once considered possible, notes steering panel member David Farmer of the Institute for Ocean Sciences in Vancouver, British Columbia. Farmer's own work with side-scanning sonar (see graphic) has shown that it is possible to identify individual fish from up to 10 kilometers away. Such sensors, mounted on seagoing "tollgates" installed along migratory routes, could provide valuable insights into population movements.

One major problem for the census takers will be deciding where to deploy such relatively expensive technologies. "The question is how many cleverly designed projects you'll need to put together a good global picture," says Ausubel. Possible targets for the next phase of the census include poorly understood environments, such as sea mounts and deep-sea vents, and heavily fished regions, such as the Gulf of Maine or the Alaskan coast.

The census has won support from biologists involved in policy-making, such as Mike Sissenwine of the National Marine Fisheries Service in Woods Hole, Massachusetts. "It's a wonderful grassroots scientific effort, and the spin-offs will be tremendous," he predicts. Grassle hopes the census will also revive such fields as systematics and biogeography. "They used to be central themes in marine science, but they've become peripheral," he says. "We want to bring them back to the center."

Achieving that will require money, and Ausubel and others are optimistic that the United States, Japan, and European nations will help foot the bill, along with private foundations. At the same time, the organizers are careful not to promise too much. "We're still developing exactly what we mean by census," says Grassle, whose working definition is "not counting everything, but doing a much better job of surveying ocean life." Such an effort would still represent a compelling opportunity, says Ausubel: "Even if the full census is never realized, this is something that will be very useful."

–DAVID MALAKOFF

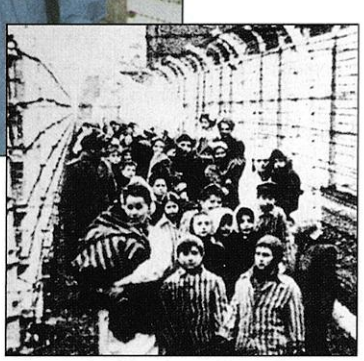
NAZI RESEARCH

Reopening the Darkest Chapter in German Science

As historians dig up disturbing new details about the complicity of German researchers in Nazi-era crimes, officials are calling for full disclosure

BERLIN—More than a half-century after it happened to her, Eva Mozes Kor can still recall the mysterious injections, the frequent blood tests, and the dark-haired young man with a hawklike brow who hovered over her bed one day, waiting for her to die. Kor would disappoint her tormentor: Neither she nor her twin sister, Miriam, succumbed to Nazi physician Josef Mengele and his World War II experiments on prisoners, mostly Jews, at the Auschwitz-Birkenau concentration camp. But the sisters did not emerge unscathed. To this day, Kor says she agonizes over not knowing what Mengele injected into her and Miriam, and for what nefarious purposes their blood was used. And she has waited in vain for an apology from any scientific institution whose Nazi-era predecessors had used Mengele's results. An apology, says Kor, who lives in Terre Haute, Indiana, "would mean a great deal to survivors. Why can't they do this simple thing?"

That question reverberates through the modern-day German scientific community, which regards Mengele as a murderous maverick but is now focused on the complicity of more legitimate researchers. Last month, at a meeting* here sponsored by the country's main science granting agency, DFG president Ernst-Ludwig Winnacker acknowledged that the wartime DFG "had allowed itself to be made into an instrument of a criminal regime. As part of Hitler's state, it allowed crimes against humanity under the guise of science." And new evidence involving Nobel laureate Adolf Butenandt, wartime director of the biochemistry institute of the prestigious Kaiser Wilhelm Society, suggests that the cover-up of certain Nazi-era abuses, and the postwar scientific community's embrace of dozens of tainted researchers, was more widespread than previously imagined.



Mengele's victims. Twins experiment subjects Eva (at right closest to nurse, front) and Miriam Mozes as they are being liberated from Auschwitz. Eva and Miriam at the same spot in 1991 *(above)*. Eva says she has only a vague idea of what was done to her and her sister.

CREDITS: COURTESY EVA MOZES KOR/C.A.N.D.L.E.S. HOLOCAUST MUSEUM AND EDUCATION CENTER

With the past appearing in an ever more sinister light, both Winnacker and Hubert Markl, president of the Kaiser Wilhelm's postwar successor, the Max Planck Society, contend that a public apology would be a hollow gesture. Instead, they have launched separate historical inquiries into the abuses of the Kaiser Wilhelm institutes and the DFG during the Nazi era and postwar years. "We need to do this not only for the victims but for future generations of scientists," Markl says. "We must make clear how murders and other criminal acts could have been conducted in the name of science in Germany."

Exposing the past. Much is already known about the horrors of Nazi-era science. Although Mengele found refuge in South America, details about his research emerged from eyewitness testimony. In his infamous twins study, for instance, Mengele would inject one twin with a toxic substance or pathogen while using the other as a control. At the postwar Nuremberg "doctors' trial"—which ended in 1947 with the conviction of 15 defendants, seven of whom were hanged—prosecutors outlined a series of cruel experiments to test the limits of endurance. Prisoners were exposed to everything from mustard gas and malaria to freezing-cold seawater and high-altitude conditions of low pressure and scarce oxygen. The evidence also shows how the Kaiser Wilhelm Institute of Psychiatry exploited Nazi pogroms to obtain the brains of mentally ill people for

* "Science and Science Policy: Interactions, Continuities, and Inconsistencies From the Late Empire to the Early German Federal Republic/Democratic Republic," 18 to 20 May.

analysis. However, many scientists in the Nazi regime escaped punishment by claiming that they were pawns—not willing participants—in the research.

Today, science historians are accumulating new details on this dark chapter of German society through painstaking analyses of fresh archival materials (see table below). "We aren't limiting ourselves to the old Kaiser Wilhelm Society files; we are examining the full range of archives, both in Germany and abroad," says Carola Sachse, a historian who directs the Max Planck commission's six-person historical research team in Berlin.

Earlier this year, Markl gave this group access to the sealed personal files of Butenandt, a biochemist who won a Nobel Prize in 1939 for isolating sex hormones. The Max Planck team offered the first crack at the files of Butenandt, who died in 1995, to Robert N. Proctor, a history professor at Pennsylvania State University, University Park. In a lecture in Berlin last week, Proctor, an expert on Nazi medicine, said letters in the archive show that Butenandt was aware of and supported a research project involving blood samples from Auschwitz in an unsuccessful effort to find disease-fighting proteins specific to race.

The project, first detailed by German molecular geneticist Benno Müller-Hill in his 1984 book *Murderous Science*, was led by Butenandt's friend Otmar von Verschuer, then director of the Kaiser Wilhelm Institute for Anthropology, Human Genetics, and Eugenics. Many of the blood analyses were carried out by a Butenandt subordinate, Guenther Hillmann. Given Butenandt's close ties to Verschuer and Hillmann, Proctor told *Science*, "it is reasonable to assume that he knew where the samples came from"—although no document unearthed so far confirms this. To his death Butenandt denied that he was aware of Auschwitz or the Verschuer-Hillmann project during the war.

Proctor has managed to cull a few other nuggets from the 80-meter-long Butenandt archive, despite his observation that it appears to have been "highly sanitized." Near the war's end, Butenandt ordered Hillmann in a letter to destroy all files that lay in an institute safe marked "Geheime Reichsache"—a top-secret Nazi classification. Proctor also found evidence that Butenandt participated in a series of Luftwaffe (Air Force) experiments at the Rechlin flight-test station, although the nature of the research remains unclear. Earlier historical work had documented that one of Butenandt's postdocs had put six epileptic children in a Luftwaffe low-pressure chamber to try to distinguish inherited from noninherited epilepsy.

Immediately after the war, Proctor says, Butenandt became "a one-man whitewashing machine," defending Verschuer and other prominent scientists during the period in which the victorious Allied powers decided which former Nazi scientists should keep their posts. Butenandt became one of the most influential figures in postwar German science, heading the Max Planck Society from 1960 to 1972.

Butenandt's defenders contend, as he always maintained, that he had no direct connection to any of the villainous Nazi projects involving his institute. "I doubt very much whether he knew any of the details related to Verschuer's project," says German biochemist Peter Hans Hofschneider, who knew Butenandt for many years.

Also coming under increasing scrutiny are the DFG's activities during the Nazi era. At the Berlin meeting, Ruhr University historian Lothar Mertens charged that DFG leaders who were members of the Nazi party, such as Rudolf Mentzel, had "misused their power" by allowing Nazi policies to influence their grant-supervision duties and by ordering "a systematic destruction of files" that documented the DFG's pre-Nazi support of Jewish professors. Nearly all of the professors were later expelled from German universities.

Winnacker says he is appalled by the sheer number of scientists engaged in questionable research during the Nazi era who, after the war, were handed prominent university positions—not to mention DFG funding. One was Verschuer, whose Nazi ties prevented him from establishing a postwar Max Planck institute but who did become a professor at Münster University. There he formed what became a major West German center of genetics research. "There were many others like him," says Winnacker.

Coming to terms. As new revelations come to light, German science officials are groping for the best way to respond—and lay the ghosts to rest. Müller-Hill, for one, has urged Markl and Winnacker to bring Kor and others to Germany to discuss historical findings and to apologize. "Max Planck and the DFG should jointly invite some survivors and show that German science can fully face its past," Müller-Hill says.

But Markl and Winnacker have indicated that they want as complete an accounting as possible of the collusion between the Nazis and the scientific community before formulating an appropriate response from their organizations. Today's science historians "owe it to the survivors to fully investigate research during those terrible years and to inform the world of exactly what did happen," says Winnacker. To that end, the DFG has set up an expert panel to oversee groups that, over the next several years, will scrutinize the agency's history.

Max Planck has already begun such a review. Saying in 1998 that the society "has done too little, for too long, to explore its predecessor's history," Markl set up a commission that's now analyzing wartime research at the Kaiser Wilhelm institutes. Markl wants to wait until the commission completes its work—perhaps in 3 years—before deciding on an appropriate formal response to the Nazi-era abuses. Some members of the Max Planck history team assert that enough is known already to warrant a formal apology. But Paul Wiendling, an expert on Nazi-era medical research at Oxford Brookes University in the United Kingdom, suggests waiting until the research is more complete: "You need to know what you are apologizing for," he says. In the meantime, the society is willing to share what information it possesses. If victims of Nazi-era research request documents relating to their cases, says Markl, "I would not withhold anything. I would send their letter to the commission and ask that they provide any materials that are available."

For her part, Kor, 66, holds out little hope of learning more about Mengele's experiments. She continues to wonder whether they contributed to the death of her sister Miriam in 1993 from an unusual kidney ailment. Liberated from Auschwitz when she was 11, Kor later founded an organization of twins who survived Mengele's research. According to Kor, many of the 100 or so surviving twins who are members of C.A.N.D.L.E.S.—after "Children of Auschwitz; Nazi Deadly Lab Experiments Survivors"—are in poor health. And all are haunted by the same question, she says: "What was done to me, and for what scientific purpose?" –ROBERT KOENIG

WHEN SCIENTISTS AND NAZIS COLLUDED

Key areas of ongoing research being examined by a six-member Max Planck commission team probing the Nazi-era history of the Kaiser Wilhelm institutes:

- **Attempts to document racial differences through the use of specimens or samples from concentration camp victims**
- **Weapons research done in collaboration with scientists at the I. G. Farben and industrial conglomerate**
- **The plunder of Soviet seed banks and the use of slave labor for agricultural research at Auschwitz**
- **Research conducted on the brains of victims of systematic killings**