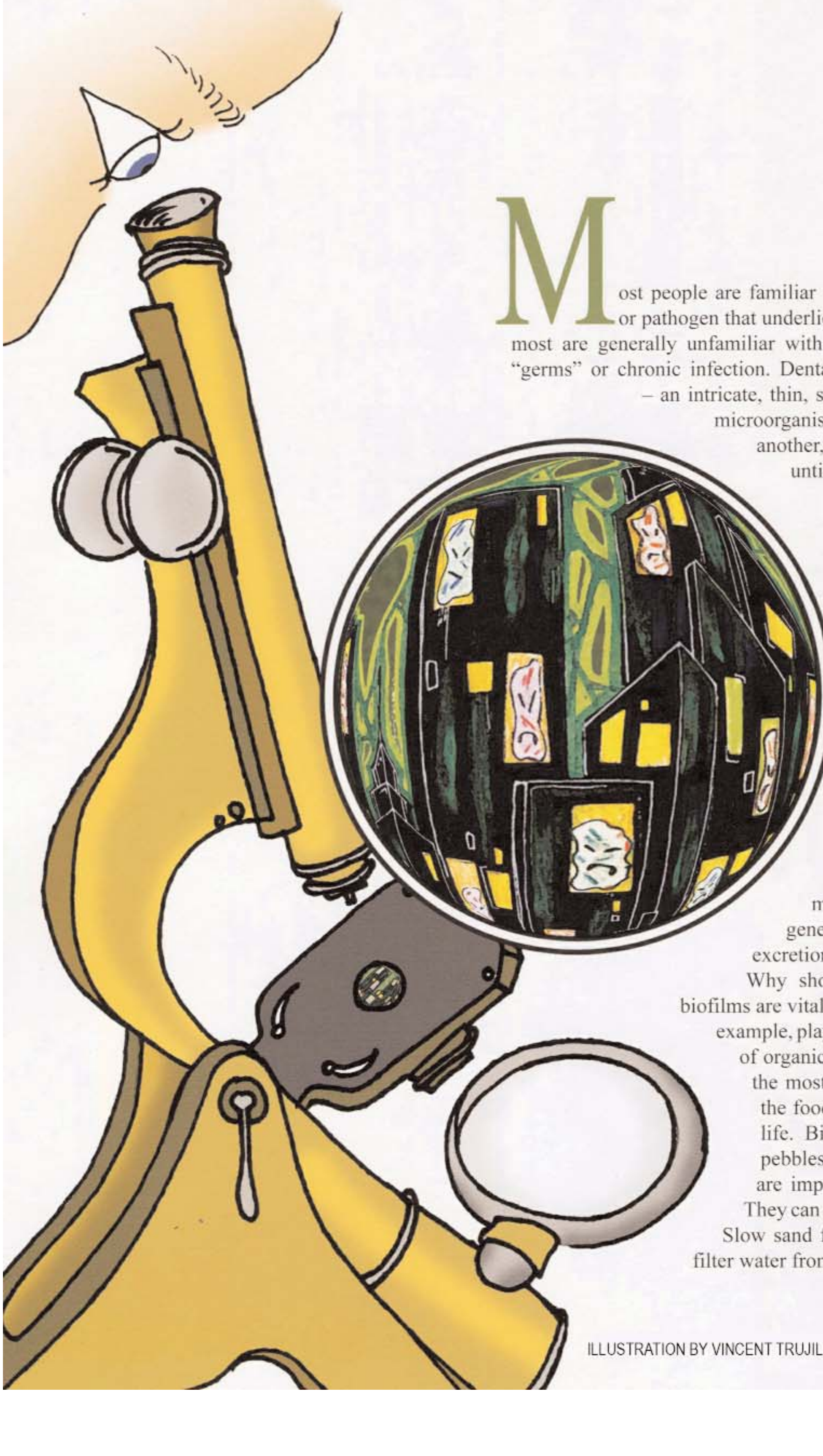
Biofilms

What they are and why we should care

When you stand at the sink, brushing your teeth, do you ever think about the colonies of bacteria you are displacing as you brush away the plaque?

ILLUSTRATION BY VINCENT TRUJILLO



Most people are familiar with the idea of bacteria as a "germ" or pathogen that underlies many infectious illnesses. However, most are generally unfamiliar with the idea of biofilms as a source of "germs" or chronic infection. Dental plaque is an example of a biofilm – an intricate, thin, slimy film construction through which microorganisms adhere to a surface and to one another, hiding within their "community" until the environment is right to activate. Biofilms can exist within the human body as well as in other environments, and contain many different types of microorganisms, including bacteria, archaca, protozoa and algae. Although some microorganisms, like algae, can form free floating mats on liquid surfaces, such as stagnant ponds, they are usually found submerged in or exposed to a water-based solution and attached to a solid surface. Biofilms are heterogeneous, differentiating to accomplish different tasks within a microbial "community." They exhibit genetic diversity and are marked by the excretion of a sticky protective matrix.

Why should we care about biofilms? Some biofilms are vital to our existence. Bacterioplankton for example, play a significant role in the remineralising of organic material in the ocean, and are among the most important organisms on earth due to the food supply they help provide for aquatic life. Biofilms also are found on rocks and pebbles in most streams and rivers where they are important components of the food chain. They can be harnessed for constructive purposes. Slow sand filters rely on biofilm development to filter water from rivers, springs and lakes for drinking

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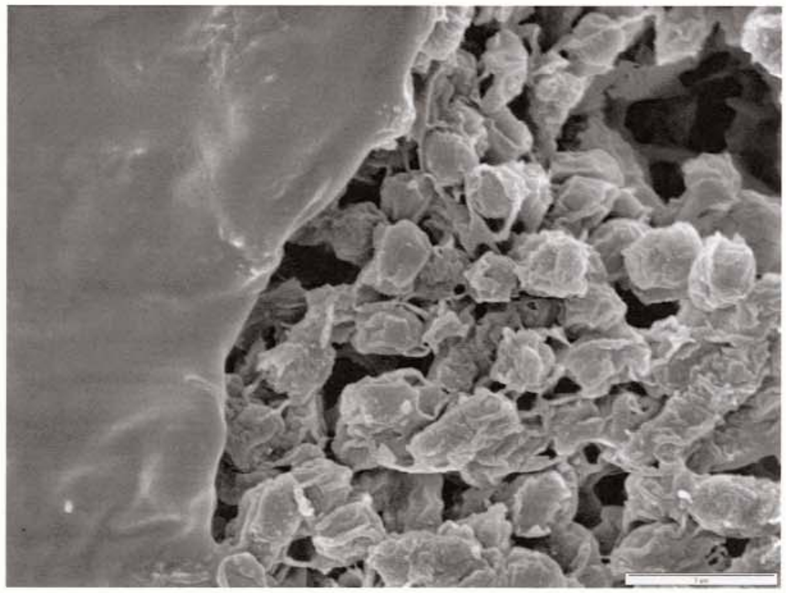

Scanning electron micrograph of a biofilm formed by an otitis media pathogen (non-typeable Haemophilus influenzae)

purposes. Many sewage treatment plants include a stage in which waste water passes over biofilms grown on filters, which extract and digest organic compounds.

Not all biofilms are constructive or benign. In industrial environments they develop on the interiors of pipes, causing clogging and corrosion. Forming on counters and floors, they can make sanitation difficult in food preparation areas leading to food contamination. Biofilms also have been linked to a variety of human microbial infections, including ear infections. In addition to dental plaque which leads to the cavities that your dentist has to fill, they are implicated in gingivitis and more serious health problems such as endocarditis, an inflammation of your heart's inner lining, the lung infections common in cystic fibrosis and numerous infections acquired in hospital. The existence of biofilms may be a significant reason why antibiotics have not always succeeded in killing off infectious bacteria inside the body, including inside the ear. Understanding biofilms may lead to improved treatment methods for a variety of illnesses that previously have not responded to antibiotics, including ones that cause deafness.

Until recently, the scientific community focused its study of infectious pathogens primarily on a bacterium. That is, scientists and the medical community have geared their studies and treatments to tracking and attacking a single free-floating microorganism, rather than on the complex community of microorganisms thriving under a surface of sticky slime – virtually impervious to antibiotics and disinfectants. Until the phenomena of biofilms and their sophisticated ability to transform from free-floating bacteria to slimy layers of hidden bacteria were observed and described in recent studies, they generally have been ignored in laboratory studies since the 1860s. An ongoing collaboration of scientists from House Ear Institute and the University of Southern California in Los Angeles, Oak Crest Institute of Science in Pasadena, and four other US research centers, employs a variety of research tools and approaches, such as confocal imaging and electron microscopy, to inquire into the complexity of biofilm structures and to verify mutual

(Continued on page 32)

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PAUL WEBSTER, PH.D.

observations about how they develop and how they may be conquered.

From viewing an extensive variety of biofilm structures, these scientists conclude that phenotypically distinct bacterial cells surround themselves with polymeric substances to form microcolonies, whose shape and structure are determined by cell-to-cell signals and are influenced by environmental conditions. A recent study generated by the collaboration notes that:

- Microbial species reproducibly form regular structures including "honeycombs" and "veils" that can grow to sizes visible without magnification.
- These structures occur both in ecosystems and in laboratory cultures and they constitute a genetically determined, previously unrecognized structural component of many microbial communities.
- These structures are associated with large numbers of bacterial cells when first formed but can be devoid of cells once the structures mature.
- The structures are not composed of a single extracellular constituent, but appear to contain many components of the cells that form them.

"If we are prepared to think of the pathogenic bacteria in the middle ear, in periodontal disease, or in the lungs of patients with cystic fibrosis, as members of highly organized communities rather than as single, free-floating microorganisms, we can begin to develop strategies for disrupting those communities by jamming their signals or draining their energy supplies," says Paul Webster, Ph.D., Director of the Ahmanson Advanced Electron Microscopy and Imaging Center at HEI.

Collaborating scientists are interested in how bacteria are able to dissolve bone. This has implications for hearing health because of the bone reabsorption that occurs in cholesteatoma patients. Biofilms have been shown to associate with cholesteatomas – a condition of the middle ear that sometimes results from infection, which can cause hearing loss and other problems – and they are also relevant in the search for prevention of otitis media, the middle ear infections common in childhood, which can lead to deafness. Investigations like these promise progress toward improved hearing health in the future.

Findings such as those produced by this collaboration enable the application of general biological concepts to bacteria, a re-evaluation of how and when we use antibiotics, and the creàtion of new strategies for treating bacterial infections. New findings and our understanding of biofilms assure an exciting future for the fields of microbiology and medicine. ❖