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Play your microbiome well

Game-based resource on gut health

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EMBL Science Education and Public Engagement

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Our research drives the development of new technology and methods in the life sciences, and we work to transfer this knowledge for the benefit of society.

About Science Education and Public Engagement

EMBL's Science Education and Public Engagement (SEPE) office leads and coordinates the institute's science education programmes and public engagement efforts.

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Our programmes convey complex, cutting-edge topics in life science research in an exciting and insightful way, fostering the discovery of current research trends, the scientific method, and scientific career paths. Our activities are developed and run in close collaboration with EMBL scientists.

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Teacher's guide

Introduction

The study of the factors that shape our gut microbiome is a rapidly developing field, revealing how our choices affect the microorganisms that live inside us. Diet, medication, sleep, exercise, household members, infections and travel can all influence this complex ecosystem. This game-based resource aims to help students explore these connections and encourage informed decision-making that can promote individual well-being.

Overview

This game-based teaching resource is specifically designed for secondary school teachers working with students aged 14-19, but anyone over the age of 14 can play for fun. It is intended for face-to-face learning where students work in small groups of 3 or 4, competing against each other. The game would take around 20-30 minutes to play. It's important to note that the suggested time is a rough estimate and will depend on factors such as the number of players, their level of engagement and elements of chance. You can allow for another 5-10 minutes for discussion at the end of the game.

By playing the game, students encounter real-life situations that positively or negatively affect the composition of their gut microbiome by adding or subtracting beneficial and harmful microbes. At the end of the game, the student with the highest score, and therefore the healthiest gut, wins.

Prerequisite knowledge

A basic understanding of the concept of the microbiome and a general awareness of the role of microbes in human health is required.

Learning outcomes

Students will:

- Get real-life examples on how diet and lifestyle affect the diversity of microorganisms in the gut.
- Evaluate the impact of infection on gut health, distinguishing between bacterial and viral causes.
- Link theoretical knowledge to practical scenarios, reinforcing the understanding that maintaining a balanced and diverse microbiome is essential for overall health and well-being.

Structure

This game-based resource includes a Teacher's guide, Fact sheets, Game instructions, and printable game materials, along with a game board provided in separate files. The game materials file contains a set of materials sufficient for a group of 3-4 players (for example if you have 20 students you will need to print this file 5 times). The file includes the following components: Tile legend, Microbe cards, Function cards, Travel cards, Envelopes and Microbe count sheet. The materials can be printed on standard A4 paper, while the game board should be printed on A3 paper for optimal use.

Fact sheets: These fact sheets provide valuable insights into the complex make-up of the gut microbiome and highlight the myriad factors that influence it. Topics covered include the impact of diet, sleep patterns, exercise routines, the presence of household members and pets, medication use, and the influence of infection and disease on

the gut microbiome. While not required to play the game, these fact sheets serve as a useful theoretical preparation for students, providing a basic understanding of the complex interplay between lifestyle factors and the gut microbiome.

Game instructions: The instructions outline the objectives, setup and mechanics of the game. It includes information on how to progress through the game, how to gain or lose microbes, how to use Function cards and how to determine the winner. They can be read or explained by the teacher, or printed out for students to read and then ask questions if they need clarification.

Game board: The board should be printed on A3 paper. It acts as the playing area, with tiles representing different scenarios that could affect gut microbes, such as dietary changes, infections and lifestyle choices, represented as circles with an image. Each tile represents a specific scenario that requires the player to take action. A legend explains each scenario.

Tile legend: This accompanies the game board and provides explanations for each tile. It tells the players when to add or remove certain Microbe cards, or when to use a Function or a Travel card.

Microbe cards: These cards represent different types of microbes. The types of microbes used in the game include *Lactobacillus*, *Bifidobacterium*, *Akkermansia muciniphila*, *Faecalibacterium prausnitzii*, *Methanobrevibacter smithii*, *Escherichia coli*, *Helicobacter pylori* and *Haemophilus influenzae*. Each card has a numerical value (+1 beneficial or -1 pathogenic) that represents how the microbes affect the player's gut microbiome. At the start of the game, each player places an initial mix of microbes in the envelope. The remaining Microbe cards are separated by species and placed next to the board. Players add and remove Microbe cards from their envelopes according to the instructions on the Tile legend, Function or Travel cards. The cards placed in each player's envelope at the end of the game are used to count the points and determine the winner(s).

Travel cards: These come into play when a player lands on the Travel tile. These cards introduce travel-related scenarios and add variety to the game by simulating different travel destinations and their impact on the gut microbiome. There are two types of Travel cards: the first sends the player to a place with high hygiene standards, in which case the microbiome remains stable. The second type represents a scenario where some factors have negatively affected the player's microbiome and provide instructions on how to proceed. After using a card, the players return it to the deck.

Function cards: There are three function cards in the game: Doctor, Pharmacy and Toilet. When a player lands on the Infection tile, they receive either a Doctor card or a Pharmacy card, depending on the result of the dice roll (dice roll of 1 to 3 bacterial infection, receive Doctor card; dice roll of 4 to 6: viral infection, receive Pharmacy card). The Toilet card is given when a player has a Travel card with a scenario involving drinking contaminated water or eating contaminated food. After using a card, the players return it to the deck.

Envelopes: These envelopes represent each player's gut microbiome and store the initial mix of Microbe cards. During the game, Microbe cards are added to and removed from the envelope.

IMPORTANT NOTE:

While using the Microbe cards ensures the best game experience, to minimise the time for game preparation, we've provided an alternative: a Microbe count sheet. This sheet contains boxes where players can keep track of their microbes' gains and losses. Players draw a vertical line to mark the microbes they have gained and cross out those they have lost during the game. If you decide not to use the Microbe cards, players don't need envelopes either.

If you intend to use the game with a few classes or in years to come, we encourage you to spend some time preparing the Microbe cards. This will ensure smoother gameplay and a more engaging experience for all players.

Procedure

1. Prepare Materials
   A. Print the game board on A3 paper and all other materials, including cards and envelopes, on A4 paper.
   B. Cut out the cards and envelopes.
   C. Glue the sides of the envelopes.
   D. Prepare a dice for each group.
   E. Prepare a counter for each student/player

HINT: Consider laminating the cards and the board for durability and multiple use.

2. Get Ready
   A. Organise the class into groups of 3 or 4 students.
   B. Take a moment to explain the rules.
   C. Answer any questions students may have.
   D. Distribute the envelopes and Microbe cards to the students.
   E. Ask each student to place the following Microbe cards in their envelope: 2x *Bifidobacterium*, 2x *Methanobrevibacter smithii*, 1x *Faecalibacterium prausnitzii*, 1x *Lactobacillus*, 1x *Akkermansia muciniphila*, 1x *Escherichia coli*.
   F. Distribute the boards, dice, counters, Function cards, Travel cards and remaining Microbe cards to the groups.
   G. Ask students to place the Function cards, Travel cards and remaining Microbe cards in the separate piles by the side of the board. Remind them that when they have used a Function or a Travel card, they must return it to the pile.

3. Start Playing
   A. Once everything is set up, start the game!

4. Reflect
   A. After playing, engage students by asking them to reflect on situations they might have encountered in the game. You could ask the winning student to give an example of how they enriched their gut with microbes, and the ones with the lower score to say which scenario caused them to lose the most microbes.
   B. Discuss how these situations relate to real-life lifestyle choices.

Game instructions

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Game instructions

Estimated time for play: 20-30 minutes

Disclaimer

Please note that the transformation of our microbiome is a complex process. While this game uses simplifications to illustrate certain existing mechanisms, it should be noted that its accuracy is somewhat limited. This is due to the unique diversity of each person's microbiome, which leads to different responses to the same changes.

Rules

The aim of the game is to create the healthiest gut microbiome. Each player has an envelope representing their gut microbiome. Before the game begins, all players receive an identical initial mixture of microbes consisting of 2x *Bifidobacterium*, 2x *Methanobrevibacter smithii,* 1x *Faecalibacterium prausnitzii*, 1x *Lactobacillus*, 1x *Akkermansia muciniphila*, 1x *Escherichia coli*, represented by Microbes cards. Each card has a numerical score indicating whether the microbe affects the gut microbiome positively (+1 beneficial) or negatively (-1 pathogenic).

Players progress through the game by rolling a dice, moving their counter on the board and encountering different situations that cause them to gain or lose different types of microbes. The tiles on the board prompt specific actions, described in the Tile legend. For example, landing on the Dog tile means adopting a dog, which results in the addition of a *Lactobacillus* and a *Bifidobacterium* to their gut.

Certain tiles may require the use of Function cards, which give further instructions.

Landing on a Travel tile requires the use of Travel cards. Players draw one to determine their destination and follow the instructions on the card.

The game continues until the first player reaches the finish tile. At this point, players add up the scores on their Microbe cards to determine the health of their microbiome. The player with the highest score, indicating the healthiest gut, is declared the winner. In the event of a tie, all tied players with the highest score are declared winners.

Fact Sheets

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Diet

What types of food and drink are good for our microbiome?
Eating a variety of foods is good for our microbiome. High-fibre foods actively encourage the growth of beneficial bacteria (Ref 1), while fermented foods provide probiotics that support a healthy gut environment (Ref 2). Prebiotics, found in garlic, onions and bananas, act as fuel for these beneficial bacteria and contribute to a balanced microbiome (Ref.3). Green tea has antioxidant properties that stimulate the growth of beneficial bacteria (Ref.4).

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How do fibre-rich foods affect our microbiome?
Fibre-rich foods, like broccoli and whole grains, support the growth of beneficial bacteria such as *Bifidobacteria* and *Lactobacillus*. These bacteria ferment fibre, producing short-chain fatty acids that help maintain the gut lining and contribute to the overall wellbeing of the microbiome (Ref 1).

How do fermented foods support a healthy gut?
Fermented foods, such as yoghurt and sauerkraut, contain probiotics. These probiotics actively contribute to a healthy gut environment by supporting the balance of microbial flora. Regular consumption of fermented foods helps to maintain a thriving microbial community in the digestive system (Ref 2).

What are the benefits of drinking green tea for our microbiome?
Green tea has potential benefits for the microbiome. Its polyphenols, known for their antioxidant properties, may stimulate the growth of beneficial bacteria in the gut. Regular consumption of green tea may have a positive effect on the balance and diversity of the microbiome (Ref 4).

What foods and drinks can negatively impact the health of our microbiome?
The health of our microbiota can be negatively affected by a diet high in processed foods, containing high levels of saturated fats and sugars. In addition, excessive alcohol consumption and drinking soda can also affect the gut microbiome (Ref 5).

How does highly processed foods affect our microbiome?
Highly processed foods, such as fast food, sweets and salty snacks, can disrupt the gut microbiome by depriving beneficial bacteria of essential nutrients. The high levels of artificial additives, preservatives and emulsifiers found in many processed foods can directly harm beneficial gut bacteria (Ref 6).

How does drinking soda affect our microbiome?
Drinking soda, especially those with sugar and artificial sweeteners, not only harms beneficial bacteria, but also creates conditions that can favour the growth of harmful bacteria such as *Helicobacter pylori*, a bacterium linked to stomach ulcers and inflammation (Ref 7).

How does alcohol affect our microbiome?
Excessive alcohol consumption can have a negative impact on the gut microbiome by altering its composition and reducing microbial diversity. This disruption can lead to various health problems due to an imbalance in the gut microbial community (Ref 8).

Sleep

Why is sleep quality important for the health of our microbiome?
Quality sleep facilitates significant interactions with the microbiome during rest periods, when the body undergoes essential repair and regeneration processes. Research suggests that overall microbiome diversity is positively correlated with increased sleep efficiency (Ref. 9).

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What happens to our microbiome when we have irregular or poor sleep patterns?
Irregular or poor sleep patterns can disrupt the balance of bacteria in the gut, as sleep deprivation affects hormonal regulation and immune function. It creates an environment that favours the growth of certain types of bacteria over others, altering the composition and diversity of the microbiome. (Ref 10).

Exercise

How does regular physical activity affect our microbiome?
Regular physical activity has a significant impact on our microbiome. It is associated with increased gut microbial diversity, which is crucial for maintaining a balanced and resilient microbial community in the digestive system (Ref 11).

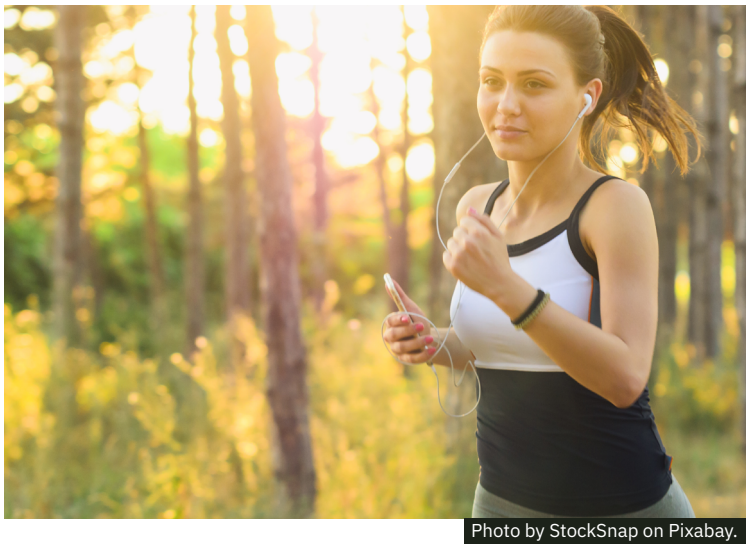
Photo by StockSnap on Pixabay.

What kind of exercise is beneficial for our microbiome and why?
Aerobic exercise, such as jogging or swimming, is thought to be beneficial for the microbiome. This type of exercise can create a more favourable gut environment by encouraging the growth of beneficial bacteria. The compounds released during aerobic exercise may serve as an energy source for these beneficial microbes. In addition, regular physical activity is associated with reduced inflammation, which further supports a healthier balance of gut bacteria (Ref 11).

Houshold members and pets

How do the people we live with influence our microbiome?
Interactions with the people we live with, including family and friends, play a crucial role in shaping our microbiome. They expose us to a wide range of microorganisms, contributing significantly to the overall diversity of our microbiome. The presence of diverse companions promotes a complex and diverse microbiome in our bodies (Ref 12).


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How does having a pet affect our microbiome?
Living with a pet positively affects our microbiome by introducing unique microbes that increase the diversity of our microbiota. These pet-derived microbes are thought to benefit the microbiota in and on our bodies (Ref 13).

Medicines

How do antibiotics affect the microbiome?
Antibiotics can have a significant impact on the microbiome. They are effective against specific bacteria, but their broad-spectrum action means that they affect both harmful and beneficial microbes. This non-selective effect can lead to a temporary reduction in microbial diversity in the gut (Ref 14).

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Can other medicines affect our microbiome?
Other medications, including anti-inflammatory drugs such as ibuprofen, have also been linked to changes in the gut microbiome. These medicines can disrupt the delicate balance of microbial communities, affecting the diversity and abundance of bacteria in the digestive system. It is important to be aware of the potential effects of different medications on the microbiome, as this understanding can help to make informed choices and strategies to reduce disruption to the complex ecosystem of the gut (Ref 15).

Dieseses

Which diseases can affect our microbiome?
Certain diseases have the potential to disrupt the delicate balance of the gut microbiome, with inflammatory Inflammatory Bowel Disease (IBD) being an important example. IBD is a group of conditions characterised by inflammation in the digestive tract, leading to symptoms such as abdominal pain, diarrhoea and fatigue.

What can inflammatory bowel disease (IBD) do to your microbiome?
Inflammatory bowel disease (IBD) significantly alters the gut microbiome, reducing microbial diversity and increasing harmful species while decreasing beneficial strains. It affects microbial metabolic functions, damages the intestinal barrier and disrupts host-immune interactions (Ref 16).

Can sinus or ear infections affect our microbiome?
Sinus and ear infections can be caused by bacteria or viruses. Typically, viral infections, often associated with colds or flu, are the main cause of such infections. However, bacteria such as *Haemophilus influenzae* can also cause sinus and ear infections. In cases where the infection is bacterial, it not only alters the respiratory microbiome, but also requires antibiotics for treatment. In addition, antibiotic treatment can also alter the gut microbiome. Viral infections can also affect the microbiome; the immune response triggered by viruses can affect the diversity of microbial species, potentially affecting the composition of the gut microbiota (Ref 17).

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What happens to our microbiome during an *E. coli* infection?
Escherichia coli (*E. coli*) infections can cause temporary changes in the gut flora. Normally present strains of *E. coli* may become pathogenic, causing gastrointestinal discomfort and potentially altering the microbial balance (Ref 18).

Examples of microbes in our gut

(Ref 19)

Lactobacillus

- Morphology: Rod-shaped and non-motile gram-positive bacteria.
- Healthy gut: Normally found in the gut microbiota.
- Sources: Found in foods such as yoghurt, kimchi, tempeh and other fermented foods.
- Function: Facilitate digestion, maintain an acidic environment and compete with pathogenic microbes.
- Health effects: Typically used in probiotics to restore the balance of intestinal flora. It is generally beneficial.
- Transmission: Can be acquired through consumption of fermented foods or probiotic supplementation.

Bifidobacterium

- Morphology: Rod-shaped, often branched, gram-positive bacteria.
- Healthy gut: Naturally inhabit the gut microbiota, especially in infants.
- Sources: Found in breast milk and fermented dairy products such as yoghurt and kefir.
- Function: Ferment carbohydrates, produce short-chain fatty acids and help maintain intestinal barrier function.
- Health effects: Promote gut health and immune system development. Generally beneficial.
- Transmission: Transmitted from mother to child during childbirth and breastfeeding, and can be obtained from fermented foods or probiotics.

Akkermansia muciniphila

- Morphology: Anaerobic, non-motile, gram-negative bacteria.
- Healthy gut: Part of the gut microbiota, particularly abundant in the mucus layer.
- Sources: Limited dietary sources, mostly dependent on preexisting gut populations.
- Function: Play a role in mucin breakdown, gut barrier integrity and metabolic regulation.
- Health effects: Associated with metabolic health, reduced inflammation and protection against obesity-related disorders. Beneficial.
- Transmission: Primarily acquired from mother during birth and early colonisation, influenced by diet and lifestyle.

Faecalibacterium prausnitzii

- Morphology: Anaerobic, non-motile, gram-positive bacteria.
- Healthy gut: Abundant in the human colon, constituting a significant proportion of the gut microbiota.
- Sources: Limited dietary sources, mainly maintained by existing gut populations.
- Function: Produce butyrate, an important short-chain fatty acid that nourishes colonocytes and maintains gut health.
- Health effects: Exhibit anti-inflammatory properties associated with reduced risk of inflammatory bowel disease. Generally beneficial.
- Transmission: Acquired early in life and maintained into adulthood, influenced by diet and environmental factors.

Methanobrevibacter smithii

- Morphology: Anaerobic, non-motile archaeon.
- Healthy gut: Part of the gut microbiota, particularly in the colon.
- Sources: Dietary sources limited; mainly maintained within the gut ecosystem.
- Function: Produce methane by metabolising hydrogen, influencing gut transit time and fermentation processes.
- Health effects: Essential for nutrient and calorie absorption, but can contribute to conditions such as constipation and irritable bowel syndrome if overabundant. Moderately beneficial.
- Transmission: Acquired early in life and maintained within the gut microbiota.

Escherichia coli

- Morphology: Gram-negative, facultatively anaerobic, rod-shaped bacteria.
- Healthy gut: Normally inhabit the gut microbiota of humans and warm-blooded animals.
- Sources: Faecal contamination of water and food, particularly in environments with poor sanitation.
- Function: May be beneficial in small amounts for digestion and vitamin synthesis.
- Health effects: Some strains can cause gastrointestinal infections, urinary tract infections and other diseases. Effects vary depending on strain and context.
- Transmission: Faecal-oral route, contaminated food or water.

Helicobacter pylori

- Morphology: Spiral shaped, microaerophilic, Gram-negative bacterium.
- Healthy gut: Can colonise the stomach lining in a subset of individuals.
- Sources: Primarily by oral-oral or faecal-oral routes, often during childhood.
- Function: Can survive in the acidic environment of the stomach.
- Health effects: Associated with gastritis, peptic ulcers and increased risk of stomach cancer. Pathogenic.
- Transmission: Person-to-person, especially in close quarters or through contaminated food and water.

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