the changes in the codons came about. Wow! We are reviewing mutation. Next, have the students try to design experiments to see if the proteins do differ and how they affect the phenotype. Now we can justify doing protein electrophoresis and genetic engineering activities.

Well, we still have not shown that biological principles can be applied as a tool. This is simple to accomplish by having the students develop a method of quickly identifying genetic differences. Now we can bring in immunology to design techniques using an organism's chemistry as a tool. We can use antibodies as tools to selectively seek out and identify proteins based on subtle differences in morphology.

Biotechnology is a broad field and has many everyday applications ranging from the mundane, making food and beverages, to the exotic, producing transgenic animals. Activities using biotechnology provide an opportunity for students to apply the principles they learn in general biology. So, turn the standard amylase kinetics activity into a biotechnology activity. Have the students devise ways to use amylase as a tool. For example, amylase is used to remove starch from freshly manufactured clothing to soften the material for comfort. Instruct them to investigate the conditions needed for amylase to do its job in a cost-effective manner (in a short amount of time using very little amylase). Now we are instilling a greater value to biological knowledge.

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Letters

Dialogue on Student's Right To Choose Dissection Alternative Continues

Dear Editor:

I was very disappointed with Wayne Carley's reply to a letter from Alicia Silverstone asking the NABT to support the right of students to choose alternatives to dissection. Carley's long-winded rejection is the sort of unscientific dogma that education can do without.

Silverstone's petition—"that all biology teachers inform students in writing of their right to choose an alternative to dissecting animals"—is supported universally by animal protection groups, by a great majority of students, and by a growing number of teachers. And if recent history is any indication, a student's right to choice in dissection is favored by state legislatures. It is an egalitarian notion receptive to the needs of the individual and befitting a democratic society.

Rather than embrace independent, ethical decision-making by students, the NABT chooses to hide behind the dogma that science teaching would suffer without animal dissection. For one thing, this misses the point; Silverstone is not requesting the removal of dissection (though surely she would prefer that). She merely asks for access to alternative exercises for students disturbed by or uncomfortable with an exercise that is distinctly not animal-friendly.

Ironically, in his zeal to promote the learning of science, Carley unwittingly undermines his own scientific credibility. Who says that the choice "between dissecting and not dissecting" is synonymous with "the choice between learning science and not learning science?" This grandiose claim is utterly unfounded. Worse, it is unscientific, for it ignores evidence from published studies (including two reviews that appeared in *The American Biology Teacher* within the last eighteen months) on the learning curves of students who have used alternatives.

Frankly, neither dissection nor its imitators are potent teachers of science, both are concept-poor, and neither allows much room for the creative thinking and problem solving that feature so prominently in scientific inquiry.

And who says that pouring acetylcholine on a living frog's heart is the only way to gain an "Aha!" experience? As a biology student and instructor I have had and witnessed countless such experiences: observing how a toad depends on prey movement to orient and strike, then uses its eyes to facilitate swallowing; getting a surprise from an Io moth's aposematic underwing; seeing the explosive effect of turgor pressure on a dehiscing seed-pod; realizing the significance of asymmetric ear placement in owls, to name but a few.

Carley's repeated use of the "unlike you" refrain underscores the diversity inherent in any student population. Just as Wayne Carley and Alicia Silverstone disagree on dissection, so too will different students vary as to what learning method works best for them. A flexible curriculum view—one that gives students a say in genuine matters of conscience regarding their learning environment—will better serve the interests of a diverse student population, and the interests of sound science education, than will the dogmatic curriculum view to which the NABT still clings.

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Author's Reply:

I thank Dr. Balcombe for continuing the important dialogue about the use of animals in education. However, he misinterprets two basic tenets of NABT's position on the use of animals in education.

First, NABT does not promote dissection for the sake of dissection, as he implies. Rather, we believe animals should be used when they best achieve the educational objective of the lesson. Abundant research strongly and clearly correlates dissection with significant gains in content learning [see, for example, McInerney, J. *ABT, 55*(5) and Offner, S. *ABT, 55*(3)]. In the example from my letter, the several "Aha!" experiences he suggests are interesting, but none of them will teach college seniors about the biochemical mechanisms of neuromuscular transmission, the point of the original lesson.

Second, NABT does believe that there should be choice in whether or not to dissect. However, we believe that choice rests with a well-educated, experienced teacher. The best learning takes place when a wise teacher presents a well-chosen lesson to accomplish an important educational objective, whether or not the lesson plan includes animals.

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