PREFACE

The Instructor's Manual is designed to assist instructors who use *Hole's Human Anatomy and Physiology*, *Thirteenth Edition*, in their human anatomy and physiology courses by offering Lecture Suggestions and Guidelines, Application Questions, and Critical Thinking Issues for the list of learning outcomes that precede each textbook chapter.

Answers to Chapter Assessments and Answers to Integrative Assessments/Critical Thinking Questions are included in the Appendices. Each question has been tied to a student learning outcome.

CHAPTER 1
INTRODUCTION TO HUMAN ANATOMY AND PHYSIOLOGY

Learning Outcomes

1.1 Introduction

1: Identify some of the early discoveries that lead to our current understanding of the human body. (p. 11)

Lecture Suggestions and Guidelines

1. Give an overview of the roles of primitive doctors.
2. Compare various beliefs regarding the connection between natural forces and the human body.
3. Identify the origins of basic terms used in the study of anatomy and physiology.

Application Question(s)

1. Ask students to develop a chart of basic terms found in the language of anatomy and physiology.
   Answer: Responses should include a minimum of 50 modern terms accompanied by their Greek/Latin derivatives.

Critical Thinking Issue(s)

1. Compare and contrast several ancient uses of herbs and potions.
   Answer: Students may be required to research this topic via the library, used book stores, or the Internet.

1.2 Anatomy and Physiology

2: Explain how anatomy and physiology are related. (p. 12)

Lecture Suggestions and Guidelines

1. Give an overview of the study of anatomy and physiology.
2. Describe the relationship between the structures of body parts and the functions of these body parts.
3. Compare the scientific research efforts of an anatomist with the concerns of a physiologist.

Application Question(s)

1. The function of a body part (physiology) is determined by the way it is constructed (anatomy). How does this relationship apply to the human heart? Ask students to give other examples, which illustrate this concept.
   Answer: The human heart is constructed such that two superior atria serve to receive blood and two inferior, thick-walled ventricles serve to pump blood. The

heart is muscular, has three major tissue layers, and contains a series of valves, which insure one-way blood flow.

2. Ask students to demonstrate ways in which structure determines function by providing examples outside the human body.
   Answer: Examples will vary. Some possibilities include small appliances, such as a toaster, a mixer, or a potato peeler. Clocks, automobile parts, and tools would be other examples.

Critical Thinking Issue(s)

1. How does the arrangement of parts in the human hand compare in functional effectiveness to analogous parts in other animals?
   Answer: The human hand is composed of long, jointed fingers, an opposable digit, and dermal papillae, all of which enhance gripping ability.
2. The authors state that "recently, researchers discovered a previously unknown muscle between two bones in the head." What characteristics would help scientists relate the anatomy of this "new" muscle to its physiology?
   Answer: The action of the muscle, the shape of the muscle, the location of the muscle's origin and insertion, the number of origins, the exact location of the muscle, and its relative size.

1.3 Levels of Organization

3: List the levels of organization in the human body and the characteristics of each. (p. 12)

Lecture Suggestions and Guidelines

1. Introduce the major levels of structural complexity.
2. Discuss how the human body illustrates levels of organization to include atoms, molecules, macromolecules, organelles, cells, tissues, organs, organ systems, and organism.

Application Question(s)

1. Ask students to apply the concept of structural complexity by preparing a flow chart, which illustrates the levels of organization for one of the major organ systems of the human body.
   Answer: Differences will become evident for each organ system once the student reaches the cell, tissue, and organ levels.

Critical Thinking Issue(s)

1. Ask students to apply the concept of levels of structural complexity to an example other than the human body.
   Answer: For example, a single letter combines with other letters to form a word. A group of words forms a sentence. A group of related sentences forms a paragraph. Paragraphs combine to form pages. Pages combine to form chapters, which then combine to form a book, etc.

1.4 Characteristics of Life

4: List and describe the major characteristics of life. (p. 14)

Lecture Suggestions and Guidelines

1. Introduce the concept of maintaining life through necessary life functions.
2. Briefly discuss the ten major characteristics of life shared by all organisms.
3. Describe the physical and chemical events, which constitute metabolism.

Application Question(s)

1. Ask students to compare and contrast a newborn baby, a teenager, and a senior citizen in terms of the ten characteristics of life, including movement, responsiveness, growth, reproduction, respiration, digestion, absorption, circulation, assimilation, and excretion.
   Answer: Responses will vary.

Critical Thinking Issue(s)

1. The sum of all chemical and physical events and reactions in the human body constitutes metabolism. How might diabetes mellitus be defined as a metabolic disease in terms of the ten major characteristics of life?
   Answer: Students should express their responses by illustrating diabetes' effects on movement, responsiveness, growth, reproduction, respiration, digestion, absorption, circulation, assimilation, and excretion.

5: Give examples of *metabolism.* (p. 14)

Lecture Suggestions and Guidelines

1. Define metabolism as the sum total of all of the chemical reactions in the body.
2. Describe respiration as an example of a metabolic process.
3. Describe digestion as an example of a metabolic process.

Application Question(s)

1. Ask students to compare human metabolic processes with processes of other animals.
   Answer: Comparisons may include mammals, fish, invertebrates, insects, etc.

Critical Thinking Issue(s)

1. Ask students to predict the dire effects on the human body when one of the major metabolic processes malfunctions.
   Answer: Responses should include a discussion of the effects on homeostasis.

1.5 Maintenance of Life

6: List and describe the major requirements of organisms. (p. 15)

Lecture Suggestions and Guidelines

1. Describe environmental factors required of organisms to maintain life, including water, food, oxygen, heat, and pressure.
2. Discuss which requirements of organisms are provided from the external environment.

Application Question(s)

1. Ask students to provide examples of ways in which the human body requires pressure to maintain life.
   Answer: Examples might include: a) hydrostatic pressure, which is necessary for kidney filtration; b) blood pressure due to heart action, which keeps blood flowing through the blood vessels; c) pressure on both surfaces of the eardrum, in order for the eardrum to vibrate freely; or d) atmospheric and pulmonary pressure, which is vital to the mechanisms of breathing.

Critical Thinking Issue(s)

1. Water is the most abundant substance in the body. Which properties make water vital to the maintenance of human life in the event of:
   a. vigorous exercise;
   b. transport of nutrients, gases, and wastes;
   c. food digestion;
   d. movement of bone within a joint cavity?

   Answer: a) Water prevents sudden changes in body temperature due to its high heat capacity. b) Nutrients, gases, and wastes can dissolve in water since water is an excellent solvent. Water also acts as a transport and exchange medium as well. c) Water molecules are added to the bonds of larger biological molecules to break them down during digestion. d) Synovial fluids, which contain a water base, lubricate the movement of bones within joint cavities. Water is present in all body lubricants.

7: Explain the importance of homeostasis to survival. (p. 17)

Lecture Suggestions and Guidelines

1. Describe homeostasis as a dynamic state of equilibrium.
2. Discuss the body's role in maintaining a relatively stable internal environment.

Application Question(s)

1. How can the concept of homeostatic imbalance be applied to the following situations? Can homeostasis be restored? How?
   a. dental caries
   b. a kidney stone
   c. a bulging intervertebral disc

   Answer: a) filling or extracting; b) "passing" it through the urinary tract, lithotripsy, surgical excision; c) physical therapy, medication, surgery

Critical Thinking Issue(s)

1. How would environmental pollution (air, water, soil) threaten homeostasis and the survival of organisms?
   Answer: Answers will vary.

8: Describe the parts of a homeostatic mechanism and explain how they function together. (p. 18)

Lecture Suggestions and Guidelines

1. Describe the process by which homeostatic mechanisms regulate body temperature, blood pressure, and blood sugar concentration.
2. Define and discuss positive and negative feedback mechanisms.

Application Question(s)

1. Apply the concept of negative feedback mechanisms by comparing a home heating system to the regulation of body temperature in the human body.
   Answer: a) Set the thermostat to 70 degrees F. b) Room temperature drops below 70 degrees; furnace comes on. c) Room temperature rises until it reaches approximately 70 degrees. 4) Thermostat transmits signal to shut off furnace. The human body operates in an analogous way through the use of a receptor and control center (thermostat located in the hypothalamus) and an effector (the heating system) to regulate body temperature.

Critical Thinking Issue(s)

1. How does a homeostatic control mechanism regulate blood glucose levels when the level is too high? Too low?
   Answer: When blood glucose levels are too high, the pancreas releases insulin into the blood, uptake of glucose in most body cells is enhanced, the liver captures glucose and stores it as glycogen, and the blood glucose levels begin to decline. When blood glucose levels are too low, the pancreas releases glucagon into the blood, the liver breaks down glycogen and releases glucose, and the blood glucose levels begin to rise.

1.6 Organization of the Human Body

9: Identify the locations of the major body cavities. (p. 20)
and
10: List the organs located in each major body cavity. (p. 20)
and
11: Name and identify the locations of the membranes associated with the thoracic and abdominopelvic cavities. (p. 20)

Lecture Suggestions and Guidelines

1. Define the terms axial portion and appendicular portion.
2. Introduce the two sets of internal cavities that provide protection to the organs within them.

3. Describe the location of the dorsal body cavity, including the cranial and spinal cavities.
4. Describe the location of the ventral body cavity, including the thoracic cavity, diaphragm, and abdominopelvic cavities.
5. Briefly describe the oral, nasal, orbital, and middle ear cavities.
6. Describe the cranial cavity, which houses the brain, and the spinal cavity, which contains the spinal cord and is surrounded by vertebrae.
7. Locate the thoracic cavity viscera, including the heart, lungs, esophagus, trachea, and the thymus gland.
8. Describe the location of the mediastinum.
9. Locate the viscera of the abdominopelvic cavity, including the stomach, liver, spleen, gall bladder, small and large intestines, urinary bladder, and the internal reproductive organs.
10. Introduce the terms visceral and parietal.
11. Describe the pleural membranes, which line the thoracic cavity and cover the lungs.
12. Describe the pericardial membranes, which surround the heart and cover its surface.
13. Describe the peritoneal membranes, which line the abdominopelvic cavity and cover the organs inside.
14. Define the pleural, pericardial, and peritoneal cavities.

Application Question(s)

1. Ask the students to use a dissectible manikin to illustrate the major body cavities, the membranes associated with those cavities, the organs found in each cavity, and the nine separate regions which comprise the abdominopelvic cavity.
   Answer: N/A.

Critical Thinking Issue(s)

1. A boxer received multiple blows to the thoracic, abdominal, and pelvic regions. Why are the organs contained in the abdominal region the most vulnerable?
   Answer: The pelvic organs receive some additional protection from the bony pelvis. The thoracic organs are shielded somewhat by the sternum and rib cage. However, the abdominal organs lie in a cavity, which is not reinforced by bone, but rather are protected only by abdominal muscles.

   12: Name the major organ systems, and list the organs associated with each. (p. 23)
   and
   13: Describe the general function of each organ system. (p. 23)

Lecture Suggestions and Guidelines

1. Introduce the major organ systems of the human body, including integumentary, skeletal, muscular, nervous, endocrine, digestive, respiratory, cardiovascular, lymphatic, urinary, and reproductive systems.

2. Describe and locate the major organs of each system, using wall charts, models, and overhead transparencies.

Application Question(s)

1. Ask the students to develop a chart which illustrates the major organ systems to include the name of the system, the major organs associated with each system, and the major functions of each system.
   Answer: N/A.

Critical Thinking Issue(s)

1. How might a physiologist place the organ systems into categories according to their main functions? Use the terms body covering, support and movement, integration and coordination, transport, absorption and excretion, and reproduction.
   Answer: Body covering-integumentary; support and movement-skeletal and muscular; integration and coordination-nervous and endocrine; transport-cardiovascular and lymphatic; absorption and excretion digestive, respiratory, and urinary; reproduction-reproductive

1.7 Life-Span Changes

14: Identify the changes related to aging, from the microscopic to the whole-body level. (p. 28)

Lecture Suggestions and Guidelines

1. Describe aging as a part of life.
2. Give examples of the evidence of aging at the tissue, cell, and molecular levels.
3. Describe the effects of lifestyle choices upon aging.

Application Question(s)

1. Have students make a comparison of a baby, a 40-year old adult, and a senior citizen in terms of the evidence of aging at the tissue, cell, molecular, and whole-body levels.
   Answer: Responses will vary.

Critical Thinking Issue(s)

1. Ask students to describe compare and contrast various products on the market that claim to impede the aging process. Which of these claims are difficult to believe? Why?
   Answer: Responses will vary.

1.8 Anatomical Terminology

15: Properly use the terms that describe relative positions, body sections, and body regions. (p. 28)

Lecture Suggestions and Guidelines

1. Use anatomical terminology to describe relative positions of the body parts. Name each term, define each term, provide an illustration to depict each term, and give practical examples of each.
2. Demonstrate the three major planes: sagittal, frontal, and transverse, by using anatomical models and textbook photographs.
3. Introduce terms which designate body regions. Define the four-quadrant and nine-region systems for describing the subdivisions of the abdominal area.

Application Question(s)

1. Have each student develop twenty flash cards, each of which contains the name of a body part on one side, and a description of its relative position using appropriate anatomical terms on the reverse. Collect the cards and quiz the students with them.
   Answer: Responses will vary.

Critical Thinking Issue(s)

1. Ask students to choose one disease or set of symptoms, and describe the patient's condition as explicitly as possible using appropriate directional terms, body planes, sections, and regions. The instructor may wish to analyze real-life medical record reports with the class. (Remember to insure patient confidentiality).
   Answer: N/A.

Topical Chapter Outline

1.1 Introduction
1.2 Anatomy and Physiology
1.3 Levels of Organization
1.4 Characteristics of Life
1.5 Maintenance of Life
  a. Requirements of Organisms
  b. Homeostasis
1.6 Organization of the Human Body
  a. Body Cavities
  b. Thoracic and Abdominal Membranes
  c. Organ Systems (Body Covering, Support and Movement, Integration and Coordination, Transport, Absorption and Excretion, Reproduction)
1.7 Life-Span Changes
1.8 Anatomical terminology
  a. Relative Position
  b. Body Sections
  c. Body Regions

SUGGESTIONS FOR ADDITIONAL READING

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CHAPTER 2
CHEMICAL BASIS OF LIFE

Learning Outcomes

2.1 Introduction

1: Give examples of how the study of living materials requires an understanding of chemistry. (p. 59)

Lecture Suggestions and Guidelines

1. Introduce biochemistry's importance in understanding physiological processes, developing new medications and treatment modalities, and improving nutrition.
2. Discuss the concept that chemical reactions are the basis for all physiological processes in the body. Integrate this concept with earlier discussions of the necessary life functions, including movement, growth, respiration, and digestion, etc.

Application Question(s)

1. Ask each student to research one therapeutic drug currently on the market and apply its chemical composition, mode of action, and possible adverse reactions to the concept that chemistry is essential for an understanding of physiology.
   Answer: Responses will vary.

Critical Thinking Issue(s)

1. Streptomycin, an aminoglycoside antibiotic, is a very effective bacterial growth inhibitor. Why is it so effective, i.e., what is the link between its chemical composition and bacterial physiology?
   Answer: Streptomycin binds to specific sites on ribosomes, thus interfering with translation. This results in incorrect amino acid sequencing, the precursor to protein synthesis. These alterations ultimately disrupt bacterial growth.

2.2 Structure of Matter

2: Describe the relationships among matter, atoms, and compounds. (p. 60) and
3: Describe how atomic structure determines how atoms interact. (p. 61) and
4: Explain how molecular and structural formulas symbolize the composition of compounds. (p. 63)

Lecture Suggestions and Guidelines

1. Introduce the concept of matter in three physical forms and give examples of each in the human body.
   Examples: solids-bones and muscles; liquids-blood and interstitial fluid; gases-oxygen and carbon dioxide

2. Lecture on the composition of matter. Define atoms, electrons, protons, neutrons, ions, molecules, elements, and compounds.
3. Describe both the major and trace elements found in the human body.
4. Introduce the periodic table, and discuss the atomic structure of elements 1 through 12 in terms of atomic number, atomic symbol, atomic weight, and isotopes.
5. Discuss the types of chemical bonds, including ionic, covalent, and hydrogen bonds.
6. Introduce the concept of molecular and structural formulas.

Application Question(s)

1. Ask students to make flash cards of the first twenty elements on the periodic table. The name of the element would appear on one side of the card, the reverse side should list the atomic number, the chemical symbol, and a major use of the element in the human body.
   Answer: N/A.
2. Prepare ball-and-stick models of several simple molecules. Ask students to name the molecule, identify which atoms are contained in the molecule, and discuss the number and type of chemical bonds involved. What would be the result of changing the molecule by altering a bond or rearranging the atoms?
   Answer: Responses will vary.
3. Bring in a variety of common elements found in the human body. Ask students to find each element on the periodic table and describe its major uses. Examples might include carbon, sulfur, zinc, copper, iodine, magnesium, iron, phosphorus, and calcium.
   Answer: Responses will vary.

Critical Thinking Issue(s)

1. What are the advantages of using ultrasound technology for diagnostic medical imaging?
   Answer: a) The equipment used is relatively inexpensive. b) Ultrasound has no harmful effects on living tissue because it uses high-frequency sound waves to obtain the desired image. c) Sonography is an excellent tool for detecting location and position of the fetus and for determining fetal age by employing sound echoes with very low penetrating power.

5: Describe three types of chemical reactions. (p. 66)

Lecture Suggestions and Guidelines

1. Introduce the three major types of chemical reactions in the human body: a) synthesis reactions, in which two or more atoms or molecules combine to form a larger, more complex structure; b) decomposition reactions, in which a molecule is broken down into smaller molecules, atoms, or ions; and c) exchange reactions, which involve both synthesis and decomposition.
2. Define the terms product, reactant, and catalyst.

Application Question(s)

1. Ask students to apply an example of each major kind of chemical reaction occurring in the human body.
   Answer: Examples might include the following: synthesis—the combining of amino acids to form a protein molecule; decomposition—the breakdown of glycogen by the liver to be released as smaller units of glucose; exchange—neutralizing hydrochloric acid in the stomach by swallowing an alkaline solution to form a salt and water.

Critical Thinking Issue(s)

1. Briefly describe the conversion of glucose to carbon dioxide and water within human cells. What kind of chemical reaction is it? Where does it occur?
   Answer: The absorption of glucose occurs at the plasma membrane. It is converted into glucose-6-phosphate. In the cell's cytosol, glucose-6-phosphate is broken down by catalysts into pyruvate, which is then absorbed by the mitochondrion. Pyruvate is decomposed to carbon dioxide and water by a sequence of reactions requiring oxygen.

6: Describe the differences among acids, bases, and salts. (p. 67)
and
7: Explain the pH scale. (p. 67)
and
8: Explain the function of buffers in resisting pH change. (p. 68)

Lecture Suggestions and Guidelines

1. Define the terms acid, base, and salt.
2. Introduce the pH scale and give examples of typical household chemicals which are characteristic of varying degrees of acidity and basicity.
3. Discuss acid-base concentrations in terms of relative concentration of hydrogen ions and hydroxyl ions and explain their relevancy to the pH scale.
4. Introduce four electrolytes of clinical diagnostic importance: sodium, chloride, potassium, and bicarbonate. Explain their importance in the human body.
5. Define buffer and give an example of its significance

Application Question(s)

1. By what mechanisms does the body maintain homeostasis through acid-base balance of body fluids?
   Answer: The regulation of acid-base balance depends upon a) buffer systems; the chief buffers of the blood are carbonic acid, bicarbonate salt, and hemoglobin; b) excretion of acids of bases by the kidneys; and 3) excretion of carbon dioxide by the lungs.

Critical Thinking Issue(s)

1. A patient arrives in the ER in severe metabolic acidosis. What does this mean, and what could be the cause?

Answer: Metabolic acidosis may develop as a result of any one of the three following situations: a) a disease state which causes an excess of acid ions, such as during diabetic acidosis or starvation; b) a condition such as renal failure in which there exists an inadequate excretion of acids; or c) during extreme loss of sodium bicarbonate caused, for example, by chronic diarrhea. In each case there is a primary deficit of alkaline ions with resulting acidosis.

2.3 Chemical Constituents of Cells

9: List the major groups of inorganic chemicals common in cells and explain the function(s) of each group. (p. 69)

Lecture Suggestions and Guidelines

1. Describe major inorganic molecules found in the human body, including water, oxygen, and carbon dioxide. Discuss some functions of each molecule.
2. Describe major inorganic ions found in the human body, including bicarbonate, calcium, carbonate, chloride, hydrogen, magnesium, phosphate, potassium, sodium, and sulfate. Discuss some functions of each ion.

Application Question(s)

1. Ask students to apply their knowledge of inorganic substances by making a chart of at least three inorganic molecules and at least ten inorganic ions which includes the name of the molecule or ion, its symbol or formula, and a description of the organ system(s), as discussed in Chapter 1, each of these substances would serve, along with its specific function.
   Answer: See textbook—Inorganic Substances Common in Cells.

Critical Thinking Issue(s)

1. Although most carbon dioxide is transported in plasma, small amounts of carbon dioxide are carried bound to the hemoglobin inside of red blood cells. How is this possible, since red blood cells seek to transport oxygen, not carbon dioxide, in the red blood cells? How does this differ from the transport of carbon monoxide, a potentially lethal gas, when bound to hemoglobin in large amounts?
   Answer: The structure of carbon dioxide molecules is such that, when carried inside red blood cells, it allows for binding at different sites than oxygen on the hemoglobin molecule. Thus, oxygen and carbon dioxide do not compete for the same binding site. Carbon monoxide, however, competes with oxygen for the same binding sites on the hemoglobin molecule. Hemoglobin molecules have a higher affinity for carbon monoxide than for oxygen, and carbon monoxide will capture the available binding sites over time. Thus, the body's tissues will be deprived of oxygen leading to impaired homeostasis and death.

10: Describe the general functions of the main classes of organic molecules in cells. (p. 70)

Lecture Suggestions and Guidelines

1. Introduce carbohydrates, lipids, proteins, and nucleic acids.
2. Describe which elements are present in each of the above organic compounds, list their building blocks, discuss functions of each type, and give examples of these organic substances found in the human body.
3. Illustrate the generalized structure of carbohydrates, lipids, proteins, and nucleic acids.
4. Distinguish between monosaccharides, disaccharides, and polysaccharides.
5. Describe major lipids, including neutral fats, phospholipids, steroids, such as cholesterol, and other lipoid substances, such as the fat soluble vitamins and lipoproteins.
6. Discuss functional proteins, including enzymes, hormones, immunoglobulins, actin and myosin, and hemoglobin.
7. Introduce the structure of DNA and RNA.

Application Question(s)

1. Ask students to give examples of typical monosaccharides, disaccharides, and polysaccharides.
   Answer: a) Monosaccharides: glucose-blood sugar; galactose and fructose-converted to glucose; ribose and deoxyribose-integral structures of nucleic acids; b) Disaccharides: sucrose-cane sugar, which is a combination of glucose and fructose; lactose-milk sugar, which is a combination of glucose and galactose; maltose-malt sugar, which is a combination of two glucose molecules; c) Polysaccharides: starch-found in grains and vegetables; glycogen-stored in the liver and later converted to glucose to meet the body's needs.
2. Ask students to prepare a list of twenty of their favorite foods. Collect package labels of each for analysis. Which are sources of carbohydrates? Proteins? Fats? Should the student consider changing his/her eating habits?
   Answer: Responses will vary.

Critical Thinking Issue(s)

1. Ask students to choose one organ system discussed in Chapter 1 and describe what possible effects a cholesterol-rich diet might have upon the organ system they choose.
   Answer: Examples might include the following: a) digestive system—the most common types of gallstones have been shown to consist of a mixture of cholesterol, calcium, and bilirubin. A smaller percent are made of pure cholesterol. Gallstones may cause a blockage of the release of bile; lead to infection, and in some cases, there is a much higher incidence of cancer of the gallbladder in patients who have had a history of gallstones; b) cardiovascular system—high cholesterol levels can lead to the buildup of plaque on arterial walls. The coronary arteries are frequently affected by atherosclerosis (plaque accumulation) and arteriosclerosis (hardening of the arteries), the end stage of the disease. Occlusions can lead to ischemia, and subsequent myocardial infarction.

Topical Chapter Outline

2.1 Introduction
2.2 Structure of Matter
a. Elements and Atoms
b. Atomic Structure
c. Isotopes
d. Molecules and Compounds
e. Bonding of Atoms
f. Chemical Reactions
g. Acids, Bases, and Salts
h. Acid and Base Concentrations
2.3 Chemical Constituents of Cells
a. Inorganic Substances (Water, Oxygen, Carbon Dioxide, and Inorganic Salts)
b. Organic Substances (Carbohydrates, Lipids, Proteins, and Nucleic Acids)

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