

Strategies in nature:
using game theory to deal
with different problems

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Evolutionary game theory

- Evolutionary games
 - *My strategy and my interactions with the others affect my fitness*

Evolutionary game theory

- Evolutionary games
 - *My strategy and my interactions with the others affect my fitness*
 - *My best strategy depends on what the others are doing*

Evolutionary game theory

Cooperation, Defection...

And in Biology? Ecology? What are the strategies?

Hawk and Dove



Hawk

Dove

Hawk

$$\frac{b-c}{2}$$


b

Dove

0

$\frac{b}{2}$

Hawk and Dove




	Hawk	Dove
Hawk	$\frac{b-c}{2}$	b
Dove	0	$\frac{b}{2}$

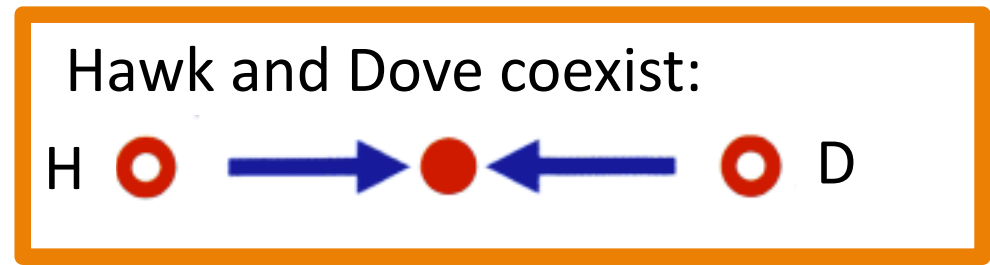


$$b > c$$

Hawk and Dove


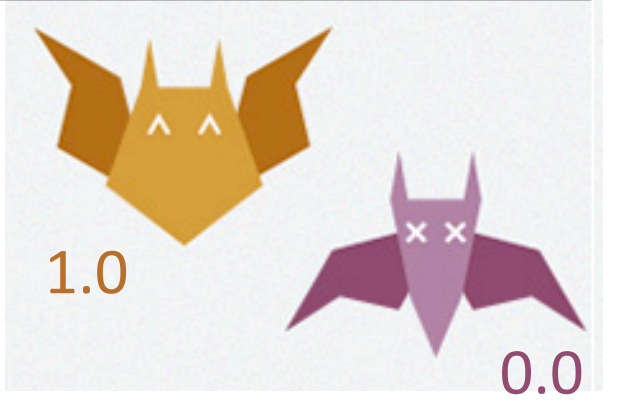

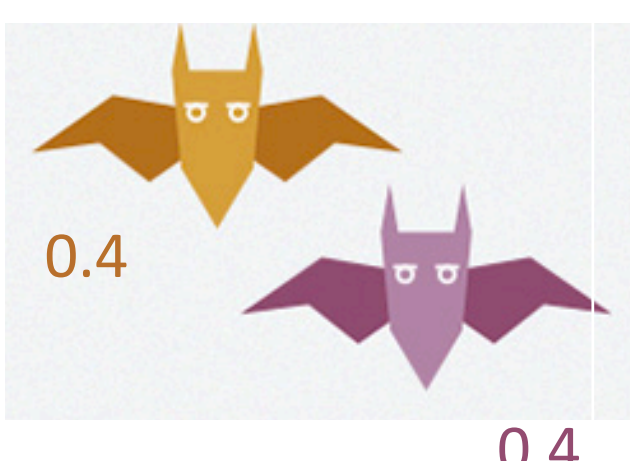


	Hawk	Dove
Hawk	$\frac{b-c}{2}$	b
Dove	0	$\frac{b}{2}$



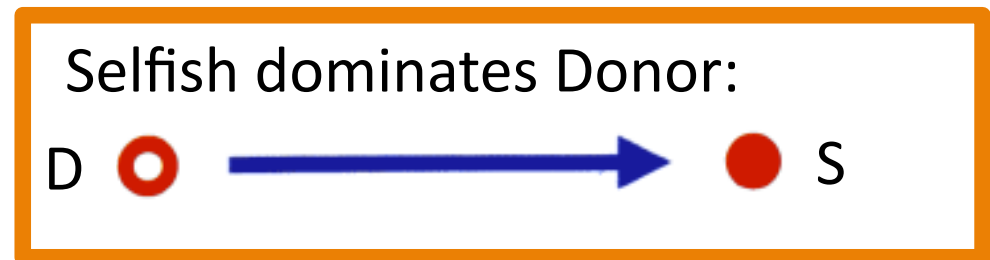
$$b < c$$

Prisoner's Dilemma


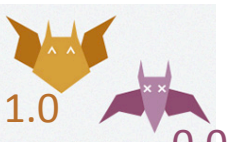


	Donor	Selfish
Donor	 <p>0.9 0.9</p>	 <p>1.0 0.0</p>
Selfish	 <p>0.0 1.0</p>	 <p>0.4 0.4</p>

Prisoner's Dilemma

	Donor	Selfish
Donor	 0.9 0.9	 1.0 0.0
Selfish	 0.0 1.0	 0.4 0.4


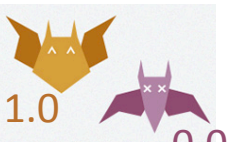
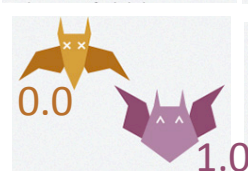



Prisoner's Dilemma

	Cooperator	Defector
Cooperator	 0.9	 1.0 0.0
Defector	 0.0 1.0	 0.4 0.4



Prisoner's Dilemma

	Cooperator	Defector
Cooperator	 0.9, 0.9	 1.0, 0.0
Defector	 0.0, 1.0	 0.4, 0.4

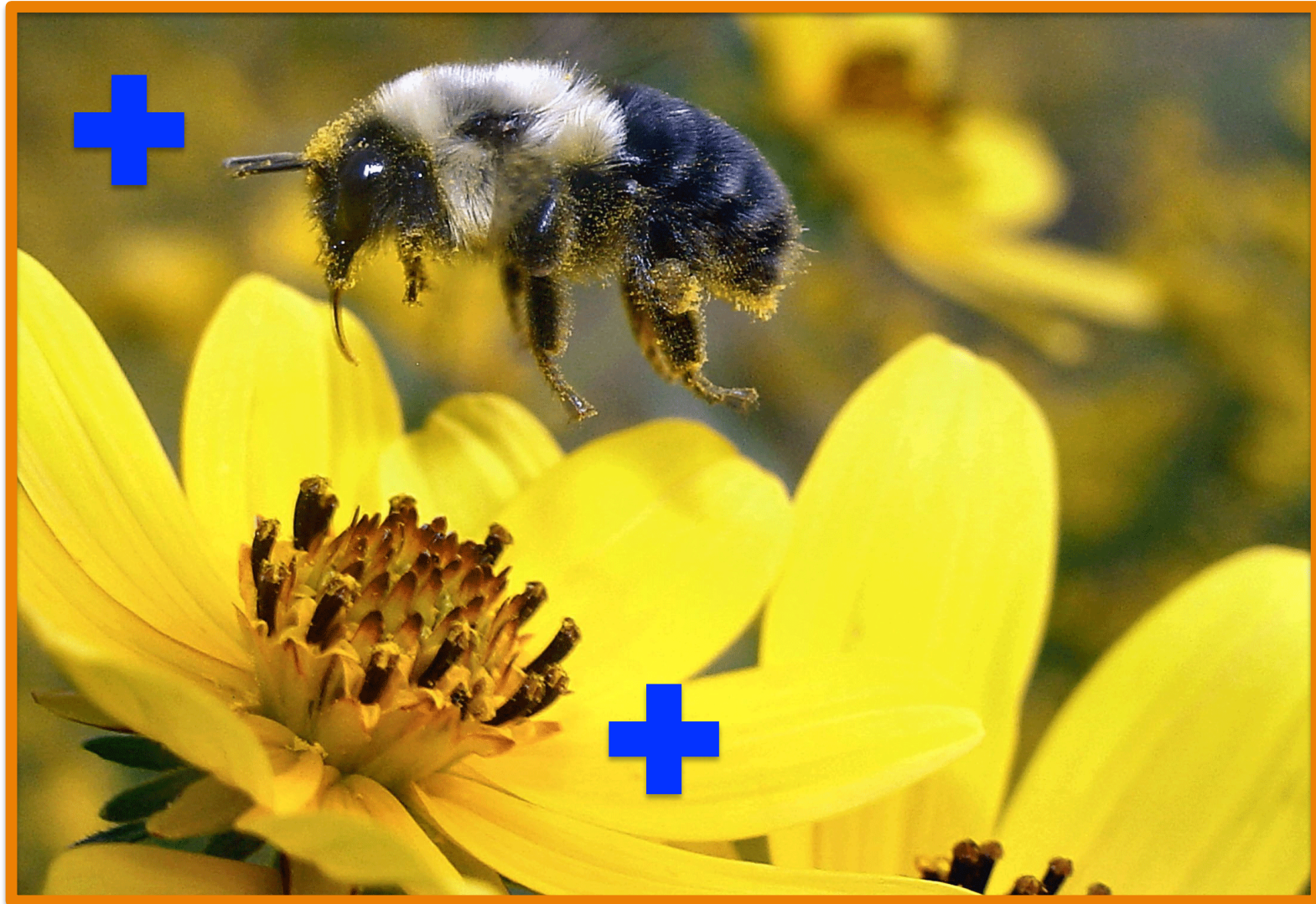


Direct reciprocity \rightarrow Cooperators

Mutualisms



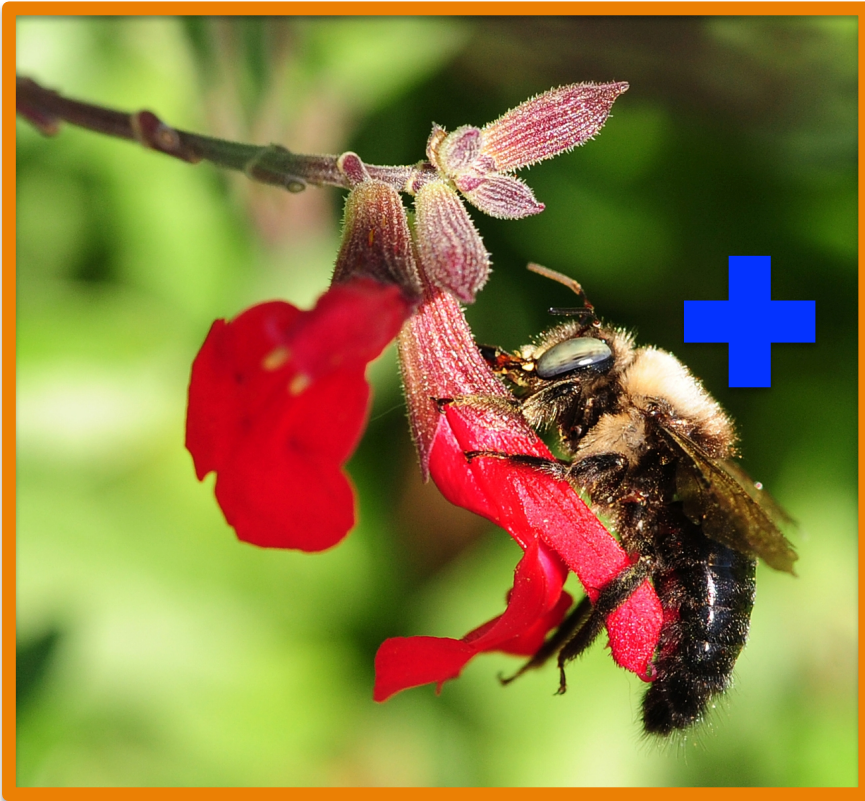
Mutualisms



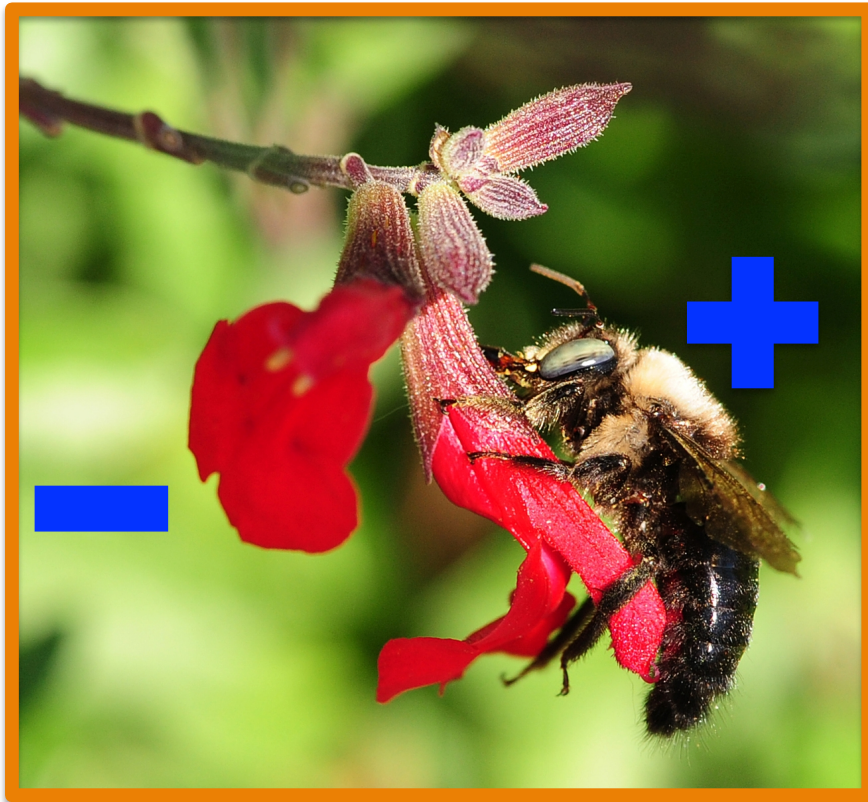
Flowers and nectar robbers



Flowers and nectar robbers



Flowers and nectar robbers



Flowers and nectar robbers



Flowers and nectar robbers



Flowers and flower visitors



Flowers and nectar robbers



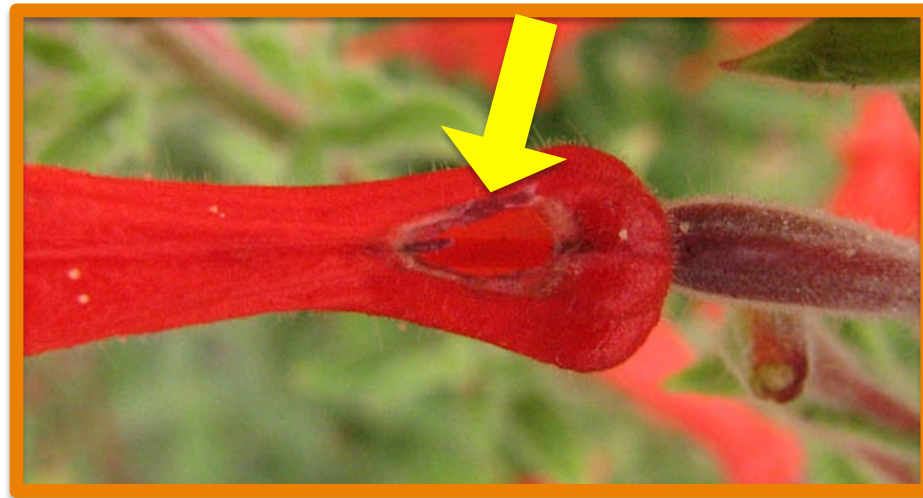
Flower structures



Flower structures







Costs of robbery







Coexistence?

Robbery cost to the tubular flower

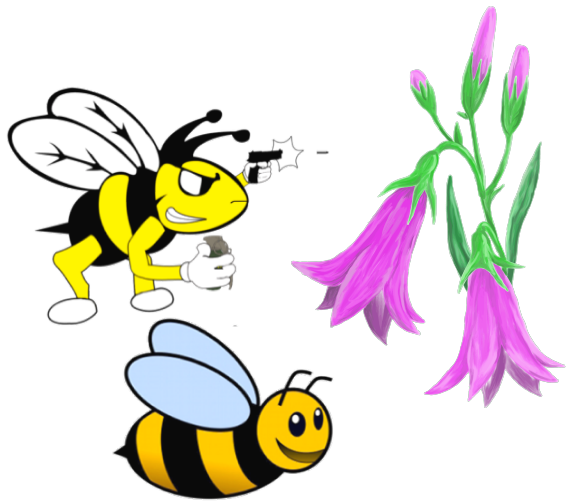
	
	
ϵ	$\epsilon - \phi$
ϵ	$\epsilon - \phi - \delta$

Benefit to the robber for robbing

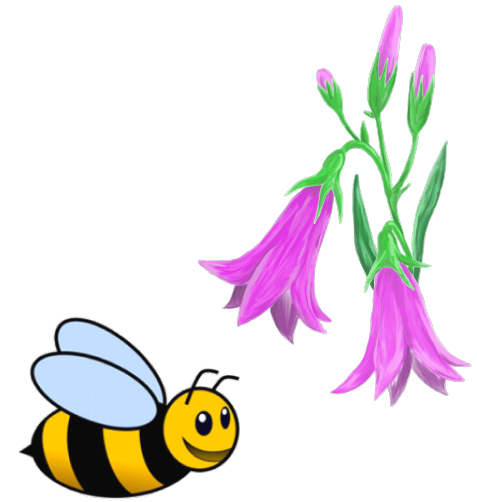
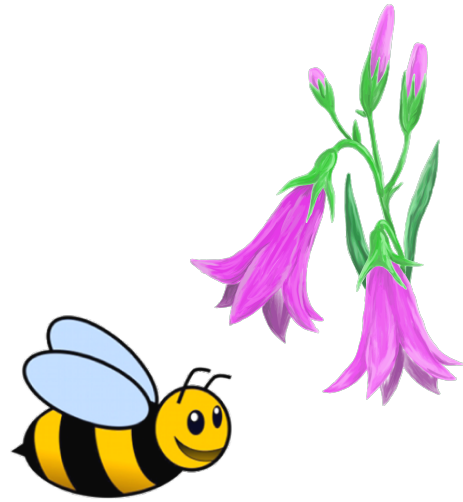
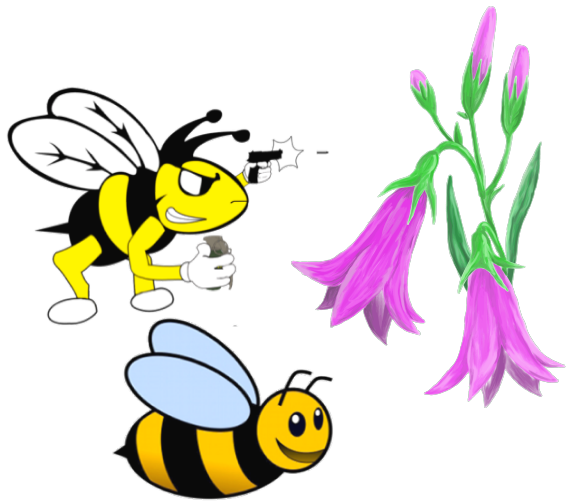
	
	
α	β
$\alpha + \gamma$	$\beta + \gamma$



Sinergy

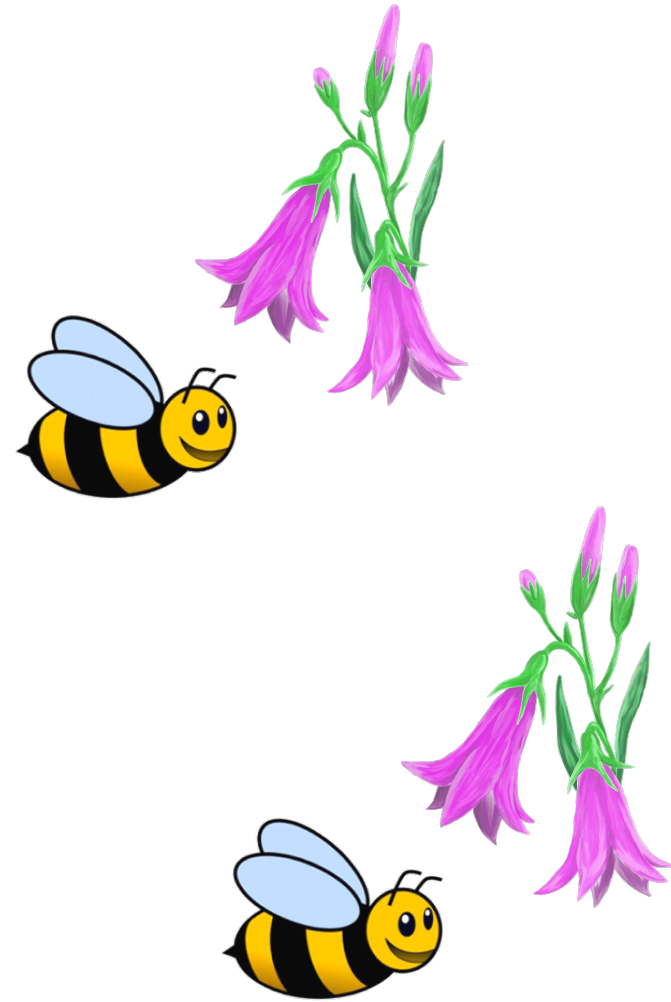
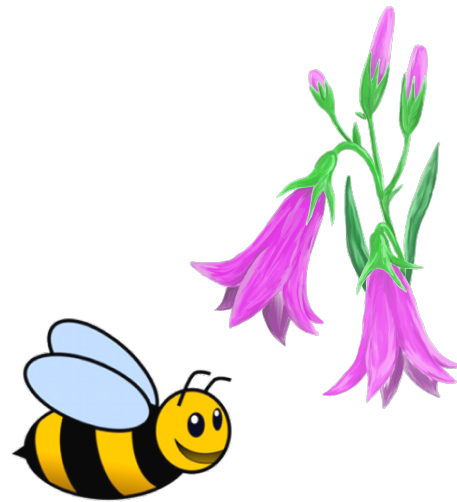
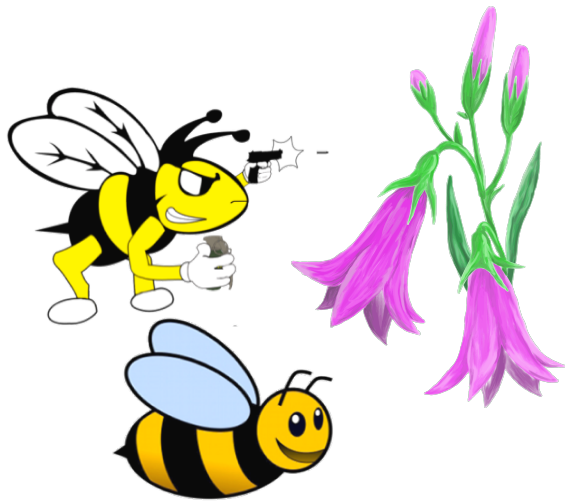


Sinergy



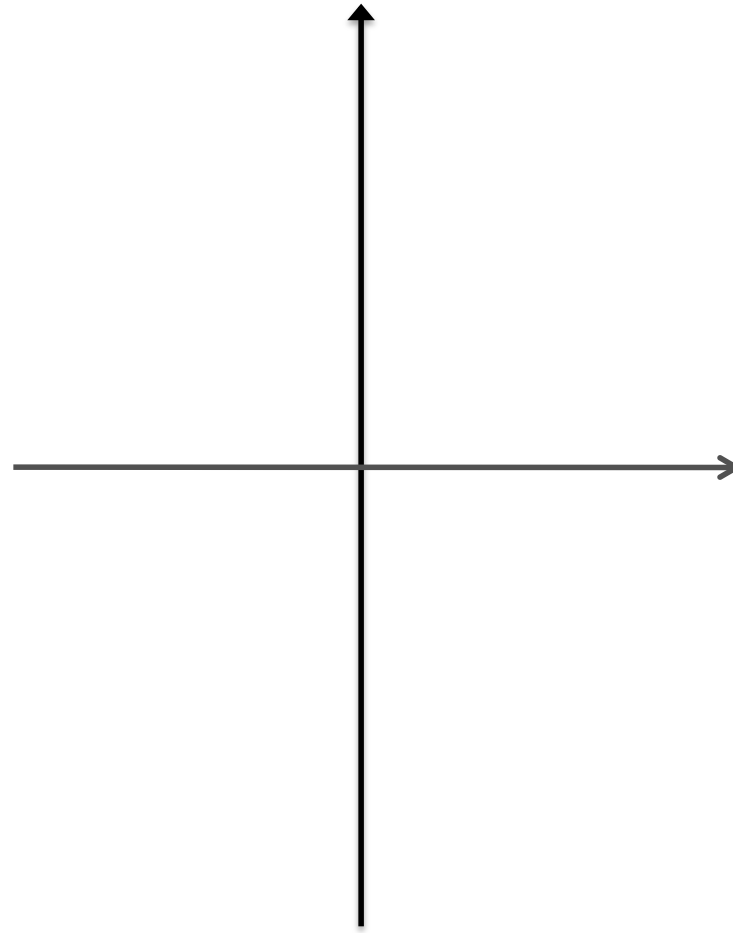
Sinergy

Cross-pollination
- higher genetic variability



Sinergy

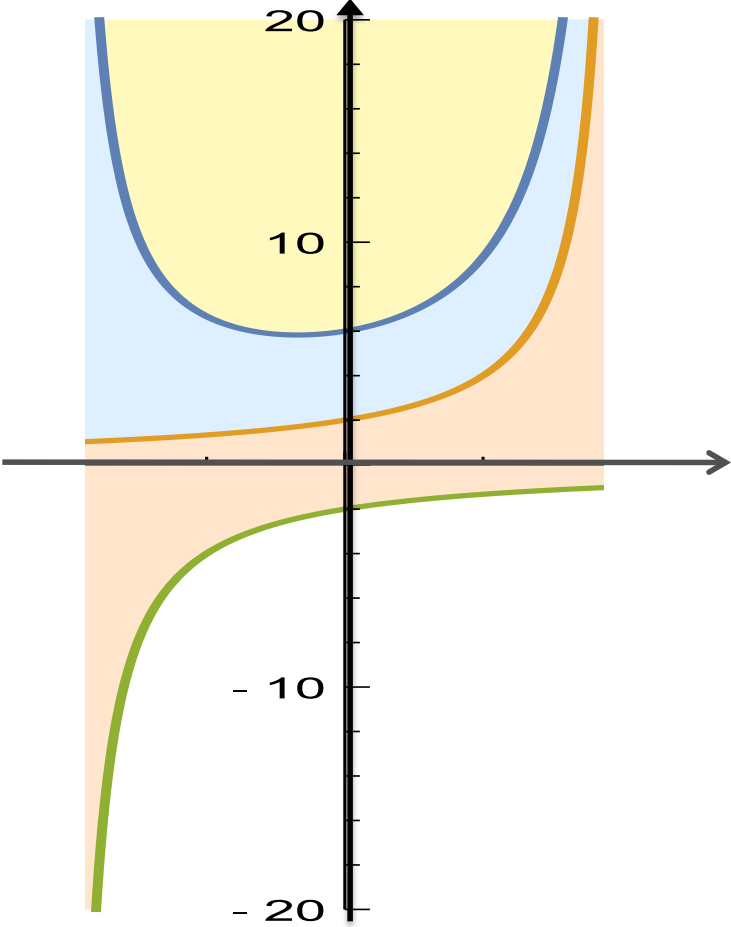
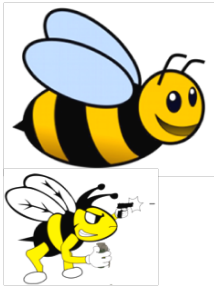
Payoff to the tubular flower
with cross pollination



Payoff to the robber for robbing

Sinergy

Payoff to the tubular flower
with cross pollination

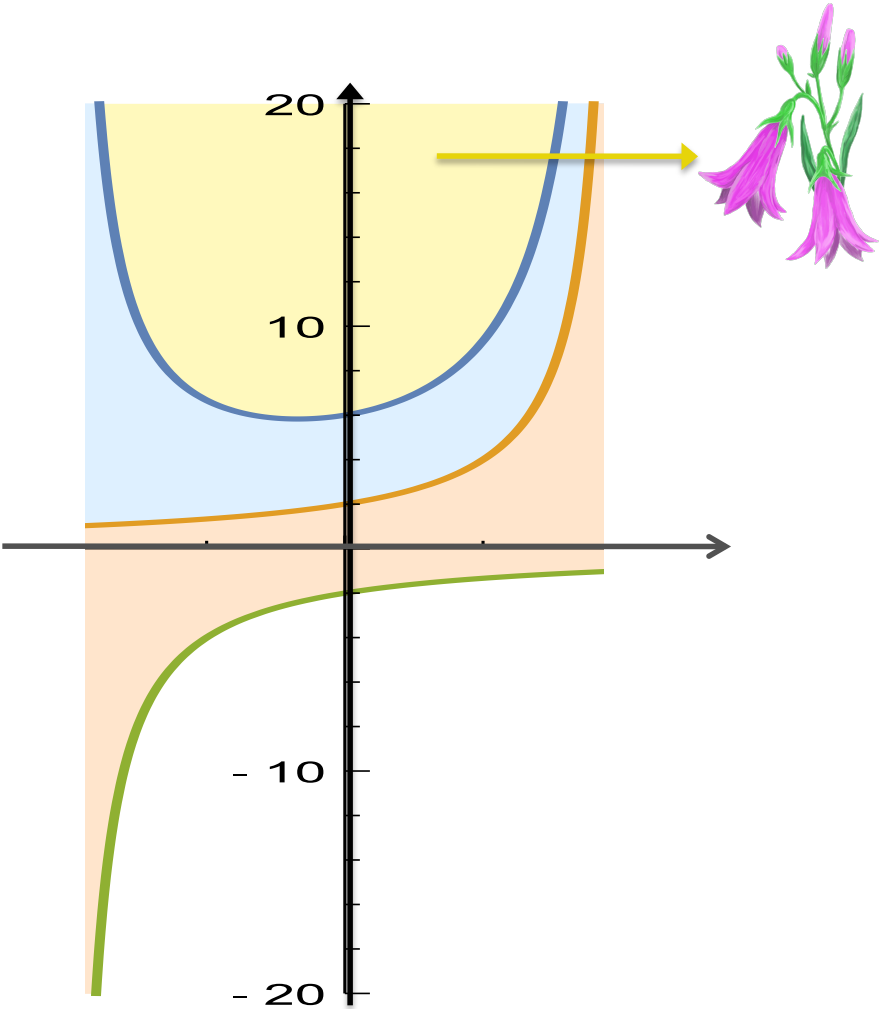
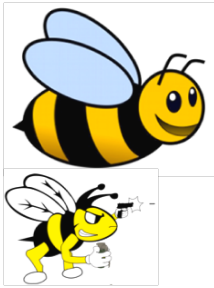


Payoff to the robber for robbing



Sinergy

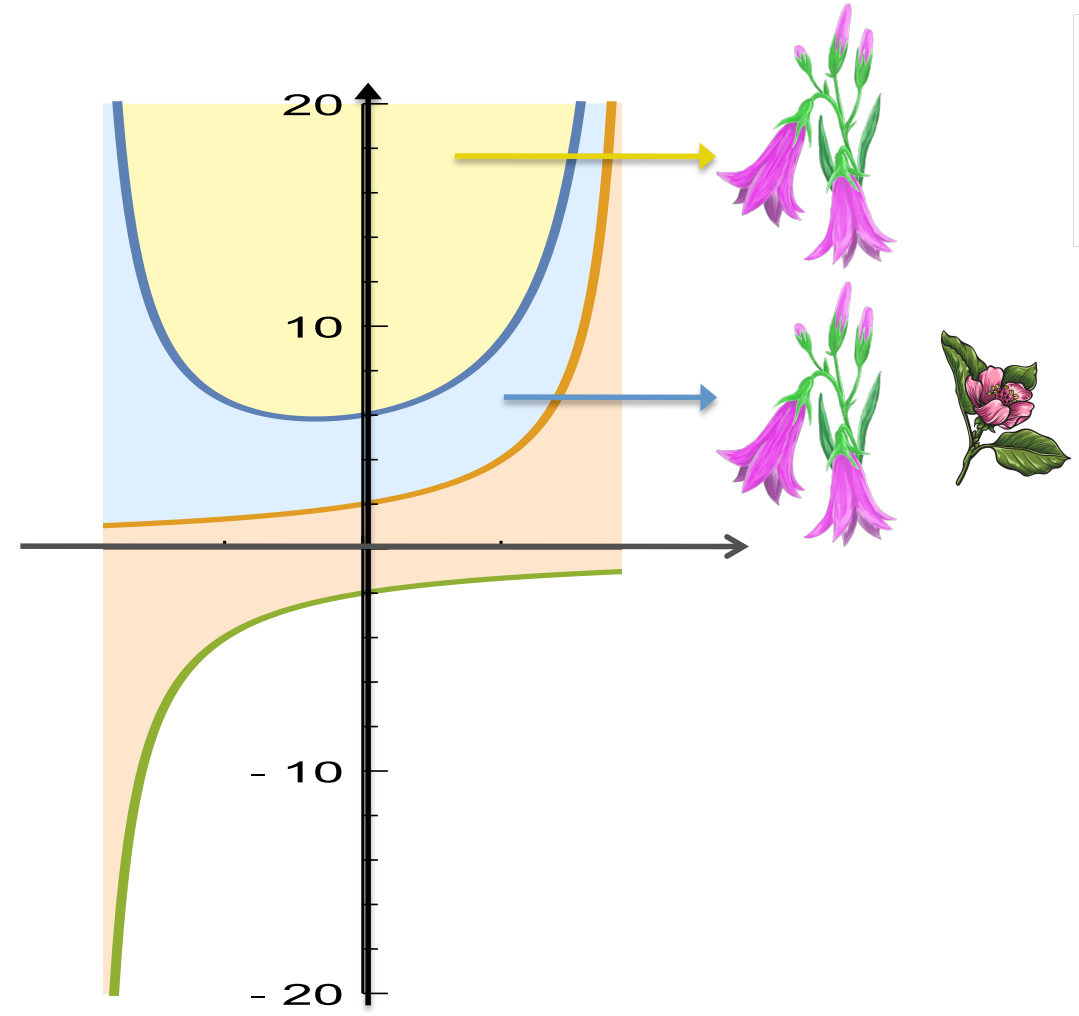
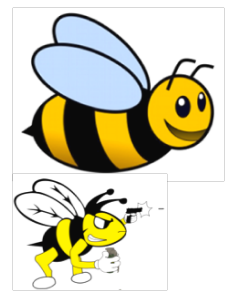
Payoff to the tubular flower
with cross pollination



Payoff to the robber for robbing

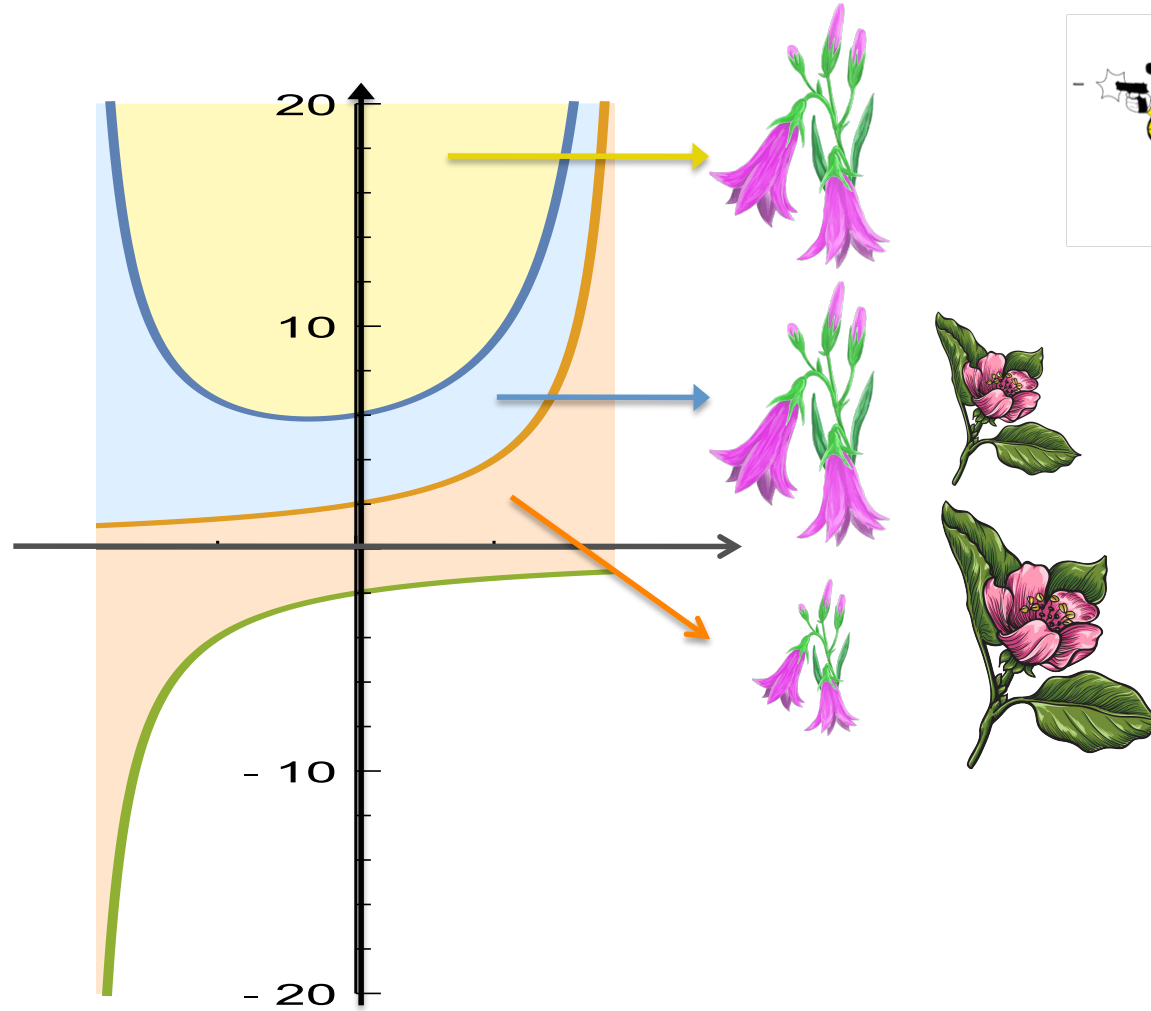
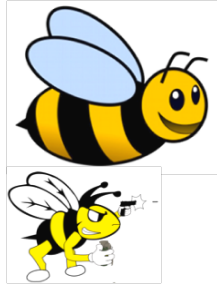
Sinergy

Payoff to the tubular flower
with cross pollination



Sinergy

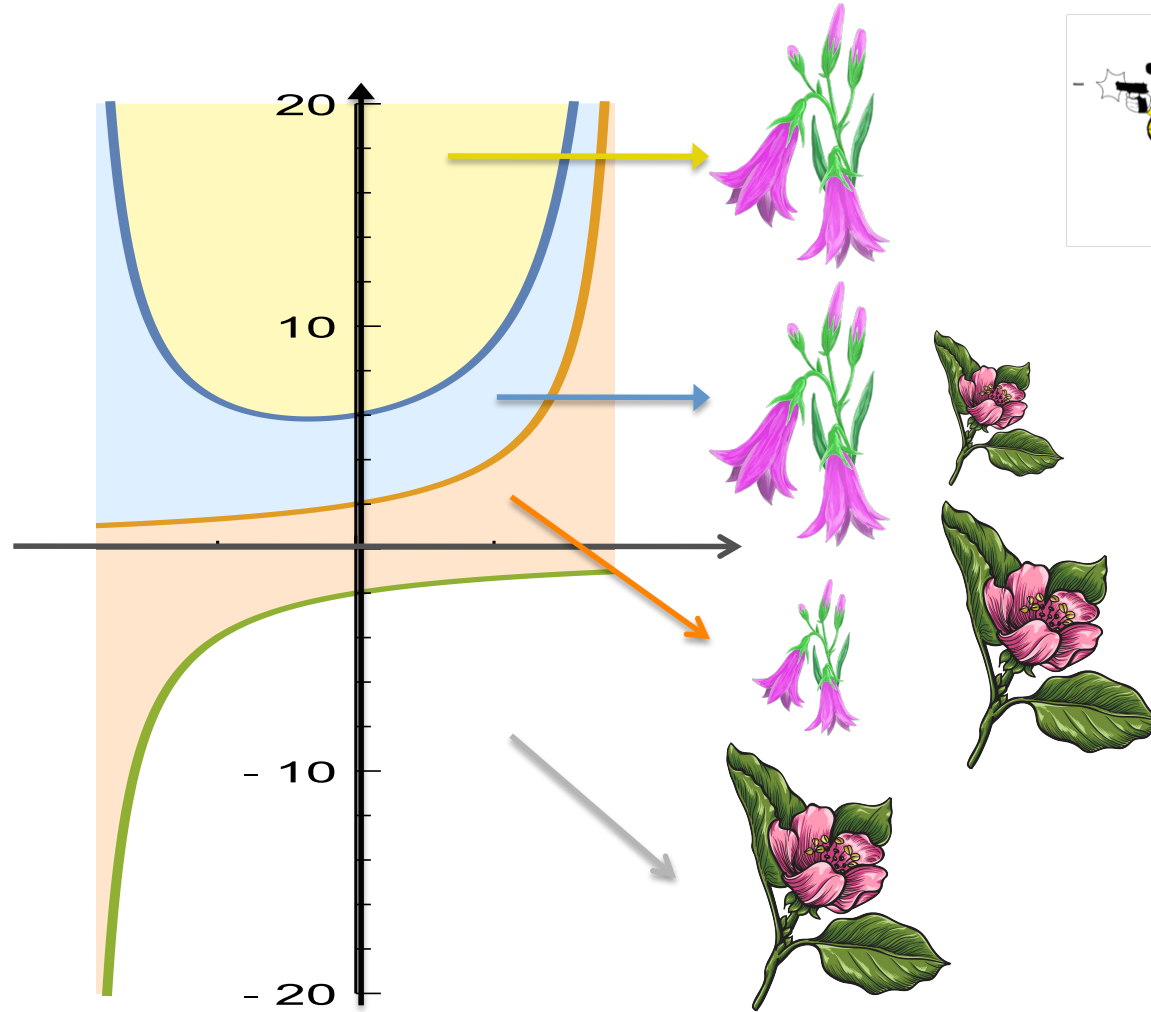
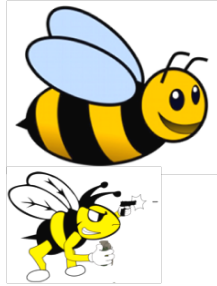
Payoff to the tubular flower
with cross pollination



Payoff to the robber for robbing

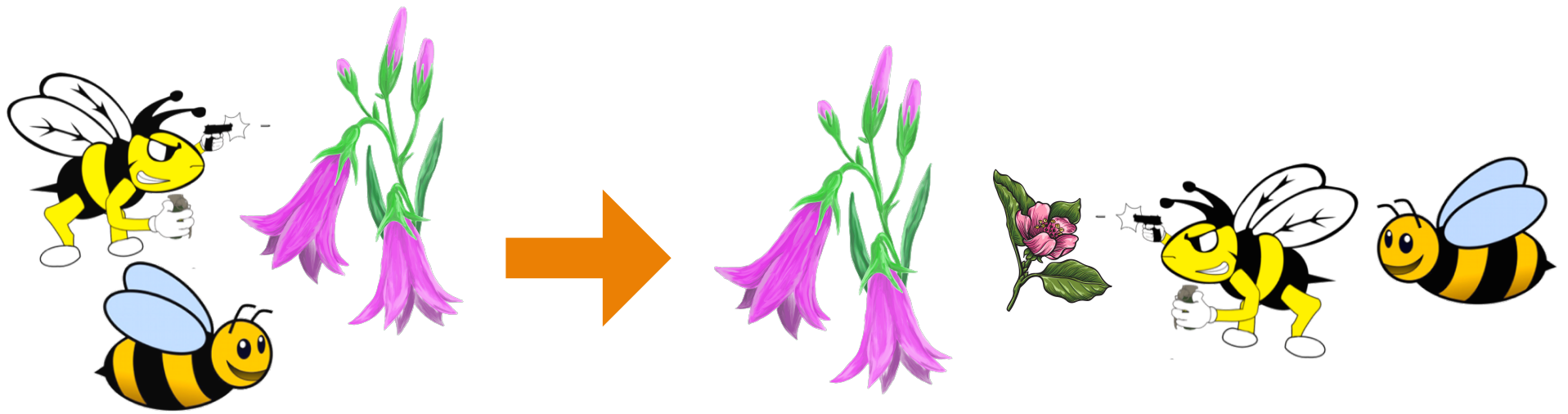
Sinergy

Payoff to the tubular flower
with cross pollination



Payoff to the robber for robbing

Sinergy



Cheating



Mimicry



Model



Mimic



Mimicry



Model



Mimic



Mimicry



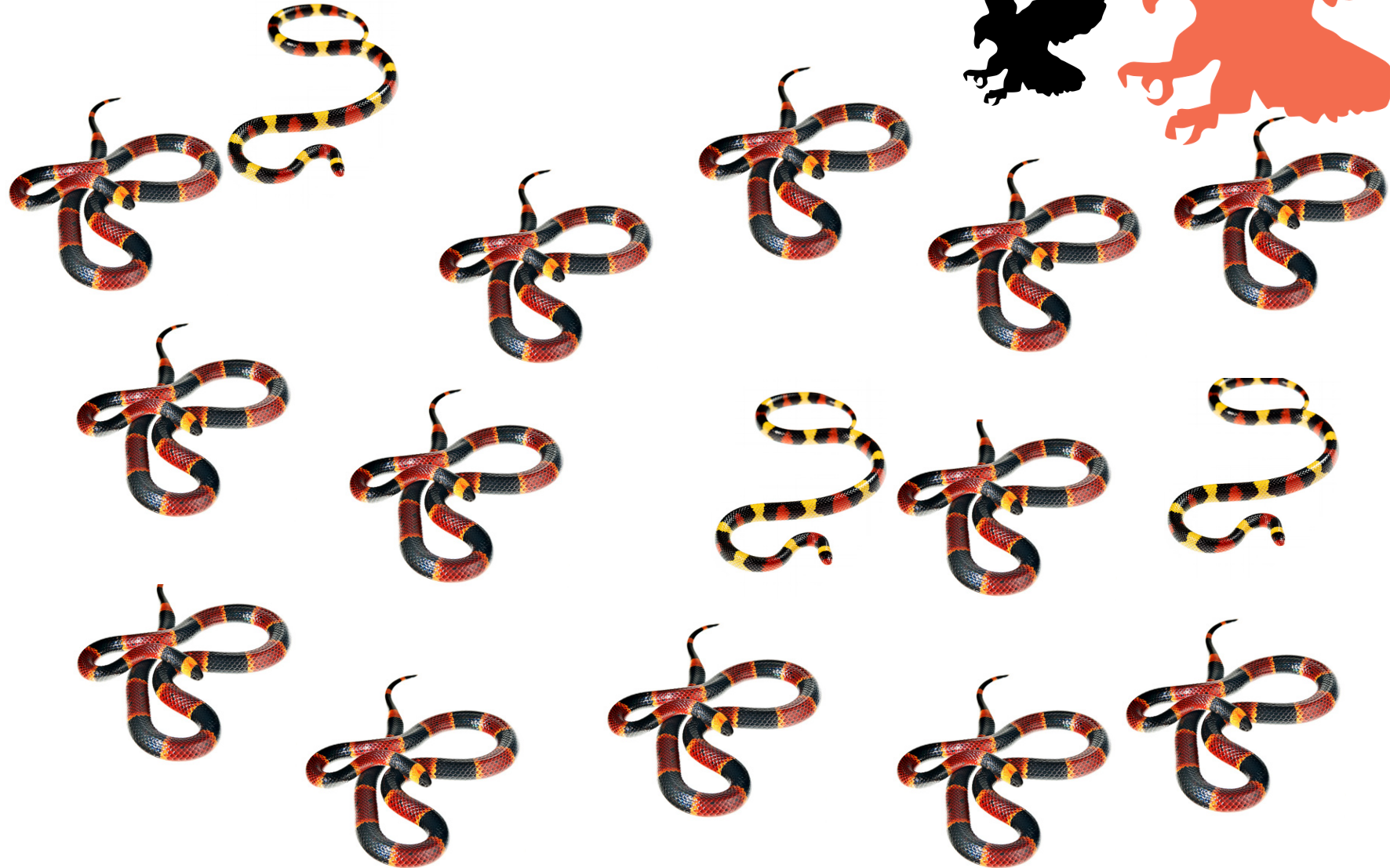
Model



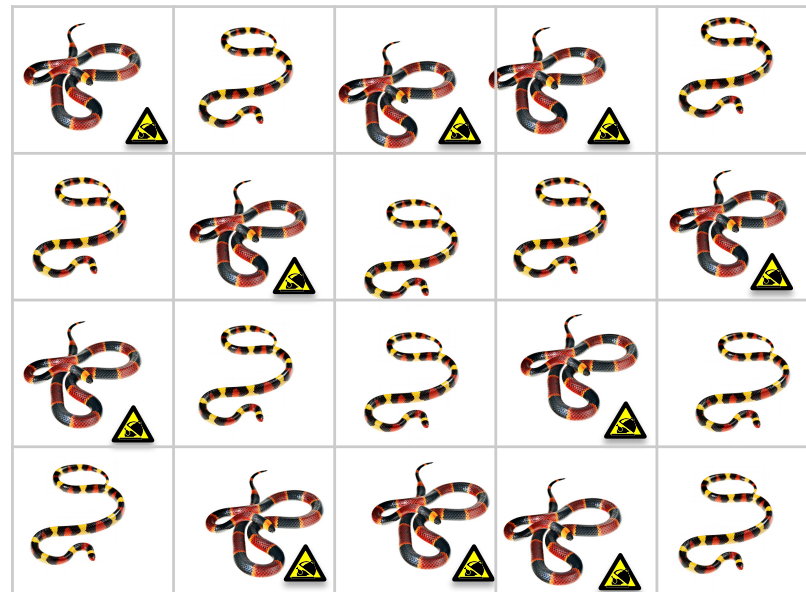
Mimic



Mimicry



Mimicry



Mimicry



Mimicry

I)



Mimicry

I)



Mimicry

I)



Mimicry

I)



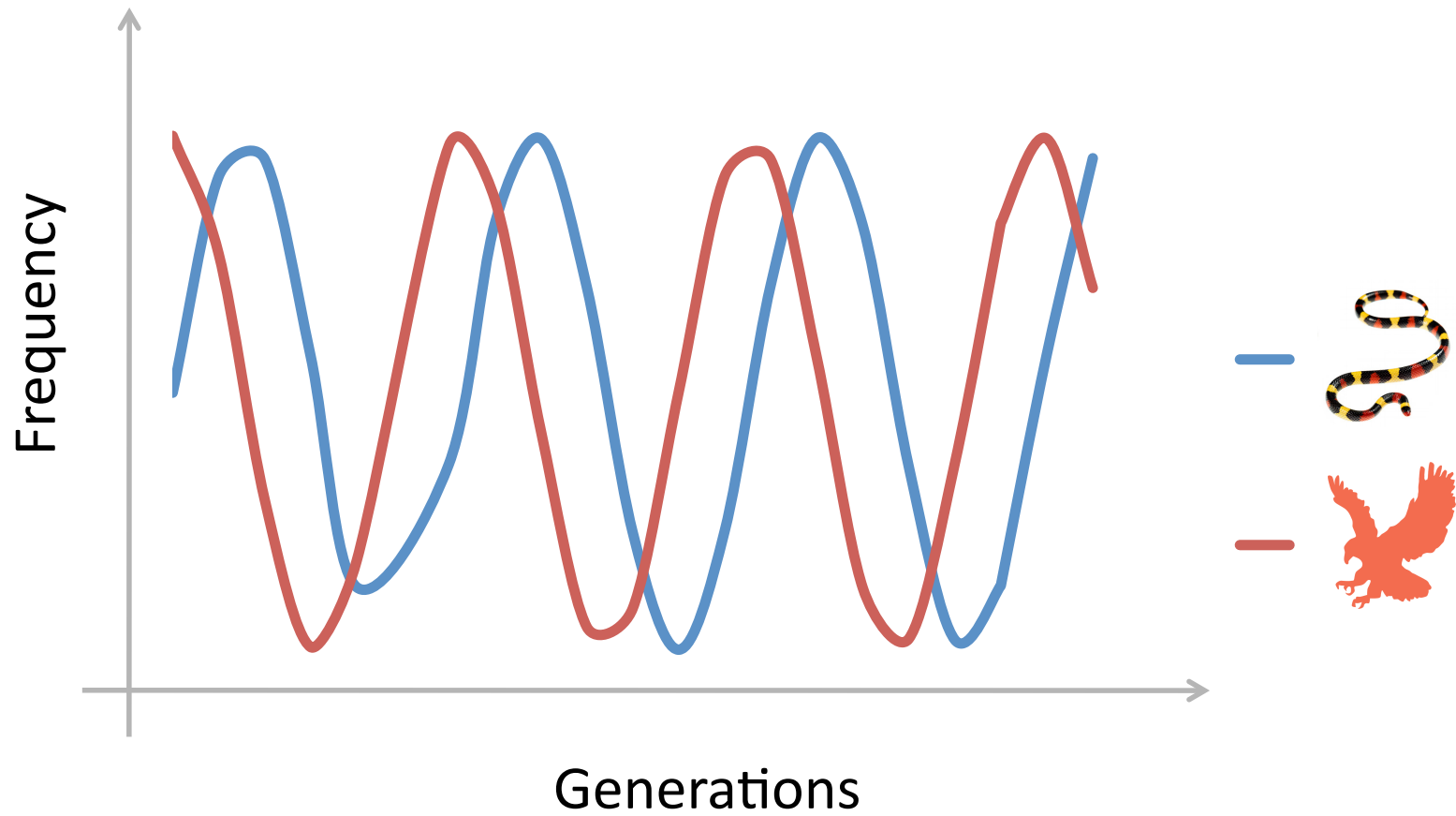
Mimicry

II)



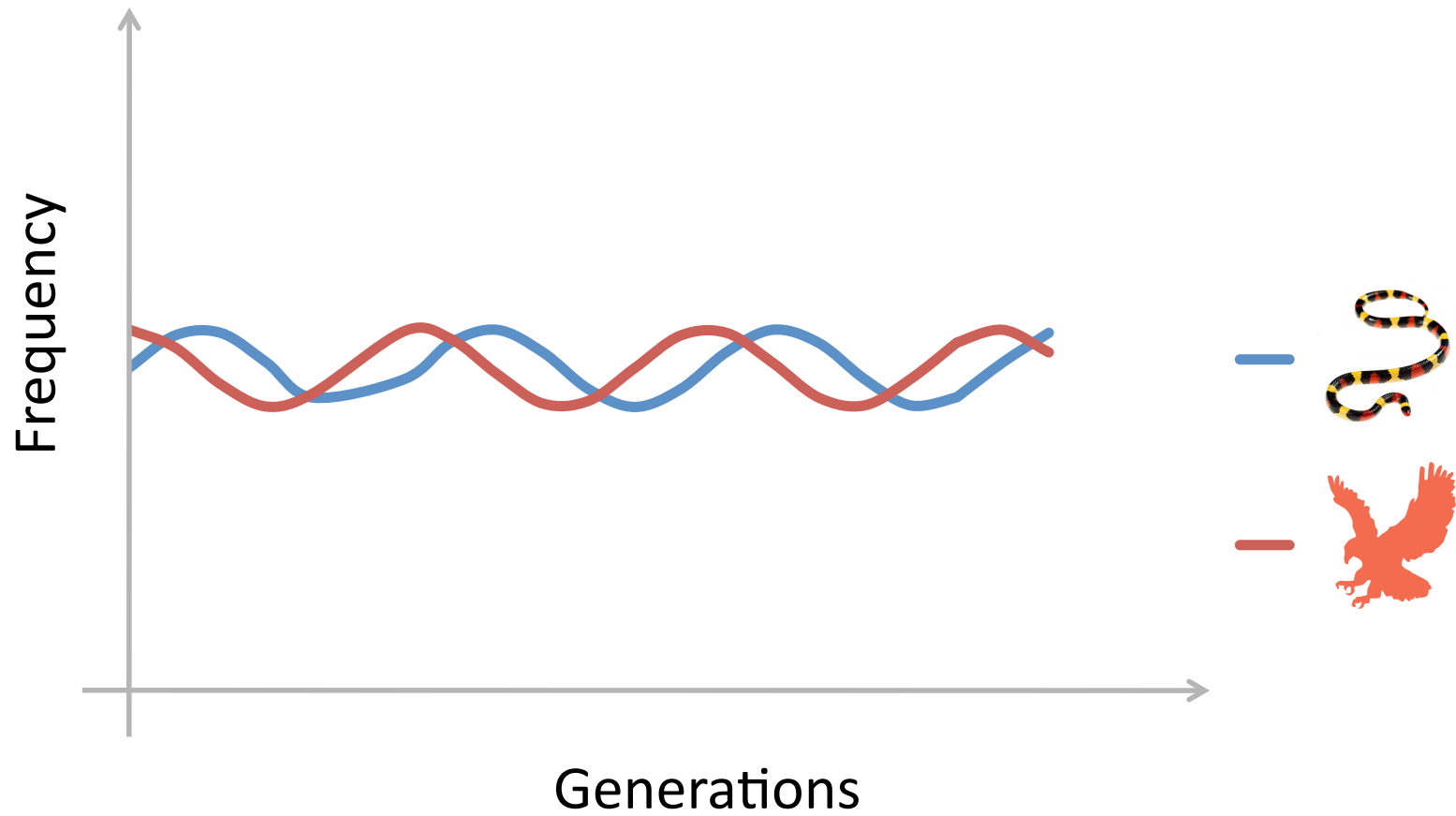
Mimicry

I)



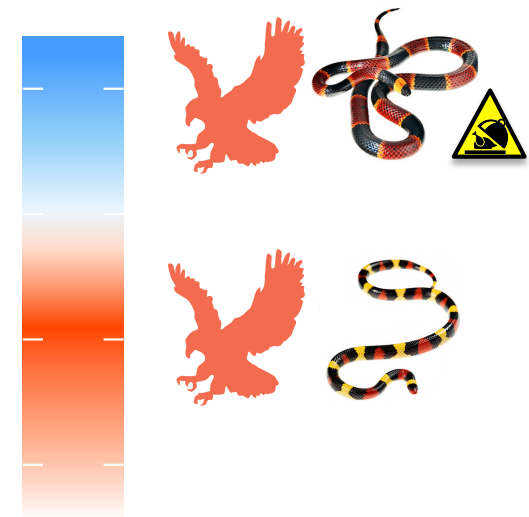
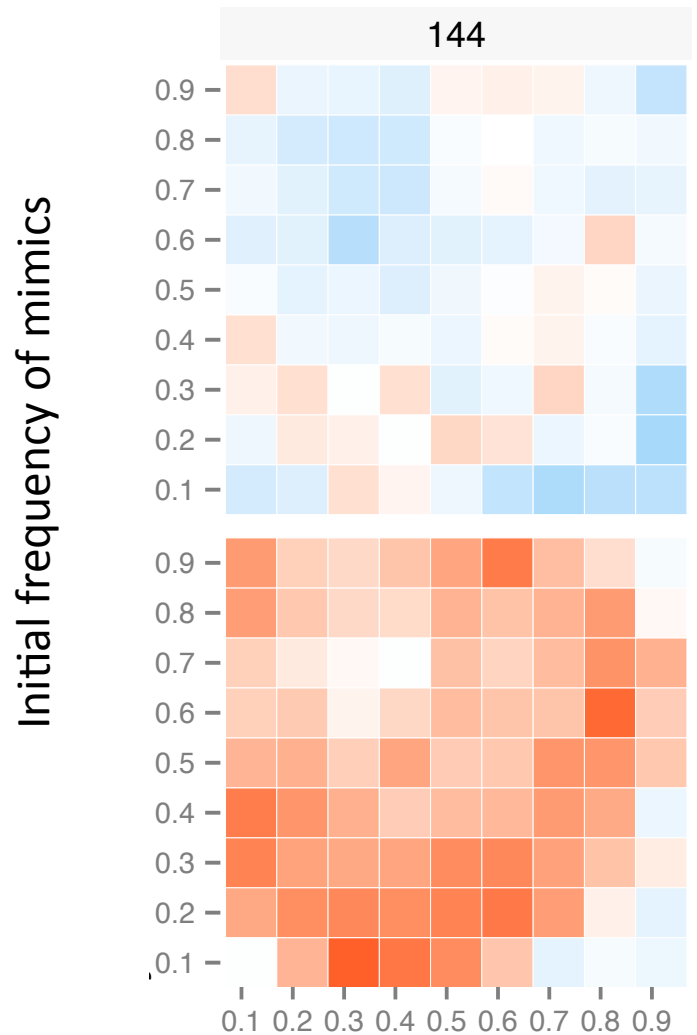
Mimicry

II)

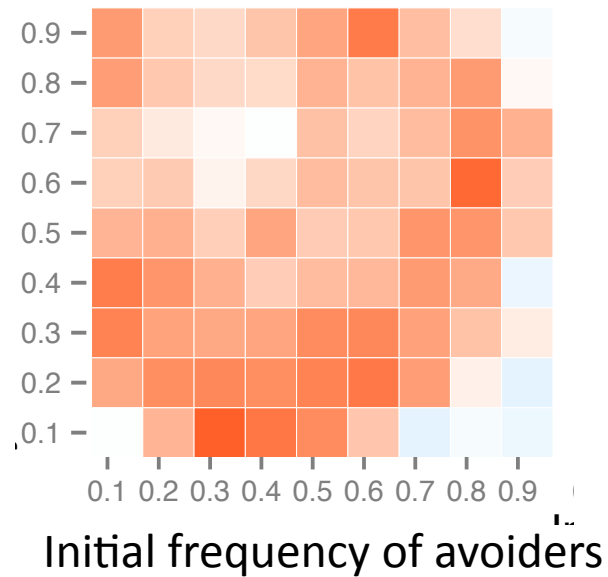


Mimicry

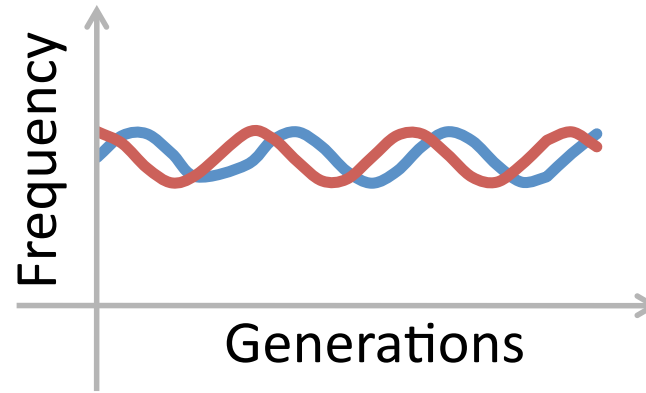
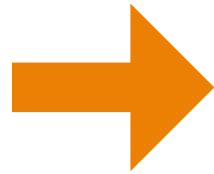
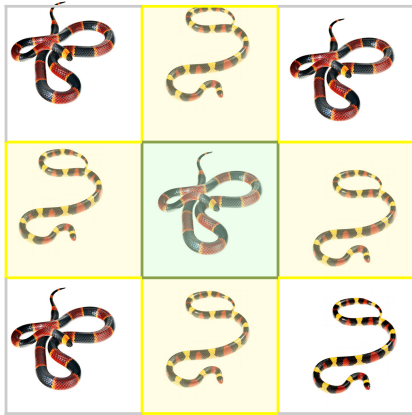
I)



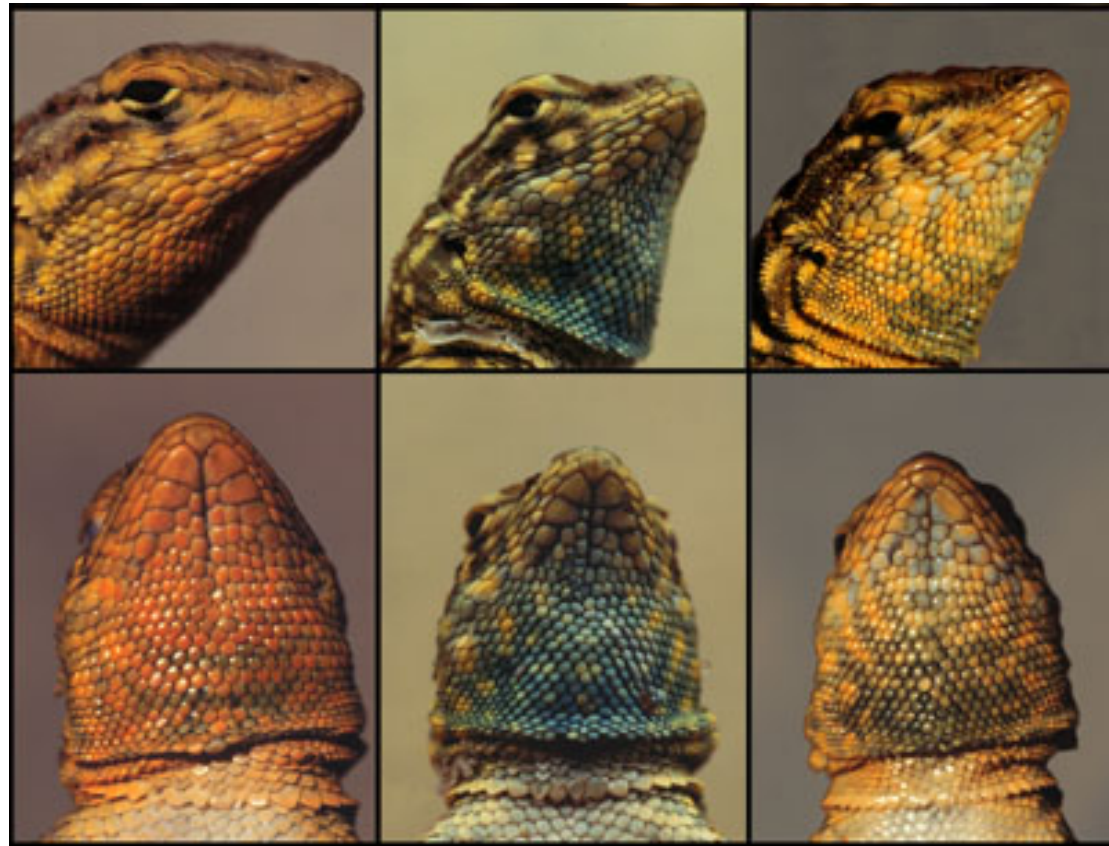
II)



Mimicry



Polymorphism in lizards

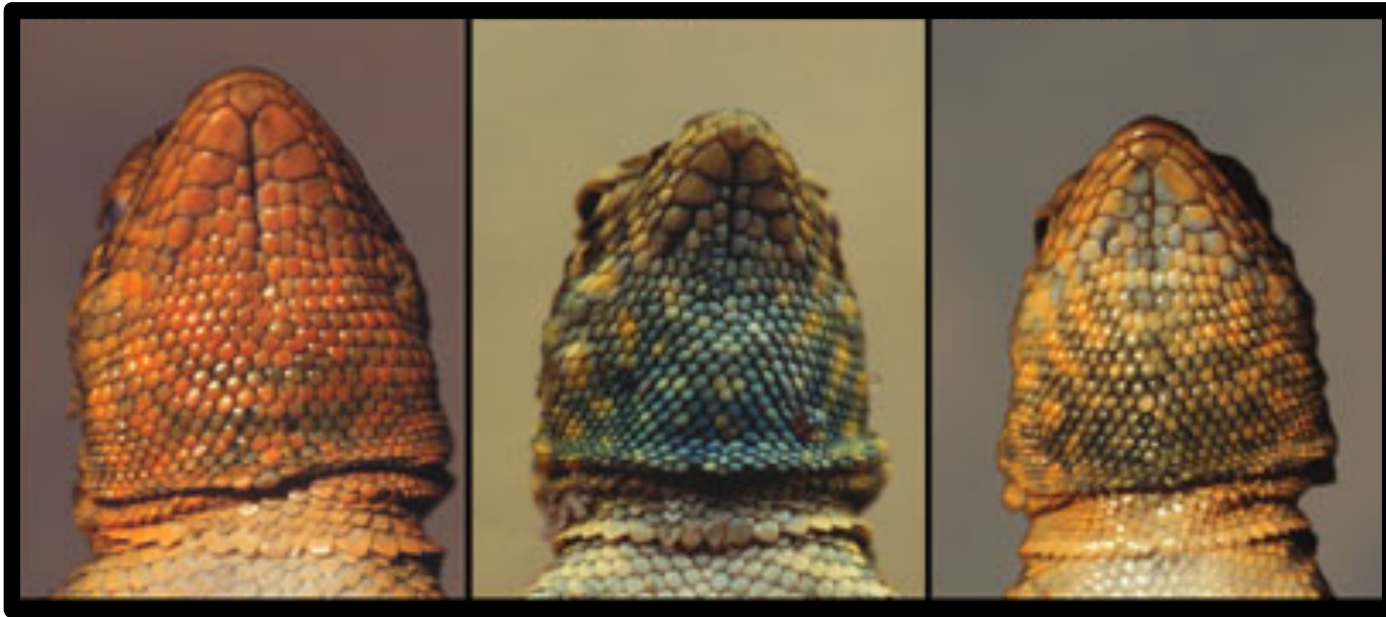


Large territory
Many females

Small territory
Few females
Good guards

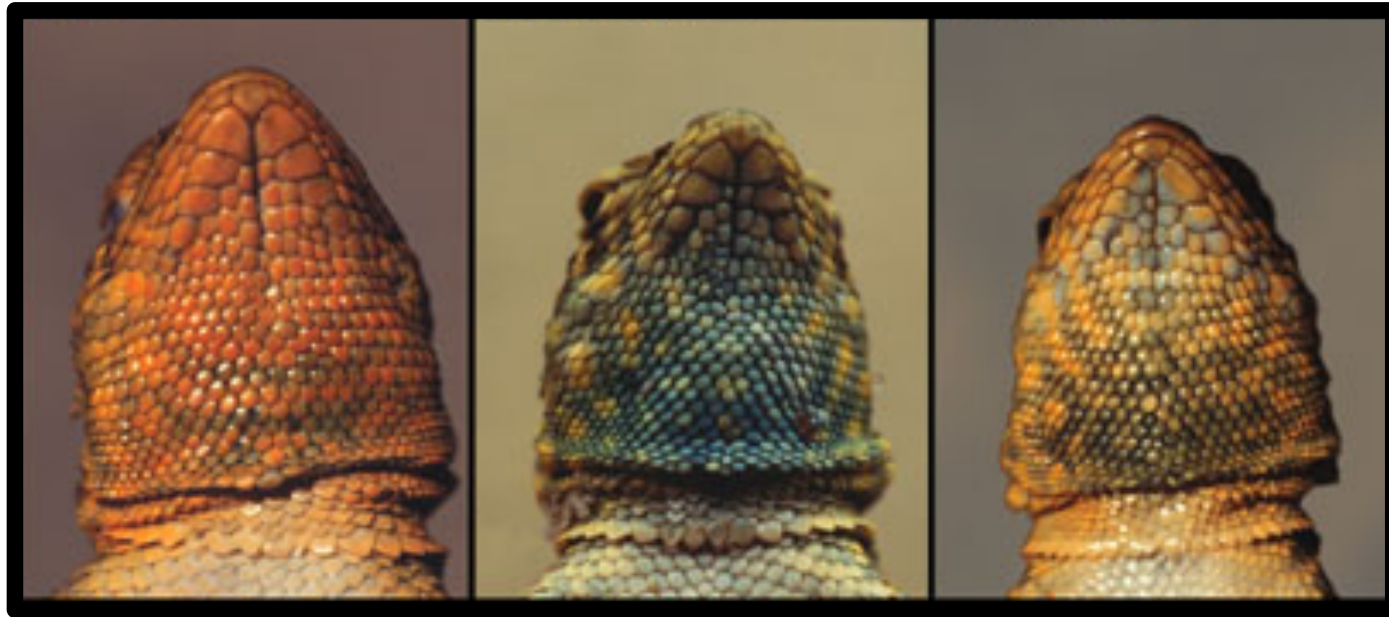
No territory
Female-like
Sneakers

Polymorphism in lizards



O>Y>B

Polymorphism in lizards



OO
OB
OY

BB

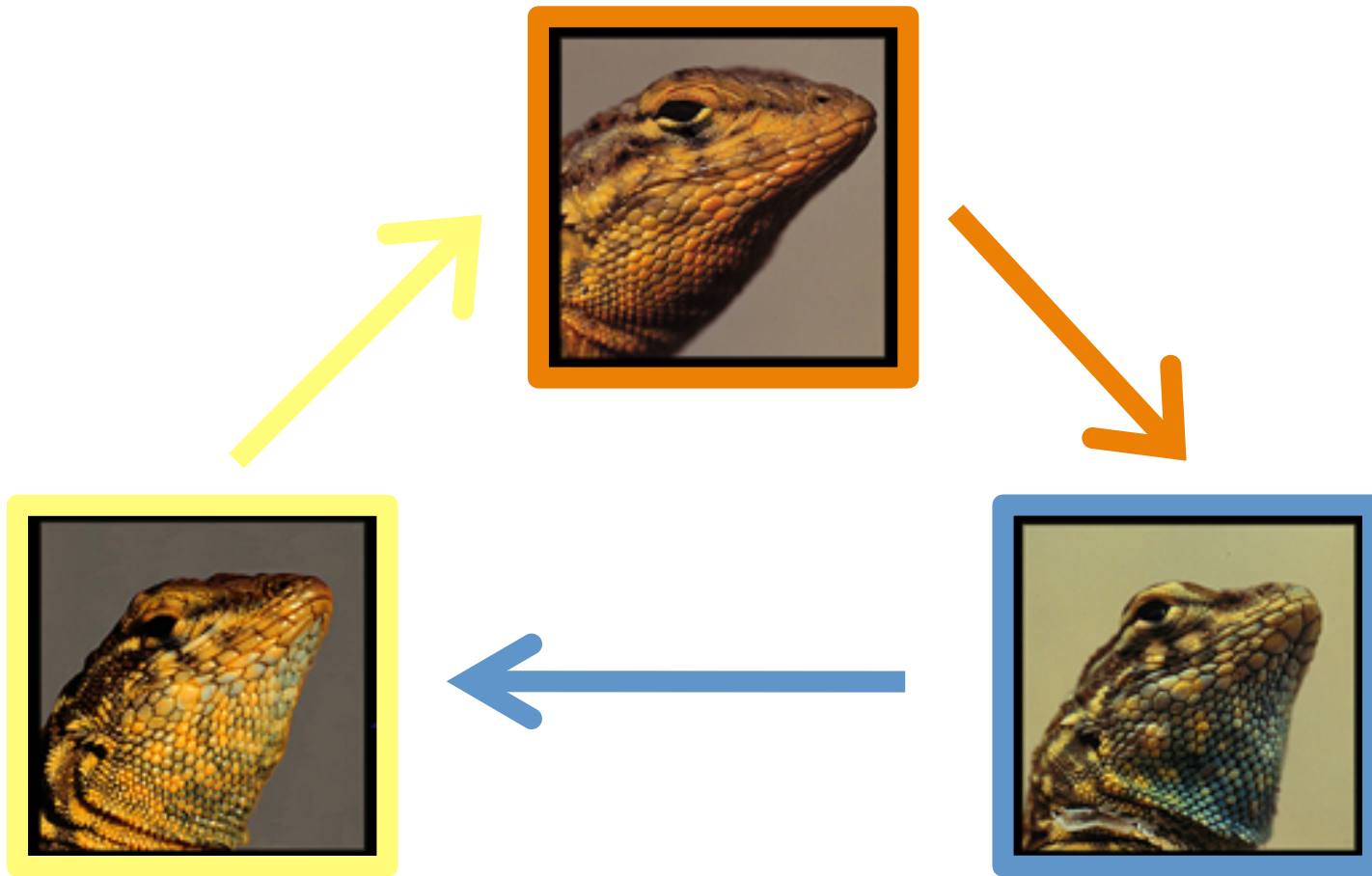
YY
YB

O > Y > B

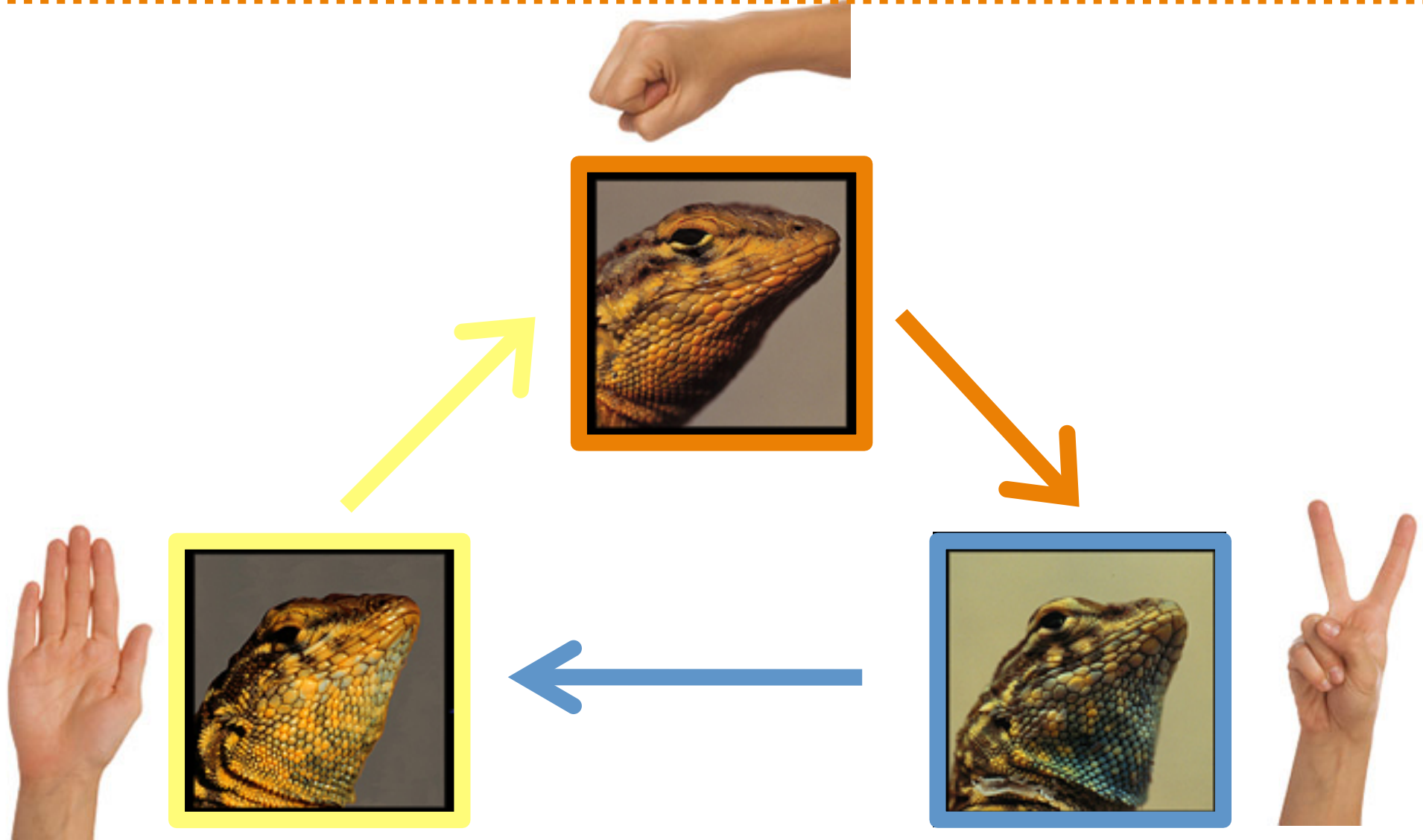
Polymorphism in lizards



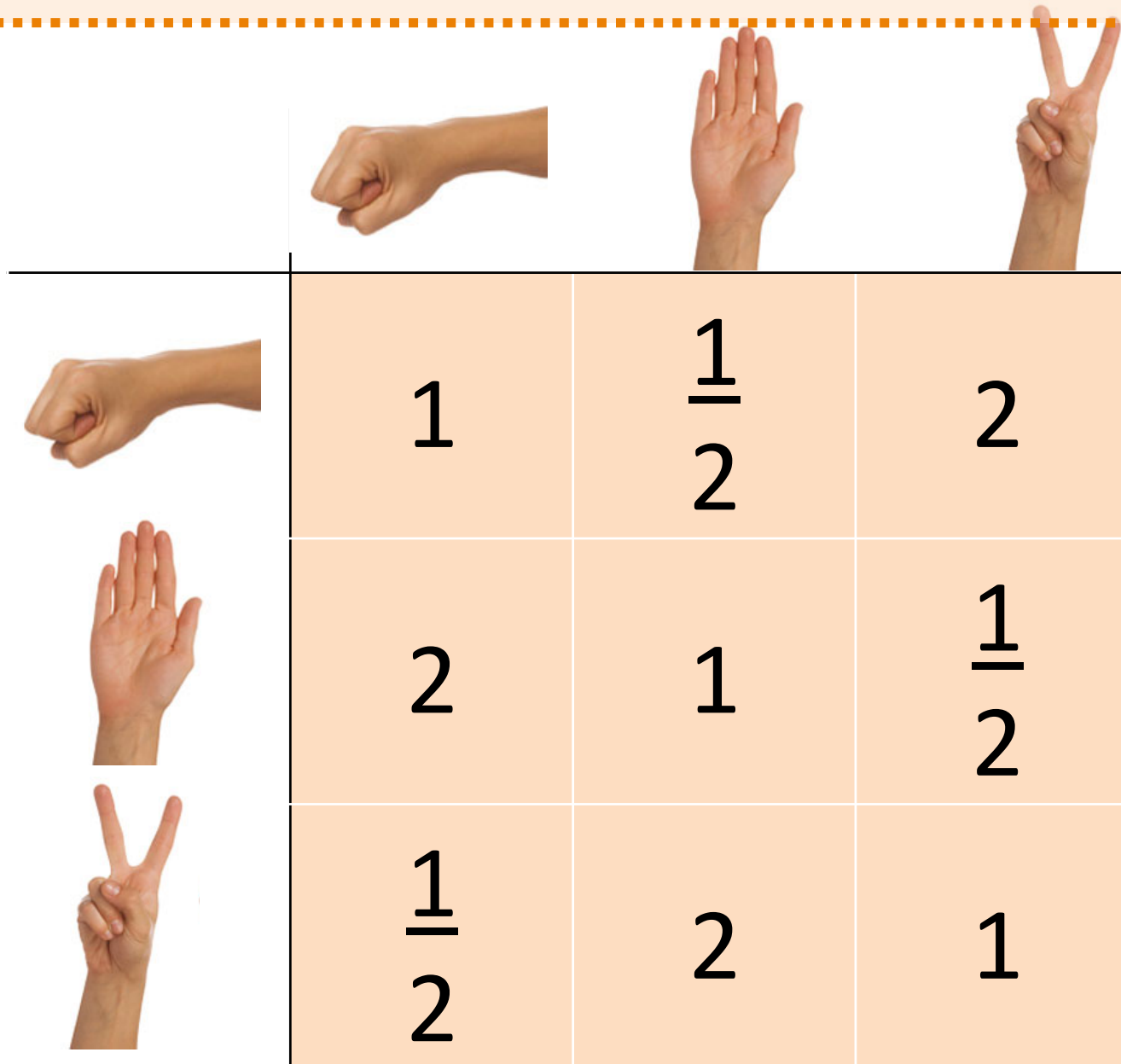
Polymorphism in lizards









Polymorphism in lizards






Rock-Paper-Scissor



A payoff matrix for the Rock-Paper-Scissors game. The rows represent the player's move (Rock, Paper, Scissors) and the columns represent the opponent's move (Rock, Paper, Scissors). The payoff is shown as a fraction where the numerator is the player's score and the denominator is the opponent's score. A tie results in a 1/2 payoff for both players.

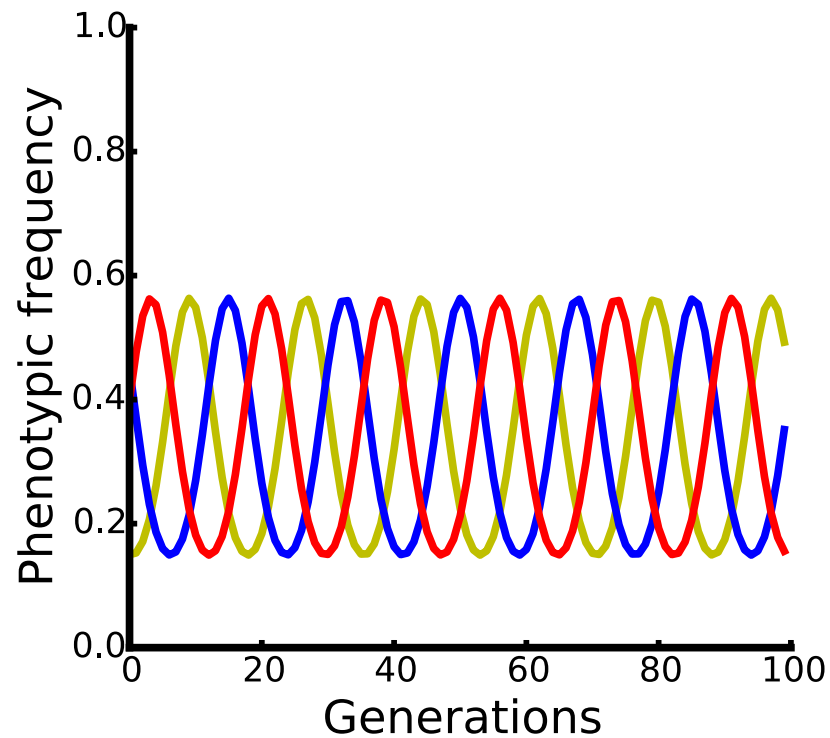
			
	1	$\frac{1}{2}$	2
	2	1	$\frac{1}{2}$
	$\frac{1}{2}$	2	1

Rock-Paper-Scissor of Lizards

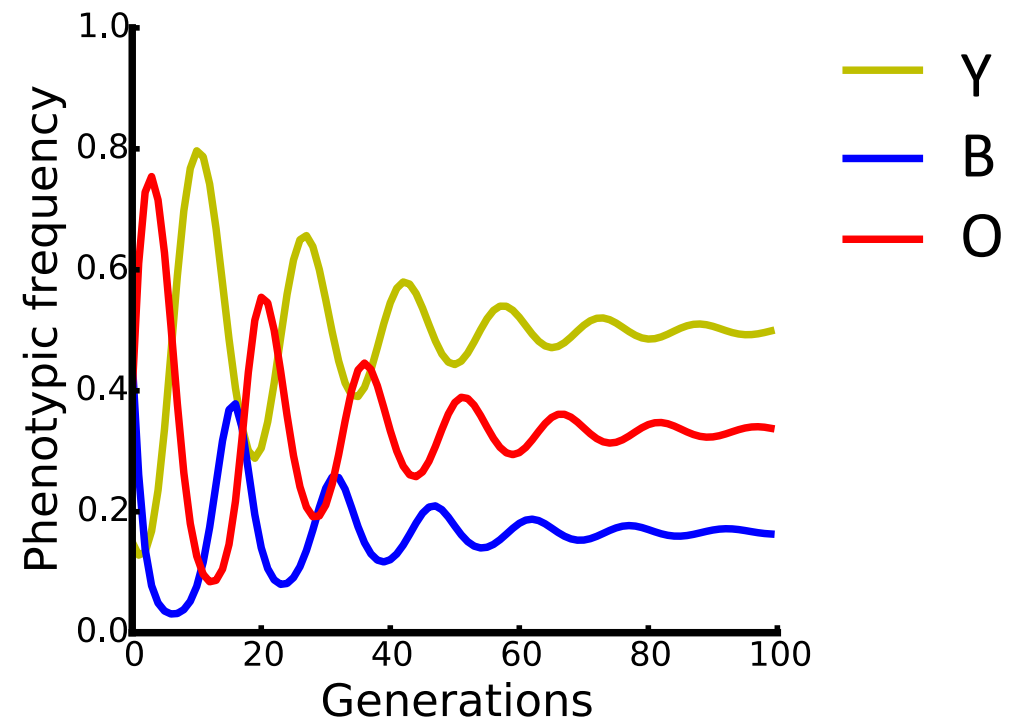
			
	1	$\frac{1}{2}$	2
	2	1	$\frac{1}{2}$
	$\frac{1}{2}$	2	1

Rock-Paper-Scissor of Lizards



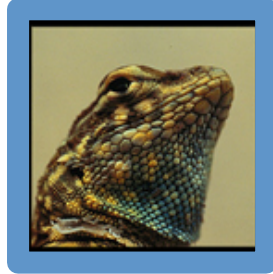


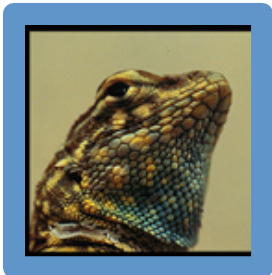
Phenotype



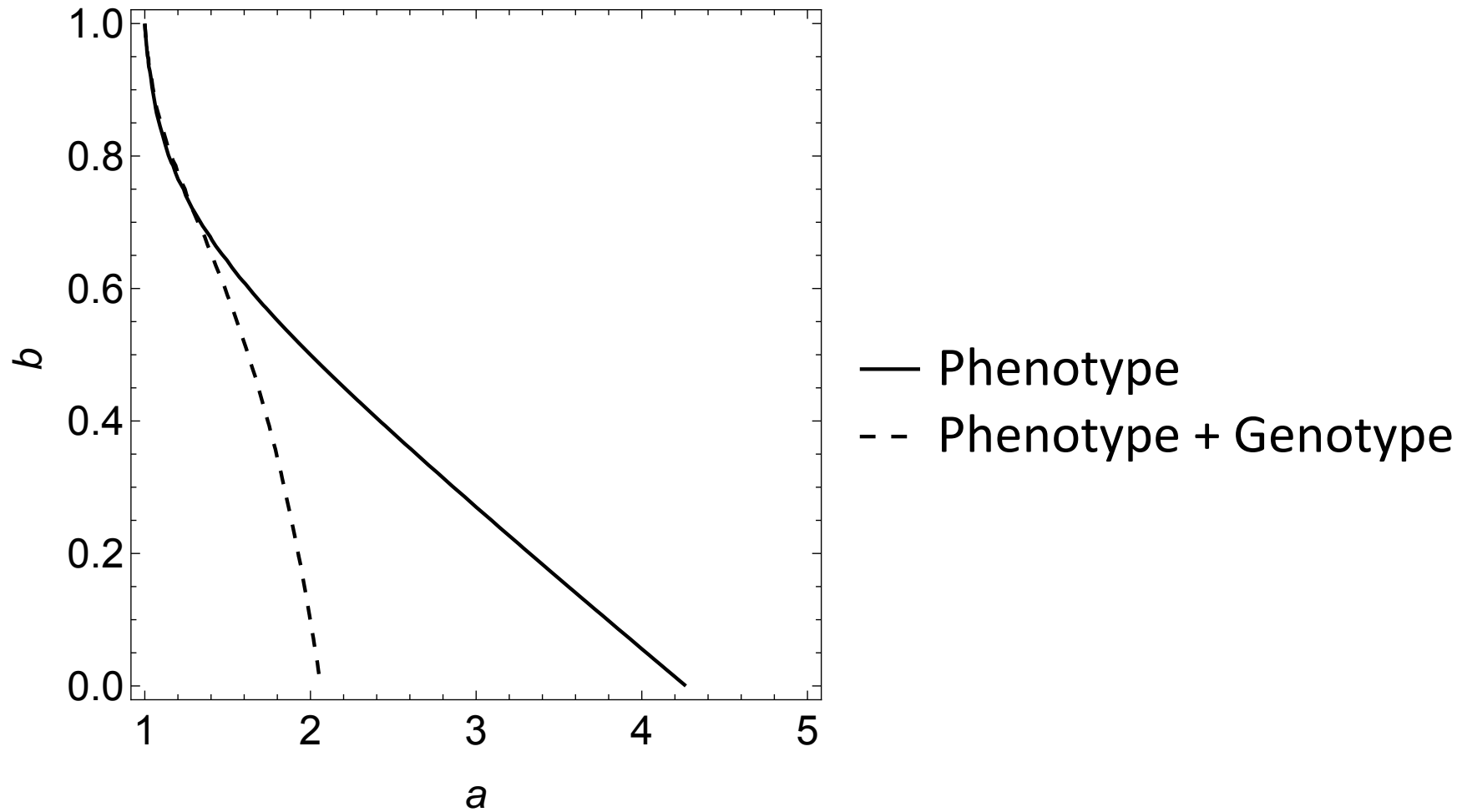
Phenotype + Genotype



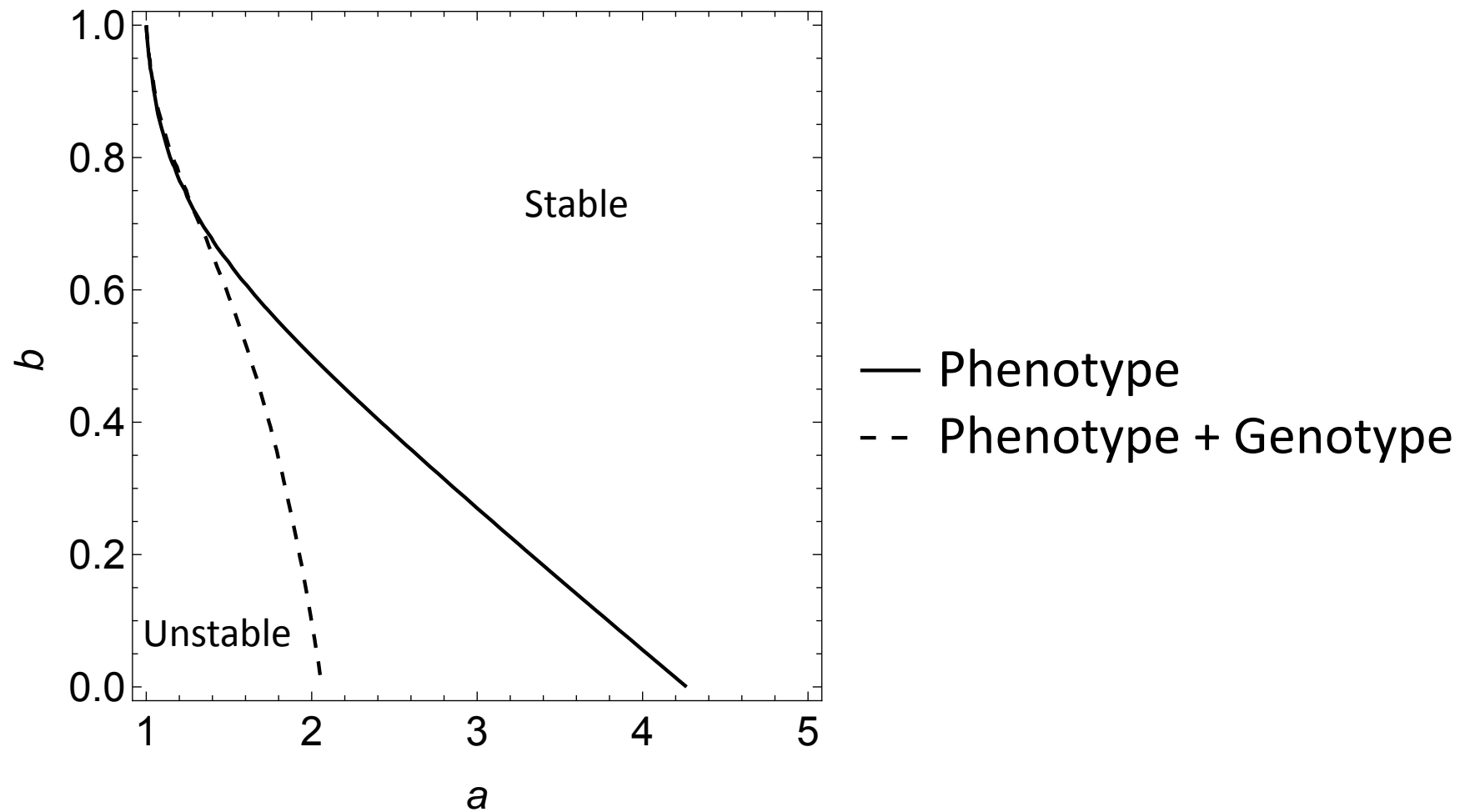
Rock-Paper-Scissor of Lizards

			
	1	$\frac{1}{2}$	a
	2	1	b
	$\frac{1}{2}$	2	1

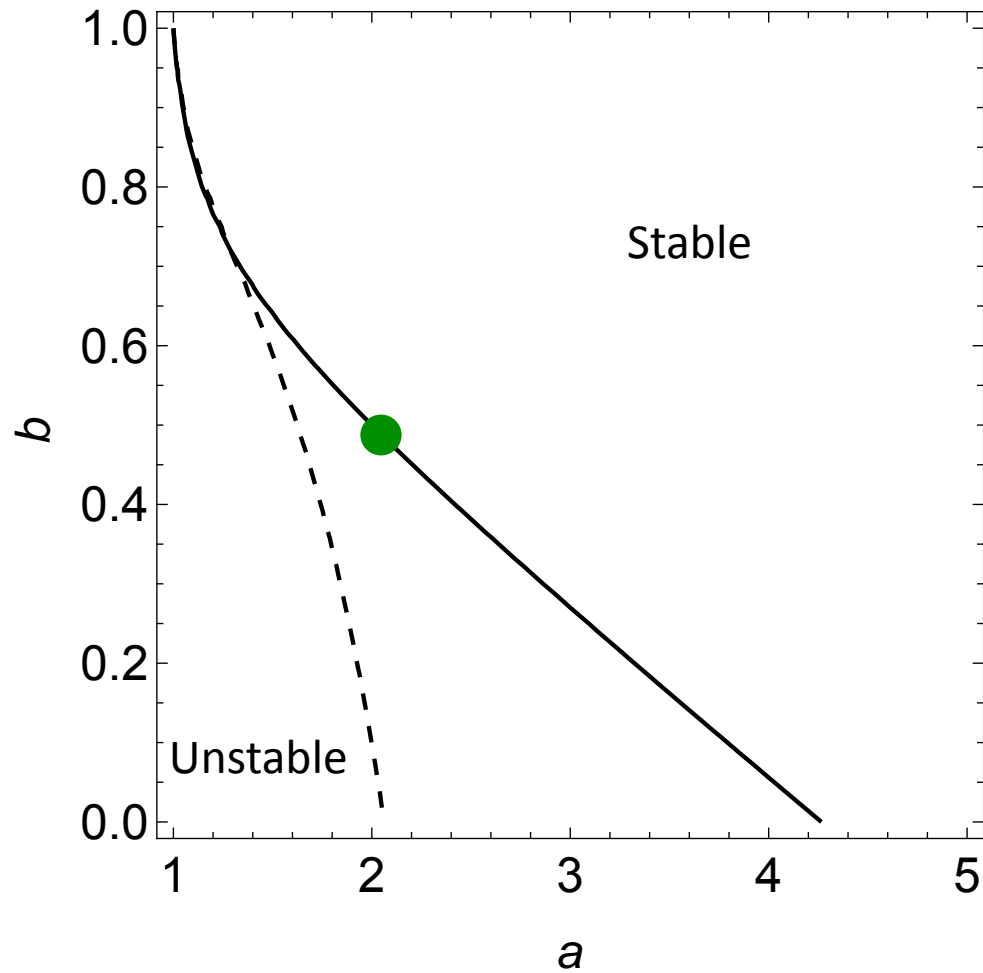
Rock-Paper-Scissor of Lizards



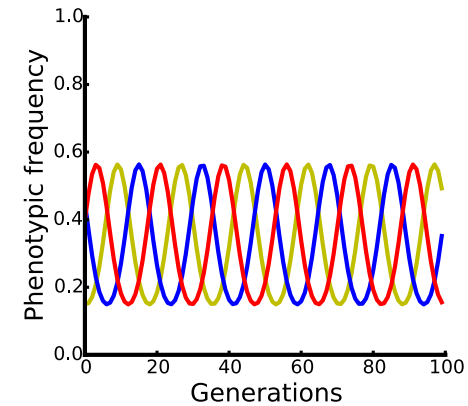
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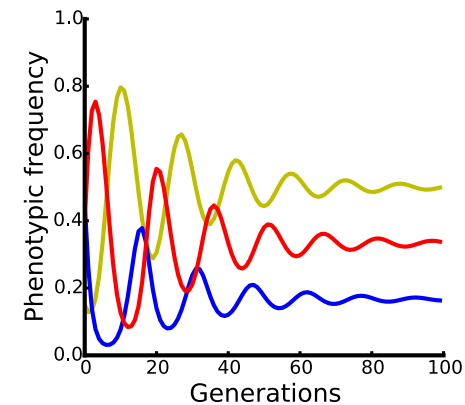
Rock-Paper-Scissor of Lizards



— Phenotype



- - - Phenotype + Genotype






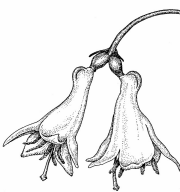
Thanks


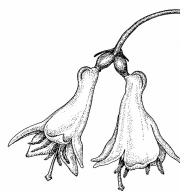


Marcus Aguiar
Paulo Guimarães Jr
Jorge Pacheco
Francisco Santos
Simon Levin



Department of
Ecology and Evolutionary Biology

Payoff matrices pollination

		
	ε	$\varepsilon - \phi$
	ε	$\varepsilon - \phi - \delta$

		
	α	β
	$\alpha + \gamma$	$\beta + \gamma$

Payoff matrices mimicry

Π_{PP}	Π_{FF}
$\begin{array}{c} \mathbf{A} \quad \mathbf{E} \\ \mathbf{A} \begin{pmatrix} \kappa & \kappa \end{pmatrix} \\ \mathbf{E} \begin{pmatrix} \kappa & \kappa \end{pmatrix} \end{array}$	$\begin{array}{c} \mathbf{M} \quad \mathbf{V} \\ \mathbf{M} \begin{pmatrix} \kappa & \kappa \end{pmatrix} \\ \mathbf{V} \begin{pmatrix} \kappa - \delta & \kappa - \delta \end{pmatrix} \end{array}$
Π_{PF}	Π_{FP}
$\begin{array}{c} \mathbf{M} \quad \mathbf{V} \\ \mathbf{A} \begin{pmatrix} \kappa & \kappa \end{pmatrix} \\ \mathbf{E} \begin{pmatrix} \kappa + \sigma_1 & \kappa - \sigma_2 \end{pmatrix} \end{array}$	$\begin{array}{c} \mathbf{A} \quad \mathbf{E} \\ \mathbf{M} \begin{pmatrix} \kappa & \kappa - \gamma \end{pmatrix} \\ \mathbf{V} \begin{pmatrix} \kappa & \kappa - \epsilon\gamma \end{pmatrix} \end{array}$

Predators: E=eater, A=avoider
 Preys: M=mimic, V=model