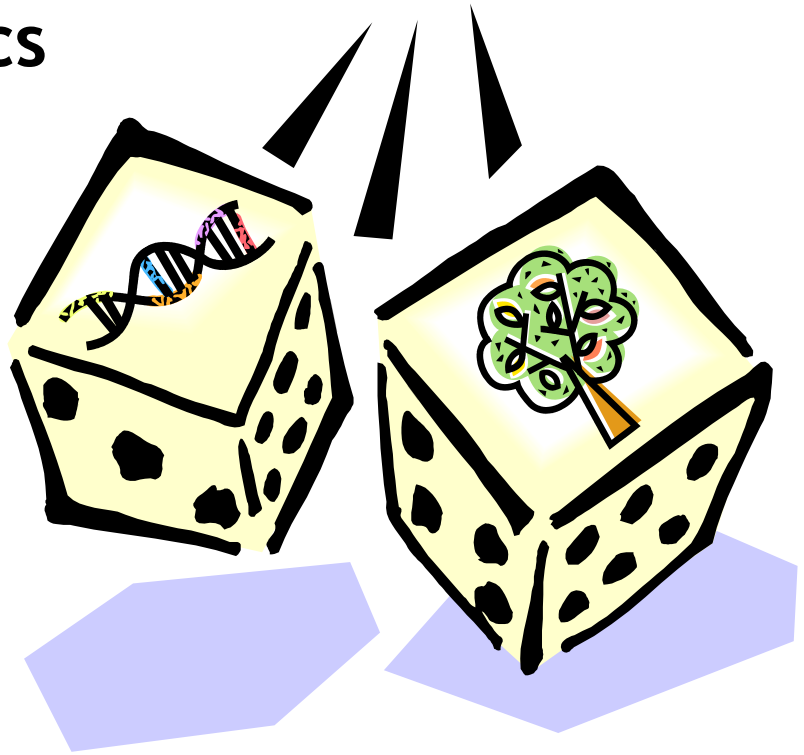
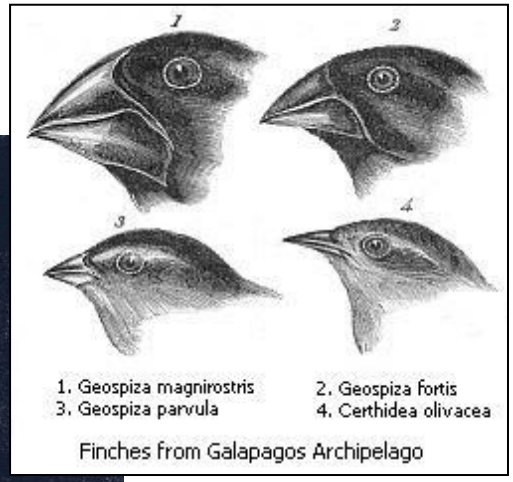
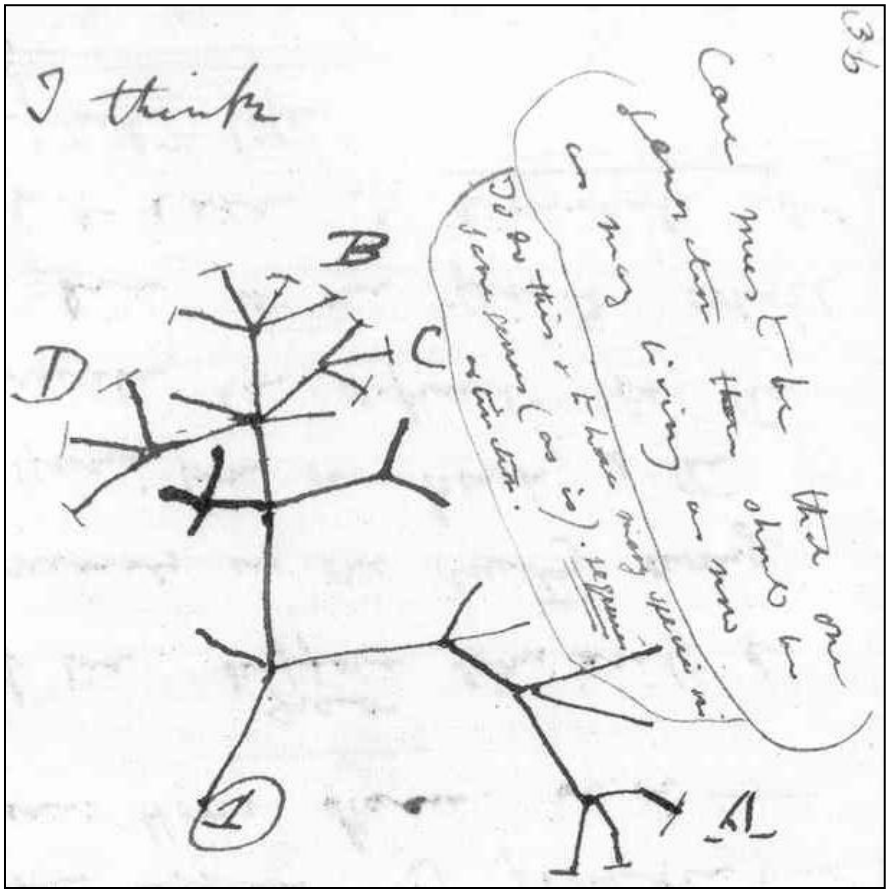
MATH285K:
Stochastic Processes
in Evolution and Genetics



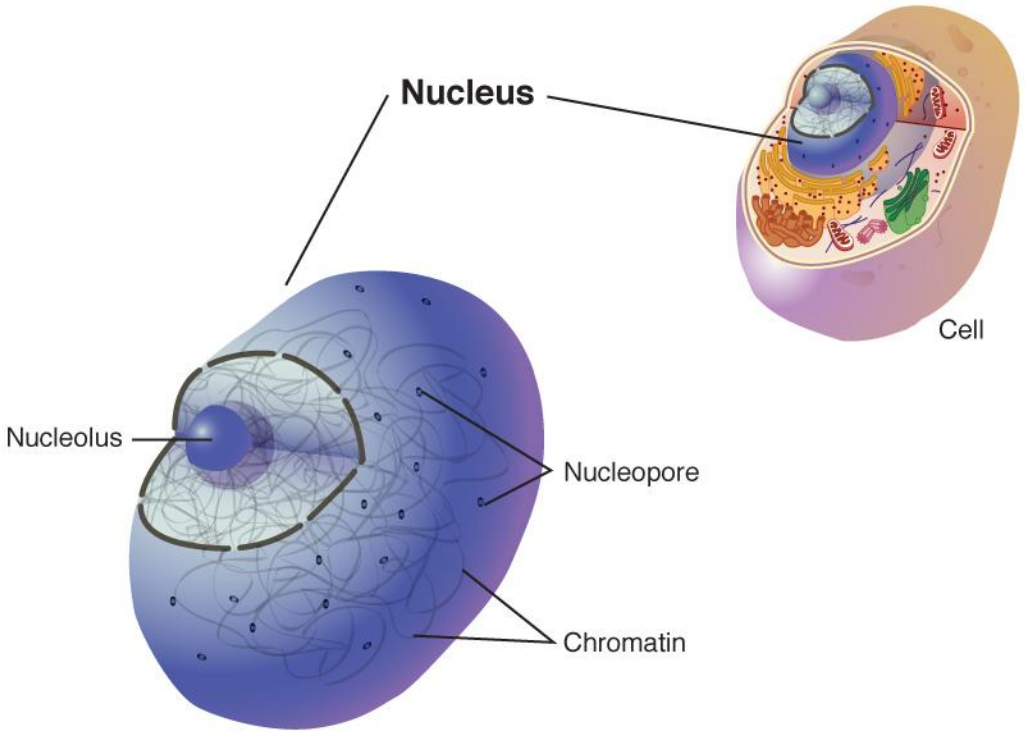
Darwin's finches



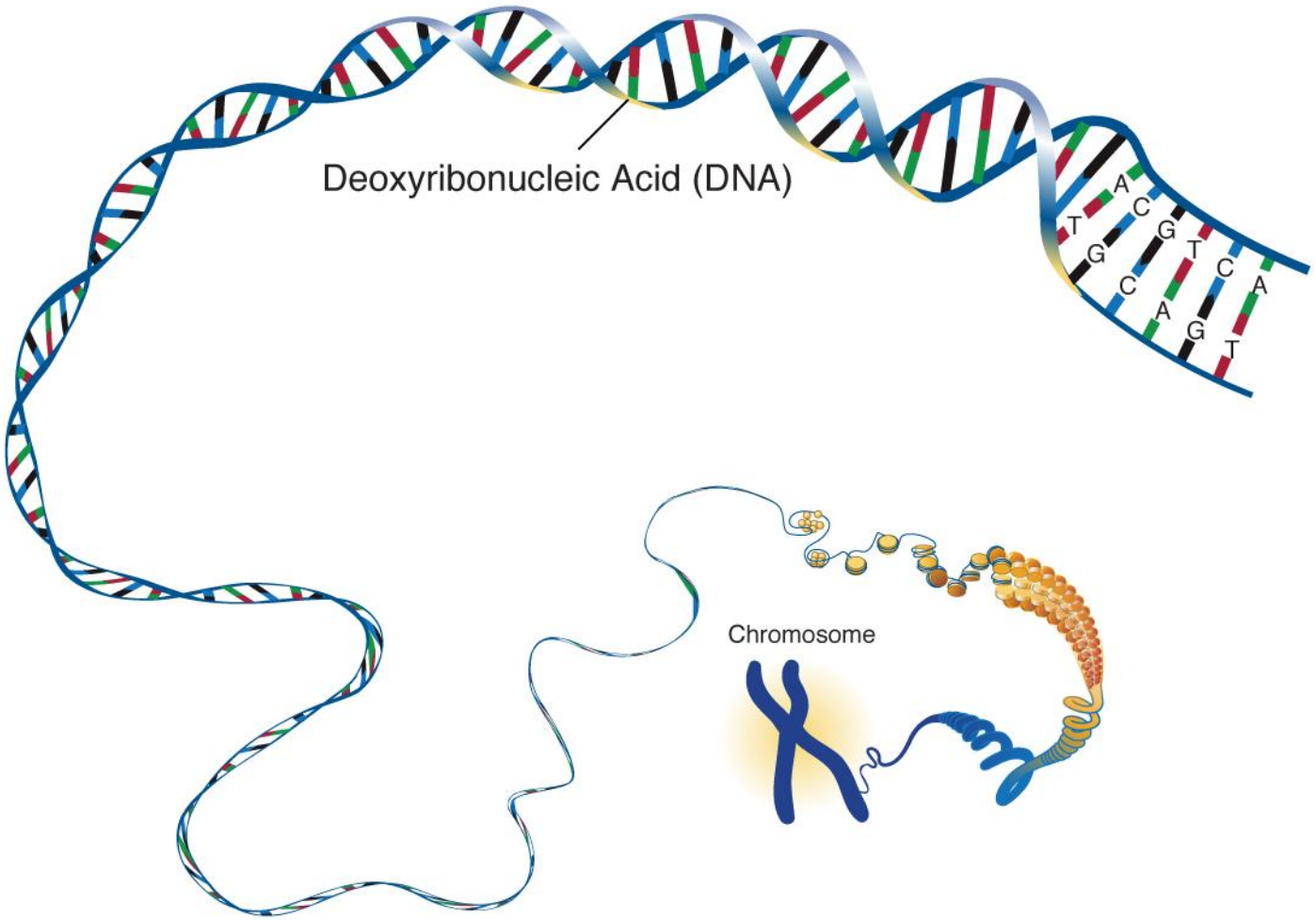
evolutionary tree



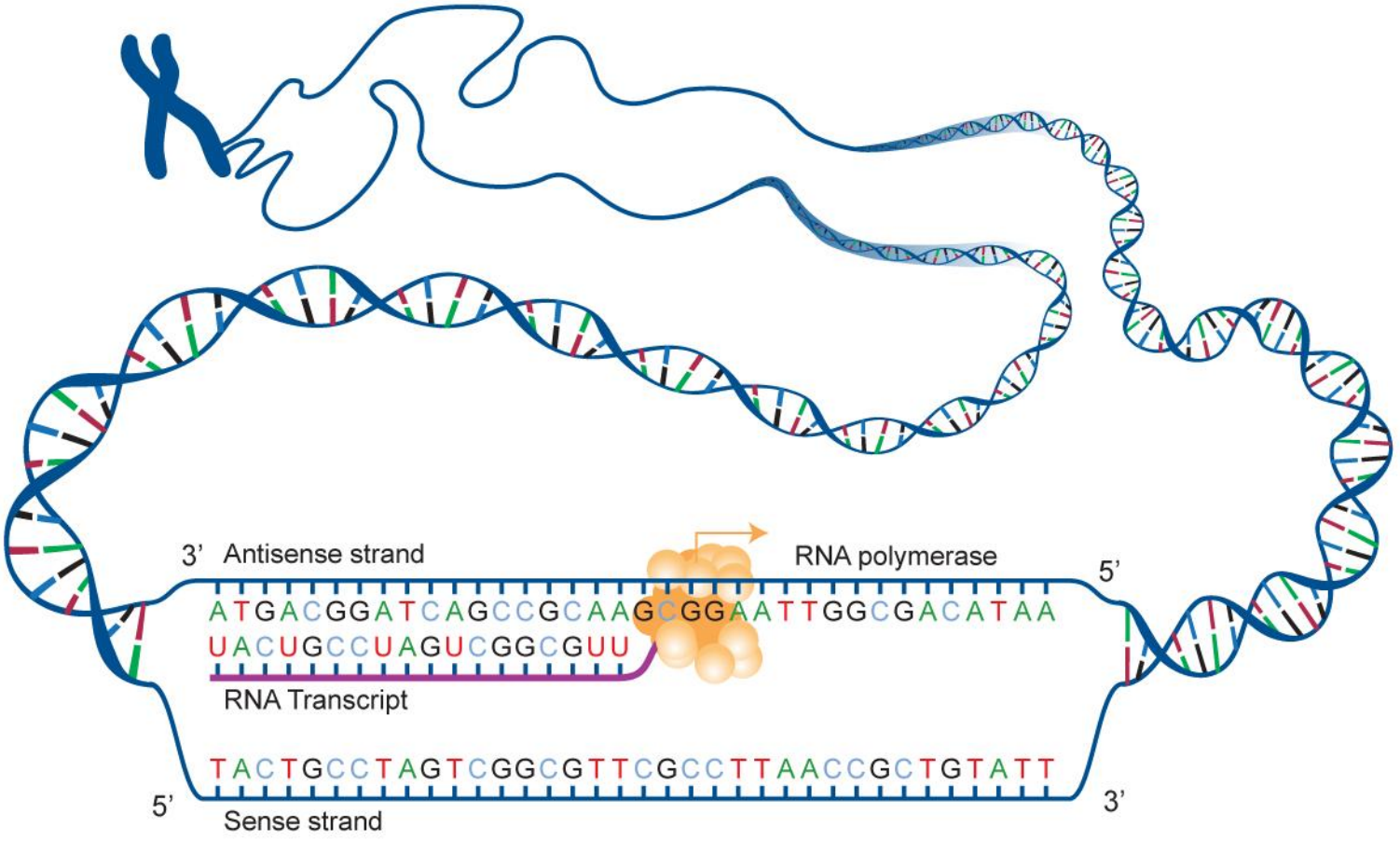
Nucleus



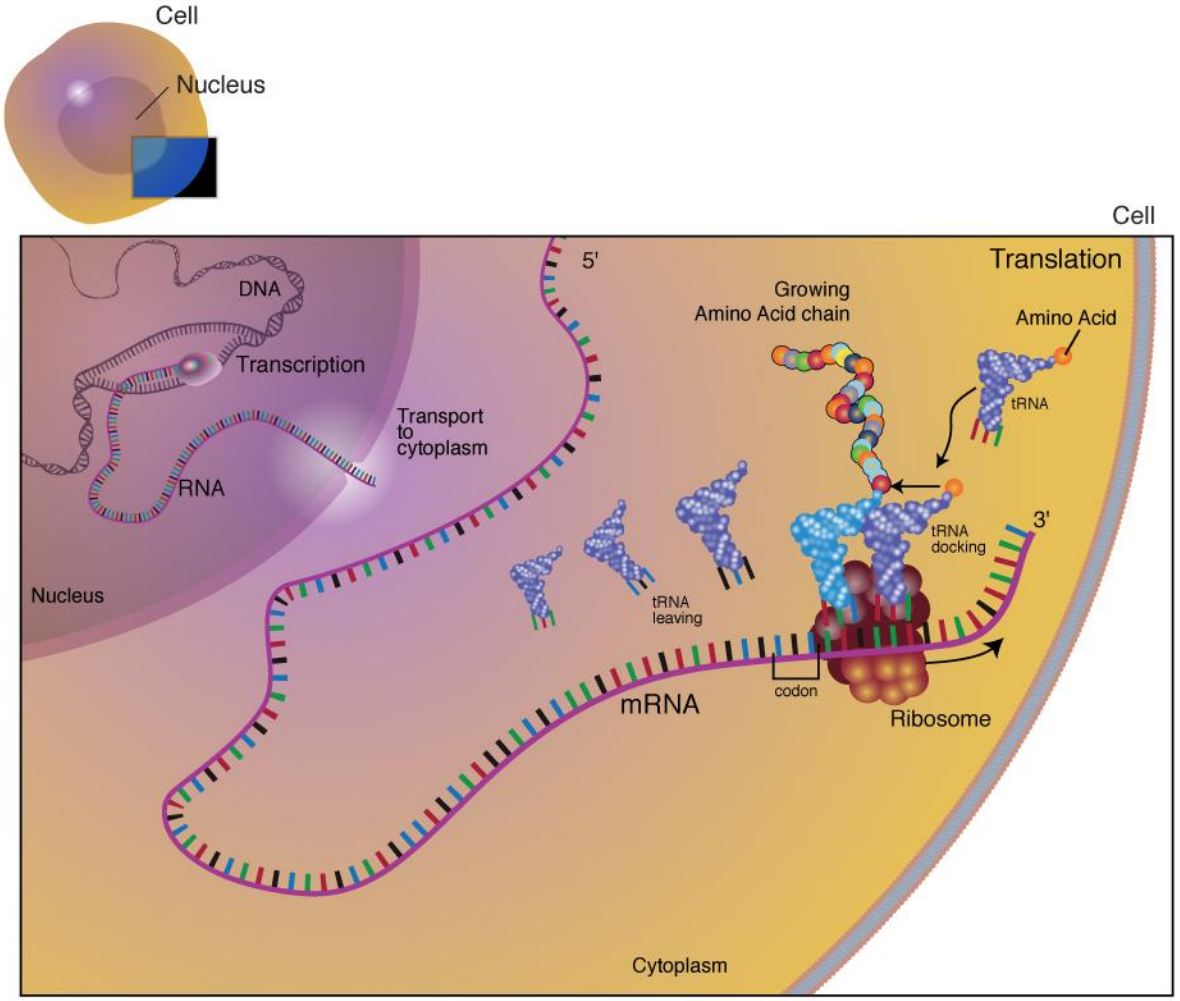
DNA (Deoxyribonucleic Acid)



Transcription



Translation



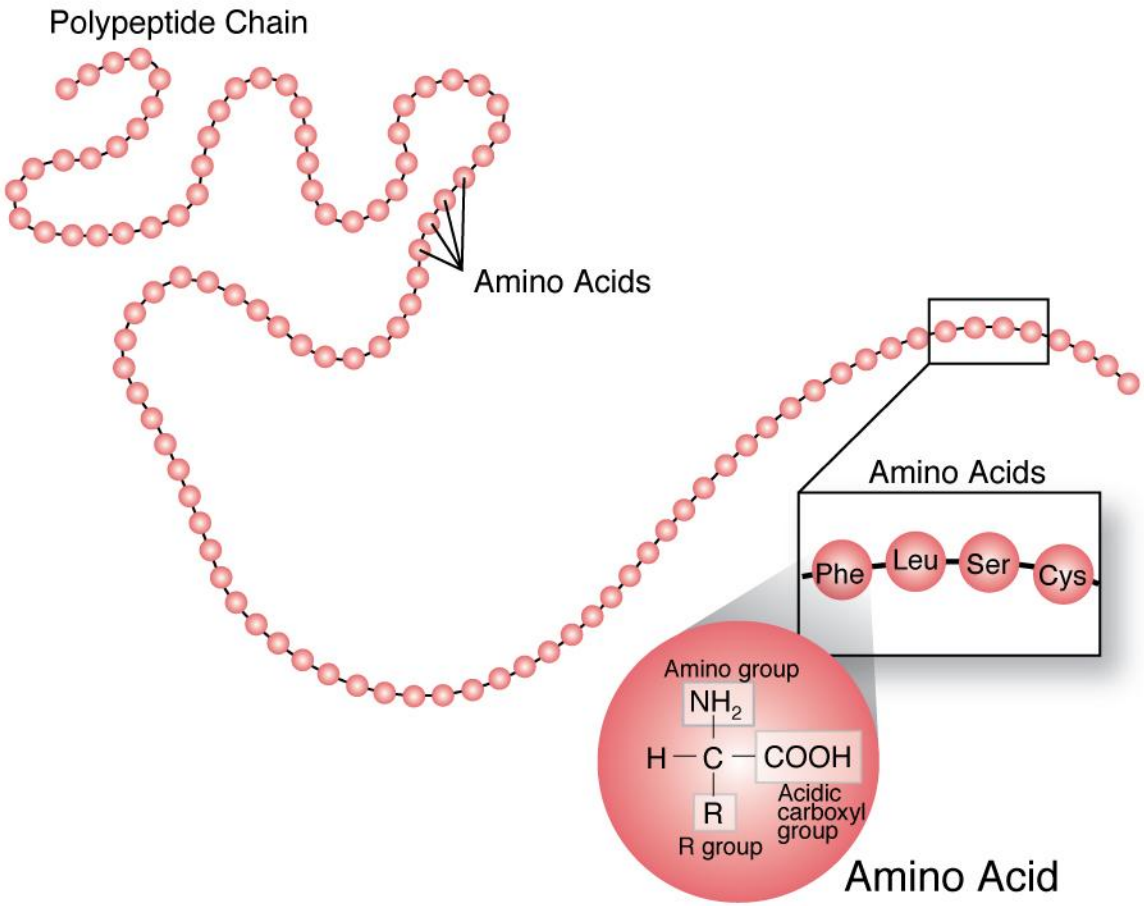
Genetic Code

RNA codon table

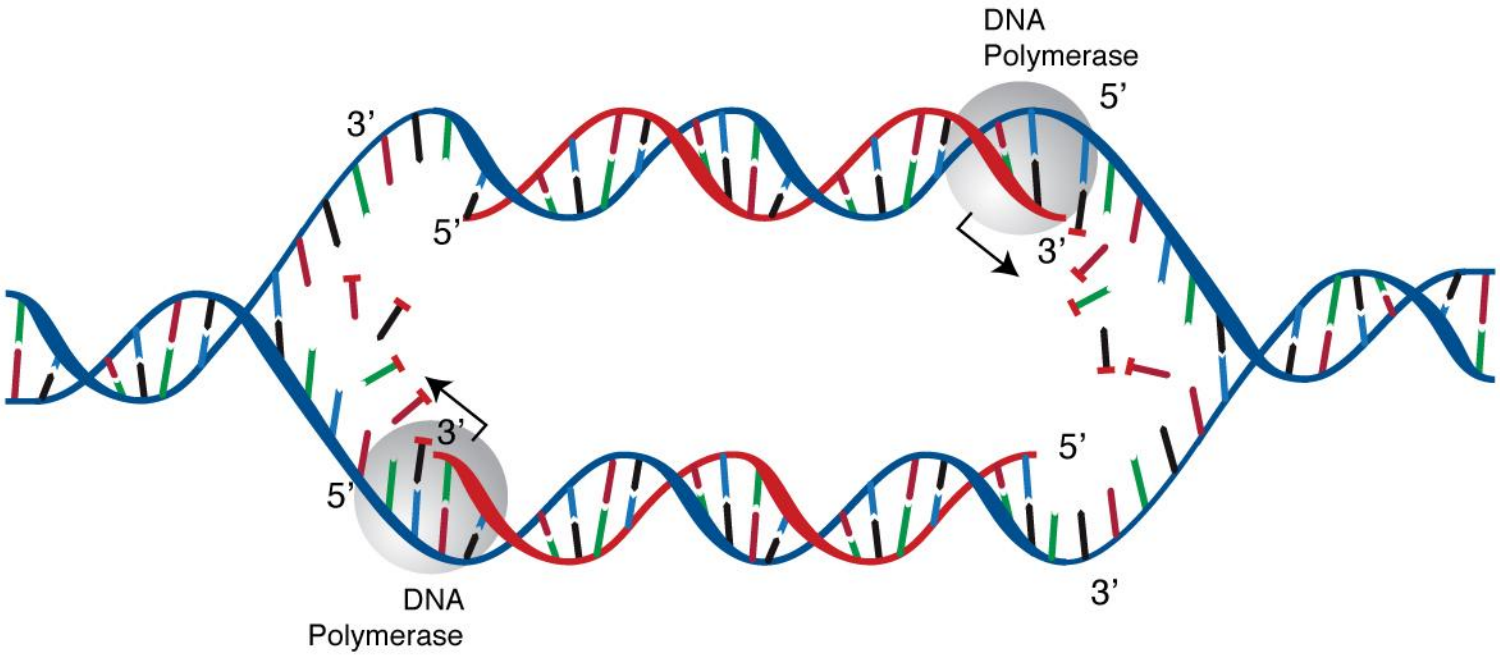
1st position	2nd position U	2nd position C	2nd position A	2nd position G	3rd position
U	Phe	Ser	Tyr	Cys	U
	Phe	Ser	Tyr	Cys	C
	Leu	Ser	stop	stop	A
	Leu	Ser	stop	Trp	G
C	Leu	Pro	His	Arg	U
	Leu	Pro	His	Arg	C
	Leu	Pro	Gln	Arg	A
	Leu	Pro	Gln	Arg	G
A	Ile	Thr	Asn	Ser	U
	Ile	Thr	Asn	Ser	C
	Ile	Thr	Lys	Arg	A
	Met	Thr	Lys	Arg	G
G	Val	Ala	Asp	Gly	U
	Val	Ala	Asp	Gly	C
	Val	Ala	Glu	Gly	A
	Val	Ala	Glu	Gly	G
	Amino Acids				

Ala: Alanine
Arg: Arginine
Asn: Asparagine
Asp:Aspartic acid
Cys:Cysteine
Gln: Glutamine
Glu: Glutamic acid
Gly: Glycine
His: Histidine
Ile: Isoleucine
Leu: Leucine
Lys: Lysine
Met: Methionine
Phe: Phenylalanine
Pro: Proline
Ser: Serine
Thr: Threonine
Trp: Tryptophane
Tyr: Tyrosisne
Val: Valine

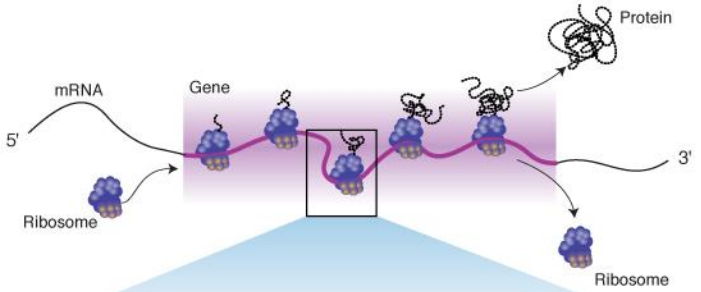
Amino Acid


Polypeptide Chain
Amino Acids
Amino Acids
Phe
Leu
Ser
Cys
Amino group
NH_2
H — C — COOH
R
R group
Acidic carboxyl group
Amino Acid

DNA Replication



Point mutation



Normal

Amino Acids — Ala Ile Arg Leu Gly Tyr Ser Ala Cys Ile His Val Ala Ile Arg

tRNA

anticodon ...CGAUAUUCCGAUCCAAUGUCACGUACGUAUGUGCAUCGAUAUGCG...

mRNA ...GCUAUAAGGCUAGGUUACAGUGCAUGCAUACACGUAGCUAUACGC...

5' codons 3'

Protein

Missense mutation

Amino Acids — Ala Ile Arg Leu **Ala** Tyr Ser Ala Cys Ile His Val Ala Ile Arg

tRNA

anticodon ...CGAUAUUCCGAUCGAAUGUCACGUACGUAUGUGCAUCGAUAUGCG...

mRNA ...GCUAUAAGGCUAGCUUACAGUGCAUGCAUACACGUAGCUAUACGC...

5' codons 3'

Missense mutation

Protein

Nonsense mutation

Amino Acids — Ala Ile Arg Leu Gly Tyr Ser Ala Cys **stop**

tRNA

anticodon ...CGAUAUUCCGAUCCAAUGUCACGUACGAUU

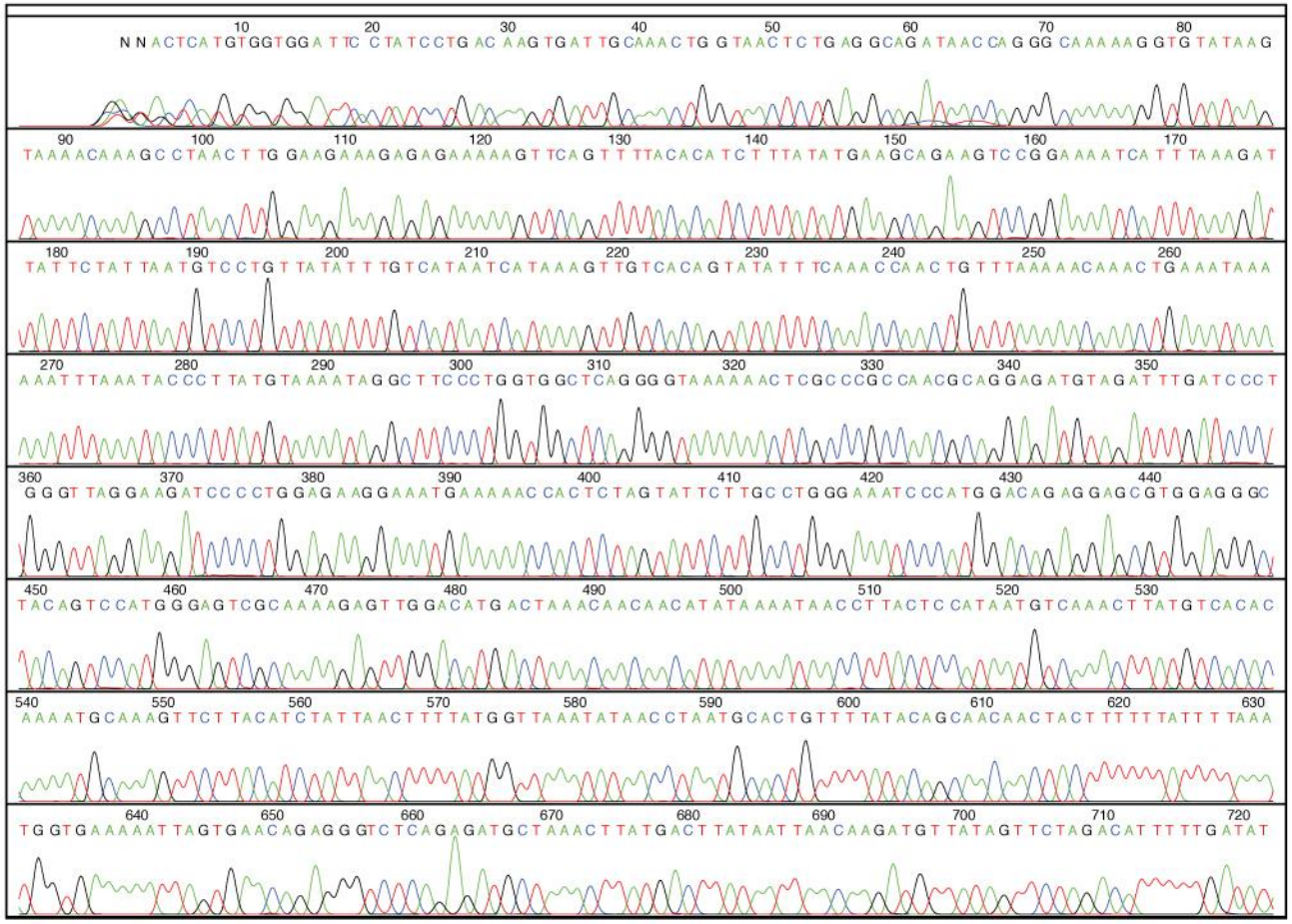
mRNA ...GCUAUAAGGCUAGGUUACAGUGCAUGCUAACACGUAGCUAUACGC... 3'

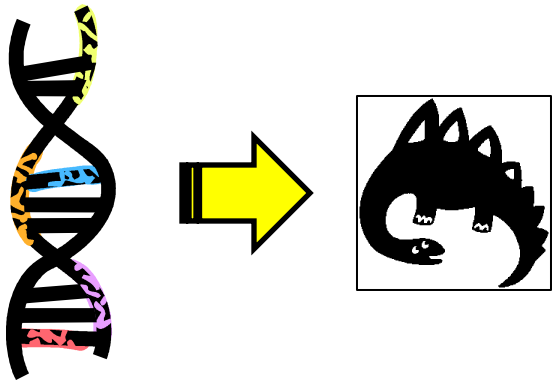
5' codons

Nonsense mutation

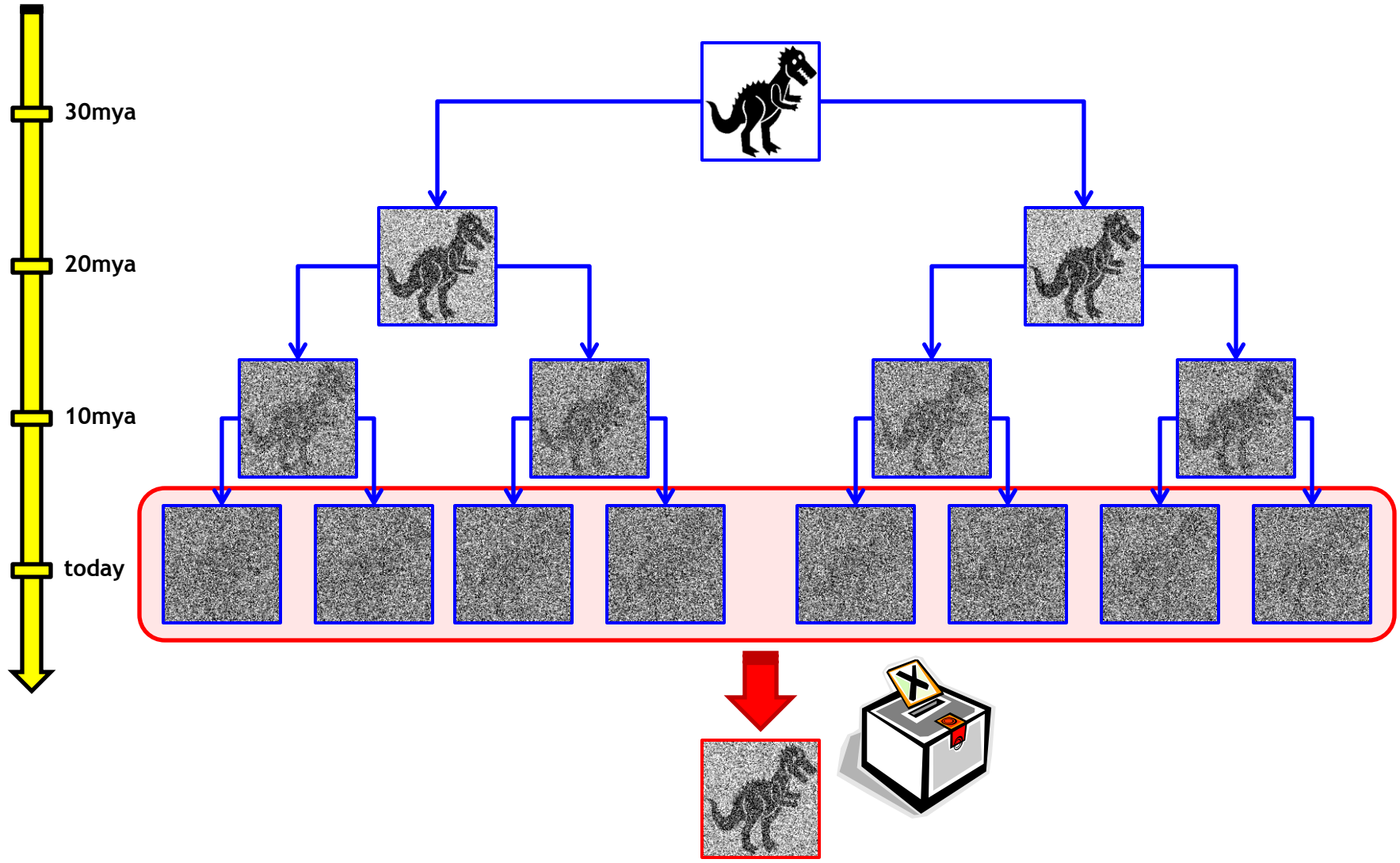
Protein

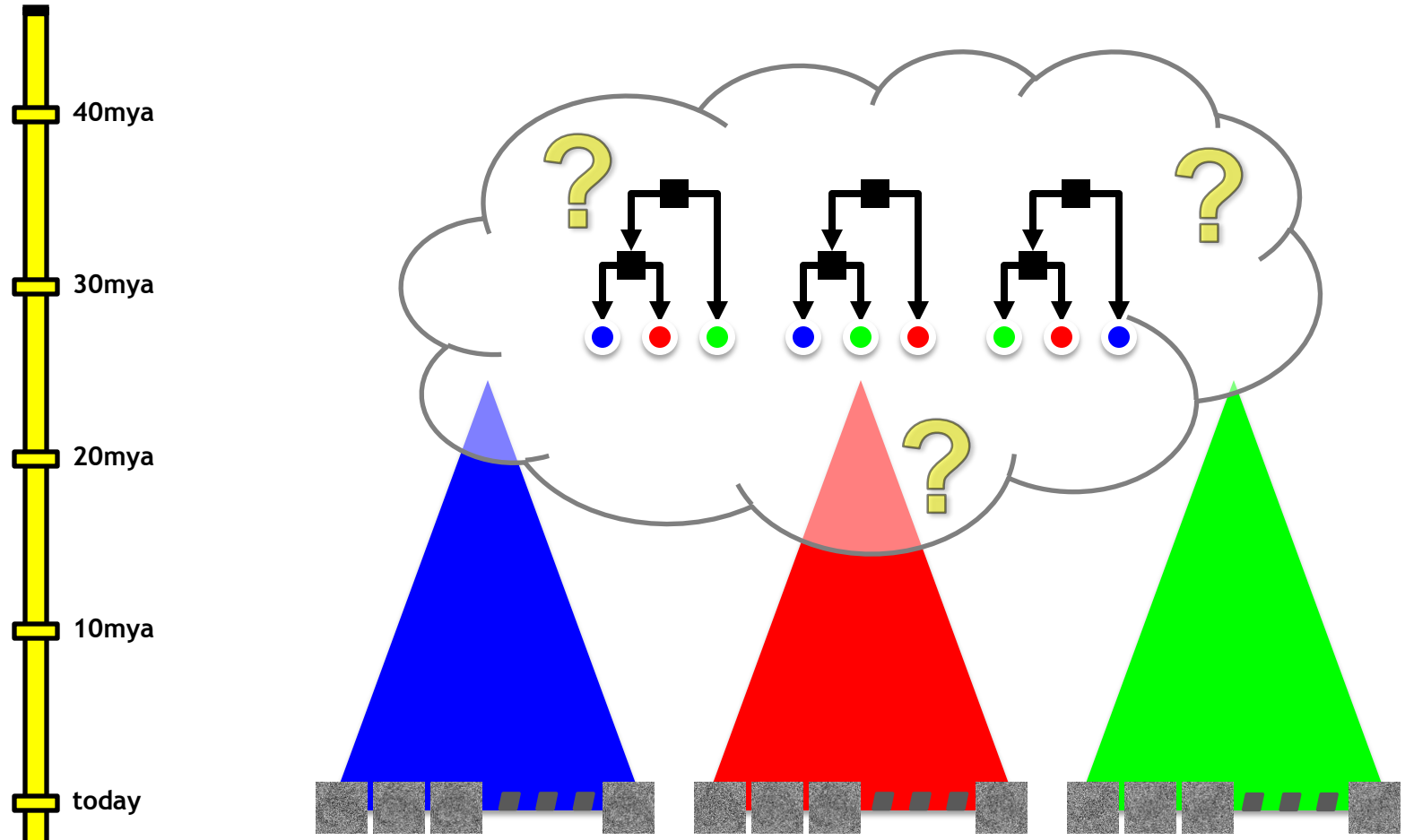
DNA Sequencing





Daskalakis & Roch


30mya
20mya
10mya
today


40mya
30mya
20mya
10mya
today
?
?
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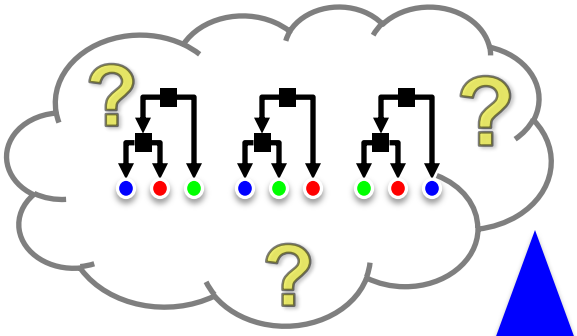
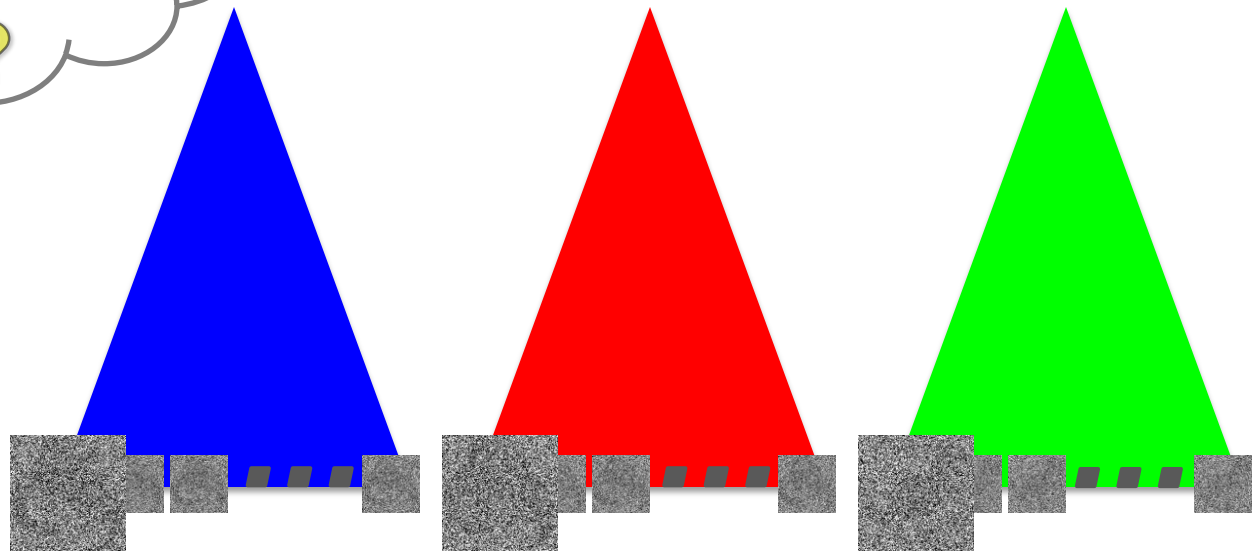
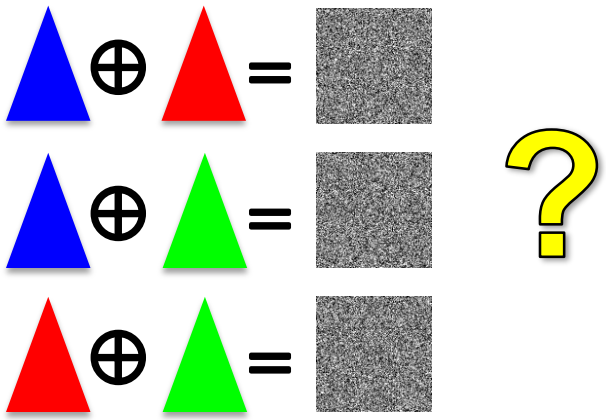
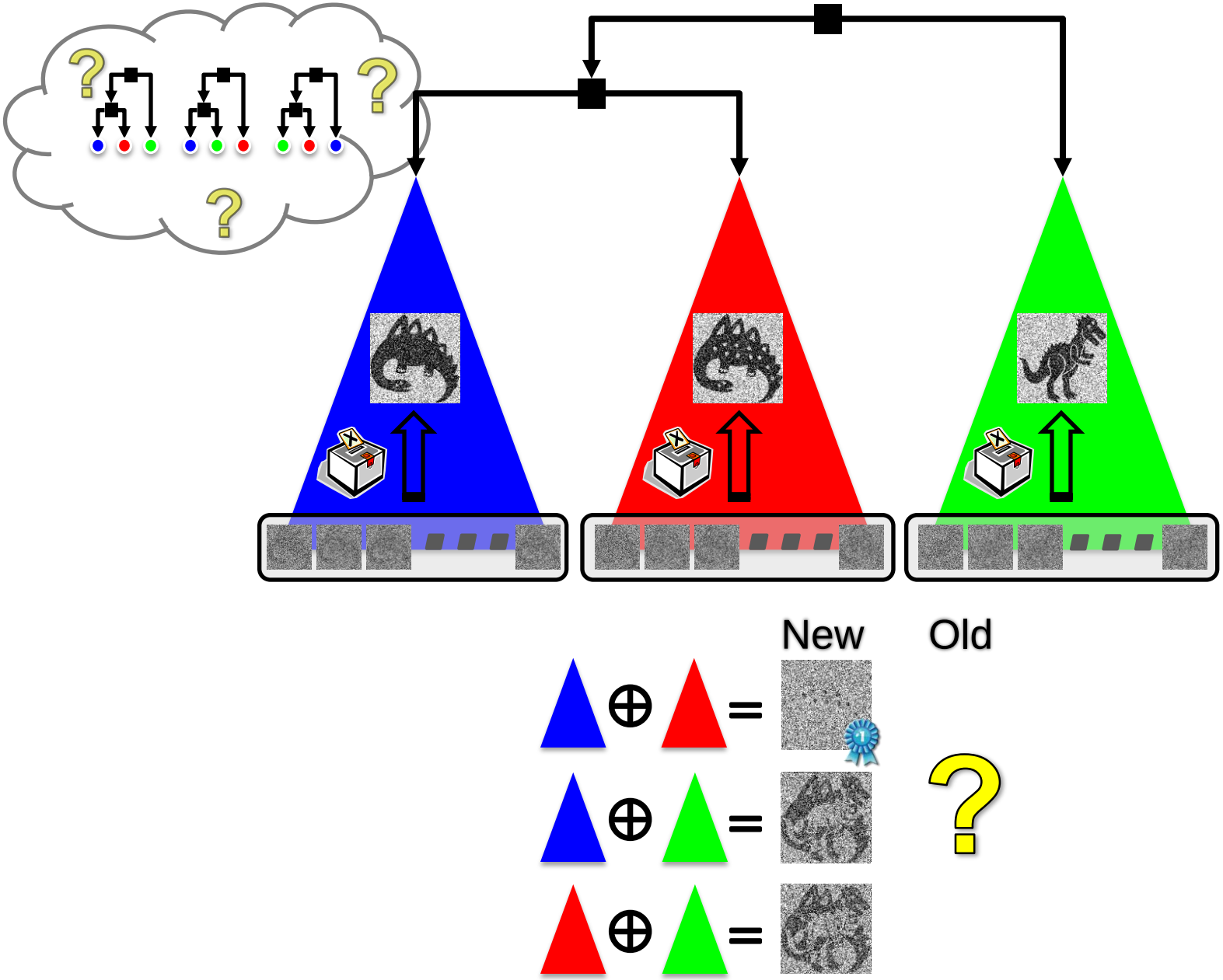


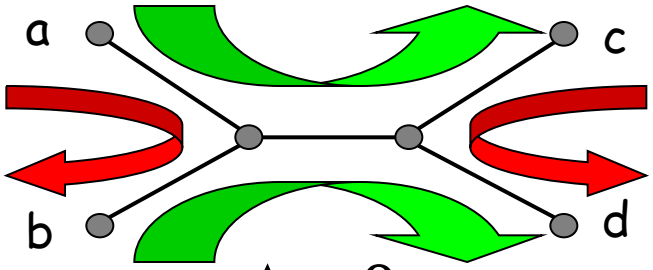




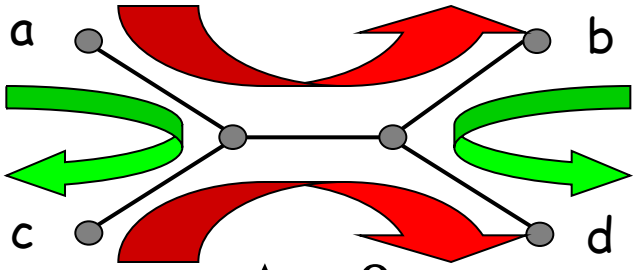

?
?
?
New
Old
⊕ =
⊕ =
⊕ =
?

beyond the molecular clock

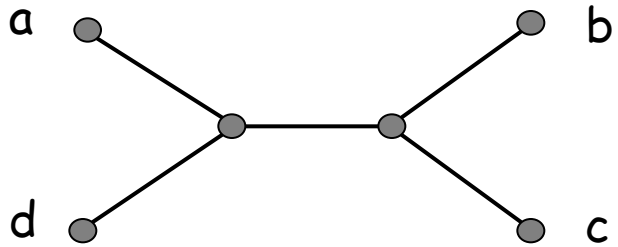
$$\Delta = D'(a,c) + D'(b,d) - D'(a,b) - D'(c,d)$$



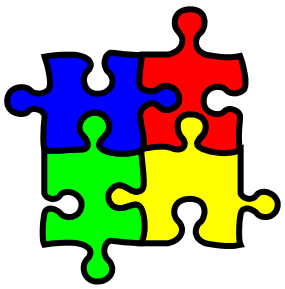
$\Delta > 0$



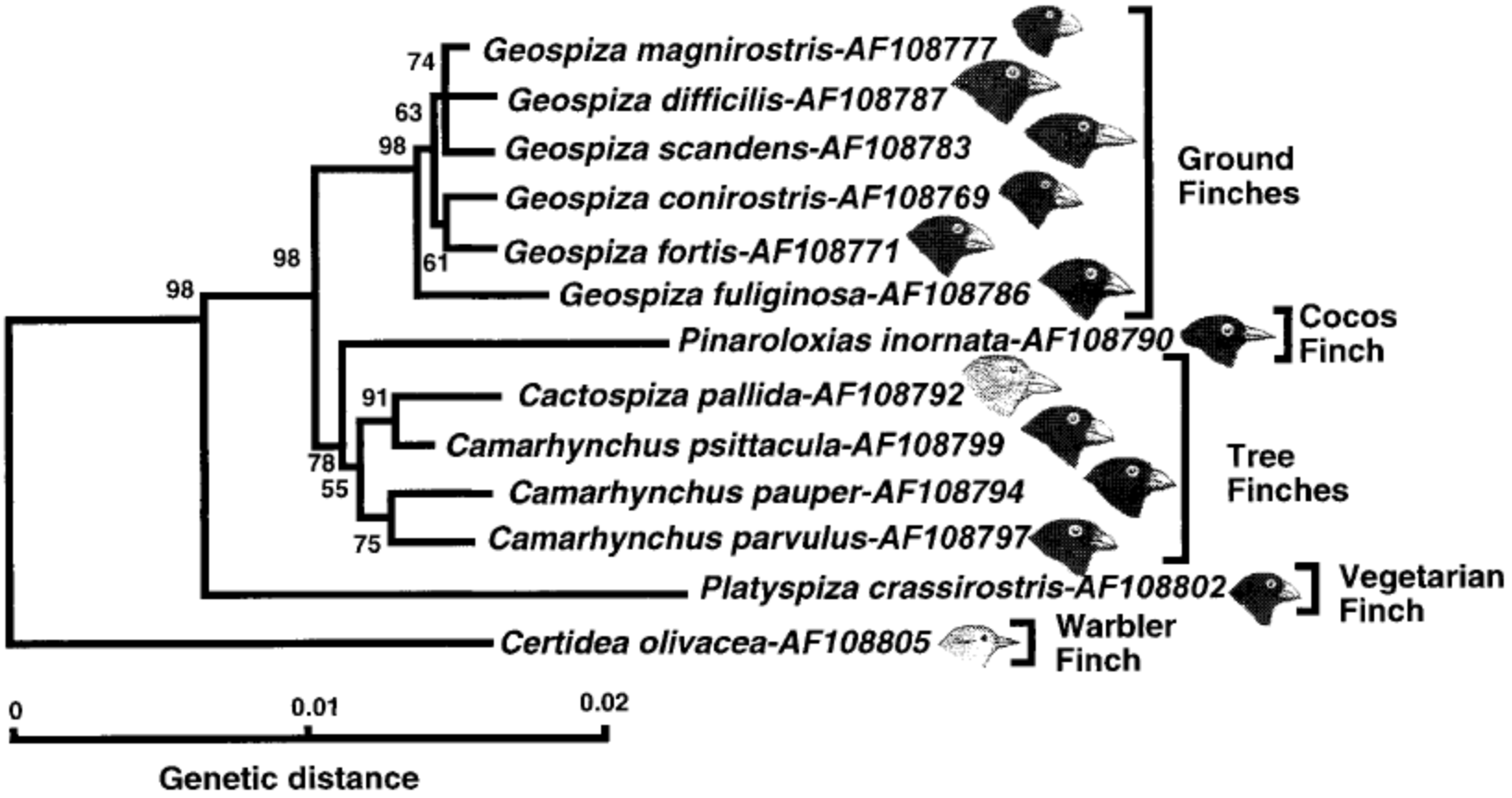
$\Delta < 0$



$\Delta = 0$

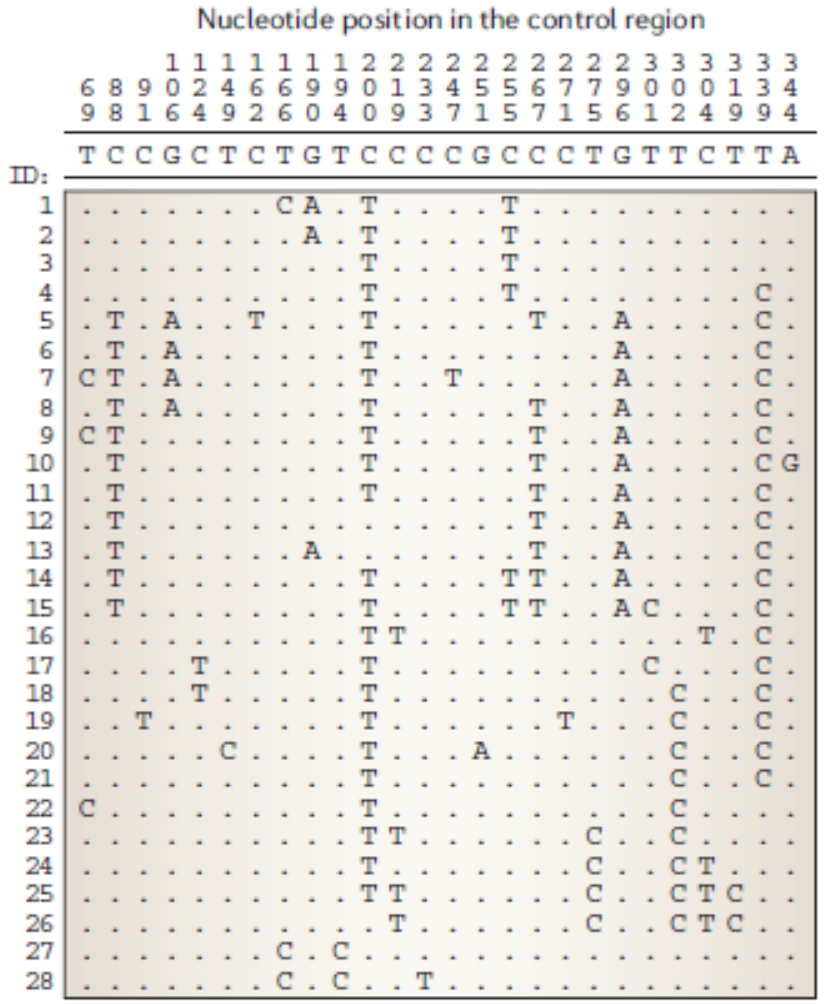


back to Darwin's finches



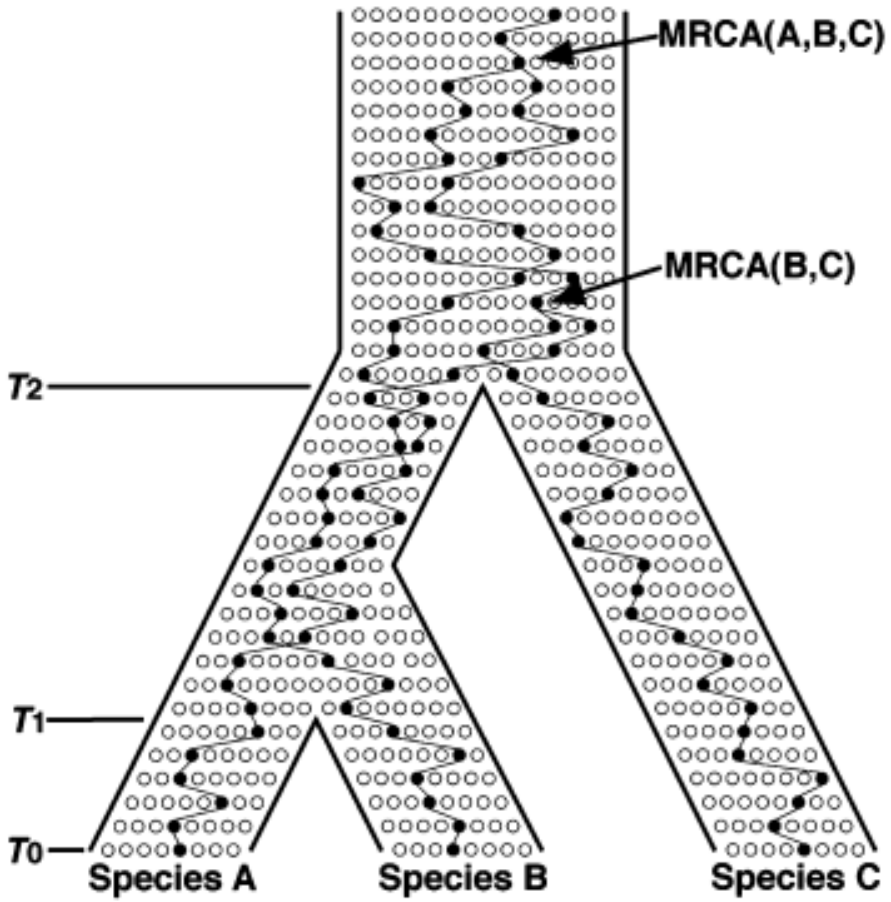
Sato et al., *PNAS* (1999)

genetic variation



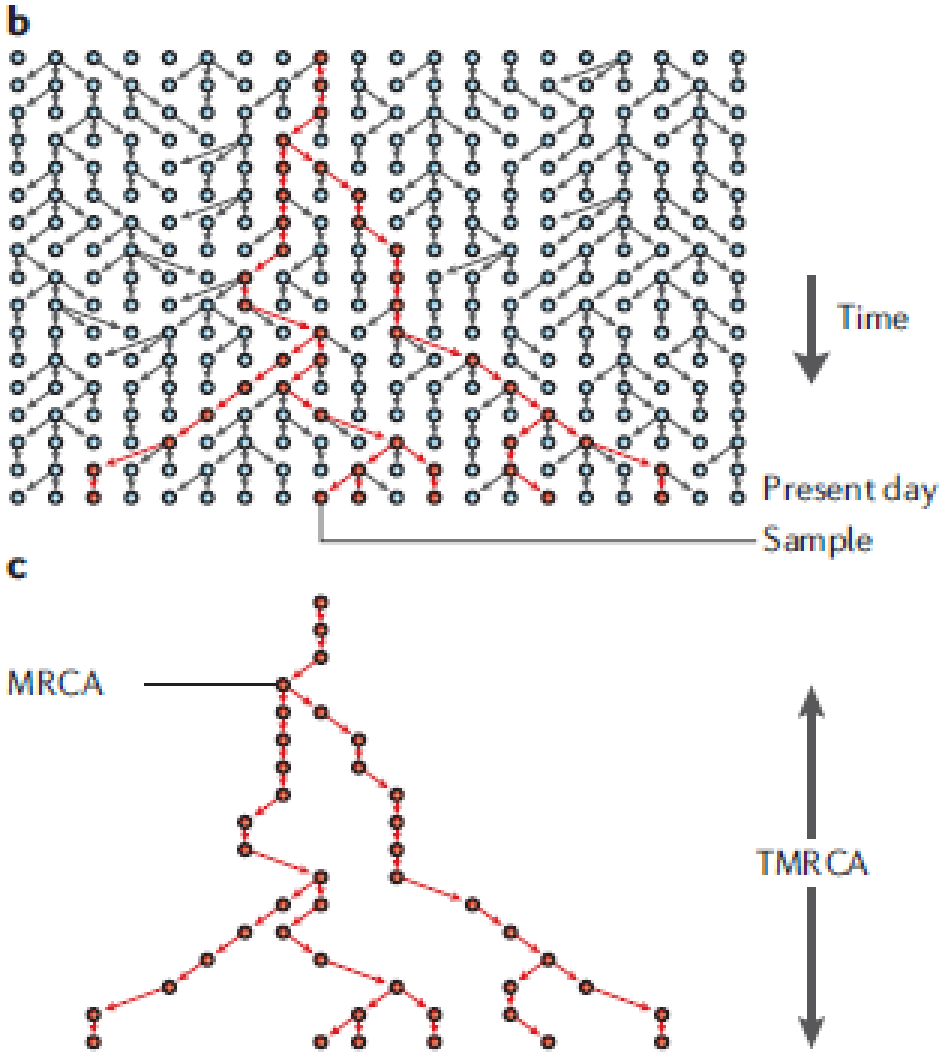
Marjoram & Tavare, *Nature Reviews Genetics* (2006)

zooming in on populations



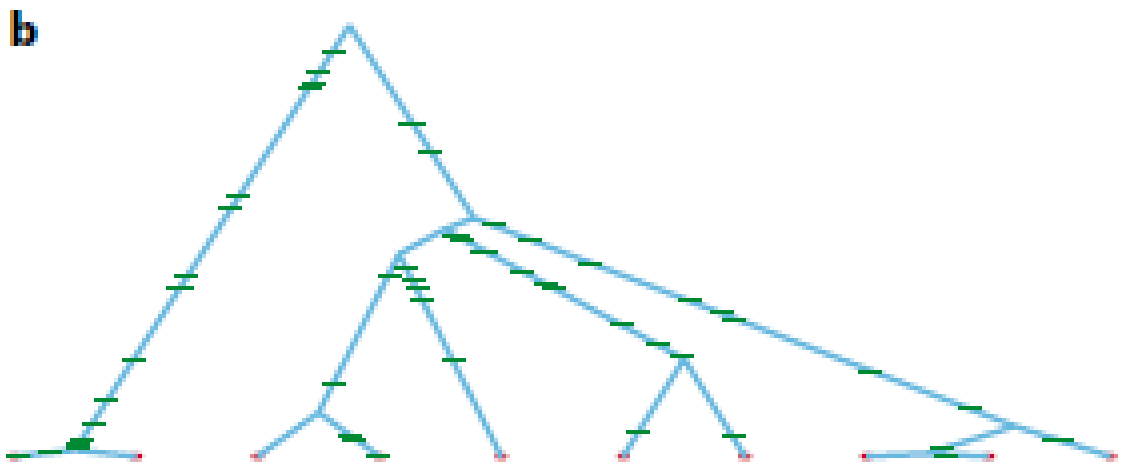
Than et al., *Journal of Computational Biology* (2007)

looking backwards in time



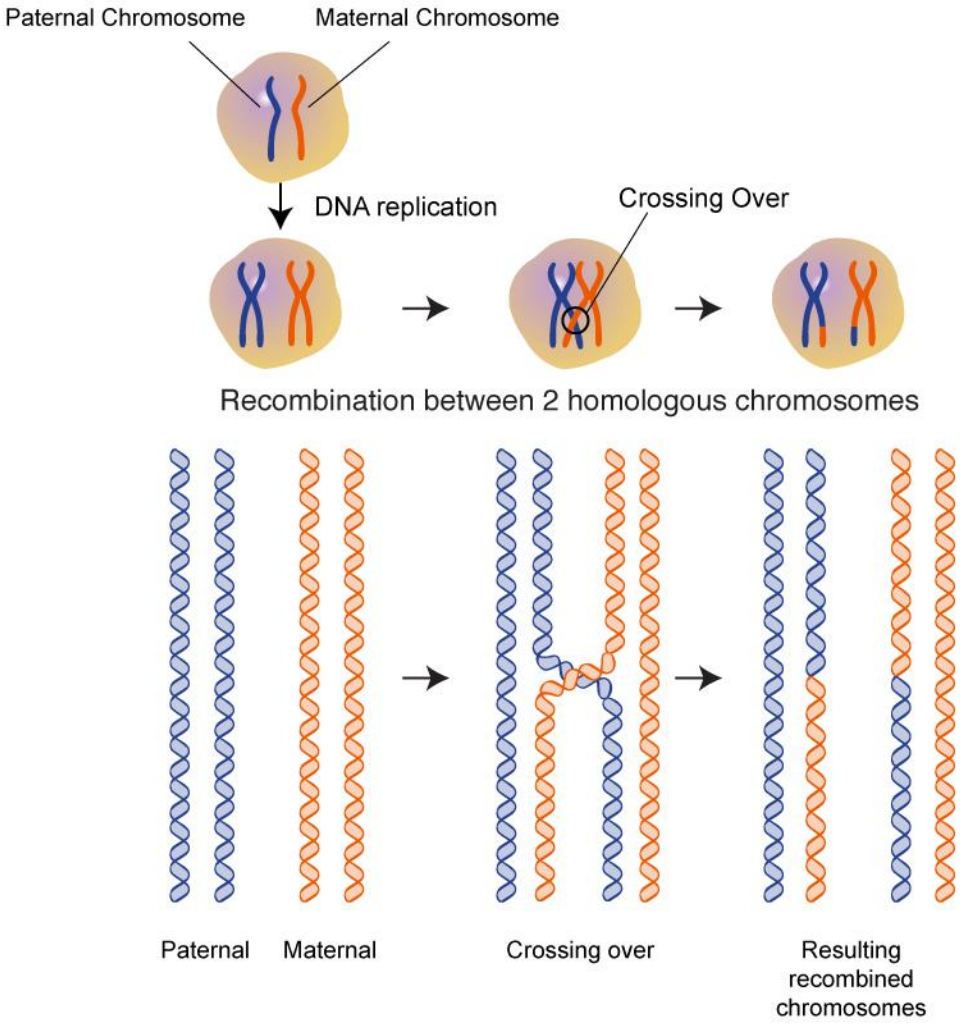
Marjoram & Tavare, *Nature Reviews Genetics* (2006)

mutations

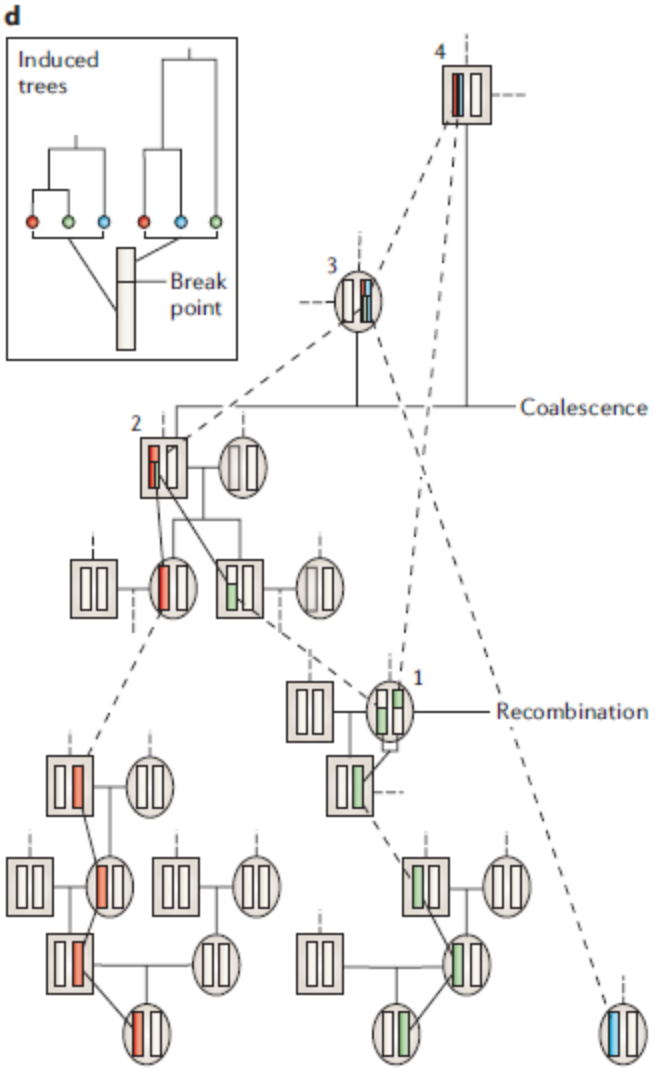


Rosenberg & Nordborg, *Nature Reviews Genetics* (2002)

Homologous recombination

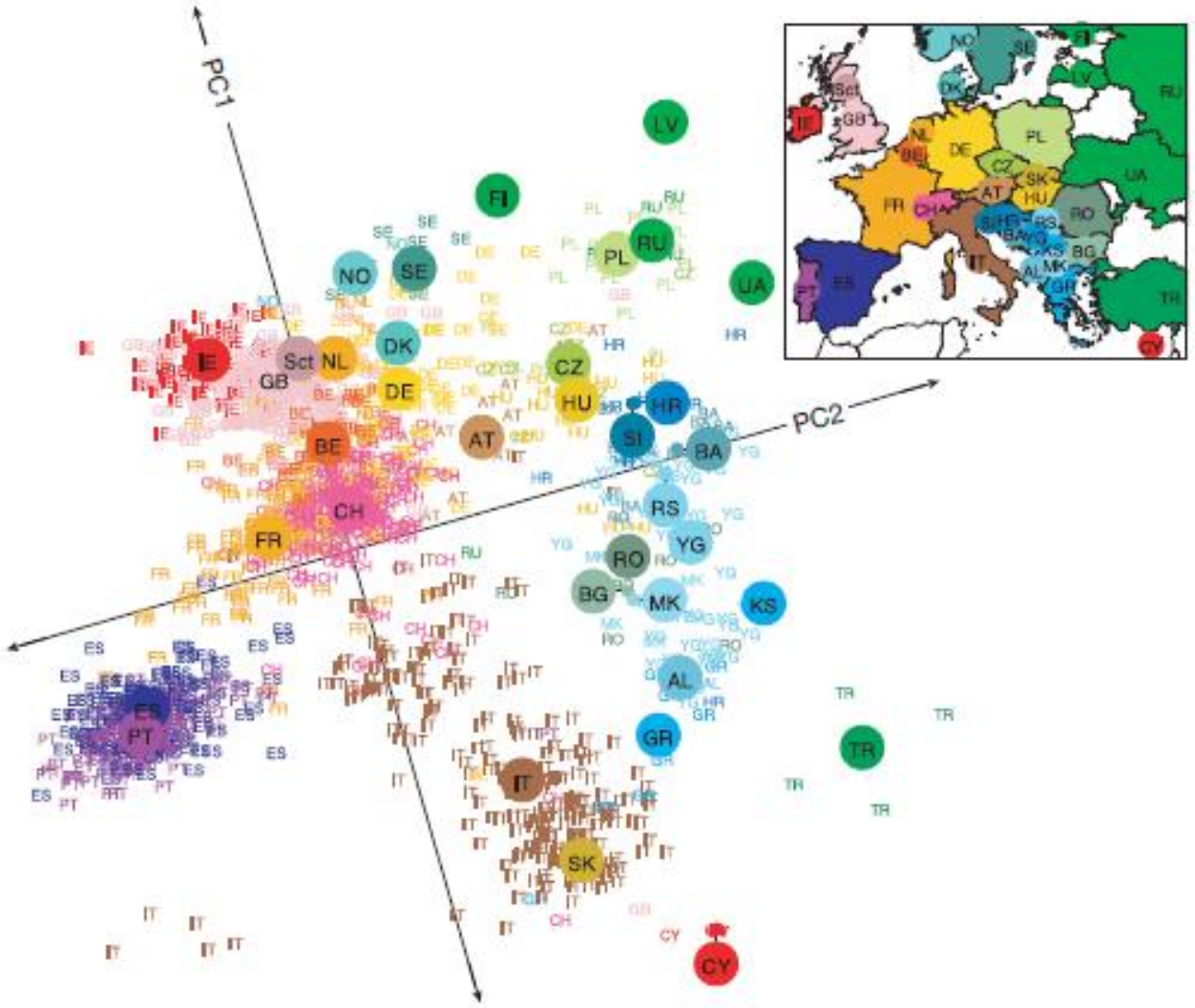


ancestral recombination graph



Marjoram & Tavare, *Nature Reviews Genetics* (2006)

population genomics



Novembre et al., *Nature* (2008)