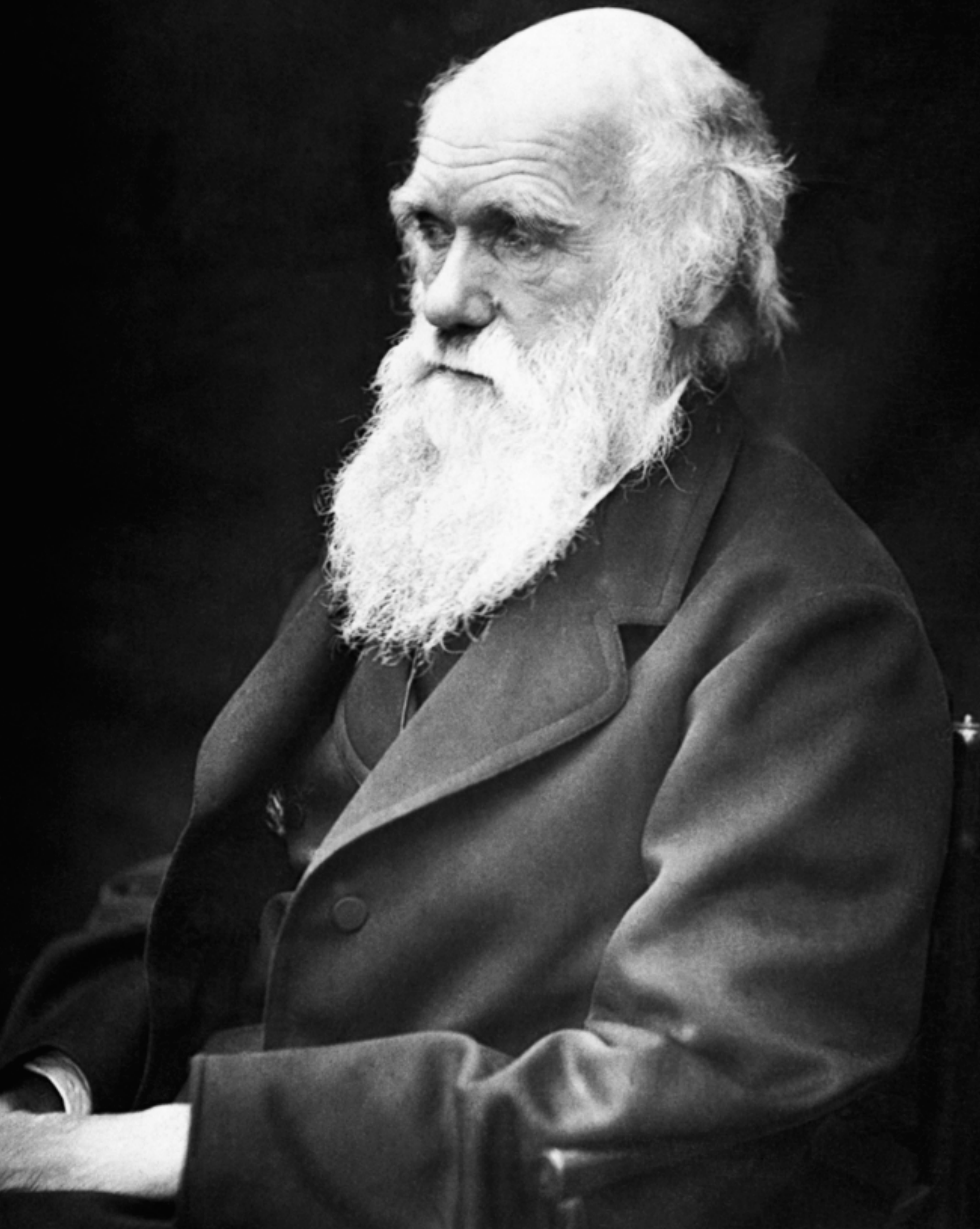


mutualistic networks





THE
VARIOUS CONTRIVANCES
BY WHICH
ORCHIDS ARE FERTILISED BY INSECTS.

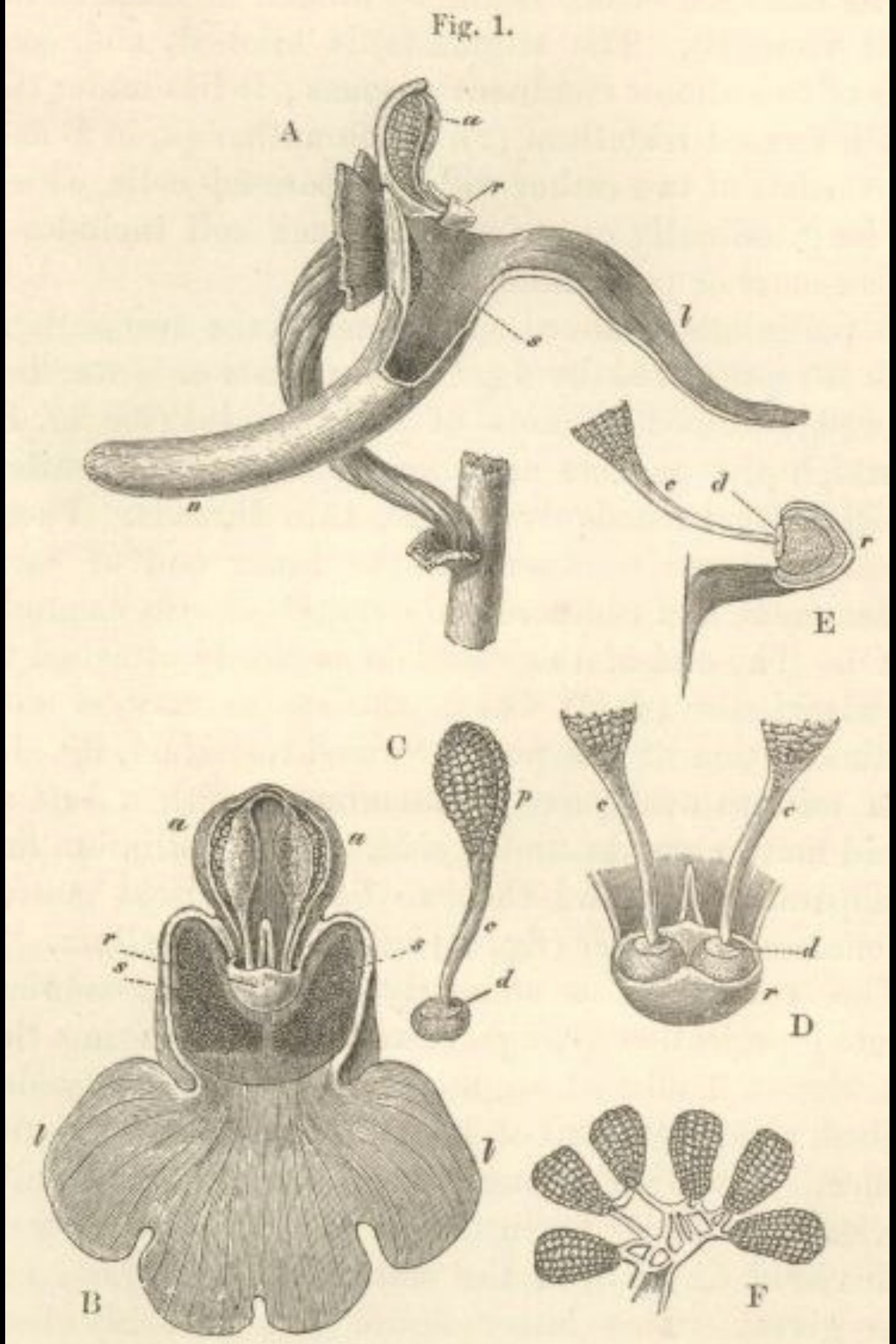
By CHARLES DARWIN, M.A., F.R.S., &c.

SECOND EDITION, REVISED.

WITH ILLUSTRATIONS.

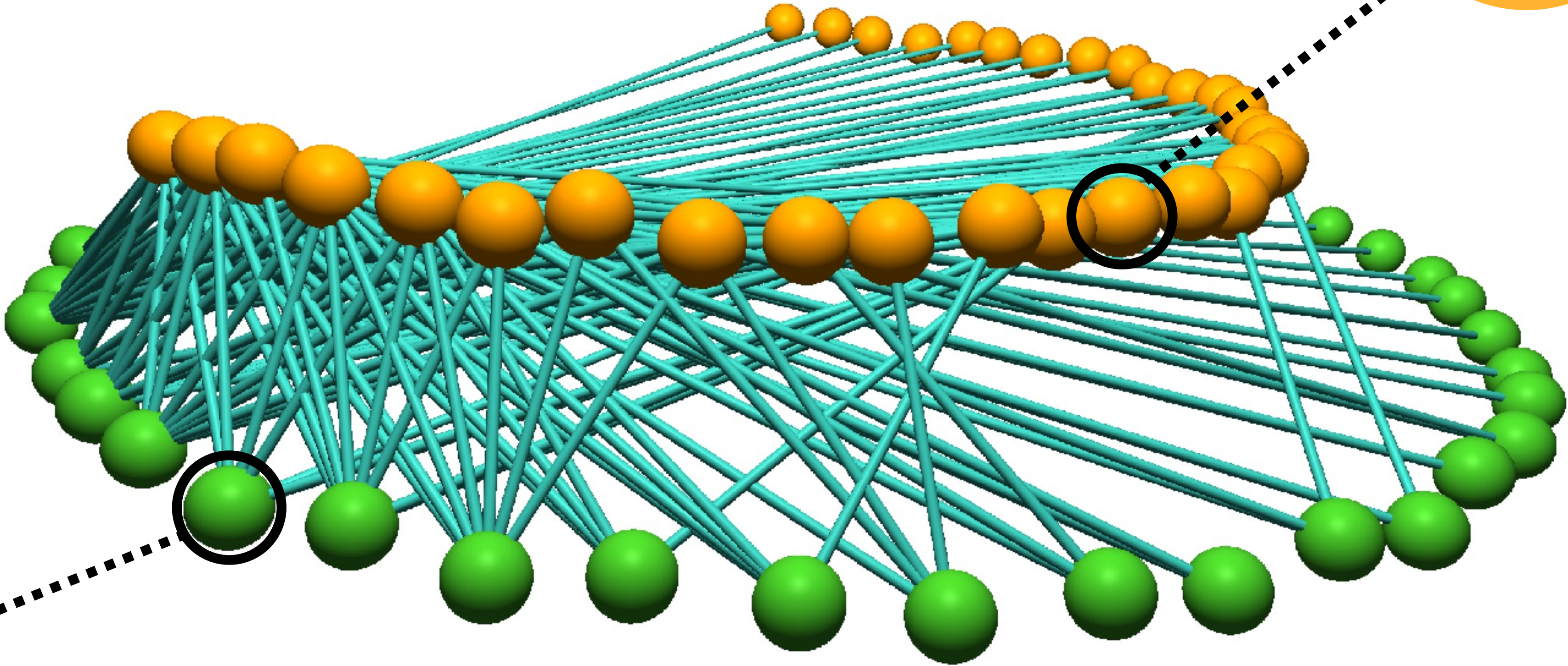
LONDON:
JOHN MURRAY, ALBEMARLE STREET.
1877.

[The right of Translation is reserved.]



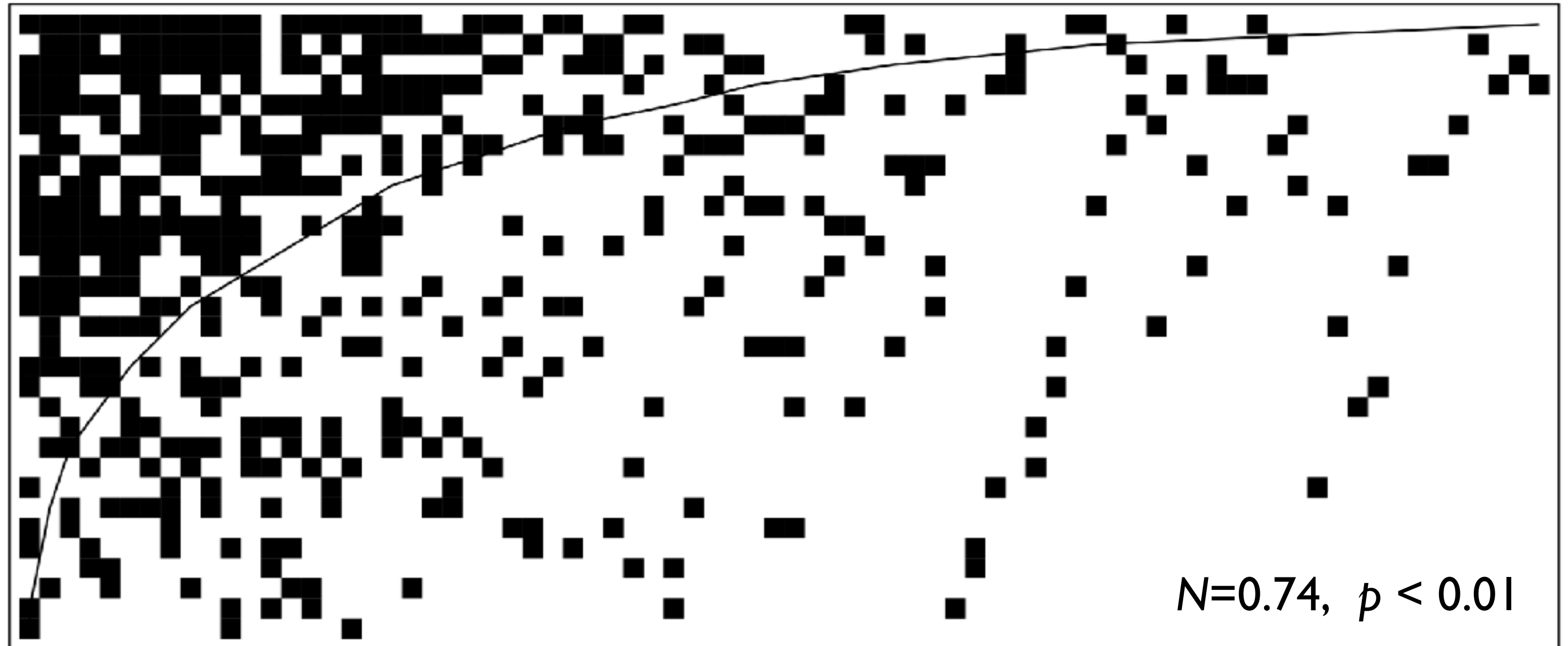
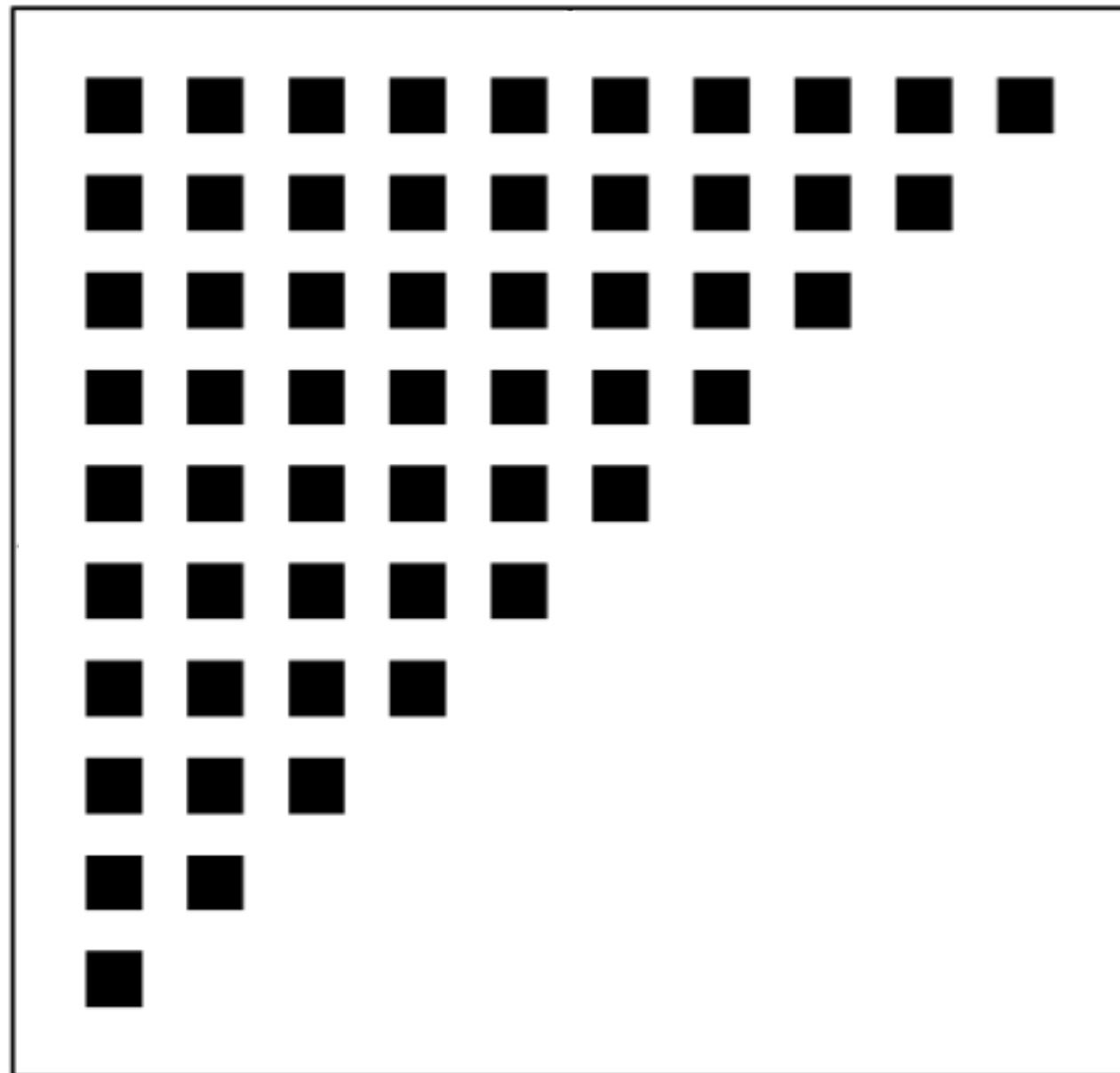
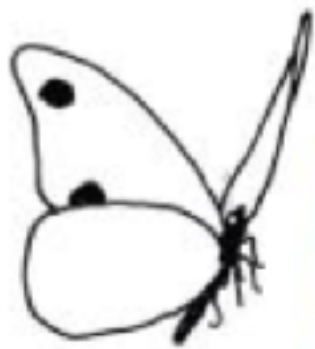


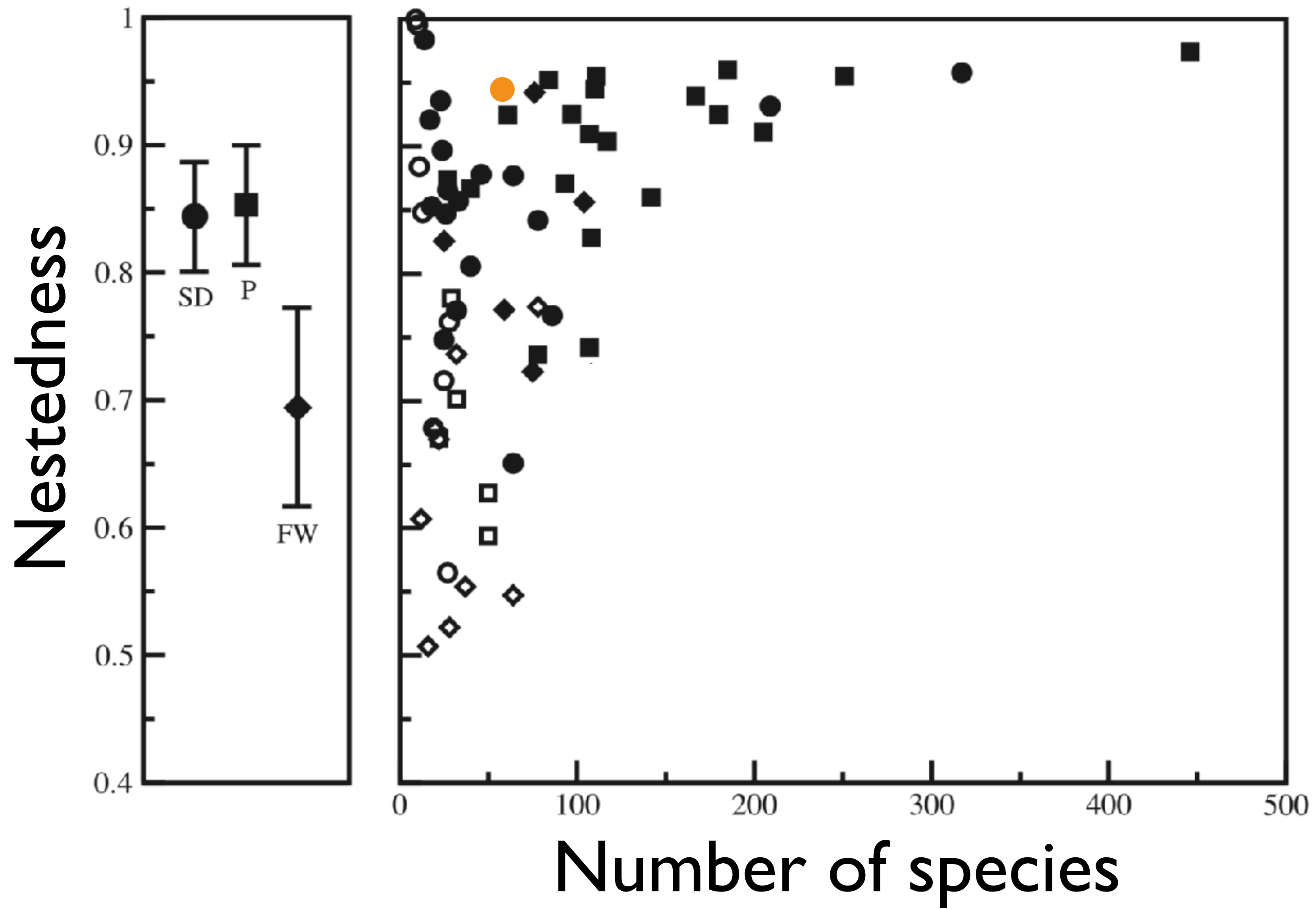
mutualistic networks





network structure

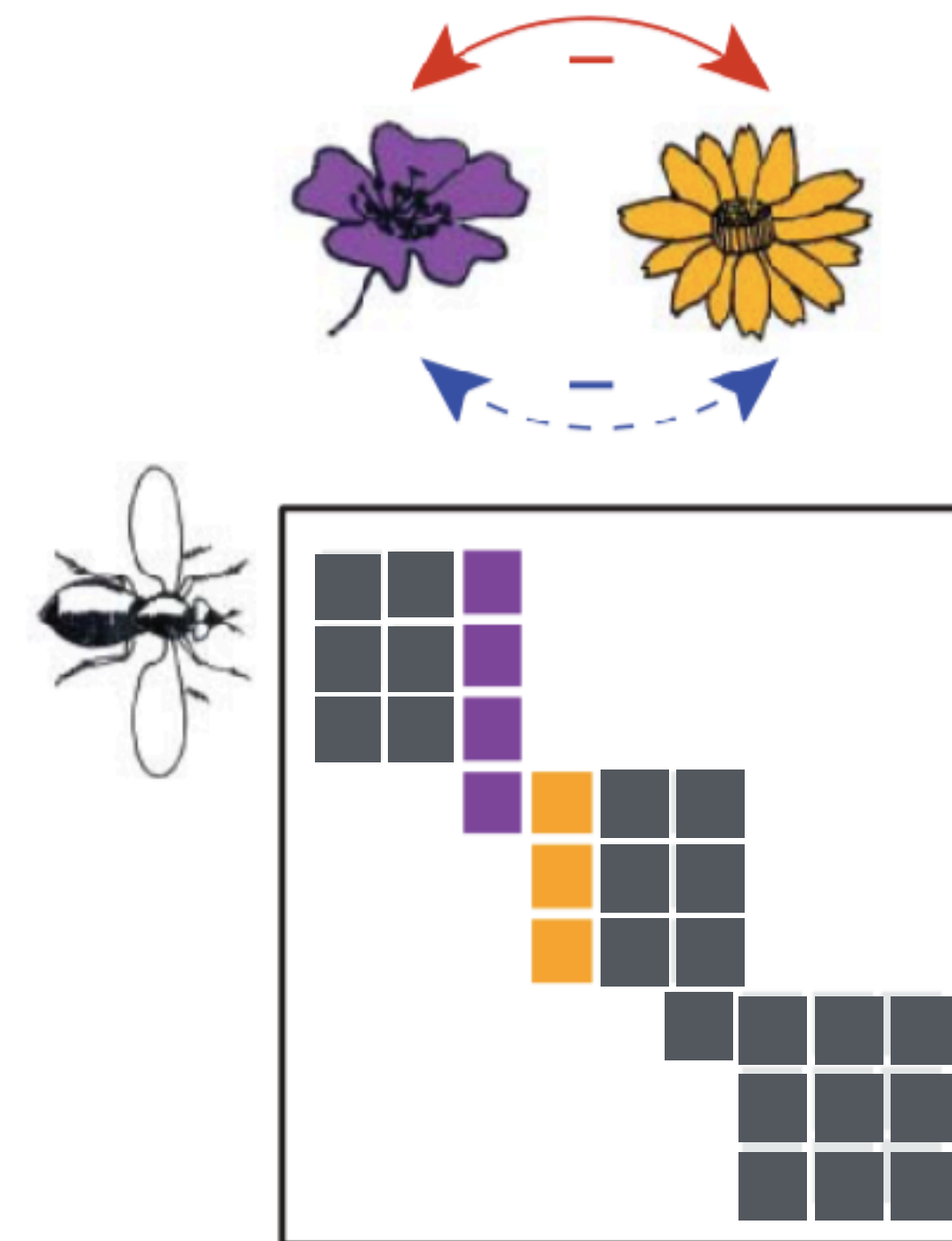
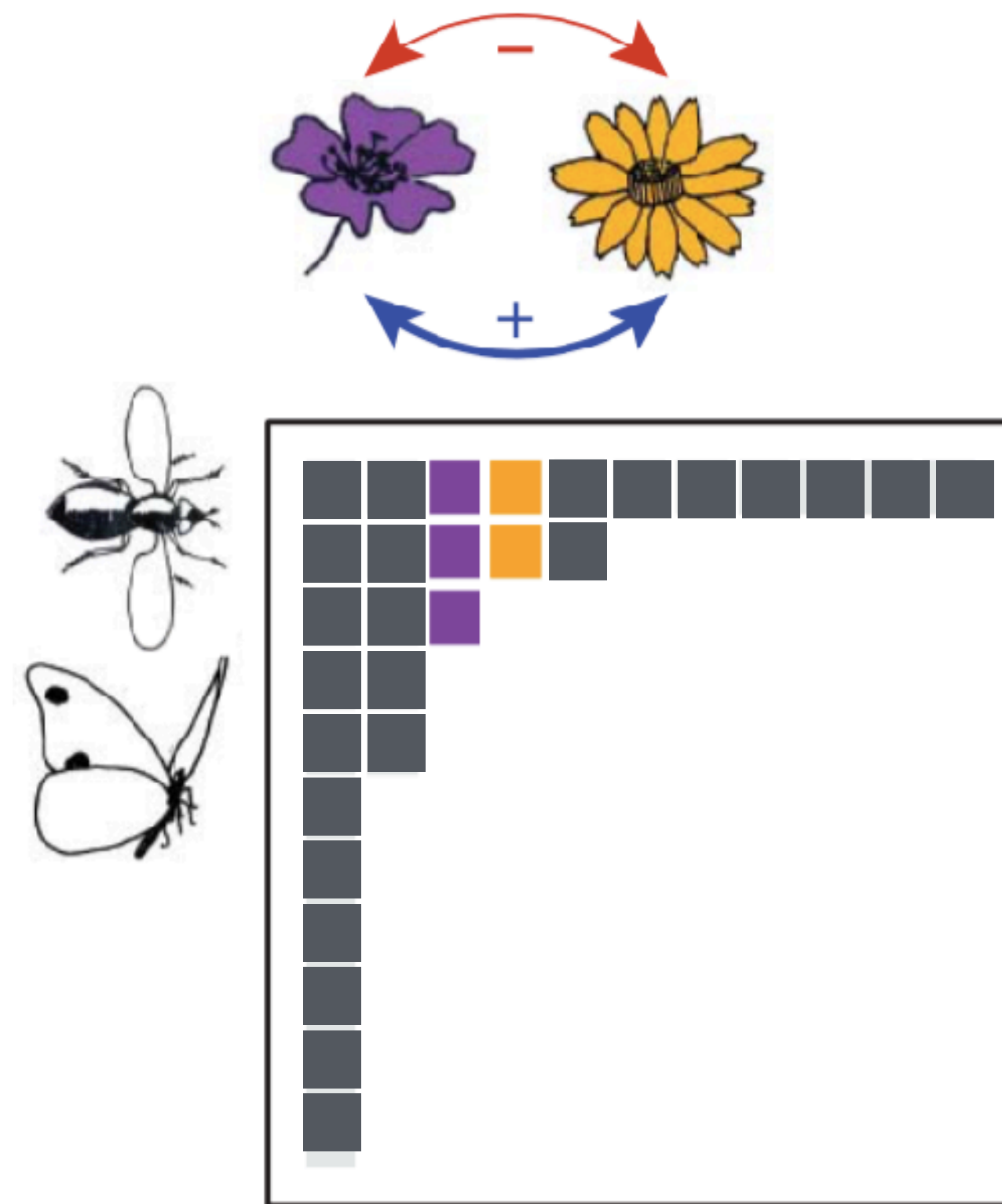


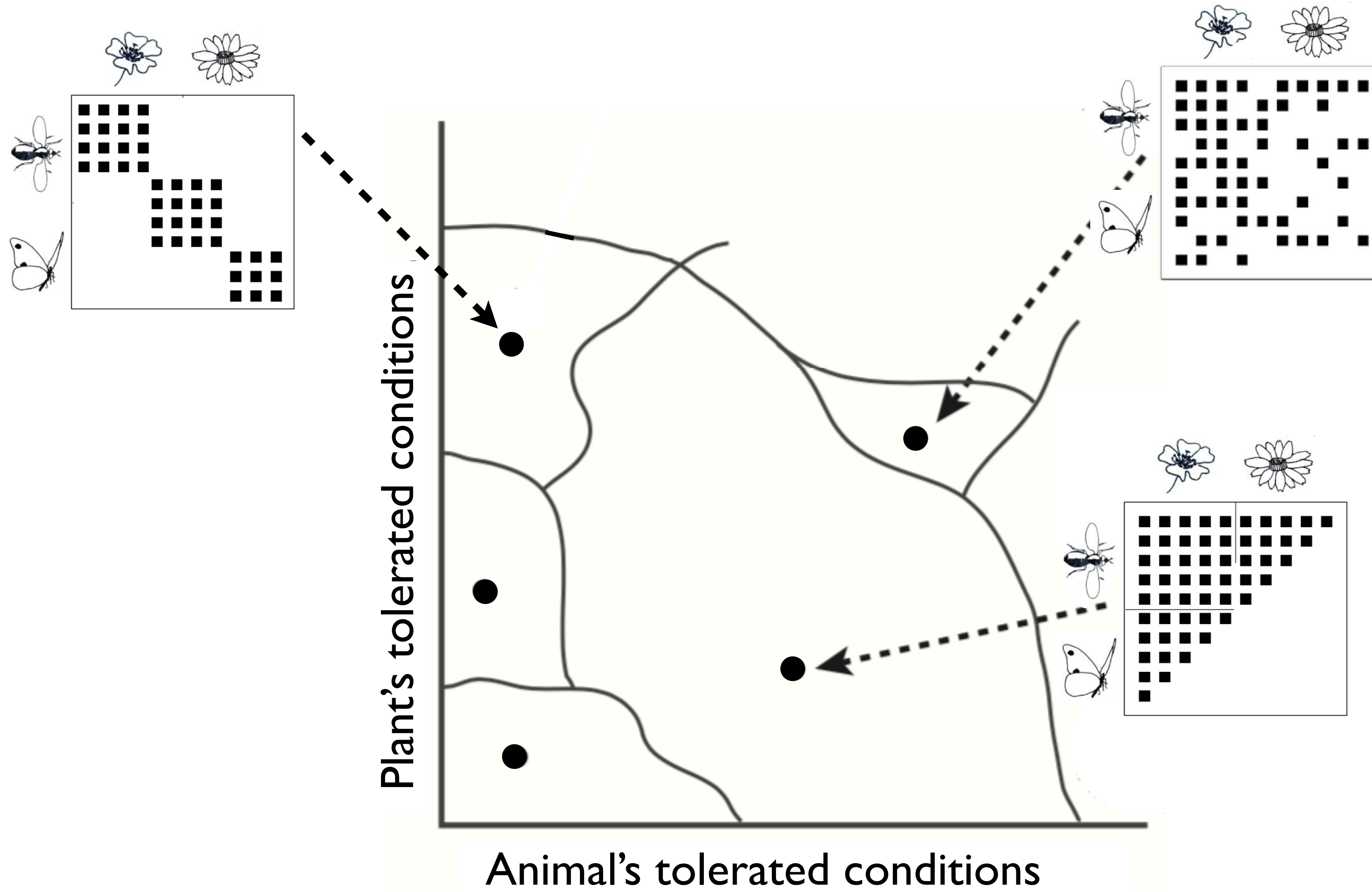


mutualistic model

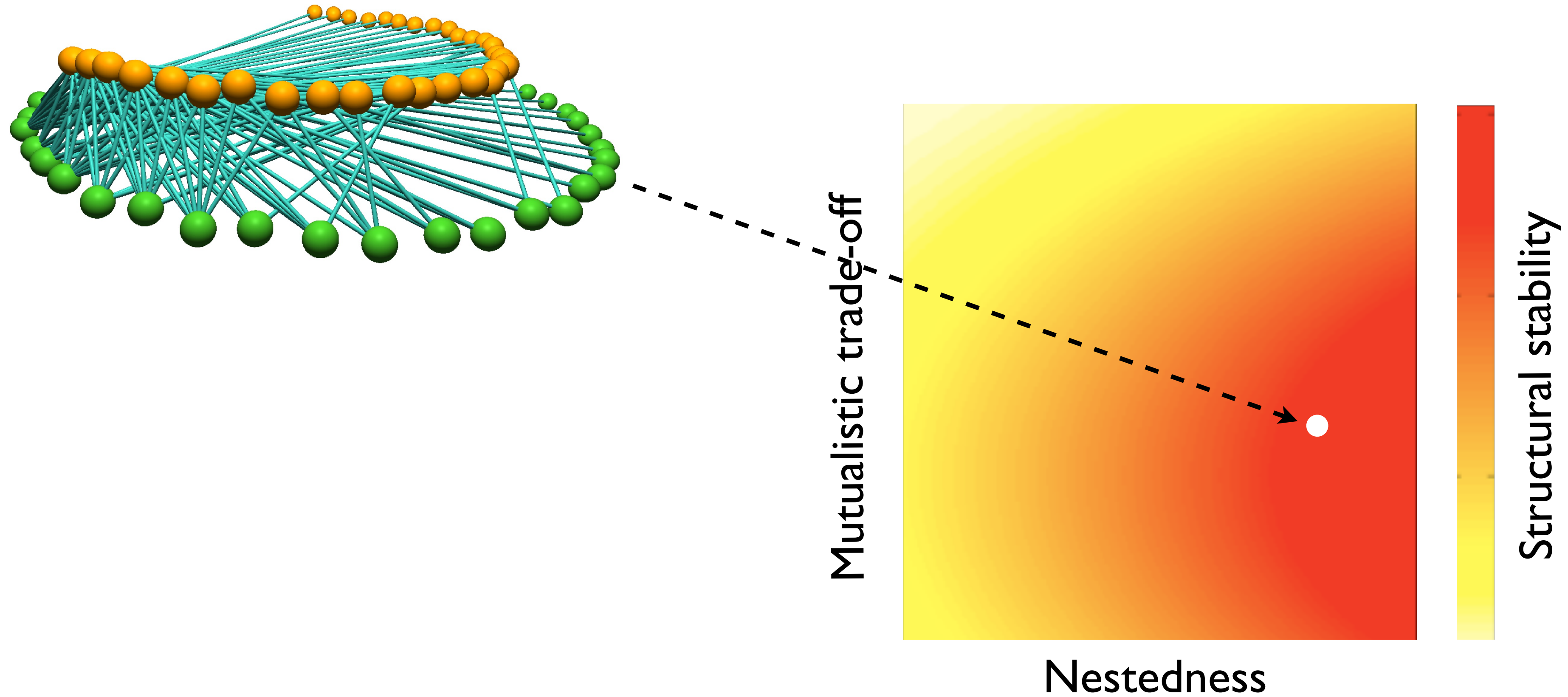
$$\frac{dN_i^{(P)}}{dt} = \underbrace{\alpha_i^{(P)} N_i^{(P)}}_{\text{Intrinsic growth rate}} - \underbrace{\sum_{j \in \mathbf{P}} \beta_{ij}^{(P)} N_i^{(P)} N_j^{(P)}}_{\text{Direct competition}} + \underbrace{\sum_{k \in \mathbf{A}} \frac{\gamma_{ik}^{(P)} N_i^{(P)} N_k^{(A)}}{1 + h^{(P)} \sum_{l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

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





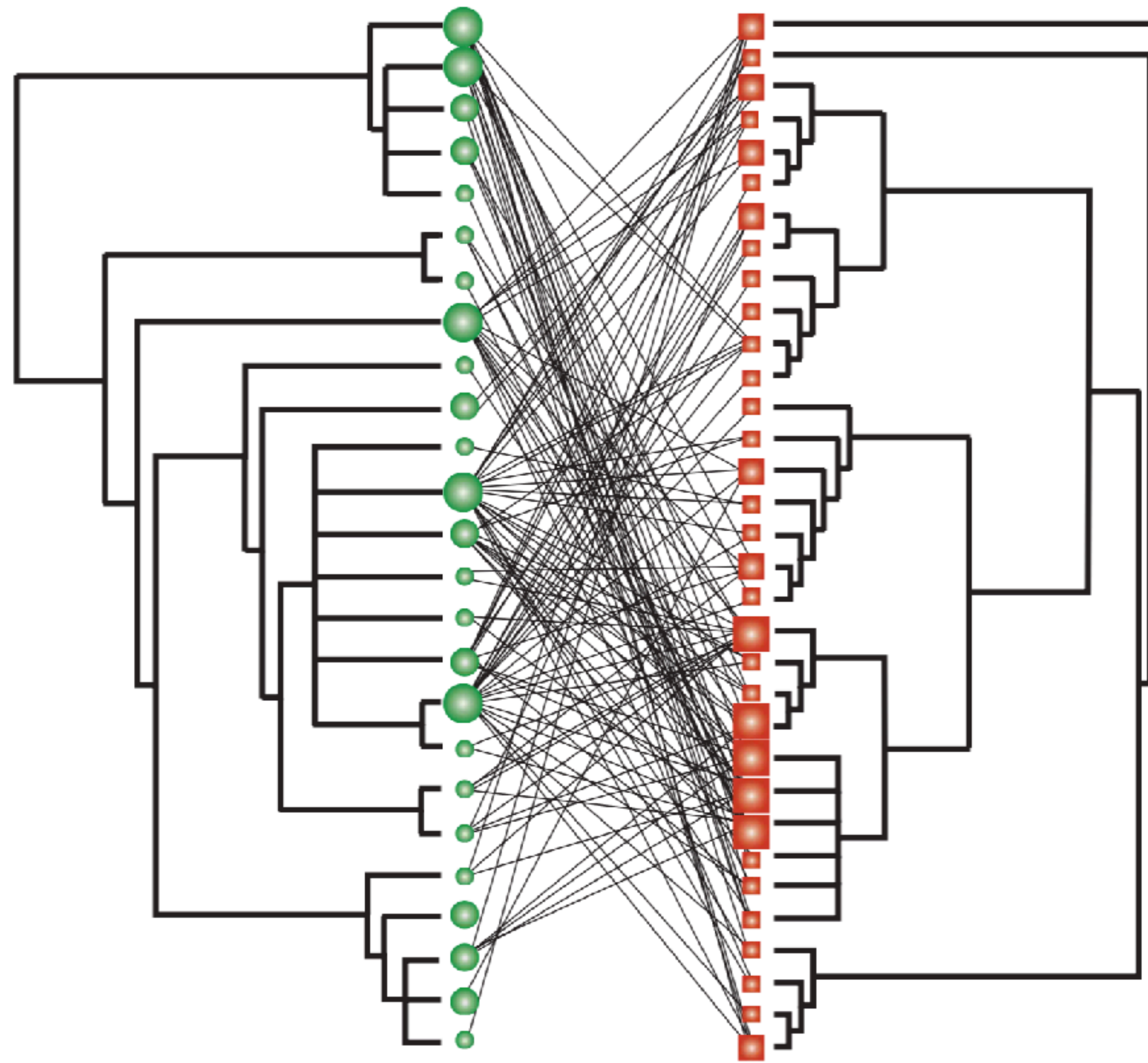
network structure increases robustness





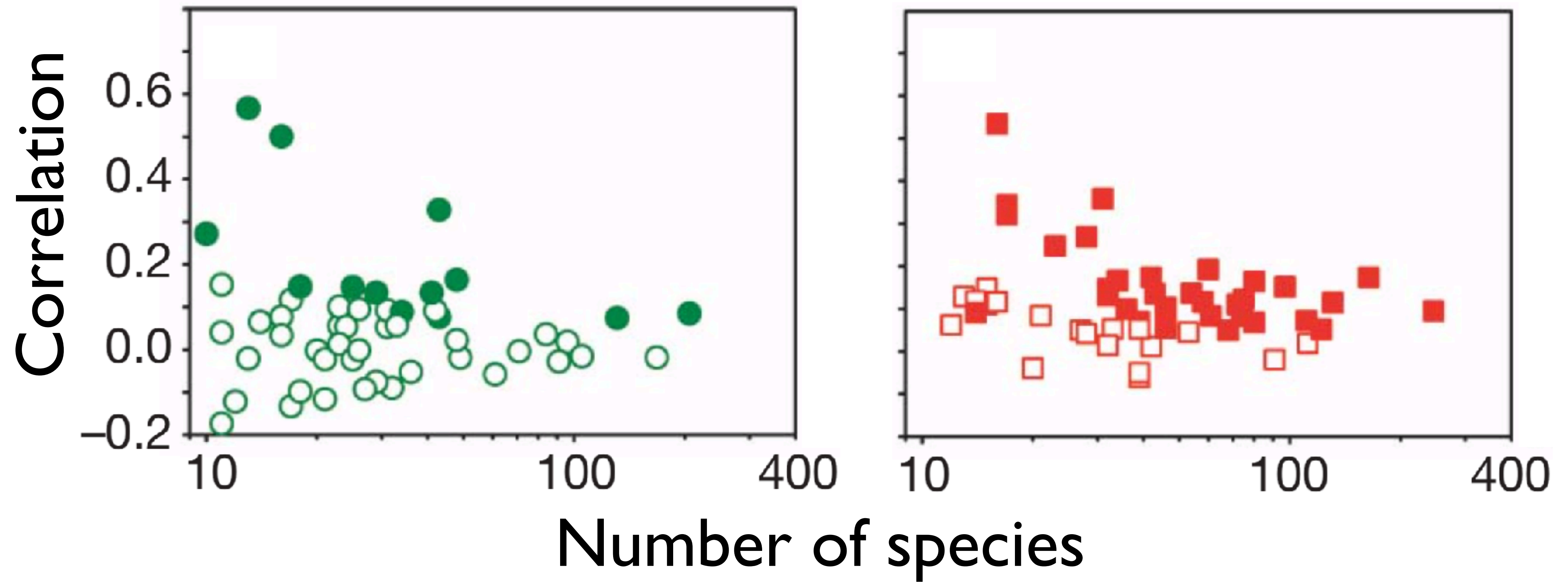
Credit art by Cheng (Lily) Li

evolutionary history

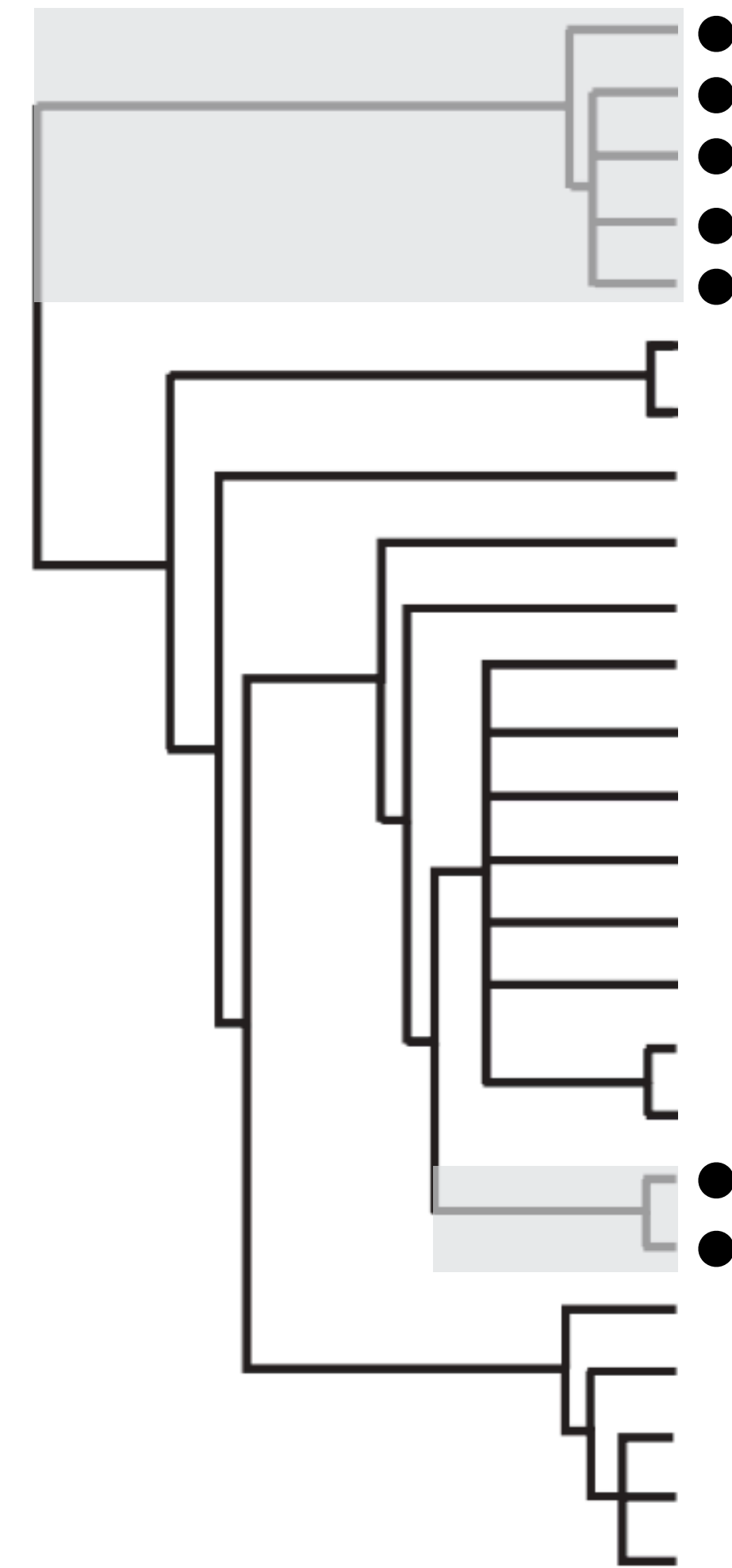
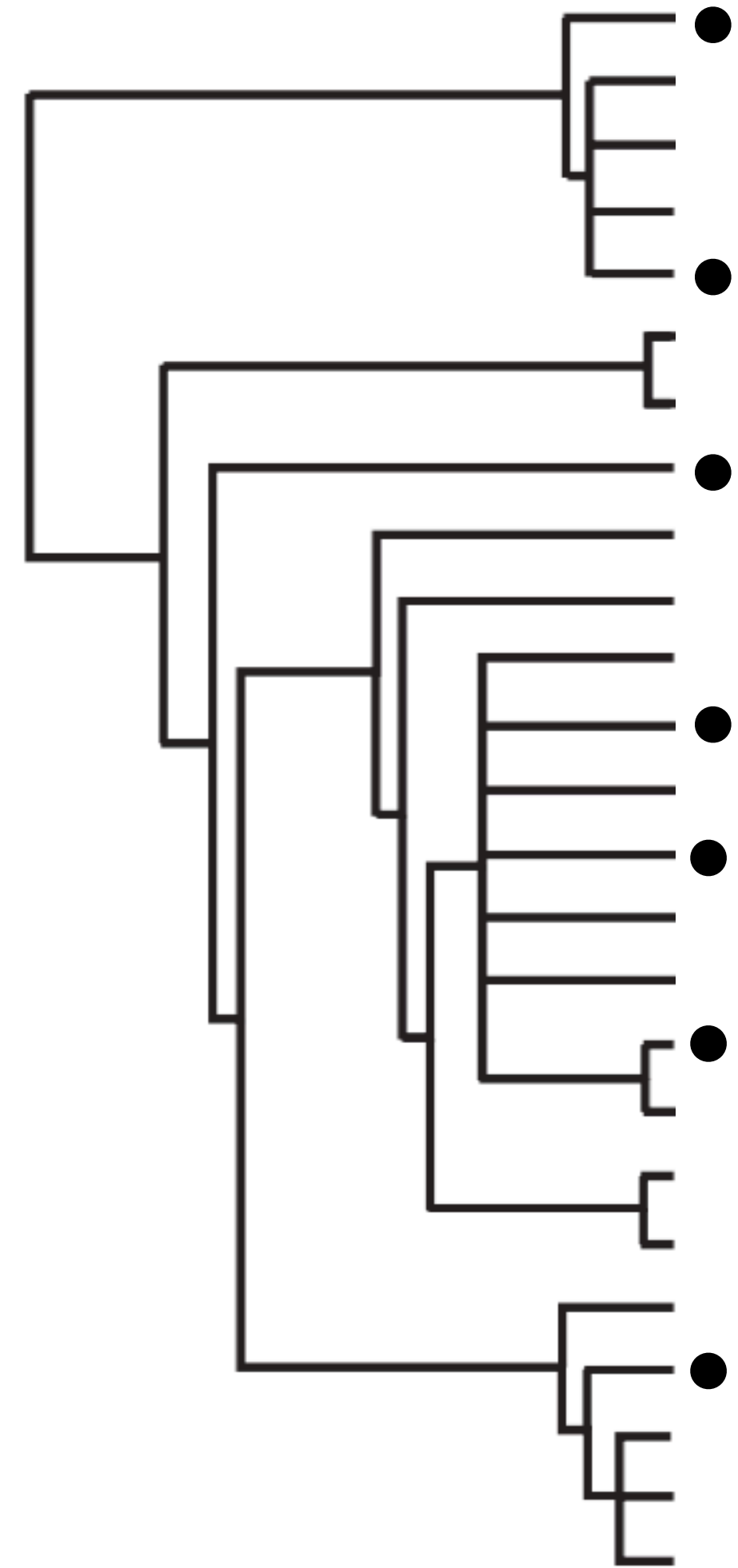
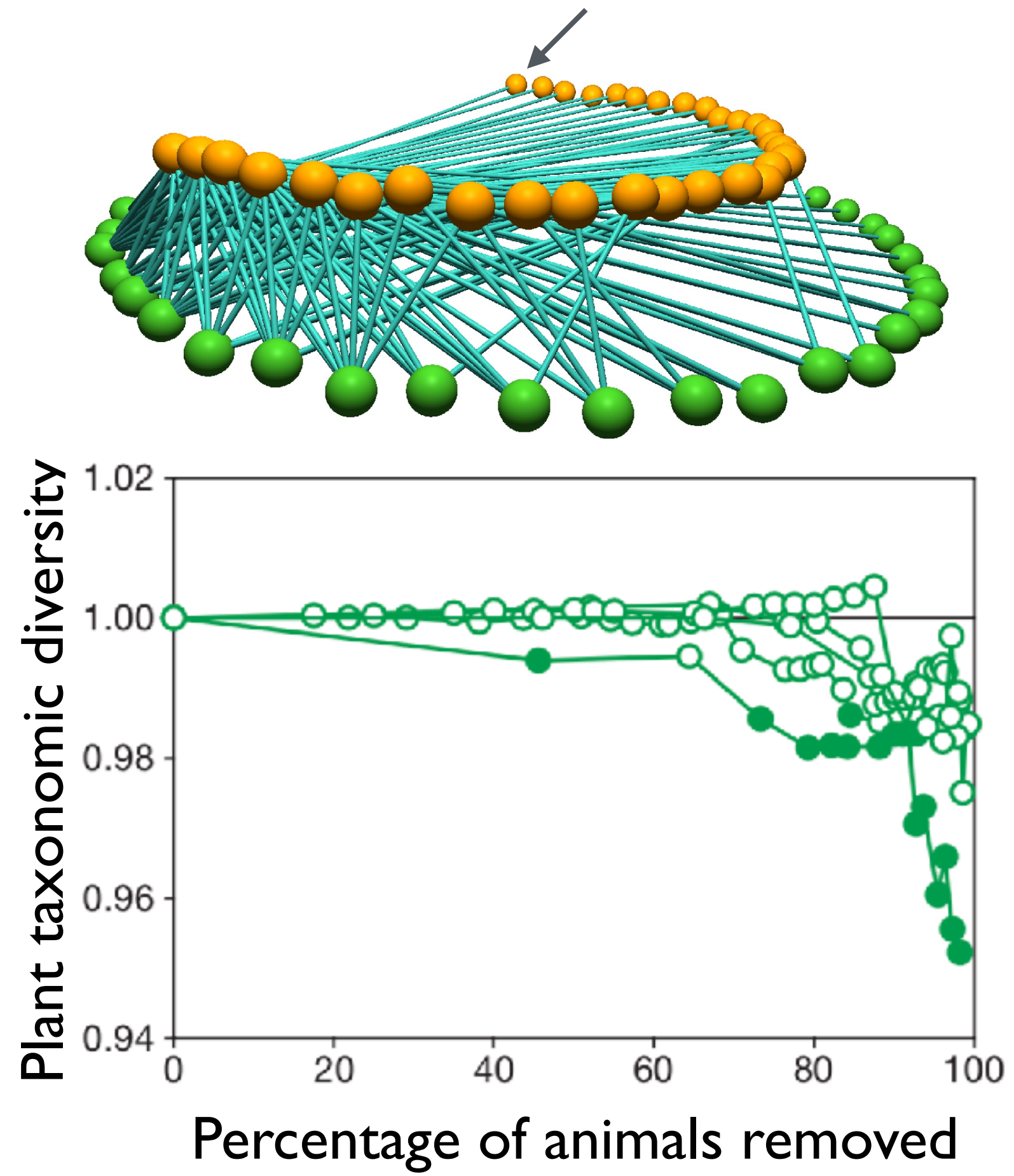


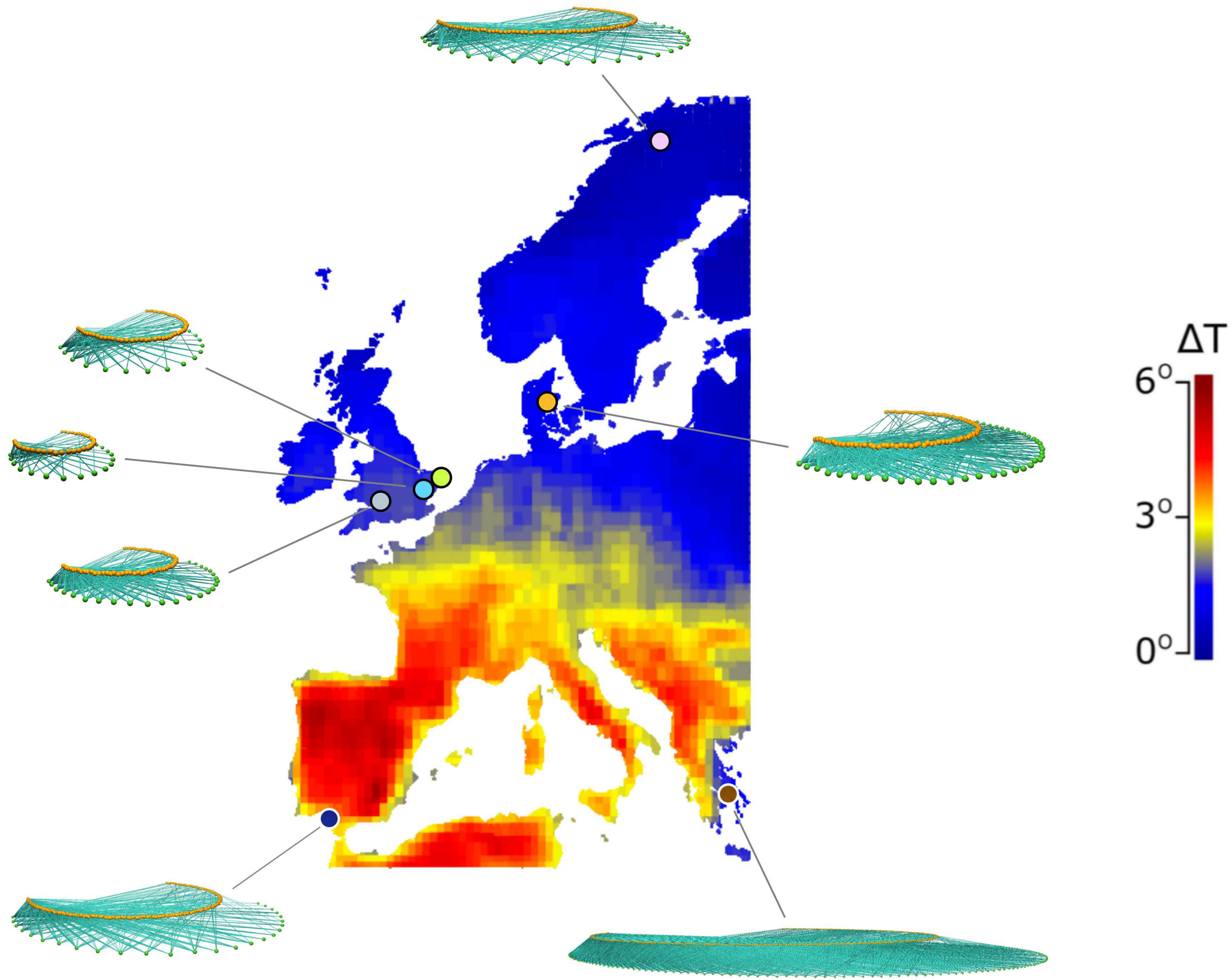
Rezende, Lavabre, Guimaraes, Jordano, and Bascompte (2007). *Nature* 448: 925-928.

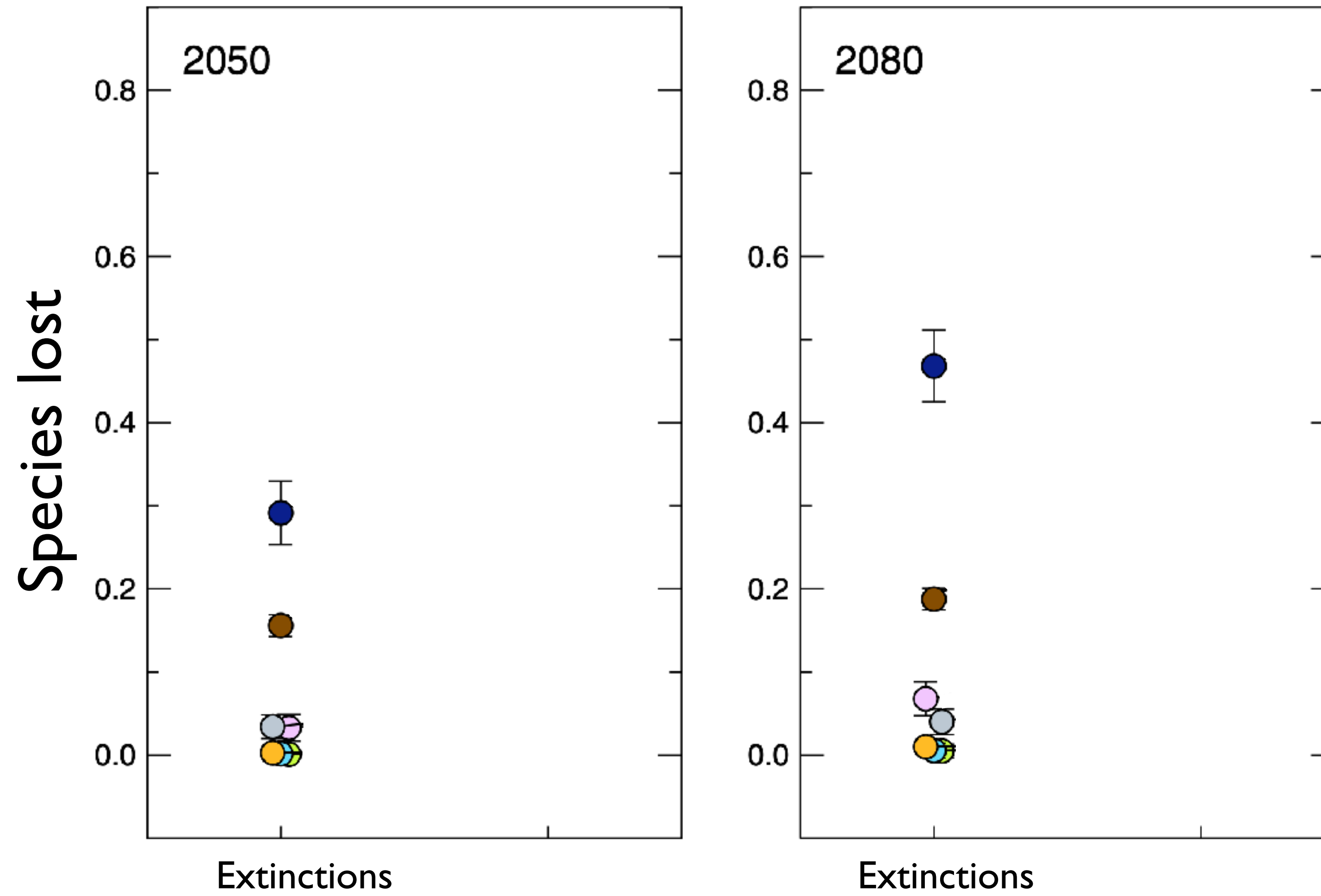
phylogenetic signal

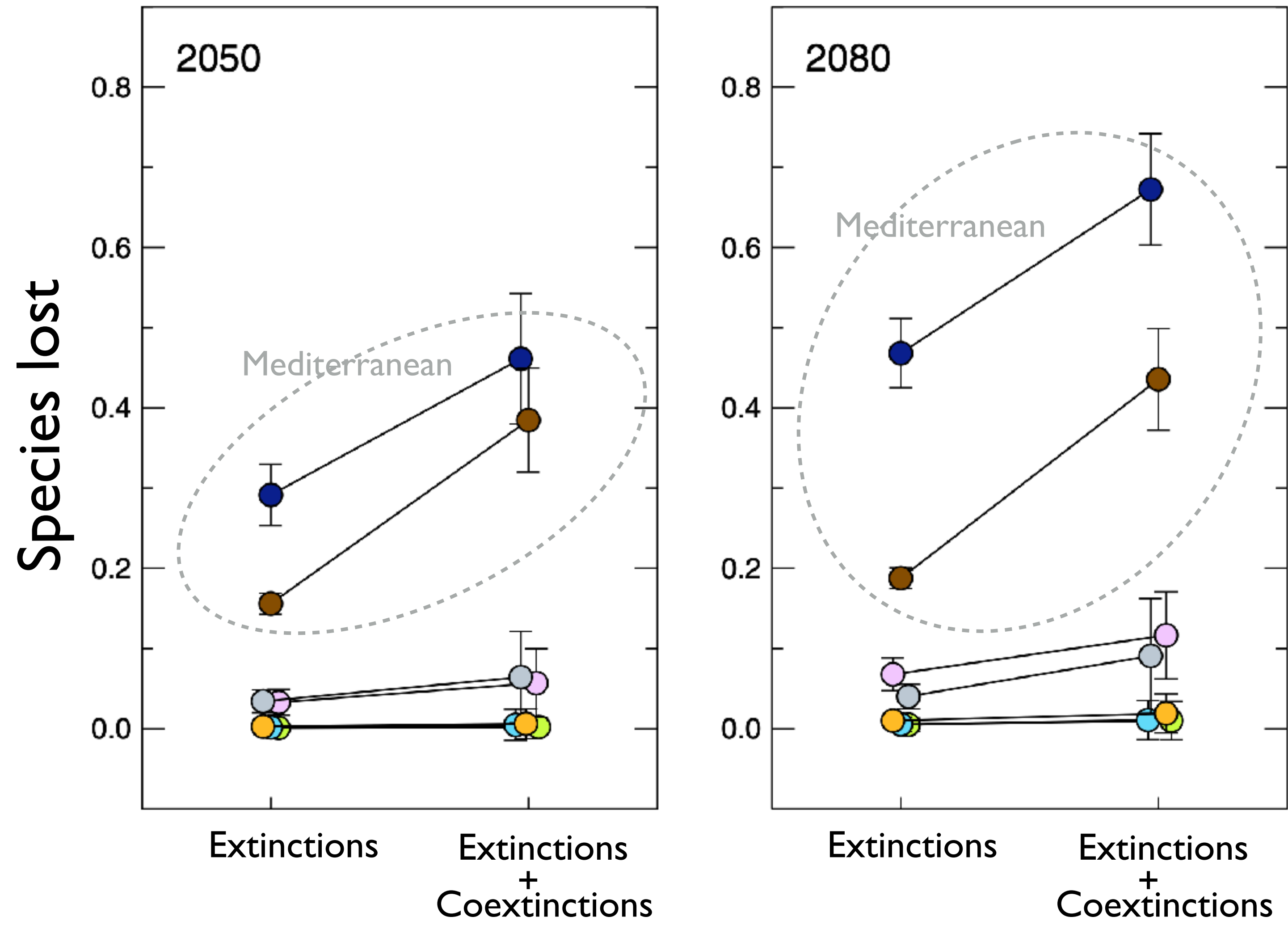


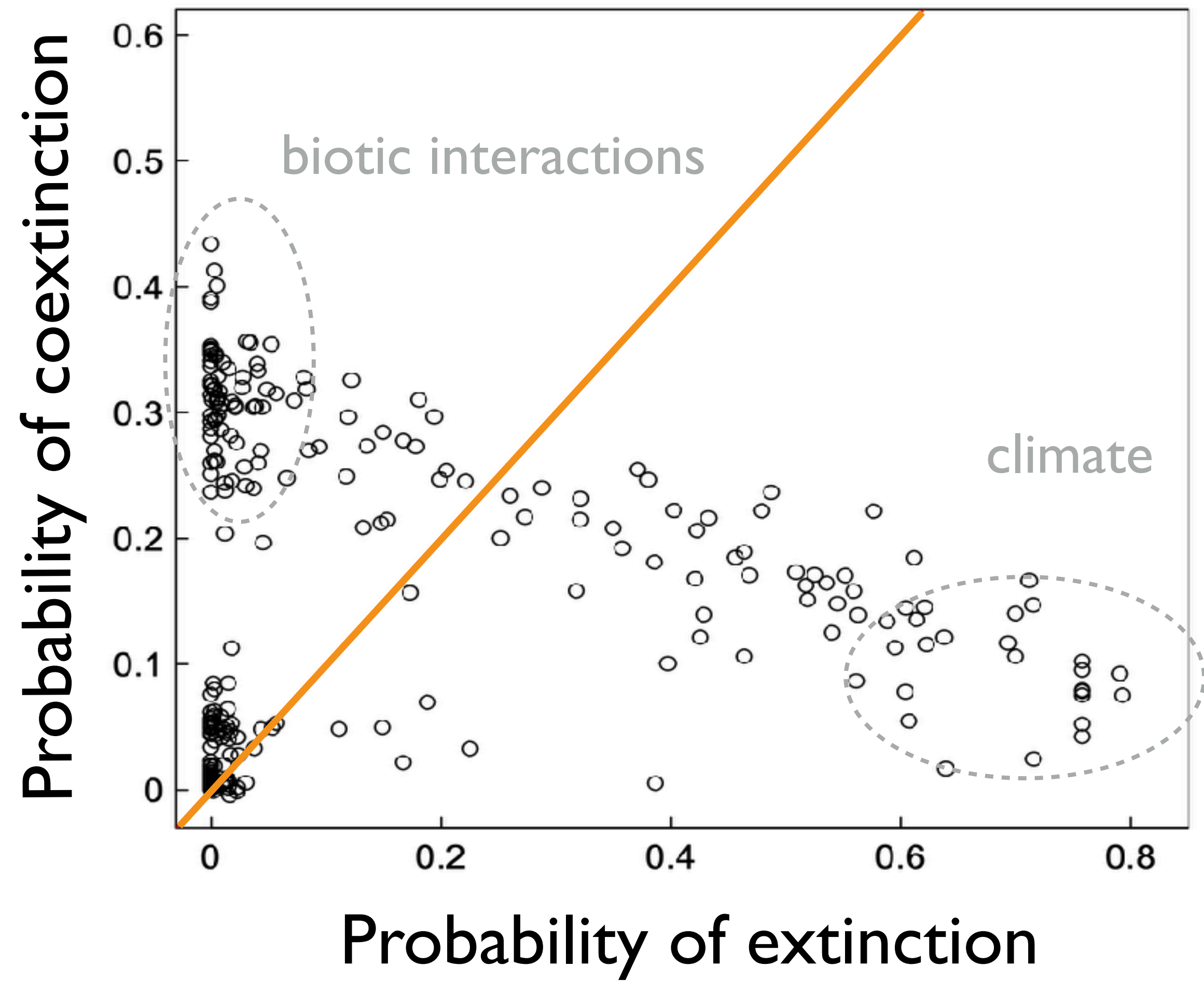
non-random coextinctions



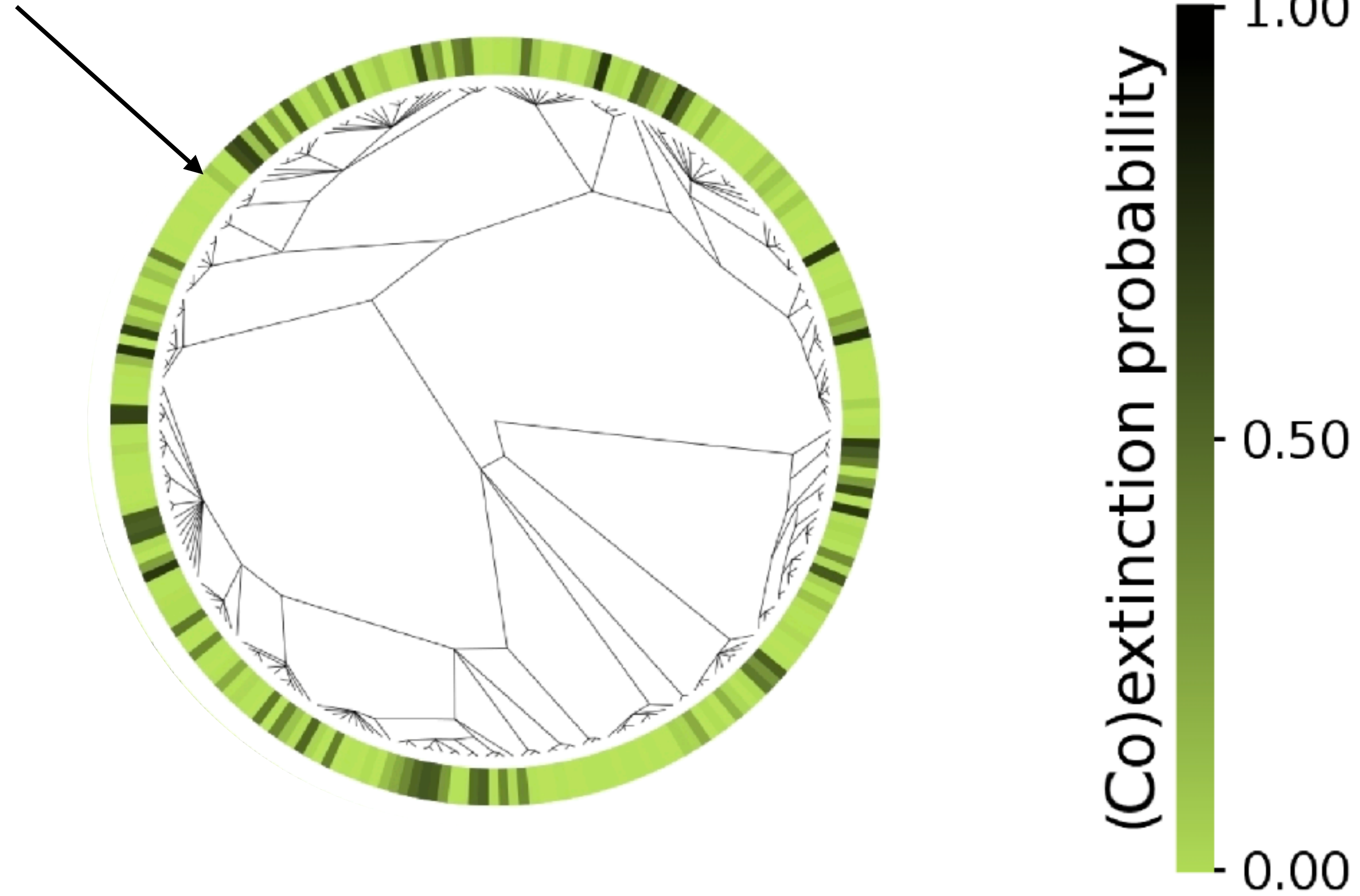






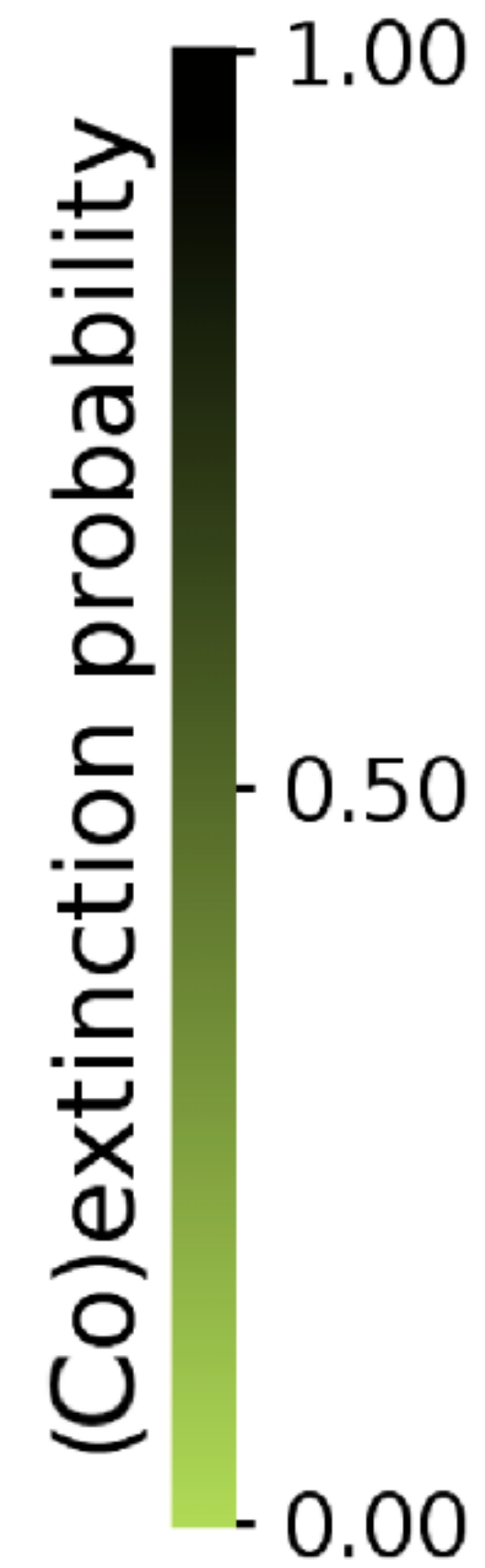
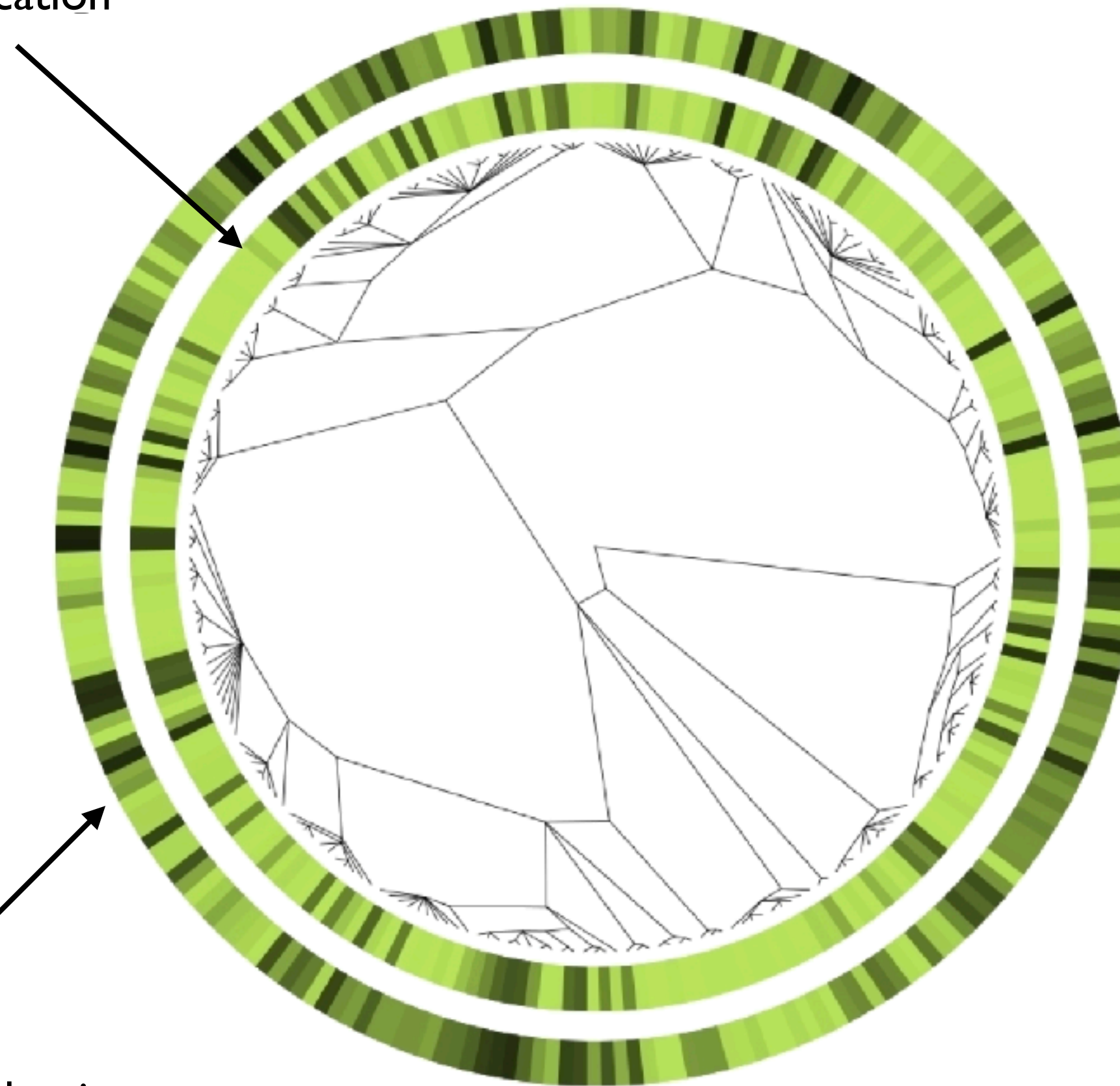


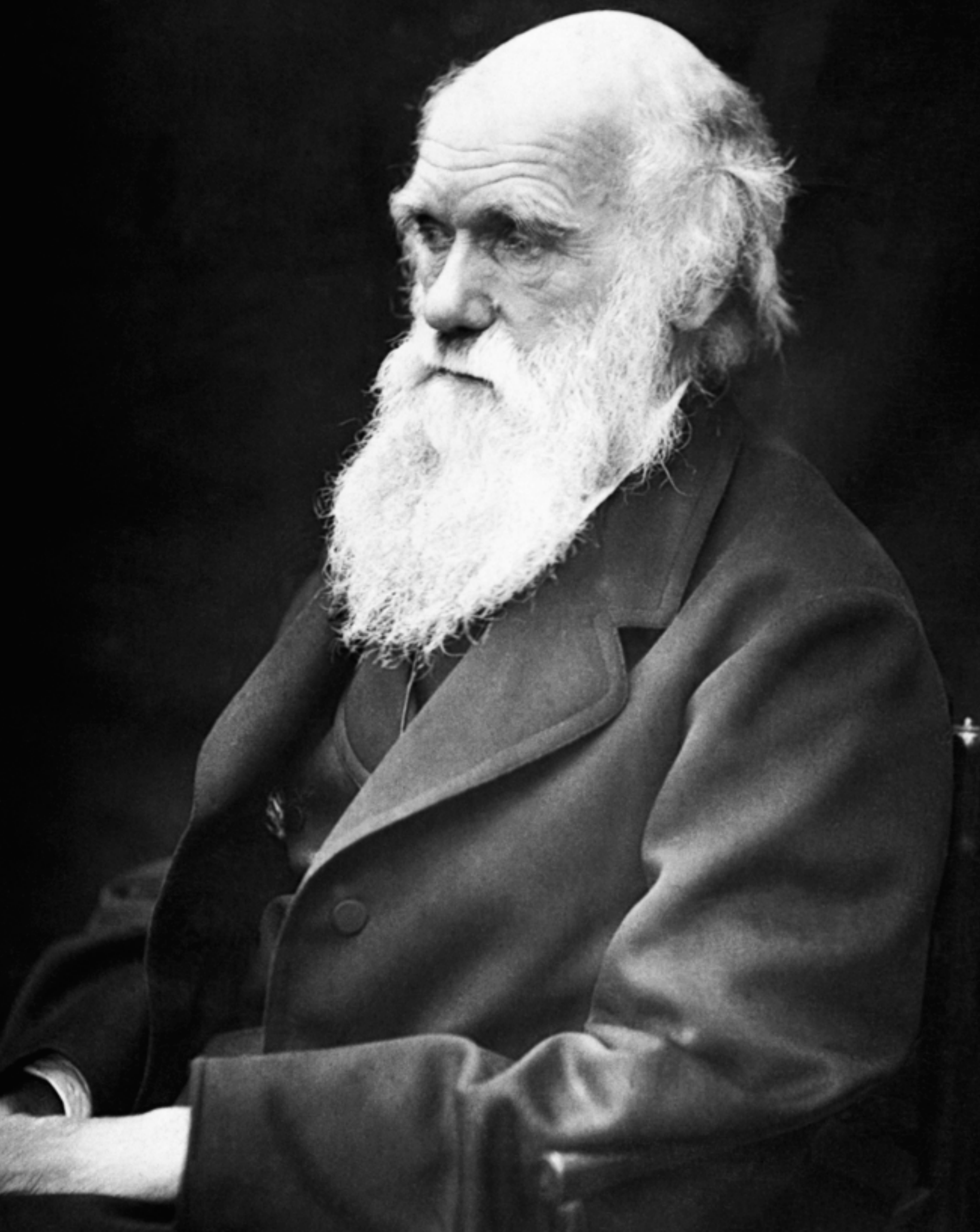
climatically-driven extinctions
best predicted by geographic location



climatically-driven extinctions
best predicted by geographic location

coextinctions
best predicted by network identity
phylogenetic signal





"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)