Biology 427 Biomechanics Lecture24. Fluid flow and elasticity

- Recap blood flow
- •Solid and fluid mechanics I: how does the elasticity of the RBC influence blood viscosity?
- •Solid and fluid mechanics II: how does the elasticity of the aorta influence blood flow dynamics?

## The Fahreaus-Lindqvist effect



Cell deformations and secondary flows

Good:

increased surface to volume ratio augmented flux of gases

Bad: higher stress (P) higher viscosity



Oxygen flow rate ~  $\mathbf{Q} \phi = \pi \phi r^4 \Delta P/(8 \mu L)$ 



Gulliver, G. (1875). "On the size and shape of red corpuscles of the blood of vertebrates, with drawings of them to a uniform scale, and extended and revised tables of measurements". *Proceedings of the Zoological Society of London* **1875**: 474– 495.



72,000 individuals

## Point mutation in the hemoglobin $\beta$ gene

Sickled cells



C Healthwise, Incorporated

#### Malaria modulates the modulus







# Anopheles



41316 [RM] © www.visualphotos.com

Blood viscosity depends non-linearly on red blood cell concentration (  $\phi$  hematocrit) and Temperature



## Gametocytes





## Plasmodium



The pathogenicity of *Plasmodium falciparum (Pf)* malaria results from the stiffening of red blood cells (RBCs) and its ability to adhere to endothelial cells (cytoadherence). The dynamics of Pf-parasitized RBCs is studied by three-dimensional mesoscopic simulations of flow in cylindrical capillaries in order to predict the flow resistance enhancement at different parasitemia levels.

**D. A. Fedosov**, B. Caswell, S. Suresh, and G. E. Karniadakis, "Quantifying the biophysical characteristics of Plasmodium-falciparum-parasitized red blood cells in microcirculation", *Proceedings of the National Academy of Sciences USA*,, 2010.



# Pf155/RESA protein influences the dynamic microcirculatory behavior of ring-stage *Plasmodium falciparum* infected red blood cells

Monica Diez-Silva, YongKeun Park, Sha Huang, Hansen Bow, Odile Mercereau-Puijalon, Guillaume Deplaine, Catherine Lavazec, Sylvie Perrot, Serge Bonnefoy, Michael S. Feld, Jongyoon Han, Ming Dao & Subra Suresh

Affiliations | Contributions | Corresponding authors

Scientific Reports 2, Article number: 614 | doi:10.1038/srep00614 Received 18 June 2012 | Accepted 03 August 2012 | Published 30 August 2012 Solid and fluid mechanics II: how does the elasticity of the aorta influence blood flow dynamics?

