BIOPAC SCIENCE LAB
For Secondary Education

NATIONAL SCIENCE EDUCATION STANDARDS

Levels 9-12: Correlation to *Biopac Science Lab* Lessons

Detail options: Click the ♦ in the table to review the lesson correlation to the specified content standard.
Click the content standard link (left column) to view all correlations for that standard.
Click the Lesson # (top row) to view all content standards for that Lesson.

Content Standard—Lesson Correlation	S01	S02	S03	S04	S05	S06	S08	S09	S10	S11	S12
A3 Unifying Concepts and Processes: Change, Constancy, and Measurement	♦	♦	♦	♦	♦	♦	♦	♦	♦	♦	♦
A5 Unifying Concepts and Processes: Form and Function	♦	♦	♦	♦	♦	♦	♦		♦	♦	♦
B1 Science as Inquiry: Abilities Necessary to do Scientific Inquiry	♦	♦	♦	♦	♦	♦	♦	♦	♦	♦	♦
B2 Science as Inquiry: Understandings About Scientific Inquiry	♦	♦	♦	♦	♦	♦	♦	♦		♦	♦
D5 Life Science: Matter, Energy, and Organization in Living Systems	♦	♦	♦		♦	♦	♦	♦		♦	♦
G1 Science in Personal and Social Perspectives: Personal and Community Health		♦	♦	♦	♦	♦	♦	♦	♦	♦	♦

Content Standard Description—Levels 9-12

A3 Unifying Concepts and Processes: Change, Constancy, and Measurement
Students should develop an understanding of the unifying concepts and processes of change, constancy, and measurement.

A5 Unifying Concepts and Processes: Form and Function
Students should develop an understanding of the unifying concepts and processes of form and function.

B1 Science as Inquiry: Abilities Necessary to do Scientific Inquiry
Students should develop an understanding of science as inquiry and develop abilities necessary to do scientific inquiry.

B2 Science as Inquiry: Understandings About Scientific Inquiry
Students should develop understandings about scientific inquiry.

D5 Life Science: Matter, Energy, and Organization in Living Systems
Students should develop an understanding of matter, energy, and organization in living systems.

G1 Science in Personal and Social Perspectives: Personal and Community Health
Students should be given a means to understand and act on personal and social issues, to help students develop decision-making skills, and to give students a foundation on which to base decisions they will face as citizens.

Lesson Descriptions

S01 EMG: Electromyography 1
S02 EMG: Electromyography 2
S03 EMG: Electrocardiography 1
S04 EMG: Electrocardiography 2
S05 EEG: Electroencephalography 1
S06 EEG: Electroencephalography 2
S08 EOG: Electrooculography
S09 Biofeedback
S10 Aerobic Exercise Physiology
S11 Reaction Time
S12 Respiration: Apnea

A3 Unifying Concepts and Processes: Change, Constancy, and Measurement

Students should develop an understanding of the unifying concepts and processes of change, constancy, and measurement.

S01—A3 Students investigate properties of skeletal muscle by recording EMG data associated with muscle contraction. They measure and correlate grip strength with recorded changes in the level of EMG activity. By measuring and comparing grip strengths of the dominant and non-dominant hands, they associate changes in skeletal muscle, such as increased strength, with increased use. They listen to audio output generated by the electrical activity associated with muscle contraction and correlate sound intensity with motor unit recruitment.

S02—A3 Students investigate the ability of skeletal muscle to perform mechanical work by recording EMG data associated with muscle contraction. They record and measure EMG responses to increased weights lifted by dominant and non-dominant arms. They associate chronic changes in skeletal muscle, such as increased size and strength, with increased use. They listen to audio output generated by the electrical activity associated with muscle contraction and correlate sound intensity with motor unit recruitment.

S03—A3 Students investigate the human cardiac cycle and associated electrical changes of the heart by recording the electrical signal of the heartbeat.

The record of the electrical signal, called an electrocardiogram (ECG), is complex. It is divided into several distinct, sequential events, the duration and intensity of which are constant or may change under varying conditions of normal health such as body position and breathing. Students observe rate, rhythm, and other changes in heart activity by making ECG measurements and analyzing their results.

S04—A3 Students investigate the human cardiac cycle and associated electrical changes of the heart by recording the electrical signal of the heartbeat detected by two recording electrodes placed on the skin.

The position of the electrodes is called a lead. The bipolar limb leads are Lead I (right arm-left arm+), Lead II (right arm - left leg +), and Lead III (left arm- left leg+). The ground electrode is placed on the right leg.

The record of the electrical signal, called an electrocardiogram (ECG), is a record of voltage changes (millivolts) vs. time (sec). It is divided into several distinct, sequential events, the duration and intensity of which are constant or may change under varying conditions of normal health such as body position and breathing.

Students record Leads I and III while performing a number of tasks designed to change the rhythm of the heart. They then compare the Lead I and Lead II records, analyze the data, and estimate the mean QRS axis and the mean ventricular potential.

S05—A3 Students investigate electrical activity of the human brain by recording voltage changes detected by recording electrodes placed on the scalp. The time record of the voltage changes is called an electro-encephalogram, or EEG.

Students learn the EEG is a complex pattern of waveforms that vary in frequency and amplitude, and that the EEG varies with the mental state of the subject.

The EEG changes as the brain grows with age, and it is variable among persons of the same age. Fundamentally, however, the EEG consists of four basic rhythms designated alpha, beta, delta, and theta.

Students determine the prominent EEG rhythm under different mental conditions by examining waveform frequency and amplitude.

S06—A3 Students investigate electrical activity of the human brain by recording, measuring, and comparing voltage/frequency changes detected by scalp recording electrodes while

performing a number of tasks. Students record and analyze changes in occipital lobe alpha rhythm observed during different experimental conditions.

The time record of the voltage changes is called an electro-encephalogram, or EEG, a complex pattern of waveforms that vary in frequency and amplitude. The EEG varies from lobe to lobe and is influenced by the mental state of the subject.

Fundamentally, the EEG consists of four basic rhythms designated alpha, beta, delta, and theta. The alpha rhythm is the prominent EEG pattern of a relaxed, inattentive state in an adult with the eyes closed. Alpha rhythm is characterized by a frequency of 8-13 Hz and amplitudes of 20-200μV. Alpha waves of the greatest amplitude are recorded from the occipital lobe region of the scalp.

S08—A3 Students investigate eye movements using temporal skin electrodes to detect and record electrical activity associated with cortical control of extra ocular muscles.

Students record horizontal eye movements and observe eye fixation and tracking. Students perform different tasks, recording and measuring the duration of saccades and fixation, and the spatial position of eye movements.

Electrooculography is the measurement and interpretation of electrooculograms (EOG), which are the electroencephalo-graphic tracings obtained while the subject, without moving the head, moves their eyes from one fixation point to another within the visual field.

S09—A3 Students explore the concept of biofeedback training as a method of influencing output of the autonomic nervous system.

The autonomic nervous system (ANS) regulates visceral activities such as blood pressure and flow, gastrointestinal functions, breathing rate and depth, and so forth. Autonomic control occurs without the need for conscious input from the cerebral cortex. We do not need to think about adjusting blood pressure, for example, when we begin to exercise. The adjustment occurs automatically by way of the ANS.

A widely held belief is that ANS control of visceral function cannot be altered by conscious input, that autonomic control is essentially, and necessarily, automatic. In this lesson, students explore the concept of biofeedback training as a method of influencing output of the autonomic nervous system by measuring changes in heart rate induced through application of a biofeedback technique.

S10—A3 Students record their electrocardiogram and heart rate at rest and during and after a specific set of dynamic exercises. Students measure changes in the electrocardiogram and heart rate and see how they change to meet the metabolic demands of physical exercise.

S11—A3 Students measure reaction times and see how easily and rapidly a person learns, as demonstrated by his/her ability to anticipate when to press a button in response to an audible signal. As a person learns what to expect, reaction time typically decreases.

Reaction time is the interval between when a stimulus is presented and when the response to the stimulus occurs. Learning, the acquisition of knowledge or skills due to experience and/or instruction, can alter reaction time in some stimulus-response situations.

S12—A3 Two principle functions of the human respiratory system are to supply oxygen to the blood and remove carbon dioxide from the blood. When the body is at rest, the rate and depth of breathing is stable and matches the body's needs for oxygen absorption and carbon dioxide removal.

Students learn that blood levels of carbon dioxide influence the rate and depth of breathing. When blood carbon dioxide increases above resting levels, as during physical exercise or after breath-holding, the rate and depth of breathing increases. When blood carbon dioxide decreases below resting levels as a result of voluntary hyperventilation or over-breathing, respiratory rate and depth decrease. Students record and measure changes in respiratory rate and depth associated with induced changes in blood carbon dioxide.

A5 Unifying Concepts and Processes: Form and Function

Students should develop an understanding of the unifying concepts and processes of form and function.

S01—A5 Students associate skeletal muscle work with skeletal muscle contraction. Because of the way skeletal muscles are attached to the skeleton, contracting skeletal muscles work by pulling on parts of the skeleton, not by pushing. Students learn about the motor unit organization of skeletal muscle and correlate the strength of a skeletal muscle's contraction and its ability to perform mechanical work with the structure and number of motor units.

S02—A5 Students learn about the motor unit organization of skeletal muscle and correlate the strength of a skeletal muscle's contraction and its ability to perform mechanical work with the structure and number of active motor units. Students observe that the increased number of motor units activated when an increased amount of weight is lifted is directly proportional to the increased amount of mechanical work muscles are asked to perform.

S03—A5 Students learn that the form of the ECG, such as wave amplitudes, depends in part on the position of the heart in the chest, and the positions of the recording electrodes on the surface of the body. Students also learn to associate the structure of the heart and its internal conduction system with the sequential, individual events of the ECG.

S04—A5 Students learn that the form of the ECG, such as wave amplitudes, depends in part on the position of the heart in the chest, and the positions of the recording electrodes on the surface of the body. Students examine the relationship between the bipolar limb lead recordings known as Einthoven's law.

The three bipolar limb leads can be arranged to form an electrical equilateral triangle, called Einthoven's triangle. The heart is in the center of the triangle. Einthoven's law says if the amplitude values of the wave forms in any two bipolar limb lead recordings are known, the amplitude values of the waveforms in the non-recorded bipolar limb lead can be mathematically determined.

S05—A5 Students learn that the prominent EEG wave pattern is correlated to the subject's mental state and can be influenced by the location of the scalp electrodes. Students record the EEG from the occipital lobe, the part of the brain involved with processing visual information. The EEG is recorded from an awake, resting subject with eyes open and eyes closed.

S06—A5 A primary function of the cortex of the occipital lobe is the processing and storage of information related to the special sense of vision or sight.. In this lesson, students examine differences in the level of alpha rhythm activity during mental arithmetic and hyperventilation compared to the control condition of eyes closed and relaxed.

S08—A5 Students learn that binocular vision requires precisely coordinated involuntary eye movements that are initiated and controlled in the motor cortex of the frontal lobes. Coordinated control of the extra ocular muscles allows the eyes to maintain clear focus on objects that are either fixed or moving in the visual field by ensuring that light reflected from the object (pendulum, written word, etc.) falls on corresponding parts of the retinas.

S10—A5 Students learn that a regular program of physical exercise increases skeletal muscle size and promotes the growth of blood vessels that supply oxygen and nutrients to the muscle and remove metabolic wastes. The adaptations and physiological changes that develop during chronic exercise generally result in an increased ability of the muscle to perform work at greater levels of intensity, and an increased capacity to work at any given level for a longer period of time before fatiguing. A Physically fit person tends to have a lower heart rate at rest and immediately after moderate exercise than does an unfit person.

S11—A5 Students learn that the ability to either involuntarily or voluntarily respond to a stimulus is dependent on a reflex or stimulus–response pathway.

Physiologically, a reflex, or a stimulus-response begins with the application of a stimulus to a sensory receptor, such as an auditory hair cell, and ends with a response by an effector, such as a skeletal muscle.

Anatomical elements of the pathway include a sensory receptor, a sensory or afferent neuron, an integrating center in the brain or spinal cord, a motor or efferent neuron, and an effector.

S12—A5 The human lungs occupy air-tight compartments within the thorax or chest. Students learn that contraction of chest muscles increases volume of the thorax and lungs which results in air pressure inside the lungs falling below atmospheric pressure and air moving into the lungs. These events characterize inspiration.

Expiration, or the exhaling of air from the lungs occurs at rest when inspiratory muscles relax, decreasing the volume of the lungs and the thorax, thereby increasing pressure within the lungs above atmospheric pressure, forcing air out of the lungs.

B1 Science as Inquiry: Abilities Necessary to do Scientific Inquiry

Students should develop an understanding of science as inquiry and develop abilities necessary to do scientific inquiry.

S01—B1 Students learn that some functions of skeletal muscle can be investigated using electromyography as a tool. They analyze individual experimental data and are encouraged to share data and perform cross-group analyses. They are encouraged to share results and to suggest reasons for observed differences. Through the applications of electromyography and their observations about muscle function, students are encouraged to ask additional questions about skeletal muscle functions and to suggest methods of obtaining answers.

S02—B1 Students learn that some aspects of the ability of skeletal muscles to perform mechanical work can be investigated using electromyography as a tool. They analyze individual experimental data regarding performance of mechanical work and time to fatigue, compare differences between male and female students, and are encouraged to suggest reasons for observed differences. Through the applications of electromyography and their observations about muscle function, students are encouraged to ask additional questions about skeletal muscle functions and to suggest methods of obtaining answers.

S03—B1 Students correlate electrical events of the cardiac cycle with mechanical events of the cardiac cycle and learn that normal and abnormal heart functions may be investigated by using electrocardiography as a tool. They learn about normal elements of the ECG recorded using Lead II, and then explore ECG changes that may result from breathing and from changing body position with respect to gravity. Students are encouraged to compare data with other subjects to see if body size, age, or gender influence ECG values. They are also encouraged to think about and explore, using the ECG as a tool, other factors that may influence heart activity and the ECG.

S04—B1 Students learn that normal and abnormal heart functions may be investigated by using electrocardiography as a tool. They are introduced to principles of planar or two-dimensional vectorcardio-graphy, calculate and graph the mean ventricular potential and mean QRS axis, and explore ECG changes that may result from breathing and from changing body position with respect to gravity.

Students are encouraged to compare data with other subjects to see if body size, age, or gender influence ECG values. They are also encouraged to think about and explore, using the ECG as a tool, other factors that may influence heart activity and the ECG.

S05—B1 Students correlate electrical activity of the brain with the performance of various tasks, and determine the prominent EEG waveforms associated with specific tasks. Students learn that the prominent EEG rhythm of a resting, alert subject with eyes open is the beta rhythm, and that the alpha rhythm is associated with the relaxed, inattentive, eyes closed state.

Students are encouraged to compare differences between male and female students, and to suggest methods of exploring other factors that might account for the variability of the EEG.

S06—B1 Students record an EEG from the occipital lobe region of an awake, resting subject under the following conditions: relaxed with eyes closed, performing mental arithmetic with eyes closed, hyperventilating (breathing quickly and deeply), and relaxed with eyes open.

Students are encouraged to offer explanations for the observed EEG changes, and are encouraged to compare differences between male and female students. They are encouraged to suggest methods of exploring other factors that might account for the variability of the EEG.

S08—B1 Students correlate electrical activity of the brain and extra ocular muscles with the performance of various visual tasks such as tracking a swinging pendulum, simulating tracking eye movement with eyes closed, reading silently, reading aloud, and reading difficult material. They measure and compare the duration of saccades and fixation. Using their laboratory experience as a foundation, they are encouraged to ask other questions about visual control systems and to explore microsaccadic eye movement.

S09—B1 Students are introduced to principles of sympathetic and parasympathetic autonomic nervous control and the concept of biofeedback training and how it can be used to study autonomic function.

Students record their ECG as an on-screen, thermometer-style heart rate display rises and falls with changes in heart rate, allowing the student to become conscious of his/her heart rate. The subject then mentally tries, without physical movement, to increase or to decrease the heart rate reading while watching the monitor.

S10—B1 Students learn that physical fitness can be assessed by measuring changes in heart rate associated with a specific set of dynamic exercises, such as performing jumping jacks, running in place, or stepping up and down in place. Students record the resting ECG and heart rate, the exercise ECG and increase in heart rate at the immediate end of an exercise period, and the time it takes from the end of the exercise period to the return of resting ECG and heart rate. They compare measured values with normalized data based on gender, age, and body weight. They compare performance levels between groups, such as young women vs. young men, or persons with body weight 75 – 150 lbs. vs. persons with body weight 151 – 250 lbs.

S11—B1 Students measure and compare reaction times of an individual subject using two stimulus presentation schedules: fixed intervals, and pseudo-random intervals.

Students are introduced to elements of statistics and their application in data analysis, and use statistics to determine the effects of learning on reaction times. They discover that when pseudo-random presentation trials are repeated, it takes longer for reaction times to decrease and the decrease is less than as occurs with fixed-interval presentation.

S12—B1 Students observe and record EMGs (electromyograms) from thoracic respiratory skeletal muscle during eupnea, or normal unlabored breathing at rest. Changes in the EMG are associated with modifications in the rate and depth of the respiratory cycle that occur before, during, and after periods of apnea vera and voluntary apnea (cessation of breathing). Students compare changes in the EMG associated with apnea to the EMG recorded during eupnea.

B2 Science as Inquiry: Understandings About Scientific Inquiry

Students should develop understandings about scientific inquiry.

S01—B2 Based on their laboratory experience with electromyography and its applications in the study of muscle function, students appreciate the limitations in using one method. Other questions about muscle function cannot be answered using electromyographic techniques, and therefore must be answered by applying different investigative tools and methods.

S02—B2 Based on their laboratory experience with electromyography and its applications in the study of muscle function, students appreciate the limitations in using one method. Other questions about muscle function cannot be answered using electromyographic techniques, and therefore must be answered by applying different investigative tools and methods.

S03—B2 Based on their laboratory experience with Lead II electrocardiography, students learn that although electrocardiography is a useful tool in exploring and understanding basic functions of the heart, its usefulness is limited. For example, the human ECG is not very useful for predicting a heart attack but can be very useful for determining the location and extent of damage after a heart attack has occurred.

S04—B2 Based on their laboratory experience with bipolar limb lead electrocardiography and vectorcardiography, students learn that although electrocardiography and vectorcardiography are useful tools in exploring and understanding basic functions of the heart, their usefulness is limited. For example, neither electrocardiography nor vectorcardiography are very useful for predicting a heart attack but they can be very useful for determining the location and extent of damage after a heart attack has occurred.

S05—B2 Electroencephalography used as tool to investigate functions of the human brain, like may other tools of neural science, has limited usefulness, and its usefulness depends on proper application. Based on their introductory laboratory experience with electroencephalography, students learn that answers to questions about brain function often require the application of more than one investigative tool.

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S08—B2 Students learn that the recording of electrical activity detected by skin electrodes placed lateral to the eyes can be used to study and understand visual phenomena associated with concerted eyeball movement. However, information gained through the application of electrooculography is limited, and therefore other methods of investigation must be employed to answer questions about the visual system.

S09—B2 Students learn about the basic functions and tone of the sympathetic and the parasympathetic divisions of the autonomic nervous system, and, the long-held tenant that autonomic functions are independent of the will. They experiment with biofeedback, a relatively recent clinical technique, to test the tenant and find that within limits it is possible to consciously alter autonomic tone. Based on their laboratory experience with biofeedback, students learn that newer technologies can be adapted to re-examine the validity of older hypotheses long held to be true

Students are encouraged to think about and explore other methods of biofeedback that could prove useful in voluntarily altering autonomic tone, and to think of reasons why this might be beneficial.

S10—B2 Students are asked to think about other physiological changes related to exercise that could be measured and used as an index of physical fitness. On the basis of their laboratory experience using heart rate changes to evaluate physical fitness, and laboratory discussion, students see that changes, such as systemic blood pressure, or respiratory rate and depth, offer other avenues for assessing physical fitness. Students begin to understand that each measure is of limited value, and no single measure of physical fitness is best.

S11—B2 Students take a relatively simple look at reaction time and how changing one variable, stimulus presentation interval, can result in differences in reaction time.

Students realize that other factors could influence reaction time and are encouraged to think about and explore them using their laboratory experience.. For example, a person’s reaction

time could be measured and compared in two different conditions, such as reading a book vs. watching TV.

S12—B2 Students use respiratory electromyography to study changes in respiratory rate and depth associated with changes in blood carbon dioxide. They learn that electromyographic methods allow only for qualitative assessment of the changes. Quantitative measurements of changes in respiratory cycle depth and more exact measurements of changes in respiratory rate require the application of more sophisticated technology and analytical techniques. Thus, the results obtained from scientific inquiry are limited by the nature of the applied methods.

D5 Life Science: Matter, Energy, and Organization in Living Systems

Students should develop an understanding of matter, energy, and organization in living systems.

S01—D5 Students learn about the basic structural and functional relationships between the nervous system and the muscular system. They develop an understanding of how the organization of the two systems allows for precise and efficient control of skeletal muscle contraction.

S02—D5 Based on their laboratory experience with electromyography and its applications in the study of muscle function, students appreciate the limitations in using one method. Other questions about muscle function cannot be answered using electromyographic techniques, and therefore must be answered by applying different investigative tools and methods.

S03—D5 Students learn that the human heart is a four-chambered structure. Two atrial chambers receive blood from venous systems and pump it to the ventricles. Two ventricular chambers receive blood from the atria and pump blood into arterial systems. In order for adequate circulation of blood to be sustained, the contraction / relaxation periods of the atria and the ventricles must be very carefully coordinated so that their actions do not oppose one another. The cardiac pacemaker system acts as an electrical coordinator during each heartbeat. The electrical activities associated with this coordination are recorded in the ECG.

S05—D5 The cerebrum is divided into hemispheres and each hemisphere is divided into frontal, parietal, temporal, and occipital lobes. Each lobe has functions that are unique but each lobe also shares functions with other lobes.

For example, as a child, we may see (occipital lobe) a flame and touch (frontal lobe) it to see what it is like, experiencing heat and pain (parietal lobe) and remembering (temporal lobe) not to repeat the experience. These functions and others such as reasoning and abstract thought occur in the outermost part of the cerebrum called the cortex. The electrical activities of the cortex are recorded as an EEG.

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For example, as a child, we may see (occipital lobe) a flame and touch (frontal lobe) it to see what it is like, experiencing heat and pain (parietal lobe) and remembering (temporal lobe) not to repeat the experience. These functions and others such as reasoning and abstract thought occur in the outermost part of the cerebrum called the cortex. The electrical activities of the cortex are recorded as an EEG.

S08—D5 The visual system of the human is complex. Normal stereoscopic vision requires receptors in the retinas to convert light energy into nerve impulses which are transmitted to several parts of the brain for processing, giving us the sense of sight. Although we see with two eyes, our brain forms a single image of a three-dimensional object with a perception of depth because concerted control of the extra ocular muscles allows each eye to be positioned so that light reflected from the object is focused on corresponding parts of the retinas. As we visually track the movement of an object in our visual field, the motor control system maintains this retinal correspondence while simultaneously maintaining gaze by moving the eyeballs in their orbits.

S09—D5 The human nervous system and the endocrine system control functions of all the other body systems. Students learn that nervous control involves voluntary and involuntary mechanisms, both of which serve to maintain homeostasis. Involuntary control is the domain of the sympathetic and parasympathetic divisions of the ANS.

Generally speaking, the divisions of the ANS have opposing actions controlling the function of a target organ. For example, an increase in sympathetic activity increases the heart rate; however, an increase in parasympathetic activity decreases heart rate. The two divisions work simultaneously and cooperatively to adjust visceral functions to meet body needs according to changes in the internal and external environment.

S11—D5 Students learn that a reflex is an involuntary or automatic, programmed motor response to a sensory stimulus. Literally, the word *reflex* is derived from a term meaning to reflect, or return back, with reference to the direction of travel of first the sensory impulses and then the motor impulses along the reflex pathway. Touching a hot object and jerking the hand away, or stepping on a tack and lifting the injured bare foot are examples of simple human reflexes. Reflexes in animals represent the earliest organization of neurons into a functional unit. Even in adult animals that lack a brain, such as a jellyfish, neurons have become specialized and organized to provide for simple, often life-preserving, reflex responses. In the human, reflex activities appear about five months before birth. Reflexes allow the body to react automatically and involuntarily to a variety of internal and external stimuli so as to maintain homeostasis.

A stimulus-response is functionally similar to a reflex except that it is voluntary rather than involuntary, and as such, it can be learned and is subject to behavioral modification. An example is lifting a finger in response to an audible click.

S12—D5 Students learn that all living cells of the body require oxygen to derive energy from food. Stored chemical energy is used by cells to perform work. Cells produce carbon dioxide as a waste product of metabolism. The respiratory system works in conjunction with the circulatory system to deliver oxygen to the cells and remove carbon dioxide.

G1 Science in Personal and Social Perspectives: Personal and Community Health

Students should be given a means to understand and act on personal and social issues, to help students develop decision-making skills, and to give students a foundation on which to base decisions they will face as citizens.

S02—G1 Given the current and general interest in the control of body weight through exercise and diet control for the purposes of preventing disease and maintaining a healthy lifestyle, it is important for students to learn about basic, normal functions of skeletal muscle. These functions involve the abilities and limitations of skeletal muscle in the performance of mechanical work, and the phenomenon of skeletal muscle fatigue.

S03—G1 Electrocardiography is routinely used in medical practice. The well-informed adult should be aware of both the usefulness of this diagnostic tool and its limitations in providing healthcare professionals with the information they need to minister proper care. This lesson helps students build a foundation on which to base the personal health decisions they will face as adults.

S04—G1 Electrocardiography and vectorcardiography are routinely used in medical practice and offer the cardiologist additional tools with which to assess normal and abnormal heart function. The well-informed adult should be aware of both the usefulness of these diagnostic tools and their limitations in providing healthcare professionals with the information they need to minister proper care. This lesson helps students build a foundation on which to base the personal health decisions they will face as adults.

S05—G1 Electroencephalography is often used in diagnostic neurology and investigative neural science. A good example is its application in the diagnosis, treatment, and study of various forms of epilepsy. The well-informed adult should be aware of both the usefulness of this diagnostic tool and its limitations in providing healthcare professionals with the information

they need to minister proper care. This lesson helps students build a foundation on which to base the personal health decisions they will face as adults.

S06—G1 Electroencephalography is often used in diagnostic neurology and investigative neural science. A good example is its application in the diagnosis, treatment, and study of various forms of epilepsy. The well-informed adult should be aware of both the usefulness of this diagnostic tool and its limitations in providing healthcare professionals with the information they need to minister proper care. This lesson helps students build a foundation on which to base the personal health decisions they will face as adults.

S08—G1 Electrooculography is commonly used to assess visual defects involving neuromuscular control of the eyes, such as in diagnosis and treatment success of sixth nerve palsy (paralysis of the lateral rectus). Similar eye movement / cranial nerve tests using other cardinal gazes may be employed in the diagnosis and assessment of eye disorders.

Recent applications of electrooculography involve the design of robotics, such as motorized wheelchairs and other devices that can be guided or otherwise controlled by movement of the subject's eyes.

S09—G1 Mental or psychological stress increases sympathetic activity and decreases parasympathetic activity, resulting in an increase in heart rate, an increase in blood pressure, reduced gastrointestinal functions, and so forth. Over the short term, these changes may be beneficial, but when they are prolonged or become chronic, they become detrimental and can cause disease. Using heart rate biofeedback techniques, an affected person can be taught to relax and to increase parasympathetic tone and thus reduce sympathetic activity, evidenced by a decrease in heart rate. Initially, a machine monitors heart rate and provides the feedback signals that help the subject develop voluntary control. Eventually, the subject is able to recognize and control reactions to stress on his own by recalling and eliciting the same relaxed state of mind used in the biofeedback laboratory when he is at home or at work. Relaxation training using biofeedback has been successfully applied to the management of asthma, cerebral palsy, hypertension, migraine headache, irritable bowel syndrome, and numerous other maladies.

S10—G1 Physiological adaptations to chronic exercise, initiated by even the most modest physical activity, play a major role in the prevention of obesity, hypertension and other cardiovascular diseases, respiratory disease, adult-onset (type II) diabetes, and other maladies associated with sedentary lifestyles. This lesson helps make students aware of the value and the need as adults to maintain a healthy lifestyle that includes regular exercise.

S11—G1 Usually, longer reaction times are a sign that the person is paying less attention to the stimulus and/or is processing other information. For example, if you took more time to respond to audible clicks while also reading a book than when you were also watching TV then you could infer that you were probably paying more attention to the book than to the TV since your brain took longer to respond.

Assessments from simple reaction time tests allows researchers a glimpse into the cognitive and neurological functioning of people as they perform tasks. Of current topical interest is the question of whether concurrent use of cell phones while driving an automobile impairs judgment and slows the driver's reaction time.

S12—G1 The normal person exhales carbon dioxide as fast as the body produces it so that blood carbon dioxide remains within normal limits. In diseases or conditions in which a person subconsciously hyper-ventilates, such as in chronic anxiety states, blood carbon dioxide may fall too low, removing the main stimulus to breathe, resulting in temporary apnea, dizziness, and fainting. Anxiety states are common in contemporary cultures.

On the other hand, if blood carbon dioxide is permitted to rise above normal, as would occur if a child held his breath to spite his parents, the elevated carbon dioxide would soon become a too powerful stimulus for the brain to ignore and breathing would automatically resume.

S01 Electromyography 1

A3 Unifying Concepts and Processes: Change, Constancy, and Measurement

Students should develop an understanding of the unifying concepts and processes of change, constancy, and measurement.

S01—Students investigate properties of skeletal muscle by recording EMG data associated with muscle contraction. They measure and correlate grip strength with recorded changes in the level of EMG activity. By measuring and comparing grip strengths of the dominant and non-dominant hands, they associate changes in skeletal muscle, such as increased strength, with increased use. They listen to audio output generated by the electrical activity associated with muscle contraction and correlate sound intensity with motor unit recruitment.

A5 Unifying Concepts and Processes: Form and Function

Students should develop an understanding of the unifying concepts and processes of form and function.

S01—Students associate skeletal muscle work with skeletal muscle contraction. Because of the way skeletal muscles are attached to the skeleton, contracting skeletal muscles work by pulling on parts of the skeleton, not by pushing. Students learn about the motor unit organization of skeletal muscle and correlate the strength of a skeletal muscle's contraction and its ability to perform mechanical work with the structure and number of motor units.

B1 Science as Inquiry: Abilities Necessary to do Scientific Inquiry

Students should develop an understanding of science as inquiry and develop abilities necessary to do scientific inquiry.

S01—Students learn that some functions of skeletal muscle can be investigated using electromyography as a tool. They analyze individual experimental data and are encouraged to share data and perform cross-group analyses. They are encouraged to share results and to suggest reasons for observed differences. Through the applications of electromyography and their observations about muscle function, students are encouraged to ask additional questions about skeletal muscle functions and to suggest methods of obtaining answers.

B2 Science as Inquiry: Understandings About Scientific Inquiry

Students should develop understandings about scientific inquiry.

S01—Based on their laboratory experience with electromyography and its applications in the study of muscle function, students appreciate the limitations in using one method. Other questions about muscle function cannot be answered using electromyographic techniques, and therefore must be answered by applying different investigative tools and methods.

D5 Life Science: Matter, Energy, and Organization in Living Systems

Students should develop an understanding of matter, energy, and organization in living systems.

S01—Students learn about the basic structural and functional relationships between the nervous system and the muscular system. They develop an understanding of how the organization of the two systems allows for precise and efficient control of skeletal muscle contraction.

S02 Electromyography 2

A3 Unifying Concepts and Processes: Change, Constancy, and Measurement

Students should develop an understanding of the unifying concepts and processes of change, constancy, and measurement.

S02—Students investigate the ability of skeletal muscle to perform mechanical work by recording EMG data associated with muscle contraction. They record and measure EMG responses to increased weights lifted by dominant and non-dominant arms. They associate chronic changes in skeletal muscle, such as increased size and strength, with increased use.

They listen to audio output generated by the electrical activity associated with muscle contraction and correlate sound intensity with motor unit recruitment.

A5 Unifying Concepts and Processes: Form and Function

Students should develop an understanding of the unifying concepts and processes of form and function.

S02—Students learn about the motor unit organization of skeletal muscle and correlate the strength of a skeletal muscle's contraction and its ability to perform mechanical work with the structure and number of active motor units. Students observe that the increased number of motor units activated when an increased amount of weight is lifted is directly proportional to the increased amount of mechanical work muscles are asked to perform.

B1 Science as Inquiry: Abilities Necessary to do Scientific Inquiry

Students should develop an understanding of science as inquiry and develop abilities necessary to do scientific inquiry.

S02—Students learn that some aspects of the ability of skeletal muscles to perform mechanical work can be investigated using electromyography as a tool. They analyze individual experimental data regarding performance of mechanical work and time to fatigue, compare differences between male and female students, and are encouraged to suggest reasons for observed differences. Through the applications of electromyography and their observations about muscle function, students are encouraged to ask additional questions about skeletal muscle functions and to suggest methods of obtaining answers.

B2 Science as Inquiry: Understandings About Scientific Inquiry

Students should develop understandings about scientific inquiry.

S02—Based on their laboratory experience with electromyography and its applications in the study of muscle function, students appreciate the limitations in using one method. Other questions about muscle function cannot be answered using electromyographic techniques, and therefore must be answered by applying different investigative tools and methods.

D5 Life Science: Matter, Energy, and Organization in Living Systems

Students should develop an understanding of matter, energy, and organization in living systems.

S02—Based on their laboratory experience with electromyography and its applications in the study of muscle function, students appreciate the limitations in using one method. Other questions about muscle function cannot be answered using electromyographic techniques, and therefore must be answered by applying different investigative tools and methods.

G1 Science in Personal and Social Perspectives: Personal and Community Health

Students should be given a means to understand and act on personal and social issues, to help students develop decision-making skills, and to give students a foundation on which to base decisions they will face as citizens.

S02—Given the current and general interest in the control of body weight through exercise and diet control for the purposes of preventing disease and maintaining a healthy lifestyle, it is important for students to learn about basic, normal functions of skeletal muscle. These functions involve the abilities and limitations of skeletal muscle in the performance of mechanical work, and the phenomenon of skeletal muscle fatigue.

S03 Electrocardiography 1

A3 Unifying Concepts and Processes: Change, Constancy, and Measurement

Students should develop an understanding of the unifying concepts and processes of change, constancy, and measurement.

S03—Students investigate the human cardiac cycle and associated electrical changes of the heart by recording the electrical signal of the heartbeat.

The record of the electrical signal, called an electrocardiogram (ECG), is complex. It is divided into several distinct, sequential events, the duration and intensity of which are constant or may change under varying conditions of normal health such as body position and breathing. Students observe rate, rhythm, and other changes in heart activity by making ECG measurements and analyzing their results.

A5 Unifying Concepts and Processes: Form and Function

Students should develop an understanding of the unifying concepts and processes of form and function.

S03—Students learn that the form of the ECG, such as wave amplitudes, depends in part on the position of the heart in the chest, and the positions of the recording electrodes on the surface of the body. Students also learn to associate the structure of the heart and its internal conduction system with the sequential, individual events of the ECG.

B1 Science as Inquiry: Abilities Necessary to do Scientific Inquiry

Students should develop an understanding of science as inquiry and develop abilities necessary to do scientific inquiry.

S03—Students correlate electrical events of the cardiac cycle with mechanical events of the cardiac cycle and learn that normal and abnormal heart functions may be investigated by using electrocardiography as a tool. They learn about normal elements of the ECG recorded using Lead II, and then explore ECG changes that may result from breathing and from changing body position with respect to gravity. Students are encouraged to compare data with other subjects to see if body size, age, or gender influence ECG values. They are also encouraged to think about and explore, using the ECG as a tool, other factors that may influence heart activity and the ECG.

B2 Science as Inquiry: Understandings About Scientific Inquiry

Students should develop understandings about scientific inquiry.

S03—Based on their laboratory experience with Lead II electrocardiography, students learn that although electrocardiography is a useful tool in exploring and understanding basic functions of the heart, its usefulness is limited. For example, the human ECG is not very useful for predicting a heart attack but can be very useful for determining the location and extent of damage after a heart attack has occurred.

D5 Life Science: Matter, Energy, and Organization in Living Systems

Students should develop an understanding of matter, energy, and organization in living systems.

S03—Students learn that the human heart is a four-chambered structure. Two atrial chambers receive blood from venous systems and pump it to the ventricles. Two ventricular chambers receive blood from the atria and pump blood into arterial systems. In order for adequate circulation of blood to be sustained, the contraction / relaxation periods of the atria and the ventricles must be very carefully coordinated so that their actions do not oppose one another. The cardiac pacemaker system acts as an electrical coordinator during each heartbeat. The electrical activities associated with this coordination are recorded in the ECG.

G1 Science in Personal and Social Perspectives: Personal and Community Health

Students should be given a means to understand and act on personal and social issues, to help students develop decision-making skills, and to give students a foundation on which to base decisions they will face as citizens.

S03—Electrocardiography is routinely used in medical practice. The well-informed adult should be aware of both the usefulness of this diagnostic tool and its limitations in providing healthcare professionals with the information they need to minister proper care. This lesson helps students build a foundation on which to base the personal health decisions they will face as adults.

S04 Electrocardiography 2

A3 Unifying Concepts and Processes: Change, Constancy, and Measurement

Students should develop an understanding of the unifying concepts and processes of change, constancy, and measurement.

S04—Students investigate the human cardiac cycle and associated electrical changes of the heart by recording the electrical signal of the heartbeat detected by two recording electrodes placed on the skin.

The position of the electrodes is called a lead. The bipolar limb leads are Lead I (right arm- left arm+), Lead II (right arm - left leg +), and Lead III (left arm- left leg+). The ground electrode is placed on the right leg.

The record of the electrical signal, called an electrocardiogram (ECG), is a record of voltage changes (millivolts) vs. time (sec). It is divided into several distinct, sequential events, the duration and intensity of which are constant or may change under varying conditions of normal health such as body position and breathing.

Students record Leads I and III while performing a number of tasks designed to change the rhythm of the heart. They then compare the Lead I and Lead II records, analyze the data, and estimate the mean QRS axis and the mean ventricular potential.

A5 Unifying Concepts and Processes: Form and Function

Students should develop an understanding of the unifying concepts and processes of form and function.

S04—Students learn that the form of the ECG, such as wave amplitudes, depends in part on the position of the heart in the chest, and the positions of the recording electrodes on the surface of the body. Students examine the relationship between the bipolar limb lead recordings known as Einthoven's law.

The three bipolar limb leads can be arranged to form an electrical equilateral triangle, called Einthoven's triangle. The heart is in the center of the triangle. Einthoven's law says if the amplitude values of the wave forms in any two bipolar limb lead recordings are known, the amplitude values of the waveforms in the non-recorded bipolar limb lead can be mathematically determined.

B1 Science as Inquiry: Abilities Necessary to do Scientific Inquiry

Students should develop an understanding of science as inquiry and develop abilities necessary to do scientific inquiry.

S04—Students learn that normal and abnormal heart functions may be investigated by using electrocardiography as a tool. They are introduced to principles of planar or two-dimensional vectorcardio-graphy, calculate and graph the mean ventricular potential and mean QRS axis, and explore ECG changes that may result from breathing and from changing body position with respect to gravity.

Students are encouraged to compare data with other subjects to see if body size, age, or gender influence ECG values. They are also encouraged to think about and explore, using the ECG as a tool, other factors that may influence heart activity and the ECG.

B2 Science as Inquiry: Understandings About Scientific Inquiry

Students should develop understandings about scientific inquiry.

S04—Based on their laboratory experience with bipolar limb lead electrocardiography and vectorcardiography, students learn that although electrocardiography and vectorcardiography are useful tools in exploring and understanding basic functions of the heart, their usefulness is limited. For example, neither electrocardio-graphy nor vectorcardiography are very useful for predicting a heart attack but they can be very useful for determining the location and extent of damage after a heart attack has occurred.

G1 Science in Personal and Social Perspectives: Personal and Community Health

Students should be given a means to understand and act on personal and social issues, to help students develop decision-making skills, and to give students a foundation on which to base decisions they will face as citizens.

S04—Electrocardiography and vectorcardiography are routinely used in medical practice and offer the cardiologist additional tools with which to assess normal and abnormal heart function. The well-informed adult should be aware of both the usefulness of these diagnostic tools and their limitations in providing healthcare professionals with the information they need to minister proper care. This lesson helps students build a foundation on which to base the personal health decisions they will face as adults.

S05 Electroencephalography 1

A3 Unifying Concepts and Processes: Change, Constancy, and Measurement

Students should develop an understanding of the unifying concepts and processes of change, constancy, and measurement.

S05—Students investigate electrical activity of the human brain by recording voltage changes detected by recording electrodes placed on the scalp. The time record of the voltage changes is called an electro-encephalogram, or EEG.

Students learn the EEG is a complex pattern of waveforms that vary in frequency and amplitude, and that the EEG varies with the mental state of the subject.

The EEG changes as the brain grows with age, and it is variable among persons of the same age. Fundamentally, however, the EEG consists of four basic rhythms designated alpha, beta, delta, and theta.

Students determine the prominent EEG rhythm under different mental conditions by examining waveform frequency and amplitude.

A5 Unifying Concepts and Processes: Form and Function

Students should develop an understanding of the unifying concepts and processes of form and function.

S05—Students learn that the prominent EEG wave pattern is correlated to the subject's mental state and can be influenced by the location of the scalp electrodes. Students record the EEG from the occipital lobe, the part of the brain involved with processing visual information. The EEG is recorded from an awake, resting subject with eyes open and eyes closed.

B1 Science as Inquiry: Abilities Necessary to do Scientific Inquiry

Students should develop an understanding of science as inquiry and develop abilities necessary to do scientific inquiry.

S05—Students correlate electrical activity of the brain with the performance of various tasks, and determine the prominent EEG waveforms associated with specific tasks. Students learn that the prominent EEG rhythm of a resting, alert subject with eyes open is the beta rhythm, and that the alpha rhythm is associated with the relaxed, inattentive, eyes closed state. Students

are encouraged to compare differences between male and female students, and to suggest methods of exploring other factors that might account for the variability of the EEG.

B2 Science as Inquiry: Understandings About Scientific Inquiry

Students should develop understandings about scientific inquiry.

S05—Electroencephalography used as tool to investigate functions of the human brain, like may other tools of neural science, has limited usefulness, and its usefulness depends on proper application. Based on their introductory laboratory experience with electroencephalography, students learn that answers to questions about brain function often require the application of more than one investigative tool.

D5 Life Science: Matter, Energy, and Organization in Living Systems

Students should develop an understanding of matter, energy, and organization in living systems.

S05—The cerebrum is divided into hemispheres and each hemisphere is divided into frontal, parietal, temporal, and occipital lobes. Each lobe has functions that are unique but each lobe also shares functions with other lobes.

For example, as a child, we may see (occipital lobe) a flame and touch (frontal lobe) it to see what it is like, experiencing heat and pain (parietal lobe) and remembering (temporal lobe) not to repeat the experience. These functions and others such as reasoning and abstract thought occur in the outermost part of the cerebrum called the cortex. The electrical activities of the cortex are recorded as an EEG.

G1 Science in Personal and Social Perspectives: Personal and Community Health

Students should be given a means to understand and act on personal and social issues, to help students develop decision-making skills, and to give students a foundation on which to base decisions they will face as citizens.

S05—Electroencephalography is often used in diagnostic neurology and investigative neural science. A good example is its application in the diagnosis, treatment, and study of various forms of epilepsy. The well-informed adult should be aware of both the usefulness of this diagnostic tool and its limitations in providing healthcare professionals with the information they need to minister proper care. This lesson helps students build a foundation on which to base the personal health decisions they will face as adults.

S06 Electroencephalography 2

A3 Unifying Concepts and Processes: Change, Constancy, and Measurement

Students should develop an understanding of the unifying concepts and processes of change, constancy, and measurement.

S06—Students investigate electrical activity of the human brain by recording, measuring, and comparing voltage/frequency changes detected by scalp recording electrodes while performing a number of tasks. Students record and analyze changes in occipital lobe alpha rhythm observed during different experimental conditions.

The time record of the voltage changes is called an electro-encephalogram, or EEG, a complex pattern of waveforms that vary in frequency and amplitude. The EEG varies from lobe to lobe and is influenced by the mental state of the subject.

Fundamentally, the EEG consists of four basic rhythms designated alpha, beta, delta, and theta. The alpha rhythm is the prominent EEG pattern of a relaxed, inattentive state in an adult with the eyes closed. Alpha rhythm is characterized by a frequency of 8-13 Hz and amplitudes of 20-200μV. Alpha waves of the greatest amplitude are recorded from the occipital lobe region of the scalp.

A5 Unifying Concepts and Processes: Form and Function

Students should develop an understanding of the unifying concepts and processes of form and function.

S06—A primary function of the cortex of the occipital lobe is the processing and storage of information related to the special sense of vision or sight.. In this lesson, students examine differences in the level of alpha rhythm activity during mental arithmetic and hyperventilation compared to the control condition of eyes closed and relaxed.

B1 Science as Inquiry: Abilities Necessary to do Scientific Inquiry

Students should develop an understanding of science as inquiry and develop abilities necessary to do scientific inquiry.

S06—Students record an EEG from the occipital lobe region of an awake, resting subject under the following conditions: relaxed with eyes closed, performing mental arithmetic with eyes closed, hyperventilating (breathing quickly and deeply), and relaxed with eyes open.

Students are encouraged to offer explanations for the observed EEG changes, and are encouraged to compare differences between male and female students. They are encouraged to suggest methods of exploring other factors that might account for the variability of the EEG.

B2 Science as Inquiry: Understandings About Scientific Inquiry

Students should develop understandings about scientific inquiry.

S06—Electroencephalography used as tool to investigate functions of the human brain, like may other tools of neural science, has limited usefulness, and its usefulness depends on proper application. Based on their introductory laboratory experience with electroencephalography, students learn that answers to questions about brain function often require the application of more than one investigative tool.

D5 Life Science: Matter, Energy, and Organization in Living Systems

Students should develop an understanding of matter, energy, and organization in living systems.

S06—The cerebrum is divided into hemispheres and each hemisphere is divided into frontal, parietal, temporal, and occipital lobes. Each lobe has functions that are unique but each lobe also shares functions with other lobes.

For example, as a child, we may see (occipital lobe) a flame and touch (frontal lobe) it to see what it is like, experiencing heat and pain (parietal lobe) and remembering (temporal lobe) not to repeat the experience. These functions and others such as reasoning and abstract thought occur in the outermost part of the cerebrum called the cortex. The electrical activities of the cortex are recorded as an EEG.

G1 Science in Personal and Social Perspectives: Personal and Community Health

Students should be given a means to understand and act on personal and social issues, to help students develop decision-making skills, and to give students a foundation on which to base decisions they will face as citizens.

S06—Electroencephalography is often used in diagnostic neurology and investigative neural science. A good example is its application in the diagnosis, treatment, and study of various forms of epilepsy. The well-informed adult should be aware of both the usefulness of this diagnostic tool and its limitations in providing healthcare professionals with the information they need to minister proper care. This lesson helps students build a foundation on which to base the personal health decisions they will face as adults.

S08 EOG: Electrooculography

A3 Unifying Concepts and Processes: Change, Constancy, and Measurement

Students should develop an understanding of the unifying concepts and processes of change, constancy, and measurement.

S08—Students investigate eye movements using temporal skin electrodes to detect and record electrical activity associated with cortical control of extra ocular muscles.

Students record horizontal eye movements and observe eye fixation and tracking. Students perform different tasks, recording and measuring the duration of saccades and fixation, and the spatial position of eye movements.

Electrooculography is the measurement and interpretation of electrooculograms (EOG), which are the electroencephalo-graphic tracings obtained while the subject, without moving the head, moves their eyes from one fixation point to another within the visual field.

A5 Unifying Concepts and Processes: Form and Function

Students should develop an understanding of the unifying concepts and processes of form and function.

S08—Students learn that binocular vision requires precisely coordinated involuntary eye movements that are initiated and controlled in the motor cortex of the frontal lobes. Coordinated control of the extra ocular muscles allows the eyes to maintain clear focus on objects that are either fixed or moving in the visual field by ensuring that light reflected from the object (pendulum, written word, etc.) falls on corresponding parts of the retinas.

B1 Science as Inquiry: Abilities Necessary to do Scientific Inquiry

Students should develop an understanding of science as inquiry and develop abilities necessary to do scientific inquiry.

S08—Students correlate electrical activity of the brain and extra ocular muscles with the performance of various visual tasks such as tracking a swinging pendulum, simulating tracking eye movement with eyes closed, reading silently, reading aloud, and reading difficult material. They measure and compare the duration of saccades and fixation. Using their laboratory experience as a foundation, they are encouraged to ask other questions about visual control systems and to explore microsaccadic eye movement.

B2 Science as Inquiry: Understandings About Scientific Inquiry

Students should develop understandings about scientific inquiry.

S08—Students learn that the recording of electrical activity detected by skin electrodes placed lateral to the eyes can be used to study and understand visual phenomena associated with concerted eyeball movement. However, information gained through the application of electrooculography is limited, and therefore other methods of investigation must be employed to answer questions about the visual system.

D5 Life Science: Matter, Energy, and Organization in Living Systems

Students should develop an understanding of matter, energy, and organization in living systems.

S08—The visual system of the human is complex. Normal stereoscopic vision requires receptors in the retinas to convert light energy into nerve impulses which are transmitted to several parts of the brain for processing, giving us the sense of sight. Although we see with two eyes, our brain forms a single image of a three-dimensional object with a perception of depth because concerted control of the extra ocular muscles allows each eye to be positioned so that light reflected from the object is focused on corresponding parts of the retinas. As we visually track the movement of an object in our visual field, the motor control system maintains this retinal correspondence while simultaneously maintaining gaze by moving the eyeballs in their orbits.

G1 Science in Personal and Social Perspectives: Personal and Community Health

Students should be given a means to understand and act on personal and social issues, to help students develop decision-making skills, and to give students a foundation on which to base decisions they will face as citizens.

S08—Electrooculography is commonly used to assess visual defects involving neuromuscular control of the eyes, such as in diagnosis and treatment success of sixth nerve palsy (paralysis of the lateral rectus). Similar eye movement / cranial nerve tests using other cardinal gazes may be employed in the diagnosis and assessment of eye disorders.

Recent applications of electrooculography involve the design of robotics, such as motorized wheelchairs and other devices that can be guided or otherwise controlled by movement of the subject's eyes.

S09 Biofeedback

A3 Unifying Concepts and Processes: Change, Constancy, and Measurement

Students should develop an understanding of the unifying concepts and processes of change, constancy, and measurement.

S09—Students explore the concept of biofeedback training as a method of influencing output of the autonomic nervous system.

The autonomic nervous system (ANS) regulates visceral activities such as blood pressure and flow, gastrointestinal functions, breathing rate and depth, and so forth. Autonomic control occurs without the need for conscious input from the cerebral cortex. We do not need to think about adjusting blood pressure, for example, when we begin to exercise. The adjustment occurs automatically by way of the ANS.

A widely held belief is that ANS control of visceral function cannot be altered by conscious input, that autonomic control is essentially, and necessarily, automatic. In this lesson, students explore the concept of biofeedback training as a method of influencing output of the autonomic nervous system by measuring changes in heart rate induced through application of a biofeedback technique.

B1 Science as Inquiry: Abilities Necessary to do Scientific Inquiry

Students should develop an understanding of science as inquiry and develop abilities necessary to do scientific inquiry.

S09—Students are introduced to principles of sympathetic and parasympathetic autonomic nervous control and the concept of biofeedback training and how it can be used to study autonomic function.

Students record their ECG as an on-screen, thermometer-style heart rate display rises and falls with changes in heart rate, allowing the student to become conscious of his/her heart rate. The subject then mentally tries, without physical movement, to increase or to decrease the heart rate reading while watching the monitor.

B2 Science as Inquiry: Understandings About Scientific Inquiry

Students should develop understandings about scientific inquiry.

S09—Students learn about the basic functions and tone of the sympathetic and the parasympathetic divisions of the autonomic nervous system, and, the long-held tenant that autonomic functions are independent of the will. They experiment with biofeedback, a relatively recent clinical technique, to test the tenant and find that within limits it is possible to consciously alter autonomic tone. Based on their laboratory experience with biofeedback, students learn that newer technologies can be adapted to re-examine the validity of older hypotheses long held to be true.

Students are encouraged to think about and explore other methods of biofeedback that could prove useful in voluntarily altering autonomic tone, and to think of reasons why this might be beneficial.

D5 Life Science: Matter, Energy, and Organization in Living Systems

Students should develop an understanding of matter, energy, and organization in living systems.

S09—The human nervous system and the endocrine system control functions of all the other body systems. Students learn that nervous control involves voluntary and involuntary mechanisms, both of which serve to maintain homeostasis. Involuntary control is the domain of the sympathetic and parasympathetic divisions of the ANS.

Generally speaking, the divisions of the ANS have opposing actions controlling the function of a target organ. For example, an increase in sympathetic activity increases the heart rate; however, an increase in parasympathetic activity decreases heart rate. The two divisions work simultaneously and cooperatively to adjust visceral functions to meet body needs according to changes in the internal and external environment.

G1 Science in Personal and Social Perspectives: Personal and Community Health

Students should be given a means to understand and act on personal and social issues, to help students develop decision-making skills, and to give students a foundation on which to base decisions they will face as citizens.

S09—Mental or psychological stress increases sympathetic activity and decreases parasympathetic activity, resulting in an increase in heart rate, an increase in blood pressure, reduced gastrointestinal functions, and so forth. Over the short term, these changes may be beneficial, but when they are prolonged or become chronic, they become detrimental and can cause disease. Using heart rate biofeedback techniques, an affected person can be taught to relax and to increase parasympathetic tone and thus reduce sympathetic activity, evidenced by a decrease in heart rate. Initially, a machine monitors heart rate and provides the feedback signals that help the subject develop voluntary control. Eventually, the subject is able to recognize and control reactions to stress on his own by recalling and eliciting the same relaxed state of mind used in the biofeedback laboratory when he is at home or at work. Relaxation training using biofeedback has been successfully applied to the management of asthma, cerebral palsy, hypertension, migraine headache, irritable bowel syndrome, and numerous other maladies.

S10 Aerobic Exercise Physiology

A3 Unifying Concepts and Processes: Change, Constancy, and Measurement

Students should develop an understanding of the unifying concepts and processes of change, constancy, and measurement.

S10—Students record their electrocardiogram and heart rate at rest and during and after a specific set of dynamic exercises. Students measure changes in the electrocardiogram and heart rate and see how they change to meet the metabolic demands of physical exercise.

A5 Unifying Concepts and Processes: Form and Function

Students should develop an understanding of the unifying concepts and processes of form and function.

S10—Students learn that a regular program of physical exercise increases skeletal muscle size and promotes the growth of blood vessels that supply oxygen and nutrients to the muscle and remove metabolic wastes. The adaptations and physiological changes that develop during chronic exercise generally result in an increased ability of the muscle to perform work at greater levels of intensity, and an increased capacity to work at any given level for a longer period of time before fatiguing. A Physically fit person tends to have a lower heart rate at rest and immediately after moderate exercise than does an unfit person.

B1 Science as Inquiry: Abilities Necessary to do Scientific Inquiry

Students should develop an understanding of science as inquiry and develop abilities necessary to do scientific inquiry.

S10—Students learn that physical fitness can be assessed by measuring changes in heart rate associated with a specific set of dynamic exercises, such as performing jumping jacks, running in place, or stepping up and down in place. Students record the resting ECG and heart rate, the exercise ECG and increase in heart rate at the immediate end of an exercise period, and the

time it takes from the end of the exercise period to the return of resting ECG and heart rate. They compare measured values with normalized data based on gender, age, and body weight. They compare performance levels between groups, such as young women vs. young men, or persons with body weight 75 – 150 lbs. vs. persons with body weight 151 – 250 lbs.

G1 Science in Personal and Social Perspectives: Personal and Community Health

Students should be given a means to understand and act on personal and social issues, to help students develop decision-making skills, and to give students a foundation on which to base decisions they will face as citizens.

S10—Physiological adaptations to chronic exercise, initiated by even the most modest physical activity, play a major role in the prevention of obesity, hypertension and other cardiovascular diseases, respiratory disease, adult-onset (type II) diabetes, and other maladies associated with sedentary lifestyles. This lesson helps make students aware of the value and the need as adults to maintain a healthy lifestyle that includes regular exercise.

S11 Reaction Time

A3 Unifying Concepts and Processes: Change, Constancy, and Measurement

Students should develop an understanding of the unifying concepts and processes of change, constancy, and measurement.

S11—Students measure reaction times and see how easily and rapidly a person learns, as demonstrated by his/her ability to anticipate when to press a button in response to an audible signal. As a person learns what to expect, reaction time typically decreases.

Reaction time is the interval between when a stimulus is presented and when the response to the stimulus occurs. Learning, the acquisition of knowledge or skills due to experience and/or instruction, can alter reaction time in some stimulus-response situations.

A5 Unifying Concepts and Processes: Form and Function

Students should develop an understanding of the unifying concepts and processes of form and function.

S11—Students learn that the ability to either involuntarily or voluntarily respond to a stimulus is dependent on a reflex or stimulus–response pathway.

Physiologically, a reflex, or a stimulus-response begins with the application of a stimulus to a sensory receptor, such as an auditory hair cell, and ends with a response by an effector, such as a skeletal muscle.

Anatomical elements of the pathway include a sensory receptor, a sensory or afferent neuron, an integrating center in the brain or spinal cord, a motor or efferent neuron, and an effector.

B1 Science as Inquiry: Abilities Necessary to do Scientific Inquiry

Students should develop an understanding of science as inquiry and develop abilities necessary to do scientific inquiry.

S11—Students measure and compare reaction times of an individual subject using two stimulus presentation schedules: fixed intervals, and pseudo-random intervals.

Students are introduced to elements of statistics and their application in data analysis, and use statistics to determine the effects of learning on reaction times. They discover that when pseudo-random presentation trials are repeated, it takes longer for reaction times to decrease and the decrease is less than as occurs with fixed-interval presentation.

B2 Science as Inquiry: Understandings About Scientific Inquiry

Students should develop understandings about scientific inquiry.

S11—Students take a relatively simple look at reaction time and how changing one variable, stimulus presentation interval, can result in differences in reaction time.

Students realize that other factors could influence reaction time and are encouraged to think about and explore them using their laboratory experience.. For example, a person's reaction

time could be measured and compared in two different conditions, such as reading a book vs. watching TV.

D5 Life Science: Matter, Energy, and Organization in Living Systems

Students should develop an understanding of matter, energy, and organization in living systems.

S11—Students learn that a reflex is an involuntary or automatic, programmed motor response to a sensory stimulus. Literally, the word *reflex* is derived from a term meaning to reflect, or return back, with reference to the direction of travel of first the sensory impulses and then the motor impulses along the reflex pathway. Touching a hot object and jerking the hand away, or stepping on a tack and lifting the injured bare foot are examples of simple human reflexes. Reflexes in animals represent the earliest organization of neurons into a functional unit. Even in adult animals that lack a brain, such as a jellyfish, neurons have become specialized and organized to provide for simple, often life-preserving, reflex responses. In the human, reflex activities appear about five months before birth. Reflexes allow the body to react automatically and involuntarily to a variety of internal and external stimuli so as to maintain homeostasis.

A stimulus-response is functionally similar to a reflex except that it is voluntary rather than involuntary, and as such, it can be learned and is subject to behavioral modification. An example is lifting a finger in response to an audible click.

G1 Science in Personal and Social Perspectives: Personal and Community Health

Students should be given a means to understand and act on personal and social issues, to help students develop decision-making skills, and to give students a foundation on which to base decisions they will face as citizens.

S11—Usually, longer reaction times are a sign that the person is paying less attention to the stimulus and/or is processing other information. For example, if you took more time to respond to audible clicks while also reading a book than when you were also watching TV then you could infer that you were probably paying more attention to the book than to the TV since your brain took longer to respond.

Assessments from simple reaction time tests allows researchers a glimpse into the cognitive and neurological functioning of people as they perform tasks. Of current topical interest is the question of whether concurrent use of cell phones while driving an automobile impairs judgment and slows the driver's reaction time.

S12 Respiration: Apnea

A3 Unifying Concepts and Processes: Change, Constancy, and Measurement

Students should develop an understanding of the unifying concepts and processes of change, constancy, and measurement.

S12—Two principle functions of the human respiratory system are to supply oxygen to the blood and remove carbon dioxide from the blood. When the body is at rest, the rate and depth of breathing is stable and matches the body's needs for oxygen absorption and carbon dioxide removal.

Students learn that blood levels of carbon dioxide influence the rate and depth of breathing. When blood carbon dioxide increases above resting levels, as during physical exercise or after breath-holding, the rate and depth of breathing increases. When blood carbon dioxide decreases below resting levels as a result of voluntary hyperventilation or over-breathing, respiratory rate and depth decrease. Students record and measure changes in respiratory rate and depth associated with induced changes in blood carbon dioxide.

A5 Unifying Concepts and Processes: Form and Function

Students should develop an understanding of the unifying concepts and processes of form and function.

S12—The human lungs occupy air-tight compartments within the thorax or chest. Students learn that contraction of chest muscles increases volume of the thorax and lungs which results in air pressure inside the lungs falling below atmospheric pressure and air moving into the lungs. These events characterize inspiration.

Expiration, or the exhaling of air from the lungs occurs at rest when inspiratory muscles relax, decreasing the volume of the lungs and the thorax, thereby increasing pressure within the lungs above atmospheric pressure, forcing air out of the lungs.

B1 Science as Inquiry: Abilities Necessary to do Scientific Inquiry

Students should develop an understanding of science as inquiry and develop abilities necessary to do scientific inquiry.

S12—Students observe and record EMGs (electromyograms) from thoracic respiratory skeletal muscle during eupnea, or normal unlabored breathing at rest. Changes in the EMG are associated with modifications in the rate and depth of the respiratory cycle that occur before, during, and after periods of apnea vera and voluntary apnea (cessation of breathing). Students compare changes in the EMG associated with apnea to the EMG recorded during eupnea.

B2 Science as Inquiry: Understandings About Scientific Inquiry

Students should develop understandings about scientific inquiry.

S12—Students use respiratory electromyography to study changes in respiratory rate and depth associated with changes in blood carbon dioxide. They learn that electromyographic methods allow only for qualitative assessment of the changes. Quantitative measurements of changes in respiratory cycle depth and more exact measurements of changes in respiratory rate require the application of more sophisticated technology and analytical techniques. Thus, the results obtained from scientific inquiry are limited by the nature of the applied methods.

D5 Life Science: Matter, Energy, and Organization in Living Systems

Students should develop an understanding of matter, energy, and organization in living systems.

S12—Students learn that all living cells of the body require oxygen to derive energy from food. Stored chemical energy is used by cells to perform work. Cells produce carbon dioxide as a waste product of metabolism. The respiratory system works in conjunction with the circulatory system to deliver oxygen to the cells and remove carbon dioxide.

G1 Science in Personal and Social Perspectives: Personal and Community Health

Students should be given a means to understand and act on personal and social issues, to help students develop decision-making skills, and to give students a foundation on which to base decisions they will face as citizens.

S12—The normal person exhales carbon dioxide as fast as the body produces it so that blood carbon dioxide remains within normal limits. In diseases or conditions in which a person subconsciously hyper-ventilates, such as in chronic anxiety states, blood carbon dioxide may fall too low, removing the main stimulus to breathe, resulting in temporary apnea, dizziness, and fainting. Anxiety states are common in contemporary cultures.

On the other hand, if blood carbon dioxide is permitted to rise above normal, as would occur if a child held his breath to spite his parents, the elevated carbon dioxide would soon become a too powerful stimulus for the brain to ignore and breathing would automatically resume.