

CAPS Bioscience Research

UNIT 1: 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

- Standard 1: Understand and apply principles of experimental design, including hypothesis formulation, variable manipulation, control group selection, and data collection methods.
- Standard 2: Demonstrate proficiency in statistical analysis techniques commonly used in biological research, such as t-tests, ANOVA, regression analysis, and chi-square tests.
- Standard 3: Critically evaluate scientific literature and research methodologies, identifying strengths, limitations, and biases in experimental design and data interpretation.
- Standard 4: Develop and implement protocols for ethical research conduct, including obtaining informed consent, ensuring animal welfare, and adhering to institutional guidelines and regulations.

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.

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UNIT 2: Research Applications and Special Topics

ESSENTIAL QUESTION

How can we critically evaluate current research literature, identify gaps in knowledge, and propose innovative research questions and methodologies for future investigation in partnership with professional researchers?

BIG IDEAS

- **Interdisciplinary Collaboration with Current Research and Researchers:** importance of collaboration across disciplines to address complex bioscience research questions.
- **Technological Advancements and Innovation:** through partnerships student access and understanding of technological advancements in driving bioscience research forward. Students explore cutting-edge research tools and techniques, such as CRISPR-Cas9 gene editing, next-generation sequencing, imaging technologies, and computational modeling, that enable precise manipulation, observation, and analysis of biological systems.

GUIDING QUESTIONS

Content

- What are the research methodologies and techniques used to investigate biological questions, and how do they enable scientists to gather and analyze data effectively?
- What are the current research trends, challenges, and breakthroughs in bioscience, and how do they impact human health, agriculture, industry, and the environment?

Process

- How can students develop and refine research questions that are scientifically meaningful, testable, and relevant to current bioscience knowledge?
- How can students make a meaningful contribution to partnering research institutions and individuals?
- What are the essential collaborative skills necessary for this contribution?

Reflective

- How can students apply the principles and techniques of bioscience research methodology to address real-world problems or questions of interest in their field of study or future career aspirations?

FOCUS STANDARDS

- Standard 1: Apply advanced research techniques and technologies relevant to specialized areas of bioscience, such as genomics, proteomics, bioinformatics, or molecular imaging.
- Standard 2: Investigate current research topics and emerging trends in bioscience, including interdisciplinary approaches and applications in fields such as personalized medicine, regenerative biology, or environmental biotechnology.
- Standard 3: Design and execute independent research projects, integrating concepts from multiple disciplines and utilizing advanced laboratory techniques and instrumentation.
- Standard 4: Communicate research findings effectively through written reports, oral presentations, and scientific posters, demonstrating clarity, coherence, and adherence to scientific conventions.

KEY LEARNING EXPERIENCES

- Literature Review and Critique: Assign students to conduct a literature review on a specialized topic within bioscience research. They can critically analyze primary research articles, synthesize key findings, and identify gaps in current knowledge.
- Guest Lectures by Researchers: Invite guest speakers, such as academic researchers or industry professionals, to lecture on their specialized areas of expertise within bioscience research. This provides students with insights into cutting-edge research and career pathways in the field.
- Laboratory Techniques Workshops: Conduct hands-on laboratory workshops where students learn advanced bioscience research techniques, such as molecular biology assays, microscopy, chromatography, or bioinformatics analysis.
- Research Proposal Development: Guide students in developing research proposals for their own bioscience research projects. This involves formulating research questions, designing experiments, outlining methodologies, and discussing potential implications and applications of the research.
- Ethical Considerations in Bioscience Research: Engage students in discussions and case studies on ethical considerations in bioscience research, such as responsible conduct of research, human and animal subjects protection, conflicts of interest, and scientific integrity.
- Field Trips to Research Facilities: Organize field trips to research institutions, biotechnology companies, or government agencies involved in bioscience research. Students can tour laboratories, interact with researchers, and learn about ongoing research projects and technologies.
- Data Analysis and Interpretation: Provide students with datasets from real bioscience research studies and guide them in data analysis and interpretation using statistical software and bioinformatics tools. This helps students develop quantitative analysis skills.

and understand how data drives scientific conclusions.

- Scientific Communication Workshops: Conduct workshops on scientific writing, presentation skills, and poster design for disseminating research findings. Students can practice writing research papers, giving oral presentations, and creating visually engaging posters to communicate their research effectively.

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UNIT 3: 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 career opportunities?

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.