disease," the group summarized its report stating, "Were these weapons ever to be used on a large scale in war, no one could predict how enduring the effects would be, and how they would affect the structure of society and the environment in which we live." They warned that the danger would apply as much to any country which initiated CBW as to the recipient of an attack.

The Pentagon had requested a total of $88 million to fund R&D for a wide range of offensive and defensive chemical and biological agents. The $16 million cut was the amount called for in fund research and development of specifically offensive lethal gas and biological capability.

The initial review of the $8.3 billion outlay for R&D submitted by the Defense Department was conducted by a special subcommittee created earlier this year, headed by Sen. Thomas J. McIntyre (D-N.H.), who is credited with amassing the support for the major cuts. McIntyre asked the Army what rationale underlay U.S. efforts in chemical and biological warfare research and development and was told that the basic justification is due to the Soviet Union's "massive effort" in the field. A strong CBW program by the U.S. will deter Russia from using their own forces, argued Lt. Gen. A. W. Betts, Chief of Research and Development for the Army. "Although we never signed the Geneva Convention, it has been our policy, generally, that we will not use lethal biological or chemical weapons except in retaliation," Betts declares.

Even though committee members have been briefed in closed session on the scope of Russia's CBW program, the concern remains in the broader effects of escalating the CB arms race and its impact on the general problem of arms control. Therefore, the committee proposal reflects the emphasis on defensive projects. However, a problem is anticipated in deciding just what is offensive and what is defensive.

The military would decide where the cut should apply; these will then be subject to Congressional approval. The lines between defensive and offensive weaponry is equivocal, depending largely on the kind of delivery system used for dispersal of CB agents and the use to which a given agent or device is used. An Army spokesman says that even a gas mask could be considered offensive if used, for example, to protect troops making an assault with a chemical agent.

In addition to CBW, the manned orbital lab and the Cheyenne cuts, other R&D defense projects eliminated are the Surface-to-Air Missile (SAM-D), a long-range missile designed to be fired from underwater by submarines, and a reconnaissance version on the F-111.

SOLAR THEORY

Quarks for neutrino-less fusion

Nuclear fusion occurs when nuclei of light elements combine with each other to form heavier ones. A good deal of energy is released in the process, and it is generally believed that this is the source of the sun's heat.

In particular theorists hypothesize that the fusion comes from the so-called carbon-nitrogen cycle, a chain of fusion processes that begins by combining carbon 12 and hydrogen to form nitrogen 13 and proceeds by way of several isotopes of nitrogen and oxygen to come back to carbon 12 plus helium. At this point the cycle can begin again. Calculation shows that this procedure best accounts for the sun's energy.

But recent experimental evidence tends to rule out the carbon-nitrogen cycle. For the last year or more, theorists have been searching for a substitute. Now there is a new suggestion that may have important effects on earth as well as in the stars.

The experimental difficulty is with the neutrinos that the carbon-nitrogen cycle should produce. They have not been found. Neutrinos are very light, electrically neutral particles with very small probability of being absorbed by other matter; the solid earth is more transparent to them than glass is to light.

But technology has advanced to the point where physicists have detectors in which they can hope to record neutrinos, and they have been avidly looking for those from the sun (SN: 7/20/68, p. 63). The negative results have led them to say definitely that the sun cannot be getting much of its energy from the carbon-nitrogen cycle. And considering the sun's energy output, no other cycle seems to fit.

Without some other mechanism, there should be neutrinos, but there are none.

Nevertheless, the dilemma may not be insoluble, if quarks can be accepted in the solution. Dr. Leona Marshall Libby of the University of Colorado and the Rand Corporation, and Dr. F. J. Thomas of Rand, suggest that the way out of the dilemma is to permit fusion processes to have the ultra elementary particle called a quark as a catalyst. The idea, if correct, could also have applications to terrestrial attempts to achieve controlled fusion for power purposes, as well as to astrophysics.

A major problem is that no one has ever seen a quark. The theory of particle physics says that they are basic elements out of which all the known particles are built, but attempts to find them or generate them in the laboratory have all so far failed, and some physicists doubt that they really exist (SN: 5/31, p. 538).

Quarks, if they exist as theoretically described, would come with electrical charge in multiples of one-third of the usual amount of elementary particle charge. A negative quark, say Drs. Libby and Thomas, might be captured by a nucleus. Orbiting around the nucleus, the quark would reduce the repulsive electrical force which that nucleus would exert on others. When such a quarkonucleus, as they call it, came close to another nucleus, the quark would serve as a binder to bring them together and help them fuse.

The fusing nuclei would need less energy with quarks helping them than they would without, and in the sun's case these criteria open the door to neutrino-less fusion processes. Drs. Libby and Thomas favor a cycle by which three helium nuclei ultimately become carbon 12.

The relative abundance of quarks would not need to be large, say Drs. Libby and Thomas. If there are no heavy elements in the sun there would need to be only one quark to a million billion billion billion (10^{33}) protons; if the sun has heavy elements in a concentration equal to that of the rest of the solar system, there would have to be one quark for every one hundred thousand billion (10^{14}) protons.

Quark-catalyzed fusion could occur in other astrophysical bodies beside the sun. It would apply to any mass of material that was accumulated out of primeval big-bang material and therefore could contain the requisite free quarks, says Dr. Libby.

It could also apply on earth. "Suppose the 300 GeV accelerator (now under construction at Batavia, Ill.) produced quarks," says Dr. Libby. A chamber containing a plasma of fusible nuclei could be put near the accelerator's target. If the plasma could be made to stay in the chamber long enough, she says, "the quarks would go in and make fusion."

"It's certainly an interesting theory," says Dr. Bernard Eastlund of the Atomic Energy Commission. "If you have a quark, that would be a very interesting application of it." He points out that the Libby-Thomas theory is similar to an older suggestion that particles called mu mesons might catalyze fusion. But mu mesons are subject to radioactive decay, and it turned out that they don't last quite long enough to bring the nuclei together. The mu meson idea, says Dr. Eastlund, "just failed. Quarks have a much longer lifetime." They might work, if they exist.