I. INTRODUCTION

A. The purpose of this course is to provide an introduction to the principles and procedures of various tests performed in Clinical Chemistry. It presents the physiological basis for the test, the principle and procedure for the test, and the clinical significance of the test results, including quality control and normal values. Also includes basic chemical laboratory technique, chemical laboratory safety, electrolytes and acid-base balance, proteins, carbohydrates, lipids, enzymes, metabolites, endocrine function, and toxicology.

B. This course is required to meet curriculum requirements for students in the Medical Laboratory Technician Program at Central Texas College. It may also be beneficial to pre-medical and other allied health fields.

C. The course is occupationally related and provides didactic and clinical knowledge required for the graduate of an MLT program.

Prerequisites: MLAB 1470-Introduction to Clinical Laboratory Science
Urinalysis and Bodily Fluids
CHEM 1411-General Chemistry I

II. LEARNING OUTCOMES

Upon successful completion of this course, Clinical Chemistry, the student will be able to:

A. Perform the following calculations: metric conversions, percent solutions, normal solutions, molar solutions, and ratio and proportion.

B. Compare the various types of glassware used in the clinical laboratory and demonstrate appropriate usage.
C. Compare the various types of pipettes and diluters used in the clinical laboratory and demonstrate appropriate usage.

D. Categorize the proper collection of these sample types: serum, plasma, whole blood, Urine, cerebrospinal fluid, gastric, and miscellaneous.

E. Evaluate appropriate anticoagulant usage and possible interferences.

F. Explain the importance of quality assurance in the clinical laboratory. Define, apply, and evaluate quality control, reference range, Levy Jennings charts, and Westgard rules.

G. Compare the principle, basic components, and use of the following types of instrumentation: Spectrophotometer, Nephelometer, Atomic absorption spectrophotometer, Fluorometer, Scintillation counter, Electrochemistry - ion specific electrodes and electrophoretic chambers, and Osmometer.

H. Recognize and use safety procedures required in the clinical laboratory, including the handling and disposal of specimens, personal protective equipment, flammable materials, and sharps disposal.

I. Describe the basic physiology, and analytical procedures, and correlate clinical normal and abnormal results for the following systems: Proteins and amino acids, Nonprotein Nitrogen, Enzymes, Carbohydrates, Blood Gases, pH, and Buffer systems, Trace elements and Iron, Lipids and Lipoproteins, Electrolytes, Endocrinology (includes Thyroid Function), Vitamins, Hemoglobins, Myoglobins, and Porphyrins, Liver Function, Cardiac Function, Renal Function, Pancreatic-Gastrointestinal Function, Therapeutic Drug Monitoring, Tumor Markers, Toxicology, Body Fluids

J. Perform routine phlebotomy of Chemistry specimens.

K. Exhibit attitudes consistent with professionalism and concern for quality health care by:

1. Performing analysis with care, adhering strictly to written procedure
2. Demonstrating flexibility by accepting and implementing approved changes to procedures
3. Attending scheduled lecture and lab regularly and punctually
4. Completing assigned tasks with minimal guidance
5. Maintains confidentiality of patient results
6. Seeks activities which further assists learning
7. Admits mistakes and take steps to correct them
8. Repeats procedures when test results are in doubt
9. Responds appropriately to authority
10. Takes pride in role in laboratory medicine
11. Complies with stated dress code for laboratory exercises
12. Recognizes the importance of continuing education activities

III. INSTRUCTIONAL MATERIALS

Required Text:
The instructional materials identified for this course are viewable through [www.ctcd.edu/books](http://www.ctcd.edu/books).

Required Dress Code: Scrubs and closed toed shoes must be worn to all MLAB classes and labs.

REFERENCES:


Access to online Allied Health Professionals database is available through CTC website. Go to CTC homepage then click library on the left. Choose eBooks (available from any location with internet capability)

IV. COURSE REQUIREMENTS

To receive transferable credit for this course, you must earn a grade of "75" or better.

You are expected to read all assigned materials and bring your textbooks to class and laboratory.

You are expected to keep a good set of notes. The major part of examinations will be taken from your notes. The rest will come from assigned reading and laboratory exercises.

Students with grades of "D" or less are to make an appointment for a conference with the instructor. Any material not understood by the student in lecture or lab can be discussed with the instructor privately. Contact the instructor for an appointment.

V. EXAMINATIONS

Five Lecture examinations, three Laboratory examinations, and three Lab Mathematics examinations will be given along with a comprehensive Final Examination.

A student must be present for all examinations. No make-up examination will be given. Students who know in advance they will be absent from an examination due to valid reasons, must arrange to take an early examination.
Students with absences will be given a zero for the examination missed.

**NOTE:** Plagiarism in any form will **not** be tolerated. A student who chooses to plagiarize will be given a zero on the assignment. A formal charge may be made to the College Disciplinary Board.

* AS100 scan Tron answer sheets will be required for lecture, lab, and final exams. Those will be given to the instructor during the 1st week of classes.

**NOTE:** Cheating in any form will not be tolerated. A student observed cheating will be given a zero on the test. A formal charge may be made to the College Disciplinary Board.

### VI. SEMESTER GRADE COMPUTATION:

<table>
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<th>Point Value</th>
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#### Laboratory Examinations

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<tr>
<td>Exam 2 Labs week 6-10</td>
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<tr>
<td>Exam 3 Labs week 11-14</td>
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#### Laboratory Assessment Points

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#### Quiz/Homework(s)

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#### Comprehensive Final

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**Total Course Points for Semester:**

| 1200 |

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<td>900-959</td>
<td>C</td>
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<tr>
<td>780-899</td>
<td>D</td>
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</table>
Below 780 F

Professionalism Grade: 50 Points (This grade cannot be replaced by final)
Grading for Professionalism Grade: Subtract 2 pts per tardy or absence, 1 pt for other infractions
Includes:
Preparation for Class
Completion of assignments (Homework assignments: Full credit at start of class, half points at end of day, 0 points after 1st day. See attendance below.)
Attendance (Must bring a doctor’s note for each absence due to illness to accept assignments the following day)
Tardies
Unlawful Use of electronics (cell phones, etc)
Observation (Team player, Participation, Stay on Task –minimal Distractions, cheating, plagiarism, talking)

Extra credit: Maximum of 3% of total grade. Extra credit for lecture portion only. Lab has lab participation points. No extra assignments without approval of professor for lecture. Again, must fit within 3% of total extra points.

NOTE: Plagiarism in any form will not be tolerated. A student who chooses to plagiarize will be given a zero on the assignment. A formal charge may be made to the College Disciplinary Board. Testing: If professor elects to use testing center, tests will only be available on Tues-Thursday only. No exceptions. Tests will only be for same time period as the class. Class must meet during original scheduled class time for extra lectures and/or labs. Professor will take test on Monday, pick up tests on Friday to be able to grade by next class period.

VII. NOTES AND ADDITIONAL INSTRUCTIONS FROM THE INSTRUCTOR

A. Course Withdrawal: It is the student's responsibility to officially withdraw from a course if circumstances prevent attendance. Any student who desires to, or must, officially withdraw from a course after the first scheduled class meeting must file a Central Texas College Application for Withdrawal (CTC Form 59). The student must sign the withdrawal form. CTC Form 59 will be accepted at any time prior to Friday of the 12th week of classes during the 16-week fall and spring semesters.

The deadline for sessions of other lengths is:

10-week session: Friday of the 8th week
8-week session: Friday of the 6th week
5-week session: Friday of the 4th week

The equivalent date (75% of the semester) will be used for sessions of other lengths. The specific last day to withdraw is published each semester in the Schedule Bulletin.

A student who officially withdraws will be awarded the grade of "W" provided the student's attendance and academic performance are satisfactory at the time of
official withdrawal.

Students must file a withdrawal application with the college before they may be considered for withdrawal.

A student may not withdraw from a class for which the instructor has previously issued the student a grade of "F" or "FN" for nonattendance.

B. **Administrative Withdrawal:** An administrative withdrawal may be initiated when the student fails to meet College attendance requirements. The instructor will assign the appropriate grade on the CTC Form 59 for submission to the registrar.

C. **Incomplete Grade:** The College catalog states,” An incomplete grade may be given in those cases where the student has completed the majority of the course work but, because of personal illness, death in the immediate family, or military orders, the student is unable to complete the requirements for a course..." Prior approval from the instructor is required before the grade of "I" is recorded. A student who merely fails to show for the final examination will receive a zero for the final and an "F" for the course.

D. **Cellular Phones and Beepers:** Cellular phones and beepers will be turned off while the student is in the classroom or laboratory. No tolerance. If the phone goes off, the student will be asked the leave the class, and receive a zero to be added in to cumulative grade.

E. **American’s With Disabilities Act (ADA):** Disability Support Services provide services to students who have appropriate documentation of a disability. Students requiring accommodations for class are responsible for contacting the Office of Disability Support Services (DSS) located on the central campus. This service is available to all students, regardless of location. Explore the website at [www.ctcd.edu/disability-support](http://www.ctcd.edu/disability-support) for further information. Reasonable accommodations will be given in accordance with the federal and state laws through the DSS office.

F. **Instructor Discretion:** The instructor reserves the right of final decision in course requirements.

G. **Civility:** Individuals are expected to be cognizant of what a constructive educational experience is and respectful of those participating in a learning environment. Failure to do so can result in disciplinary action up to and including expulsion.

VIII. **COURSE OUTLINE**

A. **Lesson One:** Basic Principles and Practices of Clinical Chemistry
1. **Learning Outcomes:** Upon successful completion of this lesson, the student will be able to:
   a. Convert results from one unit format to another using the SI and traditional systems.
   b. Describe the classifications used for reagent grade water and which influence accuracy and precision.
   c. Identify the varying chemical grades used in reagent preparation and indicate their correct use.
   d. Define primary standard, SRM, secondary standard, NIST.
   e. Describe the following terms that are associated with solutions (solute, analyte, solutions, concentrations) and, when appropriate, provide the respective units as well as relate to use in clinical chemistry: percent, molarity, normality, molality, saturation, colligative properties, redox potential, conductivity, osmolality, dilution, and specific gravity.
   f. Define Beer’s law and be able to calculate concentration, absorbance, and percent transmission.
   g. Calculate Percent Solutions using weight per unit volume (w/v): g/dL (%), mg/dL (mg %).
   h. Calculate Percent Solutions using volume per unit volume (v/v): mL/dL (%).
   i. Calculate Percent Solutions using weight per unit weight (w/w): g/dg (%).
   j. Determine the gram molecular weight (GMW) of a substance and use it to calculate the molarity of solutions.
   k. Calculate molarity using hydrates.
   l. Convert molarity to mmol/L.
   m. Calculate density (specific gravity) of a solution.
   n. Determine Percent Assay by calculating percent solution from a concentrate.
   o. Calculate the preparation of a molar solution from a concentrated liquid.
   p. Calculate the preparation of a normal solution from a concentrated liquid.
   q. Define a buffer and give the formula for pH and pK calculations.
   r. Use the Henderson-Hasselbalch equation to determine the missing variable when given either the pK and pH or the pK and concentration of the weak acid and its conjugate base.
   s. List and describe the types of thermometers used in the clinical laboratory.
   t. Classify the type of pipet when given an actual pipet or its description.
   u. Demonstrate the proper use of a measuring and volumetric pipet.
   v. Describe two ways to calibrate a pipetting device.
   w. Explain the public relations role of blood collection personnel, identify professional traits and skills, describe patient consent types, discuss the importance of confidentiality, and define legal terms associated with civil actions.
   x. Describe precautions for specimen handling. Identify standard and transmission-based precautions, select personal protective equipment to perform phlebotomy, describe hand hygiene procedures, and state the purpose of isolation.
   y. Demonstrate basic knowledge of the vascular system, identify and select veins for venipuncture, and describe the source, composition, and types of blood
specimens.
z. Identify various types of venipuncture equipment, explain color-coding used to identify tube additives, name additives and describe their functions, and state and discuss the order of draw.
a. Draw a correct diagram of meniscus.
b. Demonstrate basic knowledge of tubes and/or anticoagulants which are used for different chemistry analytes.
c. Describe each step in the venipuncture and capillary procedures, troubleshoot failed venipuncture, and identify unique aspects of specimen collection on pediatric and geriatric patients.
d. Identify and address preanalytic variables such as problem sites, procedural errors, and patient conditions or complications that can make blood collection difficult, affect specimen quality, or negatively affect the patient.
e. Discuss the importance of following recognized standards in the preanalytic phase of the testing process to ensure collection of quality specimens and protect patient safety.

f. Discuss safety awareness for clinical laboratory personnel. Identify and demonstrate the various types of safety equipment available in the student laboratory.
g. List the responsibilities of employer and employee in providing a safe workplace.
h. Identify what each quadrant of NFPA represents.
i. Identify hazards related to handling chemicals, biologic specimens, radiologic and electrical materials.
j. Choose appropriate personal protective equipment when working in the clinical laboratory.
k. Identify the classes of fires and the type of fire extinguishers to use for each.
l. Demonstrate proficiency using lab equipment. Describe steps used as precautionary measures when working with electrical equipment, cryogenic materials, and compressed gases and avoiding mechanical hazards associated with laboratory equipment.
m. Select the correct means for disposal of waste generated in the clinical laboratory.
n. Outline the steps required in documentation of an accident in the workplace.
o. Define and differentiate the following terms: quality assurance, quality control, accuracy, precision, descriptive statistics, reference interval, random error, sensitivity, specificity, systematic error, confidence intervals, Six-Sigma performance, standard deviation, Gaussian distribution.
p. Calculate the following: sensitivity, specificity, efficiency, predictive value, mean, median, range, variance, standard deviation, coefficient of variation, serum dilution, and equivalency.
q. Understand why statistics are needed for effective quality management
r. Read a descriptive statistics equation without fear.
s. Understand the types, uses, and requirements for reference intervals.
t. Understand the basic protocols used to verify or establish a reference interval.
u. Appreciate how the test cutoff affects diagnostic performance.
v. Evaluate laboratory data using multi-rules for quality control.
   Explain and apply Quality Control measures and understand the related
terminology: Calibration and Standards, NIST, Reference Range, Levy Jennings
Graph, Trend and Shift
w. Graph laboratory data and determine significant constant or proportional errors.
x. Describe the preanalytic and postanalytic phases of quality assurance. Understand
how to handle critical values.
y. Determine if there is a trend or a shift, given laboratory data.
z. Discuss the processes involved in method selection and evaluation.
a. Discuss proficiency-testing programs in the clinical laboratory.
b. Describe how a process can be systematically improved.
c. Explain why quality management is important for patients and the laboratory
d. Explain the general principles of each analytic method.
e. Discuss the limitations of each analytic technique.

f. Compare and contrast the various analytic techniques; ex. two dimensional
electrophoresis.
g. Discuss existing clinical applications for each analytic technique.
h. Compare percent transmittance and absorbance.
i. Describe and explain the relevance of electrophoresis.
j. Be able to differentiate, discuss, and evaluate electrophoretic separation of
proteins dependent on type of gel: cellulose acetate, agarose, polyacrylamide or
starch and purpose of each.
k. Outline the quality assurance and preventive maintenance procedures involved
with the following instruments: spectrophotometer, atomic absorption
spectrometer, fluorometer, gas chromatograph, osmometer, ion-selective
electrode, and pH electrode.
l. Demonstrate an understanding of basic methodologies used in determination of
chemistry values in the clinical laboratory
m. Describe safety and quality procedures and identify agencies that regulate them.

2. Learning Activities: Methods of Teaching and Learning Students will be taught
using various learning methods and activities which includes lectures,
demonstrations including hands on with practice sessions, case studies, projects,
laboratory exercises, clinical experiences, Internet exercises, quizzes, exams, and
recordings. All material covered by these methods maybe covered on Exams.

B. Lesson Two: Introduction to Principles of Clinical Chemistry Automation

1. Learning Outcomes: Upon successful completion of this lesson, the student will
be able to:
   a. Define the following terms: automation, channel, continuous flow, discrete
analysis, dwell time, flag, random access, and throughput.
b. Discuss the history of the development of automated analyzers in the clinical
chemistry laboratory.
c. List four driving forces behind the development of new automated analyzers.
d. Name three basic approaches to sample analysis used by automated analyzers.
e. Explain the major steps in automated analysis.
f. Specify the basic steps that automated analyzers used to reduce carryover.
g. Apply principles of instrumentation to specific types of analyzers seen in modern clinical laboratories. Provide examples of commercially available discrete chemistry analyzers and modular systems.
h. Compare the different approaches to automated analysis used by instrument manufacturers.
i. Define and differentiate batch testing and random access testing.
j. Correlate the throughput of an analyzer with the needs of different size laboratories.
k. Discriminate between an open versus a closed reagent system.
l. Relate three considerations in the selection of an automated analyzer.
m. Explain the concept of total laboratory automation.
n. Define Quality Control measures required for instrumentation, preventative maintenance, daily maintenance, and troubleshooting.
o. Investigate sources of errors with quality control. Know when to calibrate analyzers.
p. Differentiate the three phases of the laboratory testing process.
q. State the principle of each of the following methods: Double diffusion, Radial immunodiffusion, Immunoelectrophoresis, Immunofixation electrophoresis, Nephelometry, Turbidimetry/Nanometer, Competitive immunoassay, Noncompetitive immunoassay, Immunoblot, Direct immunocytochemistry, Indirect immunocytochemistry, Immunophenotyping by flow cytometry
r. Know which light sources are associated with UV, IF, visible and Near-infrared regions of spectrophotometers.
s. Know different types of monochromator’s principle of operation.
t. Identify and explain the utilization of the following types of instrumentation. Define, principles, describe the operation, function and component parts of the following instruments: spectrophotometer, atomic absorption spectrometer, fluorometer, gas chromatograph, osmometer, ion-selective electrode, pH electrode, colorimetry, nephelometry, nanometer, electrochemistry, potentiometry, densitometry, flame photometer as well as recognize proper specimens associated with above instruments. Scintillation counter, electrophoresis, Chromatography (High performance liquid, Gas, Column/paper/thin layer)
u. Compare and contrast the general types of labels used in immunoassays.
v. Classify an immunoassay, given its format, as homogeneous or heterogeneous, competitive or noncompetitive, and by its label.
w. Explain how the concentration of the analyte in the test sample is related to the amount of bound-labeled reagent for competitive and noncompetitive immunoassays. Discuss future trends in automated analyzer development.
x. Define, and discuss function of point-of-care testing (POCT).
y. Explain what basic structure is required to manage a POCT program.
z. Explain the nuts-and-bolts process of implementing a POCT test.
aa. State the basic principles behind these common POC applications:
   i. POC glucose
ii. POC chemistries and blood gases
iii. POC hematology
iv. POC coagulation
v. POC connectivity

2. **Learning Activities**: Methods of Teaching and Learning Students will be taught using various learning methods and activities which includes lectures, demonstrations including hands on with practice sessions, case studies, projects, laboratory exercises, clinical experiences, Internet exercises, quizzes, exams, and recordings. All material covered by these methods may be covered on Exams.

C. **Lesson Three: Amino Acids and Proteins**

1. **Learning Outcomes**: Upon successful completion of this lesson, the student will be able to:
   
   a. Describe the structures and general properties of amino acids and proteins, including both conjugated and simple proteins.
   
   b. Outline, describe protein metabolism/ synthesis and catabolism.
   
   c. List the metabolic significance of proteins.
   
   d. Discuss the general characteristics of the aminoacidopathies, including the metabolic defect in each and the procedure used for detection.
   
   e. Briefly discuss the function, methodology and clinical significance of the following proteins:
      
      i. Pre-albumin
      
      ii. Albumin- how to prepare reagents for assay. Perform albumin testing on patient and quality control specimens utilizing spectrophotometer.
      
      iii. Evaluate results of patient protein testing and quality control.
      
      iv. Correlate disease states with abnormal results.
      
      v. α1-antitrypsin
      
      vi. α1-fetoprotein
      
      vii. Haptoglobin
      
      viii. Ceruloplasmin
      
      ix. Transferrin
      
      x. Fibrinogen
      
      xi. C-reactive protein
      
   
   f. Discuss and evaluate total protein abnormalities.
   
   g. Demonstrate the use of relevant terminology.
   
   h. Describe, differentiate and perform total protein methods.
   
   i. Describe normal and abnormal values of total protein.
   
   j. Correlate values of total protein with given disease states.
   
   k. Document and evaluate quality control.
   
   l. Evaluate protein electrophoresis results and correlate with disease states.

2. **Learning Activities**: Methods of Teaching and Learning Students will be taught using various learning methods and activities which includes lectures,
demonstrations including hands on with practice sessions, case studies, projects, laboratory exercises, clinical experiences, Internet exercises, quizzes, exams, and recordings. All material covered by these methods maybe covered on Exams.

D. Lesson Four: Nonprotein Nitrogens

1. **Learning Outcomes:** Upon successful completion of this lesson, the student will be able to:
   a. Define non-protein nitrogens (NPN). Explain how non-protein nitrogens are produced. List the nonprotein nitrogen components of the blood and recognize their chemical structures and relative physiologic concentrations.
   b. Describe NPN physiology. Describe the biosynthesis and excretion of urea, uric acid, creatinine, creatine, and ammonia.
   c. Describe the major pathologic conditions associated with increased and decreased plasma concentrations of urea, uric acid, creatinine, creatine, and ammonia.
   d. Determine and State the specimen collection, transport, and storage requirements necessary for determinations of urea, uric acid, creatinine, creatine, and ammonia.
   e. Discuss commonly used methods for the determination of urea, uric acid, creatinine, creatine, and ammonia in plasma and urine. Perform and evaluate methods for measuring NPN.
   f. Identify sources of error and variability in these methods and describe the effects on the clinical utility of the laboratory measurements. Document and evaluate quality control.
   g. Recognize the reference intervals for urea, uric acid, creatinine, and ammonia in plasma and urine. State the effects of age and gender on these values. Describe normal and abnormal values. Correlate values with given disease states.
   h. Describe the use of the urea nitrogen/creatinine ratio in distinguishing between prerenal, renal, and postrenal causes of uremia.
   i. Relate the solubility of uric acid to the pathologic consequences of increased plasma uric acid.
   j. Explain purpose of reagent blank.
   k. Calculate creatinine clearance values.

2. **Learning Activities:** Methods of Teaching and Learning Students will be taught using various learning methods and activities which includes lectures, demonstrations including hands on with practice sessions, case studies, projects, laboratory exercises, clinical experiences, Internet exercises, quizzes, exams, and recordings. All material covered by these methods maybe covered on Exams.

E. Lesson Five: Enzymes

1. **Learning Outcomes:** Upon successful completion of this lesson, the student will be able to:
   a. List the general properties of enzymes.
   b. Define relevant terminology.
   c. Describe enzyme classification and nomenclature.
d. Evaluate enzyme kinetics, catalytic mechanism of enzymes, and the factors that influence the enzymatic reaction.
e. Be able to calculate the enzyme activity.
f. Know enzymes of clinical significance; know where they are produced, their function, and their primary tissue source.
g. Describe test procedures for enzyme and isoenzyme analysis.
h. Describe the clinical significance of normal and abnormal values.
i. Correlate enzyme values with given disease states.

2. **Learning Activities:** Methods of Teaching and Learning Students will be taught using various learning methods and activities which includes lectures, demonstrations including hands on with practice sessions, case studies, projects, laboratory exercises, clinical experiences, Internet exercises, quizzes, exams, and recordings. All material covered by these methods maybe covered on Exams.

F. **Lesson Six: Carbohydrates**

1. **Learning Outcomes:** Upon successful completion of this lesson, the student will be able to:
   a. Classify carbohydrates into their respective groups, and distinguish between them.
   b. Explain; discuss the physiology relating to metabolism and catabolism of carbohydrates in the body and the mode of action of hormones in carbohydrate metabolism.
   c. Explain; discuss effects of hormones on blood glucose values.
   d. Collect/process appropriate specimen for glucose testing.
   e. List the factors utilized in determining blood glucose levels.
   f. Describe and perform the methods used to determine glucose levels.
   g. Perform glucose analysis, utilizing spectrophotometers and glucometers. Describe and perform: Random glucose, two-hour postprandial, & glucose tolerance test, both oral and IV.
   h. Differentiate the types of diabetes by clinical symptoms and laboratory findings according to the American Diabetes Association (ADA).
   i. Describe normal and abnormal values of glucose testing. Describe factors affecting results and correlate values with given disease states. Evaluate results of glucose testing.
   j. Perform Quality Control of glucose procedure and evaluate results of QC values.
   k. Explain the clinical significance of the three ketone bodies.
   l. Relate expected laboratory results and clinical symptoms to the following metabolic complications of diabetes: Ketoacidosis, Hyperosmolar coma
   m. Distinguish between reactive and spontaneous hypoglycemia.
   n. Describe the principle, specimen of choice, and advantages and disadvantages of the glucose analysis methods.
   o. Describe the three commonly encountered methods for glycated hemoglobin, specimen of choice. Describe factors affecting results and correlate values with given disease states.
2. **Learning Activities:** Methods of Teaching and Learning Students will be taught using various learning methods and activities which includes lectures, demonstrations including hands on with practice sessions, case studies, projects, laboratory exercises, clinical experiences, Internet exercises, quizzes, exams, and recordings. All material covered by these methods maybe covered on Exams.

G. **Lesson Seven: Acid/Base Balance**

1. **Learning Outcomes:** Upon successful completion of this lesson, the student will be able to:
   a. Describe acid/base balance and how to calculate it.
   b. Define relevant terminology. Study ABG testing, utilizing ABG video.
   c. Recognize appropriate specimen, collection and storage procedure for ABG testing.
   d. Describe the principles of blood gas involved in the measurement of pH, PCO₂, PO₂.
   e. Outline the interrelationship of the buffering mechanisms of bicarbonate, carbonic acid, and hemoglobin.
   f. Explain the clinical significance of the following pH and blood gas parameters: pH, PCO₂, PO₂, actual bicarbonate, carbonic acid, base excess, oxygen saturation, fractional oxyhemoglobin, hemoglobin oxygen (binding) capacity, oxygen content, and total CO₂. Describe clinical significance of normal and abnormal values.
   g. Determine whether data are normal or represent metabolic or respiratory acidosis or metabolic or respiratory alkalosis using the Henderson-Hasselbalch equation and blood gas data. Identify whether the data represent uncompensated or compensated conditions. Describe factors affecting results and correlate values with given disease states.
   h. Identify and evaluate some common causes of nonrespiratory acidosis and alkalosis, respiratory acidosis and alkalosis, and mixed abnormalities. State how the body attempts to compensate (kidney and lungs) for the various conditions.
   i. Describe the significance of the hemoglobin–oxygen dissociation curve and the impact of pH, 2, 3-diphosphoglycerate (2, 3-DPG), temperature, pH, and PCO₂ on its shape and release of O₂ to the tissues.
   j. Evaluate results of ABG testing.

2. **Learning Activities:** Methods of Teaching and Learning Students will be taught using various learning methods and activities which includes lectures, demonstrations including hands on with practice sessions, case studies, projects, laboratory exercises, clinical experiences, Internet exercises, quizzes, exams, and recordings. All material covered by these methods maybe covered on Exams.

H. **Lesson Eight: Hemoglobin, Iron, and Trace Elements**
1. **Learning Outcomes:** Upon successful completion of this lesson, the student will be able to:
   a. Define metalloprotein, metalloenzyme, cofactor, trace element, ultratrace element, essential trace element, nonessential trace element and hemoglobin, myoglobin, and porphyrin.
   b. State the biologic functions, storage of selected essential trace elements.
   c. Distinguish between essential and nonessential trace elements.
   d. Discuss and evaluate the clinical significance of selected trace elements and the consequences of deficiency and toxic states.
   e. Discuss specimen collection considerations and laboratory determination.
   f. Describe instrumentation used for trace element analysis, and clinical tests to identify normal and abnormal.
   g. Describe metabolism and catabolism of hemoglobin, myoglobin, porphyrin, and iron.
   h. Describe procedures utilized in evaluation of hemoglobin, myoglobin, porphyrin, and iron.
   i. Describe normal and abnormal values. Correlate values with given disease states.

2. **Learning Activities:** Methods of Teaching and Learning Students will be taught using various learning methods and activities which includes lectures, demonstrations including hands on with practice sessions, case studies, projects, laboratory exercises, clinical experiences, Internet exercises, quizzes, exams, and recordings. All material covered by these methods maybe covered on Exams.

I. **Lesson Nine: Lipids and Lipoproteins**

1. **Learning Outcomes:** Upon successful completion of this lesson, the student will be able to:
   a. Explain how lipids are classified.
   b. Define lipoproteins and their function.
   c. Explain lipoprotein physiology and metabolism.
   d. Describe the structure and synthesis of fatty acids, phospholipids, triglycerides, cholesterol, and the various types of lipoprotein particles.
   e. Describe the effect of fasting versus non-fasting specimens and determine the acceptability of specimens.
   f. Explain the use of chylomicron separators.
   g. Describe the laboratory tests used to assess lipids and lipoproteins, including principles and procedures.
   h. Identify common lipid disorders from clinical and laboratory data.
   i. Discuss the incidence and types of lipid and lipoprotein abnormalities.
   j. Identify the reference ranges for the major serum lipids. Describe normal and abnormal values.
   k. Describe factors affecting results and correlate results with disease states.
   l. Relate the clinical significance of lipid and lipoprotein values in the assessment of coronary heart disease.
m. Perform Quality Control of cholesterol procedure and evaluate results of QC values.

n. Describe the role of standardization in the measurement of lipids and lipoproteins.

o. Collect/process appropriate specimen for cholesterol testing.


q. Evaluate results of cholesterol testing.

2. Learning Activities: Methods of Teaching and Learning

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J. Lesson Ten: Electrolytes

1. Learning Outcomes: Upon successful completion of this lesson, the student will be able to:

a. Define electrolyte, osmolality, anion gap, anion, and cation. Define electrolytes and nonelectrolytes.

b. Discuss the physiology and function of each electrolyte described in the chapter.

c. State the clinical significance of each of the electrolytes mentioned in the chapter.

d. Calculate osmolality, osmolal gap, and anion gap and discuss the clinical usefulness of each.

e. Discuss the analytic techniques used to assess electrolyte concentrations. List and describe the various procedures utilized to evaluate electrolytes.

f. Describe factors affecting results and correlate the information with disease state, given patient data.

g. Identify the reference ranges for sodium, potassium, chloride, bicarbonate, magnesium, phosphorus and calcium.

h. State the specimen of choice for the major electrolytes. Collect/process appropriate specimen for chloride testing.

i. Discuss the role of the kidney in electrolyte excretion and conservation in a healthy individual.

j. Discuss the usefulness of urine electrolyte results: sodium, potassium, calcium, and osmolality.

k. Describe the endocrine and organ physiology of calcium metabolism, and the laboratory tools to assess and correlate the clinical disease states of calcium metabolism.

l. Describe the clinical significance of normal and abnormal values.

m. Perform electrolyte analysis, utilizing the spectrophotometer.

n. Evaluate criteria of sweat chloride testing.
o. Perform Quality Control of chloride procedure and evaluate results of QC values

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K. **Lesson Eleven: The Endocrine System**

1. **Learning Outcomes:** Upon successful completion of this lesson, the student will be able to:
   a. Demonstrate the use of relevant terminology.
   b. List and give the function of each organ in the endocrine system.
   c. List the hormones used to evaluate each endocrine gland, along with corresponding sites of origin.
   d. Describe the biosynthesis of various hormones.
   e. Explain the assays available for given hormones.
   f. Describe the functions of the anterior and posterior pituitary.
   g. Define the anatomic relationship between the pituitary and hypothalamus.
   h. Understand the concept of open-loop negative feedback and relate this to the function of the various hypothalamic-pituitary-endocrine target gland loops.
   i. Understand the effects of pulsatility and cyclicity on the results of hormone measurements.
   j. Differentiate between tropic and direct effector in relationship to pituitary hormones.
   k. Discuss the regulation of prolactin secretion.
   l. State the non-neoplastic causes of prolactin elevation.
   m. Understand the difference between primary and secondary endocrine deficiency states.
   n. Describe the clinical features of the excess and deficiency states for growth hormone, prolactin, and vasopressin.
   o. Relate the physiology underlying the strategies used for screening and definitive testing for suspected disorders of growth hormone.
   p. Explain how the adrenal gland functions to maintain blood pressure, potassium, and glucose homeostasis.
   q. Describe steroid biosynthesis, regulation, and actions according to anatomic location within the adrenal gland.
   r. Discuss the pathophysiology of adrenal cortex disorders, namely Cushing’s syndrome and Addison’s disease. Differentiate the adrenal enzyme deficiencies and their blocking pathways in establishing a diagnosis.
   s. Describe the synthesis, storage, and metabolism of catecholamines.
   t. State the most useful measurements in supporting the diagnosis of pheochromocytoma.
u. List the clinical findings associated with hypertension that suggests an underlying adrenal etiology is causing high blood pressure.

v. List the appropriate laboratory tests to differentially diagnose primary and secondary Cushing’s syndrome and Addison’s disease.

w. Discuss the biosynthesis, secretion, transport, and action of the sex steroids and gonadotropins.

x. Identify the location of the pituitary, ovaries, and testes.

y. Describe the hypothalamic-pituitary-ovarian and hypothalamic-pituitary-testicular axes and how they regulate sex steroid and gonadotropin hormone production.

z. Explain the principles of each diagnostic test for pituitary-gonadal axes dysfunction.

aa. Correlate laboratory information with regard to suspected gonadal disorders, given a patient’s clinical data.

bb. Describe the appropriate laboratory testing protocol to effectively evaluate or monitor patients with suspected gonadal disease.

c. Perform the analysis of B-HCG studies.

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L. **Lesson Twelve: Thyroid Function**

1. **Learning Outcomes:** Upon successful completion of this lesson, the student will be able to:

a. Discuss; list the biosynthesis, secretion, transport, and action and function of each of the thyroid hormones.

b. Know the location of the thyroid gland.

c. Describe the hypothalamic-pituitary-thyroid axis and how it regulates thyroid hormone production.

d. Explain the principles of each thyroid function test discussed, and explain the assays available for given hormones.

e. Correlate laboratory information with regard to suspected thyroid disorders, given a patient’s clinical data.

f. Describe the appropriate laboratory thyroid function testing protocol to use to effectively evaluate or monitor patients with suspected thyroid disease.

g. Demonstrate the use of relevant terminology.

h. Describe normal and abnormal values of each thyroid assay.

2. **Learning Activities:** Methods of Teaching and Learning Students will be taught using various learning methods and activities which includes lectures, demonstrations including hands on with practice sessions, case studies, projects, laboratory exercises, clinical experiences, Internet exercises, quizzes, exams, and
Lessons Thirteen: Liver Function

1. **Learning Outcomes:** Upon successful completion of this lesson, the student will be able to:
   a. Diagram the anatomy of the liver, and describe the physiology of the liver.
   b. Explain the following functions of the liver: bile secretion, synthetic activity, and detoxification.
   c. List two important cell types associated with the liver and state the function of each.
   d. Define jaundice and classify the three different types of jaundice.
   e. Discuss, evaluate the basic disorders of the liver and which laboratory tests may be performed to diagnose them.
   f. Evaluate liver-related data and correlate those data with normal or pathologic states.
   g. Perform total, direct bilirubin and amylase assays using spectrophotometer. Compare and contrast how total and direct bilirubin measurements are performed.
   h. Calculate indirect bilirubin value.
   i. Evaluate appropriate specimen for bilirubin testing and assess specimen handling and effects of light exposure to the final results.
   j. List the enzymes most commonly used to assess hepatocellular and hepatobiliary disorders.
   k. Describe the various types of hepatitis, to include cause, transmission, occurrence, alternate name, physiology, diagnosis, and treatment.
   l. List the tests used to evaluate liver function.
   m. Describe normal and abnormal values.
   n. Evaluate results of testing done and correlate results with disease states.

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Lesson Fourteen: Cardiac Function

1. **Learning Outcomes:** Upon successful completion of this lesson, the student will be able to:
   a. Demonstrate the use of relevant terminology. Define the term *enzyme*, including physical composition and structure.
   b. Classify enzymes according to the International Union of Biochemistry (IUB).
   c. Diagram the anatomy of the heart.
   d. List the enzymes used to evaluate cardiac function. Explain why the measurement of serum enzyme levels is clinically useful.
   e. Explain the origin of six general symptoms of cardiac disease.
f. Discuss the etiology and physiologic effects of the following cardiac conditions:
   Congenital heart disease
   Hypertensive heart disease
   Infectious heart diseases
   Coronary heart disease
   Congestive heart failure

g. Identify nine risk factors for coronary heart disease.

h. List six features of an ideal cardiac marker. Explain the assays available for given enzymes.

i. List and briefly describe three novel markers of inflammation currently under investigation.

j. Compare and contrast the specificity and sensitivity of the most commonly used serum cardiac markers. Discuss which enzymes are useful in the diagnosis of various disorders, including cardiac, hepatic, bone, and muscle disorders, malignancies, and acute pancreatitis.

k. Discuss the tissue sources, diagnostic significance, and assays, including sources of error, for the following enzymes: CK, LD, AST, ALT, ALP, ACP, GGT, amylase, lipase, cholinesterase, and G-6-PD.

l. Interpret and evaluate assay results for cardiac risk assessment. Describe normal and abnormal values. Correlate values with given disease states.

m. Assess the clinical utility of the various cardiac markers to assess myocardial infarction.

n. Analyze the role of the clinical laboratory in the assessment of a patient with cardiac disease.

o. Discuss the different factors affecting the rate of an enzymatic reaction.

p. Explain enzyme kinetics, including zero-order and first-order kinetics.

q. Discuss the clinical importance for detecting macroenzymes.

r. Discuss the role of enzymes in drug metabolism.

2. **Learning Activities:** Methods of Teaching and Learning

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O. **Lesson Fifteen: Renal Function**

   1. **Learning Outcomes:** Upon successful completion of this lesson, the student will be able to:
      a. Define non-protein nitrogen compounds secreted and broken down by the kidney.
      b. Diagram, understand the anatomy and physiology of the nephron, kidney, including hormones secreted by the kidney.
      c. Describe the physiologic role of each part of the nephron: glomerulus, proximal tubule, loop of Henle, distal tubule, and collecting duct.
      d. Describe the mechanisms by which the kidney maintains fluid and electrolyte balance in conjunction with hormones.
e. Describe renal analytes along with their corresponding renal function
f. Discuss the significance and calculation of glomerular filtration rate, Creatinine clearance and estimated glomerular filtration rate.
g. Relate the clinical significance of total urine proteins, urine albumin microalbuminuria, myoglobin clearance, serum β2-microglobulin, and cystatin C.
h. Discuss proper specimen collection for twenty-four hour urines. Be able to calculate 24 hour proteins.
i. Define dilution factor and determine uses of dilutions in the clinical laboratory.
j. Calculate both simple and serial dilutions.
k. List the tests in a urinalysis and microscopy profile and understand the clinical significance of each.
l. Describe diseases of the glomerulus and tubules and how laboratory tests are used in these disorders.
m. Distinguish between acute and chronic renal failure. Describe the various types of renal disease.
n. Discuss the therapy of chronic renal failure with regard to renal dialysis and transplantation.
o. List the tests used to evaluate renal function. Calculate creatinine clearance rate.
p. Prepare standard curve for Creatinine, BUN and perform testing
q. Describe normal and abnormal values, and evaluate results.
r. Correlate values with given disease states.
s. Document and evaluate quality control.

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P. Lesson Sixteen: Pancreatic and Gastric Function

1. Learning Outcomes: Upon successful completion of this lesson, the student will be able to:
   a. Discuss the physiologic role of the pancreas in the digestive process.
   b. List the hormones excreted by the pancreas, together with their physiologic roles.
   c. Describe the following pancreatic disorders and list the associated laboratory tests that would aid in diagnosis: acute pancreatitis, chronic pancreatitis, pancreatic carcinoma, cystic fibrosis, and pancreatic malabsorption.
   d. Describe the physiology, function and biochemistry of gastric secretion.
   e. List the tests used to assess gastric and intestinal function.
   f. Explain the clinical aspects of gastric analysis.
   g. List the tests used to evaluate pancreatic and gastric function.
   h. Evaluate a patient’s condition, given clinical data.
   i. Describe normal and abnormal values.
   j. Correlate values with given disease states.
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Q. **Lesson Seventeen: Therapeutic Drug Monitoring**

1. **Learning Outcomes:** Upon successful completion of this lesson, the student will be able to:
   a. Discuss the characteristics of a drug that make therapeutic drug monitoring essential. Define relevant terminology.
   b. Describe clinical pharmacokinetics.
   c. Identify the factors that influence the absorption of an orally administered drug.
   d. Relate the factors that influence the rate of drug elimination.
   e. Define drug distribution and the factors that influence it.
   f. Calculate volume of distribution, elimination constant, and drug half-life.
   g. Relate the concentration of a circulating drug to pharmacokinetic parameters.
   h. Name the therapeutic category of each drug presented in this chapter.
   i. Describe test procedures used to measure levels of various drugs.
   j. Describe the major toxicities of the drugs presented in this chapter.
   k. Identify the features of each drug presented in this chapter that may influence its serum drug concentration.
   l. Describe therapeutic and toxic levels.
   m. Correlate levels with given toxic states.

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R. **Lesson Eighteen: Toxicology**

1. **Learning Outcomes:** Upon successful completion of this lesson, the student will be able to:
   a. Define relevant terminology. Define the term toxicology, and drugs of abuse.
   b. List the major toxicants.
   c. Discuss proper specimen collection for Toxicology specimens, including Chain of Custody and timing for Therapeutic Drugs.
   d. Define the pathologic mechanisms of the toxicants discussed in the chapter.
   e. Describe test procedures used to measure levels of various poisons.
   f. Explain the difference between quantitative and qualitative tests in toxicology.
   g. Critically evaluate clinical laboratory data in poisoning cases and provide recommendations for further testing.
   h. Define the role of the clinical laboratory in the evaluation of exposure to poisons.
i. Perform Toxilab drug screen and evaluate results.

j. Describe the clinical significance of toxic states.

k. Correlate values with given toxic states.

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S. **Lesson Nineteen: Body Fluid Analysis, Tumor Markers**

1. **Learning Outcomes**: Upon successful completion of this lesson, the student will be able to:

   a. Describe composition of various body fluids.

   b. Identify the source of amniotic fluid, cerebrospinal fluid, sweat, synovial fluid, pleural fluid, pericardial fluid, and peritoneal fluid.

   c. Describe the physiologic purpose of amniotic fluid, cerebrospinal fluid, sweat, synovial fluid, pleural fluid, pericardial fluid, and peritoneal fluid.

   d. Discuss the clinical utility of testing amniotic fluid, cerebrospinal fluid, sweat, synovial fluid, pleural fluid, pericardial fluid, and peritoneal fluid.

   e. Describe clinical lab procedures used to evaluate various body fluids along with causes of interference.

   f. Interpret a patient’s status, given the results of a TDxFLM II test, L/S ratio, CSF protein analysis, and sweat chloride test.

   g. Identify sources of error that could affect specimen quality.

   h. Differentiate between a transudate and an exudate.

   i. Discuss the incidence of cancer in the United States.

   j. Explain the various types of tumor markers. Describe clinical lab procedures used to evaluate various tumor markers.

   k. Explain the role of tumor markers in cancer management.

   l. Identify the characteristics or properties of an ideal tumor marker.

   m. State the major clinical value of tumor markers.

   n. Name the major tumors and their associated markers.

   o. Describe the major properties, methods of analysis, and clinical use of AFP, CA-125, CEA, beta-hCG, and PSA.

   p. Explain the use of enzymes and hormones as tumor markers.

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T. **Lesson Twenty: Nutritional Assessment**
1. **Learning Outcomes:** Upon successful completion of this lesson, the student will be able to:
   
   a. Discuss the contribution of individual nutrient classes to human metabolism.
   b. Discuss therapeutic nutrition support by enteral and parenteral routes.
   c. List biochemical parameters used to monitor nutritional status.
   d. Define vitamins.
   e. Explain how vitamins are classified.
   f. Describe the biochemical roles of vitamins.
   g. Describe metabolic function and importance of given vitamins.
   h. Correlate alterations in vitamin status with circumstances of increased metabolic requirements, age-related physiologic changes, or pathologic conditions.
   i. Describe drug–nutrient interactions that influence vitamin status.
   j. Delineate laboratory procedures used in the assessment of vitamin status. Describe assays for measuring vitamin levels.
   k. List normal and abnormal values.
   l. Correlate values with given disease states for vitamins.
   m. Discuss the role of the laboratory in nutritional assessment and monitoring.
   n. List the populations at risk for malnutrition.

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