CH 14: The origin of species

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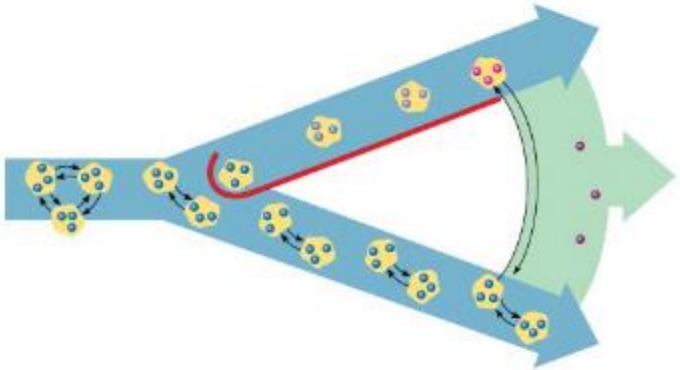
Figure 14.0-2

Chapter 14: Big Ideas

Defining Species

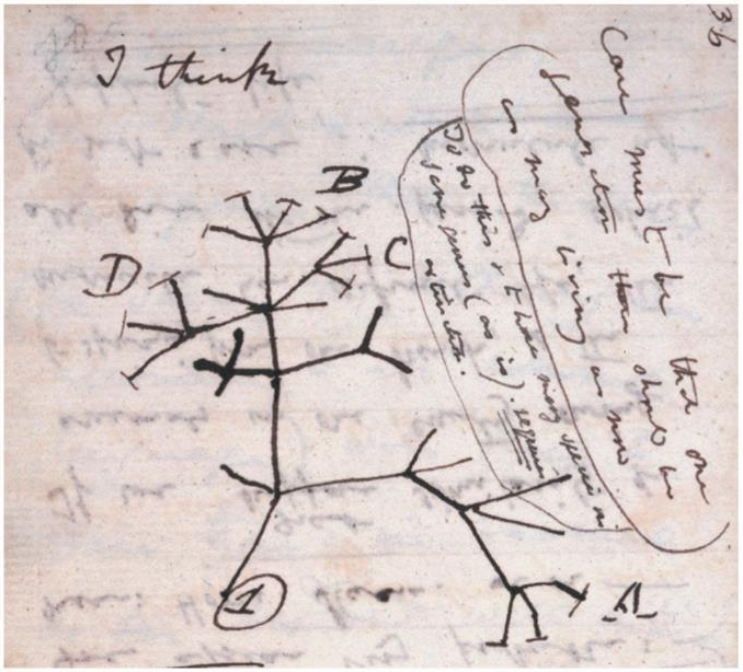


Mechanisms of Speciation

DEFINING SPECIES

14.1 The origin of species is the source of biological diversity

- **Speciation** is the process by which one species splits into two or more species.
- Each time speciation occurs, the diversity of life increases.



14.2 There are several ways to define a species

- How do you define a species?
- Phenotypic similarity?

https://www.youtube.com/watch?v=RzNAKtyKz2Q
https://www.youtube.com/watch?v=Sv2u39NDmZA
https://www.youtube.com/watch?v=Sk4S2spFdcs

Figure 14.2b

Variation within the same species

14.2 There are several ways to define a species

- **Biological species concept:** a group of populations whose members have the potential to interbreed in nature and produce fertile offspring (offspring that themselves can reproduce).
- Reproductively compatible

Is this the most widely used?

14.2 There are several ways to define a species

- **Reproductive isolation**
  - prevents genetic exchange (gene flow) and
  - maintains a boundary between species.
- But there are some pairs of clearly distinct species that do occasionally interbreed.
  - The resulting offspring are called **hybrids**.
  - Grizzly bear (*Ursus arctos*)
  - Polar bear (*Ursus maritimus*)”

Figure 14.2c-0

Grizzly bear

Polar bear

Hybrid “grolar” bear

14.2 There are several ways to define a species

- Problems of biological species concept
  - Fossil
  - Asexual organism
  - Self-fertilization
  - Need alternative species concepts
  - There are A LOT of other species concepts

14.2 There are several ways to define a species

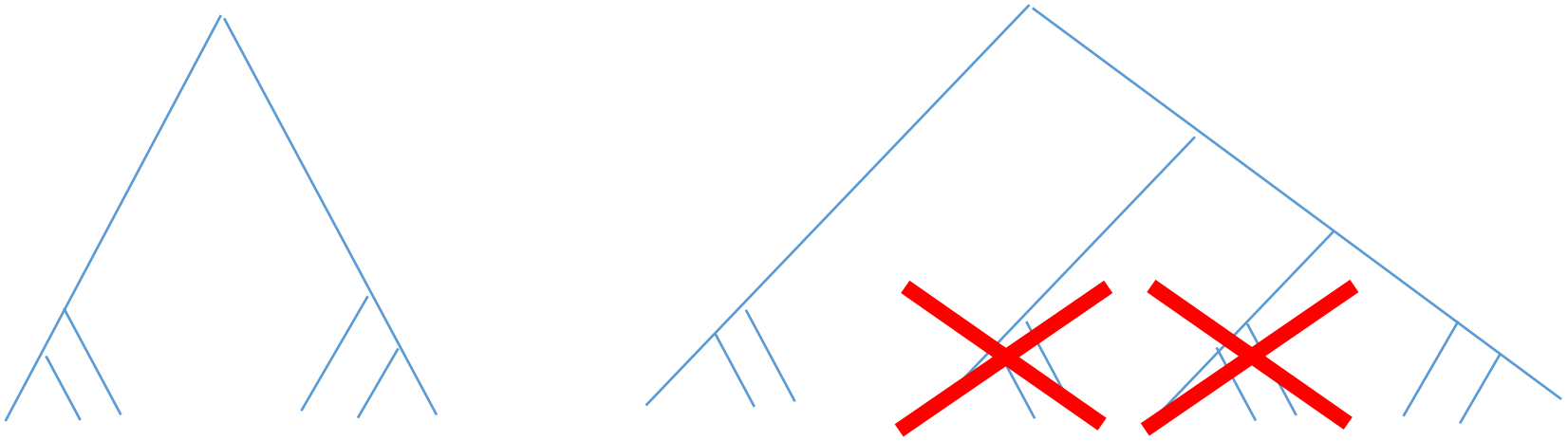
- The **morphological species concept**
  - classifies organisms based on observable physical traits and
  - can be applied to asexual organisms and fossils.
- However, there is some subjectivity in deciding which traits to use.
- Shape of reproductive organ

14.2 There are several ways to define a species

- The **ecological species concept**
  - defines a species by its ecological niche and
  - focuses on unique adaptations to particular roles in a biological community.
- For example, two species may be similar in appearance but distinguishable based on what they eat or the depth of water in which they are usually found.
- Yeah? How can they look exactly the same if they have very different ecology?
- Why is it not within-species variation?

14.2 There are several ways to define a species

- The **phylogenetic species concept**
  - defines a species as the smallest group of individuals that share a common ancestor and thus form one branch of the tree of life.
  - How much isolation is needed?



14.3 VISUALIZING THE CONCEPT: Reproductive barriers keep species separate

- Reproductive isolation: barriers to reproduction
  - isolate the gene pools of species
  - prevent interbreeding.
- Depending on whether they function *before* or *after* zygotes form, reproductive barriers are categorized as
  - **prezygotic** or
  - **postzygotic**.

Figure 14.3-0

PREZYGOTIC BARRIERS

Habitat isolation
(different habitats)

Temporal isolation
(breeding at different times)

Behavioral isolation
(different courtship rituals)

Mechanical isolation
(incompatible reproductive parts)

Gametic isolation
(incompatible gametes)

POSTZYGOTIC BARRIERS

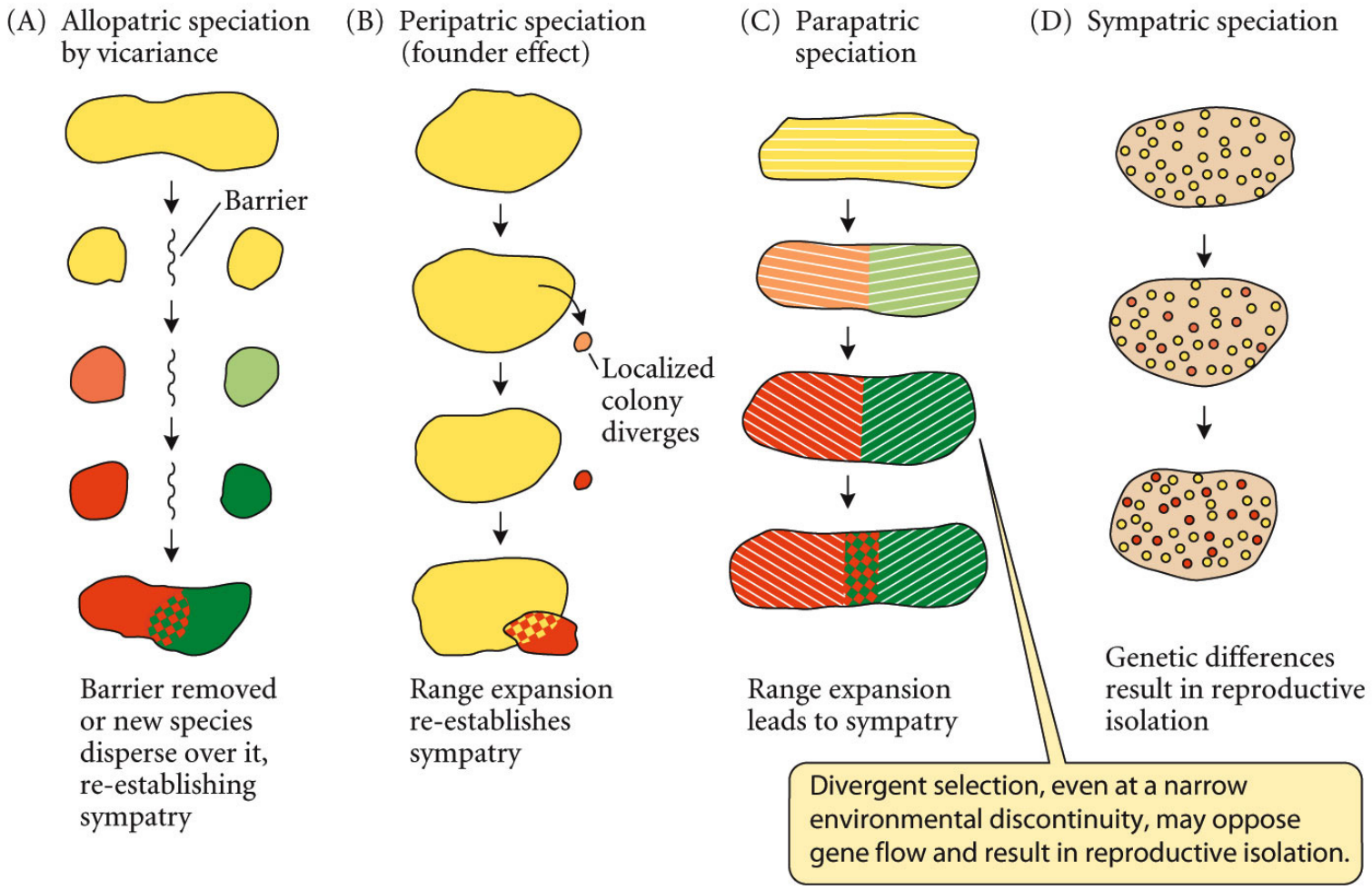
Reduced hybrid vitality
(short-lived hybrids)

Reduced hybrid fertility
(sterile hybrids)

Hybrid breakdown
(fertile hybrids with sterile offspring)

Mechanisms of Speciation

Speciation: Geographic isolation or not



***EVOLUTION 2e*, Figure 18.1**

14.4 In allopatric speciation, geographic isolation leads to speciation

- **Allopatric speciation:** speciation event caused by spatial barrier
- Related: The Wallace Line

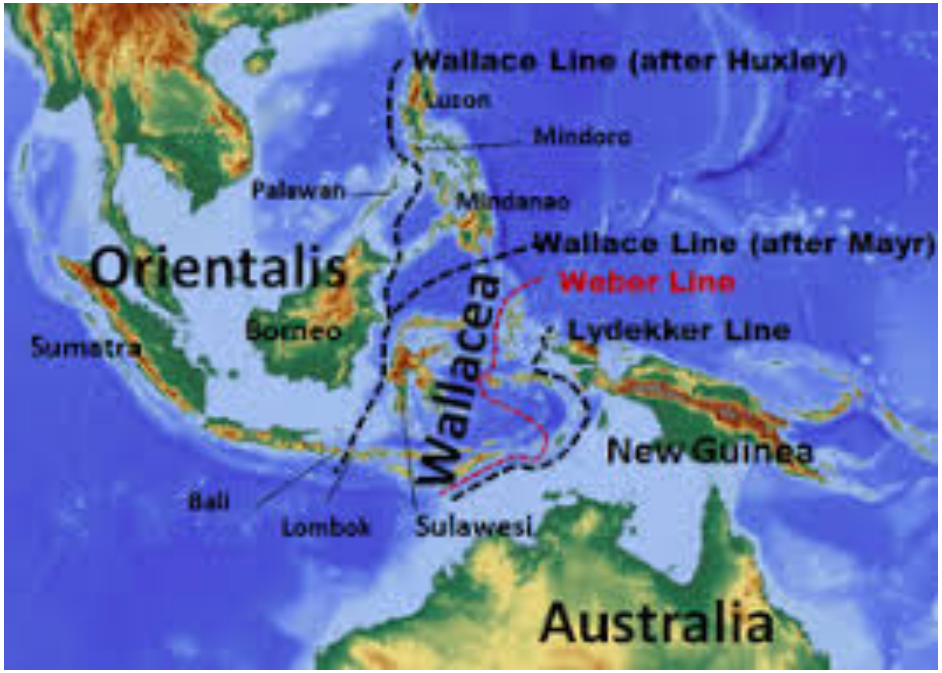
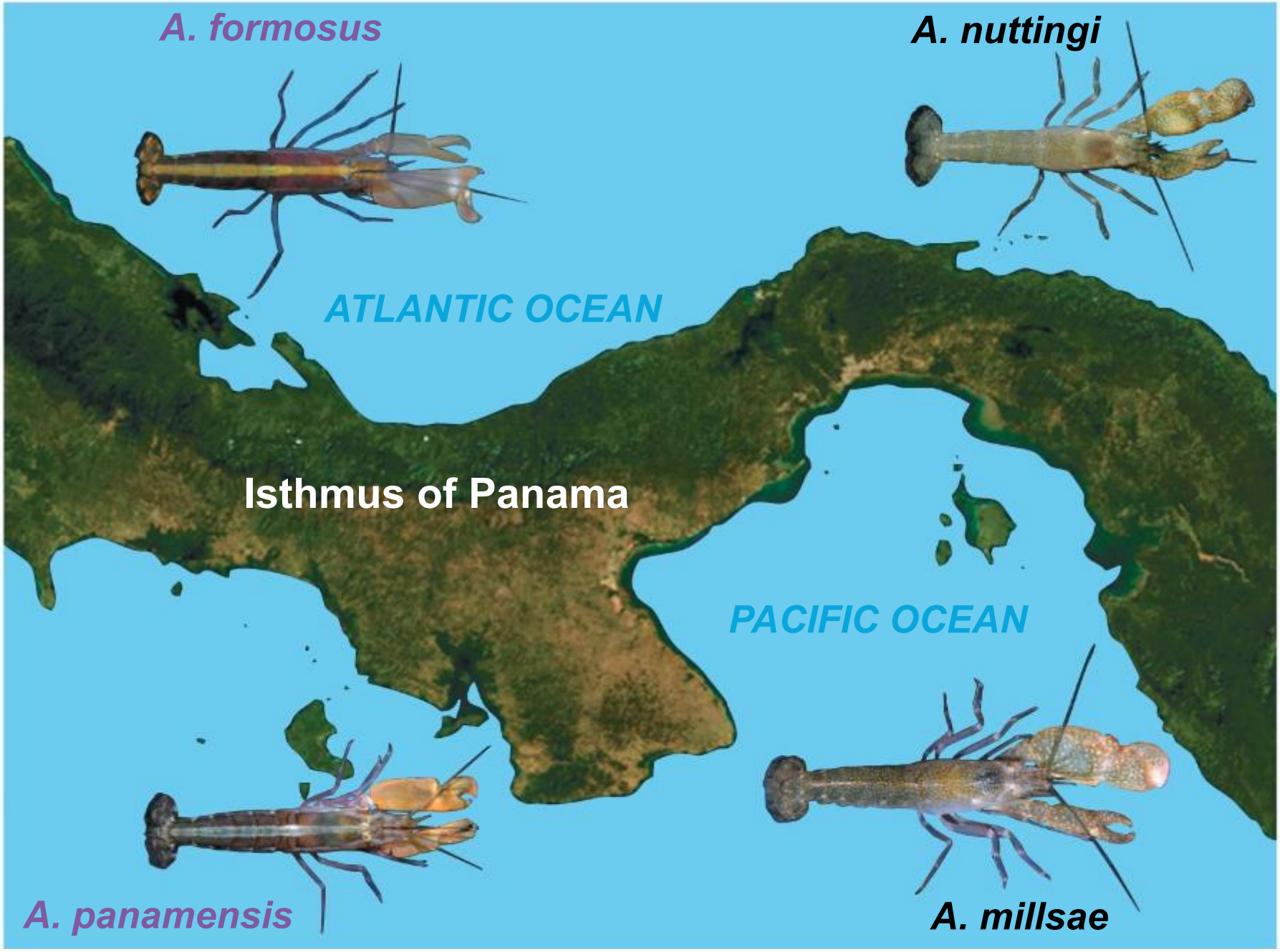


Figure 14.4a-0

14.4 In allopatric speciation, geographic isolation leads to speciation

- Thirty species of snapping shrimp in the genus *Alpheus* live off the Isthmus of Panama, the land bridge that connects South and North America.
  - Morphological and genetic data group these shrimp into 15 pairs of species, with the members of each pair being each other's closest relative.
  - In each case, one member of the pair lives on the Atlantic side of the isthmus, while the other lives on the Pacific side.
  - This strongly suggests that geographic separation of the ancestral species of these snapping shrimp led to allopatric speciation.

Figure 14.4b



14.5 Reproductive barriers can evolve as populations diverge

- Other types of reproductive barriers
- The environment of an isolated population may include
  - different food sources,
  - different types of pollinators, and
  - different predators.

Figure 14.5b-0

Pollinator choice in typical monkey flowers

Typical *M. lewisii* (pink)

Typical *M. cardinalis* (red)

Pollinator choice after color allele transfer

M. lewisii with red-color allele

M. cardinalis with pink-color allele

14.6 Sympatric speciation takes place without geographic isolation

- **Sympatric speciation** occurs when a new species arises within the same geographic area as its parent species.
- This is very rare

14.6 Sympatric speciation takes place without geographic isolation

- In some plants: polyploid
- New species formed in this way are **polyploid**, in that their cells have more than two complete sets of chromosomes.
- Sympatric speciation can result from polyploidy
  - within a species (by self-fertilization) or
  - between two species (by hybridization).

Figure 14.6a-3

Within a species (auto-polyploid)

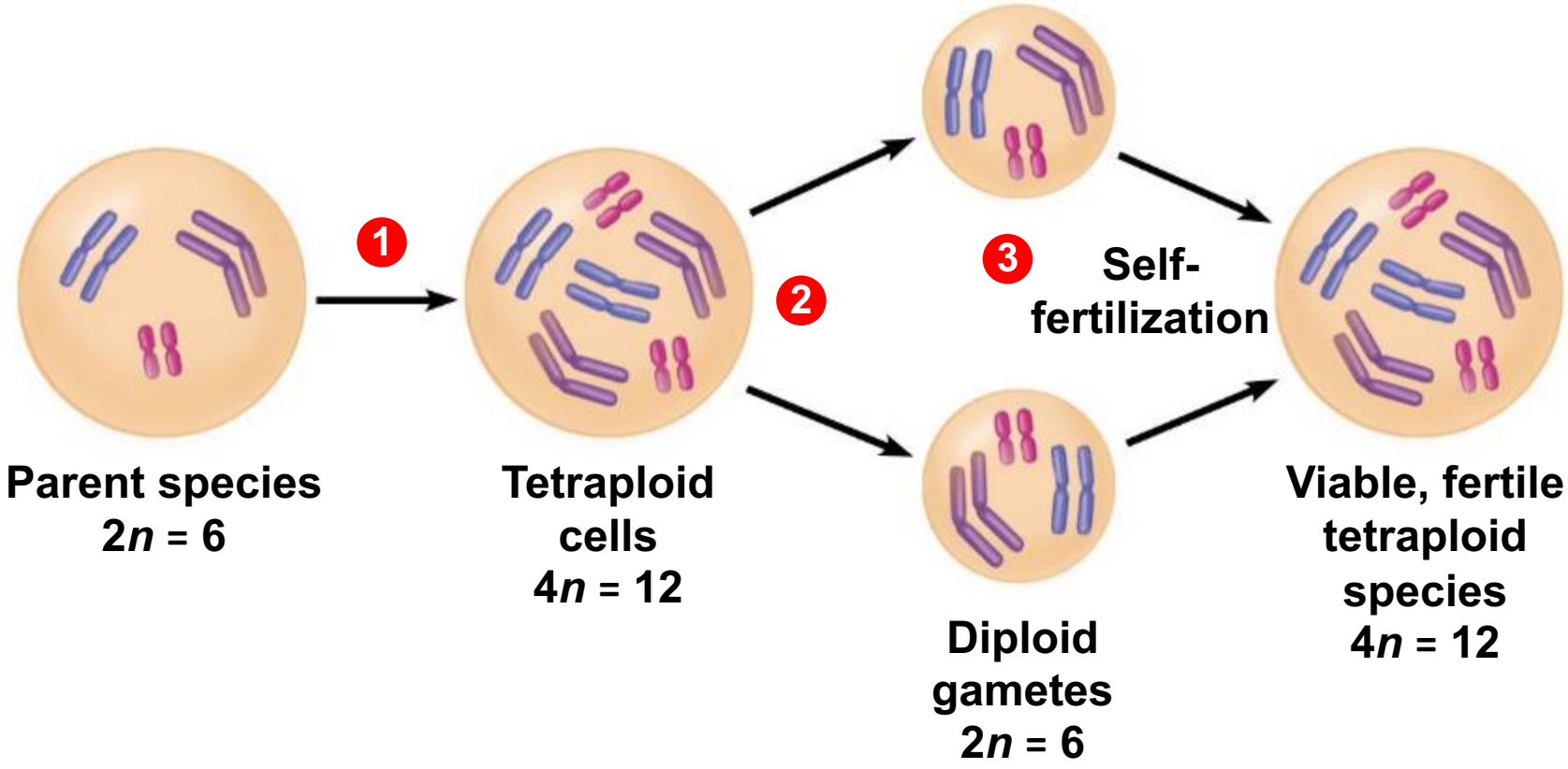
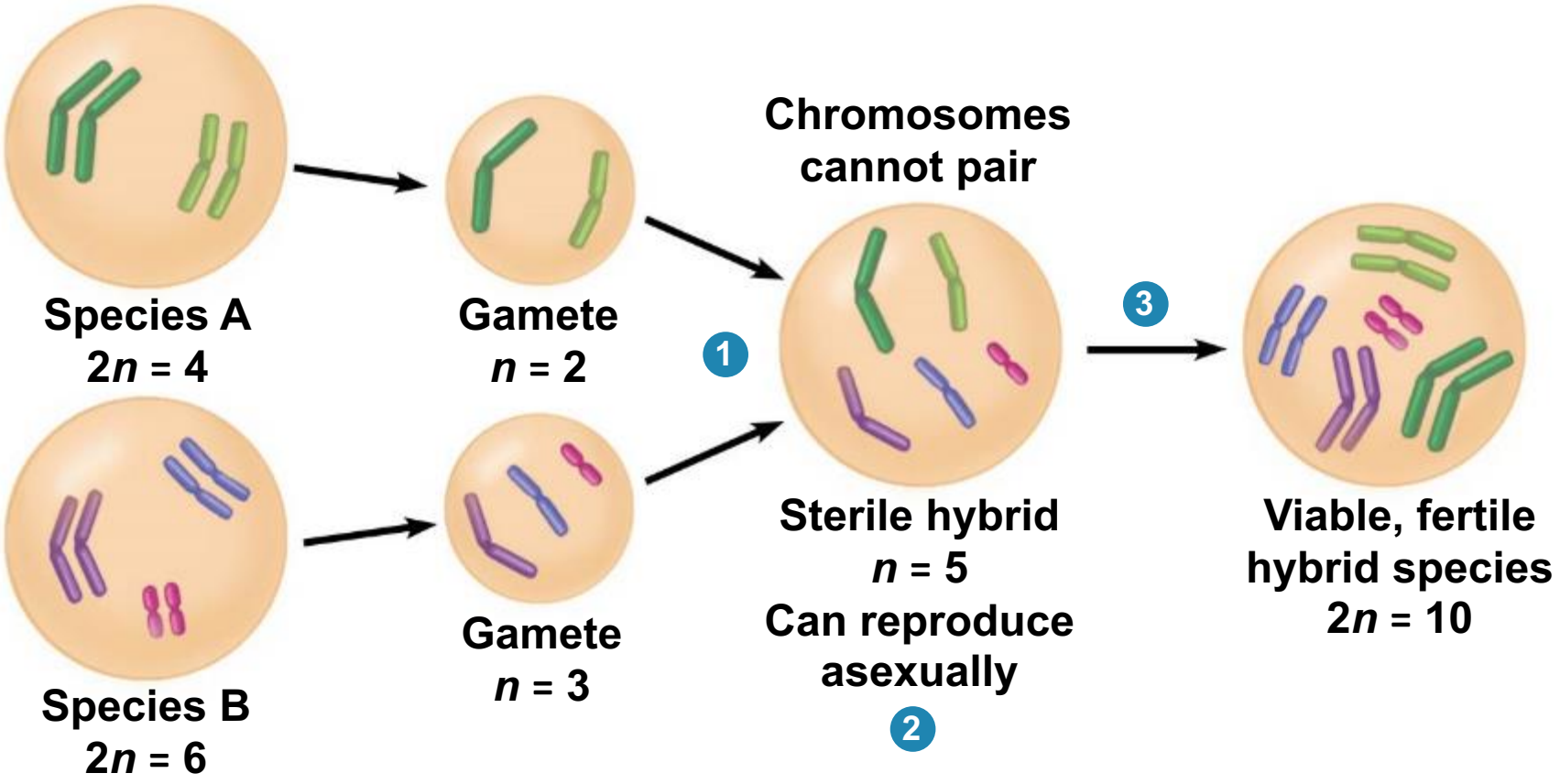


Figure 14.6b-3

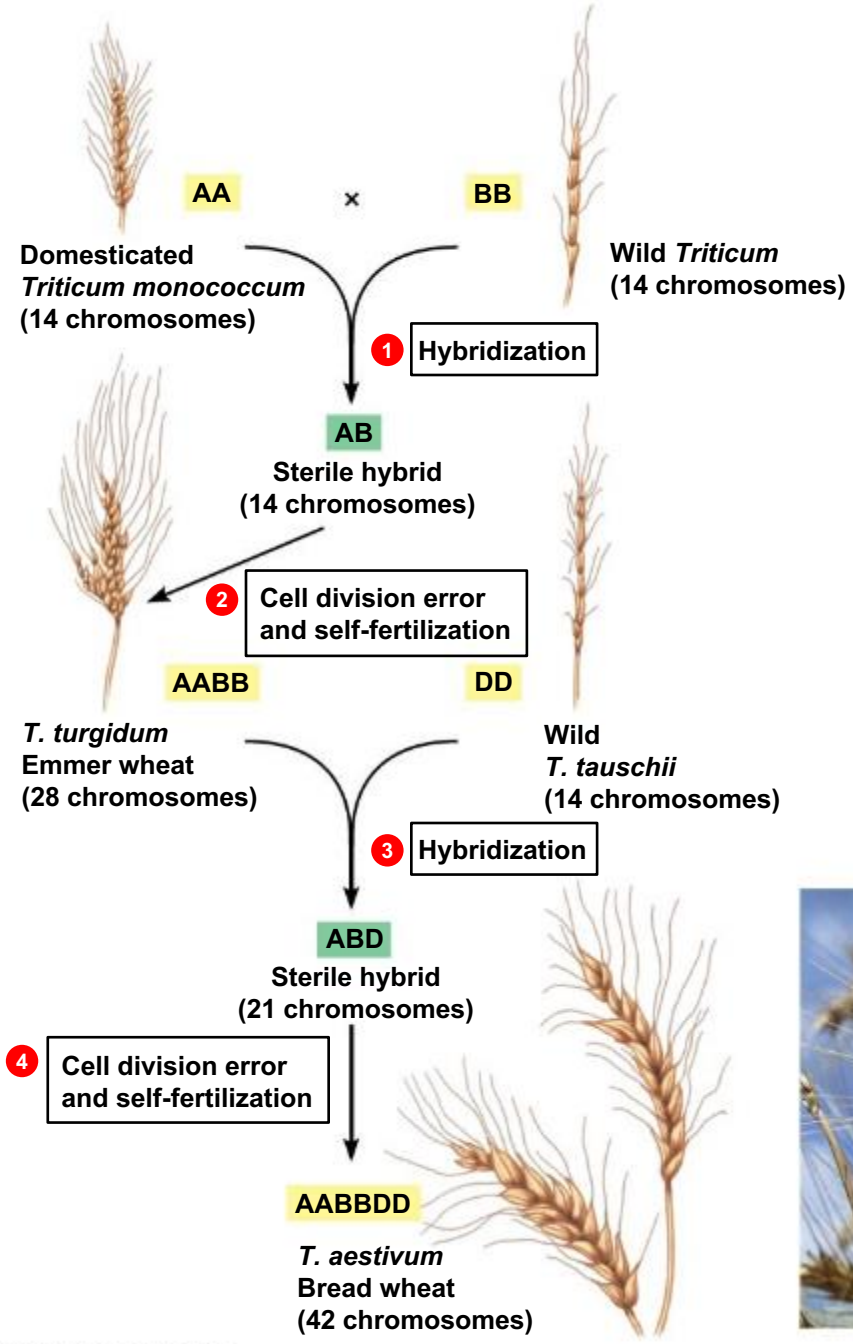
Within a species (allo-polyploid)



14.7 EVOLUTION CONNECTION: The origin of most plant species can be traced to polyploid speciation

- Wheat
  - domesticated for at least 10,000 years
  - the most widely cultivated plant in the world.
- Bread wheat, *Triticum aestivum*, is
  - a 6X polyploid with 42 chromosomes and
  - the result of hybridization and polyploidy.
- Pasta Durum wheat: 4X

Figure 14.7-0



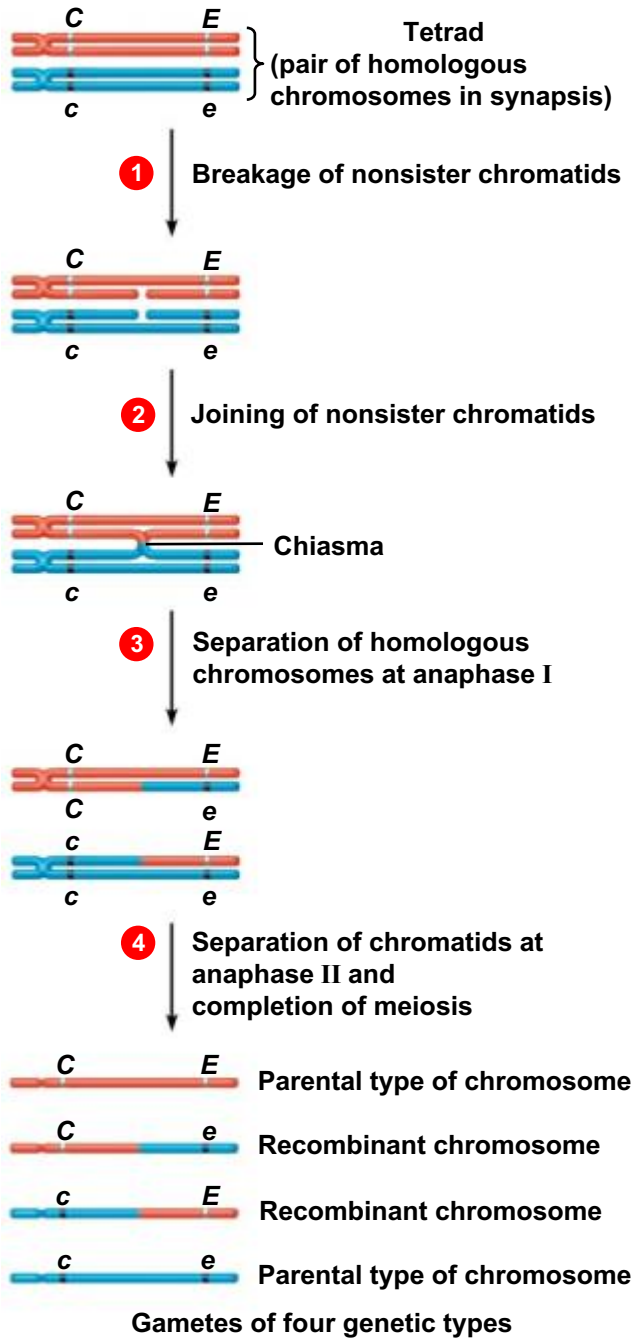
Durum wheat for pasta: AABB

14.7 EVOLUTION CONNECTION: The origin of most plant species can be traced to polyploid speciation

- Polyploid plants include
  - cotton,
  - Oats (燕麥),
  - potatoes,
  - Bananas (clonal triploid),
  - Peanuts (allo-tetraploid),
  - barley,
  - plums,
  - apples,
  - sugarcane,
  - coffee, and
  - wheat.

Meiosis and recombination: why important?

- 4X, 6X, 8X, etc. can "behave as" diploids, with normal meiosis, recombination, and sexual reproduction
- Meiosis is difficult for 3X, 5X, 7X…



The story of banana…

- Two parental species
- *Musa acuminata* (A genome)
- *Musa balbisiana* (B genome)
- Natural diploid 2X
- Occasional 3X mutant, no seed
- Different combinations of A and B
- 香蕉 (AAA), 芭蕉 (ABB), …

https://www.youtube.com/watch?v=2KVoFVS1Dz8

Photo: 邱輝龍

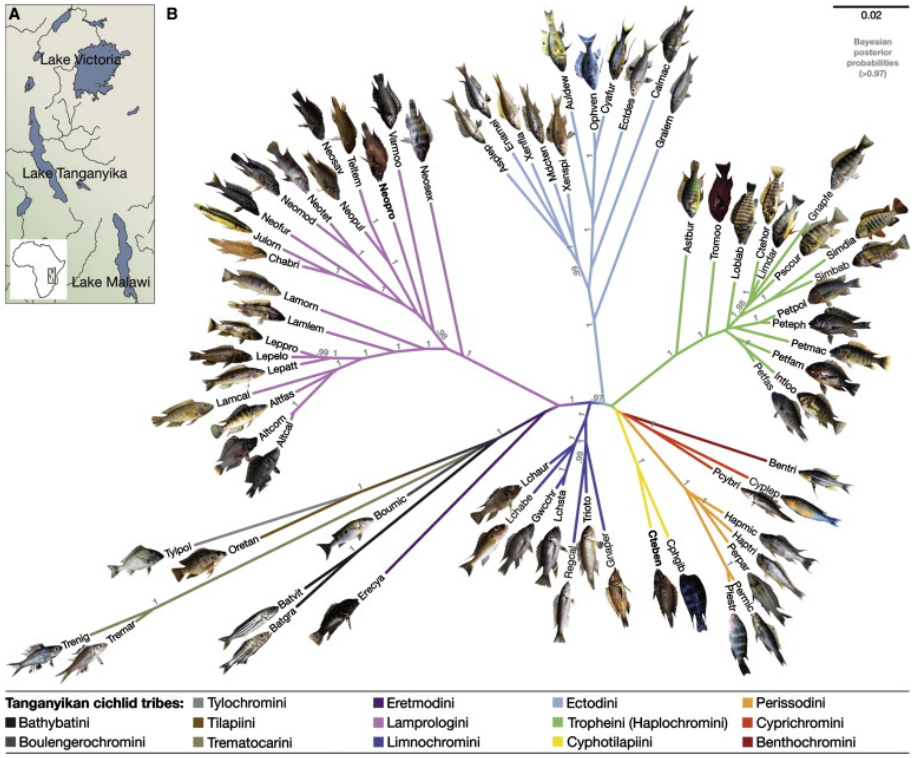
Wiki: Banana Wilt

Global banana extinction

- All global commercial AAA banana is the same clone
- Major disease: 香蕉黃葉病, caused by fungus pathogen *Fusarium oxysporum* f. sp. Cubense (Foc)
- Major banana cultivar before 1950: Gros Michel
  - Artificial banana flavor
- In the 1950s, wiped out by Foc Tropical Race 1
- Soon replaced by another cultivar: Cavendish
- New threat: Foc Tropical Race 4
- Few known AAA variety resistant to Foc TR4
- GMO?

Adaptive radiation

- Adaptive radiation: the common ancestor generated many species of diverse forms
- Cichlids in East African lakes



ScienceDirect.com

14.9 SCIENTIFIC THINKING: Lake Victoria is a living laboratory for studying speciation

- In Lake Victoria, there are pairs of closely related cichlid species that differ in color but nothing else.
  - Breeding males of *Pundamilia nyererei* have a bright red back and dorsal fin.
  - Breeding males of *Pundamilia pundamilia* males are metallic blue-gray.

Figure 14.9b

Pundamilia nyererei

Pundamilia pundamilia

	P. nyererei	*P. pundamilia*
Female prefers	Red male	Blue male
Female vision sensitive to	Red	Blue
Lives in	Deep water	Shallow water

Long wavelength light can better penetrate water…

But with water pollution…

DAILY NEWS 1 October 2008

Love is blind for fish in murky waters

By Ewen Callaway

Pundamilia nyererei

Pundamilia pundamilia

Hybrid: *Pundamilia "turbid water"*