

$F(n_{bp}) \propto \frac{\alpha}{\gamma} + \gamma \ln N_{bp}$ Quantum Mechanics and Artificial and Natural Spectroscopy $E_{bend} = \frac{\pi^2 \hbar^2 k_B T}{R}$



$$F(n_{bp}) = \frac{\alpha}{\gamma} + \gamma \ln N_{bp}$$

Quantum Mechanics and Artificial and Natural Spectroscopy

$$E_{bend} = \frac{\pi \frac{d}{p} k_B T}{R}$$

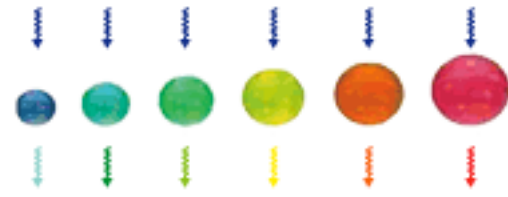
| Frequency | Wavelength | |
|----------------------------|--------------|--------------------------|
| 3 Hz | 10^8 m | |
| 3×10^1 Hz | 10^7 m | ELF |
| 3×10^2 Hz | 10^6 m | SLF |
| 3×10^3 Hz | 10^5 m | ULF |
| 3×10^4 Hz | 10^4 m | VLF |
| 3×10^5 Hz | 10^3 m | LF |
| 3×10^6 Hz | 10^2 m | MF |
| 3×10^7 Hz | 10^1 m | HF |
| 3×10^8 Hz | 1 m | VHF |
| 3×10^9 Hz | 10^{-1} m | UHF |
| 3×10^{10} Hz | 10^{-2} m | SHF |
| 3×10^{11} Hz | 10^{-3} m | EHF |
| | 10^{-4} m | 1.24×10^{-2} eV |
| Infrared | 10^{-5} m | 1.24×10^{-1} eV |
| Visible | 10^{-6} m | 1.24 eV |
| Ultraviolet | 10^{-7} m | 1.24×10^1 eV |
| | 10^{-8} m | 1.24×10^2 eV |
| | 10^{-9} m | 1.24×10^3 eV |
| X Rays | 10^{-10} m | 1.24×10^4 eV |
| | 10^{-11} m | 1.24×10^5 eV |
| mass of electron | 10^{-12} m | 1.24×10^6 eV |
| γ Rays (gamma rays) | 10^{-13} m | 1.24×10^7 eV |
| | 10^{-14} m | 1.24×10^8 eV |
| mass of proton | 10^{-15} m | 1.24×10^9 eV |

Radio bands
 AM radio
 Short wave
 CB radio
 FM radio and television
 Mobile phones
 GPS

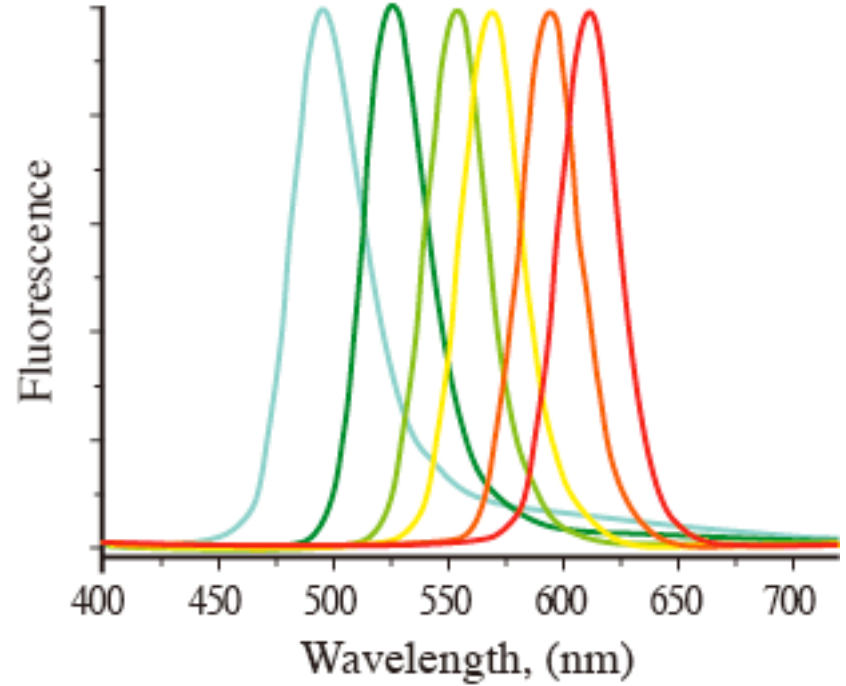
Energy per photon

JW UNSW Sydney

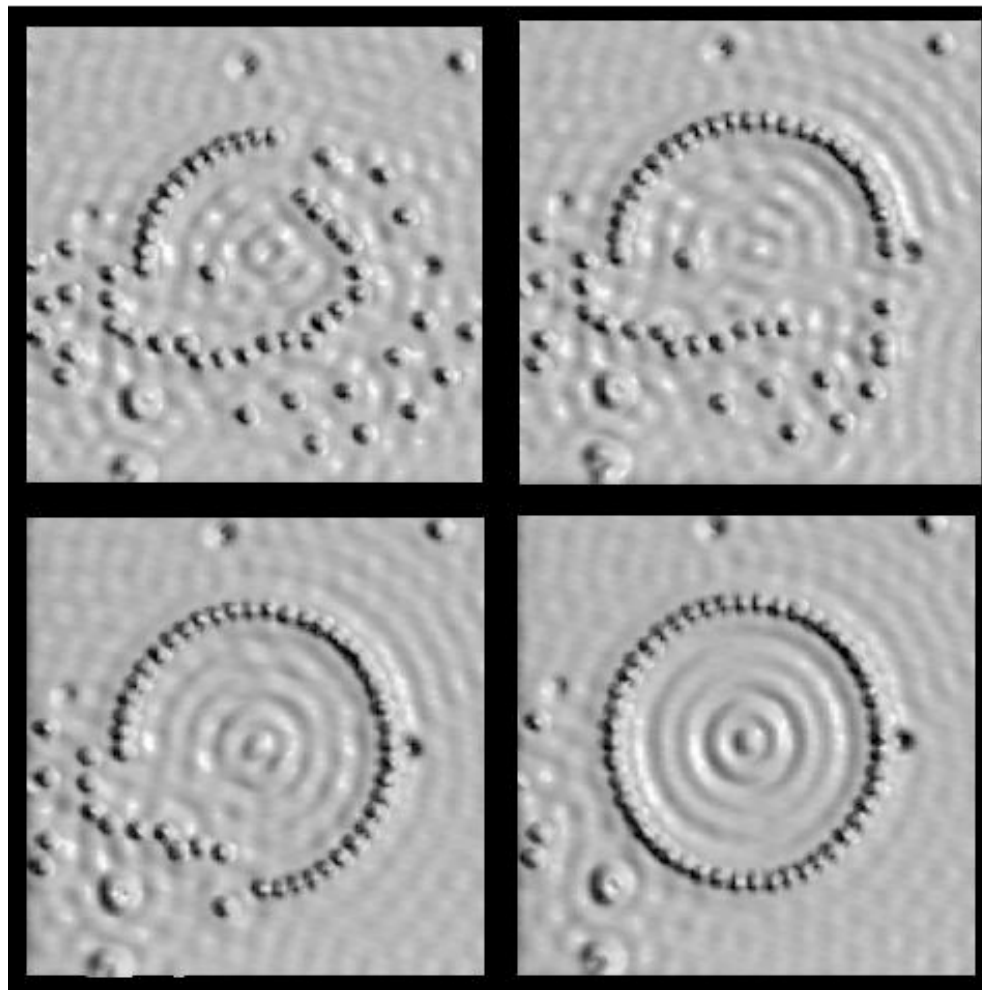
Simultaneous excitation at 365 nm



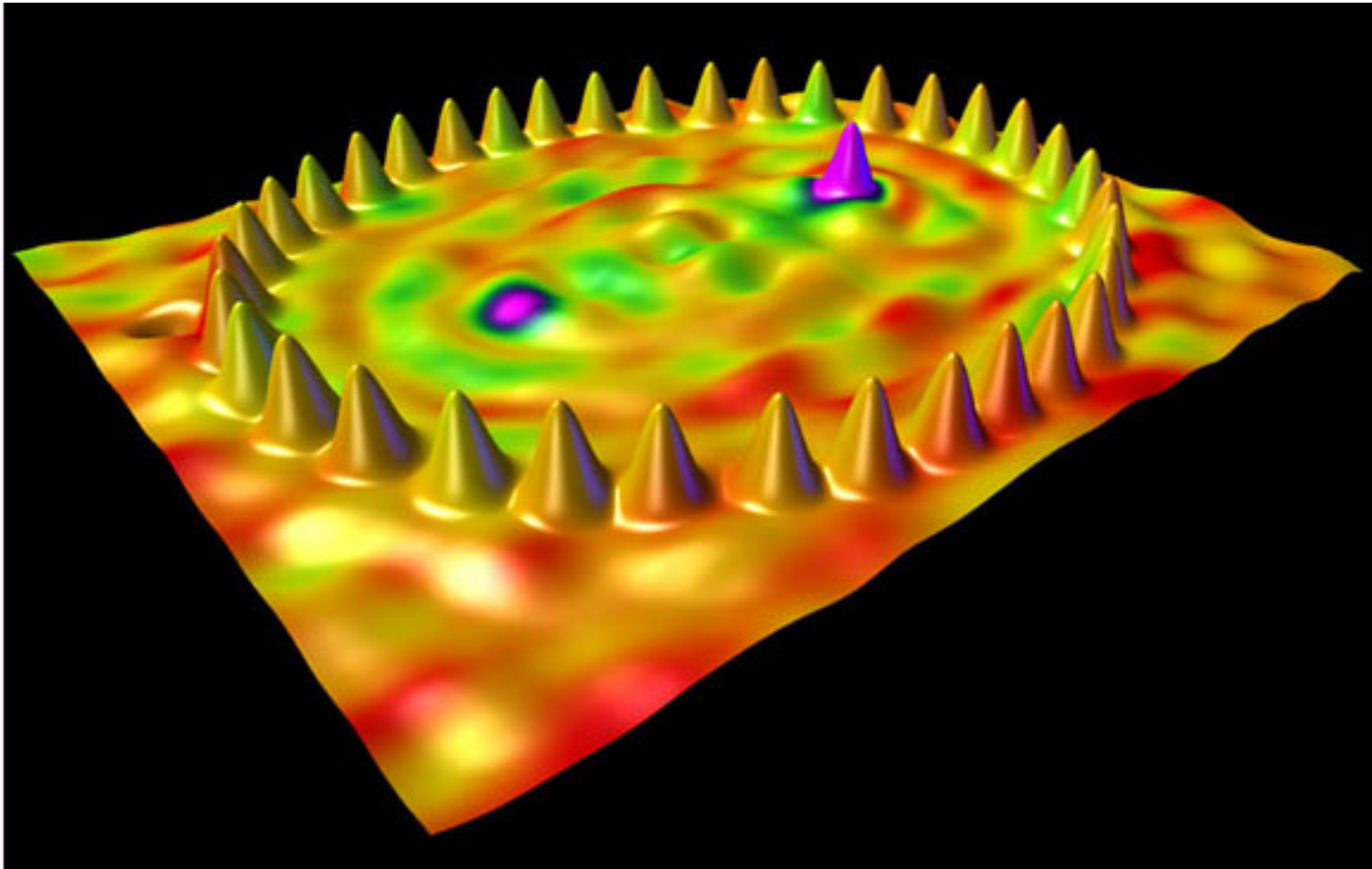
Size-dependent emission



$F(n_{bp}) \propto \frac{\alpha}{4\pi} + \gamma \ln N_{bp}$ Quantum Mechanics and Artificial and Natural Spectroscopy $E_{bend} = \frac{\pi d_p k_B T}{R}$



$F(n_{bp}) \propto \frac{\alpha}{L_p} + \gamma \ln N_{bp}$
Quantum Mechanics and Artificial and Natural Spectroscopy $E_{bend} = \frac{\pi^2 \hbar^2 k_B T}{R}$



$$F(n_{bp}) = \frac{\alpha}{\lambda} + \gamma \ln N_{bp}$$

Molecules Responsible for Absorption of Light

$$E_{bend} = \frac{\pi d_p k_B T}{R}$$

- Chlorophyll characterized by a porphyrin ring and a hydrophobic tail which anchors the molecule to the membrane.
- The porphyrin ring is host to the electronic states that participate in the interaction with light.

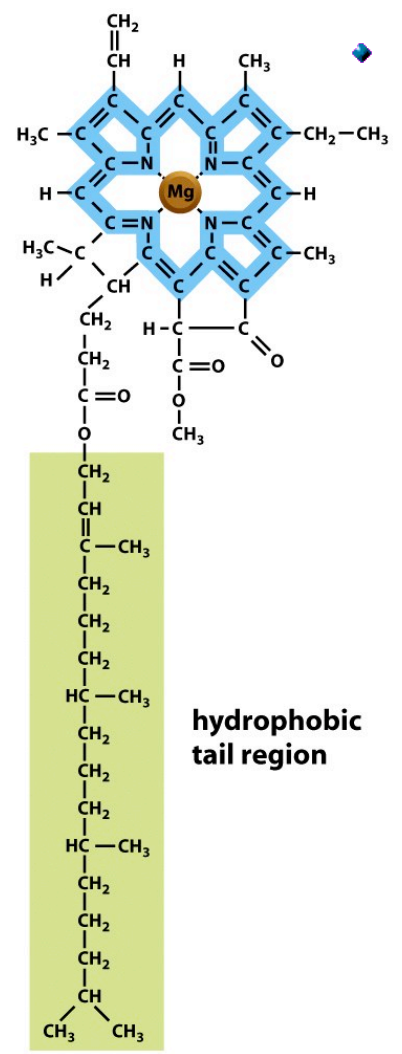


Figure 14-42 Molecular Biology of the Cell 5/e (© Garland Science 2008)

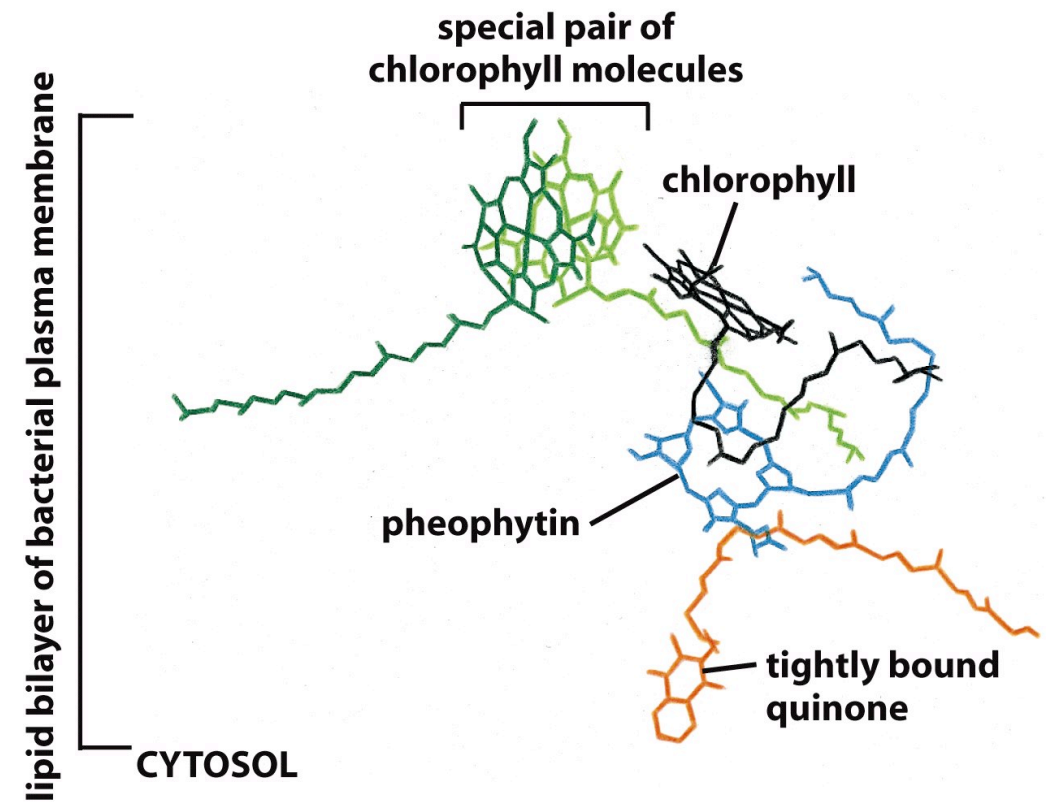
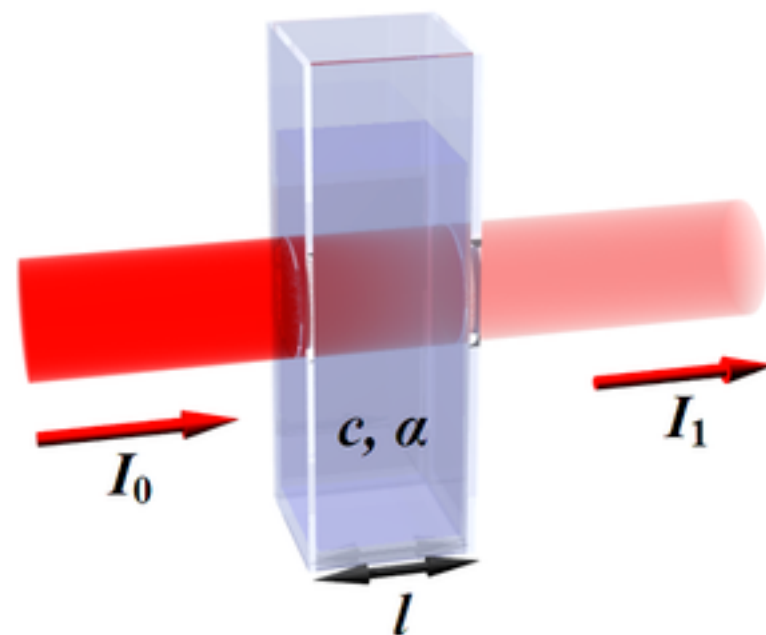
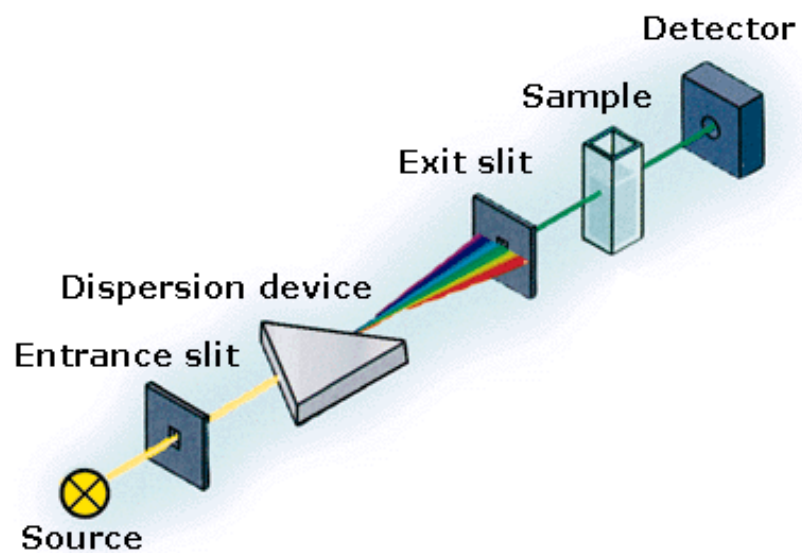


Figure 14-44 Molecular Biology of the Cell 5/e (© Garland Science 2008)

$$F(n_{bp}) = \frac{\alpha}{n_{bp}} + \gamma l n_{bp}$$

Beer's Law

$$E_{\text{bend}} = \frac{\pi d_p^3 k_B T}{R}$$

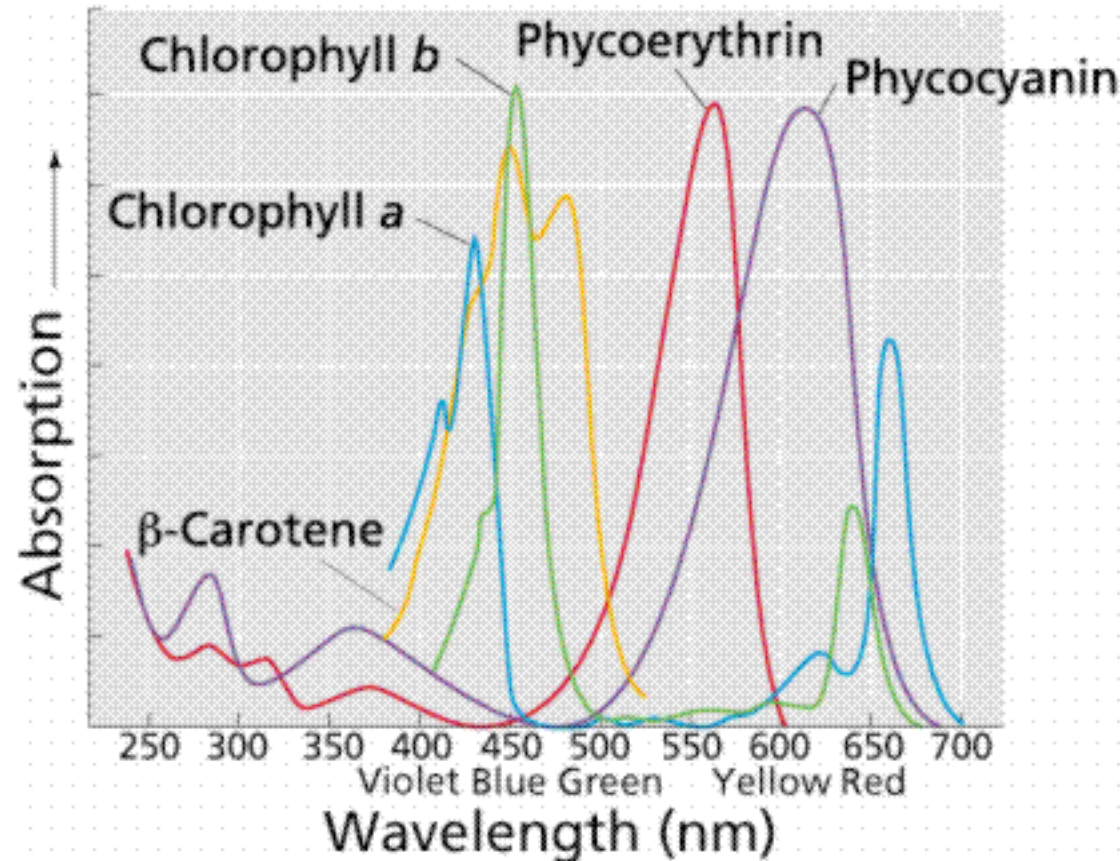
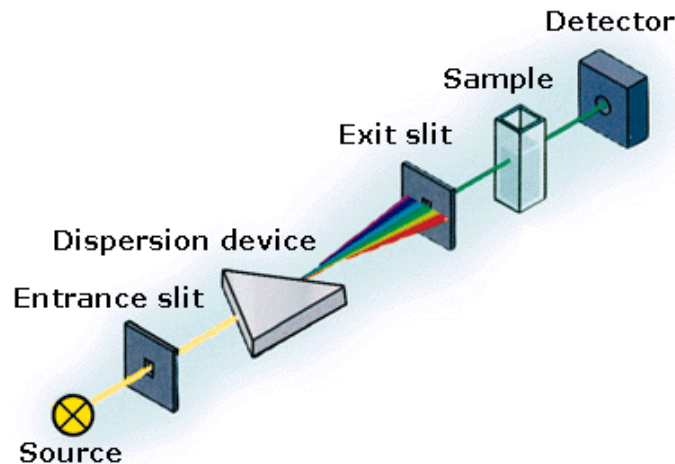


$$F(n_{bp}) = \frac{\alpha}{n_{bp}} + \gamma l n N_{bp}$$

Absorption Spectra of Biological Pigments

$$E_{\text{bond}} = \frac{5/2 p k_B T}{R}$$

- ◆ The spectrophotometer permits the measurement of absorption as a function of the incident wavelength.
- ◆ Note that chlorophyll appears green because it absorbs strongly in the blue and the red.
- ◆ We will be interested in examining the quantum mechanical underpinnings of absorption spectra.



$$F(n_{bp}) = \frac{\alpha}{n_{bp}} + \gamma \ln N_{bp}$$

"Linear" Pigments: The Carotenoids

$$E_{\text{bend}} = \frac{\pi^2 \hbar^2 k_B T}{R}$$

