BIOL 1D: INTRODUCTION TO MOLECULAR GENETICS

Foothill College Course Outline of Record

Heading	Value
Effective Term:	Summer 2023
Units:	4
Hours:	4 lecture per week (48 total per quarter)
Prerequisite:	BIOL 1A.
Advisory:	Students taking the biology majors' sequence (BIOL 1A, 1B, 1C, 1D) are strongly advised to take the sequence in order and in its entirety.
Degree & Credit Status:	Degree-Applicable Credit Course
Foothill GE:	Non-GE
Transferable:	CSU/UC
Grade Type:	Letter Grade (Request for Pass/No Pass)
Repeatability:	Not Repeatable

Student Learning Outcomes

- Explain the relationship between structure and function as observed in key enzymes used in DNA replication, transcription and translation.
- Demonstrate an understanding of how experimental evidence is used to draw conclusions regarding the structure and function of important genetic molecules.
- Demonstrate the ability to examine current scientific literature, and draw conclusions based on published current research
- Demonstrate the ability to understand the link between DNA structure, and it's function as the molecule of heredity, and evolutionary change

Description

Intended for students wishing to transfer to a four year school with a major in molecular biology, biochemistry, or molecular genetics. An introduction to molecular genetics with an emphasis in genome organization, DNA replication and repair, mutation, transcription, translation, and the regulation of gene expression.

Course Objectives

The student will be able to:

1. Explain the key experiments that led to the discovery of DNA structure and function
2. Describe the role of genes within cells
3. Discuss the evolution of the three domains: Archaea, Bacteria, and Eukarya
4. Compare and contrast genome organization of prokaryotes and eukaryotes
5. Describe the steps of DNA replication and explain the molecular basis for DNA replication's remarkable fidelity
6. Compare and contrast prokaryotic and eukaryotic DNA polymerase and DNA replication
7. Describe the various mechanisms that cause DNA damage and mutation
8. Describe DNA repair systems, comparing and contrasting prokaryotic and eukaryotic systems
9. Explain the mechanisms and importance of recombination, repair, and transposition
10. Describe transcription in prokaryotes
11. Describe transcription in eukaryotes
12. Compare and contrast transcription and RNA processing in prokaryotes and eukaryotes
13. Describe the various types of post-transcriptional processing
14. Describe protein translation
15. Compare and contrast control of gene expression in prokaryotes and eukaryotes
16. Describe basic methods in molecular genetics and discuss their applications
17. Describe some of the contributions made by eminent scientists, including women and minorities, to the fields of molecular and cell biology
18. Critically read and discuss original scientific papers
19. Explore and discuss scientific questions for which there is as yet no single, generally accepted answer

Course Content

1. Brief history/Key experiments
    a. Experiments that identified DNA as the molecule of inheritance
    b. Discovery of the structure of DNA
    c. Experiments that led to our initial understanding of transcription
    d. Experiments that led to our initial understanding of translation
    e. Elucidation of the genetic code
2. Molecular nature of genes
    a. Storing and using genetic information
    b. Replication
    c. Mutation
    d. Recombination
3. Evolution of Archaea, Bacteria, and Eukarya
    a. Molecular evolution
    b. Conserved sequences
    c. Molecular clocks
        i. rRNA
        ii. Histone genes
        iii. Subunits of DNA polymerase
        iv. Subunits of RNA polymerase
4. Genome organization
    a. Prokaryotic
    b. Eukaryotic
        i. Nucleosomes and chromatin packaging into chromosomes
        ii. Introns and exons
        iii. Nonrepetitive DNA, moderately repetitive DNA, and highly repetitive DNA
        iv. Gene clusters
        v. Organelle DNA: mitochondria and chloroplast
5. DNA replication
    a. Replicons
    b. DNA structure and the primer:template junction

   c. Enzymes
      i. Helicase and helicase loader
      ii. Single stranded binding proteins
      iii. Topoisomerases
      iv. Primase
      v. RNAse H
      vi. Ligase
      vii. Histone chaperones
      viii. Sliding clamp and sliding clamp loaders
   d. DNA polymerase
      i. Three dimensional structure - palm, finger, and thumb domains
      ii. Processivity
      iii. Fidelity of replication (molecular basis of proof-reading function)
      iv. Holoenzyme - catalytic core, tao, sliding clamp, clamp loader
   e. Initiation
   f. Elongation - trombone model
   g. Termination
   h. Regulation
6. Prokaryotic and Eukaryotic replication
   a. Origins of replication - replicators and initiators
   b. DNA polymerases - similarities and differences
   c. Regulation - similarities and differences
7. Mutation and DNA damage
   a. Types of mutation
   b. Estimating mutation rates
   c. Base pair modifications
      i. Tautomers
      ii. Alkylation
      iii. Deamination
      iv. Depurination
      v. Oxidation
      vi. Intercalating agents
      vii. Base analogs
      viii. UV radiation and dimers
      ix. Ionizing radiation and chromosome breaks
8. DNA repair systems
   a. Direct repair
   b. Mismatch repair
   c. Base excision repair
   d. Nucleotide excision repair
   e. Recombination
   f. Nonhomologous end joining
   g. Translesion synthesis
9. Recombination and transposition
   a. Homologous recombination
   b. RecA protein
   c. Holliday junctions
   d. Meiotic recombination
   e. Transposition
      i. Transposons
      ii. Retrotransposons
      iii. Transposable elements in different genomes
10. Transcription in prokaryotes
   a. Transcription overview and transcription bubbles
   b. Prokaryotic promoters
   c. Prokaryotic RNA polymerase
   d. Initiation, elongation, and termination
   e. Regulation of transcription
11. Transcription in Eukaryotes
   a. Eukaryotic RNA polymerases
   b. Transcription factors
   c. TATA box binding protein
   d. Eukaryotic promoters
      i. Class I
      ii. Class III
      iii. Class II
   e. CTD tail and mediator complex
   f. Regulation of transcription
12. Prokaryotic and Eukaryotic transcription
   a. RNA polymerases
   b. RNA processing
13. Post-transcriptional processing
   a. 5' cap
   b. Poly A tail
   c. Splicing
      i. Spliceosome
      ii. Splicing reactions
      iii. Splicing errors
      iv. Alternative splicing
14. Translation
   a. Ribosomes, messenger RNA, and transfer RNA
   b. The genetic code
   c. Initiation
   d. Elongation
   e. Termination
   f. Protein structure and localization
15. Regulation of gene expression
   a. Negative and positive control
   b. Operons
   c. Eukaryotic regulation
      i. Chromatin modification
      ii. Control elements and transcription factors
      iii. Enhancers and activators
      iv. Post-transcriptional regulation
   d. Nondcoding RNAs
      i. MicroRNAs
      ii. Small interfering RNAs
      iii. Chromatin remodeling and silencing
16. Laboratory methods (description and discussion only)
   a. Tools for recombinant DNA technology
      i. Vectors
      ii. Restriction enzymes
      iii. Ligase
   b. Cloning
   c. Selected applications

i. Centrifugation and Svedberg units
ii. Melting curves and C0t curves
iii. Electrophoresis
iv. DNA fingerprints
v. DNA footprints

Lab Content

Not applicable.

Special Facilities and/or Equipment

1. Multimedia lecture room and student access to computers
2. Students need internet access

Method(s) of Evaluation

Methods of Evaluation may include but are not limited to the following:

One or more objective written midterm exams
Frequent quizzes that include both short answer and objective questions

In-class activities involving evaluation of current relevant scientific articles
Written objective comprehensive final exam

Method(s) of Instruction

Methods of Instruction may include but are not limited to the following:

Lecture presentations
Classroom discussions on relevant scientific articles
Guided group/collaborative activities on required readings and relevant scientific articles

Representative Text(s) and Other Materials

Urry, L.A., et al.. Campbell Biology, 12th ed.. 2021.

Supplemental text:
Krebs, Jocelyn E., Elliott S. Goldstein, and Stephen T. Kilpatrick. Lewin's Genes XII. 2018.

Types and/or Examples of Required Reading, Writing, and Outside of Class Assignments

1. Reading assignments:
   a. Weekly reading assignments from primary text and assigned relevant scientific articles
   b. Supplemental reading assignments from web sources relevant to course material
2. Writing assignments:
   a. Weekly assignment to answer objective set questions and define vocabulary
   b. Participation in class discussions of scientific articles
3. Computation:
   a. Construct and interpret graphs
   b. Interpret melting curves and C0t curves
   c. Interpret DNA footprint and DNA fingerprint data
   d. Calculate and interpret recombination frequencies
   e. Interpret laboratory data from relevant key experiments in the field of molecular genetics

Discipline(s)

Biological Sciences