





What do you see?



Interactions



Interactions

cow eats grass



(co)Evolution



(co)Evolution

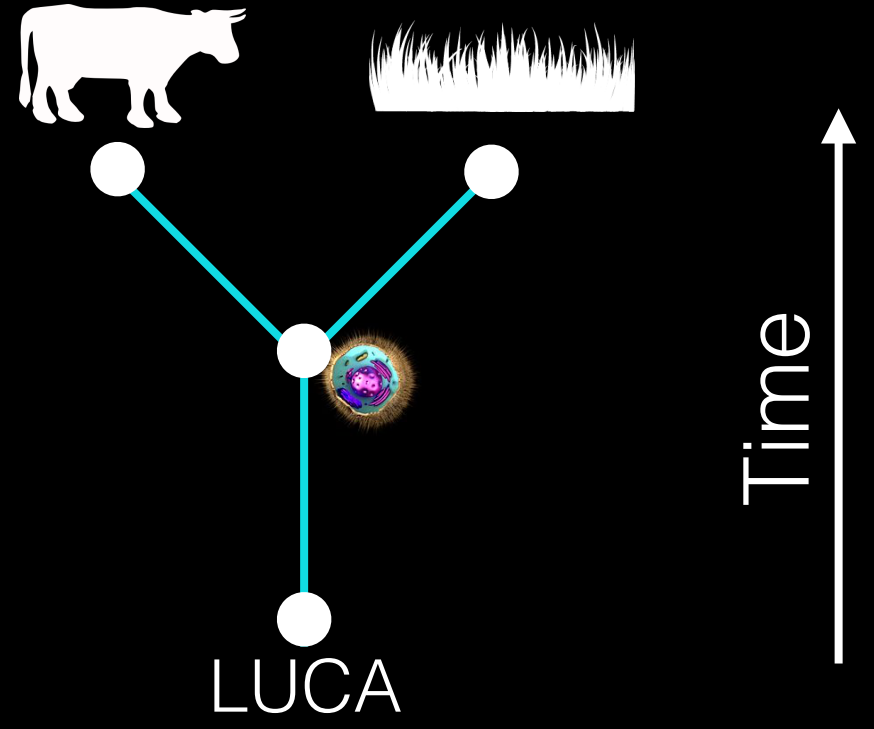
cow's stomach digest grass



How do you write it?

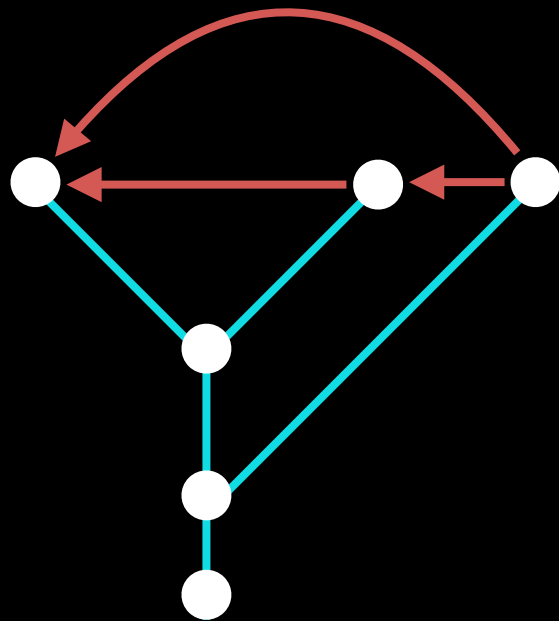
(if you are a mathematician)

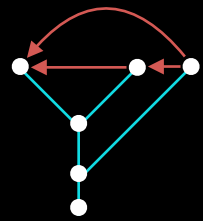




the Web and the Tree

on the interplay between ecological processes and
evolutionary histories





the Web and the Tree

on the interplay between ecological
processes and evolutionary histories

Giulio Valentino Dalla Riva

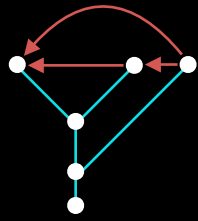
Supervisors:

Mike Steel

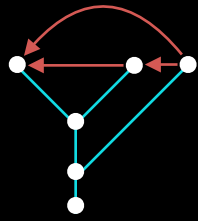
Charles Semple

Daniel Stouffer

University of Canterbury 31 March 2016

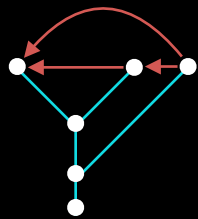


1. Random Dot Product Graphs (Chap. 4)
2. Centrality & Uniqueness (Chaps. 5 & 7)
3. Niche Evolution and Diversity (Chap. 6)



1. Random Dot Product Graphs (Chap. 4)
2. Centrality & Uniqueness (Chaps. 5 & 7)
3. Niche Evolution and Diversity (Chap. 6)

**and skip other work
(sorry coauthors)**



RDPG



OIKOS

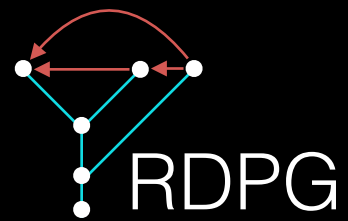
SYNTHESISING
ECOLOGY

Research

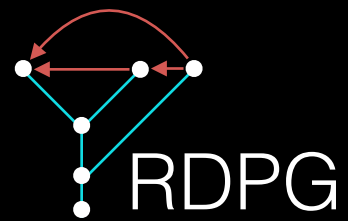
Exploring the evolutionary signature of food webs' backbones using functional traits

Giulio V. Dalla Riva¹ and Daniel B. Stouffer

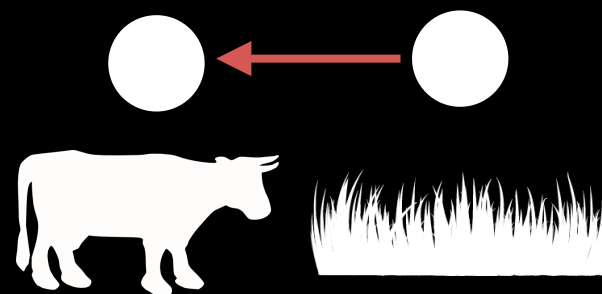
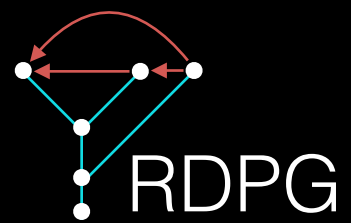
Issue

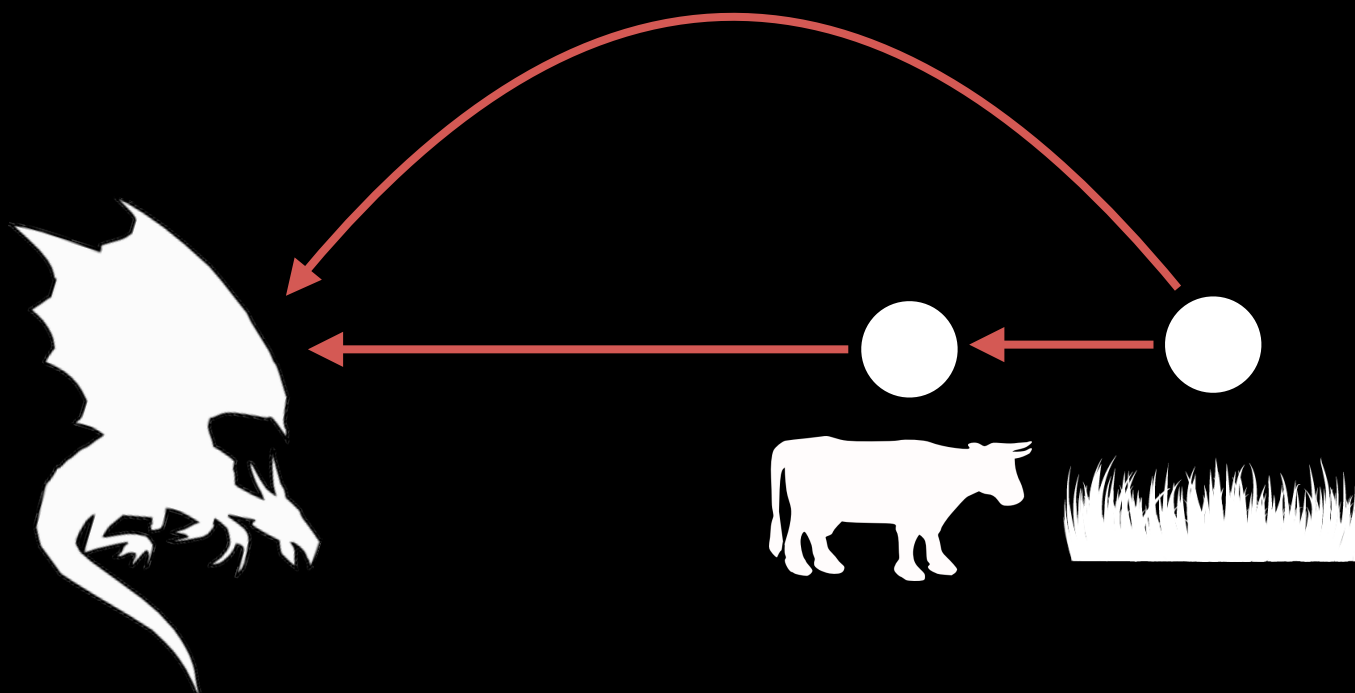


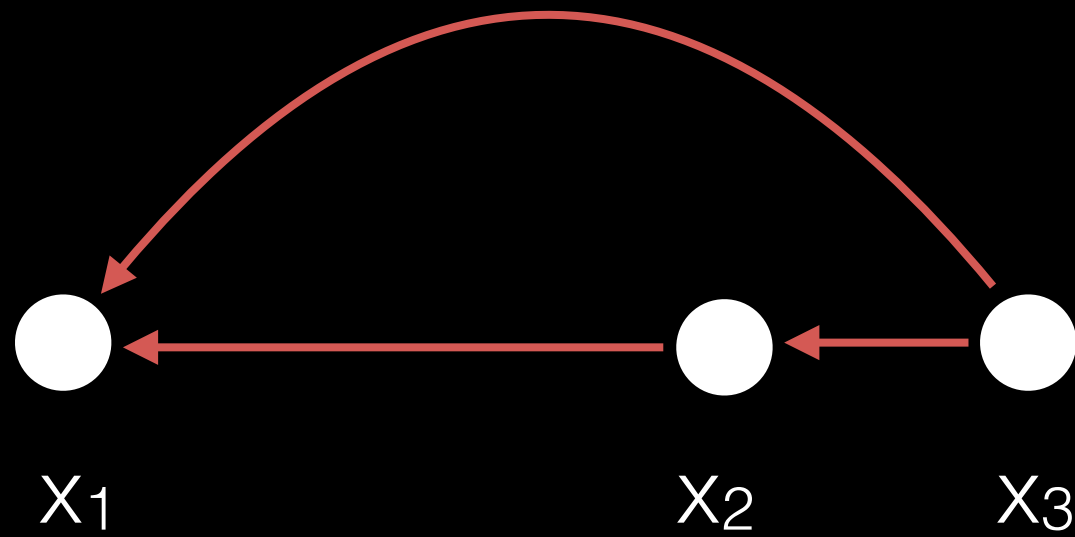
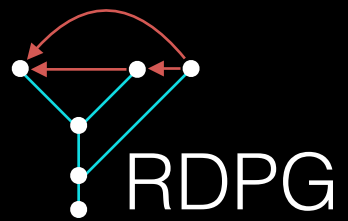
Did evolution leave a trace
in the structure
of ecological networks?

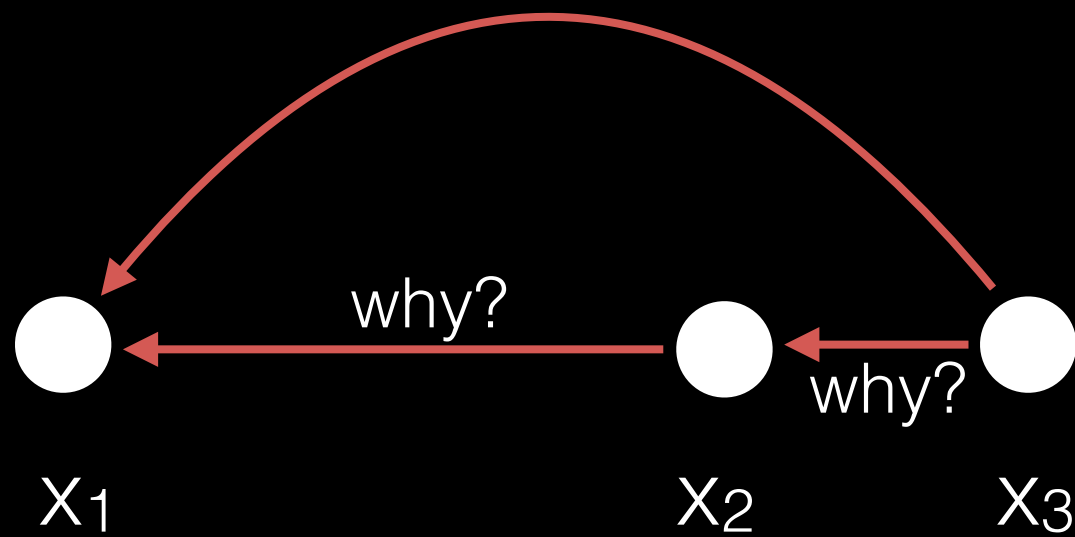
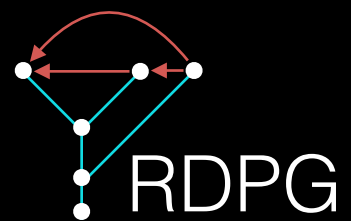


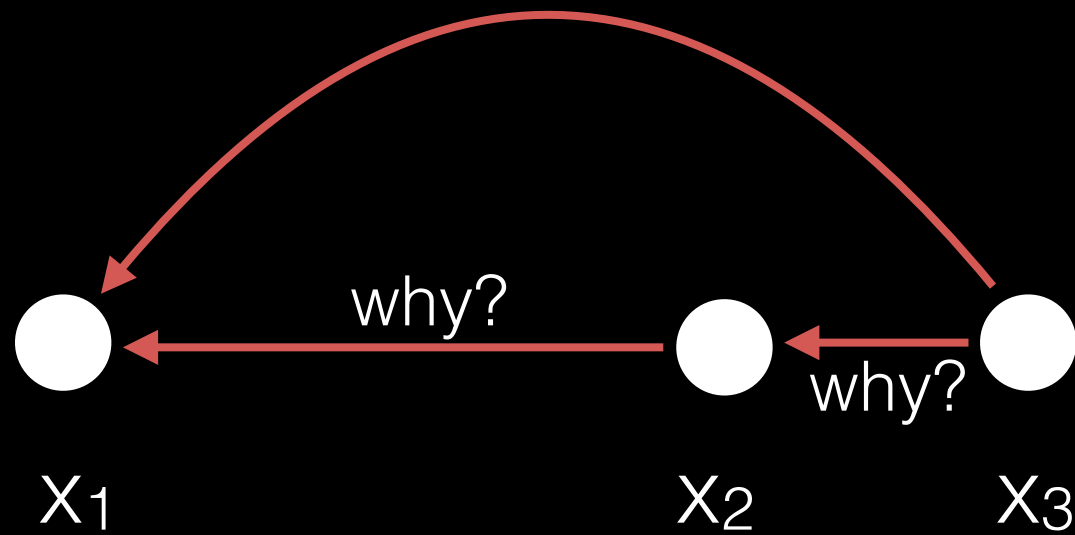
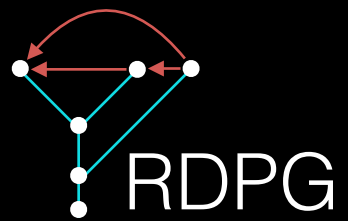
How do we do
phylogenetic comparative analysis
with food webs?



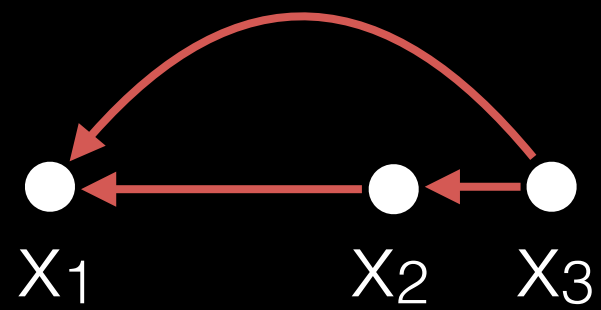
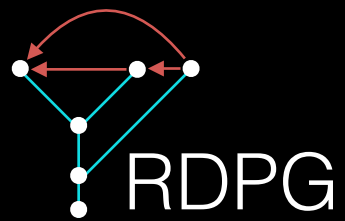








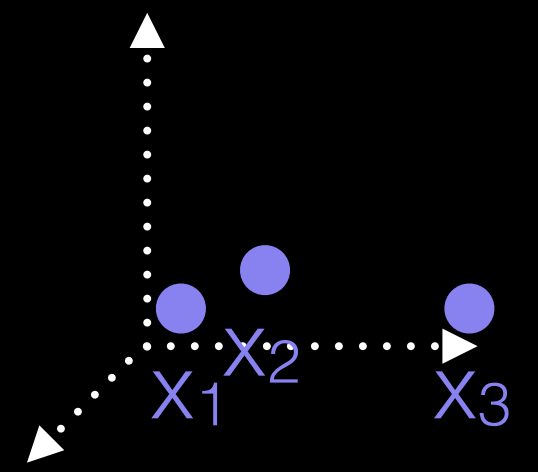
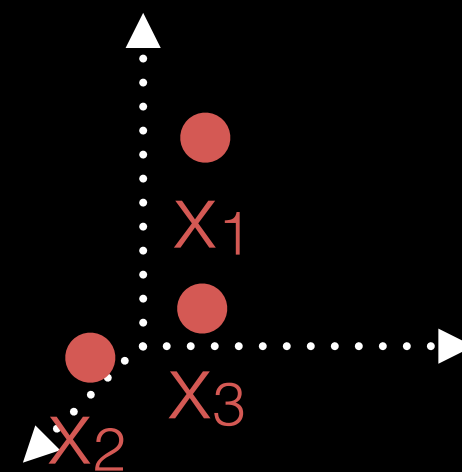
Because *TRAITS*

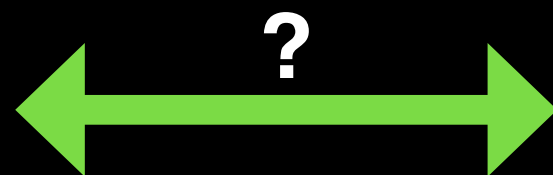
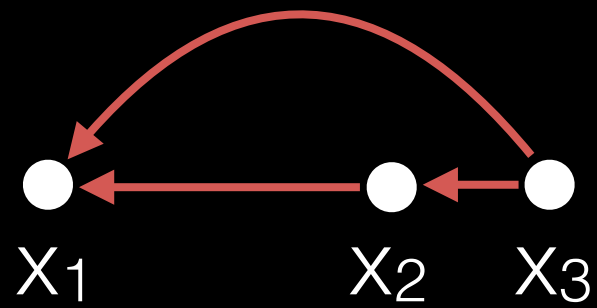
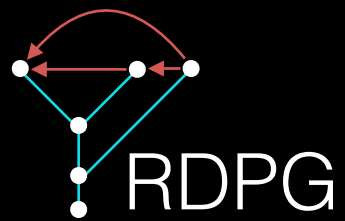


Traits

as prey

as predator

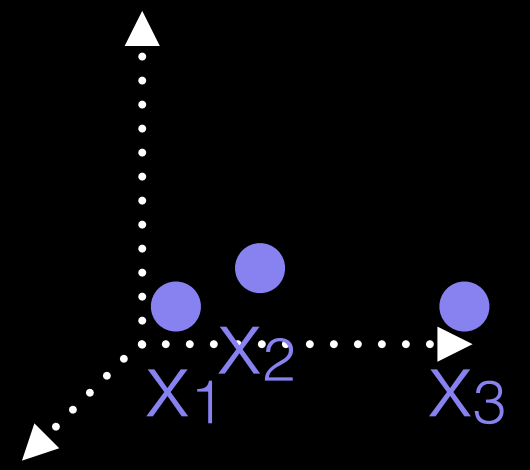
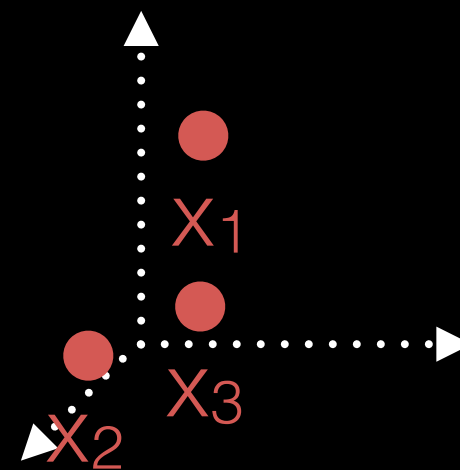


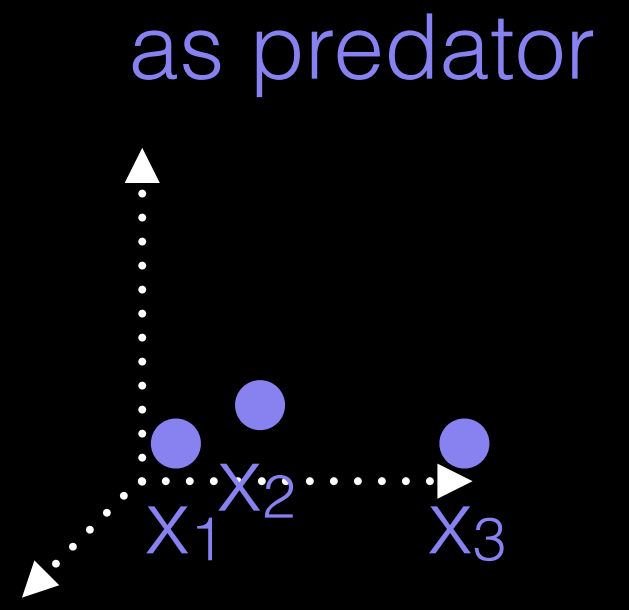
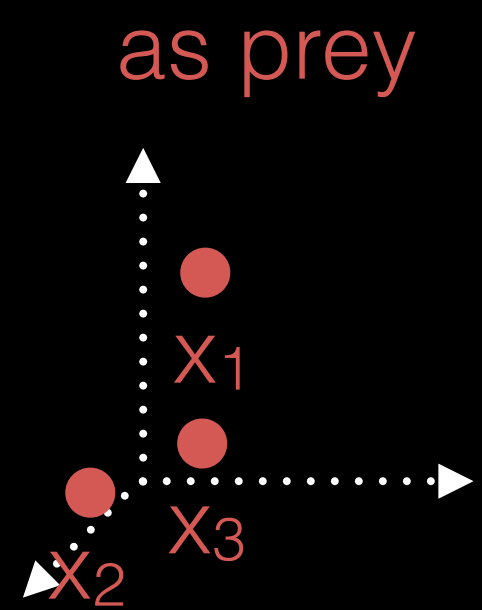
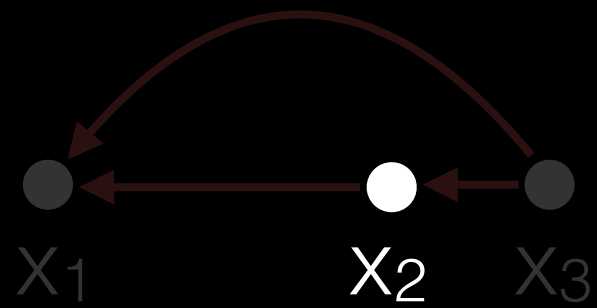
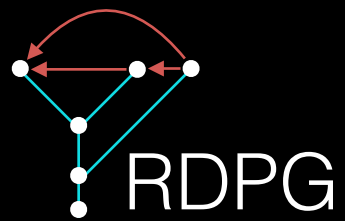


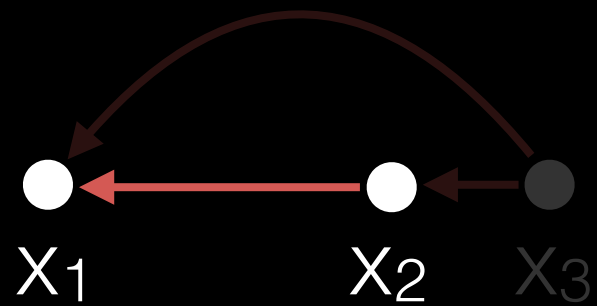
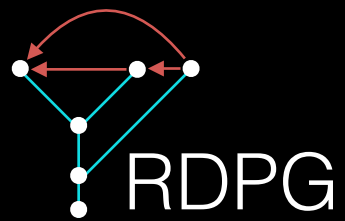
Traits

as prey

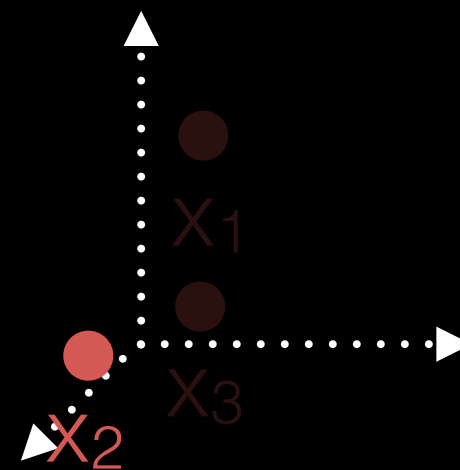
as predator



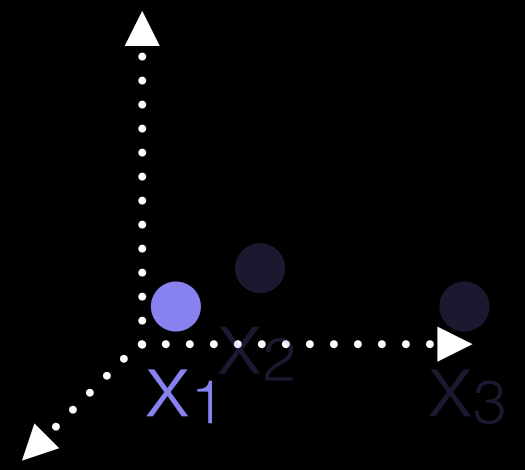




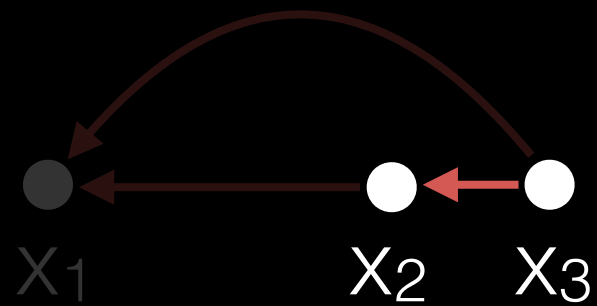
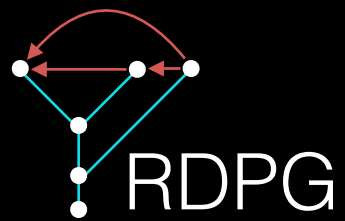
as prey



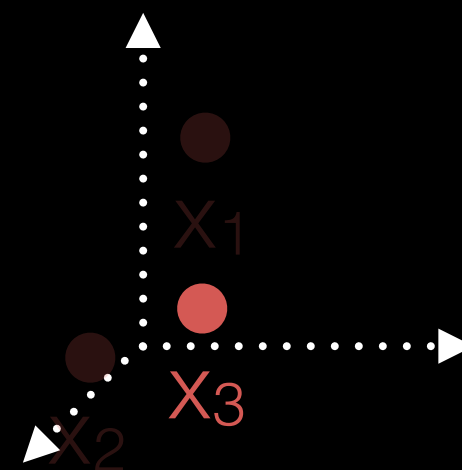
as predator



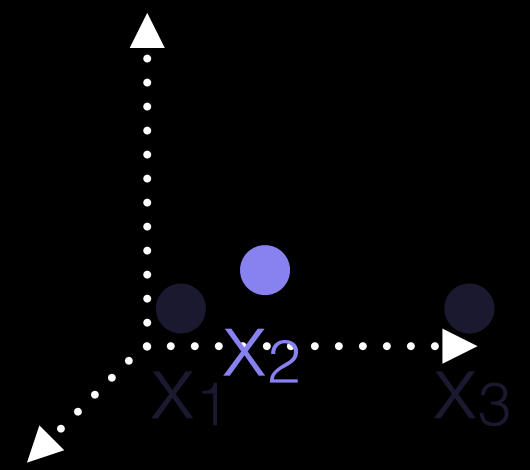
$$\mathbf{P}(X_2 \rightarrow X_1) = X_2 \cdot X_1$$



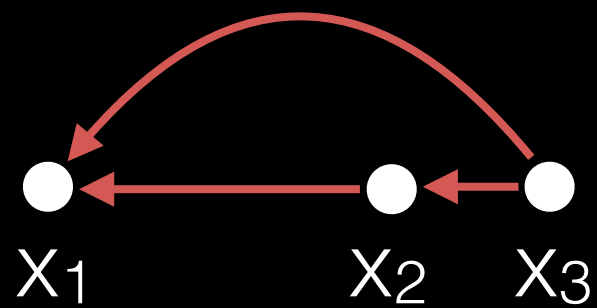
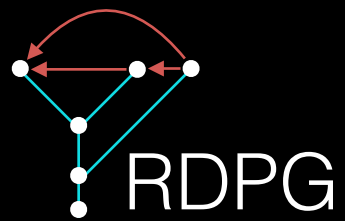
as prey



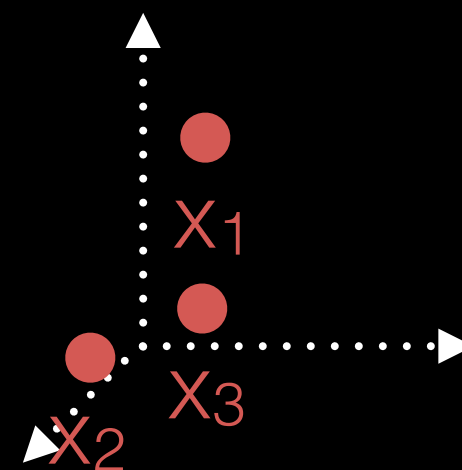
as predator



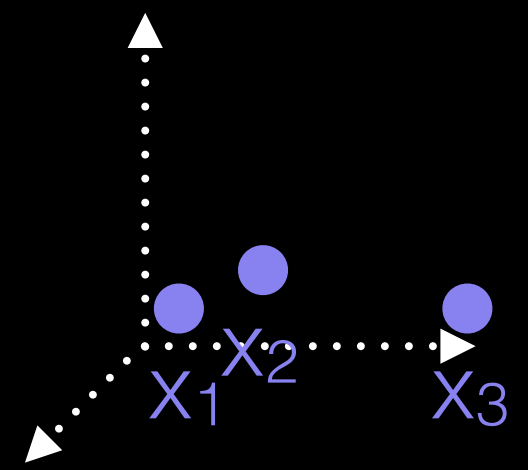
$$\mathbf{P}(X_2 \leftarrow X_3) = X_3 \cdot X_2$$



as prey

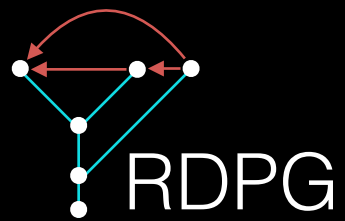


as predator

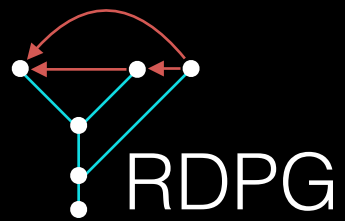


$$\mathbf{M} := \mathbf{X} \cdot \mathbf{X}^t$$

$$M_{ij} = P(x_i \rightarrow x_j)$$



$$P\left(\begin{array}{c} \text{Diagram 1} \\ \text{Diagram 2} \end{array} \right) =$$



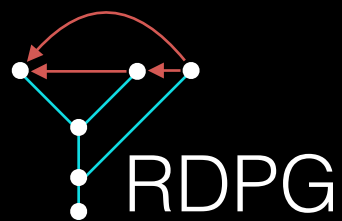
$$P\left(\begin{array}{c} \text{Diagram 1} \end{array} \middle| \begin{array}{c} \text{Diagram 2} \end{array}, \begin{array}{c} \text{Diagram 3} \end{array} \right) =$$

The equation defines a probability function P based on three diagrams. Diagram 1 shows three nodes x_1, x_2, x_3 with directed edges $x_3 \rightarrow x_2 \rightarrow x_1$ and a curved edge $x_3 \rightarrow x_1$. Diagram 2 shows three red nodes x_1, x_2, x_3 in a 2D coordinate system. Diagram 3 shows three blue nodes x_1, x_2, x_3 in a 2D coordinate system.



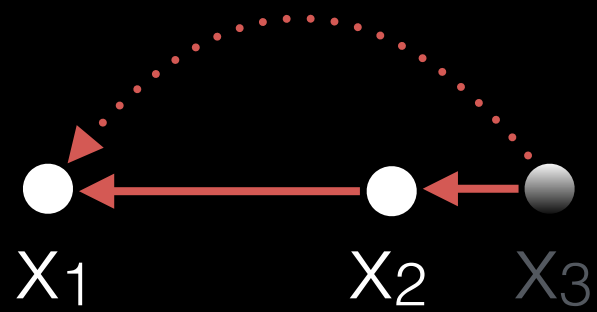
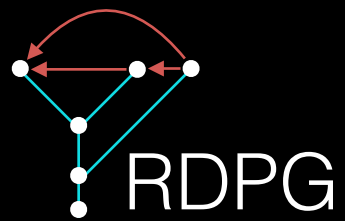
$$P\left(\begin{array}{c} \text{Diagram 1} \end{array} \mid \begin{array}{c} \text{Diagram 2} \end{array}, \begin{array}{c} \text{Diagram 3} \end{array} \right) =$$

$$B(A, M)$$

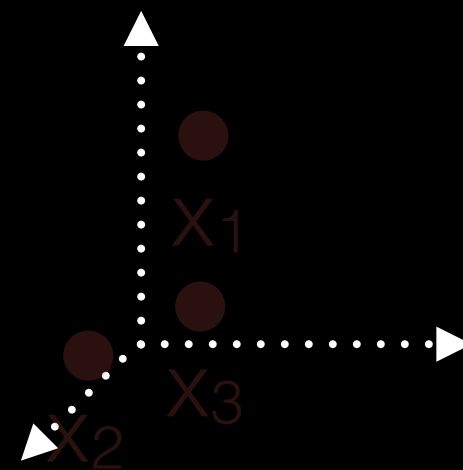


$$P\left(\begin{array}{c} \text{Diagram 1} \end{array} \middle| \begin{array}{c} \text{Diagram 2} \end{array} \right) =$$

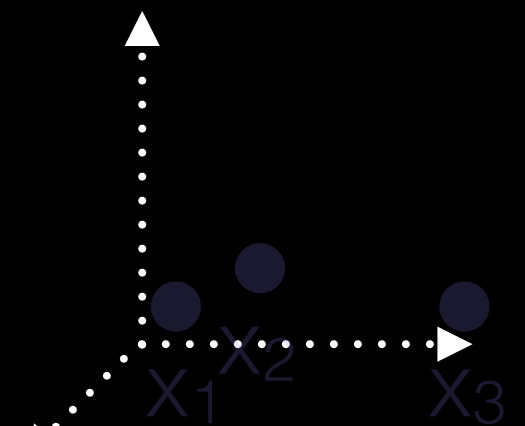
$$P\left(\begin{array}{c} \text{Diagram 1} \end{array} \middle| \begin{array}{c} \text{Diagram 3} \end{array} \right)$$



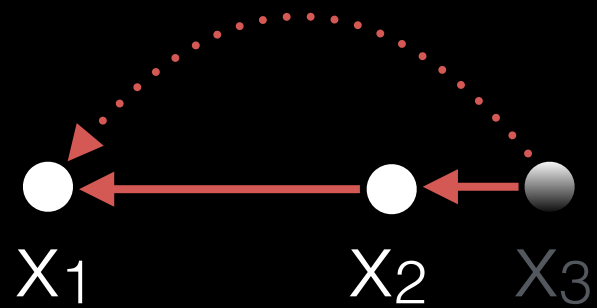
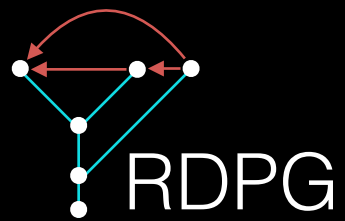
as prey



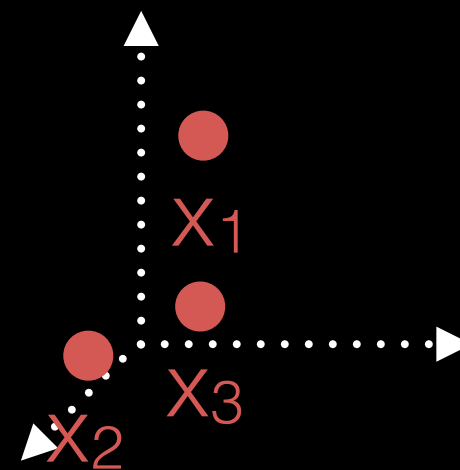
as predator



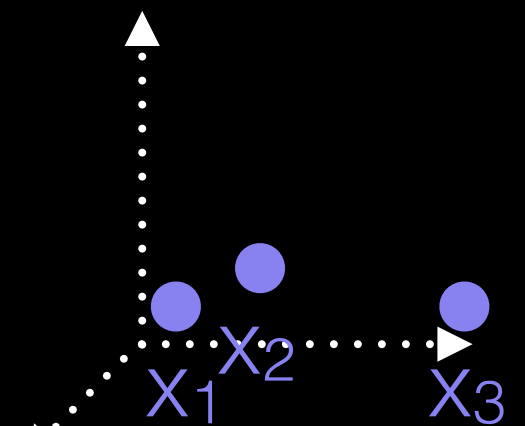
Alas!



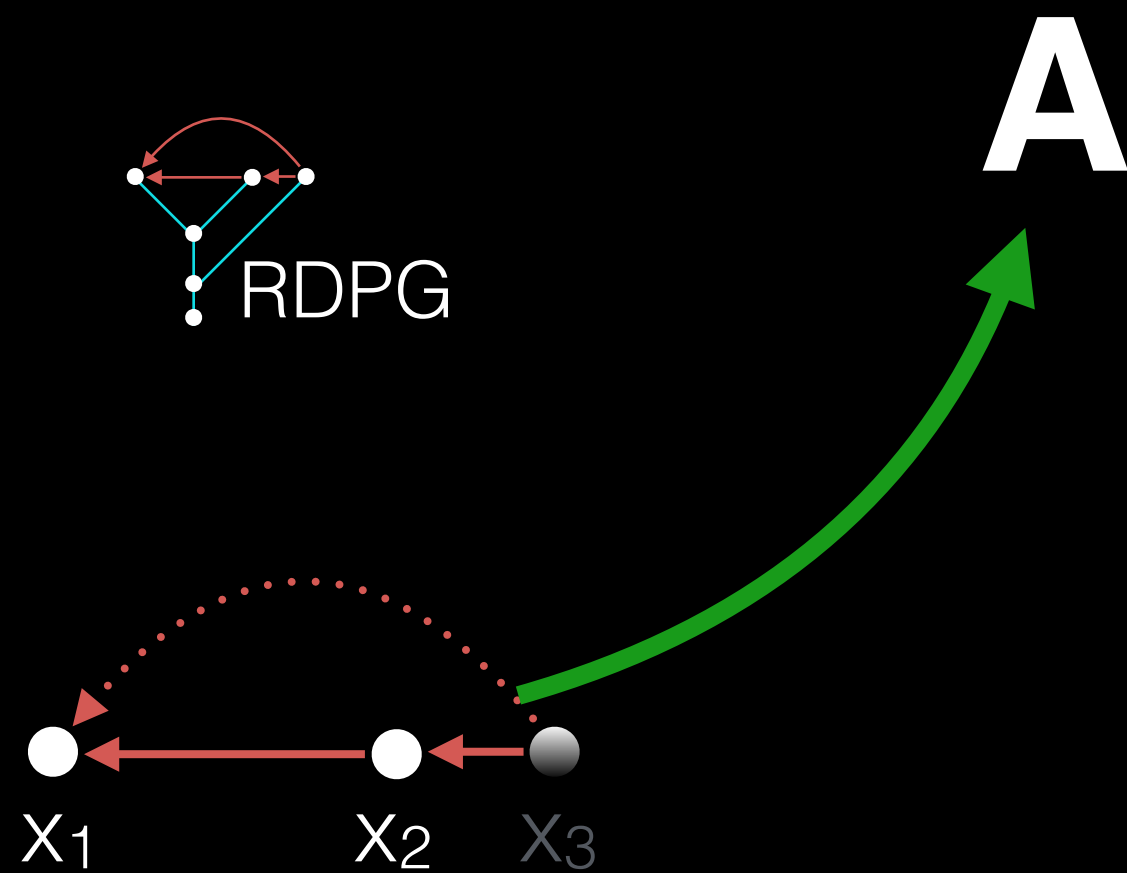
as prey



as predator



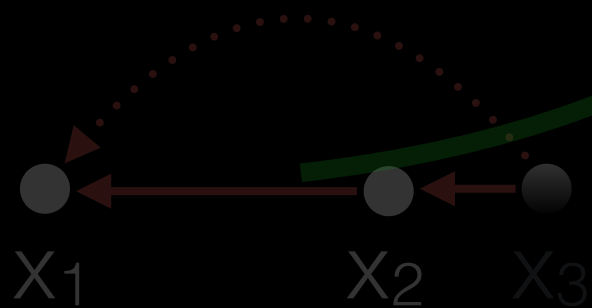
SVD!

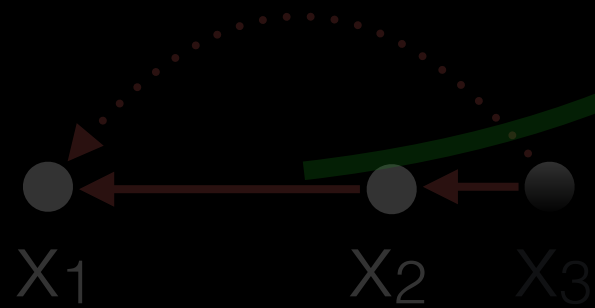
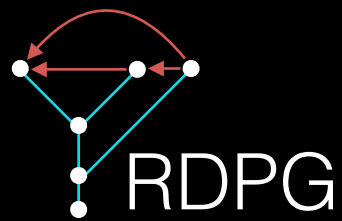




A

LSR

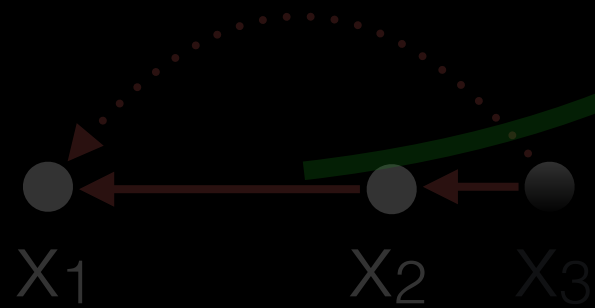
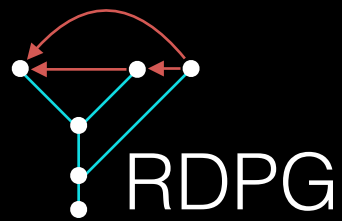




A

LSR

$L\sqrt{S} \sqrt{S}R$



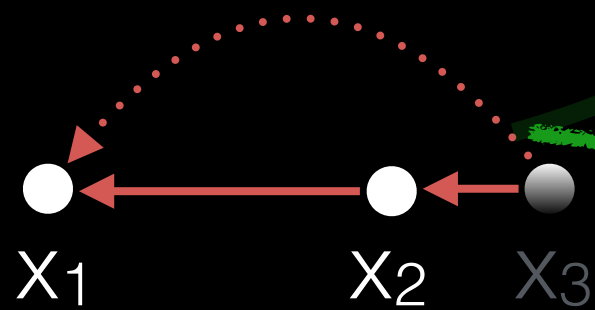
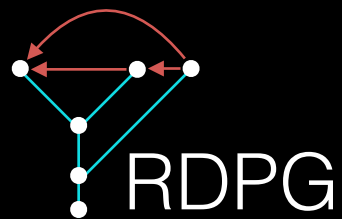
A

LSR

$$L\sqrt{S}\sqrt{S}R$$

d

$$L_d\sqrt{S_d}\sqrt{S_d}R_d$$



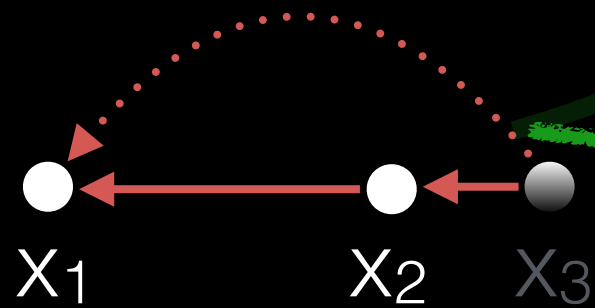
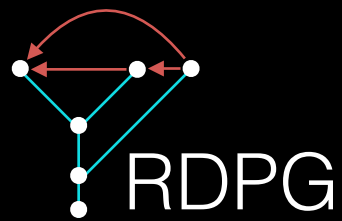
A

LSR

$L\sqrt{S} \sqrt{S}R$

d

$L_d\sqrt{S_d}$
 $\sqrt{S_d}R_d$



A

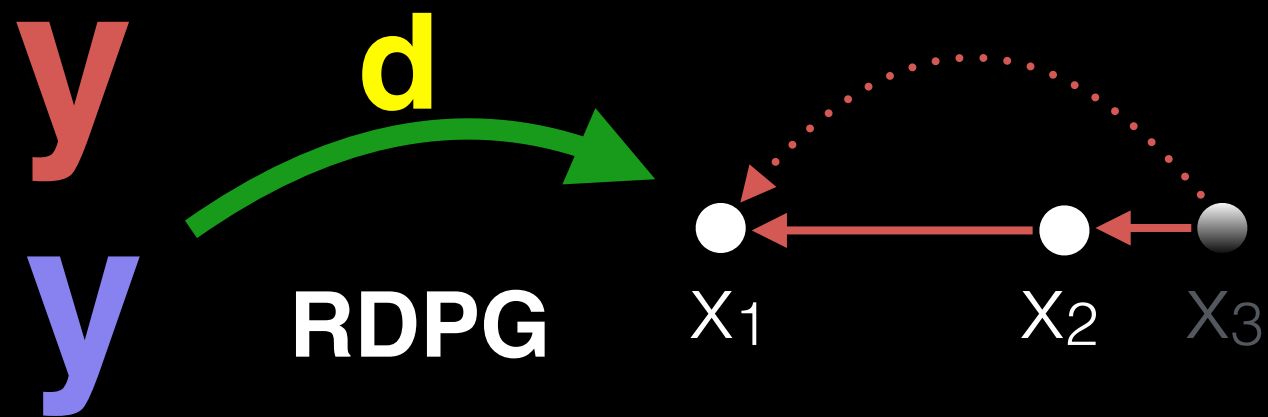
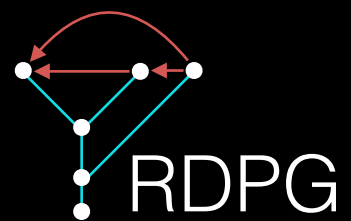
LSR

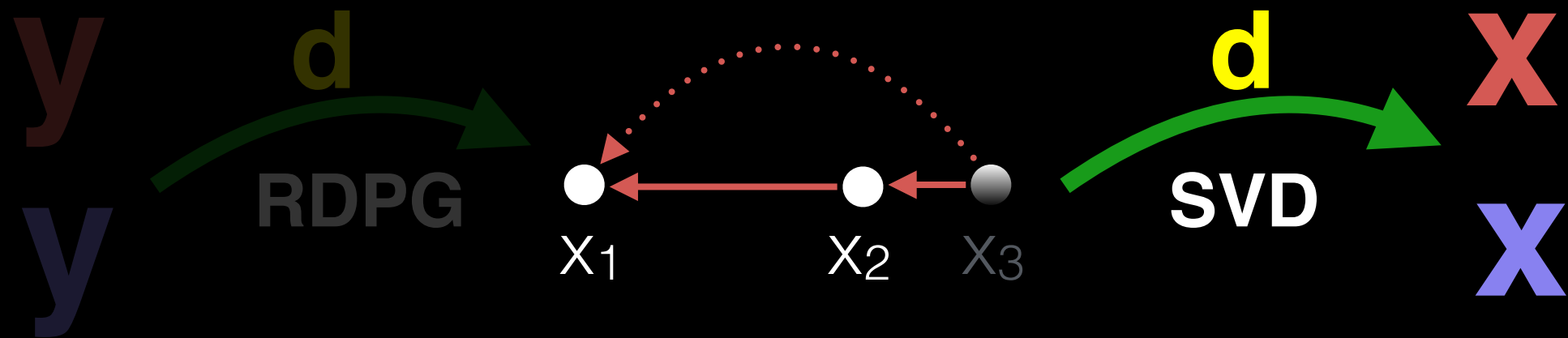
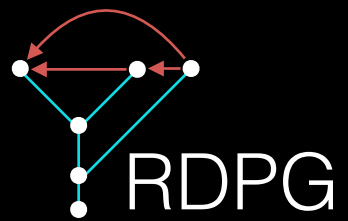
$L\sqrt{S} \sqrt{S}R$

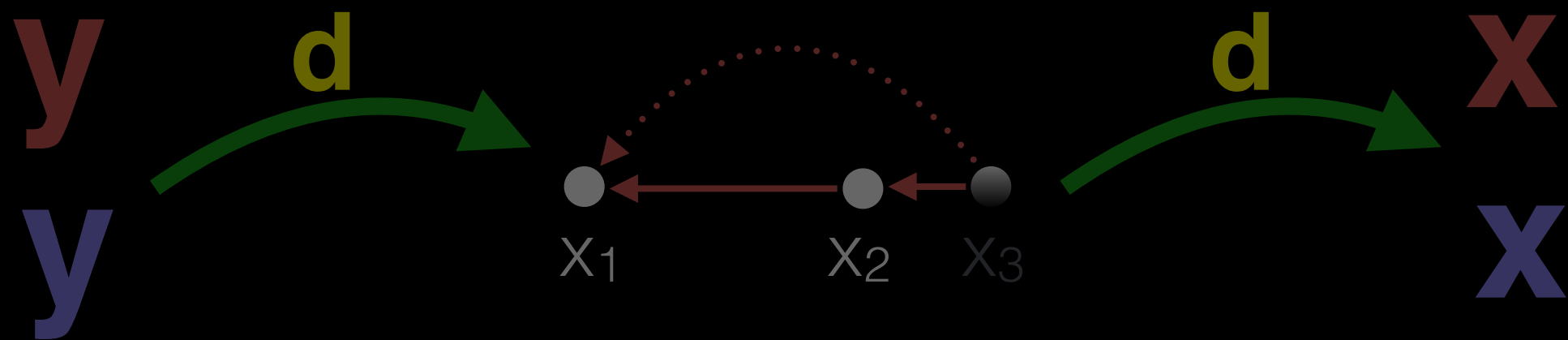
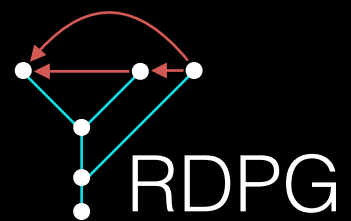
d

$$L_d \sqrt{S_d} = \text{prey } \mathbf{x}$$

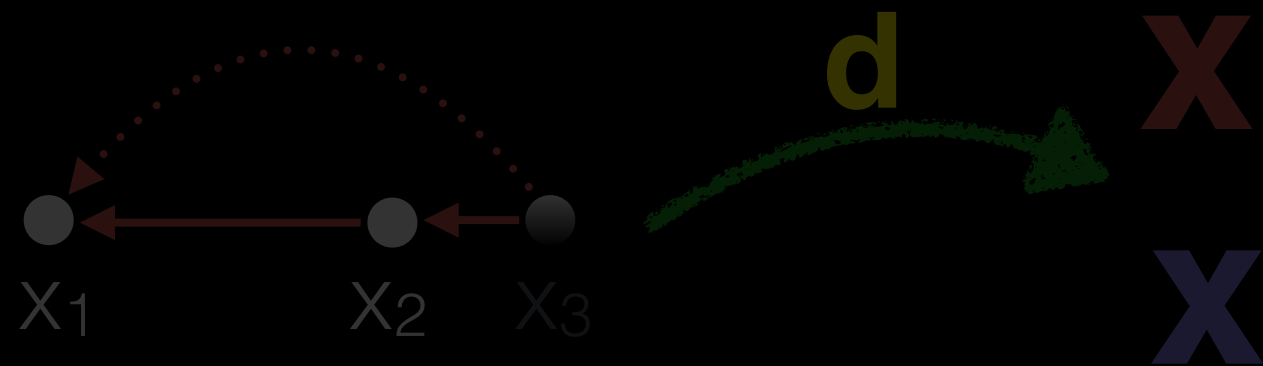
$$\sqrt{S_d} R_d = \mathbf{x}_{\text{predator}}^t$$



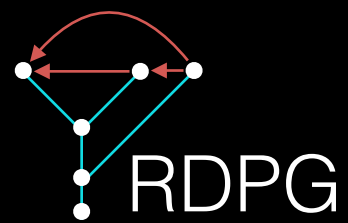




Thm: X X are MLE of y y



we need to choose **d**



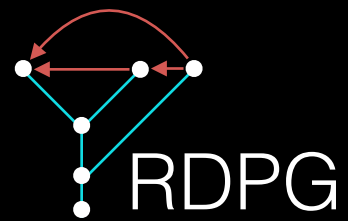
$$P\left(\begin{array}{c} \text{Graph} \\ \text{X}_1, \text{X}_2, \text{X}_3 \end{array} \middle| \begin{array}{c} \text{Point Cloud 1} \\ \text{X}_1, \text{X}_2, \text{X}_3 \end{array}, \begin{array}{c} \text{Point Cloud 2} \\ \text{X}_1, \text{X}_2, \text{X}_3 \end{array} \right) =$$

$$P\left(\begin{array}{c} \text{Graph} \\ \text{X}_1, \text{X}_2, \text{X}_3 \end{array} \middle| \begin{array}{c} \text{Point Cloud 1} \\ \text{X}_1, \text{X}_2, \text{X}_3 \end{array}, \begin{array}{c} \text{Point Cloud 2} \\ \text{X}_1, \text{X}_2, \text{X}_3 \end{array} \right)$$

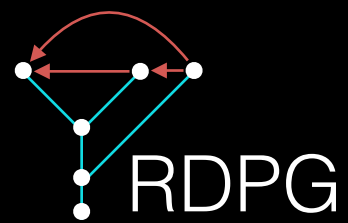


X, **X**

unique up to an orthogonal transformation



Did evolution leave a trace
in the structure
of ecological networks?

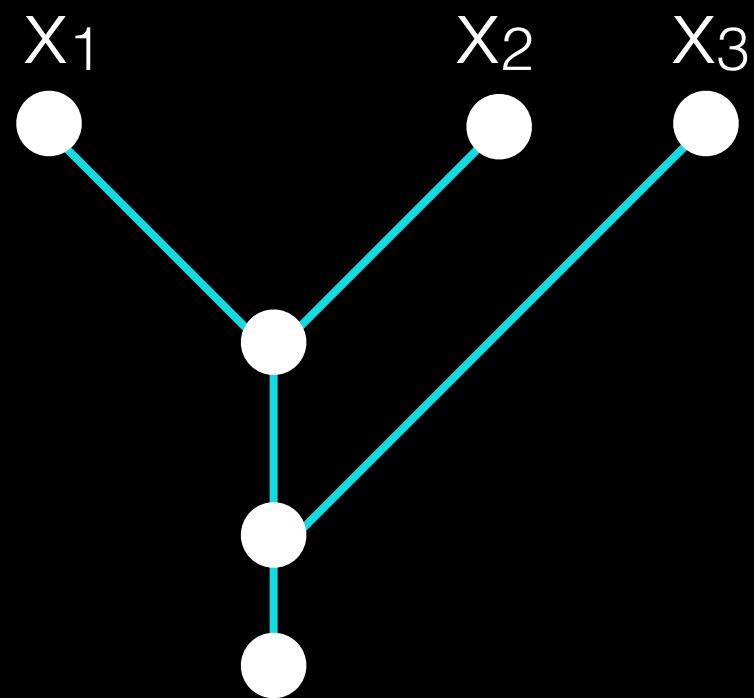


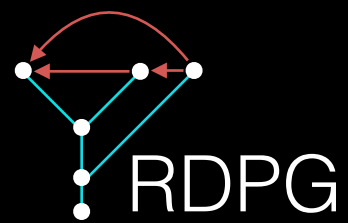
Did evolution leave a trace
in the structure
of ecological networks?

Are  *predicted by*  ?

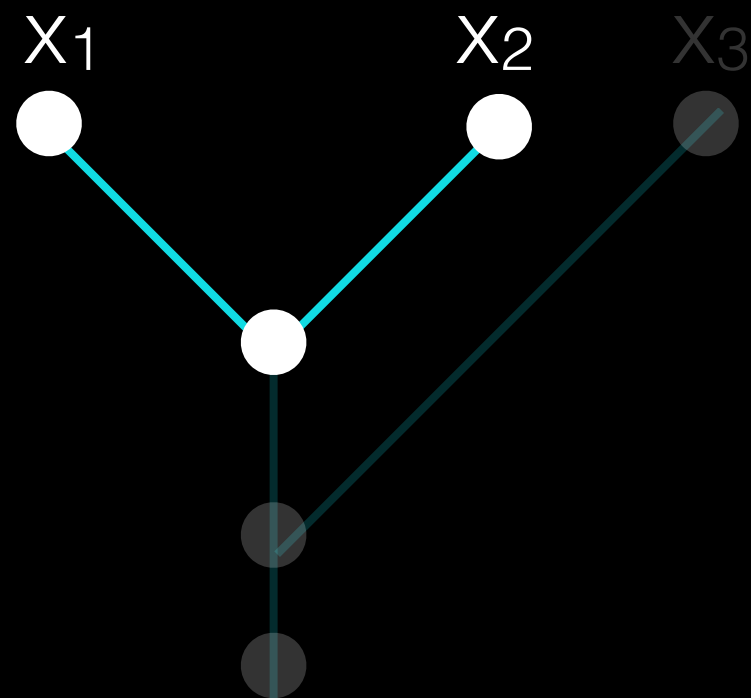


Did evolution leave a trace
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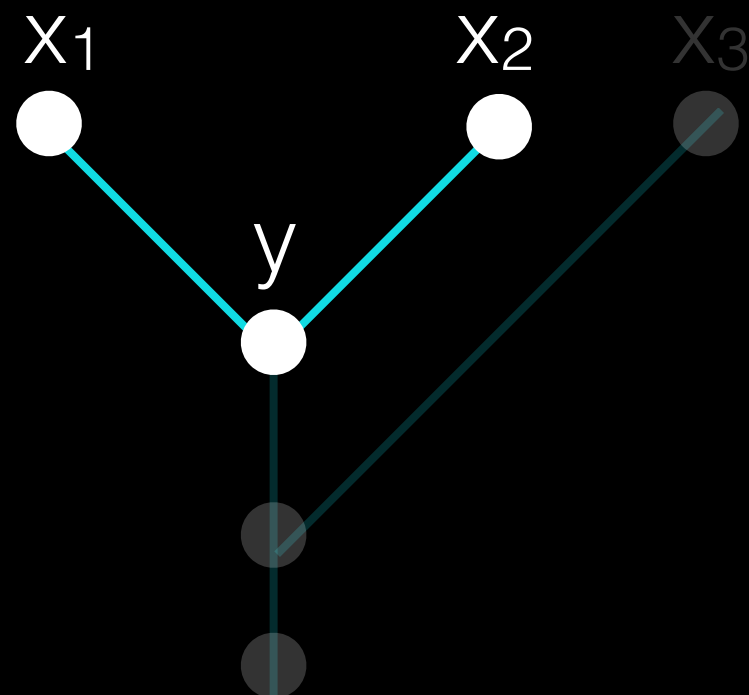


Did evolution leave a trace
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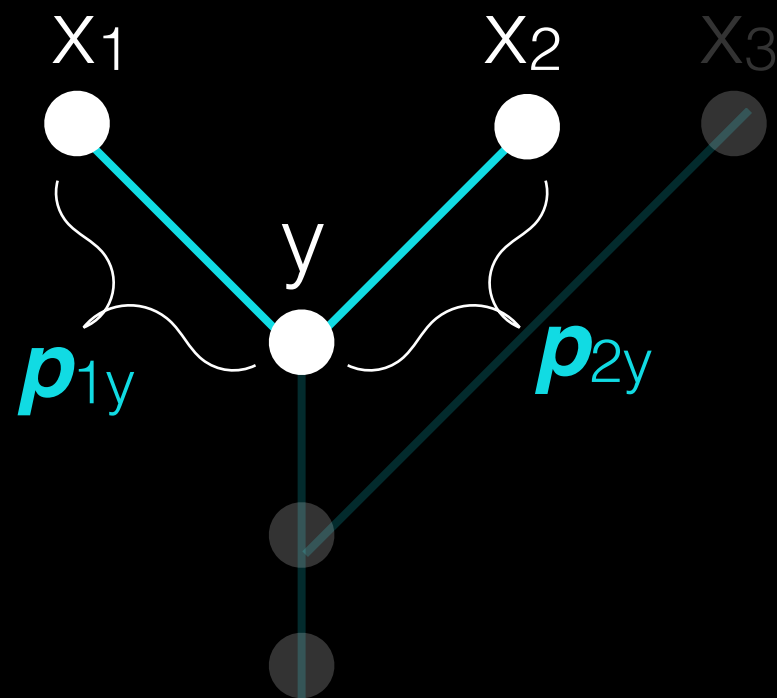


Did evolution leave a trace
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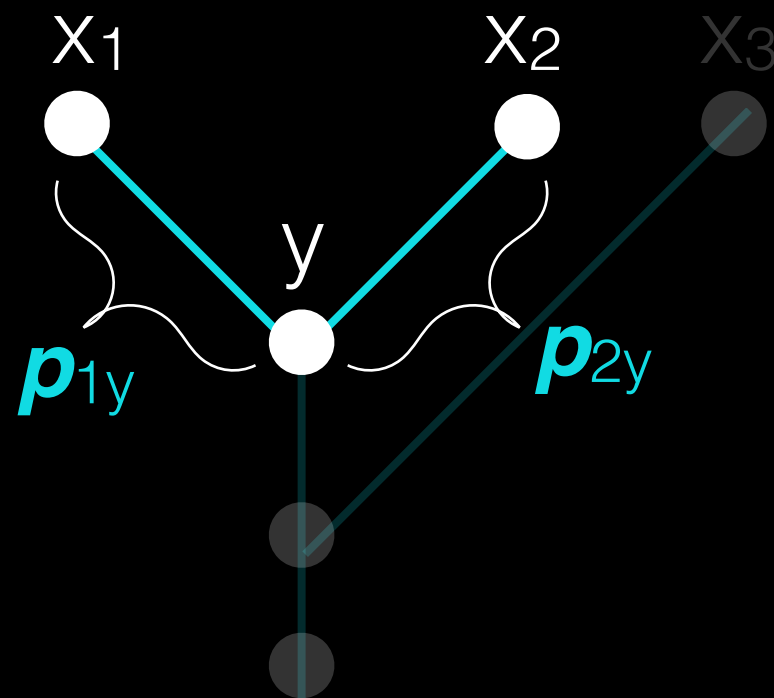


Did evolution leave a trace
in the topological structure
of ecological networks?

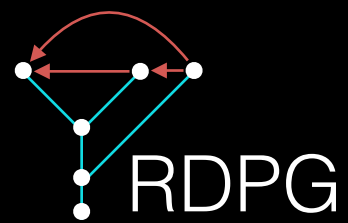




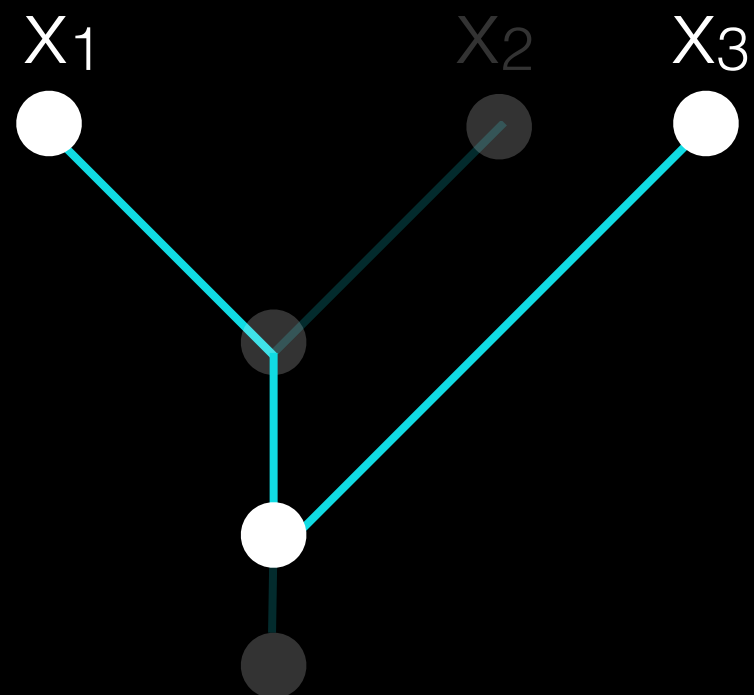
Did evolution leave a trace
in the topological structure
of ecological networks?



$$p_{12} = p_{1y} + p_{2y}$$



Did evolution leave a trace
in the topological structure
of ecological networks?

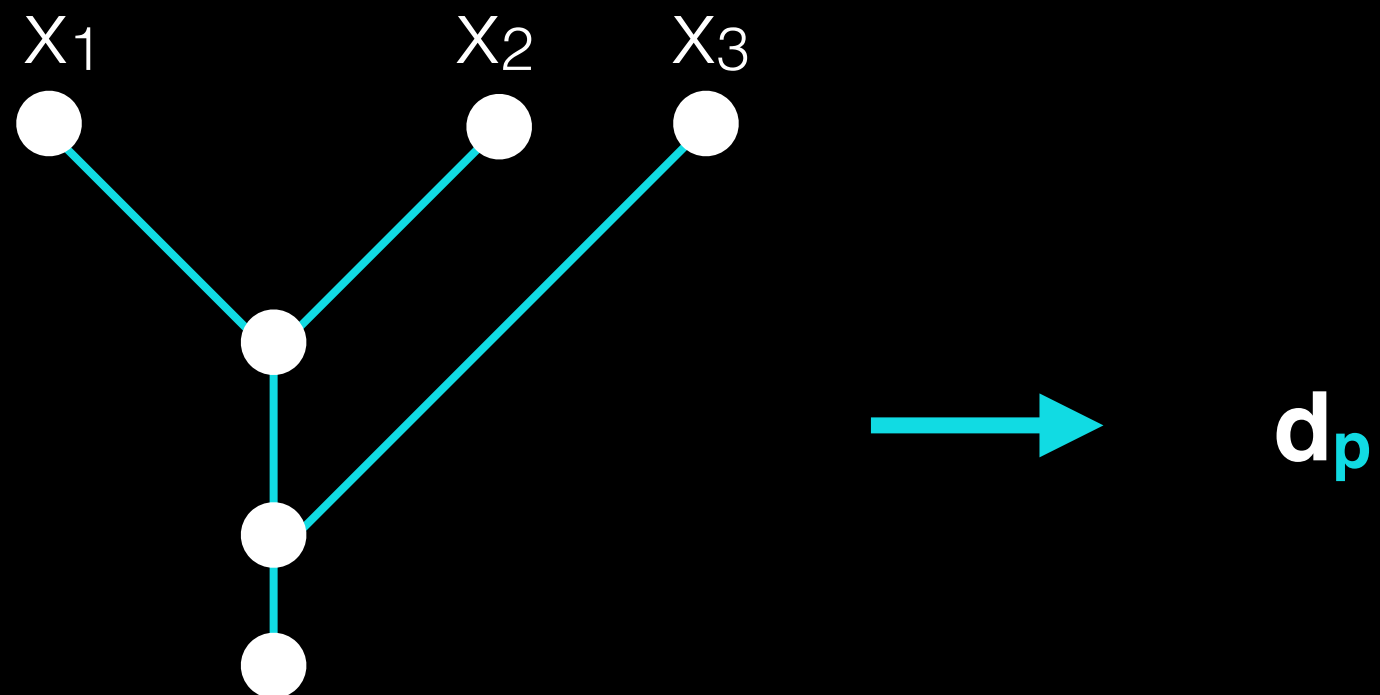


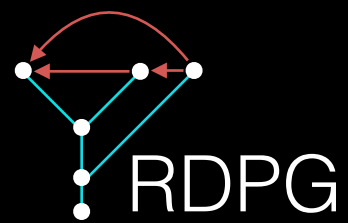
$$p_{12} = p_{1y} + p_{2y}$$

$$p_{13} = \dots$$

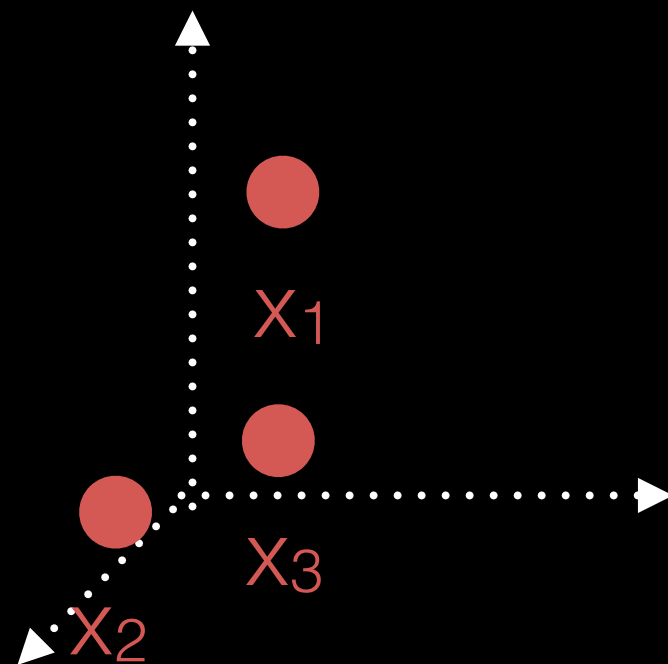


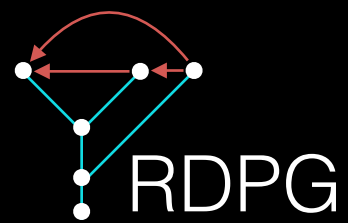
Did evolution leave a trace
in the topological structure
of ecological networks?



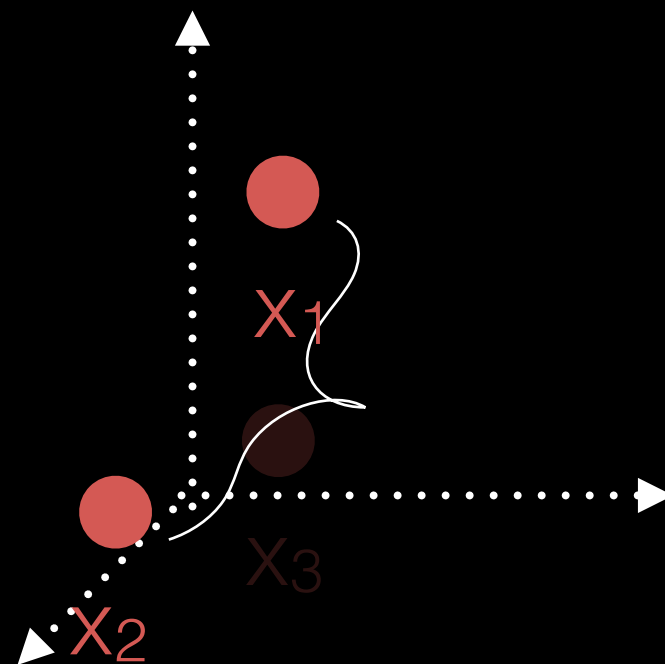


Did evolution leave a trace
in the topological structure
of ecological networks?



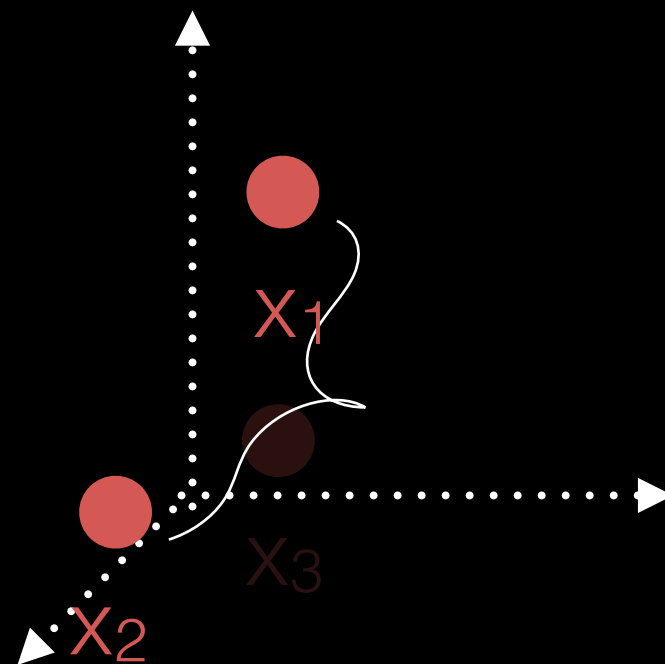


Did evolution leave a trace
in the topological structure
of ecological networks?

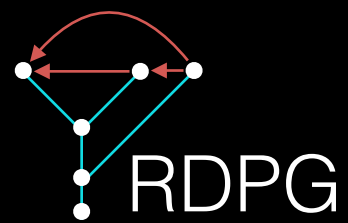




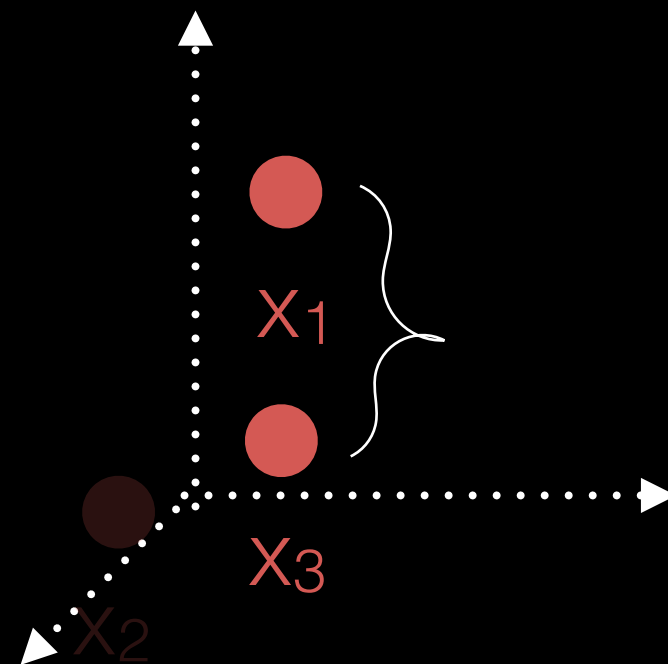
Did evolution leave a trace
in the topological structure
of ecological networks?



$$x_{12} = d(x_1, x_2)$$

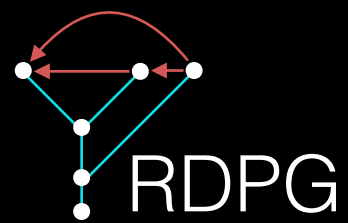


Did evolution leave a trace
in the topological structure
of ecological networks?

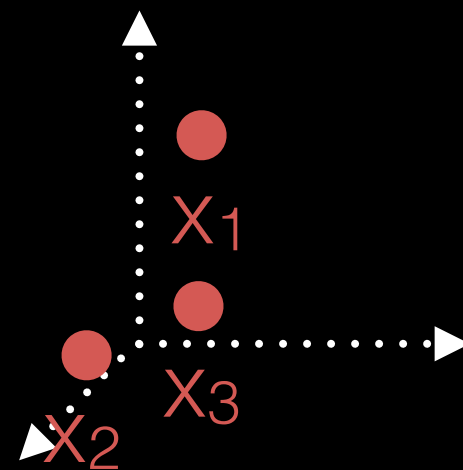


$$\mathbf{x}_{12} = d(x_1, x_2)$$

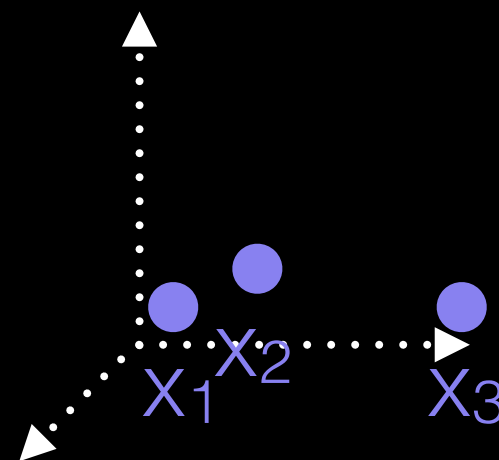
$$\mathbf{x}_{13} = d(x_1, x_3)$$



Did evolution leave a trace
in the topological structure
of ecological networks?



d_x



d_x



Did evolution leave a trace
in the structure
of ecological networks?

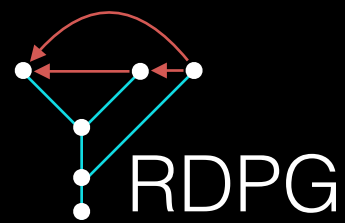
Are   *predicted* by  ?

Are \mathbf{d}_x \mathbf{d}_x *predicted* by \mathbf{d}_p ?

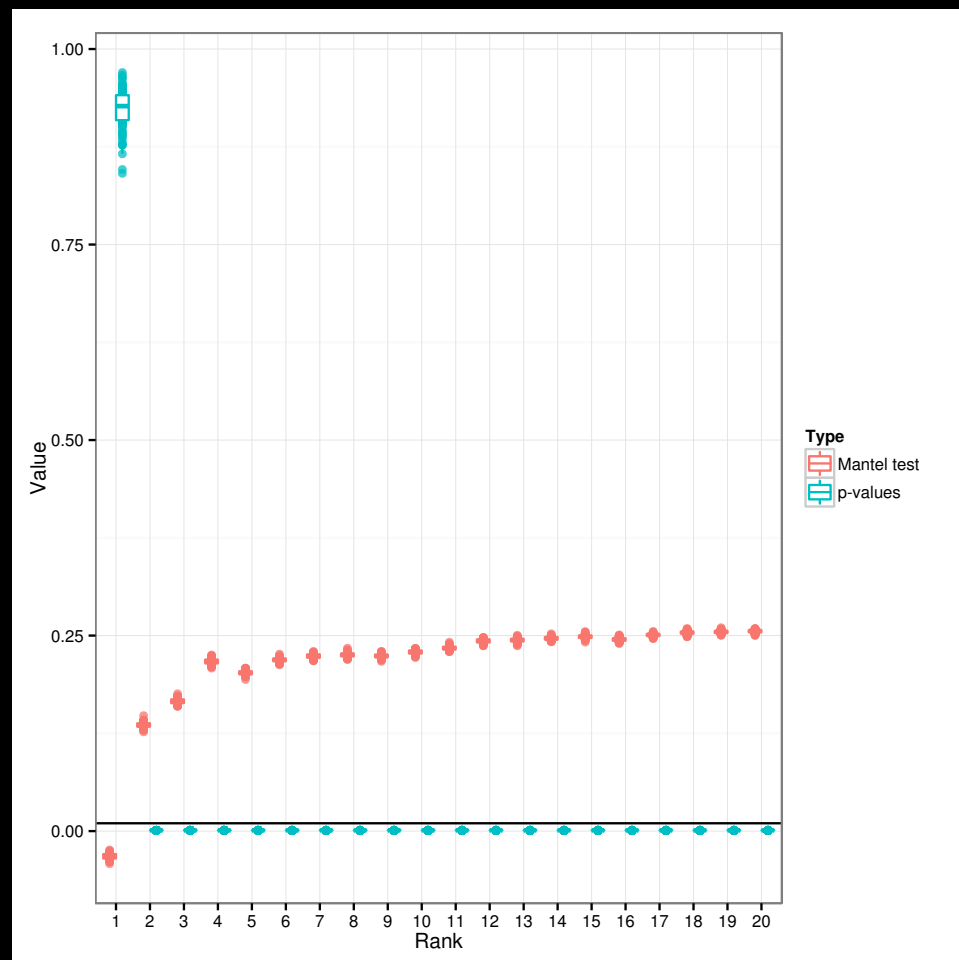


Did evolution leave a trace
in the structure
of ecological networks?

yes

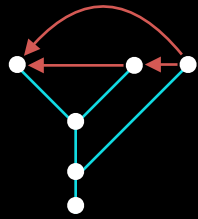


Did evolution leave a trace
in the structure
of ecological networks?



yes, and starting from **d**

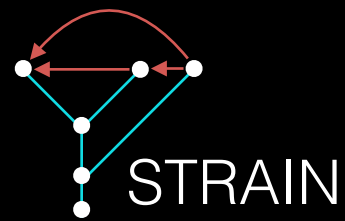
Dalla Riva, G. V. and Stouffer, D. B. (2015), Exploring the evolutionary signature of food webs' backbones using functional traits. *Oikos*. doi: 10.1111/oik.02305



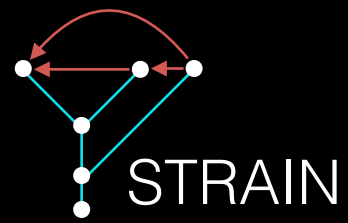
CENTRALITY

with Carey E. Priebe (JHU)

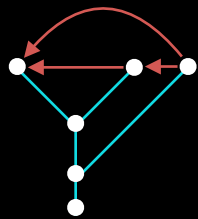
with Arne Ø. Mooers (SFU) and Mike Steel



How do we measure
the importance of nodes
in a RDPG framework?

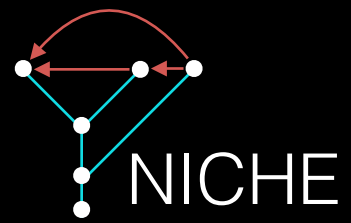


Are ecological unique species
evolutionary distinctive?

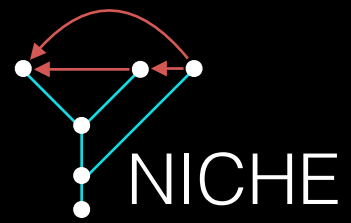


NICHE

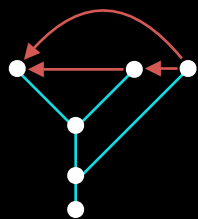
with M Huttchinson, DB Stouffer and M Dehling



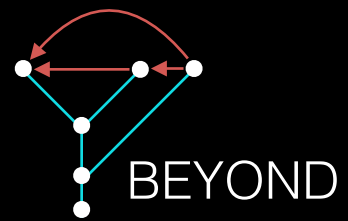
How do species' niches evolve?



How do we detect the effect
of interactions
in species' evolution?

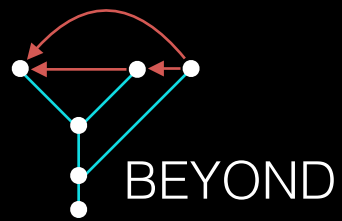


BEYOND

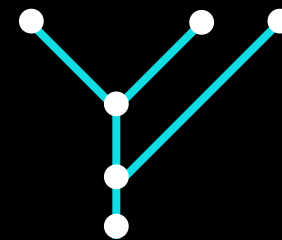


How do species' evolve in  ?

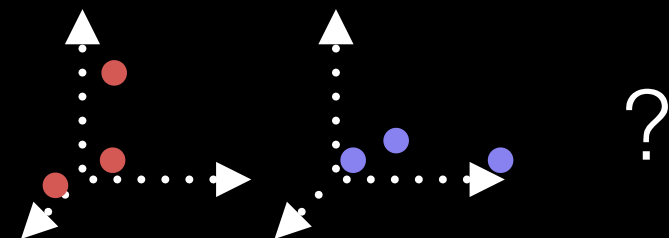
with M Doebeli (UBC)



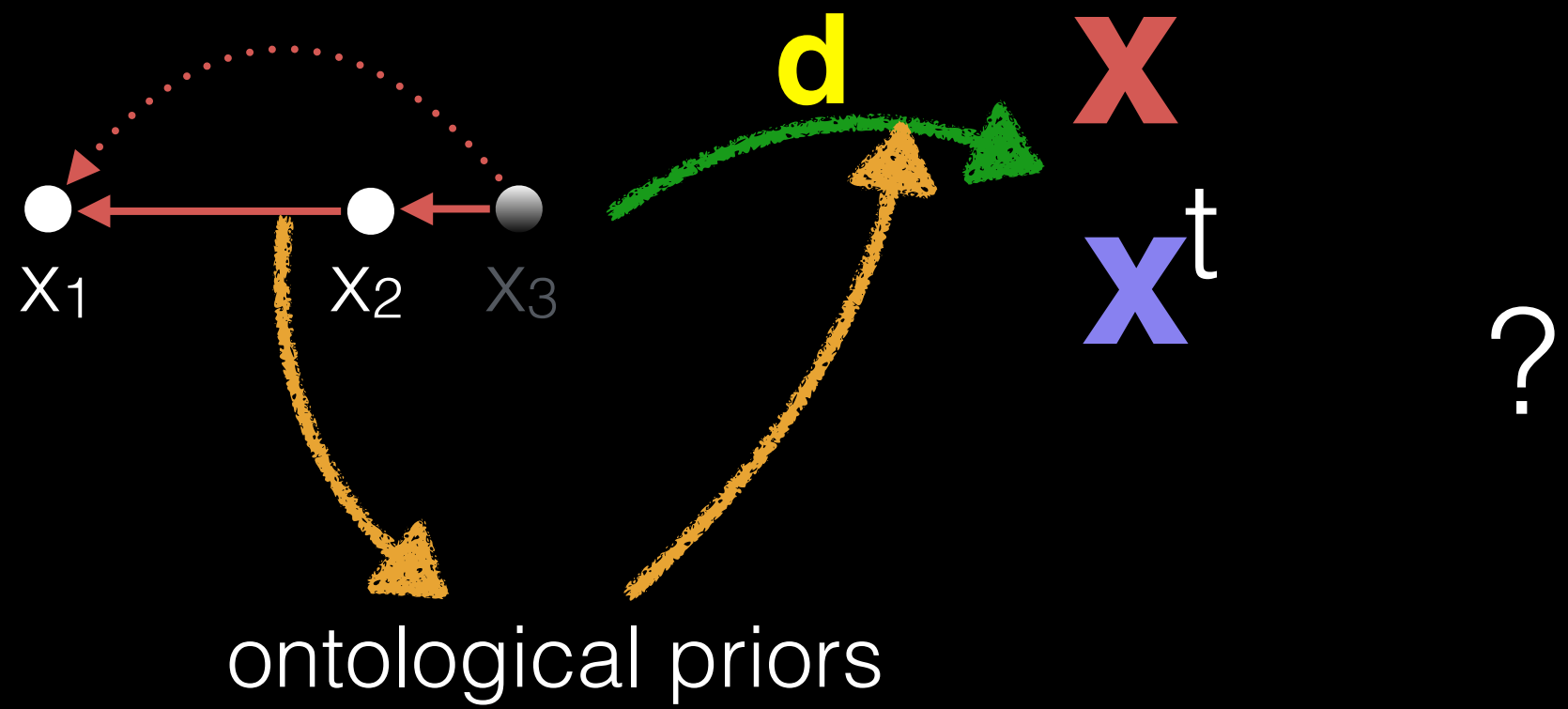
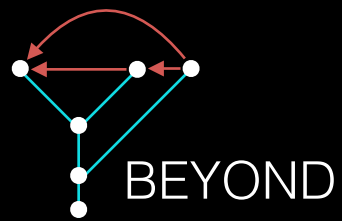
Under which scenarios unique in



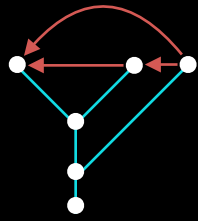
means unique in



with M Doebeli (UBC)



with Carey E Priebe (JHU)



*Because we are all responsible for all
[...] I go for all [...]*

*–Fyodor Dostoyevsky
The Brothers Karamazov*