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Not the least benefit from possible eventual reliance on "quick" bacterial tests for chemical carcinogens will be a reduction in the number of animals presently used. Antivivisectionists will not be totally satisfied, but informed citizens who recognize the need for animal-based research will be encouraged if scientists find that the "quick" tests are as good as or better than animal tests for routine screening of chemicals.

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Paper Mills and Campus Ethics

Amitai Etzioni's editorial on paper mills (23 Apr., p. 325) focuses on only the latest result of the degradation of intellectual integrity in our universities. The phrase "publish or perish" of the 1960's has now been replaced by the requirement of "accrue overhead." The corporate model applied to the university requires a profit, and the source of that profit is the research grant. Is it any wonder that students cheat in an environment where the classroom responsibilities of faculty are so openly degraded and discouraged?

The situation is ludicrous. The most dangerous act a nontenured faculty member can perform is to receive recognition as an outstanding teacher. Tenured faculty who devote too much time to the students are denied salary increments and promotion. The rewards are clear—money and release time for success in obtaining funding. If no funds, then more classes, more students, and denial of monetary reward. Merit is equated solely with money in grants, and publications which result from activity that does not generate overhead is criticized. The value of a publication to the scientific or intellectual community is of little consequence.

The student is not to blame. His teachers spend their time trying to second-guess who will give money for what. In the classroom, the faculty are preoccupied with survival problems. The faculty know it, the students know it, and in case anyone misses the point, the administrations state it in very clear terms: administrative reward for grants, departmental recognition for teaching. The salesman gets the money, the teacher gets the pen-and-pencil set.

Etzioni proposes symposia and workshops on the subject of cheating. I suggest we first remove the corruption which permeates our universities. Why not a workshop on hiring part-time instructors for our large classes, instructors who work cheap but still generate the student credit hours? Why not a symposium on how overhead monies have had a net harmful effect on academic quality? Why not a convention on how recognition can be afforded to those who meet professional standards, and on how the "for sale" tag on promotion and tenure can be removed?

Higher education is under attack, and because we have been corrupted we just may not survive with all the freedoms we now enjoy, and indeed require, for the free pursuit of what we call truth. But don't blame the student. He is only modeling.

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Etzioni skirts the real reasons for the continuing success of paper mills on many campuses and focuses incorrectly on student responsibility. The actual culprits are the faculty members.

Graduate students who submit ghost-written or researched theses are responding to the professorial practice of claiming major or total credit in published papers for work done by student assistants. Undergraduates are able to pass off phoney term papers as their own to professors who are, by and large, unable or unwilling to discover students' real research and writing capabilities. The paper mill business will continue to thrive until these and other corrupt practices and deficiencies within the "academic community," of which students are now keenly aware, are eliminated.

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Noting Etzioni's editorial on paper mills, I propose (i) that undergraduate students be passed or failed on the basis of daily laboratory performance and occasional examinations; and (ii) that just as every ethical physician makes a daily visit, at least, to patients in the hospital, so should every ethical professor make a daily visit to each graduate student. Both the physician and the professor should spend enough time and make enough observations to know whether or not progress is being made. The physician or the professor should not accept the responsibility for more people than can be effectively observed.

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Etzioni's editorial is a cry of anguish about, and a call for action on, the practice of purchasing term papers, theses, and dissertations. The ethics of the problem are the major point, but the major question is not how to stop it or detect it or punish it. The real question is, Who is cheated? The student has the opportunity to learn through research or he can purchase and be thus assumed to know ever after. Those who slide through their course work by any method (cheating, cribbing, purchasing term papers, or whatever) will find themselves passed over when it comes to finding that uniquely interesting job or that highly desired promotion, simply through lack of preparation. Ignorance is easily betrayed, long remembered, and seldom rewarded.

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The obvious answer to Etzioni's question "What is to be done about students who, in effect, purchase their degrees . . .?" is simply for employers to stop using degrees as a basis for hiring and promotion.

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Briefly, in response to the points made by Hudson and Steffey, whatever is wrong with "the system"—and there is indeed much which ought to be corrected—ultimate responsibility for unethical conduct nonetheless must rest with the acting individual. Nor can we allow individuals to disclaim responsibility for or excuse their unethical conduct on the grounds that others get away with—or are even rewarded for—unethical behavior.

At the same time, it surely is true that setting an example is one of the most persuasive modes of moral education. Walker's suggestion that professors not accept responsibility for more students than they can effectively give supervision, guidance, and attention to provides such a means for professors to demonstrate that they do take their responsibilities seriously—hopefully inspiring students to do the same and nudging the system toward reform.

Athey implies that we can rely on failure brought about by the lack of genuine learning in the "real" world, after college, to motivate students to work honestly at earning their degrees. Unfortunately this does not square with what cheaters perceive are the rewards to be gained from cheating, nor with the experiences we all have had of seeing both the ignorant and the unethical go on to attain quite considerable success.

In any event, let's not wait for future employers (or "life") to teach our students an ethics lesson; it is part of our responsibility. So let's do our share, recognizing that it is regrettably much easier said than done.

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Understanding Mathematical Proofs: Conceptual Barriers

The article by Gina Bari Kolata "Mathematical proofs: The genesis of reasonable doubt" (Research News, 4 June, p. 989) is in some respects misleading. Since it has already inspired a *New York Times* editorial on the so-called "Crisis in mathematics" (*1*), a reply seems warranted. Has mathematics in fact become so complex that proofs are often too long and involved to be properly understood by human beings?

The specific case alluded to—recent work in "homotopy theory" by E. Thomas and R. Zahler—can be dismissed. Like other scientists, mathematicians sometimes make errors and disagree; the issue in question has now been resolved (in favor of Thomas and Zahler) (Letters, 9 July, p. 98), and the amount of time required was not especially long.

Long proofs are hardly an innovation in mathematics. It is easy to find examples from the 19th century. In mathematical astronomy, Delaunay's theory of the moon's motion contained many enormous equations (some fill whole folio pages). It used to be said that one could check such an equation by measuring it—if over 18 inches long, it must be wrong. Shanks spent years calculating pi to 707 decimal places; after the advent of computers it was found that his last 200 digits were wrong.

But the intellectual barriers to be surmounted are more often conceptual than computational. Hawkins (*2*) has written an enlightening account of the struggles of some very distinguished 19th-century mathematicians with the "easy" concepts of continuity and differentiability. There were quite a few blunders. Extremely bright people went astray, not because the proofs were excessively long, but because, even though the concepts were correctly defined on a formal or verbal level, their ramifications were not yet understood on an intuitive level. The "standard" examples and counterexamples with which we now stimulate and guide our imaginations had yet to be discovered. One hundred years later these concepts and theorems cause no trouble at all; they form part of every course in advanced calculus.

Perhaps the most famous "monster proof" in recent mathematics is the theorem of Feit and Thompson (*3*), which settled a fundamental problem about the structure of finite groups. Their proof fills an entire issue of a journal. Yet this work has been assimilated without intellectual indigestion; on the contrary, the new ideas and techniques it introduced have caused group theory to flourish.

The point is simply this: a human mathematician does not attain an understanding of a proof merely by checking that all the individual steps have been strung together according to the rules. On the contrary, such detailed mechanical plodding is neither necessary nor sufficient. What is crucial is to see through the technicalities to grasp the underlying ideas and intuitions, which often can be expressed concisely and even pictorially. Once the gestalt is perceived, the competent technician can fill in as much formal detail as needed. Jacob Bronowski (*4*), speaking of the work of John von Neumann, has put it most beautifully: "What is running through the page is a clear intellectual line like a tune, and all the heavy weight of equations is simply the orchestration down in the bass."

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4. J. Bronowski, *The Ascent of Man* (Little, Brown, Boston, 1973), p. 433.

Erratum: In the letter "Kepone chronology" by Rudolph J. Jaeger (9 July, p. 94, column 3, paragraph 3, line 9), the airborne Kepone concentration in the Life Science Products plant measured by state of Virginia officials in July 1975 was erroneously given as 3 mg/cm^3. The correct concentration was 3 mg/m^3. A portion of a sentence in the preceding paragraph was also erroneously omitted (line 14). The sentence should have read, "A chronicity factor, calculated from these data, is the ratio of the single LD_{50} value *divided by the* LD_{50} *value* in repeatedly dosed animals."