Why Muscle Biology?

Relevance

Muscles, as the main tissue involved in locomotion, play a very important role in our everyday lives. We all have experienced the power that muscles can produce when we pick up a heavy suitcase or sprint to get out of the rain. And, when we exert our muscles, many of us have experienced the burn that these activities produce. Thus, students are well aware of the functioning of muscles, even if they do not understand how this tissue is built or how it works.

The purpose of this unit is to use the basic understanding of muscle function that all students have and build on it so that they can learn skills to ask questions about the functioning of their own bodies. In addition, the skills they will learn in this unit will also allow them to understand muscle dysfunction and, potentially, the impact of toxins on the functioning of muscle.

Connections

Muscle biology is a great tool because it can be used to link many important areas of biology. For example, the two experiments in this unit were designed to teach students about cellular respiration, a very important topic that is covered in many biology classes. However, the NADH staining protocol would fit well in a unit on enzymes and the acid buffering protocol could be used in a unit on pH and buffers. Thus, many different topics can be addressed using these two protocols, and the connections between these topics can be revealed.

These units could also be built upon in a unit on anatomy. Both of these protocols reveal some aspects of muscle morphology. Thus, as the students learn about muscle tissue and its functions, they can remember how muscle is built. These connections are very important, and help students understand that form and function are related.

Research Opportunities

Science teachers face many challenges in designing their curriculum and one of the most difficult is to provide students with the opportunities to conduct open-ended experiments. The acid buffering protocol, because muscle samples can be obtained from a supermarket, is well suited for student research. In addition, this technique is used by professional scientists to understand the functional abilities of muscles in various types of animals.

Students can use muscle from chickens, cows, pigs, or fish and examine their acid buffering capacities. Although they cannot use this protocol to examine their own muscle, they will be able to use the information that they gather about the muscle of other animals to make hypotheses about their own muscle. In addition, they can utilize the literature available from this type of research to learn more about muscle function in their own bodies.

Both protocols in this unit will lead to more questions than the initial experiments will answer. Thus, students may be led to form new hypotheses that could be tested with further experimentation. Given the time and freedom to carry through with these experiments, students will be able to experience first-hand the creativity that is involved in science as well as the excitement of practicing scientific inquiry.

Table 1. NSES Content Standards Addressed through EI Muscle Biology Research

National Science Education Standard (National Research Council, 1996)	Protocol 1 – NADH Activity	Protocol 2 – Acid Buffering Capacity
Unifying concepts and processes in science		
Systems, order, and organization	√	√
Evidence, models, and explanation	√	√
Change, constancy, and measurement	√	√
Form and function	√	√
Science as inquiry		
Abilities necessary to do scientific inquiry	√	√
Understanding about scientific inquiry	√	√
Life science		
Cell	√	√
Behavior of organisms	√	√
Science and technology		
Understanding about science and technology	√	√
History and nature of science		
Science as a human endeavor	√	√
Nature of scientific knowledge	√	√
Historical perspectives	√	√

Critical Thinking

One of the main problems with how students approach science is that they think every exercise has only one right answer. Thus, they undertake experiments with the idea that there is only one outcome, and when their data does not meet their expectations, then they conclude that they did their experiment incorrectly. This view of science and how it is practiced leads to problems when students read or hear about disagreements in the scientific community. If there is only one right answer to every question, then how can both sides of the argument be scientific? One of the points of view must be wrong. However, once students carry out their own research projects, they will better understand the uncertainty in science. They will have to make decisions about how to collect and interpret their data, and in discussing their project with other students, they will learn that there are many different ways to look at their results. Therefore, they will begin to see how bias can affect every step of the scientific process, from the methods to the interpretation of results.

In the NADH staining experiment, students will have to determine how many fibers they will count to get what they feel is an accurate fiber-type profile for the entire muscle. They will also have to decide how they will collect these data. Will they decide to have the whole class collect the data? If so, how will they define dark staining so that everyone is categorizing the fibers in the same way? Or, will they decide to have only one person collect the data and what type of bias does this decision introduce into the data collection? With these many questions, the students will be learning about bias and the different ways that it can be introduced into data collection.

The acid buffering protocol gives students the opportunity to design their own experiment. During this process, the students will have to make decisions about how many replicates they will use and what they will use for a control. As they work on their experimental design, they may get the opportunity to discuss their experiment with other students. This discussion will help the students refine their experiment and gives them an idea of how science is usually practiced.

In conclusion, students using the **Muscle Biology** unit will learn concepts that are integral to the study of muscle biology and to conducting scientific research. These concepts will be learned while they are conducting real-life experiments that will help them understand the functioning of their own bodies. Table 2 lists intended learning outcomes for students engaged in EI Muscle Biology Research.

Table 2. Intended Learning Outcomes

Skills: students will be able to

- Conduct scientific research, starting with well-defined protocols and progressing to open-ended research projects
- Work collaboratively to design experiments, interpret results, and critically analyze ideas and conclusions
- Define a muscle biology research question, then plan and carry out an experiment to address this question using either NADH staining or acid buffering
- Analyze data and draw conclusions about the oxidative or acid buffering capacity of a muscle sample
- Identify sources of variability in data, including potential sources of bias
- Write a concise summary of methods, results, and conclusions
- Use commentary from fellow students to revise or justify research reports and presentations
- Critically analyze summaries of other students' research to determine whether each study was based on good experimental design
- Provide constructive criticism of fellow students' data analysis, interpretations, and conclusions

Concepts: Students will understand that

- Muscle biology is the study of the form and function of muscles
- Muscle biology involves interactions between biology, chemistry, and engineering.
- NADH staining provides a measure of the oxidative capacity of a muscle.
- Acid buffering capacity provides a measure of the ability of a muscle to rely on glycolytic metabolism
- NADH staining and acid buffering reveal the functional capabilities of a muscle
- The same muscle in different animals can differ in their NADH staining properties as well as their acid buffering capacities
- Different muscles in the same animal can differ in their NADH staining properties as well as their acid buffering capacities
- Science is multidisciplinary
- Clear presentation of research results is an integral part of the scientific process
- Scientists work both individually and collaboratively, reviewing each other's work to provide feedback on experimental design and interpretation of results
- Scientific understandings are tentative, subject to change with new discoveries