Microbe Mission

Division B/C

Georgia Tech Event Workshop Series
2024-25

Science Olympiad at Georgia Tech®

01 RULES SHEET

02 DIFFICULT TOPICS

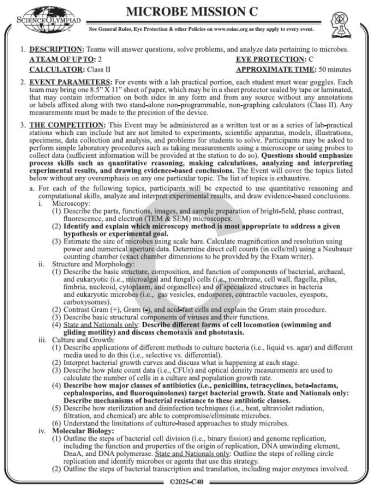
03 COMMON QUESTIONS

04 TIPS FROM A VETERAN

05 OTHER FREE RESOURCES

The Rules Sheet

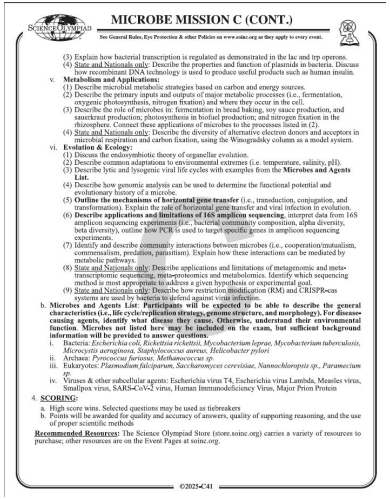
- May bring **1 8.5” by 11” sheet of paper**, both sides
  - No additions on top of the paper
  - Can be in a a sheet protector sealed with tape or laminated
- **2 non-programmable, non-graphing calculators allowed**
- Make sure that you and your teammate know every topic at least a surface level.
- Either as **lab-practical stations** or an **exam**



MICROBE MISSION C

See General Rules, Eye Protection & other Policies on www.soinc.org as they apply to every event.

1. **DESCRIPTION:** Teams will answer questions, solve problems, and analyze data pertaining to microbes.
   A TEAM OF UP TO: 2 — **EYE PROTECTION:** C
   CALCULATOR: Class II — **APPROXIMATE TIME:** 50 minutes
2. **EVENT PARAMETERS:** For events with a lab practical portion, each student must wear goggles. Each team may bring one 8.5” X 11” sheet of paper, which may be in a sheet protector sealed by tape or laminated, that may contain information on both sides in any form and from any source without any annotations or labels affixed along with two stand-alone non-programmable, non-graphing calculators (Class II). Any measurements must be made to the precision of the device.
3. **THE COMPETITION:** This Event may be administered as a written test or as a series of lab-practical stations which can include but are not limited to experiments, scientific apparatus, models, illustrations, specimens, data collection and analysis, and problems for students to solve. Participants may be asked to perform simple laboratory procedures such as taking measurements using a microscope or using probes to collect data (sufficient information will be provided at the station to do so). **Questions should emphasize process skills such as quantitative reasoning, making calculations, analyzing and interpreting experimental results, and drawing evidence-based conclusions.** The Event will cover the topics listed below without any overemphasis on any one particular topic. The list of topics is exhaustive.
   a. For each of the following topics, participants will be expected to use quantitative reasoning and computational skills, analyze and interpret experimental results, and draw evidence-based conclusions.
      i. Microscopy:
         (1) Describe the parts, functions, images, and sample preparation of bright-field, phase contrast, fluorescence, and electron (TEM & SEM) microscopes.
         (2) **Identify and explain which microscopy method is most appropriate to address a given hypothesis or experimental goal.**
         (3) Estimate the size of microbes using scale bars. Calculate magnification and resolution using power and numerical aperture data. Determine direct cell counts (in cells/ml) using a Neubauer counting chamber (exact chamber dimensions to be provided by the Exam writer).
      ii. Structure and Morphology:
         (1) Describe the basic structure, composition, and function of components of bacterial, archaeal, and eukaryotic (i.e., microalgal and fungal) cells (i.e., membrane, cell wall, flagella, pilus, fimbria, nucleoid, cytoplasm, and organelles) and of specialized structures in bacteria and eukaryotic microbes (i.e., gas vesicles, endospores, contractile vacuoles, eyespots, carboxysomes).
         (2) Contrast Gram (+), Gram (–), and acid-fast cells and explain the Gram stain procedure.
         (3) Describe basic structural components of viruses and their functions.
         (4) State and Nationals only: **Describe different forms of cell locomotion (swimming and gliding motility) and discuss chemotaxis and phototaxis.**
      iii. Culture and Growth:
         (1) Describe applications of different methods to culture bacteria (i.e., liquid vs. agar) and different media used to do this (i.e., selective vs. differential).
         (2) Interpret bacterial growth curves and discuss what is happening at each stage.
         (3) Describe how plate count data (i.e., CFUs) and optical density measurements are used to calculate the number of cells in a culture and population growth rate.
         (4) **Describe how major classes of antibiotics (i.e., penicillins, tetracyclines, beta-lactams, cephalosporins, and fluoroquinolones) target bacterial growth. State and Nationals only: Describe mechanisms of bacterial resistance to these antibiotic classes.**
         (5) Describe how sterilization and disinfection techniques (i.e., heat, ultraviolet radiation, filtration, and chemical) are able to compromise/eliminate microbes.
         (6) Understand the limitations of culture-based approaches to study microbes.
      iv. **Molecular Biology:**
         (1) Outline the steps of bacterial cell division (i.e., binary fission) and genome replication, including the function and properties of the origin of replication, DNA unwinding element, DnaA, and DNA polymerase. State and Nationals only: Outline the steps of rolling circle replication and identify microbes or agents that use this strategy.
         (2) Outline the steps of bacterial transcription and translation, including major enzymes involved.



MICROBE MISSION C (CONT.)

         (3) Explain how bacterial transcription is regulated as demonstrated in the lac and trp operons.
         (4) State and Nationals only: Describe the properties and function of plasmids in bacteria. Discuss how recombinant DNA technology is used to produce useful products such as human insulin.
      v. **Metabolism and Applications:**
         (1) Describe microbial metabolic strategies based on carbon and energy sources.
         (2) Describe the primary inputs and outputs of major metabolic processes (i.e., fermentation, oxygenic photosynthesis, nitrogen fixation) and where they occur in the cell.
         (3) Describe the role of microbes in: fermentation in bread baking, soy sauce production, and sauerkraut production; photosynthesis in biofuel production; and nitrogen fixation in the rhizosphere. Connect these applications of microbes to the processes listed in (2).
         (4) State and Nationals only: Describe the diversity of alternative electron donors and acceptors in microbial respiration and carbon fixation, using the Winogradsky column as a model system.
      vi. **Evolution & Ecology:**
         (1) Discuss the endosymbiotic theory of organellar evolution.
         (2) Describe common adaptations to environmental extremes (i.e. temperature, salinity, pH).
         (3) Describe lytic and lysogenic viral life cycles with examples from the **Microbes and Agents List.**
         (4) Describe how genomic analysis can be used to determine the functional potential and evolutionary history of a microbe.
         (5) **Outline the mechanisms of horizontal gene transfer** (i.e., transduction, conjugation, and transformation). Explain the role of horizontal gene transfer and viral infection in evolution.
         (6) **Describe applications and limitations of 16S amplicon sequencing**, interpret data from 16S amplicon sequencing experiments (i.e., bacterial community composition, alpha diversity, beta diversity), outline how PCR is used to target specific genes in amplicon sequencing experiments.
         (7) Identify and describe community interactions between microbes (i.e., cooperation/mutualism, commensalism, predation, parasitism). Explain how these interactions can be mediated by metabolic pathways.
         (8) State and Nationals only: Describe applications and limitations of metagenomic and meta-transcriptomic sequencing, meta-proteomics and metabolomics. Identify which sequencing method is most appropriate to address a given hypothesis or experimental goal.
         (9) State and Nationals only: Describe how restriction modification (RM) and CRISPR-cas systems are used by bacteria to defend against virus infection.
   b. **Microbes and Agents List. Participants will be expected to be able to describe the general characteristics (i.e., life cycle/replication strategy, genome structure, and morphology). For diseases-causing agents, identify what disease they cause. Otherwise, understand their environmental function. Microbes not listed here may be included on the exam, but sufficient background information will be provided to answer questions.**
      i. Bacteria: *Escherichia coli, Rickettsia rickettsii, Mycobacterium leprae, Mycobacterium tuberculosis, Micrococcus aeruginosa, Staphylococcus aureus, Helicobacter pylori*
      ii. Archaea: *Pyrococcus furiosus, Methanococcus sp.*
      iii. Eukaryotes: *Plasmodium falciparum, Saccharomyces cerevisiae, Nannochloropsis sp., Paramecium sp.*
      iv. Viruses & other subcellular agents: Escherichia virus T4, Escherichia virus Lambda, Measles virus, Smallpox virus, SARS-CoV-2 virus, Human Immunodeficiency Virus, Major Prion Protein
4. **SCORING:**
   a. High score wins. Selected questions may be used as tiebreakers
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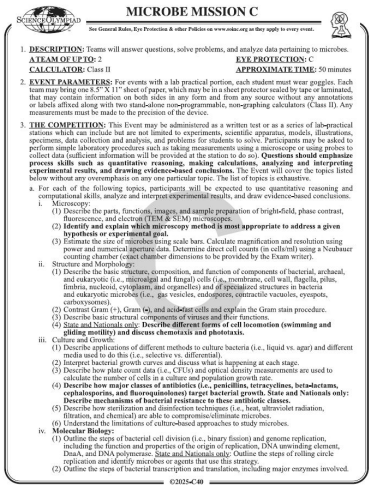
Recommended Resources: The Science Olympiad Store (store.soinc.org) carries a variety of resources to purchase; other resources are on the Event Pages at soinc.org.

Fundamental Topics

- Microscopy
- Structures of Bacteria, Archaea, Eukarya, and Viruses.
- Gram Staining.
- Molecular Biology of Bacteria*
- Metabolic Pathways
- Evolution & Ecology



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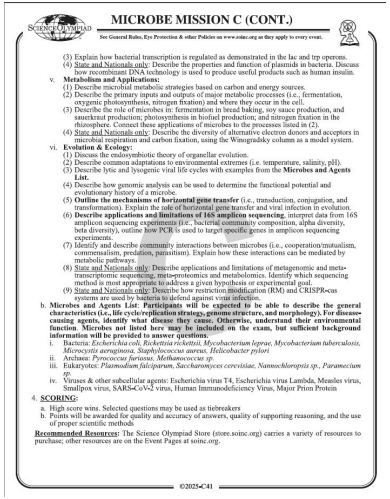

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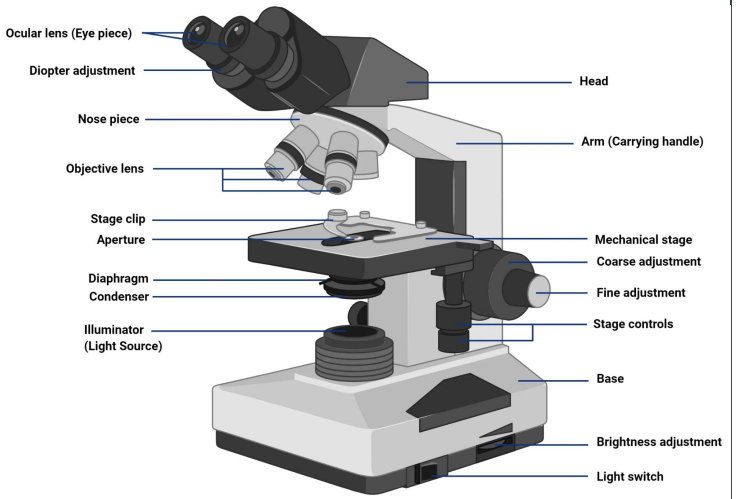
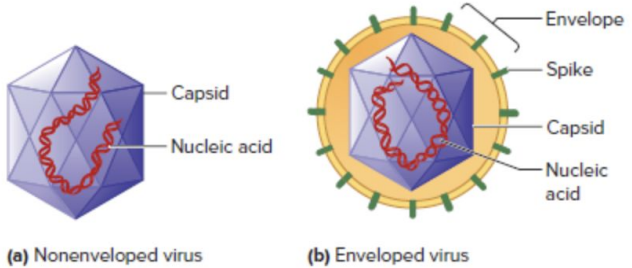
Topic 1: Microscopy

- The anatomy of *bright-field* microscopy
  - Know the functions and its limits as well.
- Know the appropriate formulas for resolution
  - Abbe's Equation: $d = \frac{0.5\lambda}{n \times \sin(\theta)}$
- The purpose of *dark-field* microscopy.
  - Living & unstained microbes
- Fluorescence Microscopy
- SEM & TEM
  - Differences and use



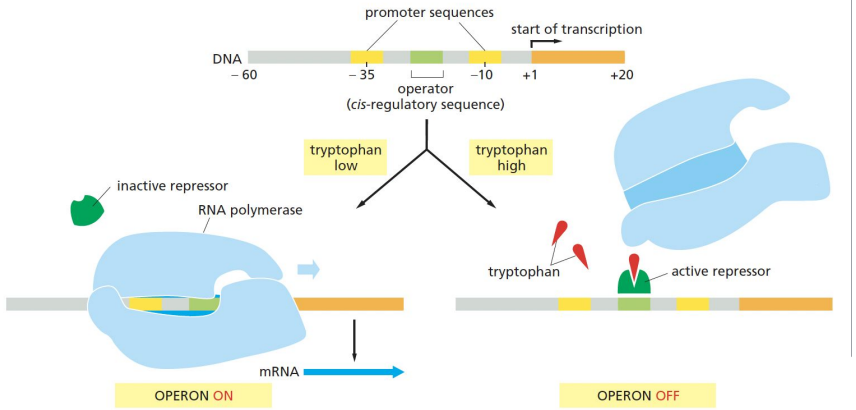
Topic 2: Structures

- Common bacterial and archaeal internal structures and their functions.
  - Carboxysomes, (CO_2 Fixation); Storage Inclusions (PHB)
- **Compare** and **contrast** the differences of cell membranes & wall's of *archaea*, *eukarya*, and *bacteria*.
  - Ether-linkage vs. ester-linkages
- **Compare** and **contrast** Gram (+) and Gram (-).
  - What about the *atypical* bacteria? Why?
- Noneveloped vs. enveloped viruses.



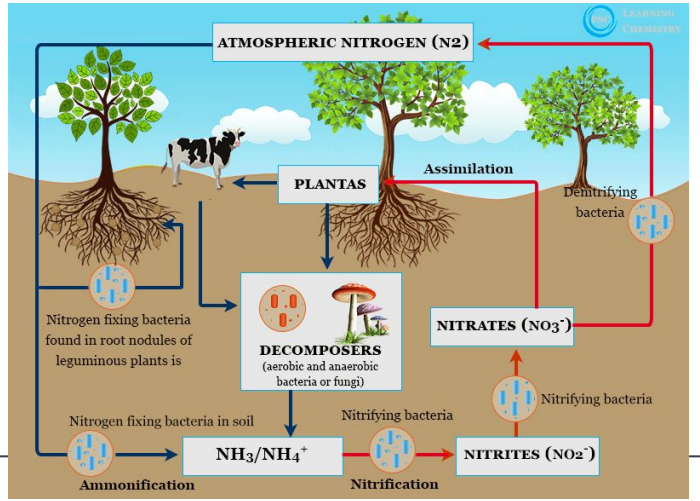
Topic 3: Molecular Bio

- Rule sheet limits the molecular biology aspect to *bacteria*.
- Model bacteria is *E.coli*.
- Know the functions of each commonly asked proteins:
  - DnaA (initiator of replication)
  - DNA Pol I & III
  - DNA Ligase
- Lac and Trp Operons
- Bacterial Translation
  - Shine-Dalgarno Sequence?



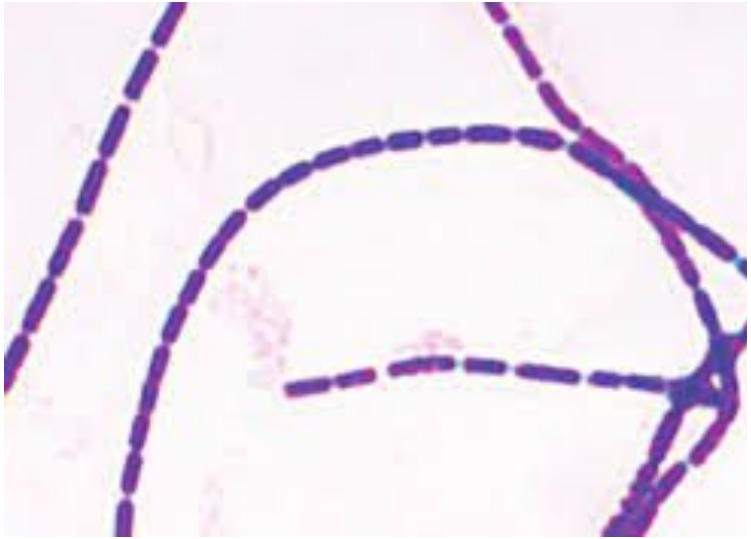
Topic 4: Metabolic Pathways

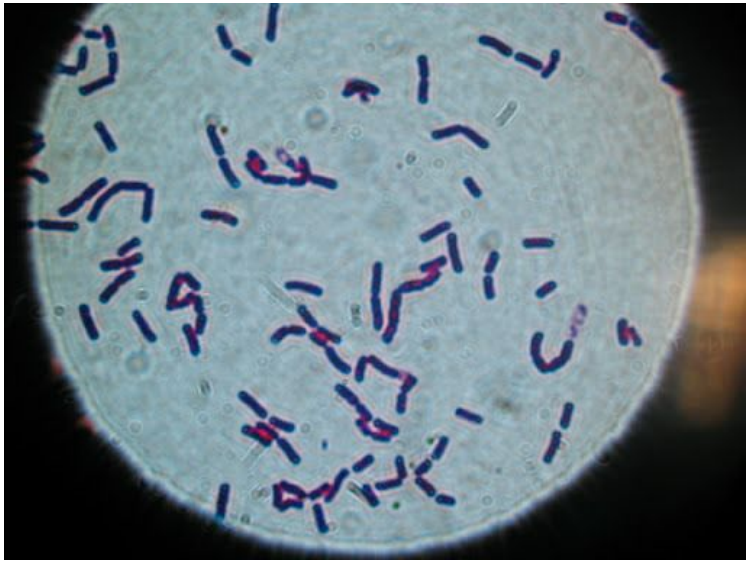
- Cheat Sheet!
- Understand difference between *catabolism* and *anabolism*.
- Know the general concepts of common pathways: Glycolysis, TCA, and ETC.
- Then, known the more specialized pathways:
  - ED-Pathways: Gram-negative, mostly soil-bacteria
  - ETCs of E.coli (*bo* and *bd*?)
- Different types of fermentation.
  - Lactic Acid
  - Ethanol
- Nitrogen Fixation



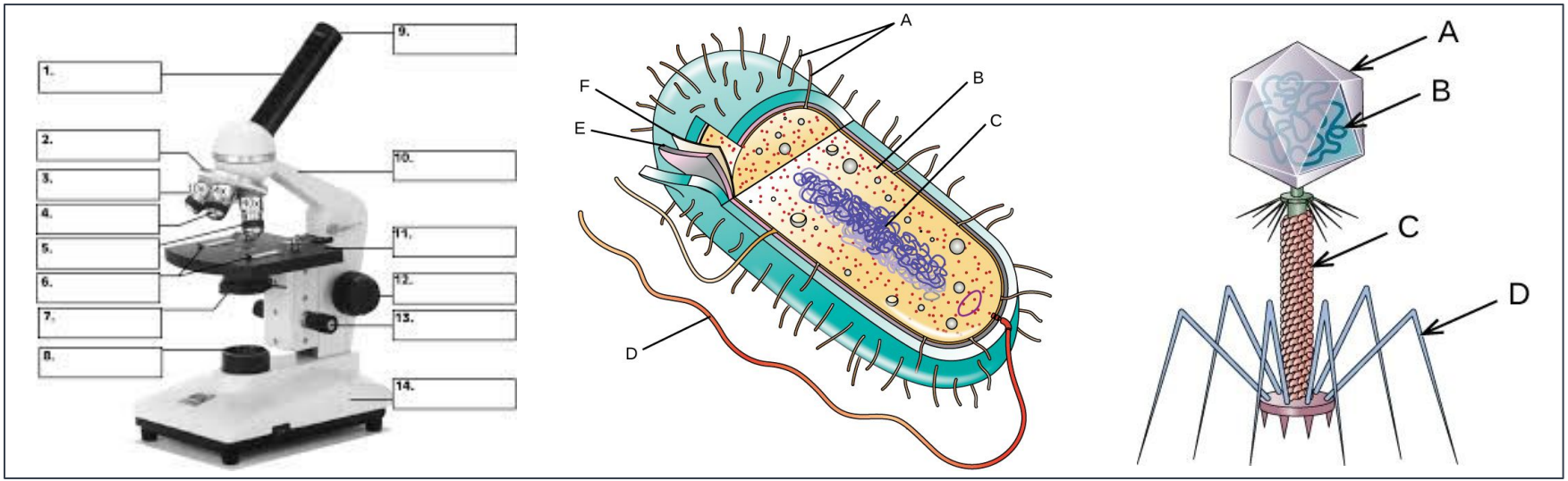

DIFFICULT
TOPICS

Topic 1: Identification

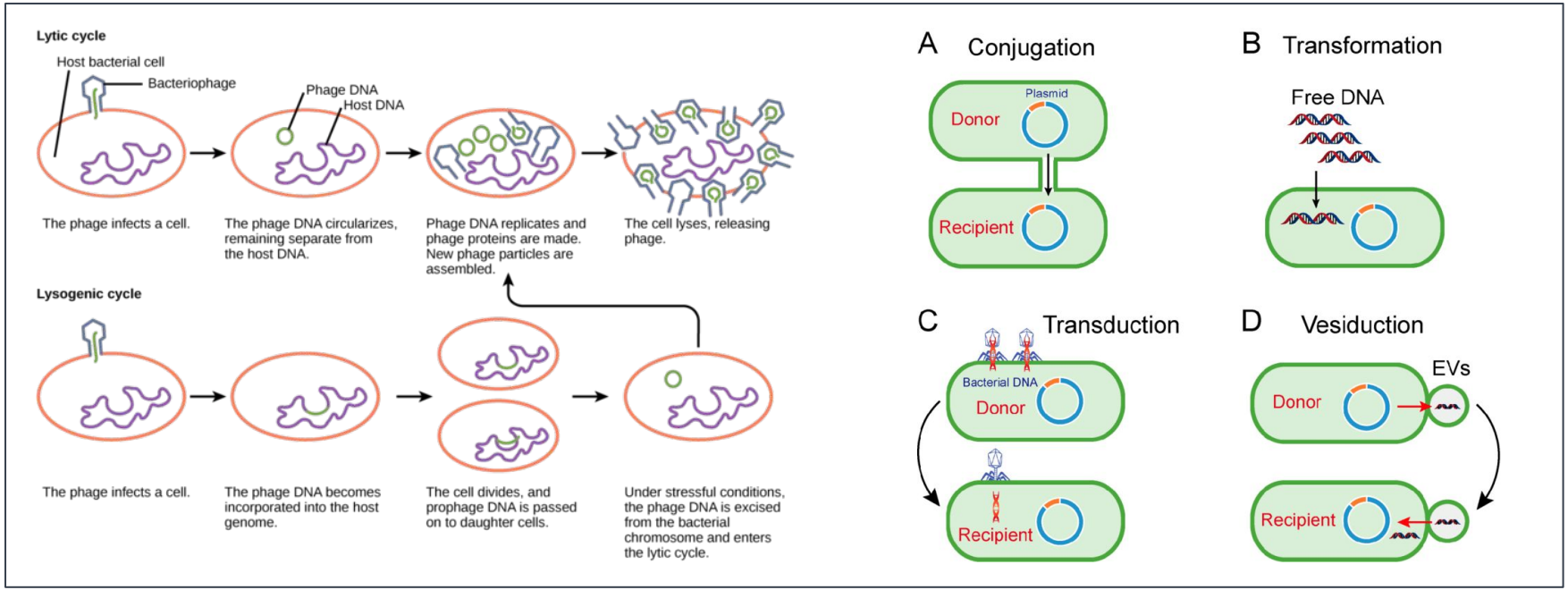




Topic 2: Specific Naming



Topic 3: Processes

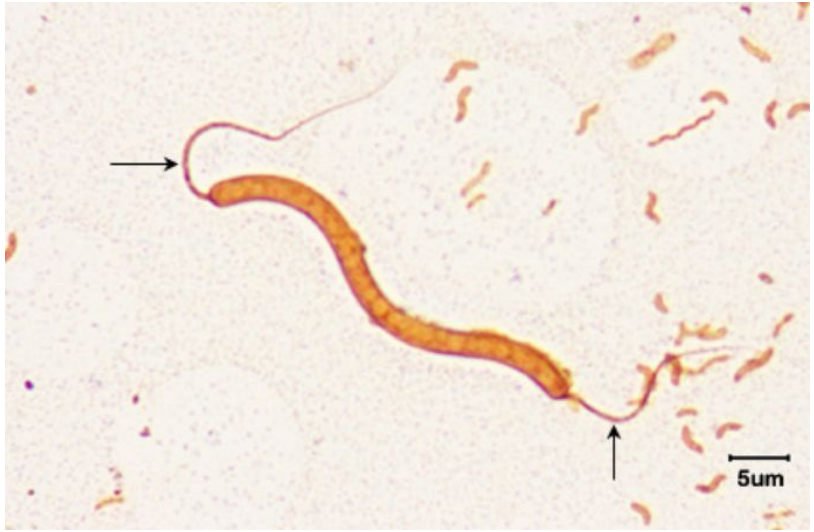


COMMON QUESTIONS

All of the following questions have been pulled from past YJI exams (which can be found on our website) or the Text Exchange on SciOly Wiki

Question 1

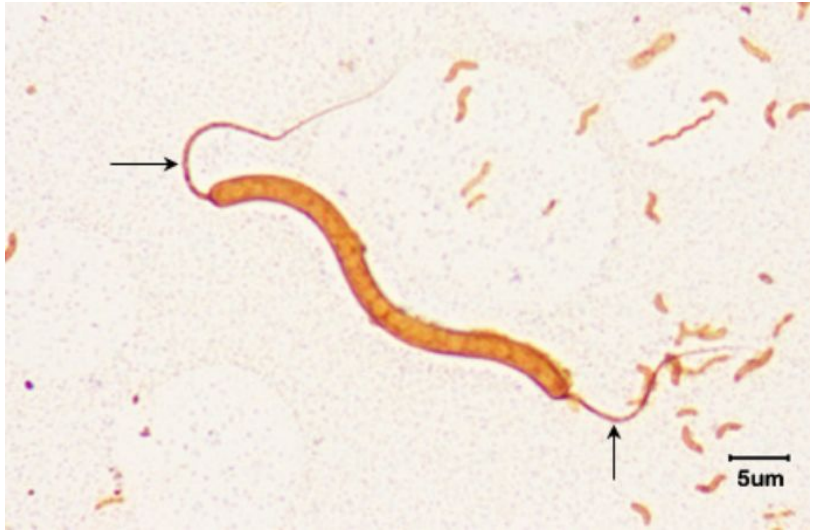
- **Name this type of flagellar arrangement.**
  - Monotrichous
  - Amphitrichous
  - Lophotrichous
  - Peritrichous



Question 1

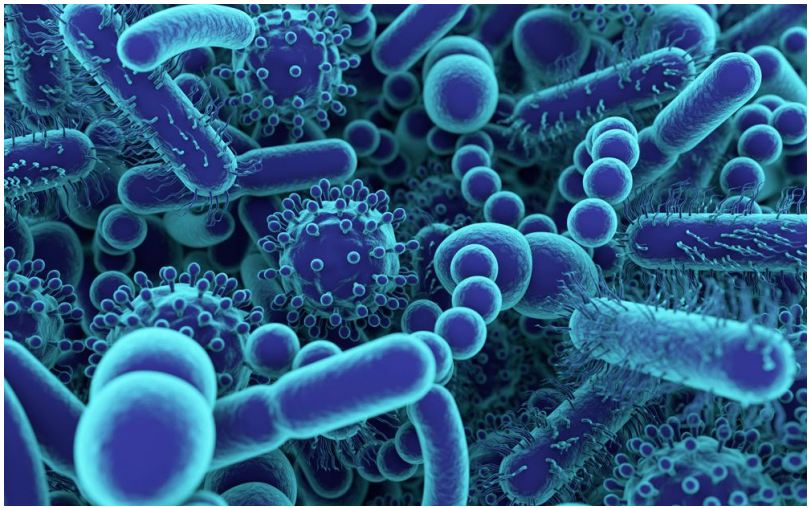
- **Name this type of flagellar arrangement**.
  - Monotrichous
  - **Amphitrichous**
  - Lophotrichous
  - Peritrichous

  - Amphitrichous bacteria have flagella on both ends of their body.



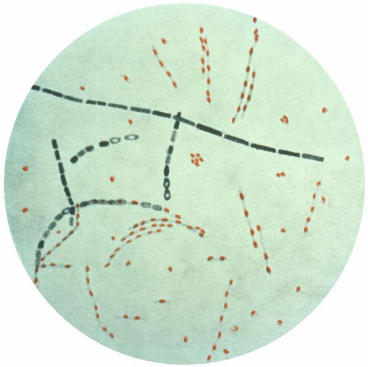
Question 2

- **Which of the following is NOT a viral disease?**
  - AIDS
  - Measles
  - Anthrax
  - Rubella



Question 2

- **Which of the following is NOT a viral disease?**
  - AIDS - caused by the human immunodeficiency virus (HIV)
  - Measles - caused by *Morbillivirus hominis*
  - **Anthrax - caused by *Bacillus anthracis***
  - Rubella - caused by *Rubivirus rubellae*



Question 3

- **Which of the following types of microscopy would most likely be used to view the insides of organelles?**
    - Darkfield
    - Scanning Electron
    - Transmission Electron
    - X-Ray
    - Phase Contrast
    - Differential Interference Contrast

Question 3

- **Which of the following types of microscopy would most likely be used to view the insides of organelles?**
    - Answer: **Transmission Electron**
    - Electron microscopy - High Resolution at High Magnification
    - Scanning Electron - Sees structure surface by reflecting electrons
    - Transmission Electron - Electrons pass through structures, visualizing internal structure

Question 4

- Given a stock protein solution with a concentration of 15 mg/ml, determine the protein concentration (in mg/ml) of a solution made by mixing 2 µL of the stock with 8 µL of a buffer.

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    - Answer: **3 mg/mL**
    - $V1 * M1 = V2 * M2$
    - $(2\ \mu L) * (15\ mg/mL) = (10\ \mu L) * (M2)$
    - $30 = 10 * M2$
    - **$M2 = 3\ mg/mL$**

More Example Q's

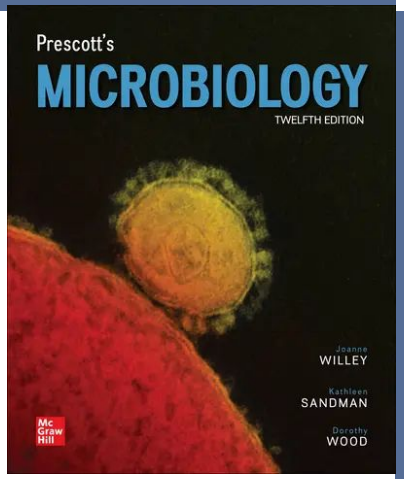
- If you want to find more example questions, head to the Scioly Wiki Test Exchange located at https://scioly.org/tests/.

Tips from a Veteran

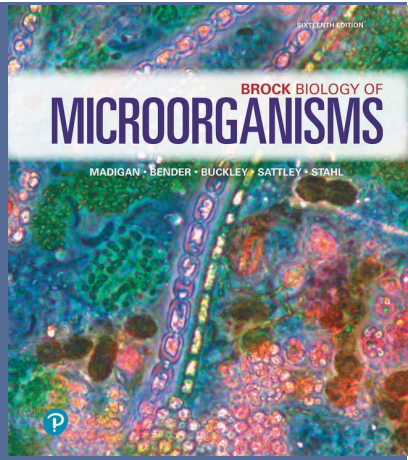
- Prepare well beforehand. Don't cram the information.
- Only include information on your notes sheet that you are sure you can't remember. The limited space is valuable!
- **Include images over words.**
- Be sure to practice several tests to learn how questions are asked.
    - **Tests v. Stations**
- **Study the classic microbiology textbooks -** many questions are usually based on the contents found in these books.

Additional Resources

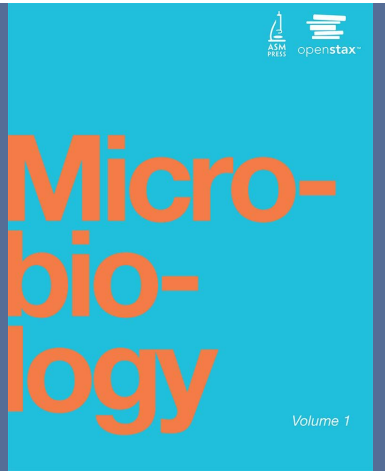
Prescott's Microbiology



Brock's Biology of Microorganisms



OpenStax Microbiology



Your Teachers!

THANKS!