"Trying to interpret what goes on in single cells by looking at these aggregates is quite clever," says John Galloway, who formerly studied the phenomenon of handedness in biological structures at Oxford University and is now associated with the Nuffield Foundation in London, a trust that supports biological and medical research. "You would never be able to study single cells this way."

Mendelson and Thwaites' strategy has also revealed that whether a fiber twists in a right- or left-hand sense, and how tightly it coils, depends on more than just the genetics of the strain. Temperature, acidity, and the presence of certain amino acids or other chemicals also affect the bacterial architecture, according to Mendelson. In almost all other cases of helical structure in biology, such as snail shells, genetics alone determines the handedness, Galloway says. "With these bacteria, you have this curious [nongenetic] flexibility."

Mendelson and Thwaites' model can successfully describe the coiling of the strands formed by another bacterial strain, the cyanobacterium *Mastitocladus laminosis*, says Edward Stevens, a molecular biologist at Memphis State University. But *Bacillus subtilis* may turn out to be more than a convenient organism for experiments into the genetics, chemistry, and mechanics of biological shape formation—it may also be a template for new materials.

Mendelson has found that the negative charges on the protein and carbohydrate polymers in the cell walls attract positively charged ions such as calcium and iron dissolved in a culture medium. These in turn serve as nucleation sites for salt formations. As a bacterial fibril is drawn from culture, almost the way nylon threads are drawn from a polymer melt, it can form "a brittle [bacterial] thread that looks like a little piece of bone," says Mendelson. He calls such bacteria/crystal composites bionites. By packaging biological material within an inorganic coating, Mendelson thinks, these composites might serve as vehicles for proteins, enzymes, and other products of biotechnology.

To probe this possibility, he grew a bionite using a bacterium genetically engineered to produce abnormally high amounts of an enzyme that can snip a test molecule, yielding a yellow product. When Mendelson dried one of the enzyme-bearing bionites, then rehydrated it and put it into a solution of the clear test molecule, the solution became yellow and then amber. "Enzyme activity was retained," he concludes. And that suggests to him that bionites built around genetically engineered bacteria might serve as implantable drug-delivery devices, or as flow-through gizmos that could perform specific chemical transformations on molecules passing through their porous coatings.

For microbiologist Mendelson, the experience of straying into an unfamiliar discipline like materials science is exhilarating. "I never dreamed that I would contribute something of interest to the materials and engineering world," he says. Of course, it's too early to say whether bionites will amount to more than a laboratory curiosity for Mendelson and Thwaites, who now are studying the strength, stiffness, and other physical properties of the structures. But for now they have every intention of bringing their movie-star bacteria back to a future materials science meeting in a sequel as dazzling as the original. ■ IVAN AMATO

Twin Study Links Genes to Homosexuality

A new study of twins and adoptive brothers has turned up fresh evidence that genes play a strong role in the development of homosexuality. Indeed, the researchers who conducted the study—psychologist J. Michael Bailey of Northwestern University and Boston University psychiatrist Richard C. Pillard—estimate in a paper published in the December *Archives of General Psychiatry* that the genetic component of homosexuality is somewhere between 30% and 70%.

Bailey and Pillard, who recruited subjects through ads in gay publications, studied three groups: identical twins, fraternal twins, and men with adoptive brothers. They interviewed 161 homosexual men and sent questionnaires to their twins or adoptive brothers. Of the 170 relatives whose sexual orientation could be rated, 52% of the identical twins, 22% of the fraternal twins, and 11% of the adoptive brothers were also homosexual.

Although these findings are consistent with the view that homosexuality has a large genetic factor, one finding was not: The researchers determined indirectly through reports from the subjects of the study that only 9.2% of the non-twin biological brothers of homosexuals were themselves homosexual. Bailey and Pillard suspect that this may be a chance finding, however. They believe that the true rate is closer to that shown in an earlier study headed by Pillard, in which brothers of gay men were found to be four to five times as likely as controls to be homosexual. "Obviously, this needs to be replicated," says Bailey.

The investigators were not able to be more precise in their heritability estimates because of uncertainty about the base rate of homosexuality in the population, which is estimated at between 4% and 10% of males. Bailey says that if the 4% figure is more accurate—as he surmises based on recent surveys—then heritability for homosexuality would be at least 50%.

That still leaves a lot of room for environmental influences but, in an interview with *Science*, Bailey argued that these are likely to be predominantly biological ones, in the form of random hormonal variations, rather than psychosocial ones. That, he says, could explain why fraternal twins—who share the same prenatal environment—are more similar in sexual orientation than siblings. He dismisses an alternative explanation, that postnatal environmental influences play a key role: "No one has ever found a postnatal social environmental influence for homosexual orientation—and they have looked plenty," he says.

Other scientists, while endorsing the central finding of the study, are more guarded in speculating about the source of nongenetic influences. Neuroscientist Sandra Witelson of MacMaster University in Ontario says she thinks the paper "shows very conclusively that there is a genetic component in homosexuality." But, "I don't think there are enough data at this point to exclude a postnatal social learning component." Psychiatrist Leonard Heston of the University of Washington in Tacoma says the study confirms the conclusions of earlier twin studies of homosexuality—most of them very small—which "all point in the same direction": that identical twins are concordant for homosexuality about 50% of the time. He agrees that there is no good evidence for postnatal environmental influences but says, "I'm a complete agnostic on that."

Bailey theorizes that the genes implicated in homosexuality are probably those involved in prenatal brain development—specifically in masculinization of the hypothalamus during sexual differentiation. That suggestion is based on animal and human studies that point to the importance of the hypothalamus for sexual behavior, and recently published research by Simon LeVay of the Salk Institute (*Science*, 30 August, p. 1034), who found a certain cell group in the hypothalamus to be smaller in homosexual than heterosexual men. "Our working hypothesis is that these genes affect the part of the brain that he [LeVay] studied," says Bailey. ■ CONSTANCE HOLDEN