

**McGraw-Hill Education**

# **MCAT**

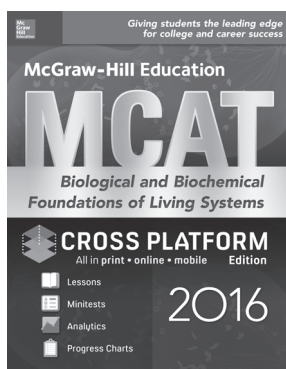
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**BIOLOGICAL AND BIOCHEMICAL  
FOUNDATIONS OF LIVING SYSTEMS**  
2016

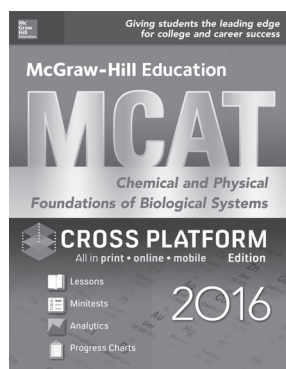
# McGraw-Hill Education

# MCAT

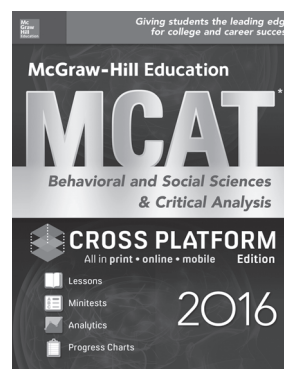
## Test Preparation Series



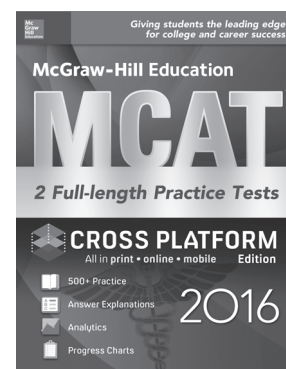
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- Molecules, Cells, and Organs
- Systems of Tissues and Organs



- Physical Foundations of Biological Systems
- Chemical Foundations of Biological Systems



- Perception and Response
- Behavior
- Self and Others
- Social Structure
- Social Strata
- Critical Analysis and Reasoning Skills



- Practice Test 1
  - Answers and Explanations
- Practice Test 2
  - Answers and Explanations

**McGraw-Hill Education**

# MCAT

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**BIOLOGICAL AND BIOCHEMICAL  
FOUNDATIONS OF LIVING SYSTEMS**  
2016

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**Kathy A. Zahler, MS**, is a widely published author and textbook writer. She has authored or coauthored numerous McGraw-Hill Education preparation guides for tests, including the GRE<sup>®</sup>, the Miller Analogies Test, the Test of Essential Academic Skills (TEAS<sup>®</sup>), and the Test Assessing Secondary Completion<sup>™</sup> (TASC<sup>™</sup>).



# How to Use the McGraw-Hill Education MCAT Preparation Series

Welcome to the McGraw-Hill Education MCAT Preparation series. You've made the decision to pursue a medical career, you've studied hard, you've taken and passed the most difficult science courses, and now you must succeed on this very tough exam. We're here to help you.

This series has been created by a dedicated team of scientists, teachers, and test-prep experts. Together, they have helped thousands of students to score high on all kinds of exams, from rigorous science tests to difficult essay-writing assignments. They have pooled their knowledge, experience, and test-taking expertise to make this the most effective self-study MCAT preparation program available.

The four books in this series contain a wealth of features to help you do your best. The four volumes are organized as follows:

*MCAT Biological and Biochemical Foundations of Living Systems* provides:

- ▶ **A general introduction to the MCAT**, including basic facts about the structure and format of the test and the kinds of questions you will encounter.
- ▶ **Important test-taking strategies** that can help you raise your score.
- ▶ **An in-depth review of all the topics tested in Part 1 of the exam: Biological and Biochemical Foundations of Living Systems.** This is the exam section that assesses your knowledge of foundational concepts in biology and biochemistry, and your understanding of how biological processes function both separately and together in living systems, including the human body.
- ▶ **Unit Minitests modeled on Part 1 of the exam.** These practice exams are designed to simulate the actual MCAT in format and degree of difficulty. The questions ask you to use your scientific research and reasoning skills to solve problems demonstrating your mastery of the skills required for success in medical school.

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How to Use the  
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Preparation Series

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*MCAT Chemical and Physical Foundations of Biological Systems* provides:

- ▶ **A general introduction to the MCAT**, including basic facts about the structure and format of the test and the kinds of questions you will encounter.
- ▶ **Important test-taking strategies** that can help you raise your score.
- ▶ **An in-depth review of all the topics tested in Part 2 of the exam: Chemical and Physical Foundations of Biological Systems.** This is the exam section that assesses your knowledge of foundational concepts in organic chemistry and physics, and your understanding of how chemical and physical processes function both separately and together in living systems, including the human body.
- ▶ **Two Minitests and a Cumulative Minitest modeled on Part 2 of the exam.** These practice exams are designed to simulate the actual MCAT in format and degree of difficulty. The questions ask you to use your scientific research and reasoning skills to solve problems demonstrating your mastery of the skills required for success in medical school.

*MCAT Behavioral and Social Sciences & Critical Analysis* provides:

- ▶ **A general introduction to the MCAT**, including basic facts about the structure and format of the test and the kinds of questions you will encounter.
- ▶ **An in-depth review of all the topics tested in Parts 3 and 4 of the exam: Psychological, Social, and Biological Foundations of Behavior and Critical Analysis and Reasoning Skills.** Part 3 of the exam tests your knowledge of basic concepts in psychology and sociology that are important to understanding how behavioral and sociocultural factors affect health outcomes and the provision of healthcare. Part 4 of the exam tests your ability to analyze, evaluate, and apply information from reading passages in a wide range of social sciences and humanities areas.
- ▶ **Unit Minitests modeled on Parts 3 and 4 of the exam.** These practice exams are designed to simulate the actual MCAT in format and degree of difficulty. The questions ask you to use your scientific research and reasoning skills to solve problems that demonstrate your mastery of the skills required for success in medical school.

*MCAT 2 Full-Length Practice Tests* provides:

- ▶ **A general introduction to the MCAT**, including basic facts about the structure and format of the test and the kinds of questions you will encounter.
- ▶ **Important test-taking strategies** that can help you raise your score.
- ▶ **Two full-length practice MCAT tests** designed to simulate the real exam in structure, format, and degree of difficulty. Of course, these practice tests can provide only an approximation of how well you will do on the actual MCAT. However, if you approach them as you would the real test, they should give you a very good idea of how well you are prepared.

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- **Explanations for every question.** After you take each test, read carefully through these explanations, paying special attention to those you answered incorrectly or had to guess on. If necessary, go back and reread the subject review sections in the corresponding chapters.

Different people have different ways of preparing for a test like the MCAT. You must find a preparation method that suits your schedule and your learning style. We have tried to make this series flexible enough for you to use in a way that works best for you, but to succeed on this extremely rigorous exam, there is no substitute for serious, intensive review and study. The more time and effort you devote to preparing, the better your chances of achieving your MCAT goals.



# Introducing the MCAT

## Read This Section to Learn About

- MCAT Basics
- The Computerized Test Format
- Where and When to Take the MCAT
- How to Register for the MCAT
- Taking the MCAT More Than Once
- Your MCAT Scores
- How Medical Schools Use MCAT Scores
- Reporting Scores to Medical Schools
- For Further Information
- The Format of the Test
- What Is Tested in the Science Sections
- What Is Tested in Critical Analysis
- General Test-Taking Strategies

## MCAT BASICS

The Medical College Admission Test (MCAT) is a standardized exam that is used to assess applicants to medical schools. The test is sponsored by the Association of American Medical Colleges (AAMC) in cooperation with its member schools. It is required as part of the admissions process by most U.S. medical schools. The test is administered by Prometric, a private firm that is a leading provider of technology-based testing and assessment services.

The questions on the MCAT are basically designed to measure your problem-solving and critical-thinking skills. Two test sections assess your mastery of fundamental concepts in biology, biochemistry, general chemistry, organic chemistry, and physics. A third section tests your understanding of concepts in psychology, sociology, and biology that are important to understanding how behavioral and sociocultural factors affect health outcomes and the provision of health care. For most questions in

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these sections, choosing the correct answer requires more than just a rote response; you must calculate a solution, interpret and evaluate given data, or apply a particular scientific principle to a given situation. You will need to demonstrate that you can reason scientifically and employ the principles of research methodology and statistics. There is also a fourth section that tests your ability to analyze, evaluate, and apply information from reading passages on topics in ethics, philosophy, cross-cultural studies, and population health.

According to the AAMC, the skills tested on the MCAT are those identified by medical professionals and educators as essential for success in medical school and in a career as a physician. The importance of the biological, biochemical, and physical sciences is self-evident. Psychological and sociological concepts are included, according to the AAMC, because “knowledge of the behavioral and social determinants of health and wellness [is] becoming more important in medical education,” and “tomorrow’s doctors need to know [these concepts] in order to serve a more diverse population and to understand the impact of behavior on health and wellness.”

## THE COMPUTERIZED TEST FORMAT

You will take the MCAT on a computer. You will view the questions on the computer screen and indicate your answers by clicking on on-screen answer ovals. As you work through the on-screen questions, you will be able to highlight relevant portions of the reading passages for easy reference. You will also be able to strike out answer choices that you know are incorrect. This will help you use the process of elimination to pick the correct answer. You will also be allowed to make notes on scratch paper (although all of your notes will be collected at the end of the test). Within each test section, you will be able to go back, review questions that you have already answered, and change your answer if you decide to do so. However, once you have finished a test section, you cannot go back to it and make any changes.

Don’t be concerned if you are not a whiz with computers; the skills required are minimal, and in any case, on test day you will have the opportunity to access a computer tutorial that will show you exactly what you need to do.

## WHERE AND WHEN TO TAKE THE MCAT

The MCAT is offered at approximately 275 sites in the United States (including the U.S. territories of Puerto Rico and the Virgin Islands) and at 12 sites in Canada. All of these sites are testing labs operated by Prometric. The test is also offered at numerous locations outside North America, including sites in Europe, Great Britain, the Middle East, Africa, Asia, and Australia.

There are 22 test dates every year. Two of the dates are in January, and the rest are in the period from April through early September. Most test dates are weekdays, but a few are Saturdays. On some dates, the test is given only in the morning; on others,

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it is given only in the afternoon. On a few dates, the test is given in both morning and afternoon sessions.

It is a good idea to take the MCAT in the spring or summer of the year before the fall in which you plan to enroll in medical school. That way, you have enough time to submit your scores to meet the schools' application deadlines.

For up-to-date lists of testing sites and also for upcoming test dates, make sure to check the official MCAT website at [www.aamc.org/mcat](http://www.aamc.org/mcat).

## HOW TO REGISTER FOR THE MCAT

You can register for the MCAT online at [www.aamc.org/mcat](http://www.aamc.org/mcat). Online registration for each test date begins six months prior to that date. Registration is available until two weeks before the test date. It's a good idea to register early, because seating at the testing centers may be limited and you want to make sure you get a seat at the center of your choice. When you register, you are charged a fee, which you can pay by credit card. If you wish to change your test date, you can do so online.

## TAKING THE MCAT MORE THAN ONCE

If your MCAT score is lower than expected, you may want to take the test again. You can take the MCAT up to three times in the same year. However, the AAMC recommends retesting only if you have a good reason to think that you will do better the next time. For example, you might do better if, when you first took the test, you were ill, or you made mistakes in keying in your answers, or your academic background in one or more of the test subjects was inadequate.

If you are considering retesting, you should also find out how your chosen medical schools evaluate multiple scores. Some schools give equal weight to all MCAT scores; others average scores together, and still others look only at the highest scores. Check with admissions officers before making a decision.

## YOUR MCAT SCORES

When you take the MCAT, your work on each of the four test sections first receives a "raw score." The raw score is calculated based on the number of questions you answer correctly. No points are deducted for questions answered incorrectly. Each raw score is then converted into a scaled score. Using scaled scores helps make test-takers' scores comparable from one version of the MCAT to another. For each of the four sections, scaled scores range from 118 (lowest) to 132 (highest). Scaled scores for the entire exam range from 472 (lowest) to 528 (highest).

Your score report will be mailed to you approximately 30 days after you take the MCAT. You will also be able to view your scores on the online MCAT Testing History (THx) System as soon as they become available. (For details on the THx system, see

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the MCAT website.) MCAT score reports also include percentile rankings that show how well you did in comparison to others who took the same test.

## HOW MEDICAL SCHOOLS USE MCAT SCORES

Medical college admission committees emphasize that MCAT scores are only one of several criteria that they consider when evaluating applicants. When making their decisions, they also consider students' college and university grades, recommendations, interviews, and involvement and participation in extracurricular or health care-related activities that, in the opinion of the admission committee, illustrate maturity, motivation, dedication, and other positive personality traits that are of value to a physician. If the committee is unfamiliar with the college you attend, they may pay more attention than usual to your MCAT scores.

There is no hard-and-fast rule about what schools consider to be an acceptable MCAT score. The AAMC recommends that admissions officers should not limit acceptance to students who score in the upper third of the range. Instead, they should focus on applicants who score “at the top of the curve,” that is, those whose scores lie at the top of the curve on the graph of the percentage of applicants who achieved each score point total. Statistically speaking, those students are likely to graduate successfully from medical school and to pass later qualifying exams on their first try. The AAMC says that this focus is “consistent with wholistic review practices” and “is designed to draw attention to applicants who might otherwise be overlooked.” The “top of the curve” scaled score for each MCAT test section is 125; for the entire exam it is 500.

Note that many medical schools do not accept MCAT scores that are more than three years old.

## REPORTING SCORES TO MEDICAL SCHOOLS

Your MCAT scores are automatically reported to the American Medical College Application Service (AMCAS), the nonprofit application processing service used by nearly all U.S. medical schools. When you use this service, you complete and submit a single application, rather than separate applications to each of your chosen schools. Your scores are submitted to your designated schools along with your application. There is a fee for using AMCAS. If you wish to submit your scores to other application services or to programs that do not participate in AMCAS, you can do so through the online MCAT Testing History (THx) System.

## FOR FURTHER INFORMATION

For further information about the MCAT, visit the official MCAT website at [www.aamc.org/mcat](http://www.aamc.org/mcat)



For questions about registering for the test, reporting and interpreting scores, and similar issues, you may also contact:

Association of American Medical Colleges  
Medical College Admission Test  
655 K Street, NW, Suite 100  
Washington, D.C. 20001-2399

## THE FORMAT OF THE TEST

The MCAT consists of four separately timed sections as outlined in the following chart.

MCAT: Format of the Test		
Section	Number of Questions	Time Allowed (minutes)
1. Biological and Biochemical Foundations of Living Systems <i>Break: 10 minutes</i>	59	95
2. Chemical and Physical Foundations of Biological Systems <i>Break: 10 minutes</i>	59	95
3. Psychological, Social, and Biological Foundations of Behavior <i>Break: 10 minutes</i>	59	95
4. Critical Analysis and Reasoning Skills	53	90
<b>Totals</b>	<b>230</b>	<b>375 (= 6 hours, 15 minutes)</b>

## WHAT IS TESTED IN THE SCIENCE SECTIONS

**The natural sciences sections of the MCAT (sections 1 and 2)** test your mastery of the concepts and principles of biology, biochemistry, general chemistry, organic chemistry, and physics as they apply to living systems, including the human body.

**The behavioral and social sciences section of the MCAT (section 3)** tests your understanding of the behavioral and sociocultural factors that play a role in health care.

These three sections have three main organizing principles:

1. **Foundational concepts:** what the AAMC calls the “big ideas” in the sciences that underlie the subjects taught in medical school
2. **Content categories:** the topics that support the foundational concepts
3. **Scientific inquiry and reasoning skills:** the skills needed to solve scientific problems

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## Foundational Concepts and Content Categories

According to the AAMS, the foundational concepts and categories for sections 1, 2, and 3 of the MCAT are as follows:

### 1. BIOLOGICAL AND BIOCHEMICAL FOUNDATIONS OF LIVING SYSTEMS

**Foundational Concept 1:** *Biomolecules have unique properties that determine how they contribute to the structure and function of cells and how they participate in the processes necessary to maintain life.*

Content categories:

- ▶ Structure and function of proteins and their constituent amino acids
- ▶ Transmission of genetic information from the gene to the protein
- ▶ Transmission of heritable information from generation to generation and the processes that increase genetic diversity
- ▶ Principles of bioenergetics and fuel molecule metabolism

**Foundational Concept 2:** *Highly organized assemblies of molecules, cells, and organs interact to carry out the functions of living organisms.*

Content categories:

- ▶ Assemblies of molecules, cells, and groups of cells within single cellular and multicellular organisms
- ▶ Structure, growth, physiology, and genetics of prokaryotes and viruses
- ▶ Processes of cell division, differentiation, and specialization

**Foundational Concept 3:** *Complex systems of tissues and organs sense the internal and external environments of multicellular organisms and, through integrated functioning, maintain a stable internal environment within an ever-changing external environment.*

Content categories:

- ▶ Structure and functions of the nervous and endocrine systems and ways in which these systems coordinate the organ systems
- ▶ Structure and integrative functions of the main organ systems

### 2. CHEMICAL AND PHYSICAL FOUNDATIONS OF BIOLOGICAL SYSTEMS

**Foundational Concept 4:** *Complex living organisms transport materials, sense their environment, process signals, and respond to changes using processes that can be understood in terms of physical principles.*

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Content categories:

- ▶ Translational motion, forces, work, energy, and equilibrium in living systems
- ▶ Importance of fluids for the circulation of blood, gas movement, and gas exchange
- ▶ Electrochemistry and electrical circuits and their elements
- ▶ How light and sound interact with matter
- ▶ Atoms, nuclear decay, electronic structure, and atomic chemical behavior

**Foundational Concept 5:** *The principles that govern chemical interactions and reactions form the basis for a broader understanding of the molecular dynamics of living systems.*

Content categories:

- ▶ Unique nature of water and its solutions
- ▶ Nature of molecules and intermolecular interactions
- ▶ Separation and purification methods
- ▶ Structure, function, and reactivity of biologically relevant molecules
- ▶ Principles of chemical thermodynamics and kinetics

### 3. PSYCHOLOGICAL, SOCIAL, AND BIOLOGICAL FOUNDATIONS OF BEHAVIOR

**Foundational Concept 6:** *Biological, psychological, and sociocultural factors influence the ways that individuals perceive, think about, and react to the world.*

Content categories:

- ▶ Sensing the environment
- ▶ Making sense of the environment
- ▶ Responding to the world

**Foundational Concept 7:** *Biological, psychological, and sociocultural factors influence behavior and behavior change.*

Content categories:

- ▶ Individual influences on behavior
- ▶ Social processes that influence human behavior
- ▶ Attitude and behavior change

**Foundational Concept 8:** *Psychological, sociocultural, and biological factors influence the way we think about ourselves and others, as well as how we interact with others.*

Content categories:

- ▶ Self-identity
- ▶ Social thinking
- ▶ Social interactions

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**Foundational Concept 9:** *Cultural and social differences influence well-being.*

Content categories:

- Understanding social structure
- Demographic characteristics and processes

**Foundational Concept 10:** *Social stratification and access to resources influence well-being.*

Content category:

- Social inequality

## Scientific Inquiry and Reasoning Skills

The scientific inquiry and reasoning skills that are tested on Sections 1, 2, and 3 of the MCAT are as follows:

- **Skill 1:** Knowledge of Scientific Concepts and Principles
- **Skill 2:** Scientific Reasoning and Evidence-Based Problem Solving
- **Skill 3:** Reasoning About the Design and Execution of Research
- **Skill 4:** Data-Based and Statistical Reasoning

To demonstrate mastery of **Skill 1: Knowledge of Scientific Concepts and Principles**, you need to be able to recall and apply basic scientific concepts and principles to solve problems in science. In many cases, you will need to analyze and interpret information presented in diagrams, charts, graphs, and formulas.

To demonstrate mastery of **Skill 2: Scientific Reasoning and Evidence-Based Problem Solving**, you need to be able to understand and use scientific theories, to propose hypotheses, and to analyze scientific models or research studies in order to identify assumptions, make predictions, and draw conclusions.

To demonstrate mastery of **Skill 3: Reasoning About the Design and Execution of Research**, you need to be able to identify appropriate research designs for investigating specified research questions, to critique and evaluate those designs, to predict results, and to recognize ethical issues involved in research.

To demonstrate mastery of **Skill 4: Data-Based and Statistical Reasoning**, you need to be able to interpret data or to describe or evaluate the results of a research study using statistical concepts.

## WHAT IS TESTED IN CRITICAL ANALYSIS

The **Critical Analysis and Reasoning Skills section of the MCAT (Section 4)** tests your ability to comprehend information in a reading passage, to analyze and evaluate arguments and supporting evidence, and to apply concepts and ideas to new situations.

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The passages in this section cover a wide range of topics in both the social sciences and the humanities. You may encounter readings in philosophy, ethics, cultural studies, and similar topics. All the information you need to answer the questions will be provided in the passage; no outside knowledge of the topics is required.

According to the AAMC, the questions in the Critical Analysis and Reasoning Skills section test the following four specific skills:

- ▶ **Comprehension:** the ability to understand new information or to view facts or ideas in a new light
- ▶ **Evaluation:** the ability to analyze ideas or arguments presented in a passage and to make judgments about their reasonableness, their credibility, and the soundness of supporting evidence
- ▶ **Application:** the ability to apply information in a passage to new conditions or situations and to predict possible outcomes
- ▶ **Incorporation of information:** the ability to consider how new information affects the ideas presented in a passage; for example, whether it strengthens or weakens an argument or a hypothesis

## GENERAL TEST-TAKING STRATEGIES

The following sections present some general test-taking strategies that apply to the multiple-choice questions on the MCAT. These strategies can help you to gain valuable points when you take the actual test.

### Take Advantage of the Multiple-Choice Format

All of the questions on the MCAT are in the multiple-choice format, which you have undoubtedly seen many times before. That means that for every question, the correct answer is right in front of you. All you have to do is pick it out from among three incorrect choices, called “distracters.” Consequently, you can use the process of elimination to rule out incorrect answer choices. The more answers you rule out, the easier it is to make the right choice.

### Answer Every Question

Recall that on the MCAT, there is no penalty for choosing a wrong answer. Therefore, if you do not know the answer to a question, you have nothing to lose by guessing. So make sure that you answer every question. If time is running out and you still have not answered some questions, make sure to enter an answer for the questions that you have not attempted. With luck, you may be able to pick up a few extra points, even if your guesses are totally random.

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## Make Educated Guesses

What differentiates great test takers from merely good ones is the ability to guess in such a way as to maximize the chance of guessing correctly. The way to do this is to use the process of elimination. Before you guess, try to eliminate one or more of the answer choices. That way, you can make an educated guess, and you have a better chance of picking the correct answer. Odds of one out of two or one out of three are better than one out of four!

## Go with Your Gut

In those cases where you're not 100 percent sure of the answer you are choosing, it is often best to go with your gut feeling and stick with your first answer. If you decide to change that answer and pick another one, you may well pick the wrong answer because you have over-thought the problem. More often than not, if you know something about the subject, your first answer is likely to be the correct one.

## Take Advantage of Helpful Computer Functions

On the MCAT, you have access to certain computer functions that can make your work easier. As you work through the on-screen questions, you are able to highlight relevant portions of the reading passages. This helps you save time when you need to find facts or details to support your answer choices. You are also able to cross out answer choices that you know are incorrect. This helps you use the process of elimination to pick the correct answer.

## Use the Scratch Paper Provided

The MCAT is an all-computerized test, so there is no test booklet for you to write in. However, you are given scratch paper, so use it to your advantage. Jot down notes, make calculations, and write out an outline for each of your essays. Be aware, however, that you cannot remove the scratch paper from the test site. All papers are collected from you before you leave the room.

Because you cannot write on the actual MCAT, don't get into the habit of writing notes to yourself on the test pages of this book. Use separate scratch paper instead. Consider it an opportunity to learn to use scratch paper effectively.

## Keep Track of the Time

Make sure that you're on track to answer all of the questions within the time allowed. With so many questions to answer in a short time period, you're not going to have a lot of time to spare. Keep an eye on your watch or on the computerized timer provided.

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Do not spend too much time on any one question. If you find yourself stuck for more than a minute or two on a question, then you should make your best guess and move on. If you have time left over at the end of the section, you can return to the question and review your answer. However, if time runs out, don't give the question another thought. You need to save your focus for the rest of the test.

## Don't Panic if Time Runs Out

If you pace yourself and keep track of your progress, you should not run out of time. If you do, however, run out of time, don't panic. Because there is no guessing penalty and you have nothing to lose by doing so, enter answers to all the remaining questions. If you are able to make educated guesses, you will probably be able to improve your score. However, even random guesses may help you pick up a few points. In order to know how to handle this situation if it happens to you on the test, make sure you observe the time limits when you take the practice tests. Guessing well is a skill that comes with practice, so incorporate it into your preparation program.

## If Time Permits, Review Questions You Were Unsure Of

Within each test section, the computer allows you to return to questions you have already answered and change your answer if you decide to do so. (However, once you have completed an entire section, you cannot go back to it and make changes.) If time permits, you may want to take advantage of this function to review questions you were unsure of or to check for careless mistakes.





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