ing from a single direction, than from diffuse, random bombardment.

A more extensive test of dusty plasmas' ability to shape features of the solar system will come if funding holds out for Cassini, a space probe that would visit Saturn near the end of the century. The encounter would give planetary scientists a chance to test Mendis and Goertz's proposals about the origin of the spokes. It will also provide a test of other, more speculative proposals about dusty plasmas around Saturn: that electromagnetic forces could account for the thousands of ringlets and the positions of the sharp ring boundaries and gaps.

If some of these tests of dusty plasmas come up positive, researchers may be willing to entertain a much grander notion: that the plasmas had a role in the origin of the solar system itself. Decades ago, Nobel laureate Hannes Alfvén suggested that electromagnetic forces could have speeded the coagulation of material during the early stages of planet formation. Recent calculations by Mendis and Marlene Rosenberg, also at UCSD, have supported this idea by showing that the solar nebula could have been pervaded by positively and negatively charged dust particles, which would have attracted each other. Still, most astrophysicists have downplayed the importance of plasma processes in the solar nebula, because, says Stuart Weidenschilling of the Planetary Science Institute in Tucson, "most of the solar nebula had a very low degree of ionization." There simply weren't enough charges around to matter, he thinks.

But theoretical work by groups in Japan and the United States is now supporting an even grander role for dusty plasmas: in star formation. The magnetic fields of many newborn stars are curiously weak, given the amount of magnetism likely to be trapped in the clouds of dust and plasma from which they formed. The new calculations show that if the dust particles captured electrical charges from the plasma, forming a dusty plasma, they would increase the cloud's electrical resistance. And that, explains Rosenberg, might explain why the magnetic fields of the new stars are so weak: Magnetic fields can escape more easily from electrical insulators than from conductors.

Thanks to dusty plasmas, says Frank Shu, a leading authority on star formation at the University of California, Berkeley, "a new direction is becoming clear" in understanding star formation. If the same turns out to be true for some mysteries closer to home, among the planets, some dusty byways may soon become as familiar to astronomers as the well-worn paths ruled by gravity.

–James Glanz

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TOXICOLOGY

Study Implicates Second-Hand Smoke

DALLAS—The only chickens that engage in such human follies as smoking cigarettes are the ones drawn by cartoonist Gary Larson in *The Far Side*. But don't be too quick to cluck at cockerel caricatures of people: Researchers at New York University (NYU) have found that cockerels exposed to environmental tobacco smoke (ETS) develop plaques in their arteries that resemble the damage seen in human victims of arteriosclerosis, a chronic disease in which artery walls gradually thicken and harden.

This finding is the strongest direct evidence yet obtained that ETS causes physiological changes and it appears to solidify the position adopted 2 years ago by the Environmental Protection Agency (EPA) that "widespread exposure to ETS in the United States presents a serious and substantial public health impact." At that time, EPA labeled ETS a known human carcinogen on the strength of an analysis of 31 epidemiological studies (*Science*, 31 July 1992, p. 607), and the agency estimated that second-hand smoke causes about 3000 lung cancer deaths a year. Recent epidemiological studies have suggested ETS may cause 10 times that number of deaths from heart disease.

The tobacco industry has disputed the heart-disease findings by noting an anomaly: ETS appears to be nearly as potent as direct tobacco smoke in causing heart disease, even though direct smoke delivers a far higher dose of chemicals. Although the new finding, presented here last month at the annual meeting of the Society of Toxicology, doesn't solve that puzzle, it is "real important" because it "bolsters human epidemiological studies that point to a correlation between ETS and cardiovascular disease," says long-time tobacco researcher Stanton Glantz, a cardiologist at the University of California, San Francisco.

The team that carried out the study, led by Arthur Penn of the Nelson Institute of Environmental Medicine at the New York University Medical Center, used cockerels because those exposed to chemicals implicated in human plaque growth develop plaques similar to those found in people. Moreover, the researchers had already found that benzo-a-pyrene, a carcinogenic chemical in cigarette smoke, accelerated the growth of plaques in cockerels. Based on these findings, Penn and an NYU colleague, inhalation toxicologist Carroll Snyder, exposed young cockerels to second-hand smoke from burning cigarettes, mixed with air, for 6 hours a day for 16 weeks. In a study reported last October in *Circulation* (vol. 88, p. 1820), the scientists found that plaques in the abdominal aorta of ETS-exposed cockerels grew much faster than those in control cockerels.

A.D. SULLIVAN/POULTRY TRIBUNE

Have a heart. Environmental tobacco smoke spurred plaque growth in white leghorn chickens.

Soon after the study appeared, however, the tobacco industry wrote a scathing letter to *Circulation* asserting that the cockerels in Penn's study were exposed to 300 times the level of particulate matter (a suspension of compounds released by a burning cigarette) measured in a private contractor's study of smokers' homes. In Penn's study, cockerels were exposed to between 7.5 and 8.5 milligrams per cubic meter (mg/m^3); the levels in smokers' homes were about 0.05 mg/m^3. "He was effectively pumping mainstream smoke into these big fat cockerels," says Chris Coggins, an inhalation toxicologist at R.J. Reynolds Tobacco Co.

In response, Penn argues that particulate levels vary greatly depending on an exposed subject's proximity to a smoker. Nevertheless, he conducted a follow-up study in which the concentration of particulate matter was reduced to about 2.4 mg/m^3. Penn also used a marker for exposure to ETS—carbon monoxide levels—and compared those in the experiment with levels at four bars in upstate New York. "We found that carbon monoxide levels in the presence of smokers were equal to or higher than levels the cockerels were exposed to," Penn says. These ETS-exposed cockerels, like their brethren, developed plaques faster than controls.

Coggins remains skeptical of Penn's findings, suggesting the cockerels developed the plaques in response to the stress of being placed in a smoky environment. Penn scoffs at the explanation. "After we put them in the cages, these cockerels become really docile—it's almost like having pet rocks around," he says. These pet rocks, however, have the potential to inflict pain on a multibillion-dollar industry.

–Richard Stone