tent of developing embryos. Achievement of such a possibility would give man more power to control his future, but it would also demand far more wisdom than he has so far seemed able to apply. Another factor that will influence biological research is the long-term social value of curing diseases like cancer and mental illness. The emotional and financial costs of cancer on a worldwide basis each year can be measured in hundreds of billions of dollars. If cures for this disease could be achieved, they would be worth an enormous sum to humanity during coming generations. Realization of the great long-term economic value of amelioration of disease is certain to provide the basis of support for much biological research of the foreseeable future.

Training New Scientists

In this résumé of important trends in research it is apparent that almost all active fields involve multidisciplinary effort. Opportunities in some older disciplines seem limited. With the fast-shifting nature of research frontiers, it is apparent that the young student is faced with a difficult problem in preparing for research. If he specializes too early and too completely he may find that much of his knowledge is obsolescent even before he finishes graduate school. The situation calls for flexibility, and for a mastery of the fundamentals of two or more disciplines.

In the end, almost any research must take into account energy and its interconversions, chemicals and their reactions. Thus, to be adequately prepared, a person planning a life in scientific work must have the fundamentals of physics and chemistry together with the necessary mathematics. He must be able to express himself, which means a solid grounding in English. Given such a foundation, he can then master the details of a special subject matter such as earth science, biology, or behavioral science and be in a position to evolve wtih the changing opportunities. This training also prepares him broadly for industrial applied research.

The universities have a special responsibility. They must ask themselves whether they are preparing students for the 1980's or for the 1940's. Many schools are training their students for the 1940's. The curricula call for far too much specialized training. The student is overloaded with required courses in his specialty. He is given neither opportunity nor guidance to train himself broadly. Indeed, some departments consider a student disloyal and rather undesirable if he indicates a wish to take too many courses elsewhere. Moreover, the prejudice is usually amply conveyed.

As long as universities are organized in departments along disciplinary lines such narrow viewpoints are certain to come to the surface. To meet the new challenges will require either a complete recasting of the administrative structure or at least the formation of interdepartmental arrangements designed to help the student, not to preserve the vested interests of the faculty.

Today we are living in an era of accelerating change. If the universities are to fill their traditional role of furnishing adequate education and guidance to the young, they must fully recognize and act on the challenges they face.

Note

1. The purpose of the Klopsteg Lectures is to help further the development of multidisciplinary science both in research and in education. The lectures have been endowed as an annual series at Northwestern University by Paul E. Klopsteg, a past president of the AAAS, formerly an associated director of the National Science Foundation, and for 16 years a member, and for 7 years chairman, of the Governing Board of the American Institute of Physics. The two previous lectures in the series were by Francis Otto Schmitt (M.I.T.), on "Biophysics: Wet and Dry," and S. S. Stevens (Harvard), on "The Pursuit of a Sensory Law."

NEWS AND COMMENT

Mohole: The Project That Went Awry (II)

In mid-1961, as Project Mohole entered its second phase, the ingredients for misfortune began to accumulate.

The experienced Bascom group, which had successfully conducted the West Coast test drillings, was on the way out; the AMSOC Committee, originator of the project, no longer wanted to be involved in day-to-day operations and had prescribed a more remote role for itself; and NSF was shopping for an engineering organization to design, build, and operate the vessel that would carry out Project Mohole.

But what was Project Mohole? Was it a quest for no more than a few lengths of rock core from the depths of the earth? Or was it a comprehensive drilling program that included the mantle among several of its goals? Closely tied to these questions was the issue of technique. Was *CUSS I* to be followed by the construction of a so-called "intermediate" ship, a vessel that could go deeper than the *CUSS* but not all the way to the mantle? Or was the ultimate ship to be built at once? Who was to decide? Was it the part-time AMSOC Committee, which got together no more than a few times a year; or was it NSF, which had to foot the bills and account for its activities to an often-querulous Congress? And, finally, if NSF did take the decision upon itself, would it not be venturing into proscribed territory? The Foundation was established to "initiate and support basic scientific research"; it was not intended to be an operational organization. Traditionally, a standing scientific or educational institution was the operating link between the Foundation and the research programs it supported. But with AMSOC backing away to a lesser role, the Foundation was drawing close to becoming the institutional base for Project Mohole.

A nasty and still unresolved fight was to break out on these issues, but in

mid-1961 the success of the *CUSS I* drillings had created an atmosphere of good will that obscured the impending difficulties. With the exception of the Bascom group, whose future had curiously been assigned to a still-unselected contractor, everyone involved was feeling quite pleased.

Cuss I Achievement

The scientific yield of phase I—previously unobtainable ocean bottom cores—was acclaimed by geophysicists around the world; the engineering achievement was similarly hailed, and in this atmosphere of success the AMSOC Committee sent Academy President Bronk a position paper that has since come to mean all things to all partisans. Hollis Hedberg, (Princeton professor of geology and vice president of Gulf Oil), who was to succeed Gordon Lill as AMSOC chairman—and later to resign in a flurry of rancor—told a congressional committee last spring that the paper clearly supports the position that AMSOC intended an intermediate *program* to be carried out by an intermediate *ship*. Leland Haworth, who was to inherit the Mohole controversy when he succeeded Alan T. Waterman as NSF director, told the same committee that the paper called for an intermediate *program,* but not necessarily for an intermediate *ship* to carry it out.

What the paper actually said was this:

> We are agreed that the major scientific objective of Project Mohole is to drill to the earth's mantle, through a deep ocean basin. . . . Our immediate objectives are (*a*) to sample through the second layer and determine its thickness and characteristics; (*b*) to sample the characteristics of the top of the third layer. Also exciting, and of prime scientific importance, is the fact that we now have a new tool, the floating drilling vessel, with which to explore thoroughly the sediments and upper crustal layers of the ocean basins. We find, however, that the major objective of the Committee will entail work enough, and that we must recommend this possible exploration program to you for separate scientific and financial consideration. . . . We agree that an intermediate drilling program is required and should be initiated during fiscal 1962. . . . The budget for fiscal 1962, based upon the utilization of an intermediate ship, is approved by the AMSOC Committee as a minimum budget. It is contingent upon the findings of the [AMSOC] Drilling Techniques Panel, working jointly with the AMSOC staff and eventually with the prime contractor. This group may very well make decisions which will increase the cost of the intermediate program. Specifically, they may decide that an intermediate ship is not needed and that work on the ultimate ship should start at once. . . . We find that the AMSOC Committee must take as its major responsibility the drilling to and sampling of the earth's mantle. This objective has achieved such worldwide significance that we dare not fail.

Now what did this mean? A reasonable analysis would seem to indicate that the AMSOC Committee was bound for the mantle and wished to share with the prime contractor the decision-making authority on how to get there. But what if—as was eventually to be the case—AMSOC and the contractor were in disagreement? Who was to decide? Apparently quite confident about its role as NSF's scientific adviser on Project Mohole, the AMSOC Committee glossed over the question of authority. So far, things had gone smoothly, and there was no reason to assume that they would go otherwise. Bascom and his staff, in an Academy document, "Design of a Deep Ocean Drilling Ship," written on the basis of the *CUSS I* experience, had emphatically recommended construction of an intermediate ship as an indispensable step toward acquiring data for design of the ultimate ship. But the Bascom group was being moved out of the picture, and its influence with AMSOC was diminishing.

Conflict of Interest

The AMSOC Committee's recommendations were forwarded to NSF through the Academy, and now, as NSF began its quest for a prime contractor, the tricky problem of conflict of interest seemed to pop up everywhere to reduce the Foundation's maneuvering room. It was not only essential to avoid conflicts of interest, but, with Congress and the press eager to pounce on any real or seeming case of mutual back scratching with federal funds, it was essential to avoid even the *appearance* of conflicts of interest. To do this it was necessary to engage in a delicate juggling act, since much of the competence needed for Mohole was already connected with the project in one way or another. It thus became necessary to make certain that persons associated with the intiation of the project did not benefit financially from its next phase. Because the Bascom group was supposed eventually to work for the prime contractor, it was deemed advisable to keep it out of the selection process, a decision that helped avoid suspicion but did nothing to assist the selection process. And, of course, it was advisable to avoid giving the job to any firm closely associated with the oil industry, since the conflict-of-interest alarmists could easily shout "give-away" on that score.

Thus, with these considerations occupying a prominent place, NSF went looking for a contractor to carry out phase II of Project Mohole.

Contractor's Task

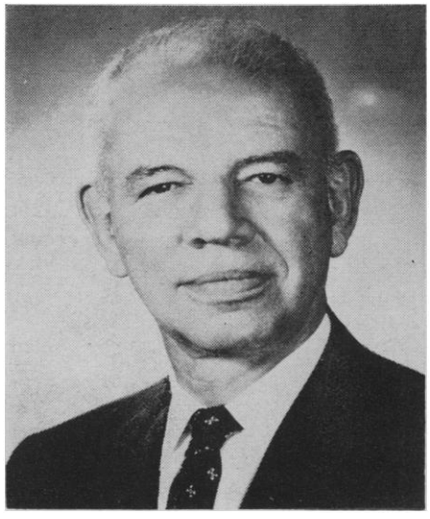
Now, what was it that NSF wanted the contractor to do? On this point, NSF fell in step with the prevailing imprecision. Up to this time Project Mohole had not occupied very much of the Foundation's attention. Although the project had been under way for 3 years, it was scarcely discussed at NSF's usually exhaustive appropriations hearings until it came up for brief mention at the House hearings in the spring of 1961, about the time *CUSS I* was completing its work. And it was not until nearly a year later that NSF set up its own Mohole Committee—consisting of William E. Benson, head of NSF's earth sciences section; Franklin C. Sheppard, executive assistant to NSF Director Waterman; and Paul A. Scherer, NSF associate director for administration.

The notification to prospective bidders stated:

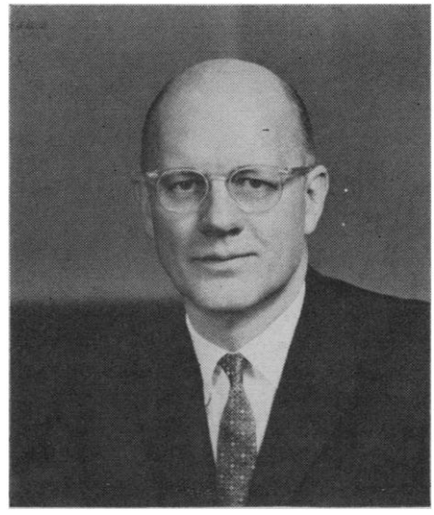
> The Mohole project will include: (1) The conduct of deep ocean surveys; (2) the design and construction of deep drilling equipment; and (3) the drilling of a series of holes in the deep ocean floor, one of which will completely penetrate the earth's crust.

From here on, NSF was to find itself on the most difficult political terrain of its decade-long existence, charged with having awarded the Mohole contract with an eye more to congressional favor than to engineering competence. Among the critics was Senator Thomas H. Kuchel (R–Calif.), who charged that "politically powerful" and "selfish" interests had dictated the contract award, and Senator Gordon Allott (R–Colo.), who declared that the project "promises to be a $100 million boondoggle."

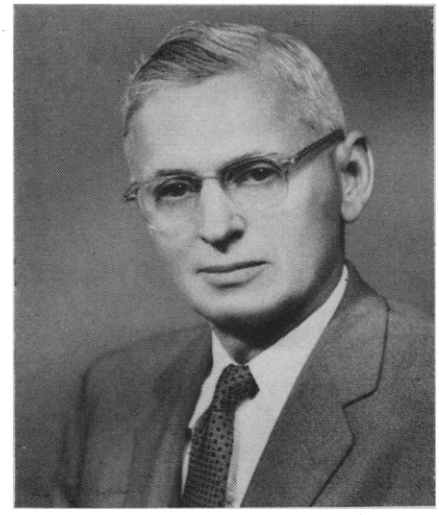
Twelve single and combined organizations responded to the bidding invitation, and, on the basis of a 1000-point scoring system, a specially appointed NSF selection panel concluded that the Socony Mobile Oil Company (936 points) was the most capable contender. Next was Global-Aerojet-Shell,



Leland Haworth



Frederick Seitz



Hollis D. Hedberg

with 902 points; the Zapata Off-Shore Company, third, with 812; General Electric, fourth, with 811; and Brown & Root, Inc., of Houston, Texas, fifth, with 801.

The selection process was described later in a report by the General Accounting Office, Congress's financial investigatory arm, which was asked to study the Mohole contract award by Senator Kuchel, who was obviously outraged at the fate of a constituent firm, which had lost out on the bidding:

> In its evaluation report, the [NSF selection] panel stated that the proposal of Socony Mobil was in a class by itself—outstanding as to every important aspect—and that the proposal of Global-Aerojet-Shell was in a strong second position. Below these two proposals, the panel found no apparent clearcut order and recommended that preliminary negotiations toward award of a contract be started first with Socony Mobil and, if unsuccessful, then with Global-Aerojet-Shell. . . .
>
> Following the preliminary evaluation, the [NSF] Director appointed a review panel of four senior officials of the Foundation to make a further evaluation. . . . The review panel also found the Socony Mobil proposal to be the best. . . . In a joint report, the two panels stated that they unanimously selected the proposal of Socony Mobil as their first choice and agreed that the proposals of Brown & Root, General Electric, Global-Aerojet-Shell, and Zapata stood out over the others. . . . Following . . . conferences with the five [above-mentioned] organizations, the preliminary evaluation panel reevaluated the proposals and gave them numerical scores as follows:
>
> 1. Global-Aerojet-Shell 968
> 2. Socony Mobil Oil Co. 964
> 3. Brown & Root, Inc. 890
> 4. Zapata Off-Shore Co. 890
> 5. General Electric Co. 846

As the evaluations proceeded and additional material was submitted by the bidders, the Comptroller General reported that the fourth and fifth entries were eliminated, leaving Global-Aerojet-Shell, Socony Mobil, and Brown & Root in the running. The panel, in a joint report, then notified NSF Director Waterman that "all three organizations were 'competent to effectively complete the Mohole Project' but made no recommendation as to the one which should be selected, because of the panels' inability to reconcile completely varying views of the individual panel members."

The selection process now moved into the final stage, guided by a 14-point set of "competence" and "policy" factors. These included such items as "ability to bring project to a successful conclusion"; "research capability and attitude"; "cost considerations"; "petroleum producer versus engineering construction company"; and "consequences of selection considerations."

Cost Estimates

As for costs and time, Global-Aerojet-Shell estimated $23 million and 33 to 45 months; Brown & Root, $35 million and 5 years; and Socony Mobil, $44 million and about 5 years. It was clearly stated by NSF, however, that because of the engineering uncertainties involved in the project, the cost estimates were to be regarded as no more than estimates.

The Comptroller General's report continued:

> . . . members of the [NSF] panels, weighing the competence and policy factors in accordance with each member's own views, were equally divided between the selection of Brown & Root and one of the oil companies, with Global-Aerojet-Shell favored if an oil company was to be selected.
>
> The record indicates that the Director of the National Science Foundation . . . awarded the contract to Brown & Root, Inc., "as the best qualified, based on (1) Brown & Root's strong management capabilities, (2) demonstrated capability in successfully completing complex projects, (3) their experience in dealing with the oil industry and other industries with capabilities that could be used in Mohole, (4) and the conclusion that the plan it had presented for going ahead with the work will give the Government the best approach to achieve the scientific and engineering goals."

In the view of the Comptroller General, was all this cricket?

> While the records are not as clear as might be desired . . . it would appear that any advantage Global-Aerojet-Shell and Socony Mobil may have held over Brown & Root in the factors previously considered in the point evaluation was offset by policy determinations favoring Brown & Root. . . . [We] are unable to conclude that the award to Brown & Root was not in the public interest.

Having made the decision on a contractor, NSF now drew up a contract—cost plus a fixed fee of $1.8 million—which made it clear that regardless of what AMSOC was thinking about, NSF was thinking about Mohole as a program to dredge up a piece of the mantle. Said the contract:

> This project . . . has as its ultimate aim the drilling of a hole to the Mohorovicic discontinuity. . . . It may prove desirable to expand this broad scope of work . . . to include other geophysical surveys, additional shallower holes in other selected oceanic or continental areas. . . . If such is deemed advisable by the Foundation . . . it would be accomplished through subsequent agreement with the contractor.

The decision to award the contract to Brown & Root, Inc., now brought into the Project Mohole a highly regarded construction and engineering organization, a multi-billion-dollar outfit that had handled everything from the construction of 359 combat vessels during World War II to the construction of a screw-worm eradication laboratory; from the construction of a 24-mile bridge across Lake Ponchartrain, near New Orleans, to the fabrication and emplacement of some 240 offshore platforms for major oil companies. However, the decision also brought into Project Mohole the suspicion that Brown & Root's rise from fifth to first choice (with the accompanying displacement of the firm that was "in a class by itself") was not altogether dissociated from the fact that Brown & Root's Houston home is close to the congressional district of Albert Thomas, the Democratic chairman of the House appropriations subcommittee which holds virtually complete sway over NSF's budgetary prospects; and that George Brown, who succeeded to the firm's presidency last year after his brother's death, was a close political ally of Albert Thomas.

OSE as Consultants

Whatever the effects of these relationships, the contract with Brown & Root became effective early in 1962. At about the same time Bascom's group resigned from the Academy, incorporated itself as Ocean Science & Engineering (OSE), and shortly afterward became consultants to Brown & Root. From the outset the relationship between Bascom and the proud Brown & Root organization was prickly. (Brown & Root has never shown any disinclination to blow its horn. As its Mohole project manager told a congressional committee, "Our policy is that we will do any job anywhere for anybody. There is nothing that we won't contract, no type of work.") Within 2 months, relations between Bascom's group and Brown & Root had deteriorated to a point where OSE quit and returned to Washington. As one Brown & Root official put it, "They had nothing to teach us." Comments Bascom, "We had everything to teach them. They just didn't want to listen." (Upon its return, OSE was engaged as consultants to NSF, to provide advice on the performance of the contractor from whose service it had just been disengaged. The role with NSF lasted 10 months and was abruptly terminated. With his severance from NSF, Bascom was completely out of Project Mohole.)

Meanwhile, Hollis D. Hedberg had succeeded Gordon Lill as AMSOC chairman, and this change brought into the picture a man who was determined to take the fuzz out of AMSOC's thinking and get it finally settled that Mohole would proceed with two ships. He was also determined to assert AMSOC's leadership of the project, but not to the point of getting the committee more closely involved with the project. Almost from the outset, Hedberg and NSF proceeded to spar.

NSF Proposal

At about the time NSF was closing the contract with Brown & Root, Geoffrey Keller, NSF's assistant director for mathematical, physical, and engineering sciences, wrote Hedberg that, while it was NSF's "hope and plan that the AMSOC Committee will continue to provide major scientific advice for the project," NSF was considering the appointment of a "scientific director" who would be on NSF's staff. Wrote Keller:

> He [the scientific director] would be responsible for making necessary scientific decisions concerning the conduct of the project subject to broad administrative, fiscal, and scientific policies that would be formulated by the Foundation on the advice of AMSOC and other interested scientific groups and individuals.

This sounded very much as though NSF was moving in to take over the project and downgrade AMSOC's role, and Hedberg's reply did not indulge in obfuscation:

> As Chairman of the AMSOC Committee, which has been responsible for original planning and progress on this project to date, I can only in behalf of the membership of this Committee strongly protest this proposed arrangement and urge on the contrary that whatever posts are necessary for scientific guidance of the project be worked out within the framework of the AMSOC Committee. Moreover, as an individual who has developed a keen sense of interest in this project but has plenty of better things to do than preside over an empty shell, I can only say that unless it can be clearly spelled out that the guidance of scientific objectives remain with AMSOC, I can see no point in continuing as Chairman of AMSOC.

NSF subsequently decided that Project Mohole could do without an NSF scientific director.

In the meantime, Hedberg labored at bringing precision into AMSOC's concepts—and at finally resolving the question of just what the objective of Project Mohole was and how it should be achieved. His answer, in a letter he sent to the AMSOC Committee, was:

> . . . the overall ultimate purpose of the project can be simply stated as to contribute to the determination of the nature and characteristics of the as yet unknown portions of the earth's crust and mantle. . . . The project which AMSOC has launched should in no way be considered merely a stunt in deep drilling. . . . And the scope of the project should be such as to take advantage of opportunities . . . wherever they may be found—water or land, deep or shallow.

After having proposed enlarging Mohole to extremely broad scope, Hedberg went on to recommend the construction of an intermediate *ship* to carry out the intermediate *program*. The two-ship approach, he said, would permit swift construction of an intermediate vessel that could conduct scientifically useful explorations while accumulating experience for the construction of the ultimate ship. Adding that he had taken up these concepts with NSF and the Academy, he noted that, "without implying any definite commitment on their part, I believe that we of the AMSOC group were impressed with their receptiveness to this proposal."

Letter to Seitz

Now, continuing his efforts to obtain agreement that Mohole was not only deep but broad and multi-level, Hedberg wrote to Frederick Seitz, who had succeeded Detlev Bronk as president of the Academy, AMSOC's institutional base.

> It is certainly my own strong feeling that this experimental-exploratory state (sometimes called intermediate stage) must be carried out as an integral part of the AMSOC project . . . since in my opinion the achievements to be expected from this stage are necessary to the justification of the whole project. I do not think, however, that as a part of the AMSOC project it necessarily has to be carried out under the same contractor as the Mohole itself, since the contract signed by NSF with Brown & Root, Inc., refers only to "*a* hole through the crust of the earth."

Seitz, in turn, forwarded the letter to Waterman, adding:

> From my acquaintance with the extensive discussions of the scope and execution of the Mohole Project, I am con-

vinced that the recommendations of the Executive Group of our [AMSOC] Committee are sound, and I am glad to transmit them to you herewith.

At this point, then, Hedberg, as chairman of the group which had originated Mohole, regarded the project as a broad and unrestricted two-ship drilling program, a program which seemingly had the endorsement of the National Academy of Sciences. Brown & Root, on the other hand, was working under a contract which directed it to devise a means for drilling to the mantle—and no more. And NSF, as author of the contract, presumably shared this conception, although, in theory, AMSOC was NSF's scientific adviser on the project. Meanwhile, as this confusion of purposes was building up, members of the Senate, egged on by disappointed constituent firms, were blasting away at NSF for the manner in which it had awarded the contract. Clearly, the engineering problems of Mohole were formidable, but they were beginning to pale alongside the organizational and political problems.

—D. S. GREENBERG

(This is the second in a series on Project Mohole.)

Tobacco Report: PHS Study Group, after 14-Month Survey, Agrees That Smoking Is Indeed Harmful

The Public Health Service's advisory committee on smoking and health produced its long-awaited report last week, and about the only good news it had to offer was that "cigarette smoking does not appear to cause asthma."

Otherwise, it condemned the cigarette as the cause or an associative element in a variety of misfortunes ranging from lung cancer to fires in the home. And, in conclusion, it stated, "Cigarette smoking is a health hazard of sufficient importance in the United States to warrant appropriate remedial action." The 387-page study, titled *Smoking and Health,* was released by Surgeon General Luther L. Terry with the observation that it is "an excellent report." Terry added that he would favor additional research, but he made it clear that he has no quibble with the report's conclusions. In fact, he acknowledged that he had switched to a pipe.

Just what action may result from the study is not at all clear at this point. The report, according to plan, was no more than a survey of previously conducted research, and contained no recommendations. These will come from a second study which is now being planned by the Public Health Service.

Nevertheless, the emphatic tone of the advisory committee's conclusions does strengthen the case for government action of some sort, particularly by the Federal Trade Commission. The FTC, which has jurisdiction over advertising, several years ago knocked the health claims out of cigarette advertising. It refrained, however, from going beyond that point, on the grounds that it lacked a definitive statement from the PHS to defend its position if the tobacco industry chose to contest its action in court. And it defended this choice on the grounds that it would be better not to try than to risk the possibility that a court decision would provide the industry with a decisive and well-publicized legal victory. Clearly, it now has such a statement, and pressure will be on it to carry through with a long-discussed plan—namely, to label all cigarette packs with a warning to the effect that continued or excessive use may be detrimental to health.

Meanwhile, the tobacco industry has responded to the PHS report with a well-worn call for more "research." In a statement issued shortly after the report's release, George V. Allen, president of the Tobacco Institute, stated in part:

> I endorse wholeheartedly and without any reservation Surgeon General Terry's call . . . not for less but for more research by the Public Health Service, the American Medical Association, and other public and private groups of scientists who are seeking the scientific facts we so urgently need.

Allen did not say whether he likewise endorsed Terry's observation that, as a physician, he would advise young people not to start smoking and would advise those who now smoke to recognize the lethal implications of their habit.

On the congressional scene, the tobacco situation is extremely complex. As an $8-billion-a-year industry that is a key economic interest in some half-dozen southern states, tobacco has demonstrated that it can look after its own interests on Capitol Hill. (Congress, which has a proclivity for investigating anything, took one stab 6 years ago at looking into the health hazards of tobacco, but before the investigation had gone very far it was quietly dropped.) The release of the report was followed by an announcement by Lister Hill (D–Ala.), who is the Senate's chief benefactor of medical research, that he would confer with Terry on the tobacco report. And Representative Harold D. Cooley (D–N.C.), who is chairman of the House Agriculture Committee, said he would offer a bill to provide $5 million for research to "accomplish maximum assurances of health in the smoking and enjoyment of tobacco."

Another ingredient in the tobacco picture is the curious role of the American Medical Association. When the PHS committee was established last year, the AMA dropped its own plans for a tobacco study. Last month, however, it announced that it would conduct a "comprehensive program of research on tobacco and health," a move that has led to speculation that the politically sensitive AMA, in its struggles against the administration's medical care proposals, is latching on to tobacco as a way to strengthen friendships with the southern delegations in Congress.

In any case, whatever does result from the report will take place against a background of a seemingly irreversible and almost universal affection for tobacco. The PHS report did not say a thing that has not been said repeatedly over the past half dozen years by the American Cancer Society and other voluntary health organizations. Nevertheless, cigarette sales—with an occasional fluctuation—have continued to rise on a per capita and an absolute basis. And in England, where the government took up arms against tobacco after a devastating report 2 years ago by the Royal College of Physicians, the sales curves are similarly upward.

Incidentally, the advertising industry is yet to respond formally to the report, but early reports are that its inclination is toward increased advertising.

(The report, *Public Health Service Publication 1103,* is available for $1.25 from the U.S. Government Printing Office, Washington, D.C., 20402.)

—D.S.G.