Biology
SCI102

Module 4
Biological Response in Context
Adaptation, Reproduction, Control & Stability, Optimized Use of Resources

Compiled from Biology for Engineers

Adaptations

Adjustment or changes in behavior, physiology, or structure of an organism to become more suited to an environment

Hold breath under the water for up to 5 minutes!

- Mutations
- More production of Carbonic anhydrase — slows build up of CO2 in the blood
- Changes in muscle contraction around spleen and responses to low O2 levels

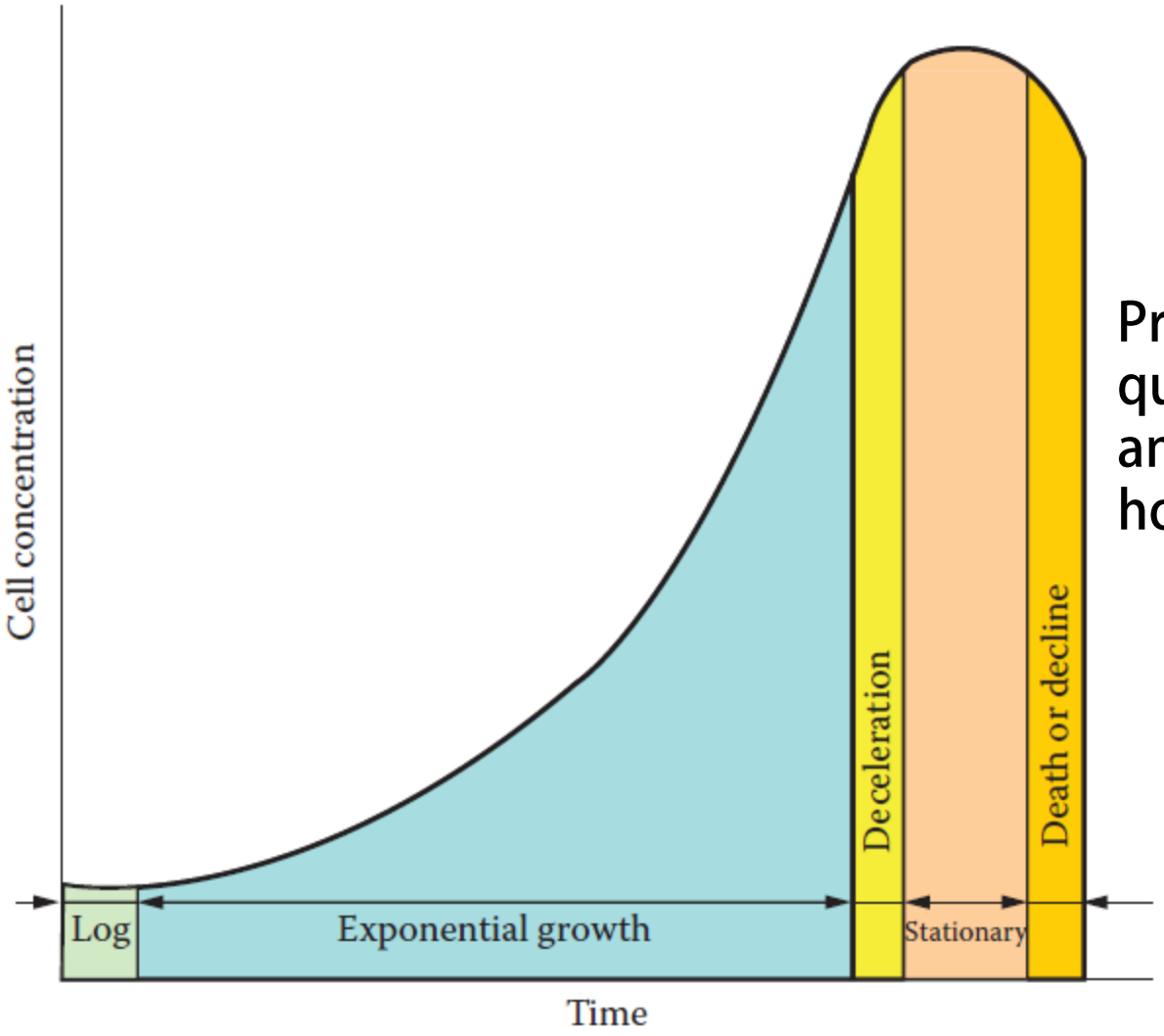
Structural Adaptations

Behavioral Adaptations

Prokaryotes – Masters of Adaptation

Utah's Great Salt Lake can reach a salt concentration of 32% pink color comes from living prokaryotes

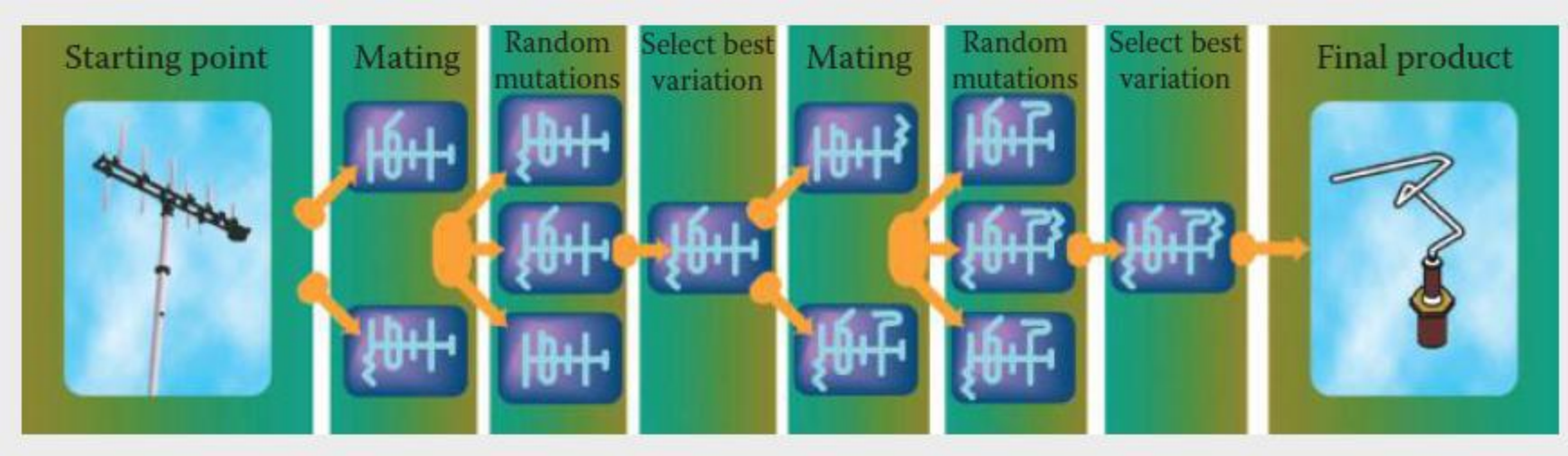
Prokaryotes – Masters of Adaptation



Prokaryotes reproduce quickly by binary fission and can divide every 1—3 hours

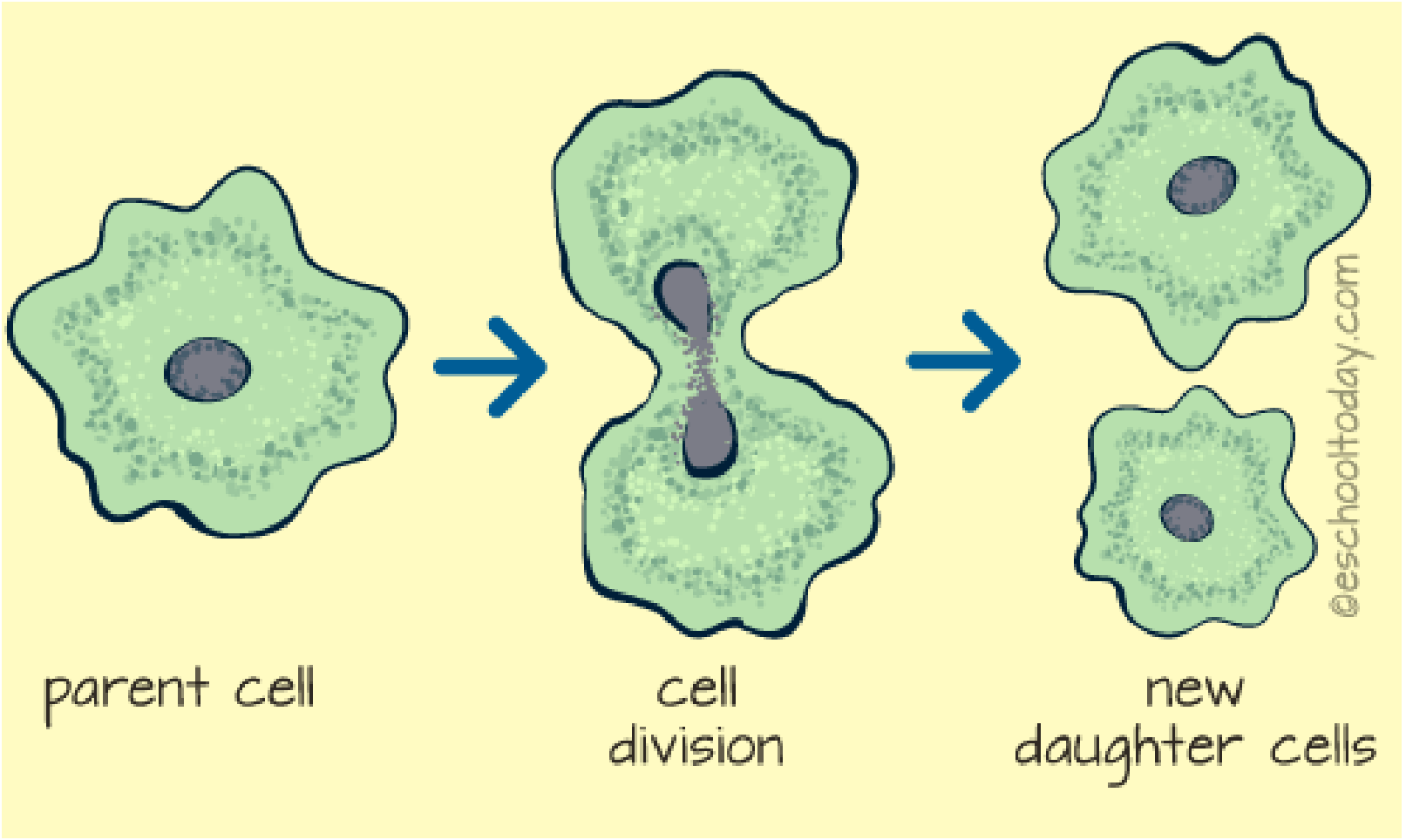
Directed Evolution As a Design Technique

Evolutionary principles are used as a design paradigm for hundreds of inventions

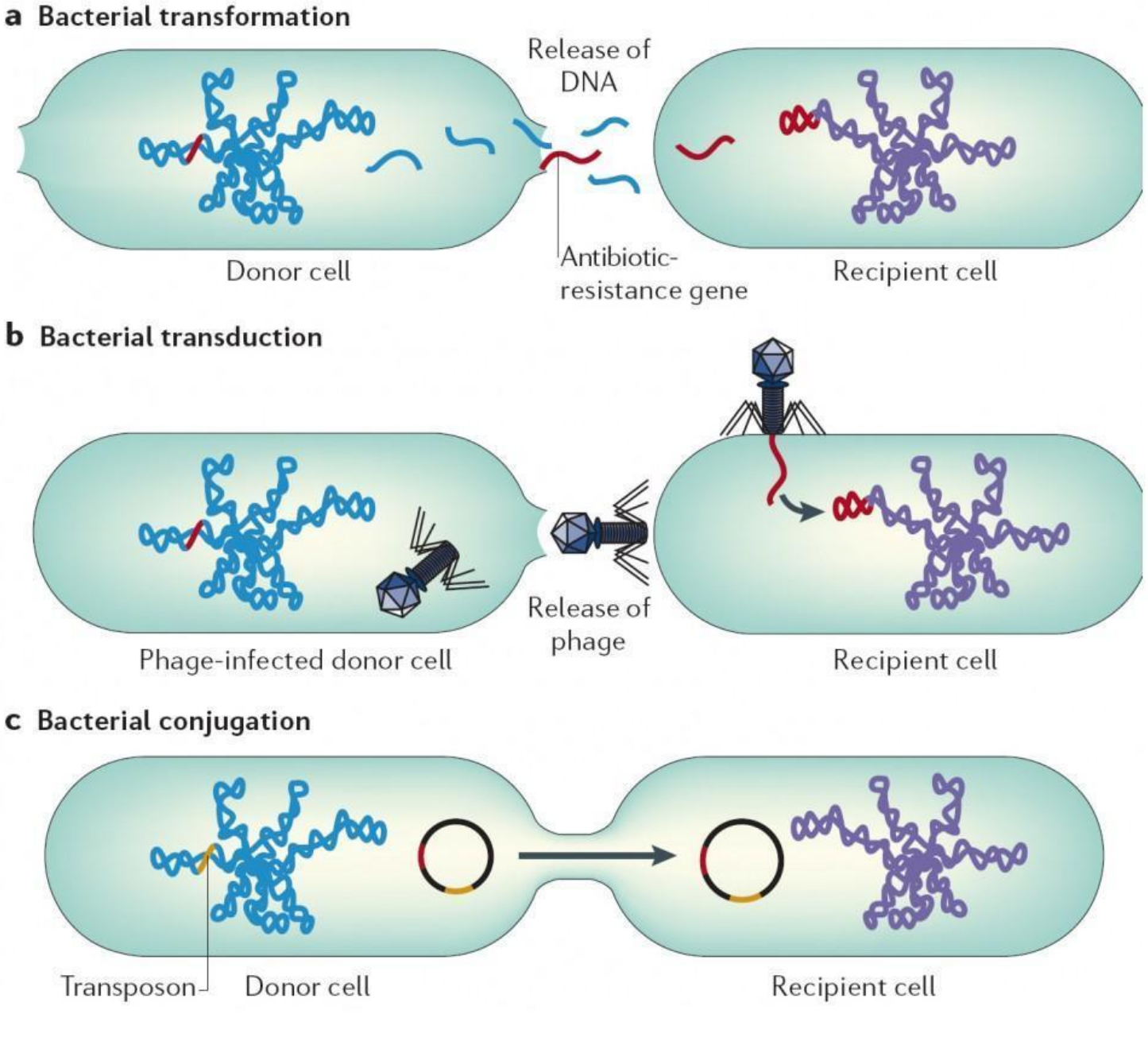


Human economies alter evolutionary paths of animals
Case of Pink Salmon

Reproduction

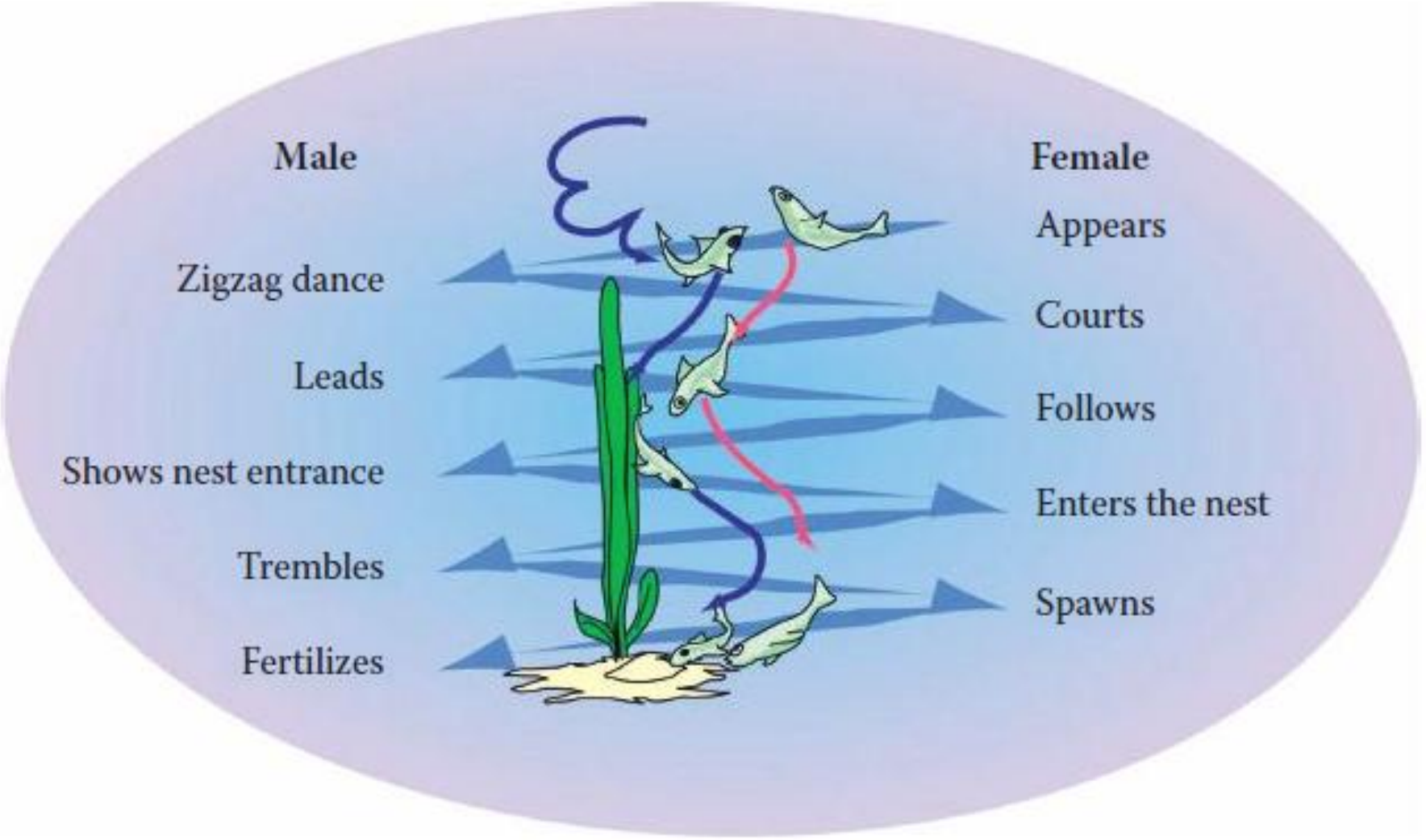


Bacteria divide by Binary Fission



Bacterial Gene Transfer

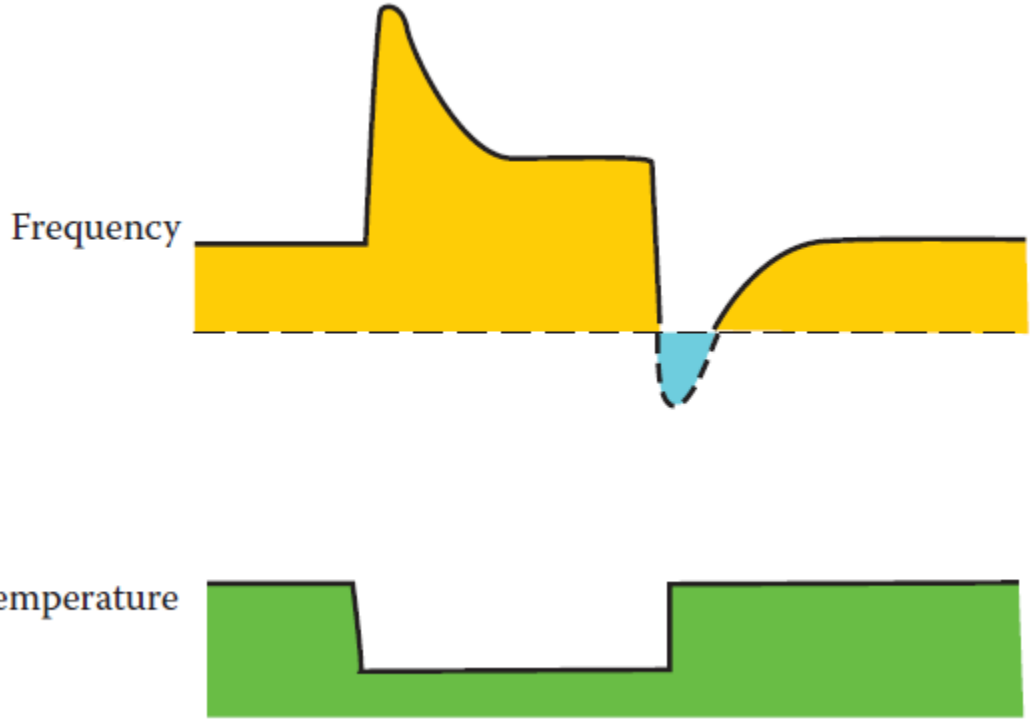
Sexual Reproduction



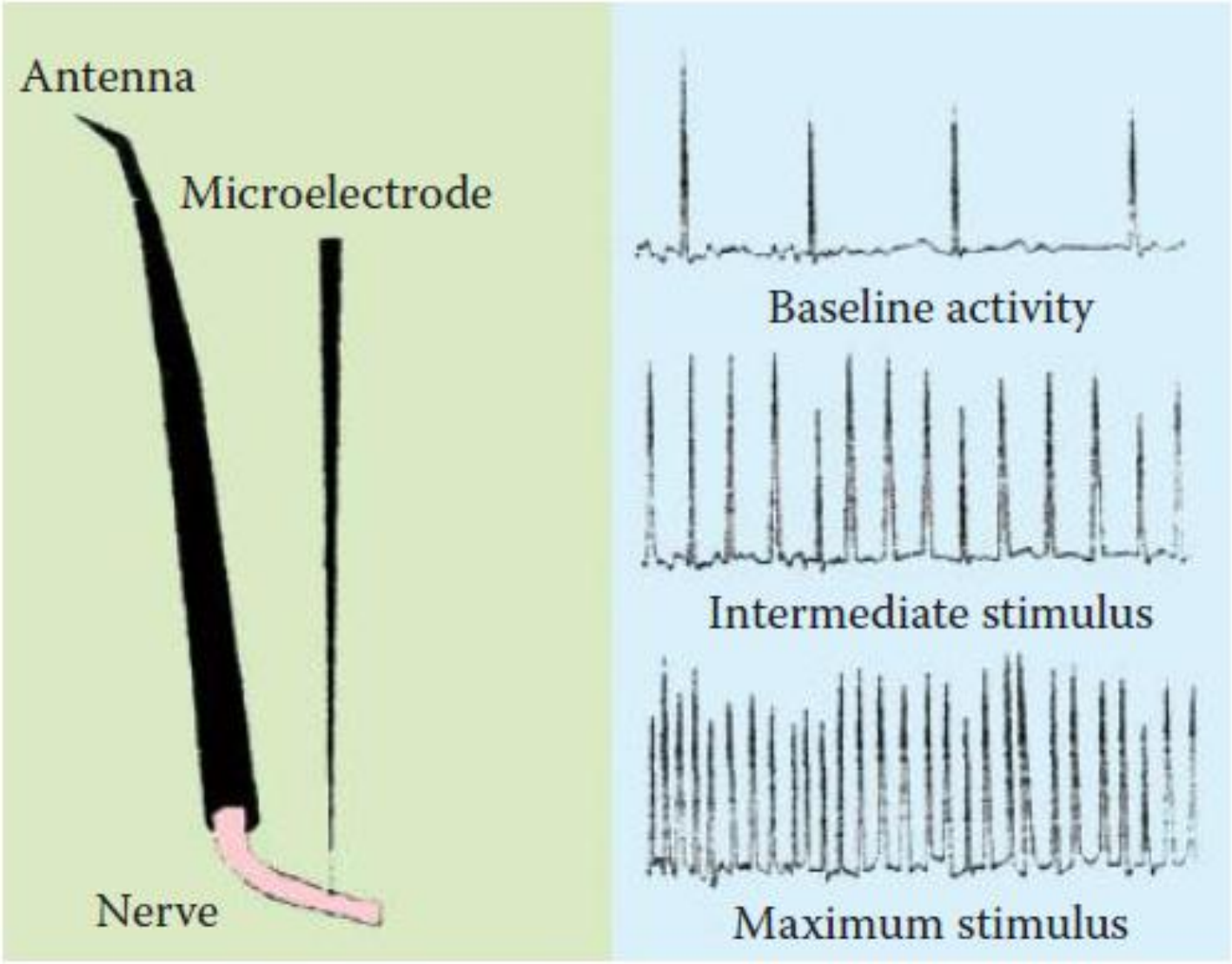
Sexual reproduction is highly complicated and mandates coordinated activities

Stability with Exquisite Control

Control systems are
- Sensors : receptors and transducers
- Actuators
- Controller
- Means to communicate among these elements



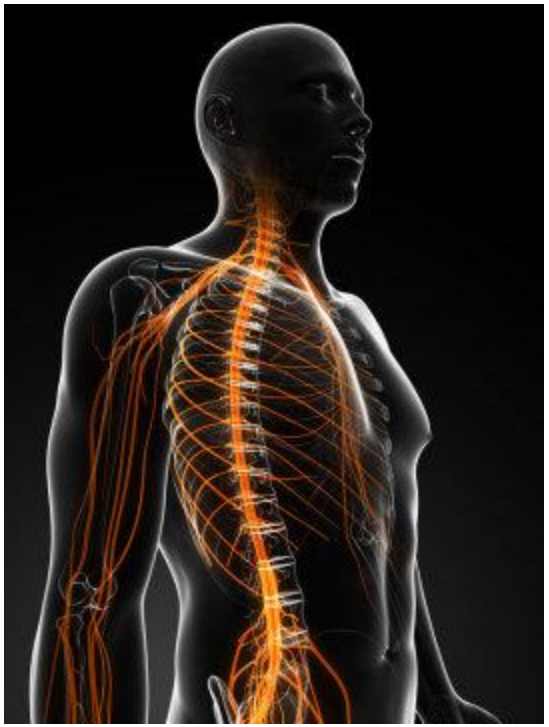
Cold Receptor Response

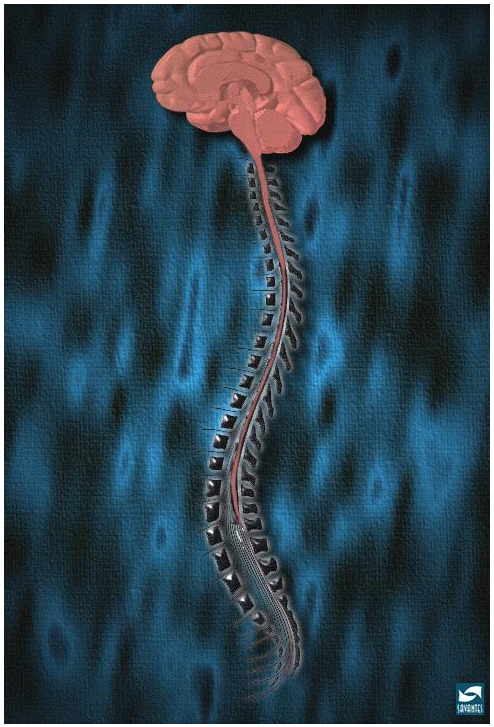


The frequency output of an insect antenna is shown for several stimulus levels — beyond threshold stimulus

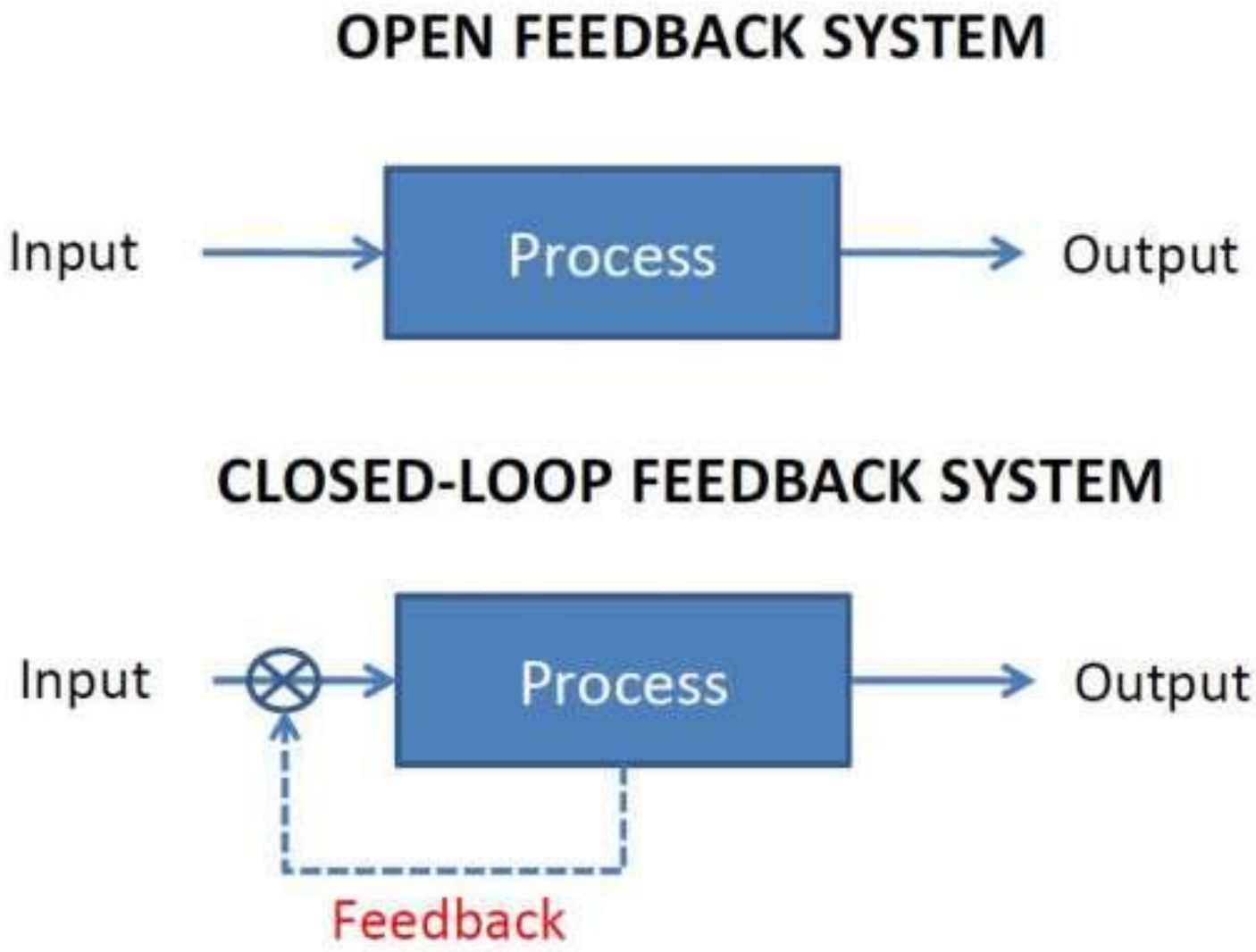
Controllers

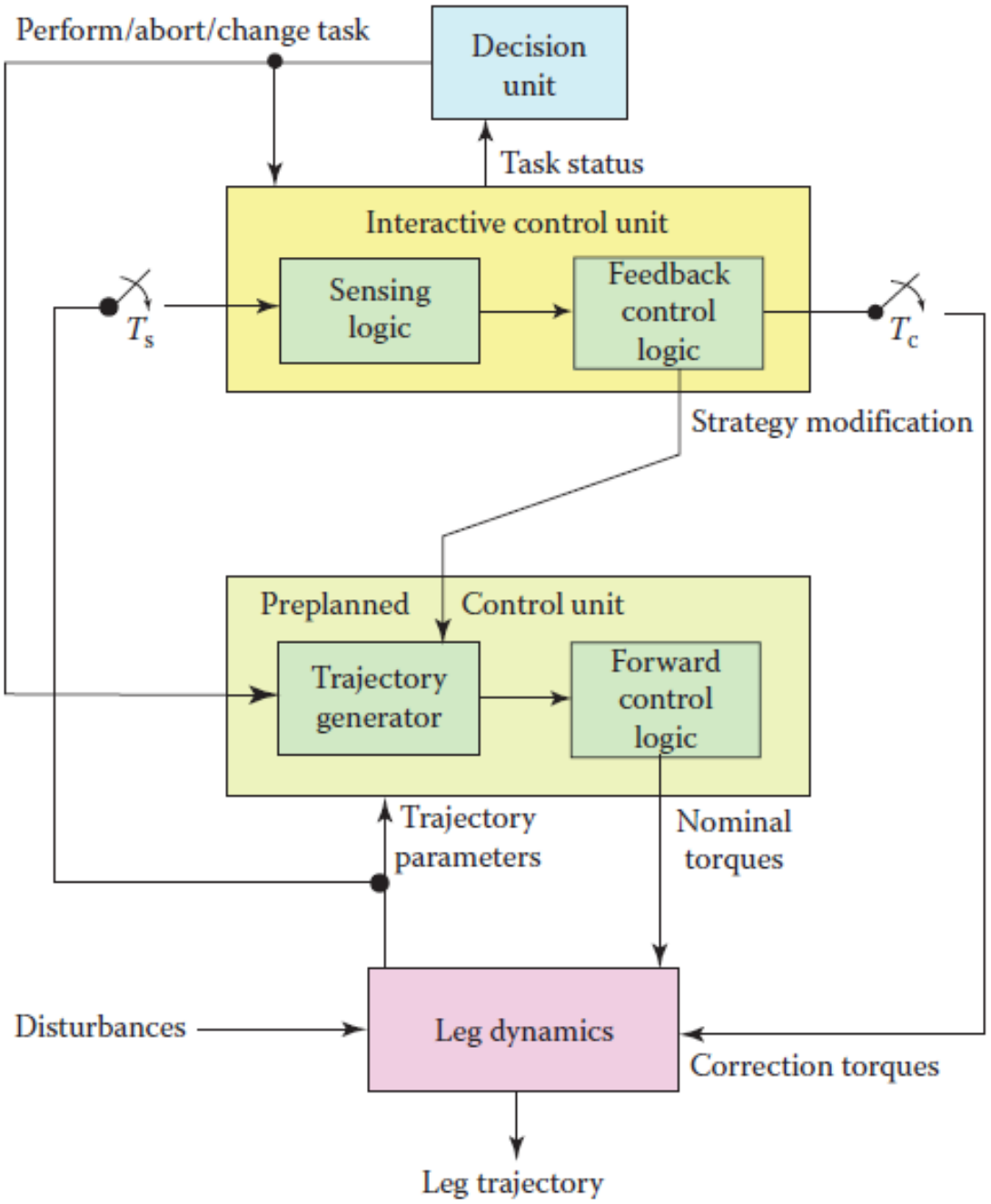
- Central nervous system : CNS
- Spatial summation of inputs from many of the same type of receptors at different locations around the body
- Loop control: Open Loop and Feed-back Control Loops





Controllers

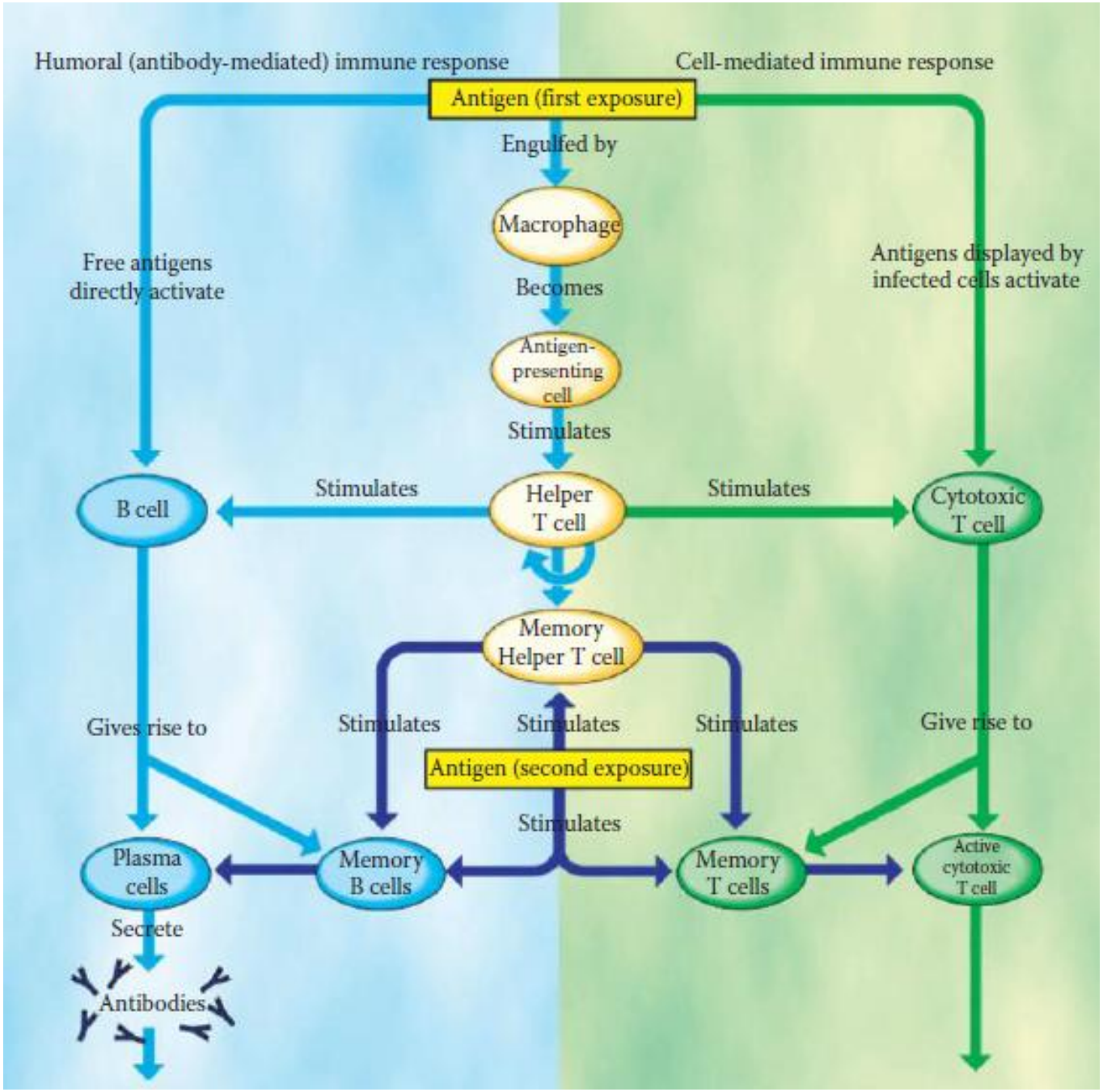




Hierarchical control of a stepping motion

Redundancy

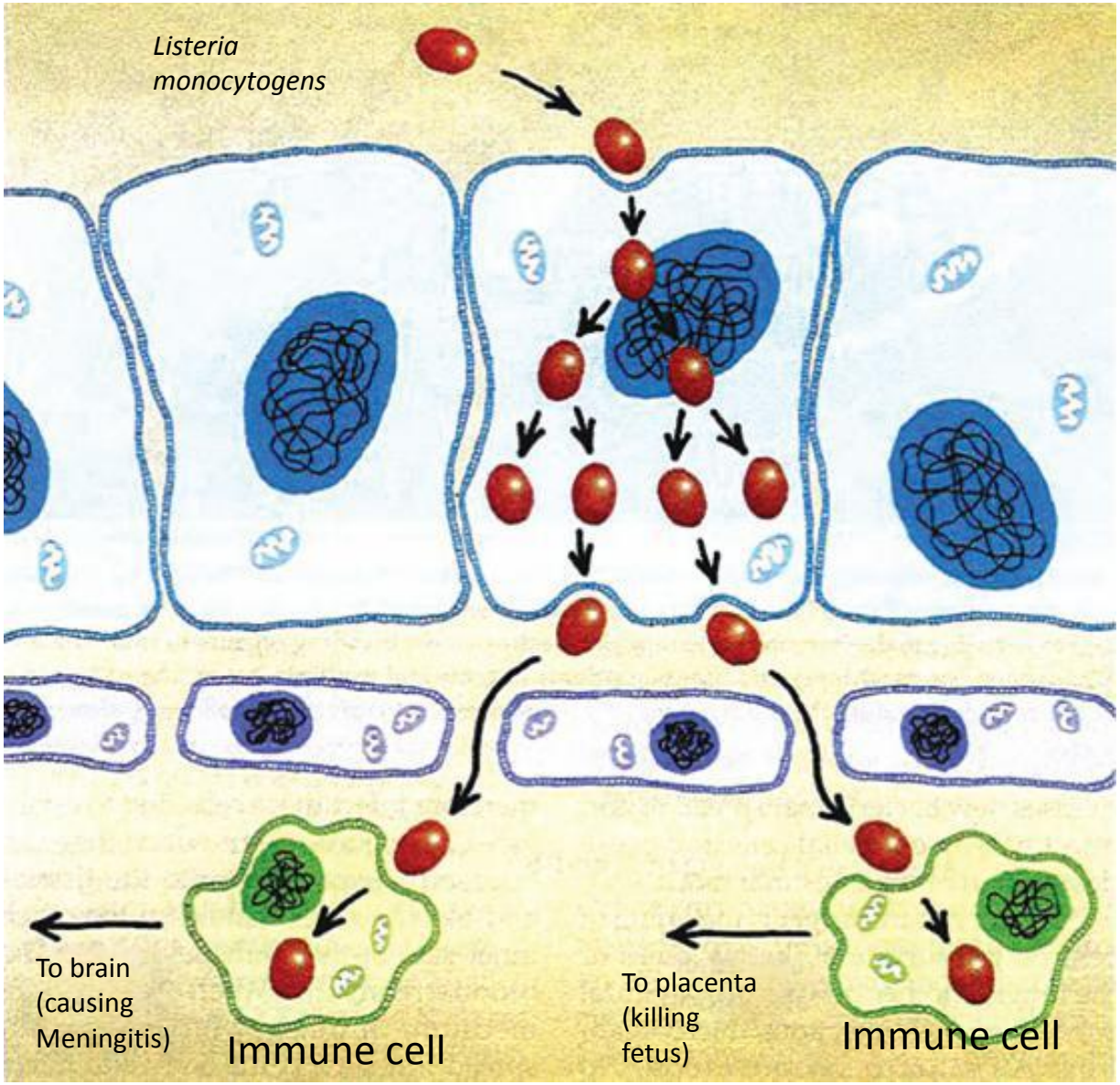
- Backup Option - Necessary in case any of the feed back loop fails
- E.g. - Sweating in paraplegic people in-spite of impaired spinal cord
- E.g. - Cells have alternate pathways to survive lower amounts of a particular metabolite
- E.g. — Adaptability of brain



Immune System – Model of Ultra Redundancy

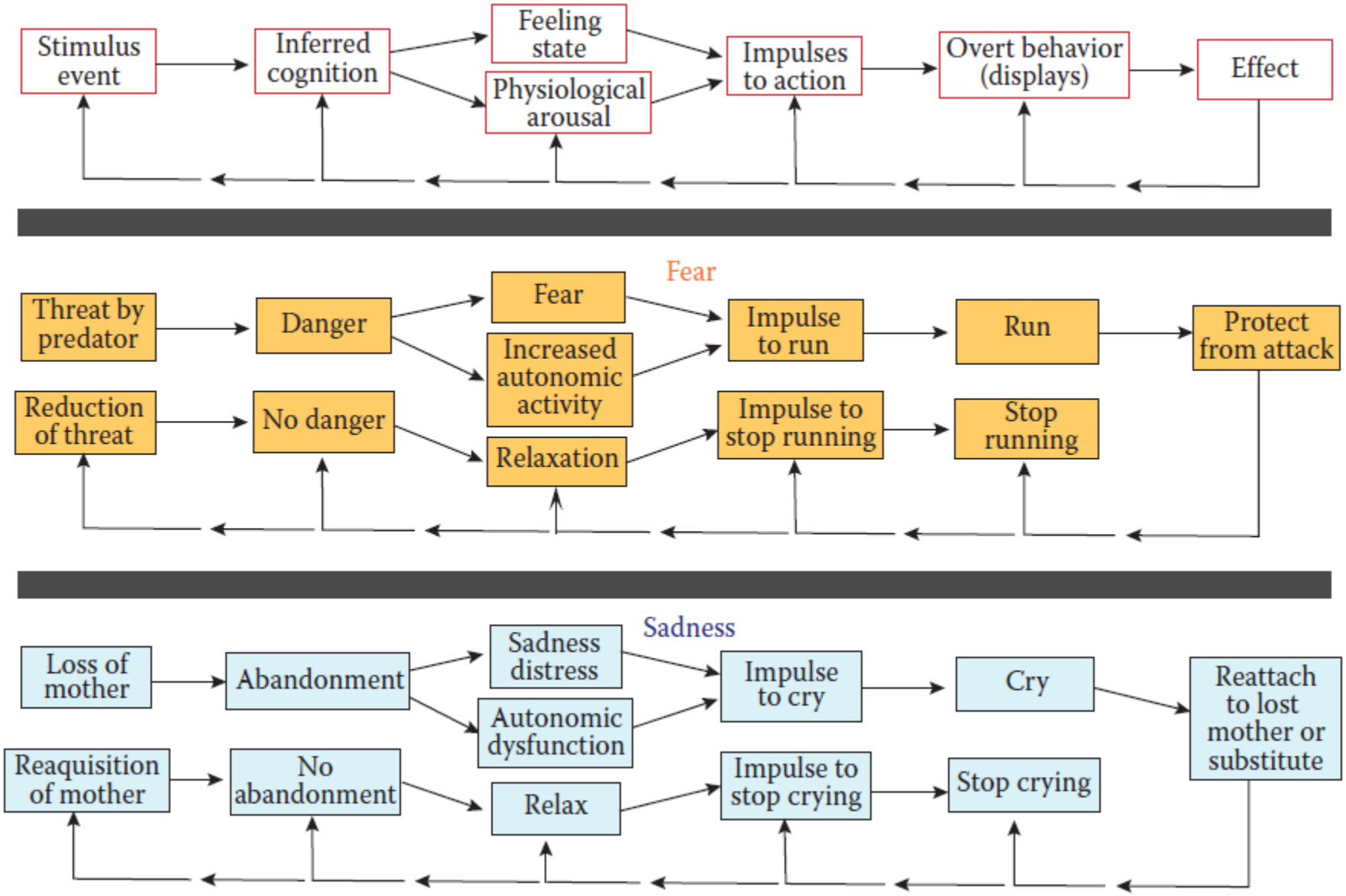
Kills extracellular pathogens

Kills intracellular pathogens



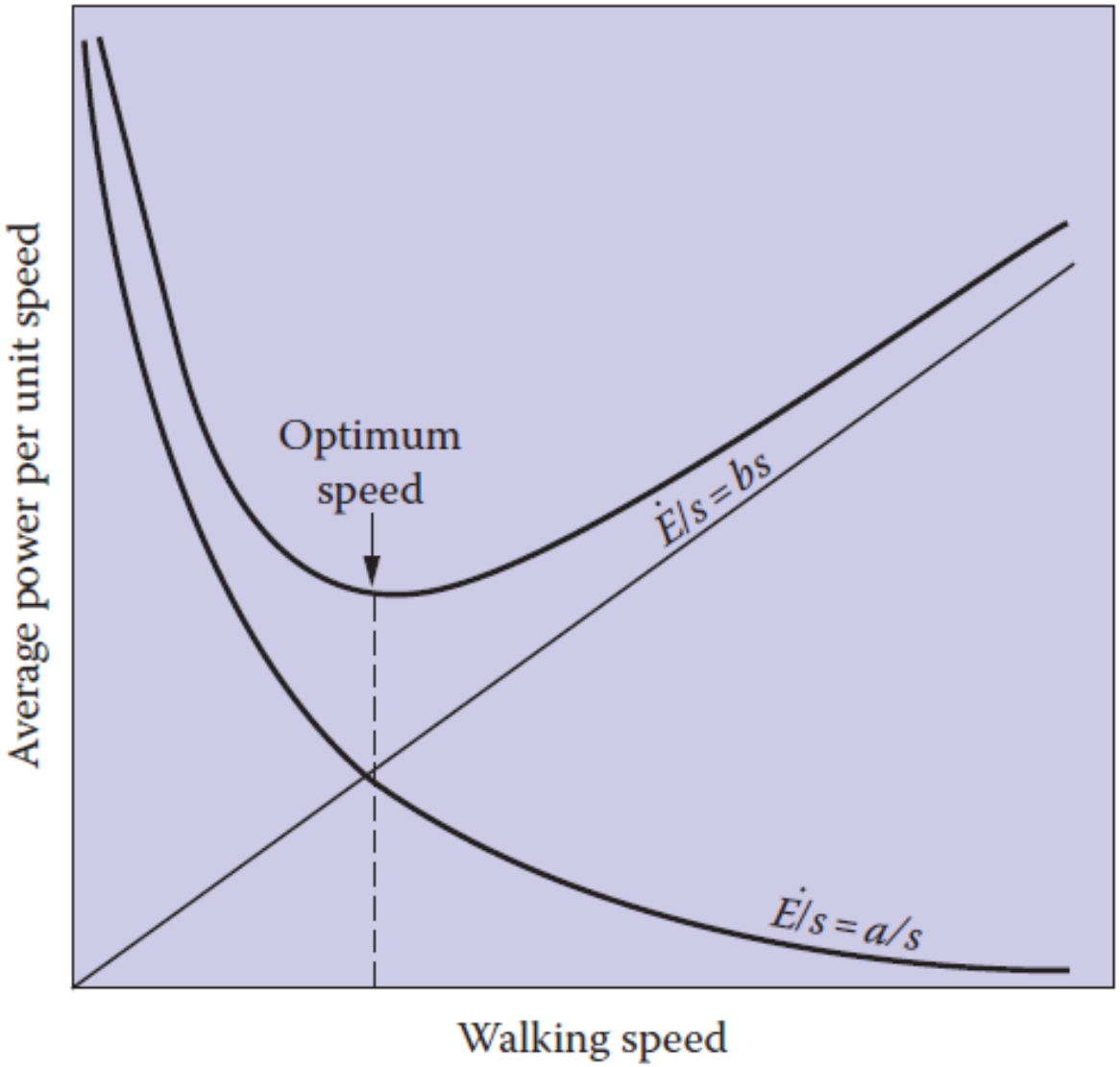
Listeria bacteria invading intestinal lining

Emotions are Under Control

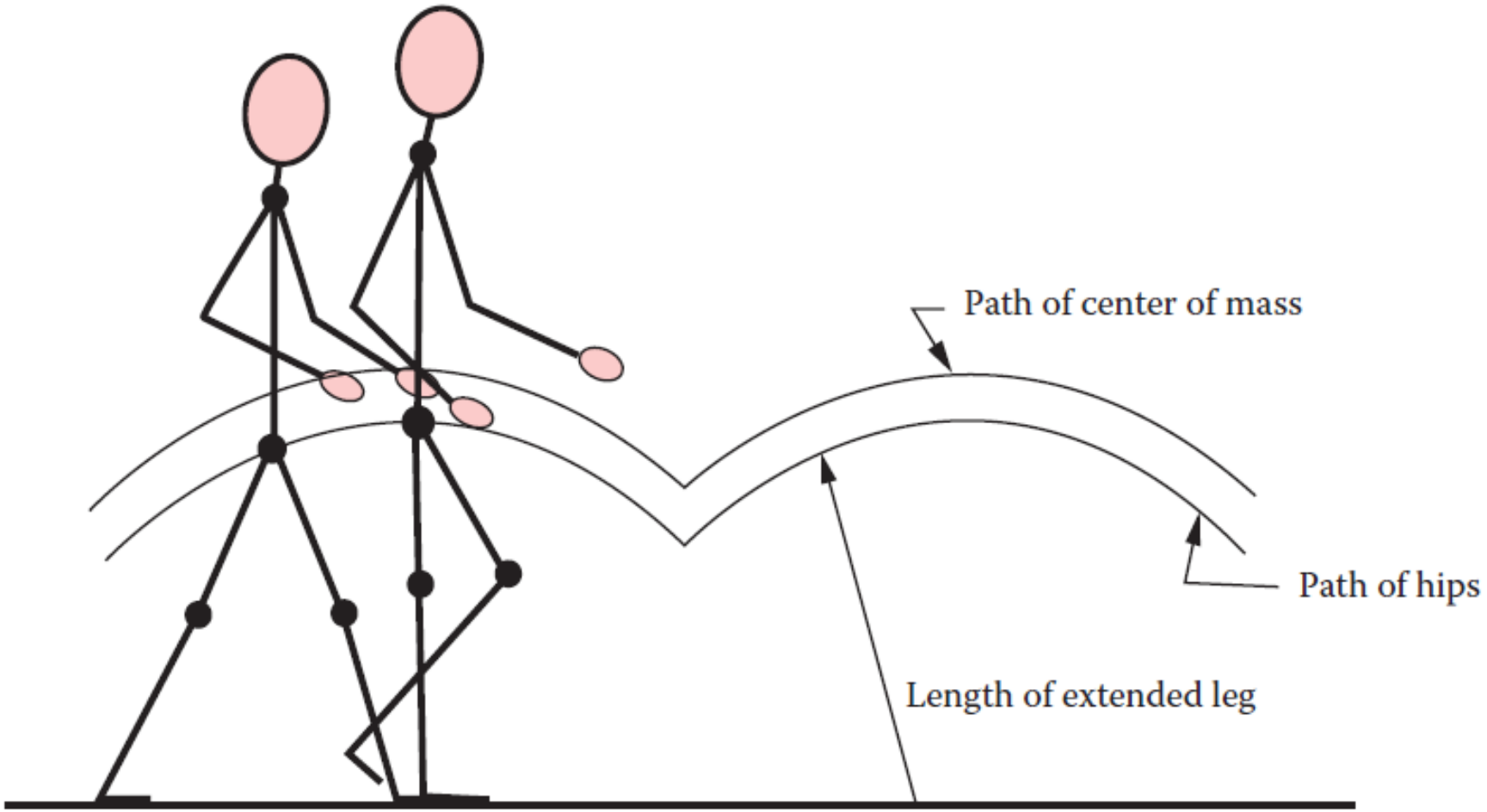


Optimized Use of Resources

- Interplay between cost and benefit

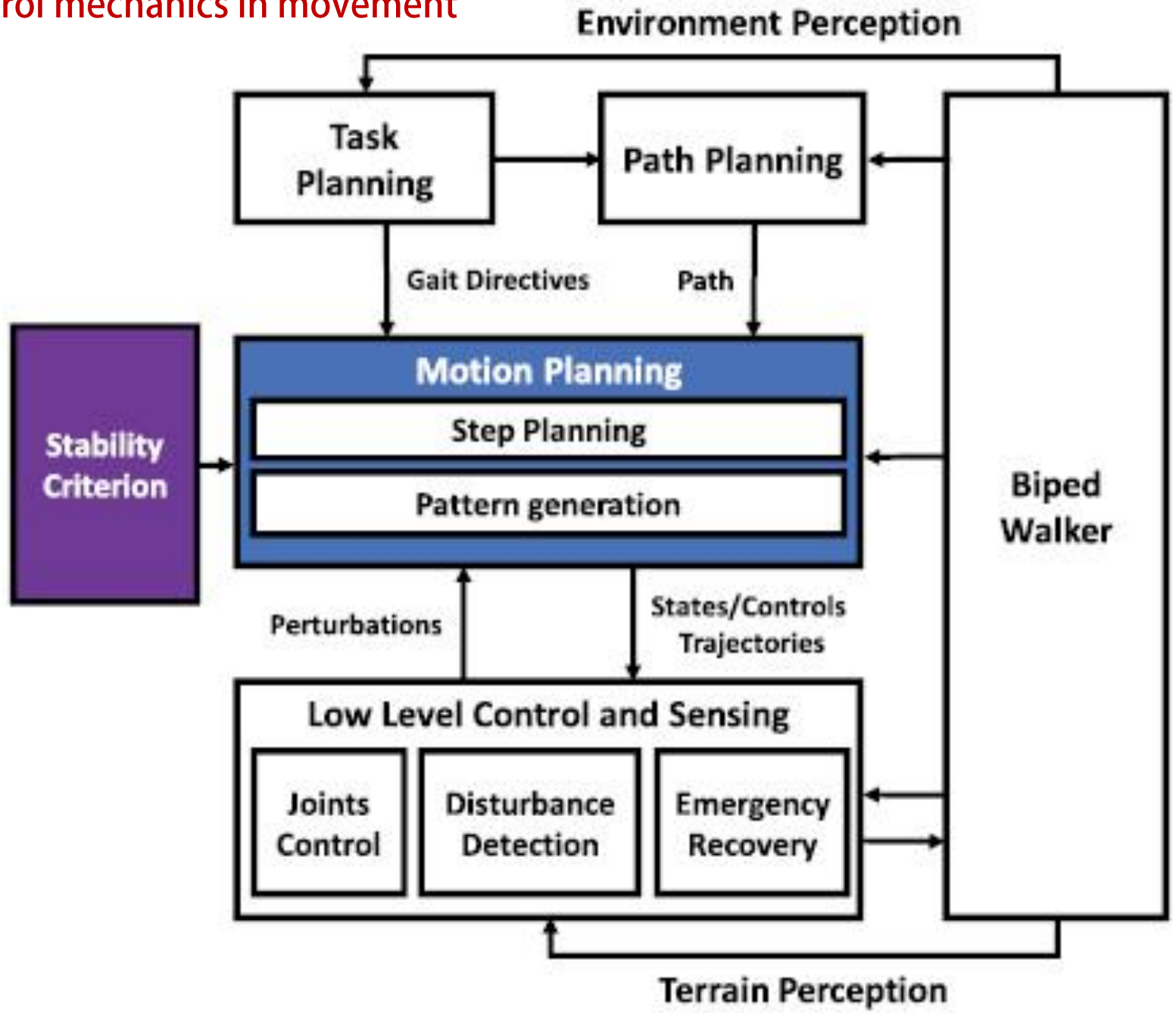


Optimized Use of Resources

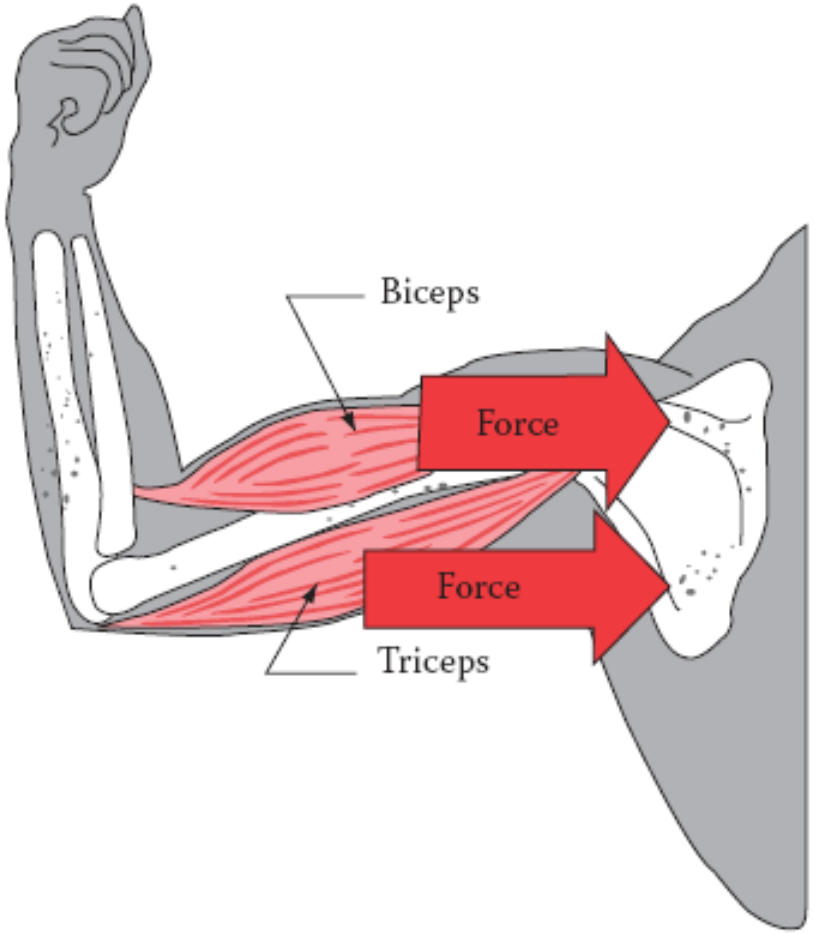


Raising and lowering of the body's center of gravity during walking contributes to walking efficiency

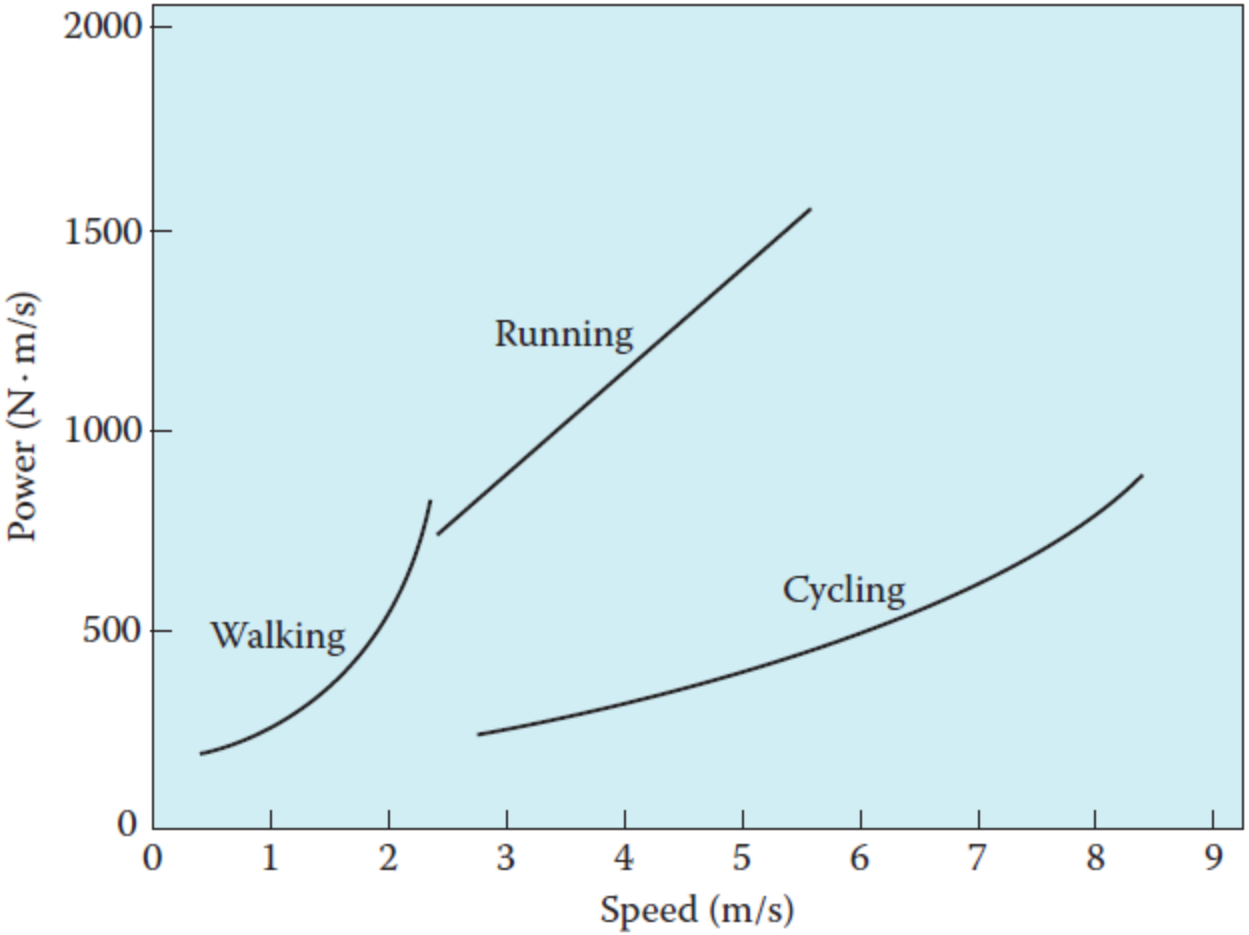
Control mechanics in movement



Antagonistic control of movements occurs as a result of two or more active muscles pulling in opposite directions. The result is that the movement can be made more precisely than if only one active muscle was involved.

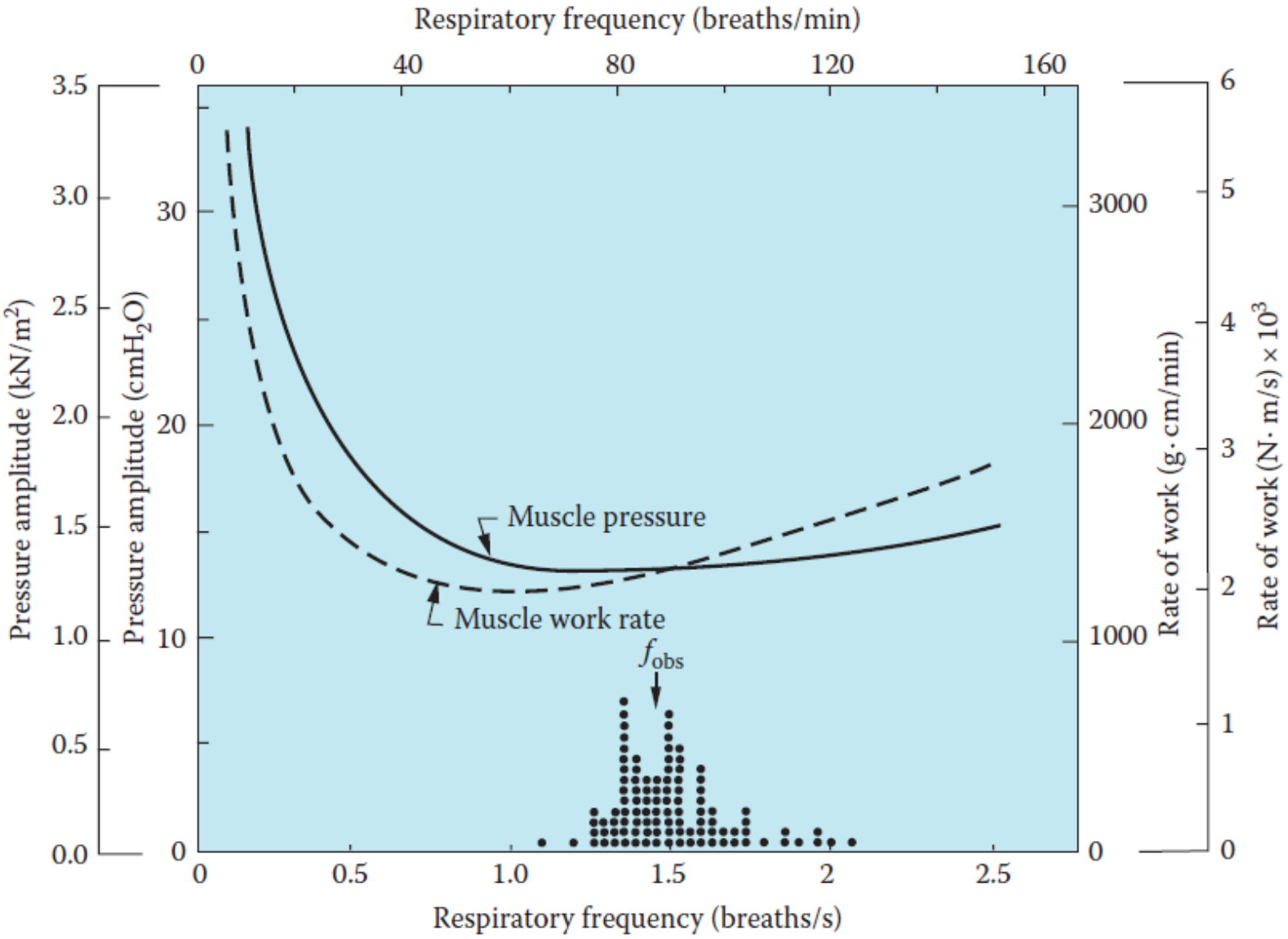


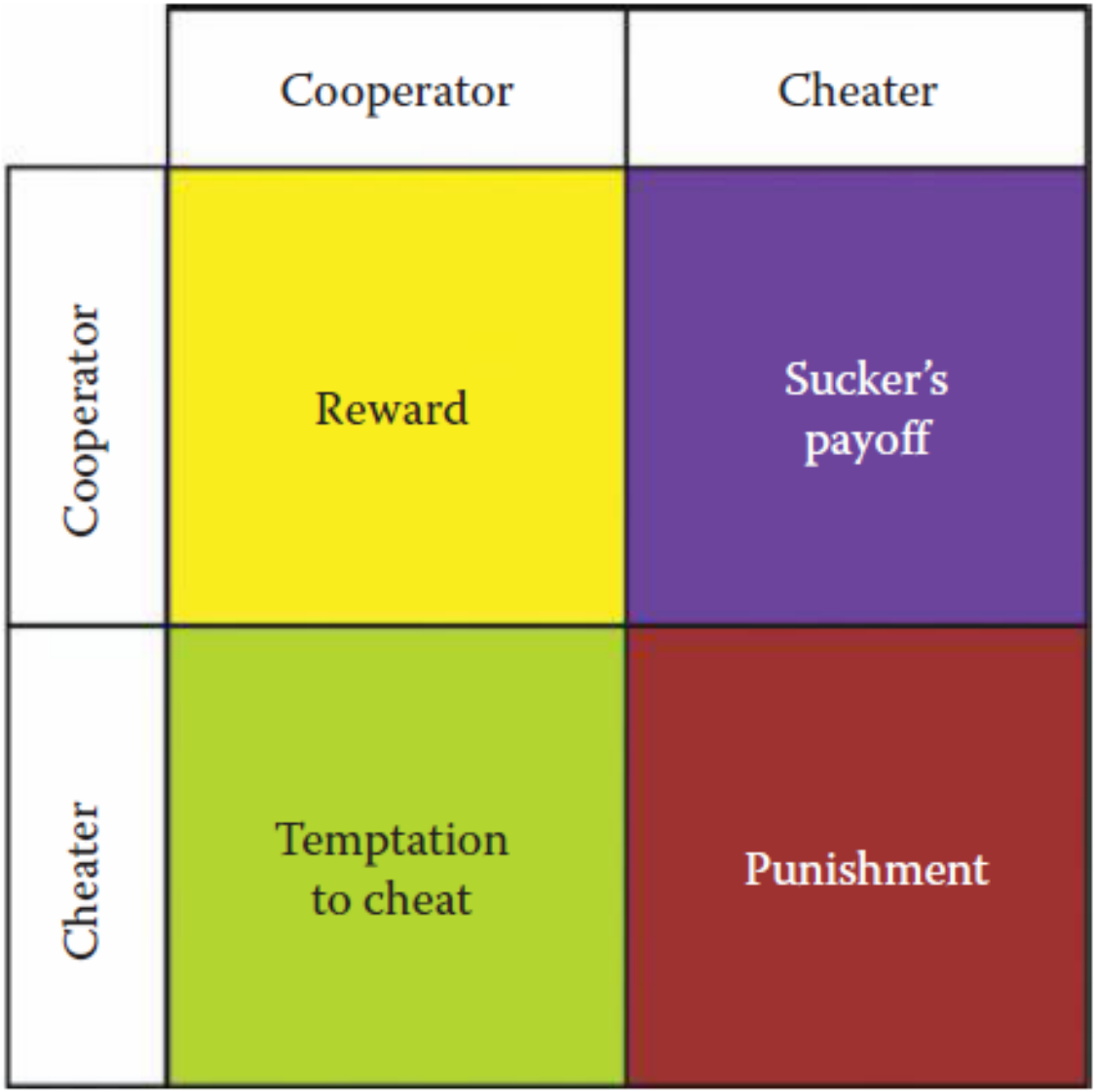
Optimized Use of Resources



Cycling is more energy efficient than walking or running, despite the extra weight of the bicycle, because the body's center of gravity stays at a particular level

Finding Optima – Trial & Error





Pay-off Matrix

Optimization in a group