Herbivore-induced resistance in seaweeds – background and bioassays

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Terminology

- Constitutive
  - Always present and active
- Inducible
  - Produced in response to a signal/cue (fast or slow)
- Activated
  - In between (precursors constitutive, response inducible) (fast)

When to expect inducible defenses?

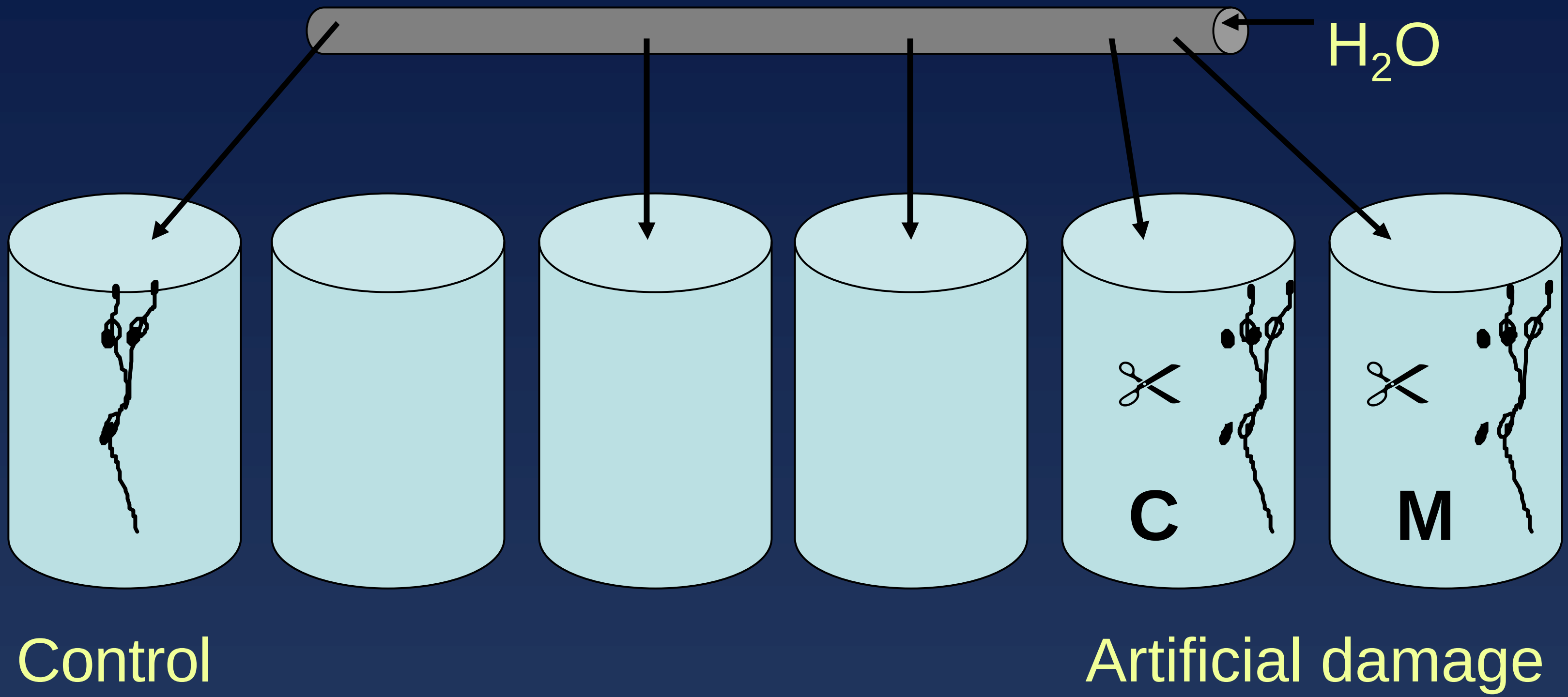
- Evolution of inducible defenses
  - Defenses are costly
  - Presence and activity of consumers is variable and unpredictable
  - Consumers active over temporal and spatial scales that enable inducible defenses to be effective
  - Increased variability in the level of chemical defenses enhance the effectiveness
  - Reliable environmental cues that the plant can sense and respond to

Starting point…

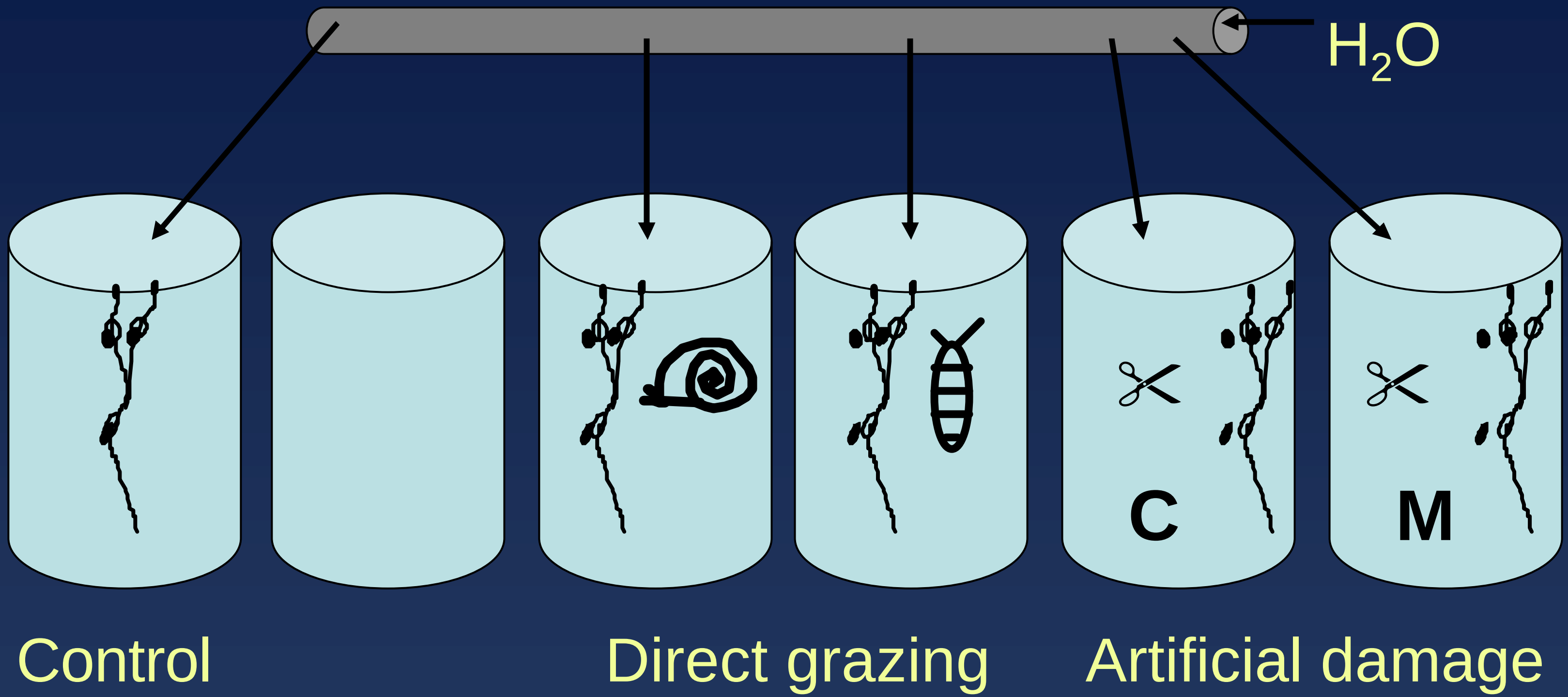
- Unknown compounds/mechanisms
  - Ecologically relevant herbivores! Herbivores and seaweeds must be present in the same habitat and herbivores must be eating the seaweeds to a certain extent.
  - Is there an unpredictable variation in herbivore density?

- Known compound
  - Is the concentration variable?
  - Are there indications of costs (e.g. negative correlations with growth/reproduction)?

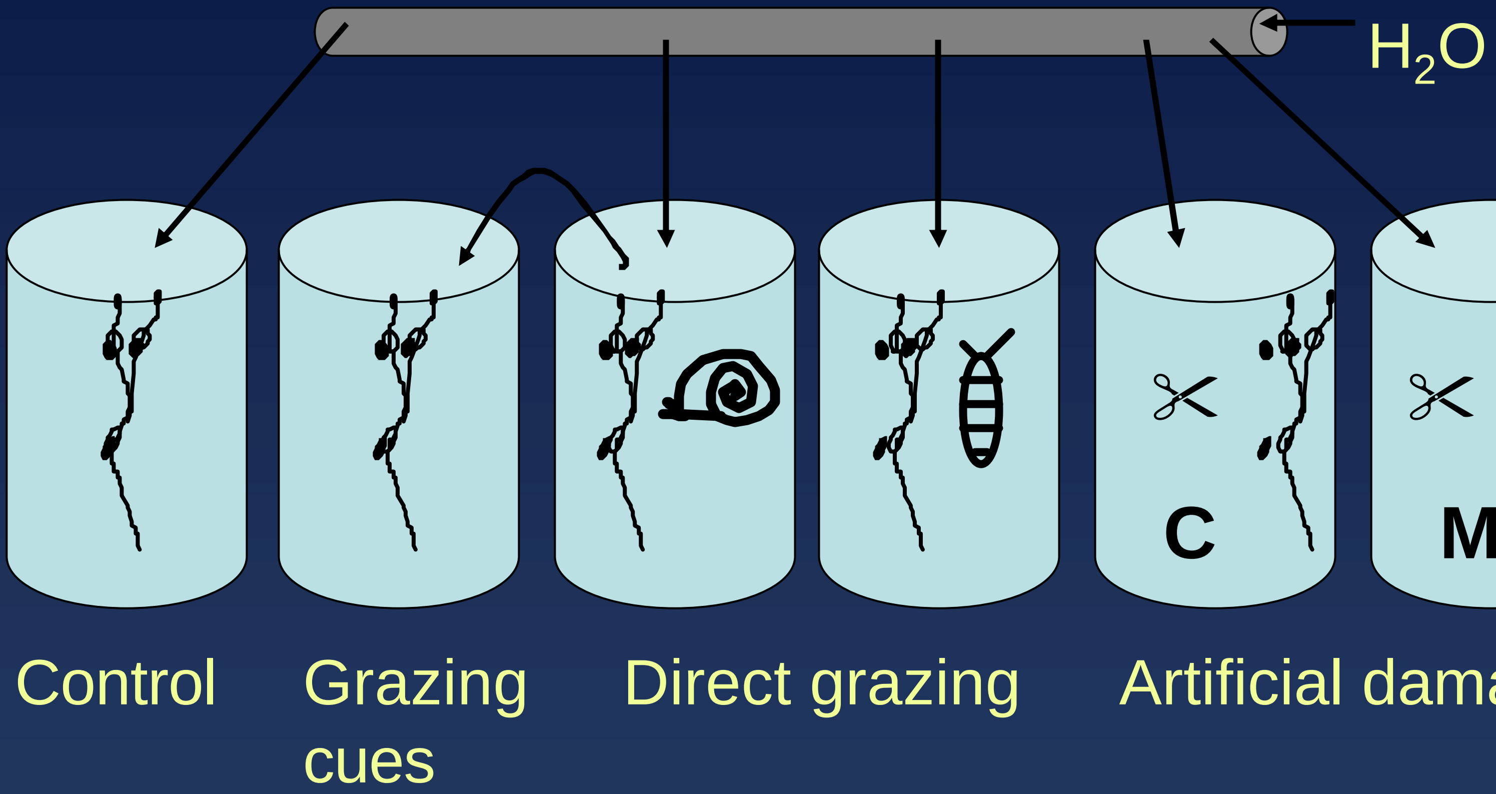
Induction experiment



Induction experiment



Induction experiment



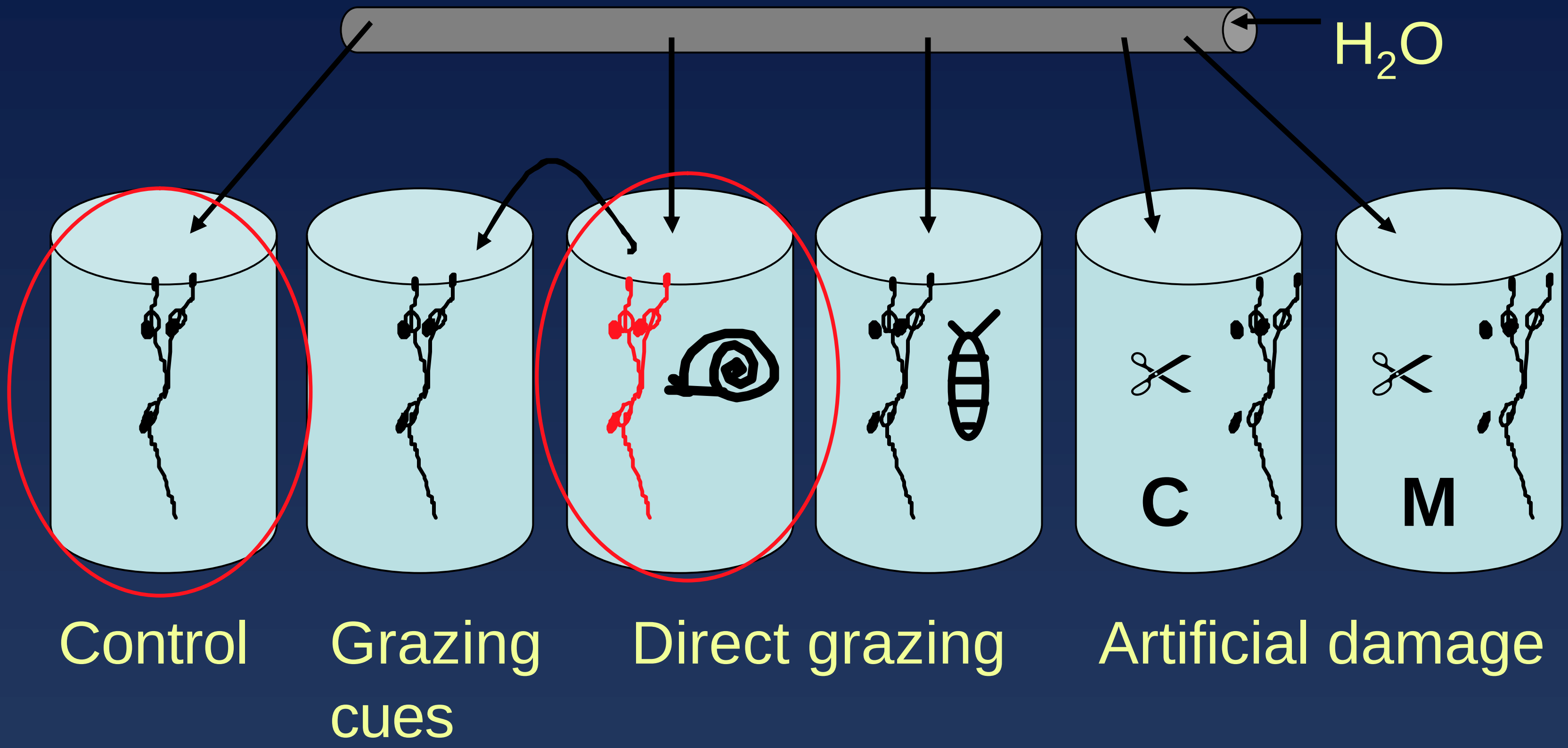
One genetic individual per aquarium!
n = 10, 60 aquaria in total
Measure weight change or grazing damage!

Bioassay?

- No-choice assays
  - Consumption
  - Compensatory feeding responses may results in herbivores feeding more on poor food!
  - Reproduction

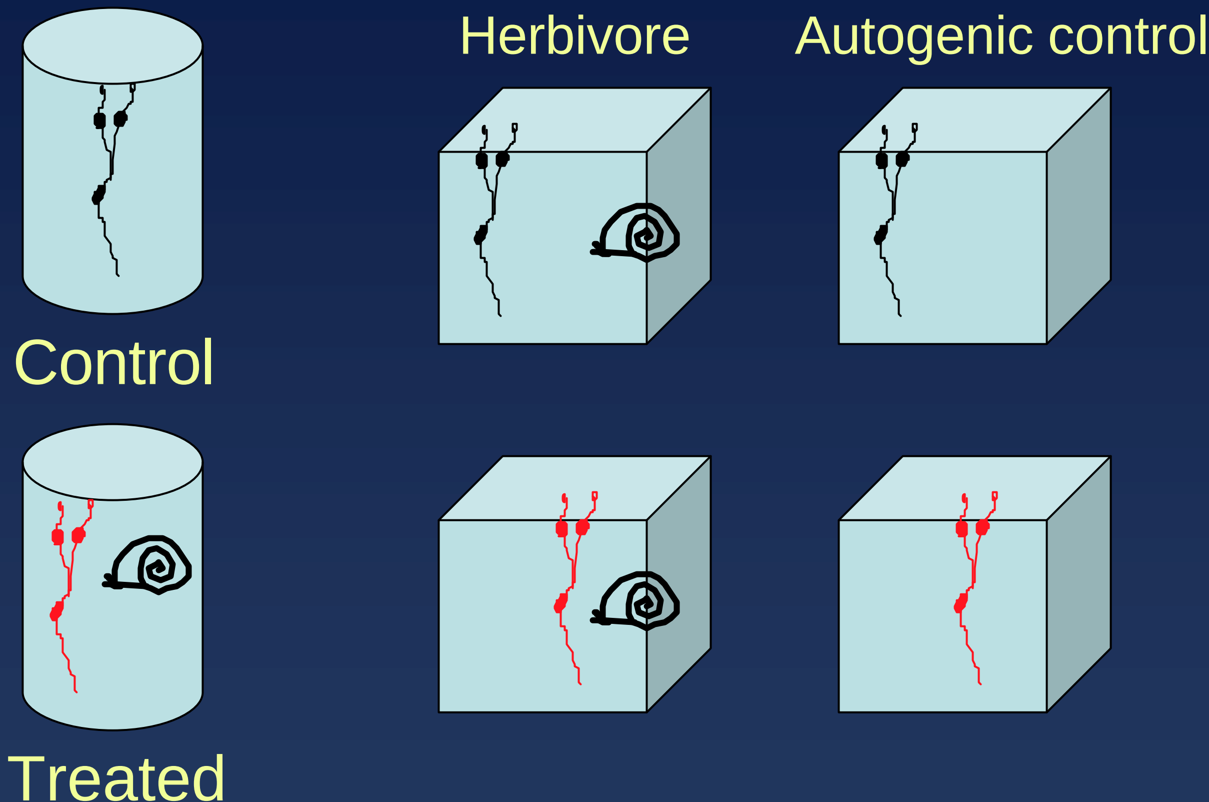
- Choice assays
  - Preference
  - 2- or multiple-choice?

Induction experiment



One genetic individual per aquarium!
n = 10, 60 aquaria in total
Measure weight change or grazing damage!

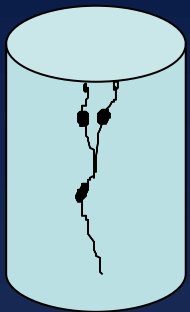
No-choice



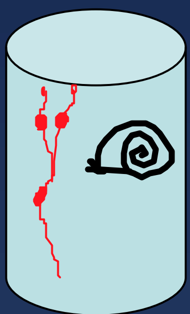
2-factor ANOVA (Treatment, Grazer)

Hypothesis - significant interaction

Two-choice

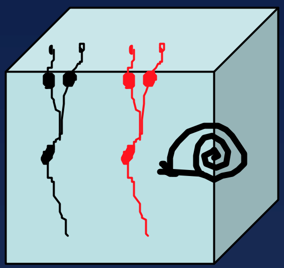


Control

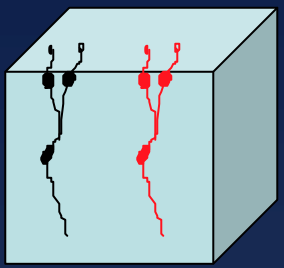


Treated

Herbivore



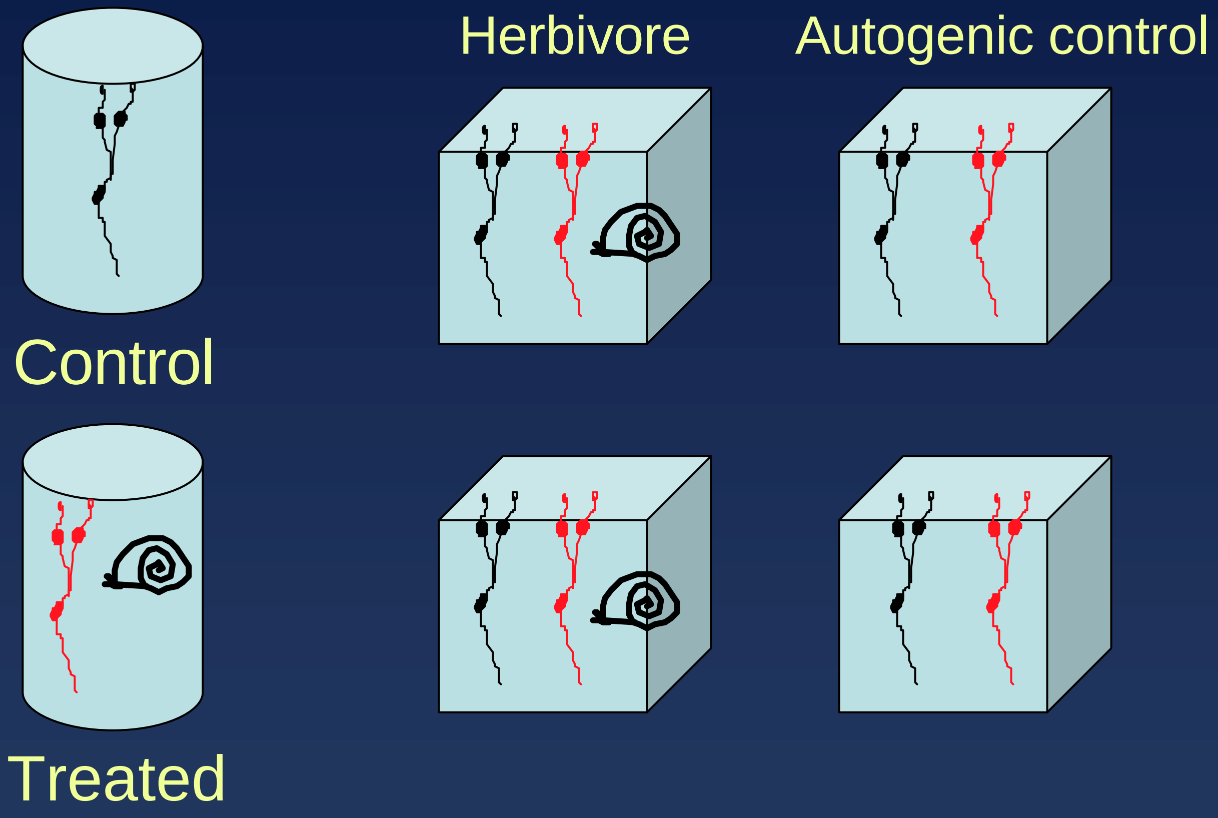
Autogenic control



2-factor ANOVA (Treatment, Grazer)

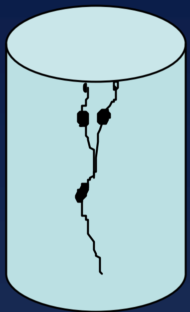
Hypothesis - significant interaction

Two-choice



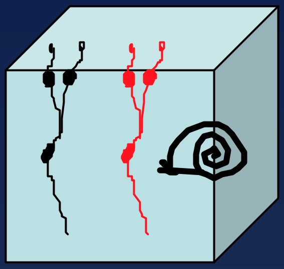
2-factor ANOVA (Treatment, Grazer)
Hypothesis - significant interaction
Throw away half of the data

Two-choice, one treatment

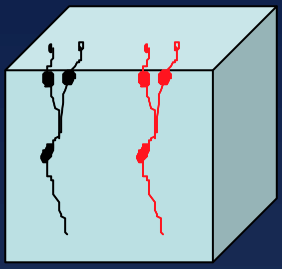


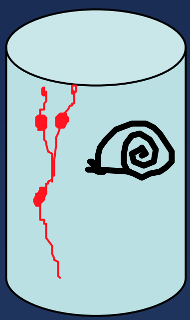
Control

Herbivore



Autogenic control





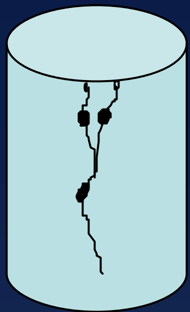
Treated

$wwch_{H1C}$ = stop-start
$wwch_{H1T}$ = stop-start
$wwch_{AC}$ = stop-start
$wwch_{AT}$ = stop-start

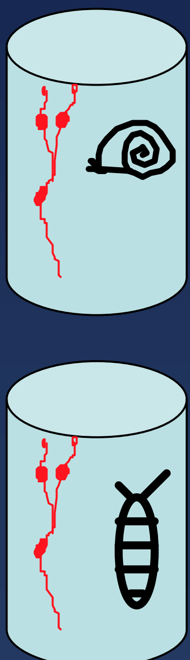
Difference in wwch:
$D_{H1} = wwch_{H1C} - wwch_{H1T}$
$D_{A} = wwch_{AC} - wwch_{AT}$

t-test

Two-choice, 2 treatments

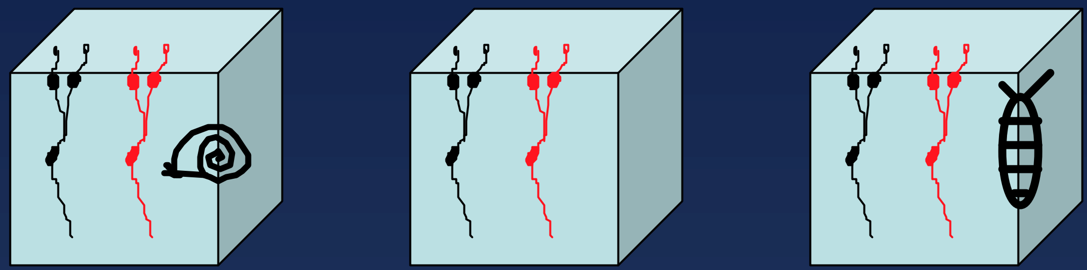


Control



Treated

Herbivore 1 AC Herbivore 2



$wwch_{H1C}$ = stop-start
$wwch_{H1T}$ = stop-start
$wwch_{AC}$ = stop-start
$wwch_{AT}$ = stop-start
$wwch_{H2C}$ = stop-start
$wwch_{H2T}$ = stop-start

Difference in wwch:

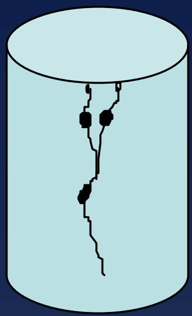
$D_{H1} = wwch_{H1C} - wwch_{H1T}$

$D_{H2} = wwch_{H2C} - wwch_{H2T}$

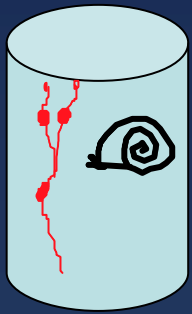
$D_{A} = wwch_{AC} - wwch_{AT}$

One-factor ANOVA!

Two-choice, consumption

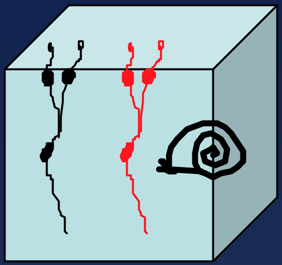


Control

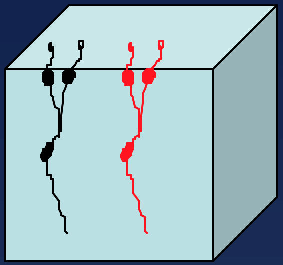


Treated

Herbivore



Autogenic control



If you pair the herbivore and autogenic control seaweed genetically, you will decrease variances due to genetic differences in growth

$wwch_{HC}$ = stop-start

$wwch_{HT}$ = stop-start

$wwch_{AC}$ = stop-start

$wwch_{AT}$ = stop-start

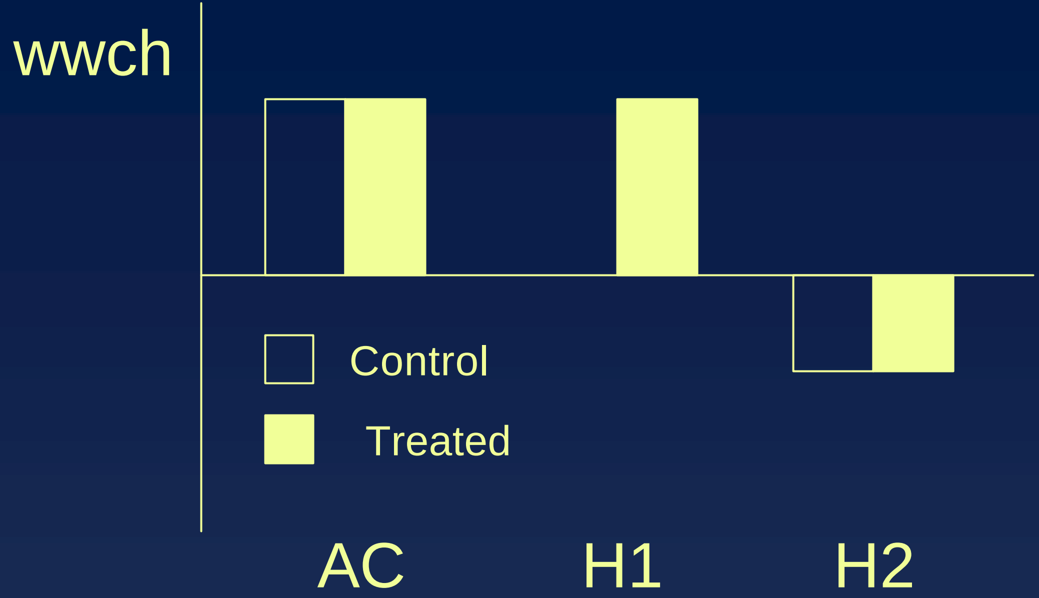
$consumption_{C} = wwch_{AC} - wwch_{HC}$

$consumption_{T} = wwch_{AT} - wwch_{HT}$

paired t-test

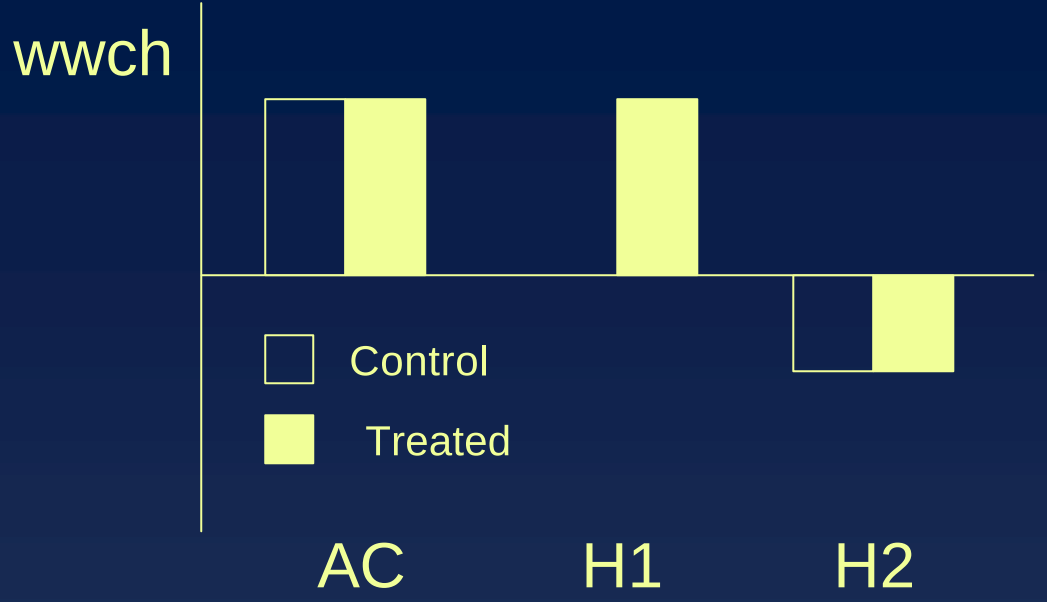
$wwch_{AC}$ = stop-start
$wwch_{AT}$ = stop-start
$wwch_{H1C}$ = stop-start
$wwch_{H1T}$ = stop-start
$wwch_{H2C}$ = stop-start
$wwch_{H2T}$ = stop-start

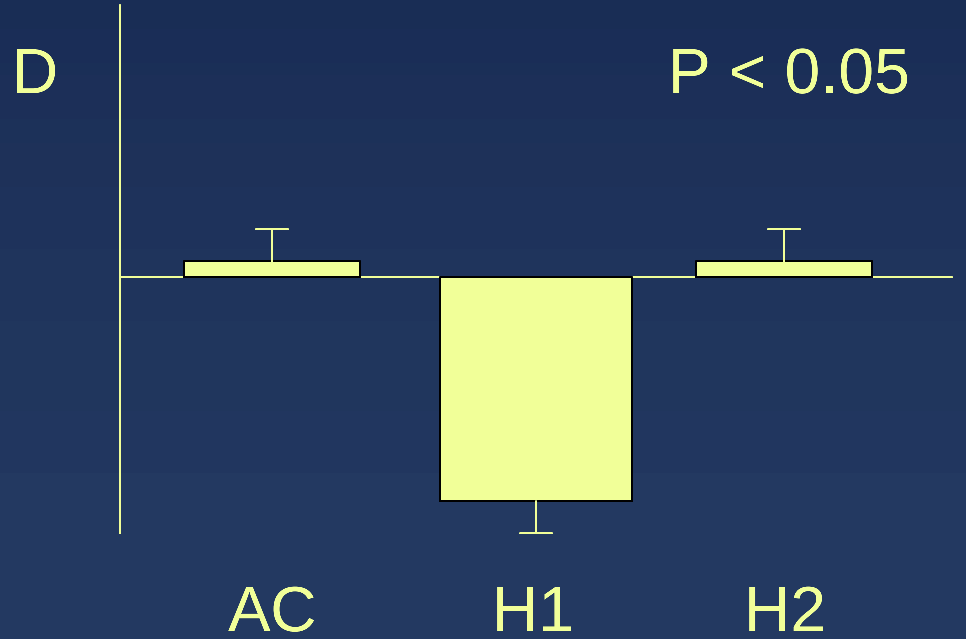
$wwch_{AC}$ = 2-1 = 1
$wwch_{AT}$ = 2-1 = 1
$wwch_{H1C}$ = 1-1 = 0
$wwch_{H1T}$ = 2-1 = 1
$wwch_{H2C}$ = 0.5-1 = -0.5
$wwch_{H2T}$ = 0.5-1 = 0.5



$wwch_{AC}$ = stop-start
$wwch_{AT}$ = stop-start
$wwch_{H1C}$ = stop-start
$wwch_{H1T}$ = stop-start
$wwch_{H2C}$ = stop-start
$wwch_{H2T}$ = stop-start

$wwch_{AC} = 2-1 = 1$
$wwch_{AT} = 2-1 = 1$
$wwch_{H1C} = 1-1 = 0$
$wwch_{H1T} = 2-1 = 1$
$wwch_{H2C} = 0.5-1 = -0.5$
$wwch_{H2T} = 0.5-1 = 0.5$



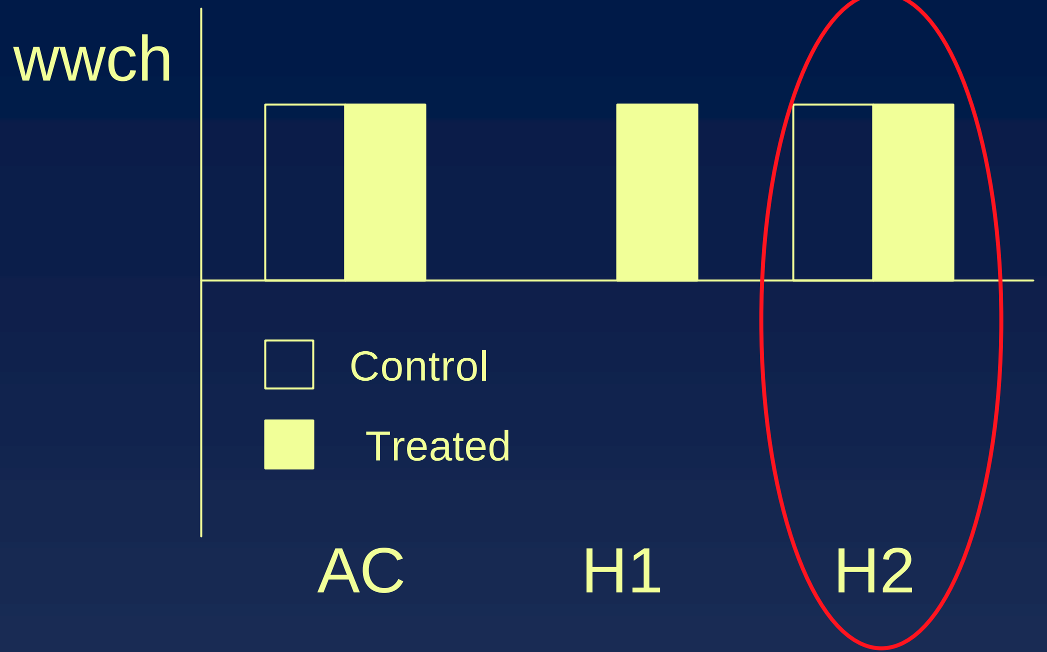


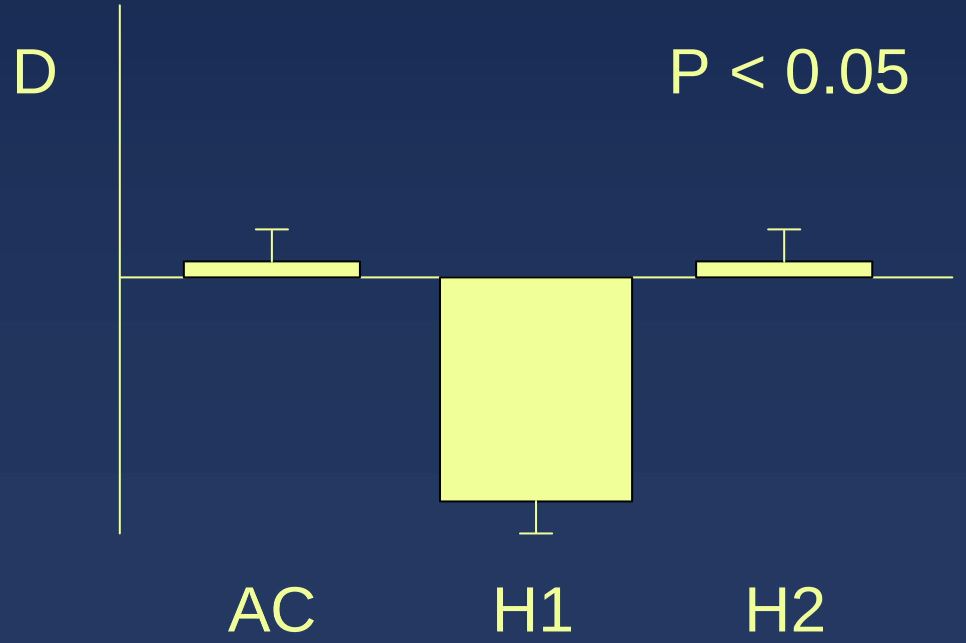
Difference in wwch:
$D_{H1} = wwch_{H1C} - wwch_{H1T}$
$D_{H2} = wwch_{H2C} - wwch_{H2T}$
$D_{AC} = wwch_{AC} - wwch_{AT}$

Difference in wwch:
$D_{AC} = 1-1 = 0$
$D_{H1} = 0-1 = -1$
$D_{H2} = -0.5-(-0.5) = 0$

$wwch_{AC}$ = stop-start
$wwch_{AT}$ = stop-start
$wwch_{H1C}$ = stop-start
$wwch_{H1T}$ = stop-start
$wwch_{H2C}$ = stop-start
$wwch_{H2T}$ = stop-start

$wwch_{AC}$ = 2-1 = 1
$wwch_{AT}$ = 2-1 = 1
$wwch_{H1C}$ = 1-1 = 0
$wwch_{H1T}$ = 2-1 = 1
$wwch_{H2C}$ = 2-1 = 1
$wwch_{H2T}$ = 2-1 = 1





Difference in wwch:
$D_{H1} = wwch_{H1C} - wwch_{H1T}$
$D_{H2} = wwch_{H2C} - wwch_{H2T}$
$D_{AC} = wwch_{AC} - wwch_{AT}$

Difference in wwch:
D_{AC} = 1-1 = 0
D_{H1} = 0-1 = -1
D_{H2} = -1-(-1) = 0