Marine Biological Labs Microbial Diversity Course
Class of 1989

Bacteria in the Environment

- The Carbon Cycle
  - The Ocean (Global Warming?)
  - Rumen (From vinegar to steak)
- The Sulfur Cycle
  - Hydrothermal vents (life without light)
- The Nitrogen Cycle (Have you thanked a bacterium today?)
  - Soil /Rhizosphere
  - Rhizobium and Legumes

Ecological Role of Microbes

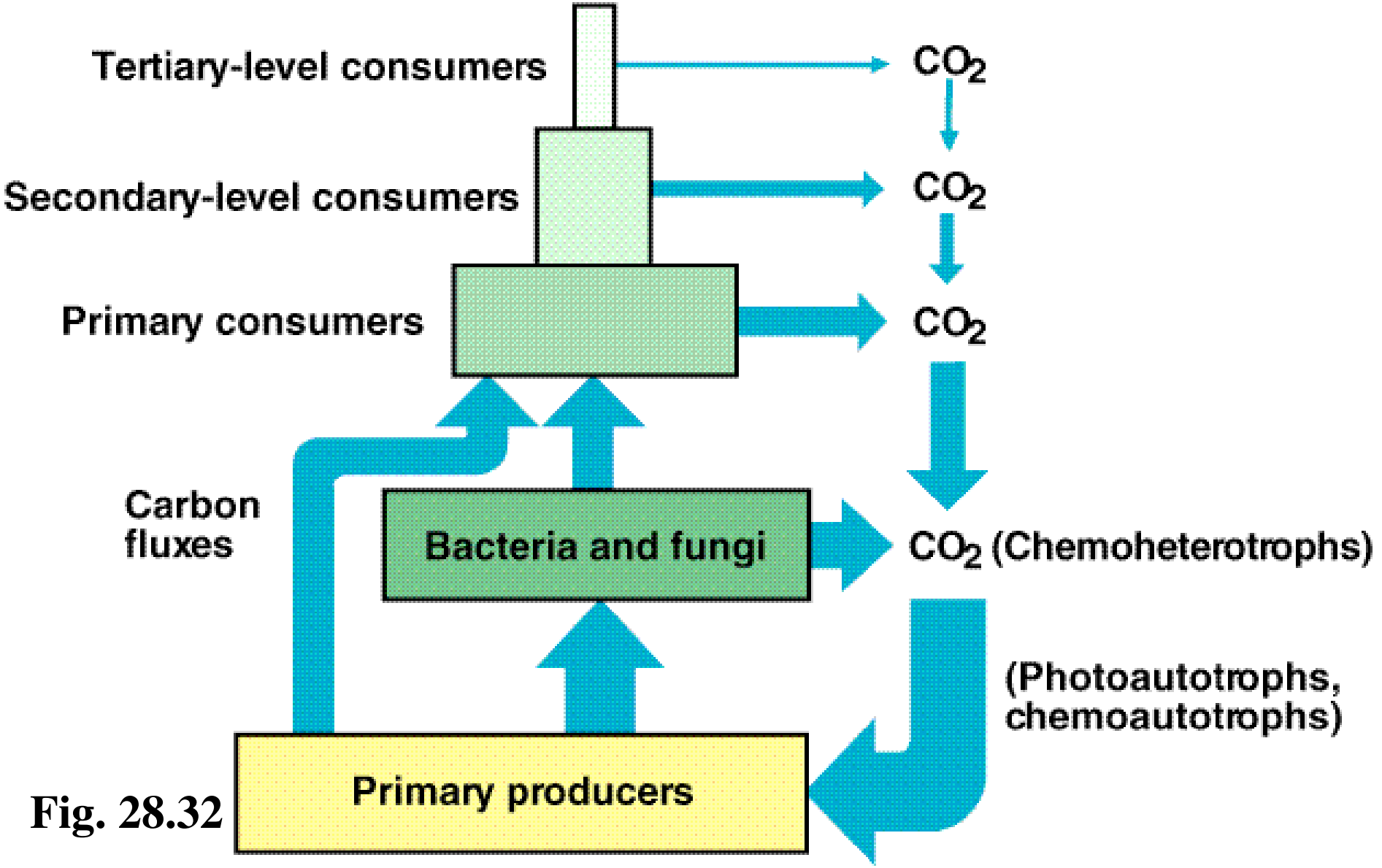


Fig. 28.32

The Carbon Cycle in Nature

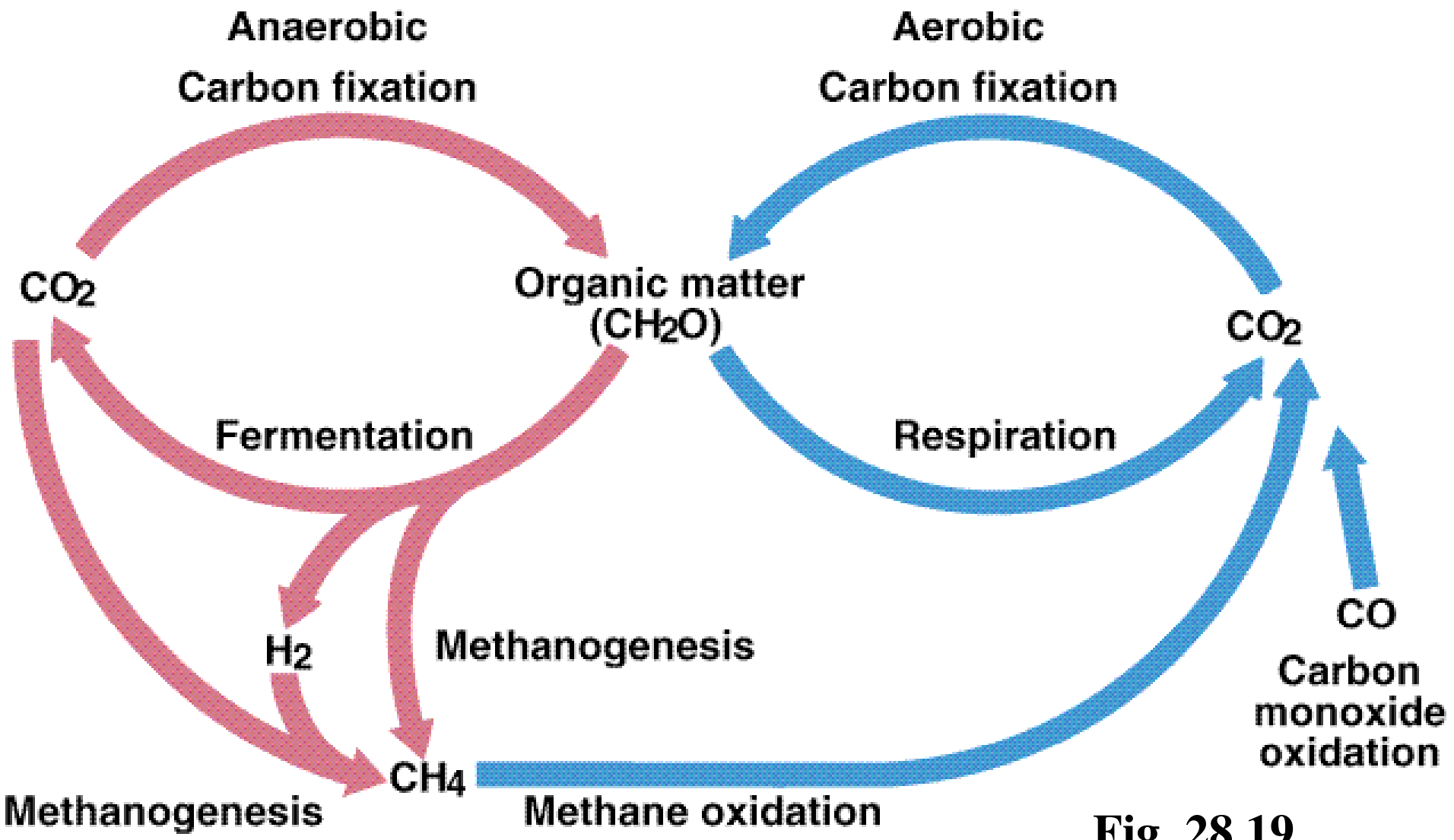
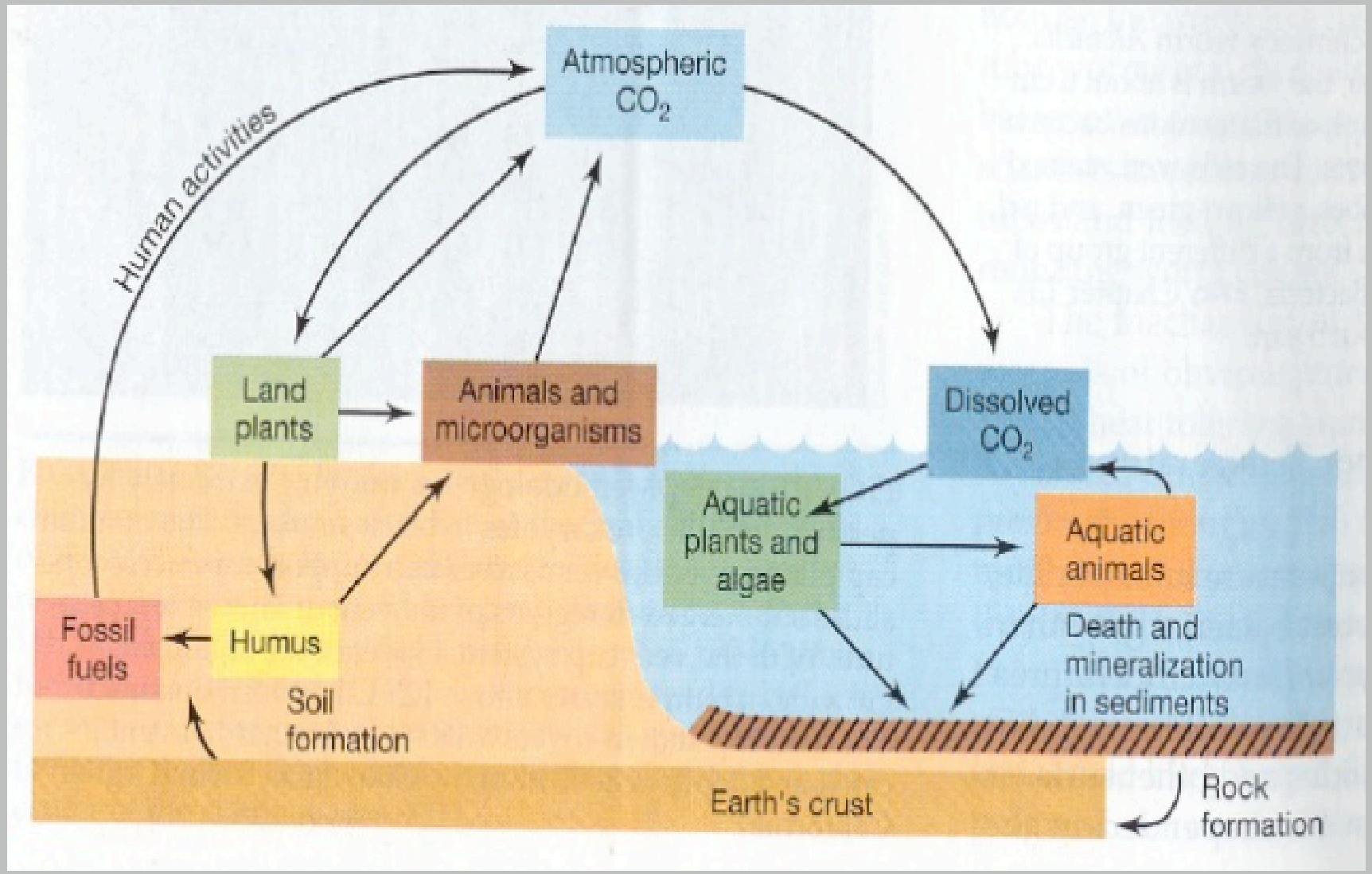
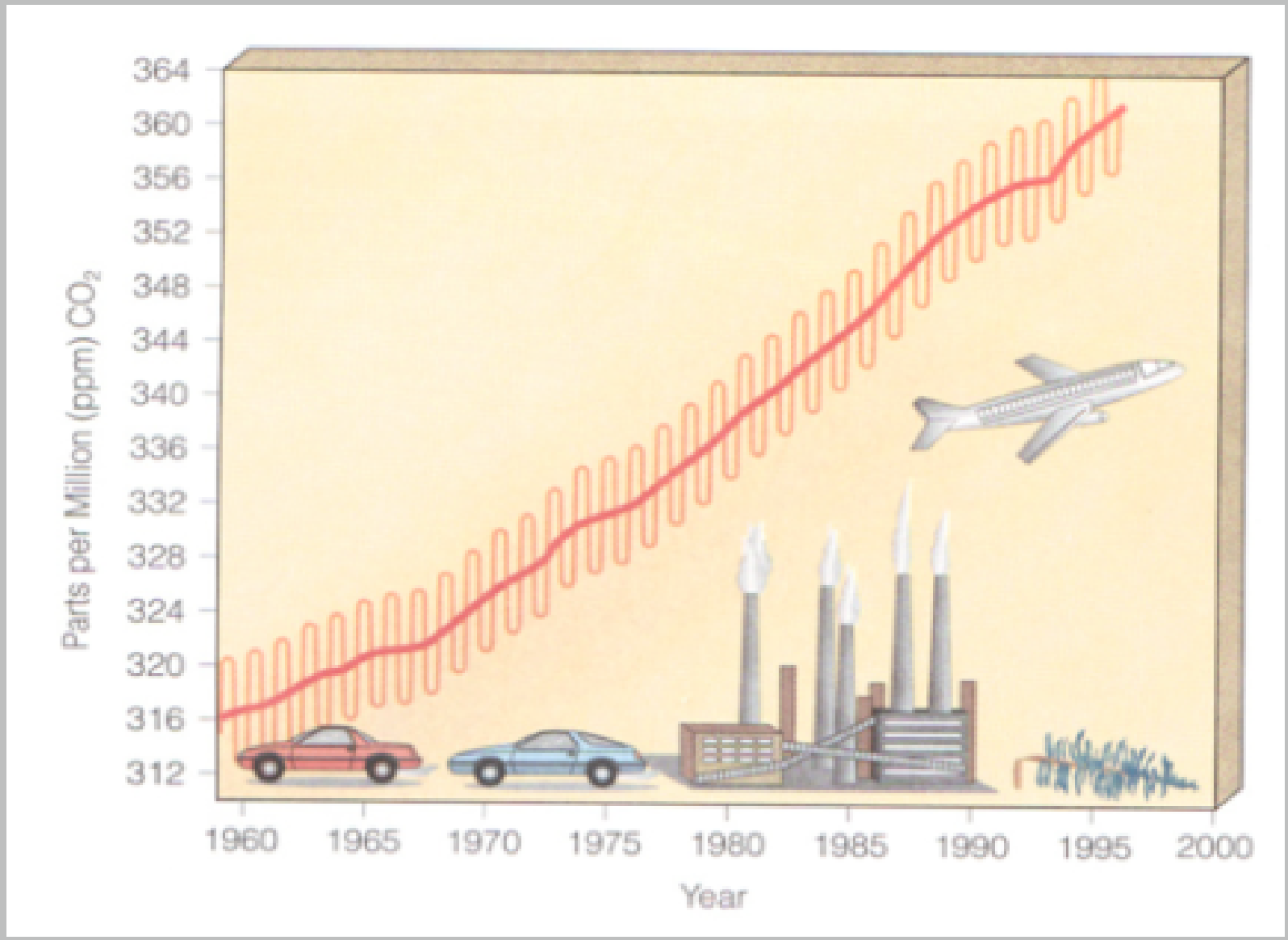
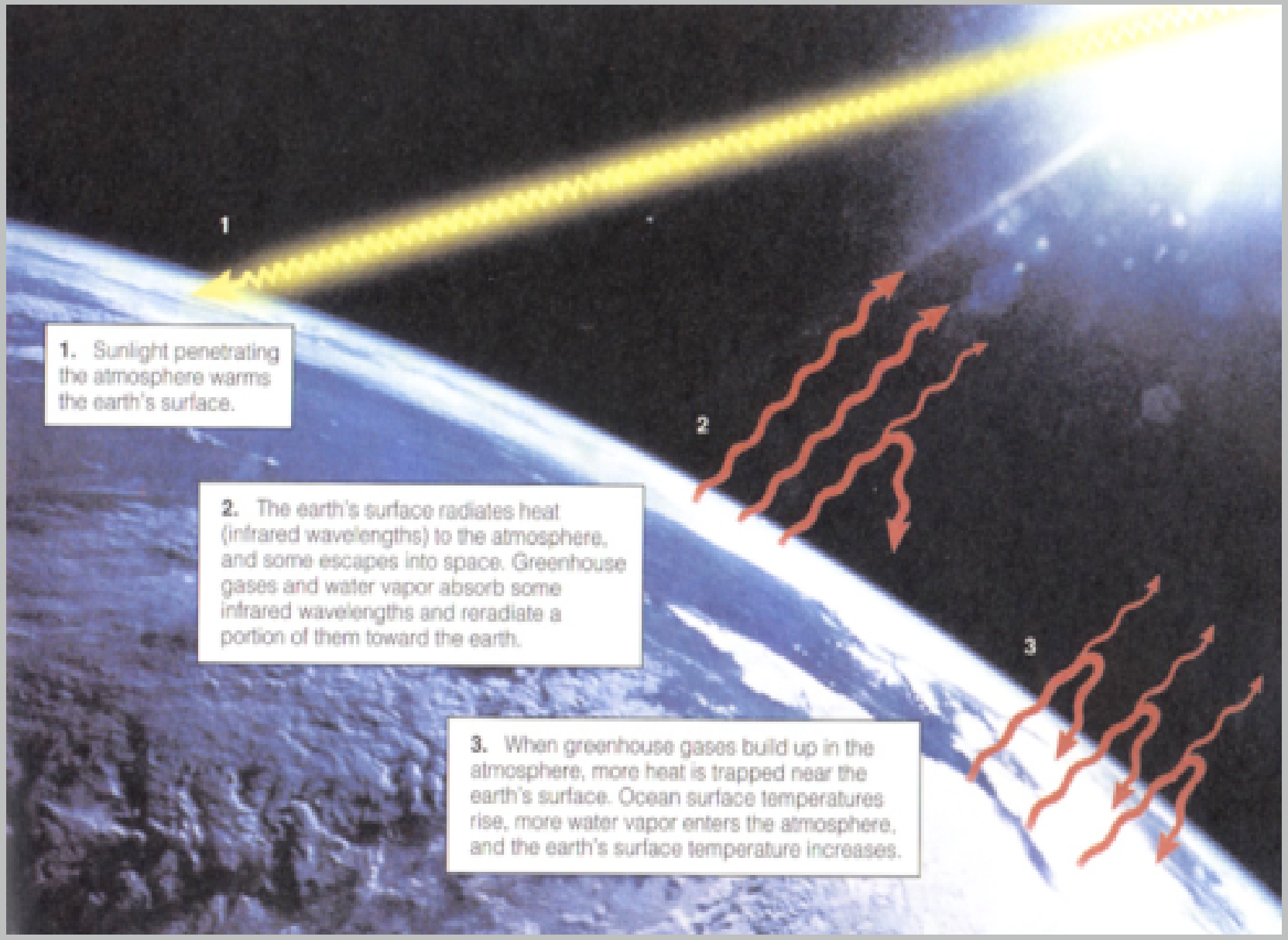


Fig. 28.19


Atmospheric CO_2
Human activities
Land plants
Animals and microorganisms
Dissolved CO_2
Aquatic plants and algae
Aquatic animals
Fossil fuels
Humus
Soil formation
Death and mineralization in sediments
Earth's crust
Rock formation


Parts per Million (ppm) CO_2
364
360
356
352
348
344
340
336
332
328
324
320
316
312
1960
1965
1970
1975
1980
1985
1990
1995
2000
Year


1
2
3
1. Sunlight penetrating the atmosphere warms the earth's surface.
2. The earth's surface radiates heat (infrared wavelengths) to the atmosphere, and some escapes into space. Greenhouse gases and water vapor absorb some infrared wavelengths and reradiate a portion of them toward the earth.
3. When greenhouse gases build up in the atmosphere, more heat is trapped near the earth's surface. Ocean surface temperatures rise, more water vapor enters the atmosphere, and the earth's surface temperature increases.

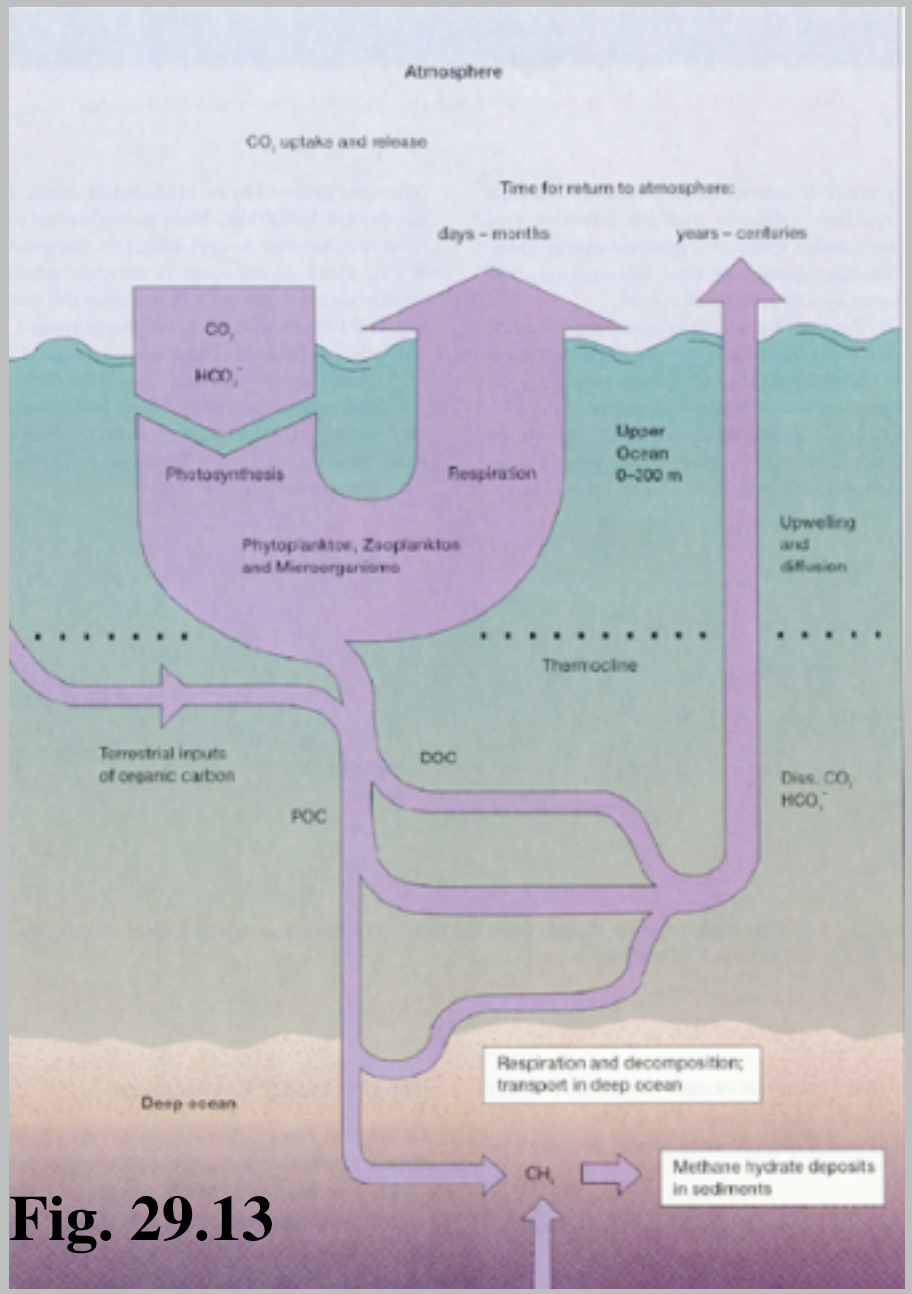
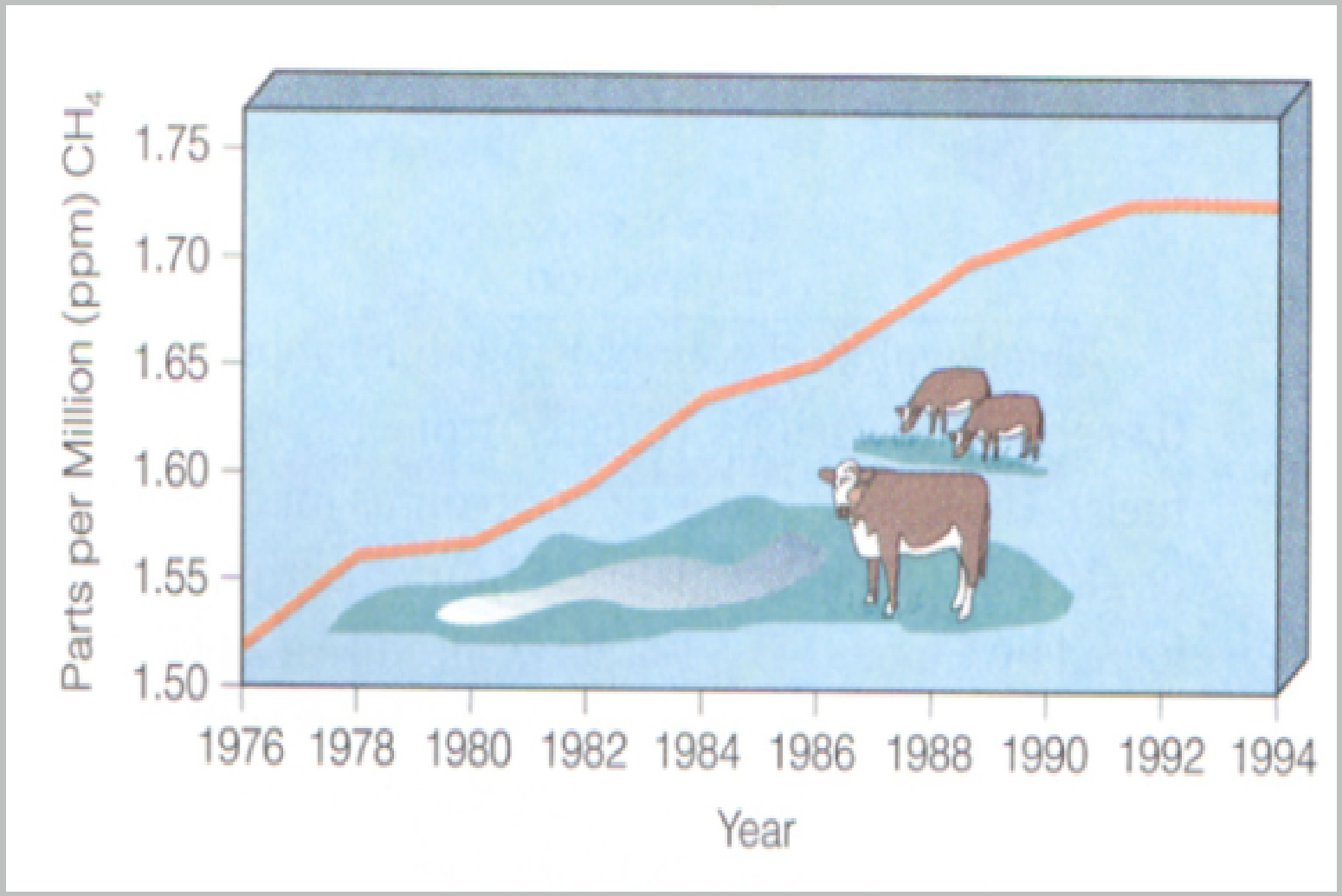
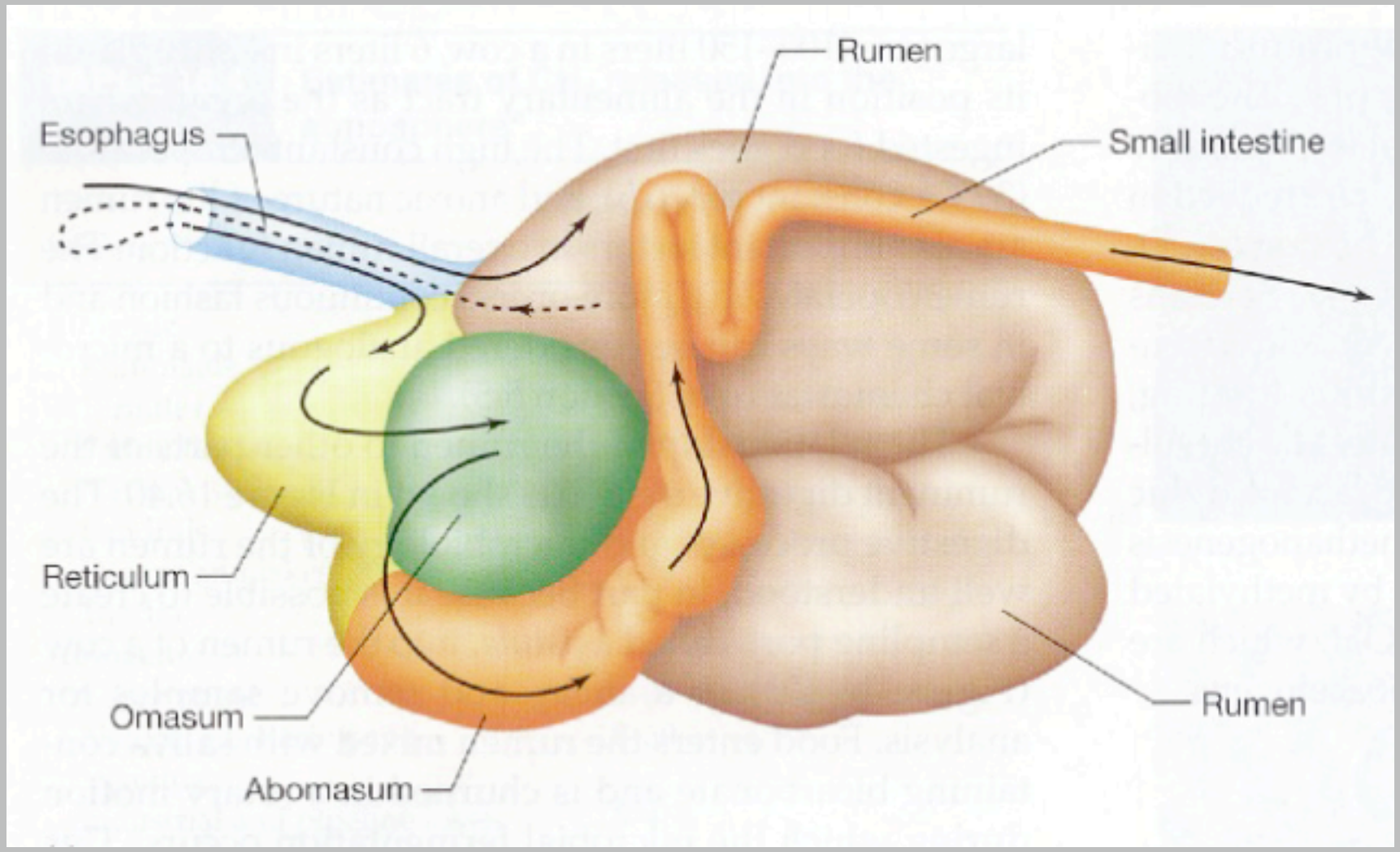


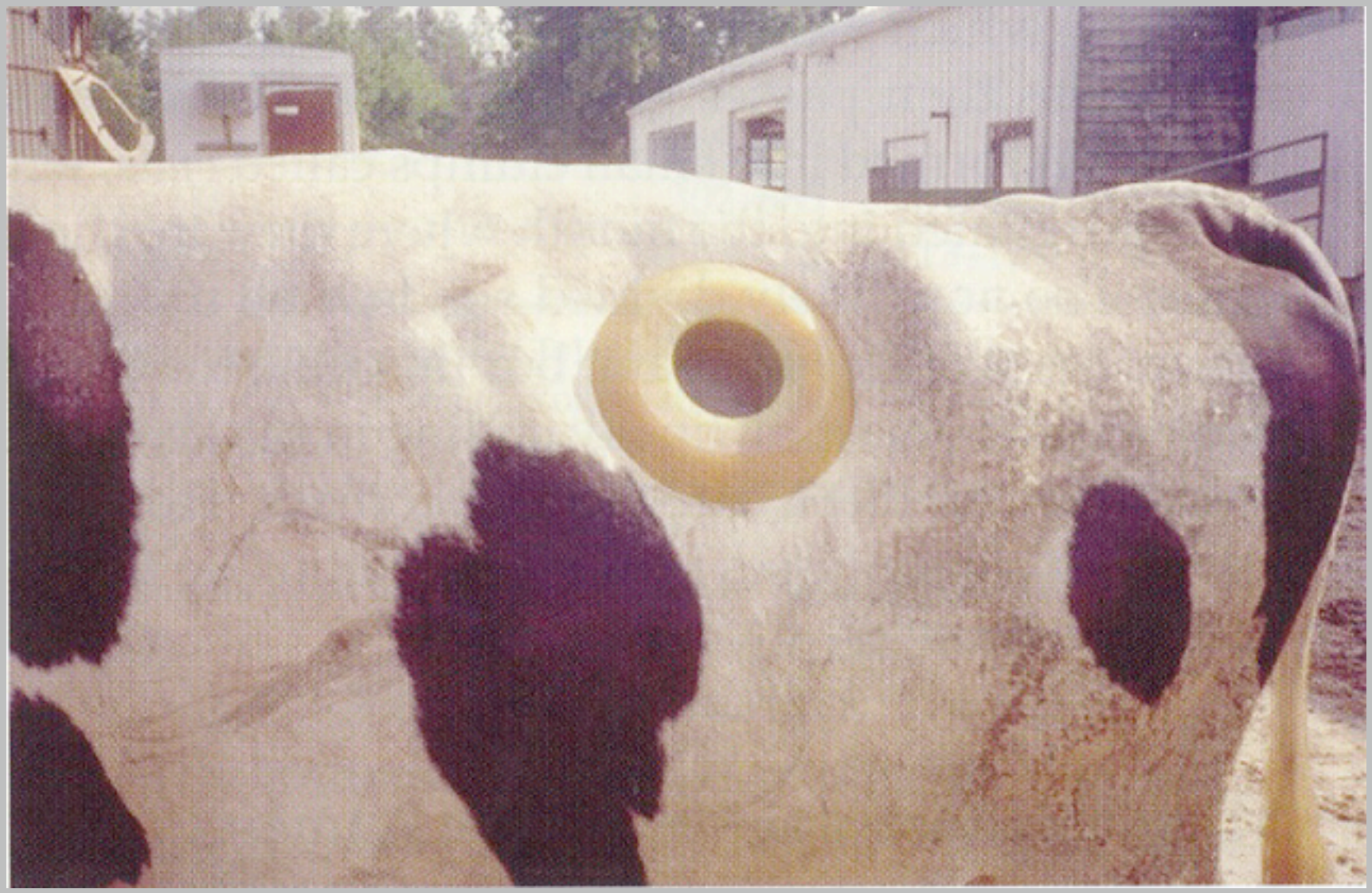
Fig. 29.13

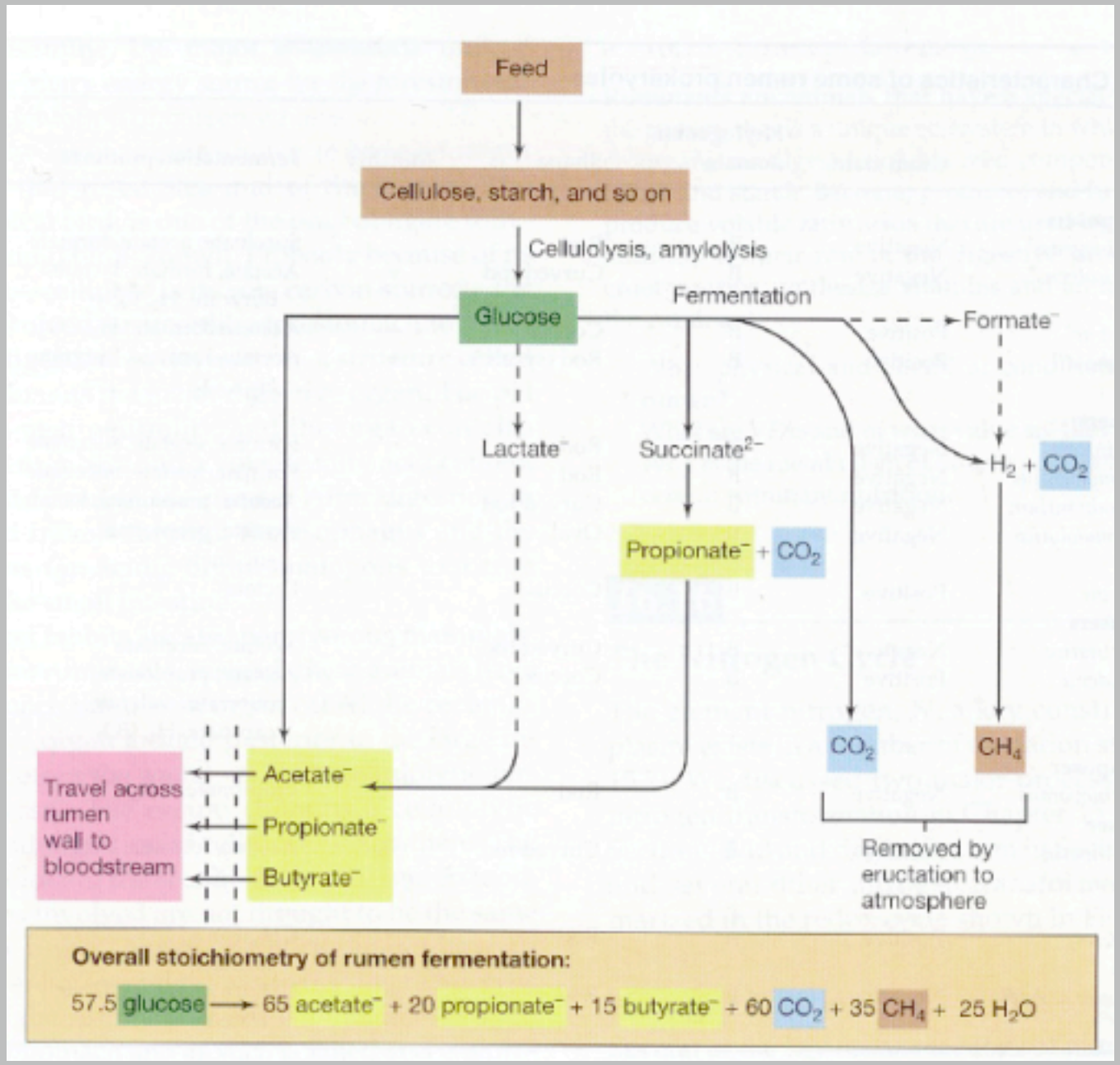
Photic zone

Methane hydrates


Parts per Million (ppm) CH_4
1.75
1.70
1.65
1.60
1.55
1.50
1976 1978 1980 1982 1984 1986 1988 1990 1992 1994
Year


Rumen
Esophagus
Small intestine
Reticulum
Omasum
Rumen
Abomasum




Feed
Cellulose, starch, and so on
Cellulolysis, amylolysis
Glucose
Fermentation
Formate⁻
Lactate⁻
Succinate²⁻
H₂ + CO₂
Propionate⁻ + CO₂
CO₂
CH₄
Acetate⁻
Propionate⁻
Butyrate⁻
Travel across rumen wall to bloodstream
Removed by eructation to atmosphere
Overall stoichiometry of rumen fermentation:
57.5 glucose → 65 acetate⁻ + 20 propionate⁻ + 15 butyrate⁻ + 60 CO₂ + 35 CH₄ + 25 H₂O

The Sulfur Cycle in Nature

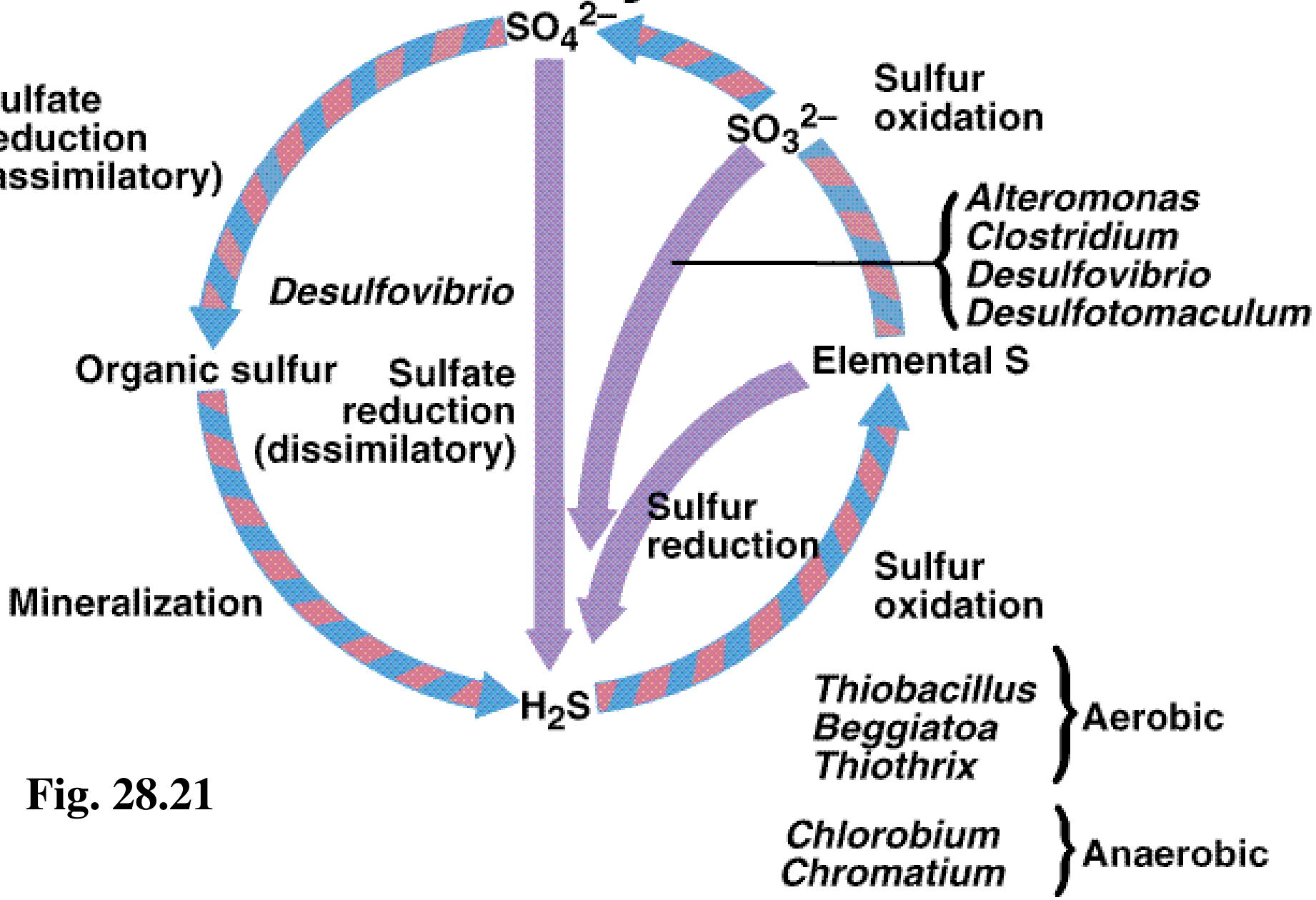
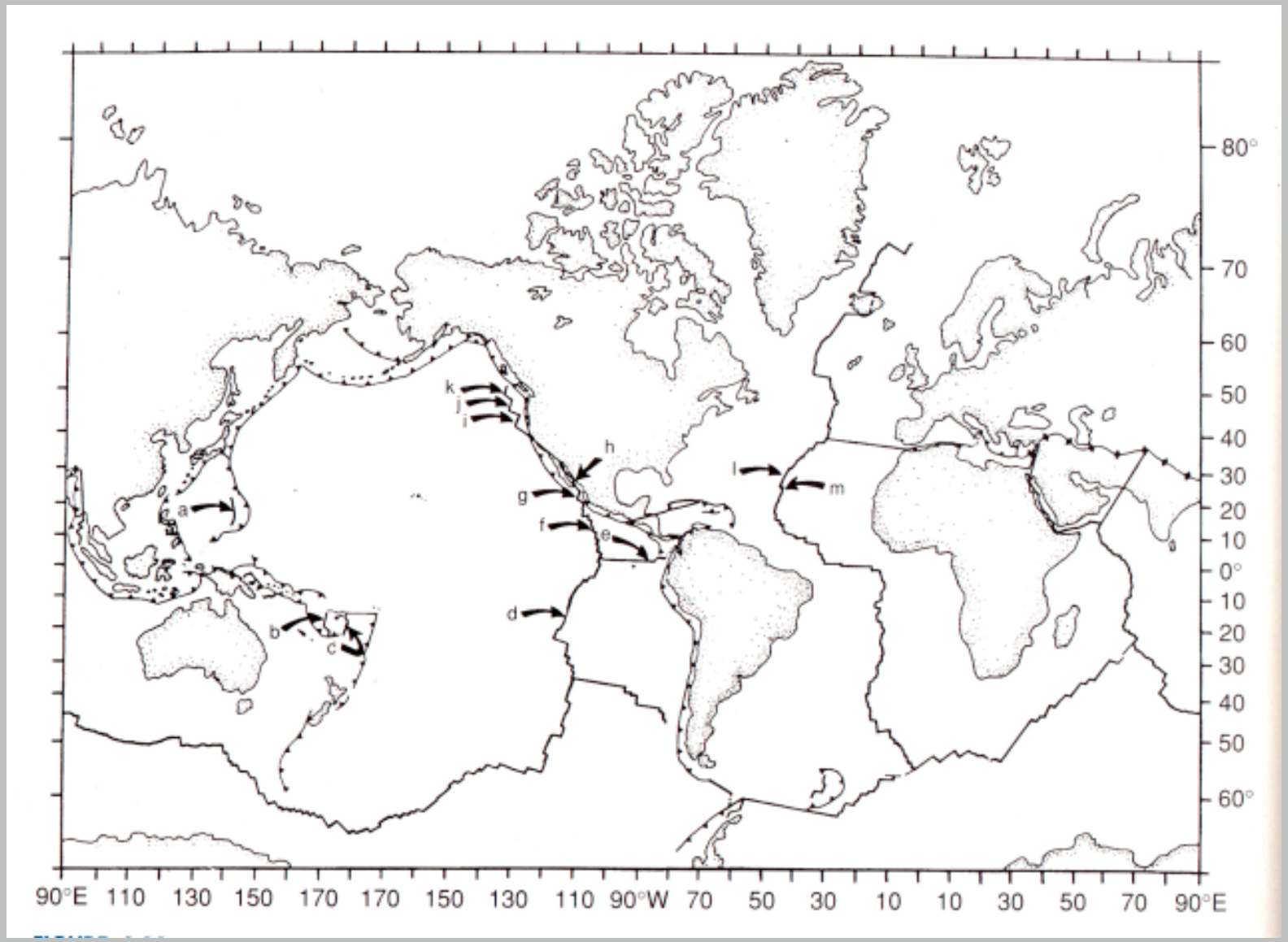
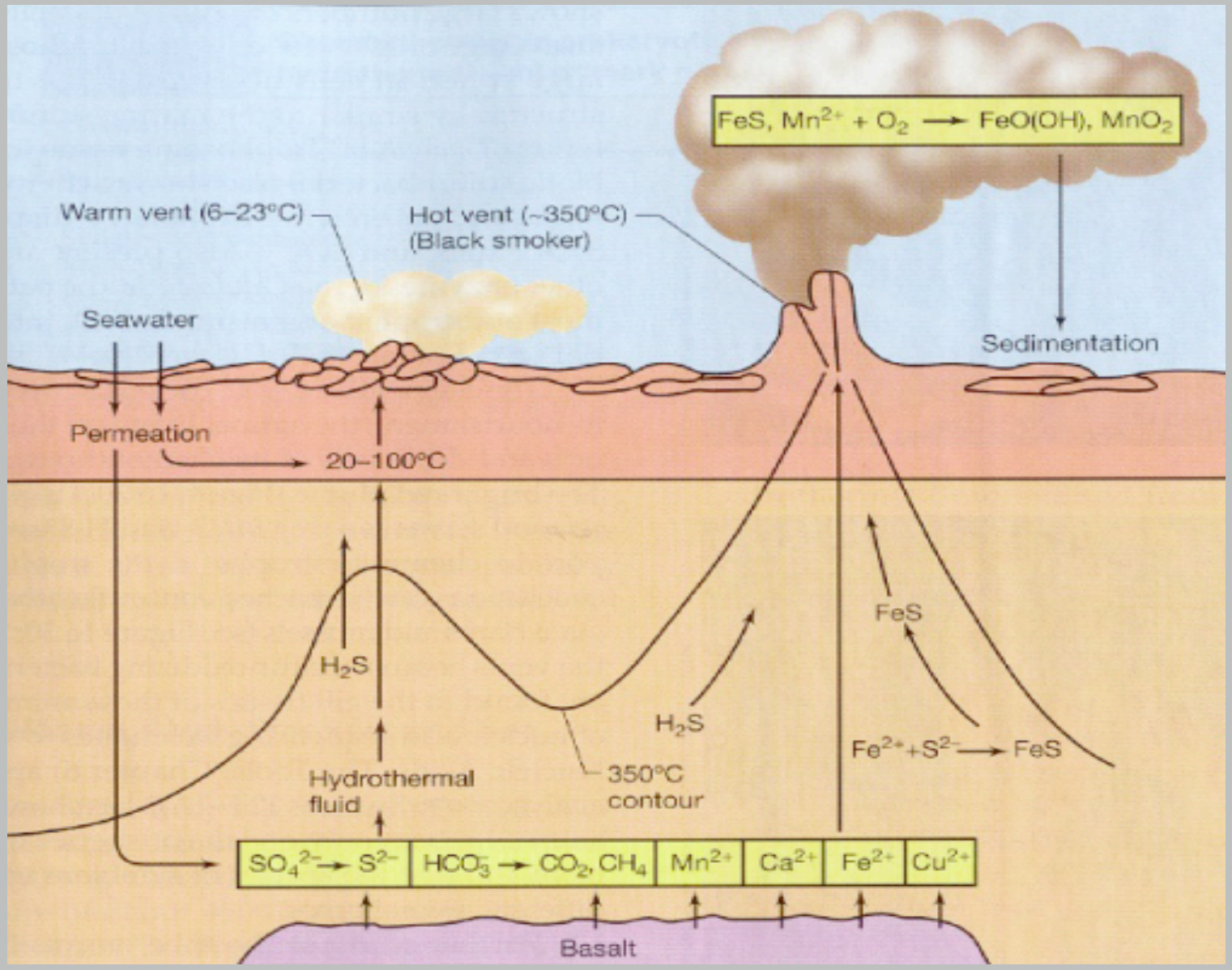
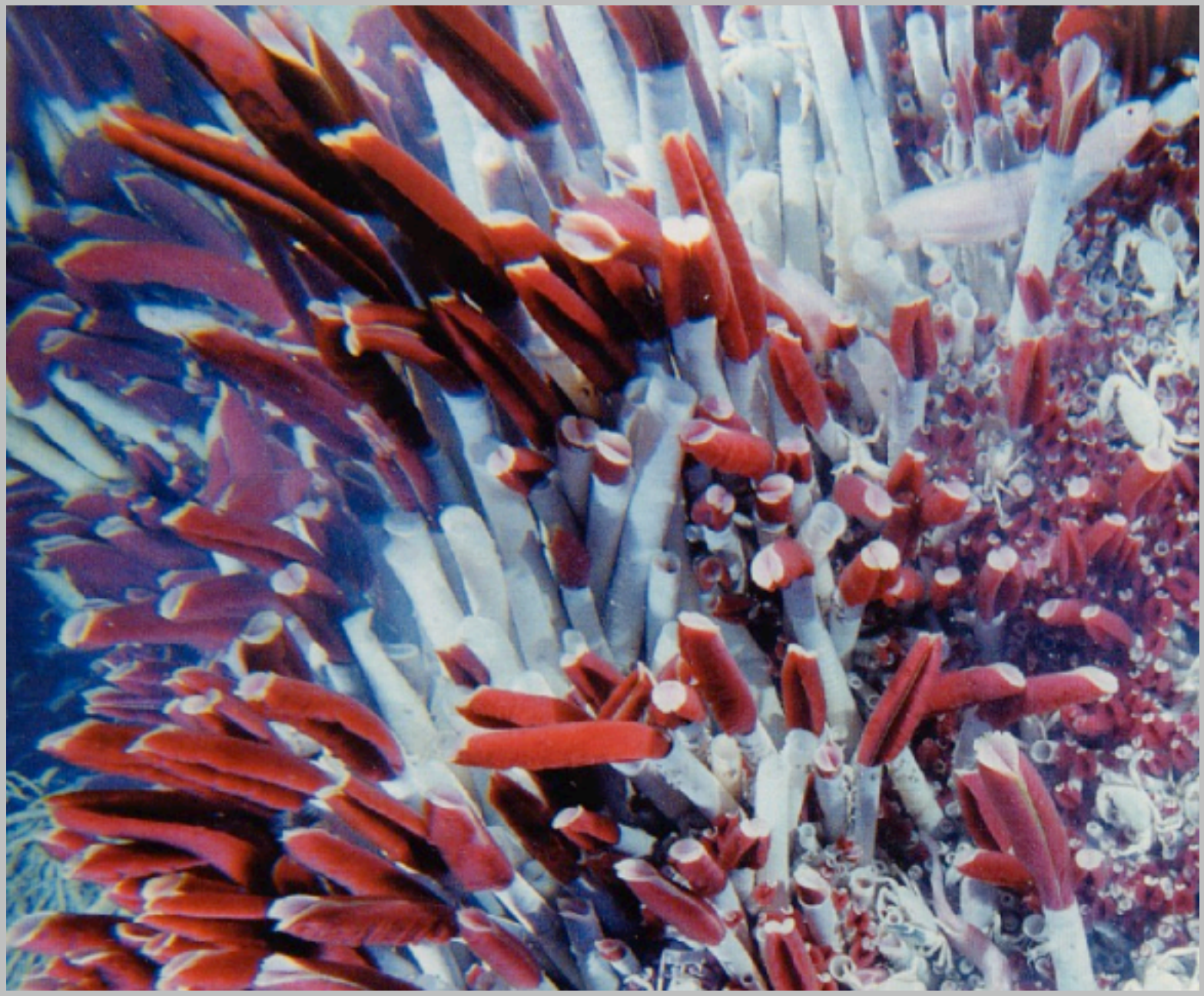


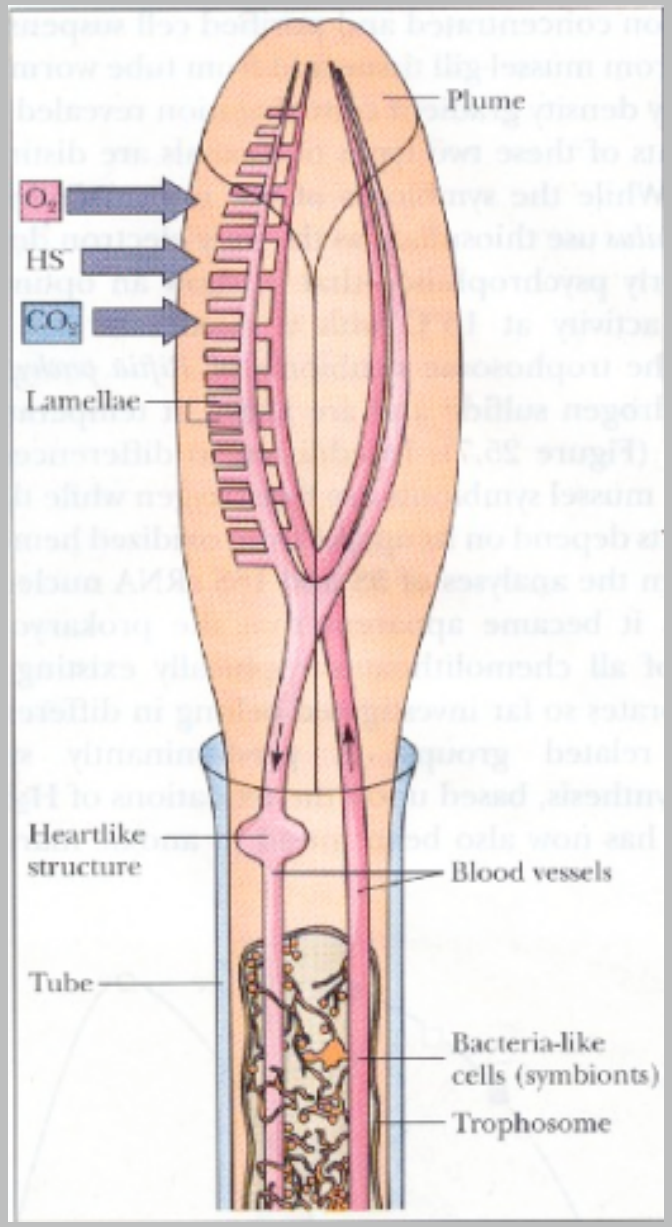
Fig. 28.21


Hydrothermal Vent Communities

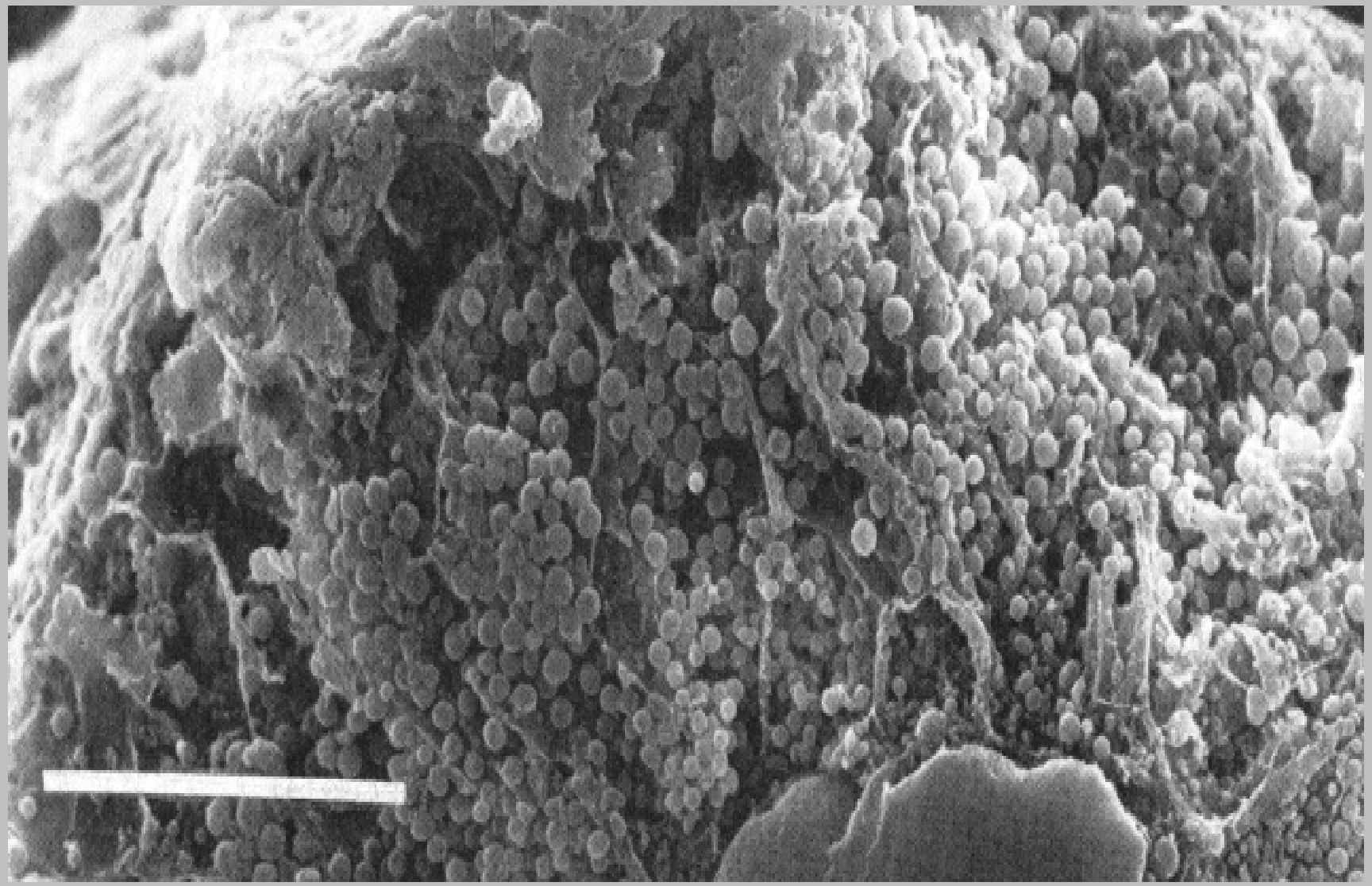

a
b
c
d
e
f
g
h
i
j
k
l
m
80°
70
60
50
40
30
20
10
0°
10
20
30
40
50
60°
90°E 110 130 150 170 170 150 130 110 90°W 70 50 30 10 10 30 50 70 90°E


FeS, Mn^{2+} + O_2 → FeO(OH), MnO_2
Warm vent (6–23°C)
Hot vent (~350°C)
(Black smoker)
Seawater
Sedimentation
Permeation
20–100°C
FeS
H_2S
H_2S
Fe^{2+}+S^{2-} → FeS
Hydrothermal
fluid
350°C
contour
SO_4^{2-} → S^{2-}
HCO_3^- → CO_2, CH_4
Mn^{2+}
Ca^{2+}
Fe^{2+}
Cu^{2+}
Basalt

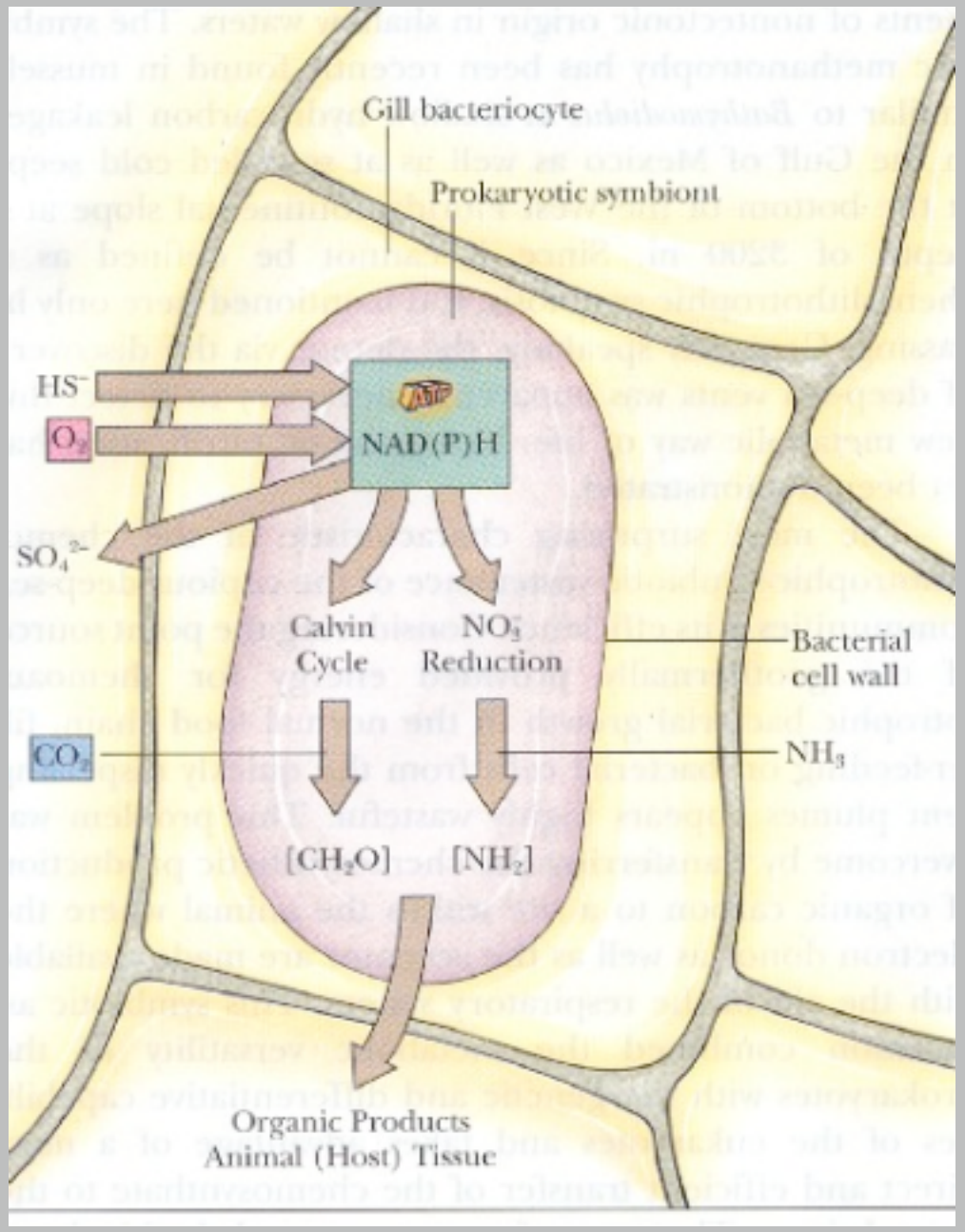




Riftia pachiptila anatomy



Riftia's endosymbiont physiology



Chemical Gradients in Nature

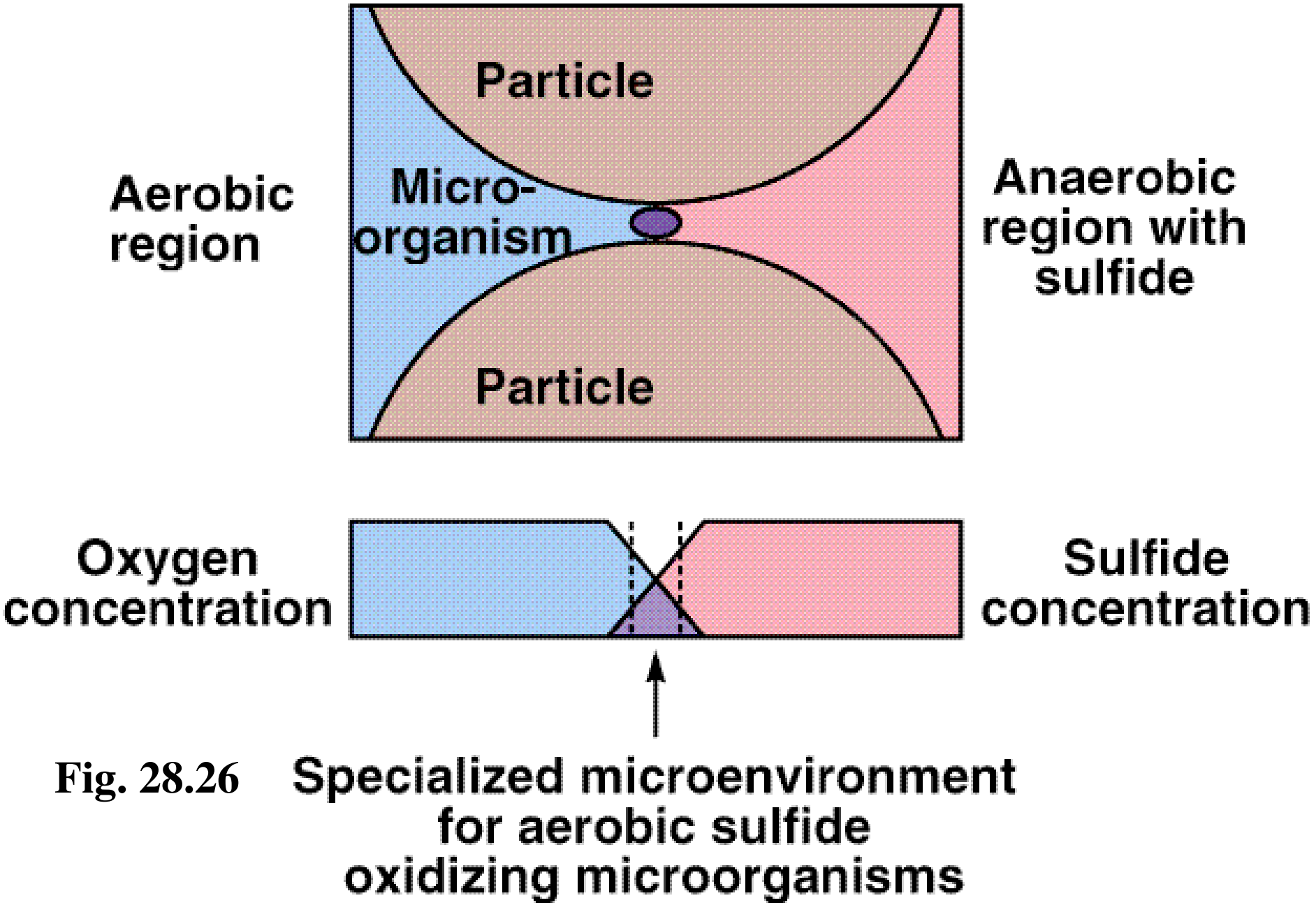
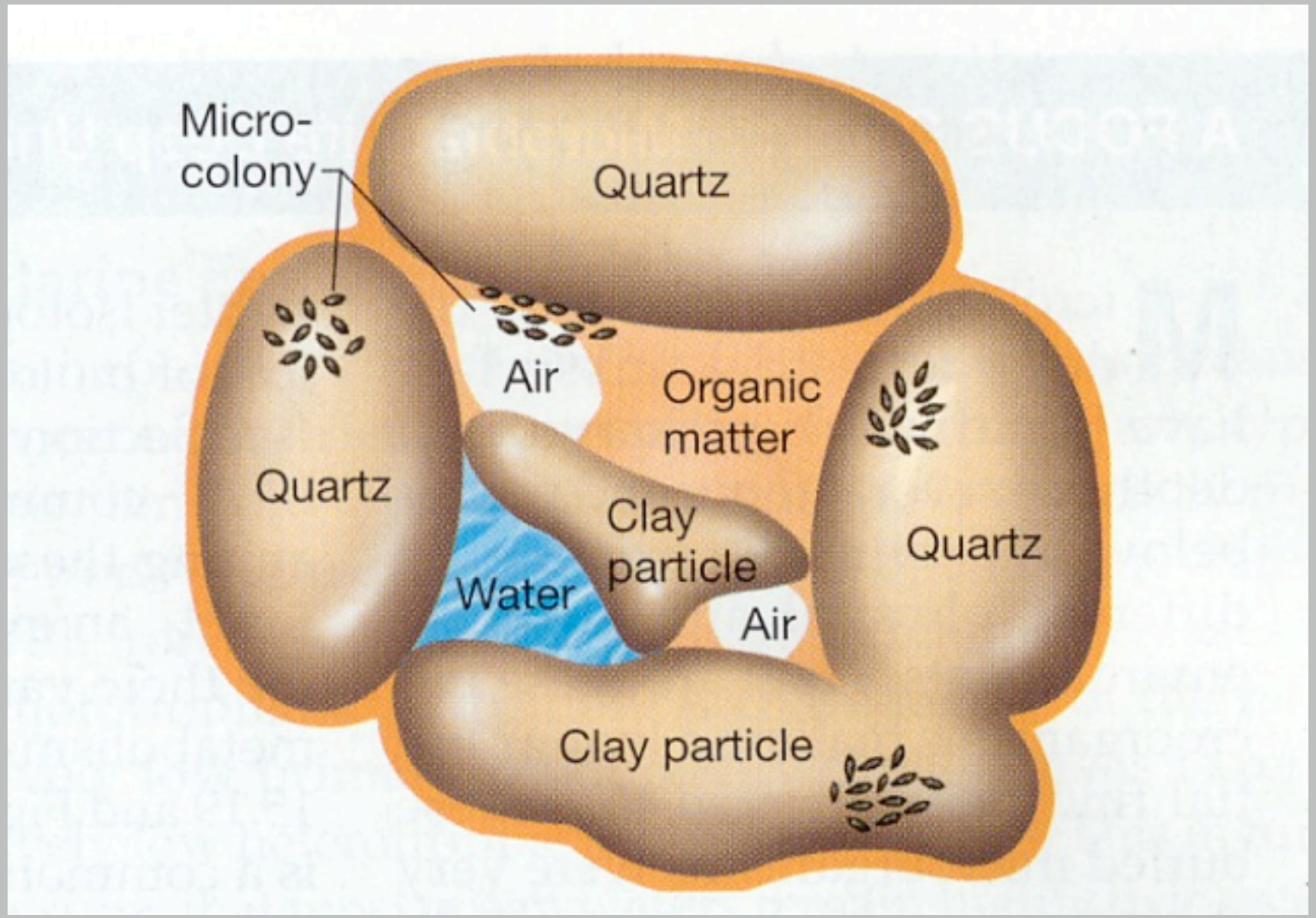
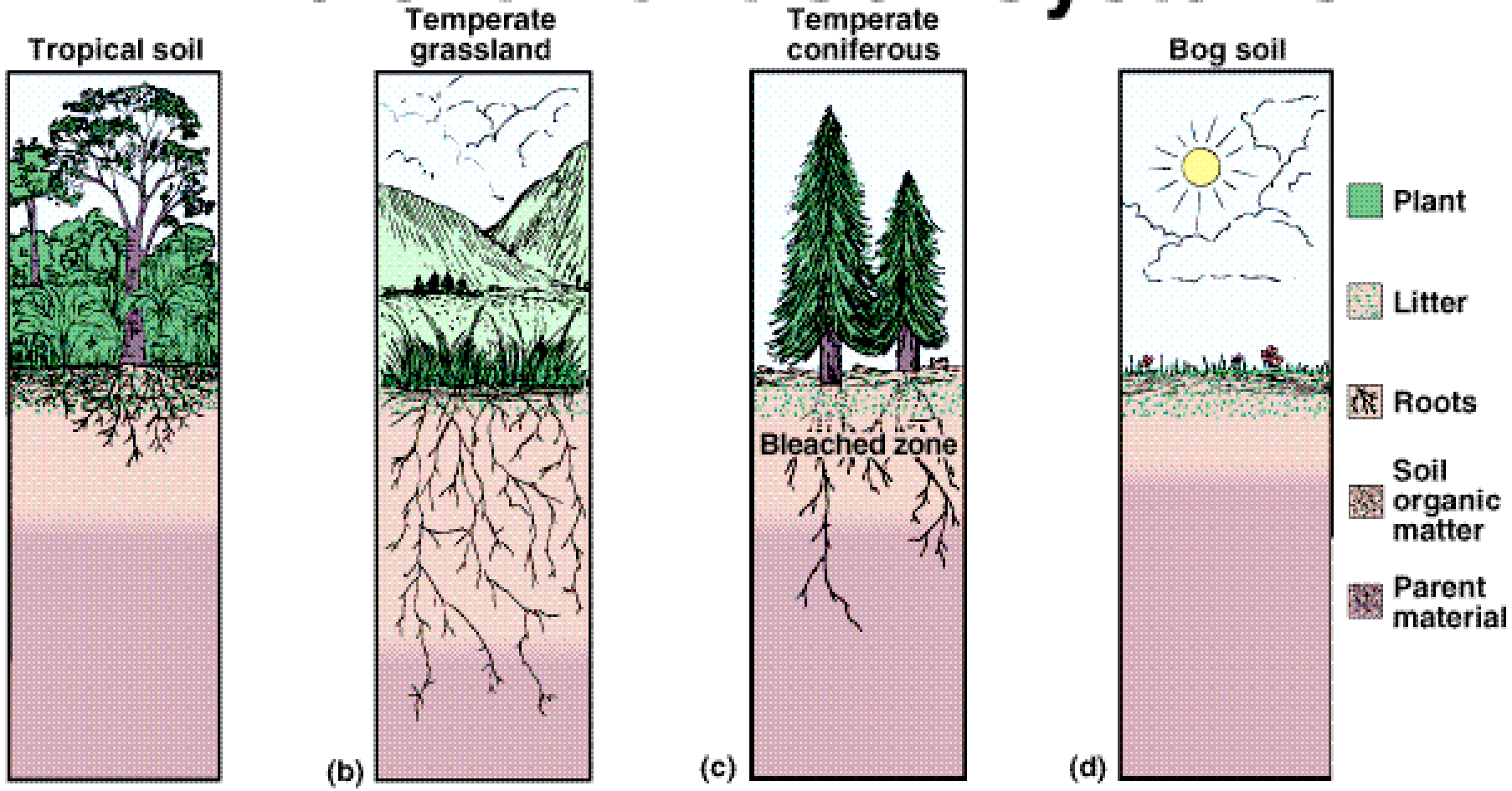


Fig. 28.26


Micro-
colony
Quartz
Air
Organic
matter
Quartz
Clay
particle
Quartz
Water
Air
Clay particle

Different Plant-Soil Systems



(a) Rapid litter decomposition

Low organic matter soil

Roots penetrate into the litter layer to absorb nutrients, which minimizes losses by leaching

(b) Litter can accumulate on surface

Deep root penetration and organic matter accumulation

(c) Moist litter layer with lower oxygen levels

Acidic products accumulate and leach into the underlying soil, resulting in the formation of a bleached zone

(d) Litter accumulation due to lower soil oxygen levels and decreased degradation

Formation of peat

Fig. 30.4

The Nitrogen Cycle in Nature

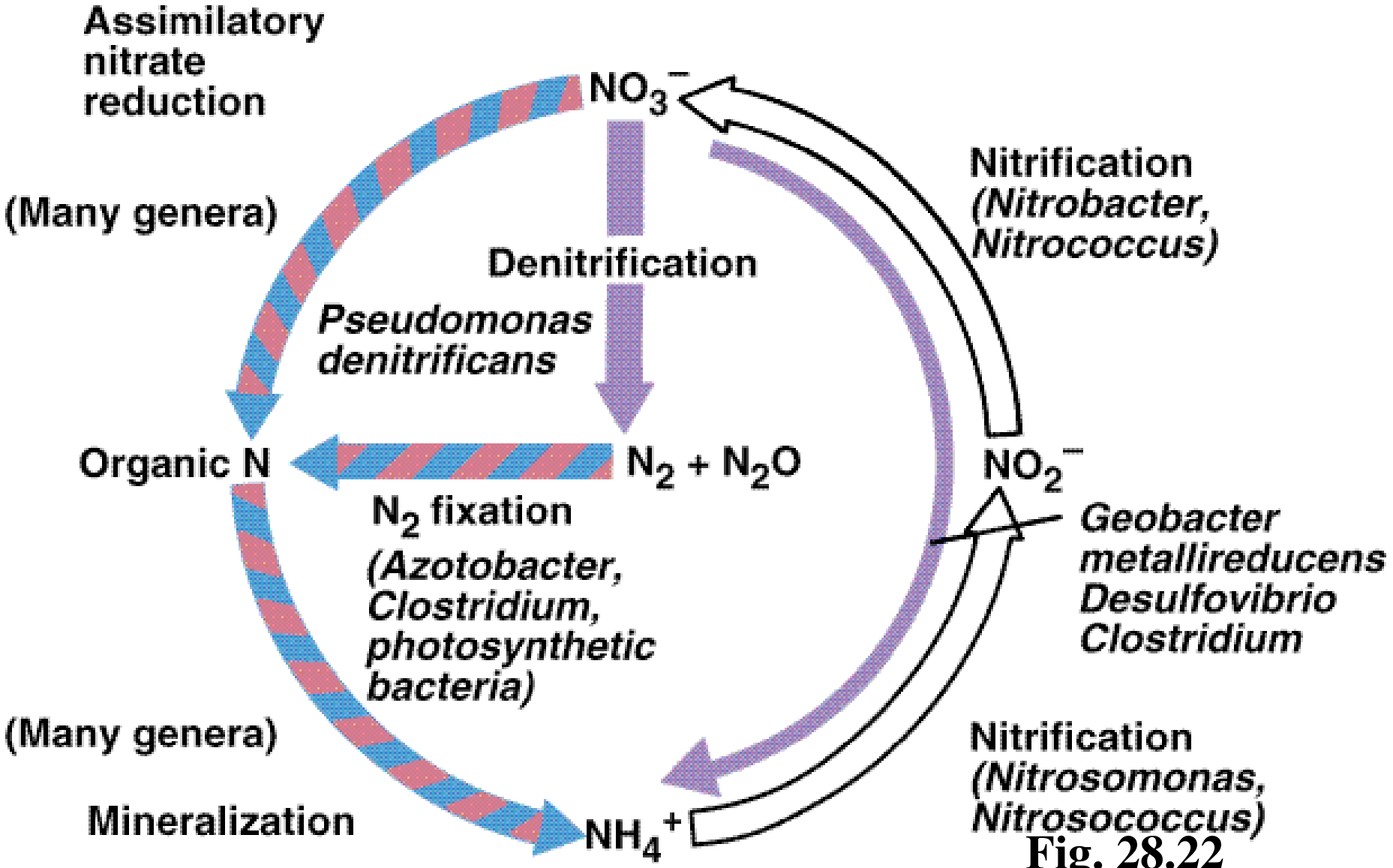


Fig. 28.22

Root Nodule Formation

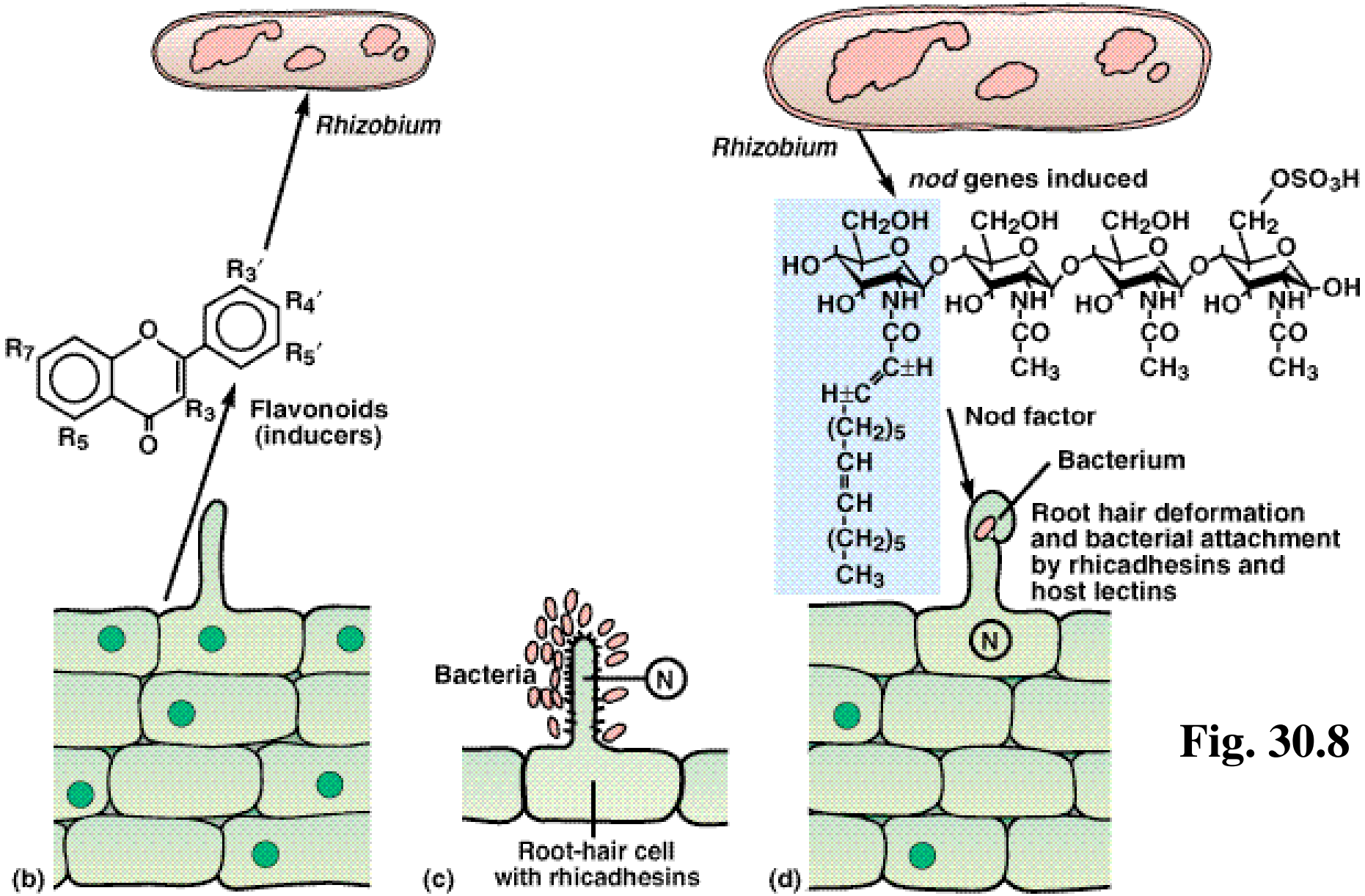


Fig. 30.8

Root Nodule Formation

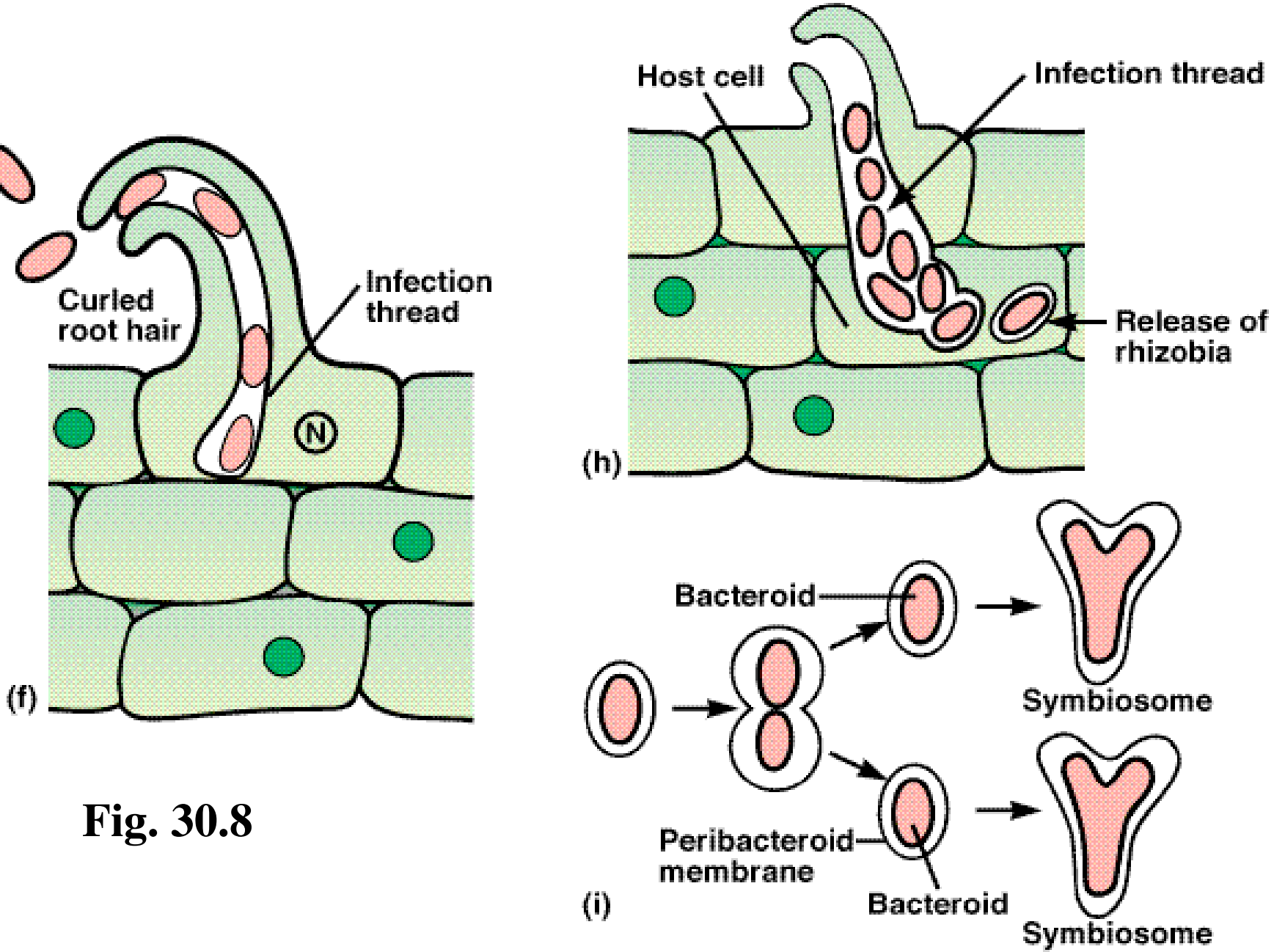


Fig. 30.8