Medical Education: Harvard Reverts to Tradition

This assessment of some of the trends in medical education is by Samuel Z. Goldhaber, a former summer intern in the News and Comment department, who is a second-year medical student at Harvard.

"The faculty at the Harvard Medical School seems to be in an extremely reactionary mood; they really want to turn the clock back," says Paul S. Appelbaum, class of 1976. The second-year Harvard medical student is referring to the faculty's decision this year to reinstitute traditional grades and also to the likelihood that the present curriculum—organized around the organs of the body—will be replaced with a traditional basic science curriculum.

Students, faculty, and administrators at the Harvard Medical School agree that the faculty has become more conservative during the past academic year and debate only the degree and significance of this change. Robert H. Ebert, dean of the Faculty of Medicine, told *Science*, "I would tend to distinguish between mini-swings and maximum swings. This I would value as a mini-swing. Sure, it looks more conservative at the moment, but I don't think this represents a substantial change in the faculty."

The faculty's simmering dissatisfaction with the radical curriculum changes that were introduced in 1968 first became apparent when the National Board exam scores of the first class under the new curriculum fell significantly. The boards, given at the end of the second year, test knowledge of basic science. The dissatisfaction came to a head this year when the faculty took a hard line on the grading issue and reinstituted grades in basic science courses for the incoming class of 1977. Meanwhile, innovations of the controversial "core" curriculum were being dismantled.

The concept behind the core curriculum was to integrate the basic sciences by teaching courses centered around individual organ systems, such as the cardiovascular system, rather than teaching the basic sciences of biochemistry, pathology, physiology, and pharmacology as separate courses. The core is supposed to teach students the language of medicine and only that basic science essential for clinical work.

When Ebert became dean in 1965, all students took the same basic science program for 2 years, followed by the same clinical experience for 1½ years, leaving only the second semester of the fourth year as elective time. Under Ebert's administration, Alexander Leaf, chief of medicine at the Massachusetts General Hospital (MGH), was given a mandate to revise the curriculum entirely. Leaf points to the old curriculum's seven-semester straightjacket and says, "When it gets that absurd, it's not too hard to get a consensus for change. A lot of change was in the air."

Encounter Group Sessions

Leaf, whom Ebert appointed chairman of the influential Curriculum Committee, guided the faculty into accepting a radically different curriculum which allowed students 17 months of elective time, instead of only 4 months. In 1966 and 1967, he resorted to locking up members of the faculty in motel rooms for the weekend so they could thrash out their views on curriculum reform in encounter group sessions. Leaf says the committee discovered that each basic science department had no idea of what the other department was teaching, nor of the large amount of repetition. "They wondered why students got bored," he says.

Leaf, whose specialty is the kidney, recounts a yearly event under the old, department-based curriculum. "We had a department of pharmacology where the chairman insisted that every bit of pharmacology be taught by a member of his department. Every year, a particular pharmacology professor took me out to lunch and asked me, 'Alex, what's new in the field of diuretics?' " Leaf would invariably state what he knew. In his own department of medicine at the MGH, there were even three or four clinical faculty members subspecializing in diuretics. "We were excluded from teaching this," Leaf says, "because it was department territory."

To create the additional months of elective time, the Curriculum Committee obviously had to make some major changes. They cut required time in the clinic from 1½ years to 10 months. Instead of requiring students to study basic science for 2 years, they said 1½ years would suffice. Nevertheless, the committee strongly encouraged but did not require students to elect at least one additional semester of basic science. Under the new core system, courses were structured along traditional disciplinary lines for the first semester and around organ systems after that. The time allotted for each first semester course was cut from months to weeks (except for biochemistry).

"With the core," Leaf explains, "everyone would learn the language of medicine as efficiently as possible. Students would then go on and take the courses that appealed to their own interests and backgrounds."

To complement the new core curriculum, Leaf and others convinced the faculty in January 1969 to adopt a pass/fail grading system for the preclinical work, while maintaining the traditional "A" through "F" grading system for clinical studies during the third and fourth years. Leaf stated at that time that abolishing preclinical grades would decrease competition among students, prevent the faculty from cramming 2 years of the old curriculum's basic science into 1½ years, increase creative study, "help develop the habit of continuing education based on curiosity," and "increase self-motivation in our students." The faculty today apparently feels this did not happen.

The changes imposed by the core curriculum were so pervasive that their effects were felt outside of the classroom, library, and laboratory. Conversations became inundated with the word "core." In December 1970, the second-year class, which traditionally writes and performs a show satirizing the medical school, produced a show called "Rotten to the Core." A member of the class of 1972, the first class to complete the core, sent a woman in the class of 1976 a pair of shellacked apple core earrings to commemorate his graduation.

However, not all commentary on the core was equally lighthearted. The

poor showing on National Boards was considered by many to be too serious to joke about. The boards test achievement in anatomy, biochemistry, microbiology, pathology, pharmacology, and physiology. The last Harvard class to study basic science under the old curriculum scored first in the nation in every category. In sharp contrast, the first class under the core took the exam in 1970 and retained the top ranking only in biochemistry, the one departmental course still intact despite the radical curricular reforms. Harvard's overall performance in 1970 was third, but National Board scores that year were notoriously low in pharmacology (15th) and pathology (10th).

Some faculty members disregarded the lower scores and called the National Boards out of date. Others said that the National Boards should not be an end in themselves. "If one were to fall *way* down, then I think one would worry," Ebert comments. "We clearly ought to be in the upper ten schools, because we've got very good students. But whether we're in first place or second place or third place really seems to me to be relatively unimportant."

For critics of the core, disappointing National Board performance became an important weapon with which to fight the new curriculum. Basic science faculty accused Harvard of lowering its standards, making core material too superficial, and taking away too much autonomy from preclinical departments.

Bernard D. Davis, professor of bacterial physiology, says, "Because the quality of medical care involves life and death, it's very important to maintain standards. The core curriculum created an excessively light curriculum." And he says that superficial basic science courses in the core curriculum take the satisfaction out of teaching. "An extreme example of deterioration was the neurobiology course—the most popular course, previously," Davis notes. "They were very disheartened by external pressures preventing them from giving an effective, meaningful course—a level no longer satisfying to teachers. Students suffer because teachers teach with less enthusiasm."

The relatively poor results on the National Boards were released during the summer of 1970. That fall, Davis offered an alternative to the core's first-semester course in microbiology, and described his course as "requiring about twice as much time and offering the students no special reward other than the opportunity to learn more." During the 3 years Davis has offered the course, about two dozen students have enrolled each year.

"The willingness of that many students to do this extra work suggests that the core curriculum, while apparently pleasing one group of students, is shortchanging another group," Davis says. "A substantial number of students who want a strong scientific education, politically tend to be nonvocal. None of them is going to go to the dean's office and scream, 'We want a more intensive course.' The core curriculum shortchanges the kind of student this school tries to admit in large numbers—students with intellectual interests."

The basic scientists were not the only ones who complained about the core curriculum. The clinicians were unhappy, too, and insisted that students were less well prepared for the clinic than previously. Ebert contends that these are impressions each clinician gets "from a relatively few students." He says, "I've heard so often before that 'The student didn't seem as well prepared as in the past' that I always take this with a bit of a grain of salt."

Students More Passive

Donald J. Glotzer, associate professor of surgery at the Beth Israel Hospital, noticed an abrupt change in the caliber of students under the core curriculum. "The core students," he says, "are much more passive and willing to accept what we've said on the basis of authority, rather than wanting to know why we've said it. It is very difficult to elicit anything out of them in the way of spontaneous inquiry. They don't know what to ask. They just simply have had such a rapid going-over of the basics that they haven't had a chance to absorb them."

A fourth-year student, Margaret S. Ross, feels that clinicians vary in their approaches to teaching medical students but "the one consistent thing is that everybody is amazed about how little we know."

Dissatisfaction with the core curriculum continued to mount when National Board scores remained below the precore level. Students further disappointed the preclinical faculty by not returning for a semester of basic science during their elective time. Equally intense was opposition to the pass/fail grading system, inextricably linked to the core curriculum. In April 1972, Elwood Henneman, chairman of the physiology department, polled the basic science faculty and found that 81 of 86 faculty members favored a grading system which better distinguished different levels of student performance than pass/fail.

Many students and some faculty members vigorously defended the pass/fail system, but in December 1972, at the end of the third heated faculty meeting to debate grading, the faculty enacted a four-level grading system for both basic science and clinical courses.

Dean Ebert interprets students' opposition to grades as a denial of competitiveness. "If there really is a characteristic of people who get into the Harvard Medical School, it is that they're competitive. They had to be. And they revolt against it," he says. "There is a strong feeling that, 'Look, let's not be this way, any more. We've been too competitive in the past, and let's really adopt the philosophy that we're really here to haul through this together and that nobody is competing with anyone else.'" Ebert adds, "I happen to believe this is a good philosophy, and anything that can be done to reduce this very artificial competition of grades is desirable."

In November 1972, a poll of all the faculty members and students showed that 76 percent of the student body but only 4 percent of the faculty wanted to retain pass/fail for preclinical work. Seventy percent of third- and fourth-year students wanted to keep the grading system for clinical work.

Many faculty members disliked the double grading systems that had been in effect because they put basic science down. "There is the very clear implication that there's something very different between clinical and preclinical work," says physiology professor Thomas H. Wilson, who believes the pass/fail system implies that basic sciences can be mastered "at some vague level," in contrast to the graded clinical work, which is "really important." This implication, he says, "was offensive to those who teach basic science."

The frequently heard arguments which Wilson and his colleagues make for reinstituting preclinical grades are that grades assist a student in assessing his own performance, help Harvard students compete in the national marketplace for the most prestigious internships, and might encourage students to study harder.

While the pass/fail battle was fought in an open field, the struggle over maintaining or abolishing the core cur-

riculum with its integrated teaching was held behind the doors of the Curriculum Committee and its subcommittees. The decision to return to grades was made largely because the basic science faculty insisted en masse that the change be made. However, the decision to return to departmental teaching and 2 instead of 1½ years of basic science was based more on individuals quietly cultivating a consensus of the Curriculum Committee.

Leaf originally involved hundreds of faculty members in making the radical changes of the core curriculum. Although the Curriculum Committee strongly recommended that students take an additional semester of basic science during their elective time, the attractions of clinical medicine were so overpowering that most students filled all their elective time with clinical courses. "Preclinical faculty felt we chopped out the first 2 years with the ruse of telling them students would come back," Leaf says. "Others [in basic science departments] got very nervous about why they were in a medical school. It created a terrible amount of anxiety."

Leaf recalls, "I couldn't get people to do individual teaching in the elective period because they were so busy elbowing for visibility in the core." Before Leaf took a sabbatical in July 1971, he proposed that students, during their elective time, be obligated to take one of six 9-month tracks which would each include basic science

Yale, Too, Reverses Policy

The Yale School of Medicine is reversing a 40-year policy of no examinations in basic science courses by insisting that students be evaluated in every basic science course they take.

"Each department would offer several alternative methods of evaluation from which the student would choose the one most suitable for himself," a Medical School Council policy recommendation states. The resolution, passed this summer, will affect first-year students entering the school this month, although they had no prior knowledge of this policy change when they accepted admission to Yale.

The statement is open to widely varied interpretations. Some faculty members insist the new policy is not at all new, by pointing to an obscure, virtually unknown passage on page 81 of Yale's catalog, which states, "The faculty reserves the right to examine students further at any time." Howard Levitin, associate dean and director of student affairs, calls the resolution "a little club, not a powerful cannon, which will put our system back where it belongs."

Yale's unique system of medical education, whereby students are not given examinations in any of their course work, has been in effect at least since the early 1930's. The only requirements for graduation have been passing the National Boards, submitting an acceptable thesis, and passing Yale's comprehensive examination in the basic sciences, which was administered until a dearth of faculty during World War II made the exam unfeasible.

Until 4 or 5 years ago, the no-exam system reportedly worked well, with close faculty-student contact and high performance in the National Boards. Yale usually scored from first to fourth in the nation. However, during the past few years, National Board performance overall plummeted to about tenth; a significant number of students began flunking the National Boards; the faculty-student ratio declined as Yale expanded the size of its class; and student attendance at lectures fell dramatically.

A third-year student at Yale, Robert F. Malacoff, calls the no-exam system "a double-edged sword. You never know if you've done enough work." Malacoff says he must ask himself constantly, "Have I really gotten everything out of it?" He explains, "For most people who worked for grades in college, you have to break out of that inculcated idea to enjoy going to school there. I had second thoughts when I was a first-year student."

Because of the no-exam system at Yale, the National Boards have assumed an extra measure of importance there because they are the only examination which a Yale medical student must take to determine whether he has grasped the science necessary to become a licensed physician. This year, Yale's performance on the part of the National Boards measuring achievement in basic science reached a new nadir. Out of a class of 105, 13 students flunked the National Boards in June.

Robert W. Berliner, who is leaving the National Institutes of Health after 23 years to become dean of Yale School of Medicine this month (*Science*, 29 June), has approved the council resolution to offer a choice of "grading" systems. Asked about anticipated student reaction to the plan, Berliner replies, "I can conceive of the possibility that we might have to delay it for a year."

While completing his undergraduate degree at Yale, Berliner was accepted to the Yale School of Medicine in 1935, but chose Columbia instead because, he says, he did not find Yale's no-exam and no-grades system suitable for his own study habits. "I'm a terrible procrastinator," Berliner explains. "I felt I needed deadlines."

Berliner believes the Medical School Council proposal is probably warranted because of the recent change in student attitude, both at Yale and nationally. "Students are less convinced of the importance of some of the work in the preclinical sciences," he says. "In many of the courses, they've been staying away in droves."

Berliner cites student concern with relevance in teaching. "The whole relevance kick has led to students deciding for themselves what's relevant, and I think they've made some bad choices."

Undoubtedly, Yale's basic science faculty, dismayed by the declining academic performance of its students, will welcome Berliner's deanship. "Faculties have been too swayed in recent years by pressures from students," Berliner comments. "We've got to swing back a bit to a little of 'Father Knows Best.' I think that should be done by persuasion rather than by hitting."—S.Z.G.

courses. Leaf's absence, however, heralded a new wave of unpopularity for the core.

In retrospect, Leaf thinks, "I should never have allowed the new curriculum to start until I had worked out the elective program as thoroughly as I could. All our efforts were spent putting out the brushfires in the core—such as placing 15th in pharmacology." Leaf calls the present unstructured-elective offerings "a frivolous berry-picking operation."

Nevertheless, Leaf remembers that before he left Boston for a year at Oxford, "The preclinical council said it was delighted" with his proposal for organizing elective tracks. "I thought I had gotten this idea across. But it just never went any farther." After Leaf's 6-year chairmanship, David G. Freiman, professor of pathology, became the Curriculum Committee chairman. Leaf feels that Freiman "had the serious intent of holding on to what was good in the curriculum, but structuring it so it was more palatable to preclinical faculty, and so they wouldn't feel so disenfranchised."

Thus, the most persuasive reason for returning to semester teaching and department courses is to console the many basic science professors who, as Freiman observes, are "terribly unhappy."

It would be a mistake to assume that the abolition of the core curriculum will mean a strict return to the traditional curriculum. The core's most important legacy—a tripling or quadrupling of elective time in the third and fourth years—will definitely survive. In addition, the rescheduling of courses along a semester basis instead of a 2- to 6-week period of time solely devoted to a particular organ system, will allow students the flexibility of taking related courses elsewhere in the university.

Nevertheless, proponents of the semester system have made too many optimistic predictions. They insist that a semester system will induce more student-faculty contact, more outside reading, more hours studying, and prevent a student from falling as far behind in his work as he can now under the core. But these problems, which those who champion the semester system claim they can solve, have much deeper roots than the structural set-up of the core curriculum. At the Yale School of Medicine which has the semester system, professors complain that the two most serious problems are that there is too little student-faculty contact and that the student relies too much on the syllabus, with insufficient outside reading.

But these arguments for a semester system draw attention away from the one overriding reason for dissolving the core—the unwillingness and unhappiness of the basic science faculty to relinquish its traditional teaching along

Briefing

A Union for Industrial Scientists?

For the first time in at least 30 years, a major union is attempting to organize the estimated 200,000 scientists and engineers in the U.S. and Canadian petroleum, chemical, and atomic industries. The AFL-CIO's Oil, Chemical and Atomic Workers International Union (OCAW), which already represents nearly 180,000 blue-collar workers in those industries, last month moved to capitalize on the discontent of industrial research personnel by establishing a professional employees division. The new division, headed by chemist Frank Collins, a longtime union advocate now on leave from Polytechnic Institute of Brooklyn, New York, launched its organization drive in Chicago at the end of August during the 166th national meeting of the American Chemical Society. Despite warm endorsements by Nobel Prize-winning chemists Harold Urey, Linus Pauling, and Salvador Luria, the union's efforts have so far met a surprising apathy.

OCAW obviously expected more of the ACS and its members. ACS president Alan C. Nixon and president-elect Bernard Friedman were both swept into office as write-in candidates espousing a platform of job security and a fairer treatment of industrial chemists. Both have devoted much of their tenure to such activities as reformulation of employment guidelines, providing irrevocable pensions, and, in general, enhancing the professionalism of chemists. Yet the society has been curiously noncommittal about the union's efforts, despite the similarity of goals.

The ACS has issued no public statement about the unionization attempt, and there was no open discussion of it during the national meeting. Nixon's own attitude was lukewarm at best: he argued privately that it would be inappropriate for the society to support the unionization effort, particularly since many ACS members are part of the chemical industry's management, but that there was also no reason to condemn the effort. Nonetheless, some subtle forms of resistance were apparent.

An OCAW request for table space at the meeting was denied by ACS, and the union was forced to rent space at the concurrent National Chemical Exposition. The ACS council also unexpectedly elevated the society's own division of professional relations to full divisional status—without even notifying the division's president that a vote might be imminent. Some ACS staff members predicted that official resistance would stiffen notably if the organization drive began to meet with success.

The ACS members, for their part, have offered vocal support for professionalism, but little else. The society's professional relations division has garnered only about 450 members, and attendance at its symposiums was sparse. Nixon's high-powered solicitation of funds for his Professional Enhancement Program has also fallen far short of its goal. The union seems to be doing little better. The volume of people visiting the OCAW booth was modest, at best, and only eight people showed up for a cocktail hour hosted by Collins.

Collins attributes this apparent apathy to a "climate of fear" in the chemical industry, arguing that most prospective members are afraid association with the fledgling union will cost them their jobs. Other observers suggest, however, that the true reason is the relative prosperity of the chemical industry and the greater job security associated with that prosperity. Only a full-scale recession, they argue, would drive professional chemists and chemical engineers into the arms of a union and such a recession—at least for the chemical industry—is unlikely in the foreseeable future.—T.H.M.

departmental lines. These departments feel if they do not have a course of their own, their reason for existing at a medical school must be necessarily questioned. Thus the guiding principles at Harvard, other universities, and undoubtedly any large organization must revolve around the politics of happiness.

Leaf criticizes the politics of happiness, which caused the downfall of the core curriculum he developed. "To set up a system that's impossible to change, all somebody has to do is vow he's going to be very unhappy if he has to teach another way," Leaf says. His solution is to "pick a few people and bypass the others." Leaf points out a very real danger when he warns that a return to departmental teaching as it used to be will make it "very difficult to reduce the amount of information each department insists you need to know. Medical school will become 4 years stuffed full of didactic exercises."

The return to grades may also be a mistake. Many students believe the faculty simply does not know the extent to which academic competition has increased since the days it went to college. With three applicants for every medical school seat in the country, competition for grades in college (*Science*, 28 July 1972) has made the theft of an afternoon's work in an organic chemistry laboratory nothing unusual. The fact that college course work in science is usually graded on a curve has made many premedical students unwilling to help each other master scientific concepts. False information deliberately released at the breakfast table on the morning of a college exam in a premedical course is not unusual, either. The pass/fail system, although it does not eliminate a subtle undercurrent of competition (partly because there are persistent rumors about secret grades), does create a spirit in which students are much more willing to help each other. An ungraded system promotes an atmosphere of partnership, rather than one of jealous competition. Revisionism at Harvard is not an isolated case. At Yale, which has had no grading system for at least four decades, changes are under way as well (see box). But Harvard and Yale both seem to be following a course that is somewhat different from that state medical schools are taking.

The original intention of writing about Yale was to contrast Yale's continued liberal approach to education, specifically the no-exam and no-grades policies, with Harvard's reversal of its radical curricular reforms of the late 1960's. What was found, instead, is that the Yale system is in serious trouble, although it had functioned smoothly for more than a generation.

Among schools like Yale and Harvard, there appears to be a strong trend toward retrenchment and reinstating the traditional educational system. Namely,

Briefing

Environmental Precedent for Nixon Tapes Case

A major achievement of the public-interest law movement is that by its persistent demands to know the basis for actions taken on the public's behalf, it has opened up considerably the process of government decision-making. That the importance of this achievement extends far beyond the immediate battles the movement has won or lost was shown last week by Judge John J. Sirica's ruling on the issue of whether President Nixon should hand over the tape recordings demanded by the Watergate special prosecutor. The most recent—and in some ways the most germane—of the five precedents cited in Sirica's opinion is the case of the *Committee for Nuclear Responsibility Incl.* v *Seaborg*, in which a coalition of eight environmental groups attempted to block the AEC from detonating a nuclear warhead beneath the Aleutian island of Amchitka.

The environmentalists fought their case up to the Supreme Court where, 4½ hours before the warhead was due to be armed, the Court voted by 4 to 3 against them. Though the case was lost, some case law was made along the way which is remarkably analogous to the situation of Nixon and the tapes. To support their contention that the Amchitka detonation was unsafe, the environmentalists demanded to see certain documents allegedly critical of the test, but the AEC claimed the documents involved national security matters and were covered by executive privilege.

The District Court decided the issue in the same way as Sirica decided that of the tapes, by ordering the defendants to produce the documents for in camera inspection by the court, which itself would decide what was privileged and what was not. The AEC appealed but the Court of Appeals under Chief Judge Bazelon ruled that the lower court's order should stand. "In our view," said Bazelon and his confrères in the opinion cited by Sirica last week, "this claim of absolute immunity for documents in possession of an executive department or agency, upon the bald assertion of its head, is not sound law." As for the government's appeal to the doctrine of the separation of powers, that it lies with the executive branch to decide what documents it will produce, the appeals court replied:

"Any claim to executive absolutism cannot override the duty of the court to assure that an official has not exceeded his charter or flouted the legislative will. . . . No executive official or agency can be given absolute authority to determine what documents in his possession may be considered by the court in its task. Otherwise the head of an executive department would have the power on his own say so to cover up all evidence of fraud and corruption when a federal court or grand jury was investigating malfeasance in office, and this is not the law."

Nixon's case for refusing to give up the tapes is so far traveling the same route as that of the AEC's attempt to suppress the environmental impact documents. David Sive, the New York attorney who argued the environmentalists' case through to the Supreme Court, believes the two cases involve the same issues and will have precisely the same result. The procedure for in camera inspection, which does not seem to have been used before as a test for executive privilege, was one that Sive suggested to the court as soon as the AEC started talking about military secrets.

When the Amchitka bomb went off with minimal damage to wildlife, the epic struggle to prevent it was held by some to have been a waste of effort. In terms of legal history the case is proving of some import.

—N.W.

a student will take several departmental courses during a semester, study the material, and be tested on it (and graded if he goes to Harvard). Yale's no-exam system and Harvard's integrated teaching of organ systems and pass/fail set-up have been labeled, perhaps too quickly, as overly progressive by a faculty that is upset with the falling academic performance of its students.

At both Yale and Harvard, 1968 marked a change from 2 years of basic science to 1½ years. The faculty teaching this material largely considered the reform to be a slap in the face. Harvard's basic science faculty counterattacked first, by focusing on the grading system in heated faculty meetings. They succeeded in abolishing pass/fail and then followed through by dismantling the core curriculum in small committee meetings.

Their counterparts at Yale, who did not have the use of an examination, brought their complaints to the Medical School Council and finally convinced the council that students should be evaluated in each course. The Yale student, for the first time in 40 years, will be obligated to choose among exams, written reports, or oral presentations as modes of evaluation in every course he takes.

The next step will be a return to 2 years of basic science, almost definite at Harvard and being lobbied for strongly at Yale. This change flies in the face of the national trend—subsidized with large financial incentives from the federal government—toward 3-year schools and abbreviated basic science curricula. The government incentives are predicated on helping to solve our health care problems by turning out more doctors more quickly.

"The financial pressures are very severe," admits Robert W. Berliner, the new dean of the Yale School of Medicine. "But somebody has to stand up and say, 'This is a lot of nonsense. This is not the way we should be going.'"

While the merits of examinations are obvious, Harvard's decisions to abolish most of its organ system teaching and to return to grades for preclinical work are probably too hasty. These decisions result largely from disgruntled faculty members displaying the political power of their hurt feelings.

Harvard and Yale are becoming more conservative in their educational policies, repudiating a 5-year experiment and a 40-year tradition, respectively. But if the focus of education at these schools continues to shift to the right, the pendulum will undoubtedly reach its limit and begin swinging the other way.—SAMUEL Z. GOLDHABER

RESEARCH NEWS

Thin Film Optics: Still in the Exploratory Stage

The prospect of optical communications systems with the capability of carrying vast amounts of information on a single light beam has tantalized communications engineers, both civilian and military, ever since the advent of the laser in 1960. But now, 13 years later, large-scale optical communications systems are still some time off, although in the last 2 years developments in optical fibers to carry light beams have greatly enhanced the practicability of long-distance optical communications. Cheap and reliable systems to generate light, to process the light to make optical signals, and to detect these signals have not yet been developed.

Present optical systems are composed of bulky assortments of lasers, mirrors, and other devices that are difficult to move or keep aligned. An increasing amount of interest and funding, therefore, is being directed toward thin film optical devices, in which optical functions will be accomplished by thin layers of materials deposited on a common backing or substrate. Such materials for use in optics have the potential for reducing the size of the devices and their cost and for eliminating mechanical alignment problems. The ultimate goal is an integrated optical system consisting of a single small substrate chip that supports a complete thin film optical circuit—a system which many researchers view as being analogous to integrated circuit electronics.

Among the components of a thin film optical system are light sources that generate an optical carrier wave, waveguides that carry the wave through the optical circuit to the transmission medium, and modulators that impress the signal to be transmitted (such as a telephone conversation or a television program) onto the optical carrier. Devices that transfer the modulated optical wave to the transmission medium —either an optical fiber or the air—and optical detectors that receive the transmitted wave are also receiving attention. The complete optical communications system would consist of these devices put together to form transmitting stations, repeater stations (to amplify the signal at intervals along the transmission path), and receiving stations.

The basic element of a thin film optical circuit is the waveguide, whose function is analogous to that of a wire in an electrical circuit. The waveguide is formed by depositing a thin film of material with a thickness comparable to the wavelength of the guided light onto a substrate; in order to delineate the waveguide pattern, excess material can be removed by means of photolithographic or related techniques that have been developed for integrated circuits. To perform as an optical waveguide, a thin film must have an index of refraction greater than that of the surrounding medium, that is, the substrate below and either air or some material above. Light that travels along the waveguide is thus reflected by the top and bottom surfaces of the thin film in a zigzag path and does not escape the film, provided that the light path does not make too large an angle with the waveguide surface. When the height and width of a waveguide are less than the wavelength of the light, there is a unique angle at which the light can reflect from the surface (single mode transmission). Larger waveguides permit light to reflect at several angles (multimode transmission). For many high-frequency applications, it is often useful to have single mode transmission.

Waveguides have been made by various processes from many different materials, including liquids, polymers, glasses, semiconductors, and insulators. Organosilicon polymer films on glass substrates have, for example, been made by P. K. Tien, G. Smolinsky,