who broke into one computer network and managed to avoid detection by that system might not be so successful on another network, she says.

"They've taken a much more exact analogy with biology by developing digital antibodies," says White. "But the analogy breaks down. All of my cells come from me, so my immune system can define self. But I put files on my computer every day.... This system may be very good for intrusion detection, but it may not be a good approach for viruses, because it will make too many mistakes. Our approach is more specific for viruses."

Both research groups caution that in nature, no defense system remains perfect forever. Just as white blood cells and viruses engage in a delicate dance, each evolving to outwit the other, so will computer viruses and antivirus technology, White says.

Viruses are getting more dangerous all the time, he says. Several programs for automating the development of macro viruses are circulating, meaning that the virus-writing community can create viruses faster than ever.

There are even some indications that viruses may be evolving on their own, White says. For example, some versions of Microsoft Word may make minor errors when copying viruses. These changes may disable the virus, or they may make the virus harder to spot. Also, if two or more viruses successfully infect a computer, one may accidentally copy itself into the other virus, creating a new kind of bug, he says. While uncommon so far, these scenarios are certainly threatening, White notes.

Whatever the form of the threat, the goal of protecting computer systems remains. "What we would ideally like is for a computer to behave the way the human body does," says Sushil Jajodia of George Mason University in Fairfax, Va. "When we are attacked by a virus, we get sick, but the immune system detects the virus, defeats it, and heals the damage. Computer systems are not like the human body, though, in that we need to provide the technology."

Because programs and operating systems are not usually designed with security in mind, antiviral programs will always be behind the curve, says Jajodia. "It still isn't clear how well this idea [of digital immune systems] will work, but we have no better alternative for detecting virus infections," he says.

Computer users have demanded ease of use but not security, says Forrest. "While people are becoming aware of the issues . . . they don't feel personally threatened yet." She notes that "when the Internet took off in the early '90s, it became evident that the computer-security problem was going to become everybody's problem."

Jajodia, editor-in-chief of the JOURNAL OF COMPUTER SECURITY, says that programmers should address the problem of viruses long before people begin using newly developed software.

Designing computer systems and programs with security in mind is an important first step, he says. More programs should check digital signatures to confirm that transferred files and computer code come from a trusted source. Better encryption systems, which help ensure that information has not been altered in transit from one computer to another, would make it harder for people to design viruses and for viruses to spread, he says.

Computer-security experts warn that no single set of changes will be enough to completely protect increasingly interconnected computer systems. They hope, however, that new security measures, such as digital immune systems, will fend off future epidemics. □

Biology

The early fetus gets the womb

The human egg, once fertilized, apparently has only a short window of time in which to make it from a fallopian tube to the uterine wall. If the fertilized egg doesn't implant there within a week or so of ovulation, scientists find, the chances of a successful pregnancy begin to plummet.

Allen J. Wilcox of the National Institute of Environmental Health Sciences in Research Triangle Park, N.C., and his colleagues recruited 221 women who were about to stop using birth control because they wanted to become pregnant. From the concentrations of certain hormones in urine, the researchers could determine the day a woman ovulated. "We collected about 20,000 urine specimens. That's a lot of women collecting urine every morning and putting it into freezers," laughs Wilcox.

By also detecting the hormone chorionic gonadotropin in urine—the same method that home pregnancy tests use—the scientists could discern when an egg implanted. Cells that will become the placenta make this hormone to halt the menstrual cycle so that the woman doesn't shed the uterine lining and the implanted egg.

As the researchers describe in the June 10 NEW ENGLAND JOURNAL OF MEDICINE, they followed 189 women after conception. In almost all the women, the egg implanted 6 to 12 days after ovulation. The later the time of implantation, however, the more likely it became that the fetus would not survive its first 6 weeks. Indeed, no egg implanting after 12 days endured that initial period, let alone produced a live birth.

Animal studies indicate that the uterine wall becomes less receptive to implantation later in the menstrual cycle, which may explain the findings. Another possibility is that fertilized eggs that journey sluggishly to the uterus may have defects that make them less likely to survive. "It could well be both: There's a limited window of receptivity, and slower conceptuses are more likely to fail," says Wilcox. —*J.T.*

Gene proves to be a pain in the back

Totaling up to 10 pounds per person, the collagens are the most abundant proteins in the human body. "These proteins support our organs and our bones," says Leena Ala-Kokko of the MCP Hahnemann University in Philadelphia. "They hold us together."

Ala-Kokko and her colleagues have now linked a defect in a collagen gene to herniated disks, an excruciatingly painful back problem that afflicts many people. The protein under scrutiny is collagen IX, which represents a relatively minor component of the spongy disks that separate the vertebrae in the back.

Several years ago, a Japanese research group created mice that have a mutation in one of the three genes needed to form collagen IX. As the rodents aged, their disks degenerated.

Curious whether collagen IX mutations trigger back problems in people, Ala-Kokko's team and colleagues in Finland surveyed people with sciatica, a pain that radiates from the lower back to below the knee. A bulging or shattered disk that presses upon a nearby nerve commonly causes sciatica, and the researchers confirmed herniated disks in 157 of the people.

The investigators then examined one of the three genes that together encode collagen IX. In six of the people, the gene had an altered DNA sequence that results in an amino acid switch, tryptophan for glutamine, within the protein. Of 174 people with no sciatica or known disk problems, none had the same alteration, the researchers report in the July 16 SCIENCE.

Finally, they looked at the families of four of the people with the suspicious DNA variation: 26 family members overall had the tryptophan-encoding sequence, and each one had disk problems. "That's when we were convinced," says Ala-Kokko.

The researchers have begun to look for alterations in the two other collagen IX genes. People with collagen IX mutations may wish to avoid other factors, such as obesity, that increase the risk of disk problems, says Ala-Kokko. —*J.T.*