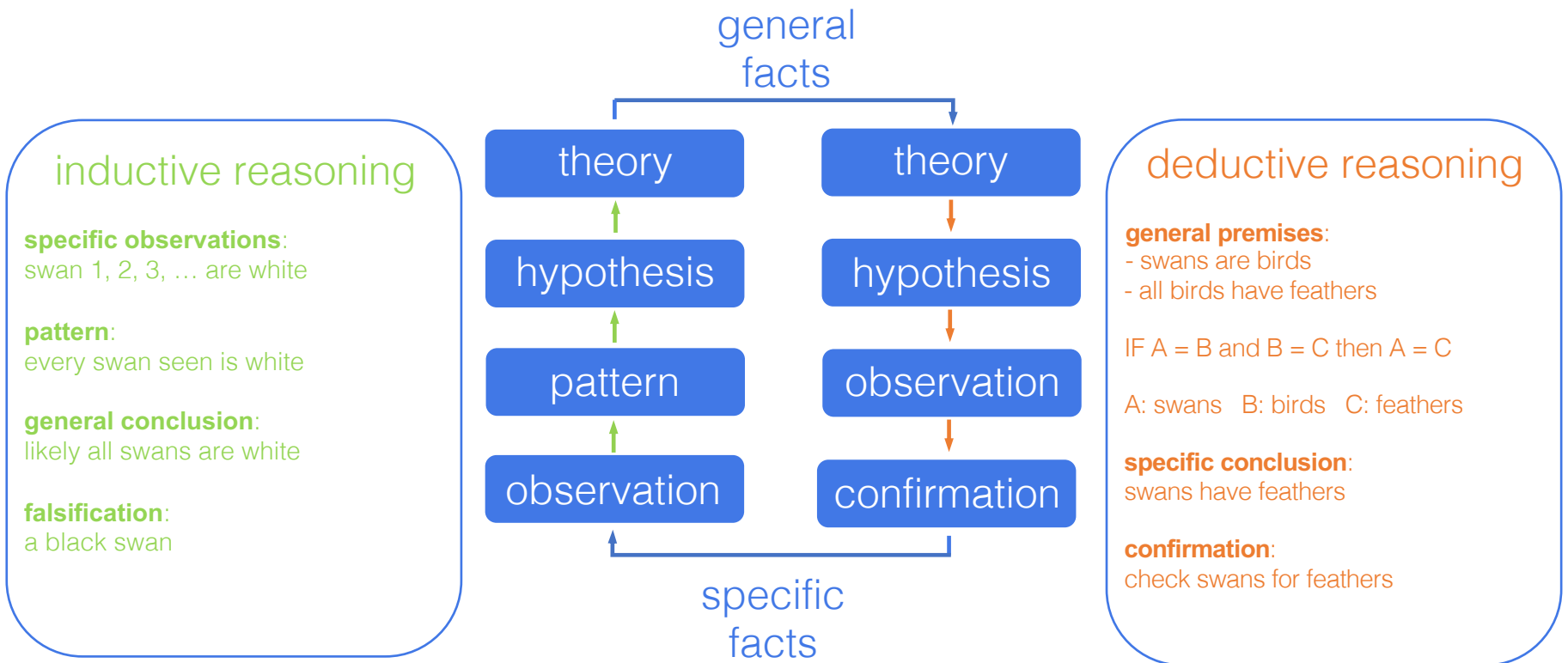


A2.2

Cell Structure

What are the features common to all cells and the features that differ?
How is microscopy used to investigate cell structure?



conclusion

- has uncertainty due to limited observations
- can be 100% falsified

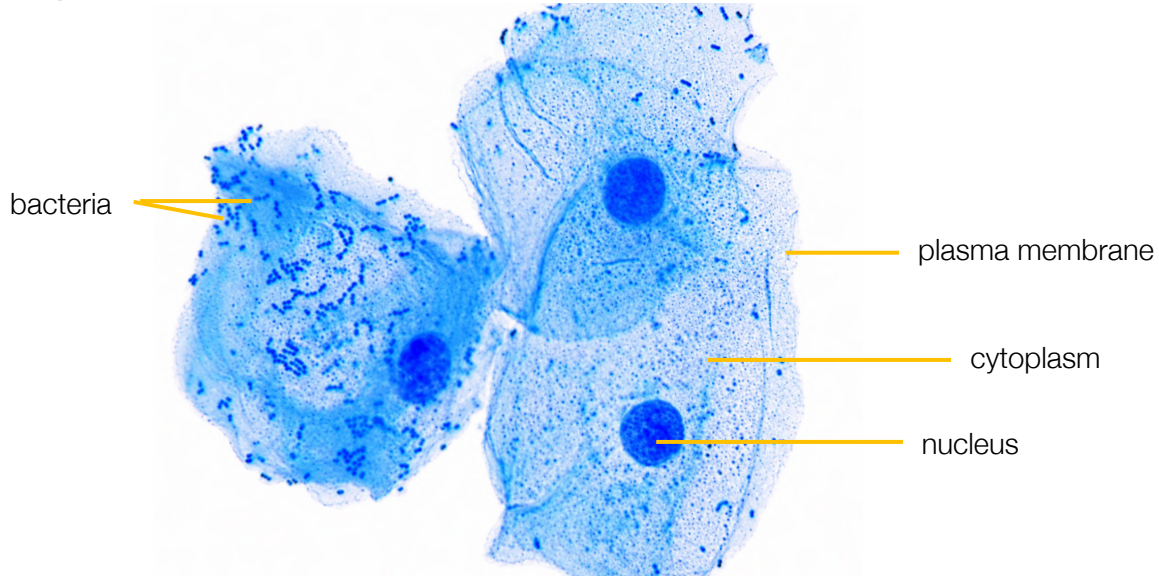
- useful to form theories

conclusion

- is certain if premises are true
- falsifiable if premises are testable

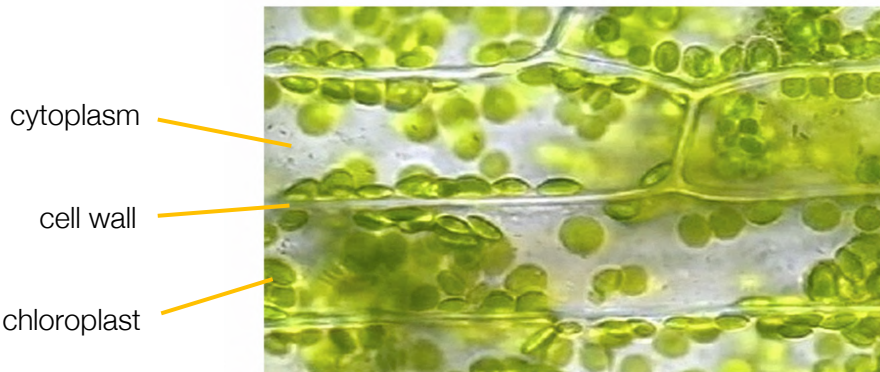
- useful to confirm theories

Animal cell
Light Microscope 400x



cheek epithelial cells

Plant cell
Light Microscope 100x

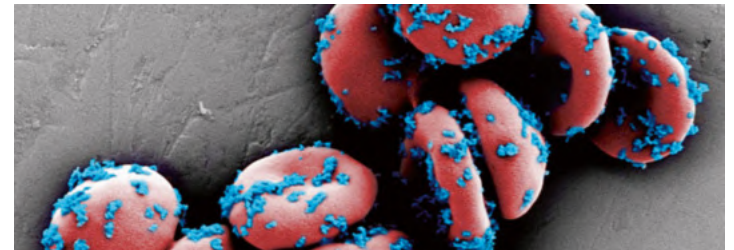


Elodea pond weed leaf cells



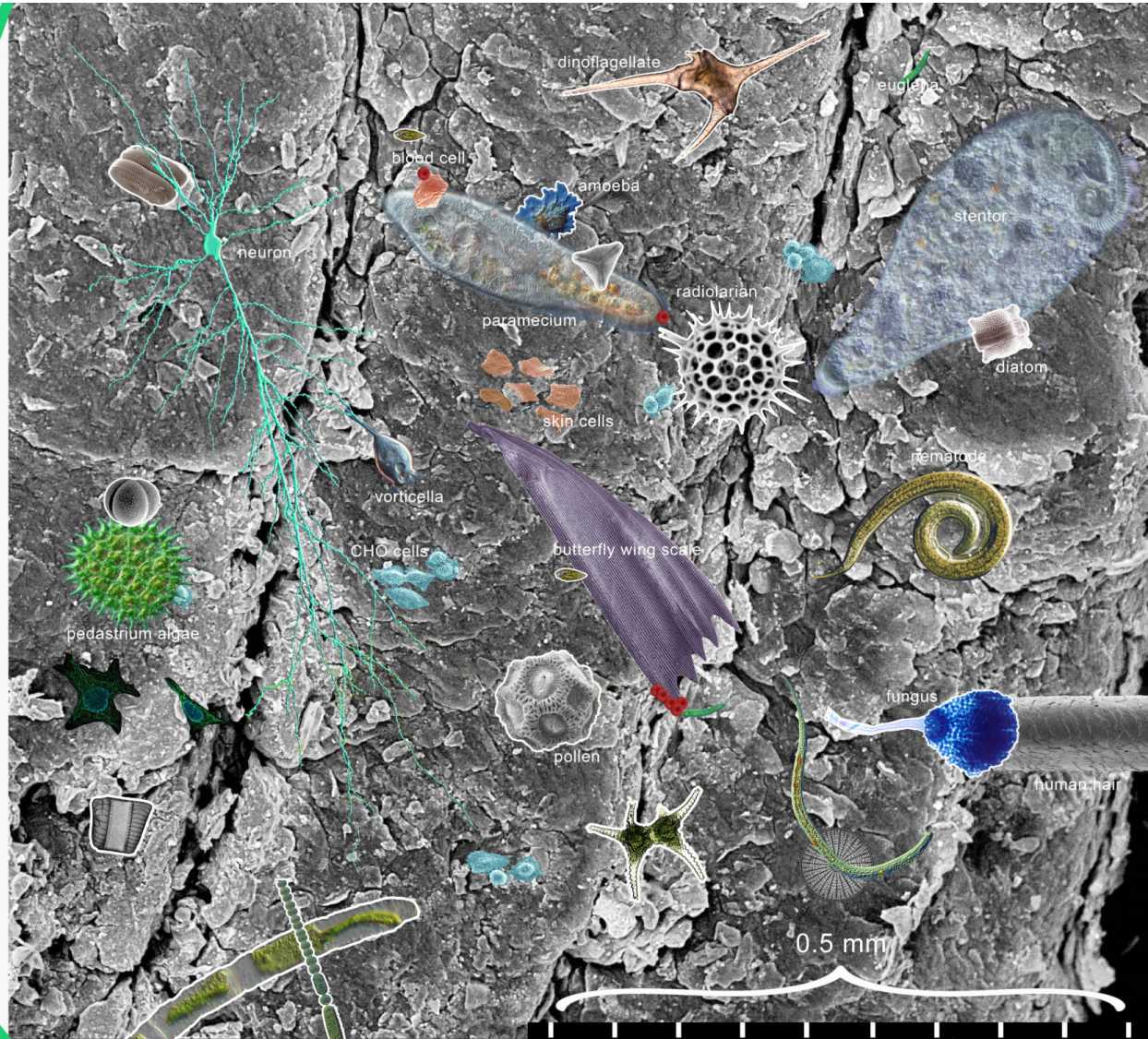
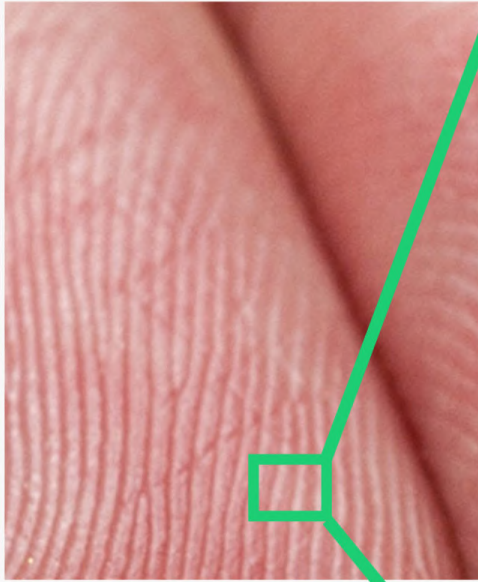
onion cell cytoplasmic streaming

[by germi.ny](#)



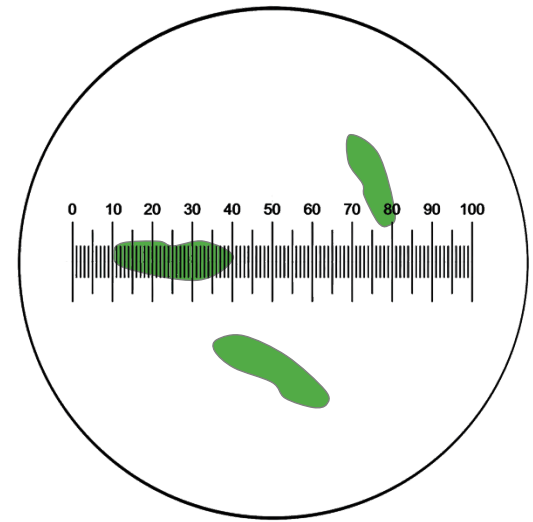
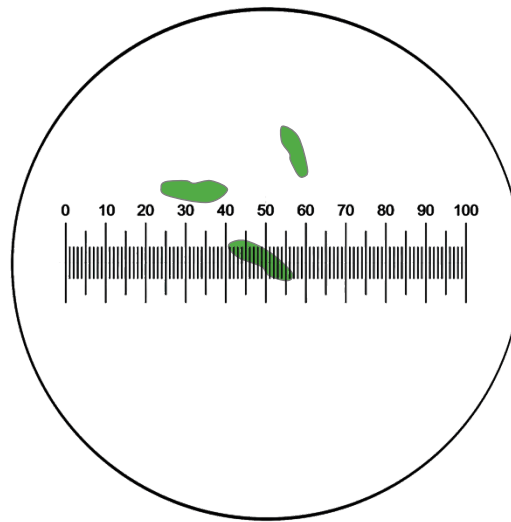
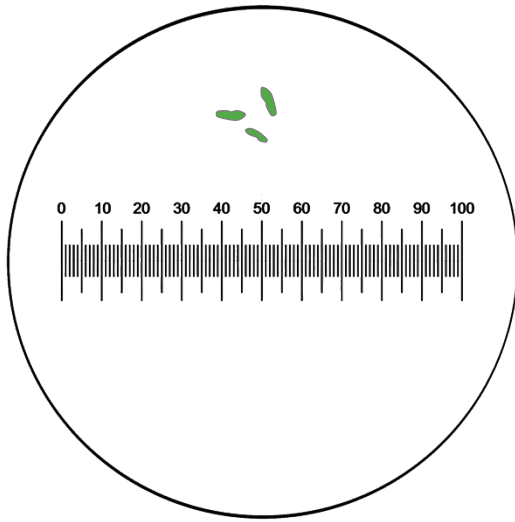
[Winkler](#)

Red blood cells covered in synthetic particles.
Scanning Electron Microscope (SEM) False Colour Image



Used with Permission Jess Holz

Cell Size and Scale [Interactive](#)



Adapted from Gilles Bolduc

eyepiece lens 10x

10x

10x

objective lens 4x

10x

40x

sample
magnification 40x

100x

400x

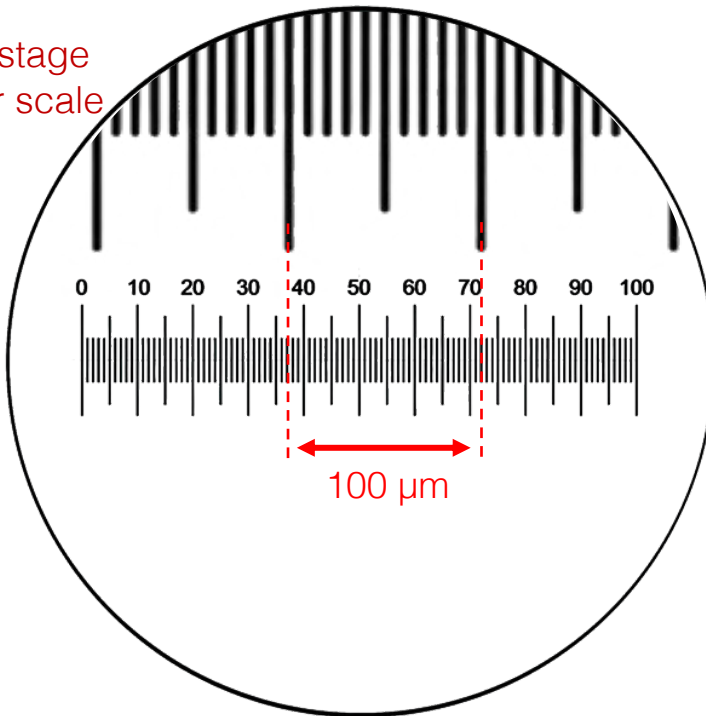
eyepiece scale
magnification 10x

10x

10x

slide with stage
micrometer scale

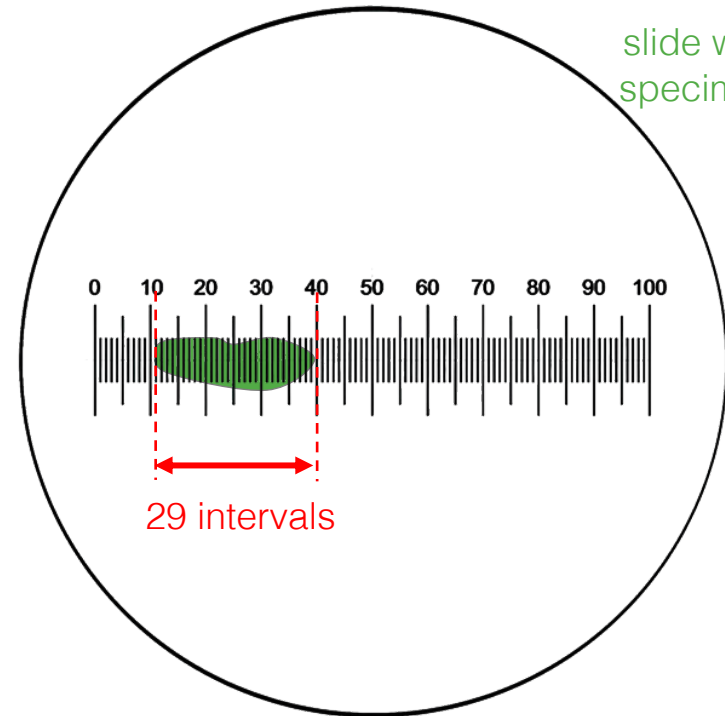
eyepiece
graticule
scale



One interval on the eyepiece scale
at 400x magnification is found by:
 $= 100 \mu\text{m} \div (72-37)$
 $= 100 \mu\text{m} \div 35 \text{ intervals}$
 $= 2.9 \mu\text{m}$

slide with
specimen

eyepiece
graticule
scale



Length of cell
at 400x magnification is found by:
 $= 40 - 11 = 29 \text{ intervals}$
 $= 29 \times 2.9 \mu\text{m}$
 $= 84.1 \mu\text{m}$

Adapted from Giles Bolduc



[Daniel Boone Native Gardens Flickr](#)



[LWDC](#)



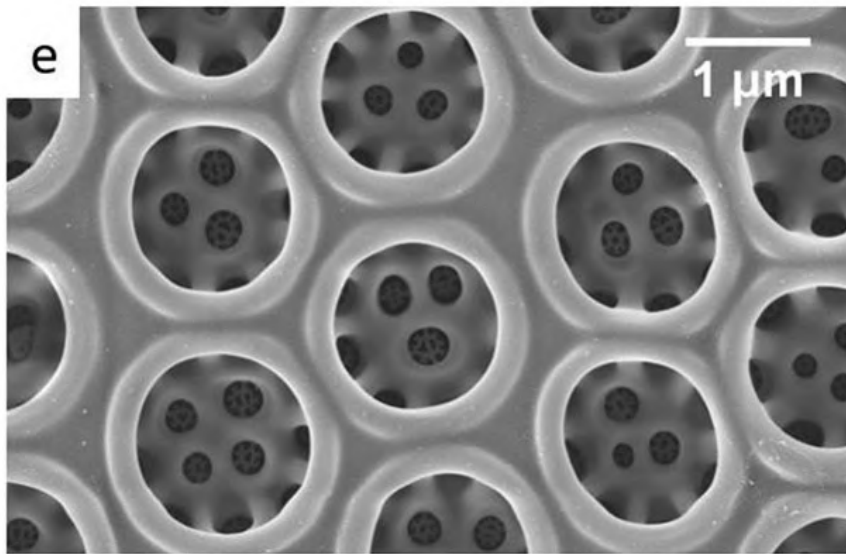
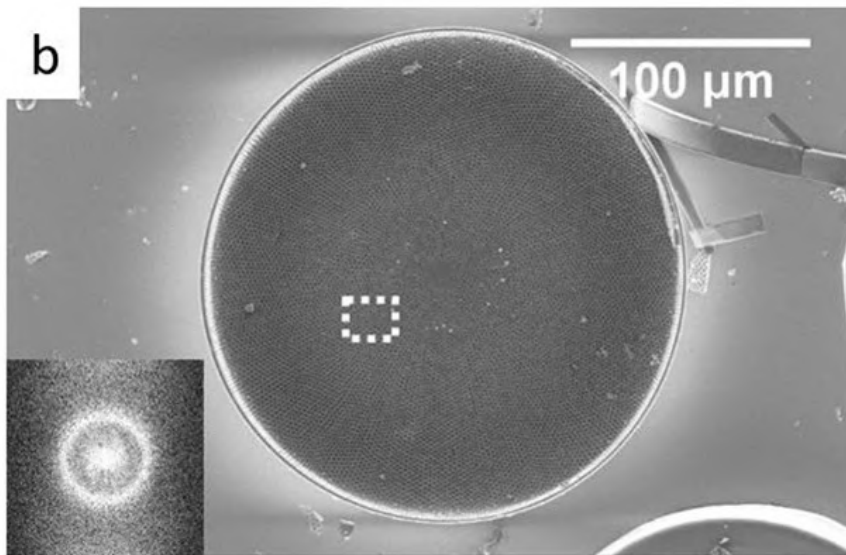
[Donald Ott](#)

Tradescantia stamen filament [cells](#) showing cytoplasmic streaming by Donald Ott



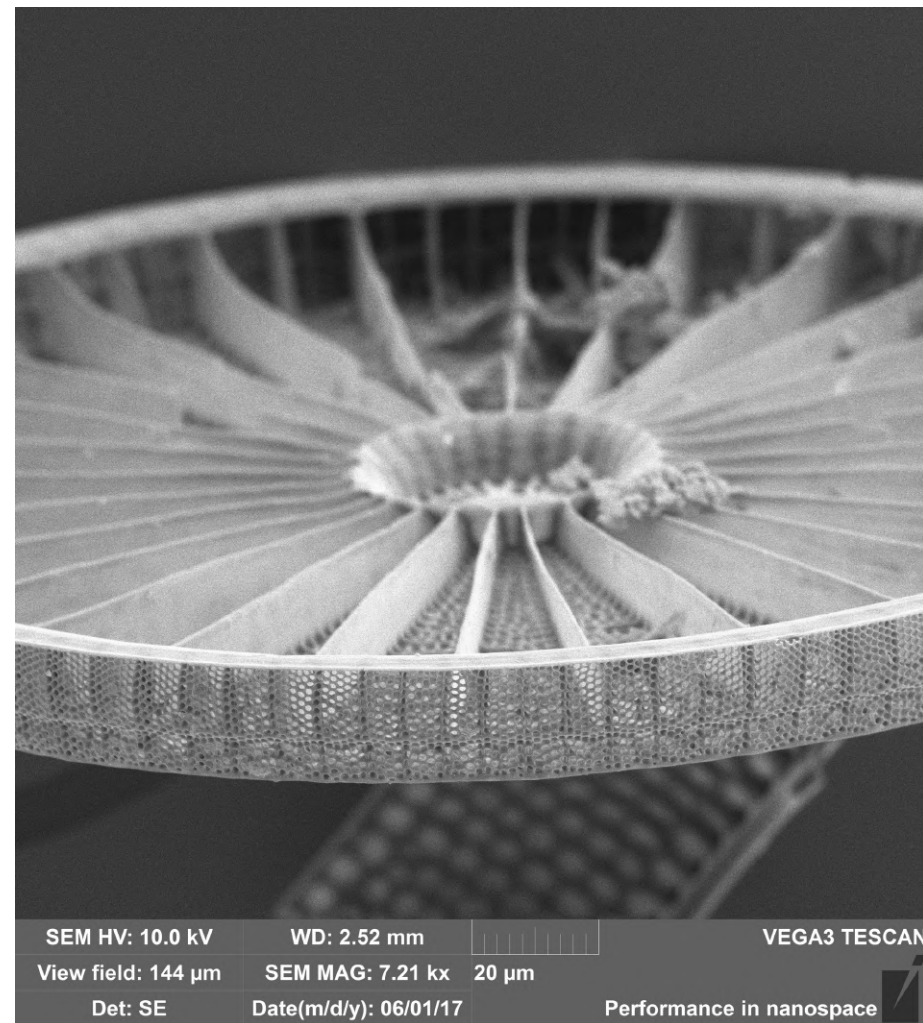
John Ray 1627 – 1705
Father of Natural History

The Observations which have been made in these latter times by the help of the Microscope, since we had the use and improvement of it, discover a vast difference between Natural and Artificial Things. Whatever is natural beheld through that appears exquisitely formed, and adorned with all imaginable Elegancy and Beauty. There are such inimitable gildings in the smallest Seeds of Plants, but especially in the parts of Animals, in the Head or Eye of a small Fly; such Accuracy, Order, and Symmetry in the frame of the most minute Creatures, a Louse, for Example, or a Mite, as no Man were able to conceive without seeing of them. Whereas the most curious Works of Art, the sharpest and finest Needle doth appear as a blunt rough Bar of Iron, coming from the Furnace or the Forge: the most accurate engravings or embossments seem such rude, bungling and deformed Work, as if they had been done with a Mattock or a Trowel, so vast a difference is there betwixt the Skill of Nature, and the Rudeness and Imperfection of Art. I might add, that the Works of Nature the better Lights and Glasses you use, the more cleaver and exactly formed they appear; whereas the effects of human Art the more curiously they are viewed and examined, the more of Deformity they discover.



[Anujir et al 2018 Nature](#)

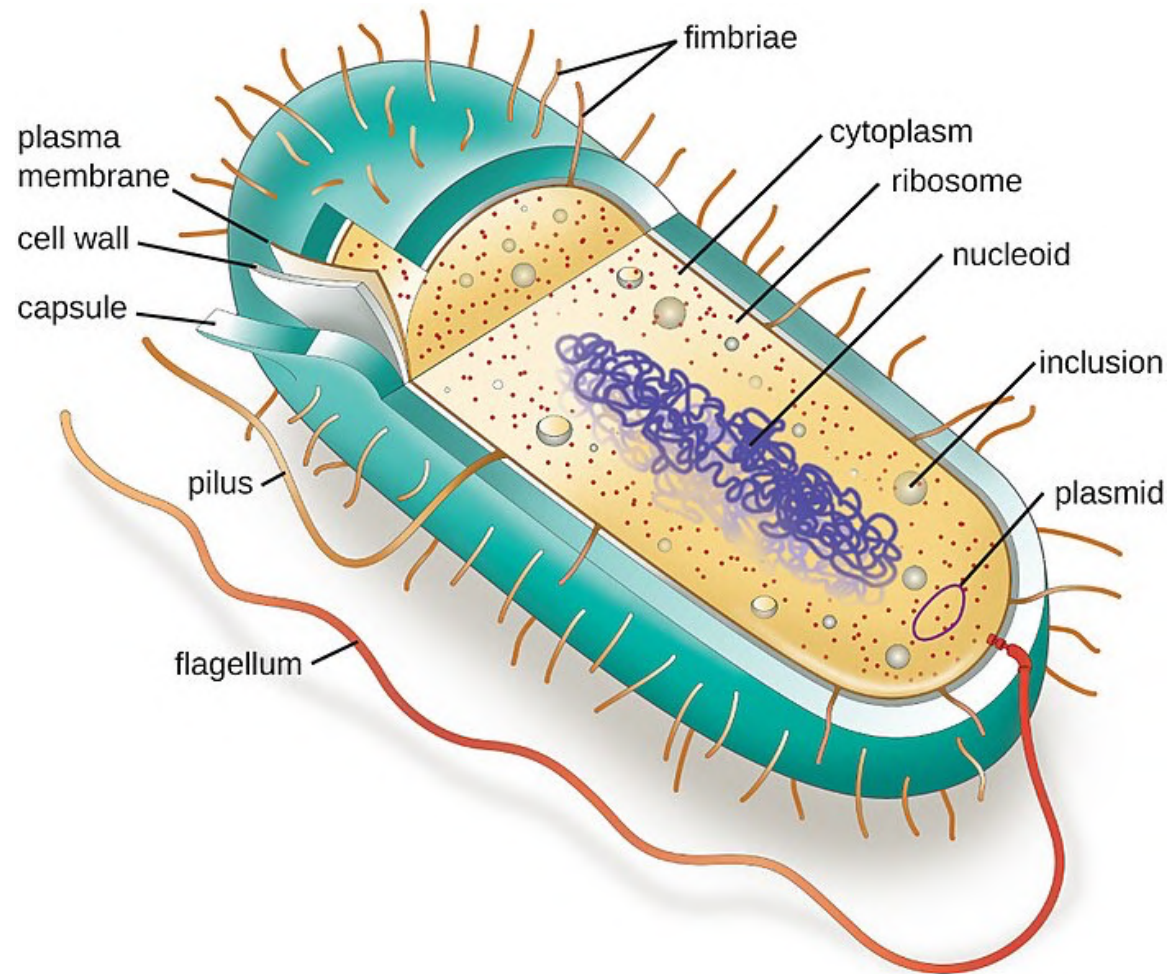
Closeup of a unicellular diatom frustule.



[Wikimedia Commons](#)

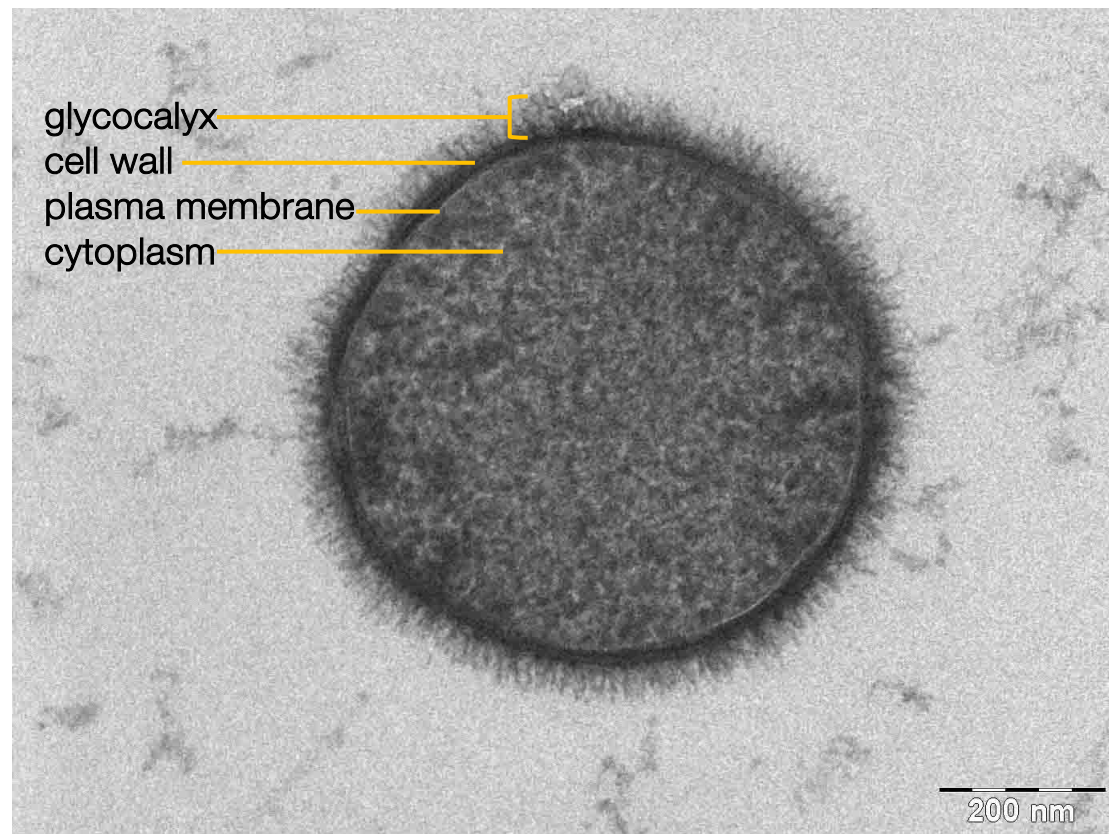
Closeup of a unicellular diatom frustule.

prokaryote structure



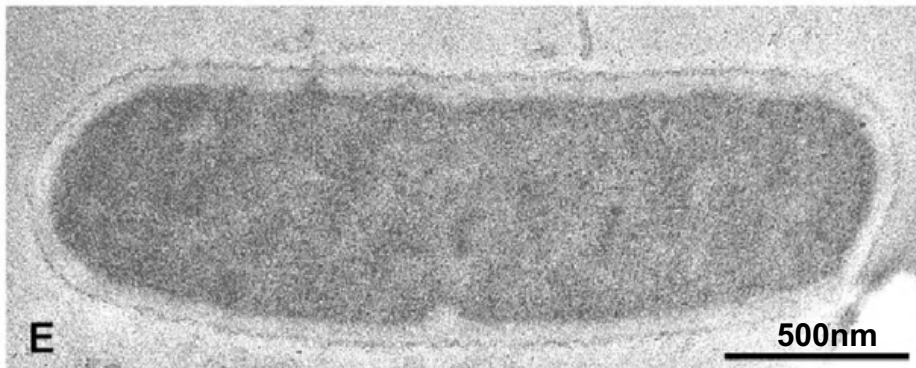
[Access for Free at Openstax](#)

prokaryote structure



Public Domain: Alton Weiner, The Weizmann Institute of Science

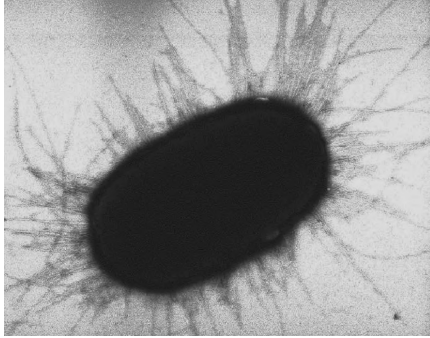
Bacillus subtilis TEM cross section – some bacteria have a glycocalyx.



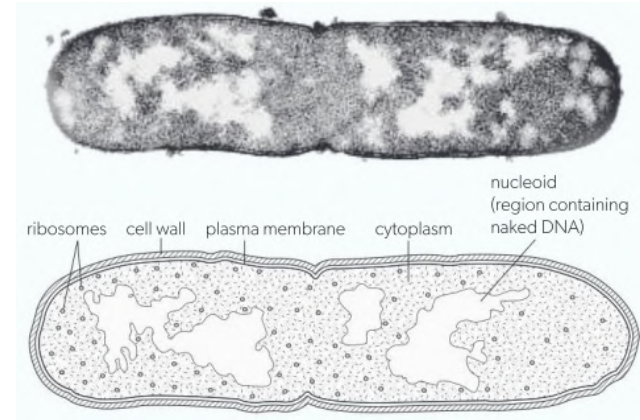
Bacillus subtilis TEM longitudinal section

Holzinger et al 2011

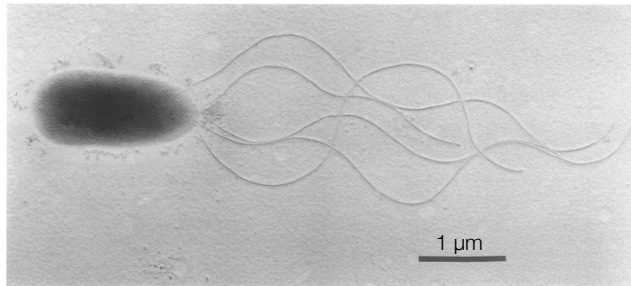
prokaryote structure



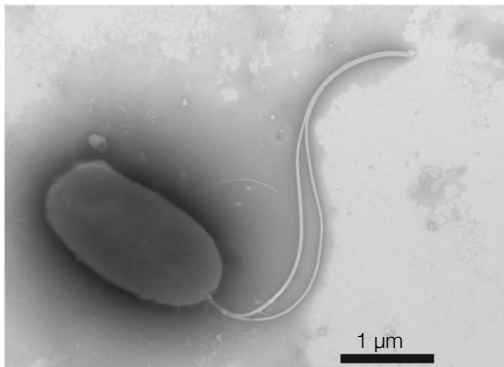
Forero 2006



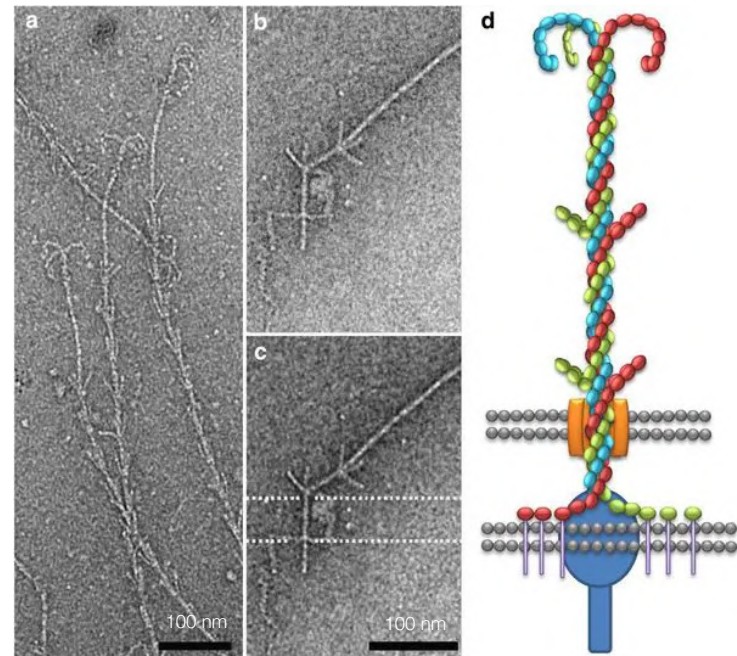
source



Harwood and Fosnaugh et al 1989



Brennan et al 2014 et al



source

Hamus – grappling hook found in Archea for attachment.

prokaryote rotary flagella

Early Research in Japan

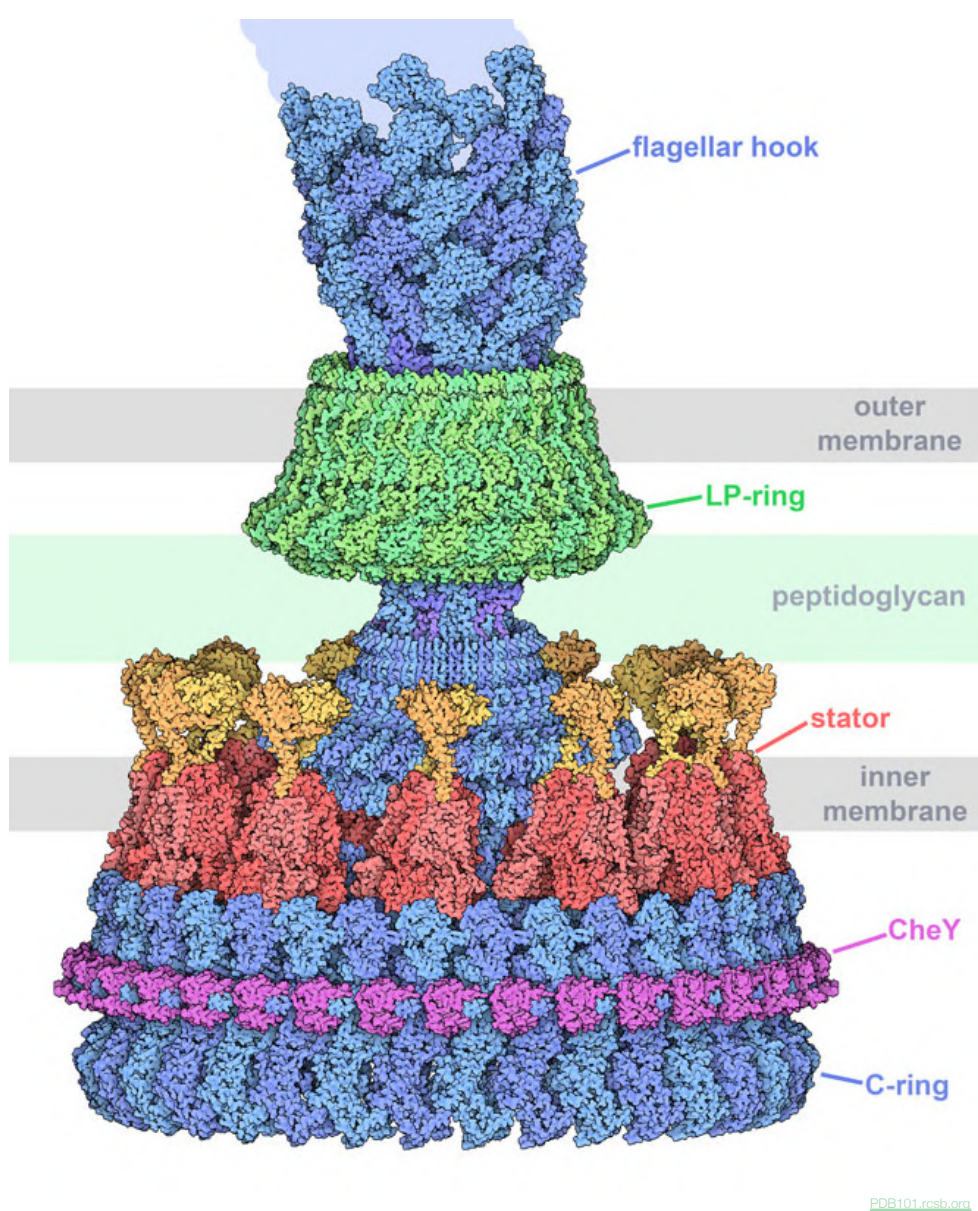
We show that magnetotactic cocci with two flagella bundles on one pole swim faster than $500 \mu\text{m}\cdot\text{s}^{-1}$ along a double helical path, making them one of the fastest natural microswimmers.

Bente et al 2020

"Flagellar motors are molecular nanomachines with a diameter of roughly 45 nm and an energy conversion efficiency of approximately 100%.

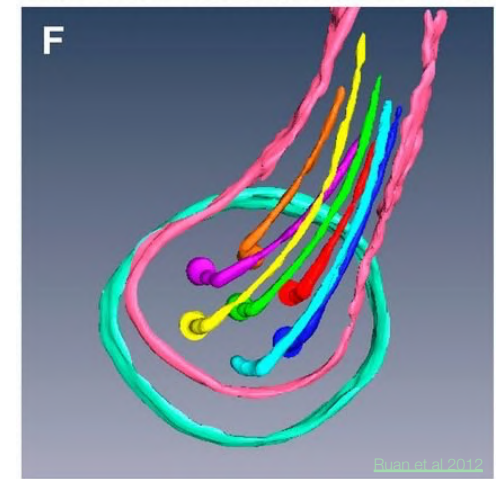
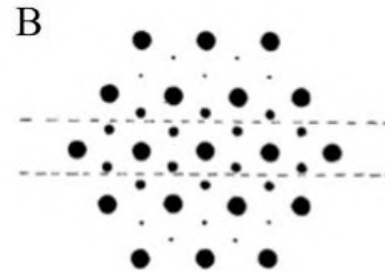
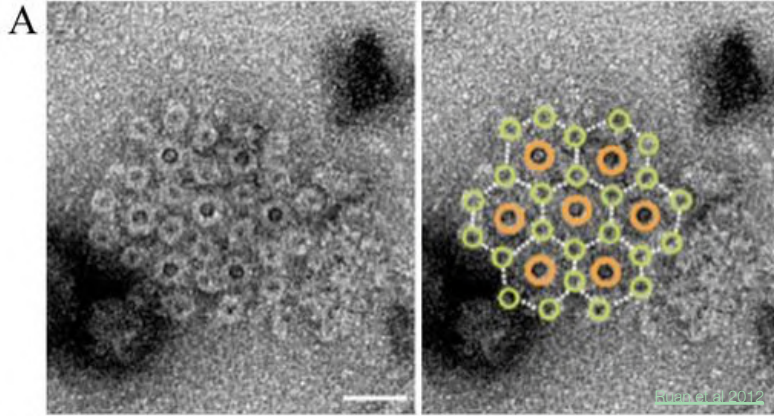
Our findings are a big step to clarify their torque-generation mechanisms, which would be essential for the engineering of nanoscale molecular motors,"

Tatsuro Nishikino



The bacterial flagellum motor is an example of irreducible complexity.

prokaryote flagella



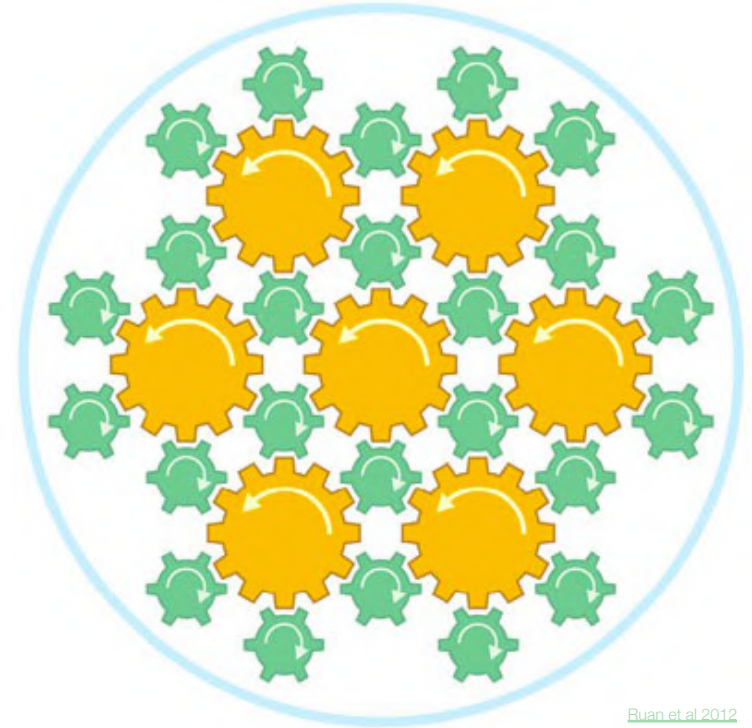
cyroEM image of 7 flagella



[Wikimedia:Michelle Kropp](#)

The MO-1 cells swim as fast as 300 $\mu\text{m/s}$, which is more than 100 body-lengths per second.

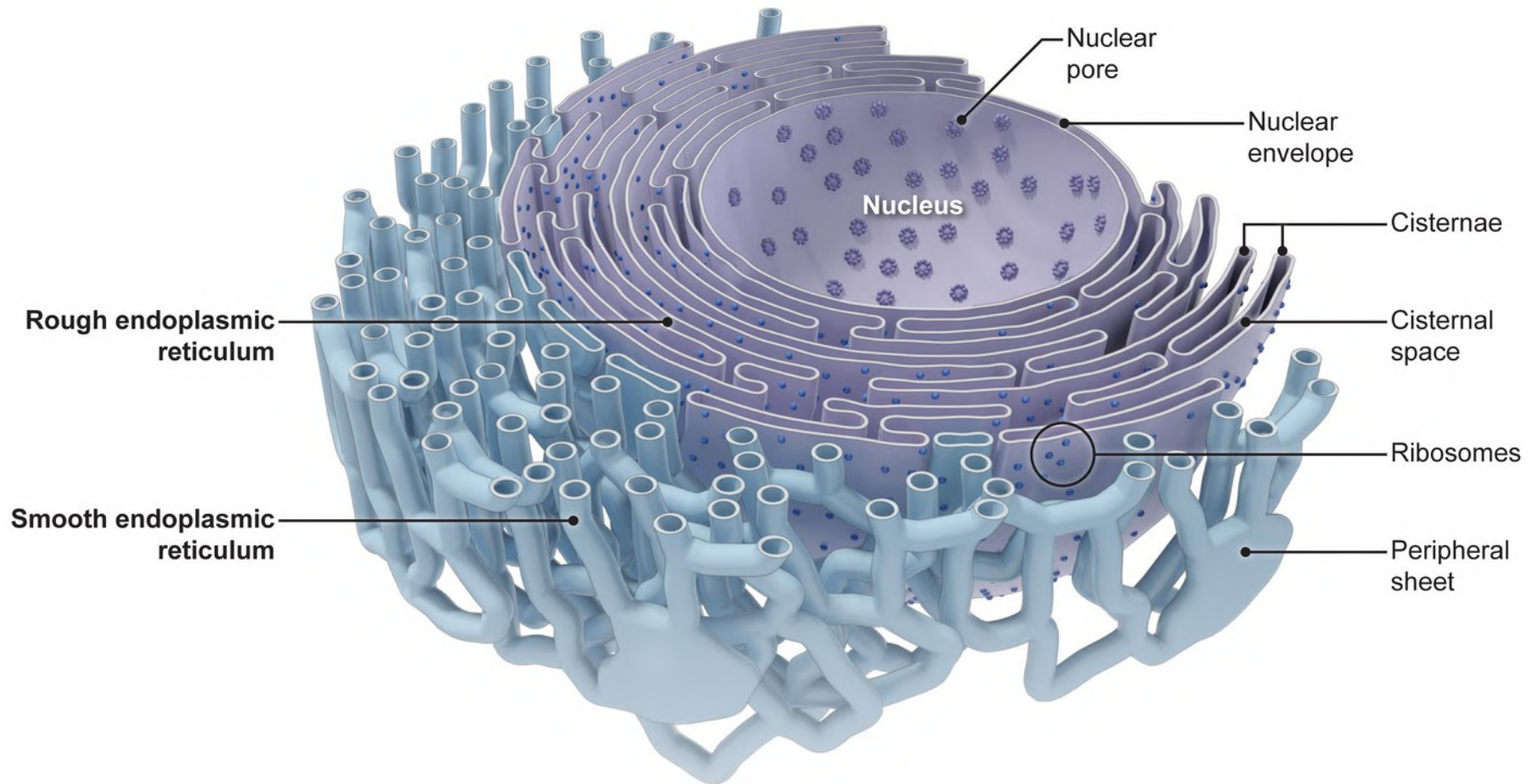
The synchronized rotation of seven flagella in a tight bundle must allow a rapid rotation of a propeller of larger diameter that can increase swimming speed.



[Ruan et al 2012](#)

A possible mechanism for a 7-tailed flagella [array](#).

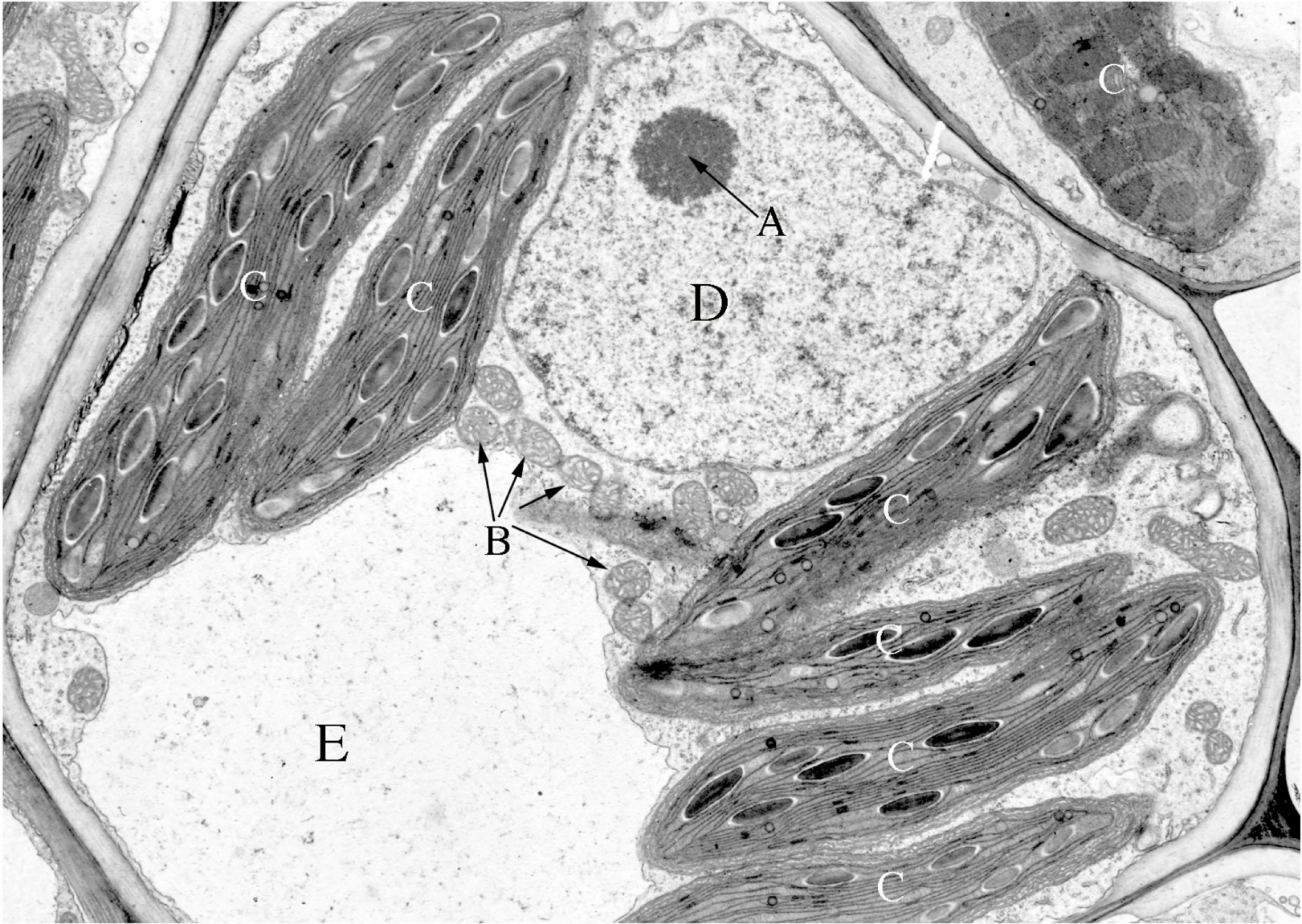
nucleus and endoplasmic reticulum



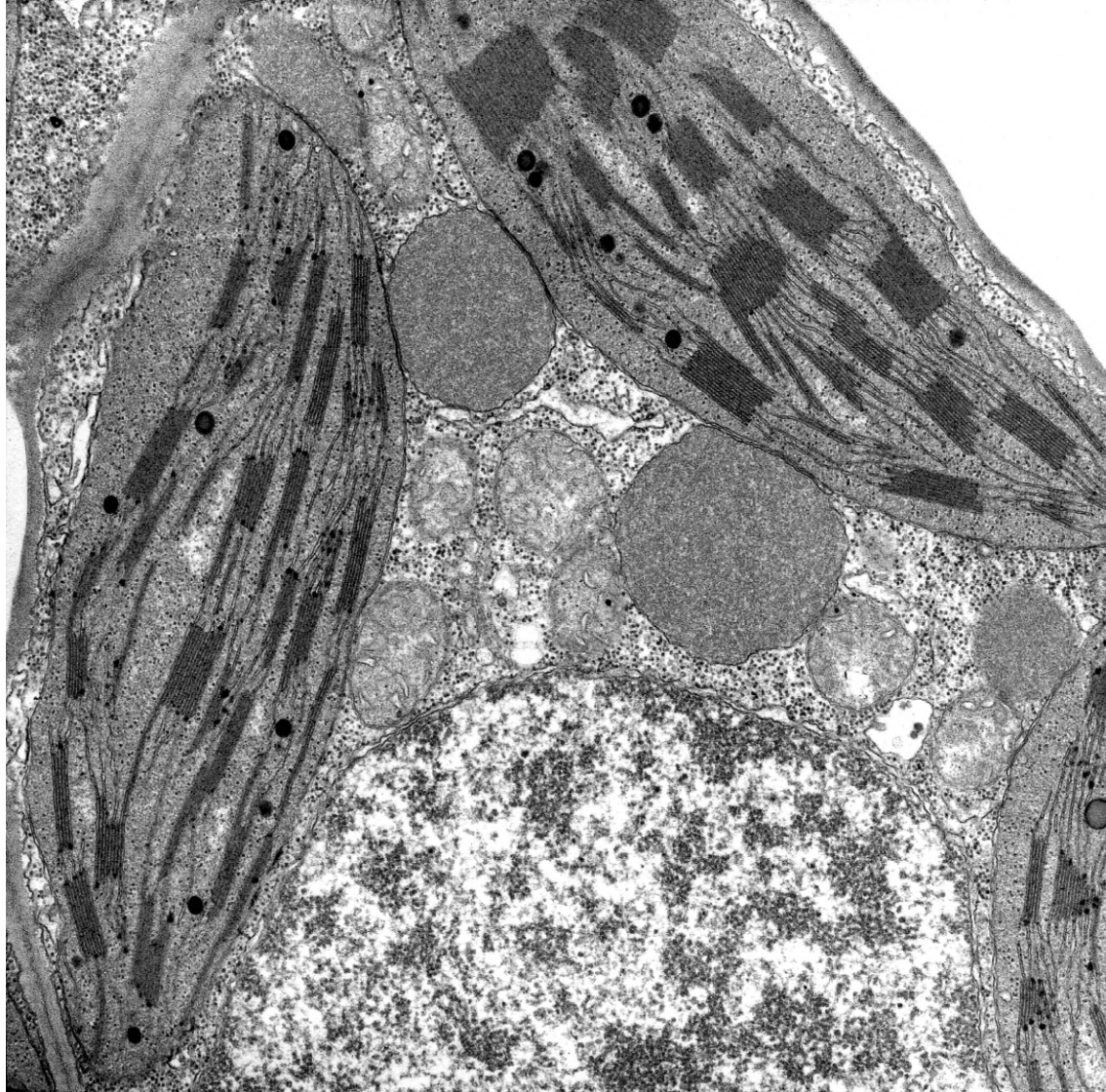
Coyle and Blackstone (public domain)

The endoplasmic reticulum is the largest single structure in eukaryote cells.

mitochondria, chloroplasts and vacuole

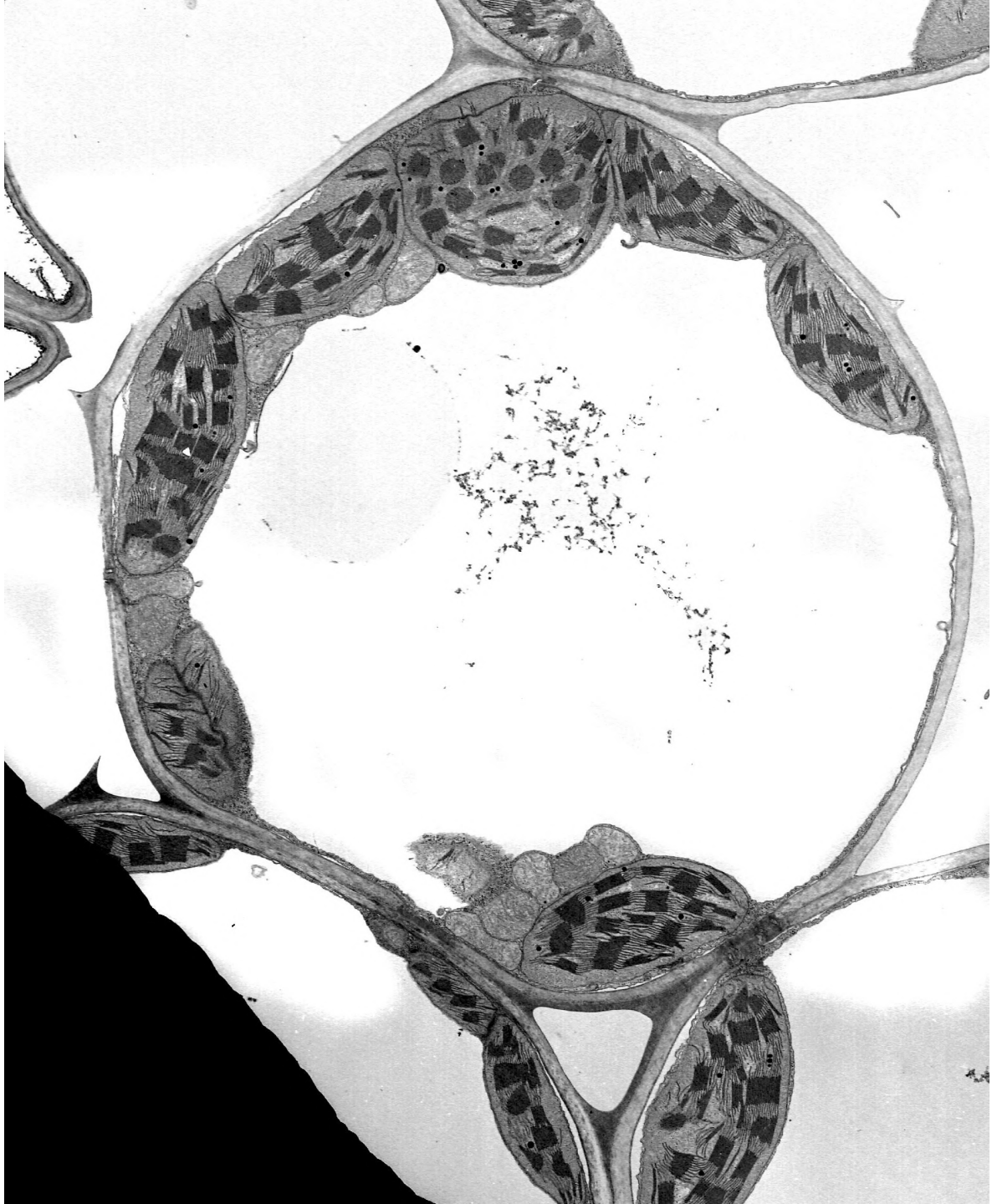


lysosomes

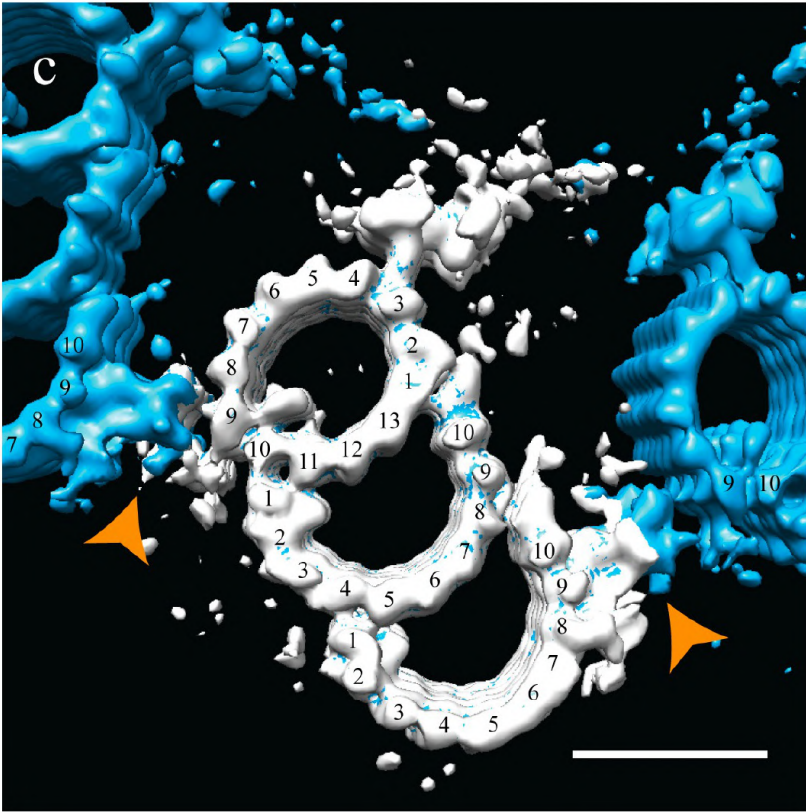
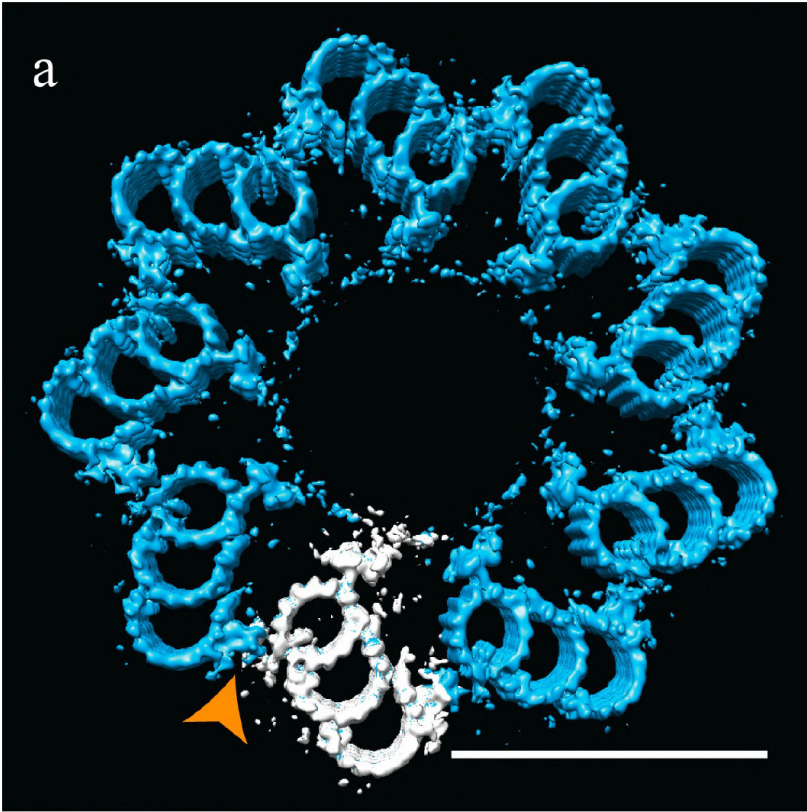


Newcomb.UWDG

cell wall

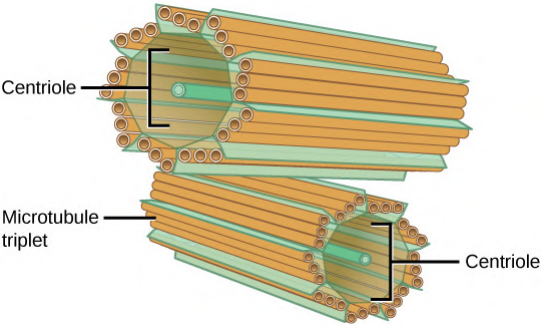


centrioles



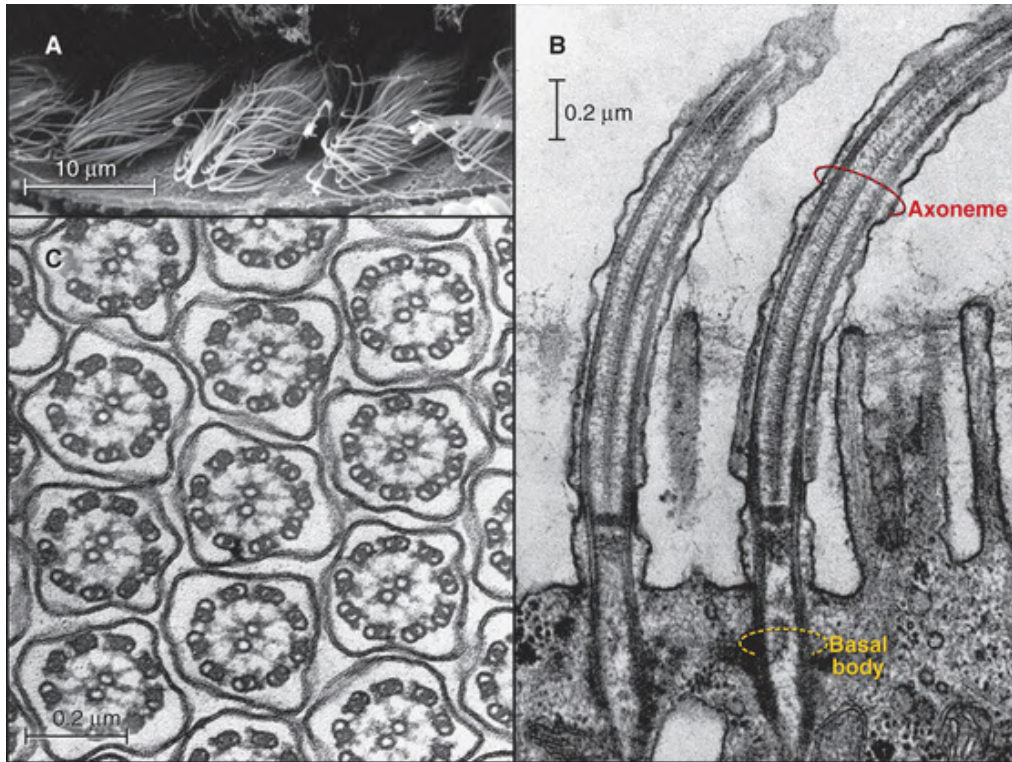
Scale bar is 100nm in (a) and 25nm in (c)

[Greenan et al 2018](#)



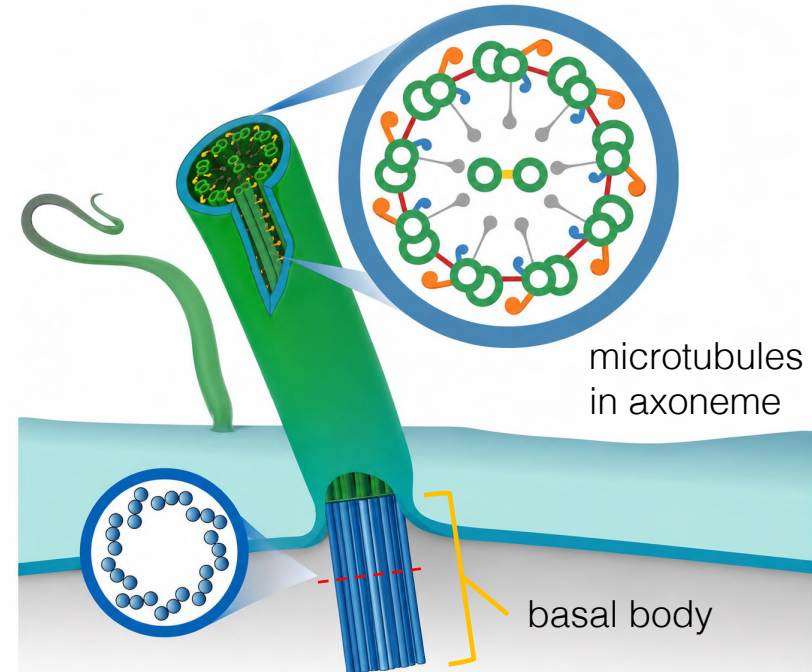
[OpenStax/CUNY](#)

eukaryote flagella and cilia



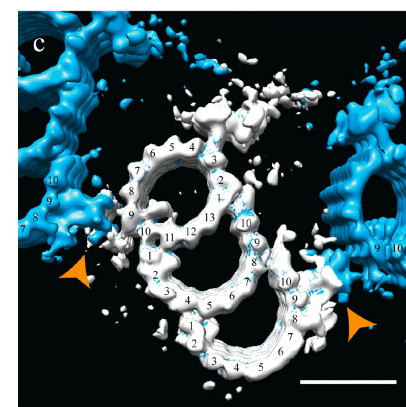
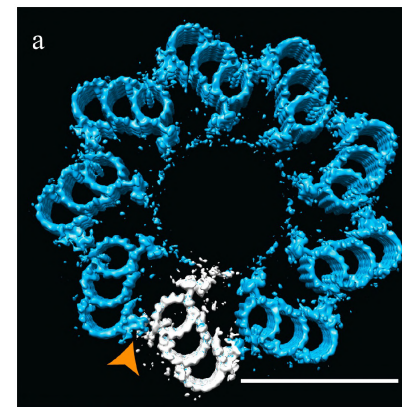
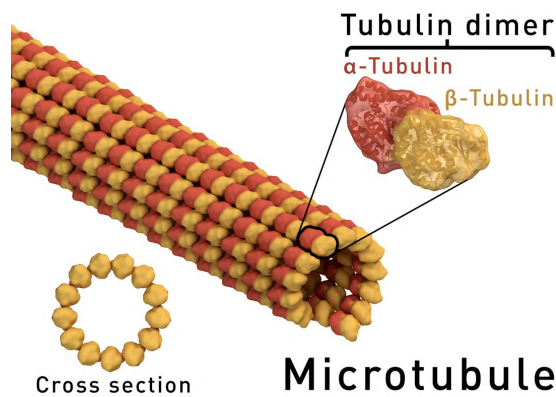
A – cilia on mussel gills
B – cilia longitudinal section
C – cilia cross section of axoneme

Satir 1974



Public domain

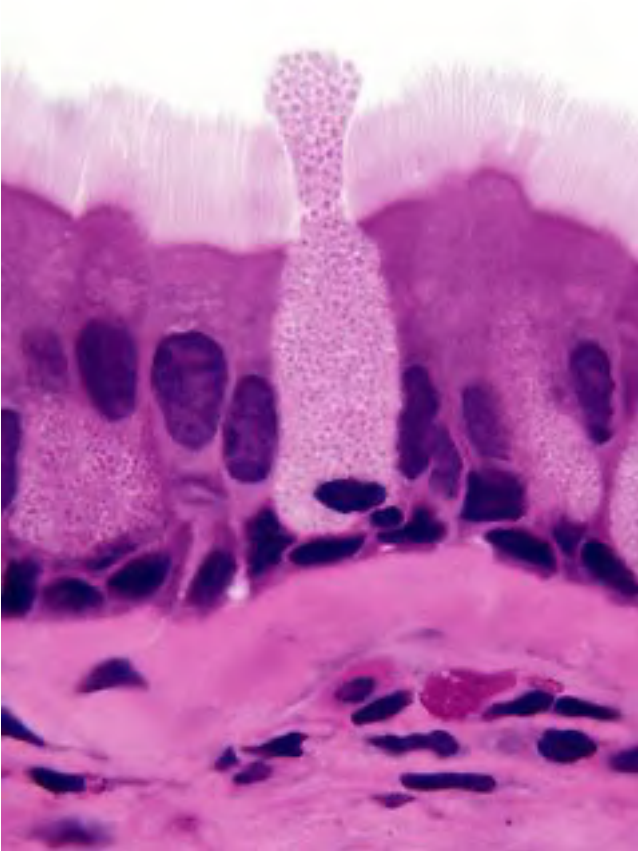
[animation](#)



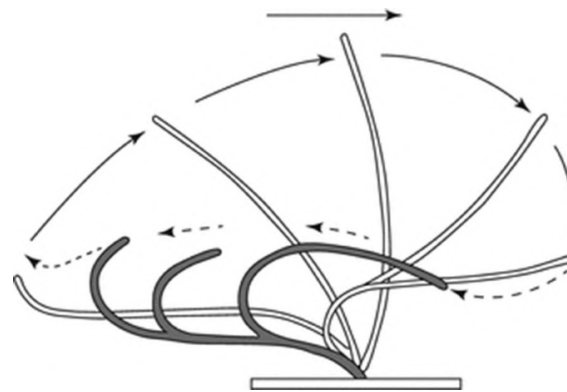
Scale bar is 100 nm in (a) and (b)

Greenan et al 2018

motile cilia



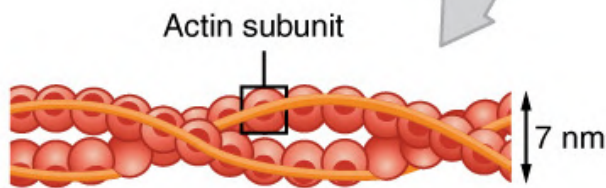
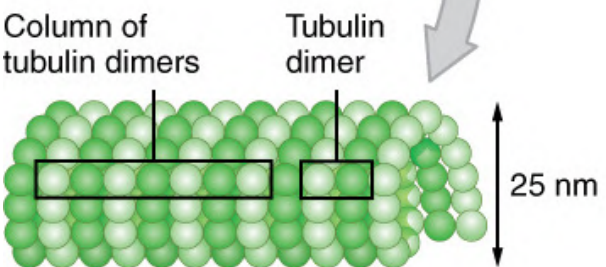
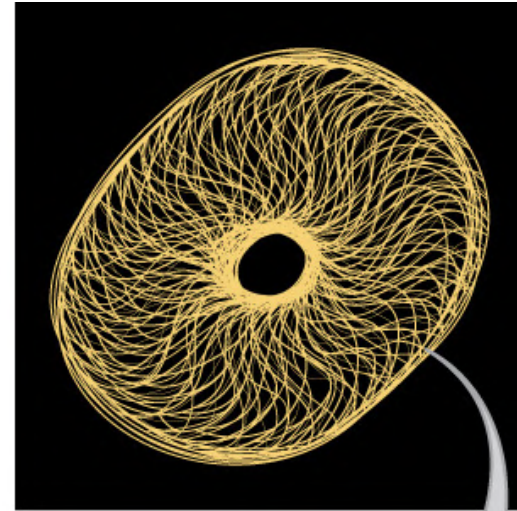
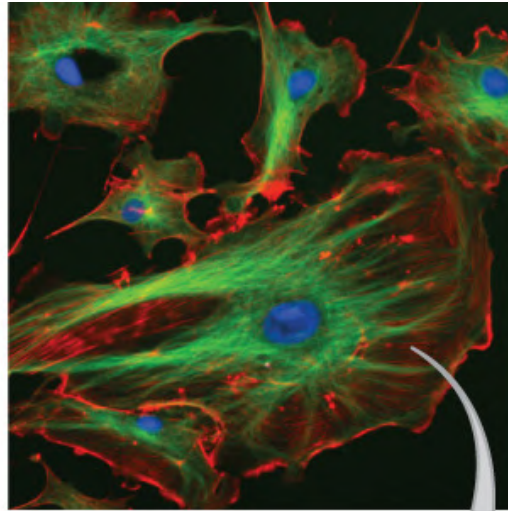
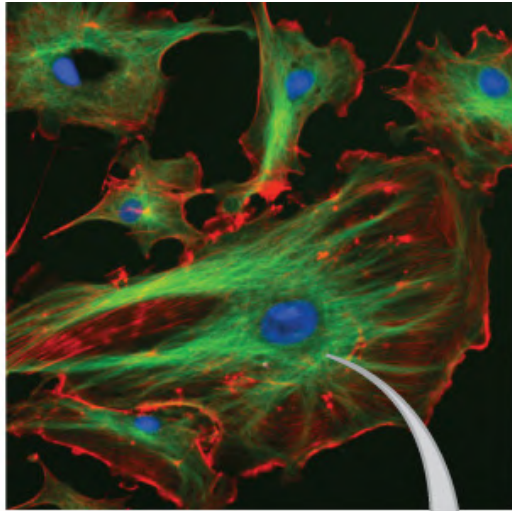
Cilia lining the lungs - a goblet cell is secreting mucus to trap particles.



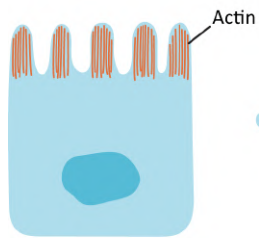
[Jorissen and Jaspers 2023](#)

Cilia do not move back and forth like wind shield wipers but as shown above in the diagram. Cilia beat together in a coordinated Mexican wave to sweep particles in one direction.

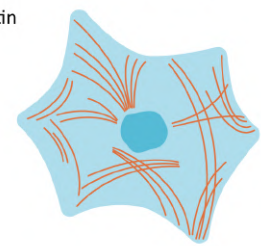
cytoskeleton



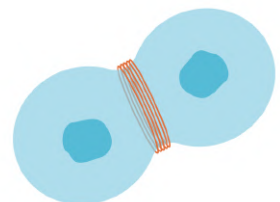
Microvilli



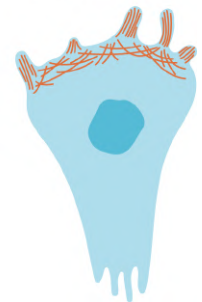
Cytoplasmic contractile fibers



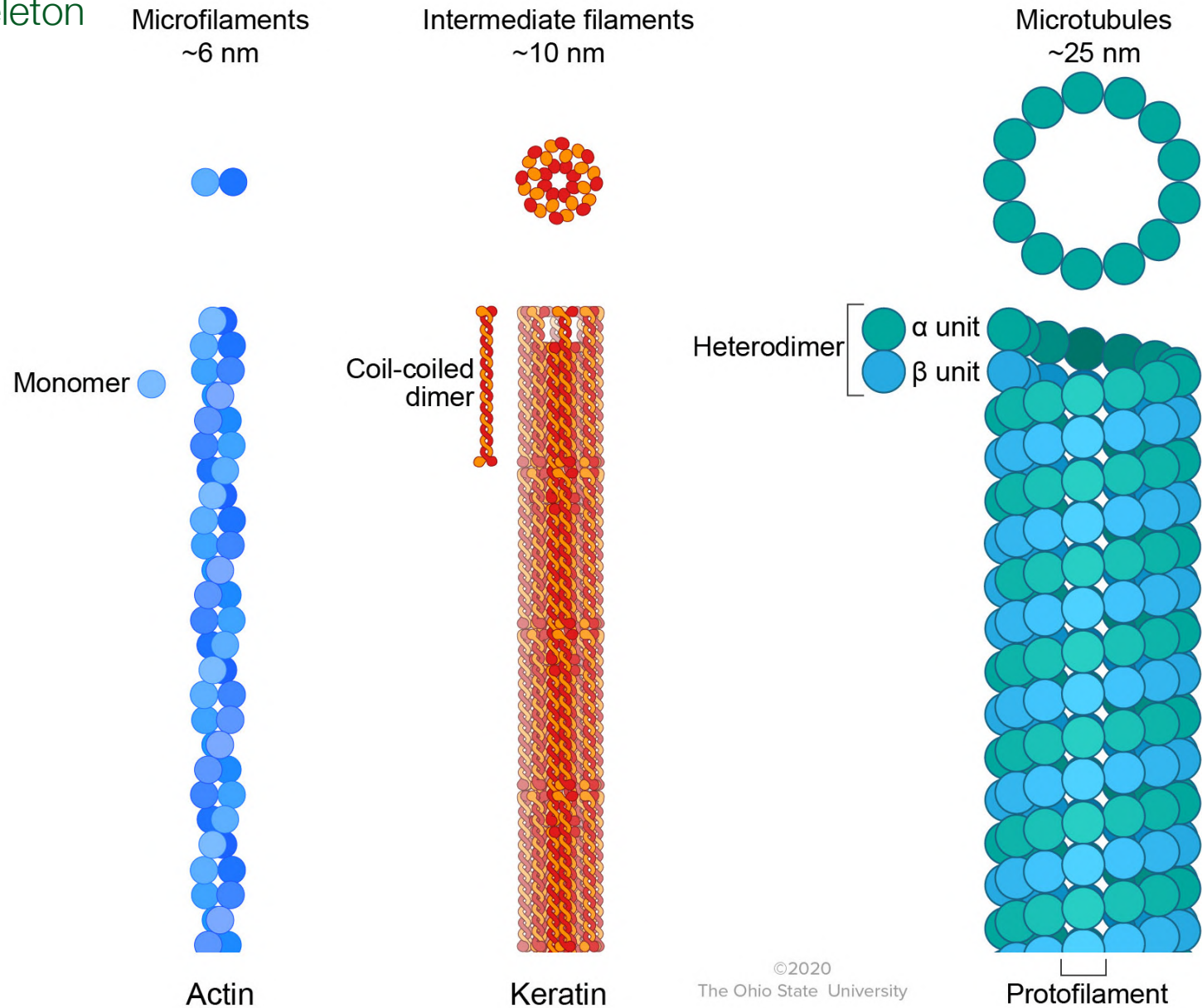
Cell division contractile ring



Lamellapodia

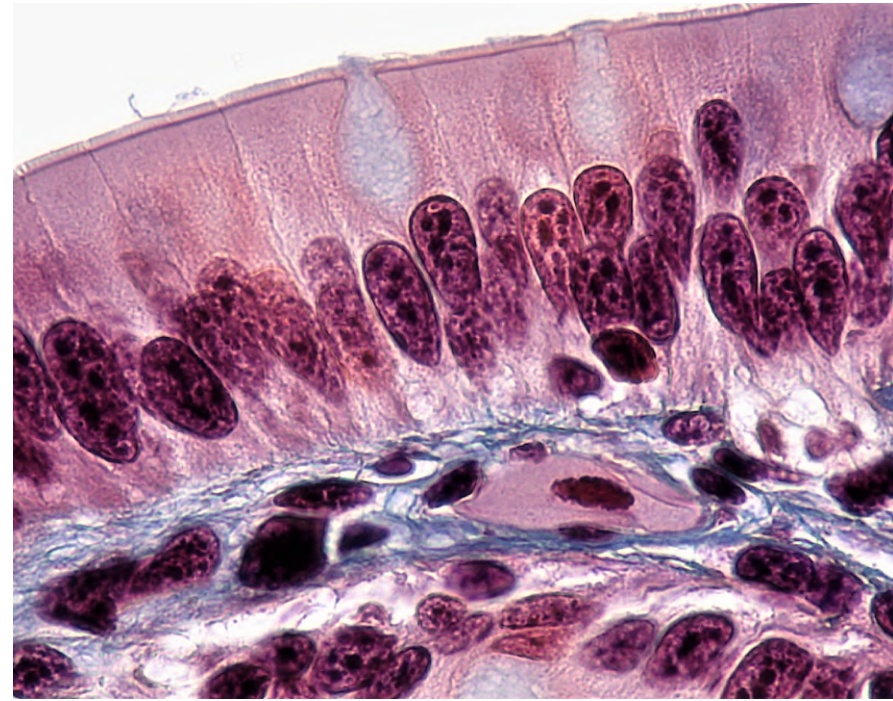
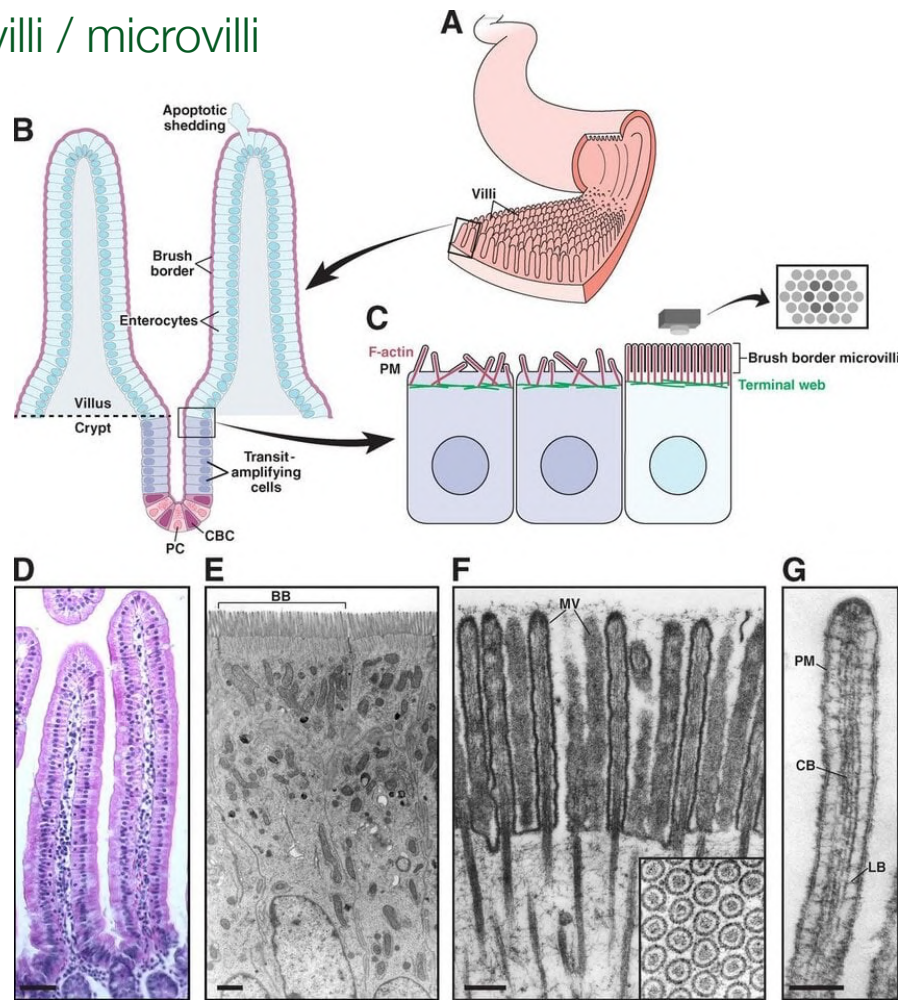


cytoskeleton



©2020
The Ohio State University

villi / microvilli

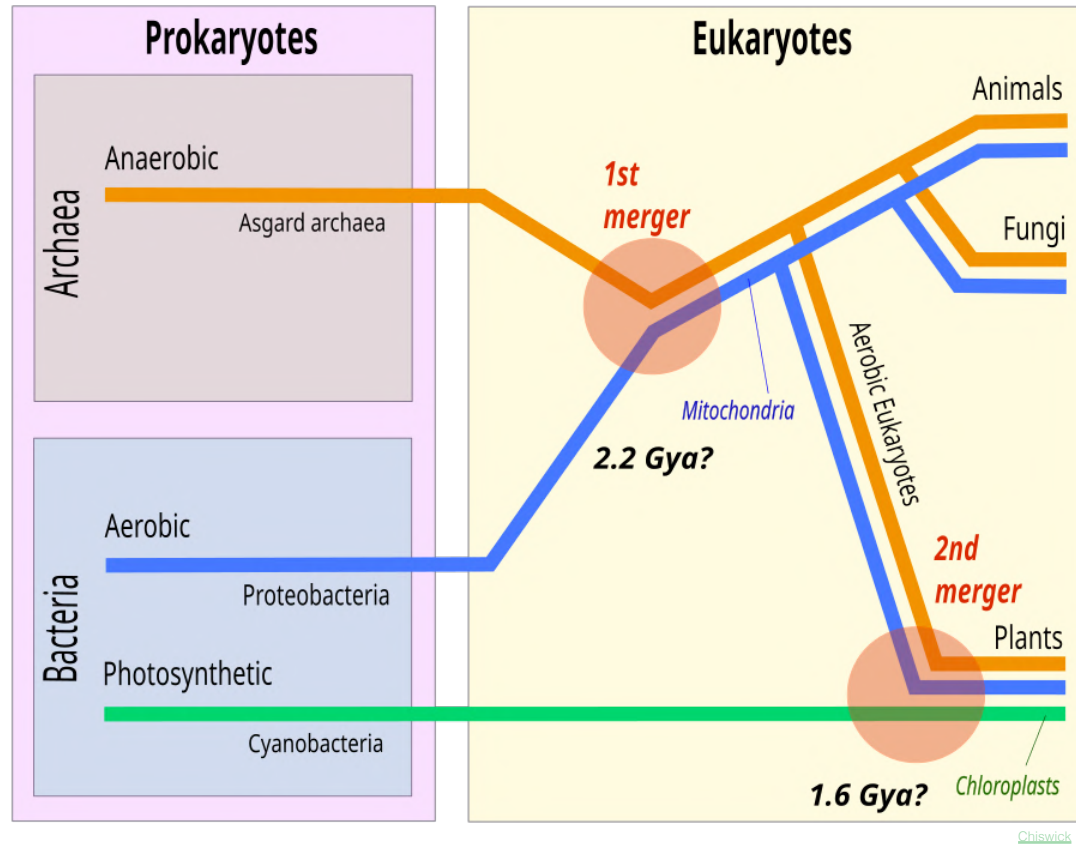


stained epithelial cells of the gut with a brush border on their surface
light microscope

- A** - small intestine **B** - two villi **C** - epithelial cells
- D** - two stained villi cross section light microscope
- E** - epithelial cells with microvilli brush border of one cell labelled TEM
- F** - microvilli close up and cross section TEM
- G** - one microvillus TEM

Scale Bars: **D** 50µm **E** 1µm **F** 0.2µm **G** 0.1µm

[Crawley et al 2014](#)

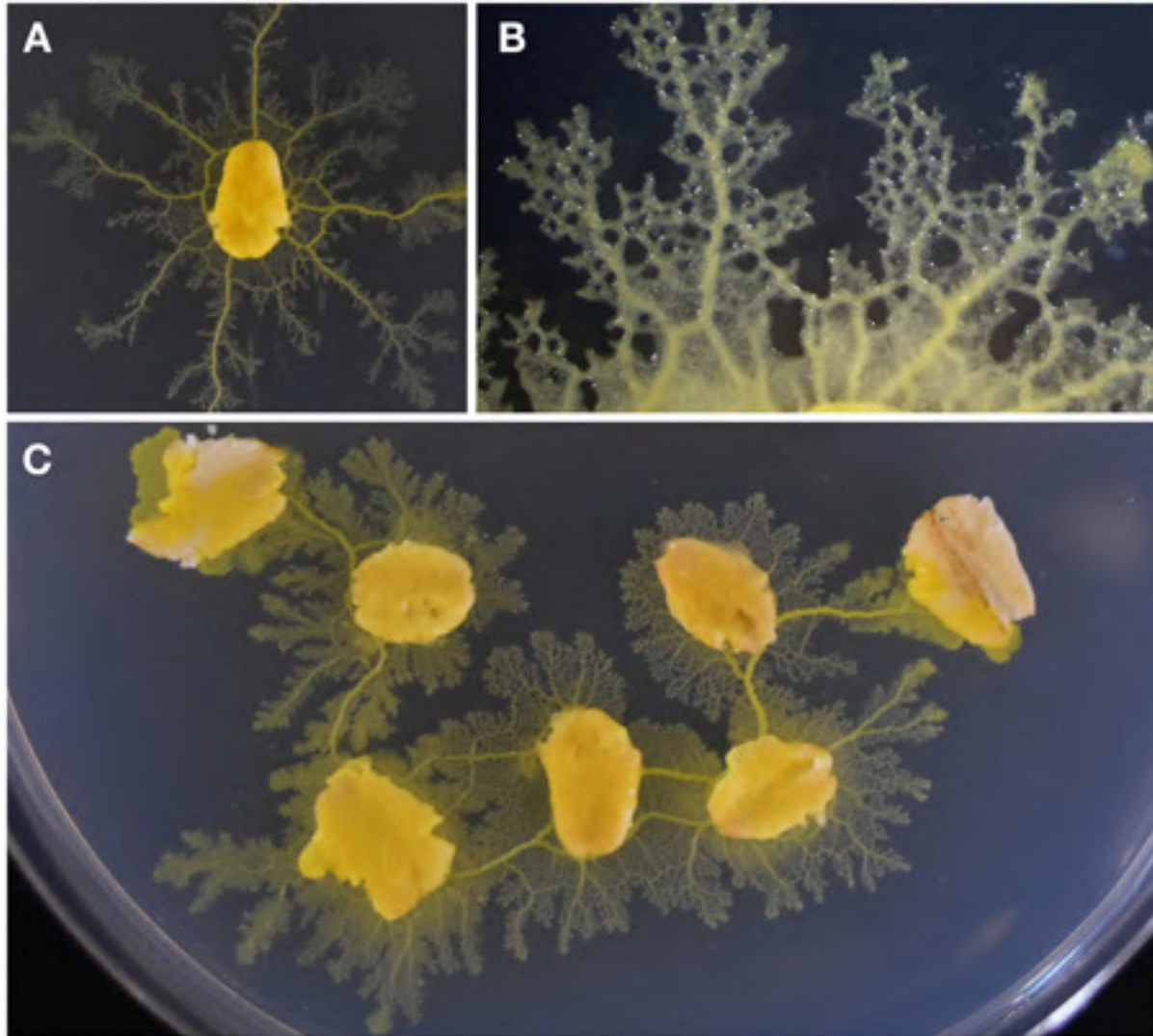




© Kittisak Songprakob; istock

Costasiella kuroshimae the Sea Leaf Sheep

It is not a true symbiont as it can only temporarily retain chloroplasts taken from ingested algae.



[Riccioliano et al 2015 Frontiers in Microbiology](#)

Physarum plasmodium spreading onto oat flakes on an agar plate.

Painting of Antony van Leeuwenhoek
By Jan Verkolji
completed between 1680 -1686



The Messenger
Painting by Jan Verkolji.



Microscopical observations (1661)

In Comendation of ye Microscope Dr Henry Power

Of all th' Inventions none there is Surpasses
the Noble Florentine's Dioptrick-glasses.
For what a better, fitter, guift Could bee
in this world's Aged Luciosity.
To Helpe our Blindnesse so as to devise
a paire of new & Artificiall eyes.
By whose augmenting power wee now see more
then all the world Has ever donn Before.
Thy Atomes (Brave Democritus []) are now
made to appeare in bulk & figure too.
When Archimide by his Arithmatick,
numbred the sands, had hee But knowne this trick.
Hee might have seene each corn a massy stone,
& counted them distinctly one by one.
Veiw[!] but the wonders in a Louse through whose
tralucent Body all Her entrayles shows.
As through a Chrystall watch I have often seene
the Counter-motions of the wheelles within.
There yow may see the pulsing Heart drive on
the Blood in it's due Circulation.

If Natures skill in optick's yow would trye
then take a Flea & looke mee at her eye.
Where in an Emarauld Iris shee hath sett,
(empaled with white) a pupill all of jett.
Change but your object Looke at common flies
how their soules peepe through Lattices of eyes.
In the gray flye is lively to bee Seene
an eye Dauncettad all of Black & greene.
As if ye nett work of her eyes were made
of Irish-stick a greene with a dark shade.
In the wood mite or -Louse yow may behold,
an eye of Trellice-Worke in Burnisht Gold.
Wich with a rare Contrivance Shee can move
inwards or outwards as her objects prove.
Nay to the Spider providence hath given

plurality. of eyes Some Six or Seaven.
Wich Like a Lockett of pure Diamonds Show
or like a Constellation in her Brow.
Here Argus eyes are fix'd & doe remaine
cleerer by farr then in the Peacock's Traine.

Nay lett mee Screw your Inquisition higher
looke but at mites & then you'le most admire.
How Nature could to Such a nothing Sett
both Heade, & Tayle, & Leggs, & mouth compleate.
Besides ye stomach, gutts, & Heart, & Spleene
wch lye within this Hollow mote unseene
To wch adde nerves, & Sinews & all these
cask'd in those Liveing exiguities.

Oh for an otacousticon to Heare
the vocall Noyse of this throng[ed] Theater.
And sett of Animalls for who can tell
but they have Severall cryes though inaudible.
Wee want thine eares Melampus that could Heare
when thou was cag'd up a close-Prisoner.
The Language that the Timber worme did speake
when they foretould thee yt ye Beame would Breake.

Looke into Liquors who would thinke that there
should Quick's breed in the keenest Viniger.
Wich though so vastly magnified appeare
noe bigger then ye smallest chire of Haire.
Here are the Curious Mathematick's Here
lyes ye rare skill of their Artificeere.
All things hee made of nothing, but in this
hee made a thinge that lesse then Nothing is.
Who can the old Phyllos[o]p[h]e[r] renounce
that sd a thousand Soules might dance at once.
Upon a needles point, when wee see Here
as many in one dropp of Viniger.
This to our mind the a'theriall wisdome brings
how God is greatest in ye Least of things
And in the smallest print wee gather hence
the world may Best reade his omnipotence.
Goe on Dioptrick Artist's still goe on

may your glass-eyes even Vie pfection.
With natures Noblest sense: from yow wee hope
such rare Emprovements of ye Microscope.
That ye Magnetick fluors of ye stone
shall bee as cleerely Seene as now there's none.
Nay then yow pretty sprit's & fairy Elves
that hover in ye aire Looke to your selves.
For with such prying Spectacles as these
wee shall see yow in yr owne essences.
Then shall I see a soule just when tis gone
as cleere as now I doe our will: & John.

Hen: Power Dr of Physick.

*probably Galileo was the
noble Florentine



Replica of Hookes Microscope 1665 (AI generated)

