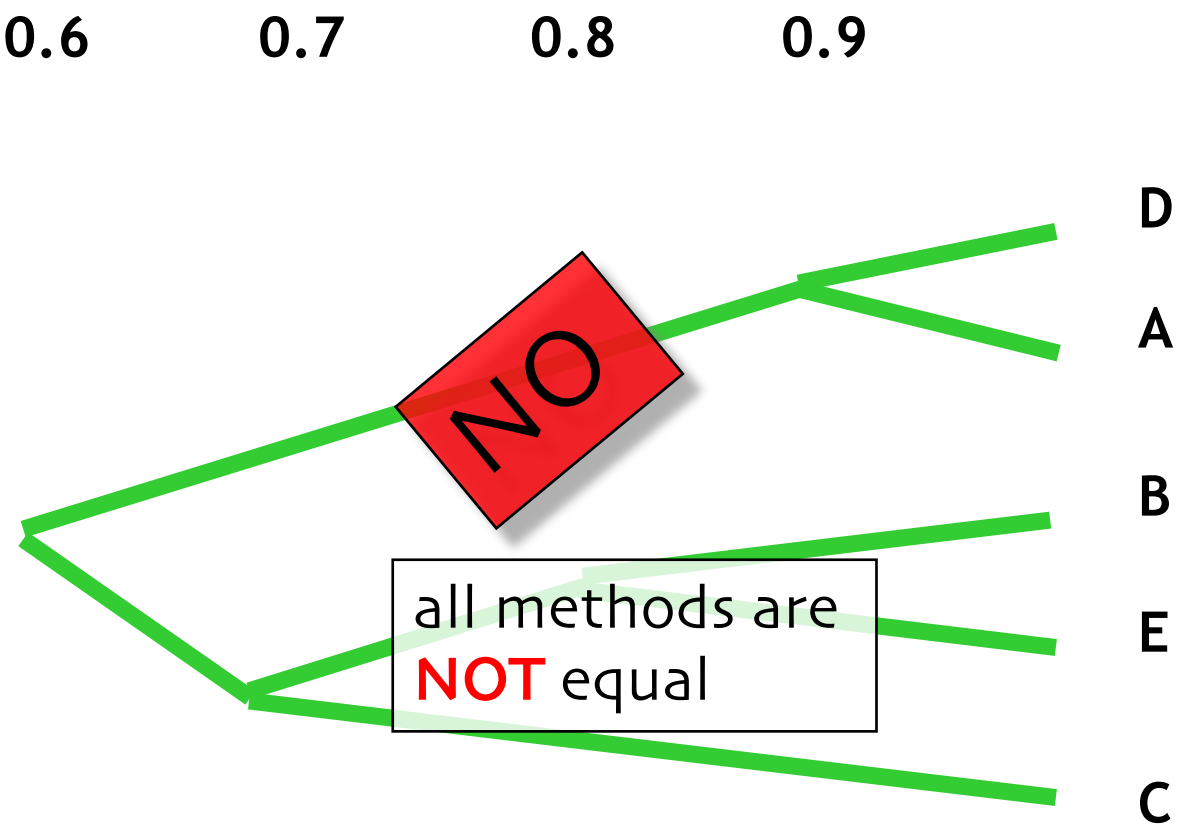
22.xi.

1. different optimality criteria

2. applications of results: classification

3. summary


0.6
0.7
0.8
0.9
D
A
B
E
C
NO
all methods are
NOT equal

	0	1	2	3	4	5	6	7	8	9
A	1	0	0	0	0	1	0	0	0	0
B	1	0	1	1	1	1	1	1	1	1
C	0	1	1	0	0	1	1	1	1	0
D	1	0	0	0	0	1	1	0	0	0
E	1	0	1	0	1	1	1	1	1	0

	A	B	C	D	E
A	10	3	4	9	5
B		10	5	4	8
C			10	5	7
D				10	6
E					10

Optimality criteria

1. evolutionary distance

(Un)Weighted Pair-Group Methods using Arithmetic averages

phenetic clustering, e.g. UPGMA, WPGMA

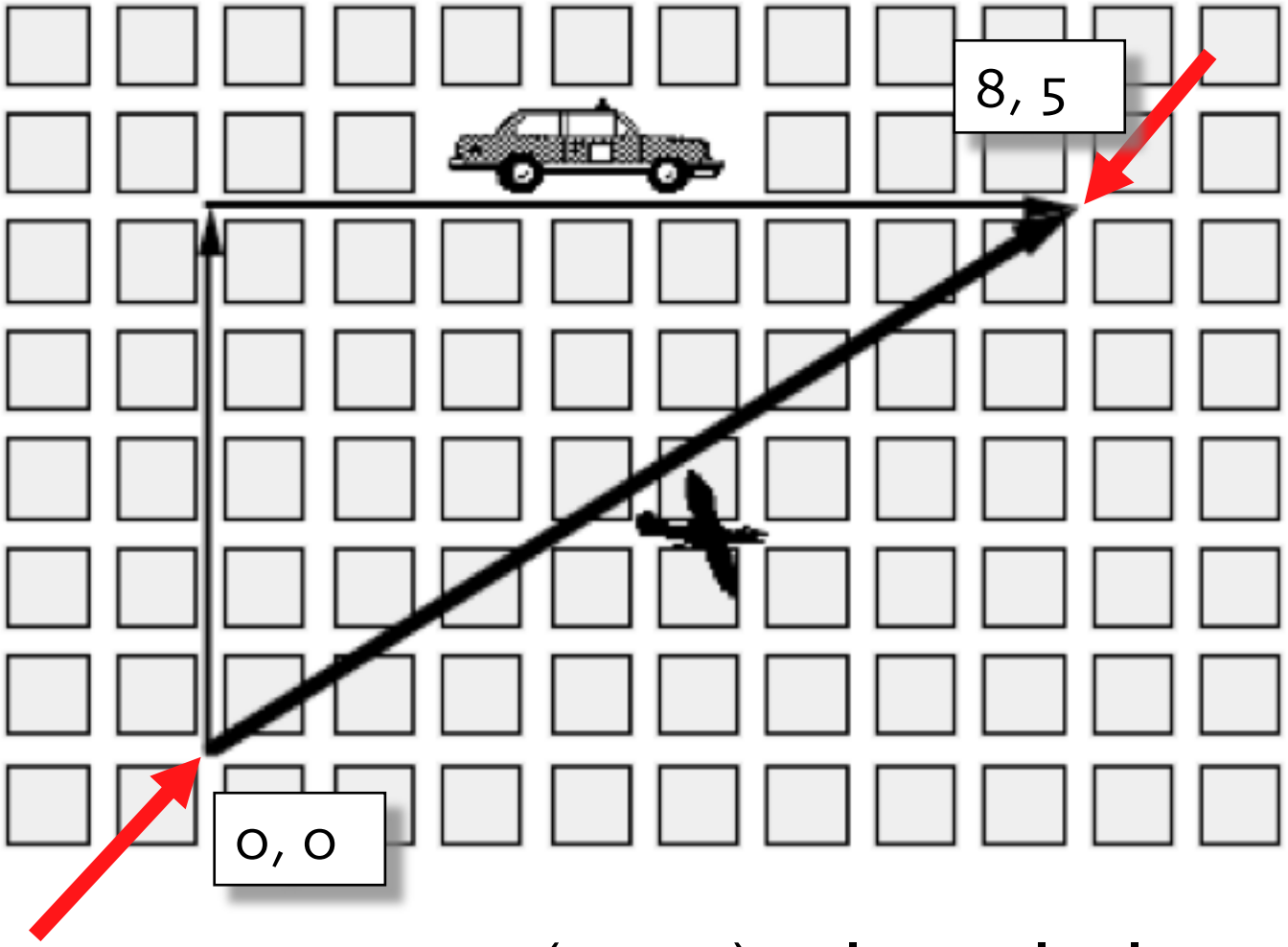
neighbor-joining (NJ)

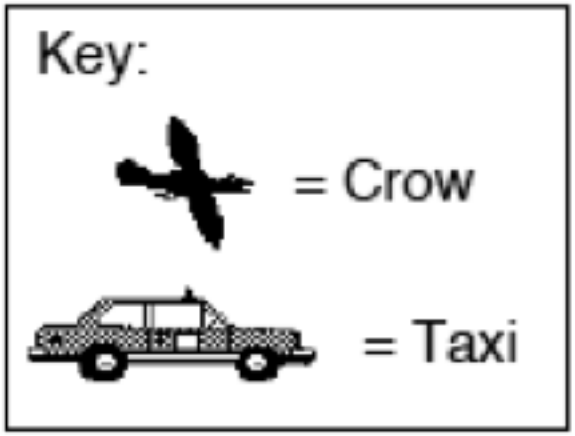
advantage SPEED

RICH information reduced to SINGLE numerical value

loss of information

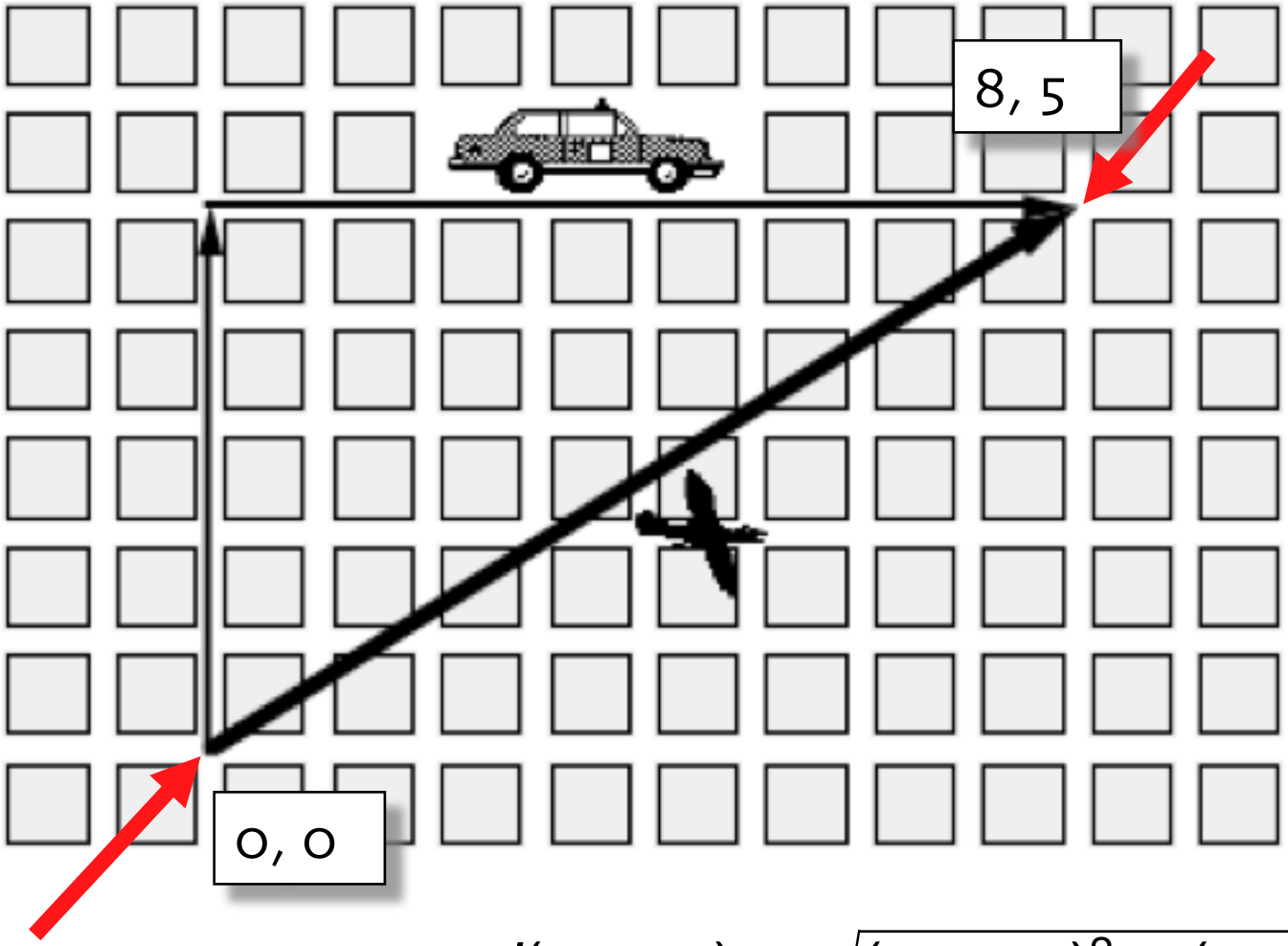
Manhattan vs. euclidean distance

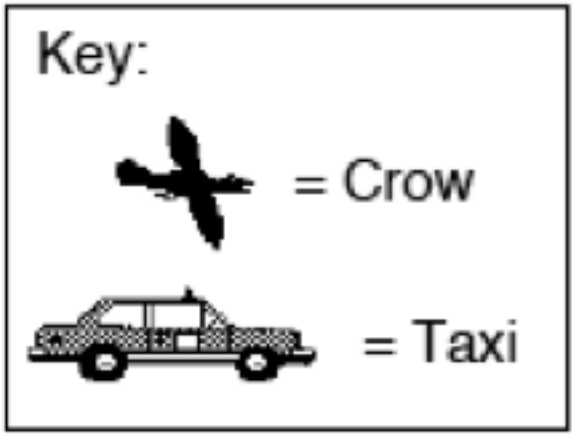




$$m(p_1, p_2) = |x_1 - x_2| + |y_1 - y_2|$$

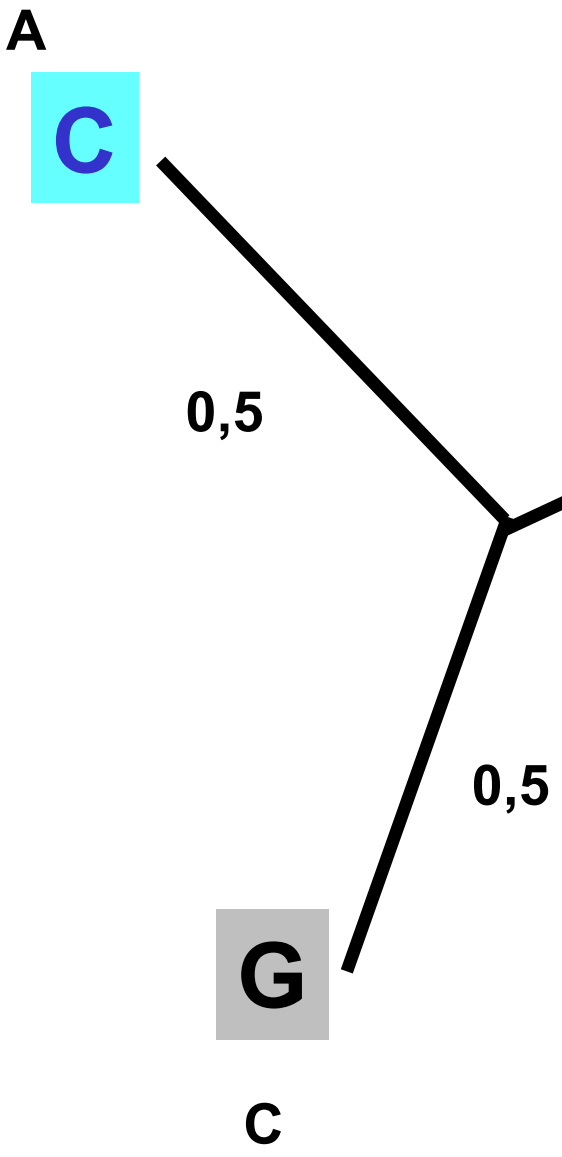
Manhattan vs. euclidean distance





$$d(p_1, p_2) = \sqrt{(x_1 - x_2)^2 + (y_1 - y_2)^2}$$

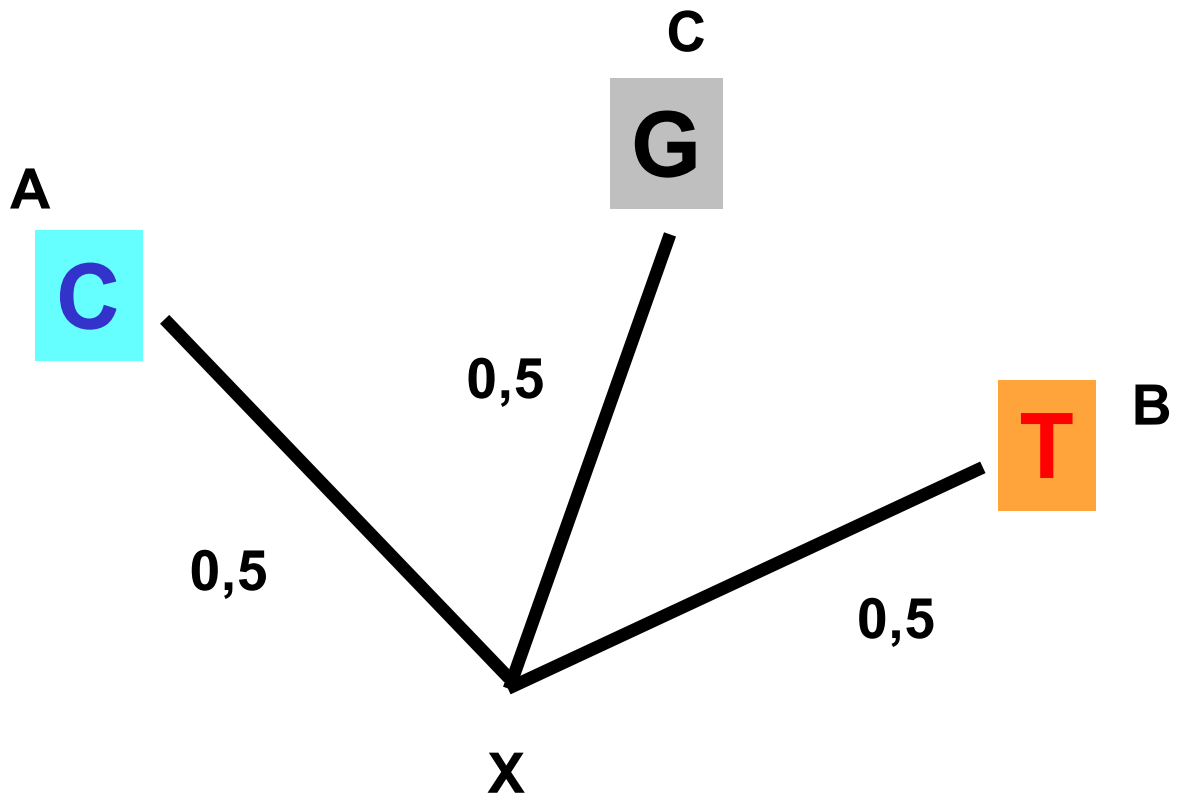
9,43



	A	B	C
A	0	1	1
B		0	1
C			0

Farris, J.S. 1985. Distance data revisited. *Cladistics* 1: 67-85.

Farris, J.S. 1986. Distances and statistics. *Cladistics* 2: 144-157.



sum of branch lengths = 1,5

BUT at least 2 substitutions must have happened to produce variation observed

Optimality criteria

1. evolutionary distance

(Un)Weighted Pair-Group Methods using Arithmetic averages

phenetic clustering, e.g. UPGMA, WPGMA

neighbor-joining (NJ)

advantage

SPEED

RICH information reduced to SINGLE numerical value

loss of information

how to combine information from different sources?

e.g. genes, biochemistry, morphology

absence of optimized character transformation events

algorithms *MIGHT* be useful but distance based methods **SHOULD NOT BE USED** for final analyses

Optimality criteria

1. evolutionary distance

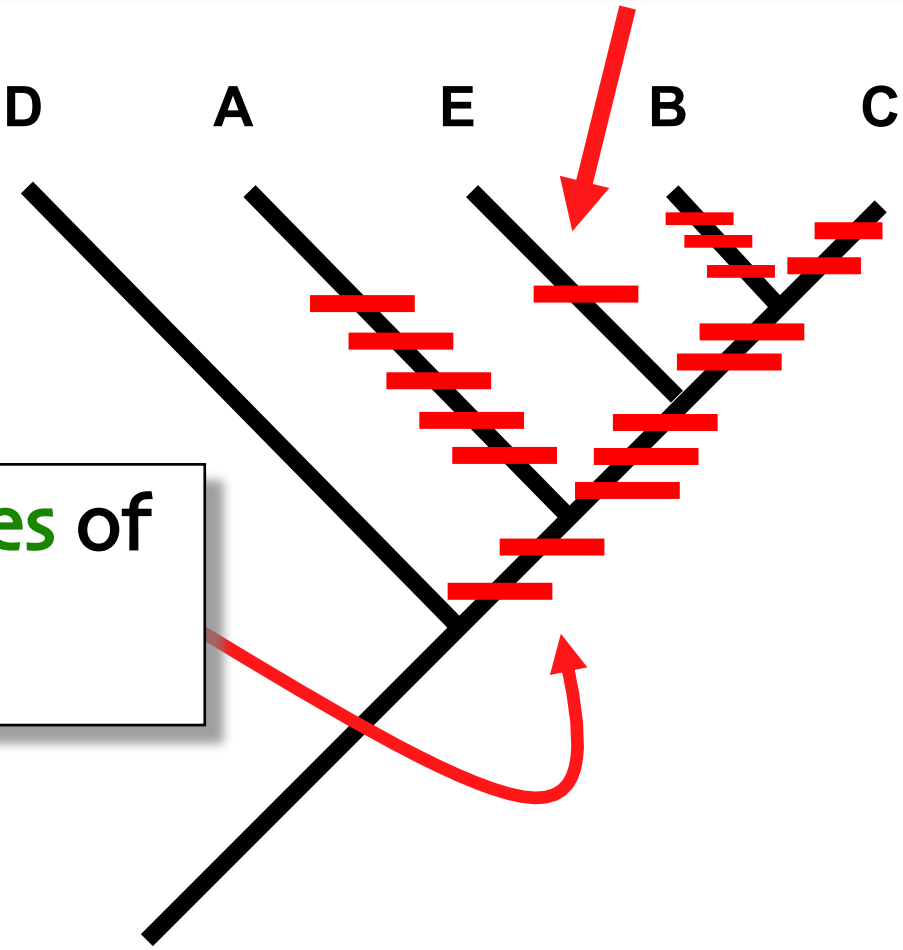
2. parsimony

comparison of hypotheses is based on optimization of CHARACTERS

information about individual characters RETAINED

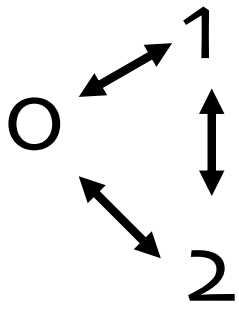
return from tree to matrix possible

autapomorphy of taxon E

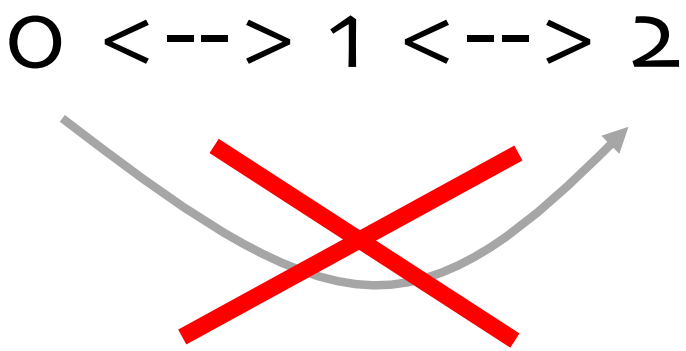


synapomorphies of group A-E-B-C

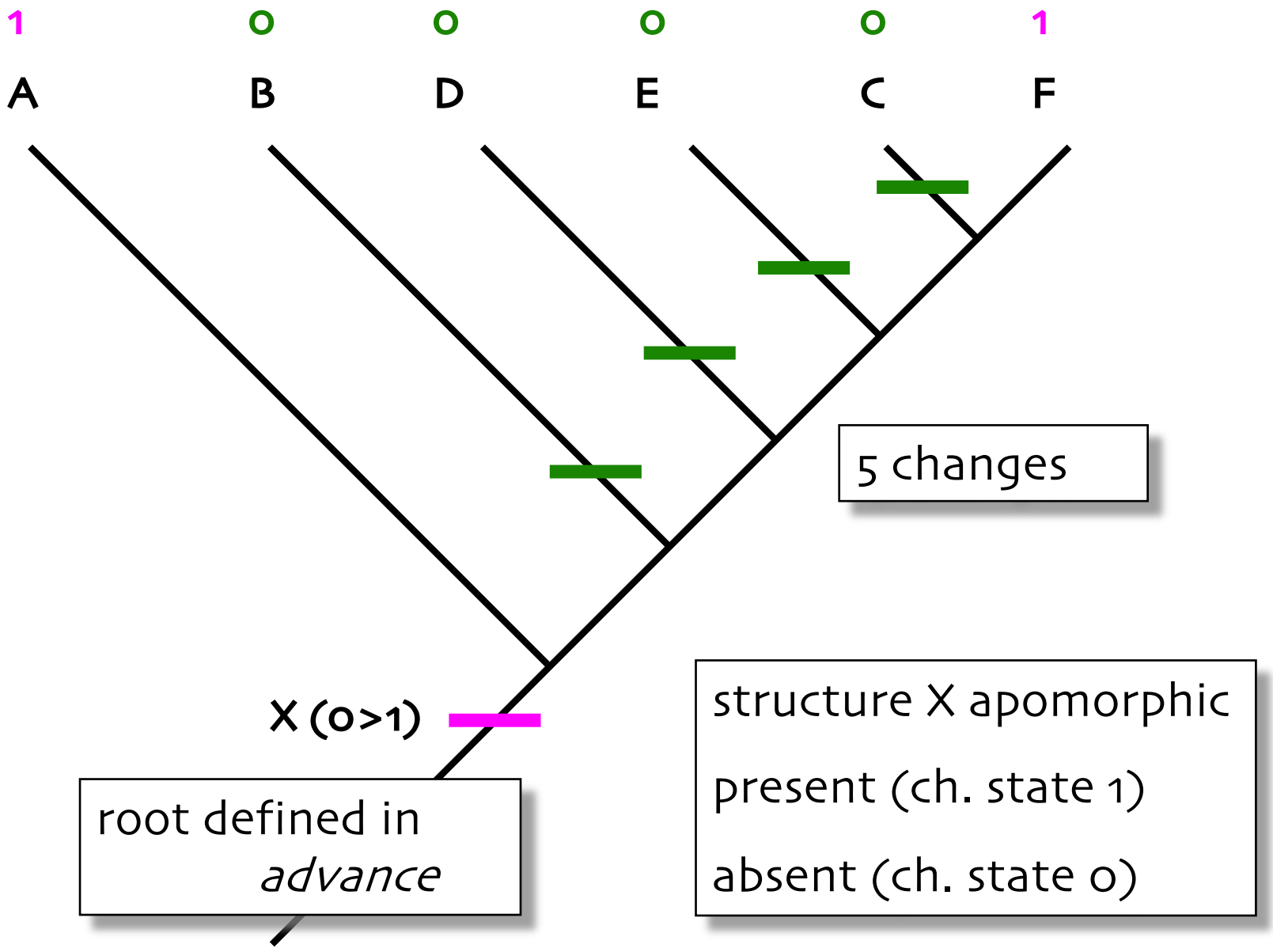
FITCH PARSIMONY

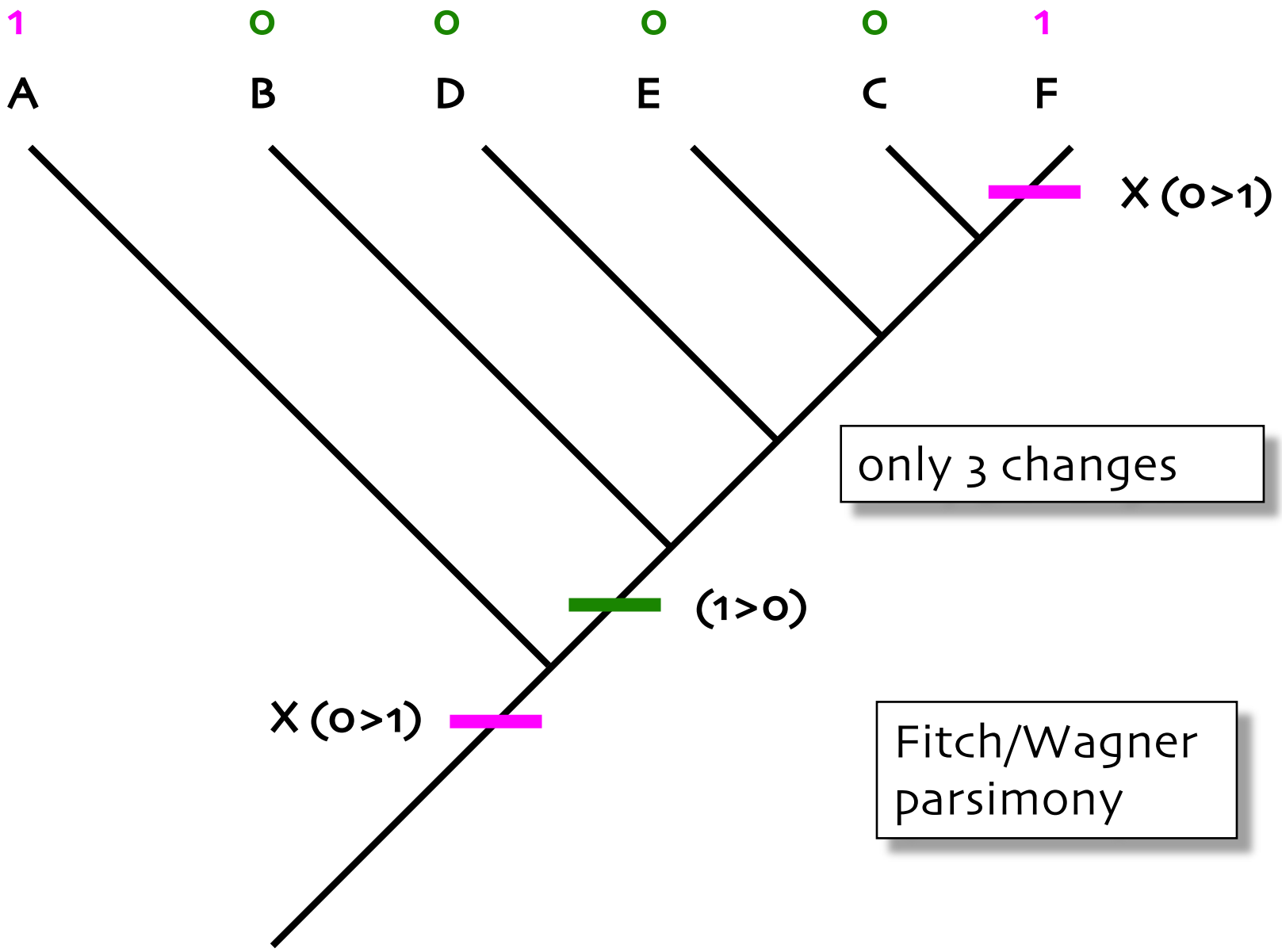


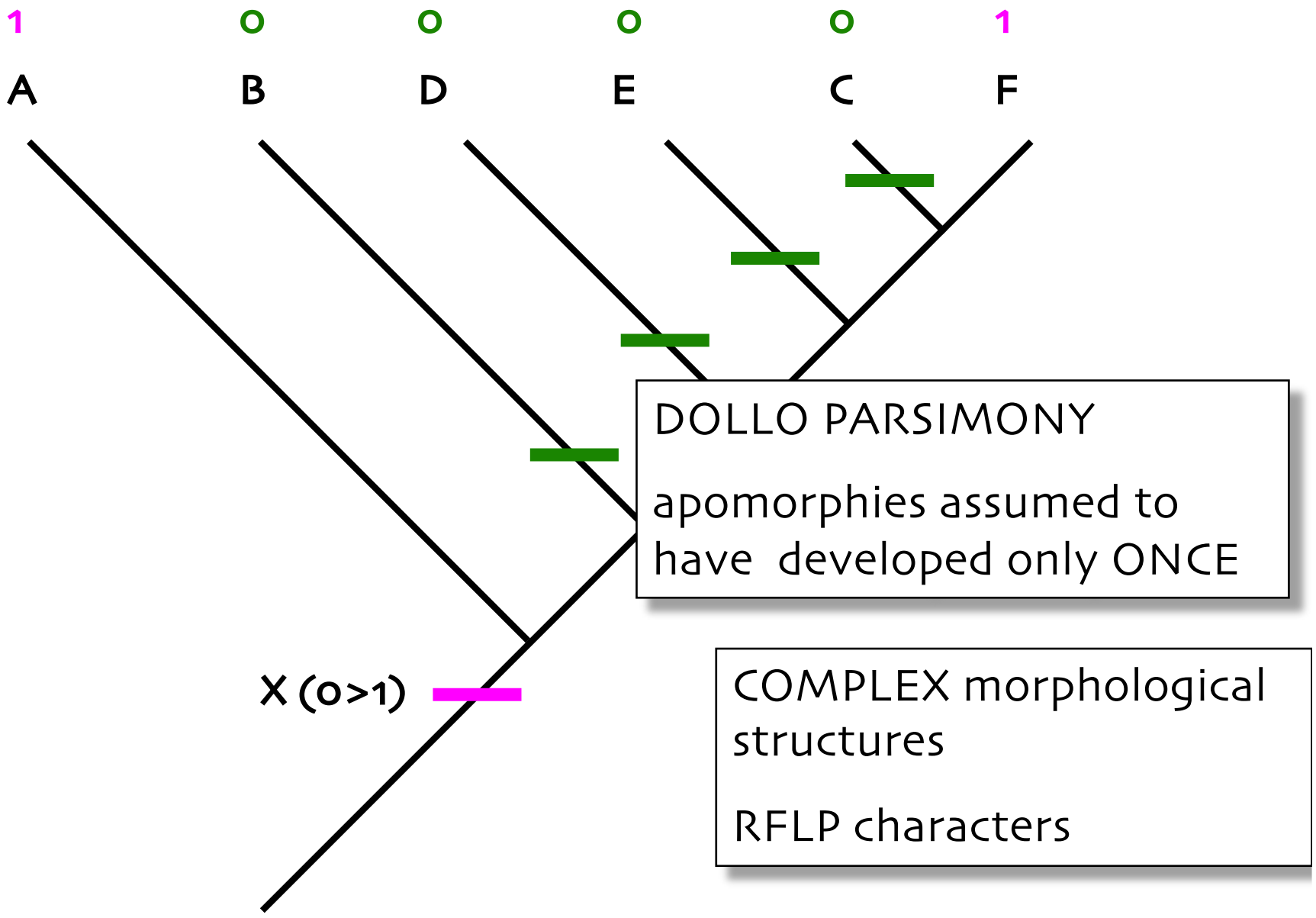
WAGNER PARSIMONY



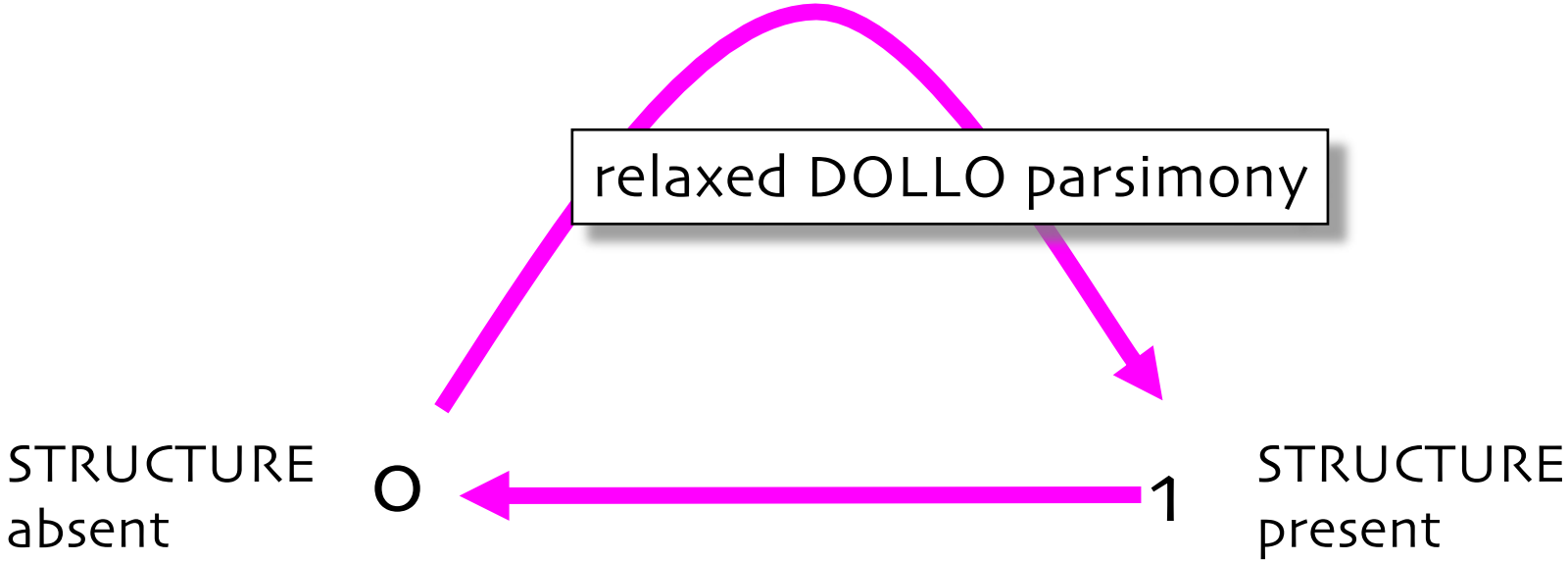
DOLLO PARSIMONY


1
0
0
0
0
1
A
B
D
E
C
F
5 changes
X (0>1)
root defined in
advance
structure X apomorphic
present (ch. state 1)
absent (ch. state 0)


1
0
0
0
0
1
A
B
D
E
C
F
X (0>1)
only 3 changes
(1>0)
X (0>1)
Fitch/Wagner
parsimony

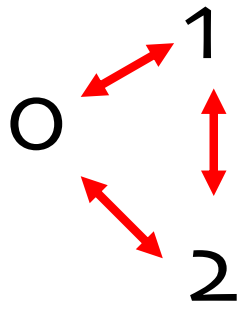

1
0
0
0
0
1
A
B
D
E
C
F
X (0>1)
DOLLO PARSIMONY
apomorphies assumed to have developed only ONCE
COMPLEX morphological structures
RFLP characters

e.g. 32 evolutionary changes



1 evolutionary change

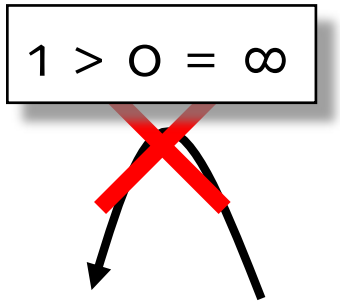
FITCH PARSIMONY



WAGNER PARSIMONY

0 < > 1 < > 2

DOLLO PARSIMONY



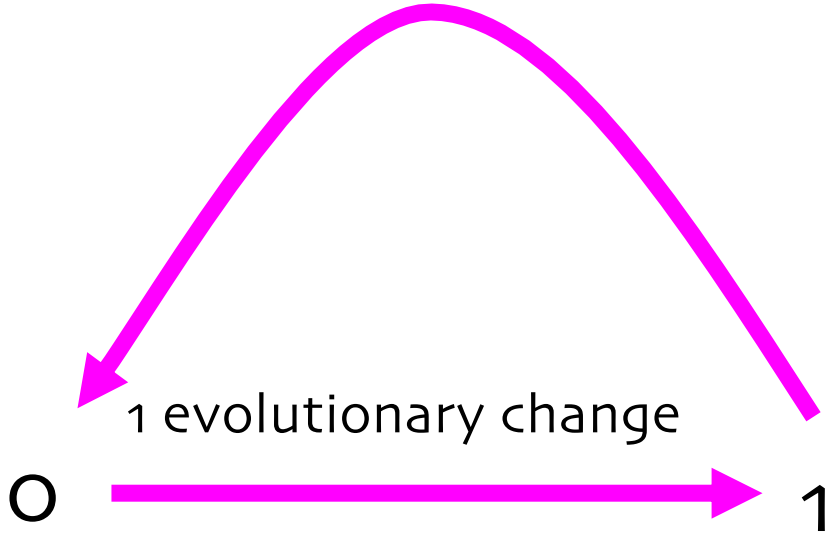
CAMIN-SOKAL PARSIMONY

evolution unidirectional

(reversals **NOT** allowed)

0 > 1

8 evolutionary changes



in principle any kind of changes possible, but…

weighted

SANKOFF PARSIMONY

	0	1	2	3
0	-	1	6	15
1	7	-	5	8
2	8	5	-	9
3	4	5	3	-

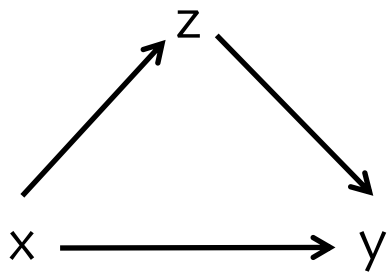
…optimization will lead to inconsistent results & thus characters states have to fulfill the following requirements:

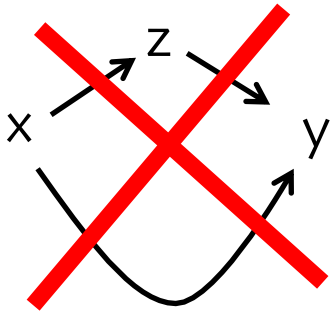
$$\forall x \qquad d(x,x) = 0$$
$$\forall x, y; x \neq y \qquad d(x, y) > 0$$
$$\forall x, y \qquad d(x,y) = d(y,x)$$
$$\forall x, y, z \qquad d(x,y) \leq d(x, z) + d(z, y)$$

x, y, z character states
d change from ch. state to another

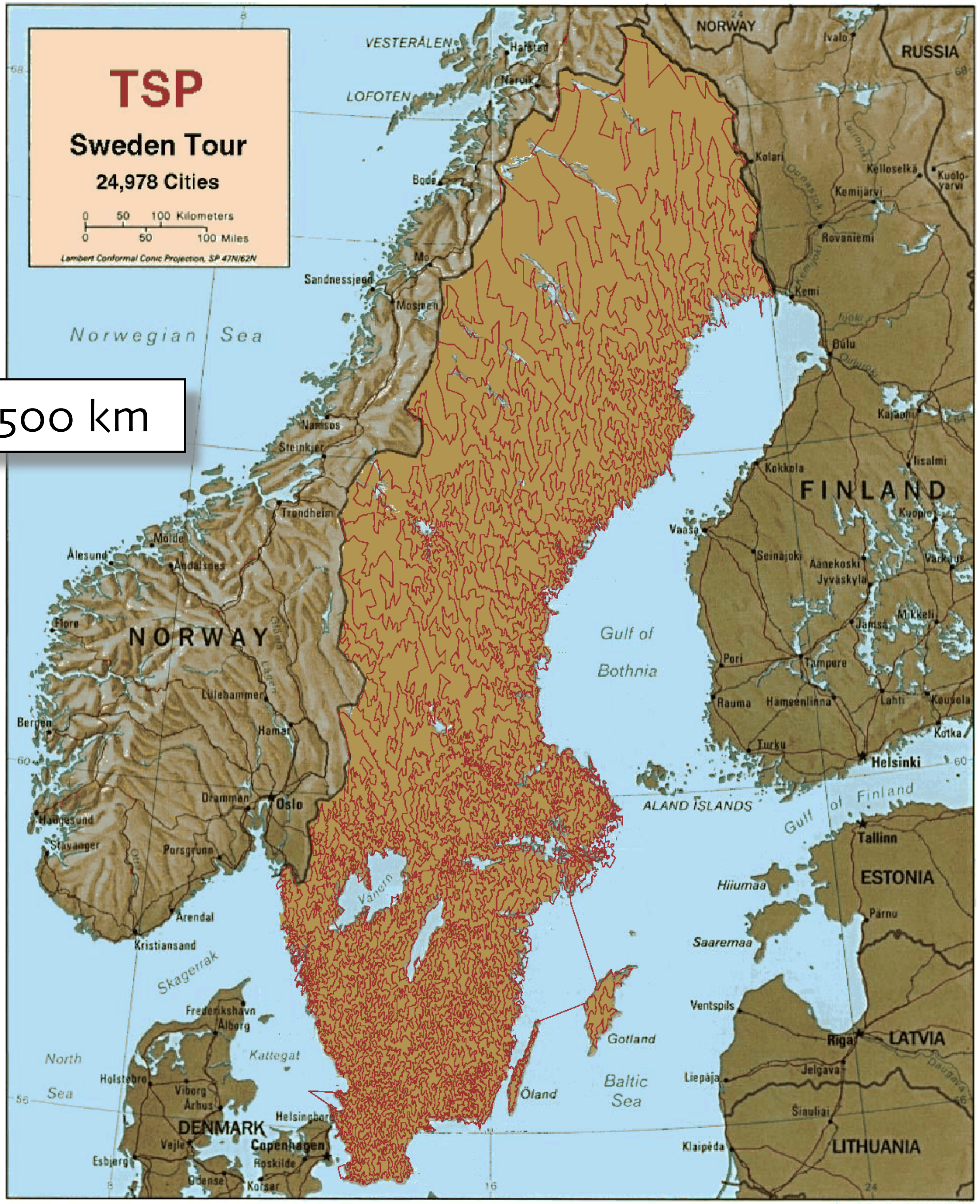
i.e.

1) change from one ch. state to another > 0
2) change x → y = y → x (changes symmetrical)
3) change x → y ≤ change x → z + change z → y (**triangle inequality**)





72 500 km



Base 802435 (A04937) 2-96

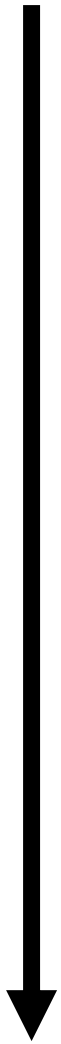
FITCH PARSIMONY

WAGNER

DOLLO

CAMIN-SOKAL

SANKOFF



a priori assumptions increase

Parsimony or models?

optimality criteria:

1. evolutionary distance
2. parsimony
3. model based methods

    MODEL of evolution of explicitly defined

Parsimony or models?

Parsimony analysis

what is the best tree (= hypothesis) based on characters, background knowledge & optimality criterion

descent with modification

model of evolution of explicitly defined

Model based analyses

models accepted *a priori*

Maximum likelihood

"Bayesian" analyses (posterior probabilities)

Applications

why bother?

Theodosius DOBZHANSKY (rephrased):

NOTHING MAKES SENSE IN BIOLOGY EXCEPT IN THE LIGHT OF EVOLUTIONARY HISTORY

Applications

Tasks of taxonomy:

1. description
2. classification
3. nomenclature

both extant & extinct (fossils)

Emil Hans WILLI HENNIG

*20.4.1913 †5.11.1976

Hennig, W. 1950. Grundzüge einer Theorie der phylogenetischen systematik

Hennig, W. 1966. Phylogenetic systematics

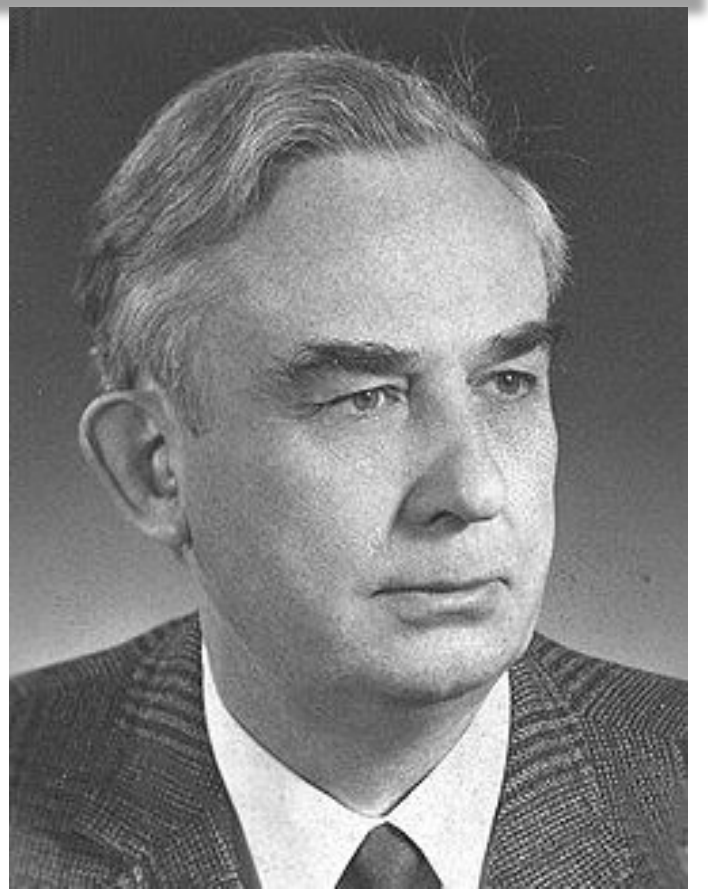
CLADISTIC REVOLUTION

CLEAR, EXPLICIT & LOGICAL presentation of basic principles of phylogenetic analysis

SYNAPOMORPHY

MONOPHYLY

PARAPHYLY



Basic principles of classification

Wiley & al. 1991 pp. 91-112

Three basic principles of CLADISTIC classification:

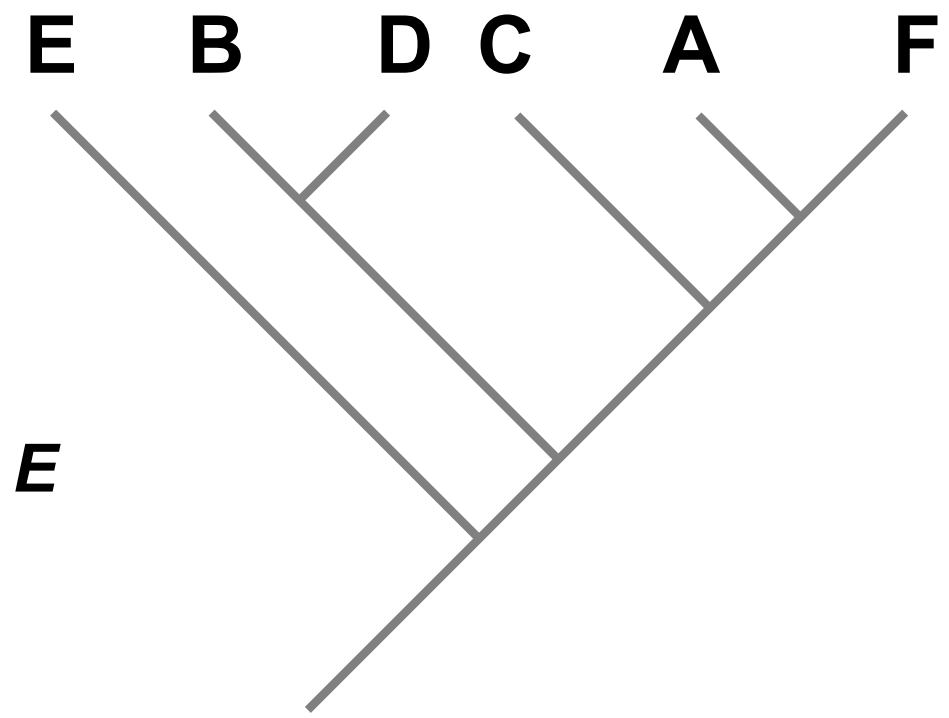
1. ONLY monophyletic groups should be given formal name

2. NO conflict between classification & phylogeny

3. Classification should give ACCURATE information about relationships

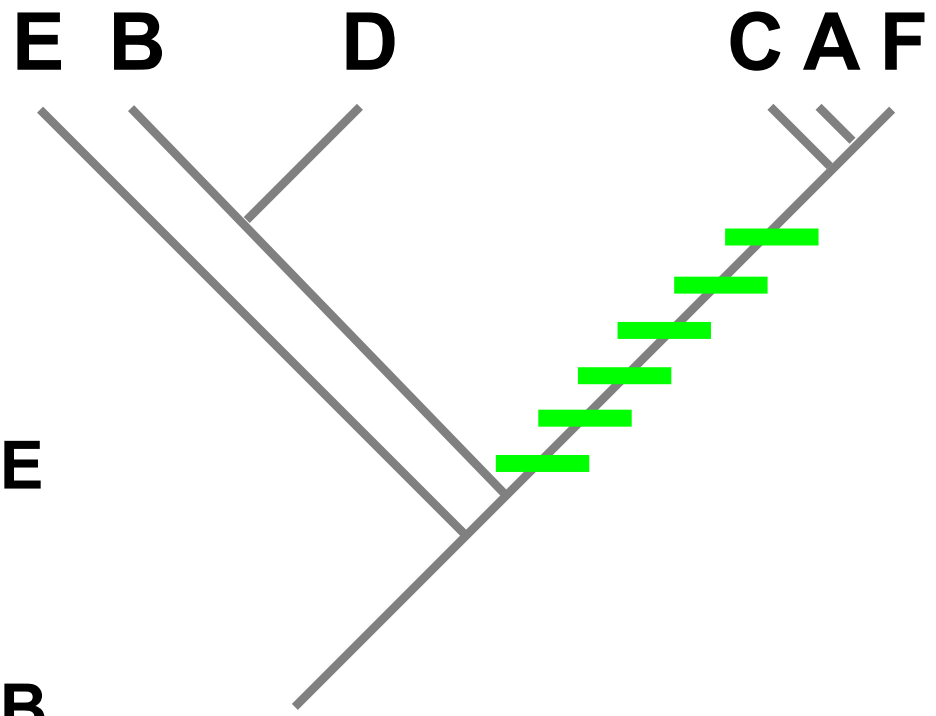
ATTENTION! many parts of classification used today DO NOT fulfill these requirements

(E ((B D) (C (A F))))

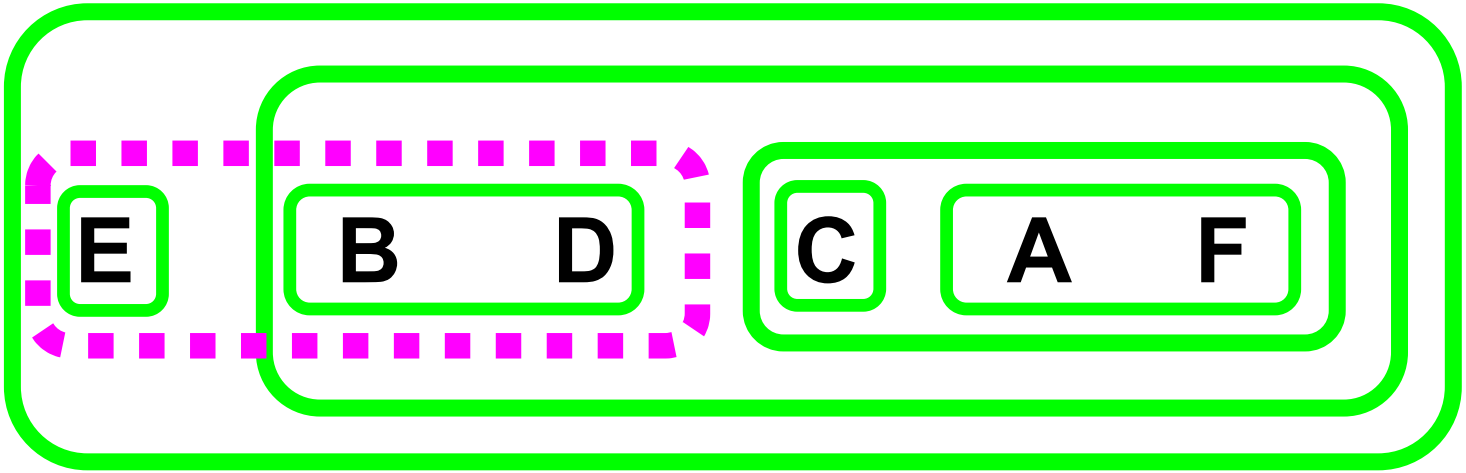


order E
- **family E**
  - **genus *E***
    - **species *E***

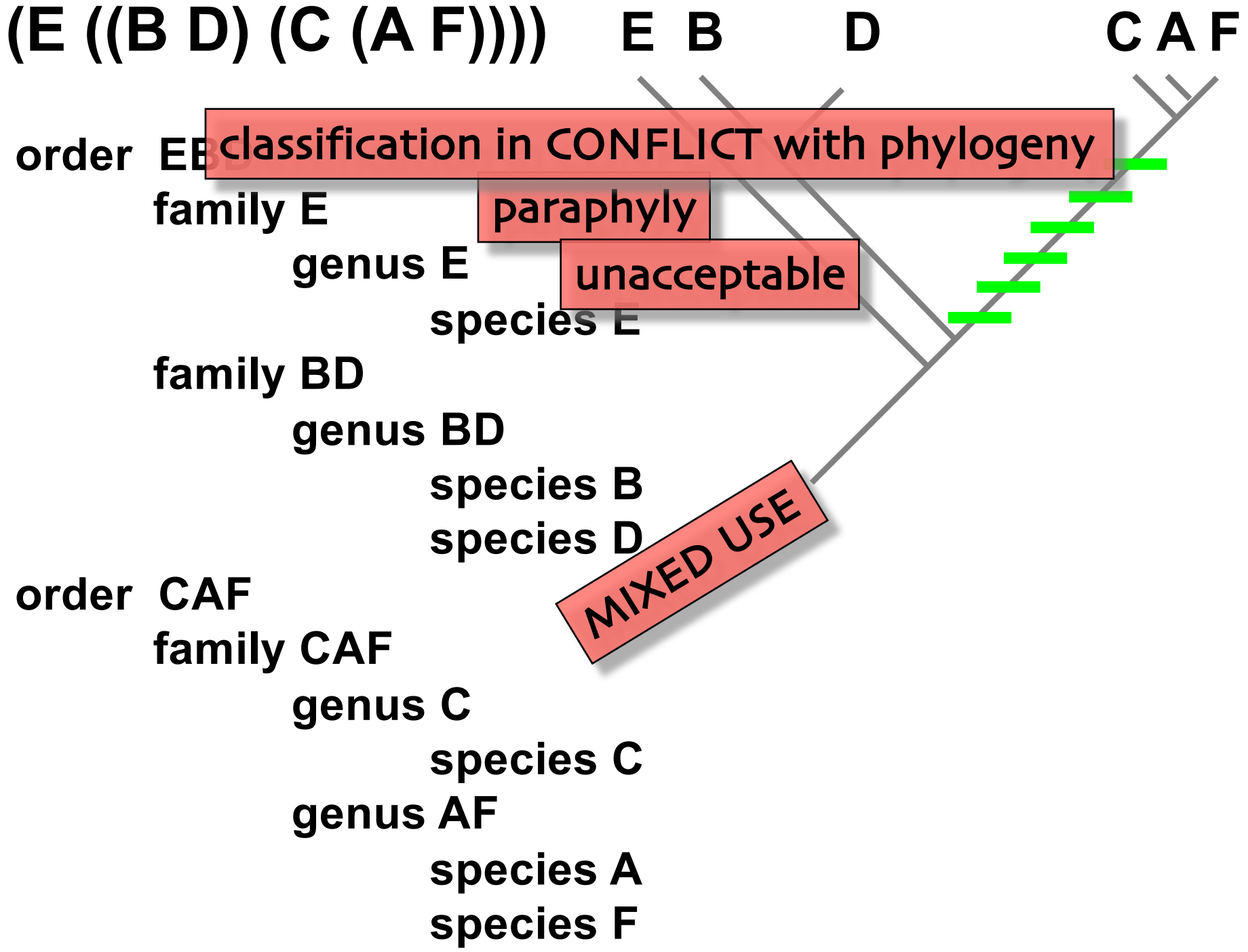
order BDCAF
- **family BD**
  - **genus *BD***
    - **species *B***
    - **species *D***
- **family CAF**
  - **genus *C***
    - **species *C***
  - **genus AF**
    - **species *A***
    - **species *F***

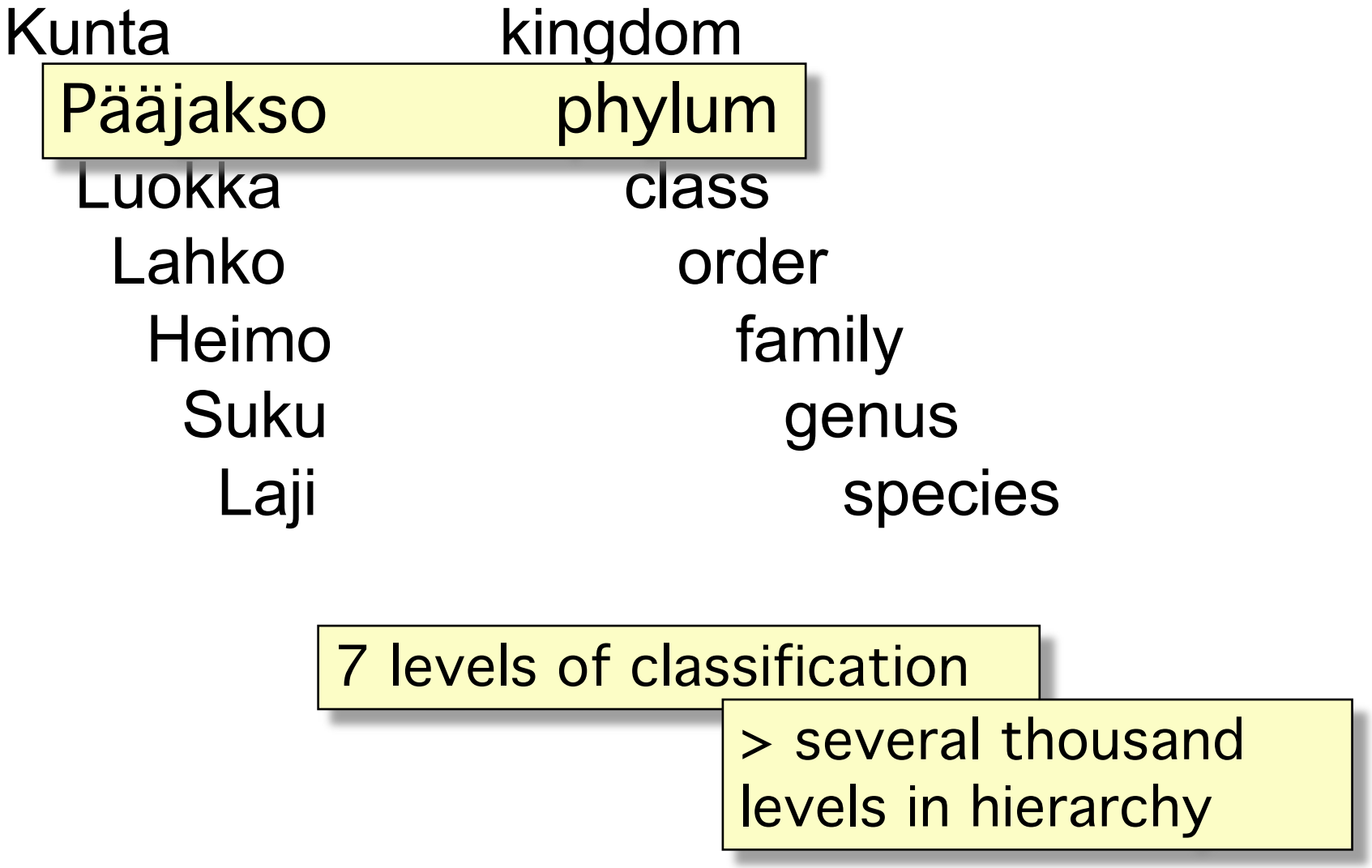


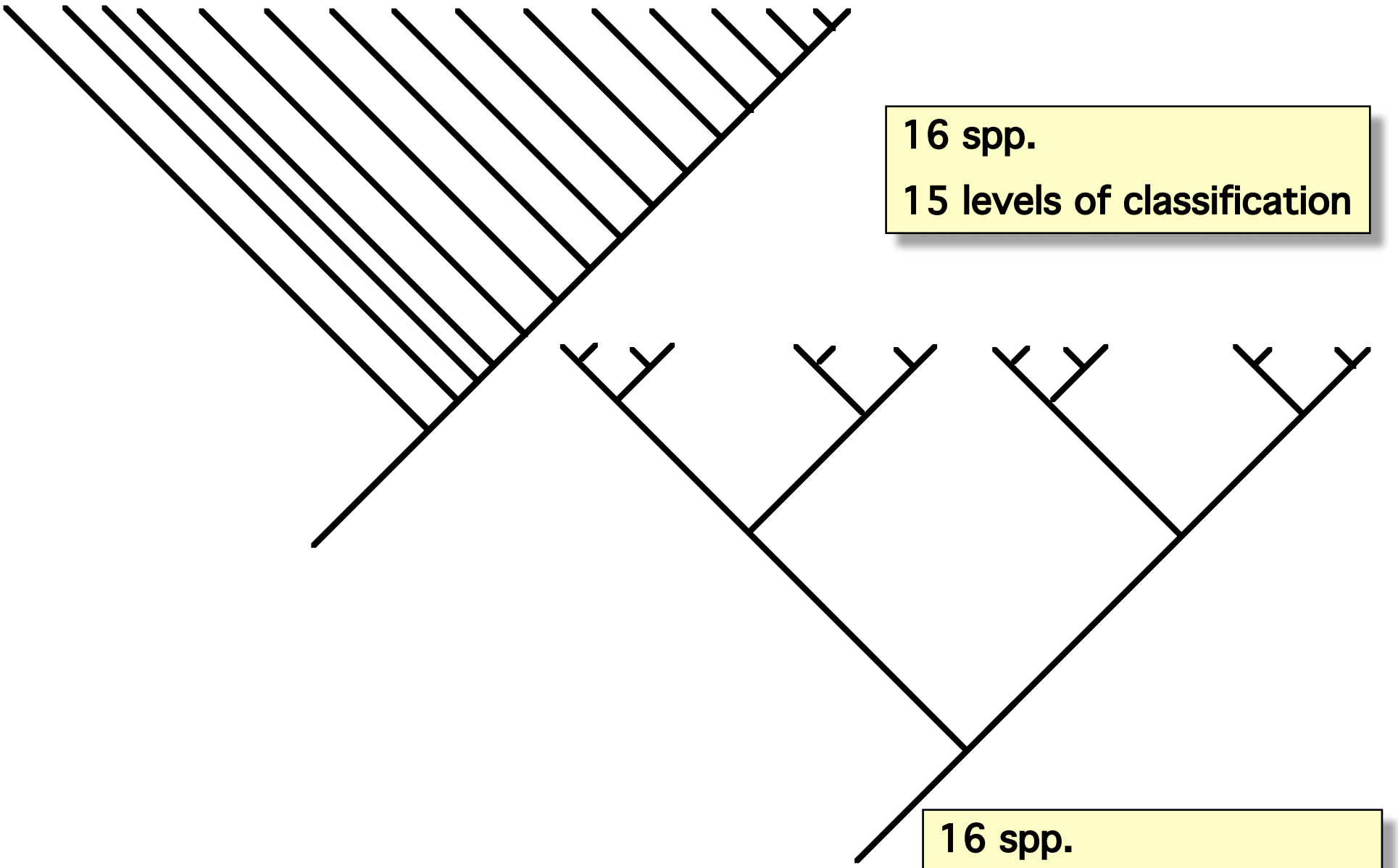
order EBD
family E
genus E
species E
family BD
genus BD
species B
species D
order CAF
family CAF
genus C
species C
genus AF
species A
species F

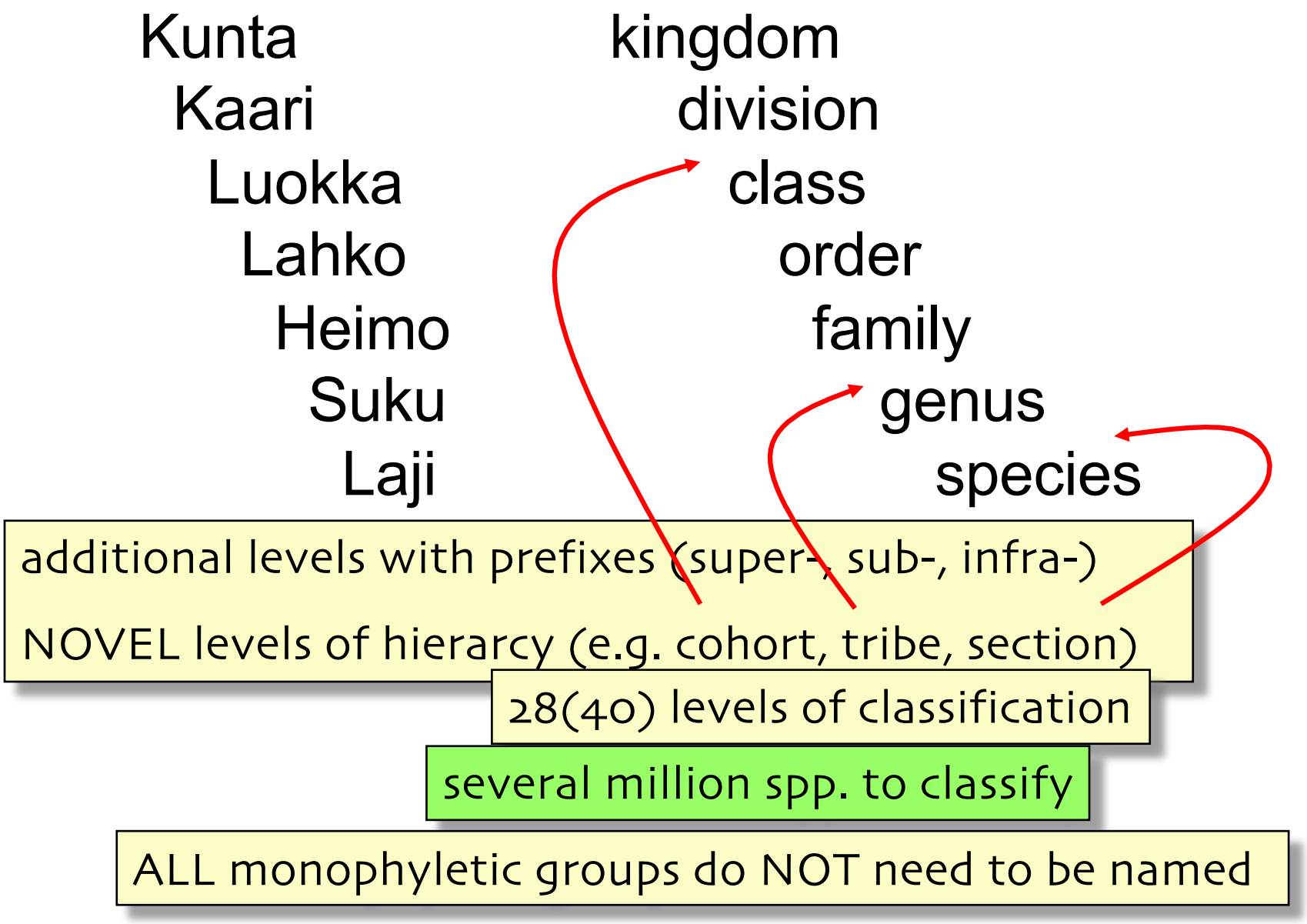


Venn diagram


(E ((B D) (C (A F))))
E B D C A F
classification in CONFLICT with phylogeny
order EBD
family E
genus E
species E
paraphyly
unacceptable
family BD
genus BD
species B
species D
MIXED USE
order CAF
family CAF
genus C
species C
genus AF
species A
species F


Kunta
kingdom
Pääjakso
phylum
Luokka
class
Lahko
order
Heimo
family
Suku
genus
Laji
species
7 levels of classification
> several thousand levels in hierarchy


16 spp.
15 levels of classification
16 spp.
4 levels of classification


Kunta
Kaari
Luokka
Lahko
Heimo
Suku
Laji
kingdom
division
class
order
family
genus
species
additional levels with prefixes (super-, sub-, infra-)
NOVEL levels of hierarcy (e.g. cohort, tribe, section)
28(40) levels of classification
several million spp. to classify
ALL monophyletic groups do NOT need to be named

Basic principles of classification

THINGS TO REMEMBER:

levels of hierarchy **DO NOT** correspond in different lineages

levels of hierarchy **ARE NOT** informative about absolute age of lineages

still useful to inform about RELATIVE position of levels of hierarchy

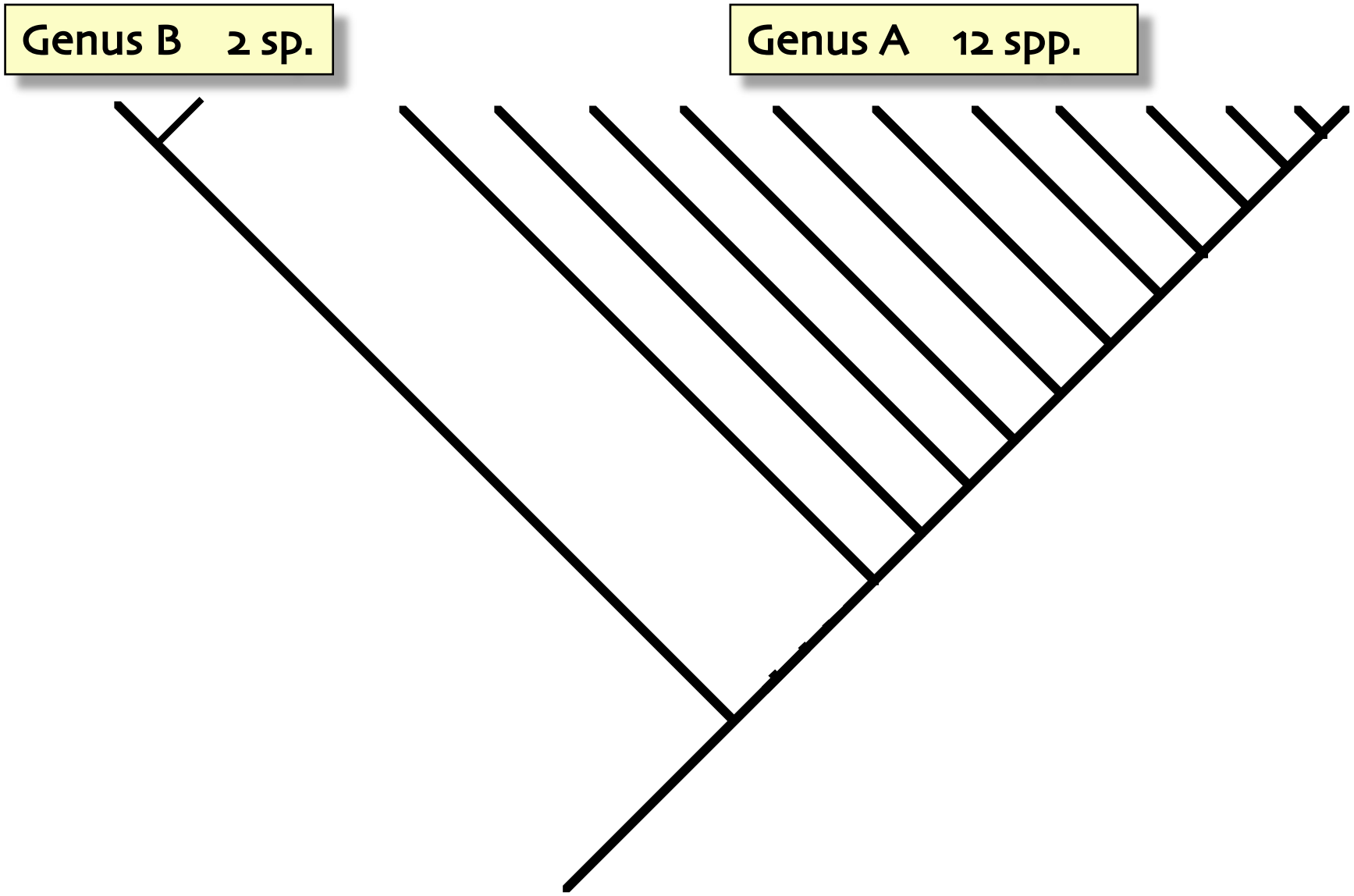
Basic principles of classification

recommendations for cladistic classification:

A) levels of hierarchy of current nomenclature rules used

B) taxa of asymmetric part of tree placed on same level of hierarchy, their order provides information about their relative position

listing/sequencing convention (Nelson 1972)


Genus B 2 sp.
Genus A 12 spp.

Basic principles of classification

recommendations for cladistic classification:

A) levels of hierarchy of current nomenclature rules used

B) taxa of asymmetric part of tree placed on same level of hierarchy, their order provides information about their relative position

listing/sequencing convention (Nelson 1972)

C) current classification should be altered as little as possible

requirements of two basic rules will NOT be compromised

Basic principles of classification

Wiley & al. 1991 pp. 91-112

Three basic principles of CLADISTIC classification:

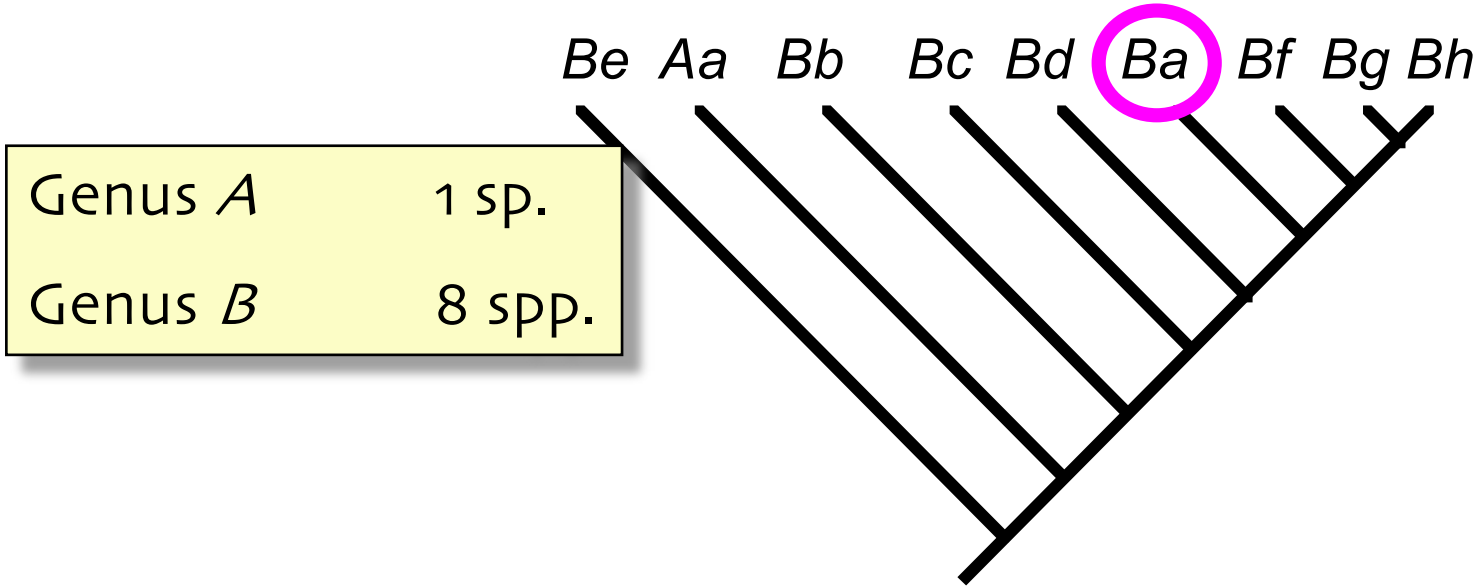
1. ONLY monophyletic groups should be given formal name

2. NO conflict between classification & phylogeny

3. Classification should give ACCURATE information about relationships

ATTENTION! many parts of classification used today DO NOT fulfill these requirements

Basic principles of classification

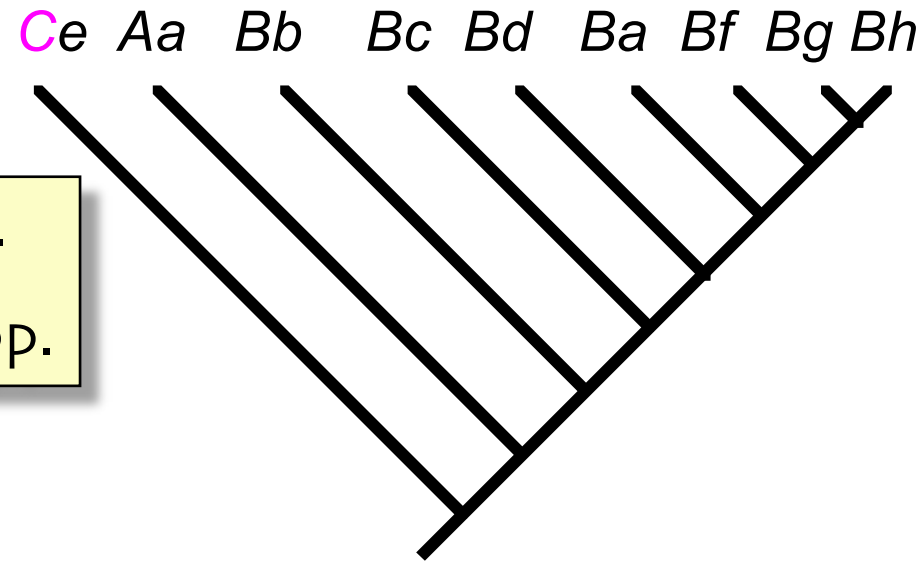


A 1 sp. ---> genus *B* ---> 1 nomenclatural change

Genus B already includes species with same name --->

2 nomenclatural changes

Basic principles of classification



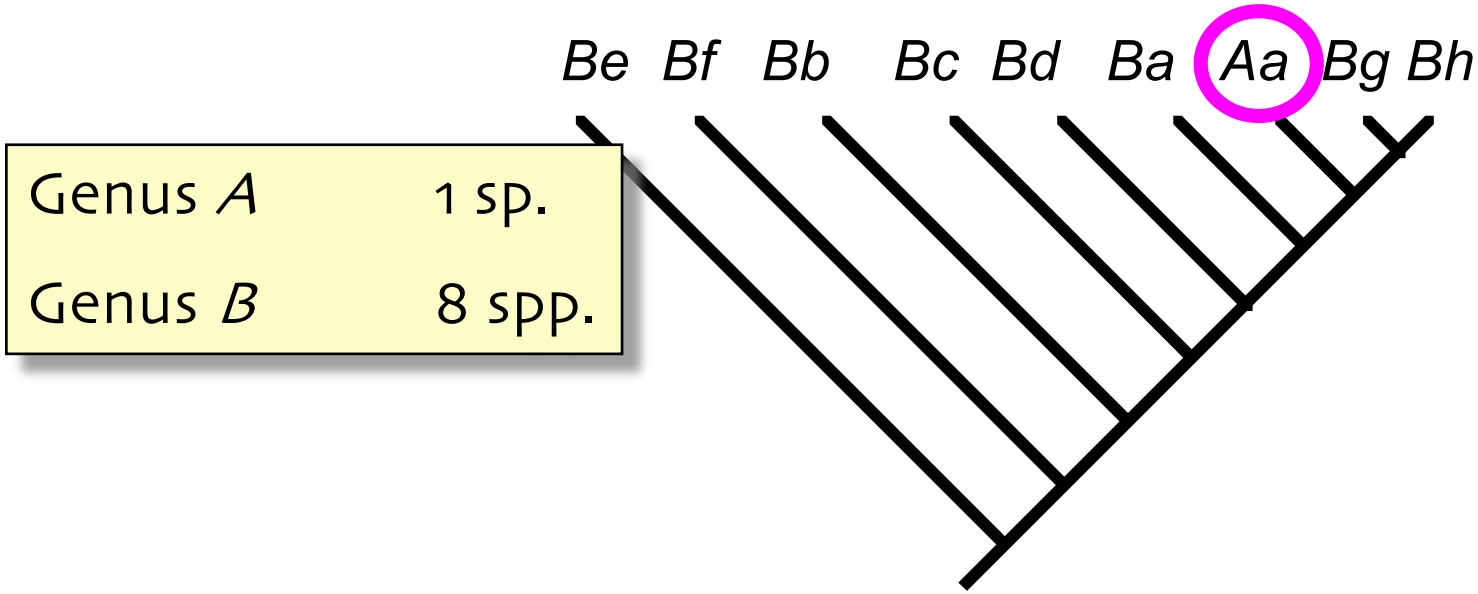
Genus *A*	1 sp.
Genus *B*	8 spp.

A 1 sp. ---> genus *B* ---> 1 nomenclatural change

Genus B already includes species with same name ---> 2 nomenclatural changes

Species Be described as a new genus C ---> 1 nomenclatural change

Basic principles of classification



Basic principles of classification

recommendations for cladistic classification:

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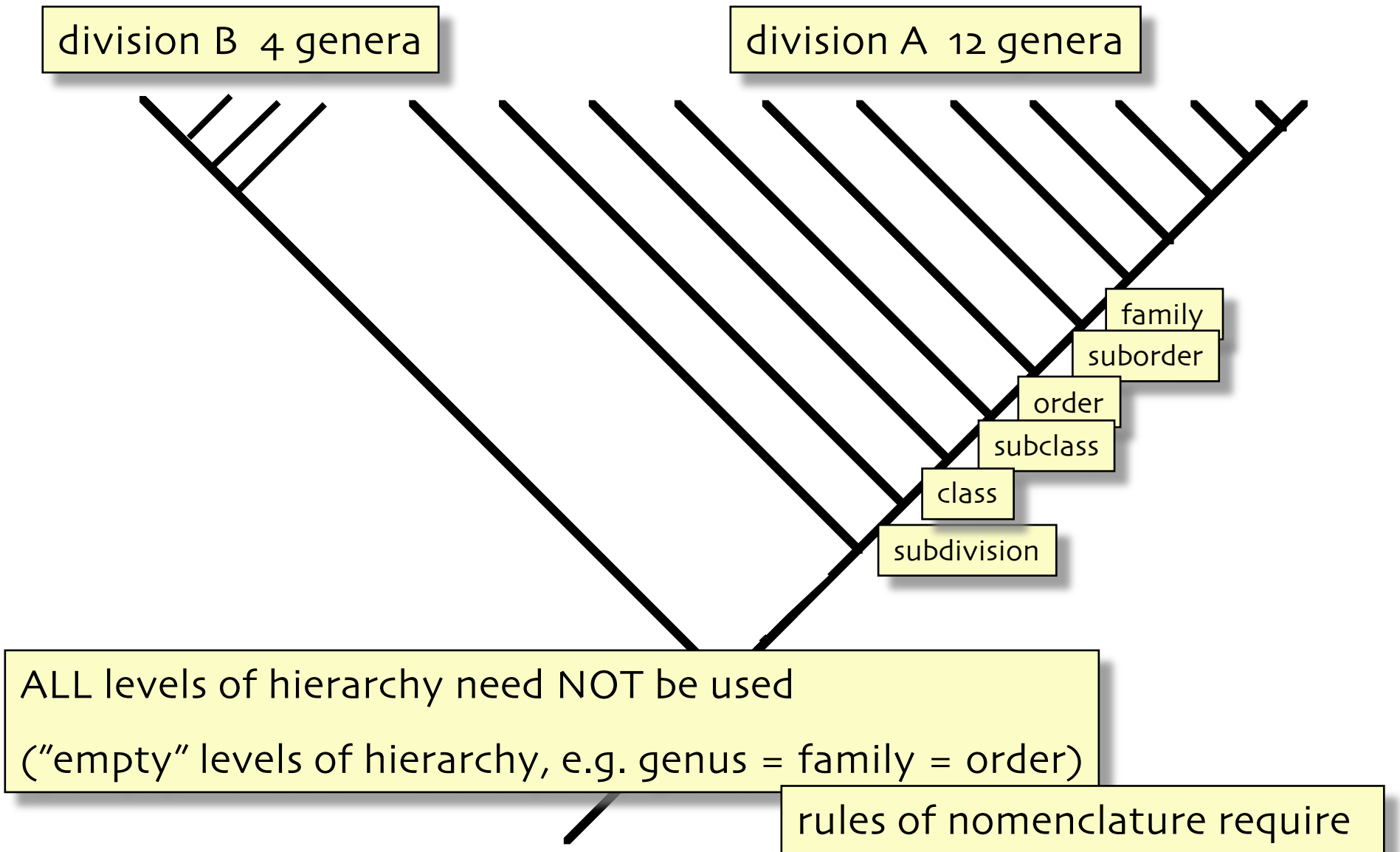
B) taxa of asymmetric part of tree placed on same level of hierarchy, their order provides information about their relative position

listing/sequencing convention (Nelson 1972)

C) current classification should be altered as little as possible

requirements of two basic rules will NOT be compromised

empty levels of hierarchy



Bufonaria borisbeckeri

Agra cadabra
Agra schwarzeneggeri

La cerveza

www.curioustaxonomy.net/

Macrocarpaea canoëfolia
M. kayakifolia
M. tabula-fluctivagifolia

Basic principles of classification

recommendations for cladistic classification:

D) taxa involved in polytomy (relationships uncertain) are put on same level of hierarchy supplemented with term *sedis mutabilis*

infracohort Cycadatae *sedis mutabilis*

E) monophyletic taxa with uncertain relationships supplemented with term *incertae sedis* and put in a larger group where they are assumed to belong with certainty

e.g. a genus belongs to certain order but no certainty (as yet) about its family

Basic principles of classification

recommen

C) **current classification should be altered as little as possible**

F) fossil taxa distinguished with special symbol (†), always following recomm. C, or they are included in classification without level of hierarchy (plesion)

prevents new fossils to change classification continuously

G) ALL new findings do NOT need nomenclatural recognition

in some cases informal names are most useful

for decades successfully used in plant taxonomy

e.g. magnolids, eudicots, rosids, malvids etc.

Basic principles of classification

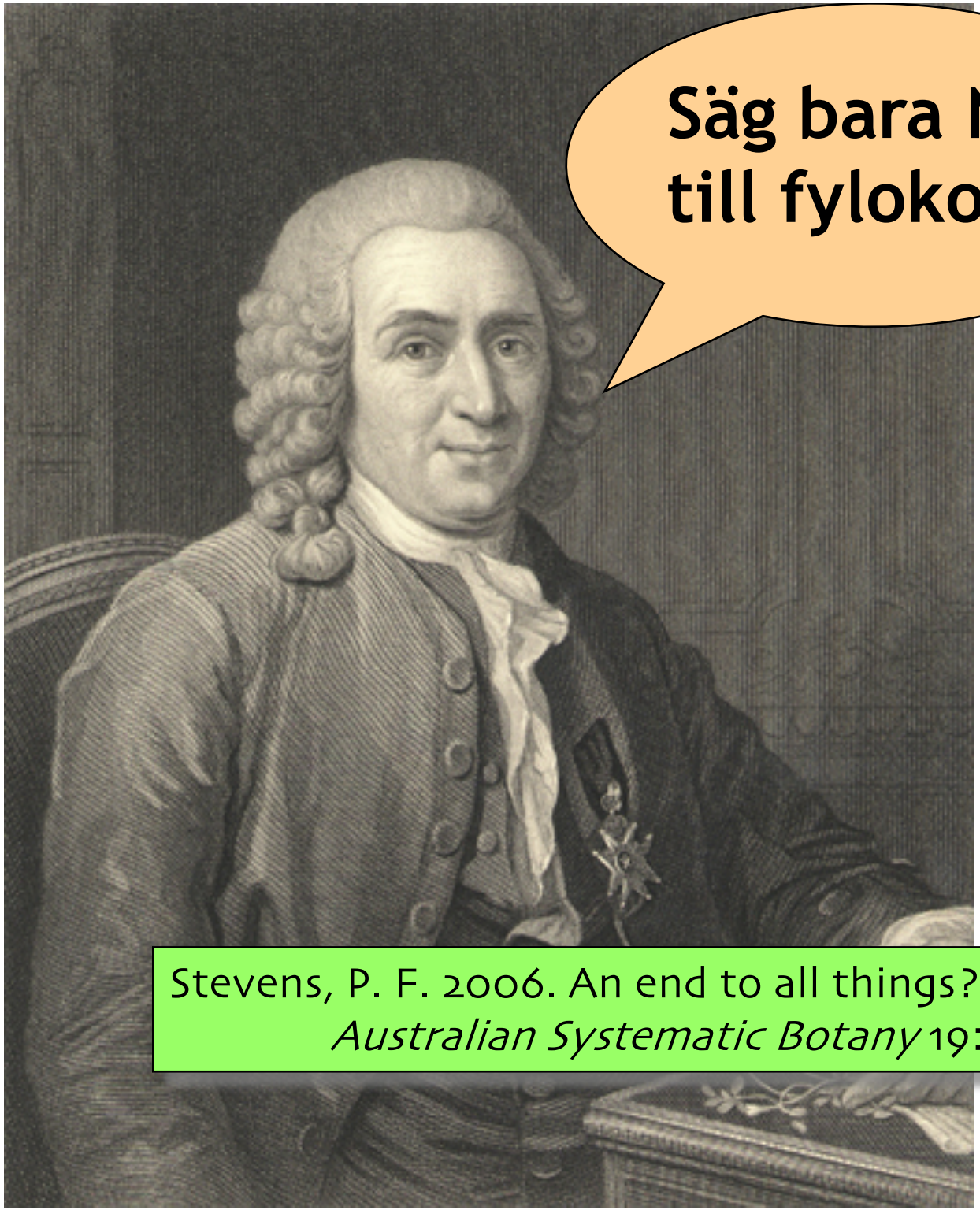
traditional rules of nomenclature have deficiencies & their use to reflect relationships is cumbersome

De Queiroz & Gauthier: traditional nomenclatureal hierarchy should be abandoned & should be replaced with….

PhyloCode
http://www.ohiou.edu/phylocode/

Revolution of Nomenclature

Cantino, P. D. & al. 2007. Towards a phylogenetic nomenclature of Tracheophyta. *Taxon* 56: 822-846.



2003

The Botanical Review 69(1)

NYBG

Stevens, P. F. 2006. An end to all things? – plants and their names. *Australian Systematic Botany* 19: 115-133.

Basic principles of classification

rules of nomenclature are not perfect

Nixon, K.C. & Carpenter, J.M. 2000. On the other phylogenetic systematics. *Cladistics* 16: 298-318.

[Phylocode will give]...stability in spelling, not what species are included.

despite of their deficencies traditional rules of nomenclature provide chance to convey much INFORMATION

orders can be divided to families including genera etc.

terminology of Linnean nomenclature is HIERARCHIC and thus it is VERY suitable for organization of hierarchic information (e.g. results of cladistic analyses)

Basic principles of classification

rules of nomenclature are not perfect

Wheeler, Q. D. 2004. Taxonomic triage and the poverty of phylogeny. *Phil. Trans. R. Soc. Lond.* B 359: 571-583.

Linnaean nomenclature is stable enough to say what we know, flexible enough to accommodate what we learn; independent of specific theory, yet reflective of known empirical data; compatible with phylogenetic theory, but not a slave to it; particular enough for precise communication...

... an effective international, inter-generational and trans-theoretical system of classification

arranging taxonomic information in COMPREHENSIVE & INTERLINKED databases is a great challenge

PLOS BIOLOGY

FORMAL COMMENT

Taxonomy based on science is necessary for global conservation

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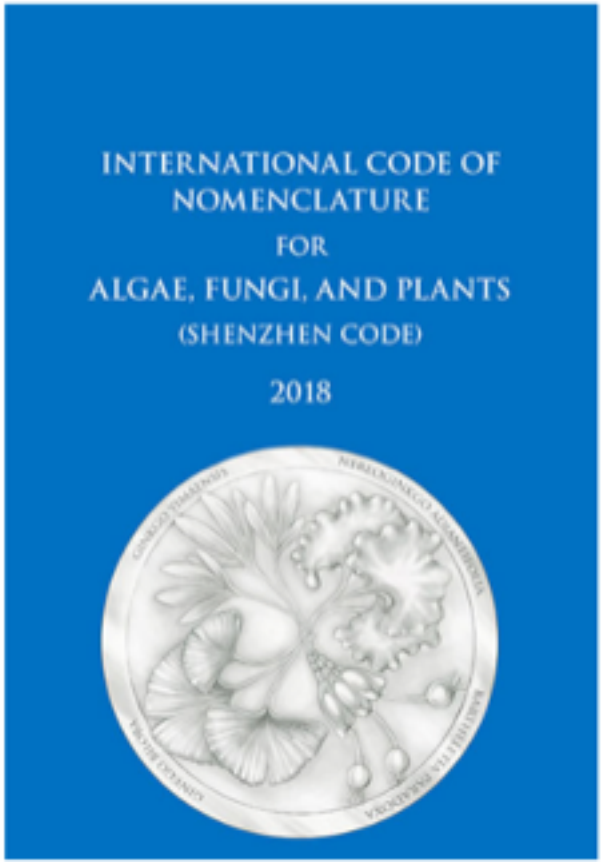
www.iapt-taxon.org/nomen/main.php



International Code of Nomenclature for algae, fungi, and plants

The *International Code of Nomenclature for algae, fungi, and plants* is the set of rules and recommendations that govern the scientific naming of all organisms traditionally treated as algae, fungi, or plants, whether fossil or non-fossil, including blue-green algae (*Cyanobacteria*), chytrids, oomycetes, slime moulds, and photosynthetic protists with their taxonomically related non-photosynthetic groups (but excluding *Microsporidia*). Before 2011 it was called the *International Code of Botanical Nomenclature* (ICBN).

This edition of the *Code* embodies the decisions of the Nomenclature Section of the XIX International Botanical Congress (IBC), which took place in Shenzhen, China in July, 2017. This *Shenzhen Code* supersedes the *Melbourne Code* (McNeill & al. in Regnum Veg. 154. 2012), published after the XVIII IBC in Melbourne, Australia in 2011. The rules of the *Shenzhen Code* became effective immediately upon acceptance of the resolution at the closing plenary session of the XIX IBC on 29 July 2017, that the decisions and appointments of its Nomenclature Section be approved. The *Shenzhen Code* in its final form was published on 26 June 2018 (printed version). This electronic version was made available on 27 June 2018.

SUMMARY

monophyly is one of the central principles of cladistics

…and classification

levels of hierarchy DO NOT correspond each other in different groups of organisms

all levels of hierarchy does NOT need to be given formal names

abandonment of hierarchic nomenclature would lead to CHAOS

classification without change is IMPOSSIBLE

requirement of stability is equally absurd in taxonomy as in any other field of science

knowledge HAS TO BE UPDATED also in taxonomy!