Quick Review Cards for Medical Laboratory Science

THIRD EDITION

Valerie Dietz Polansky • Nadine M. Lerret

F.A. DAVIS

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Dedicated to my husband, Gary, for his support and encouragement through another long project, and in loving memory of my parents, Bill and Lee Dietz, who provided me with the education that was the foundation of my career.
Valerie Dietz Polansky

Dedicated to my wonderful family for their love, support, and laughter, and especially to my students, who inspire me to find new ways to share my passion for our field and make each day in the classroom an adventure.
Nadine M. Lerret

Preface

Quick Review Cards for Medical Laboratory Science were developed as a study aid to improve student performance on Board examinations for medical laboratory science (MLS) and medical laboratory technician (MLT). (Technician candidates may skip the section on management and education.)

This card deck is the product of more than 40 years combined experience teaching hundreds of students who have successfully passed Board examinations at both levels. The card format allows for easy sorting and portability, making them ideal for quick reviews and studying. Use of these cards alone, however, does not guarantee a passing score; they are intended to be used as an adjunct to traditional textbooks. Students are encouraged to highlight unfamiliar information and refer to textbooks and class notes to supplement their study of those topics. The use of a multiple-choice review book and practice exams also will help to round out a student's preparation for the Board exam.

The review cards will also be beneficial to MLS and MLT students before graduation as they prepare for course examinations. Professionals who are cross-training or reentering the workplace will find these cards useful as well.

No review of this type can include all topics. This review focuses on common procedures and disorders, other knowledge that entry-level laboratory professionals are expected to have, and topics that are frequently included on Board exams. The review cards are written in an informal note-taking style, using abbreviations, symbols, and short phrases to maximize the amount of information included. A list of abbreviations is found in the frontmatter.

New to the third edition are relevant clinical applications of molecular diagnostics, extensive updates to the microbiology and hematology sections, and an added multiple-choice Q/A card for each section. Students are encouraged to refer to textbooks to supplement their review with additional pictures and diagrams. Further benefit could be derived from making their own drawings, diagrams, and flow charts.

Every effort was made to ensure the accuracy of the content. Sometimes, discrepancies were found within and among references; in those cases, information was either selected from the most recent publication or confirmed in another source. Please let the publisher know if you have suggestions for improving future editions.

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Abbreviations

Ab	Antibody
Ag	Antigen
AHG	Antihuman globulin
AIDS	Acquired immunodeficiency syndrome
ASAP	As soon as possible
AT	Antithrombin
BBP	Bloodborne pathogens
BP	Blood pressure
CAD	Coronary artery disease
CAP	College of American Pathologists
CDC	Centers for Disease Control and Prevention
CIA	Chemiluminescent immunoassay
CLIA '88	Clinical Laboratory Improvement Amendments of 1988
CLSI	Clinical Laboratory and Standards Institute
CMS	Centers for Medicare and Medicaid Services
CMV	Cytomegalovirus
CNS	Coagulase-negative staphylococci
CNS	Central nervous system
Ck	Check
CSF	Cerebrospinal fluid
CV	Coefficient of variation
DAT	Direct antiglobulin test
Diff	Differential
DTaP	Diphtheria, tetanus, pertussis vaccine
Dx	Diagnosis
EBV	Epstein-Barr virus
EIA	Enzyme immunoassay
ELISA	Enzyme-linked immunosorbent assay
ESR	Erythrocyte sedimentation rate
FDA	Food and Drug Administration
FFP	Fresh frozen plasma
GAS	Group A *Streptococcus*
GBS	Group B *Streptococcus*
GI	Gastrointestinal
GN	Gram negative
GNCB	Gram-negative coccobacilli
GNDC	Gram-negative diplococci
GNR	Gram-negative rods
GP	Gram positive
GPC	Gram-positive cocci
GPR	Gram-positive rods
GU	Genitourinary
HAV	Hepatitis A virus

continued...

Abbreviations *continued*

HBIG	Hepatitis B immunoglobulin
HBV	Hepatitis B virus
HCB	Hepatitis C virus
HCT	Hematocrit
HDFN	Hemolytic disease of the fetus & newborn
Hgb	Hemoglobin
Hib	*Haemophilus influenzae* type b
HIPAA	Health Insurance Portability and Accountability Act of 1996
HIV	Human immunodeficiency virus
HLA	Human leukocyte antigen
HPF	High power field
Hr	Hour(s)
IAT	Indirect antiglobulin test
ID	Identify, identification
IFA	Indirect fluorescent antibody
Ig	Immunoglobulin
IM	Infectious mononucleosis
IS	Immediate spin
LPF	Low-power field
LF	Lactose fermenter
Min	Minute(s)
MMR	Measles, mumps, rubella vaccine
Mo	Month(s)
MRSA	Methicillin-resistant *Staphylococcus aureus*
MW	Molecular weight
N	Normal
NAT	Nucleic acid testing
N:C	Nucleus to cytoplasm
Neg	Negative
NLF	Nonlactose fermenter
NRBC	Nucleated red blood cell
OIF	Oil immersion field
OSHA	Occupational Safety and Health Administration
PCR	Polymerase chain reaction
PHI	Protected health information
Plt	Platelet(s)
Poly	Polymorphonuclear leukocyte, granulocyte
Pos	Positive
PPD	Purified protein derivative
Pt	Patient
QA	Quality assurance or assessment
QC	Quality control
RBC	Red blood cell

continued...

Abbreviations *continued*

RE	Reticuloendothelial
RhIG	Rh-immune globulin
RT	Room temperature (20°–24°C)
RTI	Respiratory tract infection
Rxn	Reaction
SD	Standard deviation
Sec	Second(s)
SG	Specific gravity
SOP	Standard operating procedures
Temp	Temperature
Tf	Transfuse, transfusion
UTI	Urinary tract infection
VRE	Vancomycin-resistant enterococci
WB	Whole blood
WBC	White blood cell
Wk	Week(s)
Yr	Year(s)
#	Number
↑	Increase(s), increased
↓	Decrease(s), decreased
>	Greater than
≥	Greater than or equal to
<	Less than

Other abbreviations are defined in the text.

SECTION

1

Laboratory Operations, Management, & Education

Credentialing

PROCESS	DEFINITION	EXAMPLES
Accreditation	Recognition granted by nongovernmental agency to institutions that meet certain standards. ***Voluntary.***	AABB (formerly American Association of Blood Banks) College of American Pathologists (CAP) The Joint Commission (formerly JCAHO) National Accrediting Agency for Clinical Laboratory Sciences (NAACLS)
Certification	Recognition granted by nongovernmental agency to individuals who meet education requirements & demonstrate entry-level competency by passing exam. ***Voluntary.***	American Society for Clinical Pathology (ASCP) American Association of Bioanalysts (AAB) American Medical Technologists (AMT)
Licensure	Permission granted by state to individuals/ organizations to engage in certain professions/ businesses. ***Mandatory.*** Illegal to practice/operate in that state without license.	Licensure of laboratory personnel is required in California (CA), Florida (FL), Hawaii (HI), Louisiana (LA), Montana (MT), Nevada (NV), New York (NY), North Dakota (ND), Rhode Island (RI), Tennessee (TN), West Virginia (WV). Many states require licensure of clinical labs.

Agencies That Issue Guidelines/Standards

AGENCY	GUIDELINES/STANDARDS
Association for the Advancement of Blood and Biotherapies (AABB) (formerly American Association of Blood Banks)	Technical standards & accreditation of blood banks.
Centers for Disease Control & Prevention (CDC)	Standards & guidelines primarily related to infection control & safe work practices.
Clinical Laboratory & Standards Institute (CLSI, formerly NCCLS)	Standards on all aspects of lab practice developed through voluntary consensus.
International Organization for Standardization (ISO)	Standards to facilitate international exchange of goods & services. Developed through voluntary worldwide consensus. ISO 15189 defines standards for quality management in medical labs.

Federal Regulatory Agencies

AGENCY	AUTHORITY
Centers for Medicare & Medicaid Services (CMS)	Writes regulations for & enforces Clinical Laboratory Improvement Amendments of 1988 (CLIA '88).
Department of Health & Human Services (HHS)	Interprets & implements federal regulations related to health care. Oversees CDC, CMS, FDA, SAMSHA.
Department of Transportation (DOT)	Regulates packaging, labeling, & transportation of biological products.
Environmental Protection Agency (EPA)	Regulates disposal of toxic chemical & biohazardous wastes.
Food & Drug Administration (FDA)	Regulates market entry of instruments/reagents & production of donor blood & components. Licenses blood banks.
Nuclear Regulatory Commission (NRC)	Licenses labs that use radionucleotides.
Occupational Safety & Health Administration (OSHA)	Regulates employee safety in the workplace.
Substance Abuse and Mental Health Services Administration (SAMHSA)	Certifies laboratories to conduct forensic drug testing for federal agencies.

Federal Regulations

STANDARD	SUMMARY
Hazard Communication Standard (OSHA 1983) "Right-to-Know Law"	Requires employers to inform employees about hazardous substances in workplace & educate them in safe handling.
Clinical Laboratory Improvement Amendments of 1988 "CLIA '88"	Regulates all lab testing (except research) performed on humans in United States. Requirements for personnel & quality assurance determined by test complexity. Administered by CMS.
Occupational Exposure to Hazardous Chemicals in Laboratories (OSHA 1990) "Laboratory Standard"	Requires chemical hygiene plan to minimize personnel exposure to hazardous chemicals in labs.
Bloodborne Pathogens Standard (OSHA 1991)	Mandates work practices & procedures to minimize worker exposure to bloodborne pathogens.
Formaldehyde Standard (OSHA 1992)	Requires monitoring of formaldehyde exposure.
Health Insurance Portability and Accountability Act of 1996 "HIPAA"	Regulates use & disclosure of protected health information (PHI).

CLIA '88 Test Complexities

COMPLEXITY	CRITERIA	QUALITY CONTROL	PROFICIENCY TESTING (PT)	TESTING PERSONNEL (MINIMUM QUALIFICATIONS)
Waived	Tests cleared by FDA for home use, negligible likelihood of erroneous results, or no reasonable risk of harm to patient if performed incorrectly	None required other than to follow manufacturers' directions	Not required	None specified
Provider-Performed Microscopy (PPM)*	Certain microscopic exams performed by provider during patient's visit, e.g., direct wet mount, KOH prep, urine sediment	Required when controls are available; otherwise, reference materials (e.g., photomicrographs) fulfill requirement	PT not specifically required, but labs must verify accuracy of testing twice annually. Can be through PT, split sampling, or blind testing.	Physician, midlevel practitioner, or dentist

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CLIA '88 Test Complexities *continued*

COMPLEXITY	CRITERIA	QUALITY CONTROL	PROFICIENCY TESTING (PT)	TESTING PERSONNEL (MINIMUM QUALIFICATIONS)
Moderate Complexity	Score ≤12 on 7 criteria**	2 levels of external controls per 24 hours	Required	High school diploma or equivalent & training for testing performed
High Complexity	Score >12 on 7 criteria**	2 levels of external controls per 24 hours (except for coagulation testing, which requires 2 levels every 8 hours, and blood gases, which require 3 levels every 24 hours).	Required	Associate degree in medical laboratory technology or equivalent

*PPM is a subcategory of moderate complexity.
**Criteria used to evaluate text complexity: knowledge, training/experience, reagent/material preparation, characteristics of operational steps, calibration/quality control/proficiency testing materials, test system troubleshooting, interpretation/judgment. Each of the 7 criteria is rated 1–3 (lowest to highest), & scores are totaled.

Bloodborne Pathogens Standard

History	Published in 1991. Revised in 2001 following passage of Needlestick Safety & Prevention Act to include stronger requirements for employers to evaluate & adopt safer medical devices.
Purpose	To protect health-care workers from occupational exposure to bloodborne pathogens (bloodborne pathogens [BBP]; e.g., human immunodeficiency virus [HIV], hepatitis B virus [HBV], hepatitis C virus [HCV])
Primary Requirements	**Exposure control plan**: Determination of employees' risk of exposure & implementation of methods to control exposure. Plan must be reviewed & updated annually to reflect new technologies. Documentation of evaluation & adoption of safer devices is required. Nonmanagerial employees must be involved in evaluation & selection of devices. **Universal precautions**: All blood & certain body fluids are to be handled as if known to be infectious for bloodborne pathogens. **Engineering controls**: Control measures that isolate or remove a hazard from workplace, e.g., sharps containers, self-sheathing needles, plastic capillary tubes, Plexiglas shields. **Work practice controls**: e.g., hand washing, disposal of needles with safety device activated & holder attached, ban on eating/drinking/smoking in lab. **Personal protective clothing & equipment**: e.g., lab coats, gloves, face shields. Employer must provide & launder lab coats. **Housekeeping**: e.g., proper disposal of biohazardous waste, decontamination of work surfaces. **Training**: On assignment & annually thereafter. **Medical surveillance**: Postexposure evaluation & follow-up at no cost to employee. **Hepatitis B vaccine**: Provided by employer within 10 days of assignment at no cost to employee. **Hazard communication**: e.g., biohazard labels, red bags. **Sharps injury log**: Must include description & location of incident, device involved. Employee privacy must be protected.

Specimen Infectivity

POTENTIALLY INFECTIOUS	USUALLY NOT INFECTIOUS (UNLESS VISIBLY BLOODY)
Blood	Feces
Tissues	Nasal secretions
Semen	Sputum
Vaginal secretions	Sweat
Cerebrospinal fluid	Tears
Synovial fluid	Urine
Pleural fluid	Vomitus
Peritoneal fluid	
Pericardial fluid	
Amniotic fluid	
Saliva in dental procedures	

Packaging of Biologics for Shipping

REQUIREMENT	EXPLANATION
Primary container	Test tube, vial, etc. containing etiologic agent. Must be securely closed, watertight, surrounded by absorbent material, & placed in secondary container.
Secondary container	Must be watertight, sealed, & placed in approved mailing container.
Mailing container	Must be made of fiberboard.
Labeling	Biohazard label required on primary & mailing containers.
Training	Employees must be trained & retrained every 2–3 yr or when regulations change.

Hazard Communication Standard (HCS)

History	Issued by OSHA in 1983. Written for manufacturing industry, but courts expanded jurisdiction to clinical labs.
Also Known As	"Right-to-Know Law"; "HAZCOM"
Purpose	To inform employees about chemical hazards in workplace & protective measures
Primary Requirements	Written hazard communication plan Inventory of hazardous chemicals on site Hazard labeling Material safety data sheet (MSDS) for each chemical readily accessible to employees on each shift Training on initial assignment & when new hazard introduced

Occupational Exposures to Hazardous Chemicals in Laboratories Standard

History	Issued by OSHA in 1990. Extension of HCS written specifically for labs.
Also Known As	"Laboratory Standard"; "Chemical Hygiene Standard"
Purpose	To limit employee exposure to hazardous chemicals to levels at or below permissible exposure levels (PELs).
Primary Requirements	Written chemical hygiene plan outlining standard operating procedures for use, storage, exposure control, & disposal of hazardous chemicals. Designation of chemical hygiene officer. Hazard identification & labeling. Material safety data sheet for each chemical readily accessible to employees on each shift. Use of personal protective equipment. Proper maintenance of fume hoods & other protective equipment. Monitoring of employee exposure to hazardous chemicals. Medical exams at no cost in cases of suspected overexposure. Training on initial assignment & before assignments involving new exposures.

Hazard Categories of Chemicals

CLASSIFICATION	EXAMPLE	EFFECT	COMMENTS
Corrosives	Glacial acetic acid, hydrochloric acid, sodium hydroxide	Visible destruction of human tissue on contact. Can cause injury on inhalation or contact.	Chemicals with pH <2 or >12. Separate inorganic acids from organic acids. Concentrated acids & bases can generate large amounts of heat when mixed with water.
Toxic substances	Cyanides, sulfides	Interfere with metabolic processes when ingested, inhaled, or absorbed through skin.	Threshold limit values (TLVs) = safe level of exposure.
Carcinogens	Benzidine, formaldehyde	Capable of causing cancer.	OSHA requires monitoring of formaldehyde exposure.
Mutagens & teratogens	Benzene, lead, mercury, radioactive material, toluene	Mutagens induce genetic mutations; teratogens cause defects in embryo.	Special precautions during pregnancy.
Ignitables	Acetone, alcohols, ether, xylene	Fire.	Flashpoint = lowest temp that produces ignitable vapor. Flammables <37.77°C; combustibles ≥37.77°C.

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Hazard Categories of Chemicals *continued*

CLASSIFICATION	EXAMPLE	EFFECT	COMMENTS
Reactives	Ether, perchloric acid, picric acid, sodium azide	Explosion.	Ether forms explosive peroxides on exposure to air or light; store in explosion-proof refrigerator. Perchloric acid may react explosively with organic compounds; separate from other acids. Picric acid is shock sensitive when dehydrated; more powerful than TNT. Sodium azide solutions can form explosive lead or copper azides in drains.

Hazard Identification System

National Fire Protection Association (NFPA) Hazmat Diamond

HAZARD	SYMBOL	0	1	2	3	4
Health	Blue diamond (left)	No hazard	Can cause significant irritation	Can cause temporary incapacitation or residual injury	Can cause serious or permanent injury	Can be lethal
Flammability	Red diamond (top)	Will not burn	Must be preheated for ignition to occur	Must be heated or in ↑ ambient temp to burn	Can be ignited under almost all ambient temps	Will vaporize & burn at normal temp
Instability	Yellow diamond (right)	Stable	↑ temp makes unstable	Violent chemical change at ↑ temp or pressures	May explode from ↑ temp or shock	May explode at normal temp & pressures
Special hazards	White diamond (bottom)	W = unusual reactivity with water OX = oxidizer ALK = Alkaline				

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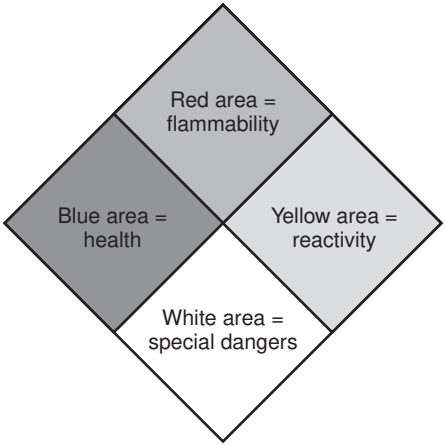
Hazard Identification System *continued*



Safety diamond. Colored areas within the diamond indicate types of danger: red area (top) = flammability; blue area (left) = health; yellow area (right) = reactivity; and white area (bottom) = special dangers. *(From Arneson W, Brickell J. Clinical Chemistry: A Laboratory Perspective. Philadelphia: FA Davis; 2007:5.)*

Storage of Chemicals

CHEMICAL CATEGORY	EXAMPLES	STORAGE GUIDELINES
Acids	Organic: formic, glacial acetic, citric Inorganic: hydrochloric, nitric, sulfuric Oxidizing: chromic, nitric, perchloric, sulfuric	Store below counter level or in acid cabinets. Separate from flammable & combustible material, bases, & active metals (e.g., sodium, potassium, magnesium). Separate organic acids from inorganic acids. Separate oxidizing acids from organic acids.
Bases	Ammonium hydroxide, potassium hydroxide, sodium hydroxide	Separate from acids. Store inorganic hydroxides in polyethylene containers.
Flammables	Acetone, alcohols, xylene	Limit amount in work area. Store in approved safety cans or cabinets. Separate from oxidizing acids & oxidizers.
Oxidizers	Nitric acid, perchloric acid, sulfuric acid, acetic acid, potassium chloride, hydrogen peroxide	Separate from reducing agents (e.g., zinc, alkaline metals, formic acid), flammable & combustible materials.
Water-reactive chemicals	Sodium, potassium	Keep away from water. Store in a dry, cool place.

Fire Safety

CLASS OF FIRE	COMBUSTIBLE MATERIAL	EXTINGUISHERS TO USE	COMMENTS
A	Cloth, wood, paper	Pressurized water (A) Dry chemical (ABC)	Don't use water on electrical fires or burning liquids.
B	Flammable or combustible liquids	Dry chemical (ABC) CO_2 (BC)	
C	Electrical equipment	Dry chemical (ABC) CO_2 (BC)	Never use water. Dry chemical may damage electrical equipment. CO_2 leaves no residue; good choice for computers, analyzers.
D	Combustible metals	Leave to professional firefighters.	

Commonly Used Anticoagulants/Additives

ANTICOAGULANT/ ADDITIVE	STOPPER COLOR	MODE OF ACTION	EXAMPLES OF USE	COMMENTS
EDTA	Lavender	Prevents clotting by chelating Ca^{2+}	CBC, diff, sed rate	Prevents platelets from clumping. Minimal morphologic changes to WBCs. Tube should be at least ½ full.
Heparin	Green	Prevents clotting by neutralizing thrombin	Many chemistries, osmotic fragility, plasma hgb, blood gases	Best anticoagulant for prevention of hemolysis. Don't use for diffs (blue background).
Sodium citrate	Light blue	Prevents clotting by binding Ca^{2+}	Most coagulation tests	Preserves labile clotting factors. Tube must be full for 9:1 blood-to-anticoagulant ratio or coagulation (coag) results falsely ↑. To ensure proper ratio when drawing with butterfly, use discard tube to clear air from tubing. Discard tube not required in other situations. Reduce anticoagulant when hematocrit (HCT) >55%.
Sodium fluoride	Gray	Inhibits glycolysis (not an anticoagulant)	Glucose, lactic acid, blood alcohol	Preserves glucose for 24 hr. Combined with K oxalate if anticoagulation needed. Oxalate binds Ca^{2+}.

Recommended Order for Drawing Evacuated Tubes & Filling Tubes From a Syringe

(CLSI H3-A6, 2007)

TUBE	STOPPER OR CLOSURE	COMMENTS
Blood culture	Yellow (SPS) or blood culture bottle	Drawing 1st avoids bacterial contamination from needle that has pierced other stoppers.
Coagulation (citrate)	Light blue	Drawing before other anticoagulant & clot activator tubes avoids contamination with additives that can affect coag results. If royal blue tube without additive is needed, it should be drawn before the citrate tube.
Serum (with/without clot activator; with/without gel)	Red, gold, speckled	Drawing before green avoids contamination with sodium heparin ($\uparrow Na^+$) or lithium heparin ($\uparrow Li^+$). Drawing before lavender avoids contamination from K_2EDTA ($\downarrow Ca^{2+}$, Mg^{2+}; $\uparrow K^+$). Drawing before gray avoids contamination with sodium fluoride/potassium oxalate ($\downarrow Ca^{2+}$, $\uparrow Na^+$, $\uparrow K^+$, interference with some enzyme assays).
Heparin (with/without gel)	Green	Drawing before lavender avoids contamination from K_2EDTA ($\downarrow Ca^{2+}$, Mg^{2+}; $\uparrow K^+$). Drawing before gray avoids contamination with sodium fluoride/potassium oxalate ($\downarrow Ca^{2+}$, $\uparrow Na^+$, $\uparrow K^+$).
EDTA	Lavender, pink, white	Drawing before gray avoids contamination with oxalate, which alters cellular morphology.
Glycolytic inhibitor (Na fluoride/K oxalate)	Gray	

Recommended Order for Filling Microcollection Tubes From Capillary Punctures

(CLSI H4-A6, 2008)

TEST/TUBE	RATIONALE FOR ORDER
Blood gases	Minimizes exposure to air
EDTA	Minimizes clumping of platelets
Heparin	Should be filled after EDTA if CBC is needed
Other additive tubes	Minimizes clotting
Serum tubes	Clotting is not a concern

Special Situations in Phlebotomy

SITUATION	APPROPRIATE COURSE OF ACTION
IV	Use opposite arm or perform fingerstick, if possible; otherwise, have nurse turn off IV for 2 min, apply tourniquet below IV, use different vein (if possible). Document location of IV & venipuncture, type of fluid.
Fistula	Draw from opposite arm.
Indwelling lines & catheters, heparin locks, cannulas	Usually not drawn by lab. First 5 mL drawn should be discarded. Lab may draw below heparin lock if nothing is being infused.
Sclerosed veins	Select another site.
Hematoma	Draw below.
Streptokinase/tissue plasminogen activator (TPA)	Minimize venipunctures. Hold pressure until bleeding has stopped.
Edema	Select another site.
Scars, burns, tattoos	Select another site.
Mastectomy	Draw from opposite arm.
Patient refuses	Try to persuade. If unsuccessful, notify nurse. Never draw without consent; could lead to charges of assault & battery.
Unidentified patient	Ask nurse to identify (ID) before drawing.

Special Test Requirements

REQUIREMENT	EXAMPLES*	COMMENTS
Fasting	Fasting blood sugar, triglycerides, lipid panel, gastrin, insulin	Nothing to eat or drink (except water) for at least 8 hr.
Chilling	Adrenocorticotropic hormone (ACTH), acetone, ammonia, gastrin, glucagon, lactic acid, pyruvate, parathyroid hormone (PTH), renin	Place in slurry of crushed ice & water. Don't use ice cubes alone because red blood cells (RBCs) may lyse.
Warming	Cold agglutinins, cryoglobulins	Use 37°C heat block, heel warmer, or hold in hand.
Protection from light	Bilirubin, carotene, erythrocyte protoporphyrin, vitamin A, vitamin B_{12}	Wrap in aluminum foil.
Chain of custody	Any test used as evidence in legal proceedings; e.g., blood alcohol, drug screens, deoxyribonucleic acid (DNA) analysis	Chain of custody form. Lock box may be required.

*Follow laboratory's established procedures.

Phlebotomy Sources of Error

ERROR	POSSIBLE EFFECT
Misidentification of patient	Treatment errors, possibility of transfusion fatality.
Drawing at incorrect time	Treatment errors if samples for certain tests aren't drawn at appropriate time, e.g., therapeutic drug monitoring, analytes that exhibit diurnal variation, analytes that are affected by recent eating/drinking.
Improper skin disinfection	Infection at site of puncture. Contamination of blood cultures & blood components. Isopropyl alcohol wipes can contaminate samples for blood alcohol.
Drawing from edematous site	Dilution of sample with tissue fluid.
Fist pumping during venipuncture	↑ K^+, lactic acid, Ca^{2+}, phosphorus; ↓ pH
Tourniquet >1 min	↑ K^+, total protein, lactic acid
IV fluid contamination	↑ glucose, electrolytes (depending on IV)
Expired collection tubes	↓ vacuum, failure to obtain specimen
Incorrect anticoagulant or contamination from incorrect order of draw	K_2EDTA before serum or heparin tube: ↓ Ca^{2+}, Mg^{2+}, ↑ K^+ Contamination of citrate tube with clot activator: erroneous coag results.
Failure to hold bottom of tube lower than top during collection	Carryover from one tube to another. Possible additive contamination.

continued...

Phlebotomy Sources of Error *continued*

ERROR	POSSIBLE EFFECT
Short draws	Incorrect blood: anticoagulant ratio affects some results, e.g., coag tests.
Inadequate mixing of anticoagulant tube	Micro-clots, fibrin, platelet clumping can lead to erroneous results.
Hemolysis from alcohol contamination, "milking" site of capillary puncture, probing with needle, vigorous shaking of tubes, exposure of samples to extremes of temperature	↑ K^+, Mg^{2+}, lactate dehydrogenase (LD), iron

Guidelines for Specimen Handling & Processing*

- Transport blood specimens carefully to avoid hemolysis.
- Protect tubes for bili, carotene from light.
- Transport samples for ACTH, lactic acid, ammonia, blood gases in ice slurry.
- Maintain tubes in vertical position to promote complete clotting.
- Allow serum & gel separator tubes to clot for 30–60 min before centrifugation to avoid fibrin strands.
- Centrifuge within 2 hr of collection.
- Spin most tubes at 1,000–1,300 relative centrifugal force (RCF) for 10–15 min.
- Spin citrate tubes at 1,500 RCF for 15 min to produce platelet-poor plasma.
- Keep tubes capped during centrifugation to avoid loss of CO_2, change of pH, evaporation, or aerosol formation.
- Don't re-spin primary tubes. Can cause hemolysis. If recentrifuging is necessary, transfer serum/plasma to another tube.
- Don't re-spin serum separator tubes. Serum in contact with RBCs under gel can be expressed & $\uparrow K^+$.
- Separate serum or plasma from cells within 2 hr of collection (exception: centrifuged gel tubes).
- When transferring samples to secondary containers, aspirate to avoid cellular contamination. Don't pour.
- Lipemic specimens can be ultracentrifuged at 10^5 x g to remove chylomicrons (triglycerides).
- Separated serum/plasma may be kept at room temperature (RT) for 8 hr or at 2°–8°C for 48 hr. For longer storage, freeze at –20°C. Avoid repeated freezing & thawing.
- Don't freeze whole blood.

*Always follow laboratory's established procedures.

Centrifuges

TERM	EXPLANATION
RCF	Force acting on sample being centrifuged. Gravities (g). Function of rpm and radius. $RCF = 1.12 \times 10^{-5} \times r \times rpm^2$.
rpm	Revolutions per minute. Speed of centrifugation. Determined by tachometer.
Radius (r)	Distance in cm from center of rotation to bottom of tube when rotating.
Horizontal-head centrifuge (swinging-bucket)	Tubes are in horizontal position when rotating. Produces a tightly packed, flat sediment surface. Recommended for serum separator tubes.
Angle-head centrifuge	Tubes are at fixed angle (25°–40°) when rotating. Capable of higher speeds. Produces a slanted sediment surface that isn't tightly packed. Decantation is not recommended.
Ultra centrifuge	High-speed. Capable of 100,000 rpm. Refrigerated to reduce heat.

Always make sure centrifuge is balanced. Don't open while spinning. Keep tubes capped.

Examples of Criteria for Specimen Rejection*

- Missing or inadequate label
- Collected at wrong time
- Collected in wrong tube
- Insufficient specimen
- Inadequate volume of blood in anticoagulant tube
- Exposure to temperature extremes
- Prolonged transit
- Clots in CBC tube
- Hemolysis (depending on test ordered)
- Lipemia (depending on test ordered)

*Follow lab's written policies.

Types of Glass

TYPE	CHARACTERISTICS
Borosilicate glass (Kimax, Pyrex)	High resistance to thermal shock & chemical attack. Heavy walls to minimize breakage. Used for most beakers, flasks, & pipets. Minimal contamination of liquids by elements in glass. Can be heated & autoclaved.
Aluminosilicate glass (Corex)	6 times stronger than borosilicate. Better able to resist clouding due to alkali & scratching.
Boron free	Used for highly alkaline solutions. Alkali resistant. Poor heat resistance.
High silica	Heat, chemical, & electrical tolerance. Excellent optical properties. Used for high-precision analytic work, optical reflectors, mirrors.
Flint glass	Soda-lime glass containing oxides of sodium, silicon, & calcium. Least expensive but poor resistance to high temp & sudden changes of temp. Only fair resistance to chemicals. Can release alkali & affect some determinations. Used for some disposable glassware.
Low actinic	Amber or red. Used to ↓ exposure to light, e.g., bilirubin standards.

Types of Plastic

TYPE	CHARACTERISTICS
Polypropylene	Relatively inert chemically. Resistant to most acids, alkalis, & salts. Can be autoclaved. Used for pipet tips, test tubes.
Polyethylene	Relatively inert chemically. Resistant to most acids (except concentrated H_2SO_4), alkalis, & salts. Used for test tubes, bottles, disposable transfer pipets, test tube racks. Can't be autoclaved.
Polycarbonate	Stronger than polypropylene & better temp tolerance, but chemical resistance not as good. Clear. Resistant to shattering. Used for centrifuge tubes, graduated cylinders.
Polystyrene	Rigid, clear. Shouldn't be autoclaved. Will crack & splinter. Used for test tubes, graduated tubes.
Polyvinyl chloride	Soft & flexible but porous. Frequently used as tubing.
Teflon	Extremely inert. Excellent temp tolerance & chemical resistance. Used for stir bars, stopcocks, tubing.