

the smallest doll is called the Planck length and is a millimeter divided by a hundred thousand billion billion. We are not about to build particle accelerators that can probe to distances that small. They would have to be larger than the Solar System, and they are not likely to be approved in the present financial climate.

"However, there are consequences of our theories that can be tested by much more modest machines. By far the most important of these is supersymmetry, which is fundamental to most attempts to unify Einstein's general relativity with quantum theory." Hawking said he is confident that physicists will discover the ultimate "theory of everything" by the end of the 21st century "and probably much sooner." In fact, he said, he would accept a bet "at fifty-fifty odds that it will be within 20 years starting now."

He gently chided the President for the cancellation of the Superconducting Super Collider. The US,

Hawking noted, "went through a fit of feeling poor and canceled the project halfway. At the risk of causing embarrassment, I have to say I think this was a very shortsighted decision. I hope that the US and other governments will do better in the next millennium."

Hawking was caustic on the subjects of population growth (currently doubling every 40 years), electricity consumption (doubling in 40 years or less) and "such heightened expectations that some people feel cheated by politicians and scientists because we have not already achieved the utopian visions of the future." He cited the 1960's film *2001*, which "showed us a base on the Moon and a manned, or should I say personned, flight to Jupiter. I can't see us managing that in the next three years, whoever wins the election."

Along with his predictions for physics, Hawking provided one for biology. "There has been no significant change for human DNA in the last 10 000 years. But it is likely that we will be

able to completely redesign it in the next 1000," he stated. "Of course, many people will say that genetic engineering on humans should be banned. But I rather doubt if they will be able to prevent it. Genetic engineering on plants and animals will be allowed for economic reasons, and someone is bound to try it on humans. Unless we have a totalitarian world order, someone will design improved humans somewhere."

At the end of his talk, Hawking declared that he expects complexity to increase rapidly in biology and physics. "Not much will happen in the next 100 years, which is all we can reliably predict. But by the end of the next millennium, if we get there, the change will be fundamental."

After Hawking left the room, Clinton joined the guests at a reception. When the President was asked about Hawking's predictions, he replied with a grin: "I'll no longer be seeking public approval for political decisions then."

IRWIN GOODWIN

WASHINGTON DISPATCHES

▶ Enlarging the Nuclear Club In April, a nationwide opinion poll of 800 American adults found that 90% feared nuclear weapons would spread to countries or groups that don't have these now. The survey, released by Washington's conservative Henry L. Stimson Center, ranked nuclear proliferation as high as violent crime, race relations and public education. One of their worst thoughts soon came true. India's newly elected Prime Minister, Atal Bihari Vajpayee, announced in an evening news conference on 11 May that his country's scientists had conducted three underground nuclear tests in the Pokharan desert, near the border with Pakistan, his nation's archrival.

Vajpayee, a Hindu nationalist elected less than three months earlier to head a weak coalition government, said the tests were essential to safeguard the nation's security—presumably from incursions by Pakistan or China. According to Indian scientists, the three tests involved a fission bomb, exploded to measure its yield, a particularly low-yield device set off as a test of miniaturization for a battlefield weapon or missile warhead and a small thermonuclear device to ascertain its capability. US nuclear experts believe the thermonuclear device was probably a trigger for a bomb.

US officials were shocked and disturbed by the turn of events. None of the US intelligence agencies had alerted the White House that the tests had been detected by the worldwide seismic or satellite networks until after the announcement from New Delhi. It was India's first test since an ambiguous explosion of a nuclear weapon in 1974. Ironically, though India had proposed the worldwide end of nuclear weapons in the 1960s, it steadfastly refused to sign the 1970 Nuclear Nonproliferation Treaty or the 1996 Comprehensive Test Ban Treaty. Within an hour of India's announcement, the head of Pakistan's nuclear program, Abdul Qadeer Khan, stated that his country would respond in "a matter of weeks." And the next day, India exploded two more devices at the underground site and declared that all tests had ended.

An arms race in the region bodes badly for the Comprehensive Test Ban Treaty. In fact, a spokesman for Jesse Helms, the North Carolina Republican who leads the Senate Foreign

Relations Committee, was quick to state that the CTBT was being shelved indefinitely. India's tests have "given us graphic and seismic evidence" that it will never participate in CTBT, he said.

▶ Safeguarding Old Soviet Nukes Among the contentious problems that remain unresolved since the breakup of the Soviet Union is how to safeguard nuclear material accumulated in several republics as byproducts of Soviet research and weapons—material that now is more of a liability than an asset for the republics. The Clinton Administration has expressed its worry about the situation, because it fears that the material may fall into the hands of terrorist gangs or renegade governments.

In 1994, Russia agreed to accept some nuclear material from Kazakhstan, but then failed to act. Warned that there was about half a ton of bomb-grade uranium for the taking, the White House ordered the Energy Department to remove the stuff and called on the US Air Force to transport the material to Oak Ridge National Laboratory, in a highly classified undertaking called Operation Sapphire.

Early last year, Georgia's president, Eduard Shevardnaze, who has been battling rebels in control of one-fourth of the country, asked the US to accept a cache of 4 kg of highly enriched uranium and about 10 kg of spent fuel from a research reactor located outside the capital, Tbilisi. The reactor was built in 1959 for Georgia's Institute of Physics, but it was shut down after the 1986 Chernobyl explosion. Shevardnaze approached Russia to take the nuclear material, and Russia's minister of atomic energy, Viktor Mihailov, publicly promised to remove the uranium and spent fuel by March 1997. He later reneged, stating that his country's laws prevent him from taking nuclear waste from any foreign country, even though Georgia is a former Soviet republic and its nuclear material was provided by the Soviet Union.

The impasse was resolved on 21 April when a US Air Force jet flew the nuclear material, bearing the code name of Auburn Endeavor, to a location in Scotland for safeguarding. The US itself had scotched the idea of accepting the stuff, said a White House source, because of potential legal challenges from American environmental activists.

IRWIN GOODWIN