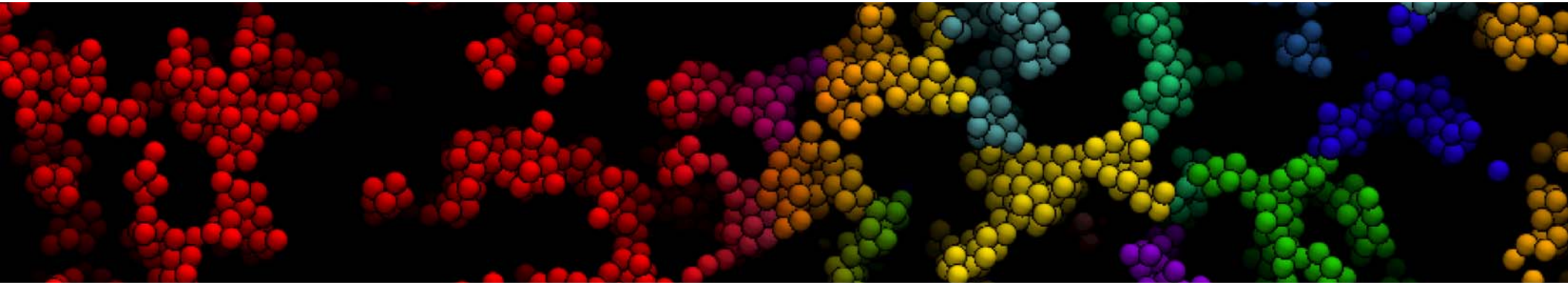
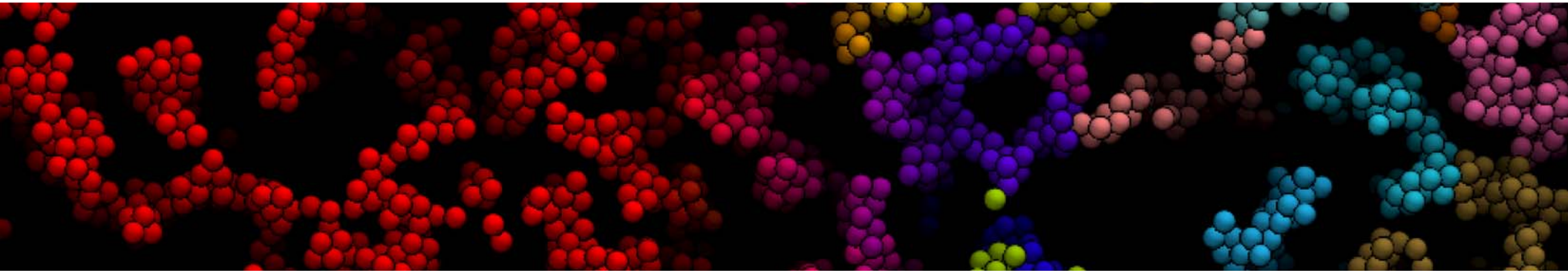
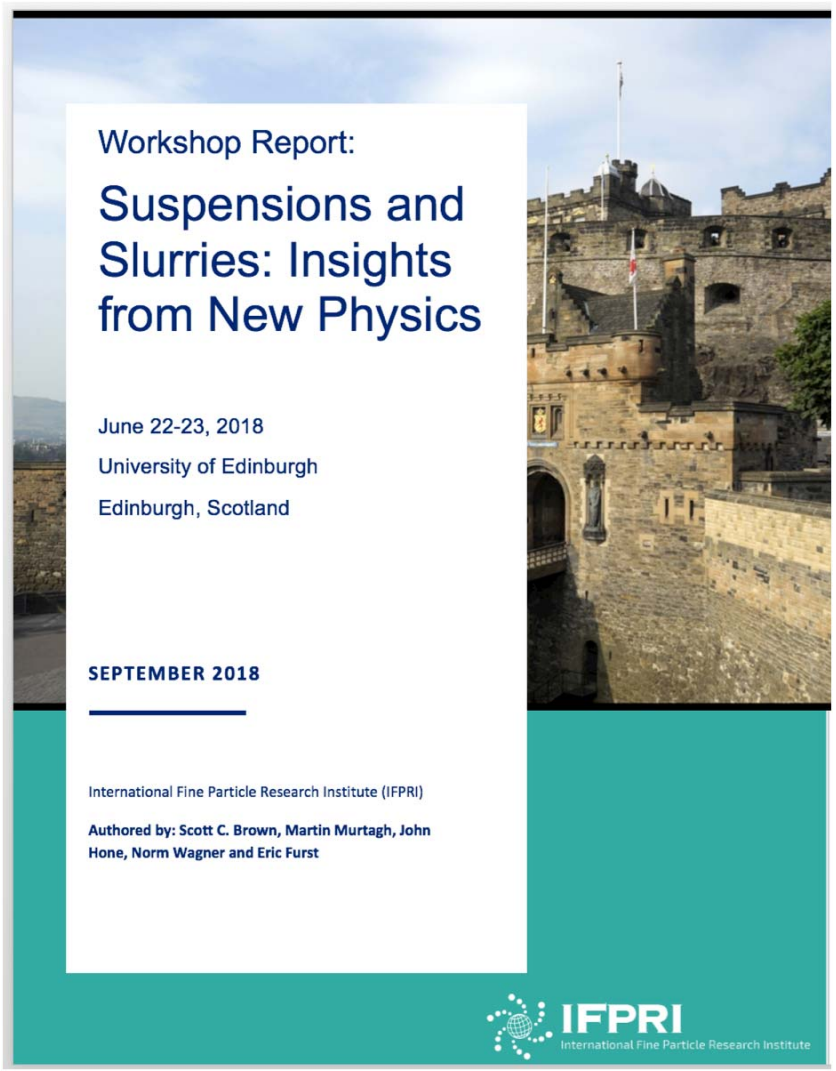


Wet Systems Consultant Report 2019

Eric M. Furst
University of Delaware



Wet systems:
IFPRI member needs and problems



From the 2018 workshop

Driving mechanisms

How can rheology / flow / jamming be tailored, changed, altered, controlled?
e.g. adsorbates, surface chemistry, physico-chemistry

Rheology, stability (especially changes)

aging, *formulation changes*, *sensitivity*, *feed variability*
predict? how close to edge?
what can go wrong / what just went wrong?
informs accelerated testing? (months / years -> days / weeks)

Processing flows and **processability** of suspensions

extrusion, die slip, static zones

Model formulations, model validation

"Is your adhesive hard sphere index matched suspension truly representative of my system?"

Effect of fines, polydispersity, roughness, shape, …

... long list …

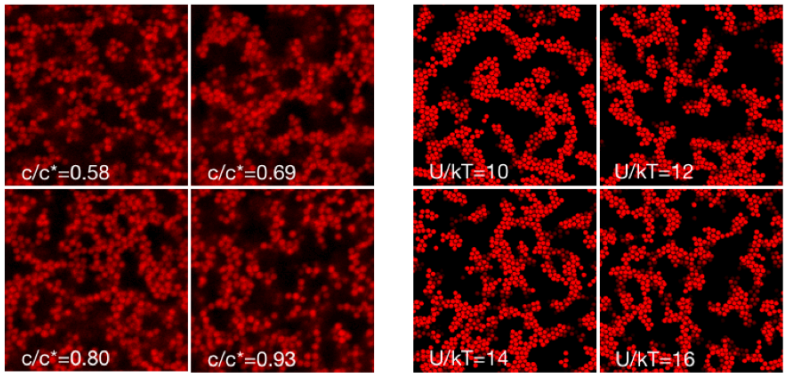
Current proposals (Vermant/Hsiao/Petekidis):
Simplified Industrial Formulations

Advances in computational modeling

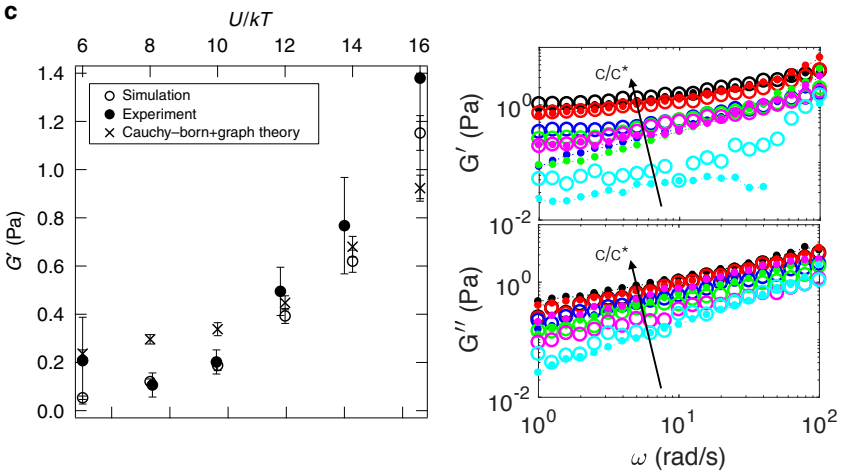
Large scale, correct physics (e.g. HI) → Properties, Processing

Colloidal gel elasticity / rheology

K.A.Whitaker et al., Nature Comm. 10, 2237 (2019).

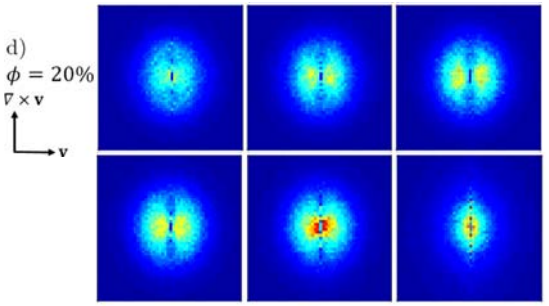


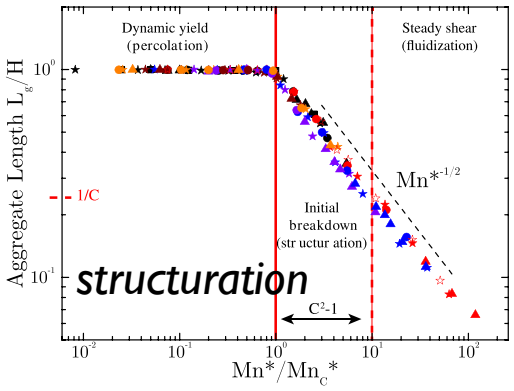
Whitaker, Hsiao, Solomon & Furst — Swan and Varga



Large scale anisotropies in sheared colloidal gels

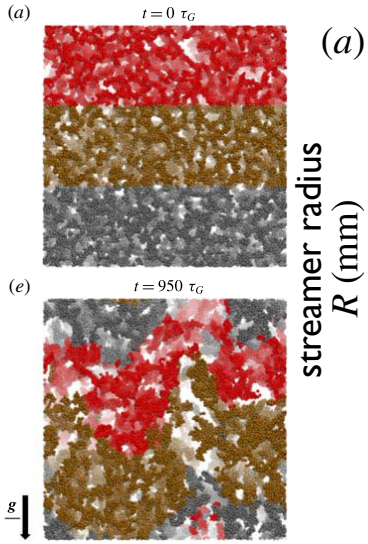
Z.Varga, J.W. Swan. J. Rheol. 62, 405–418 (2018).

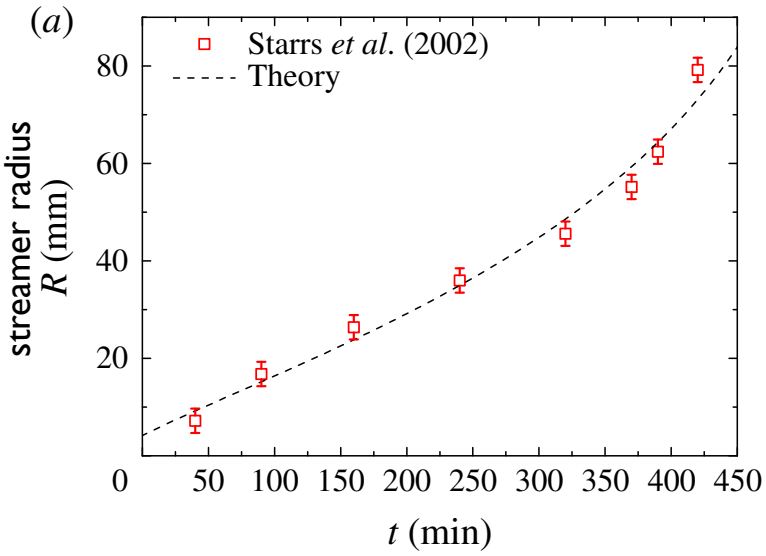




Stability / sedimentation

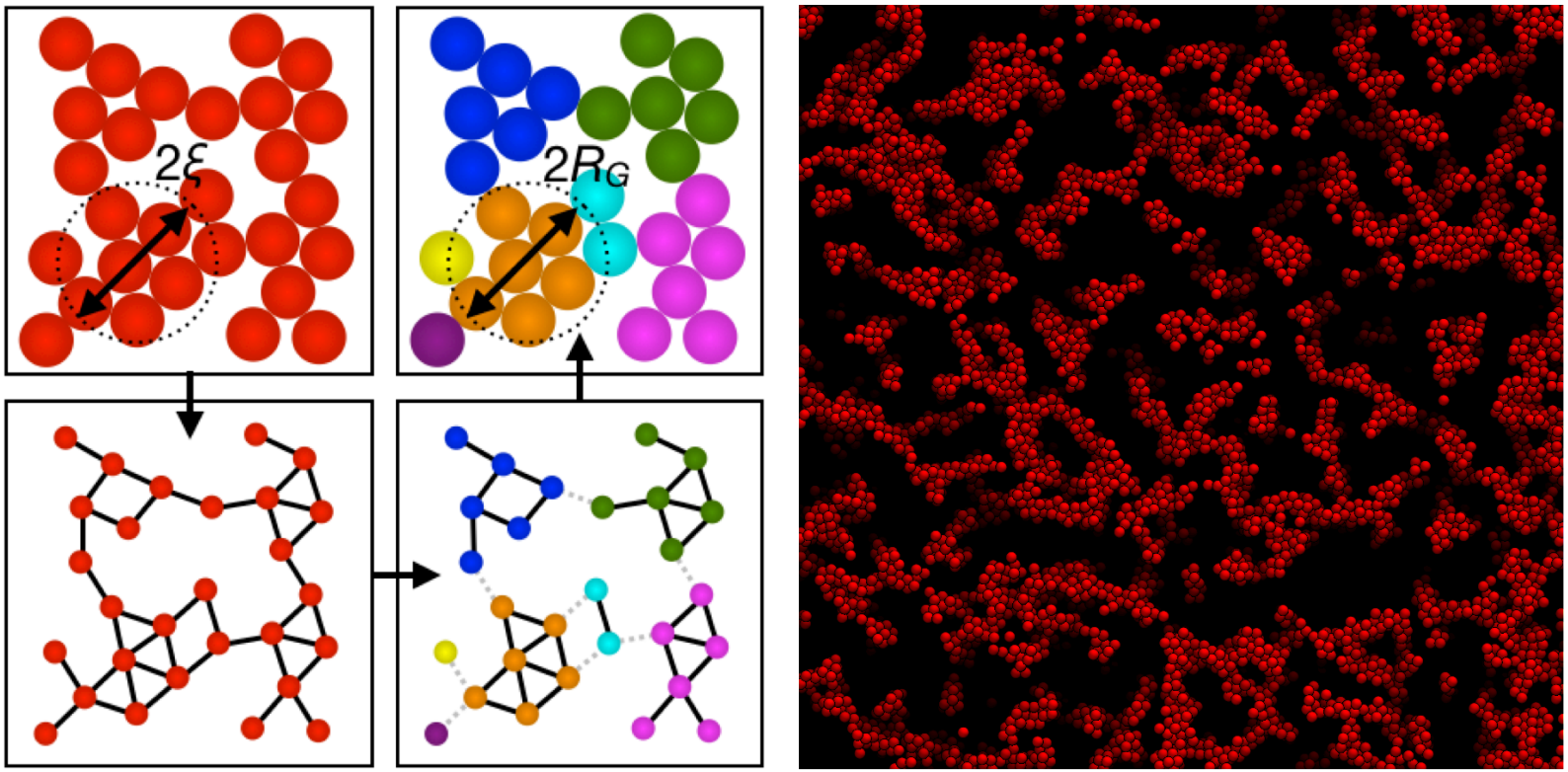
Z.Varga, J. L. Hofmann, J.W. Swan, J. Fluid Mech. 856, 1014–1044 (2018).





Graph theoretic and other emerging "data science" tools to characterize microstructure

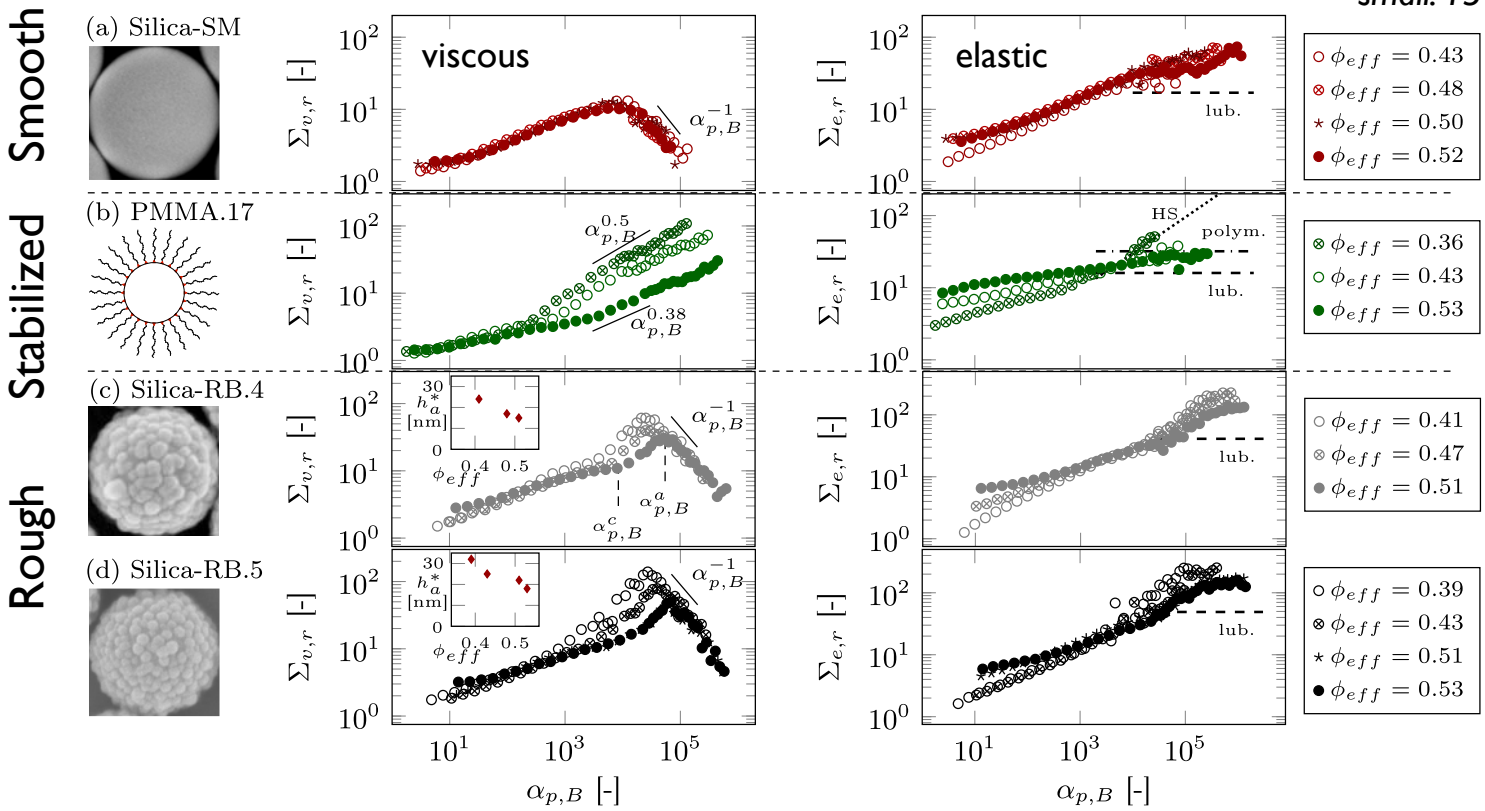
K. A. Whitaker et al., *Colloidal gel elasticity arises from the packing of locally glassy clusters*. Nat. Comm. 10, 2237 (2019).



Here: Clusters are key building blocks of microstructure
Opportunities: connect to processing, formation conditions, aging

Friction and tribology in wet / colloidal systems

High concentration - interparticle separation small: 15-45nm



B. Schroyen, C.-P. Hsu, L. Isa, P.Van Puyvelde, J.Vermant, *Phys. Rev. Lett.* 122, 218001 (2019).

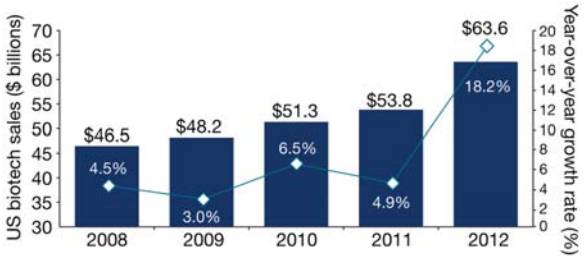
Advances in:

Model particle synthesis that capture critical characteristics
surface chemistry, stabilizers, roughness, (shape)

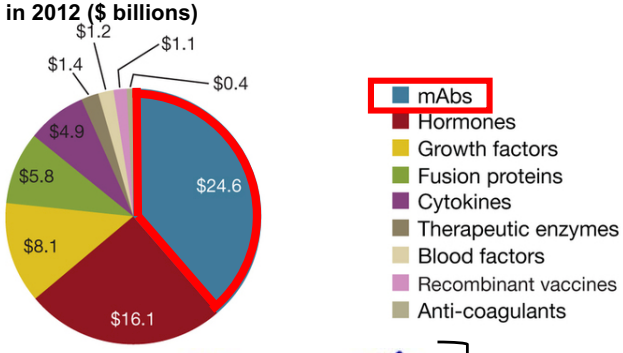
High frequency rheology (e.g. piezo shear cell)

Opportunity: Biologics

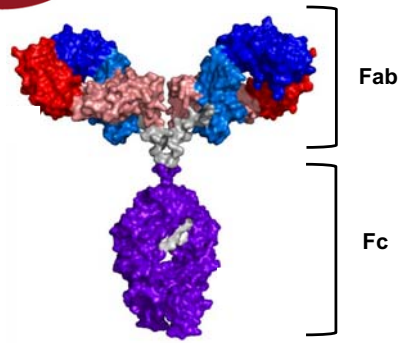
Growth trends in the US biotech market for biologic drugs (2008-2012)



Top nine categories of biologic drugs in terms of US sales in 2012 ($ billions)



Examples of illnesses:
Arthritis, cancer, auto-immune diseases, anthrax, anti-inflammatory disorders, etc.

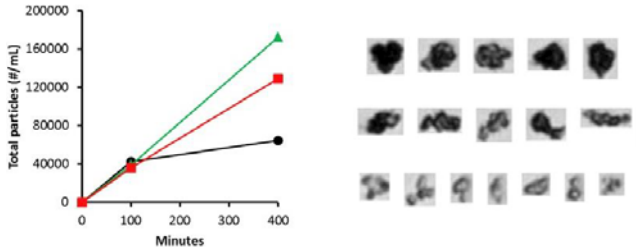


Aggarwal, S., *Nature Biotechnology*, 32, 32-39 (2014)

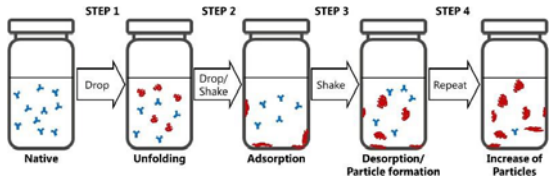
Aggregation time course of a 10 mg/mL antibody formulation with 0-0.01% PS20 stressed by shaking (▲) and stirring (□) at 5 °C

Kiese *et al.*, *J. Pharm. Sci.*, 97, 4347-4366 (2007)

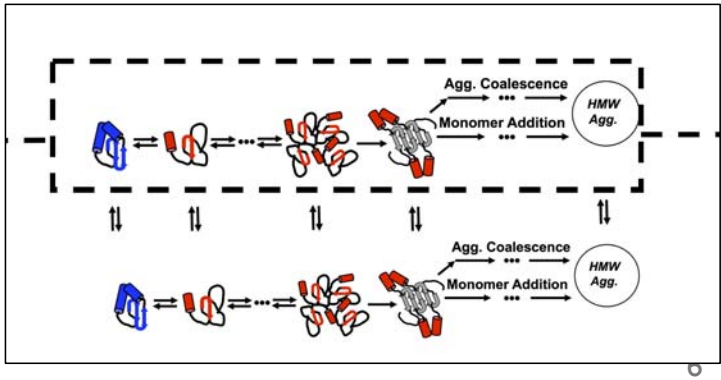
Subvisible particles are created under combination dropping and shaking stress of an 0.9 mg/mL IgG1 at different 1-2 mL fill volumes



Proposed aggregation pathway induced by combination drop and shake stress



Torisu *et al.*, *J. Pharm. Sci.*, 106, 521-529 (2017)



Exogenous particle formation
Particle characterization

Genentech, Medimmune, Janssen, Amgen, GSK, etc.

People

PI	Institution	Research
James Swan	MIT, Chemical Engineering	Computational modeling and theory
Roseanna Zia	Stanford, Chemical Engineering	Computational modeling
Roger Bonnecaze	UT Austin, Chemical Enigneering	Computational modeling, theory
Jeff Morris	City College of New York, Levich Institute	Computational modeling, theory
Emanuela Del Gado	Georgetown, Physics	Modeling and theory of suspensions
Arthi Jayaraman	University of Delaware, ChBE/MSEG	Computational modeling
Lucio Isa	ETH, Zürich, Materials	Colloid friction / tribology
Dan Blair	Georgetown, Physics	Friction and jamming in dense suspensions
Guillaume Ovarlez	Université de Bordeaux	Rheology, shear thickening, non-Brownian suspensions