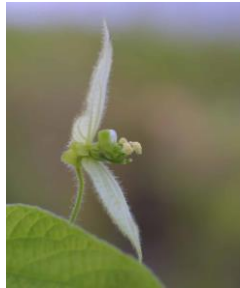
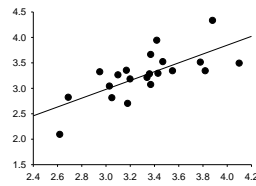


Study design, data collection and statistics

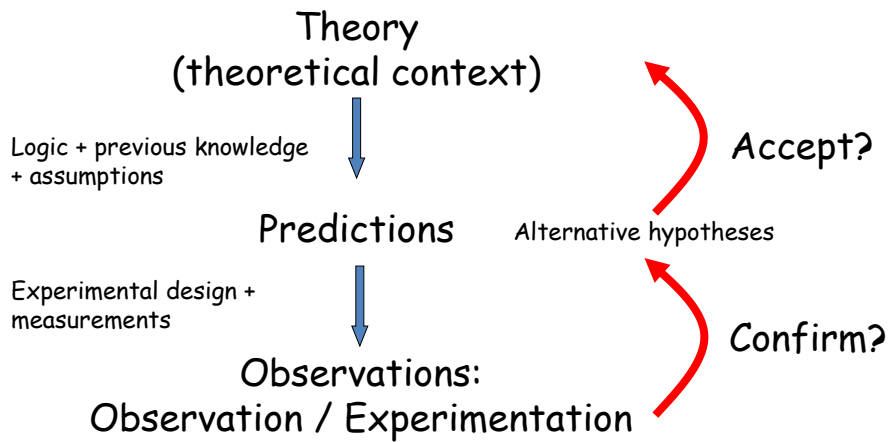


id	Species	Individual	Sex	CVL	CVL	CVL
1	SI 001	1	1	2.62	2.89	2.29
2	SI 001	1	2	2.88	4.12	3.19
3	SI 001	1	3	2.85	3.32	2.26
4	SI 001	1	4	2.92	3.04	3.72
5	SI 001	1	5	3.15	3.34	2.65
6	SI 001	2	6	3.62	3.34	3.19
7	SI 001	3	7	3.43	3.29	2.89
8	SI 001	1	8	3.16	3.26	2.44
9	SI 001	2	9	3.34	3.23	3.13
10	SI 001	1	10	3.17	3.07	3.60
11	SI 001	2	11	3.26	3.18	2.84
12	SI 001	1	12	4.02	3.49	3.72
13	SI 001	1	13	3.05	2.85	2.43
14	SI 001	1	14	3.78	3.11	3.41
15	SI 001	1	15	3.18	2.79	3.06
16	SI 001	1	16	2.42	2.94	2.44
17	SI 001	1	17	3.38	3.28	2.12



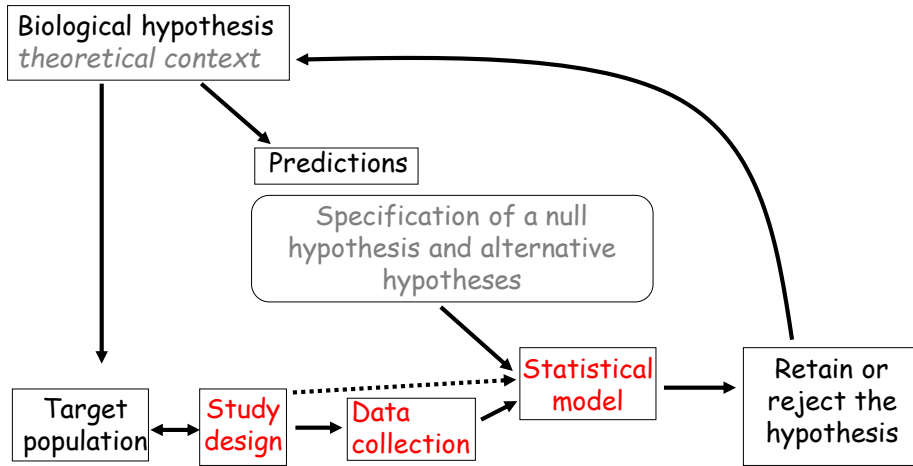
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The hypothetico-deductive method of confirmation



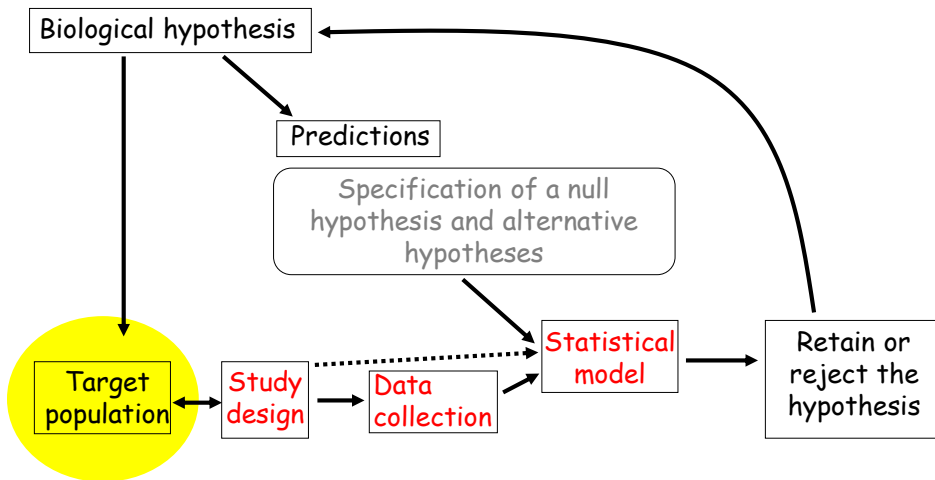
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The hypothetico-deductive method of confirmation, study design and statistics



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The hypothetico-deductive method of confirmation, study design and statistics



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Level of the study

At which level should we make the measurements?

Individual

Family

Populations

Species

...

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Level of the study

What is the sampling level* in the following studies?

1) Human genome sequencing



2) The effect of industrial fishing on age at first reproduction in cod

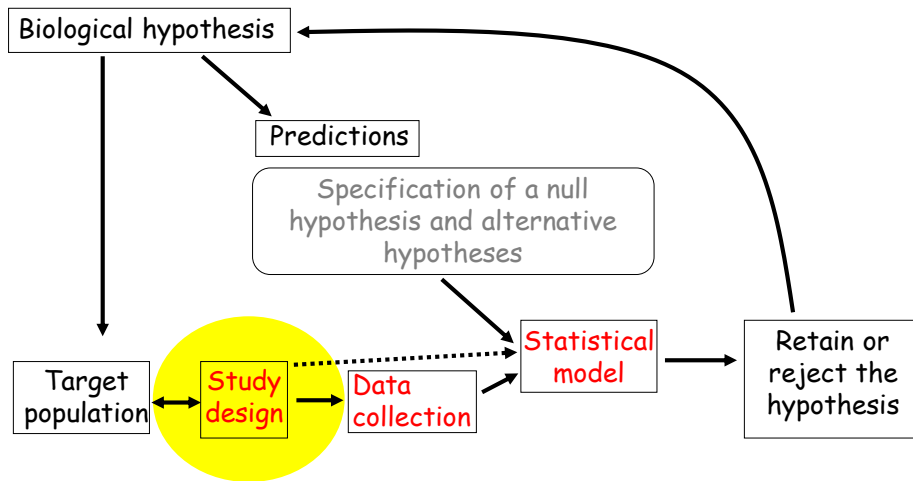
3) Distribution of the *Leontopodium alpinum* (Edelweiss)

4) The effect of size on animal longevity (maximum lifespan)

*what is the unit of observation?

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The hypothetico-deductive method of confirmation,
study design and statistics



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The type of study

Experimental study: Studies that include randomization of treatments or treatment design.

Observational studies: Controlled studies designed with respect to a particular hypothesis but which lack randomization

Surveys: descriptive studies.

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	The type of study	
	Experimental studies	Observational studies
Confounding factors	avoid	Possible
Reverse causation	avoid	Possible
Realism	Specific	general
Feasability	Sometimes difficult	Easier (often)
Ethic	Sometimes not allowed	Always allowed (but check)

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The type of study

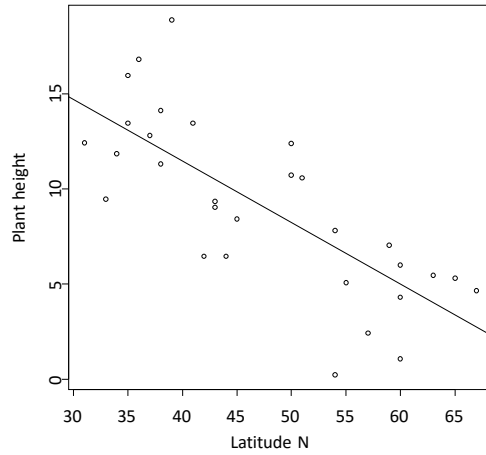
Consider the following question:

What is the effect of latitude on flowering time and seed production in plants?

Imagine three ways to study this question using a survey, an observational study, or an experimental study.

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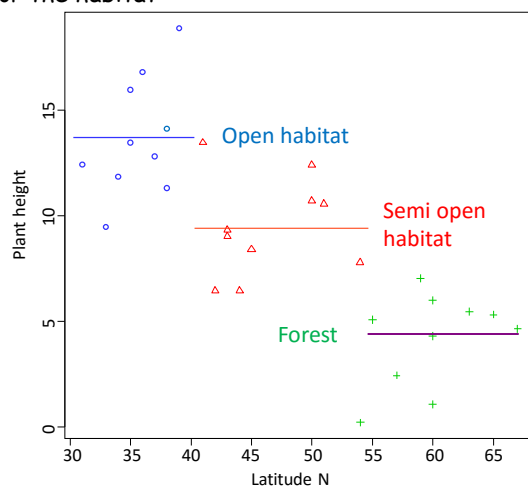
Avoiding confounding factors



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Avoiding confounding factors

Accounting for the habitat



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Study design: what to think about?

Sampling / Experimental design

Level of the study

Possible confoundings

Independence of the observations

Sample size

What do I measure?

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Independence of the observations
(survey and observational studies)

A rapid example: the evolution of the armor plate in the
sticklebacks



Pseudoreplication: Increasing sampling of non-independent study units

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Independence of the observations (Experimental studies)

Testing the effect of a chemical at three concentrations + control

Four different growth chambers

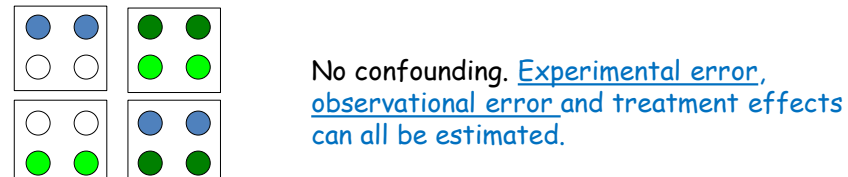
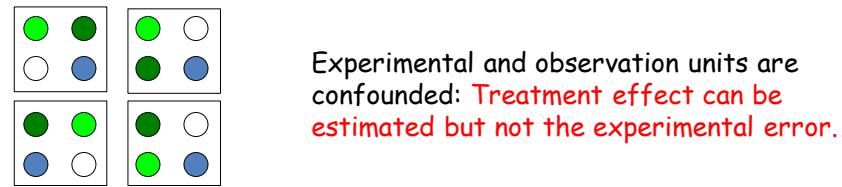
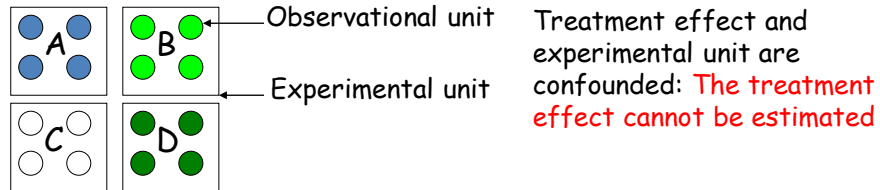
How do you do?



Experimental unit
(growth chamber)

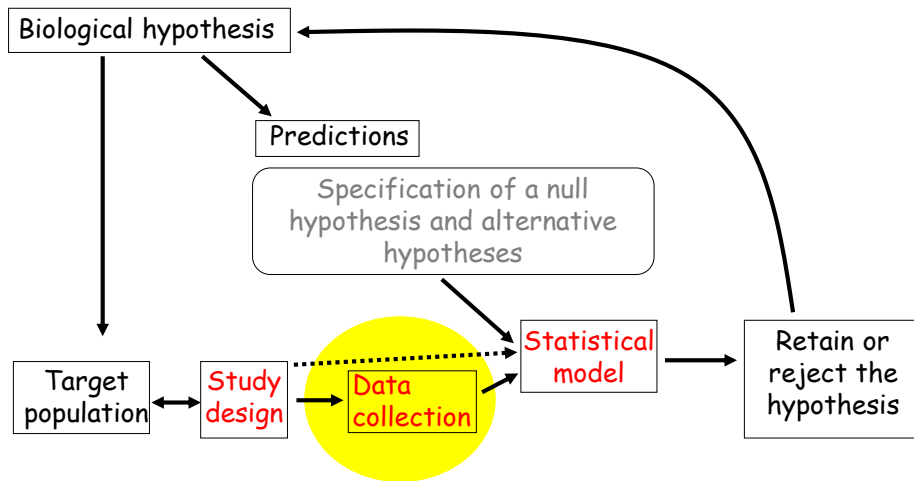
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Study design: experimental studies



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The hypothetico-deductive method of confirmation,
study design and statistics



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Measurements

Measurement consists of an assignment of numbers to attributes of entities so that the relations between the numbers can capture empirical relations among the attributes

Houle et al. 2011

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Measurements

I am measuring the right thing?

How to measure size?



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Measurements

The properties of the numbers depend on the properties of the measurements

Scaled measurements \neq number

Always assign units to your measurements!

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Measurements

Are following variables numerical or categorical?

If numerical, are they discrete or continuous?

If categorical, are they nominal or ordinal?

- Petal area of rose flowers
- Colour
- Redness measure with RGB color
- Heart beat per minute of a reindeer
- Stage of fruit ripeness (underripe, ripe , over ripe)
- Tree species
- Year of birth
- Gender
- Birth weight
- Temperature in degree C

For which variable does it make sense to calculate a mean, and a CV?

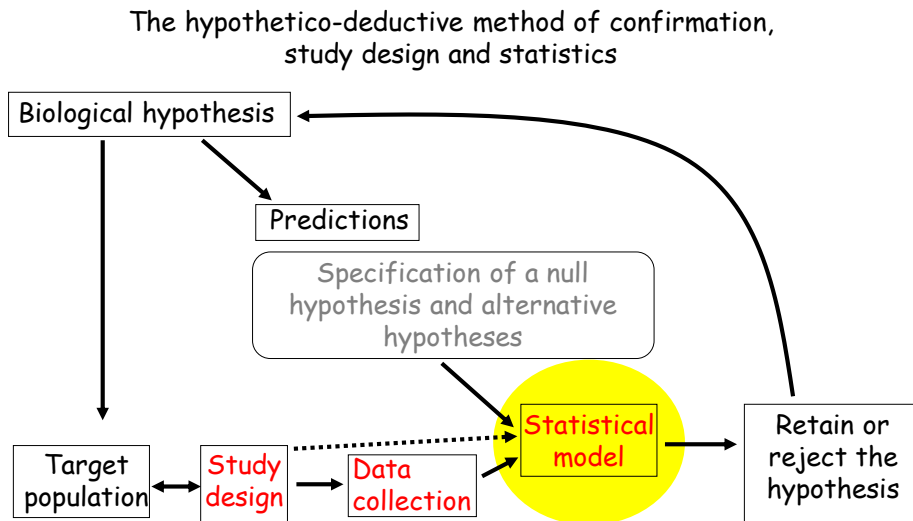
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Measurements

Using the previous studies (see 4 examples above)

- 1 - Suggest some of the measurements that can be done
- 2 - What is the scale of these measurements?
- 3 - What kind of mathematical transformation you can do while keeping the property of the measurement?

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Statistical tests

Biological hypothesis: Norwegians are taller than French

Statistical hypothesis:

Null hypothesis: Norwegians = French $\Rightarrow \beta = 0$

Alternative hypothesis Norwegians \neq French $\Rightarrow \beta \neq 0$

1. $H_0 : \beta = 0$ (β is an unknown parameter)

2. Test Statistic $T = |\bar{X}_1 - \bar{X}_2|$

3. Large values of $T \Leftrightarrow$ Stronger Evidence against the
Null Hypothesis (H_0) (less likely)

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Statistical tests

Power: probability to detect an effect while the effect exists

The statistical power of a test depends on:

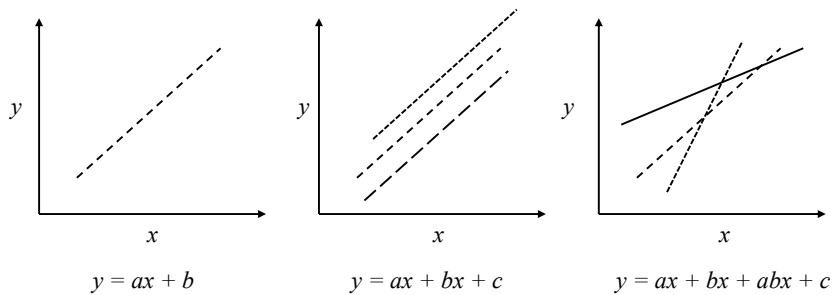
$$T = \frac{|\bar{x}_1 - \bar{x}_2|}{\sqrt{\frac{\sigma_1^2}{n_1} + \frac{\sigma_2^2}{n_2}}}$$

The effect size \rightarrow $|\bar{x}_1 - \bar{x}_2|$
 The variance \rightarrow σ_1^2 and σ_2^2
 The sample size \rightarrow n_1 and n_2

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Study design and statistics

The statistical models you will use should reflect the design of your study



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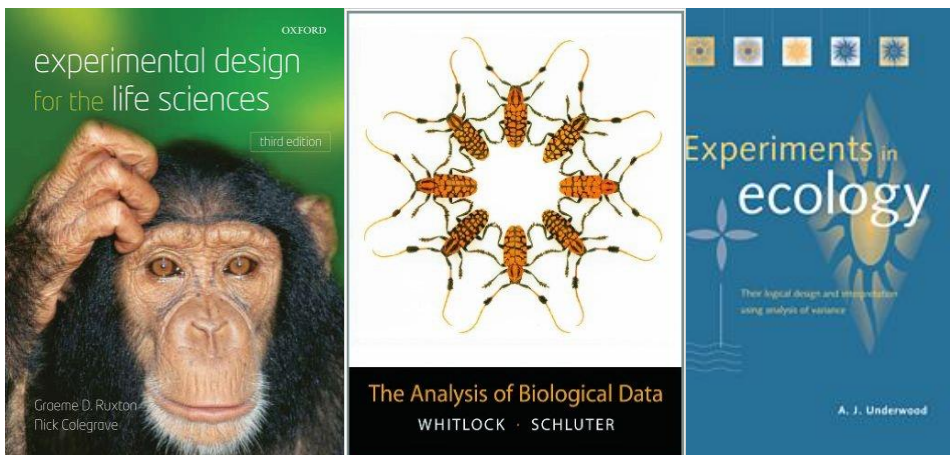
Two myths!

It does not matter how you collect your data,
there will always be a statistical «fix» that will
allow you to analyse them.

If you collect lots of data something interesting
will come out, and you will be able to detect even
very subtle effect.

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3 books to help you!



Simple & general
Syllabus for BI 3052

From simple to more
advanced statistical
methods

Extremely good for
experimental design

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Two advices

Take time to plan your study and discuss with various people to uncover possible flaws

Try to think about the data analysis when planning your study, that is , before collecting data