• ERDA's efforts to integrate environmental control research into its technology development programs seems "at present illusory." This is dangerous because "There is a significant risk inherent in the totality of ERDA's mission. The impact on climatic balance of massive increases in heat rejection to the atmosphere by man is unknown but potentially catastrophic."

• The level of funding for energy R & D may be too low, since it is an outgrowth of decisions made prior to the Arab oil embargo.

• Insufficient emphasis is placed on international cooperation, and on coordination with state and local governments.

• Only limited attention is given to research and analysis on social, economic, environmental, and behavioral aspects of the energy problem.

• ERDA's basic research program has been inherited from the agencies it incorporated, with the result that virtually all funds are devoted to nuclear power and high energy science, while materials, combustion, fuel chemistry, and other disciplines crucial to ERDA are neglected.

• The methodology used in developing the ERDA plan relies on scenarios based on questionable assumptions. The possibility of a major reduction in energy growth because of higher costs is not taken into account. Moreover, the calculated capital costs for energy systems include only supply side costs and exclude consumer costs. Thus, ERDA's programs are biased in the direction of research to decrease supply costs while minimizing research to reduce capital costs of such end-use items as refrigerators, heat pumps, and solar home-heating systems.

• ERDA has shown "timidity" and a reluctance to assume its mandated role as the "lead agency" for energy R & D. The consequences could be costly because three separate federal agencies are now exploring technologies for coal cleanup and there is a danger that agencies "might work at cross purposes."

ERDA has not yet made an official response to the OTA criticisms, but many ERDA officials are said to agree with the major thrust of the OTA critique. Thus J. Frederick Weinhold, director of ERDA's office of technical program assessments, told *Science* there is "a lot of pulling and tugging" within the agency over whether ERDA should take a broader approach to energy problems. He expects that the next version of the plan will give greater emphasis to commercialization and environmental issues, though not necessarily to all the nontechnological issues stressed by OTA, some of which, he feels, may more appropriately fall within the purview of other federal agencies. Similarly, Weinhold anticipates some efforts to increase the attention paid to end-use technologies. "We inherited programs with a lot of bucks and people on the supply side," he says, "but only minuscule things on the end-use consumption side."

Whatever ERDA does about the broader, nonhardware issues, the OTA panelists warn, "there can be no question of their importance. . . . Most are not, at present, receiving priority attention anywhere."

—PHILIP M. BOFFEY

Amniocentesis: HEW Backs Test for Prenatal Diagnosis of Disease

The federal government, taking a bold position on a controversial medical issue, has put its stamp of approval on amniocentesis, the procedure by which genetic disorders can be detected in a fetus before birth. The government's endorsement rests on the results of a 4-year study of more than 2000 women that indicates that amniocentesis is safe. The endorsement is likely to inflame "right-to-life" groups that see amniocentesis as the first step down the road to abortion (see box on p. 538).

The study, which was conducted by researchers at nine major medical centers,* was coordinated and supported by the National Institute of Child Health and Human Development (NICHD). The study was designed to answer two basic questions about the use of amniocentesis during the middle 3 months of pregnancy. Is it safe? Is it accurate? On both counts, the investigators say, the answer is Yes. Their findings were reported in detail recently at the American Academy of Pediatrics meeting in Washington, D.C.

Theodore Cooper, assistant secretary for health in the Department of Health, Education, and Welfare (HEW), spoke about policy implications of the study. Reading from a text drafted by Duane Alexander, a pediatrician who, with Charles U. Lowe, was an NICHD staff officer on the study, Cooper noted that "Few advances compare with amniocentesis in their capability for prevention of disability." He went on to declare, ". . . It is most appropriate for the Public Health Service, as a matter of policy, to foster use of amniocentesis by those women for whom it is indicated by educating both physicians and the public as to the availability and applicability of the technique and, based on the results of this study, its safety." Cooper also stated unequivocally that no one should coerce a woman into having the procedure.

The number of women for whom amniocentesis might be appropriate is enormous—perhaps as many as 400,000 a year. But the number who have it is small. Last year, mid-trimester amniocentesis was performed on only 3000 women in the United States. Dr. Aubrey Milunsky, director of the birth defects and genetics clinic at the Eunice Kennedy Shriver Center in Boston, estimates that 20,000 babies with birth defects are born every year. In 1974, he says, only 100 or so were detected in utero. Not all, but many others, could have been.

There are two groups of people who look on midtrimester amniocentesis with distrust—antiabortionists and practicing physicians, primarily obstetricians. Antiabortionists oppose amniocentesis because they reason that, except in very rare cases, the only thing one can offer a woman who is carrying a defective child is an abortion. Indeed, when Cooper referred to amniocentesis as a valuable tool for preventive medicine, what he meant, but did not spell out, is that genetic disorders can be prevented only by aborting fetuses that have them. Researchers who have devoted tremendous effort during the past 7 years to the development of prenatal diagnosis of birth defects are the first to admit that, for now, there isn't much they can offer by way of therapy. Just the same, therapy is their real, ultimate goal, and they are moving slowly in that direction.

Where abortion is not an issue, practicing obstetricians have had another reason for shying away from amniocentesis—

*The participating institutions were: Children's Memorial Hospital, Chicago; Eunice Kennedy Shriver Center, Boston; Johns Hopkins University School of Medicine, Baltimore; Mount Sinai School of Medicine, New York; University of California at Los Angeles–Harbor General Hospital, Torrence; University of California School of Medicine, San Diego; University of Michigan School of Medicine, Ann Arbor; University of Pennsylvania School of Medicine, Philadelphia; Yale University School of Medicine, New Haven.

safety. The procedure has been around for decades, but it was not until 1968 that investigators first used it on a woman in midpregnancy for purposes of prenatal diagnosis. Before that, its use was restricted to women late in pregnancy, for example, to type fetal blood in situations in which Rh disease was possible. So, in a very real sense, the use of amniocentesis on a woman only 13 to 15 weeks pregnant was "new," and obstetricians were not about to rush into anything. The procedure involves inserting a long hollow needle through the woman's abdomen and into the uterus from which amniotic fluid containing fetal cells can be withdrawn for analysis. There has been great fear that the needle might accidently jab the fetus, causing injury or even inducing abortion. Scientists participating in the NICHD study say their data indicate that such risks are extremely low.

Altogether, the researchers studied 1040 women who had amniocentesis between 1971 and 1973, and 992 controls. Staff officer Alexander presented an analysis of those women. The majority of the subjects, he said, were white, educated, and middle

Antiabortionists Challenge March of Dimes

Most women who undergo amniocentesis for prenatal diagnosis of suspected birth defects get good news—the baby is all right. To be specific, in 1974, 2187 women at 37 institutions had diagnostic amniocentesis during their second trimester of pregnancy. Two thousand one hundred and twenty-five of them were carrying babies who did not have the suspected disorder. Put another way, in 97.2 percent of the cases, amniocentesis was followed by the birth of a healthy infant, not by an abortion.

This very precise information comes to you courtesy of The National Foundation–March of Dimes which released current figures at a recent foundation-sponsored conference in Harbor Springs, Michigan. The data, collected through a survey of institutions that provide genetic services under March of Dimes grants, were not compiled to tell you more than you need to know about the outcome of amniocentesis. They were gathered as part of an attempt to respond rationally to charges by "right-to-life" groups that by endorsing amniocentesis the foundation is encouraging abortion. During the past couple of years, right-to-life groups have tried to stifle the foundation by discouraging people from contributing to its fund-raising drives. (The National Foundation–March of Dimes is a nonprofit organization that was founded by Franklin D. Roosevelt to conquer polio. Today, its mission is to "prevent birth defects.")

With impeccable logic, right-to-lifers reason that the purpose of amniocentesis is to detect genetic disorders in utero and, because virtually none of them can be "cured" before birth, the only thing that can be done if the baby is defective is to abort it. This they oppose. As a consequence, they oppose amniocentesis itself—and organizations that have anything to do with it.

The National Foundation's tack has been to turn the antiabortionists' view of the situation around, emphasizing that amniocentesis actually leads to a saving of lives. Says Arthur J. Salisbury, the foundation's vice president for medical services, "Without definitive answers made possible by amniocentesis, many of these patients, as in the past, might have opted for unnecessary abortions on the basis of statistical odds alone."

The position that amniocentesis is really lifesaving has its validity and is heard frequently from geneticists who have had experience with couples who, because of their hereditary backgrounds, are particularly at risk of bearing a defective child. But as a persuasive argument, it is utterly lost on right-to-lifers, who are not interested in reducing abortions but eliminating them. The foundation's own data make it clear that there is a relation between identifying a defective fetus and abortion. In 62 of the cases in which amniocentesis was performed, the fetus did have the disorder in question. Of these, 60 women had an abortion; the other two aborted spontaneously. As far as right-to-lifers are concerned, this merely proves their point.

The foundation has tried to escape the wrath of antiabortionists by stating that its interests lie in diagnosis and research, that its position on abortion is entirely neutral. In August, it reissued its policy statement on the subject, declaring that "Legal abortion is outside the Foundation's purview." It goes on to state that foundation policy prohibits use of its grants to conduct abortion research or defray the costs of performing an abortion. But abortion opponents want more than that. They want the foundation to take an active stand against abortion and to refuse grant money to investigators who perform abortions.

National Foundation officials say it is difficult to determine what effect the antiabortionists have had on their fund-raising drives. The total contributed in 1974 was $46 million, $6 million above the previous year. Nevertheless, it is clear the opposition, much of which is unofficially related to the Catholic church,* has made its point in certain areas of the country. In one town in California, for example, they actually stopped a fund-raising Mother's March, and contributions dropped from $8000 in 1 year to $600 the next. The impact has also been felt in Grand Rapids, Michigan, and Cincinnati, Ohio, two cities where the right-to-lifers are particularly strong. Among their tactics has been a move to get schools, especially Catholic schools, to discourage students from participating in the March of Dimes walk-a-thons which have been particularly important avenues of fund-raising during the past few years.

The Catholic church is not officially against National Foundation activities—it is individuals within the church who have been causing the foundation such grief. Indeed, during the past couple of years, many dioceses have instructed church members on the issue, declaring that it *is* morally acceptable to contribute to or volunteer to work for the foundation. During recent months, the intensity of the right-to-lifers' activities against the foundation appears to have diminished. In any case, it is less overt. But it is the fact that it is there at all, and that the church should have to address itself to the question one way or the other that concerns many foundation officials and scientists on its advisory boards who are worried about the effect this pressure will have on future research policies. There is reason to believe that it has made the foundation doubly cautious about becoming involved in new areas of research that could be even potentially controversial.—B.J.C.

*Although in many cases, right-to-life groups are dominated by Catholics, it is a distortion to see this as a rigidly Catholic issue. Many persons who are active in antiabortion groups are not associated with the Catholic church, or any church at all.

or upper-middle class. (A good deal of attention has been paid to the fact that many subjects of medical research are poor and members of a minority. Here is a situation in which the affluent were experimented on.) Although efforts were made to match subjects and controls as fully as possible for characteristics including number of previous pregnancies, health and social status, there were two areas in which matching proved to be very difficult. One was religion. Forty-four percent of the controls were Roman Catholic women who refused amniocentesis. The other was maternal age. Women in the control group tended to be younger.

The question of age presented the researchers with an ethical dilemma that they resolved by sacrificing a study with perfectly matched subjects and controls in favor of what they regard as the well-being of the individual women. There are a number of indications for amniocentesis, the most general being maternal age. It is well established that the risk of bearing a child with Down's syndrome (mongolism) increases significantly as a woman grows older. It is one of the more common of some 100 chromosomal and metabolic disorders that can be detected in utero and research physicians recommend that all pregnant women 35 years of age or older at least consider having diagnostic amniocentesis. Therefore, none of the researchers participating in the study was willing to randomly assign such women to the control group. All were offered the opportunity of having amniocentesis. Investigators estimate that, on the basis of maternal age alone, there are approximately 300,000 women a year for whom amniocentesis might be appropriate.

Other indications for amniocentesis are related to the genetic makeup of a fetus's parents. If a man and woman have already had one child with a genetic disorder, there is, of course, a chance they will have another. The woman would be an obvious candidate for amniocentesis. The procedure is also indicated when a genetic disease is known to run in the family or when both man and woman have been screened and found to be carriers of the gene for some heritable disease. Tay-Sachs disease, which destroys the central nervous system and kills its victims by the time they are four, is a good example of the latter case because it meets all the criteria that make it suitable for screening. It occurs primarily in a fairly limited, identifiable population—in this case Jews of eastern European ancestry. Its carriers can be detected and the disease itself can be diagnosed in utero. During the past 3 or 4 years—since techniques for detection have been refined—thousands of Jewish men and women have gone for testing before conceiving a child. In those cases in which both parents are carriers, amniocentesis is then offered during pregnancy to see whether the fetus has Tay-Sachs.

But There Were Errors

Although the NICHD study, officially called the National Registry for Amniocentesis, yielded mostly positive data, it also pinpointed some problems and raised questions about future public policy. While the matter of safety to mother and child was laid to rest as far as the investigators are concerned, the difficult and sensitive question of accuracy remains. Michael Kaback of Harbor General Hospital, which is affiliated with the University of California at Los Angeles, reported that data collected from the nine centers shows that the accuracy of diagnosis is 99.3 percent.

Among the 1040 women who had amniocentesis, 19 women were carrying fetuses with chromosomal anomalies and 15 others had fetuses with genetically caused metabolic disorders. In addition, 11 women were carrying male fetuses that had a 50 percent chance of being afflicted with a sex-linked disorder such as hemophilia and Duchenne's muscular dystrophy. (In these cases, it is not yet possible to detect the disease itself in utero. By identifying the sex of the fetus one can tell whether there is a risk, however. A female fetus would not have the disease.)

The trouble is that not all of the diagnoses were accurate. Of 1040 diagnoses made, 6 were wrong. Two babies were born with Down's syndrome even though prenatal diagnosis indicated they would be normal. In three cases, sex was identified incorrectly. And in one case, a fetus was diagnosed as having a metabolic disorder known as galactosemia. In that case, perhaps because the disease is treatable, the parents did not have an abortion. When the baby was born, it turned out that the diagnosis was wrong; the baby was perfectly healthy.

The errors, which seemed to the researchers to be particularly tragic in the two cases in which Down's syndrome was missed, were the result of human error, as far as can be determined. It is possible that samples of amniotic fluid were mislabeled in one or two cases and that, in the cases of incorrect diagnosis of sex, that the investigators were looking at maternal rather than fetal cells but did not realize it.

The possibility of error is one of the most disturbing aspects of prenatal diagnosis and must receive considerable attention if the use of amniocentesis is to spread. In spite of Cooper's (or Alexander's) enthusiasm for amniocentesis for the prevention of certain birth defects, and with it the promise that HEW may increase its educational efforts with the hope of "reaching the entire population," it is naive to think that the demand for the procedure will increase dramatically overnight. Conservative practicing physicians are not going to change their minds just because of some study, and it will take time before large numbers of women begin insisting on prenatal diagnosis. If they did, what is now a potential problem would suddenly become a reality of crisis proportions.

At present, there are not enough laboratories qualified to handle the potential demand. Amniocentesis—the procedure itself—takes about 5 minutes and can be performed in the office by a physician, who can be trained in the technique without major difficulty. The problem comes in the subsequent analysis of the fetal cells that will be taken from the amniotic fluid and cultured for analysis. In the NICHD study, the rate of error in diagnosis may have been small but can hardly be discounted. Here one had the very best people, in the most sophisticated centers, working with experienced laboratory personnel, and still there were mistakes.

In his remarks at the pediatrics meeting, Cooper said that, in the short span of 7 years, midtrimester amniocentesis "moves clearly from the realm of a research procedure to a part of clinical practice." Until now, all analyses of amniotic cells have been done in a research laboratory. "What is the best method to provide laboratories that will do these analyses when they have lost the excitement of research and become routine, while at the same time providing the quality assurance required by the life-death decisions hanging on the test results?" Cooper asked rhetorically. Answering his own question, he said the approach that seems to be in favor at HEW would be to have the Public Health Service, through contracts with existing medical centers, establish incrementally a network of state or regional laboratories. However, he acknowledged that because there is great pressure to reduce federal spending, there is bound to be opposition within the Administration to launching a new and expensive program.

Analysis of fetal cells falls into two categories—cytogenetic and biochemical. Cytogenetic studies involve analysis of chromosomes and are the type that would be carried out on women over 35 for prenatal diagnosis of Down's syndrome which is marked by the presence of an extra chromosome number 21. The fetus has a total of 47 rather than 46 chromosomes. The extra chromosome 21 can actually be seen under microscopic examination. Cooper said that the greatest increase in

demand is likely to be for this type of chromosomal analysis. Prenatal diagnosis of a metabolic disorder is, for now, a more sophisticated matter. Fetal cells are cultured for about 4 weeks and then examined for the presence or absence of whatever enzyme is involved in the disease for which a woman is being screened. These genetic disorders, known as inborn errors of metabolism, are comparatively rare and are not something for which one would screen a large population. Cooper predicts that "existing research laboratories would, for the near future at least, continue to provide the facilities for biochemical analyses."

Even though amniocentesis seems to be on the verge of coming into its own as a medical procedure—some insurance programs cover its cost which usually is not more than $250—it is certainly not the final answer to prenatal diagnosis. It cannot be performed safely until the 13th week of pregnancy. Depending upon what disorder one is looking for, it can take between 2 and 6 weeks to grow fetal cells in culture and analyze them appropriately. Therefore, if, on the basis of test results, a woman does elect an abortion, it will have to be performed later in pregnancy than one would wish.

Furthermore, there are many, many genetic disorders—some of them relatively common—that cannot as yet be diagnosed in utero. Prenatal diagnosis of sickle cell anemia and of Cooley's anemia has been reported just recently, and only in a handful of cases. In utero detection of cystic fibrosis remains to be perfected.

And finally, there is the matter of what science can offer a family if the fetus is found to be genetically defective in some life-threatening way. As Cooper noted at the conclusion of his address, "a preventive technique dependent on elective abortion is not a final answer to the problem of birth defects."

—BARBARA J. CULLITON

Limits to Growth: Texas Conference Finds None, but Didn't Look Too Hard

The Woodlands, Texas. Houston is a city in boom, sucking in new settlers at the rate of a thousand a week. Twenty-five miles north of the city, a new town called The Woodlands is designed to be home to 150,000 citizens come the year 1990. The town is the brainchild of a millionaire geologist named George P. Mitchell who made his money by sinking oil wells in the right places and who is father to ten children.

A conference on the theme of "Limits to Growth" was held on 19 to 21 October at The Woodlands under Mitchell's sponsorship. It could not have had a more paradoxical venue or benefactor. Yet, as it happened, little came out of the conference likely to give offense to Mitchell, or the burghers of Houston, or the boards of *Fortune's* 500, many of whom had sent delegates at Mitchell's personal invitation.

Limits to growth, as every stripling knows, is the name of the computer game which predicts that industrial economies will collapse within a hundred years, unless someone does something, because of raw materials shortages and poisoning from pollution. The exercise was performed for the shadowy Club of Rome by a team under Dennis L. Meadows, a management expert at Dartmouth College. A preliminary report, titled *Limits to Growth* and written by biophysicist Donella H. Meadows, was issued 3 years ago in a blaze of publicity (*Science*, 10 March 1972) that obscured its more serious aspects.

The howls of "Foul!" emanating from the general direction of economics departments soon made clear that the report had struck home somewhere. What had jarred the professors of a subject which is almost synonymous with growth was the use of their own stock-in-trade (computer simulation and the assumption of exponential growth) to arrive at the antithesis of the profession's most hallowed premise.

The scatological eschatology of death by waste in a century need not perhaps be taken too solemnly. But the general theme which *Limits to Growth* seeks to illustrate, that exponential growth in a finite world may not be indefinitely possible, is at least intuitively plausible. It has served as a rallying point for many current angsts, such as conservation, concern about materialist values, and zero population growth. If this potpourri of presentiments somehow lacks the tang of final proof, so too does the conventional counterargument or faith, that technology will find fixes that allow everything to go on as usual.

The chance for a public debate on the issue arose when oilman Mitchell read *Limits to Growth* 2 years ago and allegedly declared to an aide, "Dammit, we ought to do something about this." After conversations with Meadows, Mitchell decided to sponsor five conferences on the theme, of which last month's was the first, the others to follow at 2-year intervals. Mitchell also took up an idea of Meadows to award prizes for essays on the consequences of declining economic growth. He gave away $20,000 in prizes last month (the $10,000 first prize went to Bruce M. Hannon, a computer specialist at the University of Illinois) and plans to distribute $50,000 the next time around. Mitchell also put up the initial money for the conference, most of which will be recovered since the conference is expected to break even or make a small profit.

Since Mitchell's generosity is likely to be an important factor over the next 10 years in public debate about growth, it is worth noting a few facts about him. He has drilled more than 3000 oil and gas wells in the United States, about half of them producers, and 600 in "wildcat" or unproven areas. Ten years ago his company, Mitchell Energy and Development Corporation, began to diversify by buying up 20,000 acres north of Houston on which to build a new town. Mitchell has already invested $90 million on the project and earlier this year, faced with a disastrous real estate market and canceled federal grants, he transferred another $10 million from his profitable energy business. He now expects The Woodlands to be making "a good profit within 3 to 4 years."

Mitchell's interest in the limits to growth issue seems to consist chiefly of a general belief that there are problems which he would like to see discussed, particularly among the business community. He gave the organizers a free hand in arranging the conference program and deciding on speakers. He invited the University of Houston to join his company and the Club of Rome as sponsors of the conference. Mitchell has close connections with the university, having donated 400 acres at The Woodlands as the site for a new campus. The Texas state legislature will decide next year whether to vote funds for the campus. Asked if holding the Limits to Growth conference at The Woodlands might give incidental help toward a favorable decision, Mitchell said, "Anything like this helps the project and helps to broaden the horizons of the University of Houston, which is why they were interested in the conference, but that was not its