

Firefly Bioluminescence: Energy Budget Analysis

1. Total Luciferase: $1.0\text{e}+11$ molecules

2. Oxygen-limited turnover: 0.01 reactions/sec/enzyme

3. Quantum yield: 0.41 photons/reaction

4. Flash duration: 250 ms

5. Total photons: $1.02\text{e}+08$ photons/flash

ATP BUDGET CHECK:

- Energy per photon: 2.22 eV
- ATP per photon: 7.4 molecules
- Total ATP consumed: $7.57\text{e}+08$ molecules
 - Cellular [ATP]: 3.0 mM
- Total ATP available: $1.81\text{e}+14$ molecules
 - Fraction used: 0.0% ✓ PLAUSIBLE

HISTORICAL MEASUREMENT (Ives & Coblenz 1924): $3.26\text{e}+14$ photons
DISCREPANCY: $3176417\times$ overestimate (6.5 orders of magnitude)