### Pre-requisites Summarized from State Curriculum Grades 3 – 8

<table>
<thead>
<tr>
<th>C. Communicating Scientific Information (Grades 6 – 8)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Develop explanations that explicitly link data from investigations conducted, selected readings and, when appropriate, contributions from historical discoveries.</td>
</tr>
<tr>
<td>a. Give examples of how scientific knowledge is subject to modification as new information challenges prevailing theories and as a new theory leads to looking at old observations in a new way.</td>
</tr>
<tr>
<td>b. Criticize the reasoning in arguments in which fact and opinion are intermingled.</td>
</tr>
<tr>
<td>c. Conclusions do not follow logically from the evidence given.</td>
</tr>
<tr>
<td>d. Existence of control groups and the relationship to experimental groups is not made obvious.</td>
</tr>
<tr>
<td>e. Samples are too small, biased, or not representative.</td>
</tr>
<tr>
<td>f. Participate in group discussions on scientific topics by restating or summarizing accurately what others have said, asking for clarification or elaboration, and expressing alternative positions.</td>
</tr>
<tr>
<td>g. Recognize that important contributions to the advancement of science, mathematics, and technology have been made by different kinds of people, in different cultures, at different times.</td>
</tr>
</tbody>
</table>

### Skills & Processes State Curriculum (SC)

#### Expectation 1.1: The student will explain why curiosity, honesty, openness, and skepticism are highly regarded in science.

<table>
<thead>
<tr>
<th>Indicators</th>
</tr>
</thead>
<tbody>
<tr>
<td>Indicator 1: The student will recognize that real problems have more than one solution and decisions to accept one solution over another are made on the basis of many issues.</td>
</tr>
<tr>
<td><strong>Objectives</strong></td>
</tr>
<tr>
<td>- Recognize a life science issue or problem.</td>
</tr>
<tr>
<td>- Explain the reasons for an issue or problem.</td>
</tr>
<tr>
<td>- Describe reasons for controversy related to the issue or problem.</td>
</tr>
<tr>
<td>- Identify and explain the scientific facts and principles that can be used to solve a problem in science.</td>
</tr>
<tr>
<td>- Describe solutions to the issue or problem based on evidence.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Problems and Solutions</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Develop, implement, and evaluate an action plan to solve a local issue or problem.</td>
</tr>
</tbody>
</table>

#### Indicator 2: The student will modify or affirm scientific ideas according to accumulated evidence.

<table>
<thead>
<tr>
<th>Objectives</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Collect evidence from various sources to support both sides of an issue or problem.</td>
</tr>
<tr>
<td>- Analyze data from investigations to support an idea, issue, or problem.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Affirm Ideas</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Select and defend data that supports ideas, issues, or solutions to problems.</td>
</tr>
<tr>
<td>- Access and process information from print and non-print sources.</td>
</tr>
<tr>
<td>- Verify prior understanding based on analysis of new information.</td>
</tr>
</tbody>
</table>

| Indicator 3: The student will critique arguments that are based on faulty, misleading data or on the incomplete use of numbers. |

<table>
<thead>
<tr>
<th>Objectives</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Identify faulty, incomplete, and/or misleading data.</td>
</tr>
<tr>
<td>- Explain, through the use of supporting evidence, reasons for faulty or incomplete use of numbers and/or data.</td>
</tr>
<tr>
<td>- Refute ideas or solutions to problems based on faulty or incomplete data.</td>
</tr>
<tr>
<td>- Suggest methods to produce appropriate data.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Critique Arguments</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Modify prior understanding based on analysis of new information.</td>
</tr>
</tbody>
</table>
## State Curriculum - Biology

<table>
<thead>
<tr>
<th>Pre-requisites Summarized from State Curriculum</th>
<th>Skills &amp; Processes State Curriculum (SC)</th>
<th>Supplemental Topics</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Skills &amp; Processes Grades 3 – 8</strong></td>
<td>Expectation 1.1: The student will explain why curiosity, honesty, openness, and skepticism are highly regarded in science.</td>
<td>Biased Data</td>
</tr>
<tr>
<td><strong>Indicator 4: The student will recognize data that are biased.</strong></td>
<td><strong>Objectives</strong></td>
<td></td>
</tr>
<tr>
<td>➢ Identify biased data.</td>
<td>• Advertising</td>
<td></td>
</tr>
<tr>
<td>• Laboratory procedures</td>
<td>• Tables and graphs</td>
<td></td>
</tr>
<tr>
<td>➢ Recognize sources of biased data.</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Indicator 5: The student will explain factors that produce biased data.</strong></td>
<td><strong>Objectives</strong></td>
<td>Producing Biased Data</td>
</tr>
<tr>
<td>➢ Identify factors that produce biased data.</td>
<td></td>
<td>• Explain how data can be manipulated during investigations.</td>
</tr>
<tr>
<td>➢ Explain how data can become biased.</td>
<td></td>
<td>• Experimental procedures</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Display of data</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Inappropriate inferences and conclusions</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Explain reasons for the manipulation of data.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Scientific</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Economic</td>
</tr>
</tbody>
</table>
## Pre-requisites Summarized from State Curriculum Skills & Processes Grades 3 – 8

### A. Constructing Knowledge (Grades 3 – 5)

1. Gather and question data from many different forms of scientific investigations which include reviewing appropriate print resources, observing what things are like or what is happening somewhere, collecting specimens for analysis, and doing experiments.
   - Support investigative findings with data found in books, articles, and databases, and identify the sources used and expect others to do the same.
   - Select and use appropriate tools: hand lens or microscope (magnifiers), centimeter ruler (length), spring scale (weight), balance (mass), Celsius thermometer (temperature), graduated cylinder (liquid volume), and stopwatch (elapsed time) to augment observations of objects, events, and processes.
   - Explain that comparisons of data might not be fair because some conditions are not kept the same.
   - Recognize that the results of scientific investigations are seldom exactly the same, and when the differences are large, it is important to try to figure out why.
   - Follow directions carefully and keep accurate records of one’s work in order to compare data gathered.
   - Identify possible reasons for differences in results from investigations including unexpected differences in the methods used or in the circumstances in which the investigation is carried out, and sometimes just because of uncertainties in observations.
   - Judge whether measurements and computations of quantities are reasonable in a familiar context by comparing them to typical values when measured to the nearest:
     - Millimeter - length
     - Square centimeter - area
     - Milliliter - volume
     - Newton - weight
     - Gram - mass
     - Second - time
     - Degree Celsius (°C) - temperature

## Skills & Processes State Curriculum (SC)

### Expectation 1.2: The student will pose scientific questions and suggest investigative approaches to provide answers to questions.

#### Indicator 1: The student will identify meaningful, answerable scientific questions.

**Objectives**
- Identify a testable question.
- Identify a testable question to address a problem or issue in science.

#### Indicator 2: The student will pose meaningful answerable scientific questions. NTB

**Objectives**
- Pose a testable question.
- Pose a testable question to address a problem or issue in science.

#### Indicator 3: The student will formulate a working hypothesis.

**Objectives**
- Recognize and describe a testable hypothesis.
- Develop a hypothesis to address the outcome of a problem or issue in science.

### Testable Scientific Questions

- Recognize that scientific questions come from
  - prior knowledge
  - observations
  - background research
  - results from a laboratory investigation

### Posing Scientific Questions

- Develop an investigative question based on
  - prior knowledge
  - observations
  - background research
  - results from a laboratory investigation

### Hypothesis Formulation

- Recognize and describe the hypothesis in a scientific investigation.
- Evaluate the scientific validity of the collected print and non-print resources related to the problem or question being researched.
- Recognize and explain how scientifically accurate print and non-print resources can support the development of a working hypothesis

**NTB** Denotes an indicator not tested on the Biology assessment.
## Pre-requisites Summarized from State Curriculum

### Skills & Processes Grades 3 – 8

#### Expectation 1.2: The student will pose scientific questions and suggest investigative approaches to provide answers to questions.

#### Indicator 4: The student will test a working hypothesis. NTB

**Objectives**

- Recognize and describe a method to test a hypothesis.
- Conduct an experiment to test a working hypothesis.
  - Follow oral and written procedures.
  - Develop and demonstrate skills using lab and field equipment to perform investigative techniques.
  - Learn the use of new instruments and equipment by following instructions in a manual or from oral direction.
  - Recognize and demonstrate safe laboratory procedures.

**Supplemental Topics**

- Testing a Hypothesis
  - Collect and evaluate scientifically accurate print and non-print resources related to the problem or question to be investigated.

#### Indicator 5: The student will select appropriate instruments and materials to conduct an investigation.

**Objectives**

- Recognize and describe appropriate materials and equipment needed to conduct a scientific investigation to test a hypothesis.
- Identify appropriate measuring tools.
- Organize materials to efficiently conduct an investigation.
- List safety concerns relating to an experiment.
- Identify and list safety materials necessary for the experiment.

**Select Materials**

- Use mathematics to interpret and communicate data.
- Explain why accurate record-keeping, openness, and replication are essential for maintaining an investigator’s credibility with other scientists and society.

---

**State Curriculum - Biology**

<table>
<thead>
<tr>
<th>Pre-requisites Summarized from State Curriculum</th>
<th>Skills &amp; Processes State Curriculum (SC)</th>
<th>Supplemental Topics</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>A. Constructing Knowledge (Grades 6 – 8)</strong></td>
<td><strong>Expectation 1.2: The student will pose scientific questions and suggest investigative approaches to provide answers to questions.</strong></td>
<td><strong>Testing a Hypothesis</strong></td>
</tr>
<tr>
<td></td>
<td><strong>Indicator 4: The student will test a working hypothesis. NTB</strong></td>
<td><em>Collect and evaluate scientifically accurate print and non-print resources related to the problem or question to be investigated.</em></td>
</tr>
<tr>
<td></td>
<td><strong>Objectives</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Recognize and describe a method to test a hypothesis.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Conduct an experiment to test a working hypothesis.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Follow oral and written procedures.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Develop and demonstrate skills using lab and field equipment to perform investigative techniques.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Learn the use of new instruments and equipment by following instructions in a manual or from oral direction.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Recognize and demonstrate safe laboratory procedures.</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Supplemental Topics</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Testing a Hypothesis</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td><em>Collect and evaluate scientifically accurate print and non-print resources related to the problem or question to be investigated.</em></td>
<td></td>
</tr>
<tr>
<td>Pre-requisites Summarized from State Curriculum Skills &amp; Processes Grades 3 – 8</td>
<td>Skills &amp; Processes State Curriculum (SC)</td>
<td>Supplemental Topics</td>
</tr>
<tr>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
</tbody>
</table>
| **Expectation 1.2:** The student will pose scientific questions and suggest investigative approaches to provide answers to questions | **Objectives**<br>➢ Recognize and describe appropriate procedures for conducting a scientific investigation.<br>➢ Develop and describe in writing a well designed investigation that includes:<br>• One problem or purpose for the investigation<br>• A testable hypothesis related to purpose or problem<br>• An independent variable (variable being manipulated)<br>• The measurable, dependent variable (variable being measured)<br>• Control mechanisms for all other variables (variables that can change, but must be held constant)<br>• Multiple trials with appropriate sample sizes<br>• Appropriate materials and equipment<br>• Safety concerns regarding experimentation<br>• Safety materials necessary for the experiment<br>• Clear and logical procedures<br>• Appropriate data collected<br>• Clear data tables, charts, and graphs | **Investigative Methods**<br>• Design and conduct a scientific investigation to test a hypothesis.

NTB Denotes an indicator not tested on the Biology assessment.
<table>
<thead>
<tr>
<th>Pre-requisites Summarized from State Curriculum Skills &amp; Processes Grades 3 – 8</th>
<th>Skills &amp; Processes State Curriculum (SC)</th>
<th>Supplemental Topics</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Expectation 1.2: The student will pose scientific questions and suggest investigative approaches to provide answers to questions</strong></td>
<td><strong>Supplemental Topics</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Indicator 7: The student will use relationships discovered in the lab to explain phenomena observed outside the laboratory.</strong></td>
<td><strong>Apply Results from Investigations</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Objectives</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>✓ Recognize and explain scientific phenomena using data from laboratory experiences and observations.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>✓ Apply laboratory results to a real-world situation or problem.</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Indicator 8: The student will defend the need for verifiable data.</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Objectives</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>✓ Recognize and explain the importance of replicable laboratory procedures.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>✓ Analyze and compare data and conclusions in the investigation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>✓ Critique procedures and data from scientific investigations</td>
<td></td>
<td></td>
</tr>
<tr>
<td>✓ Explain why accurate data, open-mindedness, and replication of investigations are essential for verification of results.</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Verifiable Data</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>✓ Develop a procedure that other students can use to conduct a scientific investigation.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>✓ Analyze and evaluate scientific findings that relate to the investigation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>✓ Recognize and explain the scientific concepts that can be used to make conclusions about an investigation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>✓ Explain why scientific information is needed to make and defend a decision about an investigation</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
# State Curriculum - Biology

## Pre-requisites Summarized from State Curriculum
### Skills & Processes Grades 3 – 8

<table>
<thead>
<tr>
<th>Expectation 1.3: The student will carry out scientific investigations effectively and employ the instruments, systems of measurement, and materials of science appropriately.</th>
</tr>
</thead>
</table>

### A. Constructing Knowledge (Grades 3 – 5)

1. **Gather and question data from many different forms of scientific investigations which include reviewing appropriate print resources, observing what things are like or what is happening somewhere, collecting specimens for analysis, and doing experiments.**
   - Select and use appropriate tools: hand lens or microscope (magnifiers), centimeter ruler (length), spring scale (weight), balance (mass), Celsius thermometer (temperature), graduated cylinder (liquid volume), and stopwatch (elapsed time) to augment observations of objects, events, and processes.

### Indicator 1: The student will develop and demonstrate skills in using lab and field equipment to perform investigative techniques. NTR

#### Objectives
- Demonstrate proper care and use of scientific equipment
  - microscope
  - glassware
  - thermometer
  - balance
  - gel electrophoresis including micropipettes
  - probes
  - computers
    - scientific modeling (population dynamics)
    - graphical analysis
    - simulations (virtual dissection)
- Demonstrate safe and appropriate behaviors while using science equipment and materials.

### Indicator 2: The student will recognize safe laboratory procedures.

#### Objectives
- Recognize and identify situations that require the wearing of protective equipment such as gloves, goggles, aprons.
- Recognize and identify situations that require the use of emergency equipment, e.g., eye-wash, fire blanket, shower
- Follow oral directions and/or written instructions to learn the use of new equipment
- Follow safety procedures pertinent to specific laboratory investigations in biology.
- Recognize unsafe laboratory practices in the classroom and/or in a written scenario

### Use Equipment
- GPS/GIS
- spectrophotometers and/or colorimeters
- digital imaging, e.g., cameras, satellite images, microscope
- incubator

### Safety Procedures
- Read Materials Safety Data Sheets (MSDS)

### Supplemental Topics

#### A. Constructing Knowledge (Grades 3 – 5)

1. **Gather and question data from many different forms of scientific investigations which include reviewing appropriate print resources, observing what things are like or what is happening somewhere, collecting specimens for analysis, and doing experiments.**
   - Select and use appropriate tools: hand lens or microscope (magnifiers), centimeter ruler (length), spring scale (weight), balance (mass), Celsius thermometer (temperature), graduated cylinder (liquid volume), and stopwatch (elapsed time) to augment observations of objects, events, and processes.

### Indicator 1: The student will develop and demonstrate skills in using lab and field equipment to perform investigative techniques. NTR

#### Objectives
- Demonstrate proper care and use of scientific equipment
  - microscope
  - glassware
  - thermometer
  - balance
  - gel electrophoresis including micropipettes
  - probes
  - computers
    - scientific modeling (population dynamics)
    - graphical analysis
    - simulations (virtual dissection)
- Demonstrate safe and appropriate behaviors while using science equipment and materials.

### Indicator 2: The student will recognize safe laboratory procedures.

#### Objectives
- Recognize and identify situations that require the wearing of protective equipment such as gloves, goggles, aprons.
- Recognize and identify situations that require the use of emergency equipment, e.g., eye-wash, fire blanket, shower
- Follow oral directions and/or written instructions to learn the use of new equipment
- Follow safety procedures pertinent to specific laboratory investigations in biology.
- Recognize unsafe laboratory practices in the classroom and/or in a written scenario

### Use Equipment
- GPS/GIS
- spectrophotometers and/or colorimeters
- digital imaging, e.g., cameras, satellite images, microscope
- incubator

### Safety Procedures
- Read Materials Safety Data Sheets (MSDS)
### State Curriculum - Biology

<table>
<thead>
<tr>
<th>Pre-requisites Summarized from State Curriculum</th>
<th>Skills &amp; Processes State Curriculum (SC)</th>
<th>Supplemental Topics</th>
</tr>
</thead>
</table>
| Skills & Processes Grades 3 – 8               | Expectation 1.3: The student will carry out scientific investigations effectively and employ the instruments, systems of measurement, and materials of science appropriately. | Safe Handling of Materials  
- Read MSDS |

#### Indicator 3: The student will demonstrate safe handling of the chemicals and materials of science.  

**Objectives**
- Read and follow safety guidelines
- Wear appropriate safety equipment such as goggles, gloves, apron
- Handle chemicals properly such as acids, bases, and testing reagents
- Use senses safely in making observations
- Dispose of materials properly, especially bacteria and biological tissues
- Follow appropriate procedures for clean-up of spills and breakage

#### Indicator 4: The student will learn the use of new instruments and equipment by following instructions in a manual or from oral direction.  

**Objectives**
- Use pre-reading as a strategy to connect written and oral directions to prior knowledge and/or experiences
- Use pictures, diagrams, charts, graphs, etc. to learn the proper use of instruments and equipment
- Use a checklist to help focus on critical elements of text
- Demonstrate proper use of equipment (e.g., never use the coarse adjustment with the high power objective on a microscope)

Learn to Use Scientific Equipment
<table>
<thead>
<tr>
<th>Pre-requisites Summarized from State Curriculum</th>
<th>Skills &amp; Processes State Curriculum (SC)</th>
<th>Supplemental Topics</th>
</tr>
</thead>
<tbody>
<tr>
<td>C. Communicating Scientific Information (Grades 6 – 8)</td>
<td>Expectation 1.4: The student will demonstrate that data analysis is a vital aspect of the process of scientific inquiry and communication.</td>
<td>Organize Data</td>
</tr>
<tr>
<td>1. Develop explanations that explicitly link data from investigations conducted, selected readings and, when appropriate, contributions from historical discoveries. a. Organize and present data in tables and graphs and identify relationships they reveal.</td>
<td>Indicator 1: The student will organize data appropriately using techniques such as tables, graphs, and webs. (for graphs: axes labeled with appropriate quantities, appropriate units on axes, axes labeled with appropriate intervals, independent and dependent variables on correct axes, appropriate title)</td>
<td>Use other methods to display data</td>
</tr>
<tr>
<td>Objectives</td>
<td>Identify the best method to represent data.</td>
<td>o Scatter plot</td>
</tr>
<tr>
<td></td>
<td>• Graphs</td>
<td>o Box and whisker</td>
</tr>
<tr>
<td></td>
<td>o Determine the type of graph to best display the data (e.g., line, bar, circle)</td>
<td>o Stem and leaf</td>
</tr>
<tr>
<td></td>
<td>o Label with appropriate title</td>
<td>o Frequency</td>
</tr>
<tr>
<td></td>
<td>o Label with appropriate measurements (e.g., time, length, mass)</td>
<td>o Histogram</td>
</tr>
<tr>
<td></td>
<td>o Label with appropriate units (e.g., sec, meters, grams)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>o Label axes with appropriate and consistent intervals</td>
<td></td>
</tr>
<tr>
<td></td>
<td>o Place independent and dependent variables on correct axes</td>
<td></td>
</tr>
<tr>
<td></td>
<td>o Plot data correctly</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Tables</td>
<td></td>
</tr>
<tr>
<td></td>
<td>o Label with appropriate title</td>
<td></td>
</tr>
<tr>
<td></td>
<td>o Design a table with the appropriate number of columns and rows</td>
<td></td>
</tr>
<tr>
<td></td>
<td>o Identify an appropriate title and column headers</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Webs (e.g., graphic organizers, food web, biogeochemical cycle)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Using authentic data from a classroom investigation, construct a graph or table to appropriately display the data.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Label with appropriate title</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Label with appropriate measurements (time, length, mass)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Label with appropriate units (sec, meters, grams)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Label axes with appropriate and consistent intervals on graphs</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Place independent variable on the X-axis and dependent variable on the Y-axis on graphs</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Utilize technology to organize and display data.</td>
<td></td>
</tr>
</tbody>
</table>

Note: Denotes an indicator not tested on the Biology assessment.
## Pre-requisites Summarized from State Curriculum

### Skills & Processes Grades 3 – 8

#### C. Communicating Scientific Information (Grades 3 – 5)

1. **Recognize that clear communication is an essential part of doing science because it enables scientists to inform others about their work, expose their ideas to criticism by other scientists, and stay informed about scientific discoveries around the world.**
   - a. Make use of and analyze models, such as tables and graphs to summarize and interpret data.
   - b. Avoid choosing and reporting only the data that show what is expected by the person doing the choosing.
   - c. Submit work to the critique of others which involves discussing findings, posing questions, and challenging statements to clarify ideas.
   - d. Construct and share reasonable explanations for questions asked.
   - e. Recognize that doing science involves many different kinds of work and engages men and women of all ages and backgrounds.

## State Curriculum - Biology

### Expectation I.4: The student will demonstrate that data analysis is a vital aspect of the process of scientific inquiry and communication.

#### Indicator 2: The student will analyze data to make predictions, decisions, or draw conclusions.

**Objectives**

- Identify relationships among data to make predictions, decisions, or draw conclusions.
  - Results of a genetic cross
  - Predator-prey relationships
- Describe how data reflects the outcome of a scientific investigation.
- Recognize patterns among data
  - Frequency of relationship
  - Ratio of results
- Extend trends to make predictions, decisions, or draw conclusions.
- Use data to explain observed trends.

#### Indicator 3: The student will use experimental data from various investigators to validate results.

**Objectives**

- Compare data from investigations among a variety of sources
  - Classmates
  - Other classrooms
  - Published data

---

**Supplemental Topics**

- **Analyze Data**
  - Recognize patterns among data
    - Producing line of best fit

- **Use Data**
<table>
<thead>
<tr>
<th>Pre-requisites Summarized from State Curriculum</th>
<th>Skills &amp; Processes State Curriculum (SC)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Skills &amp; Processes Grades 3 – 8</strong></td>
<td><strong>Expectation 1.4: The student will demonstrate that data analysis is a vital aspect of the process of scientific inquiry and communication.</strong></td>
</tr>
</tbody>
</table>

### Indicator 4: The student will determine the relationships between quantities and develop the mathematical model that describes these relationships.

**Objectives**
- Identify the mathematical relationship between the independent and dependent variables in a scientific investigation.

### Indicator 5: The student will check graphs to determine that they do not misrepresent results.

**Objectives**
- Compare the data on a graph and a table.
- Determine sources of error in graphs.
- Identify inaccurate data points in a graph.
- Identify inappropriate scales on a graph.

### Indicator 6: The student will describe trends revealed by data.

**Objectives**
- Compare class data to individual student results.
- Describe trends revealed by data.
  - Direction
  - Rate
  - Cyclic
- Identify the correlation among data in multiple graphs.

### Supplemental Topics

#### Math Model
- Develop a mathematical equation to describe the relationship between the independent and dependent variables in a scientific investigation.

#### Check Graphs

#### Trends

---

C. Communicating Scientific Information (Grades 6 – 8)

1. Develop explanations that explicitly link data from investigations conducted, selected readings, and, when appropriate, contributions from historical discoveries.
   - Organize and present data in tables and graphs and identify relationships they reveal.
   - Interpret tables and graphs produced by others and describe in words the relationships they show.

B. Applying Evidence and Reasoning (Grades 6 – 8)

1. Review data from a simple experiment, summarize the data, and construct a logical argument about the cause-and-effect relationships in the experiment.
   - Describe the reasoning that lead to the interpretation of data and conclusions drawn.
   - Question claims based on vague statements or on statements made by people outside their area of expertise.

---

### Supplemental Topics

**NOT** Denotes an indicator not tested on the Biology assessment.
## Expectation 1.4: The student will demonstrate that data analysis is a vital aspect of the process of scientific inquiry and communication.

**Indicator 7:** The student will determine the sources of error that limit the accuracy or precision of experimental results.

### Objectives
- Identify sources of experimental error.
  - Human error
  - Equipment malfunction
  - Procedural error
- Describe how sources of experimental error affect the results.
- Determine the effects of measurement errors.
- Determine the effects of chance.
- Differentiate between accuracy and precision.
- Recognize the limitations of measurement tools.

### Sources of Error

---

**Indicator 8:** The student will use models and computer simulations to extend his/her understanding of scientific concepts.\(^{NTB}\)

### Objectives
- Identify advantages and disadvantages of models and computer simulations.
- Apply the models or computer simulations to real world situations.

### Use Models

---

### Pre-requisites Summarized from State Curriculum

**Skills & Processes Grades 3 – 8**

<table>
<thead>
<tr>
<th>1.</th>
<th>Analyze the value and the limitations of different types of models in explaining real things and processes.</th>
</tr>
</thead>
<tbody>
<tr>
<td>a.</td>
<td>Explain that the kind of model to use and how complex it should be depends on its purpose and that it is possible to have different models used to represent the same thing.</td>
</tr>
<tr>
<td>b.</td>
<td>Explain, using examples that models are often used to think about processes that happen too slowly, too quickly, or on too small a scale to observe directly, or that are too vast to be changed deliberately, or that are potentially dangerous.</td>
</tr>
<tr>
<td>c.</td>
<td>Explain that models may sometimes mislead by suggesting characteristics that are not really shared with what is being modeled.</td>
</tr>
</tbody>
</table>

---

\(^{NTB}\) Denotes an indicator not tested on the Biology assessment.
Skills & Processes State Curriculum (SC)

Expectation 1.4: The student will demonstrate that data analysis is a vital aspect of the process of scientific inquiry and communication.

Indicator 9: The student will use analyzed data to confirm, modify, or reject a hypothesis.

Objectives

- Evaluate data to determine its value in explaining a phenomenon or drawing a conclusion.
- Use data to support an explanation that confirms, modifies, or rejects a hypothesis.
- Use data to support an explanation of a concept.

Pre-requisites Summarized from State Curriculum

Skills & Processes Grades 3 – 8

C. Communicating Scientific Information (Grades 6 – 8)

1. Develop explanations that explicitly link data from investigations conducted, selected readings and, when appropriate, contributions from historical discoveries.
   a. Organize and present data in tables and graphs and identify relationships they reveal.
   b. Interpret tables and graphs produced by others and describe in words the relationships they show.
   c. Give examples of how scientific knowledge is subject to modification as new information challenges prevailing theories and as a new theory leads to looking at old observations in a new way.
   d. Criticize the reasoning in arguments to which
      - Fact and opinion are intermingled
      - Conclusions do not follow logically from the evidence given
      - Existence of control groups and the relationship to experimental groups is not made obvious
      - Samples are too small, biased, or not representative
   e. Explain how different models can be used to represent the same thing. What kind of a model to use and how complex it should depend on its purpose. Choosing a useful model is one of the instances in which intuition and creativity come into play in science, mathematics, and engineering.
   f. Participate in group discussions on scientific topics by restating or summarizing accurately what others have said, asking for clarification or elaboration, and expressing alternative positions.

Supplemental Topics

C. Communicating Scientific Information (Grades 6 – 8)

1. Develop explanations that explicitly link data from investigations conducted, selected readings and, when appropriate, contributions from historical discoveries.
   a. Organize and present data in tables and graphs and identify relationships they reveal.
   b. Interpret tables and graphs produced by others and describe in words the relationships they show.
   c. Give examples of how scientific knowledge is subject to modification as new information challenges prevailing theories and as a new theory leads to looking at old observations in a new way.
   d. Criticize the reasoning in arguments to which
      - Fact and opinion are intermingled
      - Conclusions do not follow logically from the evidence given
      - Existence of control groups and the relationship to experimental groups is not made obvious
      - Samples are too small, biased, or not representative
   e. Explain how different models can be used to represent the same thing. What kind of a model to use and how complex it should depend on its purpose. Choosing a useful model is one of the instances in which intuition and creativity come into play in science, mathematics, and engineering.
   f. Participate in group discussions on scientific topics by restating or summarizing accurately what others have said, asking for clarification or elaboration, and expressing alternative positions.

Confirm Hypotheses

7/11/2007

Page 13 of 48

Denotes an indicator not tested on the Biology assessment.
## State Curriculum - Biology

<table>
<thead>
<tr>
<th>Pre-requisites Summarized from State Curriculum</th>
<th>Skills &amp; Processes State Curriculum (SC)</th>
<th>Supplemental Topics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Skills &amp; Processes Grades 3 – 8</td>
<td>Expectation 1.5: The student will use appropriate methods for communicating in writing and orally the processes and results of scientific investigation.</td>
<td></td>
</tr>
<tr>
<td>C. Communicating Scientific Information (Grades 6 – 8)</td>
<td>Indicator 1: The student will demonstrate the ability to summarize data (measurements/observations).</td>
<td>Summarize data</td>
</tr>
<tr>
<td>1. Develop explanations that explicitly link data from investigations conducted, selected readings and, when appropriate, contributions from historical discoveries.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>a. Organize and present data in tables and graphs and identify relationships they reveal.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>b. Interpret tables and graphs produced by others and describe in words the relationships they show.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Objectives
- Summarize measurement data, such as pH, temperature, etc. from a scientific investigation.
- Summarize observations such as the effect of light on the rate of photosynthesis, from a scientific investigation.
## State Curriculum - Biology

### Expectation 1.5: The student will use appropriate methods for communicating in writing and orally the processes and results of scientific investigation.

**Objective**
- Utilize appropriate technology to enhance and more effectively deliver written and oral communication (e.g., spreadsheets, presentation software, flowcharts, data acquisition technology, digital imagery).

### Indicator 2: The student will explain scientific concepts and processes through drawing, writing, and/or oral communication.

**Objectives**
- Use supporting evidence (data and observations) from scientific investigations to support explanations in written and oral communication.
- Use appropriate scientific terminology to support explanations in written and oral communication.
- Identify the most appropriate method for communicating scientific concepts.
- Use drawings and diagrams to support explanations in written and oral communication.

### Indicator 3: The student will use computers and/or graphing calculators to produce the visual materials (tables, graphs, and spreadsheets) that will be used for communicating results.

**Objectives**
- Manipulate data from probeware to download to computer or PDA to analyze an event, e.g., cell cycle, frequency of species within a community.
## State Curriculum - Biology

<table>
<thead>
<tr>
<th>Pre-requisites Summarized from State Curriculum</th>
<th>Skills &amp; Processes State Curriculum (SC)</th>
<th>Supplemental Topics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Skills &amp; Processes Grades 3 – 8</td>
<td>Expectation 1.5: The student will use appropriate methods for communicating in writing and orally the processes and results of scientific investigation.</td>
<td>Use Tables to Communicate Information</td>
</tr>
<tr>
<td></td>
<td>Indicator 4: The student will use tables, graphs, and displays to support arguments and claims in both written and oral communication.</td>
<td>Create and Interpret Graphics</td>
</tr>
<tr>
<td></td>
<td><strong>Objectives</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Utilize appropriate technology to enhance and more effectively deliver written and oral communication (e.g., spreadsheets, presentation software, flowcharts, data acquisition technology, digital imagery).</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Objectives</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Construct and interpret spreadsheets (e.g., for analyzing data from genetic crosses)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Construct and interpret graphs (e.g., displaying experimental data)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Construct and interpret tables (e.g., illustrating data from diffusion experiments)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Determine relative size from the microscopic field of view</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Compare and differentiate between diagrams and microscopic images.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Compare scale drawings to the actual object.</td>
<td></td>
</tr>
<tr>
<td>Skills &amp; Processes State Curriculum (SC)</td>
<td>Supplemental Topics</td>
<td></td>
</tr>
<tr>
<td>----------------------------------------</td>
<td>---------------------</td>
<td></td>
</tr>
</tbody>
</table>
| **Expectation 1.5:** The student will use appropriate methods for communicating in writing and orally the processes and results of scientific investigation. | **Interpret Technical Passage**  
- Read and interpret books written by science professionals  
- Appreciate science fiction text |
| **Indicator 6:** The student will read a technical selection and interpret it appropriately. | |
| **Objectives** | |
| - Read and interpret scientific journals, periodicals, and newspaper articles.  
- Gather evidence to support a conclusion  
- Reflect on the intent of the article  
- Summarize the main idea as it relates to a scientific concept or process  
- Distinguish between opinions and evidence  
- Verify the appropriateness of a conclusion | |
| **Indicator 7:** The student will use, explain, and/or construct various classification systems. | |
| **Objectives** | |
| - Develop a classification system to sort objects based on their characteristics.  
- Explain the classification system used to sort objects (such as food webs, organisms, organic molecules).  
- Uses a variety of graphic organizers to show relationships among objects or concepts. | |
| **Classification Systems** | |
| - Use dichotomous key to classify an organism.  
- Use cladograms to show relationships among organisms. | |
| **Pre-requisites Summarized from State Curriculum**  
Skills & Processes Grades 3 – 8 | |
**State Curriculum - Biology**

<table>
<thead>
<tr>
<th>Pre-requisites Summarized from State Curriculum Skills &amp; Processes Grades 3 – 8</th>
<th>Skills &amp; Processes State Curriculum (SC)</th>
<th>Supplemental Topics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Expectation 1.5: The student will use appropriate methods for communicating in writing and orally the processes and results of scientific investigation.</td>
<td>Indicator 8: The student will describe similarities and differences when explaining concepts and/or principles.</td>
<td></td>
</tr>
<tr>
<td><strong>Indicators</strong></td>
<td><strong>Objectives</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Use comparisons to differentiate among concepts and principles (e.g., DNA/RNA, photosynthesis/respiration, abiotic/biotic, eukaryotic/prokaryotic, etc.)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Use analogies to explain complex concepts and principles (e.g., cell organelles, protein synthesis, enzyme specificity)</td>
<td><strong>Compare</strong></td>
</tr>
<tr>
<td>C. Communicating Scientific Information (Grades 6 – 8)</td>
<td>Indicator 9: The student will communicate conclusions derived through a synthesis of ideas.</td>
<td>Synthesize Ideas</td>
</tr>
<tr>
<td>1. Develop explanations that explicitly link data from investigations conducted, selected readings and, when appropriate, contributions from historical discoveries.</td>
<td><strong>Objectives</strong></td>
<td></td>
</tr>
<tr>
<td>a. Organize and present data in tables and graphs and identify relationships they reveal</td>
<td>Make connections among ideas to draw a thoughtful, logical conclusion.</td>
<td></td>
</tr>
<tr>
<td>b. Interpret tables and graphs produced by others and describe in words the relationships they show</td>
<td>Describe the relationship among ideas to develop a concept.</td>
<td></td>
</tr>
<tr>
<td>c. Give examples of how scientific knowledge is subject to modification as new information challenges prevailing theories and as a new theory leads to looking at old observations in a new way</td>
<td>Integrate evidence and information to support a conclusion</td>
<td></td>
</tr>
<tr>
<td>d. Criticize the reasoning in arguments in which</td>
<td>Use mathematical analysis of data when communicating results.</td>
<td></td>
</tr>
<tr>
<td>• Fact and opinion are intermingled</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Conclusions do not follow logically from the evidence given</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Existence of control groups and the relationship to experimental groups is not made obvious</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Samples are too small, biased, or not representative</td>
<td></td>
<td></td>
</tr>
<tr>
<td>e. Explain how different models can be used to represent the same thing. What kind of a model to use and how complex it should be depend on its purpose. Choosing a useful model is one of the instances in which intuition and creativity come into play in science, mathematics, and engineering</td>
<td></td>
<td></td>
</tr>
<tr>
<td>f. Participate in group discussions on scientific topics by restating or summarizing accurately what others have said, asking for clarification or elaboration, and expressing alternative positions.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Note:** Denotes an indicator not tested on the Biology assessment.
<table>
<thead>
<tr>
<th>Expectation 1.6: The student will use mathematical processes.</th>
<th>Supplemental Topics</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Indicator 1:</strong> The student will use ratio and proportion in appropriate situations to solve problems.</td>
<td><strong>Ratio &amp; Proportion</strong></td>
</tr>
<tr>
<td><strong>Objectives</strong></td>
<td></td>
</tr>
<tr>
<td>- Identify situations in which ratio and proportion should be used, e.g., results of genetic crosses</td>
<td>- Calculate the gene frequency in a population</td>
</tr>
<tr>
<td>- Convert ratio and proportion to percent and vice versa, e.g., offspring from a genetic cross</td>
<td>- Calculate the percent of energy transfer within a food chain and/or food web</td>
</tr>
<tr>
<td>- Identify patterns and trends represented by ratios and proportions</td>
<td>- Compare the percent of nucleotides in DNA and/or RNA</td>
</tr>
<tr>
<td>- Solve problems using ratios and proportions</td>
<td></td>
</tr>
<tr>
<td>- Use ratio and proportion to predict the outcome of an event, e.g., genetic cross</td>
<td></td>
</tr>
<tr>
<td>- Use ratio and proportion to compare the results of an investigation, e.g., population change, variation within a population</td>
<td></td>
</tr>
<tr>
<td>- Use a scale within a field of view to estimate the size of a microscopic organism</td>
<td></td>
</tr>
<tr>
<td><strong>Indicator 2:</strong> The student will use computers and/or graphing calculators to perform calculations for tables, graphs, or spreadsheets.</td>
<td><strong>Use Computers to Perform Calculations</strong></td>
</tr>
<tr>
<td><strong>Objectives</strong></td>
<td></td>
</tr>
<tr>
<td>- Gather data</td>
<td></td>
</tr>
<tr>
<td>- Perform calculations, e.g., median, average, ratio, rate of change, percent</td>
<td></td>
</tr>
<tr>
<td>- Create graphs, e.g., bar, circle, line</td>
<td></td>
</tr>
<tr>
<td>- Demonstrate computer/calculator use to solve scientific problems.</td>
<td></td>
</tr>
</tbody>
</table>
## Expectation 1.6: The student will use mathematical processes.

### Indicator 3: The student will express and/or compare small and large quantities using scientific notation and relative order of magnitude.

**Objectives**
- Use scientific notation to express and compare the relative sizes of microscopic organisms.
- Use scientific notation to express and compare large quantities, e.g., population size, numbers of molecules, energy, biomass.
- Describe the order of magnitude of values, e.g., pH scale, acid rain, metric measurements (SI), ecological pyramids, exponential population growth, concentrations (salinity, oxygen/CO₂, enzyme/substrate), light intensity.

### Indicator 4: The student will manipulate quantities and/or numerical values in algebraic equations.

**Objectives**
- Manipulate an equation to solve for one variable, e.g., probability of genetic cross, rate of photosynthesis, rate of population growth.

### Indicator 5: The student will judge the reasonableness of an answer.

**Objectives**
- Estimate a numerical value.
- Explain the process for estimating a value.
- Compare an estimated value with an actual value.
- Compare actual results with accepted results.
- Compare results with results obtained by other investigators.

### Supplemental Topics

- Use Scientific Notation
  - Geologic time
  - Relative sizes, e.g., virus, bacterium, eukaryotic cell
  - Pollutant concentration (ppt, ppm, ppb)

- Equations
  - Determine the age of a fossil using data from radiocarbon dating.
  - Determine the effect of environmental activity on the action of enzymes and metabolic rate, e.g., STELLA software.

- Judge Answer
  - Calculate percent error from experimental data.
  - Perform elementary statistical analyses.
## State Curriculum - Biology

<table>
<thead>
<tr>
<th>Pre-requisites Summarized from State Curriculum</th>
<th>Skills &amp; Processes State Curriculum (SC)</th>
<th>Supplemental Topics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Skills &amp; Processes Grades 3 – 8</td>
<td>Expectation 1.7: The student will show that connections exist both within the various fields of science and among science and other disciplines including mathematics, social studies, language arts, fine arts, and technology.</td>
<td>Apply Skills and Concepts</td>
</tr>
<tr>
<td><strong>D. Technology (Grades 6 – 8)</strong></td>
<td></td>
<td>• Evaluate all perspectives of an ethical issue</td>
</tr>
<tr>
<td>1. Analyze the value and the limitations of different types of models in explaining real things and processes.</td>
<td></td>
<td>• Use engineering skills and concepts to address a biological issue, e.g., model, prototype device, invention</td>
</tr>
<tr>
<td>a. Explain that the kind of model to use and how complex it should depend on its purpose and that it is possible to have different models used to represent the same thing.</td>
<td></td>
<td>• Participate in science fairs, expositions, inquiry conferences, and/or competitions to demonstrate application of skills and concepts to investigate issues and solve problems</td>
</tr>
<tr>
<td>b. Explain, using examples that models are often used to think about processes that happen too slowly, too quickly, or on too small a scale to observe directly, or that are too vast to be changed deliberately, or that are potentially dangerous.</td>
<td></td>
<td>• Communicate results from investigations through presentations, publications, conferences, etc.</td>
</tr>
<tr>
<td>c. Explain that models may sometimes mislead by suggesting characteristics that are not really shared with what is being modeled.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Indicator 1: The student will apply the skills, processes and concepts of biology, chemistry, physics, or earth science to societal issues.

**Objectives**

- Apply concepts and processes of chemistry, physics, environmental science and Earth/space science to analyze a biological problem.
- Analyze a biological problem from various perspectives, e.g., economic, social, political.
- Design an investigation related to a biological problem.
- Develop a strategy to address a biological problem, e.g., resource management, nutrition, agriculture, genetic counseling, medicine.
## Pre-requisites Summarized from State Curriculum

### Skills & Processes State Curriculum (SC)

**Expectation 1.7:** The student will show that connections exist both within the various fields of science and among science and other disciplines including mathematics, social studies, language arts, fine arts, and technology.

### Supplemental Topics

**Evaluate Ideas**
- Examine and evaluate potential solutions to a societal issue
- Develop an action plan to address a societal issue
- Implement an action plan to address a societal issue

---

<table>
<thead>
<tr>
<th>Indicator 2: The student will identify and evaluate the impact of scientific ideas and/or advancements in technology on society.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Objectives</strong></td>
</tr>
<tr>
<td>- Defend, debate, justify, analyze, refute, explain the consequences of societal issues resulting from scientific ideas or advancements in technology such as:</td>
</tr>
<tr>
<td>- Genetically engineered crops</td>
</tr>
<tr>
<td>- Gene therapy</td>
</tr>
<tr>
<td>- Human Genome Project</td>
</tr>
<tr>
<td>- Vaccines</td>
</tr>
<tr>
<td>- Urbanization</td>
</tr>
<tr>
<td>- Cloning</td>
</tr>
<tr>
<td>- Drug/pesticide resistance</td>
</tr>
<tr>
<td>- Evolutionary pathways</td>
</tr>
<tr>
<td>- Climate change</td>
</tr>
<tr>
<td>- Habitat destruction</td>
</tr>
<tr>
<td>- Non-native species</td>
</tr>
<tr>
<td>- Biological control of pests</td>
</tr>
<tr>
<td>- Organic food production</td>
</tr>
<tr>
<td>- Global economic pressures</td>
</tr>
</tbody>
</table>

---

**C. Communicating Scientific Information (Grades 6 – 8)**

1. Develop explanations that explicitly link data from investigations conducted, selected readings and, when appropriate, contributions from historical discoveries.
   - Give examples of how scientific knowledge is subject to modification as new information challenges prevailing theories and as a new theory leads to looking at old observations in a new way.
   - Recognize that important contributions to the advancement of science, mathematics, and technology have been made by different kinds of people, in different cultures, at different times.
### State Curriculum - Biology

<table>
<thead>
<tr>
<th>Pre-requisites Summarized from State Curriculum</th>
<th>Skills &amp; Processes State Curriculum (SC)</th>
<th>Supplemental Topics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Skills &amp; Processes Grades 3 – 8</td>
<td><strong>Expectation 1.7:</strong> The student will show that connections exist both within the various fields of science and among science and other disciplines including mathematics, social studies, language arts, fine arts, and technology.</td>
<td><strong>Role of Science</strong></td>
</tr>
<tr>
<td><strong>Indicator 3:</strong> The student will describe the role of science in the development of literature, art, and music NTB.</td>
<td><strong>Objectives</strong></td>
<td></td>
</tr>
</tbody>
</table>
**Describe the role of science in music, e.g.,**
- acoustics, musical instruments, sound production in animals
- Materials for the construction of musical instruments, e.g., wood for violins
- The biology of the senses
- State symbols, e.g., Baltimore Oriole, Black-eyed Susan, Wye Oak |
| | - Describe the role of science in literature, e.g., Beautiful Swimmers, Napoleon’s Buttons, Silent Spring, Hot Zone, Coma, Jurassic Park | **Requirements** |
| | - Describe the role of science in art, e.g., Lorenzo’s Oil, Gattaca, works of Michaelangelo and Da Vinci, biological illustration | **Indicator 3:** The student will describe the role of science in the development of literature, art, and music NTB. |

**NTB** Denotes an indicator not tested on the Biology assessment.
<table>
<thead>
<tr>
<th>Pre-requisites Summarized from State Curriculum Skills &amp; Processes Grades 3 – 8</th>
<th>Expectation 1.7: The student will show that connections exist both within the various fields of science and among science and other disciplines including mathematics, social studies, language arts, fine arts, and technology.</th>
<th>Supplemental Topics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Indicator 4: The student will recognize mathematics as an integral part of the scientific process. NTR.</td>
<td><strong>Objectives</strong>&lt;br&gt;✓ Describe how mathematics is a tool for the scientist.</td>
<td>Recognize Mathematics</td>
</tr>
<tr>
<td>Indicator 5: The student will investigate career possibilities in the various areas of science NTR.</td>
<td><strong>Objectives</strong>&lt;br&gt;✓ Describe current opportunities for employment in biology related careers, e.g., teaching, research, medicine, engineering, public health, sanitation, food science, environmental science, animal science, agriculture, biotechnology, forensic science.&lt;br&gt;✓ Describe the levels of education required for various careers in the biological sciences.</td>
<td>Careers in Science&lt;br&gt;• Plan a course sequence to prepare for a career in the biological sciences.&lt;br&gt;• Identify post-secondary institutions that provide pathways to careers in the biological sciences.</td>
</tr>
<tr>
<td>Indicator 6: The student will explain how development of scientific knowledge leads to the creation of new technology and how technological advances allow for additional scientific accomplishments.</td>
<td><strong>Objectives</strong>&lt;br&gt;✓ Describe how physics concepts allowed for the development technology to improve the understanding of biology, e.g., light refraction, heat capacity of water, thermodynamics&lt;br&gt;✓ Describe how chemistry concepts allowed for the development technology to improve the understanding of biology, e.g., food chemistry, photosynthesis, cellular respiration, water quality, enzyme/substrate interaction, chemical bonding&lt;br&gt;✓ Describe how Earth/space science concepts allowed for the development technology to improve the understanding of biology, e.g., biogeochemical cycles, biomes, climate, weather, solar radiation, characteristics of the atmosphere, fossils</td>
<td>Science and Technology</td>
</tr>
</tbody>
</table>
### Pre-requisites Summarized from State Curriculum

**Life Science Grades 3 – 8**

**Grade 4**
- E. Flow of Matter and Energy

1. Recognize food as the source of materials that all living things need to grow and survive.
   - a. Classify the things that people and animals take into their bodies as food or not food.
   - b. Describe what happens to food in plants and animals:
      - **Contributes to growth**
      - **Provides energy**
      - **Is stored for future use**
      - **Is eliminated**
   - c. Identify the things that are essential for plants to grow and survive.

**Grade 7**
- E. Flow of Matter and Energy

1. Explain that the transfer and transformation of matter and energy links organisms to one another and to their physical setting.
   - a. Cite evidence from research and observations that food provides molecules that serve as fuel and building materials for all organisms.
   - b. Cite evidence from research and observations that organisms that eat plants or animals break down what they have consumed (food) to produce the materials and energy they need to survive or store for later use.
   - c. Investigate and describe the processes that enable plants to use the energy from light to make sugars.

### Expectation 3.1 Biochemistry: The student will be able to explain the correlation between the structure and function of biologically important molecules and their relationship to cell processes.

**Indicator 1. Describe the unique characteristics of chemical substances and macromolecules utilized by living systems.**

**Assessment Limits:**
- water (inorganic molecule, polarity, density, and solvent properties)
- carbohydrates (organic molecule, monosaccharides are building blocks; supplier of energy and dietary fiber; structural component of cells; cell wall; cellulose)
- lipids (organic molecule, component of cell membranes, stored energy supply)
- proteins (organic molecule, amino acids are building blocks; structural and functional role, including enzymes)
- nucleic acids (organic molecule: nucleotides are building blocks; sugar, phosphate and nitrogen bases; DNA is a double helix; RNA is a single strand; DNA replication; DNA role in storage of genetic information)
- minerals (inorganic molecule; essential for cellular processes)
- vitamins (organic molecule; role in human body: C - wound healing; K - blood clotting; D - bone growth)

**Objectives**
- Recognize and analyze the unique characteristics of organic molecules utilized by organisms for specific life-sustaining purposes.
- Describe properties of water:
  - Classify water as an inorganic compound.
  - Structure provides properties important to life
  - Polarity of the molecule is responsible for its solvent properties
  - Effect of temperature on density of water and how changes in density affect the external environment of organisms.
- Use models and illustrations to compare the unique structure and function of macromolecules used by living things.
  - **Carbohydrates**
    - Organic molecules
    - Building block: a monosaccharide, such as glucose
    - Supplies energy and dietary fiber; stores energy
  - In plants, cellulose is a structural component of cell walls
  - **Lipids**
    - Organic molecule
    - Long term storage of energy
    - Structural component of membranes

**Supplemental Topics**

### Chemical Substances and Macromolecules
- Cells are composed mostly of six common elements: C, H, O, N, P, and S.
- Cell processes require the breakdown, rearrangement, and synthesis of molecules from food.
- The configuration of atoms in a molecule determines the molecule’s properties.
- Hydrogen bonding between neighboring water molecules leads to adhesion, cohesion, capillary action, and surface tension.

- **Carbohydrates**
  - The structure of a carbohydrate molecule is particularly important in how it interacts with other molecules, such as cellulose is not easily digested, starch is easily digested.
  - Many complex carbohydrates are broken down by specific enzymes.

- **Lipids**
  - Building block: glycerol molecule and one or more fatty acids
  - Non-polar molecule
  - The structure and composition of a phospholipid molecule is particularly important in how it functions in the membrane bilayer.

- **Proteins**
  - Specific order of amino acids determines shape of molecule
  - Shape of the protein determines its ability to function
  - Enzymes
    - Lower activation energy
    - Encourage interactions of molecules with each other
    - Regulate cell activity
    - May use certain minerals as co-factors (Ca, Fe, Na, K, P)
    - Role in cellular transport
    - Role in identification and recognition of cells
    - Replicates genetic information

- **Nucleic Acids**
  - DNA replication is semi-conservative
  - Complementary base pairing in DNA: A-T, C-G
(food) from carbon dioxide and water.

d. Provide evidence from research to explain how plants can use the food they make immediately for fuel or stored for later use.

e. Ask and seek answers to questions about the fact that transfer of matter between organisms continues indefinitely because organisms are decomposed after death to return food materials to the environment.

f. Provide evidence that supports the premise “In the flow of matter system the total amount of matter remains constant even though its form and location change.”
   - Carbon cycle
   - Nitrogen cycle
   - Food chains and food webs

- Proteins
  - Organic molecule
  - Building block of protein: amino acids
  - Structural component of cell membrane
  - Enzymes catalyze and regulate molecular interactions
  - Enzyme function is dependent upon its shape

- Nucleic Acids
  - Organic molecule
  - Building block: nucleotide is composed of a sugar, phosphate, and a nitrogen base
  - The structure of the DNA molecule helps ensure that genetic information is replicated exactly
  - DNA is a double helix that stores genetic information for assembling proteins and passing on genetic information
  - RNA is a single strand that contains instructions for protein synthesis

- Recognize and explain that minerals are inorganic substances necessary for cellular processes. A context for instruction might be: Ca and P in strength of bones and teeth and nervous transmission; Ca in muscular contraction; Fe in transport of oxygen; Na and K in transmission of nerve impulses.

- Recognize and explain that vitamins are organic molecules necessary for cellular processes.
  - Vitamin C: needed for wound healing
  - Vitamin K: needed for blood clotting
  - Vitamin D: needed for bone growth

- State Curriculum - Biology

- Protocols
  - Organic molecule
  - Building block of protein: amino acids
  - Structural component of cell membrane
  - Enzymes catalyze and regulate molecular interactions
  - Enzyme function is dependent upon its shape

- Nucleic Acids
  - Organic molecule
  - Building block: nucleotide is composed of a sugar, phosphate, and a nitrogen base
  - The structure of the DNA molecule helps ensure that genetic information is replicated exactly
  - DNA is a double helix that stores genetic information for assembling proteins and passing on genetic information
  - RNA is a single strand that contains instructions for protein synthesis

- Recognize and explain that minerals are inorganic substances necessary for cellular processes. A context for instruction might be: Ca and P in strength of bones and teeth and nervous transmission; Ca in muscular contraction; Fe in transport of oxygen; Na and K in transmission of nerve impulses.

- Recognize and explain that vitamins are organic molecules necessary for cellular processes.
  - Vitamin C: needed for wound healing
  - Vitamin K: needed for blood clotting
  - Vitamin D: needed for bone growth

- State Curriculum - Biology
## Expectation 3.1 Biochemistry: The student will be able to explain the correlation between the structure and function of biologically important molecules and their relationship to cell processes.

### Indicator 2. Discuss factors involved in the regulation of chemical activity as part of a homeostatic mechanism.

**Assessment Limits:**
- Osmosis (predicting water flow across a membrane based on the cell’s environment; explain role in living systems)
- Temperature (effect upon enzyme activity and metabolic rate; effect upon rate of diffusion and states of matter)
- pH (pH scale; relative values for acids and bases; effect on living systems; cellular; organismal)
- Enzyme regulation (effect of temperature; pH, and enzyme/substrate concentration on enzyme activity)

**Objectives**

- Define homeostasis and evaluate the importance of the ability of an organism to maintain its chemical and physical structure and function in relation to its internal and external environment.
- Use illustrations and data to investigate and describe environmental factors that organisms and cells must regulate.
  - Maintenance of water balance is a homeostatic mechanism.
    - Regulated through the process of osmosis
    - Explain the role of osmosis in living systems
    - Predict flow across a membrane in different cell environments
  - Maintenance of internal temperature is a homeostatic mechanism.
    - Effect on enzyme activity and metabolic rate
    - Effect on rate of diffusion
    - Effect on state of matter
  - Maintenance of pH is a homeostatic mechanism.
    - pH scale
    - Relative values for acids and bases
    - Effect on proteins, cells, and organisms
- Use illustrations and data to investigate, identify, describe, and analyze factors that affect enzyme activity.
  - Importance of enzyme-substrate complex
  - Enzyme and substrate concentration
  - Specificity of the enzyme to a substrate
  - Temperature
  - pH

### Homeostasis

- The rate of reactions among molecules is affected by:
  - How often molecules interact with each other
  - Temperature
  - Pressure
  - Concentration gradient
  - Permeable, selectively permeable, and impermeable barriers
- Predict behavior of molecules when certain environmental factors are present.
  - Osmosis: turgor pressure, plasmolysis, cytolysis, tonicity, dialysis.
  - Temperature: thermoregulation in reptiles, effect of fever, perspiration, effect on development of young organisms
  - pH: buffering capacity of blood, narrow range to support life in aquatic systems
- Enzyme specificity is a result of an induced fit mechanism involving the shape of the substrate and the active site.
  - Competitive inhibition. Contexts for instruction might include carbon monoxide, lead, or mercury poisoning
  - Quaternary structure of enzyme provides 3-dimensional structure and determines activity
  - Denaturation of enzymes may occur under certain conditions of temperature and pH
  - Cofactors such as vitamins and minerals affect enzyme activity

---

<table>
<thead>
<tr>
<th>Pre-requisites Summarized from State Curriculum</th>
<th>Biology State Curriculum (SC)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Life Science Grades 3 – 8</td>
<td></td>
</tr>
</tbody>
</table>

---

April 19, 2007  Page 27 of 48
Pre-requisites Summarized from State Curriculum
Life Science Grades 3 – 8

Grade 5
E. Flow of Matter and Energy

1. Recognize that some source of energy is needed for all organisms to grow and survive.
   a. Identify the sun as the primary source of energy for all living organisms.
      • Plants use sunlight to make food
      • Plants and animals use food for energy and growth
   b. Cite evidence from observations and research that some insects and various other organisms depend on dead plant and animal material for food.
   c. Provide examples that justify the statement “Most animals’ food can be traced back to plants.”

Grade 7
E. Flow of Matter and Energy

1. Explain that the transfer and transformation of matter and energy links organisms to one another and to their physical setting.
   a. Cite evidence from research and observations that food provides molecules that serve as fuel and building materials for all organisms.
   b. Cite evidence from research and observations that organisms that eat plants or animals break down what they have consumed (food) to produce the materials and energy they need to survive or store for later use.
   c. Investigate and describe the processes that enable plants to use the energy from light to make sugars (food) from carbon dioxide and water.
   d. Provide evidence from research to explain how plants can use the food they make immediately for fuel or stored for later use.

Expectation 3.1 Biochemistry: The student will be able to explain the correlation between the structure and function of biologically important molecules and their relationship to cell processes.

Objectives

- Identify and describe how atoms and molecules needed by organisms cycle among the living and nonliving components of the biosphere.
  - Water cycle: movement of water between living systems and the environment
    • Rule of water in living systems
  - Carbon cycle: movement of carbon between living systems and the environment; cyclic relationship between photosynthesis and cell respiration
    • Rule of carbon in living systems
    • Cyclic relationship between photosynthesis and cell respiration
  - Nitrogen cycle: movement of nitrogen between living systems and the environment
    • Roles of bacteria
    • Human impact on the nitrogen cycle
  - Manipulate conditions and analyze data to explain the use of energy and matter during photosynthesis.
    • Energy
      • Energy does not recycle but changes form as it flows through an ecosystem
      • Conversion of light energy to chemical energy through photosynthesis
      • ATP is the energy carrier molecule

Assessment Limits:
- Water cycle (movement of water between living systems and the environment)
- Carbon cycle (movement of carbon between living systems and the environment; cyclic relationship between photosynthesis and cell respiration)
- Nitrogen cycle (roles of bacteria; human impact)
- Photosynthesis (energy conversion: light, chemical; basic molecules involved)
- Cellular respiration (distinctions between aerobic and anaerobic: energy released, use of oxygen; basic molecules involved in aerobic)
- Chemosynthesis (from inorganic compounds)
- ATP (energy carrier molecule)

Supplemental Topics

- Matter and Energy
  • Water cycle
    • Transpiration
  • Carbon cycle
    • Word and/or symbolic equations for photosynthesis and respiration
      • During photosynthesis, atoms in CO2 and H2O are separated and recombined to form carbohydrates
      • During photosynthesis, atoms in water are separated to produce oxygen gas
    • During cellular respiration, atoms in carbohydrates and oxygen are separated and recombined to produce CO2 and H2O
  • Nitrogen cycle
    • Role of nitrogen in living systems
    • Nitrogen is a component of amino acids and nucleic acids
    • In the nitrogen cycle, nitrogen is used to produce ammonia, nitrate, and nitrate.
    • Nitrogen fixation occurs in legumes
    • Nitrogen returns to the environment through denitrification
  • Energy-related processes
    • ATP-ADP cycle
    • Light energy is transformed into chemical energy during photosynthesis by chlorophyll
    • During glycolysis, small amounts of ATP are produced.
    • During fermentation, atoms of carbohydrates are separated and recombined to form CO2 and ethyl alcohol or CO2 and lactic acid.
    • During chemosynthesis, instead of O2 produced from H2O, S is produced from H2S.
  • Anaerobic respiration
    • Occurs in cytoplasm

April 19, 2007
Page 28 of 48
Grade 7
E. Flow of Matter and Energy
e. Ask and seek answers to questions about the fact that transfer of matter between organisms continues indefinitely because organisms are decomposed after death to return food materials to the environment.

f. Provide evidence that supports the premise “In the flow of matter system the total amount of matter remains constant even though its form and location change.”
   - Carbon cycle
   - Nitrogen cycle
   - Food chains and food webs

- Matter
  - Matter is recycled between living and non-living systems
  - CO₂ and H₂O as basic molecules
  - Glucose produced as a food source

- Photosynthesis
  - Occurs in chloroplasts
  - Requires light, water, and carbon dioxide
  - Produces glucose and oxygen

- Manipulate conditions and analyze data to explain the use of energy and matter during cellular respiration.
  - Energy is released from the decomposition of glucose in cells.
    - ATP is the energy carrier molecule
    - Chemical energy from glucose converted to other energy forms

- Anaerobic respiration
  - Does not use oxygen
  - Produces less ATP energy than aerobic respiration

- Aerobic respiration
  - Occurs in mitochondria
  - Requires the presence of oxygen
  - Produces large amounts of ATP

- Identify that certain bacteria use matter and release energy from inorganic compounds through chemosynthesis.
## State Curriculum - Biology

### Pre-requisites Summarized from State Curriculum

#### Life Science Grades 3 – 8

**Grade 3**

- B. Cells
  1. Explore the world of minute living things to describe what they look like, how they live, and how they interact with their environment.
    - Use magnifying instruments to observe and describe using drawings or text (oral or written) minute organisms, such as brine shrimp, algae, aphids, etc. that are found in different environments.
  2. Describe any observable activity displayed by these organisms.
  3. Provide reasons that support the conclusion that these organisms are alive.
  4. Use information gathered about these minute organisms to compare mechanisms they have to satisfy their basic needs to those used by larger organisms.

**Grade 5**

- B. Cells
  1. Provide evidence from observations and investigations to support the idea that some organisms consist of a single cell.
    - Use microscopes, other magnifying instruments, or video technology to observe, describe, and compare single celled organisms, such as amoeoba, euglena, paramecium, etc.
  2. Describe the observable behaviors of single celled organisms.
  3. Cite evidence from data gathered that supports the idea that most single celled organisms have needs similar to those of multicellular organisms.

### Biology State Curriculum (SC)

**Expectation 3.2 Cellular:** The student will demonstrate an understanding that all organisms are composed of cells which can function independently or as part of multicellular organisms.

**Indicator 1.** Explain the processes and the function of related structures found in unicellular and multicellular organisms.

### Assessment Limits:
- transportation of materials (role of cellular membranes; role of vascular tissues in plants and animals; role of circulatory systems)
- waste disposal (role of cellular membrane; role of excretory and circulatory systems)
- movement (cellular- flagella, cilia, pseudopodia; interaction between skeletal and muscular systems)
- feedback (maintaining cellular and organismal homeostasis- water balance, pH, temperature, role of endocrine system)
- asexual (binary fission, budding, vegetative, mitosis; role in growth and repair, chromosome number remains the same); sexual reproduction (angiosperms, mammals)
- control of structures (cellular organelles and human systems) and related functions (role of nucleus, role of sensory organs and nervous system)
- capture and release of energy (chloroplasts and mitochondria)
- protein synthesis (ribosomes)

### Objectives

- Describe processes and structures that organisms use to sustain life.
- Use readings, illustrations, and observations in a survey of various organisms within several kingdoms to compare and describe the roles of organelles, tissues, and organ systems in the
  - transport of food, water, gases, and minerals by cell membranes and vascular tissues.
  - transport of waste substances by cell membranes and vascular tissues
  - methods of movement of various unicellular organisms using flagella, cilia, and pseudopodia.
  - interaction of skeletal and muscular systems resulting in movement in multicellular organisms.
  - asexual reproduction of various organisms including binary fission, budding, vegetative reproduction, and cell division following mitosis.
  - sexual reproduction in plants (angiosperms) and animals (mammals) occurs as a result of the union of two gametes.

### Supplemental Topics

#### Grade 3

- B. Cells
  1. Use magnifying instruments to observe and describe using drawings or text (oral or written) minute organisms, such as brine shrimp, algae, aphids, etc. that are found in different environments.
  2. Describe any observable activity displayed by these organisms.
  3. Provide reasons that support the conclusion that these organisms are alive.
  4. Use information gathered about these minute organisms to compare mechanisms they have to satisfy their basic needs to those used by larger organisms.

#### Grade 5

- B. Cells
  1. Provide evidence from observations and investigations to support the idea that some organisms consist of a single cell.
    - Use microscopes, other magnifying instruments, or video technology to observe, describe, and compare single celled organisms, such as amoeoba, euglena, paramecium, etc.
  2. Describe the observable behaviors of single celled organisms.
  3. Cite evidence from data gathered that supports the idea that most single celled organisms have needs similar to those of multicellular organisms.

### Processes and Functions

- The structure of the cell membrane controls the materials that enter and exit a cell in order to maintain homeostasis.
  - Passive transport
    - Diffusion/facilitated diffusion
    - Osmosis
  - Active transport
    - Role of proteins and ATP in movement of molecules
    - Endocytosis and exocytosis
    - Sodium-potassium pump
- The role of organelles in the process of protein synthesis.
  - Golgi apparatus as site of protein packaging
- Cell functions are regulated by genes on chromosomes, by proteins, such as enzymes, and through selective expression of genes that allow the cell to respond to its environment and to control and coordinate cell growth and division.
- Cells produced through mitosis contain identical genetic information.
- Cell cycle is an orderly sequence of events resulting in two identical cells.
## B. Cells

1. Gather and organize data to defend or argue the proposition that all living things are cellular (composed of cells) and that cells carry out the basic life functions:
   a. Use microscopes or other magnifying instruments to observe, describe, and compare the cellular composition of different body tissues and organs in a variety of organisms (animals and plants).
   b. Based on data from readings and designed investigations, cite evidence to illustrate that the life functions of multicellular organisms (plant and animal) are carried out within complex systems of different tissues, organs and cells:
      - Extracting energy from food
      - Getting rid of wastes
      - Making new materials
   c. Based on research and examples from video technology explain that the repeated division of cells enables organisms to grow and make repairs.
   d. Collect data from investigations using single celled organisms, such as yeast or algae to explain that a single cell carries out all the basic life functions of a multicellular organism:
      - Reproducing
      - Extracting energy from food
      - Getting rid of wastes
   e. Based on data compiled from a number of lessons completed, take and defend a position on the statement “The way in which cells function is the same in all organisms.”

2. Abilities of sensory organs and the nervous system to collect and respond to information from inside and outside the organism:
   - Recognize and explain that homeostasis is maintained through feedback within a cell, between cells, and between cells and their environment.
   - Maintenance of water balance through osmosis
   - Control of blood glucose levels, pH, and temperature by the endocrine system
   - Use readings and microscopic observations to describe that the process of mitosis results in maintenance of chromosome number and is essential for growth and repair of cells.
   - Use text and illustrations to describe the functions of the cell and cellular organelles as controlled by the nucleus:
      - Capture of light energy within chloroplasts during photosynthesis.
      - Release of energy in the form of ATP by mitochondria during cellular respiration.
      - Site of protein synthesis as the ribosome.
   - Protein synthesis is the manufacture of proteins necessary for cellular function and the maintenance of life.

- ability of sensory organs and the nervous system to collect and respond to information from inside and outside the organism.
- Recognize and explain that homeostasis is maintained through feedback within a cell, between cells, and between cells and their environment.
- Maintenance of water balance through osmosis
- Control of blood glucose levels, pH, and temperature by the endocrine system
- Use readings and microscopic observations to describe that the process of mitosis results in maintenance of chromosome number and is essential for growth and repair of cells.
- Use text and illustrations to describe the functions of the cell and cellular organelles as controlled by the nucleus.
- Capture of light energy within chloroplasts during photosynthesis.
- Release of energy in the form of ATP by mitochondria during cellular respiration.
- Site of protein synthesis as the ribosome.
- Protein synthesis is the manufacture of proteins necessary for cellular function and the maintenance of life.
<table>
<thead>
<tr>
<th>Pre-requisites Summarized from State Curriculum</th>
<th>Biology State Curriculum (SC)</th>
<th>Supplemental Topics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Life Science Grades 3 – 8</td>
<td>Expectation 3.2 Cellular: The student will demonstrate an understanding that all organisms are composed of cells which can function independently or as part of multicellular organisms.</td>
<td>Changes in Metabolic Activity</td>
</tr>
<tr>
<td>Indicator 2. Conclude that cells exist within a narrow range of environmental conditions and changes to that environment, either naturally occurring or induced, may cause changes in the metabolic activity of the cell or organism.</td>
<td></td>
<td>Buffer systems function within organisms to maintain homeostasis.</td>
</tr>
<tr>
<td>Assessment Limits:</td>
<td></td>
<td>Exposure to radiation can affect the length of the cell cycle.</td>
</tr>
<tr>
<td>• pH</td>
<td></td>
<td>Organismal behavior can be affected by factors from other parts of the organism, by other organisms, or the environment.</td>
</tr>
<tr>
<td>• temperature</td>
<td></td>
<td>Reduced rates of reproduction are usually one of the first effects of environmental stress.</td>
</tr>
<tr>
<td>• light</td>
<td></td>
<td>Some organisms function at the extremes of temperature, salinity, and pH.</td>
</tr>
<tr>
<td>• water</td>
<td></td>
<td>Light wavelength affects the rate of photosynthesis.</td>
</tr>
<tr>
<td>• oxygen</td>
<td></td>
<td>Light intensity and duration affect the rate of photosynthesis.</td>
</tr>
<tr>
<td>• carbon dioxide</td>
<td></td>
<td>Rate of plant growth is affected</td>
</tr>
<tr>
<td>• radiation (role in cancer or mutations)</td>
<td></td>
<td>Seasonal changes occur in deciduous trees</td>
</tr>
<tr>
<td>• toxins (natural, synthetic)</td>
<td></td>
<td>Behavioral changes in phytoplankton</td>
</tr>
<tr>
<td><strong>Objectives</strong></td>
<td></td>
<td><strong>Objectives</strong></td>
</tr>
<tr>
<td>➢ Recognize and explain that cell physiology can be affected by molecules from other parts of the organism or by other organisms.</td>
<td></td>
<td>Recognize and explain that cell physiology can be affected by molecules from other parts of the organism or by other organisms.</td>
</tr>
<tr>
<td>➢ Recognize and describe that changes in abiotic factors in the environment affect cells both positively and negatively and explain how these changes affect the activities of organisms.</td>
<td></td>
<td>Recognize and describe that changes in abiotic factors in the environment affect cells both positively and negatively and explain how these changes affect the activities of organisms.</td>
</tr>
<tr>
<td>➢ Manipulate conditions and analyze data to explain how changes in</td>
<td></td>
<td>Manipulate conditions and analyze data to explain how changes in</td>
</tr>
<tr>
<td>• pH levels affect the metabolic activity of organisms.</td>
<td></td>
<td>• pH levels affect the metabolic activity of organisms.</td>
</tr>
<tr>
<td>o Most organisms function best within a narrow range of pH levels</td>
<td></td>
<td>o Most organisms function best within a narrow range of pH levels</td>
</tr>
<tr>
<td>o Effect of pH on enzyme activity</td>
<td></td>
<td>o Effect of pH on enzyme activity</td>
</tr>
<tr>
<td>• Temperature affects the metabolic activity of organisms.</td>
<td></td>
<td>• Temperature affects the metabolic activity of organisms.</td>
</tr>
<tr>
<td>o Most organisms function best within a narrow range of temperatures</td>
<td></td>
<td>o Most organisms function best within a narrow range of temperatures</td>
</tr>
<tr>
<td>o Effect of temperature on proteins and enzyme reactions</td>
<td></td>
<td>o Effect of temperature on proteins and enzyme reactions</td>
</tr>
<tr>
<td>o Mechanisms used to regulate temperature such as perspiring and panting in endothermic, multicellular organisms</td>
<td></td>
<td>o Mechanisms used to regulate temperature such as perspiring and panting in endothermic, multicellular organisms</td>
</tr>
<tr>
<td>• Light intensity and duration affect the rate of photosynthesis.</td>
<td></td>
<td>• Light intensity and duration affect the rate of photosynthesis.</td>
</tr>
<tr>
<td>o Rate of plant growth is affected</td>
<td></td>
<td>o Rate of plant growth is affected</td>
</tr>
<tr>
<td>o Seasonal changes occur in deciduous trees</td>
<td></td>
<td>o Seasonal changes occur in deciduous trees</td>
</tr>
<tr>
<td>o Behavioral changes in phytoplankton</td>
<td></td>
<td>o Behavioral changes in phytoplankton</td>
</tr>
</tbody>
</table>
The amount of water in the environment affects the metabolic activity of an organism.

- Rate of plant growth is affected by the amount of water in soil
- Changes in salinity can affect osmosis
- Changes in the amount of dissolved gases in the water can affect cellular respiration and photosynthesis

Gas levels affect the metabolic activity of an organism.

- Changes in the amount of oxygen in the atmosphere can affect cellular respiration
- Changes in the amount of carbon dioxide in the atmosphere can affect photosynthesis

- Recognize and explain that radiation can cause mutations.
- Changes in chromosomes and genes can result in defective proteins
- Mutations may cause cancer

- Recognize that toxic substances can disrupt the metabolic activity of organisms.
  - Natural toxins such as mercury and lead
  - Synthetic toxins such as pesticides
## Pre-requisites Summarized from State Curriculum

**Life Science Grades 3 – 8**

### Grade 4

C. Genetics

1. Explain that in order for offspring to resemble their parents, there must be a reliable way to transfer information from one generation to the next.
   - Describe traits found in animals and plants, such as eye color, height, leaf shape, seed type that are passed from one generation to another.
   - Explain that some likenesses between parents and offspring are inherited (such as eye color in humans, nest building in birds, or flower color in plants) and other likenesses are learned (such as language in humans or songs in birds).
   - Raise questions based on observations of a variety of parent and offspring likenesses and differences, such as “Why don’t all the puppies have the same traits, such as eye color and size as their parents?” or “How do traits get transferred?”
   - Develop a reasonable explanation to support the idea that information is passed from parent to offspring.

### Grade 7

C. Genetics

1. Explain the ways that genetic information is passed from parent to offspring in different organisms.
   - Investigate and explain that in some kinds of organisms, all the genes come from a single parent, whereas in organisms that have sexes, typically half of the genes come from each parent.
   - Investigate and explain that in sexual reproduction, a single specialized cell from a female (egg) merges with a specialized cell from a male (sperm) and the fertilized egg now has genetic information from each parent, that multiplies to form the complete organism composed of about a trillion cells, each of which contains the same genetic information.
   - Investigate organisms that reproduce asexually to identify what traits they receive from the parent.

## Expectation 3.3 Genetics: The student will analyze how traits are inherited and passed on from one generation to another.

### Indicator 1. Demonstrate that the sorting and recombination of genes during sexual reproduction has an effect on variation in offspring.

**Assessment Limits:**
- meiosis (process that forms gametes; chromosome number reduced by one-half; crossing-over occurs; new gene combinations)
- fertilization (combination of gametes to form a zygote)

**Objectives**
- Use models and illustrations to describe the role of meiosis in the sorting and recombination of genes in sexual reproduction.
- Investigate and explain how fertilization combines genetic material from two parents.
- Egg and sperm are examples of gametes
- Gametes combine to form a zygote
- Zygote is a genetically unique individual

## Supplemental Topics

### Sexual Reproduction and Variation
- Independent assortment during meiosis contributes to variation.
- Meiosis is an orderly sequence of events resulting in the formation of gametes or other specialized cells with one-half the chromosome number.
- The chromosome number is changed from diploid to haploid during meiosis.
d. Use information about how the transfer of traits from parent or parents to offspring occurs, to explain how selective breeding for particular traits has resulted in new varieties of cultivated plants and domestic animals.

e. Identify evidence to support the idea that there is greater variation among offspring of organisms that reproduce sexually than among those that reproduce asexually.
### Expectation 3.3 Genetics: The student will analyze how traits are inherited and passed on from one generation to another.

**Indicator 2. Illustrate and explain how expressed traits are passed from parent to offspring.**

**Assessment Limits:**
- phenotypes (expression of inherited characteristics)
- dominant and recessive traits
- sex-linked traits (X-linked only; recessive phenotypes are more often expressed in the male)
- genotypes (represented by heterozygous and homozygous pairs of alleles)
- Punnett square – use to predict and/or interpret the results of a genetic cross; translate genotypes into phenotypes (monohybrid only)
- pedigree (use to interpret patterns of inheritance within a family)

**Objectives**
- Describe and demonstrate that the transmission of genetic information to offspring occurs through egg and sperm cells that contain only one representative from each chromosome pair.
- Identify and explain the difference between phenotype and genotype.
- Explore evidence and describe how traits that are hidden in one generation can be expressed in the next because cells contain two alleles of each gene.
- Dominant and recessive traits
- Phenotype of a heterozygous individual
- Expression and carrying of X-linked traits
- Explore the transmission of a single trait from one generation to the next generation by constructing and/or interpreting a Punnett Square.
- Monohybrid genetic crosses
- Genotypes into phenotypes
- Ratios of expected results
- Explore the transmission of a single trait from one generation to the next generation by constructing and/or interpreting a pedigree chart.
- Patterns (dominant, recessive, X-linked) of inheritance in a family
  - Proper symbols
  - Homozygous and heterozygous individuals
  - Genotype and phenotype of specific individuals

### Inherited Traits
- Exceptions to Mendelian Laws of Genetics include
  - Incomplete dominance
  - Co-dominance
  - Multiple alleles
  - Polygenic traits.
- Differences in the observed and expected results from genetic crosses may depend on sample size.
- Punnett squares of dihybrid crosses illustrate the inheritance of two traits.
- Karyotypes illustrate chromosome appearance and number.
### Pre-requisites Summarized from State Curriculum

**Life Science Grades 3 – 8**

<table>
<thead>
<tr>
<th>Expectation 3.3 Genetics: The student will analyze how traits are inherited and passed on from one generation to another.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Indicator 3.</strong> Explain how a genetic trait is determined by the code in a DNA molecule.</td>
</tr>
<tr>
<td><strong>Assessment Limits:</strong></td>
</tr>
<tr>
<td>- definition of gene (a segment of DNA that codes for protein or RNA)</td>
</tr>
<tr>
<td>- sequence of nitrogen bases directing protein formation (role of DNA, mRNA, tRNA, rRNA)</td>
</tr>
<tr>
<td>- proteins determine traits</td>
</tr>
</tbody>
</table>

#### Objectives

- Investigate and describe how the genes passed from parent to offspring are segments of a DNA molecule.
  - Gene is a segment of DNA that codes for a protein or RNA.
  - Proteins determine the expression of traits in an organism.
  - The sequence of nitrogen bases in DNA codes for amino acids
- Describe and model the process of protein synthesis.
  - The instructions for making an organism’s proteins are carried in the DNA molecule.
  - Messenger RNA (mRNA) is a single strand of nucleotides that carries the DNA code from the nucleus to the cytoplasm
  - Transfer RNA (tRNA) carries specified amino acids to the ribosome
  - Ribosomal RNA (rRNA) is a structural component of ribosomes
- Use a table of amino acids (codon table) to determine the amino acid sequence encoded in DNA or messenger RNA.

### Biology State Curriculum (SC)

<table>
<thead>
<tr>
<th></th>
<th>Supplemental Topics</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Nucleic Acids and Protein Synthesis</strong></td>
<td></td>
</tr>
<tr>
<td>- The process of transcription occurs during protein synthesis.</td>
<td></td>
</tr>
<tr>
<td>- The mechanism of base pairing when uracil replaces thymine in RNA</td>
<td></td>
</tr>
<tr>
<td>- The process of translation occurs during protein synthesis.</td>
<td></td>
</tr>
<tr>
<td>- The DNA code includes initiation and termination signals.</td>
<td></td>
</tr>
<tr>
<td>- mRNA codons and tRNA anti-codons specify amino acid sequences during protein synthesis at the ribosome.</td>
<td></td>
</tr>
</tbody>
</table>
## Expectation 3.3 Genetics: The student will analyze how traits are inherited and passed on from one generation to another.

### Indicator 4. Interpret how the effects of DNA alteration can be beneficial or harmful to the individual, society, and/or the environment.

**Assessment Limits:**
- mutations
- chromosome number (abnormalities)
- genetic engineering, (gene splicing, recombinant DNA, cloning)

### Objectives
- Recognize and explain that changes in DNA occur spontaneously and at a low rate in nature.
  - Radiation and chemicals are possible environmental causes of mutation.
  - Mutations that occur in gametes are passed on to offspring.
  - Mutations can be beneficial, harmful, or have no apparent effect.
- Investigate how changes in chromosome number can cause a genetic abnormality.
- Investigate and analyze evidence that genetic engineering enables manipulation of genes to create an altered organism.
  - Gene splicing
  - Recombinant DNA
  - Cloning
- Interpret results of gel electrophoresis
  - Contexts for instruction might include DNA fingerprinting, determining relatedness among species, determining paternity
- Evaluate and debate the possible positive and negative consequences of genetic engineering. Contexts for instruction might include:
  - Food crops
  - Vaccines
  - Gene therapy
  - Human Genome Project
  - Genetic diversity
  - Changes in evolutionary pathways

## DNA Alteration
- Types of mutations
  - Point mutations
    - Insertion, deletion, and substitution
  - Chromosome mutations
    - Insertion, deletion, substitution, translocation, and nondisjunction
- Genetic abnormalities can arise from changes in autosomes and sex chromosomes.
- Karyotypes illustrate chromosome number and size and are used to identify chromosomal abnormalities.
- Restriction enzymes cleave DNA at predictable places and are used in recombinant DNA technology.
Biology State Curriculum (SC)

Expectation 3.4 Evolution: Explain the mechanism of evolutionary change.

Indicator 1. Explain how new traits may result from new combinations of existing genes or from mutations of genes in reproductive cells within a population.

Assessment Limits:
- natural selection (definition; effects of environmental pressure)
- adaptations (effects on survival)
- variation (effects on survival and reproductive success)

Objectives
- Recognize that evolution occurs at the population level.
- Given evidence, support the statement that characteristics in structure, behavior, or chemistry can be inherited.
- Identify and describe that new traits arise from sexual reproduction or mutation and may be advantageous, have no effect, or be deleterious to an organism.
- Recognize and explain that changes in biotic or abiotic environmental factors may affect the survival advantage of inherited characteristics.
- Demonstrate and describe that some inherited variations have no survival or reproductive advantage but may still persist in a population due to chance alone.
- Investigate and explain that natural selection within and of species is the consequence of the interactions of:
  - the potential of a species to increase its numbers;
  - a finite supply of resources required for life;
  - the amount of genetic variation available in a population from mutation and recombination of genes;
  - the resulting selection of favored variations by environmental pressures;
  - the resulting offspring are more likely to survive and reproduce.

Evolutionary Change
- Natural selection causes a change in the frequency of genes in a population over successive generations.
- Fitness is differential reproductive success.
- Evolutionary processes account for the diversity of species.
- Reproductive isolation as a result of environmental pressures and natural selection
- Adaptive radiation
- Divergent evolution
- Convergent evolution
- Coevolution
- Recognize and explain that evolution does not progress in a set direction
  - Produces new populations that may continue to evolve
  - Produces well adapted populations that remain the same over time
  - Produces populations that become extinct
<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>d. Explain, with examples, ways that people control some characteristics of plants and animals they raise by selective breeding.</td>
<td></td>
</tr>
<tr>
<td>e. Describe ways in which changes in environmental conditions can affect the survival of individual organisms and entire species.</td>
<td></td>
</tr>
<tr>
<td>f. Describe how sediments of sand and smaller particles (sometimes containing the remains of organisms) are gradually buried and are cemented together by dissolved minerals to form solid rock; and describe that such fossils provide evidence for the long history of changing life forms whose remains are found in the rocks.</td>
<td></td>
</tr>
<tr>
<td>g. Explain that the more recently deposited rock layers are likely to contain fossils resembling existing species.</td>
<td></td>
</tr>
</tbody>
</table>
**State Curriculum - Biology**

<table>
<thead>
<tr>
<th>Pre-requisites Summarized from State Curriculum</th>
<th>Biology State Curriculum (SC)</th>
<th>Supplemental Topics</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Life Science Grades 3 – 8</strong></td>
<td><strong>Expectation 3.4 Evolution: Explain the mechanism of evolutionary change.</strong></td>
<td><strong>Relatedness Among Organisms</strong></td>
</tr>
<tr>
<td><strong>D. Evolution</strong></td>
<td><strong>Indicator 2. Estimate degrees of relatedness among organisms or species.</strong></td>
<td>• Species can be classified into large groups called domains and kingdoms, which are comprised of organisms with general similarities.</td>
</tr>
<tr>
<td>1. Recognize and describe that evolutionary change in species over time occurs as a result of natural variation in organisms and environmental changes.</td>
<td><strong>Assessment Limits:</strong></td>
<td>• Classification of prokaryotes and eukaryotes is based on their evolutionary relationships.</td>
</tr>
<tr>
<td>a. Recognize and describe that gradual (climatic) and sudden (floods and fires) changes in environmental conditions affect the survival of organisms and populations.</td>
<td>• classification (recognize relationships among organisms; distinguish between prokaryotes and eukaryotes)</td>
<td>• Dichotomous keys and are tools that can be used to show relatedness among organisms.</td>
</tr>
<tr>
<td>b. Recognize that adaptations may include variations in structures, behaviors, or physiology, such as spiny leaves on a cactus, birdcalls, and antibiotic resistant bacteria.</td>
<td>• anatomical similarities (evolutionary relationships; homologous structures)</td>
<td>• Cladograms are tools that can be used to suggest relatedness through ancestry.</td>
</tr>
<tr>
<td>c. Recognize and describe that adaptation and speciation involve the selection of natural variations in a population.</td>
<td>• similarities of DNA base sequence and/or amino acid sequence including results from gel electrophoresis)</td>
<td></td>
</tr>
<tr>
<td>d. Recognize and describe that extinction occurs when the adaptive traits of a population do not support its survival.</td>
<td><strong>Objectives</strong></td>
<td></td>
</tr>
<tr>
<td>e. Recognize that evolution accounts for the diversity of species.</td>
<td>• Recognize and explain that the DNA code is virtually the same for all life forms.</td>
<td></td>
</tr>
<tr>
<td><strong>Relatedness Among Organisms</strong></td>
<td><strong>Objectives</strong></td>
<td>• Integrate scientific information from a variety of disciplines to provide evidence for the relatedness of species on Earth, such as:</td>
</tr>
<tr>
<td>Species can be classified into large groups called domains and kingdoms, which are comprised of organisms with general similarities.</td>
<td>• Recognize and explain that the DNA code is virtually the same for all life forms.</td>
<td>• Geology, including fossils, radiometric dating</td>
</tr>
<tr>
<td>Classification of prokaryotes and eukaryotes is based on their evolutionary relationships.</td>
<td>• Integrate scientific information from a variety of disciplines to provide evidence for the relatedness of species on Earth, such as:</td>
<td>• Comparative anatomy, including studies of homologous structures and anatomical similarities</td>
</tr>
<tr>
<td>Dichotomous keys and are tools that can be used to show relatedness among organisms.</td>
<td>• Explain that the millions of different species that live on earth today are related by common ancestry.</td>
<td>• Biochemistry, including studies of DNA base and/or amino acid sequences</td>
</tr>
<tr>
<td>Cladograms are tools that can be used to suggest relatedness through ancestry.</td>
<td>• Classify and identify prokaryotes and eukaryotes based on their cell structures.</td>
<td>• Taxonomic systems based on biochemical and anatomical similarities</td>
</tr>
<tr>
<td></td>
<td>• Identify, explain, and demonstrate how technology can be used to determine evolutionary relationships among species.</td>
<td>• Explain that the millions of different species that live on earth today are related by common ancestry.</td>
</tr>
<tr>
<td></td>
<td>• Gel electrophoresis</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Similarities of DNA base sequences and/or amino acid sequences</td>
<td></td>
</tr>
</tbody>
</table>
## Pre-requisites Summarized from State Curriculum

<table>
<thead>
<tr>
<th>Grade 4</th>
<th>F. Ecology</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Explain ways that individuals and groups of organisms interact with each other and their environment</td>
<td></td>
</tr>
<tr>
<td>a. Identify and describe the interactions of organisms present in a habitat</td>
<td></td>
</tr>
<tr>
<td>• Competition for space, food, and water</td>
<td></td>
</tr>
<tr>
<td>• Beneficial interactions: nesting, pollination, seed dispersal, oysters filtering as in the Chesapeake Bay, etc.</td>
<td></td>
</tr>
<tr>
<td>• Roles within food chains and webs: scavengers, decomposers, producers, consumers</td>
<td></td>
</tr>
<tr>
<td>b. Explain that changes in an organism’s habitat are sometimes beneficial to it and sometimes harmful</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Grade 6</th>
<th>F. Ecology</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Give reasons supporting the fact that the number of organisms an environment can support depends on the physical conditions and resources available</td>
<td></td>
</tr>
<tr>
<td>a. Explain that populations increase or decrease relative to the availability of resources and the conditions of the environment</td>
<td></td>
</tr>
<tr>
<td>b. Identify and describe factors that could limit populations within any environment, such as disease, introduction of a nonnative species, depletion of resources, etc.</td>
<td></td>
</tr>
<tr>
<td>c. Explain that within any environment organisms with similar needs may compete with one another for resources</td>
<td></td>
</tr>
<tr>
<td>d. Cite examples to illustrate that competition is reduced when organisms use different sets of resources, such as birds in a forest eat different kinds and sizes of seeds</td>
<td></td>
</tr>
</tbody>
</table>

## Expectation 3.5: Ecology: The student will investigate the interdependence of diverse living organisms and their interactions with components of the biosphere.

### Indicator 1. Analyze the relationships between biotic diversity and abiotic factors in environments and the resulting influence on ecosystems.

### Assessment Limits:

<table>
<thead>
<tr>
<th>Abiotic/Biotic Factors</th>
</tr>
</thead>
<tbody>
<tr>
<td>space</td>
</tr>
<tr>
<td>soil</td>
</tr>
<tr>
<td>water</td>
</tr>
<tr>
<td>air</td>
</tr>
<tr>
<td>temperature</td>
</tr>
<tr>
<td>food</td>
</tr>
<tr>
<td>light</td>
</tr>
<tr>
<td>organisms</td>
</tr>
</tbody>
</table>

### Relationships

- predator – prey |
- parasite – host |
- mutualism |
- commensalism |
- competition

### Objectives

- Through investigation and analysis of data, demonstrate that biotic and abiotic environmental factors limit the distribution and abundance of organisms and populations in ecosystems.

  - Space
    - Availability
    - Species diversity
    - Number of organisms
  - Water
    - Availability
    - Concentration of dissolved and suspended materials
    - Salinity
    - pH
    - Pollutants
  - Light
    - Intensity

### Factors Influencing Ecosystems

- Factors that affect populations of organisms
  - Location
    - Climate
    - Latitude
    - Altitude
    - Depth
  - Water
    - Temperature
    - Pressure
  - Air
    - Pressure
  - Mutualism
    - Relationships arise through coevolution
    - Evolutionary change in one organism results in a change in its partner

- Extremophiles exist in unique environments. Examples may include environments extreme in salt, pH, temperature, altitude, or pressure conditions.
• Temperature
  o Range
  o Seasonal changes
• Air
  o Concentration of oxygen and carbon dioxide
  o Humidity
  o Wind speed
  o Pollutants
• Soil
  o Physical and chemical composition
  o pH
• Food
  o Abundance
  o Number of sources
• Other organisms
  o Number of species
  o Population density
  o Relationship to other organisms
  o Species interactions

Recognize and describe how specialized interactions/relationships among organisms affects the stability of an ecosystem.
• Predator and prey interactions
• Competition for resources
  o Impact of competition on the ecosystem
• Symbiotic relationships (give examples of each)
  o Parasitism
  o Commensalism
  o Mutualism
## Pre-requisites Summarized from State Curriculum

**Life Science Grades 3 – 8**

### Expectation 3.5. Ecology: The student will investigate the interdependence of diverse living organisms and their interactions with components of the biosphere.

### Supplemental Topics

**Indicator 2. Analyze the interrelationships and interdependencies among different organisms and explain how these relationships contribute to the stability of the ecosystem.**

### Assessment Limits:
- diversity
- succession
- trophic level (producer; consumer: herbivore, carnivore, omnivore, scavenger; decomposer)
- niche (role of organism within an ecosystem)
- pyramid (energy, biomass)

### Objectives

- Analyze data and interpret or construct diagrams to explain how the flow of energy maintains the stability of the ecosystem.
  - Continuous one-way input of energy from the sun to the food web
  - Rate of photosynthesis and number of photosynthetic organisms determines the amount of energy available to other trophic levels
  - Organisms exist at various trophic levels based on how they obtain energy
    - Producers are usually plants that occupy the first trophic level
    - Consumers occupy all other levels
    - Herbivores or primary consumers occupy the second trophic level and feed only at that level
    - Secondary consumers
      - Can occupy and feed at more than one trophic level
      - Smaller and larger carnivores
      - Scavengers
      - Omnivores
    - Decomposers act at all levels
  - Energy is used, transferred, stored, or dissipated as heat through the trophic levels of the food web
  - In biological systems, the usable energy decreases at each change in trophic level
  - Pyramids of energy and biomass graphically depict relationships among organisms in a food web.
- Evaluate and predict how a greater diversity of organisms contributes to the stability of an ecosystem.

### Interdependence of Organisms in the Biosphere

- Processes of bioaccumulation and biomagnification of chemicals such as lead, mercury, and DDT moving through a food chain.
- Environmental conditions may cause plants and marine organisms to grow faster than decomposers can recycle them back into the environment, resulting in an accumulation of stored energy.
- The total energy is conserved at each change of trophic level.
- There is a limit to the number of trophic levels in a food chain.
  - Autotrophs produce their own food.
  - Heterotrophs depend on other organisms for food.
- A greater number of niches permits greater diversity and stability
  - Niche overlap leads to competition and specialization into available niches
  - A species' success within a particular niche is a result of natural selection
- The cycling of matter helps maintain the stability of the ecosystem.
  - Role of global biogeochemical cycles in recycling and storage of inorganic substances as a source of nutrients.
  - Role of forests, atmosphere, and marine phytoplankton in the global carbon cycle
  - Role of respiration from soil and marine organisms as carbon sources
  - Role of decomposers in recycling of organic materials
Greater diversity of organisms contributes to an uninterrupted cycling of matter and flow of energy through the food web.
Greater diversity of habitats provides a variety of niches that reduce competition for specific resources.

- Analyze the role of niche in stabilizing an ecosystem.
  - Niche is defined and determined by the interaction of an organism with abiotic and biotic factors.
  - Each species, by its anatomy, physiology, and behavior, is adapted to occupy its own particular niche.

- Recognize and describe that when an ecosystem is disrupted, it is likely to recover in stages that eventually result in a system representative of the original one.
  - Temporary changes in diversity
  - Biodiversity and biomass increase
  - Examples of terrestrial and aquatic succession
  - Climate changes affect distribution of organisms
  - Food web dynamics affected by local population changes or by the appearance of a new species as a result of migration.
## Grade 4

### B. Environmental Issues

1. **Recognize and describe** that people in Maryland depend on change, and are affected by the environment.
   - Identify and describe that human activities in a community or region are affected by environmental factors
     - Presence and quality of water
     - Soil type
     - Temperature
     - Precipitation

### Grade 5

### B. Environmental Issues

1. **Recognize and explain** that decisions influencing the use of natural resources may have benefits, drawbacks, unexpected consequences, and tradeoffs.
   - Identify and describe personal and community behaviors that waste natural resources and/or cause environmental harm and those behaviors that maintain or improve the environment.
   - Identify and describe that individuals and groups assess and manage risk to the environment differently.

2. **Recognize and describe** that consequences may occur when Earth’s natural resources are used.
   - Explain how human activities may have positive consequences on the natural environment
     - Recycling centers
     - Native plantings
     - Good farming practice
   - Explain how human activities may have a negative consequence on the natural environment
     - Damage or destruction done to habitats
     - Air, water, and land pollution
   - Identify and describe that an environmental issue affects individuals and groups differently.

## Expectation 3.5: Ecology

### Indicator 3. Investigate how natural and human-made changes in environmental conditions will affect individual organisms and the dynamics of populations.

### Assessment Limits:
- depletion of food
- destruction of habitats
- disease
- natural disasters
- pollution
- population increase
- urbanization

### Objectives

- Use scientific data to explain that, although organisms have the capacity to produce populations of infinite size, population growth is limited by environmental factors and resources.
- Investigate and explain that environmental problems arise when human activities and technology disrupt the equilibrium in the food web or interfere with the natural biogeochemical cycles.
  - Habitat destruction
  - Biogeochemical cycles. Contexts for instruction may include:
    - Use of fossil fuels impact on the carbon cycle
    - Use of inorganic fertilizers impact on the nitrogen cycle
    - Use of water for agricultural, industrial, and residential purposes impact on water cycle
  - Introduction of non-native species
  - Eliminating a species from an ecosystem
  - Climate change
  - Release of genetically altered organisms into the environment
- Investigate and explain how natural events may affect individuals and populations.
  - Fire
  - Disease
  - Climate change
  - Population increase
  - Depletion of food

## Supplementary Topics

### Population Dynamics

- Although organisms have the capacity to produce populations of infinite size, population growth is limited by environmental factors and resources.
  - Exponential growth pattern
  - Populations can reach or temporarily exceed carrying capacity
  - Availability of space
  - Availability of resources
  - Number of competing organisms
<table>
<thead>
<tr>
<th>Grade 6</th>
<th>B. Environmental Issues</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Recognize and explain that human-caused changes have consequences for Maryland’s environment as well as for other places and future times.</td>
<td></td>
</tr>
<tr>
<td>a. Identify and describe a range of local issues that have an impact on people in other places.</td>
<td></td>
</tr>
<tr>
<td>b. Recognize and describe how environmental change in one part of the world can have consequences for other parts of the world.</td>
<td></td>
</tr>
<tr>
<td>c. Identify and describe that ecosystems can be impacted by human activities.</td>
<td></td>
</tr>
<tr>
<td>• Protection of the Chesapeake Bay watershed</td>
<td></td>
</tr>
<tr>
<td>• Resource acquisition and use</td>
<td></td>
</tr>
<tr>
<td>• Land use decisions (agriculture, mining, and development)</td>
<td></td>
</tr>
<tr>
<td>• Recycling</td>
<td></td>
</tr>
<tr>
<td>• Use and disposal of toxic substances</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Grade 7</th>
<th>B. Environmental Issues</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Recognize and describe that environmental changes can have local, regional, and global consequences.</td>
<td></td>
</tr>
<tr>
<td>a. Identify and describe a local, regional, or global environmental issue.</td>
<td></td>
</tr>
<tr>
<td>b. Identify and describe that different individuals or groups are affected by an issue in different ways.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Grade 8</th>
<th>B. Environmental Issues</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Recognize and explain how human activities can accelerate or magnify many naturally occurring changes.</td>
<td></td>
</tr>
<tr>
<td>a. Based on data from research identify and describe how natural processes change the environment.</td>
<td></td>
</tr>
<tr>
<td>• Cyclic climate change</td>
<td></td>
</tr>
<tr>
<td>• Sedimentation in watersheds</td>
<td></td>
</tr>
<tr>
<td>• Population cycles</td>
<td></td>
</tr>
<tr>
<td>• Extinction</td>
<td></td>
</tr>
<tr>
<td>b. Identify and describe how human activities produce changes in natural processes.</td>
<td></td>
</tr>
<tr>
<td>• Climate change</td>
<td></td>
</tr>
<tr>
<td>• Loss of habitat</td>
<td></td>
</tr>
<tr>
<td>• Introduction of nonnative species</td>
<td></td>
</tr>
<tr>
<td>• Cycling of matter</td>
<td></td>
</tr>
</tbody>
</table>
### Expectation 3.5: Ecology
The student will investigate the interdependence of diverse living organisms and their interactions with components of the biosphere.

**Indicator 4. Illustrate how all organisms are part of and depend on two major global food webs that are positively or negatively influenced by human activity and technology.**

**Assessment Limits:**
- oceanic food web
- terrestrial food web

**Objectives**
- Recognize and explain that the global distribution and abundance of organisms and populations in ecosystems are limited by the availability of matter and energy and the ability of the ecosystem to recycle materials.
- Recognize and explain that all of Earth’s ecosystems can be categorized within two global environments that interface with each other, either oceanic or terrestrial.
- Interpret or construct a diagram to illustrate the interrelationships of organisms within an oceanic or terrestrial food web.
- Investigate the variables that affect the distribution and relative abundance of organisms within the terrestrial and oceanic environments, such as:
  - Differences in availability and intensity of light
  - Temperature range
  - Availability and distribution of nutrients
  - Water chemistry and availability
  - Removal from or addition of an organism to an ecosystem
- Recognize and explain that one ecosystem is linked to another through the interaction of organisms and the cycling of matter and the flow of energy.
- Describe how technology and human-made changes in local environments may affect the global environment.

**Global Food Webs**
- Investigate and discuss all sides of local and global environmental issues.