

Absorption and Emission

Electronic Transitions

Ground state (S_0) → Excited states (S_1, S_2, \dots)

$$\Delta E = E_{\text{excited}} - E_{\text{ground}} = h\nu$$

Allowed transitions follow selection rules

Vibrational Modes

Molecular vibrations (stretching, bending)

IR absorption region

Fine structure in spectra

Characteristic frequencies for bonds

Selection Rules

Allowed: $\Delta l = \pm 1$ (dipole transitions)

Spin: $\Delta S = 0$ (singlet-singlet)

Symmetry: Determines intensity

Forbidden: Weak but observable

Stokes Shift

$$\lambda_{\text{emission}} > \lambda_{\text{excitation}}$$

Energy loss to vibrations

Typically 20-100 nm shift

Enables fluorescence detection

Quantum Yield (Φ)

Φ = photons emitted / photons absorbed

Range: 0-1 (0-100%)

High Φ → bright fluorophores

GFP: $\Phi \approx 0.79$