Species & higher taxa

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MA Cont. Phil.

The Nature of Species

-two problems regarding biological classification:

-> how to **divide** organisms into **species** - 'the species problem'

-> how to **classify** species into **higher-level categories** - 'the problem of systematics'

-different problems are raised by these two issues

-general philosophical issues:

a) why classify at all? (Locke on general terms)
b) why have a *hierarchical* classification?
c) are our classifications 'real' or 'conventional'? -do they 'carve nature at its joints'?
d) is *essentialism* about biological taxa correct?
e) is there one true way to classify, or not

The Linnaean Hierarchy

-biologists use the **Linnaean** system to classify organisms

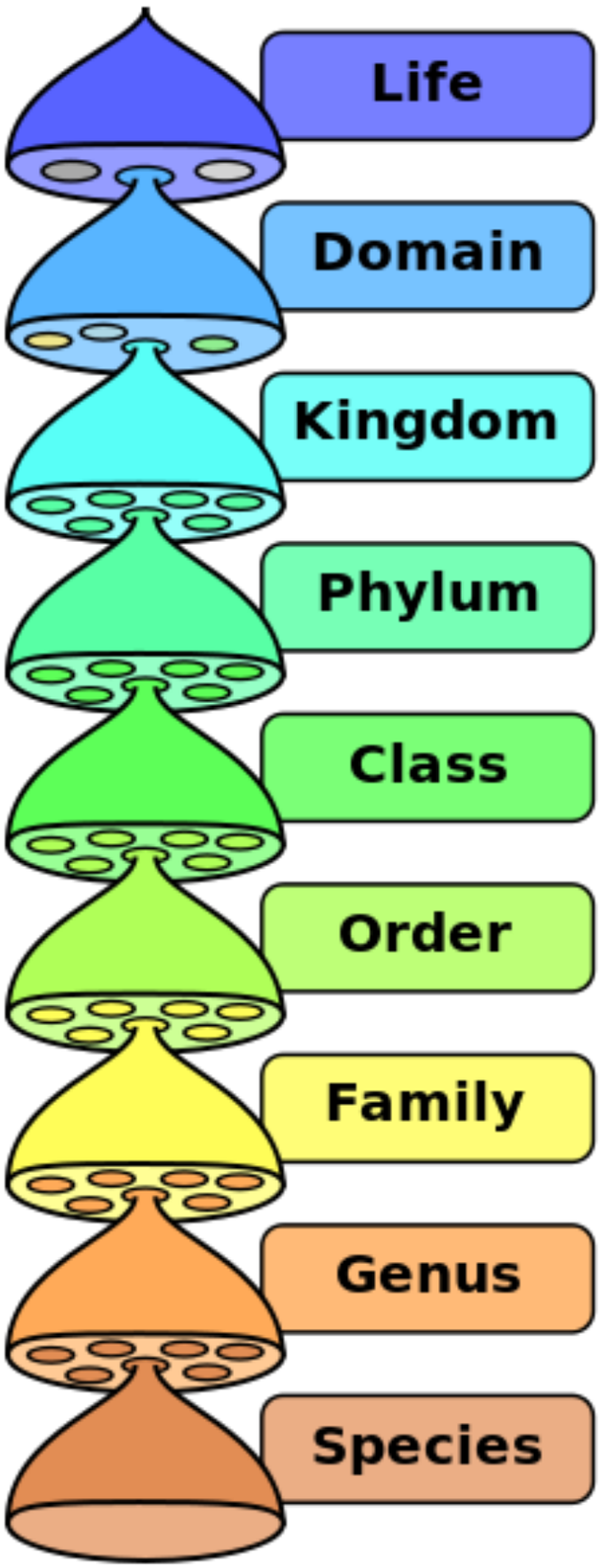
-> organisms are grouped in **species**; species in **genera**; genera in **families**; families in **orders**; orders in **classes**; classes in **phyla**; phyla in **kingdoms**

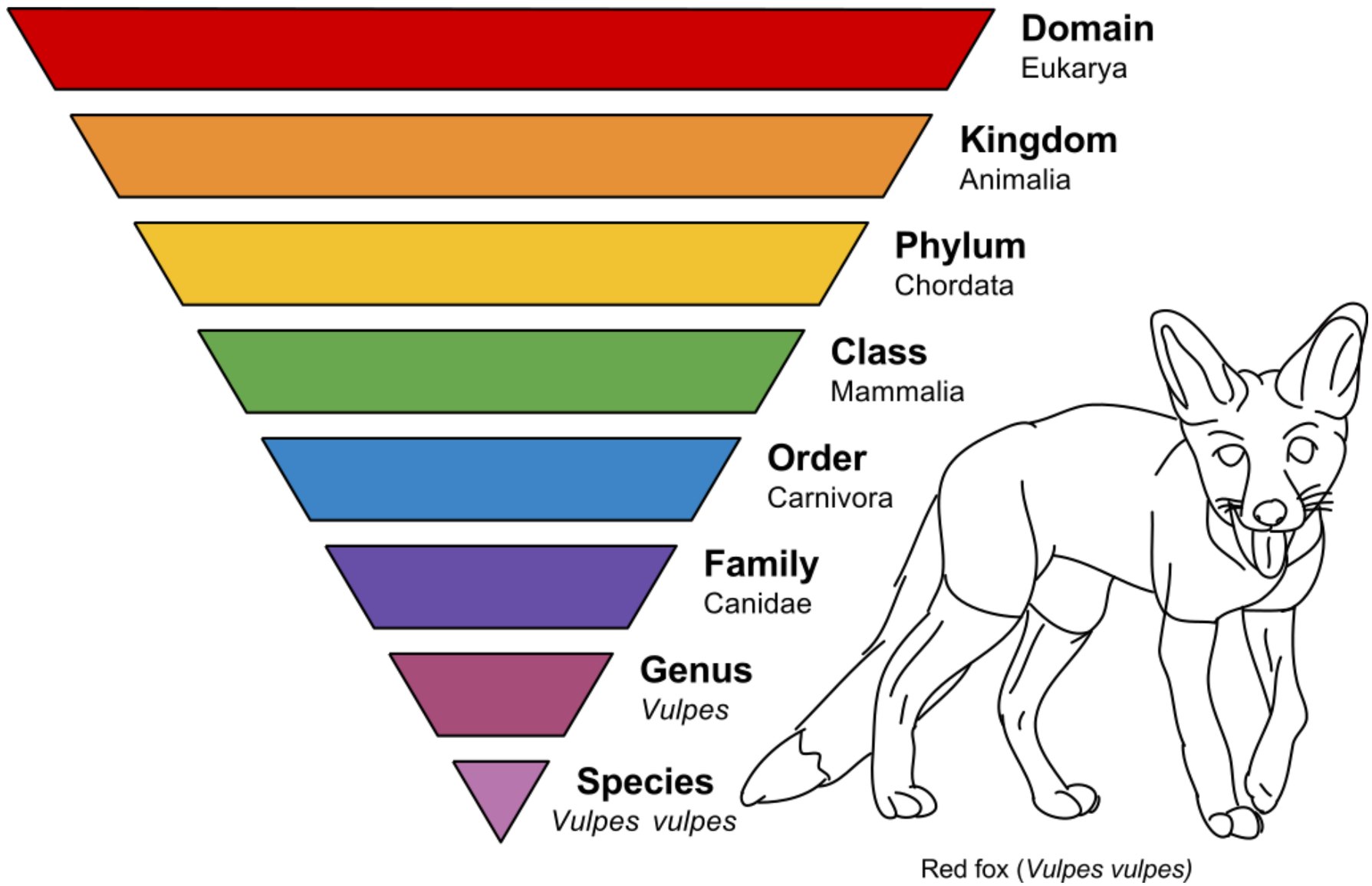
rank

-e.g. grey wolf species *Canis Lupus*
-**genus**: Canis; **family**: Canidae; **order**: Carnivora; **class**: Mammalia; **phylum**: Chordata; **kingdom**: Animalia

-species names indicate the genus to which the species belongs
-> hierarchical nature of classification

-> many biologists feel that species are ‘real’ in way that higher taxa are not





Red fox (*Vulpes vulpes*)

The Species Problem

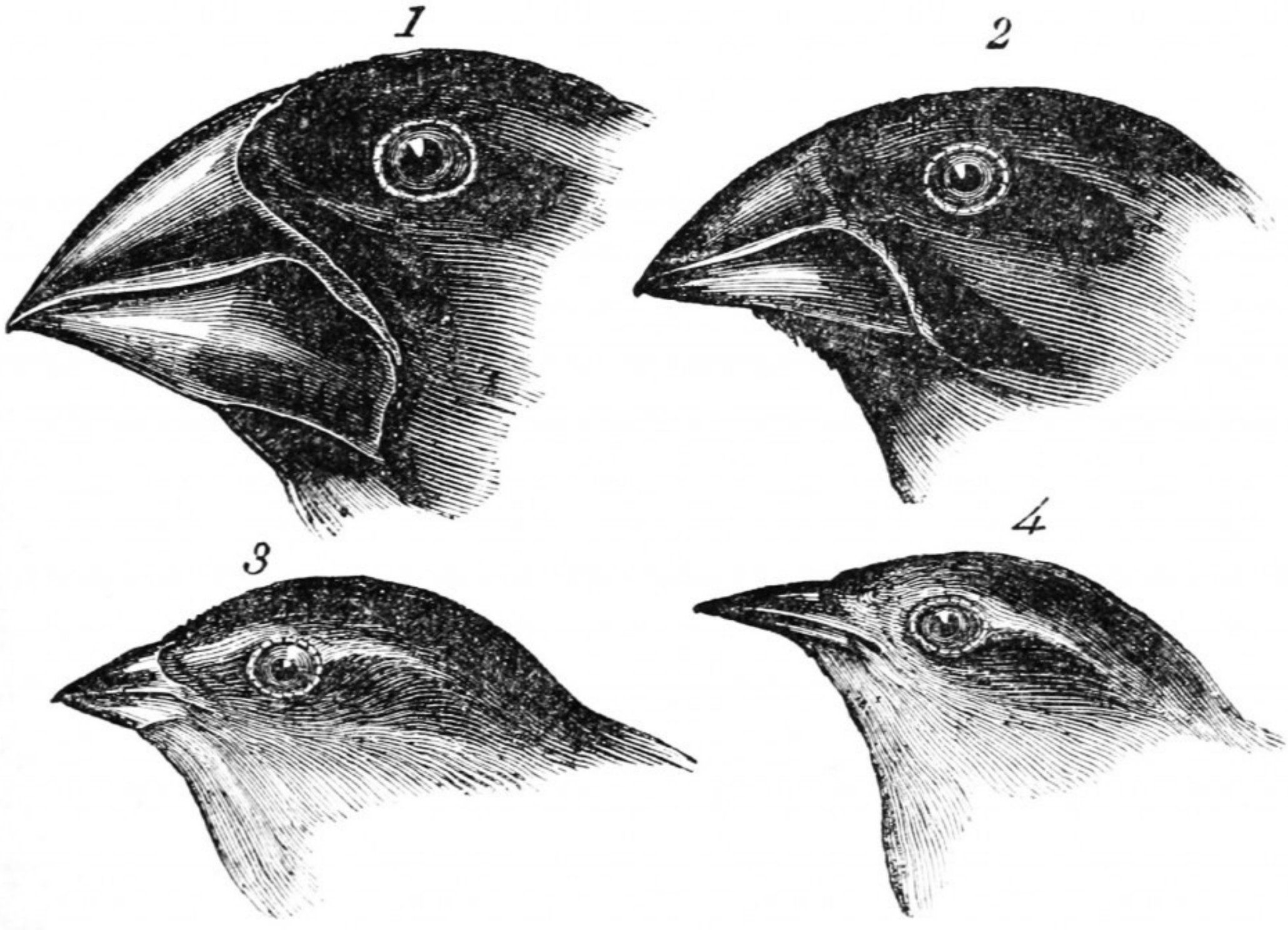
-why a problem?
answer (i): because of evolution, sharp discontinuities **may not exist**

Maynard-Smith:
‘any attempt to divide all living things, **past and present**, into sharply defined groups, between which no intermediaries exist, is foredoomed to failure’

-taxonomists are ‘faced by a contradiction between the practical necessity and the theoretical impossibility of their task’

-> division of **contemporary** organisms into species is less problematic

Mockingbird (Nesomimus)



1. Geospiza magnirostris.
2. Geospiza fortis.
3. Geospiza parvula.
4. Certhidea olivacea.

Galapagos finches -from Darwin's book *Journal of researches into the natural history and geology of the countries visited during the voyage of H.M.S. Beagle round the world, under the Command of Capt. Fitz Roy, R.N.* (1845).

Darwin (*Origin*, ch. 2):

I look at the term species as one **arbitrarily given**, for the sake of **convenience**, to a set of individuals closely **resembling** each other, and that it **does not essentially differ from the term variety**, which is given to **less distinct** and **more fluctuating** forms.

The Species Problem

answer (ii): because the species concept is meant to satisfy multiple desiderata

e.g. we want con-specific organisms to:
i) look similar
ii) interbreed only with each other
iii) be genetically similar
iv) constitute a ‘real’ evolutionary unit
v) occupy a single ecological niche

unclear whether a single concept can do all this work
-> **pluralism** about species concepts

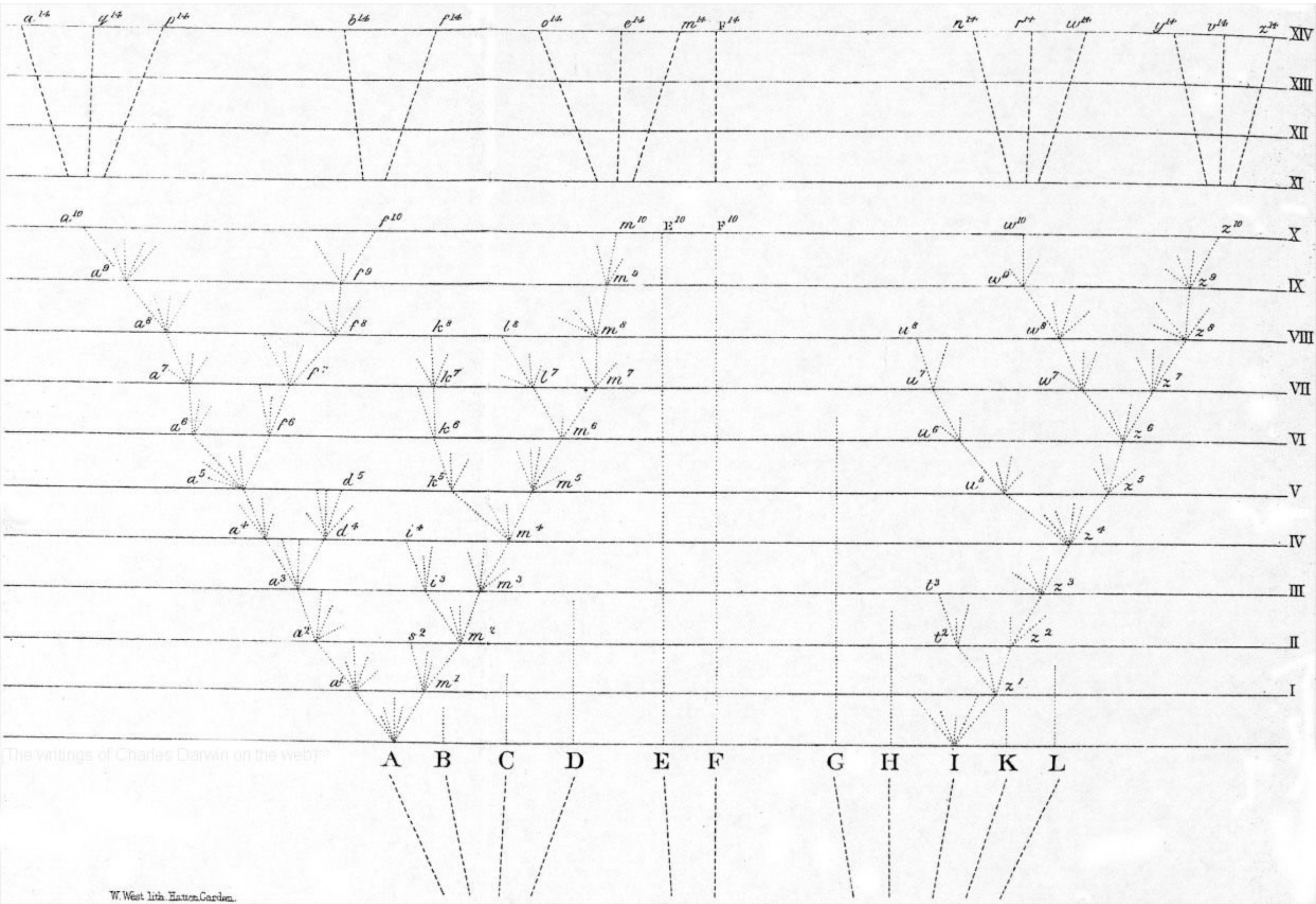
Mayr on the *typological* species concept

-> types of organisms, with characteristic properties
-> **essentialism**
[essential property/ essence]

-> hard to reconcile with **<u>darwinian evolution</u>**
-> species as ‘things’ that have a beginning and an end (but with <u>vague</u> boundaries), that originate from other species
-> **<u>diversity</u>** within a species -not deviation from a type, but the ‘normal’ state

Ernst Mayr: **typological vs population thinking**

—> <u>diversity + vague boundaries</u>



The tree of life, the only picture in *Origin*

Modern Ideas about Species

3 main types of species concepts:

a) **biological** species concept

b) **phenetic** species concept

c) **phylogenetic** species concept

-> many versions of each

Modern Ideas about Species

-the **biological species concept** is most widely used

-defines species in terms of *reproductive isolation*

-**Ernst Mayr**: 'species are groups of interbreeding natural populations that are **reproductively isolated** from other groups '

-later, Mayr replaced 'interbreeding' with 'potentially interbreeding'

'groups of actually or potentially interbreeding natural populations which are reproductively isolated from other such groups'

-when biologists use the word 'species', they often have Mayr's concept in mind

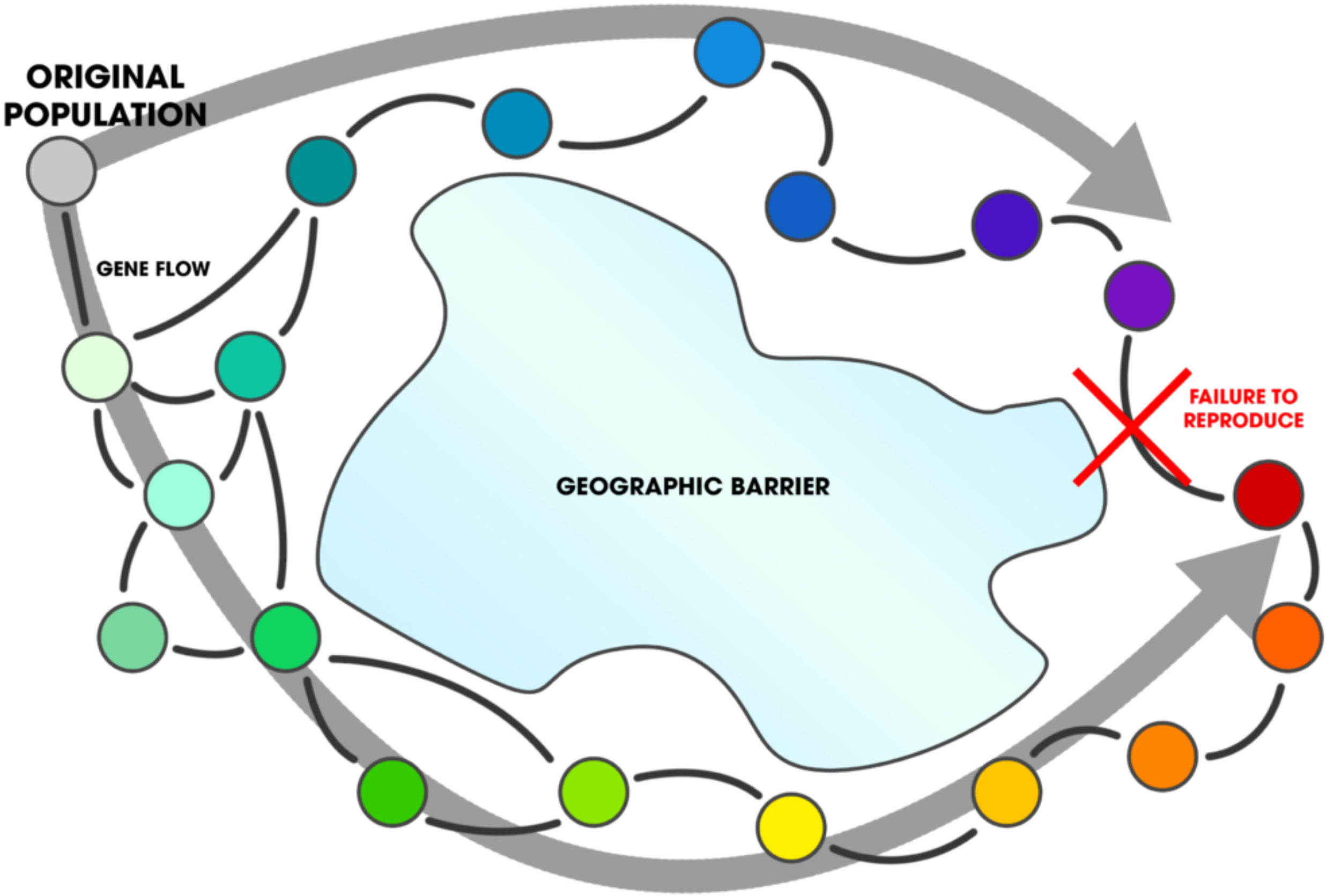
Modern Ideas about Species

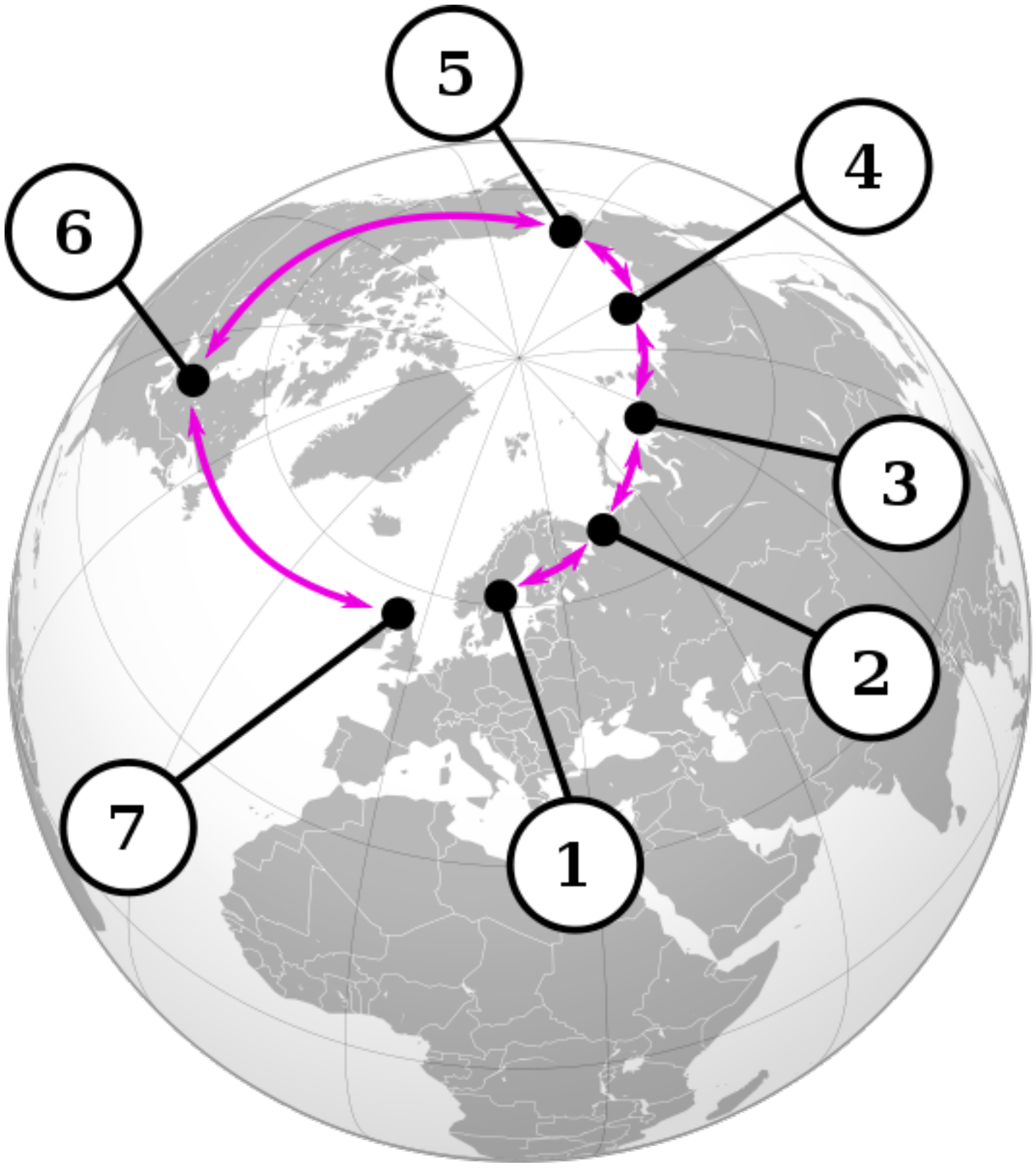
problems:
i) asexual organisms (e.g. bacteria)
ii) reproductive isolation comes in degrees -subspecies, varieties -> hybrid zones
iii) non-transitivity of the relation 'can interbreed with' -ring species
iv) can't apply over time
v) potentially vs actually interbreeding

-> **cohesion** species concept (Templeton)

-> cohesion mechanisms that give cohesion to the species -not only reproduction, but ecological factors too

-> **ecological** species concept (van Valen)





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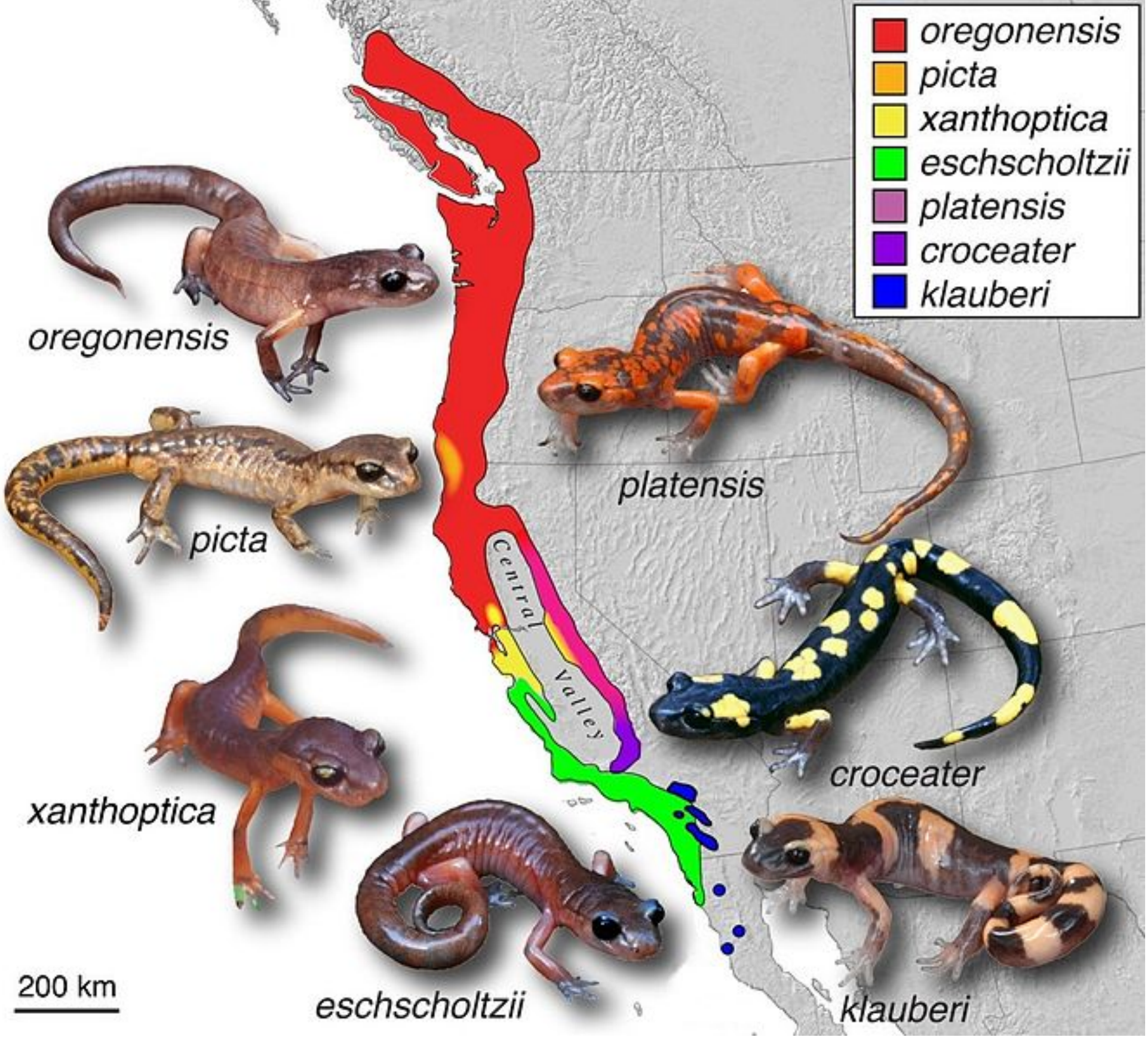
Author: Frédéric MICHEL



Modern Ideas about Species

-the **phenetic species concept** is part of a broader approach to taxonomy called **pheneticism**

-underlying philosophy: taxonomic concepts must be **operationally definable**, and 'theory-free'

-**basic idea**: species are groups of similar organisms
-hope: to find some measure of **overall morphological/ genetic similarity**

-underlying philosophy: positivism/empiricism

Modern Ideas about Species

-seems intuitive, but many problems:

i) some species are highly **polytypic**

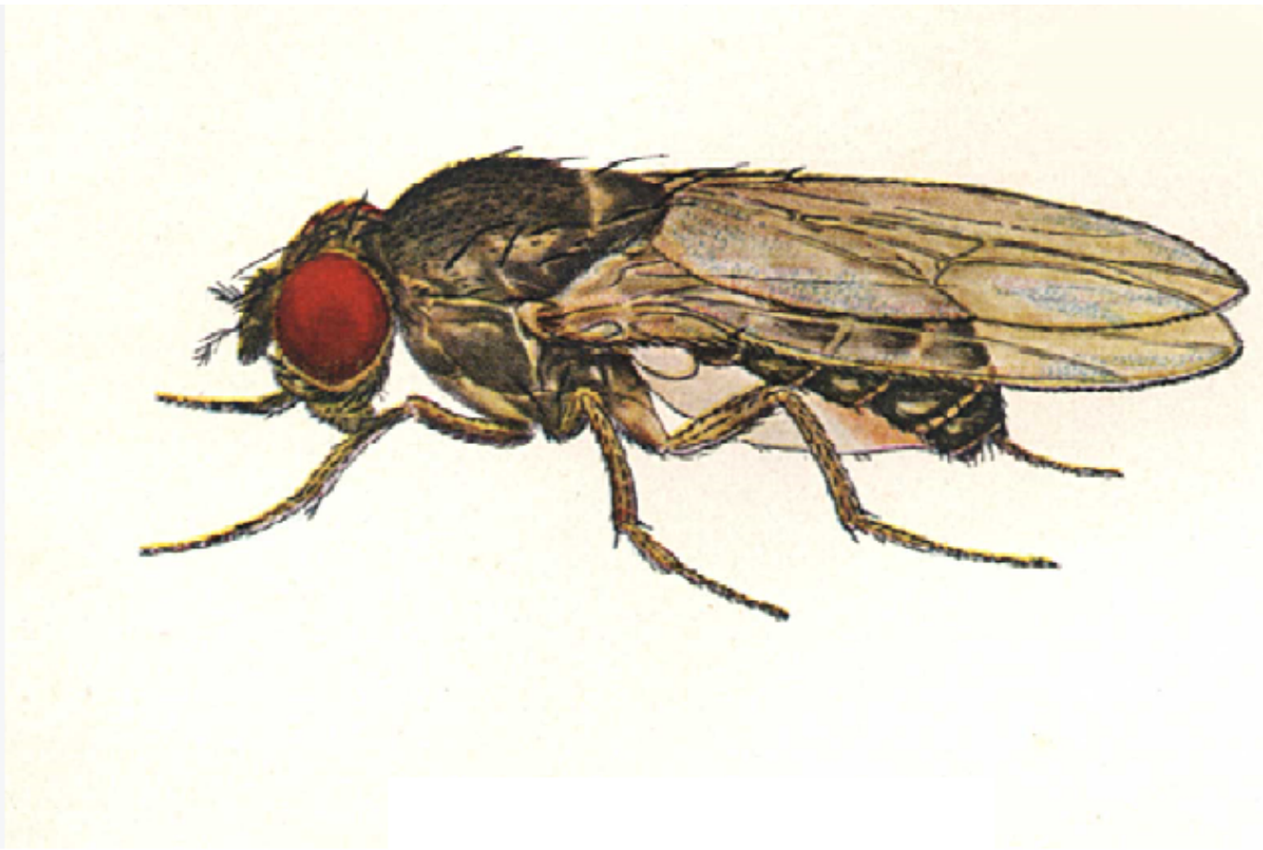
ii) intra-specific morphological and genetic variation are widespread (e.g. differences between males and females)

iii) sibling species

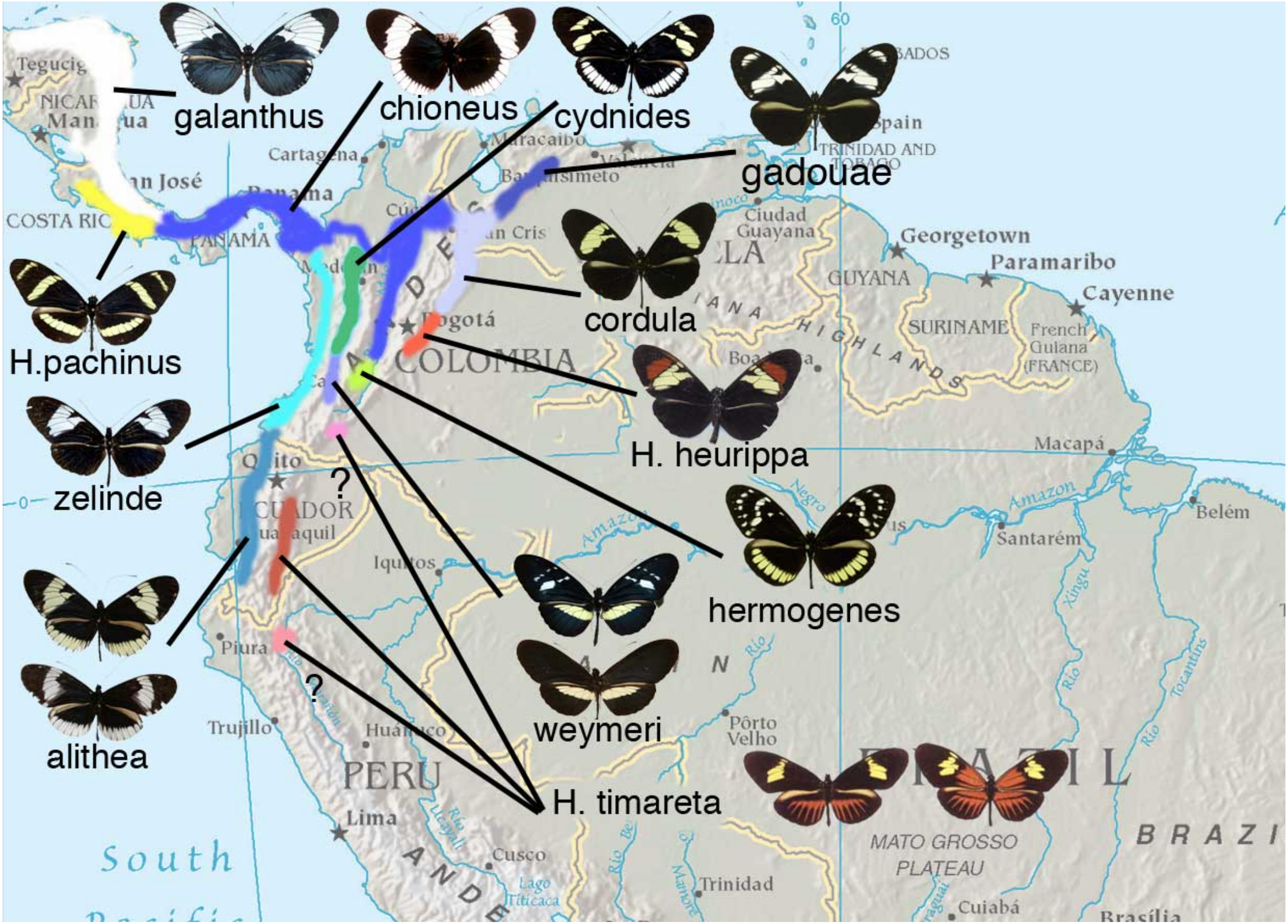
iv) different similarity measures give different results -i.e. it doesn't work

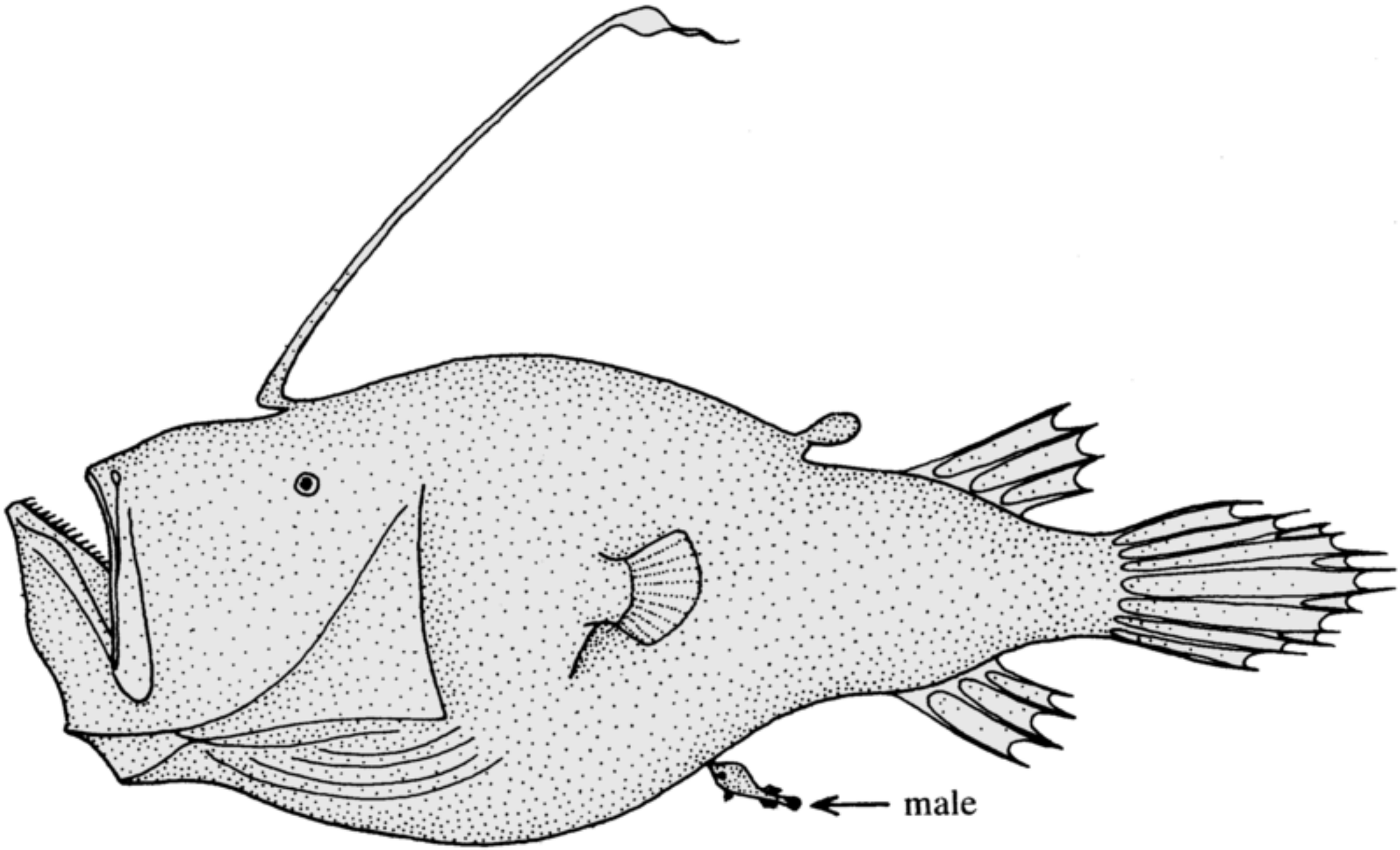
v)'overall similarity' not a fully objective notion -ideal of 'theory-free' classification is probably unattainable

Drosophila persimilis



Drosophila pseudoobscura





Modern Ideas about Species

-> all previous species concepts have difficulties with diachronic comparisons between organisms

-the **phylogenetic species concept** identifies a species with a segment of the phylogenetic tree

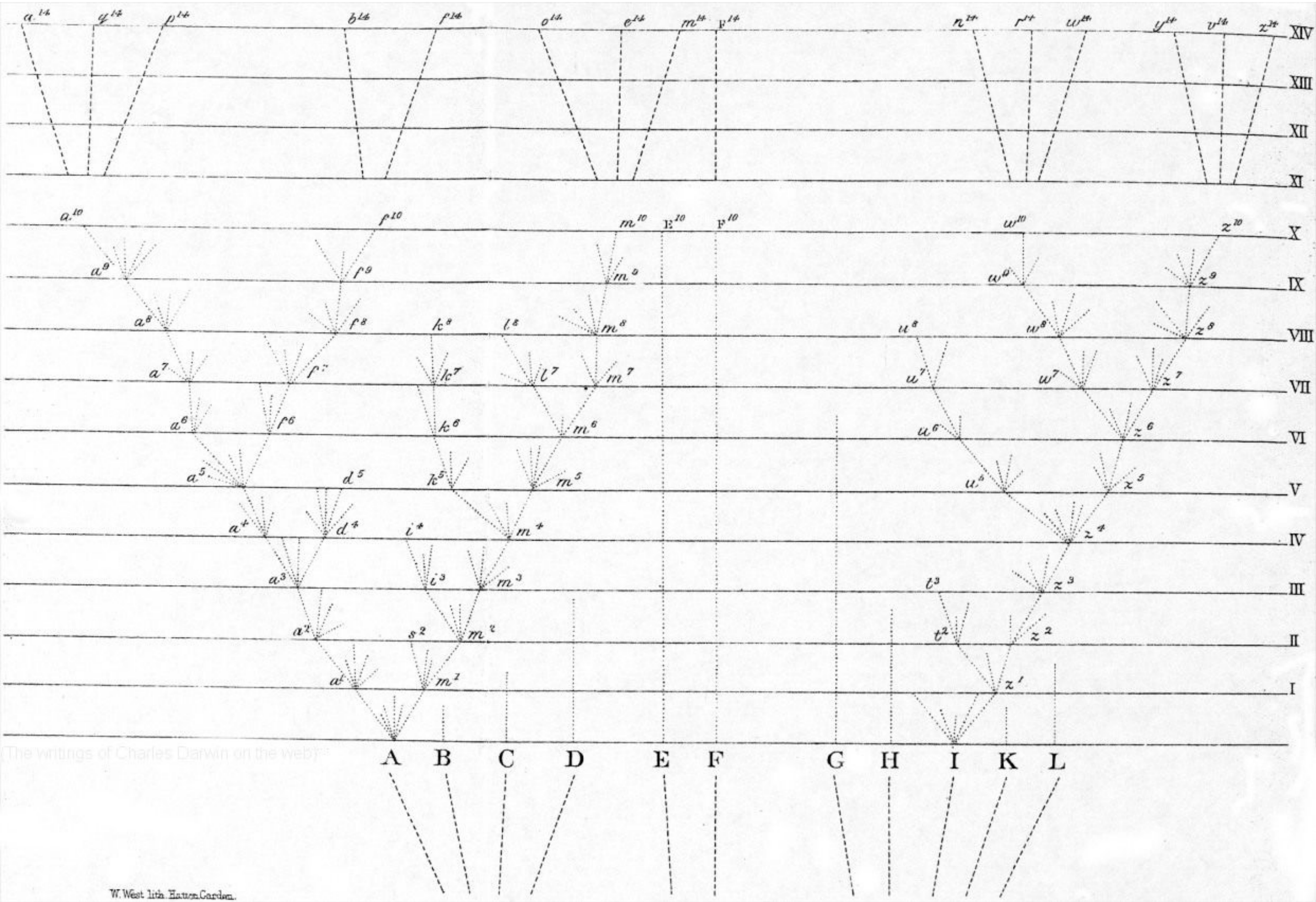
-a species is a segment of the tree bounded by two speciation events, or by a speciation event and an extinction event

-but what's a speciation event, i.e. when has one lineage split into two?

-phylogenetic concept is **parasitic** on a non-temporal concept, to provide an account of speciation events

-> BSC applies to contemporaneous organisms, PSC to organisms across time

-> a general point: despite the above problems, in many cases organisms can be unproblematically assigned to species



W. West 11th. Hatton Garden.

Modern Ideas about Species

-> PSC solves problem with organisms that cannot reproduce
π.χ. worker bees

-termination of species at each branching?
-no speciation without branching? (cladogenesis vs anagenesis)

-what about bacteria? too many branchings!
-**phenetic** species concept adopted by microbiologists
-genetic similarity instead of overall?

-> but genetic profile can change diachronically

Modern Ideas about Species

-> **<u>4 positions</u>** concerning species:

1: -> **pluralism**
-> different species concepts for different purposes

2: -> not many different species concepts, but the notion of a biological species has <u>collapsed</u>

3: (version of 2) -> useful to talk about species, but species are not real units in the worlds -they do not really exist

4: insist on **monism**
-> πχ Queiroz: **General Lineage Concept:**
τα είδη είναι “separately evolving metapopulation lineages” (2005, 1263)

The ontological status of biological species

-traditional assumption: species are **kinds**, or classes

-i.e. Charles Darwin is a particular, *Homo Sapiens* is the kind to which he belongs

-but many people today argue that species are individuals, not kinds (Hull, Ghiselin)

-kind membership vs mereological inclusion (part-whole relationship)

The ontological status of biological species

Hull/Ghiselin argument:

-natural kinds are *spatiotemporally unrestricted*, e.g. gold

-but species aren't, unless we accept a phenetic account, but phenetic accounts don't work

-species have a birth and a death, just like organisms

therefore, species are individuals

-relation between Charles Darwin and *Homo sapiens* is like the relation between a cell in Charles Darwin's hand and Charles Darwin himself

(implicit assumption: 'natural kind' vs 'individual' is an exhaustive dichotomy)

The ontological status of biological species

(alleged) consequences of individuality thesis:

a) once extinct, always extinct

b) reality of species not compromised by impossibility of finding necessary and sufficient conditions for species membership -not to be expected

c) essentialism about species refuted (perhaps)

-essentialism: kinds have essential properties, e.g. gold has essential property of having atomic number 79
(Locke, Aristotle, Kripke)

-> if essences have to be **intrinsic** properties, then essentialism about species is wrong
-> but if they can include **relational** properties, it's much less clear

-individuality thesis reconciles the *reality* of species with the impossibility of finding necessary and sufficient conditions for species membership

-analogy between cells/organs and the whole organism, and organisms and species
-part/whole relationship doesn't require essences, in a sense

Systematics and Classification

The Problem of Systematics

-systematics is the modern name for taxonomy
-basic issue: how to organise species into a classification system?
-i.e. into higher taxa or not?
-not exactly analogous to the species problem
-> for many biologists, species are real, but higher taxa are not - why?

-especially in 1970s and 80s, massively controversial subject
-one point of agreement: should be hierarchical
-why?
-one possible answer: evolution is a branching process, and classification must reflect that process
-but not everyone accepts this

The Problem of Systematics

3 competing schools in systematics:

a) pheneticists

b) cladists (phylogenetic systematics)

c) evolutionary taxonomists

The Problem of Systematics

pheneticism: defines taxa by overall similarity

cladism: classification must reflect evolutionary descent

evolutionary taxonomy: a kind of mixture of phoneticist and cladism (though it came first)

-> dispute is about methodology of classification
-> but also practical application

-> this dispute isn't about species (we treat the species problem as solved)

example:
-humans, chimpanzees, gorillas, bonobos, orangutans and gibbons are classed together as members of the **Hominoid** superfamily
-but baboons are not counted as Hominoids
-why?

-cladists and pheneticists would answer this question differently

Phenetic Approaches

-also called ‘numerical taxonomy’
-aim: classify on the basis of ‘overall similarity’

-pheneticists would say that the Hominoid species share traits that the baboons lack
-e.g. absence of tail
-hence baboons should be excluded

-underlying philosophy: empiricism
-biological taxa must be *operationally definable*

-classification should be ‘theory free’

Phenetic Approaches

-problem: similar in what respects?
-what is overall similarity
-> different similarity measures yield different classifications
-no way of choosing between them

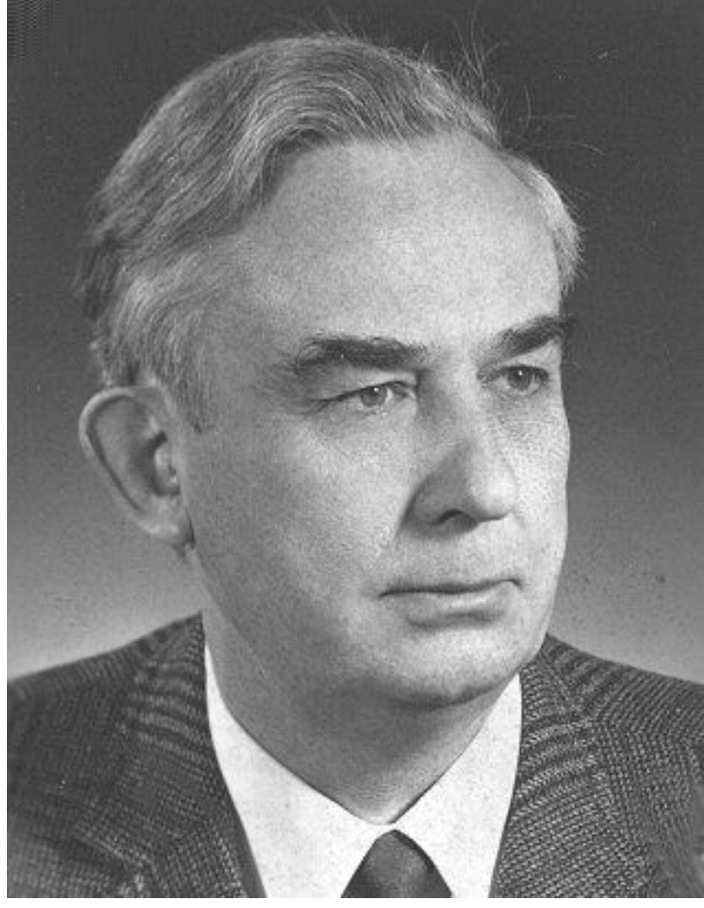
-is ‘theory-free’ classification possible?
-many say no

-> pheneticism about higher taxa faces similar problems to pheneticism about species

-note that pheneticism doesn’t care about genealogical relationships of species to one another
-but only about observable phenotypic traits

Cladism

-key idea: classification must reflect evolutionary relationships
-cladists insist that all taxa must be **monophyletic**
-according to them, any non-monophyletic taxa are not real, but mere artificial groupings

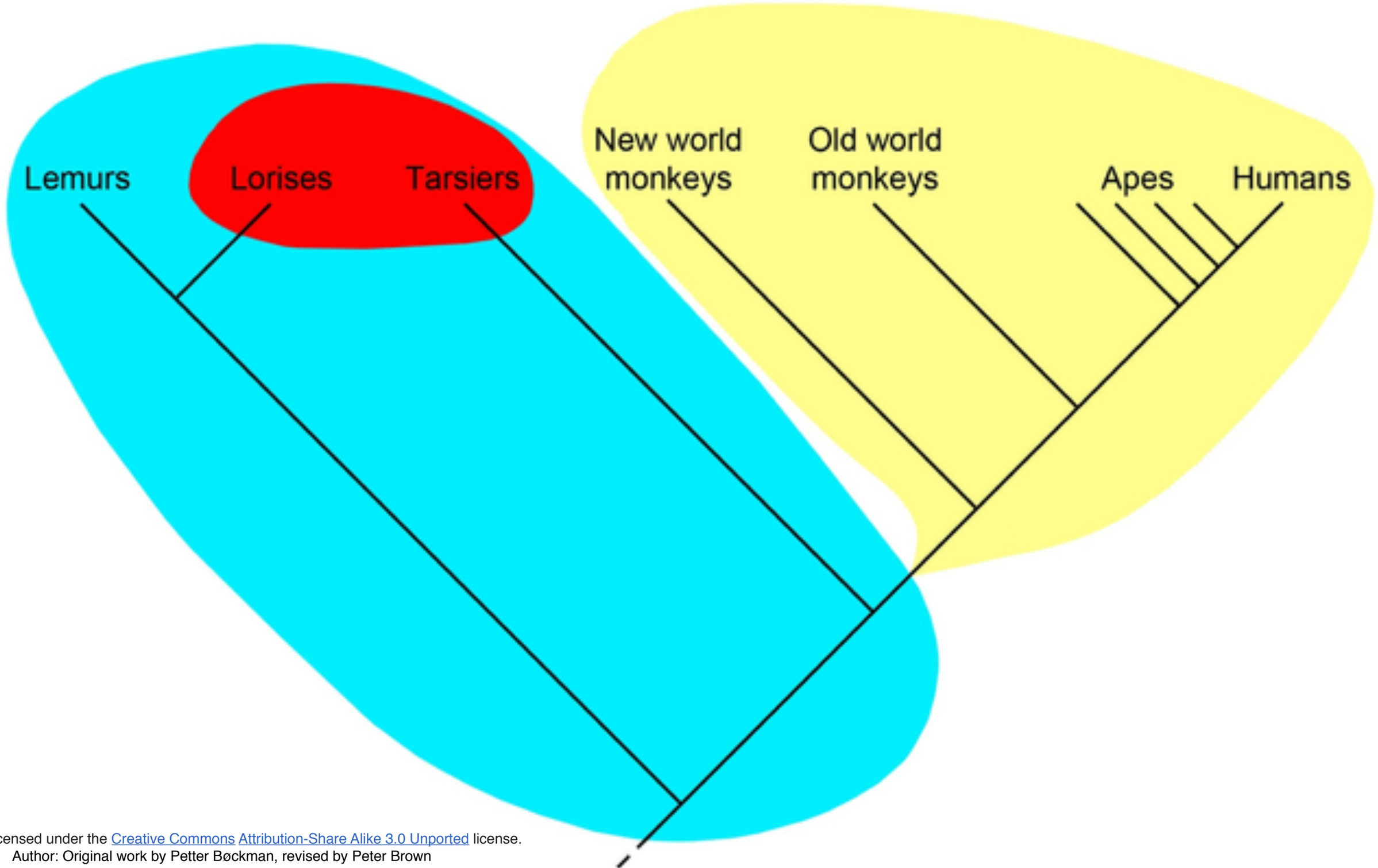


Willi Hennig
1913-1976

-concept of **monophyly**
-a monophyletic group is a group composed of an ancestor species, **all** of its descendants species, **and no-one else**

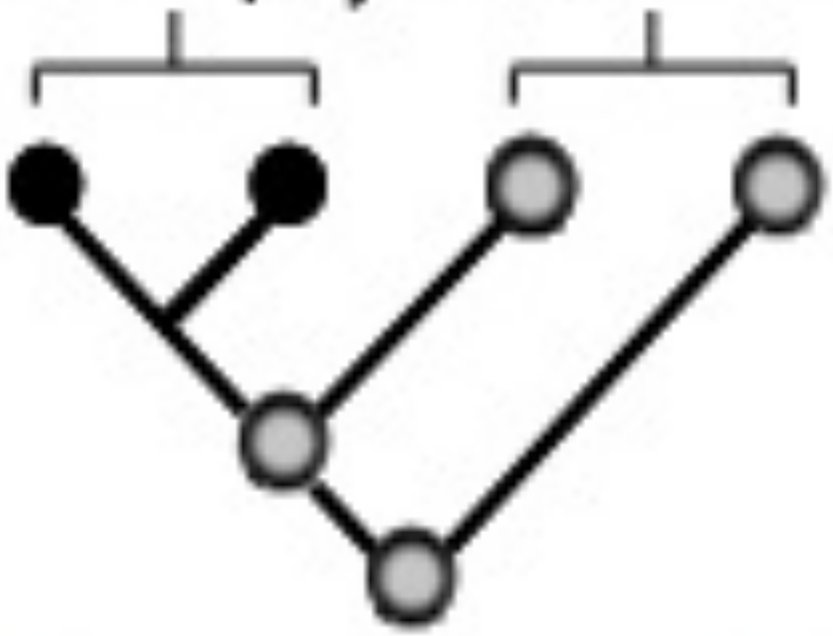
-> when we ask if a group of species is monophyletic, this doesn't mean 'do they share a common ancestor?'
-the answer to that question is always yes
-rather, it means 'do they share a common ancestor that's *not* ancestral to any species outside the group'

-> cladists don't care about the phenotypic appearances
-for them, classification should go exclusively by evolutionary relationship

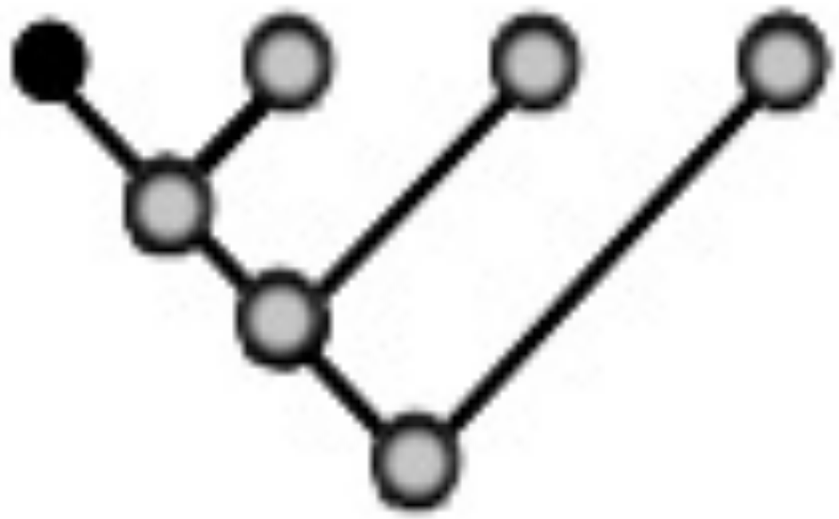


Apomorphy

Plesiomorphy

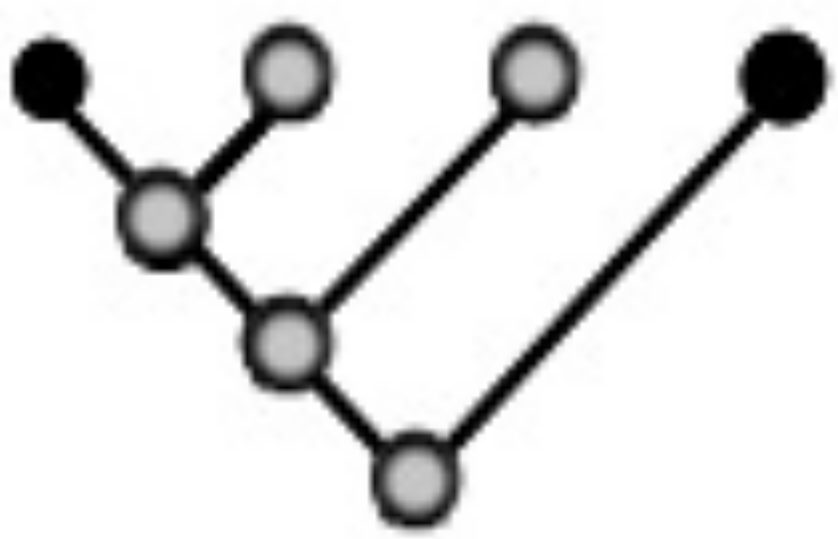


Autapomorphy



Synapomorphy

Homoplasy



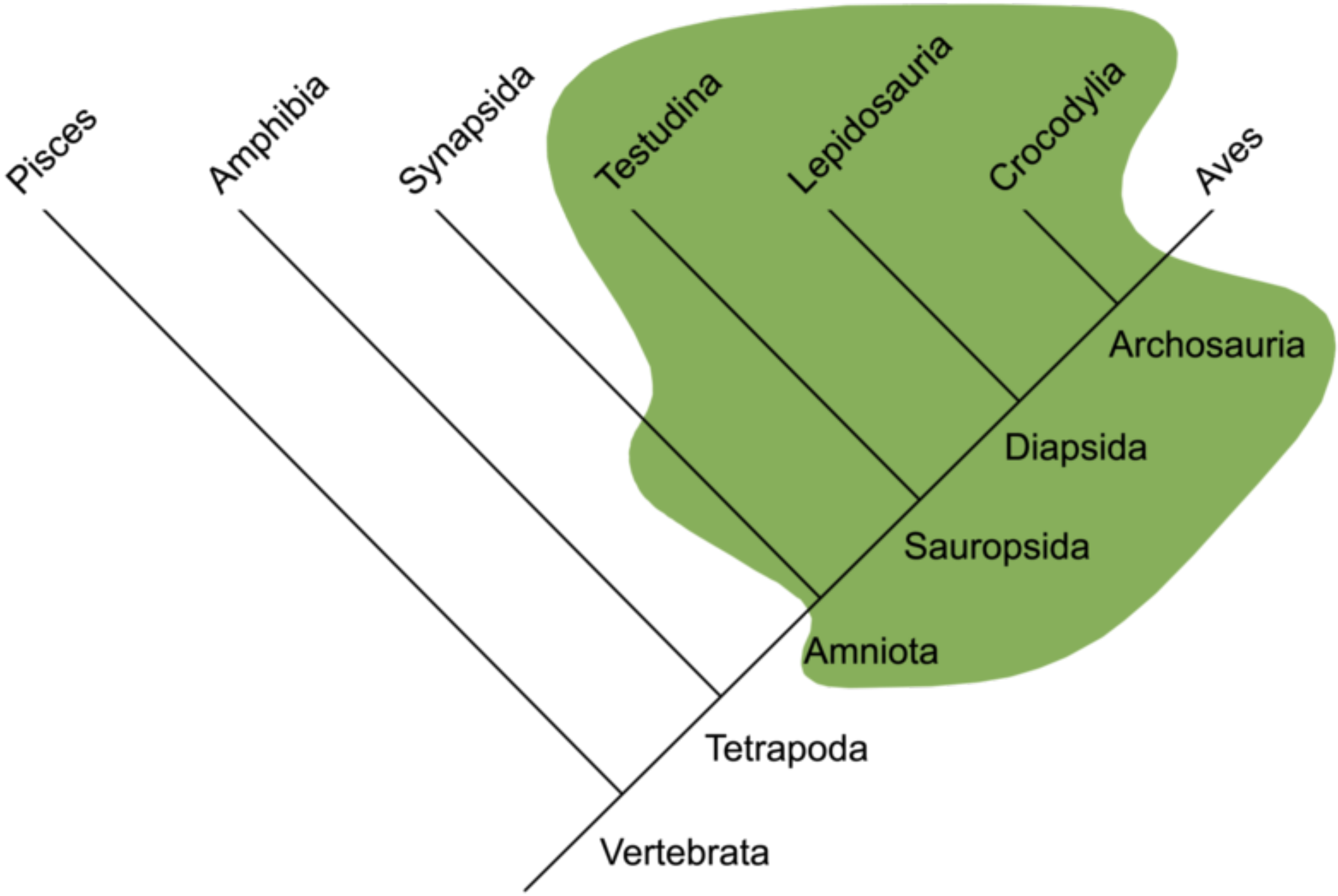
Ancestral trait (○)

Derived trait (●)

Cladism

-> this is not just an academic dispute
-example of *Reptilia* (reptile class)

-cladists insist that Reptilia should be abandoned
-because it's not monophyletic
-pheneticists say that's crazy
-in practice, unlikely that Reptilia will be abandoned



Cladism

-cladists attack others for allowing paraphyletic and polyphyletic groups (which are accepted by evolutionary taxonomists)

-**paraphyletic** groups contain only descendants of a single ancestral species, but not all of them
-**polyphyletic** groups contain species that share no common recent ancestor
-how to decide whether a **monophyletic** group is a genus, family, class, order etc?
-most cladists say, it's totally arbitrary
-i.e. *ranks* in Linnaean hierarchy are just conventions

-> rank-free taxonomy

-> cladism provides a clear justification why classification should be **hierarchical**:
-apply criterion of monophyly to a branching process, and you get a hierarchical classification
-> branching process and a reticulate process
-pheneticists have no comparable justification for the hierarchy assumption
-there is no obvious reason why similarity relationships should be nested

Cladism

advantages of cladism
a) it's unambiguous, at least in principle
b) implies there's a uniquely correct way to classify
c) justification for hierarchical classification
d) in a way the most 'natural' view -something intuitive about the idea that only monophyletic groups are 'real'

disadvantages of cladism
a) very revisionary
b) has radical implications, e.g. abandon *Reptilia*
c) how do we find out if a group *is* monophyletic or not? -this is the 'problem of phylogenetic inference'

Evolutionary taxonomy

-> evolutionary taxonomists: genealogy sometimes can override overall similarity, but not always

-aim: to include paraphyletic groups, but exclude polyphyletic groups

-method: use derived *and* ancestral homologies to identify groups, rather than just the latter

-> cladists use only shared derived homologies to determine classification
-neither group uses *analogies*

The Problem of Phylogenetic Inference

-basic issue: how to discover the phylogenetic (evolutionary) relations between species?

-e.g. three species A, B and C
-two possible hypotheses

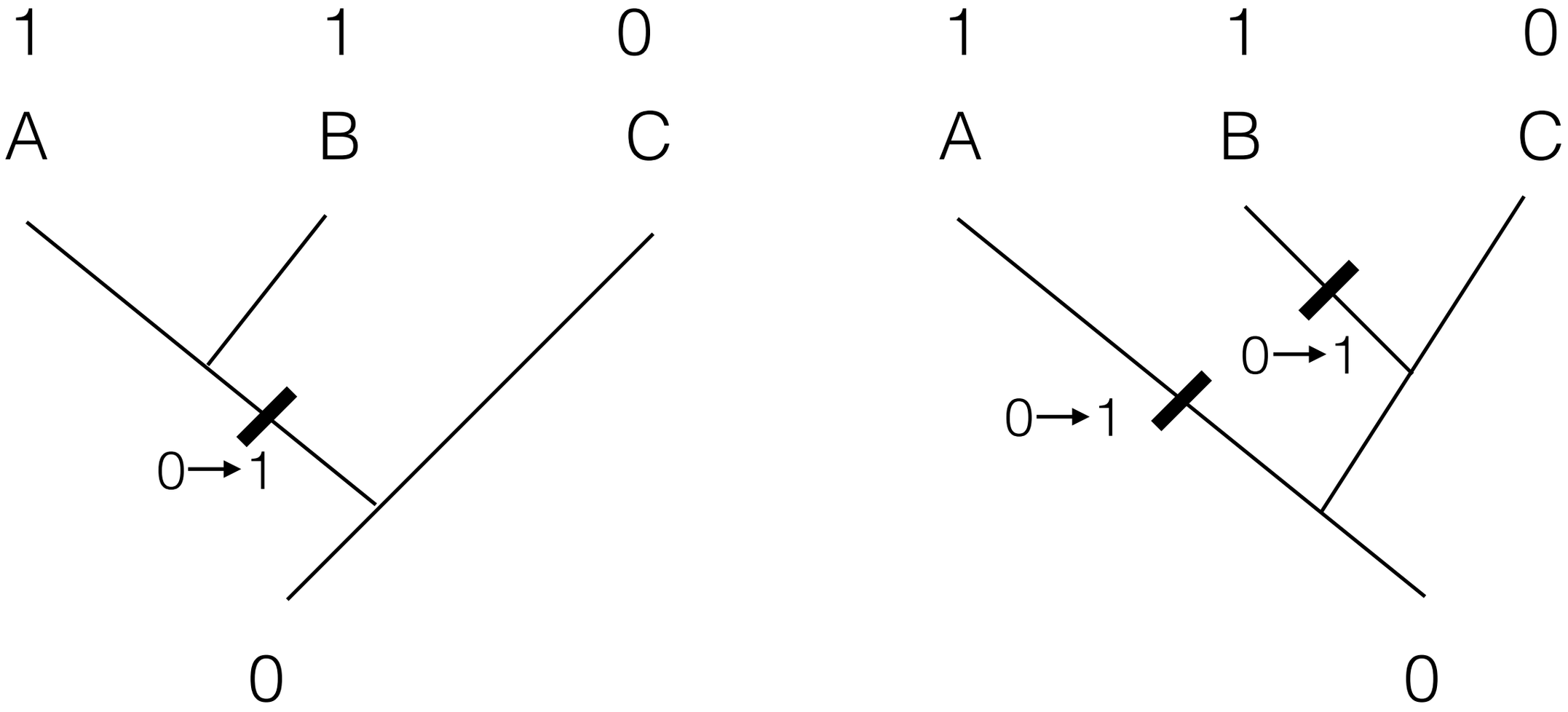
-how to decide which is most plausible?

-key cladistic idea: we use the principle of **parsimony**

-we pick the hypothesis that requires the **fewest number of evolutionary changes**

-> but two problems:
i) how do we discover the **primitive** state of the character?
ii) is there any real **justification** for the principle of parsimony?

The Problem of Phylogenetic Inference



Hypothesis (AB)C

Hypothesis A(BC)

For further study:

-Godfrey-Smith, *Philosophy of Biology*, ch. 7

-https://plato.stanford.edu/entries/species/

-https://www.nature.com/scitable/topicpage/reading-a-phylogenetic-tree-the-meaning-of-41956

-https://www.nature.com/scitable/topicpage/trait-evolution-on-a-phylogenetic-tree-relatedness-41936

-O'Hara (1997) Population thinking and tree thinking in systematics. *Zoologica Scripta* 26, 323–329

-Baum & Offner (2008) Phylogenies and tree thinking. *American Biology Teacher* 70, 222–229

- Boyd
- natural kind
- Homeostatic property cluster
- population thinking
- essentialism story