A Mouse Turns Tiger

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One year's experience in an Academic Year Institute, another important feature of in-service training programs, convinced this biology teacher that the other scientific disciplines have their inordinate share of taxonomy—or terminology if you prefer. Many teachers who have undergone this same experience will share the author's reactions to math, chemistry, and physics.

I have been teaching biology in the New York City high schools for thirty years. And for thirty years I have smarted under the charges leveled against biology by my colleagues who teach mathematics and the physical sciences.

"Biology!" one of them might snort. "What is there to biology but a lot of terms to be memorized!" Or—

"The trouble with biology is that it is so inexact. You can't do a real experiment in biology, because there are so many variables you can't control."

And I did not fight back. With the courage of a mouse, I agreed. I admitted that biology does have a plethora of terms. There is a great deal of terminology and memorization associated with, for example, the subject of taxonomy. Unfortunately, in some college courses, the terminology becomes the end in itself, and it grows to greater importance than the underlying principles. Thus the forest is obscured by the trees. Yes, there is much to be memorized in biology.

As for the second charge, the inexactness of biology, again I was forced to agree. Physicists can measure quantities as tiny as microseconds, or milliamps, or Angstroms; while at the other end of the spectrum they can measure quantities as great as the speed of light. They can weigh electrons which they have never been able to see, and they can even measure the impossibly small electric charge which these tiny particles carry. Chemists can tell at a glance how many invisible molecules there are in a liter of hydrogen gas at 23.4°C and 587 mm of mercury. Or at least they can figure it out in a moment. They can predict to the thousandth of a gram how much copper will be deposited from solution by 236 milliamperes of electricity in a period of 17 min, 11.3 sec. Like the physicists, they can also make wonderfully precise and accurate determinations, which is greatly to be admired. And who in his right mind can doubt the terrible accuracy and precision of mathematics! Yes, the physical sciences and mathematics are amazingly precise.

Of course, biology cannot match them. This argument I could not refute, so I was forced to bow my head and slink away like a timid mouse, while my confreres, having inserted the barb, and perhaps given it a twist or two, walked off in haughty triumph.

But That Was Yesterday! Today I Am A Mouse No Longer! I Have Become A Tiger!

After thirty years of teaching, I became a student again. I took leave of my normal teaching duties, and enrolled in one of the Academic Year Institutes sponsored by the National Science Foundation for the upgrading of science teaching. I did this in the hope of rejuvenation, because everything was to be very modern. And so it was. Everything *was* very much up to date. I took *modern* physics and *modern* mathematics in the first semester, followed by *modern* chemistry and *modern* biology in the next. I was modernized beyond all expectations! It was my exposure to *modern* physics, *modern* mathematics, and *modern* chemistry which changed the mouse in me to tiger. I learned new things, and gathered new courage. I sharpened my claws, and I am ready to fight back. *I most certainly reject the two charges leveled against biology by my colleagues!*

I am willing to wager that were I to count the number of new and high-sounding phrases in the first hundred pages of my math book, I would find more terms than

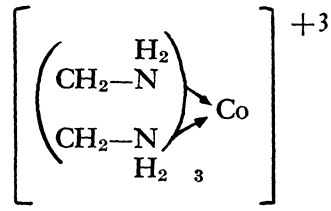
in the entire biologic subject of taxonomy. To read the book, one must learn a completely new language. The book begins with a list of fifty symbols which are to be the alphabet of the foreign language in which it is written. A dozen script letters and as many Greek letters are thrown in for good measure, because each of these is to have some special significance. Thus, while the English language uses only 26 symbols in its alphabet, the math book adds about 70 more of its own. Of course, one cannot understand a single page of the mathematics, unless he first memorizes the meanings of the symbols. But that isn't all. The first few pages are replete with definitions to be memorized; postulates, axioms, theorems to be learned; and a slew of fancy terms such as "commutative law," "the least upper bound axiom," "the trichotomy law," "the Schwartz inequality," "the scalar product," "orthogonality," etc. These are just a few choice samples. *I maintain that there are more things to memorize in modern mathematics than there were in good old fashioned biology.*

Modern physics has its share of memorization too. On top of all the terms like "non-relativistic de Broglie wave-length," "Lorentz transformations," "permittivity of free space," "thermionic emission," "excitation potential," "neutrinos," "pi mesons," "positronium," and the like, physics has its hundreds of formulas, its equations, its constants, its units. All of them must be memorized by the poor and suffering student despite the assurance of the instructor that "you don't have to memorize them because you can always derive them." Have you ever tried to derive one of these equations in your hour of need—in the middle of a test carying a time limit? *I maintain that there are more things to memorize in modern physics than there ever were in good old biology.*

And modern chemistry is no different. Aside from the names and symbols for 103 elements which obviously must be memorized if one wishes to talk the language of chemistry, there are countless compounds, radicals, and ions, each with a name and symbol of its own. Of course, every college boy under 50 years of age can easily figure out that

$$[Pt(NH_3)_2(H_2O)NO_2]^+$$

is the mononitromonoaquodiammine Platinum (II) ion, or that



is the tris (ethylenediammine) Cobalt (III) ion.

And heaven forbid that you forget a parenthesis! *Once again I must maintain that there are more things to memorize in modern chemistry than ever there were in good old biology.*

So, I reject the terminology charge out of hand! If in the future, somebody throws rocks through the windows of my little glass house, I am ready with some bombs of my own; for their houses are as much made of glass as mine. The terminology of mathematics, physics, and chemistry is at least as hard to learn as the terminology of biology.

Let some brazen mathematics teacher dare to say that there are too many terms to learn in biology. I will look him right in the eye and answer with a little double talk like this. "Are you satisfied that your multiplicative inverse rests securely on its Cartesian coordinates with its cosecant separated from the frammis by the rigid transformation of its orthogonal projection?" And while he is mulling this over, I will walk off with my head held high.

Let some calculating physics teacher dare to tell me that biology is mostly memorization. I will rise to my full height in indignation and counter with something equally silly such as, "If you met a statcoulomb on your way to school, would you use MKS units or CGS units to calculate the ratio of his Rydberg constant to the well known Boltzmans constant within the limits of e/m in Bevs?" That ought to hold him long enough to allow me to disappear in triumph.

Or let some gadfly of a chemistry teacher dare to ask me why biology has so many complicated terms. I will fix him with a hypnotic stare as I remark with sang-froid, "The next time you snap your ligands use

some Van der Waals forces on the common polydentate chelate groups which hold your resonance hybrid stereoisomerism in its p orbital. Then after you have used your electronegetivity scale to weigh the uncertainty of Le Chateliers Principle you can fill it with ethylenediaminetetracetic acid mixed with 3-s-chloro-2-s-hydroxypentane in its s-configuration equilibrated with cis-trans-1, 4-diphenyl-1,3-butadiene and go bloop!" He will be so flabergasted by this nonsense, that I can stalk away with hauteur while his mouth hangs open.

But let us forget about terminology for a while, and consider the second charge—that biology is inexact. Yes, I admit it. Biology deals with many variables, many of which cannot be controlled exactly. Biologists deal with living things, and life is dynamic. It is an everchanging process. The mere fact that we try to measure a life process alters the conditions under which it is functioning and changes the process. The mere fact that we change the environment of an organism under study, alters the organism so that it is no longer exactly the same as it was when we set out to study it.

By contrast, consider the exactness of chemistry. I will cite a few generalizations which I gleaned during my sojourn in the modern chemistry class. I must admit that developing these principles was no easy task for a mere biologist like myself. But by dint of endless hard labor, I managed to derive the following exact rules:

Rule: The boiling points and melting points of covalent substances are lower than the comparable points of ionic substances of the same molecular weight, except in cases where they are higher.

Rule: Labile complex ions are always *Outer* orbital structures except in those cases where they are *Inner* orbital structures.

Rule: The coordination number of a complex ion is twice the ionic charge of the metal, except in such cases where it is not twice the charge.

While I must admit that I have taken some editorial privileges in paraphrasing the words of the chem prof and/or of the author of the chem book, I am willing to stake my reputation as a conservative, middle-aged, biology teacher, slightly overweight but still of sound body and mind, that you would come up with precisely the same exact? rules, if *you* studied the chemistry book carefully enough.[1]

And what about physics—the quintessence of exactness! It is an accepted fact that the physicist works with precision. Every factor is perfectly controlled, except the one single variable which is being studied. Measuring instruments of infinite delicacy have been developed to make measurements more and more precise. But lo and behold—a point is reached beyond which exactness cannot go. The physicist makes a discovery and enunciates a "new" principle. This is the principle of "uncertainty or indeterminacy"! This new idea, new to the physicist, "expresses a fundamental limitation inherent in the nature of things."[2] What is this "new and revolutionary limitation"? In measuring certain things, please remember that Heisenberg said it, not I, the very act of measuring changes the thing being measured so that accurate measurements are impossible to obtain. True, the physicist is talking of things of atomic dimensions, but he admits that he is dealing with a sort of indeterminacy that is "fundamental in the nature of things."[3]

It is strange to hear a physicist admit that there is something which cannot possibly be measured accurately, for physicists have what amounts to a mania for exactness in measurement. But it does my heart good. To a biologist, this principle is not new at all. He may not describe it in the same words, and he may not be working with subatomic particles, but he knows that anything you do to a living thing alters it. Livings things are not static systems which can be controlled as a chemist controls his test tube reactions. They are dynamic systems which change in response to every outward alteration of condition, and in

[1]Hiller, L. A. and R. H. Herber, *Principles of Chemistry*, McGraw-Hill Book Co., New York, 1960.
First rule: refer to pages 173-174.
Second rule: refer to page 182.
Third rule: refer to page 220.

[2]Rusk, R. D., *Introduction to Atomic and Nuclear Physics*, Appleton-Century-Crofts, New York, 1958. (page 115).

[3]Ibid (p. 118).

response to every attempt at measurement. We need only add a single word to the physicist's statement to change it so that it becomes an old biology maxim. There is a sort of indeterminacy that is "fundamental in the nature of *Living* things."

In a way I am glad the physicists are willing to admit that there are things in nature which cannot be measured precisely. This admission removes from them a little of the aura of infallibility and makes them almost as human as biologists.

But be that as it may, from now on, let my physical science colleagues beware. Let one of them dare to tell me how inexact the biological sciences are, and he will find that I am ready for him. Thanks to my year of academic refreshment I am loaded for bear!

Biology In The News

Brother H. Charles, F.S.C.

The Grass Craze, James A. Skardon, *Saturday Evening Post*, March 17, 1962, pp. 30-33. Lawnman's Guide to Grasses and Turf Care, Arnold Nicholson, *Saturday Evening Post*, March 17, 1962, pp. 33.

How to work wonders instead of blunders with your lawn. The rules are simple, easily followed, and effective. These are followed by a condensed set of rules for lawns in different regions of the United States. Good bulletin board material.

Strawberry Shake, John S. Flannery, *Outdoor Life*, March 1962, pp. 40-43, 130-131.

Rough fish became more numerous than the game fish in Utah's Strawberry Reservoir. Sportsmen wanted game fish only. How they are effecting a game fish population again is told in detail. This article could stir up a lot of interesting discussion if your pupils are ecologically minded.

Pets Can Be Dangerous, Frances Allen and John E. Allen, M.D., *Saturday Evening Post*, February 17, 1962, pp. 65-66.

Pets can and do carry diseases which may affect us. The authors like pets and believe we should have them. If we have pets we should know about the diseases commonly carried and how they may be prevented or treated in the pets and in us.

The Great Narcotics Muddle, Benjamin DeMott, *Harpers*, March 1962, pp. 46-54.

A serious presentation of present methods of control of narcotics; the effects of these methods in use on adults and the public in general; and an appeal for proper legislation. No clear solution to the problem is offered. (For more mature readers.)

They Think We Have the Evil Eye, Bentz Plagemann, *Saturday Evening Post*, February 24, 1962, pp. 58-61.

What is your attitude towards cripples? A polio victim tells how people help and hinder the physically handicapped.

AIBS MEETINGS

NABT will hold meetings in conjunction with the AIBS in Corvallis, Oregon, August 26-31. First Vice President Addison Lee is in charge of the NABT program, and he announces co-sponsored meetings with the Botanical Society on Plant Development, with the American Phytopathological Society, and with the American Society of Zoologists. There will also be a meeting to include submitted papers. If you wish to present a paper, get in touch with Dr. Lee, Science Education Center, University of Texas, Austin.

Teachers for East Africa

Dr. Kenneth H. Toepfer, Teachers College, Columbia University, New York 27, is Coordinator of a project to recruit teachers in physics, chemistry, and biology for East African service. Information will be sent on request.

New Marine Science Center

Lehigh University, Bethlehem, Pennsylvania, has established a new Marine Science Center for study of the oceanographic process of continental shelves and coastal areas. Further information may be obtained from the director of the Center, Dr. Keith E. Chave, Department of Geology.