

**MULTIPLE CHOICE. Choose the one alternative that best completes the statement or answers the question.**

- 1) Antoni van Leeuwenhoek was the first person in history to \_\_\_\_\_  
A) disprove spontaneous generation.  
B) use a magnifying glass.  
C) develop a taxonomic system.  
D) view protozoa and bacteria.  
E) prove the germ theory.
- 2) The microbes commonly known as \_\_\_\_\_ are single -celled eukaryotes that are generally motile.  
A) viruses            B) bacteria            C) fungi            D) protozoa            E) archaea
- 3) Which of the following statements about algae is FALSE?  
A) They are a source of food for aquatic and marine animals.  
B) They provide most of the oxygen on Earth.  
C) They are important in the degradation of dead plants and animals.  
D) They are photosynthetic organisms.  
E) The group includes seaweeds and kelps.
- 4) Microbes that can live in the presence or absence of oxygen are called \_\_\_\_\_  
A) obligate parasites.  
B) prokaryotes.  
C) facultative anaerobes.  
D) anaerobes.  
E) archaea.
- 5) Which of the following scientists provided evidence in favor of the concept of spontaneous generation?  
A) Buchner  
B) Spallanzani  
C) Pasteur  
D) Needham  
E) Redi
- 6) The microbial production of alcohol from sugar is known as \_\_\_\_\_  
A) fermentation.  
B) abiogenesis.  
C) metabolism.  
D) antisepsis.  
E) pasteurization.

- 7) Which of the following statements about fungi is FALSE? 7) \_\_\_\_\_
- A) Molds form hyphae.
  - B) Fungi have a cell wall.
  - C) Yeasts are unicellular.
  - D) Fungi are photosynthetic.
  - E) Fungi are eukaryotes.
- 8) Which of the following statements concerning Koch's postulates is FALSE? 8) \_\_\_\_\_
- A) All of Koch's postulates must be satisfied before an organism can be proven to cause a particular disease.
  - B) Koch's postulates involve the experimental infection of susceptible hosts.
  - C) A suspected pathogen must be able to be grown in the laboratory.
  - D) Koch's postulates cannot be used to demonstrate the cause of all diseases.
  - E) A suspected pathogen must be found in the majority of individuals with a particular disease.
- 9) Which of the following individuals pioneered the use of chemicals to reduce the incidence of infections during surgery? 9) \_\_\_\_\_
- A) Snow
  - B) Semmelweis
  - C) Nightingale
  - D) Ehrlich
  - E) Lister
- 10) The study of the body's defenses against pathogens is called 10) \_\_\_\_\_
- A) immunology.
  - B) chemotherapy.
  - C) epidemiology.
  - D) molecular biology.
  - E) etiology.
- 11) Which of the following questions largely stimulated the research of microbes during what is known as the Golden Age of Microbiology? 11) \_\_\_\_\_
- A) What causes disease?
  - B) How are microbes related?
  - C) Is spontaneous generation of microbes possible?
  - D) How do genes work?
  - E) What causes disease, and is spontaneous generation of microbes possible?
- 12) The microbial activity of \_\_\_\_\_ is responsible for the production of various foods. 12) \_\_\_\_\_
- A) bacteria
  - B) protozoa
  - C) fungi
  - D) archaea
  - E) both fungi and bacteria
- 13) What scientist first hypothesized that gene sequences could provide new insights into evolutionary relationships between organisms such as microbes? 13) \_\_\_\_\_
- A) Woese                  B) Ehrlich                  C) Pauling                  D) Avery                  E) Kluyver

- 14) Work by \_\_\_\_\_ laid the foundations of the field of environmental microbiology. 14) \_\_\_\_\_  
A) Lister and Semmelweis  
B) Redi and Spallanzani  
C) Pauling and Woese  
D) Koch and Pasteur  
E) Beijerinck and Winogradsky
- 15) According to Kluver and van Niel, which of the following are true of basic biochemical reactions? 15) \_\_\_\_\_  
A) Basic biochemical reactions shared by all living things primarily involve transfer of electrons and hydrogen ions.  
B) They primarily involve transfers of chemical groups.  
C) There are an unlimited number of them.  
D) They are shared by all living things.  
E) They primarily involve the transfer of electrons and ions.
- 16) Semmelweis advocated handwashing as a method of preventing which of the following diseases? 16) \_\_\_\_\_  
A) cholera  
B) syphilis  
C) anthrax  
D) puerperal fever  
E) smallpox
- 17) Paul Ehrlich used chemotherapy to treat 17) \_\_\_\_\_  
A) cancer.                      B) syphilis.                      C) smallpox.                      D) anthrax.                      E) cholera.
- 18) Which of the following is NOT a characteristic of viruses? 18) \_\_\_\_\_  
A) They are smaller than prokaryotic cells.  
B) They are visible with a light microscope.  
C) They are obligatory parasites.  
D) They are acellular.  
E) They are composed of genetic material and protein.
- 19) The first true vaccine protected against disease caused by a \_\_\_\_\_ pathogen. 19) \_\_\_\_\_  
A) protozoal                      B) viral                      C) bacterial                      D) archaeal                      E) fungal
- 20) All of the following individuals were involved in improving public health in the 19th century EXCEPT 20) \_\_\_\_\_  
A) Snow.  
B) Lister.  
C) Nightingale.  
D) Semmelweis.  
E) Spallanzani.
- 21) *Saccharomyces cerevisiae* is an example of which of the following types of microbes? 21) \_\_\_\_\_  
A) protozoan  
B) prokaryote  
C) alga  
D) fungus  
E) virus

- 22) Inserting a gene from the hepatitis B virus into yeast so that the yeast produces a viral protein is an example of 22) \_\_\_\_\_
- A) gene therapy.
  - B) immunology.
  - C) genetic engineering.
  - D) microbial genetics.
  - E) etiology.
- 23) Which of the following was NOT an aspect of Pasteur's experiments to disprove spontaneous generation? 23) \_\_\_\_\_
- A) He boiled the infusions to kill any microbes present.
  - B) The necks of the flasks he used were bent into an S-shape.
  - C) The flasks were incubated for very long periods of time.
  - D) The flasks he used were sealed with corks.
  - E) The flasks were free of microbes until they were opened.
- 24) Proteins that promote chemical reactions in the cell are called 24) \_\_\_\_\_
- A) genes.
  - B) flagella.
  - C) enzymes.
  - D) spores.
  - E) protozoa.
- 25) Which of the following is NOT a characteristic of protozoa? 25) \_\_\_\_\_
- A) They are the microbes most similar to plants.
  - B) They frequently possess cilia or flagella.
  - C) Most exhibit asexual reproduction.
  - D) They are eukaryotic organisms.
  - E) They are single-celled organisms.
- 26) Which of the following scientists was the first to develop a taxonomic system for classifying organisms? 26) \_\_\_\_\_
- A) Leeuwenhoek
  - B) Lister
  - C) Pasteur
  - D) Needham
  - E) Linnaeus
- 27) Which of the following is NOT an observation Pasteur made concerning the fermentation of grape juice? 27) \_\_\_\_\_
- A) Yeast can grow with or without oxygen.
  - B) Yeast can grow in sealed or open flasks of grape juice.
  - C) Yeast cells can grow and reproduce in grape juice.
  - D) Bacteria produce acid in grape juice.
  - E) Pasteurization kills yeast to prevent spoilage of grape juice.

- 28) Put the following events in the history of microbiology in order, from the earliest to the latest: 28) \_\_\_\_\_
- I. Leeuwenhoek observes microbes using a microscope.
  - II. Pasteur disproves spontaneous generation.
  - III. Woese discovers the archaea.
  - IV. Fracastoro proposes that "germs" cause disease.
  - V. Ehrlich discovers the first "magic bullet."
- A) III, IV, I, II, V
  - B) V, IV, I, III, II
  - C) III, V, II, IV, I
  - D) IV, I, II, V, III
  - E) IV, I, V, II, III
- 29) John Snow's research during a cholera outbreak in London laid the foundation for which of the following branches of microbiology? 29) \_\_\_\_\_
- A) epidemiology
  - B) immunology
  - C) infection control
  - D) both infection control and epidemiology
  - E) infection control, epidemiology, and immunology
- 30) Robert Koch was involved in research on all of the following topics EXCEPT 30) \_\_\_\_\_
- A) the cause of anthrax.
  - B) techniques for isolating microbes in the laboratory.
  - C) the cause of tuberculosis.
  - D) the cause of fermentation.
  - E) development of a method to prove the cause of an infectious disease.
- 31) Which of the following is an INCORRECT pairing? 31) \_\_\_\_\_
- A) viruses: acellular parasites
  - B) fungi: cell walls
  - C) prokaryotes: no nuclei
  - D) protozoa: multicellular
  - E) algae: aquatic and marine habitats
- 32) What was the first disease proven to be bacterial in origin? 32) \_\_\_\_\_
- A) malaria
  - B) yellow fever
  - C) tuberculosis
  - D) cholera
  - E) anthrax
- 33) The work of Lister, Nightingale, and Semmelweis all contributed to controlling infectious disease by 33) \_\_\_\_\_
- A) identifying the sources of infectious agents.
  - B) developing techniques for isolating pathogens.
  - C) developing vaccines.
  - D) developing methods for reducing nosocomial infections.
  - E) determining the taxonomic relationships among microbes.
- 34) Who discovered penicillin? 34) \_\_\_\_\_
- A) Pasteur
  - B) Fleming
  - C) Domagk
  - D) Ehrlich
  - E) Kitasato

- 35) All of the following were involved in developing the germ theory of disease EXCEPT 35) \_\_\_\_\_  
A) Snow.  
B) Pauling.  
C) Pasteur.  
D) Koch.  
E) Fracastoro.
- 36) Microorganisms characterized by the absence of a nucleus are called 36) \_\_\_\_\_  
A) eukaryotes.  
B) viruses.  
C) pathogens.  
D) fungi.  
E) prokaryotes.
- 37) The term that literally means "against putrefaction" is 37) \_\_\_\_\_  
A) prokaryote.  
B) recombinant technology.  
C) nosocomial.  
D) antisepsis.  
E) chemotherapy.
- 38) The term \_\_\_\_\_ refers to an infection acquired in a health care setting. 38) \_\_\_\_\_  
A) abiogenesis  
B) bioremediation  
C) nosocomial  
D) archaea  
E) spontaneous generation
- 39) The term \_\_\_\_\_ literally means "produces disease." 39) \_\_\_\_\_  
A) nosocomial  
B) animalcule  
C) pathogen  
D) facultative anaerobe  
E) prokaryote
- 40) The study of the causation of disease is known as 40) \_\_\_\_\_  
A) immunology.  
B) epidemiology.  
C) biotechnology.  
D) etiology.  
E) chemotherapy.
- 41) The term for the use of microorganisms to restore damaged environments is 41) \_\_\_\_\_  
A) bioremediation.  
B) epidemiology.  
C) ecology.  
D) serology.  
E) chemotherapy.

- 42) The term \_\_\_\_\_ means the study of the blood components that fight infection. 42) \_\_\_\_\_  
 A) antisepsis  
 B) etiology  
 C) chemotherapy  
 D) bioremediation  
 E) serology
- 43) The study of the occurrence, distribution, and spread of disease is known as 43) \_\_\_\_\_  
 A) biotechnology.  
 B) serology.  
 C) epidemiology.  
 D) biochemistry.  
 E) molecular biology.

**TRUE/FALSE. Write 'T' if the statement is true and 'F' if the statement is false.**

- 44) The taxonomic scheme developed by Linnaeus remains largely unchanged in modern biology. 44) \_\_\_\_\_
- 45) Christian Gram devised a staining technique that divides all bacteria into two groups. 45) \_\_\_\_\_
- 46) The production of human blood-clotting factor by *E. coli* is an example of bioremediation. 46) \_\_\_\_\_
- 47) Walter Reed proved that a virus causes yellow fever in humans. 47) \_\_\_\_\_
- 48) Gene therapy is a modern approach to preventing infectious disease. 48) \_\_\_\_\_
- 49) Koch's postulates can be used only to prove the causes of infectious diseases. 49) \_\_\_\_\_
- 50) Joseph Lister reduced the incidence of wound infections in health care settings by using chlorinated lime water. 50) \_\_\_\_\_
- 51) Robert Koch developed a vaccine to prevent anthrax after identifying the causative agent. 51) \_\_\_\_\_
- 52) Fermentation can occur in the absence of living cells. 52) \_\_\_\_\_
- 53) Lazzaro Spallanzani was the first scientist to provide evidence disproving the spontaneous generation of microorganisms. 53) \_\_\_\_\_

**SHORT ANSWER. Write the word or phrase that best completes each statement or answers the question.**

- 54) Microbes that move by means of cilia are \_\_\_\_\_. 54) \_\_\_\_\_
- 55) A cell that contains a nucleus is called a(n) \_\_\_\_\_ cell. 55) \_\_\_\_\_
- 56) A(n) \_\_\_\_\_ organism makes its own food using solar energy. 56) \_\_\_\_\_
- 57) Microbes that cause infectious disease are called \_\_\_\_\_. 57) \_\_\_\_\_

- 58) An asexual method of reproduction associated with yeasts is \_\_\_\_\_. 58) \_\_\_\_\_
- 59) A(n) \_\_\_\_\_ is a potential explanation for a set of observations made by a scientist studying a phenomenon. 59) \_\_\_\_\_
- 60) Bacteria that can live without oxygen are termed \_\_\_\_\_. 60) \_\_\_\_\_
- 61) Robert Koch discovered the cause of \_\_\_\_\_, a disease of animals that can be spread to humans. 61) \_\_\_\_\_
- 62) A(n) \_\_\_\_\_ is a mass of cells that are descended from a single cell through successive cell divisions. 62) \_\_\_\_\_
- 63) The first true vaccine provided protection from disease caused by a(n) \_\_\_\_\_. 63) \_\_\_\_\_
- 64) Ignaz Semmelweis demonstrated the importance of \_\_\_\_\_ as a means of preventing disease transmission. 64) \_\_\_\_\_
- 65) A term synonymous with immunization, \_\_\_\_\_ is derived from the Latin name of the cowpox virus. 65) \_\_\_\_\_
- 66) The use of chemicals to treat diseases such as bacterial infections is called \_\_\_\_\_. 66) \_\_\_\_\_
- 67) Organisms such as bacteria that can convert atmospheric nitrogen into nitrate are often studied in \_\_\_\_\_ microbiology. 67) \_\_\_\_\_
- 68) The \_\_\_\_\_ of an organism is all the chemical reactions that take place in the organism. 68) \_\_\_\_\_

**ESSAY. Write your answer in the space provided or on a separate sheet of paper.**

- 69) Explain why there was such a long period of time between the era of Leeuwenhoek's work and the beginnings of the Golden Age of Microbiology.
- 70) Biotechnology can be said to have ancient roots. Explain.
- 71) Use the basic steps of the scientific method to describe Pasteur's experiments to investigate spontaneous generation.
- 72) Explain how the discipline of biochemistry grew out of the science of microbiology.
- 73) Compare and contrast the three types of eukaryotic microbes.

# Answer Key

Testname: UNTITLED1

- 1) D  
Bloom's Rank: Knowledge  
Section: The Early Years of Microbiology
- 2) D  
Bloom's Rank: Comprehension  
Section: The Early Years of Microbiology
- 3) C  
Bloom's Rank: Comprehension  
Section: The Early Years of Microbiology
- 4) C  
Bloom's Rank: Knowledge  
Section: The Golden Age of Microbiology
- 5) D  
Bloom's Rank: Knowledge  
Section: The Golden Age of Microbiology
- 6) A  
Bloom's Rank: Knowledge  
Section: The Golden Age of Microbiology
- 7) D  
Bloom's Rank: Comprehension  
Section: The Golden Age of Microbiology
- 8) E  
Bloom's Rank: Application  
Section: The Golden Age of Microbiology
- 9) E  
Bloom's Rank: Comprehension  
Section: The Golden Age of Microbiology
- 10) A  
Bloom's Rank: Knowledge  
Section: The Golden Age of Microbiology
- 11) E  
Bloom's Rank: Knowledge  
Section: The Golden Age of Microbiology
- 12) E  
Bloom's Rank: Comprehension  
Section: The Golden Age of Microbiology
- 13) C  
Bloom's Rank: Comprehension  
Section: The Modern Age of Microbiology
- 14) E  
Bloom's Rank: Comprehension  
Section: The Modern Age of Microbiology
- 15) A  
Bloom's Rank: Application  
Section: The Modern Age of Microbiology
- 16) D  
Bloom's Rank: Application  
Section: The Golden Age of Microbiology

## Answer Key

Testname: UNTITLED1

- 17) B  
Bloom's Rank: Comprehension  
Section: The Golden Age of Microbiology
- 18) B  
Bloom's Rank: Comprehension  
Section: The Early Years of Microbiology
- 19) B  
Bloom's Rank: Application  
Section: The Golden Age of Microbiology
- 20) E  
Bloom's Rank: Comprehension  
Section: The Golden Age of Microbiology
- 21) D  
Bloom's Rank: Knowledge  
Section: The Early Years of Microbiology
- 22) C  
Bloom's Rank: Application  
Section: The Modern Age of Microbiology
- 23) D  
Bloom's Rank: Application  
Section: The Golden Age of Microbiology
- 24) C  
Bloom's Rank: Knowledge  
Section: The Golden Age of Microbiology
- 25) A  
Bloom's Rank: Comprehension  
Section: The Early Years of Microbiology
- 26) E  
Bloom's Rank: Knowledge  
Section: The Early Years of Microbiology
- 27) E  
Bloom's Rank: Comprehension  
Section: The Golden Age of Microbiology
- 28) D  
Bloom's Rank: Analysis  
Section: The Modern Age of Microbiology
- 29) D  
Bloom's Rank: Application  
Section: The Golden Age of Microbiology
- 30) D  
Bloom's Rank: Comprehension  
Section: The Golden Age of Microbiology
- 31) D  
Bloom's Rank: Comprehension  
Section: The Early Years of Microbiology
- 32) E  
Bloom's Rank: Application  
Section: The Golden Age of Microbiology

# Answer Key

Testname: UNTITLED1

- 33) D  
Bloom's Rank: Application  
Section: The Golden Age of Microbiology
- 34) B  
Bloom's Rank: Knowledge  
Section: The Modern Age of Microbiology
- 35) B  
Bloom's Rank: Comprehension  
Section: The Modern Age of Microbiology
- 36) E  
Bloom's Rank: Knowledge  
Section: The Early Years of Microbiology
- 37) D  
Bloom's Rank: Knowledge  
Section: The Golden Age of Microbiology
- 38) C  
Bloom's Rank: Comprehension  
Section: The Golden Age of Microbiology
- 39) C  
Bloom's Rank: Comprehension  
Section: The Golden Age of Microbiology
- 40) D  
Bloom's Rank: Comprehension  
Section: The Golden Age of Microbiology
- 41) A  
Bloom's Rank: Comprehension  
Section: The Modern Age of Microbiology
- 42) E  
Bloom's Rank: Application  
Section: The Modern Age of Microbiology
- 43) C  
Bloom's Rank: Comprehension  
Section: The Golden Age of Microbiology
- 44) FALSE  
Bloom's Rank: Comprehension  
Section: The Early Years of Microbiology
- 45) TRUE  
Bloom's Rank: Knowledge  
Section: The Golden Age of Microbiology
- 46) FALSE  
Bloom's Rank: Comprehension  
Section: The Modern Age of Microbiology
- 47) TRUE  
Bloom's Rank: Comprehension  
Section: The Golden Age of Microbiology
- 48) FALSE  
Bloom's Rank: Comprehension  
Section: The Modern Age of Microbiology

# Answer Key

Testname: UNTITLED1

- 49) TRUE  
Bloom's Rank: Comprehension  
Section: The Golden Age of Microbiology
- 50) FALSE  
Bloom's Rank: Comprehension  
Section: The Golden Age of Microbiology
- 51) FALSE  
Bloom's Rank: Comprehension  
Section: The Golden Age of Microbiology
- 52) TRUE  
Bloom's Rank: Comprehension  
Section: The Golden Age of Microbiology
- 53) TRUE  
Bloom's Rank: Comprehension  
Section: The Golden Age of Microbiology
- 54) protozoa  
Bloom's Rank: Knowledge  
Section: The Early Years of Microbiology
- 55) eukaryotic  
Bloom's Rank: Knowledge  
Section: The Early Years of Microbiology
- 56) photosynthetic  
Bloom's Rank: Comprehension  
Section: The Early Years of Microbiology
- 57) pathogens  
Bloom's Rank: Knowledge  
Section: The Golden Age of Microbiology
- 58) budding  
Bloom's Rank: Knowledge  
Section: The Early Years of Microbiology
- 59) hypothesis  
Bloom's Rank: Knowledge  
Section: The Golden Age of Microbiology
- 60) anaerobic  
Bloom's Rank: Comprehension  
Section: The Golden Age of Microbiology
- 61) anthrax  
Bloom's Rank: Knowledge  
Section: The Golden Age of Microbiology
- 62) colony  
Bloom's Rank: Comprehension  
Section: The Golden Age of Microbiology
- 63) virus  
Bloom's Rank: Comprehension  
Section: The Golden Age of Microbiology
- 64) handwashing  
Bloom's Rank: Comprehension  
Section: The Golden Age of Microbiology

## Answer Key

Testname: UNTITLED1

65) vaccination

Bloom's Rank: Comprehension

Section: The Golden Age of Microbiology

66) chemotherapy

Bloom's Rank: Knowledge

Section: The Golden Age of Microbiology

67) environmental

Bloom's Rank: Comprehension

Section: The Modern Age of Microbiology

68) metabolism

Bloom's Rank: Knowledge

Section: The Modern Age of Microbiology

69) There are many reasons for this large gap between scientific eras. One reason was that scientists after Leeuwenhoek were unable to duplicate the quality of his microscopes because he had been extremely secretive. Another reason was the absence of a philosophical framework for the study of microorganisms, which was developed only after Pasteur conducted his experiments disproving spontaneous generation and showing that microbes were basically similar to other forms of life in their origins. A third reason was that suitable methods for studying microbes were not available until the mid-19th century, the era of scientists such as Robert Koch and his colleagues (who devised methods of growing and isolating microbes) and Christian Gram (who devised an important staining technique useful in the classification of microbes).

Bloom's Rank: Analysis

Section: The Golden Age of Microbiology

70) Biotechnology is the use of microbes to yield beneficial products. Humans have used microbes to their benefit for millennia in producing beer and wine, which were often safer to drink than the available water, and in preserving foods. Examples of the latter include the production of wine, which essentially preserved fruit juices, and of cheese and yogurt, which extended the storage life of milk products. Soy sauce and other fermented sauces were also preserved by fermentation and were later shown to enhance the flavors of certain foods.

Bloom's Rank: Application

Section: The Golden Age of Microbiology

71) The observation that life seemed to appear from non-life led some scientists to believe in the theory of spontaneous generation. However, there were some who believed in biogenesis: that life must come from life. The question Pasteur hoped to answer was "Where do microbes come from?" Pasteur's hypothesis was that the "parents" of microbes were present in the air on dust particles and that spontaneous generation was not a valid theory. In his experiments he used swan-necked flasks, which were designed to prevent microbes from entering the sterile broth inside them. He observed that the broth remained sterile in the control flask even though air could move into and out of the flask. The experimental flasks were also swan-necked, but they were tilted to allow the dust that had settled to enter the flask. The control flasks stayed sterile, and the experimental flasks became cloudy. These observations led Pasteur to accept his hypothesis. He concluded that the microbes came from the dust and that spontaneous generation was therefore not a valid theory.

Bloom's Rank: Application

Section: The Golden Age of Microbiology

72) Some of the first experiments in biochemistry are attributed to Louis Pasteur in his research on the causes of fermentation. His research was extended by Eduard Buchner, who showed that enzymes produced by microbial cells are responsible for the phenomenon of fermentation. Later, in the early 20th century, Kluyver and van Niel advocated the use of microbes in research on basic biochemical reactions, which they maintained are common to all living things. Further advances in biochemistry were made as microbiologists such as Beadle and Tatum and Avery and his colleagues explored the nature of the genetic material and its function using microorganisms as model systems.

Bloom's Rank: Analysis

Section: The Modern Age of Microbiology

## Answer Key

Testname: UNTITLED1

73) The three types of eukaryotic microbes are fungi, protozoa, and algae. Because they are all composed of eukaryotic cells, they have basic similarities in cellular structure, including the presence of a nucleus. However, these types of microbes differ in many ways as well. In terms of their nutrition, fungi and protozoa obtain their food from other organisms, whereas algae can make their own food through photosynthesis. Algae and fungi can be multicellular organisms, but protozoa are found only as single-celled organisms. Protozoa are unique among the three in that they are animal-like in their characteristics, including movement. Algae are most like plants and are found in primarily water-based environments.

Bloom's Rank: Analysis

Section: The Early Years of Microbiology