

# CAPS Molecular Medicine and Bioengineering

## UNIT 1: Molecular Biology and Genetics:

### ESSENTIAL QUESTION

**How do molecular mechanisms govern the inheritance of traits and the regulation of gene expression?**

### BIG IDEAS

- **Central Dogma of Molecular Biology:** processes of DNA replication, transcription, and translation, understanding how genetic information is encoded in DNA, transcribed into RNA, and translated into proteins.
- **Molecular Mechanisms of Gene Regulation:** molecular mechanisms that control gene expression and regulation.
- **Genetic Variation and Inheritance:** principles of genetics and the inheritance of traits from one generation to the next.

### GUIDING QUESTIONS

- **Content**

- What are the molecular mechanisms underlying DNA replication, transcription, and translation, and how do they contribute to the flow of genetic information within cells?
- How do genetic mutations and variations arise, and what are their implications for phenotypic diversity, inheritance patterns, and disease susceptibility?
- What are the molecular mechanisms of gene regulation, and how do they control gene expression in response to internal and external signals?

- **Process**

- How can students critically analyze scientific literature and research findings in molecular biology and genetics, and effectively communicate their findings to diverse audiences?
- How can students apply computational tools and bioinformatics techniques to analyze biological data and solve molecular biology and genetics research questions?

- **Reflective**
  - What are ethical considerations in the study of molecular medicine and research, and how do these considerations shape the approach to scientific inquiry and decision-making in the field?

## FOCUS STANDARDS

Biotechnical Engineering      Course No. 21014

BENCHMARK 4:      UNDERSTANDING PRINCIPLES OF BIOINFORMATICS

## KEY LEARNING EXPERIENCES

- **DNA Extraction Experiment:** Students extract DNA from a plant or animal sample using common laboratory techniques, such as cell lysis, precipitation, and centrifugation. This hands-on experience provides insight into the physical properties of DNA and introduces students to basic laboratory procedures.
- **Mendelian Genetics Simulation:** Students use Punnett squares and pedigrees to explore Mendelian inheritance patterns for traits such as eye color, blood type, or genetic disorders. This activity reinforces the principles of dominant and recessive alleles, genotype-phenotype relationships, and probability in genetics.
- **Gene Expression Analysis:** Students investigate gene expression by analyzing microarray or RNA sequencing data to identify patterns of gene regulation in different cell types or under specific conditions. This activity introduces students to molecular techniques used in gene expression profiling and highlights the dynamic nature of gene regulation.
- **PCR Amplification and Gel Electrophoresis:** Students perform polymerase chain reaction (PCR) to amplify a specific DNA fragment and analyze the results using gel electrophoresis. This hands-on activity illustrates the principles of DNA amplification, fragment size determination, and molecular marker analysis.
- **Genetic Engineering Debate:** Students engage in a debate or discussion about the ethical implications of genetic engineering technologies, such as CRISPR-Cas9 gene editing or genetically modified organisms (GMOs). This activity encourages critical thinking about the potential benefits and risks of genetic manipulation in agriculture, medicine, and biotechnology.
- **Genetic Disorders Research Project:** Students research a genetic disorder of their choice,

investigating its molecular basis, inheritance pattern, symptoms, and potential treatments. This project-based learning experience allows students to apply their knowledge of molecular biology and genetics to real-world health issues.

- **DNA Sequencing Analysis:** Students explore DNA sequencing data from the Human Genome Project or other genomic studies to identify genes, mutations, and genetic variations associated with human traits and diseases. This activity introduces students to bioinformatics tools and databases used in genomics research.
- **Gene Regulation Experiment:** Students investigate gene regulation mechanisms by designing and conducting experiments to study the effect of regulatory factors on gene expression in model organisms such as bacteria, yeast, or fruit flies. This inquiry-based activity enhances students' understanding of transcriptional and post-transcriptional control of gene expression.
- **Ethical Dilemmas in Genetic Testing:** Students explore ethical dilemmas related to genetic testing and personalized medicine, considering issues such as privacy, informed consent, genetic discrimination, and social justice. This activity fosters reflection on the societal implications of advances in molecular biology and genetics.

# CAPS Molecular Medicine and Bioengineering

## UNIT 2: Tools and Technology in Bioengineering

### ESSENTIAL QUESTION

**How do advancements in tools and technology empower bioengineers to innovate and address complex challenges in molecular medicine and biotech.**

### BIG IDEAS

- **Innovative Tools and Instrumentation:** learn how tools enable bioengineers to visualize biological structures, analyze molecular interactions, and simulate complex biological processes

### GUIDING QUESTIONS

- **Content**

- What are the key molecular biology techniques used to study DNA, RNA, and proteins, and how do they contribute to our understanding of biological processes?
- How do genomic and bioinformatics tools enable the analysis and interpretation of large-scale biological data sets?
- What are the emerging technologies and advancements in molecular biology research, and how do they impact our ability to study and manipulate biological systems?

- **Process**

- How can students develop proficiency in using molecular biology techniques and instrumentation through hands-on laboratory experiences?
- How can students effectively integrate computational and bioinformatics tools into molecular biology research and analysis?

- **Reflective**

- How do experiences with hands-on laboratory work in molecular biology enhance student understanding of the principles and applications of molecular biology techniques?

## FOCUS STANDARDS

Biotechnical Engineering      Course No. 21014

BENCHMARK 1: UNDERSTANDS BIOTECHNOLOGY ENGINEERING PROCEDURES

## KEY LEARNING EXPERIENCES

- **Microscopy Workshop:** Conduct a microscopy workshop where students learn to operate light microscopes, electron microscopes, and confocal microscopes. They observe biological samples at different magnifications and discuss the advantages and limitations of each imaging technique.
- **Biomechanics Experiment:** Design and conduct a biomechanics experiment to investigate the mechanical properties of biological tissues or engineered biomaterials. Students use force sensors, strain gauges, and other instrumentation to analyze the behavior of materials under different loading conditions.
- **Bioprinting Demonstration:** Organize a demonstration of 3D bioprinting technology, where students learn about the process of layer-by-layer deposition of living cells and biomaterials to create tissue constructs. Discuss the potential applications of bioprinting in tissue engineering and regenerative medicine.
- **Genetic Engineering Simulation:** Use online simulations or virtual labs to explore genetic engineering techniques such as recombinant DNA technology, gene editing, and gene therapy. Students manipulate DNA sequences, design gene constructs, and analyze the consequences of genetic modifications.
- **Bioinformatics Analysis:** Introduce students to bioinformatics tools and databases for analyzing nucleotide and protein sequences, predicting gene function, and identifying genetic variations. Students perform sequence alignment, gene annotation, and phylogenetic analysis using bioinformatics software.
- **Biomedical Imaging Project:** Assign students to research and present a project on a specific biomedical imaging modality, such as MRI, CT, PET, or ultrasound. They investigate the principles of image formation, contrast mechanisms, clinical applications, and technological advancements in biomedical imaging.

# CAPS Molecular Medicine and Bioengineering

## UNIT 3: Research Methods and Experimental Design

### ESSENTIAL QUESTION

How can researchers effectively design and implement experiments in molecular biology to generate reliable data and draw meaningful conclusions?

### BIG IDEAS

- **Principles of Experimental Design:** design experiments that minimize bias, maximize statistical power, and ensure the reliability and reproducibility of results.
- **Techniques and Tools for Molecular Biology Research:** hands-on experience with laboratory protocols and instrumentation.
- **Data Analysis and Interpretation:** interpret experimental results, draw meaningful conclusions, and communicate findings effectively.

### GUIDING QUESTIONS

- **Content**

- How do researchers formulate testable hypotheses and design experiments to address specific research questions?
- What are the key considerations in sample preparation, data collection, and data analysis?
- How do researchers ensure the reliability, reproducibility, and ethical conduct of experiments?

- **Process**

- How can students effectively analyze and interpret experimental data generated from biological experiments?
- How can students evaluate the reliability, reproducibility, and validity of experimental

findings in biological research?

- **Reflective**
  - How do experiences with experimental design and data analysis in biology influenced student approach to problem-solving and scientific inquiry?

## FOCUS STANDARDS

Biotechnical Engineering      Course No. 21014

## KEY LEARNING EXPERIENCES

- **Case Study Analysis:** Present students with real-world case studies of biological research projects. Students analyze experimental design, data interpretation, and conclusions drawn by researchers. Encourage critical thinking and discussion about the strengths and limitations of different approaches.
- **Field Trip to Research Institution:** Organize a field trip to a local research institution or laboratory facility. Students observe scientists at work, learn about different research methodologies, and engage in discussions with researchers about their projects and experimental techniques.
- **Experimental Protocol Investigation:** Provide students with published experimental protocols from scientific journals or online databases. Students evaluate the validity and reliability of the protocols, identify potential sources of bias or error, and propose modifications for improvement.
- **Designing Controlled Experiments:** Task students with designing controlled experiments to test specific hypotheses in biology. Students must identify independent and dependent variables, control variables, and experimental procedures to ensure valid and reliable results.
- **Data Analysis Workshop:** Conduct a workshop on data analysis techniques commonly used in biological research, such as statistical analysis, graphical representation, and hypothesis testing. Students analyze datasets, interpret results, and draw conclusions based on statistical evidence.

- Peer Review Simulation: Divide students into small groups and assign each group a research proposal or manuscript to review. Students critically evaluate the experimental design, methodology, and interpretation of results, providing constructive feedback to their peers.
- Experimental Demonstration: Perform a live demonstration of a biological experiment in the classroom or laboratory. Students observe the experimental procedure, data collection techniques, and safety protocols, gaining firsthand experience in experimental design and execution.
- Research Proposal Development: Guide students through the process of developing a research proposal for a biology-related project. Students outline research questions, justify the significance of the study, describe experimental methods, and anticipate potential outcomes and implications.
- Independent Research Project: Allow students to conduct independent research projects under supervision, focusing on a topic of interest within the field of biology. Students develop research questions, design experiments, collect and analyze data, and present their findings to the class.



# CAPS Molecular Medicine and Bioengineering

## UNIT 4: Professional Skills Development through Career Exploration

### ESSENTIAL QUESTION

**What are key professional skills needed to prepare future professionals in a career they are exploring?**

### BIG IDEAS

- **Holistic Skill Development:** Prioritize a diverse set of skills beyond technical expertise and including an entrepreneurial mindset.
- **Experiential Learning:** Hands-on experiences, internships, apprenticeships, and project-based learning opportunities provide career exploration opportunities.
- **Mentorship and Networking:** Facilitate mentorship programs and networking events to connect young professionals with experienced individuals in their field.

### GUIDING QUESTIONS

#### Content

- What are effective communication strategies and tools used in specific professions?
- Why are critical thinking, problem-solving and adaptability important?
- How can professional skill development bridge the gap between theoretical knowledge and practical application and enhance understanding of future career opportunities?
- How can mentors offer guidance, advice, and valuable insight most effectively?

#### Process

- How can students learn about their current strengths and opportunities for development?
- How can experiential learning opportunities holistically create opportunities to practice professional skills?

#### Reflective

- How does professional skill development foster lifelong learning and development?
- How can I take these skills and transfer them to post secondary and future careers?

## FOCUS STANDARDS

### CTE Professionalism Standards

- 1.1 Act as a responsible and contributing citizen and employee.
- 1.2 Apply appropriate academic and technical skills.
- 1.4 Communicate clearly, effectively and with reason.
- 1.5 Consider the environmental, social and economic impacts of decisions.
- 1.6 Demonstrate creativity and innovation.
- 1.7 Employ valid and reliable research strategies.
- 1.8 Utilize critical thinking to make sense of problems and persevere in solving them.
- 1.9 Model integrity, ethical leadership and effective management.
- 1.10 Plan education and career path aligned to personal goals.
- 1.11 Use technology to enhance productivity.
- 1.12 Work productively in teams while using cultural/global competence.

### CAPS Professional Profile

**Skills:** Communication, Collaboration, Time Management, Conflict Resolution, Critical Thinking, Interpersonal Relationship, Creativity, Leadership

**Attributes:** Adaptability, Curiosity, Self-awareness, Drive, Confidence, Enthusiasm, Resourcefulness, Integrity, Empathy

**Actions:** Networking, Interviewing, Goal Setting, Professional Manner

## KEY LEARNING EXPERIENCES

- Experiential learning opportunities such as project presentations, apprenticeships, client projects and internships.
- Interview opportunities with community members.
- Mentorship events where students are connected to professionals in their chosen careers.
- Development of digital portfolios and resume building that are industry standard and can grow with students.