

Welcome to BIO220!

Evolutionary genetic and evolutionary ecology perspectives on conservation, climate change, disease, aging, sexual conflict, and sexual differences

Course website:

q.utoronto.ca

Course Syllabus

Contains all essential course information.

- On Quercus and in your Lab Manual (available at the U of T Bookstore)

Please read it carefully!

Labs

Week 1 labs (P**01) start week of Jan. 21

Week 2 labs (P**02) start week of Jan. 28

- Lab enrollment/changes on ACORN only until Jan. 10
- Starting Jan. 15th, lab enrollment/changes can only be made in person during BIO220 Office hours
- Check “**Grades**” on Quercus after 5pm on Jan. 14th to determine **your lab room #**
- **All labs are held in Ramsay Wright (25 Harbord St)**

Required Readings

- Meant to supplement lectures
- Typically, they will be a brief overview of a topic
- We will assume you have read them for the midterm and exam
 - **Expect ~ 1 multiple choice question per reading.**

Recommendation

- Read them before the lecture, and when you are reviewing your notes afterwards

iClickers

- Participation in iClicker questions during lecture is worth 5% of your grade
- See “Important Information on iClickers” on Quercus
- It is very important that you register your iClicker
- We will start using iClickers in Lecture 2. We will post participation after Lecture 2 so you can confirm we are receiving your responses

Course Administration



Laura Heslin Piper

BIO220 Office

RW 105-E

bio220@utoronto.ca

- All course-related inquiries, including lab changes and enrollment!
- Office hours: 11am-1pm, Mon-Thurs

Academic help



LECTURES:

1. Optional weekly Q&A tutorials with professor: Thursdays 12-1pm in Con Hall
2. Discussions Page on Quercus monitored by Lecture TA Bonnie Pilkington



Bonnie Pilkington



Jill Wheeler

LABS & ASSIGNMENTS:

Course & Lab Coordinator

1. Office hours (*see BIO220 homepage on Quercus*)
2. Lab thread on Discussions on Quercus

Genomes to Ecosystems in a Changing World



Prof. Nicole Mideo

- Genes, environment & behaviour
- Sexual differences
- Social evolution
- Evolutionary medicine



Prof. Jill Wheeler

- Ecological genomics
- Conservation genetics
- Genetics of exploited populations
- Applied ecology
- Human impacts on climate

Genes, Environment and Behaviour

Evolutionary explanations for behaviours



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The Evolution of Sexual Differences & Sexual Interactions

Sexual traits & behaviours

Thinking about evolutionary explanations for dramatic differences.



Photo © 2014 "Mike" Michael L. Baird



Photo © 2007 Richard Freeman



Photo © 2013 John Dalton

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Cooperation & Conflict

Social Behaviours

Thinking about genes, rather than individuals



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Extended Phenotypes

Thinking about genes having effects *outside* of the organism that harbours those genes



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The Evolution of Disease

Applying evolutionary thinking to some of the most pressing problems of our time.

Drug resistance, virulence, emerging disease & vaccination



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The Evolution of Senescence

Aging

Evolutionary explanations for non-adaptive phenomena



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TODAY:

Genes, Environment and Behaviour

- Genes and environment influence phenotypes including behaviours
- Natural selection shapes behaviours
- Environmental effects on trait values can be described as “plasticity”; plasticity *can* be adaptive (but isn’t always)
- The influence of genes and environment can be visualized with plots of the “reaction norm”
- Natural selection shapes the reaction norm

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Two classes of scientific questions

How/What?

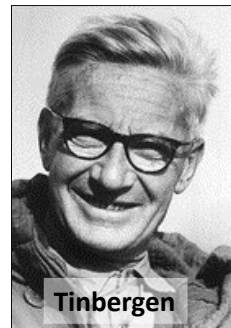
- How does an individual manage to carry out an activity?
- How do mechanisms within an animal work to produce a particular trait?

PROXIMATE CAUSES

Why?

- Why has *that* trait evolved?

ULTIMATE CAUSES



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What is the causal relationship between the animal's genes and its behaviour?



Why has this behaviour evolved and how has it changed over evolutionary time?

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What is the hormonal basis of infanticide?



Why has it evolved: what is the adaptive value of infanticide to both males and females?

For evolutionary explanations, see Taylor (2012) Why infanticide can benefit animals.
<http://www.bbc.co.uk/nature/18035811>

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Have you noticed that bees and wasps behave oddly in the fall?

They are a little bit drunk

- What? Reaction to ethanol
- How? Feeding on over ripe fruit
- Why? An adaptation for locating ripened fruit

Watch some drunken wasps at <https://www.youtube.com/watch?v=3ioX8RWTvTs>

POPULAR MECHANICS

Watch Out: Wasps Are Apparently Drunk and Angry This Time of Year

By Megan Friedman Aug 10, 2018

Daily Mail

Britain is under attack from 'drunk and irritable' wasps who are going on 'stinging rampages' after drinking cider in pub gardens because they have run out of food

How to steer clear of feisty yellow jackets this fall

Meira Gebel, Detroit Free Press Published 9:45 a.m. ET Sept. 16, 2018 | Updated 7:07 p.m. ET Sept. 16, 2018

By HARRY PETTIT FOR MAILONLINE PUBLISHED: 07:28 EST, 8 August 2018 | UPDATED: 09:12 EST, 8 August 2018

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Drunk pollinators might be good for plants!



Broad-leaved helleborine (*Epipactis helleborine*)



Wikimedia commons 14

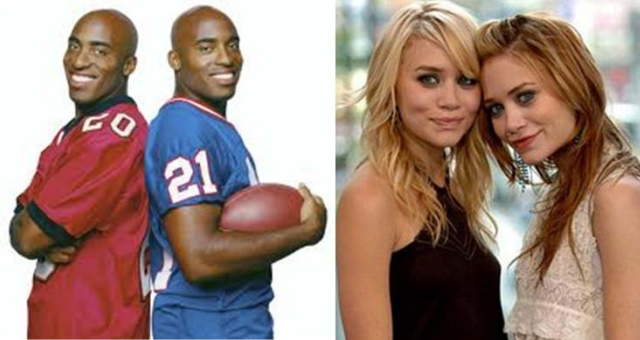


**“Nothing in biology makes sense
except in the light of evolution”**

Theodosius Dobzhansky, 1973

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Genetic and environmental variation



Identical twins

- Same genetic make-up
- Even slight differences in environment lead to variation in traits and behaviours

But, it's...uh...*difficult* to conduct experiments on humans. 🤔

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Phenotypes reflect both genetic and environmental effects

$$Z = G + E + G \times E$$

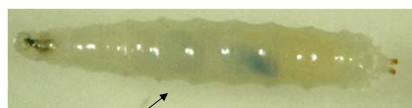
phenotype genes environment gene by environment interaction

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The Rover-Sitter Polymorphism



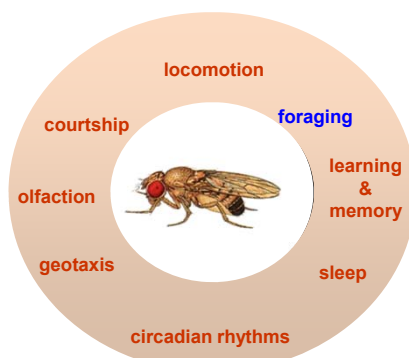
Marla Sokolowski



larva



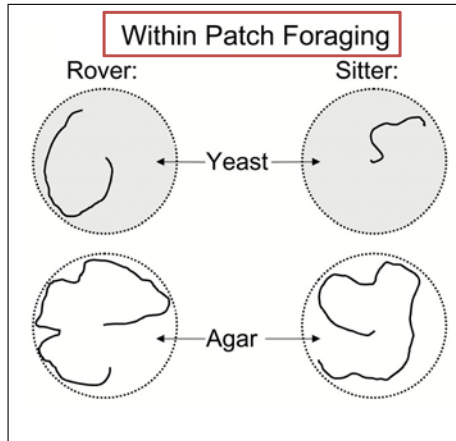
adult



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Within population variation in a behaviour: Rover/Sitter Polymorphism

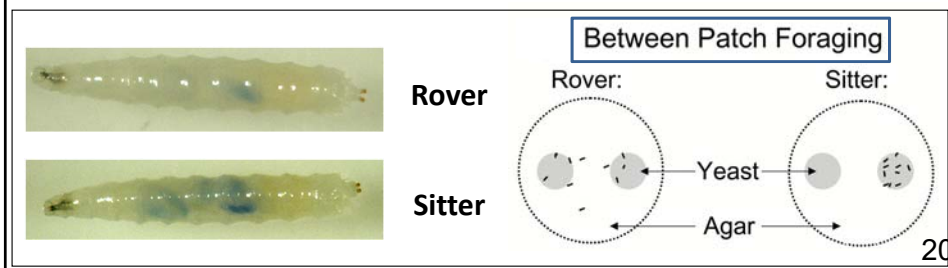
- Yeast is food, and is spread on agar, a non-food media
- Within food patches, rovers move much more than sitters
- Rovers and sitters move more often, and for similar distances in the absence of food



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Rover/Sitter Polymorphism

- Rovers move much greater distances than sitters when food is patchy
- This means that rovers are off food patches more often, but also are more likely to find new patches

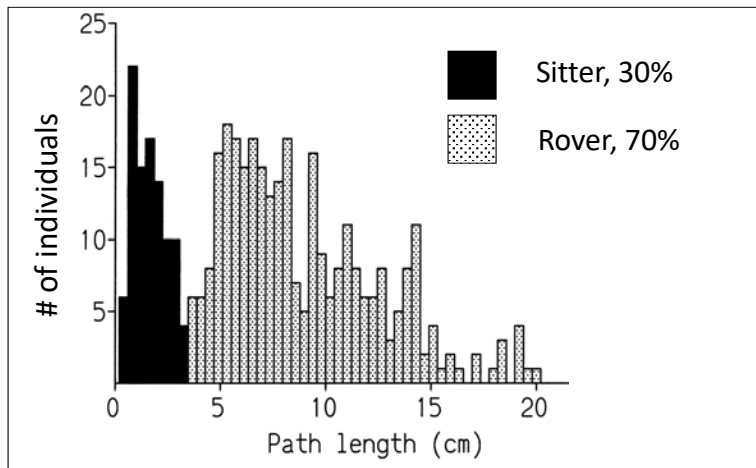


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Observed variation in the frequency of rovers and sitter larvae

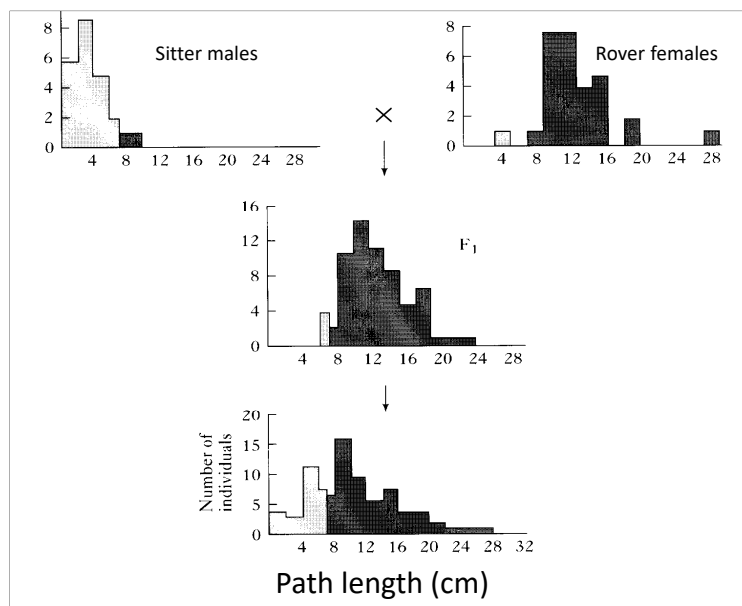
Samples of *Drosophila* larvae were obtained from pear trees found in an unkept backyard in downtown Toronto.

Sokolowski 1980 Behavior Genetics 10: 291-302



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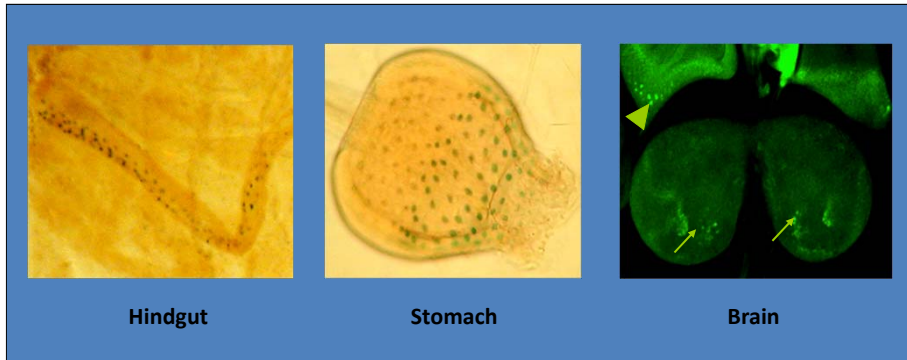
Genetic Analysis



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What do these foraging alleles produce?

PKG - an enzyme involved in cell signaling
- located in nervous system, and the gut



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Rover/sitter transgenics

We can insert the “rover” allele in otherwise genetically “sitter” larvae, then measure the effects of that allele on foraging

The composite image includes three main elements: 1) A cartoon illustration of a green syringe labeled 'ROVER' injecting a small larva into a petri dish. 2) A photograph of a woman with long brown hair and glasses, smiling. 3) A cartoon illustration of two bees on a maze. One bee is green and has a dollar sign on its chest, while the other is blue and has a red eye. A speech bubble from the blue bee says, 'OKAY—JUST GIVE IT TO ME STRAIGHT, LINDA— I'M NOT HER FATHER, AM I?'. The number '24' is visible in the bottom right corner of the cartoon.

Both foraging behaviour and PKG activity in transgenic flies resembles “rover” type more than “sitter”.

Strain	Foraging Behaviour (cm traveled, mean±SE)	PKG activity (pmol min ⁻¹ mg ⁻¹ mean±SE)
rover	9.2 ± 0.53	11.2 ± 0.64
transgenic	8.9 ± 0.63	11.3 ± 0.56
sitter (host)	4.6 ± 0.29	10.0 ± 0.65

Osborne et al. 1997 *Science* 277:834-836.

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Evolution by natural selection...

- Variation in a trait
- Variation in fitness for the trait
- Genetic basis for the trait

Evolution of **behaviour**...

- Behaviours have lots of variation
- Different behaviours have different fitness
- Behaviours have a genetic basis

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Phenotypes reflect both genetic and environmental effects

$$Z = G + E + G \times E$$

phenotype genes environment gene by environment interaction

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Environmental effects on foraging

- Adults were deprived of food for 4 or 24 hrs
- Assayed for foraging behaviour in patchy environment



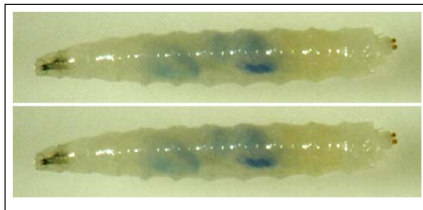
Adult foraging behaviour (cm traveled)

Food Deprivation	<i>Rover</i>	<i>Sitter</i>
4 h	36.17	22.38
24 h	25.60	16.20

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Summary: rover - sitter story

- A single major gene underlies the rover/sitter polymorphism
- The rover allele is dominant to the sitter allele
- Both larval and adult behaviours are affected by these alleles
- Elements of the environment (e.g. food deprivation) also affect these behaviours
- Homologous genes occur in bees, mice, and humans



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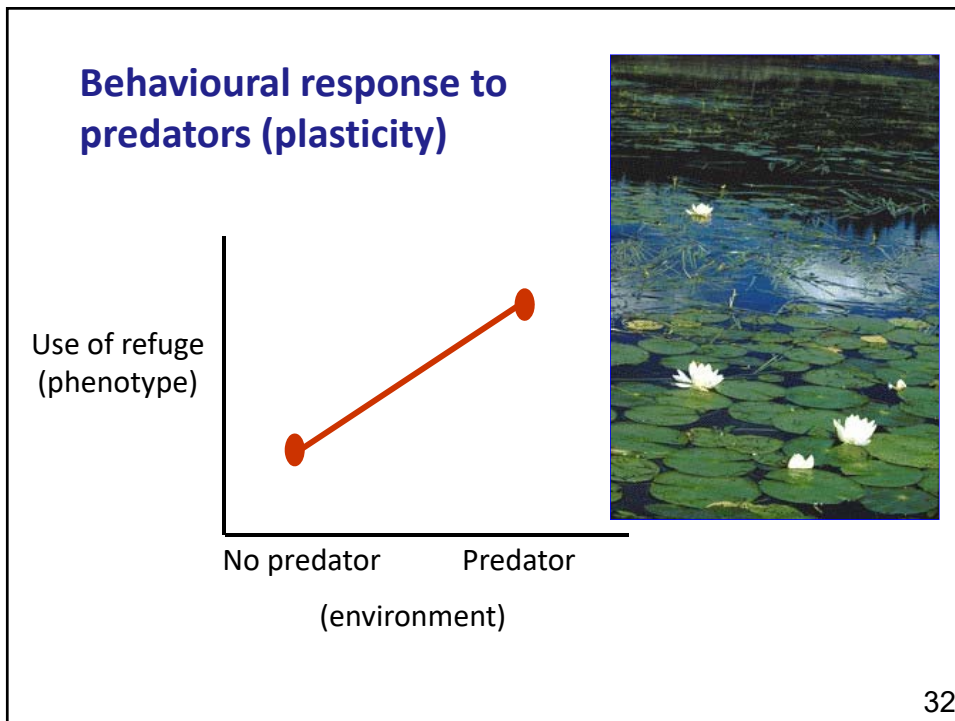
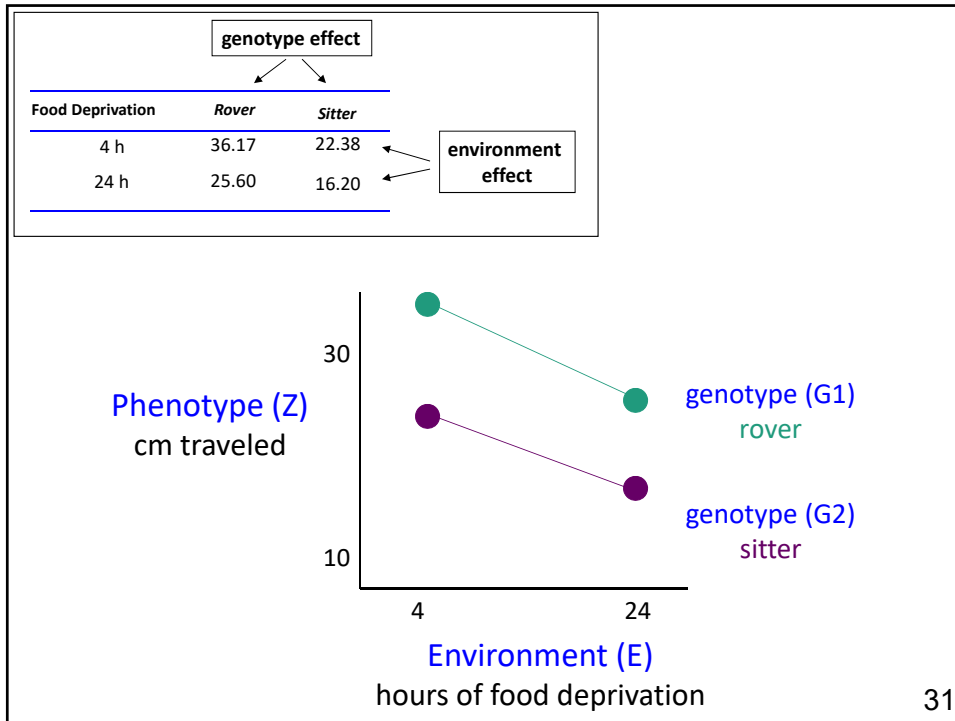
Phenotypic plasticity: an environmental effect on the phenotype

genotype effect

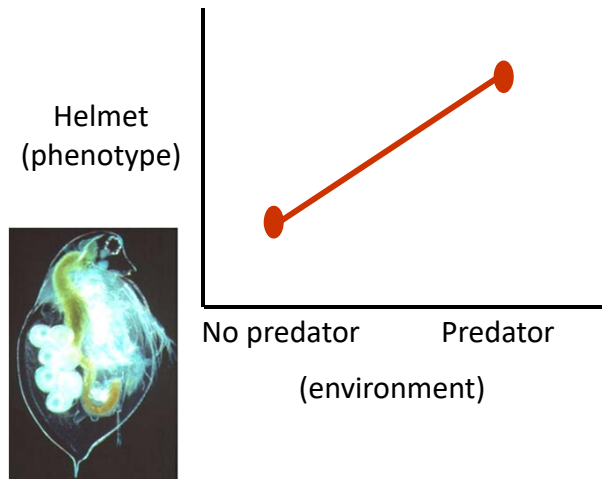
Food Deprivation	<i>Rover</i>	<i>Sitter</i>
4 h	36.17	22.38
24 h	25.60	16.20

environment effect

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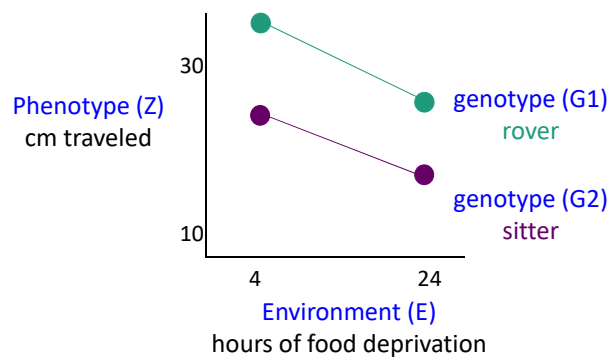
Morphological response to predators (plasticity): *Daphnia*



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Reaction Norms: Visualizing G and E

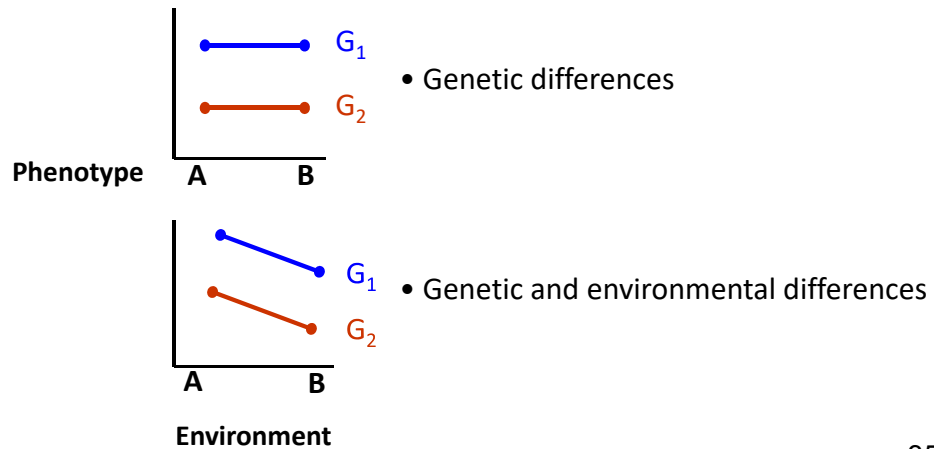
- Environmental effects on trait values can be described as **plasticity**
- The influence of genes and environment can be visualized with plots of the **reaction norm**
- The **reaction norm** describes the effect of some environmental variable on the phenotype of a single genotype.



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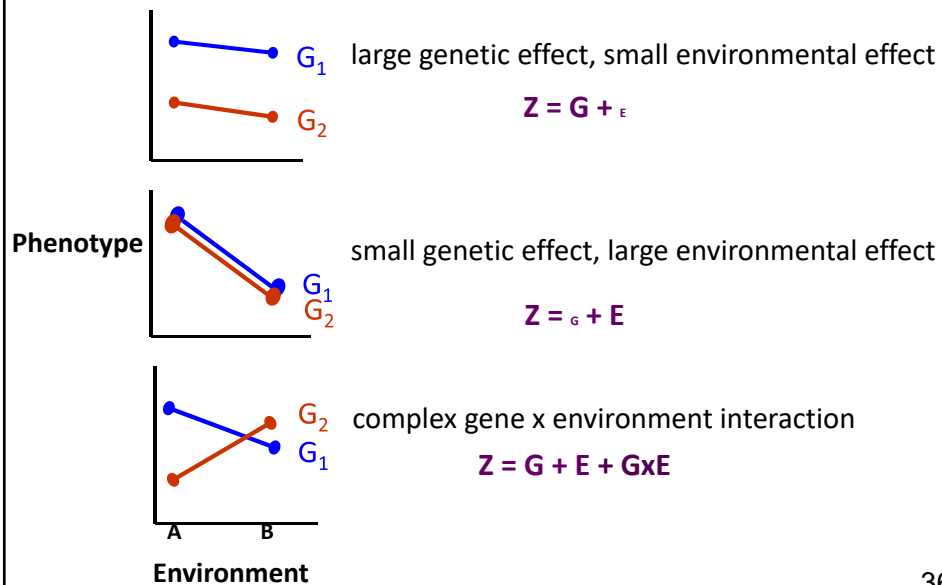
Reaction Norms: Visualizing G and E

Reaction norms describe the effect of an environmental variable on the phenotype of a single genotype.

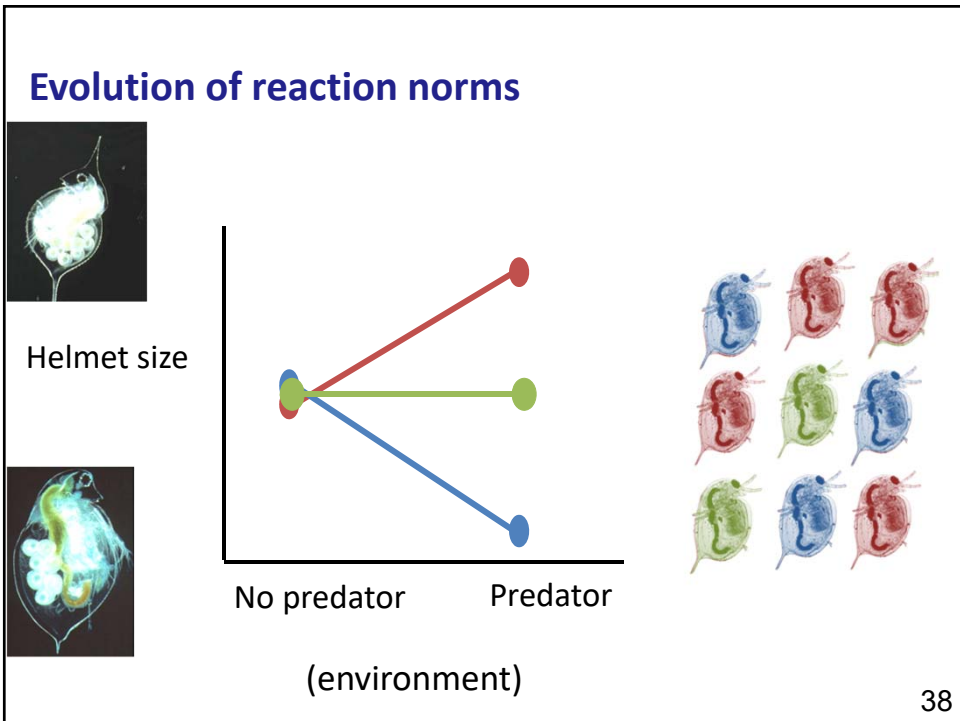
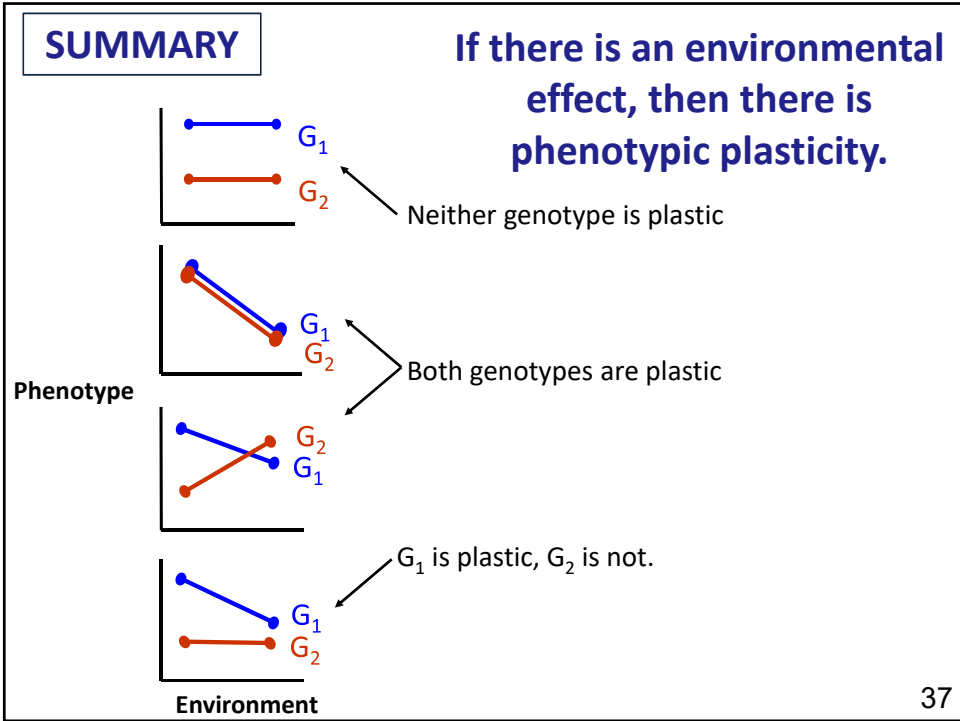


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You can learn a lot from reaction norms



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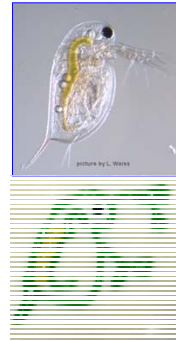
Genetic variation and evolution of reaction norms

Daphnia are a great model system

- Genotypes can easily be isolated

Daphnia tend to display phototactic behaviour

- They are attracted to – or repelled by – light
- Phototaxis can be quantified in the lab
- Food is in the light, but so are visual predators (e.g., fish)

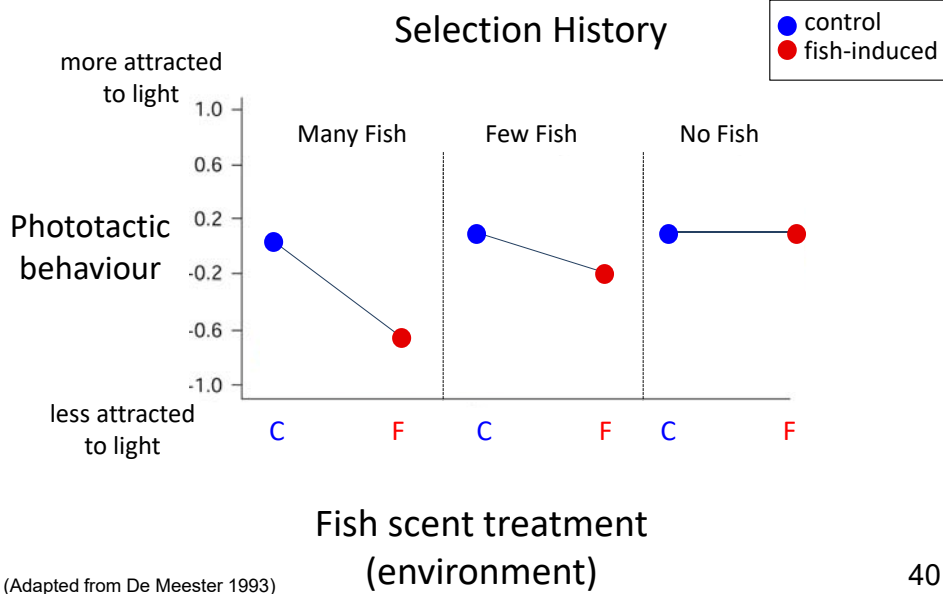


Questions:

1. Does *Daphnia* light-seeking behaviour change in the presence of predators?
 - Assayed multiple *Daphnia* genotypes from each of 3 lakes (**G**)
 - Presence of predators simulated with fish smell (**E**)
2. Is there variation in that response depending on where the *Daphnia* came from?
 - Lakes had different selection histories (many, few, or no fish)

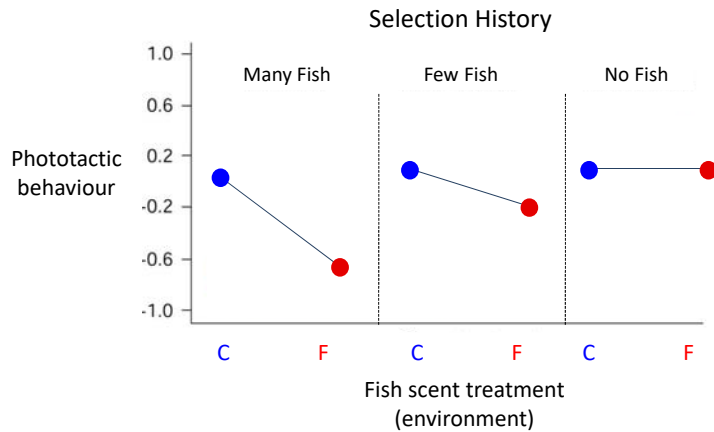
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Evolution of reaction norms



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Evolution of reaction norms



- Daphnia populations with a selective history of predation risk have evolved to avoid habitats with high risk of predation
- This has happened through the evolution of a reaction norm

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Summary

- **Genes** and **environment** influence phenotypes including behaviours
- Natural selection shapes behaviours
- Environmental effects on trait values can be described as “**plasticity**”; plasticity **can** be adaptive (but isn’t always)
- The influence of genes and environment can be visualized with plots of the “**reaction norm**”
- Natural selection shapes the reaction norm

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