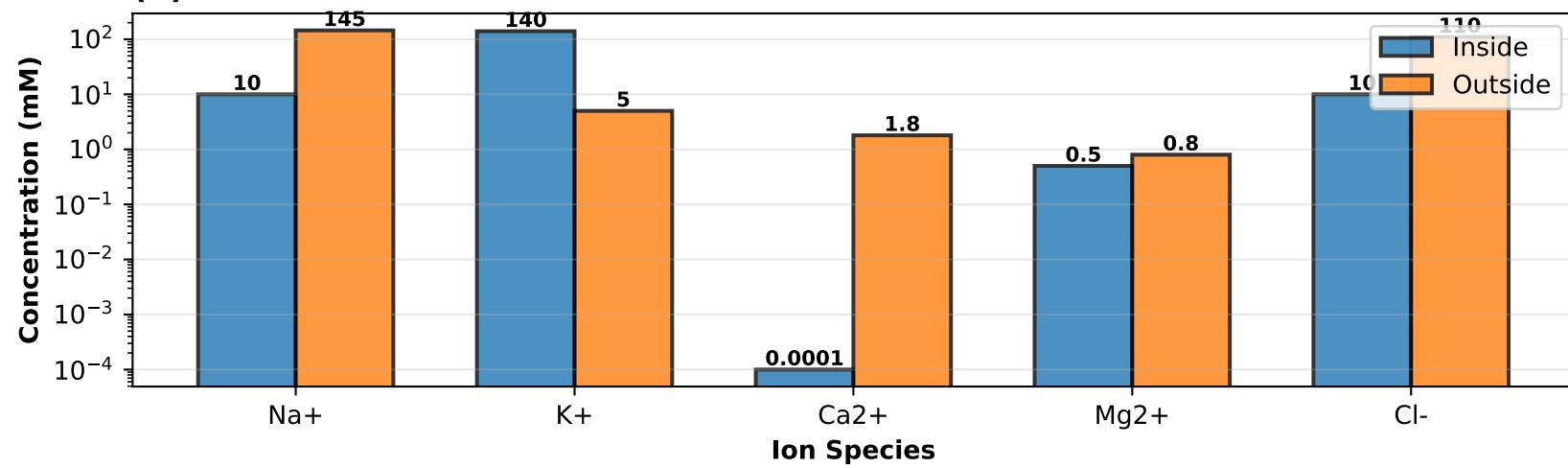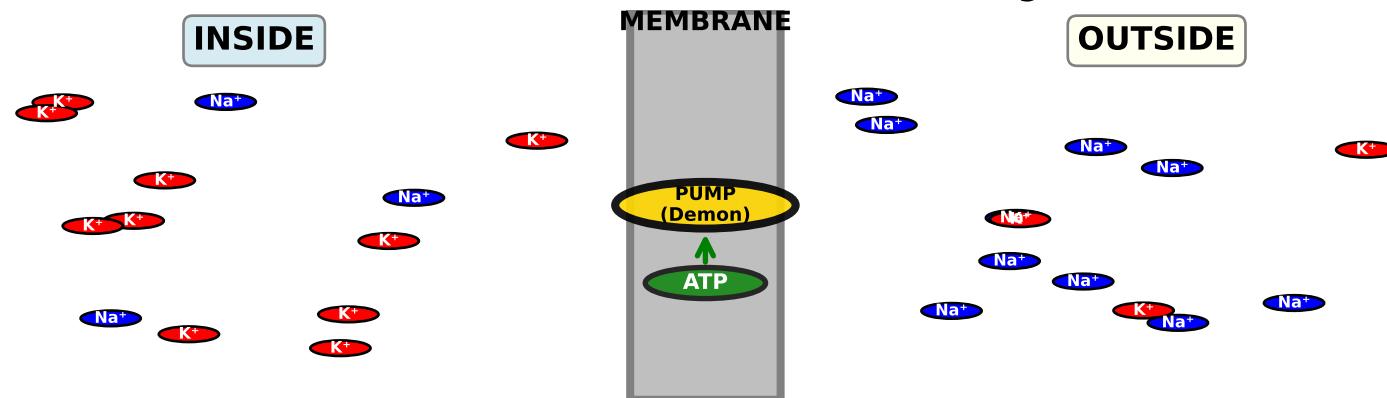Figure 20: Biological Maxwell Demon - Information-Driven Energy Extraction
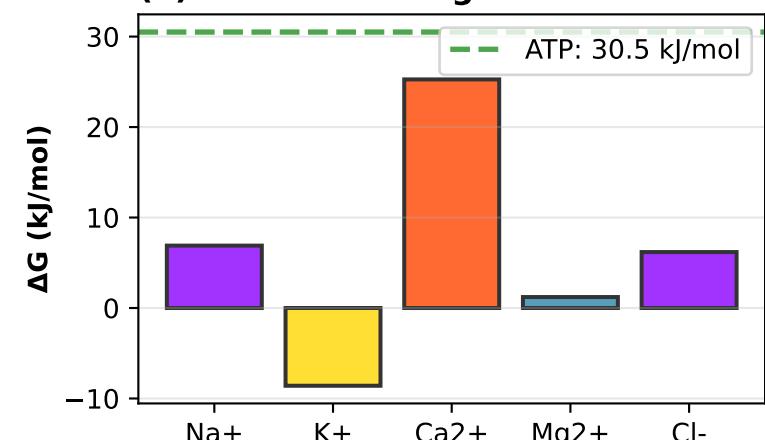
(A) Ion Concentration Gradients - Maxwell Demon Substrate

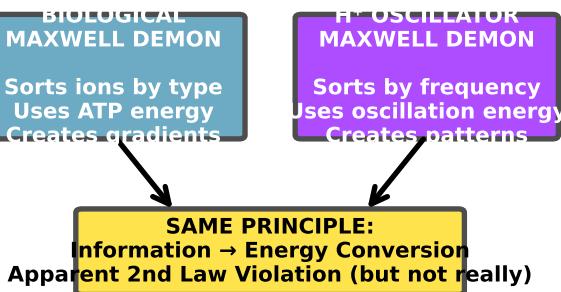**(B) Gradient Strength**

(C) Maxwell Demon Mechanism - Information-Driven Sorting
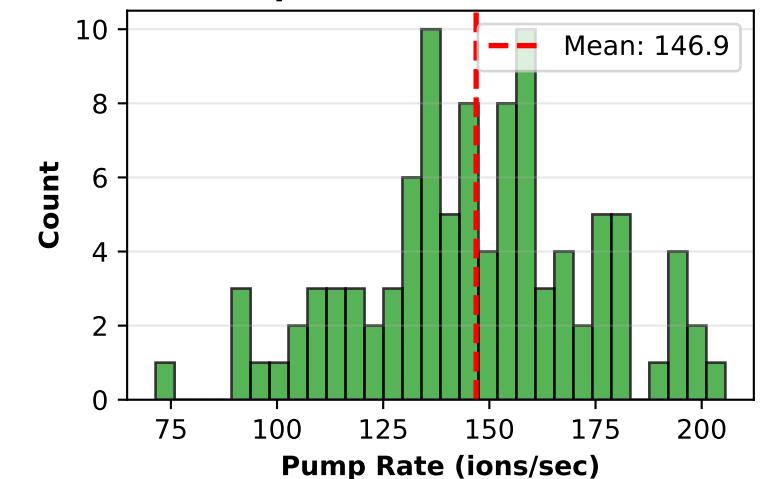
(D) Pump Rate Distribution

(E) Gradient Energies

(F) H+ Framework Analogy

BIOLOGICAL MAXWELL DEMON — Sorts ions by type, Uses ATP energy, Creates gradients

H+ OSCILLATOR MAXWELL DEMON — Sorts by frequency, Uses oscillation energy, Creates patterns

SAME PRINCIPLE: Information → Energy Conversion, Apparent 2nd Law Violation (but not really)

```
MAXWELL DEMON SUMMARY

Physical Parameters:
• Temperature: 37.0°C (310.15 K)
• ATP energy: 30.5 kJ/mol
• Trials: 100

Ion Gradients:
• Na+: 14.5× (out/in)
• K+: 0.03571428571428571× (out/in)
• Ca2+: 18000.0× (out/in)
• Cl-: 11.0× (out/in)

Demon Function:
• Sorts ions by information
• Extracts work from gradients
• ATP-driven operation
• Maintains non-equilibrium

H+ Framework Connection:
• Biological: Ion sorting
• H+ system: Frequency sorting
• Both: Information processing
• Both: Energy extraction

Validation:
• Maxwell demon: ✓
• Information → Energy: ✓
• H+ analogy: ✓
```