## Hands-on Physiology Lessons

11 tutorial-style lessons allow students to record data from their own bodies

### Lesson Features

- On-screen commands prompt students throughout the lesson.

  ![Sample prompts and lesson buttons](image)

- Video clips and downloadable sample data files provide additional insight into the use of the system.
- Extremely easy to set up and record data.
- Event markers can be added throughout the recording.
- The system includes example data files.
- Active learning options—students can design and record a new experiment to test or verify the scientific principle(s) covered in the 
  Biopac Science Lab recording and analysis segments. The lesson software is used to record new data segments to fit the student’s protocol.
- Student prep and distance learning tools available in the software and online.
- Lessons written by experienced science teachers support national curriculum standards.
- Teachers Guide includes sample questions and answers, normative values, and Biopac Science Lab support.

### Lesson Summaries

- Lesson 1 EMG I Muscle
- Lesson 2 EMG II Muscle
- Lesson 3 ECG I Heart
- Lesson 4 ECG II Heart
- Lesson 5 EEG I Brain
- Lesson 6 EEG II Brain
- Lesson 8 EOG Eyes
- Lesson 9 Biofeedback
- Lesson 10 Aerobic Exercise
- Lesson 11 Reaction Time
- Lesson 12 Respiration
Lesson 1 — EMG 1 Electromyography: Motor Unit Recruitment

EMG 1 investigates the properties of skeletal muscle. Students record the EMG data associated with the maximum clench strength for their dominant hand and non-dominant hand. The system records and displays both the raw and integrated EMG signals. Students compare clench strength between their two arms and listen to the sound of their EMG. It is also possible for students to perform a cross-group analysis.

EXPERIMENTAL OBJECTIVES

- To record maximum clench strength for right and left hands.
- To observe, record, and correlate motor unit recruitment with increased power of skeletal muscle contraction
- Optional: To listen to EMG “sounds” and correlate sound intensity with motor unit recruitment.

TASKS PERFORMED BY THE STUDENT

- Record EMG from the dominant and non-dominant forearms.
- Clench fist four times, squeezing harder each time to reach maximum clench strength with the fourth clench.
- Optional: Listen to the sound of their EMG.

KEY FEATURES

- Raw and Integrated EMG signals can be overlapped for easy interpretation of the data.
- Comparison between the dominant and non-dominant arms.
- The students listen to the sound of motor unit recruitment.

MATERIALS

- Biopac Science Lab intro system (uses six electrodes per subject)
- Optional: Headphones (40HP) to listen to the EMG signal
Lesson 2 — EMG 2 Electromyography: Mechanical Work

EMG 2 examines motor unit recruitment and skeletal muscle fatigue. Students lift hand weights to demonstrate the use of skeletal muscle and record EMG while inducing muscle fatigue. Students see the level of motor unit recruitment associated with the amount of applied force.

EXPERIMENTAL OBJECTIVES

- To record EMG response to increased weights lifted by dominant and non-dominant arms.
- To compare differences between male and female students.
- To observe, record, and correlate motor unit recruitment with increased mechanical work by skeletal muscle.
- To record EMG and Integrated EMG when inducing fatigue.
- Optional: To listen to EMG “sounds” and correlate sound intensity with motor unit recruitment.

TASKS PERFORMED BY THE STUDENT

- Lift weight (bicep curl) and hold for 2 seconds.
- Repeat cycles of weight lifting; add weight for each cycle until the Subject is lifting the maximum weight.
- Lift the maximum weight to 45 degrees and hold it until the onset of fatigue.
- Repeat the sequence for the non-dominant arm.
- Optional: Listen to the sound of their EMG.

KEY FEATURES

- Classic, clinical grid markings available for quick and easy evaluations.
- Raw and Integrated EMG signals can be overlapped for easy interpretation of the data.
- The students compare their dominant and non-dominant arms.
- The force values are scaled to kilograms.
- A clear demonstration of mechanical work.

MATERIALS

- Biopac Science Lab intro system (uses six electrodes per subject)
- Weight set (i.e., 5-10-15-20 kg dumbbells) — Subjects must lift the same weights for valid comparisons
- String to standardize distance lifted
- Ruler to measure distance lifted
- Optional: Headphones (40HP) to listen to the EMG signal
Lesson 3 — ECG 1 Electrocardiography: Components of the ECG

ECG 1 introduces the electrocardiograph and the recording of the heart’s electrical signal. Students learn about Lead II ECG recording and the components of the ECG complex. They also learn to correlate the electrical events of the ECG (P, Q, R, S & T components) with the mechanical events of the cardiac cycle. After performing a number of tasks designed to promote changes in the ECG complex, students analyze their own ECG recording.

**EXPERIMENTAL OBJECTIVES**

- To become familiar with the electrocardiograph as a primary tool for evaluating electrical events within the heart.
- To observe rate and rhythm changes in the ECG associated with body position and breathing.

**TASKS PERFORMED BY THE STUDENT**

- Lie down and relax.
- Take five deep breaths.
- Perform a physical exercise to increase heart rate.
- Relax while heart rate returns to normal.

**KEY FEATURES**

- Rate and ECG signals can be overlapped for easy interpretation of the data.
- The baseline can be adjusted for precise analysis and printing.
- Zoom in for a closer look at an individual ECG complex.
- See how the ECG complex changes under different conditions.
- Convenient electrode placement (wrists and ankles).

**MATERIALS**

- Biopac Science Lab intro system (uses three electrodes per subject)
- Cot or lab pillow
Lesson 4 — ECG 2 Electrocardiography

ECG 2 explains Einthoven’s triangle. Students record Leads I and III while performing a number of tasks designed to change the rhythm of the heart. They then analyze the data and estimate the mean QRS axis and potential.

EXPERIMENTAL OBJECTIVES

- To record ECG from Leads I and III in the following conditions: lying down, sitting up, and breathing deeply while sitting.
- To compare the direction of the QRS complex (+ or −) with the direction of the lead axis.
- To estimate the mean ventricular potential.
- To estimate the mean electrical axis of the QRS complex.

TASKS PERFORMED BY THE STUDENT

- Record ECG using bipolar Leads I and III.
- Lie down and relax.
- Sit and relax.
- Breathe in and out once in each position.

KEY FEATURES

- The software makes it very easy for the student to compute the ECG vectors.
- Classic, clinical grid markings available for quick and easy evaluations.
- See how the ECG complex changes under different conditions.
- Students place markers for each component (P, Q, R, S, and T).

MATERIALS

- Biopac Science Lab intro system (uses four electrodes per subject)
- Cot or lab pillow
- Protractor
- Two different color pens or pencils
Lesson 5 — EEG 1 Electroencephalography: Brain Rhythms

EEG 1 introduces electroencephalographic recording techniques. Students record EEG from the occipital lobe while performing a number of different tasks to demonstrate how the brain’s electrical activity varies depending on the task. The software filters the raw EEG signal to separate and display alpha, beta, delta, and theta rhythms.

EXPERIMENTAL OBJECTIVES

• To record an EEG from an awake, resting subject with eyes open and eyes closed.
• To identify and examine alpha, beta, delta, and theta components of the EEG complex
• To compare differences between male and female students.

TASKS PERFORMED BY THE STUDENT

• Record EEG from the occipital lobe.
• Record EEG from a relaxed subject with their eyes closed, eyes open, and eyes closed again.

KEY FEATURES

• Alpha, beta, delta and theta wave components are automatically filtered and displayed.
• View the different EEG wave components.
• Overlap the EEG wave components for a better view of the data.
Lesson 6 — EEG 2 *Electroencephalography: Alpha Rhythms (in the Occipital Lobe)*

In EEG 2, students will discover how the brain constantly receives sensory input and integrates the information before processing it. Students record EEG data from the occipital lobe while performing a number of tasks. The system records and displays the raw EEG together with the alpha wave and alpha-RMS activity. Students compare baseline EEG with the data recorded during the different tasks.

**EXPERIMENTAL OBJECTIVES**

- To record an EEG from 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.
- To examine differences in the level of alpha rhythm activity during mental arithmetic and hyperventilation, compared to the control condition of eyes closed and relaxed.

**TASKS PERFORMED BY THE STUDENT**

- Record EEG data from the occipital lobe.
- Lie down and relax with eyes closed.
- Perform mental math problem with eyes closed.
- Hyperventilate for two minutes.
- Recover from hyperventilation with eyes open.

**KEY FEATURES**

- Alpha wave activity and alpha-RMS waveforms are automatically filtered and displayed.
- Overlap the EEG wave components, raw and alpha, for a better view of the data.

**MATERIALS**

- **Biopac Science Lab** intro system (uses three electrodes per subject)
- **Optional**: Lycra® swim cap (such as Speedo® brand) or supportive wrap (such as 3M Coban™ self-adherent support wrap) to press electrodes against head for improved contact
- Cot or lab pillow

Lesson 7 — TBA
Lesson 8 — EOG 1 Electrooculogram

In EOG 1, students record horizontal eye movement and observe eye fixation and tracking. Students perform a number of tasks that allow them to record the duration of saccades and fixation. Students also record spatial position of eye movements.

EXPERIMENTAL OBJECTIVES

- Record EOG on the horizontal plane and compare eye movements under the following conditions: pendulum tracking, pendulum simulation, reading silently, reading aloud, and reading challenging material.
- Measure duration of saccades and fixation during reading.
- Optional: explore microsaccadic eye movement.

TASKS PERFORMED BY THE STUDENT

- Record horizontal EOG.
- Track pendulum movement with eyes only, trying not to move head or blink.
- Simulate pendulum movement (decreasing swing cycles) with eyes only.
- Read Passage 1 (easily understandable material) silently (to self) for 20 seconds.
- Read Passage 2 (challenging material) silently (to self) for 20 seconds.
- Read Passage 1 aloud.
- Optional: Focus on an on-screen guide; position of guide represents point of focus.

KEY FEATURES

- Tools for zooming in to see the saccades.
- Great introduction to EOG.

MATERIALS

- Biopac Science Lab intro system (uses three electrodes per subject)
- Pendulum (metronome may be used; signal pattern will be constant vs. diminishing)
- Passages for reading:
  Passage 1 — easily understandable (i.e., entertainment article)
  Passage 2 — challenging (i.e., scientific article)
Lesson 9 — Biofeedback Influencing Autonomic Tone

The Biofeedback lesson explores the concept of biofeedback training and its effect on autonomic control of heart rate. An onscreen, thermometer-style heart rate display rises and falls with changes in heart rate, allowing students to become conscious of their heart rates. The Subject will try to influence the reading without physical movements.

EXPERIMENTAL OBJECTIVES

- Introduce the concept of biofeedback as a technique to alter autonomic tone.
- Measure changes in autonomic tone via heart rate.

TASKS PERFORMED BY THE STUDENT

- Record ECG and heart rate.
  - Biopac Science Lab intro system (uses three electrodes per subject)
    - PowerPoint Viewer 2003 lets you view full-featured presentations created in PowerPoint 97 and later versions, which can greatly enhance the feedback segments of this lesson.
  - Presentation 1 — images or sound
  - Presentation 2 — modified
    - Presentation 1 with startling sound or image inserted
  - Watch monitor and mentally try to voluntarily increase parasympathetic tone (lower heart rate display).
  - Watch monitor and mentally try to voluntarily increase sympathetic tone (increase heart rate display).
  - Watch two PowerPoint presentations and try to remain relaxed.

KEY FEATURES

- Great introduction to biofeedback techniques,
- Shows the student how they can influence and control the autonomic nervous system.
- Excellent display format for immediate visual feedback.
Lesson 10 — Aerobic Exercise Physiology

In the Aerobic Exercise Physiology lesson, students record ECG and heart rate under a variety of conditions. Students see how the electrical activity of the heart and their heart rate change to meet changing metabolic demands. Students exercise to elevate heart rate.

EXPERIMENTAL OBJECTIVES

- Measure changes in heart rate associated with a specified set of dynamic exercises.
- Assess individual physical fitness by measuring elevated heart rate at the immediate end of a specific exercise period.
- Assess individual physical fitness by measuring the time from the end of exercise to the return of resting heart rate.
- 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.

MATERIALS

- Biopac Science Lab intro system (uses three electrodes per subject)

Optional: Tape or clip to stabilize lead cables during exercise

TASKS PERFORMED BY THE STUDENT

- Record ECG and heart rate.
- Calculate personal maximum heart rate.
- Sit and relax.
- Exercise (e.g. running in place/jumping jacks) to elevate heart rate.
- Recover from exercise (sit and relax).

KEY FEATURES

- Great introduction to physiological changes associated with exercise.
- The equipment does not interfere with the exercise.
- No expensive exercise equipment required to run the lesson.
Lesson 11 — Reaction Time *Fixed & Pseudo-random Intervals*

The Reaction Time lesson demonstrates the effect of learning and physiological processes on reaction times. Students hear two presentation schedules of clicks through a set of headphones. With electrodes in place to record the activity of the extensor digitorum (the primary muscle used to lift a finger), the Subject lifts finger as quickly as possible after hearing a click. Students then perform a statistical analysis of the results, including: group mean, variance, and standard deviation.

**EXPERIMENTAL OBJECTIVES**

- Measure and compare reaction times of an individual subject using two stimulus presentation schedules: fixed intervals and pseudo-random intervals.
- Introduce elements of statistics into data analysis.
- Use statistics to determine the effects of learning on reaction times.

**MATERIALS**

- **Biopac Science Lab** intro system (uses three electrodes per subject)
- **Stimulus-Response Set**: Feedback cable (40CBLFB1), stereo headphones (40HP), and audio extension cable (40CBLEXT)

**TASKS PERFORMED BY THE STUDENT**

- React to a schedule of fixed interval clicks (two trials).
- React to a schedule of pseudo-random clicks (two trials).

**KEY FEATURES**

- The software automatically calculates the reaction time.
- Guides students through the statistical analysis of a data set.
- The lesson will also work with different stimuli.
Lesson 12 — Respiration 1 Apnea

In Respiration 1, students observe physiologic modifications of the respiratory cycle associated with voluntarily increasing and decreasing blood carbon dioxide content by holding breath and hyperventilating. Students will qualitatively determine changes in respiratory minute volume by recording and analyzing EMGs from respiratory muscles of the thorax.

EXPERIMENTAL OBJECTIVES

- To observe and record EMGs from thoracic respiratory skeletal muscle during eupnea, or normal unlabored breathing at rest.
- To record changes in the EMG 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 and to compare those changes to eupnea.

MATERIALS

- Biopac Science Lab intro system (uses three electrodes per subject)
- "Optional: Nose clip (AFT3"

TASKS PERFORMED BY THE STUDENT

- Record EMG and respiration.
- Breathe normally with mouth open.
- Hyperventilate.
- Recover from hyperventilation.
- Hold breath.
- Hyperventilate and then hold breath.

KEY FEATURES

- Great introduction to the respiratory effects of increased or decreased blood carbon dioxide content.
- No expensive respiratory equipment required to run the lesson.
- The lesson setup can record and allow students to study other respiratory fluctuations.