

than expected. A great radioactive cloud was deposited on the tiny atoll of Rongalap, 150 kilometers away, where the inhabitants likened the explosion to the Sun rising in the West. A few hours later, radioactive ash fell on Rongalap like snow. The average dose received was only about 175 rads, a little less than half the dose needed to kill an average person. Being far from the explosion, not many people died. Of course, the radioactive strontium they ate was concentrated in their bones, and the radioactive iodine was concentrated in their thyroids. Two-thirds of the children and one-third of the adults later developed thyroid abnormalities, growth retardation or malignant tumors. In compensation, the Marshall Islanders received expert medical care.

The yield of the Hiroshima bomb was only thirteen kilotons, the equivalent of thirteen thousand tons of TNT. The Bikini test yield was fifteen megatons. In a full nuclear exchange, in the paroxysm of thermonuclear war, the equivalent of a million Hiroshima bombs would be dropped all over the world. At the Hiroshima death rate of some hundred thousand people killed per equivalent thirteen-kiloton weapon, this would be enough to kill a hundred billion people. But there were less than five billion people on the planet in the late twentieth century. Of course, in such an exchange, not everyone would be killed by the blast and the firestorm, the radiation and the fallout—although fallout does last for a longish time: 90 percent of the strontium 90 will decay in 96 years; 90 percent of the cesium 137, in 100 years; 90 percent of the iodine 131 in *only a month*.

The survivors would witness more subtle consequences of the war. A full nuclear exchange would burn the nitrogen in the upper air, converting it to oxides of nitrogen, which would in turn destroy a significant amount of the ozone in the high atmosphere, admitting an intense dose of solar ultraviolet radiation.\* The increased ultraviolet flux would last for years. It would produce skin cancer preferentially in light-skinned people. Much more important, it would affect the ecology of our planet in an unknown way. Ultraviolet light destroys crops. Many microorganisms would be killed; we do not know which ones or how many, or what the consequences might be. The organisms killed might, for all we know, be at the base of a vast ecological pyramid at the top of which totter we.

The dust put into the air in a full nuclear exchange would reflect sunlight and cool the Earth a little. Even a little cooling can have disastrous agricultural consequences. Birds are more easily killed by radiation than insects. Plagues of insects and

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\* The process is similar to, but much more dangerous than, the destruction of the ozone layer by the fluorocarbon propellants in aerosol spray cans, which have accordingly been banned by a number of nations; and to that invoked in the explanation of the extinction of the dinosaurs by a supernova explosion a few dozen light-years away.