Microevolution: Species concept
Core course: ZOOL3014
B.Sc. (Hons'): VIth Semester

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Clines

A cline is a geographic gradient in the frequency of a gene, or in the average value of a character

Clines can arise for different reasons:

• Natural selection favors a slightly different form along the gradient

• It can also arise if two forms are adapted to different environments separated in space and migration (gene flow) takes place between them

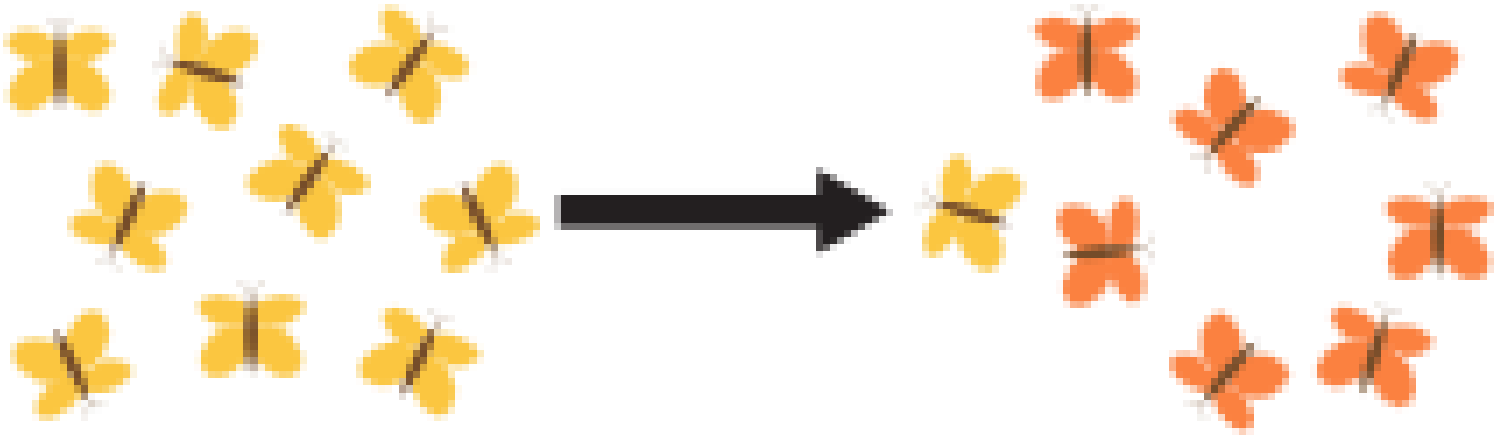
Term coined by Julian Huxley in 1838

Geographic variation normally exists in the form of a continuous cline

A sudden change in gene or character frequency is called a stepped cline

An important type of stepped cline is a hybrid zone, an area of contact between two different forms of a species at which hybridization takes place

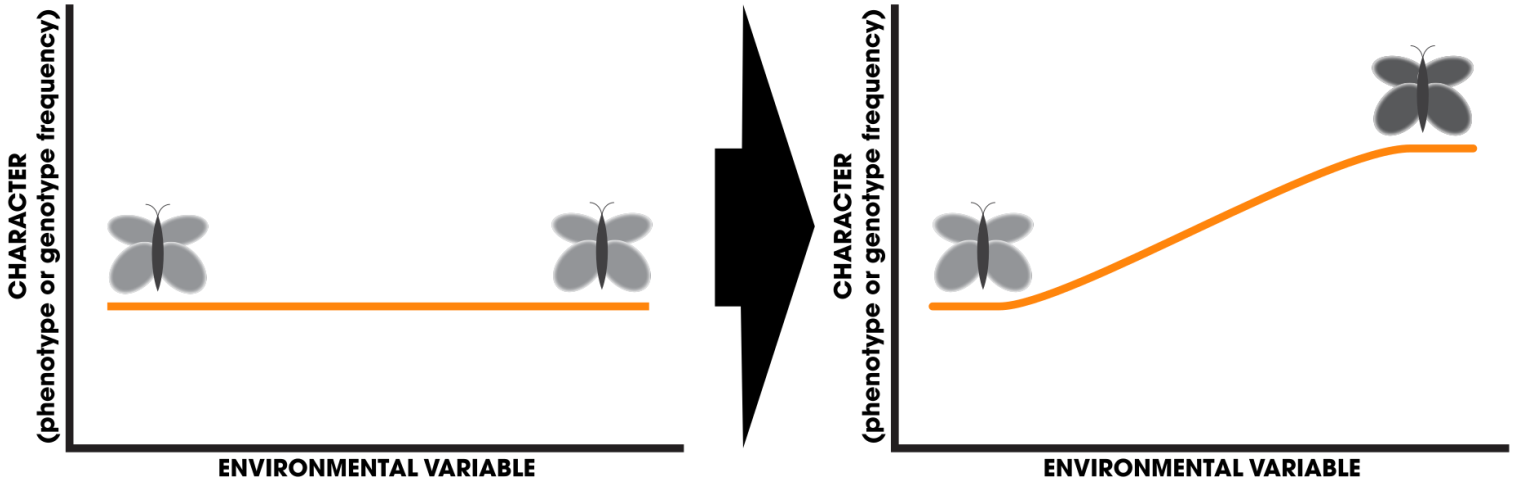
Drivers and evolution of clines



Two populations with individuals moving between the populations to demonstrate gene flow

Development of clines

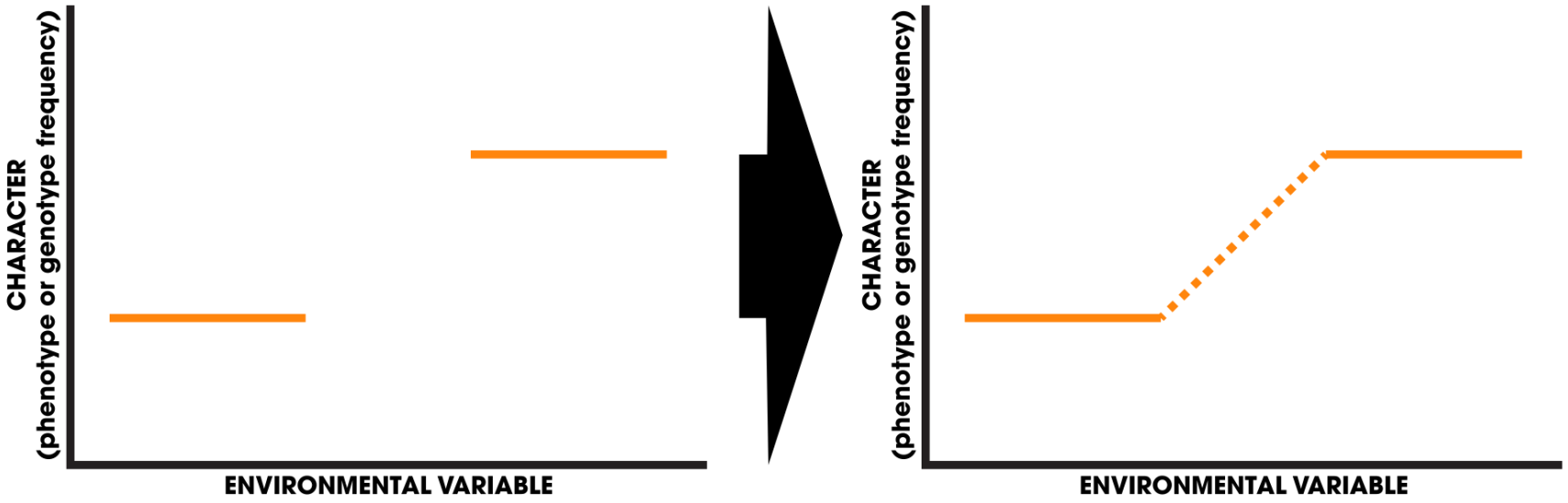
1. Primary differentiation / Primary contact / Primary intergradation



Primary differentiation is demonstrated using the peppered moth as an example, with a change in an environmental variable such as sooty coverage of trees imposing a selective pressure on a previously uniformly coloured moth population

This causes the frequency of melanic morphs to increase the more soot there is on vegetation

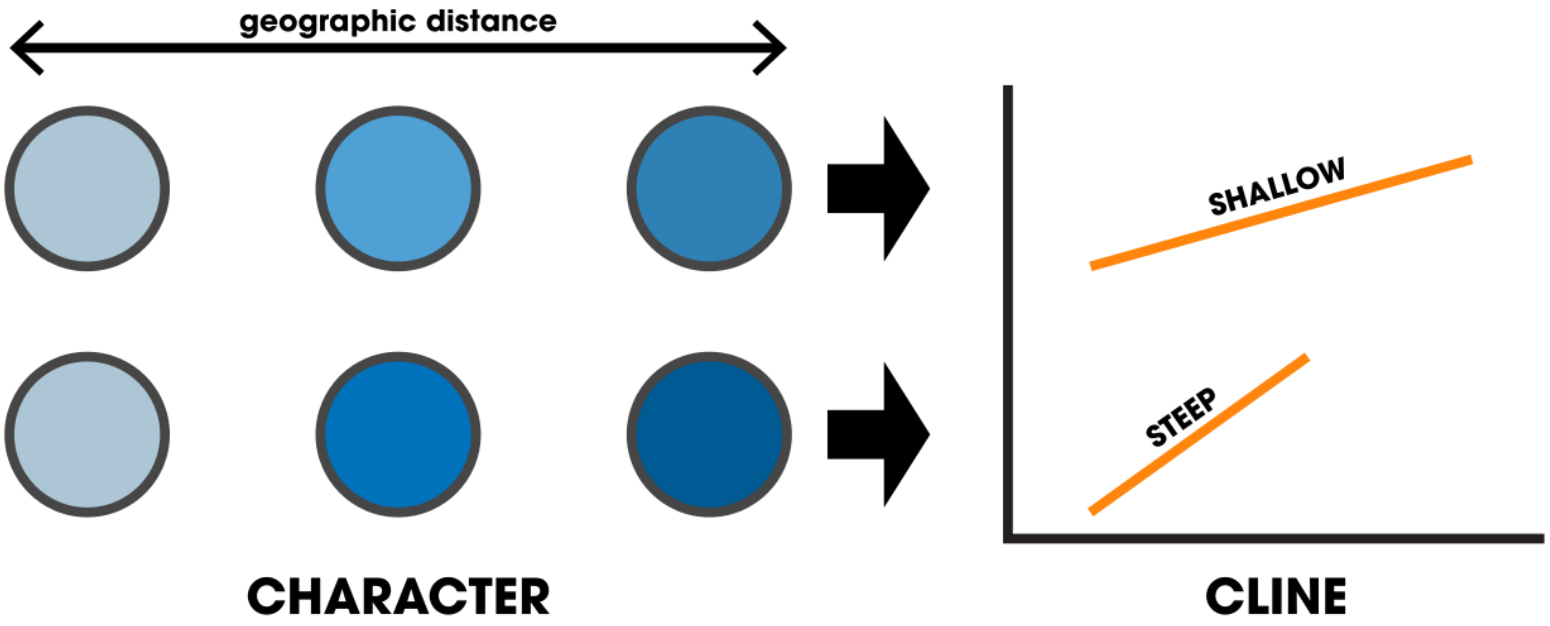
2. Secondary contact / Secondary intergradation / Secondary introgression



Secondary contact between two previously isolated populations

Two previously isolated populations establish contact and therefore gene flow, creating an intermediate zone in the phenotypic or genotypic character between the two populations

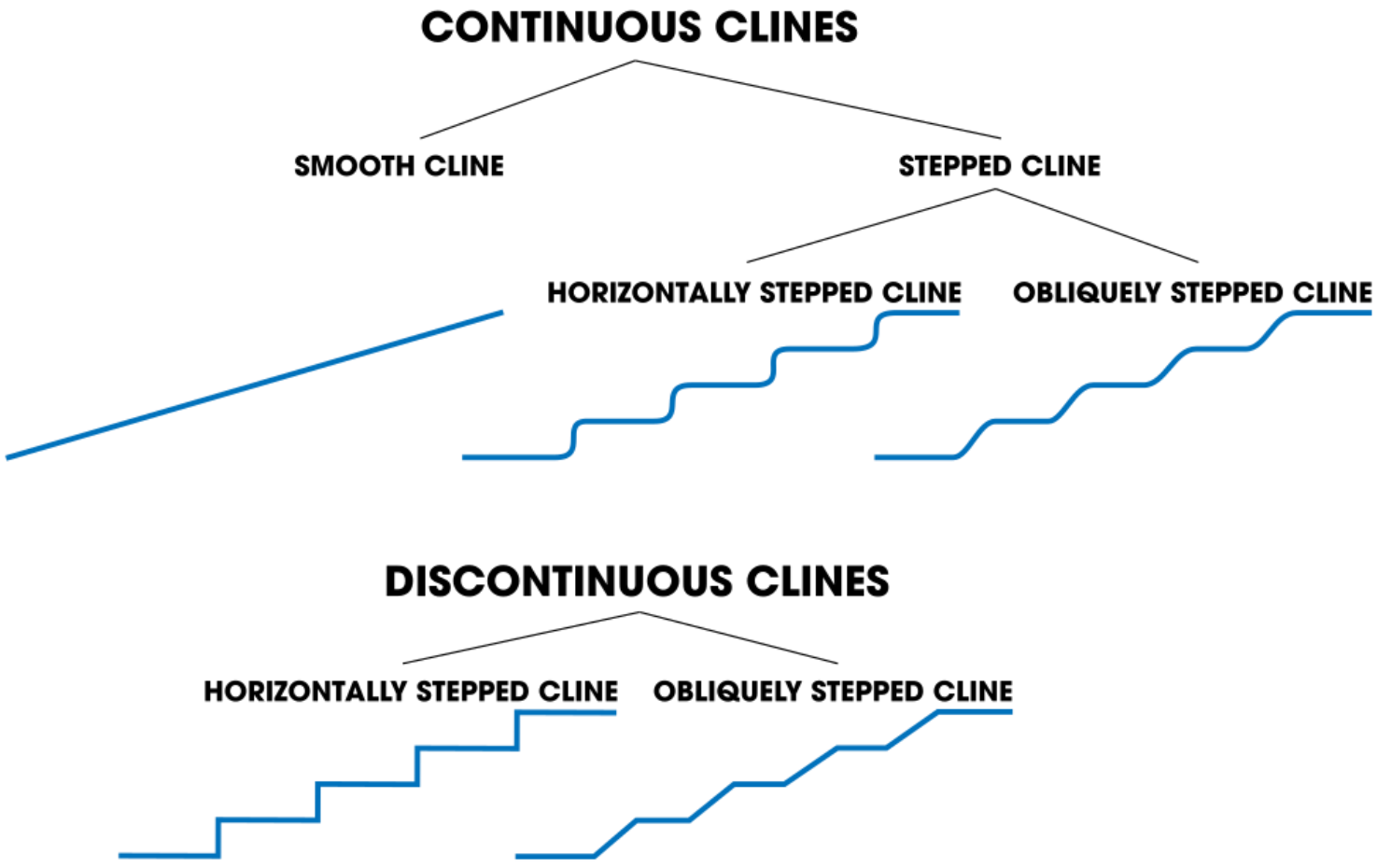
Clinal characters / structure



Clinal characters change from one end of the geographic range to another

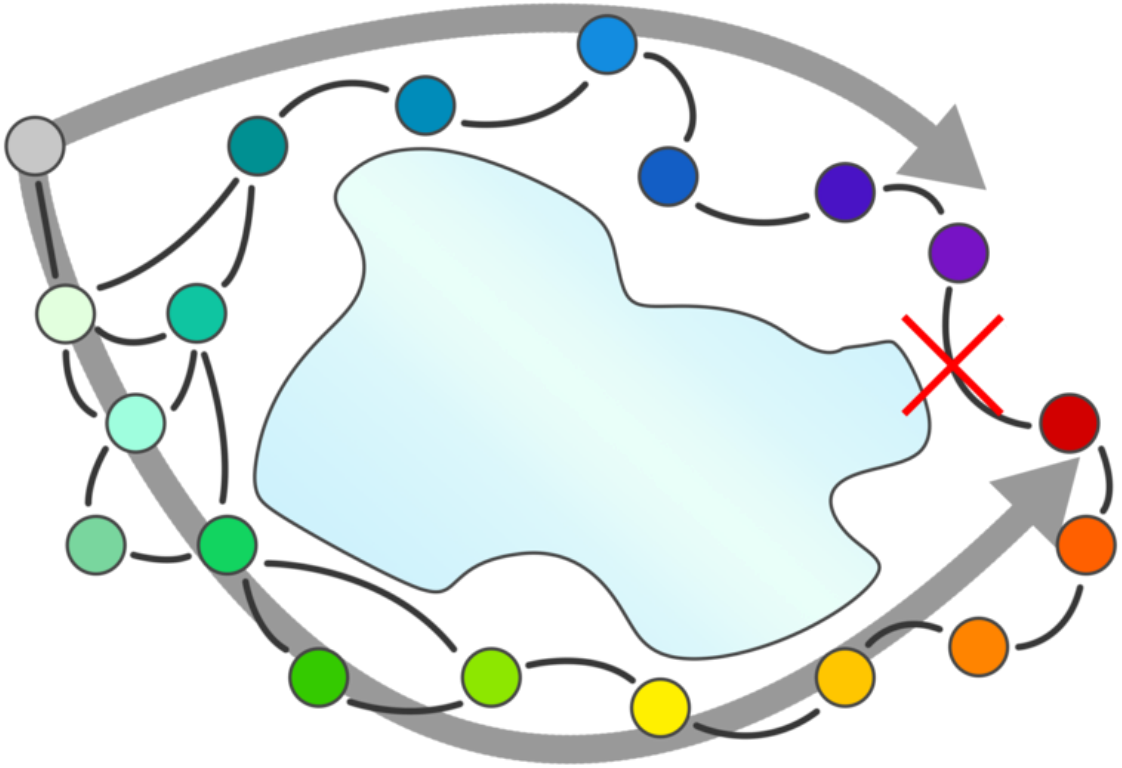
The extent of this change is reflected in the slope of the cline

Types of clines as defined by Huxley



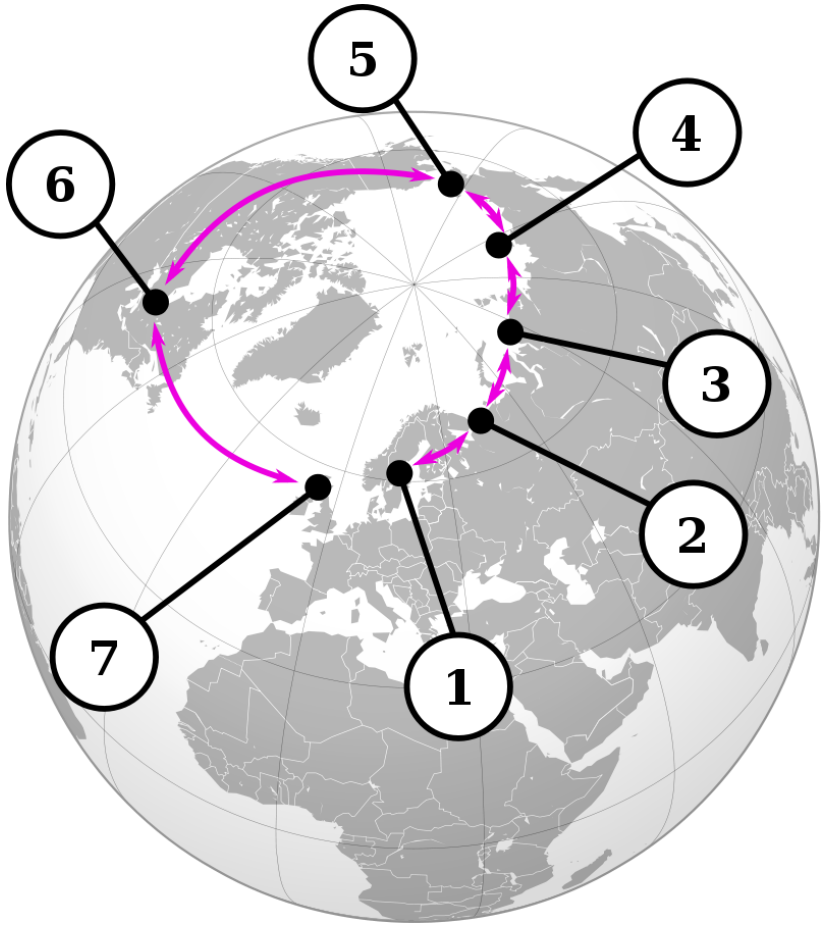
Examples of clines

Bergmann's Rule demonstrated showing the difference in size between a larger northern fox, whose range spans colder regions, and a smaller desert fox, whose range is primarily in hot regions



Interbreeding populations represented by a gradient of coloured circles around a geographic barrier

Ring species



The *Larus* gulls interbreed in a ring around the arctic

1. ***Larus argentatus argentatus***
2. ***Larus fuscus* (*sensu stricto*)**
3. ***Larus fuscus heuglini***
4. ***Larus argentatus birulai***
5. ***Larus argentatus vegae***
6. ***Larus argentatus smithsonianus***
7. ***Larus argentatus argenteus***

Race

In biological taxonomy, race is an informal rank in the taxonomic hierarchy, below the level of subspecies

It has been used as a higher rank than strain, with several strains making up one race

Various definitions exist. Races may be genetically distinct populations of individuals within the same species or they may be defined in other ways, e.g. geographically, or physiologically

Genetic isolation between races is not complete, but genetic differences may have accumulated that are not (yet) sufficient to separate species

The term is recognized by some, but not governed by any of the formal codes of biological nomenclature

Races are defined according to any identifiable characteristic, including gene frequencies

Race differences are relative, not absolute

Adaptive differences that distinguish races can accumulate even with substantial gene flow and clinal (rather than discrete) habitat variation

Hybrid zones between races are semi-permeable barriers to gene flow, for example the chromosome races of the Auckland tree wētā

Chromosomal race

A population distinguished by having a unique karyotypes, i.e., different chromosome numbers (ploidy), or different chromosome structure

Geographical race

A distinct population that is isolated in a particular area from other populations of a species, and consistently distinguishable from the others, e.g. morphology (or even only genetically)

Geographic races are allopatric

Physiological race

A group of individuals that do not necessarily differ in morphology from other members of the species, but have identifiably different physiology or behaviour

A physiological race may be an ecotype, part of a species that is adapted to a different local habitat, defined even by a specific food source

Parasitic species, often tied to no geographic location, frequently have races that are adapted to different hosts, but difficult to distinguish chromosomally

A physiological race is not to be confused with a *physiologic race*, an obsolete term for cryptic species

Neither biological form nor *forma specialis* should be confused with the formal botanical taxonomic rank of *forma* or form, or with the zoological term form, an informal description (often seasonal) which is not taxonomic

The term *race* has also historically been used in relation to domesticated animals, as another term for *breed*

this usage survives in combining form, in the term landrace, also applied to domesticated plants

Ernst Mayr wrote that a subspecies can be "a *geographic race* that is sufficiently different taxonomically to be worthy of a separate name

Study of populations preliminarily labelled races may sometimes lead to classification of a new species

For example, in 2008, two populations of the brown planthopper (*Nilaparvata lugens*) in the Philippines, one adapted to feeding on rice, and another on *Leersia hexandra* grass, were reclassified from races into "two distinct, but very closely allied, sympatric species

Based on poor survival rate when given the opposite food source, barriers to hybridization between the populations, uniform preference for mating between members of the same population, differences in mating sounds, oviposition variances, and other distinguishable characteristics

For pathogenic bacteria adapted to particular hosts, races can be formally named as pathovars

For parasitic organisms governed by the *International Code of Nomenclature for algae, fungi, and plants*, the term *forma specialis* (plural *formae speciales*) is used

Species Concepts and the Definition of "Species"

1) Biological species concept: Species are groups of actually or potentially interbreeding natural populations, which are reproductively isolated from other such groups (Mayr, 1940)

Biological species concept: A species is a reproductive community of populations (reproductively isolated from others) that occupies a specific niche in nature (Mayr, 1982)

Biological species concept: Species are the members in aggregate of a group of populations that breed or potentially interbreed with each other under natural conditions (Futuyma, 1986)

2) Cladistic species concept: **A species is a set of organisms (an evolutionary lineage) between two branch points or between one branch point and an extinction event or a modern population (Ridley 1993)**

3) Cohesion species concept: **A species is the most inclusive group of organisms having the potential for genetic and/or demographic exchangeability. (Templeton, 1989)**

4)Competition species concept: **Species are the most extensive units in the natural economy such that reproductive competition occurs among their parts (Ghiselin, 1974)**

5) Ecological species concept: **A species is a set of organisms exploiting (or adapted to) a single niche (Ridley 1993).**

Ecological species concept: A species is either
1) a lineage which occupies an adaptive zone minimally different from that of any other lineage in its range, and which evolves separately from all lineages outside its range, or
2) a closely-related set of lineages which occupy an adaptive zone minimally different from that of any other lineage in their range and which evolve separately from all other lineages outside their range (translation of Van Valen, 1975)

Ecological species concept: A species is a lineage or a closely related set of lineages, which occupies an adaptive zone minimally different from that of any other lineage in its range and which evolves separately from all lineages outside its range (Van Valen, 1976)

6) Evolutionary species concept: A species is a lineage (an ancestral-descendant sequence of populations) evolving separately from others and with its own unitary evolutionary roles and tendencies (Simpson, 1961)

Evolutionary species concept: A species is a single lineage of ancestor-descendant populations which maintain its identity from other such lineages and which has it own evolutionary tendencies and historical fate (Wiley, 1981)

Evolutionary species concept: A species is a population or group of populations that shares a common evolutionary fate through time (Templeton, 1989)

7) Isolation species concept: **Species are systems of populations: the gene exchange between these systems is limited or prevented by a reproductive isolating mechanism or perhaps by a combination of several such mechanisms. (as defined by Dobzhansky 1970; in Templeton, 1989)**

8) Phenetic species concept: **A species is a set of organisms that look similar to each other and distinct from other sets (Ridley, 1993)**

9) Phylogenetic species concept: **A species is the smallest diagnosable cluster of individual organisms within which there is a parental pattern of ancestry and descent (Cracraft 1983)**

Phylogenetic species concept: **A species is an irreducible (basal) cluster of organisms, diagnosably distinct from other such clusters, and within which there is a parental pattern of ancestry and descent (Cracraft 1989)**

10) Recognition species concept: A species is the most inclusive population of individual biparental organisms which share a common fertilization system (as defined by Paterson, 1985; in Templeton, 1989)

11) Typological species concept: A species is a group of organisms conforming to a common morphological plan, emphasizing the species as an essentially static, non-variable assemblage

According to this concept the observed diversity of the universe reflects the existence of a limited number of underlying "universals" or types (*eidos* of Plato)

Individuals do not stand in any special relation to each other, being merely expressions of the same type

Variation is the result of imperfect manifestations of the idea implicit in each species (Mayr 1969; Lincoln et al. 1982)

Additional Terms Associated with "Species“

Agamospecies: A species of uniparental (asexual) organisms (Simpson, 1961)

Morphospecies: established by morphological similarity regardless of other considerations; a.k.a. "morphological species" (Simpson, 1961)

Paleospecies: temporally successive species in a single lineage; a species which is represented in more than one geological time horizon; a.k.a. "chronospecies", "successional species" or "allochronic species" (Simpson, 1961; Wiley 1981)