

MLT 101 Lecture 1 Objectives and Exam Questions

Level 1 Objectives

- L1-1. Define the primary purpose and function of the clinical laboratory.
- L1-2. Identify the intent and scope of CLIA '88 regulations.
- L1-3. Recognize major laboratory departments and testing types.
- L1-4. Recall education/credentials for MLT/MLS personnel.
- L1-5. List and differentiate the three testing phases (pre-, analytical, post-).
- L1-6. Identify major organizations with roles in laboratory regulation.
- L1-7. Define QC, QA, and QI.
- L1-8. Recall roles of laboratory personnel (e.g., pathologist).
- L1-9. Recognize HIPAA protections for confidentiality.

Level 2 Objectives

- L2-1. Explain how CLIA, OSHA, and HIPAA support quality and safety.
- L2-2. Differentiate the three phases of testing and their impact on patient outcomes.
- L2-4. Describe professionalism and communication in laboratory practice.
- L2-5. Relate QC/QA/QI to daily operations.
- L2-6. Differentiate regulatory bodies from accreditation/certification organizations.
- L2-7. Match agencies/organizations to their primary functions.
- L2-8. Apply preanalytical error recognition to corrective action.

Multiple Choice

1. The primary purpose of the clinical laboratory is to:
 - a. Diagnose diseases directly
 - b. Provide data to assist in diagnosis and treatment
 - c. Replace physician evaluation
 - d. Perform research studies
2. The term CLIA '88 refers to:
 - a. A safety regulation for handling specimens
 - b. Federal legislation that governs all laboratory testing on human specimens
 - c. The OSHA Bloodborne Pathogens Standard
 - d. The national certification exam for laboratory personnel
3. Which department performs testing on blood and body fluids for cellular components?
 - a. Chemistry
 - b. Hematology
 - c. Microbiology
 - d. Immunology

Hagerstown Community College – Medical Laboratory Technology

4. A medical laboratory technician (MLT) typically holds:
 - a. A bachelor's degree
 - b. A high school diploma
 - c. An associate degree
 - d. A master's degree
5. The preanalytical phase includes which of the following?
 - a. Reviewing QC data
 - b. Collecting and labeling the specimen
 - c. Reporting results
 - d. Performing the test
6. The analytical phase begins when:
 - a. The specimen is collected
 - b. The specimen is tested
 - c. The results are reported
 - d. The physician interprets the data
7. The postanalytical phase involves:
 - a. Specimen collection
 - b. Quality control
 - c. Result reporting and interpretation
 - d. Reagent preparation
8. Which organization provides certification exams for MLT and MLS personnel?
 - a. CLSI
 - b. ASCP Board of Certification (BOC)
 - c. CAP
 - d. CDC
9. Which of the following is a preanalytical variable that can affect results?
 - a. Improper pipetting technique
 - b. Hemolyzed specimen
 - c. Instrument calibration error
 - d. Incorrect reference range
10. The Clinical and Laboratory Standards Institute (CLSI):
 - a. Accredits laboratories
 - b. Publishes standard procedures and guidelines
 - c. Enforces safety regulations
 - d. Administers licensure exams

True / False

11. _____ OSHA is responsible for enforcing workplace safety standards.
12. _____ The CLIA '88 regulations apply only to hospital laboratories.
13. _____ Quality assessment includes preanalytical, analytical, and postanalytical factors.
14. _____ Confidentiality of patient results is protected under HIPAA.
15. _____ A pathologist is a medical doctor responsible for directing laboratory operations.

Matching

- | | |
|-----------------|--|
| 16. ____ CMS | A. Enforces workplace safety standards for employees. |
| 17. ____ FDA | B. Accredits educational programs in the clinical laboratory sciences. |
| 18. ____ CDC | C. Grants CLIA certification; oversees testing complexity categories. |
| 19. ____ OSHA | D. Provides national public health guidance and disease control standards. |
| 20. ____ EPA | E. Regulates hazardous waste disposal. |
| 21. ____ NAACLS | G. Accredits clinical laboratories and promotes laboratory quality. |
| 22. ____ CAP | H. Provides individual credentialing/certification for lab professionals. |
| 23. ____ ASCP | I. Certifies allied health professionals (e.g., MLT). |
| 24. ____ AMT | J. Accredits physician office laboratories and small hospital labs. |
| 25. ____ COLA | |
-

- | | |
|------------------------|--|
| 26. ____ Accreditation | A. State-granted legal authority for an individual to practice a profession within a jurisdiction; typically requires meeting education/competency standards and periodic renewal. |
| 27. ____ Certification | B. Formal recognition that a program or institution meets established quality standards set by an external body. |
| 28. ____ Licensure | C. A credential awarded to an individual by a certifying agency after meeting requirements and passing a competency exam. |

Answer Key

MCQ Answers (with objectives)

1. b (L1-1)
2. b (L1-2)
3. b (L1-3)
4. c (L1-4)

Hagerstown Community College – Medical Laboratory Technology

5. b (L1-5)
6. b (L1-5)
7. c (L1-5)
8. b (L1-6)
9. b (L2-8)
10. b (L1-6)

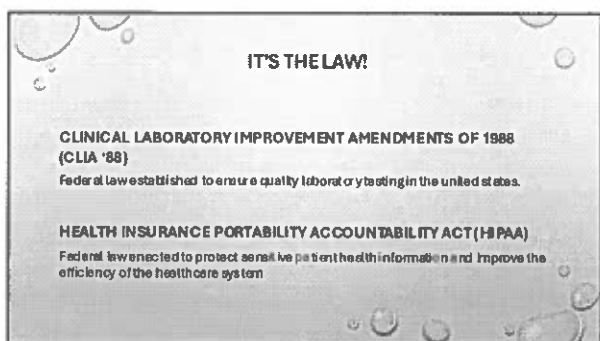
True/False Answers (with objectives)

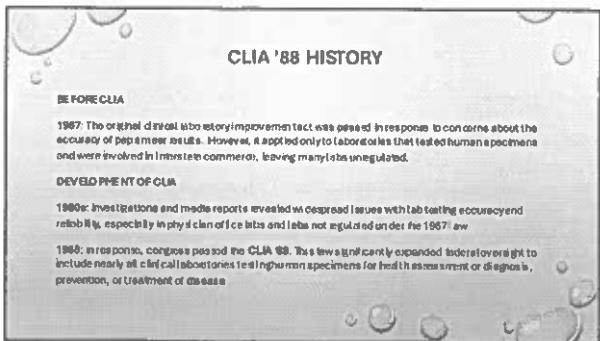
11. True (L2-1)
12. False (L1-2)
13. True (L1-7)
14. True (L1-9)
15. True (L1-8)

Matching Key (Q16-25) — (objective L2-7)

- 16 → C
- 17 → A
- 18 → D
- 19 → A
- 20 → E
- 21 → B
- 22 → G
- 23 → H
- 24 → I
- 25 → J







CLIA '88 IMPLEMENTATION

Apply to all U.S. facilities ~~in~~ sites that test human specimens for health or disease assessment.

Administered by the Centers For Medicare & Medicaid Services (CMS), in coordination with the Food and Drug Administration (FDA) and the Center for Disease Control and Prevention (CDC)

Key provisions:

- Labs must be certified by CMS based on the complexity of tests they perform
- Standards were set for personnel qualifications, quality control, proficiency testing, and record keeping.

CLIA '88 CATEGORIES OF TESTING

Waived

Simple tests with the low risk for an incorrect result.

- Certain tests listed in the CLIA regulations
- Tests cleared by the FDA for home use
- Tests that the manufacturer applies to the FDA for waived status by providing action data that verifies that the CLIA waiver criteria have been met

Non-Waived

The FDA determines the test's complexity by reviewing the package insert instructions and using a criteria scorecard to categorize a test as moderate or high complexity

Moderate Complexity: requires minimal scientific and technical knowledge.

High Complexity: requires specialized scientific knowledge and training.

DETERMINING COMPLEXITY OF NON-WAIVED TESTS

Each test is graded in level of complexity by assigning scores of 1, 2, or 3 for which of the seven criteria on the score card.

A score of 1 indicates the lowest level of complexity, and a score of 3 indicates the highest level.

The scores for the 7 criteria are added together and tests with a score of ≤12 are categorized as moderate complexity, while those with a score of >12 are categorized as high complexity.

The Seven Criteria:

1. Knowledge
2. Training and Experience
3. Reagent and Material Preparation
4. Characteristics of Operational Steps
5. Calibration, quality control, and proficiency testing materials
6. Test system troubleshooting and equipment maintenance
7. Interpretation and judgment

HIPAA HISTORY

- SIGNED BY PRESIDENT BILL CLINTON IN 1996
- PURPOSE
 - IMPROVE PORTABILITY OF HEALTH INSURANCE COVERAGE
 - COMBAT FRAUD AND ABUSE IN HEALTH CARE
 - PROMOTE ADMINISTRATIVE SIMPLIFICATION THROUGH STANDARDIZATION OF ELECTRONIC HEALTH CARE TRANSACTIONS
 - PROTECT THE PRIVACY AND SECURITY OF PATIENTS' HEALTH INFORMATION

MAJOR RULES UNDER HIPAA

- Privacy rule (2003)
 - Sets standards for how protected health information (PHI) can be used and shared.
 - Gives patients rights over their health data.
- Security rule (2003)
 - Requires safeguards to protect electronic PHI.
- Enforcement rule (2006)
 - Establishes procedures and penalties for violations.
- Breach notification rule (2009, via HITECH act)
 - Requires notification to patients when PHI is breached.
- Omnibus rule (2013)
 - Strengthens privacy protections and expands liability to business associates.

BASIC RULES TO OBSERVE FOR CONFIDENTIALITY

1. Never discuss the patient or his/her condition with family or friends. On a practical basis, a medical care worker should not be involved in matters that are not directly related to the performance of his/her specifically assigned and reasonable duties for his/her position.
2. Never discuss a patient's illness in the patient's presence or with another worker or family member unless it is within the scope of practice. There is evidence that patients may hear everything that is said, even when in a comatose state. At best, the patient may misinterpret what you have to say.
3. Refer questions by the patient regarding his/her disease and treatment to the care provider. The patient and his/her provider are the only people legally and ethically able to divulge information of any type to another party. A medical laboratory worker should not discuss test results and the clinical significance of them. The lab worker may tell the patient he/she is collecting blood for tests to assist the provider in diagnosis or treatment. The laboratory worker is not aware of the patient's condition in many instances and may give more or less accurate information that may be misinterpreted.

LABORATORY ACCREDITATION BODIES

- Accreditation is a voluntary, formal, independent verification that a program or institution meets established quality standards and is competent to carry out specific conformity assessment tasks.
- Accreditation groups are responsible for ensuring both the clinical facilities and educational programs.
 - National Accreditation Agency for Clinical Laboratory Science (NAACLS)
 - College Of American Pathologists (CAP)
 - Commission On Clinical Laboratory Accreditation (COLA)
 - The Joint Commission (TJC) formerly known as Joint Commission On Accreditation Of Healthcare Organizations Or JCAHO
 - Association For The Advancement Of Blood & Biotherapies (AABB) formerly known as American Association Of Blood Banks

CERTIFICATION

- Certification is a credential that verifies a person's knowledge, skills, and abilities to perform a specific job or work in a specific field.
- American Society Of Clinical Pathology (ASCP)
 - <https://www.ascp.org/certification>
- American Medical Technologists (AMT)
 - <https://www.amt.org/certification>
- American Association Of Bioanalysts (AAB)
 - <https://www.aab.org/certification>

PERSONNEL LICENSURE

- Licensure is a process by which an agency of government grants permission to an individual to engage in each occupation.
- Compulsory, not voluntary
- Currently, twelve (12) states have some form of personnel licensure or mandatory certification for clinical laboratory personnel. The great majority of states do not license lab techs but rely on the federal CLIA program to assure the quality of testing, including minimum personnel qualifications.
- In states where licenses are required, it's illegal to practice a profession covered by the licensing regulation without a license.
- States with no personnel licensure requirements will accept these registrants as being qualified to work in the medical laboratory.

OTHER REGULATORY AGENCIES

- Centers For Medicare & Medicaid Services (CMS) the agency within the Department of Health and Human Services (DHHS) responsible for implementing CUA - OB
- Center For Disease Control And Prevention (CDC) - central laboratory for functional public health system
- Food And Drug Administration (FDA) - the division of the Department of Health and Human Services (DHHS) responsible for protecting the public health by ensuring the safety and efficacy of foods, drugs, biological products, medical devices, and cosmetics
- Occupational Safety And Health Administration (OSHA) - the federal agency that creates workplace safety regulations and enforces the Occupational Safety and Health Act of 1970
- Department Of Transportation (DOT) - Regulates transporting hazardous waste, including shipping papers, packaging, labeling, and vehicle requirements.
- Environmental Protection Agency (EPA) - Regulates hazardous waste disposal

INFORMED CONSENT

- Every medical professional must make sure that his or her patients understand and consent to every procedure. In most instances, the patient has the right to an explanation of which medical procedure is being performed and why. If the patient is a minor, her parents or guardians must provide consent on her behalf. Phlebotomists must also bear in mind that the patient has the right to refuse consent.
- **Expressed vs Implied Consent**

ASSAULT AND BATTERY

- Assault is defined as making someone fear that you will use force to harm them. This can be a sensitive issue for phlebotomists because many people have a fear of needles, and the pain associated with venipuncture.
- Battery is actual physical contact must occur. In phlebotomy this can be an issue if a phlebotomist forces an injection on a patient against their will. If a phlebotomist intentionally holds a patient down or uses more force than necessary, they have committed battery.

NEGLIGENCE AND MALPRACTICE

NEGLIGENCE

- FAILURE TO EXERCISE REASONABLE CARE
- CAN BE COMMITTED BY ANYONE (NOT JUST PROFESSIONALS)
- EXAMPLE: SPILLING WATER ON A LAB BENCH AND NOT CLEANING IT, CAUSING SOMEONE TO SLIP

MALPRACTICE

- PROFESSIONAL NEGLIGENCE
- OCCURS WHEN A HEALTHCARE PROFESSIONAL FAILS TO MEET THE STANDARDS OF THEIR FIELD
- EXAMPLE: A MEDICAL LABORATORY PROFESSIONAL MISCALIBRATES A DRUG IN LEADING TO WRONG TREATMENT

CHAIN OF CUSTODY

- WHEN SPECIMENS ARE INVOLVED IN POSSIBLE MEDICOLEGAL SITUATIONS, CERTAIN SPECIMEN-HANDLING POLICIES ARE REQUIRED.
- FOR EVIDENCE TO BE ADMISSIBLE, EACH STEP OF THE ANALYSIS, BEGINNING WITH THE MOMENT THE SPECIMEN IS COLLECTED AND TRANSPORTED TO THE LABORATORY, TO THE ANALYSIS ITSELF AND THE REPORTING OF THE RESULTS, MUST BE DOCUMENTED; THIS PROCESS IS KNOWN AS "MAINTAINING THE CHAIN OF CUSTODY."

CLINICAL LABORATORY FUNCTIONS

- THE LABORATORY SERVES TO EDUCATE THE PHYSICIAN AND OTHER HEALTH CARE PROVIDERS SO THAT THE INFORMATION AVAILABLE THROUGH THE PROVIDED TEST RESULTS CAN BE USED APPROPRIATELY.
- WHEN TESTS ARE ORDERED, THE CLINICAL LABORATORY SHOULD ASSUME A ROLE OF LEADERSHIP AND EDUCATION IN ASSISTING THE PHYSICIAN TO SERVE THE BEST INTEREST OF THE PATIENT, IMPROVE THE CLINICAL DECISION-MAKING PROCESS FOR THE PHYSICIAN, AND CONSIDER THE COSTS INVOLVED.
- TYPICALLY, ONLY A SMALL PERCENTAGE OF AVAILABLE TESTS ARE ROUTINELY ORDERED.
- TESTS IMPROVE CLINICAL DECISION-MAKING.

STAFFING IN THE CLINICAL LABORATORY

- PATHOLOGIST (MD OR DO) OR PHD AS LABORATORY DIRECTOR
- CLINICAL LABORATORY PERSONNEL
 - LABORATORY SUPERVISOR OR MANAGER
 - RESPONSIBLE FOR THE TECHNICAL ASPECTS OF MANAGING THE LABORATORY
 - ENSURES ALL FEDERAL, STATE, AND LOCAL REGULATORY MANDATES ARE FOLLOWED BY THE LABORATORY
 - TECHNOLOGISTS, TECHNICIANS, AND SPECIALISTS
 - PHLEBOTOMISTS AND LABORATORY ASSISTANTS

STAFFING IN THE CLINICAL LABORATORY

- DUTIES OF TECHNOLOGISTS, TECHNICIANS, AND SPECIALISTS
 - THE RESPONSIBILITIES OF MISS AND MLTS VARY BUT MAY INCLUDE PERFORMING SOME OF THE SAME LABORATORY ASSAYS, SUPERVISING OTHER STAFF, TEACHING, OR RESEARCH.
 - BECAUSE OF DEPTH KNOWLEDGE OF TECHNICAL ASPECTS, PRINCIPLES OF METHODOLOGY, AND INSTRUMENTATION USED FOR THE VARIOUS LABORATORY ASSAYS THE LABORATORY PROFESSIONAL CAN CORRELATE AND INTERPRET THE DATA.
 - ALTHOUGH MISS AND MLTS MAY COLLECT BLOOD SPECIMENS OR PROCESS THEM, PHLEBOTOMISTS COLLECT BLOOD SPECIMENS IN LARGER HOSPITALS.

LABORATORY DEPARTMENTS

- THE ORGANIZATION OF A PARTICULAR CLINICAL LABORATORY DEPENDS ON ITS SIZE, THE NUMBER OF TESTS DONE, AND THE FACILITIES AVAILABLE.
 - LARGER LABORATORIES TEND TO BE DEPARTMENTALIZED; A SEPARATE AREA IS DESIGNATED FOR EACH OF THE VARIOUS DIVISIONS. CYTOGENETICS, TOXICOLOGY, FLOW CYTOMETRY, AND OTHER SPECIALIZED DIVISIONS (SUCH AS MOLECULAR DIAGNOSTICS) ARE PRESENT IN LARGER LABORATORIES.
- THE TREND IS TO HAVE A MORE "OPEN" DESIGN OR A CORE LABORATORY WHERE HEMATOLOGY, URINALYSIS, HEMOSTASIS/COAGULATION, AND CLINICAL CHEMISTRY SHARE WORKSPACE.
- CROSS-TRAINING IS IMPORTANT IN A CORE LABORATORY MODEL.

LABORATORY DEPARTMENTS

PATHOLOGY IS A SPECIALTY THAT OFFERS A GREAT DEAL OF VARIETY AND CONTAINS TWO MAIN DIVISIONS.

- **CLINICAL PATHOLOGY**
 - CLINICAL PATHOLOGY PRIMARILY DEALS WITH THE ANALYSIS OF BODY FLUIDS LIKE BLOOD AND URINE. THIS BRANCH ENCOMPASSES VARIOUS LABORATORY TESTS THAT HELP DIAGNOSE CONDITIONS SUCH AS INFECTIONS, ANEMIA, AND DIABETES.
- **ANATOMICAL PATHOLOGY**
 - ANATOMICAL PATHOLOGY PRIMARILY CONSISTS OF TISSUE EVALUATION—FROM INDIVIDUAL CELLS FROM A PAP SMEAR, A FINE NEEDLE ASPIRATION OF A MASS, OR EVALUATION OF THE ENTIRE BODY IN AN AUTOPSY, AND EVERYTHING IN BETWEEN.

LABORATORY DEPARTMENTS

- A WORKING CLINICAL LABORATORY IS TRADITIONALLY ORGANIZED INTO SEVERAL MAJOR SCIENTIFIC DISCIPLINES: BLOOD BANKING/TRANSFUSION MEDICINE, CLINICAL CHEMISTRY (MAY INCLUDE TOXICOLOGY), FLOW CYTOMETRY, HEMATOLOGY AND HEMOSTASIS, IMMUNOLOGY AND SEROLOGY, MICROBIOLOGY, AND URINALYSIS.
- THE CORE LABORATORY CONFIGURATION COMBINES ROUTINE HEMATOLOGY, HEMOSTASIS AND BLOOD COAGULATION, AND CLINICAL CHEMISTRY.
- EACH SPECIALTY DEPARTMENT FOCUSES ON A DIFFERENT AREA OF LABORATORY MEDICINE.

LABORATORY DEPARTMENTS

- MANY MEDIUM TO LARGE SIZE LABORATORIES HAVE DEVELOPED A CENTRAL TESTING AREA WITH A CLUSTER OF INSTRUMENTS DEVOTED TO HIGH VOLUMES OF TEST SAMPLES.
- EXPANDED DIRECTIONS OF LABORATORY TESTING INCLUDE MOLECULAR DIAGNOSTICS, AN APPLICATION OF BIOTECHNOLOGY.
 - APPLIES THE PRINCIPLES OF BASIC MOLECULAR BIOLOGY TO THE STUDY OF HUMAN DISEASES
 - PROVIDES INFORMATION RELATED TO MOLECULAR GENETICS RESEARCH AS REAL-TIME INFORMATION FOR APPLICATIONS SUCH AS GENE THERAPY, GENETIC SCREENING, STEM CELL RESEARCH, CLONING, AND CELL CULTURE

HEALTH CARE ORGANIZATIONS

- MODERN HEALTH CARE ORGANIZATIONS HAVE MANY DIFFERENT CONFIGURATIONS, DEPENDING ON THE GEOGRAPHIC REGION AND MARKET, MIX OF PATIENTS, OVERALL SIZE, AND AFFILIATIONS.
- THE SIZE OF HEALTH CARE ORGANIZATIONS RANGES FROM THE VERY LARGE TERTIARY CARE-LEVEL TEACHING HOSPITALS TO COMMUNITY HOSPITALS, TO FREESTANDING SPECIALTY CLINICS OR PHYSIOTHERAPY DRAWING STATIONS.
- A COMMON ORGANIZATIONAL STRUCTURE FOR A HOSPITAL INCLUDES THE CHIEF EXECUTIVE OFFICER AND THE BOARD OF TRUSTEES, WHO SET POLICY AND GUIDE THE ORGANIZATION.
- THE CHIEF OPERATING OFFICER IS RESPONSIBLE FOR IMPLEMENTING POLICIES AND DAILY ACTIVITIES.

HEALTH CARE ORGANIZATIONS

- OTHER HIGH-LEVEL POSITIONS CAN INCLUDE THE CHIEF FINANCIAL OFFICER, CHIEF INFORMATION OFFICER, AND CHIEF TECHNOLOGY OFFICER, DEPENDING ON THE SIZE OF A HEALTH CARE ORGANIZATION.
- A VARIABLE NUMBER OF VICE PRESIDENTS (VPS) HAVE SEVERAL DEPARTMENTS REPORTING TO THEM.
- ORGANIZATIONS USUALLY HAVE VPS OF NURSING, CLINICAL SERVICES, GENERAL SERVICES, AND HUMAN RESOURCES.
- THE VP OF CLINICAL SERVICES OVERSEES THE MANAGERS OF THE CLINICAL LABORATORY AS WELL AS RADIOLOGY AND PHARMACY.

ALTERNATE SITES OF TESTING

- CENTRAL LABORATORY TESTING
- POINT-OF-CARE TESTING
- REFERENCE LABORATORIES
- PHYSICIAN OFFICE LABORATORIES



Lesson Plan: Laboratory Safety Features Scavenger Hunt (MLT 101)

Instructor: _____ Date: _____

Duration: 60 minutes Location: Campus Teaching Laboratory

Pre-Lab Discussion

Principle: Laboratory safety relies on identifying hazards and controlling risk using engineering controls (e.g., eyewash, fume hood), administrative controls (policies, labels), and PPE (coats, gloves, goggles).

Clinical Significance: Correct use of safety features protects personnel and specimen integrity, reduces exposure incidents, and supports regulatory compliance and quality outcomes.

Glossary (selected)

- **PPE:** Personal Protective Equipment: lab coats, gloves, eye/face protection.
- **Engineering Control:** A physical device that isolates or removes a hazard (e.g., fume hood, eyewash).
- **Administrative Control:** Policies/signage/training that direct safe behavior (e.g., NFPA labels, biohazard signs).
- **Sharps Container:** Rigid, puncture-resistant container for needles, lancets, broken glass.
- **NFPA 704:** Standard hazard diamond for quick identification of chemical risks.

Objectives

Cognitive (L1–L3):

- 1) Define and identify laboratory safety features and symbols (L1).
- 2) Classify safety equipment by function (protective, emergency, containment) (L2).
- 3) Explain how specific features mitigate risk and support compliance (L3).

Student Scavenger Hunt – Clues & Recording Sheet

Instructions: Decode each clue, find the safety feature, and record (A) the exact location in this lab and (B) its purpose or when to use it.

1. Lab Coat

I cover your clothing and skin, protecting you from splashes and contamination. You'll find me hanging where protective garments wait to be worn.

A) Exact Location: _____

B) Purpose/When to Use: _____

2. Safety Goggles

I shield your eyes from chemicals and flying debris. I'm often stored near sinks or benches, ready to defend your vision.

A) Exact Location: _____

B) Purpose/When to Use: _____

3. Nitrile Gloves

I form a strong barrier between your hands and hazardous materials. I'm disposable, puncture-resistant, and usually blue or purple.

A) Exact Location: _____

B) Purpose/When to Use: _____

4. Face Mask / Respirator

I protect your breathing by filtering out droplets and aerosols. Look where infection-control supplies are stored.

A) Exact Location: _____

B) Purpose/When to Use: _____

Hagerstown Community College – Medical Laboratory Technology

5. Face Shield

I guard your entire face from sprays or splashes. Find me near the goggles, upright to keep my surface clear.

A) Exact Location: _____

B) Purpose/When to Use: _____

6. Fire Extinguisher

I put out flames by releasing pressurized chemicals. Mounted on the wall, I'm your ally against fire.

A) Exact Location: _____

B) Purpose/When to Use: _____

7. Safety Shower

If chemicals splash on skin or clothing, pull my handle. I deliver a heavy flow of water from overhead.

A) Exact Location: _____

B) Purpose/When to Use: _____

8. Eyewash Station

When your eyes need rapid flushing, I'm here. Look for green signage near sinks or benches.

A) Exact Location: _____

B) Purpose/When to Use: _____

9. Spill Kit

Biohazard or chemical spills can be dangerous. Find my container of absorbents and neutralizers, marked for cleanup.

A) Exact Location: _____

B) Purpose/When to Use: _____

Hagerstown Community College – Medical Laboratory Technology

10. Fume Hood

I pull harmful vapors away, protecting your lungs. With a sliding sash, I create a barrier between you and fumes.

A) Exact Location:	_____
B) Purpose/When to Use:	_____

11. First Aid Kit

For cuts or burns, I provide first response care. I'm stored in a labeled box, usually near the door.

A) Exact Location:	_____
B) Purpose/When to Use:	_____

12. Broken Glass Disposal Box

Sharp edges need a special place — not regular trash. Find my sturdy container labeled for broken glass.

A) Exact Location:	_____
B) Purpose/When to Use:	_____

13. Clean Sink

Use me to wash only your hands before and after lab. I stay free of chemicals and biological waste.

A) Exact Location:	_____
B) Purpose/When to Use:	_____

14. Dirty Sink

I'm for rinsing glassware or disposing of appropriate non-hazardous liquids.

A) Exact Location:	_____
B) Purpose/When to Use:	_____

Hagerstown Community College – Medical Laboratory Technology

15. Biohazardous Waste Container

I collect infectious or contaminated materials marked with a special symbol. My red or orange bag warns you of biological hazards.

A) Exact Location: _____

B) Purpose/When to Use: _____

16. Sharps Container

Needles and lancets go in me — never the trash. I'm puncture-proof, labeled, and built for safe sharps disposal.

A) Exact Location: _____

B) Purpose/When to Use: _____

17. Emergency Exit

When alarms sound, I show the way out. Follow my glowing sign to safety.

A) Exact Location: _____

B) Purpose/When to Use: _____

18. Fire Blanket

I smother flames without chemicals, cutting off oxygen. Folded and stored in a wall case, I'm pulled down in an emergency.

A) Exact Location: _____

B) Purpose/When to Use: _____

Post-Activity Discussion:

- Review the PASS method for fire extinguishers.
- Contrast clean vs. dirty sinks and tie to hand hygiene policy.
- Clarify regulated medical waste (biohazard) vs. broken glass disposal vs. sharps container.
- Review biohazardous/chemical spill clean up



Clues

1. Lab Coat

*"I cover your clothing and skin, protecting you from splashes and contamination.
You'll find me hanging where protective garments wait to be worn."*

2. Safety Goggles

*"I shield your eyes from chemicals and flying debris.
I'm often stored near sinks or benches, ready to defend your vision."*

3. Nitrile Gloves

*"I form a strong barrier between your hands and hazardous materials.
I'm disposable, puncture-resistant, and usually blue or purple."*

4. Face Mask / Respirator

*"I protect your breathing by filtering out droplets and aerosols.
Look where infection-control supplies are stored."*

5. Face Shield

*"I guard your entire face from sprays or splashes.
Find me near the goggles, upright to keep my surface clear."*

6. Fire Extinguisher

*"I put out flames by releasing pressurized chemicals.
Mounted on the wall, I'm your ally against fire."*

7. Safety Shower

*"If chemicals splash on skin or clothing, pull my handle.
I deliver a heavy flow of water from overhead."*

8. Eyewash Station

*"When your eyes need rapid flushing, I'm here.
Look for green signage near sinks or benches."*

9. Spill Kit

*"Biohazard or chemical spills can be dangerous.
Find my container of absorbents and neutralizers, marked for cleanup."*

10. Fume Hood

*"I pull harmful vapors away, protecting your lungs.
With a sliding sash, I create a barrier between you and fumes."*

11. First Aid Kit

*"For cuts or burns, I provide first response care.
I'm stored in a labeled box, usually near the door."*

12. Broken Glass Disposal Box

*"Sharp edges need a special place — not regular trash.
Find my sturdy container labeled for*

13. Clean Sink

*"Use me to wash only your hands before and after lab.
I stay free of chemicals and biological waste."*

14. Dirty Sink

"I'm for rinsing glassware or disposing of non-hazardous liquids."

15. Biohazardous Waste Container

*"I collect infectious or contaminated materials marked with a special symbol.
My red or orange bag warns you of biological hazards."*

16. Sharps Container

*"Needles and lancets go in me — never the trash.
I'm puncture-proof, labeled, and built for safe sharps disposal."*

17. Emergency Exit

*"When alarms sound, I show the way out.
Follow my glowing sign to safety."*

18. Fire Blanket

*"I smother flames without chemicals, cutting off oxygen.
Folded and stored in a wall case, I'm pulled down in an emergency."*

Cognitive Objectives

By the end of this lesson, students will be able to:

1. Identify the four sections of the NFPA Diamond and discuss their meanings.
2. Interpret hazard ratings (0–4) for health, flammability, and reactivity.
3. Recognize the purpose of special symbols in the white section.
4. Identify the 16 standardized sections of an SDS.
5. Interpret hazard classifications for common lab chemicals.

Performance Objectives

By the end of this lesson, students will be able to:

1. Apply SDS information to safe handling, storage, and emergency response
2. Apply knowledge by analyzing sample labels and real-world lab chemicals
3. Given an SDS, the student will translate pertinent information to NFPA labeling and appropriately label chemicals commonly used in the clinical laboratory.

NFPA (National Fire Prevention Association) Diamond

1. Structure of the NFPA Diamond

- Four colored sections:
 - **Blue (Health Hazard)**
 - **Red (Flammability)**
 - **Yellow (Reactivity/Instability)**
 - **White (Special Information)**

2. Number Rating System (0–4)

- **0 = Minimal hazard, 4 = Severe hazard**
- Examples:
 - Health 4 = deadly; 0 = no hazard.
 - Flammability 4 = extremely flammable; 0 = won't burn.
 - Reactivity 4 = may detonate; 0 = stable.

3. White Section (Special Hazards)

- Common symbols:
 - **OX** = Oxidizer
 - **ACID** = Acid
 - **ALK** = Alkali (base)
 - **COR** = Corrosive
 - **Radiation symbol** = Radiation hazard

- **W with a slash** = Reacts with water

The SDS (Safety Data Sheets, formerly MSDS)

1. The SDS Format (16 Sections)

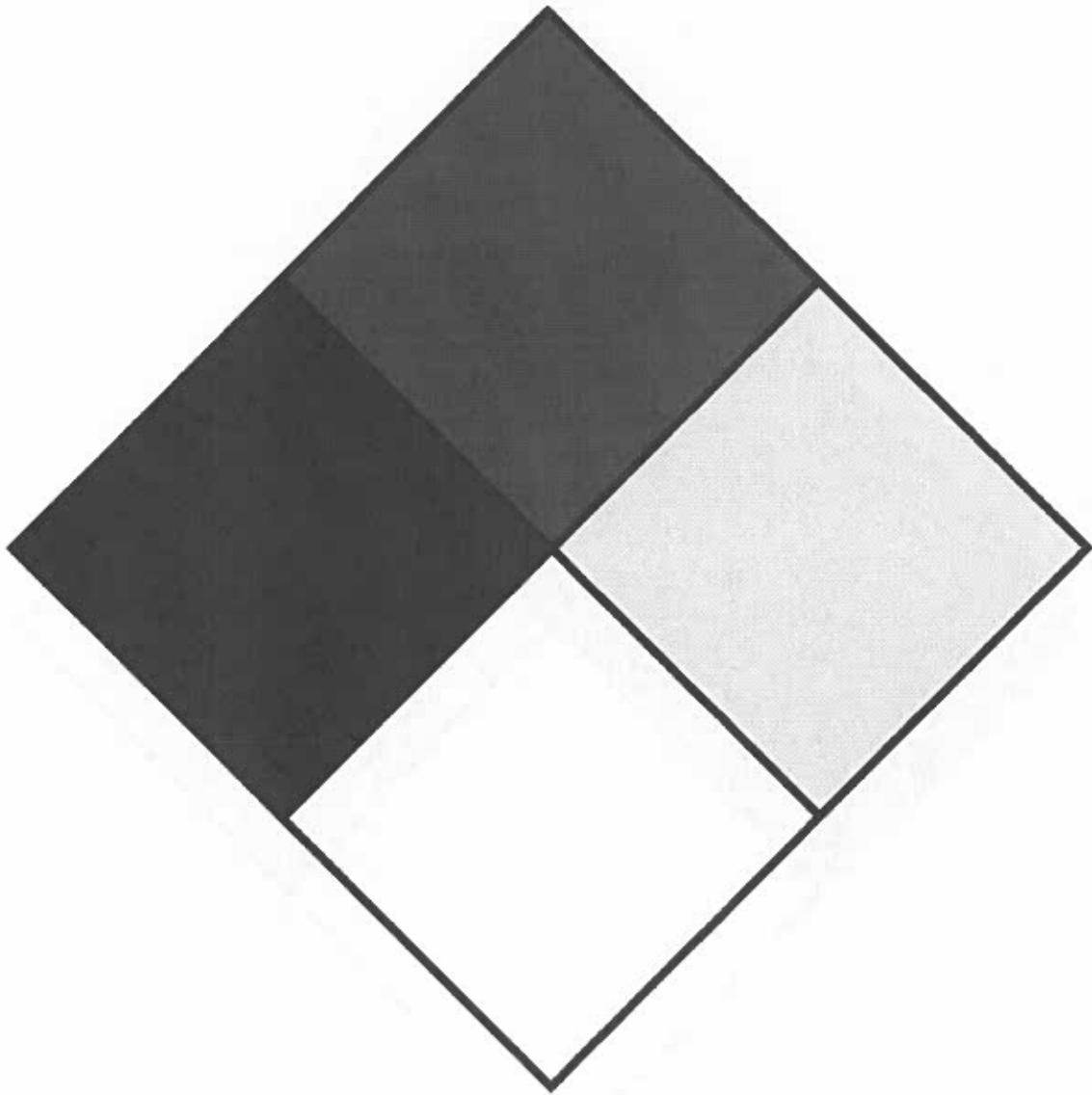
Highlight the most useful for beginners:

- **Section 1:** Identification (chemical name, use, supplier)
- **Section 2:** Hazard(s) Identification (signal word, hazard statements, pictograms)
- **Section 4:** First-Aid Measures
- **Section 7:** Handling & Storage
- **Section 8:** Exposure Controls / PPE
- **Section 10:** Stability & Reactivity
- **Section 13:** Disposal Considerations

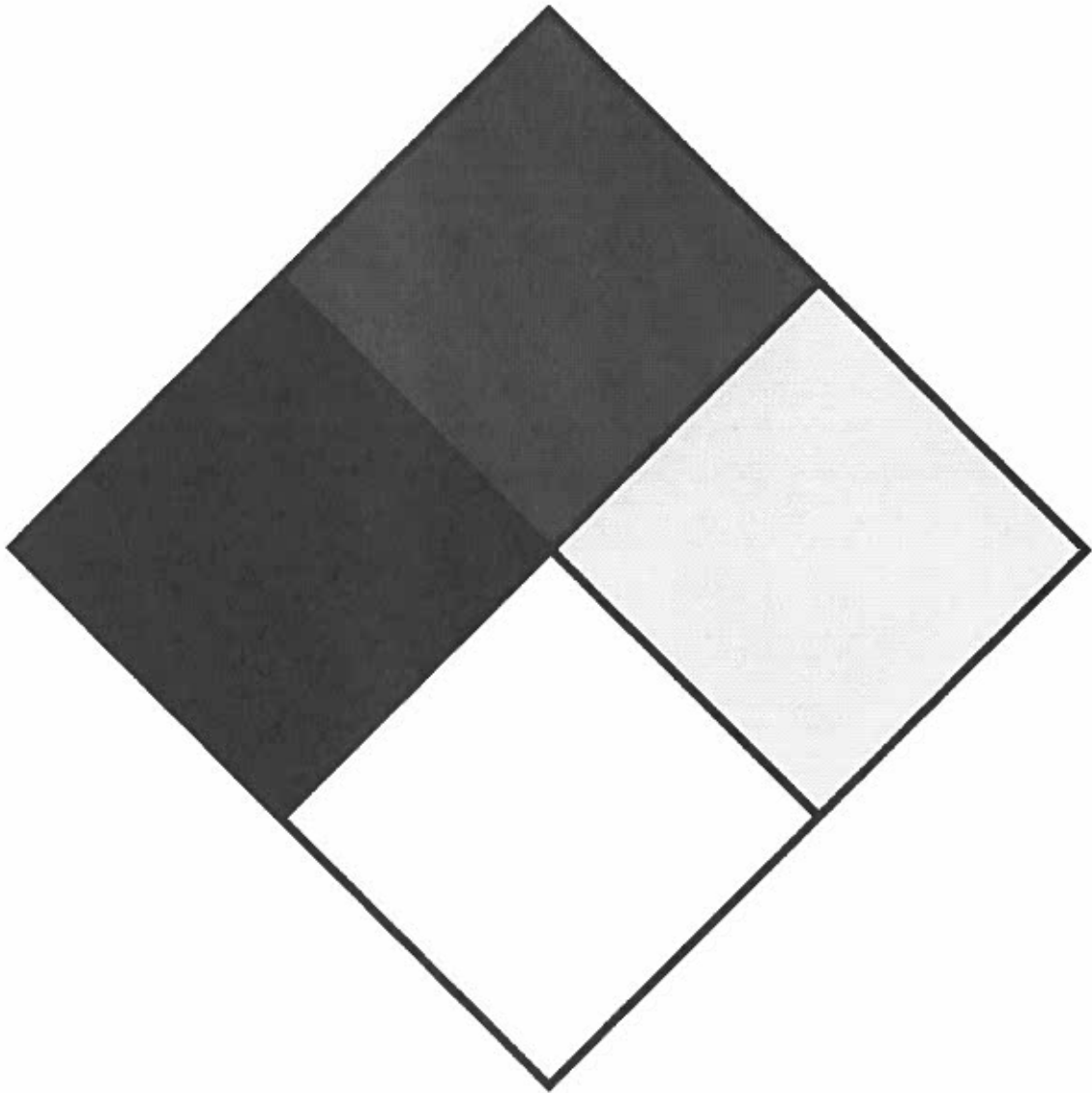
2. Example Chemicals

- **Deionized Water (DI Water):**
 - Hazard classification: Not hazardous
 - No PPE beyond good lab practice
 - Disposal: Sink drain acceptable
- **0.9% Saline Solution:**
 - Essentially nonhazardous, but still listed as “not classified” under GHS
 - First aid: Rinse eyes if splashed
 - Storage: Normal room temp, sealed
- **Bleach (Sodium Hypochlorite):**
 - Hazard classification: Corrosive, oxidizer, toxic to aquatic life
 - PPE: Gloves, goggles, lab coat
 - First aid: Flush with water immediately for skin/eye contact
 - Storage: Ventilated area, away from acids and sunlight

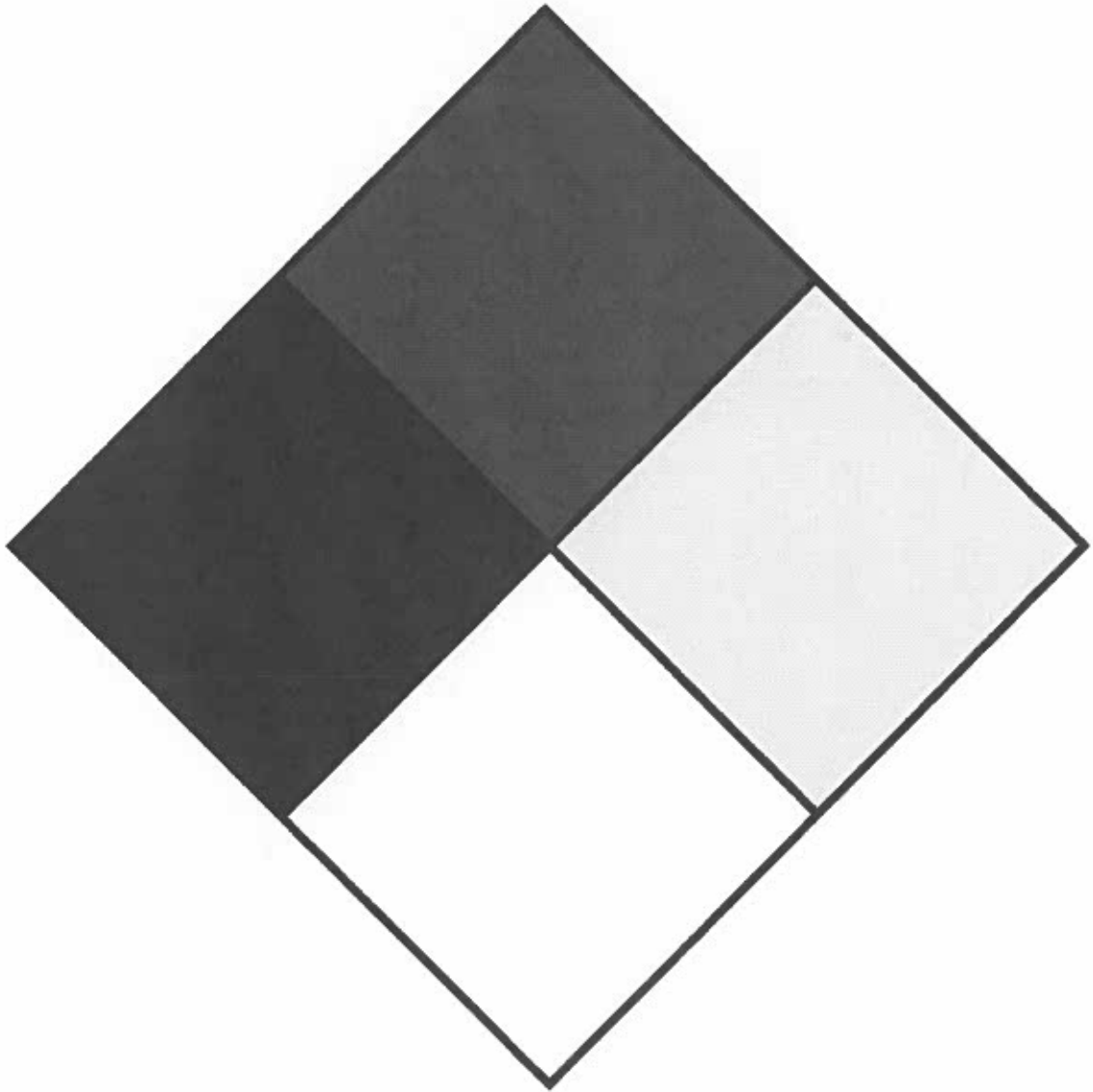
HAZARDOUS MATERIALS – Deionized Water



HAZARDOUS MATERIALS – Saline



HAZARDOUS MATERIALS – Bleach





Safety Data Sheet

according to 29CFR1910/1200 and GHS Rev. 3

Effective date : 01.08.2015

Page 1 of 6

Delonized Water, 4L

SECTION 1 : Identification of the substance/mixture and of the supplier

Product name : Deionized Water, 4L

Manufacturer/Supplier Trade name:

Manufacturer/Supplier Article number: S25293

Recommended uses of the product and restrictions on use:

Manufacturer Details:

AquaPhoenix Scientific, Inc
9 Barnhart Drive, Hanover, PA 17331
(717) 632-1291

Supplier Details:

Fisher Science Education
6771 Silver Crest Road, Nazareth, PA 18064
(724)517-1954

Emergency telephone number:

Fisher Science Education Emergency Telephone No.: 800-535-5053

SECTION 2 : Hazards identification

Classification of the substance or mixture:

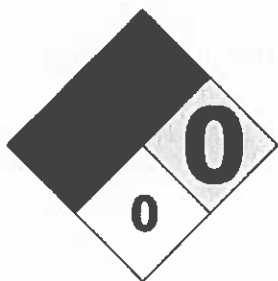
Not classified for physical or health hazards under GHS.

Hazard statements:

Precautionary statements:

Other Non-GHS Classification:

WHMIS
NFPA/HMIS



NFPA SCALE (0-4)

Health	0
Flammability	0
Physical Hazard	0
Personal Protection	X

HMIS RATINGS (0-4)

SECTION 3 : Composition/Information on Ingredients

Ingredients:

CAS 7732-18-5	Deionized Water	100 %
Percentages are by weight		

Safety Data Sheet

according to 29CFR1910/1200 and GHS Rev. 3

Effective date : 01.08.2015

Page 2 of 6

Delonized Water, 4L

SECTION 4 : First aid measures

Description of first aid measures

After inhalation: Move exposed individual to fresh air.

After skin contact: Wash affected area with soap and water.

After eye contact: Protect unexposed eye. Rinse/flush exposed eye(s) gently using water for 15-20 minutes. Remove contact lens(es) if able to do so during rinsing. Seek medical attention if irritation persists or if concerned.

After swallowing: Rinse mouth thoroughly. Do not induce vomiting. Have exposed individual drink sips of water. Seek medical attention if irritation, discomfort or vomiting persists.

Most important symptoms and effects, both acute and delayed:

Irritation, Nausea, Headache, Shortness of breath.;

Indication of any immediate medical attention and special treatment needed:

If seeking medical attention, provide SDS document to physician.

SECTION 5 : Firefighting measures

Extinguishing media

Suitable extinguishing agents: If in laboratory setting, follow laboratory fire suppression procedures.

For safety reasons unsuitable extinguishing agents:

Special hazards arising from the substance or mixture:

Advice for firefighters:

Protective equipment:

Additional information (precautions): Move product containers away from fire or keep cool with water spray as a protective measure, where feasible.

SECTION 6 : Accidental release measures

Personal precautions, protective equipment and emergency procedures:

Stop the spill, if possible. Contain spilled material by diking or using inert absorbent.

Environmental precautions:

Prevent from reaching drains, sewer or waterway. Collect contaminated soil for characterization per Section 13

Methods and material for containment and cleaning up:

If in a laboratory setting, follow Chemical Hygiene Plan procedures. Collect liquids using vacuum or by use of absorbents. Place into properly labeled containers for recovery or disposal. If necessary, use trained response staff/contractor.

Reference to other sections:

SECTION 7 : Handling and storage

Precautions for safe handling:

Follow good hygiene procedures when handling chemical materials. Avoid splashes or spray in enclosed areas.

Conditions for safe storage, including any incompatibilities:

Store in cool, dry conditions in well sealed containers.

SECTION 8 : Exposure controls/personal protection

Safety Data Sheet

according to 29CFR1910/1200 and GHS Rev. 3

Effective date : 01.08.2015

Page 3 of 6

Delonized Water, 4L



Control Parameters:

No applicable occupational exposure limits

Appropriate Engineering controls:

Emergency eye wash fountains and safety showers should be available in the immediate vicinity of use/handling.

Respiratory protection:

Not required under normal conditions of use. Use suitable respiratory protective device when aerosol or mist is formed.

Protection of skin:

The glove material has to be impermeable and resistant to the product/ the substance/ the preparation being used/handled. Selection of the glove material on consideration of the penetration times, rates of diffusion and the degradation.

Eye protection:

Safety glasses with side shields or goggles.

General hygienic measures:

The usual precautionary measures are to be adhered to when handling chemicals. Keep away from food, beverages and feed sources. Wash hands before breaks and at the end of work. Do not inhale gases/fumes/dust/mist/vapor/aerosols. Avoid contact with the eyes and skin.

SECTION 9 : Physical and chemical properties

Appearance (physical state,color):	Clear, colorless liquid.	Explosion limit lower: Explosion limit upper:	Not Determined Not Determined
Odor:	Odorless	Vapor pressure:	17.5 mmHg @20C
Odor threshold:	Not Determined	Vapor density:	Not Determined
pH-value:	Not Determined	Relative density:	1.000
Melting/Freezing point:	0C	Solubilities:	
Boiling point/Boiling range:	100C	Partition coefficient (n-octanol/water):	Not Determined
Flash point (closed cup):	Not Determined	Auto/Self-ignition temperature:	Not Determined
Evaporation rate:	Not Determined	Decomposition temperature:	Not Determined
Flammability (solid,gaseous):	Not Determined	Viscosity:	a. Kinematic:Not Determined b. Dynamic: Not Determined
Density: Not Determined			

SECTION 10 : Stability and reactivity

Reactivity:

Chemical stability:No decomposition if used and stored according to specifications.

Possible hazardous reactions:

Conditions to avoid:Store away from oxidizing agents, strong acids or bases.

Incompatible materials:Strong acids.Strong bases.

Safety Data Sheet

according to 29CFR1910/1200 and GHS Rev. 3

Effective date : 01.08.2015

Page 4 of 6

Delonized Water, 4L

Hazardous decomposition products:Carbon oxides (CO, CO2).

SECTION 11 : Toxicological information

Acute Toxicity: No additional information.

Chronic Toxicity: No additional information.

Corrosion Irritation: No additional information.

Sensitization:	No additional information.
-----------------------	----------------------------

Single Target Organ (STOT):	No additional information.
------------------------------------	----------------------------

Numerical Measures:	No additional information.
----------------------------	----------------------------

Carcinogenicity:	No additional information.
-------------------------	----------------------------

Mutagenicity:	No additional information.
----------------------	----------------------------

Reproductive Toxicity:	No additional information.
-------------------------------	----------------------------

SECTION 12 : Ecological information

Ecotoxicity Persistence and degradability: Readily degradable in the environment.

Bioaccumulative potential:

Mobility in soil: Aqueous solution has high mobility in soil.

Other adverse effects:

SECTION 13 : Disposal considerations

Waste disposal recommendations:

Product/containers must not be disposed together with household garbage. Do not allow product to reach sewage system or open water. It is the responsibility of the waste generator to properly characterize all waste materials according to applicable regulatory entities (US 40CFR262.11). Consult federal state/ provincial and local regulations regarding the proper disposal of waste material that may incorporate some amount of this product.

SECTION 14 : Transport information

UN-Number

Not Dangerous Goods

UN proper shipping name

Not Dangerous Goods

Transport hazard class(es)

Packing group:Not Dangerous Goods

Environmental hazard:

Transport in bulk:

Special precautions for user:

SECTION 15 : Regulatory information

United States (USA)

Safety Data Sheet

according to 29CFR1910/1200 and GHS Rev. 3

Effective date : 01.08.2015

Page 5 of 6

Delonized Water, 4L

SARA Section 311/312 (Specific toxic chemical listings):

None of the ingredients is listed

SARA Section 313 (Specific toxic chemical listings):

None of the ingredients is listed

RCRA (hazardous waste code):

None of the ingredients is listed

TSCA (Toxic Substances Control Act):

All ingredients are listed.

CERCLA (Comprehensive Environmental Response, Compensation, and Liability Act):

None of the ingredients is listed

Proposition 65 (California):

Chemicals known to cause cancer:

None of the ingredients is listed

Chemicals known to cause reproductive toxicity for females:

None of the ingredients is listed

Chemicals known to cause reproductive toxicity for males:

None of the ingredients is listed

Chemicals known to cause developmental toxicity:

None of the ingredients is listed

Canada

Canadian Domestic Substances List (DSL):

All ingredients are listed.

Canadian NPRI Ingredient Disclosure list (limit 0.1%):

None of the ingredients is listed

Canadian NPRI Ingredient Disclosure list (limit 1%):

None of the ingredients is listed

SECTION 16 : Other information

This product has been classified in accordance with hazard criteria of the Controlled Products Regulations and the SDS contains all the information required by the Controlled Products Regulations. Note: The responsibility to provide a safe workplace remains with the user. The user should consider the health hazards and safety information contained herein as a guide and should take those precautions required in an individual operation to instruct employees and develop work practice procedures for a safe work environment. The information contained herein is, to the best of our knowledge and belief, accurate. However, since the conditions of handling and use are beyond our control, we make no guarantee of results, and assume no liability for damages incurred by the use of this material. It is the responsibility of the user to comply with all applicable laws and regulations applicable to this material.

GHS Full Text Phrases:

Abbreviations and acronyms:

IMDG: International Maritime Code for Dangerous Goods

PNEC: Predicted No-Effect Concentration (REACH)

CFR: Code of Federal Regulations (USA)

Safety Data Sheet

according to 29CFR1910/1200 and GHS Rev. 3

Effective date : 01.08.2015

Page 6 of 6

Deionized Water, 4L

SARA: Superfund Amendments and Reauthorization Act (USA)
RCRA: Resource Conservation and Recovery Act (USA)
TSCA: Toxic Substances Control Act (USA)
NPRI: National Pollutant Release Inventory (Canada)
DOT: US Department of Transportation
IATA: International Air Transport Association
GHS: Globally Harmonized System of Classification and Labelling of Chemicals
ACGIH: American Conference of Governmental Industrial Hygienists
CAS: Chemical Abstracts Service (division of the American Chemical Society)
NFPA: National Fire Protection Association (USA)
HMIS: Hazardous Materials Identification System (USA)
WHMIS: Workplace Hazardous Materials Information System (Canada)
DNEL: Derived No-Effect Level (REACH)

Effective date : 01.08.2015

Last updated : 05.14.2015



Safety Data Sheet

Saline Solution 0.9%

1. PRODUCT AND COMPANY IDENTIFICATION

Product Name: Saline Solution 0.9%

Synonyms/Generic Names: None

Product Number: 4651

Product Use: Industrial, Manufacturing or Laboratory use

Manufacturer: Columbus Chemical Industries, Inc.
N4335 Temkin Rd.
Columbus, WI. 53925

For More Information Call: 920-623-2140 (Monday-Friday 8:00-4:30)

In Case of Emergency Call: CHEMTREC - 800-424-9300 or 703-527-3887 (24 Hours/Day, 7 Days/Week)

2. HAZARDS IDENTIFICATION

OSHA Hazards: No known OSHA hazards.

Target Organs: None

Signal Word: Warning

Pictograms:

GHS Classification:

Skin irritation	Category 3
Eye irritation	Category 2B

GHS Label Elements, including precautionary statements:

Hazard Statements:

H316	Causes mild skin irritation.
H320	Causes eye irritation.

Precautionary Statements:

P305+P351+P338	IF IN EYES: Rinse cautiously with water for several minutes. Remove contact lenses, if present and easy to do. Continue rinsing.
----------------	--

Potential Health Effects

Eyes	Causes eye irritation.
Inhalation	May be harmful if inhaled. Causes respiratory tract irritation.
Skin	May be irritating if absorbed through skin. Causes skin irritation.
Ingestion	May be harmful if swallowed.

NFPA Ratings

Health	1
Flammability	0
Reactivity	0
Specific hazard	Not Available

HMIS Ratings

Health	1
Fire	0
Reactivity	0
Personal	B

3. COMPOSITION/INFORMATION ON INGREDIENTS

Component	Weight %	CAS #	EINECS# / ELINCS#	Formula	Molecular Weight
Sodium Chloride	0.9	7647-14-5	231-598-3	NaCl	58.44 g/mol
Water	Balance	7732-18-5	231-791-2	H ₂ O	18.00 g/mol

4. FIRST-AID MEASURES

Eyes	Rinse with plenty of water for at least 15 minutes and seek medical attention if necessary.
Inhalation	Move casualty to fresh air and keep at rest. If breathing is difficult, give oxygen. If not breathing, give artificial respiration. Get medical attention if necessary.
Skin	Flush with plenty of water for at least 15 minutes while removing contaminated clothing and wash using soap. Get medical attention if necessary.
Ingestion	Do Not Induce Vomiting! Never give anything by mouth to an unconscious person. If conscious, wash out mouth with water. Get medical attention if necessary.

5. FIRE-FIGHTING MEASURES

Suitable (and unsuitable) extinguishing media	Product is not flammable. Use appropriate media for adjacent fire. Cool unopened containers with water.
Special protective equipment and precautions for firefighters	Wear self-contained, approved breathing apparatus and full protective clothing, including eye protection and boots.
Specific hazards arising from the chemical	Emits toxic fumes (sodium oxides, hydrogen chloride gas) under fire conditions. (See also Stability and Reactivity section).

6. ACCIDENTAL RELEASE MEASURES

Personal precautions, protective equipment and emergency procedures	See section 8 for recommendations on the use of personal protective equipment.
Environmental precautions	Prevent spillage from entering drains. Any release to the environment may be subject to federal/national or local reporting requirements.
Methods and materials for containment and cleaning up	Absorb spill with noncombustible absorbent material, then place in a suitable container for disposal. Clean surfaces thoroughly with water to remove residual contamination. Dispose of all waste and cleanup materials in accordance with regulations.

7. HANDLING AND STORAGE**Precautions for safe handling**

See section 8 for recommendations on the use of personal protective equipment. Use with adequate ventilation. Wash thoroughly after using. Keep container closed when not in use. Avoid formation of aerosols.

Conditions for safe storage, including any incompatibilities

Store in cool, dry well ventilated area. Keep away from incompatible materials (see section 10 for incompatibilities).

8. EXPOSURE CONTROLS / PERSONAL PROTECTION

Occupational exposure controls: Contains no substances with occupational exposure limit values.

Personal Protection

Eyes	Wear chemical safety glasses or goggles.
Inhalation	Provide local exhaust, preferably mechanical. If exposure levels are excessive, use an approved respirator.
Skin	Wear nitrile or rubber gloves, apron or lab coat.
Other	Not Available

Other Recommendations

Provide eyewash stations, quick-drench showers and washing facilities accessible to areas of use and handling.

9. PHYSICAL AND CHEMICAL PROPERTIES

Appearance (physical state, color, etc.)	Clear, colorless liquid.
Odor	Not Available
Odor threshold	Not Available
pH	Not Available
Melting point/freezing point	Not Available
Initial boiling point and boiling range	Not Available
Flash point	Not Flammable
Evaporation rate	Not Available
Flammability (solid, gas)	Not Flammable
Upper/lower flammability or explosive limit	Not Explosive
Vapor pressure	Not Available
Vapor density	Not Available
Density	Not Available
Solubility (ies)	Soluble in water.
Partition coefficient: n-octanol/water	Not Available
Auto-ignition temperature	Not Available
Decomposition temperature	Not Available

10. STABILITY AND REACTIVITY

Chemical Stability	Stable
Possibility of Hazardous Reactions	Will not occur.
Conditions to Avoid	Not Available
Incompatible Materials	Strong oxidizing agents.
Hazardous Decomposition Products	Sodium oxides, hydrogen chloride gas.

11. TOXICOLOGICAL INFORMATION

Acute Toxicity

Skin	Not Available
Eyes	Not Available
Respiratory	Not Available
Ingestion	Not Available

Carcinogenicity

IARC	No components of this product present at levels greater than or equal to 0.1% is identified as probable, possible or confirmed human carcinogen by IARC.
ACGIH	No components of this product present at levels greater than or equal to 0.1% is identified as a carcinogen or potential carcinogen by ACGIH.
NTP	No components of this product present at levels greater than or equal to 0.1% is identified as a known or anticipated carcinogen by NTP.
OSHA	No components of this product present at levels greater than or equal to 0.1% is identified as a carcinogen or potential carcinogen by OSHA.

Signs & Symptoms of Exposure

Skin	Irritation, redness.
Eyes	Irritation.
Respiratory	Irritation.
Ingestion	Irritation, thirst.

Chronic Toxicity	Not Available
Teratogenicity	Not Available
Mutagenicity	Not Available
Embryotoxicity	Not Available
Specific Target Organ Toxicity	Not Available
Reproductive Toxicity	Not Available
Respiratory/Skin Sensitization	Not Available

12. ECOLOGICAL INFORMATION

Ecotoxicity

Aquatic Vertebrate	Not Available
Aquatic Invertebrate	Not Available
Terrestrial	Not Available

Persistence and Degradability	Not Available
Bioaccumulative Potential	Not Available
Mobility in Soil	Not Available
PBT and vPvB Assessment	Not Available
Other Adverse Effects	Not Available

13. DISPOSAL CONSIDERATIONS

Waste Residues	Users should review their operations in terms of the applicable federal/national or local regulations and consult with appropriate regulatory agencies if necessary before disposing of waste product container.
Product Containers	Users should review their operations in terms of the applicable federal/national or local regulations and consult with appropriate regulatory agencies if necessary before disposing of waste product container.

The information offered in section 13 is for the product as shipped. Use and/or alterations to the product may significantly change the characteristics of the material and alter the waste classification and proper disposal methods.

14. TRANSPORTATION INFORMATION

US DOT	Not Dangerous Goods
TDG	Not Dangerous Goods
IMDG	Not Dangerous Goods
Marine Pollutant	No
IATA/ICAO	Not Dangerous Goods

15. REGULATORY INFORMATION

TSCA Inventory Status	All ingredients are listed on the TSCA inventory.
DSCL (EEC)	All ingredients are listed on the DSCL inventory.
California Proposition 65	Not Listed
SARA 302	Not Listed
SARA 304	Not Listed
SARA 311	No SARA Hazards
SARA 312	No SARA Hazards
SARA 313	Not Listed
WHMIS Canada	Not Listed

16. OTHER INFORMATION

Revision	Date
Revision 1	07/23/2013

Disclaimer: Columbus Chemical Industries, Inc. ("Columbus") believes that the information herein is factual but is not intended to be all inclusive. The information relates only to the specific material designated and does not relate to its use in combination with other materials or its use as to any particular process. Because safety standards and regulations are subject to change and because Columbus has no continuing control over the material, those handling, storing or using the material should satisfy themselves that they have current information regarding the particular way the material is handled, stored or used and that the same is done in accordance with federal, state and local law. COLUMBUS MAKES NO WARRANTY, EXPRESS OR IMPLIED, INCLUDING (WITHOUT LIMITATION) WARRANTIES WITH RESPECT TO THE COMPLETENESS OR CONTINUING ACCURACY OF THE INFORMATION CONTAINED HEREIN OR WITH RESPECT TO FITNESS FOR ANY PARTICULAR USE.





SAFETY DATA SHEET

Issuing Date January 5, 2015

Revision Date June 12, 2015

Revision Number 1

1. IDENTIFICATION OF THE SUBSTANCE/PREPARATION AND OF THE COMPANY/UNDERTAKING

Product identifier

Product Name Clorox® Regular-Bleach,

Other means of identification

EPA Registration Number 5813-100

Recommended use of the chemical and restrictions on use

Recommended use Household disinfecting, sanitizing, and laundry bleach

Uses advised against No information available

Details of the supplier of the safety data sheet

Supplier Address
The Clorox Company
1221 Broadway
Oakland, CA 94612

Phone: 1-510-271-7000

Emergency telephone number


Emergency Phone Numbers For Medical Emergencies, call: 1-800-446-1014
For Transportation Emergencies, call Chemtrec: 1-800-424-9300

2. HAZARDS IDENTIFICATION**Classification**

This chemical is considered hazardous by the 2012 OSHA Hazard Communication Standard (29 CFR 1910.1200).

Skin corrosion/irritation	Category 1
Serious eye damage/eye irritation	Category 1

GHS Label elements, including precautionary statements**Emergency Overview**

Signal word	Danger		
Hazard Statements	Causes severe skin burns and eye damage Causes serious eye damage		
			
Appearance	Clear, pale yellow	Physical State	Thin liquid
		Odor	Bleach

Precautionary Statements - Prevention

Wash face, hands and any exposed skin thoroughly after handling.
Wear protective gloves, protective clothing, face protection, and eye protection such as safety glasses.

Precautionary Statements - Response

Immediately call a poison center or doctor.
If swallowed: Rinse mouth. Do NOT induce vomiting.
If on skin (or hair): Take off immediately all contaminated clothing. Rinse skin with water.
Wash contaminated clothing before reuse.
If inhaled: Remove person to fresh air and keep comfortable for breathing.
Specific treatment (see supplemental first aid instructions on this label).
If in eyes: Rinse cautiously with water for several minutes. Remove contact lenses, if present and easy to do. Continue rinsing.

Precautionary Statements - Storage

Store locked up.

Precautionary Statements - Disposal

Dispose of contents in accordance with all applicable federal, state, and local regulations.

Hazards not otherwise classified (HNOC)

Although not expected, heart conditions or chronic respiratory problems such as asthma, chronic bronchitis, or obstructive lung disease may be aggravated by exposure to high concentrations of vapor or mist.

Product contains a strong oxidizer. Always flush drains before and after use.

Unknown Toxicity

Not applicable.

Other information

Very toxic to aquatic life with long lasting effects.

Interactions with Other Chemicals

Reacts with other household chemicals such as toilet bowl cleaners, rust removers, acids, or products containing ammonia to produce hazardous irritating gases, such as chlorine and other chlorinated compounds.

3. COMPOSITION/INFORMATION ON INGREDIENTS

Chemical Name	CAS-No	Weight %	Trade Secret
Sodium hypochlorite	7681-52-9	5 - 10	*

* The exact percentage (concentration) of composition has been withheld as a trade secret.

4. FIRST AID MEASURES**First aid measures****General Advice**

Call a poison control center or doctor immediately for treatment advice. Show this safety data sheet to the doctor in attendance.

Eye Contact

Hold eye open and rinse slowly and gently with water for 15 - 20 minutes. Remove contact lenses, if present, after the first 5 minutes, then continue rinsing eye. Call a poison control center or doctor for treatment advice.

Skin Contact

Take off contaminated clothing. Rinse skin immediately with plenty of water for 15-20 minutes. Call a poison control center or doctor for treatment advice.

Inhalation

Move to fresh air. If breathing is affected, call a doctor.

Ingestion

Have person sip a glassful of water if able to swallow. Do not induce vomiting unless told to do so by a poison control center or doctor. Do not give anything by mouth to an unconscious person. Call a poison control center or doctor immediately for treatment advice.

Protection of First-aiders

Avoid contact with skin, eyes, and clothing. Use personal protective equipment as required. Wear personal protective clothing (see section 8).

Most important symptoms and effects, both acute and delayed**Most Important Symptoms and Effects**

Burning of eyes and skin.

Indication of any immediate medical attention and special treatment needed**Notes to Physician**

Treat symptomatically. Probable mucosal damage may contraindicate the use of gastric lavage.

5. FIRE-FIGHTING MEASURES

Suitable Extinguishing Media

Use extinguishing measures that are appropriate to local circumstances and the surrounding environment.

Unsuitable Extinguishing Media

CAUTION: Use of water spray when fighting fire may be inefficient.

Specific Hazards Arising from the Chemical

This product causes burns to eyes, skin, and mucous membranes. Thermal decomposition can release sodium chlorate and irritating gases and vapors.

Explosion Data

Sensitivity to Mechanical Impact None.

Sensitivity to Static Discharge None.

Protective equipment and precautions for firefighters

As in any fire, wear self-contained breathing apparatus pressure-demand, MSHA/NIOSH (approved or equivalent) and full protective gear.

6. ACCIDENTAL RELEASE MEASURES

Personal precautions, protective equipment and emergency procedures

Personal Precautions

Avoid contact with eyes, skin, and clothing. Ensure adequate ventilation. Use personal protective equipment as required. For spills of multiple products, responders should evaluate the MSDSs of the products for incompatibility with sodium hypochlorite. Breathing protection should be worn in enclosed and/or poorly-ventilated areas until hazard assessment is complete.

Other Information

Refer to protective measures listed in Sections 7 and 8.

Environmental precautions

Environmental Precautions

This product is toxic to fish, aquatic invertebrates, oysters, and shrimp. Do not allow product to enter storm drains, lakes, or streams. See Section 12 for ecological information.

Methods and material for containment and cleaning up

Methods for Containment

Prevent further leakage or spillage if safe to do so.

Methods for Cleaning Up

Absorb and containerize. Wash residual down to sanitary sewer. Contact the sanitary treatment facility in advance to assure ability to process washed-down material.

7. HANDLING AND STORAGE

Precautions for safe handling

Handling Handle in accordance with good industrial hygiene and safety practice. Avoid contact with skin, eyes, and clothing. Do not eat, drink, or smoke when using this product.

Conditions for safe storage, including any incompatibilities

Storage Store away from children. Reclose cap tightly after each use. Store this product upright in a cool, dry area, away from direct sunlight and heat to avoid deterioration. Do not contaminate food or feed by storage of this product.

Incompatible Products Toilet bowl cleaners, rust removers, acids, and products containing ammonia.

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

Control parameters

Exposure Guidelines

Chemical Name	ACGIH TLV	OSHA PEL	NIOSH IDLH
Sodium hypochlorite 7681-52-9	None	None	None

ACGIH TLV: American Conference of Governmental Industrial Hygienists - Threshold Limit Value. OSHA PEL: Occupational Safety and Health Administration - Permissible Exposure Limits. NIOSH IDLH: Immediately Dangerous to Life or Health.

Appropriate engineering controls

Engineering Measures Showers
Eyewash stations
Ventilation systems

Individual protection measures, such as personal protective equipment

Eye/Face Protection If splashes are likely to occur: Wear safety glasses with side shields (or goggles) or face shield.

Skin and Body Protection Wear rubber or neoprene gloves and protective clothing such as long-sleeved shirt.

Respiratory Protection If irritation is experienced, NIOSH/MSHA approved respiratory protection should be worn. Positive-pressure supplied air respirators may be required for high airborne contaminant concentrations. Respiratory protection must be provided in accordance with current local regulations.

Hygiene Measures Handle in accordance with good industrial hygiene and safety practice. Wash hands after direct contact. Do not wear product-contaminated clothing for prolonged periods. Remove and wash contaminated clothing before re-use. Do not eat, drink, or smoke when using this product.

9. PHYSICAL AND CHEMICAL PROPERTIES**Physical and Chemical Properties**

Physical State	Thin liquid	Odor	Bleach
Appearance	Clear	Odor Threshold	No information available
Color	Pale yellow		

<u>Property</u>	<u>Values</u>	<u>Remarks/ Method</u>
pH	~12	None known
Melting/freezing point	No data available	None known
Boiling point / boiling range	No data available	None known
Flash Point	Not flammable	None known
Evaporation rate	No data available	None known
Flammability (solid, gas)	No data available	None known
Flammability Limits in Air		
Upper flammability limit	No data available	None known
Lower flammability limit	No data available	None known
Vapor pressure	No data available	None known
Vapor density	No data available	None known
Specific Gravity	~1.1	None known
Water Solubility	Soluble	None known
Solubility in other solvents	No data available	None known
Partition coefficient: n-octanol/water	No data available	None known
Autoignition temperature	No data available	None known
Decomposition temperature	No data available	None known
Kinematic viscosity	No data available	None known
Dynamic viscosity	No data available	None known
Explosive Properties	Not explosive	
Oxidizing Properties	No data available	

Other Information

Softening Point	No data available
VOC Content (%)	No data available
Particle Size	No data available
Particle Size Distribution	No data available

10. STABILITY AND REACTIVITY**Reactivity**

Reacts with other household chemicals such as toilet bowl cleaners, rust removers, acids, or products containing ammonia to produce hazardous irritating gases, such as chlorine and other chlorinated compounds.

Chemical stability

Stable under recommended storage conditions.

Possibility of Hazardous Reactions

None under normal processing.

Conditions to avoid

None known based on information supplied.

Incompatible materials

Toilet bowl cleaners, rust removers, acids, and products containing ammonia.

Hazardous Decomposition Products

None known based on information supplied.

11. TOXICOLOGICAL INFORMATION**Information on likely routes of exposure****Product Information**

Inhalation	Exposure to vapor or mist may irritate respiratory tract and cause coughing. Inhalation of high concentrations may cause pulmonary edema.
Eye Contact	Corrosive. May cause severe damage to eyes.
Skin Contact	May cause severe irritation to skin. Prolonged contact may cause burns to skin.
Ingestion	Ingestion may cause burns to gastrointestinal tract and respiratory tract, nausea, vomiting, and diarrhea.

Component Information

Chemical Name	LD50 Oral	LD50 Dermal	LC50 Inhalation
Sodium hypochlorite 7681-52-9	8200 mg/kg (Rat)	>10000 mg/kg (Rabbit)	-

Information on toxicological effects

Symptoms	May cause redness and tearing of the eyes. May cause burns to eyes. May cause redness or burns to skin. Inhalation may cause coughing.
-----------------	--

Delayed and immediate effects as well as chronic effects from short and long-term exposure

Sensitization	No information available.
----------------------	---------------------------

Mutagenic Effects	No information available.
--------------------------	---------------------------

Carcinogenicity	The table below indicates whether each agency has listed any ingredient as a carcinogen.
------------------------	--

Chemical Name	ACGIH	IARC	NTP	OSHA
Sodium hypochlorite 7681-52-9	-	Group 3	-	-

*IARC (International Agency for Research on Cancer)
Group 3 - Not Classifiable as to Carcinogenicity in Humans*

Reproductive Toxicity	No information available.
------------------------------	---------------------------

STOT - single exposure	No information available.
-------------------------------	---------------------------

STOT - repeated exposure	No information available.
Chronic Toxicity	Carcinogenic potential is unknown.
Target Organ Effects	Respiratory system, eyes, skin, gastrointestinal tract (GI).

Aspiration Hazard	No information available.
--------------------------	---------------------------

Numerical measures of toxicity - Product Information

The following values are calculated based on chapter 3.1 of the GHS document

ATEmix (oral)
54 g/kg
ATEmix (inhalation-dust/mist)
58 mg/L

12. ECOLOGICAL INFORMATION**Ecotoxicity**

Very toxic to aquatic life with long lasting effects.

This product is toxic to fish, aquatic invertebrates, oysters, and shrimp. Do not allow product to enter storm drains, lakes, or streams.

Persistence and Degradability

No information available.

Bioaccumulation

No information available.

Other adverse effects

No information available.

13. DISPOSAL CONSIDERATIONS**Disposal methods**

Dispose of in accordance with all applicable federal, state, and local regulations. Do not contaminate food or feed by disposal of this product.

Contaminated Packaging

Do not reuse empty containers. Dispose of in accordance with all applicable federal, state, and local regulations.

14. TRANSPORT INFORMATION

<u>DOT</u>	Not restricted.
<u>TDG</u>	Not restricted for road or rail.
<u>ICAO</u>	Not restricted, as per Special Provision A197, Environmentally Hazardous Substance exception.
<u>IATA</u>	Not restricted, as per Special Provision A197, Environmentally Hazardous Substance exception.
<u>IMDG/IMO</u>	Not restricted, as per IMDG Code 2.10.2.7, Marine Pollutant exception.

15. REGULATORY INFORMATION

Chemical Inventories

TSCA All components of this product are either on the TSCA 8(b) Inventory or otherwise exempt from listing.

DSL/NDSL All components are on the DSL or NDSL.

TSCA - United States Toxic Substances Control Act Section 8(b) Inventory

DSL/NDSL - Canadian Domestic Substances List/Non-Domestic Substances List

U.S. Federal Regulations

SARA 313

Section 313 of Title III of the Superfund Amendments and Reauthorization Act of 1986 (SARA). This product does not contain any chemicals which are subject to the reporting requirements of the Act and Title 40 of the Code of Federal Regulations, Part 372

SARA 311/312 Hazard Categories

Acute Health Hazard	Yes
Chronic Health Hazard	No
Fire Hazard	No
Sudden Release of Pressure Hazard	No
Reactive Hazard	No

Clean Water Act

This product contains the following substances which are regulated pollutants pursuant to the Clean Water Act (40 CFR 122.21 and 40 CFR 122.42)

Chemical Name	CWA - Reportable Quantities	CWA - Toxic Pollutants	CWA - Priority Pollutants	CWA - Hazardous Substances
Sodium hypochlorite 7681-52-9	100 lb			X

CERCLA

This material, as supplied, contains one or more substances regulated as a hazardous substance under the Comprehensive Environmental Response Compensation and Liability Act (CERCLA) (40 CFR 302)

Chemical Name	Hazardous Substances RQs	Extremely Hazardous Substances RQs	RQ
Sodium hypochlorite 7681-52-9	100 lb	-	RQ 100 lb final RQ RQ 45.4 kg final RQ

EPA Statement

This chemical is a pesticide product registered by the Environmental Protection Agency and is subject to certain labeling requirements under federal pesticide law. These requirements differ from the classification criteria and hazard information required for safety data sheets and for workplace labels of non-pesticide chemicals. Following is the hazard information as required on the pesticide label:

DANGER: CORROSIVE. Causes irreversible eye damage and skin burns. Harmful if swallowed. Do not get in eyes, on skin, or on clothing. Wear protective eyewear and rubber gloves when handling this product. Wash thoroughly with soap and water after handling and before eating, drinking, chewing gum, using tobacco, or using the restroom. Avoid breathing vapors and use only in a well-ventilated area.

US State Regulations**California Proposition 65**

This product does not contain any Proposition 65 chemicals.

U.S. State Right-to-Know Regulations

Chemical Name	New Jersey	Massachusetts	Pennsylvania	Rhode Island	Illinois
Sodium hypochlorite 7681-52-9	X	X	X	X	
Sodium chlorate 7775-09-9	X	X	X		

International Regulations**Canada****WHMIS Hazard Class**

E - Corrosive material

**16. OTHER INFORMATION**

NFPA Health Hazard 3 Flammability 0 Instability 0 Physical and Chemical Hazards -

HMIS Health Hazard 3 Flammability 0 Physical Hazard 0 Personal Protection B

Prepared By

Product Stewardship
23 British American Blvd.
Latham, NY 12110
1-800-572-6501

Revision Date

June 12, 2015

Revision Note

Revision Section 14.

Reference

1096036/164964.159

General Disclaimer

The information provided in this Safety Data Sheet is correct to the best of our knowledge, information and belief at the date of its publication. The information given is designed only as a guidance for safe handling, use, processing, storage, transportation, disposal, and release and is not to be considered a warranty or quality specification. The information relates only to the specific material designated and may not be valid for such material used in combination with any other materials or in any process, unless specified in the text.

End of Safety Data Sheet

Incident Response Job Aid

Exposure incidents in the laboratory can occur at any time. Knowing and practicing the proper response and reporting procedures for incidents involving blood and other potentially infectious materials (OPIM) is important. These procedures are described below.

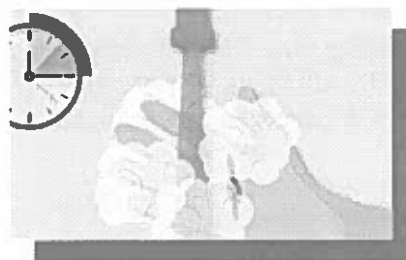
Exposed Worker – Immediate Exposure Incident Response

If someone is exposed to blood or OPIM, the **employee** should immediately:

1. Notify co-workers in the laboratory about the exposure so they can assist, if possible.
2. Remove any contaminated PPE before proceeding to the exposure-specific responses below.

For the exposure listed, the exposed worker should:

3. Needlestick and Cut Exposures
Wash needlesticks and cuts with soap and water for **at least 15 minutes**.



4. Splash Exposure
Flush splashes to the nose, mouth, or skin with water for **at least 15 minutes**.



5. Eye Exposure
Irrigate eyes with clean water, saline, or sterile wash for **at least 15 minutes**.



6. All Exposures
Promptly **report** all exposures to the laboratory supervisor to ensure that appropriate follow-up care is received.
 - The incident should be documented and used to update the laboratory risk assessments to design corrective and preventative actions to avoid future incidents.





Refer to the laboratory standard operating procedure to determine if any additional steps must be taken following a blood or OPIM exposure.

Employer of Exposed Worker – Postexposure Evaluation

Following worker exposure and reporting, the **employer** must:

1. Ensure an immediate, confidential medical evaluation and follow-up assessment is available for the worker. This evaluation must be:
 - At no charge to the worker
 - At a time and place that is convenient for the worker
 - Performed by or under the supervision of a licensed physician or other licensed healthcare professional
2. Offer the exposed worker postexposure medication for HBV, HCV, and HIV, according to the healthcare provider's instructions.
3. Offer a postexposure follow-up that includes counseling the worker about their infection status and the possible implications of the exposure.
 - Counseling should address test results and interpretations, along with information on how to protect personal contacts.
4. Perform a follow-up that includes an evaluation of reported illnesses related to exposure.

References:

Bloodborne Pathogen Exposure. National Institute for Occupational Safety and Health, Centers for Disease Control and Prevention; 2007-157. Updated June 6, 2014. Accessed February 16, 2024.

<https://www.cdc.gov/niosh/docs/2007-157/default.html>

OSHA Fact Sheet: OSHA's Bloodborne Pathogen Exposure Incidents. Occupational Safety and Health Administration, U.S. Dept of Labor. January 2011. Accessed February 16, 2024.

<https://www.osha.gov/sites/default/files/publications/bbfact04.pdf>

Medical Terminology for the Medical Laboratory – Objectives, Lesson Plan and Exam Questions

Learning Objectives

1. Define and interpret medical terms used in the clinical laboratory.
2. Apply knowledge of prefixes, roots, and suffixes to determine meaning of terms.
3. Associate terminology with its corresponding body system, test type, or specimen source.
4. Construct and deconstruct common medical terms used in laboratory SOPs and reports.

Discussion / Mini-Lecture / Flashcard Activity (90 minutes)

Introduction:

- Explain that most medical terms are built from prefix + root + suffix combinations.
- Discuss why correct terminology is essential in healthcare (documentation accuracy, patient safety, and interdepartmental communication).

Examples:

- *Cardiomegaly* → *cardi-* (heart) + *-megaly* (enlargement) → “enlargement of the heart.”
- *Nephrectomy* → *neph-* (kidney) + *-ectomy* (surgical removal) → “surgical removal of a kidney.”

Concept Reinforcement:

- Discuss how prefixes modify location, number, or condition (e.g., *hyper-* = excessive, *hypo-* = below).
- Link each to real lab or clinical examples (e.g., *hyperglycemia*, *hypokalemia*).

Group Activity Prompt:

- “How would you define *polycythemia* or *hypoglycemia* based on what we’ve covered?”
- Encourage students to reason it out before checking definitions.

Materials Needed:

- Printed or digital versions of the five provided term lists
- Index cards

Hagerstown Community College – Medical Laboratory Technology

- Markers/Colored pencils

Instructions:

- Each student creates flashcards as we move through discussion
 - Front: Word part (e.g., *hepat-* or *-megaly*)
 - Back: Meaning (e.g., *liver, enlargement*)
- In small groups, students shuffle and build terms by combining different cards.
- Teams present the term, its meaning, and one potential clinical context (e.g., test, organ system, or condition).

Extension Activity:

- Students exchange decks with another group and attempt to interpret their peers' terms.

Hagerstown Community College – Medical Laboratory Technology

Quiz

1. The prefix poly- means:

- a. small
- b. many or excessive
- c. half
- d. single

2. The combining form hepat/o refers to the:

- a. blood
- b. heart
- c. liver
- d. stomach

3. A phlebotomist performs which of the following procedures?

- a. Removal of cerebrospinal fluid
- b. Surgical fixation of a bone
- c. Collection of blood through a vein
- d. Measurement of lung volume

4. The suffix -emia refers to a condition of the:

- a. urine
- b. blood
- c. skin
- d. bone

5. The prefix brady- means:

- a. rapid
- b. slow
- c. above
- d. below

6. Cytology is the study of:

- a. cells
- b. tissue
- c. bacteria
- d. muscles

7. Nephritis is inflammation of the:

- a. liver
- b. kidney

Hagerstown Community College – Medical Laboratory Technology

- c. bladder
- d. spleen

8. The root hemat- or hem- means:

- a. air
- b. urine
- c. blood
- d. water

9. The suffix -lysis means:

- a. breakdown or destruction
- b. enlargement
- c. incision
- d. fixation

10. Microbiology is the study of:

- a. large organisms
- b. small living things
- c. the liver
- d. metabolism

11. The prefix hypo- means:

- a. excessive
- b. under or below
- c. over
- d. surrounding

12. The root leuk- refers to:

- a. blood
- b. red
- c. white
- d. tissue

13. Glycemia refers to the presence of ____ in the blood:

- a. sodium
- b. glucose
- c. protein
- d. oxygen

14. Anemia literally means:

- a. without blood

Hagerstown Community College – Medical Laboratory Technology

- b. increased blood
- c. abnormal cells
- d. excessive bleeding

15. The term osteomyelitis includes two word roots: oste/o (bone) and myel/o (_____).

- a. marrow or spinal cord
- b. muscle
- c. joint
- d. skin

16. The suffix -rrhea means:

- a. discharge or flow
- b. inflammation
- c. incision
- d. suture

17. The prefix inter- in intercostal means:

- a. between
- b. under
- c. around
- d. inside

18. The root dermat- refers to:

- a. bone
- b. nerve
- c. skin
- d. blood vessel

19. The suffix -gram means:

- a. picture or record
- b. surgical repair
- c. inflammation
- d. small

20. Thrombosis refers to a condition involving a:

- a. blood clot
- b. nerve
- c. vein
- d. bone

Hagerstown Community College – Medical Laboratory Technology

Instructor Key MC Bank

1. b (Cognitive Objectives 1–4)
2. c (Cognitive Objectives 1–4)
3. c (Cognitive Objectives 1–4)
4. b (Cognitive Objectives 1–4)
5. b (Cognitive Objectives 1–4)
6. a (Cognitive Objectives 1–4)
7. b (Cognitive Objectives 1–4)
8. c (Cognitive Objectives 1–4)
9. a (Cognitive Objectives 1–4)
10. b (Cognitive Objectives 1–4)
11. b (Cognitive Objectives 1–4)
12. c (Cognitive Objectives 1–4)
13. b (Cognitive Objectives 1–4)
14. a (Cognitive Objectives 1–4)
15. a (Cognitive Objectives 1–4)
16. a (Cognitive Objectives 1–4)
17. a (Cognitive Objectives 1–4)
18. c (Cognitive Objectives 1–4)
19. a (Cognitive Objectives 1–4)
20. a (Cognitive Objectives 1–4)

Matching Section: Match the term part with its meaning.

Matching Section: Match the term part with its meaning.

Matching Bank 1

Term Part

Meaning

1. **neph-**

a. Kidney

2. **-centesis**

b. Surgical puncture to remove fluid

3. **neur-**

c. Nerve

4. **-scope**

d. Instrument for visual examination

5. **leuk-**

e. White

Matching Bank 2

1. **intra-**

a. Within

2. **hem-**

b. Blood

3. **sub-**

c. Below, under

4. **poly-**

d. Many

5. **trans-**

e. Across, through

Matching Bank 3

1. **glyc-**

a. Sugar, glucose

2. **peri-**

b. Around

3. **epi-**

c. Upon, above

4. **thromb-**

d. Clot

5. **cardi-**

e. Heart

Matching Bank 4

1. **hemi-**

a. Half

2. **-gram**

b. A written record or image

3. **micro-**

c. Small

4. **erythr-**

d. Red

Hagerstown Community College – Medical Laboratory Technology

5. -plasty

e. Surgical reconstruction

Matching Bank 5

1. mono-

a. One

2. derm-

b. Skin

3. macro-

c. Large

4. hepat-

d. Liver

5. -otomy

e. Surgical incision

Matching Bank 6

21. -uria

a. Within

22. intra-

b. In the urine

23. epi-

c. Above or on

24. -meter

d. Instrument for measuring

25. trans-

e. Across or through

Instructions: Indicate whether each statement is True (T) or False (F).

1. T/F ___ The prefix auto- means "self."

2. T/F ___ The root cyt- refers to "tissue."

3. T/F ___ The combining form bio- means "life."

4. T/F ___ The suffix -cyte means "cell."

5. T/F ___ The prefix andr- refers to female characteristics.

6. T/F ___ The prefix poly- means "many or excessive."

7. T/F ___ Brady- means "fast."

8. T/F ___ Micro- refers to something very small.

9. T/F ___ Tachy- means "slow."

10. T/F ___ Mono- indicates "one."

Hagerstown Community College – Medical Laboratory Technology

11. T/F ___ Inter- means "between."
12. T/F ___ Intra- means "within."
13. T/F ___ Retro- means "backward or behind."
14. T/F ___ Trans- means "across or through."
15. T/F ___ Peri- means "around."
16. T/F ___ -ectomy refers to surgical removal.
17. T/F ___ -otomy means to repair or reconstruct.
18. T/F ___ -scope refers to an instrument for viewing.
19. T/F ___ -centesis means a surgical puncture to remove fluid.
20. T/F ___ -plasty means surgical fixation of a joint.
21. T/F ___ Cardi- refers to the brain.
22. T/F ___ Nephro- relates to the kidney.
23. T/F ___ Hepat- refers to the liver.
24. T/F ___ Osteo- refers to bone.
25. T/F ___ Derm- relates to the skin.
26. T/F ___ Hypoglycemia means "low blood sugar."
27. T/F ___ Leukopenia means "too few white blood cells."
28. T/F ___ Thrombocytosis refers to an increased platelet count.
29. T/F ___ Polyuria refers to decreased urine output.
30. T/F ___ Hematology is the study of blood and its components.

Instructor Key T/F Bank

1. True

2. False (cyt- = cell)

3. True

4. True

5. False (andr- = male)

Hagerstown Community College – Medical Laboratory Technology

6. True
7. False (brady- = slow)
8. True
9. False (tachy- = fast)
10. True
11. True
12. True
13. True
14. True
15. True
16. True
17. False (-otomy = incision)
18. True
19. True
20. False (-plasty = reconstruction)
21. False (cardi- = heart)
22. True
23. True
24. True
25. True
26. False (hyperglycemia = high blood sugar)
27. True
28. True
29. False (polyuria = excessive urination)
30. True

Good and Bad

Part	Definition
-alge-, -algesi	pain
a-, an-	without; lacking
anti-	against
contra-	against
dis-	separation, taking apart
-dynia	pain, swelling
dys-	difficult, abnormal
-eal, -ial	pertaining to
-ectasis	expansion or dilation
-emesis	vomiting
-emia	blood condition
-esis	state or condition
eu-	good, well
-ia	condition
-iasis	condition, formation of
-ism	condition
-ites, -itis	inflammation
-lysis, -lytic, lyso-, lys-	break down, destruction, dissolving
mal-	bad, abnormal
-malacia	softening
-mania	morbid impulse towards an object/thing
myc-, myco-	fungus
myx-, myxo-	mucus
necr-, necro-	death
normo-	normal
-odyn	pain
-oma	tumor
-oid	resembling
orth-, ortho-	straight, normal, correct
-osis	condition, usually abnormal
-pathy, patho-, path-	disease
-penia	deficiency, lack of
-phagia, phagy	eating, swallowing
-phasia	speech
-plasia, -plastic	growth
-plegia	paralysis
-pnea	breathing
-poiesis	production
-praxia	movement
pro-	favoring, supporting

Before

pseudo-	false
pro- Post	favoring, supporting After
-ptosis	falling, drooping
pyo-	pus
pyro-	fever
onco-	tumor, bulk, volume
-rrhage, -rrhagic	bleeding
-rrhea	flow or discharge
sarco-	muscular, fleshlike
schisto-	split, cleft, division
schiz-, schizo	split, cleft
sclera-, sclero-	hardness
-sclerosis	hardening
-sis	condition
-spasm	muscle condition
spasmo-	spasm
-stasis	level, unchanging
sten-, steno-	narrowed, blocked
-taxis	movement
-trophy	growth

2014

Procedures, Diagnosis and Surgery

Parts	Definition
-centesis	surgical puncture to remove fluid
-desis	surgical binding
-ectomy	cut out, removal
-gram, -graph, -graphy	recording, written
-meter	device used for measuring
-metry	measurement of
-opsy	visual examination
-ostomy	opening
-otomy	Incision
-pexy	surgical fixation
-plasty	surgical reconstruction
radio-	radiation, radius
-rrhaphy	suture
-scope, -scopy	examine, for examining
-stomy	surgical opening
-tomy	cutting; incision
-tripsy	crushing

Body Parts and Disorders

Part	Definition
acous-, acouso-	hearing
aden-, adeno-	gland
adip-, adipo-	fat
adren-, adreno-	gland
angi-, angio-	blood vessel
ateri-, arterio-	artery
arthr-, arthro-	joint
blephar-	eyelid
bronch-, bronchi-	bronchus (large airway that leads from the trachea (windpipe) to a lung)
bucc-, bucco-	cheek
burs-, burso-	bursa (a small, fluid-filled sac that acts as a cushion between a bone and other moving parts)
carcin-, carcino-	cancer
cardi-, cardio-	heart
cephal-, cephalo-	head
chol-	bile
chondr-	cartilage
Coron-	heart
cost-	rib
crani-, cranio-	brain
cutane	skin
cyst-, cysti-, cysto-	bladder or sac
dactyl-, dactylo-	digit (finger or toe)
derm-, dermato-	skin
duodeno-	duodenum (the first part of your small intestine, right after your stomach)
-esthesio	sensation
gloss-, gloss-	tongue
gastr-	stomach
gnath-, gnatho-	jaw
grav-	heavy
hem-, hema-, hemat-	blood
hemato-, hemo-	blood
hepat-, hepatic-, hepato-	liver
hydr-, hidro-	sweat
hist-, histio-, histo-	tissue
hyster-, hystero-	uterus
ileo-	ileum (the lower part of the small intestine)
irid-, irido-	iris
ischi-, ischio-	ischium (the lower and back part of the hip bone)

-ium	structure or tissue
kerat-, kerato-	cornea (eye or skin)
lacrim-, lacrimo-	tear (from your eyes)
lact-, lakt-, lacto-	milk
laryng-, laryngo-	larynx (voice box)
lingu-, linguo-	tongue
lip-, lipo-	fat
lith-, litho-	stone
lymph-, lympho-	lymph
mamm, mast-, masto-	breast
mening-, meningo-	meninges (the membranes that surround the brain and spinal cord)
muscul-, musclo-	muscle
my-, myo-	muscle
myel-, myelo-	spinal cord OR bone marrow
myring-, myringo-	eardrum
neph-, nephro-	kidney
neur-, neur-, neuron-	nerve
oculo-	eye
odont-, odonto-	tooth
onych-, onycho-	fingernail, toenail
oo-	egg, ovary
oophor-, oophoro-	ovary
op-, opt-	vision
ophthalm-, ophthalmo-	eye
orchid-, orchido-, orchio-	testis
ossi-	bone
osseo-	bony
ost-, oste-, osteo-	bone
ot-, oto-	ear
ovari-, ovario-, ovi-, ovo-	ovary
phalang-	phalanx (any bone in the fingers or toes)
pharyng-, pharyngo-	pharynx, throat
phleb-, phlebo-	vein
phob-, phobia	fear
phren-, phreni-, phrenico-, phreno-	diaphragm
pleur-, pleura-, pleuro-	rib, pleura (membrane that wraps around the outside of your lungs and lines the inside of your chest cavity)
pneum-, pneuma-	air, lung
pneumat-, pneumato-	
pod-, podo-	foot
prostat-	prostate
psych-, psyche-, psycho-	mind

Positions and Directions

Part	Definition
ab-, abs- <i>Ad-</i>	away from
ambi-	both sides
ante-	before, forward
circum-	around
cycl-	circle, cycle
dextr-, dextro-	right side
de-	away from, ending
dia-	across, through
ect-, ecto-, exo-	outer; outside
en-	inside
end-, endo-, ent- enter-, entero-,	within; inner
epi-	Upon, outside of
ex-, extra-	beyond
infra-	beneath; below
inter-	between
intra-	within
meso-	middle
meta-	beyond, change
para-	alongside, abnormal
per-	through
peri-	around
post-	behind, after
pre-	before, in front
retro-	backward, behind
sinistr-, sinistro-	left, left side
sub-	under
super-	above
supra-	above, upon
sy-, syl-, sym-, syn-, sys-	together
trans-	across, through

10



11

12

13

14

15

16

17

18

19

20

21

22



23

24

25

26

27



proct-, procto-	anus, rectum
pyel-, pyelo-	pelvis
rachi-	spine
rect-, recto-	rectum
ren-, reno-	kidney
retin-	retina (of the eye)
rhin-, rhino-	nose
salping-, salpingo-	tube
sial-, sialo-	saliva, salivary gland
sigmoid-, sigmoido-	sigmoid colon
splanchn-, splanchni-, splanchno-	viscera (internal organ)
sperma-, spermato-, spermo-	sperm
spirat-	breathe
splen-, spleno-	spleen
spondyl-, spondylo-	vertebra
stern-	sternum (breastbone)
stem-, stoma-, stomat-, stomato-	mouth
thel-, thelo-	nipples
thorac-, thoracico-, thoraco-	chest
thromb-, thrombo-	blood clot
thyr-, thyro-	thyroid gland
trache-, tracheo-	trachea (windpipe)
tympan-, tympano-	eardrum
ur-, uro-	urine
uri-, uric-, urico-, -uria	uric acid in the urine
vagin-	vagina
varic-, varico-	duct, blood vessel
vasculo-	blood vessel
ven-, veno-	vein
vertebr-	vertebra, spine
vesic-, vesico-	vesicle (cyst or pouch)

General Words

Part	Definition
-ac	pertaining to
andr-, andro-	male
auto- <i>Auto</i>	self
bio-	life
chem-, chemo-	chemistry
cyt-, cyto-	cell
-blast-, -blasto-, -blastic	bud, germ
-cyte, -cytic	cell
fibr-, fibro-	fiber
gluco-, glycol-	glucose, sugar
gyn-, gyno-, gynec-	female
hetero- <i>hetero-</i>	other, different
hydr-, hydro-	water
idio-	self, one's own
-ity	pertaining to
karyo-	nucleus
neo-	new
-osis	pertaining to
oxy-	sharp, acute, oxygen
pan-, pant-, panto-	all or everywhere
pharmaco-	drug, medicine
re-	again, backward
somat-, somatico-, somato-	body, bodily

Math Review

Order of Operations

When multiple operations are present in an equation to solve, a specific order in which those operations are executed must be applied to calculate the correct number.

A good acronym to remember is PEMDAS to execute the correct order of operations:

P = parentheses

E = exponents

M = multiplication

D = division

A = addition

S = subtraction

If two or more of the same order of operation exist within the same equation, they are prioritized from left to right.

Here are some examples of how equations with multiple operations can be calculated in the correct order:

- $2^2 \times 3 + 4 = 16$
- $(8 - 6) \times 2 = 4$
- $8 - -6 = 14$
- $6 - 10 / 2 = 1$
- $11 + (2 \times 3) - (11 + 6 \div 2) + 15 = 18$
- $2 \times (-7 + 4 \times 2^2) - 3^2 = 9$

Fractions

Simple fractions consist of a top number (numerator) and a bottom number (denominator) separated by a line. A simple fraction is effectively a division calculation that has not been solved. There are instances in laboratory medicine where displaying either a fraction, decimal number, or percentage is advantageous to visualize and/or analyze data. It is important to be

able to inter-convert a simple fraction to a decimal number and then to a percentage and in reverse.

Here are some other examples of how numbers as fractions can be converted into decimals and percentages or decimals and percentages can be converted to fractions:

- $(2/5) = 0.4 = 40\%$
- $(3/20) = 0.15 = 15\%$
- $1\% = 0.01 = (1/100)$
- $60\% = 0.6 = (6/10) = (3/5)$

Exponents

An exponent can be defined as a way of presenting numbers in terms of powers. Specifically, the exponent number determines how many times a specific base number is multiplied by itself.

Whole Number Exponents

Below are examples of how numbers with exponents can be converted to whole numbers. The top image on the right also displays how to work through a problem with an exponent.

- $5^2 = 25$
- $4^4 = 256$
- $10^3 = 1,000$
- $45,131^1 = 45,131$

Negative Exponents

When exponents are expressed as negative, the base number is multiplied by itself the number of times, as denoted by the exponent number. However, that calculated value is used to divide the number one, thereby creating a fraction. Refer to the bottom image.

The primary application uses a base number of ten which provides calculations useful for the metric system of measure (discussed later). Here are some examples of how numbers with negative exponents can be converted:

- $10^{-3} = 0.001$
- $10^{-4} = 0.0001$
- $10^{-5} = 0.00001$

- $10^{-1} = 0.1$

Scientific Notation

Scientific notation is a technique to condense and simplify the writing and viewing of very large or very small numbers. The overall format is presented beginning with a single whole number, followed by all other numbers after the decimal, multiplied by a base of 10 at a specific exponent.

Here are examples of numbers written in scientific notation:

- $5,234 = 5.234 \times 10^3$ (decimal moved to the left 3 spaces)
- $32 = 3.2 \times 10^1$ (decimal moved to the left 1 space)
- $0.0321 = 3.21 \times 10^{-2}$ (decimal moved to the right 2 spaces)
- $876.02 = 8.7602 \times 10^2$ (decimal moved to the left 2 spaces)

Note: The original number and the scientific notation have the same number of significant figures and there is always one number to the left of the decimal point.

The purpose of rounding a number is to adjust the final value to be less precise. This is required when a measured or calculated result produces a number that appears more precise than the measurement can actually provide.

An example of this would be an instrument that may produce a result with 4 digits after the decimal such as 1.004. But if that instrument is only precise to the 2nd decimal place (hundredth place), the last 2 digits of that number are not precise enough to be reported. In this case, the result would be rounded up to the hundredth place and would be reported as 1.00. See the image to identify digit placement and digit place naming.

These rounding rules apply to rounding whole numbers and decimals.

- If the digit being rounded is followed by a 6, 7, 8, or 9, the digit is rounded up.
 - An example is 37 rounded to the nearest tens place would be rounded up to 40.
- If the digit being rounded is followed by a 0, 1, 2, 3, or 4, the digit is rounded down.
 - An example is 342.2 rounded to the nearest ones place would be rounded down to 342.
- If the digit being rounded is followed by a 5, it will either be rounded up or down depending on if it is an even or an odd number. If the digit before the 5 is an odd

number, it will be rounded up. If the digit before the 5 is an even number, it will be rounded down.

- The easiest way to remember this rule is that if you are rounding a number followed by a 5, that number will either become even or stay even.
- An example is 0.2375 rounded to the thousandth place. The thousandth place is where the 7 is located. Since the 7 is followed by a 5, you will round up as the 7 is an odd number. The result is then 0.238.

Here are some other examples:

- 1.23 rounded to the ones place would be 1
- 7,252.4 rounded to the nearest hundreds place would be 7,300
- 6.392 rounded to the nearest hundredth place would be 6.39
- 78,693 rounded to the nearest thousands place would be 79,000
- 0.00389 rounded to the nearest thousandth place would be 0.004
- 634.5 rounded to the ones place would be 634
- 2.485 rounded to the hundredth place would be 2.48
- 1375.11 rounded to the tens place would be 1380

Zeros reported by an analyzer, or as part of a calculation, are a point of concern as they may represent part of the measurement precision or be merely a placeholder to define a number. Significant figure rules help to define whether these zeros are part of the measurement or are simply a placeholder. Once these rules are applied, the entire number of significant figures can be identified and used to determine the final number.

The following set of significant figure rules helps to define which figures are significant, allowing one to count the number of significant figures in the entire number.

1. All nonzero digits are always significant. For example, all the digits in the number 471.9 are significant and there are a total of 4 significant figures.
2. All zeros that are located between nonzero digits are always significant. For example, all of the digits in the number 800,007, including the 4 zeros in between the 8 and the 7. Therefore, the total number of significant figures in this number is 6.
3. Leading zeros that occur to the left of the first nonzero digit are not considered significant. For example, the number 0.0037 has only 2 significant figures because none of the zeros to the

left of the number 3 are considered significant. This is a good example of how zeros sometimes act as placeholders but do not necessarily denote any precision of the measurement.

4. Whole numbers with trailing zeros that occur to the right of the last nonzero digit are significant if the whole number ends in a decimal point. If the whole number does not end in a decimal point, then the trailing zeros are not significant. An example of this is the number "4,500." vs "4,500"; both of the zeros in the number "4,500." are significant with a total of 4 significant figures whereas neither of the zeros in the number "4,500" are significant and the number only has 2 significant figures total. This is another example of how to identify which zeros were truly measured and which are just placeholders.

5. Trailing zeros occurring after a decimal point are considered significant. An example is 34.00, where both zeros are significant, bringing the total number of significant figures to 4.

6. A number can be written in scientific notation to reflect the number of significant figures it should have.

Here is an example of how the number 6,800 can be written in scientific notation with either 2, 3, or 4 significant figures based on the precision of the instrument:

- 6,800 with 2 significant figures would be written as 6.8×10^3
- 6,800 with 3 significant figures would be written as 6.80×10^3
- 6,800 with 4 significant figures would be written as 6.800×10^3

There are instances where laboratory calculations must be applied to two or more measured values with a differing number of significant figures.

The two main rules when determining the number of significant figures in a final calculation are grouped into addition & subtraction and multiplication & division sets.

- When adding or subtracting two or more measured values, the calculated result should have the resulting value that will have the same number of decimal places as the measured value with the *fewest* number of decimal places.
 - This measured value with the fewest number of decimal places is also called the **limiting value**.
 - An example is the addition of 36.948 and 41.02, creating the calculated value of 77.968. However, the limiting value in the original calculation is 41.02 which has 2 places after the decimal, meaning the final calculated result needs to be rounded at the hundredth place (2 places after the decimal) or 77.97.

- Note that the rounding occurs after the addition or subtraction of the original numbers.
- When multiplying or dividing two or more measured values, the calculated result should have the resulting value that will have the same number of significant figures as the value with the *fewest* number of significant figures.
 - An example is the division of 9.75513 and 2.31, creating the calculated value of 4.223. However, the measured value with the fewest number of significant figures is 2.31 with 3 significant figures, meaning the final calculated result needs to be rounded at the hundredth place (to make a calculated value with 3 calculated figures) or 4.22.
 - Note that the rounding occurs after the multiplication or division of the original numbers.
- Order of operations using PEMDAS still applies.

Here are examples of calculations where the number of significant figures in each measured value must be considered to complete the resulting calculation with the correct number of significant figures.

- $38.65 + 20.103 = 58.753$ (calculated value) = 58.75 (rounded value)
- $2,350.75 - 92.3 = 2,258.45$ (calculated value) = 2,258.4 (rounded value)
- $0.1120 \times 130 \times 2,800. = 40,768 = 41,000$
- $5.055 / 0.0044 = 1,148.863636 = 1,100$

Almost all clinical laboratory applications use the metric system to perform systems of measure.

1. Length is measured in meters (m) as the base unit.
2. Mass is measured in grams (g) as the base unit.
3. Volume is measured in liters (L) as the base unit.

Besides temperature, the measures of mass, length, and volume use the same basic structure for increasing or decreasing the measure-based multiples of the number 10. **Table 2** demonstrates this standard structure which uses prefixes to identify what multiple of 10 is being measured.

Table 2. Relationship of Metric System Prefixes.

Prefix	Abbreviation	Relationship to the Basic Unit	Relationship to the Basic Unit in Scientific Notation
mega	M	Basic unit x 1,000,000	Basic unit x 10^6
kilo	k	Basic unit x 1,000	Basic unit x 10^3
deci	d	Basic unit x 1/10	Basic unit x 10^{-1}
centi	c	Basic unit x 1/100	Basic unit x 10^{-2}
milli	m	Basic unit x 1/1,000	Basic unit x 10^{-3}
micro	μ	Basic unit x 1/1,000,000	Basic unit x 10^{-6}
nano	n	Basic unit x 1/1,000,000,000	Basic unit x 10^{-9}
pico	p	Basic unit x 1/1,000,000,000,000	Basic unit x 10^{-12}

Measures of temperature are based on 3 main scales—degrees Fahrenheit, degrees Celsius, and Kelvin. Although the Kelvin scale for temperature is used in many chemistry-based applications, the metric system uses degrees Celsius ($^{\circ}\text{C}$) and is the primary scale for measuring temperature in clinical laboratory applications. The image provides a comparison of the three scales based on the boiling point of water, the freezing point of water, and absolute 0.

METRIC CONVERSION CHART

Length/Capacity/Weight(Mass)



To convert to a smaller unit, multiply by moving the decimal point to the right.



Largest unit $\times 10$ $\times 10$ $\times 10$ $\times 10$ Smallest unit

King	Henry	Died	By	Drinking	Chocolate	Milk
			BASE			
			Meter	Deci	Centi	Milli
			Liter			
			Gram			
kilometer (km)	hectometer (hm)	dekameter (dam)	meter (m)	decimeter (dm)	centimeter (cm)	millimeter (mm)
kiloliter (kL)	hectoliter (hL)	dekaliter (daL)	liter (L)	deciliter (dL)	centiliter (cL)	milliliter (mL)
kilogram (kg)	hectogram (hg)	dekagram (dag)	gram (g)	decigram (dg)	centigram (cg)	milligram (mg)



To convert to a larger unit, divide by moving the decimal point to the left.

Meter: length/distance **Liter:** capacity **Gram:** weight(mass)



Lesson Plan: Understanding Simple Dilutions

Learning Objectives:

1. Define dilution and related terms and relate their importance to the clinical laboratory.
2. Differentiate ratios and proportions.
3. Calculate dilution factors.
4. Perform simple dilution calculations using the formula $C_1V_1 = C_2V_2$.
5. Practice preparing solutions with proper measurement and technique.

Introduction (10 min)

- Engage: Ask students how to make juice from concentrate.
 - “If the can says mix 1 part concentrate with 3 parts water, what does that mean?”
 - “Why don’t we drink the juice straight from the can?”
- Context: Highlight other examples of dilutions (medications, cleaning products, reagent prep in labs).

Ratios vs. Proportions

Ratio

A ratio is a comparison of two quantities or values.

It tells you how much of one thing there is compared to another.

- Format:
 - 3:1
 - 3 to 1
 - 3/1
- Example:

If you mix 1 part juice concentrate with 3 parts water, the ratio (concentrate:water) is 1:3.

This means for every 1 unit of concentrate, there are 3 units of water.
- Key Point:

Ratios don't add up to a total. They're just comparisons.

Proportion

A proportion is an equation that states two ratios are equal.

It's used when you want to express that two relationships are the same.

- Format:
 - $a:b = c:d$

Hagerstown Community College – Medical Laboratory Technology

- $a/b = c/d$
- **Example:**
If the ratio of concentrate to water in small batch is 1:3, and in a larger batch it's 100 mL concentrate to 300 mL water, then these form a proportion:

$$\frac{1}{3} = \frac{100}{300}$$

- **Key Point:**
Proportions can be used to solve for unknowns, like scaling up a recipe or calculating a needed volume in dilutions.
 - Ratio = just a relationship
 - Proportion = a relationship that matches or scales another

Key Concepts (15 min)

- **Definition of Dilution:**
Reducing the concentration of a solution by adding more solvent (usually water).
- **Diluent:**
A substance added to another to reduce its concentration. It is typically a liquid but can also be a gas or solid, depending on context.

A liquid (often sterile water, saline, or buffer) used to dilute patient samples like blood, serum, or urine to achieve the desired concentration for testing or analysis.

Example: Saline is commonly used as a diluent in hematology to prepare blood for cell counting.

Application Example: Orange Juice Concentrate (15 min)

- **Scenario:** You have 100% orange juice concentrate. The instructions recommend a 1:3 dilution ratio (1 part concentrate + 3 parts water).
- **Question 1:** If you want 400 mL of drinkable juice, how much concentrate and how much water are needed?
 - Total parts = $1 + 3 = 4$
 - Concentrate = $\frac{1}{4} \times 400 = 100\text{mL}$
 - Water = $400 - 100 = 300\text{mL}$
- **Practice Problems (independent or group):**
 - If you have 50 mL of concentrate, how much water should you add?
 - $3 \times 50\text{ mL} = 150\text{ mL}$ of water
 - How much total final volume will you get?

Hagerstown Community College – Medical Laboratory Technology

- 50 mL + 150 mL = 200 mL

$$\text{Dilution Factor} = \frac{\text{Sample Volume}}{\text{Total Volume}}$$

Key Concepts (15 min)

What Is a Dilution?

Reducing the concentration of a substance by adding more diluent.

The Dilution Formula

$$\text{Dilution} = \frac{\text{Sample Volume}}{\text{Total Volume}}$$

Where:

- Sample Volume = Amount of patient specimen or “sample”
- Total Volume = Final mixture volume (sample volume + diluent)

Understanding “Parts” or Ratios

- A 1:4 dilution = 1 part concentrate + 3 parts water = 4 total parts
- So,

$$\text{Dilution} = \frac{1}{4}$$

What is a “fold” dilution?

Ex: A 1:4 dilution = 1 part solute, 3 parts solvent → total 4 parts.

Orange Juice (15 min)

Problem:

You want to make 400 mL of juice at a 1:4 dilution (1 part concentrate + 3 parts water).

Solution using the formula:

Answer: 100 mL concentrate + 300 mL water = 400 mL juice

Hands-On Practice (20 min)

Hagerstown Community College – Medical Laboratory Technology

1. Group Prep Task: Each group is assigned a different dilution ratio (e.g. 1:2, 1:5, or 1:9).
2. Students calculate sample and water volumes to make 100 mL of solution using:

$$\text{Sample Volume} = \frac{1}{\text{Total Parts}} \times \text{Final Volume}$$

3. Groups prepare and label their solutions (use food coloring in water if not working with juice).
4. Compare color intensities — more dilute = lighter color.

Formula for Dilutions:

$$C_1V_1 = C_2V_2$$

Where:

- C_1 = initial concentration
- V_1 = initial volume
- C_2 = final concentration
- V_2 = final volume

Handout and Laboratory Exercise (Preparing a 10% Bleach Solution)

Quick Assessment (10 min)

Problem Set: Ratios & Proportions in Dilutions

Part A: Understanding Ratios

1. Define a ratio in your own words.
Give an example of a ratio using two items (e.g., apples to oranges).
2. You mix 2 parts lemon syrup with 5 parts water.
 - What is the ratio of syrup to water?
 - What is the total number of parts in the mixture?
3. A fruit punch recipe calls for 1 part cranberry juice to 4 parts soda water.
 - Write this as a ratio.
 - If the total volume is 500 mL, how much of each ingredient do you need?

Part B: Working with Proportions

Hagerstown Community College – Medical Laboratory Technology

4. The ratio of concentrate to water in a sample is 1:3.
You use 50 mL of concentrate.
 - Set up a proportion to calculate how much water is needed.
 - Solve for the water volume.
5. A lab uses a 1:9 dilution for a liquid reagent (1 part sample, 9 parts diluent).
You want to make 1000 mL of the dilution.
 - Write a proportion relating sample volume to total volume.
 - How much sample and how much diluent are needed?
6. If 100 mL of raspberry syrup is mixed with 400 mL of water,
 - What is the ratio of syrup to total solution?
 - Simplify the ratio.

Part C: Application & Interpretation

7. You're preparing iced tea using a ratio of 1:7 (tea concentrate to water).
You need 2 liters of finished beverage.
 - How many mL of tea concentrate do you use?
 - How many mL of water do you add?
8. You've made juice at a 1:4 dilution (1 part concentrate + 4 parts water).
The resulting drink is 30% concentrate.
 - True or False? Explain your reasoning with a ratio or proportion.
9. A cleaning solution needs to be diluted using a ratio of 1:10 (soap to water).
If only 20 mL of soap is available, how much clean solution can you make?

Challenge Problem (Optional)

10. A student prepares two different batches of grape juice:
 - Batch A: 30 mL concentrate + 90 mL water
 - Batch B: 50 mL concentrate + 150 mL water
 - Are the two batches mixed in the same ratio?
 - Show your work using proportions.

Problem Set: Ratios & Proportions with Patient Samples

Part A: Understanding Ratios in the Lab

Hagerstown Community College – Medical Laboratory Technology

1. Define a ratio in your own words.
Give an example of a ratio using patient serum and saline.
2. A medical technologist prepares a dilution of 1 part patient serum to 9 parts saline for an ELISA test.
 - What is the ratio of serum to saline?
 - How many total parts are in the mixture?
3. A urine sample must be diluted in a 1:4 ratio (1 part urine, 4 parts diluent).
 - If the final volume needs to be 50 mL, how much urine and how much diluent are required?

Part B: Working with Proportions

4. A lab procedure calls for a 1:5 dilution of plasma (1 part sample + 4 parts diluent). You pipette 0.2 mL of patient plasma.
 - Write a proportion to determine how much diluent you need.
 - Solve for the diluent volume.
5. A technologist needs to prepare 1000 μL of a 1:20 dilution of a patient's cerebrospinal fluid (CSF).
 - Write the ratio as a fraction.
 - Calculate how much CSF and how much diluent are needed.
6. A blood sample must be diluted in a 1:3 ratio (blood to buffer) before use in a cell counter.
 - If you use 100 μL of blood, what is the final diluted volume?
 - Write a proportion showing how you know.

Part C: Application in Diagnostics

7. A rapid diagnostic test requires a 1:10 dilution (sample:buffer). A technologist has 35 μL of patient serum.
 - How much total volume of diluted sample can they prepare?
 - How much buffer will they need to add?
8. A tube contains 2 mL of a diluted antibody solution that was prepared using a 1:19 dilution (sample:buffer).
 - What was the original volume of antibody (before dilution)?
 - Show your calculation using ratios or proportions.

Hagerstown Community College – Medical Laboratory Technology

9. A lab manual instructs that for a certain test, any sample with a dilution ratio greater than 1:5 must be rejected and recollected.

A student uses 0.1 mL of whole blood and dilutes it with 0.7 mL saline.

- What is the dilution ratio?
- Will this sample be accepted?

Bonus Challenge

10. Two technologists prepared dilutions for a viral load test:

- Technologist A: 20 μ L sample + 180 μ L diluent
 - Technologist B: 100 μ L sample + 900 μ L diluent
 - Are the dilutions equivalent?
 - Show your work using proportions.
-

Scientific Notation In Class

Cognitive Objectives (L1–L3):

L1: Recognize and convert between standard and scientific notation.

L2: Perform arithmetic operations with numbers in scientific notation.

L3: Apply scientific notation to laboratory contexts and order-of-magnitude reasoning.

Instructions:

Unless otherwise stated, report answers to 3 significant figures. Show work for Sections D–F.

A. Convert to scientific notation (3 significant figures unless noted).

1. 1,250

2. 0.000345

3. 987,000,000

4. 0.00981

5. 60,200

6. 0.0000000702

7. 4,500,000

8. 0.1205

9. 7,001,000

10. 0.004020

11. 0.00000000089

12. 3,904

B. Write in standard (decimal) form.

1. 2.5×10^3

Hagerstown Community College – Medical Laboratory Technology

2. 7.09×10^{-4}

3. 1.02×10^6

4. 9.8×10^{-2}

5. 3.001×10^5

6. 6.0×10^0

7. 4.35×10^{-7}

8. 1.000×10^2

9. 9.99×10^8

10. 7.1×10^{-3}

C. Multiply or divide and express the answer in scientific notation (3 sig figs).

1. $3.4 \times 10^5 \times 2.0 \times 10^3 =$

2. $9.0 \times 10^{-4} \div 3.0 \times 10^2 =$

3. $6.02 \times 10^{23} \div 2.00 \times 10^3 =$

4. $7.5 \times 10^{-6} \times 1.2 \times 10^4 =$

5. $4.0 \times 10^2 \times 4.0 \times 10^2 =$

6. $8.16 \times 10^5 \div 2.72 \times 10^2 =$

7. $5.0 \times 10^{-3} \div 2.5 \times 10^{-6} =$

8. $3.33 \times 10^1 \times 3.33 \times 10^1 =$

D. Add or subtract and give the answer in scientific notation (3 sig figs).

1. $3.2 \times 10^3 + 4.5 \times 10^2 =$

2. $7.00 \times 10^{-4} + 2.50 \times 10^{-3} =$

3. $9.1 \times 10^5 - 3.0 \times 10^4 =$

4. $1.25 \times 10^{-2} - 7.5 \times 10^{-3} =$

Hagerstown Community College – Medical Laboratory Technology

5. $6.0 \times 10^1 + 4.0 \times 10^2 =$

6. $5.01 \times 10^{-6} - 2.00 \times 10^{-6} =$

E. Applied MLT problems (3 sig figs unless context dictates). Show work.

1. A patient's RBC count is 4,500,000 cells/ μ L. Write this in scientific notation (cells/ μ L).
2. A serum sample has 0.000075 mol/L of a substance. Express this in scientific notation (mol/L).
3. A bacterial culture has 3.6×10^8 CFU/mL. After a 1:100 dilution, what is the expected CFU/mL?
4. A reagent concentration is given as 7.5×10^{-3} g/mL. Express this in mg/mL (scientific notation).
5. The hematology analyzer aspirates 2.5×10^{-4} L per sample. How many μ L is this (scientific notation)?
6. Urine sediment contains 2.40×10^3 cells/ μ L. How many cells/mL is this (scientific notation)?
7. A viral load is reported as 7.0×10^5 copies/mL. After a 10-fold increase, what is the new value?
8. A solution contains 1.20×10^{-6} g of solute in 2.00×10^{-3} L. What is the concentration in g/L (scientific notation)?

F. Challenge: Order-of-magnitude reasoning.

1. Which is larger, 5.0×10^7 or 4.9×10^8 ? Circle one and justify in a phrase.
2. Place in ascending order: 2.0×10^{-3} , 2.0×10^{-5} , 2.0×10^{-2} .
3. Estimate $(1.99 \times 10^3 + 2.02 \times 10^3)$ to one significant figure in scientific notation.
4. Without a calculator, approximate $(3 \times 10^4) \div (6 \times 10^2)$ using one significant figure.

Hagerstown Community College – Medical Laboratory Technology

Metric Unit Conversions Classwork

Instructions: Report answers to 3 significant figures unless otherwise stated. Use dimensional analysis (factor-label method).

Cognitive Objectives:

L1 – recognize metric prefixes

L2 – convert between units

L3 – apply conversions to lab contexts.

A. Straight conversions

1. Convert 45 mL to L.
2. Convert 0.00750 L to mL.
3. Convert 3.2×10^5 μ L to mL.
4. Convert 0.000980 L to μ L.
5. Convert 7.05 mL to μ L.
6. Convert 2.40×10^3 nL to μ L.
7. Convert 0.00420 g to mg.
8. Convert 6.50×10^4 mg to g.
9. Convert 0.0750 g to μ g.
10. Convert 3.10×10^6 μ g to g.
11. Convert 0.00250 kg to g.
12. Convert 9.00 ng to μ g.

B. Express the given quantity in the requested unit using scientific notation (3 significant figures)

1. Express 0.065 L in scientific notation (L).
2. Express 250 mL in scientific notation (L).
3. Express 0.000450 g in scientific notation (g).
4. Express 18,500 mg in scientific notation (g).

Hagerstown Community College – Medical Laboratory Technology

5. Express $7.2 \times 10^3 \mu\text{L}$ in scientific notation (L).
6. Express $3.60 \times 10^5 \text{ ng}$ in scientific notation (g).
7. Express 0.00420 L in scientific notation (mL).
8. Express 0.0950 g in scientific notation (mg).
9. Express $6.00 \times 10^{-3} \text{ L}$ in scientific notation (μL).
10. Express $2.40 \times 10^{-4} \text{ g}$ in scientific notation (μg).

C. Applied MLT entries (record in the indicated unit).

1. A reagent calls for 2.50 g of solute. The balance reads in mg. What value should be weighed (mg)?
2. A protocol requires 750 μL of sample. Your pipette is in mL. What volume is this (mL)?
3. You have 0.850 L of buffer but need the volume in mL for the log sheet. Convert to mL.
4. A standard mass is 0.0150 g. Record this as μg .
5. A specimen volume is $3.25 \times 10^4 \text{ nL}$. Record as μL .
6. A sample weighs $6.00 \times 10^5 \mu\text{g}$. Record as g.
7. Convert $1.20 \times 10^{-2} \text{ L}$ to nL.
8. Convert $9.00 \times 10^{-3} \text{ g}$ to ng.

Dilution Factors Classwork

Objectives:

- L1- Define aliquot, dilution, diluent and dilution factor (DF) using correct terminology.
- L-1- State the formula for dilution factor
- L2- Describe how dilution proportionally changes analyte concentration while preserving ratios.
- L3- Calculate DF for given aliquot and total volume with correct significant figures and units.

Report answers to 3 significant figures.

A. Single-step dilution factors

1. 1 mL of sample brought to 10 mL total volume.
2. 0.5 mL of sample brought to 25 mL total volume.
3. 1:9 dilution (parts sample:parts diluent).
4. 2 mL of sample brought to 20 mL total volume.
5. 1:4 dilution (parts sample:parts diluent).
6. 0.2 mL of sample brought to 10 mL total volume.

B. Overall dilution factors for serial dilutions

1. Two-step serial: 1 mL to 10 mL; then 1 mL to 10 mL.
2. Three-step serial: 1:9, then 1:4, then 0.5 mL to 10 mL.
3. Two steps: 2 mL to 20 mL; then 1 mL to 5 mL.

C. Resulting concentration after dilution(s)

1. A stock standard is 100 mg/dL. After a 1:4 dilution, what is the final concentration?
2. A sample is diluted 1:9, then 1 mL to 10 mL. Starting 3.60×10^5 CFU/mL. Final CFU/mL?
3. A control at 12.5 g/L undergoes two 1:4 dilutions. Final concentration?

Laboratory Math Homework

A. Write in the standard (decimal) form.

- | | |
|--------------------------------|---------------------------------|
| 1. 4.20×10^4 _____ | 6. 2.31×10^7 _____ |
| 2. 9.5×10^{-6} _____ | 7. 6.02×10^0 _____ |
| 3. 3.006×10^2 _____ | 8. 8.010×10^{-2} _____ |
| 4. 1.005×10^5 _____ | 9. 9.99×10^{-9} _____ |
| 5. 7.00×10^{-3} _____ | 10. 1.234×10^3 _____ |

B. Convert to scientific notation (3 significant figures).

- | | |
|----------------------|--------------------------|
| 1. 0.000000312 _____ | 7. 0.0000000001205 _____ |
| 2. 45,600 _____ | 8. 6,700,000,000 _____ |
| 3. 0.0815 _____ | 9. 0.00045 _____ |
| 4. 12,030,000 _____ | 10. 382.0 _____ |
| 5. 0.0009020 _____ | 11. 0.007000 _____ |
| 6. 75,009 _____ | 12. 905,040 _____ |

C. Straight conversions.

1. Convert 62.0 mL to L.
2. Convert 0.00480 L to mL.
3. Convert 1.25×10^6 μ L to L.
4. Convert 3.60×10^4 nL to μ L.
5. Convert 0.0950 L to μ L.

Hagerstown Community College – Medical Laboratory Technology

6. Convert 8.00 mL to nL.
7. Convert 0.0125 kg to g.
8. Convert 4.75×10^5 μg to mg.
9. Convert 0.00620 g to μg .
10. Convert 5.40×10^7 ng to mg.
11. Convert 2.20 mg to μg .
12. Convert 0.000850 kg to mg.

D. Express the given quantity in the requested unit using scientific notation (3 significant figures).

1. Express 0.0380 L in scientific notation (L).
2. Express 420 mL in scientific notation (L).
3. Express 0.000730 g in scientific notation (g).
4. Express 12,800 mg in scientific notation (g).
5. Express 9.50×10^3 μL in scientific notation (L).
6. Express 2.40×10^6 ng in scientific notation (g).
7. Express 0.00360 L in scientific notation (mL).
8. Express 0.0820 g in scientific notation (mg).

Hagerstown Community College – Medical Laboratory Technology

9. Express 4.00×10^{-3} L in scientific notation (μL).

10. Express 6.25×10^{-4} g in scientific notation (μg).

How to make chlorine solutions for environmental disinfection

Example I - Using Liquid Bleach

Chlorine in liquid bleach comes in different concentrations. Any concentration can be used to make a dilute chlorine solution by applying the following formula:

$$\left[\frac{\% \text{ chlorine in liquid bleach}}{\% \text{ chlorine desired}} \right] - 1 = \text{Total parts of water for each part bleach}^\dagger$$

Example: To make a 0.5% chlorine solution from 3.5%[‡] bleach:

$$\left[\frac{3.5\%}{0.5\%} \right] - 1 = 7 - 1 = 6 \text{ parts water for each part bleach}$$

Therefore, you must add 1 part 3.5% bleach to 6 parts water to make a 0.5% chlorine solution.

† "Parts" can be used for any unit of measure (e.g. ounce, litre or gallon) or any container used for measuring, such as a pitcher.

‡ In countries where French products are available, the amount of active chlorine is usually expressed in degrees chlorum. One degree chlorum is equivalent to 0.3% active chlorine.

Example II - Using Bleach Powder

If using bleach powder,[†] calculate the amount of bleach to be mixed with each litre of water by using the following formula:

$$\left[\frac{\% \text{ chlorine desired}}{\% \text{ chlorine in bleach powder}} \right] \times 1\,000 = \text{Grams of bleach powder for each litre of water}$$

Example: To make a 0.5% chlorine solution from calcium hypochlorite (bleach) powder containing 35% active chlorine:

$$\left[\frac{0.5\%}{35\%} \right] \times 1\,000 = 0.0143 \times 1\,000 = 14.3$$

Therefore, you must dissolve 14.3 grams of calcium hypochlorite (bleach) powder in each litre of water used to make a 0.5% chlorine solution.

† When bleach powder is used, the resulting chlorine solution is likely to be cloudy (milky).

Example III - Formula for Making a Dilute Solution from a Concentrated Solution

$$\text{Total Parts (TP) (H}_2\text{O)} = \left[\frac{\% \text{ Concentrate}}{\% \text{ Dilute}} \right] - 1$$

Example: To make a dilute solution (0.1%) from 5% concentrated solution.

$$\text{Calculate TP (H}_2\text{O)} = \left[\frac{5.0\%}{0.1\%} \right] - 1 = 50 - 1 = 49$$

Take 1 part concentrated solution and add to 49 parts boiled (filtered if necessary) water.

Cognitive Objectives

By the end of this laboratory exercise, the student will be able to:

1. Define key terms related to microbial control.
 2. Describe the chemical composition and disinfectant properties of sodium hypochlorite.
 3. Explain the rationale for using a 10% bleach solution for surface decontamination in the clinical laboratory.
 4. Differentiate between the levels of microbial control and identify appropriate applications for each.
 5. Outline the steps for safely preparing a 10% bleach solution from commercial bleach.
 6. Discuss the importance of contact time, concentration, and proper storage in maintaining bleach effectiveness.
 7. Identify safety precautions and potential hazards associated with sodium hypochlorite use.
 8. Explain the importance of regular disinfection in preventing contamination and laboratory-acquired infections.
 9. Interpret labeling, expiration, and hazard warnings on disinfectant containers in accordance with laboratory safety standards.
-

Psychomotor Objectives

By the end of this laboratory exercise, the student will be able to:

1. Select appropriate personal protective equipment (PPE) prior to handling bleach.
2. Dilute commercial bleach accurately using volumetric equipment to prepare a 10% (v/v) solution.
3. Mix and label the prepared disinfectant according to laboratory safety and regulatory requirements.
4. Apply the 10% bleach solution correctly to disinfect a designated surface, observing required contact time.
5. Demonstrate safe handling, storage, and disposal procedures for sodium hypochlorite solutions.
6. Perform cleanup of a simulated biohazard spill using the 10% bleach solution while maintaining aseptic technique.

Laboratory Procedure: Preparation and Use of a 10% Bleach Solution

Purpose:

To prepare a 10% (v/v) sodium hypochlorite solution from commercial bleach for use as an effective disinfectant in the clinical laboratory and to understand key terminology related to microbial control and disinfection practices.

Principle:

Sodium hypochlorite (NaOCl), the active ingredient in household bleach, is a broad-spectrum microbicidal agent effective against most bacteria, viruses, fungi, and spores. When diluted to a 10% solution, it provides approximately 0.5–0.6% sodium hypochlorite, which is effective for decontaminating work surfaces and equipment. Regular disinfection prevents contamination and reduces the risk of laboratory-acquired infections.

Materials and Equipment:

- Commercial household bleach (5–6% sodium hypochlorite)
 - Cold distilled or tap water
 - Graduated cylinder or volumetric container
 - Labeled plastic or glass storage bottle with cap
 - Personal protective equipment (PPE): gloves, lab coat, and safety goggles
-

Procedure:

1. Don PPE before handling bleach to prevent chemical exposure.
2. Determine desired volume (example: 1 liter total).
3. Measure bleach: 100 mL of commercial bleach.
4. Add bleach to water: Place 900 mL of water in a container, then slowly add the bleach (never add water to bleach).
5. Mix gently by swirling the container.
6. Label container:
 - “10% Bleach Solution (0.5–0.6% NaOCl)”
 - Date prepared and discard date (7 days after preparation)

- Safety warnings: *Corrosive, Use in Well-Ventilated Area*
7. Store in a tightly sealed, opaque container away from heat and sunlight.
-

Use and Application:

- Apply 10% bleach solution directly to contaminated surfaces.
 - Allow 10 minutes of contact time before wiping or rinsing.
 - For biohazard spills, absorb the material with paper towels, cover with 10% bleach, and allow 10–30 minutes contact time before cleanup.
 - Rinse metal surfaces after disinfection to prevent corrosion.
-

Safety and Disposal:

- Do not mix bleach with ammonia, acids, or other cleaners—this produces toxic chlorine gas.
 - Prepare fresh solution weekly or sooner if it becomes cloudy or contaminated.
 - Dispose of unused solution according to institutional chemical waste guidelines.
-

Importance of Disinfection:

Regular and correct use of disinfectants such as 10% bleach is vital in the clinical laboratory to protect personnel and patients by preventing the spread of infectious agents. Effective disinfection ensures that work surfaces, instruments, and equipment remain free of viable pathogens, thereby maintaining aseptic conditions, ensuring regulatory compliance, and supporting safe laboratory practice.

Microbial control techniques vary in intensity and purpose depending on the level of cleanliness required. Understanding these distinctions allows laboratory personnel to select the appropriate level of microbial control for each situation.

- **Sanitization** is the least stringent method, typically used in public settings (e.g., food service) to reduce microbial counts to safe levels rather than achieving sterility.
- **Bacteriostatic and microbicidal** agents describe the *effect* of chemical compounds—whether they stop microbial growth temporarily (*bacteriostatic*) or kill microorganisms outright (*microbicidal*).
- **Asepsis** refers to the *state* of being free from pathogens and is achieved through aseptic techniques, not by a single disinfectant.

- **Disinfection** is stronger than sanitization and uses chemical agents (like bleach) to destroy most pathogens, but it does not kill resistant spores.
- **Sterilization** represents the highest level of microbial control, ensuring complete destruction of all microorganisms and spores, required for surgical instruments and culture media.
- **Decontamination** is a broad, encompassing term describing any process that reduces contamination to safe levels—often combining cleaning, disinfection, or sterilization depending on the material and risk.

Standard Operating Procedure (SOP)

Preparation of 10% Sodium Hypochlorite (Bleach) Solution for Laboratory Disinfection

SOP Number: CHEM-DIS-001 Version: 1.1 Effective Date: October 2025 Review Date: October 2026

2.0 Principle / Purpose

A 10% (v/v) sodium hypochlorite solution provides effective surface disinfection against common bacterial, viral, and fungal contaminants in the clinical laboratory. This SOP ensures consistency, safety, and compliance with CLSI, CLIA, and OSHA guidelines.

3.0 Scope and Application

Applies to all MLT student laboratories and clinical spaces where biological material is handled. Used for bench disinfection before and after lab sessions and for spill cleanup involving potentially infectious material.

4.0 Responsibilities

Laboratory Personnel/Students: Prepare and label solutions according to this SOP.

Laboratory Instructor/Supervisor: Verify correct dilution and labeling.

Program Director/Safety Officer: Ensure compliance with safety and quality requirements.

5.0 Definitions / Abbreviations

SDS: Safety Data Sheet

NFPA: National Fire Protection Association

PPE: Personal Protective Equipment

v/v: Volume per volume

6.0 Safety Precautions

Wear gloves, lab coat, and eye protection when handling bleach. Work in a well-ventilated area. Avoid mixing bleach with acids or ammonia.

NFPA Diamond (Sodium Hypochlorite): Health 3 | Flammability 0 | Reactivity 1 | Special: OX

7.0 Reagents and Materials

Item	Specification	Source / Catalog #
Commercial Sodium Hypochlorite (Bleach)	5.25%–6.00% available chlorine	Clorox™ or equivalent
Distilled Water	Room temperature	Laboratory supply
Graduated Cylinder	Class A, 100 mL	—

Beaker	1 L, Glass	—
Label Tape & Marker	Waterproof	—

8.0 Quality Control / Quality Assurance

Verify stock bleach concentration (5.25–6.0%). Label solutions with preparation and expiration dates (24 hours). Discard expired solutions. Document all preparations in the disinfectant log.

9.0 Procedure

1. Don appropriate PPE.
2. Determine required volume of 10% bleach.
3. Measure 100 mL of commercial bleach using a graduated cylinder.
4. Add to 900 mL of distilled water in a 1-L beaker.
5. Mix gently with a stir rod.
6. Label container: '10% Sodium Hypochlorite – Prepared [date/time], Expires [next day].'
7. Store at room temperature, protected from light.
8. Record preparation in disinfectant log.

10.0 Calculations

$$C_1V_1 = C_2V_2; V_1 = (C_2/C_1) \times V_2 = (10/100) \times 1000 \text{ mL} = 100 \text{ mL}$$

11.0 Limitations

Solution is unstable beyond 24 hours. Corrosive to metals and light-sensitive.

12.0 Documentation and Records

Record preparation date, time, preparer, and verifier initials in the Disinfectant Log (Attachment A).

13.0 References

CDC Laboratory Biosafety Guidelines (2024), SDS: Clorox™ Sodium Hypochlorite 6%, OSHA 29 CFR 1910.1030.

8.0 Quality Control / Quality Assurance

Verify stock bleach concentration (5.25–6.0%). Label solutions with preparation and expiration dates (24 hours). Discard expired solutions.

9.0 Procedure

1. Don appropriate PPE.
2. Determine required volume of 10% bleach.
3. Measure 100 mL of commercial bleach using a graduated cylinder.
4. Add to 900 mL of distilled water in a 1-L beaker.
5. Mix gently with a stir rod.
6. Label container: '10% Sodium Hypochlorite – Prepared [date/time], Expires [next day], initials.'
7. Store at room temperature, protected from light.

10.0 Calculations

$$C_1V_1 = C_2V_2; V_1 = (C_2/C_1) \times V_2 = (10/100) \times 1000 \text{ mL} = 100 \text{ mL}$$

11.0 Limitations

Solution is unstable beyond 24 hours. Corrosive to metals and light-sensitive.

12.0 Documentation and Records

Record preparation date, time, preparer, and verifier initials.

13.0 References

CDC Laboratory Biosafety Guidelines (2024), SDS: Clorox™ Sodium Hypochlorite 6%, OSHA 29 CFR 1910.1030.

Standard Operating Procedure (SOP)

Preparation of 10% Sodium Hypochlorite (Bleach) Solution for Laboratory Disinfection

SOP Number: CHEM-DIS-001 Version: 1.1 Effective Date: October 2025 Review Date: October 2026

2.0 Principle / Purpose

A 10% (v/v) sodium hypochlorite solution provides effective surface disinfection against common bacterial, viral, and fungal contaminants in the clinical laboratory. This SOP ensures consistency, safety, and compliance with CLSI, CLIA, and OSHA guidelines.

3.0 Scope and Application

Applies to all MLT student laboratories and clinical spaces where biological material is handled. Used for bench disinfection before and after lab sessions and for spill cleanup involving potentially infectious material.

4.0 Responsibilities

Students: Prepare and label solutions according to this SOP.

Laboratory Instructor: Verify correct dilution and labeling.

5.0 Definitions / Abbreviations

SDS: Safety Data Sheet

NFPA: National Fire Protection Association

PPE: Personal Protective Equipment

v/v: Volume per volume

6.0 Safety Precautions

Wear gloves, lab coat, and eye protection when handling bleach. Work in a well-ventilated area. Avoid mixing bleach with acids or ammonia.

NFPA Diamond (Sodium Hypochlorite): Health 3 | Flammability 0 | Reactivity 1 | Special: OX

7.0 Reagents and Materials

- 5.25%–6.00% commercial sodium hypochlorite (bleach)
- Room temperature distilled water
- 100 ml graduated cylinder
- 1 l glass beaker
- Waterproof label & marker

MLT 101 Lecture 3 Objectives and Exam Questions

Level 1 Objectives

- L1-1. Identify standard blood collection equipment and functions.
- L1-2. Recall tube colors, additives, and primary uses.
- L1-3. State the purpose and sequence of the order of draw.
- L1-4. Recognize coagulation tube fill requirements (9:1 ratio).
- L1-5. Recall venipuncture technique standards (angle, site prep, tourniquet time).
- L1-6. Select appropriate equipment for patient condition (e.g., butterfly).
- L1-7. Recall OSHA safety device purpose.
- L1-8. Recognize preanalytical variables and handling errors.
- L1-9. Recall specimen labeling requirements and patient ID policy.
- L1-10. Recognize legal/ethical basics relevant to phlebotomy practice.

Level 2 Objectives

- L2-1. Apply additive function and order of draw to prevent contamination.
- L2-2. Differentiate tube use by department and specimen type.

Multiple Choice

1. The most commonly used gauge for routine venipuncture needles is:
a. 16 b. 18 c. 21 d. 25
2. The order of draw is designed primarily to:
a. Improve turnaround time
b. Reduce specimen hemolysis
c. Prevent additive carryover contamination
d. Preserve plasma integrity
3. The light-blue top tube must be filled:
a. Half full b. To the fill line c. One-third full d. It does not matter
4. A green top tube contains which additive?
a. Sodium citrate b. Lithium heparin c. Sodium fluoride d. EDTA
5. The gray top tube is primarily used for:
a. CBC testing b. Glucose and lactic acid testing c. Coagulation studies d. Blood typing
6. Which of the following tubes should be drawn first when using a multi-tube system?
a. EDTA b. Citrate c. Heparin d. Fluoride
7. The correct angle of needle insertion for venipuncture is approximately:
a. 5° b. 15–30° c. 45° d. 60°
8. When performing a venipuncture, the tourniquet should be applied for no longer than:
a. 30 seconds b. 1 minute c. 2 minutes d. 5 minutes
9. What is the purpose of the safety device on a venipuncture needle?
a. Maintain vacuum b. Prevent accidental needlestick injury c. Improve blood flow d. Indicate order of draw

10. Which of the following tubes yields serum after centrifugation?
a. Green b. Lavender c. Red d. Light blue
11. Which vein is the first-choice site for routine venipuncture?
a. Basilic b. Cephalic c. Median cubital d. Radial
12. Cleansing the venipuncture site should be done using:
a. 70% isopropyl alcohol center-out
b. Povidone-iodine outside-in
c. Soap and water only
d. Any available disinfectant
13. A specimen collected for plasma chemistry must be:
a. Allowed to clot then centrifuged
b. Mixed with anticoagulant immediately
c. Collected in a serum tube
d. Frozen before centrifugation
14. Which additive preserves glucose and prevents glycolysis?
a. EDTA b. Heparin c. Sodium fluoride d. Potassium citrate
15. The color of the stopper identifies primarily the:
a. Tube manufacturer b. Tube additive or function c. Tube size d. Type of needle used
16. Which of the following is a pre-examination variable?
a. Specimen transport temperature b. Instrument calibration c. QC review d. Result interpretation
17. The term hemoconcentration refers to:
a. Decrease in cellular components
b. Increase in concentration from prolonged stasis
c. Rupture of RBCs
d. Mixing error
18. Which additive is used for coagulation studies?
a. Sodium citrate b. EDTA c. Sodium fluoride d. Heparin
19. The anticoagulant that inhibits thrombin formation is:
a. EDTA b. Heparin c. Citrate d. Fluoride
20. Failure to invert an anticoagulant tube after collection may cause:
a. Clot formation b. Hemolysis c. Under-filling d. Contamination
21. Which department commonly performs tests on lavender-top tubes?
a. Chemistry b. Hematology c. Microbiology d. Blood bank

True / False

31. _____ All evacuated tubes contain additives.
32. _____ The bevel of a needle should face up during venipuncture insertion.
33. _____ Sodium citrate is used for coagulation testing because it binds calcium reversibly.
34. _____ Light-blue tubes must be filled completely to maintain a 9:1 ratio.
35. _____ Heparin is used for hematology testing because it preserves cell morphology.
36. _____ The order of draw reduces additive carryover.
37. _____ A tourniquet can remain tied for up to five minutes without affecting results.

Hagerstown Community College – Medical Laboratory Technology

- 38. _____ The median cubital vein is preferred because it is usually anchored and less painful.
- 39. _____ A gray-top tube is used for glucose testing.
- 40. _____ Mixing anticoagulant tubes gently 5–10 times prevents clotting and hemolysis.
- 41. _____ The preanalytical phase occurs after test results are reported.
- 42. _____ Improper patient identification is a major cause of laboratory error.
- 43. _____ An under-filled EDTA tube can cause falsely elevated hematocrit values.
- 44. _____ All specimens must be labeled in the patient's presence before leaving the bedside.
- 45. _____ The chain of custody process applies only to blood alcohol specimens.

Matching

Match each tube color with its additive/test.

- | | |
|------------------|--|
| 46. Yellow (SPS) | A. Sodium Polyanethol Sulfonate (SPS); blood cultures |
| 47. Light Blue | B. Sodium Citrate; coagulation; fill completely |
| 48. Gold | C. No additive or clot activator + gel |
| 49. Green | D. Heparin (lithium or sodium); chemistry |
| 50. Lavender | E. EDTA; hematology |
| 51. Gray | F. Sodium Fluoride + Potassium Oxalate; glucose/lactic acid; |
| 52. Royal Blue | prevents glycolysis |
| | G. Trace element tube; toxicology, heavy metals |

MCQ Answers (objective in parentheses)

- 1. The most commonly used gauge for routine venipuncture needles is:
Answer: **c (L1-1)**
- 2. The order of draw is designed primarily to:
Answer: **c (L1-3)**
- 3. The light-blue top tube must be filled:
Answer: **b (L1-4)**
- 4. A green top tube contains which additive?
Answer: **b (L1-2)**
- 5. The gray top tube is primarily used for:
Answer: **b (L1-2)**
- 6. Which of the following tubes should be drawn first when using a multi-tube system?
Answer: **b (L1-3)**

7. The correct angle of needle insertion for venipuncture is approximately:
Answer: **b (L1-5)**
8. When performing a venipuncture, the tourniquet should be applied for no longer than:
Answer: **b (L1-5)**
9. What is the purpose of the safety device on a venipuncture needle?
Answer: **b (L1-7)**
10. Which of the following tubes yields serum after centrifugation?
Answer: **c (L1-2)**
11. Which vein is the first-choice site for routine venipuncture?
Answer: **c (L1-5)**
12. Cleansing the venipuncture site should be done using:
Answer: **a (L1-5)**
13. A specimen collected for plasma chemistry must be:
Answer: **b (L1-2)**
14. Which additive preserves glucose and prevents glycolysis?
Answer: **c (L1-2)**
15. The color of the stopper identifies primarily the:
Answer: **b (L1-2)**
16. Which of the following is considered a pre-examination variable?
Answer: **a (L1-8)**
17. The term hemoconcentration refers to:
Answer: **b (L1-8)**
18. Which additive is used for coagulation studies?
Answer: **a (L1-2)**
19. The anticoagulant that inhibits thrombin formation is:
Answer: **b (L1-2)**
20. Failure to invert an anticoagulant tube after collection may cause:
Answer: **a (L1-8)**
21. Which department commonly performs tests on lavender-top tubes?
Answer: **b (L1-2)**

True/False Answers (objective in parentheses)

- 31 False (L1-2)
- 32 True (L1-5)
- 33 True (L1-2)
- 34 True (L1-4)
- 35 False (L1-2)
- 36 True (L1-3)
- 37 False (L1-5)
- 38 True (L1-5)
- 39 True (L1-2)
- 40 True (L1-8)
- 41 False (L1-8)
- 42 True (L1-9)

Hagerstown Community College – Medical Laboratory Technology

43 False (L1-8)

44 True (L1-9)

45 False (L1-10)

Matching Key (objective L2-1/L2-2)

46 → A

47 → B

48 → C

49 → D

50 → E

51 → F

52 → G



CLSI-based Venipuncture Checklist

Pre-procedure (Preparation & Patient Identification)

1. ☒ Verify test order(s) / requisition
 - Confirm what tests are requested and any special requirements (e.g. timed draws, fasting).
2. ☒ Identify the patient using **at least two identifiers** (e.g. full name and date of birth or medical record number)
 - Compare against the lab order/requisition.
 - In inpatient setting, compare to wristband.
3. ☒ Explain procedure and obtain consent (verbal, or as facility policy)
 - Ask about allergies (e.g. chlorhexidine, latex), prior complications (syncope, hematoma), etc.
 - Confirm any special considerations (e.g. patient is pregnant, difficult veins, IV infusions).
4. ☒ Perform hand hygiene
5. ☒ Assemble and check all supplies
 - Gloves, tourniquet, antiseptic (typically 70 % isopropyl alcohol), gauze, bandages/tape, sharps container, collection devices (needle + holder or winged set), collection tubes (check expiration, integrity, additive type), labels, biohazard transport materials.
 - Ensure the needle is properly secured to holder, and that safety features (if present) are unlocked and ready.
6. ☒ Check any pre-collection requirements
 - Fasting status, correct timing, posture (sitting or supine per policy), required volumes.
 - Confirm specimen identification labeling (label or barcode) is ready.

Site Selection & Preparation

7. ☒ Place ~3–4 in above puncture site
 - Ensure tourniquet is not too tight
 - Tourniquet application time should not exceed 1 minute if possible
8. ☒ Select an appropriate vein
 - Usually antecubital fossa: median cubital, cephalic, basilic (with care)
 - Avoid veins that are sclerosed, rolled, or near sites of IV lines, edema, shunts, or injury.
9. ☒ Don gloves
10. ☒ Disinfect the venipuncture site
 - Use 70 % isopropyl alcohol (or facility-approved antiseptic)
 - Apply with firm friction, moving concentrically outward from center, covering ~2 cm beyond target
 - Allow to dry completely

- Do not touch or re-contaminate the site.
- 11. ☒ Reapply or reposition tourniquet
 - Place ~3–4 in above puncture site
 - Ensure tourniquet is not too tight
 - Tourniquet application time should not exceed 1 minute if possible

Venipuncture & Collection

- 11. ☒ Anchor the vein
 - Hold patient's arm steady; place thumb below puncture site to stabilize vein.
- 12. ☒ Insert the needle
 - Use smooth, rapid motion
 - Angle $\leq 30^\circ$
 - Bevel up
 - Advance slowly until blood flow is established
- 13. ☒ Release the tourniquet **before** withdrawing the last tube or as soon as flow is normal
- 14. ☒ Collect the required specimen(s) in the correct **order of draw**
 - To prevent additive carryover, follow the standard order:
 1. Blood culture bottles (if applicable)
 2. Sodium citrate (light blue) (C)
 3. Serum tubes (red, gold, marble/tiger) (S)
 4. Heparin (green, light green) (H)
 5. EDTA (lavender, pink, tan, royal blue) (E)
 6. Glycolytic inhibitors (gray) (O)
- 15. ☒ Gently invert tubes containing additives the required number of times
 - Gentle inversion (not shaking) to mix blood with anticoagulants or clot activators
 - Follow manufacturer instructions on number of inversions
- 16. ☒ Monitor for problems during draw
 - If blood flow is slow or stops, reposition slightly or withdraw partially and reinsert
 - Avoid excessive manipulation that may cause hemolysis
- 17. ☒ After all tubes are drawn, remove needle carefully
 - Place gauze over site (without touching needle)
 - Withdraw needle and immediately apply pressure
 - Ask patient to maintain pressure and keep arm extended (not bent)
- 18. ☒ Dispose of needle and holder immediately into sharps container (do not recap, bend, or break)

Post-collection & Labeling

- 19. ☒ Check for bleeding or hematoma at the site
- 20. ☒ Label tubes promptly at bedside (in front of the patient, before leaving)
 - Include: patient identifiers, date/time of draw, collector initials or ID
 - Verify label against patient identity

21. ☒ Remove gloves and perform hand hygiene
22. ☒ Place tubes in appropriate transport containers (biohazard, upright, temperature-controlled as required)
23. ☒ Complete any documentation (time, conditions, difficulties, comments)
24. ☒ Deliver specimens to the laboratory within acceptable time limits
 - Ensure tubes are maintained per lab requirements (e.g. temperature, upright position)

Centers for Disease Control and Prevention. (2024). *Specimen collection guidance*. U.S. Department of Health & Human Services. <https://www.cdc.gov/lab/specimen-submission/index.html>

Clinical and Laboratory Standards Institute. (2025). *PRE02: Collection of diagnostic venous blood specimens* (8th ed.). CLSI. <https://clsi.org/shop/standards/pre02/>

Clinical and Laboratory Standards Institute. (2025). *PRE02QG: Quick guide to venous blood collection*. CLSI. <https://clsi.org/shop/standards/pre02qg/>

Clinical and Laboratory Standards Institute. (n.d.). *Order of draw: Tubes and additives*. CLSI. <https://clsi.org/resources/insights/order-of-blood-draw-tubes-and-additives/>

Lippi, G., Banfi, G., Church, S., Cornes, M., De Carli, G., Grankvist, K., Simundic, A. M., & Sonntag, O. (2013). Preanalytical quality improvement: In quality we trust. *Clinical Chemistry and Laboratory Medicine*, 51(1), 229–241. <https://doi.org/10.1515/cclm-2012-0597>

World Health Organization. (2010). *WHO guidelines on drawing blood: Best practices in phlebotomy*. World Health Organization. <https://apps.who.int/iris/handle/10665/44294>



Urinalysis Quiz (Student Version)

Instructions: Answer all questions. Select the single best answer for multiple choice. Write the correct term(s) for fill-in-the-blank. Circle T or F for true/false. Objective mappings appear as codes (e.g., L2-O10).

Objective Map (Urinalysis)

L1-O1: Define key terms (specific gravity, pH, reagent strip, casts, crystals; qualitative/quantitative/semi-quantitative)

L1-O2: List kidney functions (filtration, reabsorption, secretion)

L1-O3: Identify nephron and urinary system structures

L1-O4: List the ten common reagent strip analytes

L1-O5: Recall urine specimen types, collection, preservation

L1-O6: Recognize normal/abnormal physical characteristics (color, clarity, odor, volume)

L1-O7: Explain structure–function relationship in urine formation

L1-O8: Describe principles of physical, chemical, microscopic UA

L2-O9: Demonstrate specimen handling, labeling, preservation procedures

L2-O10: Apply preanalytic/analytic/postanalytic variables for valid results

L2-O11: Categorize results as qualitative/quantitative/semi-quantitative

L3-O12: Evaluate specimen acceptability and test reliability before reporting

Multiple Choice

1) Which tube/container and additive are preferred for routine chemical urinalysis by reagent strip? (L1-O5)

- A. Sterile cup, no additive
- B. Gray-top sodium fluoride
- C. EDTA lavender-top
- D. Heparinized green-top

2) Which of the following is NOT typically included among the ten common reagent strip analytes? (L1-O4)

- A. pH
- B. Protein
- C. Urobilinogen
- D. Calcium

3) Specific gravity primarily assesses: (L1-08)

- A. Urine glucose concentration
- B. Solute concentration and renal concentrating ability
- C. Presence of ketones only
- D. Degree of hemolysis

4) The functional unit of the kidney is the: (L1-03)

- A. Glomerulus
- B. Nephron
- C. Collecting duct
- D. Renal pelvis

5) Which pair best represents kidney functions carried out by tubules? (L1-02)

- A. Filtration and secretion
- B. Reabsorption and secretion
- C. Filtration and osmosis
- D. Perfusion and diffusion

6) A first-morning specimen is preferred for some tests because it: (L1-05)

- A. Is always sterile
- B. Is more concentrated, increasing analyte detection
- C. Eliminates all preanalytic error
- D. Has lower specific gravity

Hagerstown Community College – Medical Laboratory Technology

7) Cloudy red urine with a positive blood pad and many RBCs in sediment most likely indicates: (L1-08)

- A. Hemoglobinuria
- B. Myoglobinuria
- C. Hematuria
- D. Bilirubinuria

8) Clear red urine with a positive blood pad and few/no RBCs suggests: (L1-08)

- A. Hematuria
- B. Hemoglobinuria or myoglobinuria
- C. Porphyria
- D. Contamination

9) Which finding is most compatible with old, improperly preserved urine? (L2-010)

- A. Fresh odor, clear, acidic
- B. Alkaline shift with ammonia odor
- C. Increased ketones
- D. Increased bilirubin stability

10) Which factor is preanalytic? (L2-010)

- A. Incorrect timing of strip reading
- B. Improper control storage
- C. Failure to correlate expected findings
- D. Inadequate specimen labeling

11) Leukocyte esterase on dipstick is primarily used to detect: (L1-04)

- A. RBCs
- B. WBC activity suggesting infection

C. Bilirubin

D. Ketone bodies

12) Nitrite positivity depends on: (L1-04)

A. Bacterial reduction of nitrate after sufficient bladder incubation

B. Presence of ketone bodies

C. Photodegradation of bilirubin

D. pH > 7.5 only

13) Protein on reagent strips is most sensitive to: (L1-04)

A. Albumin

B. Globulins

C. Bence Jones proteins equally

D. Hemoglobin

14) Which crystal is classically 'coffin-lid' shaped and seen in alkaline urine? (L1-08)

A. Calcium oxalate

B. Triple phosphate (struvite)

C. Uric acid

D. Ammonium biurate thorn apples

15) Which cast indicates glomerular bleeding? (L1-08)

A. Hyaline

B. Granular

C. RBC cast

D. Waxy

16) A refrigerated urine specimen for up to 6–8 hours is acceptable primarily to prevent: (L1-05)

Hagerstown Community College – Medical Laboratory Technology

- A. Bilirubin oxidation
- B. Bacterial overgrowth and chemical changes
- C. Cast formation
- D. Color change to green

17) Which BEST distinguishes qualitative, semi-quantitative, and quantitative? (L2-O11)

- A. Positive/negative; graded estimate; exact amount
- B. Exact amount; graded estimate; positive/negative
- C. Graded estimate; exact amount; positive/negative
- D. All are exact amounts

18) A reagent strip bottle left uncapped at the bench most likely leads to: (L2-O10)

- A. No effect
- B. False positives due to humidity and volatilization
- C. Improved sensitivity
- D. Better color development

19) Microscopic exam reports 'coarse granular casts.' This finding most closely reflects: (L1-O8)

- A. Tubular stasis/degeneration
- B. Glomerular bleeding
- C. Prerenal azotemia
- D. Contamination with fibers

20) Which epithelial cell type originates from the renal tubules? (L1-O8)

- A. Squamous
- B. Transitional (urothelial)
- C. Renal tubular epithelial

D. Ciliated columnar

21) A 'coarse to fine granular cast' progression that becomes highly refractile, broad, and brittle describes: (L1-08)

- A. Hyaline casts
- B. Waxy casts
- C. Fatty casts
- D. RBC casts

22) Which scenario requires specimen rejection or notation BEFORE testing (acceptability check)? (L3-012)

- A. Random sample collected 20 minutes ago
- B. Unlabeled cup with no identifiers
- C. Refrigerated first-morning specimen
- D. 12 mL volume received

23) An acid urine commonly shows which normal crystal? (L1-08)

- A. Triple phosphate
- B. Amorphous phosphates
- C. Uric acid
- D. Ammonium biurate

24) Which postanalytic step is emphasized for quality? (L2-010)

- A. Immediate refrigeration
- B. Final inspection and correlation of expected findings
- C. Proper urine volume collection
- D. Use of control solutions

25) Which statement about specific gravity methods is TRUE? (L1-08)

- A. Only osmometry is acceptable

Hagerstown Community College – Medical Laboratory Technology

- B. Refractometry estimates refractive index to infer solute concentration
- C. Strip SG is unaffected by very alkaline urine
- D. Hydrometer is the modern standard of care

Fill-in-the-Blank

- 26) List two main processes in tubules after filtration: _____ and _____. (L1-02)
- 27) Name the functional unit where urine is formed: _____. (L1-03)
- 28) The preferred preservation method if immediate testing is not possible is _____. (L1-05)
- 29) A shift to alkaline pH and ammoniacal odor indicates _____ by bacteria. (L2-010)
- 30) The dipstick test used to screen for bacteriuria via nitrate reduction is _____. (L1-04)
- 31) The leukocyte esterase pad detects activity of _____. (L1-04)
- 32) A clear red urine with positive blood but few RBCs suggests _____ or _____. (L1-08)
- 33) The cast formed by Tamm-Horsfall (uromodulin) matrix alone is a _____ cast. (L1-08)
- 34) A 'coffin-lid' crystal typical of alkaline urine is _____. (L1-08)
- 35) The thorn-apple crystal is _____. (L1-08)
- 36) Results that are reported as +/- are considered _____ results. (L2-011)
- 37) Graded estimates such as 1+, 2+, 3+ are _____ results. (L2-011)
- 38) Exact numeric values with units are _____ results. (L2-011)
- 39) Before reporting, the laboratorian must evaluate specimen _____ and test _____. (L3-012)
- 40) The reagent strip bottle should be stored _____ and capped to avoid humidity/light. (L2-010)

Hagerstown Community College – Medical Laboratory Technology

True/False

- 41) Random urine is the only acceptable specimen for urinalysis. (L1-05)
- 42) First-morning urine is typically more concentrated than random urine. (L1-05)
- 43) Immediate refrigeration slows bacterial growth and chemical changes in urine. (L1-05)
- 44) Reagent strip nitrite detects bacteria regardless of bladder incubation time. (L1-04)
- 45) Leukocyte esterase may be positive when pyuria is present. (L1-04)
- 46) Reagent strip protein primarily detects albumin. (L1-04)
- 47) Amorphous phosphates are common in acidic urine. (L1-08)
- 48) Waxy casts are highly refractile and may indicate prolonged urinary stasis. (L1-08)
- 49) Unlabeled specimens should be tested if the sample looks suitable. (L3-012)
- 50) Leaving the strip bottle uncapped does not affect test reliability. (L2-010)

Chapter 13

Renal Physiology and Urinalysis

Modern Urinalysis (1 of 2)

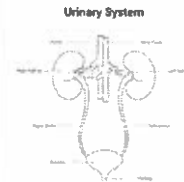
- The physical, chemical, and microscopic analysis of the urine is known as urinalysis.
- Purposes of urinalysis:
 - To aid in the diagnosis of disease
 - To monitor wellness (screening for asymptomatic, congenital, or hereditary disease)
 - To monitor therapy (effectiveness or complications)
- Test performance can be manual, semiautomated, or fully automated.

Modern Urinalysis (2 of 2)

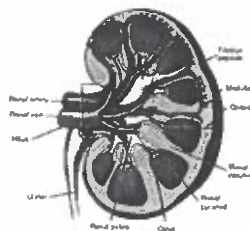
- Quality assessment and quality control
 - Pre-analytic variability:
 - Patient-related factors, specimen collection, specimen identification and labeling, specimen transfer and transport, and specimen processing
 - Analytic variability:
 - Multi-reagent strips, control solutions, storage of test bottles, refractometers
 - Postanalytic variability:
 - Results documentation and recording, final inspection of results, correlation of expected findings

Renal Anatomy and Physiology (1 of 7)

- Renal anatomy: 2 kidneys, 2 ureters, 1 bladder, 1 urethra
 - Kidney anatomy:
 - Renal artery enters kidney and branches to become arterioles entering a glomerulus, then closely associated with each renal tubule of the nephron, allowing reabsorption and secretion between the blood and glomerular filtrate
 - Each kidney's hilum is the entry or exit point for blood vessels, nerves, lymphatics, and the renal pelvis
 - Each kidney has an outer *corticomedullary* cortex and inner medulla



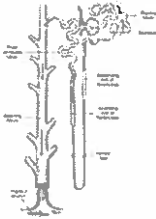
Renal Anatomy and Physiology (2 of 7)



Renal Anatomy and Physiology (3 of 7)

- Renal physiology
 - The functional unit of the kidney is the nephron, where urine is formed.
 - The formed urine flows from the kidney into the ureter and is passed to the bladder for temporary storage.
 - It is eliminated from the body through the urethra.

Renal Anatomy and Physiology (4 of 7)



- Renal physiology
 - Glomerulus
 - Glomerular (Bowman's) capsule
 - Proximal convoluted tubule
 - Loop of Henle
 - Distal convoluted tubule
 - Collecting tubules

Renal Anatomy and Physiology (5 of 7)

- Renal physiology
 - Main functions of the kidney:
 1. Removal of waste products
 2. Acid-base balance
 3. Water and electrolyte balance
 4. Hormone synthesis
 - These functions are carried out by means of filtration, reabsorption, and secretion.

Renal Anatomy and Physiology (7 of 7)

- Histology
 - All urinary system structures, from the glomerular capsule to the terminal portion of the urethra, are lined with epithelial cells.
 - Each portion of the urinary system is characterized by a specific type of epithelial cell.
 - These cells generally are classified as either renal (meaning from the kidney or nephron itself), transitional, or squamous epithelial cells.
 - A few of these cells are constantly sloughed off into the urine, but increased numbers or cytologic changes of any of these cells may have clinical significance and may be important in determining the cause of renal dysfunction.

Composition of Normal Urine (1 of 3)

- Normal urine contains a few cells from the blood and urinary tract lining but little or no protein and no casts.
 - Tests for blood (hemoglobin), nitrite, leukocyte esterase, glucose, ketones, and conjugated bilirubin should all be negative.
- Normal but concentrated urine typically crystallizes certain chemicals out of solution at room or refrigerator temperature.
 - A routine urinalysis usually shows crystals of uric acid or its salts, the urates, at an acid pH, whereas phosphates typically crystallize out of solution in concentrated urine of an alkaline pH.
 - Such crystallization appears grossly as cloudiness or turbidity of the urine, and the crystals are identified morphologically by microscopic examination.

Composition of Normal Urine (2 of 3)

Property	Reference value
Color	Yellow
Clarity	Clear
pH	5-7
Specific gravity	1.003-1.035 (adult random urine)

Collection and Preservation of Urine Specimens (1 of 4)

- The specimen must be examined when fresh, ideally within 30 minutes, or suitably preserved, such as by refrigeration for up to 6 to 8 hours.
- Types of urine specimens
 - Random specimen
 - First morning specimen
 - Midstream Clean-catch specimen
 - 24 hour or timed specimen
 - Catheter collection specimen
 - Suprapubic aspiration specimen
 - Pediatric specimen

Collection and Preservation of Urine Specimens (2 of 4)

- Containers for urine collection
 - Urine collection cups
 - Urinalysis tubes
 - 24-Hour collection containers
 - Urine culture containers
 - Urine transport tubes
- Urine volume for routine urinalysis
 - Minimum volume for routine urinalysis is usually 12 milliliters, but 50 milliliters is preferable.
 - Urine is placed in a disposable centrifuge tube, centrifuged, and concentrated 12-to-1, so that 1 milliliter of sediment is retained for microscopic analysis of the sediment.

Collection and Preservation of Urine Specimens (3 of 4)

- Collection of urine specimens
 - Routine specimens
 - Collection of timed urine specimens
 - Collection of urine for culture
- Preservation of urine specimens
 - Decomposition of urine begins within 30 minutes after collection.
 - The best method of preservation is immediate refrigeration.
 - Common chemical preservatives are hydrochloric acid, boric acid, and acetic acid.
 - Other preservatives include toluene, formaldehyde, thymol, proprietary additive, and specialized additives.
 - Specimen preservation guidelines

Collection and Preservation of Urine Specimens (4 of 4)

- Labeling and processing urine
 - Labels
 - Collection date and time
 - Collection method
 - Proper preservation
 - Light protection

Physical Properties of Urine (1 of 5)

- Volume
- Color
- Clarity
- Odor
- Specific gravity

Physical Properties of Urine (2 of 5)

- Abnormal volumes
 - Polyuria: Consistent elimination of an abnormally large volume of urine, more than 2000 mL/24 hours
 - Diuresis: Any increase in urine volume, even if the increase is only temporary
 - Oliguria: Excretion of an abnormally small amount of urine, less than 500 mL/24 hours
 - Anuria: Complete absence of urine formation
 - Nocturia: Excretion of more than 400 mL urine at night

Physical Properties of Urine (3 of 5)

- Abnormal color:
 - Pale can indicate dilute urine.
 - Amber can indicate concentrated urine or bilirubin.
 - Brown can indicate bilirubin or biliverdin.
 - Orange can indicate urobilin.
 - Bright orange can indicate azo-containing dyes or compounds.
 - Red can indicate blood or heme-derived pigment, urates or uric acid, drugs, foodstuffs.
 - Clear red can indicate hemoglobin.
 - Cloudy red can indicate red blood cells.
 - Dark red-brown can indicate myoglobin.
 - Dark red or red-purple can indicate porphyrins.
 - Black or dark brown can indicate melanin, homogentisic acid, or phenol poisoning.
 - Green, blue, or orange can indicate drugs, medications, foodstuffs.

Physical Properties of Urine (4 of 5)

- **Abnormal transparency**
 - Hazy, cloudy, turbid can indicate mucus, phosphates, urates, crystals, bacteria, pus, fat, casts.
- **Abnormal odor**
 - Odor of ammonia (ammoniacal) can indicate breakdown of urea by bacteria (old urine).
 - Other abnormal odors can indicate infection.
 - Sweet or "fruity" can indicate ketone bodies.
 - Sweaty feet, maple syrup, cabbage or hops, mousy, rotting fish, rancid can indicate a specific amino acid disorder for each scent.

Physical Properties of Urine (5 of 5)

- **Specific gravity** ①
 - Clinical aspects
 - Used for information about two general functions: the state of the kidney and the patient's state of hydration
 - Measures of urine solute concentration (specific gravity and osmolality)
 - Osmolality by osmometer
 - Specific gravity as refractive index by refractometer
 - Quality control
 - Use of reagent strips for specific gravity
 - Principles
 - Corrections and limitations

Chemical Tests in Routine Urinalysis (1 of 20)

- **Reagent strip tests**
 - Advantages
 - Convenience; cost-effectiveness; stability; ease in learning to use; disposability; smaller sample volumes required; space savings
 - Manufacturer's directions
 - Sampling or wetting
 - Storage and general precautions
 - Stability
 - Timing
 - Reading results
 - Controls

Chemical Tests in Routine Urinalysis (2 of 20)

- **pH** ②
 - Clinical importance
 - Kidneys eliminate excess acid
 - Causes and effects of acidic urine
 - Causes and effects of alkaline urine
 - Reagent strip tests for pH
 - Principle
 - Interferences
 - Additional comments
 - The specimen must be tested when fresh because bacterial growth may result in a shift to an alkaline pH, giving falsely alkaline values.
 - Do not wet the reagent strip excessively so that the acid buffer from the protein area runs into the pH area, causing an orange coloration

Chemical Tests in Routine Urinalysis (3 of 20)

- **Protein** ③
 - Clinical importance
 - Proteinuria may be the result of the following
 1. Glomerular damage
 2. Tubular damage
 3. Prerenal disorders or overflow from excessive production of low-molecular-weight proteins such as hemoglobin, myoglobin, or immunoglobulins
 4. Lower urinary tract disorders
 5. Asymptomatic disorders
 - May be found in young adults after excessive exercise; after exposure to cold; or in orthostatic proteinuria
 6. Consistent microalbuminuria in diabetes mellitus

Chemical Tests in Routine Urinalysis (4 of 20)

- Proteinuria may be classified as to the amount (quantity) or degree of protein excreted per day (24 hours):
 - Mild or minimal: less than 1 gram per day
 - Moderate: 1 to 3 or 4 grams per day
 - Large or heavy: greater than 3 or 4 grams per day
- The amount of protein per 100 mL in a random urine specimen is related to 24-hour urine volume.

Chemical Tests in Routine Urinalysis (5 of 20)

- Reagent strip tests for protein
 - Principle
 - Specificity
 - Sensitivity (minimum detectable level)
 - Manufacturers' values
 - Interferences
 - False-positive results
 - False-negative results
 - Additional comments

Chemical Tests in Routine Urinalysis (6 of 20)

- **Blood (hemoglobin and myoglobin)** (4)
 - Clinical significance
 - Hematuria
 - Hemoglobinuria
 - Myoglobinuria
 - Differentiation of hematuria, hemoglobinuria, and myoglobinuria

Chemical Tests in Routine Urinalysis (7 of 20)

- Differentiation of red blood cells, hemoglobin, and myoglobin in urine
 - Reagent strip for blood is positive for all three.
 - Urine sediment for red cells
 - Red blood cells: Present
 - Hemoglobin: Absent (few)
 - Myoglobin: Absent (few)
 - Urine appearance
 - Red blood cells: Cloudy red
 - Hemoglobin: Clear red
 - Myoglobin: Clear red-brown

Chemical Tests in Routine Urinalysis (8 of 20)

- Differentiation of red blood cells, hemoglobin, and myoglobin in urine
 - Plasma appearance
 - Red blood cells: Normal
 - Hemoglobin: Pink-to-red (hemolysis)
 - Myoglobin: Normal

Chemical Tests in Routine Urinalysis (10 of 20)

- Reagent strip tests for blood
 - Principle and specificity
 - Sensitivity (minimum detectable level)
 - Manufacturers' values
 - Interferences
 - False-positive results
 - False-negative or delayed results
 - Additional comments
 - Confirmatory tests

Chemical Tests in Routine Urinalysis (11 of 20)

- **Nitrite** (5)
 - Clinical importance
 - Reagent strip tests for nitrite
 - Principle
 - Specificity
 - Results
 - Sensitivity (minimum detectable level)
 - Interferences
 - False-positive results
 - False-negative or delayed results
 - Additional comments
 - Confirmatory tests

Chemical Tests in Routine Urinalysis (12 of 20)

- **Leukocyte esterase** (6)
 - Clinical importance
 - Another means of detecting urinary tract infections
 - Reagent strip tests for leukocyte esterase
 - Principle
 - Specificity
 - Sensitivity (minimum detectable level)
 - Manufacturers' values
 - Interferences
 - False-positive results
 - False-negative or reduced results
 - Additional comments

Chemical Tests in Routine Urinalysis (13 of 20)

- **Glucose (sugar)** (7)
 - Clinical importance
 - Reagent strip tests for glucose oxidase
 - Principle and specificity
 - Sensitivity (minimum detectable level)
 - Manufacturers' values
 - Interferences
 - False-positive results
 - False-negative or delayed results

Chemical Tests in Routine Urinalysis (14 of 20)

- **Ketone bodies** (8)
 - Clinical importance
 - Reagent strip tests for ketone bodies
 - Principle
 - Acetest tablet test
 - Interferences
 - False-positive results
 - False-negative or reduced results
 - Additional comments

Chemical Tests in Routine Urinalysis (15 of 20)

- **Bilirubin and urobilinogen** (9 & 10)
 - Normal liver function
 - Normal formation and excretion of bilirubin and urobilinogen
 - Clinical importance

Chemical Tests in Routine Urinalysis (16 of 20)

- **Bilirubin**
 - Clinical significance
 - Hemolytic (prehepatic) jaundice
 - Hepatic (hepatocellular) jaundice
 - Obstructive (posthepatic) jaundice

Chemical Tests in Routine Urinalysis (17 of 20)

- **Reagent strip tests for bilirubin**
 - Principle
 - Specificity
 - Sensitivity (minimum detectable level)
 - Manufacturers' values
 - Interferences
 - False-positive or atypical results
 - False-negative or decreased results
 - Additional comments

Chemical Tests in Routine Urinalysis (18 of 20)

- Urobilinogen and porphobilinogen
 - Clinical importance of urobilinogen
 - Clinical importance of porphobilinogen
 - Regent strip tests for urobilinogen
 - Principle
 - Specificity
 - Sensitivity (minimum detectable level)
 - Manufacturers' values
 - Interferences
 - False-positive results
 - False-negative or decreased results
 - Additional comments

Chemical Tests in Routine Urinalysis (19 of 20)

- Laboratory findings in types of jaundice
 - Unconjugated blood bilirubin
 - Normal: 0 to 1.3 milligrams per deciliter
 - Hemolytic (prehepatic): Increased
 - Hepatic (hepatocellular): Increased (varies)
 - Obstructive (posthepatic): Normal
 - Conjugated urine bilirubin
 - Normal: Negative
 - Hemolytic (prehepatic): Negative
 - Hepatic (hepatocellular): Increased (varies)
 - Obstructive (posthepatic): Increased

Chemical Tests in Routine Urinalysis (20 of 20)

- Laboratory findings in types of jaundice
 - Urine urobilinogen
 - Normal: less than 1 milligram per deciliter
 - Hemolytic (prehepatic): Increased
 - Hepatic (hepatocellular): Increased or absent
 - Obstructive (posthepatic): None (decreased)
 - Color of feces
 - Normal: Normal (brown)
 - Hemolytic (prehepatic): Increased (dark brown)
 - Hepatic (hepatocellular): Normal or pale
 - Obstructive (posthepatic): Pale, chalky white ("alcoholic")

Microscopic Analysis of Urine Sediment (1 of 2)

- Urine sediment refers to all solid materials suspended in the urine specimen.
- Specimen requirements
 - Type of specimen
 - Preservation
 - Protection from contamination
- Normal sediment
- Techniques for examination of urine sediment
 - Microscopic techniques
 - Brightfield microscopy
 - Phase-contrast microscopy
 - Plane-polarizing microscopy

Microscopic Analysis of Urine Sediment (2 of 2)

- Laboratory procedure
- Specimen preparation (concentration)
- Standardization

Constituents of Urine Sediment (1 of 9)

- Cellular constituents
 - Red blood cells (erythrocytes)
 - Clinical importance
 - Microscopic appearance
 - Structures confused with red cells
 - Other considerations

Constituents of Urine Sediment (3 of 9)

- **White blood cells (leukocytes)**
 - Clinical importance
 - Microscopic appearance
 - Structures confused with white cells
 - Other leukocytes in sediment
 - Gitter cells
 - Eosinophils
 - Lymphocytes and other mononuclear cells

Constituents of Urine Sediment (5 of 9)

- **Epithelial cells**
 - Squamous epithelial cells
 - Clue cells

Constituents of Urine Sediment (7 of 9)

- Transitional epithelial (urothelial) cells
- Renal epithelial cells
 - Renal epithelial fragments
 - Oval fat bodies
 - May have numerous highly refractile fat globules and other inclusions
 - Fat globules
 - Hemosiderin
 - Viral inclusion bodies

Constituents of Urine Sediment (9 of 9)

- **Casts**
 - Formation and significance
 - Identification and morphology
 - Classification of casts

Morphologic Classification of Casts

- | | |
|---|---|
| <ul style="list-style-type: none"> • Hyaline cast • Cellular cast <ul style="list-style-type: none"> • White blood cell (leukocyte, neutrophil, pus) cast • Epithelial cell cast • Red blood cell (blood, hemoglobin, hemoglobin pigment) cast • Bacterial cast • Granular cast, coarse and fine • Waxy cast • Fatty cast • Oval fat body cast | <ul style="list-style-type: none"> • Pigmented casts <ul style="list-style-type: none"> • Hemoglobin (blood) cast • Myoglobin cast • Bilirubin cast • Drug pigment cast • Inclusion casts <ul style="list-style-type: none"> • (Granular cast) • (Fatty cast) • Hemosiderin cast • Crystal cast |
|---|---|

Constituents of Urine Sediment (9 of 10)

- Structures confused with casts
 - Mucous threads
 - Rolled squamous epithelial cells
 - Disposable diaper fibers
 - Other structures

Constituents of Urine Sediment (10 of 10)

- Crystals and amorphous material
 - Clinical significance
 - Classification of urine crystals
 - Identification and reporting of urine crystals

Normal Crystals Found in Urine Sediment

- | | |
|---|---------------------------------|
| <i>Normal acid crystals</i> | <i>Normal alkaline crystals</i> |
| • Amorphous urates | • Amorphous phosphates |
| • Uric acid | • (Calcium oxalate) |
| • Acid urates | • Triple phosphate |
| • Monosodium or sodium urates | • Ammonium biurate |
| • Calcium oxalate (also seen in neutral and alkaline urine) | • Calcium phosphate |
| | • Calcium carbonate |

Abnormal Crystals Found in Urine Sediment

- | | |
|--|---|
| <i>Abnormal crystals of metabolic origin</i> | <i>Abnormal crystals of iatrogenic origin (drugs)</i> |
| • Cystine | • Sulfonamides |
| • Tyrosine | • Sulfamethoxazole |
| • Leucine | • Acetylsulfadiazine |
| • Cholesterol | • Sulfadiazine |
| • Bilirubin | • Ampicillin |
| • Hemosiderin | • Radiographic contrast media |
| | • Acyclovir |
| | • Indinavir sulfate |

Constituents of Urine Sediment (1 of 3)

- Other cellular constituents
 - Spermatozoa
 - Bacteria
 - Yeast
 - Parasites
 - Trichomonas vaginalis
 - Other parasites
 - Tumor cells

Constituents of Urine Sediment (2 of 3)

- Contaminants and artifacts
 - Starch
 - Fibers (including disposable diaper fibers)
 - Air bubbles
 - Oil droplets
 - Glass fragments
 - Stains
 - Pollen grains
 - Fecal contamination

Constituents of Urine Sediment (3 of 3)

- Specimen changes on standing
 - RBC distortion
 - WBC disintegration
 - Cast disintegration
 - Components of acidic urine disappear as urine becomes alkaline.
 - Bacteria multiply rapidly

Automation in Urinalysis

- **Semiautomated systems**
 - An analyzer is used to read commercial reagent strip results of chemical examination using an instrument.
- **Fully automated systems**
 - Instruments of this type determine the physical characteristics of color, clarity, and specific gravity but use various methods.
- **Automated microscopy**
 - Microscopic examination of urinary sediment can be automated through the use of digital imaging.

MLT 101 Urinalysis Case Study — L3-O12 (Student Version)

Objective (L3-O12): Evaluate specimen acceptability and test reliability before reporting.

Clinical Scenario

Patient: J.S., 23-year-old female with dysuria, urinary frequency, and low-grade fever (38.0 °C). Provider orders: Urinalysis with reflex to culture if indicated.

Specimen A — Preanalytic Details

Collection: 10/31/2025 07:40, clean-catch midstream (CCMS), properly labeled.

Transport: Delivered to lab 11:55 (~4 h 15 min after collection), kept at room temperature; no preservative; volume 6 mL.

Container: Screw-cap urine cup intact; no leakage.

Specimen A — Physical/Chemical Results

Appearance/Odor: Dark yellow, cloudy; strong ammoniacal odor noted on receipt.

Reagent strip run at 12:10 using lot UA-452; bottle observed uncapped on bench earlier in the morning.

Strip timing used: one universal 60-second read for all pads.

Results: SG 1.015 | pH 8.5 | Glucose NEG | Bilirubin NEG | Ketone NEG | Blood TRACE | Protein 1+ | Urobilinogen 0.2 mg/dL | Nitrite POS | Leukocyte esterase 3+

Specimen A — Microscopic Results (12:30)

Squamous epithelial cells: Many (>20/LPF)

WBC: 15–25/HPF | RBC: 0–2/HPF | Bacteria: Many | Casts: None seen

Quality Control / System Review

Daily QC: Positive and negative controls acceptable at 08:00 for nitrite, LE, protein, SG, pH.

Environment/handling: Strip bottle found uncapped at ~10:30; ambient humidity noted. Operator read all pads at 60 s (manufacturer's IFU requires LE at 120 s).

Analyzer: Manual strip reading with timer; microscope calibrated last week; centrifuge maintenance current.

Questions for Class Discussion

- 1) Acceptability Check (Preanalytic): Based on time/temperature, container, volume, labeling, and preservation, is Specimen A acceptable for UA? Circle: ACCEPT / REJECT. Briefly justify.
- 2) Identify at least four preanalytic variables that could impact accuracy for Specimen A.
- 3) Analytic Reliability: Evaluate the reliability of EACH pad result given the handling and timing. Flag which results are most at risk for false change (↑/↓) and explain why.
- 4) Microscopy Correlation: Interpret the sediment considering aging/alkaline urine effects. Which elements may be under- or over-represented?
- 5) Postanalytic Decision: Would you report these UA results for patient care? If no, state corrective action(s) (e.g., recollection, notation) and whether to culture.
- 6) Draft a final report comment (2–3 sentences) to communicate acceptability and next steps to the provider.
- 7) Education/Prevention: List three concrete steps to prevent recurrence of these issues.

Specimen B — Repeat (For Comparison)

Collection: 10/31/2025 14:05, CCMS; received 14:20; refrigerated at 4 °C on arrival; analyzed 14:40.

Physical: Yellow, slightly cloudy; no strong ammonia odor.

Strip (IFU-timed reads): SG 1.025 | pH 6.0 | Glucose NEG | Ketone NEG | Blood NEG | Protein trace | Urobilinogen 0.2 mg/dL | Nitrite NEG | LE 1+

Microscopy: Squamous 0–5/LPF | WBC 10–15/HPF | RBC 0–2/HPF | Bacteria few | Casts: Hyaline 0–2/LPF

Use Specimen B only after you complete Tasks 1–6 for Specimen A. Then answer:

- 8) Should Specimen B be accepted and reported? Would you reflex to culture based on institutional criteria? Defend your answer.

Microscopy 1 Laboratory Objectives

Cognitive Objectives (Knowledge & Thinking Skills)

By the end of this lab, the student will be able to:

1. List and briefly describe the function of major structures of a c
 2. Define key microscopy concepts: field of view, depth of field, and phase contrast microscopy.
 3. Explain the relationship between magnification and field of view, and how this affects specimen examination.
 4. Describe how depth of field changes with magnification and its importance in distinguishing overlapping structures.
 5. Differentiate between brightfield and phase contrast microscopy in terms of principle and application.
 6. Identify common elements in wet mount preparations: fibers, cheek cells (with and without stain), and urine sediment components (RBCs, WBCs, epithelial cells, bacteria, crystals, casts).
 7. Discuss the clinical relevance of observing unstained vs. stained specimens.
 8. Summarize appropriate safety precautions when handling biological specimens and laboratory glassware.
 9. Evaluate the advantages and limitations of using wet mounts for clinical diagnostics.
-

Psychomotor Objectives (Hands-on Skills)

By the end of this lab, the student will be able to:

1. Prepare a wet mount slide correctly using proper technique to minimize air bubbles.
2. Demonstrate correct use of the compound microscope, including scanning, centering, and focusing at 4x, 10x, and 40x.
3. Apply systematic scanning techniques to ensure thorough evaluation of specimens at higher magnification.
4. Perform a cheek cell collection safely using sterile cotton swabs.
5. Stain cheek cells with methylene blue and distinguish cell membrane, cytoplasm, and nucleus.
6. Use fine focus adjustment to visualize different planes of depth in overlapping fibers and urine sediment.
7. Operate the microscope in both brightfield and phase contrast modes, adjusting illumination for optimal viewing.
8. Handle biological specimens and slides safely, applying Standard/Universal Precautions and correct waste disposal.
9. Record microscopic observations accurately using appropriate terminology.
10. Clean and properly store the microscope after use.

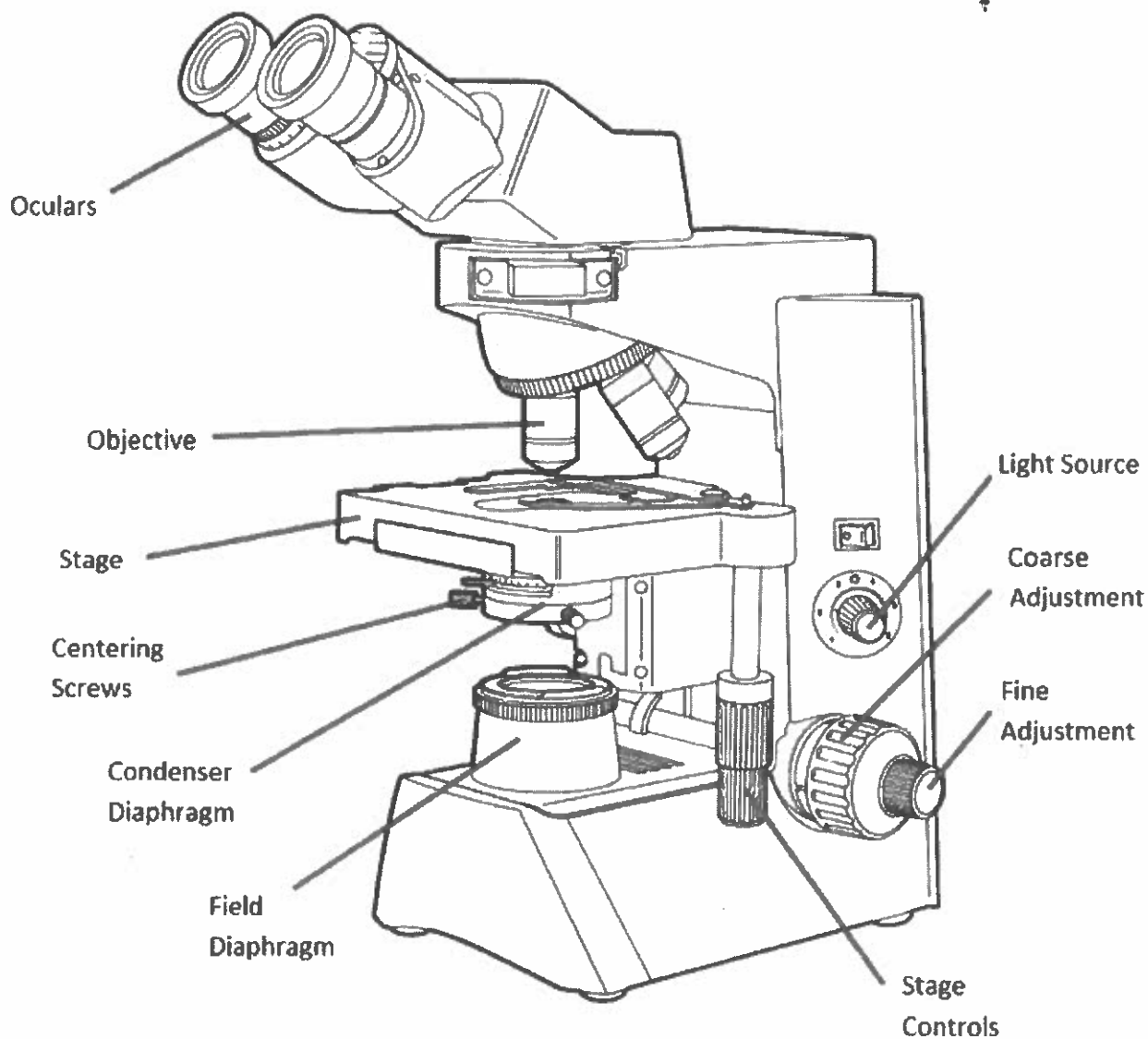


Sections of the Microscope

Introduction

Microscopy has a very important role in microbiology laboratories. A microscope is an essential tool for viewing microorganisms that are too small to be seen by the naked eye.

To use your microscope effectively and efficiently in your daily routine, it is necessary that you become familiar with the major sections of the microscope.



Functions of the Microscope Sections

Centering Screws — two screws attached to the condenser diaphragm used to center the light in Kohler illumination.

Coarse Adjustment Knob — used for rapid or rough positioning of the specimen at the focal point of the objective lens.

Condenser Diaphragm — the lens system beneath the microscope stage, positioned to concentrate light correctly on the specimen and direct the light rays into the objective. It is either a rotating disc or an iris diaphragm on the condenser used to direct the appropriate wide/slender illumination cone to the specimen and entering the objective.

Field Diaphragm — an iris diaphragm, usually located on the base of the microscope, that controls the amount of light that enters the condenser diaphragm.

Fine Adjustment Knob — exactly positions the specimen at the focal point of the objective lens.

Iris Diaphragm — An iris diaphragm is an adjustable opening made of thin metal leaves. It controls the amount of light that passes through.

Light Source — Usually located in the base of the microscope. It is responsible for shining light on the specimen on the slide.

Objectives — The lens system nearest the specimen used to magnify and direct image-forming rays of the specimen to the oculars, where they are further directed and magnified. Objectives are most important for determining the quality of the image produced.

Oculars — Magnifying lens system of the microscope nearest to the eyes. Further enlarges the image produced by the objective.

Stage Controls — Controls under the stage of a microscope that move the stage back and forth for examination of a specimen slide.

Care and Maintenance of the Microscope

Introduction

Regular maintenance of your microscope will improve its performance. You should have a professional maintain your microscope each year. In addition, you should clean the base and frame of your microscope by lightly wiping with a damp cloth or wet wipe after each use. Follow the instructions in this job aid regularly to clean the glass parts of your microscope.

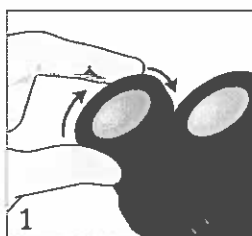
Avoid wearing eye makeup when using your microscope — especially mascara. It can leave debris that is hard to remove.

Supplies

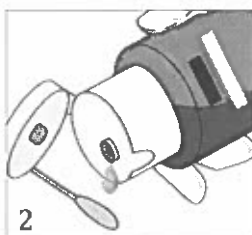
- Commercial lens paper
- Commercially available lens cleaner

Instructions

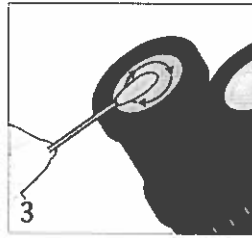
1. To determine if your oculars are clean, rotate each one between your fingers to identify debris.



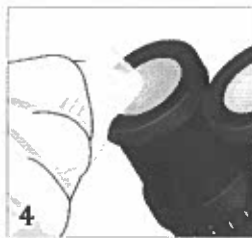
2. Moisten a piece of lens paper with lens cleaner.



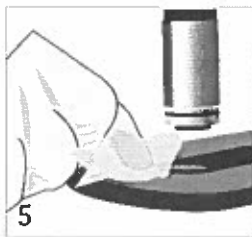
3. Working from the center out, in a circular motion, gently clean the oculars and objectives.



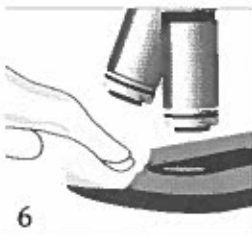
4. Dry with a clean, dry lens paper.



5. Clean the stage of the microscope with a clean lens paper moistened with lens cleaner.



6. Thoroughly dry the stage with a new piece of lens paper.



7. Wipe off the top of the condenser with a clean lens paper moistened with lens cleaner.



8. Dry the condenser with a dry piece of lens paper.



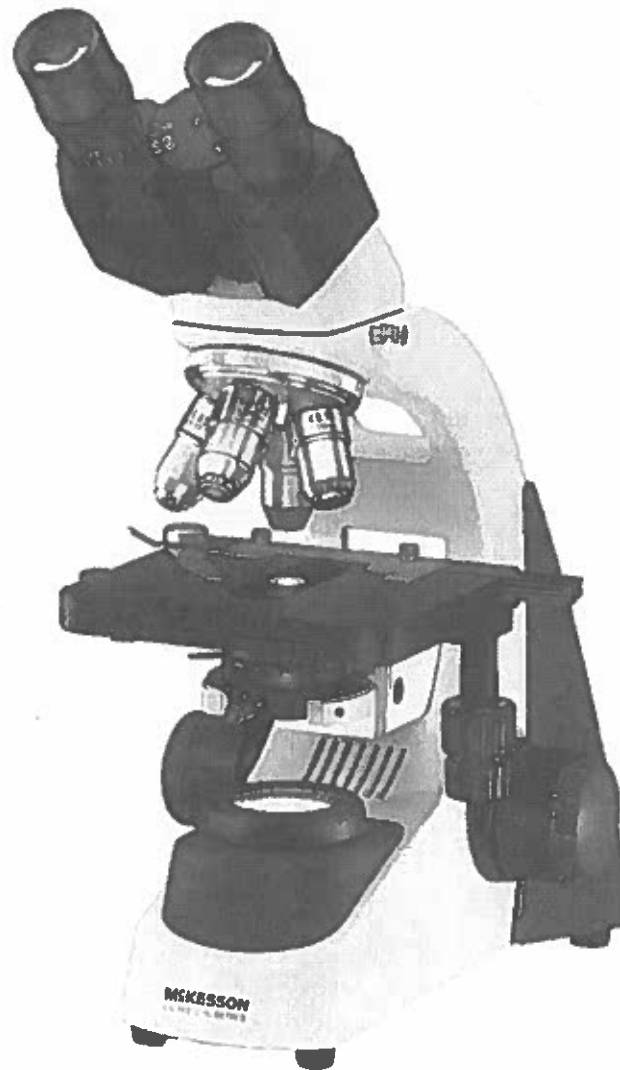


McKESSON

LUMEN. SERIES

BINOCULAR MICROSCOPE PHYSICIAN OPERATION MANUAL

For use with MFR # 600R-LED.



McKESSON LUMEON® BINOCULAR MICROSCOPE

Thank you for choosing the McKesson LUMEON® Binocular Microscope. This precisely built, durable microscope will give years of service to even the busiest office practice. Our technical and customer support departments are ready to assist you with any questions or comments you may have. If ever you require an additional accessory or spare part, please contact your local McKesson Medical-Surgical Inc. representative.

UNPACKING McKESSON LUMEON® BINOCULAR MICROSCOPE

Each McKesson LUMEON® Microscope has been packed with utmost care. Please take a moment to examine the outer and inner cartons for any visual damage. We recommend that you keep all of the packing material until you have fully assembled, examined and tested your new microscope. If you note any damage, please contact the shipping company or your representative.

Unpack the McKesson LUMEON® Binocular Microscope using the following checklist for the parts and accessories. (Your specific order may vary)

- (1) Microscope stand with Abbe condenser
- (1) Binocular head
- (2) 10x eyepieces
- (4) Achromatic objectives 4x, 10x, 40xr and 100xr (oil)
- (2) Replacement fuses (1.5A)
- (1) Dust cover
- (1) Operation manual

If any parts are missing, please contact your McKesson Medical-Surgical Inc. representative.

The McKesson LUMEON® Binocular Microscopes were designed with the user in mind. Whether it for use in a busy medical or veterinary practice, a research department, or for anyone else needs the best and most versatile microscope available, the McKesson LUMEON® series has a model to meet your needs.

Objectives:

Each McKesson LUMEON® Binocular Microscope comes equipped with 4 achromatic DIN flat field objectives (optional Semi-plan and Plan objectives are available). The color-coded, polished objectives are parfocal and parcentertric. The 100X (oil) and the 40X (high dry) are spring loaded to prevent damage.

Eyepieces:

Two Widefield 10X 18mm high eyepoint eyepieces are included with each McKesson LUMEON® Binocular Microscope. The tube size is standard 23.2mm. The specialized high eyepoint eyepieces are designed to reduce eyestrain while wearing glasses.

Head:

The head of the McKesson LUMEON® Binocular Microscope is Siedentopf style. Optional trinocular head is available. Each can be set for individual requirements and comfort. The eyepiece tube size is standard 23.2mm.

Additional McKesson LUMEON® Binocular Microscope features:

- Large mechanical stage (135mm x 150mm) with low mounted coaxial controls. The stage upper-movement limit (safety lock) can be set as desired to protect slides as well as objectives.
- Coaxial coarse and graduated fine focusing knobs with tension adjustment control
- Moveable Abbe condenser (N.A.1.25) with iris diaphragm.
- Pre-aligned illumination.
- Universal power input from 110V/60Hz to 230V/50Hz

ELECTRONICS

McKesson LUMEON® Binocular Microscope uses U/L and CSA approved electrical components. The circuit board in the base of the unit contains all the electrical functions. There are no user repairable parts on the circuit board.

Power Input: AC 115V/60Hz - 220V/50Hz universal.

Output: 4.5V; LED bulb circuitry.

Fuse: 1.5 Amp.

The fuse protects the circuit board from electrical overload. The fuse case is part of the power inlet socket located in the back of the microscope. When replacing the fuse, always install a new one of the same size and amperage.

**McKESSON LUMEON® BINOCULAR MICROSCOPE
ASSEMBLY INSTRUCTIONS**

1. Remove the stand of the microscope and place it on a sturdy, dust free surface. Set the base so that the McKesson LUMEON® label faces you.
2. Locate the nosepiece and remove the plastic dust plugs. Save these in individual objective containers. **NOTE:** Objectives may be pre-installed for you.
3. Install the objectives. Each objective is packed in an individual plastic container. Remove each objective from its container, save the containers in the styrofoam carton. Install the objectives in the following order: 4x, 10x, 40x, 100x. Make certain that they are screwed in all of the way.
4. Remove the microscope head from the styrofoam carton. Remove the plastic dust plugs from the eyepiece tubes as well as the protective plastic cover from the head (save the protective plastic parts). Plug on base the upper part of the arm and secure with the retention screw.

Note: Do not over tighten.

5. Carefully unwrap the protective tissue from the eyepieces and slide one in each eye tube.
6. Slide holder: The slide holder has already been installed on the mechanical stage. If you ever need to remove the slide holder, locate the holding screws. Loosen the two holding screws and remove the slide holder by sliding forward. When you replace the slide holder, do not over tighten the holding screws.

USING McKESSON LUMEON® BINOCULAR MICROSCOPE

Note: If the microscope has been exposed to extremes of temperature, please allow time for all the parts to come to room temperature before turning on the power. Excess cold can fog the lenses and may cause the bulb to fail.

1. Once you have assembled all the parts, plug the power cord into the power inlet at the rear of the stand and plug another end of the power cord into the AC outlet (110V/60Hz – 230V/50Hz).
2. The illumination control (intensity rheostat) wheel is located on the left side of the base. It turns the illuminator On/Off. Turn the control wheel to the brightness desired. To turn off the illumination, simply reverse the turning until you hear a click stop.
Note: Rapid repeated changes in light intensity would dramatically shorten the life of the bulb.
3. In order to speed up your familiarity with controls, choose a specimen slide you are familiar with, such as an old hematology slide or a commercially prepared slide. Place the slide into the slide holder by pushing back on the thumb guard and placing the slide toward the back of the holder. Allow the metal slide holder to gently hold the slide in place.
Note: Do not allow the slide holder to “snap-back” against the slide, this could cause the slide to chip or shatter.
4. Move the slide to the center of the stage, by turning the mechanical stage control knobs, just below the stage on the right side. These knobs allow you to move the slide in the X-Y axis (left-right and forward-backward).
5. Open the aperture of the iris diaphragm on the Abbe condenser (controlled by the small black lever on the condenser).
6. Once you are comfortably seated, look into the oculars and move the eyepiece tubes together or apart until you see only one complete circle of light. You have now adjusted the interpupillary distance. The interpupillary distance range is 55-75mm.
7. **Focusing procedures:**
 - 7.1.1 Bring the 4x objective into working position. As you bring the objective into place, will feel a “stop” (clicking) when the objective is seated properly. Use the coarse and fine adjustment knobs to locate the image and bring the 4x objective into focus.

- 7.1.2 Move the 10x objective into place. Minor coarse adjustment may be needed yet the fine focusing knob is needed to bring the 10x objective into focus.
- 7.1.3 Rotate to the 40x objective. Focus with fine focusing knob for the best image.
- 7.1.4 You will now be in the middle of the focus range. You may have to adjust the aperture diaphragm (on the condenser) for the best contrast.
- 7.1.5 Immersion oil is required when 100X Oil objectives is used. Never allow 40X or other dry objectives to touch immersion oil!

Note: *Make sure the slide cover glass must be 0.17mm or less in thickness.*

8. Diopter adjustment:

If you are using a binocular microscope, you have to adjust for the normal difference in vision between your two eyes. This is a simple but critical adjustment! McKesson LUMEON® Binocular Microscope has dual diopter adjustment rings located on each eye tube of the Siedentopf head. Follow the following procedures:

- Set both diopters at "0".
- Close your left eye and with your right eye open, look into the right ocular.
- Adjust the fine focus to give you the best image. Do not touch the diopter on the right eye tube.
- Close your right eye and look with your left eye into the left ocular.
- Rotate the adjustment (diopter) ring on the left ocular tube until you see a clear focused field.

9. Focus Tension Control:

Focus tension has been pre-adjusted. If needed, the focus tension can be adjusted at any time without tools. To adjust the tension of your focusing controls, simply turn the tension control ring. This knurled ring is located on the right side between the microscope stand and the focusing knob.

Note: Removing too much tension may cause the stage to drift down.

10. Mechanical Stage Safety Stop (Upper Limit Setting)

The safety stop is provided to help prevent objectives and slide damage. The safety stop sets the upper limit movement of the mechanical stage. The safety stop setting screw is located on top of stage driving block (behind the mechanical stage. Refer to the photo with nomenclature on page 9).

The stage upper limit is preset. If adjustment is needed, turn the setting screw with a screw driver to set the desired upper limit.

Note: Improper stage upper limit setting may cause high power objective unable to focus. (The slide should almost touch the top lens of 40X objective (the top lens of the 40X objective is retractable).when the stage is raised to its highest limit)

You are now ready to use your McKesson LUMEON® Binocular Microscope.

FUSE REPLACEMENT

A 1.5 Amp fuse protects the circuit board from electrical overload. The fuse case is part of the power inlet socket located in the back of the microscope. When replacing the fuse, always install a new one of the same size and amperage (MFR# 599).

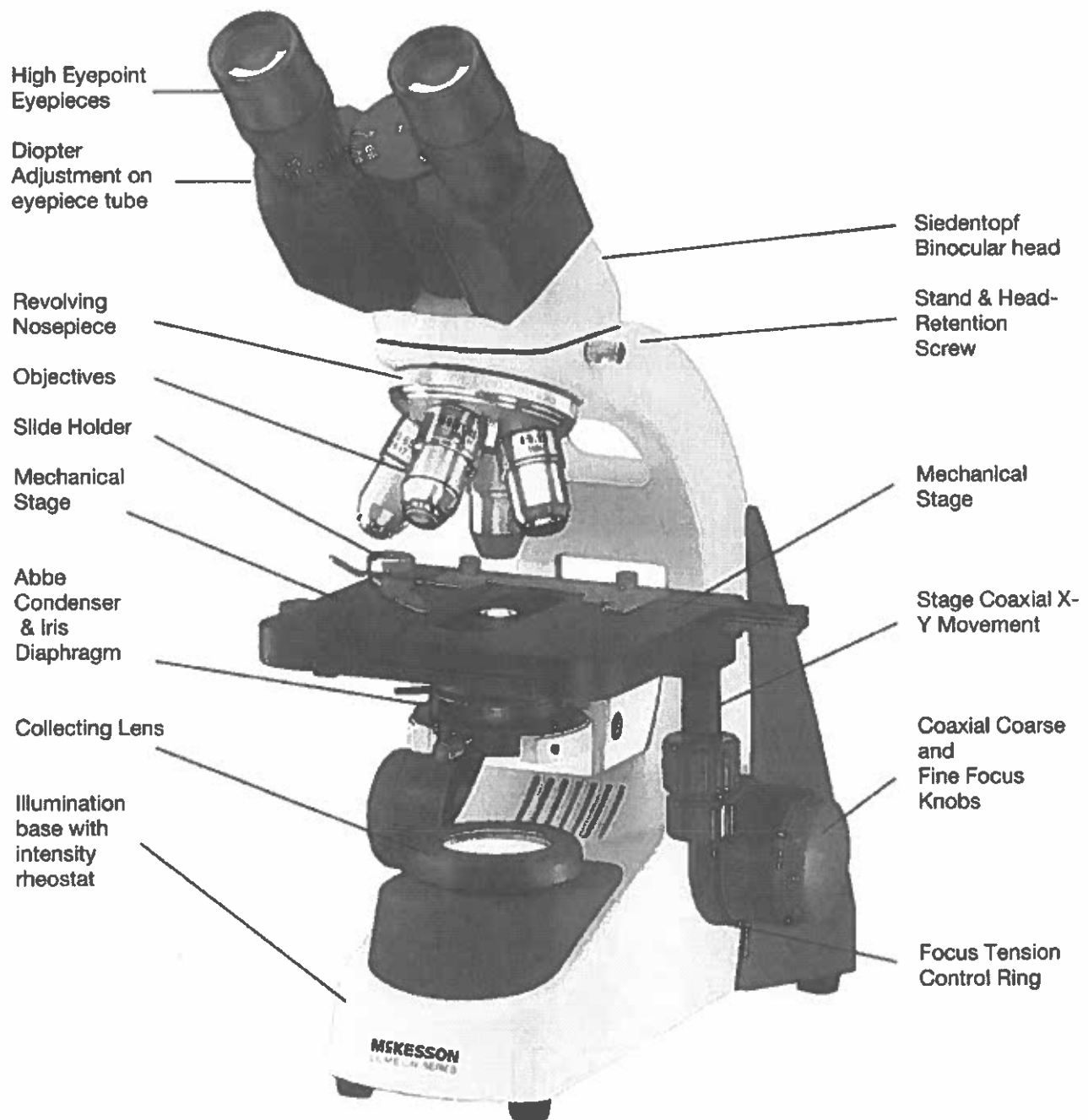
Caution: Always unplug the microscope before changing fuse.

Follow the procedures below to replace the fuse:

- a) Unplug the power cord. Turn the illuminator control wheel to "off"
- b) Remove the power cord from the power inlet on the back of the microscope.
- c) Locate the fuse holder. The fuse holder is a part of the power inlet.
- d) Use a flat head type screwdriver to take the snap-in type holder cover off. Remove the blown fuse and replace it with the same type and rating fuse which is: 250V /1.5A
- e) Put the snap-in fuse holder back.

MAINTENANCE

1. Always cover your microscope with the dust cover when not in use.
2. When cleaning the lenses, use lens paper or a Q-tip dipped in lens cleaning solution.
3. Excess immersion oil should be cleaned of at once. An alcohol pad is best for removing oil from the stage and on the other metal parts, but is not recommended for use on the lenses.
4. Dust in the nosepiece or ocular tubes should be blown out using only filtered air. Canned air dusters work well for this job.
5. Whenever you remove an objective, we recommend that you place the plastic cap over the hole and put the objective back into the original plastic shipping vial until ready to be placed back on the microscope. This will keep the objective safe from dust and other foreign matter.
6. To keep your microscope in top condition for years, we recommend that you have the microscope professionally serviced once a year.



McKesson LUMEON® Binocular Microscope

McKESSON

Questions? Call 1-800-777-4908

■ Satisfaction Guaranteed

If you are not completely satisfied with any McKesson Brands product, you may return it for a full refund or credit.

Distributed By McKesson Medical-Surgical Inc.
Richmond, VA 23233
Rev. 00 06/15
Made in China

Discussion

The preparation of wet mounts is a fundamental skill in the clinical laboratory, allowing direct visualization of cells, microorganisms, and artifacts without extensive processing. The procedures performed with fibers, cheek cells, and urine sediment provide practical demonstrations of key microscopy concepts that affect specimen interpretation:

Field of View

Definition: The circular area visible through the microscope eyepiece.

Key concept:

- As magnification increases, the field of view decreases. This trade-off allows finer details to be seen but limits the amount of the specimen visible at one time.
- At 4x, the field of view is wide, making it useful for scanning across the slide and locating areas of interest.
- At 40x, the field of view is smaller, requiring precise centering of the area to be studied.

Application:

- In urine sediment examination, the reduced field of view at higher magnifications requires systematic scanning to ensure all cellular elements are evaluated.
- In cheek cells, centering the nucleus at low power ensures it remains visible as magnification increases.

Depth of Field

Definition: The vertical thickness of the specimen that remains in focus at any one time.

Key concept:

- At low magnification depth of field is greater, allowing multiple planes to appear in focus simultaneously.
- At higher magnification depth of field narrows, so only a very thin optical slice is sharp at one time. This is critical when examining urine sediment, where overlapping cells and casts require careful fine focusing to distinguish layers.

Remember, you are looking at 3D objects.

Demonstration: The crossed fiber slide clearly illustrates depth of field as the observer focuses “through” each thread to determine which lies on top, middle, or bottom.

Phase Contrast Microscopy

Principle: Phase contrast microscopy enhances differences in refractive index between structures within a specimen. Instead of staining (which can alter or kill cells), phase contrast uses special optics to convert phase differences in light into contrast that the eye can see.

Application:

- Useful for viewing unstained cheek cells, allowing visualization of the nucleus, cytoplasm, and cell boundaries in their natural state.

- Particularly valuable in urine sediment examination, where bacteria, crystals, and hyaline casts may be faint or nearly invisible under brightfield illumination.

Safety Precautions

- Treat all biological specimens (e.g., cheek cells, urine) as potentially infectious.
- Use Standard/Universal Precautions at all times.
- Required PPE: gloves, lab coat, protective eyewear.
- Dispose of biological waste and coverslips in designated containers.
- Handle glass slides carefully to prevent cuts or contamination.

Materials and Equipment

- Compound microscope with 4x, 10x, and 40x objectives
- Glass slides and coverslips
- Sterile cotton swabs (for cheek cell collection)
- Transfer pipettes
- Methylene blue
- Clean fibers
- Fresh urine sediment
- Centrifuge and conical centrifuge tubes (urine sediment prep)
- Lens paper and microscope cleaning solution

Goals

- Fibers: Demonstrates overlapping structures and depth of field.
- Cheek cells: Clear visualization of nucleus and cytoplasmic details.
- Urine sediment: Identification of RBCs, WBCs, epithelial cells, bacteria, crystals, and casts.

Procedure

1. Wet Mount of Fibers

1. Place a clean glass slide on the work surface.
2. Position 2-3 small colored fibers overlapping in the center.
3. Add 1 drop of distilled water over the fibers.
4. Gently lower a coverslip at a 45° angle to avoid air bubbles. See figure
5. Examine under 4x objective, center the specimen, then proceed to 10x and 40x.
6. Record observations (e.g., overlapping planes, depth of field).

2. Stained Wet Mount of Cheek Cells

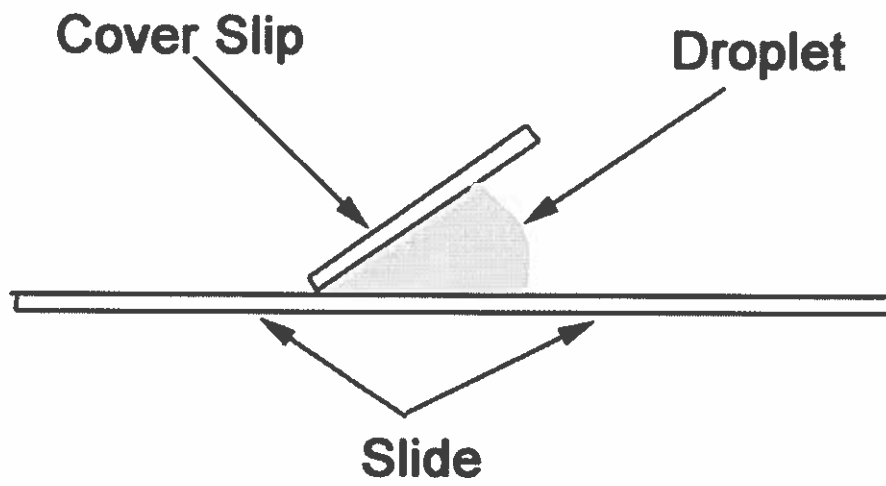
1. Wash hands and don gloves.
2. Use a sterile cotton swab to gently scrape the inside of the cheek.
3. Smear material evenly in the center of a clean slide.
4. Add 1 drop of saline.
5. Add 1 drop of methylene blue to stain the nucleus.
6. Place a coverslip at a 45° angle to avoid bubbles.
7. Examine microscopically, beginning at 4x, then 10x, and 40x.
8. Identify cell membrane, cytoplasm, and nucleus.
9. Record observations.

3. Unstained Wet Mount of Cheek Cells

1. Wash hands and don gloves.
2. Use a sterile cotton swab to gently scrape the inside of the cheek.
3. Smear material evenly in the center of a clean slide.
4. Add 1 drop of saline.
5. Add 1 drop of methylene blue to stain the nucleus.
6. Place a coverslip at a 45° angle to avoid bubbles.
7. Examine microscopically, beginning at 4x, then 10x, and 40x.
8. Identify cell membrane, cytoplasm, and nucleus.
9. Record observations.

4. Wet Mount of Urine Sediment

1. Resuspend the sediment by gently shaking the tube.
2. Place 1 drop of sediment on a clean slide.
3. Add a coverslip carefully to avoid bubbles.
4. Examine under 4x, 10x, and 40x.
5. Record observations.



Standard Operating Procedure (SOP)

Title: KOVA® Urine Microscopic Analysis System

1.0 Purpose

To provide a standardized procedure for the preparation, examination, and reporting of urine sediment using the **KOVA System**, ensuring accuracy, precision, and consistency across all urine microscopic analyses.

2.0 Principle

The **KOVA System** provides a **standardized urine sediment examination** using calibrated tubes, fixed-volume pipettes, and a counting chamber. This eliminates variability in sediment concentration and viewing area, allowing for reproducible microscopic quantitation of formed elements (cells, casts, crystals, microorganisms, and other structures).

3.0 Specimen Requirements

- **Specimen Type:** Freshly voided, clean-catch midstream urine.
 - **Minimum Volume:** 10–12 mL.
 - **Storage:**
 - Analyze within **2 hours** of collection.
 - If delayed, refrigerate at **2–8°C** and analyze within **4 hours**.
 - **Reject if:**
 - Specimen contaminated or unlabeled.
 - Excessive delay before analysis.
 - Insufficient volume or visible debris from improper collection.
-

4.0 Reagents, Supplies, and Equipment

- KOVA® tubes (calibrated 12 mL centrifuge tubes).
- KOVA® Glasstic® Slide 10 with grid.

- KOVA® Pipette or equivalent fixed-volume transfer pipette (1 mL).
 - Centrifuge (calibrated, 400 × g).
 - Disposable pipettes, gloves, lens tissue, laboratory wipes.
 - Microscope (bright-field, 10× and 40× objectives).
 - Personal protective equipment (PPE).
-

5.0 Procedure

5.1 Preparation

1. Mix urine specimen gently to suspend elements.
 2. Transfer **12 mL** of urine into a **KOVA tube**.
 3. Centrifuge at **400 × g for 5 minutes**.
 4. Carefully decant supernatant, leaving **1 mL** of urine sediment.
 5. Gently resuspend sediment by flicking the tube or using a pipette.
-

5.2 Loading the KOVA Glasstic Slide

1. Using the **KOVA pipette**, aspirate **one drop (≈15–20 µL)** of mixed sediment.
 2. Apply to one chamber of the **KOVA Glasstic Slide 10**.
 3. Ensure the chamber fills evenly by capillary action; avoid bubbles.
 4. Let the slide stand for **30–60 seconds** for sediment elements to settle.
-

5.3 Microscopic Examination

1. Place slide on microscope stage.
 2. Examine using **10× objective** for low-power field (LPF) overview:
 - Note casts and large structures.
 3. Switch to **40× objective** for high-power field (HPF):
 - Identify and count cells, crystals, bacteria, yeast, and other elements.
 4. Use the **calibrated grid** on the Glasstic slide for standardized counts.
-

6.0 Reporting Results – see (SOP)Urine Microscopic Reporting Guidelines

7.0 Quality Control

- Perform analysis on **KOVA-Trol® Urinalysis Controls** daily.
 - Record QC results and verify within manufacturer's established ranges.
 - Reject QC if results are outside acceptable limits; investigate cause and document corrective action.
 - Maintain **centrifuge calibration** (speed and time) quarterly.
-

8.0 Limitations

- Improper centrifugation or incomplete resuspension can affect counts.
 - Delay in testing may cause cell lysis or crystal formation.
 - Concentrated specimens may obscure visualization due to debris.
-

9.0 Safety Precautions

- Handle all specimens as **potentially infectious**.
 - Use appropriate **PPE** (gloves, lab coat, eye protection).
 - Dispose of biological waste in accordance with facility and OSHA regulations.
-

10.0 References

1. Clinical and Laboratory Standards Institute (CLSI). **GP26-A4: Application of a Quality Management System Model for Laboratory Services**.
 2. Clinical and Laboratory Standards Institute (CLSI). **GP02-A6: Laboratory Documents—Guideline**.
 3. KOVA® Urinalysis Systems. Manufacturer's Instructions for Use (Hycor Biomedical).
 4. Mundt, L.A., Shanahan, K. **Textbook of Urinalysis and Body Fluids**, 3rd ed. Wolters Kluwer.
-

Standard Operating Procedure (SOP)

Urine Microscopic Reporting Guidelines

(Clinical Microscopy Section — Standardized Reporting Format)

1. Purpose

To ensure **consistent, accurate, and clinically meaningful** reporting of microscopic urine sediment findings by standardizing terminology, quantitation, and reference intervals across all technologists and reporting systems.

2. General Guidelines

- Report only elements **positively identified** by microscopic examination.
- Use **consistent quantitative or semiquantitative terms** (e.g., “rare,” “few,” “moderate,” “many”).
- Include **units of measure** (e.g., per high-power field [HPF], per low-power field [LPF]).
- Use **structured comment fields** for unusual or pathologic findings.
- Avoid ambiguous terms such as *occasional* or *trace* unless defined in laboratory policy.

3. Field Definitions

Element Type	Field of View	Magnification
Cells, bacteria, crystals, yeast	High-power field (HPF)	400×
Casts, mucus, parasites	Low-power field (LPF)	100×

4. Quantitative Reporting Standards

Element	Report As	Normal Range / Reference
Red Blood Cells (RBCs)	0-2, 3-5, 5-10, 10-20, TNTC /HPF	0-2 /HPF
White Blood Cells (WBCs)	0-5, 5-10, 10-20, TNTC /HPF	0-5 /HPF
Epithelial Cells	"Few," "Moderate," "Many" /HPF	Few squamous cells normal
Casts	# /LPF, by type (hyaline, granular, RBC, WBC, waxy, etc.)	None-occasional /LPF
Bacteria	"None," "Few," "Moderate," "Many" /HPF	None
Yeast	"None," "Few," "Moderate," "Many" /HPF	None
Crystals	Identify and semiquantify /HPF	None to few
Mucus	"None," "Few," "Moderate," "Many" /LPF	None to few
Sperm, Trichomonas, or Artifacts	Qualitative description	Not normally present

5. Terminology for Semiquantitative Descriptors

Term	Approximate Count (HPF)
Rare	1-2 per 10 HPF
Few	1-5 /HPF
Moderate	6-20 /HPF
Many	>20 /HPF
TNTC ("Too Numerous To Count")	>50 /HPF

(Note: Facilities may adjust thresholds to match analyzer or local reference validation.)

6. Reporting Conventions

- **Use standard units:** “/HPF” or “/LPF.”
 - **Round counts:** When averaging multiple fields, round to nearest standard category.
 - **Abnormal findings:** Use comments (e.g., “RBC casts present,” “bacteria with WBC clumps—possible infection”).
 - **Nonformed elements:** Crystals, contaminants, or artifacts should be clearly differentiated.
 - **Abnormal casts:** Always specify type and report even if rare (e.g., “1 WBC cast /LPF”).
-

7. Correlation and Reflex Testing

- Correlate microscopic findings with **urine chemistry (dipstick)** results.
 - **Reflex urine culture** if bacteria and pyuria are present.
 - **Confirmatory tests** (e.g., Sudan stain, Hansel’s stain) as indicated by policy.
-

8. Quality Control and Competency

- Perform daily QC using **KOVA-Trol® controls** or equivalent.
- Document counts within acceptable ranges.
- Verify **microscope calibration and field size** annually.
- Competency assessment includes:
 - Sediment identification proficiency.
 - Accurate quantitation and terminology use.
 - Agreement with reference technologist within ± 1 reporting category.

KOVA Plastics System for Standardized Urinalysis

KOVA PLASTICS SYSTEM FOR STANDARDIZED URINALYSIS

Urinalysis, as currently performed in many laboratories, is carried out using various nonstandard procedures. These procedures vary from laboratory to laboratory and often the actual technique within the laboratory varies depending on the person performing the tests.

Sources of variation in conventional urinalysis:

- variable urine volumes
- different centrifugal conditions creating varying amounts of sediment for microscopic examination
- different amounts of sediment collected and suspended under the cover glass
- technique variations among individuals performing the procedure.

To standardize the urinalysis procedure, a constant specimen volume, centrifugal force and sediment volume must be maintained, and a consistent method of microscopic examination and reporting of results should be used. The KOVA Plastics System achieves this standardization by reducing variation, including technique differences among technicians.

INTENDED USE

The KOVA Plastics System offers a procedure and products that can be used to produce standardized results during routine urinalysis. Volume control, consistency and hygiene are provided from collection and transport to microscopic analysis of urine sediment. Standard controls can be used for complete quality control of physical, chemical and microscopic examination test procedures.

ADVANTAGES

If the described procedure is followed consistently, one can use the values obtained in urinalysis with confidence. Clinicians can follow the progress and treatment of patients with certainty; any changes that occur outside the narrower limits that this system allows can be considered significant.

Laboratories may be compared and patients under observation can have their urinalysis done at different laboratories with comparable results.

KOVA PLASTICS SYSTEM AND SYSTEM COMPONENTS

Product Number	Product Description	Determinations Per Package
87153E	KOVA Plastics System Super Pac 1000 w/Caps 100 KOVA Plastics Glasstic Slide 10 (10 chambered), 1000 KOVA Plastics Petters, 1000 KOVA Plastics Super Tubes, 1000 KOVA Plastics Caps	1000
87154E	KOVA Plastics System Super Pac 1000 100 KOVA Plastics Glasstic Slide 10 (10 chambered), 1000 KOVA Plastics Petters, 1000 KOVA Plastics Super Tubes	1000
87162E	KOVA Plastics System Super Pac 1000 with Grids 100 KOVA Plastics Glasstic Slide 10 (10 chambered) w/Grids, 1000 KOVA Plastics Petters, 1000 KOVA Plastics Super Tubes	1000
87155E	KOVA Plastics System Pac II 100 KOVA Plastics Slide II (4 chambered), 400 KOVA Plastics Petters, 400 KOVA Plastics Super Tubes	400
87156E	KOVA Plastics System Value Pac 500 50 KOVA Plastics Glasstic Slide 10 with grids 500 KOVA Plastics Economy Tubes, 100 KOVA Plastics Caps	500
87158E	KOVA Plastics System Value Pac 500 with Grids 50 KOVA Plastics Glasstic Slide 10 (10 chambered), 500 KOVA Plastics Petters, 500 KOVA Plastics Economy Tubes	500
87141E	KOVA Plastics KO-LEC-PAC 500 KOVA Plastics Super Tubes, 500 KOVA Plastics Caps, 500 KOVA Plastics Cups, 500 Labels and 5 Transport Racks	500
87100E	KOVA Plastics Slide II with Grid for quantitation; 100 x 4 well slides; with each 1mm x 1mm grid square	400
87118E	KOVA Plastics Slide II (without grid) 100 x 4 well slides	400
87146E	KOVA Plastics Glasstic Slide IO 100 x 10 well slides in crystal clear Acrylic	1000
87157E	KOVA Plastics Glasstic Slide IO 50 x 10 well slides in crystal clear Acrylic	500
87144E	KOVA Plastics Glasstic Slide IO with Grid 100 x 10 well slides in crystal clear Plexiglas® with quantitation grids; each chamber contains 6.6 µl and has a 3 mm x 3 mm grid with fine divisions of 0.33 mm x 0.33 mm. The test procedure includes a method for quantitating cells per µl of patient samples.	1000

KOVA PLASTICS SYSTEM AND SYSTEM COMPONENTS - CONTINUED

Product Number	Product Description	Determinations Per Package
87137E	KOVA Plastics Super Tube Graduated non-sterile disposable collection and centrifuge tubes made of high impact, unbreakable plastic to eliminate cracking or breaking during centrifugation.	500
87138E	KOVA Plastics Economy Tube As above but in economical, break-resistant styrene plastic.	500
87135E	KOVA Plastics Petter Disposable plastic transfer pipette designed to retain 1.0 ml of urine after centrifugation. The unique lock tip provides a one-step contamination-free decanting method.	500
87139E	KOVA Plastics Cap Recommended to prevent spillage during transportation, as well as aerosol contamination during centrifugation.	500
87136E	KOVA Plastics Decanting Rack Rack for decanting up to 10 specimens.	1 Rack

SPECIMEN COLLECTION AND TRANSPORT

The KOVA Plastics System KO-LEC-PAC is recommended for use in the following manner:

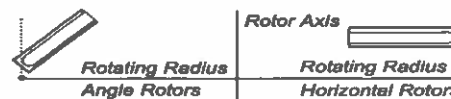
1. Label the KOVA Plastics Tube and give the patient a 3 ½ oz. KOVA Plastics Cup.
2. Instruct the patient to collect the voided urine in the KOVA Plastics Cup.
3. Transfer the urine specimen from the KOVA Plastics Cup to the KOVA Plastics Tube, filling it to the 12 ml graduation.
4. Secure the KOVA Plastics Cap on the KOVA Plastics Tube and place it in the KOVA Plastics Transport Rack for transportation and storage.
5. Deliver to the laboratory as soon as possible, preferably within two hours, but no more than four hours following specimen collection.

KOVA PLASTICS SYSTEM TEST PROCEDURE

1. Check the specific gravity by placing one or two drops of urine in a temperature-compensated refractometer or use a chemistry test strip containing a specific gravity parameter and record the results.
2. Using reagent test strips, perform chemical testing according to the manufacturer's instructions. Record the observed results. Controls should be included in each batch to ensure proper quality control of physical, chemical and microscopic test procedures.
3. Centrifuge the KOVA Plastics Tubes (each containing 12ml of urine specimen or Control) at a relative centrifugal force (rcf) of 400 for five minutes; approximately 1500 revolutions per minute (rpm) with a 6-inch radius rotor. Formula used:

$$rcf = 28.38 (R) \left(\frac{N}{1000} \right)^2 \quad \begin{matrix} R = \text{radius of rotor in inches} \\ N = \text{revolutions per minute} \end{matrix}$$

The rotating radius is the distance measured from the rotor axis to the tip of the liquid inside the tubes at the greatest horizontal distance from the rotor axis.



4. Remove the KOVA Plastics Tubes from the centrifuge, being careful not to disturb or dislodge the sediment.
5. Insert a KOVA Plastics Petter into the KOVA Plastics Tube. Push the KOVA Plastics Petter to the bottom of the KOVA Plastics Tube until it seats firmly (at the 1ml graduation).
6. Decant and discard 11ml from the KOVA Plastics Tube while the KOVA Plastics Petter is locked in position in the KOVA Plastics Tube. This will retain 1ml of urine sediment at the bottom of the KOVA Plastics Tube.
7. Withdraw the KOVA Plastics Petter from the KOVA Plastics Tube.
8. Add one drop of stain to the 1ml of urine sediment.
Note: Stain is an aid to assist in the cellular differentiation of elements and is optional.
9. Using the KOVA Plastics Petter, gently resuspend the sediment and stain until a homogeneous mixture is obtained.

KOVA PLASTICS SYSTEM TEST PROCEDURE - Continued

10. Withdraw a small sample of the urine sediment stain mixture by squeezing the bulb of the KOVA Plastics Petter.
11. Transfer the sediment mixture to the KOVA Plastics Slide by placing one drop in the cut-out notch of each chamber. When chambers 1-5 are on the top row, the notch is at the top left corner of chambers, when chambers 6-10 are on the top row, the notch is at the top right corner of chambers. The chamber will fill by capillary action. Avoid touching the V-shaped barrier between the chambers while dispensing fluid. Incorrect positioning in dispensing may cause overflowing from one chamber to the next.
12. Remove any excess specimen remaining on the open recessed area by touching the open edge with absorbent material.
13. Place the KOVA Plastics Slide on a microscopic stage under the objective lens.
14. Scan the slide chamber under low power magnification (10X eyepiece/10X objective) to enumerate casts. Enumerate all other formed elements under high power magnification (10X eyepiece/40X objective). Do not reuse KOVA Plastics products.

For Gridded slide analysis, refer to KOVA PLASTICS SYSTEM TEST PROCEDURE – GRIDDED

EXPECTED VALUES - MICROSCOPY†

HPF = High Power Field 400X

LPF = Lower Power Field 100X

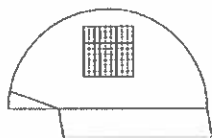
Analyte	Normal	Abnormal	Reporting Results
WBC	0-5/HPF	> 5/HPF	Numbers/HPF
RBC	0-3/HPF	> 3/HPF	Numbers/HPF
Epithelial Cells	0	Any (other than squamous)	Numbers/HPF
Crystals	0-3/HPF (non-pathogenic)	> 3 Any abnormal	Numbers/HPF
Yeasts	0	Any	1 + to 4 +/-HPF
Trichomonads	0	Any	1 + to 4 +/-HPF
Casts	0	Any especially > 1 hyaline cast/LPF	Numbers/LPF
Bacteria	0-5/HPF	> 5/HPF	1 + to 4 +/-HPF
Fat	0	Oval fat bodies or free fat	1 + to 4 +/-HPF

† Bernard Statland, MLO. p 13-14; Jan. 1985

REFERENCES FOR GENERAL INFORMATION

1. Bradley, G.M., Benson, E.S., Todd-Sanford Clinical Diagnosis by Laboratory Methods, 15th Edition, Phila. Saunders, 1974.
2. Kurtzman, N.A. and Rogers, P.W. (1974). A Handbook of Urinalysis and Urinary Sediment. Chas. C Thomas, Springfield, IL.
3. Little, P.J. (1962). Urinary white-cell excretion. Lancet. pp. 1149-1151.
4. Little, P.F. (1964). A comparison of the urinary white cell concentrations with the white cell excretion rate. Brit. J. Urol. 36, 360-363.
5. Thomas, M.(1971). A rapid slide method of urine cell counts. Med. Lab Technol. 28, 38-39.
6. Moore, T., Hira, N.R., and Stirland, R.M. (1965). Differential urethrovaginal urinary cell count. Lancet. pp. 626-627.
7. Siegle, M.D., Lab Med., 12:781, 1981.
8. Sternheimer, R. and Malbin, B. (1951). The clinical recognition of pyelonephritis with a new stain for urinary sediments. Am. J. of Med., 11:312-323.
9. Muschetto, P.A. and Waters, Jr. F.O. (1962). Manual of Medical Laboratory Techniques. Herbert-Spence, Inc. New York, N.Y., Second Edition, pp 44-45.
10. Lippman, R. W. (1957). Urine and the Urinary Sediment. Chas. C Thomas, Springfield, IL.
11. Dudas, H.C., Lab Med. 12:765. 1981.
12. Weller, J.M. and Greene, J.A. (1966). Examination of the Urine. Meredith Publishing Co., New York.
13. Albert Rabinovitch MD, PhD, Clinical And Laboratory Standards Institute, GP16-A3, Urinalysis; approved guideline – third edition Feb 2009, Volume 29 number 4

VALUE TABLE



Low Cell Count Samples:

Count the total cells of a specific type contained in 10 small grids within different quadrants of the counting grid.

Total Cells	Cells / μL
1	1
2	2
3	2
4	3
5	4
6	5
7	5
8	6
9	7
10	8
11	8
12	9
13	10
14	11
15	11
16	12
17	13
18	14
19	15
20	15
21	16
22	17
23	18
24	18
25	19
26	20
27	21
28	21

Higher Cell Count Samples:

Count the total cells of a specific type contained in 5 small grids within different quadrants of the counting grid.

Total Cells	Cells / μL
5	8
6	9
7	11
8	12
9	14
10	15
11	17
12	18
13	20
14	21
15	23
16	24
17	26
18	28
19	29
20	31
21	32
22	34
23	35
24	37
25	38
30	46
35	54
40	61
45	69
50	77
60	92
70	107

NOTE: For samples that are less than 12mL, reduce the centrifuged quantity to 6mL and double the results obtained before using the table (above).

Cell Type	Normal
Leukocytes	0-4/ μL
Erythrocytes	0-2/ μL

Borderline	Pathological*
4-6/ μL	> 6/ μL
2-3/ μL	> 3/ μL

Alternative Calculation: Determine the average number of cells per small grid and then use the following multiplication factor to calculate the cells per μL .

To calculate cells / μL using KOVA Plastics Glasstic Slide 10 with Grid:

- For uncentrifuged or neat samples, multiply the average cells obtained per small grid x 90.
- For 10mL samples concentrated to 1mL, multiply the average cells obtained per small grid x 9.
- For 10mL samples concentrated to 0.5mL, multiply the average cells obtained per small grid x 4.5.
- For 12mL samples concentrated to 1mL (KOVA System), multiply the average cells obtained per small grid x 7.5.

Calculation example (Using KOVA System 12mL to 1mL method):

Cells	Grids Counted	Total Cells	Average Cells / Grids	Multiple x Factor (7.5)	Cells per μL of Samples
Leukocytes	10	5	0.5	0.5 x 7.5	3.8
Erythrocytes	10	14	1.4	1.4 x 7.5	10.5

* Reference: Aiken, C.D. and Sokeland, J. (1983). Urologie. Thiems, Stuttgart, Ninth Edition, p.79

VALUE TABLE

UNDILUTED, UNCENTRIFUGED URINE OR BODY FLUID SPECIMENS

LOW CELL COUNT SAMPLES

Count the total cells of a specific type contained in 36 small grids or 4 complete quadrants of the counting grid.

Total Cells	Cells/ μ L	Cells/mL
1	3	2,500
2	5	5,000
3	8	7,500
4	10	10,000
5	13	12,500
6	15	15,000
7	18	17,500
8	20	20,000
9	23	22,500
10	25	25,000
11	28	27,500
12	30	30,000
13	33	32,500
14	35	35,000
15	38	37,500
16	40	40,000
17	43	42,500
18	45	45,000
19	48	47,500
20	50	50,000
25	63	62,500
30	75	75,000
40	100	100,000
50	126	125,500

HIGH CELL COUNT SAMPLES

Count the total cells of a specific type contained in 10 small grids in different quadrants of the counting grid.

Total Cells	Cells/ μ L	Cells/mL
1	9	9,000
2	18	18,000
3	27	27,000
4	36	36,000
5	45	45,000
6	54	54,000
7	63	63,000
8	72	72,000
9	81	81,000
10	90	90,000
20	180	180,000
25	225	225,000
30	270	270,000
35	315	315,000
40	360	360,000
50	450	450,000
60	540	540,000
70	630	630,000
80	720	720,000
90	810	810,000
100	900	900,000
150	1,350	1,350,000
200	1,800	1,800,000
250	2,250	2,250,000

Alternative Calculation:

Multiply the average number of cells per small grid by 90 to obtain cells per μ L; multiply by 90,000 to obtain cells per mL.

Alternative Calculation:

Multiply the average number of cells per small grid by 90 to obtain cells per μ L; multiply by 90,000 to obtain cells per mL.

DILUTED BODY FLUIDS CALCULATION METHOD:

Cells / μ L = Average number of cells per small grid \times 90 (multiplication factor) \times dilution
e.g., Spinal fluid diluted 1:10; a total of 50 RBC's counted in 10 small grids

$$\text{RBC}/\mu\text{L} = \frac{50 \text{ cells}}{10 \text{ grids}} \times 90 (\text{factor}) \times 10 (\text{dilution})$$

$$= 5 \times 900 = 4,500 \text{ RBC's}/\mu\text{L}$$

e.g., Semen diluted 1:20; a total of 150 sperm counted in 5 small grids












$$\text{Sperm}/\mu\text{L} = \frac{150}{5} \times 90 (\text{factor}) \times 20 (\text{dilution})$$





$$= 30 \times 1800 = 54,000 \text{ sperm}/\mu\text{L}$$

TOTAL CELL COUNT NORMAL RANGES ⁽¹⁾

FLUID	CELL TYPE	NORMAL	ABNORMAL	FLUID	CELL TYPE	NORMAL	ABNORMAL
Urine (2)	Leukocytes	0-6/ μ L	> 6/ μ L	Synovial	Leukocytes	< 200/ μ L	> 200/ μ L
	Erythrocytes	0-3/ μ L	> 3/ μ L		Erythrocytes	< 2,000/ μ L	> 2,000/ μ L
CSF (Adult Range)	Leukocytes	0-5/ μ L	> 5/ μ L	Pleural	Leukocytes	< 1,000/ μ L	> 1,000/ μ L
				Pericardial	Leukocytes	< 1,000/ μ L	> 1,000/ μ L
Seminal	Sperm	40,000/ μ L - 160,000/ μ L	< 40,000/ μ L	Peritoneal	Leukocytes	< 300/ μ L	> 300/ μ L
					Erythrocytes	< 100,000/ μ L	> 100,000/ μ L

References: (1) Strasinger, S.K. (1985) *Urinalysis and Body Fluids*, F.A. Davis, Philadelphia • (2) Alken, C.D., and Sokeland, J. (1983) *Urologie*, Thiems, Stuttgart, Ninth Edition, pg. 79

Symbol	English
	Batch/Lot Code
	Expiration/Use By
	Manufacturer
	Catalog Number
	Contains Quantity
	Do Not Reuse
	Unique Device Identifier
	In Vitro Diagnostics Use
 www.kovaplastics.com	Instructions for Use/ Electronic Instructions for Use
	Manufactured in Country (United States)
	Storage Limits

	Alltrista Plastics LLC 20 Setar Way Reedsville, Pa 17084 United States Customer Service: +1 864-879-8100		Advena Ltd. Tower Business Centre, 2 nd Flr. Tower Street, Swatar, BKR 4013 Malta
	EU Economic Operator MDR/IVDR Article 13 Advena Services Ltd. Tower Business Centre, Tower Street Swatar, BKR 4013 Malta		Axon Lab Ag Täferstrasse 15 CH-5405 Baden-Dättwil Switzerland

CE



1. Purpose

To describe the correct procedure for using the oil immersion objective to examine a stained blood smear, ensuring optimal image quality and preservation of microscope components.

2. Principle

- Oil immersion improves image resolution at high magnification by reducing light refraction between the slide and the objective lens.
 - Total magnification is determined by multiplying the objective lens magnification (100×) by the ocular lens magnification (10×), producing a total magnification of 1000×.
 - Resolution is the microscope's ability to distinguish fine detail; oil immersion increases resolution by maintaining the refractive index between the lens and slide.
 - Parfocality ensures that a specimen remains in near focus when switching from lower-power objectives to higher-power objectives, requiring only fine adjustment.
-

3. Safety Precautions

- Wear laboratory coat, gloves, and protective eyewear at all times.
 - Treat all blood smears and slides as potentially infectious materials.
 - Do not use coarse focus at 100× to prevent slide or lens damage.
 - Clean immersion oil from objectives and slides after use with lens paper only.
 - Dispose of biological waste and contaminated materials in designated containers.
-

4. Materials and Equipment

- Compound microscope with 100× oil immersion objective and 10× eyepiece
 - Prepared, stained blood smear slide (Wright or Wright-Giemsa stain)
 - Immersion oil, type A (for light microscopy)
 - Lens paper and lens cleaning solution
 - Laboratory gloves and PPE
-

3. Parfocal

- Microscope property where minimal refocusing is needed when switching objectives.
- Parfocal microscopes require only slight fine adjustment between 40× and 100×.

4. Light Intensity and Illumination

- As magnification increases, less light reaches the eye because the field of view narrows and the numerical aperture (NA) increases.
- To maintain image clarity and brightness:
 1. Start with low light at low power (4× or 10×).
 2. Increase light intensity gradually as you move to higher magnifications (40× → 100×).
 3. Raise the condenser and open the iris diaphragm fully when using the 100× oil objective to deliver maximum light to the specimen.
 4. Avoid glare or washout—fine-tune light intensity with the rheostat (light control knob).

5. Procedure

5.1 Focusing at Low and High Power

1. Place the stained blood smear on the microscope stage and secure it with stage clips.
2. Begin examination with the 10× objective, adjusting light intensity and condenser position for optimal illumination.
3. Locate the monolayer (area where red blood cells are evenly spaced without overlapping).
4. Switch to the 40× objective and refine the focus using the fine adjustment knob.

5.2 Applying Oil and Using the 100× Objective

5. Rotate the nosepiece halfway between 40× and 100× objectives.
6. Place one small drop of immersion oil directly over the illuminated portion of the smear.
7. Carefully rotate the 100× oil immersion lens into position so that the lens tip touches the oil drop.
8. Using fine focus only, adjust the focus until cells appear sharp and distinct.
9. Adjust the diaphragm and light intensity to enhance image brightness and contrast.

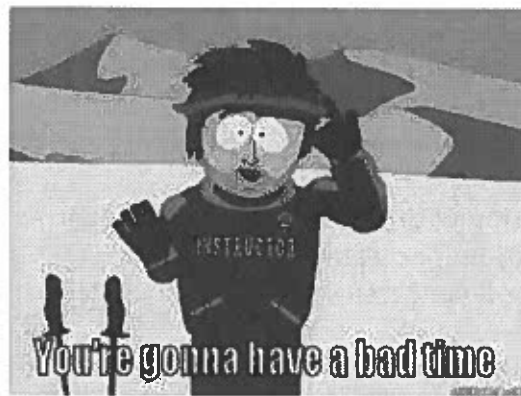
5.3 Post-Use Cleaning

10. When finished, rotate back to a lower power objective.
11. Gently wipe oil from the slide and the 100× objective lens with clean lens paper.
12. If necessary, apply a small amount of lens cleaning solution to remove residual oil.
13. Clean and dry the stage area; lower the stage and return the 4× objective to position.
14. Turn off the light source and cover the microscope with a dust cover.

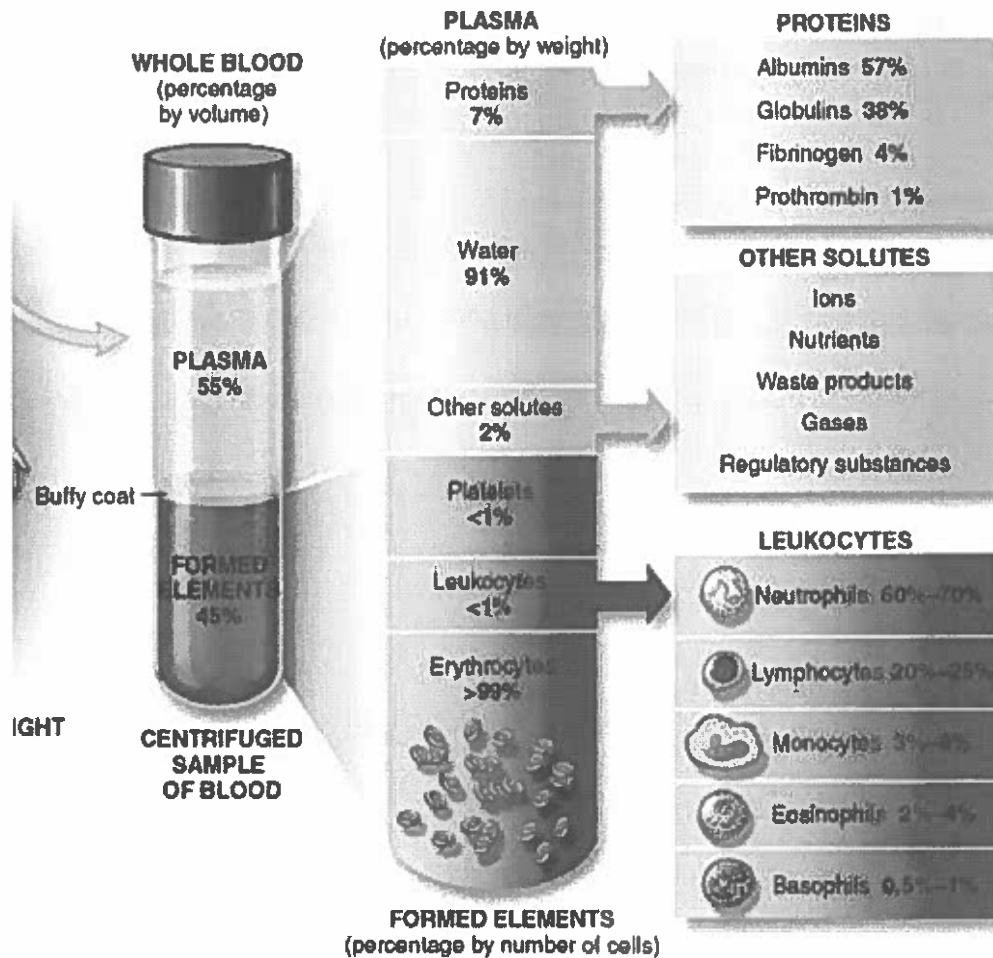
Critical Safety and Technique Notes

- Never use oil with the 40× objective lens (high-dry).
 - Oil can damage lens coatings and cause poor image quality.
 - Always check that only the 100× oil immersion lens contacts the oil.
- Use only one drop of oil—excess can spread and contaminate other lenses.
- Clean immediately after use:
 - Wipe the 100× objective lens with lens paper.
 - Check and clean the 40× lens if contaminated.
 - Remove oil from the slide and stage area.
- Store microscope with all lenses clean and the lowest power (4×) objective in place.

If your ocular or objective lenses are dirty (either with dust or immersion oil):



Components of a CBC with Differential



I. Introduction

- **Purpose of the CBC:**
 - Provides quantitative assessment of cellular elements in the blood.
 - Aids in diagnosis, monitoring, and screening for hematologic and systemic conditions.
- **Specimen:**
 - EDTA-anticoagulated whole blood (lavender-top tube).
- **Instrumentation:**
 - Automated hematology analyzers using impedance, flow cytometry, and/or optical methods.

II. Major Components of the CBC

A. Red Blood Cell (RBC) Parameters

1. Measured Parameters:

- **RBC Count:** Number of red cells per microliter ($\times 10^6/\mu\text{L}$).
- **Hemoglobin (Hgb):** Concentration of hemoglobin in **g/dL**.
- **Hematocrit (Hct):** Percent blood volume occupied by red cells (ratio of RBC volume to total blood volume).

2. Calculated Indices:

- Red blood cell (RBC) **indices** measure red blood cells' size, shape, and quality. The results of RBC indices are used to diagnose different types of anemia. There are several types of anemia, and each type has a different effect on the size, shape, and/or quality of red blood cells.
- **Mean Corpuscular Volume (MCV):** Average volume of individual RBCs.
 - Formula: $\text{MCV} = \frac{\text{Hct}}{\text{RBC Count}} \times 10$

- Reported in (fL)

- **Mean Corpuscular Hemoglobin (MCH):** Average amount of hemoglobin per RBC.
 - Formula: $\text{MCH} = \frac{\text{Hgb}}{\text{RBC Count}} \times 10$

- Reported in (pg)

- **Mean Corpuscular Hemoglobin Concentration (MCHC):** Concentration of hemoglobin in a given volume of packed RBCs.
 - Formula: $\text{MCHC} = \frac{\text{Hgb}}{\text{Hct}} \times 100$

- Reported in (g/dL)

- **Red Cell Distribution Width (RDW):**
 - Reflects variation in red cell size.
 - Formula: $RDW = \frac{RDW-CV \times 100}{MCV}$

- Reported as %.

3. Interpretation:

- Used to classify anemias (microcytic, normocytic, macrocytic; hypochromic or normochromic).

B. White Blood Cell (WBC) Parameters

1. Measured Parameters:

- **WBC Count:** Total number of leukocytes per microliter ($\times 10^3/\mu\text{L}$).

2. Differential Count (Diff):

- **Automated Differential:** Percentage and absolute counts of WBC subtypes.
- **Manual Differential (if flagged or abnormal):** 100-cell count on Wright-stained smear.

3. Types of WBCs Reported:

- **Neutrophils (segmented and bands)**
- **Lymphocytes**
- **Monocytes**
- **Eosinophils**
- **Basophils**

4. Calculated Results:

- **Absolute Counts:** Absolute Count = $\frac{\text{WBC Count} \times \text{Differential \%}}{100}$
- Reported in number per microliter ($\times 10^3/\mu\text{L}$).

C. Platelet Parameters

1. Measured Parameters:

- **Platelet Count:** Number of platelets per microliter ($\times 10^3/\mu\text{L}$).

2. Calculated or Derived Indices:

- **Mean Platelet Volume (MPV):** Average size of platelets (fL).
 - **Platelet Distribution Width (PDW):** Variation in platelet size.
3. **Clinical Significance:**
- Thrombocytopenia or thrombocytosis detection.
 - MPV reflects platelet production and destruction rates.

III. Calculated Indices Summary Table

Parameter	Formula	Units	Clinical Meaning
MCV	$(\text{Hct} \times 10) / \text{RBC}$	fL	RBC size
MCH	$(\text{Hgb} \times 10) / \text{RBC}$	pg	Hb content per RBC
MCHC	$(\text{Hgb} \times 100) / \text{Hct}$	g/dL	Hb concentration within RBCs
RDW	Calculated by analyzer	% or fL	RBC size variation
ANC	$\text{WBC} \times (\% \text{ Neutrophils})$	$\times 10^3 / \mu\text{L}$	Neutrophil defense status

IV. Interpretation and Correlation

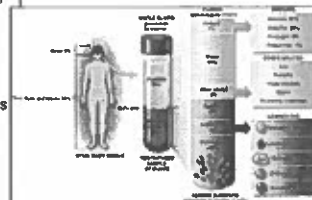
- **RBC parameters** → Assess anemia, polycythemia.
- **WBC count and diff** → Detect infection, inflammation, leukemia, immune disorders.
- **Platelet count and indices** → Evaluate bleeding or clotting disorders.
- **Morphologic review** of blood smear supports and validates automated data.

Chapter 11

An Introduction to the Principles and Practice of Clinical Hematology

Hematopoiesis: Overall Blood Cell Maturation and Function (1 of 2)

- The total volume of blood in an average adult is about 6L, or 7% to 8% of the body weight.
- Circulating blood is divided as follows:
 - 55% plasma
 - 45% formed elements
 - Red blood cells
 - White blood cells
 - Platelets



Hematopoiesis: Overall Blood Cell Maturation and Function (2 of 2)

- Blood cell production, *hematopoiesis*, begins in embryonic development, progresses to the fetal liver, and later occurs in red bone marrow.
- CD34+ pluripotent stem cells give rise to the earliest myeloid and lymphoid precursors.
 - Stem cells can repopulate bone marrow after injury or lethal radiation the basis of bone marrow transplantation.
 - Myeloid progenitors differentiate into colony-forming cells of the erythroid and myeloid lineages to give rise to: erythrocytes, platelets, neutrophils, monocytes and macrophages, eosinophils, basophils, and mast cells (tissues).
 - Lymphoid progenitors give rise to natural killer cells, T and B lymphocytes.

Erythrocytes (1 of 17)

- Erythrocyte function and maturation
 - Main function: to carry oxygen to the cells of the body
 - Oxygen is transported in a chemical combination with hemoglobin (Hb). The concentration of Hb in the blood is a measure of its capacity to carry oxygen.
 - To combine with and transport oxygen, the Hb molecule must have a certain combination of heme (which contains iron) and globin.
 - The red blood cell (RBC) begins as a nucleated cell within the bone marrow. As the cell matures in the bone marrow, its diameter decreases, and the nucleus becomes denser and smaller, and is finally released from the cell (extruded) to become a biconcave disk.

Erythrocytes (2 of 17)

- RBC maturation exists in six stages of development.
- From the youngest to the mature cell are
 - (1) Rubriblast (pronormoblast)
 - (2) Pronubricyte (basophilic normoblast)
 - (3) Rubricyte (polychromatophilic normoblast)
 - (4) Metarubricyte (orthochromic normoblast)
 - (5) Reticulocyte (polychromatic erythrocyte)
 - (6) Mature erythrocyte



Erythrocytes (7 of 17)

- Reticulocyte
 - Percent in bone marrow: 1%
 - Hours in bone marrow: 48 to 72
 - Overall size: 8 to 10 micrometers
 - Nucleus to cytoplasm ratio: —
 - Nucleus: no nucleus
 - Cytoplasm: bluish hue
- Reticulocytes become fully mature in 1 or 2 days in the circulating blood and all RNA disappears.

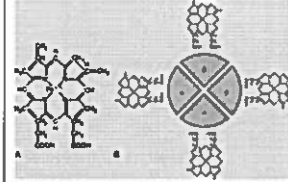
Erythrocytes (9 of 17)

- Reticulocytes differ morphologically from mature RBCs because they contain a fine basophilic reticulum or network of RNA, a cytoplasmic remnant that decreases as the cell matures.
- RBCs have a total life span of about 120 days.
- The bone marrow releases new cells into the circulatory system every day.
- The concentration of RBCs and the measurement of the packed volume of RBC (microhematocrit) are important laboratory measurements for the detection of anemia or overproduction of RBCs.

Erythrocytes (13 of 17)

• Hemoglobin (Hb) synthesis, structure, and function

- The heme (iron-containing) portion combines with globin (the protein portion) and forms an activated form of Hb that is ready to transport oxygen.
- Each Hb molecule has four heme groups and a globin moiety, which is composed of four polypeptide chains.
- Heme
 - Iron from heme is normally removed and retained, stored, and reused in the production of new Hb.



Erythrocytes (14 of 17)

- Globin
 - The globin portion of the Hb molecule is a protein substance that consists of four chains of amino acids (polypeptides).
 - Each of the four globin chains is attached to a heme portion to form a single Hb molecule.
- Hemoglobin function
 - Iron is essential for the primary function of the Hb molecule: carrying oxygen to the tissues. If iron is lacking, anemia results because Hb is not formed in sufficient quantity.
 - The molecule fully saturated with oxygen (four oxygen molecules per Hb molecule) is called oxyhemoglobin.
 - Oxyhemoglobin carries oxygen from the lungs to the tissues of the body. Hb returning to the lungs with carbon dioxide from the tissues is known as reduced hemoglobin.

Erythrocytes (17 of 17)

• Variations in hemoglobin concentrations

- The reference (or normal) values for Hb in peripheral blood vary with the age and gender.
- Altitude: Normal Hb concentration is higher at high altitudes than at sea level.
- There may be a slight decrease in hemoglobin level after 50 years of age.
- When the Hb value is below normal, the patient is said to be anemic.
 - In anemia, circulating erythrocytes may be deficient in number, in total Hb content per unit of blood volume, or both.
 - Increase in Hb can be seen in polycythemia and newborns.

Leukocytes (1 of 29)

- Formed elements of the blood go through developmental stages
 - As cells mature, they are able to move through the sinusoids of the marrow because of decreased overall cell size, decreased nuclear cytoplasmic ratio, and increased flexibility and mobility.
 - Normal peripheral blood cells include lymphocytes, basophils, eosinophils, segmented neutrophils, monocytes, and band neutrophils.
 - Each cell type has a normal life span and function.
- Normally, only mature cells are seen in the peripheral blood circulation.
 - Immature cells may appear in the peripheral blood in certain disease states, called a shift to the left.

Leukocytes (2 of 29)

• Granulocyte maturation and function

- Neutrophils normally mature in the bone marrow in stages, from the youngest to the most mature: myeloblast, promyelocyte, myelocyte, metamyelocyte, band, and segmented neutrophils.
 - Cells of the neutrophil series are generally round with smooth margins or edges. As the cells mature, they become smaller.
 - Most immature cells have cytoplasm that stains dark blue and becomes light pink as the cells mature. As the cells mature from the myeloblast to the promyelocyte stage, nonspecific granules that stain blue to reddish purple appear in the cytoplasm.
 - Eventually, these nonspecific granules are replaced by specific neutrophilic granules.
 - Nuclear changes also occur as the cells mature.
 - Nucleoli may be apparent in the early forms but gradually disappear as the chromatin thickens and the cell matures.

Leukocytes (5 of 29)

- Band
 - Overall size: 10 to 16 micrometers
 - Nucleus to cytoplasm ratio: 1:1
 - Nuclear characteristics: Elongated, curved
 - Cytoplasmic characteristics: Specific blue-pink granules
- Segmented neutrophil
 - Overall size: 10 to 16 micrometers
 - Nucleus to cytoplasm ratio: 1:1
 - Nuclear characteristics: Distinct lobes
 - Cytoplasmic characteristics: Specific blue-pink granules

Leukocytes (6 of 29)

- Characteristics of neutrophils
 - Metabolically, neutrophils are very active and can carry out both anaerobic and aerobic glycolysis.
 - The neutrophilic granules contain several digestive enzymes that are able to destroy many types of bacteria.
 - The cells are capable of random locomotion and can be directed to an area of infection by the process of chemotaxis.
 - Once in the tissues, the neutrophils destroy bacteria by engulfing them and releasing digestive enzymes into the phagocytic vacuole thus formed.

Leukocytes (7 of 29)

- Mature eosinophil
 - Overall size: 10 to 16 micrometers
 - Nucleus to cytoplasm ratio: 1:1
 - Nuclear characteristics: Distinct lobes
 - Cytoplasmic characteristics: Orange granules
- Characteristics of eosinophils
 - Eosinophils exist in the peripheral blood for less than 8 hours after release from the marrow and have a short survival time in the tissues.
 - They are active in allergic reactions and certain parasitic infections, especially those involving parasitic invasion of the tissues.

Leukocytes (9 of 29)

- The first recognizable basophilic cell type is the basophil myelocyte, which contains basophilic granules.
- Mature basophil
 - Overall size: 10 to 16 micrometers
 - Nucleus to cytoplasm ratio: 1:1
 - Nuclear characteristics: Distinct lobes
 - Cytoplasmic characteristics: Blue-black granules
- Characteristics of basophils
 - Basophils occur in very low numbers in normal peripheral blood. Their life span in blood is similar to that of neutrophils and eosinophils.

Leukocytes (11 of 29)

- Normal leukocyte morphology
 - Leukocytes are larger and more complex in appearance than the RBCs.
 - They consist of a nucleus surrounded by cytoplasm.
 - Five types of white blood cells
 - Neutrophils (segmented and band)
 - Eosinophils
 - Basophils
 - Monocytes
 - Lymphocytes

Normal Leukocytes

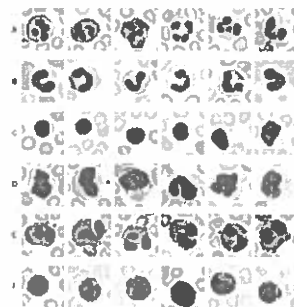


Fig 11.16 Normal leukocytes.
(A) Polymorphonuclear neutrophils;
(B) band neutrophils;
(C) lymphocytes;
(D) monocytes;
(E) eosinophils; and
(F) basophils. (From Carr JH, Rodak BF: Clinical hematology atlas, ed 3, St Louis, 2000, Saunders)

Leukocytes (12 of 29)

- Leukocytes are categorized as granulocytes and agranulocytes (lymphocytes).
- Granulocytes are leukocytes that come from the myeloid series of cell development.
 - As mature cells, neutrophils, eosinophils, and basophils contain specific granulation in their cytoplasm.
- Monocytes are classified as myeloid cells that contain nonspecific granulation.
- Lymphocytes are cells derived from the lymphoid series of cell development.
 - They are agranulocytes that may contain nonspecific granulation.

Leukocytes (13 of 29)

Examine leukocytes for the following:

1. Nuclear chromatin pattern
2. Nuclear shape
3. Size and number of nucleoli, when present
4. Cytoplasmic inclusions
5. Nuclear/cytoplasmic (N/C) ratio

Leukocytes (14 of 29)

- Normal leukocyte morphology
 - Segmented neutrophils
 - The most numerous of the granulocytes, neutrophils make up about 59% of the leukocytes in peripheral blood, with a range of 35% to 71%.
 - The usually lobular nucleus forms a relatively small part of the cell.
 - The nuclear chromatin is coarse and clumped and stains deep purple. The nuclear membrane is distinct, and no nucleoli are visible.
 - The abundant cytoplasm is colorless or faintly pink and contains a large number of very small, often indistinct, lilac-specific neutrophilic granules distributed irregularly throughout it.

Leukocytes (15 of 29)

- Normal leukocyte morphology
 - Band neutrophils
 - The band neutrophil is a younger form of the mature neutrophil.
 - Band neutrophils resemble segmented cells except for the shape of the nucleus. An increase in their numbers is significant.
- Neutrophil counts
 - Generally, an increased WBC count (leukocytosis) results from an increase in the absolute number of neutrophils present in the blood, called neutrophilia; it is usually accompanied by a shift to the left.
 - Neutropenia is a decrease in the absolute neutrophil count.

Leukocytes (16 of 29)

- Normal leukocyte morphology
 - Eosinophils
 - Slightly larger than neutrophils, usually with a bilobed nucleus.
 - Cytoplasm is usually colorless, but crowded with spherical acidophilic granules, which stain red-orange.
- Eosinophil counts
 - Eosinophilia, an increase in the number of eosinophils above normal, is associated with a wide variety of conditions, but especially with allergic reactions and drug reactions.
 - Eosinopenia, or decreased number of eosinophils, is seen with hyperadrenalemia.

Leukocytes (17 of 29)

- Normal leukocyte morphology
 - Basophils
 - About the same size as neutrophils, basophils' nuclei usually occupy a greater portion of the cell.
 - Irregularly shaped nucleus often hidden by granules
 - Cytoplasm is usually colorless; it contains a number of deeply stained, coarse, round, or angular basophilic granules.
 - Note that tissue basophils, also called mast cells, are similar but not identical to basophilic granulocytes.
- Basophil counts
 - Basophilia, an increase in the number of basophils, occurs in chronic myelogenous leukemia and other conditions.

Leukocytes (20 of 29)

- Monocyte maturation
 - Mature monocyte
 - Overall size: 12 to 18 micrometers
 - Nucleus to cytoplasm ratio: 2:1 to 1:1
 - Nuclear characteristics: Horseshoe-shaped, folded, lacelike chromatin
 - Cytoplasmic characteristics: Vacuoles common, blue-gray, abundant

Leukocytes (21 of 29)

- Monocyte function and morphology
 - Monocytes remain in the peripheral blood for hours to days after leaving the bone marrow.
 - They are motile, phagocytic cells, but they do not die after they engage in phagocytotic activity.
 - Function in the defense against microorganisms.
 - The largest of the normal leukocytes
 - Nucleus is large and usually indented and described as "kidney-bean"
 - Gray-blue cytoplasm with extremely fine and abundant azurophilic granules: "azure dust" and give the cytoplasm a "ground glass" appearance

Leukocytes (22 of 29)

- Lymphocyte maturation and function
- Lymph nodes are located all along the lymphatic vessels, and lymph (fluid within the system) circulates through the nodes as it progresses through the system.
- Many lymphocytes circulate between the blood, the organs, and the lymphatic tissues.
- Functionally, there are two types of lymphocytes, T cells, or T lymphocytes, and B cells, or B lymphocytes.
 - T cells arise in the thymus from precursors that seed the thymus during embryonic development. These CD34+ progenitor cells develop in the thymic cortex.
 - B lymphocytes are derived from hematopoietic stem cells in the bone marrow by a complex series of differentiation events.

Leukocytes (23 of 29)

- Lymphocyte maturation and function
- B-lymphocyte differentiation is complex and culminates in the generation of mature, end-stage, nonmotile cells called plasma cells or into memory B cells, long-lived cells that circulate in the blood.
- Lymphocytes act to direct the immune response system of the body.

Leukocytes (26 of 29)

- Lymphocyte maturation and function
- Maturation
 - Mature lymphocyte
 - Overall size
 - Small: 6 to 9 micrometers
 - Large: 17 to 20 micrometers
 - Nucleus to cytoplasm ratio
 - Small: 4:1 to 3:1
 - Large: 2:1
 - Nuclear characteristics: Round or oval
 - Cytoplasm characteristics: Light blue; few azurophilic granules may be present

Leukocytes (27 of 29)

- Lymphocytes
 - Comprise about 34% of leukocytes in normal adults
 - Two sizes, large and small; most are small
 - Described based on size and cytoplasmic granularity
 - After antigenic stimulation, small lymphocytes can undergo transformation, and are then called reactive, atypical, variant, or reticular lymphocytes.
 - Lymphocytosis, an increase in the number of lymphocytes, is associated with viral infections.

Leukocytes (29 of 29)

- Reporting leukocyte results
 - Total count
 - The total leukocytes in the circulating blood vary by age.
 - Can fluctuate with circadian rhythms
 - Relative count
 - In the differential leukocyte count, cells are identified while examining and counting 100 WBCs in a systematic manner, with results reported in relative numbers or percentages.
 - Absolute count
 - The absolute count is a more accurate measure. The absolute cell count by cell type is obtained by multiplying the relative number of WBCs (in decimal units) by the total WBC count per liter.

Thrombocytes

- Platelet (thrombocyte) maturation and function
 - Produced in the bone marrow, platelets are an essential part of the blood-clotting mechanism.
 - They act as plugs around the opening of a wound and release factors necessary for blood clot formation.
 - Platelets do not have a nucleus and are not actually cells; they are portions of cytoplasm pinched off from megakaryocytes and released into the bloodstream.
 - Mature platelets are small, colorless bodies 1.5 to 4 micrometers in diameter.
 - Platelets are generally round or ovoid, although they may have projections called *pseudopods*.
 - Platelets have a colorless to pale-blue background substance containing centrally located, purplish-red granules.

Clinical Hematology Procedures (1 of 12)

- Laboratory tests performed in the hematology laboratory include the following:
 - Counting the number or concentration of cells
 - Determining the relative distribution of various types of cells
 - Measuring biochemical abnormalities of the blood
- Tests basic to the evaluation and follow-up of a patient
 - Complete blood count (CBC): Hemoglobin (Hb), hematocrit (Hct), RBC count with morphology, WBC count with differential, and platelet estimate
 - The RBC indices of mean corpuscular volume (MCV), mean corpuscular hemoglobin (MCH), and mean corpuscular hemoglobin concentration (MCHC) are now a standard part of a routine automated CBC.

Clinical Hematology Procedures (3 of 12)

- Processing and testing the specimen
 - When a preserved specimen stands for a time, the components settle into three distinct layers:
 - Top layer: plasma
 - Middle layer: buffy coat, a grayish-white cellular layer composed of WBCs and platelets
 - Bottom layer: RBCs
 - Appearance of specimens
 - Hemolysis
 - Unsuitable hematologic specimens
 - Homeostasis

Clinical Hematology Procedures (6 of 12)

- Isotonic, hypotonic, and hypertonic solutions
- When in plasma, the RBCs are in an isotonic solution.
- Any diluent used to dilute blood for hematology tests must have the same ionic concentration as plasma; then the solution is called a physiologic solution.
 - A comparison of erythrocytes in three concentrations of sodium chloride solution demonstrates the net movement of water molecules into and out of the cell.
 - If the net movement of water into the cell is in excess, the cell will lyse.
 - If the net movement of water out of the cell is in excess, the cell will crenate.

Clinical Hematology Procedures (7 of 12)

- Hemoglobin measurement in the laboratory
 - Hemoglobincyanide (cyanmethemoglobin) method
 - Automated hemoglobinometry
 - Specimens
 - Point-of-care hemoglobin assay
 - Principle: Hemoglobin determination: Hemocue method

Clinical Hematology Procedures (8 of 12)

- **Hematocrit (Packed Cell Volume)**
 - The hematocrit (Hct), or packed cell volume, is a macroscopic observation of volume of the packed RBCs in a sample of whole blood.
 - The Hct is the percentage of RBCs in a volume of whole blood.
 - Hct is used in evaluating and classifying the various types of anemias according to RBC indices.
- **Methods for Measurement**
- **Specimens**
- **Capillary Tubes for Microhematocrit**

Clinical Hematology Procedures (9 of 12)

- **Blood cell counts**
 - Counting the various cells found in blood is a fundamental procedure in the hematology laboratory.
 - In modern laboratories, most cell counts are performed with automated equipment.
 - Electronic counting devices avoid human error, which is significant in manual cell counts, and are statistically more accurate because of sampling; these devices count many more cells than can be counted manually.
- **Units reported**
- **Specimens**

Clinical Hematology Procedures (10 of 12)

- **Blood cell counts**
 - **Diluents used**
 - White cell counts
 - **Counting red and white blood cells**
 - Clinical significance of cell counts
 - Red blood cell counts
 - White blood cell counts
 - **Platelet counts**
 - Specimens
 - Methods used to count platelets
 - Clinical significance of platelet count

Clinical Hematology Procedures (11 of 12)

- **Automated hematology instrument technology**
 - Principles of cell counting
 - Hemoglobin measurement
- **Automated cell counting methods**
 - Electrical impedance principle
 - Optical detection principle
- **Histograms**
 - Erythrocyte histogram
 - Red cell distribution width

Clinical Hematology Procedures (12 of 12)

- **Examples of automated hematology technology**
- **Automated leukocyte differentiation**
- **Platelet histograms**
 - Mean platelet volume calculation
 - Platelet distribution width
 - New automation technology
- **Quality control**

Additional Hematology Procedures(1 of 3)

- **Reticulocyte counts**
 - Reticulocytes are red blood cells that have lost their nuclei but not all of their cytoplasmic RNA.
 - **Normal erythropoiesis and reticulocytes**
 - High reticulocyte count, reticulocytosis, is a clinical indication that the body is attempting to meet an increased need for RBCs.
 - **Clinical uses for reticulocyte counts**
 - Follow therapy for anemia
 - **Reference values**
 - Adults: 0.5% to 1.5% of circulating red blood cells
 - Newborn: 2.5% to 6.0%

Additional Hematology Procedures (2 of 3)

- Erythrocyte sedimentation rate
 - Rate depends on the following:
 1. Number and size of erythrocyte particles
 2. Plasma factors
 3. Certain technical and mechanical factors
 - The most important factor determining the rate of fall of the RBCs is the size of the falling particle. The size of the falling particles depends on the formation of RBC rouleaux.

Red Blood Cell Indices (1 of 5)

- Mean corpuscular volume (MCV) is the average volume of an RBC in femtoliters, as calculated in this equation:

$$MCV (fL) = \frac{Hct \times 10}{RBC}$$

where *MCV* is mean corpuscular volume, *fL* is femtoliters, *Hct* is hematocrit, and *RBC* is red blood cell count.

- Reference range is 80 to 96 fL.

Red Blood Cell Indices (2 of 5)

- Mean corpuscular hemoglobin (MCH) is the content (weight) of hemoglobin in the average RBC, as calculated in this equation:

$$MCH (pg) = \frac{Hb \times 10}{RBC}$$

where *MCH* is mean corpuscular hemoglobin, *pg* is picograms, and *Hb* is hemoglobin.

- Reference range is 27 to 33 pg.

Red Blood Cell Indices (3 of 5)

- Mean corpuscular hemoglobin concentration (MCHC) is the average Hb concentration in a given volume of packed RBCs, as calculated with the equation:

$$MCHC (g/dL) = \frac{MCH}{MCV} \times 100$$

where *MCHC* is mean corpuscular hemoglobin concentration, *g* is grams, and *dL* is deciliters.

Reference range is 33 to 36 g/dL

Red Blood Cell Indices (4 of 5)

- Red cell distribution width
 - Red cell distribution width (RDW) is a measurement of the degree of anisocytosis present, or the degree of variability in RBC size, in a blood specimen, as shown in this calculation:

$$RDW (\%) = \frac{\text{Standard deviation (SD) of MCV}}{\text{Mean MCV}} \times 100$$

Reference range is 11% to 15%.

Microscopic Examination of the Peripheral Blood Film (1 of 35)

- Sources of blood for the blood film
 - Fresh blood from a finger or heel puncture can be used for morphologic examination of the white and red cells.
 - Only the drop of blood should touch the slide.
 - If blood is collected in EDTA for morphologic studies, the film should be prepared as soon as possible, certainly within 2 hours.

Microscopic Examination of the Peripheral Blood Film (2 of 35)

- Microscopic examination of the blood film
 - Accurate examination of the blood film depends on proper use of the microscope.
 - Low-power objective examination
 - Evaluation of the overall quality of the blood film smear preparation and staining
 - Estimate of the RBC and WBC counts
 - Scanning the blood film for abnormal cells and clumps of platelets
 - High-dry objective is not suitable for examination of blood films

Microscopic Examination of the Peripheral Blood Film (3 of 35)

- Microscopic examination of the blood film
 - Oil-immersion objective
 - Examination of the erythrocytes for alterations and variations in morphology
 - Estimation of platelet count and evaluation of morphologic changes
 - Differential count of the leukocytes
 - Examination of the leukocytes for morphologic alterations

Microscopic Examination of the Peripheral Blood Film (4 of 35)

- Erythrocyte alterations
 - Characteristics to note:
 1. Variations in color or staining reaction
 2. Variations in size (anisocytosis)
 3. Variations in shape (poikilocytosis)
 4. Variations in structure and inclusions
 5. Artifacts and abnormal distribution patterns
 6. Presence of nucleated red cells

Microscopic Examination of the Peripheral Blood Film (18 of 35)

- Abnormal red cell distribution
 - Rouleaux formation
 - Rouleaux represents an abnormal distribution pattern of RBCs, which stick together or become aligned in aggregates that look like stacks of coins.
 - Agglutination
 - This is irregular or amorphous clumping of red blood cells.
- Presence of nucleated red cells
 - Their presence means the WBC count will need to be corrected.

Microscopic Examination of the Peripheral Blood Film (19 of 35)

- Platelet estimation
 1. Estimate the platelet count.
 - Normally, 6 to 20 platelets per oil-immersion field represents a normal platelet count of 150 to 450×10^9 per liter.
 - Report the platelet count as adequate if 6 to 20 are seen per oil-immersion field.
 - Report the platelet count as decreased if fewer than 6 are seen per oil-immersion field.
 - Report the platelet count as increased if more than 20 are seen per oil-immersion field.
 2. Evaluate platelets for morphologic changes.

Microscopic Examination of the Peripheral Blood Film (20 of 35)

- Perform the differential count of white cells.
 - The differential count consists of identifying and counting a minimum of 100 WBCs.
 - In cases of leukopenia, only 50 cells need to be counted; then the differential percentages will need to be calculated.
- Examine the leukocytes for morphologic alterations.
 - All WBCs in the circulating blood should be mature
 - Persons with limited training in hematology should not attempt to identify abnormal WBCs.

Microscopic Examination of the Peripheral Blood Film (21 of 35)

- Clinical significance of erythrocyte alterations
 - Clinically, alterations in erythrocyte morphology are associated with many diseases and especially with anemia.
 - Anemia is not a specific, single disease. Anemia is a condition in which there is a decrease in the oxygen-carrying capacity of the blood that results in decreased oxygenation of the tissues and organs.
 - It has many causes, and the type of anemia and its underlying cause must be determined before treatment can be effectively undertaken.

Microscopic Examination of the Peripheral Blood Film (27 of 35)

- Leukocyte alterations
 - Leukocytosis is a white blood cell (WBC) count above normal.
 - Leukopenia is a WBC count below normal.
 - Quantitative changes in any of the cell types are described by the following terms:
 - Neutrophilia (increase) or neutropenia (decrease)
 - Eosinophilia or eosinopenia
 - Basophilia or basopenia
 - Lymphocytosis or lymphopenia
 - Monocytosis or monocytopenia

MLT 101 Lecture 5 Case Study for Discussion

Scenario:

You are covering Hematology and Chemistry final result review during an evening shift. Autoverification is enabled with delta checks and critical value rules. The following events occur within 45 minutes:

- 1) CBC for patient A.M. (MRN 0045123) autoverifies at 18:07. WBC $32.5 \times 10^3/\mu\text{L}$ (critical), Hgb 11.2 g/dL, Plt $184 \times 10^3/\mu\text{L}$. The LIS audit log shows no critical call documentation. The nurse later states no call was received.
- 2) A BMP for patient J.R. (MRN 0067811) is resulted at 18:12 with sodium 138 mmol/L but the physician portal shows 138 mEq/L and a reference range of 3.5–5.1. A resident pages saying “sodium looks low—range wrong?”
- 3) A repeat potassium for patient L.K. (MRN 0033344) at 18:20 is entered manually from an instrument downtime printout. You notice the previously entered K value at 16:55 was 5.6 mmol/L, but the chart now displays 3.6 mmol/L with an amendment note missing.
- 4) Two CBC reports at 18:28 appear for patient S.P. (MRN 0077001) with identical values but different specimen numbers; one is filed to the wrong encounter, which is visible in the EHR problem list.
- 5) A provider message at 18:35 requests an add-on ESR to a specimen already disposed. The front desk marked it “in process,” but there’s no specimen.

At which phase of the testing process are there errors?

Your Tasks

- 1) At which phase of the testing process are there errors? (e.g., failure to notify critical result, unit/reference range mismatch, transcription/entry error, misfiled report, workflow/communication failure).
- 2) Choose the best immediate corrective action(s) and the required documentation/amendment for each event.
- 3) Draft the exact LIS/EHR comment or amended report wording you would use for two of the events (your choice).
- 4) Indicate who must be notified (role/title) and within what timeframe for each event.

Action Menu – Select as appropriate (not all are correct):

Hagerstown Community College – Medical Laboratory Technology

- A. Immediately place a critical result call to the responsible nurse/covering provider and document call details (time, name, read-back).
- B. Ignore the unit mismatch because mmol/L and mEq/L are interchangeable in all cases.
- C. Correct the display template/reference range mapping in the provider portal; file an incident ticket and place an interpretive comment on affected results.
- D. Enter an amended report for the potassium with audit trail (original value, corrected value, reason, by whom, date/time). Notify provider.
- E. Leave duplicate reports because values match; no harm.
- F. Merge/void the misfiled report and reassign to the correct encounter; add a cross-reference note in both charts and notify Health Information Management (HIM).
- G. Mark the add-on as 'QNS' and silently cancel.
- H. Contact the provider about the add-on; explain specimen unavailable, advise recollection/new order; document communication and correct work queue status.
- I. Update autoverification rule to require mandatory critical-call documentation before release when $WBC \geq 30 \times 10^3/\mu L$.
- J. Schedule brief staff training on units, reference ranges, and amendment workflow; add quick-reference tip sheet at result entry stations.

1.0 Title

Standard Operating Procedure (SOP) Template

Version: _____ Effective Date: _____

2.0 Principle / Purpose

Enter text here...

3.0 Scope and Application

Enter text here...

4.0 Responsibilities

Enter text here...

5.0 Definitions / Abbreviations

Enter text here...

6.0 Safety Precautions

Enter text here...

7.0 Specimen / Reagents / Materials

Enter text here...

8.0 Quality Control / Quality Assurance

Enter text here...

9.0 Procedure

Enter text here...

10.0 Calculations

Enter text here...

11.0 Reference Range / Expected Results

Enter text here...

12.0 Interpretation of Results

Enter text here...

13.0 Limitations

Enter text here...

14.0 Documentation and Records

Enter text here...

Hagerstown Community College – Medical Laboratory Technology

15.0 References

Enter text here...

16.0 Appendices / Attachments

Enter text here...

17.0 Approval / Review

Enter text here...

Approval Signatures

Author: _____

Date: _____

Reviewer: _____

Date: _____

Laboratory Director: _____

Date: _____

1.0 Title

Standard Operating Procedure (SOP) Template

Version: _____ Effective Date: _____

2.0 Principle / Purpose

Enter text here...

3.0 Scope and Application

Enter text here...

4.0 Responsibilities

Enter text here...

5.0 Definitions / Abbreviations

Enter text here...

6.0 Safety Precautions

Enter text here...

7.0 Specimen / Reagents / Materials

Enter text here...

8.0 Quality Control / Quality Assurance

Enter text here...

9.0 Procedure

Enter text here...

10.0 Calculations

Enter text here...

11.0 Reference Range / Expected Results

Enter text here...

12.0 Interpretation of Results

Enter text here...

13.0 Limitations

Enter text here...

14.0 Documentation and Records

Enter text here...

Hagerstown Community College – Medical Laboratory Technology

15.0 References

Enter text here...

16.0 Appendices / Attachments

Enter text here...

17.0 Approval / Review

Enter text here...

Approval Signatures

Author: _____

Date: _____

Reviewer: _____

Date: _____

Laboratory Director: _____

Date: _____