that would fit: an 11-atom, paddle-wheel-like structure consisting of two "hub" atoms along an axle surrounded by three paddles, each containing an additional three atoms.

In the midst of the whisker work, Van Vechten realized that this structure could also be "a natural explanation for the strong prominence of 11-atom clusters in laser [vaporization]," since that process is as violent as sputtering. Support for the stability of the structure comes from the recent synthesis of similarly shaped molecules such as propellahexaene (SN: 6/6/87, p.357).

To explain the other carbon-cluster magic numbers, Van Vechten says each addition of four carbon atoms to the 11-atom molecule would allow a stable graphite six-member ring to form along the side of one paddle. The magic number series stops at 23, he believes, because there are only three paddles in the molecule. He also thinks this molecule—unlike the chain and ring structures proposed before to explain small clusters — can account for why 11, 15, 19 and 23 are observed to be magic numbers for neutral and positively charged clusters but not for negatively charged ones.

While Princeton (N.J.) University's Leland Allen says this work is "interesting and impressive," he and others caution that it is conjectural and that the chains and rings are still very much in the running. Moreover, says Richard E. Smalley at Rice University in Houston, Van Vechten's molecule is much more reactive than the other candidate structures. This property appears to be inconsistent with experiments indicating that the 11-atom clusters are not very reactive.

Van Vechten hopes to use the 11-atom structure as the basis for making a new low-density material that improves upon the properties of graphite. "Graphite is extremely strong, but there are difficulties using it as a structural material because it tends to fracture," he says.

Van Vechten would like to try to grow carbon crystals in which the 11-atom structure is stacked into a honeycomb pattern, interlocked by carbon chains. This interlocking would prevent the honeycomb planes from slipping past one another, which is at the root of graphite's brittleness. "It looks as though this material would have an order of magnitude higher tensile strength than titanium and about a third the density," he says.

"Also, the material is clearly a metal and it's nonmagnetic, so it ought to have a superconducting-transition temperature," says Van Vechten. "Its features lead one to think that it [the temperature] would be high." If so, then he says it would have vastly better structural properties than the high-temperature superconducting materials (see p.106) that are getting so much attention now, but that are difficult to form into wires because of their brittleness. — *S. Weisburd*

Hereditary highway map: Assessing the toll

Momentum is building among U.S. scientists to create a detailed road map of the entire human gene system, or genome. Last week, geneticists, molecular biologists and computer scientists convened in Washington, D.C., at the request of the Office of Technology Assessment (OTA) to help estimate the cost of such an undertaking — a biological mission so complex it has been likened to the 1960s effort to put a man on the moon. Congress is to consider funding for the project in the fall.

Scientists expect that human-gene mapping will lead to improved diagnosis of hereditary diseases, the development of new drugs and a host of unforeseen benefits. Enthusiasm for the project has grown in the past year with the mapping of genes responsible for muscular dystrophy and neurofibromatosis, and with the discovery that certain genetic sequences are related to manic depression (SN: 10/25/86, p.261; 6/6/87, p.359; 3/28/87, p.199). But a high-resolution map showing every human gene has only recently become feasible with the development of specialized automated technologies.

Recent advances in automation have made DNA sequencing both cheaper and faster. Until recently, according to scientists at the meeting, the cost has been $1 to $2 per nucleotide base; these bases spell out the genetic code. New technologies have lowered the costs to as little as 6¢ or 8¢ per base, says Leroy Hood of the California Institute of Technology in Pasadena. And within six months, he predicts, the cost could drop to a penny a base. Such differences are significant, he says, as there are approximately 3 billion bases in the human genome, and each base will have to be mapped at least two or three times to confirm its location.

Researchers at the meeting also noted progress in the number of genetic markers — key chromosomal reference points — that have been identified (SN: 8/31/85, p.140). To date, 300 to 400 "reasonably informative" markers have been identified, says Helen Donis-Keller, a senior research director at Collaborative Research Inc., a Bedford, Mass.-based biotech research laboratory. An additional 300 to 400 such markers will be needed to develop a genetic map that would have a marker every 5 million bases — a scale that would be very useful for locating the sites of disease-causing genes, Donis-Keller says. She predicts that such a map will be completed in the next two years. Detailed nucleotide sequencing, with its ability to determine exactly which proteins are coded for by defective genes, would take many more years.

Scientists say it will be necessary to develop highly sophisticated computer programs to make sense of the huge amount of genetic data that will be generated by the mapping project. It is not unreasonable to assume that a supercomputer may be needed, according to some scientists at the meeting. And millions of dollars may be needed to train specialists with combined skills in molecular biology and computer science.

How much would the gene mapping project cost? It will be some time before OTA analysts add up the numbers. But several scientists express surprise that while much of the mapping itself could be done for $100 million, the costs of simply freezing "signpost" cell lines for future use might amount to a quarter of a billion dollars or more. "At that price," says Harvard researcher and Nobel laureate Walter Gilbert, "it would be cheaper to make the stuff all over again instead of storing it."

If in fact every important cell line were to be cloned and stored, "it would take 12 of the largest liquid-nitrogen refrigerators now available," says Robert E. Stevenson, of the American Type Culture Collection, a cell-storage bank in Rockville, Md. "We're talking about a large [liquid-nitrogen] tank farm."

Total cost of the project will also hinge on the total number of human genomes mapped, says Paul Berg, Stanford biochemist and Nobel laureate: "Whose DNA are we going to sequence? Are you satisfied with one? Is that *the* human genome?" — *R. Weiss*

High-cadmium diet: Recipe for stress?

When laboratory rats consume a diet that includes relatively large doses of cadmium, a common metal and environmental pollutant, there is increasing evidence that they become more anxious and unable to deal with stress. The latest such study, conducted by psychologist Jack R. Nation and his colleagues at Texas A&M University in College Station, finds a link between exposure to cadmium and increased alcohol consumption.

Given a choice of drinking water or a 10-percent alcohol solution, rats put on a cadmium-laced diet preferred the liquor, whereas rats munching cadmium-free food favored the water. The former group may have turned to alcohol to ease cadmium-induced anxiety, says Nation. There are other indications of increased anxiety among rats who ingest cadmium, he notes, such as an exaggerated startle response and freezing in their tracks when a loud tone is presented.

But the connection between anxiety and alcohol use is tentative, say the researchers in the September NEUROTOXICOLOGY AND TERATOLOGY, since "there is

no consensus in the animal or human literature supporting the tension reduction model of alcohol consumption."

Adds Nation, "At this point, the data suggest only that research is needed to examine cadmium's effects on humans."

For 55 days, the researchers fed six rats regular laboratory chow while another six received lab chow containing 100 parts per million cadmium. (Though most humans would not encounter a dose this large, says Nation, similar levels have been seen among people who have had cadmium-poisoning symptoms.) Then, instead of the usual water supply, the researchers gave all the animals a 15-percent alcohol solution for five days in order to familiarize them with alcohol and its effects. Next, a choice between alcohol solution and water was offered for a five-day "baseline period," then for two weeks during which the animals were trained to press a lever to avoid mild electric footshocks, and finally for nearly three weeks after the footshocks were stopped.

During the stressful shock-avoidance training, cadmium-exposed rats consumed about twice as much alcohol solution as their counterparts and drank slightly more alcohol than water. This pattern became more pronounced in the period following avoidance training, although, says Nation, it is not clear why. There were no significant group differences in total fluid intake, feed intake and body weight.

In a similar study conducted about one year ago, Nation and his colleagues found that rats fed a lead-contaminated diet drank more alcohol than a control group, but the preference for alcohol is considerably stronger when the animals are exposed to cadmium. They have also found that it takes longer for alcohol to affect the behavior of cadmium-exposed rats compared to a control group.

Cadmium is used as a binding agent in the electroplating industry and also in the manufacturing of batteries. Cadmium used by industry is present in sewage sludge, says Nation, which is used by agricultural companies as fertilizer. From there, it enters the food chain. "Cadmium is mobile," says toxicologist Donald Lisk of Cornell University in Ithaca, N.Y. "It moves readily from soil to plants to animals."

In the last two years it has been detected in high concentrations in tobacco plants, says Nation. The substance is also known to "load" in some other plants, such as lettuce, says Lisk.

Although its concentrations in human diets vary and have not been fully explored, Lisk adds that "cadmium is at a level that probably should not be exceeded in the American diet."

Cadmium concentrates in the kidneys, explains Lisk. The first sign of toxicity in humans, he says, is usually kidney dysfunction. — *B. Bower*

Colon-cancer defect found

A genetic defect may be responsible for a large number of cases of colon and rectal cancers, according to British and Israeli scientists, who say the discovery could lead to improved diagnosis. Led by Walter F. Bodmer of the Imperial Cancer Research Fund Laboratories in London, the researchers reported this week that the loss of certain genes through mutations "may be a critical step in the progression of a relatively high proportion of colorectal cancers."

When comparing cancerous material from the colon and rectum with normal tissue from similar sites, the scientists found that some genetic material was missing from chromosome 5 in at least 20 percent of the tumors. In a parallel study, the group located the gene for familial adenomatous polyposis (FAP) on the same chromosome. Found in certain families, FAP is characterized by the formation of numerous polyps in the colon, which frequently become malignant if not removed. On the basis of these two studies, the scientists suggest in the Aug. 13 NATURE that mutations in the FAP gene may be involved in both familial and nonfamilial forms of colorectal cancer. They also say that further research should provide methods for prenatal and presymptomatic diagnosis of a predisposition to colorectal cancers, which will add an estimated 145,000 new cases to U.S. cancer figures this year. □

Chlordane sales halted

Sales of chlordane, heptachlor and related cyclodiene insecticides will end immediately, John A. Moore, the EPA's assistant administrator for pesticides and toxic substances, announced this week. Since the mid-1970s, only termite-control companies have been permitted to use the chemicals. The action results largely from an agreement between EPA and Velsicol Chemical Corp. in Rosemont, Ill., the sole maker of chlordane and heptachlor. It was prompted by new data provided by Velsicol showing that these compounds can contaminate household air for at least a year.

Because the chemicals cause liver disease and adverse neurologic effects in exposed animals, and are suspected human carcinogens, EPA canceled most uses of them in the 1970s. Use against termites was excepted because of a lack of effective alternatives. But the new data and the availability of alternate termiticides — some registered just this year — have now led EPA to end most remaining uses. All applications within or under the perimeter of inhabited structures are permanently suspended, for example. If Velsicol can show that applying these chemicals outside the perimeter of homes will not contaminate indoor air for at least two years, such uses may be approved in the future. □

Rock-a-bye baby crocodilian

Bronx Zoo

These broad-snouted caimans are what's new at the Bronx (N.Y.) Zoo. Eighteen of the endangered members of the crocodilian order were hatched last month from two different moms given to the Bronx Zoo by Japan's Atagawa Tropical Gardens. Their birthdays mark the first time a second generation of exotic crocodilian has been bred in a zoo. While the baby caimans are a handful now, they'll grow to be 9 feet long and will weigh as much as 150 pounds. Zoo officials hope to eventually return future generations of broad-snouted caimans and other rare reptile species to the wild. The zoo has also successfully bred other crocodilians, including the Chinese alligator, the Malayan false garial, the Siamese crocodile, the Cuban crocodile and the Yacare caiman.