tions—such as why Melanesia is so incredibly diverse. "We are talking about very complex relationships ... that reflect the influence of different migrations" at different times, Friedlaender says. And the right genes can continue to tease apart that history, he says.

–BERNICE WUETHRICH

Bernice Wuethrich writes from Washington, D.C.

SCIENCE EDUCATION

Science Fairs Pump Up The Rewards of Talent

If you can't run the nation's most prestigious high school science fair, start your own—and make it even more lucrative for the winners. That's the genesis of the Siemens Westinghouse Science & Technology Competition, which announced its first winners this week in Washington, D.C. In doing so, Siemens prompted Intel, which last year beat out Siemens for sponsorship of the venerable Science Service Talent Search, to raise its prize money as well.

Lisa Harris of Dalton High School in New York City won this year's top Siemens prize for individuals—a $100,000 college scholarship—for developing a new method

Young stars. High school seniors Daniar Hussain, Steven Malliaris, and Lisa Harris win the first annual Siemens Westinghouse Science & Technology Competition.

to detect carriers of a gene responsible for cystic fibrosis. Daniar Hussain of Richland High School in Johnstown, Pennsylvania, and Steven Malliaris of New Trier High School in Winnetka, Illinois, won the team competition and will divide a $90,000 scholarship for their method of generating computer programs to store data more efficiently. A total of 12 individuals and teams chosen from six regional competitions competed for the top prizes; combined with awards to students who score well on advanced placement tests and their teachers, the total Siemens pot comes to nearly $1 million.

Last year was tumultuous for the world of U.S. high school science competitions. Westinghouse ended 57 years of support for the annual Science Service Talent Search, which has been a scientific launching pad for five Nobel Prize winners and 30 members of the National Academy of Sciences. In a competition for a new sponsor, Siemens—which bought Westinghouse after it dropped its support—was one of 75 companies vying for the honor. After Intel won, Siemens decided to start its own contest.

"It was enlightened self-interest," says Albert Hoser, head of the Siemens Foundation, a corporate charity created in 1998. "We need employees at the cutting edge of science and math. We want to inspire students to give those subjects top priority." Not to be outdone, Intel has doubled the prize money awarded to Science Service Talent Search winners, including $100,000 to be awarded in March for first place among 40 finalists, and is offering a total pool that exceeds $1.2 million. "We like to think we're serving as a catalyst for other corporations to raise the bar," says Siemens spokesperson Esra Ozer.

Indeed, one Nobelist urges other industrial giants to follow the lead of the German telecommunications company and the U.S. chipmaker. "The more the merrier," says physicist Leon Lederman, who attended the Siemens awards ceremony. "What's wrong with General Motors? Why don't they have a prize, or Ford, or any other corporation?"

Harris started working at the Public Health Research Institute in New York City at 16 and already is a co-author of a paper classifying the virulence of different strains of tuberculosis. For the competition, she used a fluorescent marker to tag blood samples that harbor a mutation in the cystic fibrosis gene, producing a test that is simpler and faster than current techniques. "I hit a wall over the summer," she says about a project that took 11 months. "The most exciting thing for me was to make it work." She finished the latest experiments just in time to write them up for her poster session at the awards ceremony.

Hussain and Malliaris took a computer science class together in Illinois before Hussain's family moved to Pennsylvania earlier this year. "We knew the distance wouldn't be a problem," says Malliaris, who collaborated with Hussain via the Internet. The students used evolutionary principles to improve polynomials that direct the storage of items from large data sets. They introduced random mutations in a population of techniques and then repeatedly eliminated the ones that were unfit and selected ones that distributed data most efficiently.

The Siemens competition focuses on the quality of the student research projects, whereas the Intel talent search also judges contestants on creativity and their knowledge of science. In addition to these competitions, the National Science Teachers Association (NSTA) hosts three national contests that focus on a student's imagination—some are entirely conceptual—and don't require them to work in a lab outside school. "The Intel competition is for students already definitely going into science, who are already interested in science," says NSTA spokesperson Cindy Workosky. "We're trying to turn them on to science."

For Lederman, every science competition "is another opportunity for the kids in America to excel."

–LAURA HELMUTH

TECHNOLOGY

Nanotubes Generate Full-Color Displays

TOKYO—Liquid crystal displays (LCDs) are fast becoming ubiquitous—just glance at your wristwatch, laptop, or calculator. But they still can't compete with bulky cathode ray tubes (CRTs) for displaying high-quality images. Now, a team of Korean researchers at Samsung has produced a working display that promises to combine the quality of CRT images with the convenience of a flat panel by using carbon nanotubes as its source of electrons. Their work, published in the 15 November issue of *Applied Physics Letters*, gives Samsung a small lead in a heated race to commercialize the technology.

The CRT is a dinosaur in the fast-changing world of electronics, surviving because of its brightness, resolution, and ability to show moving images. But it may be driven to extinction by a technology called field emission, which like the CRT uses electrons to light up colored phosphors on a glass screen (*Science*, 31 July 1998, p. 632). Instead of a single electron gun at the far end of a bulky and heavy cone-shaped tube, however, field-emission displays use thousands of tiny pointed electron emitters arrayed within a flat panel. An electric field pulls a stream of electrons from each point. Field-emission displays can be built as thin as LCDs, yet consume less power and promise to produce images comparable to a CRT. The problem to date has been finding materials that are easily fabricated into pointed shapes yet can hold up to the intense stream of electrons.

Carbon nanotubes, which conduct electrons freely, could fit the bill—if researchers can find a way to control their fabrication and place them in a precise pattern. The Samsung group has done just that. The result, reported by Won Bong Choi and col-

CREDIT: JOHN HARRINGTON

leagues at the Samsung Advanced Institute of Technology in Suwon, South Korea, is the first full-color field-emission display using carbon nanotubes as the electron emitters. "It's an important step forward," says Yahachi Saito, an associate professor of electrical and electronic engineering at Japan's Mie University, who is also working on carbon nanotube field-emission displays.

The carbon nanotubes, cousins of the soccer ball–shaped fullerene carbon-60 molecule, are created by passing an arc discharge between graphite electrodes in a chamber filled with helium. The Samsung team mixes a conglomeration of single-walled carbon nanotubes into a paste with a nitrocellulose binder and squeezes the concoction through a 20-micrometer mesh onto a series of metal strips mounted on a glass sheet. As the nanotubes emerge from the mesh, they are forced into a vertical position. The researchers then heat the arrangement to burn off the nitrocellulose binder and melt metal particles in the paste. When the metal solidifies, it binds the nanotubes to the metal substrate. "Getting the nanotubes perpendicular to the substrate and evenly spread out is the key to getting even brightness in the finished panel," Choi notes.

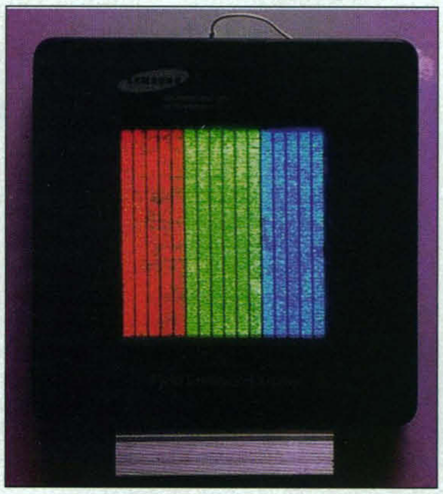
The metal strips with the carbon nanotubes sticking out of them serve as cathodes, running from top to bottom of a glass sheet that serves as the back of the finished display. The front of the display is a glass sheet containing red, green, and blue phosphors and strips of a transparent indium-tin-oxide anode running from side to side (see diagram). The glass sheets are separated by spacers. Once assembled, the edges are sealed and air is pumped out of the display. Each intersection where a vertical cathode and a horizontal anode cross forms a pixel. Each pixel is turned on or off by applying a voltage to its defining vertical cathode and horizontal anode. As with a CRT, an image is formed by setting the individual brightness and color for each pixel. "It's a very impressive display," says Sumio Iijima, a microscopist at NEC Corp.'s Fundamental Research Laboratories in Tsukuba, Japan, who discovered carbon nanotubes in 1991.

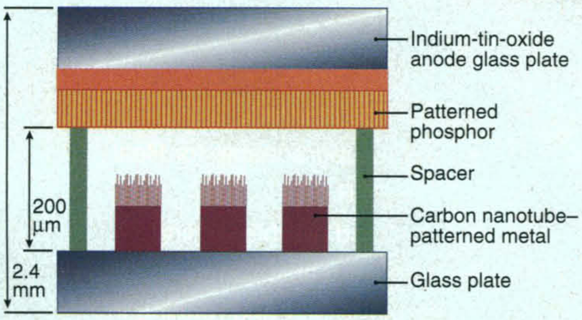
Samsung's 4.5-inch (11.4 centimeters) display could be the precursor of a new generation of more energy-efficient, higher performance flat panel displays for notebook computers and wall-hanging televisions. The carbon nanotubes appear to be durable enough to provide the 10,000-hour lifetime considered to be a minimum for an electronics product, and the panel uses just half the power of an LCD to produce an equivalent level of screen brightness. They should also be cheaper to produce than LCDs or other types of field-emission displays being developed, Choi says, adding that the technology also permits larger, more defect-free screens to be made than is possible with LCDs.

Although the Samsung group has earned bragging rights with its full-color field-emission display, which it demonstrated earlier this year at a conference, it's only a step ahead of the competition. Ise Electronics Corp. of Mie Prefecture in Japan has since then shown a similar display based on Saito's work. At least five major Japanese electronics manufacturers are working on the technology, notes Saito, but their progress is a secret. "Only Samsung and Ise Electronics are [being] open about their research," he says.

Iijima praises the technical advances in the use of carbon nanotubes, but he says that "commercialization is another question." Nanotubes must overcome the huge investment in the manufacturing of LCDs, which continue to fall in price. "LCD technology is improving very rapidly," Choi admits. His field-emission displays are at least 3 years away from stores, he estimates.

–DENNIS NORMILE





Flat-out success. A cross section of a flat-panel display, with carbon nanotubes that generate the full-color image shown.

CREDIT: W. B. CHOI ET AL./APPL. PHYS. LETT.

HUMAN GENOME RESEARCH

German Effort Stuck In Minor League

MUNICH—When Germany finally began making a contribution in the mid-1990s to the worldwide effort to sequence the human genome and utilize its information, the prevailing thinking in the scientific community was "better late than never." Germany's research ministry stepped gingerly onto the human genome bandwagon in 1996 with a modest $23-million-a-year program for an initial 3-year period. The investment has resulted in some notable achievements, and several recent reports have recommended major increases in genome research funding. But at a meeting here last week that aimed to celebrate the results of the first phase of the German Human Genome Program (DHGP), researchers seemed to be already suffering from a hangover: Phase two of the DHGP officially began last month with an unchanged budget.

"There's a lot of disappointment [in the community]. This is far from being enough. Compared to what we said we required, we're about 10-fold underfunded," says geneticist Rudi Balling of the National Research Center for Environment and Health in Munich, adding that the pharmaceutical industry in Germany is "adding close to nothing" to the project. Hans Lehrach, a molecular geneticist at the Max Planck Institute for Molecular Genetics in Berlin, says that "Cambridge, Massachusetts, is spending more money than Germany, and just the construction of the Sanger Centre [Britain's main sequencing center near Cambridge, U.K., funded by the Wellcome Trust] was worth about 8 years of German genome research."

Despite its meager resources, the DHGP has made its mark on the international genome program. German and Japanese groups are the driving force behind the sequencing of chromosome 21, which is expected to be the next one finished after chromosome 22, whose sequence was published last week. DHGP researchers are also working hard to unravel the role of the thousands of previously unknown human genes by testing their function in model organisms such as mice or fruit flies. "In many ways, Germany is ahead of us because it centers not just on sequencing but also on how [the sequence information] functionally integrates," says David Cox, a geneticist at Stanford University.

In light of these successes, Germany's main granting agency, the DFG, last June recommended that an additional $550 million be spent on genome research over the next 5 years. And recently the Association for the Promotion of Human Genome Research, an industry group, together with the DHGP's scientific coordinating committee, argued for