PA-CAT Physician Assistant College Admissions Test

Bulletin of Information

Exam Master®

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Introduction

The Physician Assistant College Admission Test (PA-CAT®) is a specialized test that is designed to measure applicant knowledge and application in key prerequisite science subjects typically required for PA school. The PA-CAT measures general academic ability and scientific knowledge necessary for success in the demanding Physician Assistant curriculum. The PA-CAT has been developed specifically for use by PA educators and admissions experts as part of a holistic admissions process.

History of the PA-CAT

Over the last five years applications to PA school have risen dramatically. This is partly a result of the increase in the number of accredited PA programs in the U.S. The increase in applications also reflects the strong interest in the profession for those looking to work as a health-care provider. A typical PA program receives many hundreds of applications for only 40-60 available incoming seats.

In 2017, Exam Master conducted a study of admissions processes at physician assistant programs across the United States. The results of the study indicated that most PA educators have a strong interest in having an admissions instrument that would help them better select from a large group of qualified applicants. Based on this response, Exam Master determined that there would be a benefit to providing a national exam as a source of data on student placement and retention.

After forming a research committee to create a norm-referenced standardized exam, and field testing the instrument in 2018 to over 1700 examinees at 36 PA programs, the first PA-CAT norms were established. The exam will be administered for admissions purposes beginning in May of 2020.

Test Structure

The PA-CAT is a four-hour standardized assessment featuring 240 single-best-answer multiple-choice test items. Of these items, 40 are pretest questions that are being field-tested for use on future test forms and are not used to determine candidate's scores. Based on item response theory, items that meet established criteria for psychometric properties and content relevance are selected for use on future test forms.

The exam was developed to assess common basic science subjects and statistics consistent with what is typically required for admission by a majority of PA programs. Test items were developed and reviewed by subject matter experts, PA educators, and editorial staff to ensure accuracy, relevance, style, and format and consistency. To view sample test items, please see Appendix A.

The PA-CAT items are mapped to a variety of Bloom's taxonomy cognitive domains for deeper assessment, as shown in table 1.

Cognitive Level	Percentage[1]
Knowledge	12%
Comprehension	25%
Application	54%
Analysis	9%

Table 1: Bloom's Taxonomy Cognitive Levels

[1] Percentages are subject to change at any time.

PA Admissions Exam Blueprint

All PA Admissions Examinations are constructed from a pre-established content outline that is reviewed annually and updated as needed for currency. The primary subject areas of the PA Admissions Exam are shown below in Table 2, with the percentage assigned to each for a typical exam[2].

Subject	Percentage	Number of Items
Anatomy	16%	39
Physiology	16%	39
Chemistry	16%	38
General Biology	11%	26
Microbiology	11%	26
Genetics	11%	26
Biochemistry	5%	12
Behavioral Sciences	9%	22
Statistics	5%	12
Total	**100%**	**240**

Table 2 PA-CAT Content Categories

Tables 2-10 show the detailed content objectives for each of the subjects assessed on the PA Admissions Exam. These detailed lists represent examples of the material that may be covered on the PA-CAT[3]. While not all the listed content objectives are included in every PA Admissions Exam, overall content coverage is equivalent among the various examination forms that will be taken by different examinees.

[2] Percentages are subject to change at any time.

[3] It is not possible to include all topics on a single exam, and it may be possible that some questions on the exam cover objectives that are not listed in the examples.

Anatomy Content Objectives	
The Back	The Pelvis and Perineum
Curvatures of the Vertebral Column	The Bony Pelvis
The Vertebrae	The Pelvic Viscera
Spinal Cord and Spinal Nerves	The Male Perineum and Reproductive Organs
The Abdomen	The Female Perineum and Reproductive Organs
The Anterior Abdominal Wall	The Thorax
The Spleen	Mediastinum
The Esophagus	Skeletal and Muscular Components
The Stomach	The Lungs, Trachea, and Bronchi
The Large and Small Intestine	The Pericardium
The Pancreas	The Heart and Great Vessels
The Liver and Biliary Ducts	The Upper Limb
The Hepatic Circulation	The Pectoral Girdle
The Kidney and Ureters	The Axilla
The Head	The Brachial Plexus
The Skull	The Arm and Forearm
The Face	The Wrist and Hand
The Ear	
The Cranial Nerves	
The Lower Limb	
The Hip and Thigh Areas	
The Gluteal Region	
The Leg	
The Hip, Knee, and Ankle Joints	
The Foot	

Table 3 PA-CAT Anatomy Blueprint

Physiology Content Objectives	
The Cell	Renal Physiology
Functions of the Cellular Organelles	Fluid Balance Regulation
Translation and Transcription	Glomerular Filtration and Renal Blood Flow
Blood and Clotting	Renal Tubular Reabsorption and Secretion
Hemostasis and Blood Coagulation	Renal Ion Regulation
Circulation	Renal Acid/Base Regulation
Basics of Flow, Pressure, and Resistance	Respiratory Physiology
Microcirculation	Basics of Pulmonary Ventilation
Mechanisms of Blood Flow Control	Basics of Gas Exchange
Cardiac Output and Venous Return	Pulmonary Circulation and Edema
The Lymphatic System	Oxygen and Carbon Dioxide Transport in Blood
Coronary Blood Flow	Regulation of Respiration
Endocrinology	Reproduction
Hypothalamus Hormones	Mitosis and Meiosis
Pituitary Hormones	Spermatogenesis
Thyroid Hormones	Oogenesis
Parathyroid Hormones	Pregnancy and Lactation
Endocrine Hormones	Basics of Fetal Physiology
Adrenocortical Hormones	The Heart
Gastrointestinal Physiology	Heart Structure Valves, and Valve Sounds
Paristalsis, Segmentation, and Defecation	Cardiac Cycle
Chemical Digestion, Absorption, and Regulation	Electrical Activity of the Heart
Membrane Physiology	Coronary Blood Flow
Diffusion and Osmosis	Heart Defects
Membrane Transport (Active and Passive)	The Special Senses
Basics of Membrane Potential	Vision, Hearing, Taste, and Smell
The Actions Potential	
The Muscular Contraction	
Metabolism	
Carbohydrate, Protein, and Lipid Metabolism	
Nervous System	
Nerve Physiology, Conduction, and Transmission	
Basics of Somatic Sensations	
Basics of Motor and Cerebral Circuits	
Basics of the Autonomic Nervous System	

Table 4 PA-CAT Physiology Blueprint

Chemistry Content Objectives
Acids and Bases
Bronsted Lowry Acids and Bases
Measuring Acidity and Basicity
Strengths of Acids and Bases
Atoms, Ions, and Molecules
Atomic Theory
Ions and Molecules
Chemical Bonding and Molecular Geometry
VSEPR Theory
Chemical Reactions
Balancing
Solubility Rules
Types of Reactions
Electrochemistry
Oxidation and Reduction
Gases
Gas Laws; Dalton's Laws of Partial Pressures
Dalton's Laws of Partial Pressures
Ideal vs. Real Gases
Liquids, Solids, and Gases
Colligative Properties of Solutes
Factors Affecting Solubility
Stoichiometry
Conversion and Conservation of Matter and Energy
Reactant and Product Calculations
Thermochemistry and Energy
Energy and Chemical Changes/Reactions
Organic Chemistry
Alkanes
Cycloalkanes
Bond Properties
Resonance
Hybridization/LCAO
Stereochemistry
Spectroscopy

Table 5 PA-CAT Chemistry Blueprint

General Biology Content Objectives		
Bioenergetics		Gene Expression
Enzymes		Regulatory Proteins
Metabolism		Eukaryotic Regulation
Energy and ATP		Posttranscriptional Regulation
Hydrogen and Electron Carriers		Protein Degradation
Thermodynamics and Free Energy		Genetics
Biotechnology		Mendelian Genetics
Mapping, Characterizing, and Sequencing Genomes		Patterns of Inheritance
Cell Structure and Function		Incomplete Dominance
Composition and Function of Cell Structures		Sex Linkage
Cell Membranes and Membranous Organelles		Mutations and Genetic Change
Cell Theory		Clinical Genetics
Cellular Reproduction		Cytogenetics
Eukaryotic Cell Reproduction		Molecular Genetics
Stages of Meiosis		Mitochondrial Genetics
Cellular Respiration		RNA
Fermentation and Anaerobic Respiration		Structure and Replication
Aerobic Respiration		Types of RNA
Oxidation of Glucose		tRNA and Ribosomes
Oxidation of Pyruvate		Pre-mRNA Splicing
Catabolism of Proteins and Fats		Eukaryotic Transcription
Cellular Transport		Signal Transduction
Diffusion and Osmosis		Intracellular Communication
Facilitated and Active Transport		Receptor Types
Pinocytosis and Phagocytosis		Intracellular Receptors
Chemical Building Blocks		G Protein-Coupled Receptor Signaling
Proteins		Receptor Kinase Signaling
Carbohydrates		Microbiology
Carbon		Viral Replication and Invasion
Nucleic Acids		Bacterial Viruses
Lipids		Human Immunodeficiency Virus
Chemical Composition of Cells		Viral Diseases
Water and Its Properties		Prions
Organization of Matter		Parasitic
Acids, Bases, and Salts		Fungal
Biological Molecules		Biochemical Testing
DNA		Polymerase Chain Reaction
Structure, Replication, Repair		

Table 6 PA-CAT General Biology Blueprint

Microbiology Content Objectives
Bacteria
Intracellular Bacteria
Gram-Positive Cocci
Gram-Positive Rods
Acid-Fast Bacteria
Gram-Negative Cocci and Coccobacilli
Fermentative Gram-Negative Rods
Nonfermenting Gram-Negative Rods
Anaerobic Bacteria
Spiral-Shaped Bacteria
Intracellular Bacteria
Role in Disease
Viruses
Human Immunodeficiency Virus
Human Herpesvirus
Respiratory Viruses
Hepatitis Viruses
Gastrointestinal Viruses
Role in Disease
Fungi
Classification
Opportunistic Fungi
Cutaneous and Subcutaneous Fungi
Systemic Dimorphic Fungi
Parasites
Classification
Protozoa
Trematodes
Nematodes
Cestodes
Arthropods
Interaction between Microbe and Host
Principles of Disease and Epidemiology
Microbial Mechanisms of Pathogenicity
Innate and Adaptive Immunity
Pathology, Infection, and Disease
Microorganisms and Human Disease
Environmental Microbiology

Table 7 PA-CAT Microbiology Blueprint

Genetics Content Objectives
Molecular Structure and Replication of Genetic Material
Molecular Structure of DNA and RNA
Chromosome Organization and Molecular Structure
DNA Replication
Patterns of Inheritance
Chromosome Transmission During Cell Division and Sexual Reproduction
Mendelian and Non-Mendelian Inheritance
Genetic Linkage and Mapping in Eukaryotes
Genetic Transfer and Mapping in Bacteria and Bacteriophages
Variation in Chromosome Structure and Number
Molecular Properties of Genes
Gene Transcription and RNA Modification
Translation of mRNA
Gene Regulation in Bacteria
Gene Regulation in Eukaryotes
Non-Coding RNAs
Genetics of Viruses
Gene Mutation and DNA Repair
Recombination, Immunogenetics, and Transposition
Genetic Technologies
Molecular Technologies
Biotechnology
Genomics
Genetic Analysis of Individuals and Populations
Medical Genetics and Cancer
Developmental Genetics
Population Genetics
Complex and Quantitative Traits

Table 8 PA-CAT Genetics Blueprint

Biochemistry Content Objectives
Intermediary Metabolism
Gluconeogenesis
Glycolysis
Respiratory Cycles and Oxidative Phosphorylation
Biologic Oxidation
Mitochondria and ATP
Citric Acid Cycle
Bioenergetics
Proteins
Structure and Function of Proteins
Structure and Classification of Amino Acids
Peptide Bonds, Polypeptides
Specialized Metabolism of Tissues
Cell and Membrane Structure and Function
Hormones and Their Mechanisms of Action
Cell Membrane
Enzymes
Properties and Classification of Enzymes
Mechanism of Actions of Enzymes
Enzyme Kinetics
Nucleic Acids
Genes and Diseases
Regulation of Gene Expression
Genetic Code, Ribosomal Translation
RNA Synthesis
DNA Organization and Replication
Eukaryotic and Prokaryotic Genetic Organization and Regulation
Individual Hormones
Classification of Hormones
Protein, Peptide, and Amino Acid-Derived Hormones
Cytokines
Lipids
Regulation of Lipid Metabolism
Lipoproteins and Disease
Cholesterol Metabolism
Carbohydrates

Table 9 PA-CAT Biochemistry Blueprint

Behavioral Sciences Content Objectives
Biological Bases of Behavior
Neuroanatomy
Human Genetics
Neural Transmission
History and Approaches
Lifespan Development
Memory
Motivation and Emotion
Emotion
Hunger and Eating
Personality
Sensation and Perception
Sensation vs. Perception
Waves and Wavelengths
Learning
Classical and Operant Conditioning
Thinking and Intelligence
Cognition
Language
Social Psychology
Dispositional Approach to Explaining Human Behavior
Self-Presentation
Stress, Lifestyle, and Health
States of Consciousness
Sleep and Dreaming
Psychoactive Drug Effects
Psychological Research
Importance of Research
Analyzing Research Findings
Approaches to Research
Statistics
Sociology
Culture
Deviance and Conformity
Social Change
Social Inequalities
Social Institutions
Sociological Perspective
Socialization
Psychological Disorders
Therapy and Treatment

Table 10 PA-CAT Behavioral Sciences Blueprint

Statistics Content Objectives
Anticipating Patterns
Probability
Combining Independent Random Variables
The Normal Distribution
Sampling Distributions
Exploring Data
Graphical Displays of Distributions
Summarizing Distributions of Univariate Data
Comparing Distributions of Univariate Data
Exploring Bivariate Data
Exploring Categorical Data
Sampling Experimentation
Methods of Data Collection
Planning and Conducting Surveys
Planning and Conducting Experiments
Generalizability of Results and Types of Conclusions
Statistical Inference
Estimation
Test of Significance

Table 11 PA-CAT Statistics Blueprint

Test Administration

Candidates can visit the PA-CAT website (PA-CAT.com) for information about registration procedures, deadline dates, test center information and regulations, fee requirements, PA-CAT content descriptions, and more. All PA-CAT exams are administered via a computer-based (CBT) format at Prometric Test Centers.

Registration and Scheduling

Candidates can register to take the exam and pay all necessary fees online at the PA-CAT website. After registering for the PA-CAT, candidates must schedule a test date with Prometric, where all PA-CAT exams are administered.

Candidates should register early, as seating is on a first-come, first-served basis for scheduling at a Prometric Test Center. Candidates must register at least 30 days prior to their desired test date. If you meet the "Registration and Schedule" deadline, you will likely get your preferred testing date, time, and location; however, there is no guarantee. If you wait until the "Late Registration and Schedule" deadline, you will be charged additional fees, and you are less likely to get your preferred testing date, time, or location.

Proceed through the on-screen instructions to select your testing date, time, and location. Please take sufficient time to carefully read the check-in policy and the cancellation policy.

We strongly suggest that you review the Prometric Testing Tutorial and Practice Test located at prior to testing at a Prometric Test Center.

Special Accommodations

Special Accommodations are provided to eligible candidates on a prior-approval basis. Special accommodations typically involve providing candidates who have special needs additional test time, with 1.5x and 2x the normal testing time the most common. The purpose of this program is to ensure that no candidate with a verified disability is prevented from having an opportunity to sit for the PA-CAT in a way that is non-discriminatory.

For the protection of the integrity of the PA-CAT, and to ensure its reliability for both candidates and participating programs, a special approval process is needed for anyone wishing to request special accommodations. More information on the special accommodations program including an application form is available here.

PA-CAT Fee Waivers and Adjustments

Exam Master recognizes that there are some qualified applicants to PA school who, through no fault of their own, may be classified as "economically disadvantaged" or who otherwise have special economic needs. Exam Master is developing a program to assist these individuals with either full or partial fee waivers. This needs-based program is designed to ensure that no aspiring physician assistant candidate is denied an opportunity to apply to PA school.

Test Day

For the PA-CAT, you will need to arrive at your scheduled Test Center 30 minutes before your scheduled appointment time. This will give you adequate time to complete the necessary sign-in procedures. After

you get settled in you will have 15 minutes to review the testing system and become familiar with it. This is an important opportunity to collect yourself, relax, and prepare yourself for the 240-item test.

Note: If you arrive more than 15 minutes late for an exam you will be denied admission, and you will also forfeit your PA-CAT Registration Fee and any other fees paid for optional services.

When you arrive at the Prometric Test Center, you must present one form of original (no photo copies), valid (unexpired) primary ID (government-issued with name, photo, and signature). A federal-compliant driver's license is an example of an acceptable ID. **You will not be admitted to the test without your ID.**

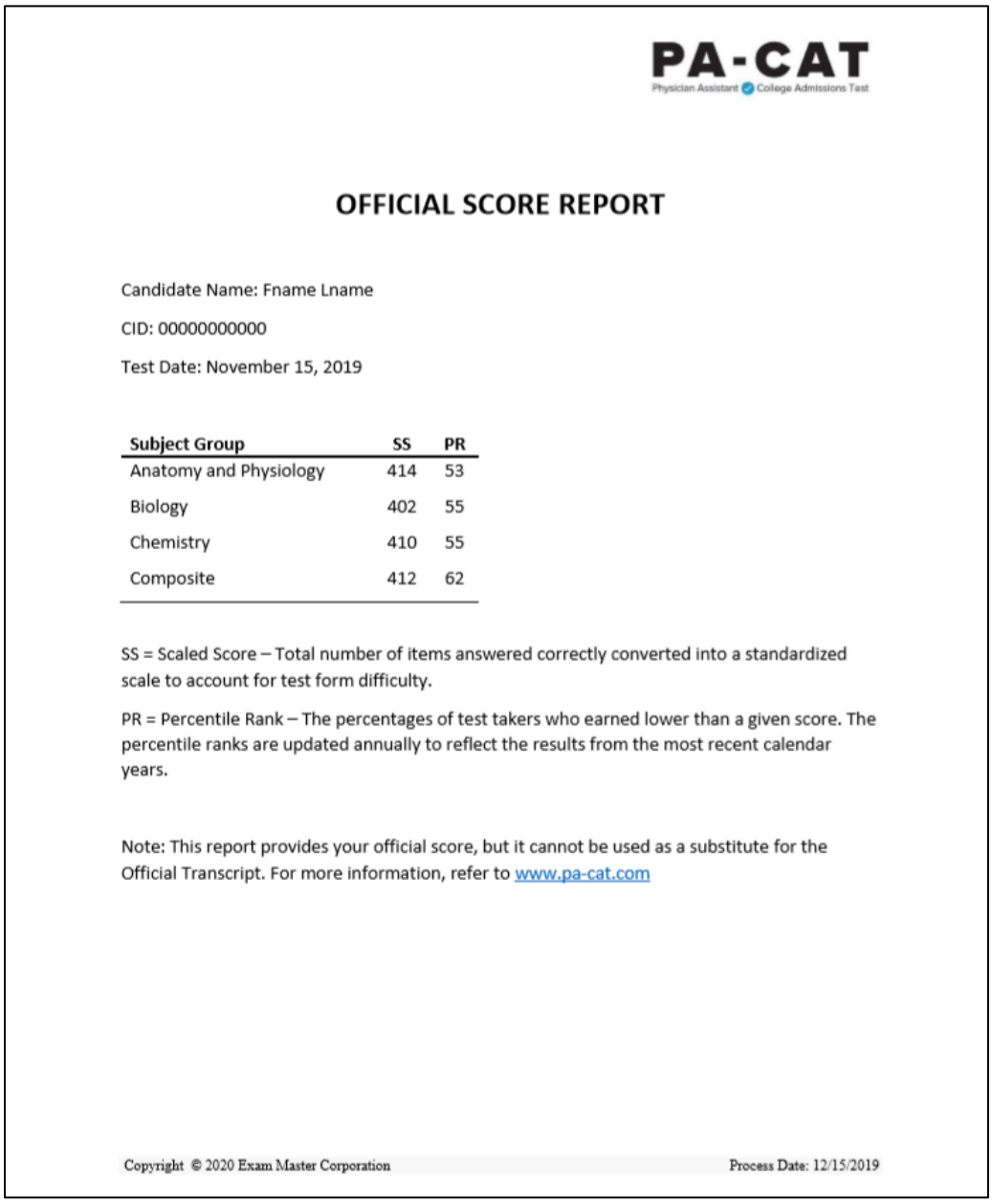
You will NOT have access to any purses, cell phones, or backpacks during the exam. These items must be stored in a designated secure area provided at the Prometric Test Center. All electronic devices must be turned off while in the secure area. If your cell phone rings or makes any noise while in the secure area, your test will be invalidated and your testing fees will not be refunded. If, at the rest break, you must access a personal item, such as an item needed to take to a restroom, this is allowed. However, if you access any other prohibited item from the secure area (cell phone, backpack, study notes, etc.), your test will be invalidated and your testing fees will not be refunded. If you access, check, or turn on your cell phone at any time during your test session (including during your break), your test will be invalidated and your testing fees will not be refunded.

If you are found to have violated the prohibited items policy in any way, your PA-CAT scores will be invalidated, no refunds will be issued, and you will not be allowed to transfer to a different testing window.

Neither Exam Master, its affiliated companies, agents, contractors, nor the Prometric Test Centers assume responsibility for the theft, loss, or damage to any prohibited electronic device or other personal property brought into the testing center or left in your car.

Score Report

You will receive your personal Official Score Report no more than 45 days after a PA-CAT administration. As shown in Figure 1, the personal Official Score Report lists the date on which the candidate took the PA-CAT, the scaled scores and percentile ranks, and Composite score earned by the candidate. In addition to a personal Score Report, each candidate also receives a receipt listing up to five schools to which Official Transcripts were sent. Candidates may request additional Official Transcripts through the PA-CAT website (PA-CAT.com).



PA-CAT
Physician Assistant College Admissions Test

OFFICIAL SCORE REPORT

Candidate Name: Fname Lname

CID: 00000000000

Test Date: November 15, 2019

Subject Group	SS	PR
Anatomy and Physiology	414	53
Biology	402	55
Chemistry	410	55
Composite	412	62

SS = Scaled Score – Total number of items answered correctly converted into a standardized scale to account for test form difficulty.

PR = Percentile Rank – The percentages of test takers who earned lower than a given score. The percentile ranks are updated annually to reflect the results from the most recent calendar years.

Note: This report provides your official score, but it cannot be used as a substitute for the Official Transcript. For more information, refer to www.pa-cat.com

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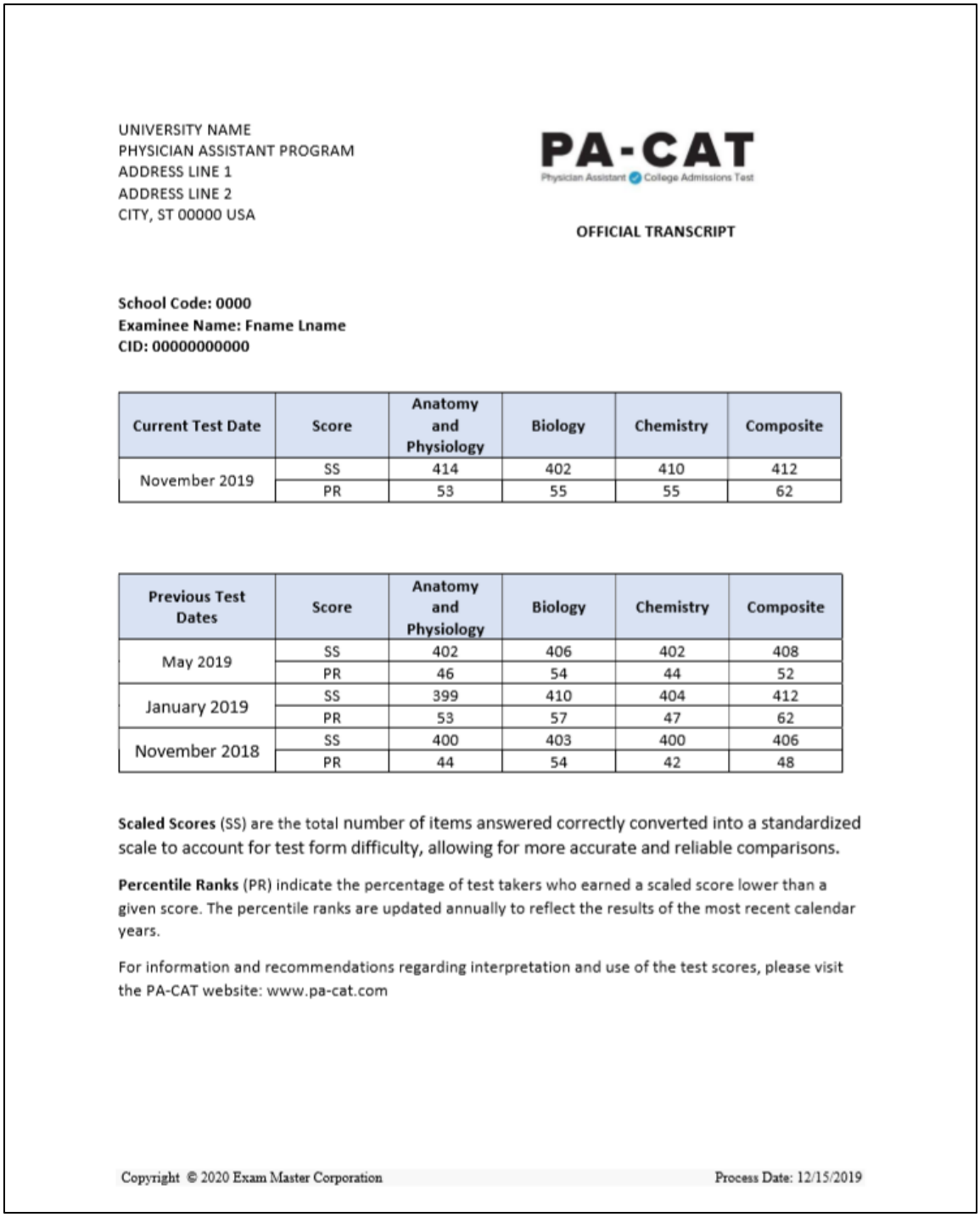
Figure 1: Sample Official Score Report

Official Transcripts

No later than 45 days after a PA-CAT administration, an Official Transcript is provided to PA programs for each candidate who completed the exam and requested a transcript be delivered to the program. The Official Transcript, shown in Figure 2, includes the same score information provided in the personal Official Score Report and candidate scores for up to four previous attempts within the past five years.



UNIVERSITY NAME
PHYSICIAN ASSISTANT PROGRAM
ADDRESS LINE 1
ADDRESS LINE 2
CITY, ST 00000 USA

PA-CAT
Physician Assistant College Admissions Test

OFFICIAL TRANSCRIPT

School Code: 0000
Examinee Name: Fname Lname
CID: 00000000000

Current Test Date	Score	Anatomy and Physiology	Biology	Chemistry	Composite
November 2019	SS	414	402	410	412
	PR	53	55	55	62

Previous Test Dates	Score	Anatomy and Physiology	Biology	Chemistry	Composite
May 2019	SS	402	406	402	408
	PR	46	54	44	52
January 2019	SS	399	410	404	412
	PR	53	57	47	62
November 2018	SS	400	403	400	406
	PR	44	54	42	48

Scaled Scores (SS) are the total number of items answered correctly converted into a standardized scale to account for test form difficulty, allowing for more accurate and reliable comparisons.

Percentile Ranks (PR) indicate the percentage of test takers who earned a scaled score lower than a given score. The percentile ranks are updated annually to reflect the results of the most recent calendar years.

For information and recommendations regarding interpretation and use of the test scores, please visit the PA-CAT website: www.pa-cat.com

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Figure 2: Sample Official Transcript

Appendix A: Sample Test Items

Anatomy

QID: 1052955 (1 of 2)

What is the likely diagnosis for a child who reports increased back pain, an uneven gait, and favoritism to the left side?

Answer Choices:

A. Kyphosis
B. Lordosis
C. Scoliosis
D. Spina bifida

Explanation:

Scoliosis is the lateral bending of the vertebral column, often in the thoracic area.

Kyphosis is a curvature of the spine that produces a "humpback."

Lordosis is having a "hollow back," or being "bent backward." Some describe it as a sway back. It may be caused by poor posture.

Spina bifida is a defect of the vertebral column where L5 or S1 fails to develop normally, leaving a hole or dimple.

References:

1. Tortora, GJ, Derrickson BH. *Principles of Anatomy & Physiology*. 15th ed. Hoboken, NJ: Wiley: 2017:255-9.

QID: 1029905 (2 of 2)

A 42-year-old man with a history of anxiety and peptic ulcer disease develops severe back pain. An analysis reveals the presence of amylase, lipase, and peptidase in his stomach. This patient's condition is caused by erosion of a peptic ulcer in what structure?

Answer Choices:

A. Left gastric artery
B. Pancreas
C. Peritoneal cavity
D. Pleural cavity
E. Splenic artery

Explanation:

This patient's sudden onset severe back pain suggests perforation of a peptic ulcer. The location of his pain along with the presence of pancreatic enzymes in the stomach suggest that the ulcer eroded into the **pancreas**. Since the pancreas is located directly posterior to the stomach, the ulcer would be located on the posterior wall of the stomach.

If the ulcer had eroded into the **peritoneal cavity**, the leakage of stomach contents into the peritoneal cavity would result in a generalized peritonitis, causing generalized severe abdominal pain and rebound tenderness, not focal back pain. If the ulcer had somehow eroded into the **pleural cavity**, we would expect to see pleuritic chest pain. If the ulcer had eroded into a blood vessel, we might see blood in the stomach or peritoneum instead of pancreatic enzymes, resulting in a much more serious clinical presentation. Two common blood vessels that a peptic ulcer can erode into are the **splenic artery**, which carries blood to the spleen, or the **left gastric artery**, which supplies blood to the lesser curvature of the stomach.

References:

1. Moore KL, Dalley AF, Agur AMR. *Clinically Oriented Anatomy.* 7th ed. Philadelphia, PA: Lippincott Williams & Wilkins; 2014:255-7.

Physiology

QID: 1049211 (1 of 2)

A patient sustains a myocardial infarction (heart attack) that damages the ventricular septum of the heart. What effect on the heart is most likely to be seen immediately after the heart attack?

Answer Choices:

A. Blood flowing from the left side of the heart to the right
B. Changes in the electrical conduction of the heart
C. Damage to the valves of the heart
D. Reduction in blood pressure

Explanation:

The septum contains fibers that coordinate the beating of the ventricles. These are sensitive and are damaged almost instantly in myocardial infarction. This damage can be seen via changes in the **conduction** of electricity through the heart.

Damage to valves, left to right **blood flow**, and dramatic **hypotension** are common late complications of myocardial infarction, generally occurring days to weeks following the initial event. This is in contrast to electrical changes, which present near instantly.

References:

1. OpenStax, Anatomy & Physiology. OpenStax CNX. Jul 31, 2018. https://cnx.org/contents/FPtK1zmh@11.1:Y5T_wVSC@5/Heart-Anatomy. Accessed September 5, 2018.

QID: 982616 (2 of 2)

If a patient ingests a poison that inhibits protein synthesis, what cellular organelle(s) is/are being targeted?

Answer Choices:

A. Lysosomes
B. Golgi apparatus
C. Plasma membrane
D. Mitochondria
E. Ribosomes

Explanation:

Ribosomes are responsible for the production of cellular proteins through the process of translation.

Lysosomes contain digestive enzymes and are involved in the breakdown of molecules and cellular maintenance.

The **Golgi apparatus** is responsible for sorting, packaging, and sending proteins throughout the cell.

The **plasma membrane** is a semi permeable boundary surrounding the cell.

Mitochondria are the energy-producing organelles within the cell. Mitochondria produce energy in the form of ATP via aerobic respiration in humans.

References:

1. Tortora GJ, Derrickson B, & Tortora GJ. *Principles of anatomy & physiology*. Hoboken, NJ: Wiley; 2014.

General Biology

QID: 1030510 (1 of 2)

Case:

Trace evidence retrieved in a crime scene revealed 2 distinct monosaccharides upon infrared spectroscopic analysis. The victim was a scientist who was working with an enzyme that cleaves disaccharides. The spectroscopic analysis from the crime lab exactly matched the last entry on the victim's electronic notebook. During their investigation, the forensics team analyzed carbohydrate samples from 4 suspects who had entered the crime scene in the past 24 hours. Each of the suspects had a unique carbohydrate sample that they needed to analyze.

Stem:

Based on this evidence, which of the following carbohydrates did the most likely suspect possess?

Answer Choices:

A. Fructose
B. Maltose
C. Starch
D. Sucrose

Explanation:

The victim was working with an enzyme that cleaves disaccharides into its constituent monosaccharides. The spectroscopic analysis revealed the presence of 2 different monosaccharides. The most likely suspect must have been the person who possessed a disaccharide made of 2 different monomers.

The suspect who possessed **sucrose** (glucose + fructose), is most likely to have seen the victim the last.

Maltose is a disaccharide made of 2 glucose monomers and could not have been the relevant disaccharide.

Fructose (a monosaccharide) and **starch** (a polysaccharide) cannot be cleaved by the enzyme in question.

References:

1. Simon EJ, Dickey JL, Hogan KA, Reece JB. Essential Chemistry for Biology. In: *Campbell Essential Biology with Physiology*. 5th ed. Harlow, UK: Pearson; 2016:22-35.

QID: 1030506 (2 of 2)

Case:

A graduate student received organellar fractions from 4 different sources. The student was asked to extract DNA from each and was surprised to find 1 sample devoid of any genetic material.

Stem:

Given that the student was careful and there were no mistakes in the extraction procedure, what source would be devoid of genetic material?

Answer Choices:

A. Beetle leaf extract
B. Onion peel
C. Red blood cells
D. Semen sample

Explanation:

Red blood cells (RBCs) extracted from blood would be devoid of any genetic material. Typically, a blood sample would contain all cellular components (lymphocytes, RBCs, and platelets) from which DNA can be extracted, but RBCs specifically do not contain nuclei or any organelles (to make room for packaging hemoglobin).

Beetle leaf extract and **onion peel**, both plant sources, and **semen sample** (human source) would all contain DNA, as they contain nuclei and organelles (mitochondria and chloroplasts), which house various amounts of DNA.

References:

1. The Princeton Review: Molecular Biology. In: *Cracking the AP Biology Exam*. New York, NY: Penguin Random House; 2018:161-81.
2. The Princeton Review: Cells. In: *Cracking the AP Biology Exam*. New York, NY: Penguin Random House; 2018:111-8.

General and Organic Chemistry

QID: 1097584 (1 of 2)

What process occurs during the increase in water solubility of a compound containing functional groups with carboxylic acids as they undergo ionization?

Answer Choices:

A. Elongation of hydrocarbons
B. Formation of salts
C. Grouping of aromatic rings
D. Standardization of charge

Explanation:

One way in which carboxylic acids increase the water solubility of a compound is through reaction with a strong base to **form salts** (carboxylate anion salts). Salt formation can increase the water solubility of a compound due to the attraction of the area of the partial positive charge within the compound to the partial negative of water (area surrounding oxygen).

Elongation of hydrocarbons, **grouping of aromatic rings**, and **standardization of charge** (reduction of polarity) serve to reduce water solubility.

References:

1. Jonsson AL, Roberts MAJ, Kiappes JL, Scott KA. Essential chemistry for biochemists. *Essays Biochem*. 2017;61(4):401-27. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5869253/.

QID: 1011381 (2 of 2)

The acetylation of 0.205 mol of p-aminophenol by acetic anhydride produced acetaminophen and acetic acid. A side reaction resulting from moisture in the reaction vessel hydrolyzed an unknown amount of acetic anhydride before the reaction was complete. After purification, only 29.47 g of acetaminophen was isolated. If 13.35 g of acetic acid was recovered from the

products, how much acetic anhydride was consumed in the acetylation reaction and how much underwent hydrolysis?

Answer Choices:

A. Acetylation – 11.71 g and Hydrolysis – 1.39 g
B. Acetylation – 19.91 g and Hydrolysis – 1.39 g
C. Acetylation – 19.91 g and Hydrolysis – 1.64 g
D. Acetylation – 20.93 g and Hydrolysis – unknown
E. Acetylation – 19.91 g and Hydrolysis – unknown

Explanation:

The correct answer is **Acetylation – 19.91 g and Hydrolysis – 1.39 g**.

Since acetaminophen is the product of the acetylation reaction, the amount of acetaminophen produced from the reaction is used to determine how much of the acetic anhydride was consumed by the acetylation reaction. Using the molecular mass, we can determine that 0.195 mol of acetaminophen was produced through acetylation. This would require 19.91 g of acetic anhydride.

Calculate the amount of acetic acid produced as a side product of the acetylation reaction: 0.195 mol*60.05 g = 11.71 g. Now, subtract the mass of acetic acid produced as a result of acetylation from the mass recovered after reaction to get the mass of acetic acid produced through hydrolysis: 13.35 g – 11.71 g = 1.64 g acetic acid. The hydrolysis reaction proceeds as follows:

$(CH_3CO)_2O + H2O \rightarrow 2CH_3COH$

Therefore, 1.64 g of acetic acid is produced by 1.39 g of acetic anhydride.

References:

1. Zumdahl SS, Zumdahl SA. *Chemistry: An Atoms First Approach*. 2nd ed. Bellmont, CA: Cengage Learning; 2015:236.

Biochemistry

QID: 1095679 (1 of 2)

What generally results from a point mutation, deletion, or insertion in the promoter region of a proto-oncogene?

Answer Choices:

A. Increased transcription of protein product
B. Stimulation of cell mitosis
C. Transduction of continuous cell growth signals
D. Uncontrolled stimulation of kinase signaling pathway

Explanation:

A point mutation, deletion, or insertion in the promoter region of a proto-oncogene is an activation mechanism that generally causes **increased transcription**.

Stimulation of cell mitosis is an example of a general process involving proteins encoded by proto-oncogenes.

Transduction of continuous cell growth signals relates to a mutation within an oncogene rather than a mutation to the promoter region; specifically, this refers to the mutated *ras* oncogene, which causes a protein to remain in an active state and transduces continuous cell growth signals.

Uncontrolled stimulation of kinase signaling pathway similarly relates to a mutation within an oncogene rather than a mutation to the promoter region; specifically, this refers to the mutated *braf* oncogene, which encodes for a protein with a modified kinase domain.

References:

1. Lowdon R, Wang T. Epigenomic annotation of noncoding mutations identifies mutated pathways in primary liver cancer. *PLoS One.* 2017;12(3):e0174032. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5363827/.

QID: 1088109 (2 of 2)

Which hormone produced by the hypothalamus and secreted by the pituitary gland would you expect to be effective in improving social interactions in children with autism?

Answer Choices:

A. Human growth hormone
B. Oxytocin
C. Thyroid-stimulating hormone
D. Vasopressin

Explanation:

Oxytocin is involved in bonding and trust; low levels of this hormone are correlated with autism in children. **Human growth hormone** is involved with physical development of children. **Thyroid-stimulating hormone** activates production of thyroid hormones. **Vasopressin** helps regulate water and electrolyte homeostasis.

References:

1. Higashida H, Munesue T, Kosaka H, Yamasue H, Yokoyama S, Kikuchi M. Social Interaction Improved by Oxytocin in the Subclass of Autism with Comorbid Intellectual Disabilities. *Diseases*. 2019;7(1):24. doi:10.3390/diseases7010024.

Microbiology

QID: 1090808 (1 of 2)

An 8-month-old boy who has never been vaccinated presents with a 3-day history of fever and watery non-bloody diarrhea. On physical examination, he appears dehydrated. What is the genome of the most likely infecting organism?

Answer Choices:

A. Double-stranded DNA
B. Non-segmented single-stranded positive-sense RNA
C. Segmented double-stranded RNA
D. Single-stranded DNA

Explanation:

Rotaviruses cause most of the watery diarrheal illness in infants and children worldwide. They are non-enveloped RNA viruses containing 11 segments of **double-stranded RNA genome** within a double-shelled capsid.

Rotaviruses, like the influenza viruses that have a segmented genome, can undergo genetic reassortment. Other viruses that cause gastroenteritis are Adenovirus, a **double-stranded DNA** virus, and Norovirus, a **non-segmented single-stranded positive-sense RNA**. **Single-stranded DNA** viruses do not cause gastroenteritis.

References:

1. Murray PR, Rosenthal KS, Pfaller MA. *Medical Microbiology*. 8th ed. Elsevier; 2016. pg. 505-508.

2. Johnson AG, Hawley L, Johnson AG, Ziegler RJ. *Microbiology and Immunology*: Wolters Kluwer/Lippincott Williams & Wilkins; 2010. pg.207

QID: 1090209 (2 of 2)

Key Words:

Case:

A 13-year-old boy presents in the ED with fever, tender joints, and rapid heartbeat. His mother says he has been sick with a sore throat, which she thought was a cold; now she is concerned it may actually be the flu. Rapid strep test and flu test in the ED are both negative. The physician assistant finds a rash with pink rings and a clear center, orders an Antistreptolysin O antibody test and EKG, and gives the patient penicillin and a round of steroids. The lab test shows a high level of antibodies against *Streptococcus*.

Stem:

What organism is the most likely pathogen?

Answer Choices:

A. *Escherichia coli*
B. *Staphylococcus aureus*
C. *Streptococcus pyogenes*
D. *Streptococcus viridans*

Explanation:

Streptococcus pyogenes typically causes "strep throat" and would cause a positive rapid strep test. A rapid strep test looks for Group A strep, which causes beta-hemolysis or full hemolysis on blood agar after culture. Untreated strep throat can lead to rheumatic fever in children and adolescents, caused by the immune system's response from an earlier strep throat or scarlet fever infection; it is thought to be caused by a generalized inflammatory response.

Escherichia coli is a Gram-negative rod that does not typically cause pharyngitis. *E. coli* can grow on blood agar as a smooth round gray-white colony. Some strains are beta-hemolytic, or they show no hemolysis at all.

Staphylococcus aureus is a Gram-positive coccus seen in clusters that does not typically cause pharyngitis. On a culture, this organism grows as a medium-sized round creamy yellow colony and shows beta-hemolysis.

Streptococcus viridans is an alpha-hemolytic (green incomplete hemolysis) Gram-positive coccus seen in chains. *Streptococcus viridans* is part of the normal flora of a human mouth. On blood agar, it grows in small grayish alpha-hemolytic colonies.

References:

1. Group A Strep. *CDC*. https://www.cdc.gov/groupastrep/diseases-public/rheumatic-fever.html. Reviewed November 1, 2018. Accessed August 4, 2019.
2. Parker N, Schneegurt M, Tu A-HT, Forster BM, Lister P. *Microbiology*. Houston, TX: OpenStaxsity; 2017:177.

Behavioral Sciences

QID: 984474 (1 of 2)

Case:

A young boy being observed at his daycare. The observer noted that he was quite relaxed and not very interested in his surroundings.

Stem:

According to the EAS Temperament Model, how would the child have scored?

Answer Choices:

A. Low on emotionality
B. Low on sociability
C. Low on activity
D. Low on affection

Explanation:

The **EAS Temperament Model** uses 3 dimensions of temperament: emotionality, activity, and sociability. Affection is not one of the 3 dimensions. The boy's relaxed and non-interested demeanor is part of the **emotionality** dimension, which measures the intensity of emotional

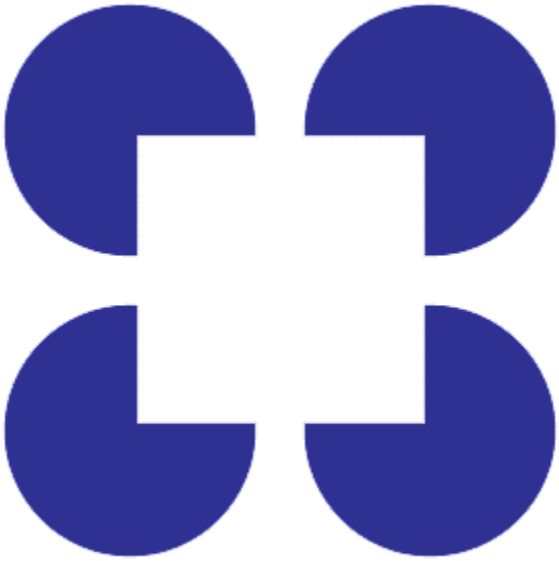
reactions. **Activity** measures a person's energy level and **sociability** measures a person's ability to affiliate and interact with others.

References:

1. Chapter 3: Section 3: Temperament and Personality. AllPsych. Available at: https://allpsych.com/personalitysynopsis/temperament/. Accessed July 14, 2017.

QID: 982314 (2 of 2)

Which Gestalt principle describes the following example? **Refer to the image.**



Answer Choices:

A. Similarity
B. Camouflage
C. Continuity

D. Closure

Explanation:

Closure is when we tend to see complete figures even when part of the information is missing. In this case, the square image in white is not really there, but rather, formed by the missing pieces of the surrounding circles.

Similarity is when things that share visual characteristics—such as shape, size, color, texture, or value—are seen as belonging together.

Continuity is when the edge of one shape continues into space and meets with other shapes or the edges of the picture plane; the viewer will follow the established pattern.

Camouflage is when the figure blends into the background, making the image visually disruptive.

References:

1. Gestalt Principles. Gestalt Principles. Available at: http://facweb.cs.depaul.edu/sgrais/gestalt_principles.htm. Accessed June 23, 2017.

Genetics

QID: 1037710 (1 of 2)

Which statement applies to the elongation stage of transcription?

Answer Choices:

A. RNA polymerase binds to a sequence of DNA known as a promoter.
B. RNA polymerase builds an RNA molecule, making a chain.
C. RNA polymerase separates the DNA strands, creating a single-strand template.
D. Sequences send signals that release the transcript from the RNA polymerase.

Explanation:

During the elongation stage of transcription, the RNA polymerase decodes the template strand, **building an RNA molecule, creating a chain**. In the initiation stage of transcription RNA polymerase is bound to a sequence of DNA referred to as the **promoter**. Once bound, the polymerase separates the DNA strands, creating the **template** strand. In the termination stage, sequences called terminators signal completion of the RNA transcript. This causes the transcript to be **released** from the RNA.

References:

1. Griffiths A, Wessler S, Carol S, Doebley J. *An Introduction to Genetic Analysis*. 11th ed. New York, NY: WH Freeman & Company; 2015:356-9.

QID: 1026003 (2 of 2)

A couple expecting a child have different blood types; the mother is AO and the father is BO. Which blood type in the infant would be an example of codominance?

Answer Choices:

A. AB
B. AO
C. BO
D. O

Explanation:

The blood type **AB is an example of codominance**. The A and B allele are both fully dominant, and the phenotype has both traits expressed equally. AO and BO blood types are examples of simple dominance, where either the A or B allele is the dominant trait and the O allele is a recessive trait. With type O blood, the offspring has received 2 copies of the recessive trait, one from each parent.

References:

1. Lashley F, Casper C, Schneidereith T. *Lashley's Essentials of Clinical Genetics.* 2nd ed. New York, NY: Springer; 2016:43-4.
2. Klug W, Cummings M, Spencer C, Palladino M. *Concepts of Genetics.* 11th ed. Edinburgh Gate, Harlow, Essex CM20 21E, England: Pearson; 2015:107-8.

Statistics

QID: 1084104 (1 of 2)

What is the standard deviation calculated for the following 10 fasting blood sugar levels of patients with diabetes?

84, 87, 93, 99, 103, 116, 126, 129, 130, 133

Answer Choices:

A. 0
B. 2.86
C. 18.02
D. 18.99

Explanation:

A standard deviation is the square root of a variance, so the variance must be calculated first.

Variance is the squared difference from the mean (average).

First, calculate the mean of the values.

84 + 87 + 93 + 99 + 103 + 116 + 126 + 129 + 130 + 133 = 1100

1100 ÷ 10 = 110

For each value, subtract the mean and square the result (the squared difference).

For example,

84 – 110 = -26

$-26^2 = 676$

After completing all the calculations, take the average of the squared difference to find the variance.

3246/10 = 324.6 Therefore, the variance is 324.6.

The standard deviation (the square root of the variance) is $\sqrt{324.6}=18.02$$324.6=18.02$
2.86 would result from squaring the negative numbers and getting negative numbers instead of positive numbers. **0** would result from forgetting to square the differences. **18.99** would result from dividing the squared difference sum by 9 instead of by 10.

References:

1. OpenStax, Introductory Statistics. OpenStax CNX. Jun 17, 2019. https://cnx.org/contents/MBiUQmmY@23.31:gp5Hz9v3@17/2-7-Measures-of-the-Spread-of-the-Data.

QID: 1039956 (2 of 2)

Researchers often wish to reduce their sample size to save money in conducting studies.

What factor might make a study's sample size smaller?

Answer Choices:

A. Measure central tendency and dispersion.
B. Reduce statistical power and use chi-squared models for analysis.
C. Reduce the nonresponse rate and stratify the population.
D. Use inferential statistics rather than descriptive statistics.

Explanation:

A study that has a nonresponse bias of 50% will need a large sample size in comparison to one with a nonresponse rate of 1%. Putting resources into follow-up can **reduce the nonresponse rate** and reduce sample size. **Stratifying** the population reduces variation within groups, allowing a smaller sample size to adequately represent a population.

Measuring central tendency and dispersion would not affect the sample size. This is synonymous with analyzing mean and standard deviation, so these calculations would not affect the experimental setup. Similar to the case of central tendency and dispersion, our method of analysis would not affect our experimental design.

Reducing statistical power would allow us to reduce our sample size, but using **chi-squared models** for analysis would not.

Using **inferential statistics** rather than **descriptive statistics** is another mode of analysis, and would not achieve the desired reduction in sample size.

References:

1. Amatya A, Bhaumik DK. Sample size determination for multilevel hierarchical designs using generalized linear mixed models. *Biom.* 2018;74:673-84. doi:https://doi.org/10.1111/biom.12764.

