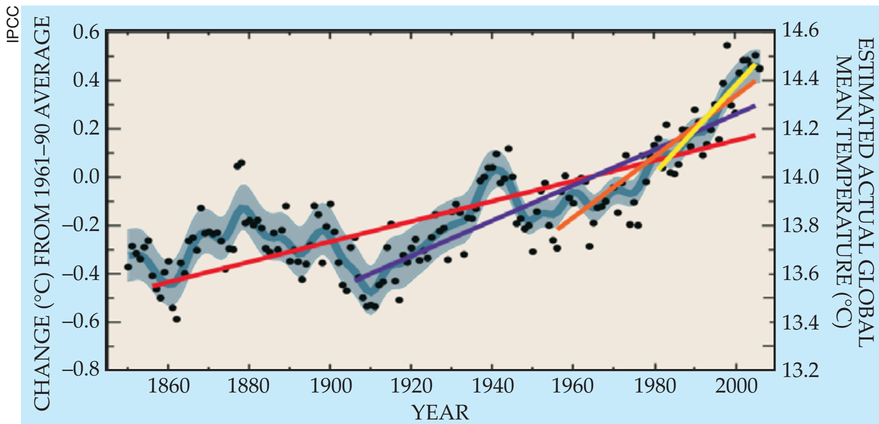


The IPCC's fourth assessment report contains details of the global mean observed temperatures (black dots) along with simple fits to the data based on the last 25 (yellow), 50 (orange), 100 (purple) and 150 years (red). The left axis shows anomalies relative to the 1961 to 1990 average and the right axis shows the estimated actual temperature.

Framework Convention on Climate Change or the Kyoto Protocol would have been developed," he says. "I also doubt that the current political movement on the issue that appears to be developing in response to observed changes in the climate and related public concern would have gotten organized quite so rapidly."

"The Nobel committee's recognition affirms that policymakers need to listen to the best available science and act upon it to avoid dangerous climate change," says Union of Concerned Scientists policy director Peter Frumhoff. That's not happening yet, though. Asked in a White House press conference if the Nobel Prize will pressure the administration to adopt a more proactive approach toward combating climate change, White House spokesman Tony Fratto replied, "No."

"The award certainly hasn't discouraged the climate-change deniers, who seem to have stepped up their attacks," says Monbiot. "It does, however, help to reinforce the case that the protection of the environment is critical to peace and human welfare and should no longer be seen as a fringe issue by policymakers and the public."

Oppenheimer agrees. "The public learns about complex issues through leaders, not organizations; but leaders learn about the problem from organizations like IPCC," he says. "The award will add further momentum to the accelerating engagement of politicians and the public toward solving the problem. But most important, it is a reward to those scientists who feel an interest or obligation to become involved in the public arena, and that acknowledgment is a very healthy development, for science and for the well-being of the world."

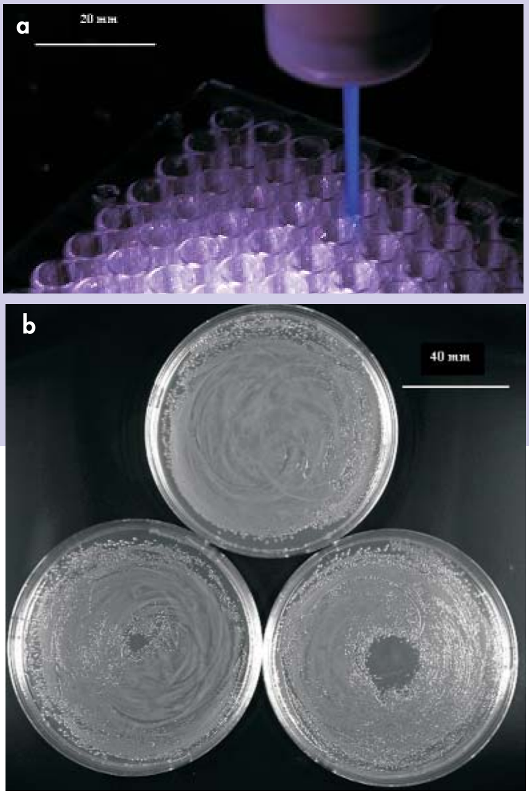
Paul Guinnessy

Cold plasmas enter the biomedical arena

With a host of prototype devices headed for the biomedical market, cold plasmas could become the hot new trend in cutting-edge health care.

Plasmas are the most common substance in the visible universe, and our ability to create them has led to their routine use in a wide range of industrial applications. In recent years, the ability to create room-temperature cold plasmas at atmospheric pressures has driven strong interest in developing them for biomedical applications. A handful of prototype cold-plasma devices are now being tested for clinical use.

Arc welding machines use searing-hot plasmas to cut and weld metals, and plasmas play a key role in nuclear fusion. But cold plasmas also have their applications. They are used in flat-screen plasma TVs, in the processing of plastics, and for the application of coatings in materials processing. Because they generate free electrons that react easily with other atoms, plasmas can be used to etch metals, to fabricate electronic circuits in the semiconductor industry, and to burn off organic contaminants via chemical reactions during wafer manufacturing.



The plasma pencil in operation (**a**). In (**b**), petri dishes hold *Escherichia coli* bacteria cultures. The top dish was not exposed to the plasma; the lower left and right dishes were exposed for 30 seconds and 120 seconds, respectively. The dark circles in the middle are regions in which bacteria colonies have been destroyed by the plasma pencil. (Photos courtesy of Mounir Laroussi, Old Dominion University.)

"Cold" is a relative term: Many cold plasmas have temperatures on the order of 100 °C. That is far too hot to be applied safely to biological cells, but cold plasmas have proven useful for decontaminating surfaces and sterilizing drinking water, according to Karl Schoenbach, who heads a new center for bioelectrics at Old Dominion University (ODU) in Virginia.

Cold plasmas inactivate bacteria through a combination of the plasmas' free radicals, charged particles, and emitted UV radiation, all of which work together to disrupt the integrity of bacterial cell membranes. For example, experiments funded by the US Air Force Office of Scientific Research have demonstrated that plasmas can break down within minutes the complex chemicals found in nerve gases and biological toxins such as anthrax, compared with the hours required for standard decontamination methods.

"Radicals can denature proteins and oxidize the lips of the cell membrane," explains Mounir Laroussi, who has been researching cold plasmas for almost two decades and is now director of ODU's Laser and Plasma Engineering Institute. "UV radiation can damage the DNA strands, while charged particles can charge the cell wall and cause electrostatic disruption."

A critical breakthrough occurred when researchers succeeded in developing techniques to create truly room-temperature plasmas at atmospheric pressures in the laboratory. "The technology [of cold ionized gases] has matured to such a degree that there are now working devices on the market, and doctors are starting to use them in their clinical practice," says Laroussi.

ODU's center for bioelectrics opened in 2003 with a $5 million grant from the US Air Force Office of Scientific Research. The center operates jointly with the Eastern Virginia Medical School to study how electromagnetic fields and ionized gases interact with biological cells. Fully half of its research program is devoted to the use of cold plasmas in medicine. Numerous start-up companies scattered across the US have prototype cold-plasma technologies in various stages of development, and in Europe, rudimentary cold-plasma "jet guns" are already being sold to medical professionals. In October, a group of plasma scientists, medical professionals, biologists, and biochemists gathered in Corpus Christi, Texas, for the first International Conference on Plasma Medicine.

Surgery without cutting

Eva Stoffels-Adamowicz of Eindhoven University of Technology in the Netherlands has called cold plasma "the surgery of the future," although, technically, it is "surgery without cutting." Cold plasmas have been shown to cause cells to temporarily detach from each other, and the detachment makes it easier to remove dead or diseased cells or to move healthy cells to an injured area to accelerate wound healing. During the healing process, bacteria, dead cells, and other debris are removed, and chemicals are released that prompt new cells to migrate to and proliferate at the wound site, where they gradually rebuild the tissue.

Stoffels-Adamowicz has developed a plasma needle for precise removal or manipulation of cells and for bacterial disinfection of wounds and dental cavities. Her device is a thin tungsten wire about 50 mm long, housed in a gas-filled quartz tube. Driving a voltage through the needle generates a small plasma spark at the tip. She hopes to further improve the device by including a scanning probe in the needle: a smart sensor capable of detecting surface irregularities in living tissue. That improvement will result in more precise control over the plasma tool. Eventually the plasma needle might be used to remove tumors or skin cancers.

The kind of plasma produced can make a difference. In the semiconductor industry, fluorine plasmas are used in etching applications, while oxygen plasmas are useful for removing organic contaminants. For biological decontamination, air is often preferred because air contains both oxygen and nitrogen and thus produces highly reactive plasmas. Stoffels-Adamowicz's plasma needle produces nitric oxide, which the body uses to fight infection and inflammation.

For his handheld plasma pencil, ODU's Laroussi opted for helium because its effective heat dissipation keeps the discharge cool and the plasma stable. The plasma pencil then can be safely applied to delicate surfaces, such as human skin, and can kill bacteria without damaging surrounding tissue. Unlike Stoffels-Adamowicz's plasma needle, which generates small plasmas of very short lengths, the pencil creates a long plasma plume measuring up to 5 centimeters.

The trick to producing a stable, room-temperature plasma of that length is to pulse the electrical energy source as much as 1000 times per second, according to Laroussi. "The timed pulses keep the temperature down and energize the plasma plume so that it reaches 2 inches past the end of the pencil," he says. The plasma does not arc or overheat, even during long periods of use.

Laroussi has conducted experiments to demonstrate that the plasma beam can kill *Escherichia coli*, for example, with no adverse effect on surrounding skin. Other groups have demonstrated the effectiveness of cold plasmas in destroying various kinds of viruses and bacteria, including salmonella. Further refinements could make the device suitable for removing dental plaque or cancerous tissue. The plasma pencil appears to kill bacterial cells selectively, perhaps because they are simpler in structure and their DNA is not as well protected as in mammalian cells.

To make sure that the cold plasmas weren't killing healthy cells and thus hindering regeneration in the wound-healing process, Laroussi and several colleagues conducted simple experiments using worms, cutting their tails and applying the plasma pencil to the wound. "If it didn't grow back, we would know we had done something bad to the normal cells," he said. "But they all grew back, so we have a preliminary indication that this plasma has a non-negative effect on cell regeneration."

A "bloodless scalpel"

Yet another prototype device is the plasma blade system being developed by Peak Surgical (Palo Alto, California). For decades surgeons have relied on scalpels to cut skin and delicate tissues, but such tools don't control bleeding. Electrosurgical devices can both cut precisely and control bleeding by cauterizing the wound site, but they also cause thermal damage to surrounding tissue. The plasma blade system offers surgeons the best of both worlds by enabling them to cut precisely and control bleeding using a highly focused plasma concentrated at the very edge of the device, without heat damage to surrounding healthy tissue.

The plasma blade differs from both the needle and the pencil in that the plasma actually makes cuts, while it simultaneously reduces bleeding. Platelets, which are critical to blood clotting, are activated by cold plasmas, although the exact mechanism is not yet understood. The cold plasmas also fight infection, reduce inflammation, and thereby accelerate wound healing.

Originally developed at Stanford University and licensed by the company for commercialization, the plasma blade uses RF energy produced by a small 4-MHz generator about the size of a DVD player. "The pulsed energy hits the target tissue and starts to break it down into charged particles, creating a plasma cloud," says Andre Bessette, Peak Surgical's vice president of marketing. "This plasma cloud acts as a conductive medium to allow more energy transmission at lower power. The lower temperatures lead to less thermal damage."

The instrument tip is a proprietary insulated electrode made out of metal, stainless steel or tungsten. The plasma forms right at the metal tip, which never touches the tissue. The system has been successfully tested on retinal tissue; the most recent clinical studies on healing of surgical incisions were conducted using pig skin. Those studies found that use of the plasma blade system resulted in "stronger, faster wound healing" compared with conventional scalpels and electrosurgery techniques, according to Peak Surgical CEO John Tighe. "Compared to a scalpel, we had 60% less bleeding," a finding that led him to dub the blade a "bloodless scalpel."

There is still a tremendous amount of scientific investigation to be done, according to Schoenbach, who sees a need for more funding of basic research on cold plasmas. "We don't understand very much about the underlying mechanisms" of these emerging tools, he explains. Cold plasmas effectively kill bacteria and improve blood coagulation, "But what is causing these effects, and how can we gain better control over the plasmas?"

For the researchers working on cold plasmas for biomedical applications, the current crop of crude devices poised for clinical use is just the beginning of a broader trend. "We are on the cusp [of greater things]," says Laroussi. "We think cold plasma will have an increasingly bigger role to play in healthcare and could revolutionize the way in which plasmas can be used in medicine."

Jennifer Ouellette

White LEDs poised for global impact

Cities around the world are discovering that solid-state lighting costs less and produces fewer greenhouse emissions than incandescent or fluorescent lights.

Rural villagers in Nepal rely on kerosene lamps to light their homes, and they aren't the only ones to do so. Worldwide, around 1.6 billion people—most of them in developing countries—don't have access to electricity and must rely on fuel-based sources for lighting.

Inadequate lighting represents a significant barrier to future development, according to David Irvine-Halliday, a professor of electrical engineering at the University of Calgary in Canada and