

生態學Ecology

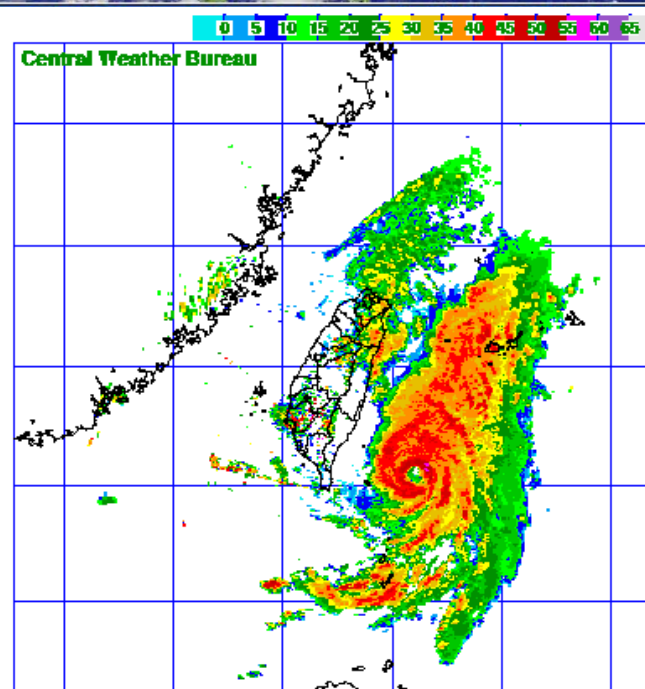
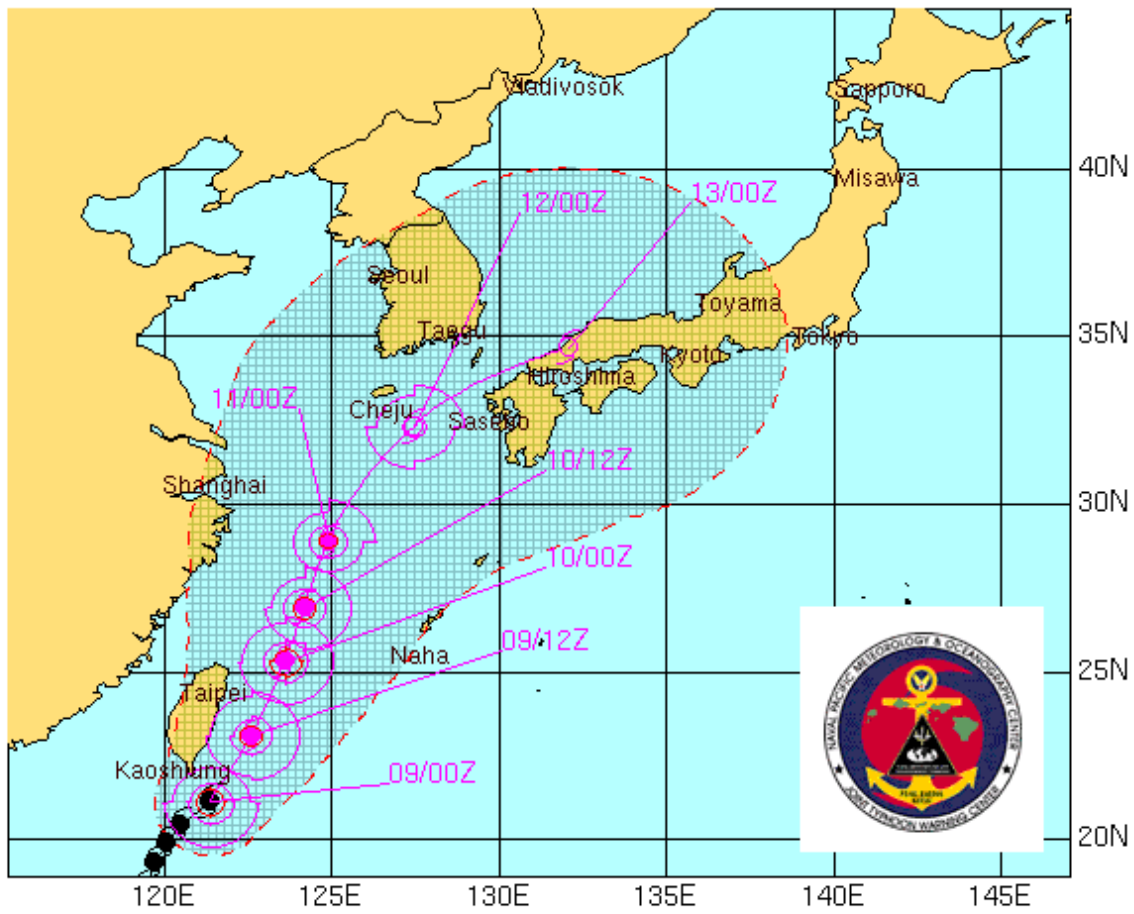
• 生態學主要探討生物與生物間，以及生物與環境間的科學。

• 族群生態學population ecology

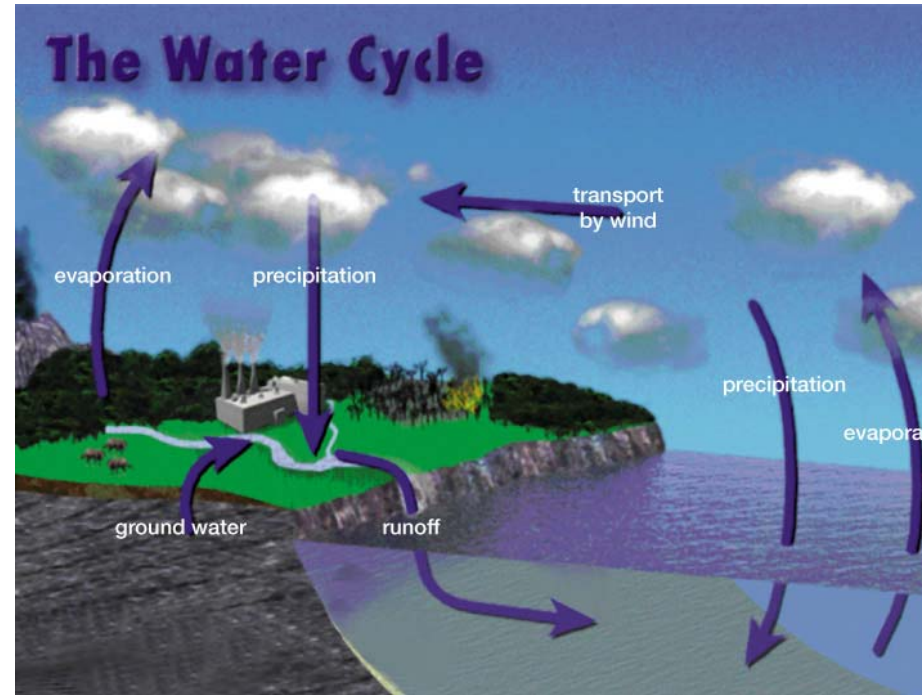
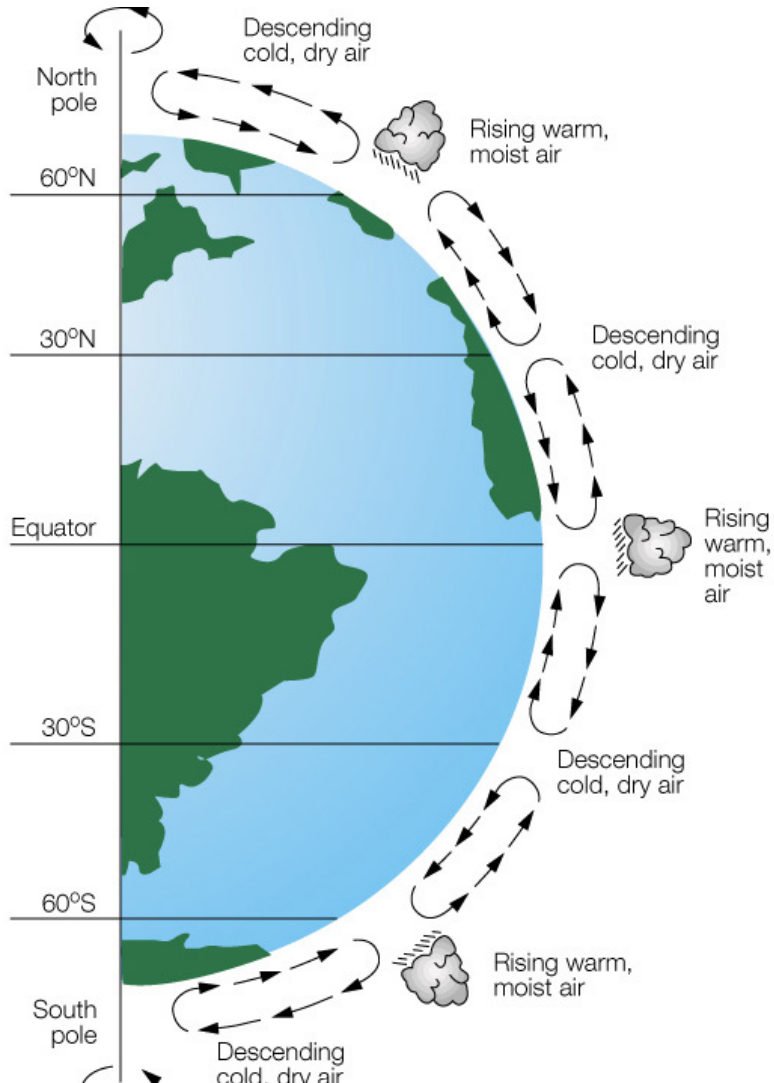
• 群落生態學community ecology

• 生態系統生態學ecosystem ecology

中度颱風，編號第4號(國際命名：CONSON，中文譯名：康森)



Earth's climates are largely determined by patterns of mass air movement



Properties of ecosystems

- They come in almost any size.
- They occupy definable spaces.
- They are open systems, with energy and matter flowing in and out freely.
- They are dynamic, showing both short-term and long-term changes.
- Within them, materials tend to cycle.

A pond: an example of an ecosystem

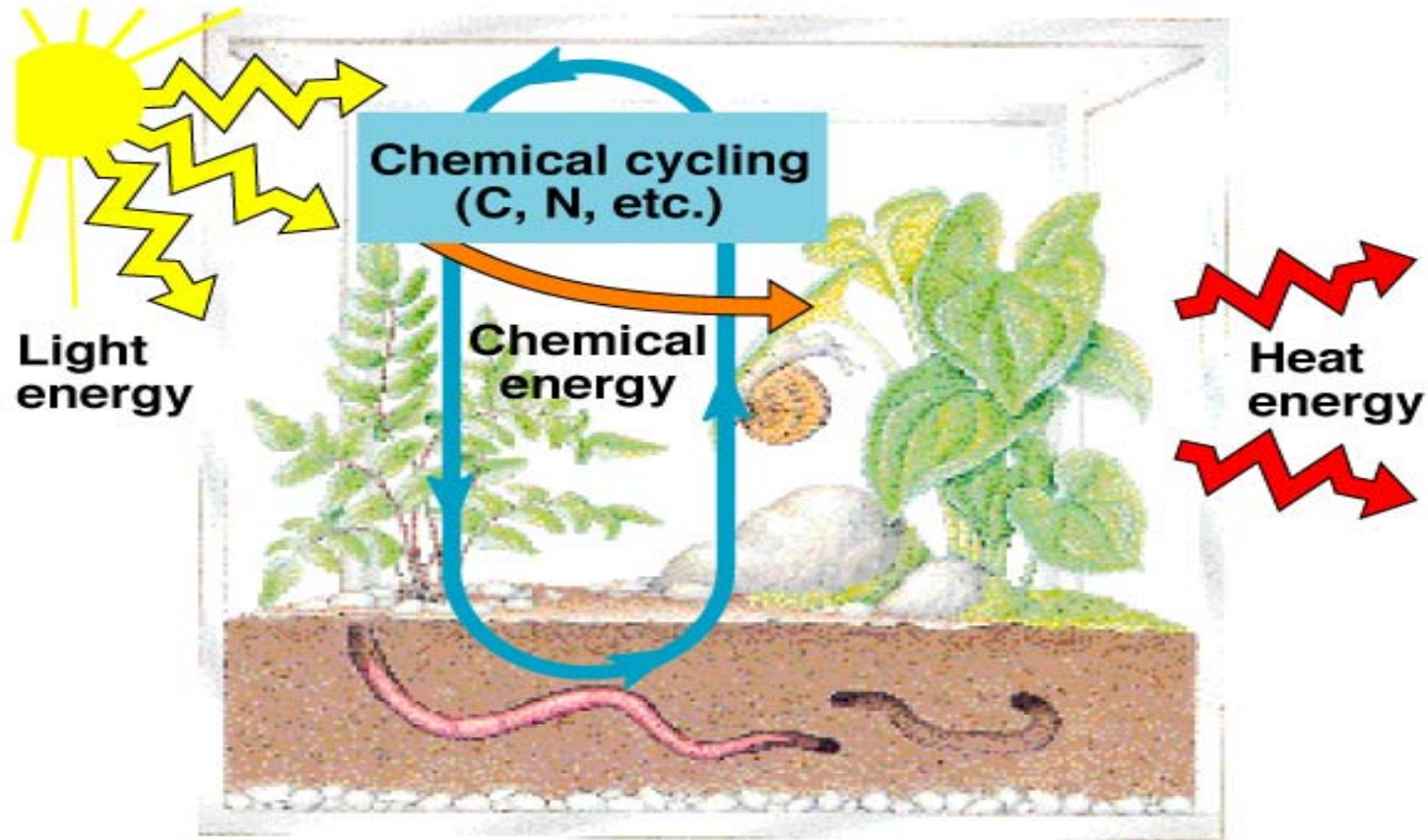


Courtesy Larry Underwood

Ecosystems 生態系統

Energy flow and trophic structure

能量流動和營養結構



The laws of thermodynamics

熱力學定律

First law: The total energy of an isolated system is constant, although within that system energy may change its form.

能量守恆定律：在自然界發生的所有現象中，能量既不能消滅亦不能憑空產生，它只能以嚴格的當量比例由一種形式轉變為另一種形式。

$$\Delta H = \Delta Q - \Delta W$$

ΔH : The change in system enthalpy, the internal energy of a system.

ΔQ : The net heat exchanged between the system and its surroundings.

ΔW : The net work exchanged with the environment.

Second law

第二定律（熵律 entropy law）

Second law: In any energy transfer, some energy is lost in the form of heat.

第二定律（熵律 entropy law）能量的傳導過程，無法達到百分之百的效率，必定有部份的能量以熱的形式散失掉了。

$$\Delta H = \Delta G + T \Delta S$$

ΔG : The net change in the Gibbs free energy of the system.

T: Temperature

ΔS : The change in the entropy, or disorder, of the system.

Energy capture in ecological systems

Primary production 初級生產量 or 第一次性生產量

The rate of accumulation of energy in organic molecules by photosynthesis. 植物所固定的太陽能或所製造的有機物質

每年每平方公尺所產生的有機物質乾重($\text{g}/\text{m}^2/\text{yr}$)

每年每平方公尺所固定的能量值(caloric)

1 g plant = 4.5 C

1 g algae = 4.9 C

primary production 初級生產量

Photosynthesis: $6\text{CO}_2 + 6\text{H}_2\text{O} \rightarrow \text{C}_6\text{H}_{12}\text{O}_6 + 6\text{O}_2$

Respiration: $\text{C}_6\text{H}_{12}\text{O}_6 + 6\text{O}_2 \rightarrow 6\text{CO}_2 + 6\text{H}_2\text{O}$

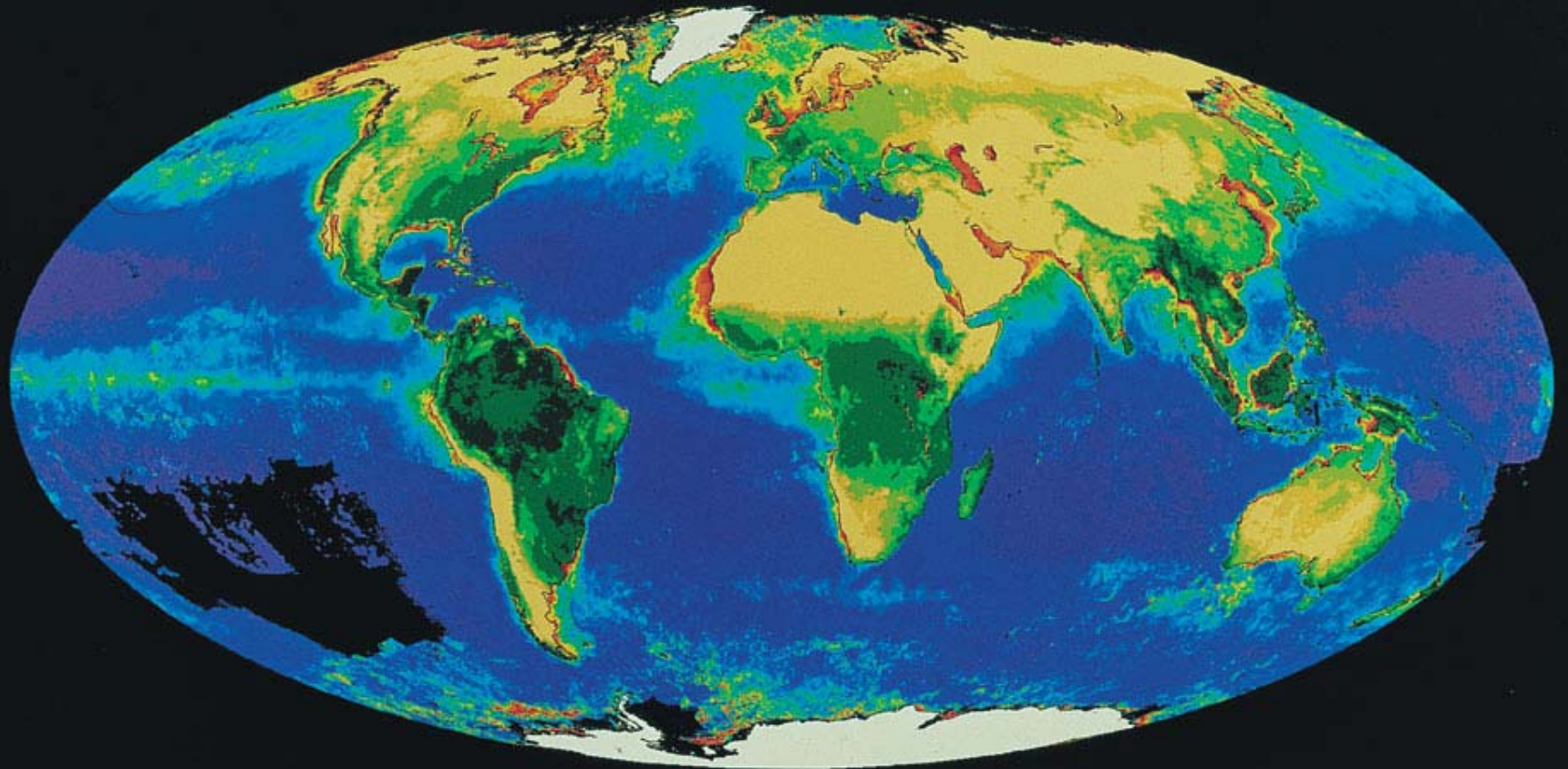
Net primary production 淨初級生產量(NP)

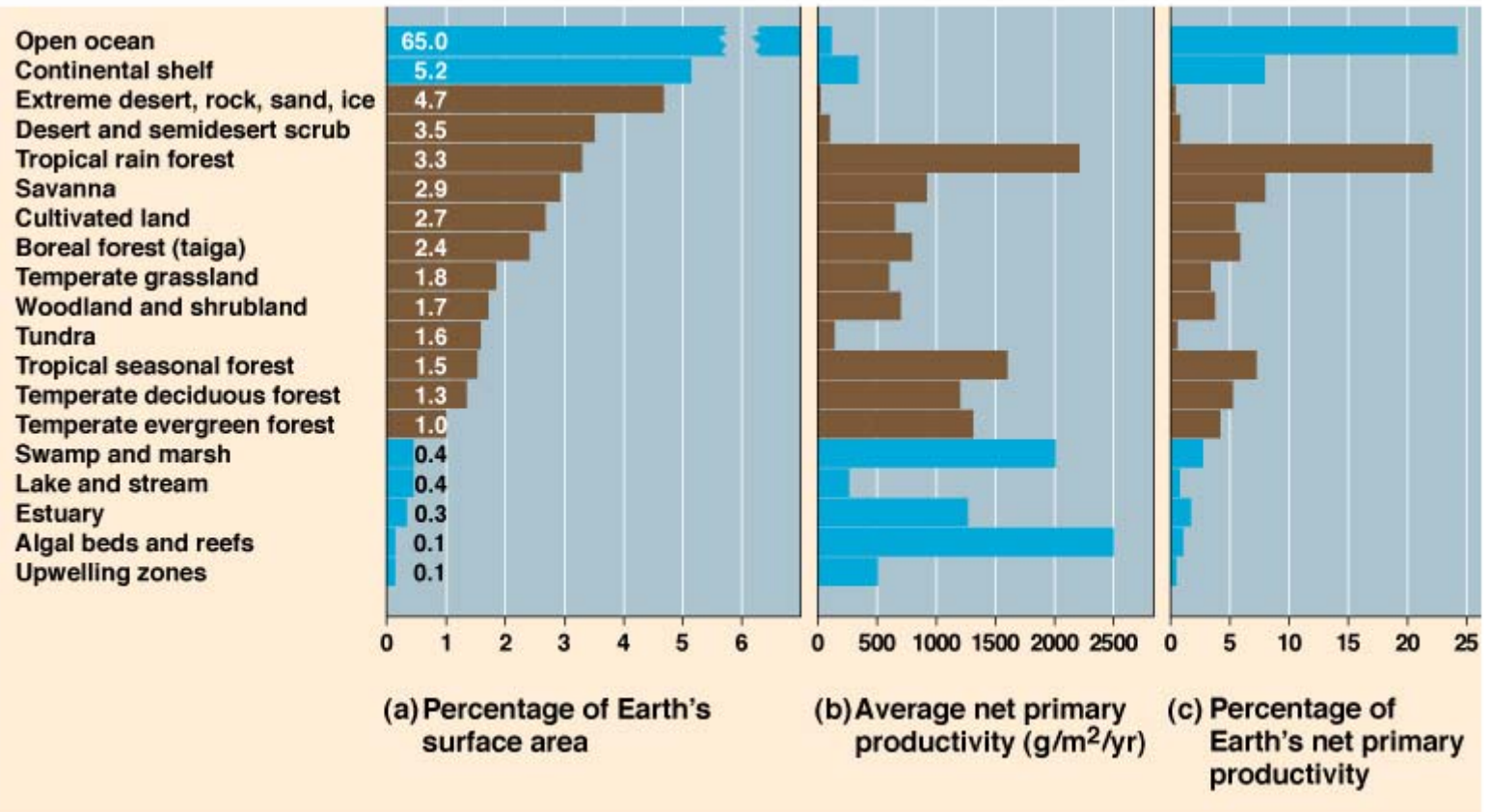
可被用於植物生長和生殖的能量

Gross primary production 總初級生產量(GP)

NP加上植物呼吸消耗的能量 (R)

$$\text{GP} = \text{NP} + \text{R}$$





Trophic structure 營養結構

Food Chains 食物鏈：

The pathway of energy transfer. A succession of organisms in an ecosystem that are linked by an energy flow and the order of who eats whom.

Trophic levels 營養階層

Primary producers (Plants)

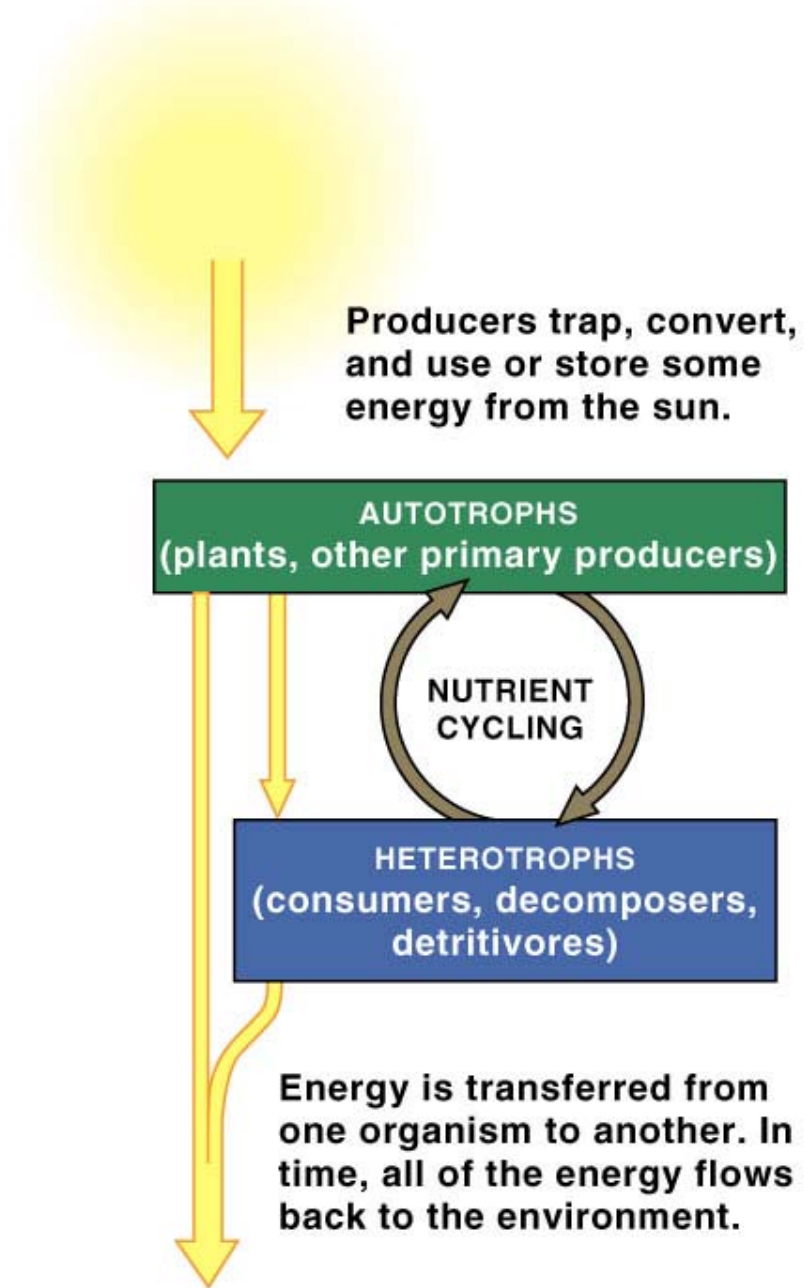
Primary consumers (herbivores)

Secondary consumers (carnivores)

Tertiary consumers (top carnivore)

Food web 食物網：

A complex pattern of interlocking and crisscrossing food chains.



Producers trap, convert, and use or store some energy from the sun.

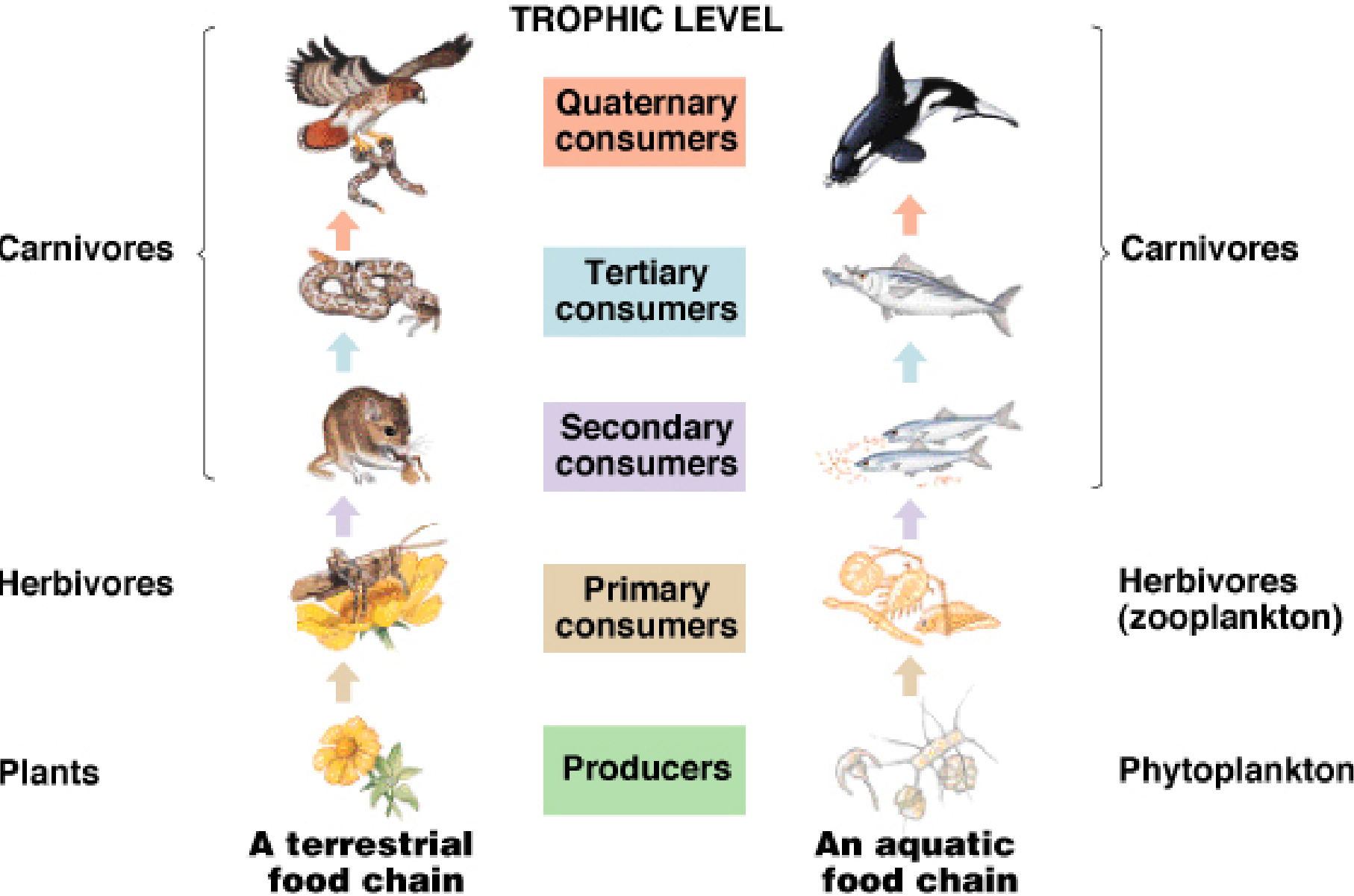
AUTOTROPHS
(plants, other primary producers)



HETEROTROPHS
(consumers, decomposers, detritivores)

Energy is transferred from one organism to another. In time, all of the energy flows back to the environment.

ONE-WAY FLOW OF ENERGY



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陸域與海洋食物鏈的例子

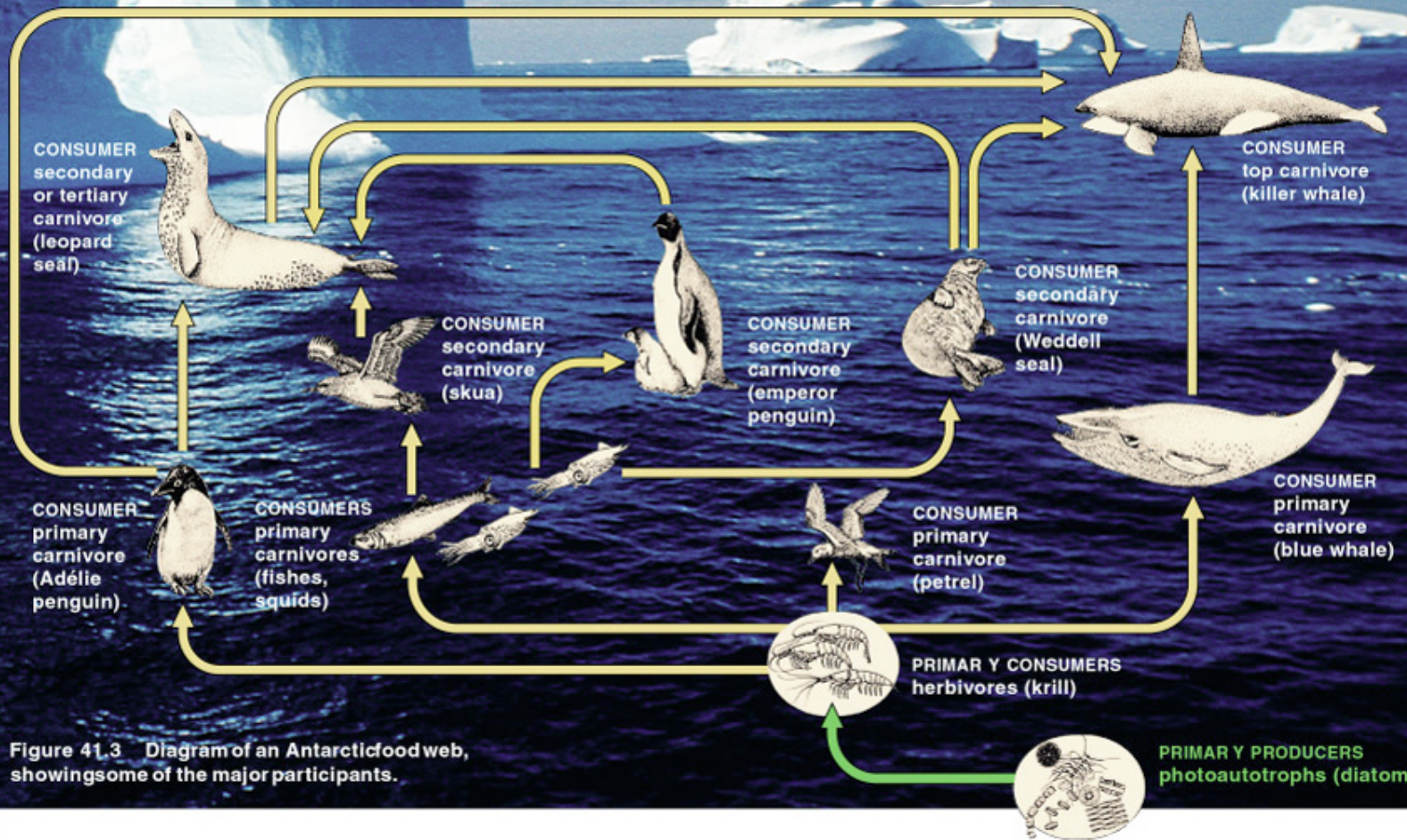


Figure 41.3 Diagram of an Antarctic food web, showing some of the major participants.

PRIMARY PRODUCERS photoautotrophs (diatoms)

Tertiary and secondary consumers

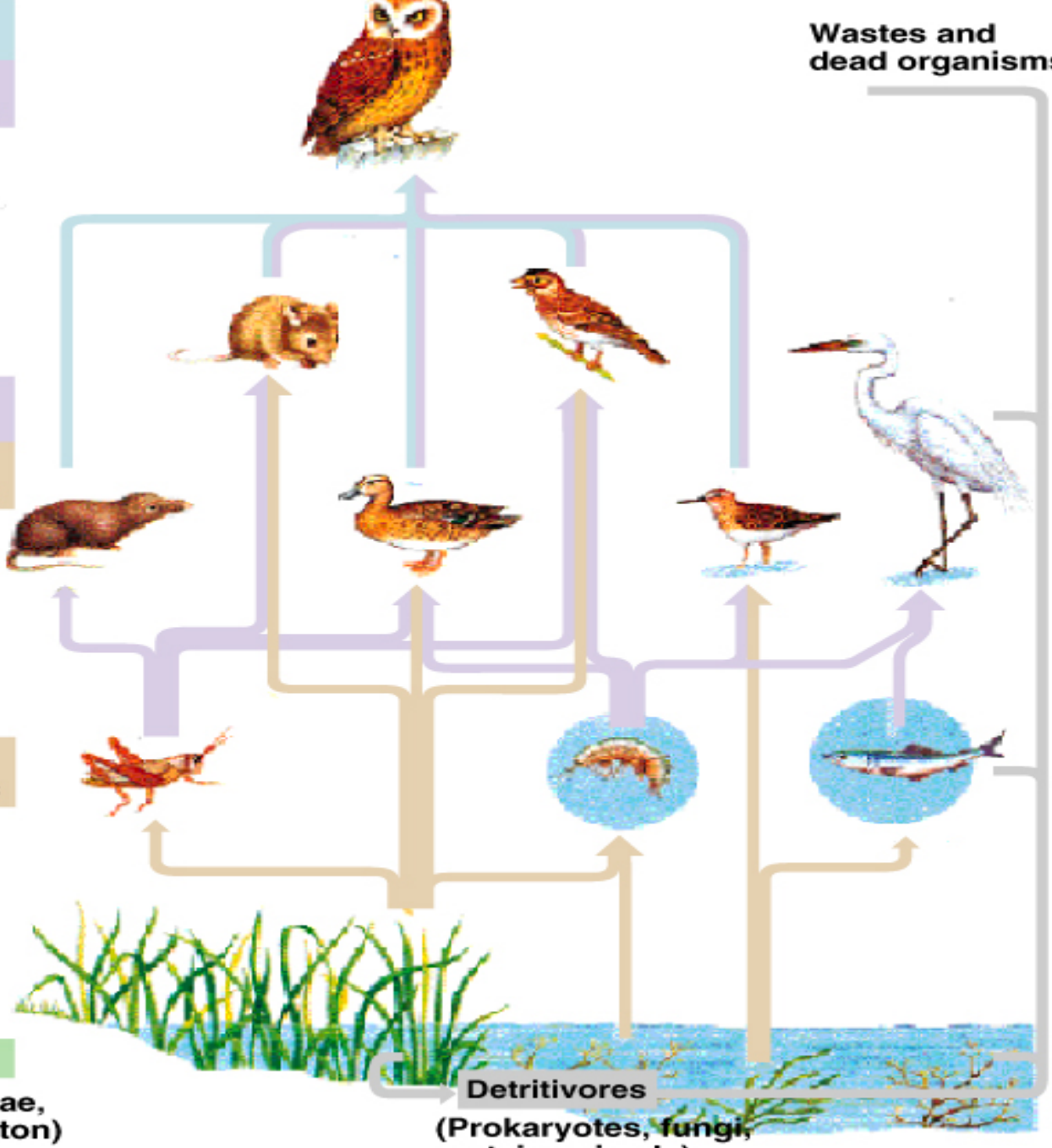
Secondary and primary consumers

Primary consumers

Producers

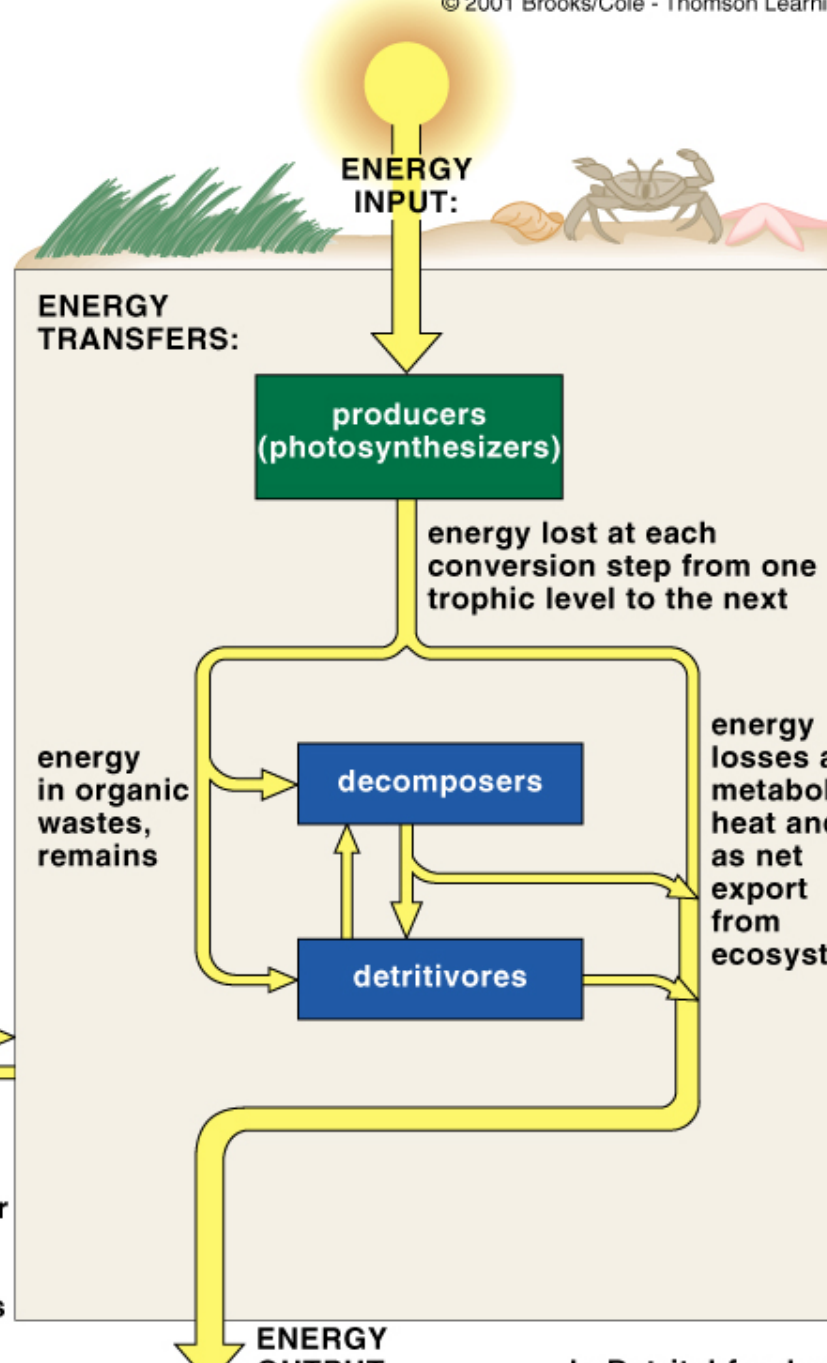
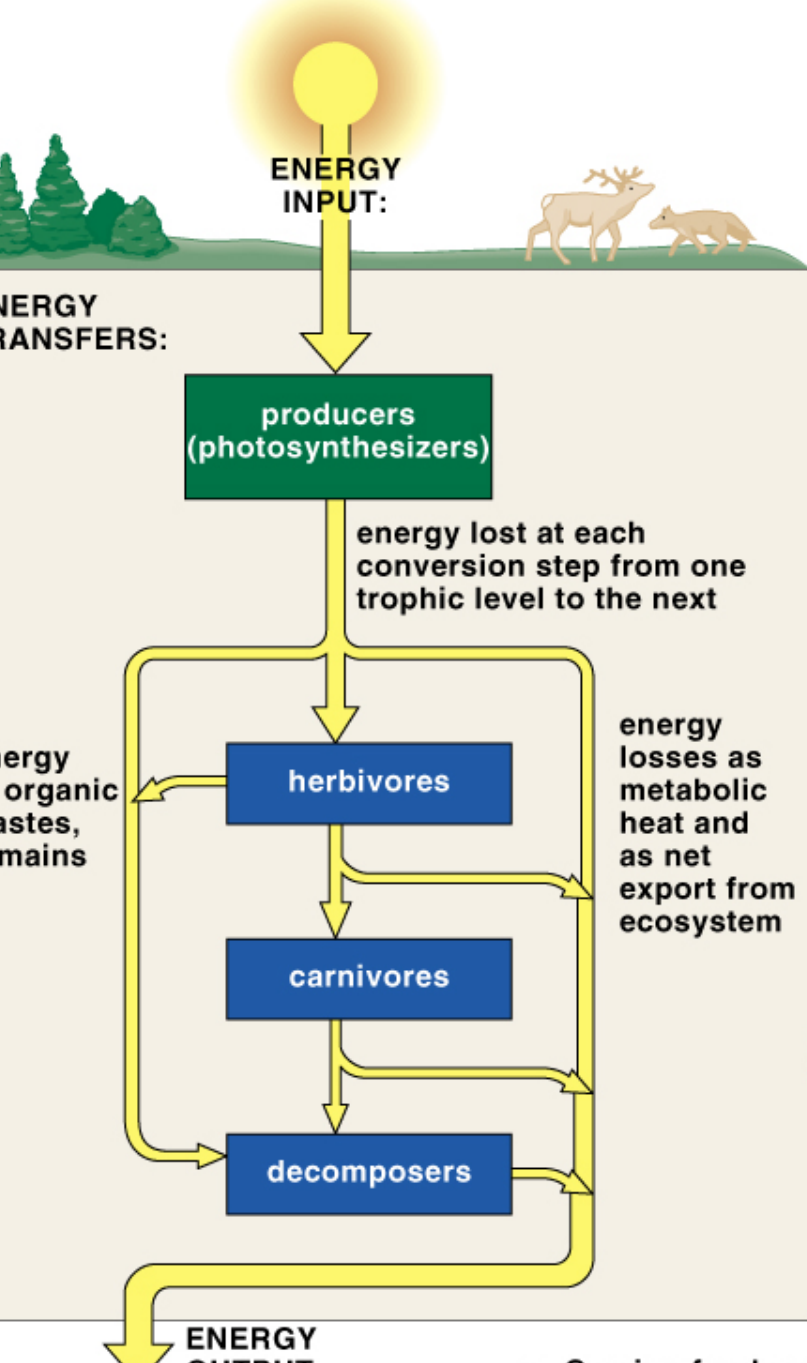
(Plants, algae, phytoplankton)

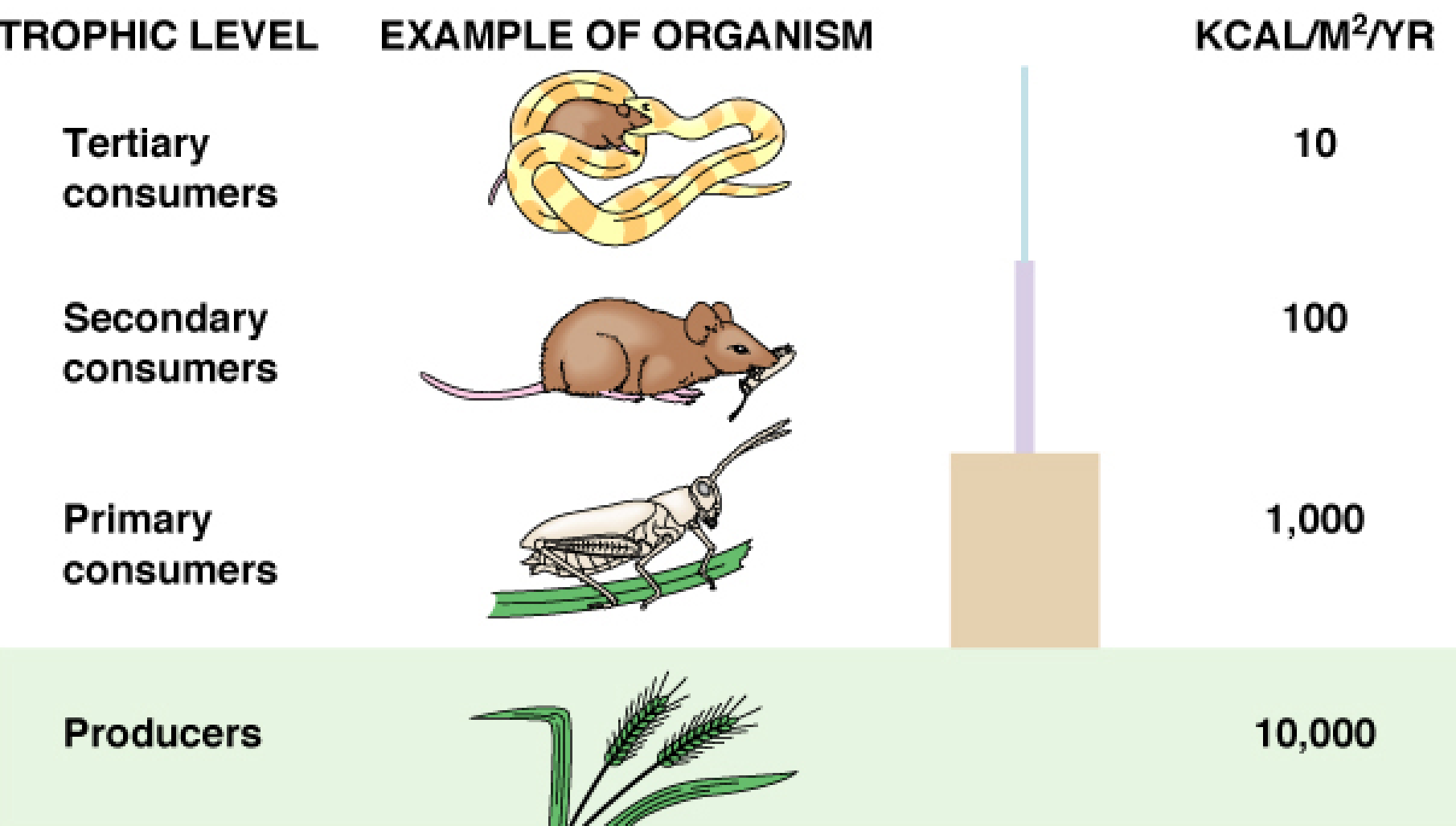
Wastes and dead organisms



Detritivores
(Prokaryotes, fungi, certain animals)

食物網

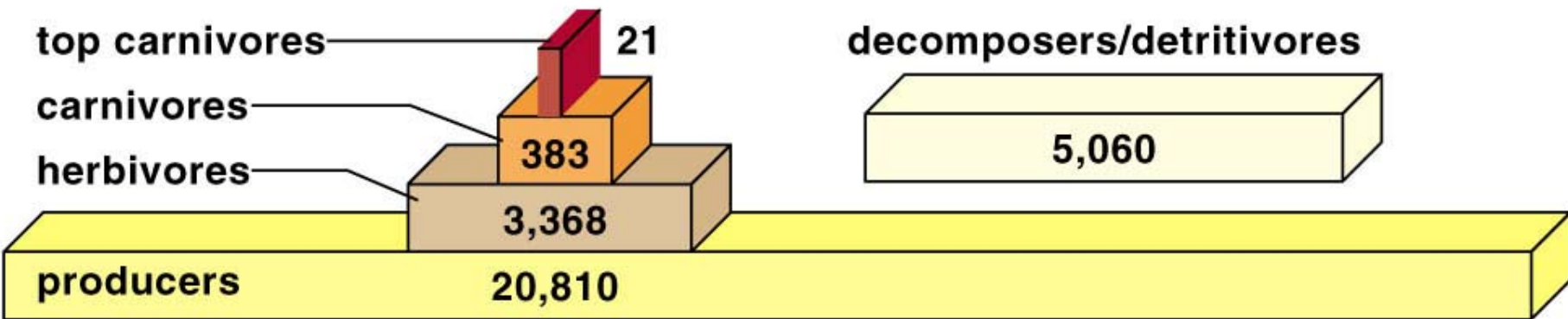




Energy at each trophic level from 1,000,000 kcal of sunlight per m² per yr

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能量金字塔

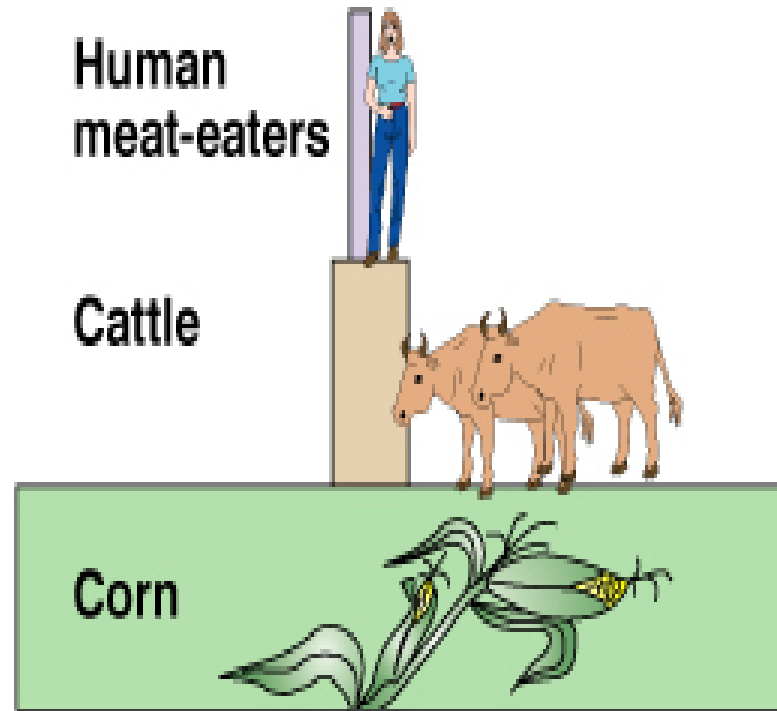
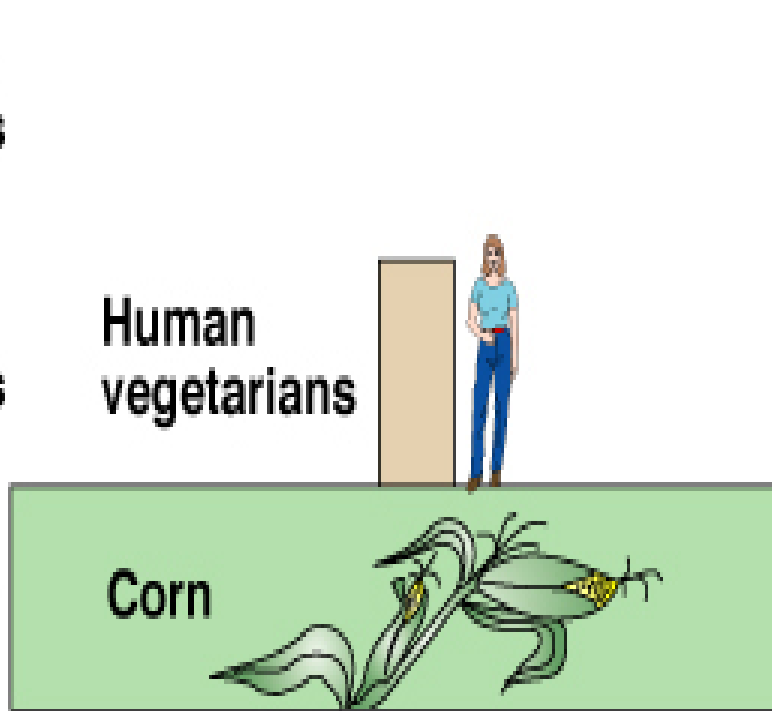


TROPHIC LEVEL

Secondary consumers

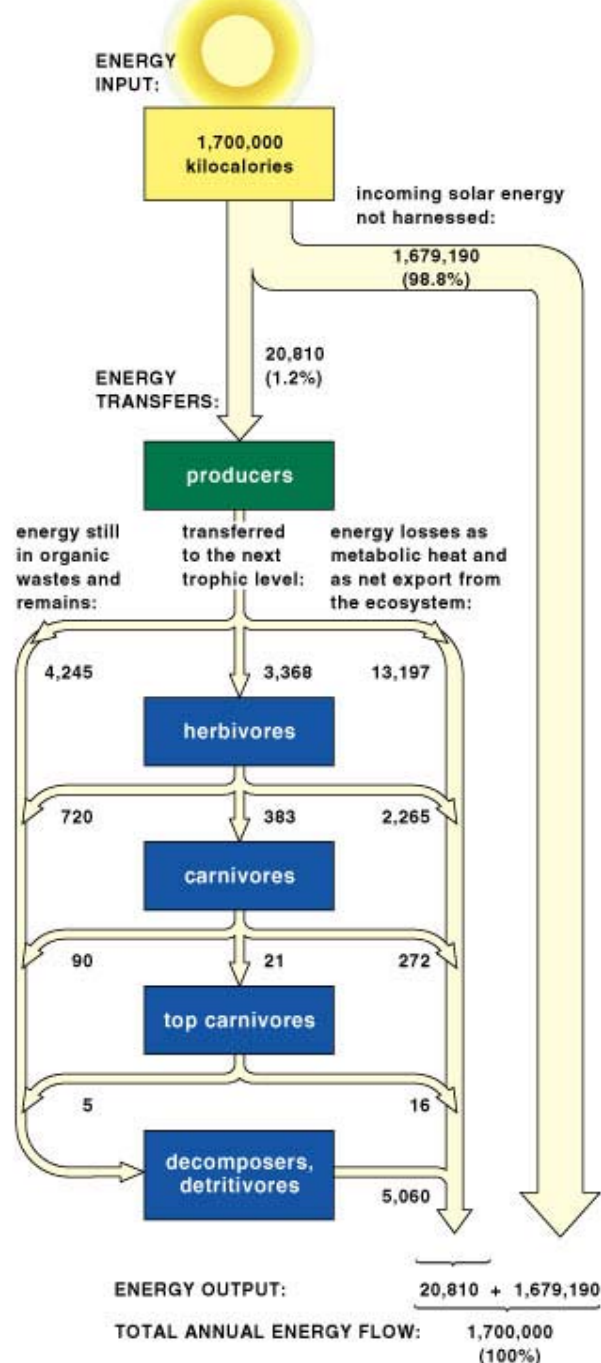
Primary consumers

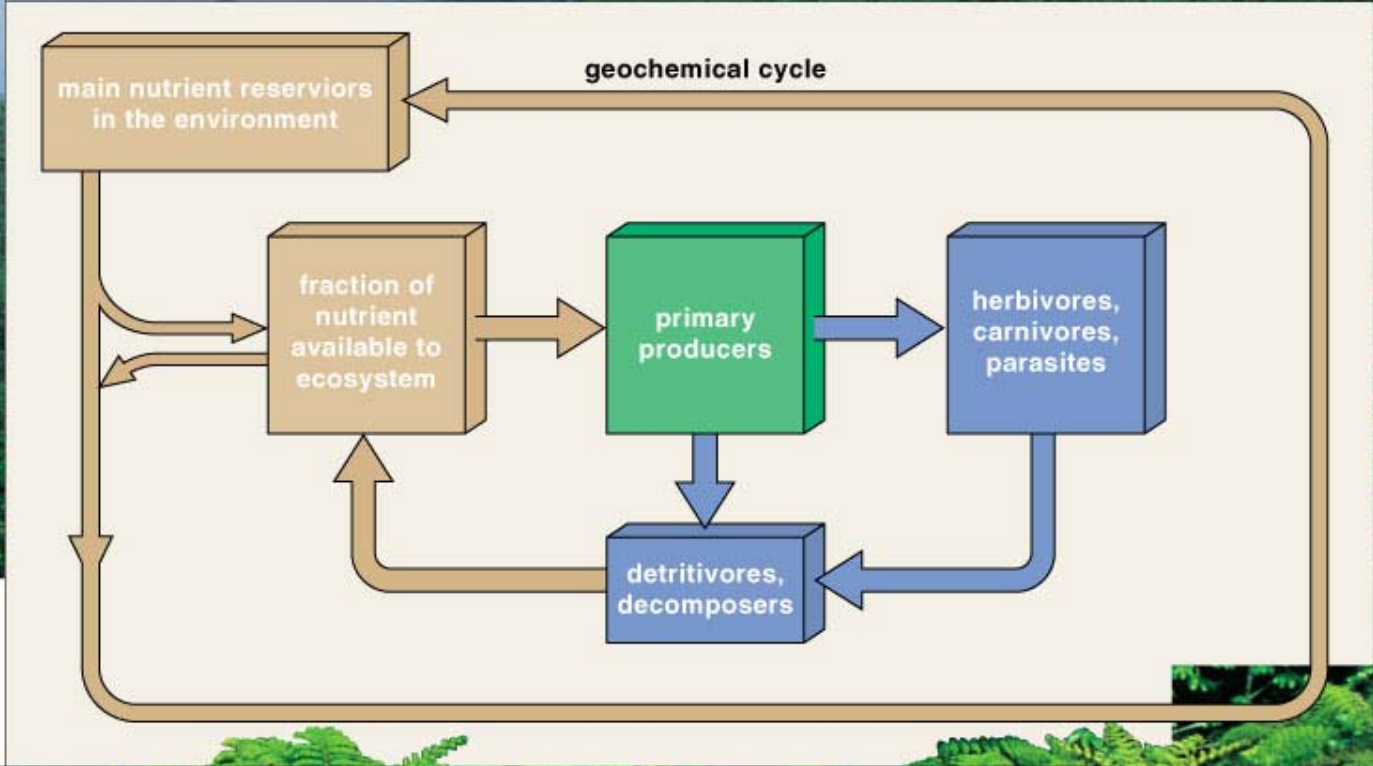
Producers



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在不同營養階層上人類族群所能夠獲取的食物能量

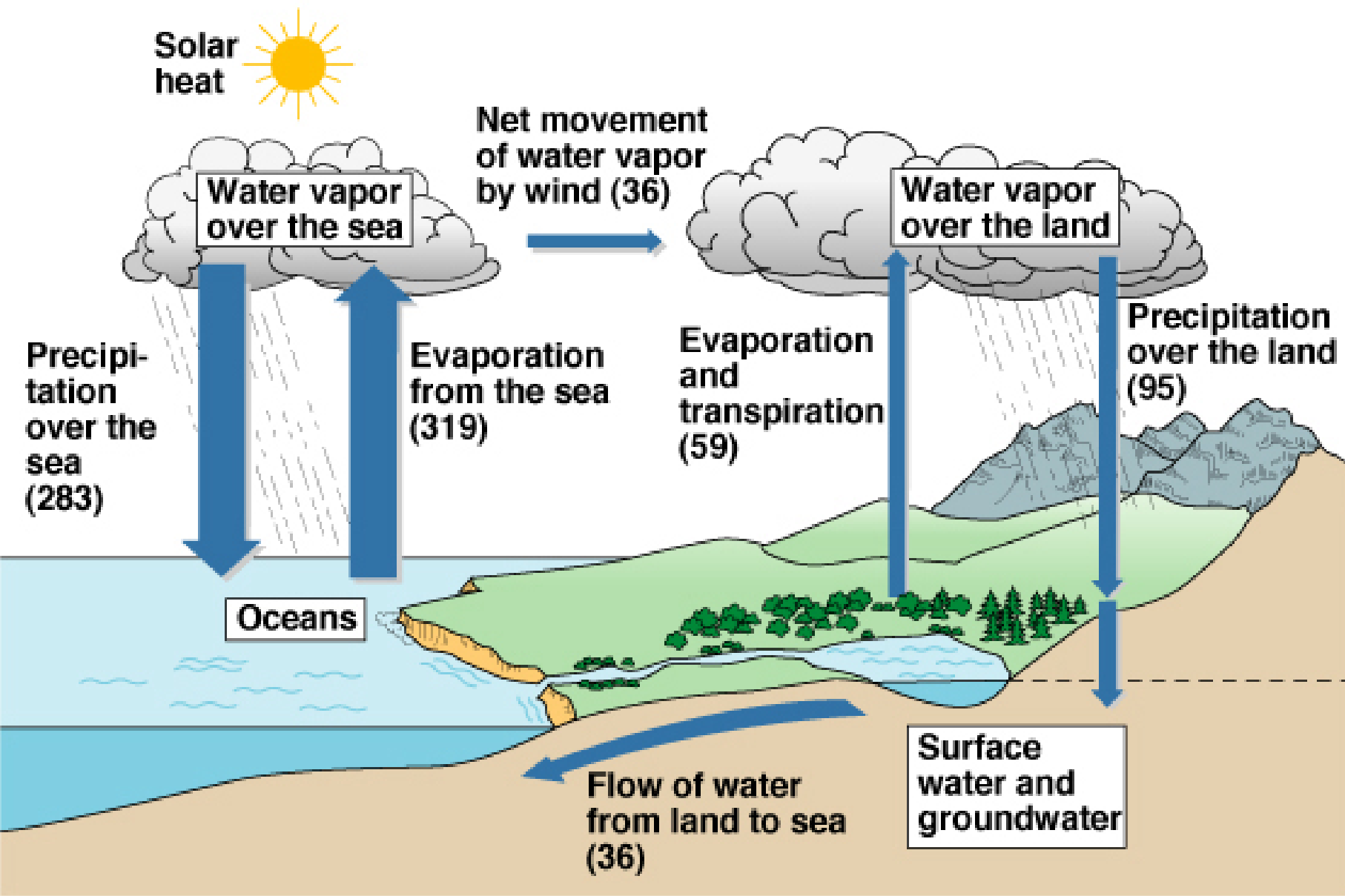


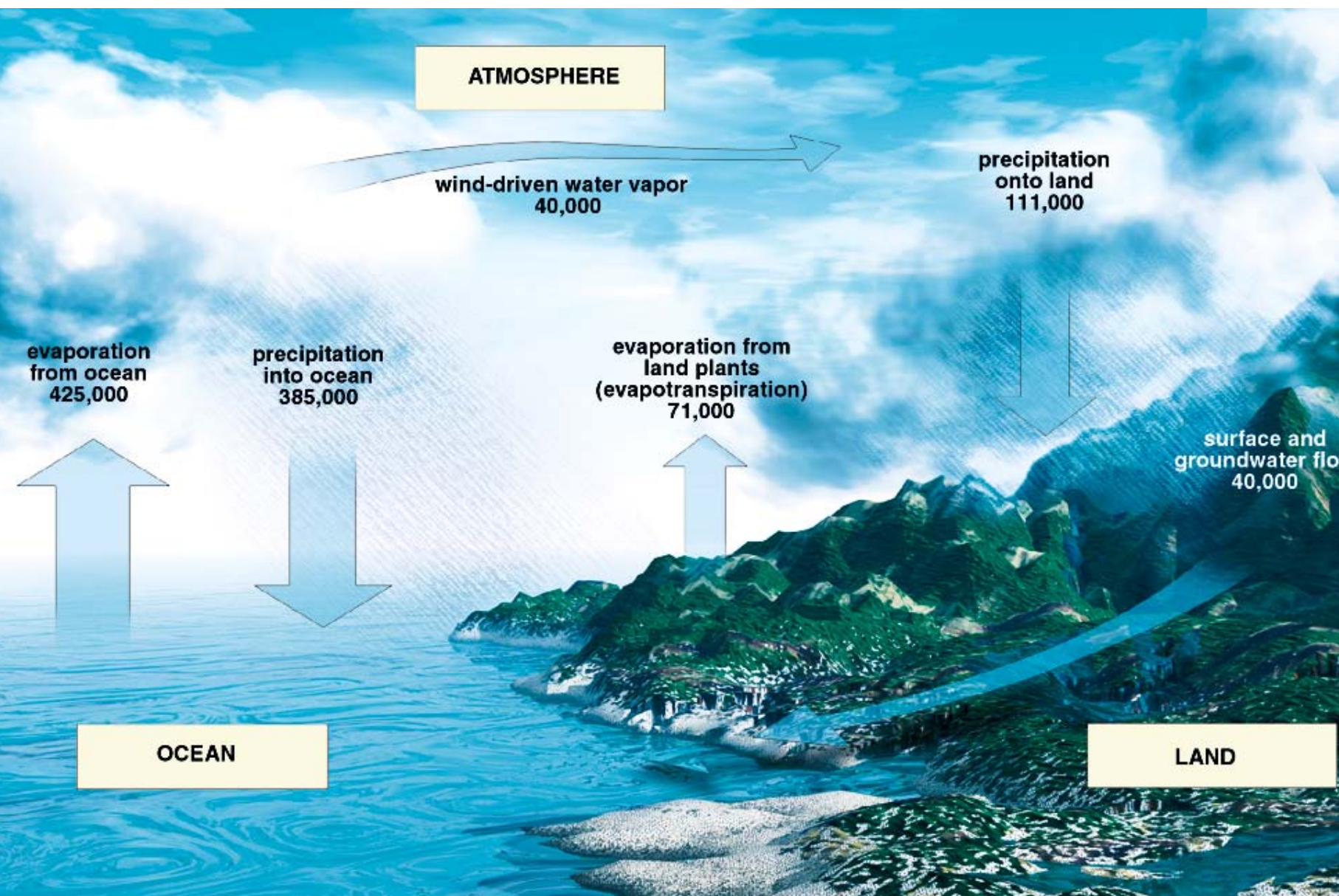


Biochemical and Nutrient Cycles

生物地化和營養循環

生態系統中的物質循環，和能量流動是生態系統的兩大基本過程。





ATMOSPHERE

wind-driven water vapor
40,000

precipitation
onto land
111,000

evaporation
from ocean
425,000

precipitation
into ocean
385,000

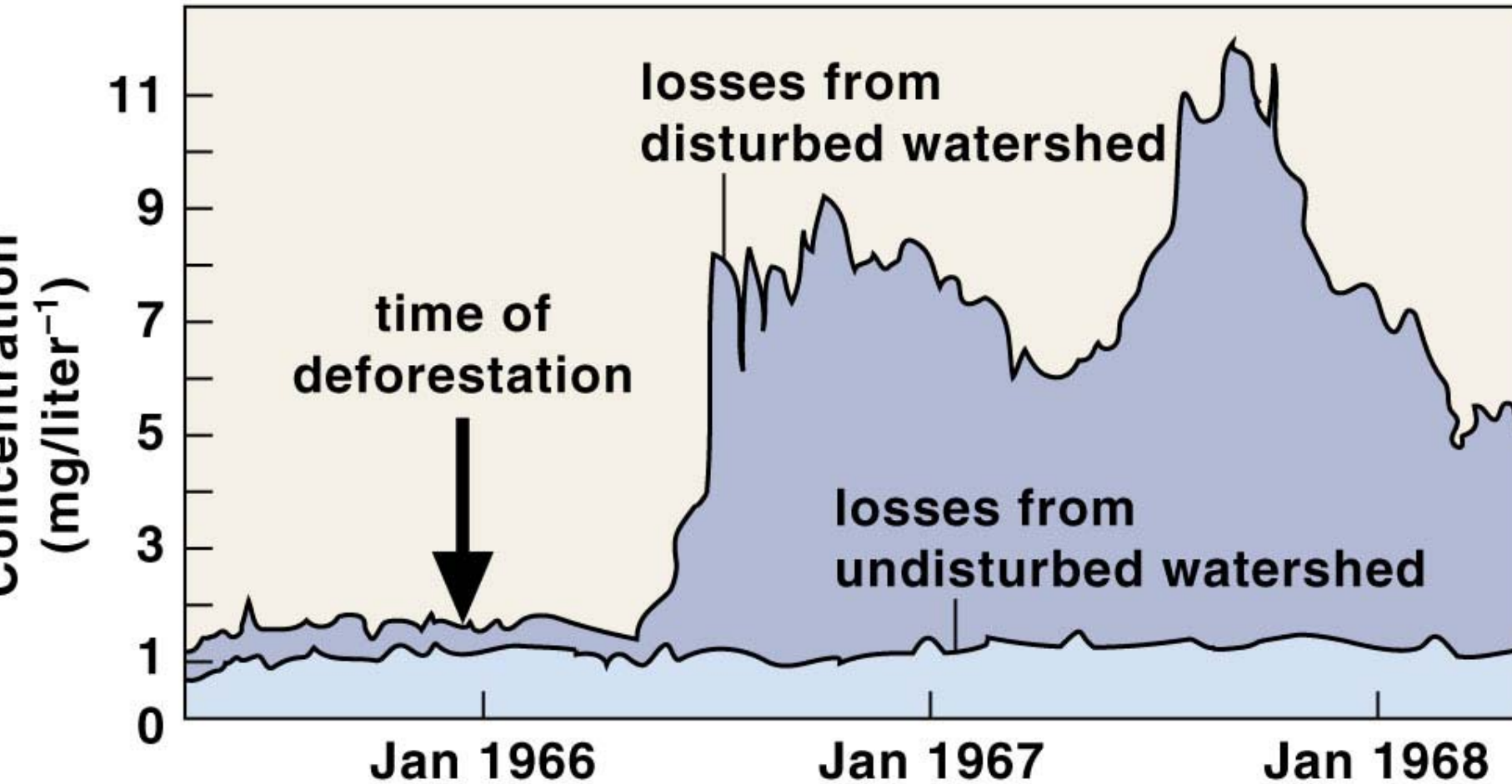
evaporation from
land plants
(evapotranspiration)
71,000

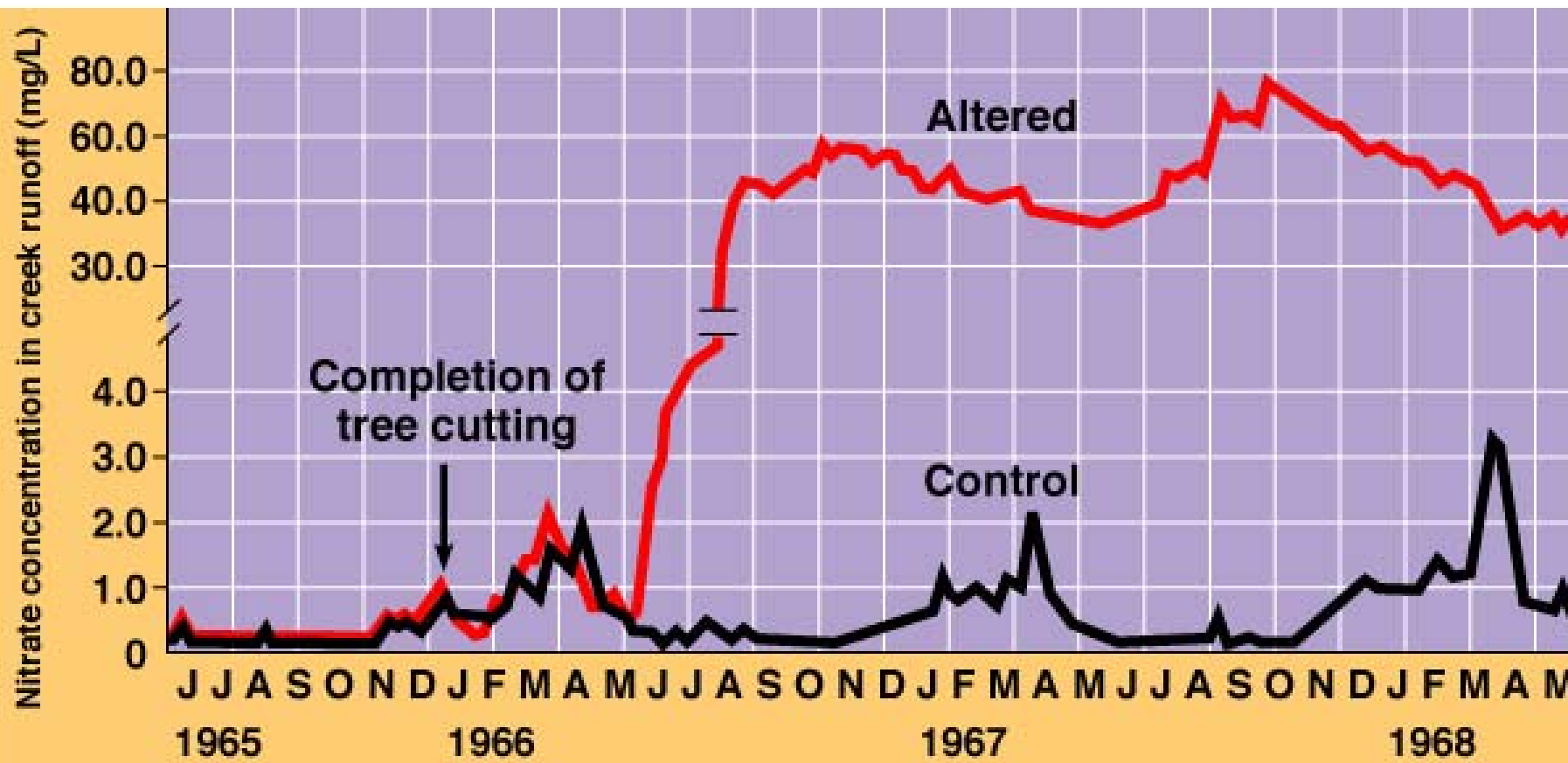
surface and
groundwater flow
40,000

OCEAN

LAND

集水區溪流水中鈣的濃度

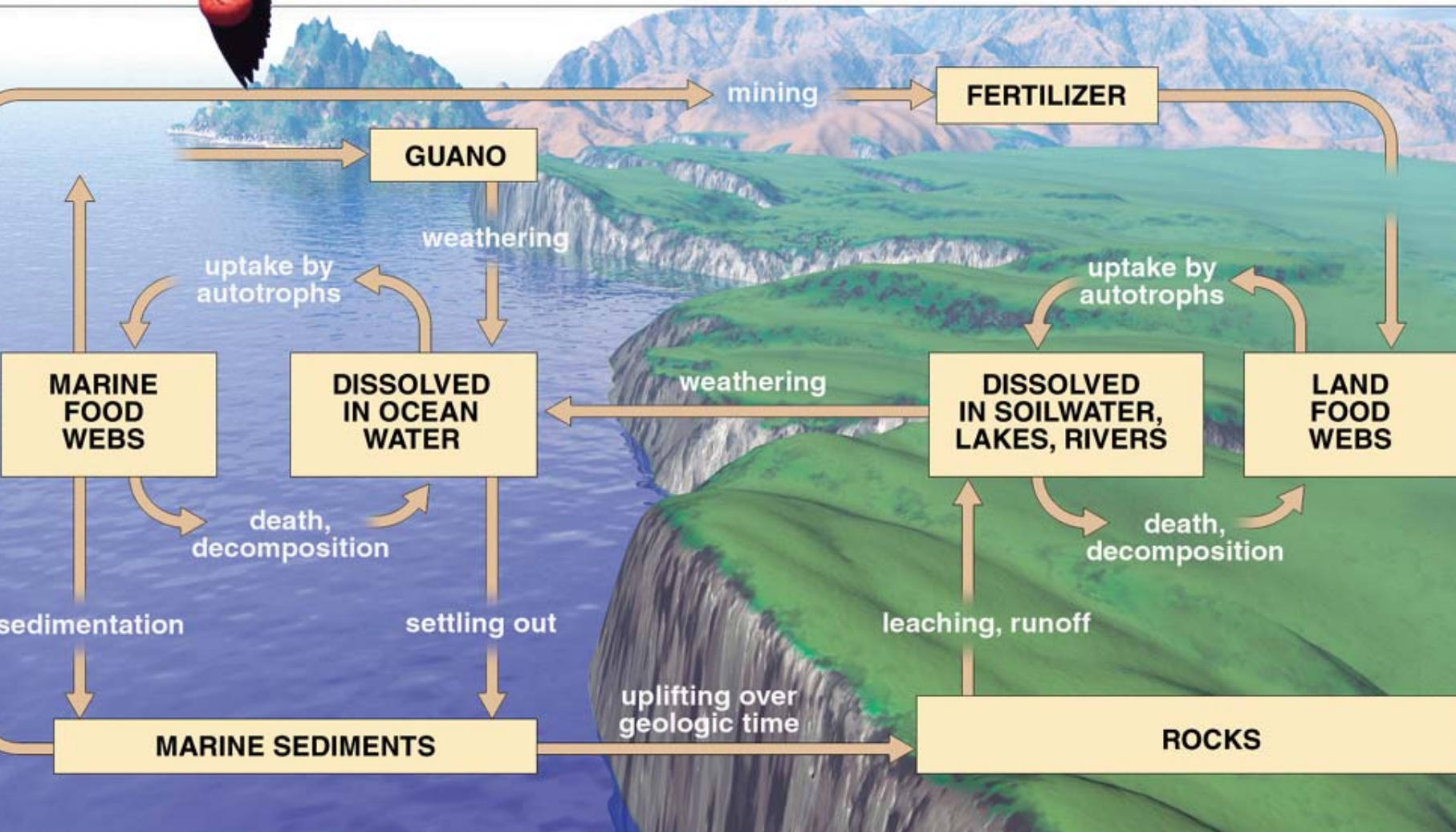


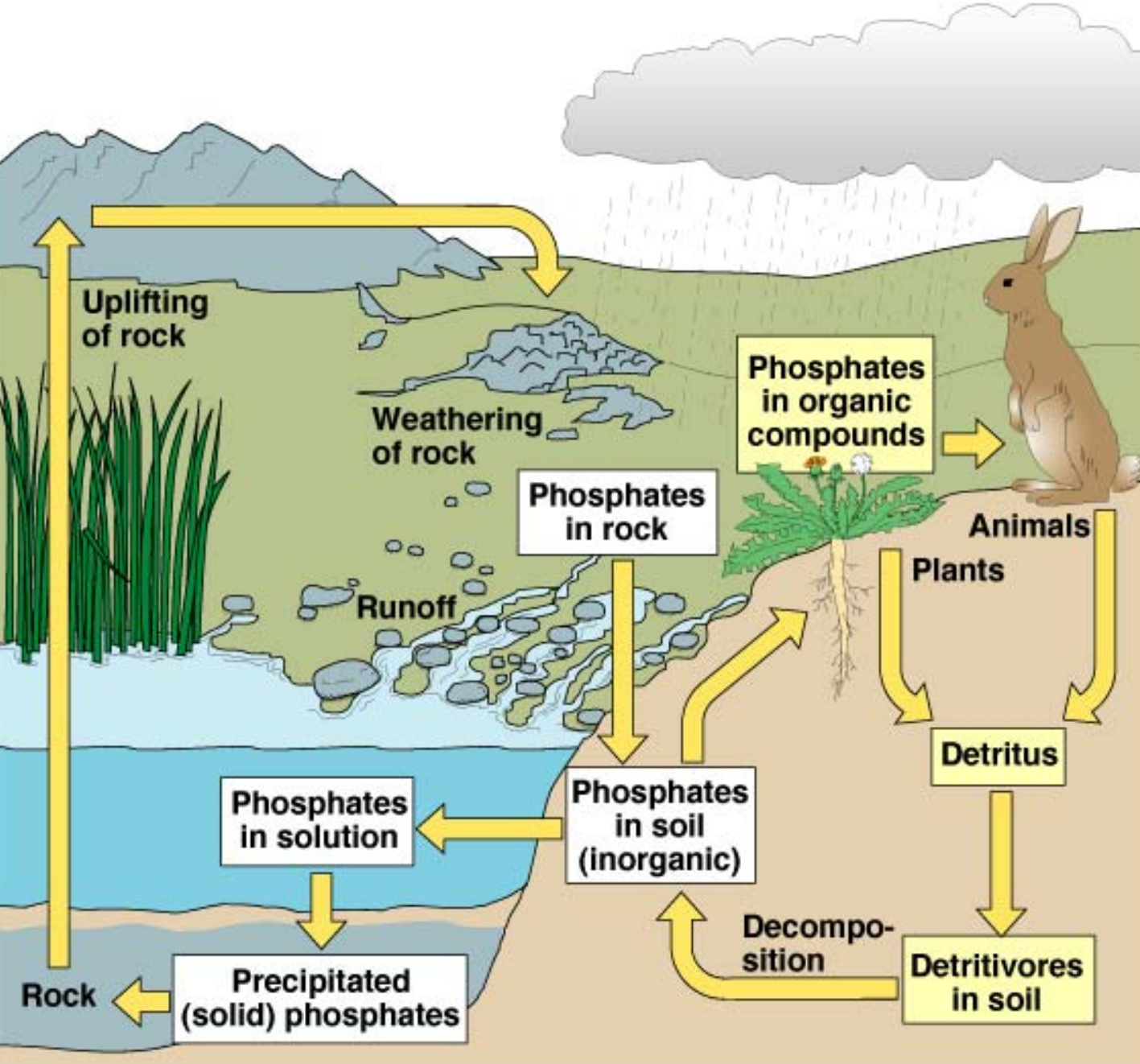


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伐木後的集水區硝酸鹽的流失

磷循環

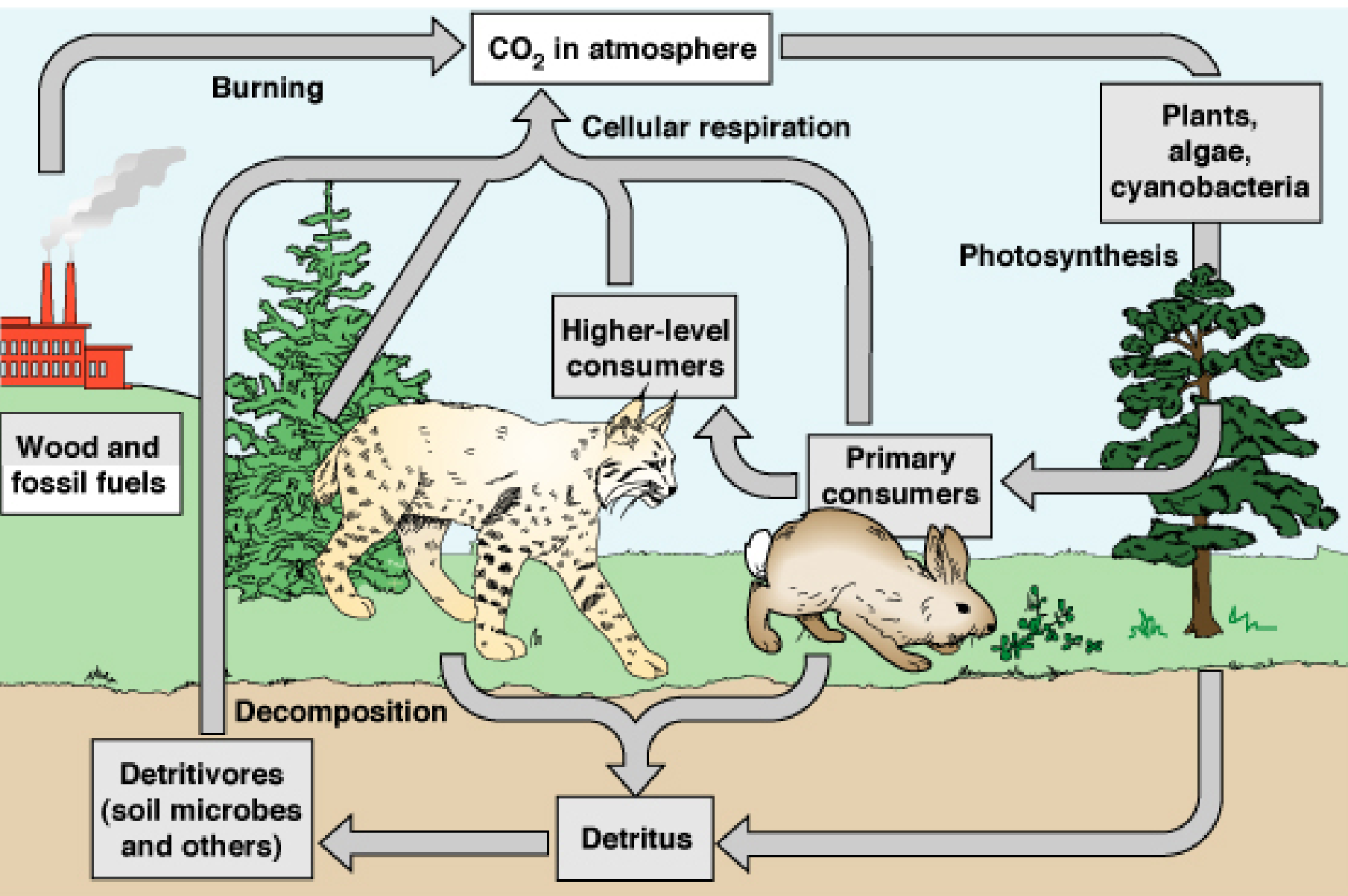




磷循環

磷和優養化湖泊的關係

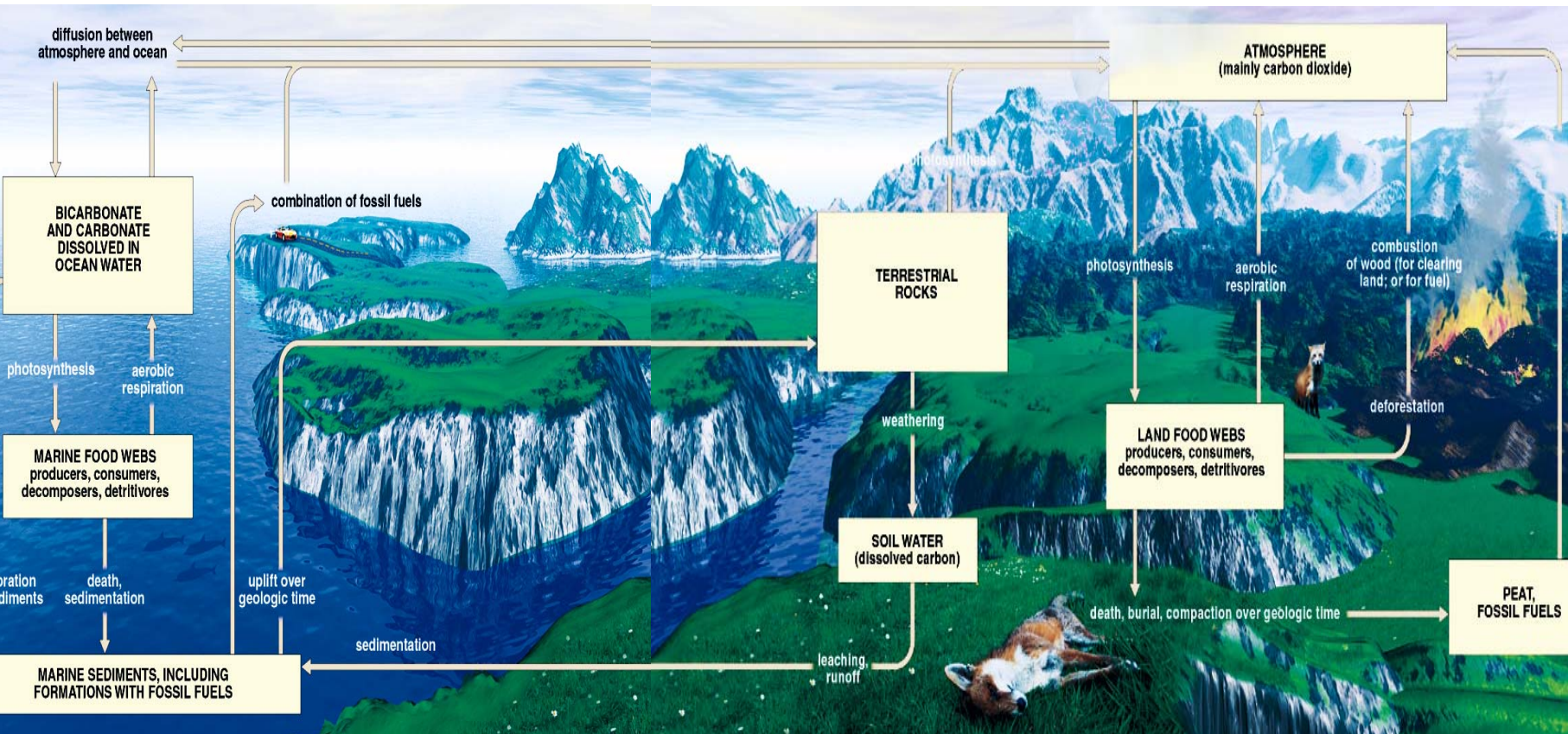




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碳循環

碳循環

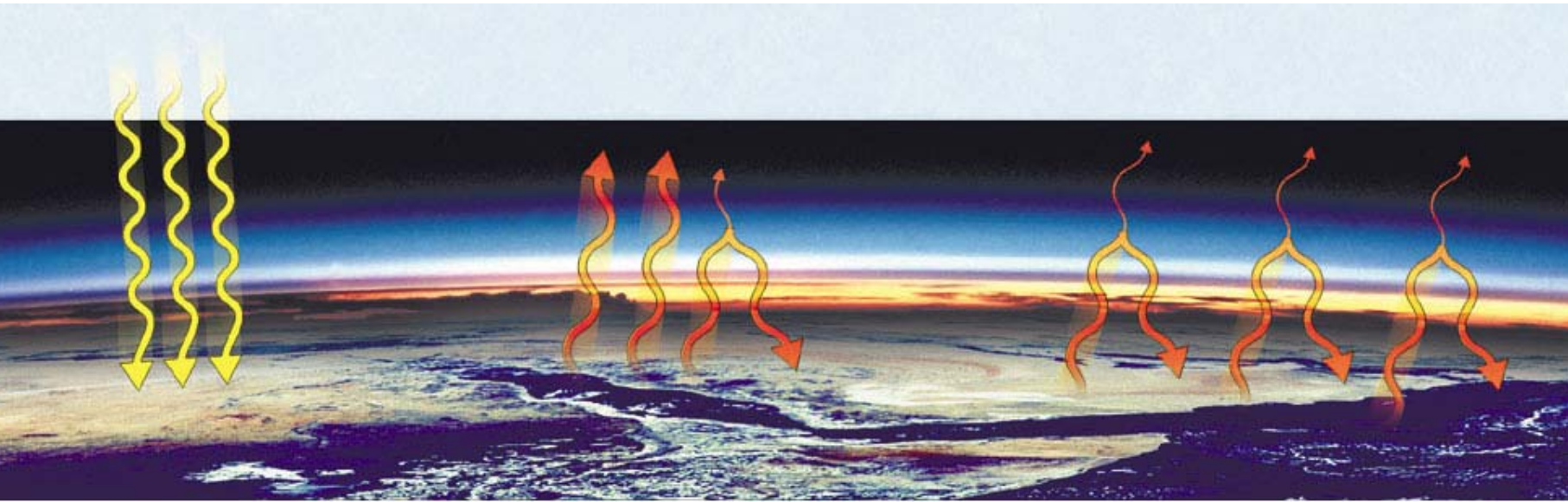


石化燃料產生的二氧化碳： 碳的型態轉變

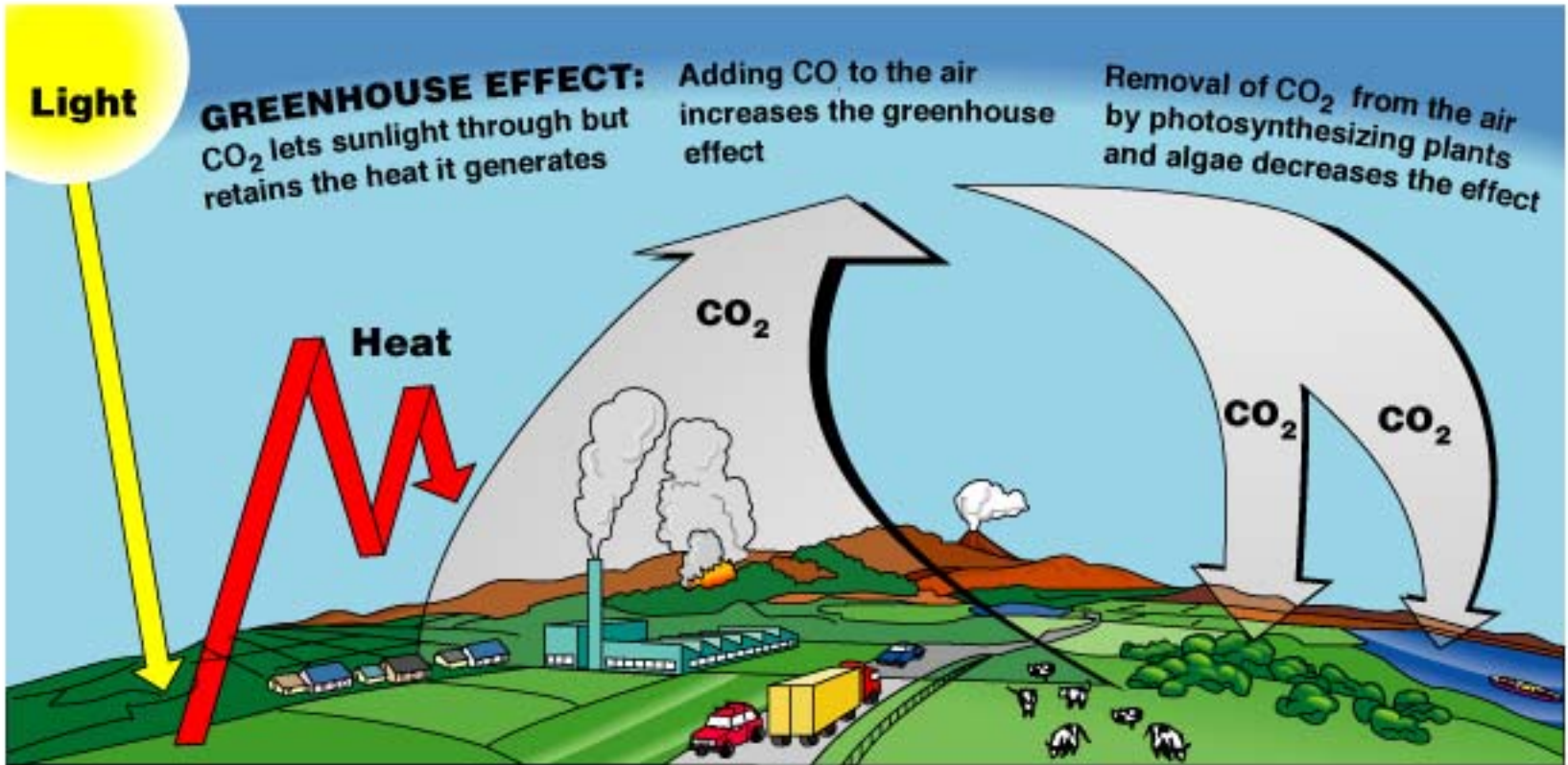
洋流帶動海洋表面與深層間碳的循環

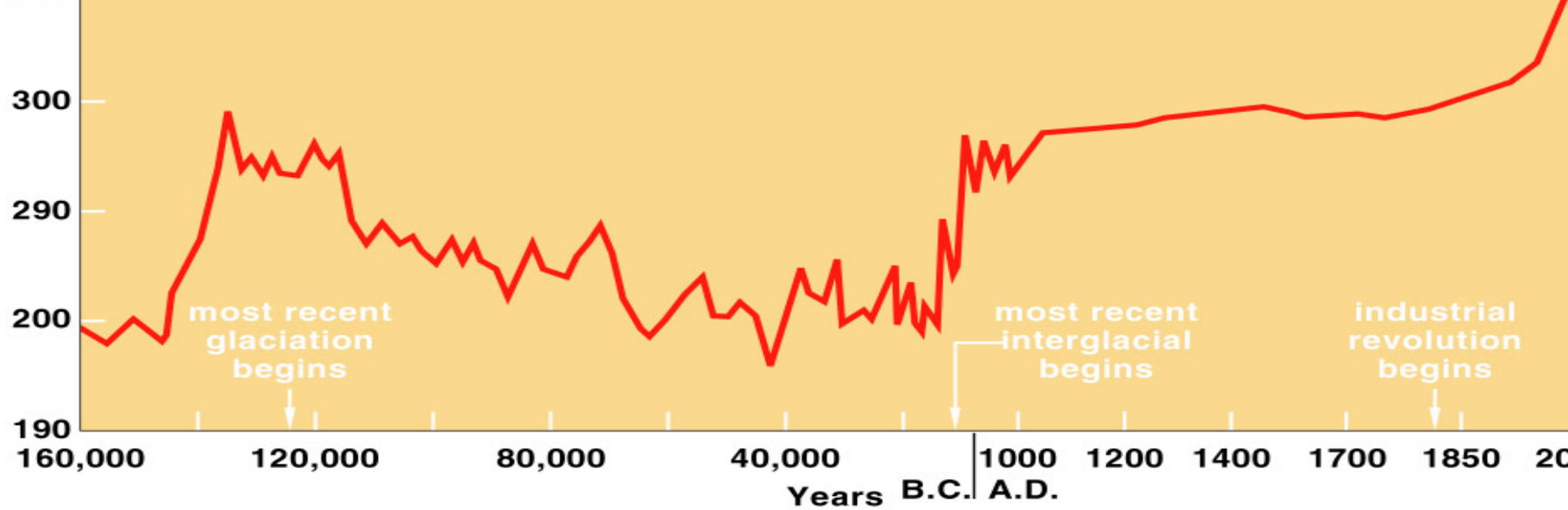


溫室效應是否百害而無一益？

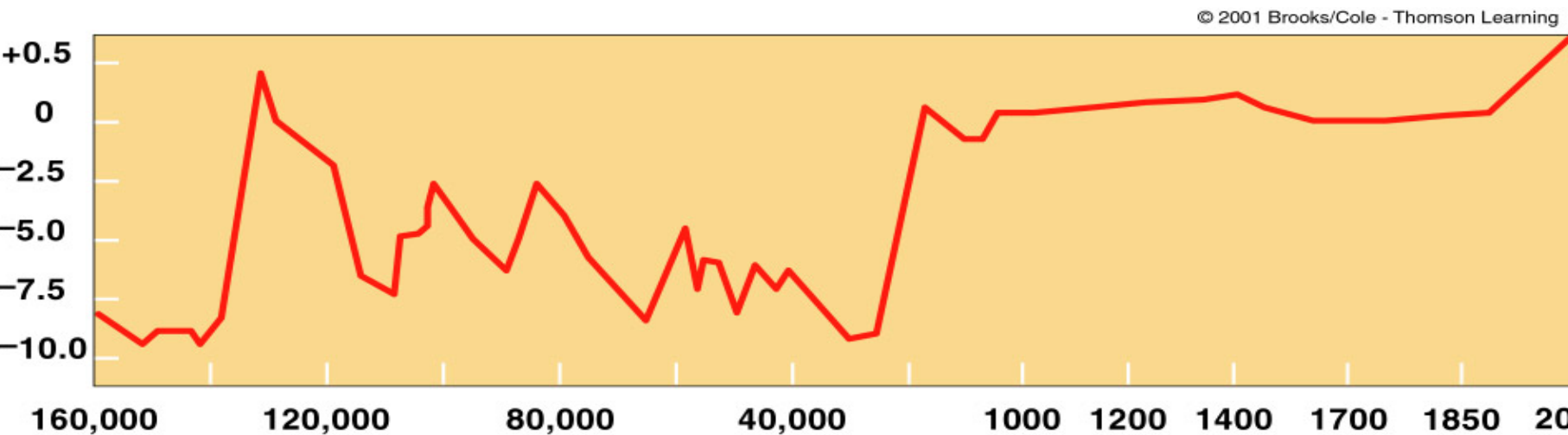


溫室效應和影響的因子

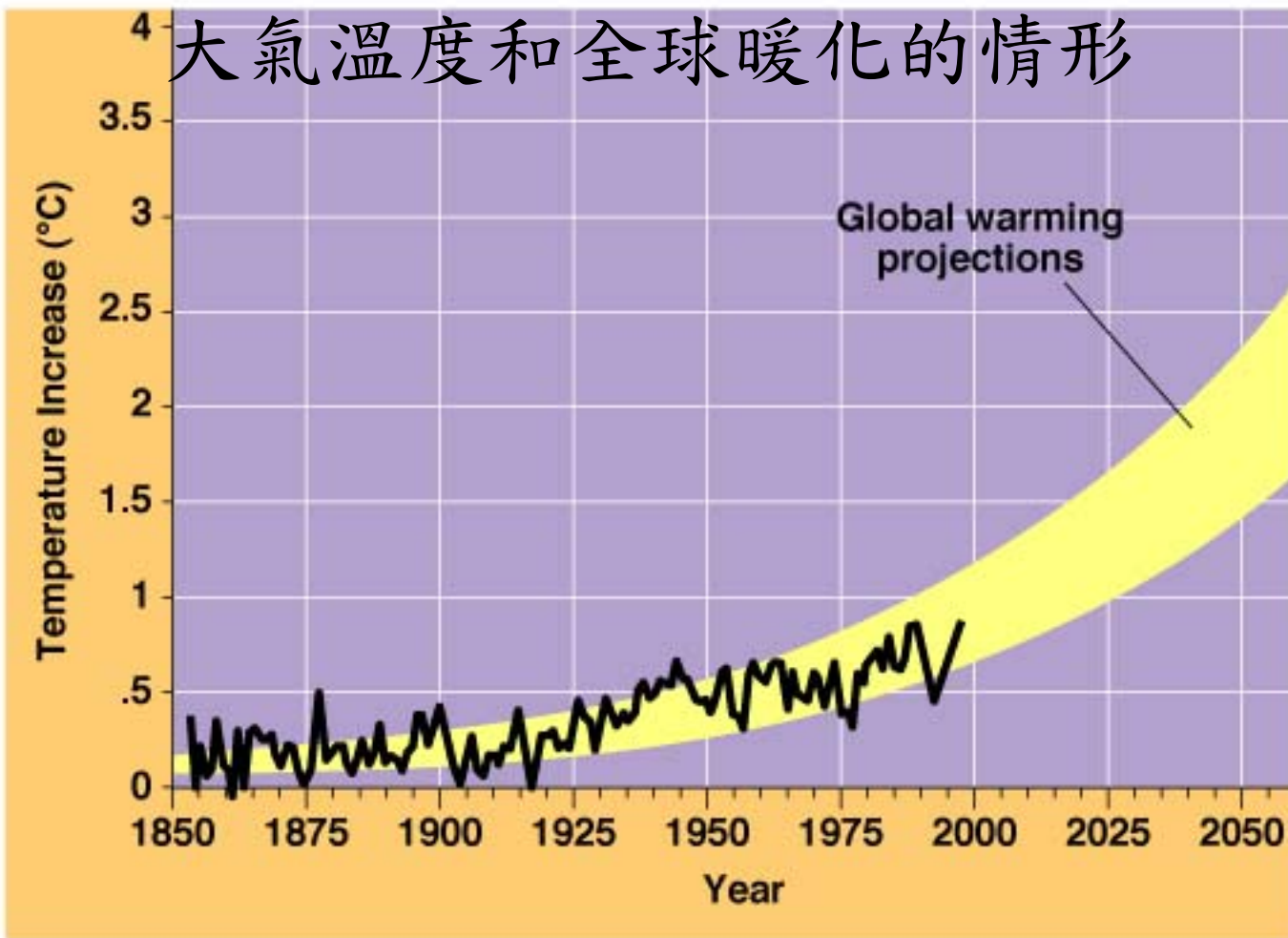


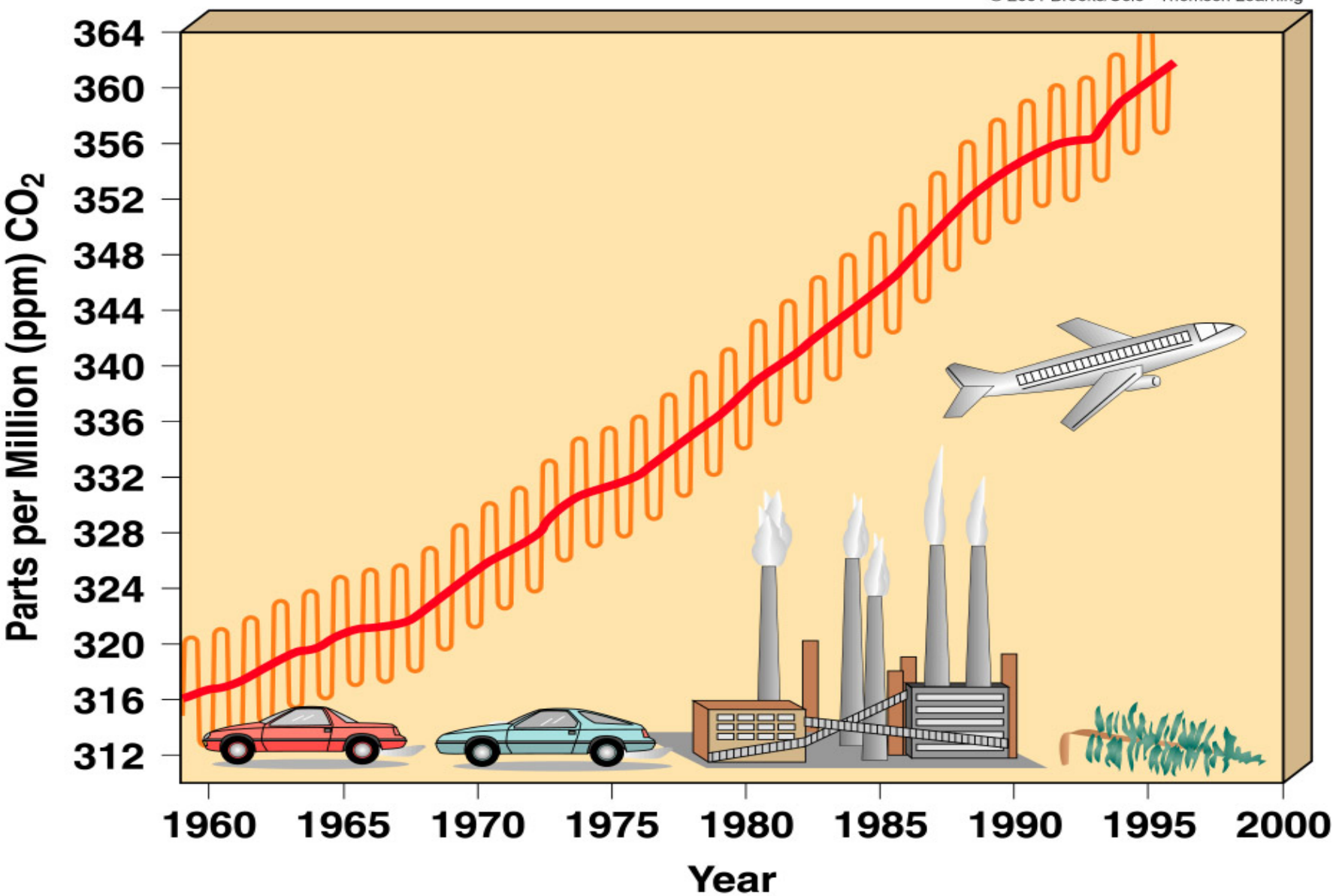


地球二氧化碳與溫度之間的關係

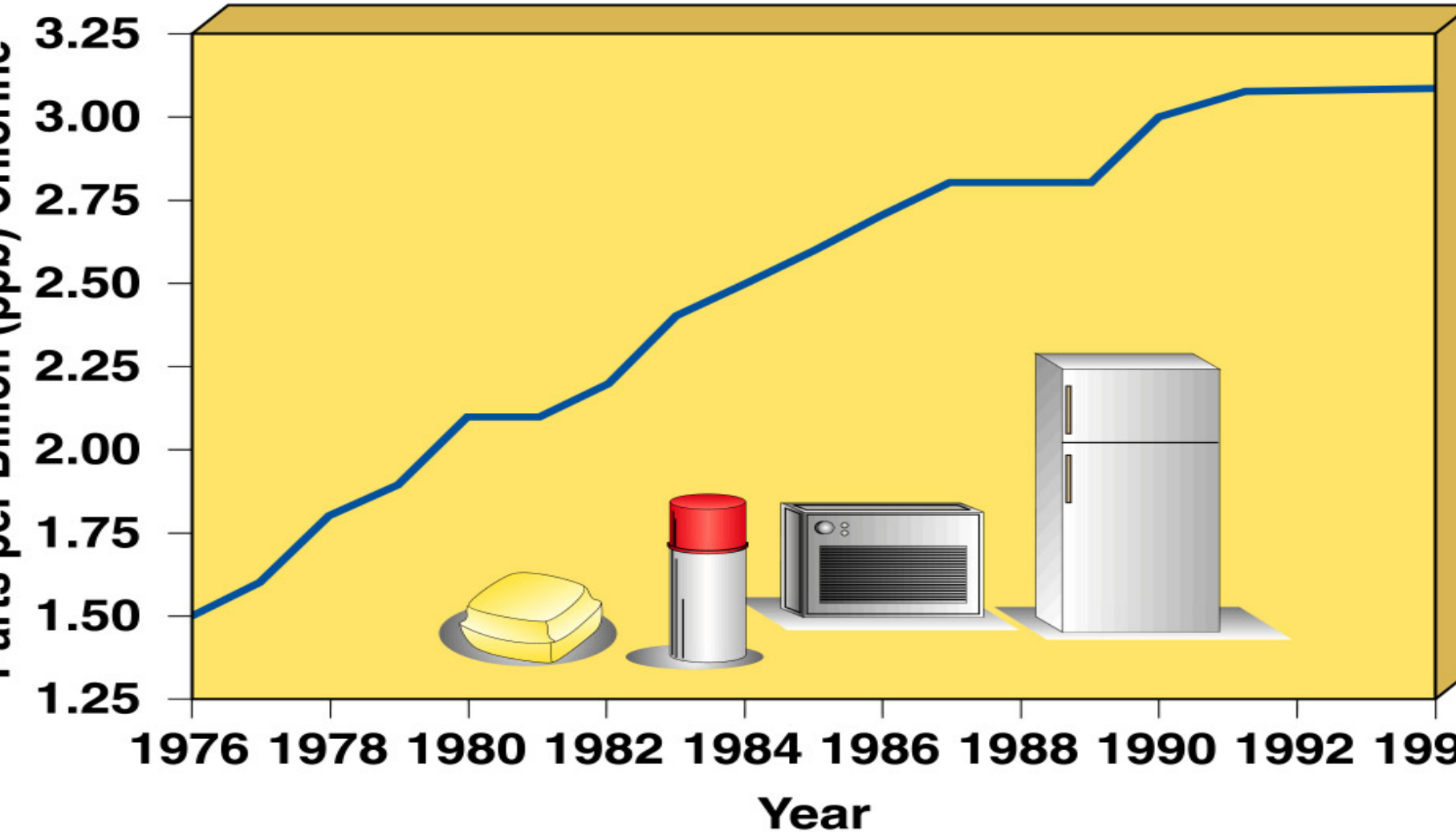


大氣溫度和全球暖化的情形

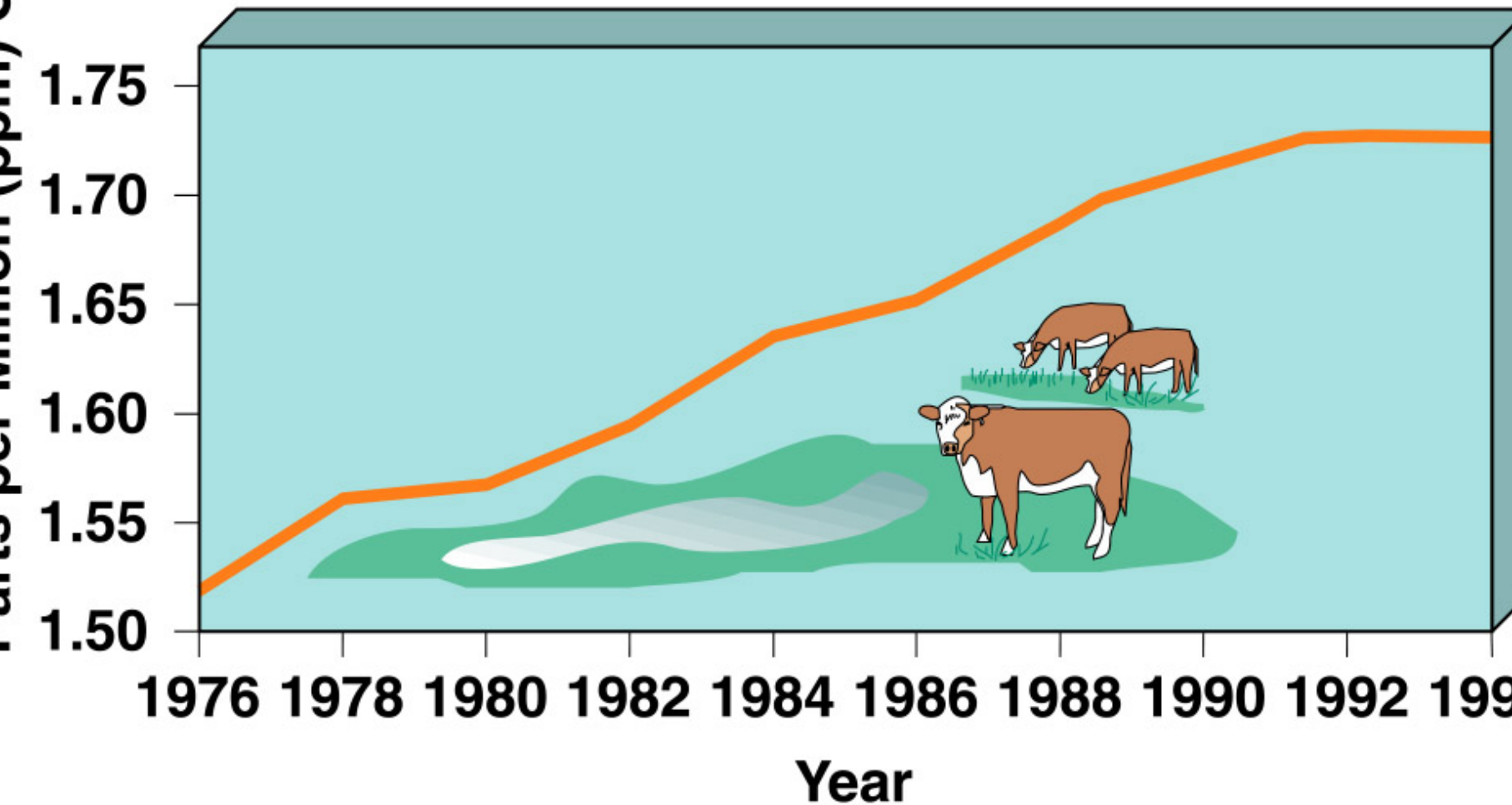




溫室氣體(CO₂)在大氣中增加的情形



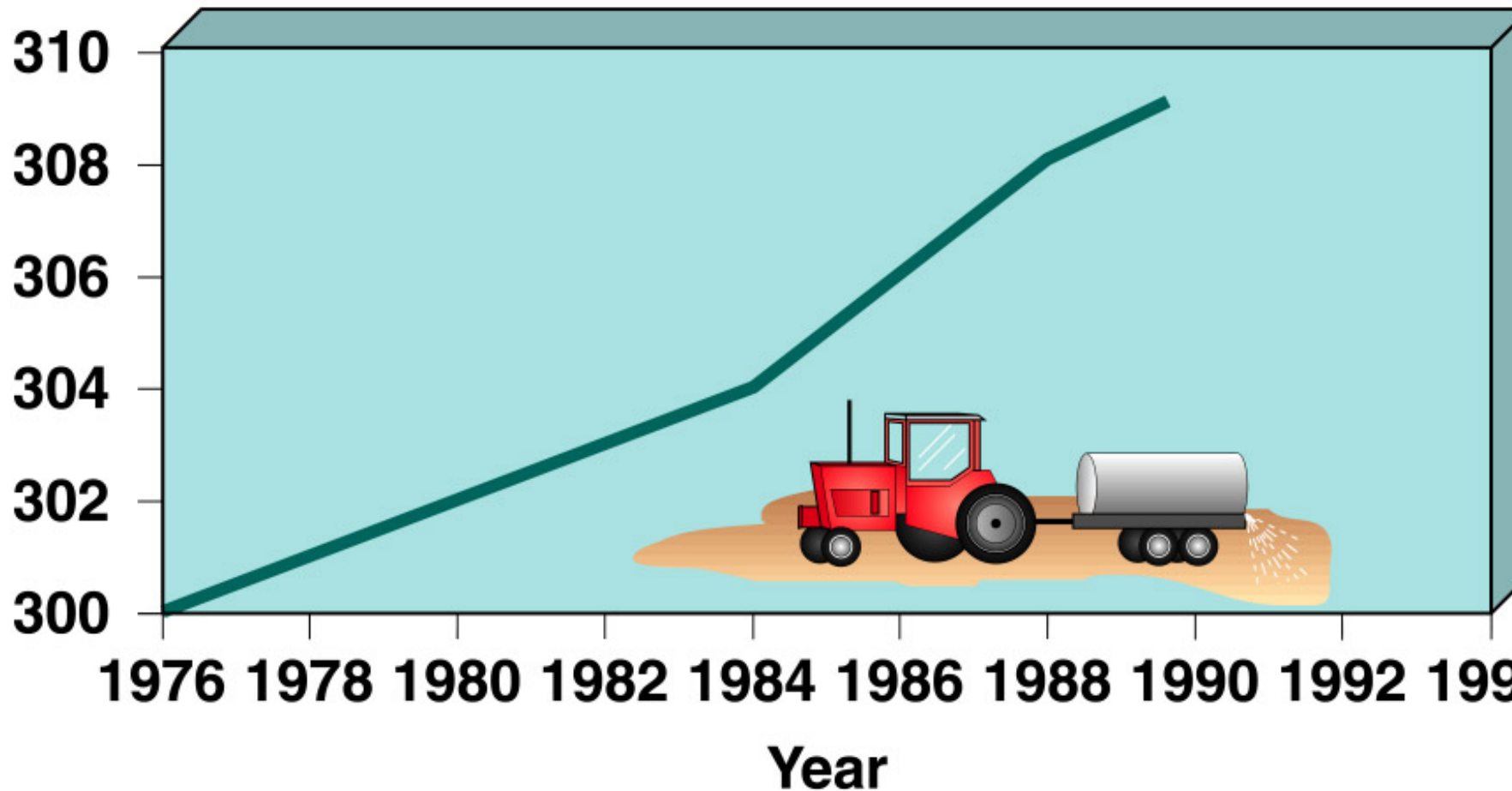
溫室氣體(CFCs)在大氣中增加的情形



溫室氣體(CH₄)在大氣中增加的情形

Parts per Billion (ppb) N_2O

© 2001 Brooks/Cole - Thomson Learning



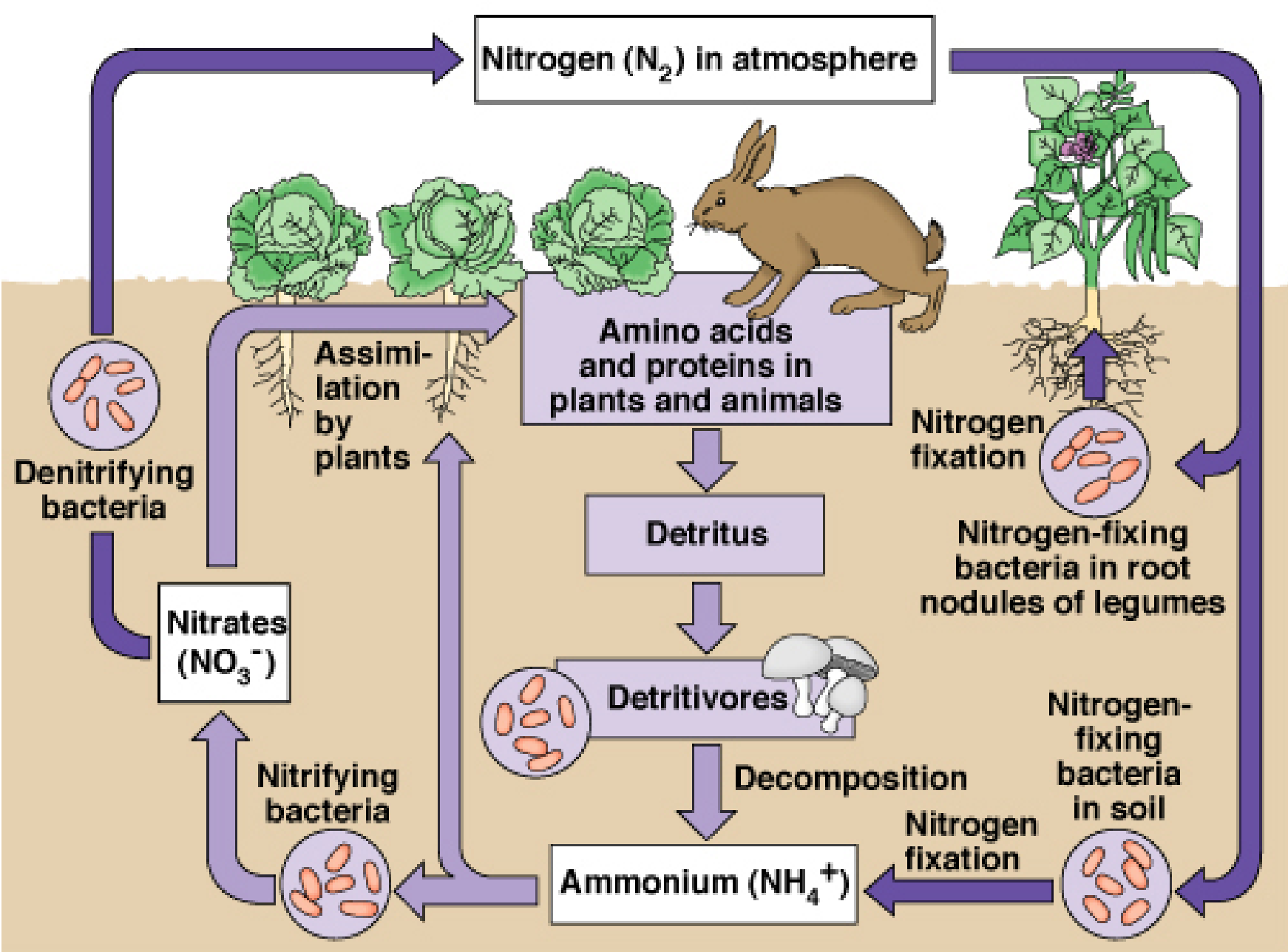
溫室氣體(N_2O)在大氣中增加的情形

各地能源消費的差異統計： 是誰在高喊節約能源？

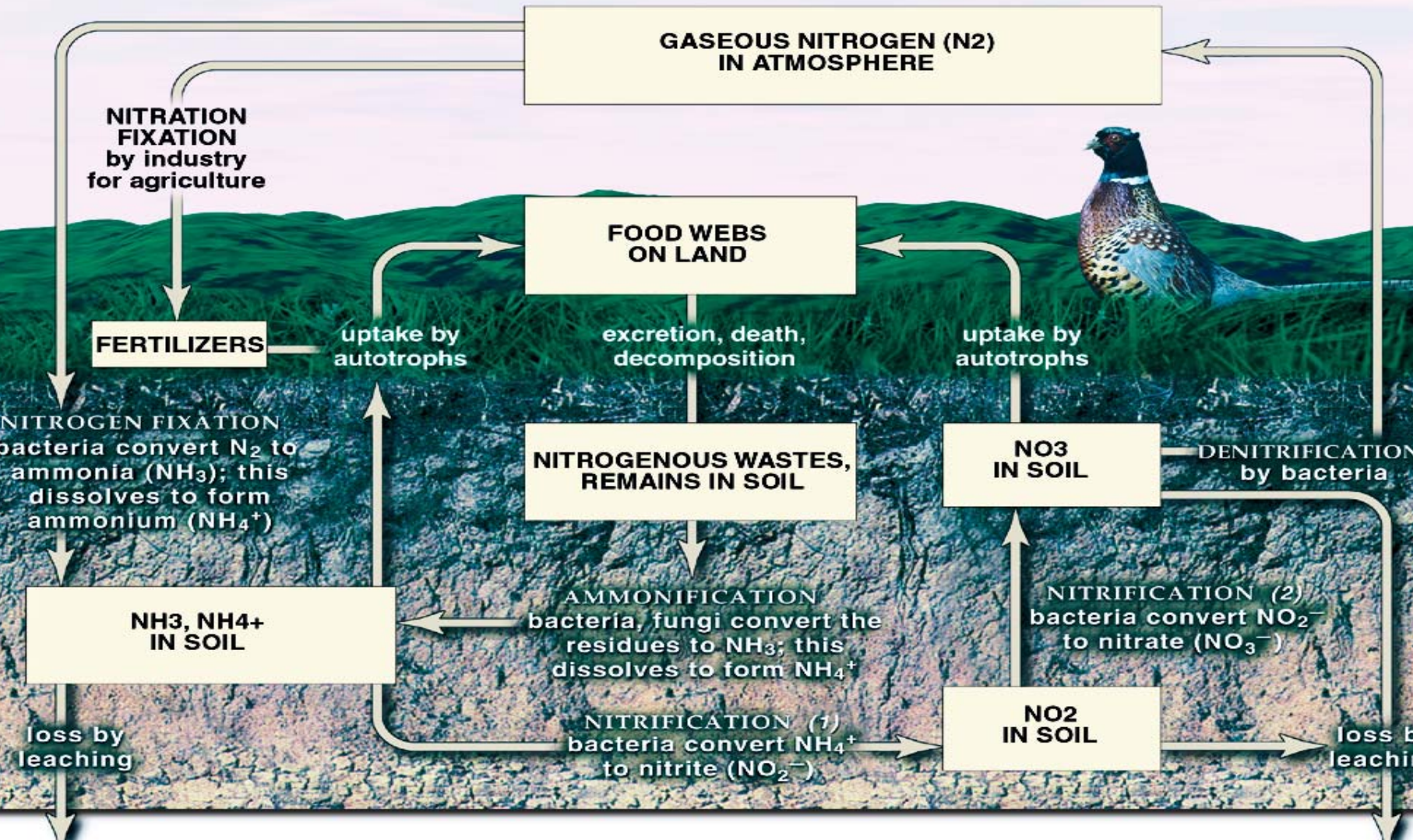
ENERGY CONSUMPTION PER CAPITA FOR SELECTED COUNTRIES (1991)

Country	Population (millions)	Energy per Person (gigajoules*)
Bangladesh	116.6	2
Nigeria	99.1	6
India	859.2	9
Indonesia	181.4	10
Brazil	163.3	23
China	1,151.3	23
Turkey	58.5	30
Mexico	85.7	56
Japan	123.8	140
Germany	79.5	187
Soviet Union (former)	292.0	193
United States	252.8	320

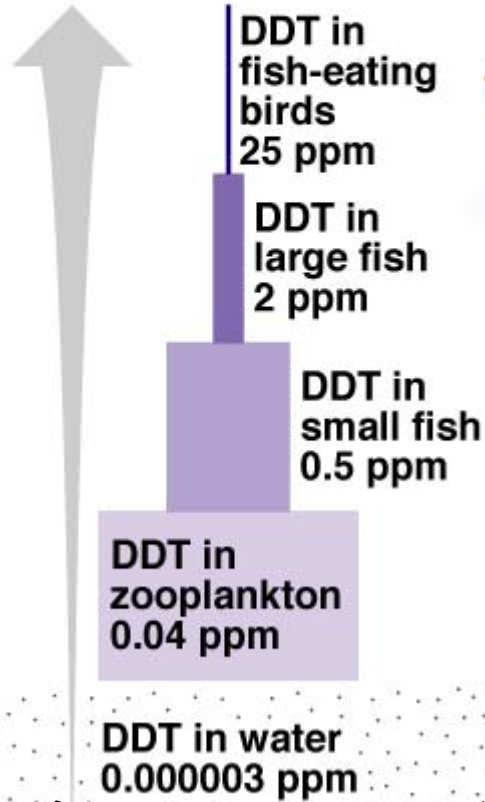
*1 gigajoule = 239,000 kcal



氮循環：哪裡的氮源最豐富？ 這些資源怎樣才能夠被利用？



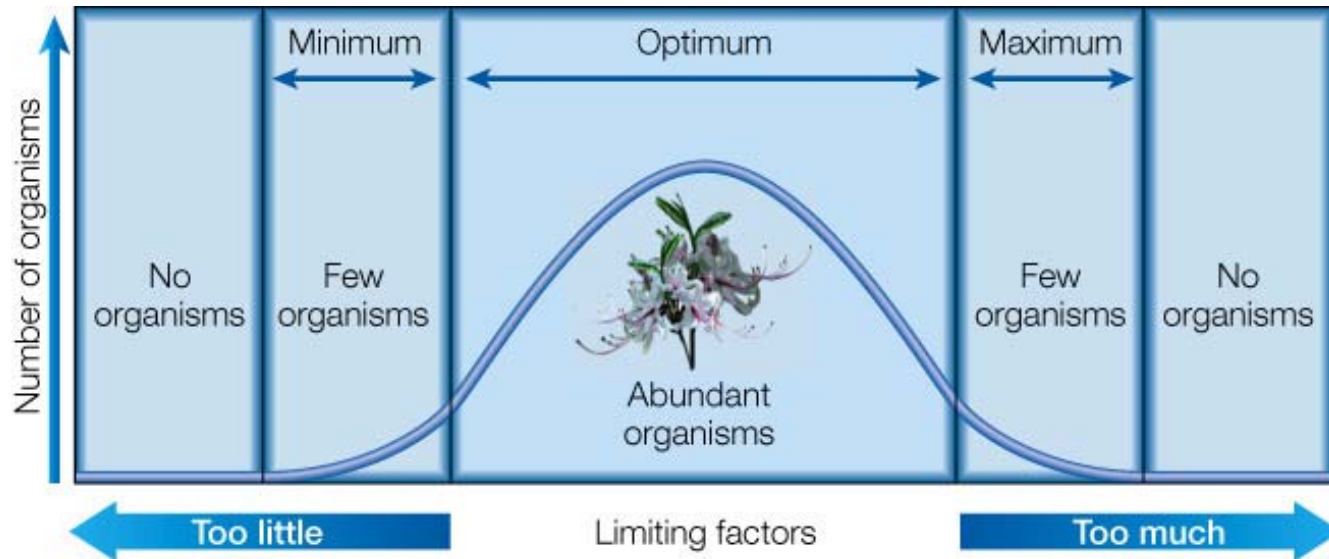
DDT concentration:
increase of
10 million times



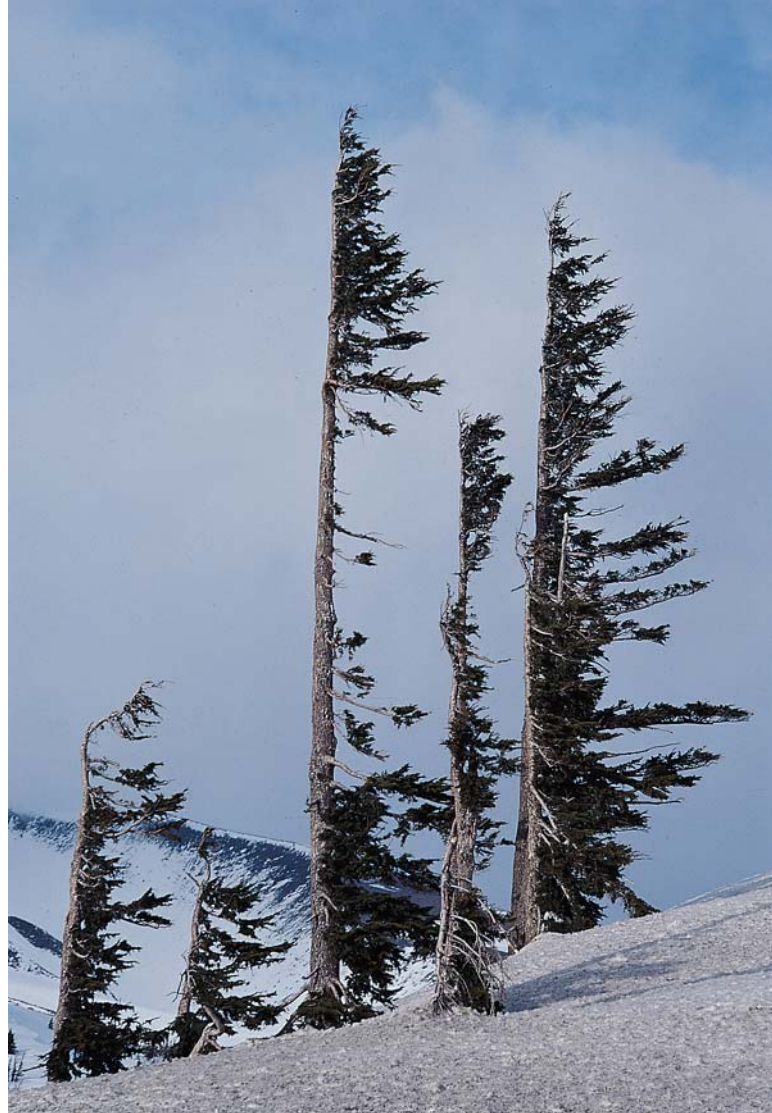
毒性物質在食物鏈的累積：

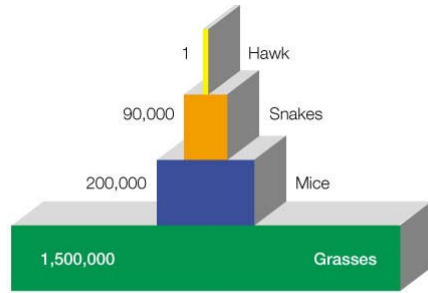
為什麼遠洋鮭魚等生魚片含有較多有害的

physical factors can be limiting

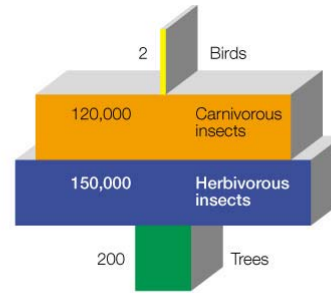


Wind is a powerful environmental factor in some ecosystem

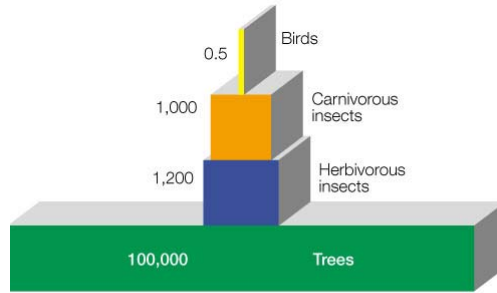




(a) Grassland community

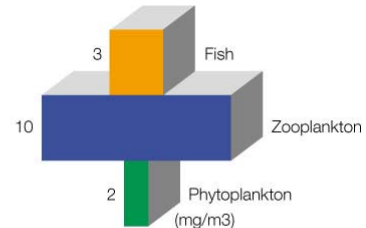


(b) Forest community

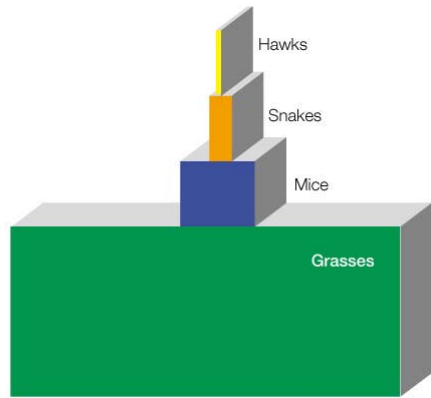


(c) Biomass of forest community

(kg)



(d) Biomass of aquatic community



(e) Energy levels of a stable community

(kcal/day)

Figure 16-10

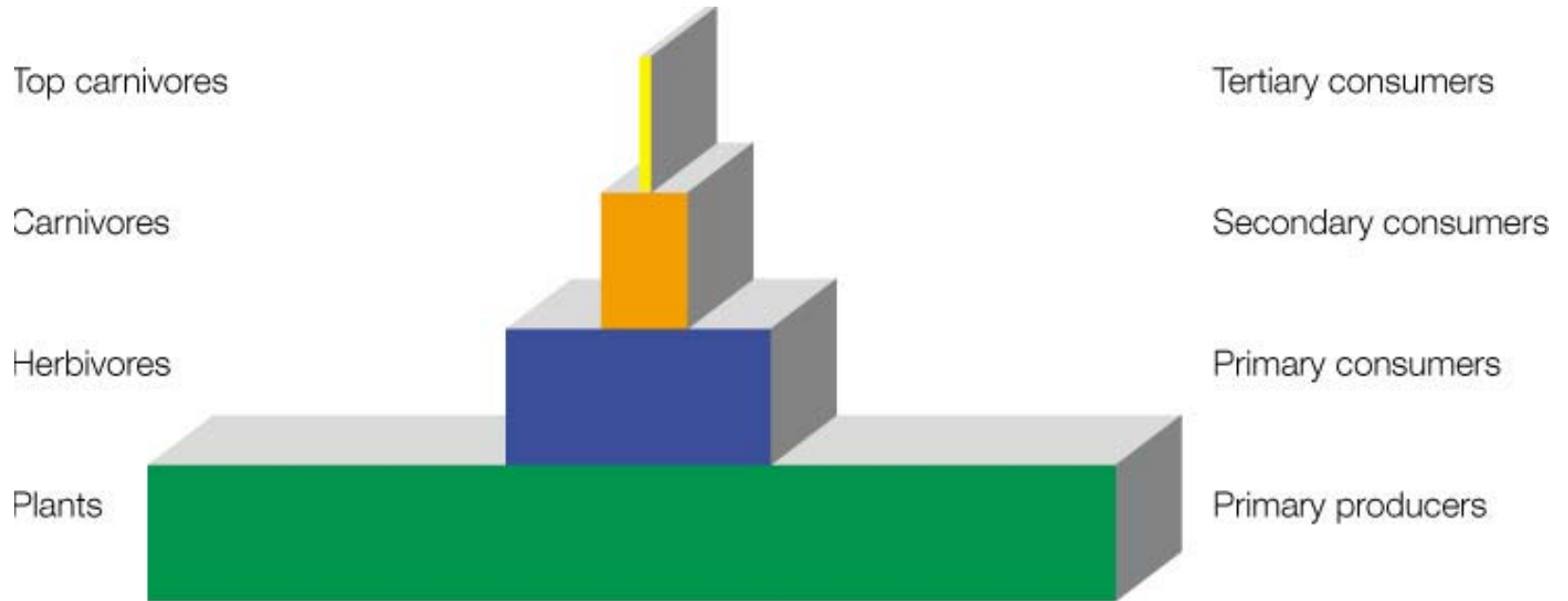


Figure 16-11a



Tom J. Ulrich/Visuals Unlimited

Figure 16-14a



Courtesy, Larry Underwood

Figure 16-14b



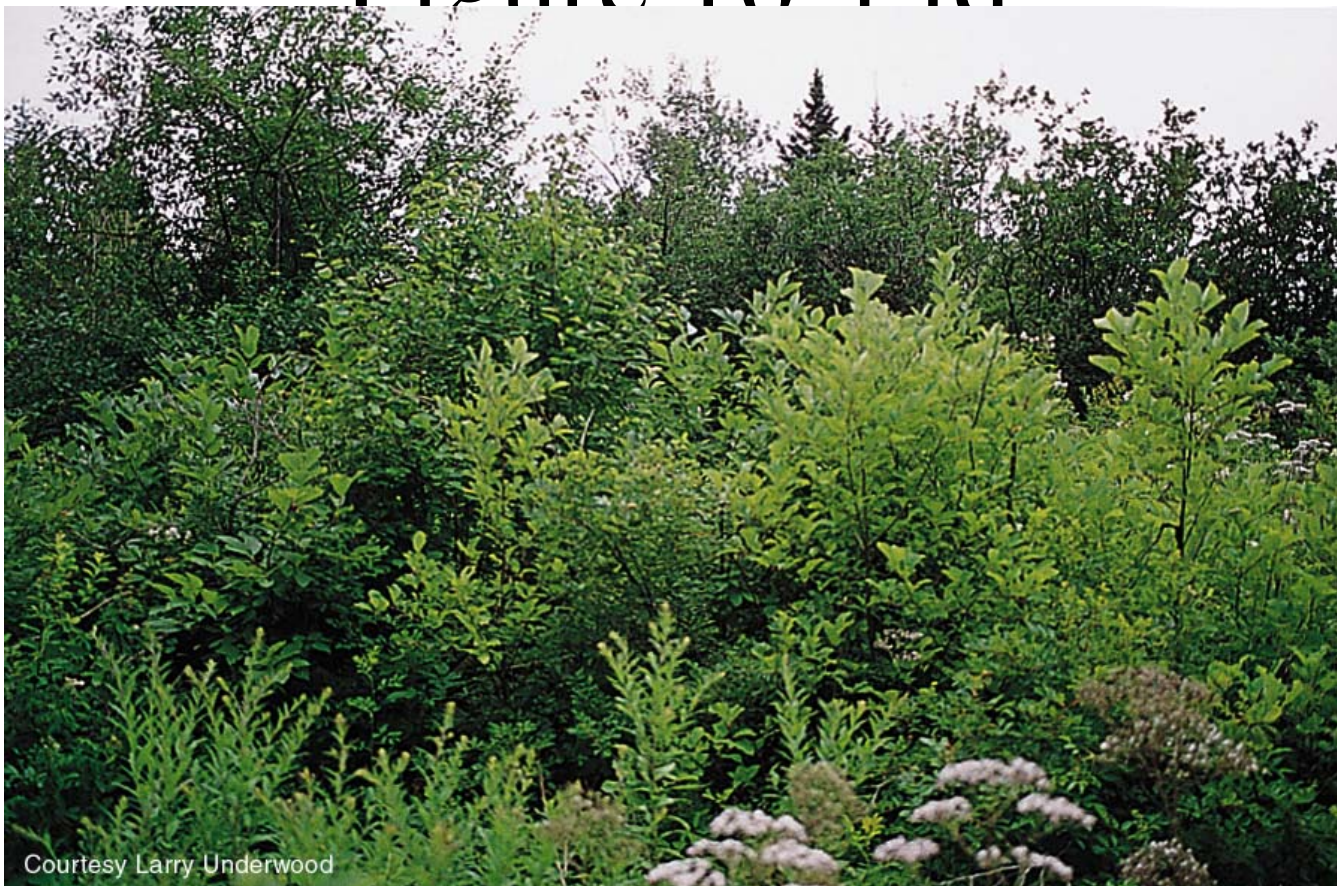
Courtesy Larry Underwood

Figure 16-14c



Courtesy Larry Underwood

Figure 16-14d



Courtesy Larry Underwood

Figure 16-14e



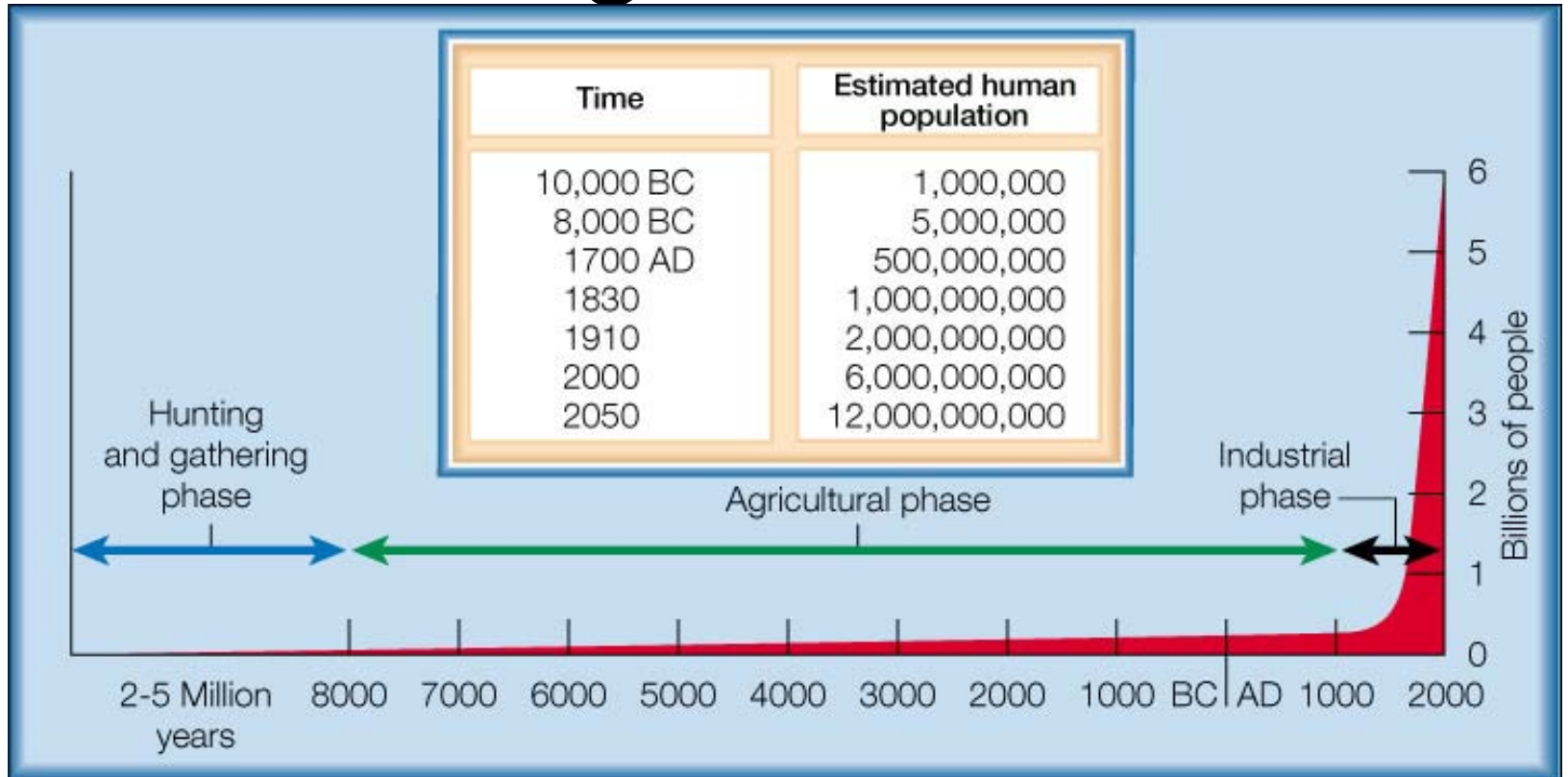
Courtesy Larry Underwood

Figure 16-14C



Courtesy Larry Underwood

Figure 16-19



(a) Rapid growth
Kenya

Male Female

(b) Slow growth
United States

Male Female

(c) Decline in growth
Austria

Male Female

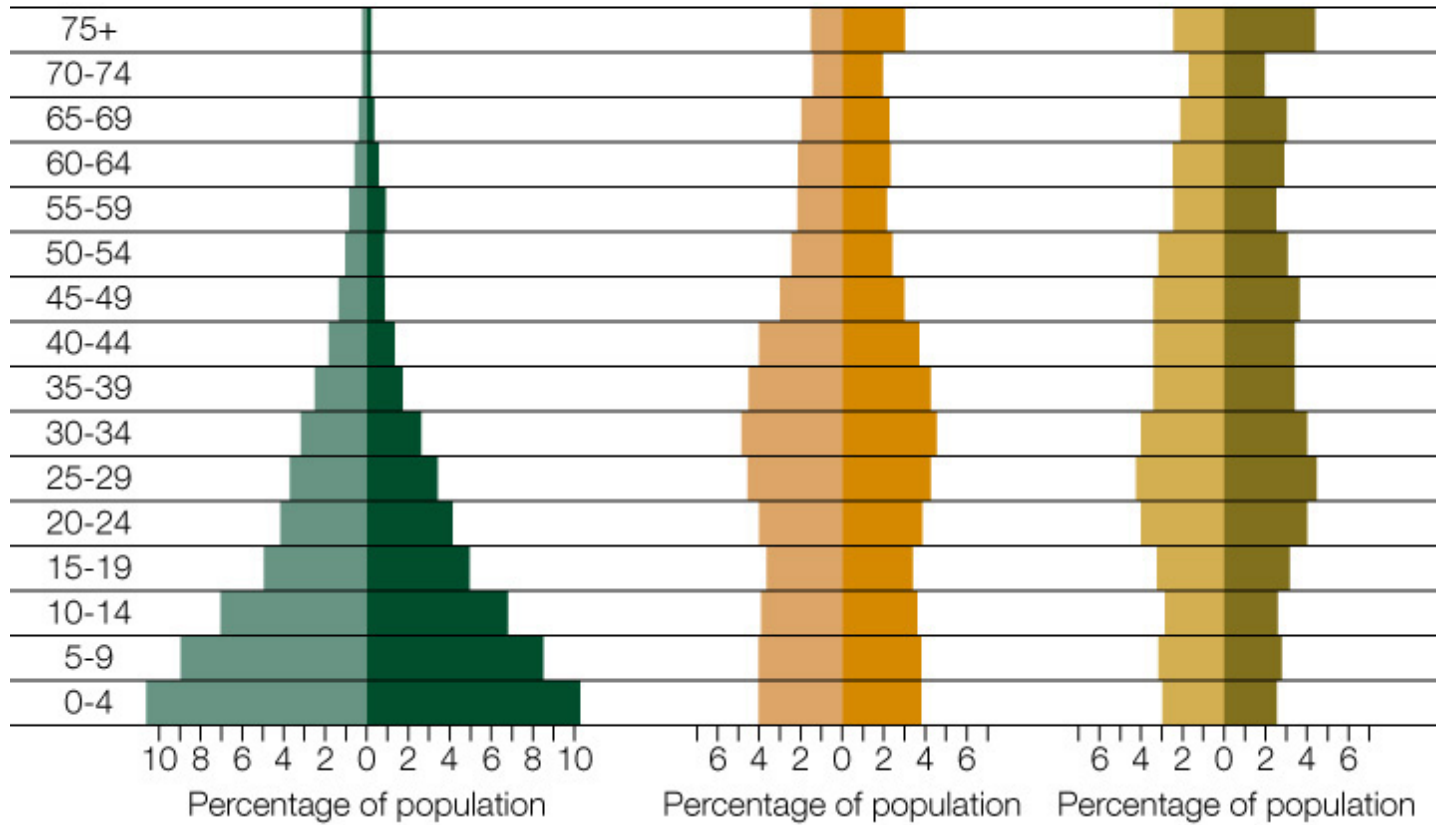
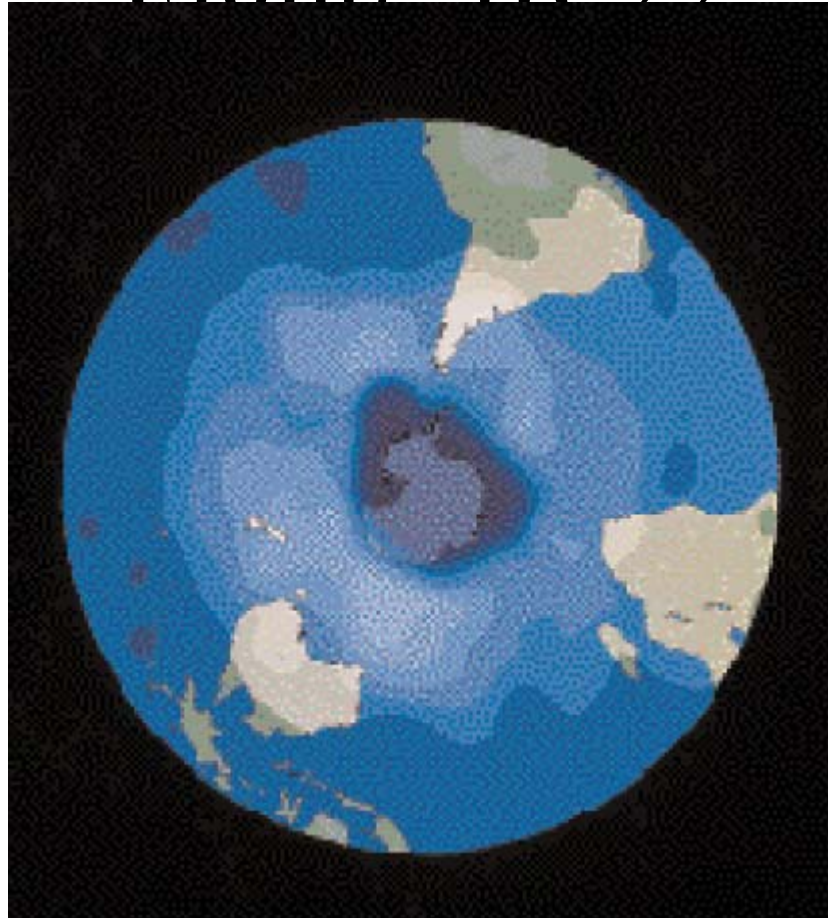


Figure 16.22



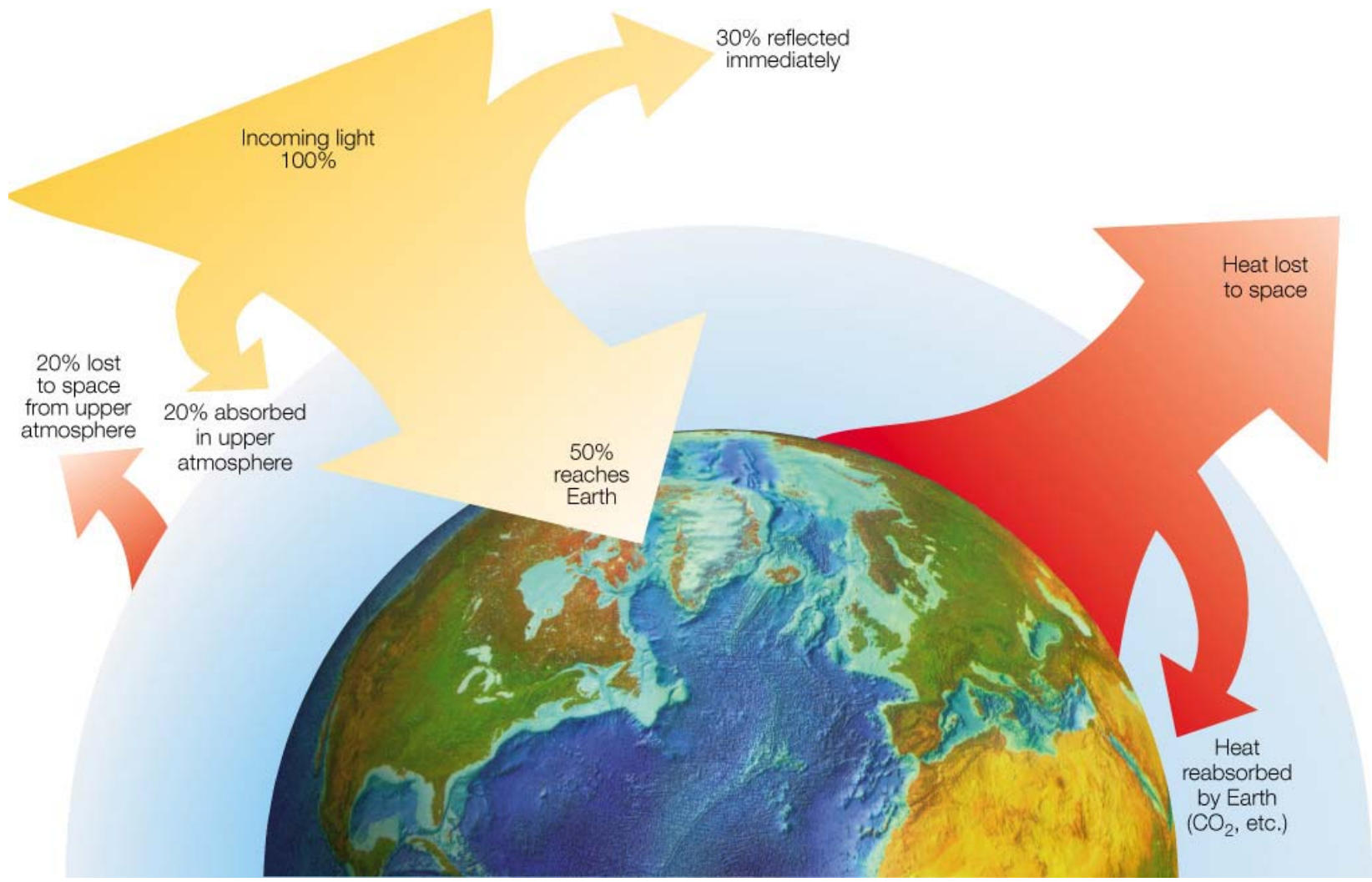
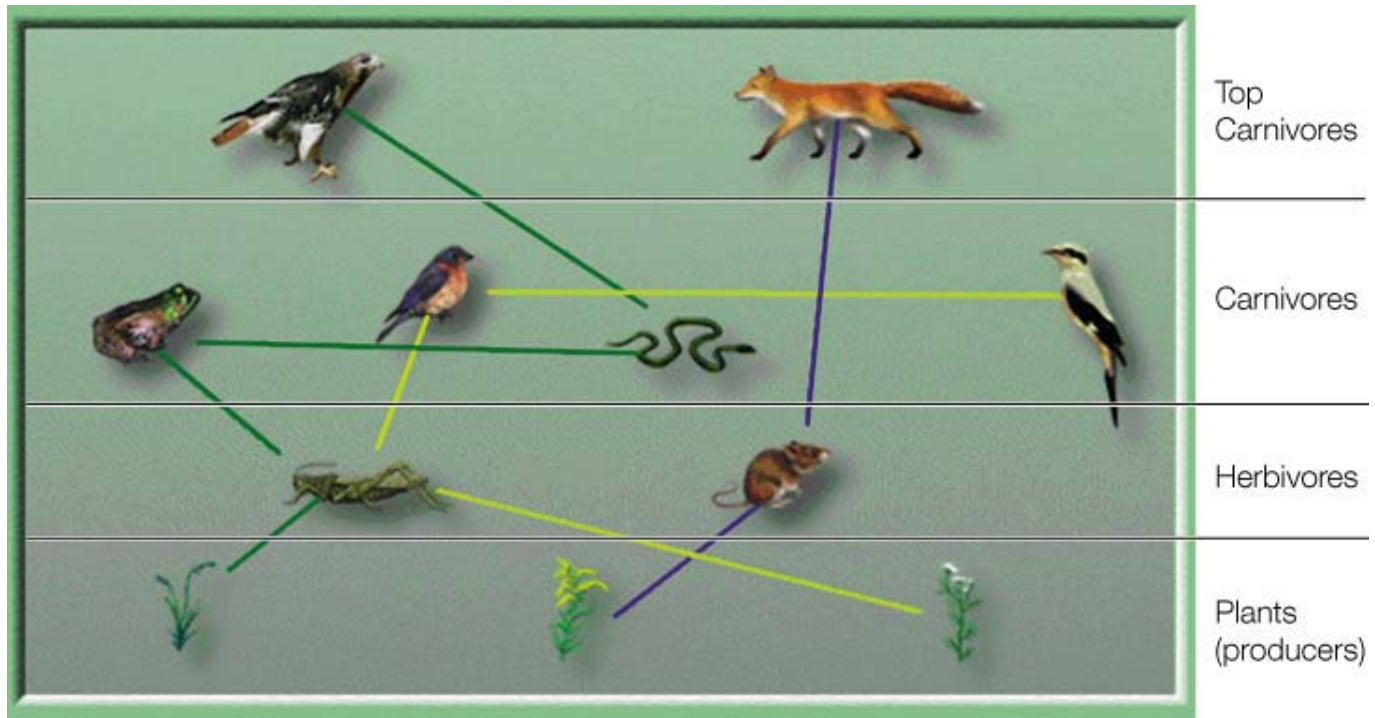
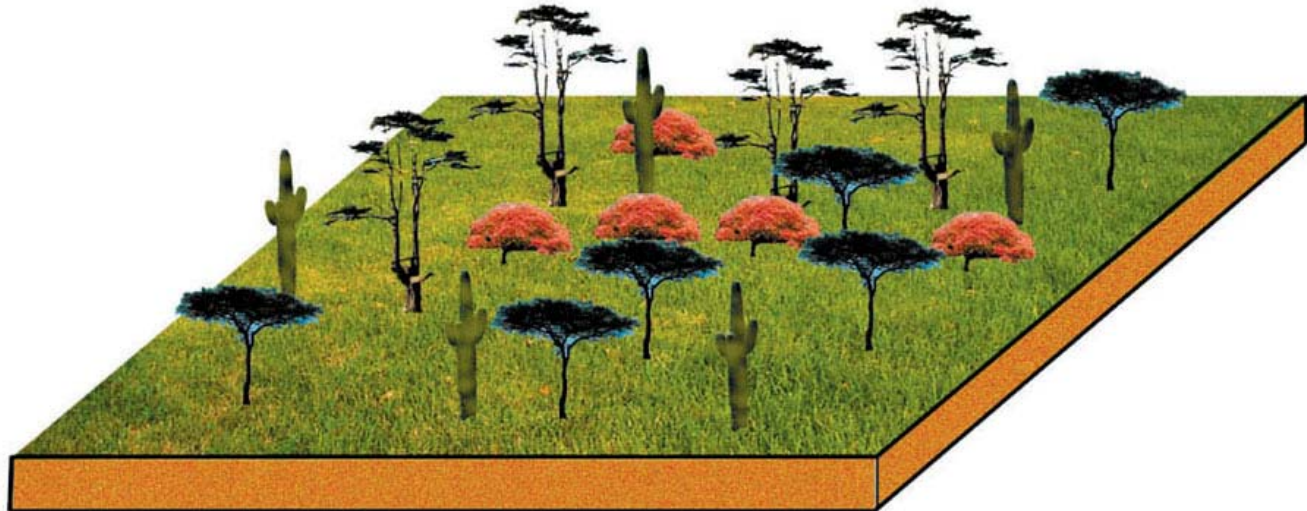
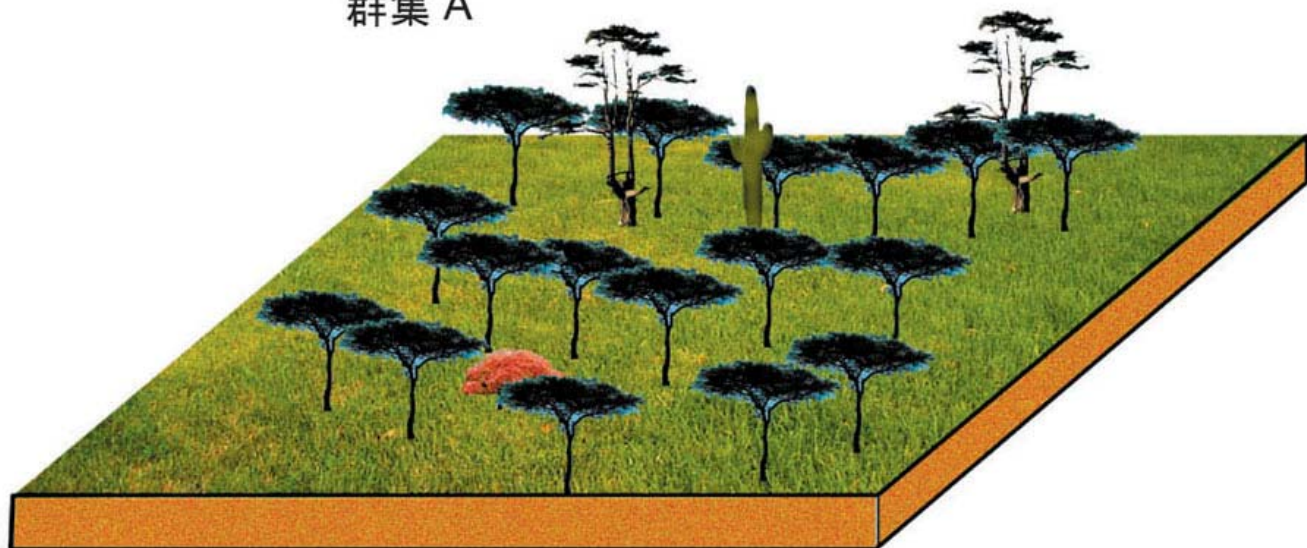


Figure 16-28





群集 A



群集 B

圖 16-26 物種數量相同、各物種相對數量不同的兩種森林群集



圖 16-27 松樹林具有較強的穩定性

圖 16-28 熱帶雨林





圖 16-29 稀樹草原



圖 16-30 沙漠的植被

圖 16-31 北極冰原的北極熊



圖 16-32 濃密常綠闊葉灌叢 (灌木林)





圖 16-33 溫帶草原



圖 16-34 溫帶落葉林



圖 16-35 針葉林



圖 16-36 凍 原



河 流



池 塘

圖 16-37 溪流和池塘

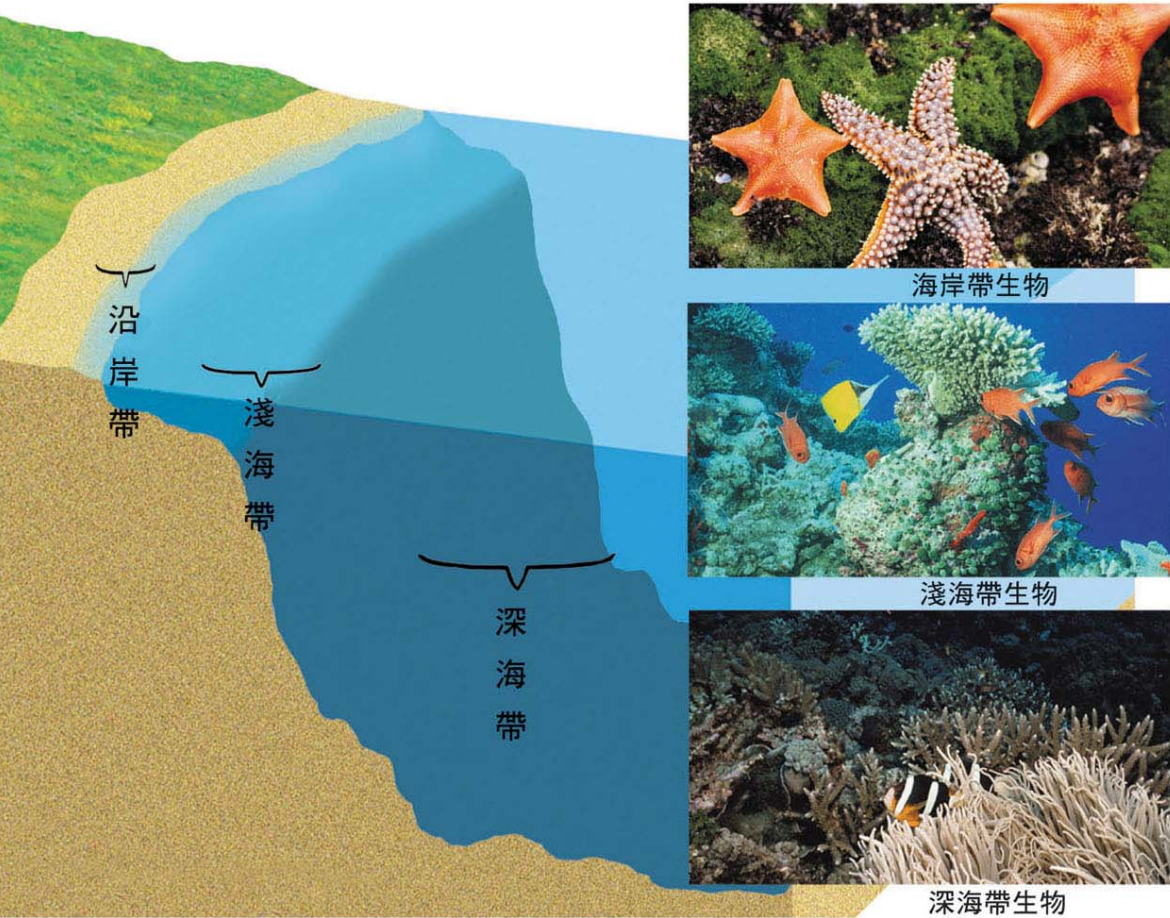


圖 16-38 海洋帶和幾種海洋生物

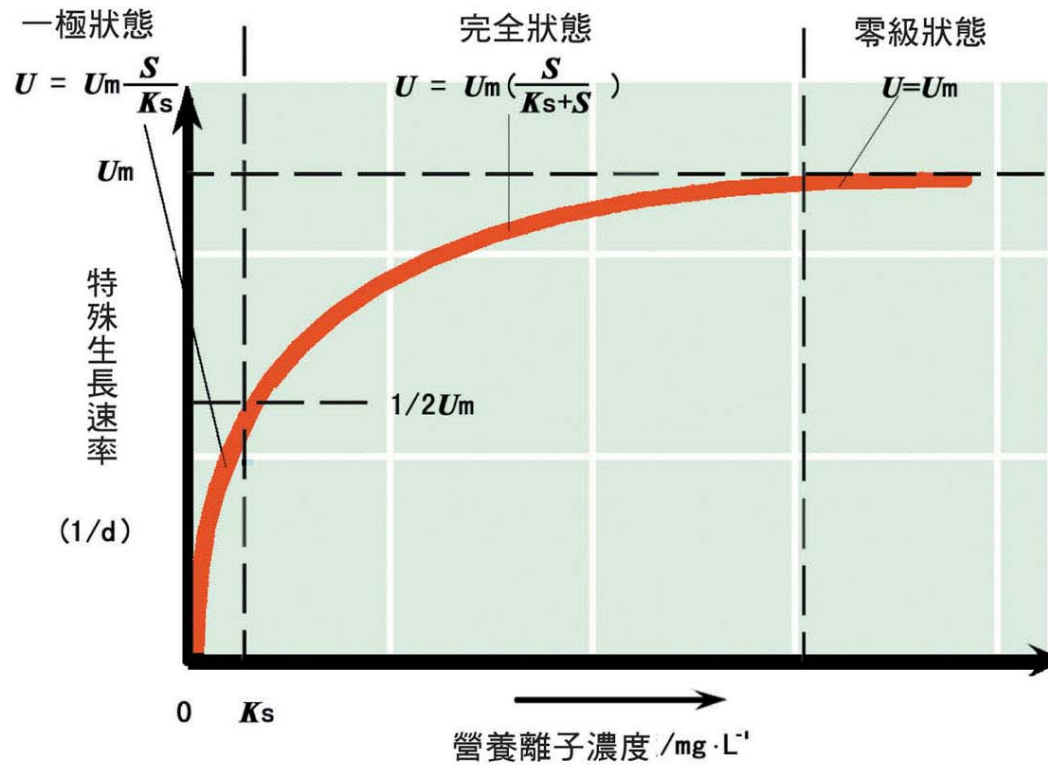


圖 16-39 微藻營養吸收與生長動力學
 方程曲線

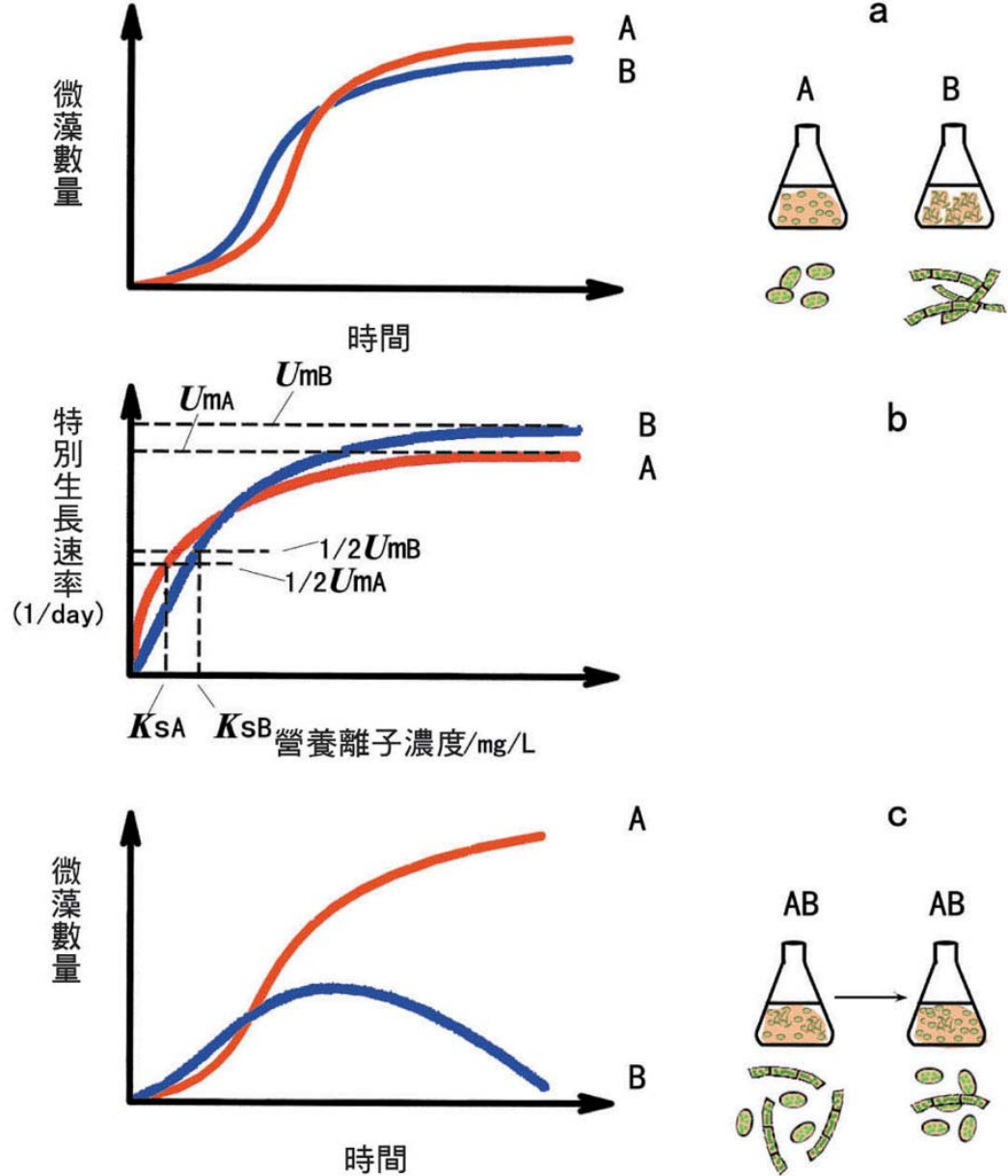


圖 16-40 兩種微藻利用和競爭營養生長結果



圖 16-41 動物的捕食現象

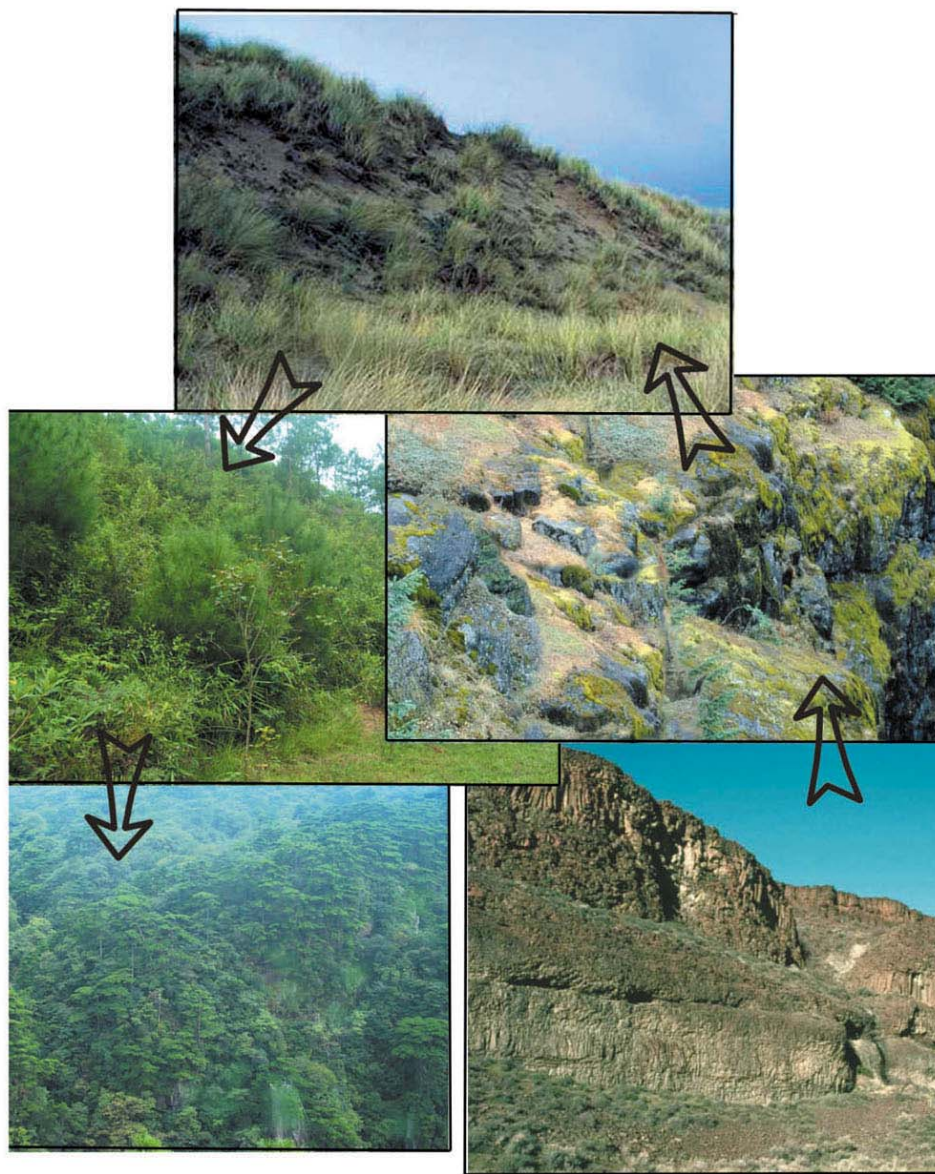


圖 16-42 群集初生消長經歷的地衣階段、苔蘚階段、草本植物階段、灌木階段和森林階段

生態系統

非生物部分

非生物環境

能源 太陽能、其它能源

基質和介質 岩石、土壤、水、空氣等

氣候 光照、溫度、降水、風等

物質代謝原料

CO_2 、 H_2O 、 O_2 、 N_2 等

無機鹽（礦物質原料）

腐殖質、脂肪、蛋白質、醣等

生物部分

生產者

綠色植物、光合細菌、化能化合物等

消費者（動物）

草食性動物 一級消費者

一級肉食性動物 二級消費者

二級肉食性動物 三級消費者

雜食性動物 雜食消費者

腐食性消費者、其他消費者

分解者（還原者）

微生物（細菌、菌類等）

圖 16-43 生態系的組成

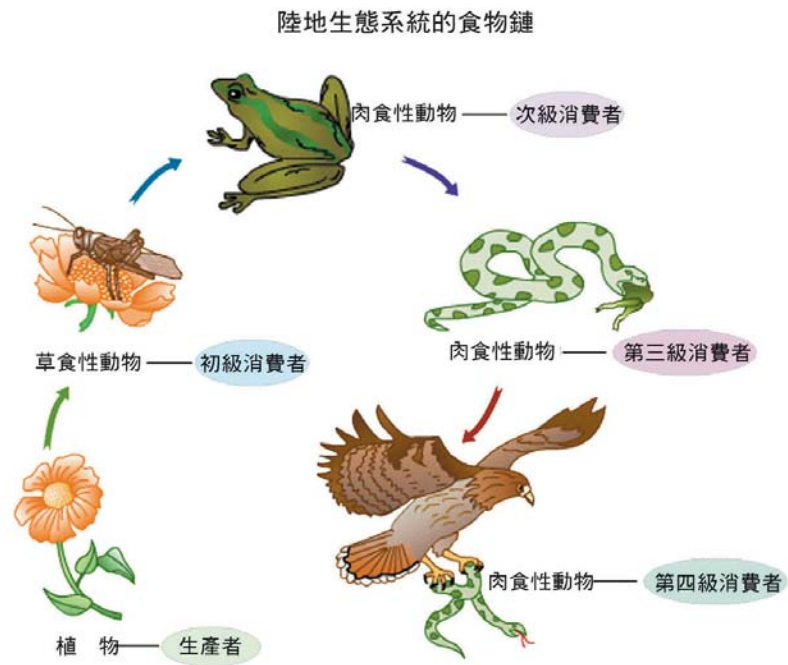
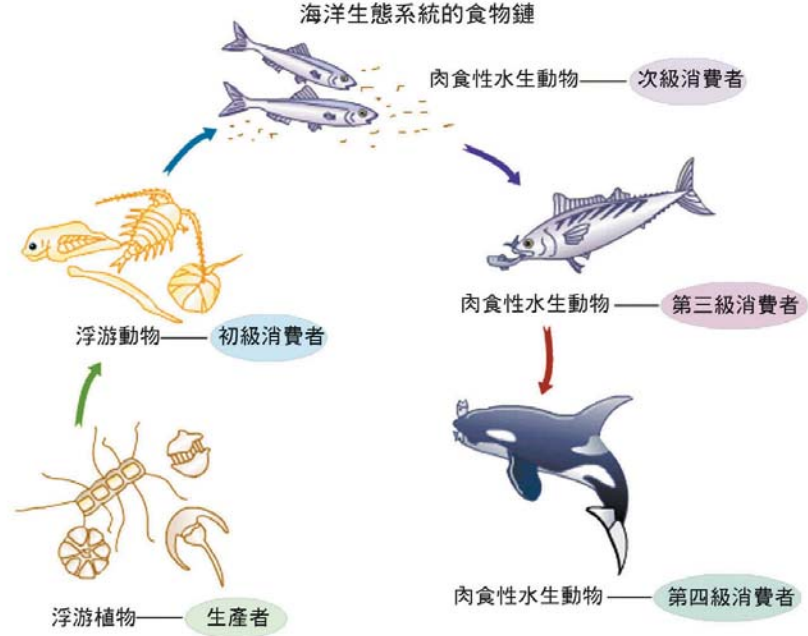


圖 16-44 陸地和海洋生態系的食物鏈

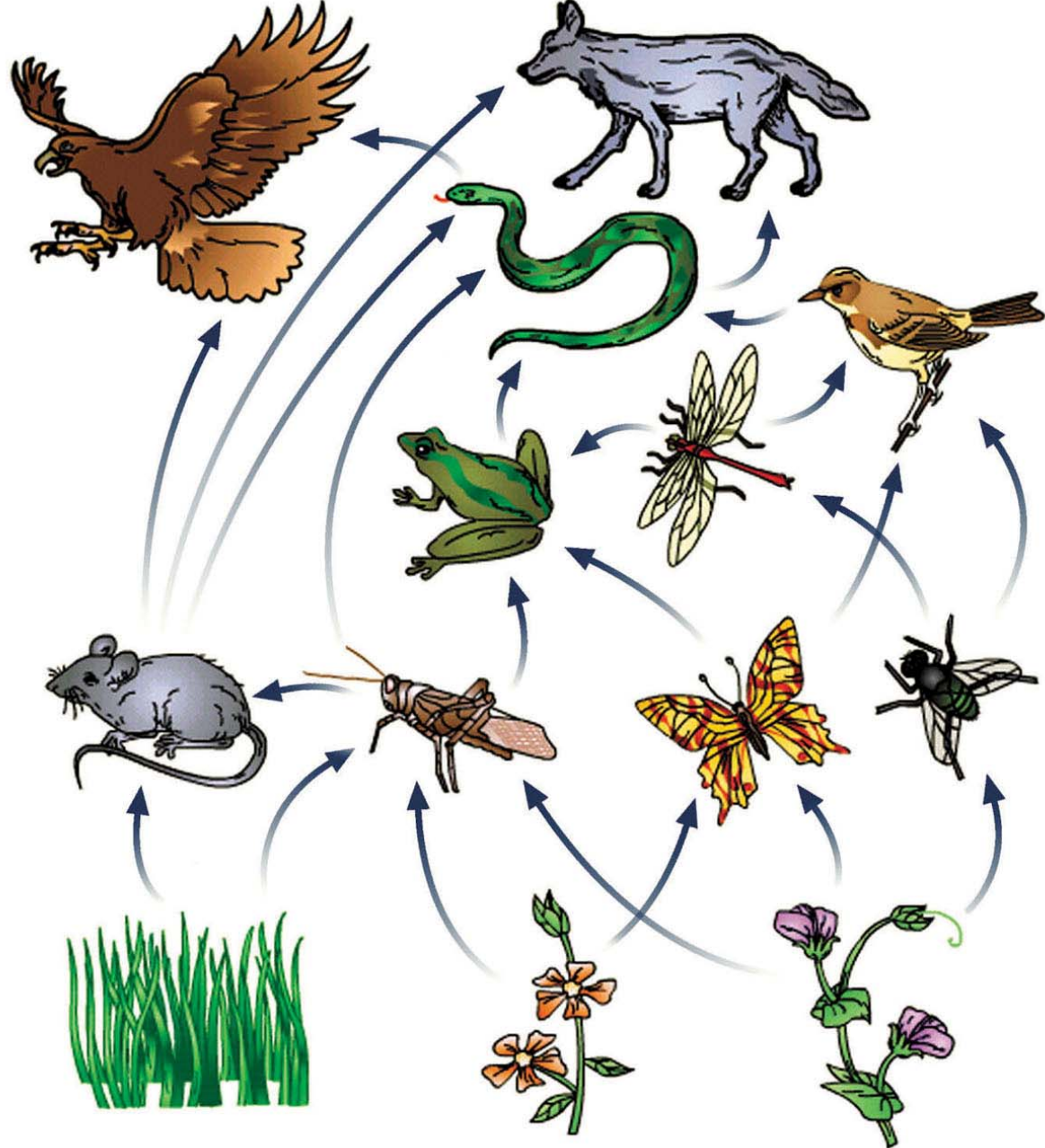


圖 16-45 陸地生態系的食物網

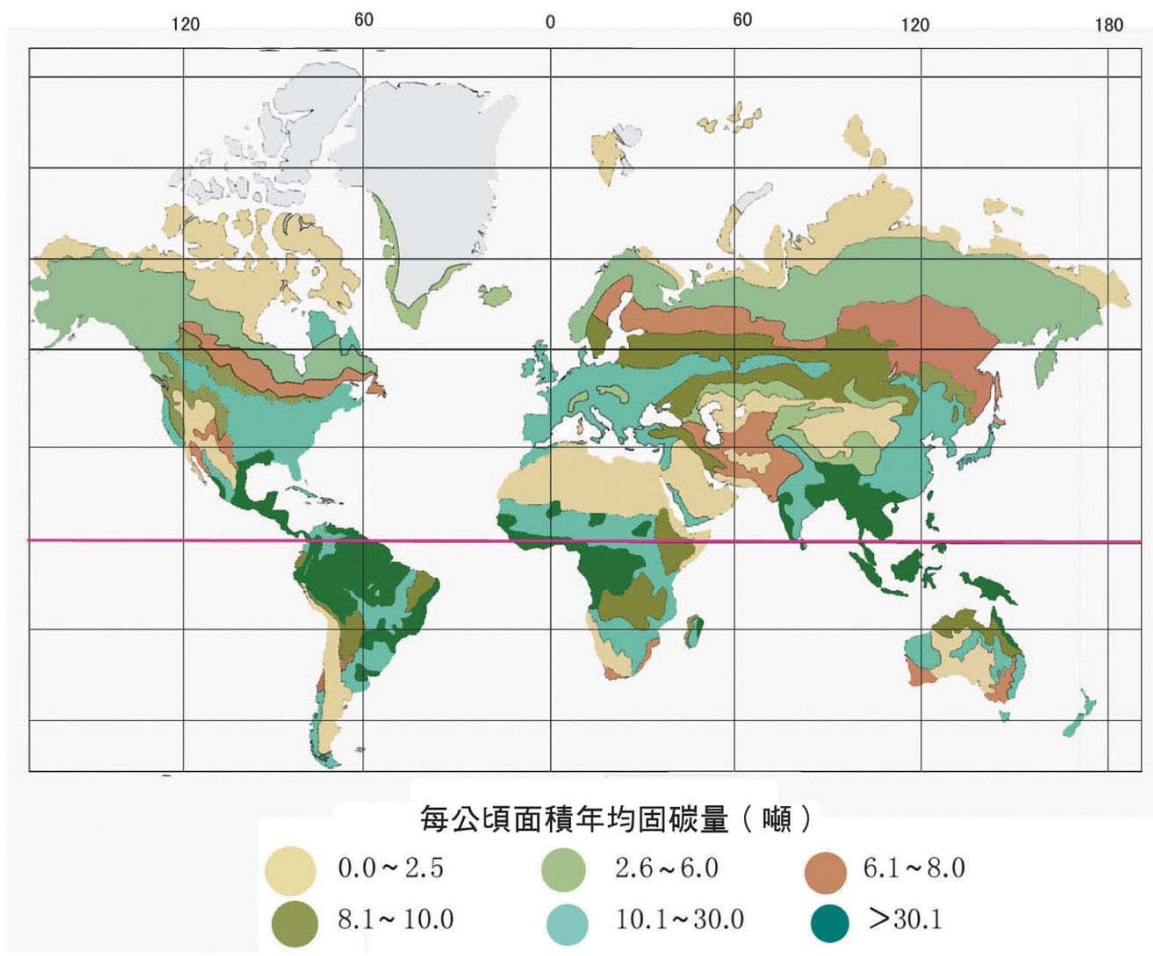


圖 16-46 全球各處陸地生態系淨初級生產力分布情況 (據 W.P. Purves 等)

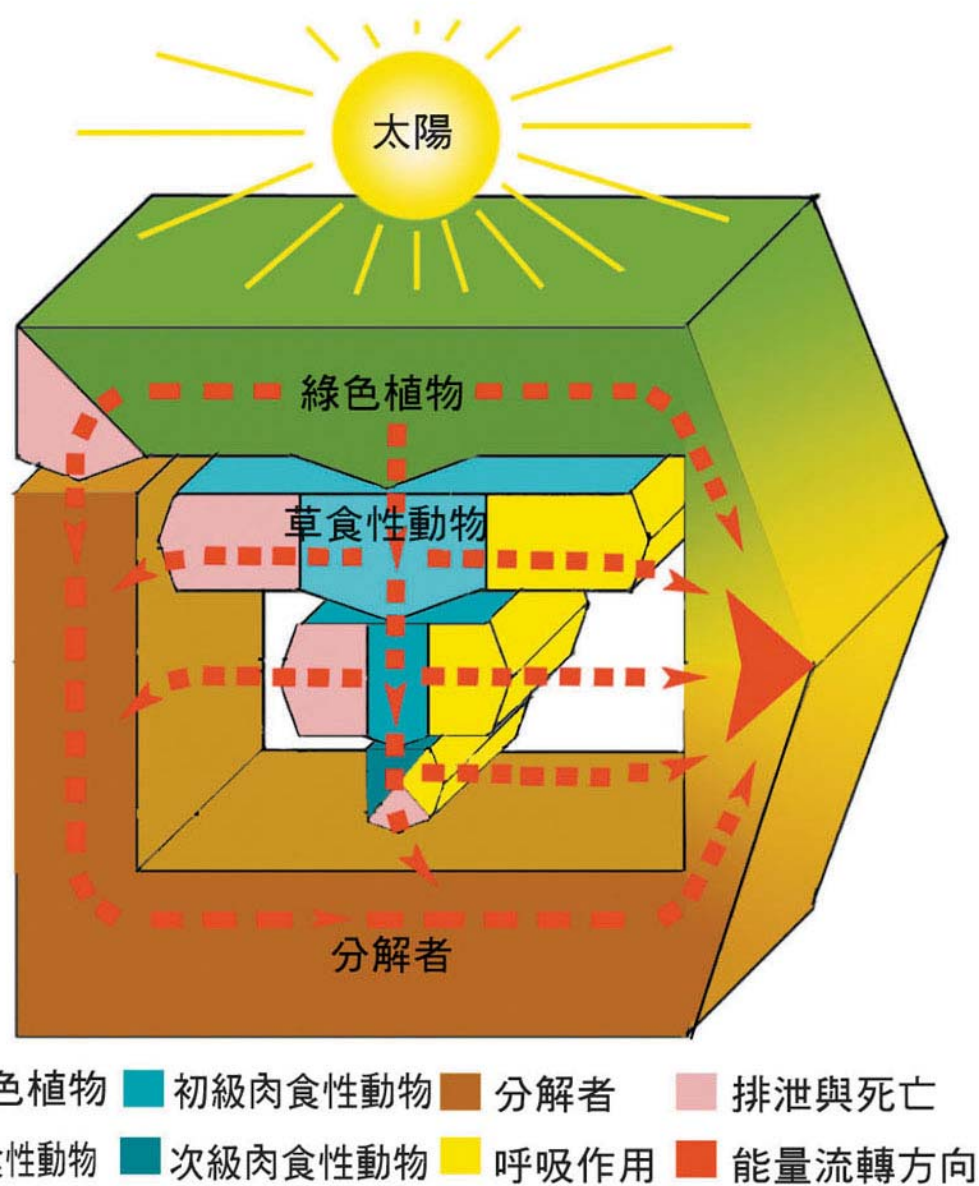


圖 16-47 生態系中的能量流轉是單方向的

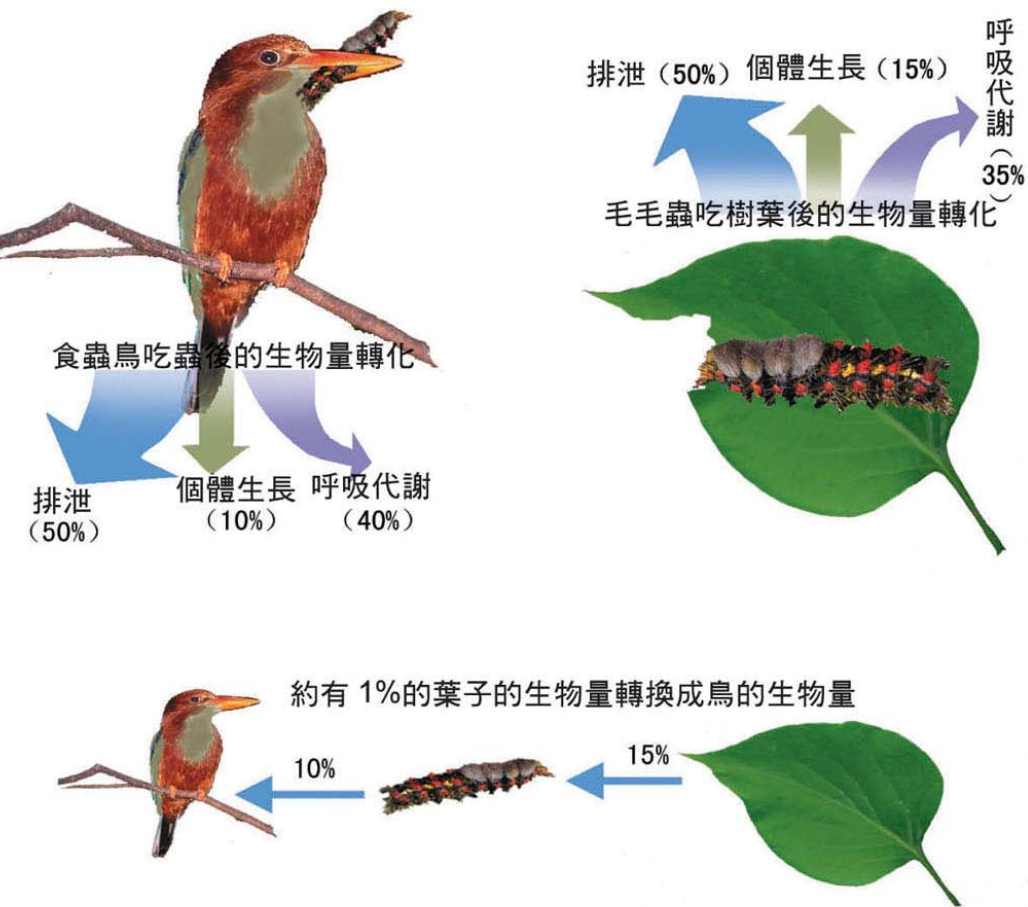
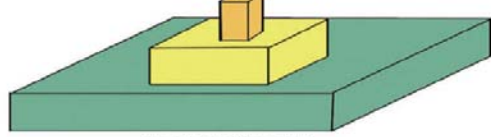
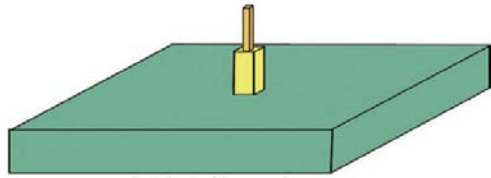


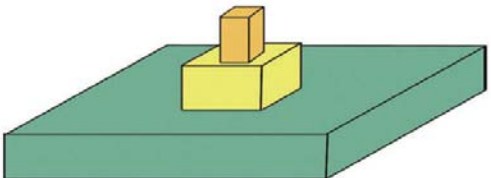
圖 16-48 能量沿食物鏈流動



海洋生態系統



森林生態系統



草地生態系統

- 次級消費者
- 初級消費者
- 生產者



金字塔

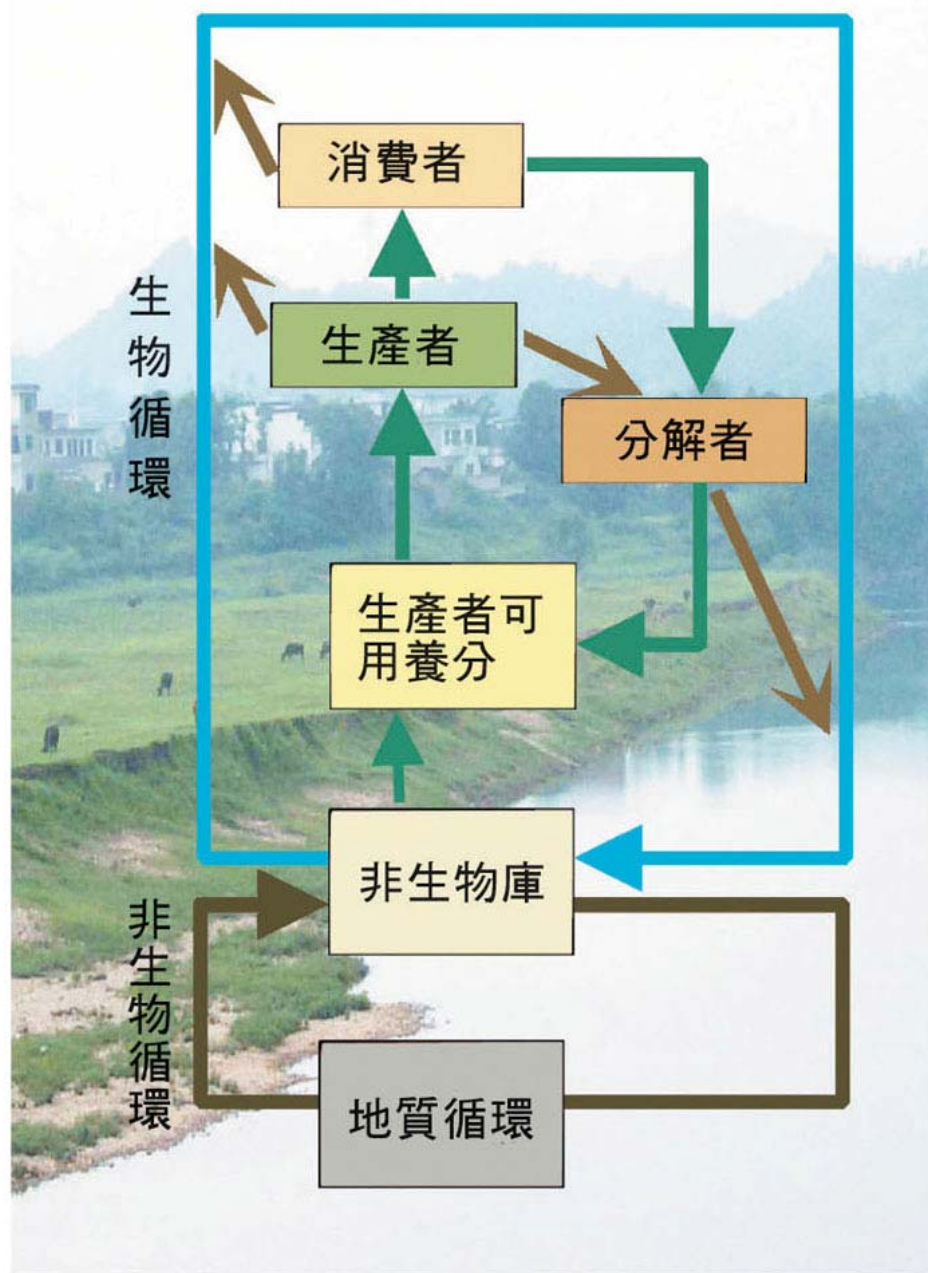


圖 16-50 生物地質化學循環示意圖

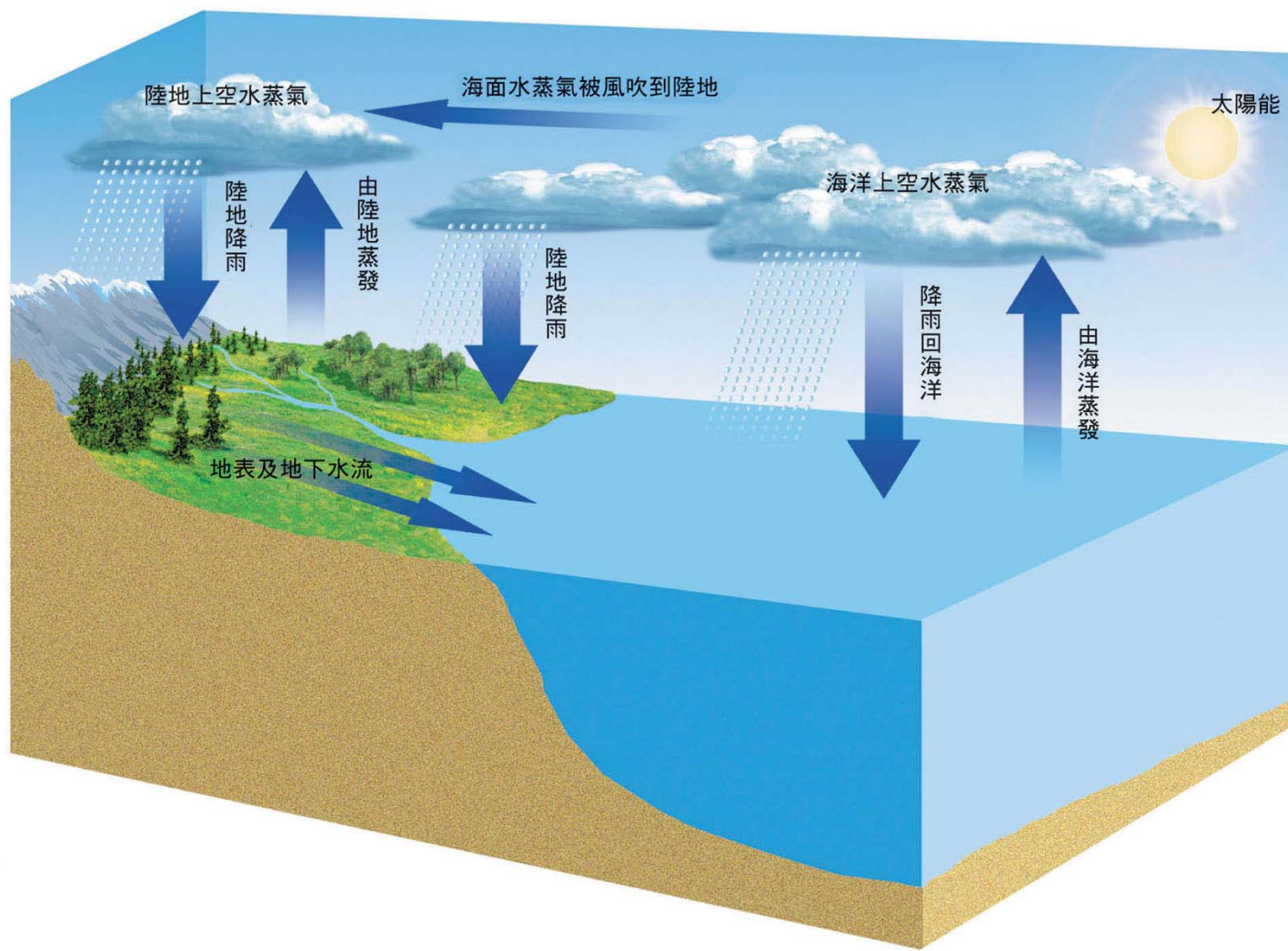


圖 16-51 自然界水的循環

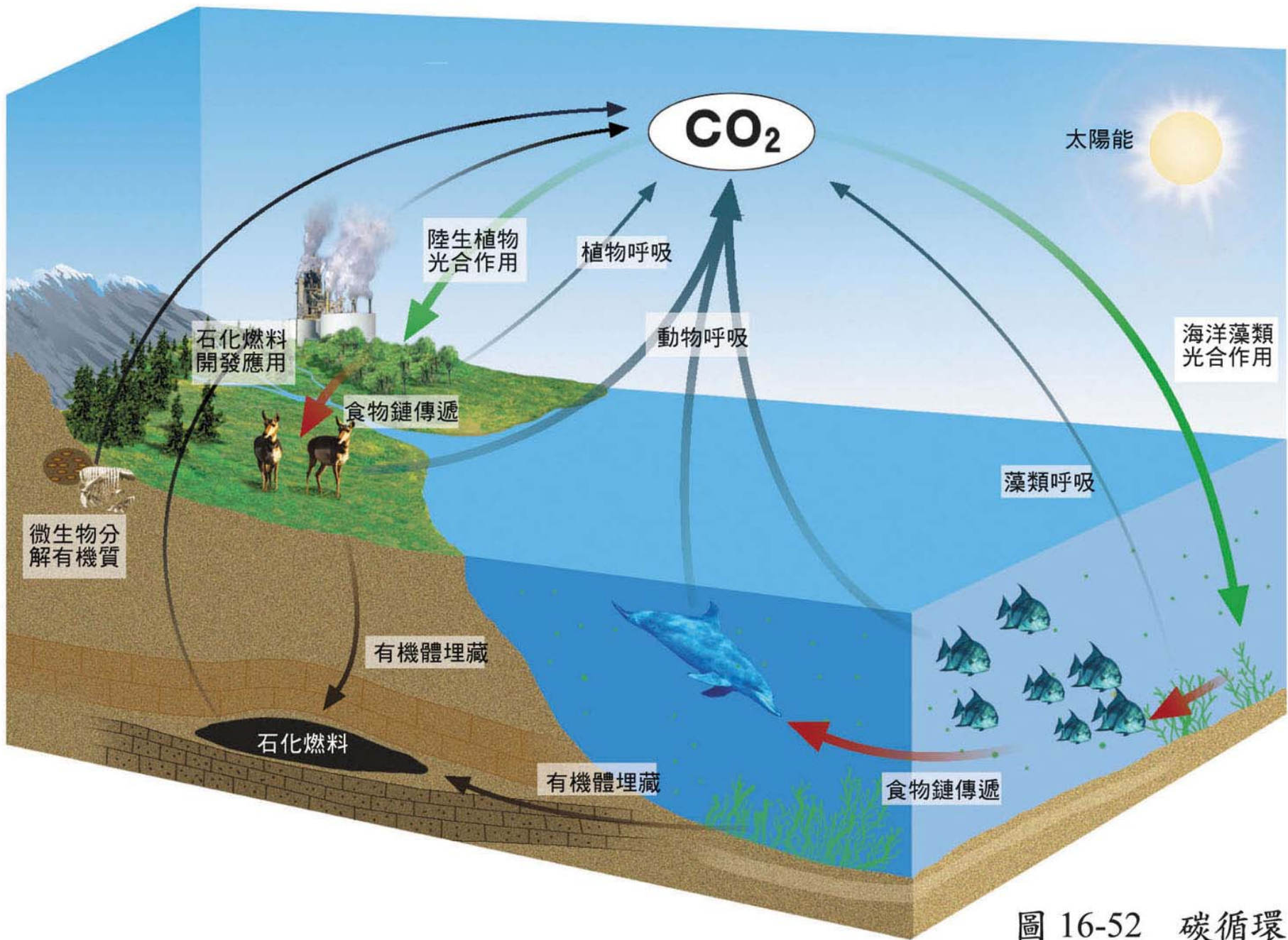
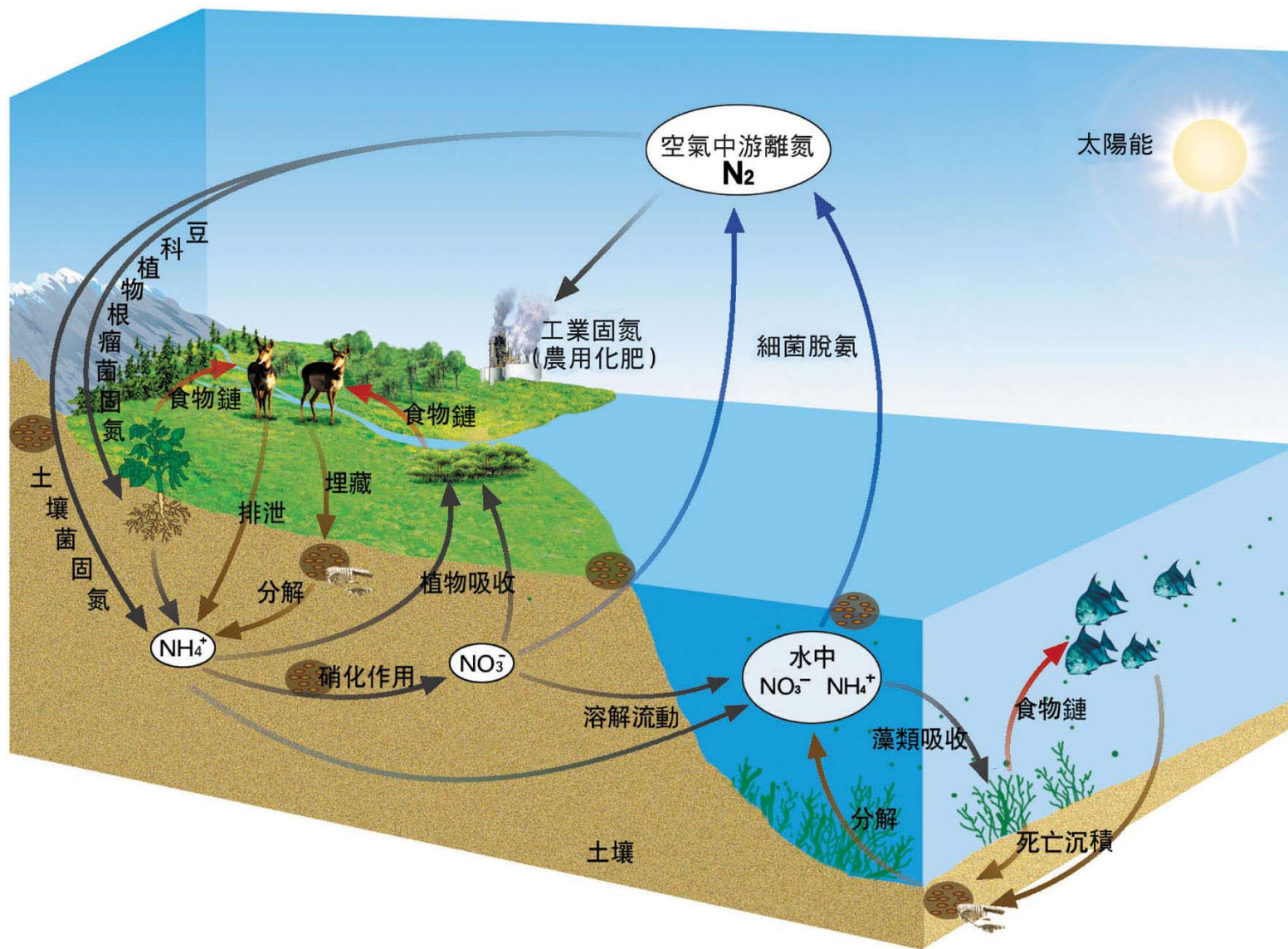


圖 16-52 碳循環



16-53 氮循環

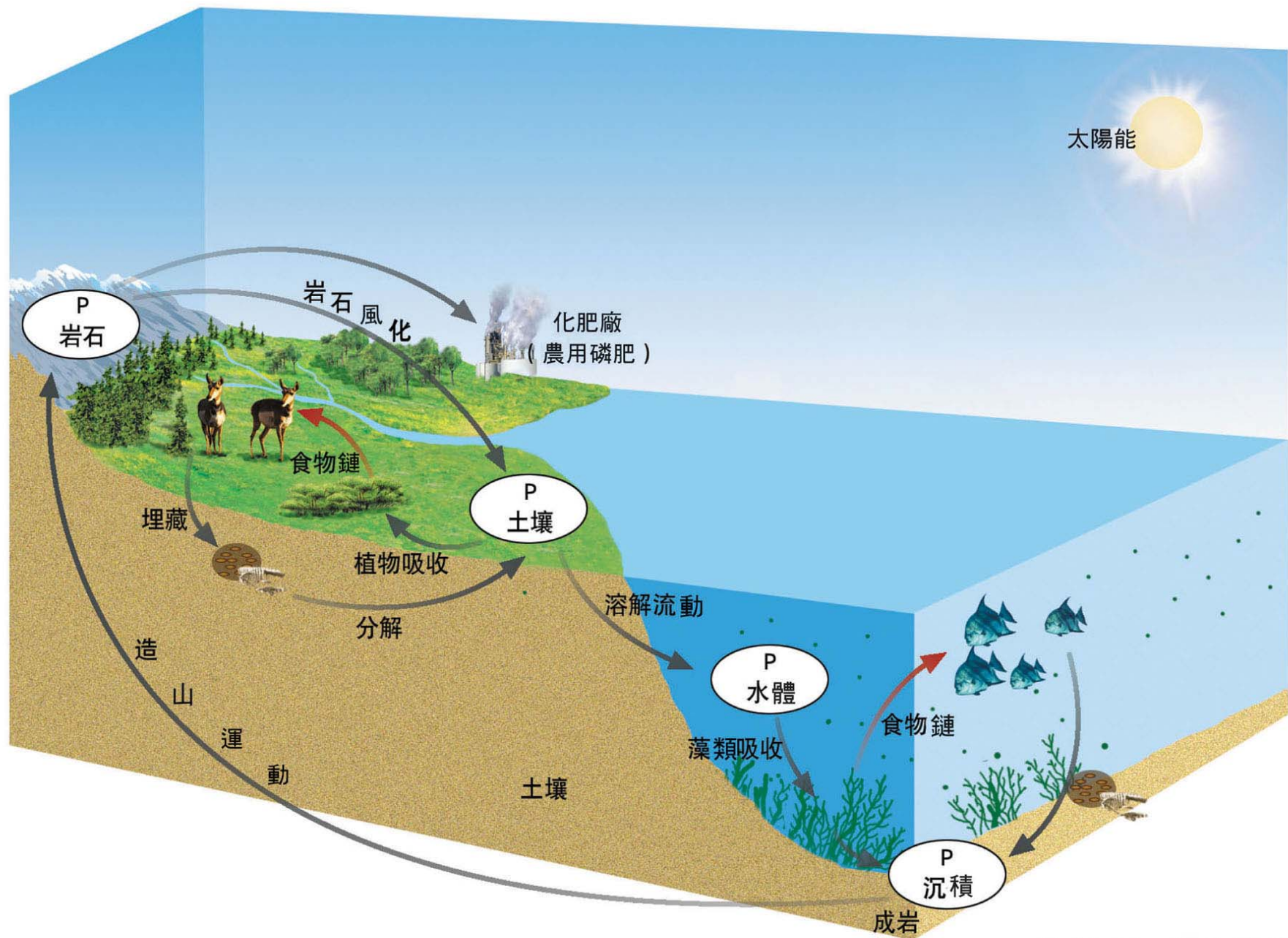
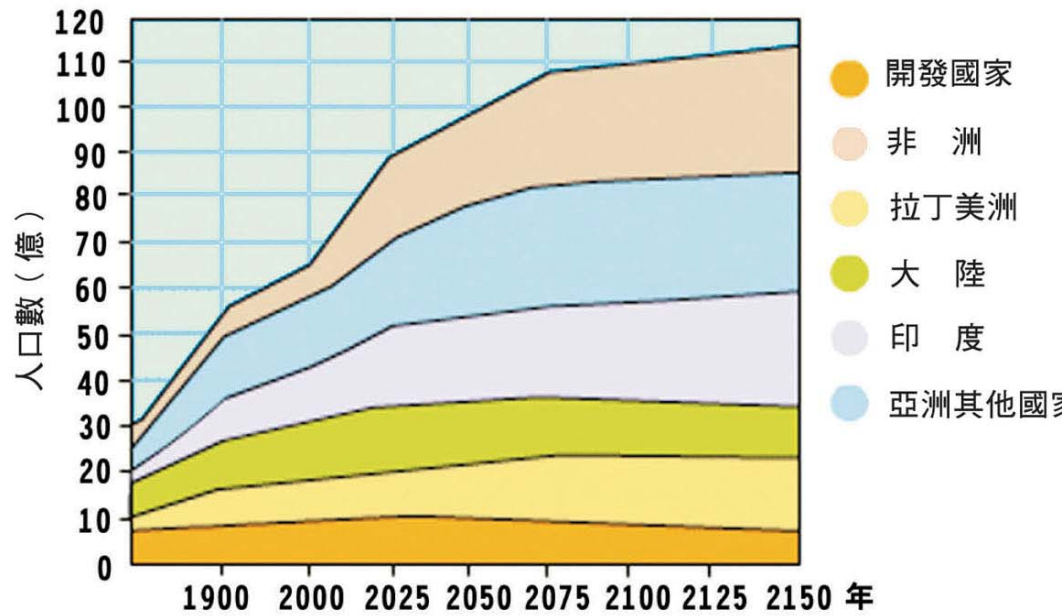


圖 16-54 磷的循環

圖 16-55 世界總人口的發展趨勢



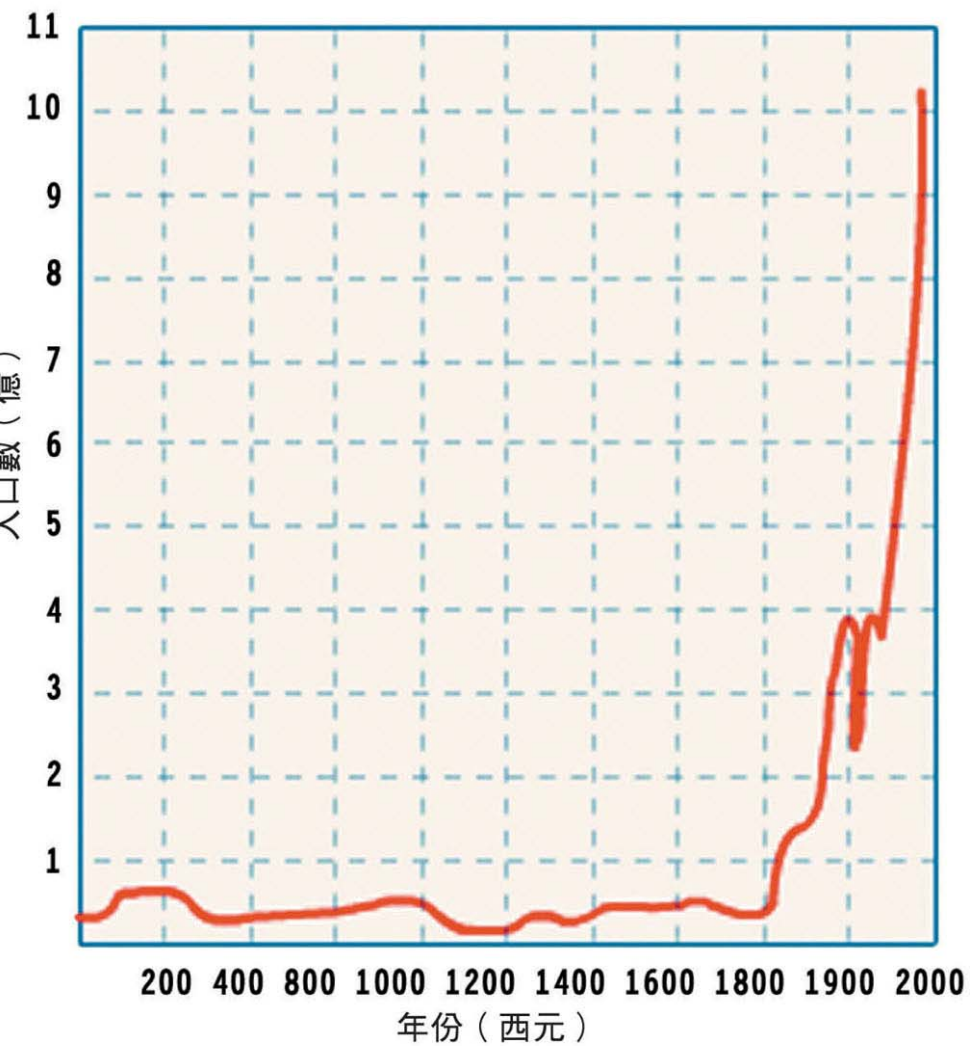


圖 16-56 西元 200 — 2000 年大陸人
數量的變化



圖 16-57 飢餓的非洲兒童



河流乾涸



顆粒無收

圖 16-58 乾旱導致糧食作物顆粒無收

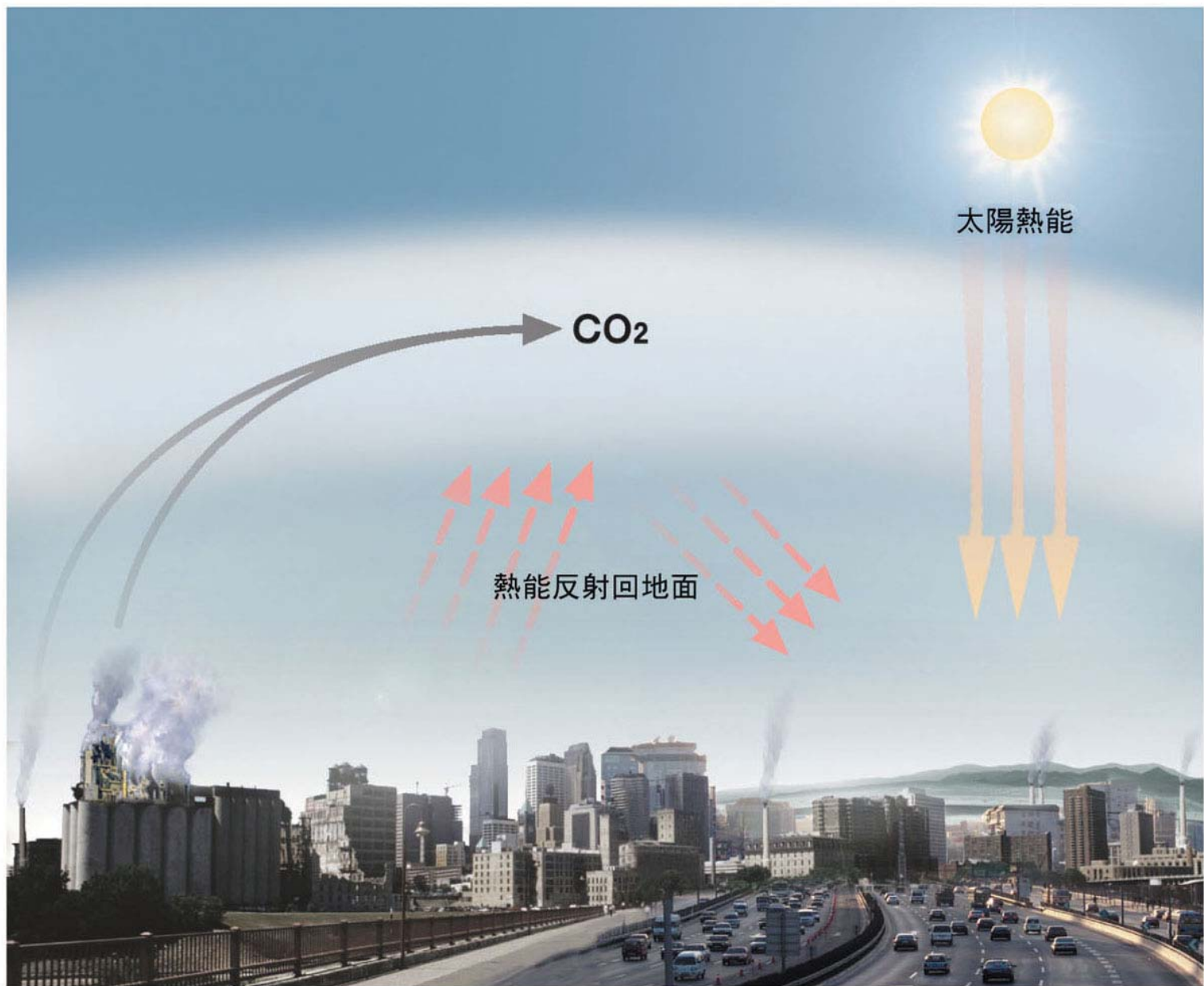


圖 16-59 CO₂濃度上升導致溫室效應

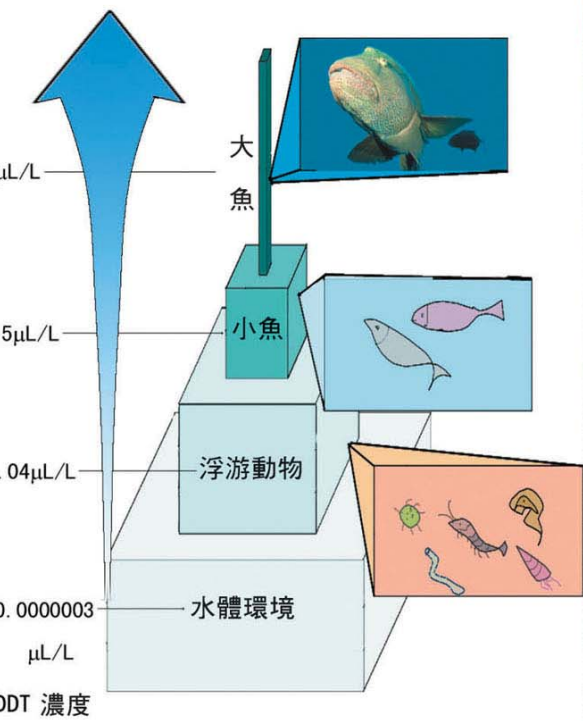


圖 16-60 DDT 污染水源後在食物鏈中的累積而放大效應



圖 16-61 口蹄疫和狂牛病導致一些國家的
畜牧業全軍覆沒
(引自《人民畫報》，2001/1)

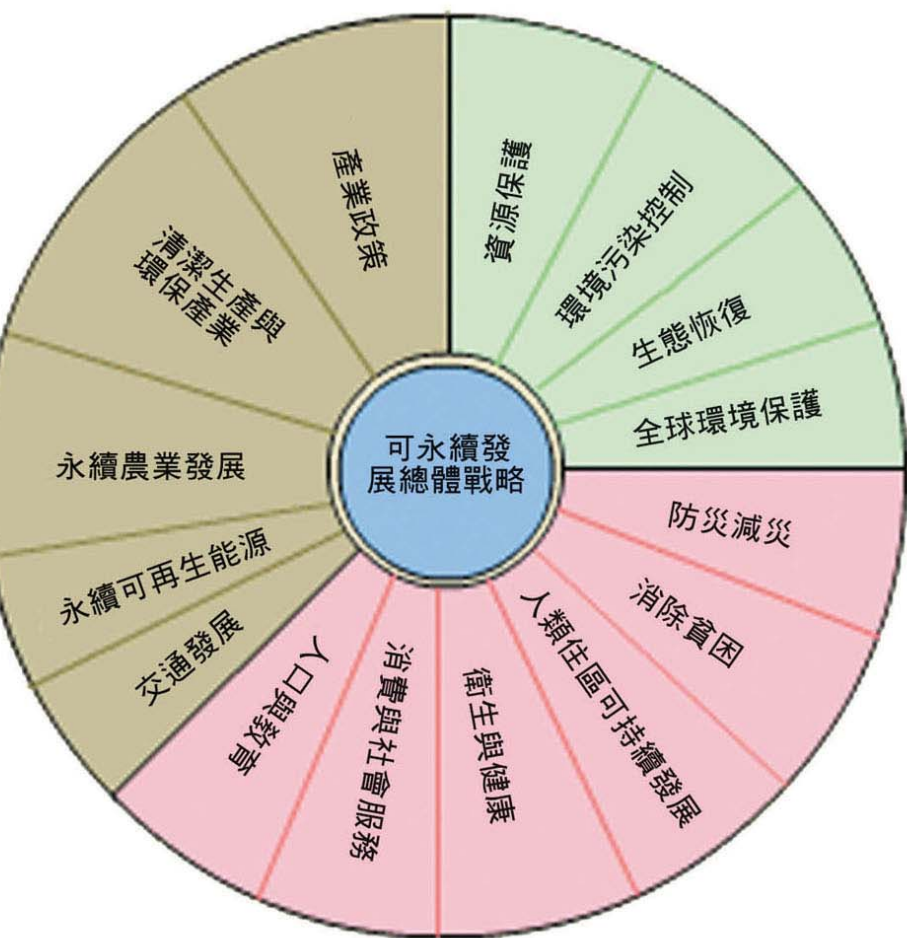


圖 16-62 可永續發展總體策略的內容

生態系統

- 生態系統所探討的層次和內容為何？請舉例說明。
- 由營養能階的角度來說明為什麼猛禽是鳥類中數量最少的種類？
- 食物鏈和食物網有什麼不同之處？
- 探討生物多樣性的層次分為哪幾類？請分別舉例說明。