Indeed, if two and a half decades of AI research has done nothing else, it has given researchers a sense of awe in the face of the ordinary. Computers seem to have an easy enough time imitating "advanced" human intelligence—systems for playing chess and proving mathematical theorems were among the first AI programs ever written—but they have a terrible time recognizing a human face or understanding a nursery rhyme. The robot has not been built that can walk across a hillside. "We shouldn't be so intimidated by our Beethovens and our Einsteins," says AI pioneer Marvin Minsky of the Massachusetts Institute of Technology. "We're simply so accustomed to the marvels of everyday thought that we never wonder about it."

In part, the mastery of these everyday miracles may just involve the prosaic matter of computing speed, especially in such fields as vision and natural language understanding. A neuron is very slow compared to a microchip, but the brain makes millions or billions of neuronal calculations simultaneously and in parallel; our current generation of serial, one-step-at-a-time computers are hopelessly outclassed. Some of the most intriguing AI research involves the efforts by many groups to build machines that can do this kind of parallel processing on a suitably massive scale—and to figure out how to program these machines sensibly once they are built.

But many AI researchers, Schank and Minsky among them, think that fundamentally new approaches are needed. Whatever is going on within our skulls when we learn something or when we figure something out, whatever is involved in recognition and memory, it is not a series of neuronal IF-THEN statements. "The thing is, AI is very hard," says Schank. "What is the nature of knowledge? How do you abstract from existing knowledge to more general rules? How do you modify the knowledge when you fail? Are there principles of problem-solving that are independent of domain? How do goals and plans relate to understanding?"

"The computer is a way of testing our ideas," he points out. "But first, we need to understand what we're supposed to be building models of."

—M. MITCHELL WALDROP

This is the first in a series of articles on artificial intelligence research. Subsequent articles will deal with such major areas of application as expert systems, machine learning, natural language understanding, and computer vision.

Fertility Hormones Cloned

A group of researchers at Integrated Genetics, a biotechnology firm in Framingham, Massachusetts, has succeeded using recombinant DNA technology to produce two human fertility hormones, human chorionic gonadotropin (hCG) and human luteinizing hormone (hLH). This is one of the first reports of investigators using recombinant DNA technology to produce molecules that are a combination of proteins and carbohydrates in mammalian cells, according to molecular biologist Leroy Hood of the California Institute of Technology. For that reason, says Hood, "I think it's interesting."

The two fertility hormones have similar structures, each consisting of two polypeptide chains that are put together inside cells and "processed." A section at one end of each chain is a marker that guides the chain to the cell's secretory apparatus and is cleaved once the chain gets there. Before the hormones are secreted from the cell, sugar molecules are added to them. The hormone hCG, for example, is 30 percent sugar by mass. If sugars are not added to these hormones, the hormones are biologically inactive.

Bacteria, which molecular biologists usually use as protein factories, cannot carry out this type of processing. Although they can express added mammalian genes, they do not add sugars to the molecules and they do not excrete them. Thus molecular biologists believe that the only way to produce molecules as complex as the fertility hormones is to make them in mammalian cells, using standard methods of genetic engineering. David Housman, a founder of Integrated Genetics and a faculty member at Massachusetts Institute of Technology, used mouse cells to make hCG and hLH, infecting them with a bovine papilloma virus, which inserts itself in the chromosomes of the cells. To the virus, he and his associates added the fertility hormone genes and a mouse metallothionein gene containing control regions that promote gene transcription. These are well-known methods, although, says Housman, to actually make the methods work was a "nontrivial achievement."

The major problem with this method is that the engineered DNA is unstable—the genes tend to rearrange themselves. If this happens, the hormone genes may not be expressed. "We had to be very careful and very persistent to avoid rearrangements," Housman says. "We had to be sure we picked clones that were stable."

Judith Vaitukaitis, an endocrinologist and fertility specialist at Boston City Hospital, has tested the biological activity of the fertility hormones produced by the Integrated Genetics group. "They're quite good," she says. She thinks that these hormones will be clinically useful in the treatment of infertility because they can induce both ovulation and sperm production. Although hCG and hLH are now available for infertility treatment, the hormones are extracted from pituitaries, urine, or placentas and so are not completely pure. Vaitukaitis estimates that there is between 1 and 5 percent cross-contamination with other hormones, which can complicate treatment and clinical research.

The pure fertility hormones also should be of interest to basic research. Robert Canfield of Columbia University's College of Physicians and Surgeons says that, to his mind, one of the more interesting prospects will be to modify the genes at the sites where the sugars attach in order to study how the sugars relate to structure and function. Irving Boimer of Washington University in St. Louis says that he and others would also like to use the cloned hCG to determine the three-dimensional structure of the molecule. "You can't look at the three-dimensional structure of hCG now because there's not enough of it around," he says. Since the fertility hormones are typical of other glycosylated polypeptide hormones, researchers hope that by learning about them they will learn about other such hormones.

In any event, the Integrated Genetics group has shown the feasibility of cloning conjugated molecules in mammalian cells. "It is certainly one very smart approach—no question about it," says John Pierce of the University of California at Los Angeles. "I think it's the way to go."—GINA KOLATA