vestigators consider herpes simplex to be a slow virus because people can harbor it for years in a dormant condition. Occasionally herpes simplex will flare up and produce the familiar cold sores. Recently, Albert Sabin, currently a Fogarty Fellow at the National Institutes of Health, Bethesda, Maryland, and Giulio Tarro of the University of Naples, Italy, proposed that herpes viruses are implicated in the etiology of several human cancers (*Science*, 11 May 1973, p. 572).

A conventional virus has also been isolated from the brains of patients suffering from SSPE. The virus isolated by John Sever and his colleagues at the National Institute of Neurological Diseases and Stroke, Bethesda, Maryland, was measles virus. Special culture conditions were required for the isolation of the SSPE virus, which appeared to exist in a suppressed state in the brain cells. Not until the cells were cultivated together with another type of human cells was the infectious virus released.

The suppression of the measles virus, rather than its total elimination from the host, probably requires a deficiency in the immune system of the SSPE victim. Sever, with J. T. Jabbour, of the University of Tennessee Medical units, Memphis, has studied the epidemiology of SSPE. They found that more than 50 percent of SSPE patients had had measles before the age of 2 years and that the average time from the measles infection to the development of SSPE symptoms was 6 years. (SSPE should not be confused with postinfectious encephalomyelitis, another neurological complication of measles that begins within a few days of the primary infection.) The high incidence of early measles infection in

Speaking of Science

Artificial Intelligence: A Fascination with Robots

In early 1972 Sir James Lighthill of Cambridge University undertook to survey the field of artificial intelligence (AI) for the Science Research Council of Britain. His report was sufficiently controversial that the Council held up its release for over a year until last month, when a somewhat sanitized version was published (along with comments from several other scientists) in an AI newsletter edited at the University of Edinburgh. Ironically enough, funding for AI research at Edinburgh, heretofore the largest center in Britain, was also cut back last month—in part due to the criticisms leveled by the Lighthill report against AI research in general and against the Edinburgh project in particular.

The report questions whether artificial intelligence is a coherent field of research or whether it is really two diverging kinds of investigations linked in a makeshift way by a fascination with robots. The report is cautiously optimistic about the future of research on particular aspects of AI (automation and computer studies of neurobiological functions), but downgrades work on robots as having, at best, discouraging prospects.

Researchers in artificial intelligence, for their part, have been quick to criticize the report as betraying a lack of understanding as to what the field is all about. They dispute not only the report's assessment of prospects in AI but also the division of what they see as a coherent field into artificial and misleading categories.

The ABC's of artificial intelligence, as Lighthill styled them, amount to

► Advanced automation, including pattern recognition, speech recognition, and automation of industrial processes; the emphasis, according to Lighthill, is on practical problems and on efforts oriented toward new hardware.

► Building robots, including coordination of eye and hand functions, use of natural languages for communicating with computers, automated analysis of visual scenes or environments, and problem solving techniques; Lighthill describes this category of research as forming an imperfect bridge between the practical area of advanced automation and the more basic research of category C.

► Computer-based research on the central nervous system, including associative recall, functioning of the cerebellum, psycholinguistic studies, and other theoretical (modeling) investigations related to neurobiology and psychology.

It is particularly the work on robots that Lighthill sees as having little future in itself and as being of marginal value to other areas of AI. He goes even further, suggesting that those who work on robots may be fulfilling "pseudomaternal" urges or catering to popular interest. Researchers on AI are understandably irked at these slurs on their motivations and, more substantively, do not see the rationale for Lighthill's ABC's. They believe that his description is limited and arbitrary, that it includes some subjects such as neurobiology which have little to do with AI, and that it excludes others central to the field. As one U.S. scientist put it, neither artificial intelligence nor neurophysiology is advanced enough to have anything to contribute to the other discipline.

Lighthill is a well-known scientist respected for his work in applied mathematics and hydrodynamics, and his criticisms, as one observer described them, "do not have the religious character" of earlier attacks on AI. But he is admittedly an outsider to AI research, and he qualifies his report as a "highly personal view." It is thus not impossible that his report, based on a 2-month survey, does misconstrue the field and that his view of its prospects is, as AI researchers claim, seriously misguided.

Lighthill's main criticism boils down to the claim that work on robots is not an intellectually important endeavor. Those working on artificial intelligence reply that robots are not their primary goal, but merely research tools. Marvin Minsky, of the Massachusetts Institute of Technology, believes that research on AI is important because it is really research on theories of intelligence, and that work with robots, with computer vision machines, and with other similar devices—whatever their practical applications—aids the unraveling of

SSPE patients implies that either immunological immaturity or a defective immune system permits the virus to remain in the patient. The defect in the immune system probably involves an absence of specific cellular immunity for measles virus, because SSPE patients have higher concentrations of antibodies against measles in both blood serum and spinal fluid than do other individuals.

Luiz Horta-Barbosa, in Sever's laboratory, has recovered measles virus from the lymph nodes of SSPE patients. Sever hypothesizes that the virus is carried in white blood cells during the incubation period. Eventually, some cells would invade the CNS and initiate the neurological phase of SSPE. The presence of measles antibody can slow the progress of the disease by inactivating virus particles that are released from brain cells but cannot prevent it entirely, because the virus can spread from cell to cell.

The availability of an animal species susceptible to SSPE would be advantageous for studying the disease and the role of the immune system. Donald Byington and his colleagues at Purdue University School of Veterinary Medicine, Lafayette, Indiana, were able to produce neurological disease in hamsters with measles virus isolated from the brain of a patient with documented SSPE. Byington, now with Kenneth Johnson at Case Western Reserve University School of Medicine, Cleveland, Ohio, has found that the response of hamsters to intracerebral injection with virus derived from an SSPE patient depends on the age of the animal. Newborn animals died of encephalitis within a few days of the injection. Adult animals, although they displayed no out-

or a Serious Intellectual Endeavor?

ideas about possible "intellectual mechanisms." Even the process of developing these devices and the computer programs that control them is leading, in his view, to deep insights into the nature of learning.

John McCarthy of Stanford puts it somewhat differently—nobody knows any mechanism that can carry out the coordination of vision and manipulation, that can distinguish objects against a background, and that can perform a number of tasks as effectively as humans and animals routinely do. Investigation of these mechanisms, he believes, is a valid intellectual goal. And it is not a trivial problem, in his view, to try to formalize a description of the intellectual structure of the world.

Researchers on AI do not claim to have made much progress in understanding the details of specifically human thought processes, but they do believe that they have made a start on discovering how intelligence might work. They point to a new interest among cognitive psychologists in the vocabulary for discussing thought processes and in a variety of simple cognitive phenomena developed by AI researchers. More concrete, if preliminary, results include a computer-directed hand-eye machine developed at Stanford which can assemble a simple pump from parts randomly placed on a table. Researchers at Bolt Beranek and Newman Inc. in Boston have developed a natural language question-answering program which, when combined with a data bank of information on moon rocks (as a demonstration), proved so irresistible and accessible to geophysicists that they soon forgot it was the program, not the data base, that was being demonstrated. In contrast to earlier presuppositions that the use of computer languages to describe cognitive phenomena would result in oversimplification, there is growing recognition that work on artificial intelligence has provided a lot of new ideas.

Even granting that AI is an intellectually important area for research, it is fair to ask whether the field is using its resources wisely. The Lighthill report suggests that, in the United States especially, little attention has been given to this question, in part because there has been a relatively assured source of funding. As is true for computer science in general, research on AI is predominantly supported by the Defense Advanced Research Projects Agency (ARPA), which provides about $4.5 million a year. Another $1.5 million comes from the National Science Foundation (NSF). The bulk of the ARPA money goes for work on robots and natural language programming at a few large centers, while smaller, more widespread research projects on pattern recognition, pattern processing, and automation make up the core of the NSF funding. There has been no overall evaluation of the field for some years, researchers admit, and there are substantial disagreements as to which of several lines of research will prove most fruitful. But while conceding the need for some reexamination, what concerns many AI researchers is that the Lighthill report will be used as ammunition by budget-conscious administrators looking for reasons to eliminate funding entirely. They report that ARPA is getting nervous about supporting basic research, and also point to a lack of U.S. research on automated manufacturing techniques comparable to the $115 million effort launched by Japan in 1971.

The term artificial intelligence was initially chosen by Minsky and McCarthy so that they and their colleagues could work on the nature of problem-solving processes without competition from psychologists. The field has outlived the excess optimism that characterized its early years, although it continues to be judged, unfairly many believe, in the light of promises made during that period. Even ardent proponents of AI admit that it still does not have any well-agreed-upon theoretical basis. Nonetheless, they are optimistic. Work on natural language programming alone, one admittedly partisan research administrator told *Science*, will greatly affect how people interact with computers. "We are looking," he said, "at a science in its infancy which will have an enormous impact." But as the Lighthill report makes clear, that impact is not yet obvious to everyone.

—ALLEN L. HAMMOND