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

Spring 2022

What do you see? What is in your Head?

Hues  [link]

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Here is the link to the technology support center in case you are having any difficulty with technology  [link]

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.

NOTE: If you are sick – stay home and…
1. Call Ms. Licerio to inform of your absence – 747-8396
2. Notify the instructor BEFORE class if possible
3. If you test positive for COVID, inform UTEP EH&S at 915-747-7162 or COVIDaction@utep.edu
**Office Hours:** Monday 1:00 – 3:00 p.m. or Tuesday 9:00 – 11:00 a.m. However, the best time to talk to me is after class or laboratory, as our schedules usually do not allow for meeting at these times. If you are unable to see me at this time, you may arrange an appointment for another time. You can reach me by phone at any time, if I am unable to answer your call, please leave a detailed message and I will return your call as soon as possible. **If you feel confused and lost please come and see me;** Please do not wait until the last minute. 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.

**Class Schedule:** Monday and Wednesday 11:00 – 12:20 p.m. & Friday 1 – 3 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
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.
The Flipped or Active Laboratory / Classroom
Most of our laboratories and some lecture courses follow the “Flipped or Active Classroom” model.

**Students prepare for the in-person sessions by reviewing course materials and content in advance.**
When they arrive in class they typically have a “quiz” and may work in groups to apply their background knowledge to problem solving case studies or situations. In this model the **faculty member acts as their guide** and can provide instruction and corrective action as the students go through the work problems. Instead of sitting in a classroom while the instructor tells them how to do the work, the students are actually practicing the problems solving work with the faculty member’s help. Although this is often a significant adjustment for students who have not taken courses like this before, they quickly realize the value of the guided practice sessions.

Your Role in This Course
In order for you to be ready for this class (active classroom, flipped, TBL), it will be important for you to **read and prepare outside of class time.** Your primary knowledge and understanding of readings will be essential for success with in-class activates and assignments, many of which will take place in collaboration with your team.

Orientation to TBL
The research on teaching and learning is very clear: students learn best when they are actively working with others in teams on real and challenging problems. In this class you will be placed in **permanent teams** to help team mates learn from each other and the instructor on basic blood bank principles and real-life problems that you will encounter. Passively listening to lecture and memorizing information will not prepare you for your profession role as a medical laboratory scientist where you will be required to solve problems on a daily basis. Discussion, debate and problem solving with others will serve you much better than listening to an instructor talk.

The Study Guide (SG): A tool to Help You Study for In-Class Assignments and Exams
The SG is a tool to help you focus your studying and prepare effectively and efficiently for each class session. The questions in the SG are questions you should be able to answer as a medical laboratory Scientist. The SG also serves as your preparation tool for the exams. In other words, the questions that are on the SG are directly related to the questions on the exams. The SG can also serve as your notebook (if you take notes) and review tool to prepare for the midterm and final exam.

If you chose not to complete the SGs, you also chose not to come to class prepared which will result in

1. not understanding what is being discussed in class;
2. not being able to contribute to the in-class assignments;
3. being an annoyance to your team mates and the instructor because you can’t contribute appropriately
4. not being able to help other team members understand the material better;
5. a negative evaluation by your team members; and importantly
6. you are not using this helpful tool to prepare for the exams and thus likely earn poor grades.

In-class Team Assignments
The in-class team assignments will ask you to make specific decisions concerning specific testing related situations and problems based on the studying you did for the Study Guide. A number of those assignments may be graded. Which ones are graded will be announced during the class session.
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 and complete the individual assignments.

Try to follow these steps:
1. DO THIS FIRST!!! Look at the TENTATIVE course schedule and read the assigned chapter to be covered that day before reviewing the power points.
2. Open PowerPoint lecture and have textbook open and take notes alongside the power point. DO NOT BE AFRAID TO MARK UP YOUR BOOK.
3. After reviewing the lecture and taking notes, RE-READ THE CHAPTER.
4. Come prepared to class by completing your group and or individual assignment BEFORE class. 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.
6. Make copies of your completed Study Guides as you will have to leave a copy of the study guide in the team folder.

Major Mistakes Students Make that Negatively Affect Their Grades:
1) Not actively contributing to teamwork.
2) Being absent when in-class assignments were selected for grading.
3) Procrastinating, not working in advance of a deadline and missing it.
4) Having poor time management skills and strategies leading to not putting in the necessary work and time outside of class.
5) Scholastic Dishonesty

Attendance of Class Sessions: Being absent from even one class session will hurt your understanding and performance in the class. You are also likely to miss graded in-class assignments that make up 10% of your grade. If you are not present, you cannot get the points.

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.
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.

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

REQUIRED TEXTBOOKS: same books used for Hematology I


OPTIONAL: A color atlas or your choice but required

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**Venipuncture:** The student must perform 10 venipunctures during the semester.

**Differentials:** The student must perform 50 differentials at the end of the semester. Differential time has been scheduled for Fridays from 1 – 3 p.m. The student is required to turn in a differential log with a minimum of 3 completed differentials on Friday. The student will receive a zero for the week if the differential log is not turned in at the end of the Friday session.
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 calculations. All exams and final will be taken electronically and are 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.

EXAMINATIONS:
Five exams and a comprehensive final will be given. Exams are worth 45% of the total grade and the final is worth 35%. **No make-up exams will be given.** If an exam is missed (0%), the final grade will be based on the average of 4 exams. **None of the test grades will be dropped.**

HOW DO YOU EARN YOUR GRADE?
Your grade will consist of 2 parts. The percentages shown for each item will be multiplied by the scores you earn.

<table>
<thead>
<tr>
<th>90% Assessments of Individual Performance</th>
<th>10% Assessments of Team Performance</th>
</tr>
</thead>
<tbody>
<tr>
<td>10% i-RAT / Ticket to Class / Quizzes/assignments</td>
<td>5% t-RAT: 5% Team Assignments; random selection</td>
</tr>
<tr>
<td>40% 5 Exams questions based on the SGs*</td>
<td></td>
</tr>
<tr>
<td>5% Differentials</td>
<td></td>
</tr>
<tr>
<td>5% venipuncture</td>
<td></td>
</tr>
<tr>
<td>30% comprehensive final exam*</td>
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</tbody>
</table>

*All exams including the final will be comprehensive

% Grade Scale

- 100 – 90 = A
- 89.9 – 80 = B
- 79.9 – 75 = C
- 74.9 – 70 = D (is not passing in CLS)
- 69.9 – 60 = F
Test Policy:
There will be five examinations and a comprehensive final. **All exams will be taken on-line during class time. 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. At the instructors discretion an exam may be taken late with an **automatic deduction of 10 points.** 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.

**Course Drop policy**
According to UTEP Curriculum and Classroom Policies, “When, in the judgment of the instructor, a student has been absent to such a degree as to impair his or her status relative to credit for the course, the instructor may drop the student from the class with a grade of “W” before the course drop deadline and with a grade of “F” after the course drop deadline.” See academic regulations in the UTEP Undergraduate Catalog for a list of excuse absences. Therefore, if I find that, due to non-performance in the course, you are at risk of failing, I will drop you from the course. I will provide 24 hours advance notice via email.

**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

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

SECTION I: LEUKOCYTES: (Chapters 4, 9, 26 – 34)

JAN 19 – FEB 2
Jan 19  Cell biology, granulocytic and monocytic series
Jan 24  Non-malignant Leukocyte disorders
Jan 26  Lipid (lysosomal) Storage Diseases and Histiocytosis
Jan 31  Non-malignant Lymphocytic disorders (Reactive lymphocytes & IM)

FEB 2 EXAM I

FEB 7 – FEB 28
Feb 7  Introduction to leukemias and acute leukemia (Acute Vs. Chronic)
Feb 9  Cytogenetics and Molecular Diagnostics
Feb 14  Flow cytometry / Acute Leukemias
Feb 23  Acute leukemias

FEB 28  EXAM II chapters 27,28,30 31

MARCH 7 – MARCH 18 Chapters 32, 33, 34.
Mar 7  Myeloproliferative Neoplasms: CMPD: CML, PV, ET, MF
Mar 9  Myeloproliferative Neoplasms CMPD: CML, PV, ET, MF
Mar 14 – 16 spring Break no class
Mar 19  Myelodysplastic Syndromes
Mar 21  Mature Lymphoid Neoplasms
Mar 23  Lymphoma, Multiple Myeloma, and related plasma cell disorders

MAR 28 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 28 – April 12
Mar 28  Mechanism of blood coagulation
Mar 30  Platelet structure and function
Apr 4   Coagulation Cascade Theory
Apr 6   Quantitative and qualitative vascular & platelet disorders
Apr 11  Laboratory Assessment of Blood coagulation factors
Apr 13  Protective agents against thrombosis

APR 18 EXAM IV (note: same day Blood bank exam IV)

APRIL 20 – May 3
Apr 20  Vascular disorders / Abnormal Platelet Morphology
Apr 25  Qualitative Platelet Disorders
Apr 27  Qualitative Characteristics of Platelets
May 2   Bleeding disorders related to blood clotting/Hypercoagulable states

MAY 4  COAGULATION EXAM V (note: same day Blood bank exam IV)

MAY 13 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

Note: all of these topics will be presented “cascade” theory and student will need to draw the cascade and include all the topics in the cascade.
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
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  Level 3

Correlate peripheral blood evaluation with automated cell analysis  Level 3

Enumerate and morphologically evaluate blood cells on Romanowsky stained smears  Level 2

Erythropoiesis (Hematology I)
Describe the distinctive features used to characterize developing cells  Level 1
   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  Level 1

Distinguish nucleated erythrocyte precursors from other hematopoietic elements  Level 2

Categorize red cells  Level 2
   Diameter or volume
   Shape
   Color
   Inclusions
   Distribution patterns

Describe nutritional and regulatory factors associated with erythropoiesis  Level 2
   Erythropoietin (EPO)
   Iron
   Vitamins (B₁₂ / folate)

List hormones associated with erythropoiesis  Level 1
   Estrogen/Androgens/Thyroxine/Growth hormone

Identify and discuss components of the mature red cell that are essential for survival and function  Level 2
   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  Level 1
   Embden-Meyerhof/glycolytic
Erthrocytic 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 A₂)

- 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
  - CO₂
  - 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)

Erthrocytic 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
Natural Killer (NK) cells
Plasma cells

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
  Hyposegmentation
  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
- 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
- Anisocytosis
- Poikilocytosis
Polychromatic
Rouleaux
Agglutination
Acanthocyte/Spur Cell
Codocyte/Target Cell/Leptocyte
Dacrocyte/Tear Drop Cell
Drepanocyte/Sickle Cell
Echinocyte/Sickle Cell
Elliptocyte
Keratocyte
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

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

Define polycythemia Level 1

Differentiate between absolute polycythemia and relative polycythemia Level 2

Compare and contrast secondary polycythemia, and relative erythrocytosis Level 3

Etiology
Clinical features
Laboratory findings
Prognosis

Describe changes in the bone marrow and peripheral blood with polycythemia vera Level 2

Red Blood Cell Disorders: Hypochromic Anemias (Hematology I)

Define hypochromic anemia Level 1

List the causes of hypochromic anemias Level 1
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
Peripheral blood changes Level 1
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
Describe the laboratory findings Level 1
Perform /observe the procedure Level 2
Apply appropriate quality control procedures Level 2
Evaluate results Level 3

Red Blood Cell Disorders: Hemoglobinopathies (Hematology I)

Define hemoglobinopathy Level 1
Distinguish between qualitative and quantitative hemoglobin defects Level 1
Describe clinical and laboratory findings of hemoglobinopathies Level 1
  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 Level 1
Describe the physiologic abnormality associated with hemoglobin variants with altered oxygen affinity (Unstable hemoglobins, Methemoglobinemia) Level 1
Describe the hemoglobin gene defect in alpha and beta thalassemia Level 1
Define the hemoglobin defect in thalassemia Level 1
Describe the terminology associated with thalassemias Level 1
  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 Level 1
Describe the pathophysiology of thalassemias Level 1
  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

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

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

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

Describe the separation of hemoglobin by capillary electrophoresis

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

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

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

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

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

Identify mechanisms of drug-induced immune hemolytic anemia

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

Describe the hematologic findings associated with nonimmune hemolytic anemias
- 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
- List the clinical symptoms of acute blood loss
- Identify the laboratory findings of acute blood loss

**Anemias associated with systemic disorders (Hematology I)**
- Describe the clinical features and laboratory findings associated with nonhematologic disorders
- 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  

Identify major systems used to classify neoplastic disorders of leukocytes  
French, American-British (FAB) Cooperative Group  
World Health Organization (WHO)  

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  

Review the criteria used to classify nonmalignant leukocytic disorders  
Quantitative changes  
Qualitative changes (inherited, acquired )  

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  

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
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 monoblastic 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 Level 1
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 Level 2
Stem cell clonality
Oncogene and tumor suppressor gene development

Describe the survival rates and prognosis Level 2

Describe the treatment options and correlation with hematologic complications Level 1
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 Level 2
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 Level 1

Apply diagnostic blood and bone marrow findings to the differential identification Level 3
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
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 thrombocythemia (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, Level 3  
- 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 Level 1  
- 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  

List diagnostic features CLL  
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  
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  
Modified Rai  
Binet  

Discuss the diagnostic features of PLL  
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  
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  
Splenectomy  
Other drugs  
Describe laboratory findings seen in the variant form of HCL  

List diagnostic features of Adult T-cell leukemia  
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

Level 2

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

Level 2

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

Level 1

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

Level 2

Lymphoma (Hematology II)
Define lymphoma and generally classify using key terminology
Hodgkin
Reed-Sternberg cells
Rye modified cells
Non-Hodgkin

Level 1

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

Level 2

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

Level 3

Plasma Cell Disorders (Hematology II)
Name disorders based on proliferation of plasma cells and abnormal production of immunoglobulins

Level 1

Discuss classification based on proliferation of plasma cells and abnormal

Level 2
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 Level 3

Compare and contrast the following for plasma cell disorders Level 3
   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 Level 2
   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 Level 1
   Cite reference values for absolute platelet counts in the peripheral blood Level 1
   Correlate quantitative variations with disease manifestations Level 3
      Thrombocytopenia
      Thrombocytosis
   Correlate functional or qualitative variations of platelets with disease manifestations Level 3
   Perform absolute platelet counts on patient and control specimens using manual and automated methods in accord with prescribed criteria for accuracy and precision Level 2
   State the principles of method analysis and histogram/scatterplot review Level 1
   Compare absolute count with those estimated from blood smear exam Level 3
   Identify platelets and platelet morphologic variations on a properly prepared Romanowsky stained blood smear and/or recognize factors that alter hemogram results Level 2
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 (examination) 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
- Vasculature
- 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)

Define the coagulation factors
- Roman numerals
- Common names
- Synonyms

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

Discuss characteristics of the coagulation factors
- Contact group
- Prothrombin group
- Fibrinogen group

List the vitamin K-dependent factors

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

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

Describe the physiologic controls of hemostasis
- Blood flow
- Feedback inhibition
- Liver clearance

Identify the inhibitors of hemostasis
- 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...
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 the fibrinolytic system  Level 1

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 with or without established protocol  Level 1

**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

- Thrombocytopenia
- Thrombocytosis
- Thrombocythemia

Describe the etiology, pathophysiology, clinical features, and laboratory findings of quantitative defects of platelets

- 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

- von Willebrand’s disease
- Bernard-Soulier syndrome
- Glanzmann’s thrombasthenia
- Storage pool deficiencies
- Acquired platelet function disorders

Disorders of secondary hemostasis (Hematology II)

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

Discuss the principle and clinical significance of the Platelet neutralization procedure

Perform the procedure (performed in preceptorship)

Describe the procedure

Describe appropriate quality control procedures and sources of error

Interpret results

Outline a protocol to follow when investigating a patient with an unknown bleeding disorder

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

Define disseminated intravascular coagulation (DIC)

Identify mechanisms by which clotting is initiated during DIC

Describe the effect of DIC on laboratory procedures

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

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

Perform the procedure (performed in preceptorship)
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