COMMENTARY

by Bernard Dixon

PUTTING STICKY BUGS TO WORK

Given the possibility of genetically engineering "a one micron scientist" to study bacterial adhesion at close range, should he/she be a microbiologist or a physical chemist? Such was one of the less serious questions considered in Berlin recently during a Dahlem Conference at which both varieties of conventionally-sized scientists exchanged views about how and why microorganisms stick to surfaces and to each other. The gathering marked a growing recognition of the tremendous importance this deceptively arcane topic holds for biotechnology, medicine, agriculture, and industrial efficiency. And the outcome was an invigorating interplay of ideas that should reap rich rewards for each of these sectors in the future.

The commercial world already enjoys a love-hate relationship with "biofilms." On the one hand, these surface layers of adhering bacteria and other organisms do untold damage. They impair the efficiency of energy transfer in heat exchangers, impede fluid flow in pipelines, interfere with chemical transformation, and cause fouling of ships' bottoms. On the other hand, they are the productive centerpiece of fixed-film bioreactors. And in the agricultural domain, attachment to plant roots is the primary event that leads to beneficial symbioses such as those between legumes and *Rhizobium* strains.

A great merit of the interdisciplinary discussion that characterizes Dahlem conferences is the wide (and occasionally wild) variety of speculations thrown up from around the room. On this occasion, it generated innumerable gambits for controlling microbial adhesion. Ian Robb, a physical chemist with Unilever, suggested the preventive strategy of coating surfaces with a protective polymer that would phase separate with the macromolecules surrounding nuisance species of bacteria. Scrutinizing the skin of whales and dolphins, he opined, might provide clues as to how they resist attachment.

Byron Johnson, a microbiologist with the National Research Council of Canada, then postulated that the genetic constitution of wild-type populations of biofouling organisms may one day be modified to make them more vulnerable to chemical attack. Although that idea raised skeptical eyebrows, it deserves to be taken seriously in light of reports in Berlin, by Michael Silverman, from La Jolla's Agouron Institute. He illustrated the remarkable progress made recently in applying modern molecular genetics to investigate the structure and regulation of the "adhesins" by which bacteria stick specifically to surfaces. Several of the structural genes concerned have been cloned. Amino acid sequences, and to some degree the secondary and tertiary structures of the adhesive proteins, have been deduced from the corresponding DNA sequences. Even the number of genes encoding certain adhesins has been identified, and information gained about how the genes are controlled.

As well as indicating potential strategies to combat fouling, these powerful techniques also raise the prospect of enhancing adhesion, and thus efficiency, in bioreactors. By combining genetics with other disciplines, Silverman said, it is now becoming possible to design genes that produce entirely new adhesions. A complementary approach explored by other speakers was that of increasing the activity of biofilms, or the rate at which they develop.

As reviewed by Paul Rutter, a British Petroleum colloid chemist and one of the Dahlem rapporteurs, developments aimed at preventing disease-causing bacteria from sticking to host tissues are also on the verge of success. One approach is to exploit bacterial adhesins as the basis for vaccines that will elicit corresponding antibodies and thus block the process of attachment. Another is to remove adherent organisms with enzymes that degrade their bridging polymers—as with glucan hydrolases capable of savaging the extracellular glucans *Streptococcus mutans* employs to cling tenaciously to human teeth. Thirdly, it seems that sublethal concentrations of certain antibiotics inhibit the synthesis of some adhesins.

The area in which preventive and provocative tactics towards bacterial adhesion come closest together is that of agriculture, because the initial contact between a plant root and a nearby microbe can be the prelude to either fatal infestation or mutual benefit. Frank Dazzo, a Michigan State University microbiologist, described examples of each—from *Rhizobium*-legume symbiosis to crown gall formation by *Agrobacterium tumefaciens*—and illustrated their common origin in specific unions between chemical groupings on the surfaces of interacting cells. There was, he said, a pressing need to identify these receptors—in order, eventually, to control the initial "docking" stages. It might prove possible, for example, to broaden the host range for nitrogen-fixing associations of *Rhizobium*, as well as to suppress harmful ones that ravish major crops.


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The Dahlem conference was a triumph for microbiologist Kevin Marshall from the University of New South Wales. It was he who first conceived the notion of assembling a variegated group to attack the familiar but highly significant topic of microbial adhesion from the disparate standpoints of microbiology and chemistry, physics and ecology. Not least for those participants concerned with industrial biology, the highly successful collaboration generated a wealth of possibilities for further research. Whether Marshall was equally delighted with *another* of the week's developments—the suggested formation of a Society of Living Immobilised Microbial Ecologists (SLIME)—is not known.

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