Stochastic Models in Cartoons

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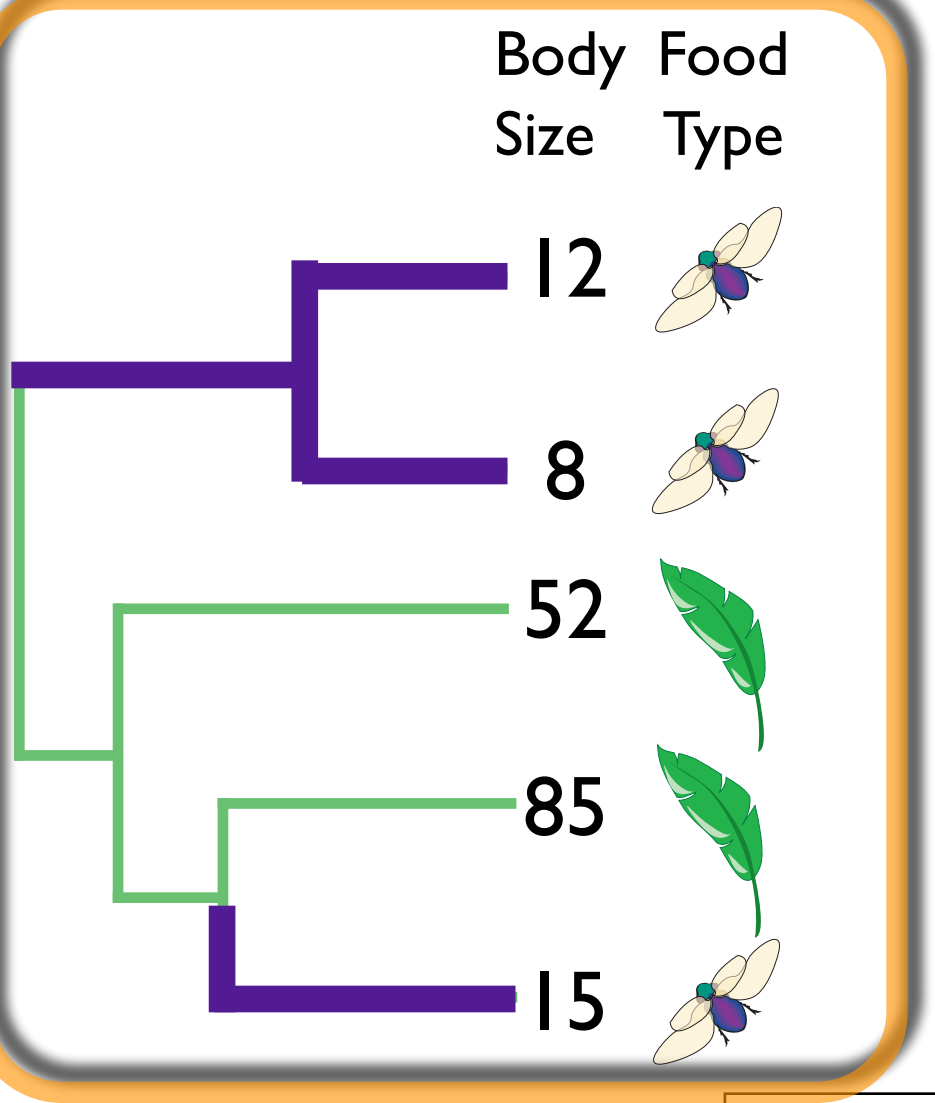

Recent theoretical developments have made it possible to perform comparative analyses using an explicit evolutionary model

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:

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

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

Hansen (1997)

Ornstein Uhlenbeck Process

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

Amount of change in character

Deterministic (**selection**)

Stochastic (**drift**)

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

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

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

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

Brownian Motion

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Amount of change in character

Brownian Motion

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proportional to std dev

Amount of change in character

Brownian Motion

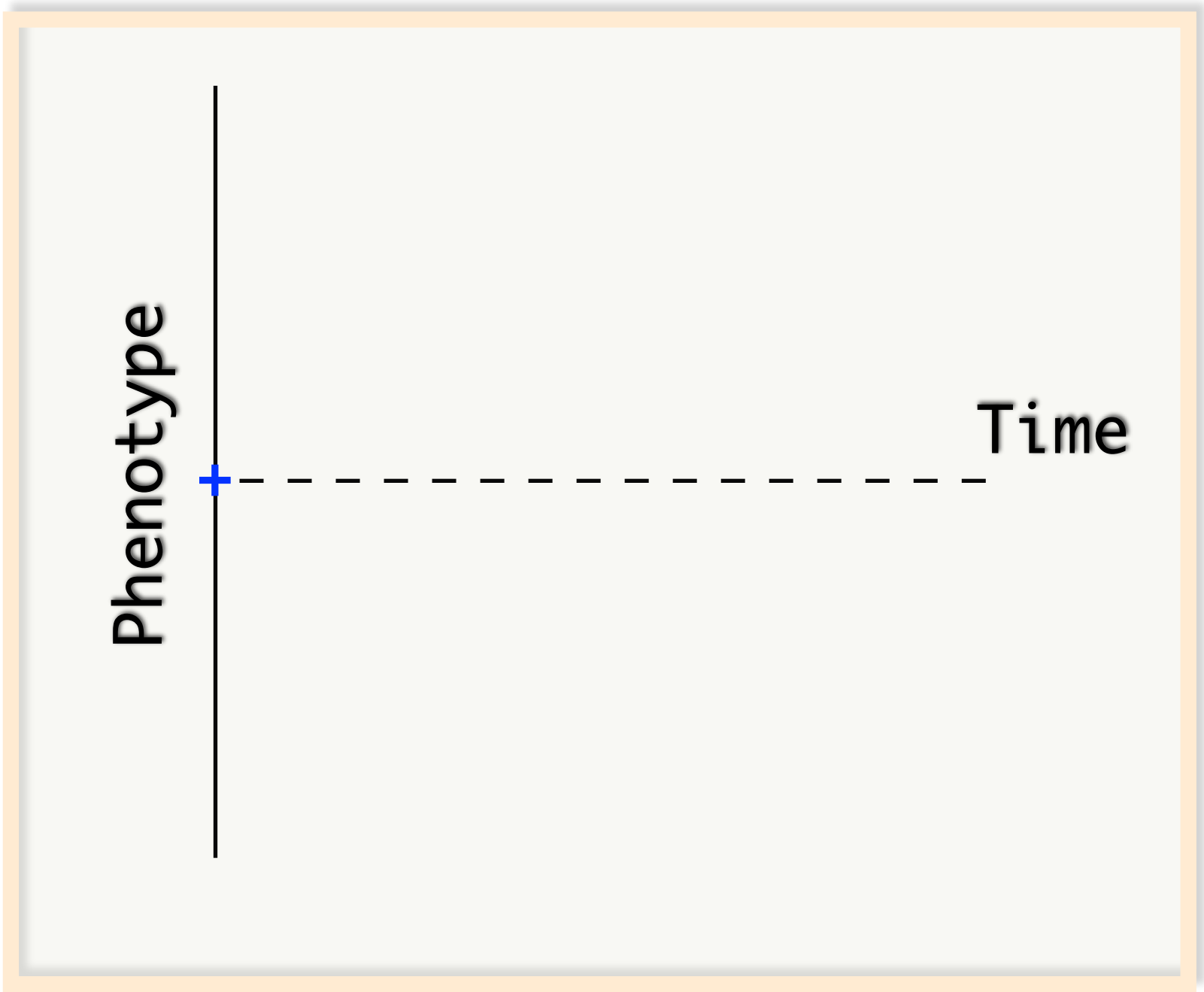
$$dX_i(t) = \qquad \sigma\, dB_i(t),$$

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



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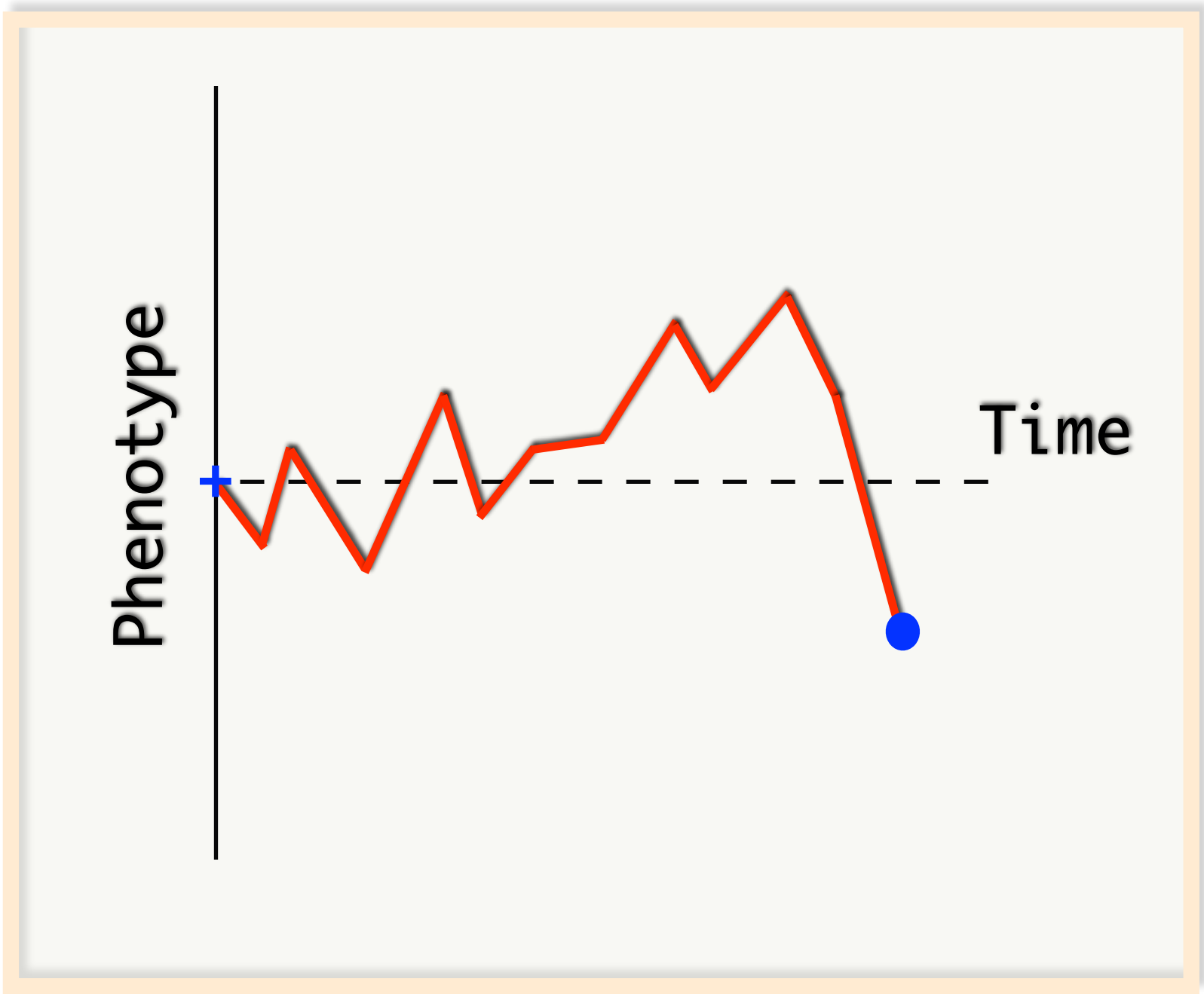
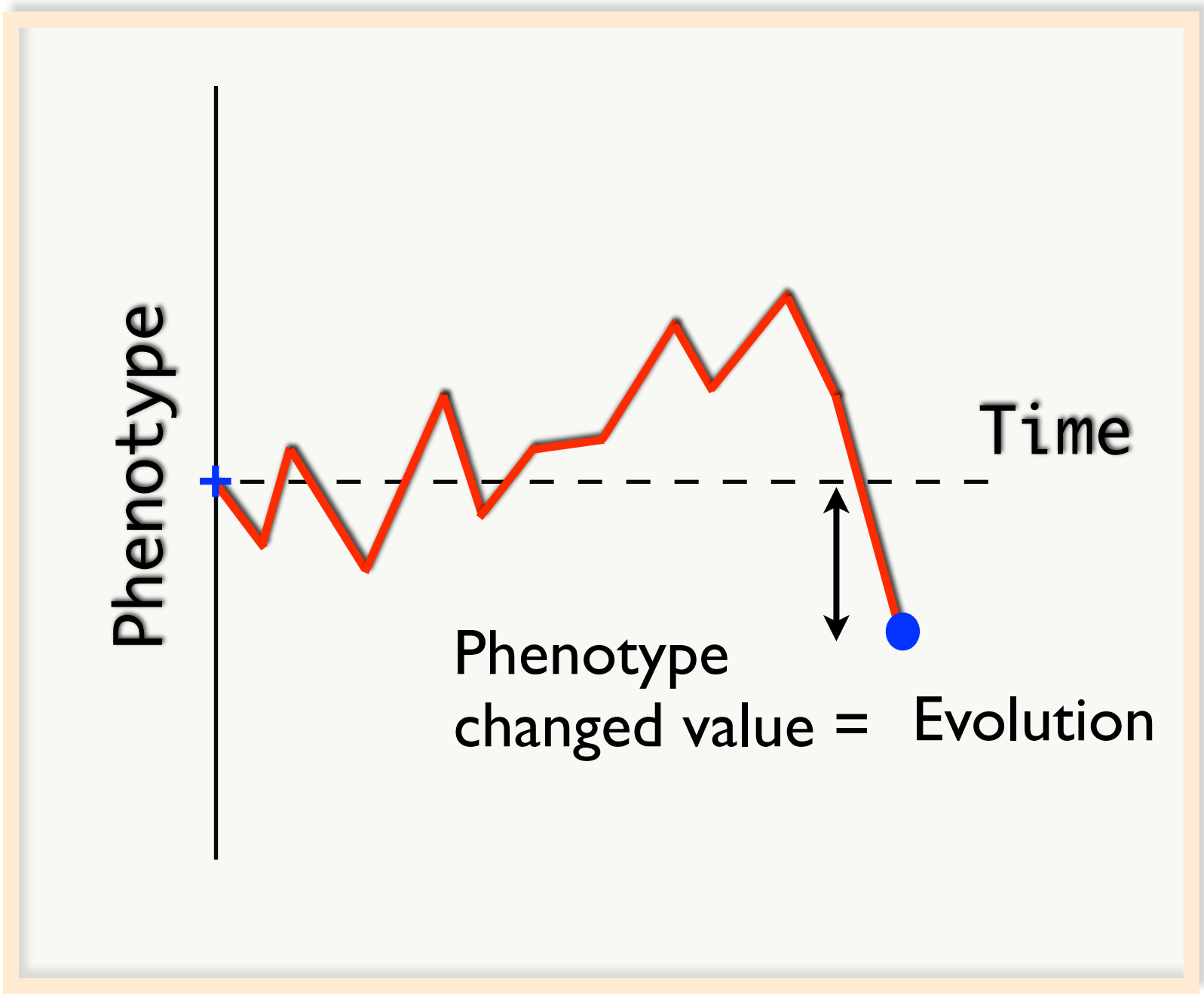
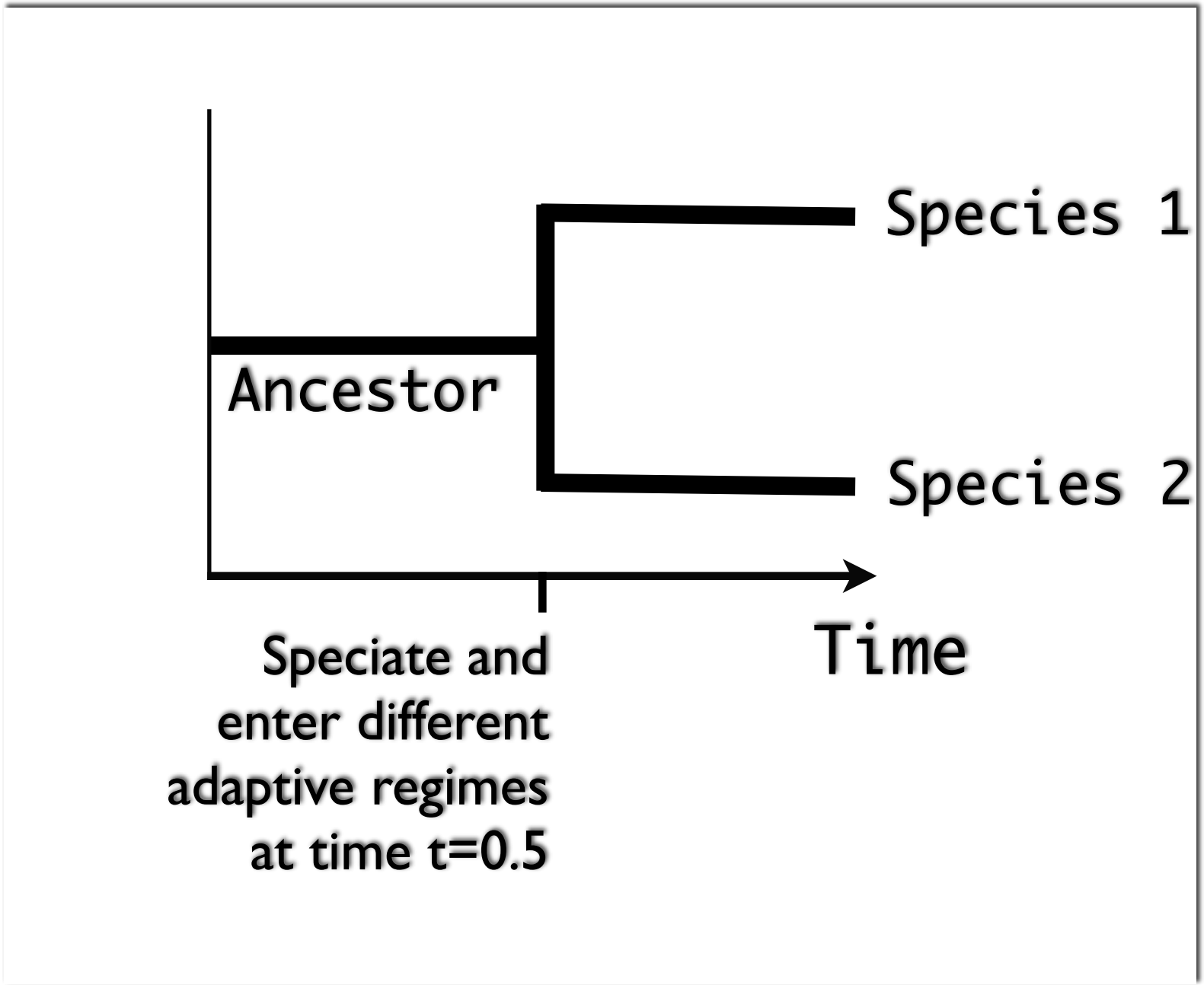


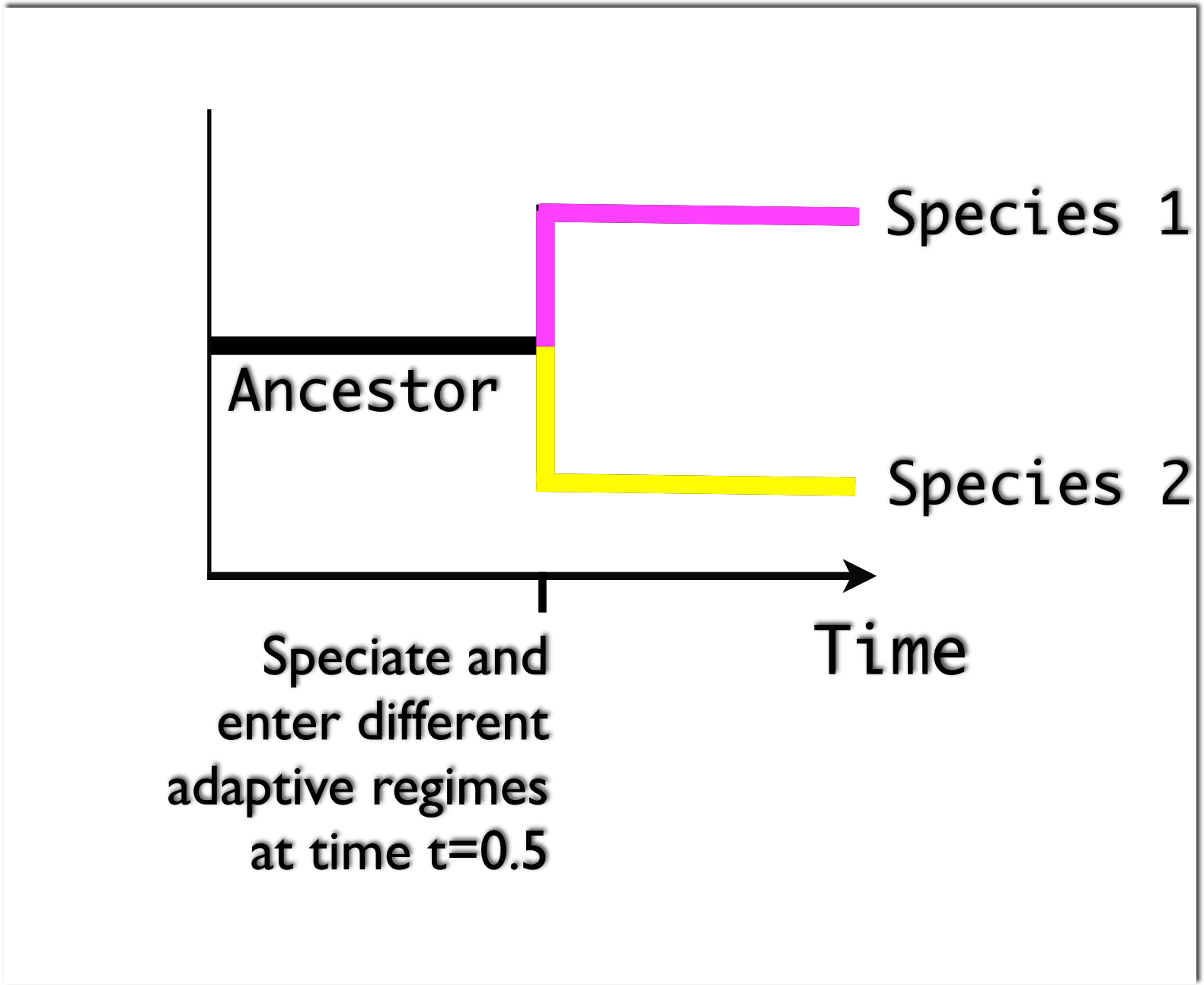
We can build up simulations of evolution



BM and OU models make different predictions



BM and OU models make different predictions



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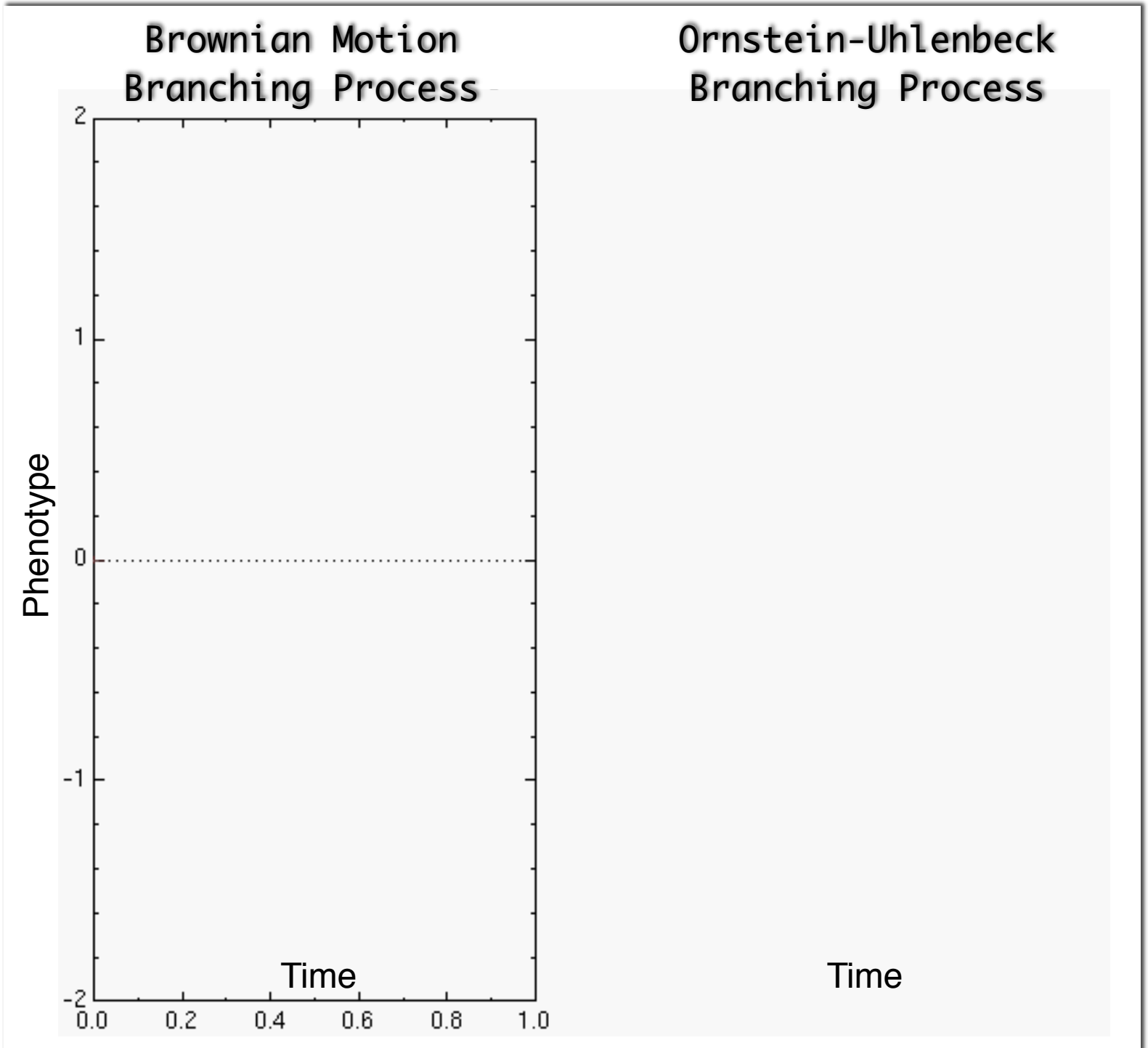
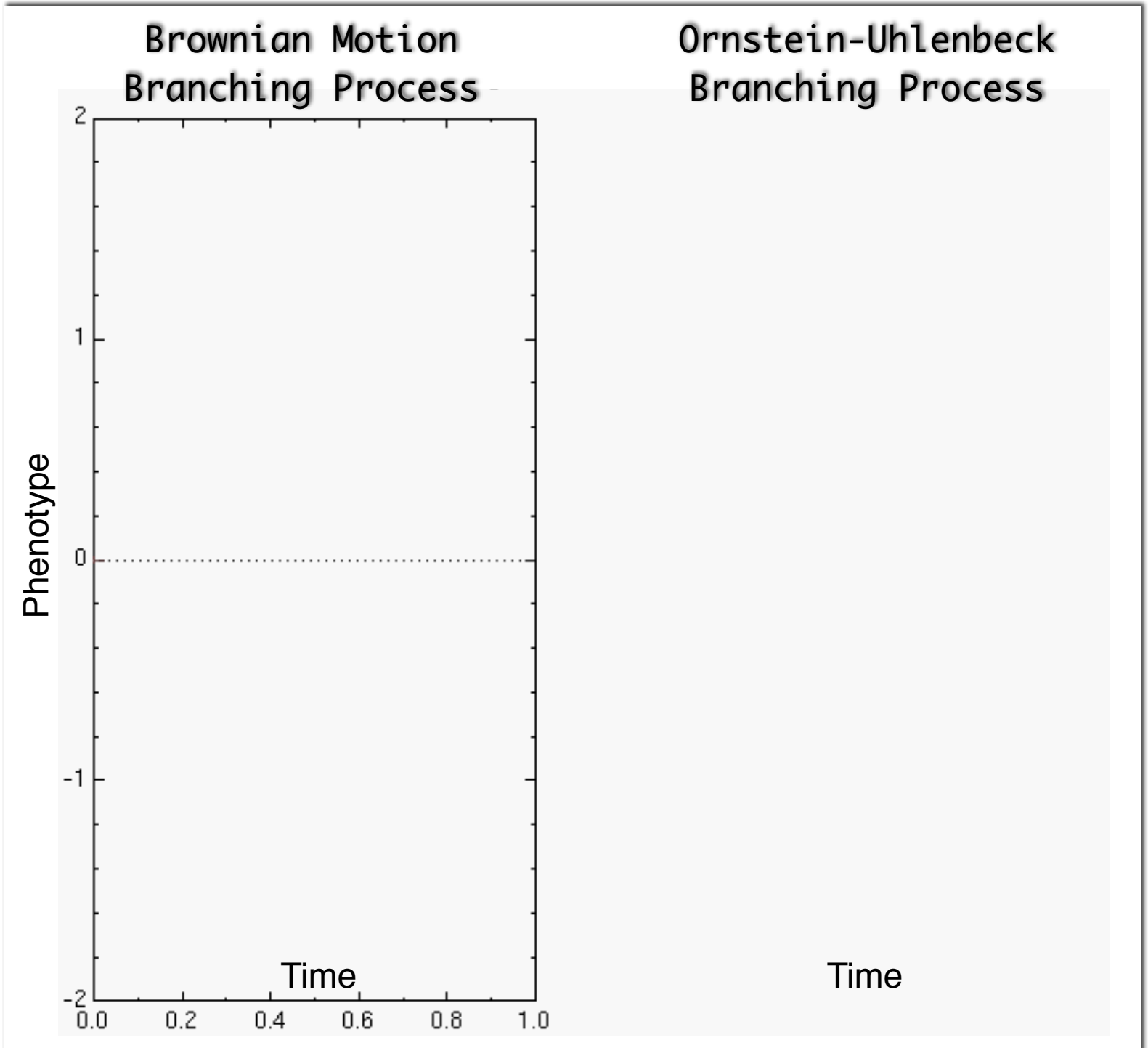
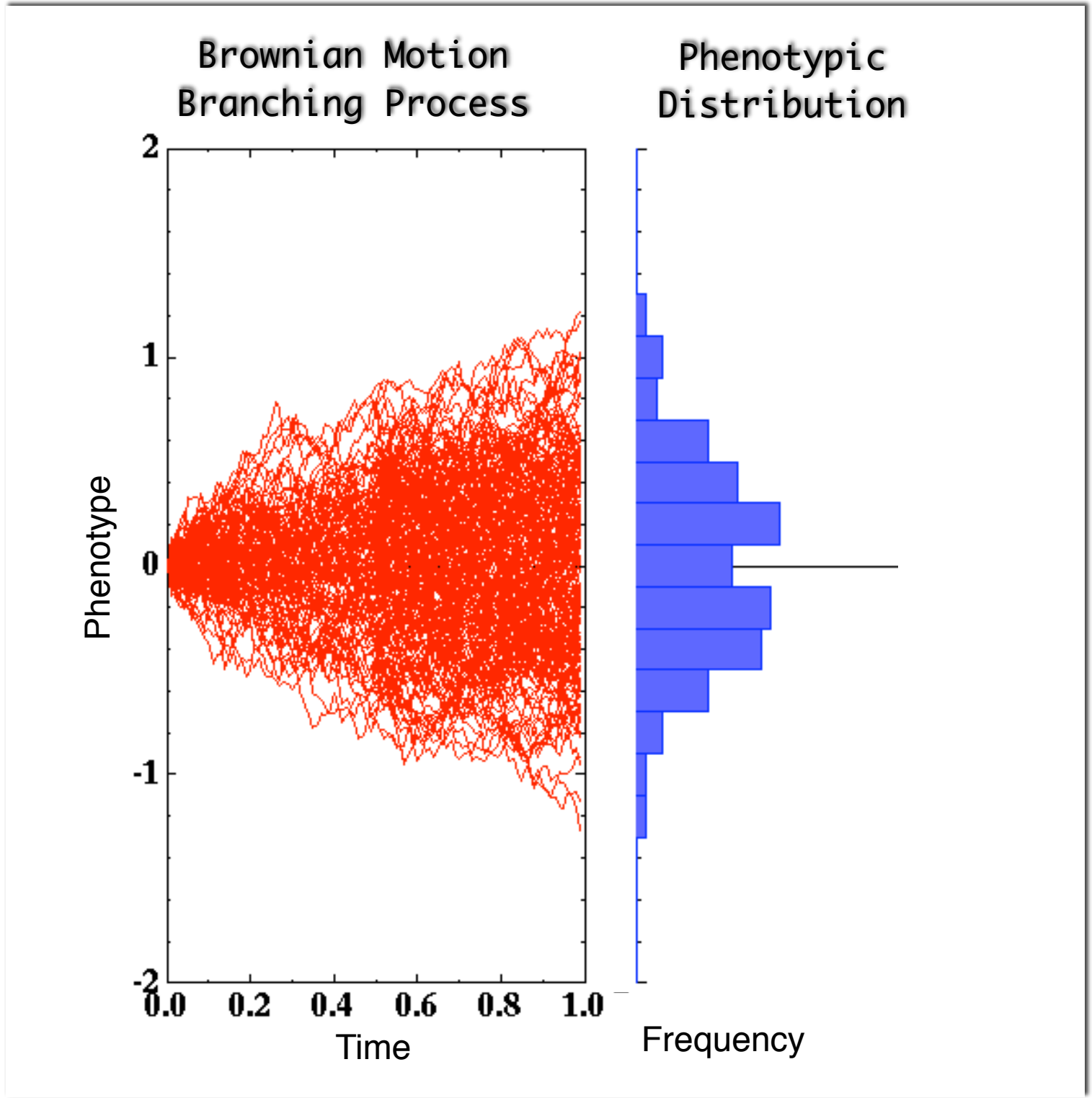
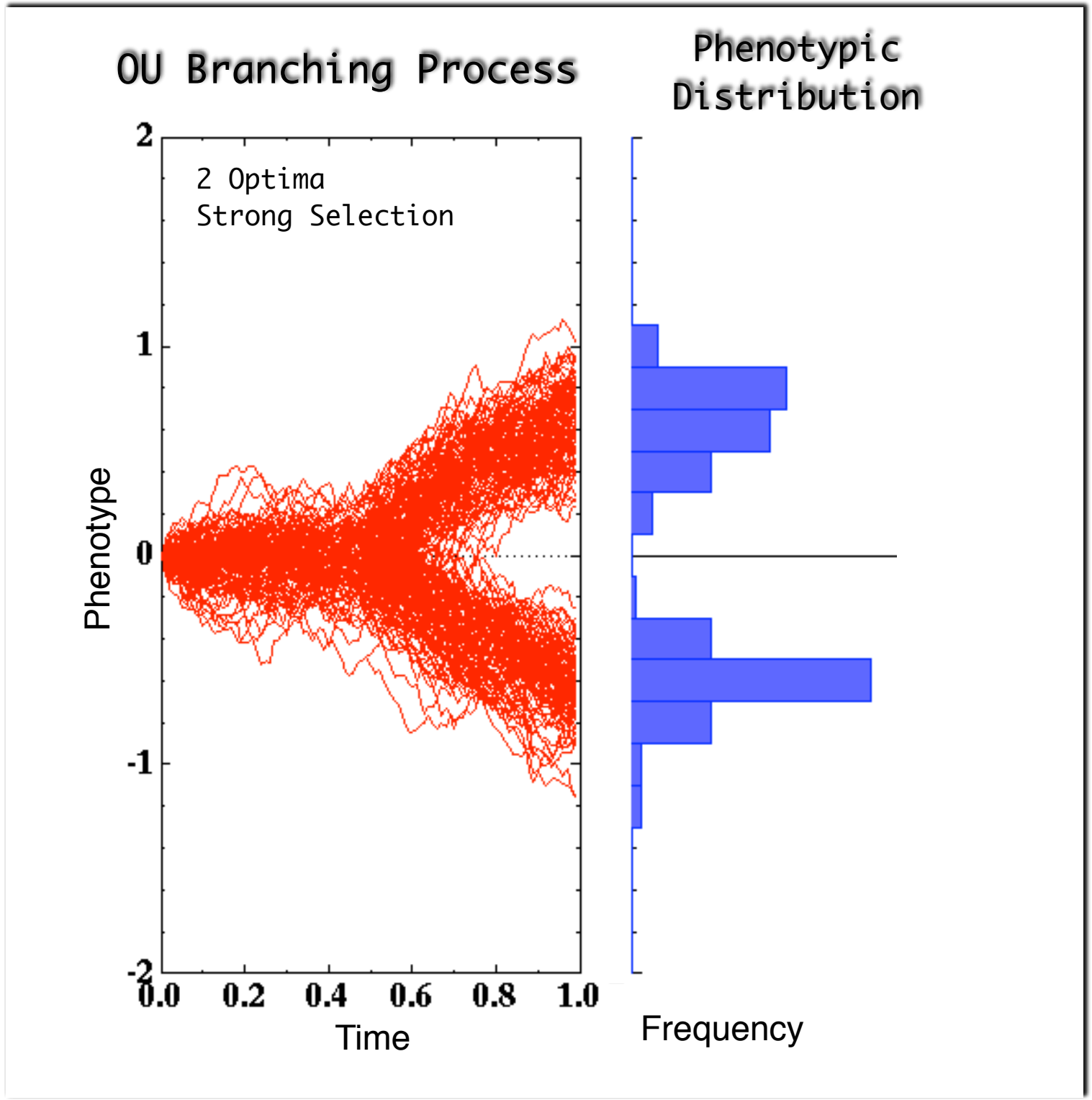


BM and OU models make different predictions




Brownian Motion
Branching Process
Phenotypic
Distribution
Phenotype
2
1
0
-1
-2
0.0
0.2
0.4
0.6
0.8
1.0
Time
Frequency


OU Branching Process
Phenotypic Distribution
2 Optima
Strong Selection
Phenotype
2
1
0
-1
-2
0.0
0.2
0.4
0.6
0.8
1.0
Time
Frequency

Thus, with:

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

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and potentially make a statement about how characters evolved!