Extremophile environments

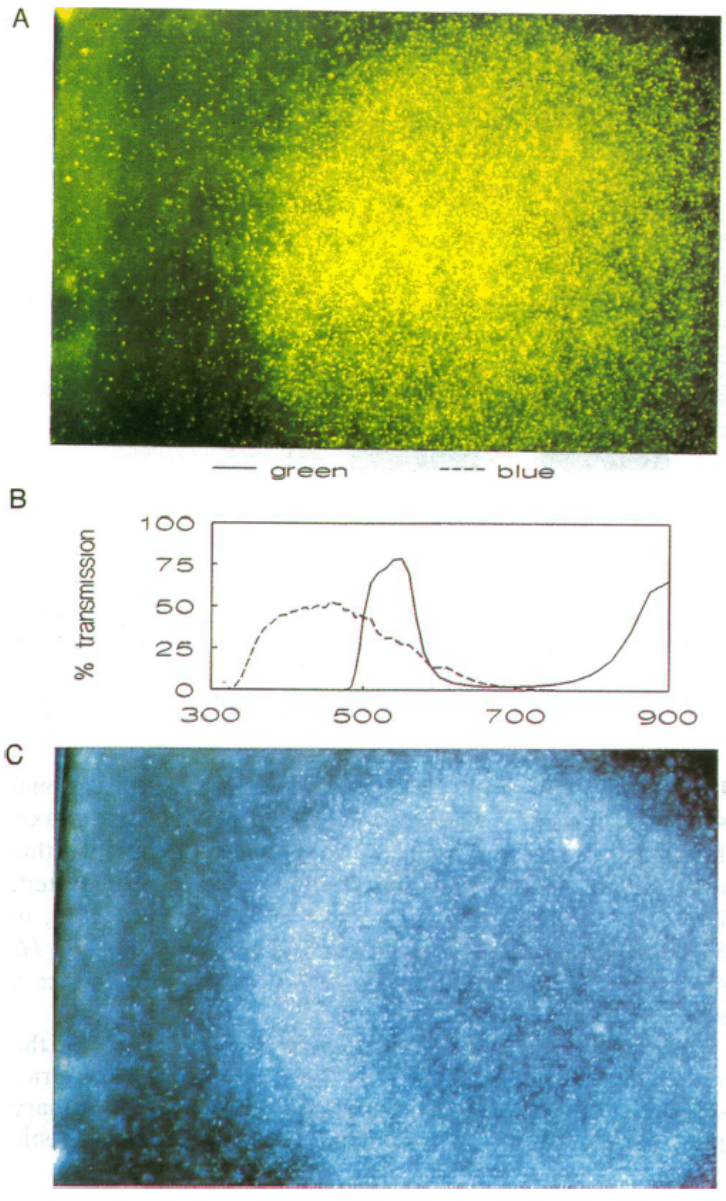
Hypersaline lakes are good places to search for “primitive” model organisms.

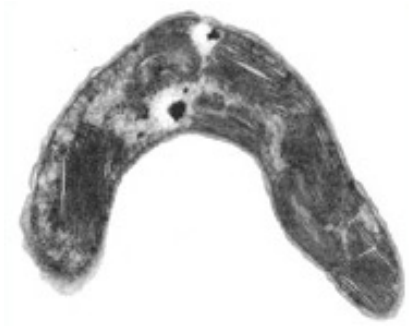
Wadi Natrun, Egypt. Inhospitable for most life: pH 10.5, 36% salt [wt/vol]

Probably pining for the fjords

Good for mummification thanks to high quantities of natron (soda ash and salt mixture), an excellent desiccating agent. Photo credit: Nick Brandt.

Home of extremophile bacteria *H. halophila*





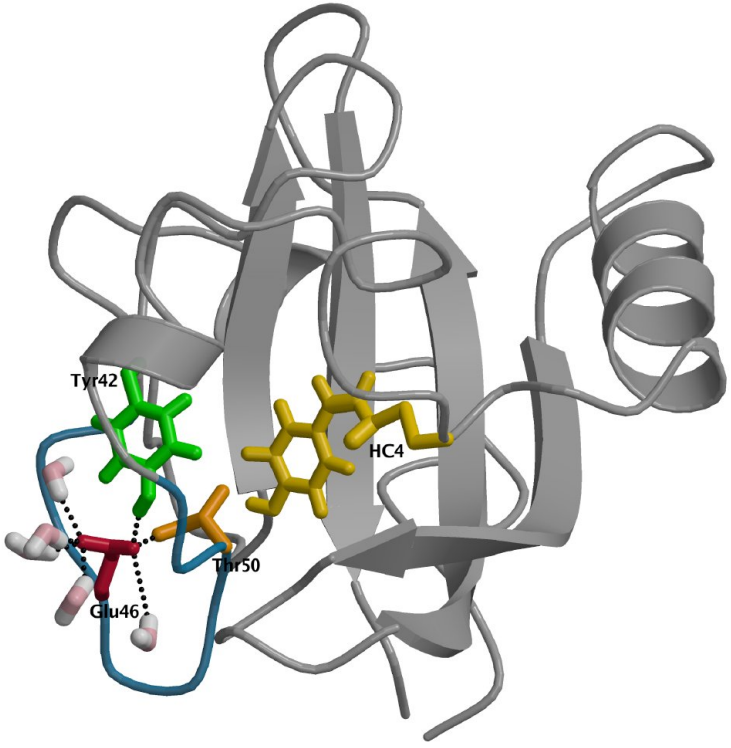
Sprenger *et al.*, J. Bacteriol. (1993):

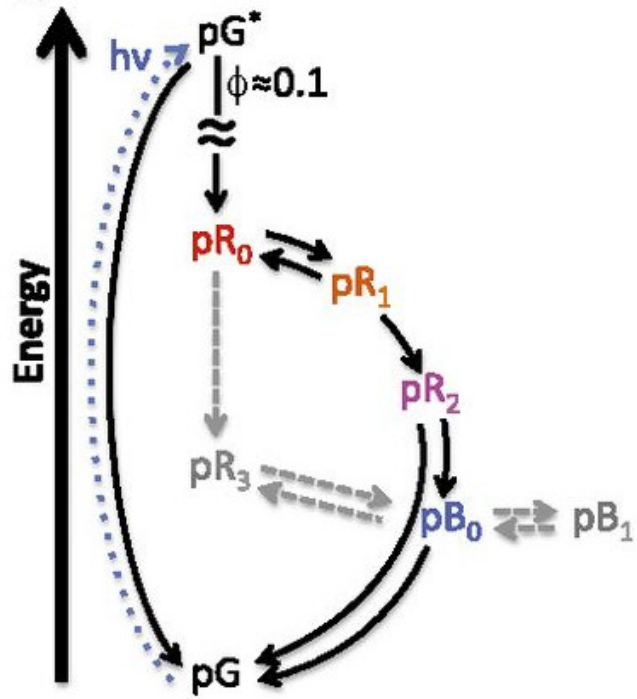
These bacteria have a mechanism to swim toward green light, a photon frequency useful for photosynthesis.

They swim away from large intensities of blue light, possibly because exposure to higher energy photons (> 2.5 eV or $100\ k_B T$) may be damaging.

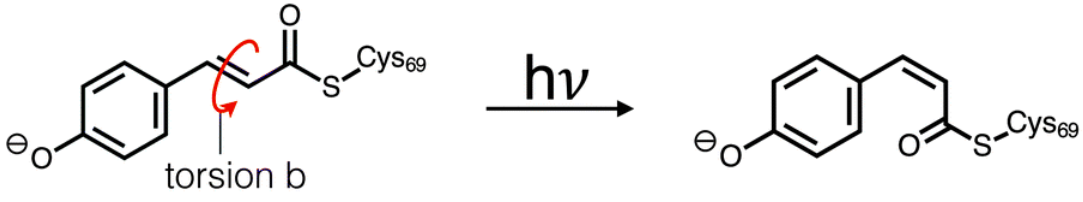
Photoactive yellow protein (PYP)

The bacterial flight response from blue photons is due to PYP, which has become a model system for photosensitive proteins.



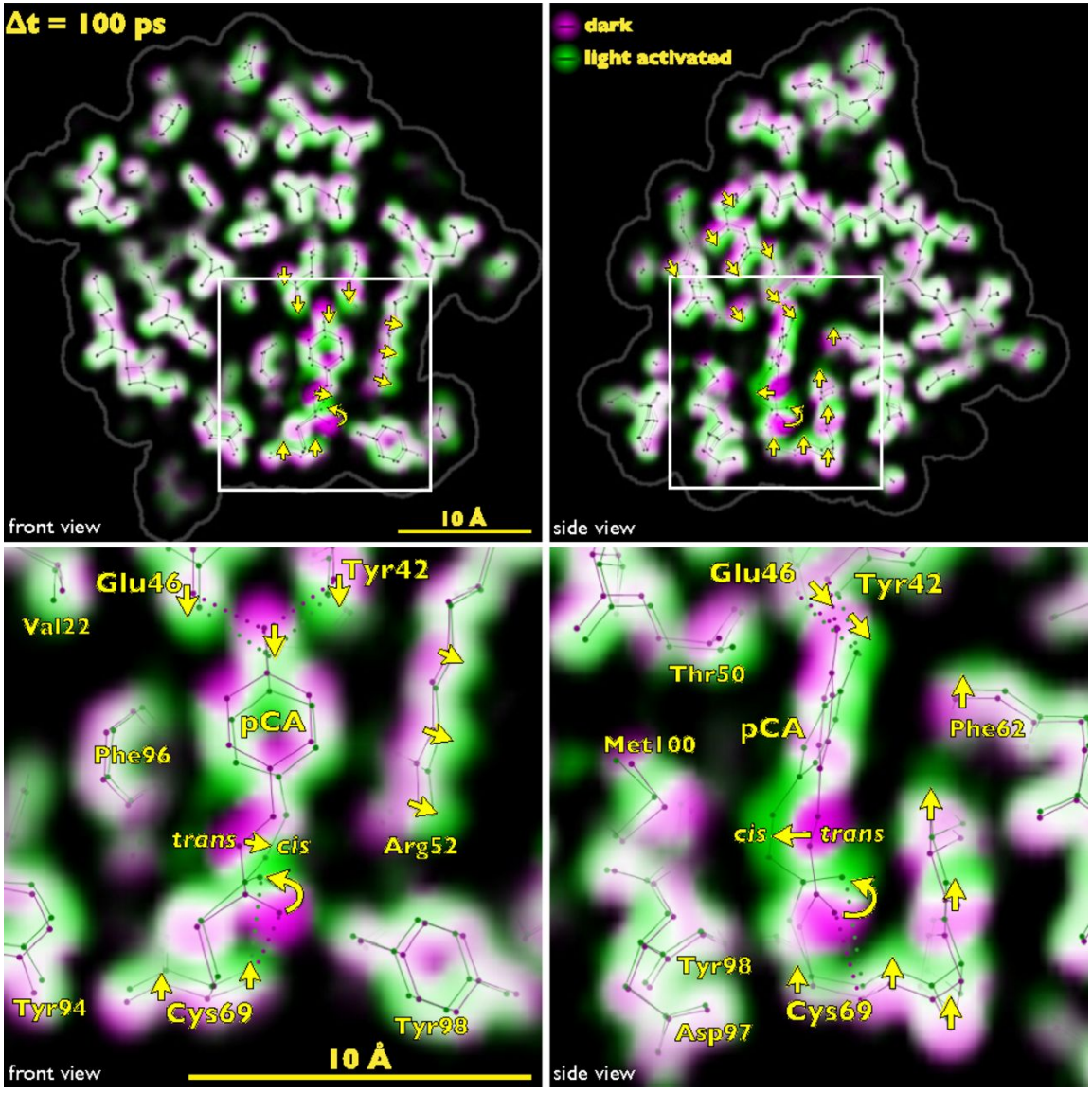


Change in *p*-coumeric acid on absorption of blue photon:



Visualizing the photon-induced protein motions

Time-resolved x-ray diffraction: seeing atomic-scale motions at 100 ps time steps, from $t = 100$ ps -1 s [Schotte *et al.*, PNAS (2012)].

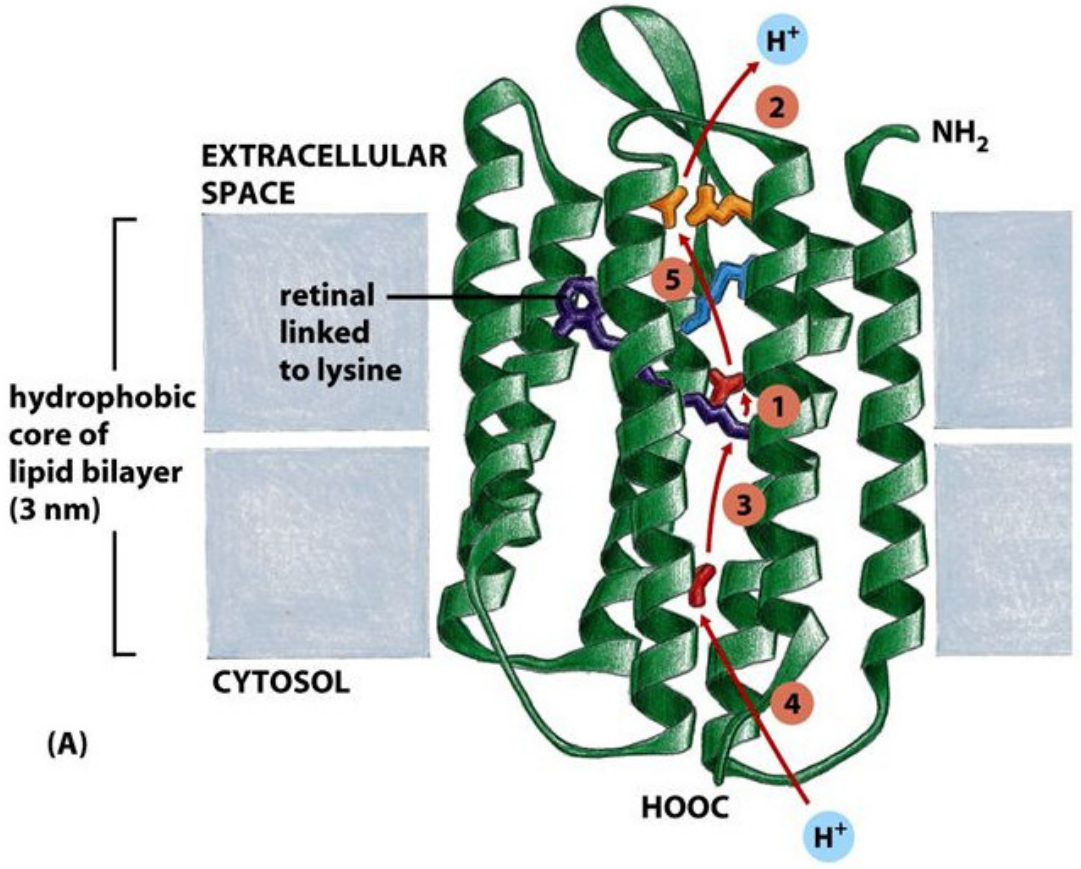


PYP in action

See movie file on course website.

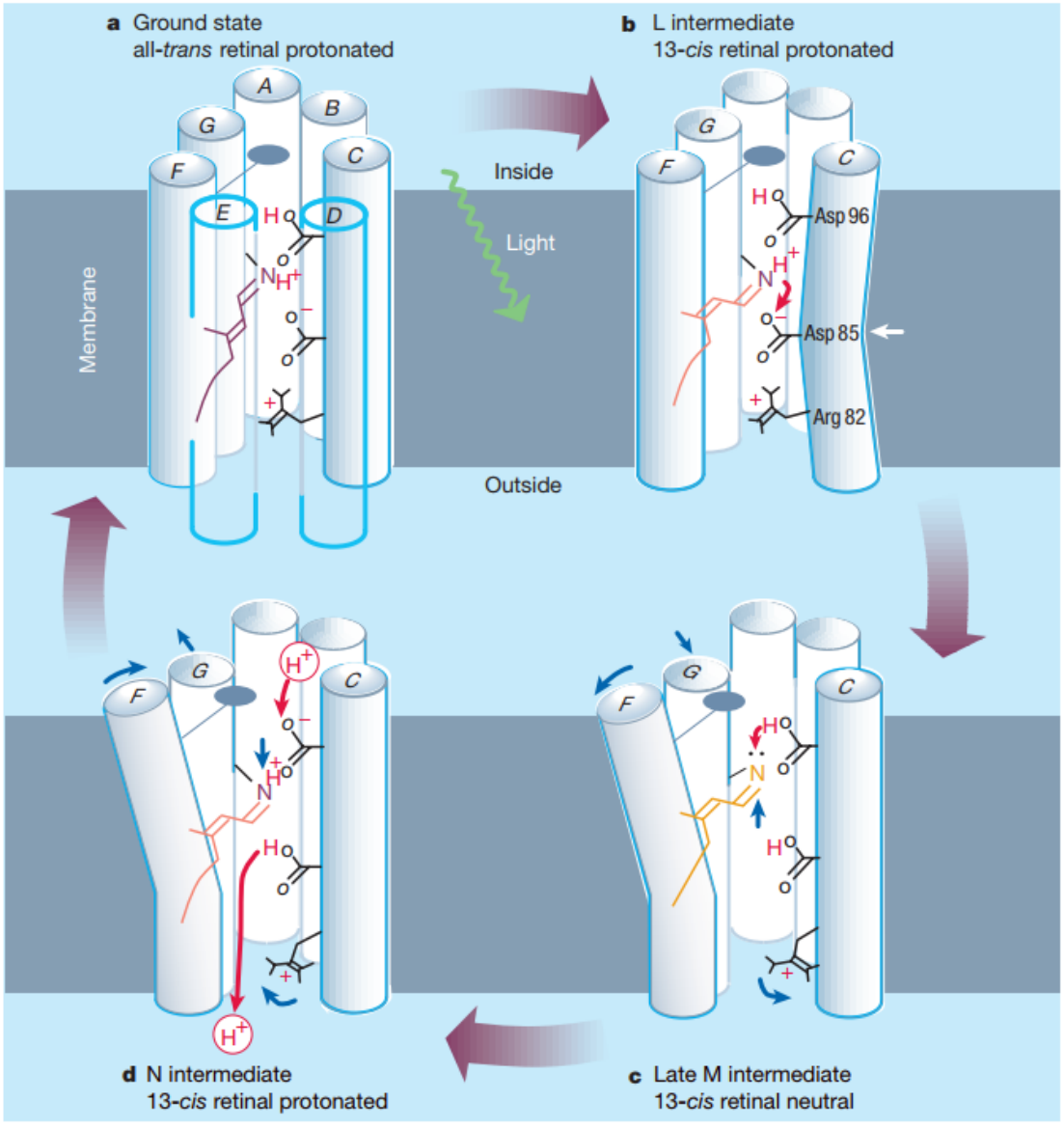
What can you do with photo-induced protein motions?

Another example from a simple, salt-loving organism: **bacteriorhodopsin** from Halobacteria (a class of Archaea)



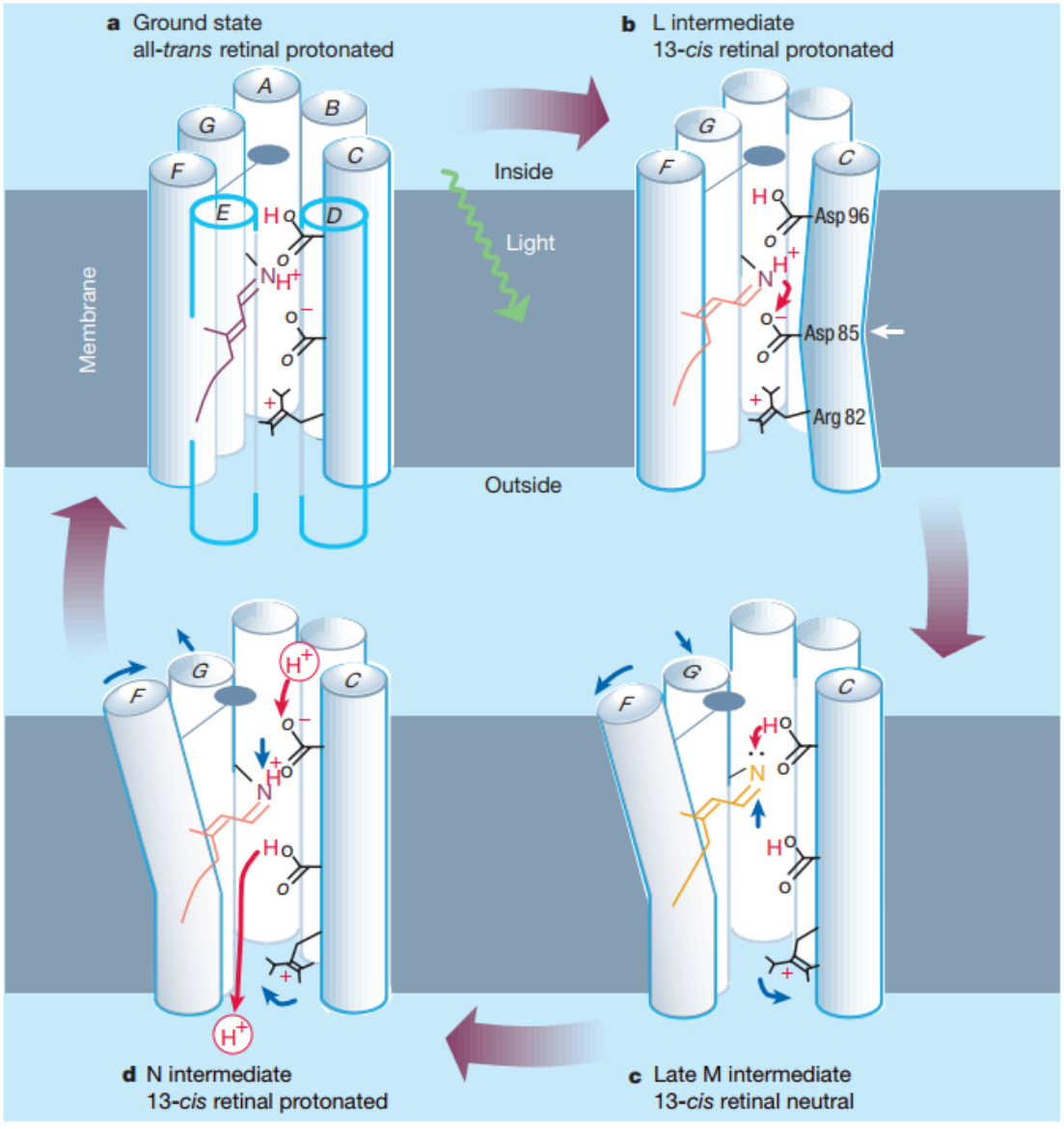
Similar in structure to the photoreceptors in our eyes. Can cover up to 50% of the surface of the archael cell.

Bacteriorhodopsin pumps protons out of cell



Key question for later: what is the advantage of pumping protons?

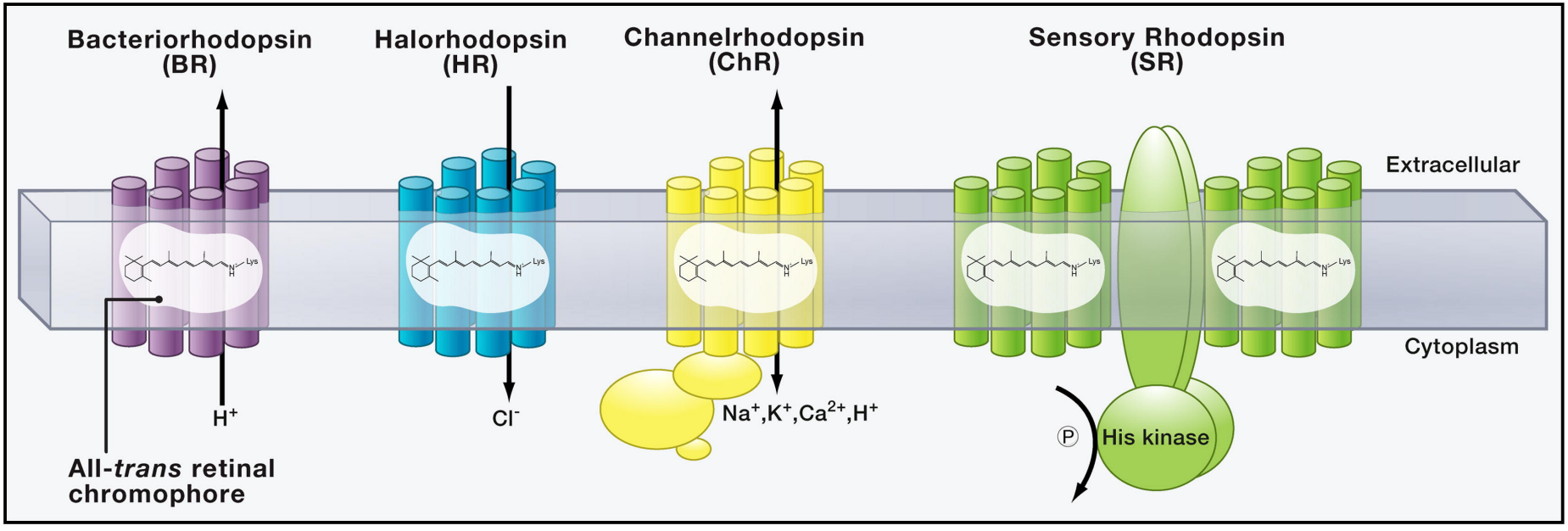
Bacteriorhodopsin pumps protons out of cell



Key question for later: what is the advantage of pumping protons?

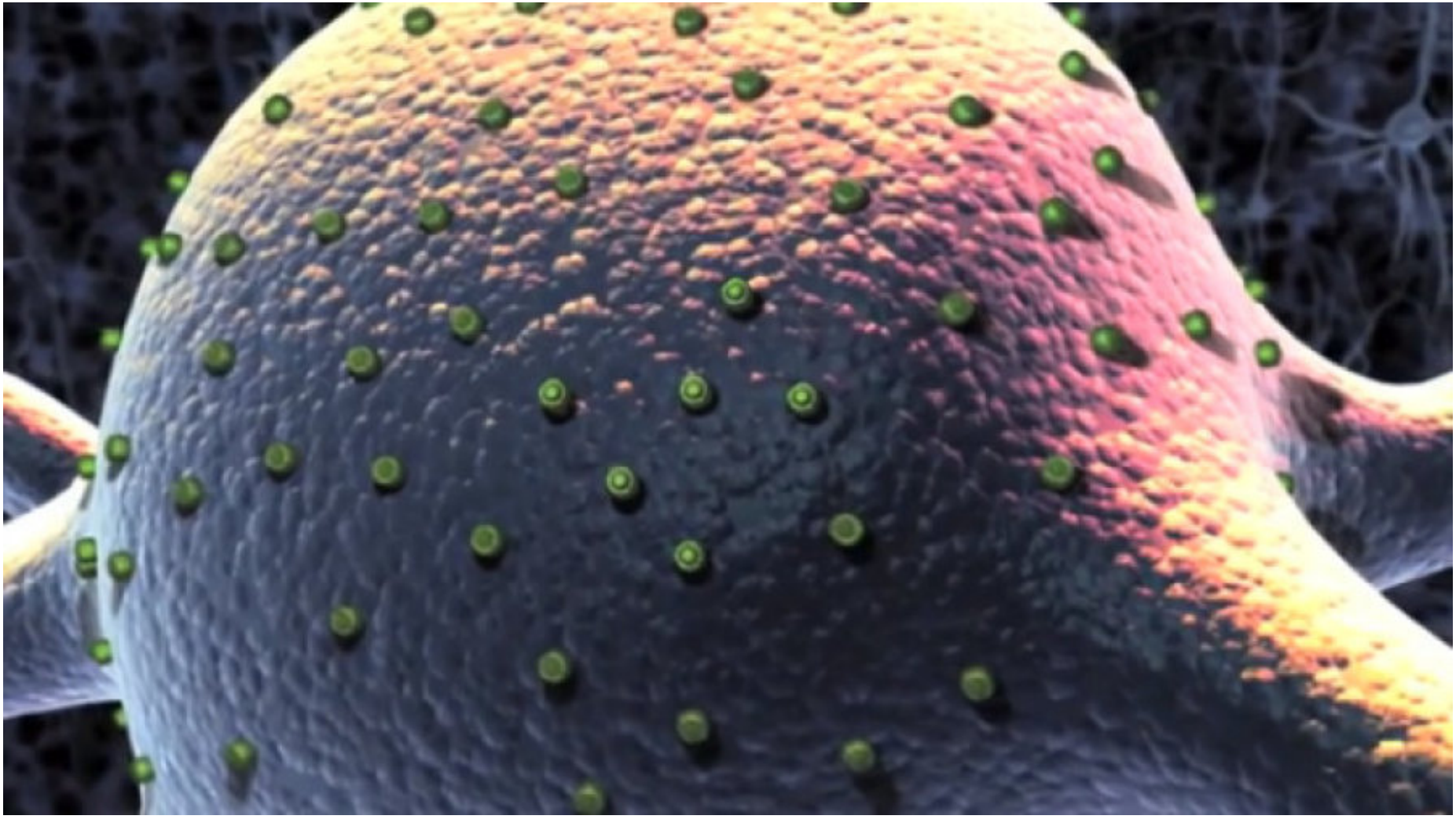
The broad family of microbial rhodopsins

Many variants have been discovered, specialized for different functions:



The broad family of microbial rhodopsins

Artifically embedded in neurons of higher organisms, they allow for **optogenetic** manipulation of behavior.



Optogenetics

See movie file on course website.

Optogenetics

See movie file on course website.