AAMC

Tomorrow's Doctors, Tomorrow's Cures®

What's on the **MCAT®** **Exam?**

Association of American Medical Colleges

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Quick Facts About the MCAT® Exam

1. The Medical College Admission Test® (MCAT®) has been part of the medical school admissions process for more than 80 years.
2. It is a standardized multiple-choice, computer-based exam, developed and administered by the Association of American Medical Colleges (AAMC) in partnership with member medical schools.
3. More than 75,000 students take the MCAT exam each year.
4. Nearly all U.S. medical schools and some Canadian medical schools require MCAT scores.
5. Many health professions and graduate programs now accept MCAT scores in lieu of other standardized tests.
6. The MCAT exam is designed to assess the examinee's problem solving, critical thinking, and knowledge of science concepts and principles that are prerequisites to the study of medicine.
7. The MCAT exam in its current format, outlined in this e-book, will be administered through January 2015. After January 2015, a new, redesigned MCAT exam will be released. To find out more about the MCAT2015 exam, visit aamc.org/mcat2015.

Overview of MCAT Content

MCAT content is divided into three multiple-choice sections:

1. Physical Sciences
2. Verbal Reasoning
3. Biological Sciences

In 2013, the Writing Sample section was removed from the exam and replaced by a voluntary, unscored Trial Section.

Get more details about the MCAT exam, preparing, registering, and what happens on test day on the AAMC MCAT website.

Exam Overview

Section	# of Questions	Time Allotted
Name Confirmation Screen		2 minutes
Examinee Agreement		10 minutes
Tutorial (optional)		10 minutes
Physical Sciences	52	70 minutes
Break (optional)		10 minutes
Verbal Reasoning	40	60 minutes
Break (optional)		10 minutes
Biological Sciences	52	70 minutes
Void Question		5 minutes
Break (optional)		10 minutes
Trial Section (optional)	32	45 minutes
Satisfaction Survey (optional)	12	10 minutes
Total Content Time		4 hours | 5 minutes
Total "Seated" Time*		**Approx. 5 hours | 10 minutes**

**Total seated time does not include check-in at the test center.*

Physical Sciences and Biological Sciences Sections

The following overview of the Physical and Biological Sciences Sections outlines passages you'll find in these sections and the cognitive skills and math concepts you'll use.

How Exam Content May Differ from Your Course Content

- Some topics covered in undergraduate courses may be omitted from the MCAT exam because they are not as relevant to the study of medicine as are the topics included.
- The organization of topics in the exam content outline may differ from topics presented in your courses.
- Some topics may not have been emphasized in your school's introductory undergraduate courses.

Types of Passages

The passages accompanying each set of questions in the Physical Sciences section will be presented in one of four formats. The number of problem sets in each format is approximately equal.

- **Information presentation**. The passage is presented in the form of textbook or journal articles. The materials assume the appropriate background knowledge but also contain new information or new uses of information. The questions test your understanding and evaluation of the given information and your ability to use the information in various ways.
- **Problem solving**. The passage describes a problem of general chemistry, physics, biology, or organic chemistry. The questions require you to determine the probable causes of the situations, events, or phenomena described and select appropriate methods for solving the problems.
- **Research study**. The passage documents all or part of the rationales, methods, and results of research projects. The questions test your understanding of the projects.
- **Persuasive argument**. The passage is designed to convince the reader that particular perspectives, methodologies, pieces of evidence, or products are correct. The passages may express single viewpoints or two opposing points of view. The questions test your understanding of the arguments presented in the passages and ask you to evaluate the validity of the arguments.

Cognitive Skills

Here's an outline of the cognitive skills you'll use to answer questions in the Physical Sciences and the Biological Sciences sections of the exam, followed by a more detailed description of each:

1. Identification of Main Ideas
2. Identification of Components in a Situation and Relationships Among Them
3. Seeking Clarification
4. Hypothesis Testing
5. Evaluation Processes
6. Flexibility and Adaptability in Scientific Reasoning
7. Reasoning Using Quantitative Data

1. Cognitive Skills: Identification of Main Ideas

These questions:

- Refer to the main idea of a passage or other points explicitly or implicitly made in the passage
- Ask for simple identification or interpretation of the material
- Often require you to demonstrate an understanding of the material by identifying:
  - The general purpose of a research study
  - Key differences among viewpoints
  - Major points or arguments
  - A major problem not specifically mentioned in the passage
  - Alternate ways of representing material from the passage

2. Cognitive Skills: Identification of Components in a Situation and Relationships Among Them

These questions:

- Refer to specific pieces of information that are important for understanding the passage, including:
  - o Hypotheses
  - o Assumptions
  - o Relevant issues
  - o Conclusions
  - o Supporting evidence
  - o Rationales
  - o Experimental variables
- Test your ability to identify these components or variables and determine basic relationships among them
- May require you to incorporate pertinent background knowledge

3. Cognitive Skills: Seeking Clarification

These questions:

- Ask for a closer definition of material in the passage or background information that clarifies a particular scientific concept
- May ask you to provide additional information relevant to concepts presented in the passage or in the question itself
- Include those that require you to:
  - o Identify relevant background information
  - o Translate presented information into a more understandable or useful form
  - o Identify appropriate clarifying information

4. Cognitive Skills: Hypothesis Testing

These questions:

- Test, relate, or extend the hypotheses or assumptions presented in the passage or require the development of new hypotheses
- Tend to focus on assumptions from the passage, rather than pre-drawn conclusions
- May ask you to:
  - Predict a result on the basis of background knowledge and specific facts about a situation
  - Form a hypothesis to explain a particular scientific phenomenon
  - Identify plausible alternative hypotheses or solutions
  - Design an experiment to test a hypothesis according to appropriate criteria (e.g., data collection procedures, control of variables, relevance to the hypothesis)
  - Determine the likely cause of a particular event or result
  - Combine steps in a research design in an appropriate sequence to test a hypothesis

5. Cognitive Skills: Evaluation Processes

These questions:

- Evaluate scientific data, procedures, conclusions, evidence, or perspectives
- May or may not require the use of background knowledge
- Often require you to make some sort of judgment based on generally accepted scientific criteria. You will be asked to:
  - Judge whether a conclusion follows necessarily from a given set of premises
  - Appraise the rationale for a procedure or generalization
  - Judge whether a conclusion is justified by the evidence
  - Judge the credibility of given information or evidence
  - Determine whether a product, argument, or perspective is acceptable on the basis of specifically given criteria (e.g., whether it fulfills task requirements, fully resolves all relevant aspects of a problem, fits available data)

6. Cognitive Skills: Flexibility and Adaptability in Scientific Reasoning

These questions:

- Require the extension of concepts presented or implied in the passage
- Often ask you to apply the given information or your background knowledge to unfamiliar situations
- Ask you to:
  - Use given information to solve a problem
  - Arrive at a conclusion based on the evidence
  - Determine the implications of results for real-world situations
  - Develop a general theory or model based on the given information
  - Determine how a conclusion can be modified to be consistent with additional information
  - Recognize methods, results, or evidence that would challenge or invalidate a hypothesis, model, or theory

7. Cognitive Skills: Reasoning Using Quantitative Data

These questions:

- Involve the interpretation of a graph, table, or figure, or the manipulation of data found therein
- Require you to:
  - Understand basic principles and methods used in the presentation of data
  - Explain, describe, identify, or compare components of graphs, charts, figures, diagrams, and tables
  - Identify background knowledge relevant to interpretation of graphs, charts, figures, diagrams, and tables
  - Select the most appropriate format for representing data or other information
  - Discern trends in data
  - Identify relationships inherent in data

Math Concepts

Here are the mathematics concepts you'll use to answer questions in both the Physical Sciences and the Biological Sciences sections of the exam:

- Ability to perform arithmetic calculations, including proportion, ratio, percentage, and estimation of square root
- Understanding of fundamental topics in the following areas (at the level of second-year high school algebra coursework): exponentials and logarithms (natural and base ten); scientific notation; quadratic and simultaneous equations; graphic representations of data and functions, including terminology (abscissa, ordinate), slope or rate of change, reciprocals, and various scales (arithmetic, semi-log, and log-log)
- Knowledge of the definitions of the basic trigonometric functions (sine, cosine, tangent); sin and cos values of 0°, 90°, and 180°; the relationships between the lengths of sides of right triangles containing angles of 30°, 45°, and 60°; and inverse trigonometric functions (arcsin, arccos, arctan)
- Use of metric units; the ability to balance equations containing physical units. Conversion factors between metric and British systems will be provided when needed

Math Concepts

- Understanding of relative magnitude of experimental error and the effect of propagation of error; understanding of reasonable estimates and the significant digits of a measurement
- Ability to calculate at an elementary level the mathematical probability of an event
- Understanding of vector addition, vector subtraction, and right-hand rule is required. Dot and cross products are not required
- Ability to calculate the arithmetic mean (average) and range of a set of numerical data; an understanding of the standard deviation as a measure of variability; an understanding of the general concepts of statistical association and correlation. Calculation of statistics such as standard deviations and correlation coefficients is not required
- **An understanding of calculus is not required**

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Physical Sciences Section

Physical Sciences

The Physical Sciences section of the MCAT exam assesses the application of introductory-level knowledge of general chemistry and physics to solve scientific problems.

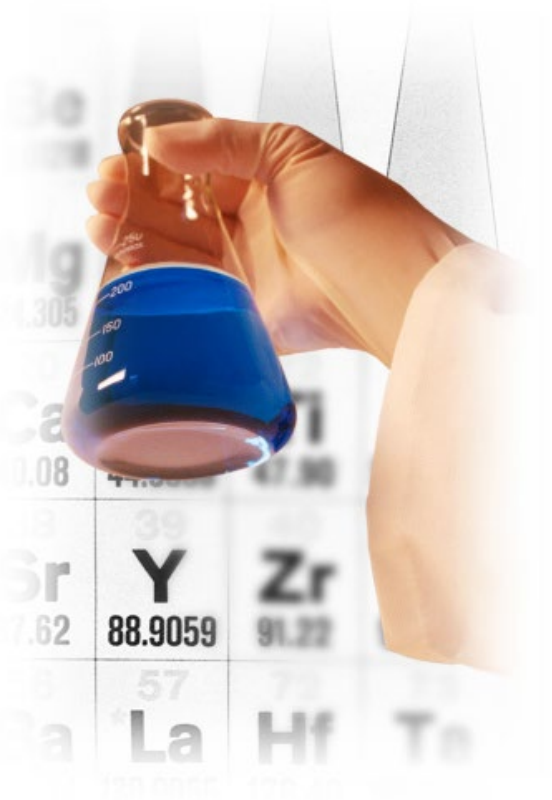
What to expect:

- 70 minutes to complete this section
- 52 multiple choice questions, including:
  - o 39 passage-based questions
  - o 13 discrete questions
- Tests your reasoning in general chemistry and physics
- Scientific competencies are drawn from basic principles and concepts that are taught at the introductory level in the vast majority of undergraduate institutions
- Advanced coursework in chemistry and physics is not needed for the test

Physical Sciences

What you should know:

- You are expected to know the topics listed in the content outlines (see page 35).
- Your cognitive skills also are tested (see pages 8–15).
- You should know equations and constants commonly used in introductory courses, as well as those specifically in the content outline.
- You need the same math skills to solve problems in both the Physical Sciences and the Biological Sciences sections (see pages 15–16).
- Other necessary constants and conversion factors are provided with the test questions.
- A periodic table of elements, including atomic numbers and atomic weights, is provided in the exam.



Physical Sciences

What you should know: Chemistry

You should be familiar enough with the following topics to solve basic chemistry problems and evaluate research in general chemistry:

- Thermodynamics
- Kinetics
- Electrochemistry
- Stoichiometry
- Electronic structure
- Bonding
- Phase equilibria
- Acids and bases

These concepts constitute the background knowledge you will need in order to answer questions, even though the questions may deal with situations or problems you have not yet previously encountered.

Physical Sciences

What you should know: Physics

You should be prepared to apply your knowledge of these concepts to experimental situations:

- Mechanics
- Wave motion
- Electricity and magnetism
- Light and optics
- Modern physics

You also will need to be familiar with the conventions of problem solving in physics.

Biological Sciences Section

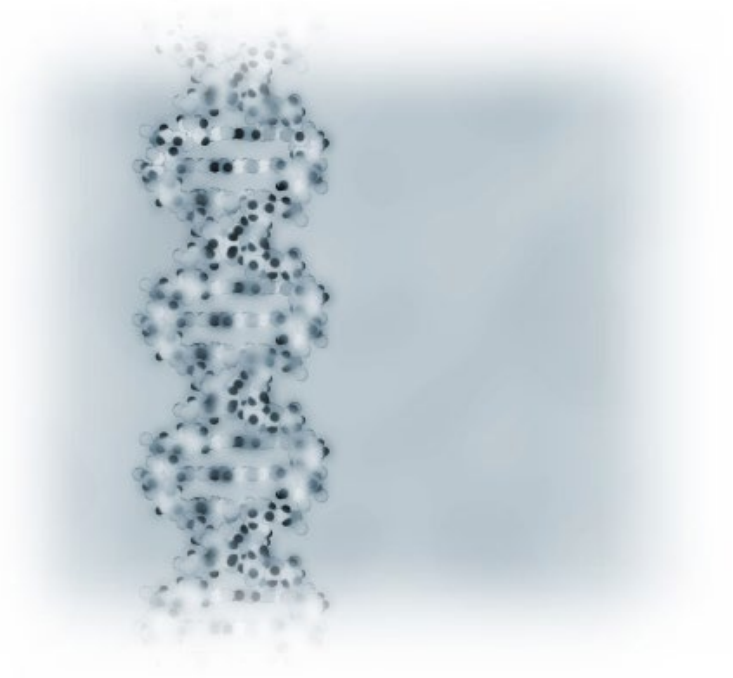
Biological Sciences

The Biological Sciences section of the MCAT exam assesses the application of introductory-level knowledge of biology and organic chemistry to solve scientific problems.

What to expect:

- 70 minutes to complete this section
- 52 multiple choice questions, including:
  - o 39 passage-based questions
  - o 13 discrete questions
- Tests your reasoning in biology and organic chemistry
- Scientific competencies are drawn from basic principles and concepts that are taught at the introductory level in the vast majority of undergraduate institutions
- Advanced coursework in biology and organic chemistry is not needed for the test

Biological Sciences



What you should know:

- You are expected to know the topics listed in the content outlines (see page 35).
- Your cognitive skills also are tested (see Physical and Biological Sciences Cognitive Skills).
- You should know equations and constants commonly used in introductory courses, as well as those specifically in the content outline.
- You need the same math skills to solve problems in both the Physical Sciences and the Biological Sciences sections.
- Other necessary constants and conversion factors are provided with the test questions.

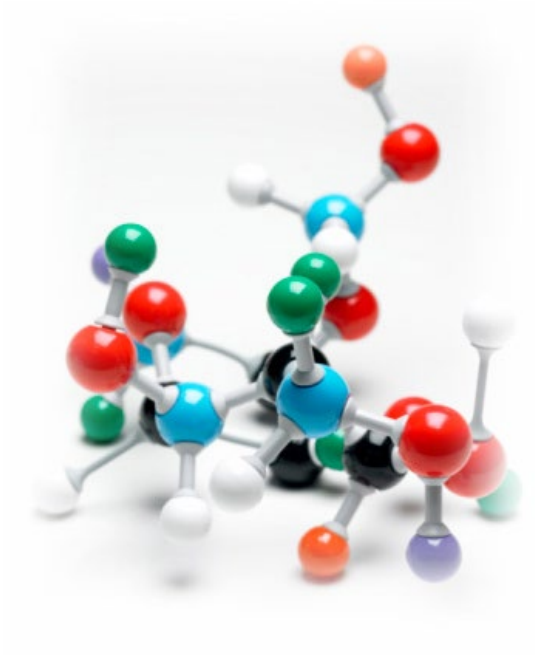
Biological Sciences

What you should know: Biology

The biology portion of the test will concentrate primarily on two major groups of living organisms: vertebrates and microbes. Topics may focus on:

- Concepts and information common to the life processes of organisms
  - o Molecular biology
  - o Cellular structure and function
  - o Genetics and evolution
- Vertebrate systems, from the organism or body-system level of organization
  - o Structure or function of a given body system
  - o Interaction of two or more body systems
  - o Effects of an external factor on the total physiology of an organism

Biological Sciences



What you should know: Organic Chemistry

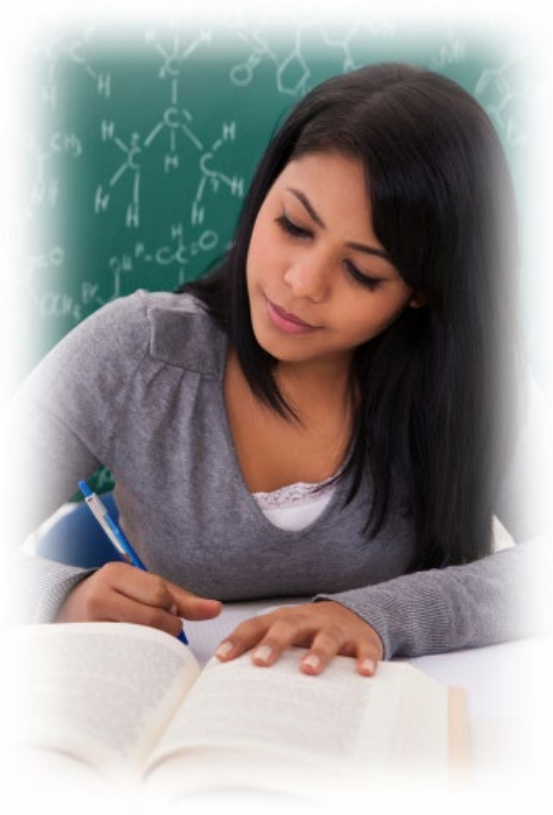
Organic chemistry plays an important role in the understanding of many biological reactions. You will be tested on your knowledge of:

- Organic compounds and reactions to explain results, arguments, and experimental procedures in terms of reactions or principles of organic compounds
- Nomenclature, classification of functional groups, and reaction mechanisms within the scope of the categories shown in the Biological Sciences Content Outline

Verbal Reasoning Section

Verbal Reasoning

The Verbal Reasoning section of the MCAT exam assesses the ability to understand, evaluate, and apply information and arguments presented in text.



What to expect:

- 60 minutes to complete this section
- 40 passage-based, multiple-choice questions
- Tests your ability to read attentively and make reasonable inferences based on the information
- Passages are selected and adapted from a variety of publications intended for well-educated readers, similar to what would be assigned to a college junior
- You are not expected to have any background knowledge or previous expertise in the subjects
- The correct answer for each question can be found either in the passage itself or by applying the information within the passage to new information contained within the question

Verbal Reasoning

Humanities Passages:

- Are drawn from excerpts in architecture, art, literature, music, philosophy, popular culture, religion, and theater
- Often focus on relationships between ideas, so are more likely to be written in a conversational or opinionated style than the social sciences, natural sciences, and technology passages

You may be required to glean information from the author's tone and word choice, in addition to the passage assertions themselves.

Verbal Reasoning

Social Sciences Passages:

- Focus on anthropology, archaeology, economics, education, history, linguistics, political science, psychology, and sociology
- Frequently center on the interpretation, implications, or applications of research in the social sciences, and often are based on studies about people in general or particular social groups
- Frequently are structured around a central claim that is either being supported or undermined by the information provided by the author
- May provide information that is very "rough" because the passage deals with complex issues and events in an artificially simplified manner

Verbal Reasoning

Natural Sciences and Technology Passages:

- Focus on astronomy, botany, computer science, ecology, ethology, geology, meteorology, technology, and zoology
- Emphasize the significance of scientific and technological issues and advances
- Center on factual knowledge and its implications or applications
- Are often straightforward in their presentation since the claims they support tend to be well defined and clearly circumscribed

Trial Section (Voluntary)

Trial Section

What to expect:

- The Writing Sample section has been eliminated so that you can participate in this voluntary, unscored Trial Section.
- You can decide to participate after you complete the "scored" sections of the exam by answering "yes" to the statement that you want to participate in the Trial Section.
- You'll test out 32 new questions that may be used in a future MCAT exam, in: biochemistry, biology, chemistry, and physics, OR in psychology, sociology, and biology.
- The Trial Section takes 45 minutes to complete and is the last section of the test.
- You do not need to prepare for the Trial Section.
- Whenever possible, questions assigned will be based on information you provided during MCAT registration about the courses you've taken.
- Your answers on the Trial Section will not contribute in any way to your MCAT score.
- No one, except you, will know how you did on the Trial Section.
- If you put forth a good-faith effort, you'll receive Gift Card (emailed to you within 3-4 weeks) and feedback on your performance.

Content Outlines

Physical Sciences Content Outline

General Chemistry

ELECTRONIC STRUCTURE AND PERIODIC TABLE

A. Electronic Structure

1. Orbital structure of hydrogen atom, principal quantum number n, number of electrons per orbital
2. Ground state, excited states
3. Absorption and emission spectra
4. Quantum numbers l, m, s, and number of electrons per orbital
5. Common names and geometric shapes for orbitals s, p, d
6. Conventional notation for electronic structure
7. Bohr atom
8. Effective nuclear charge

General Chemistry

B. The Periodic Table: Classification of Elements into Groups by Electronic Structure; Physical and Chemical Properties of Elements

1. Alkali metals
2. Alkaline earth metals
3. Halogens
4. Noble gases
5. Transition metals
6. Representative elements
7. Metals and nonmetals
8. Oxygen group

General Chemistry

C. The Periodic Table: Variations of Chemical Properties with Group and Row

1. Electronic structure

   a. representative elements
   b. noble gases
   c. transition metals

2. Valence electrons

3. First and second ionization energies

   a. definition
   b. prediction from electronic structure for elements in different groups or rows

4. Electron affinity

   a. definition
   b. variations with group and row

5. Electronegativity

   a. definition
   b. comparative values for some representative elements and important groups

6. Electron shells and the sizes of atoms

General Chemistry

BONDING

A. The Ionic Bond (Electrostatic Forces Between Ions)

1. Electrostatic energy $\propto q_1 q_2 / r$
2. Electrostatic energy $\propto$ lattice energy
3. Electrostatic force $\propto q_1 q_2 / r^2$

B. The Covalent Bond

1. Sigma and pi bonds

   a. hybrid orbitals (sp^3, sp^2, sp, and respective geometries)
   b. valence shell electron-pair repulsion (VSEPR) theory, predictions of shapes of molecules (e.g., NH_3, H_2O, CO_2)

2. Lewis electron dot formulas

   a. resonance structures
   b. formal charge
   c. Lewis acids and bases

3. Partial ionic character

   a. role of electronegativity in determining charge distribution
   b. dipole moment

Chemistry

PHASES AND PHASE EQUILIBRIA

A. Gas Phase

1. Absolute temperature, K
2. Pressure, simple mercury barometer
3. Molar volume at 0°C and 1 atm = 22.4 L/mol
4. Ideal gas
    a. definition
    b. ideal gas law ($PV = nRT$)
        i. Boyle's law
        ii. Charles's law
        iii. Avogadro's law
5. Kinetic theory of gases
6. Deviation of real-gas behavior from ideal gas law
    a. qualitative
    b. quantitative (van der Waals equation)
7. Partial pressure, mole fraction
8. Dalton's law relating partial pressure to composition

Chemistry

B. Intermolecular Forces

1. Hydrogen bonding
2. Dipole interactions
3. London dispersion forces

C. Phase Equilibria

1. Phase changes, phase diagrams
2. Freezing point, melting point, boiling point, condensation point
3. Molality
4. Colligative properties

   a. vapor pressure lowering (Raoult's law)
   b. boiling point elevation ($\Delta T_b = K_b m$)
   c. freezing point depression ($\Delta T_f = K_f m$)
   d. osmotic pressure

5. Colloids
6. Henry's law

Chemistry

STOICHIOMETRY

1. Molecular weight
2. Empirical formula versus molecular formula
3. Metric units commonly used in the context of chemistry
4. Description of composition by percent mass
5. Mole concept, Avogadro's number
6. Definition of density
7. Oxidation number

    a. common oxidizing and reducing agents
    b. disproportionation reactions
    c. redox titration

8. Description of reactions by chemical equations

    a. conventions for writing chemical equations
    b. balancing equations including redox equations
    c. limiting reactants
    d. theoretical yields

Chemistry

THERMODYNAMICS AND THERMOCHEMISTRY

A. Energy Changes in Chemical Reactions: Thermochemistry

1. Thermodynamic system, state function
2. Endothermic and exothermic reactions

   a. enthalpy *H*, standard heats of reaction and formation
   b. Hess's law of heat summation

3. Bond dissociation energy as related to heats of formation
4. Measurement of heat changes (calorimetry), heat capacity, specific heat capacity (specific heat capacity of water = 4.184 J/g·K)
5. Entropy as a measure of "disorder," relative entropy for gas, liquid, and crystal states
6. Free energy *G*
7. Spontaneous reactions and ΔG°

Chemistry

B. Thermodynamics

1. Zeroth law (concept of temperature)
2. First law ($\Delta E = q + w$, conservation of energy)
3. Equivalence of mechanical, chemical, electrical, and thermal energy units
4. Second law (concept of entropy)
5. Temperature scales, conversions
6. Heat transfer (conduction, convection, radiation)
7. Heat of fusion, heat of vaporization
8. *PV* diagram (work done = area under or enclosed by curve)

Chemistry

RATE PROCESSES IN CHEMICAL REACTIONS: KINETICS AND EQUILIBRIUM

1. Reaction rates
2. Rate law, dependence of reaction rate on concentrations of reactants
   a. rate constant
   b. reaction order
3. Rate-determining step
4. Dependence of reaction rate on temperature
   a. activation energy
      i. activated complex or transition state
      ii. interpretation of energy profiles showing energies of reactants and products, activation energy, ΔH for the reaction
   b. Arrhenius equation
5. Kinetic control versus thermodynamic control of a reaction
6. Catalysts, enzyme catalysis
7. Equilibrium in reversible chemical reactions
   a. law of mass action
   b. the equilibrium constant
   c. application of Le Châtelier's principle
8. Relationship of the equilibrium constant and ΔG°

Chemistry

SOLUTION CHEMISTRY

A. Ions in Solution

1. Anion, cation (common names, formulas, and charges for familiar ions; e.g., NH_4^+, ammonium; PO_4^{3-}, phosphate; SO_4^{2-}, sulfate)
2. Hydration, the hydronium ion

B. Solubility

1. Units of concentration (e.g., molarity)
2. Solubility product constant, the equilibrium expression
3. Common-ion effect, its use in laboratory separations
4. Complex ion formation
5. Complex ions and solubility
6. Solubility and pH

Chemistry

ACIDS AND BASES

A. Acid–Base Equilibria

1. Brønsted–Lowry definition of acids and bases
2. Ionization of water

   a. K_w, its approximate value ($K_w = [H_3O^+][OH^-] = 10^{-14}$ at 25°C)
   b. pH definition, pH of pure water
3. Conjugate acids and bases
4. Strong acids and bases (common examples; e.g., nitric, sulfuric)
5. Weak acids and bases (common examples; e.g., acetic, benzoic)

   a. dissociation of weak acids and bases with or without added salt
   b. hydrolysis of salts of weak acids or bases
   c. calculation of pH of solutions of weak acids or bases
6. Equilibrium constants K_a and K_b (pK_a and pK_b)
7. Buffers

   a. definition, concepts (common buffer systems)
   b. influence on titration curves

Chemistry

B. Titration

1. Indicators
2. Neutralization
3. Interpretation of titration curves

ELECTROCHEMISTRY

1. Electrolytic cell

   a. electrolysis
   b. anode, cathode
   c. electrolytes
   d. Faraday's law relating amount of elements deposited (or gas liberated) at an electrode to current
   e. electron flow, oxidation and reduction at the electrodes

2. Galvanic (voltaic) cell

   a. half-reactions
   b. reduction potentials, cell potential
   c. direction of electron flow

Physics

TRANSLATIONAL MOTION

1. Dimensions (length or distance, time)
2. Vectors, components
3. Vector addition
4. Speed, velocity (average and instantaneous)
5. Acceleration
6. Freely falling bodies

FORCE AND MOTION, GRAVITATION

1. Center of mass
2. Newton's first law (inertia)
3. Newton's second law ($F = ma$)
4. Newton's third law (forces equal and opposite)
5. Concept of a field
6. Law of gravitation ($F = -Gm_1m_2/r^2$)

Physics

7. Uniform circular motion
8. Centripetal force ($F = -mv^2/r$)
9. Weight
10. Friction (static and kinetic)
11. Motion on an inclined plane
12. Analysis of pulley systems
13. Force

EQUILIBRIUM AND MOMENTUM

A. Equilibrium

1. Concept of force, units
2. Translational equilibrium ($\Sigma F_i = 0$)
3. Rotational equilibrium ($\Sigma \tau_i = 0$)
4. Analysis of forces acting on an object
5. Newton's first law (inertia)

Physics

6. Torques, lever arms
7. Weightlessness

B. Momentum

1. Momentum = *mv*
2. Impulse = *Ft*
3. Conservation of linear momentum
4. Elastic collisions
5. Inelastic collisions

WORK AND ENERGY

A. Work

1. Derived units, sign convention
2. Path independence of work done in gravitational field
3. Mechanical advantage
4. Work–energy theorem
5. Power

Physics

B. Energy

1. Kinetic energy (KE = $mv^2/2$, units)
2. Potential energy

   a. gravitational, local (PE = mgh)
   b. spring (PE = $kx^2/2$)
   c. gravitational, general (PE = $-GmM/r$)
3. Conservation of energy
4. Conservative forces
5. Power, units

WAVES AND PERIODIC MOTION

A. Periodic Motion

1. Amplitude, period, frequency
2. Phase
3. Hooke's law ($F = -kx$)
4. Simple harmonic motion, displacement as a sinusoidal function of time

Physics

5. Motion of a pendulum
6. General periodic motion (velocity, amplitude)

B. Wave Characteristics

1. Transverse and longitudinal waves
2. Wavelength, frequency, wave speed
3. Amplitude and intensity
4. Superposition of waves, interference, wave addition
5. Resonance
6. Standing waves (nodes, antinodes)
7. Beat frequencies
8. Refraction and general nature of diffraction

Physics

SOUND

1. Production of sound
2. Relative speed of sound in solids, liquids, and gases
3. Intensity of sound (decibel units, log scale)
4. Attenuation
5. Doppler effect (moving sound source or observer, reflection of sound from a moving object)
6. Pitch
7. Resonance in pipes and strings
8. Harmonics
9. Ultrasound

Physics

FLUIDS AND SOLIDS

A. Fluids

1. Density, specific gravity
2. Archimedes' principle (buoyancy)
3. Hydrostatic pressure

a. Pascal's law

b. pressure versus depth ($P = \rho gh$)

4. Poiseuille flow (viscosity)
5. Continuity equation (Av = constant)
6. Concept of turbulence at high velocities
7. Surface tension
8. Bernoulli's equation

Physics

B. Solids

1. Density
2. Elastic properties (elementary properties)
3. Elastic limit
4. Thermal expansion coefficient
5. Shear
6. Compression

ELECTROSTATICS AND ELECTROMAGNETISM

A. Electrostatics

1. Charges, conductors, charge conservation
2. Insulators
3. Coulomb's law ($F = kq_1q_2/r^2$, sign conventions)
4. Electric field

    a. field lines
    b. field due to charge distribution

Physics

5. Potential difference, absolute potential at point in space
6. Equipotential lines
7. Electric dipole
   a. definition of dipole
   b. behavior in electric field
   c. potential due to dipole
8. Electrostatic induction
9. Gauss's law

B. Magnetism

1. Definition of the magnetic field **B**
2. Existence and direction of force on charge moving in magnetic field

C. Electromagnetic Radiation (Light)

1. Properties of electromagnetic radiation (general properties only)
   a. radiation velocity equals constant c in vacuo
   b. radiation consists of oscillating electric and magnetic fields that are mutually perpendicular to each other and to the propagation direction
2. Classification of electromagnetic spectrum (radio, infrared, UV, X-rays, etc.)

Physics

ELECTRONIC CIRCUIT ELEMENTS

A. Circuit Elements

1. Current ($I = \Delta Q/\Delta t$, sign conventions, units)
2. Battery, electromotive force, voltage
3. Terminal potential, internal resistance of battery
4. Resistance
   a. Ohm's law ($I = V/R$)
   b. resistors in series
   c. resistors in parallel
   d. resistivity ($\rho = RA/L$)
5. Capacitance
   a. concept of parallel-plate capacitor
   b. energy of charged capacitor
   c. capacitors in series
   d. capacitors in parallel
   e. dielectrics
6. Discharge of a capacitor through a resistor
7. Conductivity theory

Physics

B. Circuits

1. Power in circuits ($P = VI$, $P = I^2R$)

C. Alternating Currents and Reactive Circuits

1. Root-mean-square current
2. Root-mean-square voltage

LIGHT AND GEOMETRICAL OPTICS

A. Light (Electromagnetic Radiation)

1. Concept of interference, Young's double-slit experiment
2. Thin films, diffraction grating, single-slit diffraction
3. Other diffraction phenomena, X-ray diffraction
4. Polarization of light
5. Doppler effect (moving light source or observer)
6. Visual spectrum, color

    a. energy
    b. lasers

Physics

B. Geometrical Optics

1. Reflection from plane surface (angle of incidence equals angle of reflection)
2. Refraction, refractive index *n*, Snell's law ($n_1 \sin\theta^1 = n_2 \sin\theta^2$)
3. Dispersion (change of index of refraction with wavelength)
4. Conditions for total internal reflection
5. Spherical mirrors

   a. mirror curvature, radius, focal length
   b. use of formula (1/p) + (1/q) = 1/f with sign conventions
   c. real and virtual images
6. Thin lenses

   a. converging and diverging lenses, focal length
   b. use of formula $(1/p) + (1/q) = 1/f$ with sign conventions
   c. real and virtual images
   d. lens strength, diopters
   e. lens aberration
7. Combination of lenses
8. Ray tracing
9. Optical instruments

Physics

ATOMIC AND NUCLEAR STRUCTURE

A. Atomic Structure and Spectra

1. Emission spectrum of hydrogen (Bohr model)
2. Atomic energy levels

   a. quantized energy levels for electrons
   b. calculation of energy emitted or absorbed when an electron changes energy levels

B. Atomic Nucleus

1. Atomic number, atomic weight
2. Neutrons, protons, isotopes
3. Nuclear forces
4. Radioactive decay (α, β, γ, half-life, stability, exponential decay, semilog plots)
5. General nature of fission
6. General nature of fusion
7. Mass deficit, energy liberated, binding energy

Biological Sciences Content Outline

Biology

MOLECULAR BIOLOGY: ENZYMES AND METABOLISM

A. Enzyme Structure and Function

1. Function of enzymes in catalyzing biological reactions
2. Reduction of activation energy
3. Substrates and enzyme specificity

B. Control of Enzyme Activity

1. Feedback inhibition
2. Competitive inhibition
3. Noncompetitive inhibition

C. Basic Metabolism

1. Glycolysis (anaerobic and aerobic, substrates and products)
2. Krebs cycle (substrates and products, general features of the pathway)
3. Electron transport chain and oxidative phosphorylation (substrates and products, general features of the pathway)

Biology

4. Metabolism of fats and proteins

MOLECULAR BIOLOGY: DNA AND PROTEIN SYNTHESIS

DNA Structure and Function

A. DNA Structure and Function

1. Double-helix structure
2. DNA composition (purine and pyrimidine bases, deoxyribose, phosphate)
3. Base-pairing specificity, concept of complementarity
4. Function in transmission of genetic information

B. DNA Replication

1. Mechanism of replication (separation of strands, specific coupling of free nucleic acids, DNA polymerase, primer required)
2. Semiconservative nature of replication

C. Repair of DNA

1. Repair during replication
2. Repair of mutations

Biology

D. Recombinant DNA Techniques

1. Restriction enzymes
2. Hybridization
3. Gene cloning
4. PCR

Protein Synthesis

A. Genetic Code

1. Typical information flow (DNA → RNA → protein)
2. Codon–anticodon relationship, degenerate code
3. Missense and nonsense codons
4. Initiation and termination codons (function, codon sequences)

B. Transcription

1. mRNA composition and structure (RNA nucleotides, 5′ cap, poly-A tail)
2. tRNA and rRNA composition and structure (e.g., RNA nucleotides)
3. Mechanism of transcription (RNA polymerase, promoters, primer not required)

Biology

C. Translation

1. Roles of mRNA, tRNA, and rRNA; RNA base-pairing specificity
2. Role and structure of ribosomes

MOLECULAR BIOLOGY: EUKARYOTES

A. Eukaryotic Chromosome Organization

1. Chromosomal proteins
2. Telomeres, centromeres

B. Control of Gene Expression in Eukaryotes

1. Transcription regulation
2. DNA binding proteins, transcription factors
3. Cancer as a failure of normal cellular controls, oncogenes, tumor suppressor genes
4. Posttranscriptional control, basic concept of splicing (introns, exons)

Biology

MICROBIOLOGY

A. Fungi

1. General characteristics
2. General aspects of life cycle

B. Virus Structure

1. General structural characteristics (nucleic acid and protein, enveloped and non-enveloped)
2. Lack of organelles and nucleus
3. Structural aspects of typical bacteriophage
4. Genomic content (RNA or DNA)
5. Size relative to bacteria and eukaryotic cells

C. Viral Life Cycle

1. Self-replicating biological units that must reproduce within specific host cell
2. Generalized phage and animal virus life cycles

    a. attachment to host cell, penetration of cell membrane or cell wall, entry of viral material
    b. use of host synthetic mechanisms to replicate viral components
    c. self-assembly and release of new viral particles

Biology

3. Retrovirus life cycle, integration into host DNA, reverse transcriptase
4. Transduction, transfer of genetic material by viruses

D. Prokaryotic Cell: Bacteria Structure

1. Lack of nuclear membrane and mitotic apparatus
2. Lack of typical eukaryotic organelles
3. Major classifications: bacilli (rod-shaped), spirilli (spiral-shaped), cocci (spherical); eubacteria, archaebacteria
4. Presence of cell wall
5. Flagellar propulsion

E. Prokaryotic Cell: Growth and Physiology

1. Reproduction by fission
2. High degree of genetic adaptability, acquisition of antibiotic resistance
3. Exponential growth
4. Existence of anaerobic and aerobic variants

Biology

F. Prokaryotic Cell: Genetics

1. Existence of plasmids, extragenomic DNA, transfer by conjugation
2. Transformation (incorporation into bacterial genome of DNA fragments from external medium)
3. Regulation of gene expression, coupling of transcription and translation

GENERALIZED EUKARYOTIC CELL

A. Nucleus and Other Defining Characteristics

1. Defining characteristics (membrane-bound nucleus, presence of organelles, mitotic division)
2. Nucleus (compartmentalization, storage of genetic information)
3. Nucleolus (location, function)
4. Nuclear envelope, nuclear pores

Biology

B. Membrane-bound Organelles

1. Mitochondria

   a. site of ATP production
   b. self-replication; have own DNA and ribosomes
   c. inner and outer membrane

2. Lysosomes (vesicles containing hydrolytic enzymes)

3. Endoplasmic reticulum

   a. rough (RER) and smooth (SER)
   b. RER (site of ribosomes)
   c. role in membrane biosynthesis: SER (lipids), RER (transmembrane proteins)

   d. RER (role in biosynthesis of transmembrane and secreted proteins that cotranslationally targeted to RER by signal sequence)

4. Golgi apparatus (general structure; role in packaging, secretion, and modification of glycoprotein carbohydrates)

C. Plasma Membrane

1. General function in cell containment

2. Protein and lipid components, fluid mosaic model

3. Osmosis

Biology

4. Passive and active transport
5. Membrane channels
6. Sodium–potassium pump
7. Membrane receptors, cell signaling pathways, second messengers
8. Membrane potential
9. Exocytosis and endocytosis
10. Cell–cell communication (general concepts of cellular adhesion)

    a. gap junctions
    b. tight junctions
    c. desmosomes

D. Cytoskeleton

1. General function in cell support and movement
2. Microfilaments (composition; role in cleavage and contractility)
3. Microtubules (composition; role in support and transport)
4. Intermediate filaments (role in support)
5. Composition and function of eukaryotic cilia and flagella
6. Centrioles, microtubule organizing centers

Biology

E. Cell Cycle and Mitosis

1. Interphase and mitosis (prophase, metaphase, anaphase, telophase)
2. Mitotic structures and processes

    a. centrioles, asters, spindles
    b. chromatids, centromeres, kinetochores
    c. nuclear membrane breakdown and reorganization
    d. mechanisms of chromosome movement

3. Phases of cell cycle (G_0, G_1, S, G_2,M)
4. Growth arrest

F. Apoptosis (Programmed Cell Death)

Biology

SPECIALIZED EUKARYOTIC CELLS AND TISSUES

A. Nerve Cell/Neural

1. Cell body (site of nucleus and organelles)
2. Axon (structure, function)
3. Dendrites (structure, function)
4. Myelin sheath, Schwann cells, oligodendrocytes, insulation of axon
5. Nodes of Ranvier (role in propagation of nerve impulse along axon)
6. Synapse (site of impulse propagation between cells)
7. Synaptic activity
    a. transmitter molecules
    b. synaptic knobs
    c. fatigue
    d. propagation between cells without resistance loss
8. Resting potential (electrochemical gradient)
9. Action potential
    a. threshold, all-or-none
    b. sodium–potassium pump
10. Excitatory and inhibitory nerve fibers (summation, frequency of firing)

Biology

B. Muscle Cell/Contractile

1. Abundant mitochondria in red muscle cells (ATP source)
2. Organization of contractile elements (actin and myosin filaments, cross bridges, sliding filament model)
3. Calcium regulation of contraction, sarcoplasmic reticulum
4. Sarcomeres ("I" and "A" bands, "M" and "Z" lines, "H" zone—general structure only)
5. Presence of troponin and tropomyosin

C. Other Specialized Cell Types

1. Epithelial cells (cell types, simple epithelium, stratified epithelium)
2. Endothelial cells
3. Connective tissue cells (major tissues and cell types, fiber types, loose versus dense, extracellular matrix)

Biology

NERVOUS AND ENDOCRINE SYSTEMS

A. Endocrine System: Hormones

1. Function of endocrine system (specific chemical control at cell, tissue, and organ levels)
2. Definitions of endocrine gland, hormone
3. Major endocrine glands (names, locations, products)
4. Major types of hormones

B. Endocrine System: Mechanisms of Hormone Action

1. Cellular mechanisms of hormone action
2. Transport of hormones (bloodstream)
3. Specificity of hormones (target tissue)
4. Integration with nervous system (feedback control)

Biology

C. Nervous System: Structure and Function

1. Major functions

   a. high-level control and integration of body systems
   b. response to external influences
   c. sensory input
   d. integrative and cognitive abilities

2. Organization of vertebrate nervous system
3. Sensor and effector neurons
4. Sympathetic and parasympathetic nervous systems (functions, antagonistic control)
5. Reflexes

   a. feedback loop, reflex arc, effects on flexor and extensor muscles
   b. roles of spinal cord, brain
   c. efferent control

D. Nervous System: Sensory Reception and Processing

1. Skin, proprioceptive and somatic sensors
2. Olfaction, taste

Biology

3. Hearing

    a. ear structure
    b. mechanism of hearing

4. Vision

    a. light receptors
    b. eye structure
    c. visual image processing

CIRCULATORY, LYMPHATIC, AND IMMUNE SYSTEMS

A. Circulatory System

1. Functions (circulation of oxygen, nutrients, hormones, ions, and fluids; removal of metabolic waste)
2. Role in thermoregulation
3. Four-chambered heart (structure, function)
4. Systolic and diastolic pressure
5. Pulmonary and systemic circulation

Biology

6. Arterial and venous systems (arteries, arterioles, venules, veins)

    a. structural and functional differences
    b. pressure and flow characteristics

7. Capillary beds

    a. mechanisms of gas and solute exchange
    b. mechanism of heat exchange

8. Composition of blood

    a. plasma, chemicals, blood cells
    b. erythrocyte production and destruction (spleen, bone marrow)
    c. regulation of plasma volume
    d. coagulation, clotting mechanisms, role of liver in production of clotting factors

9. Oxygen and carbon dioxide transport by blood

    a. hemoglobin, hematocrit
    b. oxygen content
    c. oxygen affinity

10. Details of oxygen transport: biochemical characteristics of hemoglobin

    a. modification of oxygen affinity

Biology

B. Lymphatic System

1. Major functions

   a. equalization of fluid distribution
   b. transport of proteins and large glycerides
   c. return of materials to the blood

2. Composition of lymph (similarity to blood plasma; substances transported)

3. Source of lymph (diffusion from capillaries by differential pressure)

4. Lymph nodes (activation of lymphocytes)

C. Immune System: Innate and Adaptive Systems

1. Cells and their basic functions

   a. macrophages, neutrophils, mast cells, natural killer cells, dendritic cells
   b. T lymphocytes
   c. B lymphocytes, plasma cells

2. Tissues

   a. bone marrow
   b. spleen
   c. thymus
   d. lymph nodes

Biology

3. Basic aspects of innate immunity and inflammatory response
4. Concepts of antigen and antibody
5. Structure of antibody molecule
6. Mechanism of stimulation by antigen; antigen presentation

DIGESTIVE AND EXCRETORY SYSTEMS

A. Digestive System

1. Ingestion

   a. saliva as lubrication and source of enzymes
   b. epiglottal action
   c. pharynx (function in swallowing)
   d. esophagus (transport function)

2. Stomach

   a. storage and churning of food
   b. low pH, gastric juice, protection by mucus against self-destruction
   c. production of digestive enzymes, site of digestion
   d. structure (gross)

Biology

3. Liver

    a. production of bile
    b. roles in nutrient metabolism, vitamin storage
    c. roles in blood glucose regulation, detoxification
    d. structure (gross)

4. Bile

    a. storage in gallbladder
    b. function

5. Pancreas

    a. production of enzymes, bicarbonate
    b. transport of enzymes to small intestine
    c. structure (gross)

6. Small intestine

    a. absorption of food molecules and water
    b. function and structure of villi
    c. production of enzymes, site of digestion
    d. neutralization of stomach acid
    e. structure (anatomic subdivisions)

Biology

7. Large intestine

    a. absorption of water
    b. bacterial flora
    c. structure (gross)

8. Rectum (storage and elimination of waste, feces)

9. Muscular control

    a. sphincter muscle
    b. peristalsis

B. Excretory System

1. Roles in homeostasis

    a. blood pressure
    b. osmoregulation
    c. acid–base balance
    d. removal of soluble nitrogenous waste

2. Kidney structure

    a. cortex
    b. medulla

Biology

3. Nephron structure

    a. glomerulus
    b. Bowman's capsule
    c. proximal tubule
    d. loop of Henle
    e. distal tubule
    f. collecting duct

4. Formation of urine

    a. glomerular filtration
    b. secretion and reabsorption of solutes
    c. concentration of urine
    d. countercurrent multiplier mechanism (basic function)

5. Storage and elimination (ureter, bladder, urethra)

Biology

MUSCLE AND SKELETAL SYSTEMS

A. Muscle System

1. Functions

    a. support, mobility
    b. peripheral circulatory assistance
    c. thermoregulation (shivering reflex)

2. Structural characteristics of skeletal, smooth, and cardiac muscle; striated versus nonstriated

3. Nervous control

    a. motor neurons
    b. neuromuscular junctions, motor end plates
    c. voluntary and involuntary muscles
    d. sympathetic and parasympathetic innervation

B. Skeletal System

1. Functions

    a. structural rigidity and support
    b. calcium storage
    c. physical protection

Biology

2. Skeletal structure

   a. specialization of bone types; structures
   b. joint structures
   c. endoskeleton versus exoskeleton

3. Cartilage (structure, function)

4. Ligaments, tendons

5. Bone structure

   a. calcium–protein matrix
   b. bone growth (osteoblasts, osteoclasts)

RESPIRATORY SYSTEM

A. Respiratory System

1. General structure and function

   a. gas exchange, thermoregulation
   b. protection against disease, particulate matter

2. Breathing mechanisms

   a. diaphragm, rib cage, differential pressure
   b. resiliency and surface tension effects

Biology

SKIN SYSTEM

A. Skin System

1. Functions in homeostasis and osmoregulation
2. Functions in thermoregulation

    a. hair, erectile musculature
    b. fat layer for insulation
    c. sweat glands, location in dermis
    d. vasoconstriction and vasodilation in surface capillaries

3. Physical protection

    a. nails, calluses, hair
    b. protection against abrasion, disease organisms

4. Structure

    a. layer differentiation, cell types, tissue types (epithelial, connective)
    b. relative impermeability to water

Biology

REPRODUCTIVE SYSTEM AND DEVELOPMENT

A. Reproductive System

1. Male and female reproductive structures and their functions

   a. gonads
   b. genitalia
   c. differences between male and female structures

2. Gametogenesis by meiosis

3. Ovum and sperm

   a. differences in formation
   b. differences in morphology
   c. relative contribution to next generation

4. Reproductive sequence (fertilization, implantation, development, birth)

Biology

B. Embryogenesis

1. Stages of early development (order and general features of each)
    a. fertilization
    b. cleavage
    c. blastula formation
    d. gastrulation
        i. first cell movements
        ii. formation of primary germ layers (endoderm, mesoderm, ectoderm)
    e. neurulation
2. Major structures arising out of primary germ layers

C. Developmental Mechanisms

1. Cell specialization
    a. determination
    b. differentiation
    c. tissue types
2. Cell communication in development
3. Gene regulation in development
4. Programmed cell death

Biology

GENETICS

A. Mendelian Concepts

1. Phenotype and genotype (definitions, probability calculations, pedigree analysis)
2. Gene
3. Locus
4. Allele (single, multiple)
5. Homozygosity and heterozygosity
6. Wild type
7. Recessiveness
8. Complete dominance
9. Codominance
10. Incomplete dominance, leakage, penetrance, expressivity
11. Gene pool

Biology

B. Meiosis and Genetic Variability

1. Significance of meiosis
2. Important differences between meiosis and mitosis
3. Segregation of genes
   a. independent assortment
   b. linkage
   c. recombination
   d. single crossovers
   e. double crossovers
4. Sex-linked characteristics
   a. very few genes on Y chromosome
   b. sex determination
   c. cytoplasmic inheritance, mitochondrial inheritance
5. Mutation
   a. general concept of mutation
   b. types of mutations (random, translation error, transcription error, base substitution, insertion, deletion, frameshift)
   c. chromosomal rearrangements (inversion, translocation)
   d. advantageous versus deleterious mutation
   e. inborn errors of metabolism
   f. relationship of mutagens to carcinogens

Biology

C. Analytic Methods

1. Hardy–Weinberg principle
2. Testcross (backcross; concepts of parental, F1, and F2 generations)

EVOLUTION

A. Evolution

1. Natural selection
   a. fitness concept
   b. selection by differential reproduction
   c. concepts of natural and group selection
   d. evolutionary success as increase in percent representation in the gene pool of the next generation
2. Speciation
   a. definition of species
   b. polymorphism
   c. adaptation and specialization
   d. concepts of ecological niche, competition
   e. concept of population growth through competition

Biology

f. inbreeding
g. outbreeding
h. bottlenecks, genetic drift
i. divergent, parallel, and convergent evolution
j. symbiotic relationships
    i. parasitism
    ii. commensalism
    iii. mutualism

3. Relationship between ontogeny and phylogeny
4. Evolutionary time as measured by gradual random changes in genome
5. Origin of life

B. Comparative Anatomy

1. Chordate features

    a. notochord
    b. pharangeal pouches, brachial arches
    c. dorsal nerve cord

2. Vertebrate phylogeny (vertebrate classes and relations to each other)

Organic Chemistry

THE COVALENT BOND

A. Sigma and Pi Bonds

1. Hybrid orbitals (sp^3, sp^2, sp, and their respective geometries)
2. Valence shell electron-pair repulsion (VSEPR) theory, predictions of shapes of molecules (e.g., NH_3, H_2O, CO_2)
3. Structural formulas
4. Delocalized electrons and resonance in ions and molecules

B. Multiple Bonding

1. Its effect on bond length and bond energies
2. Rigidity in molecular structure

C. Stereochemistry of Covalently Bonded Molecules

1. Isomers

   a. constitutional isomers
   b. stereoisomers (e.g., diastereomers, enantiomers, cis and trans isomers)
   c. conformational isomers

2. Polarization of light, specific rotation

Organic Chemistry

3. Absolute and relative configuration

   a. conventions for writing R and S forms
   b. conventions for writing E and Z forms

4. Racemic mixtures, separation of enantiomers

MOLECULAR STRUCTURE AND SPECTRA

A. Absorption Spectroscopy

1. Infrared region

   a. intramolecular vibrations and rotations
   b. recognizing common characteristic group absorptions, fingerprint region

2. Visible region

   a. absorption in visible region yielding complementary color
   b. effect of structural changes on absorption

3. Ultraviolet region

   a. π-electron and nonbonding electron transitions
   b. conjugated systems

Organic Chemistry

B. Mass Spectrometry

1. Mass-to-charge ratio (*m/z*)
2. Molecular ion peak

C. ^{1}H NMR Spectroscopy

1. Protons in a magnetic field, equivalent protons
2. Spin–spin splitting

SEPARATIONS AND PURIFICATIONS

A. Extraction (Distribution of Solute Between Two Immiscible Solvents)

B. Distillation

C. Chromatography (Basic Principles Involved in Separation Process)

1. Gas–liquid chromatography
2. Paper chromatography
3. Thin-layer chromatography

D. Recrystallization (Solvent Choice from Solubility Data)

Organic Chemistry

HYDROCARBONS

A. Alkanes

1. Description

    a. nomenclature
    b. physical properties

2. Important reactions

    a. combustion
    b. substitution reactions with halogens, etc.

3. General principles

    a. stability of free radicals, chain reaction mechanism, inhibition
    b. ring strain in cyclic compounds

c. bicyclic molecules

Organic Chemistry

OXYGEN-CONTAINING COMPOUNDS

A. Alcohols

1. Description

   a. nomenclature
   b. physical properties

2. Important reactions

   a. substitution reactions (S_N1 or S_N2, depending on alcohol and derived alkyl halide)
   b. oxidation
   c. pinacol rearrangement in polyhydroxyalcohols, synthetic uses
   d. protection of alcohols
   e. reactions with $SOCl_2$ and PBr_3
   f. preparation of mesylates and tosylates
   g. esterification
   h. inorganic esters

3. General principles

   a. hydrogen bonding
   b. acidity of alcohols compared to other classes of oxygen-containing compounds
   c. effect of chain branching on physical properties

Organic Chemistry

B. Aldehydes and Ketones

1. Description

   a. nomenclature
   b. physical properties

2. Important reactions

   a. nucleophilic addition reactions at C=O bond
      i. acetal, hemiacetal
      ii. imine, enamine

   b. reactions at adjacent positions
      i. haloform reactions
      ii. aldol condensation
      iii. oxidation

   c. 1,3-dicarbonyl compounds, internal hydrogen bonding
   d. keto–enol tautomerism
   e. organometallic reagents
   f. Wolff–Kishner reaction
   g. Grignard reagents

Organic Chemistry

3. General principles

   a. effect of substituents on reactivity of C=O; steric hindrance
   b. acidity of α hydrogens; carbanions
   c. α, β–unsaturated carbonyl compounds, their resonance structures

C. Carboxylic Acids

1. Description

   a. nomenclature
   b. physical properties and solubility

2. Important reactions

   a. carboxyl group reactions
      i. nucleophilic attack
      ii. reduction
      iii. decarboxylation
      iv. esterification

   b. reactions at α position
      i. halogenation
      ii. substitution reactions

3. General principles

   a. hydrogen bonding

Organic Chemistry

b. dimerization
c. acidity of the carboxyl group
d. inductive effect of substituents
e. resonance stability of carboxylate anion

D. Acid Derivatives (Acid Chlorides, Anhydrides, Amides, Esters)

1. Description

   a. nomenclature
   b. physical properties

2. Important reactions

   a. preparation of acid derivatives
   b. nucleophilic substitution
   c. Hofmann rearrangement
   d. transesterification
   e. hydrolysis of fats and glycerides (saponification)
   f. hydrolysis of amides

3. General principles

   a. relative reactivity of acid derivatives
   b. steric effects
   c. electronic effects
   d. Strain (e.g., β-lactams)

Organic Chemistry

E. Keto Acids and Esters

1. Description

   a. nomenclature

2. Important reactions

   a. decarboxylation
   b. acetoacetic ester synthesis

3. General principles

   a. acidity of α hydrogens in β–keto esters
   b. keto–enol tautomerism

AMINES

1. Description

   a. nomenclature
   b. stereochemistry, physical properties

2. Important reactions

   a. amide formation
   b. reaction with nitrous acid

Organic Chemistry

c. alkylation
d. Hofmann elimination

3. General principles

a. basicity
b. stabilization of adjacent carbocations
c. effect of substituents on basicity of aromatic amines

BIOLOGICAL MOLECULES

A. Carbohydrates

1. Description

a. nomenclature, classification, common names
b. absolute configurations
c. cyclic structure and conformations of hexoses
d. epimers and anomers

2. Hydrolysis of the glycoside linkage

3. Reactions of monosaccharides

Organic Chemistry

B. Amino Acids and Proteins

1. Description

   a. a absolute configuration(s)
   b. amino acids classified as dipolar ions
   c. classification
      i. acidic or basic
      ii. hydrophobic or hydrophilic

2. Important reactions

   a. peptide linkage
   b. hydrolysis

3. General principles

   a. 1° structure of proteins
   b. 2° structure of proteins

C. Lipids

1. Description, structure

   a. steroids
   b. terpenes
   c. triacyl glycerols
   d. free fatty acids

Organic Chemistry

D. Phosphorus Compounds

1. Description

   a. structure of phosphoric acids (anhydrides, esters)

2. Important reactions

   a. Wittig reaction

MCAT Verbal Reasoning Skills Content Outline

I. Comprehension

A. Identify the central concern or thesis of the passage.

B. Identify the reasons or evidence offered in support of a thesis.

C. Identify the background knowledge contained in the passage or question that is relevant to a particular interpretation.

D. Determine, from context, the meaning of significant terminology or vocabulary used in the passage.

E. Recognize an accurate paraphrase of complex information presented in the passage.

F. Identify comparative relationships among ideas or pieces of information contained in the passage.

G. Identify stated or unstated assumptions contained in the passage.

H. Recognize appropriate questions of clarification.

MCAT Verbal Reasoning Skills Content Outline

II. Evaluation

A. Judge the soundness of an argument or a step of reasoning presented in the passage.

B. Judge the credibility of a source.

C. Judge whether a conclusion follows necessarily from the reasons given in the passage.

D. Appraise the strength of the evidence for a generalization, conclusion, or claim.

E. Distinguish between supported and unsupported claims.

F. Judge the relevance of information to an argument or claim.

III. Application

A. Predict a result on the basis of passage content and specific facts about a hypothetical situation.

B. Use given information to solve a specified problem.

C. Identify the probable cause of a particular event or result based on information presented.

D. Determine the implications of conclusions or results for real-world situations.

E. Recognize the scope of application of hypotheses, explanations, and conclusions.

F. Identify a general theory or model based on given information.

MCAT Verbal Reasoning Skills Content Outline

IV. Incorporation of New Information

A. Judge the bearing of new evidence on conclusions presented in the passage.

B. Recognize methods or results that would challenge hypotheses, models, or theories given in the passage.

C. Determine how a conclusion from the passage can be modified to be consistent with additional information.

D. Recognize plausible alternative hypotheses or solutions.

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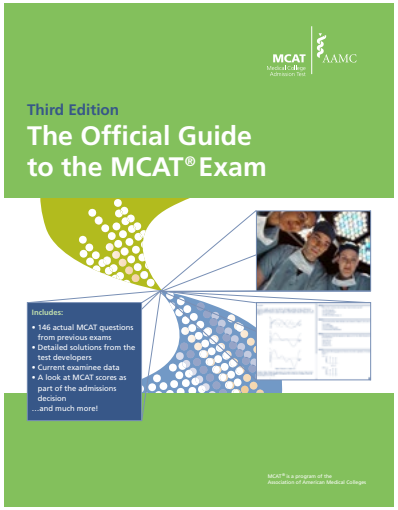

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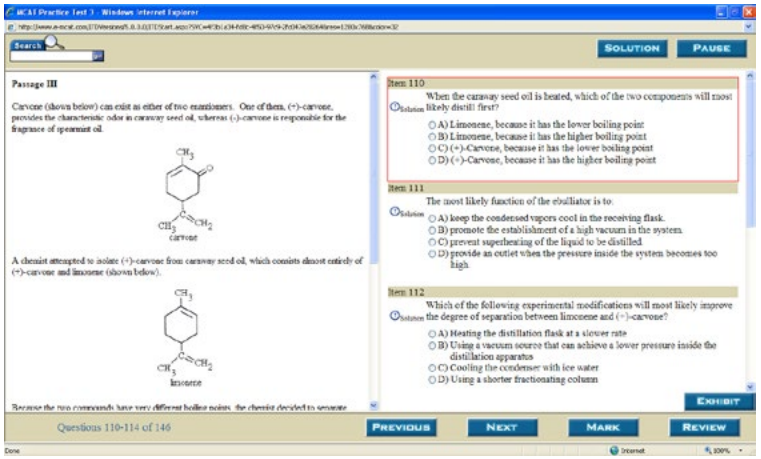

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