ATOC 1060-002
OUR CHANGING ENVIRONMNET

Class 6 (Chapters 2,3)

Objectives of today's class:

a) External forcing: the response of daisyworld to increasing solar luminosity (chapter 2);

b) Global energy balance (Chapter 3).

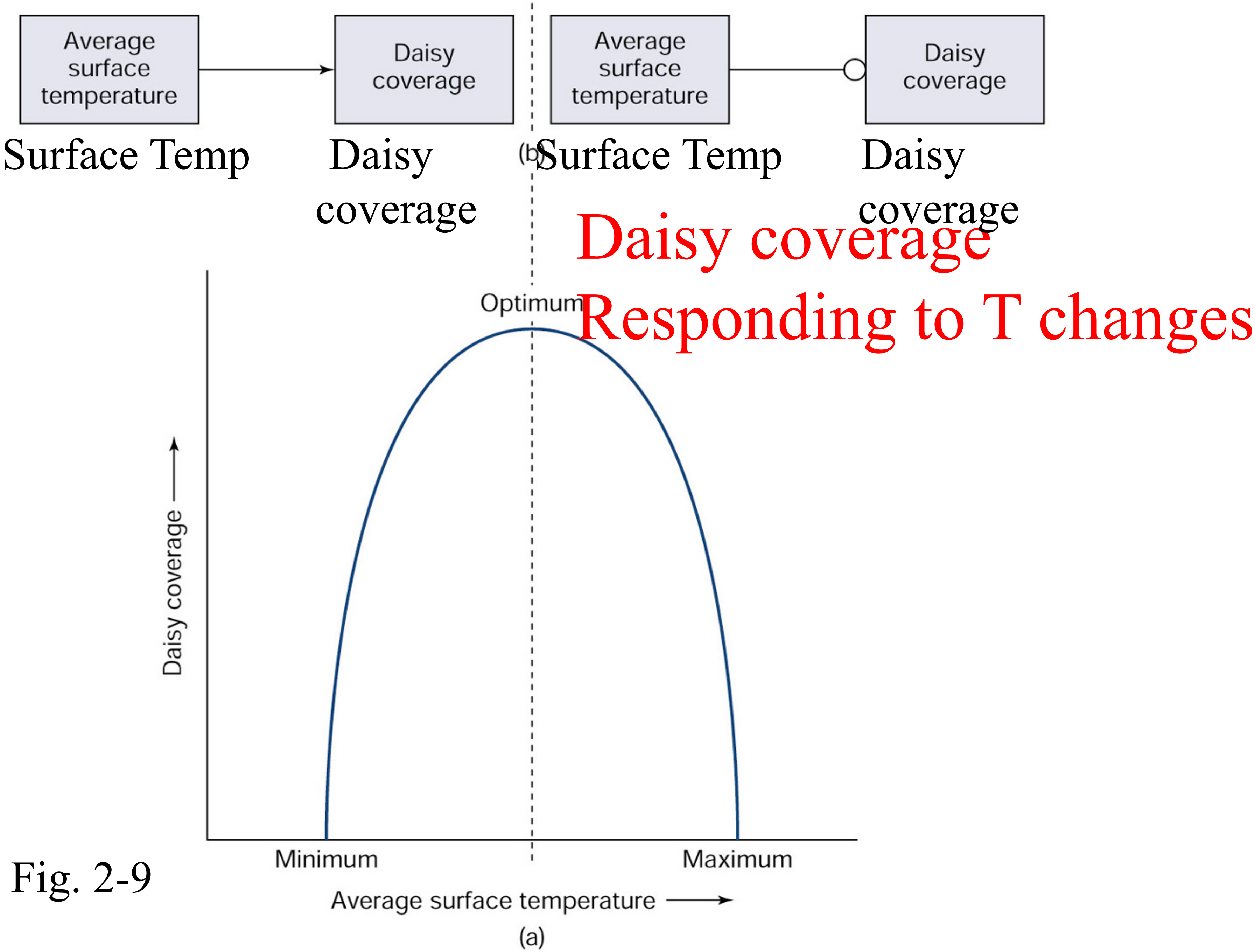

Average surface temperature
Daisy coverage
Average surface temperature
Daisy coverage
Surface Temp
Daisy coverage
(b)
Surface Temp
Daisy coverage
Daisy coverage
Responding to T changes
Optimum
Daisy coverage
Minimum
Maximum
Average surface temperature
(a)

Fig. 2-9

Previous class: Feedback of daisy coverage on T

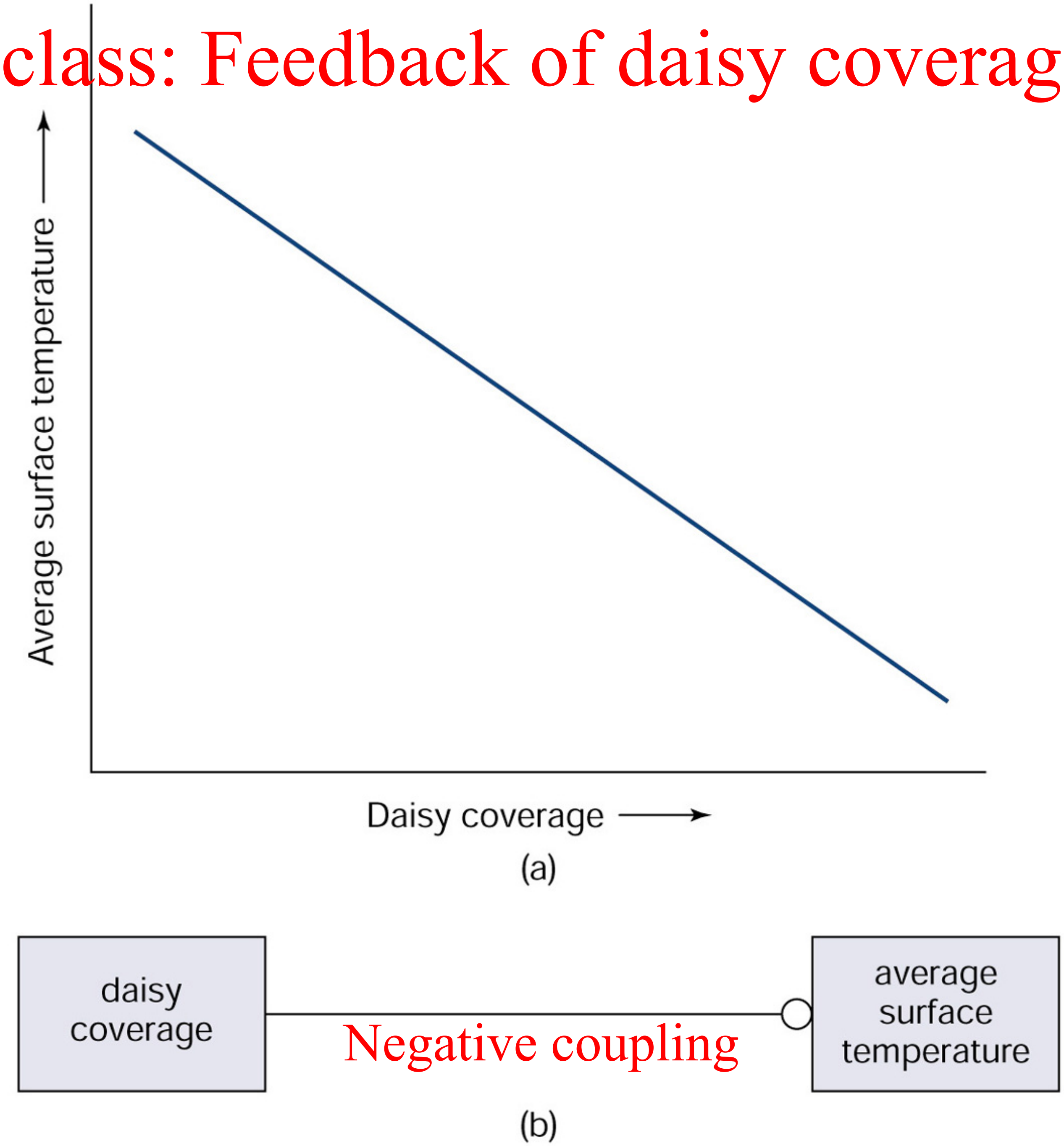
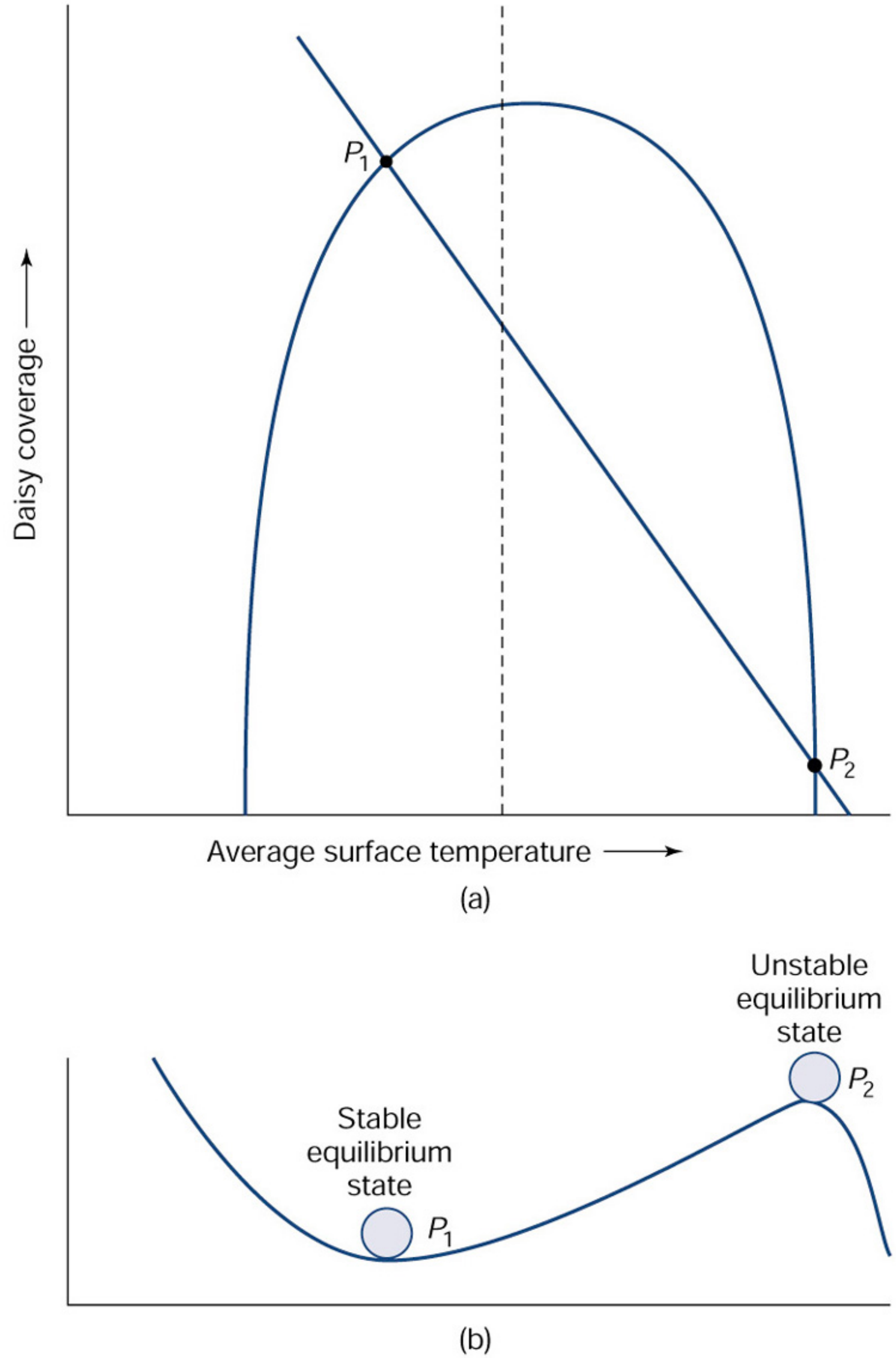


Fig 2-7a

Equilibrium state in Daisyworld.

P1 and P2 are the two equilibrium states of the system



Clicker question 1

Today: a) External forcing: the response of daisyworld to increasing solar luminosity

Equilibrium state - perturbation or forcing - how the system respond;

Idealized daisyworld:

daisy coverage & planet temperature;

Complex system: The Earth system.

Response of daisyworld coupling to forcing

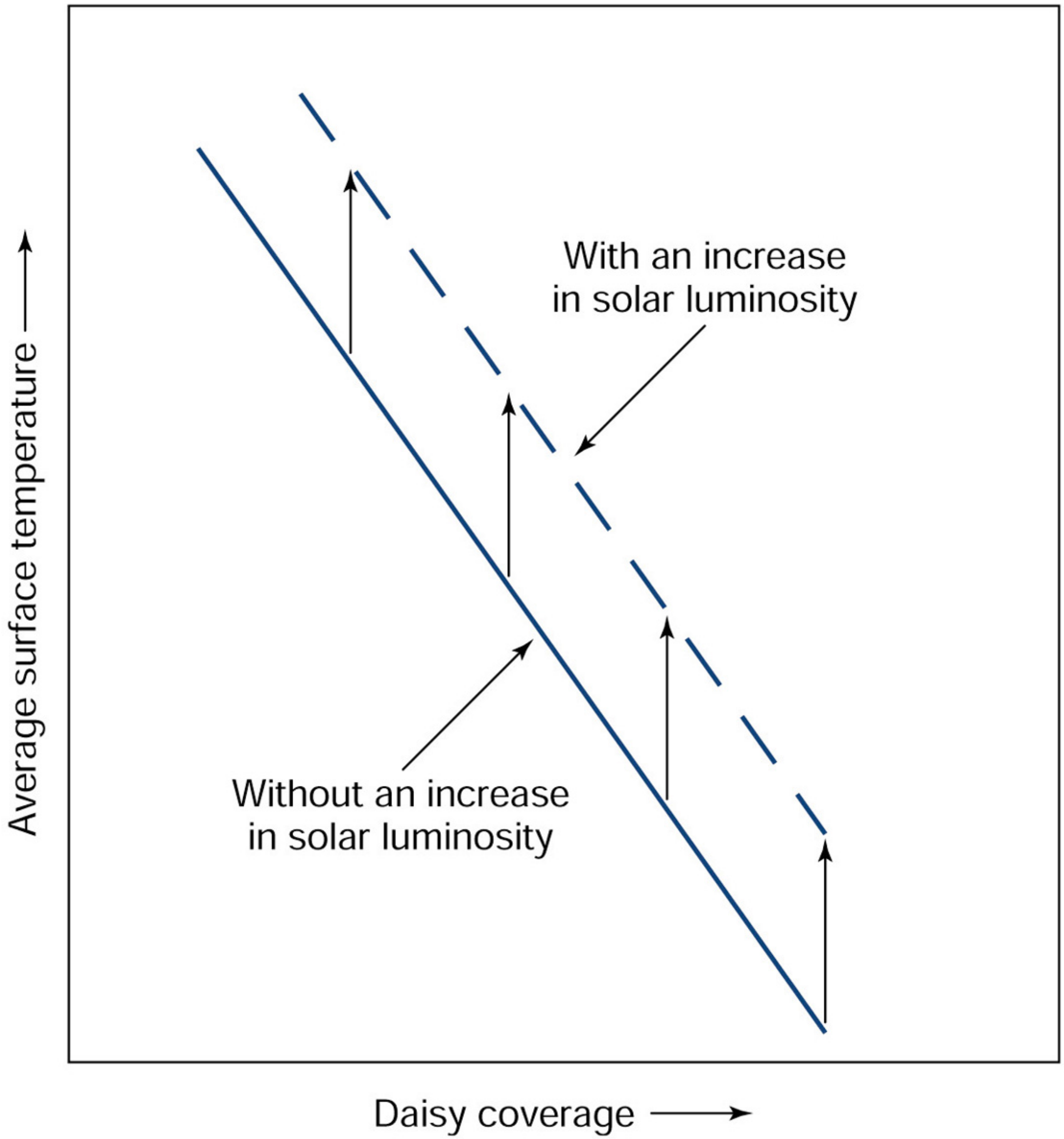


Fig. 2-12

Response of equilibrium states to forcing

$$\Delta T_{eq} = \Delta T_0 + \Delta T_f$$

negative

Feedback factor:

$$f = \frac{\Delta T_{eq}}{\Delta T_0}$$

⇒Longer time span for daisies!

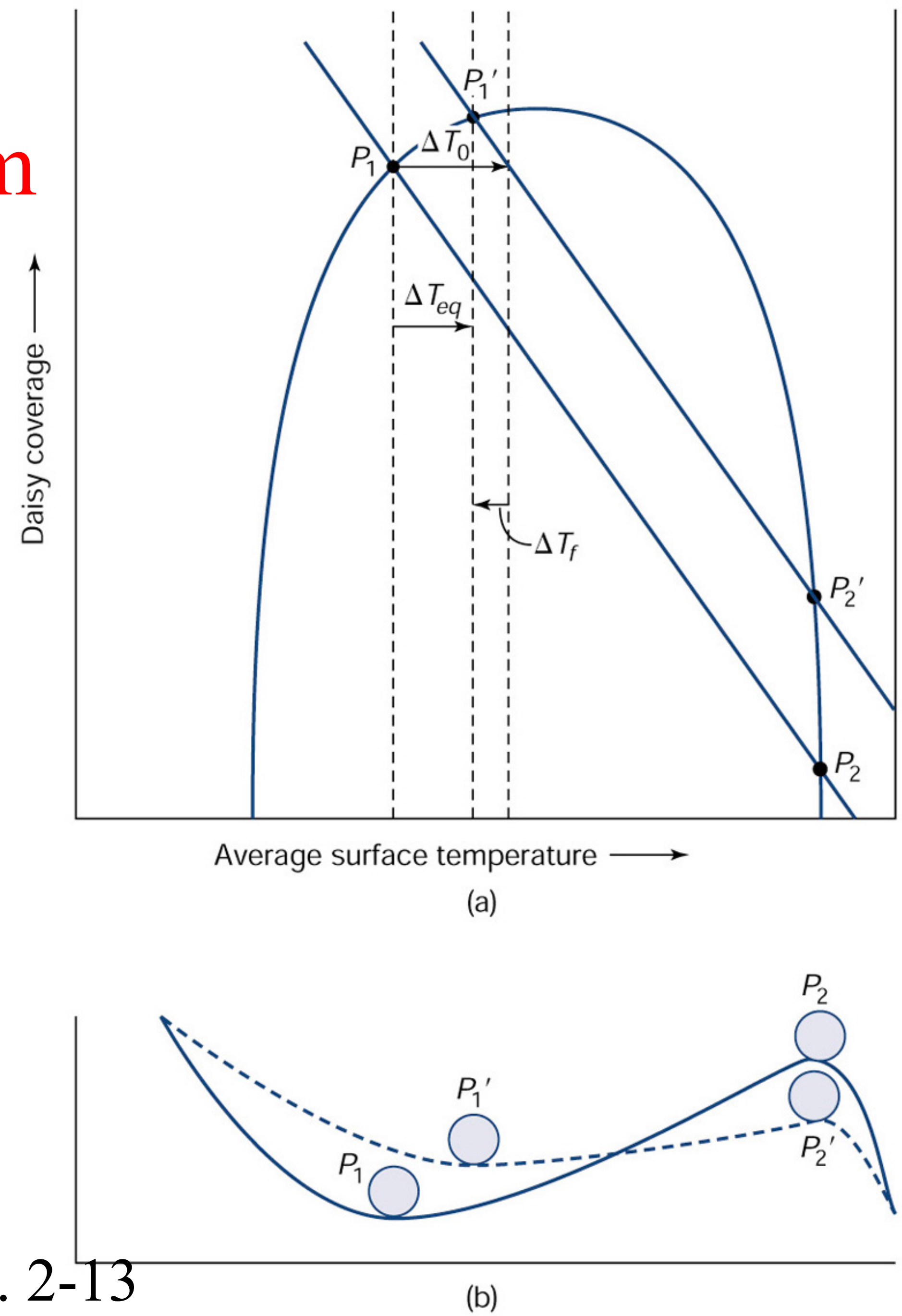


Fig. 2-13

The lessons of daisyworld

Climate system: not just passive,
there are feedback loops;
negative feedback loop =>
damp external forcing.
Daisyworld: increase life span;
Real climate system: negative feedback
loops => stabilize the system.

Self regulating. Coupling in the system
self regulates. Gaia hypothesis.

Even a stable system: persistent forcing, could
become unstable.

Summary of chapter 2

Systems: components - couplings - feedback loops;

Positive feedback loop - amplify perturbation or forcing;

Negative feedback loop - damp;

Equilibrium states: stable & unstable;

Daisyworld climate system - negative feedback Loop => self regulating (naturally).

Clicker’s question 2

b) Global energy balance: the greenhouse effect (chap. 3)

The Earth system: components & interactions.

life

Fig. 3-1

Venus:460C

Earth: 15C

Mars:-55C

Why is Venus so hot?

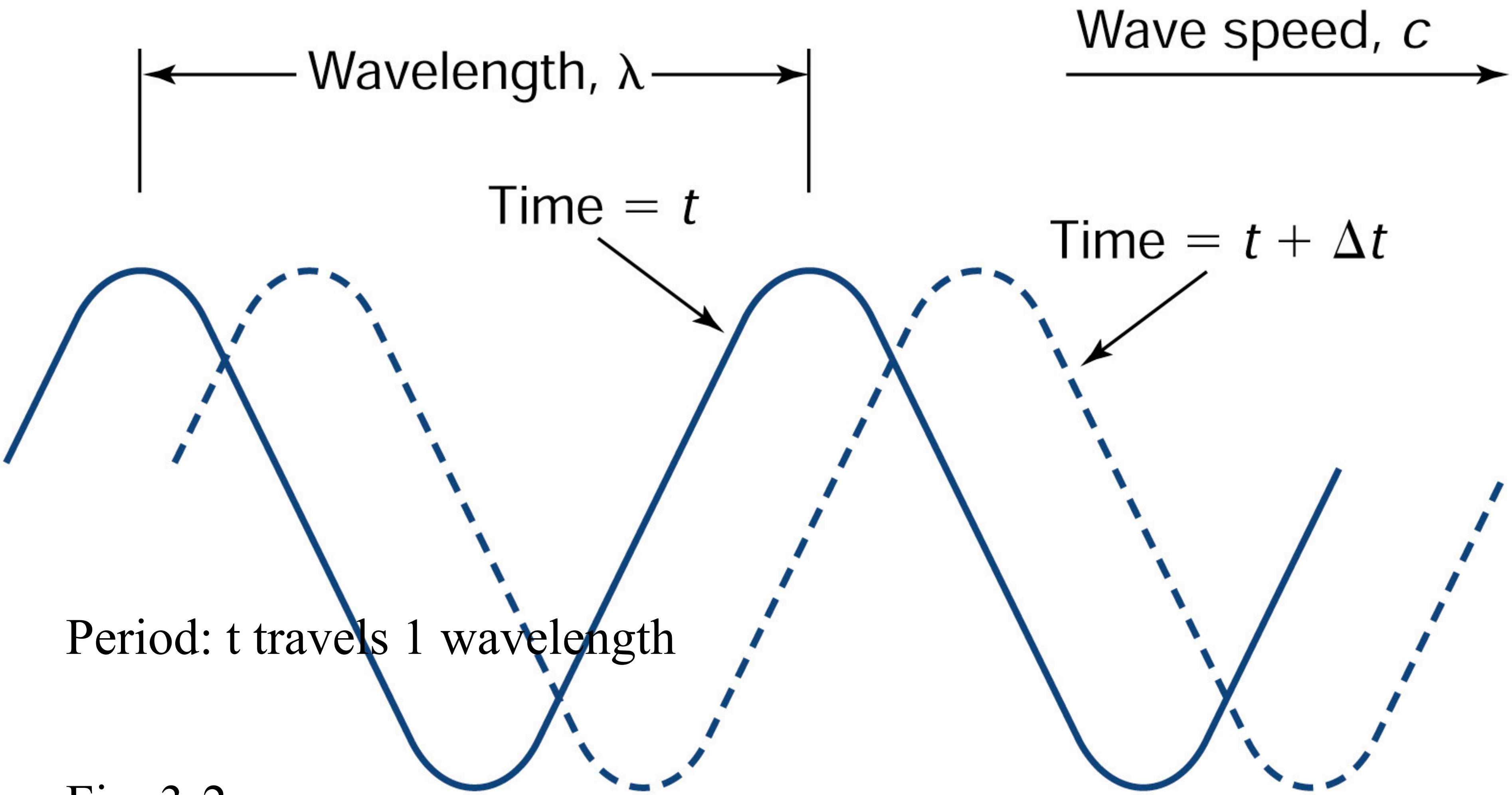
Why is Mars so cold?

Why is Earth just right?

Distance from the Sun: Venus - close;
Earth -middle;
Mars - far;
Greenhouse effects: Earth no greenhouse,
33C colder.

Electromagnetic radiation

Self-propagating electric and magnetic wave.



Period: t travels 1 wavelength

Fig. 3-2

Speed: $c = 300,000 km/s = 3 \times 10^8 m/s$

λ : wavelength, the distance between two adjacent crests.

: frequency, at a fixed point, a given number of crests passed by in 1 second.

P : period, the time it takes the electromagnetic waves to travel for one wavelength.

$$\lambda = c \times P = c/\nu$$

Wavelength=speed x period=speed/frequency

$$P = \frac{1}{\nu}$$

$$Period = \frac{1}{frequency}$$

Photons and photon energy

Electromagnetic waves:
also behave more like a stream of particles.
(wave-particle duality)
A single particle, or pulse, of electromagnetic radiation is referred to as a photon.
Energy E of a photon is:

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

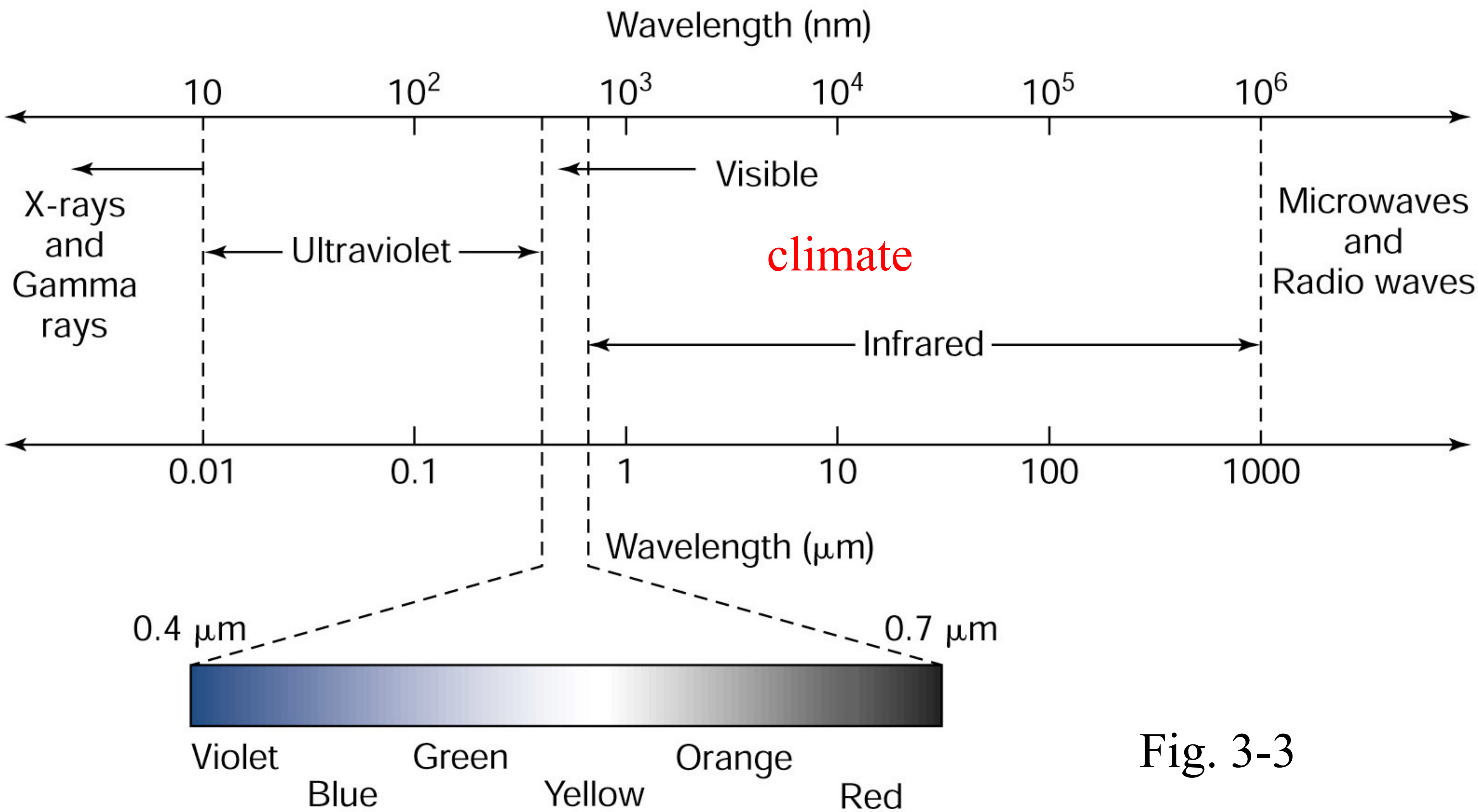
$$E = h\nu = \frac{hc}{\lambda}$$

$$Energy = \frac{h \times speed}{wavelength}$$

(300,000km/s)

The electromagnetic spectrum

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



climate

Fig. 3-3

40% IR; 10% UV; 50% visible light;

Clicker’s question 3

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

$$W/m^2$$

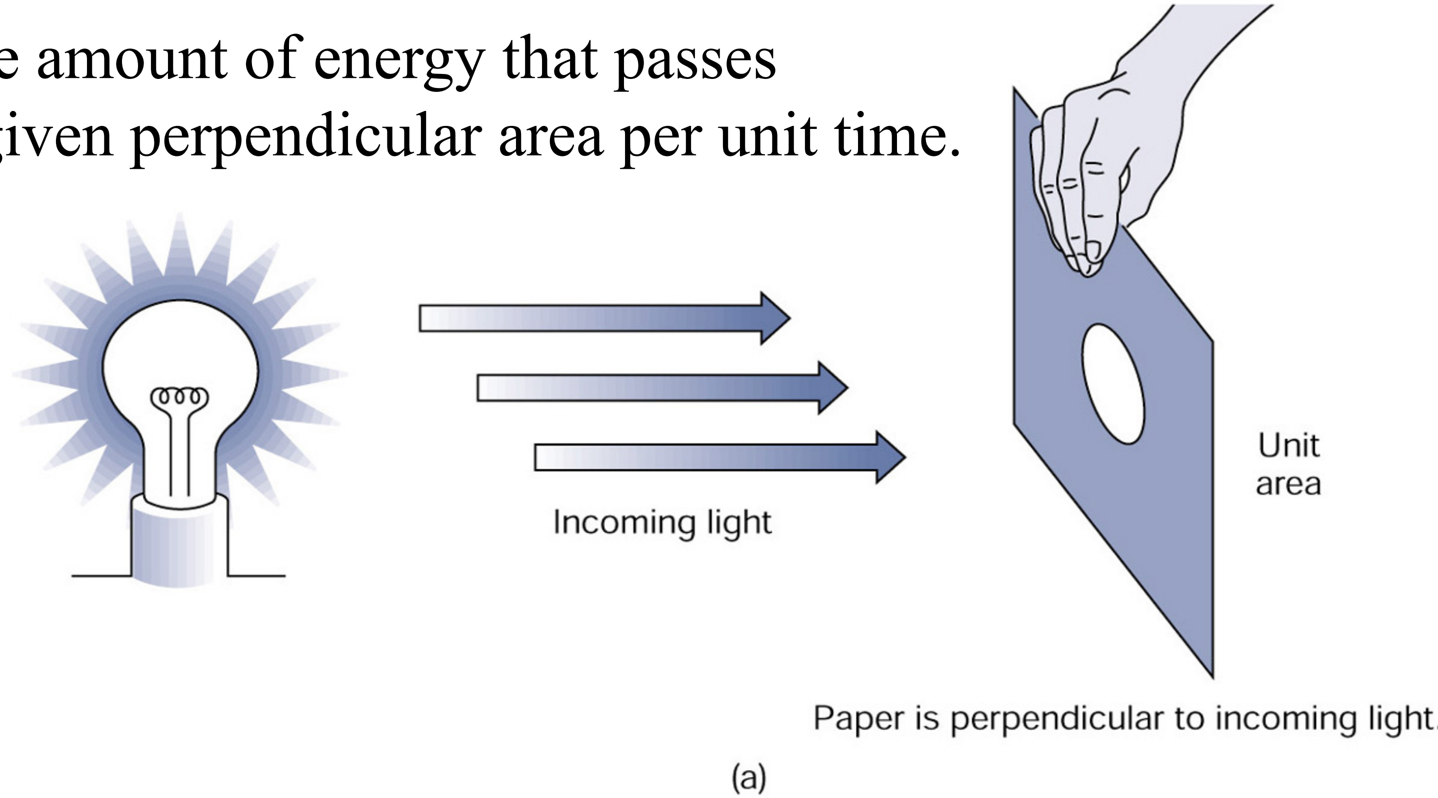
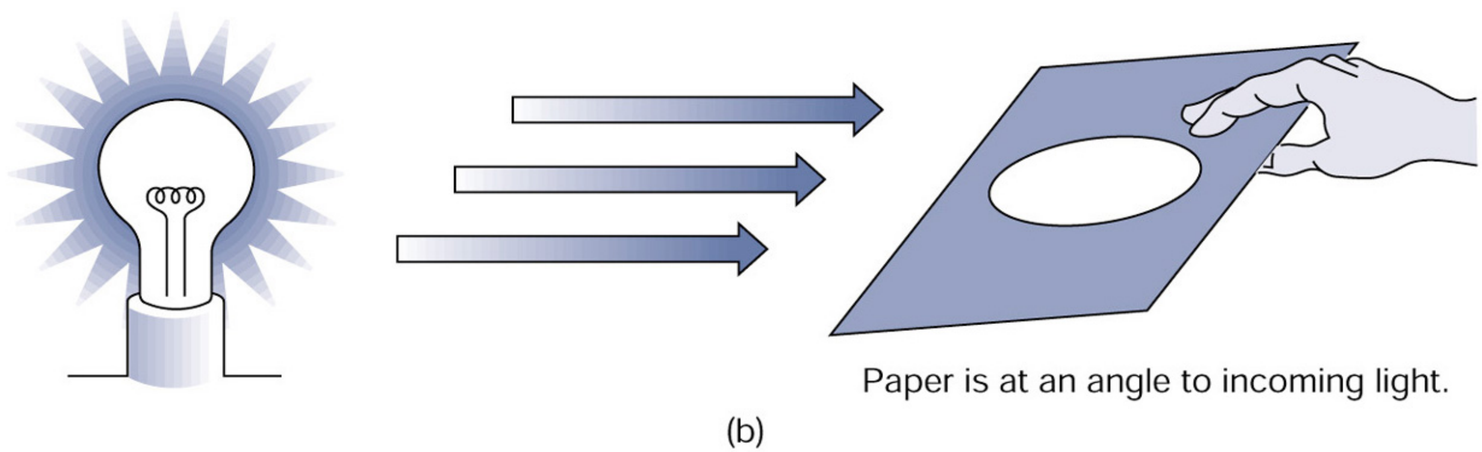
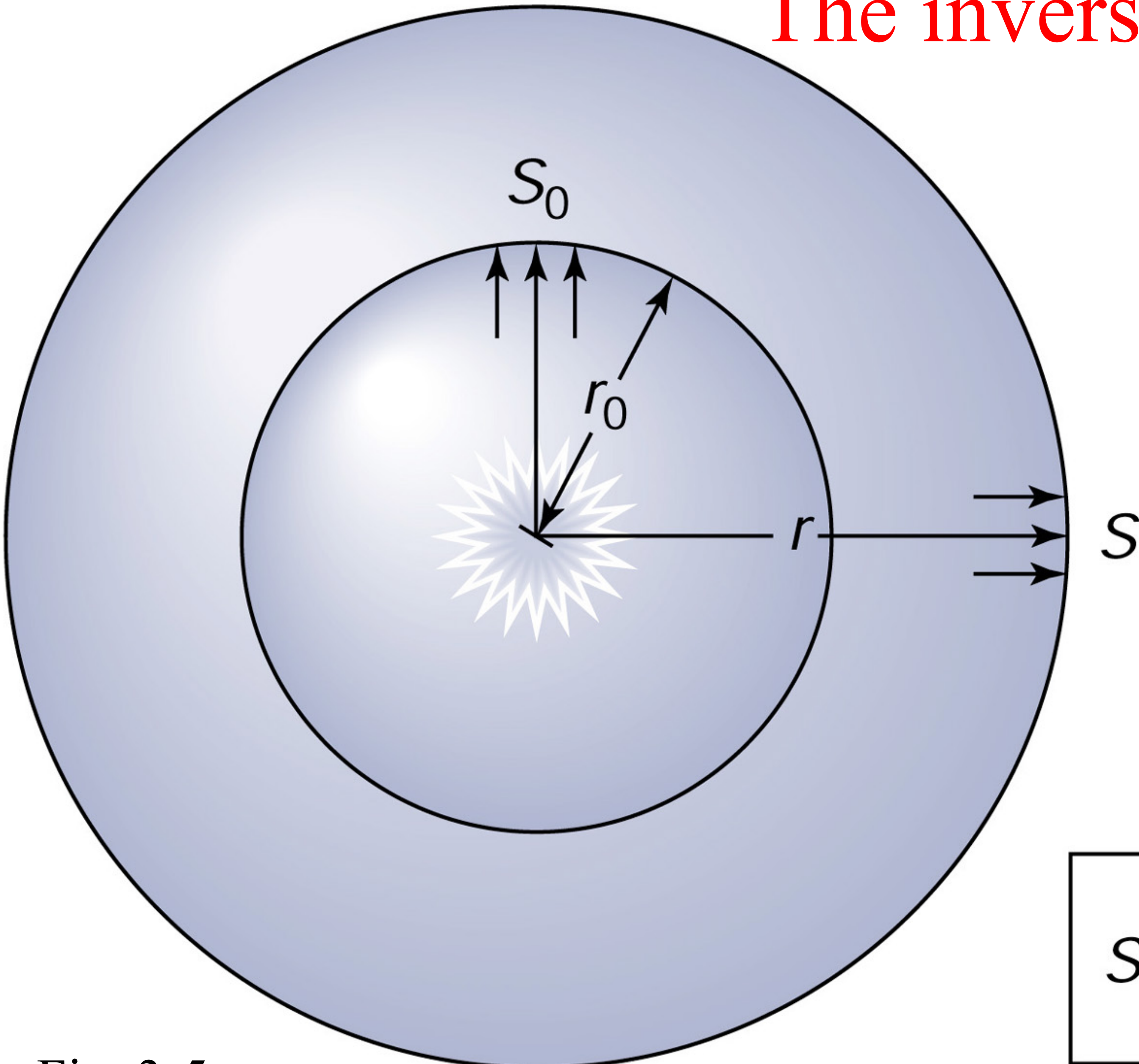


Fig. 3-4



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

TABLE 3-1

Freezing and Boiling Points of Water by Temperature Scale

Temperature Scale	*Freezing Point*	*Boiling Point (at sea level)*
Fahrenheit	32°	212°
Celsius	0°	100° (sea level pressure)
Kelvin (absolute)	273.15	373.15

$$T(^oC) = \frac{T(^oF) - 32}{1.8}$$

$$T(^oF) = [T(^oC) \times 1.8] + 32$$

$$T(K) = T(^oC) + 273.15$$

Clicker's question 4