The new millennium —The way ahead—

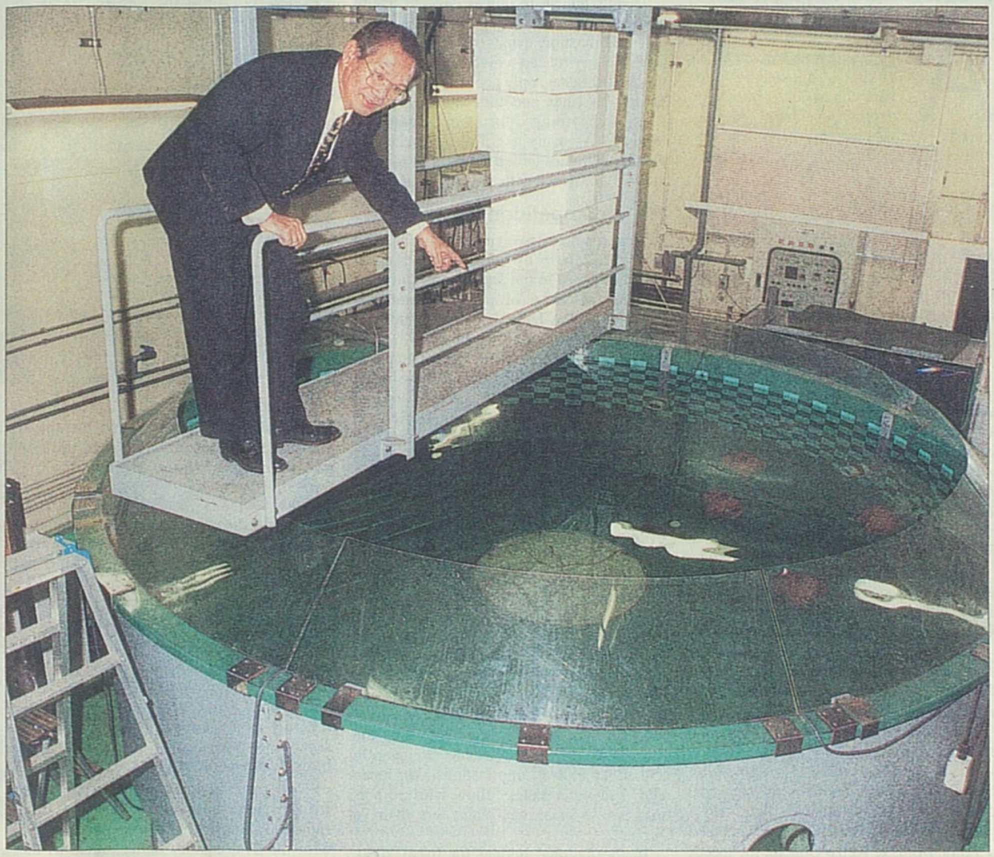
Squid cells give impetus to human brain studies

The year 2000, the first year of the new millennium, has dawned.

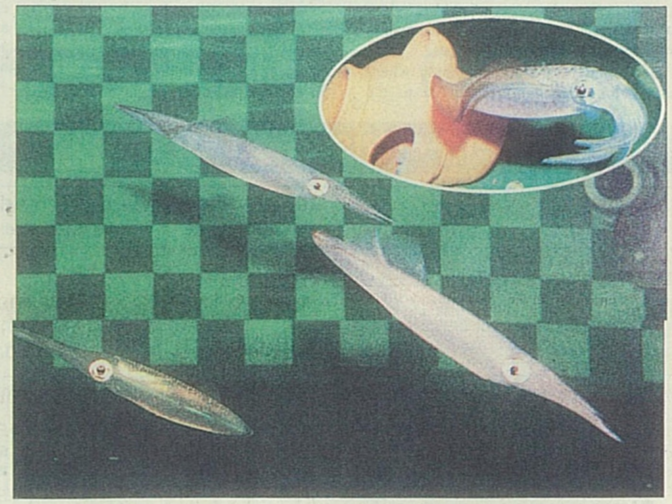
Scientific research in the 20th century has successfully carved out new frontiers—far beyond our expectations—in the quest for the ultimate nature of matter and the universe.

A major target of exploration for human beings in pursuit of knowledge in this new age is a "one-liter universe"—the brain—which is central to our very existence.

Matsumoto



Top: Matsumoto points to the Squid Maintenance Aquarium System, a tank in which squids are raised. He developed his method of raising squids in captivity at the Institute of Physical and Chemical Research so that he could study the giant cells of the marine animal as a preliminary step toward creating a brain-simulating computer.



Right: Squids in the tank swim as vigorously as if they were in the ocean. Inset is a squid emerging from a pot.

By Masaharu Asaba
Yomiuri Shimbun Senior Editor

An innovative scientist is trying to determine the way the brain works through a unique method—using squids and a computer.

He is Gen Matsumoto of the Institute of Physical and Chemical Research (Riken) in Wako, Saitama Prefecture. The 59-year-old scientist heads the "Brainway Group" of the Brain Science Institute of Riken. A public corporation under the jurisdiction of the Science and Technology Agency, Riken is one of the nation's major governmental research organizations.

Matsumoto's brain research is not merely to advance medical science or create an ultrahigh-performance computer. He is ambitious enough to ask "What is man?," a key, centuries-old scientific and religious question. He asks this to help formulate a philosophy and system of values for the new age.

His intriguing studies and unique brain theories have surprised even Nobel laureates at home and abroad, while attracting the interest of executives at major companies in this country.

Initially majoring in physics, Matsumoto extended his academic research to the field of biology to create a new computer capable of "soft computing," or thinking in a way similar to that of the human brain.

Clearing daunting obstacle

To this end, he is in the process of determining the physics of the way squids' nerve cells function.

These nerve cells, which are more than 10 times larger than those of human beings and whales, are extremely useful in preliminary research, he said.

Many researchers were aware of this, but raising squids in captivity, indispensable for studying the neurological systems of live squids, had long been impossible. When squids are put in a water tank, they live no longer than half a day. This was a daunting obstacle that scientists spent years trying to overcome, Matsumoto says.

Matsumoto finally achieved the all-important breakthrough.

He learned that squids discharge ammonia. Whereas ammonia disperses in the ocean, in the limited area of a tank, it becomes concentrated and is lethal to the squid. He then discovered a microbe that was able to dissolve the ammonia. This allowed him to raise squids in captivity for the first time and he was able to keep them alive for nearly six months.

The news prompted Konrad Lorenz, a Nobel Prize-winning scientist of animal behavior, to fly to Japan to see the squids at Matsumoto's laboratory.

Matsumoto's success in keeping squids alive for a relatively long period of time enabled him to test the theoretical model of how nerve cells transmit and process stimuli.

He attracted international attention when he pointed out errors in an approach that leading scholars, such as Nobel laureate Andrew Huxley, had advocated and that appeared in many biology texts.

In addition, Matsumoto also developed a new type of ultrahigh-speed camera to observe the brain cell activity of a live rat.

By inputting electric signals into the rat's brain, he traced the signals through the brain cells using the high-speed camera. He ascertained that the signals were faster and spread to a wider area if they were input repeatedly rather than being transmitted only once.

This indicates that the brain retains information better when the information is repeatedly learned. This research may help us understand the memory function of the human brain, Matsumoto said.

The human brain has 10 billion to 100 billion nerve cells, each of which serves as a microcomputer with a memory function.

Furthermore, the nerve cells, which have a learning capability, are linked in a "massively paralleled" system, or a system capable of processing different types of information at the same time, according to Matsumoto.

These findings enabled him to envision a "brain computer," and gave him the confidence to create such a computer.

Man-machine interaction

Matsumoto also has made experimental artificial circuits of the nervous system, using silicon elements, which function as if they are the real thing. So far, he has successfully connected the equivalent of 1 million cells, but he says he is still at a preliminary stage in his ambitious project.

People tend to think that making a "brain computer" is possible only if all the functions of the brain are known. But Matsutomo feels a brain-simulating computer must be developed while brain studies are being carried out. He emphasized that the development of such a computer can lead to a better understanding of the brain itself.

He uses the relationship between birds and the development of airplanes to explain the relationship between the development of the computer and the understanding of the brain.

No matter how much we learn about birds, we cannot understand the theory of flight, Matsumoto said.

However, through the development of aircraft, the theory of flight was discovered, Matsumoto said.

"What birds taught us is the fact that birds can fly and they made us believe that if we tried hard, we would be able to fly, too," he said.

Similarly, the existence of the brain gives us the confidence to make machines that mimic the workings of the brain. Through the process of developing such machines, we learn to better understand the brain, Matsumoto said.

This is a unique way of thinking in the field of brain research.

Matsumoto also stresses the need for the "science of living creatures" rather than a "science of inanimate objects" as is the case with conventional studies of physics.

Nobel laureate Susumu Tonegawa, who participated in a symposium with Matsumoto, said he wanted to pursue the scientist's theories.

Never-ending pursuit

Unlike many Japanese scientists, Matsumoto has a knack of surprising Nobel laureates with his ideas, and he enjoys presenting his theories to others.

His descriptive use of words is fascinating: "Love can stimulate the functioning of the brain"; "Whatever the brain believes can be done can be done"; "The brain's purpose is to cause us to grow"; "Religious faith can be compatible with the functions of the brain."

Matsumoto has formed these hypotheses through the study of the squid's nervous system and the development of his brain-simulating computer. He is now trying to prove these hypotheses.

Although his hypotheses may sound like the teachings of a cult, Matsumoto has drawn a sharp line between religion and science.

"Followers of a religion gain strength by firmly believing in facts they want to be true. Although science needs hypotheses, scientists should never have convictions that cannot be verified," he said. "In science, beliefs can be supported by proving verifiable facts."

Matsumoto does not call his studies brain science. Instead, he coined the word "Brainway."

The "way" in "Brainway" corresponds to the kanji character "do," which appears in such words as "judo," "kendo" and "sado" (tea ceremony). "Do" signifies the eternal, never-ending pursuit of the ideal.

The reason Matsumoto calls his studies "Brainway" is that he does not want to merely study the functions of the brain. He wants to better understand the nature of human beings through his research.

The fundamental difference between conventional types of computer and the human brain, Matsumoto said, is that "the purpose of computers is to produce programmed results, but the brain is an organ that processes information creatively."

"The nature of the brain lies in the process rather than results. Human beings by nature attain happiness through their efforts," Matsumoto said.

However, our society rejects failures and only respects achievements.

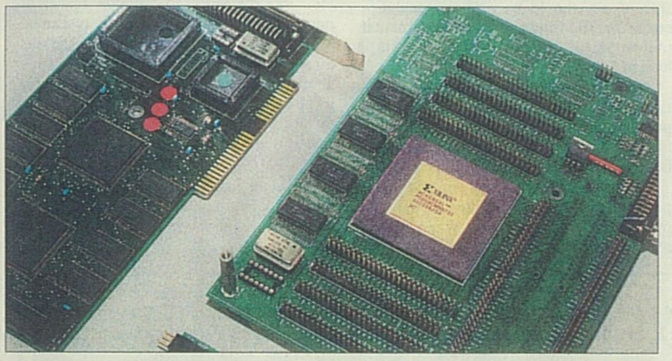
"Since this tendency is incompatible with the nature of the brain, society cannot inspire people to act vigorously and make them happy. We should not be content to adapt our society to the computer model," Matsumoto said.

He also talked enthusiastically about the feelings of professional baseball player Kazuhiro Kiyohara, who was in a batting slump all year long, and professional shogi chess player Yoshitsugu Habu, as well as religion and education, from the viewpoint of his brain theories.

Many top executives at leading computer software, distribution and information machinery companies are impressed with Matsumoto's research.

At a time when it is hard to see where the new century is heading, Matsumoto's studies seem to have encouraged corporate executives, who are having a difficult time trying to shake off their anxieties over the future.

Photos by Masafumi Nanjo
Daily Yomiuri



Matsumoto and his research team are developing a computer that is capable of "soft-computing"—one that will think and learn in a way similar to the human brain—through studies of squid cells. The processing unit on the left is the first model that the team has developed and the one on the right is a more advanced model, even though Matsumoto refers to it as "fairly clever, but a little less intelligent than a cockroach."