CHAPTER ONE

**BIOCHEMISTRY: AN INTRODUCTION**

1) The ultimate source of energy for life on earth is \_\_\_\_\_\_\_\_\_\_.

A) The sun

B) Geothermal heat

C) Carbohydrates

D) Fats

E) Other organisms

**Ans**  A

2) Which of the following is not a common component of biomolecules?

A) Carbon

B) Hydrogen

C) Oxygen

D) Nitrogen

E) Chlorine

**Ans** E

3) Which of the following is the basic structural unit of living organisms?

A) Nucleus

B) Cell membrane

C) Tissue

D) Cell

E) Cytoskeleton

**Ans**  D

4) Which of the following is not an organelle?

A) Mitochondria

B) Chloroplast

C) Nucleus

D) Plasma membrane

E) Golgi complex

**Ans**  D

5) Which of the following is not a role played by carbohydrates in living cells?

A) Energy source

B) Structural support

C) Intercellular communication

D) Both A and B are correct

E) All are roles played by carbohydrates in living cells

**Ans** D

6) Metabolism is best defined as the \_\_\_\_\_\_\_\_\_.

A) Reactions of living cells

B) Reactions that synthesize large molecules in living cells

C) Reactions that degrade molecules in living cells

D) Conversion of food molecules to energy

E) Reactions that synthesize and degrade molecules in living cells

**Ans** E

7) The average life span of a species is about \_\_\_\_\_\_\_\_years

1. One million
2. Ten million
3. Five hundred thousand
4. Five million
5. One hundred thousand

**Ans** A

8) Which of the following is not a waste product of living organisms

A) Carbon dioxide

B) Water

C) Urea

D) Ammonia

E) Glycine

**Ans** E

9) Biochemistry is defined as

A) The study of life processes

B) The study of the molecular basis of life

C) The study of living organisms

D) The study of organic compounds in living organisms

E) The study of living compounds

**Ans** B

10) One of the principal methods that organisms use to obtain energy from chemical bonds is by \_\_\_\_\_\_\_\_\_\_\_.

A) Substitution reactions

B) Dehydration reactions

C) Oxidation/reduction reactions

D) Hydration reactions

E) Addition reactions

**Ans** C

11) The following is an example of which reaction class?

CH3Br + HSCH2CH(NH2)COOH 🡪 CH3SCH2CH(NH2)COOH + Br-  + H+

A) Substitution

B) Elimination

C) Addition

D) Isomerization

E) Oxidation/Reduction

**Ans** A

12 The following is an example of which reaction class

HOOCCH=CHCOOH + H2O 🡪 HOOCCH2CH(OH)COOH

A) Substitution

B) Elimination

C) Addition

D) Isomerization

E) Oxidation/Reduction

**Ans** C

13) The following is an example of which reaction class?

CH3CH2OH 🡪 CH3CHO + H2O

A) Substitution

B) Elimination

C) Addition

D) Isomerization

E) Oxidation/Reduction

**Ans** E

14) Which of the following is not a component of nucleic acid?

A) Nucleotides

B) Glucose

C) Phosphate group

D) Purines

E) Pyrimidines

**Ans** B

15) The largest molecules in living organisms are \_\_\_\_\_\_\_\_\_.

A) proteins

B) lipids

C) nucleic acids

D) carbohydrates

E) steroids

**Ans**  C

16) All of the following classes of compounds are lipids except \_\_\_\_\_\_\_.

A) fats

B) sterols

C) fatty acids

D) phosphoglycerides

E) nucleotides

**Ans** E

17) Which of the following classes of biomolecules are the most abundant in nature?

A) Lipids

B) Amino acids

C) Carbohydrates

D) Proteins

E) Nucleotides

**Ans** C

18) Consider the following molecule. Which arrow is pointing to a peptide bond?



A) A

B) B

C) C

D) D

E) E

**Ans** C

19) The following molecule is an example of which single class of compounds?

CH3CH2CH(NH2)COOH

A) Amine

B) Acid

C) Ester

D) Amino acid

E) Alcohol

**Ans** D

20) The following molecule is an example of which class of compounds?

CH3CH2CH2COOCH2CH3

A) Hydrocarbon

B) Acid

C) Ester

D) Ether

E) Aldehyde

**Ans**  C

21) The following molecule is an example of which class of compounds?

CH3CH2CH2COOH

A) Hydrocarbon

B) Acid

C) Alcohol

D) Aldehyde

E) Ketone

**Ans**  B

22) The chemical properties of organic molecules are determined by specific arrangements of atoms called \_\_\_\_\_\_\_\_\_\_\_\_\_.

A) Structure

B) Bonds

C) Functional groups

D) Radicals

E) Molecules

**Ans** C

23) Which of the following classes of compounds make up most of the mass of an organism?

A) Amino acids

B) Proteins

C) Lipids

D) Carbohydrates

E) Water

**Ans**  E

24) Which of the following is not a basic element of life?

1. Phosphorous
2. Hydrogen
3. Nitrogen
4. Oxygen
5. All of the above are basic elements of life

**Ans** E

25) Most biomolecules can be considered to be derivatives of

1. Amino acids
2. Carbohydrates
3. Fats
4. Hydrocarbons
5. Alcohols

**Ans**  D

26) Which of the following amino acids contain a hydrophobic side chain

1. Leucine
2. Arginine
3. Glutamine
4. Glutamic acid
5. Aspartic acid

**Ans** A

27) Which of the following small molecules do not form biopolymers

1. Amino acids
2. Sugars
3. Fatty acids
4. Nucleotides
5. C and D

**Ans** C

28) Choose the amino acid that can function as a neurotransmitter

1. Glutamic acid
2. Alanine
3. Tyrosine
4. Lysine
5. Cysteine

**Ans** A

29) A constant source of \_\_\_\_\_\_\_ is required for maintenance of a cell’s ordered state.

A) Heat

B) Oxygen

C) Energy

D) Stimulus

E) Water

**Ans** C

30) Which of the following is not true of life?

A) Life is cellular

B) Life is information based

C) Life is complex and dynamic

D) All living things produce energy using mitochondria

E) Life adapts and evolves

**Ans**  D

31) Which of the following classes of compounds contain the same functional group as an ester?

1. Amino acids
2. Fatty acids
3. Carbohydrates
4. Proteins
5. Fats

**Ans** E

32) Which of the following is not a component of DNA

1. Uracil
2. Adenine
3. Cytosine
4. Guanidine
5. Thymine

**Ans** A

33) The sum total of all reactions of an organism is called

1. Life
2. Metabolism
3. Biosynthesis
4. Anabolism
5. Energetics

**Ans** B

34) Which of the following is not characteristic of an autopoietic system?

A) Autonomous

B) Self-organizing

C) Self-maintaining

D) Intelligent

E) B and D

**Ans**  D

35) The assumption that a complete understanding of a living organism can be obtained solely by investigating all of its components is called \_\_\_\_\_\_\_\_\_.

A) Systems biology

B) Reductionism

C) Emergence

D) Robustness

E) Feedback control

**Ans**  B

36) Which of the following is not a core principle of systems biology?

A) Emergence

B) Robustness

C) Redundancy

D) Modularity

E) Limit of resolution

**Ans**  E

37) The field of study associated with the investigation of gene expression patterns is called:

A) Proteomics

B) Bioinformatics

C) Genomics

D) Functional genomics

E) Synomics

**Ans** D

38) Which of the following is not an example of a macromolecule?

A) Nucleic acid

B) Protein

C) Polysaccharide

D) Enzyme

E) Amino acid

**Ans E**

39) Which of the following is not considered a class of small biomolecule?

A) Amino acid

B) Sugar

C) Nucleic Acid

D) Fatty acid

E) Nucleotide

**Ans C**

40) The functional group present in the following molecule is called:



A) Amine

B) Ketone

C) Amide

D) Ester

E) Acid

**Ans C**

41) The majority of Earth’s species belong to which of the following classifications?

1. Eukaryotes
2. Prokaryotes
3. Viruses
4. Mammals
5. Archea

**Ans B**

42) The conversion of earths atmosphere from anerobic to aerobic was due to the development of \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ by cyanobacteria.

1. Photosynthesis
2. Metabolism
3. Chemosynthesis
4. Oxidation of iron
5. Fixation of nitrogen as cyanide

**Ans A**

43) The largest mass extinction also known as the great dying was called the

1. Cenezoic extinction
2. Permian extinction
3. Mesozoic event
4. Great ice age
5. The great plague

**Ans B**

44) The most prominent function of RNA is

1. Energy source
2. Nutrient source
3. Protein synthesis
4. Structural elements
5. B and C

**Ans C**

45) An organism’s entire set of DNA is called

1. Genome
2. Genetic sequence
3. Polynucleotide sequence
4. Gene
5. Inheritance

**Ans A**

46) The major function of carbohydrates is

1. Catalysts and structural elements
2. Energy sources and structural elements
3. Genetic information
4. Protein synthesis
5. Insulation

**Ans B**

**SHORT ANSWER**

47) What is meant by the term biomolecule?

**Ans** A biomolecule is a molecule synthesized by living organisms.

48) What is meant by the term metabolism?

**Ans** Metabolism is the sum total of all reactions in a living organism.

49) What is meant by the term hydrophobic?

**Ans** Hydrophobic molecules are incapable of hydrogen bonding with polar molecules including water.

50) What is meant by the term sugar?

**Ans** Sugars are polyhydoxy aldehydes and ketones that are the basic unit of a carbohydrate.

51) Define the term fatty acid.

**Ans** Fatty acids are monocarboxylic acids represented by the formula R-COOH in which R is an alkyl group that contains carbon and hydrogen.

52) Define the term nucleotide.

**Ans** A Nucleotide is composed of a 5-carbon sugar (ribose or deoxyribose), a nitrogenous base, and one or more phosphate groups.

53) Why is DNA sometimes referred to as the double helix?

**Ans** DNA is sometimes referred to as the double helix because it is composed of two antiparallel polynucleotide strands wound around each other.

54) Identify the functional groups in the following molecule.



**Ans** The functional groups present in the above molecule are two carboxylic acid groups and an amino group.

55) Identify the functional group in the following molecule.



**Ans** The functional group present in the above molecule is an amide group.

56) Name four classes of small biomolecules. In what larger biomolecules are they found?

**Ans** Amino acids occur in peptides and proteins. Sugars occur in oligosaccharides and polysaccharides. Nucleotides are the components of nucleic acids. Fatty acids are components of several types of lipid molecules (e.g., triacylglycerols and phospholipids).

57) What are the functions of fatty acids?

**Ans** The functions of fatty acids include energy storage and components of membrane. Some fatty acids are also precursors to hormone-like molecules.

58) What are two functions of nucleotides?

**Ans** Nucleotides are involved in energy transformations. They are also components of DNA and RNA.

59) Compare the features of an airplane autopilot system with a biological system in terms of robustness, control mechanisms and redundancy.

**Ans** Both an airplane autopilot system and a biological system are robust (i.e., they have the ability to maintain stability despite changes in the environment or other events that threaten the continuation of system functions). They both have feedback control mechanisms, in which information regarding internal processes is used to adjust functions to maximize performance. The actual failsafe mechanisms differ in that human-made systems have redundancy (duplicate parts) while biological systems have degeneracy, in which duplicate (or similar) functions may be carried out by different parts of the system.

60) How do plants dispose of waste products?

**Ans P**lants dispose of waste products either by degradation or by storage in vacuoles or cell walls.

64) To what major class of biomolecules does the following molecule belong?



**Ans** Amino acid

61) To what major class of biomolecules does the following molecule belong?



**Ans** Nucleoside

62) What are the primary functions of metabolism?

**Ans** The primary functions of metabolism are acquisition and utilization of energy, synthesis of biomolecules, and removal of waste products.

**ESSAY QUESTIONS**

63) Compare and contrast the general features of human-designed complex systems and living systems.

**Ans** Both human-designed complex systems (such as machines or factories) and living systems require raw materials (nutrients) and energy to manufacture components; systems of both types also produce waste products and heat. Machines can be designed to self-regulate upon receiving feedback from the environment (e.g., by monitoring temperature to determine heating or cooling needs). In contrast, living systems are self-sustaining; that is, they produce and repair all of their own structural and functional components and, via nucleic acids, they build the machines (enzymes) that make the components. Even the nucleic acids themselves are reproduced by living systems. This level of self-sustainability is not present in human-designed complex systems.

64) Biochemistry and molecular biology are often thought of as very similar fields. In what ways do they differ?

**Ans** Biochemistry is the study of the chemical transformations occurring in living systems that are controlled by enzymes and regulatory mechanisms. Molecular biology, the study of the genome and its expression in a living system, is concerned with the formation, structure and function of the nucleic acids DNA and RNA.

65) Humans synthesize most of the cholesterol required for cell membranes and for the synthesis of vitamin D and steroid hormones. What would you expect to happen if a person’s diet is high in cholesterol. Provide a reason for your response.

**Ans** The capacity of healthy bodies to adapt to high-cholesterol diets by inhibiting cholesterol synthesis is an example of the means by which living organisms regulate their metabolic processes.

66) DNA structure must be stable because it acts as an organism’s repository of genetic information. However, it is equally important that DNA is not completely stable. Explain.

**Ans** If DNA were completely stable no variation in the organism would take place and evolution would be impossible. Species would not have the possibility to adapt to environmental changes, a circumstance that would inevitably lead to extinction.

67) Describe the significance of the phrase “robust yet fragile”.

**Ans** Complex control mechanisms and protective systems allow living organisms to withstand various physical and/or chemical challenges, e.g. multiple fail-safe mechanisms exist that protect against fluctuations in temperature, availability of nutrients, and energy needs. As such, living organisms are robust, yet they are fragile in their vulnerability to unusual or rare events that cause irreparable damage. For example, a bleeding cut will clot and heal, but exposure to high levels of carbon monoxide can cause death.

68) Comment on the statement that carbon is not the most abundant element in the body by weight.

**Ans** While carbon containing compounds are essential for life, the body is largely composed of water. As a result, oxygen is the most abundant element in the body.

69) Why do anabolic processes consume energy and catabolic processes release energy?

**Ans** Anabolic processes involve the formation of new carbon-carbon bonds, which is an endothermic process that requires an external source of energy. Catabolic processes involve bond cleavage, in which bond energy is released and in some cases captured so as to drive anabolic reactions.

70) Comment on the statement that a species whose organisms are composed of exceptionally robust systems will most likely become extinct.

**Ans** Adaptation to new environmental conditions requires the capacity to change existing systems. If a robust system is resistant to change, as the environment changes the species cannot adapt and will eventually become extinct.

71) When insulin binds to the insulin receptor, information is exchanged. Explain.

**Ans** Insulin is released when glucose concentrations in the blood have increased. The binding of the insulin molecule to its receptor, made possible by the complementary three-dimensional structures of insulin and its receptor, triggers a signal transduction process that allows the target cell to remove glucose from the blood stream and alters the expression of insulin-sensitive genes.