# Introduction to Statistical Modeling Introduction

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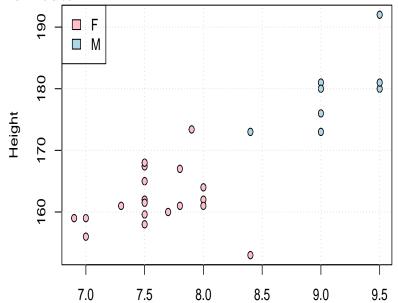
# Problem setting

- 26 observations from class of 2021-22 (19 female and 7 male)
   + 1 professor (27 total)
- Measurement of right palm width and height (both in cm).
- Random sample? From which population?
- Sources of bias, error?
- i Research questions
  - Is there an association between height and palm width?
  - Can we predict a person's height from their palm width?
  - If yes, how confident are we in these results?

# Simple and multiple linear regression

- In this lecture, we build a **simple linear regression** model.
- Simple regression: effect on height of a single predictor (palm width)
- Multiple regression: multiple predictors (palm width, gender, year, ...)

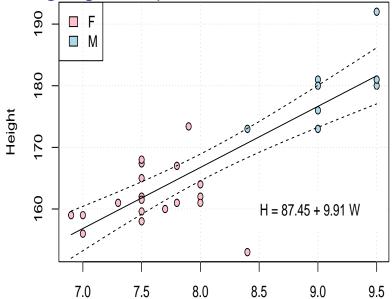
#### The raw data



Dalm Width

4 / 12

Associating height with palm width



Dalm Width

#### Via R

```
m <- lm(Height ~ Palm.width, data=heights)
summary(m)
```

```
Call:
```

```
lm(formula = Height ~ Palm.width, data = heights)
```

#### Residuals:

```
Min 1Q Median 3Q Max
-17.7055 -3.1967 -0.2853 3.1882 10.3919
```

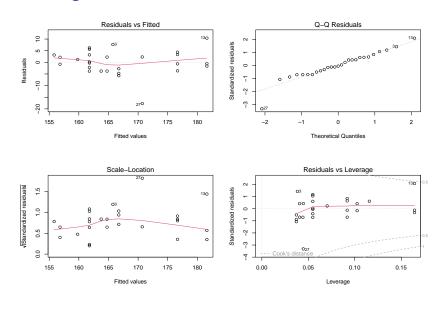
#### Coefficients:

```
Estimate Std. Error t value Pr(>|t|)
(Intercept) 87.450 10.814 8.087 1.93e-08 ***
Palm.width 9.911 1.338 7.408 9.26e-08 ***
```

Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 5.459 on 25 degrees of freedom Multiple R-squared: 0.687, Adjusted R-squared: 0.6745 F-statistic: 54.88 on 1 and 25 DF, p-value: 9.264e-08

### Model diagnostics



### Predicting height from palm width

- Model:  $E(H|W=w) = 87.45 + 9.91 \times w$ .
- Predicted expected height of a person with palm width 8.75cm:

$$E(H|W=8.75)=87.45+9.91\times 8.75=174.17\,\mathrm{cm}$$

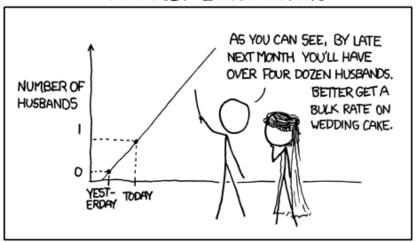
#### Regression coefficients:

- **Intercept** (87.45cm): height of a hypothetical student with palms that are 0 cm wide. Often makes more sense after mean-centering.
- **Slope** (9.91): each extra cm in palm width is associated with an increase of 9.91 cm in height.

# Be careful with extrapolating

Predicting outside the range of the data can yield misleading results.

#### MY HOBBY: EXTRAPOLATING



Source: XKCD

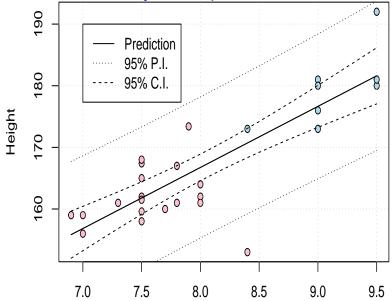
### What is the uncertainty in our prediction?

Assuming that our model is good, how accurate are the predictions from it?

For prediction  $E(H|W=8.75)=174.17\,\mathrm{cm}$ :

- 95% confidence interval: [171.27, 177.08]. Uncertainty in average prediction.
- 95% prediction interval: [162.56, 185.79]. Uncertainty in individual predictions.

What is the uncertainty in our prediction?



Dalm Width

#### Association between predictor and outcome

The regression slope  $\beta=9.91$  measures the strength of the association between palm width and height.

- If close to 0: no association
- If different from 0: some degree of association

How do we test whether  $\beta$  is 0?

```
Estimate Std. Error t value Pr(>|t|) (Intercept) 87.449557 10.813838 8.086819 1.928912e-08 Palm.width 9.911427 1.337903 7.408178 9.263523e-08
```