er than that. Many of the specimens had greatly deteriorated during the 2 to 4 days of transit to the health department laboratories. Thus traces of the botulinum organisms and toxin may have been lost.

The bacteria have recently been found in one SIDS victim in Utah by Joel Thompson and Richard Jackson of the Primary Children's Medical Center and Taira Fukashima and Merlin Smith of the Utah Department of Health, and in another in Seattle by J. Bruce Beckwith and Donald Peterson of the University of Washington Medical School and Melvin Eklund of the National Marine Fisheries Service of the U.S. Department of Commerce. The Seattle researchers have examined specimens from 30 SIDS victims and six controls and have found the bacteria, but not the toxin, in only one of the SIDS victims.

Beckwith, who is a leading authority on SIDS, says he does not expect botulism to be a major cause of the deaths, although it may account for those of a small subgroup of the infants. The Seattle data are consistent with the 5 percent figure reported in California. He points out that the development of the paralysis of botulism does not appear consistent either with the observation that most of the SIDS victims he studied were active and apparently normal just before they died or with evidence, such as tumbled bedclothes, that they were capable of strenuous movements.

According to Peterson, there are also uncertainties about the significance of the presence or absence of bacteria and toxin in the specimens. The Seattle samples were at least several hours old and Peterson agrees that deterioration might lead to loss of evidence incriminating botulism. But another possibility is that deterioration might have allowed growth of a botulinum contaminant that was not actually the cause of the infant's death. Thus far, however, the bacteria have not been found, either by the Seattle or California investigators, in specimens from infants who have died of clearly identifiable causes.

As further evidence in favor of the hypothesis that botulism may cause SIDS, Arnon and his colleagues cite epidemiological data on the age distribution of infants afflicted by the two conditions. Both occur most commonly in infants between the ages of 2 and 4 months, and then the incidences decline with age. Few cases occur in infants older than 6 months. The seasonal occurrence of infant botulism cases in California also parallels that of SIDS cases. Both reach peaks in the late fall and early winter.

Although the importance of botulism as a cause of SIDS remains to be established, the condition is a significant disease in its own right. Since 1976, about 80 cases have been diagnosed throughout the United States. Well over half of them have been reported in California, but this seemingly high incidence undoubtedly reflects the greater awareness of the condition on the part of the physicians and public health officials in that state. Arnon estimates that if the incidence in the rest of the country is the same as that in California, at least 250 cases severe enough to require hospitalization occur annually in the United States. (In 1977, 25 infants were hospitalized for botulism in California, which has

Microcomputers: The Great Electronic Mouse Race

Apart from the experimental psychology community, racing mice through a maze has never caught on as a popular pastime. Microelectronics, which makes it possible to pack the essential elements of a computer on one or a few chips of silicon, could turn this situation around. A contest sponsored by the Institute of Electrical and Electronics Engineers (IEEE) by way of its *Spectrum* and *Computer* magazines is under way which offers $1000 to the builder of the self-contained electronic mouse that can negotiate a maze in the shortest time. Although no one knows what will come of it all, *Spectrum*'s Roger Allan noted that some 6000 persons from around the world were interested enough to pay a $3.95 entry fee by the March deadline.

James Hamblen's mouse tries the maze.

The contest consists of a series of trial runs to be held at computer conferences and electronic trade conventions. Entries that successfully negotiate a maze at one or more of the trial runs (a different maze will be used at each trial) are scheduled to compete in a final race-off next June at the National Computer Conference in New York City. The first trial has already been held at a personal computing conference this past June in California. Of six entries, two mice managed to complete the course.

The rules of the contest are designed to emphasize microelectronics. Mice are allowed three passes through the maze. Thus, by using a microcomputer to "remember" where it has been, an electronic mouse can "learn" the vagaries of the maze on its first two trips and select an optimum path on the last pass. Furthermore, the mouse must be completely self-contained, although it need not physically look like a real animal. Live mice are not prohibited, but a rule outlawing the deposition of any material substances on the race course strongly discourages their use. Finally, radio-controlled mice are barred.

Basic elements of the maze include straightaways, U's, T's, L's, and dead ends (mousetraps). These are connected to form a maze of up to 20 feet square. The width of the pathway is $6\frac{1}{2}$ inches, and the height of the walls is 2 inches. There is no ceiling, so that the mice can be tall enough to look over the walls, but they cannot be so tall that they tip over. Neither can they step or fly over the walls.

Winning mice in the first trial run negotiated a 5- by 10-foot maze of this type in 51.4 seconds and 4 minutes 32.5

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a population one-tenth that of the nation as a whole.) And the hospitalization is expensive. The average victim spends 28 days in the hospital at a cost of $10,000.

Moreover, the disease is not limited to this country; at least one case has now been reported in England and another has turned up in Australia. Since botulinum spores are found throughout the world, additional cases will probably be found in other countries as more physicians become aware of the existence of infant botulism.

Arnon stresses, however, that this is not a new disease. It simply was not recognized before. In the past, the condition may have been diagnosed as any of a variety of ailments, such as "failure to thrive," myasthenia gravis (a disease characterized by muscular weakness), meningitis, encephalitis, or acute infantile polyneuropathy (polyneuropathy is a catch-all term meaning a disease affecting several nerves).

A major question investigators would like to answer is why botulinum spores can produce toxin-producing bacteria in the intestinal tracts of only some infants even though all infants are presumably exposed. Daniel Mills and Hiroshi Sugiyama of the University of Wisconsin have recently developed an animal model for infant botulism that they think will help in answering this question. According to these investigators, spores introduced directly into the stomachs of infant mice develop into toxin-producing bacteria in the gastrointestinal tracts of animals between the ages of 7 and 12 days. The toxin is not found in animals younger or older than that.

Mills says, however, that the toxin does not appear to be absorbed from the intestines of the mice. The animals do not get sick, even though there is enough toxin in their intestines to kill other mice injected with extracts of the intestinal contents. Mills speculates that differences in the intestinal conditions, possibly in the composition of the bacterial populations found there, account for the increased susceptibility to botulinum infection of 7- to 12-day-old mice compared with mice of other ages.

Because botulinum spores are so common, there is little anyone can do to protect their children from contact with the spores. One precaution can be taken, however, that is, not giving honey to infants under 1 year of age. The California investigators and others have identified botulinum spores in 10 to 15 percent of the honey samples they tested. Even the Sioux Honey Association, a cooperative of honey producers, has issued a press release advising parents to avoid giving the sweetener to infants less than a year old. Thirty percent of the infants hospitalized in California for botulism had been fed honey before they became ill, but Arnon says that none of the ten SIDS victims whose deaths were linked to *C. botulinum* had eaten any honey. Soils, dust, and most raw agricultural products carry the spores and there are numerous other ways in which an infant can come in contact with them. Thus, although the importance of botulism as a cause of SIDS remains to be established, it now appears that parents and physicians need to be aware that it is possible for infants to contract a disease from which they were once thought to be safe.—JEAN L. MARX

seconds, respectively. The large time difference was primarily due to the different strategies devised by the "trainers" of the mice. Surprisingly enough, the four nonfinishers failed not because of poor learning ability but because they could not make 90-degree turns—the only kind in the maze—when they bumped into the walls of a corner.

The fastest mouse was built by Art Boland, Phil Stover, and Ron Dilbeck of the Battelle Northwest Laboratories in Richland, Washington. According to Boland, they built their entry around a microcomputer with enough memory to store the information needed to make decisions at 99 different positions in the maze. The general strategy adopted was, for the first of the three allowed passes through the maze, to allow the mouse to make random choices at each decision point. For the second pass, the mouse was made to try new paths that it "knew" it had not tried on the first. The information collected was then used to compute the best course to follow on the third run.

The Battelle engineers used a number of infrared emitting light diodes (LED's) coupled with photodetectors as sensors to monitor the white walls of the maze and to locate the holes in the walls at corners or where new paths began. The mouse, measuring 5 inches long by 5 inches wide by 7 inches tall, was powered by alkaline cells.

James Hamblen of Martin Marietta Aerospace, Denver, designed the second place finisher. Hamblen's mouse was not as smart as the Battelle entry; it was programmed simply to follow the left wall of the maze. As long as the entry and exit slots are on the outside perimeter of the maze, such a strategy guarantees a solution, even if it takes a while to find it. Another difference was that Hamblen's mouse was cylindrical; thus, it could always manage a turn, even after running into a wall. The Battelle mouse's sensing system was designed to prevent the square mouse from getting too close to a wall. In other respects the two mice were similar. In particular, the use of separate stepper motors to drive a wheel on each side of the mouse permitted both to make sharp turns—one wheel could be driven forward and the other in reverse, for example.

Both mice took considerable effort to build. Boland estimates his group put in about 500 man-hours, all after hours, while Hamblen guesses he spent approximately 1000 hours on his project.

According to Allan, the reason for the "Amazing Micro-Mouse Maze Contest" is twofold. The first is promotional, to give the society a bridge to the general public. The trial run held this June, for example, appeared on a Los Angeles news telecast. The trial also attracted strong spectator interest; particularly popular was one Italian entry that appeared lifelike but which failed to solve the maze. A second goal was to present a challenge to engineers that might ultimately have an impact elsewhere, although exactly where is not clear. Credit for coming up with the contest idea is given to the editor of *Spectrum*, Donald Christiansen.

It is said that no matter what new idea one comes up with, a thorough search of the literature will reveal that it has already been published. The electronic mouse is no exception. It turns out that in the early 1950's Claude Shannon, now retired from Bell Laboratories, demonstrated a maze-solving mouse. What Shannon did not emphasize, however, was that under the maze, connected to the mouse by a magnet and surrounded by curtains, was a device driven by instructions from a large electromechanical (no solid state electronics in those days) computer. As it happens, Shannon's maze-solving mouse was using a program based on those being developed for the electronic switching machines that route calls through the maze of the telephone network.—ARTHUR L. ROBINSON