and hence farther away—than astronomers had realized.

The ripples from Hipparcos are now spreading through the age debate. The result pushes up the distances to globular clusters, which means their stars' intrinsic brightnesses must be greater, and shifts the brightness-temperature charts toward younger ages. "My current best estimate for the age of the oldest globular clusters is now 11.5 ± 1.3 billion years," says Chaboyer—a dramatic downward revision. The new Cepheid scale also affects measurements of the Hubble constant, says Feast. Of Freedman's value for the Hubble constant of 73, Feast says, "I would bring that down to 66 with my Cepheid scale." The revision does not blunt the conflict between Freedman's result and Sandage's, however, because Sandage's constant also comes down—to 54 or less.

Bruce Peterson, also at Mount Stromlo, and his colleagues on the MACHO Project have found that Hipparcos data support a revision in another distance scale, this one based on a different set of pulsating stars called RR Lyrae stars. They have been studying RR Lyrae stars in the Large Magellanic Cloud, relying on a quirk in pulsations of some of the stars that allows the team to tie down the actual star brightnesses very accurately. When compared with the observed brightnesses, this yields an accurate distance for the Large Magellanic Cloud that matches the new Cepheid distance. Applying the same calibration scheme to RR Lyraes in the globular cluster M15 "reduces the globular cluster ages by about 30%," says Peterson. His best estimate of the cluster age is 12.6 ± 1.5 billion years.

One dissenting voice comes from John Fernley, of Britain's University of Sussex, and colleagues, who used Hipparcos parallax measurements to check RR Lyrae distances and found that the traditional distance scale held up well. But the lower cluster ages are consistent with another set of stellar ages, from the ancient stars called white dwarfs, which Terry Oswalt of the Florida Institute of Technology in Melbourne describes as "basically the 'dead' cores of stars." Oswalt explains that white dwarfs "are slowly cooling. They shine only because they were initially very hot, and the cooling process takes billions of years."

Because of their faintness, astronomers can only see white dwarfs in our galactic neighborhood, but in that area they see none cooler than about 4000 kelvin. The implication of this abrupt cutoff is that even the oldest white dwarfs have not yet had time to chill out completely. Based on the cutoff and the estimated cooling rate, Oswalt and his colleagues will soon publish a best guess for the age of the galactic disk of 9.6 billion years. Add to that figure 2 billion years for the galaxy to collapse from the big bang and the disk to form, and "we get an absolute lower limit to the age of the entire universe of about 11 billion to 12 billion years," he says. A new white dwarf age result from Sandy Leggett of the Joint Astronomy Center in Hilo, Hawaii, and his colleagues, to appear in April's *Astrophysical Journal*, puts the age of the oldest dwarfs at a younger 8 ± 1.5 billion years.

"I now believe ... that no crisis exists in cosmology regarding stellar ages."

—Brian Chaboyer

Open-and-shut case

With this new batch of ages for the oldest stars, the battle lines in the age debate have shifted. If not for high Hubble constant readings like Freedman's, astronomers could be forgiven for heading to a betting shop and putting a sizable bet on 12 billion years as the age of the universe. But one surprise factor could make the entire debate moot. The young expansion ages are all based on the assumption that the universe is "flat"—that it contains just enough mass to prevent it from expanding forever. Many recent observations, however, indicate that the universe may actually be "open," its mass density low enough that it will expand forever rather than stopping or even collapsing again (*Science*, 4 April 1997, p. 37; 31 October 1997, p. 799; 21 November 1997, p. 1402).

The lower the mass of the universe, the less gravitational pull there is to slow its expansion: For an open universe, a given Hubble constant implies an older universe. A 12-billion-year open universe could easily have a Hubble constant as high as the one Freedman measured. "If it's as high as 73, it makes it look more like an open universe," says Feast. Whatever vintage the universe is, it now looks certain to last long enough for astronomers to figure out its true age.

–Andrew Watson

Andrew Watson is a writer in Norwich, U.K.

INFECTIOUS DISEASES

A Method in Ebola's Madness

It's a demon suitable for a horror flick—a quick and gruesome killer. When the Ebola virus struck Zaire 3 years ago, it felled more than 160 people with symptoms that included raging fevers and widespread hemorrhaging—even from the eyes. From 50% to 90% of those infected in that outbreak and others died within 2 weeks, typically from shock. Now, researchers have a new clue about just what makes the Ebola virus so dangerous.

On page 1034, a team led by molecular virologist Gary Nabel of the University of Michigan Medical Center in Ann Arbor reports results suggesting that the virus uses different versions of the same glycoprotein—a protein with sugar groups attached—to wage a two-pronged attack on the body. One glycoprotein, secreted by the virus, seems to paralyze the inflammatory response that should fight it off, while the other, which stays bound to Ebola, homes in on the endothelial cells lining the blood vessels, helping the virus infect and damage them. "It's a remarkable paper," says immunologist Barry Bloom of Albert Einstein College of Medicine in New York City. It shows that these glycoproteins "can account for the two major aspects of the disease—failure of the immune response to kill the virus and damage to endothelial cells."

If confirmed in infected animals and humans, the findings suggest that these glycoproteins could be targets for anti-Ebola vaccines as well as for drugs that treat Ebola infections. And, in an ironic twist, some of this work could yield a new way to treat common ailments such as heart disease and cancer with gene therapies. The Ebola glycoprotein that homes in on endothelial cells could be attached to a harmless viral vehicle that delivers therapeutic genes to these cells, either spurring the growth of new blood vessels that bypass blocked coronary arteries or closing down the blood vessels that feed tumors.

Ever since Ebola was isolated 22 years ago, after the first outbreaks in Zaire and Sudan, virologists have sought the molecular weapons it uses to produce its deadly hemorrhagic fever. In 1979, Michael Kiley and his colleagues at what is now the Centers for Disease Control and Prevention (CDC) in Atlanta found a clue when they plucked from the viral surface a glycoprotein that looks like a molecular tool for gaining entry into animal cells. But the cellular targets of this molecule remained unknown.

To try to pin down this protein's role, the Michigan team, in collaboration with Anthony Sanchez at the CDC, induced cells to

make an avian retrovirus containing the Ebola glycoprotein. They then used fluorescent antibodies that bind specifically to the glycoprotein to trace the virus's interactions with various kinds of cultured cells. The glycoprotein, they found, preferentially binds to human endothelial cells, allowing the retrovirus, which would not normally infect human cells, to enter them. Presumably, this protein also helps the Ebola virus infect endothelial cells, making them fragile and leading to hemorrhaging.

Antibodies also helped the group work out the role of the secreted version of the glycoprotein. Sanchez's team had discovered this protein in the late 1980s in the blood of infected patients. It is a truncated version of the protein found on the virus, and researchers had thought that this similarity might allow the secreted protein to serve as a decoy, sopping up immune cells and antibodies that might otherwise attack the membrane glycoprotein on the virus.

But the Nabel team found that the secreted glycoprotein attaches not to the immune cells that might specifically attack the virus, but to neutrophils, which trigger inflammation, an early general assault in which scavenger cells clear the body of foreign bodies. These results suggest, says Nabel, that rather than serving as a decoy, the secreted glycoprotein actively blocks an inflammatory response that might otherwise stamp out the virus. "It's as if the virus is throwing darts at the neutrophil," he says.

ANTHONY SANCHEZ

Demon virus. Researchers are getting a handle on Ebola virus's high pathogenicity.

No one has shown that the Ebola virus proteins behave the same way in animals as they do in cell cultures, although experiments to find out are under way in monkeys. And even if the cell-culture results hold up, nagging questions may remain. One strain of Ebola, for instance, kills with unusually severe symptoms but makes relatively little soluble glycoprotein, raising doubts that it is always critical for causing the disease. Another unknown is the identity of the endothelial cell receptor to which the membrane glycoprotein binds—information crucial to devising therapies that might block Ebola's binding to these cells.

But even as researchers work to answer those questions, Nabel's team is already exploring another possibility: adding the Ebola virus membrane glycoprotein to a harmless virus that could then carry therapeutic genes specifically to endothelial cells. With such a tool, notes Bloom, doctors might someday treat cardiovascular disease.

Gene-carrying viruses equipped with the Ebola glycoprotein might be used, for example, to deliver growth-factor genes that could trigger the growth of new blood vessels to circumvent damaged ones. Because cardiovascular disease alone afflicts hundreds of millions of people worldwide, that would be an astounding achievement, and it could even give a lift to Ebola's macabre reputation. Says Bloom: "As I read the paper, I started cheering."

–Ingrid Wickelgren

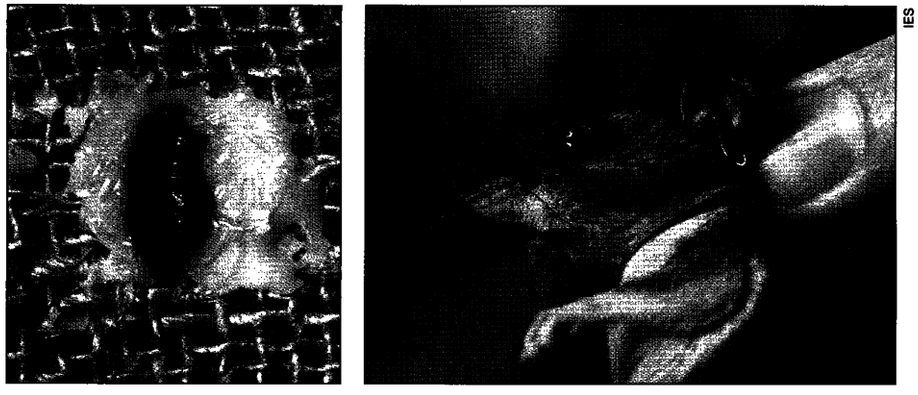
ECOLOGY

Of Mice and Moths—and Lyme Disease?

Charles Darwin once speculated that English cat lovers might unwittingly be setting off an ecological domino chain that leads to prettier gardens. Cats eat the mice that normally pillage the nests of bumblebees, so Darwin reasoned that more cats would mean more bees—and more of the red clover and purple-and-gold pansies, called heartsease, that the bees pollinate. "It is quite credible," Darwin playfully digressed in his 1859 treatise, *The Origin of Species*, "that the presence of a feline animal in large numbers in a district might determine ... the frequency of certain flowers in that district!"

Neither Darwin nor anybody else apparently tested this idea, but ecologists have now unraveled an equally intriguing, albeit less picturesque, skein of interactions that may govern upsurges of Lyme disease and tree-ravaging gypsy moths. In a 3-year study described on page 1023, a team led by Clive Jones and Richard Ostfeld of the Institute of Ecosystem Studies (IES) in Millbrook, New York, traced the links between several forest species to show that bumper crops of acorns lead to an explosion of mice. The mice in turn protect the oak trees by eating gypsy moths, but they also host ticks that can spread Lyme disease, a sometimes disabling human infection.

To tease out these links, Jones and Ostfeld had to manipulate large forest patches by trapping mice or adding acorns—an effort other ecologists are applauding. "It's a wonderful example of how perturbing the system produces results that you wouldn't have expected to be there, unless you'd done the experiments," says Princeton University ecologist Andrew Dobson. But some epidemiologists say too many other factors determine Lyme disease outbreaks for the work to have much predictive value for now. "People are talking about the acorn connection with Lyme disease risk, and it's not established," cautions Yale Lyme disease expert Durland Fish.



IES IES

Sic 'em. More mice munch more gypsy moth pupae *(left)* but may mean more Lyme disease.

Jones and Ostfeld's team, collaborating with Jerry Wolf of Oregon State University in Corvallis, initially set out to learn what controls populations of gypsy moths, a European invader that plunders eastern U.S. forests every decade or so. The researchers knew that white-footed mice are important predators of gypsy moth pupae. The mice also eat acorns, and their population booms after "masting"—the term for an abundant acorn season that occurs naturally every 2 to 5 years. To the ecologists, it seemed plausible that masting would check moth populations, which would take off only a few years after mouse populations crashed.

Jones's team tested this idea in upstate New York in the summer of 1995, 1 year after a masting, when mice were abundant. They removed most mice from three unfenced 2.7-hectare forest patches. Next, they compared the survival rate of moth pupae in