MISCONCEPTIONS CONCERNING INFECTIOUS DISEASE IN COLLEGE-AGED STUDENTS : A DEVELOPMENTAL APPROACH TO THE DISCOVERY OF MYTHS

By

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A Thesis Submitted to The Honors College

In Partial Fulfillment of the Bachelor's degree
With Honors in

Microbiology

THE UNIVERSITY OF ARIZONA

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Abstract

The idea for this thesis began with the acknowledgment of misunderstandings and ignorance concerning infectious disease in college-aged students, and, through survey research of many classes, ended in the disclosure of several distinct and specific misconceptions. We administered a very general questionnaire to a general microbiology class, freshman colloquium, and upper division virology class asking what misconceptions they had coming into class which were later debunked. The results of this survey showed the majority of students did not understand the means or ease of transmission, the efficacy of washing one's hands, the use of antibiotics for all infections, the hardiness of microbes, and the belief that they are all harmful. These prominent misconceptions became the hypotheses in our second survey which was more delineated and specific. In this survey it was noted that many students were unaware of the route of transmission of certain pandemics such as cholera, and highly aware of those epidemics with extreme media coverage, such as SARS and HIV. It was shown that students tended to generalize, believing that antibiotics could be used against fungus and viruses and that most antiseptics were extremely effective. Students also evaluated diseases at face value with the belief that symptoms present on the skin could have only arisen from microbes transmitted by direct contact, an extreme standardization of disease. It was also a prominent belief that microbes could not survive more than minutes outside of the human body.

Introduction

It was like any other day in the Zimbabwean village, when the woman was asked to describe her disease and its cause. She did not respond, but stared vacantly into the sky, not understanding the question now any more than she understood it the day she was diagnosed. It was dark outside and red cloths were tied on all the doors of homes with sickness… like a warning… a beckoning call. She pointed aimlessly at the lit-up houses, spotted red now like Kaposi's sarcoma on the body of what used to be a happy village, too grief-stricken to notice the irony. No, she did not understand the disease. This woman knew nothing of T helper cells and interferon and viral spread. She didn't speak the language of erythrocytes. She could not have told you she had a lethal virus in her blood, but she could have told you about a more-alarming, made-up virus in the news, a Western one. All gaps in medical knowledge she bridged with the meaning of the disease, the despair and the hopelessness. She never asked *how* it happened, only *why* it happened to *her*. HIV was some fabricated thing by a white man's government. But this, this was personal. And when things are personal, there is a person to blame… a sorcerer.

Perhaps she would not have contracted HIV from her husband if he had worn a condom. But she had heard, from the best gossip of course, that HIV was somehow put into condoms by "the companies" (Rodlach 113). Perhaps her husband never would have contracted the virus had prostitution by desperate women not been so prevalent in the African cities. Perhaps if the government didn't silence the disease and the associated guilt and blame, this never would have happened. Giving the cause of AIDS a root in sorcery means that prevention, and even a cure, would be of no use whatsoever. After all, drugs don't cure evil, and unfortunately, science never could help cure dangerous ideas.

This woman believed the agent of her disease was not a retrovirus one could see, even with the help of an electron microscope. Her agent was *ondofa,* a spirit-being grown with maleficent intent (Rodlach 53). AIDS was akin to *ulunyoka*, a substance which required some sort of physical contact with

the victim to cause harm. It was a being spread through sex. It was anything but a virus. No, this woman's agent was of the impossible kind… the dangerous kind. It was the idea of conspiracy and sorcery, the tradition, the need to blame; it was a voracious and fear-inspired misconception. And it was invisible, unquantifiable, and if possible, more unconquerable than the HIV virus itself.

Under the African sun, in most countries, it is believed that humans never die naturally; they are always, in some way, murdered (Rodlach 54). This woman needed someone to blame and she chose sorcery as her murderer. It is astounding that, even with no real evidence to support it, the belief in sorcery is common among Zimbabwean households, because sorcery, at least, offers hope that one can change their fate. It offers the chance to blame, to accuse the powerful in order to demote their power or the weak to sever one's name from any hint of immorality. So, why is it that even despite education which teaches that AIDS has a viral cause, people still believe its number one cause to be sorcery? It is our attitudes, our environment, and our cultures. Facts cannot alleviate any misconceptions unless one first addresses the root of the problem. Most Zimbabwean citizens, when asked for evidence of sorcery in an AIDS case, could name nothing other than family grudges. They have grown up with sorcery rumors; they use it is a scapegoat daily. It has become the makings of tradition. And without knowing about this seemingly cemented traditional value, how could you ever correct it? Always, you need to understand the foundation of myth before you can uproot it.

In the late 19th century, the discovery and understanding of microbes as the cause of some diseases set into motion a medical and scientific search for germs unmatched by any other era. Men were anxious to find a microbial cause to nearly every known disease, particularly with pellagra, the red plague. The time was ripe for infectious discovery as men started appearing with inexplicable skin rashes covering their appendages and an "ugly butterfly pattern" across their necks (Sherman 356). The disease became known as the Mal de la Rosa and those marked by the butterfly were outcast from society, not unlike the lepers of Molokai Island. Sufferers often became weak and melancholy and had

burning sensations of the mouth before they were ultimately characterized by the four D's: dermatitis, diarrhea, dementia, and death. As other infectious diseases were subsiding, pellagra hit the American South where it had a fatality rate of 40% and became the second leading cause of death in South Carolina. Many had searched for a microbial cause of the disease without any answers until Joseph Goldberger, a skilled microbe hunter, was placed as principal investigator. Goldberger traveled throughout the American South visiting insane and orphan asylums, in which the disease seemed to be prevalent, and disclaimed its contagiousness when he noticed the doctors and nurses were unaffected. He noted that it mainly occurred among the poor who had a diet of cornmeal mush and grits without supplementation with meat and vegetables (Sherman 362). He performed experiments which eventually proved that pellagra was caused by a deficiency in the "p factor" which was found in foods the poor had been lacking. To further credit his theory, Goldberger actually had "filth parties" in which he injected himself and others with the blood of a pellagra patient without ever acquiring the disease. Even so, it took years for "the contagionists," who believed the disease had an infectious origin, to accept the findings of Goldberger's experiments. This investigative story and the attitudes of skepticism which the contagionists so stingily held, show how the era in which they lived and the environment they grew up in shaped their beliefs and prompted their misconceptions (Sherman 366). The discovery of microbes was a recent one, and a popular one. It took years for the myth of infection to be disproved because the scientific attitudes and foundational knowledge had to be disproved first.

Whether it be the long-founded societal belief in sorcery, the popularity of searching and discovering microbes, or the modern day student who believes he is likely to contract an STD from sitting on a toilet seat, it is necessary to understand exactly what people are thinking and believing to debunk a myth.

It is not hard to see, sitting in on a lower division microbiology class, the looks of confusion on students' faces when infectious disease is being taught. It is not hard to hear the surprise in someone's

voice as they ask questions about epidemics they do not understand, or see the same question answered in nods by others. It is not hard, as a student in microbiology myself, to wonder at the wonder students experience as they learn and correct their fallacious knowledge of infectious disease. I realized that while lecture focused on the different metabolic pathways, it was absolutely unavoidable to focus on the topic of the mental pathways we take in reaching our own thought endproducts. Sitting in on this *Microbes and Society* class for a semester, a class typically for non-science majors, helped me to realize just how many misconceptions about microbes are out there and to conceptualize a means of ascertaining what they were. Knowing that students were entering microbiology-related classes often without a firm foundation in the subject matter and with innumerable misunderstandings, it was likely that they shared many of these common "myths" concerning infectious disease. Building knowledge upon already-present misconceptions is like building a wall upon a vacillating foundation. In order for students to truly understand infectious disease, we must first discover what students do not understand so that we can correct their skewed education early in their academic career and circumvent further confusion.

The questions students asked in class made it clear that their misconceptions encompassed a wide range of areas in microbiology, including everything from antiseptics to specific disease transmission. Therefore, in order to disclose the common misconceptions in college-aged students we chose to administer an initial diagnostic survey to discover the general misconceptions which were relatively common. From this we would derive hypotheses which incorporated the misconceptions we previously unveiled for further testing. What unfolded was a process of unique development and the uncovering of specific myths which students held before taking the class. It has been a learning process as no answers are levels of understanding are black and white, nor easily interpretable without analyzing mental processes and other factors. One thing for certain is that often, students know very

little about microbiology, and it is their misconceptions which we must understand to take steps forward in improving education and awareness.

A Sequential and Developmental Approach to the Discovery of Myths

Overview

In order to first disclose and then delineate the many misconceptions circulating in the student population, we took a two-tier approach to our investigation of "myths" concerning infectious disease. Our case study used three different classes of undergraduate students at the University of Arizona which would represent potentially different educational backgrounds. An upper division virology class, a lower division general microbiology class, and a freshman colloquium were each surveyed regarding the misconceptions about microbiology and infectious disease that they had coming into class. The initial survey was designed to pinpoint which misconceptions were common among students without using specific questions which might lead the students in their answers and bias the result. The questions on each survey were slightly tailored to each class, but the main focus of the survey regarding misconceptions was the same. From the results of this initial, general survey we derived six hypotheses, each a common misconception in all three classes. These misconceptions included misunderstandings in how infectious diseases were transmitted, the belief that most microbes are harmful, the belief that antibiotics can be used for all types of infections whether they be bacterial or viral, the belief in almost total efficacy of washing one's hands, and the belief that microbes are unable to survive for long periods of time in the environment. Had we provided a more delineated survey first, we would have biased and led students in their answers with our presupposed hypotheses about what their misconceptions were. For this reason, we initially chose a general questionnaire in which the students wrote down their answers for us to then draw hypotheses from for our second, delineated survey. In the delineated survey we took the common misconceptions we found from our first survey and set out to identify

specific sub-myths pertaining to each. This survey was comprised of 70 questions which were multiple choice, ranking, true/false, and questions based on pictures for visual material.

Study Population

For our initial data gathering, we chose three separate survey populations to study: a lower division freshman colloquium class studying plagues and society, a general microbiology class, and an upper division virology class. The enrollment for Spring 2008 semester in each of these classes was 27 students, 344 students, and 102 students, respectively. In the general microbiology class, there was a diversity of educational backgrounds and interests, the most prevalent majors being pre-nursing, pre-pharmacy, physiology, veterinary science, microbiology, and nutrition. The majority of these majors, and majors which were not well-represented placed in the "other" category, had required coursework in the basic sciences (chemistry, biology, physics, organic chemistry) as well as in major-specific sciences. Most of the students however, were in their sophomore year and were thus still taking lower division classes and working on their premajor requirements. In the basic sciences required for each of these majors, the most relevant to microbiology was general biology. Within the first and second semester classes in biology at UA there is very little microbiology and infectious disease, other than a very general background on structure and function. Most students taking the survey from this class noted that the general microbiology course was the first time they had ever learned about microbiology and infectious disease. This class of students, not having been inundated with this material and subject matter, expressed very general misconconceptions most representative of what we might find in society. Yet, it should be noted that our study population consisted of college students, and science-degree seeking students, who might be more apt to know about microbiology and infectious disease through their education compared to the average American.

We also surveyed an upper division virology class which consisted almost entirely of juniors and seniors studying either microbiology, veterinary science, or molecular and cellular biology. This is an advanced course covering medical and molecular virology which requires an extensive background in science. Students enrolled in this course had, for the most part, taken all of their core science classes. In particular, those students which were microbiology and veterinary science had taken several supplementary classes providing a strong background on microbes and infectious disease. This was mirrored in survey answers; misconceptions in this class centered more around the complexity of viruses and pathogenic pathways than it did on general myths. The misconceptions which students noted in this class had more to do with their lack of education in virology specifically which they, expectedly, would not have known without the course. For this reason, in our second delineated survey we chose not to survey this population as they had already been exposed to the subject for most of their educational career and had few correlating misconceptions with the other lower division classes.

The final class we surveyed with this general questionnaire was a freshman colloquium class called Plagues, Peoples, and Society. This class centers on different epidemics throughout history, the science behind them and the societal impact which stemmed from them. Most of the students in this class were also science majors but without any real background in science or microbiology as they had yet to take upper-division and many lower division classes.

For the secondary, specific survey identifying sub-myths, we chose to survey the general microbiology class again in Fall 2008 and a general education course called *Microbes and Society* which stresses the significance and consequences of microbes and microbial parasitism to individuals, society and the environment. This class consists mainly of non-science majors and is thus, potentially, a better representation of misconceptions we might find in the general public.

As more accurate results and reliable data comes from larger study populations, we chose to survey several classes, some with large class sizes and others with small class sizes. Over the course of

our research, 5 classes were surveyed, increasing our sample size and both increasing and reaffirming the reliability of our data.

Interestingly enough, many of the students in these classes are pre-health majors, such as nursing and pharmacy, to whom these misconceptions are most relevant. It would be advantageous to know what misconceptions these students have concerning infectious disease, proper disinfection, and even treatment so that we can correct them early in their educational career.

Survey Administration

The primary survey was handed out to each of the three classes as a take- home assignment. They had a week to complete it, allowing them time to really think about their answers. Students were told to answer the questions based on misconceptions they had *prior* to taking the class, as it is likely the misconceptions they noted were "debunked" by course material. A note was made in the directions which asked students not to use any outside sources as they would not be graded on wrong or right answers. The reliability of our results was contingent upon these qualifiers and whether or not the students followed the directions.

Initial Survey

Other than the awareness that students have misconceptions in the subject of microbiology and infectious disease, we made no pretensions about what those misconceptions actually were. In essence, this experiment began backwards on purpose. We sought to obtain preliminary data from this initial survey about general misconceptions present in the student body. From there, we took our results, the most prevalent misconceptions among students, and made them our hypotheses upon which to conduct further research with our secondary survey.

For data to be logically comparable, particularly in different survey populations, there must be a correlation in both the way in which the survey is provided and the questions asked. Therefore, for meaningful results, we asked the same cardinal questions in the hopes of uncovering common results we could draw conclusions from. These fundamental questions concerned the misconceptions students held before taking the class, what they identified as probable causes of these misconceptions, and how personally knowing someone with a disease, ultimately changed their perception of it. Students gave essay responses describing these misconceptions in detail and were allowed multiple answers to each question, which were all taken into account separately when analyzing the data. As class structures and content varied largely between these three courses, there were some additional questions which were tailored to each class. For example, the freshman colloquium survey included questions about the impact of society on infectious disease and the student's relative interest in learning about the two together. This course, called *Plagues, Peoples, and Society*, is rich not only in the science behind epidemics, but also in societal reactions and their influence in history. As the content that each course covers was naturally what led students to identify a misconceptions as a misconception, this tailoring was important. In other words, a myth only becomes a myth in the student's mind when they actually learn that they are wrong. Therefore, students in different courses identify different misconceptions as their track of learning is different and distinct course material is covered. Nevertheless, in this first, more general survey, we sought answers without parameters. A question was asked without the provision of an answer, such as multiple choice and printed items, which might bias them in their responses. It was asked to make the student think, without our lead, about concepts they truly did not understand about infectious disease and microbes.

As we worked backwards, it is necessary to expound upon some of our results from the first survey in our methodology as it was these which became our hypotheses for further research. The most commonly identified myth in all classes concerned the ease and means of transmission of different

infectious diseases. This became our first hypothesis. Students expressed that they did not understand transmission routes in general (i.e.- did not understand direct transmission versus airborne etc.) or they mentioned that they previously thought specific microbes were transmitted differently than they are. Further under this hypothesis, students noted that they did not know how easily or uneasily certain diseases were spread. Another major misconception we identified with this initial survey, and our second hypothesis, was the belief among students that most to all microbes are harmful to us. Many students did not understand what normal flora were and that we actually are hosts to many microbes naturally and beneficially. A third hypothesis was that students held the belief that antibiotics could be used for most anything, whether it be a bacterial or viral infection. Subcategorized under this hypothesis is the additional misunderstanding not just in different treatment for different microbes but a fundamental ignorance as to the differences between different microbes. Students tended to generalize infections, treatments, and microbes to apply one standard for all, a myth which was further tested in our secondary survey. Another misconception we noted was that students were entirely unaware of the sheer number of microbes and their variety in nature. Students likewise expressed the common belief that washing one's hands and using antiseptics are almost entirely effective in the prevention of sickness. Lastly, students expressed that they did not know the hardiness of microbes in the environment and whether or not they were able to survive long outside of the human body. A subcategory under this belief was the idea that people rarely become sick from touching microbes on surfaces (as they do not survive long) but rather from direct, person-to-person contact and touching in some way. These were the hypotheses used in our subsequent, delineated survey. What follows is the initial survey which was administered to both the freshman colloquium and the general microbiology and upper-division virology classes.

Initial Survey 195 (freshman colloquium)

1) We live in a world where you cannot see what is making you ill, yet, you have likely acquired some knowledge about epidemics and infectious diseases before taking this class. Was there anything you thought you knew which you learned was wrong, and what was it? What has transpired to make you realize it was wrong?
2) Can you give three examples about how you thought people got infectious disease and whether or not this has now changed?
3) How has your education at U of A or in this class changed any of the misconceptions you may have had about infectious disease?
4) Were there any particular teaching strategies, lectures, readings, discussions, other students questions, powerpoints, etc. that you found to be effective in learning relevant facts and/or correcting any misconceptions?
5) Have you known someone or have you personally experienced a severe infectious disease? How has that changed your perception of the disease and any misconceptions you may have had about it?
6) Outside of UA classes, do you ever talk about or learn about infectious disease and how?
7) Has studying the social aspect of epidemics and not just the science and biology changed your perception of these epidemics? If so, how?
8) What do YOU think the reasons are behind any misconceptions in society regarding infectious disease or epidemic threats?
9) What do you personally think would be helpful in correcting the misconceptions that are out there in society?

Initial Survey MIC 205 / Virology 433

1. How has your education at U of A or in this class changed any of the misconceptions you may have had about infectious disease?
2. Have you known someone or have you personally experienced a severe infectious disease? How has that changed your perception of the disease and any misconceptions you may have had about it?
3. Were there any particular teaching strategies, lectures, readings, discussions, other students questions, powerpoints, etc. that you found to be effective in learning relevant facts and/or correcting any misconceptions?
4. What science courses have you taken at the UA and did any of them cover infections (viruses, bacteria, immunology, etc…) and how much?
5. What is your major and is this course a requirement or pre-req or neither?

Secondary Survey

In this more comprehensive survey, we took our original hypotheses derived from our first survey and asked detailed questions to disclose the specific myths. This survey consisted of 70

questions using differing question formats including multiple choice, ranking, fill in the blank, and answering questions about pictures. Using multiple formats we hoped to appeal to people who were able to understand more specific and different types of questions. In fact, some of the questions were very similar, but in different format, to see if answers changed based on how questions were framed, as this would influence our results. Although this survey was far more specific, there was also an increased risk of bias as the nature of the survey involves set answers which the student might not have developed on their own. Nevertheless, in a survey designed to obtain specific answers it was necessary in some way to direct the students' thoughts on the subject matter. As how we define and understand the questions influences how we perceive the questions, the way in which questions are framed was essential in deriving reliable results. Some of the questions were similar to those you would see on a chapter test in a class to directly ascertain if the student knew the truth about a subject or if they thought differently. However, there were also indirect questions which involved ranking, enabling us to see the degree of the misconception in a way which was less black and white. Some questions of this indirect nature did not identify a misconception the student had but rather what they thought the prevalence was of certain misconceptions in society. In summary, this survey took our very general hypotheses and delineated them into specific misconceptions. Unlike our initial survey, this allowed us to uncover the specific traits and nature of these myths, but it also did it in a manner which allowed us to measure the homology of students' misconceptions as the questions had narrow parameters. What follows is the secondary survey which was administered.

Secondary Survey

Directions:
Please answer the following questions **as if you had never taken this course**, we want to know exactly what you did NOT know before you learned it in this class. The following survey will not be graded based on wrong or right answers, we are merely interested in knowing the common misconceptions students have about infectious disease. We want to know what you don't know! So please **do not look up or use outside sources for ANY of the following questions** as this does not help us. Again, you will not be graded on what you get right!

1) How influential do you think the following sources are in forming these misconceptions about infectious disease. Rank them, 1 being most influential.
   _____ media (TV, news, movies, etc.)
   _____ wrong information on the internet
   _____ can't understand terminology
   _____ fear and stigma
   _____ people telling other people wrong information
   _____ lack of education
   _____ culture/ lifestyle you grow up with
   _____ denial (don't want to know if you have disease)

2) Infectious diseases which are said to be airborne are transmitted: Rank the following as often, sometimes, rarely, or never transmitted this way
   _____By microbes which are in the air all the time but which are only inhaled sometimes
   _____In respiratory droplets containing microbes which are aerosolized when people cough/sneeze
   _____ By microbes which can move on their own from person to person in the air
   _____By microbes in the air which land on surfaces that we eventually touch and ingest
   _____Only in crowded areas

3) You can become infected by Pathogens which cause intestinal disturbance such as diarrhea By: Rank the following as always, often, sometimes, rarely, or never transmitted this way
   _____eating food contaminated with fecal matter
   _____ touching a surface contaminated with feces and then touching your mouth
   _____ eating food that has been left sitting out in open air
   _____ sitting on a toilet seat with the microbes on it
   _____ eating an animal infected with some microbe you can become infected with the same microbe

4) For microbes which can be transmitted by direct contact, you can become infected by: Rank the following as always, often, rarely, or never transmitted this way.
   _____ touching an infected wound
   _____ being bitten
   _____ droplets entering an eye, nose, or mouth
   _____ sitting on a toilet seat with the microbe
   _____ an open wound touching an open wound
   _____ kissing someone
   _____ breathing near the infected person
   _____ sexual intercourse
   _____ grabbing a doorknob an infected person just touched

5) When you get a cut that becomes infected (red and/or swollen, and/or painful) what is happening? Rank in order of probability, 1 being the most probable
   _____You were cut with something that had the microbe on it
   _____There was a microbe on your skin that got into the cut
   _____Microbes from the air landed in the cut
   _____After you are cut you rub up against a surface with a microbe on it
   _____Your immune system is causing the infection by reacting to the cut

6) If you inhale a microbe, the majority of the time:
   a. It is completely harmless
   b. There is a low chance you will get sick
   c. You will probably get sick
   d. You will get sick only if the microbe is pathogenic

7) Once someone is infected with an airborne microbe: Rank the following as **a**lways, often, rarely, or never transmitted this way
   _____They can infect you the moment they have been infected
   _____They can infect you when they no longer have symptoms
   _____They can infect you only after the microbe has had a time to "incubate" in host
   _____They can infect you before they show symptoms
   _____You can become infected by touching the person
   _____You can become infected if you eat food they have touched
   _____ Other
8) Some diseases are caused not by the microbes themselves but substances they secrete, such as toxins. If it is a toxin causing the disease condition. Circle all that apply:
   a. Antibiotics will be effective in eliminating the problem
   b. The disease will persist after the microbes are dead
   c. If somehow someone else came into contact with a small amount of the toxin they would get the disease
   d. The disease can be transmitted when others come into contact with the toxin
   e. The disease can be transmitted when others come into contact with the microbe and not the toxin
   f. The disease symptoms usually present themselves faster

9) If you eat food with microbes on it:
   a. You will get sick
   b. You will only get sick if there are a lot of the microbes on it
   c. You get sick because of toxins the microbes secreted to spoil the food
   d. You will get sick only if the microbe is pathogenic

10) We are told to wash our hands- often to keep from getting sick because: Rank the following based on how common they are (A=always, L=likely, R=rarely, N=never)
   a. We have unclean hands with infectious pathogens all the time, they just don't always infect us
   b. The air contains microbes which can land on our hands
   c. We have touched food with microbes on it
   d. We have touched something contaminated with dirt
   e. To get rid of ALL the bacteria on our hands
   f. We have compromised immune systems on our hands which, in particular, cannot handle microbes transmitted by direct contact, such as by a handshake
   g. Washing our hands works only if we do it often because soap only kills with multiple rinses, you won't kill anything by washing once
   h. Each wash kills most microbes, but you pick up new ones continually

11) Once you have been infected with a pathogen and recover (Circle the answer or answers you believe are what happens most of the time):
   a. You cannot become infected again, you have immunity
   b. You can become infected with a different strain of the same organism
   c. You sometimes can become infected again with the same strain
   d. The same pathogen can become latent in your body and you may have recurrent infections
   e. You will have immunity against bacterial infections, but not viral infections

12) Do you know how the following microbes are transmitted? If so, write in a one word answer in the blank saying how (for example: water, food, touch, air, STD, etc.)

_____ HIV _____herpes simplex 1 _____vibrio cholera
_____Coccidiodes immitus _____Varicella Zoster _____Staphylococcus aureus

_____SARS virus	_____ West Nile Virus	_____ malaria
_____ Giardia lamblia	_____ measles virus	_____ influenza
_____ rotavirus	_____ norovirus	_____ polio virus

13) In general, How easily transmissible (contagious) do you think the following are? Rank (V= very easily transmitted, M= somewhat easily transmitted, H- hard to transmit)

____ Measles	____ influenza	____ Smallpox
____ Chicken pox	____ HIV	____ Leprosy
____ polio virus	____Staphylococcus aureus	____ Herpes simplex 1

14) You come across a patient who is suffering from a disease which is transmitted by direct contact, such as a bacterium which causes staph infection, which of the following precautions are helpful?

_____ gloves	_____ air mask
_____ room that filters the air	_____ swabbing everything with alcohol
_____ no touching the patient whatsoever	_____ no touching the food the patient has touched
_____ full body suit/ scrubs	_____ goggles/ safety glasses

15) How effective (give an estimated percentile) do you think the following are in killing microbes or preventing them from getting on your skin?

____ bleach	____ hand sanitizer
____ washing your hands with just water	____ washing your hands with antimicrobial soap
____ not touching dirt, dust, or surfaces	____ autoclaving
____ pasteurization	____ alcohol
____ boiling	____ treating with base (NaOH)
____ freezing	____ refrigerating

16) Antibiotics are effective in most (circle all that apply):
    a) Bacterial infections b) Fungal infections c) Viral infections d) Parasite infections

17) If you have an infection and take antibiotics for it, get better temporarily, and the infection comes back, what is happening (circle all that apply)?
    a) You have a viral infection
    b) The microbe has become resistant to the drug
    c) It is a new infection with a different microbe, as your immune system is weak
    d) It is the same exact microbe which was not fully killed when you stopped taking medication
    e) You were taking the wrong antibiotic

18) Many microbes are becoming resistant to drugs and treatments. Which of the following contribute to antimicrobial resistance? Circle all that apply.
    a) We take over- the counter drugs
    b) We do not follow prescriptions properly and take them for the full time
    c) We do not take correct dosages of drugs
    d) We eat food with antibiotics in it constantly
    e) Microbes mutate constantly

19) When you refrigerate food to prevent it from becoming spoiled:
    a) There are lots of bacteria which cause spoilage on the food, but their growth is being prohibited by the cold
    b) The cold kills microbes
    c) The microbes have not yet contaminated the food, they take days, sometimes weeks to actually get on the food
    d) Other spoiled food has to touch them before they become spoiled
    e) If the food has been washed previously it will not spoil

20) If an infectious microbe needs the human body as a host to live (circle all that apply):
    a) It can only last seconds outside of the human body, it must be taken up immediately to survive
    b) If can only survive hours outside of the human body
    c) It can survive days outside of the human body
    d) It can survive weeks outside the human body, only in warm temperature
    e) It dies outside the human body but can reactivate itself if taken up by another host

21) All those food products (which are highly commercialized as of late) containing lactobacillus for our digestive health work because:
    a. Lactobacillus eats up all the bad, infectious bacteria in our guts
    b. We do not have bacteria in our gut, so by consuming foods with lactobacillus we are placing microbe there that produces healthy enzymes we need
    c. Lactobacillus "teaches" our immune system which toxins are tolerable and which are to leave our system
    d. Lactobacillus consumes toxins in our gut
    e. Lactobacillus competes, along with other normal flora, with bad bacteria in our gut

True or False.

22) ____ In Hospitals, due to sanitary measures, you are far less likely to acquire a serious infectious disease than in other places.
23) ____ we have E. coli already in our intestine.
24) ____ We have Staphylococcus spp. naturally on our skin.
25) ____ Infectious microbes cannot live freely in the environment for long periods of time.
26) ____ Once you have been infected with certain microbe, you cannot have the same infection again.
27) ____ Washing your hands with antimicrobial soap is an effective means of ridding your hands of all harmful bacteria.
28) ____ Most viruses can only be killed with several antiviral drugs.
29) ____ Antibiotics can help treat viral infections.
30) ____ Other than being helpful in beer and food production, most microbes are harmful to us.
31) ____ Direct contact between infected people is really the only way microbes are transmitted.
32) ____ With most microbes, regardless of how the disease is normally transmitted, if you ate the meat of an animal infected with the disease you would probably get it.
33) ____ If you were to eat a bird that had influenza, you could get the flu.
34) ____ If you were to eat a rabid animal, you could get rabies.
35) ____ Some diseases have NO symptoms
36) ____ Most diseases have characteristic, telltale symptoms.
37) ____ It doesn't matter how a disease is naturally transmitted (blood, air, direct, etc.) if you eat the meat of an animal infected you will become infected.
38) ____ Infectious diseases are only transmitted horizontally (from person to person via contact) not vertically (from mother to child).
39) ____ HIV can be transmitted by mosquitos
40) ____ Anthrax is contagious.
41) ____ All diseases a human gets from an animal can then be transmitted from that human to other humans.
42) ____ Most vector-borne diseases need a specific vector (such as a tick or mosquito) to be transmitted but do not need a specific species of that vector (such as the Aedes aegypti mosquito) to be transmitted, any mosquito can.
43) ____ All infectious diseases have a narrow host range (they can only infect a few particular species).
44) ____ Direct transmission of disease only involves human to human transmission, not animal to human.
45) ____ Most microbes die within minutes when outside of their natural hosts.
46) ___ Some bacteria form spores which enable them to live for years when there are no nutrients or favorable conditions.
47) ____ if you have a foodborne illness, it only took a few organisms to make you sick and for the infection to worsen.
48) ____ You can only disinfect surfaces with viruses on them with bleach or base.
49) ____ Bacterial infections are easier to treat than viral infections.

50) ____ Some people carry bacteria naturally in their gut, but most people have little to no bacteria in their gut naturally.
51) ___ Every organ system in our body naturally has bacteria in it.

52) ___ When people come infected with the cold or the flu, they are far more likely to have been infected by direct contact or aerosol droplets than by touching a surface the viruses were on.
53) _____ There is no place in the world that bacteria cannot live.
54) _____ The same basic precautions can be taken to prevent acquiring leprosy, smallpox, herpes, and Ebola, which are all transmitted by direct contact.
55) _____ Infectious diseases you get by direct contact are, in most cases, more severe than airborne diseases.
56) _____ It doesn't matter if you eat meat with a few salmonella or hundreds of salmonella, you have the same chance of getting sick and experience the same degree of sickness because they multiply.
57) _____ It's only people who are in poor health that have to worry about West Nile Virus.
58) _____ When an infectious microbe jumps species, such as from monkeys to humans, it can only be transmitted in the same way it is transmitted between members of the original species (monkey to monkey).
59) _____You have a better chance of getting the flu from shaking someone's hand than holding a doorknob.
60) _____In underdeveloped countries which tend to be plagued with many severe diseases, it is more related to risky behaviors (such as drug use and prostitution) than to poor living conditions.
61) _____ Many bacterial infections can be treated with only one antibiotic.
62) _____ Many viral infections can be treated with only one antiviral drug.
63) Do you think vaccines are…? (most are, some are, none)
Harmful_____
Beneficial_____
Ineffective_____

64) Check which of the following would be effective for sterilizing water, can you kill most bacteria by--- rank the following in efficacy
_____ Shining UV light on water in tub.
_____ boiling water for 20 minutes
_____ adding chemicals such as chlorine
_____ filtration
_____ heating to just below boiling for 24 hours

65) Which of the following are you more likely to become sick from?
_____ eating cooked food after it has been left out a few hours
_____ eating food right after it has been cooked which was left out for hours before it was cooked.



66) _____ the above are probably caused by different microbes as they have different symptomology.
67) _____ The above are probably all caused by direct contact as they involve the skin.

68) What are some differences between viruses and bacteria (circle all which are true):

a) Viruses are harder to kill with antiseptics
b) Viruses last longer in the environment
c) Viruses are dead
d) Viruses cannot be treated
e) You cannot make vaccines for bacteria
f) Bacteria cannot mutate as quickly as viruses to resist drugs
g) Viruses are more contagious
h) Viruses cause more serious infections
i) Viruses always need a host

69) Rank the following in order of how hardy they are in the environment.
_____ viruses _____ bacteria _____fungi _____ parasites _____ protozoans
_____ they are all the same _____ they cannot be ranked, depends on the specific organism

70)  This picture shows small calcified nodules in the lungs that are the result of an infectious disease. Was this caused by…
a) An airborne microbe
b) A microbe you might have eaten
c) A microbe spread by direct contact
d) An STD
e) It could be anything

71) Name four beneficial uses of microbes. (If you cannot think of 4 that is OK!, just think of as many as you can).
1. _____
2. _____
3. _____
4. _____

72) If you were sitting in a crowded classroom and someone was sitting in the front row that was coughing because they were sick with _____, you have a good probability of becoming sick. Yes/No

_____Influenza	_____ rhinovirus
_____tuberculosis	_____ norovirus
_____ Ebola	_____ West Nile virus
_____ valley fever	_____ anthrax

Data/Collection

From our initial survey, the most common misconceptions were tallied up according to major and placed in a data table in order of prevalence. For each of the 3 data tables (one per class), there is a bar graph which represents the results by percentage. Of all those who submitted a survey, the number of those which held a particular misconception were counted and divided by the total number of responses to gain a percent prevalence of the misconception within the class.

Results:

In our initial survey, all three classes were asked to answer the most important question relevant to this thesis, "What misconceptions regarding infectious disease did you have coming into class?" Though answers tended to be specific and diverse, most within the general microbiology and freshman colloquium classes had similarities. A prominent misconception between all classes concerned how certain microbes were transmitted, the ease/nonease of that spread, and how certain types of transmission occurred. Answers within this category ranged from the belief that airborne microbes were able to fly (extremely misguided) to not knowing Herpes virus could be spread by direct contact (less misguided). Misconceptions, like microbes, come in different shapes and sizes. Another prevalent misconception was the belief that all microbes are harmful to us; many were also ignorant of the normal microbial flora which benefit us. Thirdly, students cited the belief that antibiotics could be used to treat most types of infections, whether it be viral, fungal, or bacterial. Within this category, students had trouble differentiating between these microbes, not really knowing their characteristics. Students were unaware of the massive numbers and types of microbes just as they were unaware of the numerous infections a single microbe could cause. Students held the misconception that washing one's hands is an extremely effective means of preventing sickness. They believed that most antiseptics are

entirely effective in killing microbes. Lastly, students believed that most microbes were unable to survive for periods of time outside of the human body and were unable to persist on surfaces. In other words, they believed that most infectious diseases were spread by direct contact rather than from touching fomites and environmental objects like doorknobs. The following tables highlight the results for this question on the initial survey, with the total numbers of students who noted the misconception. The graphs are a percentage representation of this data.

The following tables include the results of a survey distributed to a general microbiology class, an upper division virology class, and a lower division freshman colloquium at the University of Arizona. The survey consisted of questions requiring written answers which identified the misconceptions that students had before enrolling in the class, what they believed to be the probable causes of these misconceptions in society, whether or not they knew someone with infectious disease, and how it changed their perception of it. Students in the freshman colloquium, *Plagues, Peoples and Society*, were asked additional questions regarding the societal reactions to disease as this was emphasized in class.

Table 1: Common Misconceptions Concerning Infectious Disease Amongst General Microbiology Students

	Number of Students with Misconception (N= 344 total students)	

	Undergraduate Major or Career Interest							
Misconception	Nursing N= 86	Pharmacy N= 54	Physiology N= 16	Veterinary science N= 65	Microbiology N= 29	Nutrition N= 54	Other[I] N= 48	**Total N= 344**
Transmission and spread[A]	17	23	4	23	7	25	13	**112**
All microbes are harmful[B]	8	6	2	6	1	5	3	**33**
Antibiotics used for all infections[C]	9	8	2	3	2	5	3	**32**
Amount and variety of microbes[D]	8	3	1	1	2	8	5	**28**
Washing hands/ antiseptic kills everything[E]	4	4	1	2		7	2	**20**
Didn't know certain diseases caused by microbes[F]	5	5	1	2	1	5	1	**20**
Concept of latency[G]	4	3	2	3	2	2		**16**
Microbes cannot survive on surfaces[H]	5	4	1	2	1	2		**15**

[A] The student did not understand how certain microbes were transmitted, what different means of transmission were, and how easily or non-easily they are spread.

[B] Student believed that all or most microbes are harmful and/or did not know about normal microbial flora and their benefits.

[C] Students believed antibiotics cured everything and did not differentiate between viruses and bacteria and their treatments.

[D] Students were unaware of the sheer amount and variety of different strains and types of microbes and/or were unaware that some certain microbes were responsible for certain diseases.

[E] Students believed that if you washed your hands it would be entirely effective and kill all the microbes on the skin. Students also thought certain disinfectants and antiseptics were entirely effective.

[F] Students were unaware that certain diseases were caused by microbes (for example, didn't associate acne with propionobacteria and ulcers with helicobacter)

[G] Students did not know infections can be latent and/or believed that once you had an infection you were immune for life.

[H] The student did not know microbes were able to survive long in the environment and thought they were always transmitted via direct contact and touching, not from picking them up in the environment.

[I] Majors which were less common were placed in "other" which includes students studying public health, family health and consumer sciences, environmental and animal sciences, and general biology.

*** Not mentioned in the above table were misconceptions which involve negative stigmas towards vaccination and its effectiveness, how students defined things such as "epidemic" and "disease" which changed their entire perception of how they viewed epidemics and diseases and their feelings about them, the belief that people who came down with infections led risky lifestyles such as prostitution or "just being dirty," the belief that infections ALWAYS present symptoms and if you have one you will know it and get treated, the belief that cold weather causes the common cold, hospitals are always safe

and cleanly, not knowing that two different diseases were in fact different or that treatment was available/ or unavailable for so many diseases, and misconceptions about the immune system in general.

Table 2: Common Misconceptions concerning Virology among Upper Division Virology Students

Misconception	Number of students with misconception N= 102 students
Transmission and spread[A]	35
Amount and complexity of viruses[B]	16
Did not know how outbreaks started or were controlled	12
Did not know or understand the Pathogenic pathway of certain viruses	11
Viruses cannot survive long on surfaces[C]	10
Thought untreatable or treatable when not, or vaccine available/unavailable when not[D]	9
Role of mutations[E]	9

[A] The student did not understand how certain microbes were transmitted, what different means of transmission were, and how easily or non-easily they are spread.
[B]Students were unaware of the sheer amount and variety of different strains of viruses and/or were unaware that some certain viruses were responsible for certain diseases.
[C] The student did not know microbes were able to survive long in the environment and thought they were always transmitted via direct contact and touching, not from picking them up in the environment.
[D] Students believed vaccines and treatments were available for certain viruses when they were not and vise versa.
[E] Students were unaware of the importance and role of mutations and certain genes in viruses.

Table 3: Common Misconceptions Concerning Infectious Disease in a Freshman Colloquium

Misconception	Number of Students with Misconception (N= 27 students)
Transmission and spread[A]	10
Antibiotics used for all infections[B]	1
Amount and variety of microbes [C]	1
Washing hands/ antiseptic kills everything[D]	1
Thought untreatable or treatable when not, or vaccine available/unavailable when not [E]	12
Did not realize profound effect of microbes on society and vice versa	9

[A] Students did not understand how certain microbes were transmitted, what different means of transmission were, and how easily or non-easily they are spread.

[B] Students believed antibiotics cured everything and did not differentiate between viruses and bacteria and their treatments.
[C]Students were unaware of the sheer amount and variety of different strains and types of microbes and/or were unaware that some certain microbes were responsible for certain diseases.
[D]Students believed that if you washed your hands it would be entirely effective and kill all the microbes on the skin. Students also thought certain disinfectants and antiseptics were entirely effective.
[E] Students believed vaccines and treatments were available for certain viruses when they were not and vise versa.

We also asked students what they believed the causes of the above misconceptions to be. In all three classes, students predominantly noted the lack of education in infectious disease as the cause of misconceptions in society. Secondly, students blamed the media, in the newspapers, television, and internet, for exaggerating stories to pique public interest which often causes hysteria. Rumor and hearsay were mentioned as other causes as many students accepted myths which their parents or friends had told them, such as sitting on toilet seats and acquiring sexually transmitted diseases. Some students, though to a lesser extent, mentioned fear and stigma as playing a role in propagating myths and influencing our judgment. A small number of students identified the inability to understand the scientific terminology used to describe infections as an additional cause of misconceptions.

As education was at the heart of most misconceptions, students suggested increased education in microbiology starting at a younger age as a means of correcting the myths. Students also mentioned the benefits of teaching in an informal manner to allow for open discussion, or combining subjects such as teaching history and microbiology so as to whet interest. Some students mentioned the importance of the internet in debunking misconceptions and the use of the media to calm the public with reliable information, rather than shock and scare.

When students in the freshman colloquium were asked if they thought learning the social aspect of disease was helpful in understanding epidemics and disease, they asserted that it made it a far more interesting topic to learn. Learning the social aspect made it easier to understand the science behind

disease, which was vital for non-science majors who did not always understand science terminology. Students in the freshman colloquium were asked if they discussed anything regarding infectious disease outside of class. Most students claimed they never discussed infectious disease, some discussed it with parents or coworkers because they worked in the medical field, others said they only discussed it when there was something big in the media about an outbreak or on TV, and a few said they had intelligent conversations about it every once in awhile.

Students were also asked if they knew someone who had an infectious disease and how that affected their perception of it. Some students mentioned that they knew of no one with an infectious disease, which may or may not be accurate as it depends on their definitional barriers for "disease." Several students, for example, mentioned that they never before considered chickenpox as an infectious disease and from taking classes redefined the meaning of disease and epidemics in general (which they previously always thought to be severe and sporadic). A few students also mentioned that they knew of someone with an infectious disease, but then denoted natural diseases of the body rather than infectious ones, such as breast cancer. The majority of students, however, did know of someone with an infectious disease and had the misguided belief that severe infectious diseases were acquired elsewhere in "other" people with risky behaviors. In addition to learning more about the disease itself, students now linked the disease with emotion and empathy. They felt more sympathetic with those suffering from such infections and held a new sense of compassion for them. Students also mentioned that it helped them to realize that diseases have no standard course as every patient experiences infections differently.

Secondary Survey

The results of the secondary survey were very similar for both the general microbiology class and the Microbes and Society class for non-science majors. In the secondary survey students noted the

media and people telling people the wrong information as the top causes of misconceptions in society. The power of the media was reflected in question 12 as many were unable to name the route of transmission of infectious diseases which were pandemics (cholera, rotavirus) as they are not highly publicized here, though they knew much about the highly-publicized SARS outbreak. Students knew most about HIV and Herpes transmission and had trouble identifying diseases with their scientific names, such as Varicella Zoster for Chickenpox. Students seemed to believe that washing one's hands is extremely effective and meant to kill all bacteria on one's hand. Students understood that there were beneficial normal flora on our hands but were unaware of the specific organisms which colonize specific areas, such as *S. aureus* on our skin. Students seemed to believe that no matter how a disease is transmitted, if you eat an animal that has it, you will acquire it. They also believed that because symptoms were seen on the skin, that it must be a disease of direct contact, not thinking about the pathogenic pathways different microbes may take once in the body. Students also commonly noted in this survey that pathogenic microbes which used humans as hosts could survive only seconds outside of the body or were immediately inactive.

What follows are the questions I chose to analyze in my discussion, each followed by a table of results for that particular question. All of the true/false questions were grouped together in one table for convenience. With the exception of the first table following question 1, all of the result tables show the answer which was mentioned or asked for in the question, and the number of students who marked this as their answer. As there were several questions which some students left blank, likely meaning they did not know the answer, the number of students who answered each question varied for each of the questions. For this reason, and for an easier way to compare results, a percentile is given next to the number of students who answered each question which represents the percentile of all students who chose this particular answer. Therefore, in every table, the percentile is a representation of the portion of the class who put each answer and allows us to logically correlate the data between different

questions by giving us one standard measure of comparison. The true or false questions had two possible answers and the percentages of those students which picked either true are false are listed. For the other questions, students had multiple answer choices to pick from and the percentage of students who chose each one is listed next to the number. Knowing the percent of the class which had particular wrong or right answers gives us a means of correlating common misconceptions. We can compare what percentage of students answered right or wrong in differently formatted questions with this standardized percentile. No matter what students answer, we know how many of them compared to the whole class carry such beliefs and misconceptions. As nearly every question is testing a different and specific misconception, we needed to analyze every question separately, which is why every question has its own table of results.

The only question which did not tally the number or percentile of questions was the first question, in which we asked students to rank different potential sources of misconceptions according to their prevalence in society. As they were ranked 1 through 8, 1 being the most influential source of misconceptions, all of the numbers which were listed for each source were added up, the source with the lowest sum being the most influential. Our results show that the media and people passing on false information as the most influential sources of society's misconceptions as these had the lowest sum totals after being ranked with lower numbers.

Secondary Survey Results General Microbiology

Question 1: How influential do you think the following sources are in forming these misconceptions about infectious disease. Rank them, 1 being most influential.

_____ media (TV, news, movies, etc.) _____ people telling other people wrong information
_____ wrong information on the internet _____ lack of education

_____ can't understand terminology _____ culture/ lifestyle you grow up with
_____ fear and stigma _____ denial (don't want to know if you have disease)

Media	751
Wrong information	1033
Can't understand terminology	1345
Fear and stigma	1220
People telling people wrong information	763
Lack education	809
Culture	1103
denial	1447

Question 10: We are told to wash our hands- often to keep from getting sick because: Rank the following based on how common they are (A=always, L=likely, R=rarely, N=never)

a. We have unclean hands with infectious pathogens all the time, they just don't always infect us
b. The air contains microbes which can land on our hands
c. We have touched food with microbes on it
d. We have touched something contaminated with dirt
e. To get rid of ALL the bacteria on our hands
f. We have compromised immune systems on our hands which, in particular, cannot handle microbes transmitted by direct contact, such as by a handshake
g. Washing our hands works only if we do it often because soap only kills with multiple rinses, you won't kill anything by washing once
h. Each wash kills most microbes, but you pick up new ones continually

	Answer choices for Question 10	**# and % of students who chose this answer**
A	L –likely	128 (52%)----------
	A-always	66 (27%)----------
	N-never	11 (4%)
	R-rarely	43 (17%)
B	L –likely	82 (34%)----------
	A-always	74 (32%)----------
	N-never	8 (4%)
	R-rarely	64 (28%)----------
C	L –likely	114 (50%)----------
	A-always	68 (30%)----------
	N-never	2 (2%)
	R-rarely	44 (19%)------
D	L –likely	131 (57%)----------
	A-always	55 (24%)----------

	N-never	9 (4%)
	R-rarely	33 (14%)----------
E	L –likely	30 (13%)-----
	A-always	22 (10%)--
	N-never	121 (53%)----------
	R-rarely	56 (25%)----------
F	L –likely	42 (20%)----------
	A-always	15 (7%)
	N-never	79 (37%)----------
	R-rarely	75 (36%)----------
G	L –likely	65 (28%)----------
	A-always	29 (12%)---
	N-never	49 (21%)----------
	R-rarely	90 (39%)----------
H	L –likely	70 (30%)----------
	A-always	144 (63%)----------
	N-never	2 (1%)
	R-rarely	14 (6%)

Question 12: Do you know how the following microbes are transmitted? If so, write in a one word answer in the blank saying how (for example: water, food, touch, air, STD, etc.)

_____ HIV	_____herpes simplex 1	_____vibrio cholera
_____Coccidiodes immitus	_____Varicella Zoster	_____Staphylococcus aureus
_____SARS virus	_____ West Nile Virus	_____ malaria
_____ Giardia lamblia	_____ measles virus	_____ influenza
_____ rotavirus	_____ norovirus	_____ polio virus

Microbe being transmitted	**Means of transmission**	**# of students who chose this means of transmission**	**% of students who chose this means of transmission for this microbe**
HIV	STD	215	93%
	IV drug use/blood	15	
Coccidiodes immitus	Student did not know	130	57%
	Air	34	15%
	Touch	25	11%
	Water	15	7%
	Food	20	9%
	Soil	4	2%
SARS	Student did not know	45	19%
	Air	157	67%
	Touch	19	8%

	Food	12	5%
Giardia lamblia	Student did not know	81	34%
	Water	55	23%
	Food	44	18%
	Touch	22	9%
	Air	13	5%
	STD	25	10%
Rotavirus	Student did not know	91	27%
	Touch	44	13%
	Food	41	12%
	Water	16	5%
	Air	140	42%
	Animals	3	1%
Herpes Simplex	Student did not know	13	5%
	STD	163	67%
	Touch	64	26%
	Kissing	3	1%
Varicella Zoster	Student did not know	88	36%
	Air	33	14%
	Touch	72	32%
	Food	11	5%
	STD	6	3%
	Water	18	8%
West Nile Virus	Student did not know	24	11%
	Mosquitos/bugs	123	53%
	Air	29	13%
	Touch	34	15%
	Water	21	9%
Measles	Student did not know	74	34%
	Air	61	28%
	Touch	76	35%
	Food	5	2%
Norovirus	Student did not know	93	40%
	Touch	35	15%
	Air	48	21%
	Food	41	18%
	Water	17	7%
Cholera	Student did not know	88	37%

	Food	29	12%
	Touch	23	10%
	Water	72	30%
	Air	21	9%
	STD	7	3%
Staphylococcus aureus	Student did not know	85	31%
	Touch	144	53%
	Air	25	9%
	Water	6	2%
	Open wound touching	2	1%
	Food	10	4%
Malaria	Student did not know	73	28%
	Mosquitos/bugs	88	33%
	Air	36	14%
	Water	30	11%
	Food	16	6%
	Touch	22	8%
Influenza	Student did not know	28	12%
	Air	163	68%
	Touch	44	18%
	Food	4	2%
Polio	Student did not know	97	43%
	Touch	48	21%
	Water	13	6%
	Air	44	19%
	Food	24	11%

Question 15: How effective (give an estimated percentile) do you think the following are in killing microbes or preventing them from getting on your skin?

____ bleach
____ washing your hands with just water
____ not touching dirt, dust, or surfaces
____ pasteurization
____ boiling
____ freezing
____ hand sanitizer
____ washing your hands with antimicrobial soap
____ autoclaving
____ alcohol
____ treating with base (NaOH)
____ refrigerating

Antiseptic type	Percentile range effectiveness	# of students choosing a percentile within this range	% of students choosing a percentile within this range
Bleach	0-20	9	4%
	21-40	4	2%
	41-60	17	8%

	61-80	44	21%
	81-100	140	65%
Washing hands just water	0-20	128	61%
	21-40	32	15%
	41-60	32	15%
	61-80	12	6%
	81-100	7	3%
Not touching dirt	0-20	116	53%
	21-40	37	17%
	41-60	37	17%
	61-80	18	8%
	81-100	11	5%
pasteurization	0-20	21	10%
	21-40	18	9%
	41-60	34	16%
	61-80	55	26%
	81-100	83	39%
boiling	0-20	5	2%
	21-40	4	2%
	41-60	12	6%
	61-80	43	20%
	81-100	151	70%
freezing	0-20	66	31%
	21-40	29	13%
	41-60	35	16%
	61-80	48	22%
	81-100	38	18%
Hand sanitizer	0-20	10	5%
	21-40	10	5%
	41-60	28	14%
	61-80	51	26%
	81-100	96	49%
Washing hands with soap	0-20	6	3%
	21-40	12	5%
	41-60	45	20%
	61-80	58	26%

	81-100	99	45%
autoclaving	0-20	14	8%
	21-40	1	1%
	41-60	16	9%
	61-80	32	18%
	81-100	113	64%
alcohol	0-20	2	1%
	21-40	3	1%
	41-60	18	8%
	61-80	57	27%
	81-100	132	62%
Treat with base (NaOH)	0-20	42	20%
	21-40	25	12%
	41-60	40	19%
	61-80	46	22%
	81-100	57	27%
refrigerating	0-20	88	42%
	21-40	30	14%
	41-60	55	26%
	61-80	26	12%
	81-100	11	5%

Question 16: Antibiotics are effective in most (circle all that apply):

a)Bacterial infections b) Fungal infections c) Viral infections d) Parasite infections

Answer choice	# students who chose answer	% students who chose answer
A	220	49%
B	106	23%
C	49	11%
D	78	17%

Question 20: If an infectious microbe needs the human body as a host to live (circle all that apply):

f) It can only last seconds outside of the human body, it must be taken up immediately to survive
g) If can only survive hours outside of the human body
h) It can survive days outside of the human body
i) It can survive weeks outside the human body, only in warm temperature
j) It dies outside the human body but can reactivate itself if taken up by another host

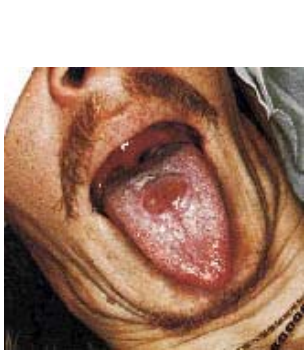
Answer Choice	# students who chose answer	% students who chose answer
A	109	30%

B	75	21%
C	45	12%
D	29	8%
E	105	29%

Question 23 ____ we have E. coli already in our intestine.
Question 24 ____ We have Staphylococcus spp. naturally on our skin.
Question 27 ____ Washing your hands with antimicrobial soap is an effective means of ridding your hands of all harmful bacteria.
Question 29____ Antibiotics can help treat viral infections.
Question 32 ____ With most microbes, regardless of how the disease is normally transmitted, if you ate the meat of an animal infected with the disease you would probably get it.
Question 33 ____ If you were to eat a bird that had influenza, you could get the flu.
Question 34 ____ If you were to eat a rabid animal, you could get rabies
Question 36 ____ Most diseases have characteristic, telltale symptoms.
Question 39____ HIV can be transmitted by mosquitos
Question 40____ Anthrax is contagious.
Question 41____ All diseases a human gets from an animal can then be transmitted from that human to other humans.
Question 42____ Most vector-borne diseases need a specific vector (such as a tick or mosquito) to be transmitted but do not need a specific species of that vector (such as the Aedes aegypti mosquito) to be transmitted, any mosquito can.
Question 45____ Most microbes die within minutes when outside of their natural hosts.
Question 52 ___ When people come infected with the cold or the flu, they are far more likely to have been infected by direct contact or aerosol droplets than by touching a surface the viruses were on.
Question 55 _____ Infectious diseases you get by direct contact are, in most cases, more severe than airborne diseases.

Question #	True/False Answer	# students who chose answer	% students who chose answer
23	True	181	79%
	False	48	21%
24	True	129	56%
	False	100	44%
27	True	124	54%
	False	107	46%
29	True	70	36%
	False	126	64%
32	True	148	65%
	False	79	35%
33	True	138	59%
	False	95	41%
34	True	142	61%
	False	91	39%
36	True	183	79%

	False	48	21%
39	True	90	39%
	False	140	61%
40	True	104	45%
	False	126	55%
41	True	145	64%
	False	82	36
42	True	163	71%
	False	66	29%
45	True	120	52%
	False	109	48%
52	True	164	72%
	False	65	28%
55	True	90	39%
	False	142	61%



Question 66 _____ the above are probably caused by different microbes as they have different symptomology.
Question 67 _____ The above are probably all caused by direct contact as they involve the skin.

Question #	True/False Answer	# students who chose answer	% students who chose answer
66	True	142	71%
	False	58	29%
67	True	116	59%
	False	82	41%

Question 70 This picture shows small calcified nodules in the lungs that are the result of an infectious disease. Was this caused by…

f) An airborne microbe
g) A microbe you might have eaten
h) A microbe spread by direct contact
i) An STD
j) It could be anything

Question 70-

Answer choice	# students who answered with this choice	% students who answered with this choice
A	166	72%
B	2	1%
C	3	1%
D	2	1%
E	57	25%

Secondary Survey Results Microbes and Cells 204

Question 1: How influential do you think the following sources are in forming these misconceptions about infectious disease. Rank them, 1 being most influential.

_____ media (TV, news, movies, etc.) _____ people telling other people wrong information
_____ wrong information on the internet _____ lack of education
_____ can't understand terminology _____ culture/ lifestyle you grow up with
_____ fear and stigma _____ denial (don't want to know if you have disease)

Media	108
Wrong information	169
Can't understand terminology	185
Fear and stigma	147
People telling people wrong infor	97
Lack education	98
Culture	124
denial	189

Question 10: We are told to wash our hands- often to keep from getting sick because: Rank the following based on how common they are (A=always, L=likely, R=rarely, N=never)

i. We have unclean hands with infectious pathogens all the time, they just don't always infect us
j. The air contains microbes which can land on our hands

k. We have touched food with microbes on it
l. We have touched something contaminated with dirt
m. To get rid of ALL the bacteria on our hands
n. We have compromised immune systems on our hands which, in particular, cannot handle microbes transmitted by direct contact, such as by a handshake
o. Washing our hands works only if we do it often because soap only kills with multiple rinses, you won't kill anything by washing once
p. Each wash kills most microbes, but you pick up new ones continually

A	L –likely	18 (60%)----------
	A-always	10 (33%)----------
	N-never	
	R-rarely	2 (7%)
B	L –likely	12 (40%)----------
	A-always	9 (30%)----------
	N-never	
	R-rarely	9 (30%)----------
C	L –likely	14 (45%)----------
	A-always	10 (32%)----------
	N-never	1 (3%)
	R-rarely	6 (19%)-----
D	L –likely	16 (53%)----------
	A-always	10 (33%)----------
	N-never	1 (3%)
	R-rarely	3 (10%)
E	L –likely	7 (23%)---------
	A-always	5 (17%)----
	N-never	13 (43%)----------
	R-rarely	5 (17%)----
F	L –likely	2 (7%)
	A-always	3 (10%)
	N-never	13 (43%)----------
	R-rarely	12 (40%)----------
G	L –likely	11 (37%)----------
	A-always	1 (3%)
	N-never	6 (20%)-----
	R-rarely	12 (40%)----------
H	L –likely	8 (27%)----------
	A-always	21 (70%)----------
	N-never	1 (3%)
	R-rarely	

Question 12: Do you know how the following microbes are transmitted? If so, write in a one word answer in the blank saying how (for example: water, food, touch, air, STD, etc.)

_____ HIV _____herpes simplex 1 _____vibrio cholera

_____Coccidiodes immitus _____Varicella Zoster _____Staphylococcus aureus

_____SARS virus _____ West Nile Virus _____ malaria
_____ Giardia lamblia _____ measles virus _____ influenza
_____ rotavirus _____ norovirus _____ polio virus

Microbe being transmitted	**Means of transmission**	**# of students who chose this means of transmission**	**% of students who chose this means of transmission for this microbe**
HIV	STD	25	86%
	IV drug use/blood	4	14%
Coccidiodes immitus	Student did not know	12	39%
	Air	4	13%
	Touch	3	10%
	Water	2	6%
	Food	9	29%
	Soil	1	3%
SARS	Student did not know	1	3%
	Air	28	90%
	Touch	2	6%
	Food	0	0%
Giardia lamblia	Student did not know	10	33%
	Water	11	37%
	Food	7	23%
	Touch	1	3%
	Air	1	3%
	STD	0	0%
Rotavirus	Student did not know	9	
	Touch	10	45%
	Food	5	24%
	Water	1	5%
	Air	6	29%
	Animals	0	0%
Herpes Simplex	Student did not know	1	3%
	STD	20	65%
	Touch	10	32%
	Kissing	0	0%
Varicella Zoster	Student did not know	14	37%
	Air	4	11%
	Touch	7	18%
	Food	6	16%
	STD	0	0%
	Water	0	0%
West Nile Virus	Student did not know	6	21%
	Mosquitos/bugs	12	43%
	Air	1	4%
	Touch	6	21%
	Water	3	11%

Measles	Student did not know	3	10%
	Air	5	16%
	Touch	23	74%
	Food	0	0%
Norovirus	Student did not know	13	42%
	Touch	8	26%
	Air	5	16%
	Food	4	13%
	Water	1	3%
Cholera	Student did not know	8	28%
	Food	5	17%
	Touch	2	7%
	Water	13	45%
	Air	2	7%
	STD	1	3%
Staphylococcus aureus	Student did not know	7	22%
	Touch	16	50%
	Air	4	13%
	Water	1	3%
	Open wound touching	1	3%
	Food	3	9%
Malaria	Student did not know	5	16%
	Mosquitos/bugs	10	31%
	Air	4	13%
	Water	5	16%
	Food	0	0%
	Touch	8	25%
Influenza	Student did not know	2	7%
	Air	24	83%
	Touch	3	10%
	Food	0	0%
Polio	Student did not know	12	39%
	Touch	9	29%
	Water	1	3%
	Air	5	16%
	Food	4	13%

Question 15: How effective (give an estimated percentile) do you think the following are in killing microbes or preventing them from getting on your skin?

____ bleach
____ washing your hands with just water
____ not touching dirt, dust, or surfaces
____ pasteurization
____ boiling
____ freezing
____ hand sanitizer
____ washing your hands with antimicrobial soap
____ autoclaving
____ alcohol
____ treating with base (NaOH)
____ refrigerating

Antiseptic type	Percentile range effectiveness	# of students choosing a percentile within this range	% of students choosing a percentile within this range
Bleach	0-20	1	3%
	21-40	0	0%
	41-60	0	0%
	61-80	2	7%
	81-100	24	89%
Washing hands just water	0-20	16	57%
	21-40	5	18%
	41-60	6	21%
	61-80	1	4%
	81-100	2	7%
Not touching dirt	0-20	16	59%
	21-40	3	10%
	41-60	3	10%
	61-80	4	15%
	81-100	1	4%
pasteurization	0-20	3	11%
	21-40	1	4%
	41-60	4	15%
	61-80	6	22%
	81-100	13	48%
boiling	0-20	0	0%
	21-40	0	0%
	41-60	1	4%
	61-80	6	22%
	81-100	20	74%
freezing	0-20	7	26%
	21-40	1	4%
	41-60	7	26%
	61-80	7	26%
	81-100	5	19%
Hand sanitizer	0-20	4	15%
	21-40	2	7%
	41-60	3	11%
	61-80	5	19%
	81-100	13	48%
Washing hands with soap	0-20	1	4%
	21-40	2	7%
	41-60	0	0%
	61-80	10	37%

	81-100	14	52%
autoclaving	0-20	6	21%
	21-40	0	0%
	41-60	3	11%
	61-80	3	11%
	81-100	16	57%
alcohol	0-20	0	0%
	21-40	0	0%
	41-60	2	7%
	61-80	5	19%
	81-100	20	74%
Treat with base (NaOH)	0-20	4	15%
	21-40	4	15%
	41-60	5	19%
	61-80	8	30%
	81-100	6	22%
refrigerating	0-20	15	56%
	21-40	3	11%
	41-60	6	22%
	61-80	2	7%
	81-100	1	4%

Question 16: Antibiotics are effective in most (circle all that apply):

a) Bacterial infections b) Fungal infections c) Viral infections d) Parasite infections

Answer Choice	# students who chose this answer	% students who chose this answer
A	29	51%
B	12	21%
C	9	16%
D	7	2%

Question 20: If an infectious microbe needs the human body as a host to live (circle all that apply):

k) It can only last seconds outside of the human body, it must be taken up immediately to survive
l) If can only survive hours outside of the human body
m) It can survive days outside of the human body
n) It can survive weeks outside the human body, only in warm temperature
o) It dies outside the human body but can reactivate itself if taken up by another host

Answer Choice	# students who chose this answer	% students who chose this answer
A	17	33%
B	11	21%
C	3	6%
D	6	12%
E	15	29%

Question 23 ____ we have *E. coli* already in our intestine.
Question 24 ____ We have *Staphylococcus* spp. naturally on our skin.
Question 27 ____ Washing your hands with antimicrobial soap is an effective means of ridding your hands of all harmful bacteria.
Question 29____ Antibiotics can help treat viral infections.
Question 32 ____ With most microbes, regardless of how the disease is normally transmitted, if you ate the meat of an animal infected with the disease you would probably get it.
Question 33 ____ If you were to eat a bird that had influenza, you could get the flu.
Question 34 ____ If you were to eat a rabid animal, you could get rabies
Question 36 ____ Most diseases have characteristic, telltale symptoms.
Question 39____ HIV can be transmitted by mosquitos
Question 40____ Anthrax is contagious.
Question 41____ All diseases a human gets from an animal can then be transmitted from that human to other humans.
Question 42____ Most vector-borne diseases need a specific vector (such as a tick or mosquito) to be transmitted but do not need a specific species of that vector (such as the Aedes aegypti mosquito) to be transmitted, any mosquito can.
Question 45____ Most microbes die within minutes when outside of their natural hosts.
Question 52 ___ When people come infected with the cold or the flu, they are far more likely to have been infected by direct contact or aerosol droplets than by touching a surface the viruses were on.
Question 55 _____ Infectious diseases you get by direct contact are, in most cases, more severe than airborne diseases.

Question #	True/False Answer	# students who chose answer	% students who chose answer
23	True	20	65%
	False	11	35%
24	True	17	55%
	False	14	45%
27	True	20	65%
	False	11	35%
29	True	12	39%
	False	19	61%
32	True	21	66%
	False	11	34%
33	True	15	48%
	False	16	52%
34	True	16	52%
	False	15	48%
36	True	23	74%
	False	8	26%
39	True	11	35%
	False	20	65%
40	True	15	48%
	False	16	52%
41	True	15	48%

	False	16	52%
42	True	24	77%
	False	7	23%
45	True	16	52%
	False	15	48%
52	True	22	71%
	False	9	29%
55	True	20	65%
	False	11	34%



Question 66 _____ the above are probably caused by different microbes as they have different symptomology.

Question 67 _____ The above are probably all caused by direct contact as they involve the skin.

Question #	True/False Answer	# students who chose answer	% students who chose answer
66	True	16	67%
	False	8	33%
67	True	8	33%
	False	16	67%

Question 70 This picture shows small calcified nodules in the lungs that are the result of an infectious disease. Was this caused by…

b) An airborne microbe
c) A microbe you might have eaten
d) A microbe spread by direct contact
e) An STD
f) It could be anything

Question 70-

Answer Choice	# of students who chose this answer	% of students who chose this answer
A	21	54%
B	2	5%
C	3	8%
D	1	3%
E	12	31%

Discussion

For a microbiologist, and in fact for most scientists, finding the source of anything is something of an intellectual goldmine. The epidemiologist works to find the common transmission factor among the many ill just as the geneticist works to find which altered gene caused the change in phenotype. When you find a source, you find a means of approaching it. Maybe, you find a cure. So, in the same manner in which George Beadle pioneered "forward genetics," divining the mutation from the mutated appearance, we sought to find the causes of the misconceptions students were identifying in conjunction with the identification of what they actually were.

Students, in reply to a question about the causes of misconceptions in society, first and foremost asserted that people are not educated in the subject of infectious disease or microbiology. In other words, they noted ignorance as the chief constituent of myths. As the students in the upper division virology class had taken more classes concerning the subject than the lower division classes,

they were the perfect model for divulging the truth in this. Nearly all of the misconceptions which the virology students noted were based on very specific topics which they would not have known without having taken an advanced class delving into the subject. Yet, for the most part they did not identify things which they thought they knew and learned were wrong, but rather the things they never knew at all. Contrarily, those students in the general microbiology class and the freshman colloquium rarely identified something they did not know as a misconception but something they thought they knew which the class had disproved. From these results it would seem that the virology students did not already have myths when the class began, just ignorance of what they had not yet learned, likely due to their years of education in microbiology. This makes a strong case for the importance and potency of education in our lives and how we perceive everything, including that unseen world of microbiology.

With the portrayal of man-eating viruses which transform the body in seconds and kill within hours, it is no great surprise that the big screen has more than slightly misguided students in their view of microbes. Every time there is an outbreak of a foodborne illness it heralds an odd sense of hysteria in the United States. The media breaks the story into an audience which automatically fears before it logically confirms and understands. And from an exaggerated tone belted by a sometimes misinformed informant, we listen with complete acceptance, because it is the news and the news just does not lie. The story becomes the “Did you hear?”and the “Well, my mom said” which are the breeding ground of myth and misconception both. And so, it is not shocking that beyond the mention of education itself, when students were asked what they believed the causes of microbiological misconceptions in society to be, they noted the media as the second most guilty offender.

Yet, it is not just the news media which sculpts our perception of microbes, but also those purposefully fictional accounts which distort what we know about microbes into an imaginative idea of them. Popular among college-aged students are “flicks” such as *Resident Evil* and *28 Days Later* which involve viruses that infect in mere seconds and somehow metamorphose the body and mind into blood-

crazed monsters. One might argue that television, computer games, and magazines tailored to the teenage mind are paramount in these misconceptions because amongst this age group, these are the largest forms of entertainment. In many ways we are shaped by our environment and surroundings in areas which education cannot reach. For example, one student mentioned a computer game he often played in which the goal was to create the most effective bioterrorist agent. They created viruses meant to kill, which may have been both a learning experience and a myth-instiller.

Aside from education and the ever-exaggerating media, another commonly noted cause of myths was hearsay and rumors. After all, once the media has leaked that often incomplete story, it is echoed in warnings from mother to child, altered in whispers between office cubicles, and embellished among friends. For example, many students grew up with their parents telling them not to go out in the cold because that is how one catches a cold. Though there is no doubt cold weather tends to be conducive to virus spread, it is not the cold itself causing the disease. Growing up under that constant chastening by our parents helps that myth set in and we often accept it without question, passing it on to others as well.

Though to a lesser extent, perhaps, especially among educated individuals, fear and stigma were mentioned as playing a role in propagating these misconceptions. People are often afraid of what they do not know or understand when it comes to infectious disease; society has not changed much in this regard. In retrospect, it is no great surprise that in the early years of the AIDS epidemic, not too many people could have told you what it was, or rather, what "GRID" was. Everything in our society is translated by the media middleman, and the knowledge of the epidemic was as brief as the scanty reports on that "gay plague" caused by an unknown "something." And in its unknown, it spread with frivolity. How it was spread was not yet understood and those afflicted felt the consequences of this as good friends and family stopped visiting and politely declined from any physical touching. It was fear. The fear of the disease, especially in an already stigmatized gay population, helped stigmatize the

disease. And so… the virus was quiet, sitting in office chairs and in hushed street corners where secretive people meet with even more secretive tramps, in clubs, among drug users and homosexuals… among white heterosexuals. It has thrived in ordinary moms and dads and teachers and doctors, in whose veins it has persisted for years but in whose conversations it has not. People did not know what the virus was, so false information was spread and misconceptions born.

This same stigma was apparent in answers students gave to another question on our survey, "Have you known someone with infectious disease, and if so, how has it changed your perception of the it?" Although the diseases mentioned ranged from chickenpox to malaria, one common remark was the "I never thought it could happen to me" mentality. They saw severe infectious diseases as primarily infecting "other" people in other underdeveloped nations. They associated these diseases with character traits and a person's illness, in essence, was acquired because of their personhood. Infections only happened to "dirty" people who don't take care of themselves, to prostitutes who carelessly sell their bodies. Most students, before knowing someone close to them with a disease, basically believed that if they maintained good hygiene, they wouldn't acquire an infectious disease. It's unfortunate that such feelings of immunity don't do much for the immune system, or for ridding ourselves of judgmental attitudes. Students did not seem to understand that often it is the economic, political, and cultural forces which shape the dynamics of disease transmission.

For example, a recent survey of African-American and Latina women recruited through homeless shelters or drug treatment programs, showed that they were equally knowledgeable "about AIDS symptomalogy; the etiological agent of AIDS; and behaviors known to reduce risk of HIV infection." (Farmer 85). In this article the argument is that women are rendered vulnerable to AIDS not because of any lack in education or understanding, but through social processes. In this article, three different HIV positive women are interviewed about their lives, with striking similarities. All women came from impoverished families, were beaten by their parents, and forced into both destitute and paternally dominant family settings. Women aware of the risk of contracting HIV knowingly have unprotected sex

because of their situations and their submission to husbands and abusive boyfriends. When we arbitrarily constrict the social field we are using as a context to pull out risk factors, we tend to eliminate the important words like racism, sexism, powerlessness, and despair. Infections, even if they are sometimes directly related to actions such as prostitution, cannot be helped because of the behavioral requirements of prostitution in the local social and economic environment.

Learning of the acquisition of a disease by a close friend makes the experience all the more personal and emotional. In the survey, students who knew a person with disease knew of not only its cause and symptoms, but of its tears, its loss of hope, and its fear. Knowing these and knowing that it happened to someone they loved often helped the students to shed the judgment they had previously coupled with the condition. Some of the infectious diseases were typically not severe, such as chickenpox, but which became severe in the person involved. Some of the diseases were completely asymptomatic. This helped students to realize that there is no standard for how an infection will affect someone; disease doesn't follow a blueprint. Above all else, students said it bred caution and compassion.

The most important question on our initial survey, and the main focus of this thesis, asked students in all three classes what their actual misconceptions were. Answers were strikingly similar amongst the general microbiology class and the freshman colloquium. Most misconceptions involved how infectious diseases were transmitted and the ease of that spread, the belief that antibiotics cure most infections, the belief in almost total efficacy of washing one's hands and other antiseptics, the hardiness of microbes in the environment, the belief that most microbes are harmful, and the variety of microbes. Students in the virology class, however, had far fewer "general" misconceptions about treatments and characteristics of microbes but rather misconceptions concerning very specific details about viruses involving pathological pathways, structure, host range, and ability to replicate. This was to

be expected as one would not be exposed to such topics unless they were enrolled in an advanced microbiology class.

Additionally, students in the freshman colloquium were asked how they might correct so many misconceptions in society. The number 1 response was increased education concerning infectious disease beginning at a younger age. After all, education was identified as the primary cause of misconceptions and the amount of people who actually attend college and take classes which would introduce the subject matter are few. This would be crucial in debunking myths as, outside of the classroom, students claimed they rarely discussed anything regarding infectious disease except for the occasional media frenzy about an outbreak of foodborne illness or some rare, dramatic disease. In this particular class, students learned about infectious disease in conjunction with their societal impact and repercussions. For this reason many students suggested teaching microbiology together with history, as it was this integrative subject material and their complementary nature which really enlivened the class for them. It also would help attenuate those previously mentioned misconceptions caused by fear and stigma because through learning about epidemics in history and the role of fear, faith, and love in their spread, students became acutely aware of human nature and its impact on disease. In addition to the more informal teaching style of the class, which allowed for open discussion and a positive atmosphere, students felt that the combination of science and social environment amped up their interest to an entirely new level. It was interesting for them to see how little society has changed in its immediate and often faulty judgment and how closely related both epidemic prevention and termination were to society's understanding of the disease. Where science offers drugs and treatment, it is society which can offer quarantine, isolation, and stigma (it's own quarantine), which also aid in disease prevention. As many students in the class had yet to learn much science, being freshman, learning non-science aspects of infectious disease in turn helped them to digest and understand the science behind them. It also helped them to bring microbiology into perspective as they were better able to relate it to the real

world and current events. On the emotional side, learning about society helped students to realize that there is a mental disease which accompanies physical disease, that how we feel and how we understand are paramount to reaching and helping someone. Without this emotion, social reactions and processes become infectious diseases themselves, stigmatizing and prejudicing parts of the population against others and infecting our thoughts and minds. Ultimately, it helped students learn that science and society are entirely intertwined as it is people's fears and bias which heavily influence the course of scientific progress. When we hold onto old ideals and understandings, which are often misconceptions, we need insurmountable evidence to change them. This is good in that it drives us to support with strong evidence, to experiment and test and retest and find conclusions. But in the same sense, if we need such hefty evidence to really change how we see things and accept hypotheses, change comes to a standstill, just as the world was thought to be flat for centuries upon centuries. Before science proved that wrong.

The secondary survey offered an extensive look into the specific misconceptions students had regarding infectious disease and showed how differently formatted questions gave very different results. For example, it was a common theme among students that they were better able to answer multiple choice questions correctly than the true/false and the ranking questions. This was probably due to the students' perception and understanding of the questions, as true/false questions are inherently black and white in the answers they require. Unless the question specifies straightforward guidelines for the student to take into consideration, it is hard to distinguish between answers that the student chose with only one microbe in mind and those with all microbes in mind.

Nevertheless, in all question formats, it was interesting to see a number of students choose absolute answers involving the always', nevers', and completelys' in the question and characterize very different microbes and diseases by one standard. This was made particularly interesting by the fact that there are almost no absolutes in microbiology; where one microbe dies within seconds outside of the

body, another can survive for weeks. Although they seemed absolutist, it is hard to determine from the true/false data whether or not students were truly thinking in the absolute sense, or whether they thought of one particular case in which it was true or false, knowing it was not the case for all microbes. Likewise, in questions regarding transmission, in which students were asked to rank the particular means of transmission with an occurrence of often, sometimes, rarely, always or never, we cannot know for sure if they were answering for most infectious diseases or for how often certain diseases, such as HIV, were transmitted. For example, we asked students how often diseases spread by direct contact were transmitted in certain ways, such as touch, kissing, or being bitten. There is no way of knowing whether or not students answered taking all direct contact diseases into consideration for each of their answers, or whether or not they thought of particular direct contact diseases normally spread in that manner and how likely that transmission was. For example, they may have been thinking that direct contact diseases are not often spread by biting, or they may have thought, even though rabies is spread by biting, it is not often, or easily, transmitted. With our subjective test it is hard to know what the taker may have been thinking to get to a certain answer; perhaps a verbal interview process would have been more revealing in this aspect. As we are not psychologists, we cannot analyze every possible thought process a student undertakes in answering questions, just as professors cannot fathom the processes students take when taking chapter tests. It's all a gamble. That being said, let's analyze some questions!

As the second survey had 70 questions, the results of each one being a possible thesis in itself, I chose to focus on a few of those which better represent some common misunderstandings. One of the more surprising results obtained in this survey was the general lack of knowledge when it comes to microbes and their transmission. This was hypothesized after students noted that they did not understand transmission routes or the ease of transmission in the first survey. There were several questions which specifically addressed this question in the secondary survey, one of which was a fill-in-

the-blank question asking students to identify the means of transmission of certain diseases. I chose this question to analyze first because it does not speak to any one misconception, but rather, really introduces us to the areas of ignorance (the non-conceptions) in the student population. These "areas" of ignorance can likely be attributed to what students identified in a previous question as the reasons behind misconceptions in society concerning microbes. Unlike in the initial survey, in which students first named the lack of education and the media as primary causes of misconceptions concerning infectious disease, in this survey, people named the media and people telling other people incorrect information. It is not surprising, then, to note that when students were asked to name the means of transmission for certain diseases, they were more likely to identify the correct answer with those diseases which the media has highly publicized.

Every student correctly identified HIV as being transmitted as a sexually transmitted disease or through IV drug use. Herpes was also, in the majority of cases, identified correctly as a sexually transmitted disease, though it was only identified as being transmitted by other means of direct contact by 1/3 of those students who noted it as an STD. Reasons behind the majority of students being able to correctly identify how HIV and Herpes viruses are transmitted likely does lie behind their attention in the media and the fact that college-aged students tend to be more sexually active. There are hundreds of clubs on campus supporting the AIDS foundation and constant coverage in the news about the HIV crisis in countries worldwide. Likewise, the commercials portraying Valtrex (an effective oral anti-herpes drug) as the happy-herpes-couple maker constantly light up TV screens, which is of particular interest to our more sexually active age group. As Herpes is, for the most part, solely portrayed as an STD, it is also not a surprise that few people were able to identify Herpes simplex one as being transmitted by touch. The fact that the majority of people were able to correctly identify the means of transmission for these viruses is testament to the power of the media in shaping our knowledge and the influence of word of mouth. Both of these were the most noted causes of microbiological misconceptions in this survey and

both are evidenced throughout the survey in answers such as this one. Another viral disease which was correctly identified the majority of the time was SARS, another credit to the media middleman, who never falls short of amplifying epidemics, shocking the public, and getting the point across. In our country, which runs on public television and other forms of media, there is the potential to amplify epidemics for both the good and bad. There was full and complete coverage of the SARS outbreak, which is what raised awareness of the epidemic and catalyzed the action needed to enforce precautions such as quarantine and isolation. Yet, in many cases, when epidemics are rare and isolated, such as minor outbreaks of foodborne illness, the media can scare the public beyond what is necessary. The fact that students knew of SARS, which mainly affected China and Canada in the Toronto area, is further evidence of the media's power, as other pandemics rarely are so coddled. This result was mirrored in a true/false question which stated that anthrax is contagious. The majority of students marked true when in fact, anthrax is not contagious from human to human. I mention this along with SARS as it is likely the media which has spurred the belief in the contagiousness of anthrax through extreme exaggeration of it as a bioterrorist weapon. When people are shocked and afraid of what is being shown on the news, they often assume the worst as many believed that anthrax was extremely contagious and that all those infected had the most severe form, inhalation anthrax.

When epidemics are not in our own country, are not sudden and immediately drastic, they receive far less attention, which was also evidenced in answers to this question regarding transmission of parasites such as *Giardia*, bacteria such as *Cholera*, and viruses such as *Rotavirus*. These three organisms are major problems in other parts of the world and are often fatal, yet few students actually knew how they were transmitted. *Giardia* and *Cholera* are far less common in the United States as our water has stricter guidelines of sanitation and rotavirus, for the most part, only causes mildly severe infections as the proper hydration and treatment can be provided for. The fact that students often did not know how or what these diseases were is authentication of one of our notes in the initial survey

concerning students who, before knowing someone with an infectious disease, held an attitude of invincibility. They believed infectious diseases were problems elsewhere but that the United States was as a sterile cushion in which they could feel safe from "dirty" diseases and "dirty" people. This is also a probable reason that *Giardia*, *Cholera,* and *Rotavirus* are not generally publicized as serious pandemics in the media… because the public is generally disinterested. It was surprising to know that even malaria, another generally third-world-limited disease, was far less understood than *HIV* or *Herpes*. Although many students were able to identify mosquitos as the transmission vector, there were a number of students who noted "water" and "air" as the transmission routes. In fact, many students were unable to deem mosquitos as the source of the problem, but said "bugs" were the main cause. This is another indication that students tend to generalize and apply one standard set of characteristics for all microbes. Students often do not understand that it is specific kinds of bugs and that, even within that category, specific species of those kinds. This "standardizing mindset" was seen in several of the true/false questions as well. For example, when students were asked if all diseases have telltale symptoms which characterize the disease, the majority of students marked true, when in fact, there are many asymptomatic diseases. Students also generalized in questions regarding whether or not antibiotics could treat most infections, believing they could, and also marked true in questions stating that *all* diseases which were transmitted from animal to human could be propagated from human to human. A majority of students also confirmed this standardizing misconception when they answered true to the belief that you need a particular type of bug but no specific species of that bug (in other words a mosquito but not necessarily an *Aedes aegypti* mosquito) to transmit vector-borne diseases. Students take what is true for a few microbes and apply it to the entire field, possibly one of the biggest sources of misconception prevalent in the answers to this survey.

This idea of immunity to microbes due to our sanitation measures and practices as a country goes along with the immunity students also felt to diseases which are no longer a problem in the U.S. When asked to identify the route of transmission which the polio and measles viruses take, the majority of students noted that they were unsure or incorrectly answered the question. As polio has largely been eradicated worldwide after the Sabin and Salk vaccines were developed in the 50s, polio is a rare disease in the U.S. which can be paired with the rare knowledge of its acquisition, apparently. Measles, like polio, has been nearly eradicated in most sectors of the U.S. population as most sectors are vaccinated with the effective (if in proper dosages) measles vaccine. There are still, however, religious groups and others who refuse vaccination as it is adverse to their religion or feelings of harmfulness. A few students in the class did note in another question, in fact, that most vaccines are harmful and few are beneficial. Measles is really only common among unvaccinated populations and in underdeveloped nations in which vaccination is unavailable, which is the probable reason students are completely unaware of how it is transmitted.

When asked about the *Influenza* virus and *Staphylococcus aureus* infections, students did relatively well identifying the correct route of transmission which is probably due to the prevalence of these diseases in our population. *Coccidioides immitis* and *Varicella Zoster* presented a new level of complexity to the question: the ability of students to recognize common scientific terms in microbiology. We used these proper scientific names, as opposed to valley fever and chickenpox, to see the barriers to understanding that the predicament of scientific jargon creates. Although surely many students could have identified the correct means of transmission of chickenpox and, to a lesser extent, valley fever as it is endemic to the Southwest, most people claimed they did not know the route of transmission when posed with the scientific name of the organism. We cannot be sure whether or not the student recognized the name of the organism and was unable to answer or whether they did not recognize the name. We can learn from this question, however, that often barriers in understanding between

professors and students and the news and its viewers are as simple as how we word and frame information. Also on the list of diseases was *West Nile Virus* and *Norovirus*, which have had recent outbreaks in Tucson. As *West Nile Virus* is prevalent in mosquitos in Tucson and *Norovirus* can commonly break out in dorms, the perfect setting for spread, these questions were to see if students were better able to relate to local settings and answer correctly. With *Norovirus*, which is far less known than common viruses such as *Influenza* and *Rhinovirus*, the majority of students still did not know how it was transmitted. In contrast, the majority of students knew how *West Nile Virus* was transmitted, or at least that it was transmitted by "bugs." Perhaps this indicates that, even with small local outbreaks which hit close to home, in the dorms, *Norovirus* is still not common and widespread enough to affect how students perceive it.

Now that we have shown the possible sources of ignorance behind the lack of knowledge and incorrect knowledge, there were some very prominent misconceptions concerning antiseptics and the hardiness of microbes in the environment. A possible prelude to this misconception also has a root in transmission as students often did not understand where infectious microbes were coming from. When students were asked, simply, the reason behind washing their hands, the majority of students did realize they had microbes on their hands all the time and either replied "likely" or "always" to attaining microbes through touching contaminated food or surfaces. Most students also correctly identified that we are "never" or "rarely" washing our hands to rid them of *all* bacteria, though there was some dissension here as some students did note that we were often washing our hands for this purpose. Interestingly enough, 27% of students marked that we were "always" or "often" washing our hands because we have weak immune systems *on* our hands which cannot subdue direct-contact infections. As this result was wrong and unusually fabricated, the result is surprising and may reflect the approximate percentage of students which answered questions they did not know because they thought the answer sounded decent. Wording is of paramount importance and, for this reason, there is likely

bias in the answers to these questions as students probably would not have thought of such an answer without it already present on the survey. About 40 % of students marked that soap only works with multiple rinses and cannot work if used only once, another prominent misconception. One quite interesting result was received in the last part of this same question which stated that washing ones hands kills most microbes but that we pick up new microbes continually (approximately 93% of students deemed this as likely or always true). Although we do indeed constantly pick up microbes through touch and other methods, what is most surprising is the belief that washing ones hands is extremely effective in killing the majority of microbes on our hands. It was noted in the first survey that students believed in the exaggerated or almost complete efficacy of many antiseptics and methods of sterilization. In this survey, however, this question was repeated throughout with different wording and question styles. It was interesting to note that when this question was posed as a true/false question, which asked if students believed washing your hands with soap was an effective means of ridding your hands of bacteria, the result was nearly split 50/50. The discrepancies found between question types shows the discrepancies in student understanding and thought processes. This survey, in essence, was more effective for having differently framed questions as it not only clearly divulged these discrepancies, but offered students a chance to view the question with multiple understandings. If a student misread or misunderstood a question in one case, perhaps in a differently worded question he answered more correctly, thereby increasing the accuracy of the results. This result was mirrored both in this question and another question asking students to estimate a percent effectiveness of several means of sterilization.

Strangely enough, in this ranking question, the majority of students believed the efficacy of washing ones hands with water alone was between 0 and 20% effective and that washing one's hands with antimicrobial soap is between 81% and 100% effective. In truth, it is often the scrubbing action of washing one's hands and not the antimicrobial soap itself which aids in ridding our hands of microbes.

In an experiment performed in a general microbiology lab, washing one's hands with water and then with additional soap showed the same amount of colonial growth on agar. In fact, there seemed to be fewer colonies before washing, likely due to the fact that you dislodge oils, and thus bacteria, from your hands when you rub them. In most of the rankings of the efficacy of sanitizers, students seemed to believe extreme efficacy of antiseptics which were not very effective and lower efficacy of those which were more effective. A number of students, though not the majority, deemed refrigeration as between 41% and 60% effective in killing microbes when refrigeration is mainly responsible for slowing and inhibiting growth. A number of students likewise mentioned freezing as being between 60% and 100% effective in killing microbes when it is also merely inhibitory. Although boiling is effective in killing most microbes, there are spore-formers which are particularly hard to kill with this method. It is hard to say whether or not students took most microbes into account when answering this question or if they acknowledged spore-forming bacteria in their answers and were in the minority that answered between 0 and 60% efficacy.

It is ironic that using a strong base (such as the mentioned NaOH) to microbes was often not recognized as an effective means of killing them when it is one of the only methods to destroy prions, extremely hardy proteins which are killed by little else. Many students did not seem to know what autoclaving was and ranked it with low efficacy of between 0 and 60%.

The majority of students noted the efficacy of pasteurization as between 81-100% which is probably an overestimation of its efficacy. As hand sanitizer and alcohols are constantly used on campus and advertized in commercials, it is not surprising that many students estimated their efficacy to be between 81 and 100%.

In question 16 in the secondary survey, students were asked to state whether or not antibiotics were effective in most bacterial, viral, fungal, and/or parasitic infection. The majority students seemed to understand that antibiotics are to be used in bacterial infections, yet, at least 10% of these students

still noted that viral infections could be treated and at least 23% noted their use in fungal infections. Students, again, seem to be standardizing all infections, believing there to be a common treatment for these very different organisms. Antibiotics are ineffective in viral infections and can exacerbate, rather than help, fungal infections. This common misconception concerning the all-encompassing efficacy of antibiotics probably stems from the fact that bacterial and viral infections have very similar symptoms and are often indistinguishable, even for trained physicians, without elaborative testing. Students are probably constantly prescribed antibiotics after complaints as it gives them a sense of action… that they can actually do something to stop the microbe. Many viral infections do not have effective antiviral drugs available and little other than fluids and bedrest, unsatisfactory answers both, can be prescribed. Students and doctors both are probably also confusing type of infection as the same range of symptoms is experienced in many infections. This same result is mirrored in question 66 and 67 in which students were shown three pictures of three different patients with different symptomology. One patient had an open sore on his tongue, another woman had red spots all over her skin, and a third patient had severe deformations of the face. All three of these patients were syphilitic, infected by the same bacterium *Treponema pallidum*, though the students were unaware of this fact. In the two questions below these pictures, students were asked if they were all caused by different microbes as different symptomology was present, to which most of them responded with true. They were also asked if the diseases were all caused by direct contact as the symptoms all involved the skin, to which the majority also responded with true. The results of these two questions show how students tend to visualize and understand things at face value. They did not realize that just because all of the symptoms are found on the skin does not mean that the infection had to be transmitted by direct contact. In this case, as it was syphilis (which, granted, is a complex infectious disease), the disease did happen to be spread by contact, but it did not have to be spread in this way. Students did not understand the pathogenic pathway organisms can take in the body. There are airborne pathogens, bloodborne parasites, and oral/fecal pathogens

which can all eventually get into the skin, though they began in the lungs or the blood or the digestion tract. Symptoms are results, they are not sources. Students seem to view infectious disease in a very limited scope which does not delve into the many routes and characteristics of different pathogens. They do not understand that there is no particular symptom, disease, or microbe with universality. Microbiology is a science of microbes, a science of complexity and ever-changing mutations. If it was as simple as students perceive it to be, the ever-mutating and unconquerable HIV and hepatitis C would have been cured long ago.

Another question along these lines was question 70, which showed a picture of a calcified nodule in the lung, which was actually an X-ray of another syphilitic patient. The question asked if the picture showed someone infected with an airborne pathogen, direct-contact pathogen, an oral/fecal pathogen, an STD, or whether we couldn't possibly know from the picture. Although a number of students did mention the correct answer, that we would be unable to tell from this symptomology exactly how the microbe was spread, the overwhelming majority of students chose the airborne pathogen. They saw a symptom in the lungs, and again, assumed, it had to be spread by the lungs, a very misleading generalization. This same misconception was emulated in the belief that if one eats an animal with any infectious disease, regardless of how the disease is transmitted, you will acquire the disease. In the true/false questions, half the students believed you could get influenza by eating a bird with influenza and half the students also believed if you ate an animal with rabies, you would acquire rabies. However, curiously, when essentially the same question was worded differently in another true/false question which queried, if you eat the meat of an animal with a disease, regardless of how the disease is transmitted, you can get the disease, the percent of students answering true rose by 10%. By generalizing the question with "any disease" rather than choosing specific diseases such as influenza, students were more likely to answer that it was true. This is yet another testament to the students' propensity to generalize microbiology and their failure to break the question down with reasoning.

Though some diseases, mainly those spread by the oral/fecal route, are transmitted by ingestion, most others which are not transmitted in this way are destroyed by the HCl in our stomachs and other components of the digestive system. We could not acquire HIV, for example, by eating the meat of an HIV infected individual; the virus would be destroyed before it ever reached the blood.

In continuation of this standardizing theme, the majority of students also noted in the true/false questions, that airborne diseases were inherently less severe than direct-contact diseases. Perhaps students may not have thought this had it not been a question, but the majority of them marked true. They did not understand that one cannot rank disease severity based on its transmission, there are many airborne diseases which are mild and many which are extremely severe. It depends on the specific disease mechanism, the specific patient, and the specific organism. Most students in this secondary survey, in opposition to the initial survey, did note the presence of normal flora on our bodies. In fact, a great number of students noted that we naturally have bacteria in every organ system of our body (another misconception). Yet, even though many noted that we have normal flora on our bodies, the majority of students said it was true we have *E. coli* in our intestine while the majority of students said it was false that we had *S. aureus* on our skin. It was interesting to see students, who have so many misconceptions due to generalization, have unstandardized and microbe-specific misconceptions when it comes to the microbes on our bodies and their natural presence.

Beyond the common theme of generalizing information, however, there were also misconceptions based on misguided reasoning. One such misconception was the belief that HIV could be transmitted by mosquitos. If we were to break this myth down into logical components, it is easy to see how students could draw this conclusion. HIV is a virus in our blood, and more specifically, in our T helper cells. Mosquitos take up our blood and, when biting another individual, can essentially transmit this HIV infected blood to another host. The logic is there, but it is lacking. Students were unable to

think all the way through the question, such as the virus' survival time outside of its human host, as it cannot replicate in mosquitos.

Lastly, students, through many questions, also disclosed with their answers that they did not know that microbes could last for long periods of time outside of the body. In a true/false question, students were divided half and half over the question which stated that microbes died within minutes outside of the human body. In a different form of this question presented in multiple-multiple choice format, the two most prevalent answers were that microbes die within seconds outside of the human body and that microbes die immediately and only become reactivated once taken up by another host. Perhaps the reason so many students express sentiments of invincibility to severe infections lies within this misconception as they believe microbes cannot survive long in the environment. Many viruses are extremely hardy and can survive for months outside of their host due to stability in their structures. Again, there is no standard; some microbes would die within minutes while others could take hours, days, or months to die/ become inactivated.

The results of this survey were tentative, and, of course, based upon whether or not students were able to understand questions, upon the different thought processes they may have taken, and upon whether or not they cared enough to think about the answers and not use outside information. Students were also asked to answer the questions as if they had never taken the class, but it is hard to unlearn and answer appropriately. Nevertheless, there were common trends among students and classes and a common theme of generalization, mis-reasoning, and ignorance. The explanations for the reasons behind these misconceptions are anyone's best guess, and perhaps equally a psychologist's guess than an educator's or a fellow student's. Nevertheless, in this discussion, there are plausible theories behind several of the misconceptions we divulged from the viewpoint of a student in the microbiology classroom, trying to find cause in an ever-causing society.

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