

Chapter 2

Light and Matter



Units of Chapter 2 – Part 1

Information from the Skies

Waves in What?

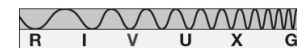
The Electromagnetic Spectrum

Thermal Radiation

2.1 Information from the Skies

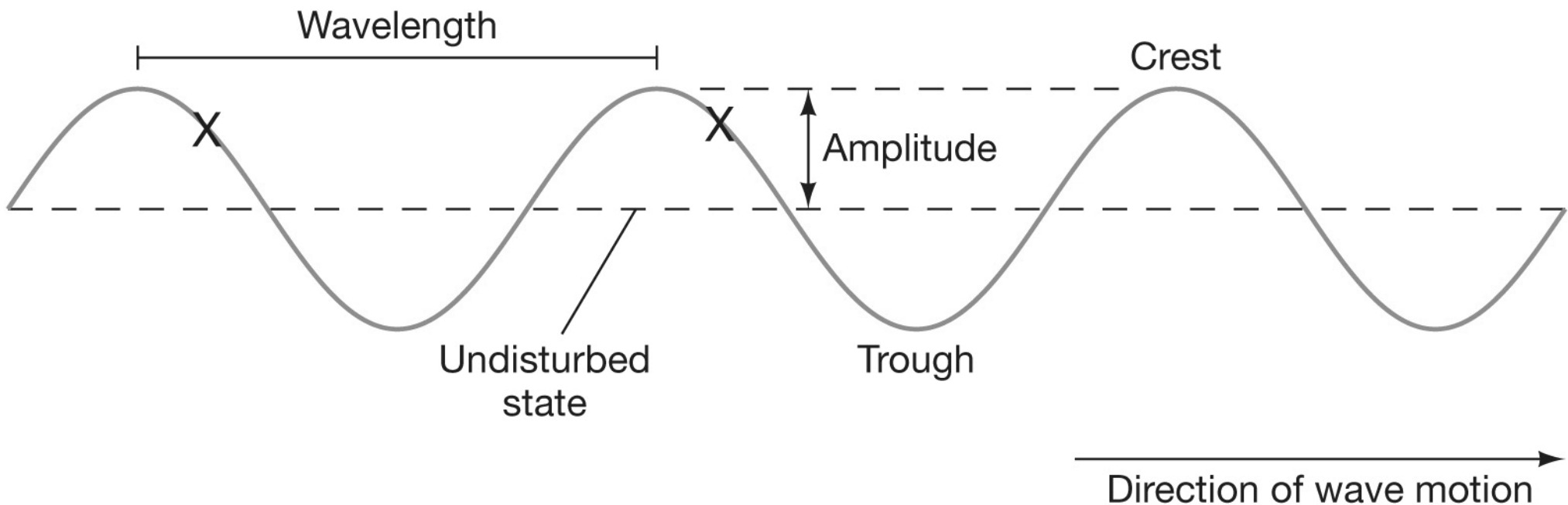
Electromagnetic Radiation: Transmission of energy through space without physical connection through varying electric and magnetic fields

Example: Light



2.1 Information from the Skies

Wave motion: transmits energy without the physical transport of material

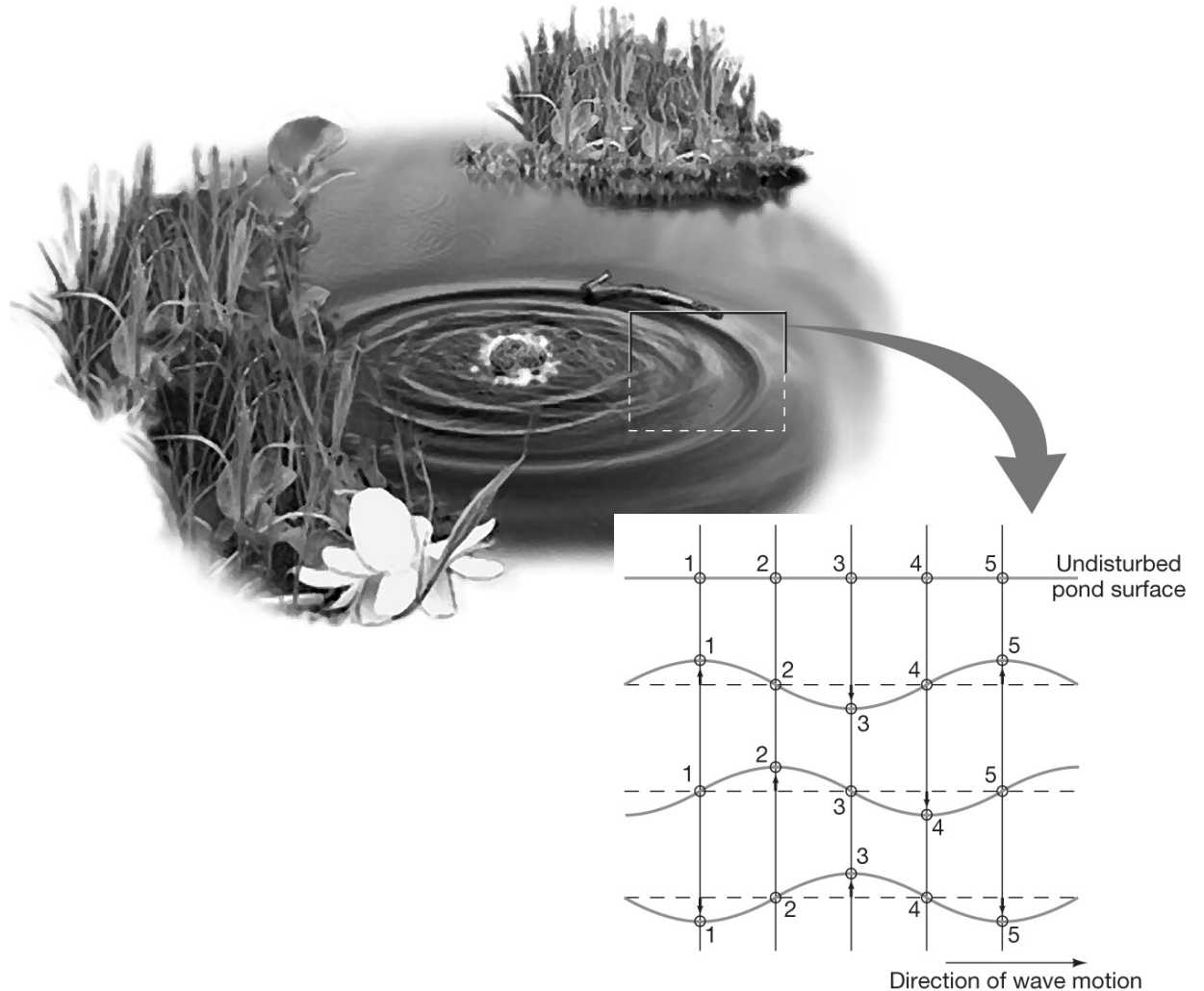


2.1 Information from the Skies

Example: water wave

**Water just
moves up and
down**

**Wave travels and
can transmit
energy**



2.1 Information from the Skies

Frequency: number of wave crests that pass a given point per second

Period: time between passage of successive crests

Relationship:

$$\text{Period} = 1 / \text{Frequency}$$

2.1 Information from the Skies

Wavelength: distance between successive crests

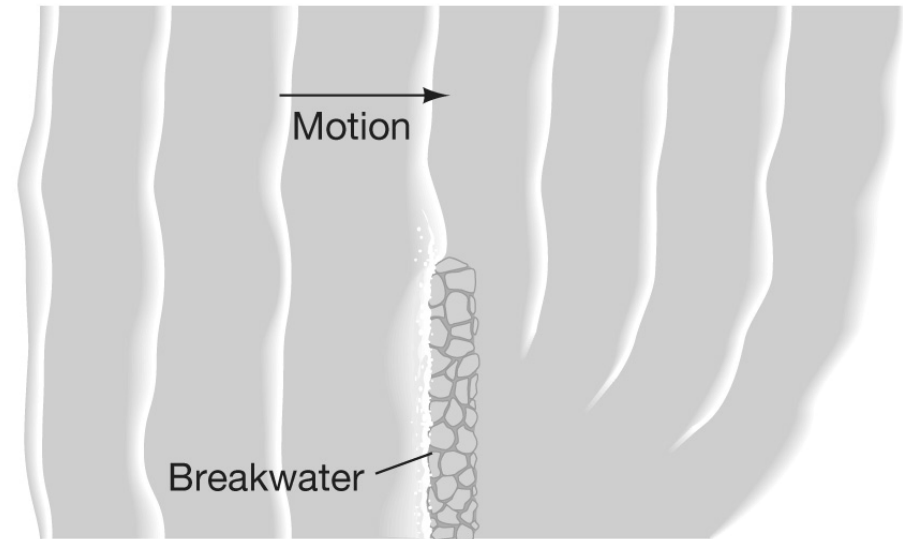
Velocity: speed at which crests move

Relationship:

$$\mathbf{Velocity = Wavelength / Period}$$

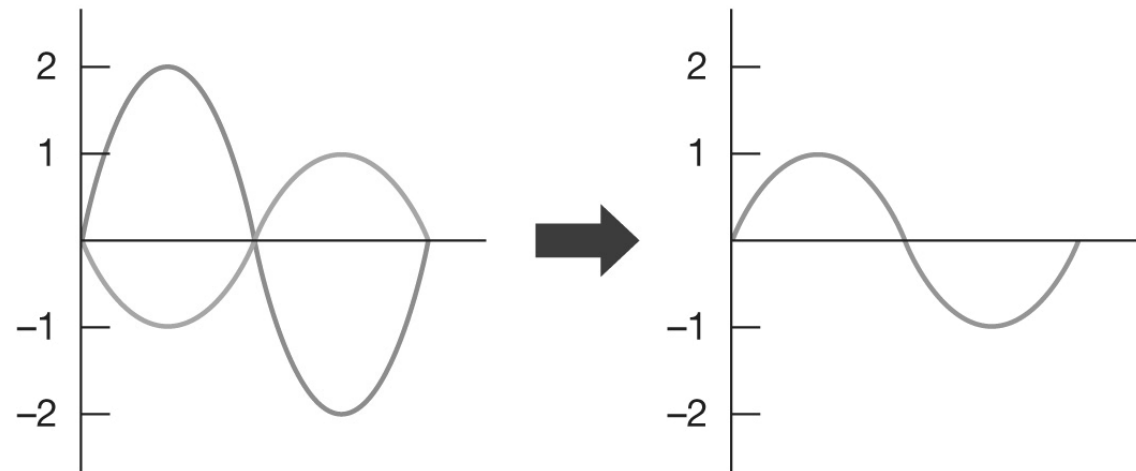
2.2 Waves in What?

Diffraction: the bending of a wave around an obstacle



(a)

Interference: the sum of two waves; may be larger or smaller than the original waves



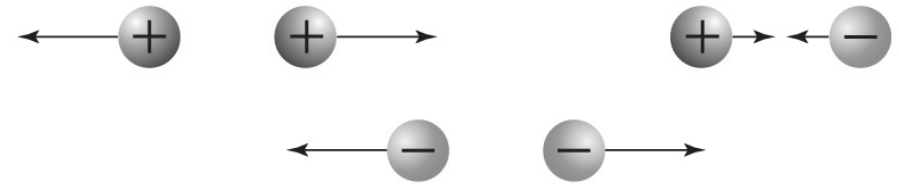
(b)

2.2 Waves in What?

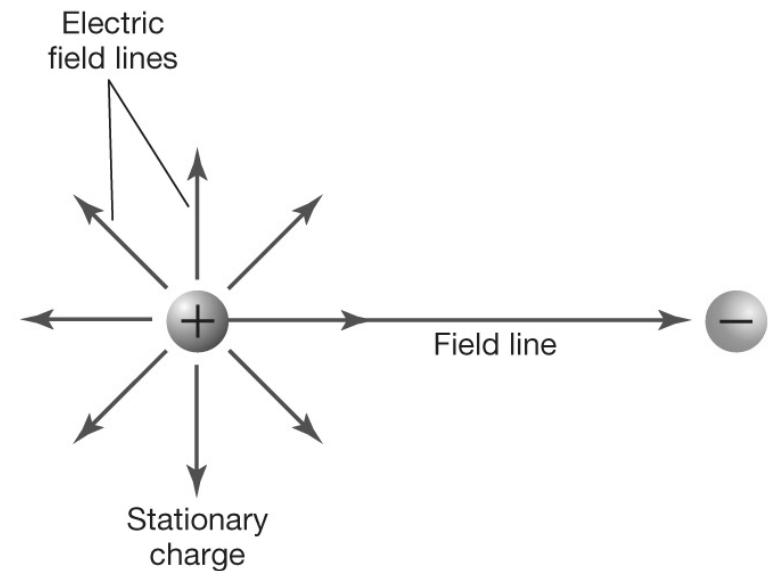
Water waves, sound waves, and so on, travel in a medium (water, air, ...)

Electromagnetic waves need no medium

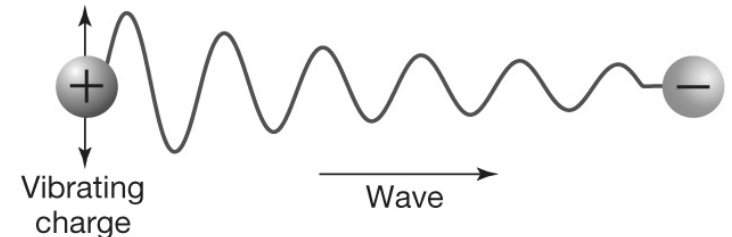
Created by accelerating charged particles:



(a)



(b)

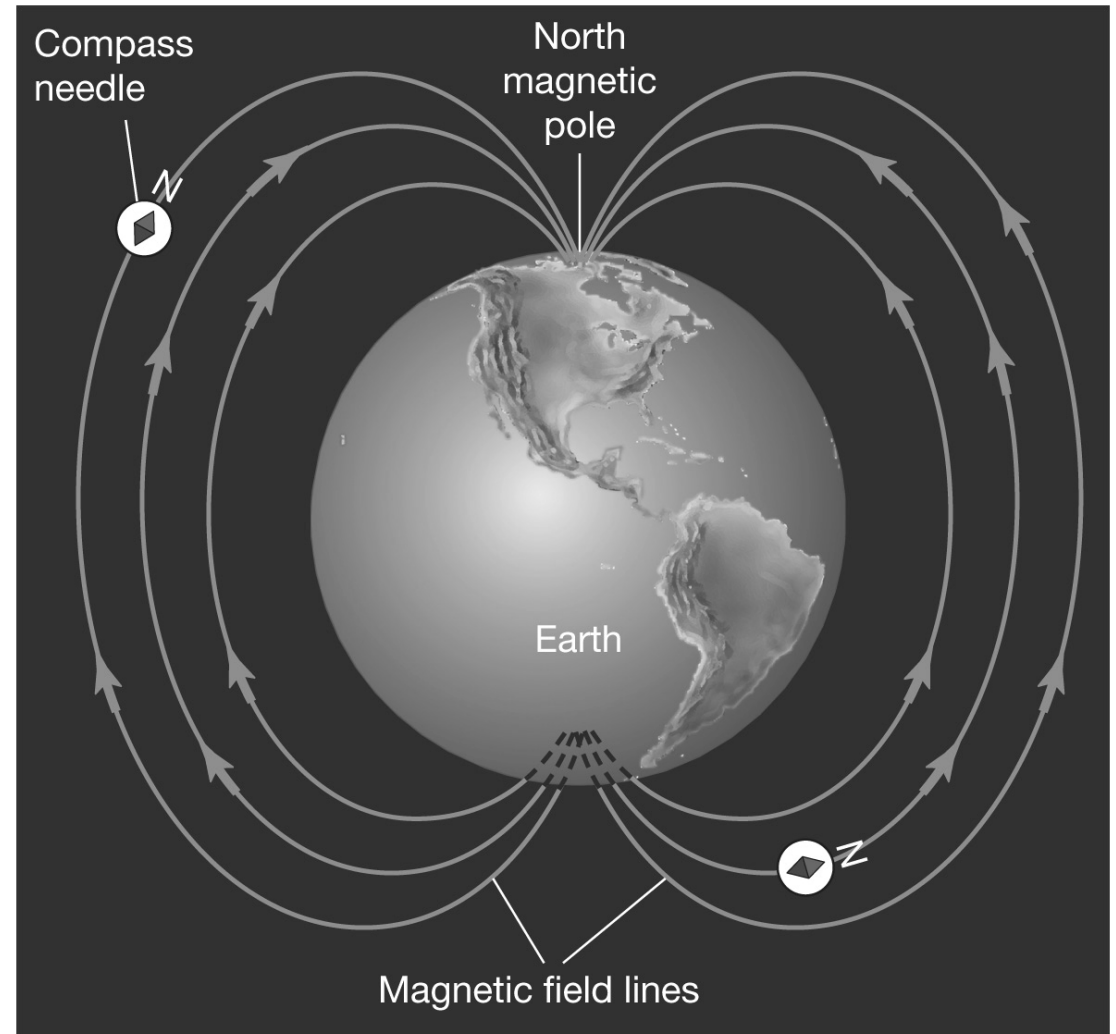


(c)

2.2 Waves in What?

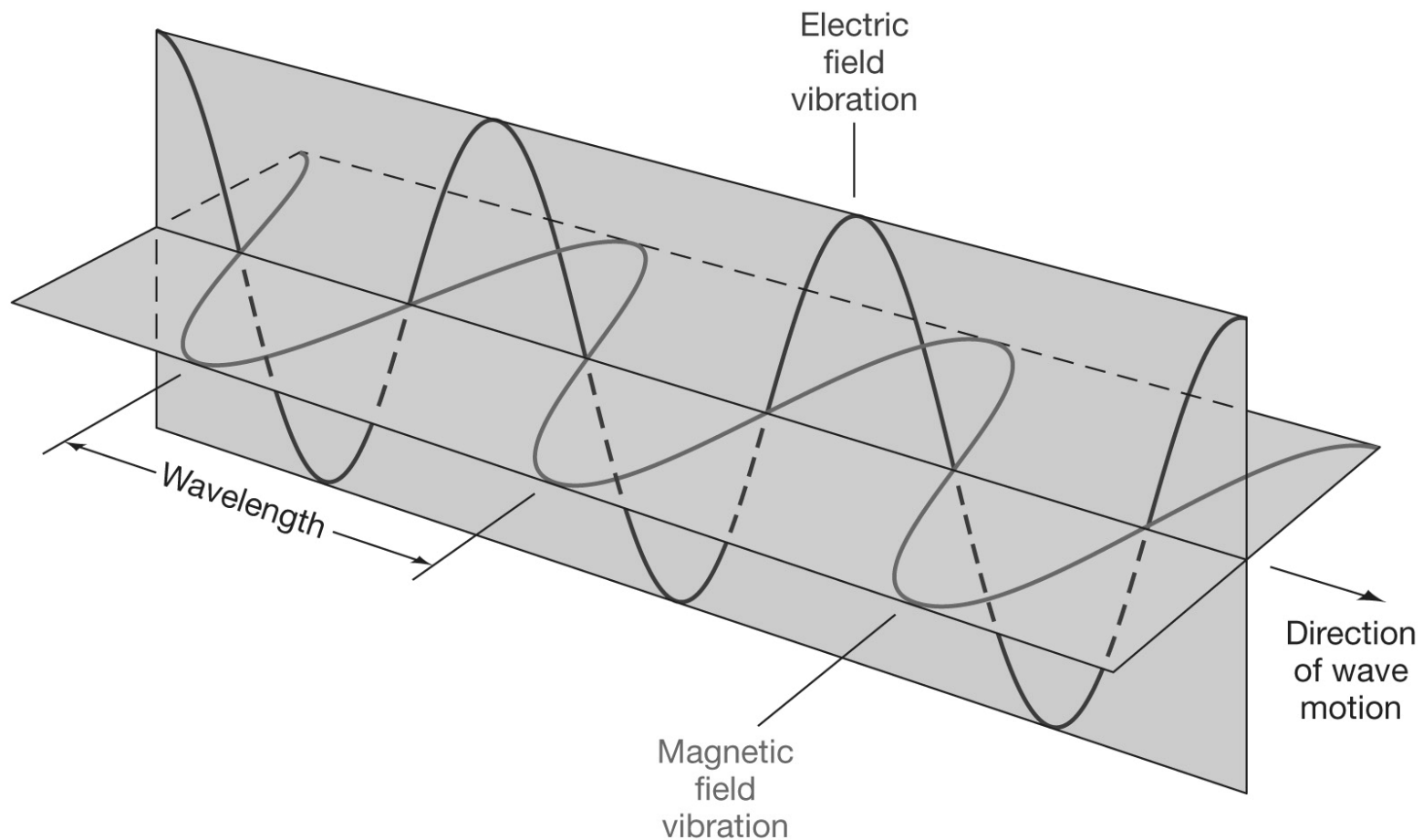
Magnetic and electric fields are inextricably intertwined.

A magnetic field, such as the Earth's shown here, exerts a force on a moving charged particle.



2.2 Waves in What?

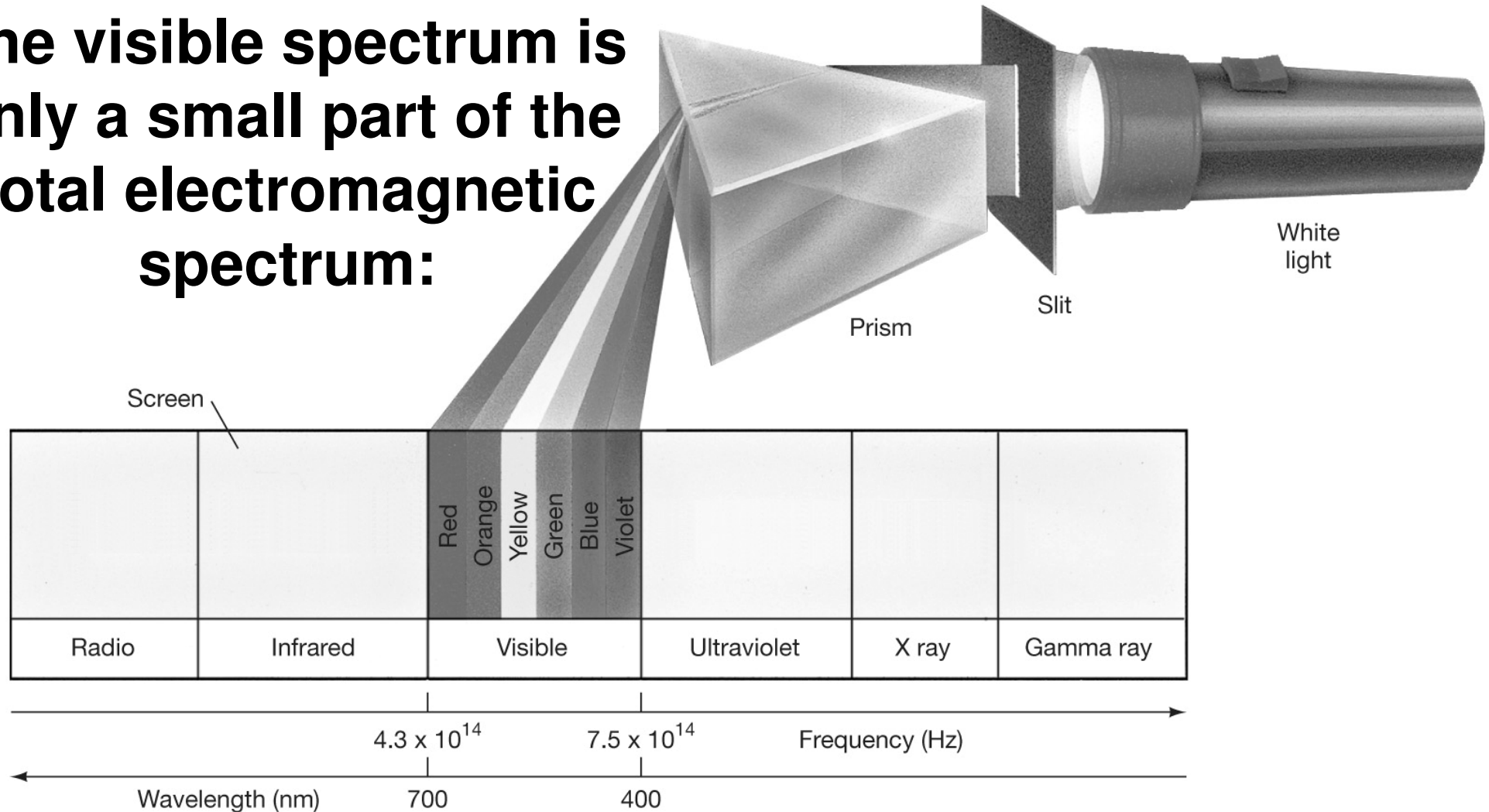
Electromagnetic waves: Oscillating electric and magnetic fields. Changing electric field creates magnetic field, and vice versa



2.3 The Electromagnetic Spectrum

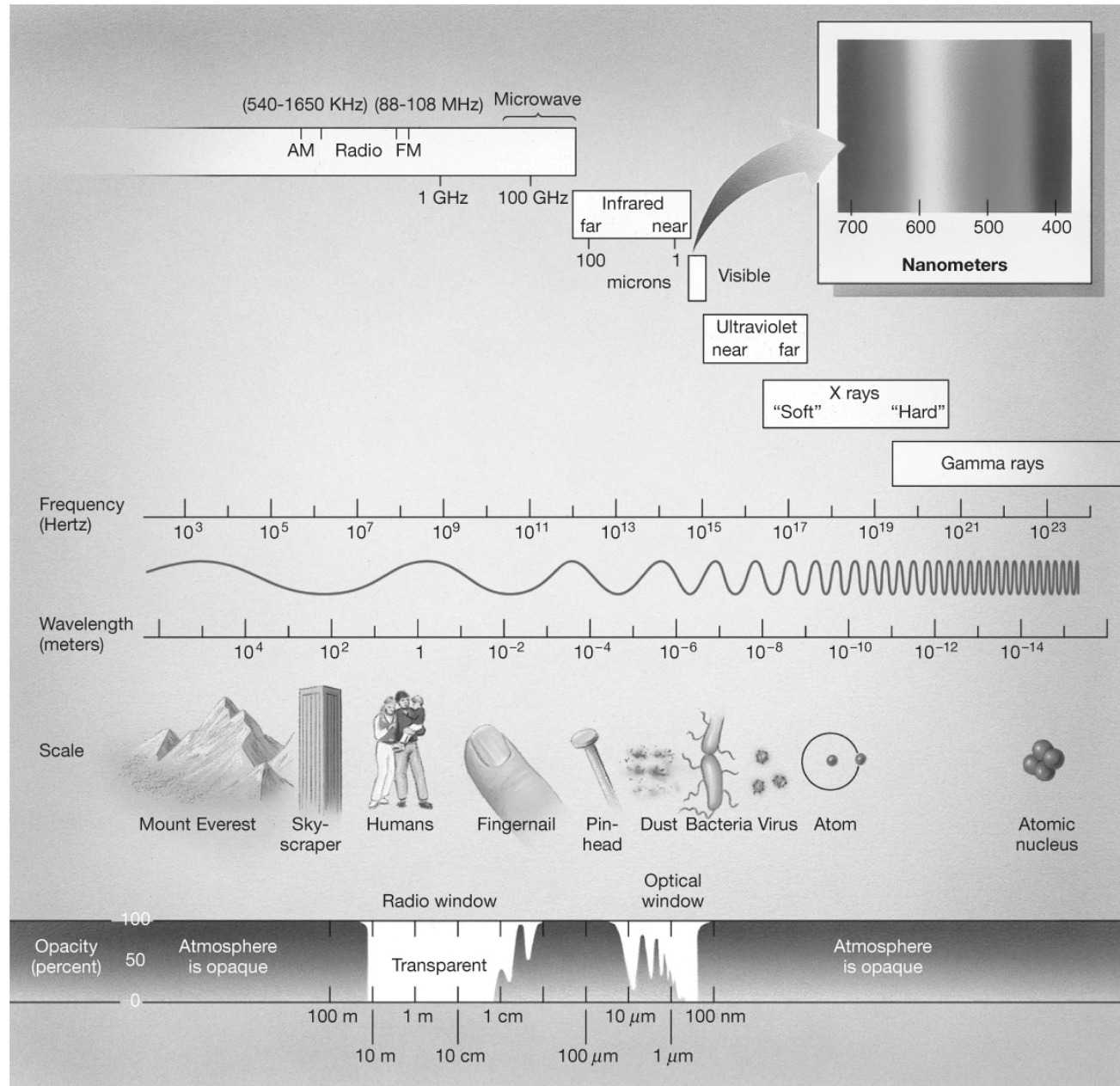
Different colors of light are distinguished by their frequency and wavelength.

The visible spectrum is only a small part of the total electromagnetic spectrum:



2.3 The Electromagnetic Spectrum

Different parts of the full electromagnetic spectrum have different names, but there is no limit on possible wavelengths.



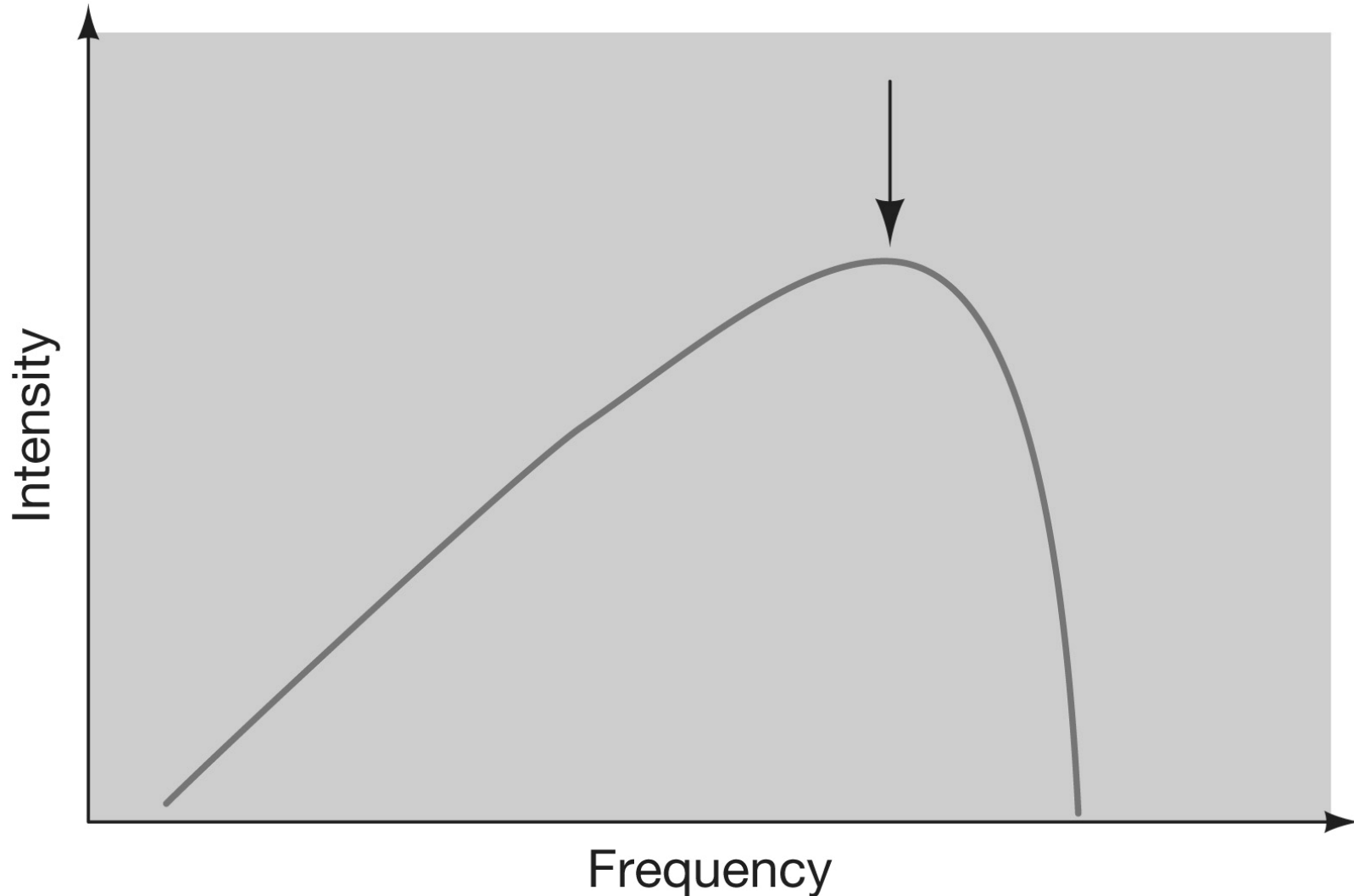
2.3 The Electromagnetic Spectrum

Note that the atmosphere is only transparent at a few wavelengths – the visible, the near infrared, and the part of the radio spectrum with frequencies higher than the AM band. This means that our atmosphere is absorbing a lot of the electromagnetic radiation impinging on it, and also that astronomy at other wavelengths must be done above the atmosphere.

Also note that the horizontal scale is logarithmic – each tick is a factor of 10 smaller or larger than the next one. This allows the display of the longest and shortest wavelengths on the same plot.

2.4 Thermal Radiation

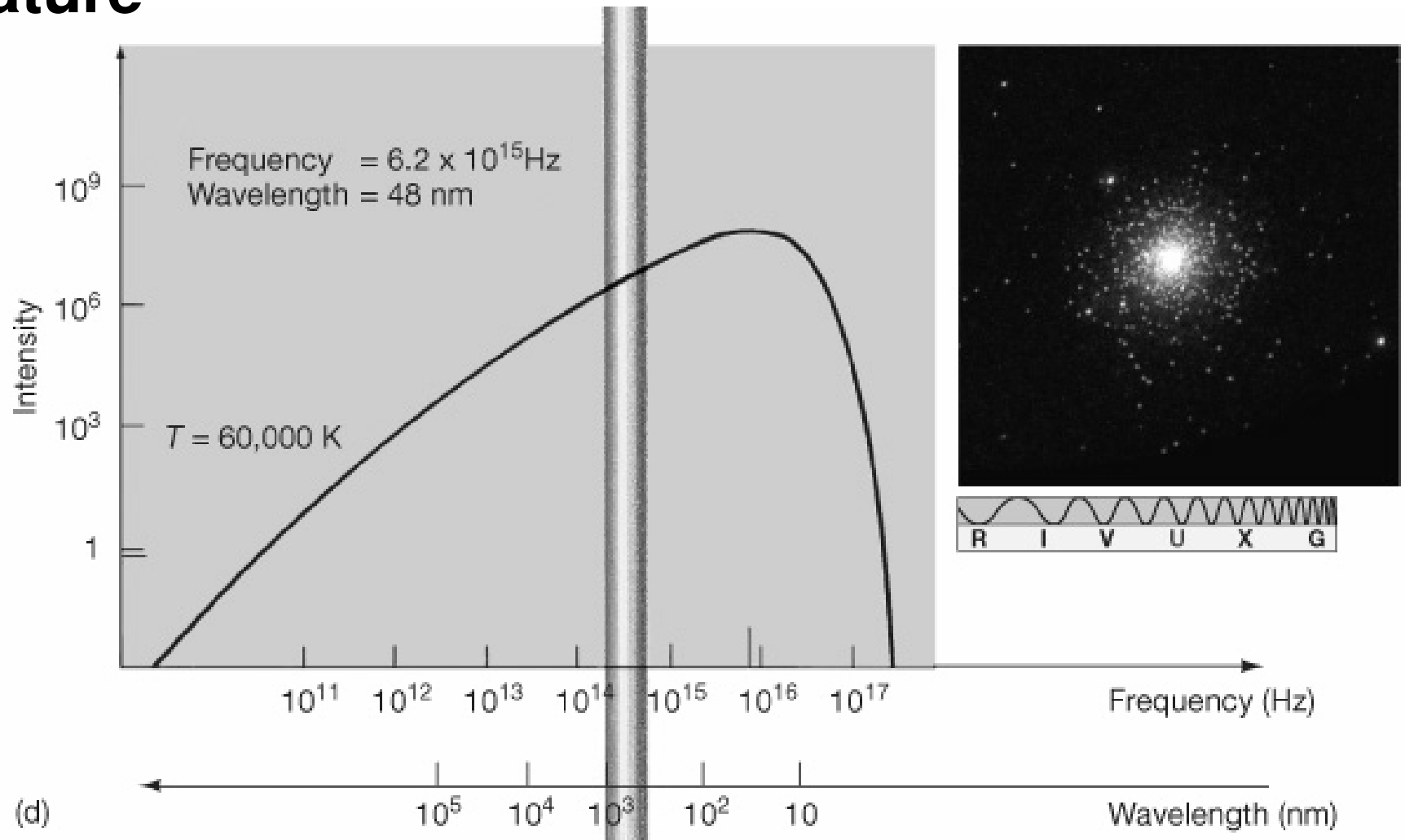
Blackbody Spectrum: radiation emitted by an object depending only on its temperature



2.4 Thermal Radiation

Radiation Laws

1. Peak wavelength is inversely proportional to temperature



2.4 Thermal Radiation

Radiation Laws

2. Total energy emitted is proportional to fourth power of temperature

$$F = \sigma T^4 .$$

energy per
unit area

constant

temperature
to the fourth
power

More Precisely 2.2

Kelvin Temperature scale:

- All thermal motion ceases at 0 K
- Water freezes at 273 K and boils at 373 K

