these bombardment by-products. Although it is difficult to correlate age with depth exactly, they point out, the sample indicated three increases spaced about 100 to 200 million years apart and of similar duration. All are too old for comparison with known earthly ice epochs, but they are evidence. □

Final nuclear study: 'Risks still low'

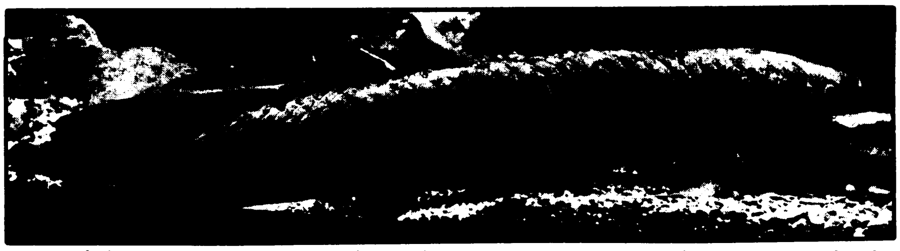
After a year of collecting comments and criticisms—more than 1,800 pages of them—and following up with some revisions on the draft report, the U.S. Nuclear Regulatory Commission (NRC) has released the final version of the Rasmussen Reactor Safety Study. And although many of the projected consequences of a major nuclear accident have been revised upward, an NRC release concludes that "the level of risk still remains very low relative to existing non-nuclear risks."

The objective of the study, begun in 1972, was to make a "realistic" estimate of risks inherent in the operation of commercial light-water nuclear power plants, and to compare these risks with others to which society is already exposed. Many critics were not surprised that the three-year, $4-million Atomic Energy Commission-sponsored effort found the risks low and the comparisons favorable (SN: 8/24/74, p. 117). The final report replaces a 1957 risk estimate (the Brookhaven report). It had been fertile ground for nuclear critics for years due to the relatively high risks estimated during the early years of nuclear power.

The risk estimates in the study, directed by Norman C. Rasmussen, a nuclear engineer at Massachusetts Institute of Technology, are based on the operation of 100 large pressurized and boiling-water reactors (the number projected for operation in 1980). The study used "fault tree" and "event tree" analyses, methodologies strongly attacked during the comment period (SN: 5/3/75, p. 286). The report estimates that an individual's chances of dying in a nuclear reactor accident would be about 1 in 5 billion. The chance of death during a hurricane is 1 in 2.5 million; by lightning, 1 in 2 million; by air travel 1 in 100,000, and by traffic accident, 1 in 4,000.

Upward shifts in the final report include, for the worst-case accident: early fatalities, 2,300 to 3,300; early illness, 5,600 to 45,000; property damage, $6.2 billion to $14 billion; latent cancer fatalities, 110 to 1,500; various other cancers and genetic effects, up 50 to 300 percent. Upward revisions notwithstanding, NRC chairman William A. Anders says nuclear power plants designed, built and operated under NRC regulations "provide adequate protection" to public health, safety and the environment. □

Lungfish: Ins and outs and evolution



Lungfish: Living, breathing links in the evolutionary journey from water to land.

"Four hundred million years ago they were the cream of life, lords of creation, pioneers in a new way of living, escaping the threat of death that lurks in droughts, stagnant pools, poisoned waters, through breathing air by means of their newly invented lungs." So wrote British physiologist Homer W. Smith about lungfish in his classic science novel of 1932, *Kamongo or The Lungfish and the Padre.*

It turns out that Smith may have been as prophetic as he was poetic in his novella-treatise on evolution. Modern researchers have just now provided experimental data to confirm the view that Smith penned so eloquently—that true breathing first appeared in the lungfish.

The great classes of terrestrial animals owe an odd progenitor for that first step taken in the evolutionary journey from water to land. Modern lungfish, nearly unchanged from those fossil pioneers, look a bit like large eels with massive jaws and rope-like fins. They live in swampy areas in Africa, Australia and South America, and when the dry season comes, they dig into the mud and estivate (hibernate in the heat). As the mud dries rock hard, they are imprisoned, and lie fasting—and breathing—until the rains wash them free, sometimes months, sometimes years later.

Three animal physiologists, J.P. Lomholt and K. Johansen of the University of Aarhus (Denmark) and G.M.O. Maloiy of the University of Nairobi (Kenya) have studied the lungs of estivating lungfish. Pressure pulses recorded in the buccal cavity and the air space in front, along with other evidences of forced inhalation, convinced them that during estivation, the lungfish draws air in forcibly. (Exhalation is passive.) They state, in the Oct. 30 NATURE, that the first appearance of negative-pressure inhalation is credited to now-extinct amphibians. Yet, no suctional breathing has been seen in air-breathing vertebrates below reptiles. "Suctional breathing," they conclude from their experiments, "probably evolved first in the estivating lungfishes."

The link, then, between water breathing and air breathing, between swimming and walking, was the strange, primitive lungfish, just as Smith wrote four decades ago before much of the data were in. But what of the evolutionary success of that living link himself? "When he dived into the mud," Smith wrote, "he dived into a blind alley; a mode of life that must ultimately end in extinction. . . . That lung of his, which promised to bring him freedom from the old way of living, promised to break the bonds that chained him to a life beneath the water, but it only left him chained alternately between the water and the mud. If anything, he was worse off than before." □

Mars-bound Viking survives an ordeal

No one said it would be easy. The first of the two unspeakably complicated Viking spacecraft took off for Mars nine days late on Aug. 20 due to pre-launch problems. Viking 2, similarly delayed because it had to use the same launch pad, was then further held up by a troublesome antenna assembly, finally getting off the ground on Sept. 9 instead of Aug. 21. Now the "lander" section of Viking 2 has undergone another technical trauma, one which flight officials at first feared could prevent it from safely reaching the Martian surface. Yet not only has it survived, but the Viking team at Jet Propulsion Laboratory in Pasadena seem in better spirits than did their predecessors during the early stages of the trouble-plagued Mariner 10 mission to Venus and Mercury.

When the two Vikings were launched, the batteries in the two landers were uncharged, so as to prolong their lifetimes. A few weeks ago, flight controllers signaled Viking 1 to charge them up, and on Oct. 31 attempted the same thing with Viking 2. But the batteries on the second lander would not charge. A vital role for the batteries is to power a motor-driven switch, which will enable the lander to switch over to its own power supply just before descending from its orbit around Mars, instead of drawing its current from the solar panels on the "orbiter" vehicle to which it is presently attached. Analysis at JPL and at Martin-Marietta (the spacecraft prime contractor) in Denver showed a faulty component in the main battery charger, so the vehicle was switched to its backup system, which performed perfectly.

As it turns out, engineers discovered, a