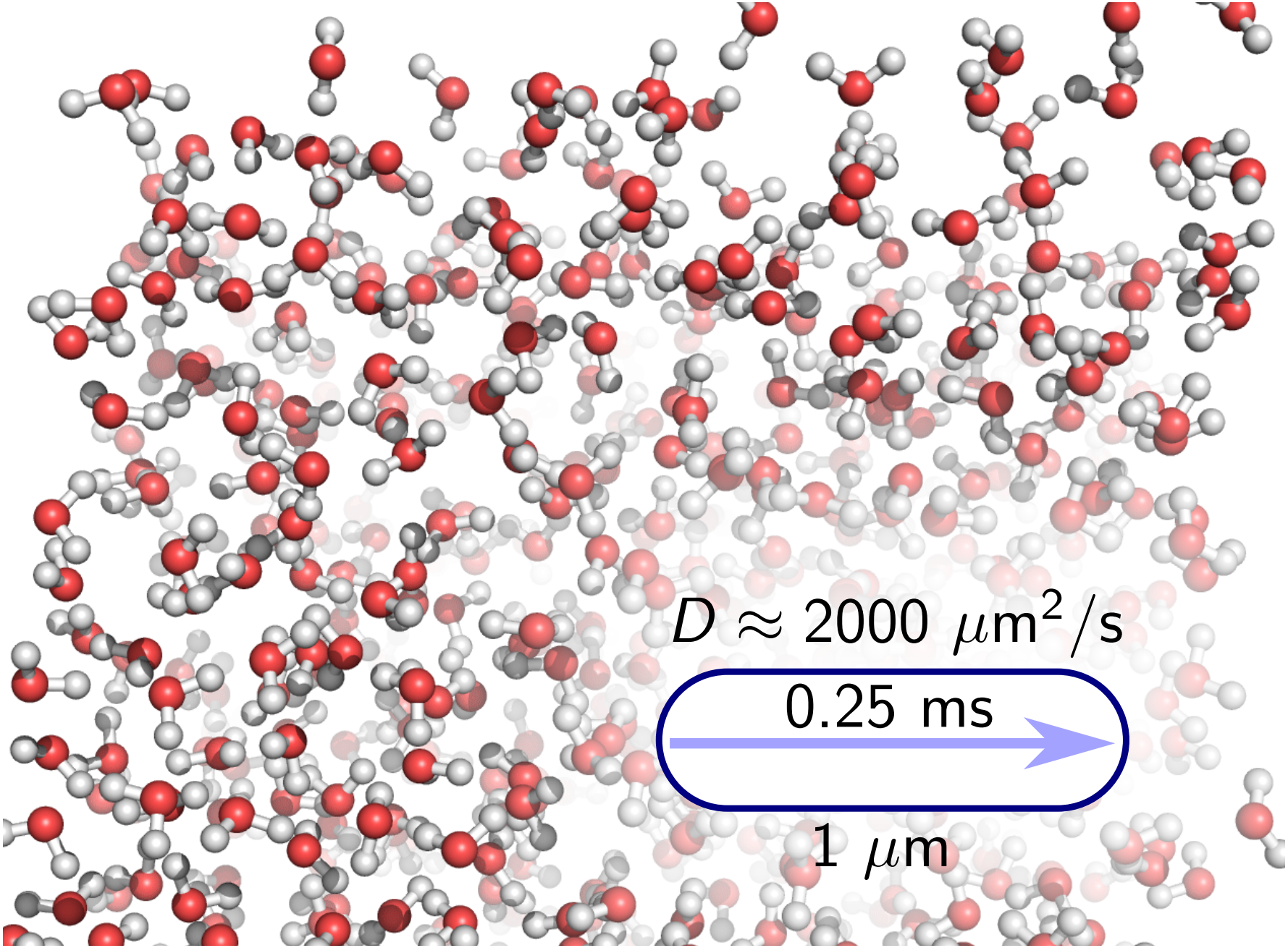
Red ball in vibrating box

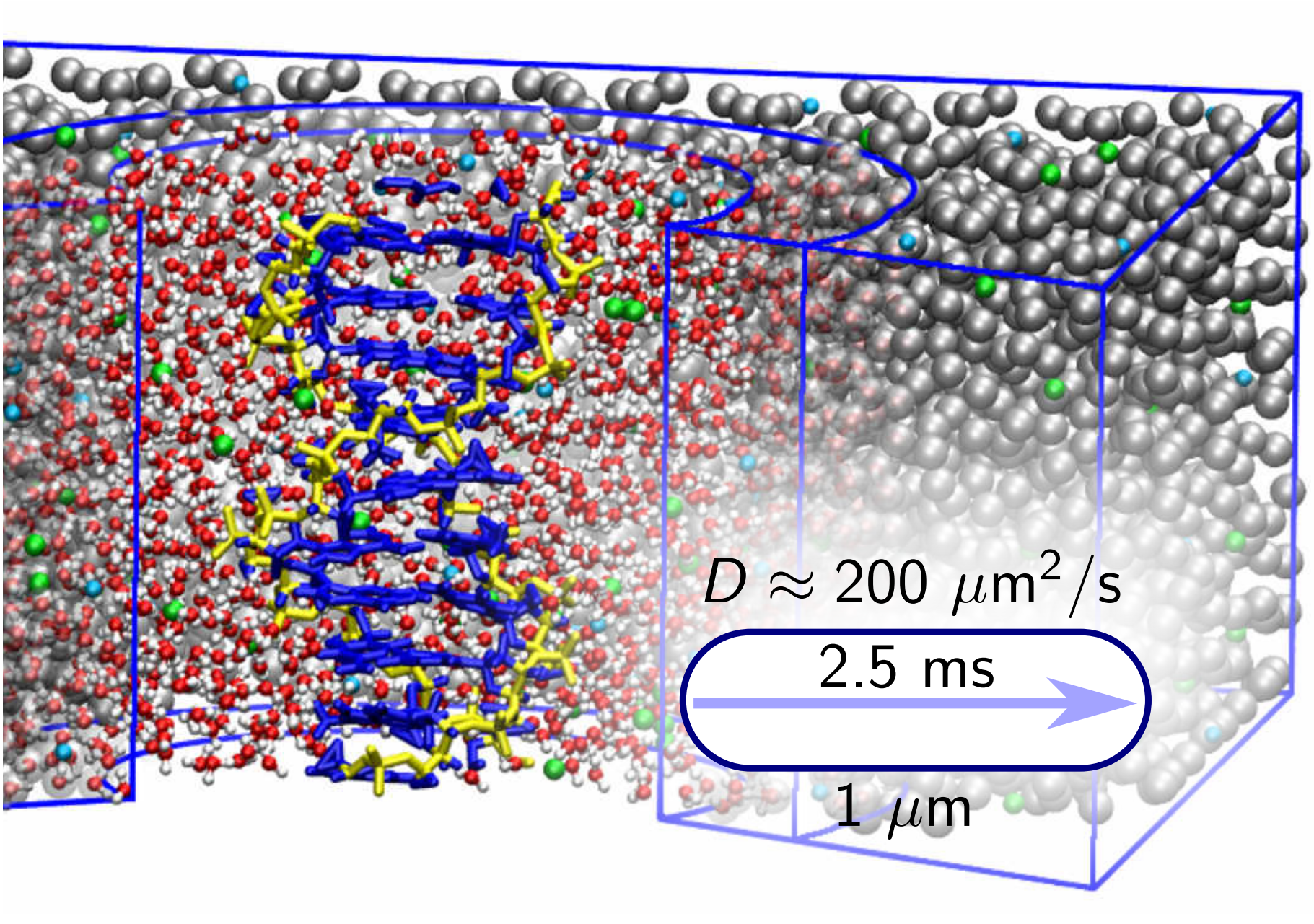
See Lecture 3 diffusion experiment movie on course website.

$D = 0.2$ cm^2/s. Red ball diffuses $L = 23$ cm along x-axis in roughly $L^2/2D = 1323$ s.

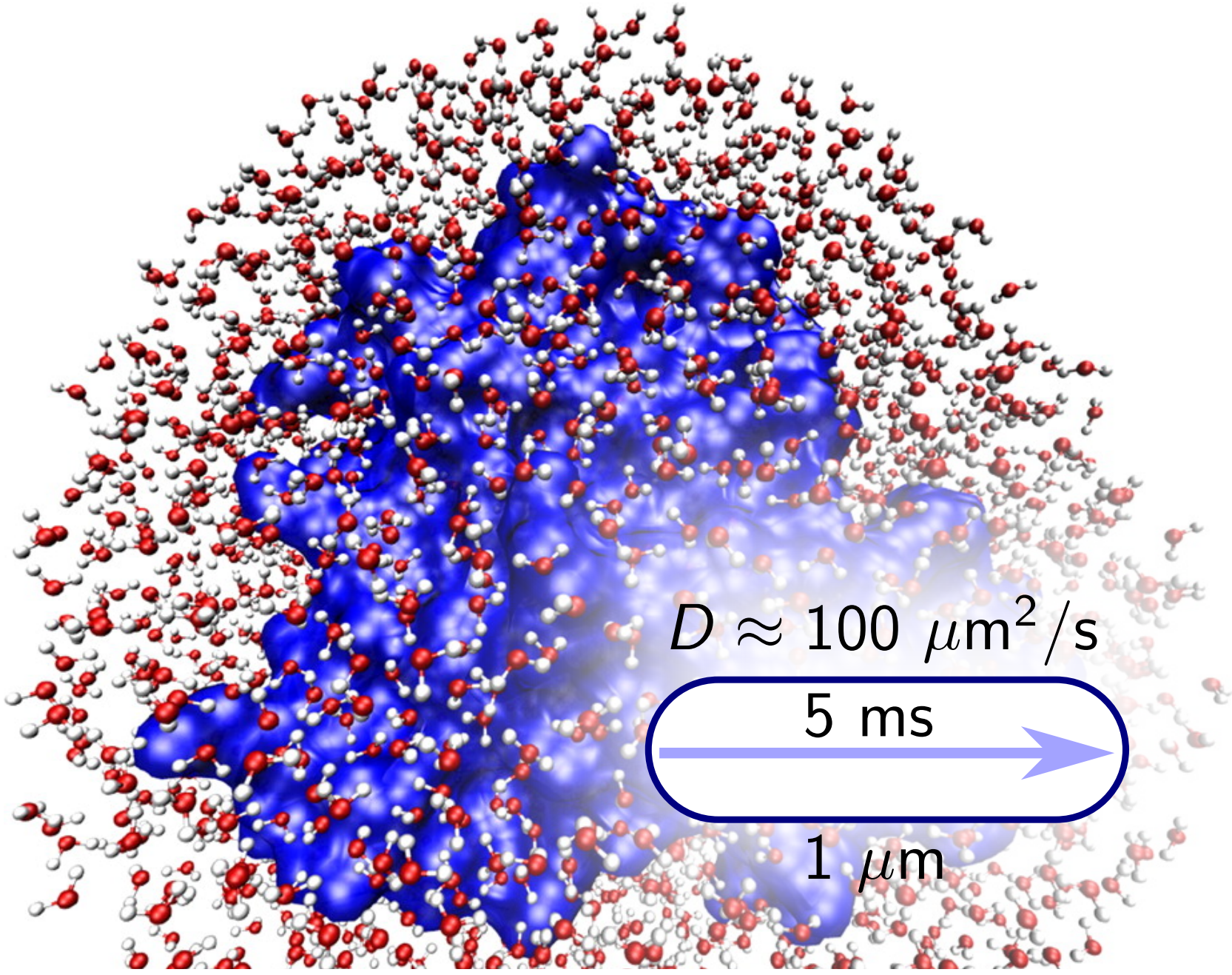
Water molecule [0.3 nm diameter] surrounded by water



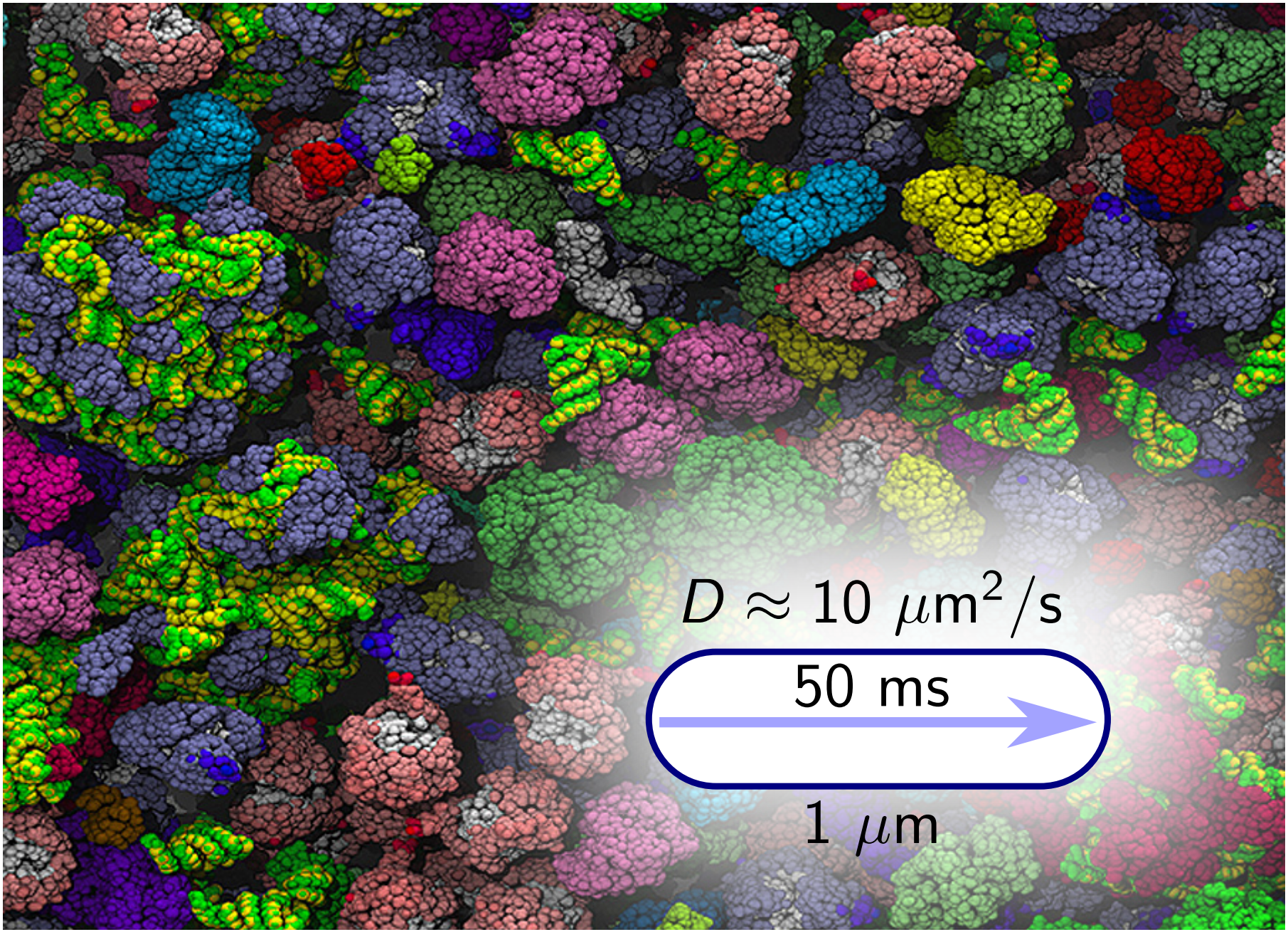
Water molecule inside cell nucleus



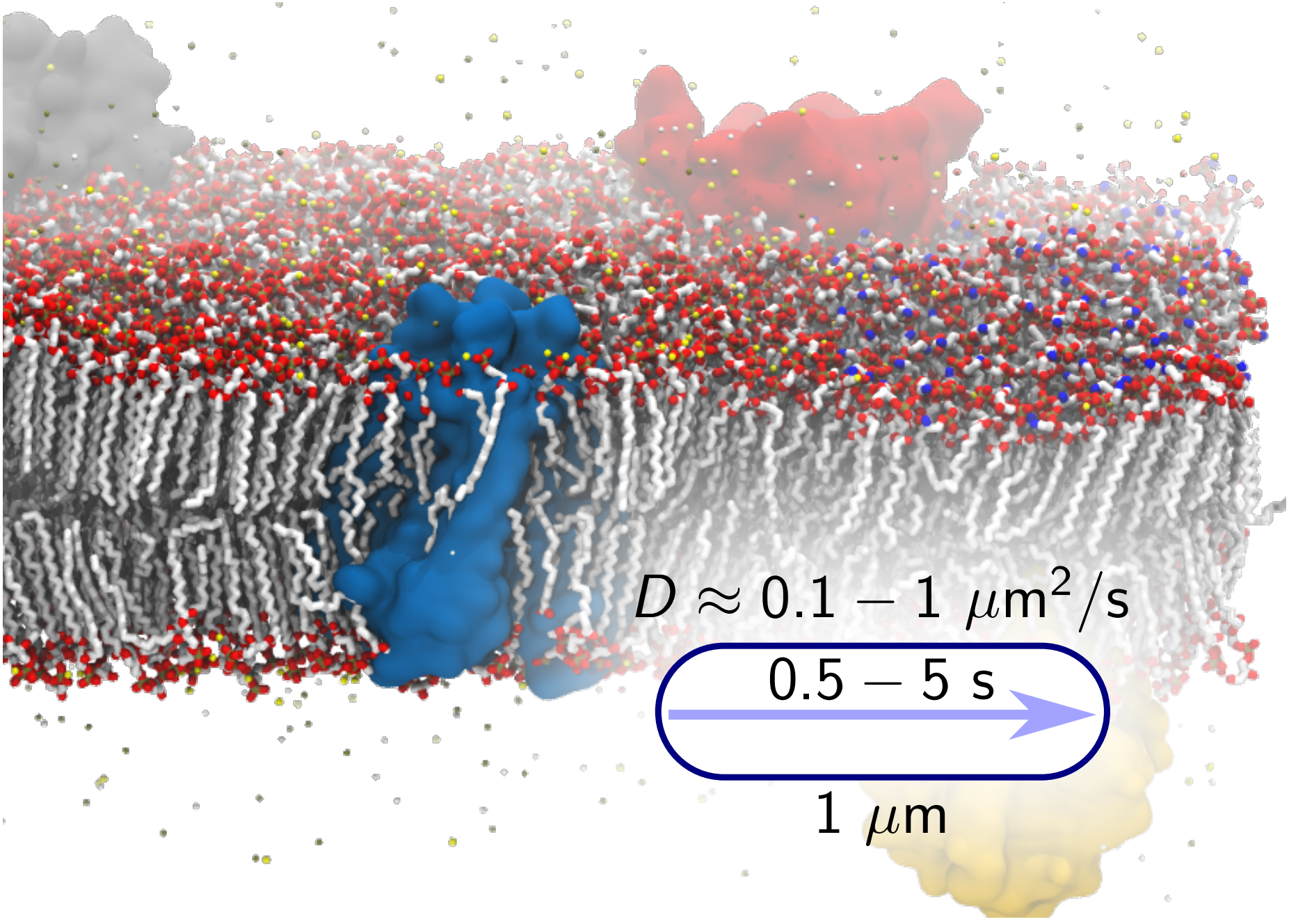
Protein [2 nm diameter] surrounded by water



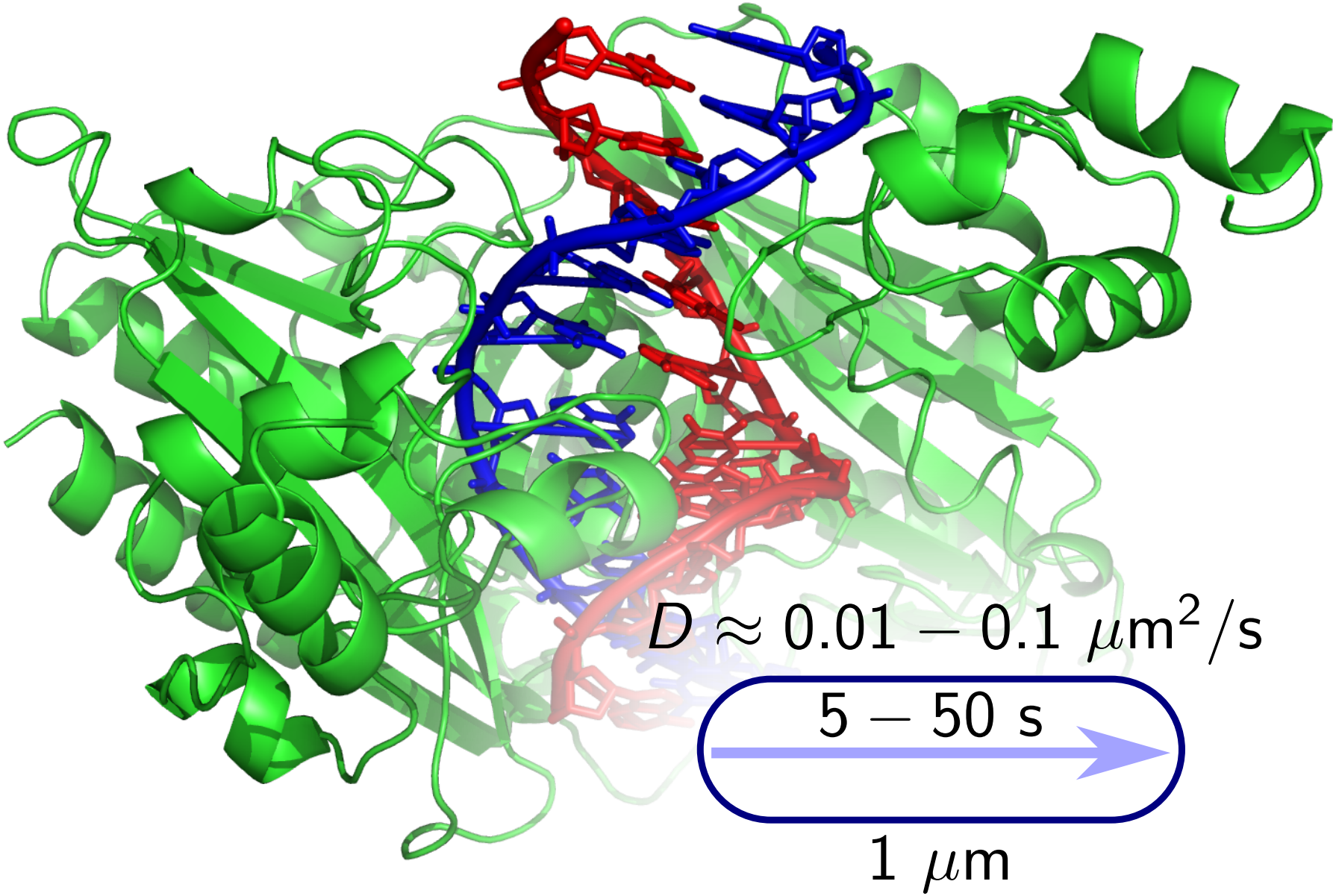
Protein inside cell



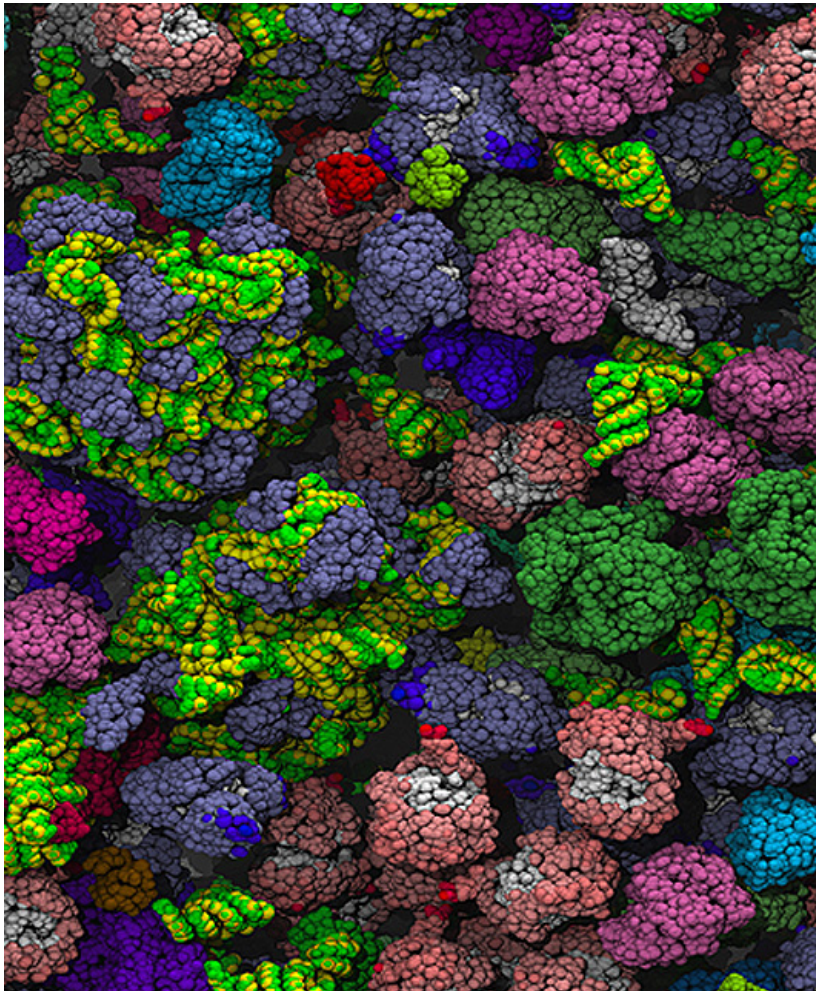
Protein bound to membrane



Protein sliding along DNA



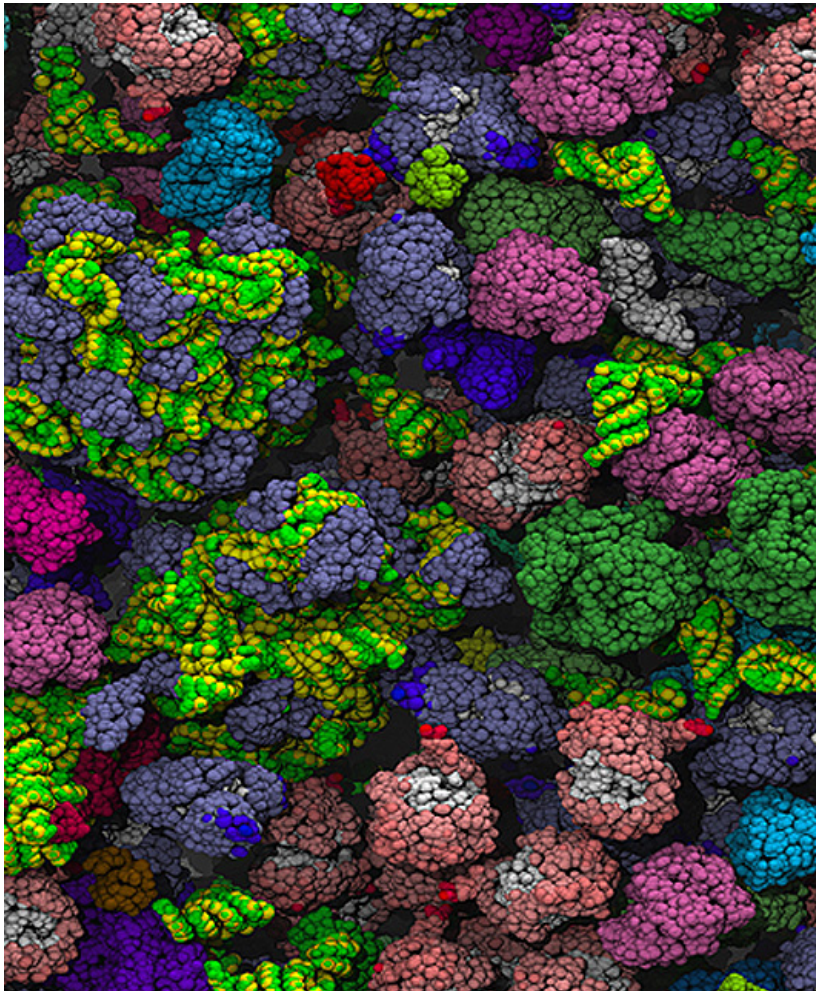
Protein inside cell: different cell sizes



Typical time to diffuse across:

1 μm bacterium: 0.05 s

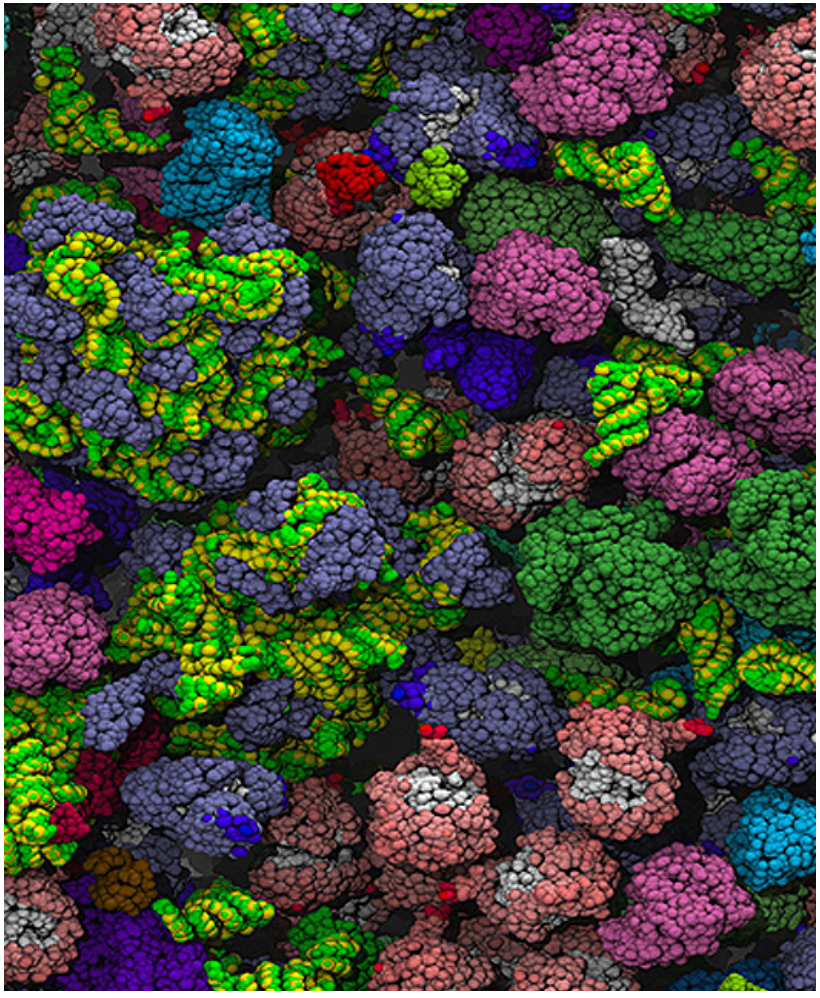
Protein inside cell: different cell sizes



Typical time to diffuse across:

1 μm bacterium:	0.05 s
10 μm human cell:	5 s

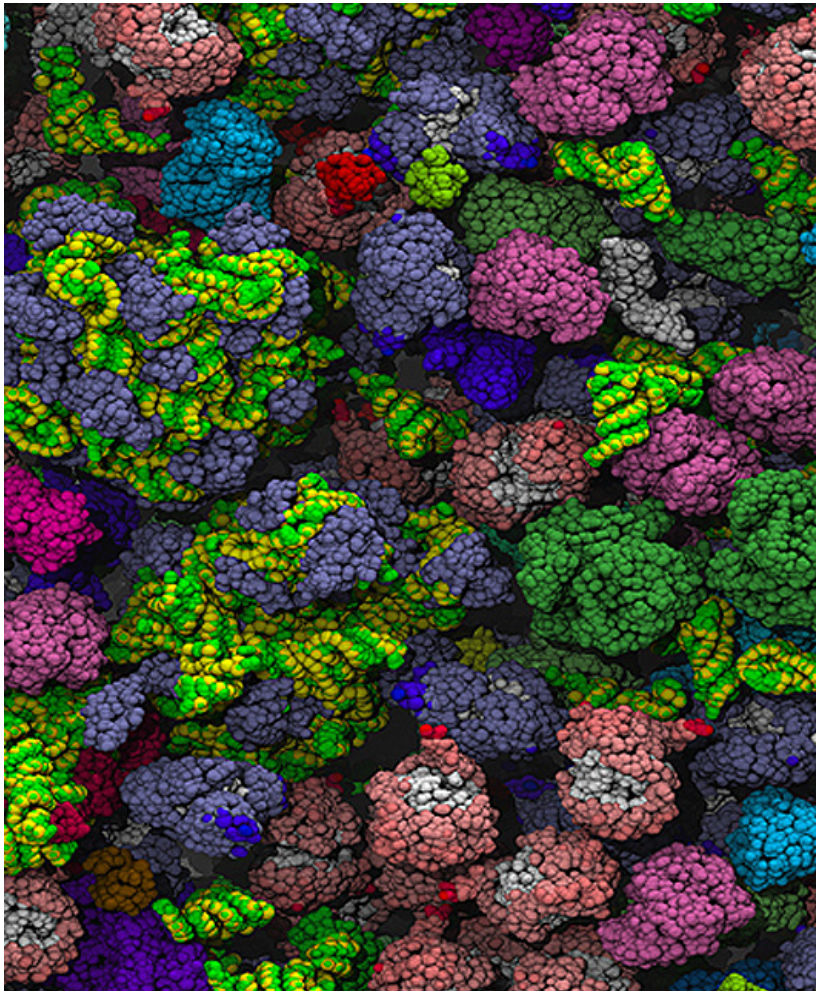
Protein inside cell: different cell sizes



Typical time to diffuse across:

1 μm bacterium:	0.05 s
10 μm human cell:	5 s
3 m giraffe neck neuron:	**14,000 yrs !!**

Protein inside cell: different cell sizes



Typical time to diffuse across:

1 μm bacterium:	0.05 s
10 μm human cell:	5 s
3 m giraffe neck neuron:	**14,000 yrs !!**

Giraffes do not exist.

Life at larger scales is an exception rather than the rule

While the mechanisms of how large-scale life operates are fascinating, keep in mind they are a sideshow to the primarily unicellular, small-scale nature of life on earth:

numbers of cells on Earth:

prokaryotes	5×10^{30}
plants	2.4×10^{28}
unicellular eukaryotes	2.3×10^{26}
animals	1.3×10^{26}

Landenmark *et al.*, PLoS Biol. (2015)