Results are determined by comparing fresh weights of the calli produced or by histological examination. If a histological examination is carried out, the effect of these treatments on xylem differentiation may also be studied.

This exercise has several merits that earn it a recommendation for use in undergraduate courses. It offers a unique *in vivo* demonstration of the effects of cytokinins at both the cellular and organismic levels. Gibberellic acid's enhancement of cytokinin induced cell division provides a good example of hormone interaction. The procedures are uncomplicated, inexpensive and produce initial results within a three-week period. Students are introduced to solution culture techniques and provided with experience in measuring plant growth and collecting data. The root callus provides an excellent material for introducing histological methods. It is small enough to fix well and is easily handled during the dehydration, embedding and microtoming processes. Finally, the exercise establishes an open-ended experimental system which may be used for further investigations.

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How-To-Do-It

Using the Muscle Response Phenomenon to Enhance Biology Teaching

Barry S. Kendler

This paper's primary purpose is to share a method which introduces biology students to some fundamental aspects of scientific methodology. This is done through an unusual demonstration which involves simple muscle testing procedures and which can be quickly learned and easily implemented. The instructor can also use the technique to probe the scope and limit of scientific knowledge; students can use it to conduct research projects with minimal expenditures for equipment.

This article was inspired by a paper in *ABT* on an imaginative teaching strategy employed in human anatomy and physiology and embryology courses (Conway 1987). In an effort to "catch students' interests, hold their attention and facilitate their learning," Conway introduces his students to a number of abnormal and/or unusual facts compiled from various sources which depict noteworthy clinical case histories, disorders of famous people, athletic injuries, world records and unusual feats and phenomena. This paper pertains to the latter category.

Several years ago I presented a seminar with the enigmatic title "MURP: The Muscle Response Phenomenon" to our undergraduate senior biology majors and biology faculty. The seminar was regarded by both groups as a notable success. Since that time, I have used components of that presentation with similar success in anatomy and physiology and introductory biology classes and as a guest lecturer in other courses at my college and in other institutions.

Historical Perspective

MURP is demonstrated by standard manual kinesiological testing procedures which have been used by orthopedists and physical therapists for years (Daniels & Worthington 1972; Kendall, Kendall & Wadsworth 1971). During the past two decades, kinesiological testing has been adapted by Goodheart (1966) and subsequently by some other chiropractors (Stoner 1977; Thie 1979; Walther 1976) for the diagnosis and treatment of certain disorders. It has even found its way into the professional literature in dentistry (Eversaul 1985) in the diagnosis and therapy of temperomandibular joint dysfunction and in veterinary medicine (Tiekert 1981). The validity of these latter uses of kinesiological testing is the subject of much controversy and is currently unresolved. This is also true of the assertions of some popularizers of muscle testing that the phenomenon can be adapted to detect food allergies and determine nutrient requirements (Diamond 1979; Fischman & Grinims 1979).

Muscle Testing Procedures

A volunteer of the same sex, but preferably one who is noticeably stronger than the instructor, is recruited from the class. Only those volunteers who have no present or past injury to arms, shoulders, chest or back should be used as subjects. Since the deltoid and latissimus dorsi muscles are accessible, they are appropriate for demonstrating MURP (Figure 1).

To test the deltoid, ask the subject to extend his or her arm outward at the shoulder, with palm facing down and elbow locked (Figure 2). When told to resist, the subject attempts to prevent the instructor from adducting

Barry S. Kendler is associate professor of biology at Manhattan College, Bronx, NY 10471, where he teaches undergraduate courses in nutrition, introductory biology, anatomy and physiology and coronary heart disease. A graduate of the City College of New York, Kendler received a M.S. in zoology and a Ph.D. in nutrition from Pennsylvania State University. He is a member of the New York Academy of Sciences, Sigma Xi, the Metropolitan Association of College and University Biologists and the International Academy of Nutrition and Preventative Medicine. He has published articles in *Preventive Medicine* and the *Journal of Applied Nutrition.*

his or her arm or moving it downward by exerting pressure on the subject's wrist. I generally use only my first two fingers for this purpose to show that I am pushing down with maximal force each time the test is conducted. For subjects much stronger than the instructor, the use of three or four fingers may be necessary. However, my experience has been that even subjects who are considerably stronger than the instructor will be unable to resist downward pressure on the wrist under the appropriate experimental conditions. The subject that I used in my biology seminar was a bodybuilder who routinely bench-pressed more than 300 pounds (roughly twice my body weight).

The latissimus dorsi muscle is tested by asking the subject to hold his or her arm close to the side of the body with the palm facing backward, again with the elbow locked. When asked to resist, the subject adducts the arm while the instructor attempts to move it away from the subject's body, again with contact at the subject's wrist (Figure 3).

The two tests can be used alternately to avoid muscle strain; different arms can also be used. It is imperative that a smooth—not jerky—pressure be exerted for a few seconds until the subject's arm either successfully resists or yields. It is also important to exert force only after the subject has been told to resist and thus anticipates the test. The subject should look straight ahead during the test, and conditions should be kept as identical as possible each time except for the particular variable being studied. It is not advisable to move the subject's arm through its full range of motion once it fails to resist the instructor's efforts. This would only serve to weaken the muscle unnecessarily. Both subject and audience can easily distinguish between a muscle that is successfully resisting and one that is not, even if the muscle is moved only a few inches. Finally, the subject should not be permitted to recruit other muscle groups during the test because this may overcome the instructor's strength and cause the demonstration to fail. Recruitment of other muscle groups involves shifting body position, leaning away from the instructor, bending the arm at the elbow and similar movements. The instructor should stabilize the subject during the deltoid test by holding him or her by the shoulder muscle that is not being tested and during the latissimus dorsi test by holding the shoulder of the arm being tested.

Experimental Variables for MURP

The variables with which these muscle tests can be conducted are limited only by the instructor's imagination. Following are some suggestions which, if carefully executed by the subject, tend to weaken the subject's muscle response.

If the subject places his middle finger in his umbilicus during the test, a weakened response is evoked. When the index finger is so placed, the muscle responds normally. When acupuncture meridian pathways (Ulett 1982) are stroked by the subject in reverse direction, muscle strength is compromised. When they are traced in the direction of meridian flow, this does not occur. For example, the lung meridian exhibits a descending direction of flow from the top of the chest, a few inches above the nipple, downward along the inside of the arm to the thumb. If the subject strokes his body starting at the thumb and proceeding in the opposite direction to the top of the chest and if this is repeated a few times, the muscles should test weak. Stroking the body a few times in the normal direction of flow of this meridian ordinarily does not weaken the muscle. Some authors suggest that meridian reversal may occur when an individual is ill, is taking certain medication, or has a poor diet (Thie 1979). In that case, the effect on muscle strength may be reversed.

Two volunteers are used to demonstrate, through muscle testing, another concept derived from oriental medical practice: polarity. When the two grasp right hands as if shaking hands, the subject's muscle tests weak. When opposite hands are grasped, as if holding hands, this weakening effect is not observed.

MURP can also be demonstrated without touching the body. One person is asked to stand behind the subject, back to back, during the test. Muscle strength is apparently depleted during this procedure. If the person stands behind the subject facing his back, the subject's muscle does not weaken.

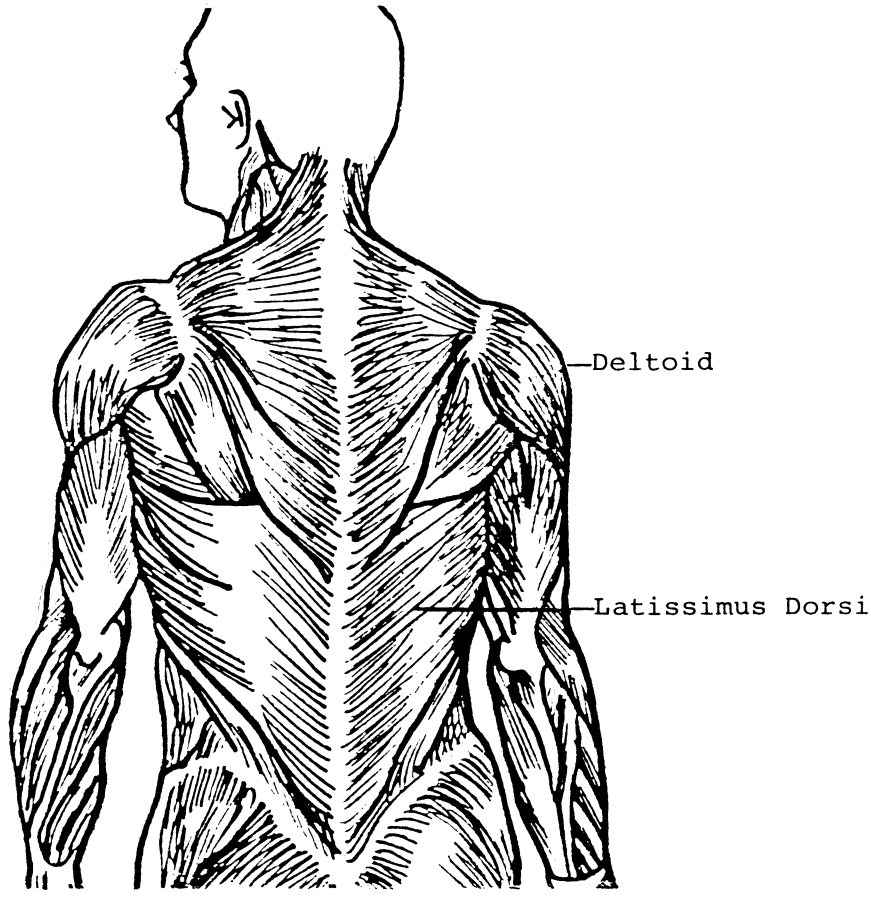

Figure 1. Location of deltoid and latissimus dorsi muscles.

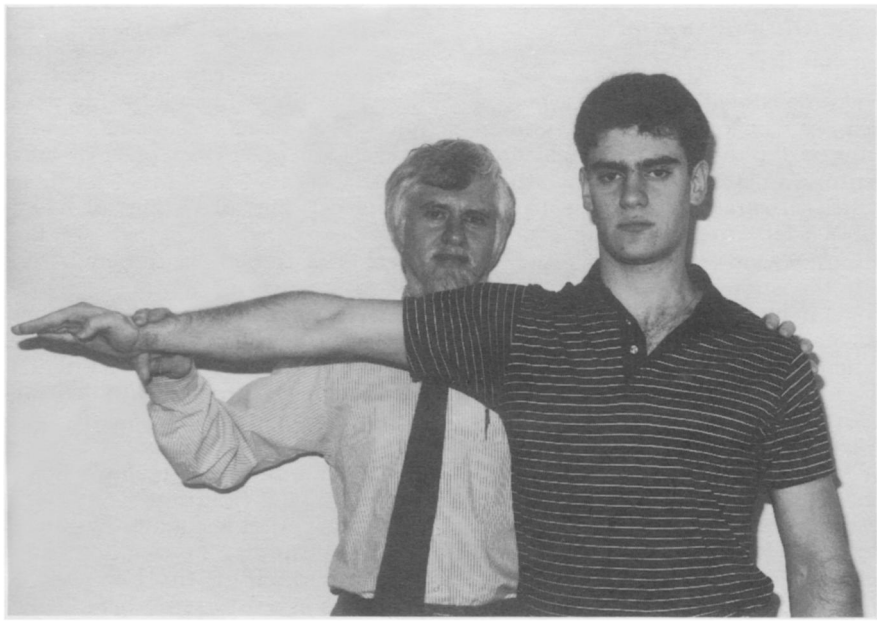

Figure 2. Testing the deltoid muscle.

MURP also appears to function when emotions or thoughts are the experimental variables. A test conducted when the subject is told that he is ugly or is asked to think of himself as bad is apt to weaken the muscle. This does not occur when a male subject is told that he is handsome or a female subject is told that she is attractive. Nor does it seem to occur when the subjects hold in their minds the thought that they are good.

Homolateral movements, such as jumping jacks, appear to weaken the muscle while contralateral movements, such as jogging in place, do not. Among some of the many other variables that can be tested are different kinds of music or colors and the placement of different poles of a strong magnet.

Surrogate testing is done by conducting the muscle test on a subject while he or she is touching the body of a person who is carrying out any of the above actions. The muscle of the surrogate will test weak during the muscle-weakening actions of the person with whom he or she is in contact.

Possible Mechanisms of MURP Action

Muscle weakness can be attributed to nerve involvement, disuse atrophy, pain, fatigue, among other factors (Wakin, Gersten, Elkins & Martin 1950). Muscle strength is even compromised by as innocuous a procedure as tactile stimulation of the skin (Nicholas, Melvin & Saraniti 1980). Conversely, muscle strength is considered to be a function of age and body weight (Falkel 1978), body build (Watson & O'Donovan 1977) and body position (Clarke, Elkins, Martin & Wakin 1950). There is an ongoing controversy pertaining to the effects of mandibular position on muscle strength with some authors reporting positive results (Verban, Groppel, Pfautsch & Ramseyer, 1984; Williams, Chaconus & Bader 1983) and others negative results (Burkett & Bernstein 1983; Greenberg, Cohen, Springer, Kotwick & Vegso 1981).

Over the years, a variety of instruments has been developed and used to objectively measure muscle strength (Marino, Nicholas, Gleim, Rosenthal & Nicholas 1982). The use of such instrumentation in a single-blind (Rybeck & Swenson 1980) or double-blind (Grossi 1981) research protocol has not provided objective evidence of phenomena related to that which I have termed MURP. Nor have certain kinesiological procedures been validated by manual muscle tests conducted in a double-blind manner (Friedman 1981).

The fact that manual muscle testing can demonstrate MURP when conducted in a non-blinded experimental environment suggests that there is either bias on the part of the individual conducting the test or that some poorly defined mental phenomenon is occurring. Evidence documenting the placebo effect is considerable (White, Tursky & Schwartz 1985), and there is some evidence that suggestion plays a role in MURP (Friedman 1981). Other factors, similar to those occurring in acupuncture (Ulett 1982) or electromagnetic effects (Becker & Marino 1982) may also be involved.

Pedagogical Uses of MURP

The initial reaction of both subject and audience to MURP is one of surprise and sometimes even incredulity, followed by attempts to explain the phenomenon in terms of known neurophysiologic mechanisms. After demonstrating MURP, the instructor should be prepared to propose tentative explanations and possibly more esoteric speculations. MURP thus provides the instructor with an opportunity to discuss both mechanistic and vitalistic concepts of muscle function. Moreover, MURP can be used to explain the necessity for strictly controlled experimental protocols in scientific methodology. MURP can also be used to probe the present scope and limitations of scientific knowledge.

MURP provides a means by which more advanced students can conduct their own research. For example, one of my students who observed a MURP demonstration became so enthused with the phenomenon that he designed and carried out a study of it in college students. He submitted the study in partial fulfillment of the requirements for the senior seminar course at our college. For this study, he assembled a mechanism capable of

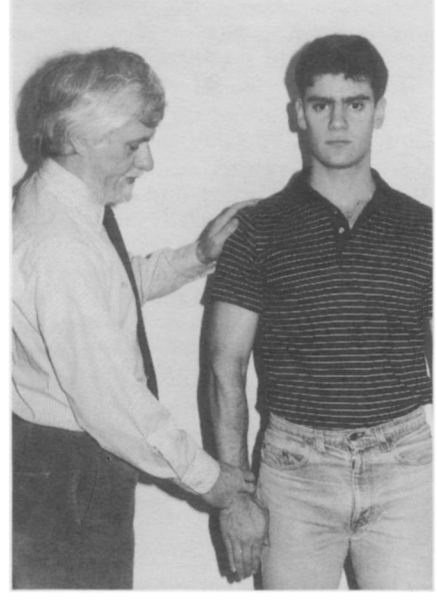

Figure 3. Testing the latissimus dorsi muscle.

objectively measuring muscle strength by means of a cable tensiometer[1], without experimenter—subject contact. One of the variables that he investigated was the effect of sugar on muscle strength which, on manual muscle testing, usually results in weakening of the muscle. His findings concurred with published data suggesting that while manual muscle testing with sugar as the experimental variable diminishes muscle strength in most subjects, this cannot be objectively demonstrated (Rybeck & Swenson 1980).

Paul Burgess of the Department of Physiology, University of Utah School of Medicine has received a National Institutes of Health grant to study this phenomenon. Preliminary observations have been published in abstract form (Burgess & Wei 1984). Briefly, subjects were "xed" by moving the hand rapidly in an X pattern over the sternum without touching the body. The 12 participants were invariably defeated in a contest of strength after "xing" but never during 150 control trials.

To sum up, with MURP, the biology educator has a means of stimulating student interest in biological phenomena and introducing scientific methodology in a meaningful and dramatic fashion. When properly used, it also has the potential for generating lively and productive discussions concerning the scope of biological knowledge and philosophical concepts such as mechanism and vitalism. Finally, it offers advanced students an opportunity to design and conduct research projects with minimal expenditure for equipment.

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[1]Pacific Scientific Co., Anaheim, California (Model T5-6007-114-00)