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.

References

1. H. J. Aaron, Harvard Business Review, September–October 1992, p. 172.
2. L. M. Branscomb, Harvard Business Review, March–April 1992, p. 24.

JON D. CANADAY
Canada Centre for Mineral and Energy Technology
Ottawa, Ontario, Canada
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.

JOHN BECHHOEFER
Simon Fraser University
Burnaby, British Columbia, Canada
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