Occupational hazards to the unborn

The danger to industrial workers of exposure to toxic chemicals in the workplace has been the object of much research interest by epidemiologists and toxicologists, and has led to indictment of such quiet killers as vinyl chloride and kepone. A relatively new effort, however, is gaining momentum — the study of industrial health hazards to the unborn.

In a symposium on chemical health and safety at the recent meeting of the American Chemical Society in Anaheim, Calif. (SN: 3/25/78, p. 187), two researchers described recent findings and perspectives on reproductive hazards of the workplace.

Sherry Selevan, an epidemiologist for the National Institute for Occupational Safety and Health in Cincinnati, explained the difficulties of collecting data from workers: Populations are often too small within single factories for good statistical evidence linking exposure to toxic chemicals with birth defects, stillbirths, low sperm counts, sperm mutations, spontaneous abortions and childhood cancers, even though strong suggestive evidence exists. Records of such events are often inadequate, and personal recall by the workers and their families is even less adequate. And male workers are often uncooperative about semen collection and analysis.

Despite the attendant problems of epidemiological studies, however, patterns of toxicity have emerged. Chemicals in the workplace can affect reproduction at many levels and in both sexes. Mutagens can affect ovary and testes tissues before conception, causing chromosomal abnormalities that lead to poor fertility and early miscarriages. Carcinogens can cross the placenta, affect growing tissue of the fetus and bring about cancer in the child. Teratogens usually kill cells of the conceptus during the very early stages of development (the third to the eighth weeks), and cause either miscarriages, stillbirths or birth defects.

Fully 15 percent of all babies born in the United States, according to University of Cincinnati toxicologist Jeanne Manson, have physical or mental birth defects, and 65 to 70 percent of those defects are due to unknown causes. Perhaps more surprising, 40 to 80 percent of all pregnancies in this country end in spontaneous abortion. The average woman, says Manson, with no exposure to toxic chemicals, can lose three to four fetuses for each baby carried to term. Of those spontaneously aborted fetuses studied, most have shown chromosomal abnormalities; such abnormalities are, in fact, 60 to 100 times more frequent in a spontaneously aborted fetus than in a full-term baby.

It is clear from these figures, according to Selevan and Manson, that the fetus is enormously sensitive to both genetic and environmental insults, and that monitoring early loss through spontaneous abortion would be a more accurate representation of toxic exposure than tabulating defects in babies that survive.

While the precise reproductive hazards are known for only a few toxic chemicals, the existing data show the critical need for additional studies. An epidemiological study of more than 400 children who died of cancer before the age of five found "overrepresentation" by their fathers in industries involving hydrocarbon exposure. Exposures of male and female adult workers to carbon disulfide revealed menstrual changes, more spontaneous abortions, decreased sperm motility and sperm counts and an increase in chromosomally defective sperm. Constant exposure to gas anesthetics in hospitals is correlated with more stillbirths, malformations and spontaneous abortions among operating room nurses and among the wives of doctors. Benzene and vinyl chloride have been shown to cause chromosomal aberrations in sperm-producing tissue. And the list goes on — DES, chloroprene, mercury, cadmium, DBCP, pesticides, chlorinated hydrocarbon solvents, each with their own damaging effects on the workers' progeny.

At this point, the effort to study reproductive hazards in the workplace is small and underfunded, and the list of suspect chemicals is long. Both Selevan and Manson, however, discussed ways in which science and industry can approach the problem more effectively. One traditional way industry has dealt with reproductive hazards is to bar women of child-bearing age from the workplace or to make them prove sterility. Such practices are common, for example, in lead-related industries. It is obvious, however, according to both researchers, that besides being a discriminatory work practice, this "lopsided" approach fails to protect workers and their progeny since heavy metals affect the male reproductive tract, as well as the female, and are carried home on clothing.

A second necessary major change in approach would be to monitor sperm changes and rates of spontaneous abortion rather than birth defects, since the former are more sensitive indicators of environmental insult than are the latter. □

Physics examines bacteria's world

Bacteria are Aristotelean in their physics, Edward M. Purcell explained at last week's joint meeting in Washington of the American Physical Society and the Biophysical Society. The Harvard University physicist, encouraged by biologists studying how bacteria move toward more favorable environments, has been looking at the world from a bacterial point of view. For example, to a bacterium the surrounding fluid seems as thick as molasses. If a cell swimming at top speed (30 microns per second) stops, it only coasts 0.1 angstrom. That situation fits Aristotle's mechanics, Purcell says. With no push there is no movement.

Evanescence is the other striking quality of the bacterial world. "Same place has no meaning, there is no coordinate system," Purcell says. Small particles diffuse so rapidly in the solution surrounding a bacterium that within 0.1 second all the molecules are replaced. Purcell finds it useful to compare the flow of material around a bacterium with the flow of electrical current around a sphere.

Using that model, Purcell investigated why a bacterium bothers to swim. He rules out the explanation that it swims to gather material. Moving, instead of standing still, it only would collect a few percent more attractive molecules, he calculates. "It is looking for greener pastures, not just scooping up grass," Purcell says. The bacterium samples its surroundings to determine whether its chemical situation, the balance of attractants and repellents, is getting better or worse.

But if the chemicals are swirling around the bacterium, moving just a little would not give a better sample. Purcell figures that to outrun diffusion, the bacterium traveling in a straight line would have to move about 30 microns. "If you don't swim that far, you haven't gone anywhere," he explains. Actual, nontheoretical bacteria do seem to go someplace. The straight segments of their tracks stretch 30 to 40 microns.

Purcell also considered how bacteria sample their fluctuating environment. Specific receptors on the cell surface bind attractant and repellent molecules. Those receptors' state of occupancy dictates whether the bacterium moves long distances in straight paths or whether it frequently changes direction.

Again using an analogy from electrostatics, Purcell compares the bacterial receptors to small capacitors connected to a central metal disc. He finds that with a few thousand receptors, covering less than 0.1 percent of the cell surface, the sample of attractant (or repellent) molecules can almost equal the accuracy of a situation in which the entire surface is the receptor. If small receptors for different chemicals are intermingled, Purcell points out, each type is almost as effective as if it had the whole cell to itself.

And that accuracy is important. "Bacteria have a hell of a signal to noise problem," Purcell says. They must average their samples over time. "Consideration of random noise in chemoreceptor occupancy indicates that in gradient sensing *E. coli* performs about as well as physics permits," Purcell concludes. □