CENTRAL TEXAS COLLEGE  
MLAB 2221  
Molecular Diagnostics  
Semester Hours Credit: 2  

INSTRUCTOR: Ann Kelly - Lecture & Lab  
OFFICE HOURS: As Posted on Room 1020  

I. INTRODUCTION  

A. An introduction to the theory and laboratory techniques in molecular biology with an emphasis on molecular diagnostics, including DNA replication, transcription, gene expression and regulation, recombinant DNA and RNA techniques. Topics include hybridization techniques and amplification techniques such as QPCR.  

B. The courses are designed to meet basic curriculum requirements for the Central Texas College Medical Laboratory Technician Program.  

C. This course is occupationally related and provided didactic and practical knowledge required for entrance into the clinical portions of the Medical Laboratory Technology Program.  

D. Prerequisite(s): None  

II. LEARNING OUTCOMES  

Upon successful completion of the courses, Molecular Diagnostics, the student will be able to:  

A. Identify the important parameters in the design of a laboratory to conduct the most commonly-used molecular diagnostics protocols.  

B. Identify the important parameters in the design of a quality system for molecular analyses.  

C. Become proficient with the techniques required in order to perform the most commonly-used molecular diagnostics protocols.  

D. Identify the important parameters in the design of a molecular diagnostic test.  

E. Identify the components of a well-controlled diagnostic test.  

F. Use critical thinking skills to trouble shoot problems as they occur and determine possible causes.  

G. Utilize appropriate safety equipment and procedures according to established laboratory protocol and regulatory compliance.  

H. Exhibit the professional and ethical attributes required by the medical laboratory technician.  

I. Perform quality control (QC) procedures according to established protocol and evaluate the results.
J. Relate the clinical significance of laboratory procedures to the appropriate
disease process. Correlate values with given diseases states, diagnosis, and
treatment.

K. At the conclusion of this lecture series, the student will have achieved the
following: Achievement will be met when a minimum score of 75 percent is
earned on the written examination covering the material.

III. INSTRUCTIONAL MATERIALS

The instructional materials identified for his course are viewable
through www.ctcd.edu/books

IV. COURSE REQUIREMENTS

A. To receive transferable credits for this course, you must earn a grade of 2.5 or
better.

B. Class attendance is mandatory. A student who is late for 15 minutes or more will
be marked absent. A student who is late for less than 15 minutes late will be
marked tardy. 2 tardy will count as an absence. 3 absences result in loss of a letter
grade for the course. 4 absences will disqualify a student from the MLT program
and the student will be required to meet with the program director for
readmission.

C. Students with a grade of 2.4 or less should make an appointment with the
instructor to discuss the reason for low performance. Any material not understood
by the student can be discussed with the instructor privately during office hours.
Office hours are posted; please try to schedule an appointment at your
convenience.

D. Lecture examinations will be taken from class notes, assigned pages in your text,
and any additional information such as computer assignments or videos.

E. Laboratory examinations will be taken from a combination of lecture and any
laboratory information covered in any format. Often theory of procedures is
required to perform the procedure and evaluate your results.

V. EXAMINATIONS

A. Five lecture, three laboratory examinations, and laboratory assessment will be
given. A comprehensive final examination will be given.

B. Makeup examinations will not be given. If you must miss an exam, you can use
your final exam grade to replace your missed exam grade. Any additional missed
exams would result in a “0” and cannot be made up.
VI. SEMESTER GRADE COMPUTATION

<table>
<thead>
<tr>
<th>*Lecture Examinations</th>
<th>Point Value</th>
<th>*Laboratory Examinations</th>
<th>Point Value</th>
</tr>
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<tbody>
<tr>
<td>Lecture 1</td>
<td>100</td>
<td>Laboratory 1</td>
<td>100</td>
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<td>Lecture 2</td>
<td>100</td>
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<tr>
<td>Lecture 3</td>
<td>100</td>
<td>Laboratory 3</td>
<td>100</td>
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<tr>
<td>Lecture 4</td>
<td>100</td>
<td>Laboratory Assessment</td>
<td>100(50% lab, 50% professionalsim)</td>
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<tr>
<td>Lecture 5</td>
<td>100</td>
<td>Total Lab Points</td>
<td>400</td>
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<tr>
<td></td>
<td></td>
<td>Possible</td>
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Homework/Quizes 50

Final Examination 200

Total Lecture/Lab/Final Points Possible 1150

<table>
<thead>
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<th>Number of Points</th>
<th>Grade</th>
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<tbody>
<tr>
<td>1035-1150</td>
<td>A</td>
</tr>
<tr>
<td>920-1034</td>
<td>B</td>
</tr>
<tr>
<td>862-919</td>
<td>C</td>
</tr>
<tr>
<td>690-861</td>
<td>D</td>
</tr>
<tr>
<td>689 – Below</td>
<td>F</td>
</tr>
</tbody>
</table>

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.

*Seven clean 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.

**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.

**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 class 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 withdrawal form must be signed by the student. 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 as follows:

<table>
<thead>
<tr>
<th>Session Length</th>
<th>Deadline for Withdrawal</th>
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<tbody>
<tr>
<td>10-week session</td>
<td>Friday of the 7th week</td>
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<tr>
<td>8-week session</td>
<td>Friday of the 6th week</td>
</tr>
<tr>
<td>5-week session</td>
<td>Friday of the 3rd week</td>
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</table>

The equivalent date (75% of the semester) will be used for other sessions of other lengths. The specific last day to withdrawal 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 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” for Incomplete 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:** Student cellular phones and beepers will be turned off while the student is in the classroom or laboratory. Students choosing to disregard this policy will be asked to leave and will be recorded as absent. If a cell phone rings or is used during testing, the test will be taken and a grade of zero will be given.

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 or final decision in course requirements.

G. **Civility:** The collegiate expectation is that students will conduct themselves with civility at all times in classrooms. Minimal civility includes:
   a. Being in class on time
   b. Staying in class for the entire class period
   c. Leaving early occurs only after informing the teacher, prior to class, of an unavoidable conflict requiring your early departure (if possible, position yourself close to the door for a minimum disruption of the class)
   d. Avoiding such uncivil conduct as talking, sleeping, reading papers/magazines, or working on some other class homework assignment
   e. Using socially acceptable language in classroom discussions

   Failure to do so can result in disciplinary action up to and including expulsion.

VIII. COURSE OUTLINE

A. **Section One: Fundamentals of Nucleic Acid Biochemistry**

Chapter 1: DNA, 1

1. **Learning Outcomes:** Upon completion of this lesson, the student will be able to:
   a. Diagram the structure of nitrogen base, nucleosides, and nucleotides.
   b. Describe the nucleic acid structure as a polymer of nucleotides.
   c. Demonstrate how deoxyribonucleic acid (DNA) is replicated such that the order or sequence of nucleotides is maintained (semi-conservative replication)
d. Explain the reaction catalyzed by DNA polymerase that results in the phosphodiester backbone of the DNA chain.

e. Note how the replicative process results in the antiparallel nature of complementary strands of DNA.

f. List the enzymes that modify DNA, and state their specific functions.

g. Illustrate three ways in which DNA can be transferred between bacterial cells.

h. Define recombination, and sketch how new combinations of genes are generated in sexual and asexual reproduction.

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 microscope preserved slides, 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.

**Chapter 2: RNA, 28**

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

a. Compare and contrast the structure of RNA with that of DNA.

b. List and compare the different types of RNA.

c. Describe the cellular processing of messenger RNA.

d. List and compare the different types of RNA.

e. Describe the cellular processing of messenger RNA.

f. List several types of RNA polymerases, their substrates, and products.

g. Recognize the reactions catalyzed by ribonucleases and RNA helicases and their roles in RNA metabolism.

h. Describe how ribonucleotides are polymerized into RNA (transcription) and the relation of the sequence of the RNA transcript to the DNA sequence of its gene.

i. Describe gene regulation using the Lac operon as an example.

j. Define epigenetics and list examples of epigenetic phenomena.

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 microscope preserved slides, 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.
Chapter 3: Proteins and the Genetic Code, 52

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

   a. Describe the structure and chemical nature of the 20 amino acids.
   b. Show how the chemistry of the amino acids affects the chemical characteristics and functions of proteins.
   c. Define primary, secondary, tertiary, and quaternary structure of protein organization.
   d. Give the definition of a gene.
   e. Recount how the genetic code was solved.
   f. Describe how amino acids are polymerized into proteins, using RNA as a guide (translation).

B. **Section Two: Common Techniques in Molecular Biology**

Chapter 4: Nucleic Acid Extraction Methods, 69

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

   a. Compare and contrast organic, inorganic, and solid-phase approaches for isolating cellular and mitochondrial DNA.
   b. Note the chemical conditions in which DNA precipitates and goes into solution.
   c. Compare and contrast organic and solid-phase approaches for isolating total RNA.
   d. Distinguish between the isolation of total RNA with that of messenger RNA.
   e. Describe the gel-based, spectrophotometric, and fluorometric methods used to determine the quantity and quality of DNA and RNA preparations.
   f. Calculate the concentration and yield of DNA and RNA from a given nucleic acid preparation.

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 microscope preserved slides, 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.
Chapter 5: Resolution and Detection of Nucleic Acids, 87

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

   a. Explain the principle and performance of electrophoresis as it applies to nucleic acids.
   b. Compare and contrast the agarose and polyacrylamide gel polymers commonly used to resolve nucleic acids, and state the utility of each polymer.
   c. Explain the principle and performance of capillary electrophoresis as it is applied to nucleic acid separation.
   d. Give an overview of buffers and buffer additives used in electrophoretic separation, including the constituents, purpose, and importance.
   e. Describe the general types of equipment used for electrophoresis and how samples are introduced for electrophoretic separation.
   f. Compare and contrast pulse field gel electrophoresis and regular electrophoresis techniques with regard to method and applications.
   g. Compare and contrast detection systems used in nucleic acid applications.

Chapter 6: Analysis and Characterization of Nucleic Acids and Proteins, 102

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

   a. Describe how restriction enzyme sites are mapped on DNA.
   b. Construct a restriction enzyme map of a DNA plasmid or fragment.
   c. Diagram the Southern blot procedure.
   d. Explain depurination and denaturation of resolved DNA.
   e. Describe the procedure involved in blotting (transfer) DN from a gel to a membrane.
   f. Discuss the purpose and structure of probes that are used for blotting procedures.
   g. Define hybridization, stringency, and melting temperature.
   h. Calculate the melting temperature of a given sequence of dsDNA.
   i. Compare and contrast radioactive and nonradioactive DNA detection methods.

Chapter 7: Nucleic Acid Amplification, 130

1. **Learning Outcomes:** Upon completion of this lesson, the student will be able to:
a. Compare and contrast among the following in vitro assays for amplifying nucleic acids: polymerase chain reaction, (PCR), branched DNA amplification, ligase chain reaction, transcription-mediated amplification, and Qβ replicase with regard to type of target nucleic acid, principle, major elements of the procedure, type of amplicon produced, major enzyme(s) employed, and applications.

b. Describe examples of modifications that have been developed for PCR.

c. Discuss how amplicons are detected for each of the amplification methods.

d. Design forward and reverse primers for a PCR, given the target sequence.

e. Differentiate between target amplification and signal amplification.

Chapter 8: Chromosomal Structure and Chromosomal Mutations, 168

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

   a. Define mutations and polymorphisms.
   b. Distinguish the three types of DNA mutations: genome, chromosomal, and gene.
   c. Describe chromosomal compaction and the proteins involved in chromatin structure.
   d. Diagram a human chromosome, and label the centromere, q arm, p arm, and telomere.
   e. Illustrate the different types of structural mutations that occur in chromosomes.
   f. State the karyotype of a normal male and female.
   g. Identify the chromosomal abnormality in a given karyotype.
   h. Compare and contrast interphase and metaphase FISH analyses.
   i. Distinguish between the effects of balanced and unbalanced translocations on an individual and the individual’s offspring.

Chapter 9: Gene Mutations, 187

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

   a. Compare phenotypic consequences of different types of point mutations.
   b. Distinguish detection of known mutations from scanning for unknown mutations.
   c. Discuss methods used to detect point mutations.
d. Determine which detection methods are appropriate for screening of new mutations or detection of previously identified mutations.

e. Describe gene mutation nomenclature for expressing sequence changes at the DNA, RNA, and protein levels.

Chapter 10: DNA Sequencing, 222

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

   a. Compare and contrast the chemical (Maxam/Gilbert) and the chain termination (Sanger) sequencing methods.
   
b. List the components and the molecular reactions that occur in chain termination sequencing.
   
c. Discuss the advantages of dye primer and dye terminator sequencing.
   
d. Derive a text DNA sequence from raw sequencing data.
   
e. Describe examples of alternative sequencing methods, such as bisulfite sequencing and pyrosequencing.
   
f. Define bioinformatics, and describe electronic systems for the communication and application of sequence information.
   
g. Recount the events of the Human Genome Project.

C. Section Three: Techniques in the Clinical Laboratory, 249

Chapter 11: DNA Polymorphisms and Human Identification, 249

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

   a. Compare and contrast different types of polymorphisms.
   
b. Define restriction fragment length polymorphisms and discuss how they are used in genetic mapping, parentage testing, and human identification.
   
c. Describe short tandem repeat structure and nomenclature.
   
d. Describe gender identification using the amelogenin locus.
   
e. Explain matching probabilities and the contribution of allele frequencies to the certainty of matching.
   
f. Describe the use of Y-STR in forensic and lineage studies.
   
g. Give examples of the use of STR for bone marrow engraftment monitoring.
   
h. Show how STR may be used for quality assurance of histological sections.

Chapter 12: Detection and Identification of Microorganisms, 288
1. **Learning Outcomes**: Upon completion of this lesson, the student will be able to:

   a. Name the organisms that are common targets for molecular-based laboratory tests.
   b. Identify advantages and disadvantages of using molecular-based methods as compared with traditional culture-based methods in the detection and identification of microorganisms.
   c. Differentiate between organisms for which commercially available nucleic acid amplification tests exist and those for which “home-brew” polymerase chain reaction (PCR) is used.
   d. List the genes involved in the emergence of antimicrobial resistance that can be detected by nucleic acid amplification methods.
   e. Compare and contrast the molecular methods that are used to type bacterial strains in epidemiological investigations.
   f. Explain the value of controls, in particular amplification controls, in ensuring the reliability of PCR results.

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 microscope preserved slides, 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.

**Chapter 13: Molecular Detection of Inherited Diseases, 342**

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

   a. Describe Mendelian patterns of inheritance as exhibited by family pedigrees.
   b. Give examples of laboratory methods designed to detect single-gene disorders.
   c. Discuss non-Mendelian inheritance, and give examples of these types of inheritance, such a mitochondrial disorders and trinucleotide repeat expansion diseases.
   d. Show how genomic imprinting can affect disease phenotype.

**Chapter 14: Molecular Oncology, 369**

1. **Learning Outcomes**: Upon completion of this lesson, the student will be able to:
a. Identify checkpoints in the cell division cycle that are critical for regulated cell proliferation.
b. List molecular targets that are useful for diagnosis and monitoring of solid tumors.
c. Explain how microsatellite instability is detected.
d. Describe loss of heterozygosity and its detection.
e. Contrast cell-specific and tumor-specific molecular targets.
f. Show how clonality is detected using antibody and T-cell receptor gene rearrangements.
g. Describe translocations associated with hematological malignancies that can be used for molecular testing.
h. Interpret data obtained from the molecular analysis of patients’ cells, and determine if a tumor population is present.

Chapter 15: DNA-Based Tissue Typing, 419

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

   a. Describe the structure and function of the major histocompatibility (MHC) locus.
   b. List the human leukocyte antigens (HLAs) that are encoded by the MHC locus, and explain their role in tissue engraftment and rejection.
   c. Compare and contrast the levels of typing resolution that are achieved by different laboratory methods.
   d. Describe the laboratory methods used to identify HLAs by serology testing.
   e. Describe the DNA-based testing methods used for the identification of HLAs.
   f. Explain how combining different test methods to identify HLAs increases resolution and resolve ambiguities.
   g. Discuss factors, in addition to the HLAs, that affect engraftment.
   h. Relate the use of HLA typing for confirming disease diagnosis and predisposition.

Chapter 16: Quality Assurance & Quality Control in the Molecular Laboratory, 447

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

   a. Describe proper specimen accession for molecular testing.
   b. Describe the optimal conditions for the holding and storage of various specimens, including nucleic acids.
c. Explain the basic components of molecular test performance, including quality assurance and controls.

d. Discuss instrument maintenance, repair, and calibration, particularly for instruments used in molecular analysis.

e. Describe recommendations for the preparation and use of reagents in the molecular laboratory.

f. Explain documentation and reporting of results, including gene sequencing results.