The history of the modern forms of prenatal diagnosis is not a very long story, as historical narratives go, but it is longer than most people think; it starts in about 1950, 40 years ago. In addition it is a complex story because prenatal diagnosis is a complex technology. Indeed, prenatal diagnosis should properly be thought of as a sociotechnological system composed of several subsidiary parts: the medical delivery services that convince women to become patients; the means of obtaining fetal tissue from those patients; biochemical assays of the tissue; the culturing and karyotyping of fetal cells; molecular analysis of fetal DNA; ultrasound examination and guidance; and abortion. Each part of the system has its own scientific history and its own inseparable social history and, to make matters even more complicated, those separate histories have transpired in many different countries, under many different social, economic, and scientific conditions.

This chapter focuses only on a small portion of that complex of histories, that portion which is concerned with the means of obtaining fetal tissue for diagnosis. I have chosen to examine the histories of amniocentesis and chorionic villi sampling (CVS)—as well as what remains the only available therapy for a positive diagnosis, abortion—because doing so allows me to look at particular aspects of women’s roles in the history of prenatal diagnosis and to make certain suggestions about what policy
directions seem most likely to achieve the necessary goals in the United States.

Historians and other students of technology make a useful distinction when they discuss technological change—that between the developmental phases and the diffusion phases of a technology. Although it is not always an easy distinction to make, roughly speaking, when a technology is in development it is changing rapidly and being applied narrowly, under various kinds of testing conditions. When it is in diffusion, as the word suggests, it is spreading; its form is more or less fixed—or changing only slowly—and it is coming into routine use, becoming embedded in, we might say, a social matrix.

Amniocentesis is now in diffusion and has been since the late 1970s; chorionic villi sampling, on the other hand, has only recently started to diffuse and may arguably (at the date of publication) still be in the last stages of development. The distinction between development and diffusion is important to keep in mind because when a technology shifts from development to diffusion the cast of important social actors shifts with it; those who have the power to make changes in development are not those who have the power to make changes in diffusion.

The two most common means today for obtaining fetal tissue are amniocentesis and chorionic villi sampling. Amniocentesis came first. The amniotic tap itself, the low-tech part of the procedure, had become a routine part of obstetric practice by at least the mid-1950s, in part because it was used in the third trimester, sometimes to relieve patients with hydramnios, and sometimes to permit biochemical testing of the incompatibility between Rh-negative mothers and their fetuses (Fuchs & Cederqvist, 1970).

In 1949 Murray L. Barr and his colleagues discovered that the cells of female and male mammals could be distinguished from each other by the presence or absence, not of sex chromosomes (which in those years were very difficult to see under the microscope), but of another, very small, cellular body, which has since been named after him—the Barr body, or sex chromatin. Females seemed to have it and males didn't, so it could be used to ascertain sex where that was anatomically or visually unclear; sex chromatin is visible under the microscope even when cells
are not in active division. By 1953 Barr and his coworkers had
discovered that sex chromatin was characteristic in humans as
well as in cats and mice (Moore, Graham, & Barr, 1953).

In the 1950s a small group of medical specialists, medical ge­
eticists, were interested in ascertaining sex when it was neither
anatomically nor visually obvious in order to discover the sex
of fetuses being carried by women with family histories of sex­
linked diseases such as hemophilia. Such patients were referred
to medical geneticists for consultations about whether to have
children, whether it was wise to marry a specific person, or
whether a specific pregnancy should be carried to term. Medi­
cal geneticists, unfortunately, had no diagnostic techniques to
offer except the construction and analysis of a sometimes faulty
family medical history. In most cases the diagnoses were little
more than probability statements: "The chances are 50-50 that
your child will be afflicted," or, "The chances are very slim that
your partner will carry the same recessive gene that you do."
Not surprisingly, both patients and specialists found this to be
a tragically frustrating enterprise (Hammons, 1959). Barr's dis­
covery, however, held the promise of relieving a small portion
of this frustration. If a woman had been identified as a carrier of
the gene and if the sex of her fetus could be determined in utero,
the geneticist could predict with much greater certainty (albeit
not with complete certainty) whether the child, when born,
would have hemophilia (Macintyre, 1973).

Four different groups of researchers are credited with the dis­
covery in 1955 that the sex of human fetuses could be predicted
through analysis of fetal cells in amniotic fluid: one each in New
York, Minneapolis, Copenhagen, and Haifa (Shettles, 1956;
Makowski, 1956; Fuchs & Riis, 1956; Serr, Sachs, & Danon,
1955). A short while later the Copenhagen group became the
first to report that they had performed an abortion in order to
prevent the birth of a fetus, diagnosed as being male, whose
mother was a carrier of hemophilia (Riis & Fuchs, 1960). Pre­
natal diagnosis through amniocentesis was, if you will excuse
the pun, born; the year was 1960.

Amniocentesis remained in its developmental stages for an­
other 15 years, partly because it took several years for tech­
niques to be developed for the diagnosis of fetal conditions
other than sex, partly because it took that long for the safety of the procedure to be ascertained, and partly because Scandinavia was the only place, for much of that time, in which so-called eugenic therapeutic abortions could be legally performed and obtained (Callahan, 1970). We can assume, although documentation is difficult to produce, that outside of Scandinavia prenatal diagnosis for sex was performed on a very limited number of pregnant women—those who had been referred to specialists because of a family history of a known sex-linked hereditary disease—and only in a few medical research centers whose staff were willing to "look the other way" when a D&C was ordered. We can also assume (although, again, documentation is difficult to produce), that most of those women believed that the D&Cs were in their best interests; they knew what it was like to have hemophilia, for example, or to be the parent of a child with hemophilia, and they were willing to go to considerable trouble to have the operation performed (Macintyre, 1973).

In 1959 a French cytogeneticist, Jerome LeJeune, discovered that one common form of Down syndrome was caused by trisomy of the 21st chromosome, and at that point several medical geneticists realized that there was a wider potential for amniocentesis if some way could be found to culture fetal cells successfully; because the cells in amniotic fluid are neither numerous nor in active division, mitotic figures were few and far between, making karyotyping exceedingly difficult (LeJeune, Gauthier, & Turpin, 1959a, 1959b). The culturing problem was solved, seven years later, in 1966 (Steele & Breg, 1966). The first abortions after midtrimester amniocentesis and karyotyping were reported very shortly thereafter, in 1968, and the cooperative registry, intended to ascertain the safety of the procedure was begun in the United States in 1971 (Nadler, 1968; Valenti, Schutta, & Kehaty, 1968). When the results of those trials were announced in the fall of 1975, and finally published in the winter of 1976, the developmental stage of amniocentesis can be said to have been drawing to a close (NICHD, 1976).

The equipment needed for the amniotic tap was not particularly expensive and the skills were relatively easy to learn. Many of the larger hospitals and clinics had already purchased devices
for obstetric ultrasound, which could be used to ascertain the position of the fetus. Ever larger populations of potential patients could be anticipated, just over the horizon, since the presenting symptom “advanced maternal age” is more widely distributed in the population than the presenting symptom of having a family history of a sex-linked hereditary disease. Therapeutic eugenic abortion, along with other forms of abortion, had, in the intervening years, become legal in the United States, Canada, and Britain, in addition to Scandinavia. Diffusion was about to begin.

In the United States the events which, possibly more than any other, were responsible for kicking amniocentesis out of development and into diffusion, were the settlement in 1978 and 1979 of several lawsuits in which parents of children with a disability successfully sued for malpractice when an obstetrician had failed to refer a patient over the age of 35 for amniocentesis (Rogers, 1982). In one of the first of those cases, Dolores Becker, who was 37 years old when she became pregnant, was awarded her child’s medical costs for life (Becker, 1978). The American College of Obstetricians and Gynecologists and the American Academy of Pediatrics subsequently advised their members that, henceforth, they had better offer prenatal diagnostic services or referrals for prenatal diagnosis to their patients, or risk the same kind of suit (American Academy, 1983).

Three analytic points about the role of women in the history of amniocentesis can be made at this juncture in the story. First, the initial stages of development were determined, in part, by the ways in which research physicians interpreted the behavior of their female patients. In the period between 1955 and 1975 some women voluntarily presented themselves as eager recipients of counseling from medical geneticists. Some of these women willingly submitted to the experimental trials of amniocentesis, and some sought eugenic therapeutic abortions when there was hardly any hope of finding one. None of those women sued their physicians (or even complained publicly) for offering advice that was not requested, or for performing a diagnostic procedure that was not wanted; if there were women who felt that their interests or their rights had been ignored or diminished during this early period, they have left no trace of
their sentiments in the public record. Amniocentesis was designed by research physicians who believed, with considerable justification, that they were acting in the best interests of their patients, patients who were, let us remember, at very high risk for becoming the parents of afflicted children. The physicians perceived, also with considerable justification, that their patients were grateful for the services—however rudimentary—that were being offered.

Second, amniocentesis would not have passed out of the developmental stage into the diffusion stage unless the abortion laws in the United States, Canada, and Britain had been reformed. Since many women played various active roles in working for the reformation of those laws, we must conclude that through their organized activity, as well as through their individual efforts, some women acted so as to make prenatal diagnosis possible, whether they were conscious of the effects of their actions or not.

Third, the women who, like Dolores Becker, sued for wrongful birth acted (whether they realized it or not) in such a way as to ensure that prenatal diagnostic services would become a routine part of obstetric care—at least in the United States, and at least in those parts of the medical system in which patients interact with private practitioners on a fee-for-service basis. Not all technologies that go through development also go through diffusion; indeed the vast majority of new technologies fail to make the transition. Even those that go into the diffusion stage sometimes fail there, either because they do not find, or fail to create, a niche in the market. That amniocentesis made the transition and made it successfully is at least partly due to the individual actions of women who, presumably acting in what they thought to be their own best interests, sued their obstetricians for malpractice.

Chorionic villi sampling has had, in some ways, a more torturous history than amniocentesis. The first efforts to biopsy the chorion were made by Jan Mohr and Niels Hahnemann in Copenhagen in the late 1960s (Mohr, 1968; Hahnemann, 1974). The instrument that they used (and designed) was 6 mm in diameter; it contained a fiber-optic device for direct visualization of the chorion (Mohr, 1968). Living and working in Copenha-
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Women who desired therapeutic abortions after amniocentesis were, he believes, humiliated by the paperwork that was required in order to obtain permission for such an abortion from the panel of physicians that Danish law then required (Mohr, personal communication, May 1989, June 1992). Mohr and Hahnemann's trials were not successful; they had what they regarded as an unacceptably high miscarriage rate and considerable difficulty in culturing the cells. They abandoned their efforts in 1974 (Mohr, 1968). A year earlier a pair of Swedish researchers had reported more promising results using an instrument 5 mm in diameter, but there was no follow-up to their initial study (Kullander & Sandahl, 1973). In 1975 a team of Chinese researchers published an article in which they reported efforts they had made over a period of several years to diagnose the sex of fetuses, without cell culture, using an exceedingly simple instrument (no fiber optics, an essentially blind approach). They reported 100 attempts, out of which 82 produced vaginal smears and three resulted in spontaneous abortion; there were six incorrect diagnoses and 30 induced abortions, of which 29 were of females (Tietung, 1975).

With the exception of one unsuccessful effort to get chorionic cells by uterine lavage (Goldberg, Chen, Ahn, & Reidy, 1980), nothing else appeared in the literature on chorionic villi sampling (or biopsy, as it was then called) until a spate of articles late in 1982 and in the early months of 1983. One team, working under the aegis of the former Soviet Union's Ministry of Health, reported on 165 biopsies using an embryo-fetoscope 1.7 mm in diameter in which they had considerable success in
obtaining tissue, in not causing pregnancy loss, in diagnosis of sex, and also in several biochemical diagnostic analyses (Kazy, Rosovsky, & Bakharev, 1982). Two British groups reported using real-time ultrasound and a more flexible and even narrower (1.5 mm) biopsy instrument in the diagnosis of the hemoglobinopathies, through molecular analysis (Williamson et al., 1981; Old et al., 1982). A third British group, using a somewhat different instrument, reported success in determining fetal sex through molecular analysis of DNA (Gosden, Mitchell, Gosden, Rodeck, & Morsman, 1982). Within months a French group was using yet another instrument to take samples and diagnose sickle-cell anemia, and an Italian group was beginning to perfect a technique for direct karyotyping of chorionic tissue, without the need to wait for culturing (Goossens et al., 1983; Simoni, Brambati, & Danesino, 1983). Under the auspices of the World Health Organization, a working group on first trimester fetal diagnosis met in April, 1984, in Geneva, and a full-scale international conference on the subject was held in Rapallo, Italy, six months later (WHO, 1984).

An enormous amount of developmental research work has been done on chorionic villi sampling in the intervening years. Some of this work has been devoted to perfecting an instrument that will be both relatively easy to manipulate and reasonably nonintrusive. Other work has been devoted to standardizing the techniques for karyotyping, molecular analysis, and biochemical assaying of chorionic tissue. Yet other work has been devoted to assessing the safety of the procedure—safety gauged in terms of pregnancy loss as well as in terms of maternal and child health.²

Yet it is possible to assert that, at least for the United States, chorionic villi sampling has, for the moment, been stalled in its developmental phase; many knowledgeable people question whether it will, or should, ever emerge into diffusion, especially in view of the recent claims that sampling increases the likelihood of birth defects (Firth et al., 1989). The reasons for this delay, despite what many claim to be very clear advantages of a first trimester diagnostic technique, seem multiple and varied. There is always a competitive advantage for the technology that gets to the marketplace first—and amniocentesis got there
first. Since the techniques for chorionic biopsy are harder for practitioners to learn, this recency means that CVS was initially bound to be less safe than amniocentesis.

But something else is operating in the story of the delayed diffusion of chorionic villi sampling. "Social pressures in the United States," one participant observed, "were antagonistic to the development of new fetal diagnostic techniques" (Modell, 1986, p. 14). Between 1980 and the early months of 1993, clinical research on chorionic villi sampling was impeded by the various and sundry prohibitions against the use of federal funds for fetal research. Counterfactual history ("What would have happened if . . . ") is always a risky undertaking, but there are very good reasons to believe that had American research teams, and other research teams assisted with federal funding from the United States, been able to work as intensively on chorionic villi sampling as they had once worked on amniocentesis, it is possible—at least in the United States—that we might be much closer to diffusion of the technique than we are today. In an ironic way the politics of abortion in the 1970s helped to move amniocentesis out of development and into diffusion, while the anti-abortion politics of the 1980s worked to keep chorionic villi sampling from making the same transition.

Women have influenced the development of chorionic villi sampling in two of the same ways in which they influenced the development of amniocentesis: by their behavior as patients and by their participation in abortion reform movements, most notably those in France and Italy. The women who as patients stimulated (through their willingness to be patients, through their gratitude for the services provided, and through their return visits) the developmental work on chorionic villi sampling were, however, very different from the women who as patients first stimulated the development of amniocentesis. Many were neither white nor middle class: Pakistani women living in London; African women, many of them Muslims, living in France; Chinese women in Anshan; and Russian and Hungarian women. Yet something about their behavior, as perceived by the physicians whom they came to consult, convinced those physicians that first trimester prenatal diagnosis and first trimester abortion would ease their burdens as mothers. As Modell (1986) put
Earlier diagnosis seemed particularly necessary because of the social and religious attitudes of some ethnic groups at risk. For instance, British Muslims originating from Pakistan are as distressed as anyone else by having children suffering from thalassemia major, but most find midtrimester diagnosis and abortion unacceptable. However they expressed a lively interest in the possibility of first trimester diagnosis [italics added]" (p. 14). In the United States most of the women requesting prenatal diagnostic services (and most of those who participated as patients in research trials) have been white women of above-average income and educational levels, but the history of chorionic villi biopsy teaches us that there are circumstances in which women who do not fit in any of those categories have played a role in technological change.

Historians are, in general, uncomfortable making predictions about the future, but I believe that it is possible to learn some lessons from these stories about the history of prenatal diagnosis that can provide guidance about future policy options. First, there is every reason to believe that women can affect the future of prenatal diagnosis because they have, in the various ways I have tried to specify, affected its past. Second, I believe the chances of putting a brake on the progress of prenatal diagnosis—a brake that some feminist groups have recently advocated—are very slim, not just because medical genetics is now a well established specialty, not just because various governments have, for various reasons, ulterior motives in promoting prenatal diagnosis, but also because large groups of women, in several different countries, of several different social classes, very much want the services that medical geneticists can provide. Third, the only mechanism that I can see, on the basis of my view of the past, for applying that brake will be to outlaw abortion, a mechanism that—whatever its other faults may be—very few activist women are going to be convinced to advocate. Fourth, those who believe that women’s interests will be best served by the diffusion of chorionic villi sampling and by the development and diffusion of noninvasive diagnostic techniques ought to pay attention to the fate of fetal research; the ban that was recently overturned by one president’s executive order may just as easily be reinstated by another’s. Fifth,
and finally, those who believe that one desideratum for change is to extend prenatal diagnosis services to all sectors of the American population—especially to those who are poor or members of minority groups—need to think through, very carefully, not only the social and ethical pros and cons of such services, but also the pros and cons of malpractice suits as devices for ensuring the diffusion of medical technologies.

NOTES
1. There are no published histories of prenatal diagnosis that are comprehensive or that integrate the social, scientific, medical, and technical aspects of that history; the author is currently writing one. Parts of that history can be examined, however, in Cowan (1992), Cederqvist & Fuchs (1970), and Modell (1986).


BIBLIOGRAPHY


