How do you follow a scent?

Readings for today

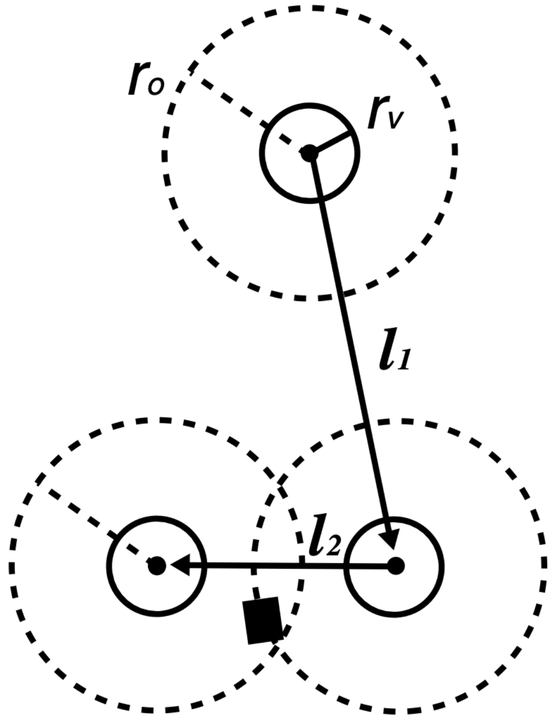
- Baker, K. L., Dickinson, M., Findley, T. M., Gire, D. H., Louis, M., Suver, M. P., ... & Smear, M. C. (2018). Algorithms for olfac- tory search across species. Journal of Neuroscience, 38(44), 9383-9389.

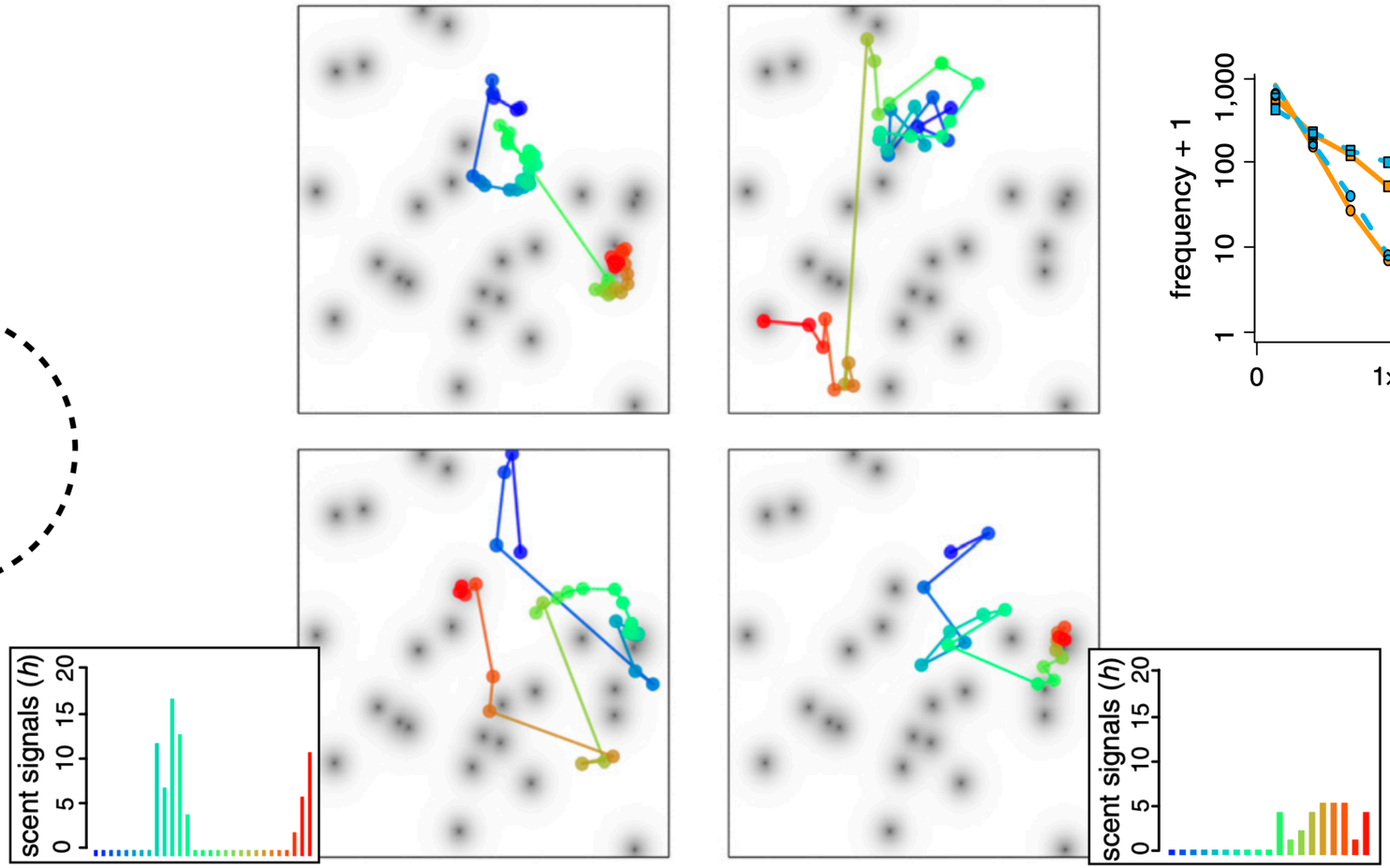
Topics

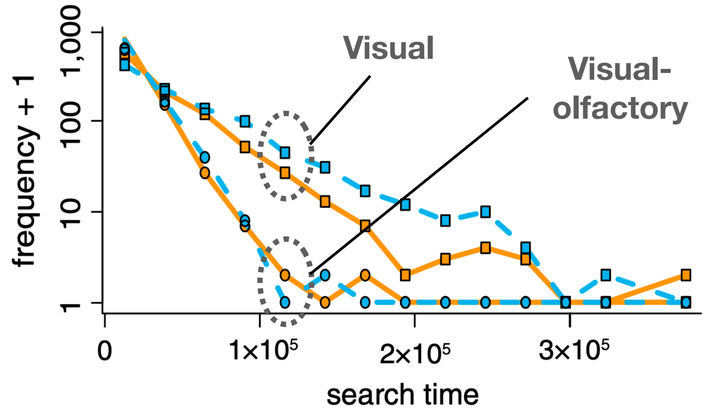
- Basic chemotaxis
- Active search

Basic chemotaxis

Recall the value of sensing in search



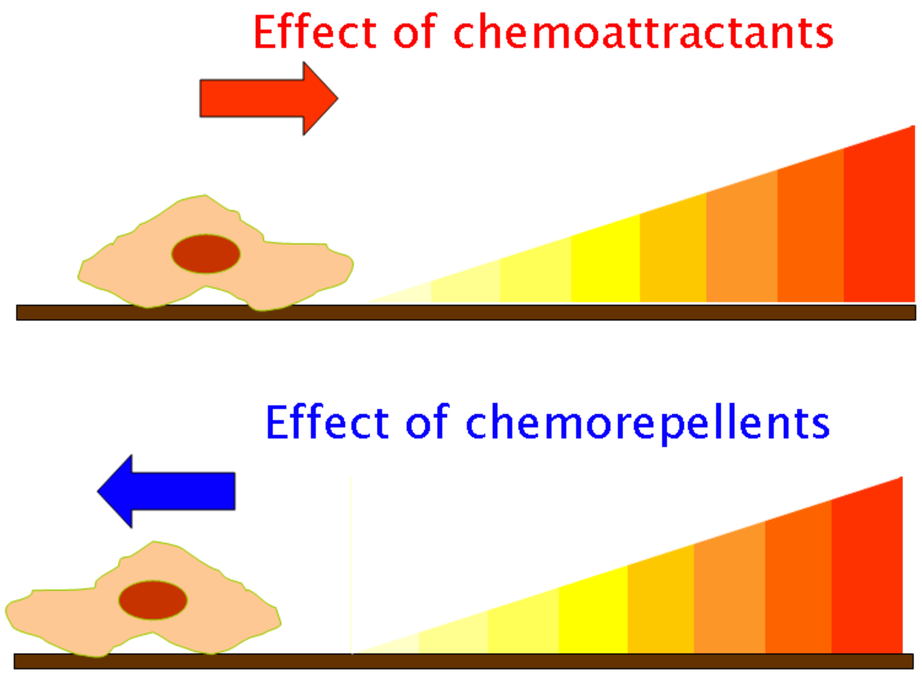


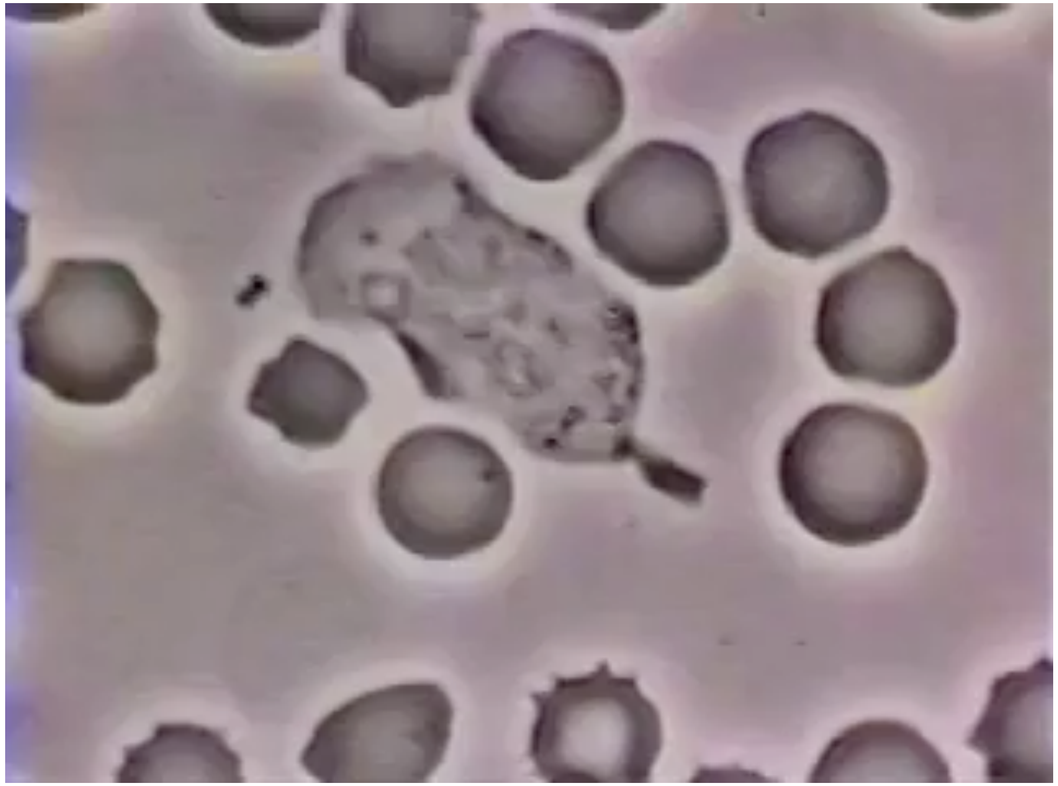


(Hein & McKinley, 2012)

Chemotaxis

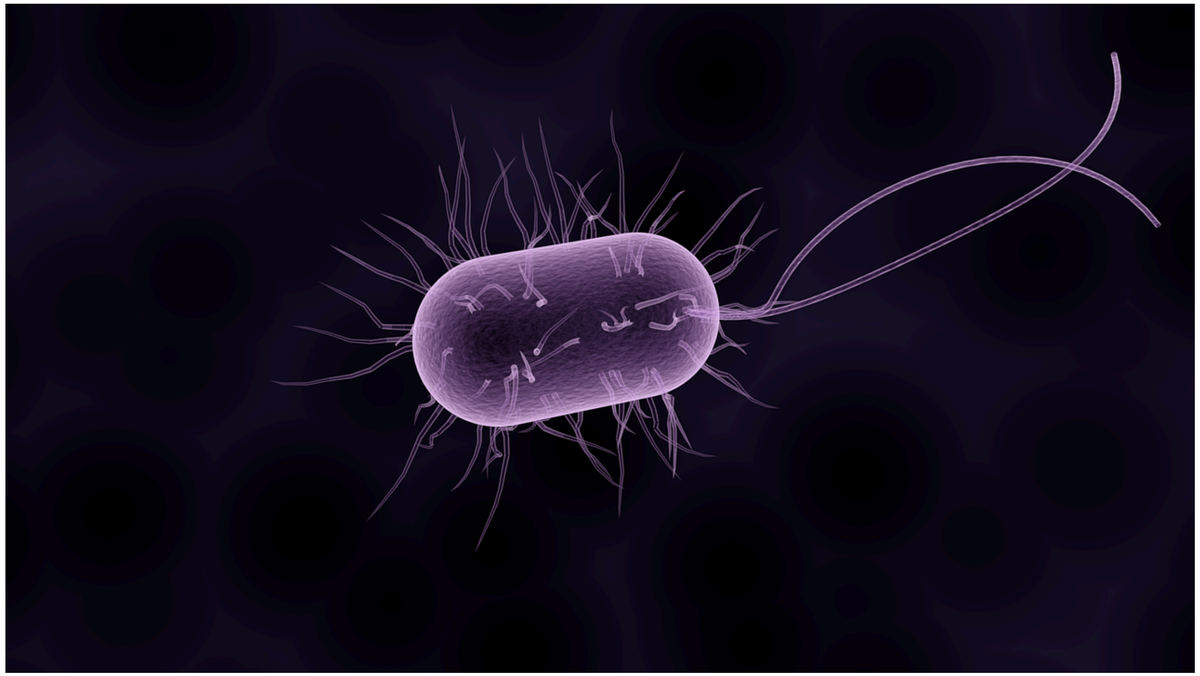
Movement in response to a chemical stimulus.

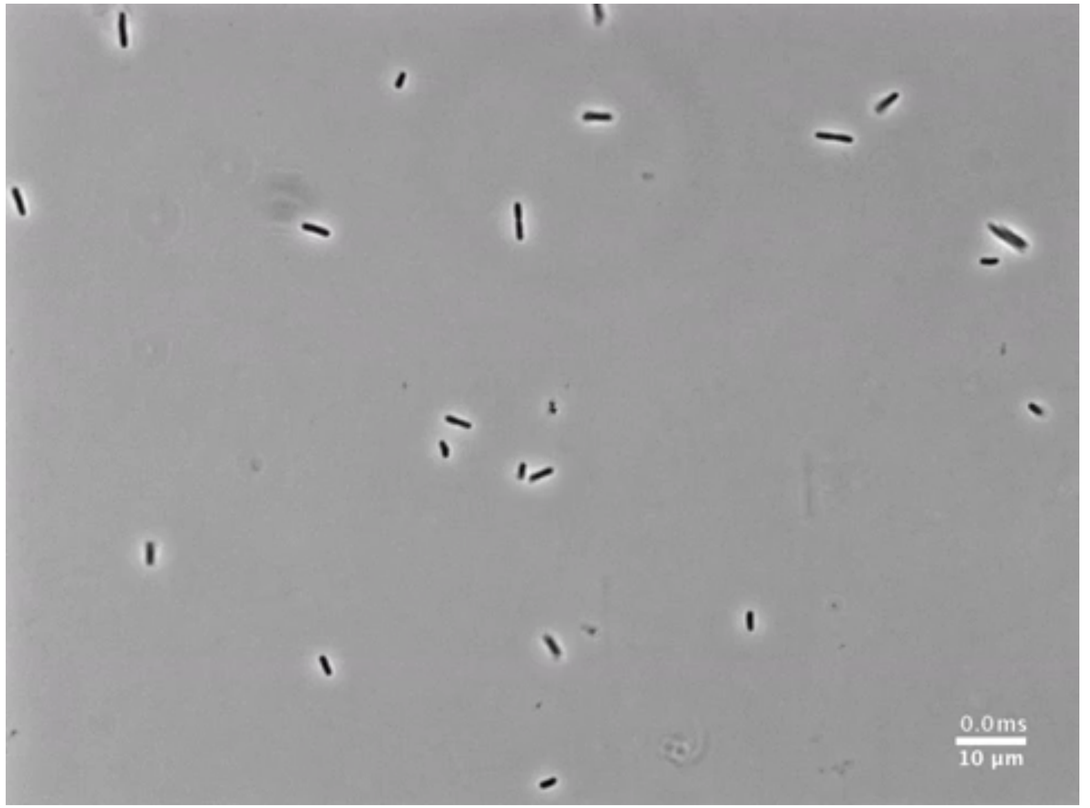




https://routledgetextbooks.com/textbooks/9780815344506/videos.php

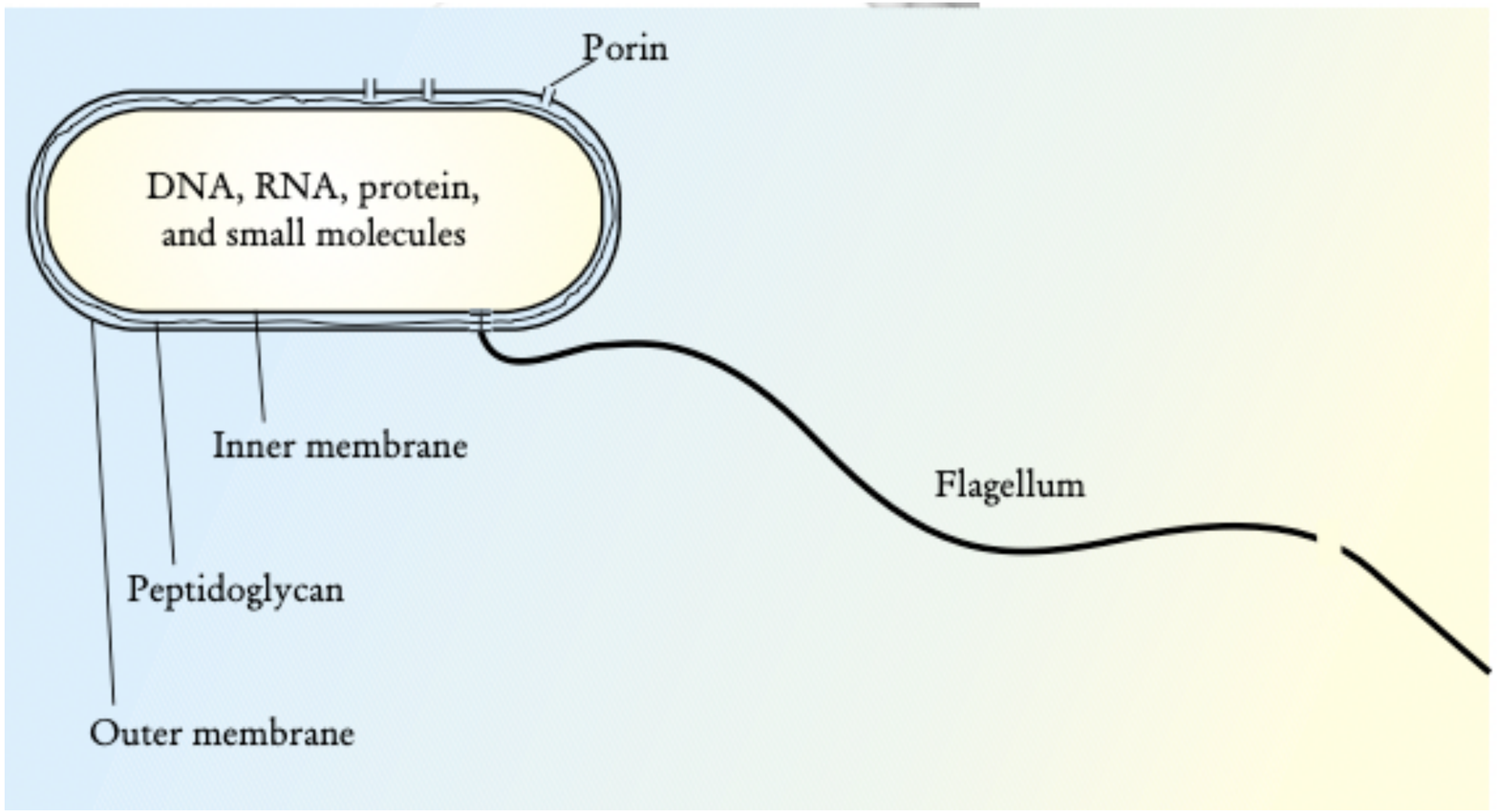
Back to E. Coli





https://www.youtube.com/watch?v=CldjFTSr4fY

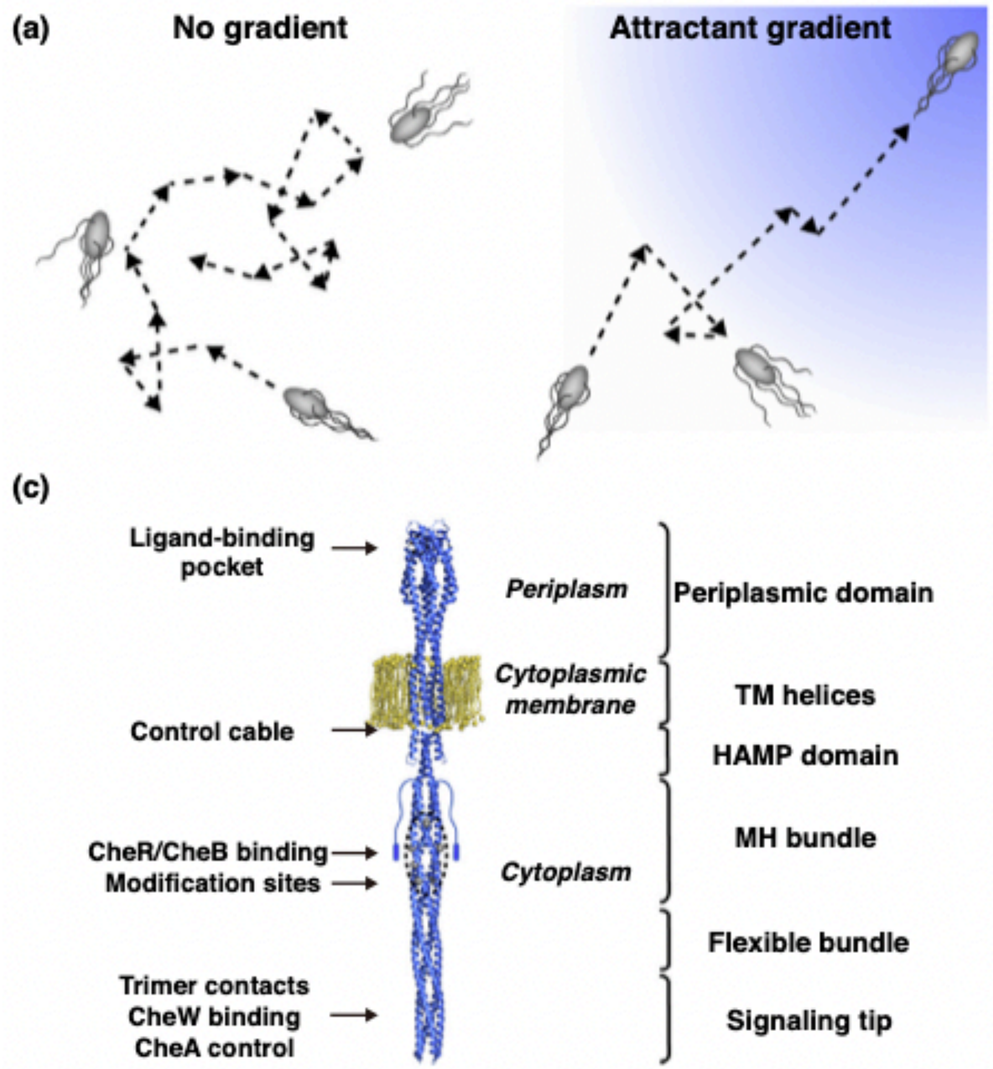
“Simple” chemotaxis machinery

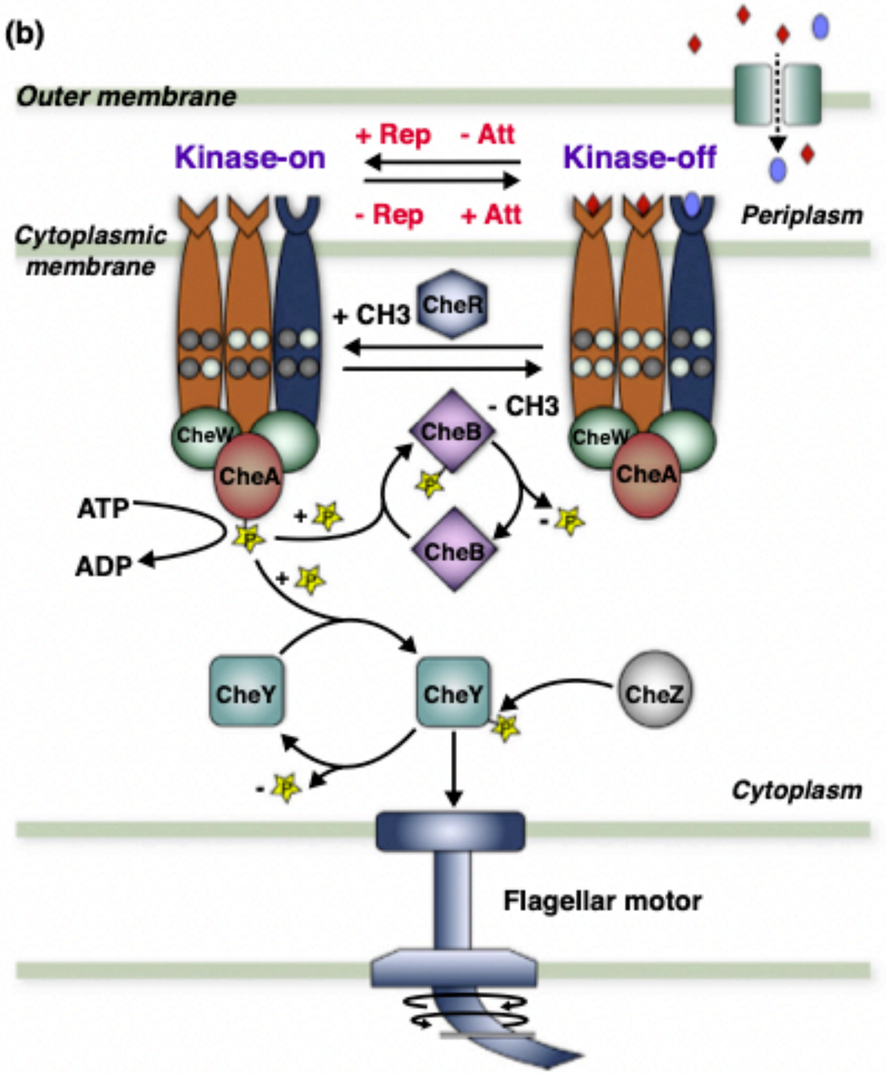


E. Coli have a molecular pathway that links chemosensing on the membrane to motor drives of the flagellum.

(Berg 2000)

“Simple” chemotaxis machinery

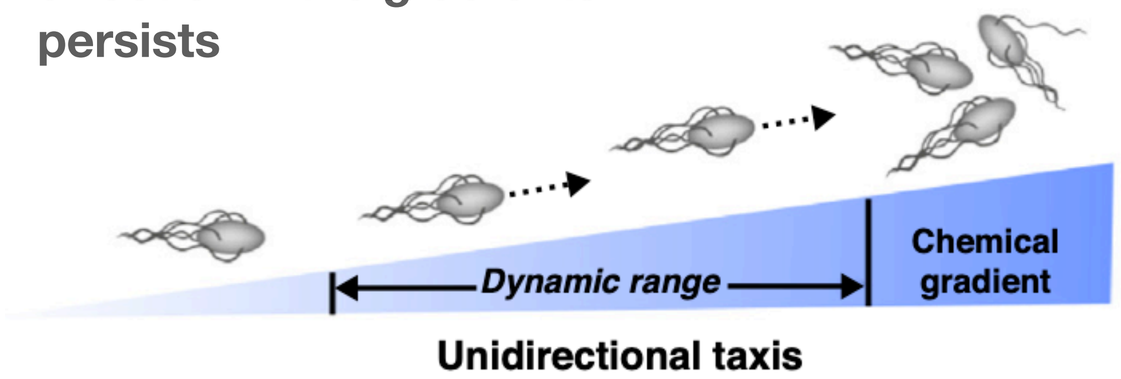


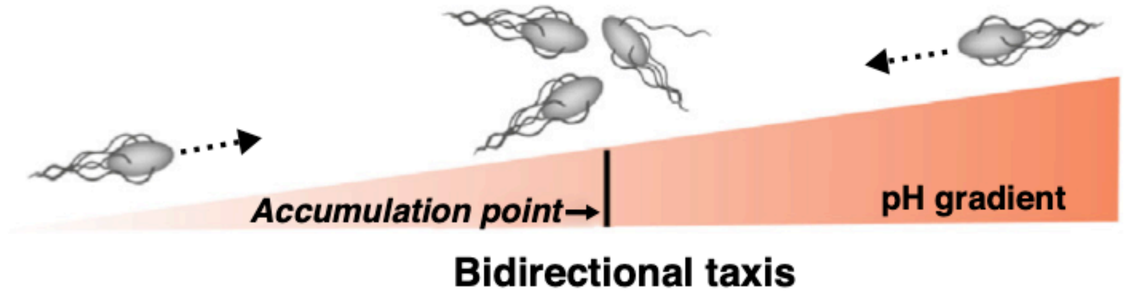


(Bi & Source, 2018)

The chemosensing algorithm

Keep moving in the same direction if the gradients persists





Calculate gradient

olfactory scent magnitude

$$\nabla o = o_t - o_{t-1}$$

Accumulate evidence

accumulation noise

$$e_t = \gamma * \nabla o + \eta$$

accumulation rate

Make decision

movement angle

$$\theta_t = \begin{cases} \theta_{t-1}, & \text{if } e_t < a \\ U(-\pi, \pi), & \text{if } e_t \geq a \end{cases}$$

random turn

(Bi & Source, 2018)

Active search

Olfactory search

Fly larvae

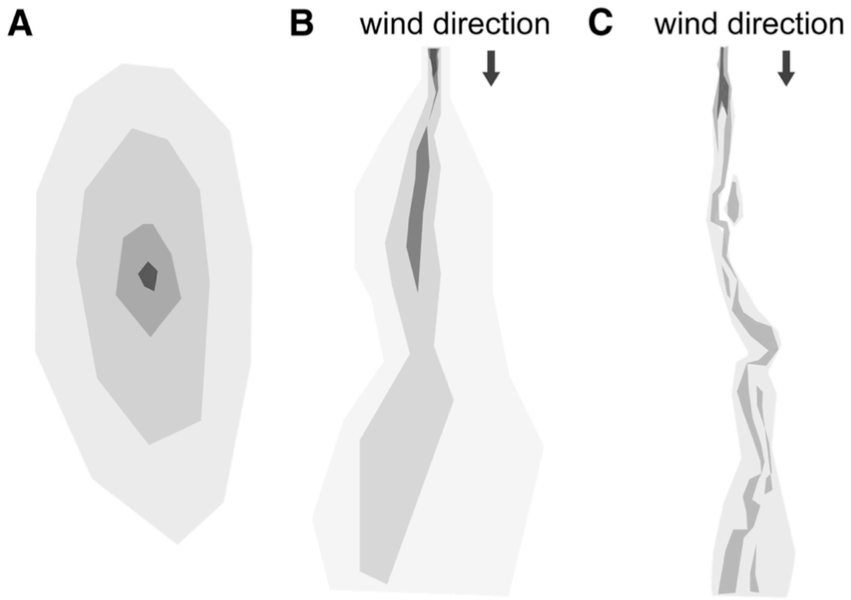
Mice

Animals across phyla engage in **active** olfactory **search**.

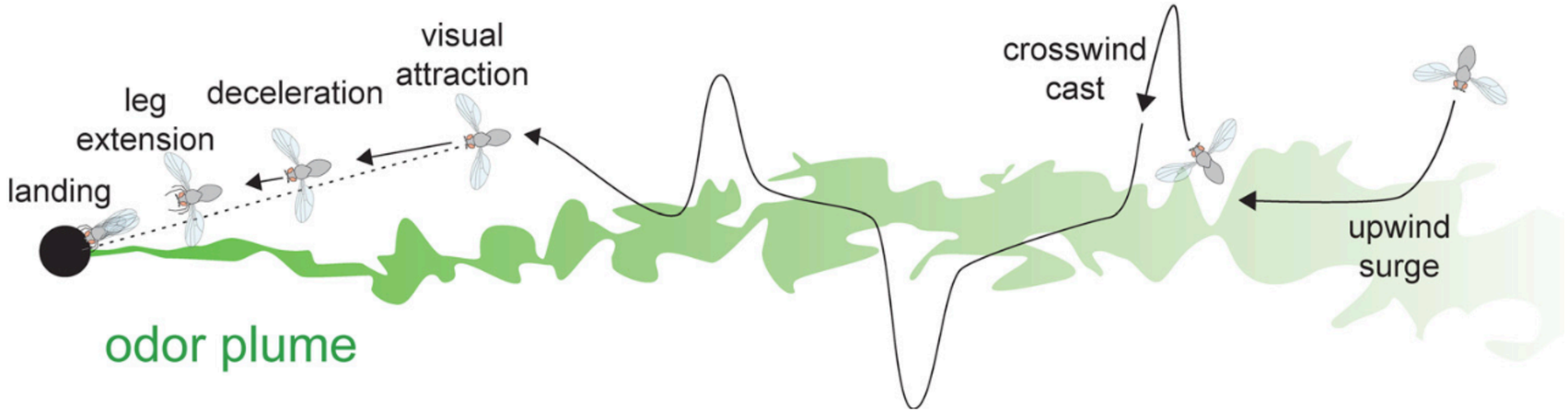
Using strategic movements to follow a scent trail.

(Baker et al, 2018)

Move to track across complex trails

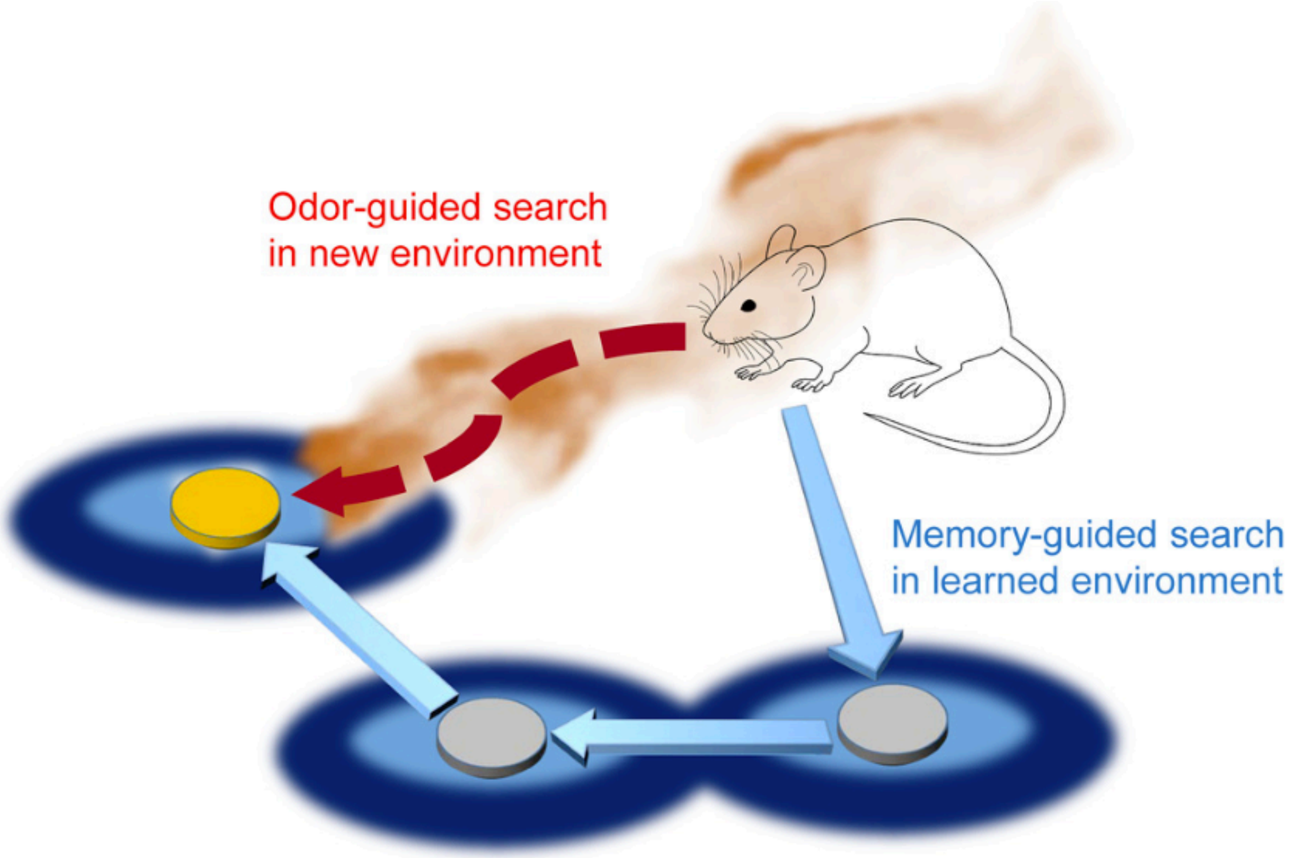


Wind creates complex plume patterns that can be tracked using simple sequential reflexes



(Baker et al, 2018)

Having a brain helps



Having a spatial memory with a cognitive map aids in tracking scents in more complex environments.

(Baker et al, 2018)

Take home message

- Chemotaxis is one of the evolutionarily oldest goal directed actions.
- It reflects a simple algorithm: keep moving in this direction until the scent signal decreases.
- More complex abilities (e.g., cognitive maps) can boost search efficiency.

Lab 3: Random exploration

URL: https://coaxlab.github.io/BIX-book/notebooks/lab3-chemotaxis.html