

# **CLEMSON BIOLOGY PROJECT USING CASIO TECHNOLOGY**

## **20 HIGH SCHOOL BIOLOGY INVESTIGATIONS**

### **Titles and Concepts**

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### **UNIT 1 Cell Biology**

#### **CB 1. Diffusion**

##### Materials

- Casio fx2 Graphing Calculator
- Casio QV2800 Digital Camera
- marking pen
- seven small beakers
- HCl solutions (5%, 0.5%, 0.05% and 0.0005%)
- block of phenolphthalein agar
- knife or dental floss to cut the agar
- four plastic spoons
- stopwatch
- paper towels
- metric ruler
- safety goggles
- latex gloves

##### Concepts

1. Diffusion is the tendency for molecules to disperse from area of greater to area of lesser concentrations.
2. Diffusion tends to occur evenly in all directions.
3. Variables such as temperature can affect the rate of diffusion through a medium.
4. Although the concentration of a substance undergoing diffusion can affect the number of molecules moving per unit time, it will not affect the distance moved per unit time.
5. The rate of diffusion of molecules through a gel (or a cell) will depend upon the ratio of the volume of that gel to its surface area. Thus diffusion will occur through a smaller object faster than a larger object.

#### **CB 2. Fermentation**

##### Materials

- Casio fx2 Graphing Calculator
- Casio QV2800 Digital Camera
- Casio Data Collector EA-100
- CO<sub>2</sub> probe

##### Concepts

1. Anaerobic organisms are those who do not require oxygen to metabolize, grow and reproduce.
2. Anaerobes use an alternate pathway to extract energy from carbohydrates such as sugars. This alternate pathway does not use oxygen and produces carbon dioxide and ethyl alcohol as waste products.
3. Anaerobic respiration can be observed by placing yeast in sugar water.

#### **CB 3. Biological Decomposition**

##### Materials

- Casio QV2800 Digital Camera
- Casio Data Collector EA-100
- CO<sub>2</sub> probe

##### Concepts

1. Fungi and bacteria are important organisms involved in helping to decompose dead organic matter. These organisms can be observed on rotting food.
2. Organic decomposition is a process by which decomposing organisms use dead organic matter as nutrients for themselves.
3. Since decomposing organisms are alive, they require a nutrient source, moisture and oxygen to grow and reproduce.
4. Optimum decomposition occurs at warmer temperatures and higher humidity.

## CB 4. Sugar Metabolism

### Materials

- Casio fx2 Graphing Calculator
- Casio QV2800 Digital Camera
- Casio Data Collector EA-100
- CO<sub>2</sub> probe

### Concepts

1. Yeast will metabolize a variety of carbohydrates. One product of yeast fermentation is carbon dioxide.
2. Yeasts can ferment less complex carbohydrates more quickly than more complex ones. This can be determined experimentally by mixing yeast with different carbohydrates such as glucose, sucrose and starch.
3. A control is useful in an experiment in order to make comparisons to variables manipulated.
4. The extent of yeast fermentation can be determined by measuring the carbon dioxide output visually and volumetrically.

## CB 5. Factors in Yeast Growth

### Materials

- Casio fx2 Graphing Calculator
- Casio QV2800 Digital Camera
- Casio Data Collector EA-100

### Concepts

1. Yeasts are microscopic fungi that thrive under conditions of adequate water, heat and food.
2. Temperature and type and amount of food are variables that affect the growth rate of yeasts.
3. Yeasts do not use oxygen in their metabolism because they are anaerobic organisms.
4. The products of yeast fermentation are carbon dioxide, ethyl alcohol and heat.
5. Careful experimentation, data collection, and data interpretation can determine answers to questions about the variables contributing to the rate of yeast growth.
6. Independent variables are those factors that may cause different results to occur in an experiment and dependent variables are the results.

## UNIT 2 Physiology & Behavior

## CB 6. Effects of Exercise on Pulse & Breathing Rates

### Materials

- Casio fx2 Graphing Calculator
- Casio QV2800 Digital Camera
- Casio Data Collector EA-100
- EKG probe
- breathing rate probe
- heartbeat rate probe
- CO<sub>2</sub> probe

### Concepts

1. The human cardiovascular system will make adjustments to the level of activity being done by the body.
2. Among the variables that can be measured when the human body responds to different levels of activity are pulse rate, breathing rate, blood pressure and CO<sub>2</sub> production. These can be determined experimentally by varying the level of exercise.
3. Normally the more active the level of exercise in the human body, the higher is the pulse rate, breathing rate, blood pressure and CO<sub>2</sub> production.

## CB 7. Temperature and Heartbeat Rate in Earthworms

### Materials

- Casio fx2 Graphing Calculator
- Casio QV2800 Digital Camera
- Casio Data Collector EA-100
- temperature probe

### Concepts

1. The earthworm, *Lumbricus terrestris*, has a relatively complex nervous and circulatory system.
2. The "hearts" in an earthworm do not have their own musculature, as does the human. These hearts are compressed by contractions of muscles along the side of the worm.
3. The major blood vessel of the earthworm is the dorsal aorta. It lies along the dorsal or topside of most of the length of the worm providing oxygenated blood and nutrients to the brain and other organs and tissues.
4. When the hearts of the worm are compressed an enlarged dorsal aorta can be observed. These enlargements and constrictions can be observed at the heartbeat rate of the worm.

5. The heartbeat rate of the earthworm will vary with the temperature of the environment. This can be determined experimentally by submerging the worm in a thin layer of water at different temperatures from approximately 0-30 degrees C. Higher temperatures may cause shock or death.
6. Since the earthworm does not have gills or lungs, oxygen must diffuse into the body through its skin. Being submerged in water for extended periods of time may cause the worm to experience oxygen deprivation.

## **CB 8. Metabolism of Germinating Pea Seedlings**

### Materials

- Casio fx2 Graphing Calculator
- Casio QV2800 Digital Camera
- Casio Data Collector EA-100
- CO<sub>2</sub> probe
- oxygen probe
- temperature probe

### Concepts

1. Plants and many microorganisms are capable of photosynthesis when sunlight and water are available. Plants, fungi, animals and many microorganisms also carry out cellular respiration or fermentation as well.
2. Until a germinating plant seedling can develop leaves and photosynthesize, it will carry out cellular respiration in order to grow.
3. The respiration of a germinating plant seedling can be detected experimentally.

## **CB 9. Anatomy and Physiology of Human Response Rates**

### Materials

- Casio fx2 Graphing Calculator
- Casio QV2800 Digital Camera
- meter stick

### Concepts

1. Reaction to sensory stimuli in the environment by a human will involve both sensory and motor nerve pathways.
2. The physiological reaction rate of humans to stimuli can be estimated experimentally.
3. The reaction rate by different sensory systems in a human will vary and may be dependent upon the specific nerve pathway taken by the stimulus.
4. Differences in visual, auditory and tactile sensory pathways in the human may take different amounts of time.

## **CB 10. The Limits of Learning**

### Materials

- Casio fx2 Graphing Calculator
- stopwatch or clock with second hand
- 2-piece jigsaw puzzle
- Casio QV2800 Digital Camera

### Concepts

1. The time taken to complete a routine task can be improved only up to a point. This point is often determined by the physiological limits of human coordination. Often the time taken on a task may increase due to fatigue and other factors.
2. The graph made from the times taken to put together a simple jigsaw puzzle is a typical learning curve. Often the phases include: increased efficiency, plateau and fatigue.
3. The learning curve has applications to many human tasks.

## **UNIT 3 Diversity**

### **CB 11. Who Else Goes to My School?**

#### Materials

- Casio fx2 Graphing Calculator
- Casio QV2800 Digital Camera

#### Concepts

1. Many different organisms other than humans can be found at or near a typical school.
2. There are systematic methods of sighting and identifying diverse organisms living at or near a school. Among these is a quick survey approach utilizing a data table of counts of different organisms. Data tables also help to communicate the results of the survey.
3. A quick survey approach to sighting organisms at or near a school will only find a fraction of the actual organisms that live at or near a school. Among the reasons for this are time of the day at which some organisms may be active and visible, season, weather conditions, instrumentation available to find microorganisms, or simply not seeing organisms out at the time of the survey.

## **CB 12. Trophic Scavenger Hunt**

### Materials

- Stopwatch
- Casio FX graphing calculator
- natural area outside classroom
- field guides to identify organisms
- colored construction paper
- scissors
- tape

### Concepts

1. A trophic level represents an organism's position on an energy pyramid and is determined by the food they eat and the type of organisms that may eat them.
2. Common trophic levels on an energy pyramid are producers (photosynthesizers), primary consumers (herbivores), secondary consumers (carnivores) and tertiary consumers (those that eat carnivores or those who are scavengers).
3. An energy pyramid is a graphical representation of the amount of total energy contained in any trophic level. The amount of energy in each trophic level is shown by a rectangle. When each rectangle is stacked with producers at the bottom, then herbivores, then carnivores, in order, a visual comparison of the relative amounts of energy in each level can be seen.
4. The energy pyramid also represents the flow of energy through a typical ecosystem.
5. The energy pyramid is roughly shaped like a triangle or pyramid because, as energy is consumed and utilized by organisms in each trophic level, only a fraction of the energy at a given level is available for the next level up the pyramid.

## **CB 13. Investigating an Ecosystem**

### Materials

- Casio fx2 Graphing Calculator
- Casio QV2800 Digital Camera

### Concepts

1. Biomes are large ecosystems with characteristic climate and characteristic flora and fauna. Some examples are forest, grassland, desert, tundra and chaparral. Examples of characteristic and dominant organisms in these biomes are broadleaf deciduous trees and bears, grasses and rabbits, cacti and rattlesnakes, mosses and moose, and shrubs and deer respectively. Each biome also has its characteristic food web.
2. The major factors that determine the organisms present in any ecosystem are the annual patterns of temperature and precipitation.
3. A climatogram is a graphical representation of the annual temperature and precipitation pattern in a given biome. The organisms present in a biome can be predicted by examining its climatogram.
4. The general nature and characterization of any ecosystem can be determined by collecting data on organisms present in defined plot of an ecosystem. The food web for an ecosystem can be constructed from these data.

## **UNIT 4 Ecology & Environment**

### **CB 14. Measuring Biomass**

#### Materials

- Casio fx2 Graphing Calculator
- Casio QV2800 Digital Camera
- ruler or meter stick
- corn and lima bean seedlings
- sand
- compost or potting soil
- local soil.

#### Concepts

1. The basic needs for seed germination are moisture and moderate warmth. Healthy seedling growth additionally requires minerals from the soil and light to the leaves.
2. Organic content, such as humus, in the soil helps to keep moisture available to the roots of plants and serves as a habitat for microorganisms that provide rich nutrients for growth.
3. The rate of seedling growth will vary depending upon the amount of moisture, light, temperature, minerals and other materials in the soil.
4. Careful experimentation, data collection, and data interpretation can determine answers to questions about the variables contributing to the rate of plant growth.

## **CB 15. How Much Land Can Support a Person?**

### Materials

- Casio FX graphing calculator

### Concepts

1. A calorie (c) is a measure of food energy equal to the amount of heat needed to raise 1 gram of water by 1 degree Celsius. Most food labels report the energy in their contents in kilocalories (capital C or Calories).  $1000\text{ c} = 1\text{ C}$ .
2. Most teenagers consume between 2,000 and 5,000 Calories per day, depending upon their metabolic rate and their level of activity. Most adults who keep their weight stable consume between 1,000 and 2,000 calories per day. Many diet plans will try to keep an average adult at approximately 1,000 calories per day.
3. The amount of Calories consumed by a person over a period of time can be easily estimated by keeping a record of all food consumed each day.
4. Since all food Calories come directly or indirectly from plants such as corn and wheat, the amount of land needed to produce a given number of calories for a given crop is quite constant.
5. The amount of land needed to support a human at a given caloric intake can be calculated.
6. Most North Americans consume more food energy than they utilize. The frequent result is obesity.

## **CB 16. Sustaining A Population**

### Materials

- Casio fx2 Graphing Calculator
- Casio QV2800 Digital Camera

### Concepts

1. Populations have basic needs in order to grow. Although each species has somewhat different requirements, typical growth requirements include nutrients, sunlight or food source, water, shelter, and protection from extreme temperatures and space.
2. The growth requirements of a specific population can be learned by observing that population attempting to grow over time. Ideal growth conditions can be determined experimentally.

## **CB 17. My Family Population in 100 Years**

### Materials

- Casio fx2 Graphing Calculator
- Casio QV2800 Digital Camera

### Concepts

1. Several important variables affect the growth rate of human populations. Among these is the number of children born to a set of parents each generation, the time between generations, and the age at which a couple first has children .
2. The age at which couples first have children in an extended family may have greater impact on the total family population after a long period (such as 100 years) than does other variables.
3. The only way that a family can produce little or no net growth over long period is to have only one child per couple each generation. Achieving XPG is possible but it takes careful planning.

## **CB 18. A Trash Audit**

### Materials

- Casio fx2 Graphing Calculator
- Casio QV2800 Digital Camera
- Casio Data Collector EA-100
- pH and humidity probes
- electronic balance
- disposable plastic gloves
- large garbage bags
- trash

### Concepts

1. The total matter of a system is conserved.
2. Trash from typical human activity can be sorted into four categories: Recyclable or reusable, compostable, burnable and disposable. The first three of these categories make land fill unnecessary.
3. The vast majority of human-generated trash is either reusable or compostable.
4. Human trash enters a waste stream containing many routes depending upon the care and decisions made to deal with the trash components.

## **CB 19. Building a Compost Column**

### Materials

- Casio QV2800 Digital Camera
- 3, 2L plastic soda bottles
- clear and sticky packing tape
- scissors with sharp ends, shoe box
- mix of compostable trash such as leaves, grass and vegetable food scraps.

### Concepts

1. Much waste from human households is naturally biologically degradable (biodegradable).
2. Biodegradation is the process of organic materials being metabolized by decomposing organisms. When this occurs, materials such as food wastes, paper and other plant material will be changed from mass to both usable and heat energy in the organisms. As for aerobic respiration, the process also uses oxygen and releases carbon dioxide and water vapor.
3. The original mass of compostable materials is significantly reduced over time. This loss is due to respiration of decomposing organisms and dehydration.
4. The residue left from a mass left to decompose over several months is a combination of minerals and some organic materials that take even longer to decompose. This rich material can be used in gardens and flowerbeds.

## **CB 20. Collecting Composting Data**

### Materials

- Casio fx2 Graphing Calculator
- Casio QV2800 Digital Camera
- Casio Data Collector EA-100
- pH and humidity probes
- electric balance

### Concepts

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2. Trash from typical human activity can be sorted into four categories: Recyclable or reusable, compostable, burnable and disposable. The first three of these categories make land fill unnecessary.
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