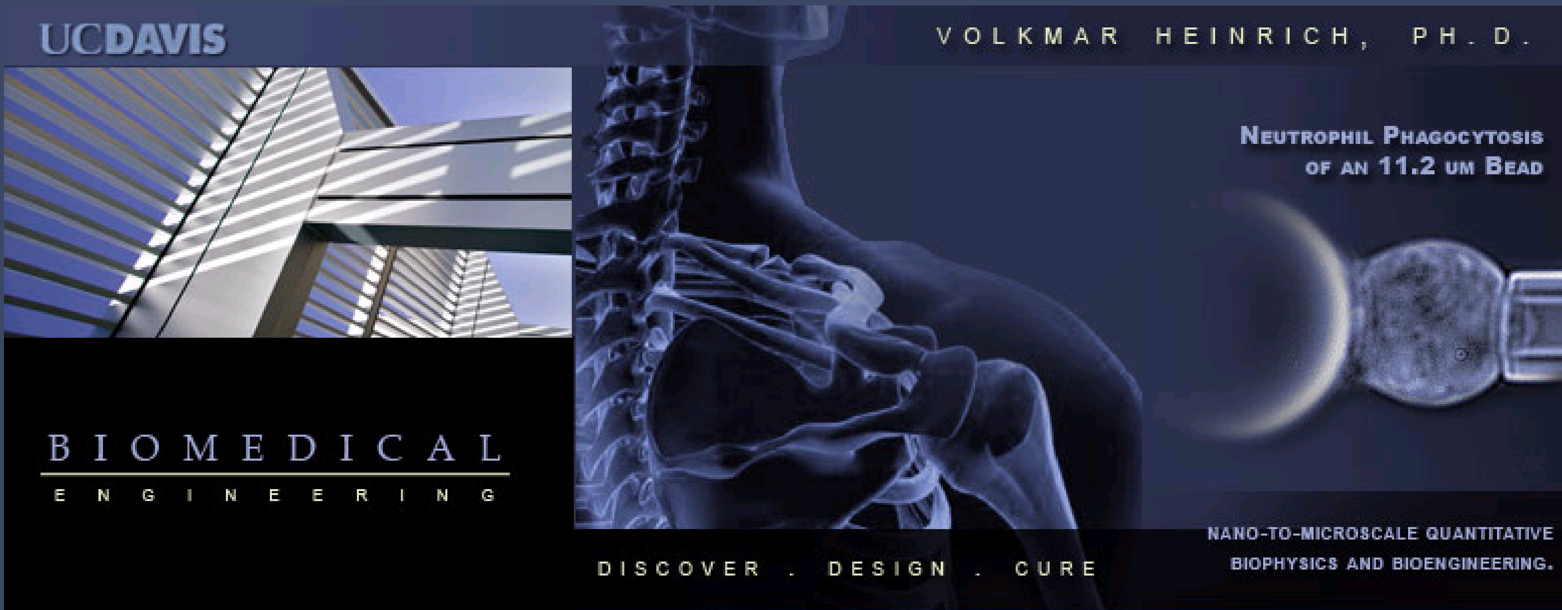

Volkmar Heinrich

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PERSONAL EDUCATION

Ph.D. in Biophysics, Humboldt University Berlin, Germany 1992
Postdocs with Dr. R. Waugh (University of Rochester) and Dr. S. Svetina (Ljubljana University, Slovenia)
Research faculty in the group of Dr. E. Evans (University of British Columbia and Boston University)

AFFILIATION

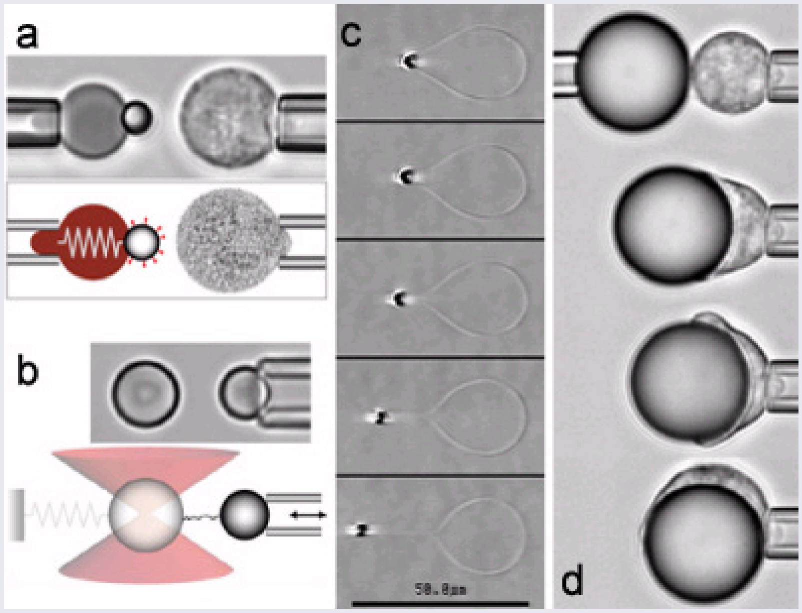
Biomedical Engineering Graduate Group
Biophysics Graduate Group

RESEARCH INTEREST

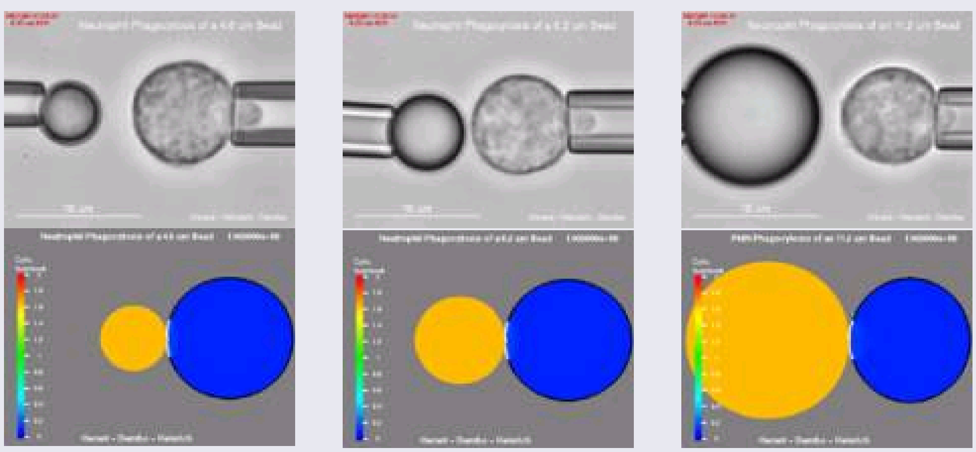
Molecular-to-cellular bioengineering/biomechanics: Towards a quantitative understanding of mechano-sensing, -signaling, and -regulation

Minuscule mechanical forces, though often overlooked, play a vital role in many molecular-to-cellular processes. Prominent examples include the interaction between adhesive biomolecules that glue cells together to form tissues, and the active deformation of a white blood cell engulfing its (e.g., an opsonized bacterium). Likewise, a bioengineered drug-delivery capsule inevitably encounters a number of mechanical dilemmas in its transport and attachment to a target and during the controlled release of its content.

Examples of nano-to-micro-mechanical experiments. (a) A biomembrane force probe is used to test the adhesion strength between P-selectin and a neutrophil. (b) A combination of optical tweezers and micropipette manipulation is used to study DNA elasticity. (c) A paramagnetic bead is manipulated using a magnetic puller as it drags along a lipid vesicle, extruding a membrane tether. (d) A human neutrophil attempts to a large, antibody-covered bead (â??frustrated phagocytosis).



Phagocytosis of beads of different sizes: Comparison of experiment *(top)* and computer simulation *(bottom)*. (Click on each picture to view movie or right-click to download.)



Our multiscale approach uses the tools of mechanics and high-resolution optical microscopy to deepen the understanding of how nature does things in the nanoworld and where pathogens may attack our natural defenses. On the smallest scale, we characterize isolated single-molecule interactions using custom-developed, ultrasensitive force probes. In vivo these biomolecules are often supported by soft subcellular structures like membranes or the cytoskeleton. The dynamical properties of such structures crucially affect the way in which the interacting molecules experience force. A more complete picture of biologically relevant nano-to-microscale processes, therefore, requires a sound knowledge of the mechanics of membranes and whole cells. Combining our force probes with advanced micropipette aspiration and micromanipulation allows us to study with exceptional resolution the elasticity and cohesive strength of artificial and biological membranes. Similar experimental setups are used to establish and characterize the mechanical determinants of cellular processes like leukocyte adhesion and phagocytosis and how they are affected by disease.

RESEARCH FACILITY

Automated micromanipulation and micropipette aspiration.
Custom-built force probes:
Biomembrane force probe.
Optical tweezers.
Atomic force microscope.

SELECT PUBLICATIONS

Kim, S.V.; Mehal, W.Z.; Dong, X.; Heinrich, V.; Pypaert, M.; Mellman, I.; Dembo, M.; Mooseker, M.S.; Wu, D.; Flavell, R.A. Modulation of cell adhesion and motility in the immune system by Myo1f. Science 2006, 314(5796), 136-139.

Link to article

Herant, M.; Heinrich, V.; Dembo, M. Mechanics of neutrophil phagocytosis: experiments and quantitative models. J. Cell Sci. 2006, 119, 1903-1913.

Link to article

Heinrich, V.; Leung, A.; Evans, E. Nano-to-microscale mechanical switches and fuses mediate adhesive contacts between leukocytes and the endothelium. J. Chem. Inf. Model. 2005; 45, 1482-1490. (PERSPECTIVE)

Link to article

Heinrich, V.; Leung, A.; Evans, E. Nano- to microscale dynamics of P-selectin detachment from leukocyte interfaces. II. Tether flow terminated by P-selectin dissociation from PSGL-1. Biophys. J. 2005, 88, 2299-2308.

Link to article

Heinrich, V.; Rawicz, W. Automated, high-resolution micropipet aspiration reveals new insight into the physical properties of fluid membranes. Langmuir 2005, 21, 1962-1971.

Link to article

Herant, M.; Heinrich, V.; Dembo, M. Mechanics of neutrophil phagocytosis: behavior of the cortical tension. J. Cell Sci. 2005, 118, 1789-1797.

Link to article

Evans, E.; Leung, A.; Heinrich, V.; Zhu, C. Mechanical switching and coupling between two dissociation pathways in a P-selectin adhesion bond. Proc. Natl. Acad. Sci. USA 2004, 101, 11281-11286.

Link to article

Evans, E.; Heinrich, V.; Ludwig, F.; Rawicz, W. Dynamic tension spectroscopy and strength of biomembranes. Biophys. J. 2003, 85, 2342-2350.

Link to article

Heinrich, V.; Bozic, B.; Svetina, S.; Zeks, B. Vesicle deformation by an axial load: from elongated shapes to tethered vesicles. Biophys. J. 1999, 76, 2056-2071.

Link to article

Heinrich, V.; Sevsek, F.; Svetina, S.; Zeks, B. Large deviations of the average shapes of vesicles from equilibrium: Effects of thermal fluctuations in the presence of constraints. Phys. Rev. E 1997, 55, 1809-1818.

Link to article

Heinrich, V.; Waugh, R. E. A piconewton force transducer and its application to measurement of the bending stiffness of phospholipid membranes. Ann. Biomed. Eng. 1996, 24, 595-605.

MAJOR RESEARCH INTEREST

Nano-to-microscale quantitative biophysics and bioengineering. Single-molecule interactions. Biomembrane mechanics. Cell adhesion and cellular shape and motion. Design and advancement of nano-to-micromechanical core technologies: Dynamic force spectroscopy. Dynamic tension spectroscopy. Biomembrane force probe. Optical tweezers. Automated micromanipulation and micropipette aspiration.