must also be viewed against the demand side of the marketplace.[2]

Examples of Langer's statement that "advances in materials underlie all modern technologies" can be seen in the collaborative works of our Canadian federal laboratory with the university and industrial sectors. Solid electrolytes developed for batteries, electrolyzers and sensors have applications in energy conversion and environmental measurement. Piezoelectric materials and structural ceramics will be used in manufacturing. Fluoride glasses processed in microgravity will form fiber, laser and amplifier components for telecommunications systems.

While institutional adoption of these concepts is necessary, I believe that it is also essential that they be accepted on an individual basis. It will first be required that we study and understand the processes of technology transfer as they relate to particular technologies and markets. Second, participants must be convinced of their importance for the long-term benefit of both science and society. Finally, having understood the process and believing in its benefits, we must teach others at different levels and in different sectors of their merits.

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10/92

Computerizing March Meeting Program

Recently, I received my copy of the "telephone book," also known as the program of the APS March meeting, and began my ever longer yearly ritual of searching through it to identify the talks that I will attend. My own interests include liquid crystals, and as I tracked such talks through a dozen different sessions—only a few of which had "liquid crystals" in the title—it occurred to me that there is a better way: Computerize it.

Once on computer, the entire March meeting program would fit on one standard floppy disk. The APS could easily develop—or license—software to search the program by name or key word. One could even imagine a routine that would allow session-hoppers to check off talks of interest and print out a schedule.

As for the practical question of how to compile such an index, the APS could change its rules to require that talks be submitted either by e-mail or on a floppy disk. Nearly all talks currently submitted "camera ready" are prepared on computer anyway. (In addition, I doubt that anybody who has the $1000 or so it costs to attend an APS meeting would have difficulty in either finding a computer or having someone prepare a computerized abstract.) Acceptable formats (such as Revtex or various word processors) could be specified to minimize handling by APS staff. Members could choose to receive the meeting program on paper, disk or—for an extra fee—both. The information might also be made available on electronic networks.

Several APS committees have pointed to the increasing role computers will play in the dissemination of the physics literature. APS journals already accept electronic submission of articles and referee reports. Not only would publishing electronic versions of meeting programs be a manageable first step toward electronic journals; it also would be a solution to some of the problems posed by ever larger meetings filled with ever greater numbers of contributed talks.

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3/93

Junior Physics Review Recommended

Better communication of basic physics both to physics students and to the general public is a desirable goal that has been discussed extensively in the pages of PHYSICS TODAY. There is increasing awareness that the transmission model of teaching—student as sponge—should be replaced by a constructivist model—student as active processor.[1] Nevertheless there seems to persist the attitude that a college education consists of running a gauntlet of disconnected courses, each of which the student may forget once passed. Many seniors recall little of what they studied as freshmen, leading Lauren Resnick[2] to observe that "knowledge is retained only when embedded in some organizing structure. Thus, students who learn many separate facts are unlikely to retain their knowledge beyond the period of test-taking—a much noticed, worrisome feature of the current educational system." Addressing this and related problems, I wish to suggest an *addition* to the undergraduate physics curriculum that is needed independent of improvements in the basic course.

To prepare students better for upper-division courses, immediately following the multisemester introductory sequence should be a required one-semester "junior review" including five areas of emphasis. Listed in decreasing order of allocated time, they would be:

▷ a conceptual recap of the entire introductory course
▷ conservation laws and other themes common to separate topics
▷ proportionalities, approximations, estimations and graphical interpretations
▷ historical contexts; past, present and future relation of the physicist to society
▷ sketches of current frontier research problems.

Placing those areas of emphasis in a junior review course is highly desirable because *the most efficient learning includes spaced reviews.* The junior review will be needed no matter how much the first course is improved, since each student is unique and won't initially respond to all concepts. As Arnold Arons[3] says, "the gaps in understanding *cannot* be fully resolved for all students on the first passage through . . . , even with better exercises and tests. Genuine learning of abstract ideas is a slow process and requires both time and repetition. Repetition without intervening time yields meager results." According to findings of experimental psychologists, "in studies that contrasted 'massed practice' (numerous consecutive exposures to an item) with 'distributed practice' (the same number of exposures interspersed among other items), distributed practice consistently proved to be superior."[4]

A traditional curriculum contains topical reviews, but from freshman through graduate years yields only two or three cycles on the "helix of learning." The junior review would be another turn on the helix at a particularly crucial time, before students start tough upper-division courses.

The conceptual recap is the most important aspect of the junior review because the conventional problem-solving focus of the introductory course promotes technique more than understanding. Jose Mestre (PHYSICS TODAY, September 1991, page 58) notes that many students in traditional courses "achieve good grades on exams but can still display little understanding of the concepts underlying the problems' solutions."

Similarly, qualitative skills like estimations, approximations and proportionalities are seldom emphasized in conventional calculus-based introductory physics courses. But qualitative reasoning ability is a component of understanding: Michelene Chi, Robert Glaser and Marshall Farr[5] note that experts in various fields, including physics, spend considerable time in qualitative analysis and recognize large patterns: "Experts typically try to 'understand' a problem, whereas novices plunge immediately into attempting to apply equations and to solve for an unknown." Arons[3] says that students "exhibit *very* strong resistance to . . . thinking in terms of ratios and functional relationships. They want initial numerical values, and they want to substitute into the formulas without having to think." Although additional qualitative reasoning practice might be squeezed into the already crowded introductory semesters, it would more readily form part of a junior review class, in which physics majors might for the first time be in the majority.

From yet another viewpoint, the physics major's fifth semester is a point of convergence for several groups who especially need the junior review, including students who:

▷ are unmotivated in the introductory course and fall behind
▷ start the introductory course with deficient math skills
▷ are motivated but are undecided about being physics majors
▷ transfer from junior college
▷ change majors from another science
▷ begin preparing for the GRE
▷ want to teach in secondary school
▷ wish to minor in physics.

In the relatively large first two groups are students off to a slow start, who are usually given no reasonable second chance to catch up: On the one hand they face the awesome rigor of advanced courses, taught by professors who tend to assume that students *do* understand basic physics. On the other hand they can consider repeating the introductory course or, discouraged, may simply drop out. As Chiara Nappi (PHYSICS TODAY, May 1990, page 79) remarks, "the American educational system, which is generally perceived as . . . liberal . . . , is actually very selective. It selects the very talented and self-motivated students, those who would do well in any system. But it does not give a fair chance to the others; it simply neglects them. Many students, if properly and systematically educated, can blossom."

As to the third group on the list, Sheila Tobias[6] debunks the popular mythology that "scientists are born, not made" by citing evidence that a majority of college freshmen who switch out of science do so not because of its difficulty but because other fields seem more desirable. Some students are still undecided about continuing as physics majors even after honorably completing introductory physics, which they found dominated by computational minutiae and lacking broad correlations. To maintain interest in practicing the necessary technical skills they also need exposure to long-range goals, the interrelation of concepts and "the big picture." Thus a message from Tobias's research is that student motivation is enhanced by overviews; an implication is that a junior review course could keep more of these people in the physics arena.

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1/93

Surplused Research Professor's *Shared* Saga

I am both amused and irritated by Alex Lempicki's letter "Saga of the Surplused Research Professor" (March 1993, page 15). His anger is commendable, his self-pity misplaced. Let me start with the latter. We learn that after an apparently successful career in industry (where he certainly earned considerably more than his colleagues at universities), Lempicki was no longer considered essential and decided to move into academia. At a time when many young physicists were having difficulty getting jobs, he succeeded (surely with rare good luck and the help of "connections") in becoming a research professor at a major university, at an age when it is most unusual to begin a new career. Now 70 years old, well beyond the average age of retirement, he complains that he no longer receives a salary and thus has become an SRP (Surplused Research Professor). True, he still writes grant proposals and even manages somehow to receive from agencies a "summer salary" as 2/9 of his (nonexistent) base salary. It is not clear if he uses the money solely to support research students and such (as he expects regular faculty to do).

The trouble with Lempicki is, he doesn't realize that SRPs are only a tiny subgroup of SOUP (Surplused Once Useful People). The SOUP family begins with old parents who are surplused by their children and put into old people's homes; it includes writers, musicians, politicians and artisans as well as scientists. Indeed, some SOUP are surplused several times in their careers. I know of an elderly colleague who, for ideological reasons, was surplused in his youth by both the Nazis and the Communists. He then moved to the West and had a successful career as a professor at a major private university, only to be surplused ("given the mashroom treatment," as Lempicki puts it) when his research field could no longer attract further grant monies. Undaunted, he began a new career as an administrator at a state university. After several successful and pleasant years he was surplused when the state's disastrous finances required "reorganization" at the university. A new job in a research administration position ended abruptly when he was surplused at the whim of an alcoholic president. Then came a third career in a respected branch of the government, but surplusing occurred once again when, after a few years, his term contract expired and the promised new position did not materialize (obviously because he lacked old-boy connections). Although not yet of the usual age, he gave up and retired to the countryside. As far as I know, he now successfully tends his garden and cares for his dog, quietly waiting for the time when the Good Lord will SOUP him—for good this time.

The moral? Count your blessings.

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4/93