appointment of his career; it explains in part the fervor behind the challenge problems of 1657 (*4*).

25. Quadratic forms are numbers of the form $a^2 + mb^2$, where m is a nonsquare integer, and a and b integers.
26. Since we assume the relation $a^2 = b^4 + c^4$ to be in reduced form (that is, that the terms contain no common factor), b^2 and c^2 cannot be both even. Since, in turn, $b^2 = 2pq$, one of p or q must be even, the other odd. Were q odd, $c^2 = p^2 - q^2 \equiv -1$ (modulus 4), which is impossible. Therefore, q is even.
27. L. Euler, "Observationes de theoremate quodam Fermatiano, aliisque ad numeros primos spectantibus," *Comment. Acad. Sci. Imp. Petropolitanae* **6**, 103 (1733).
28. See J. Itard's introduction to the 1966 reprint of Noguès' *Théorème de Fermat* (*2*, p. iv).
29. For Euler's proof, see (*22*, paragraph 243); for his theory of quadratic forms, see (*22*, chapter 12).
30. A form of this identity is the basis for Diophantus' solution of Proposition II,8 of the *Arithmetica*, the proposition that prompted Fermat's statement of the "last theorem."

NEWS AND COMMENT

Medicine at Michigan State (II): The Architecture of Accountability

After World War II, the availability of federal funds for biomedical research and hospital construction encouraged a particular growth pattern for the American medical school. First came a basic sciences building; next, a clinical sciences teaching and research facility, often combined with or closely followed by a big university hospital. Frequently, the cycle would be repeated, with the university medical center expanding to monumental proportions.

In the late 1960's, however, medical schools began to suffer the financial pinch caused by the Vietnam war and inflation. Keynesian logic led federal agencies to make their deepest cuts in construction funds, and the effects, consequently, were felt most sharply by new medical schools or those in the midst of building programs.

The new syndrome was nowhere more inopportune than at Michigan State University (MSU), which operates two new medical schools, one of them the College of Osteopathic Medicine. While the MSU schools have the advantage over private schools of receiving state support, they have had to contend with a restive state legislature. The state is committed to supporting four state medical schools, but the legislature has developed something of an immune reaction to the costly prospect of supporting major university medical centers at three campuses (*Science*, 22 September). The legislators' constituents have been complaining about the shortage of physicians in many areas and the high cost of medical care, and the legislators have grown increasingly skeptical about the likelihood that the medical centers will turn out the recruits for general practice and community medicine they think are needed.

The appropriations committees of the legislature have used their considerable practical influence to increase class size at all state medical schools and to encourage an emphasis on family and community medicine. At MSU, the legislators had more leverage than at the University of Michigan or Wayne State, simply because the new schools had to be built literally from the ground up.

It would be a distortion to say that the Michigan legislature dictated the terms under which the two schools would operate. The medical schools themselves initiated the innovations at MSU which resulted in the extensive use of community facilities for clinical teaching and the unusual departmental arrangements for teaching in the basic sciences. And the university at large has a special adaptability that made it possible for innovations to take root. (The organization of medical education at MSU will be discussed in another article.) To ignore the influence of the legislature, however, would be highly unrealistic, and that influence is reflected most clearly in the medical school buildings constructed, and particularly those not constructed, on the MSU campus.

The first building specifically designed and built for medical education at MSU is Life Sciences I, which was completed in 1971. The building cost about $9.5 million, with some $4 million of that provided by the state. Life Sciences I was built on a site designated for a medical complex. The site is located near the edge of MSU's expansive main campus, with easy access to interstate roads and virtually unlimited room to build.

Life Sciences I was planned at a time when MSU had only a 2-year medical school. Like many a medical school building elsewhere, it reflects the patchwork financing by which medical schools put facilities for a number of programs under one federally subsidized roof. The building accommodates the school of nursing, the pharmacology department, the offices of the dean of the College of Veterinary Medicine, and laboratories and animal facilities. Architecturally, it is not viewed as a very flexible building.

Actually, the prospects of medical education on the campus were taken into account when building plans were made for the past 10 years. A biochemistry building, completed in the mid-1960's, includes facilities for instruction of medical students, and a new veterinary clinic incorporates space suitable for instruction and research in both human and animal surgery. Both facilities are near—by the standards of MSU's wide-open spaces—Life Sciences I.

But authorization by the legislature of a 4-year program in human medicine in 1969 and the decision a year later to move the College of Osteopathic Medicine to the East Lansing campus presented the university with a greatly increased demand for space. Two buildings have undergone major renovation. Giltner Hall, an academic building, now houses the departments of anatomy, microbiology, pathology, and physiology, as well as animal facilities. MSU's gifts for improvisation were more clearly demonstrated in the renovation of a residence hall for the use of both medical schools. In recent years, student life-styles have changed in such a way that many prefer sharing apartments off campus to traditional dormitory living. As a result, the university was left with empty rooms in the residence halls and a problem in paying off dormitory mortgages. One reaction to this situation at MSU was

to remodel Fee Hall, a high-rise dormitory built in 1964 with space for dining, social, and even academic facilities. Fee Hall now provides administrative offices for the two medical schools, carrels for students of the College of Osteopathic Medicine, and teaching and laboratory space for several departments. The needs of the gross anatomy laboratory have been fortuitously met by the big refrigerators of the former dining hall.

But even with the renovations, the two schools still had to provide for more room as their classes grew in size and the clinical sciences programs went into full operation. A blueprint for major physical expansion was in the works in the late 1960's, and it is here that the hand of the legislature has been most clearly seen.

Life Sciences I building at MSU

About the time of the approval of MSU's 4-year program in human medicine, plans were drawn up for a Life Sciences II building and a small hospital. What the planners envisioned was a clinical sciences teaching building and a teaching hospital with about 342 beds and a sizable outpatient clinic. The price tag on the project when it was submitted to the federal government was $42 million for the hospital and $17.3 million for Life Sciences II.

In May 1970, a degree of euphoria was produced at the College of Human Medicine when word came from Washington that a federal grant of $27.4 million had been approved, subject to the availability of federal funds and of matching funds from the state and private sources.

There were two major snags. First, the likelihood of full funding from Washington was fading fast because of cutbacks in construction money. Second, legislators balked at providing the state's $18 million share of the money.

There were external factors for the legislators to consider, such as a strike in the auto industry, which had crimped state revenues. But more than money was involved. The legislators on the appropriations committees wanted several fundamental questions answered about medical programs at MSU. They asked if the building plans reflected real intentions by the two medical schools to share facilities. And they wanted to know if the plans to use community facilities for clinical instruction were really being followed.

The initial answers did not satisfy the legislators. They pointed out that the building had been planned before the College of Osteopathic Medicine was established on campus, and they asked for a report that would relate the requirements of the educational programs of the two schools to the teaching and clinical facilities being planned. The legislators wanted a third party-involved and, in an unusual action, put pressure on MSU to engage a California consulting and planning firm, KMB Health Systems, Inc.

KMB had been hired first by Wayne State's medical school when the legislators had made a similarly inspired request for an explanation of medical programs in order to justify funds for a Wayne State clinics building in Detroit. KMB representatives had taken the trouble to go to Lansing to keep the legislators in touch on options and costs for the project, and the legislators had found the dialogue useful. When the issue of buildings and programs came up to MSU, the legislators hinted, not very delicately, that they would like to see KMB involved. Not surprisingly, there was some feeling among officials and faculty members at MSU that outsiders, perhaps unfriendly outsiders, were being imposed on them. But they chose to take the hint and KMB.

The main inputs into the ensuing study and report came from the two medical schools and MSU's Institute of Biology and Medicine as well as KMB. The result was a report in which the essential features were a detailed appraisal of the community-based clinical education program and a scaled-down redesign of the building project. The alternate proposal was for a building that would combine clinical teaching and ambulatory care facilities in a way that would provide for a genuine sharing of facilities by students in M.D. and D.O. programs. The cost of the revised Life Sciences II would be about $10 million, with about half of the funds to be provided by the state. Clearly the redesign was tailored not only to fit MSU programs, but also to win approval in Washington and Lansing.

Word from Washington indicates that the new proposal fit both the priorities of the granting agency and the realities of the federal funding situation. The MSU schools were awarded some $4.9 million in federal construction funds, $3 million of which was earmarked for the College of Human Medicine and $1.9 million for the College of Osteopathic Medicine—and this in a year when a total of $143 million in construction grants was given out in response to requests for well over four times as much. No other Michigan medical school was on the list. There is no guarantee that the legislature will come up with matching funds, but it would be very surprising under the circumstances if it didn't.

Michigan legislators, in dealing with medical educators, have not hesitated to hold their feet to the fire. Medical schools are particularly vulnerable to such tactics when construction projects are at issue, but it is clear that the legislators are not going to let it end there. Mainly on the instance of Senator Garland Lane, the appropriations committee of the state senate has been looking for ways to determine

how well the medical schools are achieving their stated objectives, and the committee seems to be intent on instituting a formalized system of accountability.

Michigan Governor William G. Milliken, through his budget bureau, is taking a similar tack. This could, in the long run, have at least as heavy an impact on medical schools, since it is the governor and his budget advisors, after all, who make up the state budget in the first place. Michigan state government is moving to a new system of program budgeting. What this means in broad terms, says budget bureau director Charles Sturtz, is that attention is being shifted to program outputs from inputs. In the case of medical education, instead of looking, for example, at the number of first-year medical students or of degree credits being earned, an effort will be made to identify the numbers of physicians trained and the primary areas in which they can be expected to work. All institutions of higher education, including medical schools, have been told to gather information on a program basis, and this necessitates a kind of detailed reporting never before required of medical schools. Sturtz concedes that the system will take a few years to shake down.

At Lane's behest, however, the senators seem to be concentrating on the medical schools in the effort to elicit information on program effort. The appropriations committee has engaged KMB as its agent, and negotiations with the four medical schools have been going on since the spring. The schools are being asked to define their programs in detail, to categorize expenses and identify their sources of revenue, and to link both income and expenditures to particular programs.

The impression in the legislature this summer was that the four medical school deans had decided to hang together and were doing a bit of stonewalling. There are some understandable reasons for the lack of enthusiasm about the new requirements. The more demanding record-keeping and reporting involves costs and effort that might be expended elsewhere. Furthermore, the methodology for developing data is by no means at the finger tips of medical school administrators. It is notoriously difficult to separate the costs of particular aspects of medical education—teaching, research, and care. And in the past, at least, solvency could depend on not allocating costs too precisely. Then there is said to be conflict between the data requested by the governor's office and by the appropriations committee.

Even if the technical questions could be easily disposed of, there remains the more sensitive issue of what some university people see as an infringement of academic freedom. It is not a subject on which medical school or university officials expatiate to reporters—it would

Earthquake Accord and the Test Ban

American seismic devices will be placed on Soviet soil as part of an agreement on environmental research signed last month in Moscow. The purpose of the exchange is to further research on earthquake prediction, but because of the role of seismic measurements in discriminating between earthquakes and underground nuclear explosions, the agreement has raised flutters of excitement that it constitutes an inadvertent step toward cooperation on the means of verifying a test ban treaty. The significance of the agreement for this purpose seems likely, at most, to be indirect.

The agreement signed last month stipulates that Soviet scientists may set up and jointly operate seismic instruments on the San Andreas fault and Americans may do likewise in the Garm-Dushanbe region of the U.S.S.R., near Tashkent. The instruments the American team will station there have not yet been decided but may include tiltmeters, magnetometers, devices for recording the water level in boreholes, and possibly short period seismographs. Robert M. Hamilton, a Geological Survey geophysicist who coordinated the American proposals, says that these instruments, designed for earthquake prediction studies, would not be especially helpful in discriminating earthquakes from underground nuclear tests. A principal way this is done is by comparing the long period surface waves and short period body waves generated by an event, but there are no plans to install a long period seismograph on Soviet territory, even if the Russians would allow it. The purpose of the agreement as Hamilton sees it is to benefit from the Russians' longer experience with earthquake prediction and to open up a dialogue. "If things become too misunderstood a really worthwhile scientific exchange could be jeopardized," he says.

Earthquake prediction, one of 11 subject areas in the environmental agreement, was a topic included at the suggestion of Gordon J. F. MacDonald, then a member of the Council on Environmental Quality. MacDonald, a geophysicist and former member of the President's Science Advisory Committee, says that neither side mentioned the possible relevance of earthquake prediction to underground test detection. But he considers the agreement as "a step in the direction in which one might conduct broader kinds of seismic research relevant to verification."

Placement of American scientists and instruments on Soviet soil is a "minor policy breakthrough," as MacDonald describes it, but is unlikely to reveal any information about Soviet nuclear tests that is not available by other means. It has been pointed out that the intended site for the U.S. station, in the Pamir mountains of Tadzhikistan, is only 900 miles southwest of the Soviet test site near Semipalatinsk. It is also only 300 miles north of Kabul, in Afghanistan, where American seismographs are presumably sited. The station on Soviet soil "would make a difference you could stick on a gnat's eyelash," says a White House official.

The negotiations on a complete test ban treaty became stalled in 1963 on the issue of on-site inspections. Since then, the United States has proposed an exchange of seismic research information as a way of resolving the disagreement, while the Soviet Union has contended that existing detection methods were adequate to police a ban. Exchange of information on earthquake prediction could develop into a discussion on methods of detecting underground nuclear explosions. Even so, detection is not by any means the only obstacle to a test ban treaty.—N.W.

be bad form and could be bad politics. But a tone, a wince, a bit of body language confirms second-hand reports that the feeling is there. It is not surprising that it is, since the discussion on accountability in Michigan amounts to an encounter between two groups of people with very different responsibilities and weltanschauungs. Physicians are not in the habit of telling their patients everything, and, in most places, medical school officials are not accustomed to telling their patrons in the legislature everything.

In Michigan, however, the legislators are pressing for a change. At a meeting last week called by Lane and state senate appropriations committee chairman Charles Zollar, there was reportedly a stormy scene. Lane said the legislature had been making important decisions on the basis of poor information, and he understood that there had been a lack of cooperation from the schools in providing better information. He then indicated that the committee didn't want to harass the schools, but that, if necessary, the committee would hold hearings at each school and even go into matters of salary and productivity to get the information. The meeting ended on a friendlier note, however, since the four schools responded with a pledge of cooperation.

In Michigan, relations between legislators and medical educators are evolving rapidly. It is evident that the days are done when legislators limited themselves to voting money for a building and then perhaps turning up for the ribbon-cutting ceremony. The legislators are in the process of extending action in the public interest in a way that may impinge on the traditional conception of academic freedom. There is a clear example of this in Michigan in the collision over university autonomy. Under the state constitution, universities have exercised considerable control over expenditure of funds. After the legislature recently "line-itemed" programs on which funds were to be spent, and thus restricted university self-determination, the universities went to court and had their autonomy confirmed. But the realities, as MSU president Clifford Wharton and other university officials acknowledge, are summed up in what one legislator observed, apparently without rancor: "They have the autonomy and we have the money and they have to come back up here next year."

The appropriations committees have pioneered in developing new mechanisms intended to ensure that public funds are spent effectively. This by no means ensures that the legislators or their advisers are infallible or that they are immune to old-style patronage or pork-barrel impulses. Medical school deans still get phone calls from legislators lobbying to get a constituent's son or daughter accepted as a student. But individual legislators have done a good deal to change the system. With Garland Lane, for example, as one observer said, "the constituent interest and the public interest have merged in his mind." The longer term effects, however, probably do not depend on personalities. In Michigan, and in many other states, the idea of linking numerate skills and the public interest is resulting in a new kind of accountability being built into the system.

The effects on higher education are already visible in states where legislatures have taken steps to prescribe contact hours for faculty or to force abandonment of doctoral or master's degree programs that are deemed uneconomic. In the medical education community, the awkward questions of the costs of medical education precipitated a search for a methodology in a sequence of studies funded by NIH but still not released in full. An even more ambitious effort is only now getting under way at the National Academy of Sciences' Institute of Medicine (*Science*, 2 June.) What seems to be happening in Michigan, therefore, is that educators and legislators are working out, however painfully, a new modus vivendi that is likely to become increasingly familiar elsewhere.

—JOHN WALSH

Earthquake Research: A Consequence of the Pluralistic System

Fragmented responsibility in national research on earthquakes and duplicative rivalry between two of the federal agencies concerned are among the findings of a report released last month by the General Accounting Office (GAO), the investigatory arm of Congress. A general response of those criticized is that the problems are smaller in reality than as portrayed in the GAO report, and that corrective action has now been taken.

The two agencies said by the GAO auditors to conduct overlapping research are the National Oceanic and Atmospheric Administration (NOAA) in the Department of Commerce and the Geological Survey in the Department of The Interior. Other agencies with fingers in the earthquake research pie are the National Science Foundation, the Atomic Energy Commission, and the Department of Defense. The GAO report, which is confined chiefly to civilian research, concludes that "the fragmentation of federal responsibility and the lack of national goals have made it extremely difficult for the various federal agencies supporting earthquake research to launch a coordinated attack on the nation's earthquake problem and to obtain maximum benefit from available resources."

As its prime example of uncoordinated research, the GAO report cites the studies of the San Andreas fault system in California conducted by NOAA and the Survey. NOAA's Earthquake Mechanism Laboratory (EML) is situated in San Francisco, and the Survey's National Center for Earthquake Research (NCER) is 35 miles south, in Menlo Park. The EML was established in 1964, NCER in the following year, the purpose of both being the study of earthquakes in general and the San Andreas fault in particular. Competition is a feature of all but the dullest branches of inquiry, but at what point in the overlapping of research interests does heuristic rivalry become unnecessary duplication? The GAO auditors view the competition be-