

# Species Concept

**II MSc Botany**

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## **How many species exist on earth?**

- about 3.5 million species have been described.
- only about 1.56 million in any detail.
- estimates of the number of species present range from 5 million to 100 million.

**Why this broad band?**

## **1. Many groups are poorly studied.**

- notably microorganisms and parasites.

## **2. Many environments are poorly sampled.**

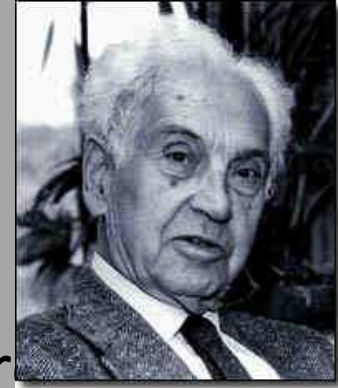
- tropical environments - both terrestrial and aquatic.

## **3. Molecular approaches are identifying more and more “cryptic species”.**

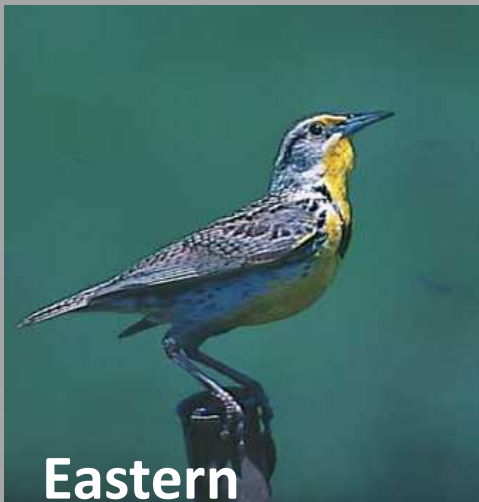
- a cryptic species is indistinguishable from another species at the morphological level, but is distinguishable genetically.

# species

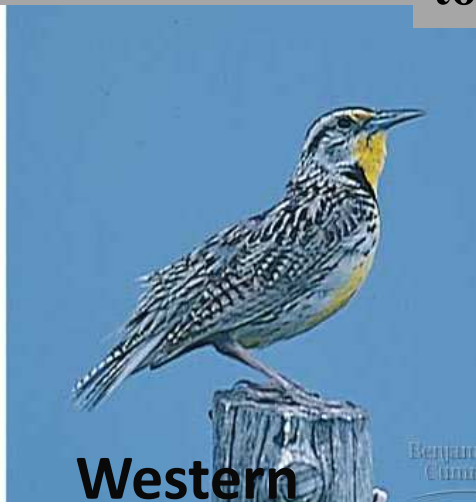
- Biological species concept
  - defined by Ernst Mayr
  - population whose members can interbreed and produce viable, fertile offspring
  - reproductively compatible



**Distinct species:  
songs & behaviors are different enough  
to prevent interbreeding**



**Eastern  
Meadowlark**



**Western  
Meadowlark**

# How and why do new species originate?

Species are created by a series of evolutionary processes

populations become isolated

geographically isolated

reproductively isolated

isolated populations

evolve independently

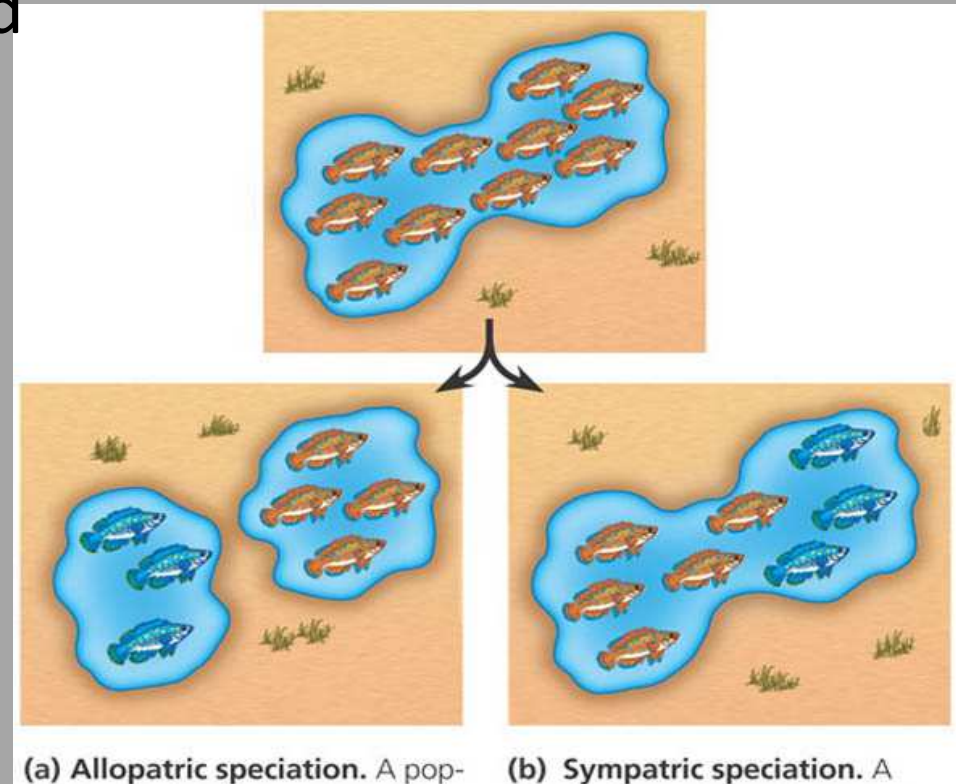
Isolation

allopatric

geographic separation

sympatric

still live in same area

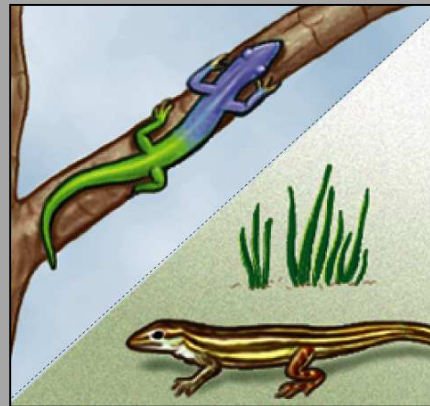


# Pre-zygotic barriers

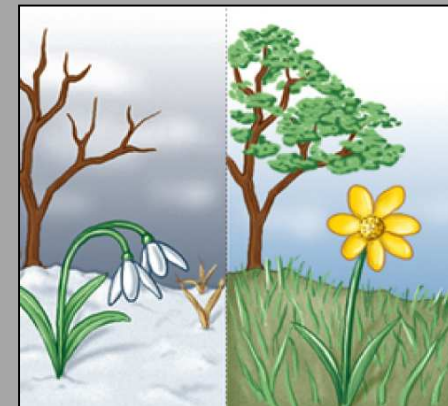
Obstacle to mating or to fertilization if mating occurs



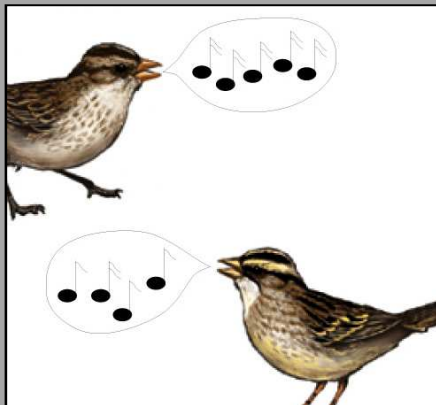
geographic isolation



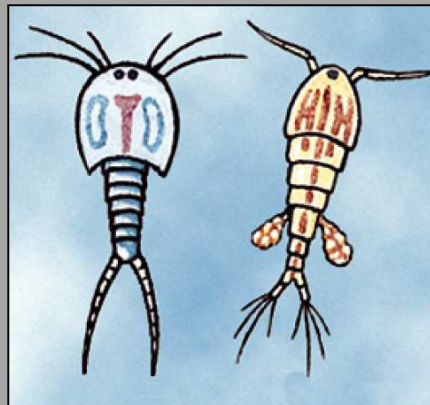
ecological isolation



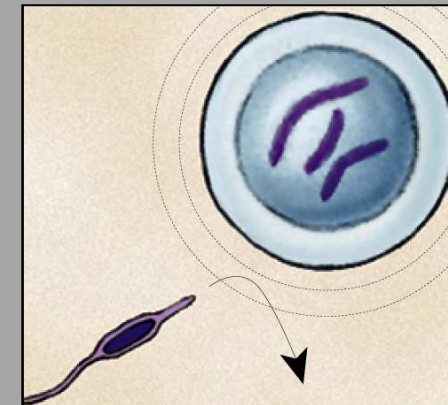
temporal isolation



behavioral isolation



mechanical isolation



gametic isolation

# Geographic isolation

*Ammospermophilus spp*

Species occur in different geographical areas

- Mostly due to physical barrier
- allopatric speciation
  - “other country”



**Harris's antelope squirrel inhabits the canyon's south rim (L). Just a few miles away on the north rim (R) lives the closely related white-tailed antelope squirrel**

# Ecological isolation

- Species occur in same region, but occupy different habitats so rarely encounter each other
  - reproductively isolated

Two species of garter snake, *Thamnophis*, occur in same area, but one lives in water & other is terrestrial



lions & tigers could hybridize, but they live in different habitats:

- lions in grasslands
- tigers in rainforest





# Temporal isolation

Species that breed during different times of day/ different seasons, or different years cannot mix gametes

- reproductive isolation
- sympatric speciation  
*“same country”*

Eastern spotted skunk (L) & western spotted skunk (R) overlap in range but eastern mates in late winter & western mates in late summer



sympatric speciation?

# Behavioral isolation

- Unique behavioral patterns & rituals isolate species
  - identifies members of species
  - attract mates of same species
    - courtship rituals, mating calls
    - reproductive isolation



*Blue footed Boobies* mate only after a courtship display unique to their species



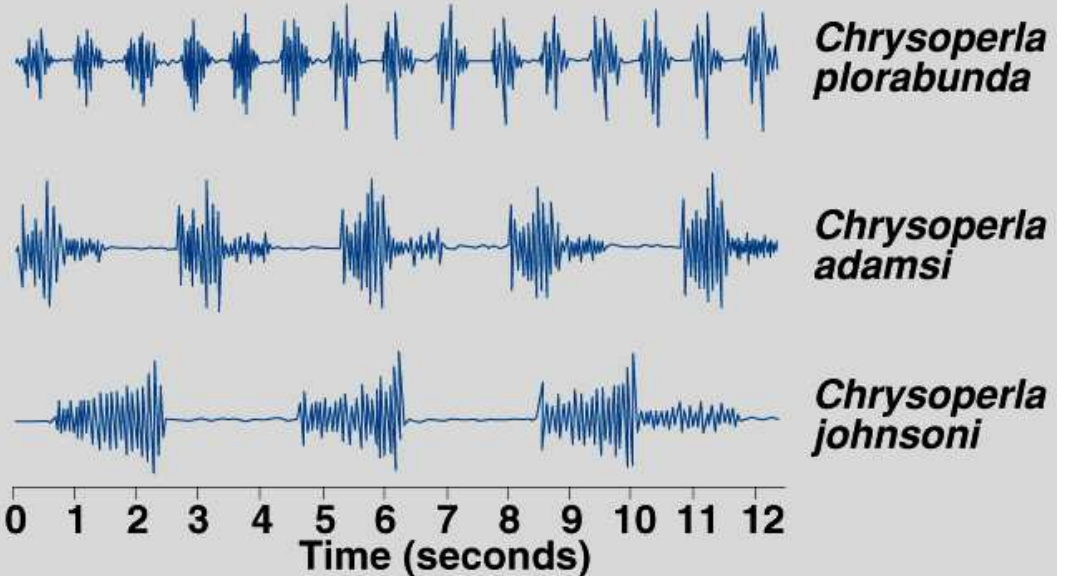
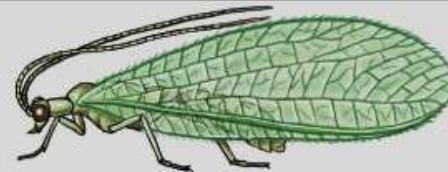
**courtship display of  
Gray-Crowned Cranes, Kenya**



**Firefly courtship displays**

# Recognizing your own species

**courtship songs of sympatric  
species of lacewings**



# Mechanical isolation

sympatric speciation?

Plants

Morphological differences can prevent successful mating

– reproductive isolation

**Even in closely related species of plants, the flowers often have distinct appearances that attract different pollinators. These 2 species of monkey flower differ greatly in shape & color, therefore cross-pollination does not happen.**



# Mechanical isolation

- For many insects, male & female sex organs of closely related species do not fit together, preventing sperm transfer

**Animals**



- lack of “fit” between sexual organs:  
hard to imagine for us... but a big issue for insects with different shaped genitals!



**Damselfly penises**

# Gametic isolation

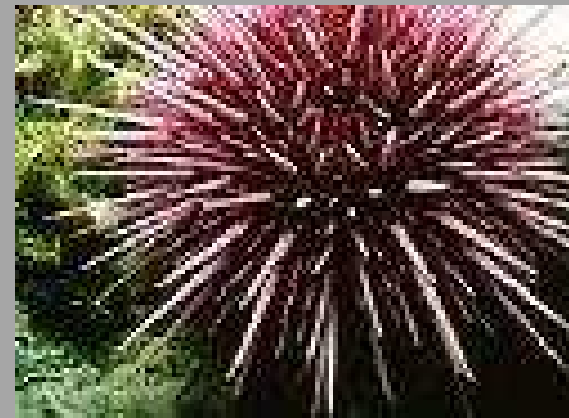
sympatric speciation?

Sperm of one species may not be able to fertilize eggs of another species

– mechanisms

- **biochemical barrier** so sperm cannot penetrate egg
  - receptor recognition: lock & key between egg & sperm
- **chemical incompatibility**
  - sperm cannot survive in female reproductive tract

**Sea urchins release sperm & eggs into surrounding waters where they fuse & form zygotes. Gametes of different species— **red** & purple —are unable to fuse.**



# Pre-zygotic barriers

- Prevent hybrid offspring from developing into a viable, fertile adult
  - reduced hybrid viability
  - reduced hybrid fertility
  - hybrid breakdown

## Zebroid



# Reduced hybrid viability

sympatric speciation?

Genes of different parent species may interact & impair the hybrid's development

Species of salamander genus, *Ensatina*, may interbreed, but most hybrids do not complete development & those that do are frail.

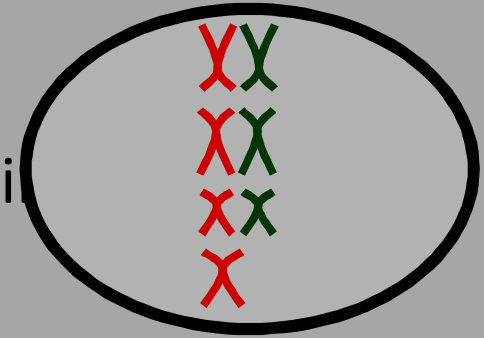




# Reduced hybrid fertility

- Even if hybrids are vigorous they may be sterile

- chromosomes of parents may differ in number or structure & meiosis in hybrids may fail to produce normal gametes



**Horses have 64 chromosomes (32 pairs)**



**Mules have 63 chromosomes!**

**Mules are vigorous, but sterile**



**Donkeys have 62 chromosomes (31 pairs)**

# Hybrid breakdown

sympatric speciation?

- Hybrids may be fertile & viable in first generation, but when they mate offspring are feeble or sterile



**In strains of cultivated rice, hybrids are vigorous but plants in next generation are small & sterile.**

**On path to separate species.**

# Species Concepts

## 1. The Typological Species Concept (TSC, Linnaeus)



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## 1. The Typological Species Concept (TSC, Linnaeus)

**A group of individuals that differ from other groups by possessing constant diagnostic characters.**

- based on collecting and describing a “type” specimen for a given species.

## **Problems with the TSC:**

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### 1. Polymorphism within populations



*Teagueia sancheziae*

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## **Problems with the TSC:**

**1. Polymorphism within populations**

**2. Geographic variation among populations**

**3. Sibling or cryptic species**

- sibling species are reproductively isolated groups that are morphologically indistinguishable.

## 2. The Biological Species Concept (BSC, Dobzhansky & Mayr)

Mayr (1940): **species are groups of actually or potentially interbreeding natural populations that are reproductively isolated from other such groups.**



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Dobzhansky (1937): **species are the largest and most inclusive reproductive community of sexual and cross-fertilizing individuals that share a common gene pool.**



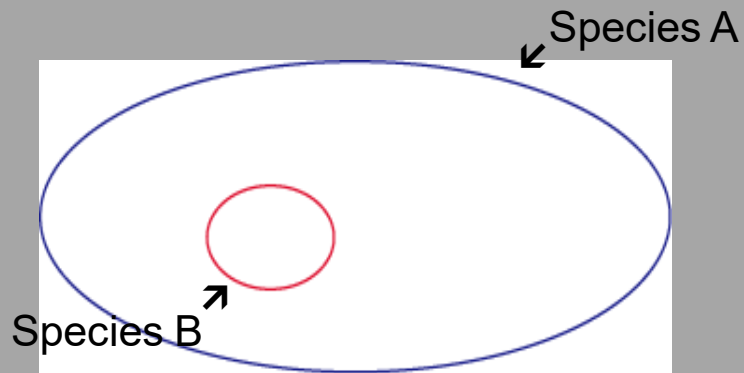
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**Nondimensional  
species concept**

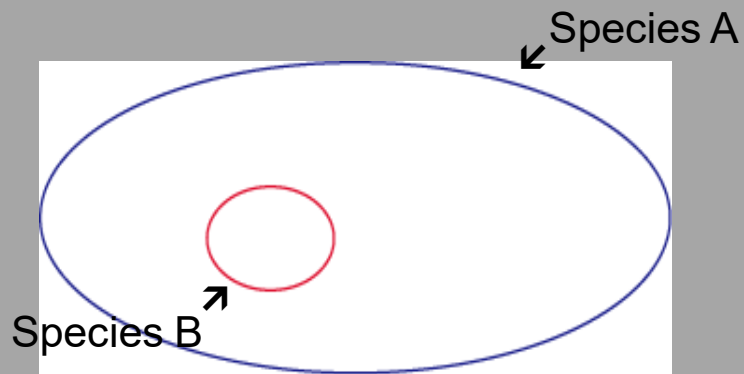
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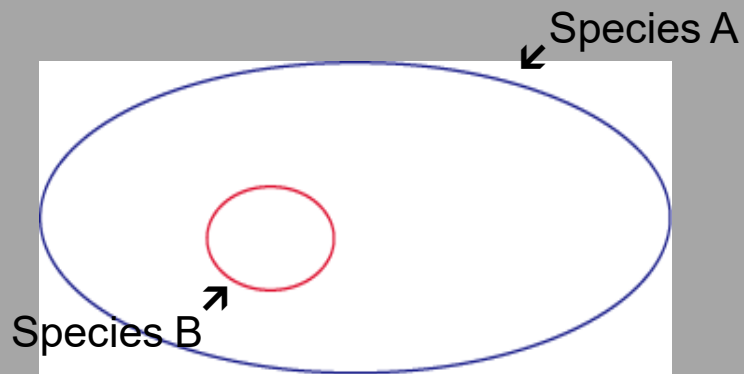
## **Nondimensional species concept**



species **sympatric**  
and **synchronous**

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### **Nondimensional species concept**



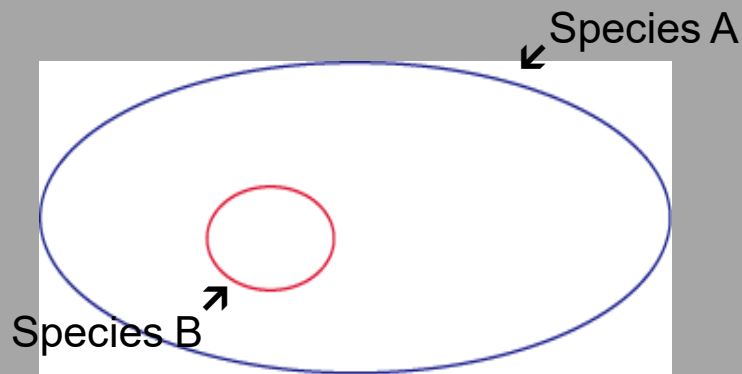
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### **Multidimensional species concept**



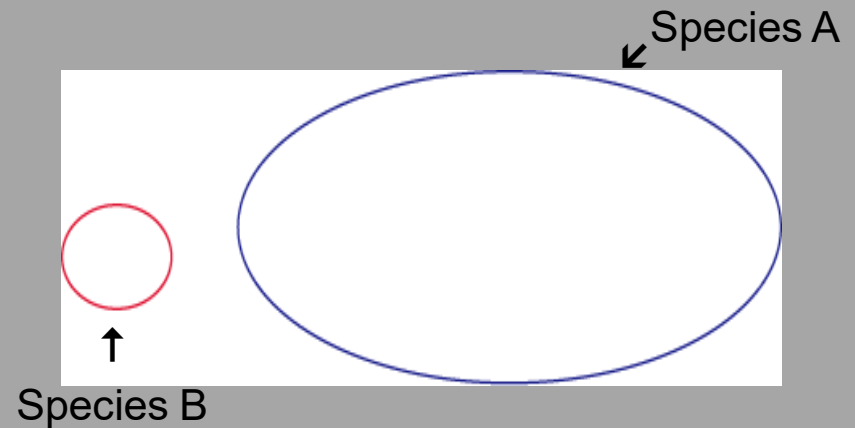
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### **Nondimensional species concept**



species **sympatric**  
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### **Multidimensional species concept**



## **“nondimensional” and the “multidimensional”**

**Non-dimensional-Species that are sympatric and synchronous morphologically similar but non inter breeding.**

**Multi-dimensional-Species that are allopatric allochronous. Set of morphologically distinct populations, that are dispersed geographically yet that form a network and are capable of replacing each other. Individual populations may be regarded as morphospecies, the multidimensional species concept is an extreme form of lumping.**

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Top: False killer whale dad

Middle: Dolphin mom

Bottom: Baby wholphin

Wholphin mom Kekaimalu



With daughter  
Kawili'Kai



Kawili'Kai



# A “liger”



Hercules, the liger

# A “tigon”



## **Problems with the BSC:**

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**3. Multidimensional concept difficult to verify**

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### **1. Not applicable to asexual species**

### **2. Reproductive isolation is often incomplete**

- hybridization is common among many groups (waterfowl, terrestrial plants, freshwater fishes).

### **3. Multidimensional concept difficult to verify**

- how do we assess the “potential to interbreed”?

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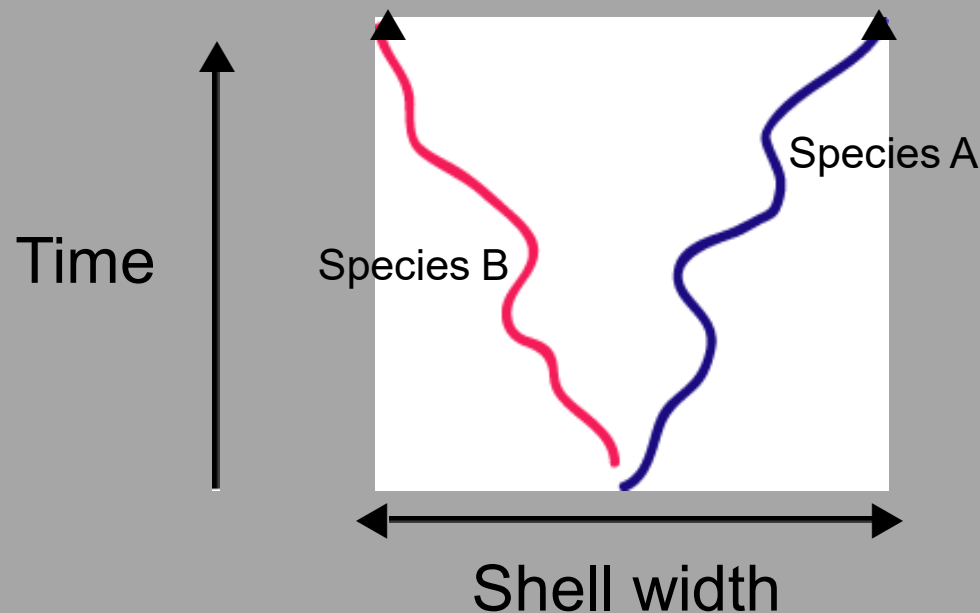
**An evolutionary species is a lineage evolving separately from others with its own unitary evolutionary role and tendencies.**

- initially developed to define fossil species.

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- how do you define independent roles and tendencies?

## **2. Does not provide a mechanism**

## 4. The Phylogenetic Species Concept (PSC, Cracraft, 1983)



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The smallest diagnosable monophyletic group of populations within which there is a parental pattern of ancestry and descent.

- two recent extensions are the **internodal species concept** and the **genealogical species concept**.

# Phylogenetic species

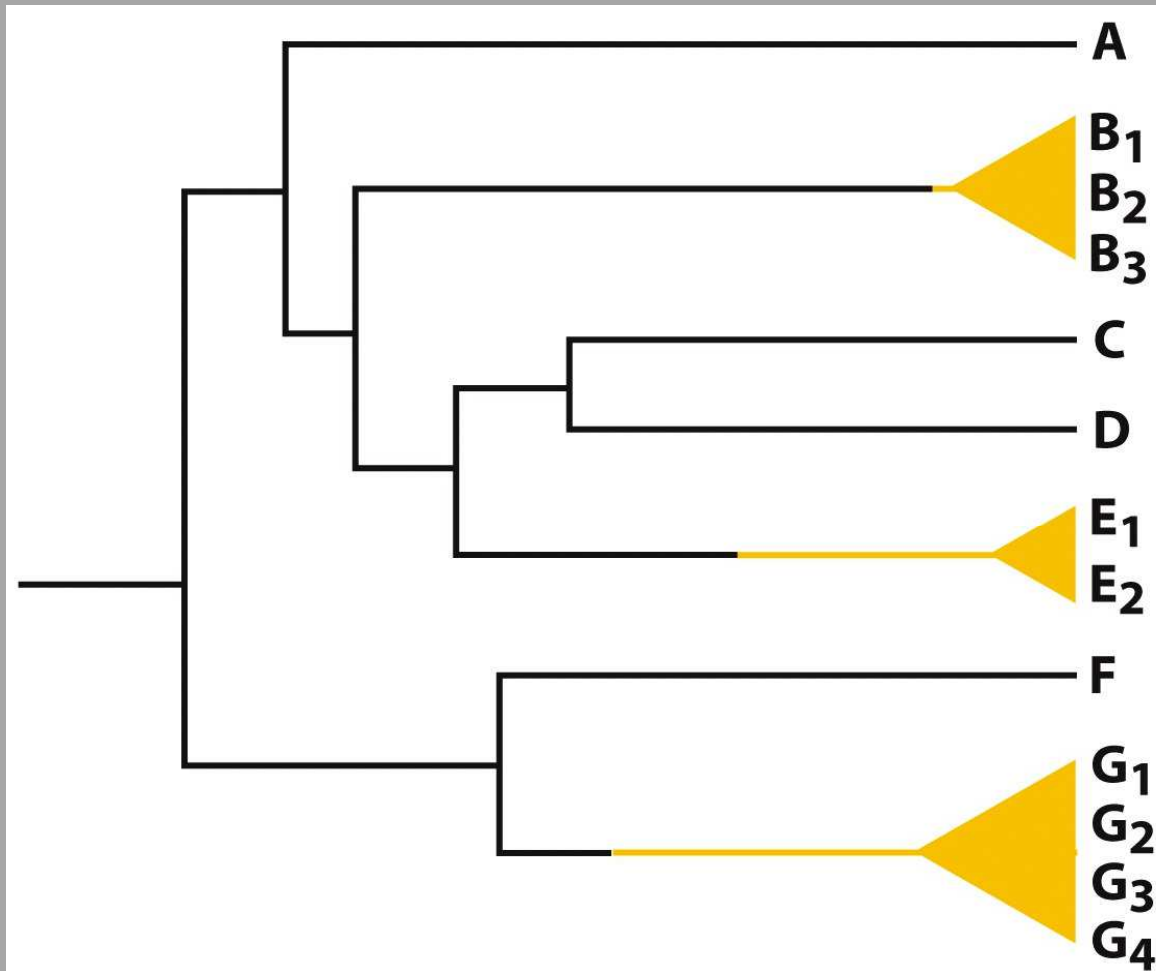
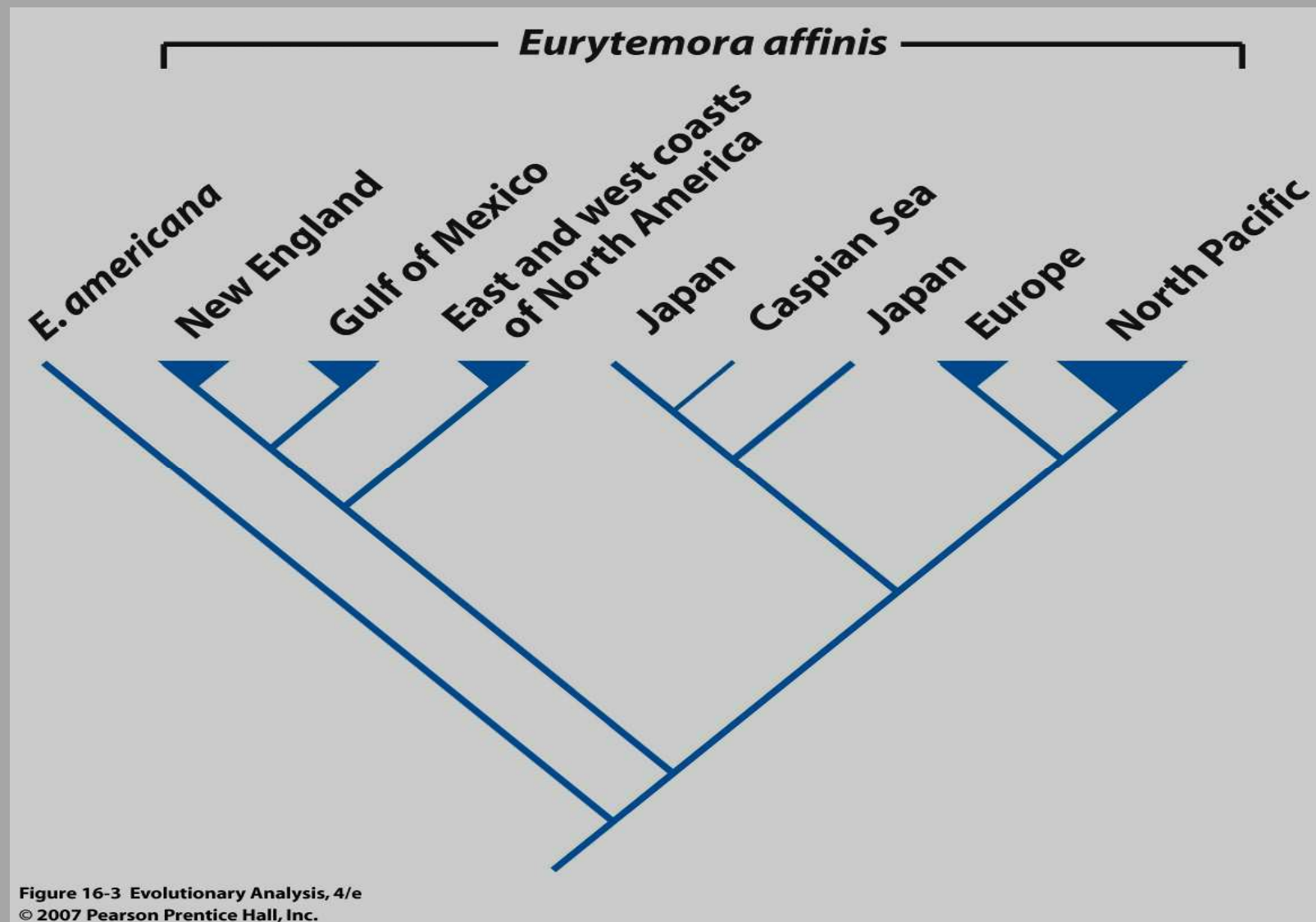


Figure 16-1 Evolutionary Analysis, 4/e  
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A “cosmopolitan” copepod, *Eurytemora affinis*



# Phylogenetic analyses reveals at least 8 cryptic species





# Problems with the PSC

1. What characters to use?
2. What level of divergence constitutes a species?
3. Distinguishing between gene trees and species trees.
- 4. Does not address mechanism.**

# Questions?

