The University of Texas at El Paso
College of Health Sciences

Clinical Laboratory Science Program

Course: CLSC 3364 Hematology II
Restricted for CLIN majors only
On-line asynchronous

Spring 2021

What do you see? What is in your Head?

Hues  http://www.xrite.com/online-color-test-challenge

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Here is the link to the technology support center in case you are having any difficulty with technology  UTEP Technology Support Help Desk
Virtual Office Hours
TW 10:00 – 11:00 a.m., after blood bank labs or by appointment.
You can also set up a meeting via e-mail. I would like to invite you to use the office hours to clarify points you did not understand in lecture, to discuss subject matter according to your special interests, or to talk about your career goals. If you feel confused or lost, do not wait until the last minute to see me. The best time to reach me is during my office hours or during the Blood Bank laboratory.

Class Schedule: on-line asynchronous, Alternate Saturday 9 – 12 for differentials.

Course Description
This course is a sequel to Hematology I. It will include but is not limited to the study of the white blood cells with emphasis on white cell formation and function and the etiology and treatment of white blood cell disorders such as but no limited to leukemia. This course will also encompass an introduction to hemostasis and laboratory determination of hemostatic disorders. Prerequisite: CLSC 3356 & CLSC 3257.

Topical Outline
1. Maturation series and biology of white blood cells
2. Disorders of neutrophils
3. Reactive lymphocytes and Infectious Mononucleosis
4. Acute and chronic leukemias
5. Myelodysplastic syndromes
6. Myeloproliferative disorders
7. Multiple Myeloma and related plasma cell disorders
8. Lymphomas
9. Lipid (lysosomal) storage diseased and histiosytosis
10. Hemostatic mechanisms, platelet biology
11. Coagulation pathways
12. Quantitative and qualitative vascular and platelet disorders (congenital and acquired)
13. Disorders of plasma clotting factors
14. Interaction of the fibrinolytic, coagulation and kinin systems
15. Laboratory methods

Course Objectives:
Successful completion of the course will require that the student be able to

NOTE: As a UTEP CLS student all, our courses are interrelated and you may be asked questions over material you have covered in previous CLS courses and or concurrent courses you are taking in a semester.
1. Describe normal and abnormal white cell biology according to the various white cell, WHO and FAB classifications and its manifestation seen in bone marrow and peripheral smears.

2. Demonstrate the ability to differentiate between normal and abnormal white cell reactions to various stimuli and relate these reactions to the appropriate disease and or neoplastic states along with the patient’s clinical picture and correlating laboratory exams.

3. Describe platelet development and biology and its role in hemostasis.

4. Recognize and describe normal and abnormal coagulation pathways and relate them to various hemostatic disorders along with the corresponding laboratory exams.

Detailed Cognitive Objectives: Covered in Hematology I and II and Hematology Lab found at end of this syllabus.

Affective Objectives

Goals / Purpose: Clinical laboratory science students are expected to show growth in professional behaviors appropriate to a laboratory setting and to maintain those behaviors possessed at time of entry.

Objectives: To show the appropriate responsible behaviors, students will demonstrate:

1. A positive attitude by being prepared for lecture and laboratory sessions, completing assigned tasks on time, and displaying self-motivation and initiative.

2. Organization by utilizing time efficiently, sequencing and prioritizing tasks for completion with time constraints, & maintaining a neat & clean work area.

3. Attention to detail by diligently pursuing accuracy and documenting data accurately and legibly

4. Problem solving ability by explaining the purpose of each step in a diagnosis, interpretation, procedure, or instrument operation, recognizing discrepancies in techniques or procedures, and repeating lab tests when necessary.

5. Dependability by following directions, working independently, after being given directions, and being present and on time with only excused absences.

6. Stability and self-confidence by approaching and performing routine tasks confidently without assistance, and maintaining composure.
7. Appropriate interpersonal skills by cooperating and communicating effectively with classmates and instructors, and displaying courteous, considerate behavior and appropriate appearance.

8. Ethical behavior and integrity by respecting the confidentiality of patient information, complying with professional standards and code of ethics, adhering to safety policies and abiding by all rules and regulations of the institution.

REQUIRED TEXTBOOKS: same books used for Hematology I


OPTIONAL: A color atlas or your choice but recommend

![Hematology Book](image1)
![Heme Notes Book](image2)
![Clinical Laboratory Science Review](image3)

UTEPO Bookstore
The University Bookstore will be open during the spring semester. In an effort to reduce the number of individuals inside the bookstore, students are encouraged to purchase their items online and either pick up their products in store or have their items delivered. An online pickup location will be available in the lobby.

University Bookstore Hours: Monday -Friday: 8 a.m. to 5 p.m. Saturday: 10 a.m. to 2 p.m. Sunday: Closed

Hours during first week of school: Monday – Thursday: 7 a.m. – 7 p.m. Friday: 8 a.m. – 5 p.m. Saturday 9 a.m. – 5 p.m. Sunday: Closed

For more information, please visit the University Bookstore at utepbookstore.com. Email: 1006mgr@follett.com or 1006asm@follett.com
Staff members will try to respond within 72 hours during the work week, but it may be longer because of the expected heavy volume of back-to-school shoppers.

Technology Requirements
Course content is delivered via the Internet through the Blackboard learning management system (LMS). Ensure your UTEP e-mail account is working and that you have access to the Web. You may use any of the primary Web browsers—Explorer, Google Chrome, Firefox, Safari, etc. When having technical difficulties, try switching to another browser.

You will need to have or have access to a computer/laptop, printer, scanner, a webcam, and a microphone. You will need to purchase a USB (flash drive). You will need to download or update the following software: Microsoft Office, Adobe, Flashplayer, Windows Media Player, QuickTime, and Java. Check that your computer hardware and software are up-to-date and able to access all parts of the course. If you encounter technical difficulties of any kind, contact the Help Desk.

Netiquette: 10 Rules of Netiquette for Students.
The rules for online learning and classroom learning are virtually the same: You have to study, take notes, attend classes and participate in discussions. In the classroom, your words, gestures, posture and facial expressions communicate your thoughts and observations to your classmates and teachers, but how do you express yourself online, where the written word is all they see?

During your online CLS classes, you will frequently be asked to participate in online discussions and will occasionally do peer reviews of your classmates’ work. Here are 10 rules of netiquette that will help you successfully communicate as you learn online.

1. Make sure identification is clear in all communications. Begin with a salutation (“Hi, Jason!”) and end with your signature (“Hannah Kay, CLS Immunology class”).

2. Review what you wrote and try to interpret it objectively. When we speak face to face and are misunderstood, we have an on-the-spot opportunity to rephrase our words. In writing, we must strive twice as hard to be understood, as we do not have the benefit of modifying or elaborating in real time. All caps (“I’M SHOUTING”) and exclamation points (“Give me a break!!!”) can be misinterpreted as intense anger or humor without the appropriate context.

3. If you wouldn’t say it face to face, don’t say it online. When you’re working online, you’re safe behind a screen, but that’s no excuse to be ill-mannered or say things you would never say in public.

4. Don’t assume everyone understands where you’re coming from. Sarcasm and wit is often the spice of in-person conversation, but in online discussion, it can not only lose its edge, it can bite! In your high school classroom, all students were the same age, came from similar backgrounds and lived in the same area. In contrast, your
online classroom is made up of people of all ages and cultures who have varied backgrounds, lifestyles and geographic locations. With this in mind, review what you wrote before contributing to the conversation and ask yourself, “Will everyone get the joke?”

5. **Don’t spam.** Please don’t take advantage of your connection with the other students in your online classroom to forward emails and links regarding your political/spiritual beliefs or to sell your services.

6. **Use emoticons.** In casual chatroom settings, emoticons can help convey feelings that may otherwise get lost in translation, including humor, exasperation, exhaustion and even confusion.

7. **Respect others’ privacy.** Don’t give out another student’s personal email address without permission.

8. **Remember, if it’s on the internet, it’s everywhere.** Don’t share personal information about yourself in a public online forum, especially something that could put your safety or security at risk.

9. **Follow the rules.** Just as your online college posts guidelines related to academic integrity and student expectations, online forums also have rules of conduct. Make a point to read them every time, as they can vary from class to class.

10. **Forgive and forget.** If you’re offended by something another student says online, keep in mind that you may have misunderstood their intentions. Give them the benefit of the doubt.

**Technology Support, Study Spaces, and Wi-Fi**

Technology Support will be available for all students studying remotely or taking classes on campus. Students may contact Technology Support for laptop repair, academic software needs or to set up personal computers to print documents utilizing campus printers. Laptops and Wi-Fi hotspots also are available for checkout. Students should contact Technology Support when help is needed with Blackboard or the online proctoring software.

**UTEP’s Technology Support page** offers links to three web pages that are available to help the UTEP community learn, teach and work from off-campus: learning remotely, remote teaching, and working remotely. For students, they’ve included links to Blackboard tutorials and access to various software and OneDrive downloads. Also, check out tips to optimize your internet home usage.

Lounges, lobbies, and common areas for studying have been reconfigured to support social distancing. Students are encouraged to take advantage of outdoor venues where Wi-Fi has been expanded and enhanced. These venues include:

- Centennial Plaza
- Engineering breezeway
- Interdisciplinary Research Building patio
- Fox Fine Arts 2nd floor breezeway
Venipuncture: The student must perform 10 venipunctures during the semester.

Differentials: The student must perform 50 differentials during Saturday schedule. On alternate Saturdays, the student is required to turn at least 7 completed differentials. The student will receive a zero for the week if the differential log is not turned in at the end of the Saturday session.

Lab A: Jan 23, Feb 6, 20, Mar 6, Apr 3, 17, May 1 (total 7 days, need to do 7–8/day)
Lab B: Jan 30, Feb 13, 27, Mar 13, 27, Apr 10, 24, May 1 (total 7 days, need to do 7–8/day)

UNANNOUNCED QUIZZES AND ASSIGNMENTS:
Both announced and unannounced quizzes and assignments will be given throughout the course and will constitute 10% of the final grade. You will need to log on to your Hematology class every day to make sure you do not miss any of the assignments or quizzes. There are no make-up exams or quizzes. Assignments turned in late will not be accepted.

Hematology, for educational purposes, has been divided into two components, Hematology I (CLSC 3356) which encompassed the study of the Red Blood Cell and Hematology II (CLSC 3264) which will entail the study of the White Blood Cells and Hemostasis. The Student is expected to recall the information presented in Hematology I and relate the information to Hematology II so as to “complete the picture”. Make it a habit to keep up with the readings and ask me questions or for clarifications. All exams will be on-line and comprehensive. NO MAKE UP EXAMS WILL BE GIVEN! At the instructors discretion an exam may be taken late with an automatic deduction of 10 points.

% Grade Scale
100 – 90 = A  Exams (5)  45%
89 – 80 = B  Quizzes & assignments  10%
79.9 – 75 = C  Differentials  5%
74.9 – 70 = D  Venipuncture  5%
69.9 – 60 = F  Comprehensive final including last semester  35%

Test Policy:
Exams will be scheduled on a Monday and opened from 6 – 8 p.m. There will be five examinations and a comprehensive final. All exams are on-line and you will need a camera and respondus lockdown to take the exam. The lecture exams may include brief essay questions and case studies along with multiple choice questions. No make-up exams will be offered. If you cannot attend an exam for a legitimate reason, (death, illness etc.) inform the instructor as soon as possible and the instructor will arrange a new time. If the student does not make any arrangements (s)he will receive a ZERO on the exam. Please notice that our grade scale is different from the standard grade scale. In order to pass the course you must earn a 75% average and a 74.9% does not constitute a passing grade. Students in the CLS program cannot continue with the program with a grade of D or below.
INSTRUCTIONAL STRATEGIES:
Hematology is an entirely new subject for most students so it is imperative that the student keeps current in all the readings. **MAKE A SPECIAL EFFORT TO LEARN ALL THE HEMATOLOGY VOCABULARY.** Each chapter of the book has written objectives. The student should answer these objectives in order to understand the material fully. At the end of the chapters there are review questions the student should answer to help assess the student’s grasp of the chapter content. The back of the chapter also includes a summary chart of the chapter to help the student recall the important subject matter.

**TIME NEEDED TO STUDY! How to be successful in this course**
The typical rule is for each hour you spend in class, you should spend 2-3 hours outside of class studying. **ON AVERAGE, YOU NEED TO READ A MINIMUM OF ONE CHAPTER PER DAY.** Try to follow these steps:

1. **DO THIS FIRST!!!** Look at the tentative course schedule, read that chapter to be covered.
2. Open PowerPoint lecture and have text book open and take notes alongside the power point. **DON’T BE AFTAID TO MARK UP YOUR BOOK.**
3. After reviewing the lecture and taking notes, **RE-READ THE CHAPTER.**
4. **Answer the objective in the beginning of the chapter, review case studies, and answer questions in the back of the chapter.**
5. **Bring questions or ask for clarifications with you when you come to the lab.**

**Scholastic Integrity**
Academic dishonesty is prohibited and is considered a violation of the UTEP Handbook of Operating Procedures. It includes, but is not limited to, cheating, plagiarism, and collusion. Cheating may involve copying from or providing information to another student, possessing unauthorized materials during a test, or falsifying research data on laboratory reports. Plagiarism occurs when someone intentionally or knowingly represents the words or ideas of another as ones' own. Collusion involves collaborating with another person to commit any academically dishonest act. Any act of academic dishonesty attempted by a UTEP student is unacceptable and will not be tolerated. All suspected violations of academic integrity at The University of Texas at El Paso must be reported to the **Office of Student Conduct and Conflict Resolution (OSCCR)** for possible disciplinary action. To learn more: **HOOP: Student Conduct and Discipline.**

**Accommodations Policy**
The University is committed to providing reasonable accommodations and auxiliary services to students, staff, faculty, job applicants, applicants for admissions, and other beneficiaries of University programs, services and activities with documented disabilities in order to provide them with equal opportunities to participate in programs, services, and activities in compliance with sections 503 and 504 of the Rehabilitation Act of 1973, as amended, and the Americans with Disabilities Act (ADA) of 1990 and the Americans with Disabilities Act Amendments Act.
(ADAAA) of 2008. Reasonable accommodations will be made unless it is determined that doing so would cause undue hardship on the University. Students requesting an accommodation based on a disability must work with the UTEP Center for Accommodations and Support Services BEFORE class. Accommodations are NOT given after the fact.

STATEMENT ON HARRASSMENT

Harassment:
Please be aware that harassment is unacceptable in the classroom. No jokes, comments of sexual nature as well as racists will be tolerated. The student that uses harassment will be sent to the Dean of students for disciplinary action.

NON-DISCRIMINATION STATEMENT

Title IX Statement:
Title IX of the Education Amendments of 1972 (Title IX), prohibit discrimination on the basis of sex in education programs or activities operated by recipients of Federal financial assistance. Sexual harassment of students, which includes acts of sexual violence, is a form of sex discrimination prohibited by Title IX. Sexual violence refers to physical sexual acts perpetrated against a person's will or where a person is incapable of giving consent due to the victim's use of drugs or alcohol. An individual also may be unable to give consent due to an intellectual or other disability. A number of different acts fall into the category of sexual violence, including rape, sexual assault, sexual battery, sexual coercion, stalking, and relationship violence. All such acts of sexual violence are forms of sexual harassment covered under Title IX.

In accordance with Title IX of the Education Amendments of 1972, UTEP does not discriminate on the basis of sex in the operation of its educational programs and activities. This commitment to non-discrimination applies to both employment in and admission to such programs and activities. [Link to full text at http://admin.utep.edu/Default.aspx?tabid=68750] Inquiries regarding Title IX should be referred to the University's Title IX Coordinator(s):
Sandy Vasquez, Title IX Coordinator (Investigation of concerns related to Faculty and Staff) 915.747.5662 svasquez@utep.edu
Dr. Catie McCorry-Andalis, Deputy Title IX Coordinator (Education, Training and Outreach) 915.747.5648 cmandalis@utep.edu
Dr. Charlie Gibbens, Deputy Title IX Coordinator (Interim Assistant Vice President for Student Support) Oversees investigations of concerns related to Students 915-747-7448 cegibbens@utep.edu
Related Resources

- Center Against Family Violence Hopelines: 915.593.7300 or 1.800.727.0511
- El Paso Police Department (911) or UTEP Police Department (747-5611).
- For suspected harm of children or older persons, Child/Adult Protective Services 1-800-252-5400.
- National Domestic Violence Hotline 1-800-799SAFE (7233).

**STUDENT SUPPORT SERVICES STATEMENT**

Student Support Services:

All students experience stress and emotional challenges. The following resources can help those feeling stressed, experiencing loss, and considering ending their life.

- UTEP’s Counseling Center offers free counseling to all students with the same number leading to an after-hours crisis line: (915) 747-5302
- Mental Health Crisis Line (915) 779-1800
- National Suicide Prevention Hotline 1-800-273-8255 and Veterans Crisis Line 1-800-273-8255
- NAMI of El Paso (National Alliance Against Mental Illness) (915) 534-5478

**Student Due Process**

Students who believe they have been unfairly evaluated must:

Step 1: Attempt to resolve the difficulty with the faculty member.

Step 2: If the dispute cannot be resolved in Step 1, the student may within 5 school days appeal to the program director stating the evidence for the continued dispute in writing.

Step 3: If still unresolved a written complainant, evidence, and reason for the dissatisfaction must be submitted to the Assistant Dean of the College of Health Sciences. The Assistant Dean will call upon the Due Process Committee to review and make recommendations to the Assistant Dean based on statements, written evidence, and interviews with all parties involved.

Step 4: If the matter is still not settled, the complainant will notify the Dean, within five (5) school days. The Dean will then pursue the matter with the Vice President for Student Affairs. The process will continue until the matter is resolved.

Course schedule on next page
VERY TENTATIVE COURSE SCHEDULE AND BOOK CHAPTERS
ALL EXAMS WILL BE OPEN ON A MONDAY FROM 6 – 8 P.M.

LEUKOCYTES: (Chapters 4, 9, 26 – 34)
JAN 18 – FEB 1
Cell biology, granulocytic and monocytic series
Non-malignant Leukocyte disorders
Lipid (lysosomal) Storage Diseases and Histiocytosis
Non-malignant Lymphocytic disorders (Reactive lymphocytes & IM)
FEB 1 EXAM I

FEB 3 – FEB 26
Introduction to leukemias and acute leukemia (Acute Vs. Chronic)
Cytogenetics and Molecular Diagnostics
Flow cytometry
Myeloproliferative Neoplasms: CMPD: CML, PV, ET, MF
Myeloproliferative Neoplasms CMPD: CML, PV, ET,MF
FEB 22 EXAM II

FEB 24 – MARCH 15
Myelodysplastic Syndromes
Acute Leukemias
Mature Lymphoid Neoplasms
Lymphoma, Multiple Myeloma, and related plasma cell disorders
MAR 15 EXAM III

HEMOSTASIS: NOTE: I do a lot of drawing on the board and limited power points for the first section of hemostasis (Chapters 10, 35-42)
MAR 22 – April 12
Mechanism of blood coagulation
Platelet structure and function
Coagulation Cascade Theory
Quantitative and qualitative vascular & platelet disorders
Laboratory Assessment of Blood coagulation factors
Protective agents against thrombosis
APR 12 EXAM IV

APRIL 14 – May 3
Vascular disorders / Abnormal Platelet Morphology
Qualitative Platelet Disorders
Qualitative Characteristics of Platelets
Bleeding disorders related to blood clotting/Hypercoagulable states
Bleeding disorders related to blood clotting/Hypercoagulable states
MAY 3 COAGULATION EXAM V

MAY 14 COMPREHENSIVE FINAL (including Heme I) 9A.M. – 12: P.M.
As a reminder, the final exam in Hematology II will be comprehensive including information covered in Hematology I
MLS Hematology cognitive objective covered in Hematology I, Hematology I Laboratory and Hematology II
Upon completion of this course, the student should be able to: Define, discuss, explain, identify and perform …

Normal hematopoietic system (Hematology I)

Define hematopoiesis
   - Theory of pluripotent stem cell development
   - Stem cell kinetics: Generative cell cycle
   - Hematopoietic inductive environment of regulatory growth factors and inhibitors
   - Apoptosis

Identify phases and site of origin for cellular development of active hematopoietic tissue in embryo and fetus
   - Yolk sac
   - Mesoblastic phase
   - Hepatic phase (extramedullary)
   - Medullary/myeloid phase

Identify phases and site of origin for cellular development of active hematopoietic tissue in infant and young child
   - All red marrow spaces (all cell lines)
   - Thymus fully developed (T lymphs)
   - Secondary lymphoid tissue (B-cell, T-cell and NK-cell)

Identify phases and site of origin for cellular development of active hematopoietic tissue in adult
   - Red marrow (axial skeleton and proximal ends of long bones)
   - Primary and secondary lymphoid tissue (B-cell, T-cell and NK-cell)

Explain the role of other organ systems in hematopoiesis
   - Mononuclear phagocyte system
   - Spleen (Structure, blood flow, function)
   - Liver (Structure, blood flow, function)
   - Lymph nodes (Structure, blood flow, function)
   - Thymus (Structure, blood flow, function)

State the physical findings commonly present in hematologic disease
   - Splenomegaly
   - Hypersplenism
   - Hepatosplenomegaly
   - Lymphadenopathy

Bone Marrow Tissue (Hematology I)

List indications for performing bone marrow examination

Describe bone marrow collection techniques
   - Aspiration
Core biopsy

Describe key terms and apply concepts used to assess bone marrow structure and function
- Myeloid to erythroid ratio (M:E)/erythroid to granulocyte ratio (E:G)
- Erythropoiesis
- Granulopoiesis
- Megakaryopoiesis
- Non-hematopoietic cells
- Cellularity: fat (yellow marrow) to cell (red marrow) ratio
- Aplastic marrow
- Hypoplastic marrow

Describe concepts related to the assessment of iron stores and sideroblast population in the bone marrow
- Type I
- Type II
- Type III

Perform differential count on normal bone marrow specimens

Distinguish between normal and abnormal hematopoietic elements found within the peripheral blood

Correlate bone marrow findings with peripheral blood evaluation

Prepare peripheral blood for routine hematologic procedure and smear analysis

Determine specimen acceptability

List appropriate anticoagulants and mechanism of anticoagulation

Identify acceptable ratio of anticoagulant to blood for specimens obtained from venipuncture and skin puncture

List reasons for rejecting specimens

Stain smears using Romanowsky dyes and techniques according to established procedures
- Manual, Automated

List and define components of stain and explain the principle

Judge the acceptability of blood smears through microscopic evaluation and established criteria
- Random distribution of cells
- Good stain quality
Absence of artifact

Troubleshoot staining problems

Correlate peripheral blood evaluation with automated cell analysis

Enumerate and morphologically evaluate blood cells on Romanowsky stained smears

Erythropoiesis (Hematology I)

Describe the distinctive features used to characterize developing cells

- Overall cell diameter or volume
- Nucleus (diameter or volume, relative diameter or volume, staining reaction, chromatin pattern, presence or absence of nucleoli)
- Cytoplasm (relative amount, staining reaction)
- Nuclear:cytoplasmic ratio

List the maturation sequence of developing erythrocytes given Romanowsky stained smears, electronic images or other visual means of representation of blood and bone marrow

Distinguish nucleated erythrocyte precursors from other hematopoietic elements

Categorize red cells

- Diameter or volume
- Shape
- Color
- Inclusions
- Distribution patterns

Describe nutritional and regulatory factors associated with erythropoiesis

- Erythropoietin (EPO)
- Iron
- Vitamins (B<sub>12</sub> / folate)

List hormones associated with erythropoiesis

- Estrogen/Androgens/Thyroxine/Growth hormone

Identify and discuss components of the mature red cell that are essential for survival and function

- Membrane composition
  - Lipids/Proteins/Skeletal proteins
- Membrane Function
  - Maintain RBC shape, deformability, and permeability
  - Support system for surface antigens
  - Transport and exchange of gases and ions (cationic pumps)

Describe metabolic pathways for maintenance of cell function

- Embden-Meyerhof/glycolytic
Hexose monophosphate shunt
Methemoglobin reductase
Luebering-Rapoport

**Erythrocytic Hemoglobin (Hematology I)**

Summarize the mechanisms by which normal hemoglobin is structured and synthesized in the developing red cell
- Iron transport, uptake, and supply
- Protoporphyrin IX (heme) formation
- Globin synthesis and genetic control (Chromosome 11 and 16)
- Embryonic hemoglobins (Gower I, Gower II, Portland)
- Adult hemoglobins (Hb A, Hb F, Hb A$_2$)

Describe normal hemoglobin-oxygen function using the oxygen dissociation curve (ODC)

Identify the effect various conditions can have on the oxygen dissociation curve
- pH (Bohr effect)
- Temperature
- CO$_2$
- 2,3-DPG (2,3-BPG)
- Hb S,F and other variants

Interpret the effect of various factors on the concentration of hemoglobin
- Age and gender
- Pregnancy
- Altitude
- Smoking
- Associated disease
- Altered hemoglobin derivatives
  (carboxyhemoglobin/methemoglobin/sulfhemoglobin)

**Erythrocytic Catabolism (Hematology I)**

Summarize the mechanism by which red cells are catabolized

Identify phases (extravascular, intravascular)

Trace the basic steps associated with each phase

Define terms associated with red cell destruction
- Biliverdin
- Bilirubin (unconjugated/conjugated)
- Urobilinogen
- Urobilin
- Hemoglobin dimers
- Haptoglobin
- Hemopexin
- Hemoglobinemia
- Hemoglobinuria
- Hemosiderinuria
Erythrocyte Evaluation (Hematology I)

Describe procedures to evaluate erythrocytes and their physical properties using patient blood and quality control samples  
Level 1

Perform procedures to evaluate erythrocytes and their physical properties using patient blood and quality control samples  
Level 2

State the clinical utility of histogram review in erythrocyte evaluation  
Level 1

Determine if results are in accordance with prescribed criteria for accuracy and precision  
Level 3

Discuss automated hemogram parameters used for erythrocyte evaluation  
Level 1
- Hemoglobin
- Hematocrit
- Mean cell volume (MCV)
- Mean cell hemoglobin (MCH)
- Mean cell hemoglobin concentration (MCHC)
- Red cell distribution width (RDW)

Calculate red blood cell indices when provided appropriate data  
Level 2

State the principles of method analysis for hemoglobin determination  
Level 1
- Hemoglobin measured at the point-of-care
- Cyanmethemoglobin method
- Other instrument methods for hemoglobin

Perform erythrocyte sedimentation rates  
Level 2
- Wintrobe
- Westergren and its modifications
- Automated

Perform standard reticulocyte assays  
Level 2
- Supravital smear method with Miller disc
- Supravital smear method without Miller disc
- Automated methods

Perform and interpret calculations associated with reticulocyte assays  
Level 3
- Corrected
- Absolute
- Production index (RPI)
- Reticulocyte hemoglobin concentration
- Reticulocyte mean volume
- Immature reticulocyte fraction (IRF) or reticulated hemoglobin content (CHr)

Determine the appropriate area of a peripheral blood smear to evaluate red  
Level 2
blood cell morphology

Distinguish between normal and abnormal red blood cell morphology Level 2

List red blood cell count and indices reference values that account for variations in gender and age Level 1

Correlate automated hemogram parameters and calculated indices with each other and with peripheral smear exam results Level 3

Calibrate and perform preventive maintenance on instruments used to evaluate erythrocytes and their physical properties Level 2

Recognize and troubleshoot pre-analytical (pre-examination), analytical (examination), and post-analytical (post examination) causes of problems or unexpected results Level 3

Take corrective action to resolve unexpected results and/or events on instruments used to evaluate erythrocytes Level 3

Make decisions to recommend appropriate follow-up to prevent unexpected results and/or events from reoccurring Level 3

**Leukopoiesis (Hematology II)**

State reference values that reflect variations in gender and age for the leukocyte counts in peripheral blood Level 1

- Total leukocyte count
- Relative and absolute values for neutrophil, lymphocyte, eosinophil, basophil and monocyte counts

Identify factors that alter leukocyte values Level 1

- Physiologic variation
- Pathologic abnormalities

Enumerate and/or calculate leukocyte counts Level 2

- Relative values
- Absolute values

List morphologic features used to differentiate developing leukocytes Level 2

- Overall cell diameter or volume
- Nucleus
- Shape
- Relative diameter
- Nuclear to cytoplasmic ratio (N:C)
- Staining reaction
- Chromatin pattern
- Presence or absence of nucleoli
- Relative amount of cytoplasm
- Cytoplasmic staining properties
Presence or absence of granules and staining reaction in cytoplasm

**Leukopoiesis: Granulocytes (Hematology I and II)**
- List the maturation sequence of neutrophils, eosinophils, and basophils  
  Level 1
- Differentiate distinguishing morphology for stages of developing blood granulocytes  
  Level 2
- Explain mechanisms that regulate and modulate granulopoiesis  
  Level 2
  - Regulatory growth factors and inhibitors
  - Kinetics (life span, circulation)
  - Biochemistry (granule content and surface membrane receptors, energy metabolism)
- Explain the functions associated with granulocytes  
  Level 2
  - Chemotaxis
  - Phagocytosis and killing
  - Allergic response (eosinophils and basophils)
  - Host defense against parasites (eosinophils)
  - Hypersensitivity mediator (basophils and mast cells)

**Leukopoiesis: Monocytes and Lymphocytes (Hematology II)**
- Summarize structural and functional features that characterize monocytes and macrophages  
  Level 2
  - Kinetics (life span, circulation, tissue phase)
  - Function (phagocytosis, antigen-presenting cells (APC), pathogen presenting cells)
- List the maturation sequence of monocytes and macrophages  
  Level 1
- List the maturation sequence of lymphocytes  
  Level 1
- Summarize structural and functional features that characterize lymphopoiesis  
  Level 2
  - Sites of formation and production (Bone marrow, Thymus, Lymph nodes and secondary lymphoid tissue)
  - Kinetics (Life span, Migration
  - Function
    - Humoral immunity (B lymphocytes and subsets)
    - Cell mediated immunity (T lymphocytes and subsets)
    - Natural killing and antibody dependent cellular cytotoxicity
- Recognize morphology of developing monocytes and macrophages  
  Level 1
- Recognize morphology of developing lymphocytes  
  Level 1
- Describe the use of monoclonal antibodies to differentiate lymphocytes by immunophenotype  
  Level 2
  - B-cell lymphocytes and subsets
  - T-cell lymphocytes and subsets
Leukocyte Evaluation (Hematology I and II)

- Perform commonly used methods to evaluate leukocytes
  - Level 2

- State the principles and clinical utility of histogram/scatterplot review
  - Level 1

- Determine absolute and relative white cell counts on patient and control specimens using manual and automated methods in accordance with prescribed criteria for accuracy and precision
  - Level 2

- Calibrate and perform preventive maintenance on instruments used to evaluate white cells
  - Level 2

- Determine differential cell counting using automated methods
  - Level 2

- Evaluate white cell histograms and scatterplots for diagnostic and quality control purposes
  - Level 3

- Identify and classify normal and abnormal white cells on a properly stained Romanowsky blood smear
  - Level 2

- Correlate and verify automated cell counts and differentials with established criteria
  - Level 3

- Estimate the total white blood count from a smear
  - Level 2

- Correct leukocyte counts for the presence of nucleated red cells
  - Level 2

- Calibrate and perform preventive maintenance on instruments used to evaluate leukocytes and their physical properties
  - Level 2

- Recognize and troubleshoot pre-analytical (pre-examination), analytical (examination), and post-analytical (post examination) causes of problems or unexpected results
  - Level 3

- Take corrective action to resolve unexpected results and/or events on instruments used to evaluate leukocytes
  - Level 3

- Make decisions to recommend appropriate follow-up to prevent unexpected results and/or events from reoccurring
  - Level 3

Nonmalignant Leukocyte Disorders (Hematology II)

- Explain the classification of nonmalignant leukocytic disorders
  - Level 1
  - Quantitative changes
  - Qualitative changes
Compare and contrast absolute values with relative values  
Neutrophilia  
Neutropenia  
Eosinophilia  
Eosinopenia  
Basophilia  

Associate quantitative and qualitative leukocyte disorders with expected results  
Bone marrow production and release  
Rate of entry into peripheral circulating pools  
Shifts between circulating and marginating pools  
Rate of exit into tissues  

Identify morphologic changes in neutrophils that may accompany nonmalignant neutrophilic disorders  
Shift to the left  
Toxic granulation  
Dohle bodies  
Vacuolization  
Leukemoid reaction  
Leukoerythroblastic reaction  
Agranulocytosis  
Hypossegmentation  
Hypersegmentation  

State characteristic abnormalities and clinical features for the qualitative/functional disorders of neutrophils  
Pelger-Huet anomaly  
Alder-Reilly anomaly  
Chediak-Higashi anomaly  
May-Hegglin anomaly  
Chronic granulomatous disease (CGD)  
Myeloperoxidase deficiency  
Leukocyte adhesion deficiency  

Describe qualitative and quantitative alterations of monocytes  
Define monocytosis  

Compare absolute monocyte values with relative values  
Identify causes of monocytosis  
Identify abnormal lipid accumulations within monocytes and macrophages  
Identify causes of non-neoplastic disorders of lymphocytes and plasma cells
Define lymphopenia/lymphocytosis Level 1

Compare lymphocyte absolute values with relative values Level 2

Compare and contrast morphologic features of reactive lymphocytes and normal lymphocytes Level 3
   Size
   Nucleus
   Cytoplasm
   Heterogeneity

Differentiate between reactive and resting lymphocytes on Romanowsky stained smears Level 2

Identify the causes of reactive lymphocytosis Level 2

Red Blood Cell Disorders: Anemia (Hematology I)

Define anemia Level 1

State the clinical signs and symptoms of anemia
   Hemoglobin
   Hematocrit
   Red blood cell count
   RBC indices
   Red cell distribution width (RDW)
   Peripheral smear
   Reticulocyte count
   Bone marrow evaluation

List the categories used in a morphological classification of the anemias Level 1

Describe the expected laboratory results seen in the various pathophysiologic classifications of anemias Level 2
   Decreased red cell production (Bone marrow failure, ineffective hematopoiesis, Myelophthsic)
   Increased red cell destruction, hemolytic processes
   Loss of red blood cells

Discuss the clinical utility of the RBC indices as relates to physiologic conditions Level 3

Explain sources of error of the red cell indices Level 2

Use the RBC indices as a quality control mechanism for assessing the validity of the erythrocyte count, hemoglobin, and hematocrit values Level 2

Define common terms used to describe red cell morphology
   Level 1 Anisocytosis
   Poikliocytosis
Polychromatic
Rouleaux
Agglutination
Acanthocyte/Spur Cell
Codocyte/Target Cell/Leptocyte
Dacryocyte/Tear Drop Cell
Drepanocyte/Sickle Cell
Echinocyte/Burr Cell
Elliptocyte
Keratocyte
Schistocyte
Spherocyte
Stomatocyte
Basophilic stippling
Cabot rings
Heinz bodies
Howell-Jolly bodies
Malarial parasites
Pappenheimer bodies/siderotic granules
Hemoglobin crystals
Hemoglobin H

Describe the composition and morphology and list the possible pathologic conditions of various red blood cell inclusions
   Basophilic stippling
   Cabot rings
   Heinz bodies
   Howell-Jolly bodies
   Malarial and other blood parasites
   Pappenheimer bodies/siderotic granules
   Hemoglobin crystals (C, S, SC, H inclusion bodies)

Red Blood Cell Disorders: Erythrocytosis (Polycythemia) (Hematology I)
Polycythemia vera is in Hematology II
Define polycythemia

Differentiate between absolute polycythemia and relative polycythemia

Compare and contrast secondary polycythemia, and relative erythrocytosis
Etiology
Clinical features
Laboratory findings
Prognosis

Describe changes in the bone marrow and peripheral blood with polycythemia vera

Red Blood Cell Disorders: Hypochromic Anemias (Hematology I)
Define hypochromic anemia

List the causes of hypochromic anemias
Discuss the etiology and pathophysiology of hypochromic anemias

- Iron deficiency anemia
- Sideroblastic anemia
- Anemia of chronic disease
- Hemochromatosis/ Hemosiderosis
- Porphyrias
- Thalassemia

Compare and contrast laboratory findings in iron deficiency anemia, anemia of chronic disease/inflammation and sideroblastic anemia

- Serum ferritin
- Serum iron
- Transferrin/ Total Iron Binding Capacity (TIBC)
- Percent transferrin saturation
- Bone marrow evaluation for ringed sideroblasts
- Free erythrocyte protoporphyrin (FEP)/zinc protoporphyrin (ZPP)
- Transferrin receptor tests
- Hepcidin

Outline a laboratory approach to the evaluation of a patient’s iron status

Red Blood Cell Disorders: Megaloblastic Anemias (Hematology I)

Discuss the absorption and metabolism of vitamin B₁₂ and folate

Describe clinical features of megaloblastic anemia

Identify the hematologic abnormalities present in megaloblastic anemia

- Peripheral blood changes
- Bone marrow-morphological changes

Compare and contrast pernicious anemia to the other types of vitamin B₁₂ deficiency

Outline a sequential approach to the differential diagnosis of megaloblastic anemia using the following laboratory procedures

- Mean corpuscular volume (MCV)
- Blood and bone marrow smear evaluation
- Serum B₁₂
- Serum folate
- Red cell folate
- Anti-intrinsic factor antibodies
- Anti-parietal cell antibodies
- Methylmalonic acid
- Homocysteine

Differentiate nonmegaloblastic macrocytosis from megaloblastic anemia

Peripheral blood and bone marrow characteristics
Serum vitamin B12 level
Serum folate level
Red cell folate level
Reticulocyte findings

Red Blood Cell Disorders: Hypoproliferative Anemias: Congenital and Acquired (Hematology I)

Define aplastic anemia Level 1

Identify common factors associated with the development Level 1

Describe the clinical features and pathophysiology Level 2
Acquired aplastic anemia
Fanconi’s anemia
Congenital pure red blood cell aplasia
Anemia caused by myelophthisis

Describe the laboratory findings Level 1
Peripheral blood changes
Bone marrow changes
Other laboratory findings

Define Fanconi’s anemia Level 1

Describe the genetics and possible pathophysiology Level 2

Describe the laboratory findings Level 1
Peripheral blood changes
Bone marrow changes
Other laboratory findings

Define pure red cell aplasia (Diamond-Blackfan anemia) Level 1

Describe the clinical features and pathophysiology Level 2

Describe the laboratory findings Level 1
Peripheral blood changes
Bone marrow changes
Other laboratory findings
Define and differentiate Congenital dyserythropoietic anemias (types I, II, and III)  Level 2

Describe the clinical features  Level 1

Describe the laboratory findings  Level 1

Define myelophthisis  Level 1

Describe the clinical features  Level 1

Describe the laboratory findings  Level 1

Peripheral blood changes
Bone marrow changes
Other laboratory findings

Red Blood Cell Disorders: Hemolytic Anemias (Hematology I)

Describe the etiology, pathophysiology, clinical features, and laboratory findings of red cell membrane defects  Level 1

Hereditary spherocytosis
Hereditary elliptocytosis
Paroxysmal nocturnal hemoglobinuria (PNH)
Hereditary pyropoikilocytosis
Hereditary acanthocytosis
Hereditary stomatocytosis (hydrocytosis)
Hereditary xerocytosis

Identify and correlate data from laboratory tests that are used to detect increased RBC destruction and production due to RBC membrane abnormalities  Level 2

Discuss the principle of the Osmotic fragility test  Level 1

Describe the clinical features  Level 1

Describe the laboratory findings  Level 1

Perform /observe the procedure  Level 2

Apply appropriate quality control procedures  Level 2

Evaluate results  Level 3

Describe the utility of flow cytometry in assessing red cell membrane defects  Level 2

Describe the etiology, pathophysiology, and clinical features of red cell enzyme abnormalities  Level 1

Glucose-6-phosphate dehydrogenase (G6PD) deficiency
Pyruvate kinase (PK) deficiency
Methemoglobin reductase

Discuss the principles of G6PD assay, pyruvate kinase assay and staining for Heinz Bodies  Level 1

Identify laboratory test results based upon  Level 1
Red Blood Cell Disorders: Hemoglobinopathies (Hematology I)

Define hemoglobinopathy

Distinguish between qualitative and quantitative hemoglobin defects

Describe clinical and laboratory findings of hemoglobinopathies

Hb SS
Hb AS
Hb CC
Hb AC
Hb DD
Hb EE
Hb SC

Identify the amino acid substitutions associated with sickle cell anemia and hemoglobin C disease

Describe the physiologic abnormality associated with hemoglobin variants with altered oxygen affinity (Unstable hemoglobins, Methemoglobinemia)

Describe the hemoglobin gene defect in alpha and beta thalassemia

Define the hemoglobin defect in thalassemia

Describe the terminology associated with thalassemias

Alpha thalassemia
  4 gene deletion
  3 gene deletion (Hb H disease)
  2 gene deletion
  1 gene deletion

Beta thalassemia
  Beta-thalassemia major
  Beta-thalassemia intermedia
  Beta-thalassemia minor

Describe the clinical features associated with different gene combinations in alpha and beta thalassemia

Describe the pathophysiology of thalassemias
  Hemoglobin Lepore
  Delta-beta thalassemia
  Hb H
Bart's hemoglobin
Hereditary persistence of fetal hemoglobin
Hb Constant Spring

Identify the characteristic clinical and laboratory findings associated with thalassemia Level 1

Describe the peripheral blood morphology associated with different gene combinations in alpha and beta thalassemia Level 1

Discuss the principle of the solubility test for sickling hemoglobin
Describe the laboratory findings Level 1
Perform /observe the procedure Level 2
Apply appropriate quality control procedures Level 2
Evaluate results Level 3

Discuss the principles of hemoglobin electrophoresis (cellulose acetate, alkaline pH vs. citrate agar, acid pH)
Describe the laboratory findings Level 1
Perform /observe the procedure Level 2
Apply appropriate quality control procedures Level 2
Evaluate results Level 3

Discuss the separation of hemoglobin by capillary electrophoresis Level 1

Discuss the principles of hemoglobin quantification (HbA, HbA2, HbF)
Describe the laboratory findings Level 1
Perform /observe the procedure Level 2
Apply appropriate quality control procedures Level 2
Evaluate results Level 3

Describe acid elution test (Kleihauer-Betke) or flow cytometry in regards to Hemoglobinopathies Level 1

Correlate screening test for sickling hemoglobin with peripheral blood morphology and electrophoretic patterns of hemoglobin Level 3

Identify the electrophoretic patterns (cellulose acetate, alkaline pH vs. citrate agar, acid pH)
Hb F, Hb A, Hb S, Hb C, Hb D, Hb E, Hb A2

Hemolytic Anemias (Hematology I)

Identify mechanisms of immune hemolytic anemias Level 1

Define and describe the etiology and clinical features and laboratory findings of Alloimmune hemolytic anemias Level 1
Acute hemolytic transfusion reaction
Delayed hemolytic transfusion reaction
Hemolytic disease of the newborn (HDN)

Define and describe the etiology and clinical features and laboratory findings of Level 1
Autoimmune hemolytic anemias
  Warm autoimmune hemolytic anemia (WAIHA)
  Cold autoimmune hemolytic anemia
  Cold agglutinin syndrome (Idiopatic, Secondary)
  Paroxysmal cold hemoglobinuria

Identify mechanisms of drug-induced immune hemolytic anemia Level 1

Identify the etiology of nonimmune hemolytic anemia Level 1
  Infectious organisms
  Mechanical agents
  Chemicals

Describe the hematologic findings associated with nonimmune hemolytic anemias Level 1
  Malaria
  Babesiosis
  Bartonellosis
  Clostridium perfringens (welchii) infection
  Cardiac prosthetic devices
  Microangiopathic hemolytic anemia
  Chemicals and venoms
  Thermal injury
  Disseminated intravascular coagulation

**Acute Blood Loss (Hematology I)**
Describe the etiology of anemia of acute blood loss Level 1
List the clinical symptoms of acute blood loss Level 1
Identify the laboratory findings of acute blood loss Level 1

**Anemias associated with systemic disorders (Hematology I)**
Describe the clinical features and laboratory findings associated with nonhematologic disorders Level 1
Chronic disorders and inflammation
  Connective tissue disorders
  Malignant diseases
  Renal disease
  Liver disease
  Alcoholism
  Endocrine disease
Neoplastic Disorders (Hematology II)

Define and list categories associated with Neoplastic Disorders of Leukocytes

- Leukemias
- Myelodysplastic syndromes
- Myeloproliferative disorders
- Lymphoproliferative disorders

Level 1

Identify major systems used to classify neoplastic disorders of leukocytes

- French, American-British (FAB) Cooperative Group
- World Health Organization (WHO)

Level 1

Observe and/or perform procedures, apply appropriate quality control procedures, and interpret laboratory findings for laboratory procedures used in the identification, classification and differentiation of neoplastic disorders

- Complete blood count
- Hemograms
- Scatterplots and histograms

Level 2

Review the criteria used to classify nonmalignant leukocytic disorders

- Quantitative changes
- Qualitative changes (inherited, acquired)

Level 1

Identify on Romanowsky stained smears, photographs, electronic images or other visual means of representation of morphologic changes in neutrophils that may accompany nonmalignant neutrophilic disorders

- Shift to the left
- Toxic granulation
- Döhle bodies
- Vacuolization
- Leukemoid reaction
- Leukoerythroblastic reaction
- Agranulation, hypogranulation
- Hypossegmentation
- Hypersegmentation
- Intracellular microorganisms

Level 2

Compare and contrast the principles of various cytochemical stains and the cell lineages they react with

- Myeloperoxidase
- Sudan black B (SBB)
- Esterases (specific substrate/non-specific substrate
- Periodic-acid Schiff (PAS)
- Leukocyte alkaline phosphatase (LAP)
- Tartrate resistant acid phosphatase (TRAP)
- Iron staining

Level 2
Describe the use of various diagnostic techniques used to assess neoplastic disorders of blood and bone marrow cells
- Immunophenotyping
- Terminal deoxynucleotidyl transferase (TdT)
- Monoclonal antibodies
- Myeloid from lymphoid
- T and B cell immunophenotypes
- Acute myelocytic leukemia (AML) subgroups cell lineages
- Cytogenetics
- Molecular genetics

Apply knowledge and skills in interpreting laboratory results and recognizing clinical syndromes that are unique to the neoplasm

Read case studies of neoplastic disorders and apply knowledge and skills in interpreting laboratory results

**Acute Leukemias** (Hematology II)

Apply general criteria to classify leukemias
- Cell maturity (Acute/Chronic)
- Cell lineage (Myeloid /nonlymphoid)
- Lymphoid

Describe the clinical findings and laboratory results for leukemia

Compare the FAB with the WHO acute myeloid leukemia subgroups and apply diagnostic blood and bone marrow findings to the differential identification
- FAB classification
  - M0--acute myeloid leukemia with minimal differentiation
  - M1--acute myeloid leukemia without maturation
  - M2--acute myeloid leukemia with maturation
  - M3--acute promyelocytic leukemia
  - M4--acute myelomonocytic leukemia
  - M5--acute monocytic leukemia
  - M6--acute erythroleukemia
  - M7--acute megakaryoblastic leukemia
- WHO classification
  - AML with recurrent genetic abnormalities
  - AML with myelodysplasia-related changes
  - Therapy-related myeloid neoplasms

List the WHO acute leukemia subgroups
- AML with recurrent genetic abnormalities
- AML with myelodysplasia-related changes
- Therapy-related myeloid neoplasms
- AML, not otherwise specified

Interpret findings from immunophenotypic, cytogenetic and molecular findings
and apply to criteria used by WHO

Describe for each leukemia
  Clinical findings and symptoms
  Incidence and epidemiology
  Risk factors associated with the development of leukemia
  Hereditary abnormalities
  Environmental
  Viral infections
  Immunologic disorders

Identify the pathophysiology of leukemia
  Stem cell clonality
  Oncogene and tumor suppressor gene development

Describe the survival rates and prognosis

Describe the treatment options and correlation with hematologic complications
  Chemotherapy
  Bone marrow/stem cell transplant

Identify diagnostic findings on permanently stained blood and bone marrow smears, photographs, kodachromes, or electronic images by which the FAB cooperative group and WHO classify acute leukemia
  Morphology, number, and differentiation of blast and immature cells
  Greater than 30%
  Predominant cell type
  Auer rods

Define the reactivity of leukemic cells with cytochemical stains

Apply diagnostic blood and bone marrow findings to the differential identification
  Acute myeloid leukemia (AML)
  Acute nonlymphocytic leukemia (ANLL)
  M0--acute myelogenous with minimal differentiation
  M1--acute myelogenous without maturation
  M2--acute myelogenous with maturation
  M3--acute promyelocytic leukemia
  M3m--acute promyelocytic leukemia variant
  M4--acute myelomonocytic leukemia
  M4Eo--acute myelomonocytic leukemia variant
  M5--acute monocytic leukemia
  M5a--poorly differentiated
  M5b--well differentiated
  M6--acute erythroleukemia
  M7--acute megakaryocytic leukemia
  Acute lymphocytic leukemia (ALL): L1, L2, L3-Burkitt’s
List the subgroups (WHO) and apply diagnostic blood, bone marrow, immunophenotype, cytogenetics and molecular findings to the differential identification

- B lymphoblastic leukemia/lymphoma, not otherwise specified
- T lymphoblastic leukemia/lymphoma

Interpret findings from an immunologic workup to formulate an immunophenotypic classification for ALL apply to criteria used by WHO

- B lineage
- Early B precursors
  - “Common” CALLA (CD10) positive
- Pre-B
- T-cell lineage and early T precursor (pro-T, pre-T, cortical-T, medullary-T)
- Precursor lymphoid neoplasms

List cytogenetic and molecular abnormalities commonly associated with the major acute leukemic subtypes

**Myelodysplastic Syndromes (MDS) (Hematology II)**

Define and describe cellular features that characterize the MDS

- Dyserythropoiesis
- Dysgranulopoiesis
- Dysmegakaryocytopoiesis

List subgroups recognized by the World Health Organization (WHO) Cooperative Groups for the MDS classification and discuss the rationale for revisions to the classification

- Refractory cytopenia with unilineage dysplasia (RCUD)
- Refractory anemia (RA)
- Refractory neutropenia (RN)
- Refractory thrombocytopenia (RT)
- Refractory anemia with ringed sideroblasts (RARS)
- Refractory cytopenia with multilineage dysplasia (RCMD)
- Refractory anemia with excess blasts (RAEB)
- RAEB-1
- RAEB-2
- Myelodysplastic syndrome, unclassifiable (MDS-U)
- Myelodysplastic syndrome with isolated del (5q)

List subgroups recognized by the French, American, and British (FAB) Cooperative Group for the MDS classification

- Refractory anemia (RA)
- Refractory anemia with ringed sideroblast (RARS)
- Refractory anemia with excess blast (RAEB)
- Chronic myelomonocytic leukemia (CMML)
- Refractory anemia with excess blasts in transition (RAEB-t)

Identify key morphologic features on permanently stained blood and bone marrow
smears, photographs, electronic images or other visual means of representation

Correlate the diagnostic blood and bone marrow findings to the differential identification

Describe characteristics of MDS
- Median age of onset
- Epidemiology
- Chromosomal association with pathogenesis
- Clinical course with associated hematologic changes
- Treatment options
- Prognosis

**Chronic Myeloproliferative Neoplasms (Hematology II)**

Classify Chronic Myeloproliferative Neoplasms by cell type
- Granulocytes—Chronic myelogenous/granulocytic leukemia (CML/CGL)
- Erythrocytes—polycythemia vera (PV)
- Megakaryocytes—essential thrombocythemia (ET)
- Fibroblasts—agnogenic myeloid metaplasia (AMM)

List Chronic Myeloproliferative Neoplasms subtypes
- Chronic myelogenous leukemia (CML) BCR/ABL1 positive
- Essential thrombocythemia (ET)
- Primary myelofibrosis (PMF)
- Chronic neutrophilic leukemia (CNL)
- Chronic eosinophilic leukemia not otherwise specified (CEL, NOS)
- Mastocytosis

List subgroups recognized by WHO for the myelodysplastic/myeloproliferative classification and discuss the rationale for the classification
- Chronic myelomonocytic leukemia (CMML)
- CMML-1
- CMML-2
- Atypical chronic myeloid leukemia (aCML), BCR-ABL1 negative
- Juvenile myelomonocytic leukemia (JMML)
- MDS/MPN, unclassifiable

Discuss and compare features commonly shared by Chronic Myeloproliferative Neoplasms
- Clinical manifestations
- Pathophysiologic mechanisms
- Blood and bone marrow findings
- Transitional forms between stages
- Disease evolution with potential for blastic transformation

Identify key morphologic features on permanently stained blood and bone marrow smears, photographs, kodachromes, or electronic images

Level 3
Level 2
Level 1
Level 2
Level 1
Level 3
Level 2
Correlate diagnostic criteria to these findings for the differential identification

**Chronic myelogenous leukemia (CML)**
- Leukocytosis with absolute neutrophilia and left shift maturation
- Absolute basophilia and eosinophilia
- Thrombocytosis
- Bone marrow hypercellularity with granulocytic proliferation
- Cytogenetic (karyotype): t(9;22)(q34;q11)
- Molecular products: \( BCR/ABL \) fusion gene, fusion mRNA

**Polycythemia vera (PV)**
- Increased red blood cell (RBC) mass
- Leukocytosis with mild left shift maturation and basophilia
- Thrombocytosis
- Bone marrow hypercellularity with all cell lines increased
- Molecular studies (\( JAK2 \))
- Red cell morphology (Initial phase, “Spent” phase)

**Essential thrombocytopenia (ET)**
- Marked thrombocytosis with platelet aggregates and abnormal forms
- Megakaryocytic hyperplasia of bone marrow
- Molecular studies

**Primary myelofibrosis (PMF)**
- Leukoerythroblastosis with teardrop-shaped red cells
- Leukocytosis with left shift maturation to occasional immature myeloid cell
- Bone marrow fibrosis and relationship to megakaryocytic hyperplasia
- Molecular studies

Identify treatment options and recognize effects on peripheral blood white cells,

- Chemotherapy
- Splenic irradiation/splenectomy
- Phlebotomy
- Bone marrow or stem cell transplant
- Targeted molecular therapy

**Chronic Lymphoproliferative Disorders (Hematology II)**

Name and classify the chronic lymphoid leukemias by T and B cell lineage

- Chronic lymphocytic leukemia (CLL)
- B-cell prolymphocytic leukemia (PLL)
- Plasma cell neoplasms
- Hairy cell leukemia (HCL)
- Adult T-cell leukemia
- Sézary syndrome
- Extranodal marginal zone lymphoma or mucosa-associated lymphoid tissue (MALT lymphoma)
- Follicular lymphoma
- Mantel cell lymphoma
- Diffuse large B-cell lymphoma, not otherwise specified
- Burkitt lymphoma
Identify key morphologic features on permanently stained blood and bone marrow smears, photographs, kodachromes, or electronic images Level 2

List diagnostic features CLL Level 1
Median age of onset
Symptoms and clinical findings
Blood and bone marrow findings
Peripheral blood absolute lymphocytosis
Leukemic cell line of mature, small lymphocytes with monotonous morphology and smudge/basket cells
Immunophenotypic cell surface markers and clonality
Bone marrow lymphocytosis

Recognize and describe features associated with aggressive forms of the disease Level 1
Autoimmune hemolytic anemia (AIHA)
Chromosome and/or molecular abnormalities
Richter’s syndrome
Immunophenotypic cell surface markers

Name and compare systems used to stage disease severity and progress Level 2
Modified Rai
Binet

Discuss the diagnostic features of PLL Level 2
Median age of onset and gender
Clinical finding of severe splenomegaly
Blood and bone marrow findings
Markedly elevated white count with absolute lymphocytosis
White cell differential predominantly of prolymphocytes (greater than 55%)
Immunophenotypic profile
Chromosome and/or molecular

Discuss the diagnostic features of HCL Level 2
Median age of onset and gender
Clinical finding of severe splenomegaly
Blood and bone marrow findings
Pancytopenia
Morphology: leukemic cell line of “hairy” cells
Immunophenotypic B-cell profile
“Dry” tap; marrow fibrosis and infiltrates

Discuss treatment options Level 2
Splenectomy
Other drugs
Describe laboratory findings seen in the variant form of HCL Level 1

List diagnostic features of Adult T-cell leukemia Level 1
T-cell large granular lymphocytic leukemia (LGL)
Human T-cell lymphotropic virus-1 (HTLV-1)

Endemic areas

Apply diagnostic criteria to blood and bone marrow findings for the differential identification of Adult T-cell leukemia
   Lymphoid cell line of small to large cells with cloverleaf/knotty nucleus
   Immunophenotypic T cell associated profile

Identify key morphologic features on permanently stained blood and bone marrow smears, photographs, electronic images or other means of visual representation

List diagnostic features of Sézary syndrome
   Relationship to mycosis fungoides
   Clinical findings--skin involvement

Review blood and bone marrow findings of Sézary syndrome
   Absolute lymphocytosis
   Morphology: lymphoid cell line of medium cells with cerebriform nucleus
   Immunophenotypic T cell associated profile

Lymphoma (Hematology II)

Define lymphoma and generally classify using key terminology
   Hodgkin
   Reed-Sternberg cells
   Rye modified cells
   Non-Hodgkin

Outline a multidisciplinary workup and list laboratory findings used to diagnose and stage Hodgkin lymphoma
   Complete blood count (CBC)
   Liver function tests
   Renal function tests
   Blood and bone marrow findings of Hodgkin’s lymphoma
   Radiologic studies
   Physical examination
   Lymph node biopsy

Recognize key morphologic features and correlate with diagnostic criteria for the presence of lymphoma cells

Plasma Cell Disorders (Hematology II)

Name disorders based on proliferation of plasma cells and abnormal production of immunoglobulins

Discuss classification based on proliferation of plasma cells and abnormal
production of immunoglobulins
  Multiple myeloma
  Waldenstrom’s macroglobulinemia
  Plasma cell leukemia (PCL)
  Heavy-chain disease
  Monoclonal gammopathy of undetermined significance (MGUS)

Compare and contrast classification based on proliferation of plasma cells and abnormal production of immunoglobulins

Compare and contrast the following for plasma cell disorders
  Pathophysiology
  Clinical findings
  Laboratory findings
  Complete blood count (CBC) and peripheral smear review
  Bone marrow biopsy including immunophenotypic cell markers
  Blood and urine protein electrophoresis and immunoelectrophoresis
  Quantitative immunoglobulins
  Chemistry panels—blood urea nitrogen, creatinine, calcium, lactic dehydrogenase
  Serum viscosity
  Beta-2-microglobulin
  Radiologic studies of bones

Identify key morphologic features for plasma cell disorders on permanently stained blood and bone marrow smears, photographs, electronic images or other visual means of representation
  Flaming plasma cell
  Mott cells
  Rouleaux formation of red blood cells

Thrombopoiesis/megakaryopoiesis (Hematology II)
  List the maturation sequence for stages of developing megakaryocytes and platelets
  Cite reference values for absolute platelet counts in the peripheral blood
  Correlate quantitative variations with disease manifestations
    Thrombocytopenia
    Thrombocytosis
  Correlate functional or qualitative variations of platelets with disease manifestations
  Perform absolute platelet counts on patient and control specimens using manual and automated methods in accord with prescribed criteria for accuracy and precision
  State the principles of method analysis and histogram/scatterplot review
  Compare absolute count with those estimated from blood smear exam
  Identify platelets and platelet morphologic variations on a properly prepared Romanowsky stained blood smear and/or recognize factors that alter hemogram results
Platelet satellitism
Platelet aggregates
Giant platelets
Cell fragments
Extreme microcytosis

Evaluate platelet histograms and scatterplots for diagnostic and quality control purposes
Platelet satellitism
Platelet aggregates
Giant platelets
Cell fragments
Extreme microcytosis
Agranular and hypogranular platelets

Recognize and troubleshoot pre-analytical (pre-examination), analytical
and post-analytical (post-examination) causes for problems or unexpected results

Make decisions to recommend appropriate follow-up to prevent unexpected
results and/or events from reoccurring

Calibrate and perform preventive maintenance on instruments used to
evaluate platelets

**Hemostasis/ Coagulation** *(Hematology II)*

Define hemostasis

Explain the general interaction of systems involved in maintaining hemostasis
Of systems involved in maintaining hemostasis describe how changes in one
effect the other
Vasculation
Platelets
Plasma coagulation factors
Fibrinolysis

Differentiate between primary and secondary hemostasis

**Vascular** *(Hematology II)*

Explain the functions of the vascular system in maintaining hemostasis

Describe metabolic functions of the endothelium and substances contributing
to the thromboresistance properties of endothelium
Heparan sulfate
Thrombomodulin
Tissue plasminogen activator
Prostacyclin (PGI2)
Tissue factor pathway inhibitor

**Platelets** *(Hematology II)*

Discuss the production of platelets  
Level 1

State the average time in circulation, normal peripheral count, and total body distribution of platelets  
Level 1

Describe the ultrastructural components of a platelet  
Level 1
- Alpha granules
- Dense bodies
- Lysomes
- Microtubules
- Open canalicular system
- Platelet membrane
- Glycocalyx

Discuss the physiological role of platelets in hemostasis  
Level 1
- Platelet plug formation
- Maintaining normal vascular integrity

Describe the series of morphologic changes that occur in platelets following physiologic stimulation  
Level 1
- Adhesion
- Aggregation
- Activation

Discuss the effect of aspirin on platelet function  
Level 1
- Biochemical mechanism
- Duration of the effect

Discuss principle for platelet aggregometry and platelet function analyzers  
Level 2

Interpret results of platelet function assay tests  
Level 3
- Significance in terms of platelet function
- Associated abnormal conditions
- Sources of error

Discuss the principle and clinical significance of platelet aggregation  
Level 1
- Describe the principle of light transmittance, whole blood impedance and lumiaggregometry  
Level 1
- Perform the procedure  
Level 2
- Describe the procedure  
Level 2
- Describe appropriate quality control procedures and sources of error  
Level 1
- Interpret results and clinical significance  
Level 3
### Plasma coagulation factors  
(Hematology II)

<table>
<thead>
<tr>
<th>Define the coagulation factors</th>
<th>Level 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Roman numerals</td>
<td></td>
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<tr>
<td>Common names</td>
<td></td>
</tr>
<tr>
<td>Synonyms</td>
<td></td>
</tr>
</tbody>
</table>

Discuss the physiological role of the coagulation phase within the hemostatic process  
Level 1

Discuss characteristics of the coagulation factors  
Level 1

- Contact group
- Prothrombin group
- Fibrinogen group

List the vitamin K-dependent factors  
Level 1

Compare and contrast the plasma-based (in vitro) and cell-based (in vivo) mechanisms of coagulation (Level 3)  
Level 3

- Plasma-based (in vitro) mechanism
  - Intrinsic
  - Extrinsic
  - Common

- Cell-based (physiologic, in vivo) mechanism
  - Initiation
  - Amplification
  - Propagation

Identify substances that are contact activators *in vitro*  
Level 1

Summarize the interaction of the coagulation system with the vascular and platelet systems to form a hemostatic plug  
Level 2

Describe the physiologic controls of hemostasis  
Level 1

- Blood flow
- Feedback inhibition
- Liver clearance

Identify the inhibitors of hemostasis  
Level 2

- Antithrombin III
- Heparin cofactor II
- Tissue factor pathway inhibitor (TFPI)
- Protein C
- Protein S
- Alpha-2-macroglobulin
- Alpha-1-antitrypsin
- C1 inactivator
- Z-dependent protease inhibitor (ZPI)

Identify the special precautions that must be taken in the collection and Level 1
subsequent handling of specimens for coagulation testing
  Anticoagulant
  Ratio of blood to anticoagulant
  Patient hematocrit values
  Centrifugation
  Storage conditions including temperature
  Transport
  Phlebotomy procedure
    (e.g., time tourniquet is on arm, needle gauge, probing, etc.)

Identify and describe tests that are used to monitor the coagulation phase of Hemostasis

Discuss the principle and clinical significance of the Prothrombin time test
  Perform the procedure (performed in preceptorship)
  Describe the procedure
  Describe appropriate quality control procedures and sources of error
  Interpret results
  Describe the International Normalized Ratio (INR)
  Calculate an INR given the international sensitivity index of the thromboplastin
  Describe interferences and sources of error

Discuss the principle and clinical significance of the Activated partial thromboplastin time
  Perform the procedure (performed in preceptorship)
  Describe the procedure
  Describe appropriate quality control procedures and sources of error
  Interpret results
  Describe interferences and sources of error

Discuss the principle and clinical significance of the Activated clotting time
  Perform the procedure (performed in preceptorship)
  Describe the procedure
  Describe appropriate quality control procedures and sources of error
  Interpret results
  Describe interferences and sources of error

Discuss the principle and clinical significance of the Thrombin clotting time
  Perform the procedure (performed in preceptorship)
  Describe the procedure
  Describe appropriate quality control procedures and sources of error
  Interpret results
  Describe interferences and sources of error

Discuss the principle and clinical significance of the Fibrinogen assay
  Perform the procedure (performed in preceptorship)
  Describe the procedure
  Describe appropriate quality control procedures and sources of error
  Interpret results
Describe interferences and sources of error Level 1

Discuss the principle and clinical significance of Factor assays Level 1
Perform the procedure (performed in preceptorship) Level 2
Describe the procedure Level 2
Describe appropriate quality control procedures and sources of error Level 1
Interpret results Level 3
Describe interferences and sources of error Level 1

Identify technical conditions that cause false coagulation testing results Level 1

Fibrinolytic system (Hematology II)
Define fibrinolysis Level 1
Discuss the physiological role of the fibrinolytic system Level 1
Identify the major components of the fibrinolytic system Level 1
Discuss the mechanisms of the activation of plasminogen Level 1
Intrinsic activators
Extrinsic activators
Exogenous activators
List the major fragments of fibrinogen degradation Level 1
Explain the role and clinical significance of physiologic controls Level 1
Alpha-2-antiplasmin
Alpha-2-macroglobulin
Plasminogen activator inhibitors (PAI)
Identify and describe laboratory procedures that are used to evaluate Level 1
the fibrinolytic system

Discuss the principle and clinical significance of the FDP assay Level 1
Perform the procedure (performed in preceptorship) Level 2
Describe the procedure Level 2
Describe appropriate quality control procedures and sources of error Level 1
Interpret results Level 3

Discuss the principle and clinical significance of the D-Dimer Assay Level 1
Perform the procedure (performed in preceptorship) Level 2
Describe the procedure Level 2
Describe appropriate quality control procedures and sources of error Level 1
Interpret results Level 3

Identify technical conditions that cause false coagulation testing results Level 1
with or without established protocol

Disorders of primary hemostasis (Hematology II)
Differentiate between disorders of the vasculature Level 2
Acquired purpura
Henoch-Schölein purpura
Hereditary hemorrhagic telangiectasia
Ehlers-Danlos syndrome
Pseudoxanthoma elasticum

Define the following terms associated with hemostasis disorders Level 1
Thrombocytopenia
Thrombocytosis
Thrombocytemia

Describe the etiology, pathophysiology, clinical features, and laboratory findings of quantitative defects of platelets Level 3
Idiopathic thrombocytopenic purpura
Autoimmune thrombotic thrombocytopenic purpura
Post-transfusion purpura
Disseminated intravascular coagulation
Hemolytic uremic syndrome
MYH9 inherited thrombocytopenias, e.g. May-Hegglin anomaly
Wiscott Aldrich anomaly
Neonatal alloimmune thrombocytopenia
HELLP syndrome
Heparin-induced thrombocytopenia
Drug-induced immune thrombocytopenia
Myeloproliferative disorders
Secondary (reactive) conditions

Describe the etiology, pathophysiology, clinical features, and laboratory findings of qualitative defects of platelets Level 3
von Willebrand’s disease
Bernard-Soulier syndrome
Glanzmann’s thrombasthenia
Storage pool deficiencies
Acquired platelet function disorders

Disorders of secondary hemostasis (Hematology II) Level 1
Describe the inheritance pattern, pathophysiology, clinical features, and laboratory findings
Factor I deficiency
Factor II deficiency
Factor V deficiency
Factor V Leiden
Factor VII deficiency
Factor VIII deficiency (Hemophilia A)
Factor IX deficiency (Hemophilia B)
Factor X deficiency
Factor XI deficiency
Factor XII deficiency
Factor XIII deficiency
Prekallikrein deficiency
High-molecular-weight kininogen deficiency
von Willebrand’s disease
Alpha-2-antiplasmin deficiency
Antithrombin III deficiency
Heparin co-factor II deficiency
Protein C deficiency
Protein S deficiency
Plasminogen deficiency
Homocystinemia/homocystinuria

Describe clinical features and laboratory findings of acquired coagulation disorders
Vitamin K deficiency
Liver disease
Renal disease

Describe the significance and clinical implications of the development of circulating anticoagulants
Specific factor inhibitors
Nonspecific factor inhibitors
Global inhibitors

Identify and describe laboratory procedures that are used to evaluate circulating anticoagulants or inhibitors

Discuss the principle and clinical significance of Correction study using normal plasma
Perform the procedure (performed in preceptorship)
Describe the procedure
Describe appropriate quality control procedures and sources of error
Interpret results

Discuss the principle and clinical significance of APTT screening with moderate-high LA responsive reagent (LA-sensitive, low phospholipid)
Perform the procedure (performed in preceptorship)
Describe the procedure
Describe appropriate quality control procedures and sources of error
Interpret results

Discuss the principle and clinical significance of the Dilute Russell viper venom time (DRVVT)
Perform the procedure (performed in preceptorship)
Describe the procedure
Describe appropriate quality control procedures and sources of error
Interpret results

Discuss the principle and clinical significance of the Low-phospholipid (LA-sensitive) vs. high-phospholipid APTT
Perform the procedure (performed in preceptorship)
Describe the procedure
Describe appropriate quality control procedures and sources of error
Interpret results Level 3

Discuss the principle and clinical significance of the Platelet neutralization procedure Level 1
Perform the procedure (performed in preceptorship) Level 2
Describe the procedure Level 2
Describe appropriate quality control procedures and sources of error Level 1
Interpret results Level 3

Outline a protocol to follow when investigating a patient with an unknown bleeding disorder Level 2
Factor assays with dilutions for detection of nonparallel results
Bethesda titer for factor VIII or IX inhibitors
Describe interferences and sources of error

Disorders of fibrinolysis (Hematology II)
Differentiate between primary and secondary fibrinolysis Level 1

Define disseminated intravascular coagulation (DIC) Level 1

Identify mechanisms by which clotting is initiated during DIC Level 1

Describe the effect of DIC on laboratory procedures Level 1
Prothrombin time
Activated partial thromboplastin time
Thrombin clotting time
Platelet count
Fibrinogen
Fibrin/fibrinogen degradation products (FDP)
D-dimer
Blood smear

Describe conditions that are predisposing to recurrent thrombosis Level 1
Antithrombin III deficiency
Heparin cofactor II deficiency
Primary antiphospholipid antibody syndrome
Protein C deficiency
Protein S deficiency
Activated Protein C resistance
Prothrombin gene mutation (G20210A)
Hyperhomocystinemia
Acquired risk factors to thrombophilia (e.g., age, malignancies, including leukemias, chronic inflammation, surgery, immobilization, obesity, pregnancy, hormone replacement therapy, oral contraceptives, PNH, autoimmune disorders)

Describe laboratory tests for antithrombin III, protein C, and protein S comparing activity vs. antigen techniques Level 1
Perform the procedure (performed in preceptorship) Level 2
Describe the procedure Level 2
Describe appropriate quality control procedures and sources of error Level 1
Interpret results Level 3

**Anticoagulant therapy** (Hematology II)

- Explain the action of anticoagulant therapy Level 1
- Vitamin K Reductase inhibitors
- Direct acting oral anticoagulants
- Heparin high/low molecular weight
- Antiplatelet agents

Identify laboratory tests used to monitor anticoagulant therapy, indicate therapeutic intervals and sources of error and discuss emerging assays Level 2

- Oral anticoagulant therapy (warfarin) Vitamin K Reductase inhibitors
- Direct acting oral anticoagulants
  - Oral direct Xa inhibitors; anti-Xa
- Heparin high/low molecular weight
  - Low molecular weight heparin; chromogenic anti-Xa
  - Unfractionated heparin; PTT and chromogenic anti-Xa
  - Pentasaccharide, e.g., fondaparinux sodium (chromogenic anti-Xa)
  - Direct thrombin inhibitors; APTT, ecarin clotting time, dilute thrombin assay
- Antiplatelet agents; platelet aggregometry
  - Aspirin
  - Thienopyridines: Clopidogrel, prasugrel
  - Glycoprotein IIbIIIa inhibitors

**Instrumentation** (Hematology I)

Identify basic concepts of electrical impedance, optical detection, radio frequency, and of light scatter plus cytochemical stain systems Level 1

- Discuss the principle Level 1
- List components Level 1
- Describe operation Level 1
- Perform Analysis (performed in preceptorship) Level 2
- Describe maintenance and troubleshooting Level 1
- Perform maintenance/ corrective action (performed in preceptorship) Level 2

Identify basic concepts of quality assurance for automated hematology cell counting systems Level 1

- Describe acceptable practices Level 1
- Perform basic quality assurance (performed in preceptorship) Level 2
- Assess data to ensure quality Level 3
- Monitor quality assurance program Level 3
- Describe the limitations and list interfering substances Level 1

Identify and describe hemogram parameters Level 1

- Evaluate patient data Level 3
- Describe the flagging system Level 1
- Correlate scatter plots, histograms and data plots with the peripheral smear Level 3
- Describe the mathematical calculations used to monitor instruments Level 3
Recognize unexpected results Level 1
Troubleshoot and corrective action Level 2

Discuss the principle of Automated reticulocyte counting Level 1
Describe acceptable practices Level 1
Perform basic quality assurance (performed in preceptorship) Level 2
Assess data to ensure quality Level 3
Monitor quality assurance program Level 3
Describe the limitations and list interfering substances Level 1

Identify basic concepts of electromechanical and photo-optical systems Level 1
Describe acceptable practices Level 1
Perform basic quality assurance (performed in preceptorship) Level 2
Assess data to ensure quality. Level 3
Monitor quality assurance program Level 3
Describe the limitations and list interfering substances Level 1

Identify basic concepts of quality assurance for automated coagulation systems Level 1
Describe acceptable practices Level 1
Perform basic quality assurance (performed in preceptorship) Level 2
Assess data to ensure quality. Level 3
Monitor quality assurance program Level 3
Describe the limitations and list interfering substances Level 1

Identify basic concepts of spectrophotometric, chromogenic substrate assays Level 1
Describe acceptable practices Level 1
Perform basic quality assurance (performed in preceptorship) Level 2
Assess data to ensure quality. Level 3
Monitor quality assurance program Level 3
Describe the limitations and list interfering substances Level 1

Identify basic concepts of overall laboratory quality assurance Level 1
Describe acceptable practices Level 1
Perform basic quality assurance (performed in preceptorship) Level 2
Assess data to ensure quality. Level 3
Monitor quality assurance program Level 3