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Exercise in Teaching

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In a sense, teaching is like muscle building; once you stop working at it, atrophy sets in. After you've been teaching for a few years, you've developed enough instructional muscle that it's easy to coast, to use the same text, the same notes, the same lab assignments over and over. With the numerous pressures involved in teaching, it is often difficult to exert the mental energy necessary to change things. It's not that you don't have good ideas or great plans; the problem is in the execution.

Athletes who want to train properly need coaches to keep spurring them on to greater accomplishments. Often teachers need the same kind of goad, usually provided by administrators. Last year, the dean asked me to develop a course in the physiology of exercise as part of the course offerings for a new minor in athletic training. If I had been asked to develop a course of my own choosing, this would not have been it. I am not Jane Fonda (to say the least!). Ten minutes of aerobics and a mile of jogging strains my physical limits. But I accepted the assignment because it was a chance to reduce my intellectual flab; my coach was forcing me to exercise my teaching muscles.

It turned out to be a wonderful experience, despite the fact that when I teach a course for the first time it never comes out quite the way I want it to. It's never smooth. Getting a course into shape can be as painful as getting a body into shape. But this course caused me less mental cramps than others have, for a variety of reasons. First of all, I had a wonderful group of students. Students can make or break a class, particularly one being taught for the first time. The subtle, and sometimes not so subtle, student feedback that a teacher constantly receives in the classroom is the best guide to how well things are going.

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But in some classes there just is no feedback. If my first exercise physiology class had been composed of such semi-conscious students, I would probably have been too discouraged to ever attempt it again.

The students liked the idea of a biology course about exercise. Some were working toward a minor in athletic training, so naturally they would find this material interesting, but many were nonmajors, taking the course just to fulfill part of their science requirement. Many in both these categories were athletes, interested in how their bodies worked, though there was also a sizable group who thought walking to the parking lot was more than enough physical exertion for their taste. Even with this diversified population, there seemed to be something in the course for everyone. The athletes liked the section on physical conditioning; the nonathletes enjoyed the discussion of nutrition and weight control. The female students were interested in the section on sex differences in exercise, while the males were especially attentive when the topic of anabolic steroids came up.

The second reason things went so well has to do with the nature of the course material. Basically, it is a course in physiology, but taught from the viewpoint of how the body's functioning changes in response to physical exertion. I had taught human physiology before, but with a more standard approach. In comparison, I found this new viewpoint exciting. Obviously, it's a less balanced approach; the respiratory and circulatory systems, for example, are stressed at the expense of the excretory and digestive systems. But it does provide a nice focus, an organizing principle around which to structure the course material. Everything ties together because you are always asking the same question of the different systems of the body: what happens when the body works harder?

One of the reasons exercise physiology provides such a nice viewpoint is that exercise changes so many functions of the body. The body is a unity; all of its activities are so well integrated that a change in one will cause responses and adjustments in many others. This unity is easy for students to forget when each system is treated separately. Response to exercise is a nice thread with which to weave the systems together; they are all acting in response to the body's increased workload. The most obvious responses involve the circulatory, respiratory and skeletomuscular systems. Though these changes may seem apparent, the mechanisms involved are far from well understood. An article on athletic heart syndrome illustrates this point (Huston, Puffer & Rodney 1985). With exercise, there are changes in the heart's electrophysiology, including increases in certain types of dysrhythmias. There is uncertainty as to the significance of these irregularities. Can they truly be termed irregularities, or are they normal responses to increased workload? What happens to the heart when training ceases? Does the heart revert back to its pretraining condition? These are some of the questions researchers are now investigating.

A classroom discussion of the heart and exercise leads to questions about heart attacks during jogging, tennis playing, etc. A recent study (Siscovick, Weiss, Fletcher & Lasky 1984) indicates that vigorous exercise both provokes fatal heart attacks and protects against them! In other words, heart attacks are more likely to occur during vigorous activity, particularly

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in individuals who are not accustomed to such activity, but in those who exercise regularly, the risks decrease.

Metabolism is an important topic in any physiology course, but in exercise physiology the emphasis is on the metabolic processes of energy production where there is a complex interplay between four processes (Brancazio 1984). The ATP-creatine phosphate system provides immediate energy, but only for about 30 seconds. Anaerobic glycolysis takes over, but the resulting buildup of lactic acid leads to muscle fatigue, so this system will provide energy for only a couple of minutes. For any activity lasting longer, aerobic metabolism of either sugar or fat is involved. Many students don't enjoy the biochemical explanations of these processes until they see how they affect performance. Biochemistry explains why sprinters can run so much faster than marathoners, and why runners get a second wind when aerobic processes take over in muscle tissue.

If any theme recurs repeatedly through the semester, it is how the body strives to obtain and utilize oxygen. In response to training, the respiratory muscles become stronger and more flexible, so lung capacity increases. The red blood cell count also increases so the blood becomes more efficient in carrying oxygen. Augmenting this natural process is the rationale behind blood doping, giving transfusions of either whole blood or packed red cells to increase the blood's oxygen-carrying capacity. This, in turn, should increase the muscles' ability to generate energy aerobically (Klein 1985). Blood doping has been criticized for medical and ethical reasons. Transfusion of donated blood carries with it the risk of infections and allergic reactions. These problems are reduced if athletes receive blood they previously donated themselves. While this is safer and elininates the ethical question of using a precious medical resource for a nonmedical purpose, there are still problems. It can be unsafe if the blood is not collected, stored, and transfused properly. And there is still argument as to whether blood doping is effective because the increased oxygen-carrying capacity of the blood is at least partially offset by higher blood viscosity and reduced blood flow.

Medical and ethical issues are also involved in the use of anabolic steroids in athletics. These steroids, related to the male hormone testosterone, are attractive to athletes because of their supposed muscle-building effects. These effects have not been substantiated in controlled studies, perhaps because the doses used were many times lower than those often used by athletes. These high doses not only produce greater anabolic or tissue building effects, but more severe side effects as well, including decreased fertility, cholesterol build-up and altered liver function. After long-term use these effects may not always be completely reversible. In women, these drugs produce the same effects, as well as masculinization.

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Thomas Murray (1983) looks at steroid use as an ethical issue. Should athletes be banned from using such drugs? How can harm to the body be balanced against restriction of personal liberty? Such a discussion obviously includes other performance-enhancing drugs or 'ergogenic aids,' particularly amphetamine and cocaine. This is a topic of interest to students, especially student-athletes, and it is a topic that shows the power of exercise physiology to lead into many other areas, areas as seemingly far afield as ethics.

Another direction in which exercise physiology leads is toward an awareness of the changing role of women in our society. On the whole, women's increased participation in sports has had positive effects. It has increased physical fitness among women and shown that the female is capable of a level of athletic attainment that was unsuspected two decades ago (Wood 1980). But the changes, negative as well as positive, that occur in women's bodies as a result of regular exercise have only recently been investigated. A particular area of concern is exercise-associated menstrual disorders (Bullen et al. 1985). These seem to be triggered by lower sex hormone levels caused by the stress of exercise and by the reduction in the percentage of body fat. They are reversible, in most cases, when the exercise level is reduced. Another troublesome effect of low hormone levels is the demineralization of bone similar to what occurs when the estrogen level decreases at menopause. Physicians are concerned that this demineralization may leave bones more susceptible to injury (Drinkwater et al. 1984).

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Bone demineralization, which, with aging, can lead to osteoporosis, has received much publicity recently, and naturally, it came up in exercise physiology class. Bone formation and maintenance are under a variety of complex and only partially understood controls (Raisz & Kream 1983). That's why there is such controversy over how to treat and prevent osteoporosis, about how much vitamin D and calcium are needed in the diet, and in what form they should be taken.

This leads to the whole question of good nutrition, and presents a problem in a course like this. Exercise physiology is a topic linked to so many others that it is easy to go off on tangents, valuable tangents perhaps, but none-the-less tangents that can weaken the unity of the course. I tried to limit my discussion of nutrition to the changes in diet demanded by vigorous physical activity, to pointing out, for example, that increases in carbohydrate for energy should be greater than increases in protein for muscle building. Without a tight rein on this topic, it could lead almost anywhere, including outer space—because there is good evidence that prolonged space travel leads to increased calcium excretion and decreased bone density (Goode & Rambaut 1985). NASA researchers have developed a bone stiffness analyzer to detect small changes in bone structure (Bone analyzer 1985), and the Soviets have designed a 'penguin' suit to help stem skeletal deterioration. It provides a load of about 50 percent of the body weight on a Cosmonaut when in a normal earth-bound posture.

In any class I've taught in physiology, health, and now in exercise physiology, a question always raised is: "Does cracking your knuckles ruin your joints?" For some reason, this burning issue fascinates the student mind. Apparently *The New York Times* also gets such queries, because in a short item (for which, unfortunately, I have no date) they answer this question—yes and no. In young people with still-forming bones, knuckle cracking may lead to bone deformity "as well as causing nerve damage to their parents." But in a study of older people, knuckle crackers were no more likely to have arthritis than non-knuckle crackers.

On the more technical side, we discussed the structure of skeletal muscle fibers and of their contractile units. This is rough going for students who are more interested in what a muscle can do rather than how it does it. But the interaction of actin and myosin filaments is worth careful study because here physiology can be carried down to the molecular level. Yet even in this well-studied system there are still mysteries. Three recent articles (Craig 1985; Irving 1985; Clarke 1985) indicate that the exact structure and activity of the actin-myosin crossbridge in contracting muscle is still a matter of debate. In discussing this, I like to tie the students' confusion to that of researchers in the field. This a complex mechanism that we are all, at different levels, trying to grasp.

Another area students find frustrating is how to make sense of all the devices and procedures used to measure such things as metabolic activity, energy expenditure and oxygen consumption. I've just come across a practical example of one technique, and I'll use it next time I teach this course. It involves a recent study on energy expenditure in cigarette smokers (Hofstetter, Schutz, Jéquier, & Wahren 1986). Researchers used a chamber that was an open-circuit, indirect calorimeter to discover that in a 24-hour period smokers expend about 10 percent more energy than non-smokers. This helps to explain why smokers gain weight when they stop smoking; it's because the rate of metabolism decreases. For exercise phsyiology, it makes a nice example of the use of an indirect calorimeter, that is, a device that measures heat production indirectly by measuring oxygen consumption.

As I just mentioned, I'm looking forward to teaching this course again next year. Now that I've discovered this field, or been goaded into discovering it, I'm fascinated by it. One of the things that makes it so rewarding is the number of good books available. They range from the highly technical, such as Thomas McMahon's *Muscles, Reflexes, and Locomotion* (1984), to the simple and practical, such as *Science and Sport* by Vaughan Thomas (1970) and *The Sportsmedicine Book* by Gabe Mirkin and Marshall Hoffman (1978). One of my favorites is *Newton at the Bat* (Schrier & Allman 1984). It's a collection of essays on science in sports. All the pieces are fascinating, but the ones on physiology are particularly pertinent to this course. They include a discussion of the effectiveness of Gatorade in maintaining electrolyte balance, and an article on wrestlers trying to 'make weight.' All these books have helped me develop the background material necessary to augment the assigned text, *Essentials of Exercise Physiology* (Shaver 1981).

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But there was no point in getting excited about this course if my students found it repulsive, so at the end of the semester, I asked for their anonymous comments. This is really asking for trouble, and I got what I deserved. The course was described as "not as boring as others I have had," "for a bio course, it wasn't that bad," and "entertaining (at times)." I was called a "great teacher" by one student, and "a bit dull" by another. But on the whole, students enjoyed the course. The comments I found most constructive were those suggesting more emphasis on how exercise physiology relates to specific sports activities. Next time, I plan to use more examples involving particular exercises.

This is where my experience might be useful to other teachers. Most teachers must follow tightly-packed syllabi; they have little room to introduce new material. But an example from athletics from time to time may stimulate student interest. Anabolic steroids might come into a discussion of sex hormones, aerobic exercise into a class on metabolism. We all have to keep exercising our teaching muscles if we're going to keep our mental flab under control, and exercise physiology is a nice training device.

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