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IN DEFENSE OF AMBIGUITY

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Introduction

If I recall correctly, one of the first adjectives I learned as a freshman in college was *ambiguous*. I do not remember looking it up in any dictionary when I learned it after the first midterm tests. It was then enough for me to learn that if a professor's test-questions were deemed "ambiguous," I could excuse my failure to answer test-questions accurately and blame the professor for having hidden from me what I should have learned and understood. In my years since, as a professor, I find that the freshmen and upper classmen and even graduate students are still sophomoric in their use of this unacademic "cop-out".

What has precipitated me into writing this defense of ambiguity is the requirement by my present university administration that all classroom instructors of all ranks be rated each time they teach a course by the members of the class. They rate instructors in response to a series of questions devised by a committee of obscure, anonymous and ambiguous constitution. The class-members respond to each question, numerically, on a rating scale.

One of these questions is: "Are the instructor's examination questions phrased ambiguously?" If the student believes, for any reason or opinion, that the instructor's test questions are unclear to him he may (anonymously) record: 5 for *agree*; 4 for *moderately agree*; 3 for *neutral*; 2 for *moderately disagree*; and 1 for *disagree*.

These numerical codings are later fed into a computer which is apparently told to regard a high mean number as implying a high degree of ambiguity. Apparently then, the students may assume that a high score on ambiguity implies some unfairness (or maliciousness) on the part of the instructor in testing their academic competency.

Many of my pupils rate my questions as ambiguous and if I am to accept my most recent *ambiguity rating* of 3.9 (above the 85th percentile) as factual, I shall plead guilty to that charge.

Some of my questions are *deliberately* written to be confusing to that pupil who does *not* study and who does *not* wish to learn. I believe I have an

obligation to my pupils, to my university and to myself to determine which pupils may become students in the academic sense, which pupils are becoming students, and which pupils *are* already students! I also must be able to distinguish among those who study; those who memorize, but do not understand; those who understand, but do not memorize; and those who capably do both — the latter being the *real* students.

Testing

I regularly strive to teach principles of biology to large classes of undergraduates. For some reason, pupils in large classes seldom ask questions of the professor during class — even if they are invited to — although in a small group they willingly do so. Maybe it's *fear-pressure* as well as *peer-pressure* in action. So, I find, I *must*, in testing, ask questions of an *ambiguous* nature to tell me to whom I failed to sell the information and the biological principles involved, as well as to tell me who *did* understand and learn.

Therefore, in a matching-series of statements and terms, I will list more terms than there are statements and sometimes let one term be a correct answer to *two* statements (e.g., make two statements about photosynthesis) to require some knowledge of the *correct* matching, rather than providing opportunity to score "points," without knowledge, by elimination. (Table 1)

My pupils cry, "Ambiguous!"

Instead of writing, for example, to match *mitochondrion*, "A green-staining protein in the cytoplasm," I will write "A green-staining, membranous vesicle in the cytoplasm; it makes ATP," thereby requiring the test-taker to think about the *function* of as well as the *artificially colored identity* of the mitochondrion and distinguish it from a chloroplast, which is a *naturally* green, membranous, ATP-making vesicle in the cytoplasm.

My pupils cry, "Ambiguous!"

Or for a "fill-in," instead of writing not only "the living boundary of a cell" for *plasma membrane*, I may write "A layered sheet of protoplasm, containing proteins and phospholipids, through which materials enter or leave the cytoplasm of the cell," requiring the examinee to assemble and compare some of the facts I have promulgated concerning the membranous surface of a living cell. (Table 2)

My pupils cry, "Ambiguous!"

Or, once each term, I ask, as a multiple-choice question, "Who is the

author(s) of your textbook in this course?" (Table 3) Loud moans and screams of "Unfair!" from the assembled (only about 40% of whom can answer correctly). If they do *not* know who wrote their text, it is also likely that they rarely use it for study; but they are embarrassed that I'm that "nosey!"

Table 1

**A Sample Set of Definitions to be Matched
with Terms at the Right***

T	1.	Type of bond which holds amino acids together in a strand of protein.	A. alcohol
V	2.	Acronyms (initial letters) of a critical carbohydrate repeatedly formed in energy transfers.	B. ATP
M	3.	The author of your textbook.	C. carbon
H	4.	Receives energy from chemical bonds broken in the Krebs cycle and transfers it to ATP.	D. carbohydrate
Z	5.	The most abundant chemical compound of the constituents of protoplasm.	E. chloroplast
J	6.	A food substance which is composed almost entirely of carbon and hydrogen.	F. citric acid
H	7.	Collects energy trapped by cyclic photo-phosphorylation and relays most of it to adenosine triphosphate.	G. Curtis
Q	8.	The membranous vesicle in a cell which contains the enzymes of the tricarboxylic acid cycle.	H. Cytochrome
X	9.	The structure in the cell which fastens amino acids together as a strand of protein.	I. DNA
F	10.	Six-carbon substance which is repeatedly synthesized in, then broken by the tricarboxylic acid cycle.	J. fat
			K. glucose
			L. hydrogen
			M. Keeton
			N. Kimball
			O. lactic acid
			P. lysosome
			Q. mitochondrion
			R. nitrogen
			S. oxygen
			T. peptide
			U. peroxisome
			V. PGAL
			W. protein
			X. ribosome
			Y. sulfide
			Z. water

**The student is asked to make the best match. Note that items 4 and 7 have the same answer. There are 26 terms to choose from as possible answers for 10 definitions. Note that the list of terms is alphabetical so the pupil can quickly find the answer if he knows it.*

If my test-questions are *always* clear to *all* members of the class (*i.e.*, always unambiguous) then I have no basis to distinguish between rote memorization and comprehension. To be sure, I include enough "push-button-response" questions to assure the university that there *will* be athletic teams next year and that fraternity and sorority houses and dorms *will* continue to be occupied. However, unless some of my questions contain the basis for thought and comparison of the information to have been learned, then I must fail in my duty to the *real* students and students-to-be in my classes and in my academic responsibility as a teacher.

Table 2*

Statements of Differing "Clarity" Concerning Chlorophyll, for a "Fill-in" Answer

1. The green color of a leaf. (Clear to everyone, or should be.)
2. The green, energy-trapping chemical of the leaf. (Clear to about half of the class, because about half are confused about photosynthesis.)
3. A magnesium-containing protein in the leaf which traps energy. (Ambiguous to about three-fourths of the class, because I didn't call it green.)
4. Substance in the grana of the chloroplast which traps the energy which becomes stored in ATP. (Ambiguous to most of the class, because they thought I wouldn't ask about grana.)
5. The porphyrin-and-magnesium-containing protein which transfers energy via cytochrome to ATP in a green plant. (Intelligible only to the upper 3-5% of the class.)
6. A resonant, plant-protein with a phytol tail which traps blue light to raise electrons to a higher energy level during the cyclic photosynthetic reaction. (For the class genius.)

**All of the above information about chlorophyll is included in the textbook used and/or in the lectures on the roles of chlorophyll in photosynthesis, in my Principles of Biology classes.*

Table 3*

How to be Ambiguous with Multiple-choice Questions

- c 1. The commonest 6-carbon sugar used by living things:
a) glucagon; b) glycogen; c) glucose; d) galactose; e) glycerol.
- c 2. The metal used in the cytochromes:
a) calcium; b) copper; c) iron; d) magnesium; e) zinc.
- c 3. Won the Nobel prize for revealing the tricarboxylic acid cycle:
a) Krause; b) Kripps; c) Krebs; d) Kraal; e) Keith.
- c 4. Part of the cell which contains hydrolytic enzymes:
a) centrosome; b) ribosome; c) lysosome; d) peroxisome; e) chromosome.
- d 5. The author of your textbook:
a) Carson; b) Carlson; c) Colson; d) Curtis; e) Curtin.
- c 6. Part of an enzyme which is often a vitamin:
a) apoenzyme; b) holoenzyme; c) coenzyme; d) lysozyme; e) zymogen
- c 7. "Storehouse" for RNA in the nucleoplasm:
a) chromatin; b) histones; c) nucleolus; d) operon; e) codon.
- c 8. Part of the cell from which spindle fibers form during mitosis:
a) chromosome; b) cytotome; c) centrosome; d) cytoplasm; e) cytoproct.
- c 9. The principal carbohydrate in the wood of a tree:
a) glucose; b) sucrose; c) cellulose; d) lactose; e) xylene.
- b 10. The most abundant atomic ion in protoplasm:
a) oxygen; b) hydrogen; c) nitrogen; d) carbon; e) sulfur.

**Note that "c" is the answer for all questions except 5 and 10. They won't believe you'd do it! Students are asked to choose the best answer. Note the use of similar words in questions 1, 4 and 8; similar names in 3 and 5.*

Conclusion

I claim that a certain amount of deliberate ambiguity in testing is a useful *teaching* procedure to: 1) sort students and students-to-be from their classmates — who are still only pupils, placed by registration-mechanics in my charge as their instructor; 2) engender thought and comparison, sometimes enlightenment; 3) cause a realization *on the part of the student* that he or she has failed to learn a *relationship* of key items of information; 4) point out a relationship of informational items implied, but not specifically written, in the text, nor previously given by the teacher in the classroom presentation; 5) bring to the attention of the class an important new item or relationship in biology not mentioned previously in either the text or the lectures; 6) give the teacher a chance in discussing the test-questions later with the class (as I always do) to clear up the ambiguities (*i.e.*, to teach, associatively).

Certainly we should in teaching strive for clarity and understanding, but rote memory conveys neither. The human mind is a heuristic computer and it thrives on associative relationships. Recall by association is better than rote even if the association or a mnemonic, is nonsense.

A certain amount of ambiguity in test-questions forces the student to strive for the associative relationship, engendering a better recall of the associated (and therefore learned) information, which is then better understood. I believe that to be what we as teachers intend as the essence of study and learning.

I am guilty of such ambiguity and I shall continue to be.

* * *

Third Northeast Iowa Science and Engineering Fair

Upper Iowa College will be host to the Northeast Iowa Science and Engineering Fair on March 26th and 27th. Sponsors of the science fair entrants are:

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Exhibits for the fair will be set up in the Dorman Gymnasium on the Upper Iowa Campus. For further information, contact Dr. David L. Pippert, Upper Iowa University, Fayette, Iowa 52142.