

The rate of synonymous substitution (D_s or K_s)

The rate of nonsynonymous substitution (D_n or K_a)

D_s (K_s) = the number of synonymous substitution/the average number of synonymous sites for two seq

D_n (K_a) = the number of nonsynonymous substitution/the average number of nonsynonymous sites for two seq

Approximately:

61 codons, ~19 synonymous codons and ~42 nonsynonymous codons

The ratio of the synonymous site and nonsynonymous site \approx 1:2~3

The stringency of synonymous substitutions in the codon position:
3rd codon position > 1st codon position > 2nd codon position

Case study to calculate the substitution sites

Seq (SPECIES) 1	Ser	Thr	Glu	Met	Cys	Leu
	TCA	ACT	GAG	ATG	TGT	TTA
Seq (SPECIES) 2	TCG	ACA	GAG	ATA	TGT	CTA
	Ser	Thr	Glu	Ile	Cys	Leu

The total number of **synonymous** sites for **seq 1** = $1+1+1/3+0+1/3+5/3= 4.333$

The total number of **nonsynonymous** sites for **seq 1** = $2+2+8/3+3+8/3+4/3=13.677$

The total number of **synonymous** sites for **seq 2** = $1+1+1/3+2/3+1/3+5/3 =5$

The total number of **nonsynonymous** sites for **seq 2** = $2+2+8/3+7/3+8/3+4/3 =13$

The average of synonymous sites as $N_s = (4.333+5)/2=4.667$

The average of nonsynonymous sites as $N_A = (13.677+13)/2=13.333$

Case study to calculate Ka, Ks, and Ka/Ks

		Ser	Thr	Glu	Met	Cys	Leu
Seq (SPECIES) 1		TCA	ACT	GAG	ATG	TGT	TTA
		↕	↕		↕		↕
Seq (SPECIES) 2		TCG	ACA	GAG	ATA	TGT	CTA
		Ser	Thr	Glu	Ile	Cys	Leu

The average of synonymous sites as $N_s = (4.333+5)/2 = 4.667$

The average of nonsynonymous sites as $N_a = (13.677+13)/2 = 13.333$

3 synonymous substitution

1 nonsynonymous substitution

$$K_a = 1/13.333 = 0.0750$$

$$K_s = 3/4.667 = 0.643$$

$$K_a/K_s = 0.075/0.643 = 0.1166$$