ATOC 1060-002
OUR CHANGING ENVIRONMNET

Class 7 (Chapter 3)

Objectives of today's class:

a) Blackbody Radiation (with lab demo);

b) Planetary energy balance

Assignment #1 online: Due: Thursday.

Lab Demo

a)Infrared Radiation;
b)Stefan-Boltzmann Law:

$$F = \sigma T^4$$

$$\sigma = 5.67 \times 10^{-8} W/m^2/K^4$$

Previous class:

A single particle, or pulse, of electromagnetic radiation is referred to as a photon.

Energy E of a photon is:

$$h = 6.63 \times 10^{-34} Joule - seconds$$

$$E = h\nu = \frac{hc}{\lambda}$$

$$Energy = \frac{h \times speed}{wavelength}$$ (300,000km/s)

The electromagnetic spectrum

$$1m = 10^6 \mu m = 10^9 nm$$

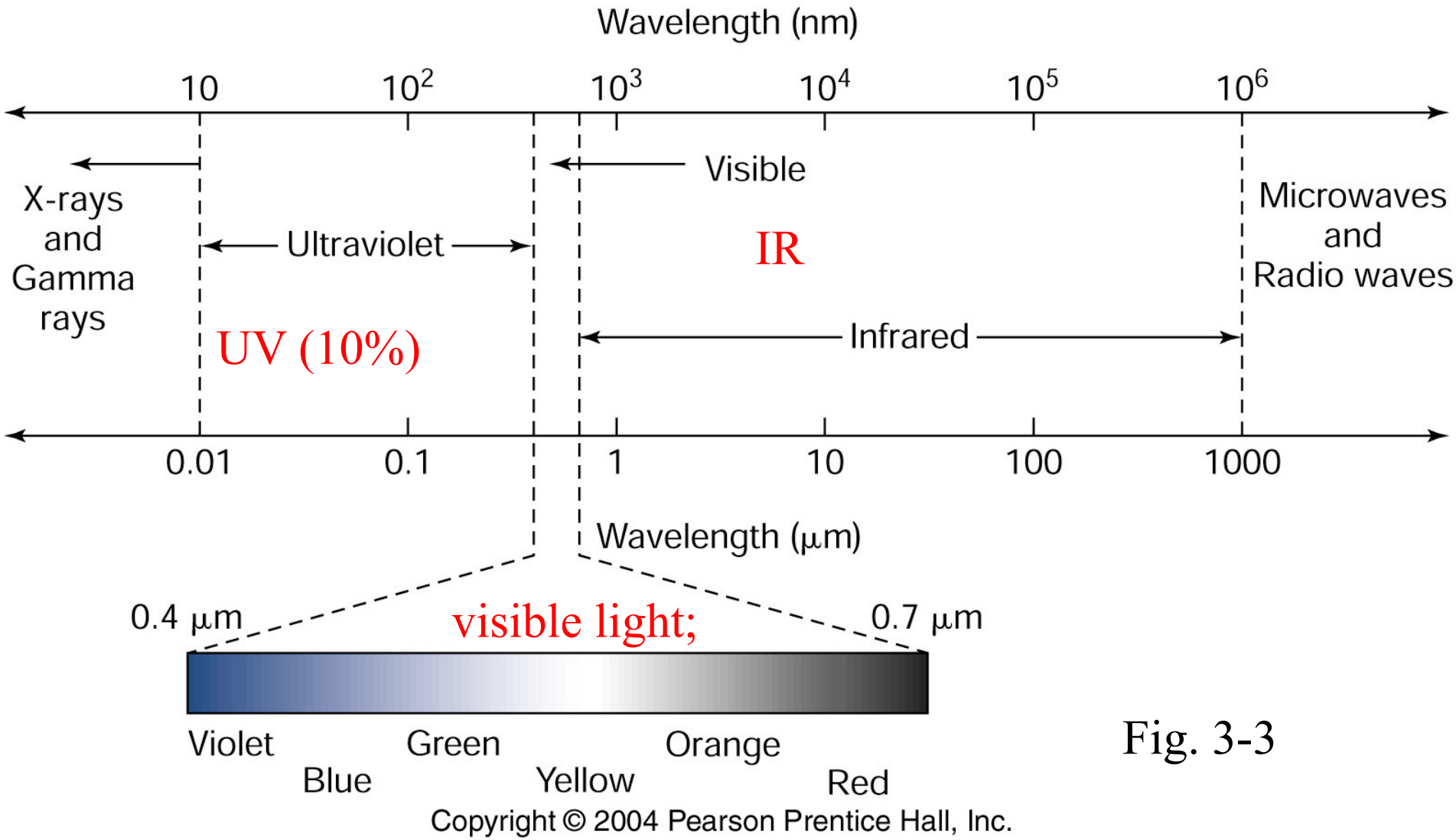


Fig. 3-3

Clicker’s question 1

1. Blackbody radiation

In order to fully understand greenhouse effect,
-concept: blackbody radiation.

Blackbody: emits (or absorbs) electromagnetic radiation with 100% efficiency at all wavelengths.

Blackbody radiation laws

Planck function

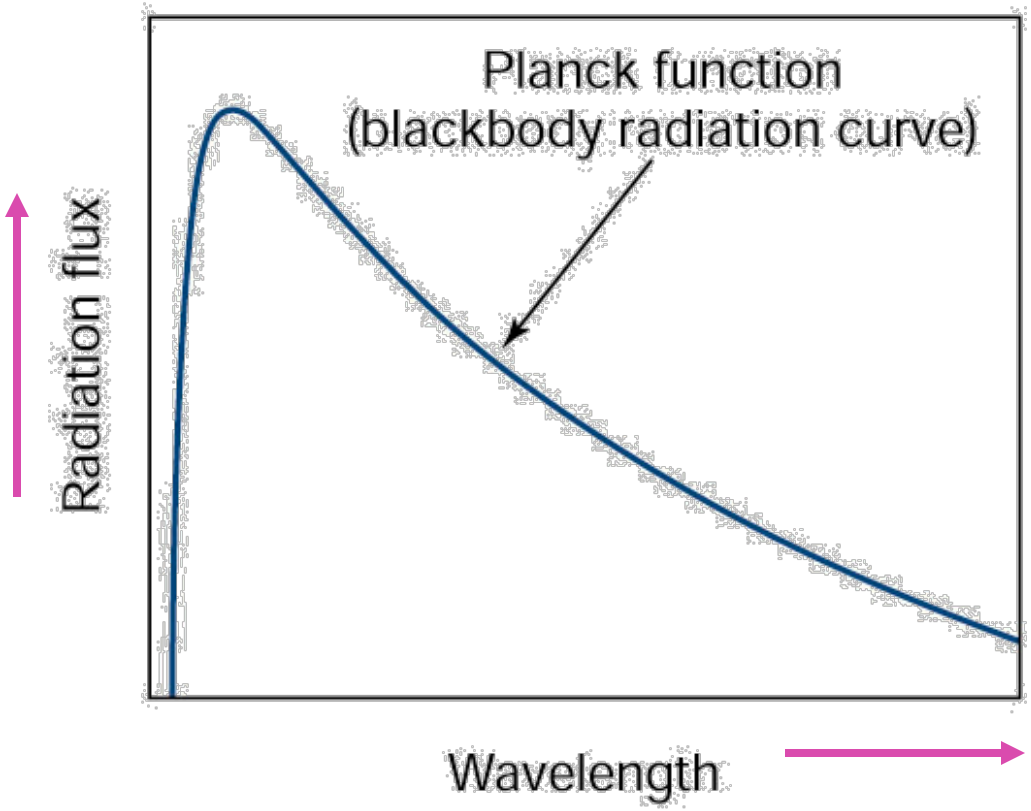


Fig. 3-7

Planck function relates the intensity of radiation from a blackbody (**at a specific temperature**) to its wavelength, or frequency.

Wien's Law: the flux of radiation emitted by a blackbody reaches its peak value at a wavelength λ_{max}

$$\lambda_{max} \approx \frac{2898}{T}$$

Micrometers (μm) Kelvin (K)

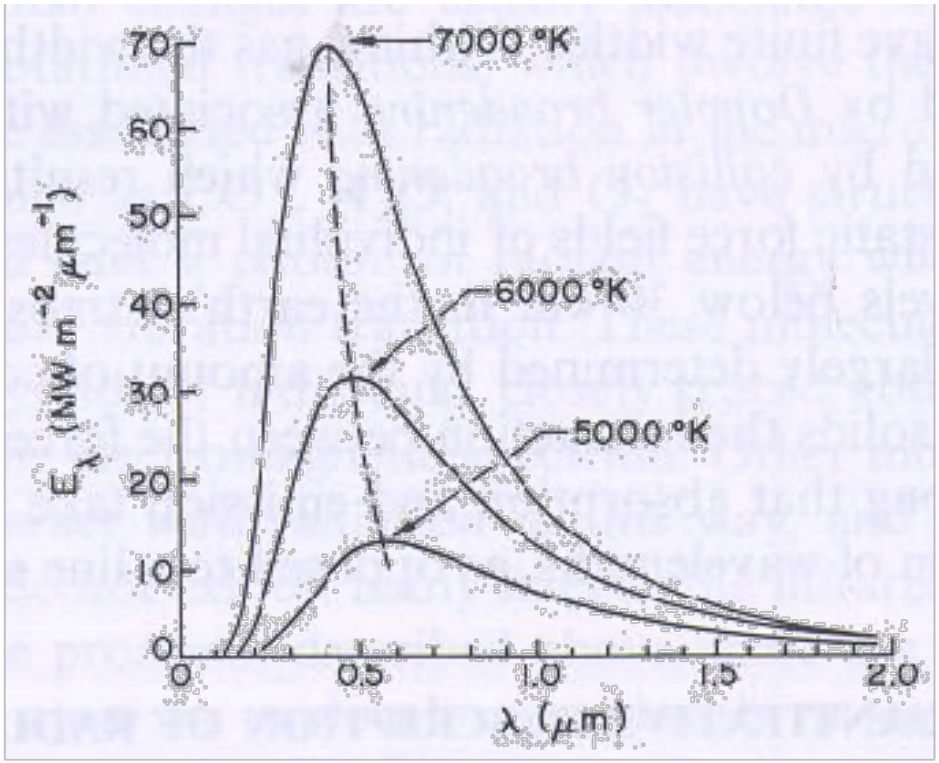


Figure a)

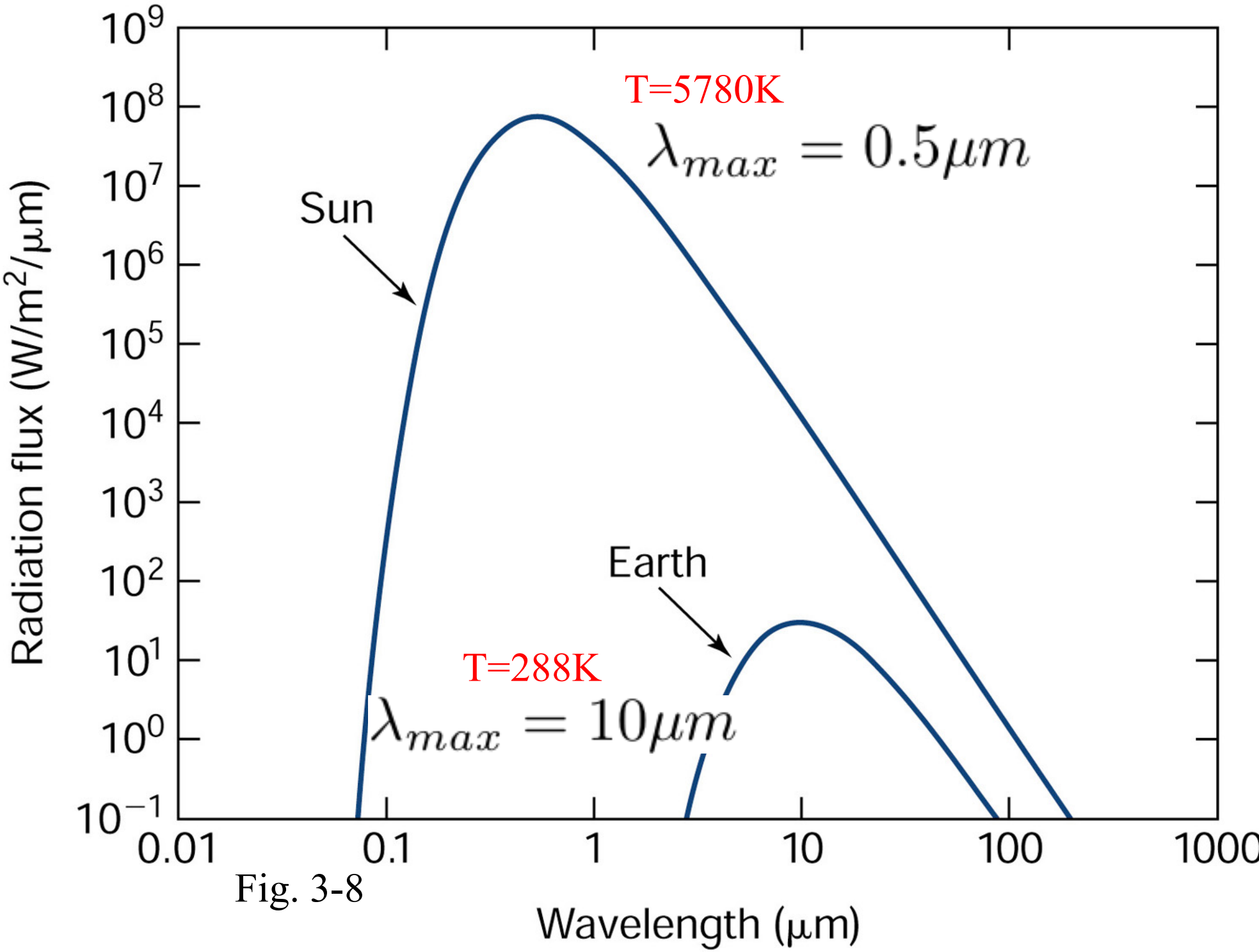

T=5780K
$\lambda_{max} = 0.5\mu m$
Sun
Earth
T=288K
$\lambda_{max} = 10\mu m$
Radiation flux (W/m²/μm)
Wavelength (μm)
10⁹
10⁸
10⁷
10⁶
10⁵
10⁴
10³
10²
10¹
10⁰
10⁻¹
0.01
0.1
1
10
100
1000

Fig. 3-8

Clicker’s question 2

The Stefan-Boltzmann Law

The energy flux emitted by a blackbody is related to the fourth power of the body's absolute temperature.

$$F = \sigma T^4$$

Kelvin (K)

$$\sigma = 5.67 \times 10^{-8} W/m^2/K^4$$

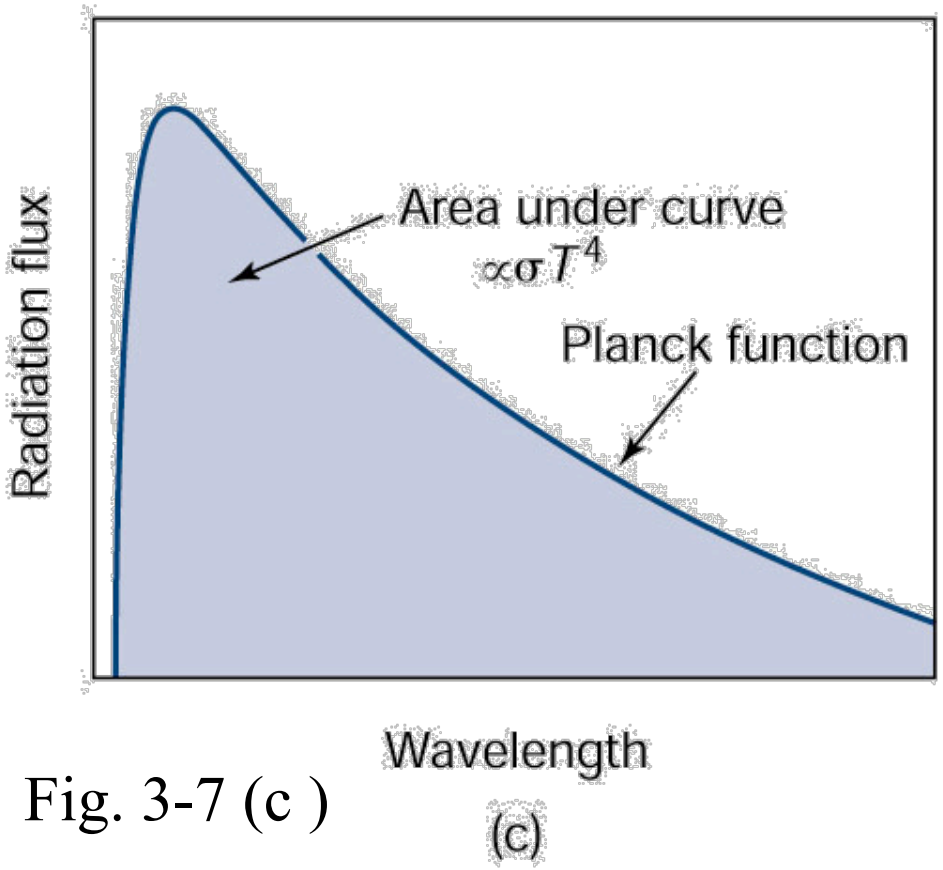


Fig. 3-7 (c)

Clicker’s question 3

2. Planetary energy balance

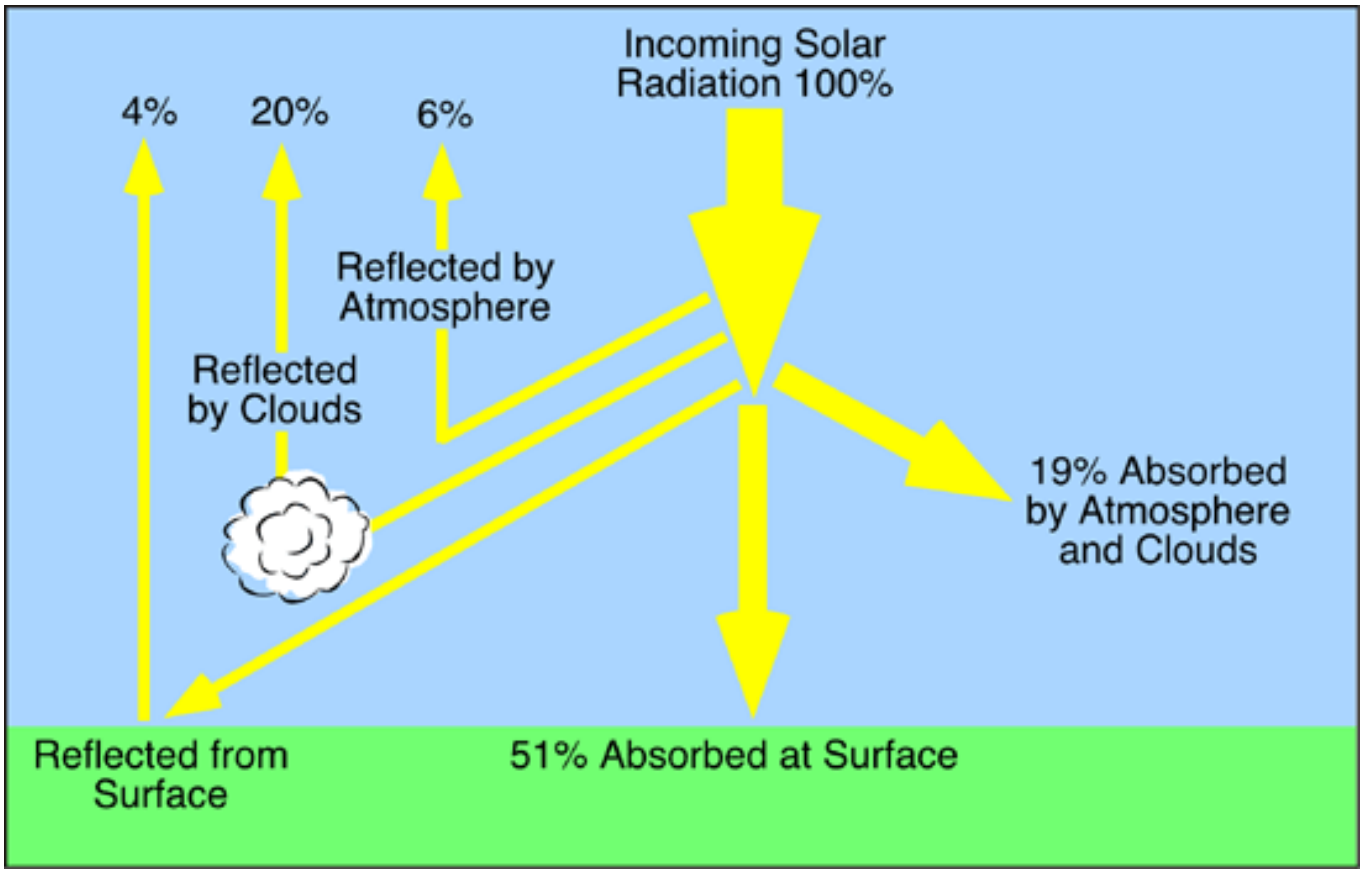
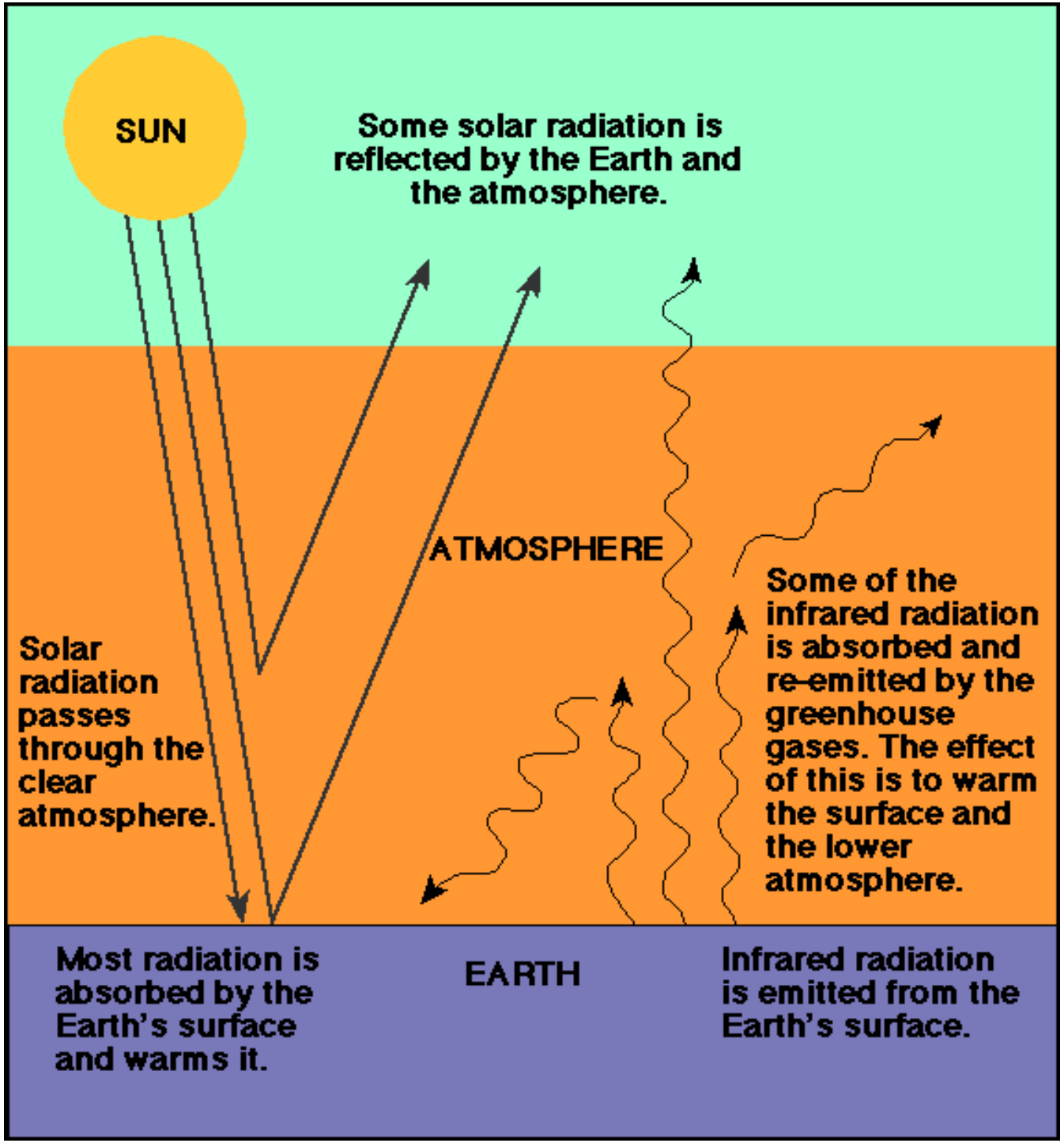


Figure b)


SUN
Some solar radiation is reflected by the Earth and the atmosphere.
ATMOSPHERE
Solar radiation passes through the clear atmosphere.
Some of the infrared radiation is absorbed and re-emitted by the greenhouse gases. The effect of this is to warm the surface and the lower atmosphere.
Most radiation is absorbed by the Earth's surface and warms it.
EARTH
Infrared radiation is emitted from the Earth's surface.

Earth's surface temperature depends on:

i) Solar flux at top of earth's atmosphere, which is largely determined by the distance from the Sun; $1370 W/m^2$

ii) Earth's reflectivity (albedo; ~30%);

iii) warming provided by atmosphere (greenhouse effect).

Greenhouse effect: view the Earth as a blackbody (although not exactly true).

Clicker’s question 4

Flux (F): the amount of energy that passes through a given perpendicular area per unit time.

W/m^2

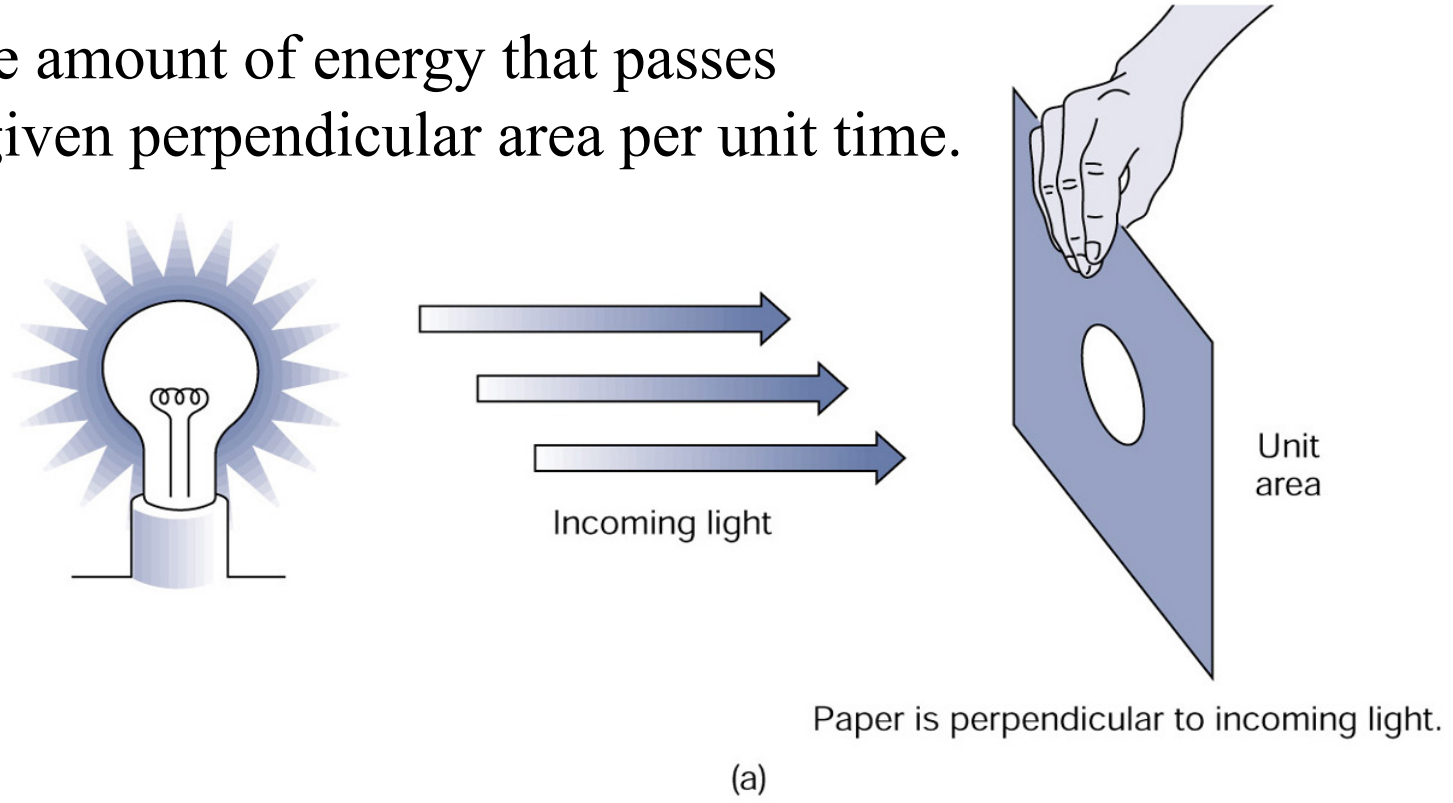
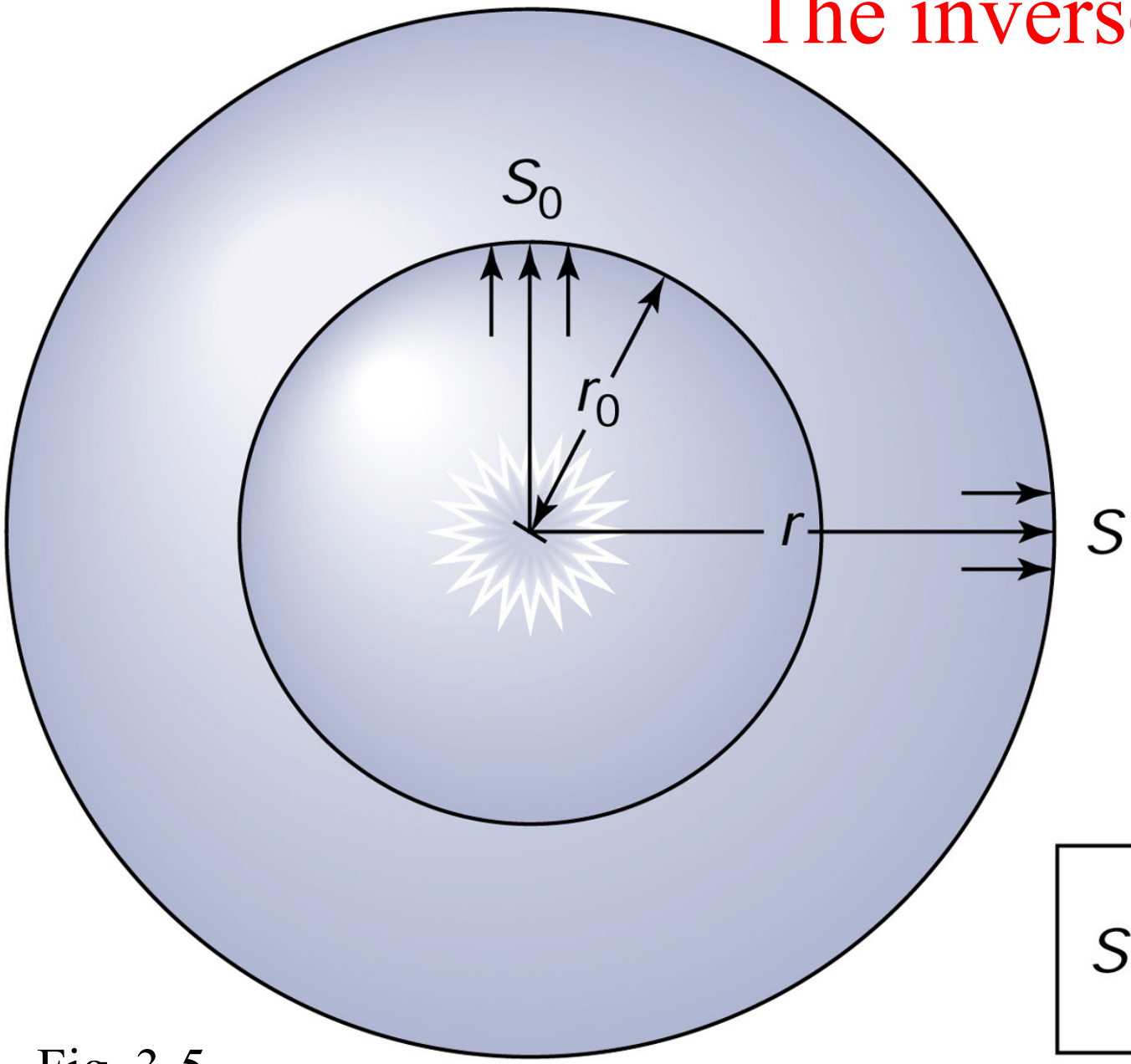


Fig. 3-4

The inverse square law



$$S = S_0\left(\frac{r_0}{r}\right)^2$$

Fig. 3-5

Temperature: measure of the internal heat energy of a substance

Celsius (degree centigrade): $^{\circ}C$

Fahrenheit: $^{\circ}F$

Kelvin (absolute): $^{\circ}K$

$$T(^{o}C) = \frac{T(^{o}F) - 32}{1.8}$$

$$T(^{o}F) = [T(^{o}C) \times 1.8] + 32$$

$$T(K) = T(^{o}C) + 273.15$$

Clicker’s question 5