Biofilm Mechanics Workshop

June 28-30, 2007

Review by Phil Stewart, CBE Director

Late June can be a beautiful time in Montana, and so it was this year when the Center for Biofilm Engineering (CBE) hosted a workshop on the topic of biofilm mechanics on the Montana State University campus. This event brought together 26 participants from Montana, Texas, Florida, New York, Minnesota, Pennsylvania, North Carolina, Canada, Germany, and the Netherlands to share ideas and recent results about what holds microbial biofilms together and how these biological assemblages can be understood as mechanical structures that deform, move, and flow.

The meeting was informal, convivial, and collaborative in spirit. Technical presentations were interspersed with discussion sessions. The modest size of the group and relaxed atmosphere helped make the questioning and discussion particularly unfettered, creative, and leavened with humor. The group dined together in the cellar of an attractive restaurant in historic downtown Bozeman, and a free afternoon allowed for some fishing, hiking, beer sipping, and project planning.

We are indebted to Isaac Klapper for conceiving this event and organizing the program. The interdisciplinary nature of the group was obvious at lunch one day when our table of five included a physicist, a chemical engineer, two microbiologists, and an electrical engineer. Also represented among the workshop participants were mathematicians, civil engineers, mechanical engineers, a biomedical engineer and a biochemist.

Workshop organizers Paul Stoodley, Center for Genomic Sciences at the Allegheny-Singer Research Institute, Pittsburgh; Phil Stewart, CBE Director; Isaac Klapper, MSU Professor, Mathematics.

Rather than encapsulate specific talks, let me just summarize here some of the themes, hypotheses, and ideas that emerged in the course of the workshop:

- Biofilm cohesion is realized through multiple polymers and multiple cohesive forces;
- Specific polysaccharides are distributed heterogeneously in the biofilm matrix; these can be localized via lectin staining and microscopy;
- Abiotic components (precipitates, corrosion products, dead white blood cells, etc.) are significant in real-world systems and likely contribute to the material properties of biofilms;
- Biofilm should not be a prison; biological pathways for dispersion of cells from a biofilm are being elucidated;
- Biofilm properties are being probed and forces measured by pushing and pulling on biofilms with ingenious instrumental adaptations of atomic force microscopes, micropipette cantilevers, magnetic resonance microscopes, and fluid jets;

- These measurements point to microscale heterogeneity in the distribution of EPS and in local mechanical properties;
- Fluid-biofilm interactions give rise to drag, lift, detachment, channeling, differential effects during antimicrobial treatment and also to complex motions of the biomass such as oscillation, mixing, and rolling;
- Cells compete for space and displace their neighbors as bacteria grow inside a biofilm;
- Modelers are tackling biofilm mechanics by simulating a network of interconnected, breakable springs or by describing the biofilm as a compressible fluid subjected to combined attractive and repellant forces.

Participant list

Recep Avci
Physics, MSU, Bozeman, MT

Bruce Ayati
Mathematics, Southern Methodist University, Dallas, TX

Sarah Codd
Mechanical & Industrial Engineering & CBE, MSU, Bozeman, MT

Nick Cogan
Mathematics, Florida State University, Tallahassee, FL

Al Cunningham
Civil Engineering & CBE, MSU, Bozeman, MT

David G. Davies
Biological Sciences, Binghamton University Binghamton, NY

Willy Davison
Chemical & Biological Engineering & CBE, MSU, Bozeman, MT

Jack Dockery
Mathematical Science & CBE, MSU, Bozeman, MT

John Dutcher
Physics, University of Guelph, ON, Canada

Hans-Curt Flemming
Biofilm Centre, University of Duisburg-Essen Duisburg, Germany

Michael Franklin
Microbiology & CBE, MSU, Bozeman, MT

Gill Geesey
Microbiology & CBE, MSU, Bozeman, MT

Robin Gerlach
Chemical & Biological Engineering & CBE, MSU, Bozeman, MT

Raymond M. Hozalski
Civil Engineering, University of Minnesota, Minneapolis, MN

Jennifer Horneman
Chemical & Biological Engineering & CBE, MSU, Bozeman, MT

Isaac Klapper
Mathematical Science & CBE, MSU, Bozeman, MT

Ben Klayman
Civil & Environmental Engineering & CBE, MSU, Bozeman, MT

Bertram Manz
Magnetic Resonance Imaging, Fraunhofer-Institut für Biomedizinische Technik, St. Ingbert, Germany

Thomas R. Neu
Helmholtz Centre for Environmental Research, Magdeburg, Germany

Ekaterina Paramonova
Biomedical Engineering, University Medical Center Groningen and University of Groningen, The Netherlands

Joseph Seymour
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Zhiyong Suo
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Michael Sutton
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Ahmed Touhami
Physics, University of Guelph, ON, Canada

Daniel Wozniak
Microbiology & Immunology, Wake Forest University School of Medicine, Winston-Salem, NC

Beautiful June weather encouraged outdoor activities during free time. Above, from left, are participants: Ekaterina Paramonova, Groningen, The Netherlands; Ahmed Touhami and John Dutcher, Guelph, Ontario, Canada; and Bruce Ayati, Dallas, Texas.