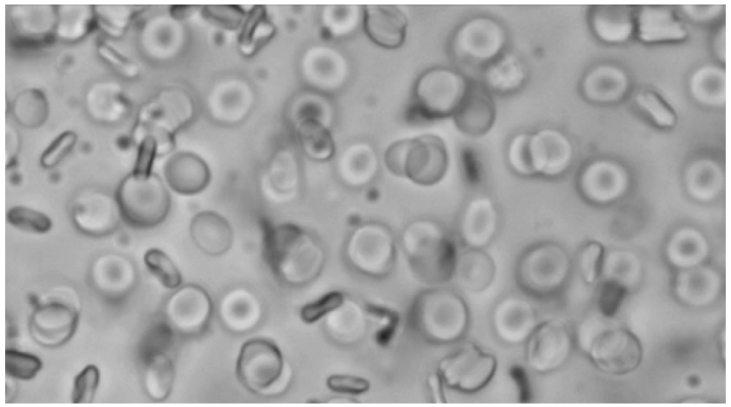
Reconstruction of the brain vasculature for 3D microfluidic applications

Amirreza Gholivand

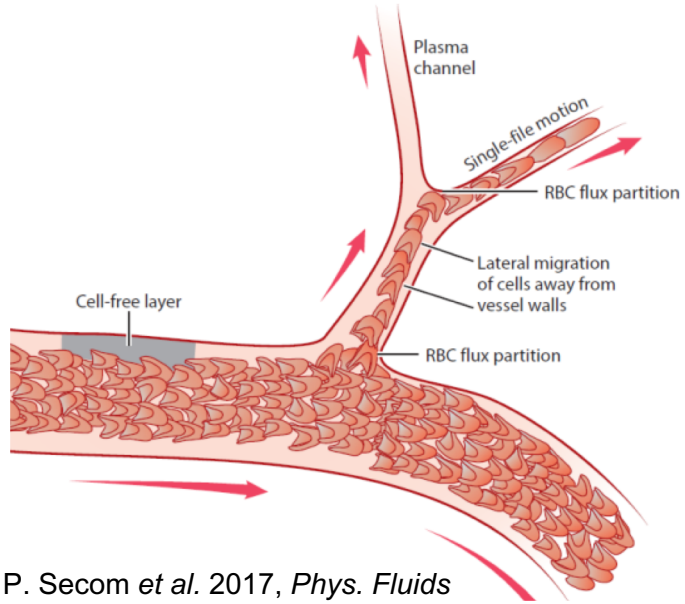
in collaboration with INM1 and ZEA1

PARAMETERS THAT INFLUENCE BLOOD FLOW

Aggregation
(Tuning attraction force)

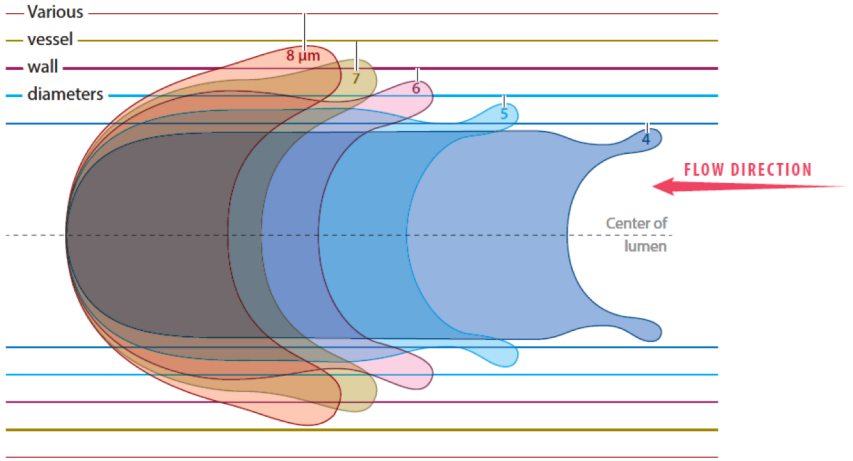


Shape of the vessels



P. Secom *et al.* 2017, *Phys. Fluids*

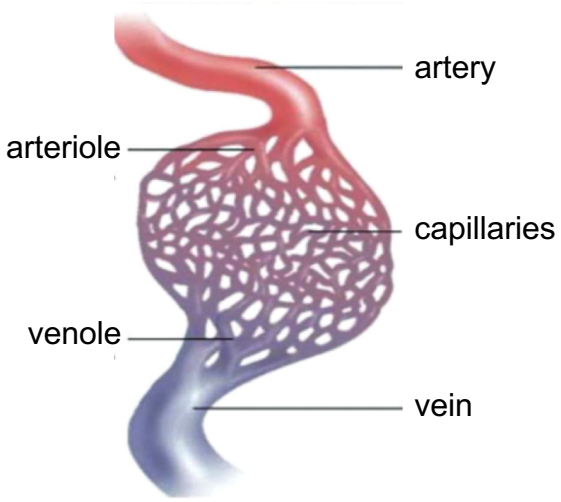
Deformation of Red Blood Cells (RBC)



Need system where we can study blood on large (many cells) and small (one cell) length scale

BLOOD FLOW IN BRAIN MICROCAPILLARIES

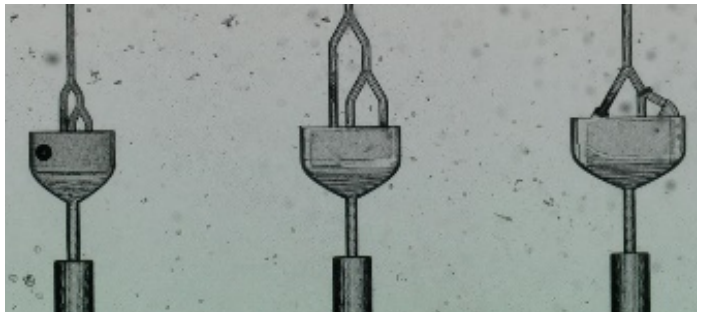
Name	Shear rate (s-1)	Vessel diameter (mm)
Capillaries	1300	0.005–0.010
Arterioles	1600	0.100–0.300
Small artery	1350	0.300–0.500
Coronary artery	450	3.5

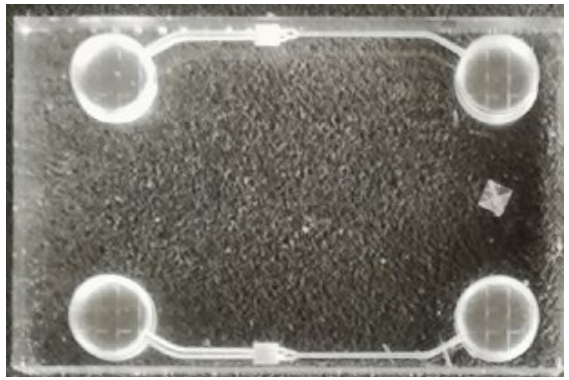


(μ)vascular network

- 3D microfluidic with non planner design
- Novel bio mimicking design based on brain micro vasculature

SELECTIVE LASER-INDUCED ETCHING



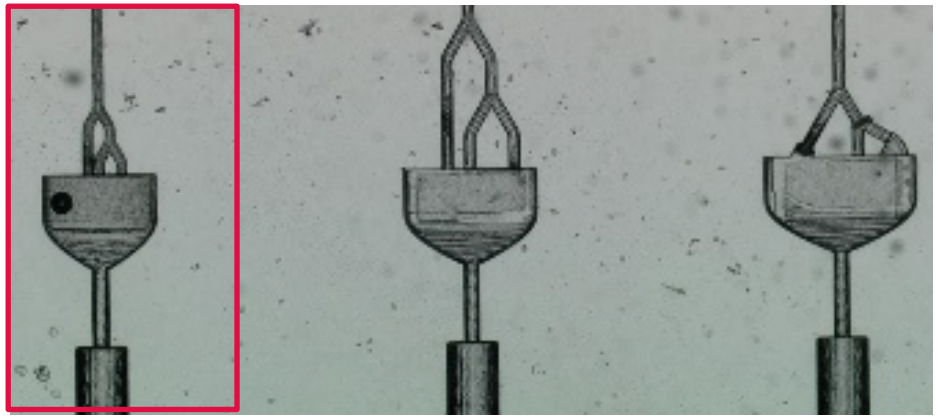


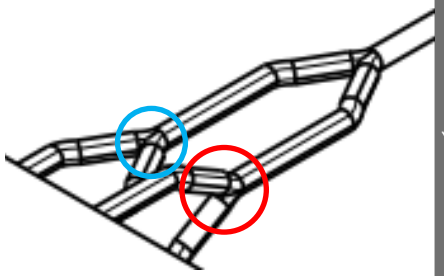
In collaboration with Knut Dalhoff from ZEA-1

LightFab

Information processing

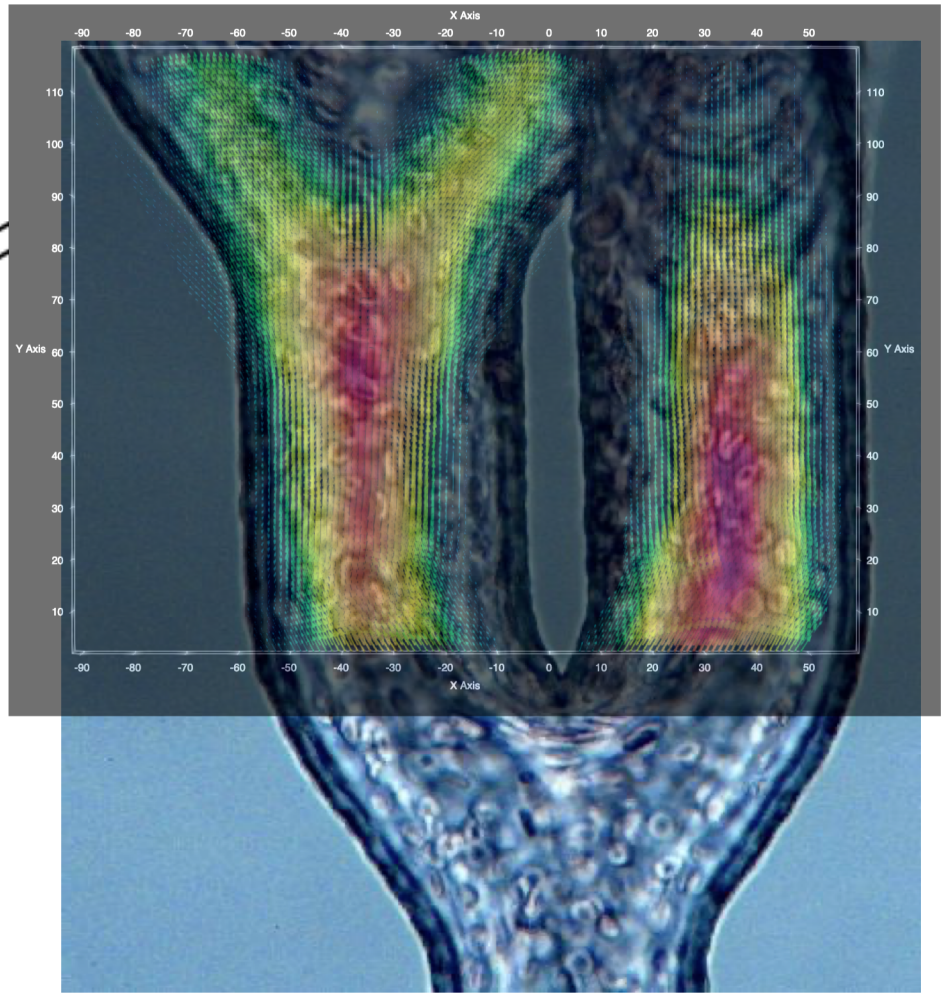
Programming the highway in 3D





Parallel bifurcation

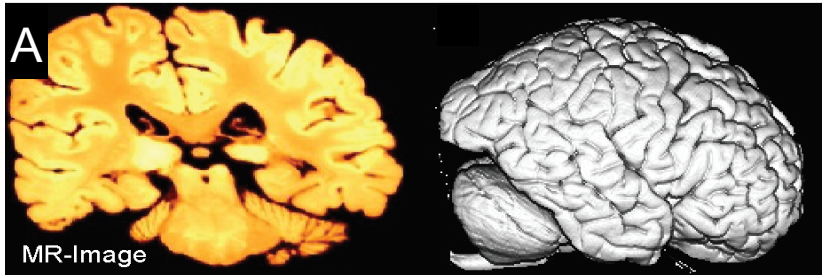
Vertical bifurcation



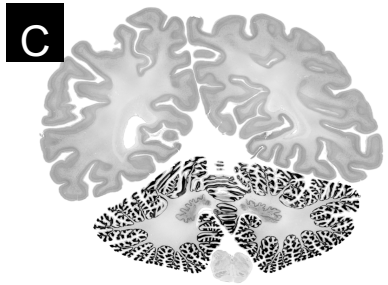
First round channel with diameter of 40 µm

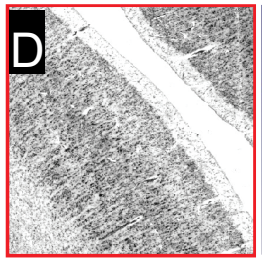
HUMAN BRAIN 3D RECONSTRUCTION

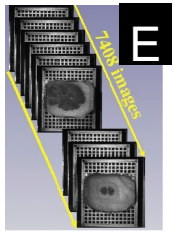
Sectioning (7404 sections, 20µm)



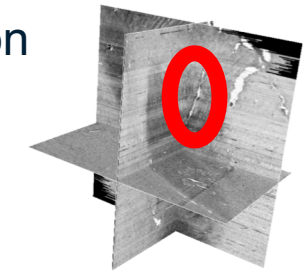
Histological section stained for cell bodies







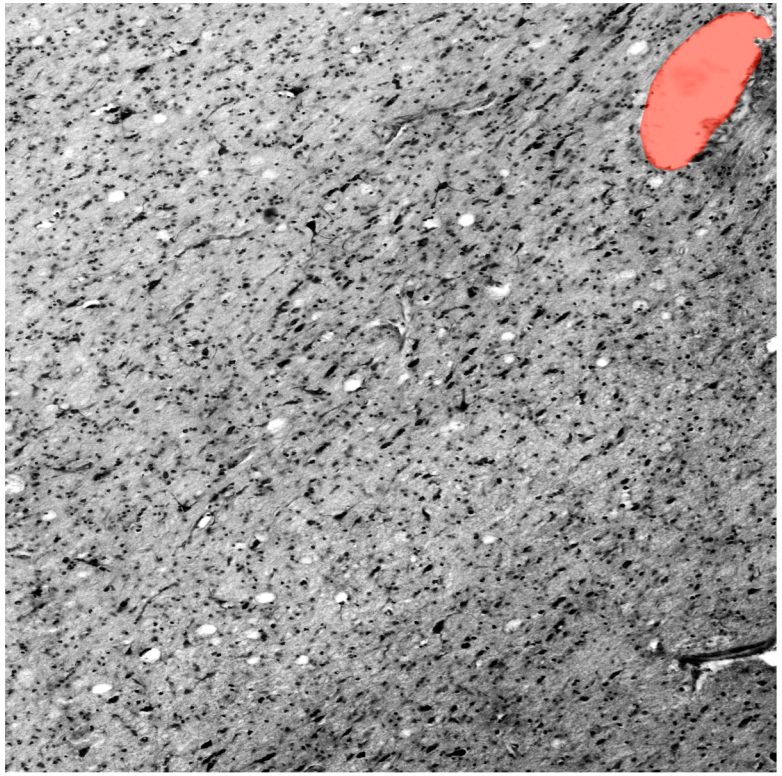
3D reconstructed image based on the truncated cells, 1µm Resolution



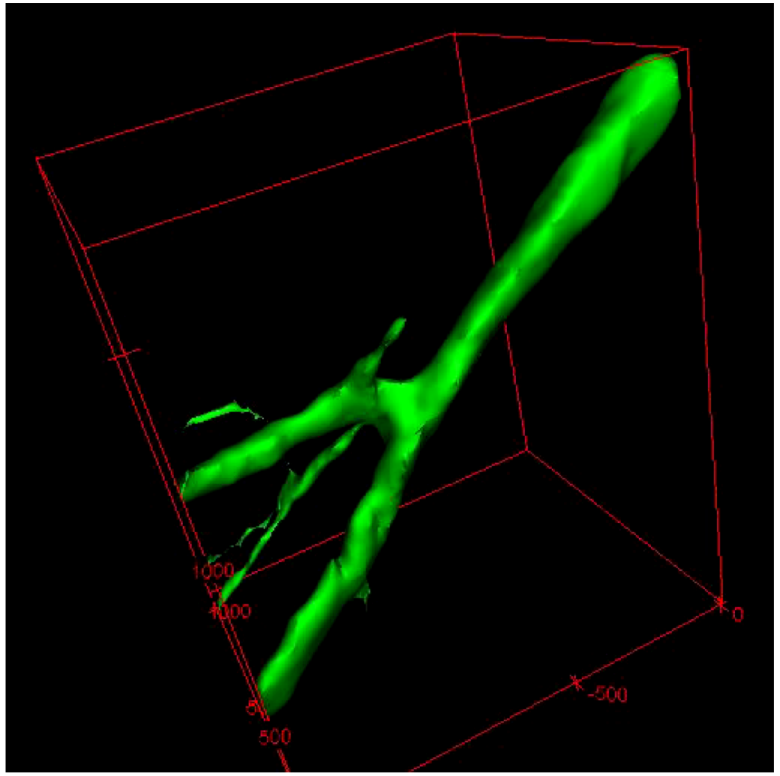
In collaboration with Dr. Timo Dickscheid from INM-1

3D REPRESENTATION

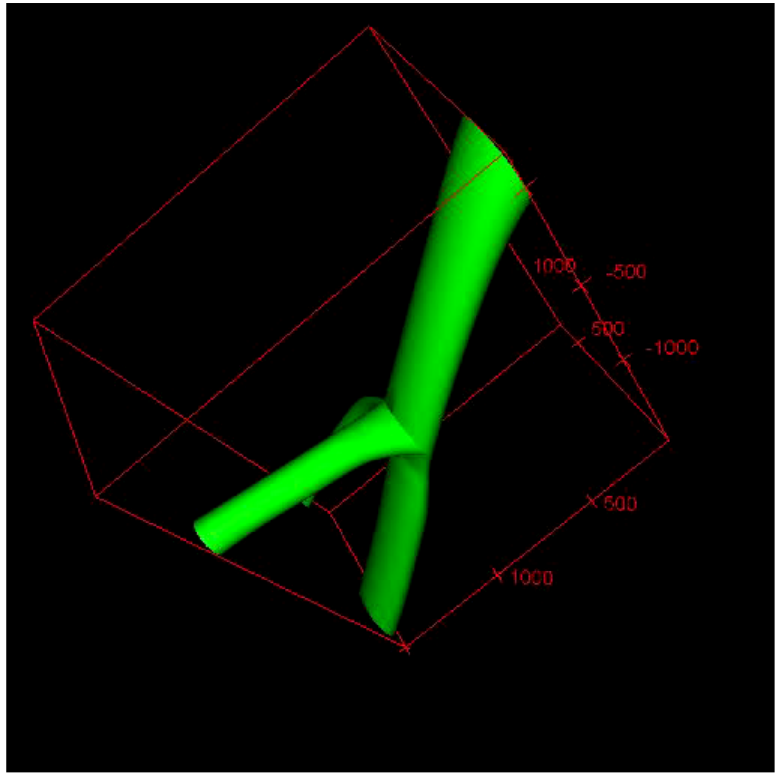
Brain Sections



Rendered data



Translated structure



OUTLOOK

- Excavation reconstructed structure in the glass.
- Mimicking biological conditions.
- Investigation of aggregates break up and their effect on blood flow.

Thank you for your attention!



Prof. Dr. Pavlik Lettinga IBI-4

Prof. Dr. Jan Dhont IBI4
Dr. Olivera Korculanin IBI-4


Dr. Timo Dickscheid INM-1

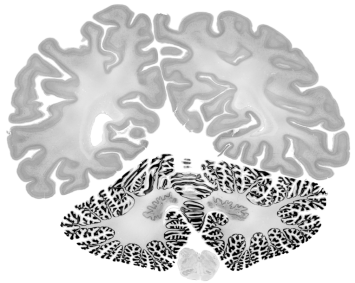
Marcel Huysegoms INM-1

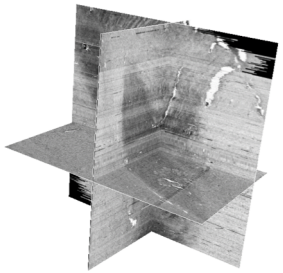
Knut Dahlhoff ZEA-1

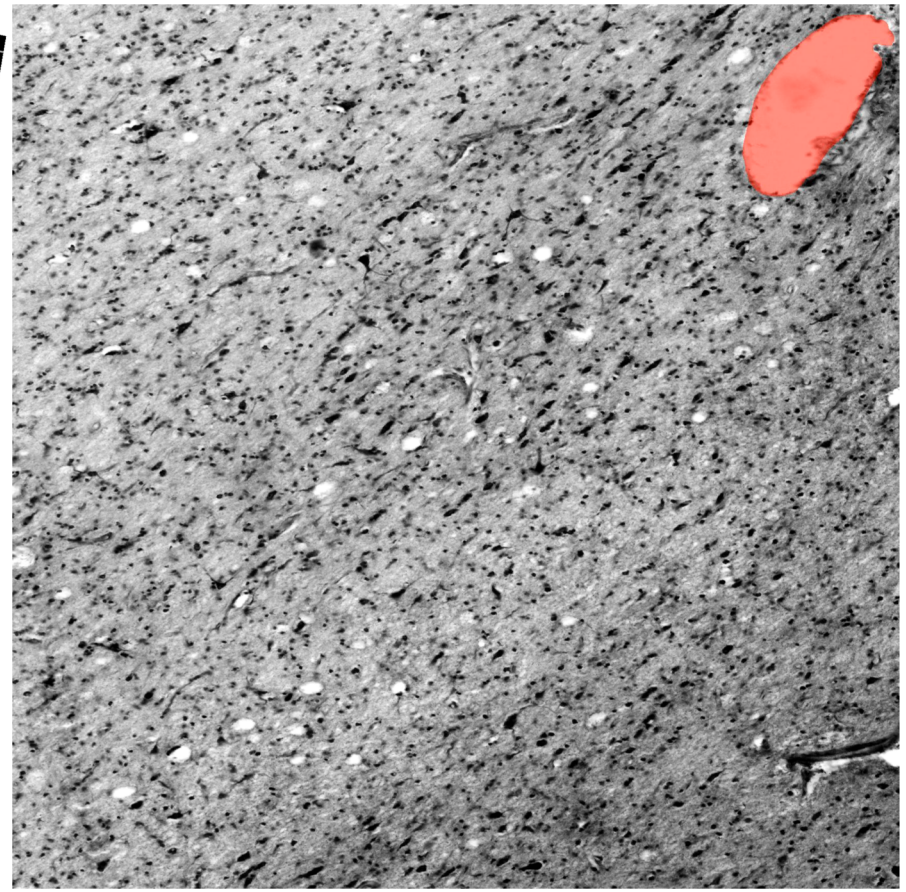

Prof. Dr. Stephan Foerster IBI-8
Benjamin Reineke IBI-8

Information processing

Programming the highway from brain structure







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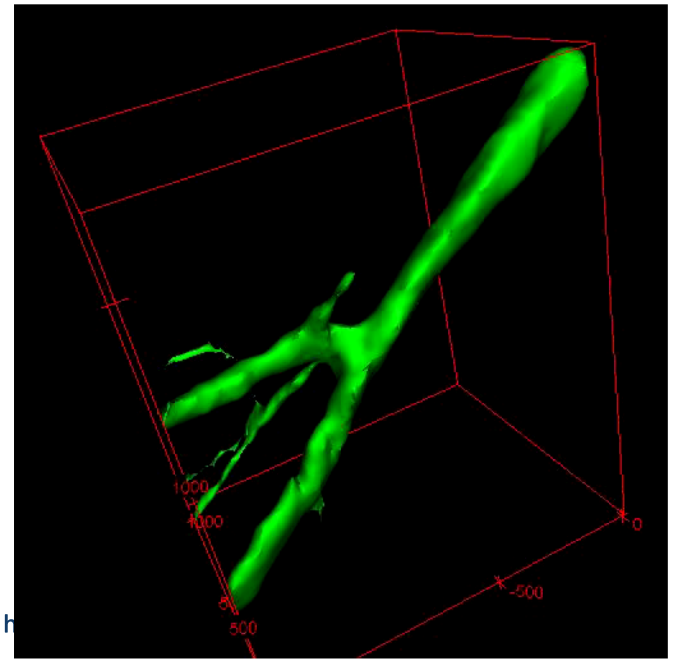
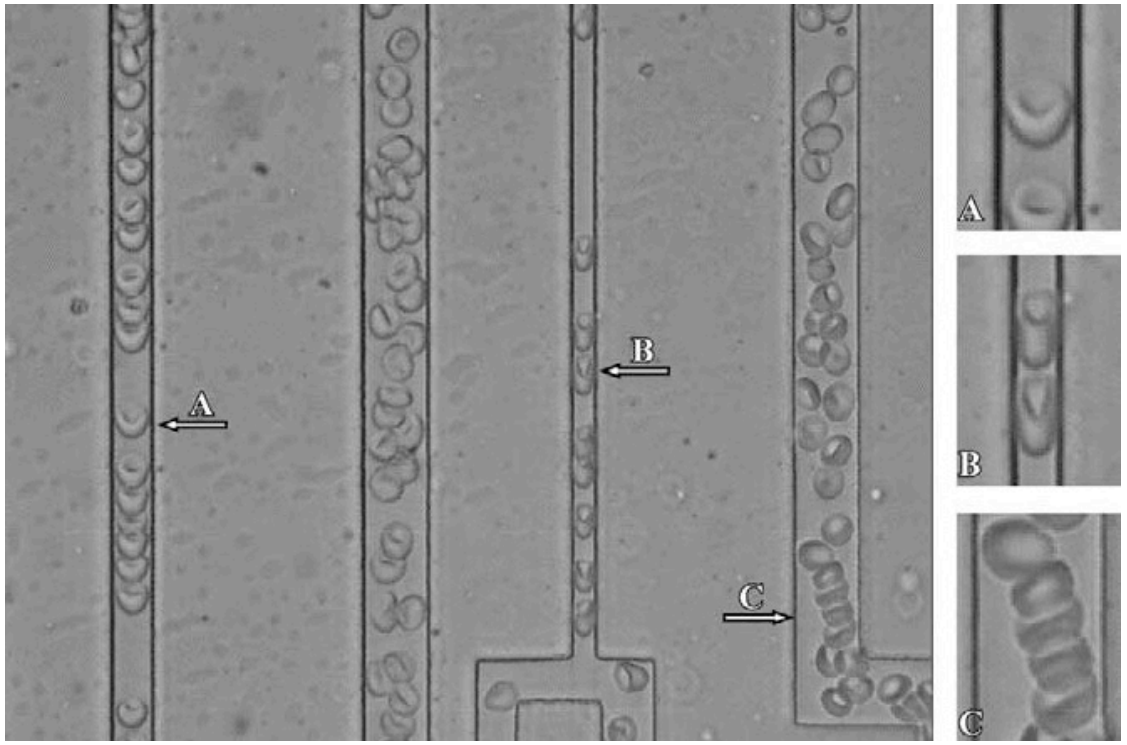


With: INM-1, ZEA-1, IBI-8
Vorstandsdoktorand

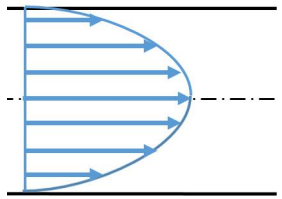
HOW DOES AGGREGATES AID BLOOD FLOW?

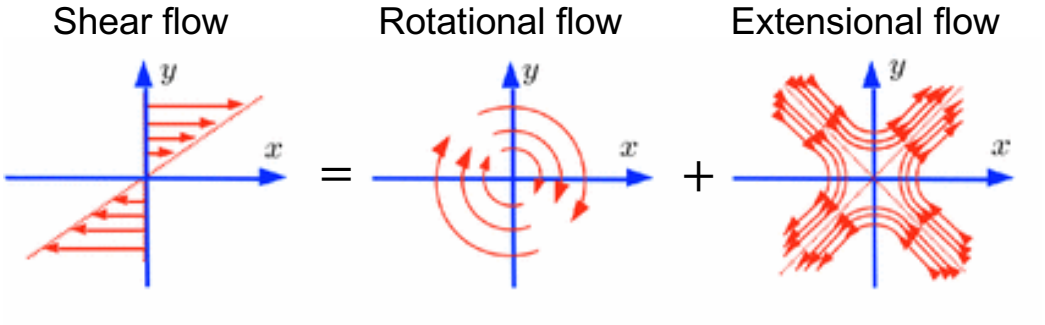


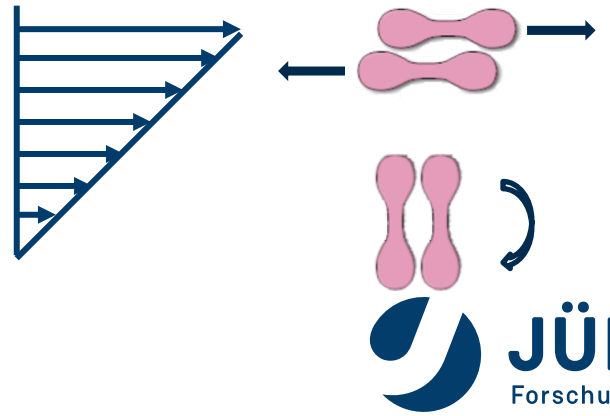
J. Burns. *et al.* 2012, *Transfusion*

No control over aggregation

Unphysiological channels







JÜLICH
Forschungszentrum

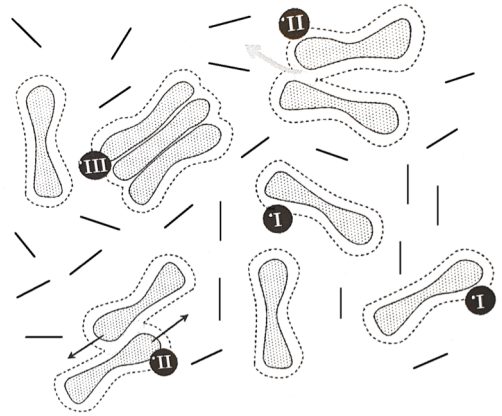
TUNE THE INTERACTION

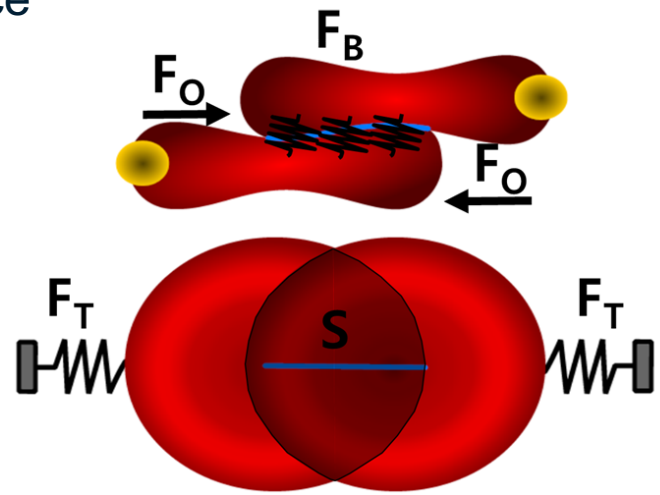
- Bridging:

  Adsorption of macromolecules onto adjacent cell surfaces

- Depletion:

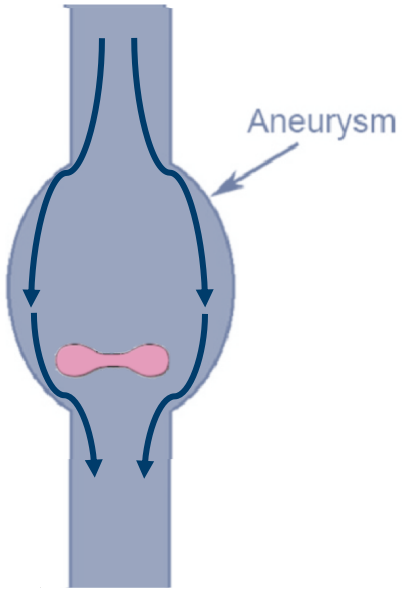
  Exclusion of macromolecules near cell surface and formation of depletion layer around the surface



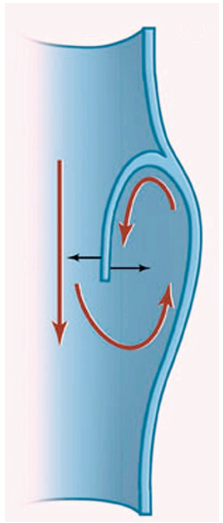


$F_T = F_O + F_B$ (Static)
$F_T > F_O + F_B$ (Disaggregation)
$F_T < F_O - F_B$ (Aggregation)

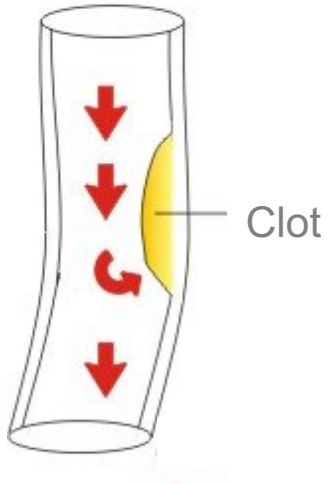
HOW DO ANOMALIES IN THE STRUCTURE AFFECT FLOW?



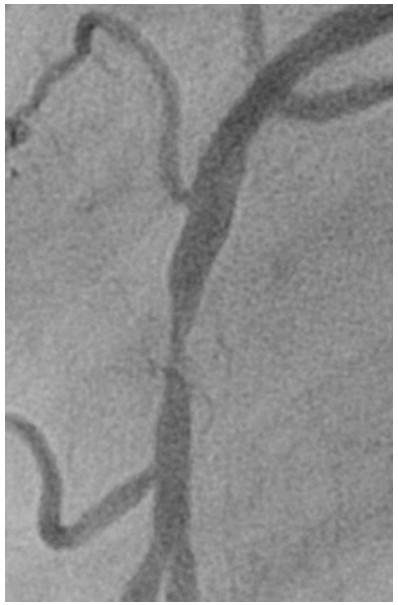
G. Caruana. *et al.* 2017, *ESR*



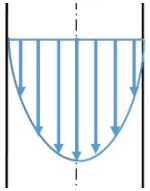
J. Chiu. *et al.* 2009, *Physiol Rev*

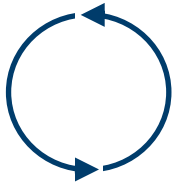


AM. Malek. *et al.* 2000, *JAMA*



Y. Li. *et al.* 2015, *JACC*





Newtonian:

$$\mu\nabla^2 u - \nabla P + f = 0$$

$$\nabla . u = 0$$

Non-Newtonian:

$$\mu_{eff} = k\left(\frac{du}{dy}\right)^{n-1}$$

$$\mu_{eff}(\dot{\gamma}) = \mu_{inf} + (\mu_0 - \mu_{inf})(1 + (\lambda\dot{\gamma})^2)^{\frac{n-1}{2}}$$

Your Title