nium and thorium, explains Dr. Neufeld, the McGill team has been asking practical questions such as, How large can a column containing this fungus in the form of fragile beads be made? How many times can these metals be washed out of such a "biofilter"? Where does the biosorption take place? Can the reaction be reversed? "We're starting to question our own findings," says Neufeld. "We're starting to take the cell wall apart piece by piece."

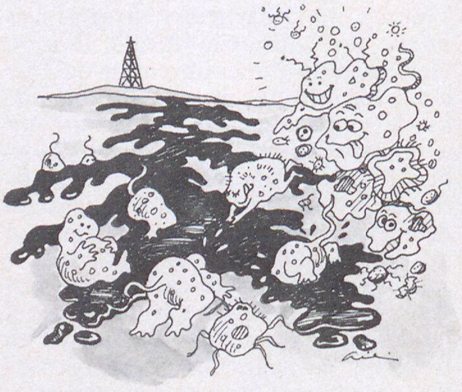
Finding a helpful bug is only the first step. The engineer must then devise an environment — vats, pumps, pipes and so on — in which the microorganism can grow, and from which its products can be removed. To this end the team has designed a way of continuously feeding microbes which are retained or in a sense immobilized by a spinning porous membrane, and which ferment their flow of nutrients, producing solvents such as acetone and butanol.

"Engineers," says Neufeld, "always like to make models; it's the lazy way of doing experiments." The models, in this case are mathematical. With their help, and that of instruments which constantly monitor the chemicals inside the reactor, the subtle cookery of this fermentation is optimized. Computers make this possible, and more important control the laboratory reaction.

Neufeld and his colleagues are also looking at microbes that produce surfactants. These surface-active compounds cluster around oil globules like pins on a cushion, their water-loving heads in the aqueous phase, their water-hating tails buried in the oil. Acting somewhat like a detergent, such surfactants could enable more oil to be pumped from wells in which it is now "stuck" to sand and porous rock. They could also help in de-emulsifying the mixtures of oil and water which are the products and wastes of sands projects and enhanced oil recovery techniques.

All of this work is being carried out at the laboratory scale. "Whether we actually come up with a commercially successful process or not is beside he point," says Neufeld. "We approach this as a training exercise."

Will there be jobs in Canada for the graduate students, the engineers, microbiologists, and chemists now carrying out research with Neufeld and co-workers? At the moment, biotechnology plays an insignificant role in Canada's economy: there are less than five firms or institutes actively working in the field. "We are babes in arms when it comes to biotechnology," says Neufeld. "Canada has been sitting on the sidelines, and if we're going to get



on the bandwagon it will take an enormous and immediate investment."

In the last few years, according to the recent publication of the Science Council of Canada entitled *Biotechnology in Canada: Promises and Concerns,* Japan, West Germany, England, France, and the United States have invested billions of public and private dollars in biotechnology. A task force of Canada's Ministry of State for Science and Technology (McGill's Dr. Vohumil was a member) recently recommended that the federal government spend $500 million on biotechnology over the next 10 years.

What results would such an investment bring? The biotechnological revolution has sent shock waves through universities, companies, and governments in those countries where it began. The field changes rapidly, competition between scientists is intense, unprecedented, and highly profitable links are being forged between industry and the academy. Some are concerned about the bias and dependence that this trend may introduce, and some are concerned that in circumventing Nature's biological checks and balances, and especially in using recombinant DNA techniques to create new life forms and alter existing ones, we may create grave, unforseeable dangers.

Others talk, passionately and convincingly, of biotechnology's great promise. One such is McGill graduate Ronald Cape, co-founder and chairman of the first and, in terms of stock market value, largest of the new biotechnology companies, Cetus Corporation of Berkeley, California. Cape, whose doctorate is in biochemistry, spoke recently at a McGill biotechnology symposium. "Anything a chemist can do," he said, "a bug can do better, cheaper, and cleaner. Biotechnology will produce much of what the heavy chemical industry now produces; and some of the small innovative companies of today will be the DuPonts and Monsantos of tomorrow." Bugs are tiny factories; befriend them and they will look after our future. But, insisted Cape, $500 million is not nearly enough to seed this revolution in Canada. □

**Séan McCutcheon**

*Séan McCutcheon is a freelance writer working in Montreal.*

**Biotechnology background**

Man used bugs long before he knew anything about them, or coined the word biotechnology. More than 8000 years ago, Sumerians and Babylonians were making beer. Almost 6000 years ago Egyptians were using yeast to leaven bread. Our forefathers used bacteria and molds to make yoghurt, cheeses — and after the Flood, the Bible tells us, Noah "drank of the wine and was drunken."

It was not until the 17th century that Anton van Leeuwenhoek, examining scrapings from his teeth through his primitive microscope, saw for the first time some of the moving "animacules" which had been providing generation after generation with food and drink.

Louis Pasteur in the 19th century untangled some of the complex metabolic pathways followed by yeasts during fermentation, and his studies enabled him to answer practical questions such as "Why is German beer better than French?"

During World War I, bugs were put to work for the first time *outside* the food and drink industries. Working at the University of Manchester, Chaim Weizmann (later the first president of Israel) succeeded in isolating bacteria which convert corn or molasses into acetone (used to stiffen the fabric wings of aircraft and to make explosive cordite), butanol (used to make synthetic rubber), and other industrial solvents. His process of natural synthesis remained commercially viable until it was ousted in the mid-1950's when petroleum became cheaper than biomass.