WEBQUEST

Walking Away from Spinal Cord Injury:
A Look at Physics and Engineering in Biology

Teacher Resources

1.Background

a. Why Be Interdisciplinary?

Every science teacher should have a favorite Stanley Harris cartoon. A good candidate would be one that shows a researcher saying to a colleague "I'm on the verge of a major breakthrough, but I'm also at that point where chemistry leaves off and physics begins, so I'll have to drop the whole thing." Unfortunately, this is the view of science practice that most students learn from the "layer cake" curriculum in high schools. Science subjects are typically isolated from one another in a way that obscures the increasingly multi-disciplinary nature of work in the field. One goal of this activity is to allow students to see how physics, biology and engineering can provide an integrated approach to a real-world problem. The biologist provides the knowledge of the normal operation of the nervous and skeletal/muscular systems and the nature of the failure in injury. The physicist provides mathematical analysis and modeling of the uninjured nervous system and the prospective technological solutions based on the principles of electromagnetics, force and motion. The engineer provides the design and implementation of an electromechanical solution based on the input from the biologist and physicist.

b. Why This Topic?

Perhaps your students never saw Christopher Reeve's portrayal of Superman, but they may know of his battle with spinal cord injury. If not, the news unfortunately provides many other examples of people in a similar struggle, all too often the same age as our students. Paralysis is a concept that the students already grasp. We can use this understanding to motivate new understandings. How do the nervous and skeletal/muscular systems normally provide walking? What really happens in a spinal cord injury? What other problems come with a spinal cord injury? What is currently being done to help people in this situation?

People with spinal cord injuries deal with much more than the loss of mobility. (Can your students guess what other problems exist?) Without stimulation, muscles atrophy. Without load, bones lose density. Without the demand of the body's largest muscle groups, the cardiovascular system degrades. Muscles sometimes experience spasms or spasticity (rigidity). Change in the appearance of the affected muscles can lead to a loss of self-esteem. All of these problems can contribute to depression. These symptoms arise because the legs don't work… or do they? Ask your students what's really broken here. You can use a telephone to communicate with people that your voice can't reach. Can you use something to allow your brain to communicate instructions to muscles it can no longer reach?

Functional electrical stimulation (FES) uses low voltages applied externally to the legs and torso to create muscle contraction. When innervated in the correct sequence, the muscles can provide an approximation of a normal walking gait or peddling on an exercise bike. Performed in a lab with a large computer and as many surface electrodes as desired, this approximation can be remarkable. In typical clinical (or home) use, the limits of time (patient can't spend hours

attaching and removing electrodes), and computing power (the computer that coordinates the voltages to contract the muscles in the proper sequence needs to be wearable) necessitate a movement that looks less like normal walking, but patients can use a walker to provide mobility. Although this is not easy and tends to be very tiring, use of this system has shown reduction in the severity of most of the problems above. FES systems were designed with the coordination of experts in biology, medicine, physics, biomechanics and electronics. Hopefully, stem cell research will one day provide a cure for spinal cord injury, but when that happens patients will need to be ready with strong bones, muscles and cardiovascular systems.

c. Why a webquest?

Technically speaking, this activity is probably a "treasure hunt" instead of a webquest. What's the difference? Perhaps the biggest distinction lies in what stage of learning the activity is designed to address. If the students are in the information gathering stage, a treasure hunt leads them on a path through fact-based websites. If the students have enough background to begin synthesis, analysis and evaluation, a webquest takes advantage of the diversity of opinion and passion that can be found in the electronic community. That passion and diversity of opinion is not typically found in textbooks. Our books also cannot provide the engaging animations and videos found on the Web, nor the opportunity to approach a subject a little less linearly. The people who claim to have coined the term "webquest" present a great case for using the Web in the classroom as well as the proper design and use of the webquest at their website. Check it out.
http://www.ozline.com/learning/index.htm

2. Using This Activity

a. Preparation

If you have not used web-based activities, there are a few precautions to keep in mind. First, be sure to visit the required sites near the time you expect to have students do the activity. Websites change and even come and go. It's not hard to replace a site, but tougher to do so "on the fly." Decide ahead of time how much you may want to let the students stray from the pages cited in this activity. One of the Web's unique qualities is its non-linearity. This activity removes most of that by directing the learner to specific sites. There is much additional information to be found on pages directly linked to the ones in this investigation, but be careful to watch time if you allow your students to "wander."

b. Group Adaptation

While this activity can be accomplished individually, a group setting would allow a more authentic learning experience. Constructivism tells us that learning is best constructed in a social setting… if you want to read all about it, try
http://www.artsined.com/teachingarts/Pedag/Dewey.html
http://unr.edu/homepage/jcannon/ejse/ejsev2n2ed.html
http://www.cdli.ca/~elmurphy/emurphy/cle.html
The different parts of this activity could be assigned to different students in a group who then get back together and share with one another. Another "jigsaw" approach would be to begin with students in small groups, with each group focused on one part of the investigation. A second set of groups would then be organized with one or two members of each original group summarizing for their new partners what they found during the first round. These summaries would be expected to include demonstrations of the illustrations, videos and graphics that would aid in the retelling.

It would be in these second groupings that the students would address the larger, central questions of the webquest. This approach is an attempt at cooperative learning. Expert descriptions of the methods used in cooperative learning (and some interesting disagreements over it) can be found at
http://edtech.kennesaw.edu/intech/cooperativelearning.htm
http://www.co-operation.org/
http://www.kaganonline.com/KaganClub/index.html

c. Further Adaptations

This activity was designed for use in a biology class, during the study of human physiology. It can be used as review after presentation of the nervous and muscular/skeletal systems. A better idea might be to use it as an introduction to physiology, to provide a more inquiry-based approach. By adding detail to the level of the questions, this activity could be used in a higher-level biology class or an anatomy/physiology course. For use in a physics class, emphasis can be shifted to physics and its use in biology by adding question about electronics taken from
http://www.rwc.uc.edu/koehler/biophys.2ed/circuits.html
One possible question for physics students would be "What advantages does the nervous system gain by relying more on synapses than on "hardwired" connections between neurons? (Look for answers involving the ability of a post synaptic neuron to "sum up" the inputs from several incoming neurons, the ability to inhibit as well as promote the firing of a post synaptic neuron, and the flexibility or plasticity provided by the ability to change synapses.
Another area for thought in physics is biomechanics. (Gait analysis provided the knowledge of the sequence of muscle activation to approximate walking.) See
http://guardian.curtin.edu.au:16080/cga/
http://www.motionanalysis.com/