

Is intelligent life  
inevitable? Paleobiological  
perspective from the  
Neotropical rainforest

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Is there life outside Earth?

# Time (Ma)

4500 4000 3500 3000 2500 2000 1500 1000 500

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\*? earliest biogenic carbon

\* earliest bacteria

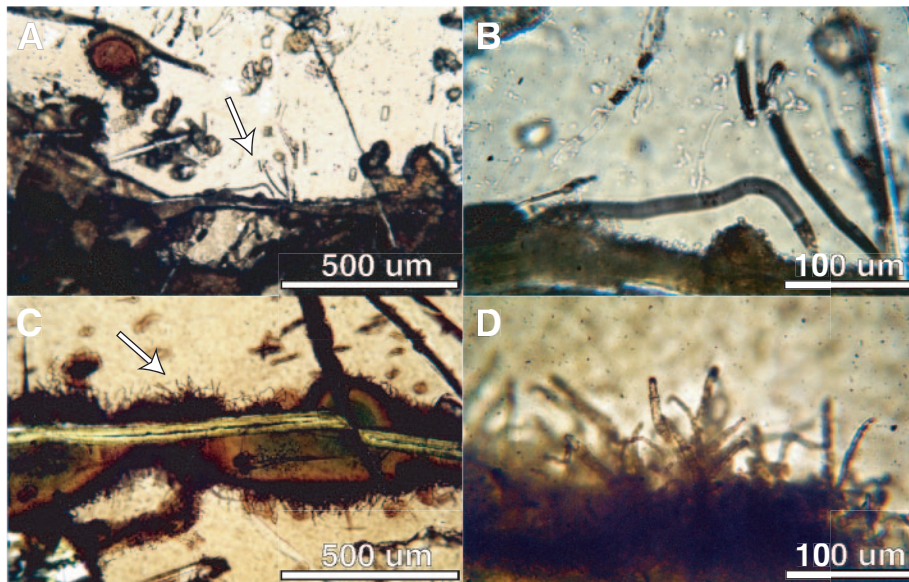
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\* earliest photosynthetic  
bacteria

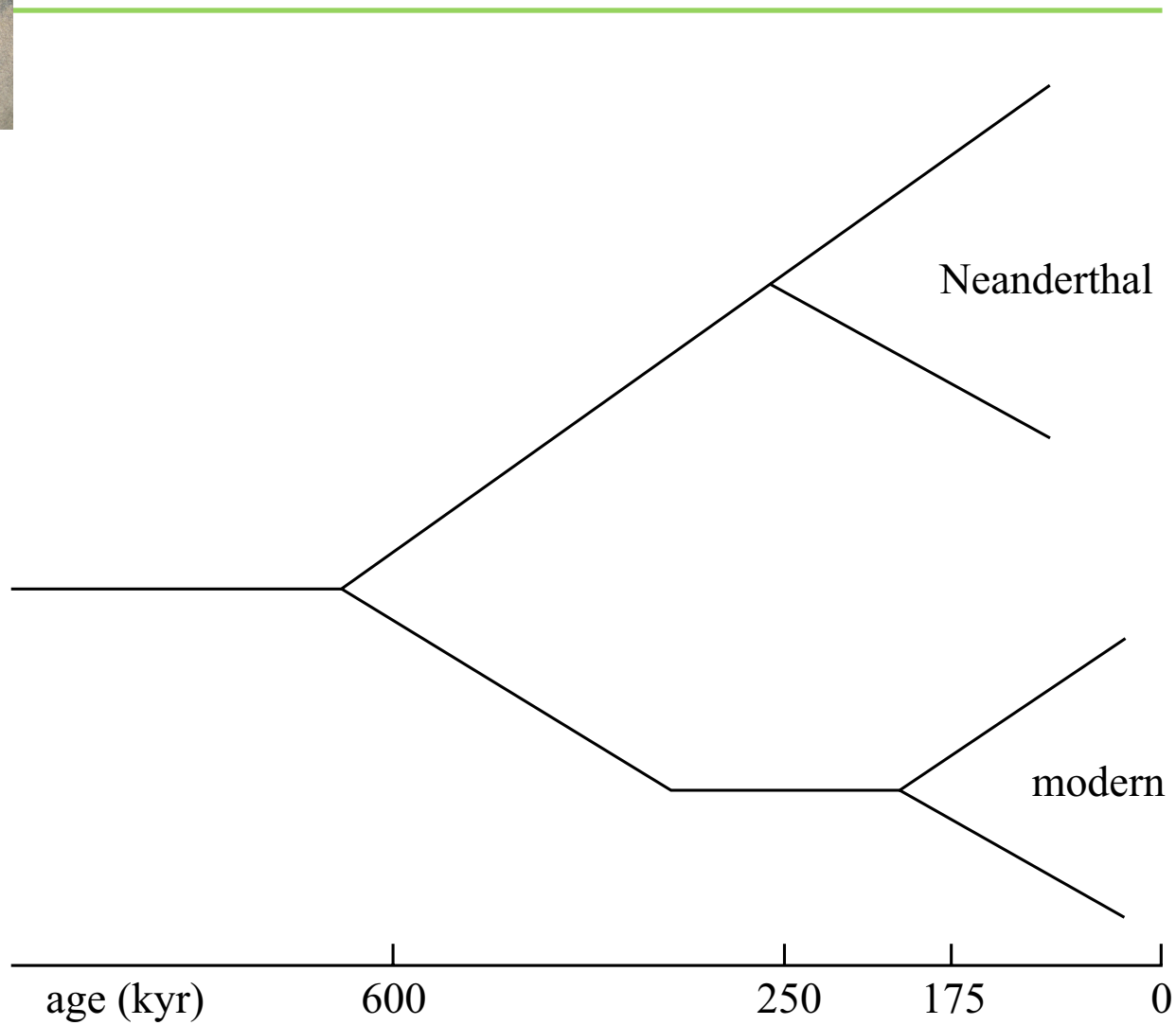
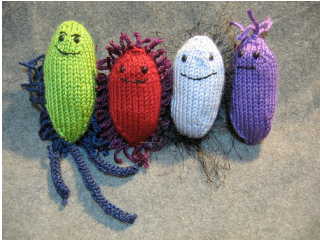
\* first green algae  
(eukaryotes)

first metazoans \*

first skeletons \*



Furnes et al. 2004



What is an 'intelligent' species?



Interstellar communication

What is the likelihood of discovering  
life outside Earth?

What is the likelihood of discovering  
life on an Earth-like planet outside of  
the solar system?

What is the likelihood of discovering  
intelligent life outside of the solar  
system?

# The Drake Equation

$N$  = Probability of finding intelligent life beyond our solar system

$$N = N_* f_p n_e f_l f_i f_c L$$

$N_*$  = number of stars in the Milky way

$f_p$  = fraction of stars that have planets around them

$n_e$  = fraction of planets capable of sustaining life

$f_l$  = fraction of planets in  $n_e$  where life evolves

$f_i$  = fraction of planets where intelligent life evolves

$f_c$  = fraction of  $f_i$  that try to communicate

$L$  = length of time for which such civilizations release detectable signals into space

Probability of life  
evolving =  $N_* f_p n_e f_l$

200 billion  $\times 0.2 \times 0.1 \times 0.5 =$   
2 billion of planets with  
life in Milky Way



# Probability of finding intelligent life beyond our solar system

$$N = (N_* f_p n_e f_l) f_i f_c L$$

2 billion  $\times 0.000000001 \times 1 \times 0.00001 =$   
 $0.00002$  planets with intelligent life  
capable of communication and alive  
during our civilization

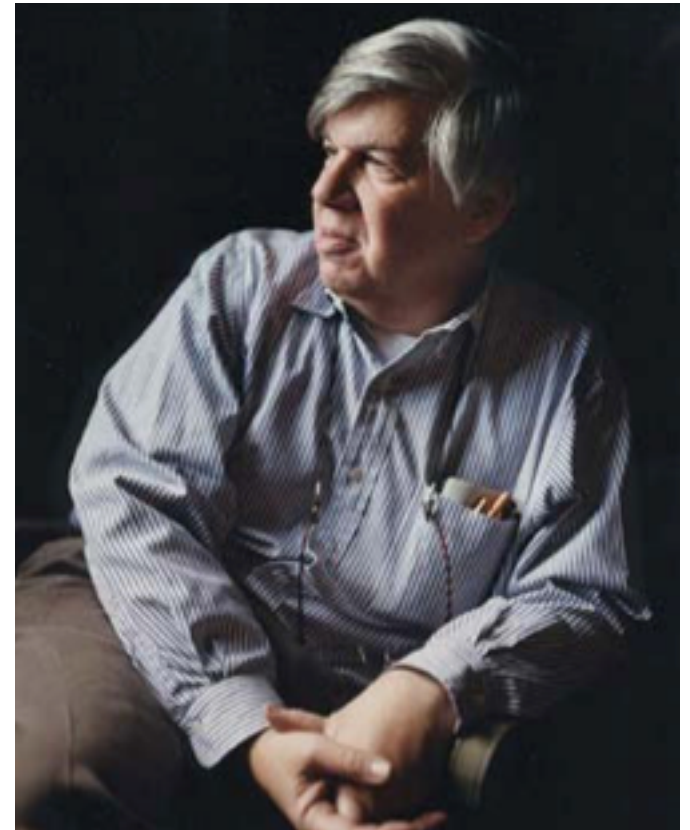
Is intelligent life an  
inevitable  
outcome of any given  
evolutionary  
process?

...Almost any planet with life, in my view, will produce living creatures we would recognize as parallel in form and function to our own biota.

...But first, life must arise, and we have no idea how rare an event that might be.



...If complex consciousness has evolved but once...how can anyone defend the inevitability of its convergent evolution?



# What is a 'Neotropical rainforest'?



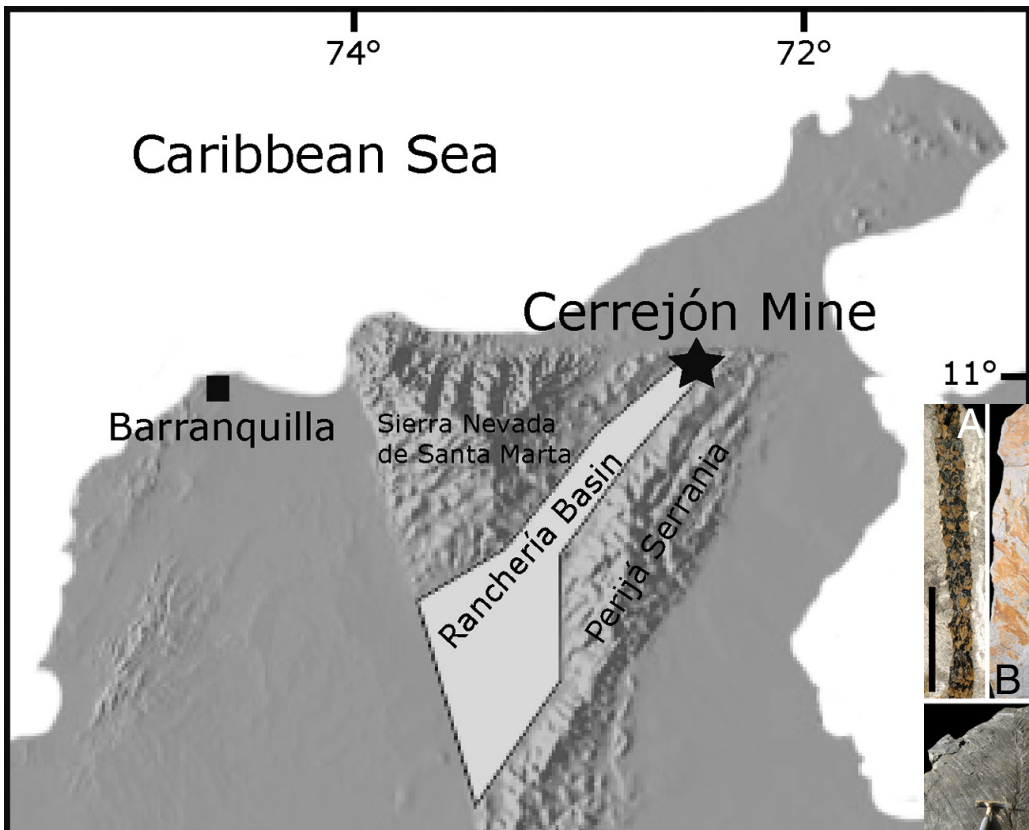
High MAP > 1.8 m/yr

High MAT > 18 °C

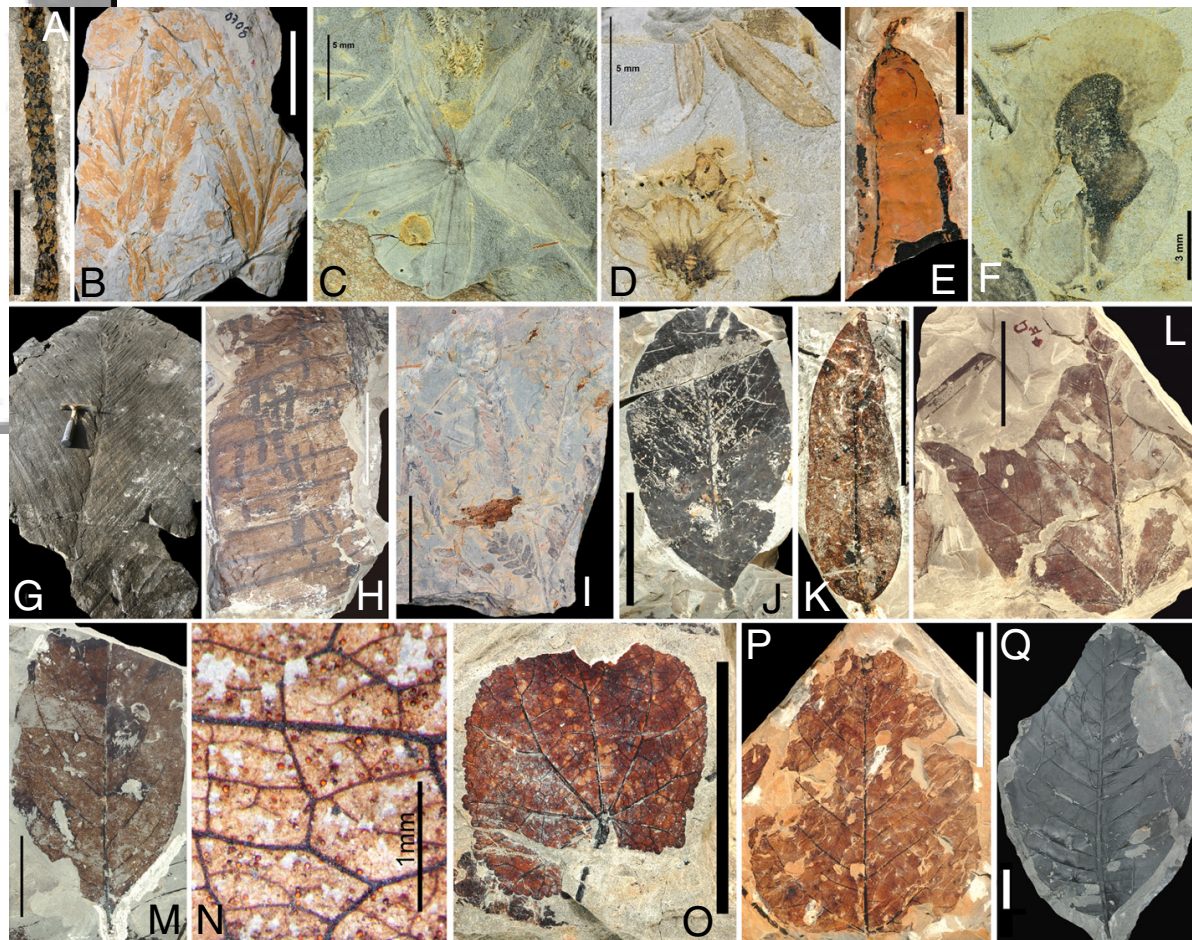
Small seasonal  
variation T < 7 °C

Angiosperms > 90%





58 Ma





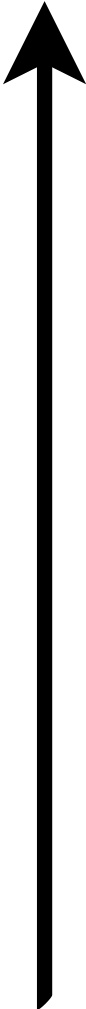


*Carbonemys cofrinii*



*Titanoboa cerrejonensis*

TIME

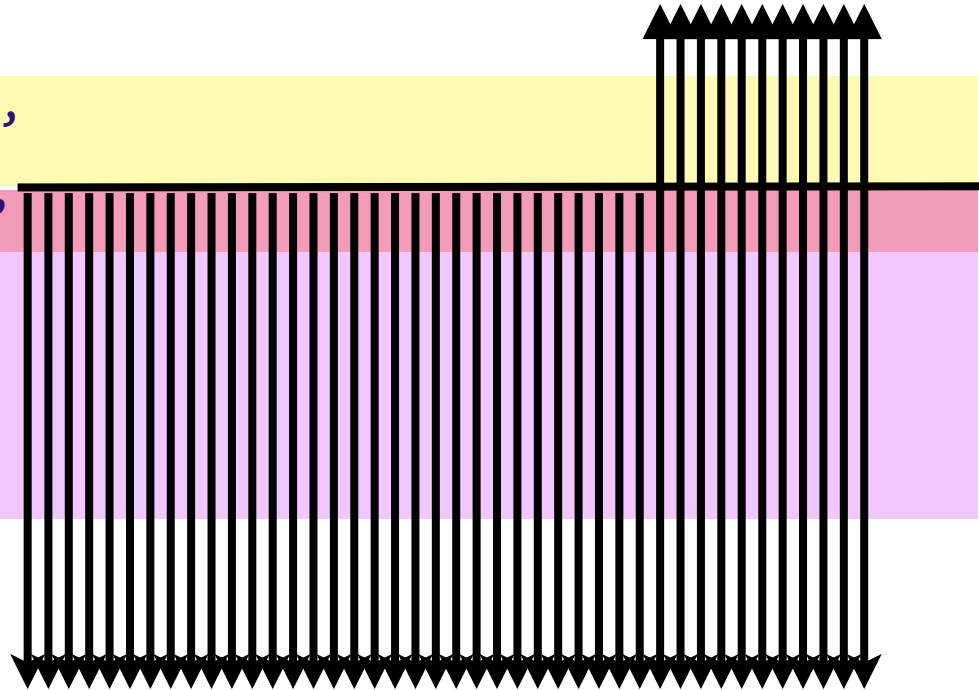


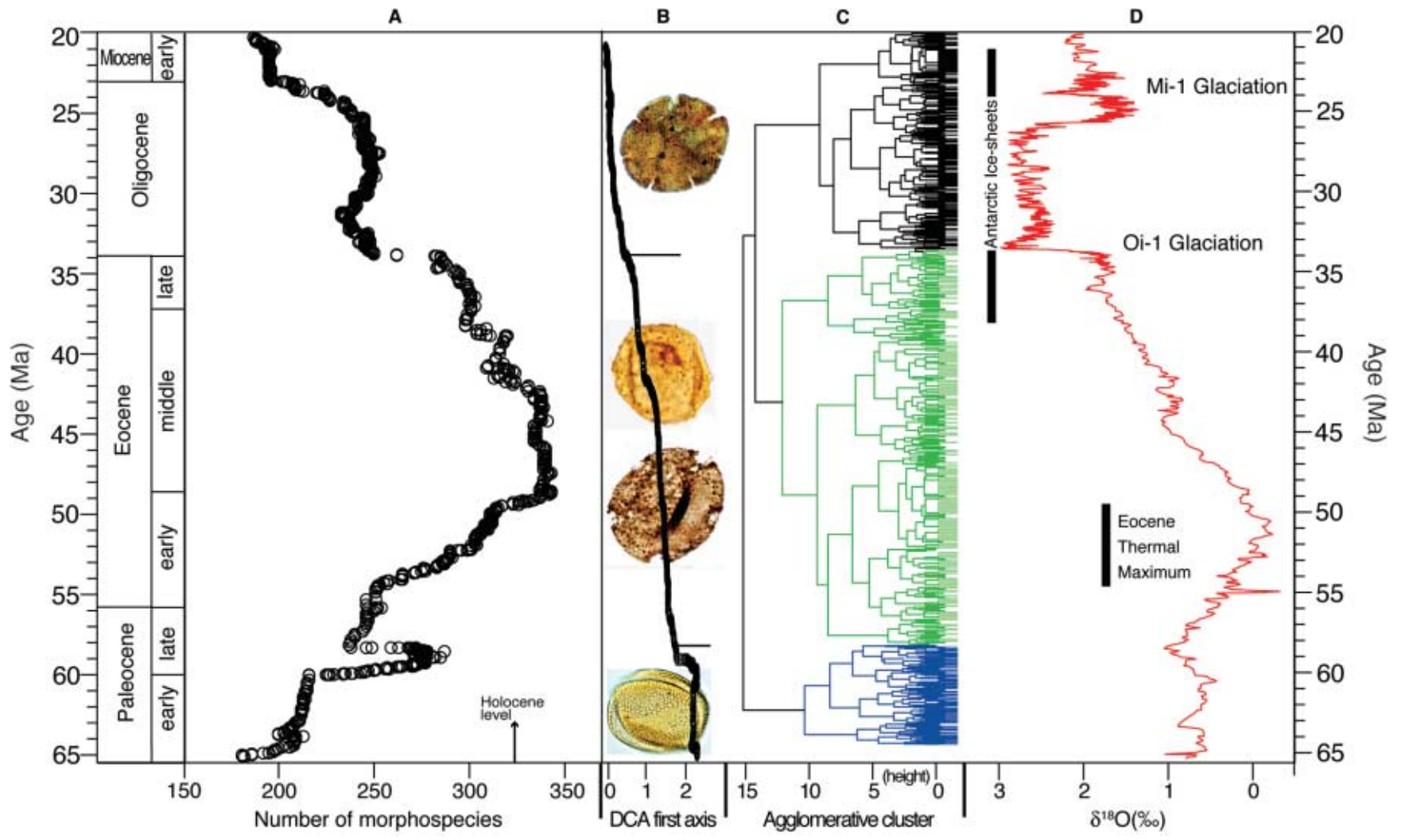


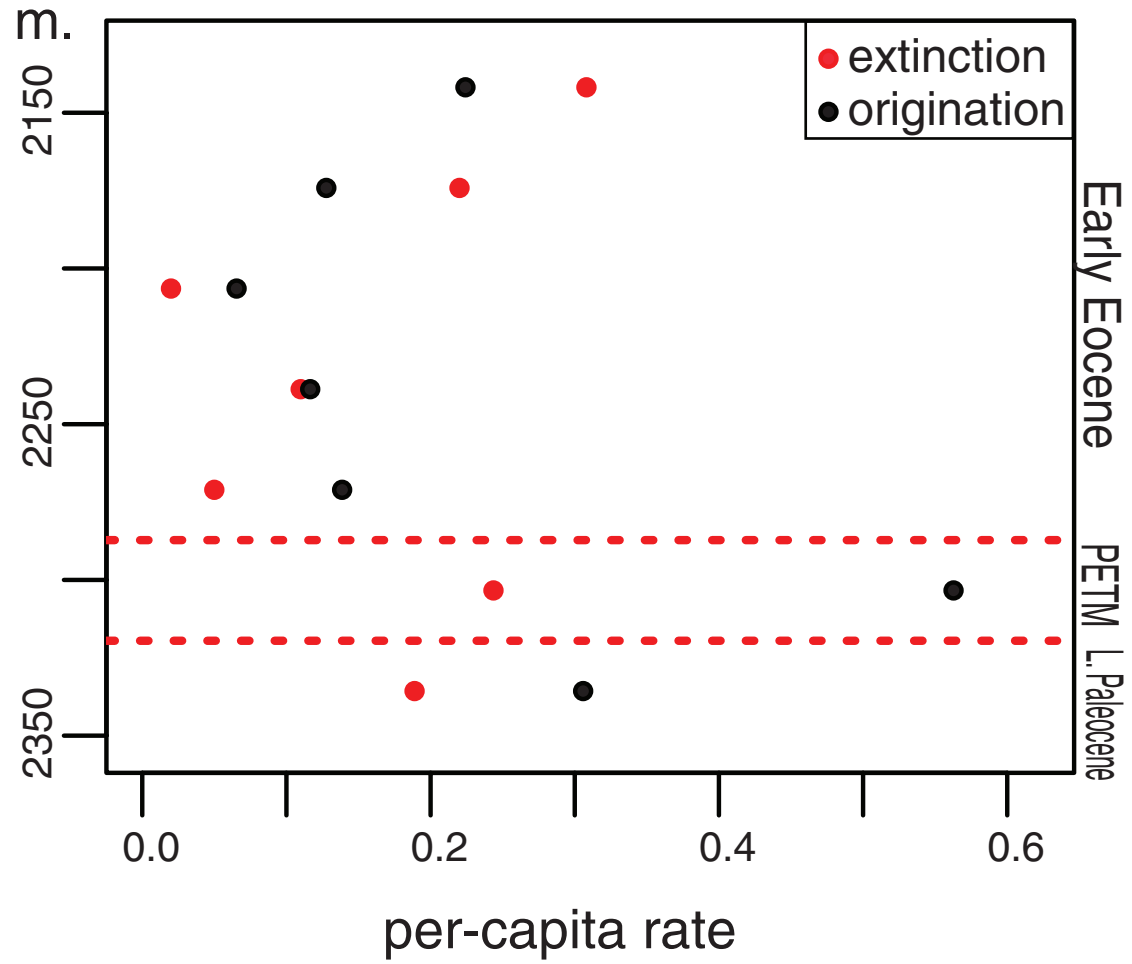
'Post-extinction interval'

'M. Extinction interval'

'Background'

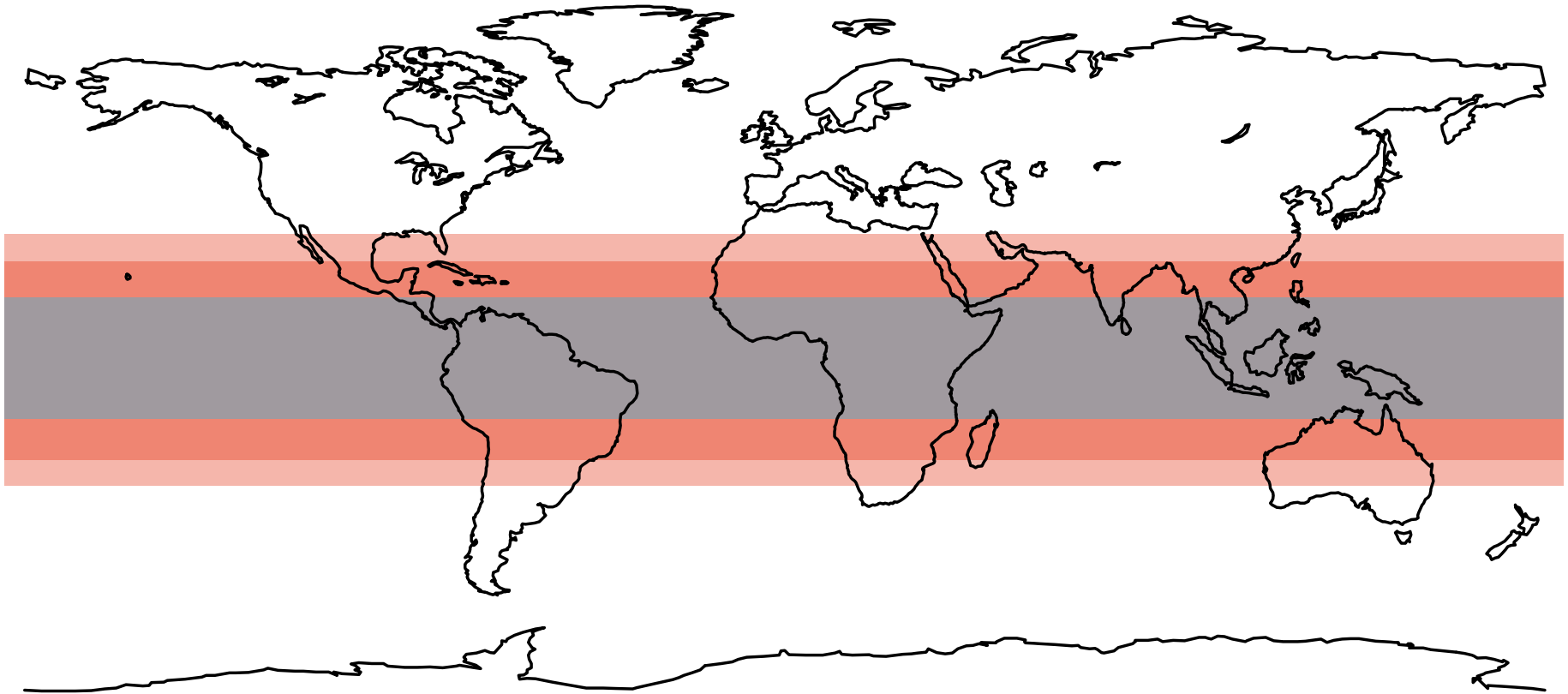




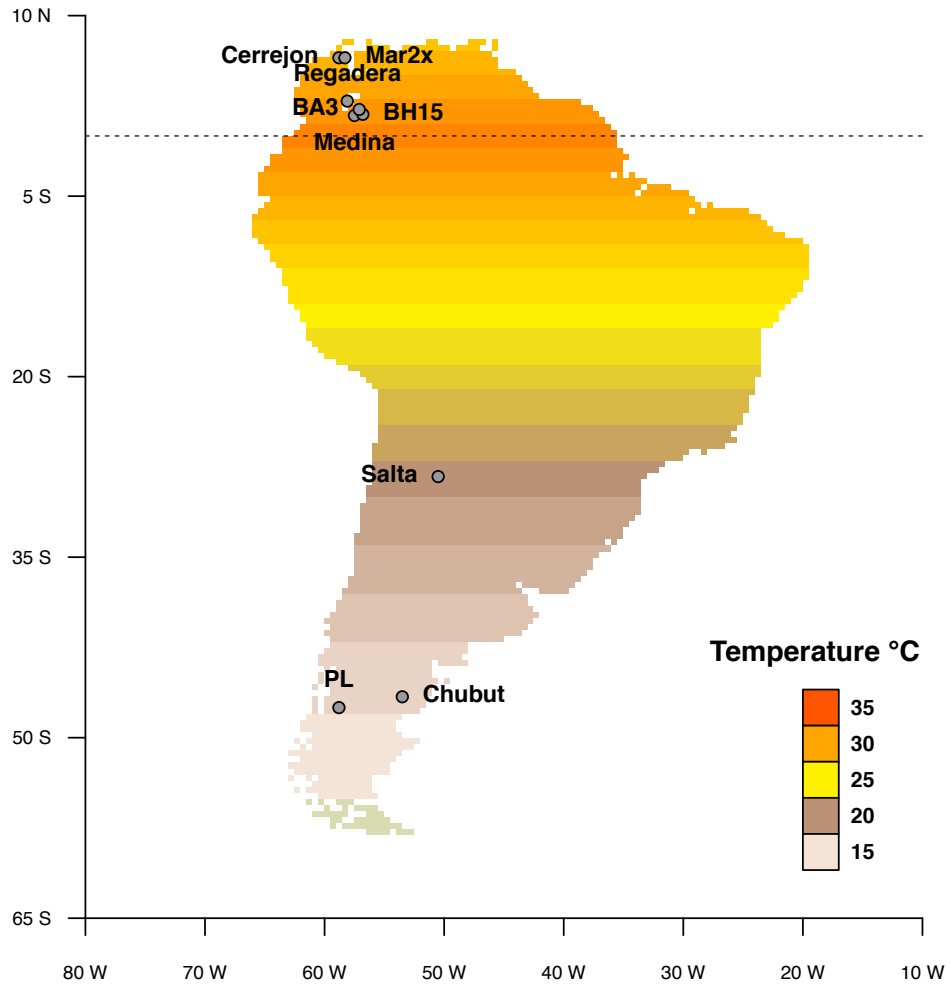


How temperature has influenced  
the long-term evolutionary  
process on the Neotropical  
rainforest?

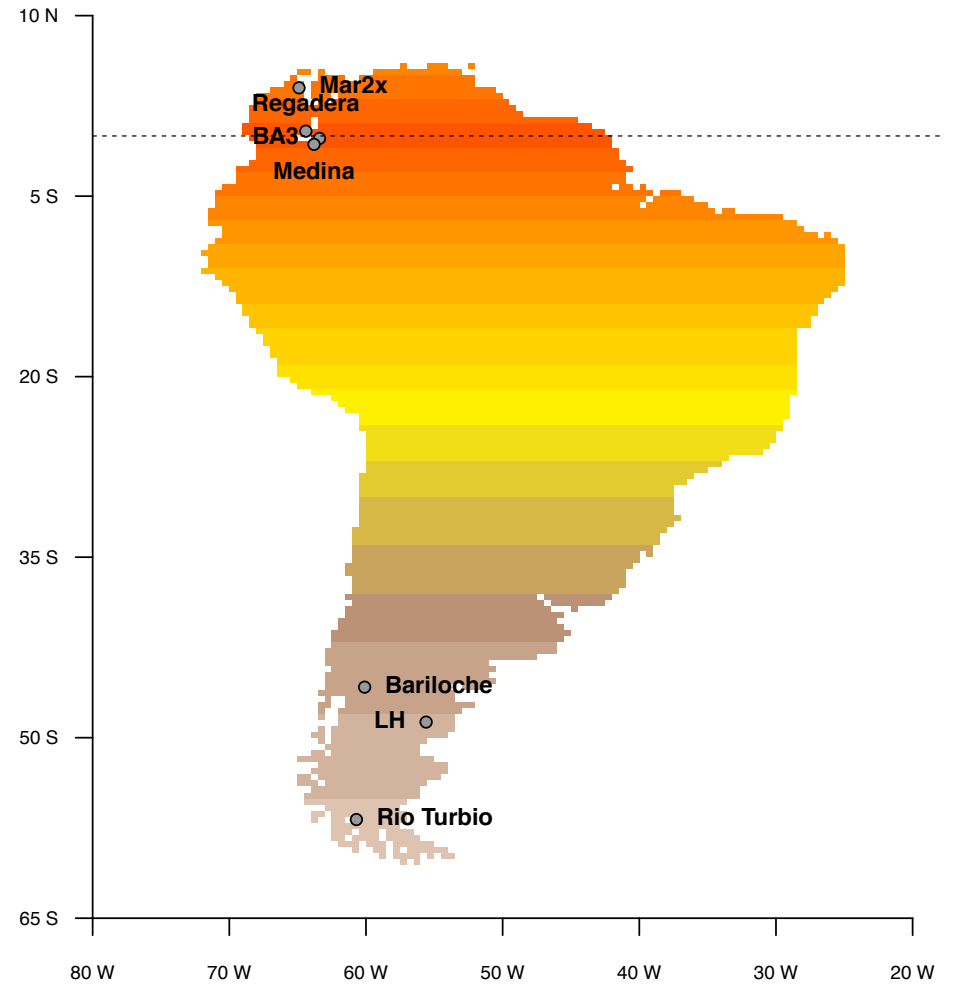
# Species-area effect



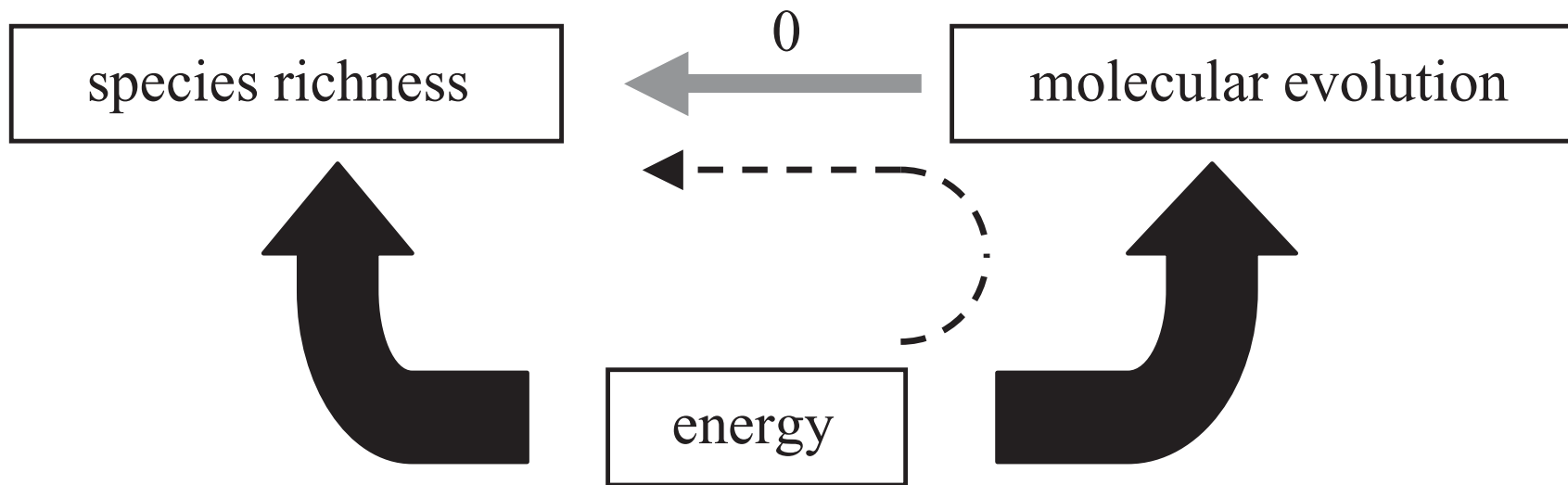
# Paleocene



# Eocene



# Energy-supply hypothesis

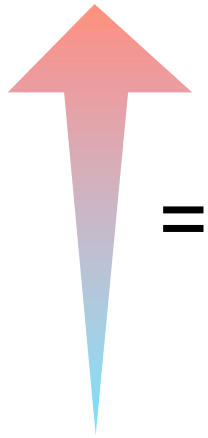


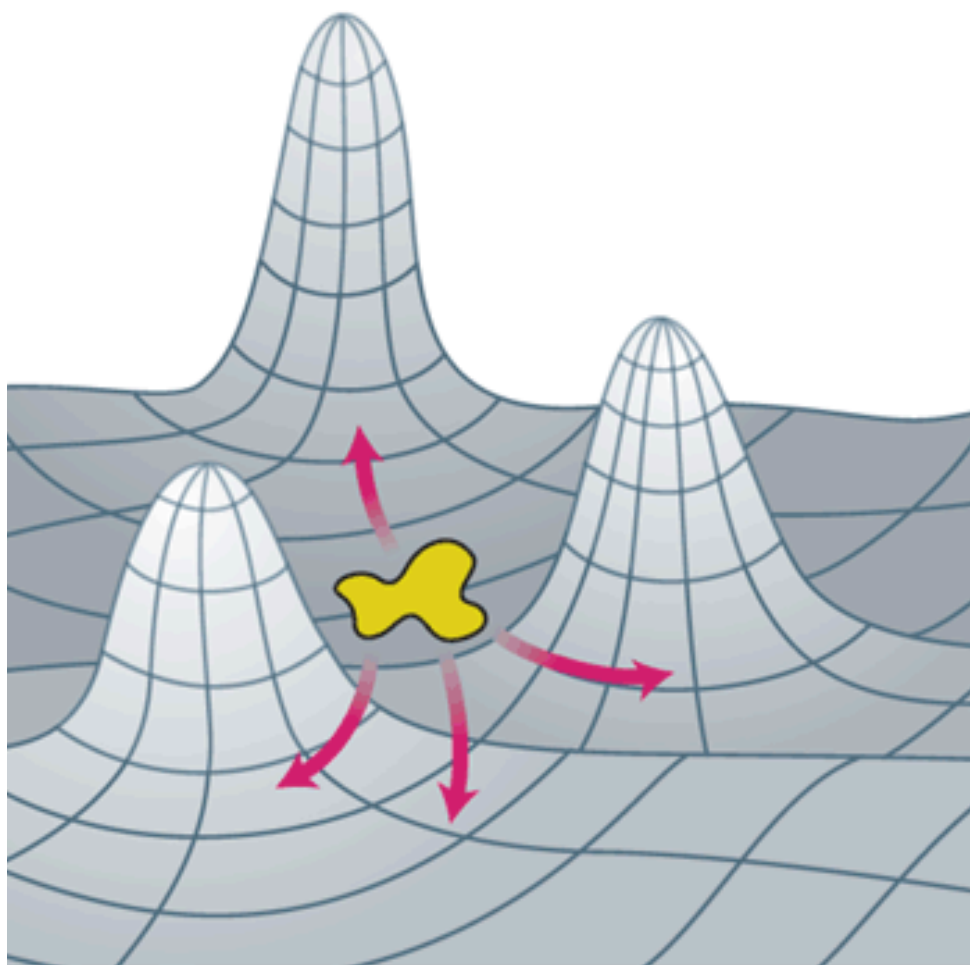
Species-area effect X

Energy-supply hypothesis X



# Biotic interactions hypothesis







+

$\delta T$

+

BI  
strength

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inevitable  
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