

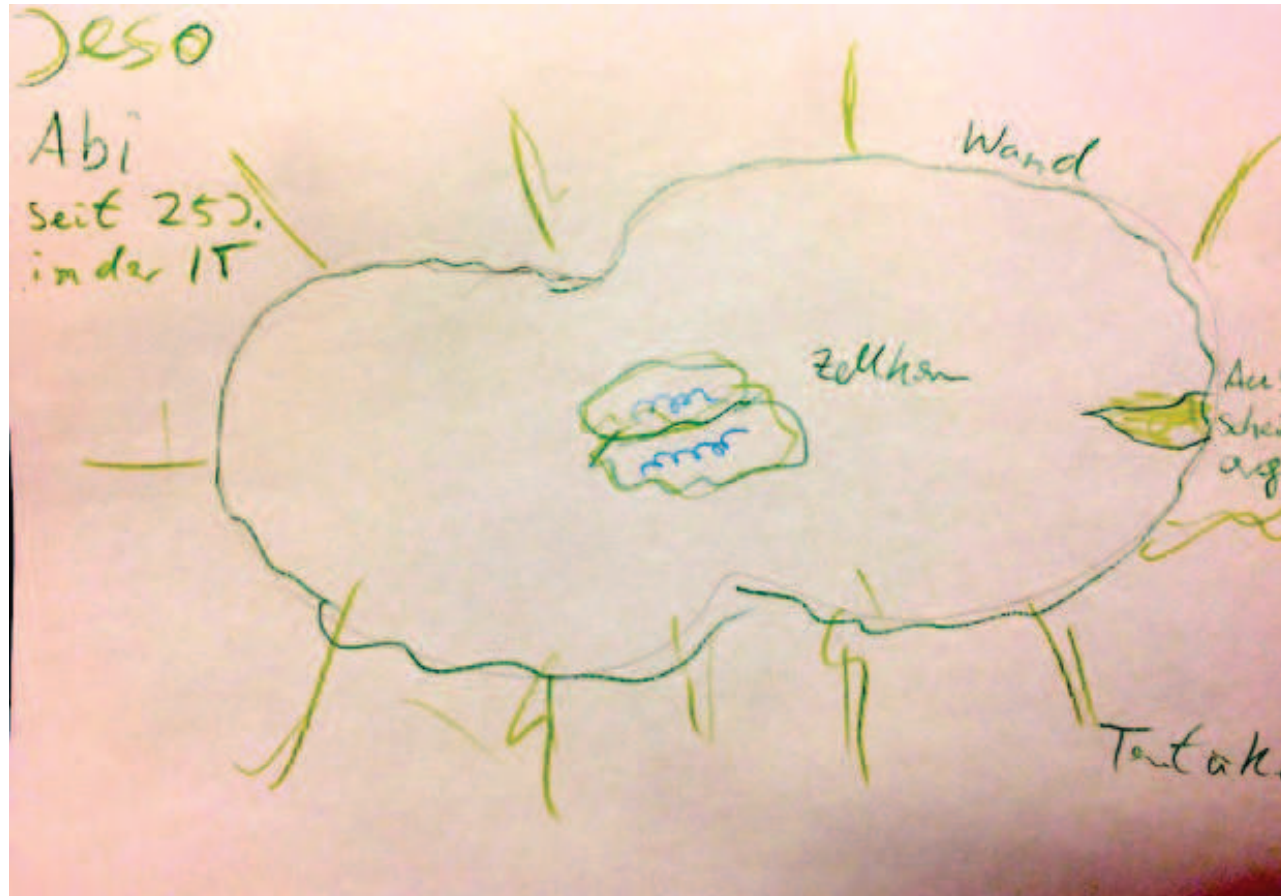
Zooming in on bacterial behavior

Ariane Briegel | NGL lecture, April 19

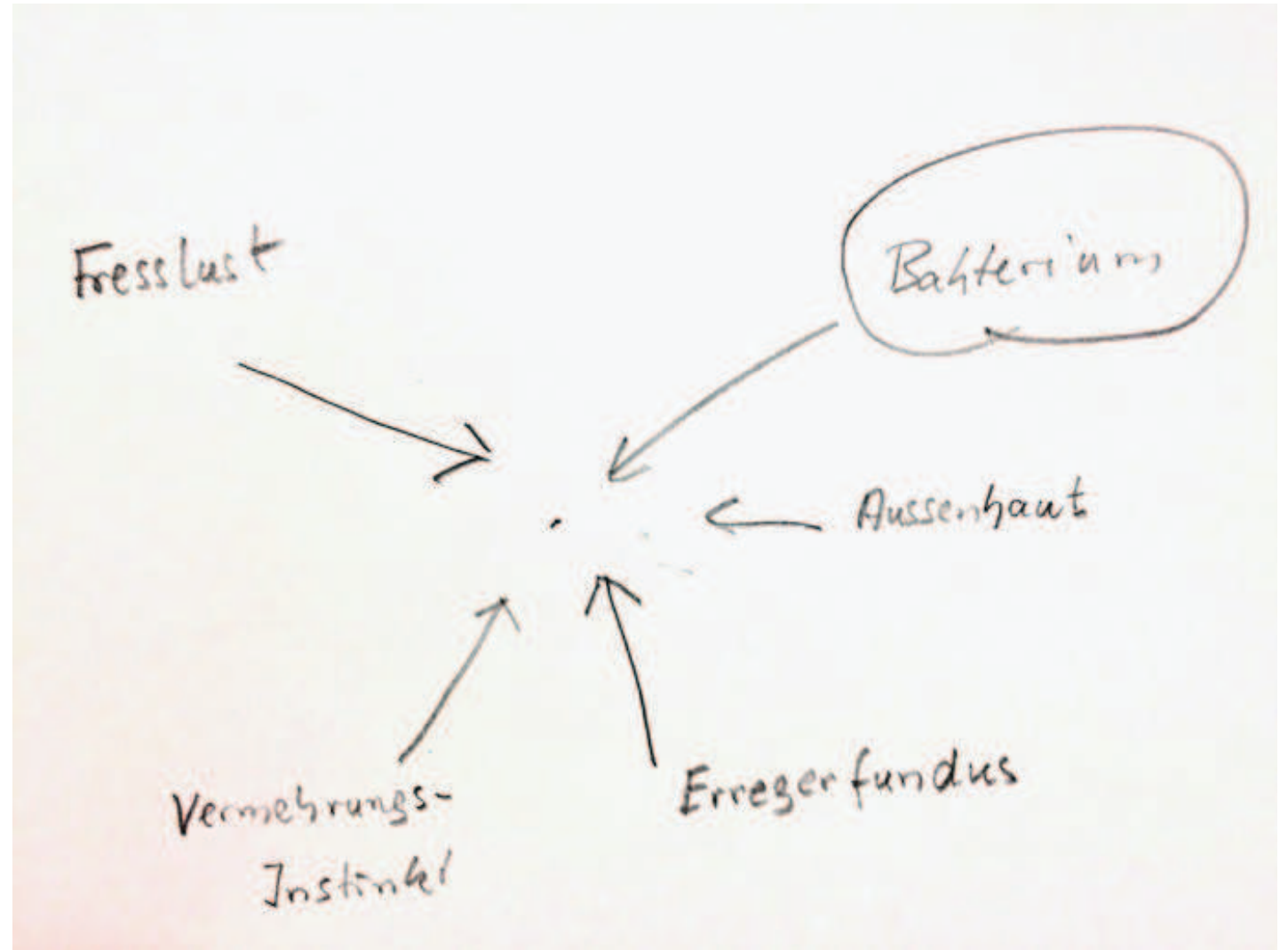


**Universiteit
Leiden**
The Netherlands

What do people think bacteria look like?



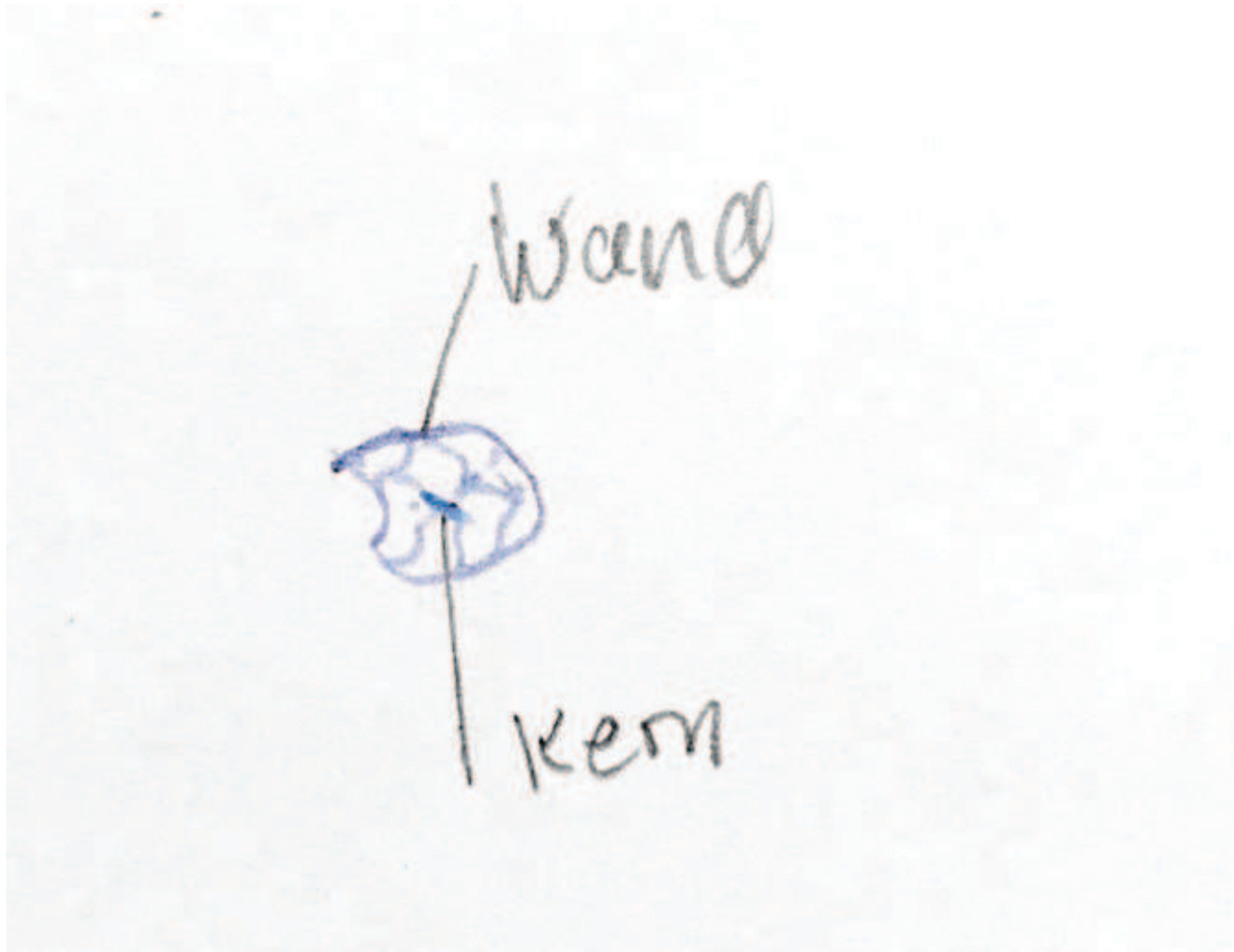
What do people think bacteria look like?



What do people think bacteria look like?



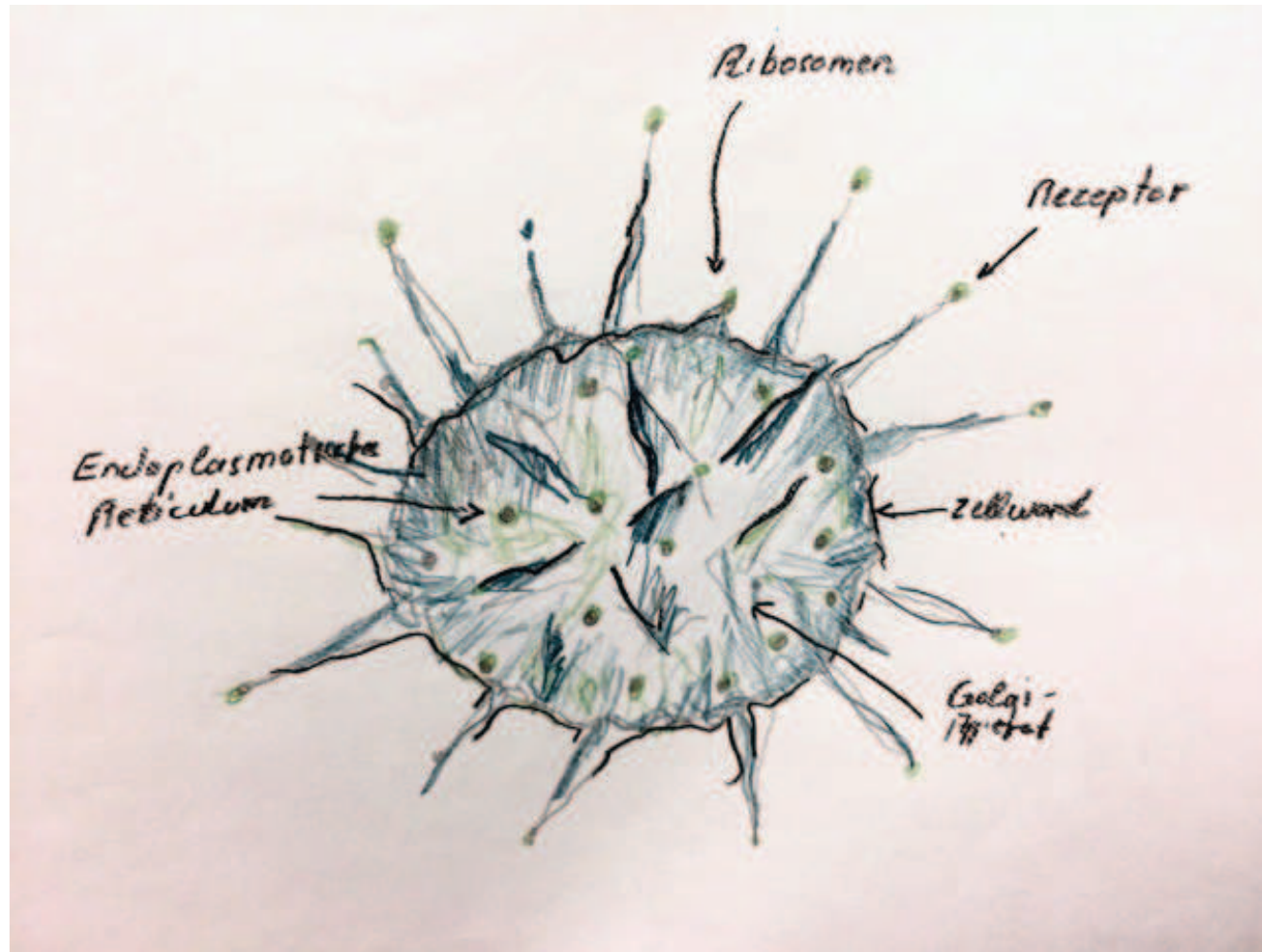
What do people think bacteria look like?



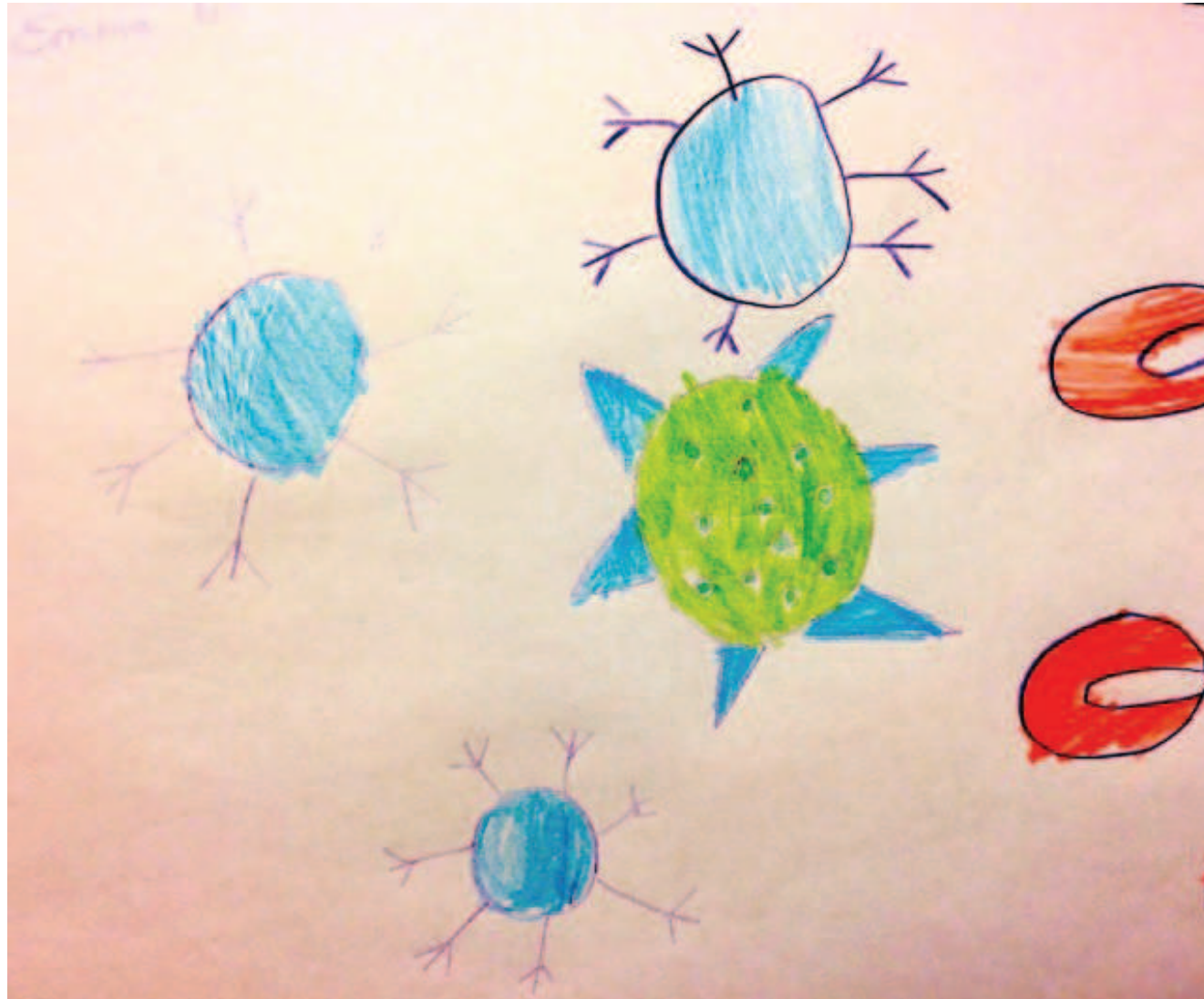
What do people think bacteria look like?



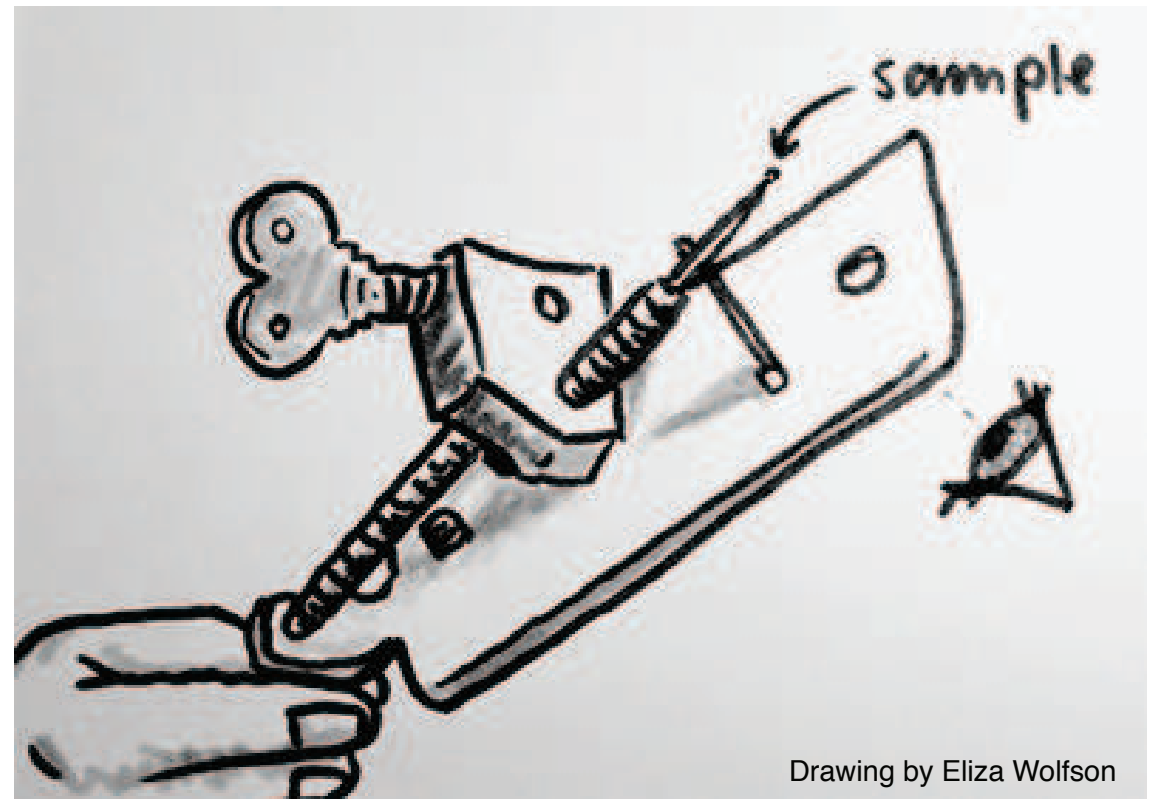
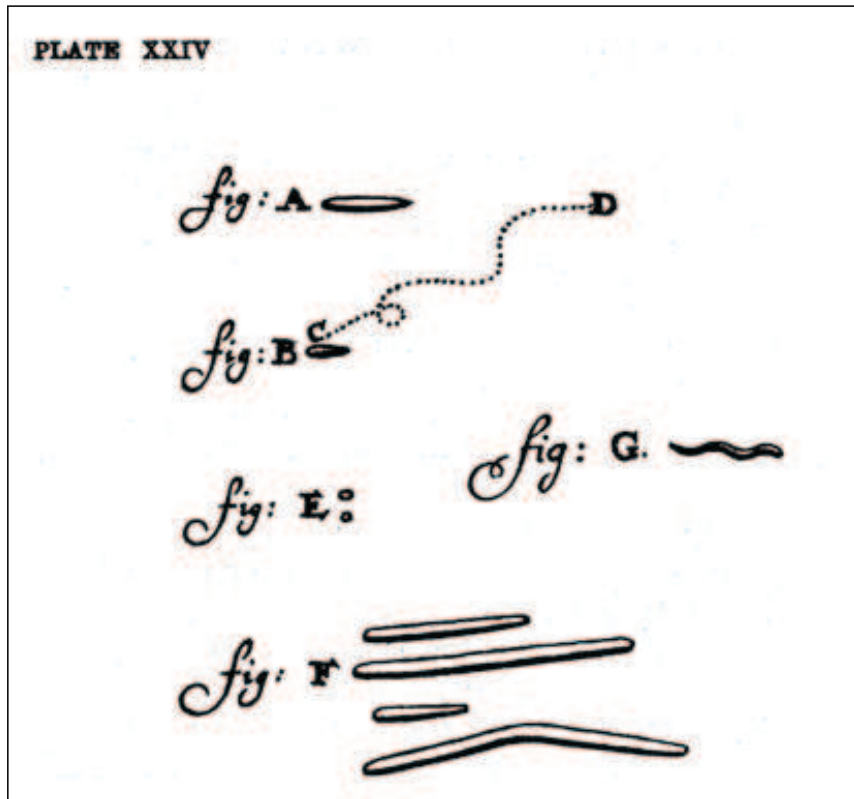
What do people think bacteria look like?



What do people think bacteria look like?



The beginning of bacterial imaging in the Netherlands



Antonie van Leeuwenhoek's drawings of bacteria in the human mouth. Published 1684.

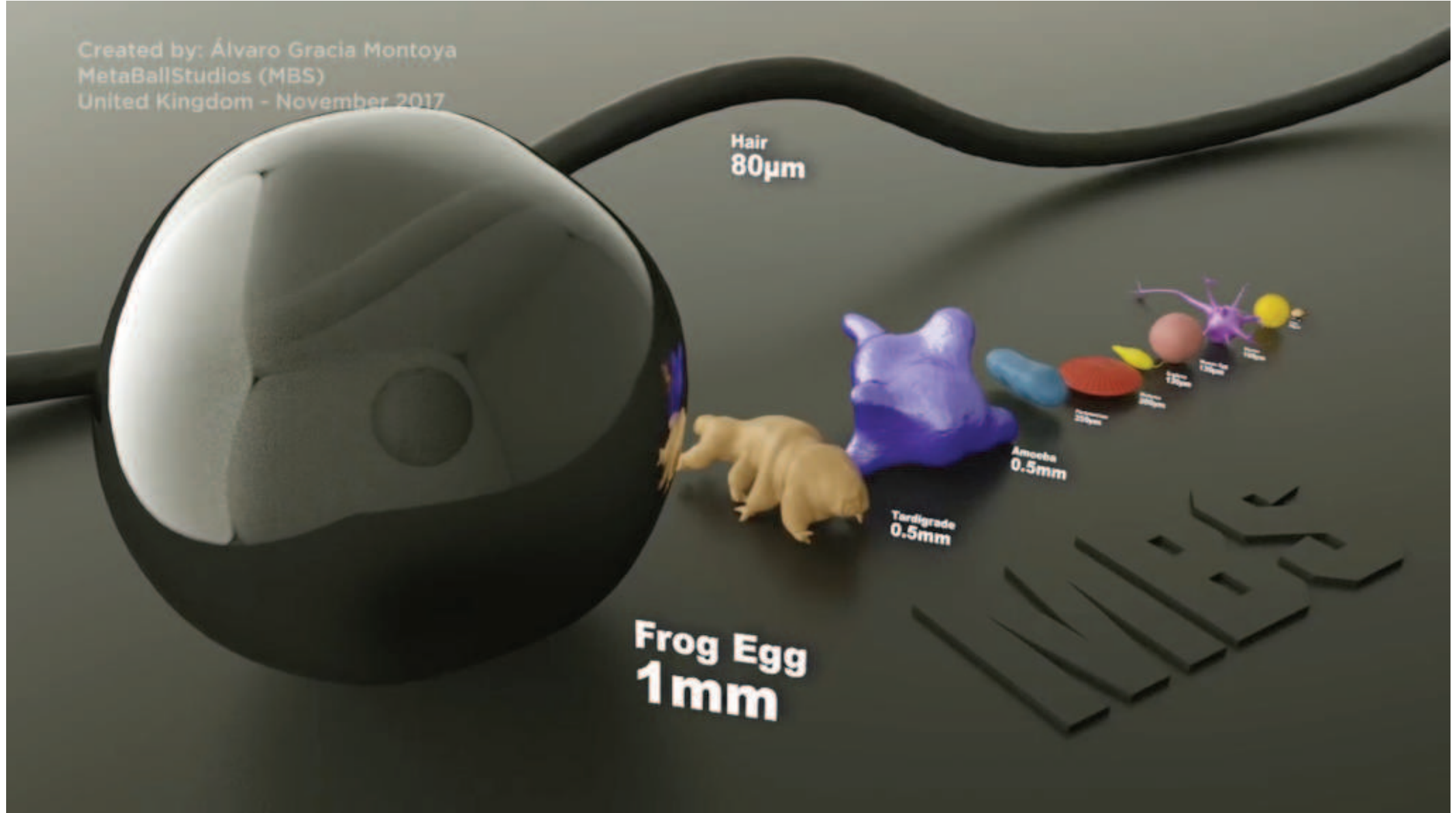
Created by: Álvaro Gracia Montoya
MetaBallStudios (MBS)
United Kingdom - November 2017

Hair
80 μ m

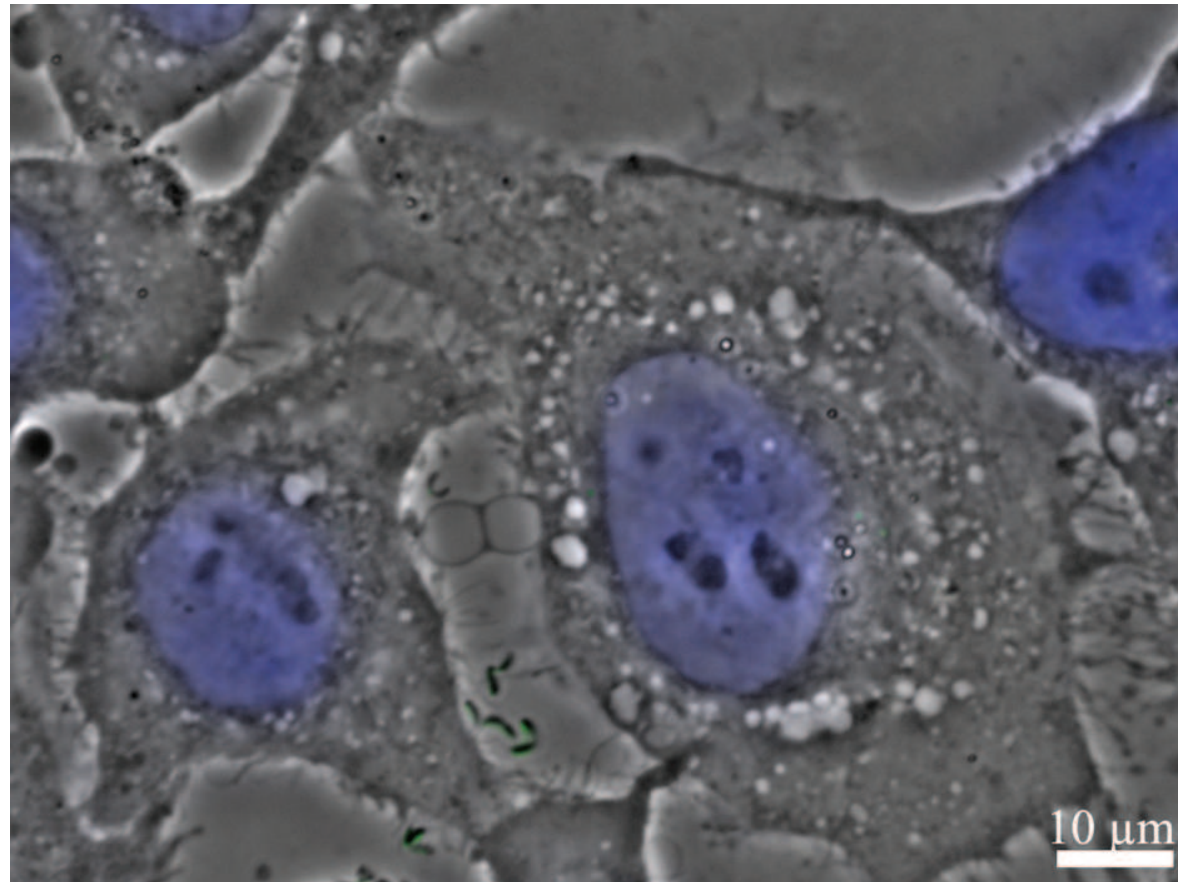
Frog Egg
1mm

Tardigrade
0.5mm

Amoeba
0.5mm



Size is a challenge for structural studies



Electron microscopy makes atomic resolution possible

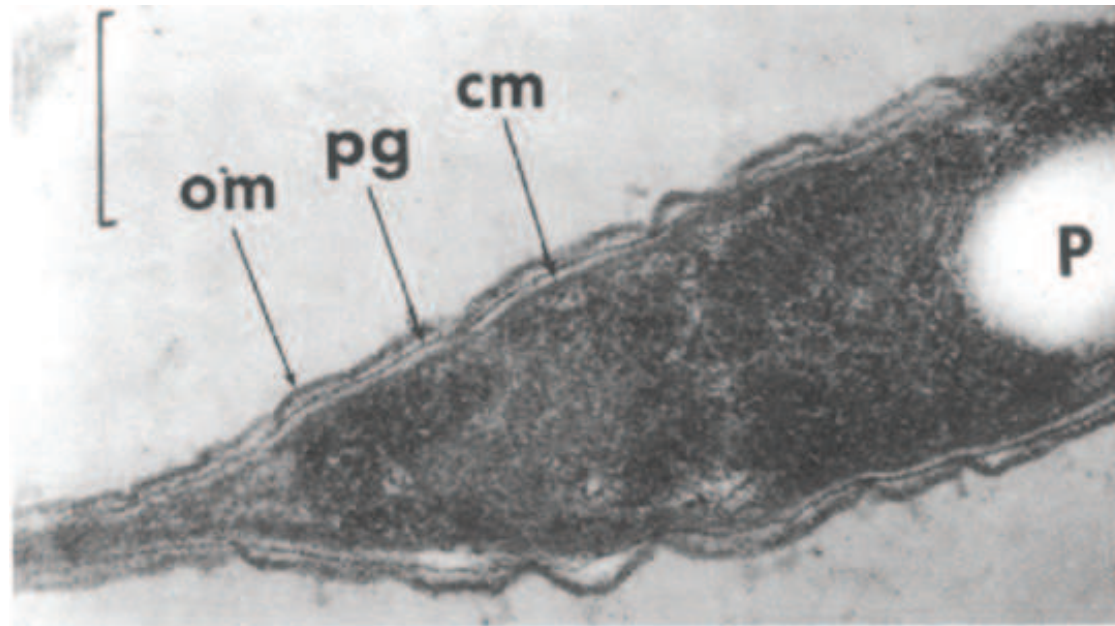


gold atoms

NeCEN



Why do EM images of biological samples look so poor?



Pointdexter, J Bacteriol, 1982

How can you image a biological specimen in the vacuum of an electron microscope?

Staining, dehydration, plastic embedding and sectioning

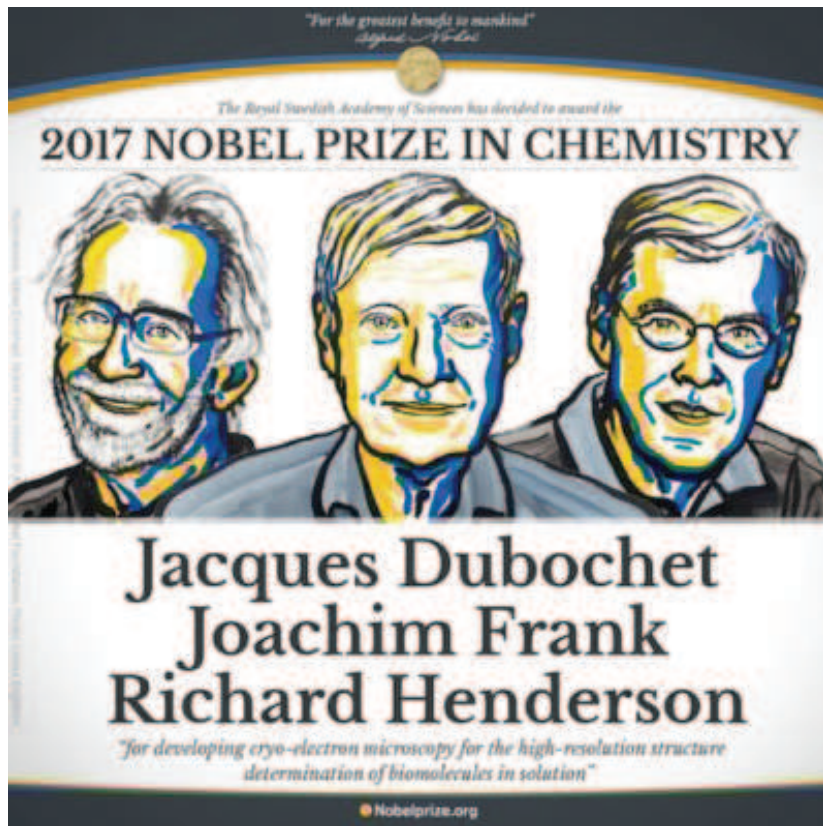


http://pngimg.com/upload/potato_PNG7085.png



www.potatoes.com





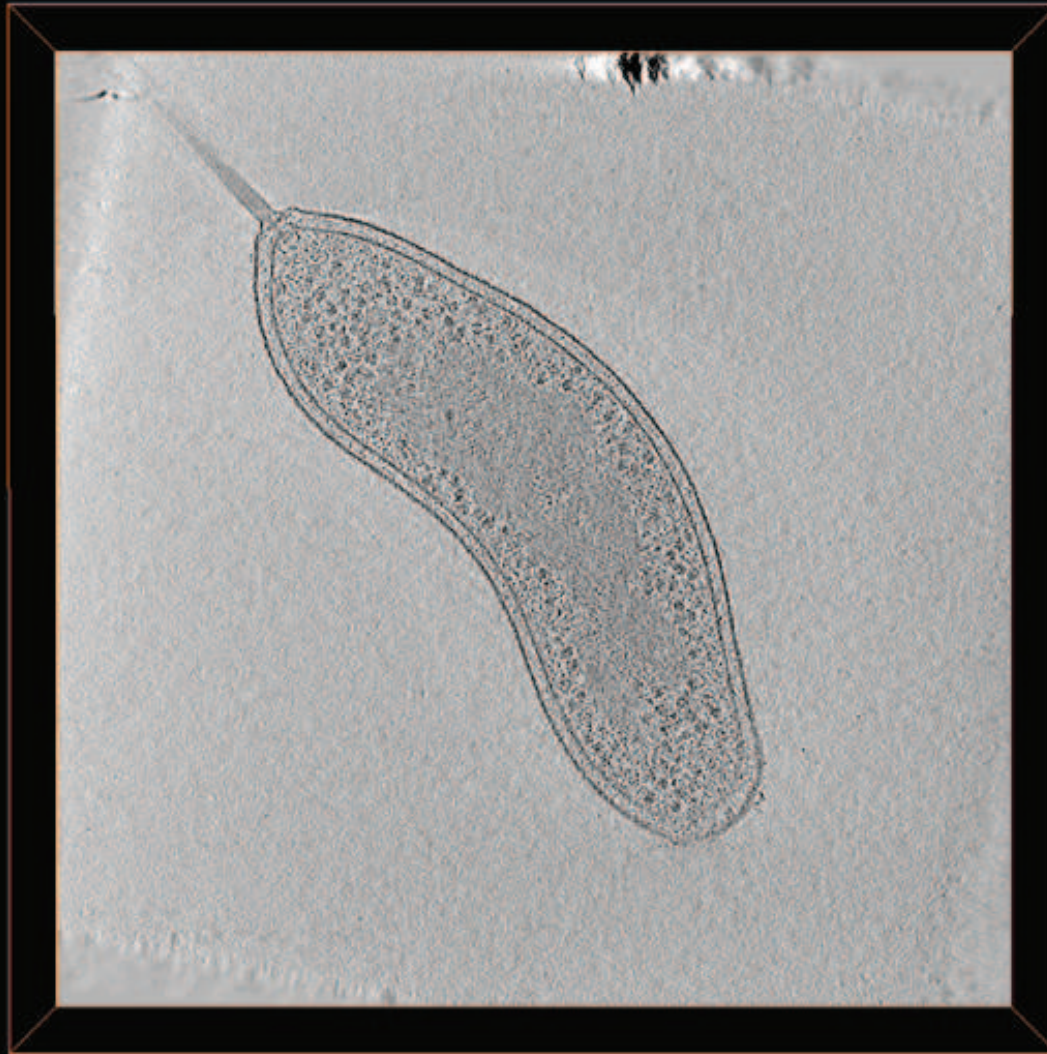
Jaques Dubochet: Methods for preparation of samples for cryoEM



Electron Cryotomography provides three-dimensional information



Movie courtesy of Dr. Stephan Nickell



Oikonomou et al, Nature Microbiol Reviews, In Press

Chemotaxis- bacterial behavior to seek out preferred environmental niches

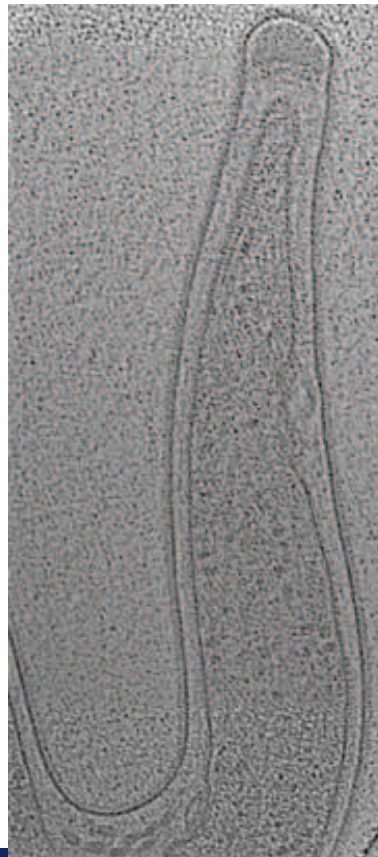


One in five ticks infected with Lyme disease bacteria

Society     April 16, 2013



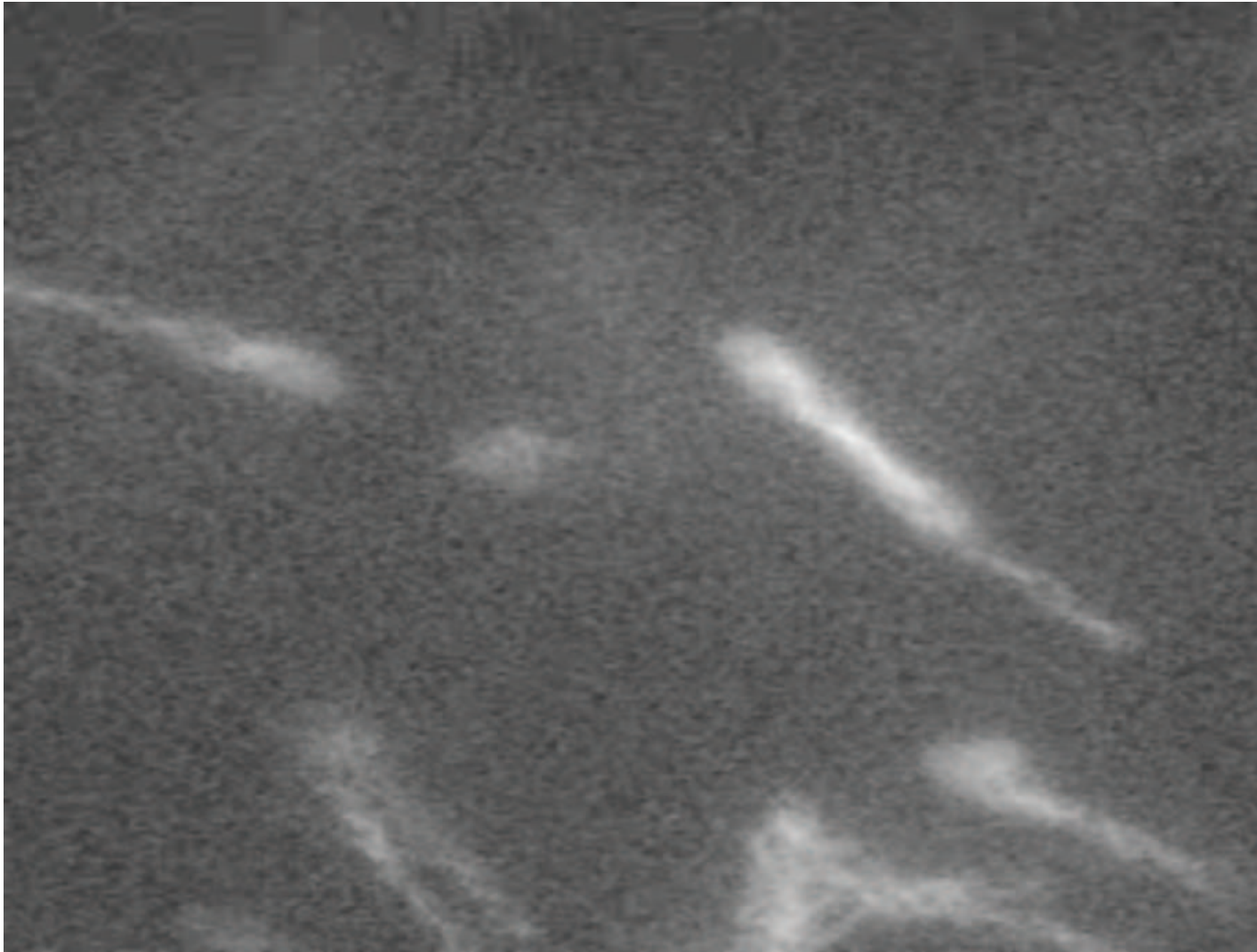
theforeigner.no/pages/news/borrelia-bearing-ticks-on-the-increase/



www.kellykite.com/213/lyme-disease-lyme-borreliosis.html

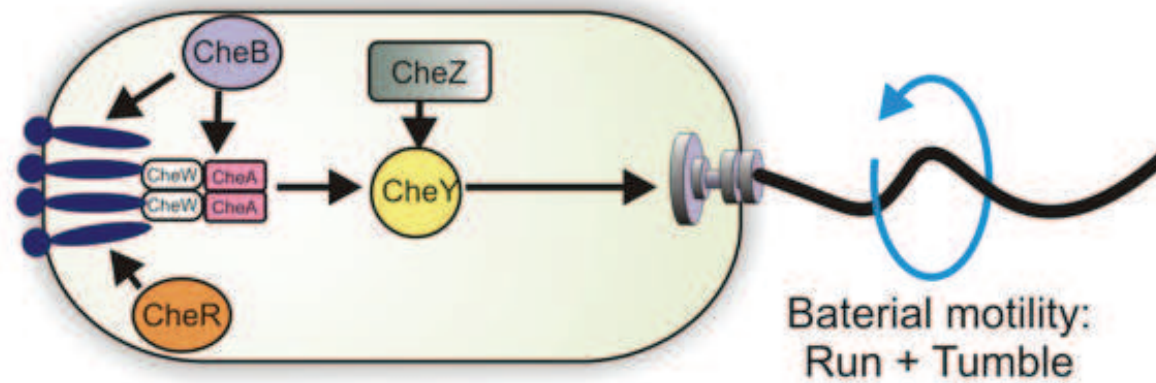
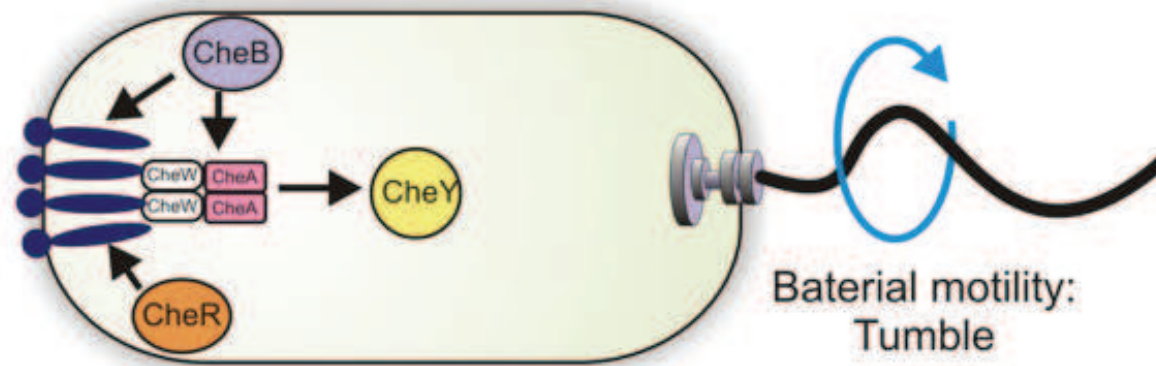


Image: Center for Disease Control



courtesy of Howard Berg, lab website

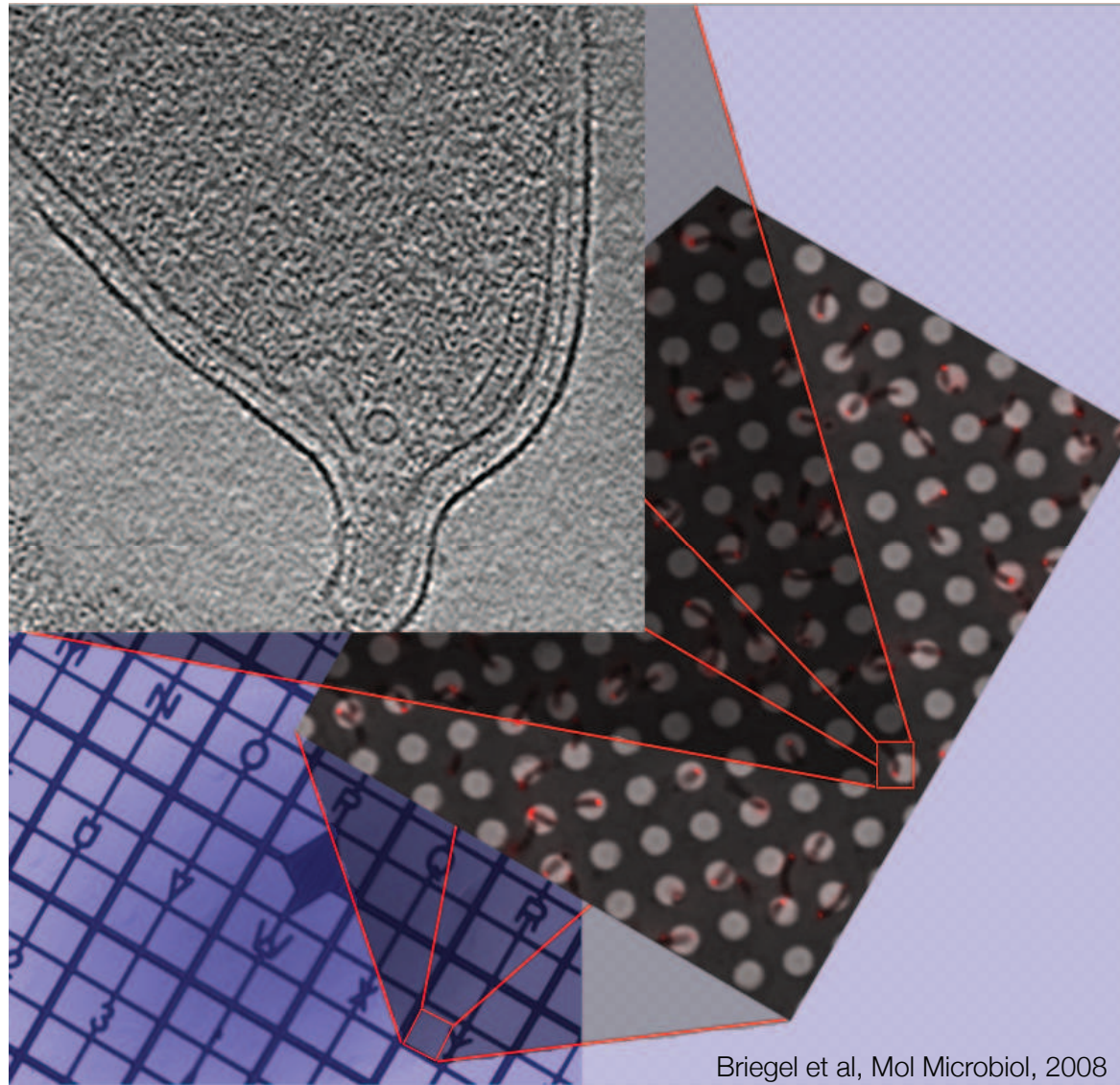
Chemotaxis Model for *Escherichia coli*



**Electron cryotomography of
Treponema primitia and its
periplasmic flagellar motor**

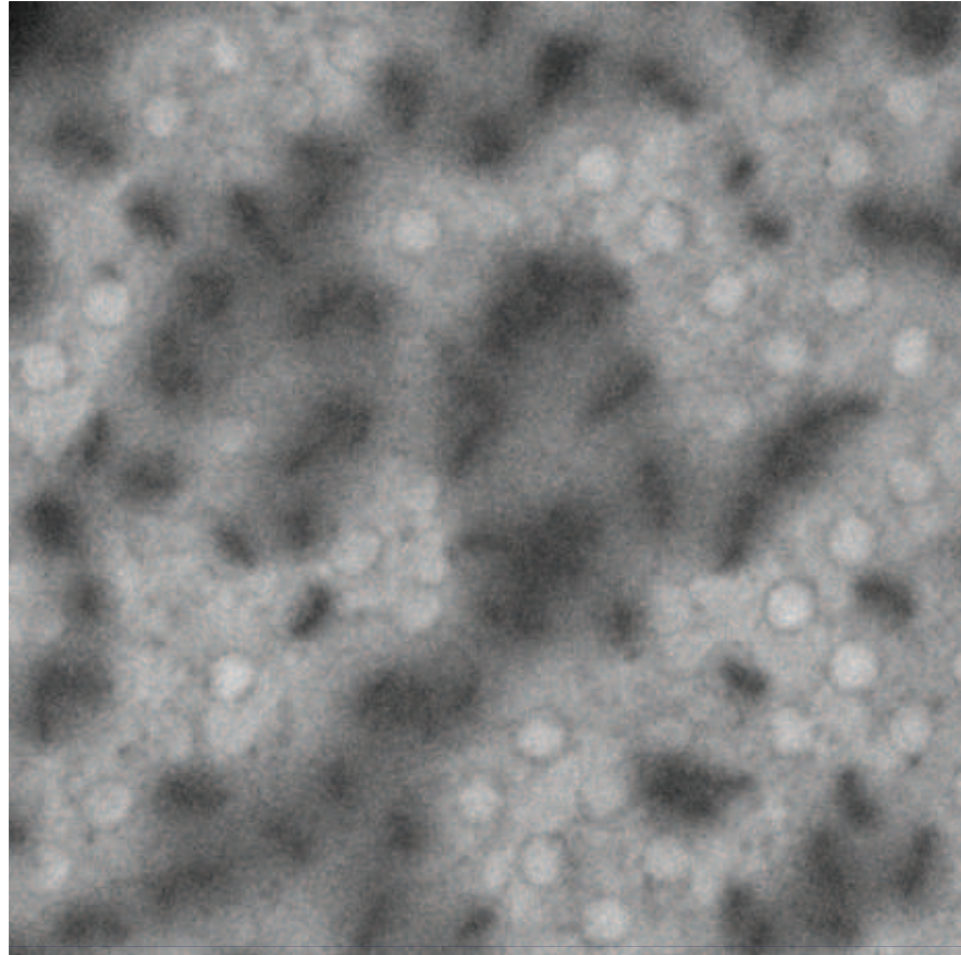
**Gavin E. Murphy
Jensen Lab
2006**

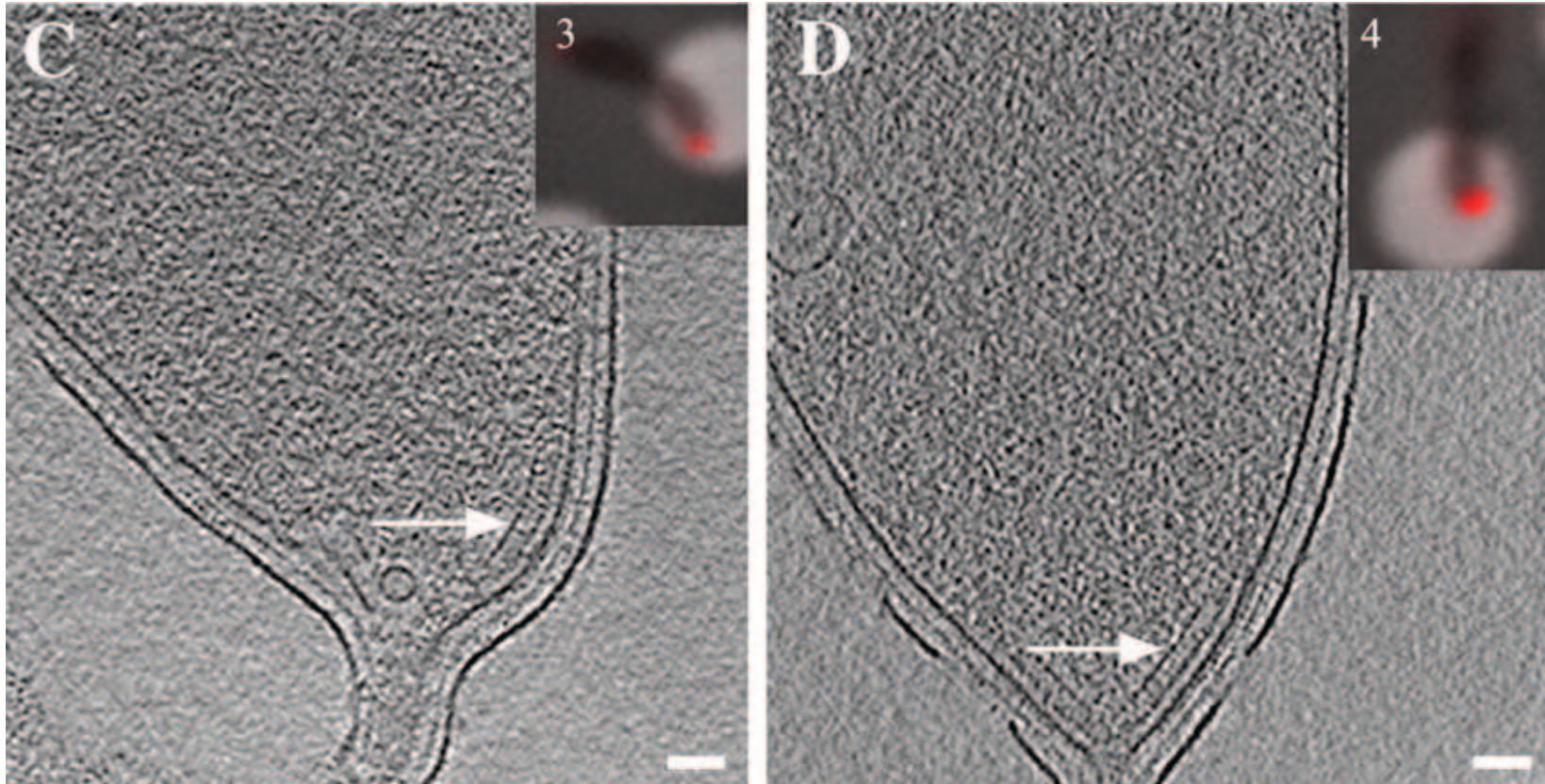
Correlative Light- and Electron Microscopy



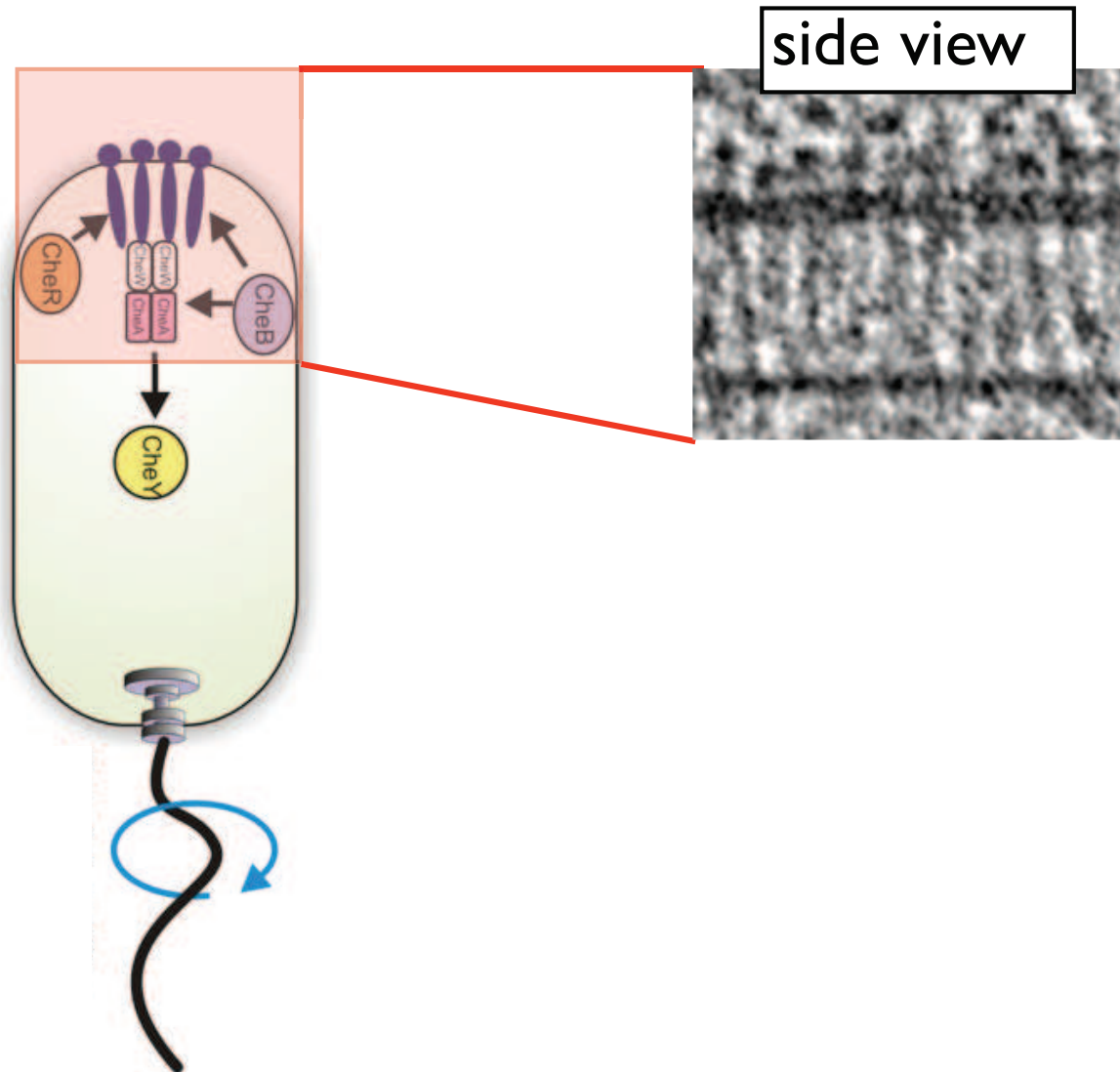
Briegel et al, Mol Microbiol, 2008

Correlative Light- and Electron Microscopy

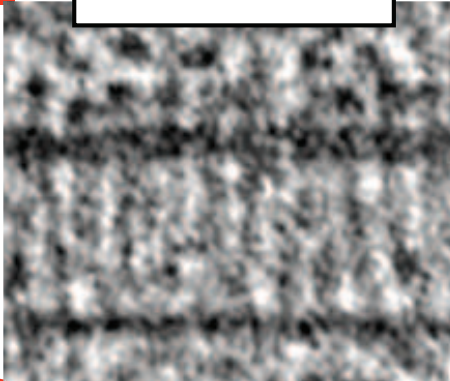




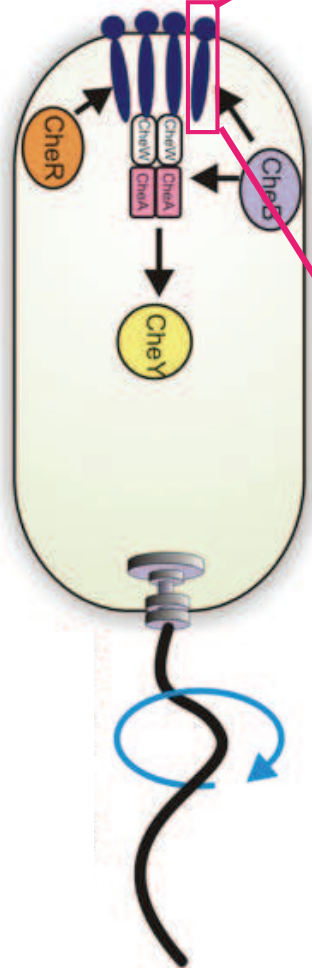
Briegel et al, Mol Microbiol, 2008

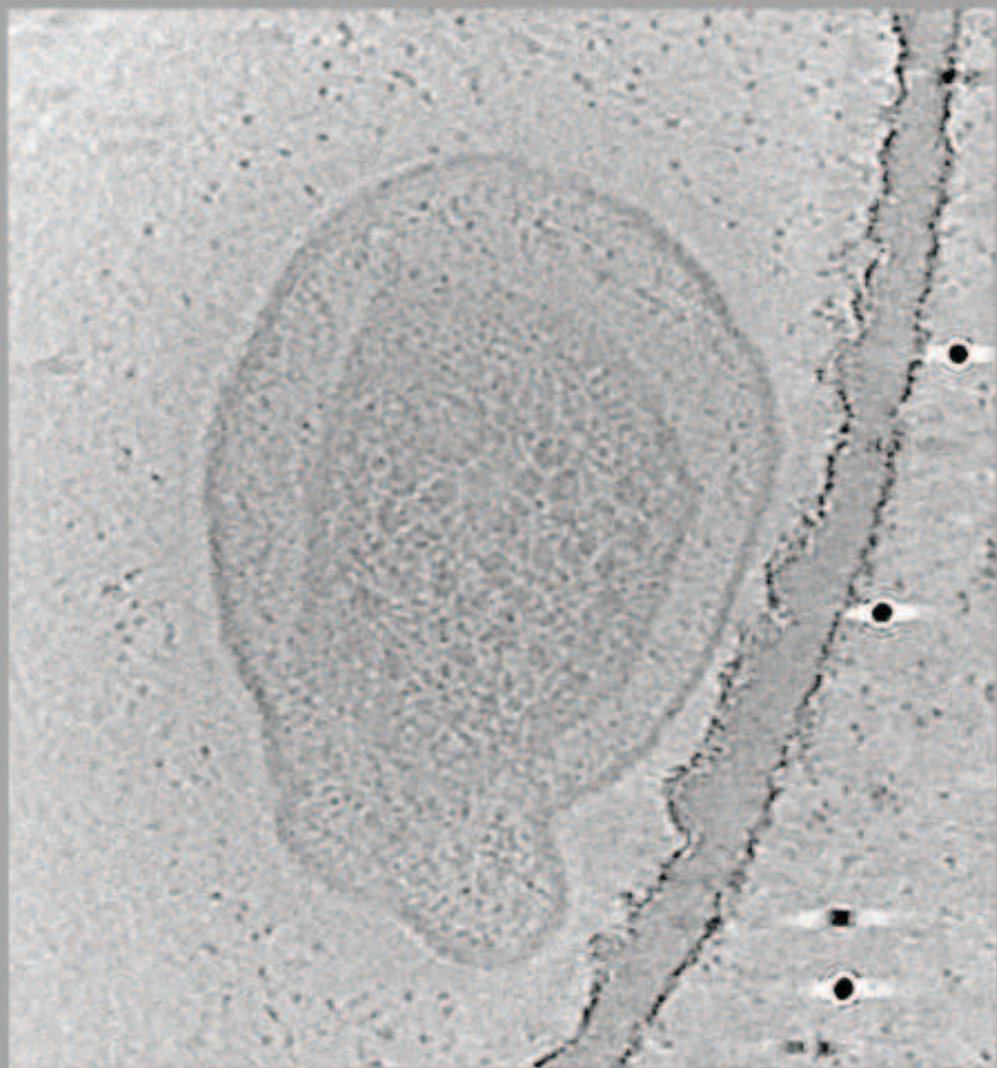


side view



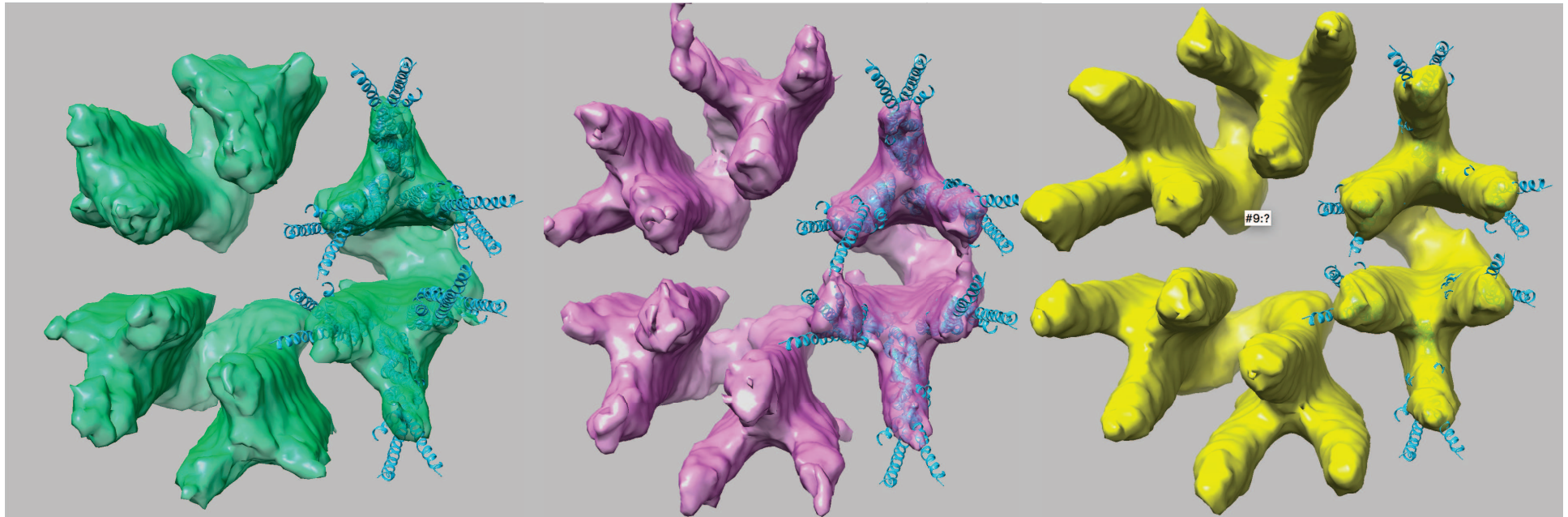
The chemoreceptors (MCPs)







Wen Yang



kinase off

default state

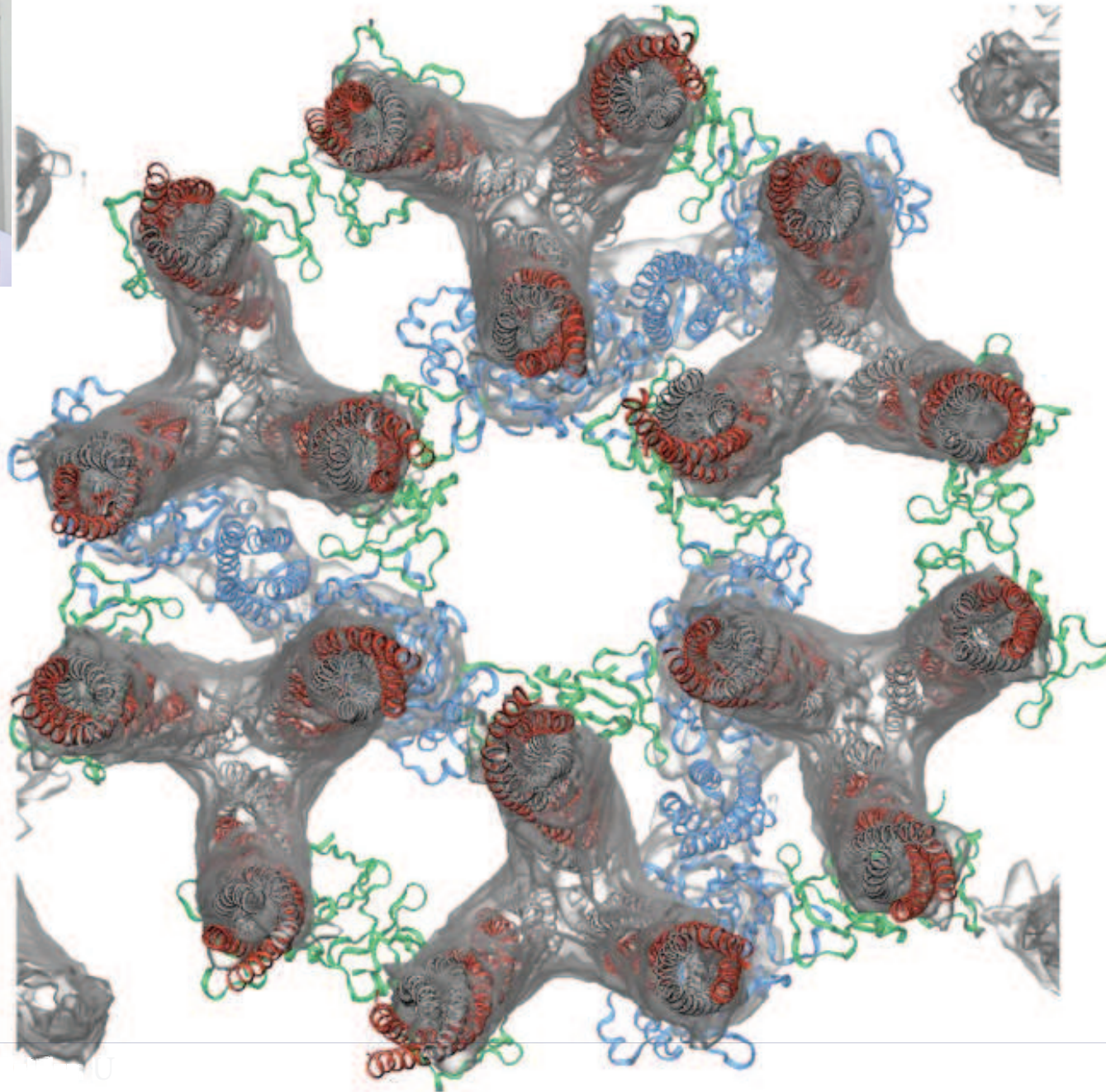
kinase on



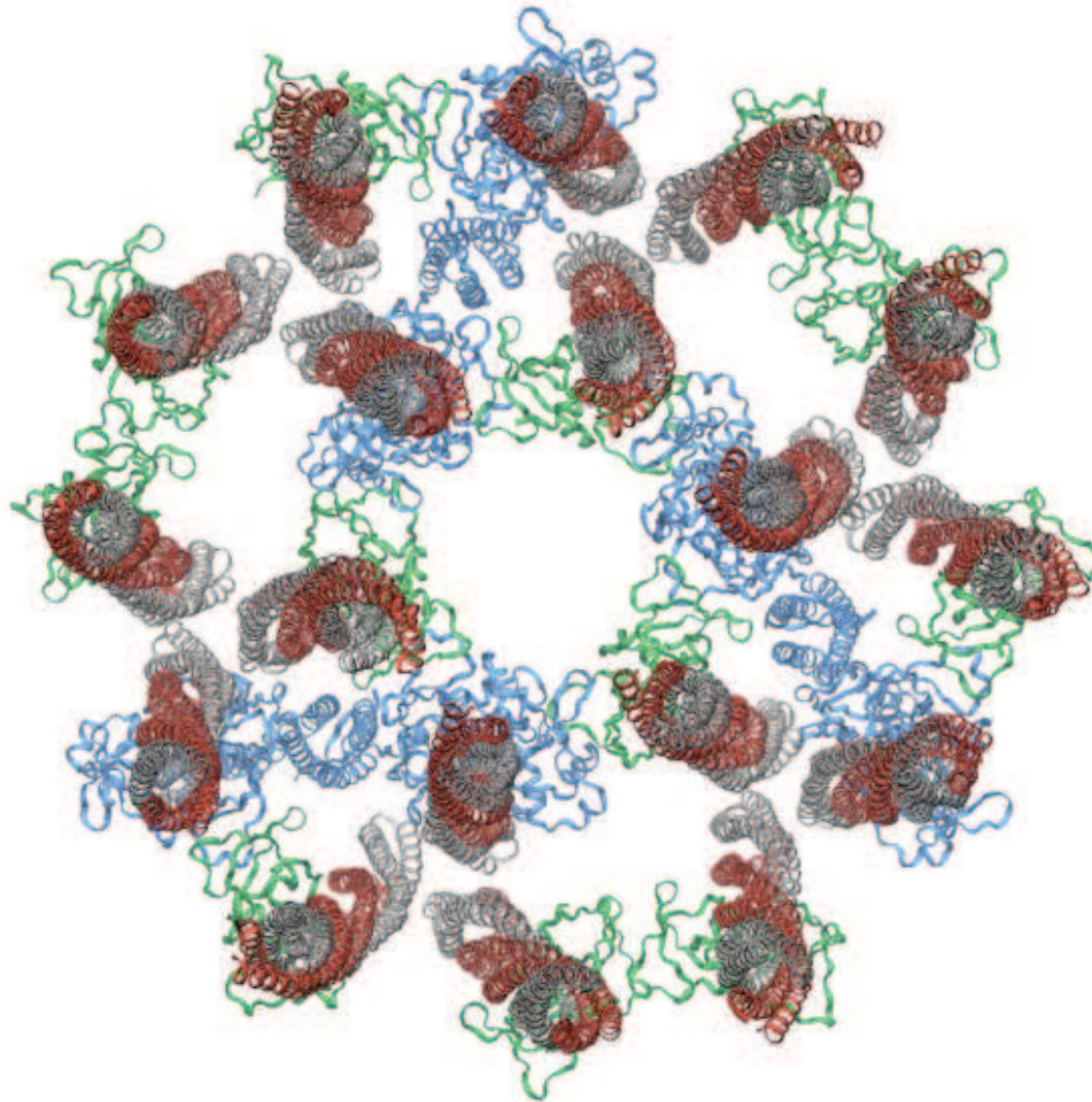




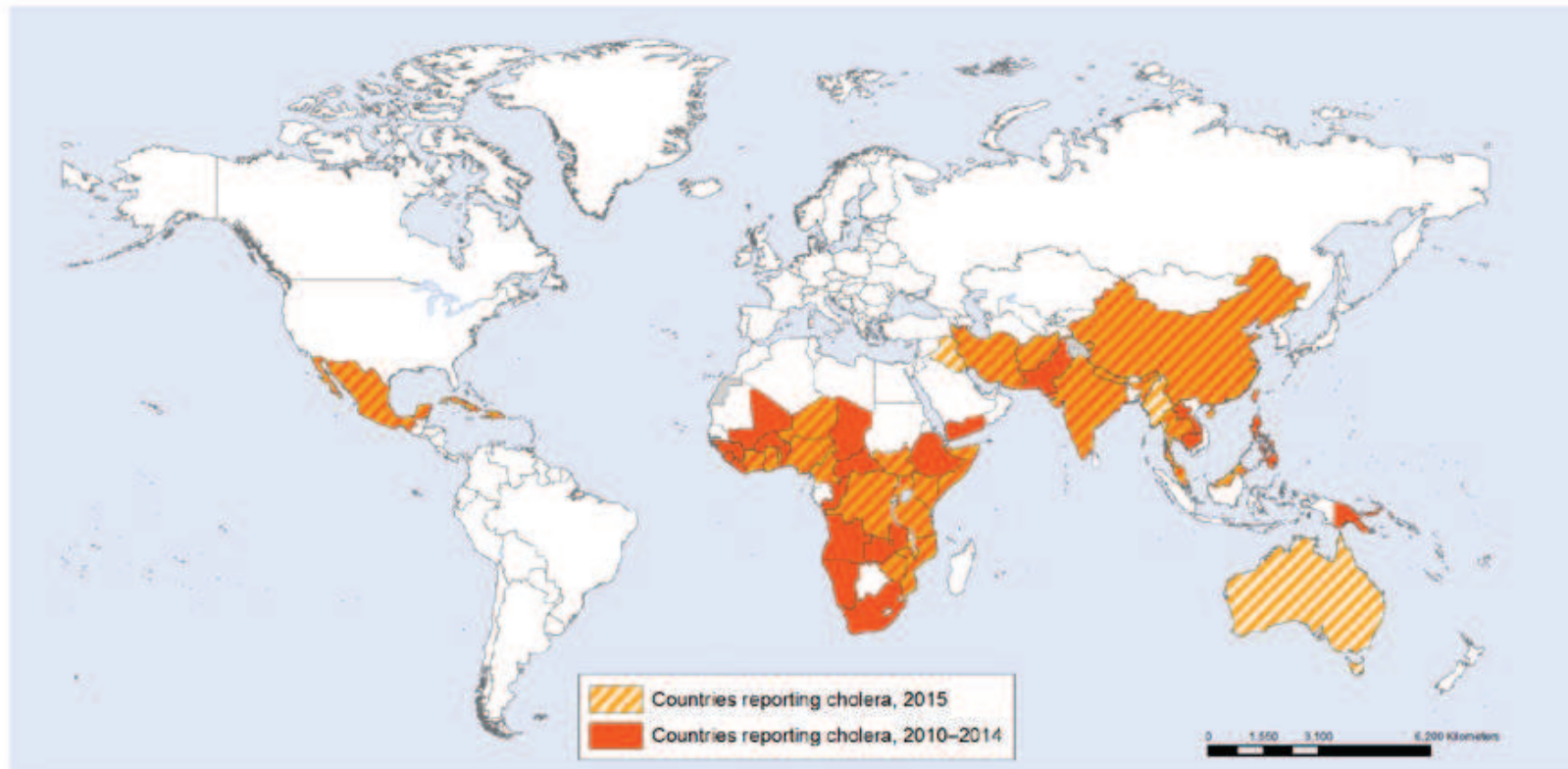
Keith Cassidy



MDFF simulations: ~ 2 Million Atoms, 10 nanoseconds for each state



Countries reporting cholera, 2010–2015



The boundaries and names shown and the designations used on this map do not imply the expression of any opinion whatsoever on the part of the World Health Organization concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries. Dotted and dashed lines on maps represent approximate border lines for which there may not yet be full agreement.

Data Source: World Health Organization
Map Production: Information Evidence
and Research (IER)
World Health Organization



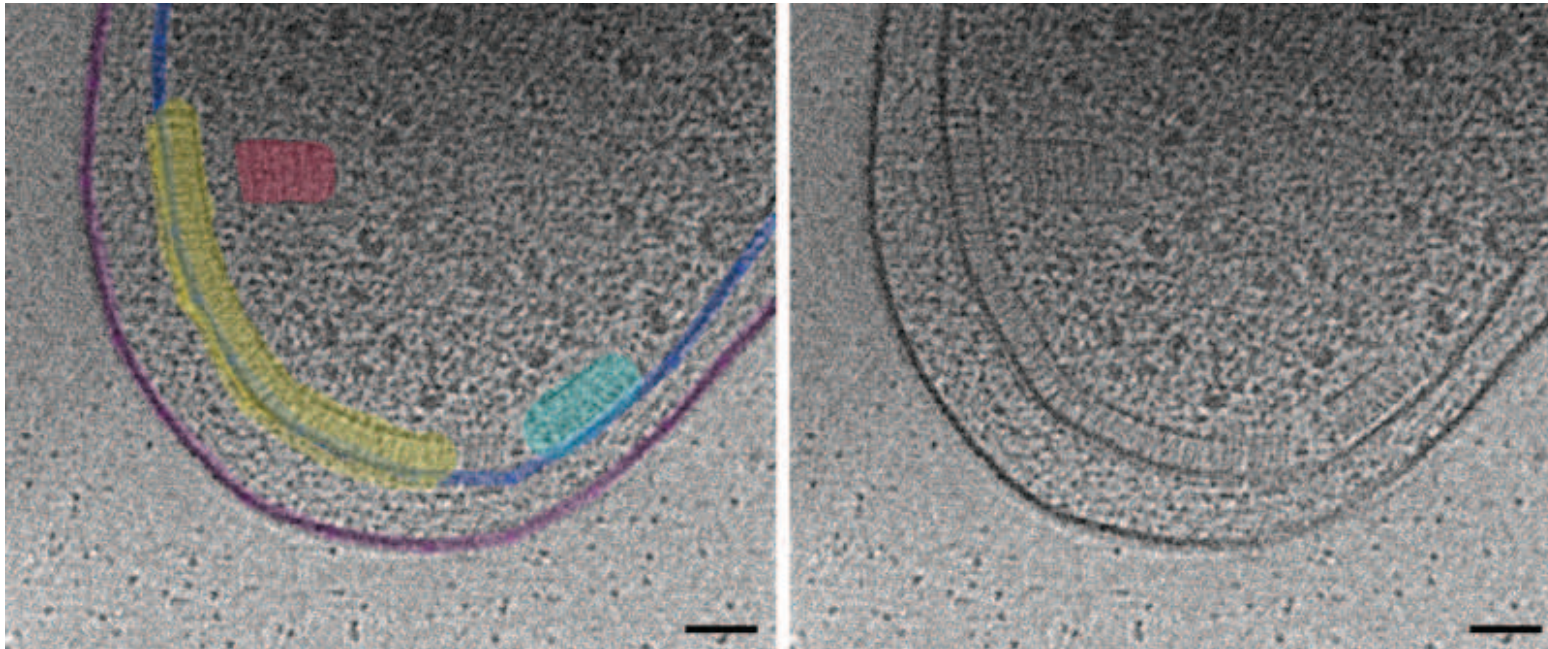
© WHO 2015. All rights reserved.

Cholera in Leiden: 2 epidemics (1832,1866)

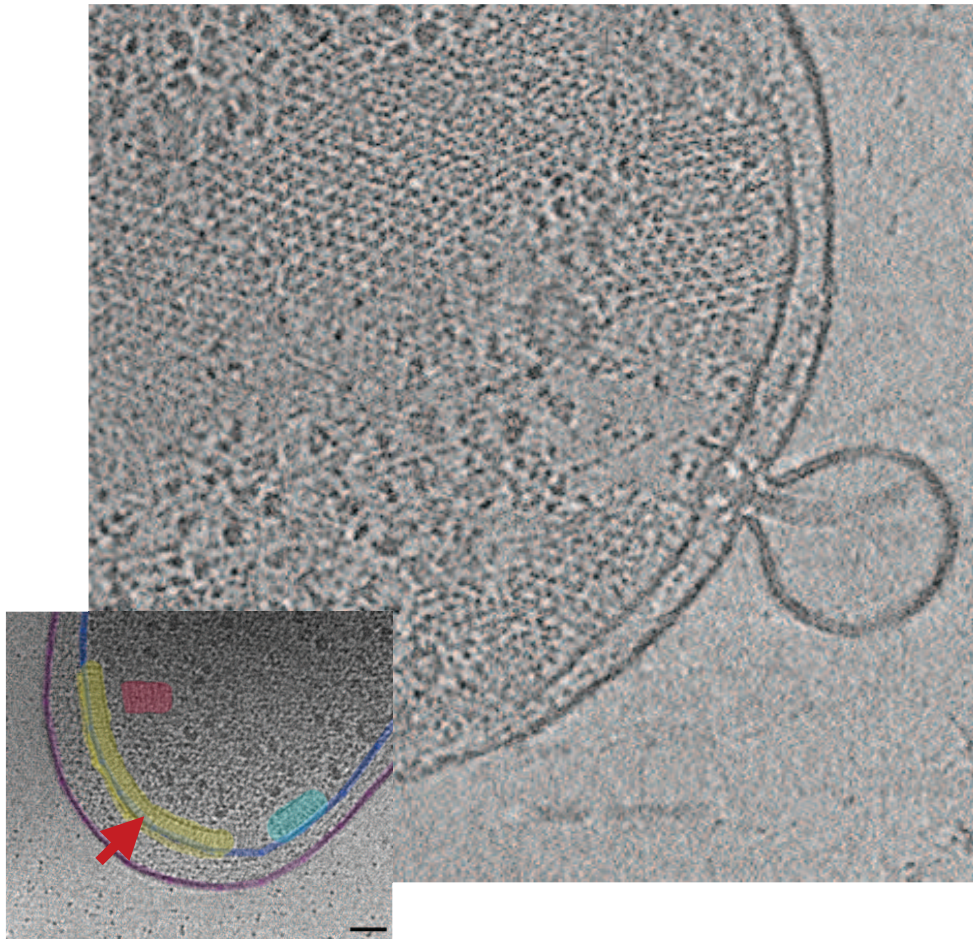


Boerhaave museum Leiden

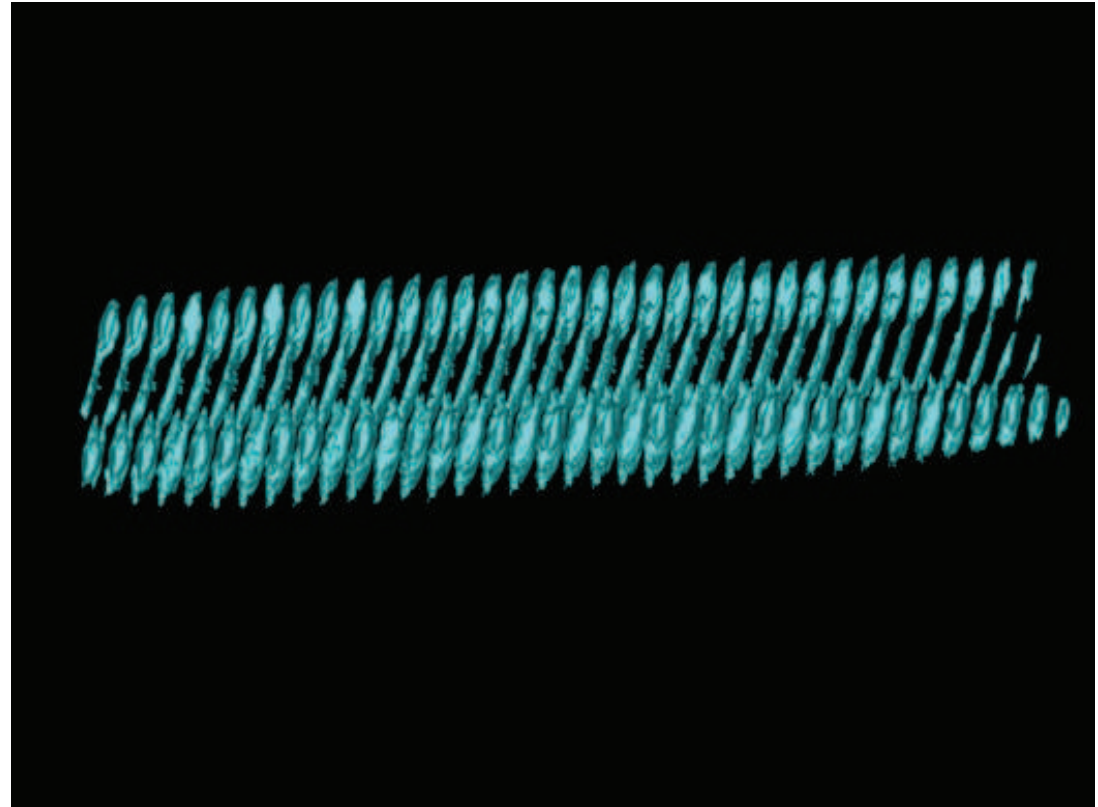
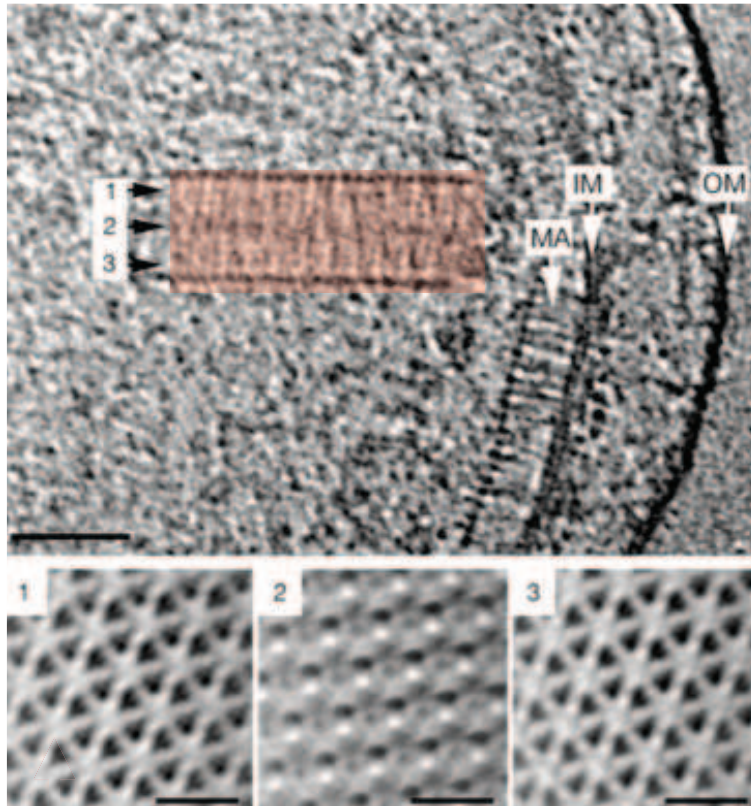
Three chemotaxis arrays in *Vibrio cholerae*



Three chemotaxis arrays in *Vibrio cholerae*

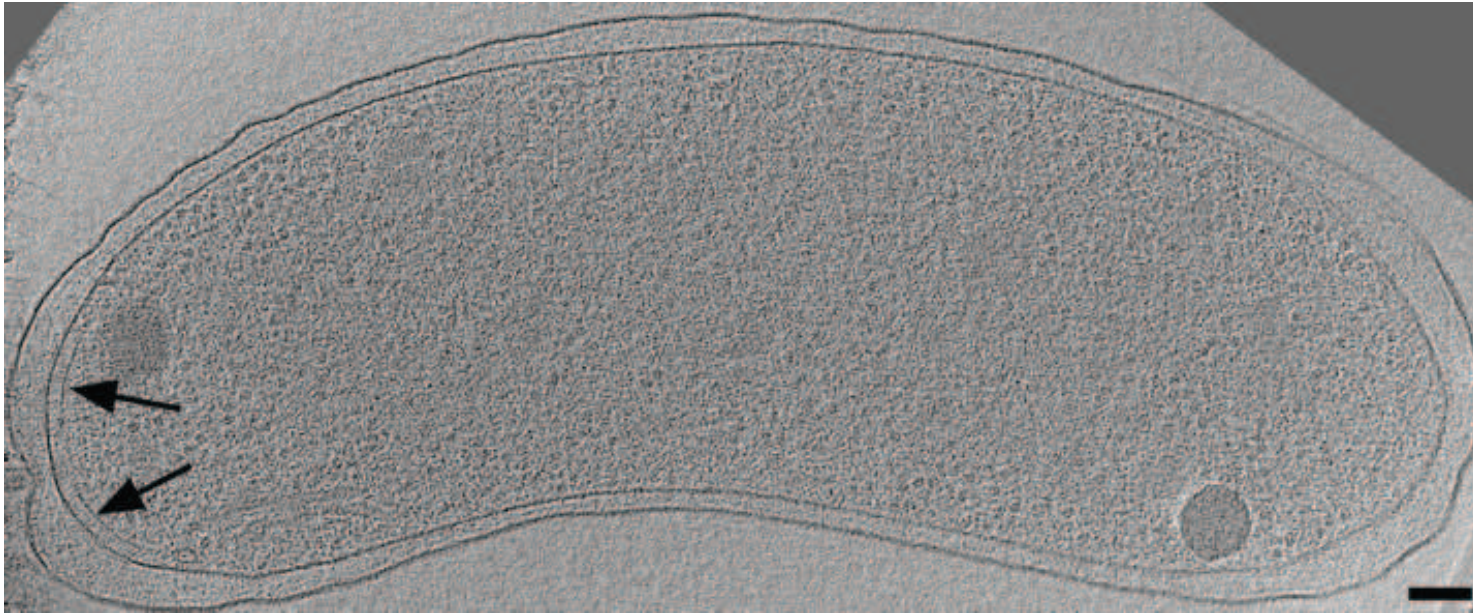


Three chemotaxis arrays in *Vibrio cholerae*



Briegel et al, PNAS 2016

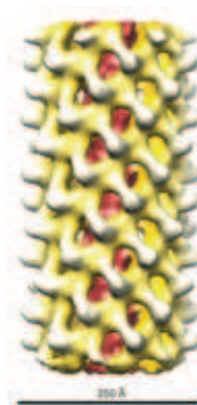
Molecular Machines in Vibrio



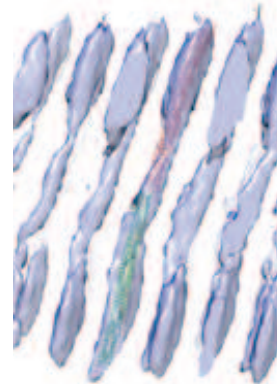
Chen et al



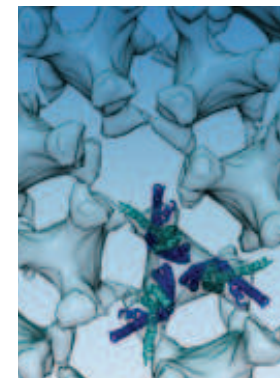
Chang et al



Wang et al

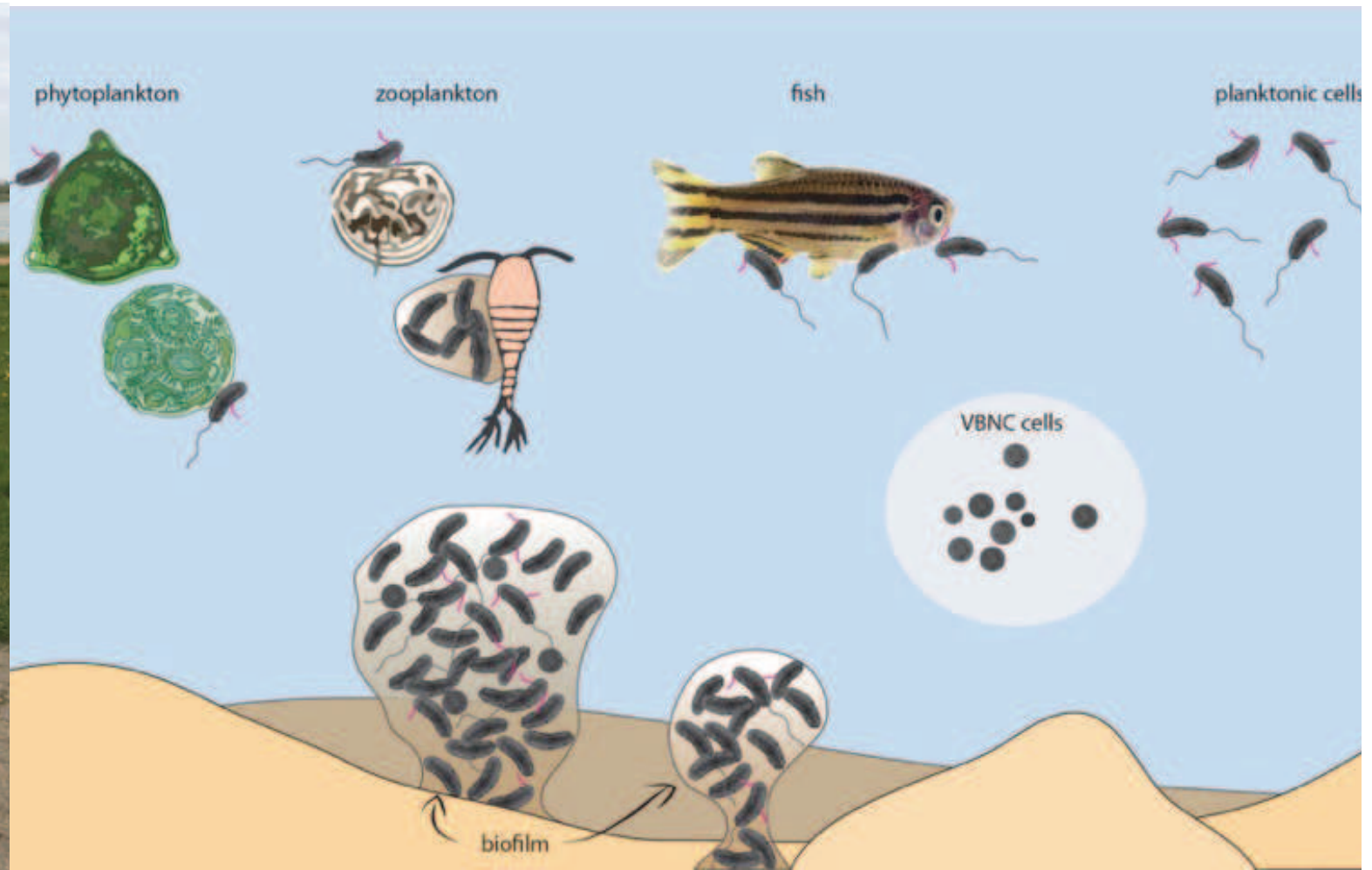


Briegel et al



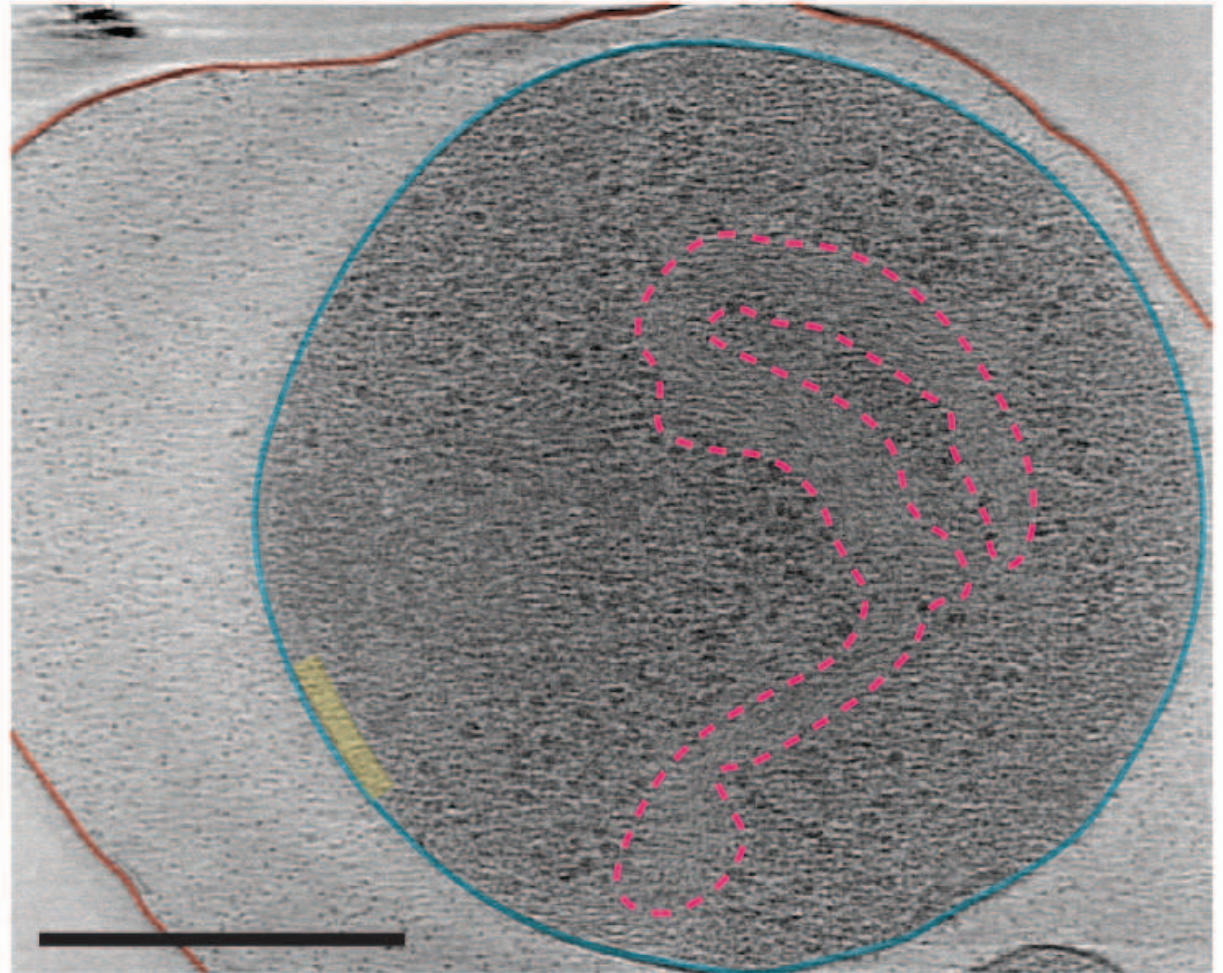
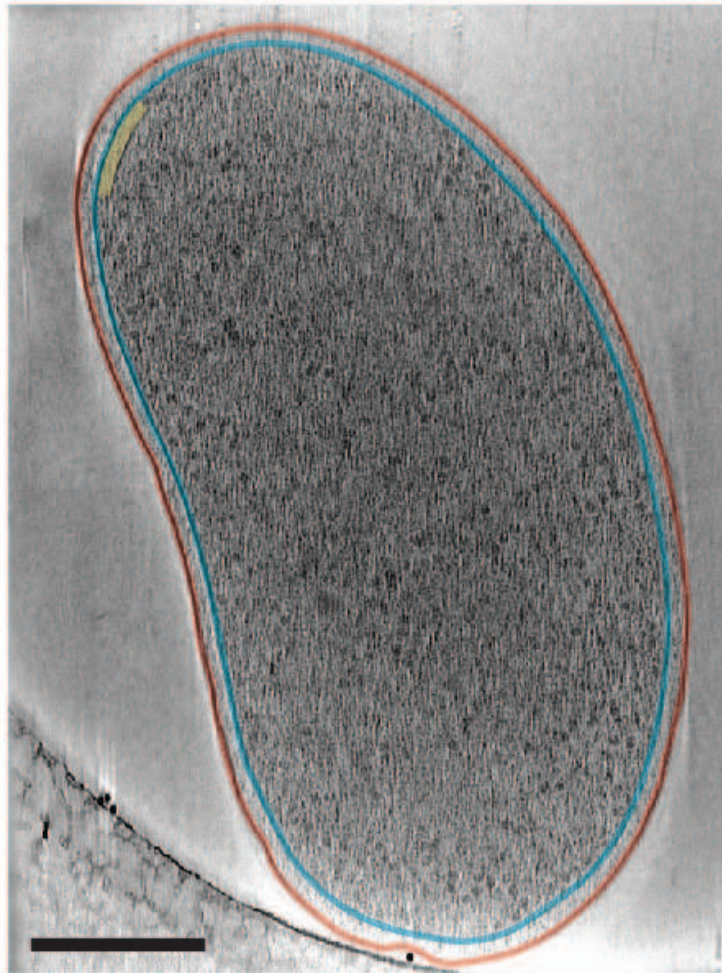
Briegel et al

Vibrio bacteria in the environment



Susanne Brenzinger

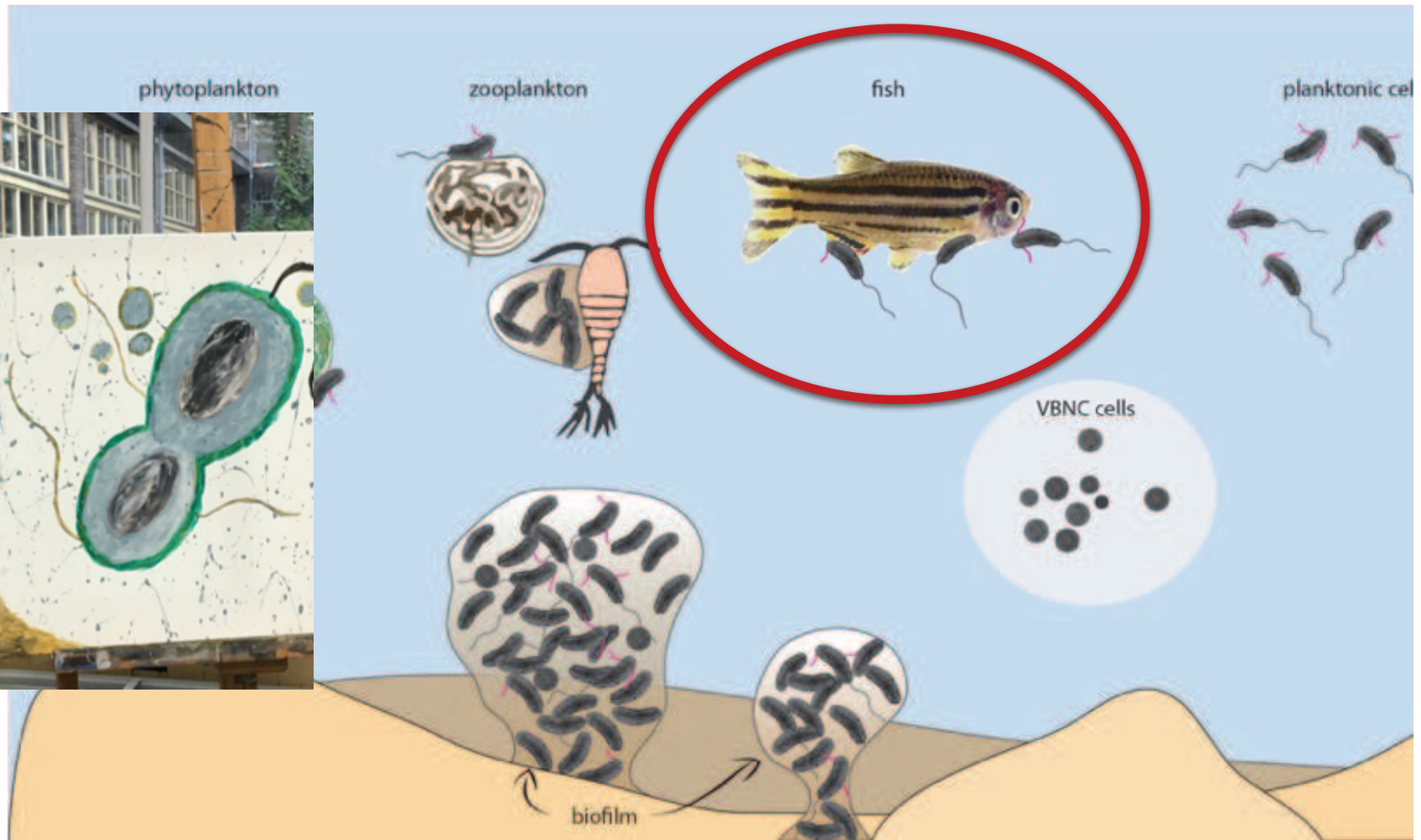
Vibrio changes morphology according to its environmental stage



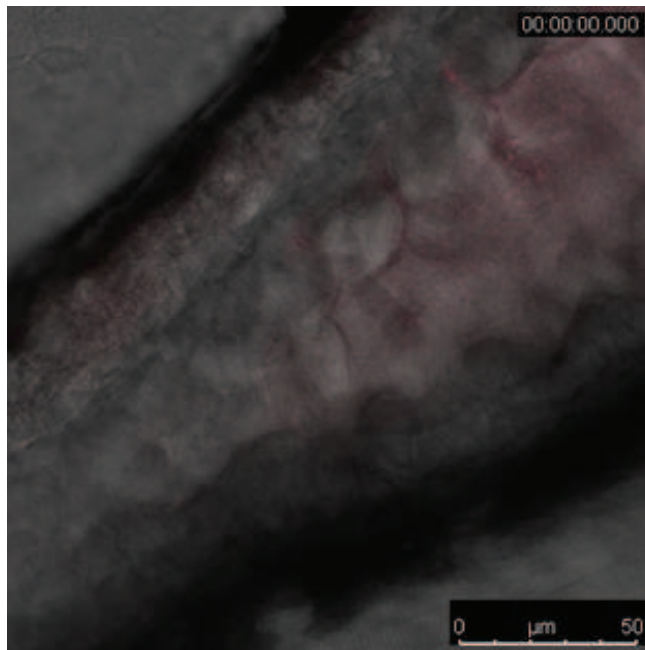
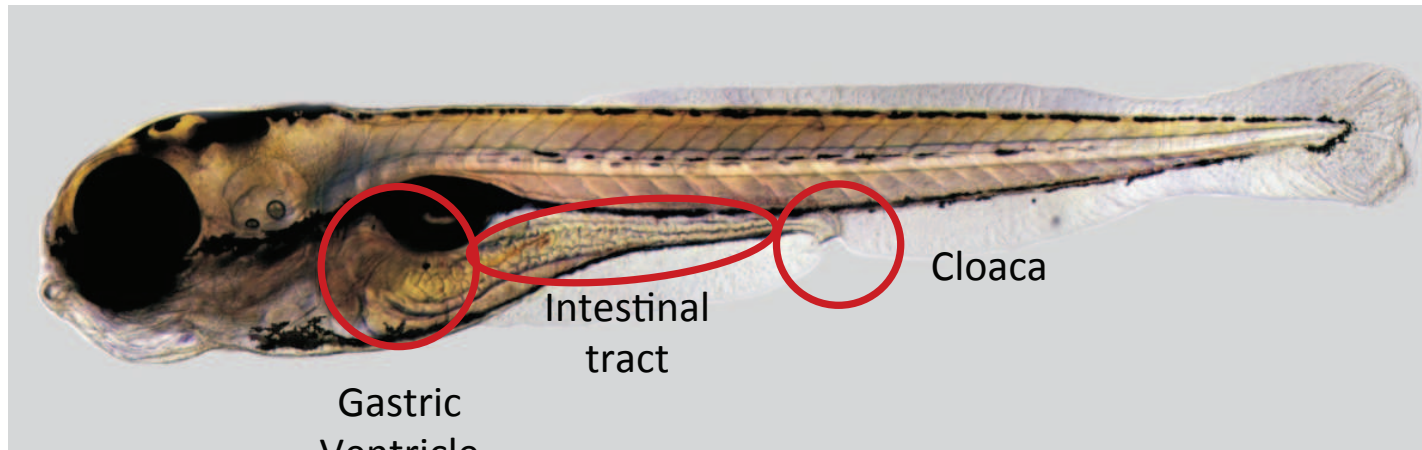
Vibrio bacteria during host infection



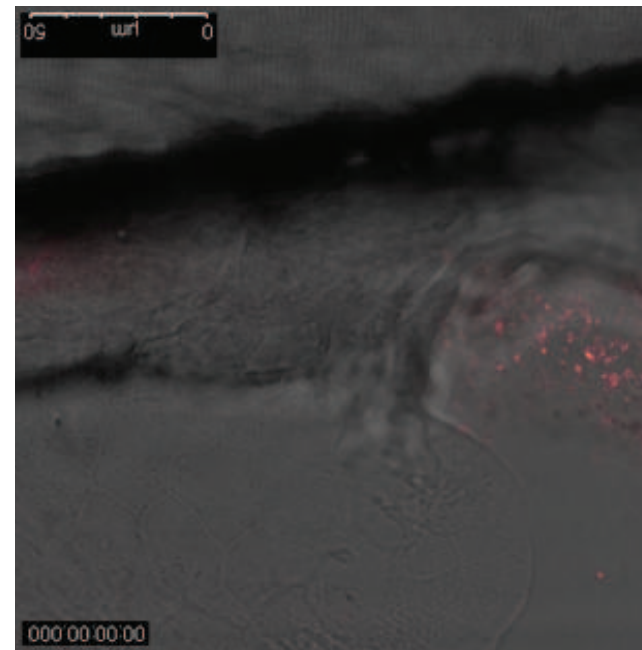
Jamie Depelteau



Vibrio Infection of germ-free Zebrafish Larvae (5dpf)

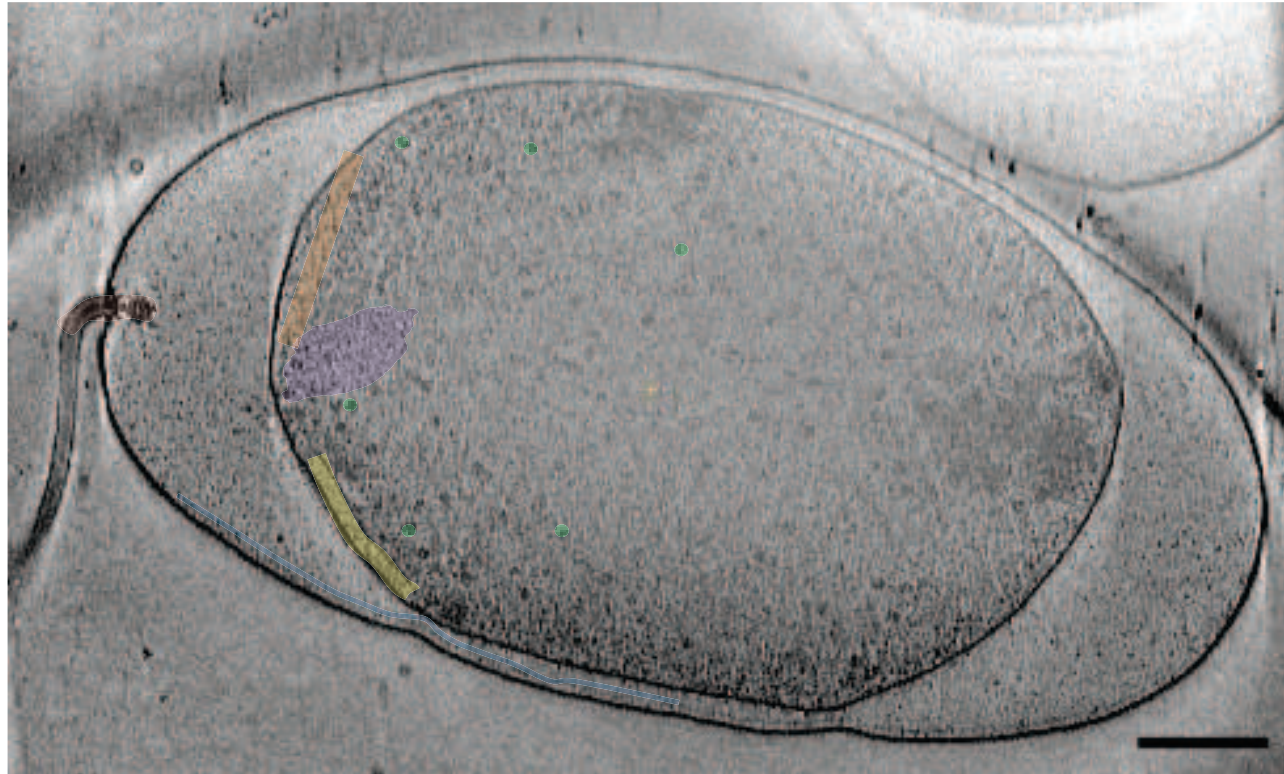


Mid intestine, 40x, z = 1,57µm

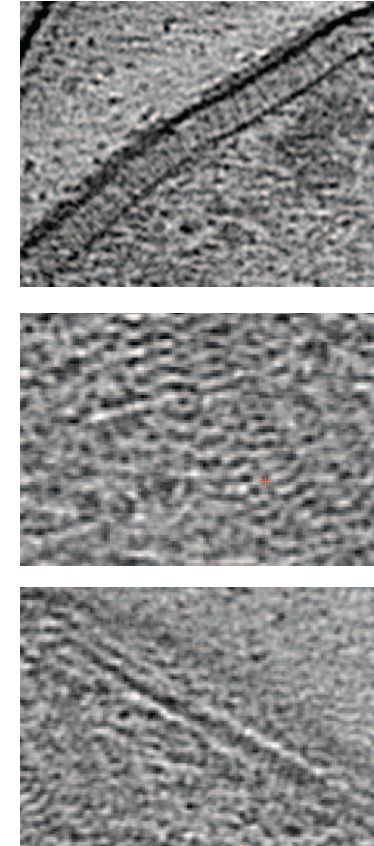


Lower intestine, 40x, z = 1,57µm

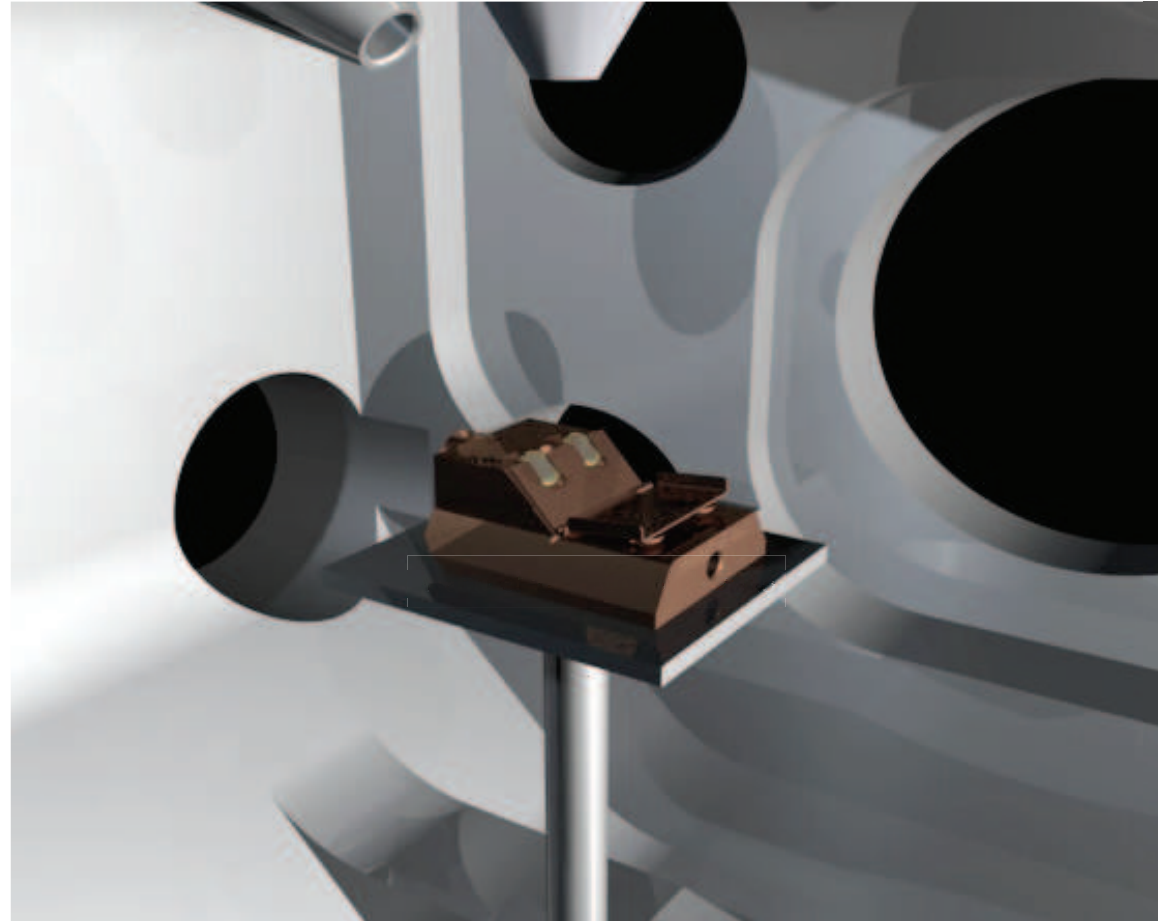
Vibrio cell after 48 hours contact with zebrafish larvae

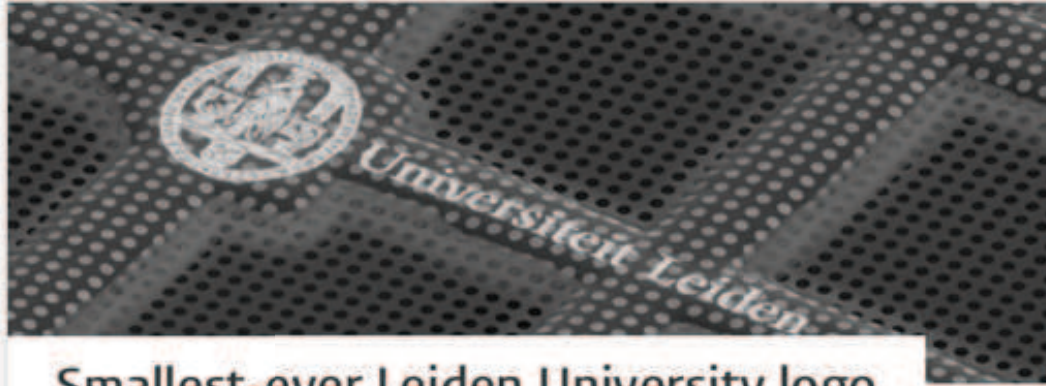


100nm



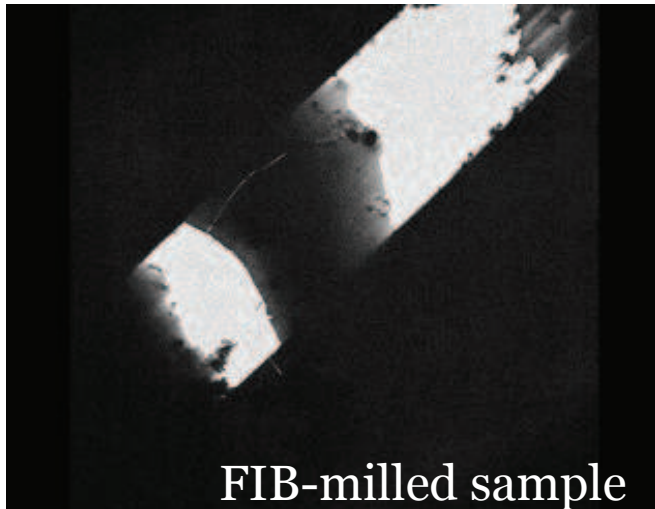
Cryogenic Focused Ion Beam Milling



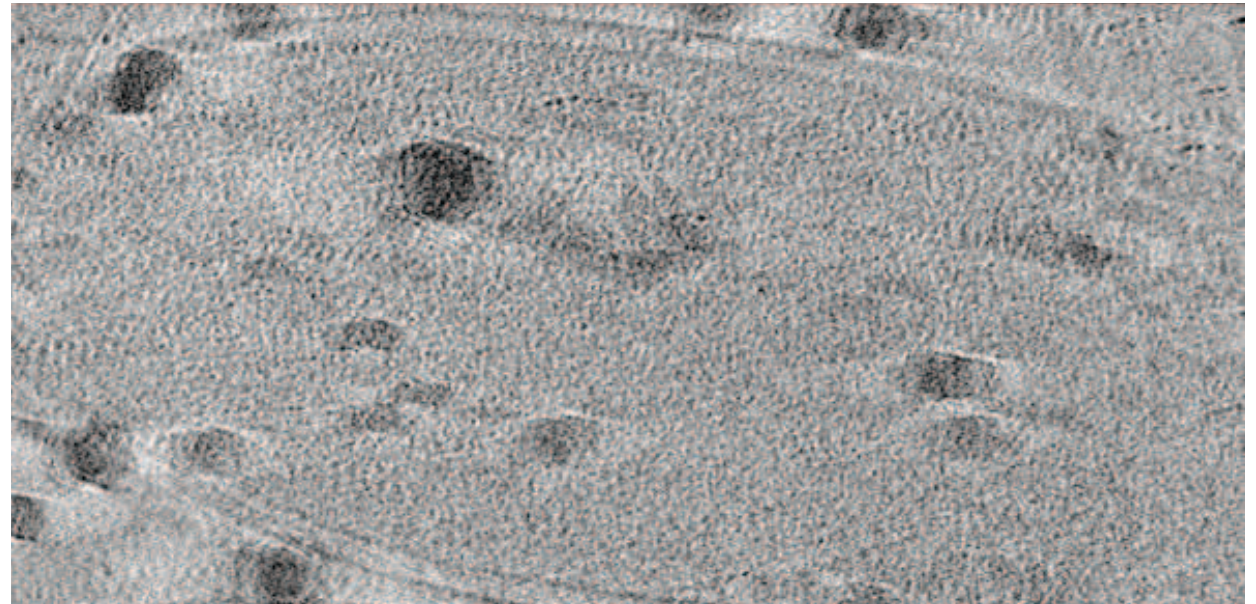


Smallest-ever Leiden University logo

23 February 2018



FIB-milled sample



**Tomography of a Vibrio cell
after Cryo-FIB milling**





Wen Jang
Eveline Ultee
James Depelteau
Susanne Brenzinger
Rohola Hosseini
Lasse Sprankel

Collaborators:

Sandy Parkinson (University of Utah)
Keith Cassidy (University of Urbana-Champaign)
Annemarie Meijer, Bjorn Koch (IBL Leiden)
Simon Ringgaard (MPI Marburg)



NeCEN/LUMC:

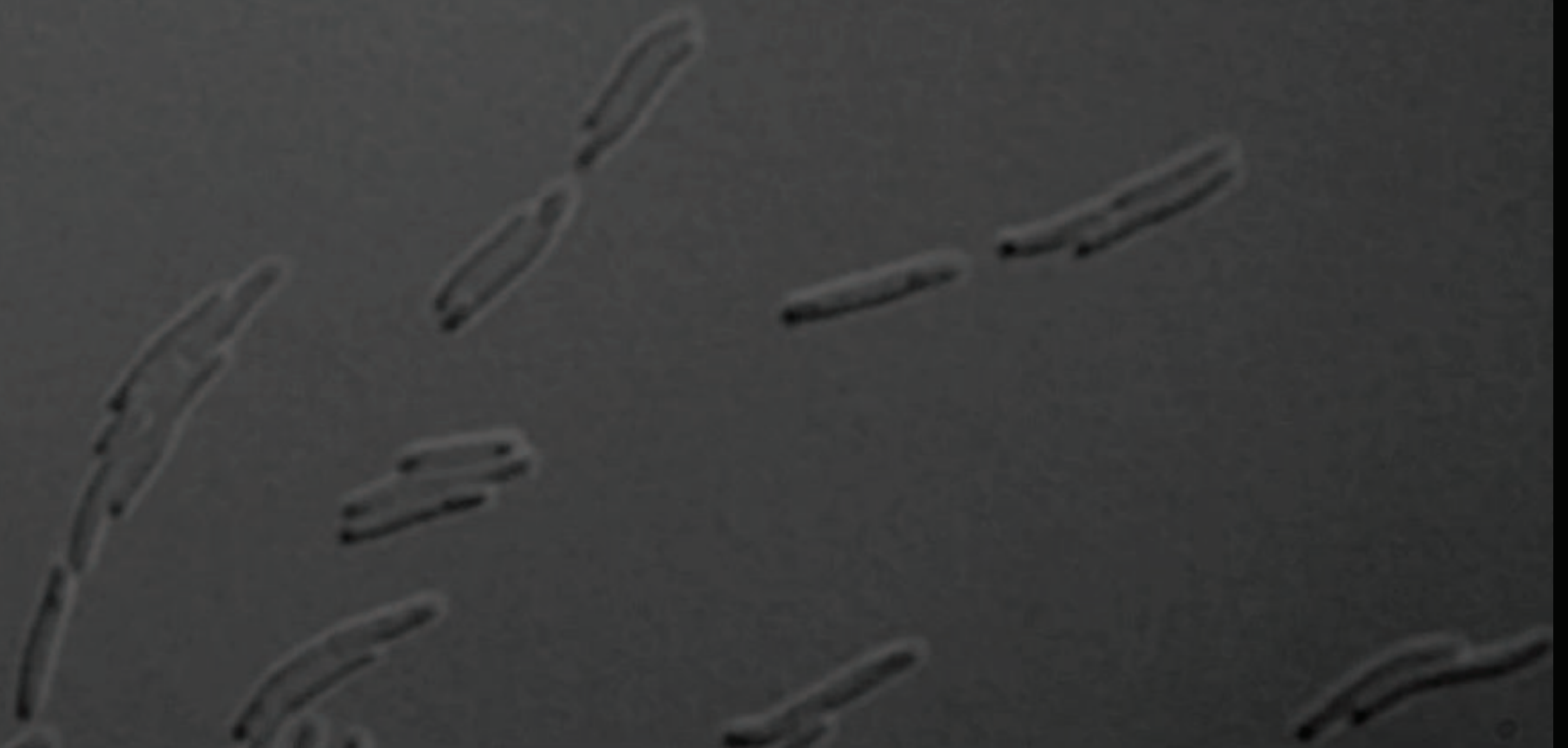
Bram Koster
Roman Koning
Christoph Diebolder
Ludovic Renault
Stuart Howes



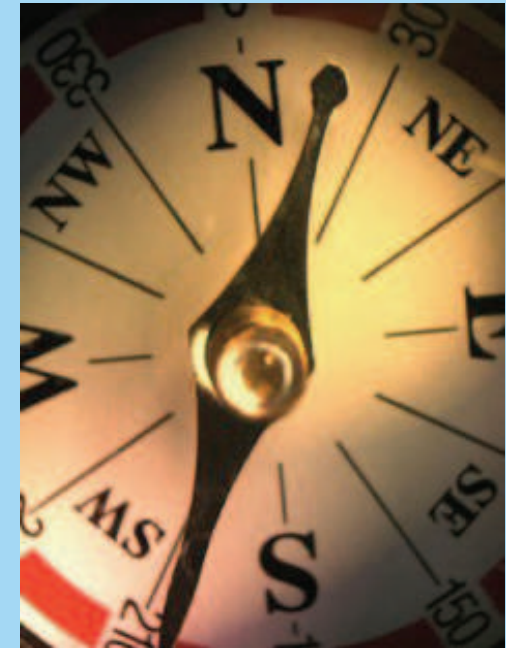
Leopoldina
Nationale Akademie
der Wissenschaften

ThermoFisher
SCIENTIFIC

Working hypotheses of mechanisms involved in the extension and retraction of the bacterial type IV pilus



Some bacteria
can also sense
the earth's magnetic field



http://senr.osu.edu/Organisms_Living_on_Earth.html





<http://historicromance.wordpress.com/>

Some bacteria can defend their territory against intruders.... Type VI secretion system



The bacterial T6SS is a spring-loaded poison dagger

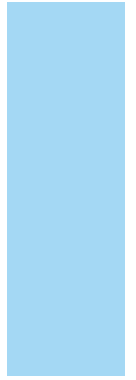
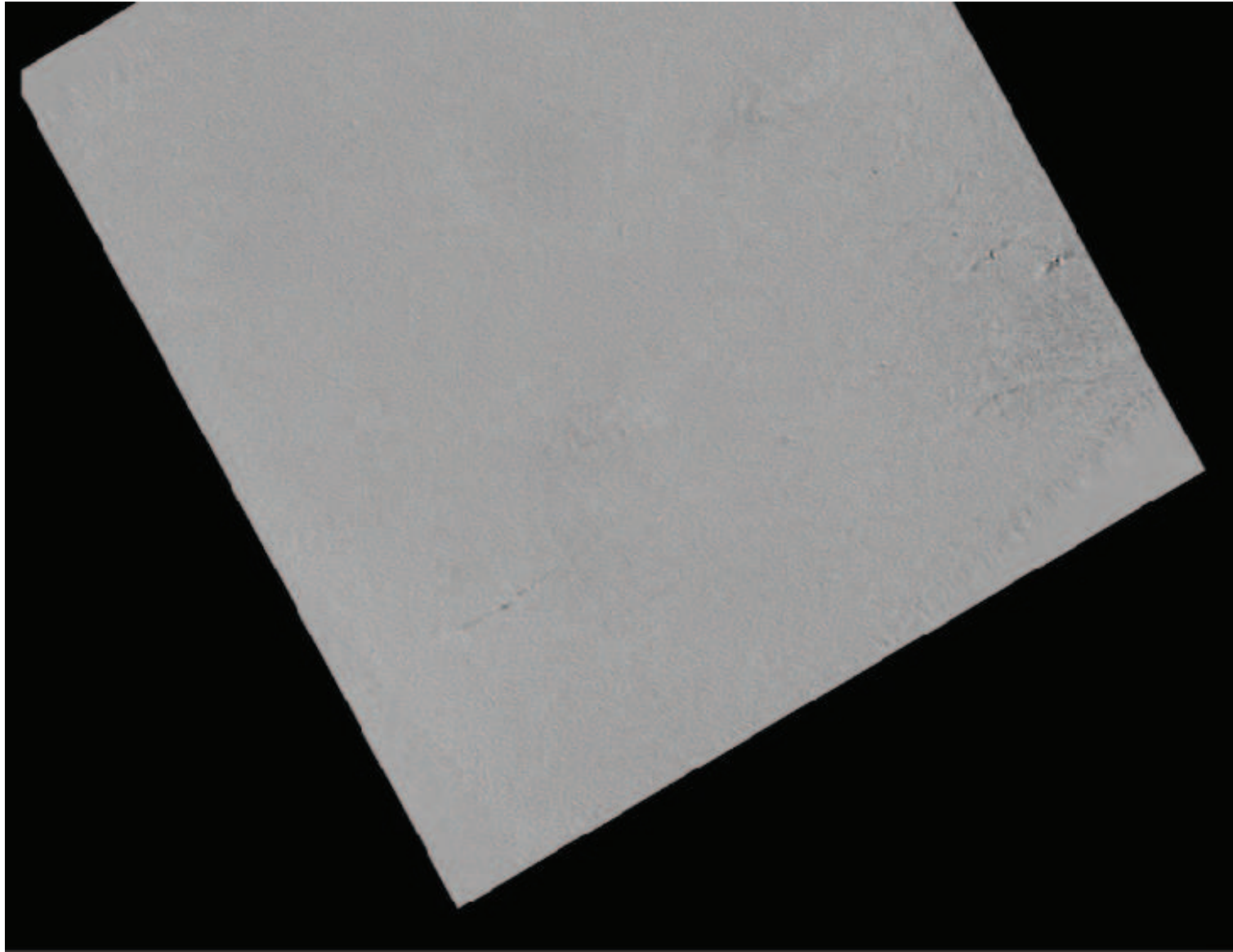
jensenlab.caltech.edu

mekalanoslab.med.harvard.edu




Marine Tube Worm *Hydroides elegans* metamorphosis requires contact with marine bacterium *Pseudoalteromonas luteoviolacea*

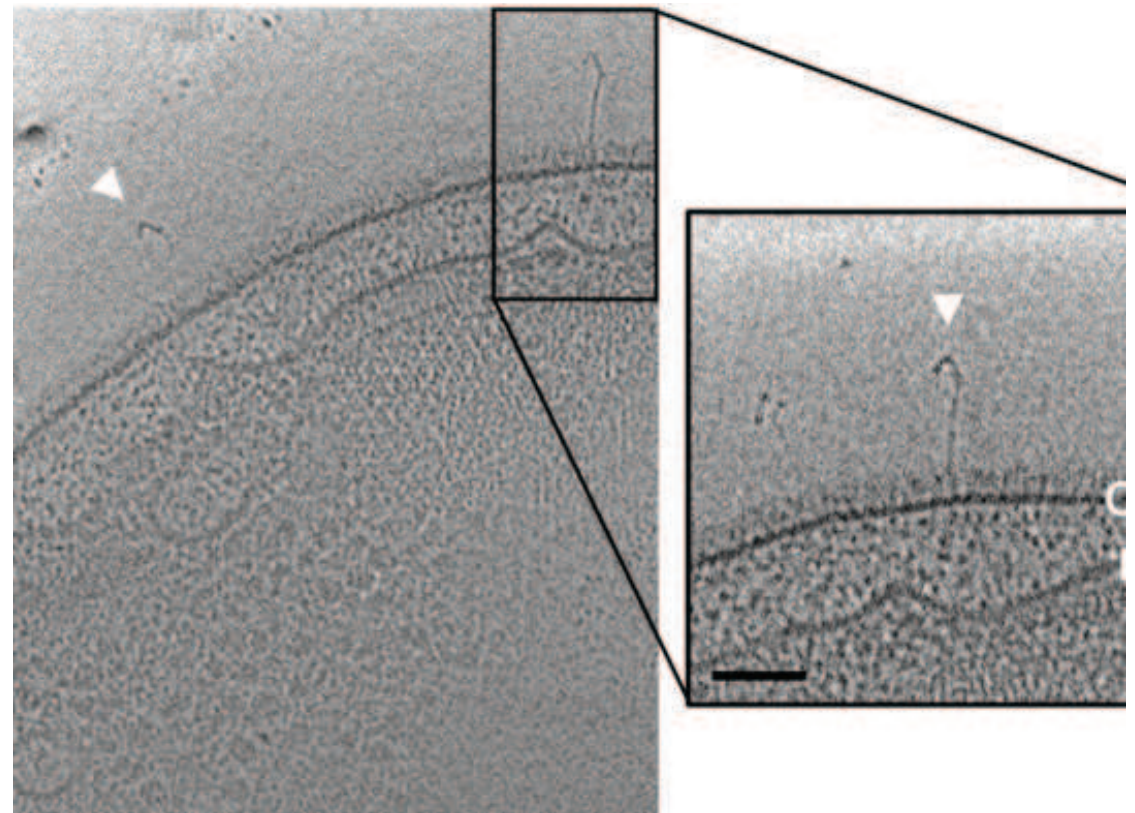
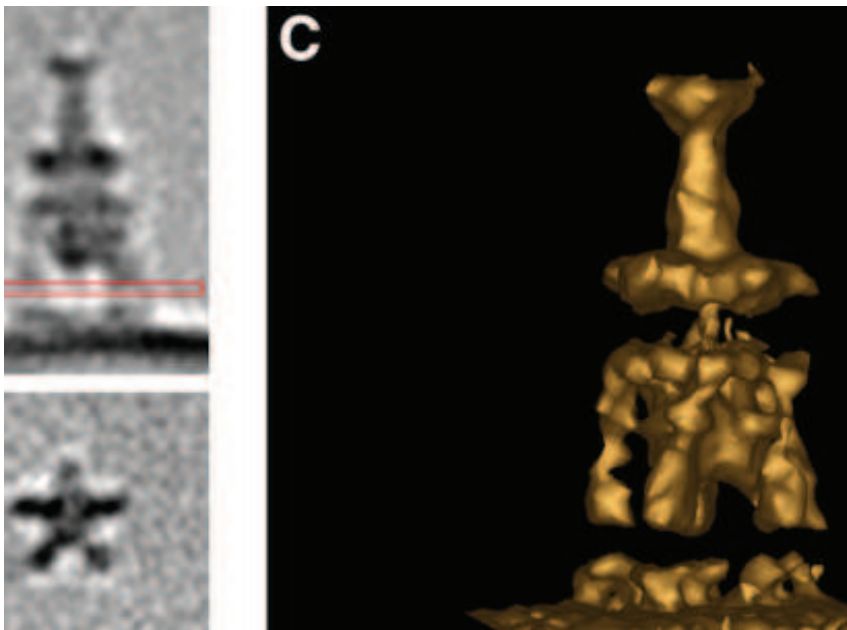




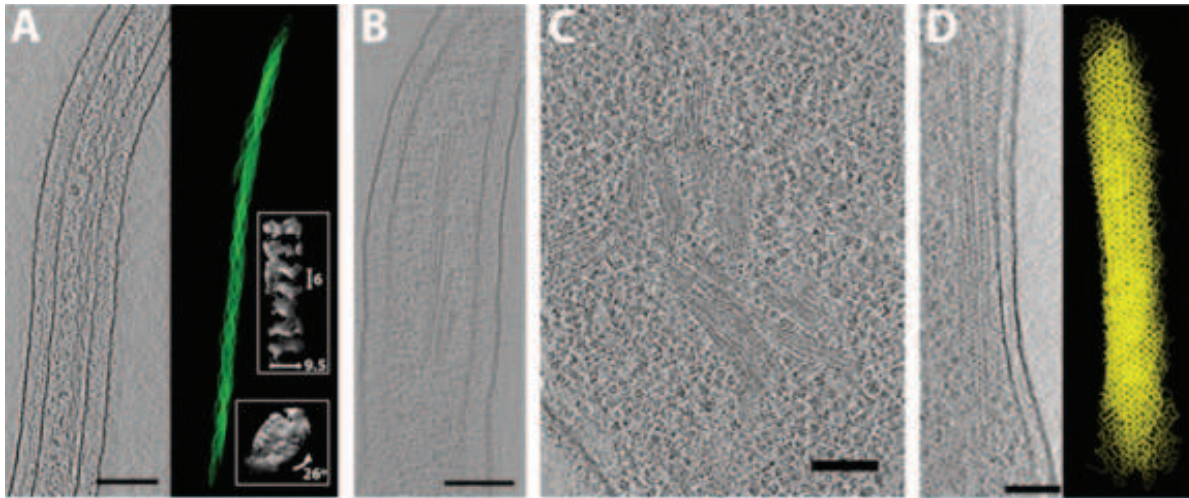
Are we close to fully understand bacterial cells?

Uncharacterized Bacterial Structures Revealed by Electron Cryotomography

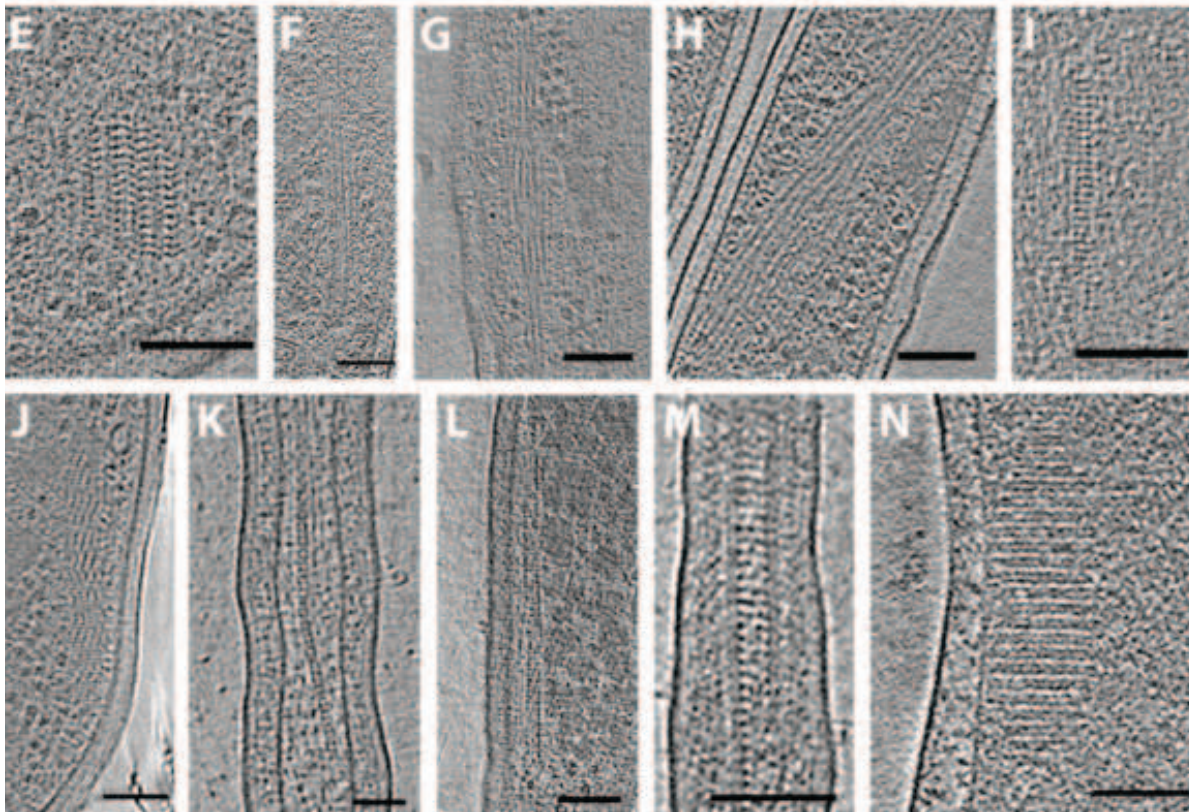
Megan J. Dobro,^a Catherine M. Oikonomou,^b Aidan Piper,^a John Cohen,^a Kylie Guo,^b Taylor Jensen,^b Jahan Tadayon,^b Joseph Donermeyer,^b Yeram Park,^b Benjamin A. Solis,^c Andreas Kjær,^d Andrew I. Jewett,^b Alasdair W. McDowall,^b Songye Chen,^b Yi-Wei Chang,^b Jian Shi,^e Poorna Subramanian,^b Cristina V. Iancu,^f Zhuo Li,^g Ariane Briegel,^h Elitza I. Tocheva,ⁱ Martin Pilhofer,^j  Grant J. Jensen^{b,k}



cell appendages



Fimbriae...



Filament bundles, arrays, chains...

What do people think bacteria look like?



How can we share our research with the public?



How can we share our research with the public?



How can we share our research with the public?

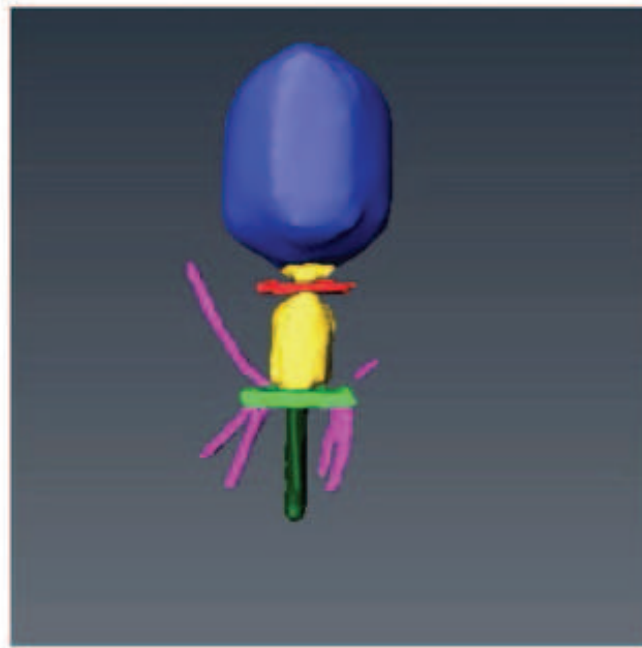
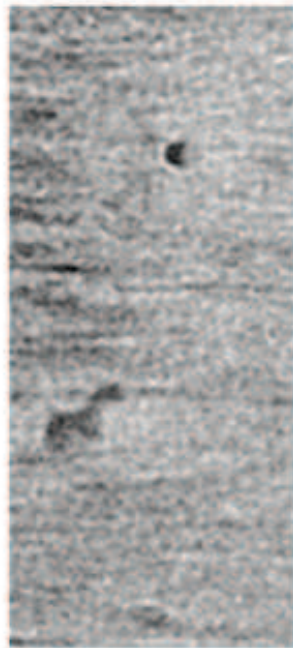


How can we share our research with the public?





How can we share our research with the public?



- capsid
- collar
- tail
- baseplate
- injection pore
- fibers