

Probiotics and the Human Gut Microbiome

Savanna Stoy

Honor's Thesis Report

Oklahoma State University

May 10, 2019

TABLE OF CONTENTS

- I. Introduction
- II. Literature Review: The Microbiome
- III. Literature Review: Educational Material Development
- IV. Methods
- V. Results
- VI. Discussion
- VII. Acknowledgments
- VIII. References
- IX. Appendix

INTRODUCTION

The human gut microbiome has become a popular topic in science due to its vast implications on human health (Singh et al. 2017). The gut microbiome isn't a new topic in the field of science, however, extensive research over its structure has recently increased in order to better understand what constitutes a healthy microbiome. Evidence supports the idea that a healthy microbiome is robust and diverse, containing a wide variety of microorganisms. As it is currently understood, the gut microbiome consists of trillions of bacteria that naturally colonize our gastrointestinal tract and each bacterial species is impacted by our genetics, environment, and lifestyle choices (Rothschild et al. 2018; Sidhu & Poorten, 2017; Suez et al., 2018).

Probiotic supplementation is a popular tactic to achieve and maintain a healthy gut microbiome. Probiotics are defined as live microorganisms, directly ingested, which confer health benefits to the host and aim to modulate the existing microbiome. They are often confused with prebiotics, which are supplements that potentially support the growth of bacteria already found inside the microbiome (Bindels, Delzenne, Cani, Walter, 2015; Cohen, 2018). One of the main appeals of probiotic supplements stems from the desire to limit or eradicate the imbalance in microbial communities (Chassaing et al., 2015). Microbial balance has been claimed to aid in weight loss and prove beneficial in a variety of chronic illnesses. However, there is not sufficient evidence to support the unregulated claims made by many supplement companies (Cohen, 2018; Rockwood et al., 2018; Sidhu & Poorten, 2017; Tsia et al., 2019). This increases the need for the distribution of accurate information and evidence-based advice when it comes to considering supplementing the diet with probiotics.

In order to address this need, I created a piece of nutrition education material after reviewing current scientific literature and popular science sources of information. The

educational handout addresses the topics of probiotics and the gut microbiome in order to provide college-aged students with evidence-based information concerning probiotic supplementation. By identifying important facts and common misconceptions about the interactions between the microbiome, probiotics, and human health, I created a source of credible information that could be easily understood. Faculty at Oklahoma State University reviewed each of the scientific topics discussed to ensure relevance and accuracy and the educational handout was tested by interviewing college-aged students who have not previously been exposed to nutrition or microbiology courses.

LITERATURE REVIEW: The Microbiome

Only 1.9-8.1% of our commensal bacteria are heritable. In fact, microbiomes of unrelated persons in close living quarters share more similarities when compared to the microbiomes of their distant relatives. Thus, research focuses on discovering what causes the stability of the microbiome and what factors result in dysbiosis. Dysbiosis of the gut microbiome is assumed to be related to a wide variety of chronic diseases including obesity, cardiovascular disease, ulcerative colitis, psoriasis, and autoimmune disorders (Rothschild et al. 2018; Sidhu & Poorten, 2017; Singh et al., 2017; Wilkins & Sequoia, 2017). If an imbalance in gut microorganisms can lead to such detrimental outcomes, understanding the impact different environmental factors have on the microbiome is especially important.

One of the main factors that can affect the gut microbiome's composition is our diet. The most well-known dietary benefit to our microbiome is the consumption of indigestible carbohydrates such as fiber (Gentile & Weir, 2018; Singh et al., 2017; Turner, 2019). These carbohydrates are unable to be digested by human gastrointestinal enzymes, however, the intestinal microorganisms of the microbiome contain more carbohydrate degrading enzymes,

making fiber one of their primary energy sources (Singh et al., 2017; Turner, 2019).

Additionally, the microbial breakdown of these inaccessible carbohydrates, results in the production of short chain fatty acids, which benefit the host by serving as regulatory molecules in important physiological pathways such as activating G-protein coupled receptors, control disease through the regulation of inflammation and metabolism. (Singh et al., 2017; Tan et al., 2014).

Current literature focuses on the different impacts of the typical Western diet and a



Figure 1. Current food intake compared to dietary recommendations. Dietary Guidelines 2015-2020

<https://health.gov/dietaryguidelines/2015/guidelines/>

traditional Mediterranean diet on the microbiome. The Western diet is high in animal fat and protein, refined grains, and processed foods compared to the Mediterranean diet, which focuses primarily on the consumption of plant based foods, healthy fats, and whole grains. The United States typically follows a Western Diet. As seen in Figure 1, the current eating habits of people in the United States compared to

recommendations allow much room for improvement to help support a healthy lifestyle and a healthy microbiome (Dietary Guidelines 2015-2020).

The Western diet is high in processed foods, which commonly contain emulsifiers. These emulsifiers disrupt the mucosal barrier between gut bacteria and our intestinal cell surfaces leading to low-grade inflammation (Chassaing et al., 2015). This chronic and systemic inflammation could lead to major disease states such as obesity and metabolic syndrome, which

then increase risk for diseases such as diabetes, hypertension, and cardiovascular disease (Martinez, Leone, Chang, 2017; Medina-Rejon, Kirwan, Lamuela-Raventos, Estruch, 2018). Additionally, the composition of the Western diet is associated with a decrease in total bacteria and an increase in anaerobic bacterial species.

Adhering to the Mediterranean diet, however, is recommended for cardiovascular disease prevention due to its components of mono- and polyunsaturated fatty acids, complex carbohydrates, and limited processed food consumption (Widmer, Flammer, Lerman, Lerman, 2015). The high levels of phytochemicals are associated with a decrease in inflammation and therefore a decrease in a key risk factor for obesity and diabetes. Both obesity and diabetes are associated with the development of Alzheimer's Disease, so by decreasing the likelihood of those diseases, there is also a potential to decrease the likelihood of Alzheimer's disease (Godos, Federico, Dallio, Scazzina, 2017; Miranda, Gomez-Gaete, Mennickent, 2017). The Mediterranean diet is associated with an increase in total bacteria and a greater diversity of microorganisms. (Rockwood et al., 2018; Singh et al., 2017). Interestingly, one review also found that adherence to a Mediterranean diet led to a decrease in pathogenic bacteria within the gut microbiome (Singh et al., 2017).

Because diet plays a major role in the composition of our gut microbiome, it is not surprising that dietary supplementation to support our gut microbiome has become popular. This has allowed probiotic manufacturing to grow into a multibillion dollar industry. Unfortunately, the consequence of booming business is that the commercializing of probiotics has outgrown its scientific support (Rockwood et al., 2018; Singh et al., 2017).

Some of the most common health claims are in weight loss and relief from gastrointestinal discomfort. These typically include relief from diarrhea and antibiotic associated

diarrhea, irritable bowel syndrome, and indigestion. Probiotics have also made claims for the prevention of Alzheimer's Disease, vaginal infections, and diabetes (Tweed, 2017). However, many of these claims are missing consistent results in scientific studies.

In the United States, probiotics are found in food sources and in supplement pills. They are considered dietary supplements, which are regulated by the Food and Drug Administration. While probiotic supplements are not allowed to claim to treat a disease, they can make "structure-function" claims. A structure-function claim states that probiotics support a specific structure or function within a body system, and allow consumers to draw their own conclusions regarding probiotic use for disease treatment (Cohen, 2018). Probiotics however, often lack accuracy in reporting the identity, purity, and strength of supplements marketed for over the counter use (Cohen, 2018).

Prebiotics are another way people aim to modulate their current gut microorganisms. Prebiotics refer to non-digestible ingredients that stimulate the growth and activity of beneficial bacteria (Bindels, Delzenne, Cani, Walter, 2015). They aim to modulate the microorganisms that are already present within the gastrointestinal tract. Prebiotics are commonly consumed in adequate amounts in the diet through fruits, vegetables, and whole grains. Prebiotic supplementation can be confusing to consumers because of the similarities between prebiotics, probiotics, and even dietary fiber.

The main difference between prebiotics and probiotics are that probiotics aim to introduce new microorganisms into the microbiome, while prebiotics are supposed to only affect the preexisting microorganisms. Additionally, it is important to note the difference between dietary fiber and prebiotics. Fiber typically acts as a fuel source for existing microorganisms, but

has little modulating effects of the microbiome as a whole, which is opposite of the aim for both prebiotics and probiotics (Bindels et al., 2015).

The frequently recurring theme in research is that more evidence is needed to identify the true efficacy of probiotic supplements, their effect on the gut microbiome, and how it could possibly influence human health (Cohen, 2018; Hanaway, 2017; Rockwood, 2018; Sidhu & Poorten, 2017; Tsia et al., 2019). Pieter Cohen (2018), an associate professor of medicine at Harvard Medical School, and others argue that “there isn’t good evidence that most probiotics even take up residence in the gut if we have a healthy, intact microbiome” (p. 8). Additionally, one study even found that taking probiotics after being treated with antibiotics can actually delay the restoration of the normal gut microbiome (Suez et al., 2018). Lack of evidence paired with the loose regulations set by the Food and Drug Administration are key concerns when considering the true efficacy of current probiotic supplements.

At the current state of overall understanding of the human gut microbiome, probiotic supplementation can’t be recommended or discouraged when it comes to having an influence over human health. Research has shown that certain lifestyle choices, such as our diet, show profound affects over the composition of our gut microbiome, but there isn’t a definitive answer for what these microbiome alterations could mean for human health. After further evidence is discovered for clinical application of probiotic supplementation, a possible future direction for probiotics would be to become more individualized (Zmora et al., 2018). As for now, if an individual does choose to use a probiotic supplement, they should first consult their doctor, who will have access to higher quality probiotics better suited for clinical application. Doctors should also consider using specific species and doses of probiotics that have been researched for particular diseases for clinical use (Hanaway, 2017; Tsia et al., 2019; Wilkins & Sequoia, 2017).

LITERATURE REVIEW: Educational Material Development

It is estimated that after two weeks we remember 10% of what we read and 30% of what we see (viewing charts and photos). Pairing this information with the Message Development Model suggests an effective way to construct an appropriate and engaging consumer message, which I considered and utilized during the creation, and revision of my educational handout.

The Message Development Model consists of 5 steps: define issues, develop initial message concepts, assess message concepts, fine tune messages, and validate messages. These steps were used in conjunction with the four stages of writing *Interesting, Clear, Informative, Concise* (ICIC) communications (Liou, 2014).

The four stages of ICIC communications include: ASOAP Analysis, Outline and Collect Resources, Write the First Draft, and Polish your Paper.

- Stage 1, ASOAP Analysis, provides a clear direction for effective writing. It has you identify your audience, subject, objective, angle, and publication.
- Stage 2, Outline and Collect Resources, serves as an outline for writing and ensures that all important information is included.
- Stages 3 and 4, Writing the First Draft and Polishing your Paper, are used to evaluate and the effectiveness and consistency of writing and provide room for revision until the final project is cohesive and free of error (Liou, 2014).

I used these proven strategies for effective print material publication to create the most appealing educational handout to cover the information regarding the microbiome and probiotic supplementation. To ensure I was adding clarity to this topic for my audience, I conducted formative evaluations throughout my writing process, which allowed for feedback and revision between evaluations. By following these writing strategies, I created a two-page educational

handout that was tested among college-aged students with limited previous exposure to the topics of nutrition and microbiology.

METHODS

All of the following procedures were approved by the Institutional Review Board (IRB) at Oklahoma State University (Appendix I). Each participant, both student and faculty, signed a consent form prior to participation (Appendix V & VI). A sample handout was created using Microsoft Publisher and approved by the IRB (Appendix IX). All procedures were followed as approved.

Participants:

For the initial evaluation of content for the nutrition education material, four faculty members from Oklahoma State University (OSU) reviewed the topic outline. Three of the faculty members came from the Nutritional Sciences Department in the College of Human Sciences and one came from the Microbiology Department in the College of Arts and Sciences. Faculty members were chosen for their expertise in either nutrition, nutrition education, or microbiology.

Then, 14 OSU students, seven male and seven female, reviewed my completed educational handout. Students with previous exposure to Nutritional Sciences or Microbiology were excluded from participation in order to assure the students would not already have been exposed to credible information regarding the microbiome.

Procedure:

A literature review of both scientific and popular science sources was completed prior to any experimentation. Popular science sources were reviewed to have an understanding of what information had previously been distributed to the general public in order to have a better idea of what misconceptions to address on my educational handout. Following the literature review, a

topic outline (Appendix XX) was created that included the main points to be addressed on the educational handout. This topic outline was then presented to the faculty members for evaluation.

Faculty members were interviewed using a basic interview format. The initial evaluation was completed by the four faculty members to ensure the content was correct and relevant. Each were first allowed time to review the topic outline. Then, faculty members were asked a series of three questions based on content, emphasis, and presentation (Appendix VII). The results of each of the interviews were grouped into themes based on the initial question, and each theme was later reviewed and finalized with the faculty advisor.

Following the four faculty interviews, draft one of the two-page educational handout on the human gut microbiome and the potential health effects of probiotics was developed using Microsoft Publisher (Appendix X). The first page explains what the human gut microbiome is and what lifestyle choices affect it. The second page covers information regarding probiotics including what a probiotic is and what information to consider when deciding whether or not to take a probiotic supplement.

After the faculty evaluations, draft one (Appendix X) of the handout was assessed by college-aged students. Each student was asked to evaluate eight different statements on a scale of one to five after reviewing the handout. Then, each student was asked for additional suggestions for improvement (Appendix VIII). Results from student feedback were grouped into themes, which were reviewed and finalized with the faculty advisor. An average score from all 14 student evaluations was computed for each statement scored on a scale from one to five. These scores and suggestions were used during revision of the handout. Revision followed an emergent design

plan, or a plan that allows for frequent alterations of the handout based on student evaluations (Hurworth, 2005).

After the first three student reviews, I edited and revised draft one (Appendix X) of the handout based on their feedback. After interpreting their scores and using their suggestions I created draft two, which I then presented to the next four students (Appendix XI). Following their feedback, the handout was again edited and revised before being presenting draft three to the next group of four students (Appendix XII), and again before presenting draft four to the final group of three students (Appendix XIII). The review and revision process was considered complete at the conclusion of the 14 student interviews as their responses collected no new substantial comments. Following the interview of the final three students, the final nutrition education handout was created (Appendix XIX).

RESULTS

The outline that was reviewed by faculty members generated a largely positive response. All faculty members felt the outline was comprehensive and covered the necessary information to understand the microbiome and probiotic supplementation. A summary of faculty answers are provided in Table 1. The three questions faculty were asked included, “Is there any information that you think should be added?” “Are there any topics you feel deserve more emphasis on the handout than others?” and “Do you have any other suggestions for me over the information or presentation of the handout?”

For question one, faculty members felt that the information was adequate with the main concern being that the intended audience understood that conclusive evidence is limited and eliminating any information that could be interpreted beyond its scientific support. For question two, faculty primarily felt as though most of the topics deserved equal emphasis on the

educational handout. For question three, faculty felt that either an infographic or a FAQ design could be effective. Overall, however, there was little revision to the content of the handout and subsequently little revision to the initial handout (Appendix IX) before designing draft one of the handout (Appendix X) that would be presented to the student audience.

A total of four drafts were presented to the student audience. Overall, the students shared mostly positive responses. Before viewing the handout, students were asked to share what they already knew about the gut microbiome and probiotics. All of the responses fell within one of three main categories which are listed in Table 2. The most common answer was the students had no prior knowledge of the subject, followed by no knowledge of the gut microbiome, but some knowledge of probiotics and varying health claims, and the least common response was that the students had personally taken probiotics.

Students then ranked seven statements using a scale of one to five, five being agree and one being disagree. An average of the 14 scores were calculated for the seven statements, which are shared in Table 3. All averages ranked above a four, with the lowest score being 4.04 for students feeling like the information was useful to them as a college student and the highest score being 5.00 for the graphics being visually appealing.

Then a series of five open ended questions were asked to each of the students. Their responses were categorized into common themes. The themes are listed for each question in Table 4. Most comments were repetitive among student participants, resulting in only three or four main themes per question. By the last group of student interview, no substantial new comments were given and the student evaluation process was considered complete.

QUESTION ONE: Is there any information that you think should be added?	QUESTION TWO: Are there any topics you feel deserve more emphasis on the handout than others?	QUESTION THREE: Do you have any other suggestions for me over the information or presentation of the handout?
<ul style="list-style-type: none"> • Keep terms, such as microbiome, probiotics, prebiotics, general to be better understood by the intended audience. • Be sure the audience is aware that conclusive evidence is limited. • Be careful not to make any health claims on the handout. 	<ul style="list-style-type: none"> • The distinction between probiotics and prebiotics. • All topics deserve about the same amount of emphasis on the handout. 	<ul style="list-style-type: none"> • Use an infographic or FAQ approach. • Devise an attention getter for the heading of the handout. • Be sure not to make any definitive statements. • Microbiome information on page one of the handout and probiotic information on page two of the handout.

Table 1. Summary of themes from faculty comments over the topic outline.

What students already knew about the gut microbiome and probiotics:	<ul style="list-style-type: none"> • Did not know anything about the gut microbiome or probiotics • Did not know anything about the gut microbiome, but had heard of probiotics before • Had taken/is taking a supplement (capsule) form of probiotics for GI conditions (n=2)
--	---

Table 2. What students from the target audience already knew about the human gut microbiome and probiotics.

Statement:	Average Score: (Statements were evaluated on a scale of one to five, one being disagree, three being neither agree or disagree and five being agree).
This handout is easy for me to understand.	4.85
This handout is written appropriately for the intended audience. (Non-Nutritional Sciences or Microbiology majors)	4.79
The overall handout is appealing.	4.93
The handout layout is easy to follow.	4.29
The handout graphics are visually appealing.	5.00
The handout graphics are helpful.	4.25
The handout content is useful to you as a college student.	4.04

Table 3. Average scores of statements regarding the handout ranked by 14 students.

Suggestion Questions:	Summary of Student answers:
What do you like best about this handout?	<ul style="list-style-type: none"> • The color scheme and graphic quality • The information provided • That both pros and cons of probiotics are addressed by current research
What did you like least about this handout?	<ul style="list-style-type: none"> • Confused by what order you were supposed to read the text • Hyphens and spacing issues • Graphics given with little to no context
What, if anything, would you change about the layout?	<ul style="list-style-type: none"> • Try a different layout on page two with the text square • Eliminate all hyphens and correct different spacing • Make both pages have a more similar layout • Layout is good/wouldn't make any changes
What suggestions do you have that might help me improve this handout as a whole?	<ul style="list-style-type: none"> • Same as previous question • Eliminate hyphenated text • Make the purpose of the handout more clear by highlighting important text in brighter colored boxes
Is there anything else you would recommend regarding this handout?	<ul style="list-style-type: none"> • Make all headings throughout the handout match • Try using more than one font • Add an explanation/context captions to the graphics

Table 4. Summary of themes for each open-ended question the 14 students were asked over the handout.

DISCUSSION

In order to educate a general audience of college-aged students who were not familiar with the human gut microbiome or probiotics, I created a piece of nutrition education material and evaluated its appeal to the target audience. To do this, I began with faculty evaluations of my topic outline and used that information to create the first draft of my handout. The draft was then presented to students who evaluated the content and the layout by answering questions in an interview style. An emergent design plan was followed, which resulted in four drafts of the

handout and one final handout. From this study, I was able to create the most appealing educational handout for college-aged students over the human gut microbiome and the current understanding of the effects of probiotics.

The topic outline I created covered information from the literature review that would be beneficial to the target audience. The information I presented on my handout reflects what is expressed in current scientific literature (Cohen, 2018; Sidhu & Poorten, 2017; Singh et al., 2017). Each chosen topic was supported by the OSU faculty members, with their comments aligning with available research. Additionally, the faculty members emphasized that clear, conclusive evidence for the implications of the human gut microbiome is not yet supported by science. This supports what I found in current, published research. Limited conclusive evidence reinforces the need for the creation of an educational handout based on scientific evidence, with a main goal of addressing the vast circulation of misinformation available to the public (Cohen, 2018; Hanaway, 2017).

This was further reinforced by responses to the initial question in the student interviews. The students did not have any knowledge of the gut microbiome and only a limited understanding of probiotics. Furthermore, the understanding they had over probiotics presented the health claims made by probiotic companies, which do not have currently have conclusive scientific support. This was the most important finding during this study because it identified the need for educational material over the potential influence of the gut microbiome on human health and the lack of conclusive evidence supporting probiotic supplementation.

To ensure the educational handout was appealing and understood by students, I followed an emergent design plan. Following this plan gave me a structured way to revise my handout based on the feedback of the students. Through student comments and questions, I was able to

better clarify the content and fix small formatting issues to increase the readability and appeal of the overall handout. I paired the emergent design plan with the Message Development Model, which allowed me to present the information in an interesting, clear, informative, and concise way to maximize the appeal to a general audience (Liou, 2014). The revisions I made to my handout utilized both of these communication models, and allowed me to collect meaningful feedback from students to outline the future direction of my educational handout.

To further this research, there are two possible directions. First, student education on the human body, specifically the microbiome, needs to increase as it becomes more popular for therapeutic treatments. The lowest scoring statement was that students didn't feel as though the information applied to them, which gives a direct target for intervention. Second, the educational handout should be tested for information retention over a larger sample size to better assess the understanding and usefulness of the content.

ACKNOWLEDGEMENTS

First and foremost, I would like to thank Dr. Tay Kennedy for helping me to be successful in completing this research. From the initial IRB submission to reading and re-reading the many drafts I have sent her over this past semester, this would not have been possible without her. Additionally, I would like to thank Dr. Tyrell Conway for introducing me to the microbiome during my Freshman year, serving as my second reader, and encouraging me to dig deeper and value the information I was working with. I would also like to thank my friends for serving as my participants when needed and each of the faculty members that were more than willing to take time out of their day to help me complete the first step of my thesis. I would like to thank my parents for always pushing me academically and for making me into the person I am today. Lastly, I would like to thank Oklahoma State University and specifically the College of Human

Sciences for being my home away from home these past four year and for forcing out of my comfort zone, providing me with an education I will always cherish, and giving me friendships that will last a lifetime.

REFERENCES

- Bindels, L. B., Delzenne, N. M., Cani, P. D., Walter, J. (2015). Towards a more comprehensive concept for prebiotics. *Nature Reviews Gastroenterology & Hepatology*, 12, 303-310. Retrieved from <https://www.nature.com/articles/nrgastro.2015.47>
- Chassaing, B., Koren O., Goodrich, J. K., Poole, A. C., Srinivasan S., Ley, R. E., Gewirtz, A. T. (2015). Dietary emulsifiers impact the mouse gut microbiota promoting colitis and metabolic syndrome. *Nature*, 519, 92-96. Retrieved from <https://www.nature.com/articles/nature14232>
- Cohen, P. (2018). Bugs with Benefits? *Nutrition Action Health Letter*.
- Gentile, C. L., Weir, T. L. (2018). The gut microbiota at the intersection of diet and human health. *Science*, 362(6414), 776-780. DOI: 10.1126/science.aau5812
- Godos, J., Federico, A., Dallio, M., Scazzina, F. (2017). Mediterranean diet and nonalcoholic fatty liver disease: molecular mechanisms of protection. *International Journal of Food Science Nutrition*, 68, 18-27. Retrieved from <https://www.ncbi.nlm.nih.gov/pubmed/27484357>
- Hanaway, P. J. (2017). Which Probiotics Should I Take? A Practical Guide for Family Physicians. *American Family Physician*, n.d. Retrieved from <https://www.aafp.org/afp/2017/0801/p156.html>
- Hurworth, R. (2005). Emergent Design. In the *Encyclopedia of Evaluation* (pp. 124). Thousand Oaks, CA: SAGE Publications

- Liou, B., (2014). Educational Strategies, Mass Media, and Evaluation (3rd ed.). *Nutrition Counseling and Education Skill Development* (pp. 303-323). Boston, MA: Cengage Learning.
- Martinez, K. B., Leone, V., Chang, E. B. (2017). Western diets, gut dysbiosis, and metabolic disease: Are they linked? *Gut Microbes*, 8(2), 130-142. Retrieved from <https://www.ncbi.nlm.nih.gov/pubmed/28059614>
- Medina-Remon, A., Kirwan, R., Lamuela-Raventos, R. M., Estruch, R. (2018). Dietary patterns and the risk of obesity, type 2 diabetes mellitus, cardiovascular disease, asthma, and neurodegenerative disease. *Critical Reviews in Food Science and Nutrition*, 58 (2), 262-296. Retrieved from <https://www.tandfonline.com/doi/full/10.1080/10408398.2016.1158690>
- Miranda, A., Gomez-Gaete, C., Mennickent, S. (2017). Role of Mediterranean diet on the prevention of Alzheimer's disease. *Medical Journal of Chile*, 145(4), 501-507. Retrieved from <https://www.ncbi.nlm.nih.gov/pubmed/28748997>
- Rockwood, K. (2018). Feed Your Gut. *Health.com*.
- Rothschild, D., Weissbrod, O., Barkan, E., Kurilshikov, A., Korem, T., Zeevi, D., Costea, P., Godneva, A., Kalka, I., Bar, N., Shilo, S., Lador, D., Vich Vila, A., Zmora, N., Pevsner-Fischer, M., Israeli, D., Kosower, N., Malka, G., Wolf, B. C., Avnit-Sagi, T., Lotan-Pompan, M., Weinberger, A., Halpern, Z., Carmi, S., Fu, J., Wijmenga, C., Zhernakova, A., Elinav, E. & Segal, E. (2018). Environment dominates over host genetics in shaping human gut microbiota. *Nature*, 555, 210-215. doi:10.1038/nature25973

Shifts Needed To Align With Healthy Eating Patterns. (n.d.). In Dietary Guidelines 2015-2020.

Retrieved from <https://health.gov/dietaryguidelines/2015/guidelines/chapter-2/current-eating-patterns-in-the-united-states/>

Sidhu, M., & van der Poorten, D. (2017). The gut microbiome. *Australian Family Physician*, 46(4), 206-211. Retrieved from <https://www.racgp.org.au/afp/2017/april/the-gut-microbiome/>

Singh, R. K., Chang, H., Yan, D., Lee, K. M., Ucmak, D., Wong, K., Abrouk, M., Farahnik, B., Nakamura, M., Zhu, T. H., Bhutani, T., & Liao, W. (2017). Influence of diet on the gut microbiome and implication for human health. *Journal of Translational Medicine*, 15(73). DOI 10.1186/s12967-017-1175-y

Suez, J., Zmora, N., Zimberman-Schapira, G., Mor, U., Dori-bachash, M., Bashiardes, S., Zur, M., Regev-Lehavi, D., Brick, R., Federici, S., Horn, M., Cohen, Y., Moor, A., Zeevi, D., Korem, T., Kotler, E., Harmelin, A., Itkovitz, S., Maharshak, N., Shibolet, O., Pevsner-Fischer, M., Shapiro, H., Sharon, I., Halpern, Z., Segal, E., Elinav, E. (2018). Post-Antibiotic Gut Mucosal Microbiome Reconstitution Is Impaired by Probiotics and Improved by Autologous FMT. *Cell*, 174(6), 1406-1423.
<https://doi.org/10.1016/j.cell.2018.08.047>

Tan, J., McKenzie, C., Potamitis, M., Thorburn, A. N., Mackay, C. R., Macia, L. (2014). The role of short-chain fatty acids in health and disease. *Advances in Immunology*, 121, 91-119. Retrieved from <https://www.sciencedirect.com/science/article/pii/B9780128001004000039?via%3Dihub>

Tsai, Y., Lin, T., Chang, C., Wu, T., Lai, W., Lu, C., & Lai, H. (2019). Probiotics, prebiotics, and amelioration of diseases. *Journal of Biomedical Science*, 26(3).

<https://doi.org/10.1186/s12929-018-0493-6>

Turner, L. (2019). Gut Health Remedies. *Better Nutrition*.

Tweed, V. (2017). Probiotics Update. *Better Nutrition*.

Widmer, R. J., Flammer, A. J., Lerman, L. O., Lerman, A. (2015). The Mediterranean diet, its components, and cardiovascular disease. *The American Journal of Medicine*, 128(3), 229-238. Retrieved from

<https://www.sciencedirect.com/science/article/pii/S0002934314009139?via%3Dihub>

Wilkins, T., Sequoia, J. (2017). Probiotics for Gastrointestinal Conditions: A Summary of the Evidence. *American Family Physician*, 96(3), 170-178. Retrieved from

<https://www.ncbi.nlm.nih.gov/pubmed/28762696>

Zmora, N., Zilberman-Schapira, G., Suez, J., Mor, U., Dori-Bachash, M., Bashardes, S., Kotler, E., Zur, M., Regev-Lehavi, D., Brik, R., Federici, S., Cohen, Y., Linevsky, R., Rothschild, D., Moor, A. E., Ben-Moshe, S., Harmelin, A., Itzkovitz, S., Maharshak, N., Shibolet, O., Shapiro, H., Pevsner-Fischer, M., Sharon, I., Halpern, Z., Segal, E., Elinav, E. (2018). Personalized Gut Mucosal Colonization Resistance to Empiric Probiotics is associated with Unique Host and Microbiome features. *Cell*, 174(6), 1388-1405. DOI 10.1186/s12967-017-1175-y

APPENDIX



Oklahoma State University Institutional Review Board

Date: 03/11/2019
Application Number: HS-19-14
Proposal Title: Can Probiotics affect Human Health in Relation to the Gut Microbiome?

Principal Investigator: Savanna Stoy
Co-Investigator(s):
Faculty Adviser: TAY KENNEDY
Project Coordinator:
Research Assistant(s):

Processed as: Exempt
Exempt Category:

Status Recommended by Reviewer(s): Approved

The IRB application referenced above has been approved. It is the judgment of the reviewers that the rights and welfare of individuals who may be asked to participate in this study will be respected, and that the research will be conducted in a manner consistent with the IRB requirements as outlined in 45CFR46.

This study meets criteria in the Revised Common Rule, as well as, one or more of the circumstances for which continuing review is not required. As Principal Investigator of this research, you will be required to submit a status report to the IRB triennially.

The final versions of any recruitment, consent and assent documents bearing the IRB approval stamp are available for download from IRBManager. These are the versions that must be used during the study.

As Principal Investigator, it is your responsibility to do the following:

1. Conduct this study exactly as it has been approved. Any modifications to the research protocol must be approved by the IRB. Protocol modifications requiring approval may include changes to the title, PI, adviser, other research personnel, funding status or sponsor, subject population composition or size, recruitment, inclusion/exclusion criteria, research site, research procedures and consent/assent process or forms.
2. Submit a request for continuation if the study extends beyond the approval period. This continuation must receive IRB review and approval before the research can continue.
3. Report any unanticipated and/or adverse events to the IRB Office promptly.
4. Notify the IRB office when your research project is complete or when you are no longer affiliated with Oklahoma State University.

Please note that approved protocols are subject to monitoring by the IRB and that the IRB office has the authority to inspect research records associated with this protocol at any time. If you have questions about the IRB procedures or need any assistance from the Board, please contact the IRB Office at 405-744-3377 or irb@okstate.edu.

Sincerely,
Oklahoma State University IRB

COLLEGE STUDENT RECRUITMENT SCRIPT

Hi everyone, my name is Savanna Stoy. I am currently completing my undergraduate Honor's Thesis in the department of Nutritional Sciences with additional incorporation of microbiology. I am here today to ask for your help because you are all current students at Oklahoma State University and I would greatly appreciate your assistance if you are not currently a Nutritional Sciences or Microbiology major. My thesis includes a literary review over the human gut microbiome, lifestyle choices that effect it, and the current research on potential health effects of probiotics. With this information, I am creating a two page, educational handout, which you will be asked to review. After, you will be given a short survey over the content and presentation of the handout.

Overall, participation in this project includes signing a consent form, reviewing my handout, and answering questions in an interview survey format. If you chose to participate in both, your total time commitment will be around 25-35 minutes.

If you have additional questions, or would like to participate, please write your name and contact information on the sign-up sheet and I will be in contact with you. Additionally, you can also reach me at sstoy@okstate.edu or 816-401-2772. If you have further questions and would like to talk to my thesis advisor, she can be reached at tay.kennedy@okstate.edu.

Thank you for your time and I look forward to working with some of you!



RECRUITING SCRIPT FOR OSU FACULTY MEMBERS

SENDING EMAIL ADDRESS: sstoy@okstate.edu
SUBJECT: Honors Thesis Participation Request

Hello, my name is Savanna Stoy. I am completing my undergraduate Honor's Thesis in the department of Nutritional Sciences while also incorporating the field of microbiology. My thesis includes a literary review where I have gathered topics about the microbiome, lifestyle choices that effect it, and the current research on probiotics and human health. I am asking for your help because of your expertise in nutritional sciences or microbiology. I have created an outline of topics for my educational handout, which I will be asking you to review and answer questions about its information and presentation.

Participation in this interview includes signing a consent form, which takes approximately 5 minutes. If you agree to participate, I will have you review my handout and answer questions about it in an interview format, which will take approximately 20-30 minutes. If you chose to participate in both, your total time commitment will be from 25-35 minutes.

If you have additional questions, or would like to participate, please contact me at sstoy@okstate.edu or 816-401-2772. If you have further questions and would like to talk to my thesis advisor, she can be reached at tay.kennedy@okstate.edu.

Thank you for your time and I look forward to hearing from you!



APPENDIX IV: STUDENT SIGN UP SHEET

PARTICIPANT SIGN-UP

NAME:	MAJOR:	E-MAIL:



Approved: 03/11/2019
Protocol #: HS-19-14

COLLEGE STUDENT CONSENT FORM OKLAHOMA STATE UNIVERSITY

PROJECT TITLE:

Honors Thesis: Can Probiotics Affect Human Health in Relation to the Gut Microbiome

INVESTIGATORS:

Savanna Stoy, Nutritional Sciences
Tay Kennedy, Ph. D Nutritional Sciences

PURPOSE:

This project will develop a handout describing the human gut microbiome, the microbiome's possible implications on health, and the potential impact of probiotics on the microbiome.

PROCEDURES:

I will be asking you to review and assess the content that I am including in my handout. I will allow you time to look over the handout, then I will have a set of questions to ask you. You will record your answers on the survey provided. This study is designed to take approximately 20 minutes.

RISKS OF PARTICIPATION:

There are no known risks associated with this project that are greater than those ordinarily encountered in daily life.

BENEFITS OF PARTICIPATION:

There is no expected benefit for participation in this study. If you are interested, we will send you a copy of the final handout when it is finished.

CONFIDENTIALITY:

The records of this study will be kept private. Any written results will discuss collective findings and will not include information that will identify you. Research records will be stored in a folder in a locked office and only researchers and individuals responsible for research oversight will have access to the records. The results from the survey will be stored anonymously, and only the researchers will know your identity. Data will be kept until one year after the study has been completed.

COMPENSATION:

There will be no compensation for your participation.

CONTACTS:

You may contact any of the researchers at the following addresses and phone numbers, should you desire to discuss your participation in the study and/or request information about the results of the study: Savanna Stoy, Nutritional Sciences Undergraduate, sstoy@okstate.edu, (816)-401-2772, or Tay Kennedy, Ph.D., College of Human Sciences, Dept. of Nutritional Sciences Oklahoma State University, Stillwater, OK 74078, tay.kennedy@okstate.edu, or (405) 744-5965.



APPENDIX V: STUDENT CONSENT FORM (PAGE 2)

If you have questions about your rights as a research volunteer, you may contact the IRB Office at 223 Scott Hall, Stillwater, OK 74078, 405-744-3377 or irb@okstate.edu

PARTICIPANT RIGHTS:

I understand that my participation is voluntary, that there is no penalty for refusal to participate, and that I am free to withdraw my consent and participation in this project at any time, without penalty.

CONSENT DOCUMENTATION:

I have been fully informed about the procedures listed here. I am aware of what I will be asked to do and of the benefits of my participation. I also understand the following statements:

I affirm that I am 18 years of age or older.

I have read and fully understand this consent form. I sign it freely and voluntarily. A copy of this form will be given to me. I hereby give permission for my participation in this study.

Signature of Participant _____ Date _____

I certify that I have personally explained this document before requesting that the participant sign it.

Signature of Researcher _____ Date _____



FACULTY CONSENT FORM OKLAHOMA STATE UNIVERSITY

PROJECT TITLE:

Honors Thesis: Can Probiotics Affect Human Health in Relation to the Gut Microbiome

INVESTIGATORS:

Savanna Stoy, Nutritional Sciences
Tay Kennedy, Ph. D Nutritional Sciences

PURPOSE:

This project will develop a handout describing the human gut microbiome, the microbiome's possible implications on health, and the potential impact of probiotics on the microbiome.

PROCEDURES:

I will be asking you to review and assess the content that I am including in my handout. I will allow you time to look over the handout, then I will have a set of questions to ask you. I will record your answers to my questions on paper. This study is designed to take approximately 20 minutes.

RISKS OF PARTICIPATION:

There are no known risks associated with this project that are greater than those ordinarily encountered in daily life.

BENEFITS OF PARTICIPATION:

There is no expected benefit for participation in this study. If you are interested, we will send you a copy of the final handout when it is finished.

CONFIDENTIALITY:

The records of this study will be kept private. Any written results will discuss collective findings and will not include information that will identify you. Research records will be stored in a folder in a locked office and only researchers and individuals responsible for research oversight will have access to the records. The results from the survey will be anonymous, and only the researchers will know your identity. Data will be kept until one year after the study has been completed.

COMPENSATION:

There will be no compensation for your participation.

CONTACTS:

You may contact any of the researchers at the following addresses and phone numbers, should you desire to discuss your participation in the study and/or request information about the results of the study: Savanna Stoy, Nutritional Sciences Undergraduate, sstoy@okstate.edu, (816)-401-2772, or Tay Kennedy, Ph.D., College of Human Sciences, Dept. of Nutritional Sciences Oklahoma State University, Stillwater, OK 74078, tay.kennedy@okstate.edu, or (405) 744-5965.



APPENDIX VI: FACULTY CONSENT FORM (PAGE 2)

If you have questions about your rights as a research volunteer, you may contact the IRB Office at 223 Scott Hall, Stillwater, OK 74078, 405-744-3377 or irb@okstate.edu

PARTICIPANT RIGHTS:

I understand that my participation is voluntary, that there is no penalty for refusal to participate, and that I am free to withdraw my consent and participation in this project at any time, without penalty.

CONSENT DOCUMENTATION:

I have been fully informed about the procedures listed here. I am aware of what I will be asked to do and of the benefits of my participation. I also understand the following statements:

I affirm that I am 18 years of age or older.

I have read and fully understand this consent form. I sign it freely and voluntarily. A copy of this form will be given to me. I hereby give permission for my participation in this study.

Signature of Participant _____ Date _____

I certify that I have personally explained this document before requesting that the participant sign it.

Signature of Researcher _____ Date _____



COLLEGE STUDENT HANDOUT INTERVIEW

I will allow time for the interviewee to read over the handout.

Content

1. Before reading this handout, can you tell me a little bit about what you know about the human gut microbiome? Probiotics?

For the next questions please answer using a scale of 1 to 5. 1 being disagree, 3 being neither agree nor disagree, and 5 being agree.

2. This handout is easy for me to understand. 1 2 3 4 5

3. The handout is written appropriately for the intended audience 1 2 3 4 5

(Non-Nutritional Sciences or Microbiology majors).

4. The overall handout is appealing. 1 2 3 4 5

5. The handout layout is easy to follow. 1 2 3 4 5

6. The handout graphics are visually appealing. 1 2 3 4 5

7. The handout graphics are helpful. 1 2 3 4 5

8. The handout content is useful to you as a college student. 1 2 3 4 5

APPENDIX VIII: STUDENT INTERVIEW QUESTIONS

Suggestions:

1. What do you like best about this handout?
2. What did you like least about this handout?
3. What, if anything, would you change about the layout?
4. What suggestions do you have that might help me improve this handout as a whole?
5. Is there anything else you would recommend regarding this handout?

Would you like to read over the notes I have taken to confirm that your responses were accurately recorded? Yes or No (Circle one)

Thank you for your help with my Honor's Thesis!

HONORS



What is the gut microbiome?

The human gut microbiome consists of the trillions of bacteria and microorganisms that colonize our gastrointestinal tract all the way from the mouth to the rectum.

Why is it important?

The gut microbiome has the potential to play a critical role in human health, several chronic diseases, and systemic inflammation.

What makes a healthy microbiome?

A healthy microbiome is one that is robust and diverse. This allows the natural bacteria to be resilient and fight off potential pathogens and carcinogens.

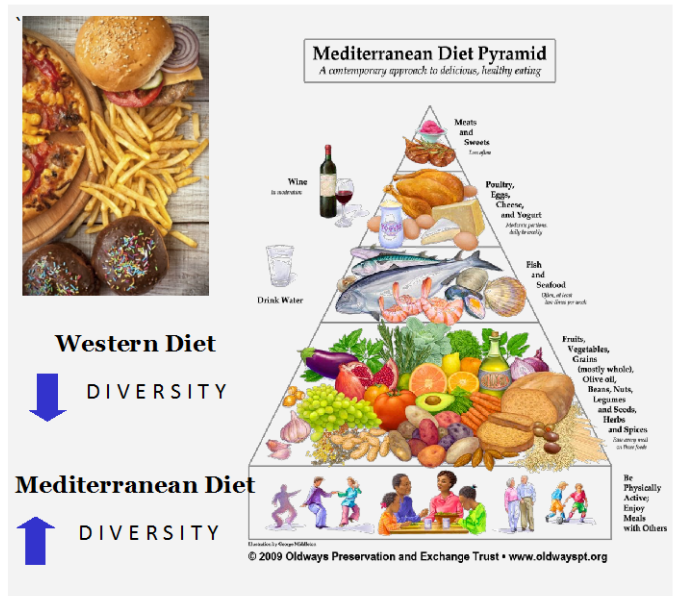
The Microbiome Could Influence Your Health.

Current research has shown that roughly only 2-8% of our gut bacteria are inherited from our family, which means that our environment and lifestyle choices dominate when it comes to shaping our gut microbiome.

Influences of diet on the gut microbiome:

The typical Western diet is higher in fat and protein.

The Mediterranean diet is typically high in fiber and unsaturated fatty acids and is low in animal fats.



PRO TIP

Some natural sources of probiotics are: fermented dairy products, cheese, fermented sausage, and fermented vegetables.

Should I Take a Probiotic Supplement?

A probiotic is a live microorganism that confers health benefits to the host.

An important difference to note is the difference between a *probiotic* and a *prebiotic*.

“A probiotic is an ingested live microorganism that confers health benefits to the host”

In the United States, probiotics are considered food supplements.

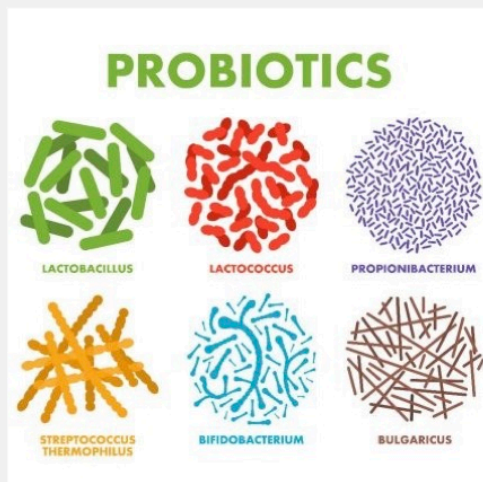
A prebiotic is a supplement that aims to feed the natural bacteria already within the gut microbiome.

What Current Research Says:

- Probiotics are species, dose, and disease specific to give maximum benefit.
- Probiotics affect each individual differently.
- Currently there are many quality control concerns due to the lack of regulations.



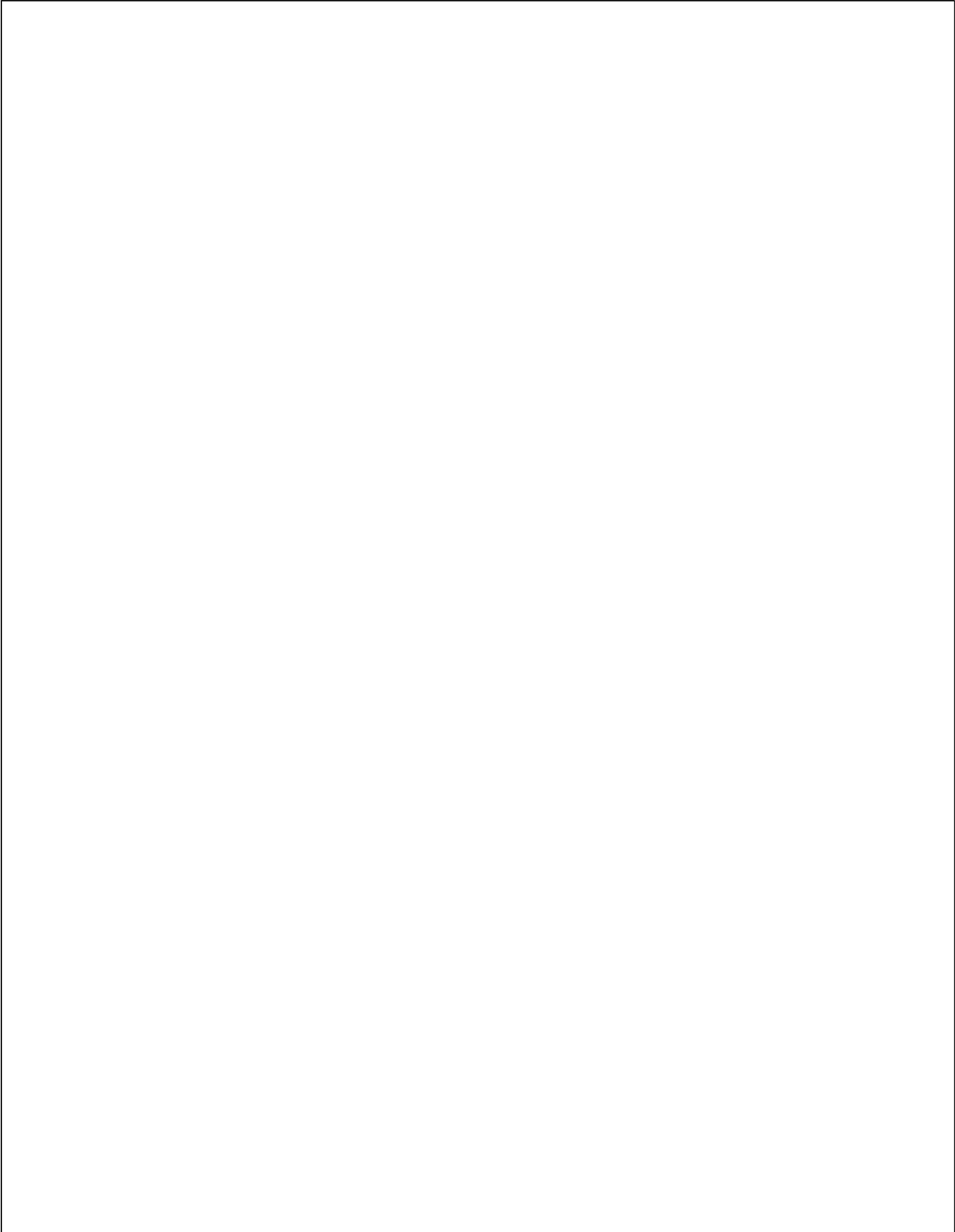
If You Want to Take a Probiotic...



If you decide that you want to take an over the counter probiotic, there are a few things you should consider.

1. Considerer species strains that have been studied specifically for your purpose.
2. Make sure there is an expiration date printed on your bottle and that the dosage recommendation is viable through the expiration date.
3. Be sure storage instructions are followed (temperature, refrigeration, etc.).

FOR ADDITIONAL INFORMATION



PRO TIP Some natural sources of probiotics are: fermented dairy products, cheese, fermented sausage, and fermented vegetables.

What is a Probiotic Supplement?

An important difference to note is the difference between a *probiotic* and a *prebiotic*.

A probiotic is a live microorganism that confers health benefits to the host.

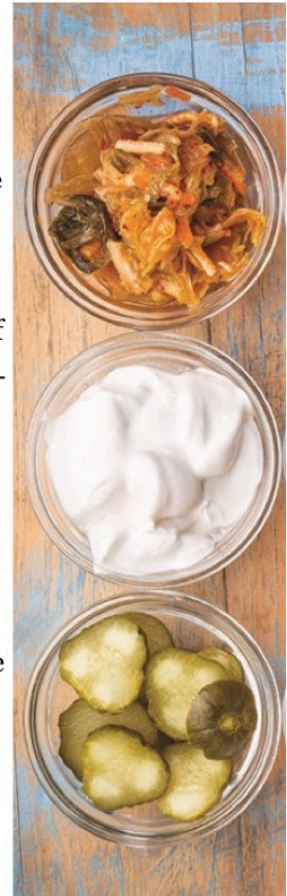
“A probiotic is an ingested live microorganism that confers health benefits to the host”

A prebiotic is a supplement that aims to feed the natural bacteria already within the gut microbiome.

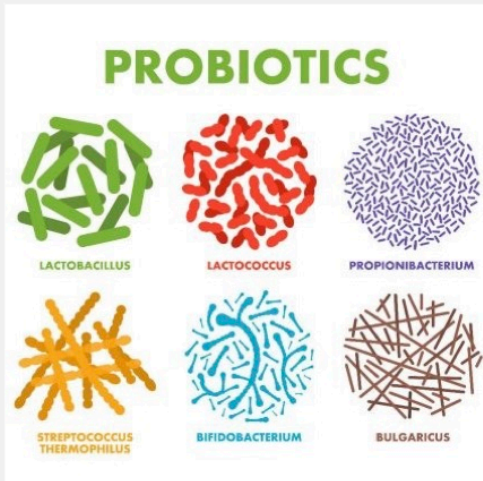
In the United States, probiotics are considered food supplements and are regulated by the FDA.

What Current Research Says:

- More evidence is needed to identify the true efficacy of probiotic supplements.
- At the current state of understanding, probiotics can't be recommended or discouraged when it comes to influencing human health.
- There is not definitive answers for what alterations of the microbiome could mean for human health.



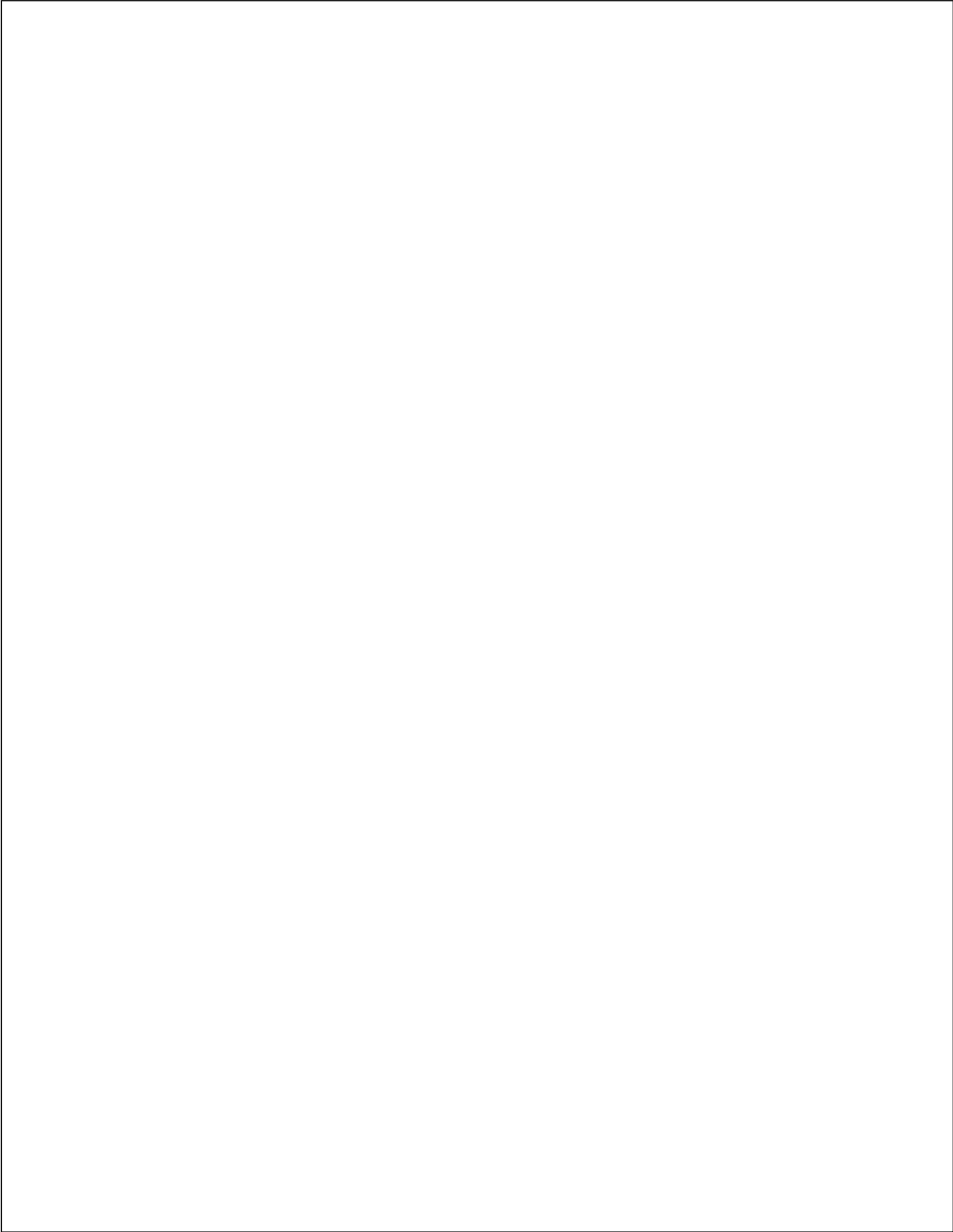
If You Want to Take a Probiotic...



If you decide that you want to take an over the counter probiotic, there are a few things you should consider.

1. Considerer species strains that have been studied specifically for your purpose.
2. Make sure there is an expiration date printed on your bottle and that the dosage recommendation is viable through the expiration date.
3. Be sure storage instructions are followed (temperature, refrigeration, etc.).

FOR ADDITIONAL INFORMATION



PRO TIP

Some natural sources of probiotics are: fermented dairy products, cheese, fermented sausage, and fermented vegetables.

What is a Probiotic Supplement?

An important difference to note is the difference between a *probiotic* and a *prebiotic*.

A *probiotic* is a live microorganism that confers health benefits to the host.

“A probiotic is an ingested live microorganism that confers health benefits to the host”

A prebiotic is a supplement that aims to feed the natural bacteria already within the gut microbiome.

In the United States, probiotics are considered food supplements and are regulated by the FDA.

What Current Research Says:

- More evidence is needed to identify the true efficacy of probiotic supplements.
- At the current state of understanding, probiotics can't be recommended or discouraged when it comes to influencing human health.
- There is not definitive answers for what alterations of the microbiome could mean for human health.



If You Want to Take a Probiotic...

PROBIOTICS



LACTOBACILLUS



LACTOCOCCUS



PROPIONIBACTERIUM



STREPTOCOCCUS THERMOPHILUS



BIFIDOBACTERIUM



BULGARICUS

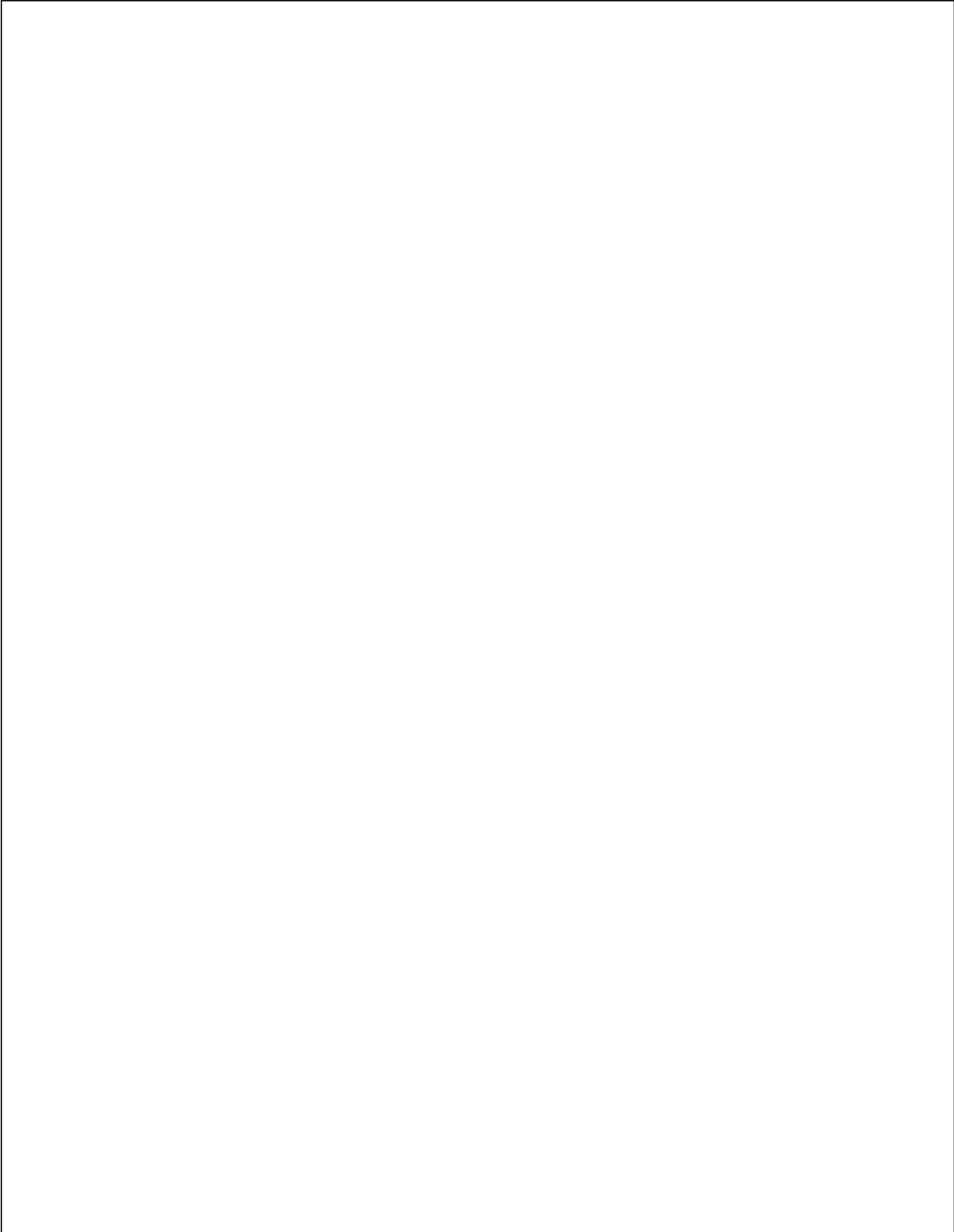
If you decide that you want to take an over the counter probiotic, there are a few things you should consider.

1. Considerer species strains that have been studied specifically for your purpose.

2. Find the expiration date on your bottle and that the dosage recommendation is viable through the expiration date.

3. Be sure storage instructions are followed (temperature, refrigeration, etc.).

FOR ADDITIONAL INFORMATION



PRO TIP

Some natural sources of probiotics are: fermented dairy products, cheese, fermented sausage, and fermented vegetables.

What is a Probiotic Supplement?

An important difference to note is the difference between a *probiotic* and a *prebiotic*.

A *probiotic* is a live microorganism that confers health benefits to the host.

“A probiotic is an ingested live microorganism that confers health benefits to the host”

A *prebiotic* is a supplement that aims to feed the natural bacteria already within the gut microbiome.

In the United States, probiotics are considered food supplements and are regulated by the FDA.

Current Research:

- More evidence is needed to identify the true efficacy of probiotic supplements.
- At the current state of understanding, probiotics can't be recommended or discouraged when it comes to influencing human health.
- There is not definitive answers for what alterations of the microbiome could mean for human health.



Examples of foods containing probiotics.

If You Want to Take a Probiotic...

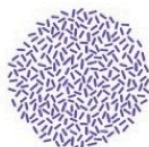
PROBIOTICS



LACTOBACILLUS



LACTOCOCCUS



PROPIONIBACTERIUM



STREPTOCOCCUS THERMOPHILUS



BIFIDOBACTERIUM



BULGARICUS

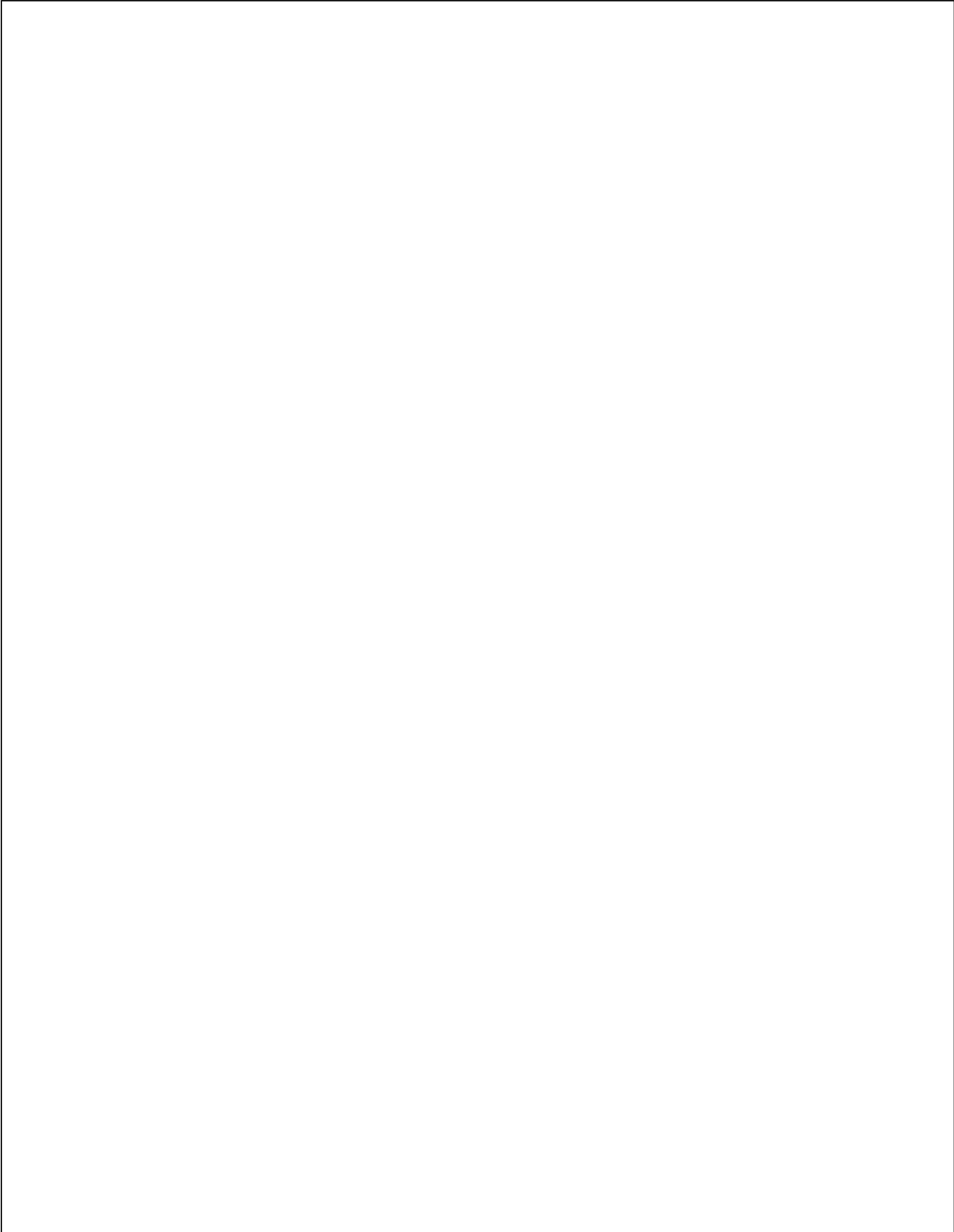
If you decide that you want to take an over the counter probiotic, there are a few things you should consider.

1. Consider species strains that have been studied specifically for your purpose.

2. Find the expiration date on your bottle and that the dosage recommendation is viable through the expiration date.

3. Be sure storage instructions are followed (temperature, refrigeration, etc.).

FOR ADDITIONAL INFORMATION



PRO TIP

Some natural sources of probiotics are: fermented dairy products, cheese, fermented sausage, and fermented vegetables.

What is a Probiotic Supplement?

An important difference to note is the difference between a *probiotic* and a *prebiotic*.

A *probiotic* is a live microorganism that confers health benefits to the host.

“A probiotic is an ingested live microorganism that confers health benefits to the host”

A *prebiotic* is a supplement that aims to feed the natural bacteria already within the gut microbiome.

In the United States, probiotics are considered food supplements and are regulated by the FDA.

Current Research

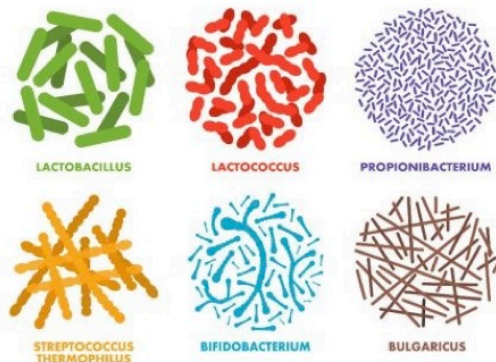
- More evidence is needed to identify the true efficacy of probiotic supplements.
- At the current state of understanding, probiotics can't be recommended or discouraged when it comes to influencing human health.
- There is not definitive answers for what alterations of the microbiome could mean for human health.



Sauerkraut, pickles, and yogurt are examples of food that contain probiotics.

If You Want to Take a Probiotic...

PROBIOTICS



Common bacterial strains found in probiotics

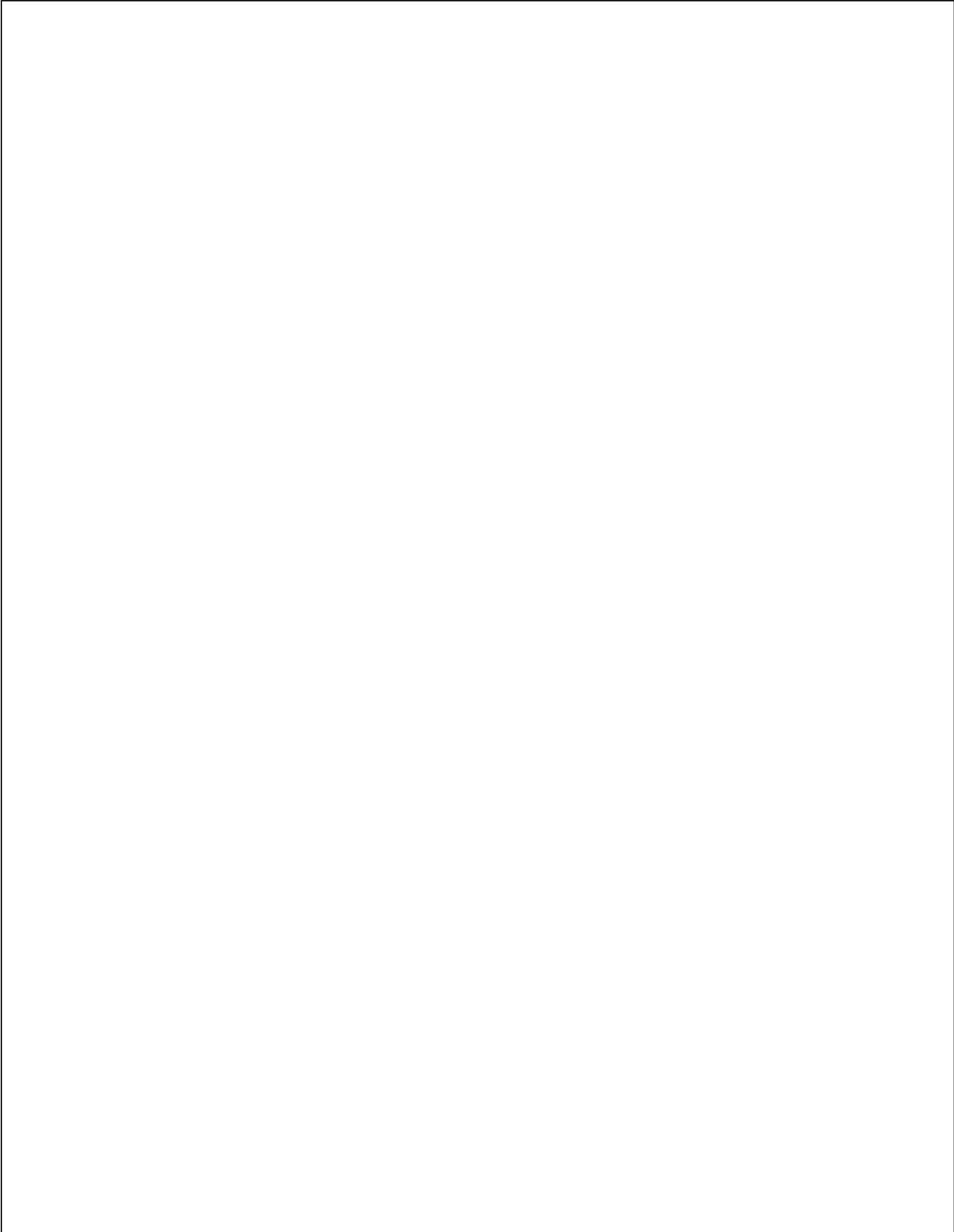
If you decide that you want to take an over the counter probiotic, there are a few things you should consider:

1. Consider species strains that have been studied specifically for your purpose.

2. Find the expiration date on your bottle and that the dosage recommendation is viable through the expiration date.

3. Be sure storage instructions are followed (temperature, refrigeration, etc.).

FOR ADDITIONAL INFORMATION:



PRO TIP Some natural sources of probiotics are: fermented dairy products, cheese, fermented sausage, and fermented vegetables.

What is a Probiotic Supplement?

An important difference to note is the difference between a *probiotic* and a *prebiotic*.

A *probiotic* is a live microorganism that confers health Benefits to the host.

“A probiotic is an ingested live microorganism that confers health benefits to the host”

In the United States, probiotics are considered food supplements and are regulated by the FDA.

A *prebiotic* is a supplement that aims to feed the natural bacteria already within the gut microbiome.

Current Research

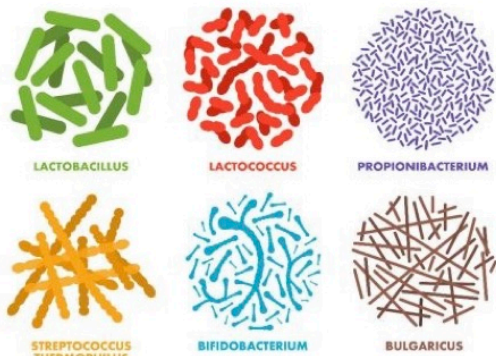
- More evidence is needed to identify the true efficacy of probiotic supplements.
- At the current state of understanding, probiotics can't be recommended or discouraged when it comes to influencing human health.
- There is not definitive answers for what alterations of the microbiome could mean for human health.



Sauerkraut, pickles, and yogurt are examples of food that contain probiotics.

If You Want to Take a Probiotic...

PROBIOTICS



Common bacterial strains found in current probiotics.

If you decide that you want to take an over the counter probiotic, there are a few things you should consider:

1. Consider species strains that have been studied specifically for your purpose.

2. Find the expiration date on your bottle and that the dosage recommendation is viable through the expiration date.

3. Be sure storage instructions are followed (temperature, refrigeration, etc.).

References available upon request
sstoy@okstate.edu

APPENDIX XX: TOPIC OUTLINE

- I. What is the gut microbiome?
 - a. The gut microbiome consists of the trillions of (commensal and non-commensal) microbes that colonize our gastrointestinal tract. (Sidhu, M., Poorten, D. 2017)
 - b. While the gut microbiome is still a relatively new topic in the field of science, it has the potential to play a critical role in human health and several chronic diseases. (Singh, RK., Chang, HW., Yan, D., Lee, KM., Ucmak, D., Wong, K., Abrouk, M., Farahnik, B., Nakamura, M., Zhu, TH., Bhutani, T., Liao, W. 2017)
 - c. Currently, a healthy gut microbiome is considered one that is robust and diverse, containing many species of bacteria at varying quantities (Post-Antibiotic Gut Mucosal Microbiome Reconstitution Is Impaired by Probiotics and Improved by Autologous FMT)
- II. How do lifestyle choices influence the gut microbiome?
 - a. Environment has a profound effect on the composition of the microbiome when compared to genetics (Environment Dominates Over Host Genetics in Shaping Human Gut Microbiota. 2018)
 - b. It is estimated that 1.9-8.1% of our gut bacteria is heritable (Environment Dominates Over Host Genetics in Shaping Human Gut Microbiota. 2018)
 - c. Diet choices: Influence of diet on the gut microbiome and implications for human health. (Figure 4 and Table 8: Western Diet v. Mediterranean Diet)
 - i. Western Diet – high in animal fat/higher protein content
 1. Decrease total bacteria diversity
 - ii. Mediterranean – High fiber/UFAs and low animal fat content
 1. Increase total bacteria diversity
- III. How does the microbiome influence health?
 - a. The microbiome could play an important role in immune health; both the recruitment and differentiation of immune cells and the integrity of the intestinal cell lining (Influence of diet on the gut microbiome and implications for human health)
 - b. Dysbiosis: imbalances in microbial communities in or on the body. For the gut microbiome, it would be an imbalance of the microorganisms within the gastrointestinal tract. (ref Nature)
 - c. Dysbiosis of the gut microbiome could be related to chronic disease related to a state of chronic, systemic inflammation.

APPENDIX XX: TOPIC OUTLINE

IV. What is a probiotic?

- a. According to the World Health Organization, a probiotic is “A live microorganism which confers health benefits to the host.”
- b. In the US, probiotics are typically seen as food supplements and therefore are regulated by the FDA. While they regulate probiotics, the regulations can be limited in scope and product efficacy cannot always be guaranteed. This is a common concern with most dietary supplements.
- c. Is a prebiotic a probiotic?
 - i. Prebiotics
 1. Non-digestible food ingredients that are selectively fermented to support the growth of health-promoting gut bacteria (Bindels, L.B, Delzenne, N.M., Cani, P.D., & Walter, J. 2015).
 2. Could be used to modulate the composition of the gut microbiome.
 3. Probiotics can contain both pre- and probiotics.

V. Should I take a probiotic?

- a. According to current research, probiotics should be species, dose, and disease specific to confer health benefits to the host.
- b. Each person has a different microbiome composition, so consequently probiotics will affect each individual differently. (Personalized Gut Mucosal Colonization Resistance to Empiric Probiotics Is Associated with Unique Host and Microbiome Features)
- c. Currently, probiotics cannot be discouraged or recommended due to the lack of conclusive, scientific evidence. Consult your doctor if you feel like you could benefit from a probiotic because they will have access to probiotics with better quality.
- d. If you want to take an over the counter probiotic, choose species strains that have been studied, make sure there is an expiration date printed on the bottle, and that the dosage recommendation is viable through the expiration date. Also be sure to follow storage instructions (i.e. temperature, refrigeration, etc.) (Which Probiotics Should I Take? A Practical Guide for Family Physicians)
- e. A possible future direction for probiotic supplements could be to make them personalized to each individual compared to the current “one size fits all” model. (Personalized Gut Mucosal Colonization Resistance to Empiric Probiotics Is Associated with Unique Host and Microbiome Features)

What is the gut microbiome?

- Sidhu, M., & van der Poorten, D. (2017). The gut microbiome. *Australian Family Physician*, 46(4), 206-211. Retrieved from <https://www.racgp.org.au/afp/2017/april/the-gut-microbiome/>
- Suez, J., Zmora, N., Zimberman-Schapira, G., Mor, U., Dori-bachash, M., Bashiardes, S., Zur, M., Regev-Lehavi, D., Brick, R., Federici, S., Horn, M., Cohen, Y., Moor, A., Zeevi, D., Korem, T., Kotler, E., Harmelin, A., Itzkovitz, S., Maharshak, N., Shibolet, O., Pevsner-Fischer, M., Shapiro, H., Sharon, I., Halpern, Z., Segal, E., Elinav, E. (2018). Post-Antibiotic Gut Mucosal Microbiome Reconstitution Is Impaired by Probiotics and Improved by Autologous FMT. *Cell*, 174(6), 1406-1423. <https://doi.org/10.1016/j.cell.2018.08.047>
- Rothschild, D., Weissbrod, O., Barkan, E., Kurilshikov, A., Korem, T., Zeevi, D., Costea, P., Godneva, A., Kalka, I., Bar, N., Shilo, S., Lador, D., Vich Vila, A., Zmora, N., Pevsner-Fischer, M., Israeli, D., Kosower, N., Malka, G., Wolf, B. C., Avnit-Sagi, T., Lotan-Pompan, M., Weinberger, A., Halpern, Z., Carmi, S., Fu, J., Wijmenga, C., Zernakova, A., Elinav, E. & Segal, E. (2018). Environment dominates over host genetics in shaping human gut microbiota. *Nature*, 555, 210-215. doi:10.1038/nature25973

Why is it important?

- Cohen, P. (2018). Bugs with Benefits? *Nutrition Action Health Letter*.
- Rockwood, K. (2018). Feed Your Gut. *Health.com*.
- Sidhu, M., & van der Poorten, D. (2017). The gut microbiome. *Australian Family Physician*, 46(4), 206-211. Retrieved from <https://www.racgp.org.au/afp/2017/april/the-gut-microbiome/>
- Tsai, Y., Lin, T., Chang, C., Wu, T., Lai, W., Lu, C., & Lai, H. (2019). Probiotics, prebiotics, and amelioration of diseases. *Journal of Biomedical Science*, 26(3). <https://doi.org/10.1186/s12929-018-0493-6>

What makes a healthy microbiome?

- Rothschild, D., Weissbrod, O., Barkan, E., Kurilshikov, A., Korem, T., Zeevi, D., Costea, P., Godneva, A., Kalka, I., Bar, N., Shilo, S., Lador, D., Vich Vila, A., Zmora, N., Pevsner-Fischer, M., Israeli, D., Kosower, N., Malka, G., Wolf, B. C., Avnit-Sagi, T., Lotan-Pompan, M., Weinberger, A., Halpern, Z., Carmi, S., Fu, J., Wijmenga, C., Zernakova, A., Elinav, E. & Segal, E. (2018). Environment dominates over host genetics in shaping human gut microbiota. *Nature*, 555, 210-215. doi:10.1038/nature25973
- Sidhu, M., & van der Poorten, D. (2017). The gut microbiome. *Australian Family Physician*, 46(4), 206-211. Retrieved from <https://www.racgp.org.au/afp/2017/april/the-gut-microbiome/>
- Suez, J., Zmora, N., Zimberman-Schapira, G., Mor, U., Dori-bachash, M., Bashiardes, S., Zur, M., Regev-Lehavi, D., Brick, R., Federici, S., Horn, M., Cohen, Y., Moor, A., Zeevi, D., Korem, T., Kotler, E., Harmelin, A., Itzkovitz, S., Maharshak, N., Shibolet, O., Pevsner-Fischer, M., Shapiro, H., Sharon, I., Halpern, Z., Segal, E., Elinav, E. (2018). Post-Antibiotic Gut Mucosal Microbiome Reconstitution Is Impaired by Probiotics and Improved by Autologous FMT. *Cell*, 174(6), 1406-1423. <https://doi.org/10.1016/j.cell.2018.08.047>

The microbiome could influence your health

- Cohen, P. (2018). Bugs with Benefits? *Nutrition Action Health Letter*.
- Rockwood, K. (2018). Feed Your Gut. *Health.com*.
- Sidhu, M., & van der Poorten, D. (2017). The gut microbiome. *Australian Family Physician*, 46(4), 206-211. Retrieved from <https://www.racgp.org.au/afp/2017/april/the-gut-microbiome/>
- Tsai, Y., Lin, T., Chang, C., Wu, T., Lai, W., Lu, C., & Lai, H. (2019). Probiotics, prebiotics, and amelioration of diseases. *Journal of Biomedical Science*, 26(3). <https://doi.org/10.1186/s12929-018-0493-6>

How you influence your microbiome

- Rothschild, D., Weissbrod, O., Barkan, E., Kurilshikov, A., Korem, T., Zeevi, D., Costea, P., Godneva, A., Kalka, I., Bar, N., Shilo, S., Lador, D., Vich Vila, A., Zmora, N., Pevsner-Fischer, M., Israeli, D., Kosower, N., Malka, G., Wolf, B. C., Avnit-Sagi, T., Lotan-Pompan, M., Weinberger, A., Halpern, Z., Carmi, S., Fu, J., Wijmenga, C., Zernakova, A., Elinav, E. & Segal, E. (2018). Environment dominates over host genetics in shaping human gut microbiota. *Nature*, 555, 210-215. doi:10.1038/nature25973

Influences of diet on the gut microbiome

- Chassaing, B., Koren O., Goodrich, J. K., Poole, A. C., Srinivasan S., Ley, R. E., Gewirtz, A. T. (2015). Dietary emulsifiers impact the mouse gut microbiota promoting colitis and metabolic syndrome. *Nature*, 519, 92-96. Retrieved from <https://www.nature.com/articles/nature14232>
- Widmer, R. J., Flammer, A. J., Lerman, L. O., Lerman, A. (2015). The Mediterranean diet, its components, and cardiovascular disease. *The American Journal of Medicine*, 128(3), 229-238. Retrieved from <https://www.sciencedirect.com/science/article/pii/S0002934314009139?via%3Dihub>

What is a probiotic supplement

- Bindels, L. B., Delzenne, N. M., Cani, P. D., Walter, J. (2015). Towards a more comprehensive concept for prebiotics. *Nature Reviews Gastroenterology & Hepatology*, 12, 303-310. Retrieved from <https://www.nature.com/articles/nrgastro.2015.47>
- Cohen, P. (2018). Bugs with Benefits? *Nutrition Action Health Letter*.

Current research

- Cohen, P. (2018). Bugs with Benefits? *Nutrition Action Health Letter*.
- Rockwood, K. (2018). Feed Your Gut. *Health.com*.
- Sidhu, M., & van der Poorten, D. (2017). The gut microbiome. *Australian Family Physician*, 46(4), 206-211. Retrieved from <https://www.racgp.org.au/afp/2017/april/the-gut-microbiome/>
- Tsai, Y., Lin, T., Chang, C., Wu, T., Lai, W., Lu, C., & Lai, H. (2019). Probiotics, prebiotics, and amelioration of diseases. *Journal of Biomedical Science*, 26(3). <https://doi.org/10.1186/s12929-018-0493-6>

If you want to take a probiotic

- Cohen, P. (2018). Bugs with Benefits? *Nutrition Action Health Letter*.

APPENDIX XXI: HANDOUT REFERENCES

Pro Tip

Rezac, S., Kok, C. R., Heermann, M., Hutkins, R. (2018). Fermented foods as a dietary source of live organisms. *Frontiers in Microbiology*, 9, 1785. Retrieved from <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6117398/pdf/fmicb-09-01785.pdf>

Picture References:

Georgiou, A. (2018, January 15). The Western diet is so unhealthy, your body thinks it's a dangerous infection. Retrieved from <https://www.ibtimes.co.uk/western-diet-so-unhealthy-your-body-thinks-its-dangerous-infection-1655221>

Mediterranean diet: A heart-healthy eating plan. (2019, January 26). Retrieved from <https://www.mayoclinic.org/healthy-lifestyle/nutrition-and-healthy-eating/in-depth/mediterranean-diet/art-20047801>

The Potential of Probiotics | Food & Nutrition | March-April 2018. (2018, April 12). Retrieved from <https://foodandnutrition.org/from-the-magazine/the-potential-of-probiotics/>

Thryve. (2017, March 13). The Development of the Gut Microbiome. Retrieved from <https://medium.com/@thryve/the-development-of-the-gut-microbiome-f060a6ba41bf>

What Are Probiotics And What Should You Know Before Taking Them? (2018, September 07). Retrieved from <https://www.menshealth.com.sg/health/what-are-probiotics-gut-health/>