Introduction to Microfluidics [pln84]

Micron length scales:

Microfluidics describes fluid flow in systems with linear dimensions in the range between hundreds of nanometers and single-digit millimeters.

Microfluidics operates with small samples. The advantages of small samples include, quite generally, cost effectiveness and speed. In medical diagnostics invasiveness can be reduced. In pharmocology small dosages become better controllable. Environmental monitoring can be done traveling light and hazards can be detected at lower thresholds.

Fluid dynamics scaled down to micron lengths changes the relative importance of forces. Surface and boundary effects gain prominence. The role of inertia is diminished.

Continuum description:

Fluids are quantized on a sub-micron length scale. Microfluidics is based on a continuum description of fluid media.

Most relevant variables are fields (functions of space and time), including

- *scalar fields* (e.g. density, viscosity, pressure, temperature, free energy),
- *vector fields* (e.g. velocity, current density, pressure gradient, force density, electric field),
- *tensor fields* (e.g. stress tensor, velocity gradient).

The smallest unit of volume in microfluidics (named 'fluid particle') has a linear dimension of $\sim$ 10nm. It contains $\sim 10^4$ molecules. That number fluctuates below the 1% level.

Fluid particles must be small compared to any relevant spatial variation of external forces and fields.

The continuum description breaks down on sub-micron length scales. This is the domain of nanofluidics, which describes, for example, the fluid transport through nanopores in cell membranes or through artificially constructed nanochannels in microfluidic devices.

[extracted from Bruus 2008]