

Equipment List and Tips for Running the Event

This equipment should be supplied by the college.

Stop watches or timer to time the stations.

Station A – microscope with 4X, 10X, and 40 X objectives
2 transparent mm rulers (6 inch)

Tips: You may want to print the answer sheet on one sheet front and back to make it easier for the teams.

Be sure to print the pictures in color.

It might be a good idea to put the questions, diagrams, and photos in protective sleeves and tape them to the table.

Putting arrows between stations will help student rotate. They can be made of masking tape.

There are 10 stations. 4 minutes per station is a good scheme. It will allow time for directions and handing out answer sheets at the beginning and collecting answer sheets at the end of the competition.

Use the Set Up Checklist to be sure you have everything at each station.

Be sure to grade all teams the same – give the benefit of the doubt to the students. You may count questions 2 points each if you wish to give partial credit where possible.

Be sure to break all ties – use questions where partial credit is possible to break ties.

If you have any questions, feel free to contact me
Karen Lancour - (989) 354-2547 or (989) 657-5206 cell

TEAM NUMBER _____
STATE _____
SCHOOL _____

STUDENT NAMES: (PLEASE PRINT)

1. _____
2. _____

RAW SCORE _____
RANK _____
POINTS _____

BE SURE TO INCLUDE APPROPRIATE UNITS WITH ALL ANSWERS!!!

STATION A: Microscopy

1. _____
2. _____
3. _____
4. _____
5. _____
6. _____
7. _____
8. _____
9. _____
10. _____

STATION D: Cell Types & Cycles

31. _____
32. _____
33. _____
34. _____
35. _____
36. _____
37. _____
38. _____
39. _____
40. _____

STATION B: Microscope Types

11. _____
12. _____
13. _____
14. _____
15. _____
16. _____
17. _____
18. _____
19. _____
20. _____

STATION E: Major Groups

41. _____
42. _____
43. _____
44. _____
45. _____
46. _____
47. _____
48. _____
49. _____
50. _____

Go to Station F-turn over answer sheet

STATION C: Relative Size

21. _____
22. _____
23. _____
24. _____
25. _____
26. _____
27. _____
28. _____
29. _____
30. _____

STATION F: Food Safety

- 51. _____
- 52. _____
- 53. _____
- 54. _____
- 55. _____
- 56. _____
- 57. _____
- 58. _____
- 59. _____
- 60. _____

STATION I: Microbes & Disease

- 81. _____
- 82. _____
- 83. _____
- 84. _____
- 85. _____
- 86. _____
- 87. _____
- 88. _____
- 89. _____
- 90. _____

STATION G: Analysis

- 61. _____
- 62. _____
- 63. _____
- 64. _____
- 65. _____
- 66. _____
- 67. _____
- 68. _____
- 69. _____
- 70. _____

STATION J: Dichotomous Keys

- 91. _____
- 92. _____
- 93. _____
- 94. _____
- 95. _____
- 96. _____
- 97. _____
- 98. _____
- 99. _____
- 100. _____

Go to Station A—turn over answer sheet

STATION H: Microbes & Ecology

- 71. _____
- 72. _____
- 73. _____
- 74. _____
- 75. _____
- 76. _____
- 77. _____
- 78. _____
- 79. _____
- 80. _____

TEAM NUMBER _____

STATE _____

SCHOOL _____

ANSWER KEY

STUDENT NAMES: (PLEASE PRINT)

1. _____
 2. _____

RAW SCORE _____

RANK _____

POINTS _____

BE SURE TO INCLUDE APPROPRIATE UNITS WITH ALL ANSWERS!!!

STATION A: Microscopy

- *1. _____ X to _____ X
 2. _____ toward 1 o'clock
 3. _____
 4. _____ focus thru object
 5. _____ L diaphragm
 6. _____ C nosepiece
 7. _____ F & G
 8. _____ ~1.6 mm ~1600 mcm
 9. _____ ~ 400 mcm
 10. _____ ~ 150 mcm

*Determine on site

STATION D: Cell Types & Cycles

31. _____ B A C
 32. _____ A B C
 33. _____ C
 34. _____ fungi, algae, protozoa
 35. _____ bacteria, Archaea
 36. _____ viruses, prions
 37. _____ log # of bacteria time
 38. _____ nonviable viable
 39. _____ D B
 40. _____ 1024

STATION B: Microscope Types

11. _____ A, D, F
 12. _____ B, E
 13. _____ C
 14. _____ B, E
 15. _____ A, D, F
 16. _____ C
 17. _____ F
 18. _____ D
 19. _____ E
 20. _____ A

STATION E: Major Groups

41. _____ B
 42. _____ G
 43. _____ E
 44. _____ D
 45. _____ B
 46. _____ F
 47. _____ C
 48. _____ G
 49. _____ E
 50. _____ A

Go to Station F-turn over answer sheet

STATION C: Relative Size

21. _____ 1000 mcm
 22. _____ 1000 nm
 23. _____ 1,000,000 nm
 24. _____ 3 mcm X 1 mcm
 25. _____ 16 mcm
 26. _____ 100
 27. _____ 16
 28. _____ 130,000 nm 800,000 nm
 29. _____ 4333
 30. _____ 26,667

STATION F: Food Safety

- *51. _____ degrees Celcius
- 52. _____ Psychrotrophs
- 53. _____ Mesophiles
- 54. _____ slows- crystallizes water
- 55. _____ kills - denatures protein
- *56. _____ pH of
- 57. _____ colas and ginger ale
- 58. _____ baking soda & lime water
- 59. _____ cheese & white bread
- 60. _____ 100 times more

* **Determine on site**

STATION I: Microbes & Disease

- 81. _____ F3
- 82. _____ D5
- 83. _____ C8
- 84. _____ C4
- 85. _____ C9
- 86. _____ B1
- 87. _____ A7
- 88. _____ E10
- 89. _____ C2
- 90. _____ B6

STATION G: Analysis

- 61. _____ 95 liters
- 62. _____ 1,000 billion
- 63. _____ 8 times more
- 64. _____ type of organism
- 65. _____ number of organisms
- 66. _____ lograthmic 10^2
- 67. _____ a drop
- 68. _____ about 10^4
- 69. _____ about 10^2
- 70. _____ methane

STATION J: Dichotomous Keys

- 91. _____ Spirogyra
- 92. _____ Diatom
- 93. _____ Spirula
- 94. _____ Anthrax
- 95. _____ Aspergillum
- 96. _____ Bread mold
- 97. _____ Stentor
- 98. _____ Lactobacillus
- 99. _____ Oscillatoria
- 100. _____ Dinoflagellate

Go to Station A-turn over answer sheet

STATION H: Microbes & Ecology

- 71. _____ Bacteria, Fungi, Protozoa
- 72. _____ Bacteria, Fungi
- 73. _____ Protozoa
- 74. _____ Bacteria
- 75. _____ Type of Soil Organism
- 76. _____ Biomass in tons per acre
- 77. _____ Shortgrass prarie 13tons
- 78. _____ Scotch pine forest ~2tons
- 79. _____ Bacteria
- 80. _____ Bacteria and fungi

Station A: Microscopy

For Questions 1-4 use to the compound microscope, the clear mm rulers, slide with FJ.

1. What is the **range of magnification** for this microscope (**lowest to highest**)?
2. Using the hands of the clock to describe objects under the field of view, what direction will an organism **actually be moving** if it appears to be moving **toward 7 o'clock**?
3. A student prepares a slide with the letters **"FJ"** and positions it on the stage in the normal reading position. When viewed, how will the **"FJ "** will appear? Draw it on your answer sheet.
4. On this light microscope, only two dimensions are visible. How is the third dimension of a specimen determined?

For questions 5-7, use the diagram of the microscope.

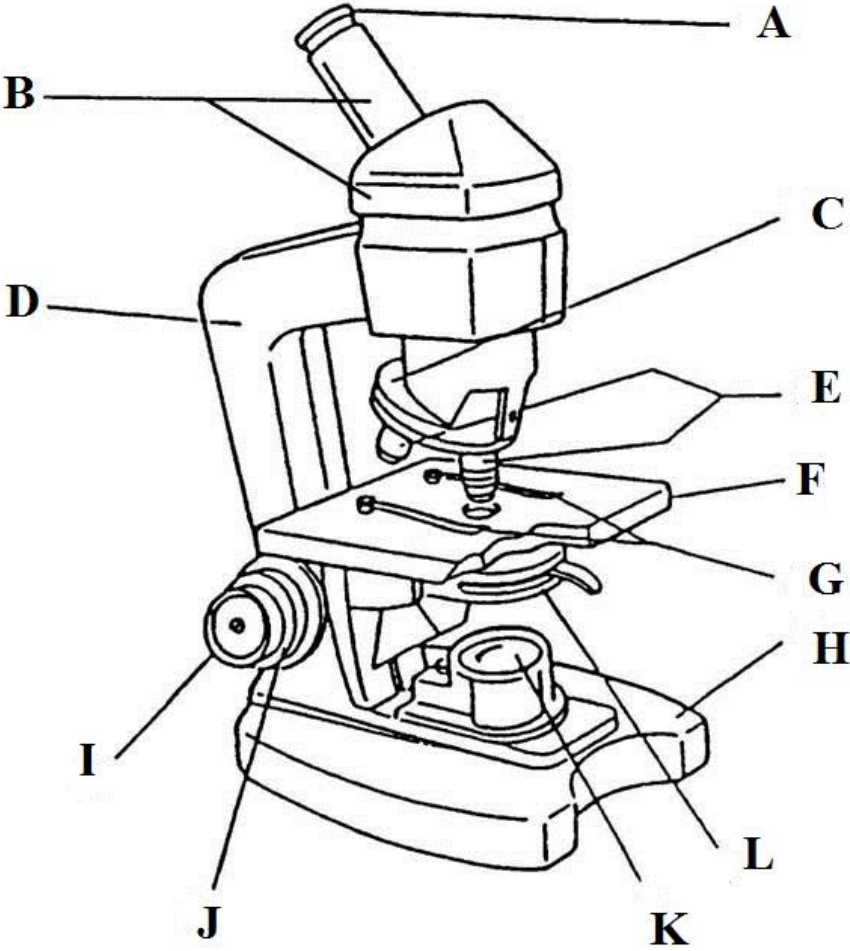
5. Give the **letter from the diagram** of the part of the microscope which adjusts the amount of the light reaching the specimen. What is the **name** of this part?
6. Give the **letter from the diagram** of the part of the microscope which allows you to change objectives. What is the **name** of this part?
7. Give the **letters from the diagram** of the parts of the microscope which support the slide and hold it in place.

For Questions 8-10 use the diagram of the stage with mm ruler and photo of Paramecium and the transparent mm ruler.

8. Examine the **diagram of the stage with the millimeter ruler** from a 10X objective. What is the diameter of this field of view **in millimeters? in micrometers or mcm?** (Note: the space between line at the edge and the line in view is 1 mm.)
9. What would be the diameter of the 40X field of view based upon diameter of the 10X objective from question # 8 in millimeters? **in micrometers or mcm?**
(Remember: it must be calculated using the diameter from question # 8 and the ratio of magnification (1/4) because it is less than 1 mm)
10. Examine the Photo of **Paramecium**. Assume that the length of the photo is the same as the diameter of the **40X** field of view calculated in question 5, what is the length of the paramecium **labeled A** in **micrometers or mcm?**

Station A: Microscopy

Diagram of the Microscope



Station A: Microscopy

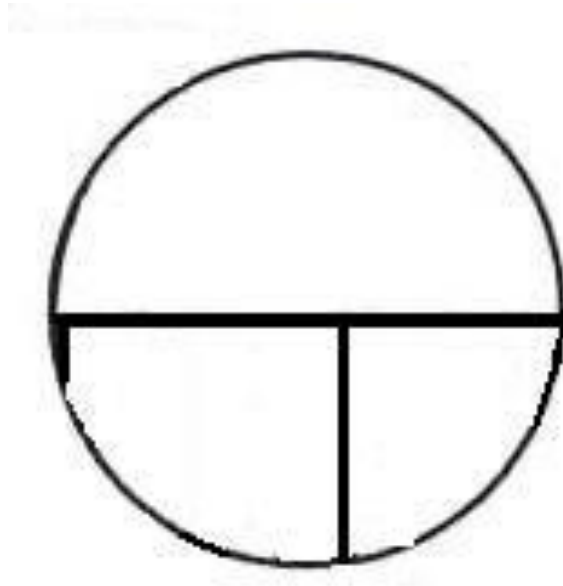
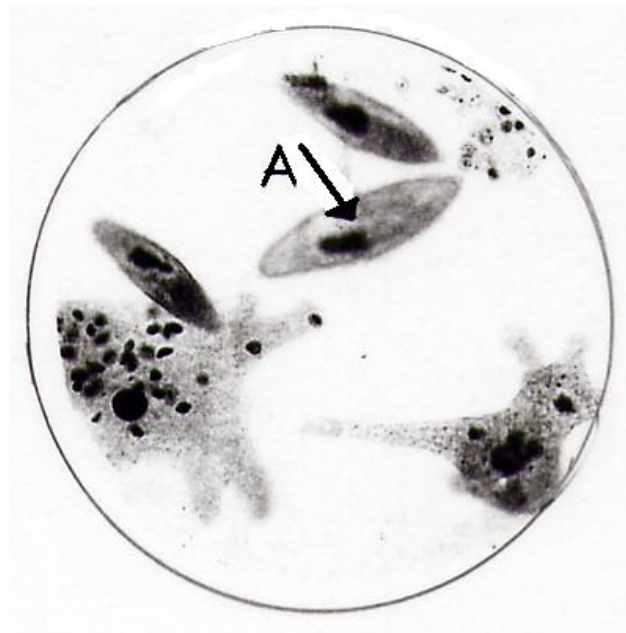


Diagram of Stage with millimeter ruler (10X objective)



Paramecium (40X objective)

Station B: Types of Microscopes

- Key:**
- A. Light microscope**
 - B. Scanning Electron Microscope**
 - C. Florescent Microscope**
 - D. Phase Contrast Microscope**
 - E. Transmission Electron Microscope**
 - F. Dark Field Microscope**

Use the above key in answering questions 11-15. There may be more than one answer

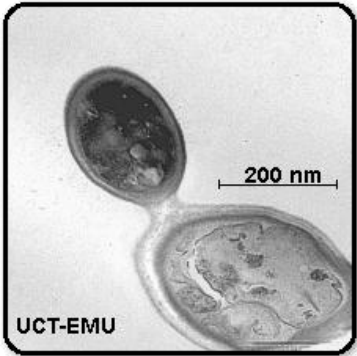
11. Which **microscopes** use **light** as a source of illumination?
12. Which **microscopes** use **electrons** as a source of illumination?
13. Which **microscopes** use **ultraviolet rays** as a source of illumination?
14. Which **microscopes** can be used to observe **images of viruses**?
15. Which **microscopes** can be used to observe a **live Volvox colony**?

Use images A-F in answering questions 16-20.

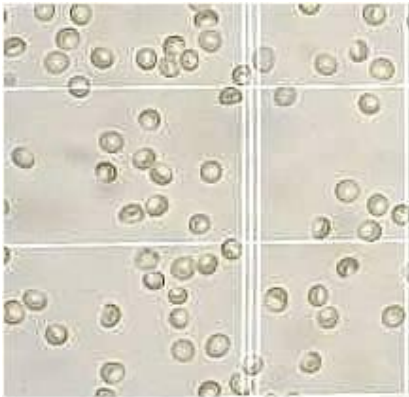
Each image is of yeast taken from a different type of microscope.

16. Which image is from a **scanning electron microscope**?
17. Which image is from a **dark field microscope**?
18. Which image is from a **phase contrast microscope**?
19. Which image is from a **florescent microscope**?
20. Which image is from a **transmission electron microscope**?

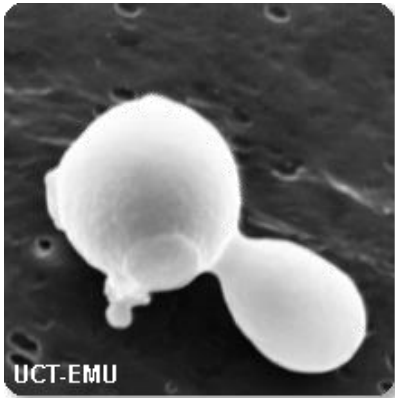
Station B: Types of Microscopes



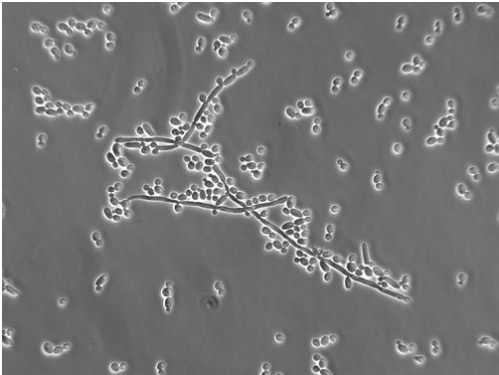
A



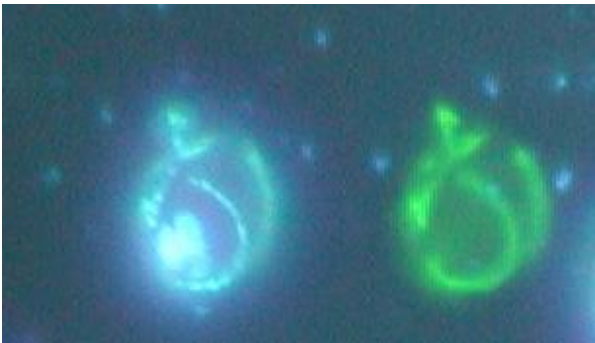
B



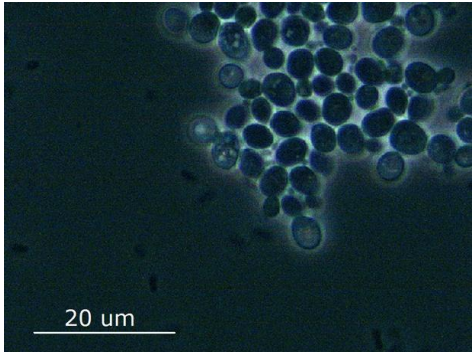
C



D



E



F

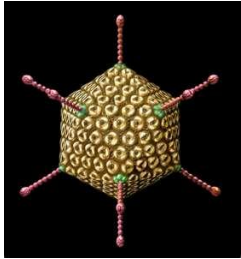
Station C: Relative Size of Microbes

21. How many micrometers (**mcm**) are in a millimeter (**mm**)?
22. How many nanometer (**nm**) are in a micrometers (**mcm**)?
23. How many nanometers (**nm**) are in a millimeter (**mm**)?

Use the images provided in answering questions 24-30. Conversions may be necessary. Be sure to use appropriate units.

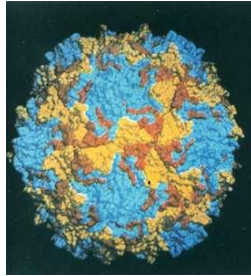
24. What are the dimensions of *E. coli* in micrometers (**mcm**)?
25. What is the diameter of a red blood cell in micrometers (**mcm**)?
The dimension given below the picture is for diameter.
26. How many poliovirus would fit along the length of an *E. coli* if they were placed in a line?
27. How many *E. coli* could fit along the diameter of a red blood cell if they were lined up side by side (width dimension)?
28. What is the length of the *Euglena* in nanometers (**nm**)?
What is the diameter of the *Volvox* colony in nanometers (**nm**)?
29. How many poliovirus would fit along the length of the *Euglena*?
Round off to the nearest whole number.
30. How many poliovirus would fit along the diameter of the *Volvox* colony? *Round off to the nearest whole number.*

Station C: Relative Size of Microbes



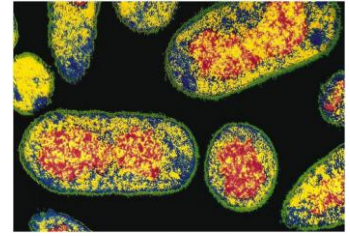
Adenovirus

90 nm



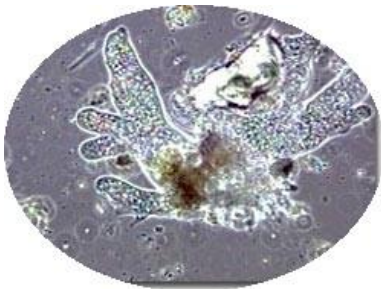
Polio virus

30 nm



E. coli

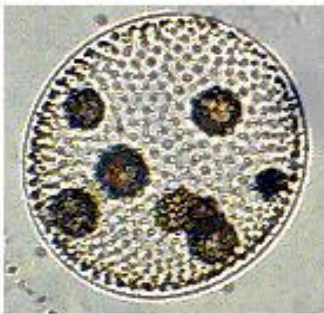
3000 x 1000 nm



Amoeba - 500 mcm



Euglena - 130 mcm long



Volvox - 800 mcm



Human red blood cell

16,000 nm

Station D: Cell Types and Life Cycles

For questions 31-33, use Diagrams A, B, and C.

31. Using the letters from the Diagrams, list the letter of the **prokaryotic cell** first, then the letter for the **acellular structure**, and finally the letter for the **Eukaryotic cell**.
32. List the letter(s) of the diagrams which would have **DNA or RNA**.
33. List the diagram letter(s) that would have membrane bound organelles.

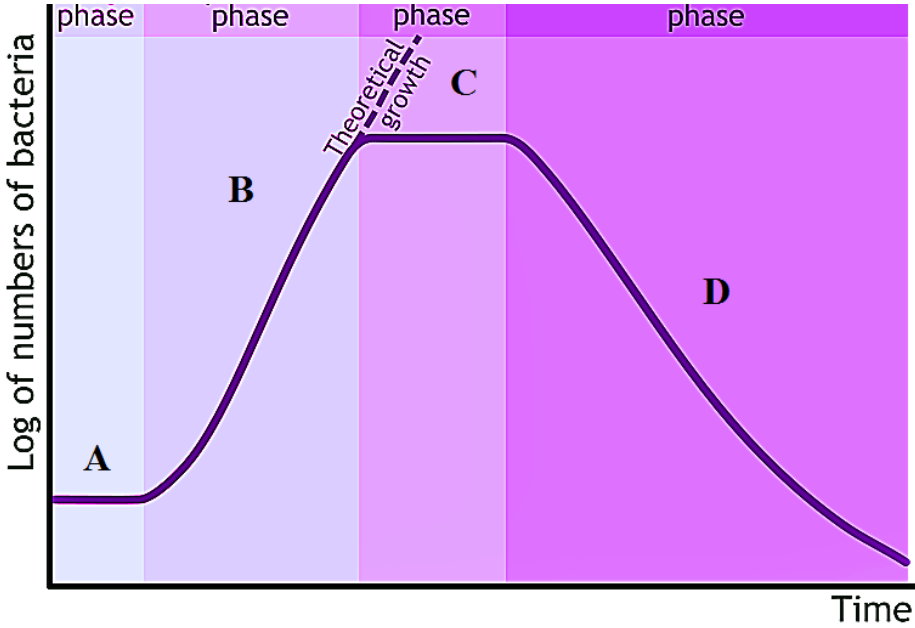
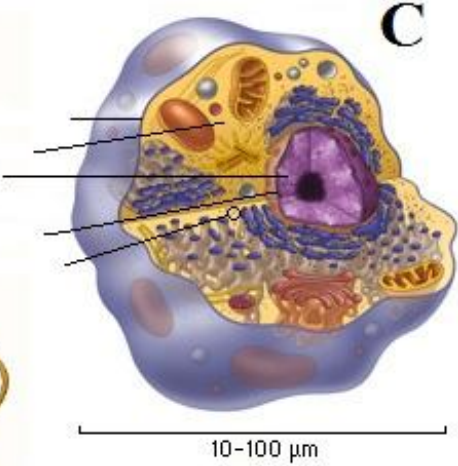
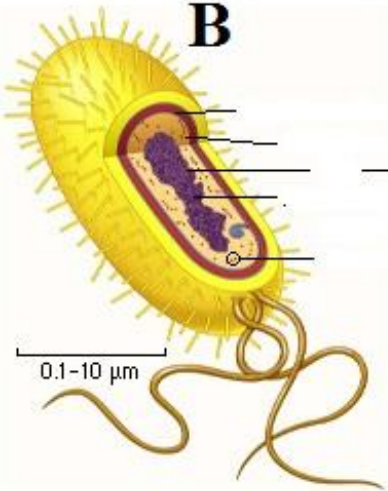
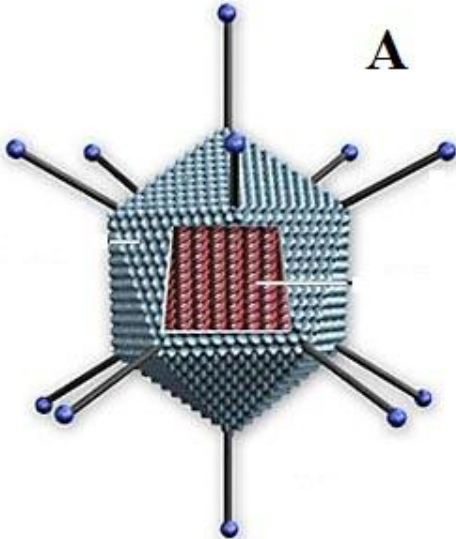
For questions 34-36, use the following groups of microbes - *bacteria, Archaea, fungi, algae, protozoa, viruses, prions*

34. Which groups of microbes are **eukaryotic**?
35. Which groups of microbes are **prokaryotic**?
36. Which groups of microbes are **acellular**?

For questions 37-40, use the Life Cycle Graph

37. What is the **dependent variable** for this graph? The **independent variable**?
38. Which cells would be dead? (viable or nonviable)
Which cells would be living? (viable or nonviable)
39. Which area on the graph (A,B,C,D) represent the greatest **increase in nonviable cells**? Which area on the graph (A,B,C,D) represent the **greatest increase in viable cells**?
40. If you started with one bacterium and it reproduced every 30 minutes without any cells dying, how many bacteria would be present after **5 hours (10 reproductions)**?

Station D: Cell Types and Organelles



Station E: Major Groups of Microbes

Major Group

- A. Prion**
- B. Archeae**
- C. Bacteria**
- D. Fungi**
- E. Algae (Plant-like protists)**
- F. Protozoa (Animal-like protists)**
- G. Virus**

For questions 41-50, use the above key to identify the appropriate group of microbes being described.

- 41.** Some species are extremophiles - living in extremes of pH, temperature, salinity as well as heat, acid and toxic gases. May be the most primitive forms of life - important in waste treatment but not known to cause disease
- 42.** Cluster of DNA or RNA encased in a protein
- 43.** Have cell walls and chloroplasts - primary producers in many aquatic environments
- 44.** Important decomposers - Eukaryotic heterotrophs
- 45.** Similar to bacteria in many characteristics but not are known to cause disease.
- 46.** Feed on bacteria or phytoplankton in the water, many have food vacuoles
- 47.** Some species of these prokaryotic cells have chlorophyll but not in chloroplasts and are primary producers in many aquatic environments.
- 48.** Must use the cell machinery of the host cell to reproduce
- 49.** Diatoms are this type of microbe - their shells are mined as abrasives
- 50.** Proteinaceous infectious particles

Station F: Microbes and Food

For questions 51-55, use the temperature probe and background on temperature.

51. Using the Easy temp probe, determine and record the **temperature** of **Solution A**.
52. Which type of microbe would live best in solution A?
53. Which type of microbe would live best in the human body?
54. What does **freezing** do to the microbes in food? Why?
55. What does **boiling** do to the microbes in food? Why?

For questions 56-60, use the pH probe and background on pH.

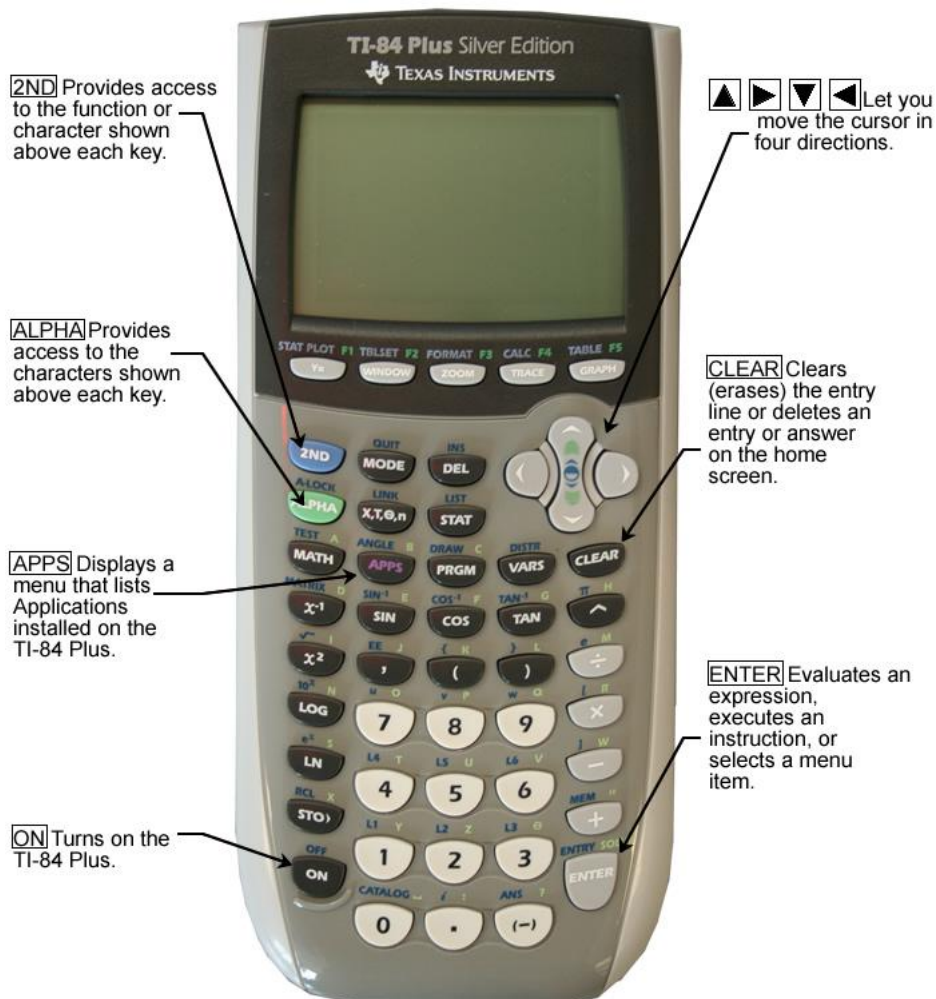
56. Using the pH probe, determine and record the **pH** of **Solution A**.
57. List the two **most acidic** foods on the pH of common foods list.
58. List the two **most basic** foods on the pH of common foods list.
59. From the following foods, which foods would be perfect candidates for mold growth? (Cheese, yogurt, eggs, white bread)
60. How many times more hydrogen ions are in a pH of 3 than a pH of 5?

Station F: Microbes and Food

Using the pH probe

Note: Steps 1-6 have been done for you.

1. Before each use of the pH Sensor, you need to rinse the tip of the sensor thoroughly with distilled water. Raise the pH Sensor from the sensor soaking solution and set the solution aside. Use a wash bottle filled with distilled water to thoroughly rinse the pH Sensor. Catch the rinse water in the second beaker or cup. **Important:** Do not let the pH Sensor dry out. Place it in the **holding beaker** with 100 mL of distilled water. The tip of the sensor is made of glass—it is fragile. Handle with care!
2. Turn on the calculator. Connect the pH Sensor to EasyLink interface and the EasyLink to the calculator. (With EasyLink the calculator will automatically launch EasyData and detect the sensor.)
3. Set up the data-collection mode.
4. Start the EasyData application, if it is not already running.
5. Select from the Main screen, and then select **New** to reset the application.
6. Select from the Main screen, and then select **Events with Entry**.
7. Place the pH sensor in **beaker A** and determine the pH of the solution.
8. Rinse the pH sensor with distilled water and place it back in the **holding beaker** of distilled water.

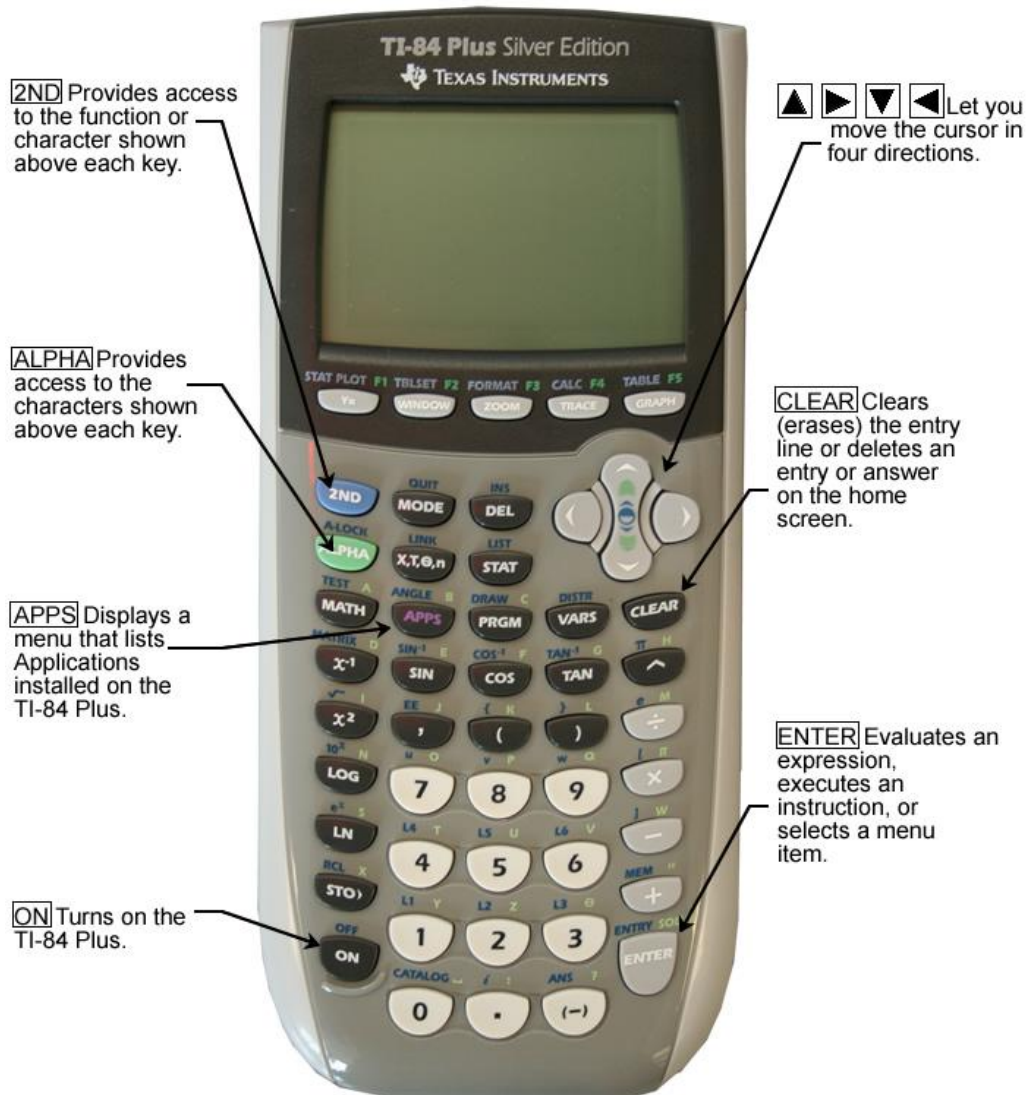


Station F: Microbes and Food

Using the Easy Temp Probe

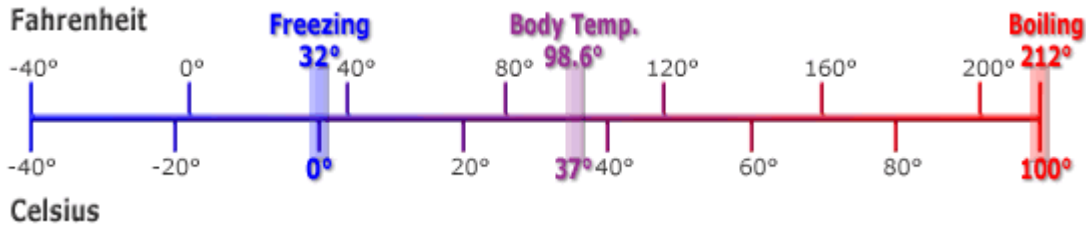
Note: Steps 1-3 have been done for you.

1. Turn the TI-84 Plus calculator on, and display the home screen (a flashing dark square in upper right corner). If another application is open select **Quit** and/or **Clear** to get the home screen.
2. Connect the EasyTemp sensor to the calculator. After a few seconds, the EasyData main screen is displayed. The screen shows the current EasyData mode and the current sensor reading.
3. Select **File** and then the option **New**.
4. Measure the temperature of the lab.
 - Watch the temperature until the temperature levels off.
 - Record the highest temperature to the nearest 0.1°C.



Station F: Microbes and Food

Temperature Conversion Charts



Fahrenheit	Celsius
-40°F	-40°C
-22°F	-30°C
-20°F	-28.9°C
-10°F	-23.3°C
-4°F	-20°C
0°F	-17.8°C
10°F	-12.2°C
14°F	-10°C
20°F	-6.7°C
30°F	-1.1°C
32°F	0°C
40°F	4.4°C
50°F	10°C
60°F	15.6°C
68°F	20°C
70°F	21.1°C
80°F	26.7°C
86°F	30°C
90°F	32.2°C
100°F	37.8°C

Fahrenheit	Celsius
104°F	40°C
110°F	43.3°C
120°F	48.9°C
122°F	50°C
130°F	54.4°C
140°F	60°C
150°F	65.6°C
158°F	70°C
160°F	71.1°C
170°F	76.7°C
176°F	80°C
180°F	82.2°C
190°F	87.8°C
194°F	90°C
200°F	93.3°C
210°F	98.9°C
212°F	100°C
220°F	104.4°C
230°F	110°C
240°F	115.6°C

Classification of microbes based on temperature

- **Psychrophiles** can grow at 0° C but optimum is about 15° C.
- **Psychrotrophs** can grow at 0° C also but optimum is 20 - 30° C – important in food spoilage.
- **Mesophiles** grow best at moderate around 37° C – many pathogens fall in this category.
- **Thermophiles** have a growth optimum at around 60° C.
- **Hyperthermophiles** have growth optima of 80° C or higher (Archaea).

Station F: Microbes and Food

Most bacteria grow best at a pH of 6.5 - 7.5 (neutral or near neutral).

Most bacteria do not grow at all below a pH of about 4 but a few do tolerate acidity.

Molds and yeasts prefer a pH of 5 - 6, but tend to grow at least some over a wide range of pH.

Acid foods usually do not undergo bacterial spoilage. Alkalinity could also be used to preserve food, but high pH tends to make foods bitter and slimy, so this method of preservation is not desirable.

pH of Common Foods

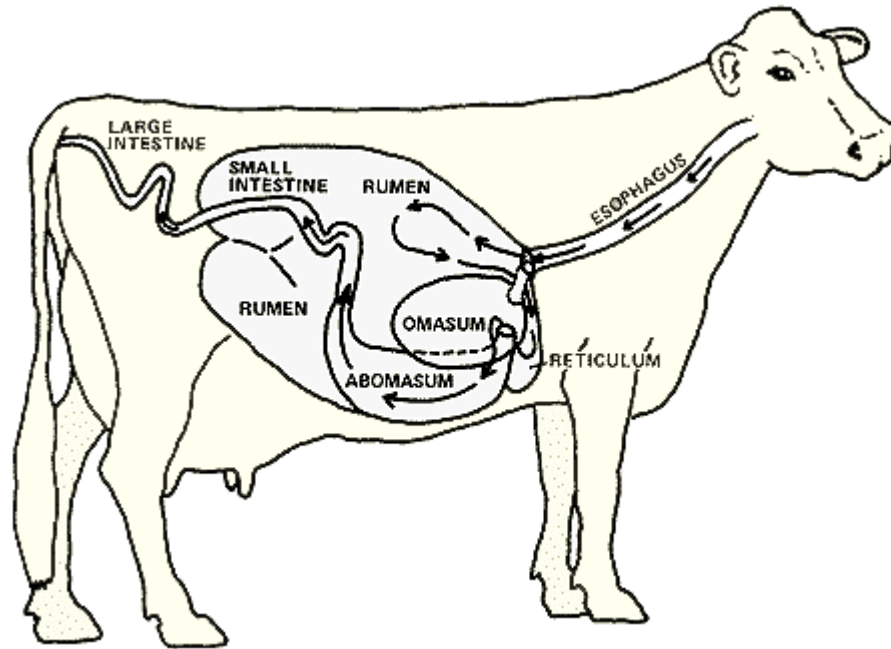
Common Foods	pH
Baking Soda	8.0 - 8.2
Beef	5.3 - 6.2
Chicken	5.5 - 6.4
Cheese	5.0 - 6.1
Colas	2.3 - 3.2
Distilled Water	7.0
Eggs	7.6 - 8.0
Ginger Ale	2.0 - 3.0
Hot Dogs	6.2 - 6.3
Kidney Beans	5.2 - 5.4
Limewater	12.0 - 12.4
Milk	6.6 - 6.8
Orange Juice	3.0 - 4.0
Potatoes - white	5.4 - 6.3
Soda Crackers	7.5 - 8.5
Tomato Juice	4.2 - 4.5
White Bread	5.0 - 6.0
Yogurt	3.8 - 4.2

Station G: Analysis

Use the background information and the graph to answer the following questions about the role of microbes in the cow digestion.

61. How many liters of food and fluid can be held in the rumen of a cow?
62. According to Prescott, Harley and Klein, how many billion of microbes are found per milliliter of rumen fluid?
63. Using the data given in the background, calculate the number of times more microbes are in a drop of rumen fluid than the total population of the world in 2008.
Round off to the nearest whole number.
64. What is the independent variable for the graph?
65. What is the dependent variable for the graph?
66. What type of scale is used for the data and what is the value of each increment or graduation labeled on the graph?
67. What amount of rumen does the data on the graph represent? (a drop, a milliliter, or the whole rumen)
68. According to the graph data, about how many more bacteria are there than fungi?
69. According to the graph data, about how many more bacteria are in the sample than the number of humans in the human population?
70. What do the Archaea in the rumen produce?

Station G: Analysis



The ruminant digestive tract ([University of Minnesota](#), 1996), showing the rumen, where most cellulose digestion takes place.

How many microbes live in the rumen?

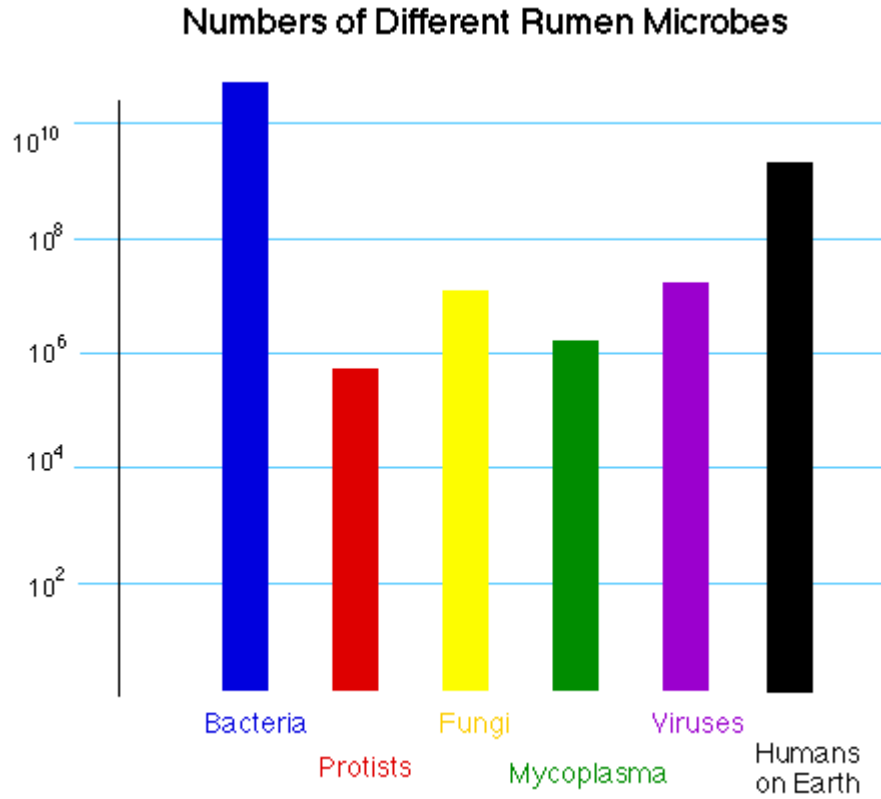
The number of microbes in one drop of rumen fluid is more than 10 times bigger than the number of people on Earth! (If there are 10^{12} microbes in 1ml of fluid, then 1 drop (1/20ml) contains 50,000,000,000. And 2008 data from the US Census Bureau tell us that there are around 6,602,000,000 people on Earth.)

That's a lot of microbes - about one thousand billion, or 10^{12} , or 1,000,000,000,000 organisms per millilitre (Prescott, Harley & Klein, 2005). The rumen may hold up to 95 litres of food & fluid.

There are all sorts of different types of microbes in the rumen, such as viruses, fungi, bacteria and protozoans. There are also some Archaea produce methane. Mycoplasma are bacteria without a cell wall.

Station G: Analysis

A cow rumen is home to billions and billions of microbes. These many different rumen microbes form a complex community of organisms that interact with one another, helping the animal digest its food.



Data courtesy of Mel Yokoyama, Michigan State University

This graph shows the relative numbers of different microbes in a cow's rumen. The scale on the left is logarithmic. The total number of humans on Earth is given as a comparison.

Station H: Microbes and Ecology

For Questions 71 - 74, examine the Soil Food Web.

71. List the groups of microbes that are present in the Soil Food Web?
72. Which of the microbes in the Soil Food Web act as decomposers?
73. Which group of microbes eat living organisms?
74. What do they eat?

For Questions 75 - 80, examine the Biomass of Soil Organisms

75. What is the independent variable of this graph?
76. What is the dependent variable of this graph?
77. Which ecosystem has the most bacteria? How much?
78. Which ecosystem has the most fungi? How much?
79. What organisms are increased the most by tilling the ag system near Athens Georgia?
80. Which organisms in these 4 ecosystems are responsible for decomposition of dead organisms and recycling nutrients into the soil?

Station H: Microbes and Ecology

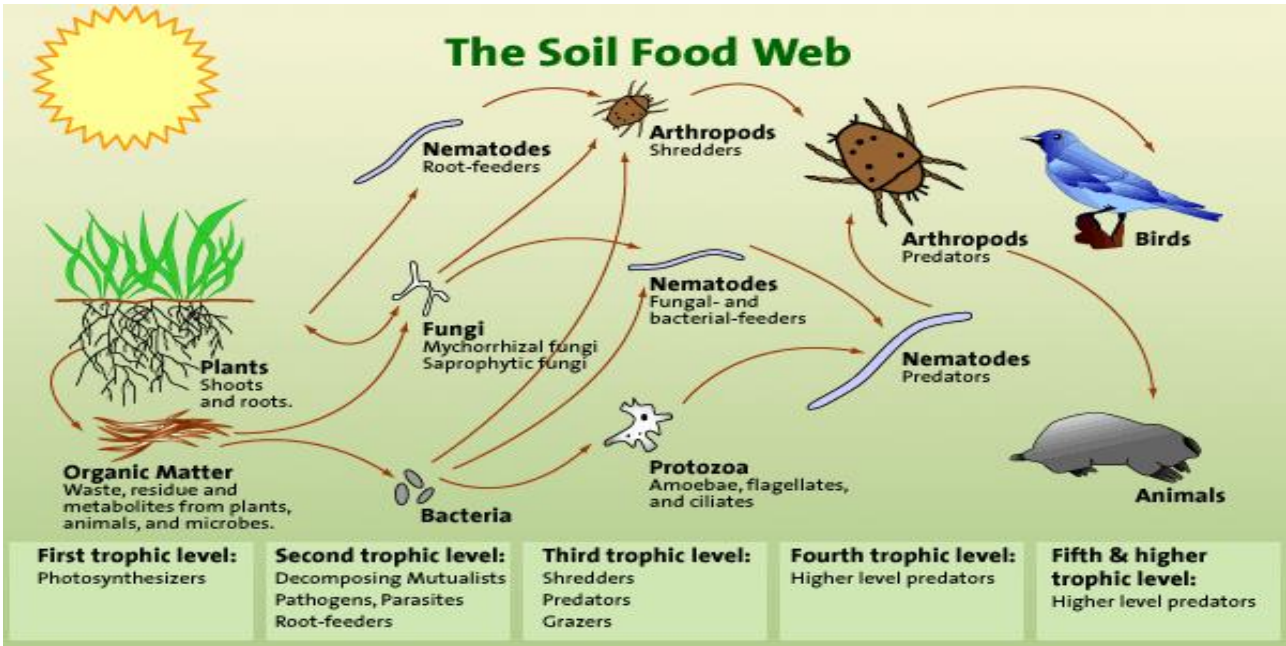


Figure 1

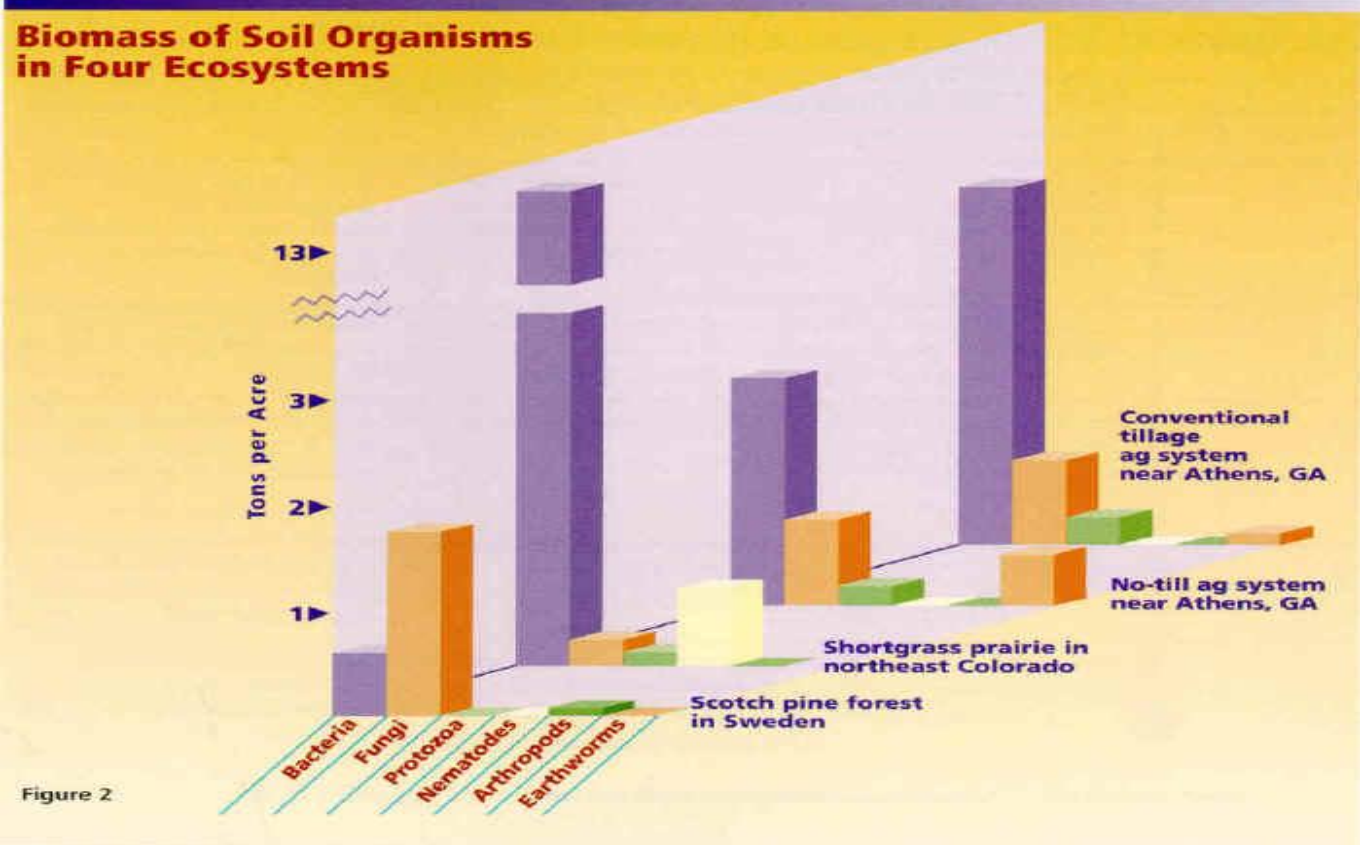


Figure 2

Station I: Microbes and Disease

Key: Microbe

- A. Fungi
- B. Virus
- C. Bacteria
- D. Protozoan
- E. Prion
- F. Parasitic worms

Key: Disease

- 1. Rabies
- 2. Pertusses (whooping cough)
- 3. Trichinosis
- 4. Crown Gall Disease
- 5. Malaria
- 6. Polio
- 7. Thrush
- 8. Botulism
- 9. Legionnaires
- 10. Mad Cow Disease

For each of the described diseases, **first** list the appropriate **letter** for the microbe from the Microbe Key that causes the disease and **then** list the **number** for the Disease Name from the Disease Key (such as A5)

- 81. Intestinal parasite ingested from undercooked meat esp. pork
- 82. Microbe spread through mosquito bites - attack red blood cells
- 83. Food poisoning caused by microbial produced neurotoxin
- 84. Most common plant disease forming galls on roots and stems
- 85. Acute respiratory disease from inhaling infected water droplets often from water systems
- 86. Deadly infection of the brain spread through bites from infected animals
- 87. Infection of the mouth, throat, and tongue forming white spots
- 88. Neurodegenerative disease caused by piece of protein
- 89. Highly contagious disease characterized by uncontrollable, violent coughing
- 90. Highly infectious disease which invades the nervous system and may cause paralysis

Station J: Dichotomous Key

For questions 91-100, Identify the MICROBE specimen & give the name from the key

91. What is specimen **A**?
92. What is specimen **B**?
93. What is specimen **C**?
94. What is specimen **D**?
95. What is specimen **E**?
96. What is specimen **F**?
97. What is specimen **G**?
98. What is specimen **H**?
99. What is specimen **I**?
100. What is specimen **J**?

Station J: Dichotomous Key

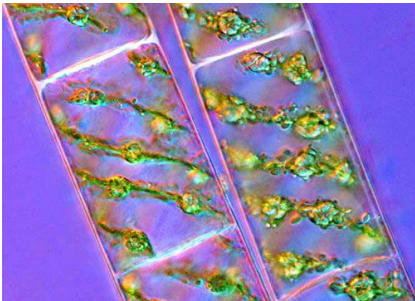
DICHOTOMOUS KEY FOR SELECTED MICROBES

- 1. Microbe is trumpet shaped with cilia **Stentor**
- 1. Microbe is not trumpet shaped **2**
- 2. Microbe has stalk with circular region at end of stalk **3**
- 2. Microbe does not have a stalk **4**
- 3. Circular region atop stalk is black **Bread mold**
- 3. Circular region atop stalk has green circles **Aspergillum**
- 4. Microbe is filamentous **5**
- 4. Microbe is not filamentous **6**
- 5. Filamentous cells have chlorophyll in chloroplasts **Spirogyra**
- 5. Filamentous cells have chlorophyll spread through cytoplasm **Oscillatoria**
- 6. Microbe is rod shaped **Lactobacillus**
- 6. Microbe is not rod shaped **7**
- 7. Microbe looks like a coiled spring **Spirula**
- 7. Microbe is not coiled **8**
- 8. Microbe is spherical or oval shaped **9**
- 8. Microbe has 4 long prongs from a central region **Dinoflagellate**
- 9. Microbe is spherical with many small bumps on surface **Anthrax**
- 9. Microbe is oval shaped with a silica shell **Diatom.**

Station J: Dichotomous Key

SELECTED MICROBES

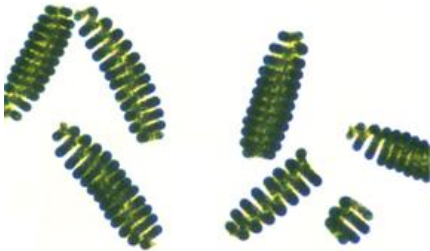
A



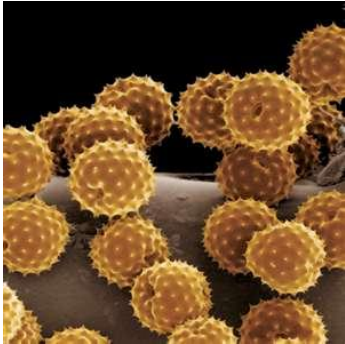
B



C



D



E



F



Station J: Dichotomous Key

SELECTED MICROBES

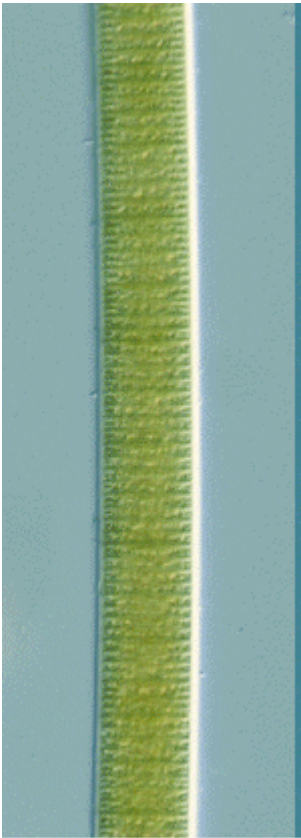
G



H



I



J

