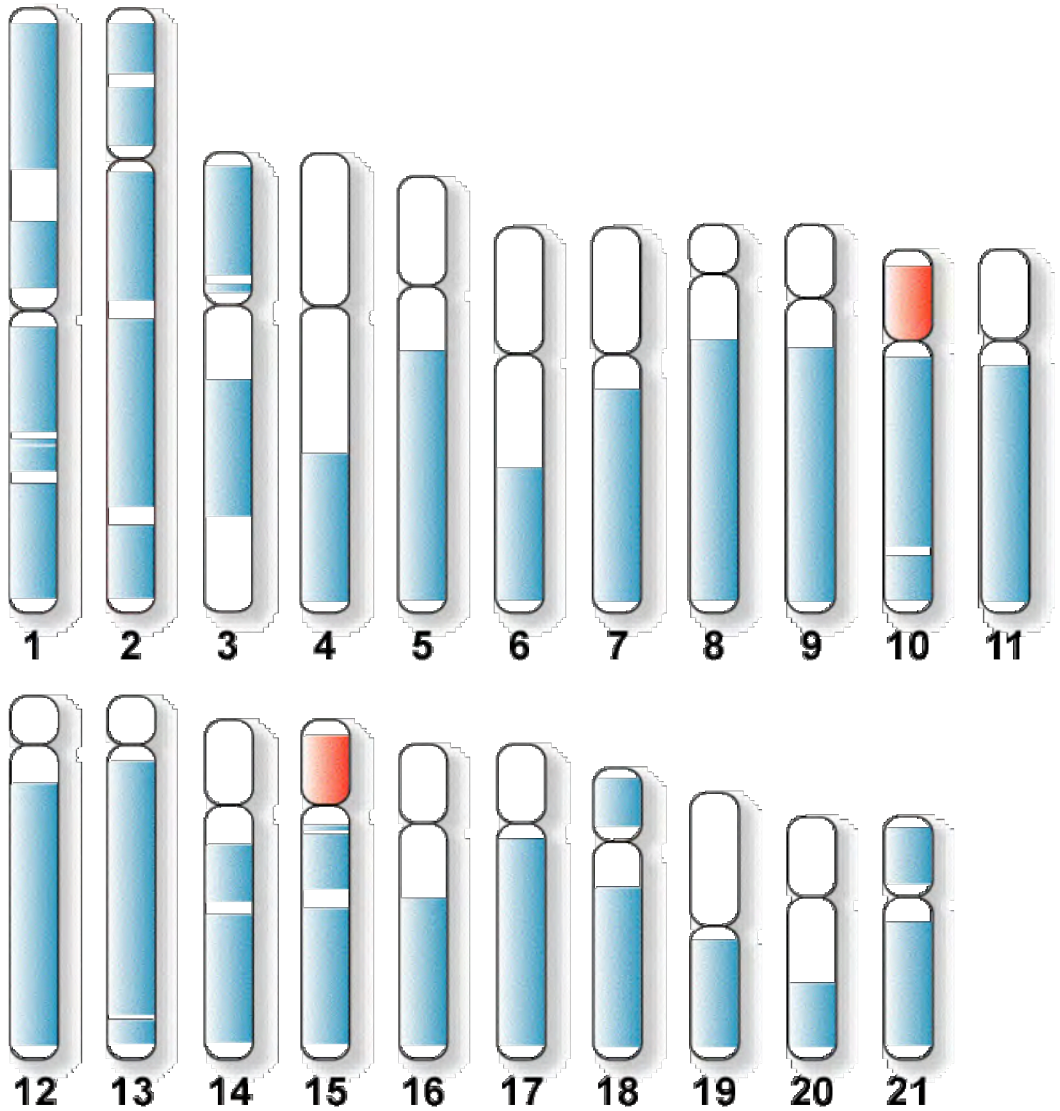
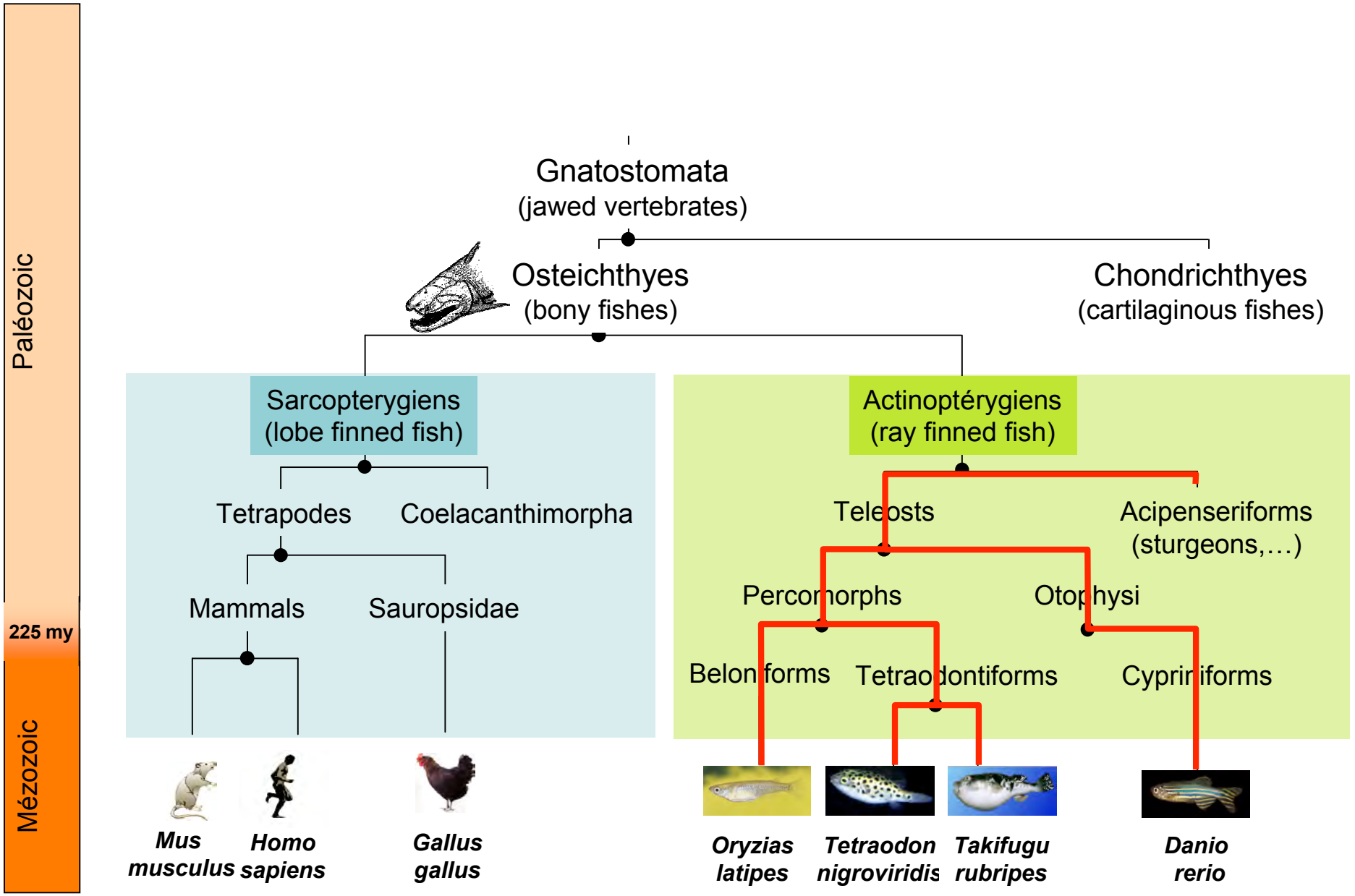
Genome duplication in the Tetraodon nigroviridis genome reveals the early vertebrate karotype

What did our paleozoic ancestor genome look like ?

64% of the genome is anchored to chromosomes

36% remains as independent sequences




Paléozoic
225 my
Mézozoic
Gnatostomata
(jawed vertebrates)
Osteichthyes
(bony fishes)
Chondrichthyes
(cartilaginous fishes)
Sarcopterygiens
(lobe finned fish)
Actinoptérygiens
(ray finned fish)
Tetrapodes
Coelacanthimorpha
Teleosts
Acipenseriforms
(sturgeons,…)
Mammals
Sauropsidae
Percomorphs
Otophysi
Belon forms
Tetrao dontiforms
Cyprin iforms
Mus musculus
Homo sapiens
Gallus gallus
Oryzias latipes
Tetraodon nigroviridis
Takifugu rubripes
Danio rerio

Genome Duplication

- A powerful source of functional innovation (whole metabolic pathways)
- How do duplicate gene copies evolve (redundancy) ?
- How does a genome duplication spread in a population?
- What impact does it have on the cell (cycle, regulation, nutrients)?

- Following a genome duplication, all genes are in two copies

 important redundancy

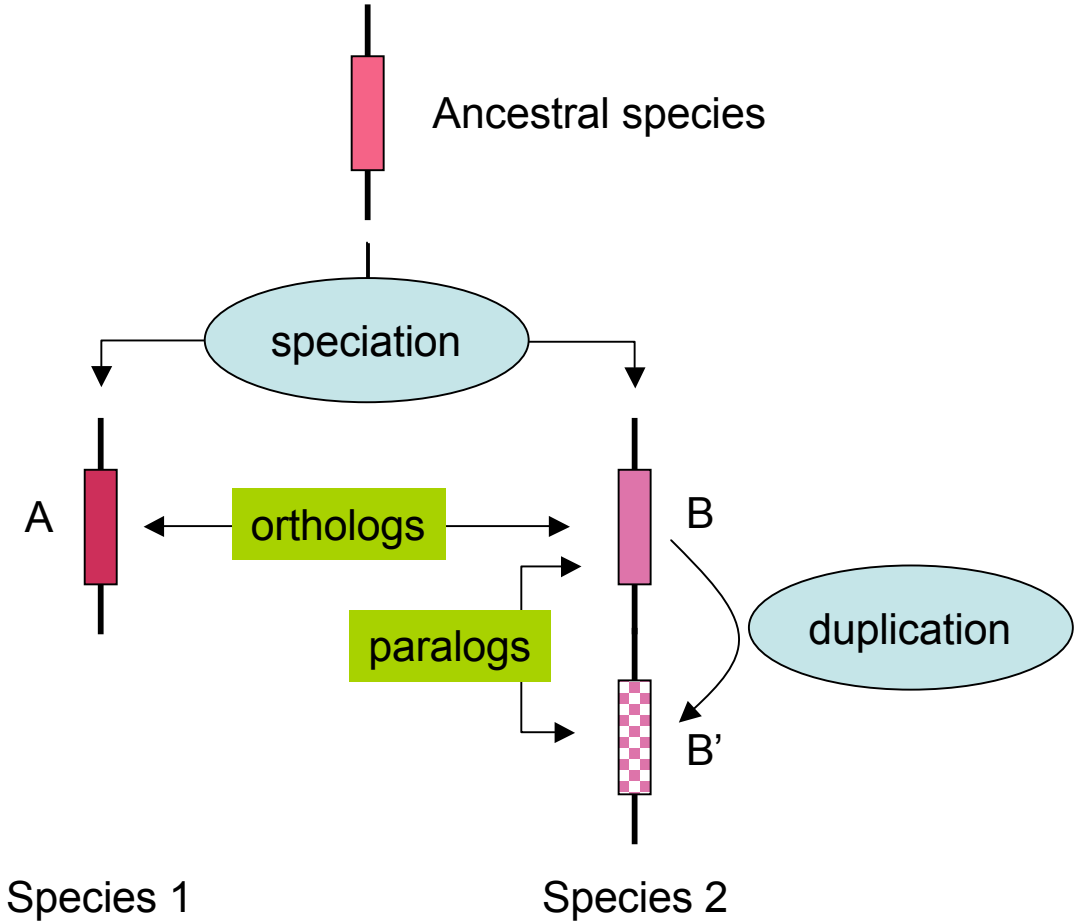
- Most supernumerary gene copies are progressively eliminated

diploid  tetraploid  diploid

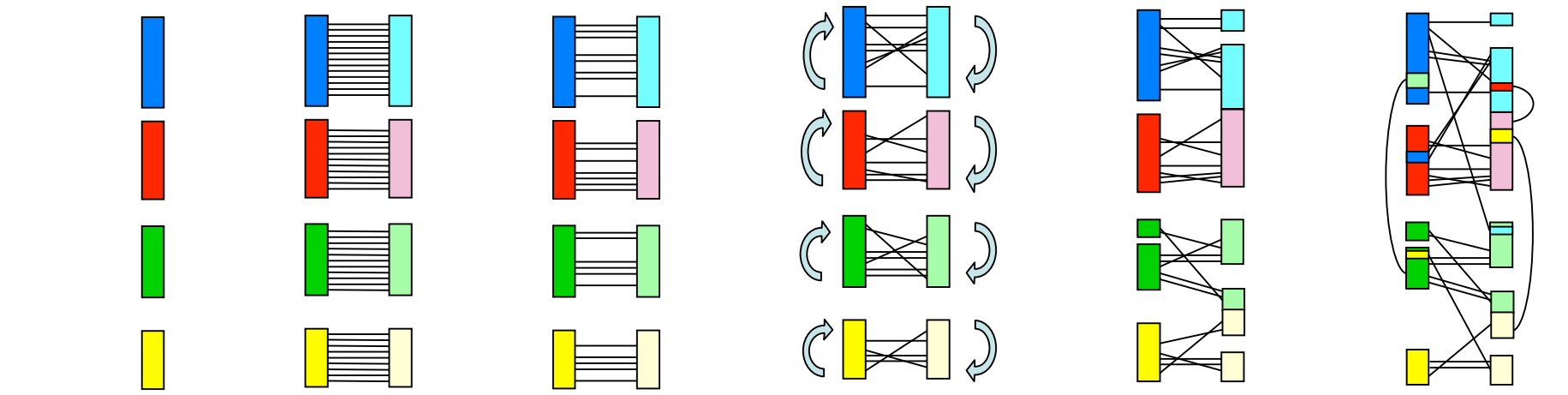
duplication

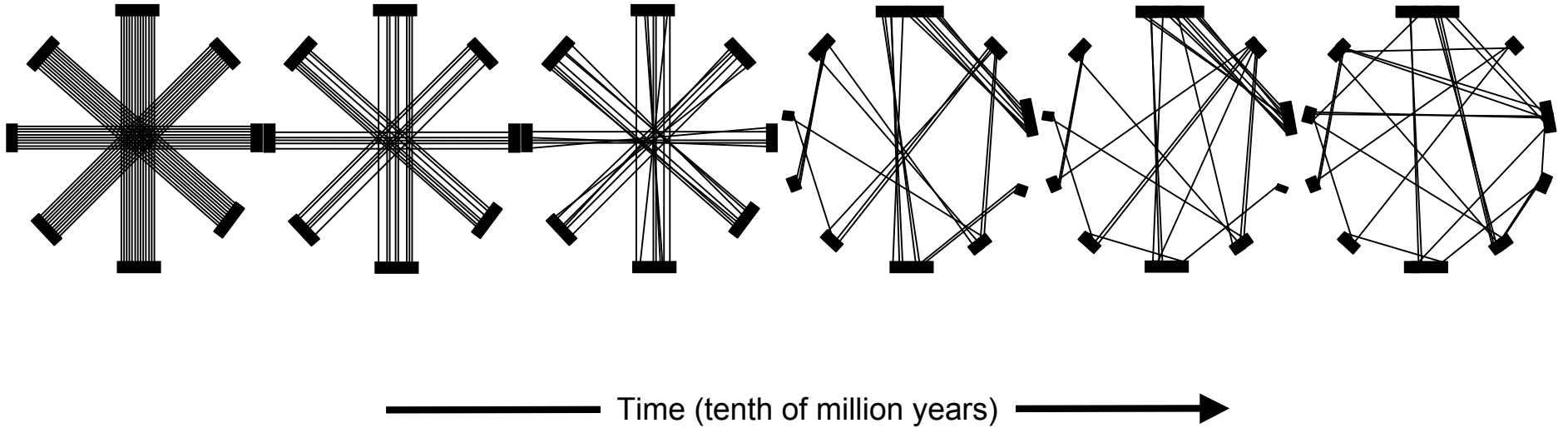
diploidization

- If most copies are eliminated, what is there left to prove that a duplication took place?

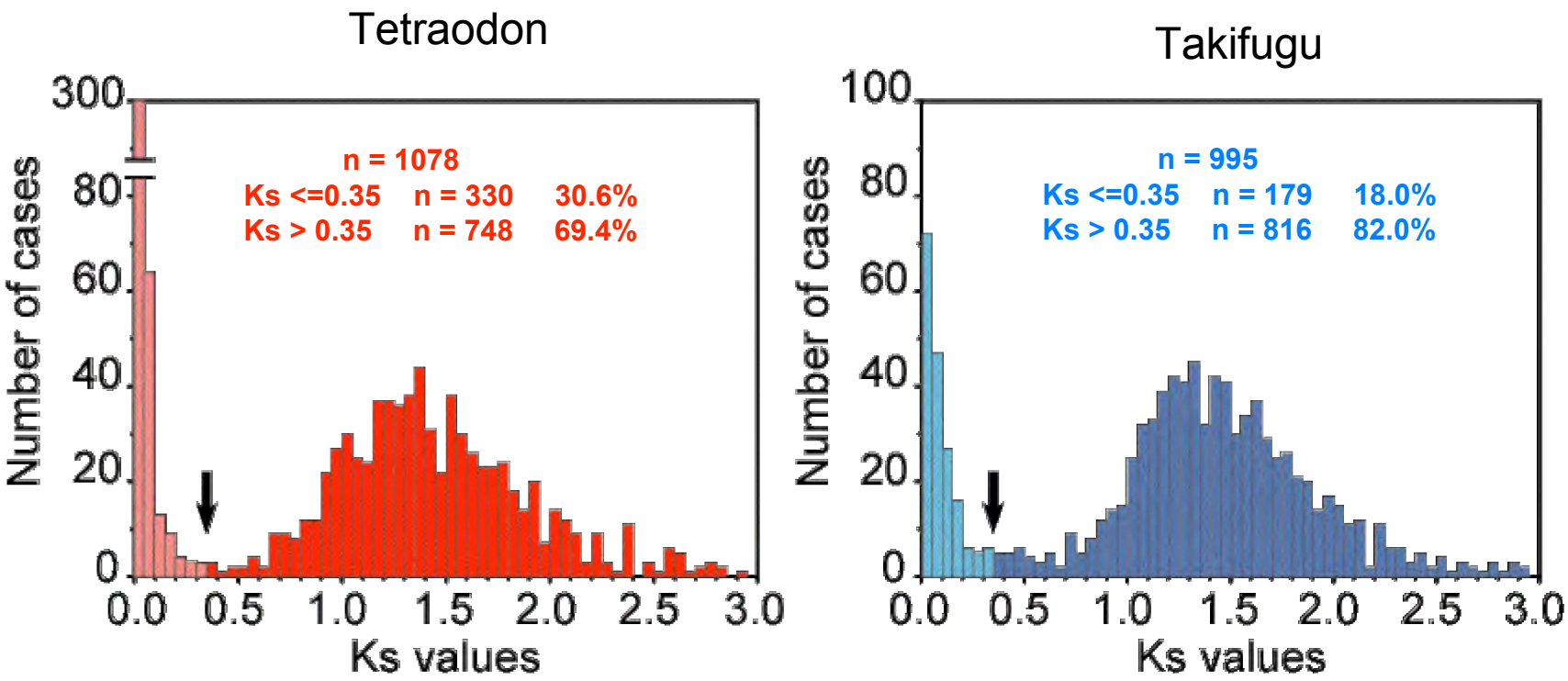


- A and B derive from an ancestral gene by ***speciation***: they are ***orthologs*** ⇨ Signature?
- B' appears by duplication of B: they are ***paralogs*** ⇨ Signature?

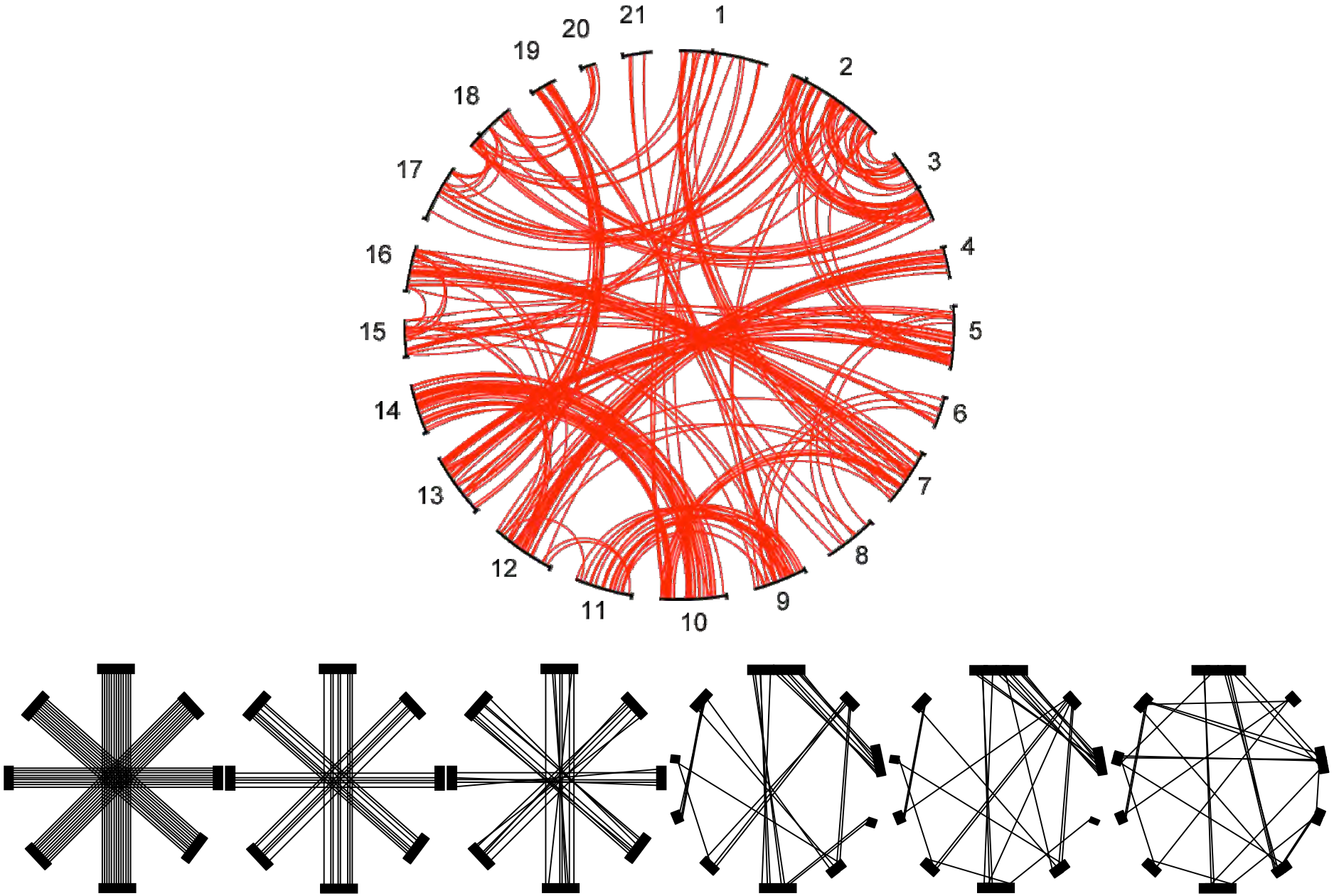

Ancestral genome
Duplication
Deletions
intra-chromosomal rearrangements
Fusions and
Translocations

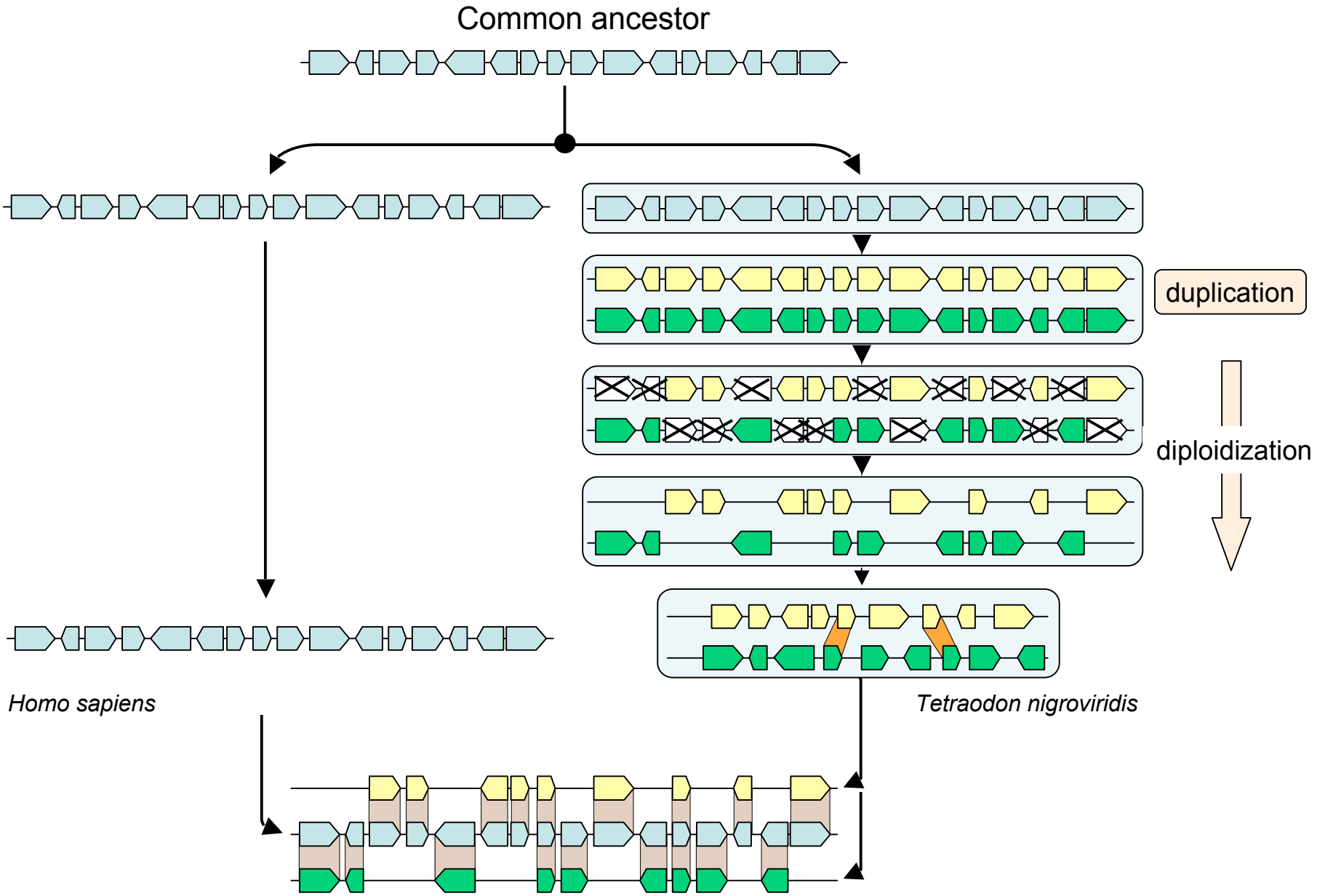

Time (tenth of million years)

Identification of duplicate genes



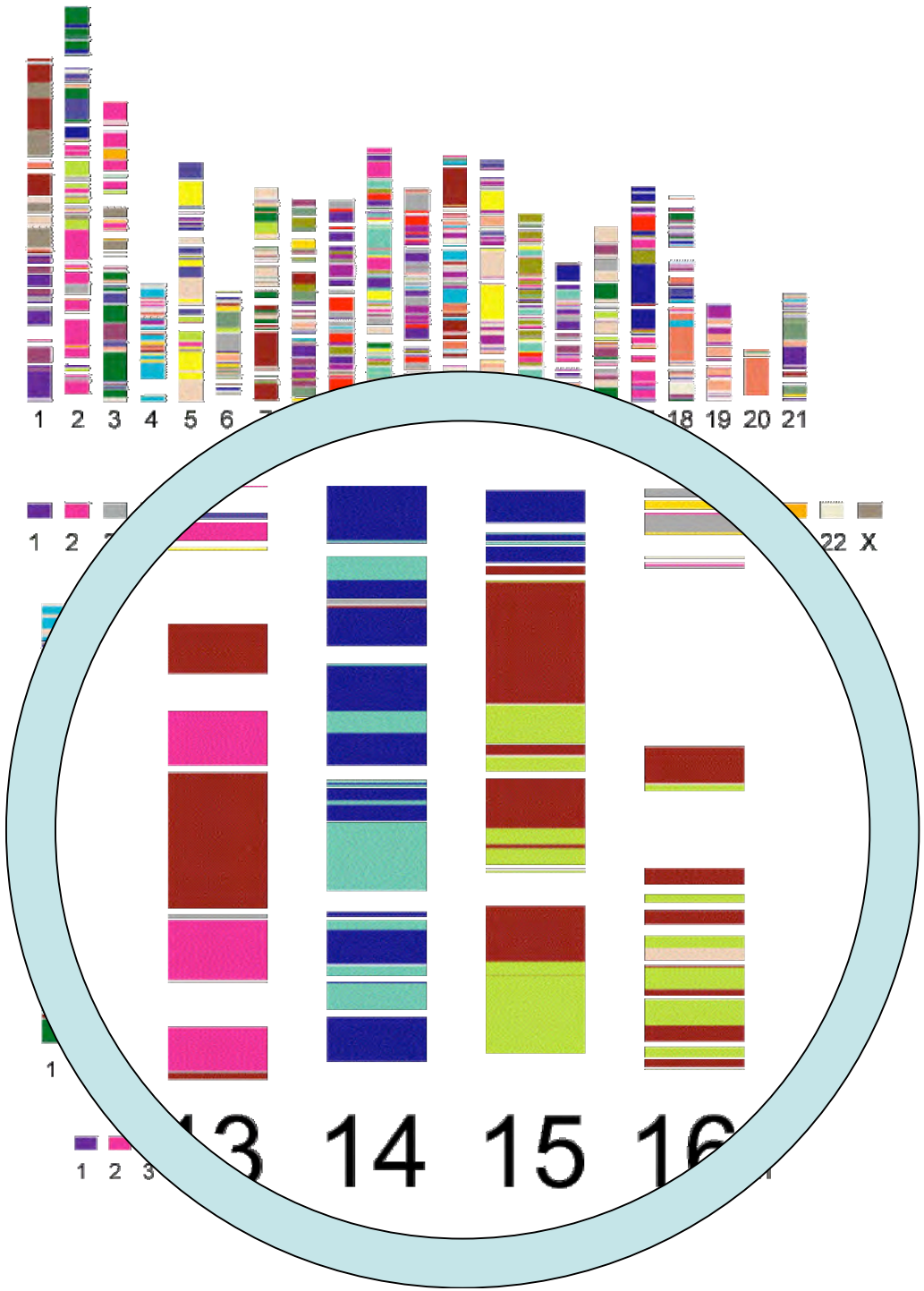
Distribution of 748 duplicate genes in the Tetraodon genome




Common ancestor
duplication
diploidization
Homo sapiens
Tetraodon nigroviridis

Tetraodon genome:
Synteny with the human genome

Human genome:
Synteny with the Tetraodon genome

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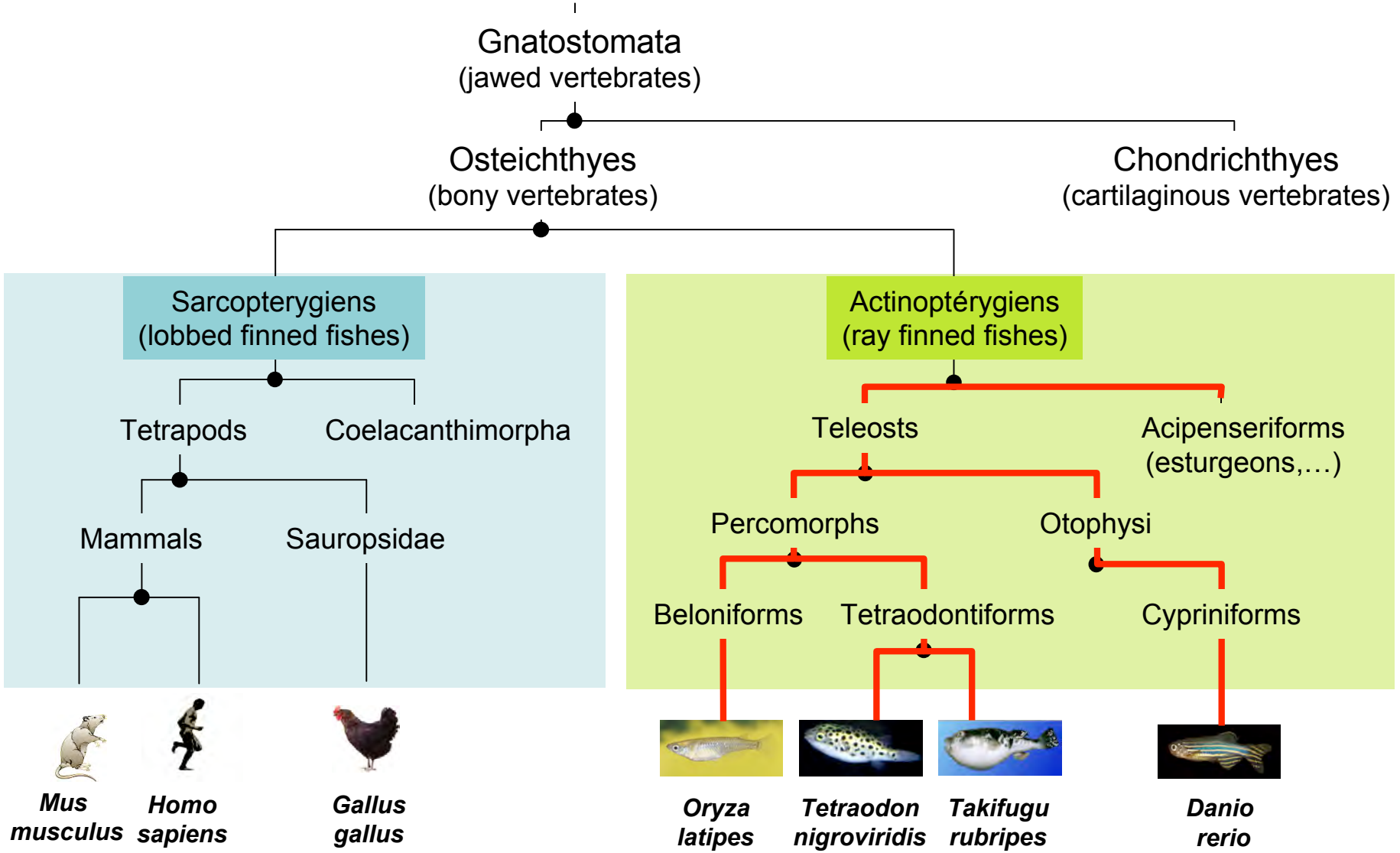
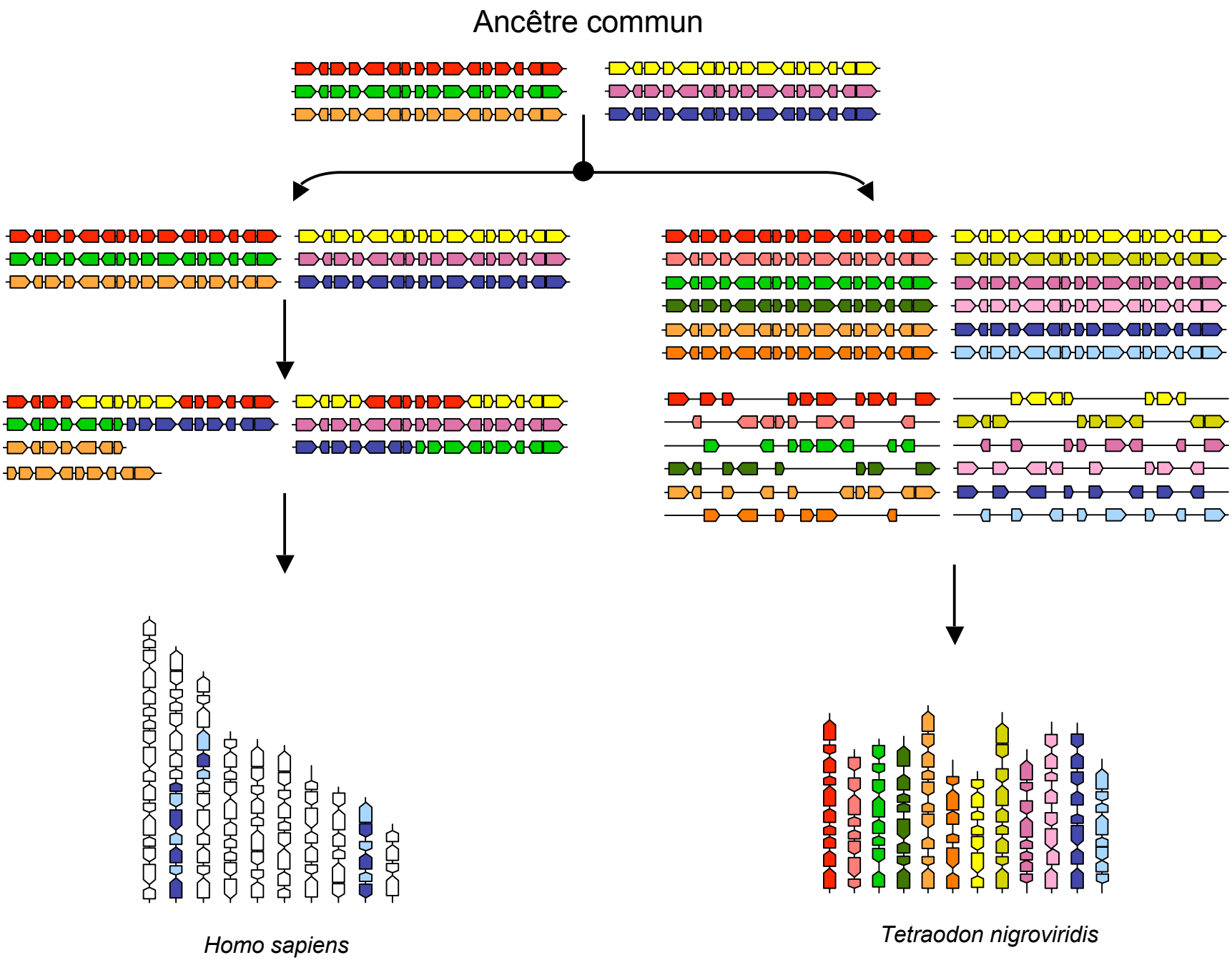
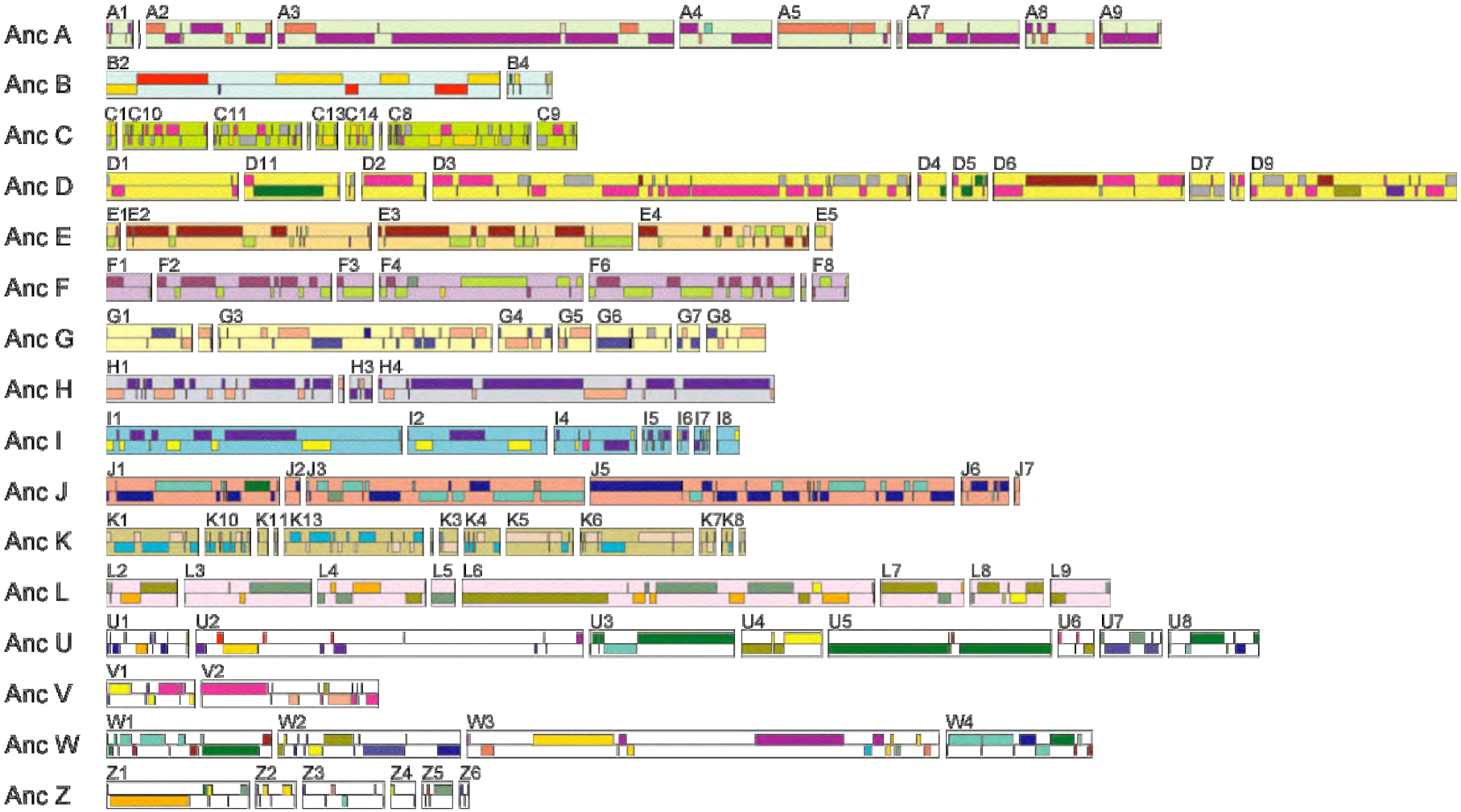

Gnatostomata
(jawed vertebrates)
Osteichthyes
(bony vertebrates)
Chondrichthyes
(cartilaginous vertebrates)
Sarcopterygiens
(lobbed finned fishes)
Actinoptérygiens
(ray finned fishes)
Tetrapods
Coelacanthimorpha
Teleosts
Acipenseriforms
(esturgeons,…)
Mammals
Sauropsidae
Percomorphs
Otophysi
Beloniforms
Tetraodontiforms
Cypriniforms
Mus musculus
Homo sapiens
Gallus gallus
Oryza latipes
Tetraodon nigroviridis
Takifugu rubripes
Danio rerio


Ancêtre commun
Homo sapiens
Tetraodon nigroviridis

The ancestral osteichthyes genome (bony vertebrates)



What are the intermediary steps in the evolution of the Tetraodon and the human genome ?

Modeling the evolution of a duplicated Tetraodon chromosome

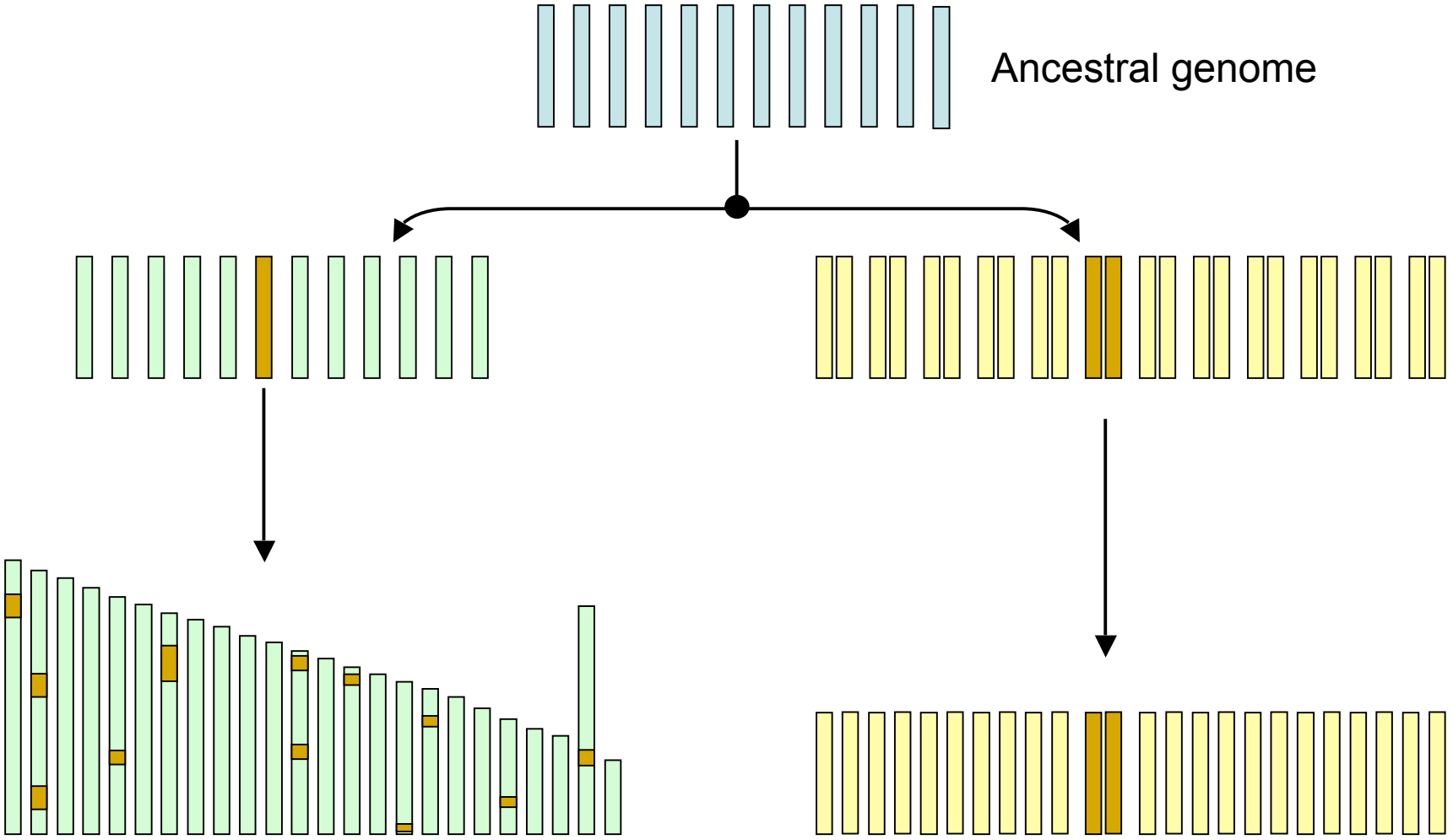
Gene order is progressively rearranged over time along Tetraodon and human chromosomes (independently)

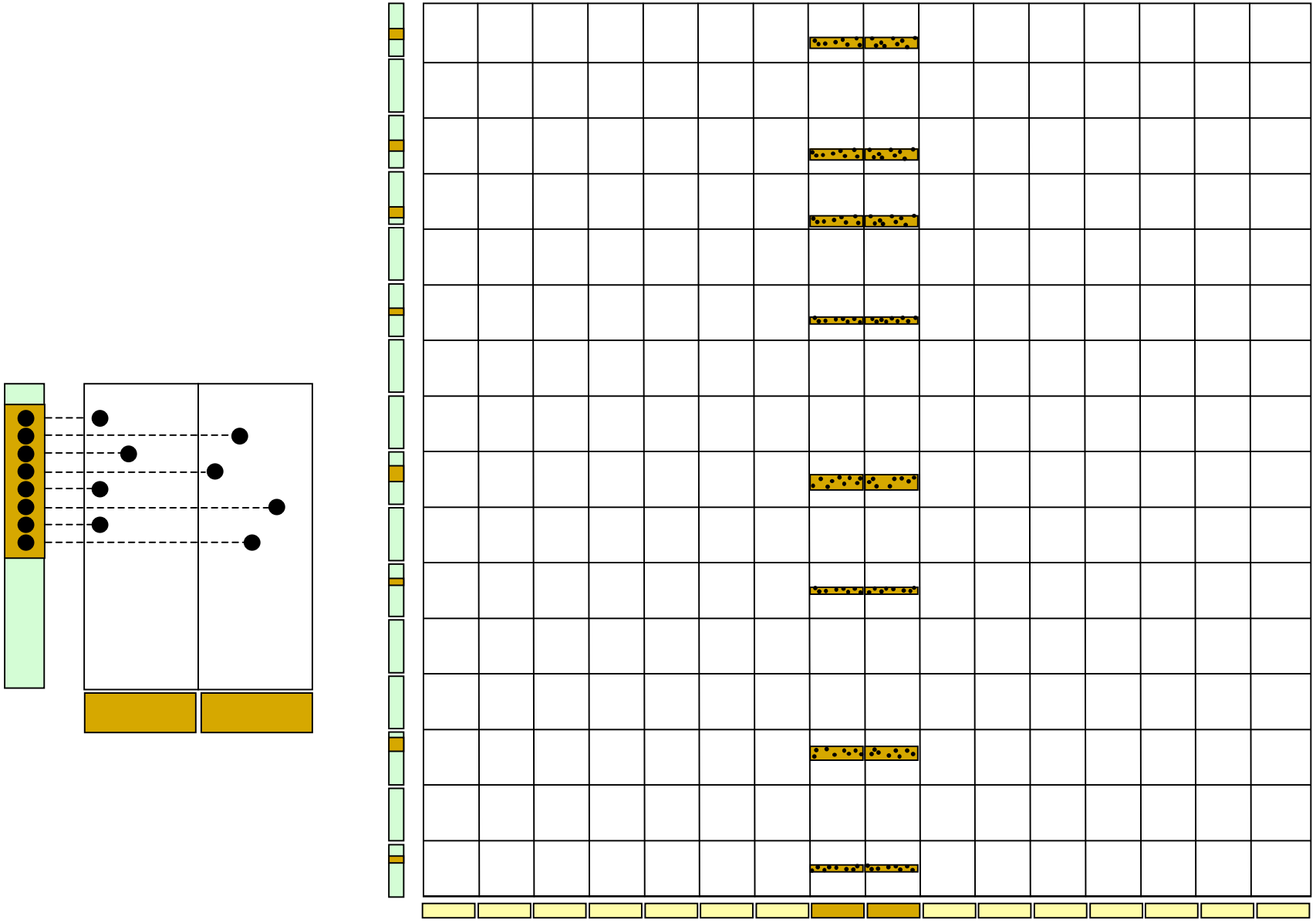
The degree of rearrangement along a chromosome segment is thus a measure of elapsed time

Modeling a few simple cases of chromosomal rearrangements in Tetraodon:

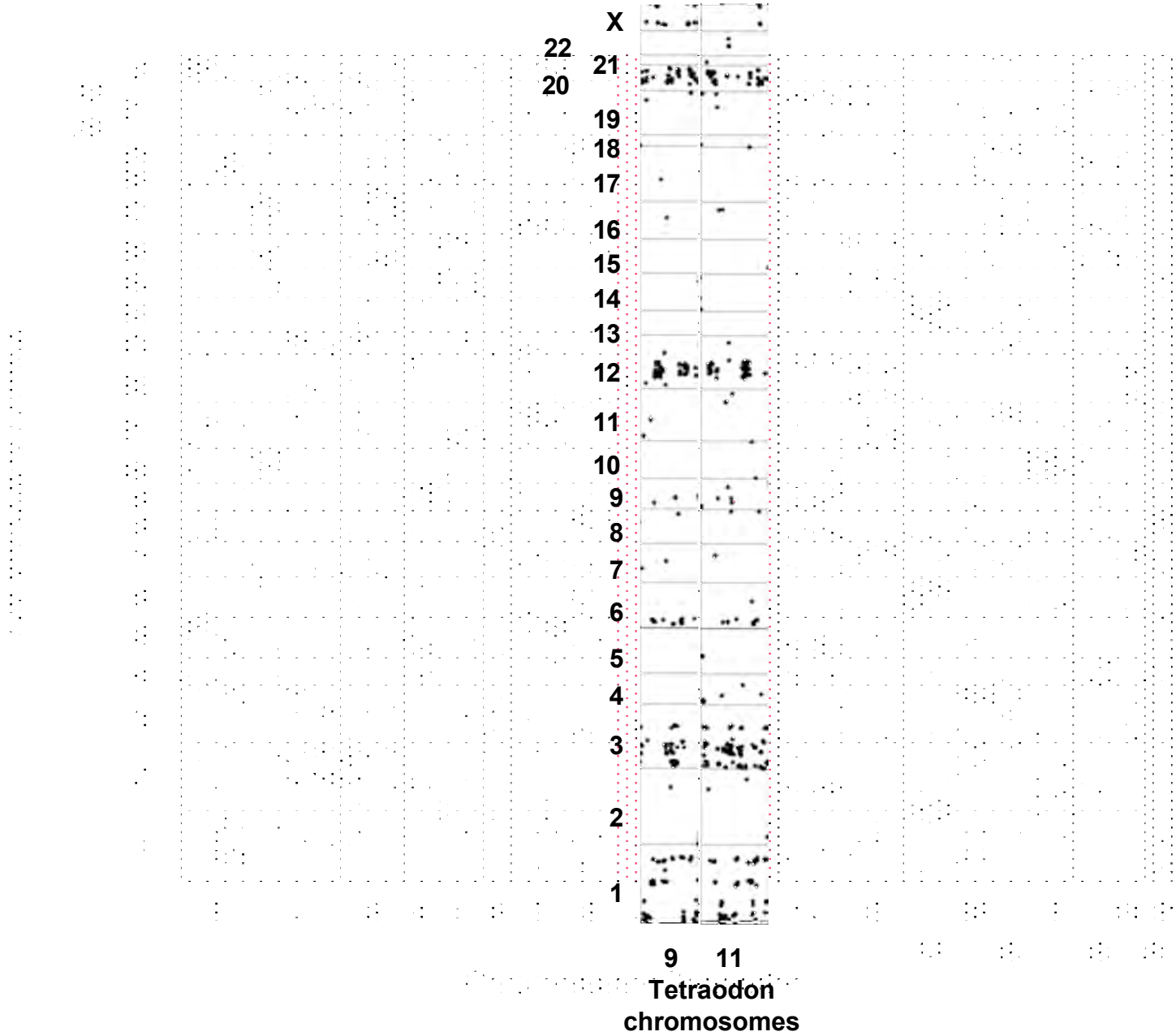
1) No rearrangement
2) a recent fusion between two chromosomes
3) an ancient fusion between two chromosomes
4) a fission (break) of a chromosome

A simple case: no interchromosomal rearrangement after the dulication

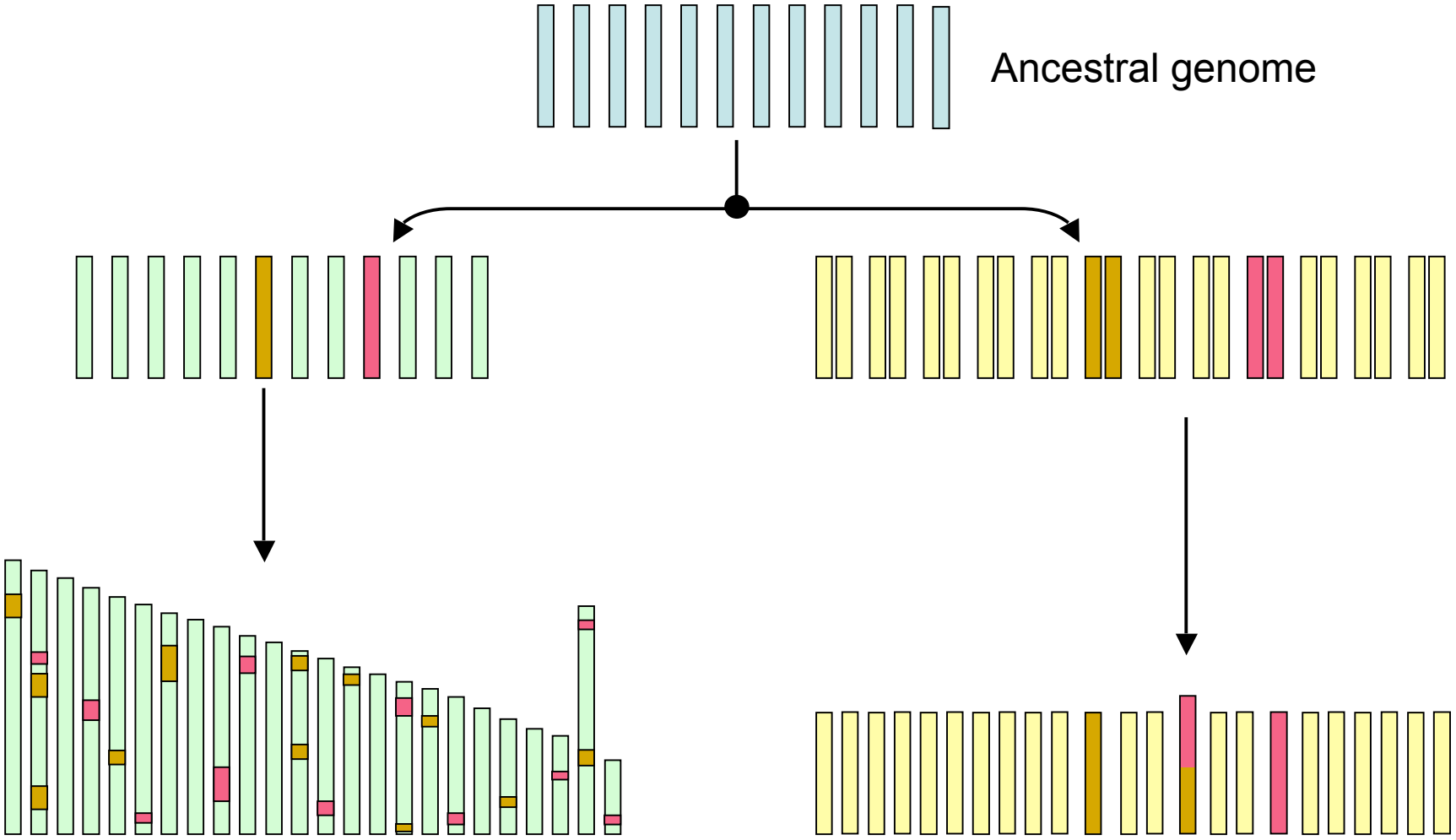


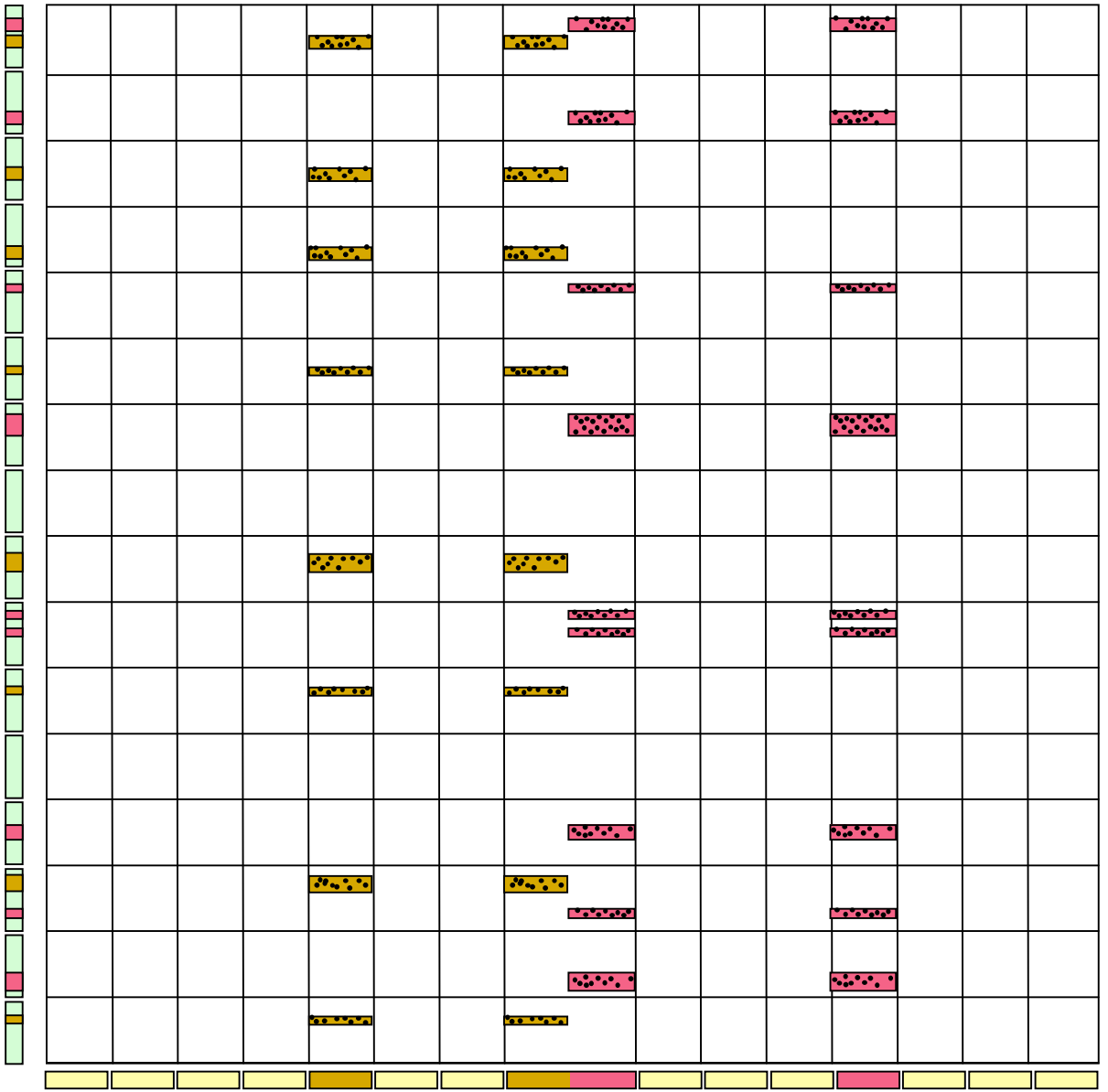


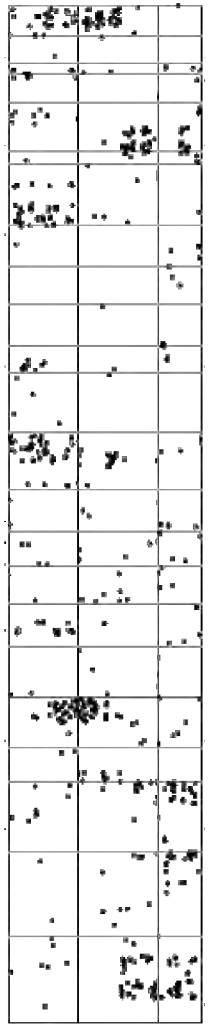
Distribution of 6884 orthologs in their respective genomes



Case 2) : recent fusion between two chromosomes



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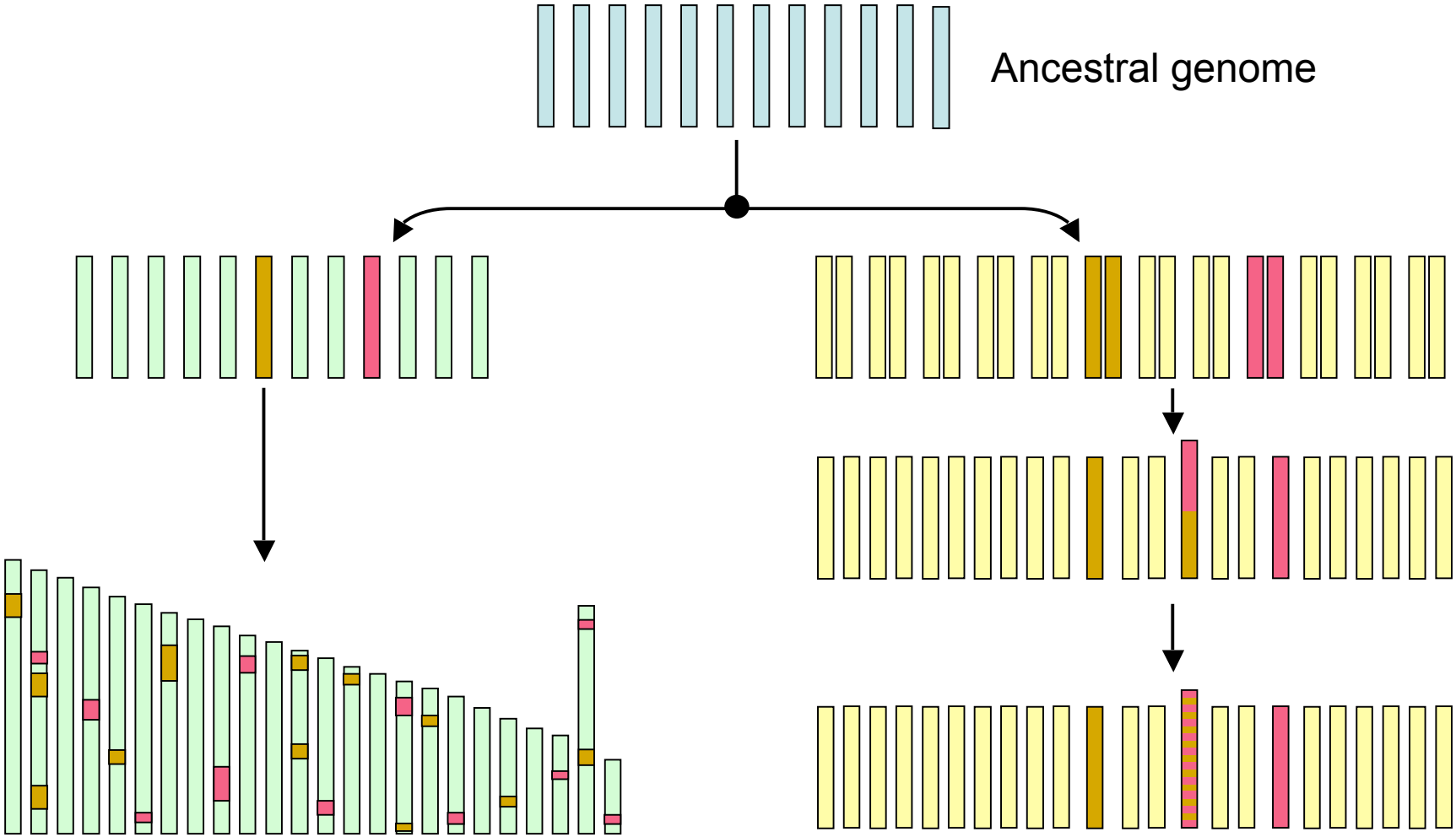
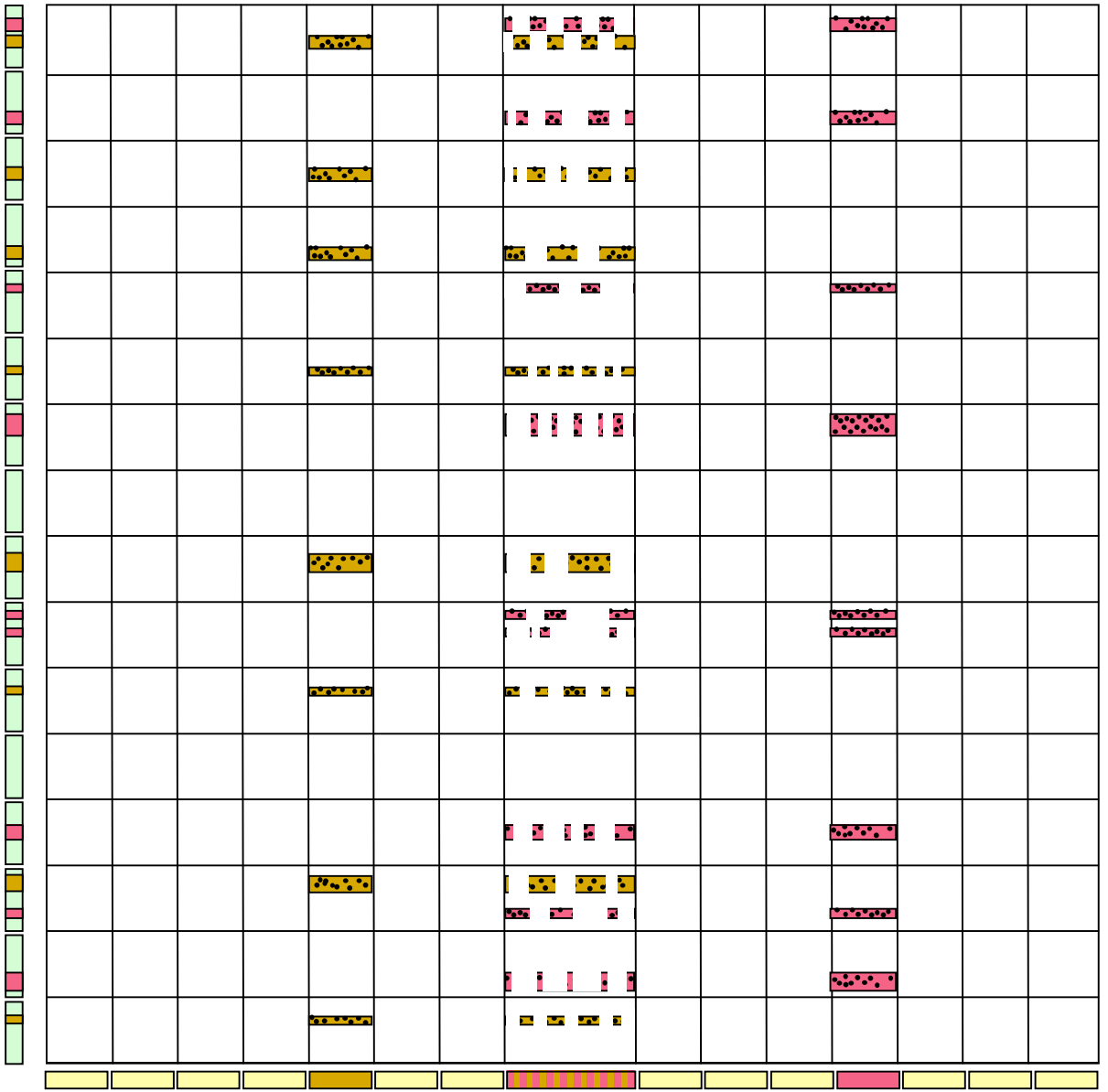
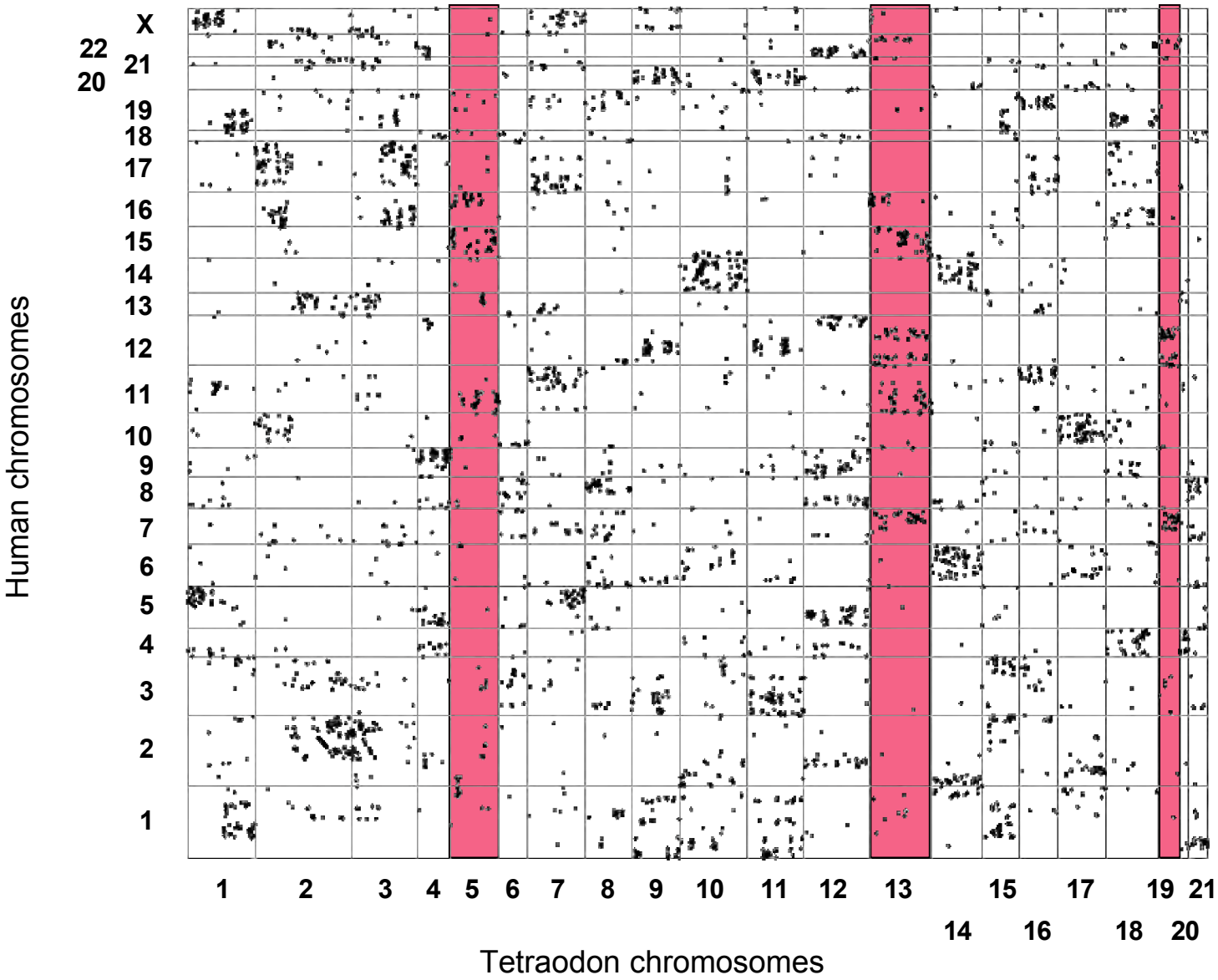
Case 3) : ancient fusion between two chromosomes






Human chromosomes
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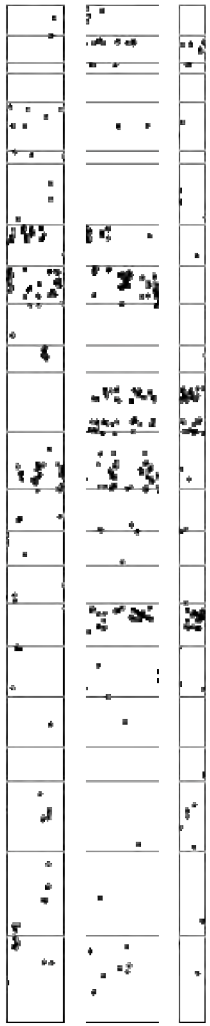
Tetraodon chromosomes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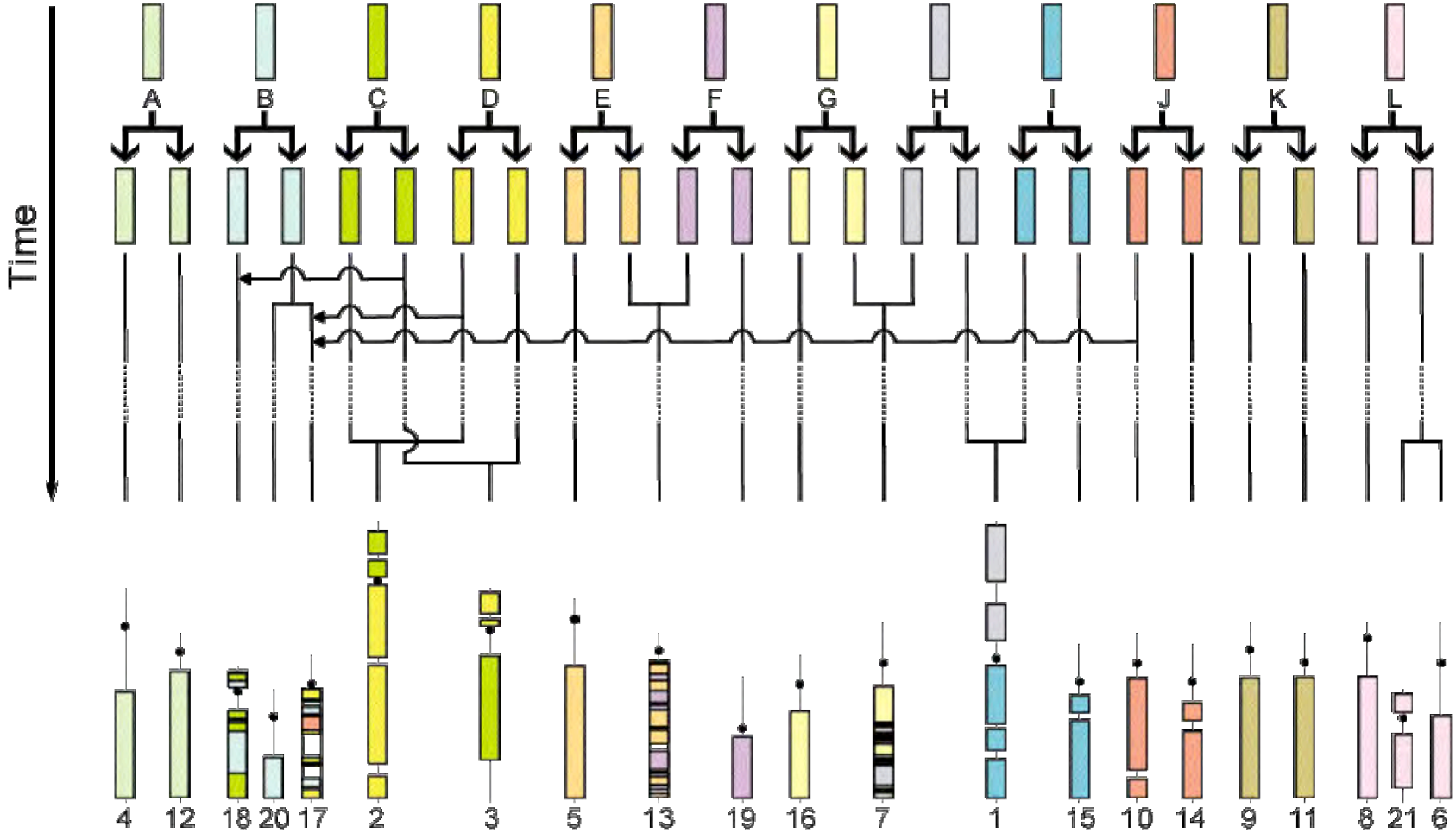
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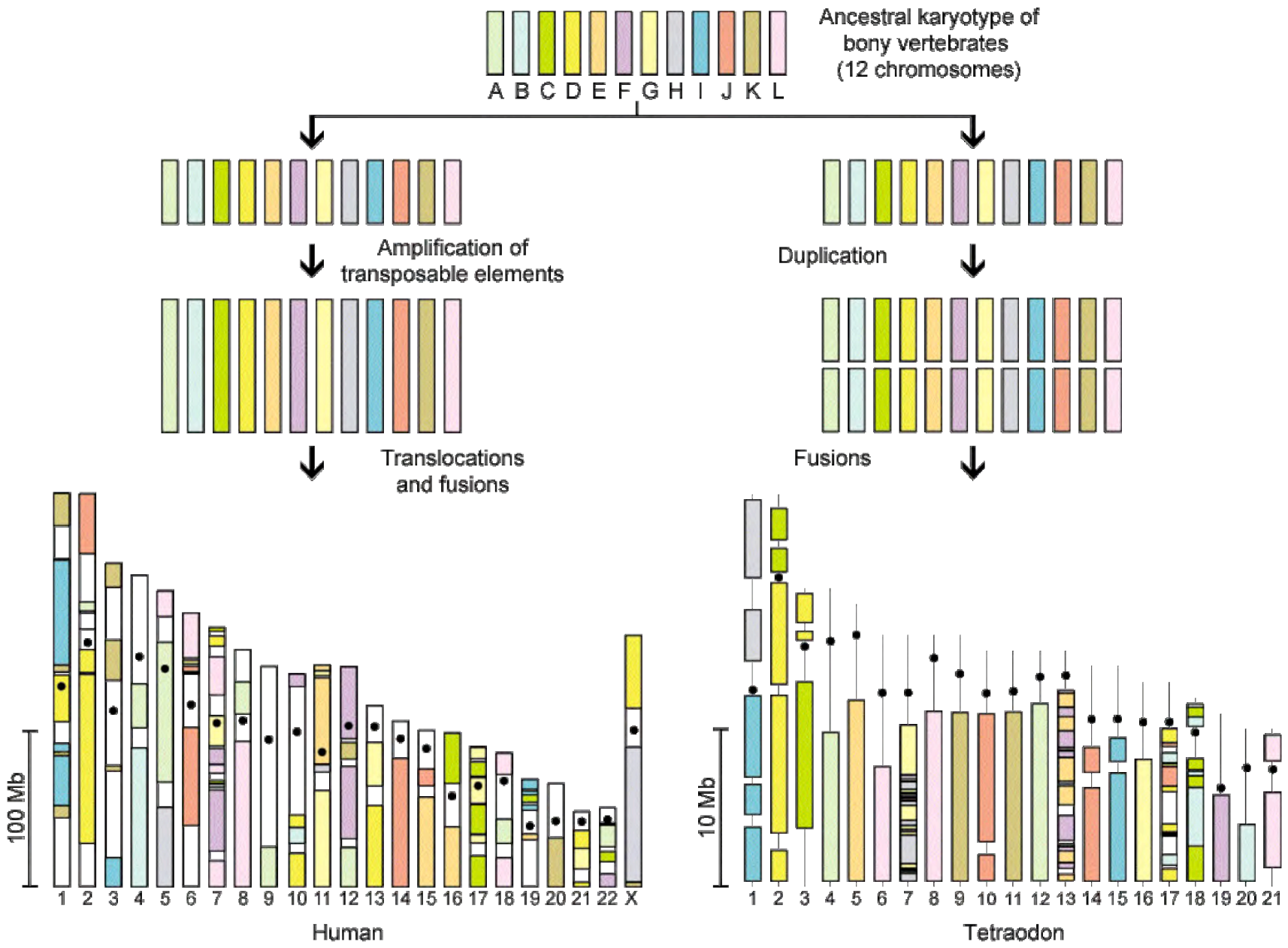
A B C D E F G H I J K L
Ancestral karyotype of
bony vertebrates
(12 chromosomes)
Amplification of
transposable elements
Duplication
Translocations
and fusions
Fusions
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Human
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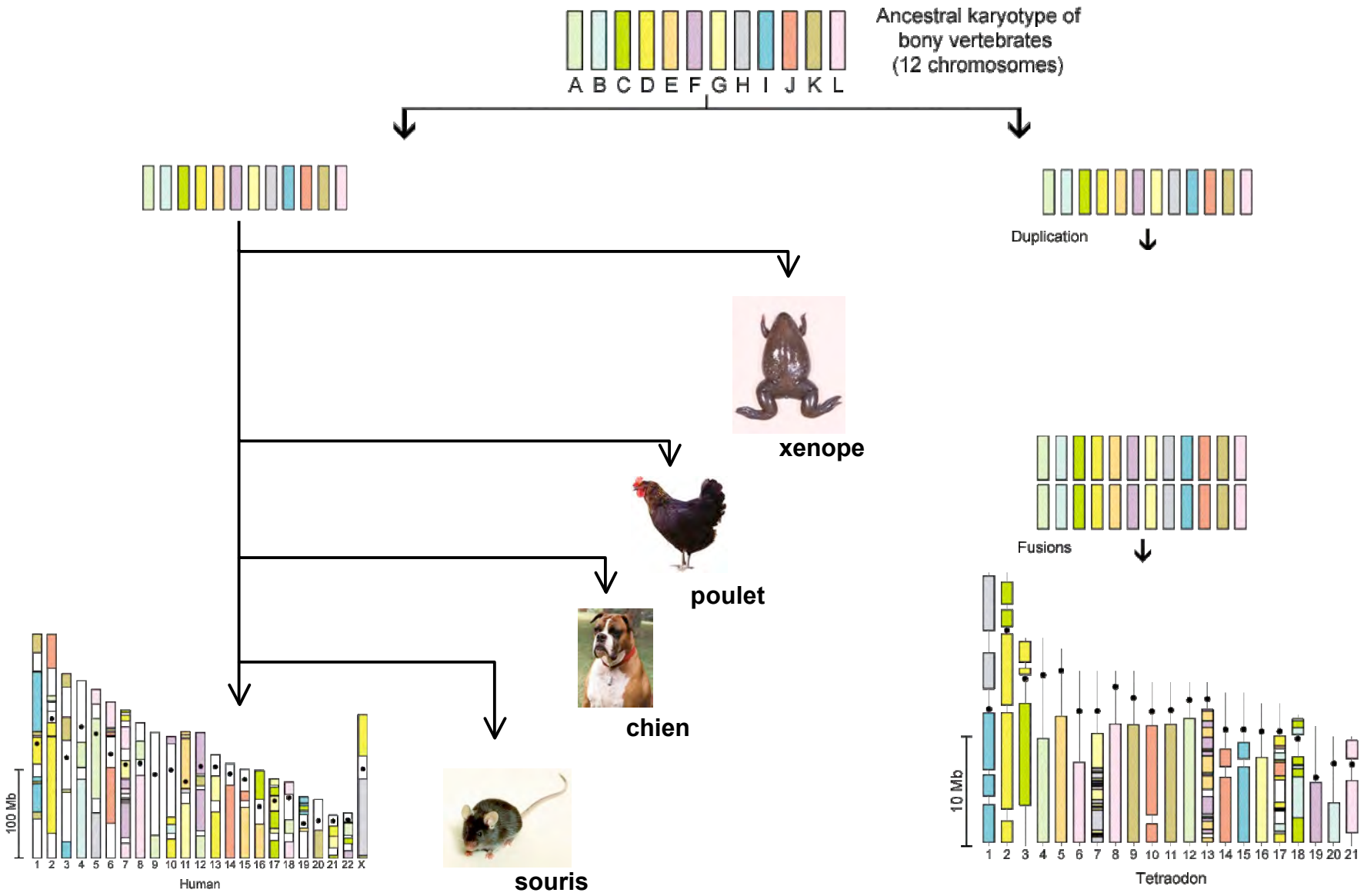
Tetraodon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Ancestral karyotype of
bony vertebrates
(12 chromosomes)
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Human
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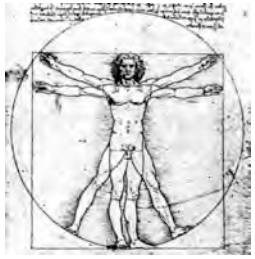
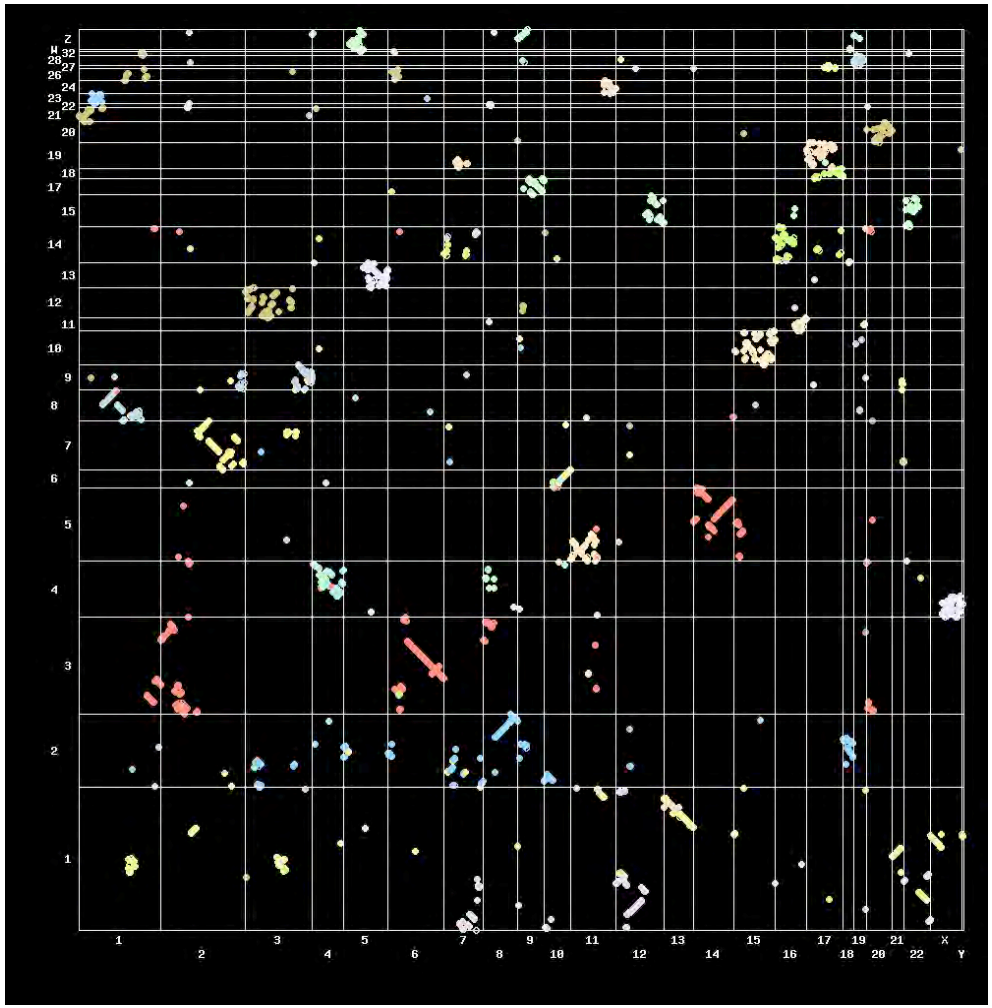
Tetraodon

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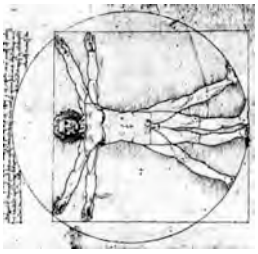

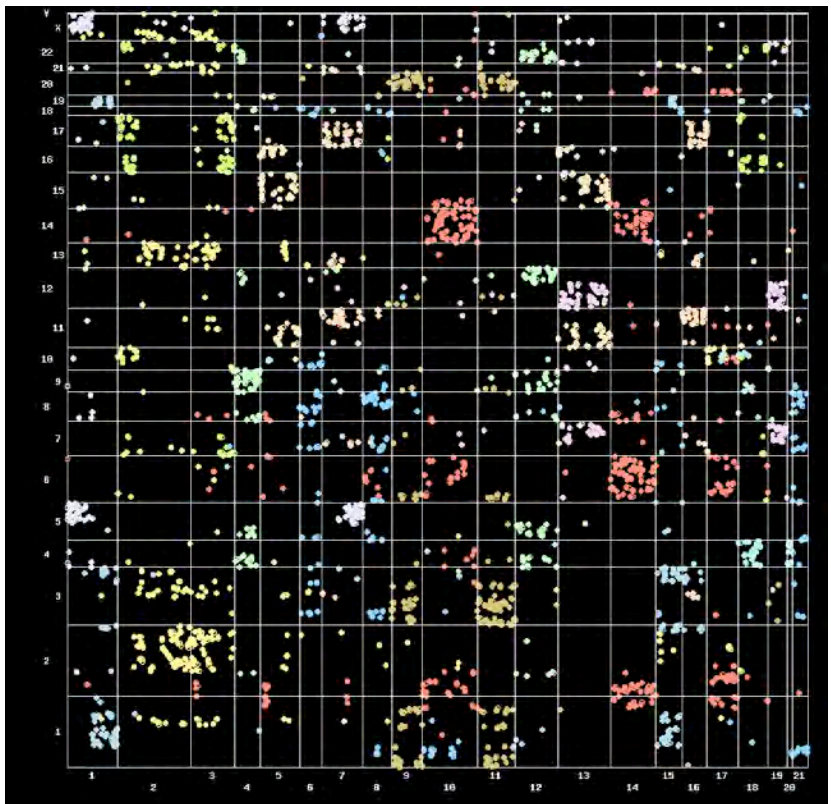

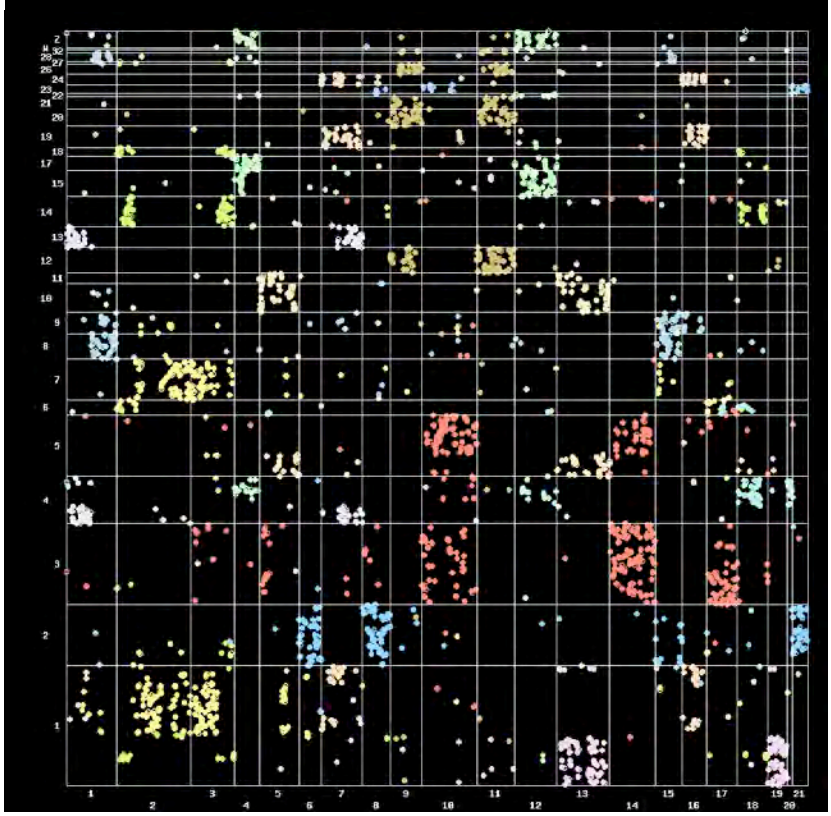

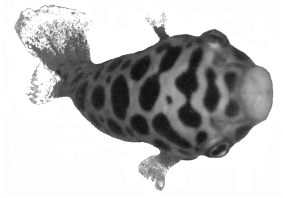

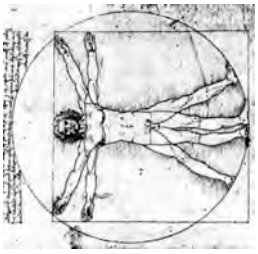

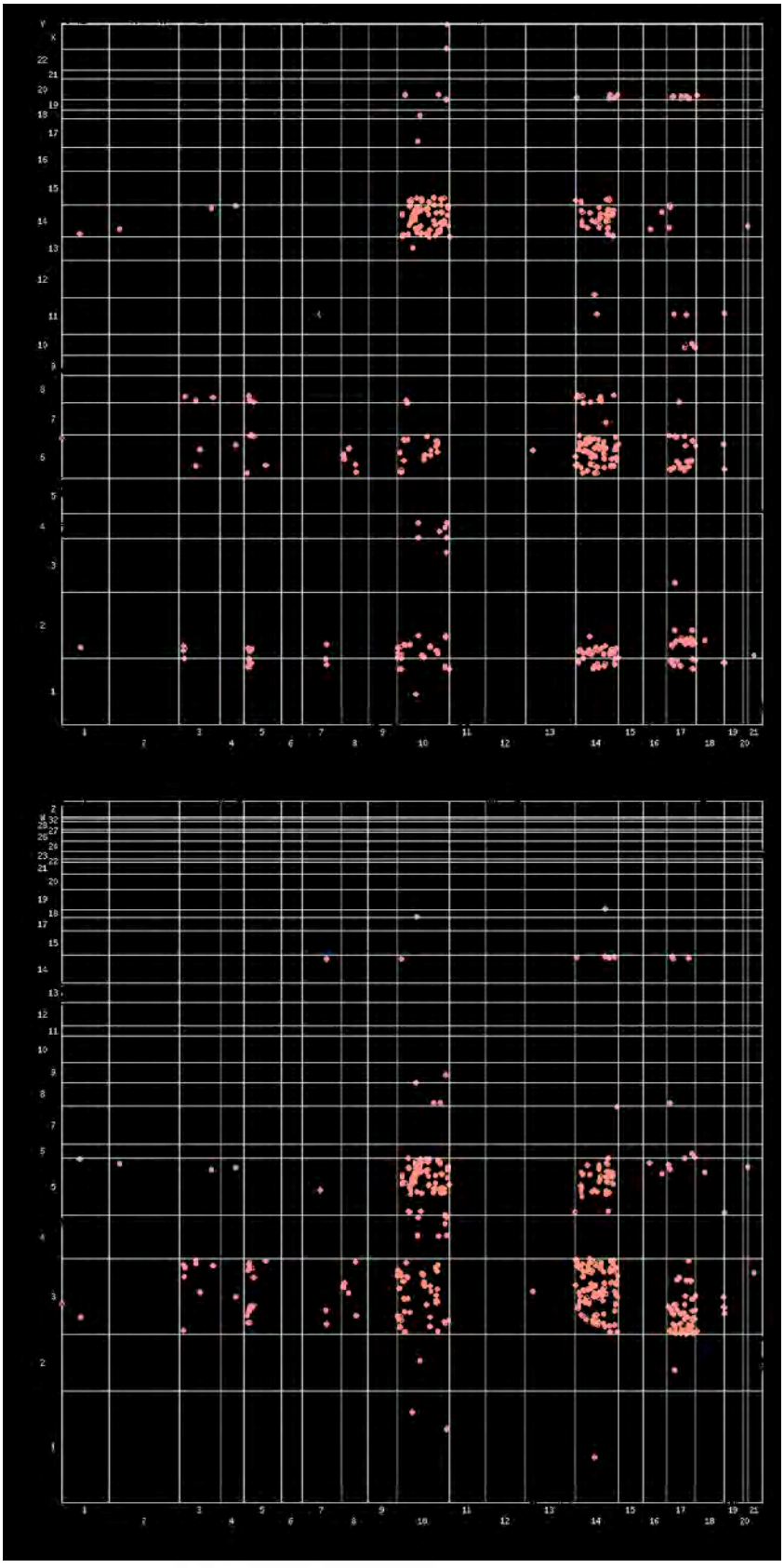

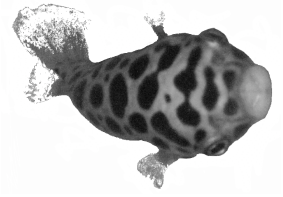

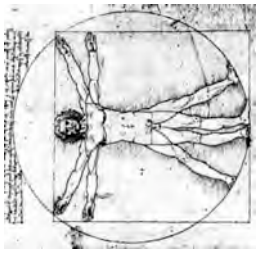

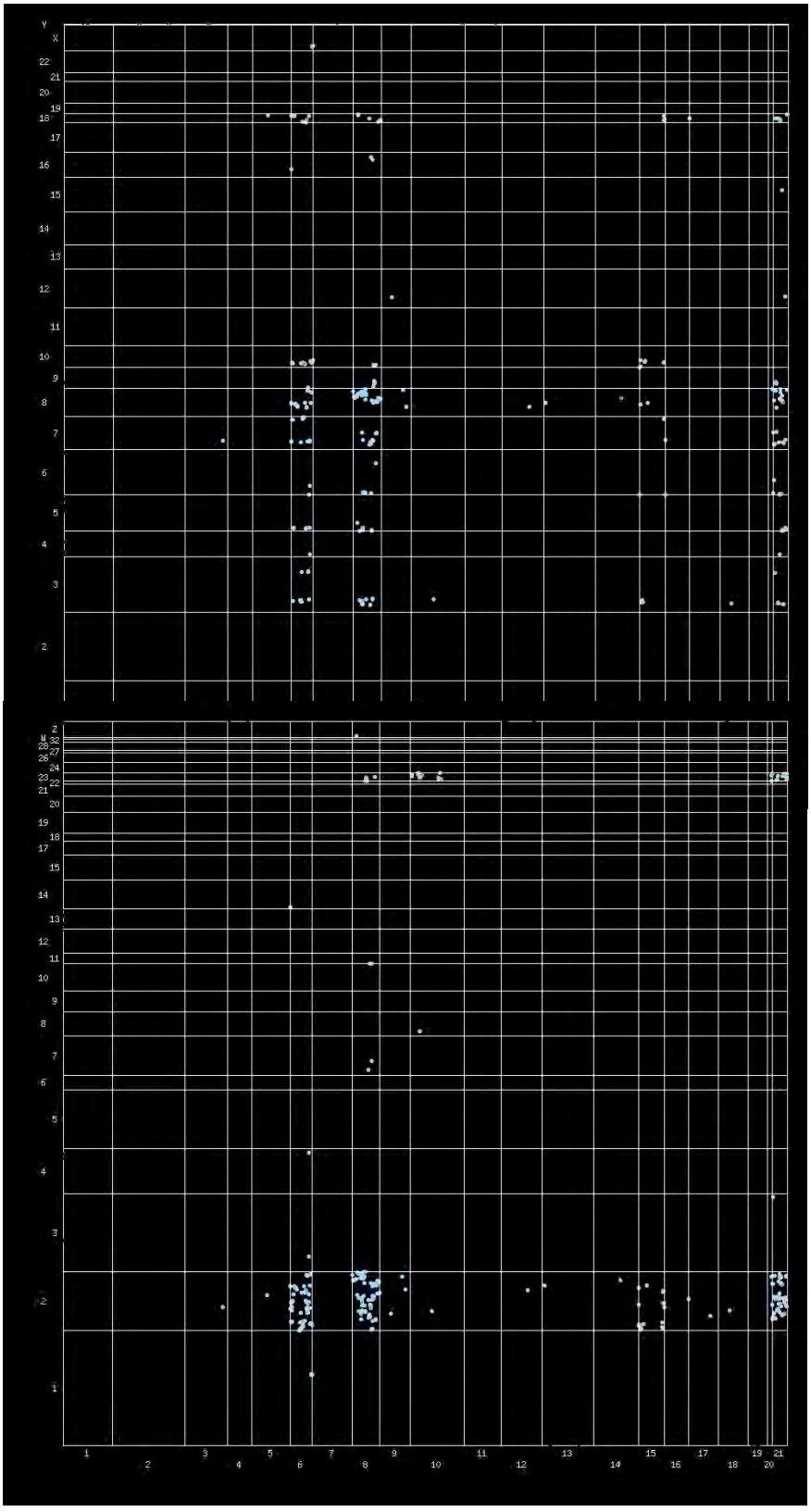
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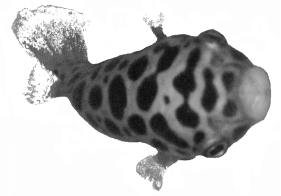

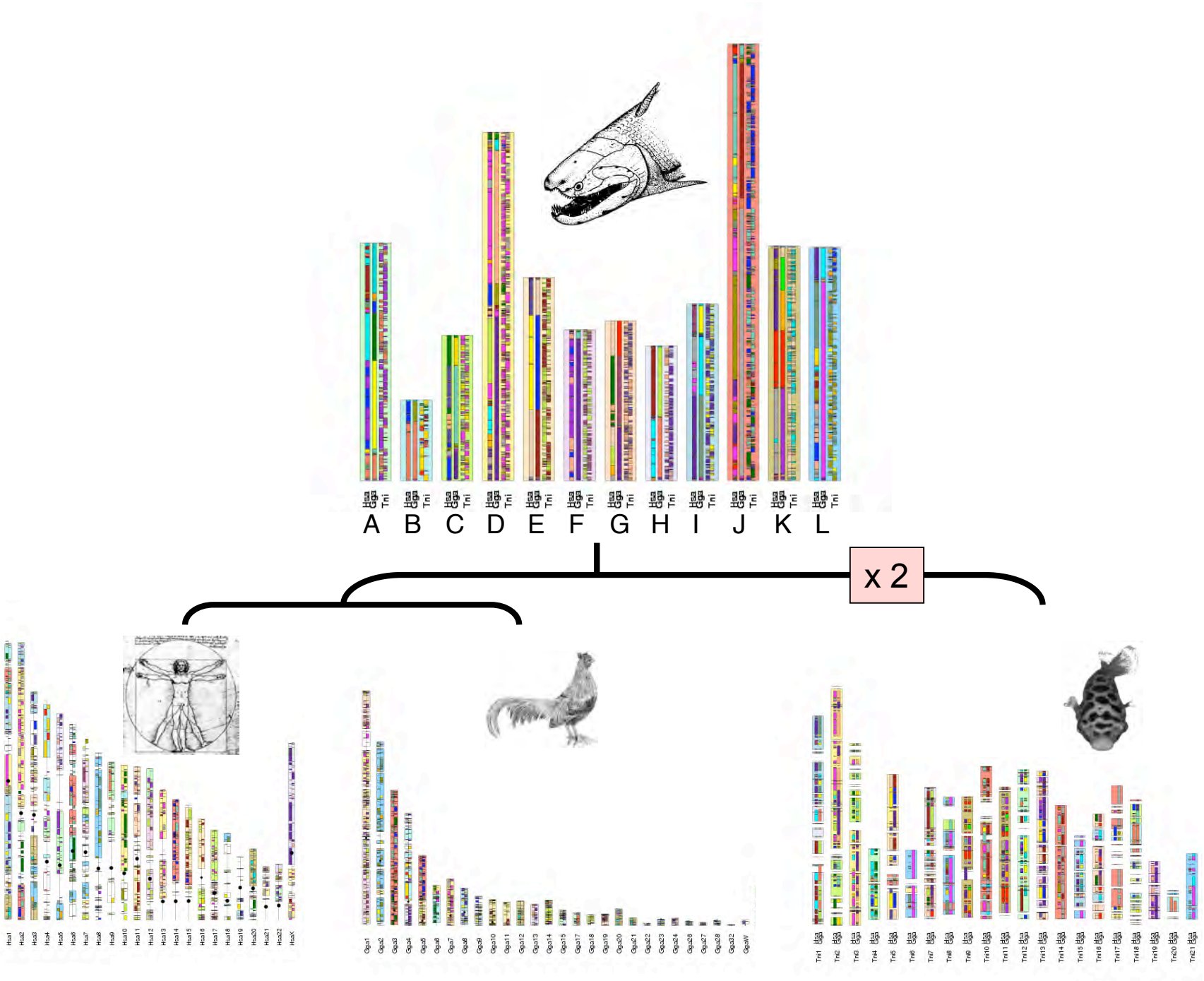
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Centre National de Séquençage

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