Lecture Outline: Molecular Evolution (part 2)

1. **Standard Models of Molecular Evolution**

Model	Stationary Distribution	Rates	# Parameters
JC69 (Jukes and Cantor 1969)	Uniform $\pi = (0.25, 0.25, 0.25, 0.25)$	Equal	1
K80 (Kimura 1980)	Uniform $\pi = (0.25, 0.25, 0.25, 0.25)$	Transitions $\neq$ Transversions	2 2
F81 (Felsenstein 1981)	Flexible $\pi = (\pi_A, \pi_C, \pi_G, \pi_T)$	Equal	4
HKY85 (Hasegawa *et al.* 1984, 1985) F84 (Felsenstein 1984)	Flexible Flexible $\pi = (\pi_A, \pi_C, \pi_G, \pi_T)$	Transitions $\neq$ Transversions 5	5 5
TN93 (Tamura and Nei 1993)	Flexible $\pi = (\pi_A, \pi_C, \pi_G, \pi_T)$	Two Transition rates, Transversions	6 6
GTR (General Time Reversible)	Flexible $\pi = (\pi_A, \pi_C, \pi_G, \pi_T)$	Flexible	9

The matrix $Q = \{q_{ij}\}$ is typically parameterized as $q_{ij} = r_{ij}\pi_j/\mu$ for $i \neq j$.

(If matrices are scaled, number of free parameters is one less.)

2. **Model Extensions**

   (a) Partitioning sites:

   (b) Gamma distributed rates among sites:

   (c) Invariant sites: