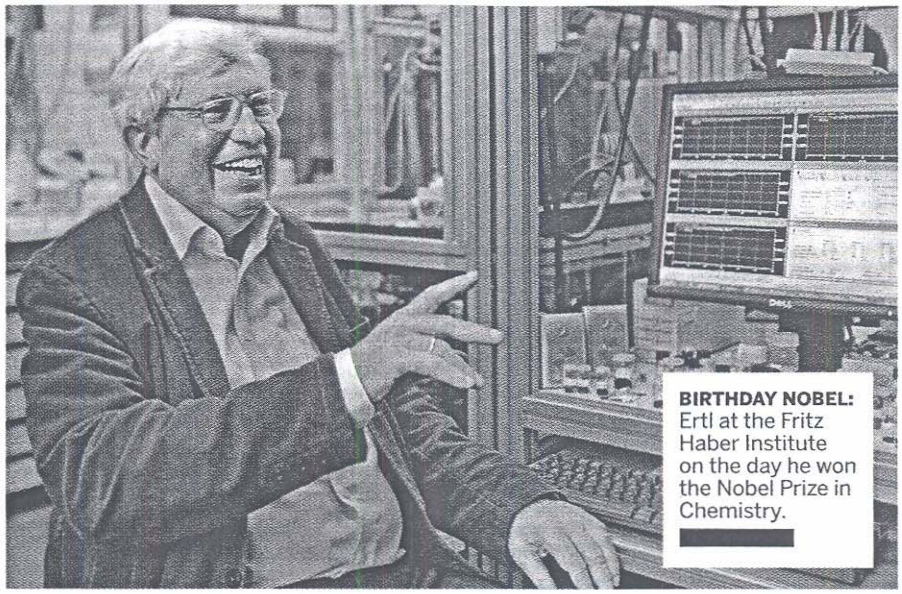

JOHANNES EISELE/DPA

BIRTHDAY NOBEL: Ertl at the Fritz Haber Institute on the day he won the Nobel Prize in Chemistry.

SURFACE SURVEYOR

Gerhard Ertl's mapping of chemical landscapes landed him the **2007 NOBEL PRIZE** in Chemistry

SARAH EVERTS, C&EN BERLIN

WHEN HE WAS A BOY, Gerhardt Ertl told his mother he wanted to be a surveyor, someone who charts the landscapes of cities and countrysides. But she nixed the idea, saying, "If you do that you'll always have dirty shoes."

So instead, Ertl spent a career mapping how chemicals react on microscopic landscapes, a pursuit that secured him this year's Nobel Prize in Chemistry.

More specifically, the Nobel Committee commended Ertl, now professor emeritus at the Fritz Haber Max Planck Institute in Berlin, "for his thorough studies of fundamental molecular processes at the gas-solid interface." Ertl will receive the award in Stockholm on Dec. 10.

The border between solid and gas is at the heart of everyday life. This interface is where metal catalysts clean up the gaseous pollutants created as side-products in your car's combustion reaction. This interface is also where metal catalysts split dinitrogen gas molecules to make the ammonia used for fertilizer production that likely hastened the growth of your dinner vegetables.

"When Ertl began studying the gas-solid interface, surface science was pretty much a black box," says Charles Campbell, a chemist at the University of Washington, Seattle; the editor-in-chief of *Surface Science*; and a former postdoc of Ertl's. "Throughout his career he has systematically pieced together atomic level understanding of surface catalysis."

Born near Stuttgart in 1936, Ertl grew up taking radios apart, conducting chemical reactions in his bedroom, and playing piano. As a university student, he studied physics, supporting himself by joining a band that performed in dance halls and at weddings. When Ertl began his doctorate in physical chemistry at the Technical University of Munich in 1962, he asked his thesis adviser, Heinz Gerischer, if there was an emerging field that he might study for his dissertation. Gerischer told him that there was almost nothing known about the solid-gas interface. Ertl quickly got hooked. "The field was so exciting," says Ertl. "It was a completely unexplored country that you could march into and investigate. Whatever you picked up was new."

In 1968, Ertl got a professorship at the relatively early age of 31 at the University of Hannover. "It was an exciting time in the lab," says Klaus Christmann, who joined Ertl's research group in the late 1960s. "In

MORE ONLINE Listen to music set to oscillating reactions that was composed for Ertl's retirement at *C&EN Online* www.cen-online.org.

those days, to motivate us in the lab, he would write an abstract for a conference promising data we hadn't yet taken," says Christmann, now a physical chemist at the Free University in Berlin. "This really got us working."

EVEN AMID the stiff decorum of the German academic system, where the more formal "Sie" was used to address coworkers instead of the familiar "du," Ertl "always treated everyone with a great deal of respect," Campbell says. "He would sit down and have a beer with you, smile easily, and make you feel important."

"He had a magic ability to convince and motivate his coworkers to do what he wanted them to do," says Klaus Wandelt, a physical chemist at the University of Bonn, who was also an early student of Ertl's. Wandelt recalls that one could go into Ertl's office with contrary ideas, but leave with a total change of heart, fully convinced that Ertl's ideas were best for you.

Christmann points out that the level of dedication of those in Ertl's group was so high that in 1973, when Ludwig Maximilians University recruited him for the chair of physical chemistry position, all 10 members followed him from Hannover to Munich. Ertl moved to the Fritz Haber Max Plank Institute in Berlin in 1986, and again his entire lab group, then near 30, made the move with him.

Many of these faces, captured in group photos over a 40-year career, now grace the wall of Ertl's office at the Fritz Haber Max Planck Institute.

The faces of eminent chemists also peer down from Ertl's office wall, including pioneers such as Jöns Jacob Berzelius, a Swedish scientist who coined the word "catalysis," and Fritz Haber, who won the Nobel Prize for developing a synthetic route to ammonia, widely known as the Haber-Bosch process. In particular, the Nobel Committee cited Ertl's work to resolve the mechanism of this process, which was, in the early 1970s, a controversial topic.


FRITZ HABER INSTITUTE

SPIRAL CHEMISTRY
Oscillating reactions of carbon monoxide oxidation on platinum.

Although the answer had been long elusive, the conundrum was simple: Did the iron catalyst, on its own, break the stalwart dinitrogen bond upon its adsorption to the surface, such that atomic nitrogen reacted with hydrogen atoms to form ammonia? Or was molecular nitrogen reacting with atomic hydrogen to form ammonia?

Ertl says he was inspired to tackle the problem after he attended a seminar in 1974 in Switzerland, "where one of the old great men of catalysis, Paul Emmett, was being honored for his 50 years in ammonia synthesis."

"Emmett gave the last lecture and ended with something like, 'Although many efforts have been made, we do not know the mechanism of ammonia synthesis,'" Ertl recalls. "So I came back to my students and told them I thought we could attack this problem."

USING VACUUM TECHNIQUES to study the reaction in reverse, Ertl and his colleagues found that the first step of the Haber-Bosch reaction involves atomic nitrogen that had been split from its two-part embrace by the iron catalyst, not molecular nitrogen. He often returned to the Haber-Bosch process when new technologies such as scanning tunneling microscopy allowed new information to be extracted about the reaction mechanism, a typical trait of the man, says Campbell. "Ertl digs deep to get a final correct explanation," Campbell adds. "He always solved problems with quantitative models that stood up in court."

The Nobel Committee also focused on Ertl's contributions to uncovering the mechanism of oscillating catalytic reac-

100 YEARS AGO

1907 Chemistry Nobelist Discovered Cell-Free Fermentation

For most chemists, Eduard Buchner's surname rings familiar because of the Bűchner funnel and flask, common types of laboratory equipment. But the 1907 chemistry Nobel Laureate had nothing to do with these famous bench-top items—that credit belongs to industrial chemist Ernst Büchner. Rather, Buchner garnered renown for discovering cell-free fermentation.

Buchner

COURTESY OF THE EDGAR FAHS SMITH COLLECTION/UNIVERSITY OF PENNSYLVANIA

Buchner was born in Munich on May 20, 1860. His father, a physician and professor of forensic medicine, died when Eduard was 12. His older brother Hans became a well-known bacteriologist.

The younger Buchner joined the military; for four years he worked in a canning and preserve factory to raise money for tuition. He studied organic chemistry with Adolf von Baeyer (who would win the 1905 Nobel Prize in Chemistry). At Hans' suggestion, he began examining anaerobic fermentation induced by brewer's yeast.

"As a student, Eduard Buchner made only a modest impression on his doctoral advisor," writes Lothar Jaenicke of University of Cologne, Germany, in a retrospective on Buchner (*Angew. Chem. Int. Ed.* 2007, *46*, 6776). And though von Baeyer may have considered Buchner as "not having any talent for chemistry," he secured a grant for Buchner's initial yeast studies, Janicke adds.

Buchner became a professor in analytical and pharmaceutical chemistry at the University of Kiel and the University of Tűbingen, both in Germany. During a break in the academic calendar in 1896, he studied fermentation at the Hygienic Institute in Munich, where his brother was on the board of directors. Buchner proved with this work that extracts from yeast cells could elicit fermentation.

This contradicted a claim by Louis Pasteur that fermentation was an "expression of life" and could occur only in living cells. Pasteur's claim had put a decades-long brake on progress in fermentation research, according to an introductory speech at Buchner's Nobel presentation. With Buchner's results, "hitherto inaccessible territories have now been brought into the field of chemical research, and vast new prospects have been opened up to chemical science."

In his studies, Buchner gathered liquid from crushed yeast cells. Then he demonstrated that components of the liquid, which he referred to as "zymases," could independently produce alcohol in the presence of sugar. "Careful investigations have shown that the formation of carbon dioxide is accompanied by that of alcohol, and indeed in just the same proportions as in fermentation with live yeast," Buchner noted in his Nobel speech.

Buchner later married and pursued agricultural and biochemical research at various universities. When war broke out in 1914, he rejoined the military. On Aug. 3, 1917, while serving as a major in Romania, he was wounded and died just over a week later at the age of 57.
—RACHEL PETKEWICH

tions. At the beginning of the 1980s, says Ertl, there had been tantalizing reports that reaction rates for the oxidation of carbon monoxide on platinum catalysts, such as those in car's catalytic converters, are not constant but instead oscillate. Ertl then set out to connect the oscillations with the physical characteristics of the catalyst.

It turns out that the two reaction rates corresponded to two different crystalline phases of the platinum crystal, says Peter Norton, a chemist at the University of Western Ontario, in Canada, who was involved in the research as a visiting scientist in Ertl's lab.

To minimize surface strain, surface atoms on platinum crystals rearrange from "what can be loosely described as a square-like ordering to a hexagonal-like ordering," Norton explains. Although the crystals favor the hexagonal organization, CO reactants prefer to adsorb on the square phase.

"Ertl always solved problems with quantitative models that stood up in court."

Still, the CO slowly collects on the hexagonal phase until it finally accumulates enough to push the crystal's surface toward the square-like phase. Oxygen gas, the other reactant, prefers the square phase, and so when this phase transition occurs, oxygen gas rapidly adsorbs, and the rate of the catalytic process shoots up, that is, until all the adsorbed CO is used up. Without the adsorbed CO, the surface atoms revert to the hexagonal form, and the reaction rate slows down.

By adjusting the pressure of carbon monoxide and oxygen, "Ertl went on to discover a whole zoo of oscillation behavior," such as spirals of oscillating rates, Norton says.

Since his retirement, Ertl still takes the daily five-minute walk from his home, which was initially built for Nobel Laureate Otto Heinrich Warburg, to his office.

And so, on Oct. 10, his 71st birthday, Ertl was in his office as usual when the phone rang at 11:30 AM. "I saw on the digital display that it was Sweden and so I started trembling," recalls Ertl. "The man said, 'I am calling with a very favorable message,' and he told me I had won a Nobel Prize.

"My first question after I was given the news was, 'With whom do I share the prize?'" Ertl says. To his astonishment, he was the sole recipient, which can be shared by up to three people. Many people in the surface science field thought that if the Nobel Prize were to be awarded within the surface chemistry field, it would be shared between Ertl and Gabor Somorjai, a physical chemist at the University of California, Berkeley. "It was really a surprise because my work is usually discussed with Somorjai's," Ertl told C&EN. For example, Somorjai, who has also conducted pioneering studies of surface chemistry at high pressure, shared the 1998 Wolf Prize in Chemistry with Ertl.

"Ertl is well-deserving of the prize," Somorjai says. "And granting the prize to surface chemistry defines the importance of that field so I'm glad that the prize was granted there.

"But the Nobel Prize honors those that did seminal work in a field," continues Somorjai. "I wanted to be a part of that history for surface chemistry. I feel that I was a part of that history," he says. The last time the prize was granted in the field of surface chemistry was in 1932, to Irving Langmuir, an American who studied the reactions of gases on filaments of tungsten, among other things.

When Ertl accepts the 2007 Chemistry Nobel, he will pass up, if only for one evening, his other great love—music. An accomplished piano and harpsichord player, Ertl is known for his chamber music soirees at his home in Berlin. He's also the accompanist for the Berliner Oratorium Choir, where his wife, Barbara, sings. The choir, which was established in 1904, will hold their annual Christmas concert when Ertl must perform his official Nobel duties in Stockholm next week. "I guess they understand why I can't perform this time," he says. ■