\[ \nu \sim 30 \frac{\mu m}{sec}, \tau \sim 1 \text{ sec}, D \sim \frac{(v\tau)^2}{2 \tau} \sim \frac{v\tau}{2} \sim 500 \frac{\mu m^2}{\text{sec}}, x \sim \sqrt{Dt} \]

10 sec : 70 \mu m
1 min : 170 \mu m
1 hr : 0.15 cm
1 day : 0.7 cm

Not fast enough!
Increase \( \nu \)? Increase \( \tau \)?

Motor Brownian
limitation rotation
(power\( \sim \nu \cdot v \)) (20 deg.in 1 sec)
Two mechanisms for detecting gradients:
Spatial detection mechanism (simultaneously compare the intensity of stimulation of receptors at different parts of organism) and
Temporal detection mechanism (sequential compare the intensity of stimulation at different times, between which the organism moves from one location to another.
Spatial gradient sensing is impossible. Thus, temporal mechanism.
flagella: left-handed helices
Attractant – CCW (run); repellant – CW (tumble).
Bacteria are not so simple. They can detect very small changes in chemical concentrations in the range from $10^{-3} \mu M$ to $10^3 \mu M$.

But they are not so complicated, either. In the present of positive or negative gradient, the cells achieve the chemotaxis by varying tumbling frequency.

*The main question is: what is the molecular mechanism?*
How does the temporal sensing mechanism works?

First, how does bacterium swim?
Each receptor is responsible for a group of chemicals
1) CheW is a docking protein
2) CheA is an autophosphorylating kinase (wasteful cycle)
3) CheA-P passes P to CheY and CheB
4) CheY-P diffuses, binds to the motor, CCW → CW. (~ 0.1 sec)
5) CheZ dephosphorylates CheY-P
6) Methylation increases ability to phosphorilate CheA
7) CheR transfers methyl groups to the receptor
8) CheB-P demethylates the receptor (~ 10 sec – 10 min)

MCP = methyl-accepting chemotactic protein

Conformational change

4 methylation sites at each α-helix; 8 - total