

Microevolution: Reproductive isolation
Core course: ZOOL3014
Semester: VI

Prof. Pranveer Singh

Isolating mechanisms

Factors that prevent gene exchange

Agent that hinders the interbreeding of the group of individuals (T. Dobzhansky)

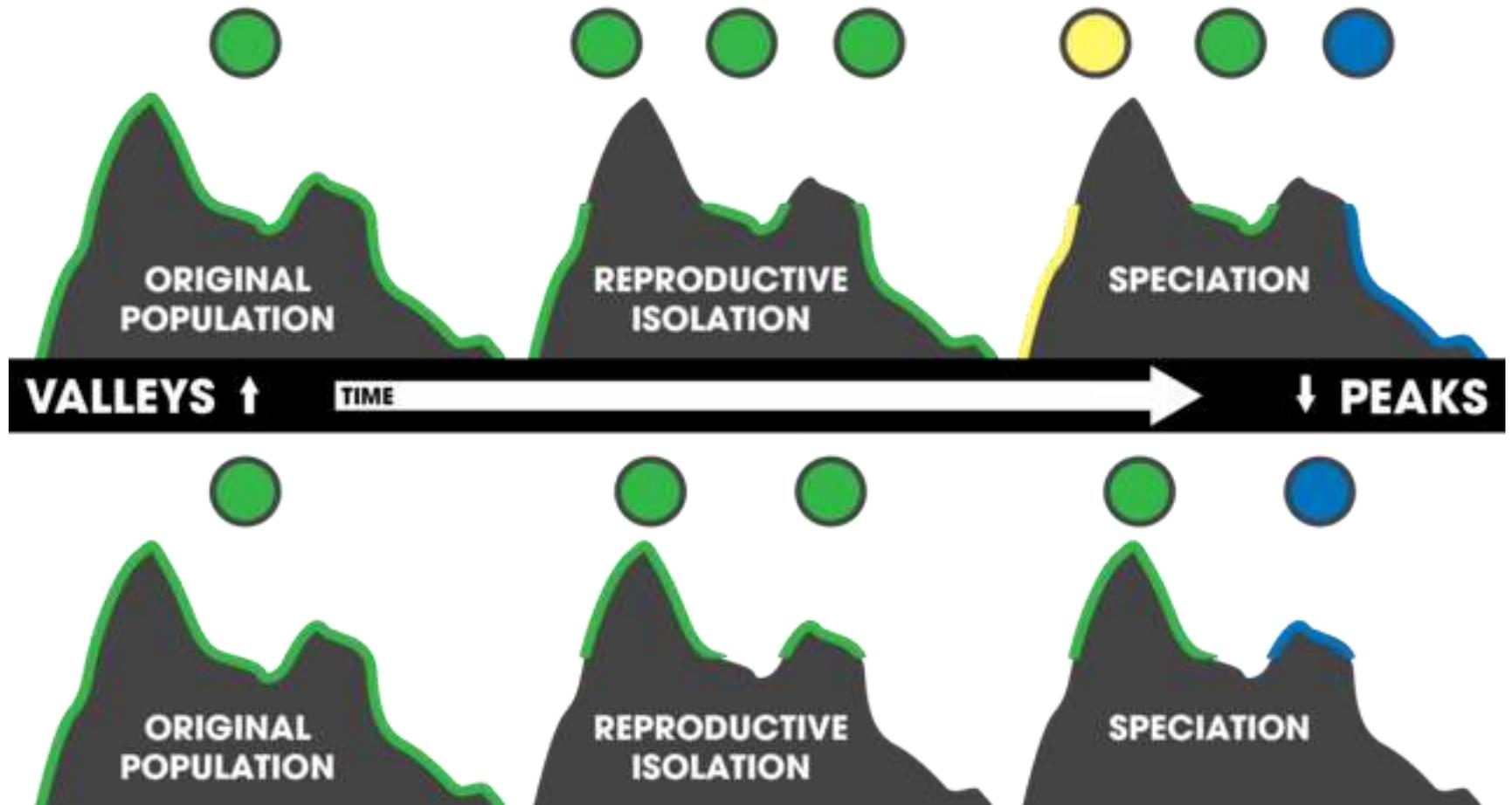
E. Mayr has restricted this term to sympatric populations and defined it as the “biological properties of the individuals which prevent interbreeding of populations that are actually or potentially sympatric

However, this definition has excluded ‘geographic barrier

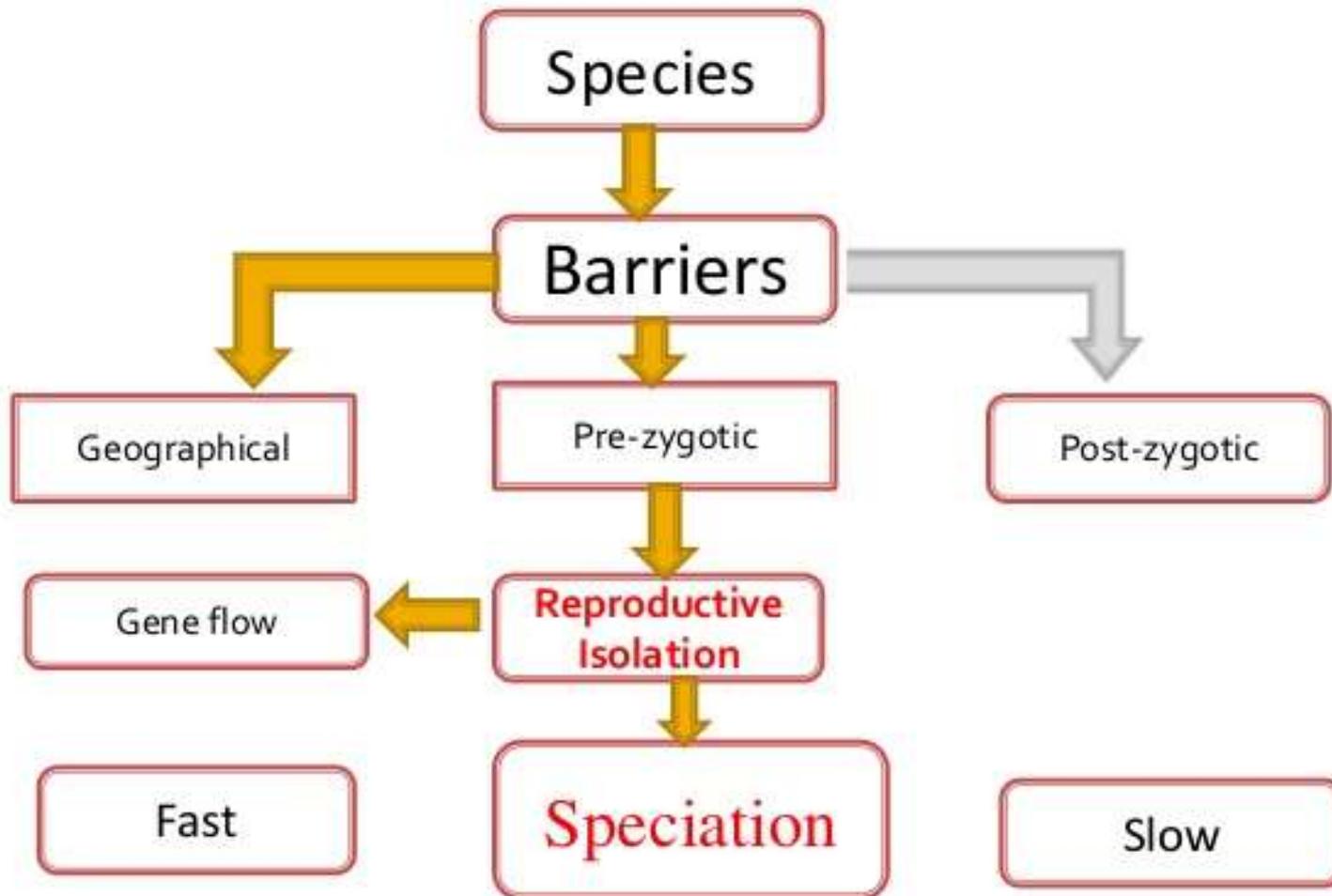
Isolating mechanisms are particularly important in the *Biological species concept*, in which species of sexual organisms are defined by *Reproductive isolation*, i.e. a lack of gene mixture

The term isolating mechanisms was introduced by T. Dobzhansky in the 1930s, and has been popularized in a number of books by E. Mayr

Reproductive isolation



Scheme of classification

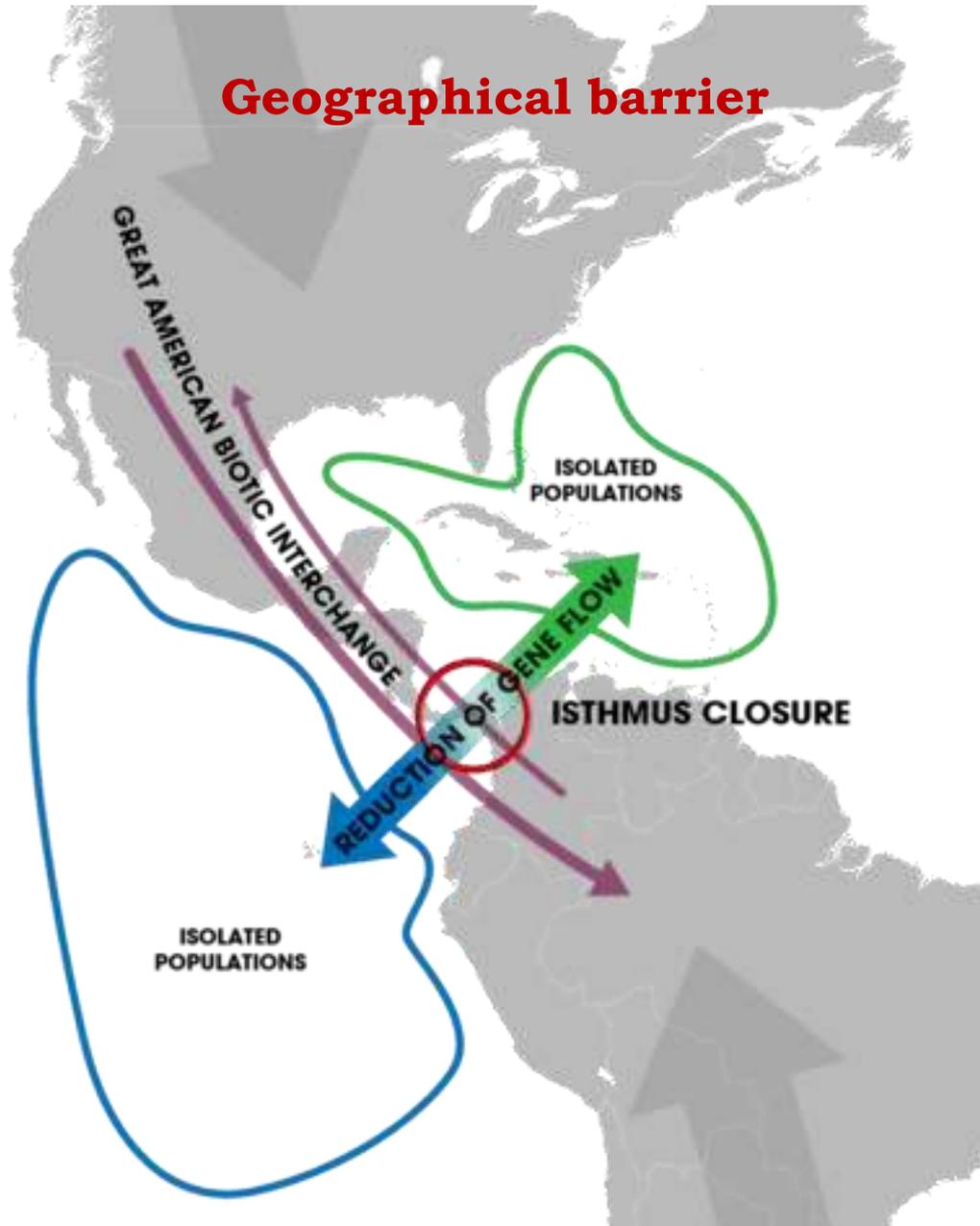


Geographical isolation

- **Geographical isolation** occurs when populations cannot mate because of physical barriers
- Geographically separated populations aren't necessarily distinct species.
- Example: Northern Spotted Owl and Mexican Spotted Owl.



Geographical barrier



Two broad kinds of isolating mechanisms between species are typically distinguished, together with a number of sub-types (modified from Mayr 1970):

1) Pre-mating isolating mechanisms

2) Post-mating isolating mechanisms

Pre-mating isolating mechanisms (Prezygotic isolation)

**Factors which cause species to mate with their own kind
(*assortative mating*)**

These mechanisms operate before fertilization

a) Temporal isolation: Individuals of different species do not mate because they are active at different times of day or in different seasons



+



=



D. persimilis

D. pseudoobscura



Wood frog (*Rana sylvatica*)

Leopard frog (*Rana pipens*)

***R. Sylvatica* mates in March-April when water temparture is 7.2 degree celsius while *R. pipens* mates in mid April when Water temparture is 12.8 degree celsius**

b) Ecological isolation: Individuals mate in their preferred habitat, and therefore do not meet individuals of other species with different ecological preferences

**e.g. Red-legged frog (*R. draytonii*) breeds in large ponds
Yellow-legged frog (*R. boylii*) breeds in fast moving streams**

**Common black bird (*Trudus merula*) lives in forest
Ring ouzel (*Trudus torquatus*) lives and breeds in moors**



c) Behavioral isolation: Potential mates meet, but choose members of their own species

(i) Visual stimuli

Feather displays and dancing in male birds is necessary to attract the female, e.g. peacocks, pheasants and birds of paradise

The colour and shape of the feathers as well as display pattern is unique for each species so that mating between two different species is not possible

Collection of the nest material and construction of the nest as by the weaverbird male is also a very specific display that cannot be imitated by the other species

(ii) Auditory stimuli

Songbirds like cuckoos, mynas, nightingales, parakeets etc. use auditory signals to attract the opposite sex

Sometimes the singing goes on for several days before the pair can actually come together for mating

Auditory communication is used by a large number of animals, viz. frogs, toads, cicadas, gibbons, monkeys, jackals etc.



Eastern meadowlark



Western meadowlark

Eastern meadowlark may not respond to the courtship/mating song from western meadowlark and vice versa

(iii) Chemical stimuli

This includes odors of the animals that attract the opposite sex for mating

Example includes scent of musk deer and musthing in elephants to attract the females

In insects, particularly Lepidoptera, females produce highly specific pheromones that can be detected by the highly specialized antennae of males from a distance of about few kilometers.

d) Mechanical isolation: Copulation is attempted, but transfer of sperm does not take place
e.g. Snails with shells having left handed spirals may be unable to mate with snails having shells with right-handed spirals



**Mechanical
incompatibility
in snail**



Dufour's Hypothesis

Genital armature acts like lock and key and prevent mating between individuals of different species

Karl Jordan's contradiction

Out of 698 species of family sphingidae of order insecta , 48 are not different in genitalia from the other species of the family.

50 percent of species with geographic variation in the colour show geographic variation in the genital structure, thus indicating importance of the structure of genitalia in the isolating mechanisms

Post-mating isolating mechanisms (Postzygotic isolation)

Operates after fertilization

2) *Post-mating isolating mechanisms (Postzygotic isolation)*

Genomic incompatibility, hybrid inviability or sterility

a) Gametic incompatibility: Sperm transfer takes place, but egg is not fertilized

**Sperm encounter antigenic reaction in the female genital tract, gets immobilized and killed before it reaches egg
e.g. insemination reaction in *Drosophila***

Chemical attractants for sperm and ovum may vary from species to species

Gametes may not recognize each other rendering fertilization impossible

b) Zygotic mortality: Egg is fertilized, but zygote does not develop

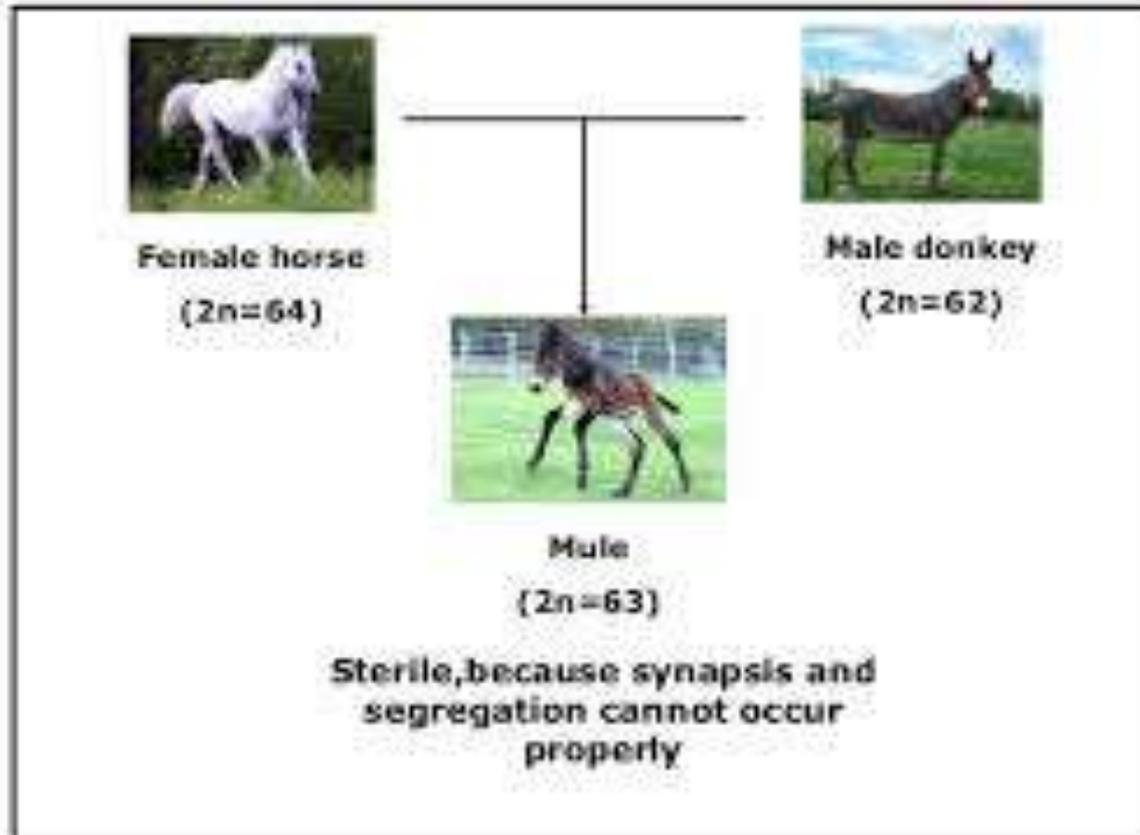
c) Hybrid inviability: Hybrid embryo forms, but of reduced viability

e.g. Sheep & Goat



d) Hybrid sterility: Hybrid is viable, but resulting adult is sterile

Common in parent species with different chromosome numbers, e.g. mule



e) Hybrid breakdown: First generation (F1) hybrids are viable and fertile, but further hybrid generations (F2 and backcrosses) may be inviable or sterile

e.g. *D. pseudoobscura* & *D. persimilis*



D. Persimilis



D. pseudoobscura

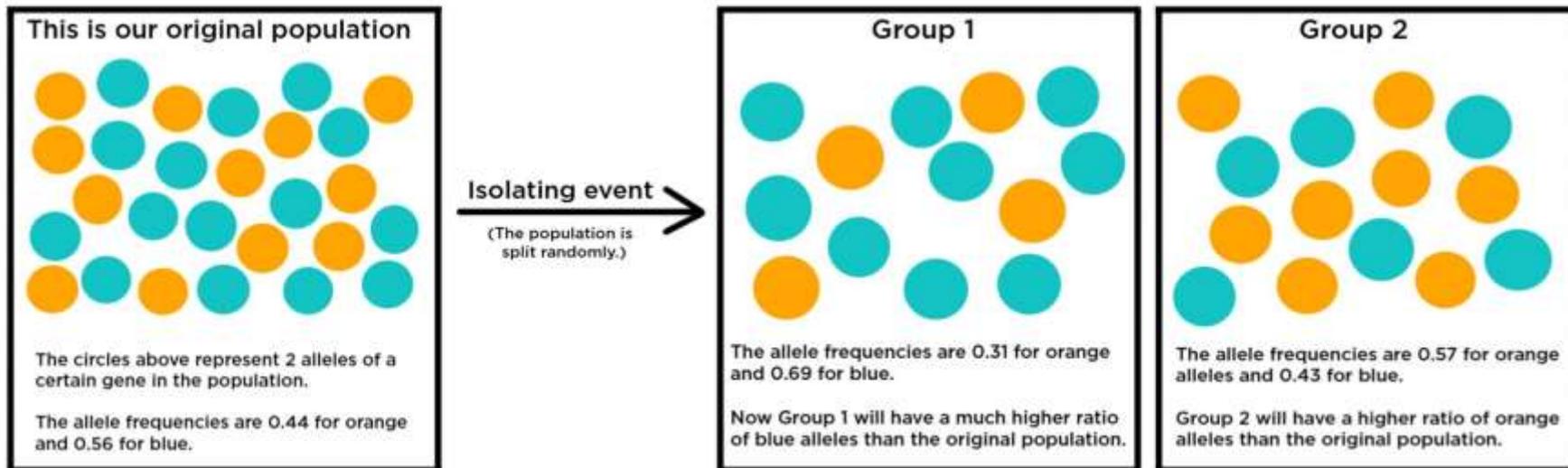
How do isolating mechanisms change allele frequencies within a population?

Isolating mechanisms are things that prevent some members of a population from mating with others.

This could be:

1. a geographical barrier, like a natural disaster
2. a behavioral barrier, like a difference in mating calls
3. a temporal barrier, like a difference in when some organisms look for mates.

Example:



Reinforcement

***Pre-mating* and *post-mating isolation* are likely to evolve as a by-product of natural selection or genetic drift within species, rather than as a direct result of their utility as barriers to fertilization and gene mixing between species (a process known as *reinforcement*)**

Significance of isolating mechanism

Wasteful courtship is avoided

If isolating mechanisms are distinct and specific only individuals of the same species indulge in courtship

Isolating mechanism protects gene pool of a species and prevents hybridization

It prevents wastage of gametes and energy

A weak isolating mechanism leads to production of new species through hybridization

Absence of isolating mechanism leads to production of new species by instant speciation

Geographical isolation followed by reproductive isolation ultimately leads to production of new species

Isolating mechanisms protect the identity of a species, which all species fiercely guard

Objections to the theory of reproductive isolation

HEH Paterson argues that species are cohesive wholes as a result of *pre-zygotic* sexual signalling within species, rather than due to isolating mechanisms between species

Paterson therefore introduced a competing idea of species, the *recognition concept* of species, in which isolating mechanisms were replaced by *specific mate recognition systems* as an alternative

However, the word "system" has as many group-benefit connotations as "mechanism", and the *recognition concept* of species has not gained universal acceptance

Reproductive isolation combines traits that reduce *gene flow*, such as mate choice or fertilization barriers, with traits that select against genes that have flowed, such as hybrid incompatibility

***Gene flow* as the opposite of *reproductive isolation*; in other words, *gene flow* comes to include not only the flow of genes, but also the effects of any natural selection on the frequency of such genes within each population**

Most fundamental problem with isolating mechanisms is that species are implied to be qualitatively different from subspecies, races, or forms by their possession of these traits. Races cannot, in theory, differ in either type of trait because only species are defined by their possession

Arguably, by making species seem qualitatively different from races, these terms have spawned a number of special models of speciation where *geographic isolation*, also known as *allopatry*, or sudden bursts of evolution in small founder populations (*founder events* or *punctuated equilibria*) play important roles

Only such unusual conditions were thought to be able to give rise to new species that differ in isolating mechanisms (or *specific mate recognition systems*)

In reality, there is little to distinguish *mate choice* and *disruptive natural selection* commonly observed within species from *pre-mating* and *post-mating isolation* between species; and, indeed, it is hard to distinguish species from races in many actual organisms (see species concepts)