"is dangerous and likely to fail." Weissman also said that testimony presented this summer from individuals with plans to clone humans raised serious questions about safety and monitoring (*Science*, 17 August 2001, p. 1237). Even so, the panel concluded that any ban should be revisited in 5 years because of probable research advances in related fields.

Funded by the National Academies themselves, the panel seconded an NAS study issued last fall that strongly endorsed so-called therapeutic cloning—making an embryo that can supply genetically tailored stem cells by inserting the DNA of a person's body cell into an enucleated egg. But it suggested that the procedure be labeled "nuclear transplantation to produce stem cells," rather than cloning, if the blastocyst is not to be implanted in a uterus.

One day before the panel issued its call for a "broad national dialogue" on ethical and societal aspects of a reproductive cloning ban, the president's bioethics council began a 2-day discussion on the larger issues surrounding human cloning, including therapeutic cloning. The newly appointed 18-member group includes three biologists and a clutch of doctors, lawyers, and public thinkers (www.whitehouse.gov/news/releases/2002/01/20020116-9.html).

Its chair, University of Chicago bioethicist Leon Kass, said that the group hopes to go beyond influencing public policy and stimulate a national debate about bioethics. "One feels a palpable increase in America's moral seriousness" since the terrorism attacks, Kass said in welcoming the group to Washington, D.C. He signaled a scholarly approach to the subject by leading a discussion of "The Birthmark," a story by Nathaniel Hawthorne in which a husband kills his wife while trying to make her perfect.

Calling cloning "the hot topic in bioethics circles today," Kass said that the panel "would be remiss not to try to clarify the subject and place it on the most solid moral ground. Public concern stems from the intuition that what's at stake here is what it means to be a human being."

Although council members all seemed to take a dim view of cloning for reproduction, they are clearly divided on the virtues of therapeutic cloning. For example, Michael Gazzaniga, a neuroscientist at Dartmouth College, thought harvesting cells from a blastocyst was no more problematic than harvesting an organ from a brain-dead patient. Others, including Kass himself, believe that a complete ban on all related work is needed even if the goal is only to prohibit the implantation of cloned embryos.

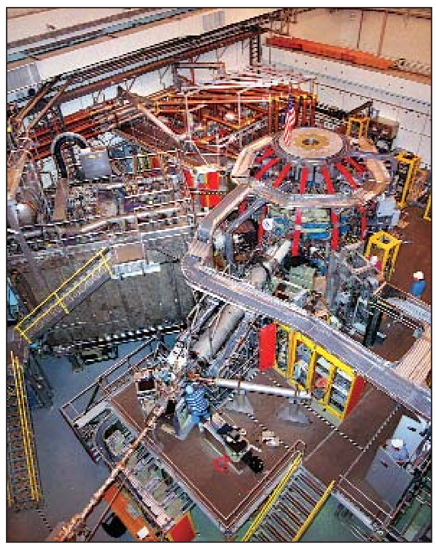
Kass warned reporters that the group plans to move with deliberate speed. The council will meet every couple of months and will convene next month to talk more about cloning. He said to look for a report, with policy guidance, by the summer.

–CONSTANCE HOLDEN AND JOCELYN KAISER

FUSION POWER

Spherical Tokamaks Are on a Roll

Results from two fusion experiments, one in the United States and one in the United Kingdom, suggest that making a reactor, or tokamak, spherical with a hole through the middle—like a cored apple—may be more efficient than the traditional doughnut shape. The two machines both managed to confine a hot plasma of hydrogen ions in the dense, calm state used by traditional machines—an important first step toward fusion. Spherical reactors "may in the end be a better bet for a fusion reactor than the conventional … tokamak," says Geoff Cordey, a plasma physicist at the Joint European Torus (JET) in Culham, near Oxford, the world's largest conventional tokamak. Still, he cautions, it's not yet a new ball game: "It's very, very early days."



Smooth operator. Princeton's National Spherical Torus Experiment.

Nuclear fusion—the process that powers the stars—promises almost limitless energy with little nuclear waste. But researchers must first find a way to squeeze atomic nuclei together against their electromagnetic repulsion, close enough that pairs of them fuse into a new species of nucleus the mass of which is less than the combined starting masses. The missing mass emerges as energy. In tokamaks, heat does the squeezing: A whirling gas of hydrogen ions, or plasma, is held inside a big vacuum chamber by magnets and heated to millions of degrees by passing electrical currents through it or firing beams of atoms into it.

Doughnut-shaped tokamaks, such as JET and Princeton's Tokamak Fusion Test Reactor, have managed to achieve fusion, but the amount of energy put in to keep the reactor running far exceeds the amount of energy produced. To reach or even exceed the breakeven point and produce excess energy, researchers say they will have to build the biggest tokamak so far, the $4.2 billion International Thermonuclear Experimental Reactor (ITER). Governments around the world are currently considering whether to go ahead and build the machine.

Proponents of spherical fusion, however, think it can be done more simply and cheaply. A brace of papers in this week's issue of *Physical Review Letters* shows that the Mega Amp Spherical Tokamak (MAST), also in Culham, and the National Spherical Torus Experiment (NSTX) in Princeton have both made first base by achieving high plasma confinement mode, or H-mode. Like a river that regains its composure downstream from white-water rapids, the H-mode is a smooth, dense flow of plasma that is twice as good as the lower density, more turbulent flow at retaining heat. "All the tokamak reactor proposals use H-mode," says Cordey. Alan Sykes, head of the physics team at MAST, adds: "It wasn't obvious that spherical tokamaks would be able to access this higher mode of confinement."

Interest in spherical tokamaks began in the early 1980s when Martin Peng and Dennis Strickler of Oak Ridge National Laboratory in Tennessee suggested reshaping the torus. Their work attracted little attention until experimenters at Culham cobbled together a baby spherical tokamak. "That was very successful indeed, and the world saw that spherical tokamaks seem to produce good, high-quality plasmas," says Sykes. The upshot was a whole new generation of spherical machines, of which MAST and NSTX are the largest.

The potential advantage of the spherical tokamak is that it takes less magnetic field to give the same level of plasma control. This is because the magnetic field lines in a tokamak spiral like a helical spring down around the central hole before looping back from bottom to top via the outer reaches of the container. Crucially, it's the spiral around the hole that imparts stability to the plasma. Because a spherical tokamak turns the central hole into a long, narrow tube, the magnetic field lines can not only wrap round more tightly, but they do so over a much greater distance. Hence spherical tokamaks make much more efficient use of their magnetic fields and are better able to resist the plasma's urge to break free, says Rajesh Maingi, who led the NSTX search for the H-mode. This improved efficiency translates into as much as nine times the fusion output of the corresponding doughnut tokamak, according to Masa Ono of the Princeton Plasma Physics Laboratory, a co-leader with Peng of NSTX. What's more, it's "simpler and smaller engineering construction," says Sykes.

Although the performance achieved by these first attempts is promising, "they are quite a long way off from a reactor," says Cordey. The spherical tokamaks must increase their temperatures 10-fold to reach that in JET and ITER—about 150 million degrees Celsius—while still keeping the plasma stable, he says. Sykes worries that such a small spherical machine may require impossible power densities when working as a real reactor. ITER remains the main focus for fusion researchers. Delaying or rejigging this $4.2 billion project "would be a big mistake," says Cordey. The hope is to develop ITER and spherical tokamaks in tandem. "It may be that after ITER, when utilities want to build a fusion power plant, they find that the spherical tokamak is a more economical way of doing it," says Sykes.

–ANDREW WATSON

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HIGH-ENERGY PHYSICS

Atom Smasher Probes Realm of Nuclear 'Gas'

"Oh, that this too too liquid nucleus would evaporate." If Hamlet were a nuclear physicist, he might be feeling a bit more cheerful. Strange as it may seem, atomic nuclei do sometimes act like liquids, and when blasted apart at high enough energies they can sizzle into gas. Now scientists working at Brookhaven National Laboratory in Upton, New York, have charted the conditions under which gold nuclei make that leap, information that might help unravel the secrets behind the birth of a neutron star.

The work builds on a model that physicists cooked up in the 1930s to explain the fission of uranium. A neutron striking a nucleus more than 200 times its mass doesn't just knock off a chip or two; it splits the nucleus neatly in two. Physicists realized that the uranium nucleus is behaving like an oversized drop of water. When it is struck by a neutron, the nucleus oscillates, stretches out, and then blurps into two roughly equal parts (throwing off a few smaller fragments, such as neutrons, in the process). "Everyday garden-variety nuclei behave like a liquid," says Victor Viola, a physicist at Indiana University, Bloomington. "It's a very successful description."

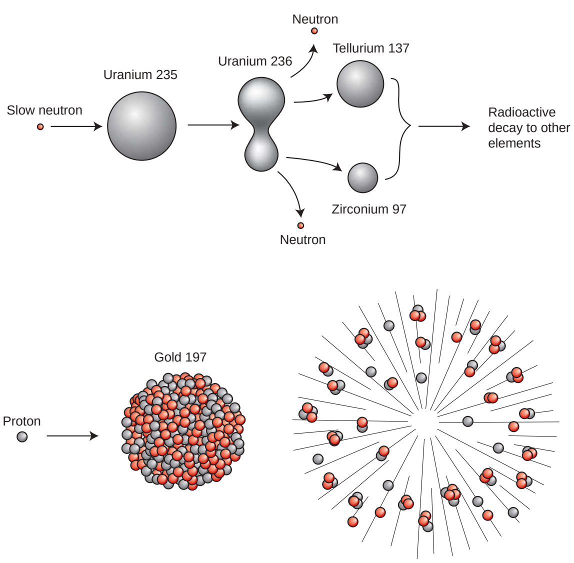
Viola and colleagues decided to take the liquid analogy one step further by determining the nucleus's equation of state—the relations between pressure and temperature that govern when the nucleus behaves like a gas and when it behaves like a liquid. At Brookhaven, they shot protons, pions, and antiprotons at thin gold foil, adding energy that brought the gold nuclei to a boil. Meanwhile, a device called the Indiana Silicon Sphere (ISiS)—a beach ball–sized sphere studded with 450 detectors—kept careful track of the size and energy of the particles that flew off.

The physicists analyzed the readings in two different ways. The first starts with the distribution of the sizes of chunks that fly out of the nucleus. "In boiling water, you don't get individual water molecules coming off," says Viola. "You get dimers, trimers, tetramers. The temperature of the vapor is related to the relative numbers of those clusters." By comparing the energy added to the nucleus (hence its "temperature") with the relative abundances of fragments, the physicists figured out the properties of the nuclear "liquid," including its critical temperature: the point above which the liquid phase can no longer exist, which they calculate at about 7 million electron volts (MeV). The second analysis directly models the breaking and making of nuclear bonds and comes up with a slightly higher critical temperature, slightly above 8 MeV.

"I do think it's a really nice piece of work they've done," says Joseph Natowitz, a physicist at Texas A&M University in College Station, who thinks that physicists will resolve the discrepancy once they get a better grip on how the nucleus expands and breaks up after the collision. "I have some ideas."

Even though wrinkles need to be ironed out, the results have given

ILLUSTRATION: C. SLAYDEN



Steamed. Physicists gave liquid-drop model of fission (top) a new twist by "evaporating" gold nuclei (bottom).

ScienceScope

Bioweapons Cleanup The United States and Uzbekistan are close to finalizing plans for a $6 million cleanup of a former Soviet bioweapons facility. The effort is aimed at preventing terrorists from harvesting live anthrax spores from a secret dumping ground.

For nearly 60 years starting in the 1930s, the Soviets released anthrax, plague, and other weaponized pathogens on Vozrozhdeniye (Resurrection) Island in the middle of the Aral Sea. In 1988, at the end of the Cold War, weaponeers buried tons of a particularly potent strain of powdered anthrax at the site, mixing the bacteria with bleach in steel drums to kill it. But several years ago testers found that some of the anthrax is still alive, and water diversions from the shrinking Aral Sea have since opened a land bridge to the once isolated island. Fearing that terrorists might try to harvest ready-made bioweapons from the site, U.S. officials agreed in October to pay for destroying the anthrax and a nearby testing facility.

Next month, U.S. experts—including researchers at the Department of Energy's Sandia National Laboratory in Albuquerque, New Mexico—are expected to meet with Uzbeki authorities to work out the details, Richard Tucker of the Monterey Institute of International Studies last week told a briefing organized by the Carnegie Endowment for International Peace in Washington, D.C. One possible approach, researchers say, is to soak the 11 burial pits with a strong antibacterial solution.

Backtracking The Jones Institute for Reproductive Medicine, which drew heavy criticism last summer when it revealed it had fertilized donated human eggs solely for the purpose of generating stem cells, has changed its priorities. Last week the institute, a private clinic that is part of Eastern Virginia Medical School in Norfolk, announced that it won't be generating any new human stem cell lines.

The reasons are partly political, according to Roger Gosden, the institute's new scientific director. After a state lawmaker recently introduced legislation that would have criminalized the creation of embryos for research, "my scientific priorities had to become public," says Gosden. The bill was withdrawn, but Gosden says the institute hopes to secure federal funds that can't go to research involving the controversial embryos. The institute will now focus on animal studies to identify molecules involved in reprogramming a cell's nucleus so that it will revert to a primordial state.

Contributors: Eliot Marshall, David Malakoff, and Constance Holden