Mutualism & other interactions

Molles ch 15, and
Townsend ch 7

Definitions

- Mutualism: Interactions between individuals of different species that benefit both partners.
  - Facultative (非必要的) Mutualism – a species can live without its mutualistic partner.
  - Obligate (必要的) Mutualism – a species is dependent on a mutualistic relationship.
    - *Margulis:* all eukaryotes originated as mutualistic associations.

How important is mutualism to the ecological integrity?

Imagine …

- Hummingbird & flower…
- Plant's mycorrihizae
- Deer & protozoans, bacteria in gut
- Microworld: evolution of eukaryote (ancient mutualism, mitochondria, chloroplasts)

Chapter Concepts

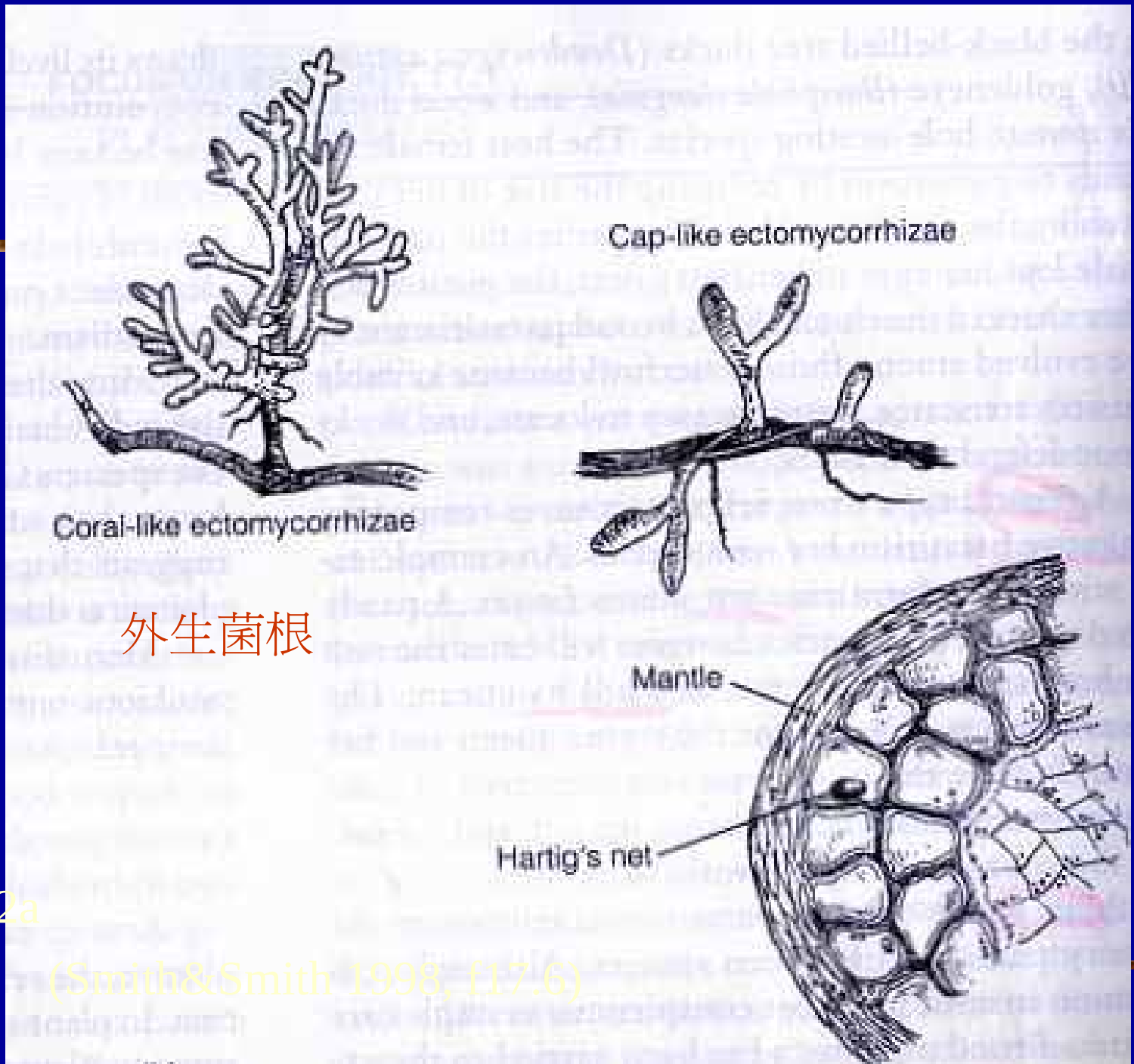
- Plants benefit from mutualistic partnerships with a wide variety of bacteria, fungi, and animals.

- Plants are the center of M relationships– (nutrient absorption, pollination, seed dispersal)

Plant Mutualisms

Plant performance & Mycorrhizal Fungi（菌根真菌）

- Two most common types of mycorrhizae:
  - Arbuscular mycorrhizal fungi (AMF)（叢狀菌根）
    - Produces arbuscules – site of exchange between plants and fungi.
  - Ectomycorrhizae (ECM)　（外生菌根）
    - Forms mantle around roots – important in increasing plant access to phosphorus and other immobile nutrients.

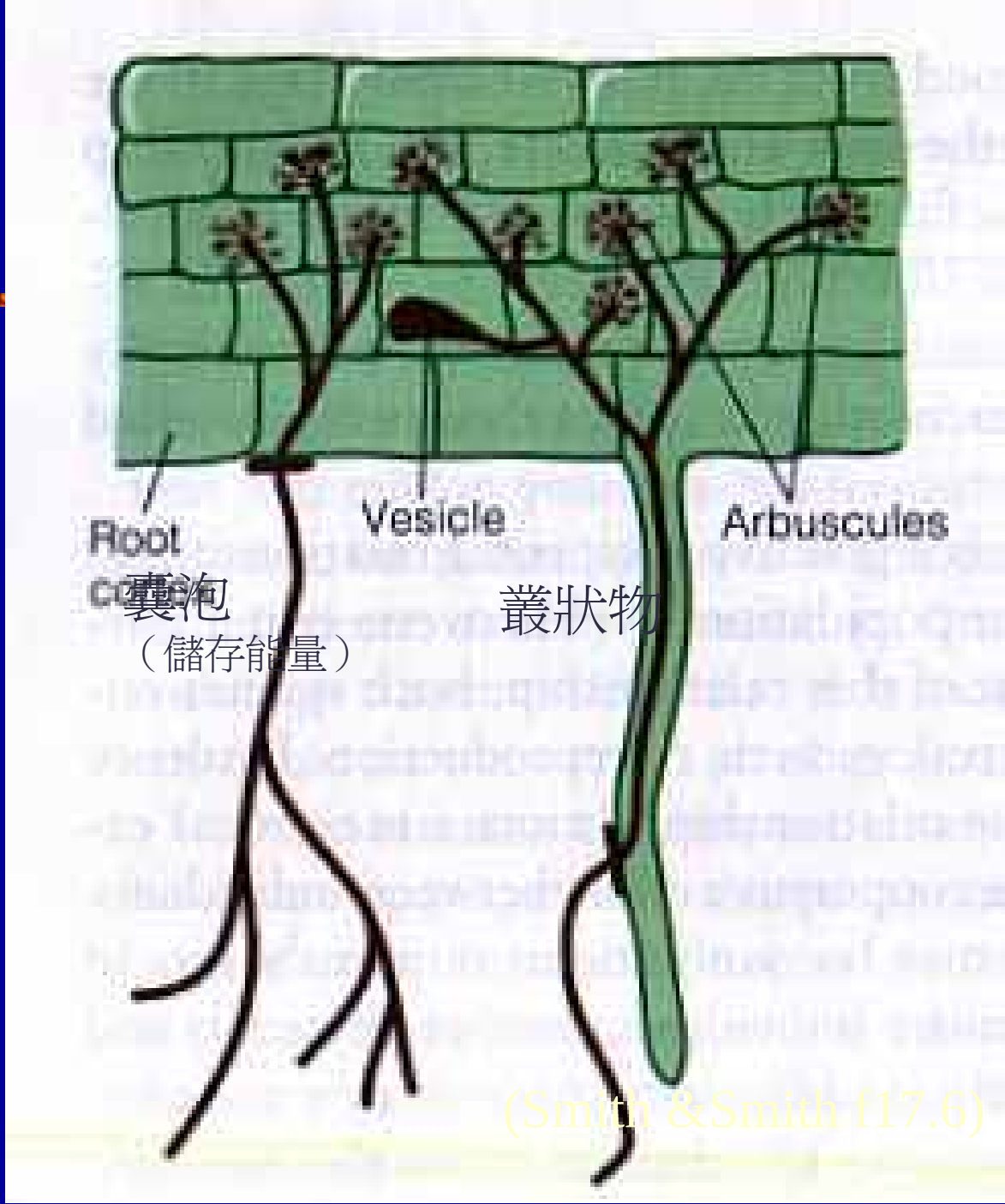


外生菌根

Fig 15.2a

(Smith&Smith 1998, f17.6)

叢狀菌根



Molles fig15.2b

(Smith &Smith f17.6)

Mycorrhizae & Plant Water Balance

- *Allen and Allen* studied water relations of grass *Agropyron smithii.*
  - Plants with mycorrhizae maintained higher leaf water potentials.
    - Plants with greater access to phosphorus may develop roots that are more efficient at extracting and conducting water.

Fungi influence on water transpiration

Hardie Exp:
Remove hyphae,
tracer dye
→Reduce transpiration rate
→Mycorrhizal hyphae
provide extra
contact surface for
absorption

Influence by Nutrient Availability? Balanced mutualism? (Mut→ Parasitism)

- Imbalanced benefits: (公平交易？)
  - Fungal partner received an equal or greater quantity of photosynthetic product in trade for low quantity of nutrients.
- In nutrient poor environments, many plants invest disproportionately in roots.
  - Found higher root investment in low N soils.

Can fertilization of soil select for less mutualistic mycorrhizal fungi?

- *Johnson's* exp

Nutrient Availability - Johnson

- Suggest: mycorrhizal fungi from unfertilized soils supplied plants with more nutrients.
  - Plants able to invest more energy in above-ground photosynthetic material (inflorenscences).

Ants and Bullshorn Acarcia

- Acarcia ants (*Pseudomyrmex* 假相思樹屬)
- Larger colony size, 12-hr activity outside of the nest, highly-aggressive defenders.
- Ant Benefits:
  - Thorns provide living space.
  - Folliar nectaries(蜜腺) provide sugar.
  - Beltian Bodies（貝氏體）source of oils and protein.

Plants offer nectar and Beltian bodies

Fig 15.7

Figure 7.7

Structures of the Bull's Horn acacia (*Acacia cornigera*) that attract its ant mutualist. (a) Protein-rich Beltian bodies at the tips of the leaflets. (b) Hollow thorns used by the ants as nesting sites. (Courtesy of L. E. Gilbert.)

Evidence For Mutualism

- *Ant needs plant, but do Acacias need ants?*
- *Janzen* Exp on plant performance:
  - Growth rate, fig 15.8
  - Mortality, fig 15.9
  - Herbivore insect loading, fig 15.10

Temperate Mutualism

- Potential conflict between mutualists?
  - Ex. Aspen sunflower produce extrafloral nectaries, ants (temperate plant protection)
  - Overlapped in time? Yes, in space?
  - Flowers restricted to older shoots, foliar nectar & Beltian body occur on new shoots
- Raine, Willmer & Stone exp: Repellent in the flowers,.. Fig 15.11, fig 15.12

Chapter Concepts

- Reef-building corals depend on mutualistic relationships with algae and animals.

Coral Mutualisms
Zooxanthallae and Corals

- Zooxzanthallae live within coral tissues.
  - Zooxzanthallae receive nutrient from coral.
  - coral receives organic compounds synthesized by zooxanthallae during photosynthesis.

Coral Mutualisms

- Corals' manipulations:
  - Control Z's release of organic compounds: by "signal compounds" that alter permeability of zooxanthallae cell membrane.
  - Control Z's population growth rate and density by influencing organic matter secretion. (1/10~1/100)
  - Imbalanced growth, secrete more carbohydrate, >90% carbohydrate used by coral
- Main zooxanthallae benefit is: Uptakes ammonium excreted by coral.

Coral Protection Mutualism

- *Glynn* found 13 coral spp. protected by crustacean mutualists.
  - crustacean mutualists substantially improved chances coral will avoid attack by sea stars. (decr predation rate)

Crustaceans: Pistol shrimp & crabs

Coral Protection Mutualism

- Also found crab activity promotes coral health and integrity.
  - *Pocillopora* coral increases production of fat bodies in the presence of crabs.
    - Digestive tract of crabs inhabiting corals contained large quantities of lipids.

Chapter Concepts

- Theory predicts mutualism will evolve where the benefits of mutualism exceed the costs.

Evolution of Mutualism

- Theory predicts mutualism will evolve where the benefits of mutualism exceed the costs.
  - Keeler developed models to represent relative costs and benefits of several types of mutualistic interactions.

- $W_m = pw_{ms} + qw_{mu}$
  - Successful mutualists
    - Give and receive benefits.
  - Unsuccessful mutualists
    - Give, but do not receive benefit
- W_{nm}, Non-mutualists
    - Neither give nor receive benefit.

Evolution of Mutualism

- For a population to be mutualistic, fitness of successful mutualists must be greater than unsuccessful or non-mutualists.
  - If not, natural selection will eventually eliminate the interaction.
- $W_m > W_{nm}$
- $pw_{ms} + qw_{mu} > W_{nm}$

- Selection coefficient, s= 1-w, w=1-s
- S = *f* (H, A, D, I) (P389, eq 4,5,6)代入
  - H: proportion damaged by herbivory
  - A: ant protection
  - D: other defense
  - I: plant investment toward Ants

Facultative Ant-Plant Mutualisms

- *Keeler* proposed for a facultative ant-plant mutualism to evolve and persist,
- $p\,[\,H\,(1\text{-}D)A\,] > I_A$
- proportion of plant's energy budget ants save from destruction by herbivores must exceed proportion of the plant's energy budget invested in extrafloral nectaries and nectar.

  i.e. Benefit > cost

Facultative Ant-Plant Mutualisms

- $p\,[\,H\,(1\text{-}D)A\,] > I_A$

Conditions that may produce this mutualism?

- Low proportion of plant's energy budget invested in extrafloral nectaries.(low I_A)
- High probability of attracting ants. (high *p*)
- High potential for herbivory. (high H)
- Low effectiveness of alternate defenses.(low D)
- Highly effective ant defense.(high A)

Chapter Concepts

- Applicatons:
- Mutualism & Humans
  - Greater honeyguide birds, *Indicator indicator*
  - 15/17 sp native to Africa, feed on waxes
  - Tropical savanna & dry forest
  - Brood parasite, (nestling with bill hooks)
  - Guiding behavior

- Guiding behavior
- First written report, Dos Santos, 1569
- East Africa, Mozambique
- Scientifically examination, 1955, Friedmann
- Proverbs.. → long association history
- Could originated from honey badger, Human vocalizations imitate the calls of honey badgers
- Fig 15.23

- Isak & Reyer, Boran people, Kenya
- Investigated the communication model
- People use penetrating whistle to attract birds
- How birds attract people? (leading-following chain behavior)
- How to give instructions on direction & distance?

- When arrive the destination,
  - Bird emits a distinctive guiding call (incr freq)
- When arrive bee nest,
  - bird give a few special “indication” calls, perch & remain silent

Supplement

Types of interactions	Respns of sp. A	Respns of sp. B
Competition	-	-
Amensalism	-	0
Neutralism	0	0
Mutualism	+	+
Commensalism	+	0
Parasitism	+	-
Parasitoidism	+	-
Predation	+	-
Herbivory	+	-

Consumer-Resource (+, -) =Exploitation

Predation
Parasitism
Parasitoidism
Herbivory

Mutualism (+,+)

- Nonsymbiotic:
  - Mycorrhizae
  - Pollination
  - Cleaning reef fish
  - Dispersal (squirrel& nuts)
- Symbiotic:
  - lichens, algae& coral,
  - fermentation bacteria

Compare:parasites *vs.* mutualists

- No. of species, P >> M
- Life cycles, M is simpler,

  not require host alternation
- Parasites are dominant by dispersal
- M almost complete suppression of sex

  no battle btw Mutualist and Host

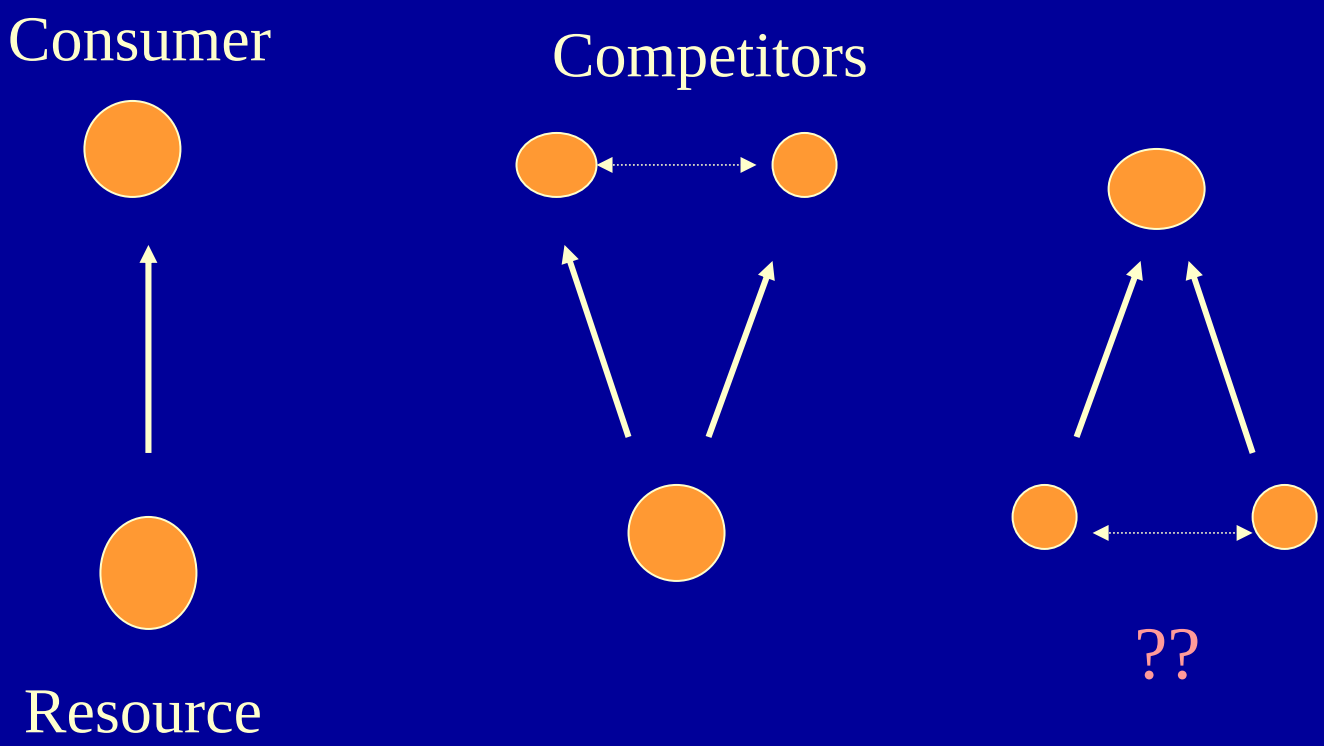
Commensalism (+, 0)

- Ex. Detritivore-detritus

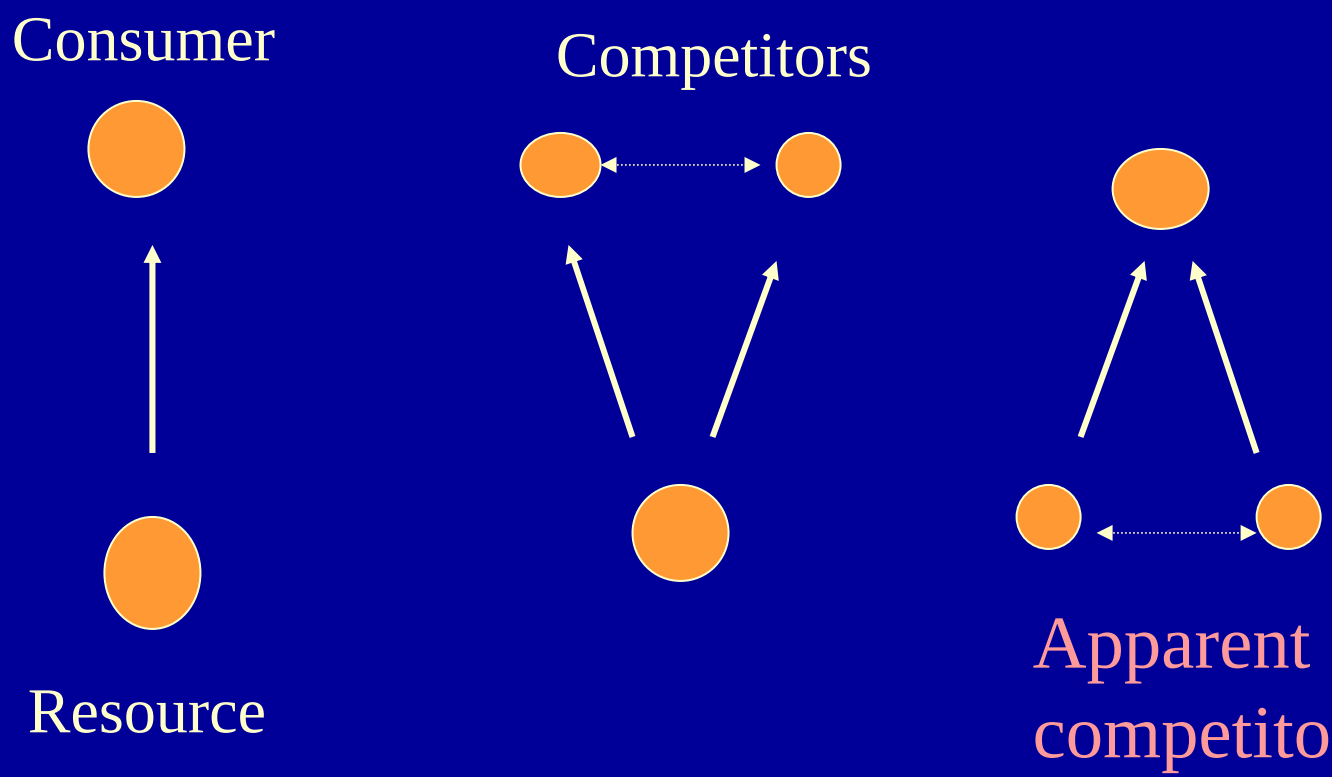
Alleopathy (-, 0) 相剋作用

- *Allelo*-: other individuals
- *-Pathy*: injury
- Causing injury to other individuals by chemical released by residents
- Important in Agriculture
- One type of Amensalism

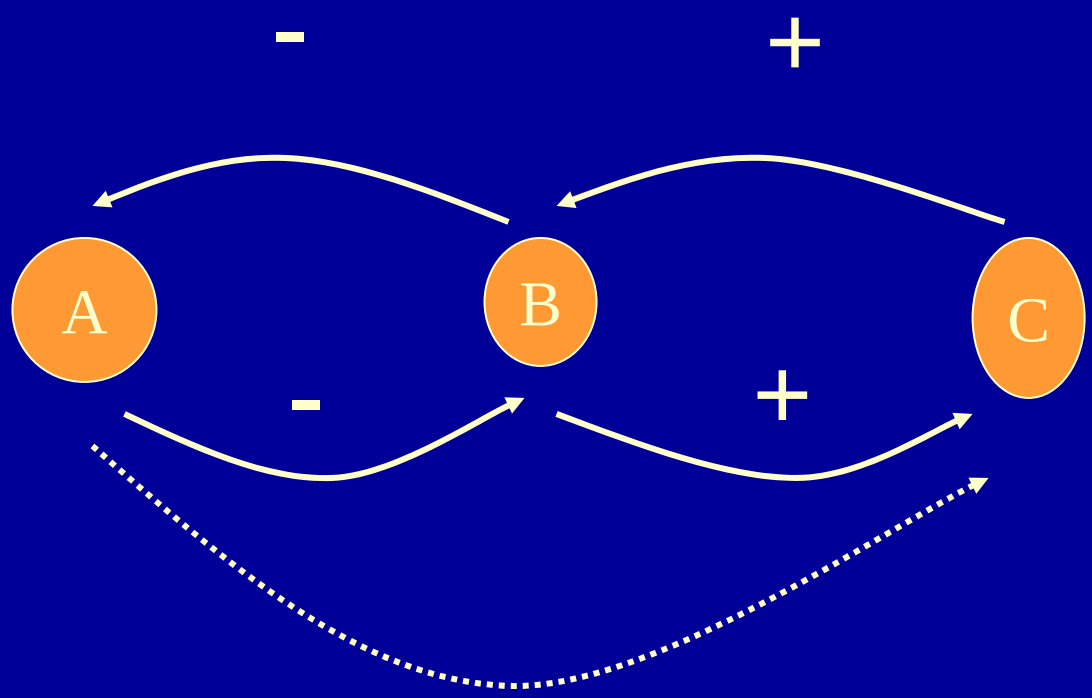
Indirect interaction-- Apparent competition



Indirect interaction-- Apparent competition



Indirect interaction– (at the same trophic level)



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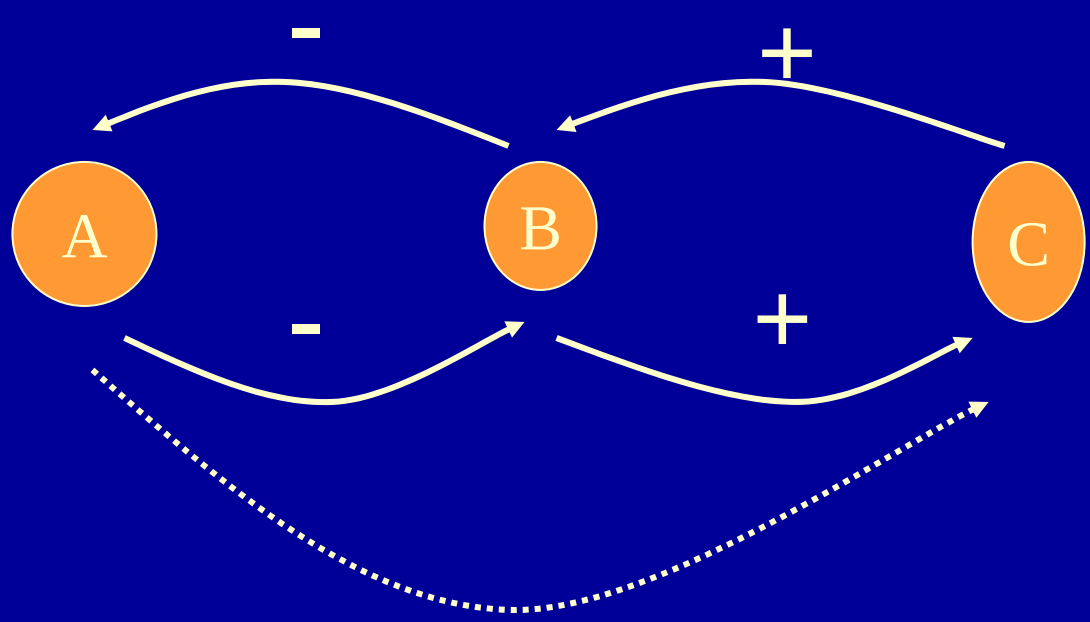
Indirect interaction–

At the same trophic level



Apparent competition

E N D !