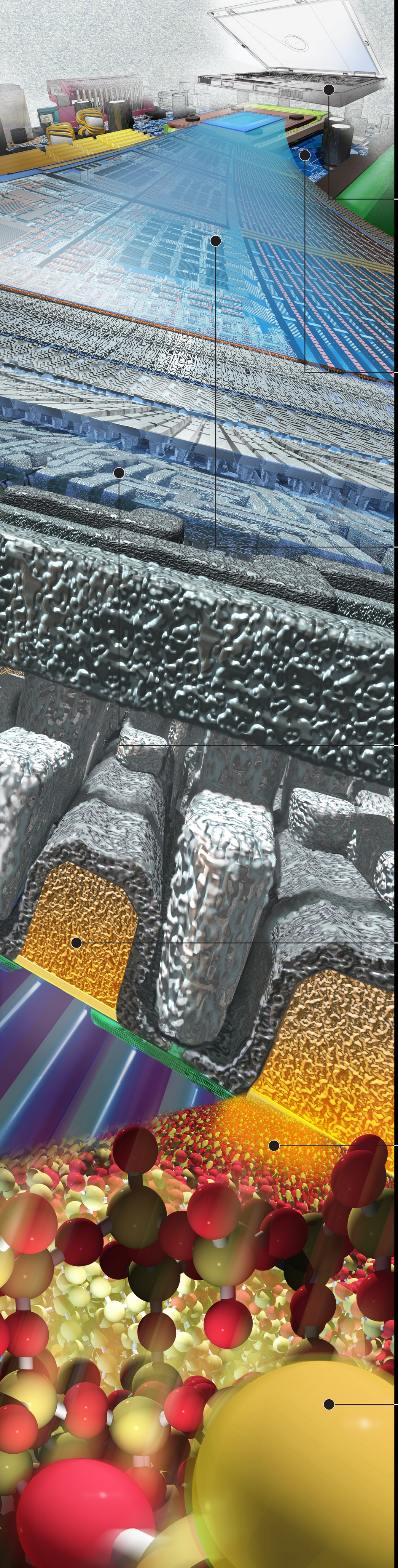
Zoom into a Computer Chip



Laptop Computer
(width 30 centimeters)

Laptop computers initially lagged behind desktop machines in storage capacity, calculation speed, and graphics capabilities. But the computer industry's continuing drive to miniaturize components and improve efficiency led to dramatic improvements in laptop performance. Today's laptops are both extremely powerful and increasingly ubiquitous—in fact, they outsold desktop models for the first time in 2005.

Motherboard
(thickness 1-2 millimeters)

Also called a *logic board*, this thin sheet of plastic holds components that carry out calculations and store information. These components are connected by wires permanently etched or printed onto the board itself. Because they simplify repairs and upgrades and can be mass-produced, printed circuit boards have replaced messy tangles of wiring in virtually all electronic devices.

Microprocessor
(thickness 1 millimeter)

The microprocessor is the computer's "brain." A microprocessor is an *integrated circuit*, a microchip of silicon with embedded electronic components. Its intricate circuitry makes possible the logical and arithmetic operations underlying everything from letters and spreadsheets to games and image manipulation. Beginning in the 1960s, the evolution of these devices has powered the explosion of computer technology around the world.

Interconnections
(diameter .3 millimeters)

These tiny wires conduct electrical signals between microprocessor components. At this scale, the gradual displacement of atoms by flowing electrons is an important cause of broken or short circuits. As circuits continue to get smaller, this *electromigration* problem becomes increasingly serious. Today's thinnest interconnections are often made of copper, which is less susceptible to electromigration effects than the aluminum commonly used in the past.

Transistor Gate Electrode
(width 50-70 nanometers, or billionths of a meter)

The *field-effect transistor* is the microchip's core decision-making element. Comprised of gate, source, and drain electrodes, transistors are essentially electronic switches controlling the flow of electrons through the circuit. Today's computer chips contain millions of individual transistors. Roughly analogous to neurons in a human brain, transistors process billions of electronic signals that are translated by the computer's software into operations people can understand and control.

Silicon Dioxide Gate
(height 1.5 nanometers)

Transistors in a silicon microchip contain a thin layer of silicon dioxide, or *silica*, just above a pure silicon substrate. This layer acts as a gate, turning the flow of current through the chip on and off. As transistors are further miniaturized, other compounds more efficient at these tiny scales are being investigated as the gates of the future.

Silicon Atom
(.1 nanometers)

In its crystalline state, silicon's lattice-like molecular structure prevents electrons from flowing. But when augmented, or *doped*, with other elements (like phosphorus, boron, or arsenic), its structure changes, allowing current to pass through. This ability to act as a *semiconductor* has made silicon nearly synonymous with the electronics industry. Other elements can act as semiconductors, but silicon's flexibility and tolerance of high temperatures make it the most widely used.

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Grant No. ESI-0532536

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