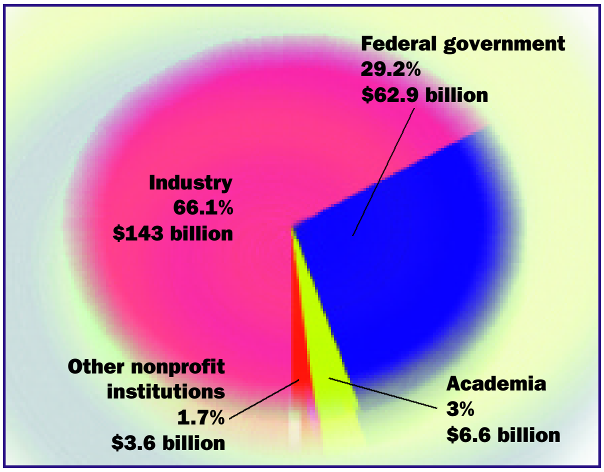
Higher R&D Spending Forecast for 1998 and 1999

Funding of research and development in the United States will increase by almost 5% to $215 billion in 1998, according to Battelle (Columbus, OH). Nearly all of the growth will come from industry, which is expected to invest $143 billion in R&D, an increase of 6.7% from 1997. Spending on R&D by the federal government will reach $63 billion, slightly more than last year. Universities and nonprofit institutions will devote nearly $10 billion to R&D.



"The increase signals a trend that is expected to last into the next century," says Jules J. Duga, Battelle's senior analyst and the forecast's principal author. "Industry realizes that changes in operations and structure are not the only roads to profitability. Investment in research and technology is required for long-term survival."

The study reports that high-tech industries have led the economic growth in the United States for the past decade. Last year, one-third of the increase in the U.S. gross domestic product (GDP) came from information technology. Companies such as Intel and Microsoft rank among the top 10 in R&D spending. Intel is expected to increase its R&D budget by almost 14% in 1998 to $2.35 billion, and Microsoft's R&D budget also will top $2 billion.

The computer and pharmaceutical industries should lead the U.S. R&D growth in 1998 with projected investments of almost $28 billion, followed by the automotive industry with about $23 billion. Significant increases will also take place in telecommunications, electronic components, scientific and mechanical-measuring instruments, and nonelectrical machinery. The smallest changes in R&D funding will occur in mature industries such as paper, petroleum, refining, industrial chemicals, and aerospace, according to the report.

This growth follows years of stagnation in R&D spending. "After a decade or more of down-sizing and cost-cutting, American companies are shifting their attention to top-line growth," says Stephen M. Millett, a researcher and futurist at Battelle. "The great challenge of the future is to both grow sales and increase profitability."

Before 1980, the federal government was the dominant supporter of R&D, funding more than 50% of the work. Since then, however, the government's share of the total R&D expenditure in the United States has dropped to about 30%, and its share is expected to continue falling over the next five years. The government supports R&D in federal laboratories, private industry, academic institutions, and other nonprofits. However, the Battelle forecast notes that only academia will enjoy increased federal funding, and its total growth in spending will barely keep pace with inflation.

The report expresses concern that current R&D spending is concentrated on short-term gains for rapid product commercialization rather than long-term research-oriented goals. It predicts that future R&D investments will become less focused on short-term profits.

For fiscal year 1999, the Clinton administration has proposed an increase of 8% for nondefense research under the umbrella of a new initiative called Research Fund for America. Defense basic and applied research would increase by 5%, but defense development funding would decrease by 1%. R&D to universities would increase by 6%. By 2003, the administration plan would increase spending under the Research Fund for America by 23%. The high priority of the research budget increase was stressed by Vice President Al Gore, who said, "There has never been a better time to make this historic investment because many areas of science are close to major discoveries." Both the National Science Foundation and the Department of Energy would receive an 11% increase in research funding.

Biosensors to the Rescue

Contamination of food by toxic strains of bacteria, such as those of *Escherichia coli* (*E. coli*) and *Salmonella*, has resulted in several massive outbreaks of food poisoning and some deaths. The U.S. Department of Agriculture, which is responsible for inspecting meat and other food products, plans new regulations that will require more-thorough testing for pathogens by food processors. This change has opened a new market for biological sensors, especially ones that can rapidly and automatically detect bacteria or other contaminants in meat, poultry, seafood, fruits, and vegetables.

Dozens of companies have launched efforts to create a new generation of biosensors, and scientists at universities and research laboratories are eagerly trying to develop novel techniques for rapid detection of specific pathogens.

An R&D team at Texas Instruments' Components and Materials Research Center in Dallas has used its expertise in digital-signal processing (DSP) to produce a miniaturized biosensor that uses changes in refractive index to identify chemical and biological substances. A surface-plasmon resonance sensor detects changes in refractive index, which are instantly analyzed by an integrated digital-signal processor. Texas Instruments pioneered the development of DSP chips, which are used in computers to display graphics and in cellular telephones.

Plasmon-based instruments are normally restricted to laboratory use, although some versions can be operated by lap-top computers in the field. Texas Instruments has developed a miniature, hand-held, plasmon-sensor system for use in biological, chemical, and environmental monitoring. The sensor

This optical sensor can detect ***Salmonella.***

Georgia Institute of Technology

consists of a plasmon layer, light-emitting diode, polarizer, CMOS photodiode array, temperature sensor, analog-to-digital converter, and digital-signal processor with memory and embedded software. The unit is about the size of a small matchbox. “The potential applications for this technology are extensive,” says Jose Melendez, manager of analytical sensors. Applications of the miniature sensor system include, among other things, food- and beverage-process control, detection of pathogens in foods, environmental monitoring, water-quality control, medical-diagnostic testing, and drug research and manufacture.

“In wine making, for instance,” Melendez notes, “the plasmon sensor can provide an on-the-spot, digital readout of sugar content.” Future versions of the sensor will contain a thin layer of antibodies that can detect the presence of a specific bacterium or chemical. Texas Instruments researchers are developing a multiple-channel plasmon sensor, and they envision a sensor system that will incorporate hundreds or thousands of channels, each one of which will produce a specific measurement.

SatCon Technology Corp. (Cambridge, MA) has tested a noncontact sensor for detecting *E. coli* and *Salmonella* in meat. The biosensor, amusingly called RIBS (remote inspection biological sensor), was developed by SatCon’s Space and Electro-Optics Division in Tucson, Arizona, and was tested by Northern Plains Premium Beef, an agricultural cooperative in the Midwest.

At the Georgia Institute of Technology in Atlanta, Nile Hartman, Paul Edmonds, and Dan Campbell have developed a laser-based sensor that can detect *Salmonella* in meat in a fraction of the time required by conventional methods. The biosensor integrates optics, immunoassay, and surface chemistry, and detects bacteria by measuring their effect on the optical properties of the sensor. The device also has potential applications in medical testing and environmental monitoring, according to the researchers who are working on it.

An instant litmus test for the extremely virulent *E. coli* 0157:H7 strain has been developed by Raymond Stevens and his team at the Lawrence Berkeley National Laboratory. The sensor changes color from blue to red when it comes into contact with the 0157:H7 toxin. Higher concentrations of the toxin create a greater color change, which is instantaneous. The biosensor consists of a thin film containing a composite molecule. The surface of the molecule binds to the toxin, and the underlying backbone of the molecule is the color-changing system.

A team of researchers at the Scripps Research Institute (La Jolla, CA) and the University of California, San Diego, has reported a porous-silicon biosensor that changes colors in response to specific molecules. Light refracted from a thin film of porous silicon changes color when other molecules bond to the surface of the film. The biosensor is extremely sensitive, according to Michael Sailor and M. Reza Ghadiri, who head the team. It can detect DNA concentrations down to 9 femtograms (10^{-12} gram) per square millimeter. In another test, the biosensor matched tiny concentrations of specific DNA sequences to their complementary strands, thus indicating its potential for applications such as DNA matching for clinical and forensic purposes and a variety of genetic tests. The biosensor is also sensitive to the binding of antibodies to antigens, and it could be used to detect bacteria, toxins, and allergens.

— Updates —

Magnetic hard-disk technology continues to leap ahead with impressive increases in capacity. Using giant magnetoresistive technology, researchers at IBM's Almaden Research Center (San Jose, CA) have succeeded in storing 11.6 Gb/in.^{2} (11.6 billion bits per square inch), more than double the 5 Gb/in.^{2} they had achieved previously (see *The Industrial Physicist*, 6/97, p. 20). The data density of magnetic hard disks has increased at the rate of 60% a year since 1991. If this trend continues, the areal density of magnetic disks could reach 40 Gb/in.^{2} by 2004. Commercialization of higher densities lags only a few years behind research. IBM demonstrated a density of 3 Gb/in.^{2} in 1994 and began manufacturing 3.38-Gb/in.^{2} magnetic hard-disk drives with giant magnetoresistive technology in 1997.

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After two years of "intense effort," researchers at the Xerox Palo Alto Research Center have succeeded in producing a pulsed gallium nitride (GaN) blue-laser diode. The Xerox announcement follows a successful demonstration of a pulsed GaN blue laser by Cree Research (see *The Industrial Physicist*, 9/97, pp. 16, 18). Cree's blue laser uses GaN on silicon carbide, while the Xerox blue laser has GaN on sapphire, a method also used by Nichia Chemical, which already has developed a blue laser that operates continuously at room temperature. The Xerox GaN research is supported by the Department of Commerce's Advanced Technology Program and the Defense Advanced Research Projects Agency (DARPA), which fund the eight-member Blue BAND II Consortium that includes Xerox. Meanwhile, Power Laser Corp. (San Diego, CA) has received from the U.S. Patent Office a notice of allowability, a stage in the patent process, for its solid-state blue- microlaser technology. Applications for blue-laser diodes include high-resolution television, computer displays, image scanners, color printers, biomedical-diagnostic instruments, remote sensors, and underwater communications.