This will be used to assess the summaries generated by participants, which we consider as learning outcome.

Topic tree

<u>Note</u>:
-Nodes marked with (*) serve as placeholders and mentions of them do not contribute to the scoring.
-Do *not* count redundant pieces of information, meaning if a participant mentioned 'diet as a factor' in the first bullet point and later mentions that diet plays a role again in the notes, we give it +1, not +2.
-Do *not* count generic statements that repeat the ideas mentioned in the task description. For instance, we don't give a score to the following phrases/statements: "gut-brain connection," "Research shows that gut microbiome plays a role in mental health," "We know there's a connection between the brain and the gut."

Gut microbiome: information about gut microbiome/gut microbiota.

1. definition of gut microbiota. e.g., living microorganisms that inhabit the intestine
2. definition of gut microbiome. e.g., the intestinal microorganisms and their genetic material, community of microorganisms, including bacteria, viruses, fungi, and other microbes
3. gut microbiomes are found in (*)
    a. stomach
    b. small intestine (the longest part of the digestive tract)
    c. large intestine / colon
    d. GI tract /digestive system
4. functions of gut microbiome (*)
    a. digestion
    b. nutrient absorption
    c. immune system function (help killing pathogens)
    d. metabolism
    e. vitamin synthesis
    f. release hormones like ghrelin (fullness cue)
    g. detects harmful substances (triggers certain responses such as nausea or vomiting to expel those substances)
    h. breaking down cellulose into fiber
    i. maintaining the health of ENS
5. microbial composition influences: (*)
    a. nutrient absorption and sensing
    b. peptide synthesis
    c. production of enzymes contributing to metabolic processes in both ENS and CNS
        i. changes in metabolic reactions are influenced by gene expression either expressed (upregulated) or inhibited (downregulated) and
        ii. these gene expressions are influenced by diet consumed and processed by the gut microbiota
    d. mood
6. facts about gut microbiome (*)
    a. related to the quantity of microorganisms within the gut (*)
        i. trillions of microbes

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        ii. approximately 10 times more microbial cells are in the gut than in the entire body
        iii. the combined weight of these microorganisms can reach 6 pounds
        iv. helpful and harmful bacteria coexist in gut microbiome
        v. certain gut bacteria can influence the expression of gut lining genes (genes in the cells that line the gut)
    b. the gut is referred to as “second brain”
    c. the gut microbiome is understood as an “additional organ”
    d. microbiota is also referred to as microflora
    e. intrinsic vagal reflexes. e.g., reflex actions that occur within the enteric nervous system (ENS) without direct involvement or signals going to the brain
    f. each person has unique gut microbiome
    g. gut microbiome is (partially) determined by DNA
    h. more nerves in the gut than anywhere else in the body
    i. there are symbiotic microbes and pathogenic microbes (simply put, ‘helpful’ vs. ‘harmful’ microbes)
    j. gut microbiome changes throughout one’s life
    k. it is possible to change your gut health through small changes over time (and sticking to them)
7. fact about gut (*)
    a. the ‘gut’ encompasses, no just stomach, but other organs such as (*)
        i. intestines
        ii. pancreas
        iii. liver
        iv. gallbladder
8. early development (*)
    a. gut microbiome begins to develop at birth / during the birthing process through exposure to microorganisms in the birth canal
    b. microbial exposure in the womb remains debated
    c. the composition of microbiota in babies appears to converge around the age of 1, with some variations still present
9. gut health (*)
    a. amount of microbiome (there’s a certain amount of microbiota necessary, too little and too many leads to gut dysbiosis)
    b. diversity (a wide variety of different microbial species in the gut)
    c. stability or resilience (ability to resist drastic changes and return to a balanced state after disruptions)
    d. balance (a balanced ratio of different microbial species. either overgrowth of harmful bacteria or a reduction in beneficial ones is not good)
10. gut dysbiosis (imbalanced or disruption in the composition of the gut microbiota)
    a. statements related to gut dysbiosis (*)
        i. gut dysbiosis can occur relatively quickly (in response to various factors)
11. short-fatty chain acid (SCFA)

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   a. definition. fatty acids produced in the colon through the fermentation of dietary fibers by gut bacteria (e.g., butyrate)
   b. functions (*)
      i. serves as an energy source for the cells lining the colon
      ii. supports production of mucus
      iii. and contribute to balanced pH environment in the GI tract
      iv. can influence muscle health
      v. can be beneficial in preventing some diseases (e.g., liver disease)

12. a balanced pH level or an appropriate PH range in the gut is important
   a. why (*)
      i. it supports the effective digestion and absorption of nutrients
      ii. it creates an environment conducive to the growth of beneficial bacteria
      iii. while inhibiting the growth of harmful pathogens
13. statements related to gastric juices (*)
   a. gastric juices play a critical role in digestion
   b. production of gastric juices depends on diet
14. Lactic acids are beneficial for gut microbiome
   a. why (*)
      i. breaks down (complex) carbs

Gut-brain connection: information addressing the connection between gut and brain, mechanisms or pathways through which gut and brain communicate.

1. gut-brain axis (GBA)
2. two-way communication (signals go both ways)
   a. How (*)
      i. through chemical messengers
      ii. Neural network / vagus nerve
      iii. Endocrine cells (systems) / hormones
      iv. Metabolites
      v. Immune cells (systems)
3. CNS (central nervous system)
4. ENS (enteric nervous system)
5. facts about vagus nerve (*)
   a. vagus nerve is one of the largest nerves in the body, supporting the communication between the gut and the brain
   b. vagus nerve serves as a communication link between the brain and various organs, including the gut, heart, and lungs
   c. patients with IBS/Chron's disease may have reduced activity of vagus nerve
   d. reduced vagal responses are associated with increased levels of anxiety and depression-like symptoms
6. gut-brain communication occurs via neurotransmitters
7. gut microbiota is involved in production and regulation of neurotransmitters
8. neurotransmitters are necessary for the communication between ENS and CNS
9. neurotransmitters produced by the gut can influence emotions (anxiety, fear, and happiness)

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10. gut microbiome influences the HPA (hypothalamic-pituitary-adrenal) axis through vagus nerve
11. certain bacteria in the gut produce neurotransmitters such as
    a. GABA (gamma-aminobutyric acid, a primary inhibitory neurotransmitter in the CNS)
    b. serotonin, and
    c. dopamine
12. Examples of gut-brain connection (*)
    a. butterflies in stomach
        i. how: gut movements interrupted in response to the nervousness
    b. needing to use the bathroom (need for a bowel movement) when stressed
    c. can't digest well or stomach hurting when stressed
    d. fight or flight response
        i. how: gut slow down due to the energy diverted towards brain due to this stress response
    e. nervousness before a test manifests as nausea
13. physical and mental symptoms caused by poor gut health can create a vicious cycle because those symptoms discourage healthy eating
14. brain influences the gut by sending signals related to hunger, thirst, pain, stress, and nervousness

Physical health: information related to the impact of gut on physical health and vice versa.

1. Gut → blood-brain barrier (BBB)
2. Gut → stroke
    a. how
3. Gut → motivation to exercise
    a. how
4. Gut → inflammation
    a. how (cytokines)
    b. link between the gut, inflammatory and cytokine markers in responses to COVID-19
    c. Inflammatory disease includes (*):
        i. asthma
        ii. arthritis
5. Gut → allergies
    a. how (by reduced exposure to diverse microbes due to increased hygiene and sanitation practices, through compromised immune system)
6. Gut → immune system
    a. how (*)
        i. Overreactivity (an imbalance or dysbiosis in the gut can cause the immune system to become more sensitive or reactive to harmless substances)
        ii. Underreactivity (a lack of microbial diversity of the absence of certain beneficial microorganisms may result in a compromised immune system)
        iii. by producing molecules that can activate T cells, which is a type of white blood cell that helps to fight off infections
        iv. by reducing the production of pro-inflammatory cytokines
        v. by producing short-chain fatty acids (SCFAs) which help fight pathogens

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7. Exercise → gut
8. Gastrointestinal (GI) issues → pain sensitivity
    a. how (*)
        i. being more prone to experiencing stress, which can exacerbate pain sensitivity
9. Stress / high cortisol level → gut / GI symptoms
    a. variables that can be involved in this effect include (*)
        i. hypothalamic-pituitary-adrenal (HPA) axis
        ii. circadian rhythm
10. Gut → nerve health
    a. how (*)
        i. by impacting microglial function in the central nervous system (e.g., increased microglia cell count)
11. Gut → muscle health and performance
12. Gut → cancer
13. Poor gut health can lead to physical health conditions, such as: (*)
    a. weight gain
    b. nausea
    c. IBS
    d. obesity
    e. diabetes
    f. cholesterol level
    g. heart disease
        i. how
    h. high blood pressure
14. Healthy gut can contribute to (*):
    a. better sleep
    b. higher energy levels
    c. better absorption of information
    d. glucose (blood sugar) regulation
15. Obesity → gut
16. Gut → physical diseases
17. Gut → Sclerosis (*)
    a. ALS (Amyotrophic Lateral Sclerosis)
    b. MS/ML (Multiple Sclerosis)
18. Unwanted microorganisms in the gut → physical symptoms such as discomfort
    a. how (*)
        i. by producing gases and chemicals that can contribute to bloating and GI distress
19. Psychological treatments → reduced digestive / GI issues
    a. hypnotherapy
    b. cognitive behavioral therapy (CBT)
    c. biofeedback
        i. what it is (one learns to regulate heart rate, muscle tension, or skin temperature based on electronic monitoring)
    d. relaxation training

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20. Fecal matter transplant (FMT, fecal transplant) (*)
    a. a mention of FMT or a mention that FMT can help improve your gut
    b. what it is
    c. outcomes (*)
        i. treat severe bacterial infections in the colon and other parts of the GI tract
21. Women are more likely to experience irritable bowel syndrome (IBS)
    a. how/why (*)
        i. gut plays a role in estrogen metabolism
22. IBS (*)
    a. IBS can affect the interactions between the gut and the brain
    b. IBS can be influenced by prebiotics (prebiotics can help reduce IBS symptoms by promoting a healthier balance of gut bacteria)
    c. IBS can be influenced by antibiotics (antibiotic can disrupt the balance of bacteria in the gut)
    d. IBS is common (depending on a source, 10-15%, 20%)
    e. About 40% of those with IBS are diagnosed with VH (Visceral Hypersensitivity)
        i. what VH is (increased sensitivity to pain in the internal organs, including GI tract)
        ii. VH disproportionately affects women more than men (about twice more)

Mental health: information related to the impact of gut on mental health and vice versa, mental health here includes cognitive function as well.

1. Gut → anxiety
    a. how
2. Gut → depression
    a. how (*)
        i. some studies found specific strains of bacteria being associated with decreased vs. increased depressive symptoms in people
    b. those with major depressive disorder were found to have lower microbial diversity than those without
3. Gut → perception and experience of pain
4. Gut → schizophrenia
    a. those with schizophrenia were found to have lower microbial diversity than those without
    b. analyzing the gut microbiota can help determine the effectiveness of certain medications in treating schizophrenia
5. Gut → Alzheimer's disease
    a. how
6. Gut → dementia
    a. how
7. Gut → Parkinson's
    a. how
8. Gut → OCD
9. Gut → serotonin
    a. how (around 90% of serotonin is produced in the gut)
10. Gut → GABA

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    a. GABA is associated with fear and anxiety
    b. GABA plays a role in regulating appetite
11. Gut → cognitive function
12. Gut → attention test (e.g., point and stare test)
13. Emotion → actions in the gut
14. Different psychological stressors → gut microbes in terms of their
    a. population
    b. composition
    c. synthesizing rate
15. Negative emotions (feeling anxious and depressed) → perception of pain in the gut
16. Anxiety → gut
17. Depression → gut
18. Gut → emotions / mood
    a. reference to a study (*)
        i. absence of gut microbes ("sterile") → high stress
        ii. presence of certain microbes → increased exploration behavior in mazes
        iii. gut microbe biodiversity in rats was found to correlate with better resilience to stress
19. Gut → psychosocial health
20. Gut → autism
    a. how (*)
        i. the composition of the gut microbiota during early life can influence the development of neural pathways (brain pathways), particularly during critical periods of brain development in early life
        ii. a study showed a potential link between high-carbohydrate diets and ASD symptoms in children
21. Gastrointestinal (GI) issues → mental health issues (*)
    a. those with mental health issues are also found to have GI issues
    b. those with GI issues are found to have high stress levels
    c. GI issues can worsen mental health symptoms
    d. those with GI issues may have an increased risk of experiencing mental health issues
        i. such as schizophrenia
    e. treating GI issues can result in improving mental health
22. IBS (*)
    a. IBS is caused by distressed or unhealthy gut
    b. is linked with anxiety
    c. is linked with depression
23. IBD (*)
    a. what IBD is
    b. those with IBD were found to have lower diversity in the gut compared to those without
24. Unwanted microorganisms in the gut → mental state
    a. how (by producing harmful chemicals into the bloodstream)
25. Mental state (stress, anxiety) → (functional) gastrointestinal issues

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26. Fecal metal transplant (FMT, fecal transplant)[1] (*)
    a. a mention of FMT or a mention that FMT can help improve your mental state
    b. what it is
    c. outcomes (*)
        i. can help with C. difficile (C. diff) infection
        ii. reduced symptoms of autism
        iii. reduced symptoms of depression
    d. challenges (*)
        i. it is hard to find a good donor due to high requirements
27. Treatment for mental health works for treating GI issues (e.g., IBS)
    a. antidepressants
    b. therapy
    c. other ways to reduce stress (*)
        i. body scan
        ii. yoga and/or meditation
        iii. deep breathing
28. emotions such as anxiety, stress, and excitement share some common physiological responses (activate the body's stress response system).

Note: We anticipate significant overlaps between 'factors influencing gut health' and 'ways to improve gut health' since these two facets are intrinsically related. Both perspectives address the various elements impacting the state of gut. One way to distinguish them is that 'factors influencing gut health' adopts a more observational perspective, focusing on understanding or identifying what contributes to a specific state of the gut, while 'ways to improve gut health' takes a more interventional stance, focusing on actionable steps and strategies to positively impact gut health.

Factors influencing gut health

1. Diet
    a. how food influences gut health in general (*)
        i. food serves as fuel for the bacteria in our gut microbiota. It promotes the growth and reproduction of beneficial (or harmful) bacteria
    b. plant-based
        i. how (*)
            1. polyphenols (which is a group of compounds found in plants that act as prebiotics, promoting the growth of beneficial gut bacteria)
            2. short-chain fatty acids (SCFAs) (fiber, a main component of plant-based foods contributes to SCFAs production)
    c. fiber
        i. types (*)
            1. soluble

[1] Fecal microbial transplantation (FMT), also known as stool transplantation or bacteriotherapy is a procedure in which fecal matter is collected from a healthy donor and placed into the gastrointestinal tract of a patient to restore their gut microbiome.

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        2. insoluble
    ii. how (*)
        1. through the production of short-fatty chain acids (SCFAs)
        2. encourages the growth of health bacteria in the gut
    iii. examples of fiber
d. resistant starch / complex carb
    i. how
e. fermented food
    i. how (pH level)
f. macronutrients
    i. carb
    ii. lipids
    iii. protein
        1. how (*)
            a. Tryptophan (an essential amino acid found in dietary proteins) serves as a common pathway of gut-brain connection
g. micronutrients
h. sugar
i. some research suggests that high-carb diet (*)
    i. can decrease diversity in gut microbiome
    ii. and increase depressive symptoms

2. Alcohol (can negatively affect gut health)
3. Tobacco (can negatively affect gut health)
4. Genetics
5. Environment (exposure to different microbes can influence the state of gut)
    a. hygiene hypothesis. reduced exposure to diverse microbes, especially in early childhood, may have consequences for the development of the immune system
    b. use of disinfectants can influence the gut microbiome as it kills or inhibits not only harmful but also beneficial bacteria
6. Mode of delivery (infants born by c-section vs vaginally tend to have a different early gut microbiome composition)
    a. how (*)
        i. vaginal delivery → exposure to bacteria and antibodies during birth / helps establish microbiota
        ii. cesarean (c-section) → missing direct exposure to maternal microbes, exposure to skin and environmental bacteria in the operating room instead
7. Mother's microbiota (*)
    a. mother's microbiota (and health conditions) at birth impacts the child's microbiota development
    b. stress can alter the composition of the maternal microbiome, including the vaginal microbiota
8. Mode of feeding (whether the baby was breastfed or not)
9. Medication use (i.e., antibiotics)
    a. how (*)

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        i. reduction in microbial diversity
10. Activity level
11. Infection
12. Inflammation
13. Sleep
14. Stress
15. Age (life stage)
16. Geographical location
17. Socio-cultural factors (e.g., cultural attitudes and social norms related to gut health, access to healthcare, nutrition education, etc.)
18. Socio-economic factors (e.g., access to nutrition, access to healthcare)

Ways to improve gut health

1. Diet
    a. fiber-rich food / high-fiber diet
        i. how (*)
            1. fiber helps the growth of beneficial bacteria
        ii. related statements (*)
            1. Americans consumes about 40-50% of the recommended daily intake of fiber
        iii. examples of fiber-rich food
    b. vegetables
    c. fruits
    d. protein
        i. how (*)
            1. protein (i.e., amino acids contained in protein-rich foods) can help serotonin production, decreasing depressive symptoms
    e. nuts
    f. seeds
    g. whole grains
    h. legumes
    i. water
    j. fermented food
        i. examples of fermented food (yogurt, kimchi)
        ii. prioritize ones that contain active culture (live microorganisms)
        iii. when heated or cooked (especially at high temperature), it may not be effective (as it can kill or deactivate the beneficial bacteria)
        iv. how (*)
            1. contain healthy bacteria
            2. feed bacteria in the gut (in general)
                a. such as Lactobacillus
            3. help lower bacteria associated with the inflammation
            4. Lactobacillus (certain strains) may have benefits for brain functioning
    k. probiotic-rich food

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        i. how (*)
            1. introduces beneficial microbes into the gut / probiotics themselves are beneficial bacterial strains
            2. helps maintain or restore a balanced and/or diverse gut microbiome after disruptions like antibiotic use
        ii. probiotic food example
    l. prebiotic-rich food
        i. how (*)
            1. supports the growth of beneficial bacteria / “feeds” bacteria in your colon and intestine
        ii. prebiotic food example
    m. limit processed food
    n. limit inflammatory food, such as
        i. sugar
        ii. foods high in fat
        iii. artificial sweeteners
    o. limit sugar
    p. limit artificial sweeteners
    q. limit caffeine intake
    r. variety / diversity in diet
    s. Mediterranean diet is known to be good
    t. plant-based diet can be beneficial
    u. certain foods can help improve stress tolerance
2. Eat slowly
3. Exercise
4. Sleep well
5. Manage/reduce stress
6. Breastfeed
7. Supplements
    a. prebiotics
        i. how
    b. probiotics
        i. some suggests that over-the-counter probiotics may not be effective
        ii. probiotics were found to improve depression and/or anxiety symptoms
        iii. probiotics were found to improve ASD-like symptoms in a mice study
        iv. probiotics were found to mitigate the negative impacts of a high-fat diet
        v. probiotics can be used for people with illness or on medication such as antibiotics (to help restore or maintain a healthy balance of gut bacteria)
        vi. generally healthy people do not need to supplement with probiotics
        vii. can be particularly important for young and old age groups
        viii. probiotic supplements are not regulated by the FDA
        ix. how (*)
            1. contain beneficial bacteria

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    c. psychobiotics are probiotics (beneficial bacteria) or prebiotics (support for the beneficial bacteria) that have potential mental health impact
    d. melatonin
        i. how (partly through its role in regulating sleep and circadian rhythms)
8. Omega-3 fatty acid can help improve mental functions
    a. mood
    b. attention
    c. memory
9. Restoring gut health takes time

Other

1. Research on the topic (*)
    a. significant increase in research on gut health and gut microbiome in recent years
    b. still more to be studied, and many aspects are not fully understood