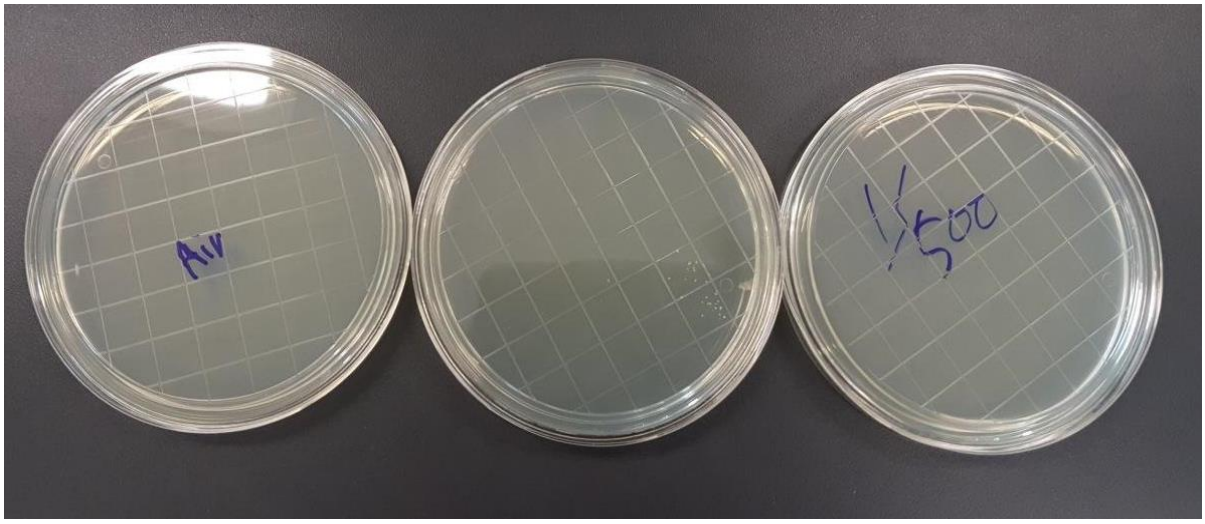



Figure 4. Result of first pre-lab. Bacteria collected on 3 different petri dish each by air exposure, fingerprint, and swab with dilution are incubated for a day and displayed from the left to right.

**Second Pre-Lab**

In the second pre-lab, we compared the methods of collecting bacteria to check which is better: exposing the agar gel to the air or using a swab. Considering the poor growth of bacteria in the first pre-lab, we increased the exposure time in the air and rubbed the swag directly on the agar plate without dilution. We ordered the culture medium for general bacteria premade on petri dish by the company. We used three petri dishes for the second pre-lab. One of the agar plates was used for collecting bacteria sample from library desks with a cotton swab. The other two plates were left open for the air exposure to collect the bacteria sample floating in the air each for 15 minutes and 30 minutes. Small colonies started to appear on the swab agar plate after 33 hours of incubation. We ended our observation after 77 hours when the colonies in the swab plate became larger and still no visible differences could be seen in the air exposure plates. Followings are the pictures we took during while conducting the second pre-lab.


*Figure 5.* Swabs (cotton tipped applicators) used for the experiment.

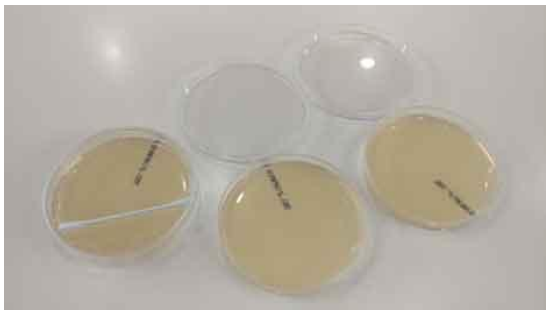


*Figure 6.* Agar plates before collecting the sample bacteria. The plates contain agar culture medium.

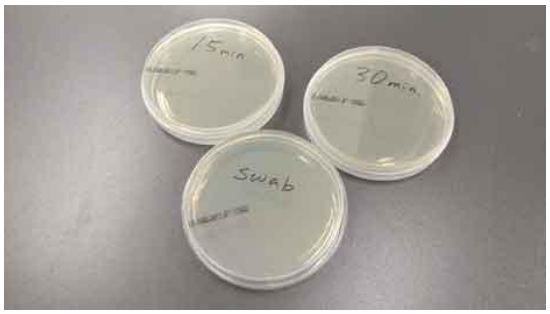



*Figure 7.* Labeled and sealed agar plates. Air agar plates were labeled '15 min' and '30 min'. Air agar plates were tightly sealed with Parafilm. Swab agar plate was labeled 'swab'.

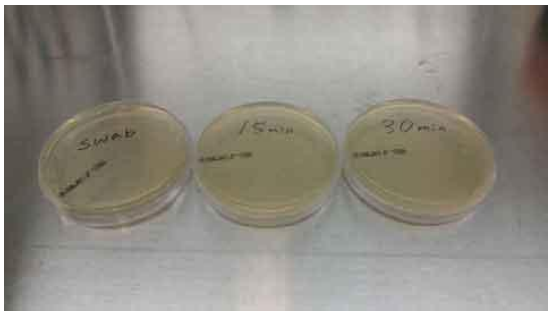



*Figure 8.* Agar plates 26 hours after incubation. None of the colonies were visible in all three agar plates.

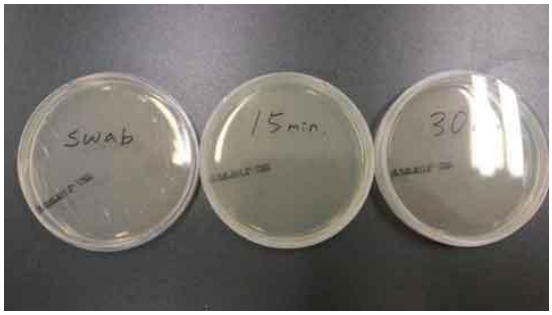



*Figure 9.* Agar plates 33 hours after incubation. Small colonies started to appear on the swab agar plate. There was no visible difference on the air agar plates.

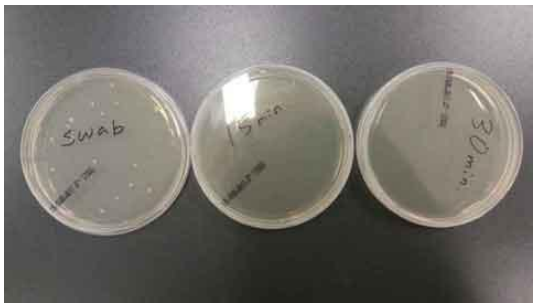



*Figure 10.* Agar plates 53 hours after incubation. The small colonies became more visible on the swab agar plate. There was still no difference on the air agar plates.

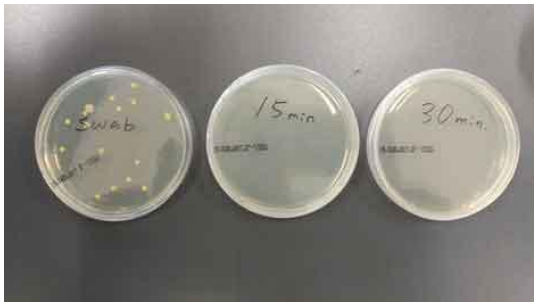



*Figure 11.* Agar plates 77 hours after incubation. The previously visible colonies became larger and additional small colonies appeared on the swab agar plate. There was still no difference on the air agar plates.

## Third Pre-Lab

After the observation that only bacteria sample collected through the swab method have successfully cultured, we decided to use the swabs for our main method of collecting bacteria. The third pre-lab was conducted in order to figure out the best dilution level of the bacteria sample. We created a dilution gradient by varying the amounts of distilled water in the conical tube used for dilution as: 2mL, 1.6mL, 1.2mL, 0.8mL, 0.4mL, and no dilution (rubbing the swab directly onto the plate). For the first 5 treatments, we collected the sample

from computer keyboards, and for the no dilution treatment, we collected it from elevator buttons. Before the pre-lab, we thought of the ways to swab. We thought of rubbing the surface (1cmX1cm) of each location 3 times side by side and 3 times up and down in a zigzag pattern. However, after the pre-labs, we realized that colonies do not form as easily as we thought, we decided to rub unrestricted surface area. We rubbed numbers of computer keyboards and numbers of elevator buttons for each trial. Moreover, we added a dish for the cellphone, which we thought would contain the most bacteria, without dilution. This was used for an extreme case with a lot of bacteria. If none of these samples culture bacteria colonies, we would need to change our method completely. Surprisingly, we could observe more colonies for the elevator buttons than the cellphone. Also, we had overgrown colonies in three of the petri dishes that were diluted. Followings are the pictures taken during the third pre-lab.

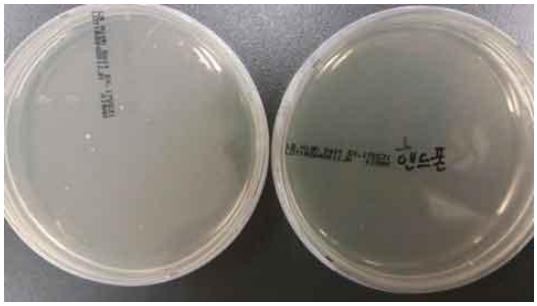


*Figure 12*. Swab agar plates after 20 hours of incubation. Locations were elevator button (left) and smartphone (right). Small colonies appeared on the elevator button agar plate.

*Figure 13.* Same agar plates as *Fig.12* after 44 hours of incubation. Some colonies started to grow on the smartphone agar plate (left), and the colonies grew larger on the elevator switch agar plate (right).

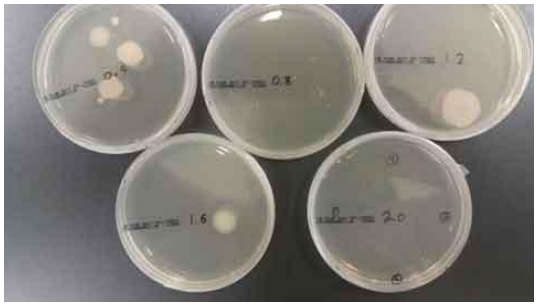


*Figure 14.* Agar plates applied with diluted (0.4, 0.8, 1.2, 1.6, 2.0ml of distilled water) swab samples from computer keyboards after 20 hours of incubation. Colonies grew on all five plates, and their shapes and sizes varied regardless of the degree of dilution.

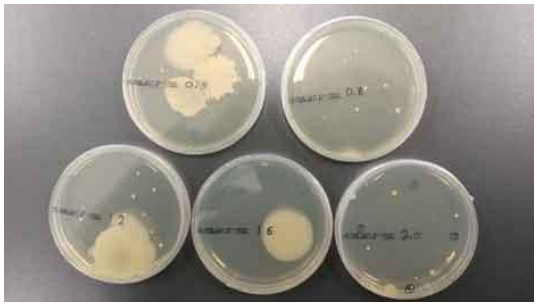


*Figure 15*. Same agar plates as *Fig.14* after 44 hours of incubation. The colonies grew larger in all five agar plates.

Based on all three of the Pre-Labs, we finalized our procedure. We decided to use the swab method in our experiment without dilution, since this method gave the clearest result from our pre-labs. Following is the finalized method of the actual laboratory experiment.

## Method

### Laboratory Experiment

**Equipment.** 150 petri dishes with bacteria culture medium, Distilled water in conical tube, Sterilized cotton swab, Incubator, Parafilm, Scissor, Camera, Pen for labeling

**Finalized Procedure.**

1. Leave three petri dishes open in each building for air exposure. Remember the order you put the petri dishes in the buildings so that you can collect it in the same order.

2. Go to the library.
3. Soak 3 sterilized swabs with distilled water. Rub the swabs on different elevator buttons each.
4. Open 3 of the petri dishes and rub each swab on the surface of the culture medium.
5. Close the petri dishes and rap them with Parafilm.
6. Label each petri dish with ‘Building-Location-Trial number’. ex) U-E-1
7. Move on to the next location and do the same thing. Do this until all of the locations are covered in each building.
8. When swab procedure is finished, collect the petri dishes left for air exposure in the order you put them.
9. Put all 150 petri dishes in an incubator.
10. Wait for a day and come back to take pictures of them. Count the numbers of bacteria colonies.

Followings are the photographs taken during the procedure as we conducted the experiment. We took the boxes of agar plates out from the incubator after 39 hours and observed the bacteria colonies.

*Figure 16*. Inside the incubator. All 150 sealed agar plates are placed inside the cardboard boxes.

*Figure 17.* Incubator with the agar plate boxes. This figure shows the incubator machine.

*Figure 18*. Agar plate boxes after 39 hours of incubation. The boxes were taken out to observe the bacteria growth.

**Survey Methods**

In order to find out the student recognition on bacteria habitation and compare it with the experiment result, we planned a simple survey consisting five questions. We used Google survey form and uploaded the survey link on Kakaotalk (messenger program most widely used in Korea) chat rooms. Participation was therefore completely voluntary and was only encouraged by small gift we purchased within our budget: Kakaotalk gift card of coffee for six random people. We added a non-mandatory question at the end of the survey page to collect phone numbers from people who wants the gift. The information was used only for the purpose of delivering the gift and no record was left after the survey. The target population was the students who studied at the Songdo International Campus in 2016 fall semester.

All five questions were multiple choice questions written both in Korean and English.

The explanation of our research was also written in both languages at the beginning of the survey and in the notices we uploaded on the Kakaotalk chat rooms along with the survey link. The first two questions were multiple choice questions in which the participants can check more than one answers. The following three questions were multiple choice questions in which the participants can choose only one answer.

The five survey questions and provided answer choices were as follows:

Q1. Which Buildings do you think would have the most bacteria? Please choose 3.

A1: a) Veritas A, b) Veritas B, c) Veritas C, d) Veritas D, e) Libertas A , f) Libertas B, g) Dorm 1, h) Dorm 2, i) Underwood Memorial Library

Q2. Which location do you think would have the most bacteria? Please choose 3.

A2: a) Elevator Buttons, b) Desk, c) Washing Machines, d) Toilet, e) Display Stands in SaengHyeop, f) Cafeteria Table, g) Computer Keyboards, h) Fitness Center

Q3. Which do you think is the best way to remove bacteria on your hand?

A3: a) Washing hand with water only, b) Washing hand with soap, c) Using hand-sanitizer

Q4. At which building did you spend the most time?

A4: a) Veritas A, b) Veritas B , c) Veritas C, d) Veritas D, e) Libertas A, f) Libertas B, g) Dorm 1, h) Dorm 2, i) Underwood Memorial Library

Q5. Which location have you accessed the most?

A5: a) Elevator Buttons, b) Desk, c) Washing Machines, d) Toilet, e) Display Stands in SaengHyeop, f) Cafeteria Table, g) Computer Keyboards, h) Fitness Center

# Results

## Lab Results

**Raw Data.** In this section, the rough data of the experiment is displayed by photographs of the bacteria culture. The photographs are categorized by the buildings and the locations the bacteria collection

Table 2: Photographs of the Bacteria Colonies Collected from five Different Locations (Elevator, Desk, Toilet, Computer, and Air) in Underwood Memorial Library after 39 Hours of Incubation

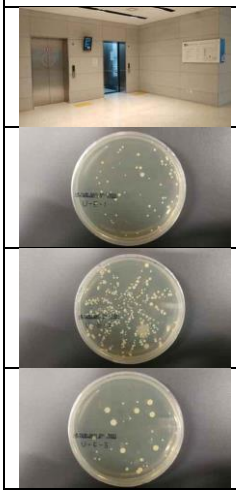
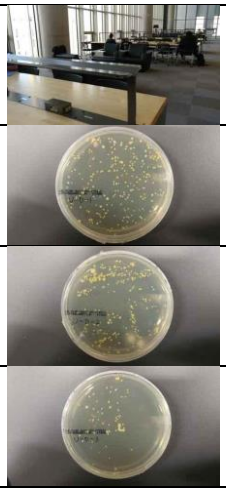
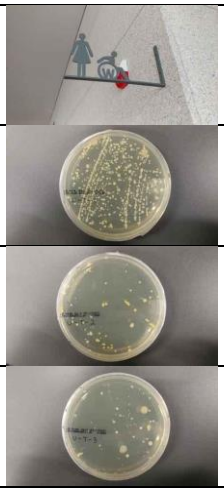
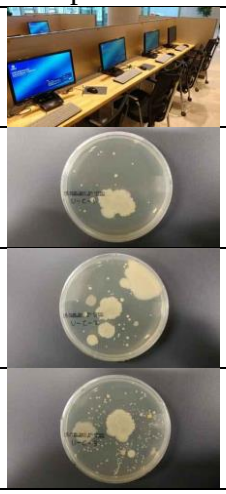
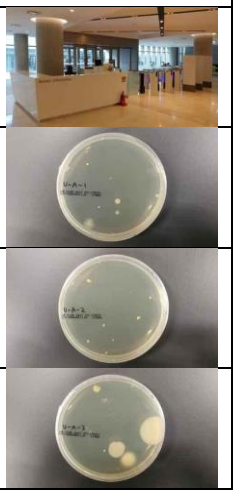
| Elevator | Desk | Toilet | Computer | Air |
|---|---|---|---|---|
|  |  |  |  |  |

Table 3: Photographs of the Bacteria Colonies Collected from five Different Locations (Elevator, Toilet, Cafeteria, Fitness Center and Air) in Vision Hall after 39 Hours of Incubation

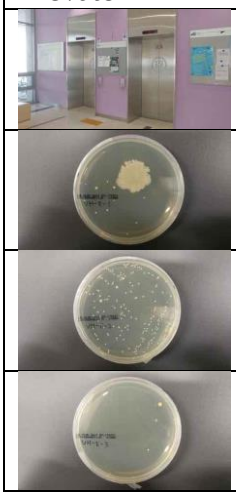
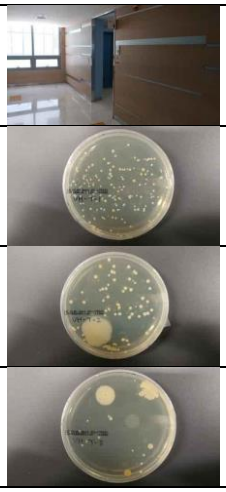
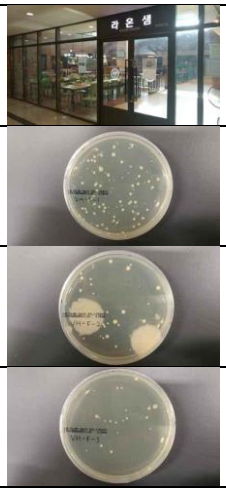
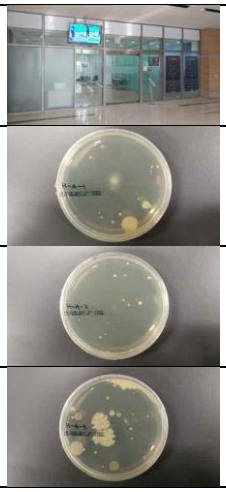
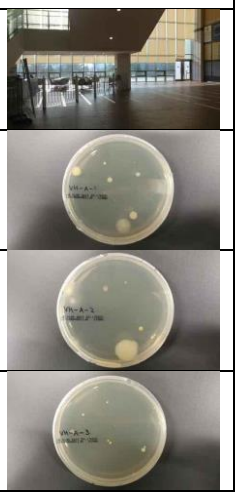
| Elevator | Toilet | Cafeteria | Fitness Center | Air |
|---|---|---|---|---|
|  |  |  |  |  |

Table 4: Photographs of the Bacteria Colonies Collected from four Different Locations (Elevator, Desk, Toilet, and Air) in Libertas Hall A after 39 Hours of Incubation

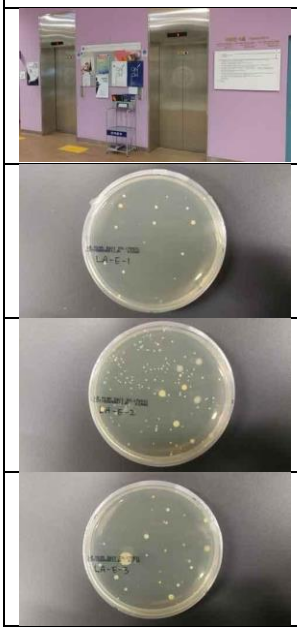
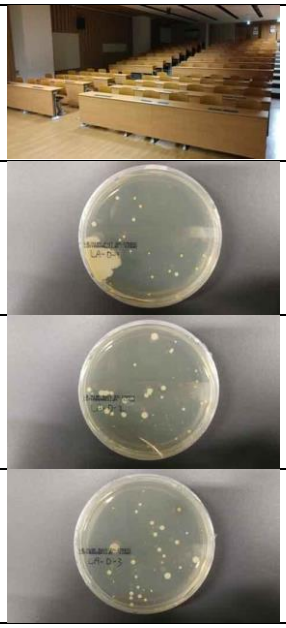
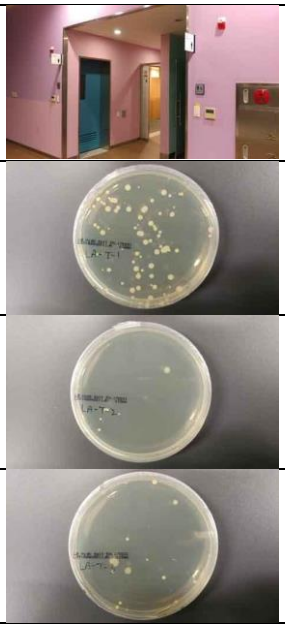
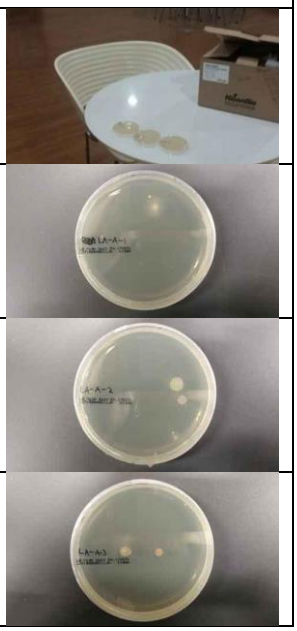
| Elevator | Desk | Toilet | Air |
|---|---|---|---|
|  |  |  |  |

Table 5: Photographs of the Bacteria Colonies Collected from four Different Locations (Elevator, Desk, Toilet, and Air) in Libertas Hall B after 39 Hours of Incubation

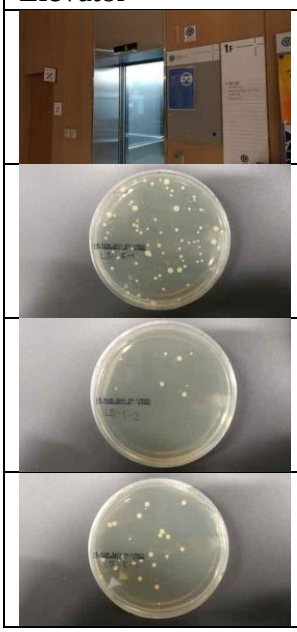
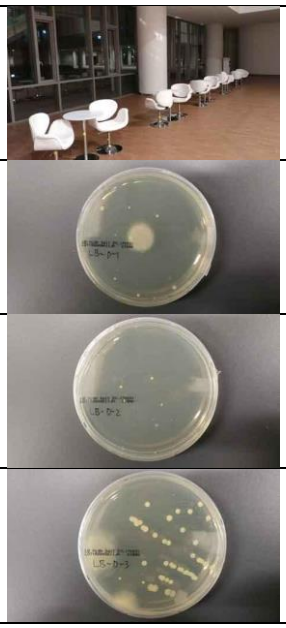
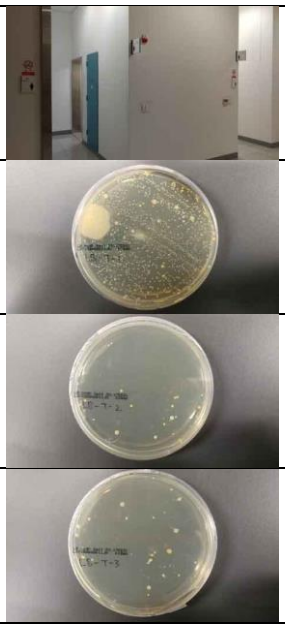
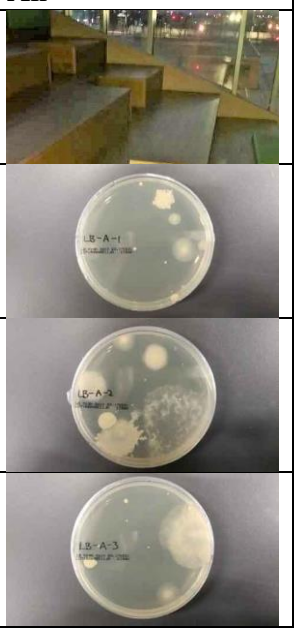
| Elevator | Desk | Toilet | Air |
|---|---|---|---|
|  |  |  |  |

Table 6: Photographs of the Bacteria Colonies Collected from four Different Locations (Elevator, Desk, Toilet, and Air) in Veritas Hall A after 39 Hours of Incubation

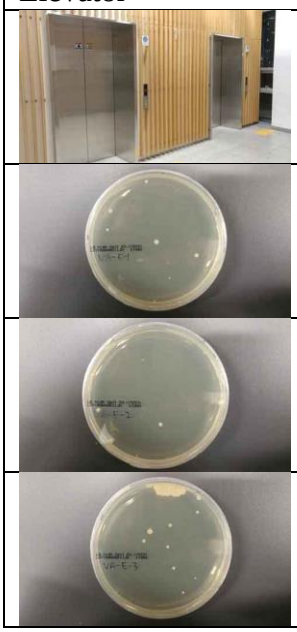
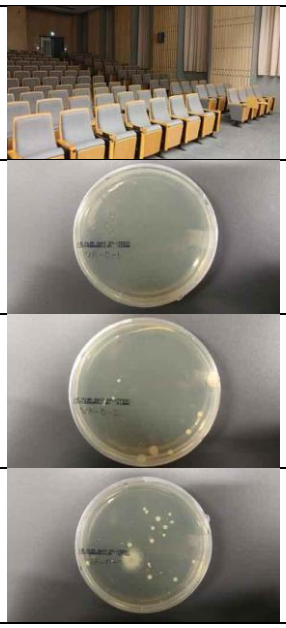
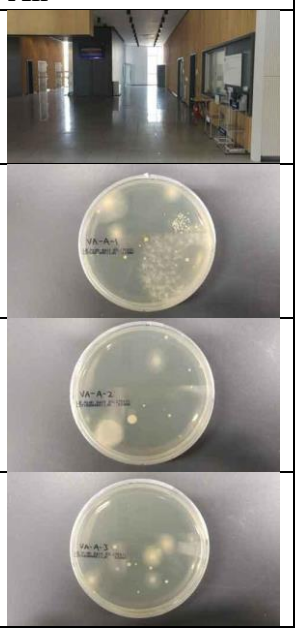
| Elevator | Desk | Toilet | Air |
|---|---|---|---|
|  |  |  |  |

Table 7: Photographs of the Bacteria Colonies Collected from four Different Locations (Elevator, Desk, Toilet, and Air) in Veritas Hall B after 39 Hours of Incubation

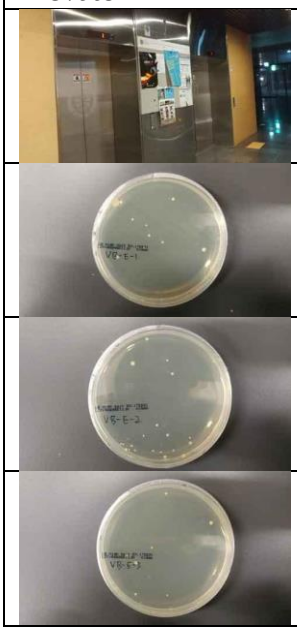
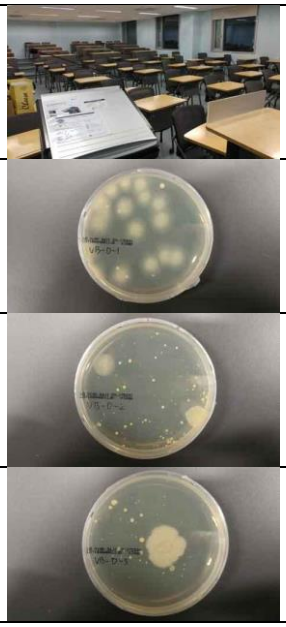
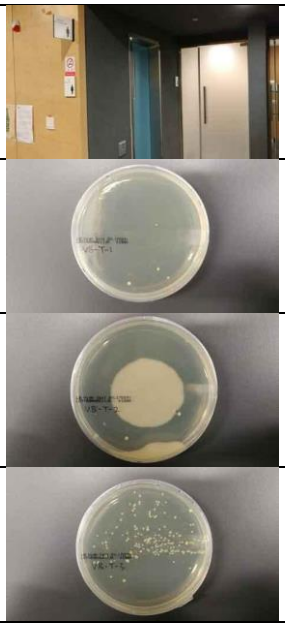
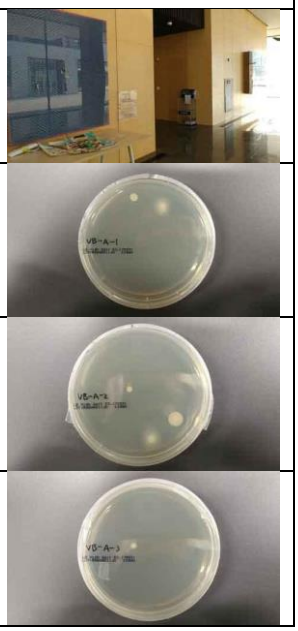
| Elevator | Desk | Toilet | Air |
|---|---|---|---|
|  |  |  |  |

Table 8: Photographs of the Bacteria Colonies Collected from four Different Locations (Elevator, Desk, Toilet, and Air) in Veritas Hall C after 39 Hours of Incubation

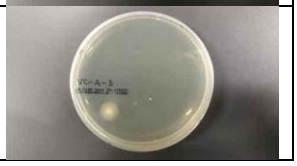
| Elevator | Desk | Toilet | Air |
|---|---|---|---|
|  |  |  |  |
|  |  |  |  |
|  |  |  |  |
|  |  |  |  |

Table 9: Photographs of the Bacteria Colonies Collected from four Different Locations (Elevator, Desk, Toilet, and Air) in Veritas Hall D after 39 Hours of Incubation

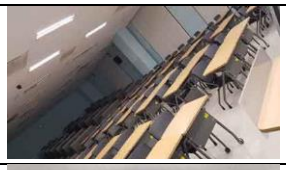
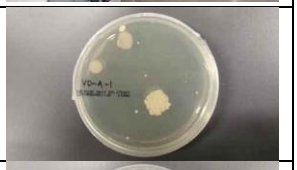
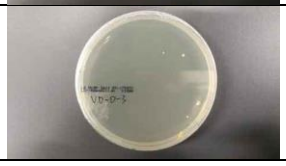
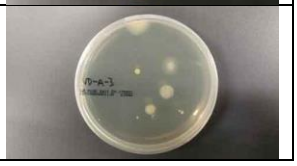
| Elevator | Desk | Toilet | Air |
|---|---|---|---|
|  |  |  |  |
|  |  |  |  |
|  |  |  |  |
|  |  |  |  |

Table 10: Photographs of the Bacteria Colonies Collected from eight Different Locations (Elevator, Desk, Washing Machine, Toilet, Cooperative Store, Cafeteria, Computer, and Air) in Dormitory 1 after 39 Hours of Incubation

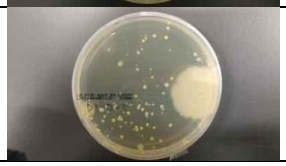
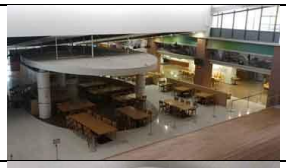
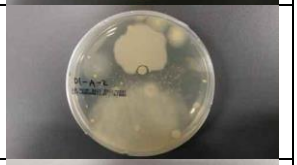
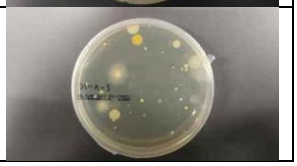
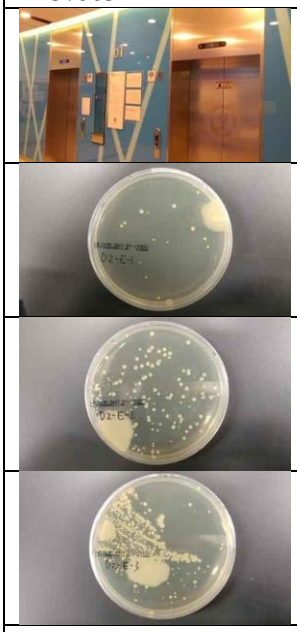
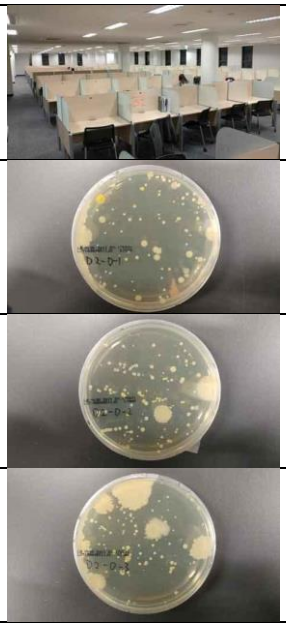
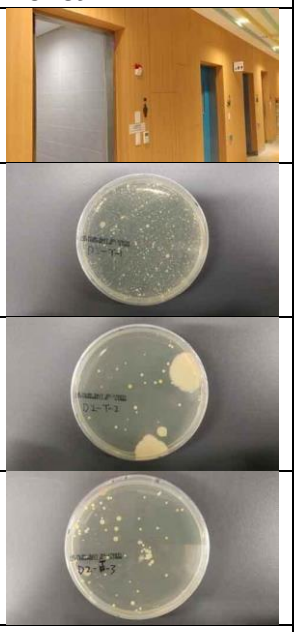
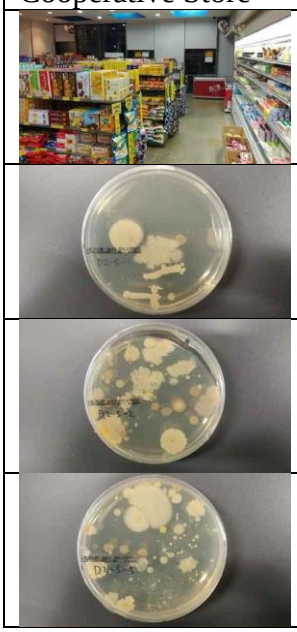
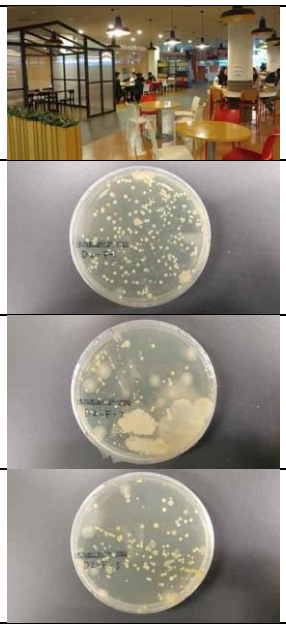
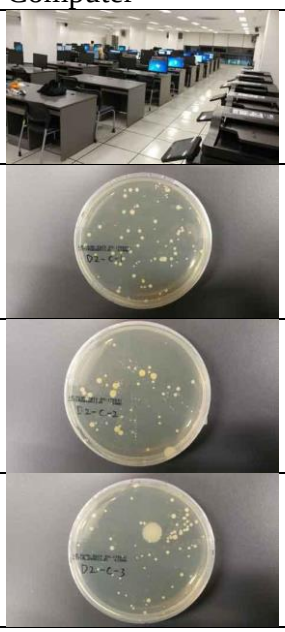
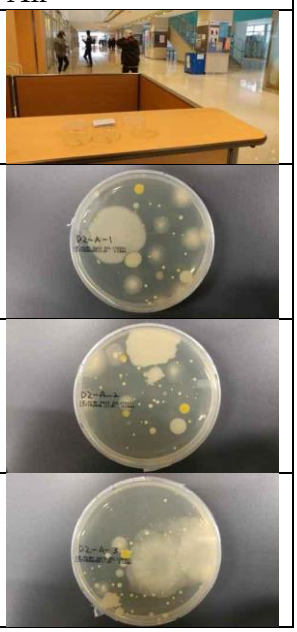
| Elevator | Desk | Washing Machine | Toilet |
|---|---|---|---|
|  |  |  |  |
|  |  |  |  |
|  |  |  |  |
|  |  |  |  |
| **Cooperative Store** | **Cafeteria** | **Computer** | **Air** |
|  |  |  |  |
|  |  |  |  |
|  |  |  |  |
|  |  |  |  |

Table 11: Photographs of the Bacteria Colonies Collected from eight Different Locations (Elevator, Desk, Washing Machine, Toilet, Cooperative Store, Cafeteria, Computer, and Air) in Dormitory 2 after 39 Hours of Incubation

| Elevator | Desk | Washing Machine | Toilet |
|---|---|---|---|
|  |  |  |  |
| Cooperative Store | Cafeteria | Computer | Air |
|  |  |  |  |

After recording the data by taking pictures of the bacteria colonies, we counted the number of colonies. Following *Table12* shows the number of the colonies each collected from different locations in different buildings. The results are shown for all three trials. Then the data is put into various graphs to better compare the results.

Table 12: Colony Numbers Counted for Each Plate (the Blanks are Locations without Data).

| Plate #1 | Underwood Memorial Library | Vision Hall | Libertas Hall A | Libertas Hall B | Veritas Hall A | Veritas Hall B | Veritas Hall C | Veritas Hall D | Dormitory 1 | Dormitory 2 |
|---|---|---|---|---|---|---|---|---|---|---|
| Elevator | 204 | 18 | 25 | 98 | 6 | 13 | 60 | 76 | 92 | 95 |
| Desk | 320 | | 29 | 12 | 0 | 22 | 63 | 25 | 360 | 188 |
| Washing Machine | | | | | | | | | 38 | 210 |
| Toilet | 1176 | 240 | 125 | 1776 | 1080 | 7 | 122 | 664 | 344 | 3112 |
| Cooperative Store | | | | | | | | | 1528 | 9 |
| Cafeteria | | 226 | | | | | | | 162 | 340 |
| Computer | 26 | | | | | | | | 44 | 94 |
| Air | 9 | 9 | 5 | 14 | 420 | 6 | 28 | 13 | 48 | 44 |
| Fitness Center | | 26 | | | | | | | | |

| Plate #2 | Underwood Memorial Library | Vision Hall | Libertas Hall A | Libertas Hall B | Veritas Hall A | Veritas Hall B | Veritas Hall C | Veritas Hall D | Dormitory 1 | Dormitory 2 |
|---|---|---|---|---|---|---|---|---|---|---|
| Elevator | 360 | 259 | 149 | 7 | 4 | 20 | 27 | 32 | 18 | 188 |
| Desk | 264 | | 70 | 8 | 9 | 84 | 67 | 4 | 330 | 141 |
| Washing Machine | | | | | | | | | 310 | 2400 |
| Toilet | 92 | 142 | 7 | 18 | 31 | 163 | 300 | 260 | 713 | 55 |
| Cooperative Store | | | | | | | | | 77 | 62 |
| Cafeteria | | 220 | | | | | | | 56 | 202 |
| Computer | 64 | | | | | | | | 110 | 200 |
| Air | 12 | 34 | 3 | 17 | 12 | 2 | 2 | 31 | 94 | 78 |
| Fitness Center | | 21 | | | | | | | | |

| Plate #3 | Underwood Memorial Library | Vision Hall | Libertas Hall A | Libertas Hall B | Veritas Hall A | Veritas Hall B | Veritas Hall C | Veritas Hall D | Dormitory 1 | Dormitory 2 |
|---|---|---|---|---|---|---|---|---|---|---|
| Elevator | 45 | 3 | 34 | 26 | 38 | 7 | 52 | 100 | 26 | 457 |
| Desk | 78 | | 51 | 78 | 39 | 140 | 85 | 7 | 168 | 165 |
| Washing Machine | | | | | | | | | 1100 | 48 |
| Toilet | 85 | 33 | 13 | 76 | 233 | 210 | 33 | 18 | 4 | 110 |
| Cooperative Store | | | | | | | | | 122 | 218 |
| Cafeteria | | 28 | | | | | | | 354 | 203 |
| Computer | 268 | | | | | | | | 39 | 97 |
| Air | 34 | 11 | 3 | 14 | 25 | 1 | 5 | 25 | 43 | 121 |
| Fitness Center | | 42 | | | | | | | | |

**Processed Data.**

Table 13: Average of the Three Trials of the Number of Bacteria Colonies for Each Building and Location.

| Average | Underwood Memorial Library | Vision Hall | Libertas Hall A | Libertas Hall B | Veritas Hall A | Veritas Hall B | Veritas Hall C | Veritas Hall D | Dormitory 1 | Dormitory 2 |
|---|---|---|---|---|---|---|---|---|---|---|
| Elevator | 203.00 | 93.33 | 69.33 | 43.67 | 16.00 | 13.33 | 46.33 | 69.33 | 45.33 | 246.67 |
| Desk | 220.67 | | 50.00 | 32.67 | 16.00 | 82.00 | 71.67 | 12.00 | 286.00 | 164.67 |
| Washing Machine | | | | | | | | | 482.67 | 886.00 |
| Toilet | 451.00 | 138.33 | 48.33 | 623.33 | 448.00 | 126.67 | 151.67 | 314.00 | 353.67 | 1092.33 |
| Cooperative Store | | | | | | | | | 575.67 | 96.33 |
| Cafeteria | | 158.00 | | | | | | | 190.67 | 248.33 |
| Computer | 119.33 | | | | | | | | 64.33 | 130.33 |
| Air | 18.33 | 18.00 | 3.67 | 15.00 | 152.33 | 3.00 | 11.67 | 23.00 | 61.67 | 81.00 |
| Fitness Center | | 29.67 | | | | | | | | |

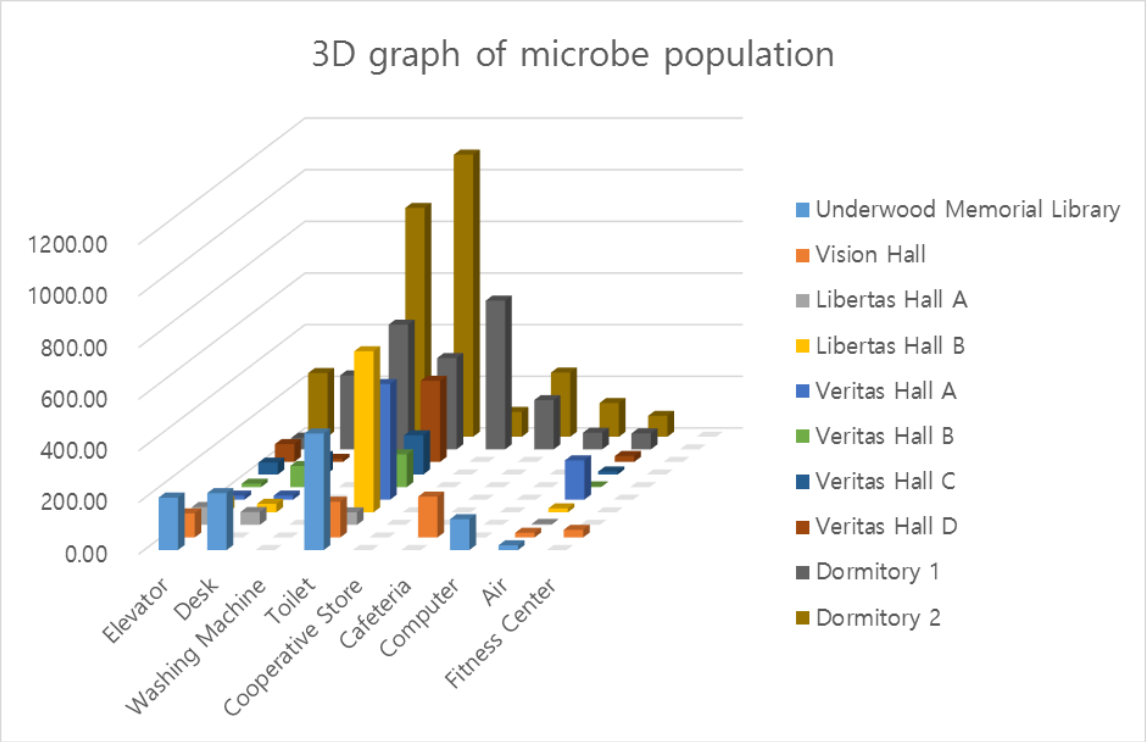
Table 14: Average of the Three Trials of the Number of Bacteria Colonies for Each Building.

| Underwood Memorial Library | Vision Hall | Libertas Hall A | Libertas Hall B | Veritas Hall A | Veritas Hall B | Veritas Hall C | Veritas Hall D | Dormitory 1 | Dormitory 2 |
|---|---|---|---|---|---|---|---|---|---|
| 202.47 | 87.47 | 42.83 | 178.67 | 158.08 | 56.25 | 70.33 | 104.58 | 257.50 | 368.21 |

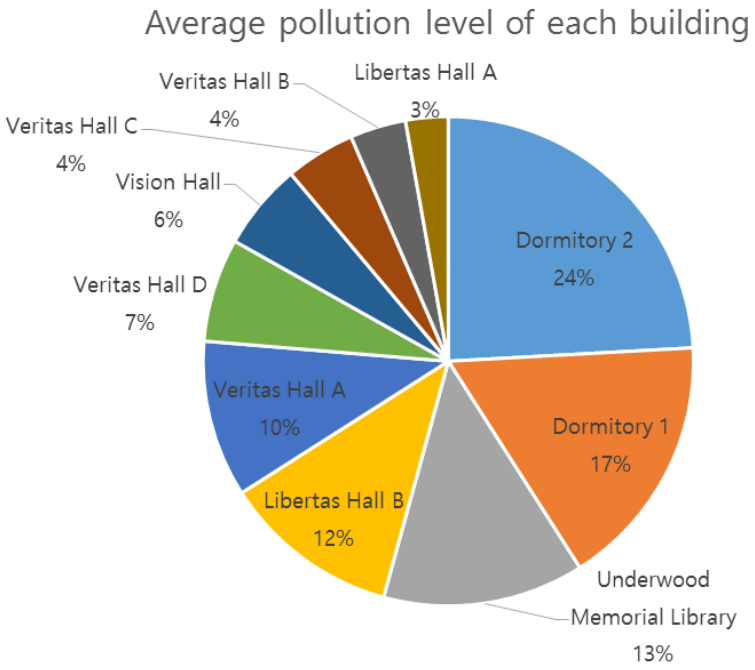
Table 15: Average of the Three Trials of Number of the Bacteria Colonies for Each Location.

| | |
|---|---|
| Elevator | 84.63 |
| Desk | 103.96 |
| Washing Machine | 684.33 |
| Toilet | 374.73 |
| Cooperative Store | 336.00 |
| Cafeteria | 199.00 |
| Computer | 104.67 |
| Air | 38.77 |
| Fitness Center | 29.67 |

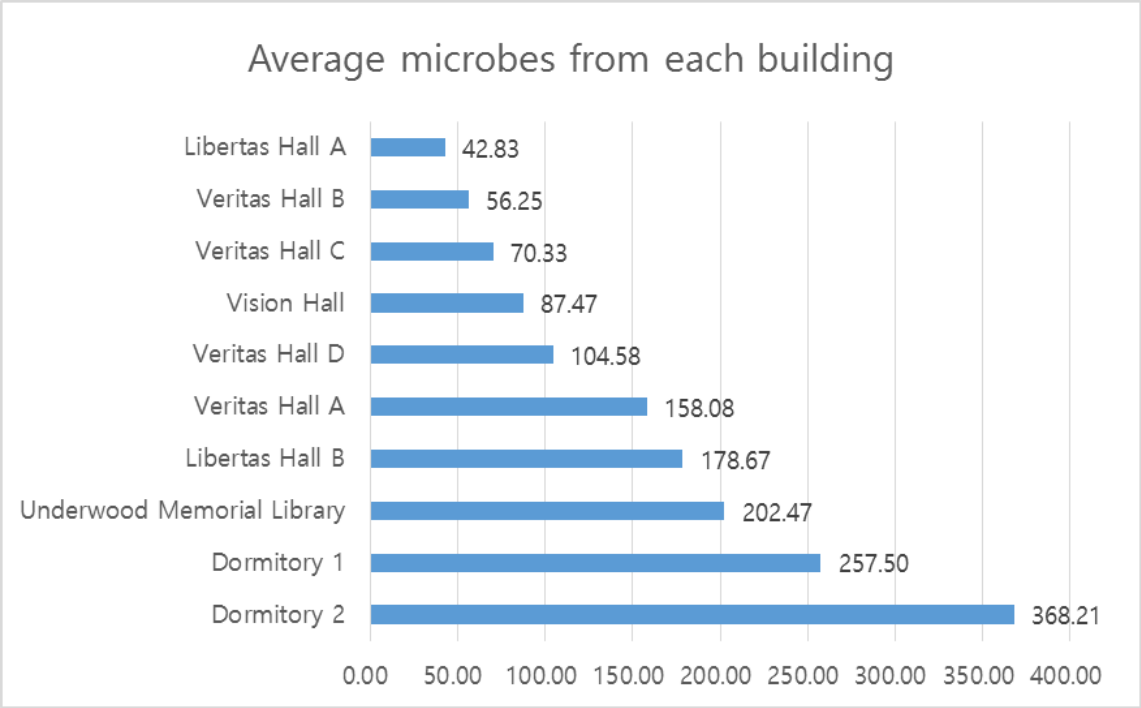
Graph 1. 3D graph of microbe population. Each color refers to a building. Locations without experimental data are shown in light gray color with no height. Each bar represents the average number of colonies from three agar plates.



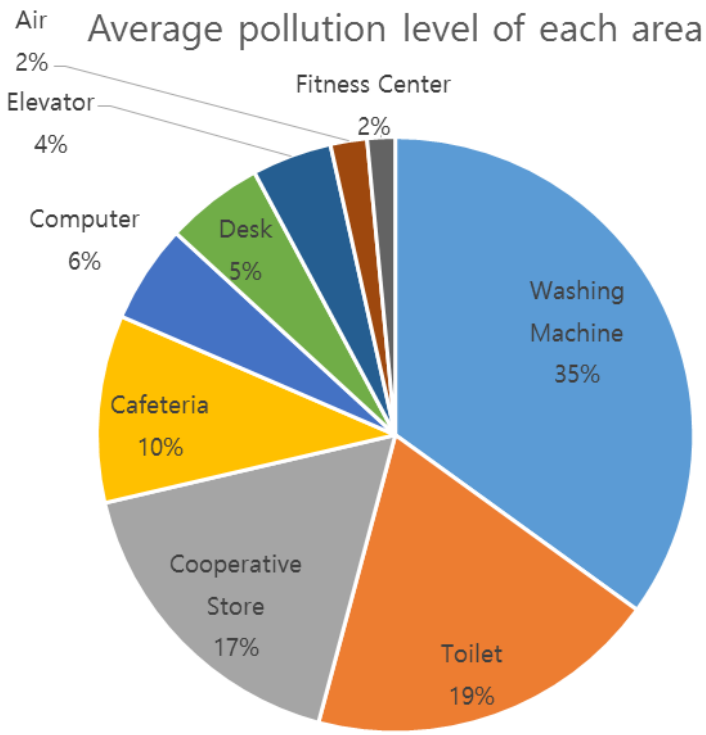

Graph 2. Average pollution level of each building. The microbial population was the largest in the dormitories, followed by the library. Buildings where lectures are held was less populated compared to the dormitories and the library.



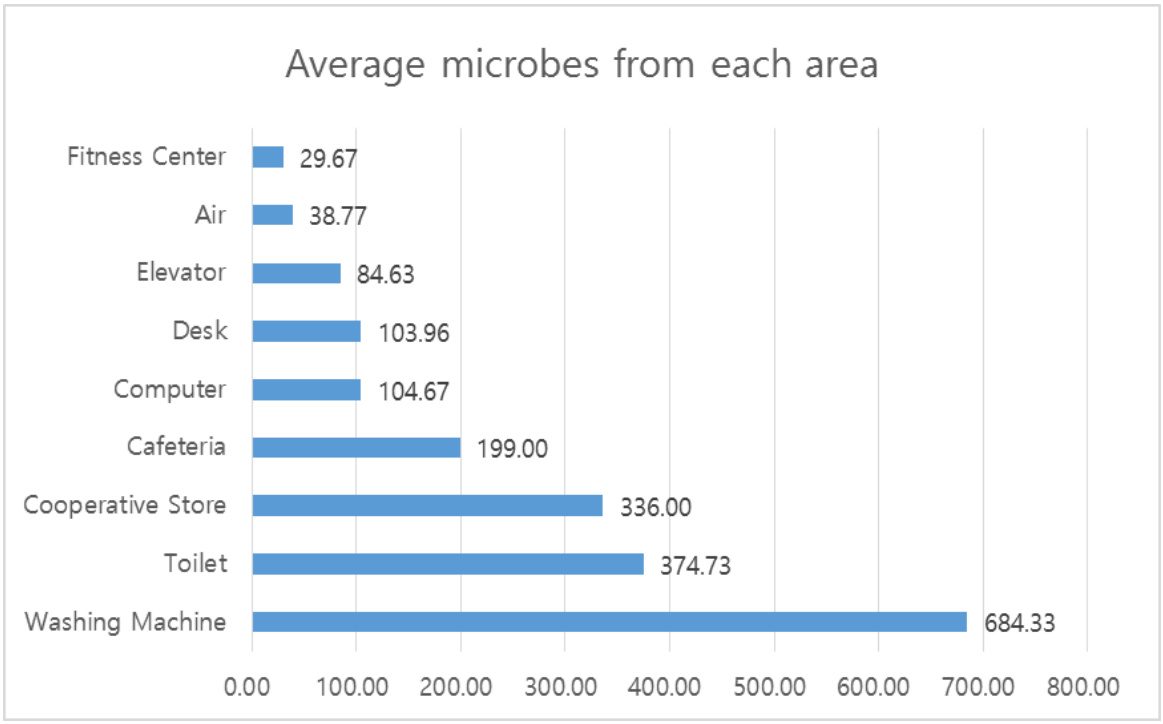
Graph 3. Average microbes from each building. The order is from the least populated to the most populated.




Graph 4. Average pollution level of each area. The microbial population was the largest in washing machines, followed by toilet and cooperative stores. Air and fitness center was least populated compared to other areas.

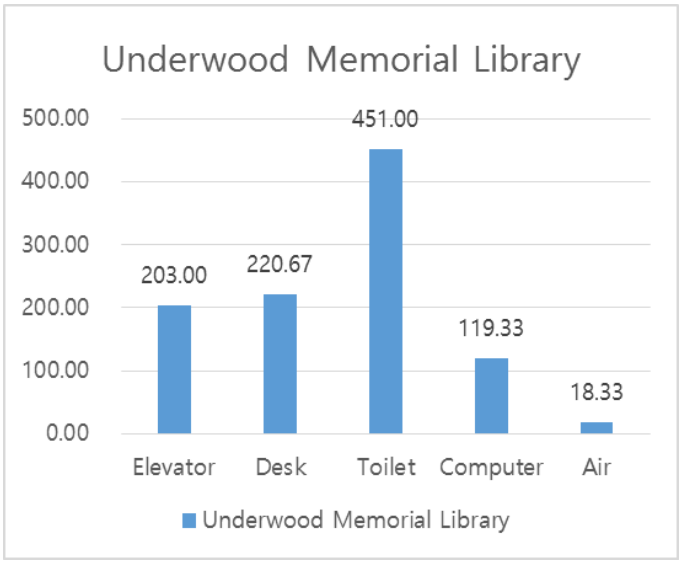


Graph 5. Average microbes from each area. The order is from the least populated to the most populated.

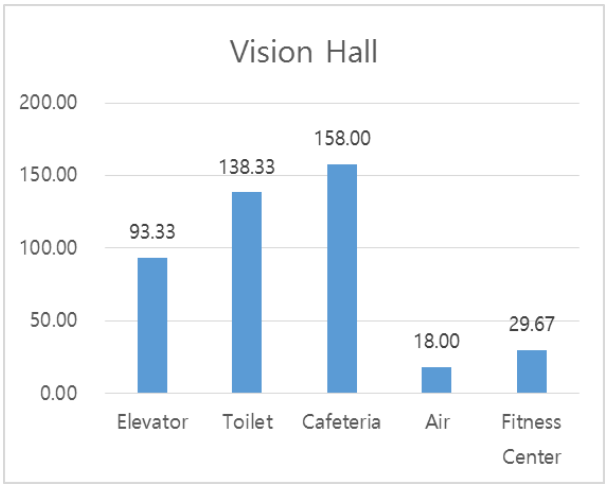



Graph 6 to 15 shows the average number of bacteria colonies from different areas in a building for all 10 buildings separately.

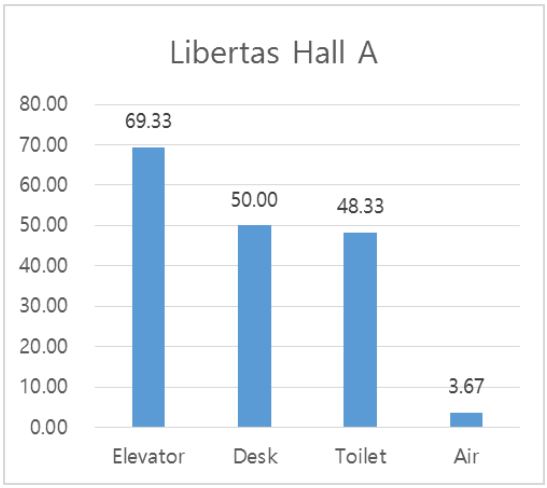
Graph 6. Microbes in Underwood Memorial Library. The microbe population was the largest in the toilet and the smallest in the air.



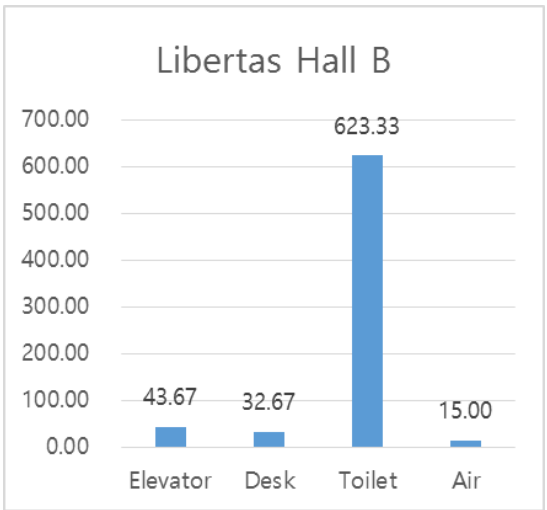
Graph 7. Microbes in Vision Hall. The microbe population was the largest in the cafeteria and the smallest in the air.



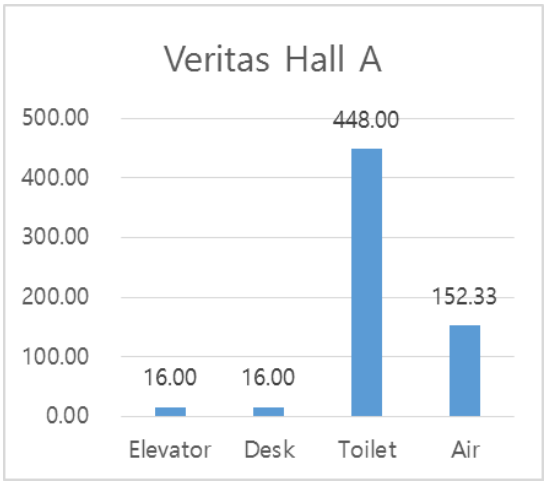

Graph 8. Microbes in Libertas Hall A. The microbe population was the largest in the elevator and the smallest in the air.



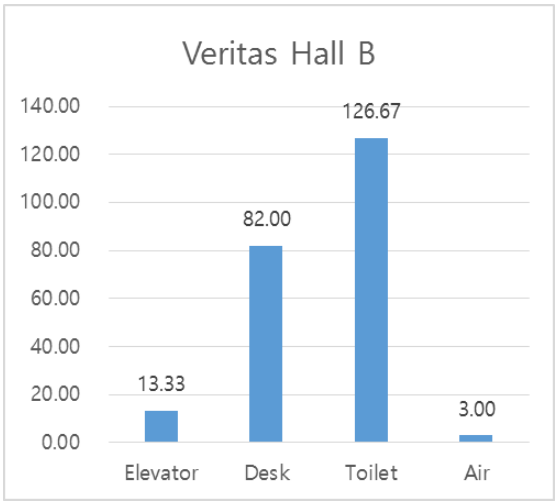

Graph 9. Microbes in Libertas Hall B. The microbe population was the largest in the toilet and the smallest in the air.



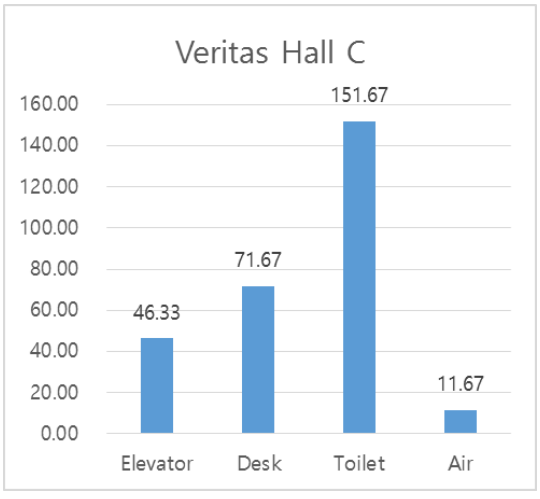
Graph 10. Microbes in Veritas Hall A. The microbe population was the largest in the toilet and the smallest in the elevator and the desk.



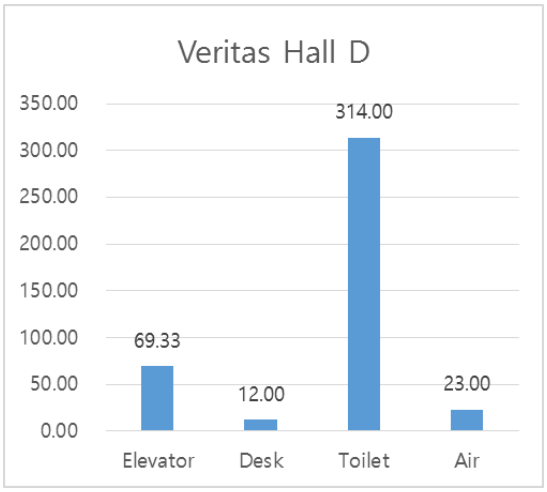

Graph 11. Microbes in Veritas Hall B. The microbe population was the largest in the toilet and the smallest in the air.



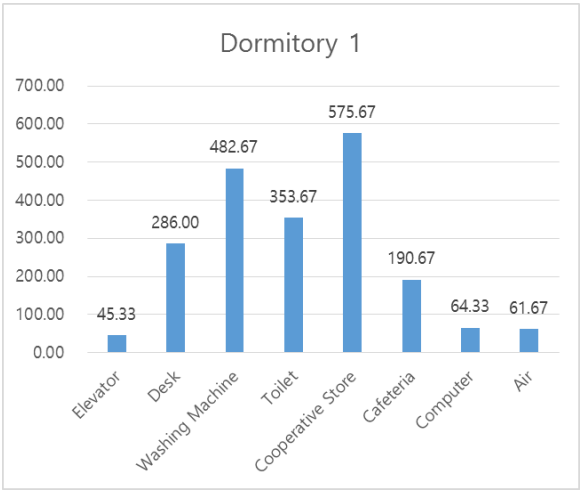

Graph 12. Microbes in Veritas Hall C. The microbe population was the largest in the toilet and the smallest in the air.



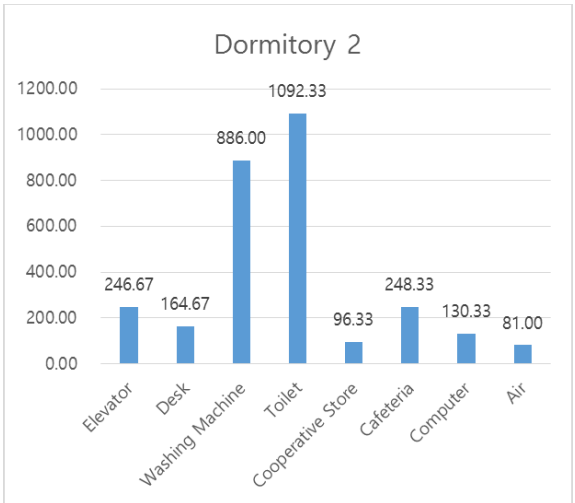
Graph 13. Microbes in Veritas Hall D. The microbe population was the largest in the toilet and the smallest on the desk.




Graph 14. Microbes in Dormitory 1. The microbe population was the largest in the cooperative store and the smallest in the elevator.

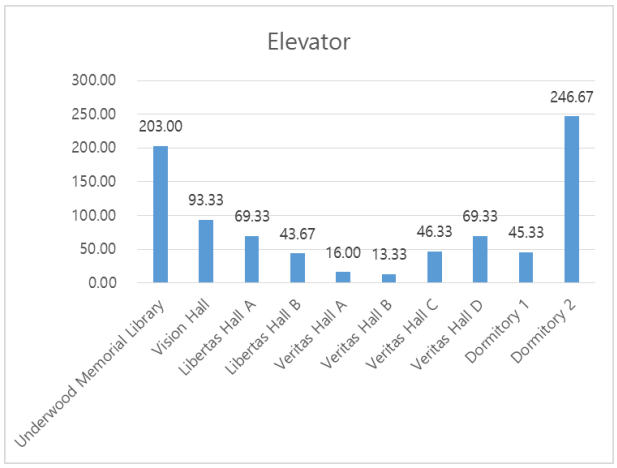



Graph 16. Microbes in Dormitory 2. The microbe population was the largest in the toilet and the smallest in the air.

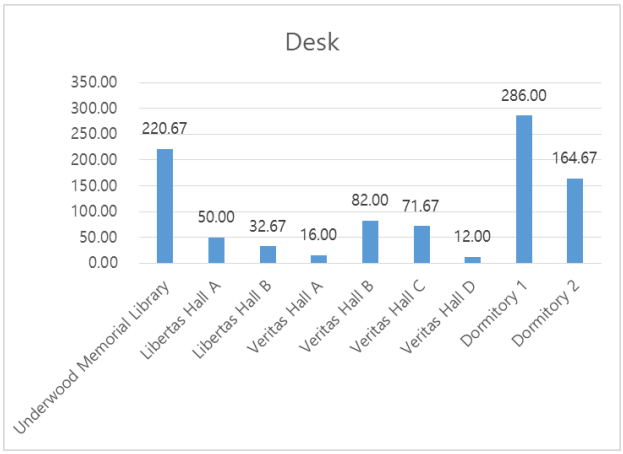


In Graph 16 to 23, the different bacteria colony numbers of each building is compared for each area.

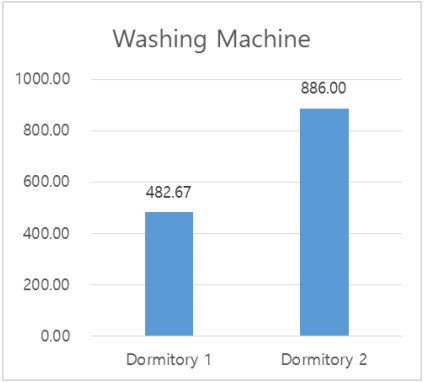
Graph 16. Microbes in the elevator. The microbe population was the largest in dormitory 2 and the smallest in Veritas Hall B.



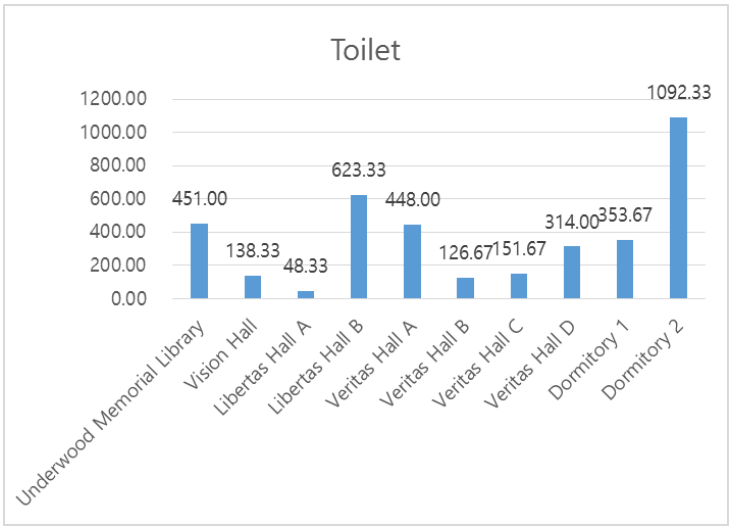

Graph 17. Microbes on the desk. The microbe population was the largest in dormitory 1 and the smallest in Veritas Hall D.



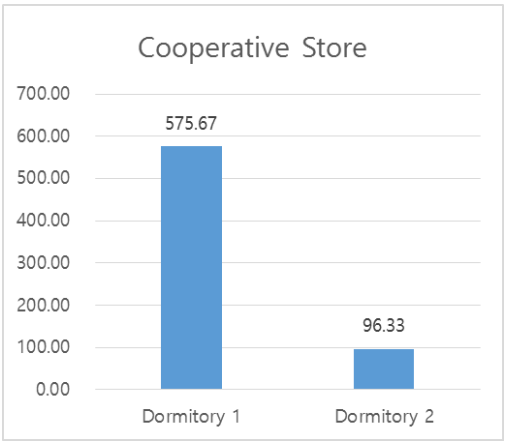

Graph 18. Microbes in washing machines. The microbe population was larger in dormitory 2 compared to dormitory 1.



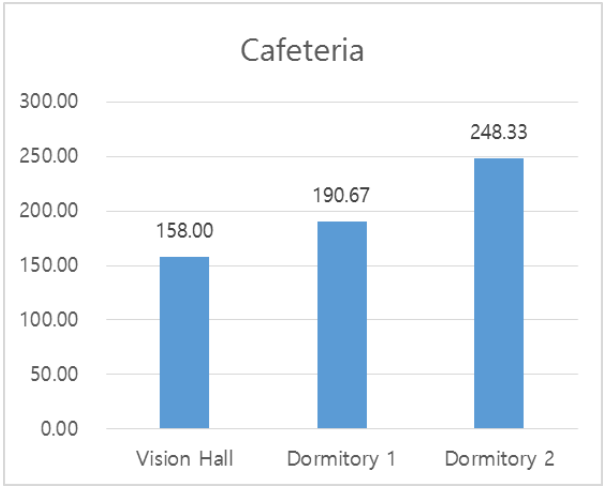
Graph 19. Microbes in the toilet. The microbe population was the largest in dormitory 2 and the smallest in Libertas Hall A.



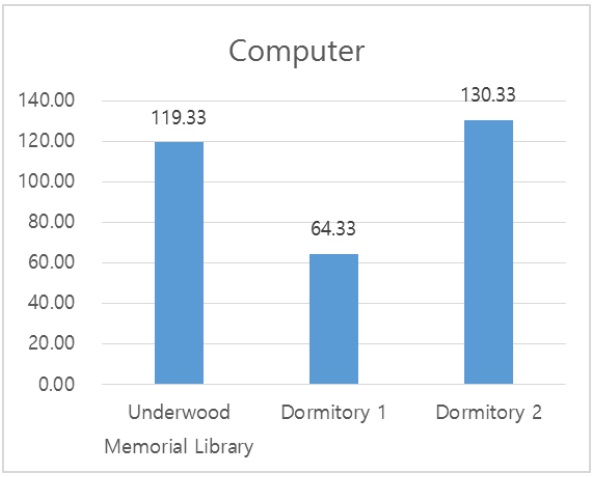

Graph 20. Microbes in the cooperative store. The microbe population was larger in dormitory 1 compared to dormitory 2.



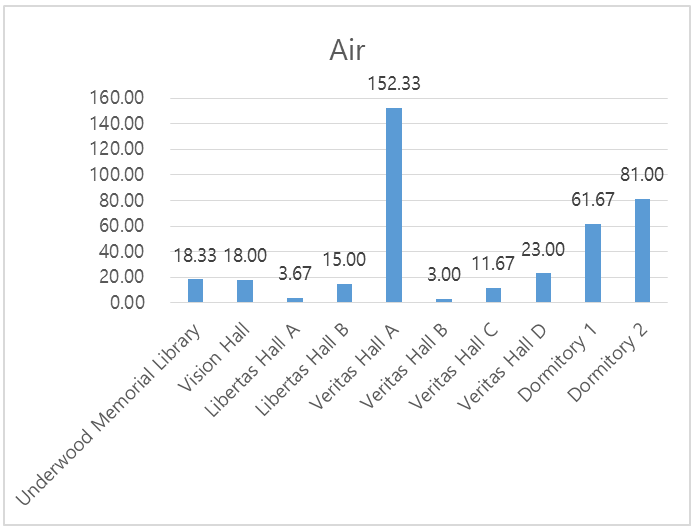

Graph 21. Microbes in the cafeteria. The microbe population was the largest in dormitory 2 and the smallest in Vision Hall.



Graph 22. Microbes on the computer. The microbe population was the largest in dormitory 2 and the smallest in dormitory 1.



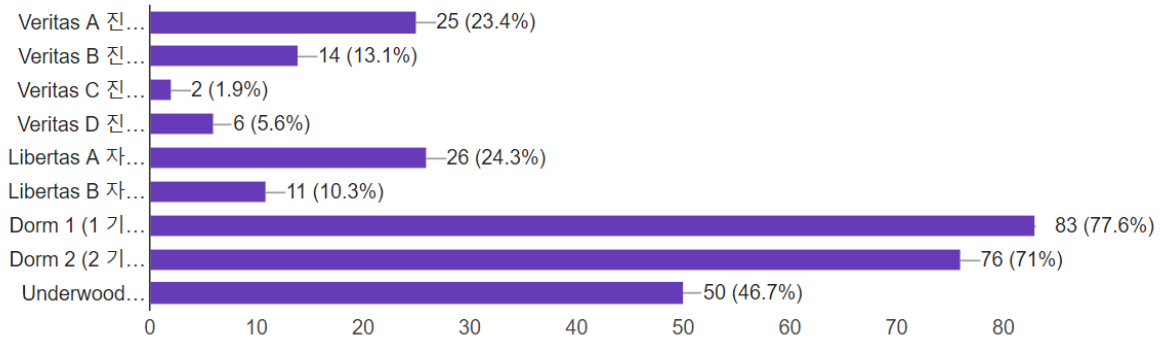

Graph 23. Microbes in the air. The microbe population was the largest in Veritas Hall A and the smallest in Veritas Hall B.



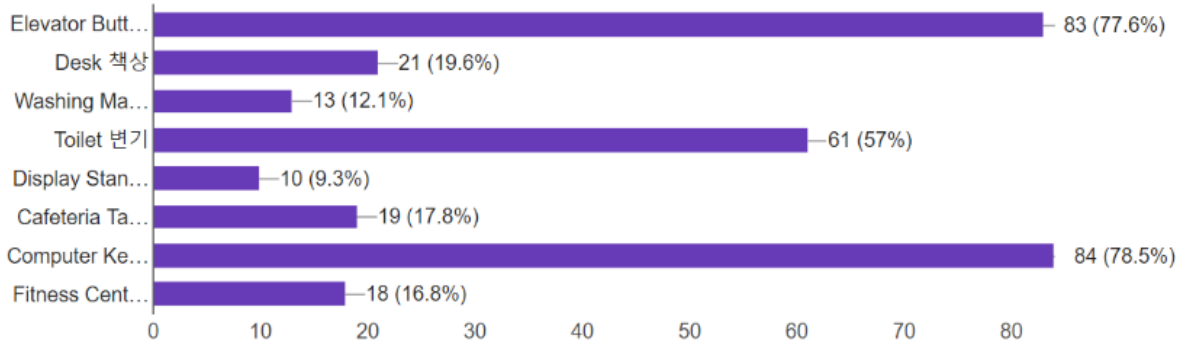

**Survey Results**

We aimed for minimum 100 responses, and we gained 107 responses. Out of 107 responders, 87 wrote their phone number for the additional question at the bottom. Following is the graph version of the responses for each question.

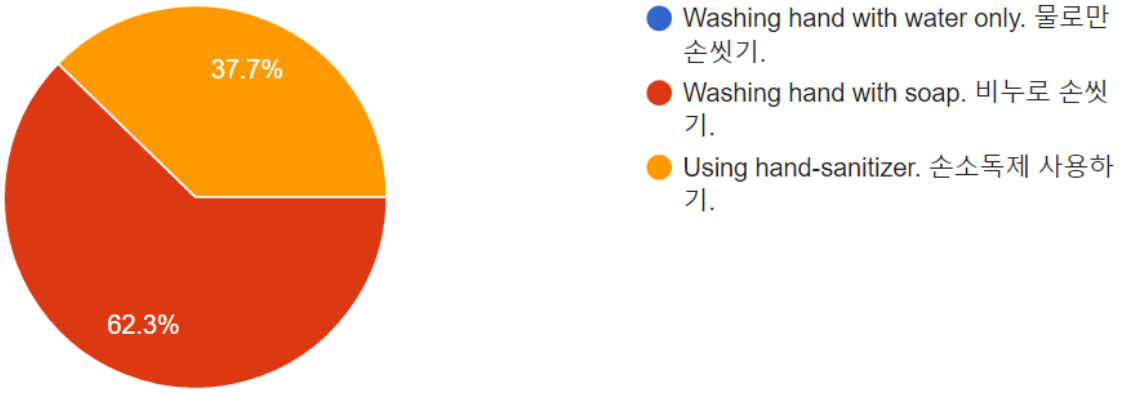
Graph 24. Result of Question 1: Which Buildings Do You Think Would Have the Most Bacteria?



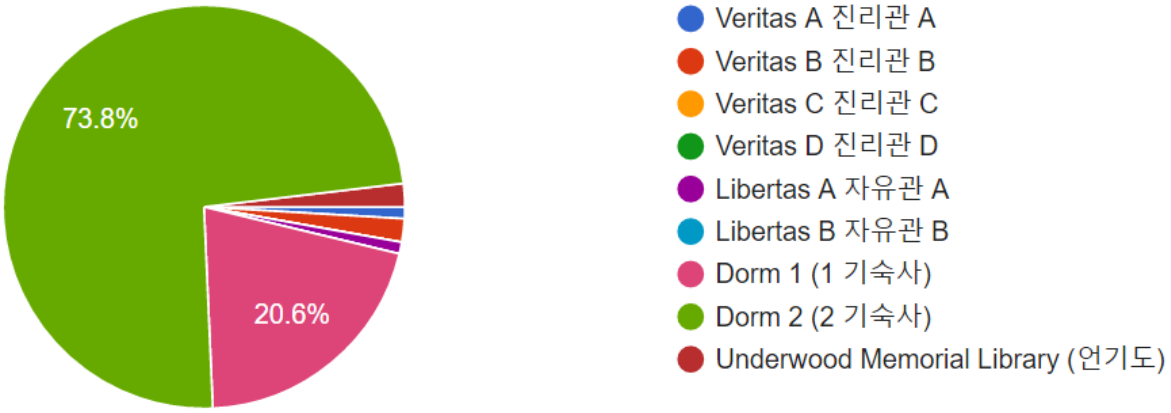

Graph 25. Result of Question 2: Which Locations Do You Think Would Have the Most Bacteria?



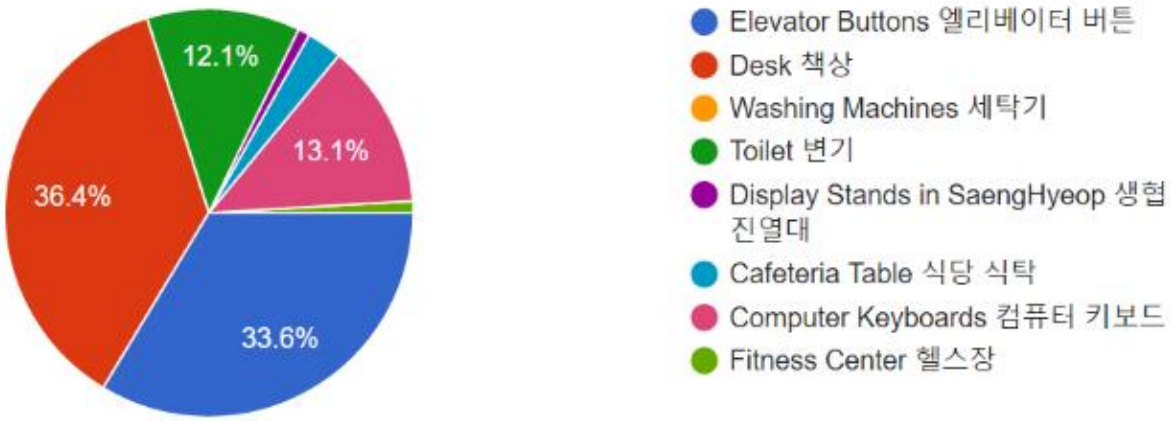

Graph 26. Result of Question 3: Which Do You Think is the Best Way to Remove Bacteria on Your Hand?



Graph 27. Result of Question 4: At Which Building Did You Spend the Most Time?




Graph 28. Result of Question 5: Which Location Have You Accessed the Most?




## Conclusion

The laboratory experiment results tell us that the building with highest bacteria habitation at the time of our experiment was dormitory 2, followed up by dormitory 1 and the library (*Graph 3*). This result shows an agreement to the student expectation as they answered that there will be the most bacteria at dormitory 1, followed up by dormitory 2 and the library (*Graph 24*). This also matches with the survey result for the most accessed buildings. The top three buildings that the students spent the most time was dormitory 2, dormitory 1, and the library (*Graph 27*). For the locations, the experiment results tell us that washing machine contains the most bacteria, followed up by the toilet and display shelves at

the cooperative store (*Graph 5*). This is quite different from what students expect. They answered that they expect the most bacteria on the computer keyboards, elevator buttons and toilets (*Graph 25*). Although toilet is shown by the experiment as the place with second most bacteria, elevator buttons and computer keyboards are found to contain one of the fewest bacteria. The student expectation is at least in some accordance with their answer to the most accessed locations, which were the desks, elevator buttons, and computer keyboards (*Graph 28*). Although the comparison of the two results show some consistency, it is hard to make a solid statement out of it. We had many difficulties throughout the experiment, which also contributes to the rooms of error.

One of the difficulties that we met during this project was when an agar plate had more than 1,000 small colonies that overlapped with each other. Especially in the case of the plate that had over 3,000 colonies, the size of each colony was very small and evenly distributed on the medium. In these cases, instead of counting every colony, we divided the plate into four or eight equal sections and counted the number of colonies on one section that appeared to represent the average amount of colonies of that plate. Then we multiplied the number by the number of sections. We also met with problems when colonies spread over a large portion of the plate, and discussed methods on how to count them more accurately.

We have encountered with unexpected results in the analyzing process. Also, although the samples were obtained from the same location, there were cases where the number of colonies on the three trials differed noticeably. For example in the case of dormitory 2 toilet, plate #1 had 3112 colonies while plate #2 and #3 had 55 and 110 colonies each, which means there is about 30~60-fold difference between the plates. This could have been from various reasons such as toilet seats that were frequently used and those that were not, or from different methods of swiping during sampling and spreading the swabs on the

plates. There was a considerable number of these kinds of plates, and because we calculated the average to analyze the data there were difficulties in considering the errors in the data analysis process. For a more accurate analysis there are several methods of improving the experiment, such as repeating the same experiment several times and using the increased amount of data for analysis, or creating more precise standards and performing a new experiment. Since this experiment was done in between the exam period and the start of winter vacation, we faced some problems in gathering a large number of samples in a short period of time, so we expect a more systematic experiment if we are provided with another opportunity.

Moreover, the survey was not distributed equally to every Yonsei students who have stayed in the international campus in the fall semester of 2016. The survey links were distributed to the certain limited majors for the speed of the data collection. This could have made the data lean to certain way because different majors may use different buildings and that could make difference to the students' answers on the most accessed buildings and their expectations about the bacteria habitation. This survey can be therefore improved by either distributing the link to every major, or to simply upload to a page in which the students from every major are involved in, such as the freshman Facebook page.

When there are many microbes around us, it increases the possibility of the existence of harmful microbes and that of making contact with them. After people learned the existence of microbes, they changed their views of hygiene and started various attempts on improving poor sanitary conditions. Even at Yonsei University International Campus, school cleaners work every day to clean up our surroundings. However, since school buildings are regularly used by students and faculty members, cleaning every few hours or days is not enough.

The easiest way to compensate for this insufficiency is washing our hands. Hands are

almost always in contact with surfaces of various objects, which means that most infectious diseases can be prevented just by frequently washing or sterilizing one's hand (Burton, Akrum).

There are many products for hygiene that are sold and used. However. the most important part would be being concerned about and taking care of your own personal hygiene. Even if these hygienic goods are provided, they are useless if we do not use them properly. For instance, as we checked in the survey question #3, students answered that hand sanitizers are the best way to wash out bacteria (*Graph 26*). Although it could be true in the sense of the efficiency, hand sanitizers are not always the best option. The highly efficient hand sanitizers could kill beneficial or benign bacteria on our skin as well. Washing hand with water and soap frequently is enough to get rid of the harmful bacteria.

As the results from our experiment show, microbes exist everywhere around us. Some places are more populated while some are sparse. Although performing an experiment once cannot represent the microbial population of every location, this experiment showed us that the number of microbes is fairly large and the diversity of their species is huge. While there are microbes that are harmless to humans among these, there is also a mixture of microbes that are potentially dangerous and those that are normally dormant but can cause problems if their population grows. The best option for us, who cannot see nor differentiate the microbes, would be maintaining personal hygiene within an appropriate limit and preventing the development of diseases.

References

Akrum T, Sheri C, Sarah E, Charles G. Impact of an alcohol-based hand sanitizer intervention on the spread of viruses in homes. Food Environ Virol. 2014;6:140-144.

Burton M, Cobb E, Donachie P, Judah G, Curtis V, Schmidt WP. The effect of handwashing with water or soap on bacterial contamination of hands. *Int J Environ Res Public Health*. 2011;8:97–104.

CELL DIVISION: BINARY FISSION AND MITOSIS. (n.d.). Retrieved February 28, 2017, from https://www2.estrellamountain.edu/faculty/farabee/biobk/BioBookmito.html

D. (2016, February 12). Plant Guild #4: Nitrogen-fixing Plants. Retrieved February 28, 2017, from http://www.vegetariat.com/2015/12/plant-guild-4-nitrogen-fixing-plants/

Eukaryotic Cell vs Prokaryotic Cell. (n.d.). Retrieved February 28, 2017, from http://www.diffen.com/difference/Eukaryotic_Cell_vs_Prokaryotic_Cell

(n.d.). Retrieved February 28, 2017, from http://study.com/academy/lesson/do-prokaryotic-cells-have-a-nucleus.html

Lactobacillus Acidophilus Probiotic Research. (n.d.). Retrieved February 28, 2017, from http://buyprobiotics.net/tag/lactobacillus-acidophilus

PhD, C. P. (n.d.). H. pylori (Helicobacter Pylori ) Infection Symptoms, Treatment, Causes – How does a person become infected with H. pylori? Retrieved February 28, 2017, from http://www.medicinenet.com/helicobacter_pylori/page3.htm

Sandhyarani, N. (2016, August 22). Examples of Bacteria That are Commonly Present All Around Us. Retrieved February 28, 2017, from http://www.buzzle.com/articles/examples-of-bacteria.html

Vidyasagar, A. (2015, July 23). What Are Bacteria? Retrieved February 28, 2017, from http://www.livescience.com/51641-bacteria.html

Bohyun Kim

Looking back on the experiment procedures and the choices we made in between, I find many places where I hope we have done differently. At the time we were doing the experiment, we thought we had the right reasons to choose certain methods. However, now that we are done with it, it feels like we could have considered more details in our decisions and been more meticulous in the procedures. Still, it was a great experience to plan an experiment ourselves. We learned a lot about what to consider when we plan and run a lab by ourselves. The experiment we performed in this project included a simple method of culturing bacteria on petri dishes. However, it was nice to repeat the collecting-culturing-observing steps and get used to the small things we need to take care in the procedure. Also, although we have done several test experiments, we would end up with unexpected results in the actual experiment. Looking at these incidents, I realized how much trial and errors the scientists would go through before coming up with a legitimate experiment. Lastly and most importantly, I thank Nayoung and Dabin for working with me. It was much more fun to work together and I cannot imagine how much more mistakes and times it would have taken to finish this project if I was alone. We would always share our opinions, suggest better ideas, and remind each other when someone forgets something, which I think have led us in a better direction. It was one of my few experiences to plan and run an experiment from the beginning to the end without instructions, so it was good to have friends to rely on. Moreover, I am proud of our team to finish the research paper regardless of our tough situation of staying in different places of the world during most of this vacation.

Dabin Che

Currently having finished the first draft, which includes the introduction and the body, I was in charge of the body part. Using my previous experience of organizing experiment results, I organized the graphs and pictures in our paper and learned the importance of data organizing through visualizing the raw data of colony numbers into graphs. The biggest advantage of this program was being given the opportunity to actually perform experiments that we have learned only through textbooks and are hard to conduct by ourselves. In the pre-lab we placed the agar plates in a small incubator, and not many colonies grew on the plates although the incubation time was long. In the actual experiment, placing the boxes of agar plates into a large incubator resulted in a surprising amount of colonies, which makes me tentatively presume that the difference in the growth of colonies came from the different efficiency of the incubators. Frequently visiting the labs of the college of pharmacy through the pre-lab steps and the actual

experiment and watching graduate students performing experiments also provided the chance of experiencing the atmosphere of laboratories, although it was only for a short period of time. If given a chance, I look forward to improving the weak points in this experiment and improving them to gain better results in future experiments. Lastly, I thank my teammates for actively participating in the experiment and in creating the bacteria map of the international campus.

Na young Lee

I was able to learn the importance of planning, performing, recording, and analyzing experimental procedures. Although I have taken several lab classes before, running an entire experiment was a completely different experience. In lab classes, TAs used to prepare all the necessary materials and guide us the most efficient way to reach the conclusion we wanted. In contrast, for our own project, we had to decide details ranging from where to acquire microbes to how long to cultivate colonies. Therefore, we solidified our understanding in terms of role of each step.