

# Class 1: An introduction to Bayesian Hierarchical Modelling

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## Let's get started

- ▶ Tell me who you are, what you are working on, and what you hope to get out of the week
- ▶ Timetable for the week
- ▶ Pre-requisites

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## How this course works

- ▶ This course lives on GitHub, which means anyone can see the slides, code, etc, and make comments on it
- ▶ The timetable html document provides links to all the pdf slides and practicals
- ▶ The slides and the practicals are all written in `Rmarkdown` format, which means you can load them up in Rstudio and see how everything was created
- ▶ Let me know if you spot mistakes, as these can be easily updated on the GitHub page
- ▶ There is a `bhm_course.Rproj` R project file from which you should be able to run all the code

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## Course format and other details

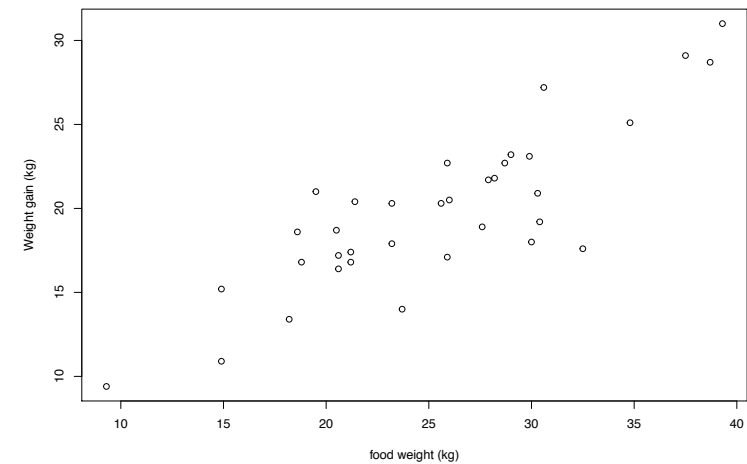
- ▶ Lectures will take place in the morning, practical classes in the afternoon
- ▶ We will finish earlier on Wednesday/Thursday for a mini-trip
- ▶ Please ask lots of questions
- ▶ Some good books:
  - ▶ *Data Analysis using Regression and Hierarchical Models* by Gelman and Hill
  - ▶ *Bayesian Data Analysis* by Gelman et al

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## What is a Bayesian hierarchical model?

- ▶ **A model** is just a representation/approximation of the real world, here expressed in equations
- ▶ **Hierarchical** means that the model is built up in *ordered layers* which makes it easier to fit very complex models
- ▶ **Bayesian** means the model involves both a *likelihood* and a *prior* probability distribution (more on this tomorrow)

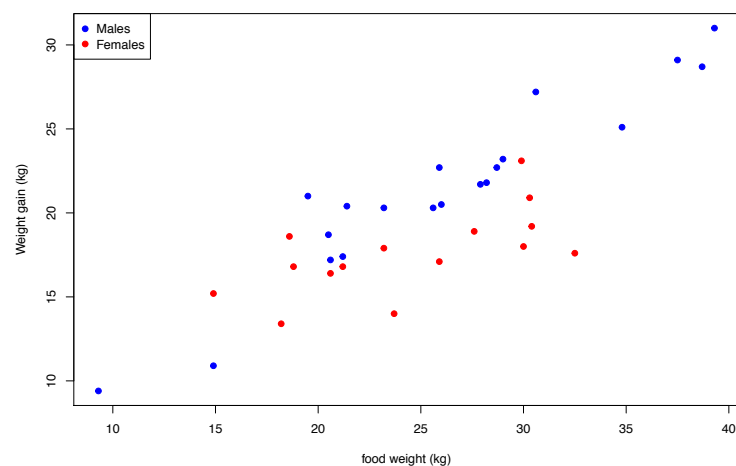
## Thinking hierarchically: example 1



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## More information:



## Example 2: 8 Schools

We have 8 schools in a region, with a relative performance score (column score) compared to the national average and a standard error (sigma) based on 3 repeated visits

##	school	score	sigma
## 1	1	28	15
## 2	2	8	10
## 3	3	-3	16
## 4	4	7	11
## 5	5	-1	9
## 6	6	1	11
## 7	7	18	10
## 8	8	12	18

- ▶ If you had to pick an overall score for this region how would you calculate it?
- ▶ If you had to guess the score of a new measurement for school 1 what value would you use?

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## Example 3: Earnings data

1192 observations on earnings (in USD) and various measurements about ethnicity, age, height, etc

```
##   earn age eth height height_cm      y  x  x_centered
## 1 50000  2  3   74   187.96 10.81978 74   6.932011
## 2 60000  3  3   66   167.64 11.00210 66  -1.067989
## 3 30000  1  3   64   162.56 10.30895 64  -3.067989
## 4 51000  2  3   63   160.02 10.83958 63  -4.067989
## 5  9000  1  3   64   162.56  9.10498 64  -3.067989
## 6 29000  2  3   62   157.48 10.27505 62  -5.067989
```

- ▶ Does height affect earnings?
- ▶ Are there different rates of change for different groups (e.g. age/ethnic groups)?

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## Example 4: Swiss Willow Tit data

3 replicate measurements on whether Swiss Willow Tits were found with covariates on forest cover and elevation

```
##   rep.1 rep.2 rep.3 c.2 c.3 elev forest dur.1 day.2 day.3 length alt
## 1     0     0     0  0  0  420     3   240   58   73   6.2 Low
## 2     0     0     0  0  0  450    21   160   39   62   5.1 Low
## 3     0     0     0  0  0 1050    32   120   47   74   4.3 Med
## 4     0     0     0  0  0 1110    35   180   44   71   5.4 Med
## 5     0     0     0  0  0  510     2   210   56   73   3.6 Low
## 6     0     0     0  0  0  630    60   150   56   73   6.1 Low
```

- ▶ How do the covariates affect the chance of finding the birds?
- ▶ Are these effects linear?
- ▶ What do we do with the missing data?

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## More data sets in the data directory

- ▶ The data directory contains a few more data sets which we will play with throughout the week
- ▶ The data\_descriptions.txt file shows what they contain
- ▶ If you have some spare time it's worth loading them in, exploring relationships, and fitting some simple models

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## Summary

- ▶ In hierarchical models we avoid fitting models separately as much as possible
- ▶ By fitting models together we **borrow strength** from the different groups in the data and reduce uncertainty
- ▶ Bayesian models allow us to incorporate all the available data into providing information on the question we want to answer

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