

mutualistic networks



THE  
VARIOUS CONTRIVANCES  
BY WHICH  
ORCHIDS ARE FERTILISED BY INSECTS.

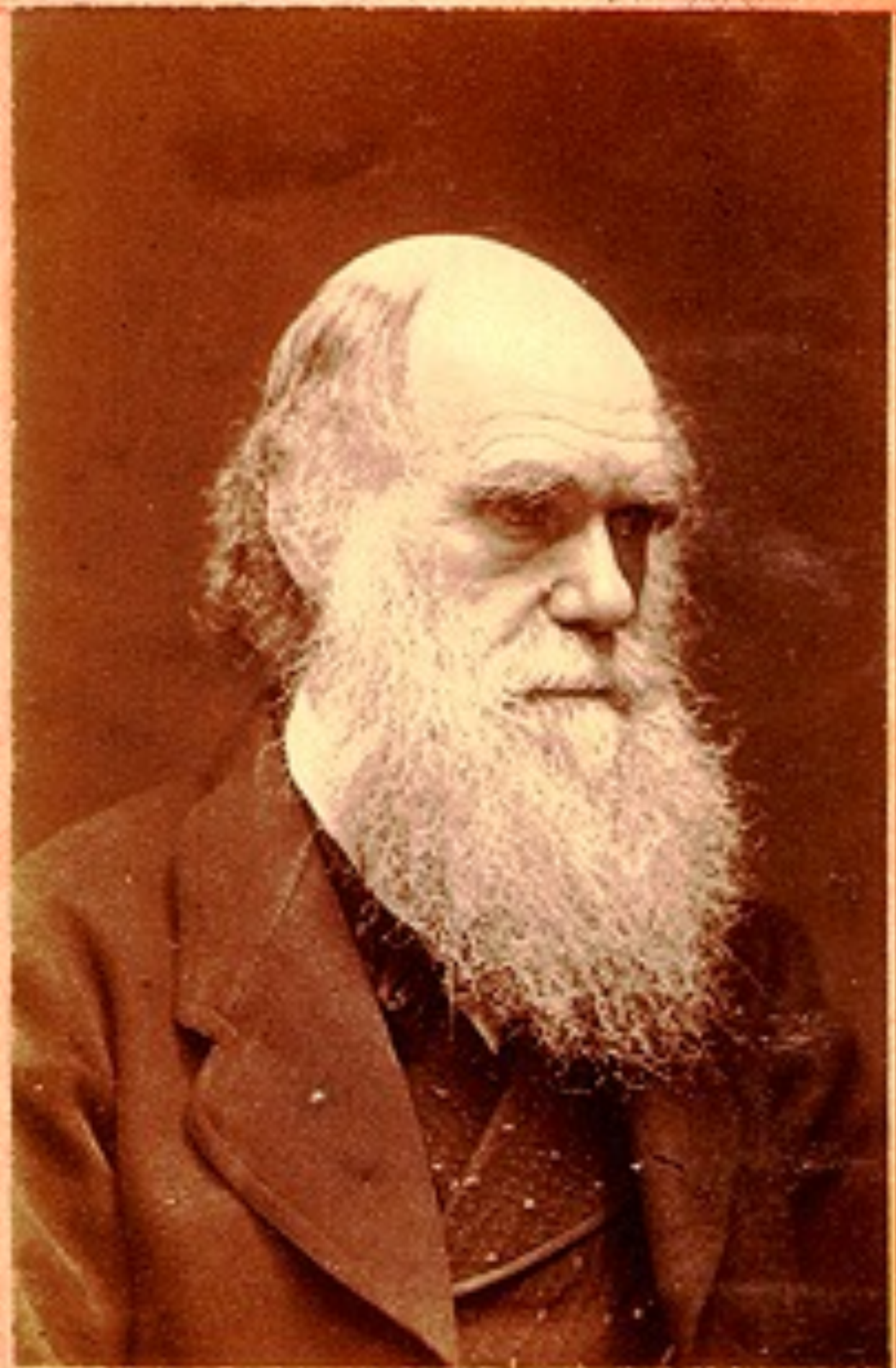
By CHARLES DARWIN, M.A., F.R.S., &c.

SECOND EDITION, REVISED.

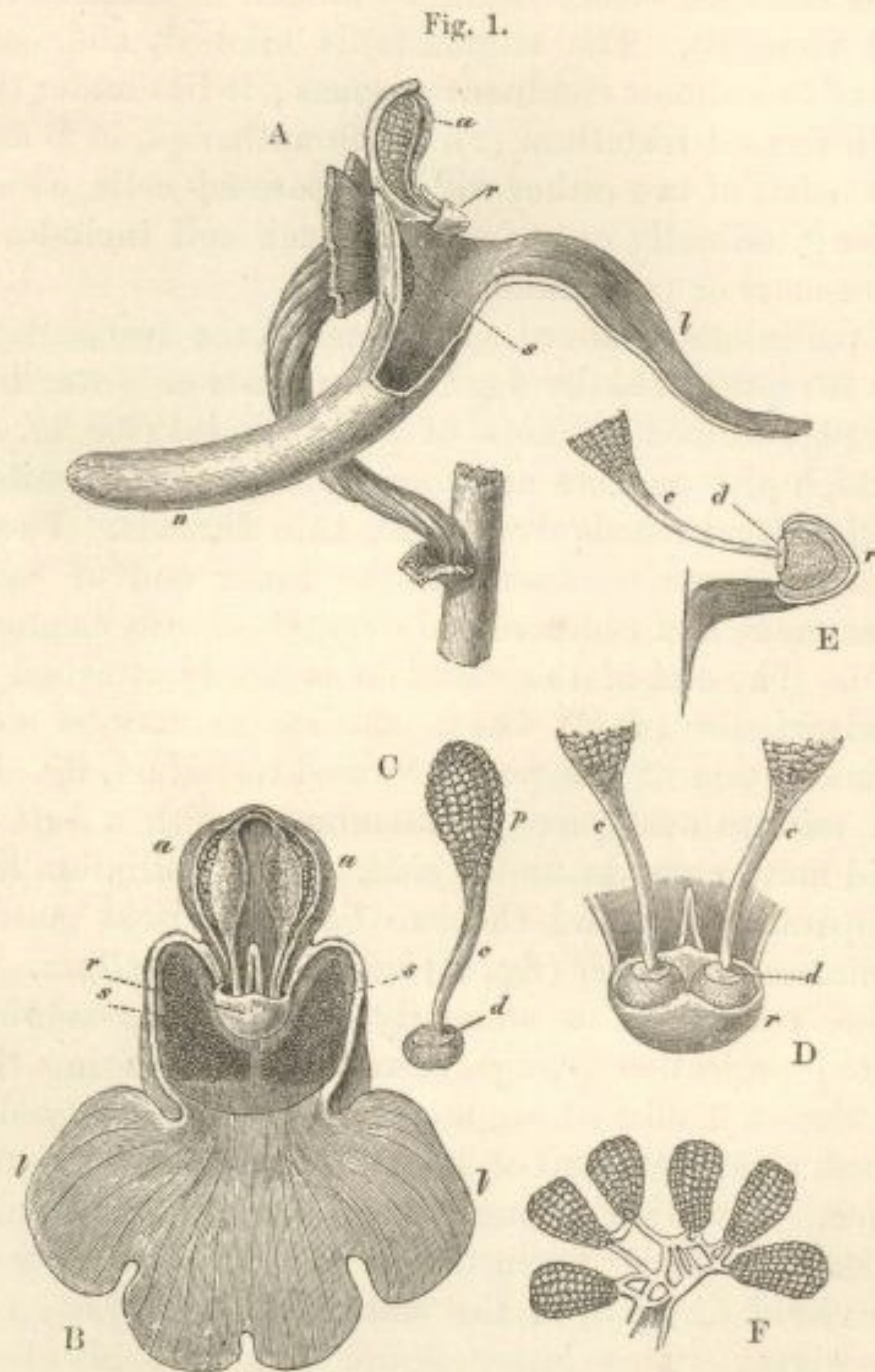
WITH ILLUSTRATIONS.

LONDON:  
JOHN MURRAY, ALBEMARLE STREET.  
1877.

[The right of Translation is reserved.]

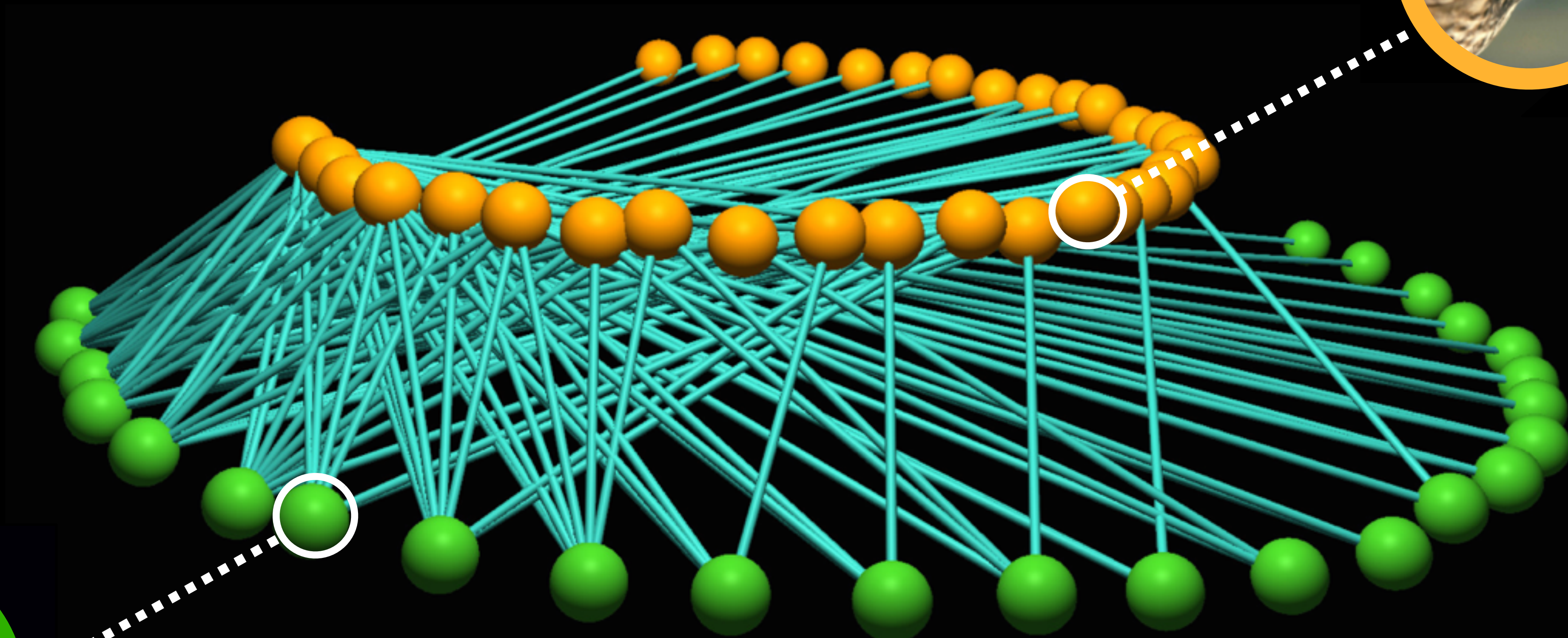


Chas Darwin  
Mend. 7<sup>th</sup> 1874.





# Mutualistic networks

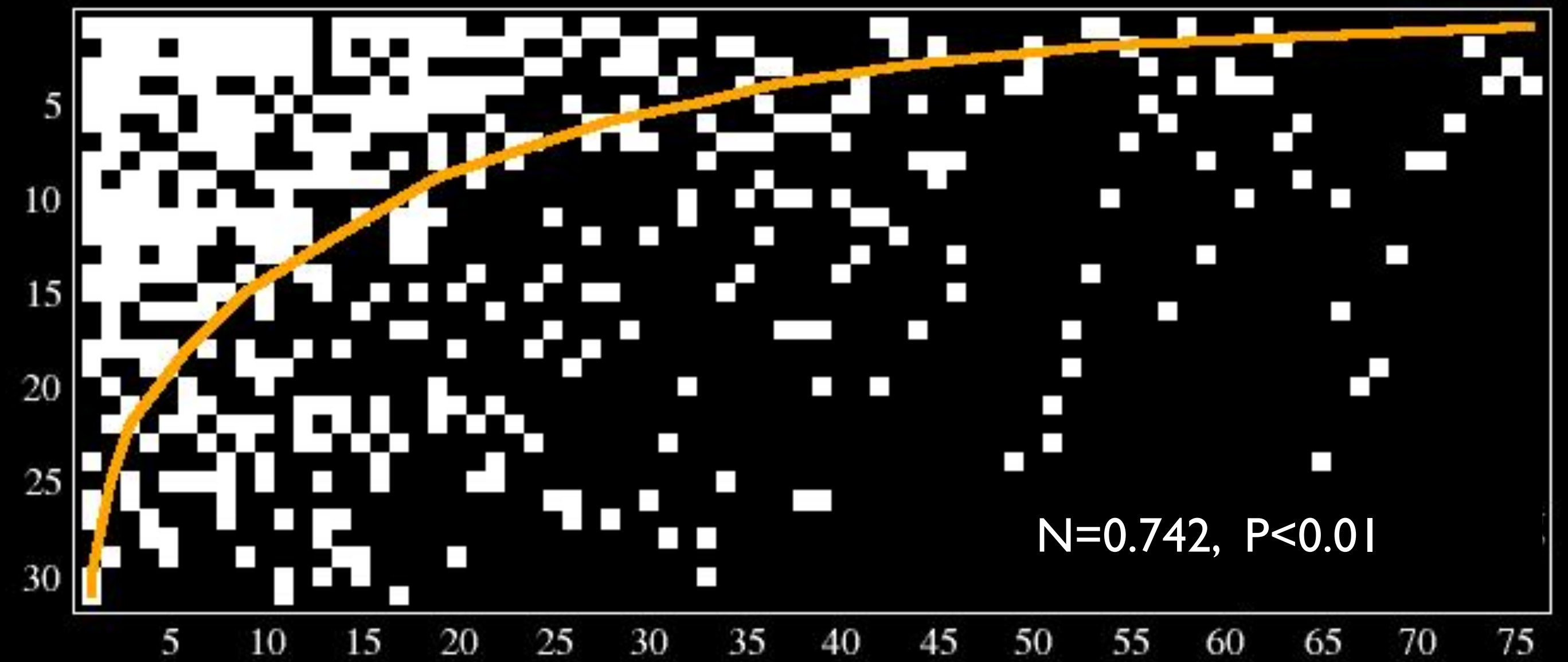
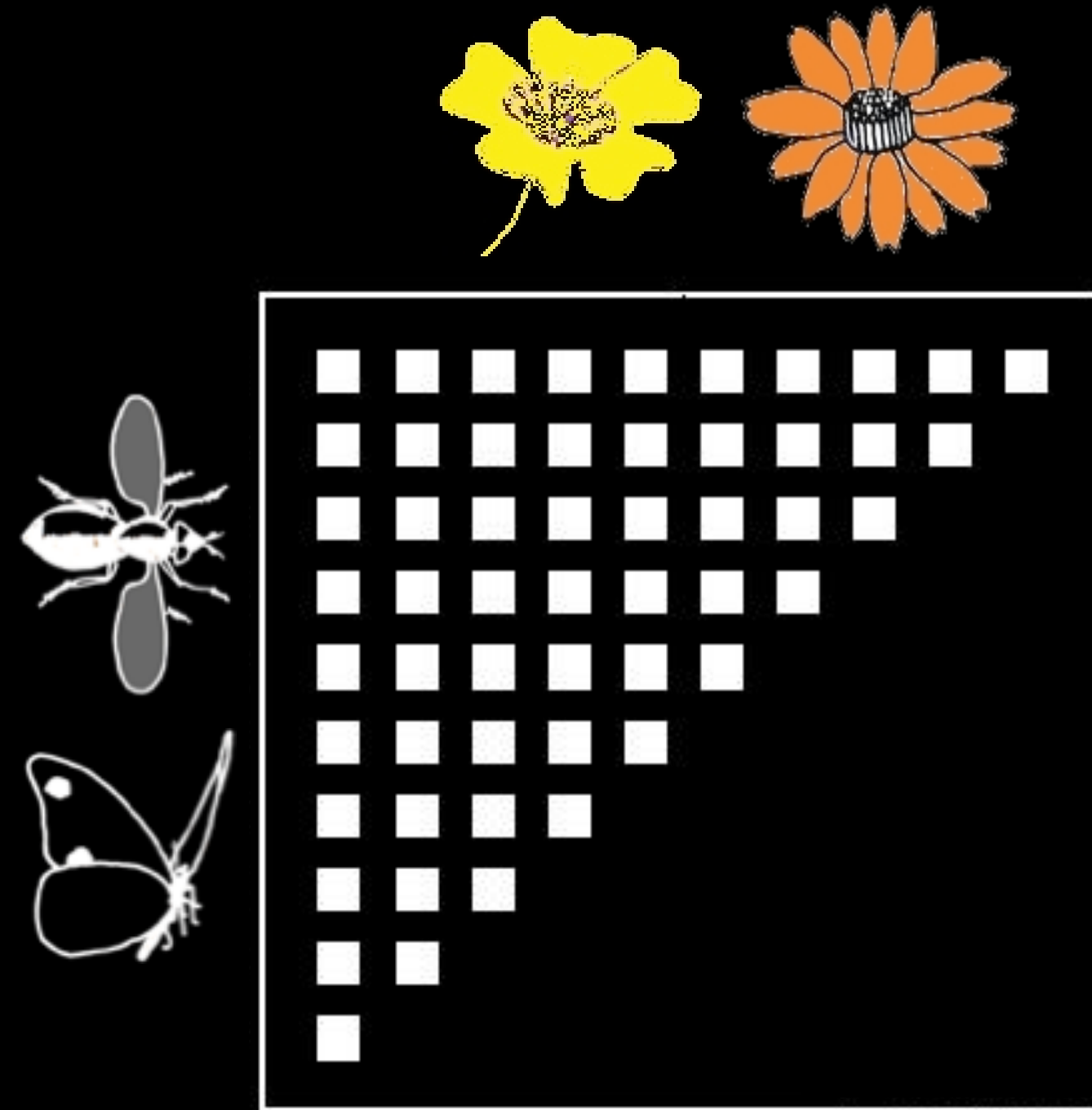




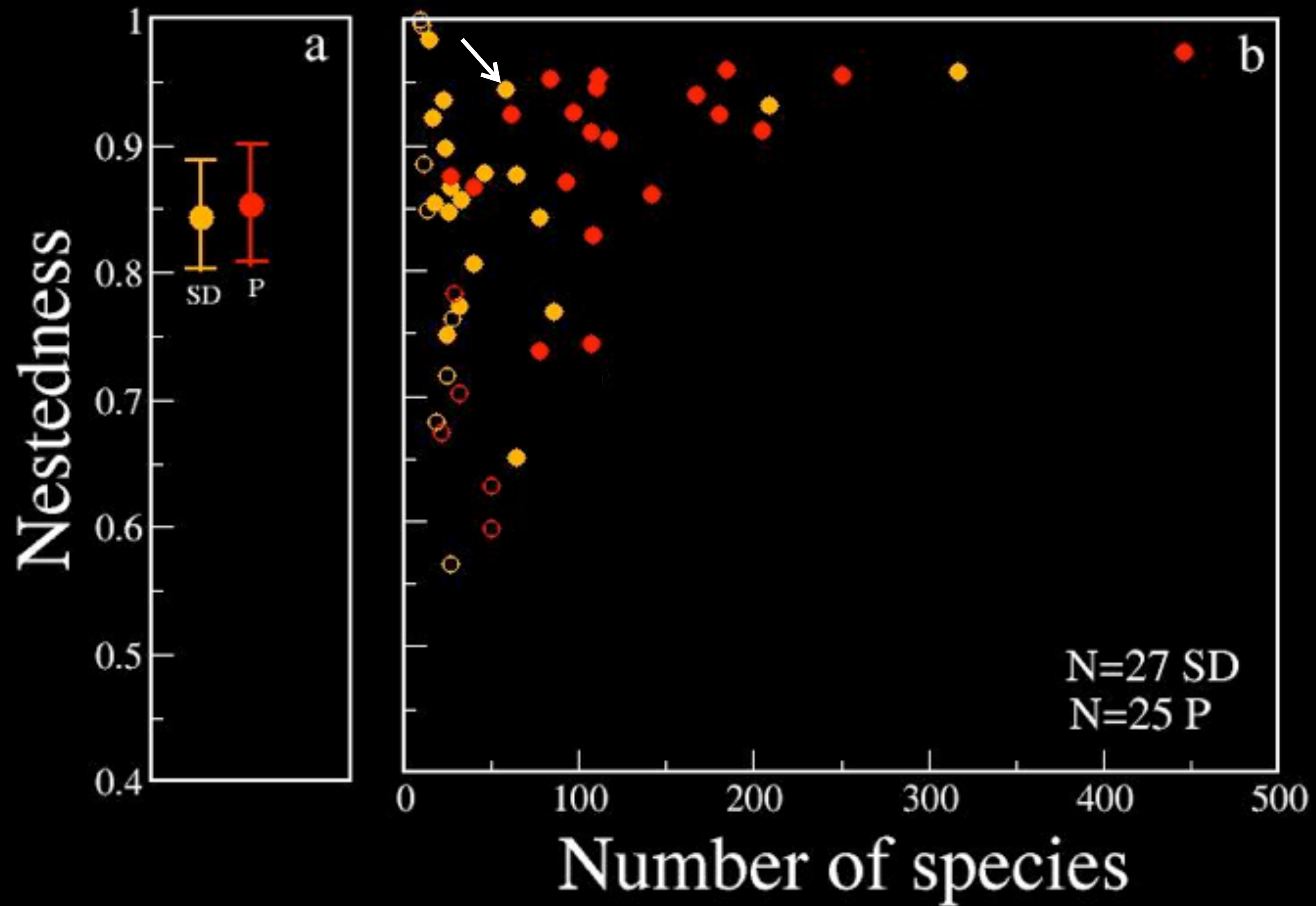
# Outline

- (i) Describe network **architecture**
- (ii) Infer the **ecological, environmental,**  
and **evolutionary** consequences

# Network structure







# Number of species

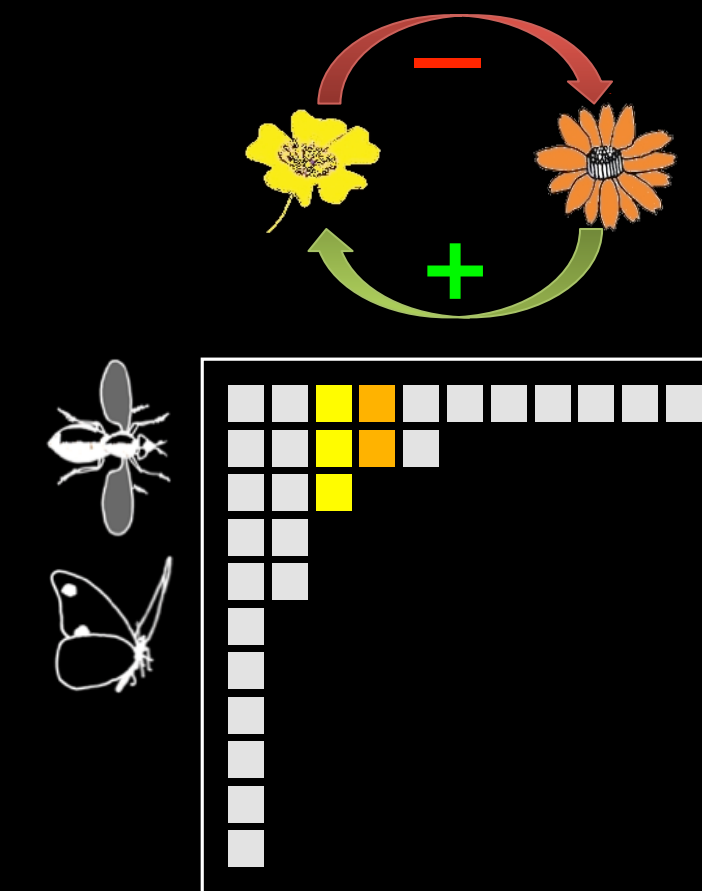
$$\frac{dN_i^{(P)}}{dt} = \underbrace{\alpha_i^{(P)} N_i^{(P)}}_{\text{Intrinsic growth rate}} - \underbrace{\sum_{j \in P} \beta_{ij}^{(P)} N_i^{(P)} N_j^{(P)}}_{\text{Direct competition}} + \underbrace{\sum_{k \in A} \frac{\gamma_{ik}^{(P)} N_i^{(P)} N_k^{(A)}}{1 + h^{(P)} \gamma_{ik}^{(P)} N_k^{(A)}}}_{\text{Mutualistic interaction}}$$

# Number of species

$$c_{ij}^{(P)} = \delta_{ij} + \frac{1}{\bar{S}^{(P)}} + R \left( \frac{1}{S^{(A)} + \bar{S}^{(A)}} \underbrace{n_i^{(P)} n_j^{(P)} - n_{ij}^{(P)}} \right)$$

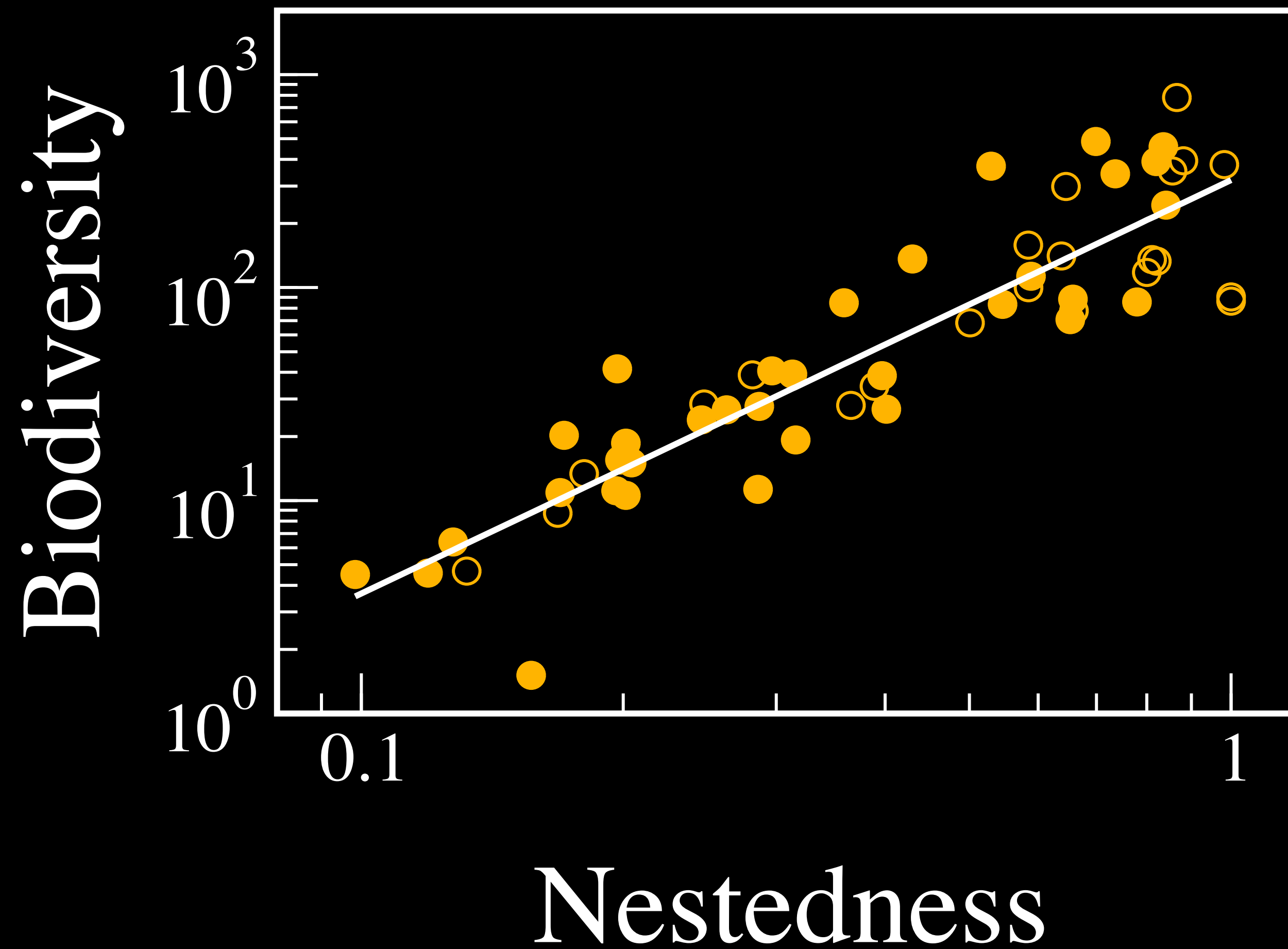
$$\rho^{(P)} = f(\lambda_1)$$

$$\bar{S}^{(P)} = \frac{1 - \rho^{(P)}}{\rho^{(P)}}$$

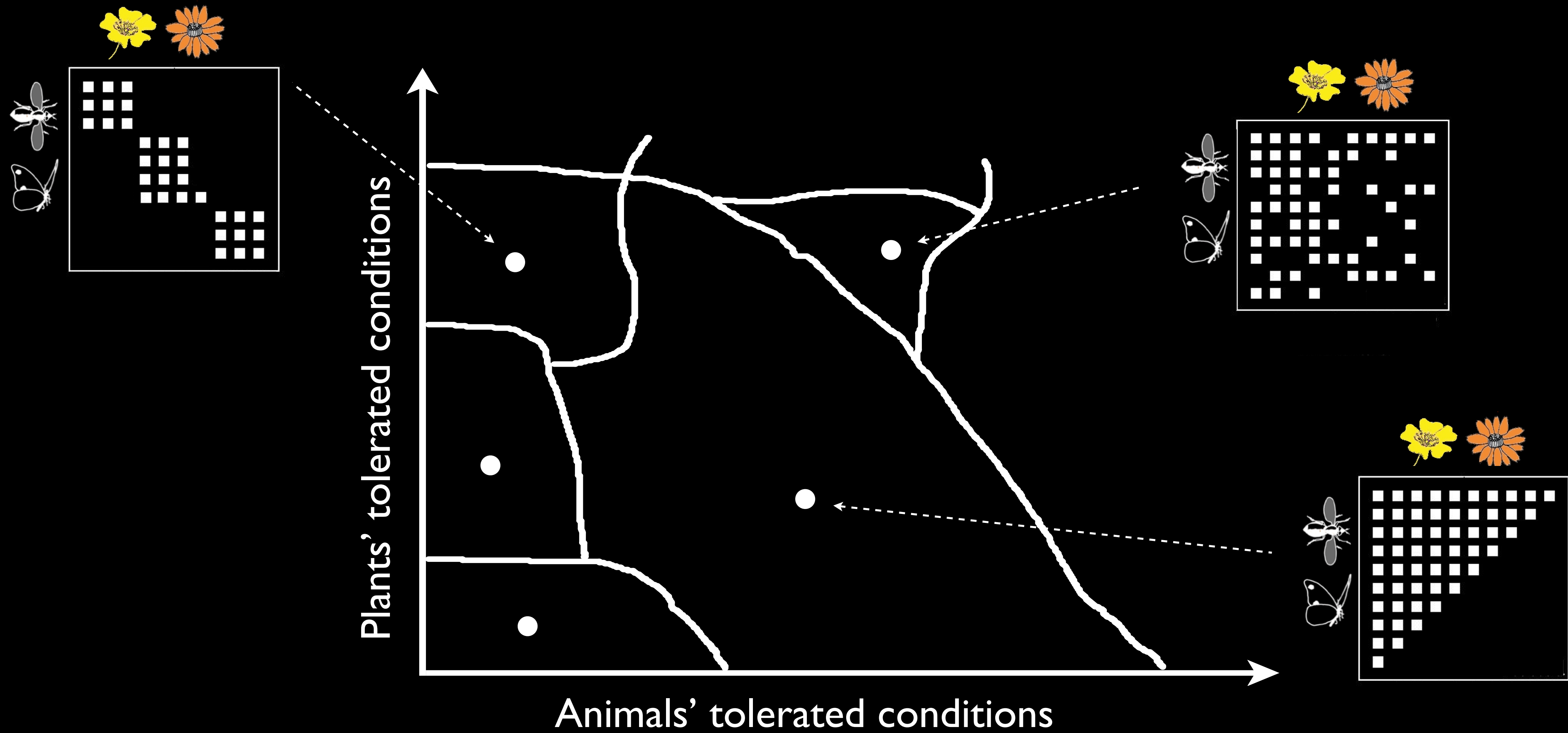


The **higher nestedness**, the lower the effective interspecific competition, and the **higher** the maximum **biodiversity**

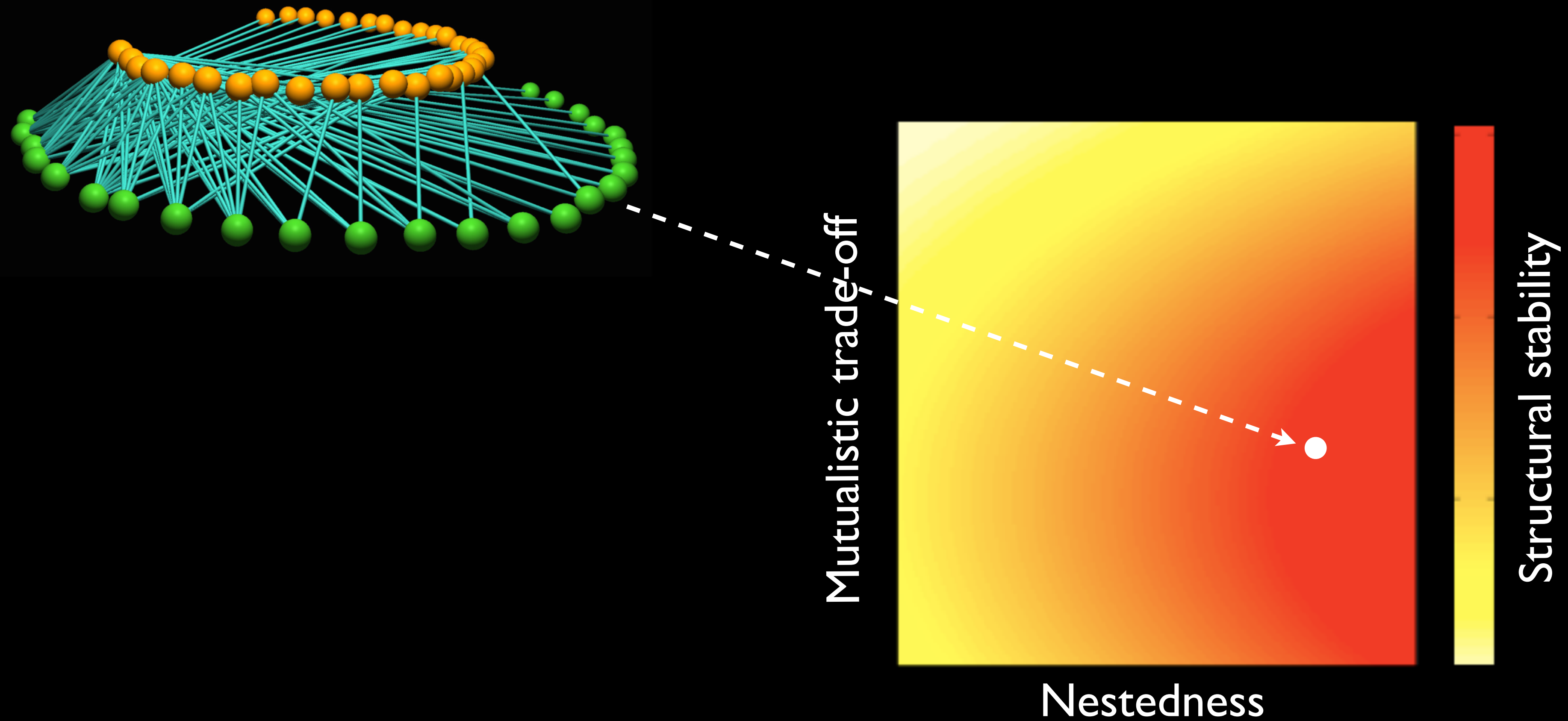
# Nestedness Increases Biodiversity



# Network robustness



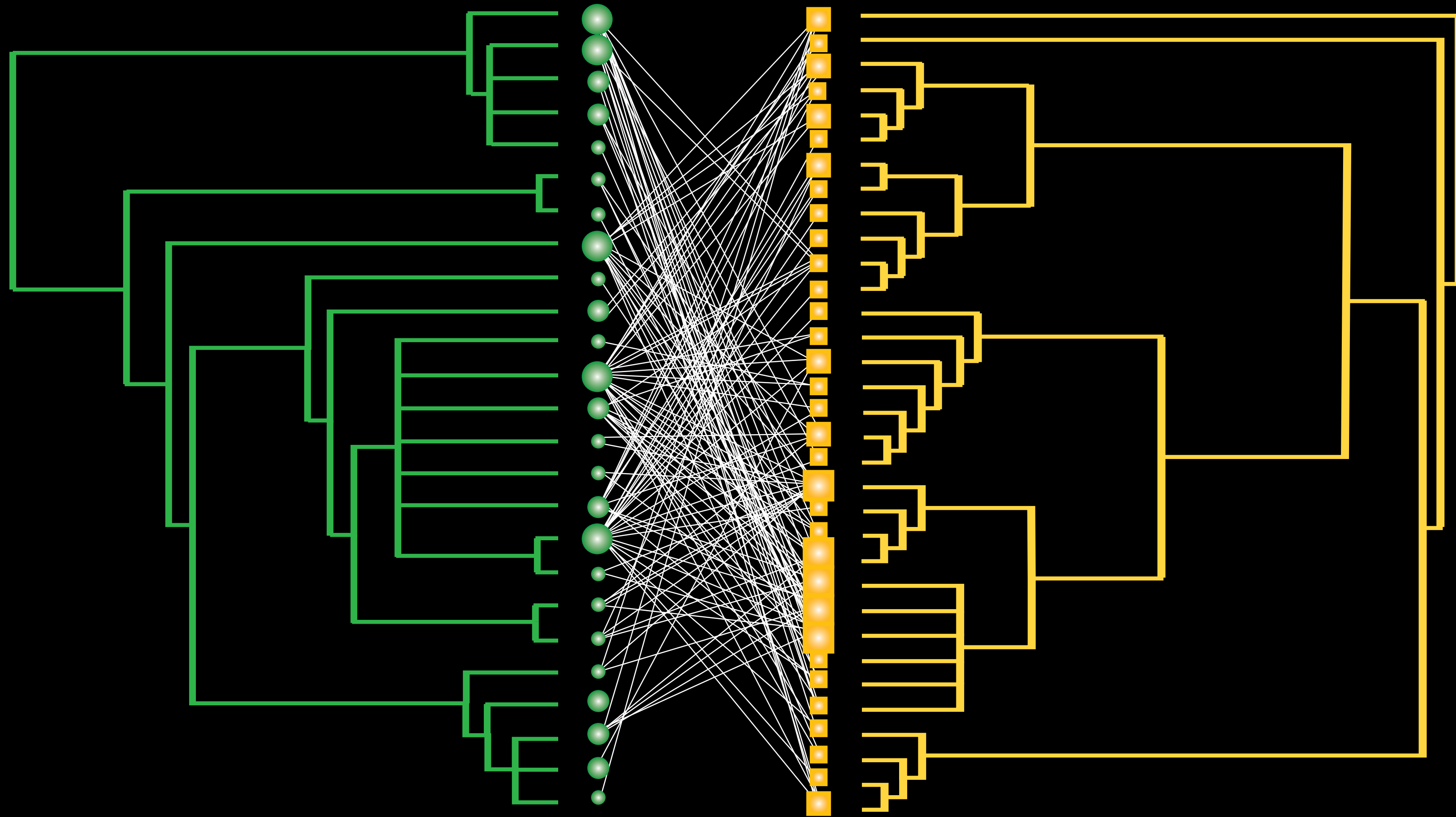
# Nestedness increases robustness





Credit art by Cheng (Lily) Li

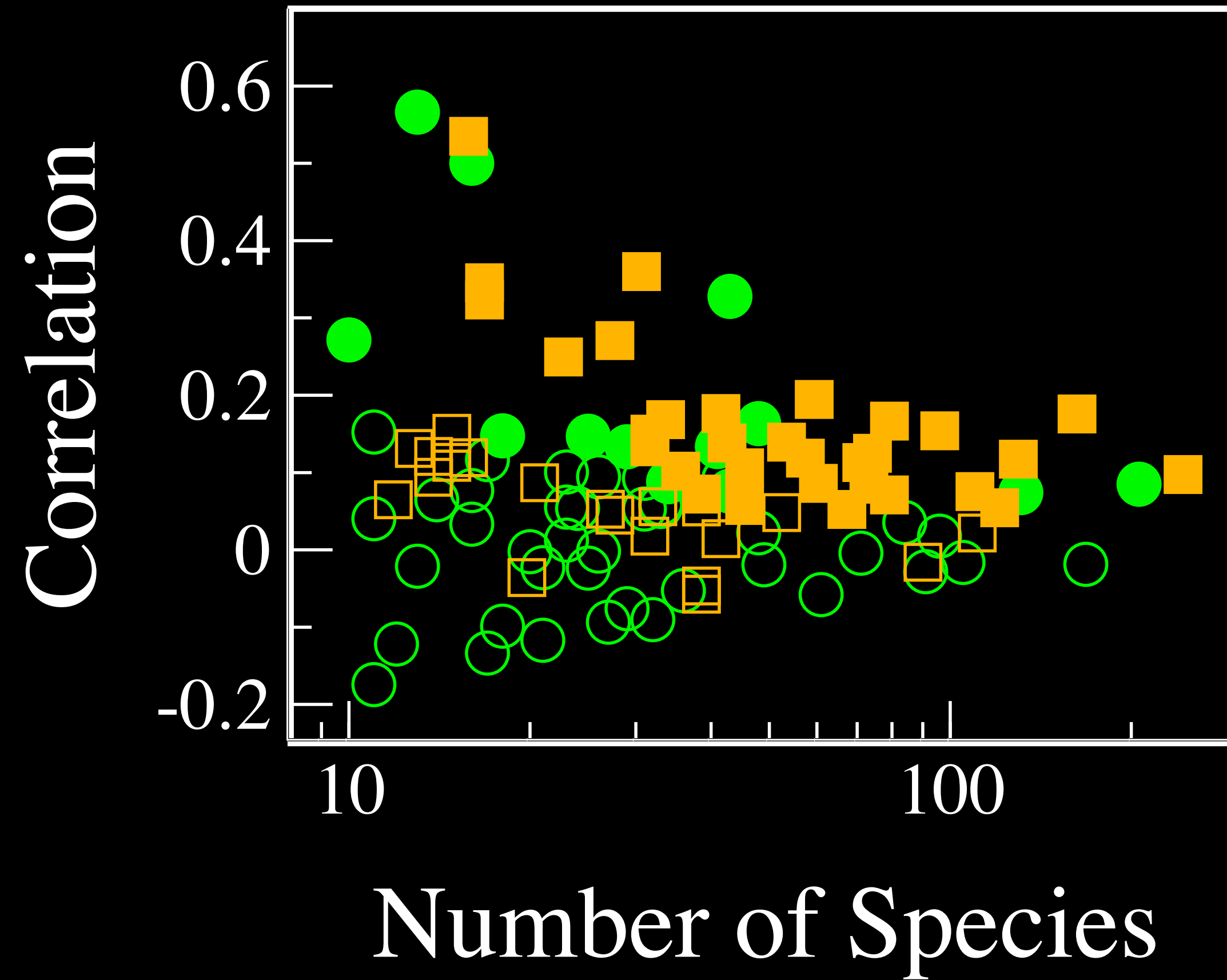
# Evolutionary history



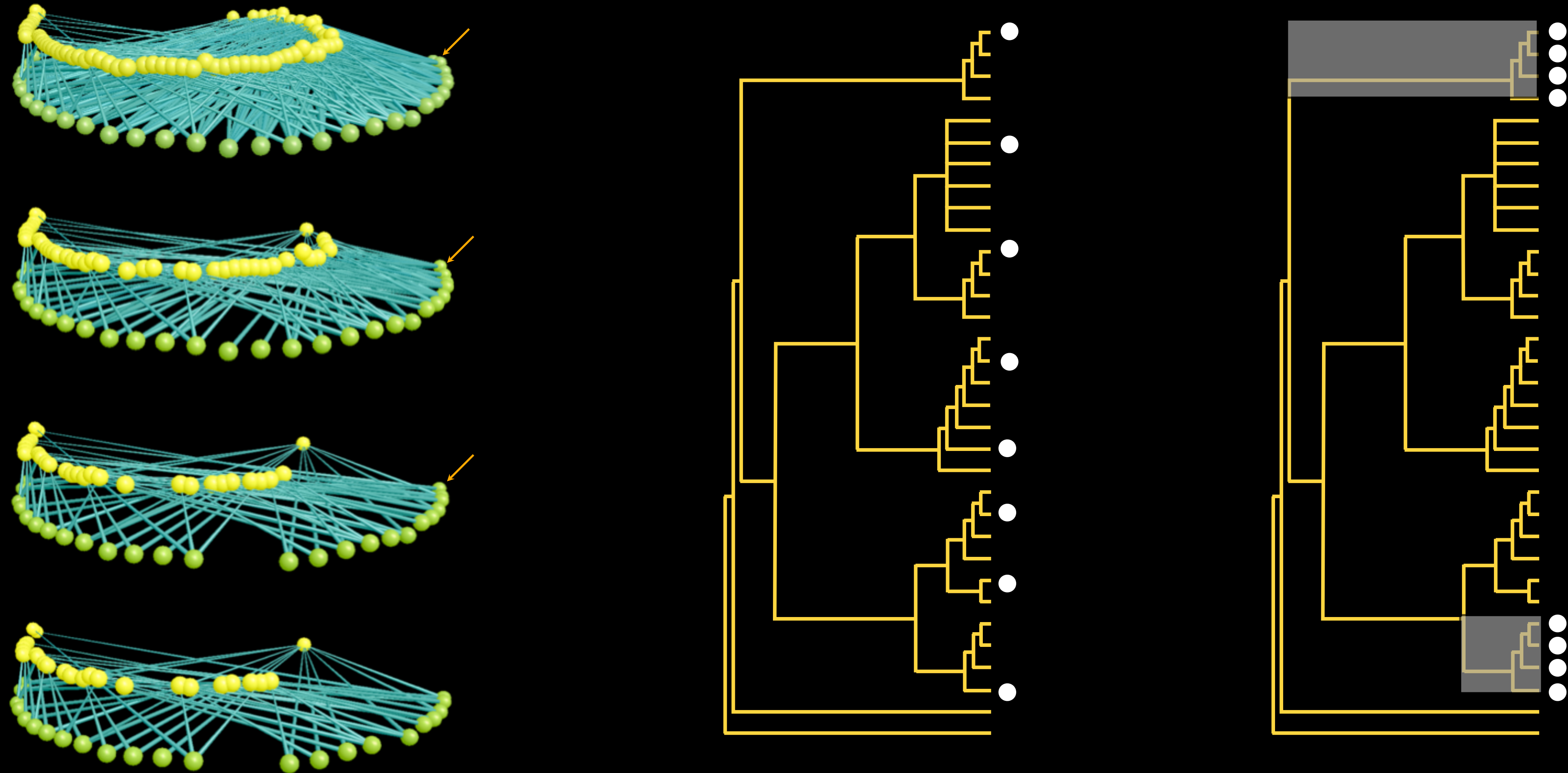
Rezende, Lavabre, Guimaraes, Jordano, and Bascompte (2007). *Nature* 448: 925-928.



# Phylogenetic signal

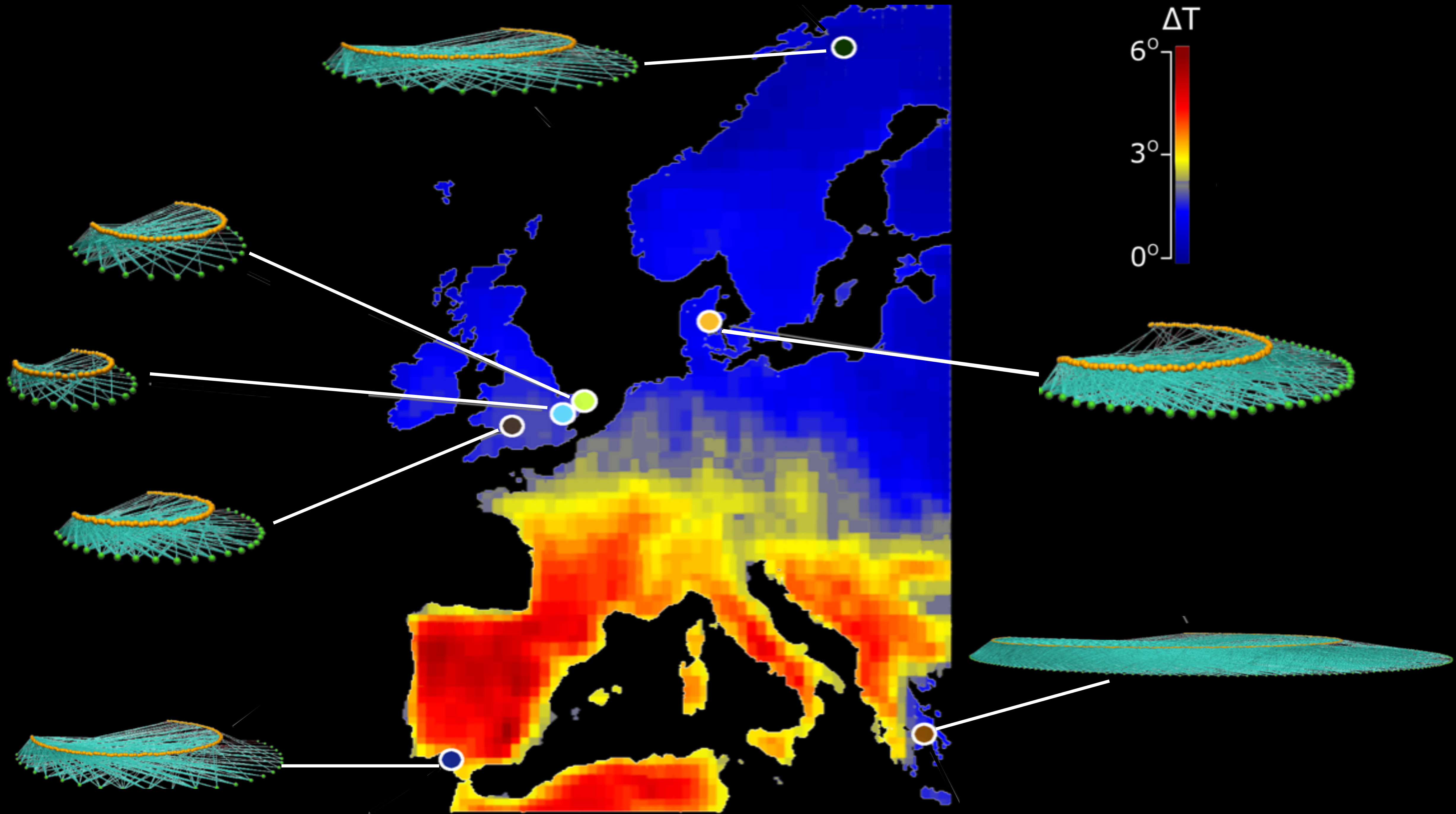


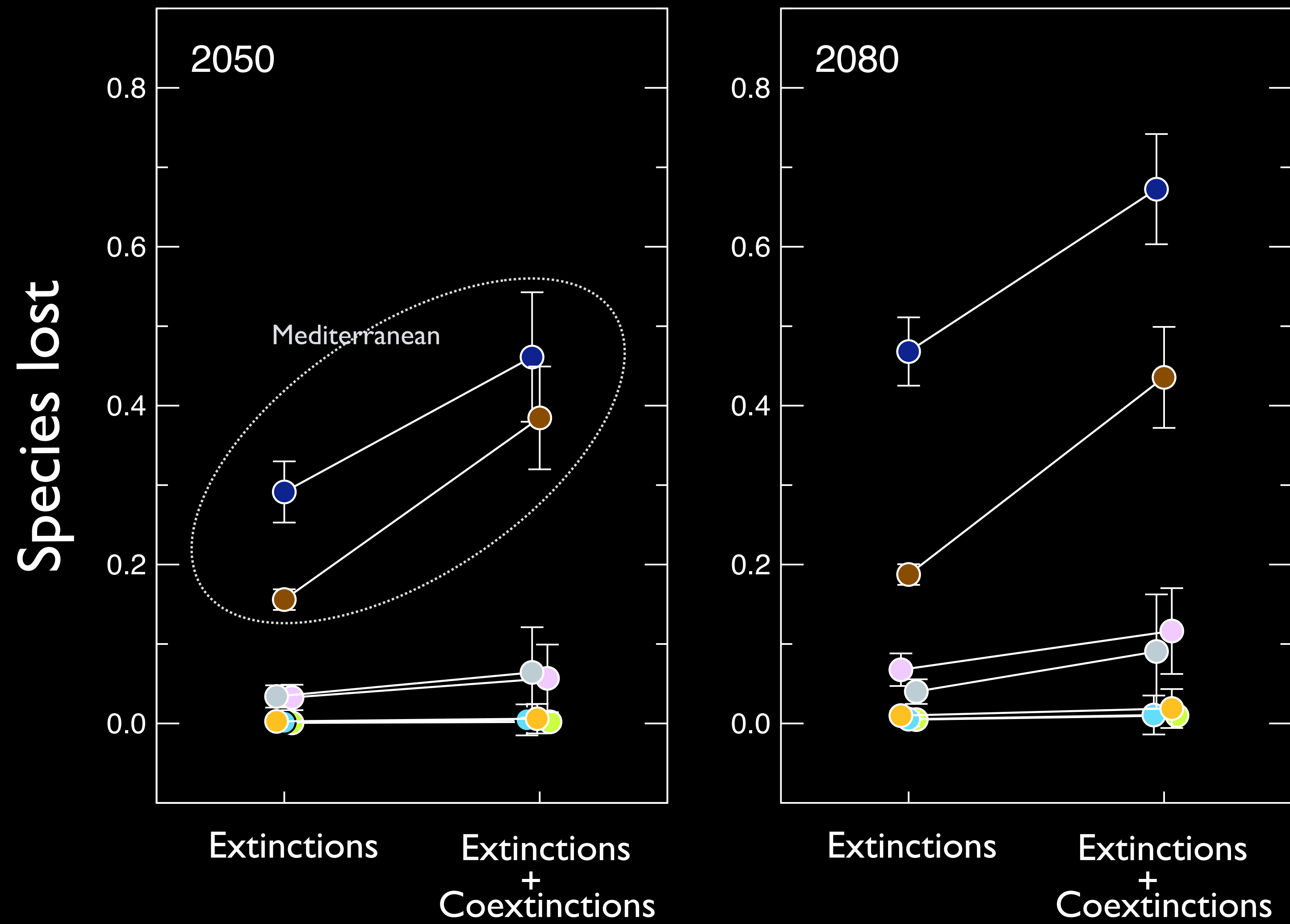
# Non-random coextinctions

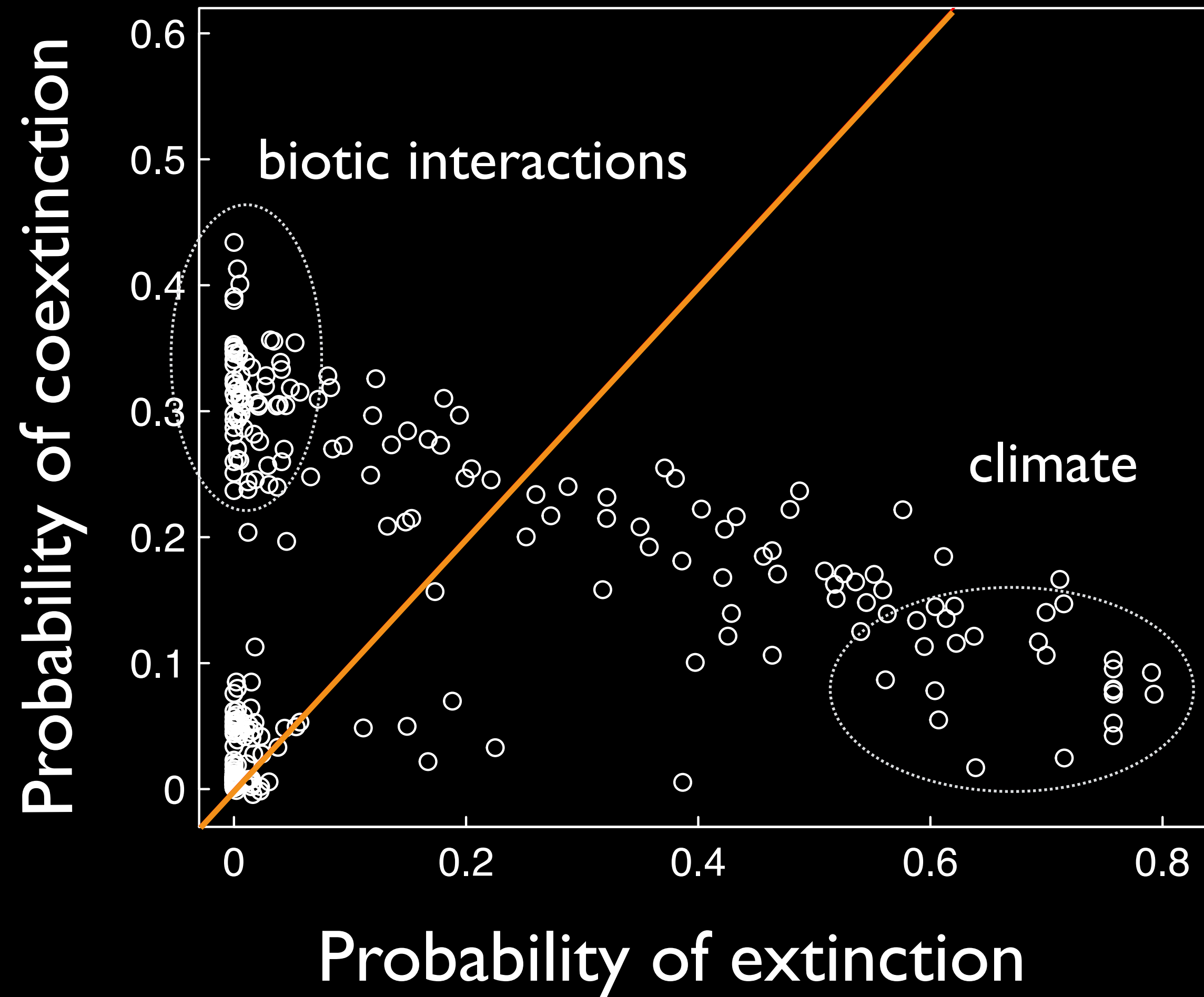


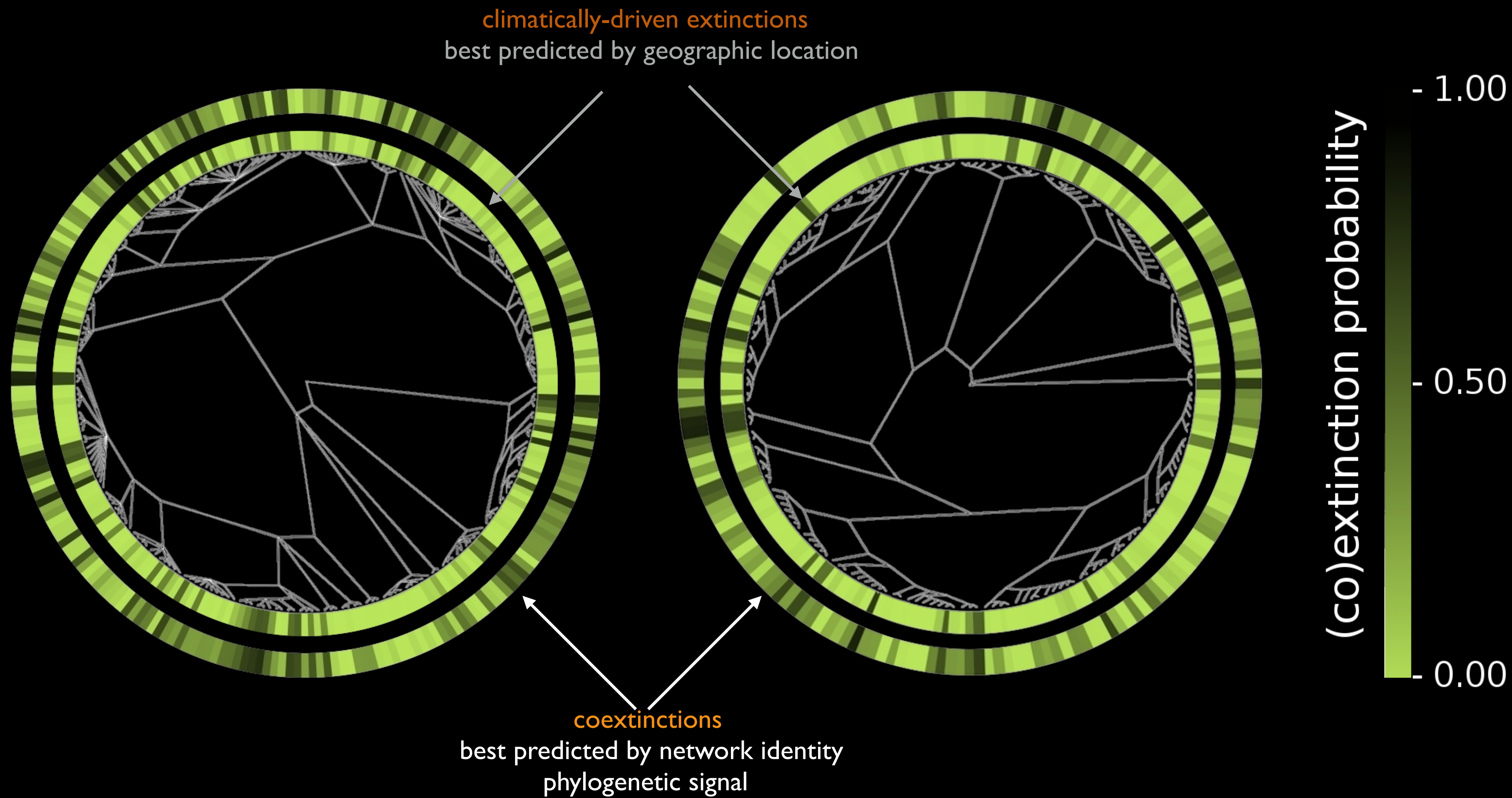
Rezende, Lavabre, Guimaraes, Jordano, and Bascompte (2007). *Nature* 448: 925-928.

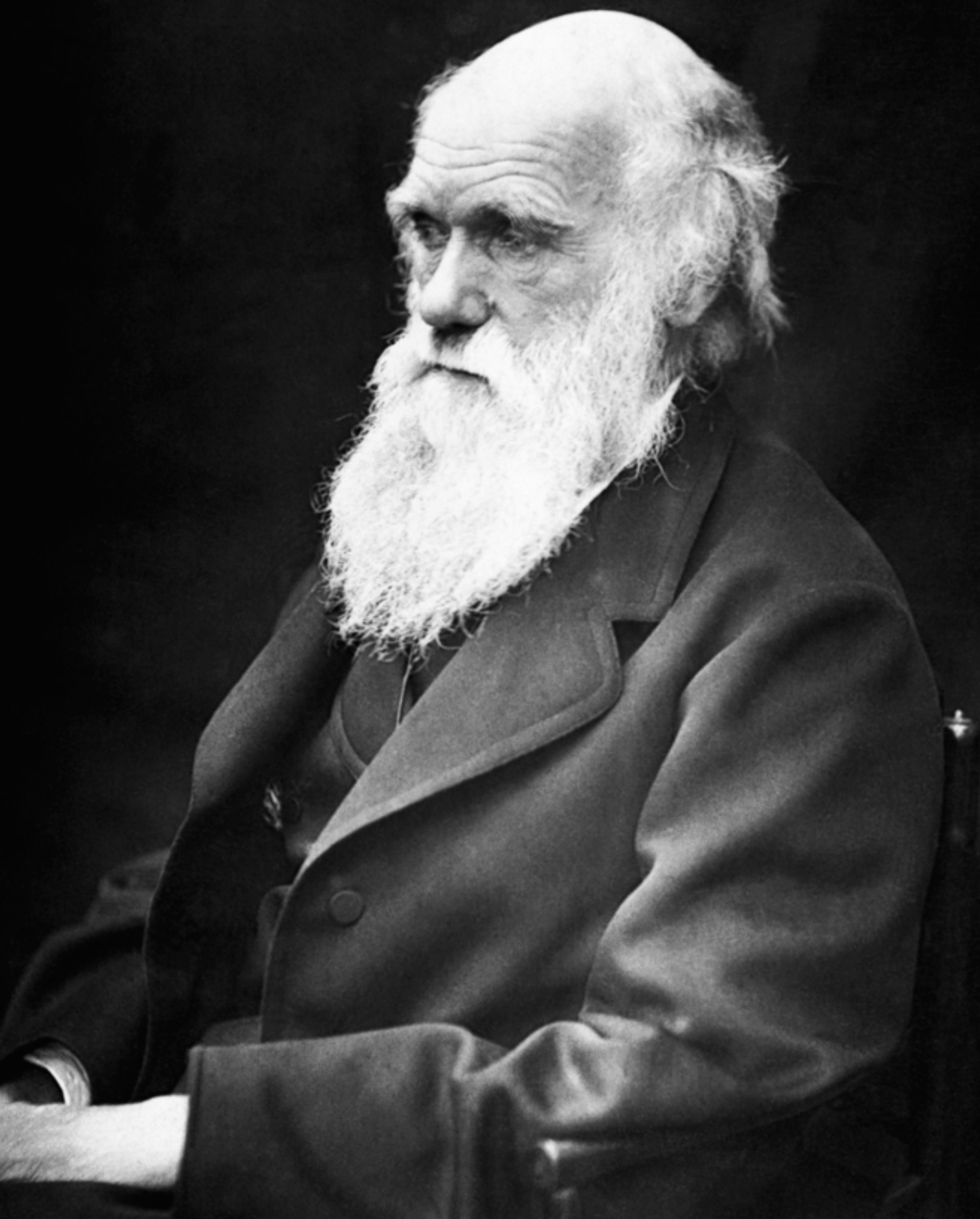












*"I have deeply regretted that I did not proceed far enough at least to understand something of the leading principles of mathematics, for men thus endowed seem to have an extra sense"*

*(Darwin's autobiography, p. 13)*