

Do You Know Your Sh*t?

Students' Awareness, Attitude, and Perception about Current and Relevant Events in Microbiology

Keywords: education, fecal transplant, SENCER microbiology course, student learning outcomes

ABSTRACT

Aims: To probe the knowledge, insight and attitude of students who had previously taken a traditional microbiology class and those who had not been exposed to any relevant knowledge of microbiology.

Methodology: A total of 228 undergraduate students participated in survey containing 22 questions. The survey was collected from 99 microbiology students (called group 1, with a 90.9% completion rate), and from 129 non-microbiology students (called group 2, with a 100% completion rate). The survey focus was on students' general knowledge of bacteria, in particular beneficial bacteria, where they exist, what happens in the lack or absence of them; the usage/misusage of antibiotics; general knowledge about poop, and what it is made of; and fecal transplant as an example of the new medical procedures available today that use live microbes as alternative treatments.

Results: Our results show that current and relevant topics should be included in the curriculum of microbiology courses to motivate students to engage in the learning process.

Conclusion: We conclude this approach will not only inform students about the current knowledge of the field, but will also increase motivation among students which leads to spending more time on task and developing a better understanding of the subject matter and long-term retention of the learned concepts.

INTRODUCTION

"Professor, it seems you know your sh*t... pardon my language"! This is what one of my students told me at the end of a microbiology class. I smiled as I knew what she meant, while I was also thinking that I have finally found the theme for my future SENCER (Science Education for New Civic Engagements and Responsibilities) microbiology courses! To design the course, we deliberated and conducted a survey to probe the knowledge, insight, and attitude of students who had previously taken a traditional microbiology class (group 1) as well as those who had not been exposed to any relevant knowledge of microbiology (group 2). This study focused on general knowledge of bacteria, in particular beneficial bacteria, where they exist, what happens in the lack or absence of them; the usage/misusage of antibiotics; the general knowledge about poop, and what it is made of; and fecal transplant, which is one of the new medical procedures available today.

Bacteria are unicellular organisms that are characterized by peptidoglycan cell walls and a single circular chromosome. Without the help of bacteria, the world as we know it would not exist. Bacteria are essential for the life of every multicellular organism. There are more bacterial cells in and on the human body than the number of human cells in the body. The human body contains approximately 10 trillion human cells while playing host to roughly 90 trillion bacterial cells.

These bacteria make up the normal flora of our bodies and are found on our skin, eyes, nose, upper respiratory system, mouth, large intestine, and reproductive organs [1]. Bacteria play important roles in our health from synthesizing vitamins to protecting against possible pathogens through competitive exclusion [2], [3]. Antibiotics often kill not only the targeted bacteria, but other bacteria which are not pathogenic or the intended target of the prescribed antibiotic. Eliminating some bacteria that might be beneficial to the human body could put the body in a situation that leads to other problems. The human body is an ecosystem comprised of a multitude of non-pathogenic microorganisms. By eradicating beneficial bacteria from the human microbiome, we are potentially causing more harm than good.

Alternatives to the use of antibiotics are needed to treat diseases. Overuse and abuse of antibiotics has led to many pathogenic bacteria becoming resistant to antibiotics. Antibiotic resistance is one of the world's pressing public health problems. One alternative to the use of antibiotics is fecal microbiota transplantation, or FMT, which is used to treat infections caused by *Clostridium difficile*, a bacterium known for causing severe and sometimes fatal diarrhea. Fecal microbiota transplantation is one of the new successful alternative approaches for treatment. FMT is a procedure in which donor stool is transplanted into a patient to reestablish the normal microbiota of the colon. Stool is collected from a donor and screened for parasites, bacteria, *C. difficile*, and other potential risks. Donor stool is diluted, strained and transplanted into the patient either by a nasogastric tube, colonoscopy/endoscopy, or enema [4], [5], [6].

To understand and appreciate FMT and the science of the human microbiome, you need to understand how *C. difficile* bacterium causes the disease. "Roughly 3 percent of the population (and perhaps as much as 15 percent of the elderly population) carries the *C. difficile* bacterium. The organism usually lives benignly in the gut; it makes trouble only after the carrier undergoes chemotherapy, antibiotic therapy, or some other disruption to the gut's normal ecology. When that happens, *C. difficile* can run wild, causing long days of watery, green-tinged diarrhea. (Roughly 14,000 Americans, most of them elderly, are estimated to die from the illness each year). Fecal transplantation resolves *C. difficile* illness by restoring a healthier ecosystem to the patient's gut, undoing whatever insults were done by chemotherapy or antibiotics." [6, ¶ 12 & 13]

Fecal microbiota transplantation is very effective in curing infections caused by *C. difficile*. FMT has a success rate that is over 90% [7]. A randomized study published in January 2013, compared the effectiveness of FMT to vancomycin and to vancomycin with bowel lavage. In that study, cure was defined as having no diarrhea with three negative stool tests for *C. difficile*, while relapse was determined as a positive stool test with diarrhea. The group that was assigned to receive FMT had a cure rate of 81% after the first fecal infusion. After the second infusion, 94% of these patients were cured. Of the patients that received vancomycin only 31% were cured and of the patients that received vancomycin with bowel lavage only 23% were cured. The study was ended early and those that were given antibiotics were offered FMT. The recurrence of infection five weeks after treatment was 6% in the FMT group, compared to 62% in the vancomycin group and 54% in the vancomycin with bowel lavage group [4]. In our study, we surveyed students from both group 1 and group 2 classes to find out how much they knew about bacteria, antibiotics and fecal transplantation as one of the alternatives to the use of antibiotics for treatment of certain diseases.

METHOD

Using related literature and microbiology course materials, pool of questions were generated to focus on and cover the intended surveyed topic. The instructor and three students then discussed each questions using the following criteria: why the questions needs to be asked, and how the information obtained from the questions can be used to validate the study. Upon completing the process, we created a 22 multiple choice question survey that questioned the respondents' knowledge of bacteria in general, bacteria in the human body, the respondents' use of antibiotics, and knowledge of fecal transplants as a medical treatment. Surveys were then distributed to students in microbiology (group 1) and non-microbiology (group 2) classes at Harold Washington College in Chicago, Illinois. As data was collected, we separated the surveys into two groups: students who have taken microbiology courses, named group 1, and those who had not, named group 2. We carefully categorized and analyzed students' responses and drew conclusions from the data collected from both groups.

Data collection, analysis and interpretation

In collecting data and gathering responses from our target populations, the survey was administrated through SurveyMonkey. Some students responded directly into the SurveyMonkey system while the majority turned in paper survey forms; therefore most of the data was manually entered in by surveyors from these survey forms. SurveyMonkey automatically calculated the data for each question and generated a report detailing the percentage of how often an answer was chosen to the total number of people that answered that question. To

analyze the data the authors reviewed the results of each question, made comparisons between what students stated in group one versus group two, and used descriptive statistics to interpret the results. Finally, the authors consulted two additional colleagues to individually confirm the results, and interpretation of the data. Whenever a disagreement on the interpretation arose, both colleagues and the authors conferred to reach a consensus interpretation.

SURVEY RESULTS

General Results

A total of 228 surveys were conducted with students at Harold Washington College. Of the surveys collected, 99 (with a 90.9% completion rate) were from group 1 and 129 (with a 100% completion rate) were from group 2.

Detailed Results

Whereas the majority, 73.1%, of group 1 knew that only a few bacteria are pathogenic, only 22.7% of group 2 knew this (shown in Fig. 1). Despite background knowledge on bacteria, more than half of both groups agreed that bacteria can become pathogenic if the environment is altered.

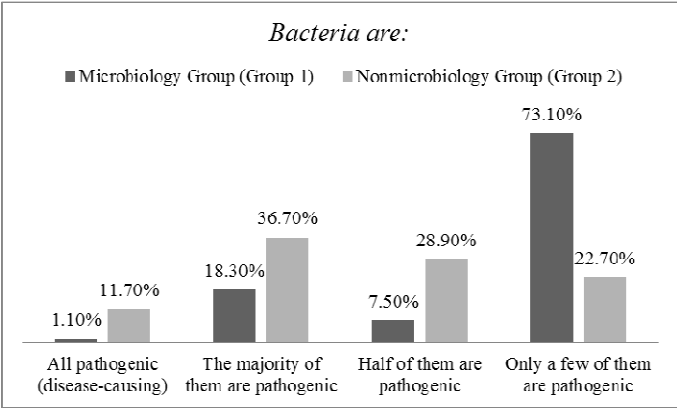


Fig. 1 Student responses to Survey Question 5

More than half of both groups surveyed believe incorrectly that our bodies have more human cells than bacterial cells; 56.2% of the group 1 students and 68.2% of group 2 students were erroneous. More than 4/5, 82.6%, of students who took microbiology courses thought more bacteria live in the large intestines than any other part of the human body, however less than 1/5, 14.7%, of students who had not taken a microbiology course believed the same (shown in Fig. 2).

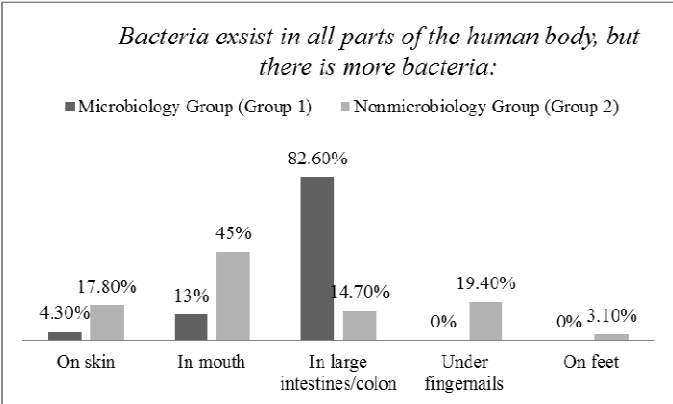


Fig. 2 Student responses to Survey Question 7

Results on questions regarding medication use showed that 47.3% of group 2 students take antibiotics almost every time they get sick, or when they get colds or the flu, whereas 88.9% of group 1 students take antibiotics

very rarely, and only when they will not recover from their illness without them (shown in Fig. 3). 92.2% of group 1 indicated that they take antibiotics as prescribed and only when they have infections caused by bacteria, only 52.3% of group 2 students stated the same.

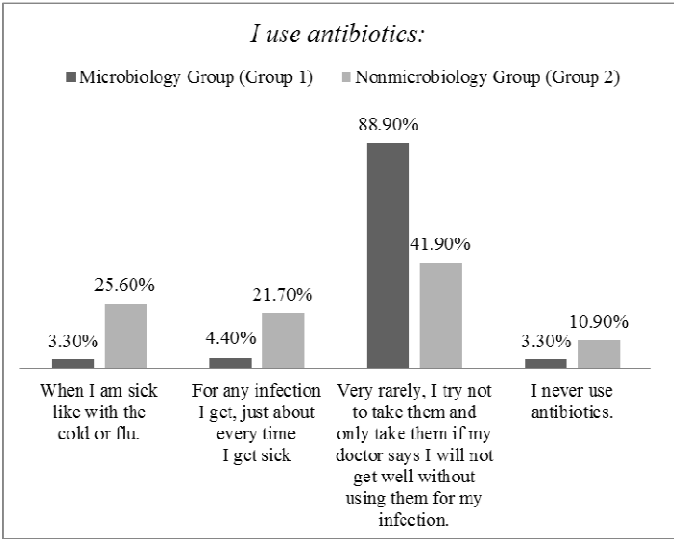


Fig. 3 Student responses to Survey Question 11

Results on questions regarding FMT showed that 57.8% of group 1 students and 77.2% of the group 2 students have never heard of a fecal transplant before (shown in Fig. 4). Only 67.8% of group 1 and 34.1% of group 2 students were aware that a fecal transplant is basically a stool transplant. The majority of both groups say that their knowledge of fecal transplant before taking this survey was between 0% - 25%. Only 32.6% of group 1 students and 21.8% of group 2 students indicated that their knowledge of a fecal transplant before taking this survey was between 50-100%. Roughly half of both groups, 48.9% of students who have taken microbiology (group 1) and 52.7% who have not (group 2), say that they do not have enough knowledge to decide if they would get a fecal transplant if it were recommended by their doctor.

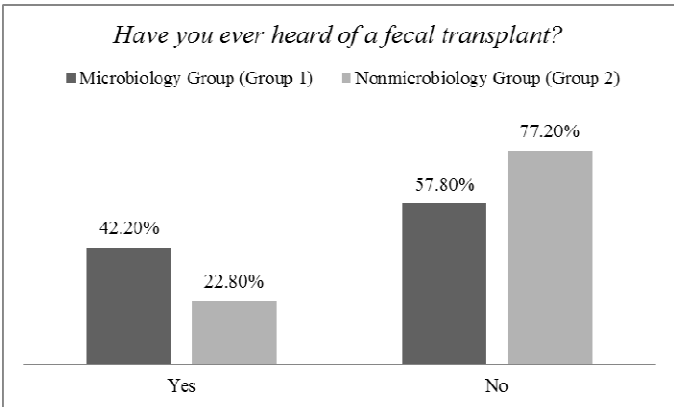


Fig. 4 Student responses to Survey Question 14

The last question on the survey addressed the students' forthcoming educational plans (shown in Fig.5). According to the results of this question, 84.2% of group 1 indicated that they will or may continue with microbiology studies in the future to learn more. Similarly, 70.5% of group 2 stated the same.

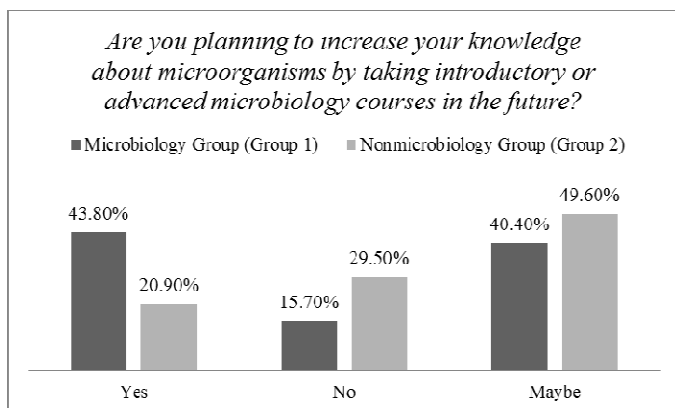


Fig. 5 Student responses to Survey Question 22

ANALYSIS AND CONCLUSION

A recent study shows motivation and study habits are mentioned most frequently as the root cause behind student failure at the college level [8]. “Motivation influences students’ attitudes, study habits, academic readiness, etc. Students who have a good understanding of the content being taught are generally more motivated and have a more positive attitude and thus have a greater chance of doing well in their school work” [8]. The results from our study showed that more than half of the students of both groups were interested in learning more about microbiology. More than half, 57.8%, of group 1 and over 3/4, 77.2%, of group 2 have never heard of a fecal microbiota transplant prior to this survey. Incorporating relevant and current topics into a class can generate motivation and spark more interest not only during the class, but also preceding the class. Students will enter the class prepared to talk and learn about the most recent discoveries and be able to apply what they would be learning to their everyday lives. By combining the two, students would be able to see how they can identify and address issues of public concern. The key goal for these classes is to increase motivation and allow the students to engage in the changes that need to be implemented in the sciences so they can participate in the charge of their own education.

Student-based and current topic-based class modification will attract more students to science, technology, engineering, and mathematics (STEM) classes, and open possibilities for those students to educate others on what they believe to be important when it comes to their chosen topic. Using fecal transplants as the topic for a microbiology SENCER class has already sparked interest in students. During their education, students will not only gain experience on the latest learning skills, but will also be prepared to do research independently and with a set goal in mind. Such changes will benefit them and the society in which they live. However, this goal cannot be achieved without a critical look at our existing educational system. Today, this system does not leverage these types of ideas to benefit students and teachers. A majority of the time, classes are taught with material straight out of the textbook. It is rare that a student has input on the course content to include what he or she believes to be an important and interesting topic to study. How can we get students more involved and accountable for their learning? We propose that the way classes are taught needs to be changed. By allowing the student and professor to create a topic that relates to the subject of the class, both the student and the teacher can set goals that will still follow key learning outcomes that need to be taught and incorporate them into the chosen topic. According to the President of the University of Houston, Bill Flores, “we must move from the learner as prisoner (in a system that not only locks in the student, but also the teacher), to the learner as explorer, stimulating their creativity, allowing them to explore new worlds” [9]. With enrollment in the fields of science, technology, engineering, and mathematics (STEM) shrinking, teachers are faced with the problem of appealing to a new generation of students without sacrificing educational quality [10]. Exploring unusual or contemporary topics, methods and procedures (or “New Worlds”) like fecal transplant can stimulate the minds of many students, and motivate students to invest time and energy in their own learning [8]. Furthermore, it is also the main goal of SENCER course programs, as clearly stated in its mission, to strengthen student learning and

interest in STEM field by connecting course topics to issues of critical local, national, and global importance [11].

Our data support the SENCER course programs as well as claim that integrating the current and relevant events in Microbiology pique the interest among students in microbiology and science in general. Over 75% of students surveyed (groups 1 and 2 combined) showed interest in taking a microbiology class after completing the survey (both yes and maybe answers are included). Approaching microbiology from a different perspective can make the class motivating instead of tedious. Using contemporary topics like fecal transplant creates interest in students and changes their perspective of not only microbiology, but the sciences as a whole. Another benefit to this form of teaching is that the topic can relate to an issue going on in their community. For example, almost 50% of subjects in group 2 (lay people) say they take antibiotics almost every time they get sick, or when they get colds or influenza. Coupling antibiotic misinformation and misuse of antibiotics, as well as easy access to different kinds of medication available in drugstores with no medical prescription (as observed in many countries worldwide) creates potential public health problems. Non-pathogenic microorganisms beneficial to human health may be eliminated; in addition infection with certain pathogenic microorganisms may increase (for example, *C. difficile* infections). What we are trying to do at Harold Washington College is to create awareness of research into medical alternatives, and contrast them with traditional forms of medication. Fecal transplants have shown promising results and the more people are educated on the subject, the more likely they are to engage their doctors in discussion to find the treatment that is best for them. Today, however public awareness and support are needed since only a “few laboratories are equipped to screen would-be donors’ stool for the vast array of viruses, parasites, and other conditions that might make their feces too dangerous to transplant, and most hospitals simply don’t have protocols in place for stool transplants.” [6, ¶ 5]

In short, we conclude that current and relevant topics are needed to be included in the curriculum of microbiology courses to motivate students to engage in the learning process. This approach will not only inform students about the current knowledge of the field, but will also increase motivation among students that leads to spending more time on and developing a better understanding of the subject matter and long-term retention of the learned concepts. All this will in turn lead to a more positive attitude toward science in general and microorganisms in particular among students. This strategy is one solution to increase the students who enter the STEM fields in the next decade.

REFERENCES

- [1] Cherif, A.H., Movahedzadeh, F., Michel, L., Marthakis, N.B. (2012). How Well Do You Know Your Closest Neighbors? Activity for Promoting Active Learning in Biology Classes, Science Education and Civil Engagement, An International Journal , 4:2, pp. 5-16.
- [2] Cherif, A., Michel, L., Movahedzadeh, F., Aron, R., Adams, G., Jenkins, S., (2009). Defending the Lowly Prokaryotes: New Challenges for BIOGaia Learning Activity, The American Biology Teacher, 71(6):346-353
- [3] Tortora, GJ., Funke, BR., Case, CL. (2013). Microbiology: an introduction. 11th edition Pearson, pp. 402-405.
- [4] Van Nood, E. et al (2013), Duodenal infusion of donor feces for recurrent *Clostridium difficile*, New England Journal of Medicine, 368:407-15
- [5] McKenna, M. (2013). Fecal Transplants: a clinical trial confirms how well they work Available: <http://www.wired.com>
- [6] Glenn, D. (2014). Student-led project banks on promise of fecal transplants. *The Chronicle of Higher Education*, February 7, 2014. <http://chronicle.texterity.com/chronicle/20140207a?pg=16#pg16>
- [7] Neimark, J. (2012). Big Idea Tap the healing power of poop, Discover magazine
- [8] Cherif, A., Movahedzadeh, F., Adams, G., & Dunning, J. (2013). Why Do Students Fail? Higher Learning Commission: A Collection of Papers on Self-Study and Institutional Improvement (29th edition) 2013, pp. 35-51.

- 244 [9] Freedman, G. (2009). From an education pipeline to cycles of learning: Is the tipping point for education in
245 sight?, Summary from the Pipeline matters council: Improving K20 student progression, The Blackboard
246 Institute
- 247 [10] Movahedzadeh, F., Patwell, R., Rieker, J. E., and Gonzalez, T., "Project-Based Learning to Promote
248 Effective Learning in Biotechnology Courses," Education Research International, vol. 2012, Article ID
249 536024, 8 pages, 2012. doi:10.1155/2012/536024
- 250 [11] 2014 Science Education for New Civic Engagements and Responsibilities - SENCER.net

Part 1: Personal Information	A. Science (non- medical) B. Science (medical) C. Non- science
1. What is your major?	
2. Number of years at college?	A. 1 or less B. 2 C. 3 D. 4+ years
3. Gender?	A. Male B. Female C. No answer
Part 2: How well do you know bacteria?	A. Living organisms B. Nonliving things C. Part of viruses
4. Bacteria are:	
5. Bacteria are:	A. All pathogenic (disease causing) B. The majority of them are pathogenic C. Half of them are pathogenic D. Only a few of them are pathogenic
6. The beneficial bacteria:	A. Will never become pathogenic B. Can become pathogenic C. Some can become pathogenic when the environment is altered.
7. Bacteria exist in all parts of the human body, but there is more bacteria:	A. On skin B. In mouth C. In large intestines/ colon D. Under fingernails E. On feet
8. Would a lack or absence of bacteria be beneficial to the human body?	A. Of course, bacteria are gross and make you sick. B. Getting rid of some may be good, but not all of them, we need certain kinds. C. All the bacteria are beneficial to the human body.
Part 3: Bacterial Medical Treatment and You	A. More human cells than any other types of microorganism cells in or on the body. B. More bacterial cells than human cells. C. More viral cells than human cells.
9. My body is made up of :	
10. If you had to choose an option for medical treatment, you would choose:	A. Treating illness using harmless (non-pathogenic) bacteria. B. Taking a medicine like an antibiotic. C. A medical procedure (like surgery) D. Any of the above as long as it is recommended by a medical doctor. E. None of the above
11. I use antibiotics:	A. When I am sick like with the cold or flu B. For any infection I get, just about every time I get sick. C. Very rarely, I try not to take them and only take them if my doctor says I will not get well without using them for my infection. D. I never use antibiotics.
12. Do you abuse and/ or misuse medications such as antibiotics?	Of course not, I take them exactly as prescribed until there are no more left and only when I have infections caused by bacteria. B. Of course not, I take them until I feel better and have no more symptoms. C. Of course not, I take them every time I get sick. D. I have taken antibiotics that were not prescribed to me, or I have given someone some of my prescribed antibiotics. E. Not applicable; I never use antibiotics.
Part 4: How well do you know your poop?	A. All organic waste materials, there isn't any bacteria in my poop. B. Waste materials, and less than 15% of its mass is bacteria. C. Waste materials, and about 40% of its total mass is actually made up of bacteria. D. Waste materials, and more than 70% of its total mass is actually made of bacteria.
13. My poop is made up of:	
	A. Yes

14. Have you ever heard of a fecal transplant?	B. No
15. Fecal transplant is:	A. Stool transplant from a healthy individual into a recipient. B. Tissue transplant from a healthy individual into a recipient. C. Organ transplant from a healthy individual into a recipient. D. All of the above E. None of the above
16. The process of transplantation of fecal bacteria from a healthy individual into a recipient as a treatment for patients suffering from, for example, <i>Clostridium difficile</i> infection (CDI) which causes diarrhea to pseudomembranous colitis, is known as fecal transplant. Who would be the best candidate for this procedure?	A. A patient with diarrhea. B. A patient who lost all his/ her established normal microbiota in the large intestines. C. A person who would like to live longer.
17. Fecal transplant involves single or multiple infusions of bacterial fecal flora originating from a healthy donor. Donors must be tested for a wide array of bacterial and parasitic infections. Therefore the best donor is:	A. A close relative because the genetic similarities or differences do affect the success of the procedure. B. Not a close relative because a close relative may be an asymptomatic carrier of, for example <i>C. difficile</i> , a disadvantage. C. The genetic similarities or differences do not appear to play a role in the success of the procedures as long as the donor is tested for a wide array of bacterial and parasitic infections. D. Don't have enough information to provide an opinion about this question.
18. Would you accept a fecal transplant if your medical doctor suggested it to you?	A. Yes B. No way C. I don't have enough knowledge to make a decision. D. I don't know
19. Before this survey, how would you assess your knowledge of fecal transplants and it as an effective medical treatment?	A. 0% B. 25% C. 50% D. 75% E. 100%
20. Given all things are equal, if I have to receive a fecal transplant, I would select:	A. A donor who is a genetically close relative B. A donor who is not a genetically close relative C. A healthy donor regardless of whether or not he/ she is a genetically close relative.
21. Given all things are equal, if I have a fecal transplant, I would select a donor who is:	A. A baby donor B. A child donor C. A teenage donor D. A young adult donor. E. A grown up donor F. A donor who is much older than me.
22. Are you planning to increase your knowledge about microorganisms, by taking introductory or advanced microbiology courses in the future?	A. Yes B. No C. Maybe