Advanced Cell Biology. Lecture 25

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Outline

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Previous final question: the answer

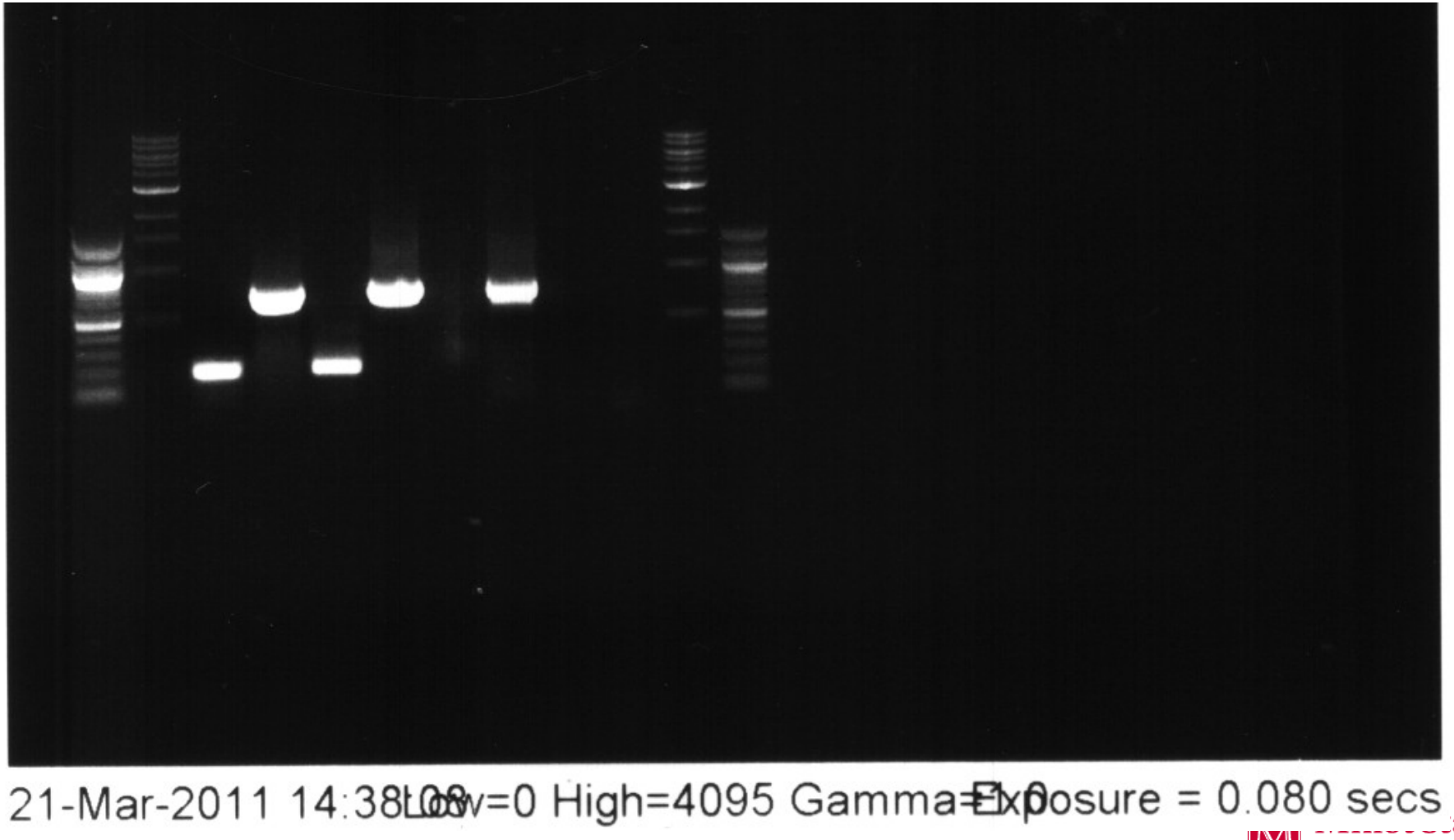
Are riboswitches capable to facilitate the epigenetic inheritance?

Previous final question: the answer

Are riboswitches capable to facilitate the epigenetic inheritance?

- No. They are temporarily repressors/activators. [= 2 points].

Lab 6 gel (section 1)



Mechanisms of genome changes

- Mutation within gene
- Mutation in regulatory region
- Duplication
- Exon shuffling
- Mobile elements and HGT

Types of evolutionary changes in genome

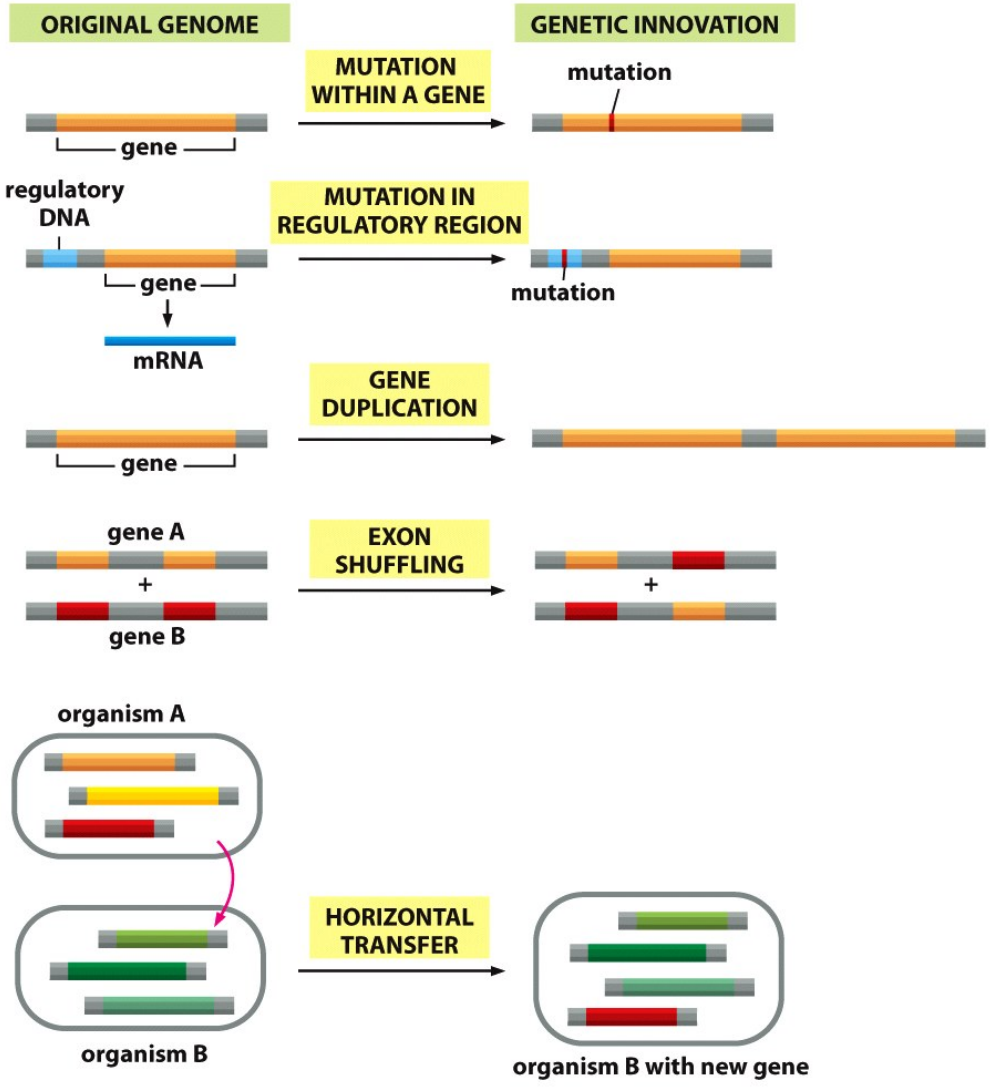


Figure 9-2 Essential Cell Biology 3/e (© Garland Science 2010)

Germ line and somatic cells

- Germ line: every mutation will change progeny
- Somatic line: mutations have no direct effect on progeny
- However, phenocopies show a way of transition between these two lines

Himalayan rabbit: example of phenocopies

Point mutations: neutral and lethal

- Neutral mutations either will not change protein, or change insignificant part of it
- Lethal mutations will not allow to leave progeny
- Typical mutation rate is 10^{-6}
- Simple mutations could be reversible

Regulatory mutations

- Simple point mutation could block expression of the gene
- Reverse mutation will unblock expression
- Lactose digestion in adults is an example of rapidly spreading mutation of this kind

Evolution theough regulatory genes

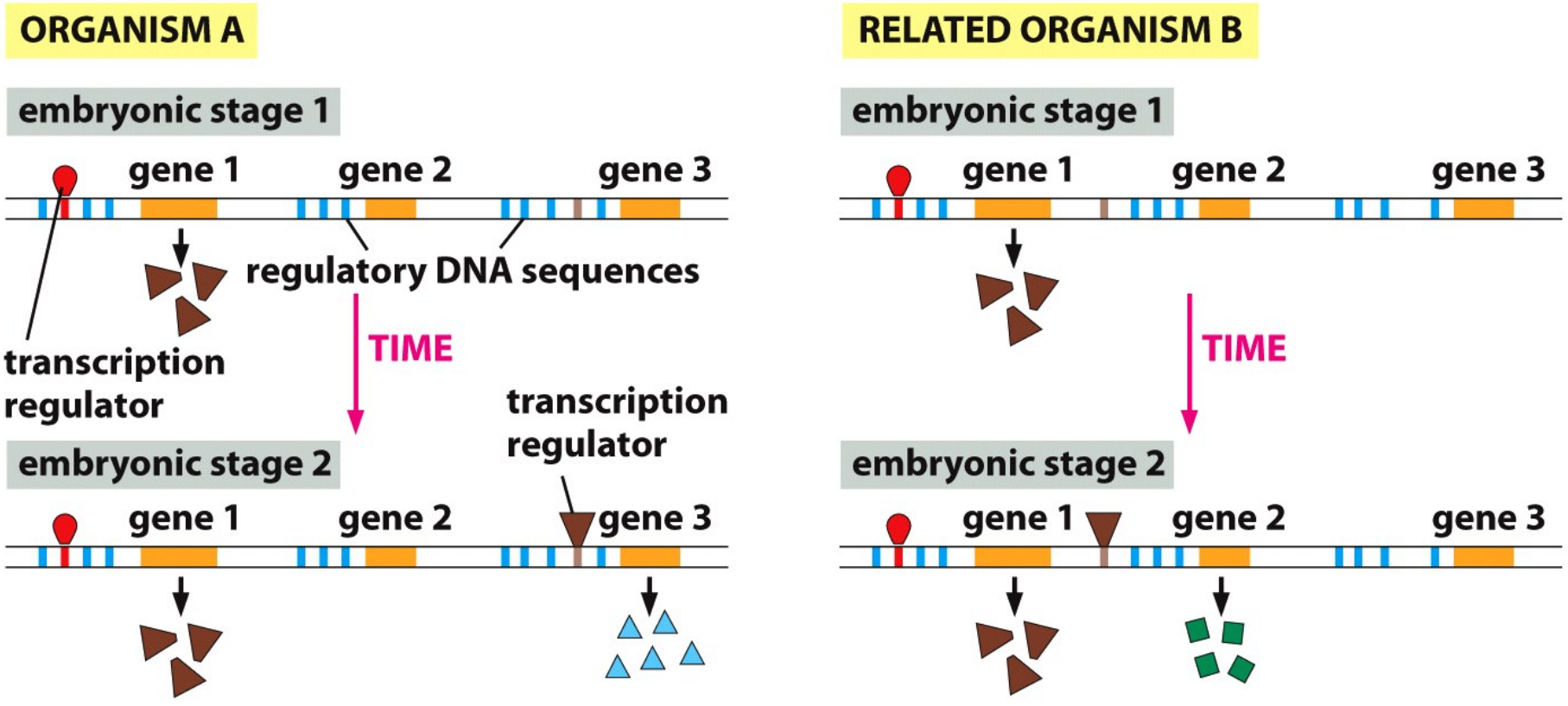


Figure 9-7a Essential Cell Biology 3/e (© Garland Science 2010)

Rise of gene families

- Gene duplication (e.g., in crossover) will ultimately result in accepting of neutral (at first) and non-neutral changes (later)
- This is a gene divergence
- Gene families (e.g., globin family)are mostly results of these divergencies

Gene dubplication in crossover

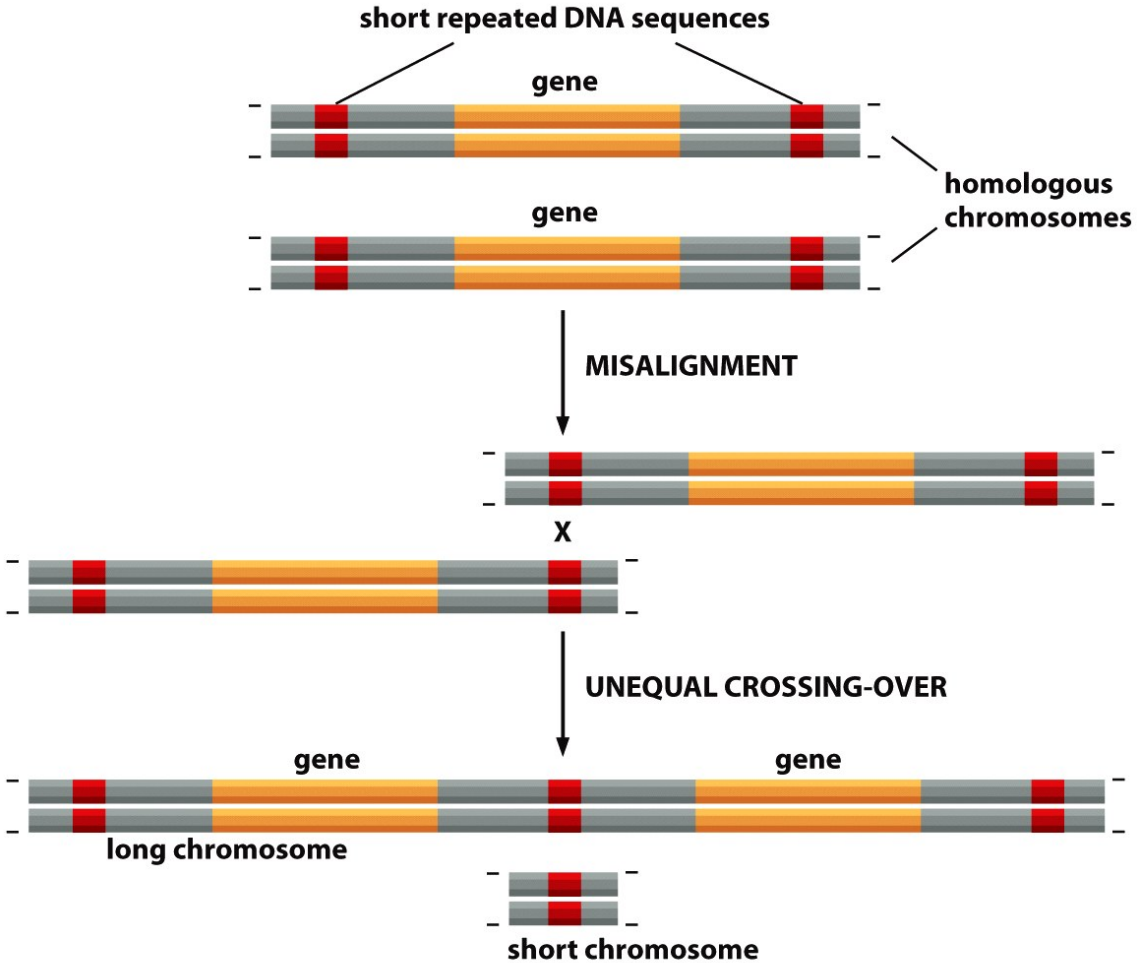


Figure 9-9 Essential Cell Biology 3/e (© Garland Science 2010)

Globine family

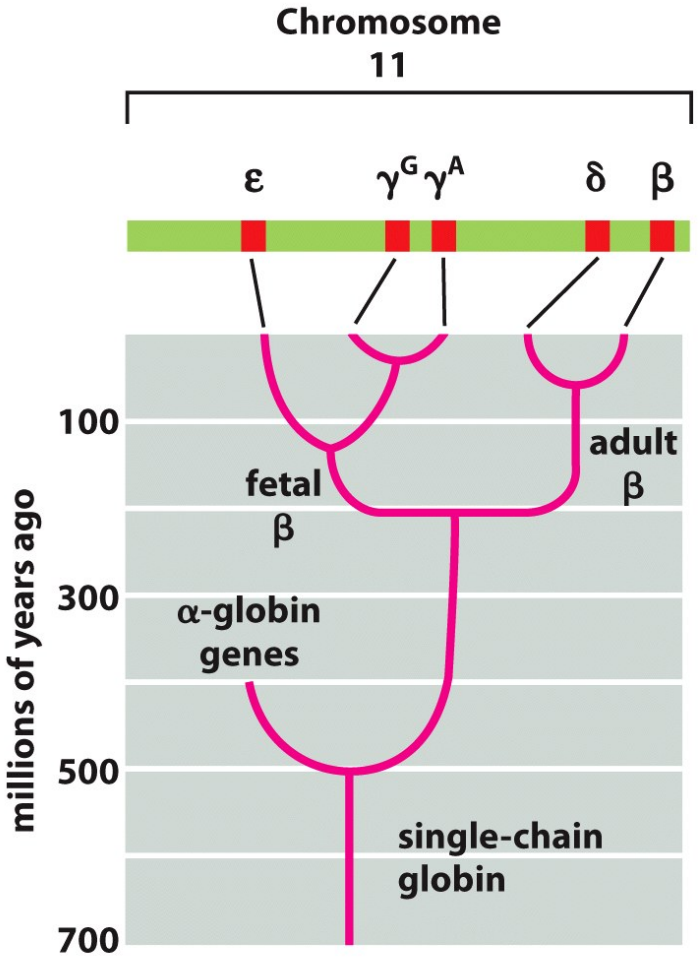
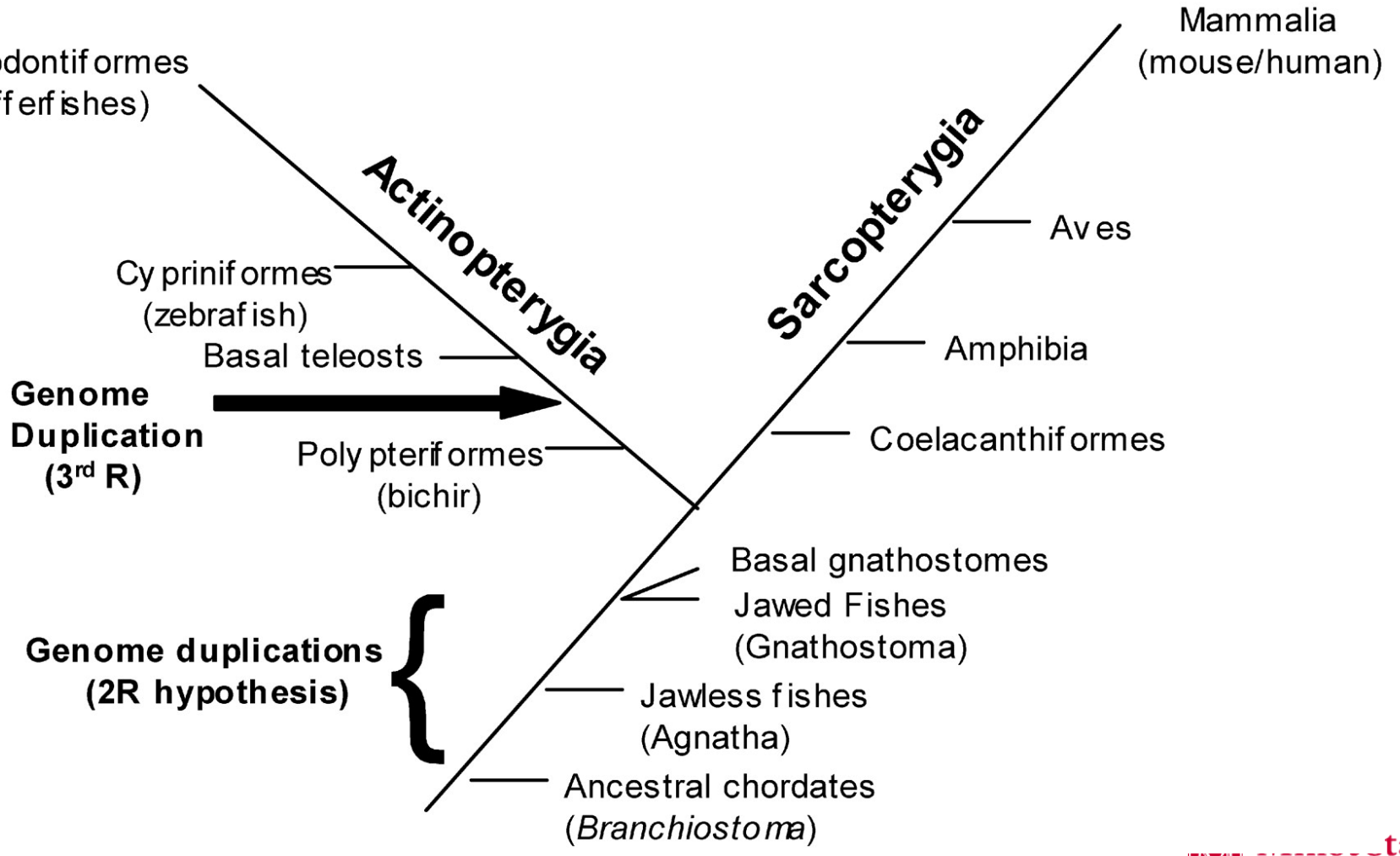


Figure 9-11 Essential Cell Biology 3/e (© Garland Science 2010)

Whole genome duplications

- Whole genome duplication will immediately provide a “space” for new genes and even gene families
- Several major duplications makr evolution of vertebrates and angiosperms
- Duplications also occur in smaller lineages like *Xenopus* frogs or grasses

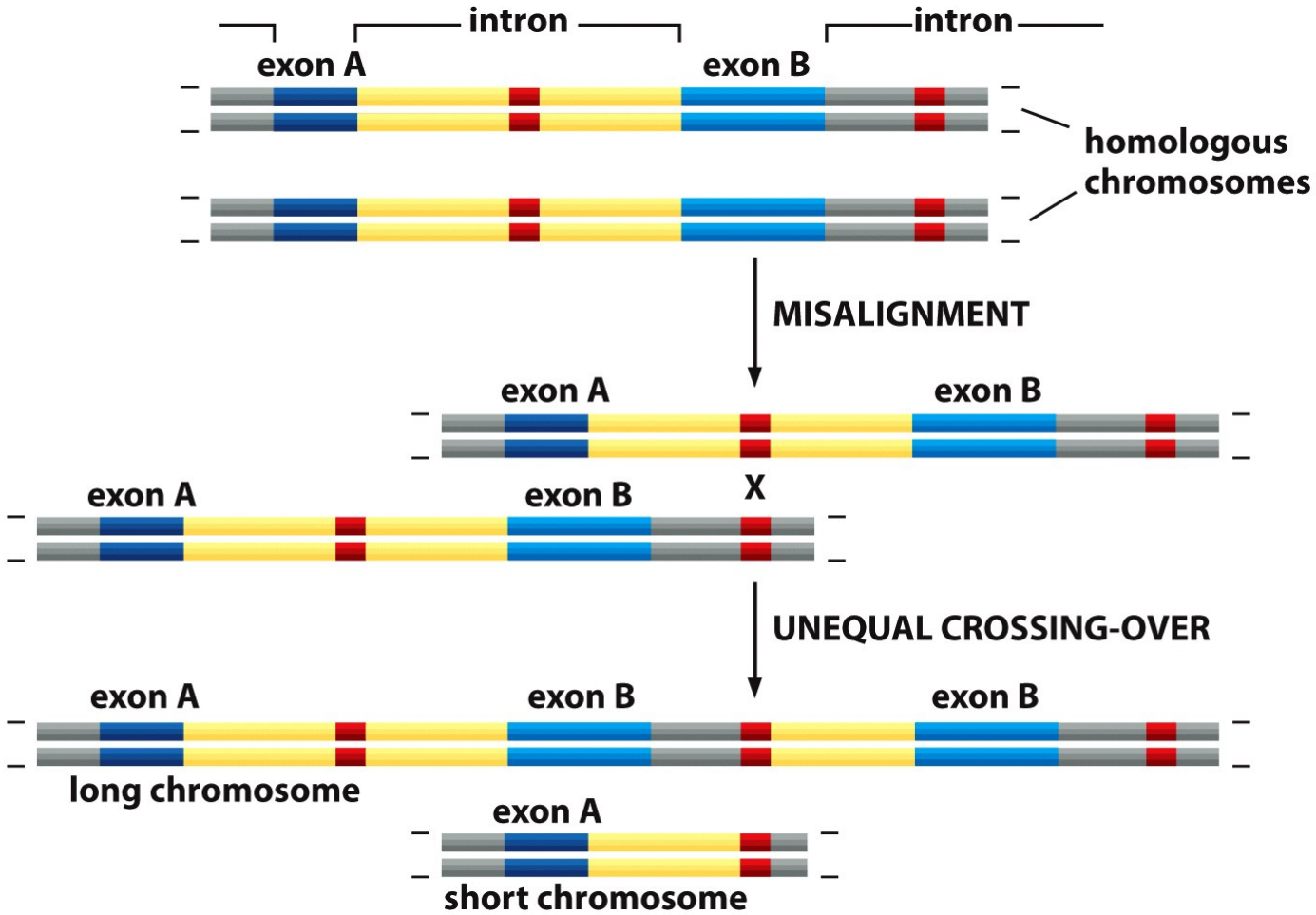
Chordate genome duplications



Recombinant duplications

- In a crossover, exons could be repeated by mistake (“unequal crossover”)
- This will modify a gene, making new introns and exons

Exon duplication in crossover



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Exon shuffling

- If exons correspond with protein domains, exon shuffling could produce a functional protein with different relative location of domains
- Many proteins arouse in this way

Mobile elements

- Mobile elements could modify existing genes through insertions, deletions and also translocations of bigger fragments
- They can add exons to genes

Mobile elements move exons

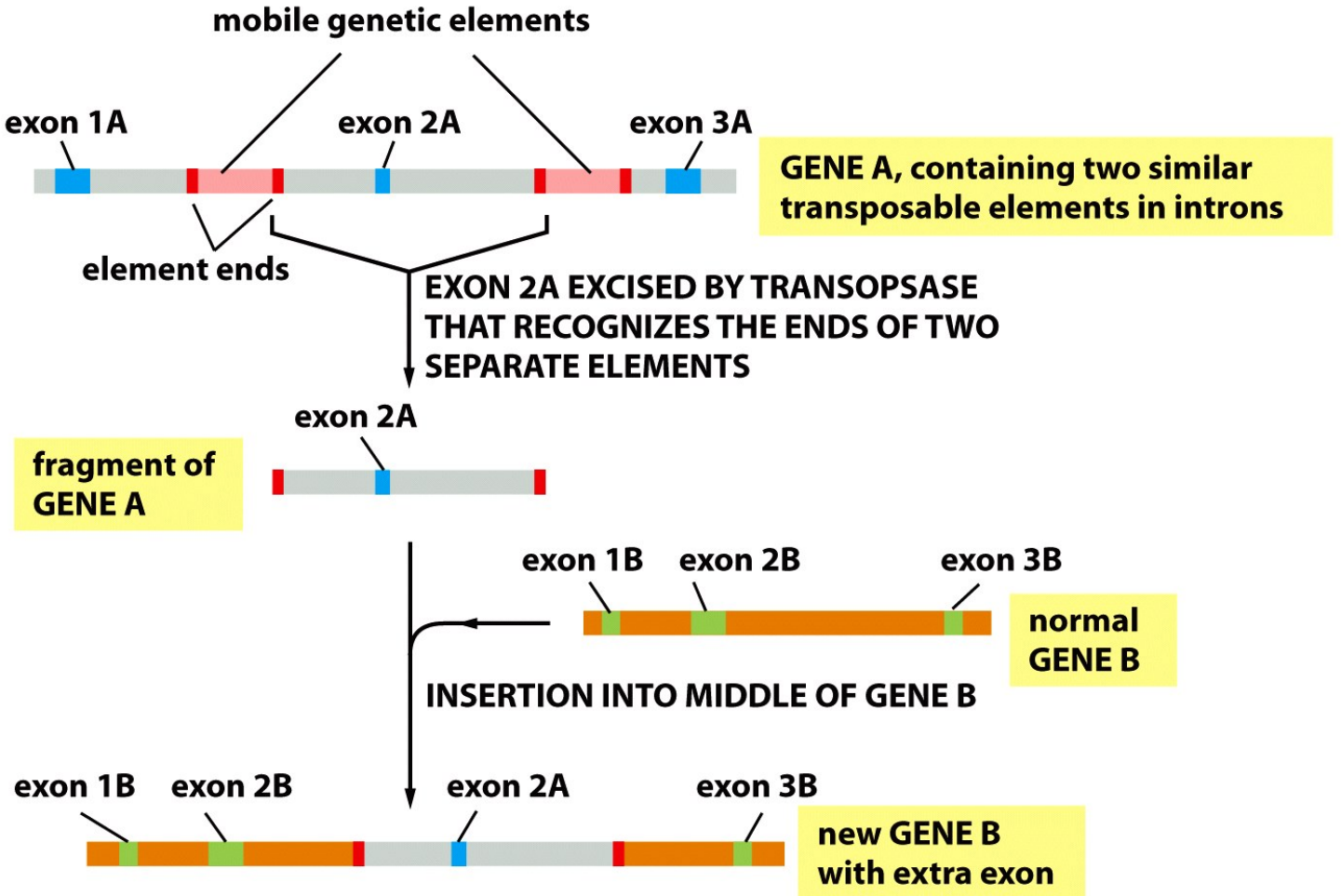
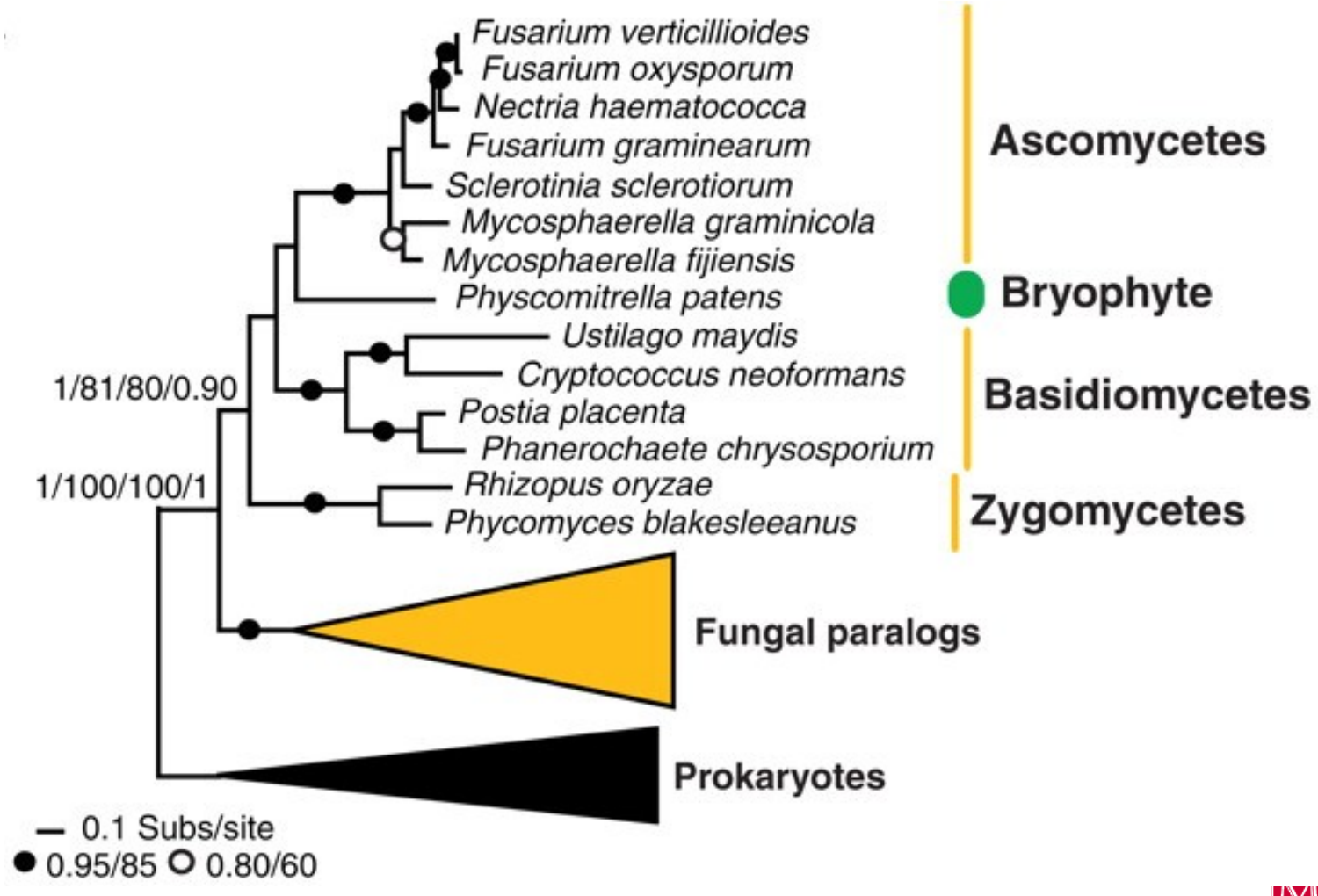


Figure 9-16 Essential Cell Biology 3/e (© Garland Science 2010)

HGT

- Horizontal gene transfer occurs mostly in prokaryotes
- However, more in more HGT examples have been found in eukaryotes: plant-fungal HGTs, host-symbiont HGTs etc.

L-fucose permease sugar transporter gene HGT



Making a tree from genes

- To understand, which gene variant is more ancient, we need a reference point (outgroup)
- To obtain a phylogeny, minimum three groups (taxa) are needed
- If we have tree taxa and an outgroup, we can construct a rooted phylogenetic tree

How to find ancestral sequence

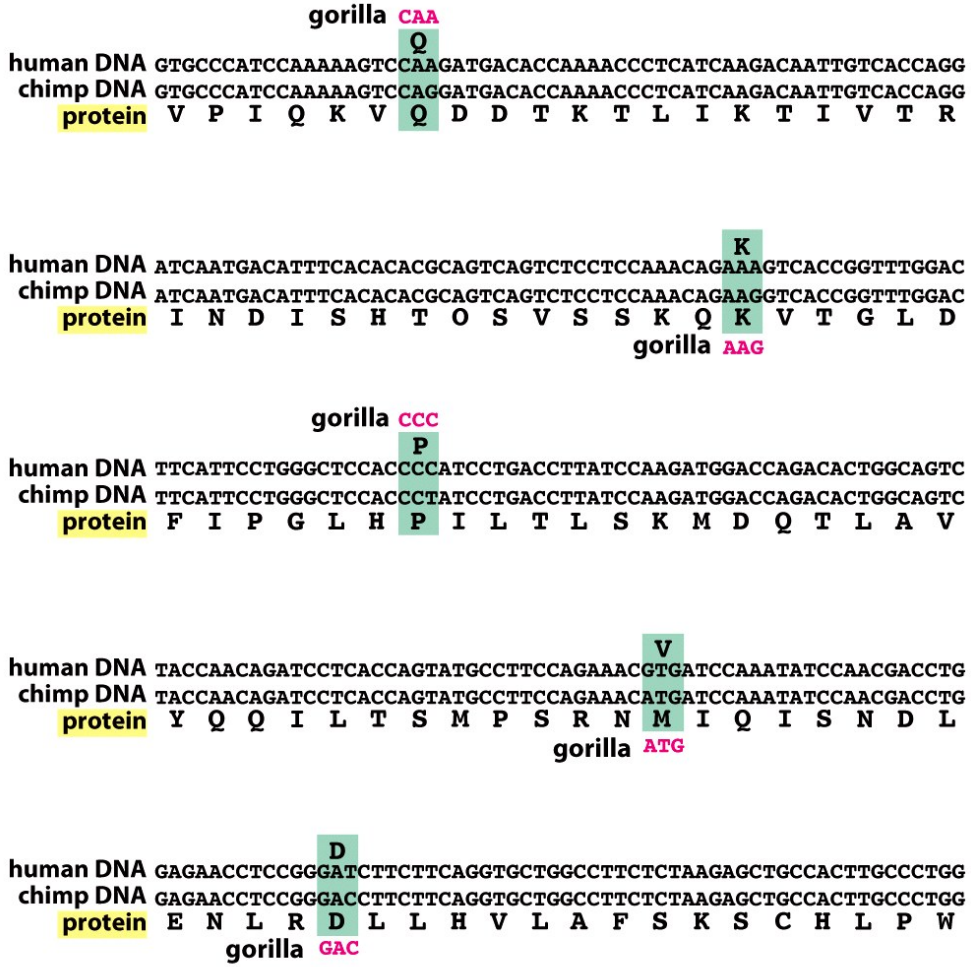


Figure 9-19 Essential Cell Biology 3/e (© Garland Science 2010)

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Conserved synteny

- Some genes and/or gene groups are more prone to mutations
- Typically, there are multiple gene block which appear to be more stable
- These genes are often housekeeping ones, and therefore they are under constant pressure of purifying selection.

Conserved synteny

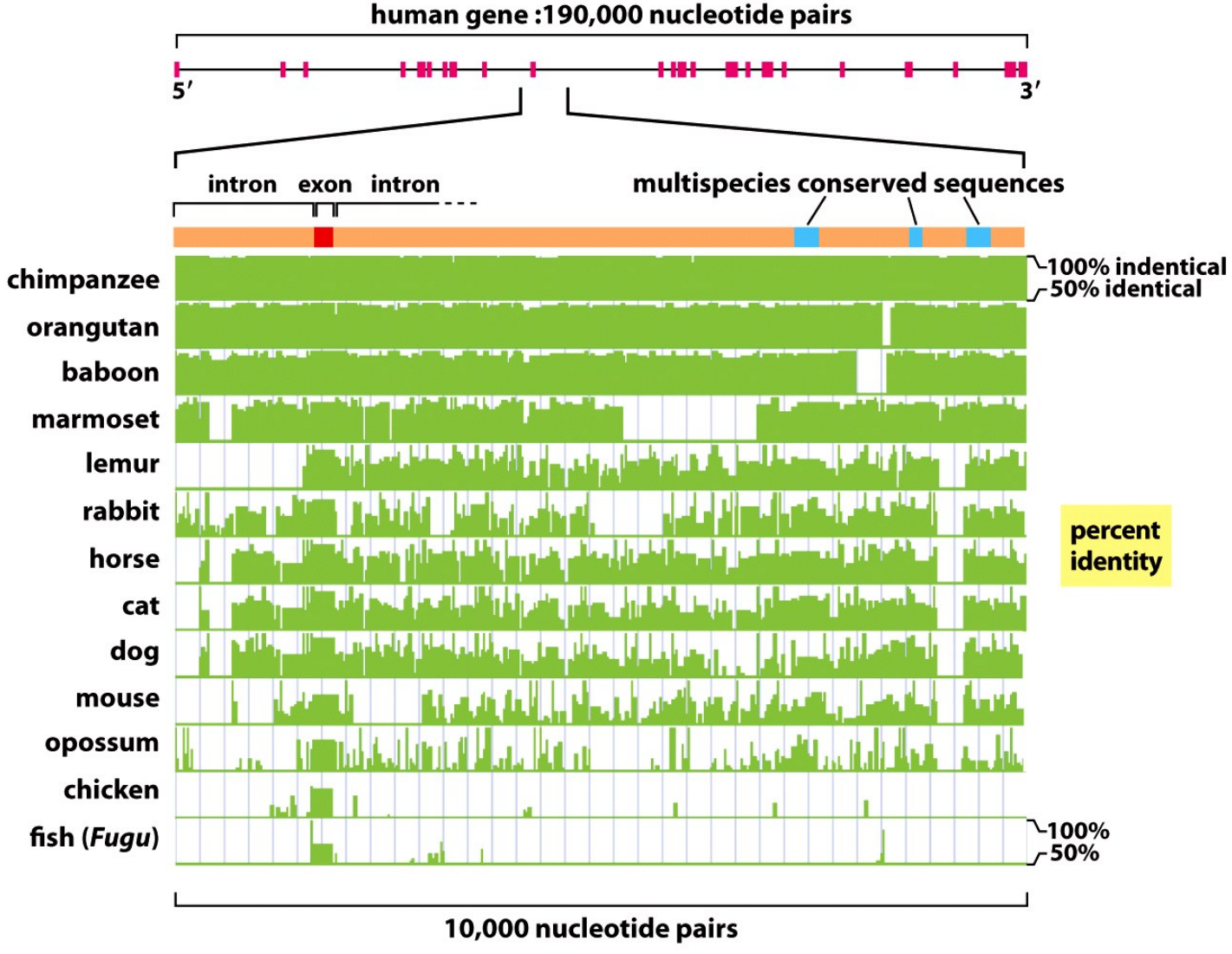
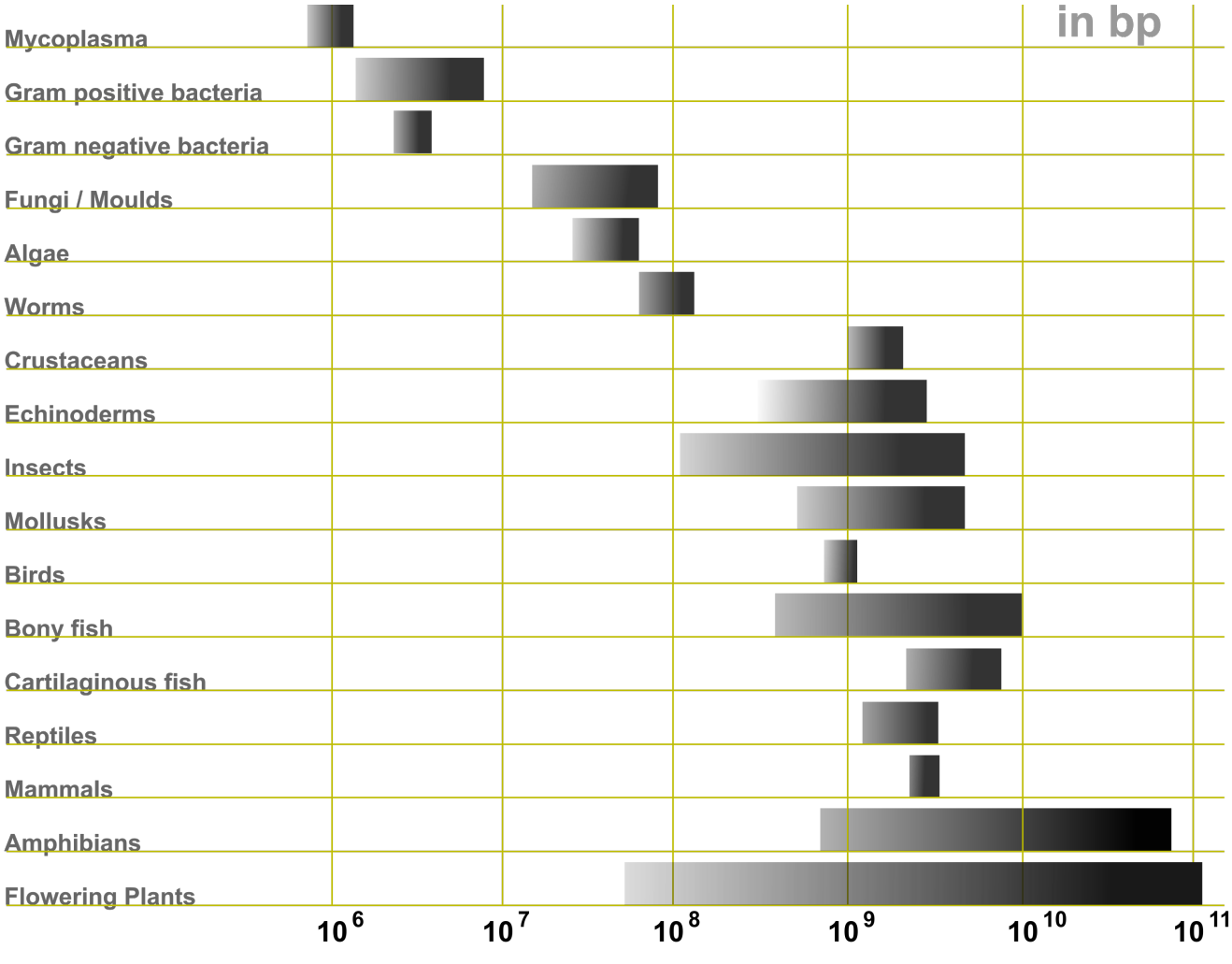


Figure 9-22 Essential Cell Biology 3/e (© Garland Science 2010)

Size differences between genomes

- Genome size typically increased during evolution time, but this is not a absolute rule
- Sometimes genome of “primitive” organisms are much bigger than genomes of “advanced” organisms (like hyge genomes of several amoebas)
- Some genomes experienced extensive compactization (*Fugu* fish, many parasites)

Genome sizes



Summary

- Genome evolutionary processes include point mutations, duplications + divergencies, recombinations of gene parts and HGTs
- Analysis of genes allows to create phylogenetic trees
- Some parts of genome are more conservative than others
- Genome size is not strictly related with “advancedness” of organism

For Further Reading

A. Shipunov.
Advanced Cell Biology [Electronic resource].
2011—onwards.
Mode of access: `http://ashipunov.info/shipunov/school/biol_250`.

B. Alberts et al.
Essential Cell Biology. 3rd edition.
Garland Science, 2009.
Chapter 9, pp. 297–314.