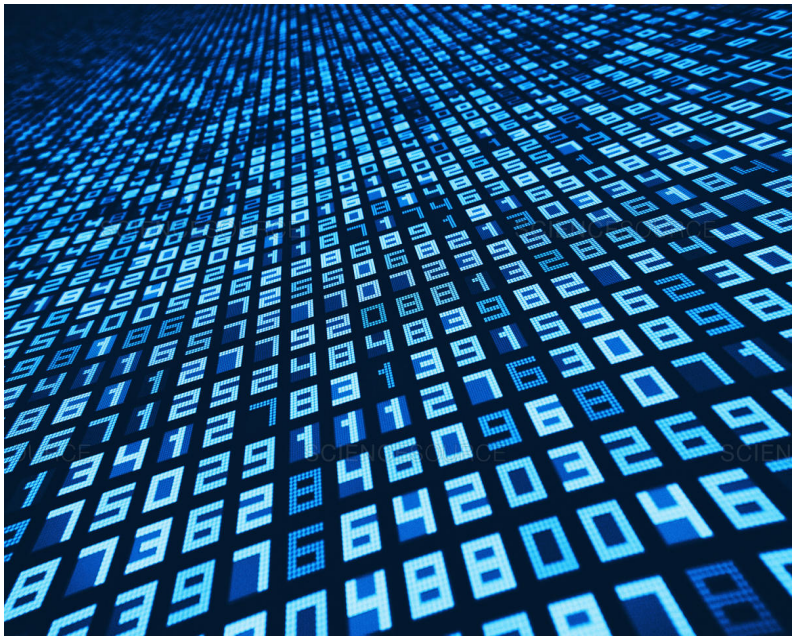
# Describing data

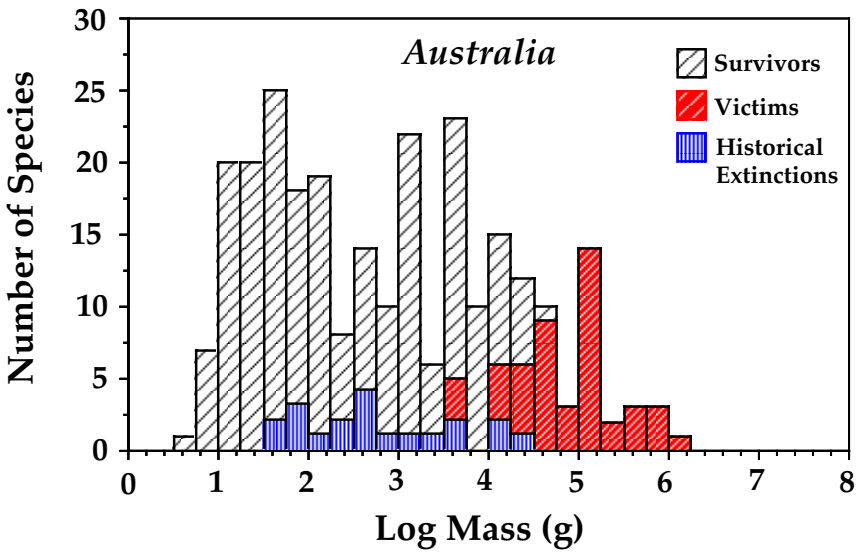
Samples and populations are often made of lots of individual (observational) units and their associated information (observations, variables).

We need to be able to describe samples by summary statistics (mean, median, variance, etc) so that these summaries can serve as an estimate of the same summaries for their statistical populations.



## Scientific question: Did humans drive mammal extinctions in Australia?

## Statistical question: Are “victims” bigger than “survivors” and historical extinctions?




**Frequency distribution of mammal mass categorized into survivors, “victims” and older (historical) extinctions**

**Survivors (extant species, i.e., alive today).**

**Victims (late Pleistocene, i.e., past 50 000 years, 50 ka).**

**Historical extinctions (older than 50 ka) are based on samples (fossils).**

We want to make inferences about all past and present mammals in Australia (i.e., statistical population are all mammal species, past or present, in Australia).

Study by Lyons et al. (2004; Evolutionary Ecology Research 6:339-358)

ka = kiloannus (1000); ~ 50 ka = “behavioural modernity” in humans.

# How measures of location (mean versus median) and spread (standard deviation versus interquartile range) compare

**Disarming fish**
**(protection against predation)**

Threespine stickleback
(*Gasterosteus aculeatus*)

**Plate Genotypes**
**Ectodysplasin (Eda) locus**
**(3rd generation)**

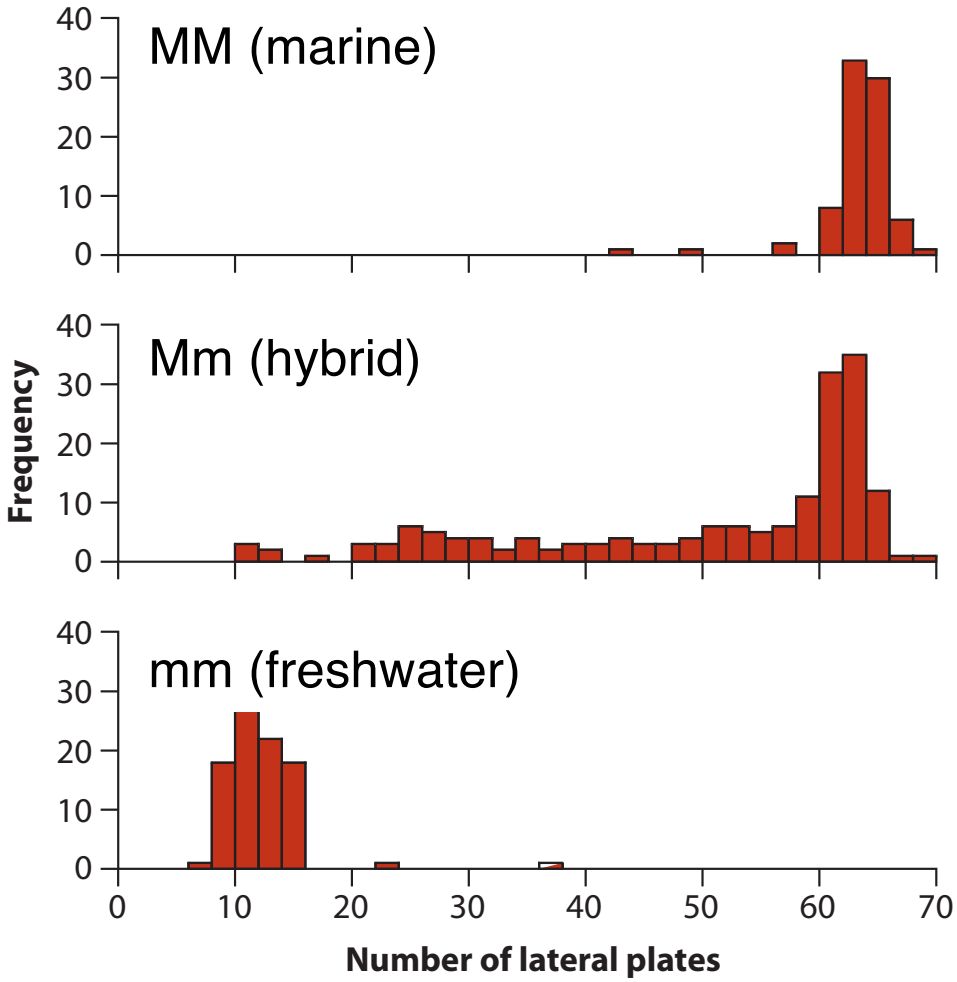
MM (marine)

Mm (hybrid)

mm (freshwater)

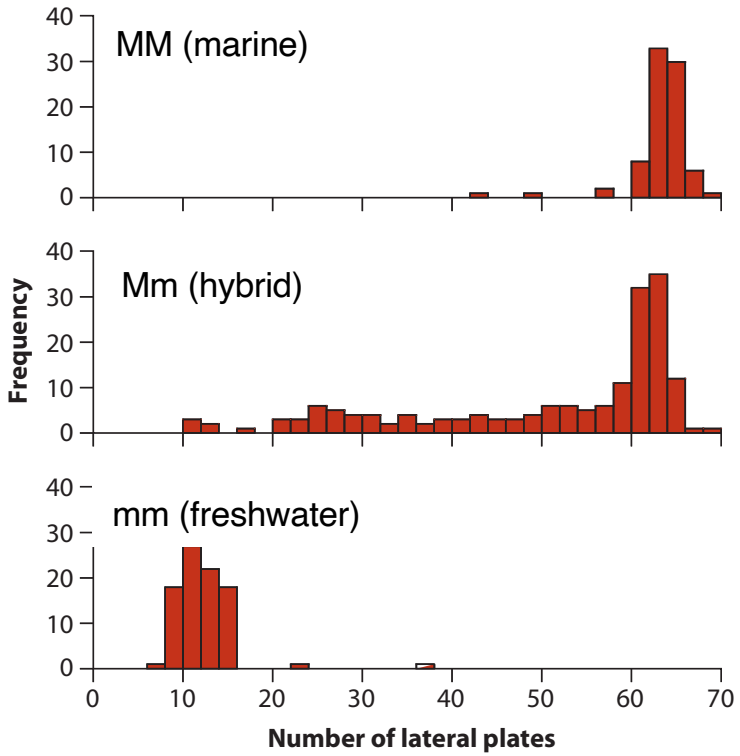
# How measures of location (mean versus median) and spread (standard deviation versus interquartile range) compare

**Disarming fish**
**(protection against predation)**




Which distribution is more asymmetric?

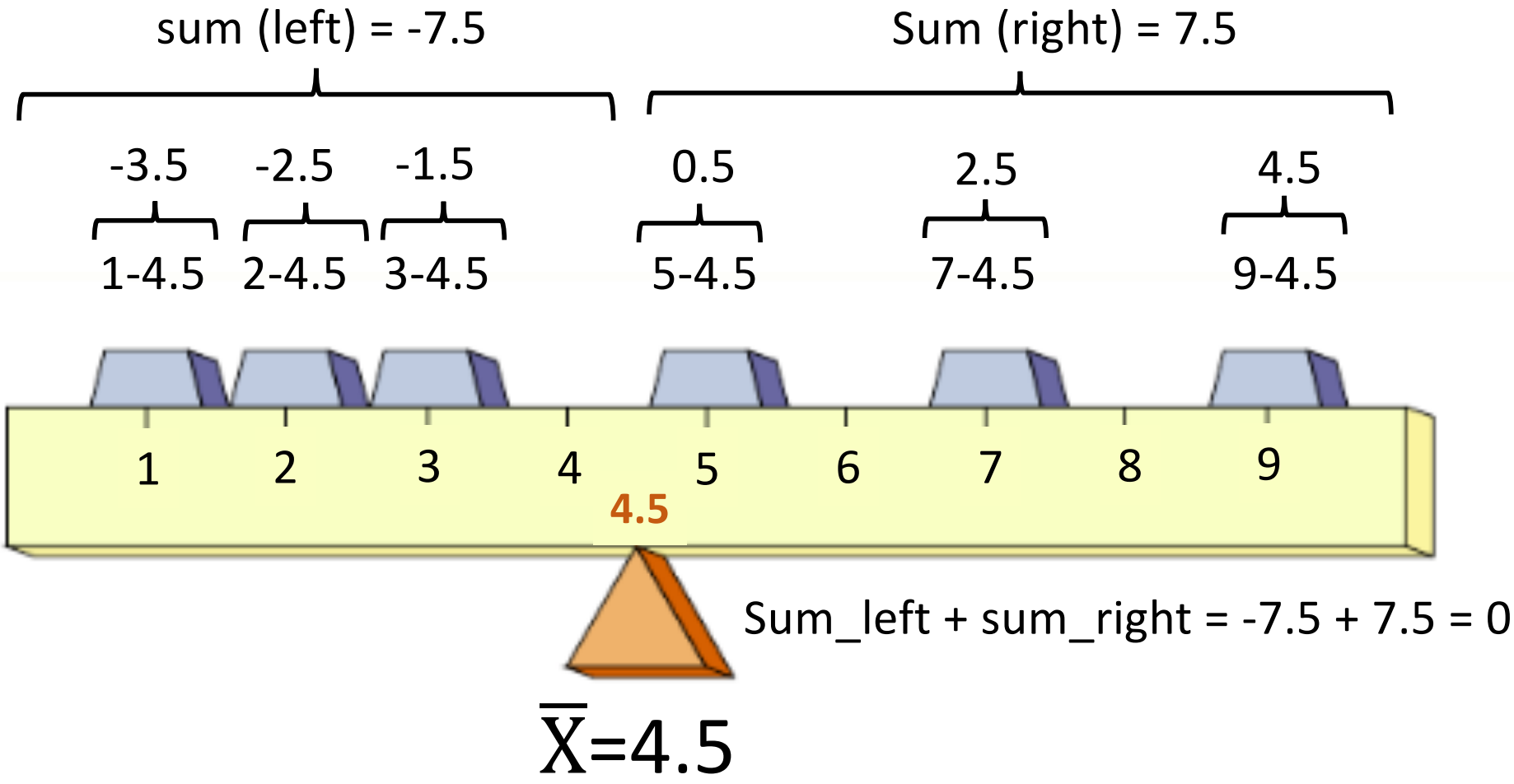
# How measures of location (mean versus median) and spread (standard deviation versus interquartile range) compare




Which distribution is more asymmetric?

| Genotype | *n* | Mean | Median | Standard deviation | Interquartile range |
|---|---|---|---|---|---|
| *MM* | 82 | 62.8 | 63 | 3.4 | 2 |
| *Mm* | 174 | 50.4 | 59 | 15.1 | 21 |
| *mm* | 88 | 11.7 | 11 | 3.6 | 3 |

# The mean understood as the centre of gravity of a distribution – sum of values to the left and to the right of the mean




Assume the scale has no weight. Values in the sample are represented by “weights”

# Remember from lecture 5 – the sum of the deviations from the mean is always zero – the mean is then always the "centre of gravity" of a distribution

Quantities needed to calculate the standard deviation and variance of snake undulation rate ($\bar{Y} = 1.375\ Hz$).

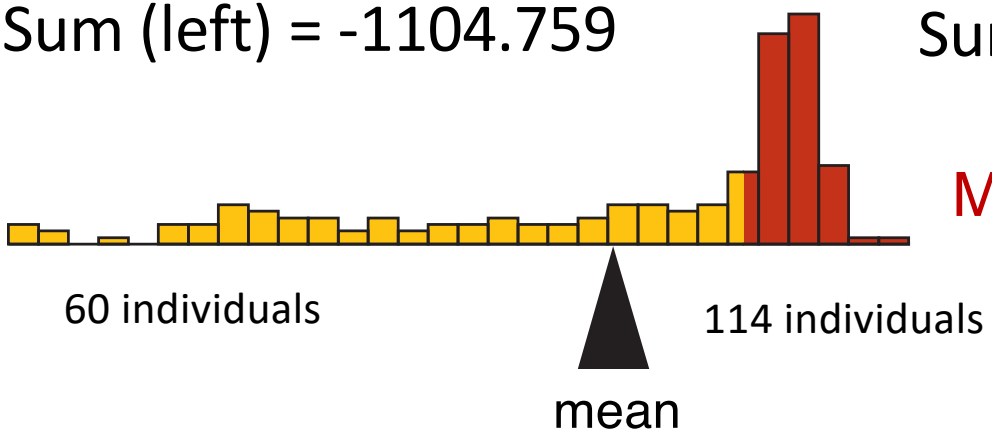
| Observations $(Y_i)$ | Deviations $(Y_i - \overline{Y})$ | Squared deviations $(Y_i - \overline{Y})^2$ |
|---|---|---|
| 0.9 | −0.475 | 0.225625 |
| 1.2 | −0.175 | 0.030625 |
| 1.2 | −0.175 | 0.030625 |
| 1.3 | −0.075 | 0.005625 |
| 1.4 | 0.025 | 0.000625 |
| 1.4 | 0.025 | 0.000625 |
| 1.6 | 0.225 | 0.050625 |
| 2.0 | 0.625 | 0.390625 |
| Sum | 0.000 | 0.735 |

# Mean ($\bar{Y}$) versus Median ($Q_2$)

## Mm (hybrid) - most asymmetric distribution

Sum (left) = -1104.759

Sum (right) = 1104.759



Mean is the “centre of gravity”

60 individuals

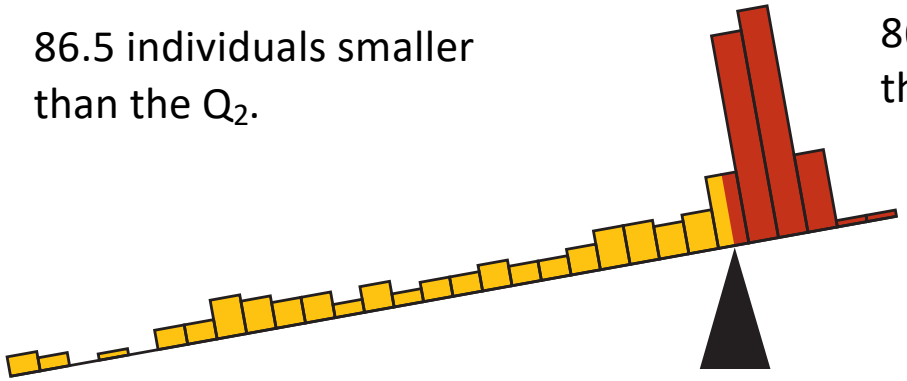
114 individuals

mean

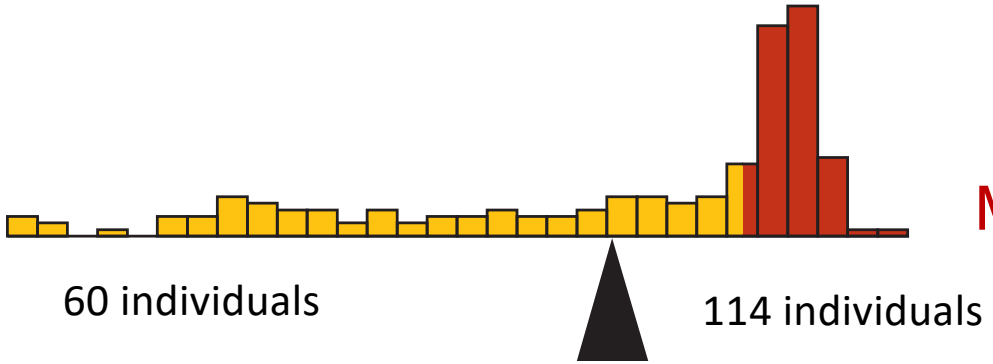
$\overline{Y}$=50.4

# Mean ($\bar{Y}$) versus Median (referred as to $Q_2$)

## Mm (hybrid) - most asymmetric distribution

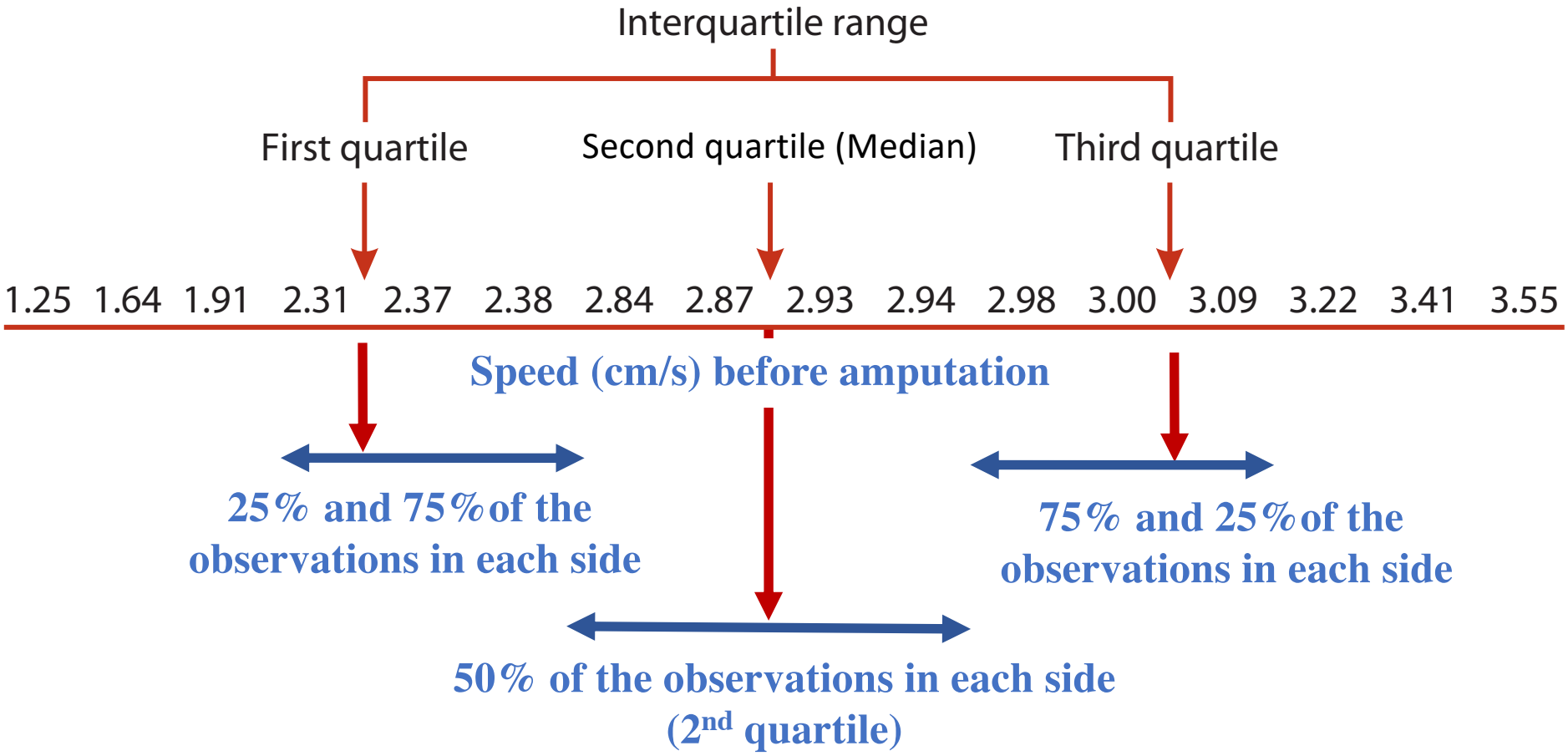



Median is the middle of the distribution



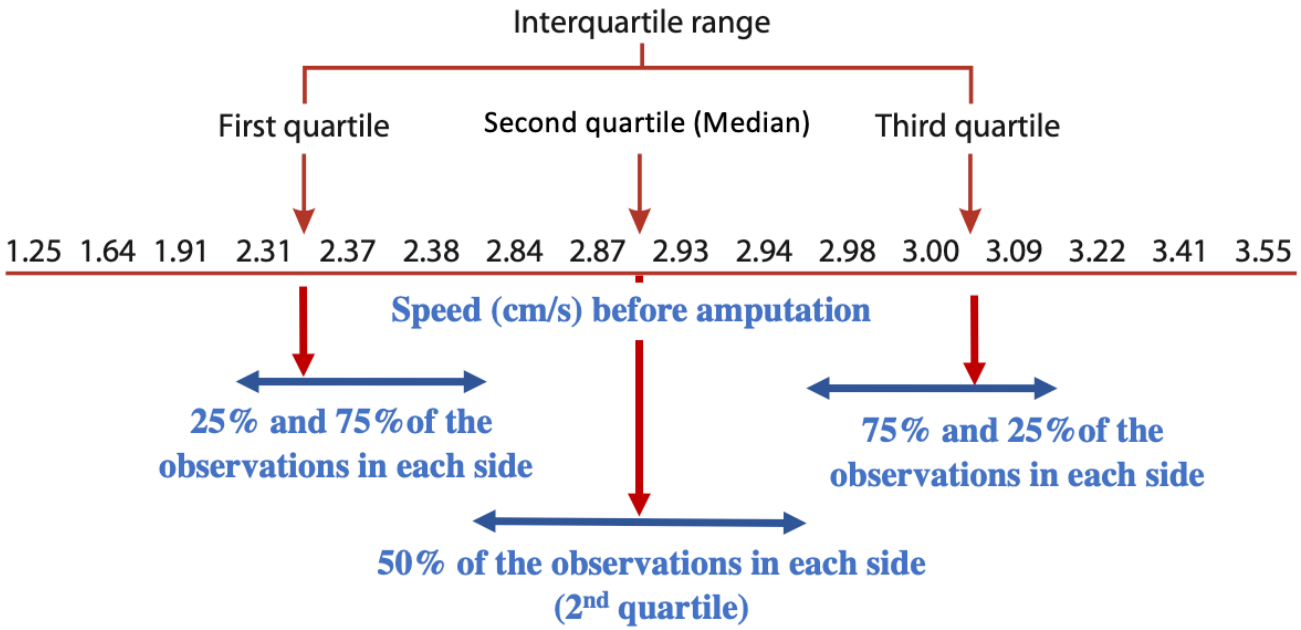

Mean is the "centre of gravity"

# The accompanying metric of spread for the median is called the interquartile range



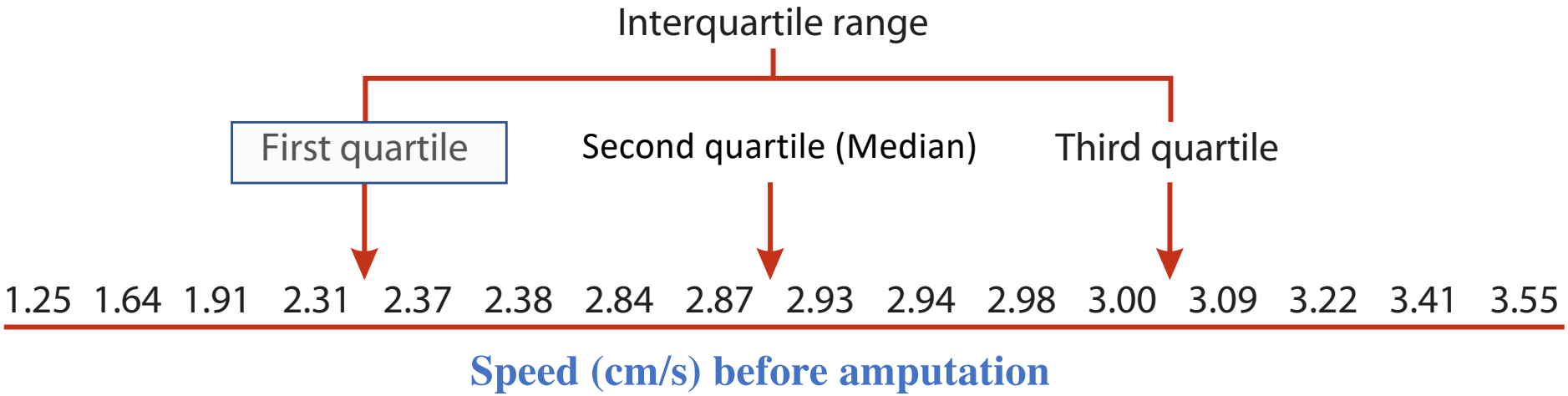

Remember: The accompanying metric of ***spread*** for the mean is called the ***standard deviation***

# The accompanying metric of spread for the median is called the interquartile range



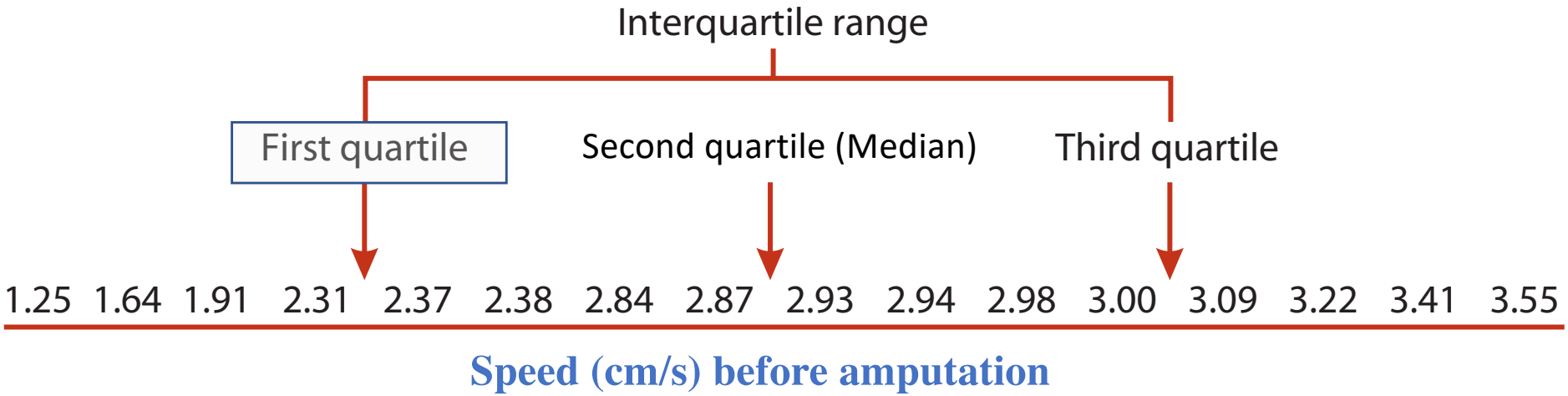

It's critical to know what first, second (median) and third quantiles represent and what aspects that the median represent in contrast to the mean BUT I don't expect you to memorize how these are calculated. But it's important to show you some of the calculations involved (helps with numeracy).

# The accompanying metric of spread for the median is called the interquartile range




Although the median (2nd quartile or $Q_2$) involves different calculations for when the number of observations in the data are odd or even, the calculations involving the 1st ($Q_1$) and 3rd ($Q_3$) quartiles do not.

# The accompanying metric of spread for the median is called the interquartile range



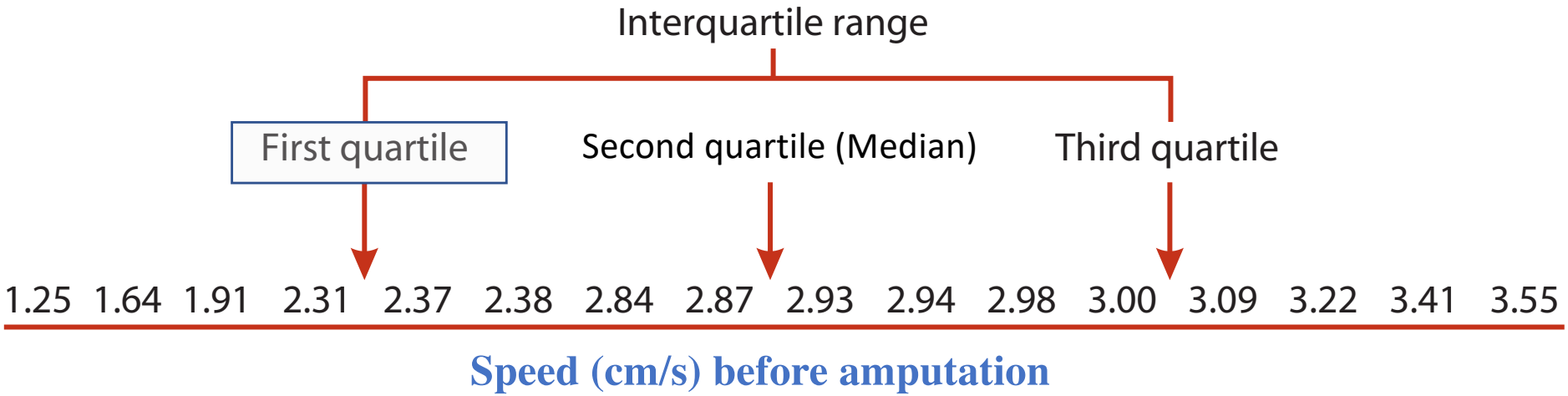

$$\text{Positioning } Q_1 \; j = 0.25n = (0.25)(16) = 4$$

where *n* is the number of observations in the data.

Because here *j* is an integer (i.e., whole number, not a fraction), then the 1st quartile is the average of
$Y_{(j)}$ and $Y_{(j+1)}$ = $Y_{(4)}$ and $Y_{(4+1)}$ =(2.31 + 2.37) / 2 = 2.340 cm/s

**First quartile ($Q_1$) = 2.340 cm/s**

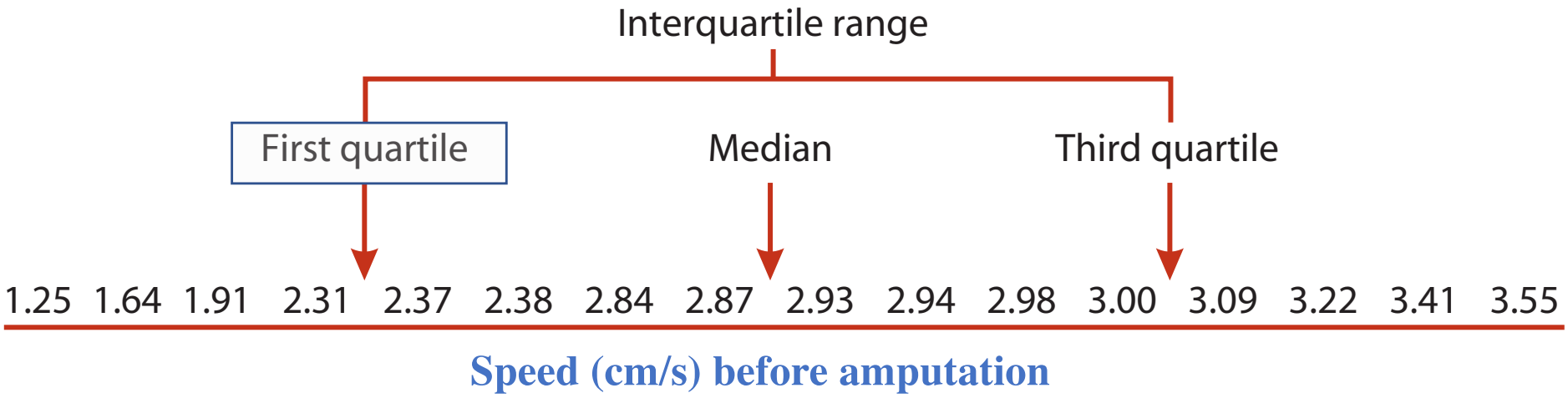
# The accompanying metric of spread for the median is called the interquartile range




**THIS IS NOT EXACTLY THE DEFAULT RULE in R: BUT VALUES ARE VERY SIMILAR (THERE ARE A FEW DIFFERENT RULES FOR CALCULATING QUARTILES)**

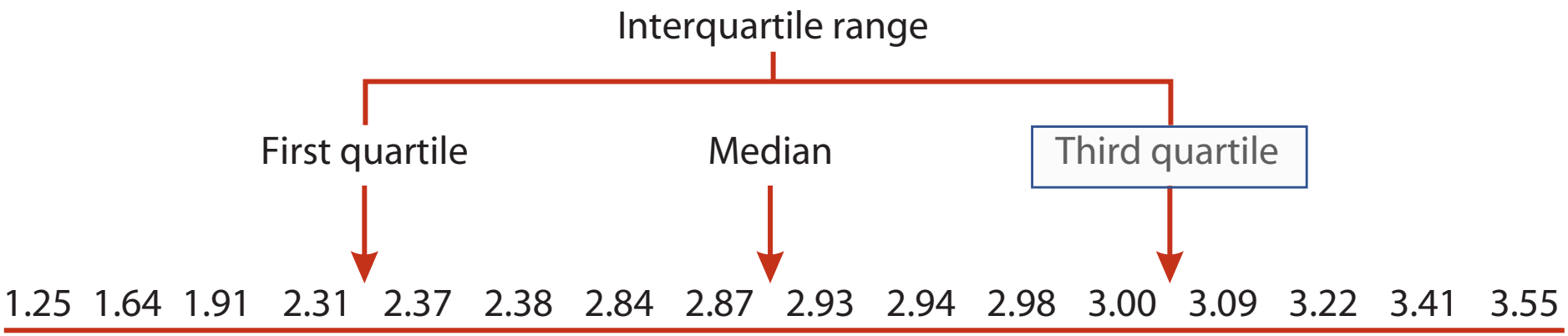
**First quartile ($Q_1$) = 2.340 cm/s**

# The accompanying metric of spread for the median is called the interquartile range




If *j* was not an integer, round *j* (e.g., say *j* was 4.32 then round *j* = 4). We would then have picked the 4$^{th}$ value in the ranked distribution (i.e., 2.31 cm/s)

# The accompanying metric of spread for the median is called the interquartile range

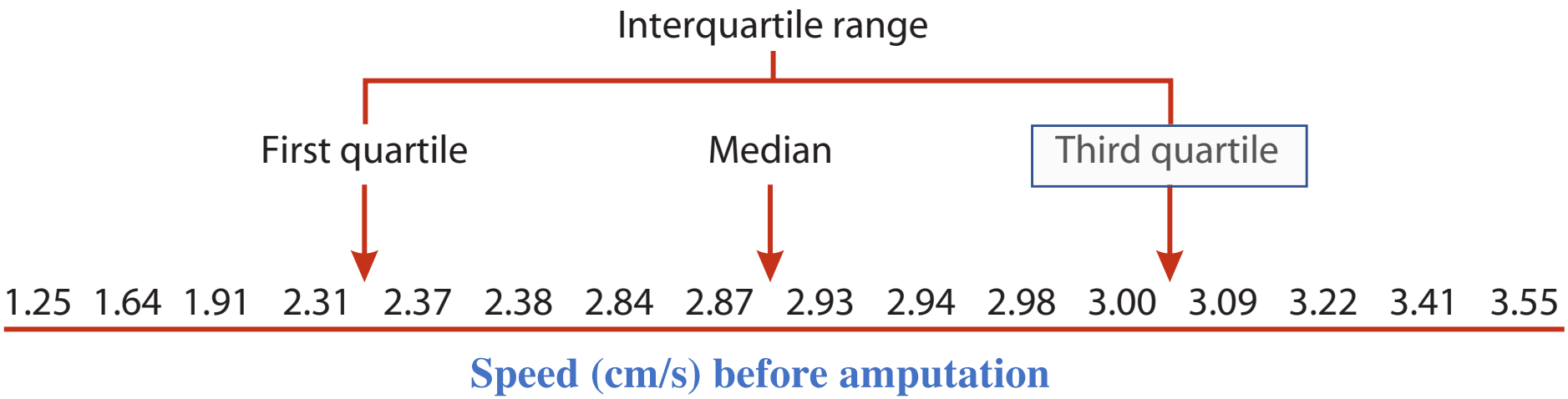



$$\text{Positioning } Q_3 \; j = 0.75n = (0.75)(16) = 12$$

where *n* is the number of observations. If *j* is an integer (*whole number, not a fraction*), then the 3rd quartile is the average of $Y_{(j)}$ and $Y_{(j+1)}$ = $Y_{(12)}$ and $Y_{(12+1)}$ =(3.00 + 3.09) / 2 = 3.045 cm/s

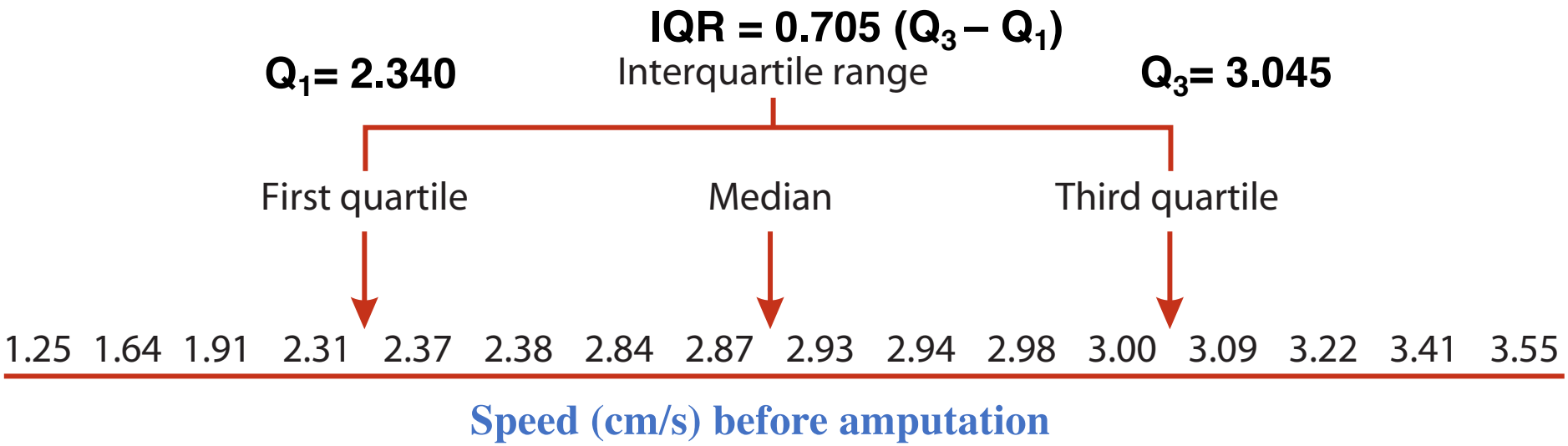
**Third quartile ($Q_3$) = 3.045 cm/s**

# The accompanying metric of spread for the median is called the interquartile range




If *j* was not an integer, round *j* (e.g., say j was 12.72 then *j* = 13). We would then have picked the 13$^{th}$ value in the ranked distribution (i.e., 3.09 cm/s)

# The accompanying metric of spread for the median is called the interquartile range




The ***interquartile range*** (IQR) for the speed data before amputation is then $Q_3 - Q_1 = 3.045 - 2.340 = 0.705$ cm/s

Remember: the mean carries information about all values in any given frequency distribution, but it is influenced by extreme values. The median does not characterize frequency distributions as well as the mean (i.e., not influenced by all values), but it is not sensitive to extreme values.

$$Y = 53, 58, 62, 64, 68, 72, 73, 77, 86, 87, 88, 92$$

$$\bar{Y} = 73.3$$

$$Q_2 = 72.5$$

$$Y = 53, 58, 62, 64, 68, 72, 73, 77, 86, 87, 88, 192$$

$$\bar{Y} = 81.7$$

$$Q_2 = 72.5$$

# Let’s take a power break – 2 minutes

## The median is the middle measures of a set of observations (distribution)

# If the number of observations (*n*) is ***even***, then the median is calculated differently:

*Tidarren* (spider)

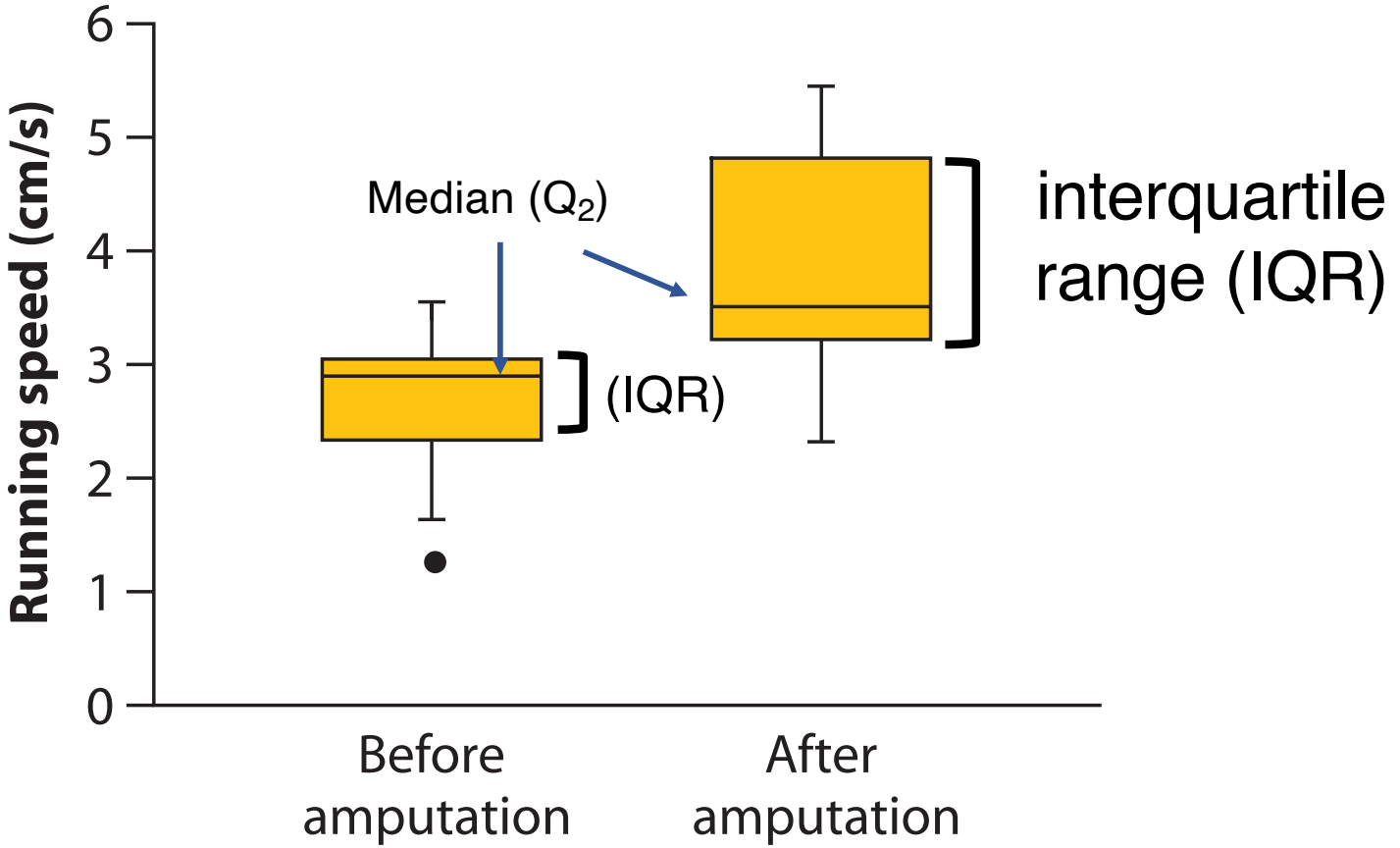
It gives an "arm" (or a pedipalp) for a female spider.

Running speed (cm/s) of male *Tidarren* spiders before and after voluntary amputation of one pedipalp.

*Oxyopes salticus*

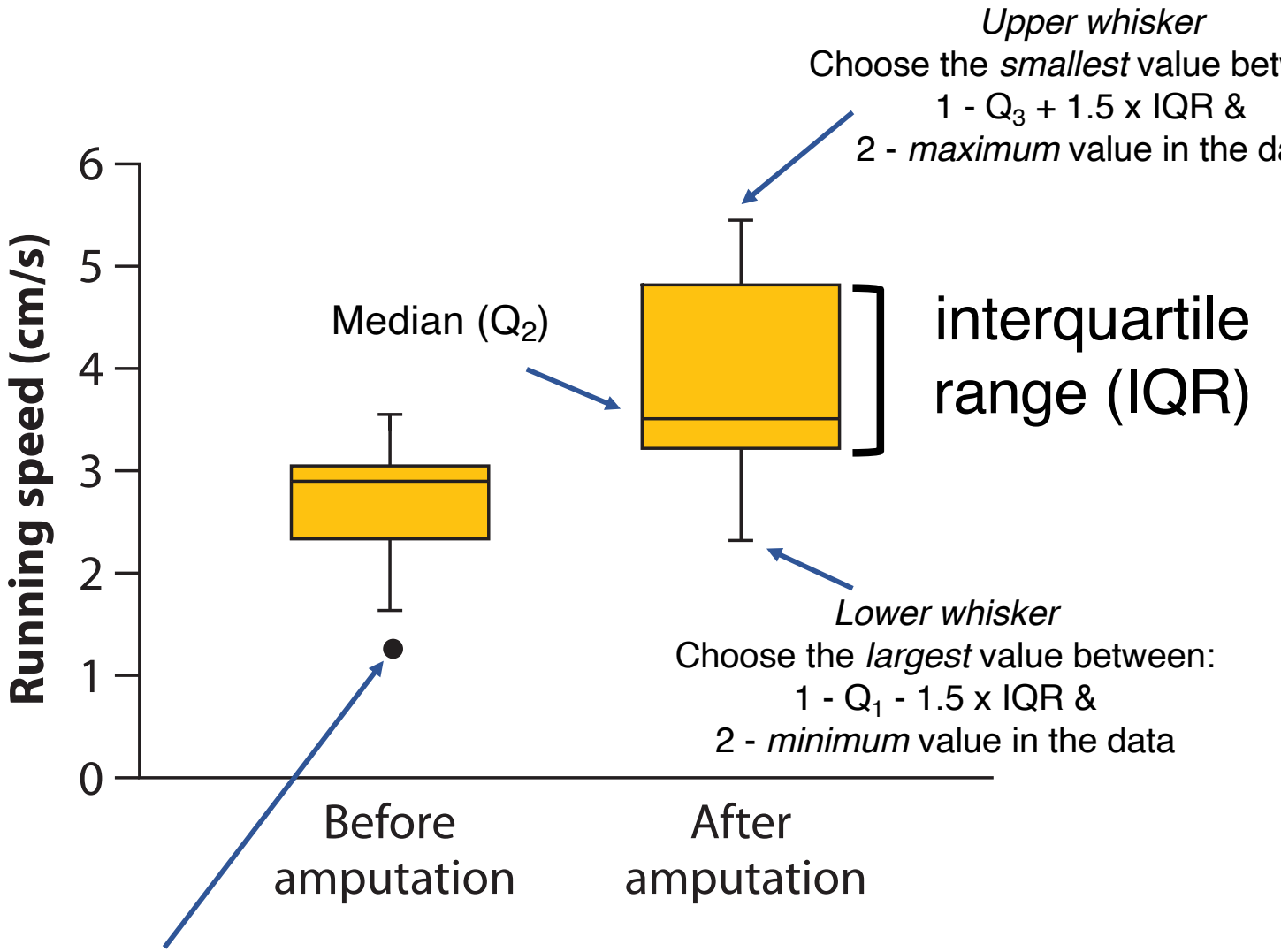
| Spider | Speed before | Speed after | Spider | Speed before | Speed after |
|---|---|---|---|---|---|
| 1 | 1.25 | 2.40 | 9 | 2.98 | 3.70 |
| 2 | 2.94 | 3.50 | 10 | 3.55 | 4.70 |
| 3 | 2.38 | 4.49 | 11 | 2.84 | 4.94 |
| 4 | 3.09 | 3.17 | 12 | 1.64 | 5.06 |
| 5 | 3.41 | 5.26 | 13 | 3.22 | 3.22 |
| 6 | 3.00 | 3.22 | 14 | 2.87 | 3.52 |
| 7 | 2.31 | 2.32 | 15 | 2.37 | 5.45 |
| 8 | 2.93 | 3.31 | 16 | 1.91 | 3.40 |

# Representing data distributions by their quartiles: Boxplot (box-and-whisker plot)




John Tukey
(box-and-whisker 1977)

# Representing data distributions by their quartiles: Boxplot (box-and-whisker plot)




There are many ways to calculate whiskers; this is one common way and one of the methods in R

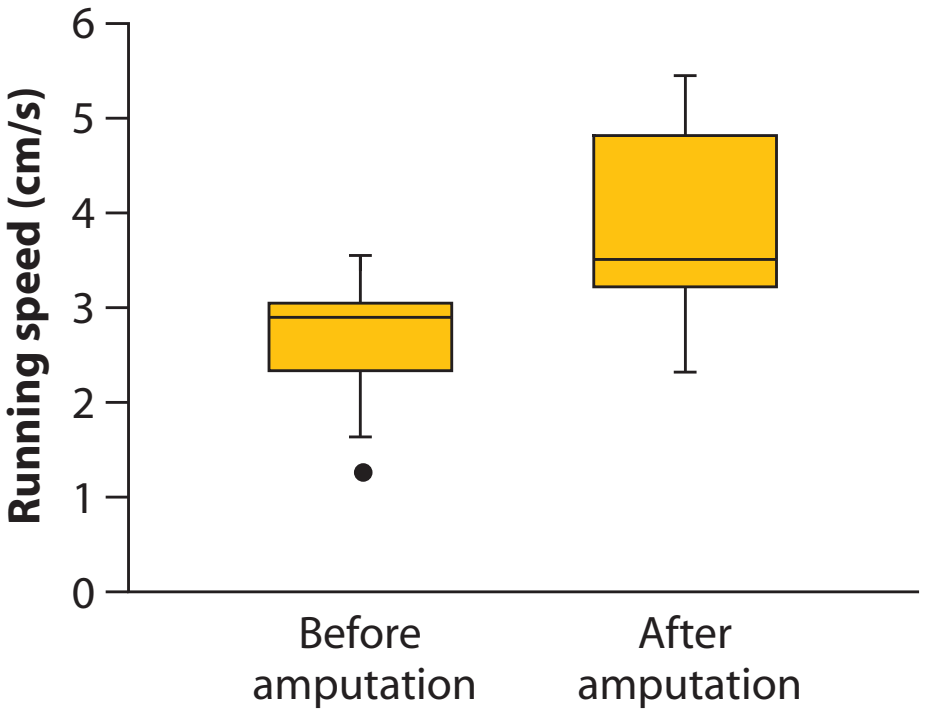
# Representing data distributions by their quartiles: Boxplot (box-and-whisker plot)

## What are the advantages of a box plot?

Graphically display a variable's location and spread in a glance.

It provides *some* indication of the data's symmetry and skewness.

Unlike many other methods of data display, boxplots show outliers.



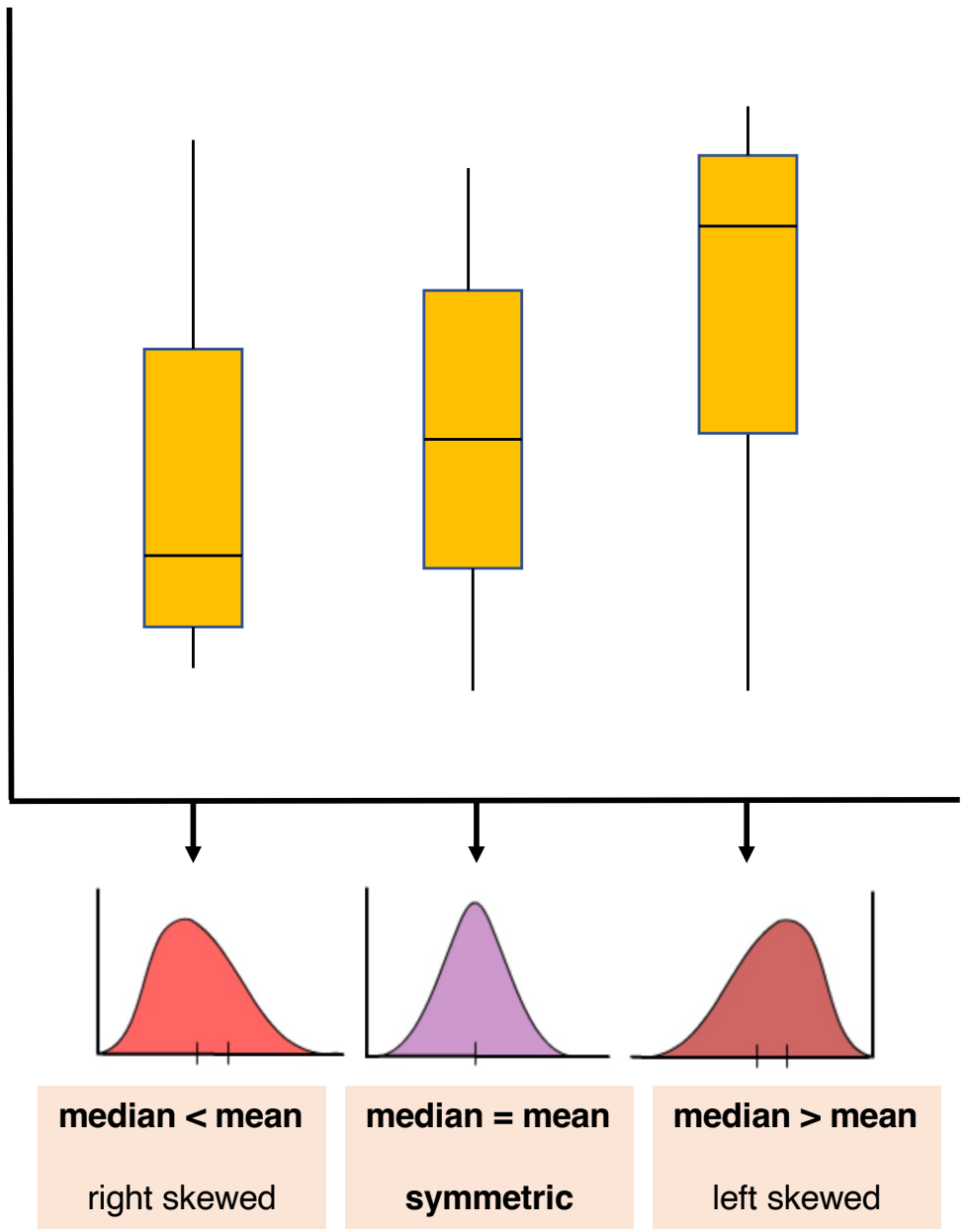

source - www.netmba.com/statistics/plot/box/

# Representing data distributions by their quartiles: Boxplot (box-and-whisker plot)

## What are the advantages of a box plot?

Graphically display a variable's location and spread at a glance.

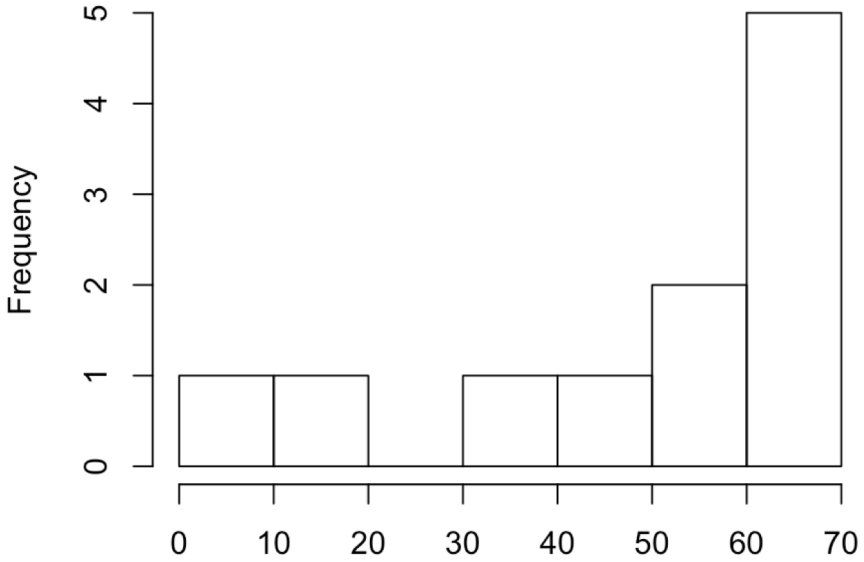
It can (not always) provide ***some*** indication of the data's symmetry and skewness (not always true but very often the case).



# Representing data distributions by their quartiles: Boxplot (box-and-whisker plot)

Three fictional data sets to show calculation and properties of distributions via their boxplots (boxplot in the next slide) – do you see their differences?

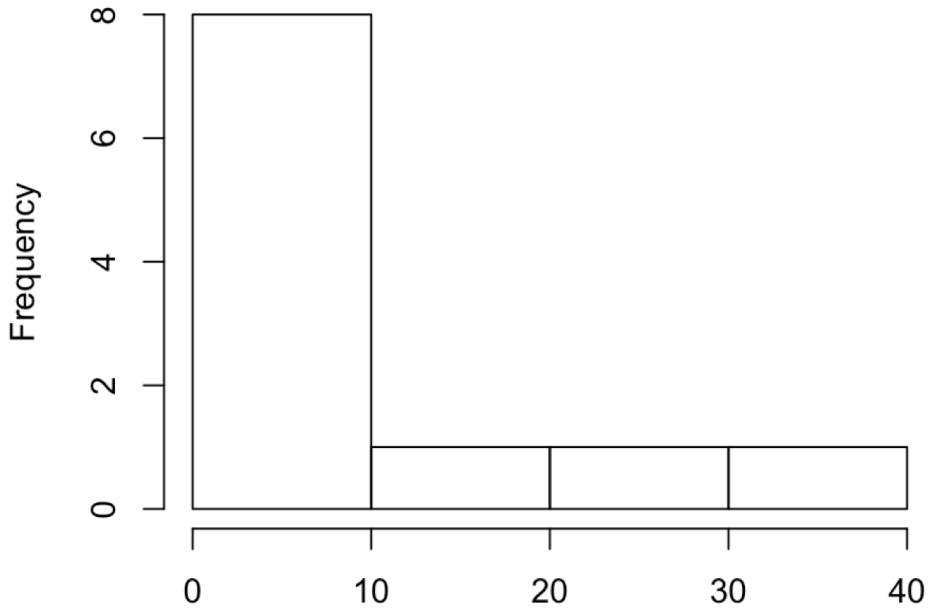
Left-skewed distribution: 9,11,31,44,52,58,61,61,63,64,66

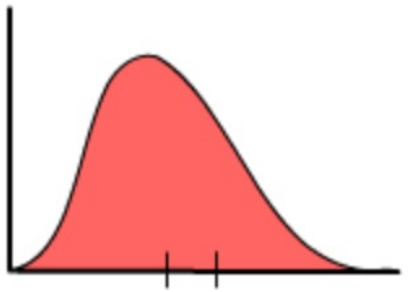



# Representing data distributions by their quartiles: Boxplot (box-and-whisker plot)

Three fictional data sets to show calculation and properties of distributions via their boxplots (boxplot in the next slide) – do you see their differences?

Right-skewed distribution: 1,2,3,4,5,6,7,10,20,30,40

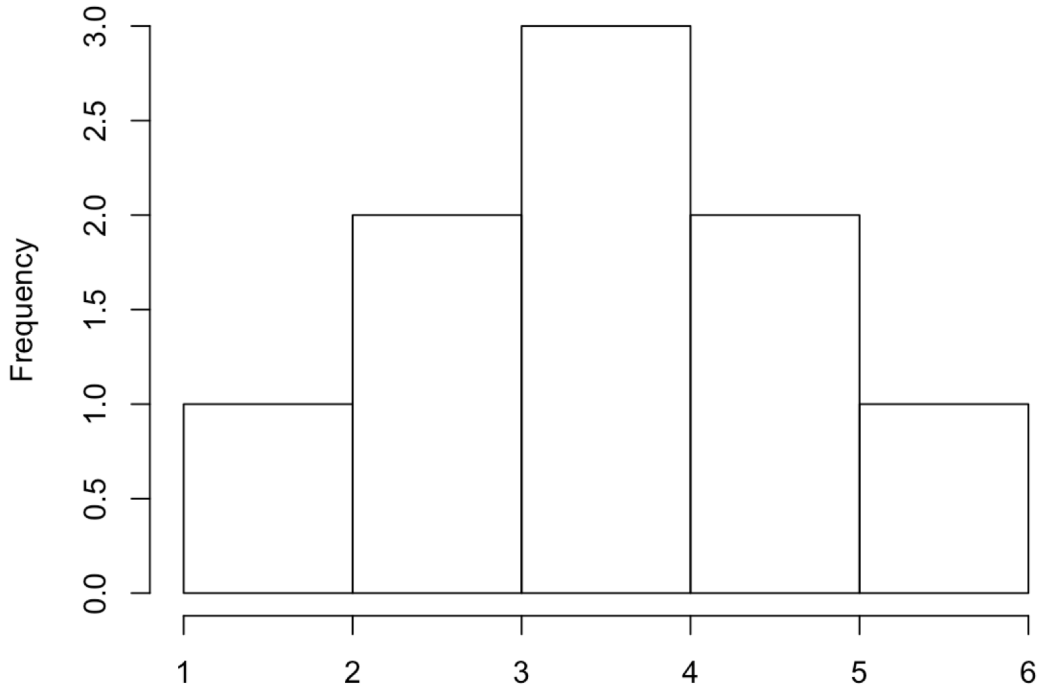


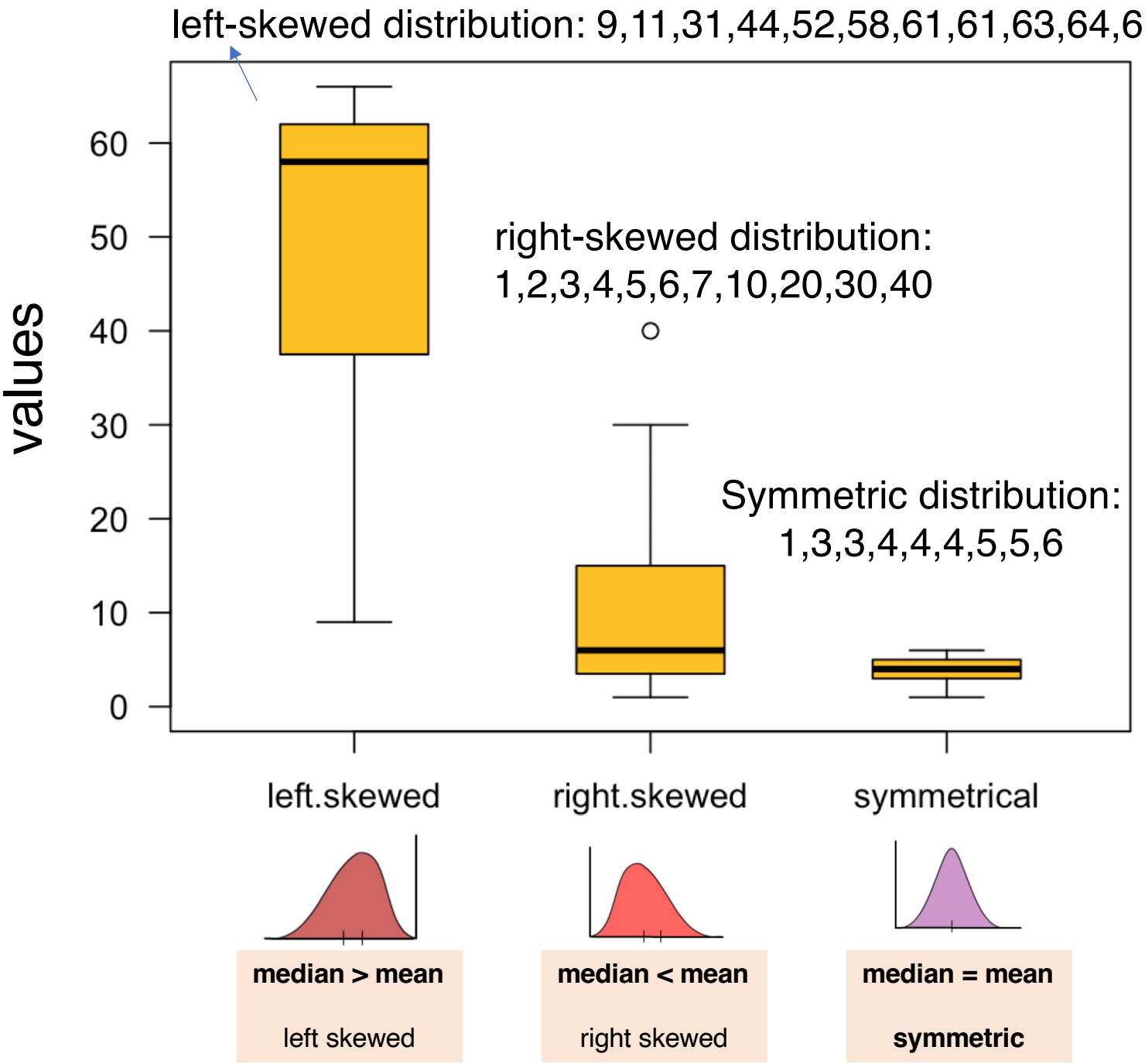
# Representing data distributions by their quartiles: Boxplot (box-and-whisker plot)

Three fictional data sets to show calculation and properties of distributions via their boxplots (boxplot in the next slide) – do you see their differences?

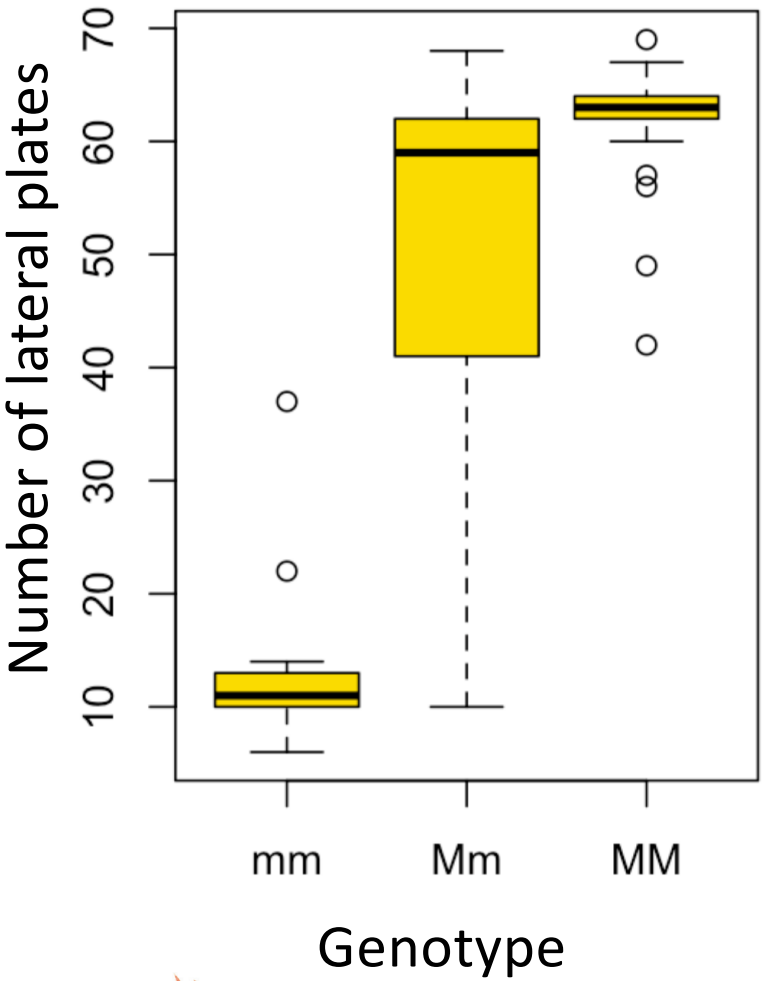
## Symmetric distribution: 1,3,3,4,4,4,5,5,6

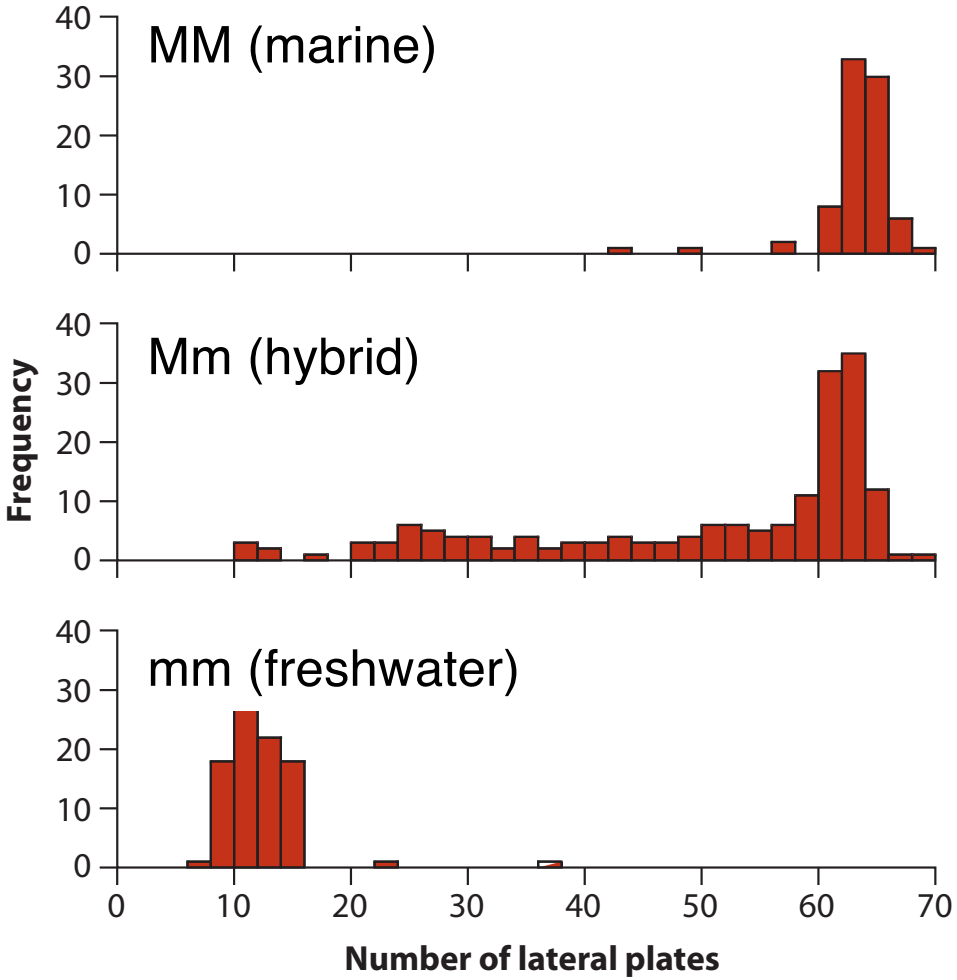



# Boxplot (box-and-whisker plot): contrasting distributions



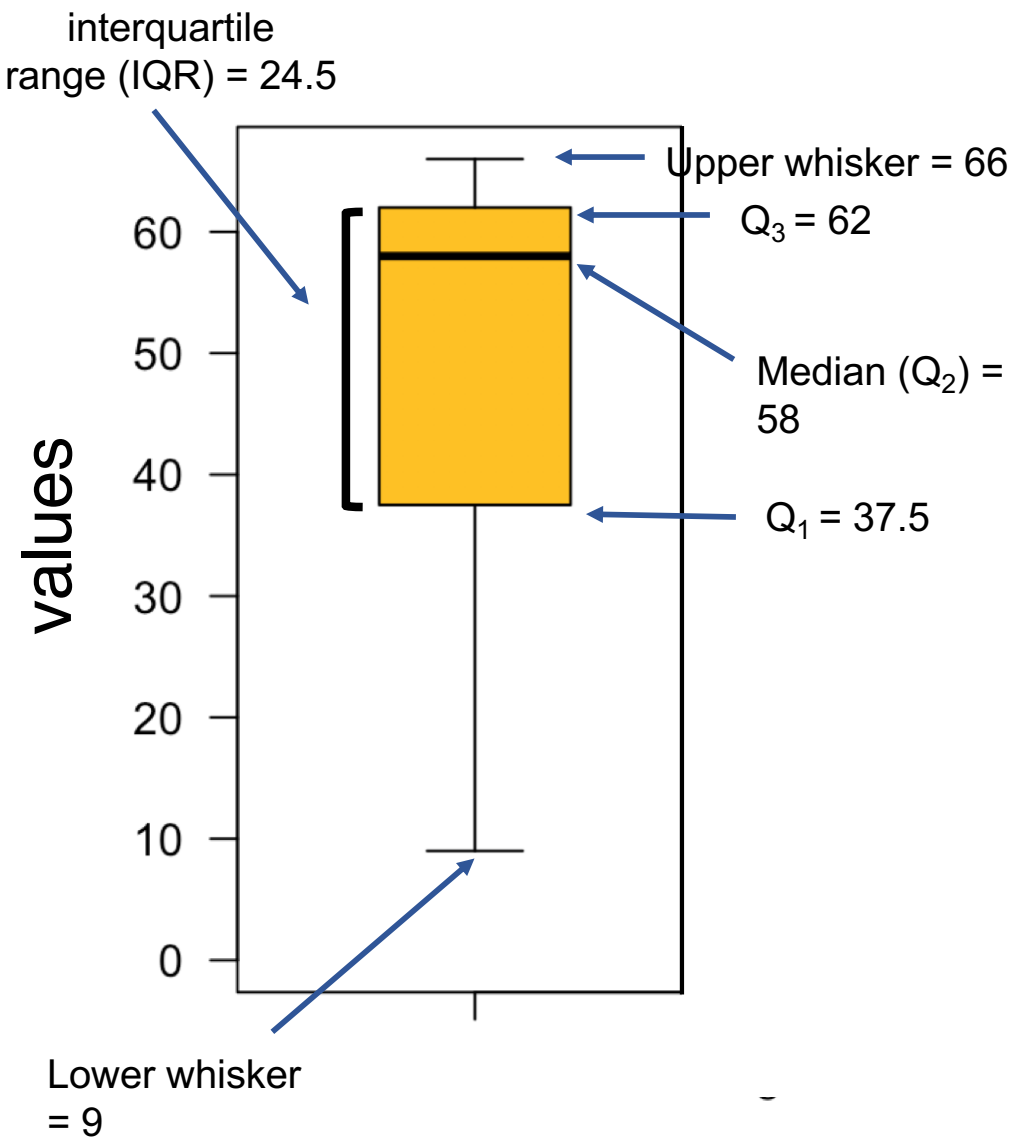
# Boxplot (box-and-whisker plot): contrasting distributions




# Not for the Faint of Heart: no need to know this calculations but some students always ask

9,11,31,44,52,**58**,61,61,63,64,66




$Q_1$ = (31+44) / 2 = 37.5
Median ($Q_2$) = 58
$Q_3$ = (63+64) / 2 = 62.0

IQR (Interquartile range) = 62.0 - 37.5 = 24.5

*Lower whisker* = 9; calculation:
Choose the *largest* value between:
1 - $Q_1$ - 1.5 x IQR = 37.5 – 1.5 x 24.5 = 0.75
2 - *minimum* value in the data = **9**

*Upper whisker* = 66; calculation:
Choose the *smallest* value between:
1 - $Q_3$ + 1.5 x IQR = 62 + 1.5 x 24.5 = 98.8
2 - *maximum* value in the data =

# Statistics is based on samples!

The most important goal of statistics is to estimate (infer) an unknown quantity of an entire population based on sample data.

Statistics is the science of making decisions with incomplete knowledge (i.e., based on samples) based on populations that too often have unknown sizes.

But sample quantities (mean, median, standard deviation, etc) vary from sample to sample (i.e., they have some level of uncertainty).

**Next lecture - Estimating with uncertainty**