### Program-Level Learning Outcomes

**SCIENTIFIC THINKING**
- Explain how scientists use inference and evidence-based reasoning to generate knowledge.
- Describe the iterative nature of science and how new evidence can lead to the revision of scientific knowledge.
- Relate scientific thinking to the natural world.

**INFORMATION LITERACY**
- Locate, interpret, and evaluate scientific information.
- Differentiate between primary and secondary sources.

**QUESTION FORMULATION**
- Pose testable questions and hypotheses to address gaps in knowledge.
- Formulate testable hypotheses and state their predictions.

**STUDY DESIGN**
- Plan, evaluate, and implement scientific investigations.
- Design controlled experiments, including plans for analyzing the data.
- Execute protocols and accurately record measurements and observations.
- Identify methodological problems and suggest how to troubleshoot them.

**DATA INTERPRETATION & EVALUATION**
- Interpreting, evaluating, and drawing conclusions from data in order to make evidence-based arguments about the natural world.
- Analyze data, summarize resulting patterns, and draw appropriate conclusions.
- Describe sources of error and uncertainty in data.
- Make evidence-based arguments using your own and others’ findings.
- Relate conclusions to original hypotheses, consider alternative hypotheses, and suggest future research directions based on findings.

**DOING RESEARCH**
- Apply science process skills to address a research question in a course-based or independent research experience.
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**QUANTITATIVE REASONING**
- **Program-Level Learning Outcomes**
  - Perform basic calculations (e.g., percentages, frequencies, rates, means).
  - Select and apply appropriate equations (e.g., Hardy-Weinberg, Nemtsov, Gibbs free energy) to solve problems.
  - Interpret and manipulate mathematical relationships (e.g., scale, ratios, units) to make quantitative comparisons.
  - Use probability and understanding of biological variability to reason about biological processes and statistical analyses.
  - Use rough estimates informed by biological knowledge to check quantitative work.

- **Course-Level Learning Outcomes**
  - Describe how quantitative reasoning helps biologists understand the natural world.
  - Record, organize, and annotate simple data sets.
  - Create and interpret informative graphs and other data visualizations.
  - Select, carry out, and interpret statistical analyses.
  - Describe how biologists answer research questions using databases, large data sets, and data science tools.
  - Interpret the biological meaning of quantitative results.

**QUANTITATIVE & COMPUTATIONAL DATA ANALYSIS**
- Apply the tools of graphing, statistics, and data science to analyze biological data.
  - Describe why biologists use simplified representations (models) when solving problems and communicating ideas.
  - Describe examples of real-world problems that are too complex to be solved by applying biological approaches alone.
  - Suggest how collaborators in STEM & non-STEM disciplines could contribute to solutions of real-world problems.
  - Be able to explain biological concepts, data, and methods, including their limitations, using language understandable by collaborators in other disciplines.

**MODELING & SIMULATION**
- **Program-Level Learning Outcomes**
  - Describe why biologists use simplified representations (models) when solving problems and communicating ideas.
  - Given two models of the same biological process or system, compare their strengths, limitations, and assumptions.

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  - Describe why biologists use simplified representations (models) when solving problems and communicating ideas.
  - Given two models of the same biological process or system, compare their strengths, limitations, and assumptions.
  - Summarize relationships and trends that can be inferred from a given model or simulation.
  - Use models and simulations to make predictions and refine hypotheses.
  - Identify important components of a system and describe how they influence each other (e.g., positively or negatively).
  - Evaluate conceptual, mathematical, or computational models by comparing their predictions with empirical data.

**INTERDISCIPLINARY NATURE OF SCIENCE**
- **Program-Level Learning Outcomes**
  - Interconnect concepts across other STEM disciplines and multiple fields of biology.
  - Understand the natural world.
  - Be able to explain biological concepts, data, and methods, including their limitations, using language understandable by collaborators in other disciplines.

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### COMMUNICATION & COLLABORATION

**COMMUNICATION**
- Share ideas, data, and findings with others clearly and accurately.
- Use a variety of modes to communicate science (e.g., oral, written, visual).

**COLLABORATION**
- Work effectively with teammates to complete projects.
- Work with teammates to establish and periodically update group plans and expectations (e.g., team goals, project timelines, goals, and multiple fields of biology).
- Elicit, listen to, and incorporate ideas from teammates with different perspectives and backgrounds.

**COLLEGIATE REVIEW**
- Provide and respond to constructive feedback in order to improve individual and team work.
- Evaluate feedback from others and revise work or behavior appropriately.
- Critique others’ work and ideas constructively and respectfully.

**METACOGNITION**
- Reflect on your own learning, performance, and achievements.
- Assess personal progress and contributions to your team and generate a plan to change your behavior as needed.
The BioSkills Guide comprises program- and course-level learning outcomes that elaborate what general biology majors should be able to do by the time they graduate. Building on the six core competencies of Vision and Change, the learning outcomes were developed and then nationally validated using input from over 500 college biology educators with experience in different course levels, biology subdisciplines, and institution types.