

# Stochastic Models in Cartoons

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# Brownian Motion



$$dX_i(t) = \sigma dB_i(t),$$



Amount of  
change in  
character

# Brownian Motion



$$dX_i(t) = \sigma dB_i(t),$$

proportional  
to std dev

Amount of  
change in  
character

# Brownian Motion

$$dX_i(t) = \sigma dB_i(t),$$

Amount of  
change in  
character

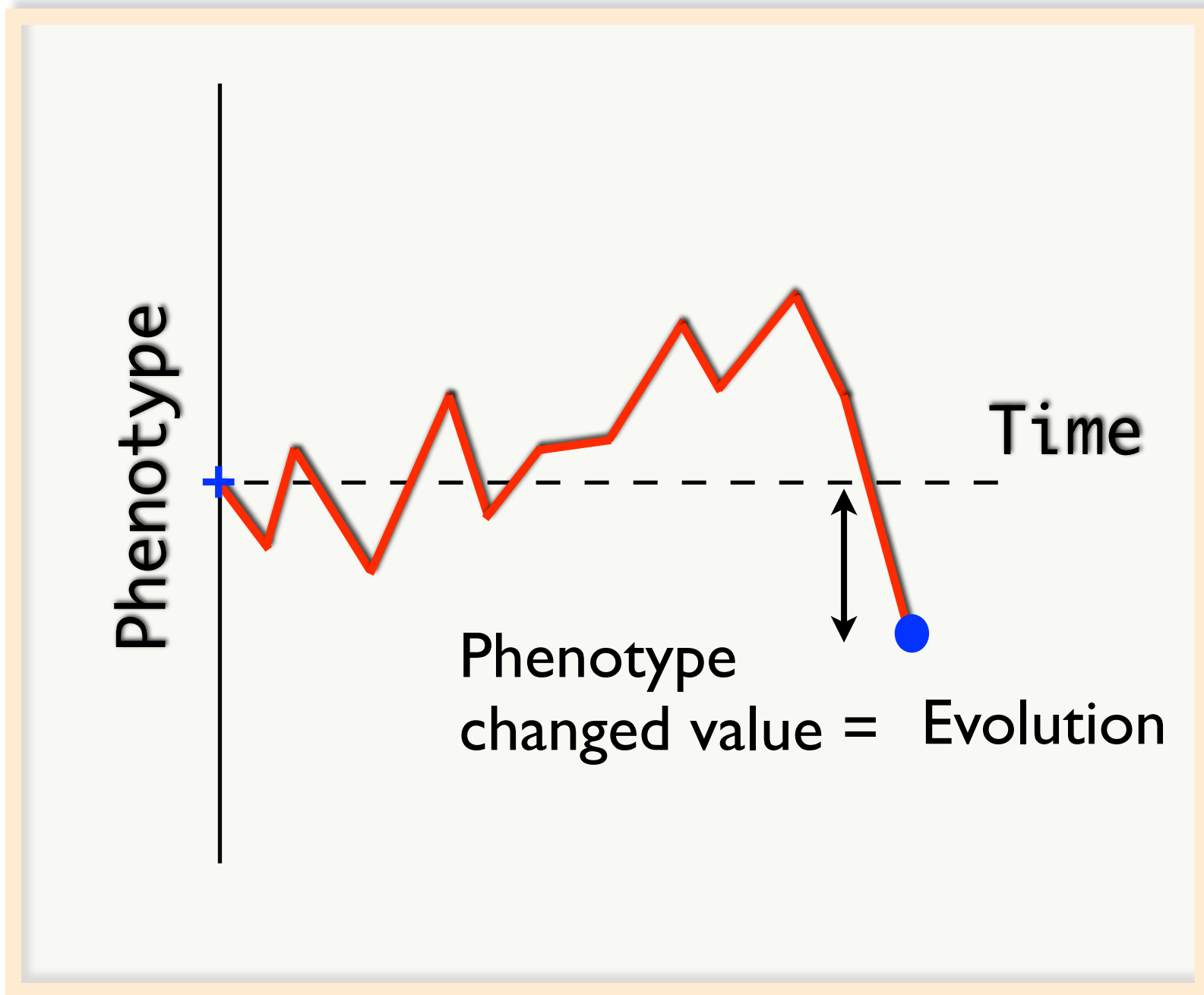
proportional  
to std dev

and a random  
amount of change



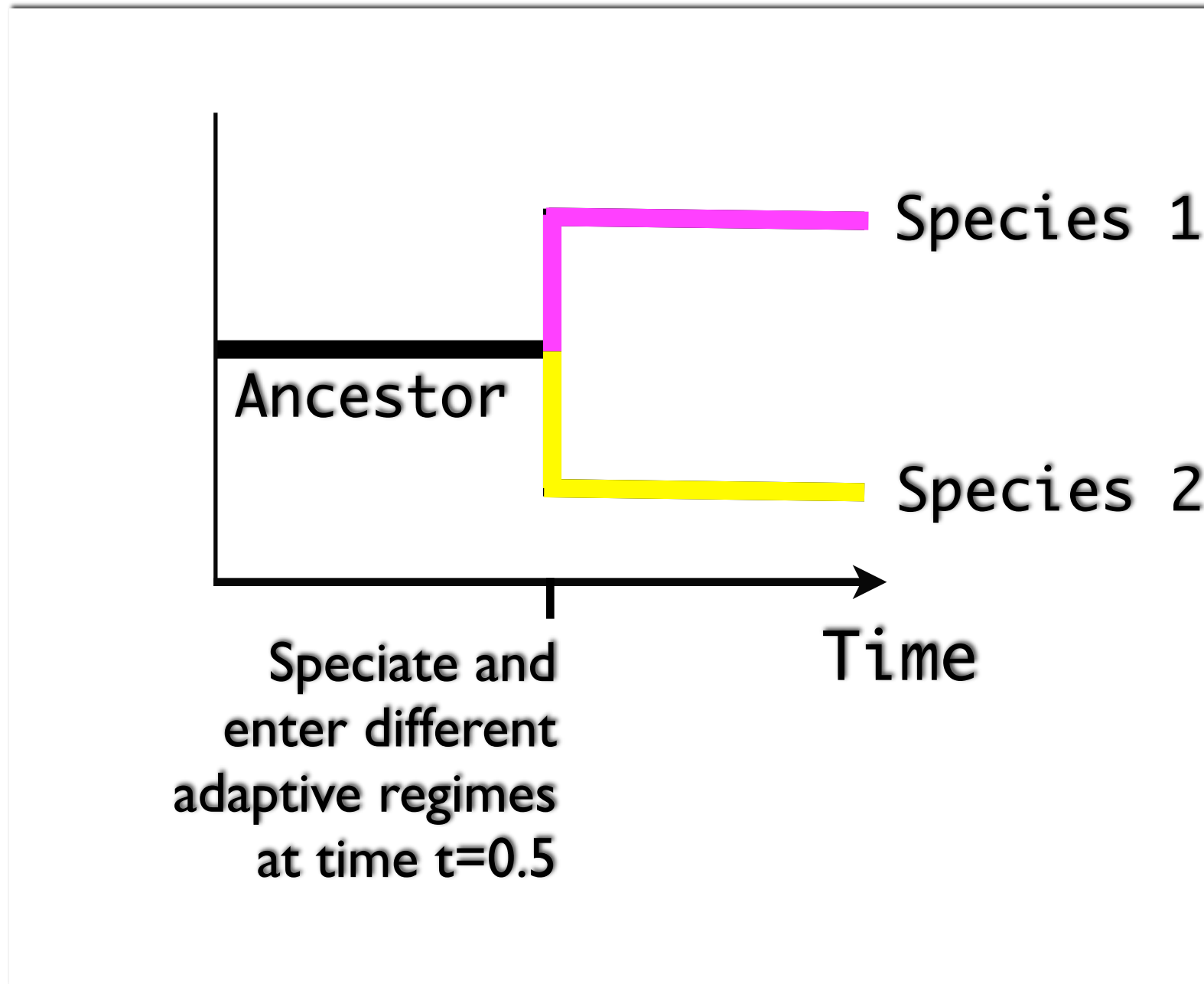
**Let's create some cartoons!**

# ***We can build up simulations of evolution***



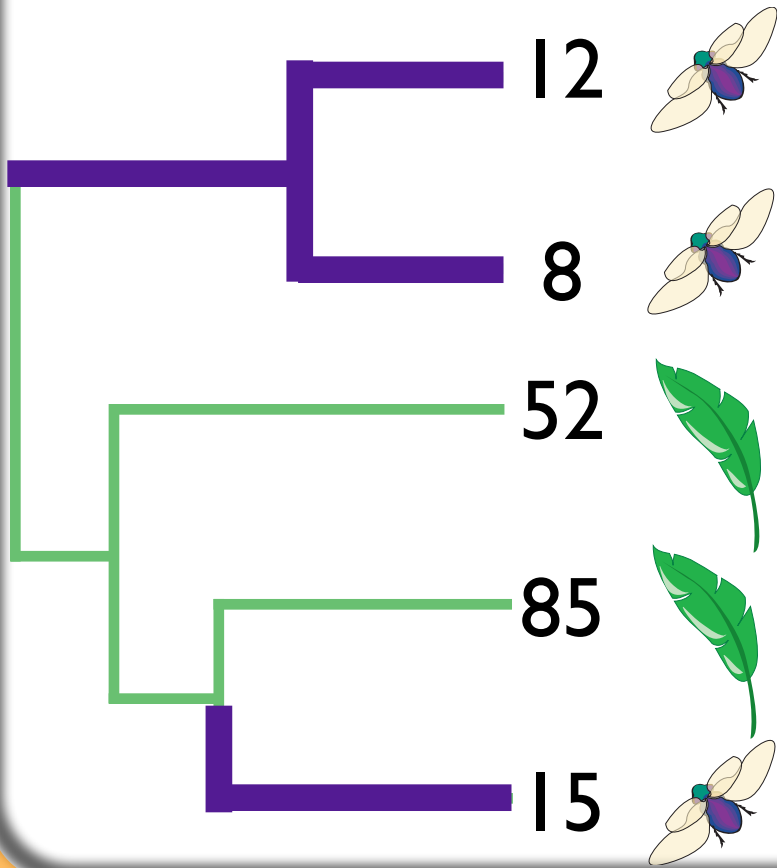


# BM and OU models make different predictions





Body Size Food Type



Recent theoretical developments have made it possible to perform comparative analyses using an explicit evolutionary model

*Brownian Motion*

$$dX_i(t) = \sigma dB_i(t), \quad t_i^{j-1} \leq t \leq t_i^j.$$

*Orstein Uhlenbeck Process*

$$dX_i(t) = \alpha (\beta_i^j - X_i(t)) dt + \sigma dB_i(t)$$

# Ornstein Uhlenbeck Process

A model for evolution with selection

time interval  $t$ :

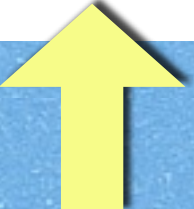
$$t_i^{j-1} \leq t \leq t_i^j.$$

$$dX_i(t) = \alpha (\beta_i^j - X_i(t)) dt + \sigma dB_i(t),$$

Hansen (1997)

# Ornstein Uhlenbeck Process

$$dX_i(t) = \alpha (\beta_i^j - X_i(t)) dt + \sigma dB_i(t),$$



Amount of  
change in  
character



Deterministic  
(**selection**)



Stochastic  
(**drift**)

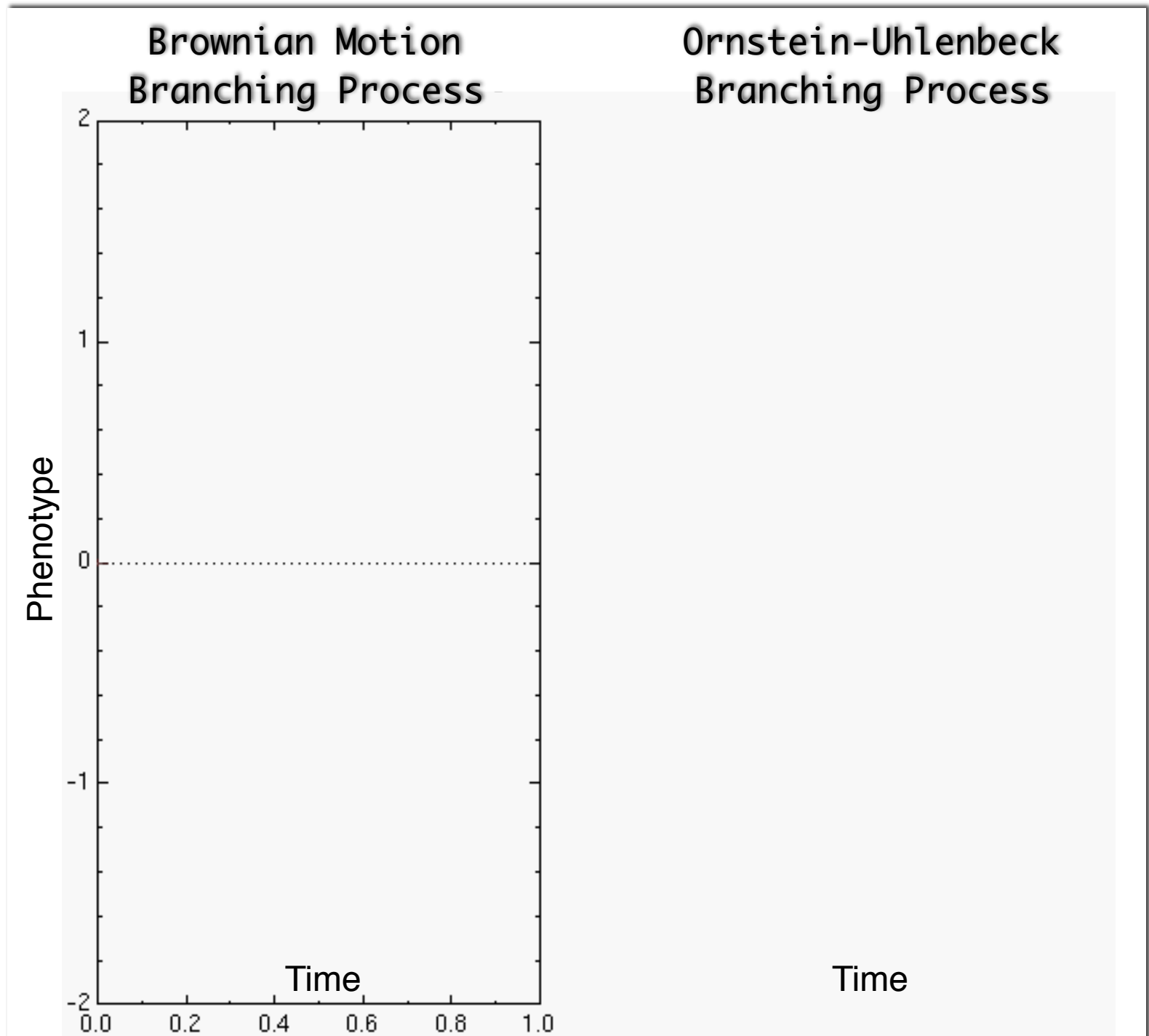
OU in the limit as  $\alpha \rightarrow 0$

$$dX_i(t) = \overset{0}{\cancel{\alpha}} (\beta_i^j - X_i(t)) dt + \sigma dB_i(t),$$

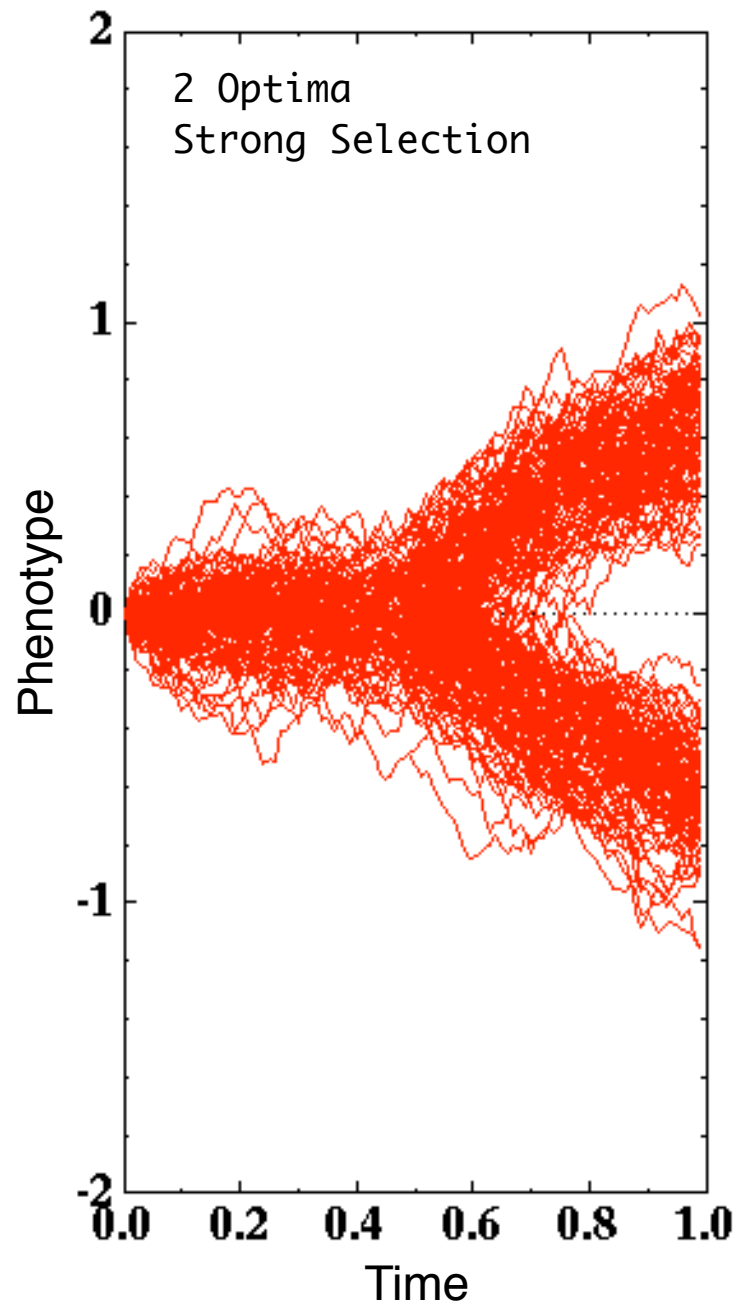
OU in the limit as  $\alpha \rightarrow 0$

$$dX_i(t) = \alpha (\beta_i^j - X_i(t)) dt + \sigma dB_i(t),$$

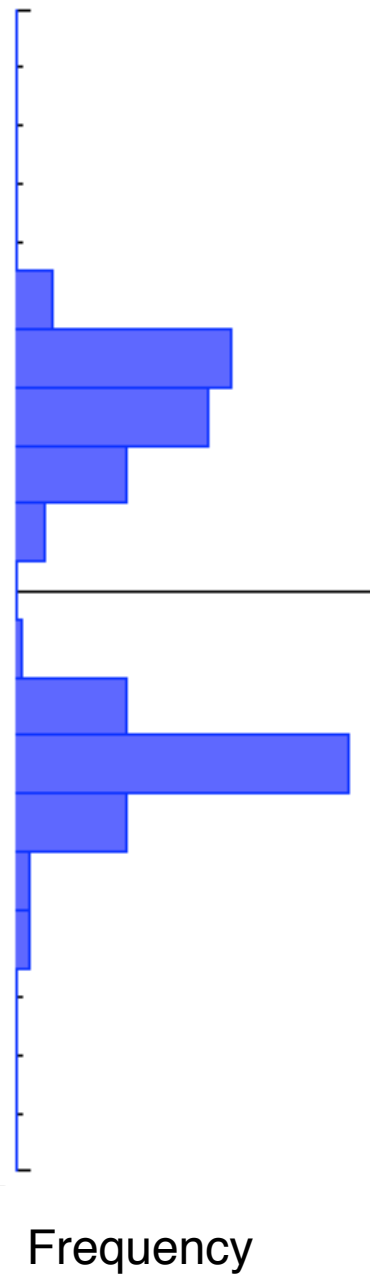
# BM and OU models make different predictions



## OU Branching Process



## Phenotypic Distribution





**Thus, with:**

a set of interspecific data,  
a phylogeny, and  
a little biological insight,

**we can explore alternative  
evolutionary scenarios**

**and potentially make a statement  
about how characters evolved!**