The University of Texas at El Paso
College of Health Sciences
Clinical Laboratory Science Program

Course: CLSC 3356 Hematology I
Restricted for CLIN majors only
Corequisite: CLSC 3257
Class meets M & W 9:00 – 10:20 A.M. HSSN Rm 135

What do you see? What is in your Head?

Hematology is the branch of internal medicine, physiology, pathology, clinical laboratory work, and pediatrics that is concerned with the study of blood, the blood-forming organs, and blood diseases. Hematology includes the study of etiology, diagnosis, treatment, prognosis, and prevention of blood diseases. The laboratory work that goes into the study of blood is performed by a clinical laboratory scientist.

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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:
Tuesday 3:00- 4:00 p.m. Thursday 10:00 – 11:00 p.m. Friday 10:00 – 12:00 a.m. and after class.

If for some reason you are not able to see me at this time, you are welcome to see me after class or we can arrange an appointment at another time. You can also schedule meetings with me by e-mail. I would like to invite you to use the office hours to clarify points you did not understand, to discuss subject matter according to your special interests or talk about your career goals. **If you feel confused and lost, please come and see me.** Please do not wait until the last minute. The best time to reach me by phone is during my office hours. If I do not answer, please leave a detailed message and I will return your call as soon as possible.

**Welcome to the UTEP Clinical Laboratory Science Program**
Clinical Laboratory Sciences is a profession that serves as a vital partner in clinical diagnosis and medical decision-making. Clinical laboratory scientists perform laboratory analyses to diagnose, treat, and monitor disease, and to evaluate the maintenance of an individual’s health. These healthcare professionals are experts in the scientific disciplines of clinical chemistry, hematology, immunology, immunohematology, and microbiology.

**THIS COURSE WILL BE USING SEVERAL DIFFERENT MODES OF INSTRUCTION, FOR EXAMPLE, FLIPPED CLASSROOM, TEAM BASED LEARNING AND ACTIVE PARTICIPATION**

**REQUIRED TEXTBOOKS:**


Here is the link to the [UTEP Bookstore](#)
COURSE DESCRIPTION
This course is the first part of a two part Hematology course series. Hematology I will cover the red cell series and Hematology II will cover the white cell series and hemostasis. Hematology I is designed to provide a basic understanding of the fundamental mechanisms involved in all facets of erythrocyte formation and function and etiology and treatment of red blood cell disorders. This course will examine normal and abnormal erythrocyte hematopoiesis and the resulting anemias, hemoglobinopathies, polycythemia, and other erythrocyte dyscrasias.

GOAL:
This course is designed to introduce the basic concepts of hematology and its clinical application to the Clinical Laboratory Science student. This course will provide the student with the knowledge to accurately identify normal and abnormal components of the hematopoietic system and identify various testing procedures to evaluate the patient results in light of clinical evidence.

OBJECTIVES
At the end of this course, students will be able to:

1. Recognize and describe normal and abnormal hematopoiesis and its manifestation in bone marrow and peripheral smears.
2. Demonstrate their ability to differentiate between normal and abnormal blood cells in the peripheral blood.
3. Select the appropriate hematological analysis and evaluate results in light of patient abnormalities.
4. Given patient blood results / data, the student should be able to recall objectives at the basic taxonomic level and use this recall to interpret patient results to apply and examine knowledge gained and apply this knowledge in a problem-solving manner to correctly predict diagnose of the patient.
5. Synthesize and appreciate the importance of accurate testing and evaluation in providing the patient and the clinician with the accurate tools for diagnosis, treatment and disease prevention by evaluating patient results and correlating these results to situations when erroneous results are obtained either though instrument error or apathy among laboratoriens.

NOTE: Each chapter of the book has written objectives. The student should answer these objectives in order to understand the material fully.

Affective Objectives
Upon completion of this course, the student should be able to exhibit the appropriate responsible behaviors by demonstrating:

1. A positive attitude by being prepared for lecture and laboratory sessions completing assigned tasks on time and displaying self-motivation.
2. Organization by utilizing time effectively, sequencing and prioritizing tasks for
completion with time constraints and maintaining a neat clean work.

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

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

5. Dependability by following directions, working independently after being given directions.

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 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.

**Detailed Cognitive Objectives:** Covered in Hematology I and II and Hematology Lab. The objectives are listed at the back of the syllabus (beginning on page 13).

**Psychomotor Objectives:** Refer to the Hematology Laboratory syllabus.

**UTEP Bookstore**
The University Bookstore will be open during the fall 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 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

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 hematology 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 then 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.

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.

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.

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.

Student Resources
UTEP provides a variety of student services and support:

- **UTEP Library**: Access a wide range of resources including online, full-text access to thousands of journals and eBooks plus reference service and librarian assistance for enrolled students.
- **Help Desk**: Students experiencing technological challenges (email, Blackboard, software, etc.) can submit a ticket to the UTEP Helpdesk for assistance. Contact the Helpdesk via phone, email, chat, website, or in person if on campus.
- **University Writing Center (UWC)**: Submit papers here for assistance with writing style and formatting, ask a tutor for help and explore other writing resources.
- **Math Tutoring Center (MaRCS)**: Ask a tutor for help and explore other available math resources.
- **History Tutoring Center (HTC)**: Receive assistance with writing history papers, get help from a tutor and explore other history resources.
- **Military Student Success Center**: UTEP welcomes military-affiliated students to its degree programs, and the Military Student Success Center and its dedicated staff (many of whom are veterans and students themselves) are here to help personnel in any branch of service to reach their educational goals.
- **RefWorks**: A bibliographic citation tool; check out the RefWorks tutorial and Fact Sheet and Quick-Start Guide.

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 getting enough sleep.** If you are not getting enough sleep and pulling all-nighters, you are damaging your ability to think if you try to study or work through the night. While it might feel like getting ahead in the moment, you will most likely only set yourself back.

2) **Skipping the reading.** Do not assume you will get all the information by attending lecture and looking at power points.

3) **Skipping class:** Being absent from even one class session will hurt your understanding and performance in the class. You are also likely to miss graded quizzes or in-class assignments that make up 20% of your grade. If you are not present, you cannot get the points.

4) **Procrastinating,** not working in advance of a deadline and missing it.

5) **Having poor time management** skills and strategies leading to not putting in the necessary work and time outside of class.

6) **Working too much** and then having to do “all-nighters” or “cramming”.

7) **Studying in a distracting environment.** Everyone has different preferences on where to study. Identifying your distractors and minimizing them will help you focus on your work. Experiment with background sounds and locations until you find the golden combination that works for you.

8) **Memorizing without understanding.** You need to understand the relevance, context and inner workings of a subject—not just the figures, names and dates.

9) **Procrastinating** until crunch time. It is important to pace your course work.

10) **Scholastic Dishonesty**

11) **Not taking advantage of tutoring**

Test Policy:
There will be four examinations and a comprehensive final. **All exams are taken in class and will be in an electronic format via blackboard.** 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.

EXAMINATIONS:
Four 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.**

GRADE SCALE:
- A 100 – 90%
- B 89 – 80%
- C 79 – 75%
- D 74.9 – 70%
- F 69% or below
HOW DO YOU EARN YOUR GRADE?
Your grade will consist of 3 parts. The percentages shown for each item will be multiplied by the scores you earn.

- Exams: 45%
- Quizzes and ticket to class, tickets to class: 20%
- Final comprehensive exam: 35%

This is the “Ticket to Class” You will need one on scheduled days to enter the classroom. **You will not be allowed to enter the class without a ticket unless you have a “free” day.** The tickets are posted on Blackboard / Announcements and you are responsible for downloading them and completing the assignment.

Organization of the Course
The course consists of 4 units (check schedule for details) that focus on key elements and your competencies related Hematology. Specific dates for the Study Guides and reading assignments will be posted on Blackboard—check the course site regularly and **watch for emails from the instructor on your UTEP email account.** Pay careful attention to which Study Guides are associated with which class sessions. Units are subject to change thus make sure you are keeping up with blackboard and are aware of changes.

University / CLS Policy on examinations:
When examinations are administered, students are to place backpack, papers and other personal belongings out of reach and view while taking the on-line exams. No hats, caps, or bulky clothing may be worn. Phones may not be used as a calculator. Programmable calculators are not to be used in the CLS Program, only basic calculators will be allowed and the on-line exam will have the calculator on screen if needed. If a student misses an exam or a quiz, a make-up exam may be taken **ONLY IF** the student has informed the instructor of the absence prior to the beginning of the day of examination, and only if the absence is approved by the instructor, only in rare instances will a student be excused from an examination or a quiz. If permission is given to take an exam or a quiz, it will be scheduled at the convenience of the instructor. Make-up exams/quizzes, while they may cover the same material may differ from the exam/quiz taken by the rest of the class in organization, format, or specific item data.
MAKE UP EXAMS/QUIZZES (WITH INSTRUCTOR’S APPROVAL)

Make up exams/quizzes will have an **automatic deduction of 7 points**. Make ups exams/quizzes, while they may cover the same material may differ from the exam/quiz taken by the rest of the class in organization, format, or specific item data.

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 assigned reading should be read at least twice. There will be a quiz and or a ticket to class at the beginning of almost every class. **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.

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.

**Part Three of the textbook (chapters 11 – 13) are the chapters on Hematology methods. The methods will be discussed mainly in the laboratory (CLSC 3257) however; the student will be required to know the material from these chapters for the lecture class. Students need to be aware that this is a comprehensive course. The information in previous chapters we have covered and laboratory procedures will be built upon and tested over the information.**

**Hematology TENTATIVE COURSE SCHEDULE**

On next page
You may want to print the next page and keep it available
# Hematology TENTATIVE COURSE SCHEDULE

## Unit 1: Overview, Hematopoiesis, Indices, and RBC morphology (chapters 1, 3 – 7, 11, 14)

<table>
<thead>
<tr>
<th>Date</th>
<th>Topic</th>
</tr>
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<tbody>
<tr>
<td>Aug 28</td>
<td>Formation of Teams</td>
</tr>
<tr>
<td>Aug 30</td>
<td>Overview of Hematology &amp; Hematopoiesis</td>
</tr>
<tr>
<td>Sept 4</td>
<td>No class Labor Day</td>
</tr>
<tr>
<td>Sept 6</td>
<td>Bone Marrow / Red Blood Cell Structure &amp; function</td>
</tr>
<tr>
<td>Sept 11</td>
<td>Erythrocyte structure &amp; function, hemoglobin</td>
</tr>
<tr>
<td>Sept 13</td>
<td>Erythrocyte structure &amp; function, hemoglobin / corpuscular constants</td>
</tr>
<tr>
<td>Sept 18</td>
<td>Evaluation of Cell Morphology</td>
</tr>
<tr>
<td>Sept 20</td>
<td>EXAM 1 (Chapters 1, 3, 4 – 7, 11, 14)</td>
</tr>
</tbody>
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## Unit 2: Microcytic and Macrocytic Anemias

<table>
<thead>
<tr>
<th>Date</th>
<th>Topic</th>
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<tbody>
<tr>
<td>Sep 25</td>
<td>Automated cell Analysis</td>
</tr>
<tr>
<td>Sep 27</td>
<td>Anemia: Diagnosis and Clinical Considerations</td>
</tr>
<tr>
<td>Oct 2</td>
<td>Iron Metabolism</td>
</tr>
<tr>
<td>Sep 28</td>
<td>Hypochromic anemias / Fe deficiency</td>
</tr>
<tr>
<td>Oct 3</td>
<td>Hypochromic anemias</td>
</tr>
<tr>
<td>Oct 4</td>
<td>Megaloblastic anemia</td>
</tr>
<tr>
<td>Oct 9</td>
<td>EXAM 2 (chapters 8, 11 - 12, 16 -18)</td>
</tr>
</tbody>
</table>

## Unit 3: Bone Marrow Failure and Anemias due to Destruction of RBCs

<table>
<thead>
<tr>
<th>Date</th>
<th>Topic</th>
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<tbody>
<tr>
<td>Oct 11</td>
<td>Mini break – no class</td>
</tr>
<tr>
<td>Oct 16</td>
<td>Aplastic Anemia, Hypoproliferative anemia</td>
</tr>
<tr>
<td>Oct 18</td>
<td>Aplastic Anemia etc –</td>
</tr>
<tr>
<td>Oct 23</td>
<td>Intro to increased destruction of erythrocytes</td>
</tr>
<tr>
<td>Oct 30</td>
<td>Hemolytic anemia: Intracorpuscular defects: Hereditary defects of membrane</td>
</tr>
<tr>
<td>Nov 1</td>
<td>Hemolytic anemia: Intracorpuscular defects: Hereditary enzyme deficiencies</td>
</tr>
<tr>
<td>Nov 6</td>
<td>EXAM 3 (chapters 11- 12, 19- 21)</td>
</tr>
</tbody>
</table>

## Unit 4: Anemias due to Structural Defects in Hemoglobin

<table>
<thead>
<tr>
<th>Date</th>
<th>Topic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nov 8</td>
<td>Principles of Automation</td>
</tr>
<tr>
<td>Nov 13</td>
<td>Nonimmune – Extrisic defects / Immune- Extrisic defects</td>
</tr>
<tr>
<td>Nov 15</td>
<td>Nonimmune – Extrisic defects / Immune- Extrisic defects</td>
</tr>
<tr>
<td>Nov 20</td>
<td>Hemoglobinopathies</td>
</tr>
<tr>
<td>Nov 22</td>
<td>Hemoglobinopathies</td>
</tr>
<tr>
<td>Nov 27</td>
<td>Thalassemias</td>
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<tr>
<td>Nov 29</td>
<td>Thalassemias</td>
</tr>
<tr>
<td>Dec 4</td>
<td>Quality Management, Quality Assurance and Quality Control</td>
</tr>
<tr>
<td>Dec 6</td>
<td>EXAM 4 (chapters 11-12, 22-25, 2 )</td>
</tr>
<tr>
<td>Dec 11</td>
<td>FINAL EXAM</td>
</tr>
</tbody>
</table>
MLS Hematology cognitive objective covered in Hematology I, Hematology I Laboratory and Hematology II. Psychomotor objective performed in Preceptorship I and or II.

Upon completion of this course, the student should be able to: Define, discuss, explain, identify and perform ...

**Normal hematopoietic system Hematology I, Lab and Preceptorship**

Define hematopoiesis Level 1
- 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 Level 1
- 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 Level 1
- 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 Level 1
- 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 Level 2
- 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 Level 2
Splenomegaly
Hypersplenism
Hepatosplenomegaly
Lymphadenopathy

**Bone Marrow Tissue** Hematology I, Lab and Preceptorship

List indications for performing bone marrow examination Level 1

Describe bone marrow collection techniques Level 1
Aspiration
Core biopsy

Describe key terms and apply concepts used to assess bone marrow structure and function Level 2
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
Hyperplastic marrow

Describe concepts related to the assessment of iron stores and sideroblast Population in the bone marrow Level 2
Type I
Type II
Type III

Perform differential count on normal bone marrow specimens Level 2

Distinguish between normal and abnormal hematopoietic elements found within the peripheral blood Level 2

Correlate bone marrow findings with peripheral blood evaluation Level 3

Prepare peripheral blood for routine hematologic procedure and smear analysis Level 2

Determine specimen acceptability Level 2

List appropriate anticoagulants and mechanism of anticoagulation Level 1
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, Lab and Preceptorship**

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 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
  Hexose monophosphate shunt
  Methemoglobin reductase
  Luebering-Rapoport

**Erythrocytic Hemoglobin Hematology I, Lab and Preceptorship**
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 Level 3
  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
    Level 3
    Age and gender
    Pregnancy
    Altitude
    Smoking
    Associated disease
    Altered hemoglobin derivatives
    (carboxyhemoglobin/methemoglobin/sulphemoglobin)

Erythrocytic Catabolism Hematology I, Lab and Preceptorship

Summarize the mechanism by which red cells are catabolized
    Level 2
    Identify phases (extravascular, intravascular)
    Level 1
    Trace the basic steps associated with each phase
    Level 1
    Define terms associated with red cell destruction
    Level 1

    Biliverdin
    Bilirubin (unconjugated/conjugated)
    Urobilinogen
    Urobilin
    Hemoglobin dimers
    Haptoglobin
    Hemopexin
    Hemoglobinemia
    Hemoglobinuria
    Hemosiderinuria
    Methemalbumin
**Erythrocyte Evaluation** Hematology I, Lab and Preceptorship

- 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 blood cell morphology

Distinguish between normal and abnormal red blood cell morphology

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

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

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

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

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

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

**Leukopoiesis Hematology II, Lab and Preceptorship**

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

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

Identify factors that alter leukocyte values

- Physiologic variation
- Pathologic abnormalities

Enumerate and/or calculate leukocyte counts

- Relative values
- Absolute values

List morphologic features used to differentiate developing leukocytes

- 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

Leukopoeisis: Granulocytes *Hematology II, Lab and Preceptorship*
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)

Leukopoeisis: Monocytes and Lymphocytes *Hematology II, Lab and Preceptorship*
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
  B-cell lymphocytes and subsets
  T-cell lymphocytes and subsets
  Natural Killer (NK) cells
  Plasma cells

**Leukocyte Evaluation Hematology II, Lab and Preceptorship**
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

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, Lab and Preceptorship*

Explain the classification of nonmalignant leukocytic disorders Level 1
- Quantitative changes
- Qualitative changes

Compare and contrast absolute values with relative values Level 2
- Neutrophilia
- Neutropenia
- Eosinophilia
- Eosinopenia
- Basophilia

Associate quantitative and qualitative leukocyte disorders with expected results Level 1
- 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 Level 2
- 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

Compare lymphocyte absolute values with relative values

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

Differentiate between reactive and resting lymphocytes on Romanowsky stained smears

Identify the causes of reactive lymphocytosis

Red Blood Cell Disorders: Anemia Hematology I, Lab and Preceptorship
Define anemia
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

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

Explain sources of error of the red cell indices

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

Define common terms used to describe red cell morphology
   Anisocytosis
   Poikilocytosis
   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

Level 2
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, Lab and Preceptorship**

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, Lab and Preceptorship**

Define hypochromic anemia     Level 1

List the causes of hypochromic anemias     Level 1

Discuss the etiology and pathophysiology of hypochromic anemias     Level 2
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, Lab and Preceptorship**

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


*Hematology I, Lab and Preceptorship*

Define aplastic anemia

Identify common factors associated with the development

Describe the clinical features and pathophysiology

   Acquired aplastic anemia
   Fanconi’s anemia
   Congenital pure red blood cell aplasia
   Anemia caused by myelophthisis

Describe the laboratory findings

   Peripheral blood changes
   Bone marrow changes
   Other laboratory findings

Define Fanconi’s anemia

Describe the genetics and possible pathophysiology

Describe the laboratory findings

   Peripheral blood changes
   Bone marrow changes
   Other laboratory findings

Define pure red cell aplasia (Diamond-Blackfan anemia)

Describe the clinical features and pathophysiology

Describe the laboratory findings

   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
    Bone marrow changes
    Other laboratory findings  Level 1

Red Blood Cell Disorders:  Hemolytic Anemias

Hematology I, Lab and Preceptorship

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  Level 1
enzyme abnormalities
   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
Identify laboratory test results based upon
   Describe the laboratory findings
   Perform/observe the procedure
   Apply appropriate quality control procedures
   Evaluate results

Red Blood Cell Disorders: Hemoglobinopathies
Hematology I, Lab and Preceptorship
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 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 thalasemia 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 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

Discuss the principles of hemoglobin electrophoresis (cellulose acetate, alkaline pH vs. citrate agar, acid pH) 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 separation of hemoglobin by capillary electrophoresis Level 1

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

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

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

Identify the electrophoretic patterns (cellulose acetate, alkaline pH vs. citrate agar, acid Level 2
pH) Hb F, Hb A, Hb S, Hb C, Hb D, Hb E, Hb A2

Hemolytic Anemias Hematology I, Lab and Preceptorship
Identify mechanisms of immune hemolytic anemias Level 1

Define and describe the etiology and clinical features and laboratory findings of Level 1
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 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, Lab and Preceptorship*

- 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, Lab and Preceptorship*

- 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, Lab and Preceptorship*

- Define and list categories associated with Neoplastic Disorders of Leukocytes LEVEL 1
  - Leukemias
  - Myelodysplastic syndromes
  - Myeloproliferative disorders
  - Lymphoproliferative disorders

- Identify major systems used to classify neoplastic disorders of leukocytes LEVEL 1
  - French, American-British (FAB) Cooperative Group
  - World Health Organization (WHO)

- Observe and/or perform procedures, apply appropriate quality control procedures, Level 2 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, Lab and Preceptorship*

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
- 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 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, Lab and Preceptorship

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 Level 1 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 Level 2

Correlate the diagnostic blood and bone marrow findings to the differential identification Level 3

Describe characteristics of MDS Level 2
- Median age of onset
- Epidemiology
- Chromosomal association with pathogenesis
- Clinical course with associated hematologic changes
- Treatment options
- Prognosis

**Chronic Myeloproliferative Neoplasms** *Hematology II, Lab and Preceptorship*

Classify Chronic Myeloproliferative Neoplasms by cell type Level 1
- Granulocytes--Chronic myelogenous/granulocytic leukemia (CML/CGL)
- Erythrocytes--polycythemia vera (PV)
- Megakaryocytes--essential thrombocytemia (ET)
- Fibroblasts--agnogenic myeloid metaplasia (AMM)

List Chronic Myeloproliferative Neoplasms subtypes Level 1
- Chronic myelogenous leukemia (CML) BCR/ABL1 positive
- Essential thrombocytemia (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 Level 2
- Chronic myelomonocytic leukemia (CMML)
CMML-1
CMML-2
Atypical chronic myeloid leukemia (aCML), BCR-ABL1 negative
Juvenile myelomonocytic leukemia (JMMML)
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 of
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 I, Lab and Preceptorship**

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 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 Level 2
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 Level 2
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, Lab and Preceptorship*

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 Level 3 presence of lymphoma cells

**Plasma Cell Disorders** *Hematology II, Lab and Preceptorship*

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 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, Lab and Preceptorship

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 Level 2
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 Level 3
   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 Level 3

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

Calibrate and perform preventive maintenance on instruments used to evaluate platelets Level 2

**Hemostasis/ Coagulation Hematology II, Lab and Preceptorship**

Define hemostasis Level 1

Explain the general interaction of systems involved in maintaining hemostasis Level 1

Of systems involved in maintaining hemostasis describe how changes in one effect the other Level 2
   Vasculature
   Platelets
   Plasma coagulation factors
   Fibrinolysis

Differentiate between primary and secondary hemostasis Level 3
**Vascular Hematology II, Lab and Preceptorship**

Explain the functions of the vascular system in maintaining hemostasis  
Level 1

Describe metabolic functions of the endothelium and substances contributing to the thromboresistance properties of endothelium  
Level 1

Heparan sulfate  
Thrombomodulin  
Tissue plasminogen activator  
Prostacyclin (PGI2)  
Tissue factor pathway inhibitor

**Platelets Hematology II, Lab and Preceptorship**

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, Lab and Preceptorship*

Define the coagulation factors Level 1
   Roman numerals
   Common names
   Synonyms

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
   Plasma-based (in vitro) mechanism
      Intrinsic
      Extrinsic
      Common
   Cell-based (physiologic, in vivo) mechanism
   Level 3
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 subsequent handling of specimens for coagulation testing Level 1
- 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 Level 1

Discuss the principle and clinical significance of the Prothrombin time test 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 the International Normalized Ratio (INR) Level 1
Calculate an INR given the international sensitivity index of the thromboplastin Level 2
Describe interferences and sources of error Level 1

Discuss the principle and clinical significance of the Activated partial thromboplastin time
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

Discuss the principle and clinical significance of the Activated clotting time
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

Discuss the principle and clinical significance of the Thrombin clotting time
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

Discuss the principle and clinical significance of the Fibrinogen assay
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

Discuss the principle and clinical significance of Factor assays
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, Lab and Preceptorship

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, Lab and Preceptorship

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
Thrombocythemia

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, Lab and Preceptorship

Describe the inheritance pattern, pathophysiology, clinical features, Level 1 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 Level 1 disorders
Vitamin K deficiency
Liver disease
Renal disease

Describe the significance and clinical implications of the development Level 1 of circulating anticoagulants
Specific factor inhibitors
Nonspecific factor inhibitors
Global inhibitors

Identify and describe laboratory procedures that are used to evaluate Level 1 circulating anticoagulants or inhibitors

Discuss the principle and clinical significance of Correction study using Level 1 normal plasma
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 APTT screening with moderate-high LA responsive reagent (LA-sensitive, low phospholipid)

- 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 Dilute Russell viper venom time (DRVVT)

- 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 Low-phospholipid (LA-sensitive) vs. high-phospholipid APTT

- 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 Platelet neutralization procedure

- 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

- 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, Lab and Preceptorship*

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, Lab and Preceptorship**

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

- 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, Lab and Preceptorship**

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

- 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

- 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
Discus 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