



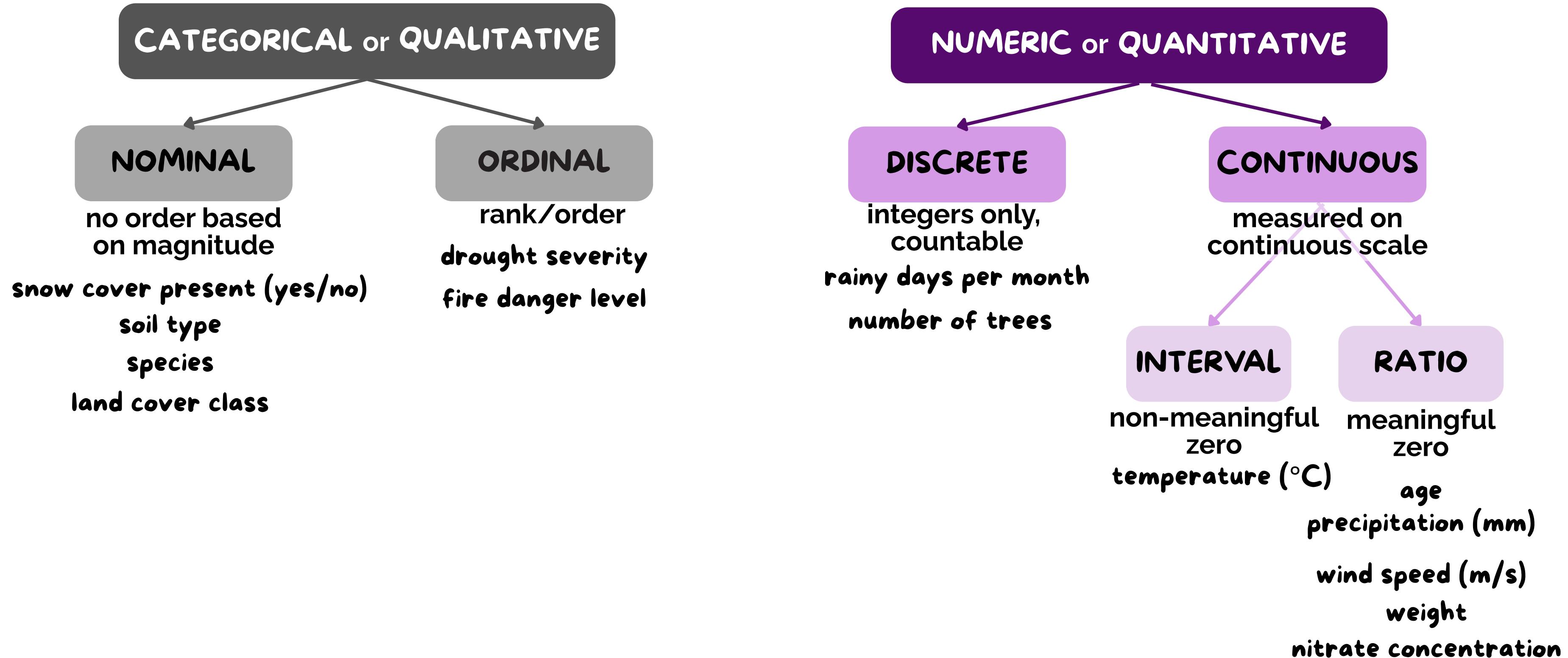
MODELLING TOOLS FOR ENVIRONMENTAL SCIENTIFIC STUDIES

Descriptive Statistics and
Exploratory Data Analysis

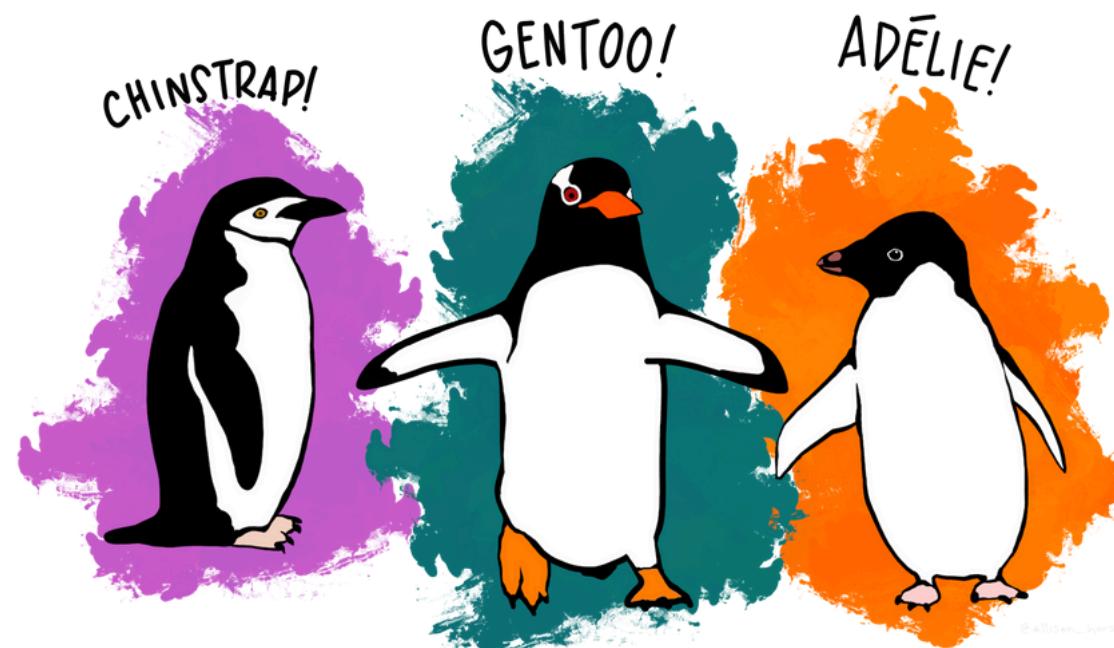
IDA RAHU

VARIABLES & THEIR TYPES

VARIABLE = RECORDED INFO



CATEGORICAL VARIABLES



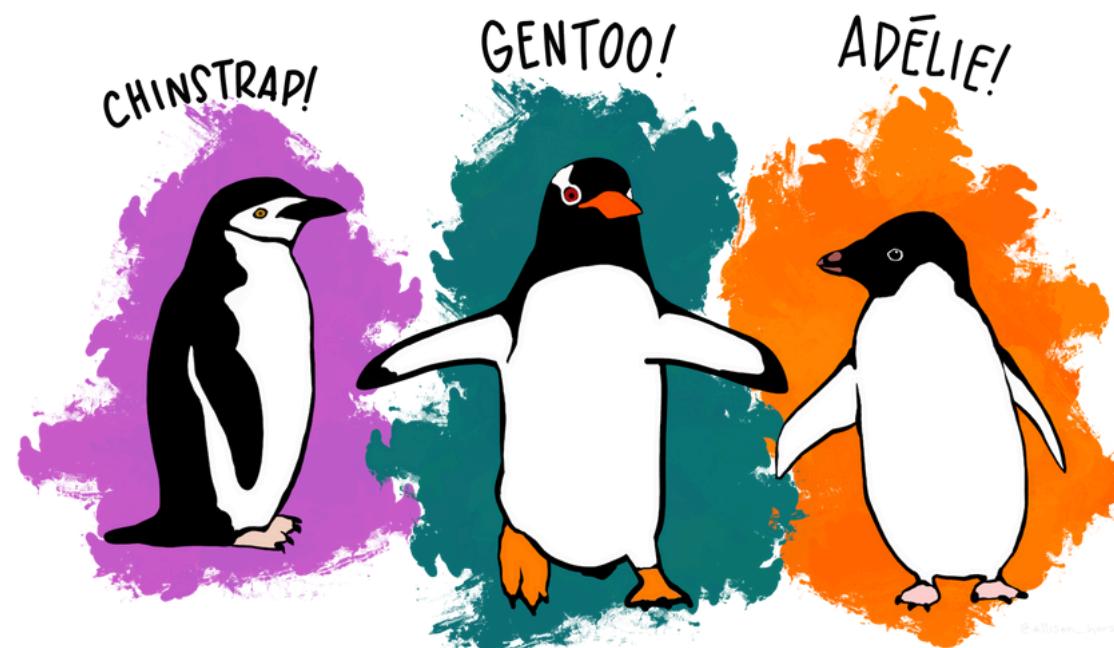
8 variables (n = 344 penguins)

The **palmerpenguins** data contains size measurements for three penguin species observed on three islands in the Palmer Archipelago, Antarctica.

Species	Penguin species (Adélie, Chinstrap, Gentoo)
Island	Island in the Palmer Archipelago where observed
Bill length (mm)	Length of the penguin's bill (mm)
Bill depth (mm)	Depth (thickness) of the penguin's bill (mm)
Flipper length (mm)	Length of the penguin's flipper (mm)
Body mass (g)	Body mass of the penguin (g)
Sex	Male or female (some values missing)
Year	Year of observation (2007–2009)

These data were collected from 2007 - 2009 by Dr. Kristen Gorman with the Palmer Station Long Term Ecological Research Program, part of the US Long Term Ecological Research Network.

CATEGORICAL VARIABLES



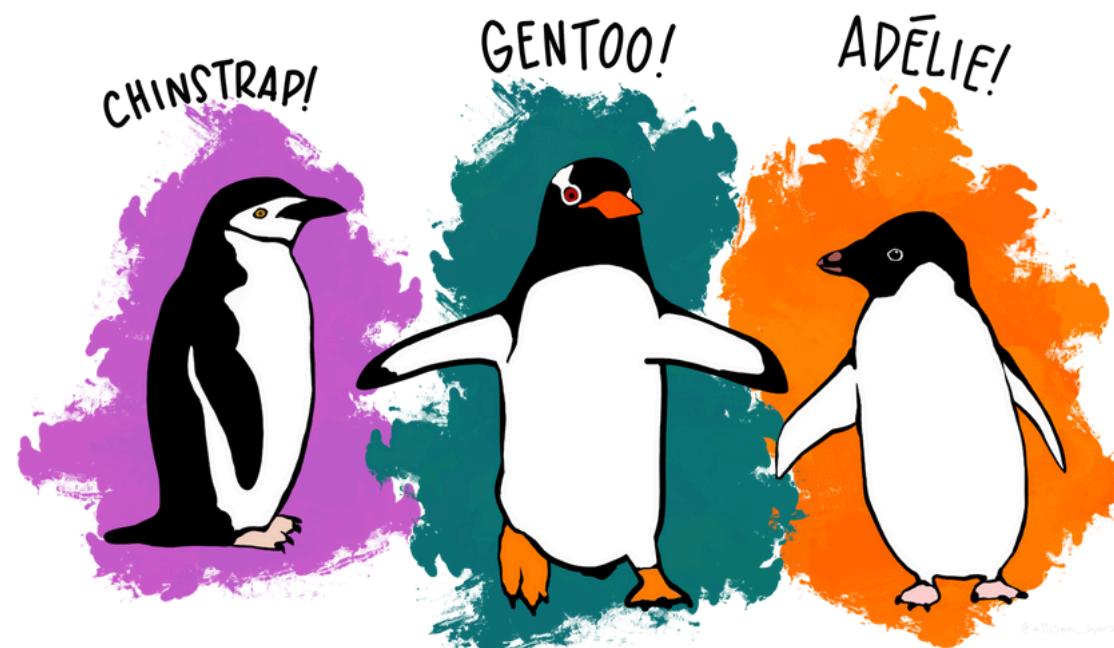
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CATEGORICAL VARIABLES



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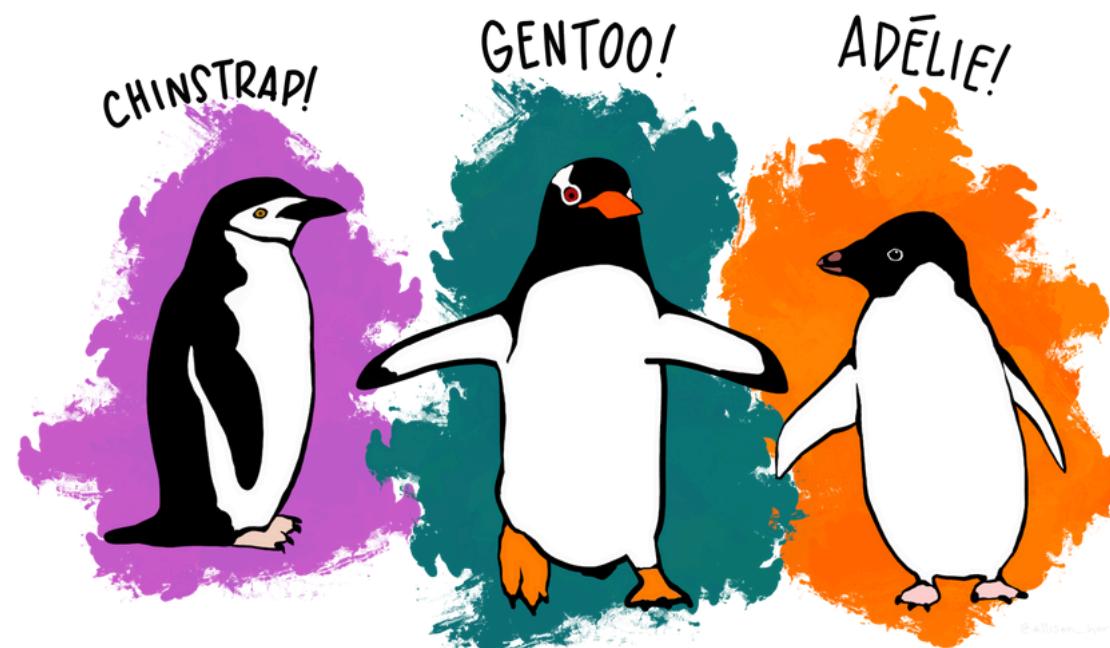
8 variables (n = 344 penguins)

Species	Penguin species
Island	Island in the Palmer
Bill	Length of the
Bill	Depth (thickness) of
Flipper	Length of the
Body	Body mass of the
Sex	Male or female (some)
Year	Year of observation

Island	Frequency	Proportion
Biscoe	168	
Dream	124	
Torgersen	52	
TOTAL	344	

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CATEGORICAL VARIABLES

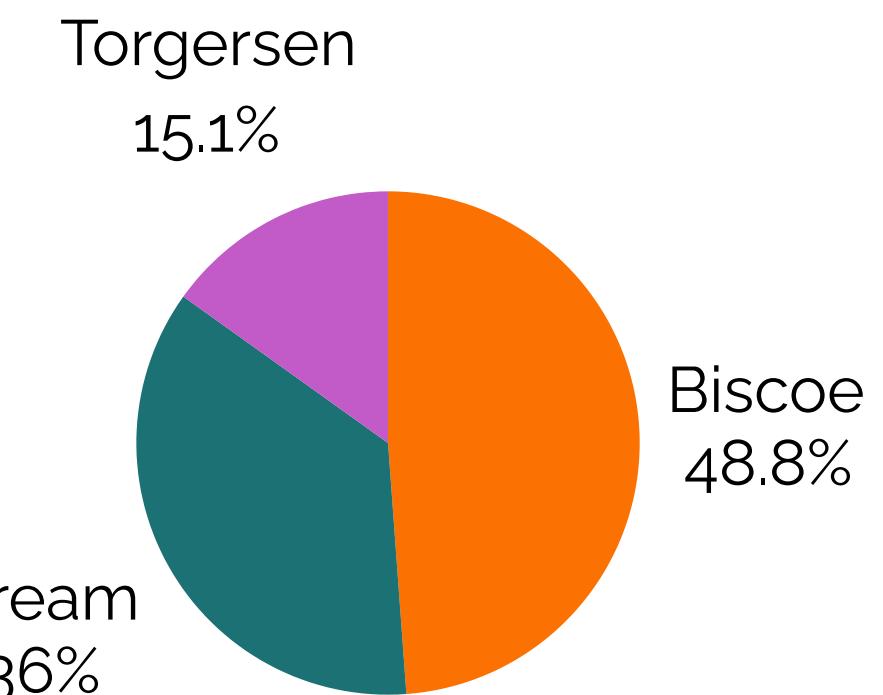


8 variables (n = 344 penguins)

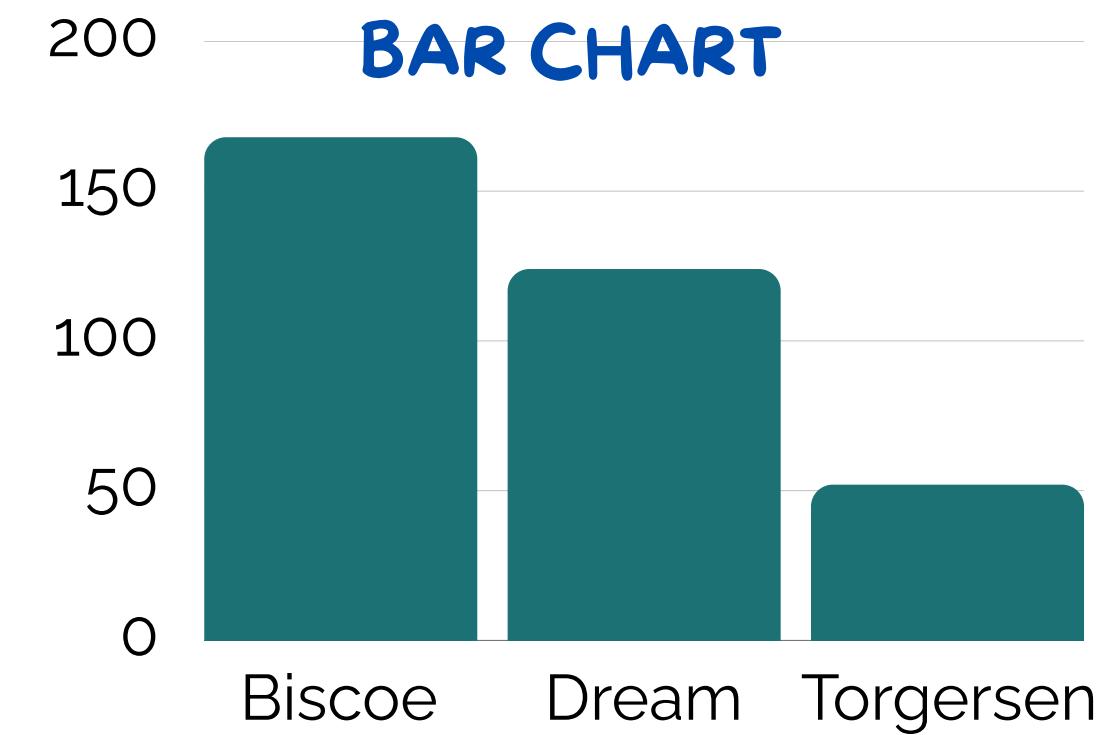
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Flipper	Length of the
Body	Body mass of the
Sex	Male or female (some)
Year	Year of observation

Island	Frequency	Proportion
Biscoe	168	0.489
Dream	124	0.36
Torgersen	52	0.151
TOTAL	344	1

PIE CHART

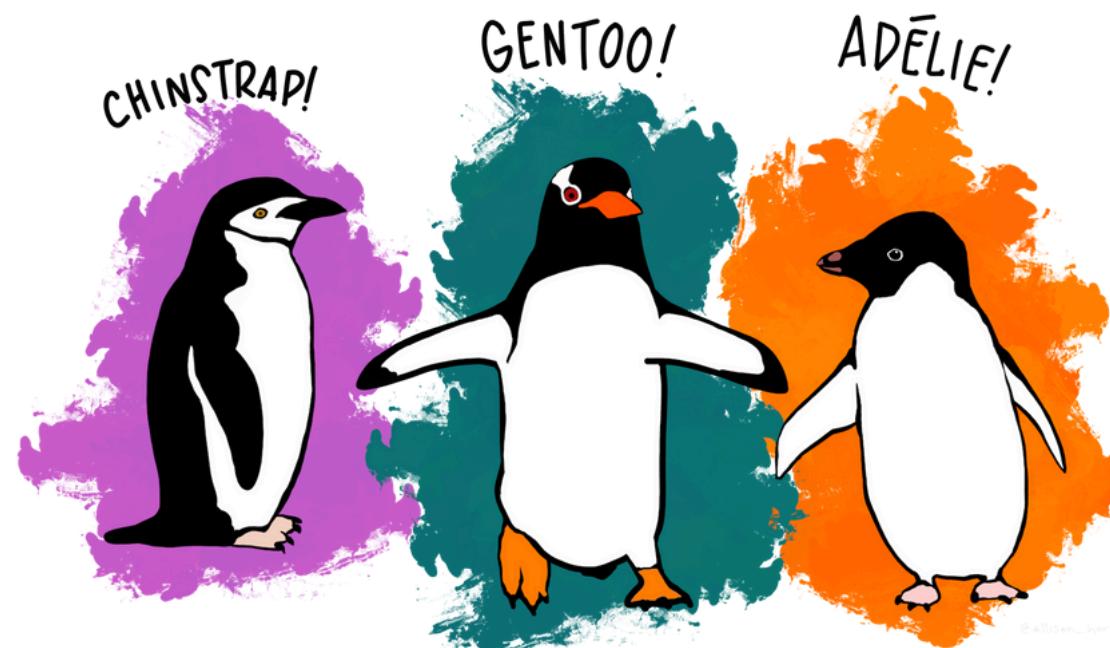


BAR CHART



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CATEGORICAL VARIABLES

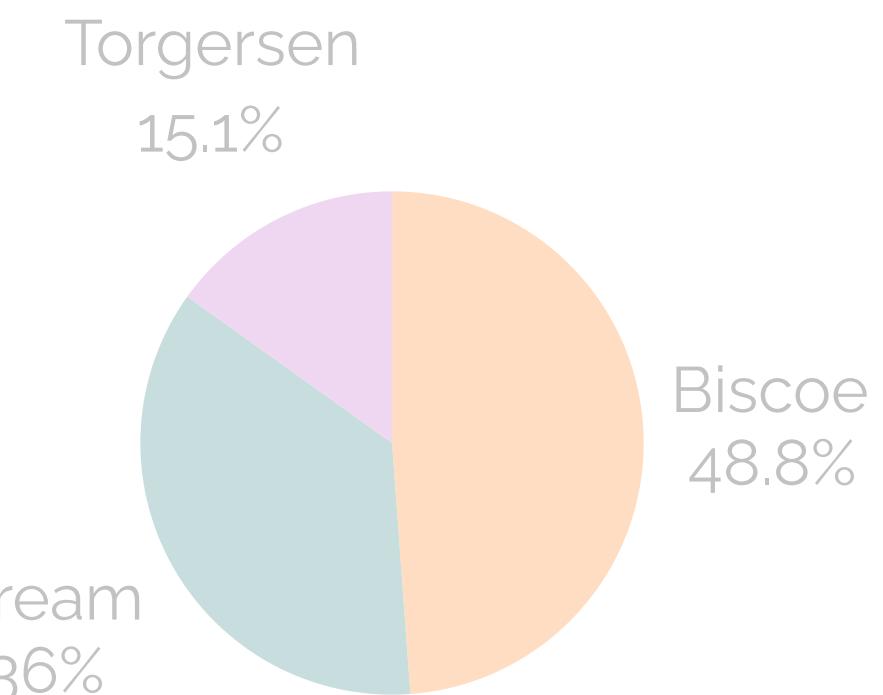


8 variables (n = 344 penguins)

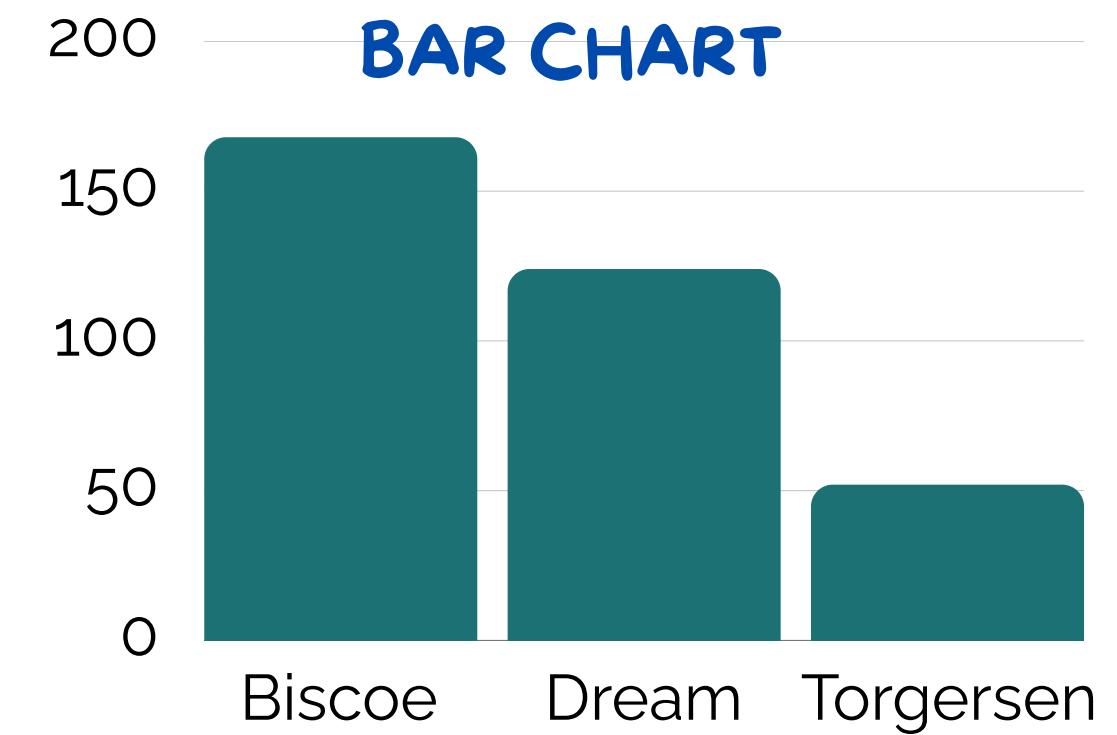
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Sex	Male or female (some)
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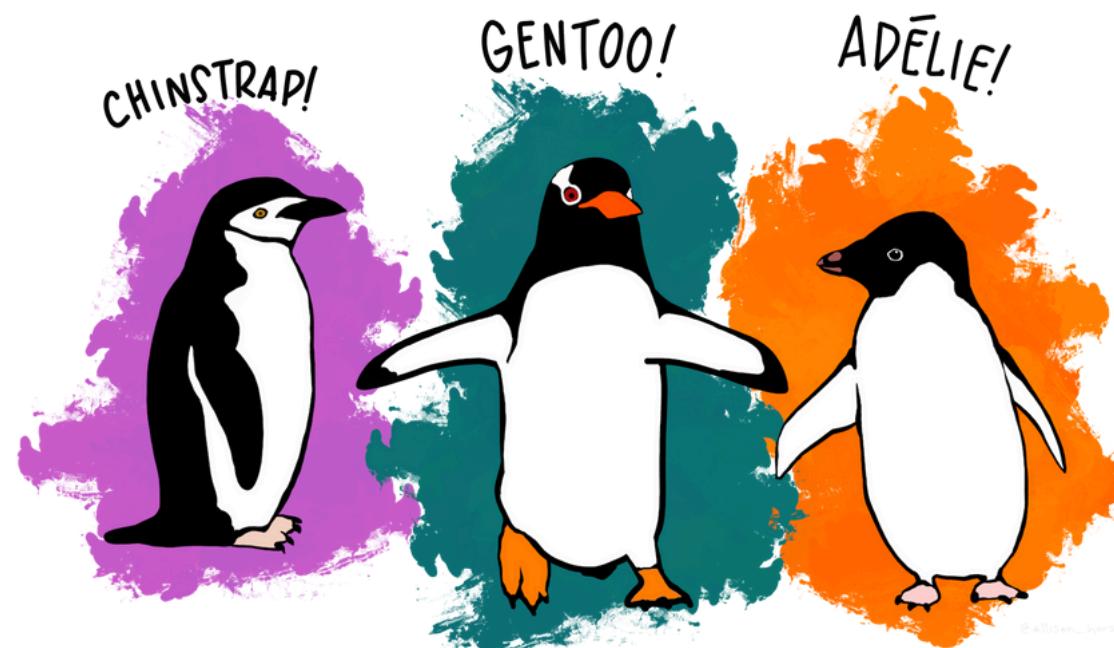


BAR CHART



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NUMERIC VARIABLES



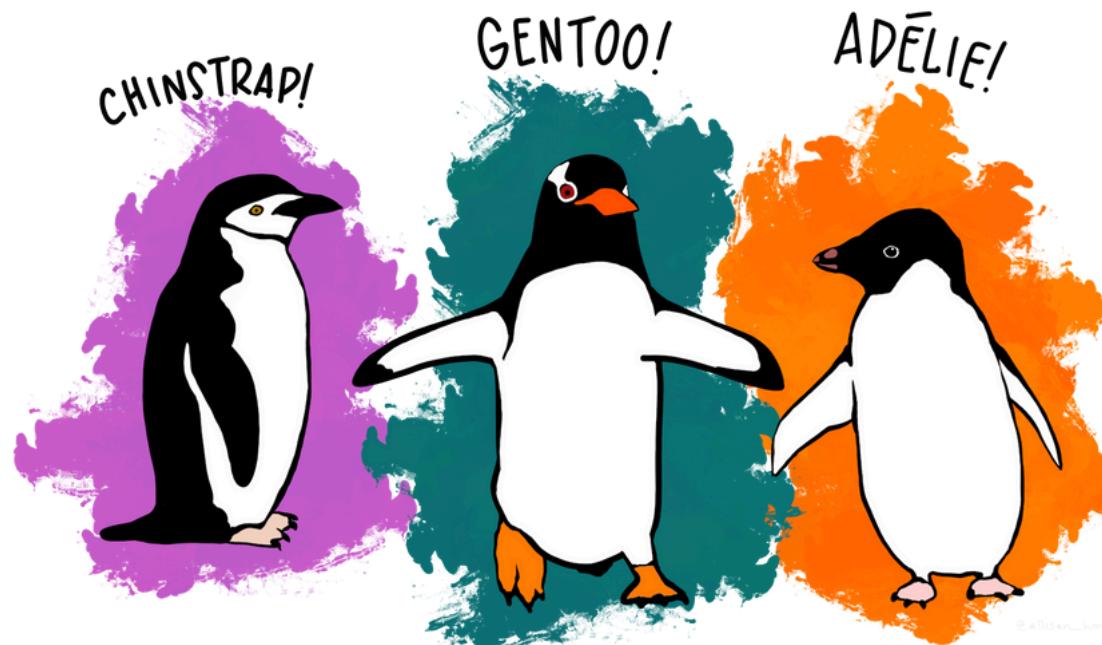
The **palmerpenguins** data contains size measurements for three penguin species observed on three islands in the Palmer Archipelago, Antarctica.

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NUMERIC VARIABLES



8 variables (n = 344 penguins)

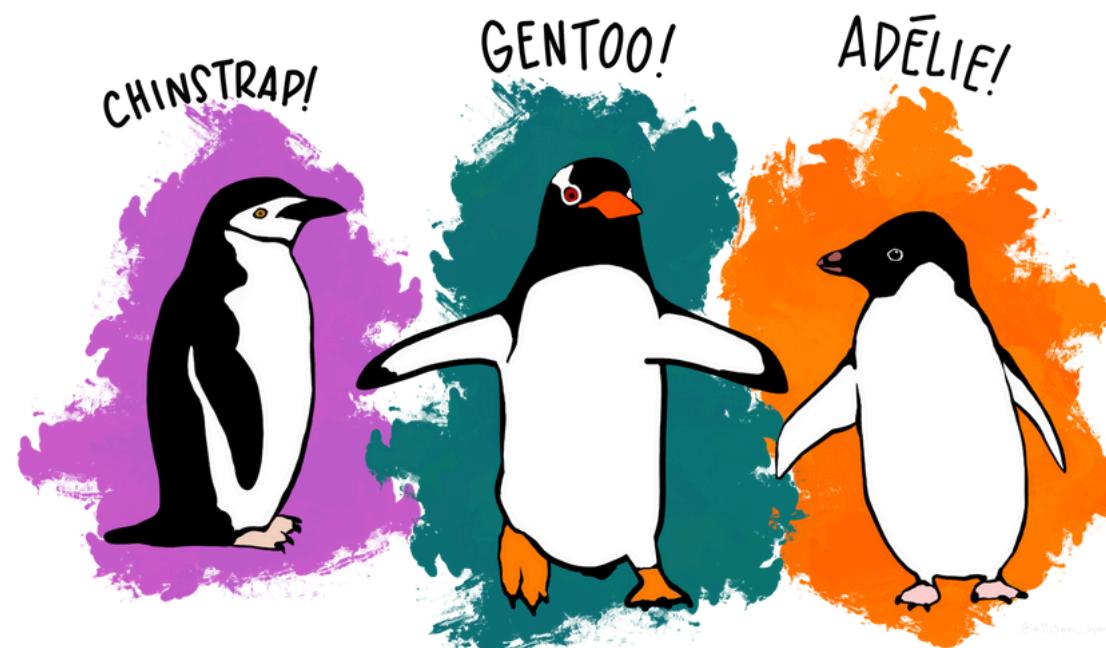
The **palmerpenguins** data contains size measurements for three penguin species observed on three islands in the Palmer Archipelago, Antarctica.

73 male Adelie penguins
 min body mass = 3325 g
 max body mass = 4775 g

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NUMERIC VARIABLES



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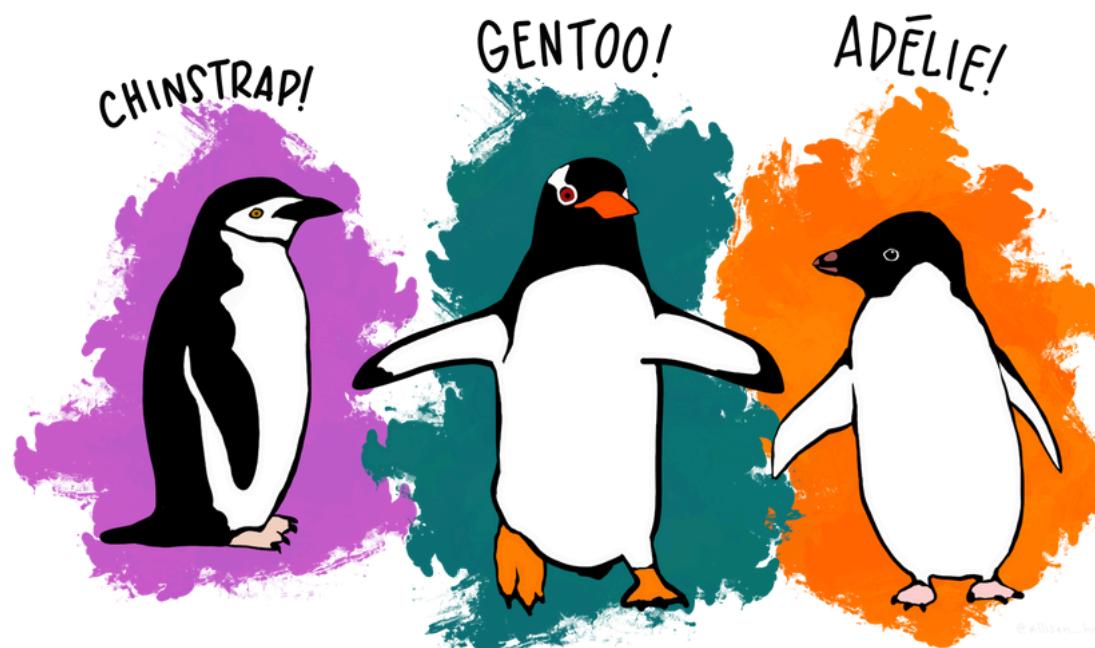
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Speci	Penguin
Island	Island in the Palmer Archipelago
Bill	Length of the bill
Bill depth	Depth of the bill
Flippe	Length of the flipper
Body	Body mass of the penguin
Sex	Male or female
Year	Year of collection

	Body mass (g)	Frequency	Proportion
	[3325...3615)	9	
	[3615...3905)	20	
	[3905..4195)	18	
	[4195...4485)	18	
	[4485...4775)	8	
	TOTAL	73	

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NUMERIC VARIABLES



8 variables (n = 344 penguins)

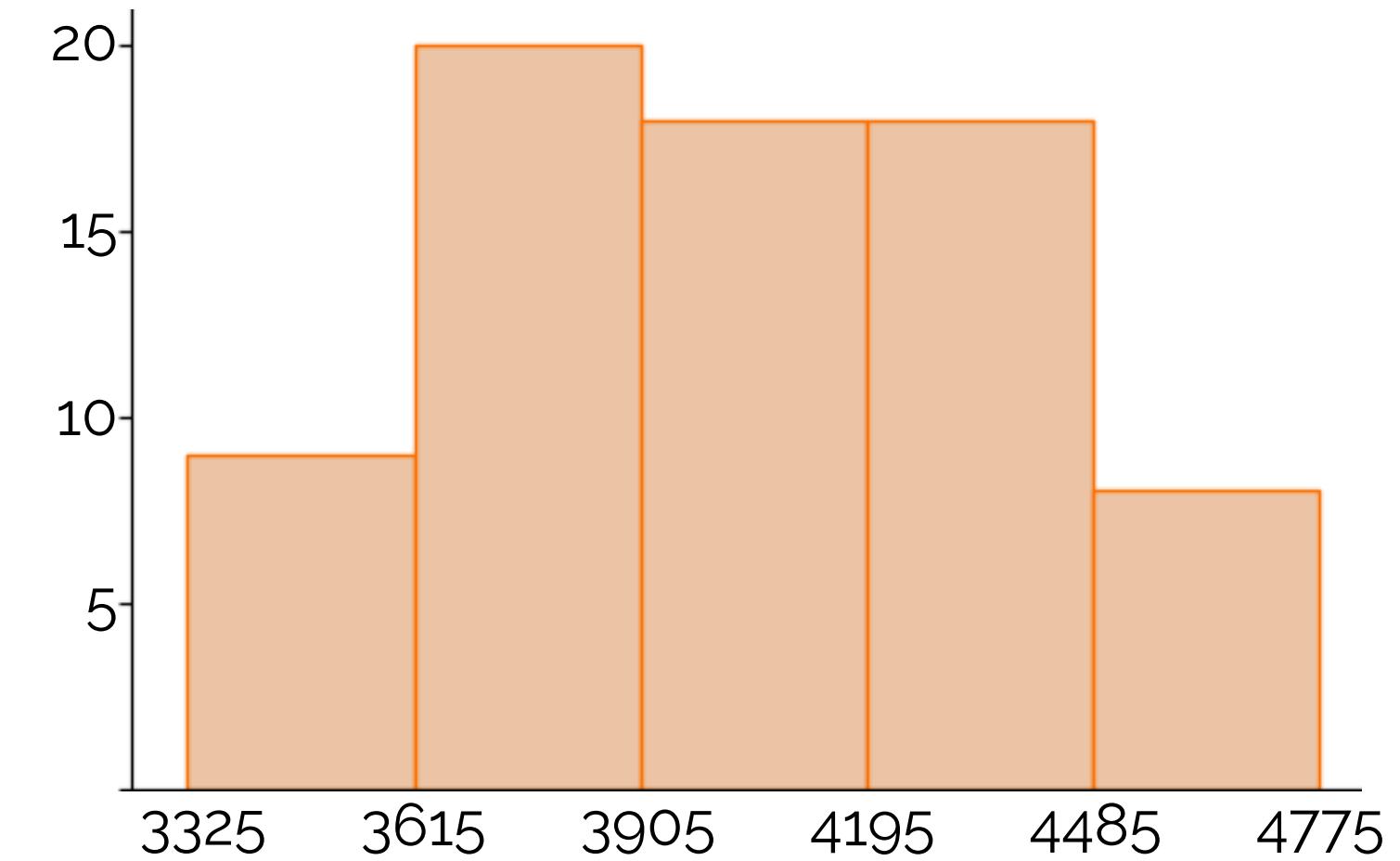
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Bill depth	Depth of the bill
Flippe	Length of the flipper
Body	Body mass of the penguin
Sex	Male or female
Year	Year of collection

Body mass (g)	Frequency	Proportion
[3325...3615)	9	0.123
[3615...3905)	20	0.274
[3905..4195)	18	0.247
[4195...4485)	18	0.247
[4485...4775)	8	0.11
TOTAL	73	1

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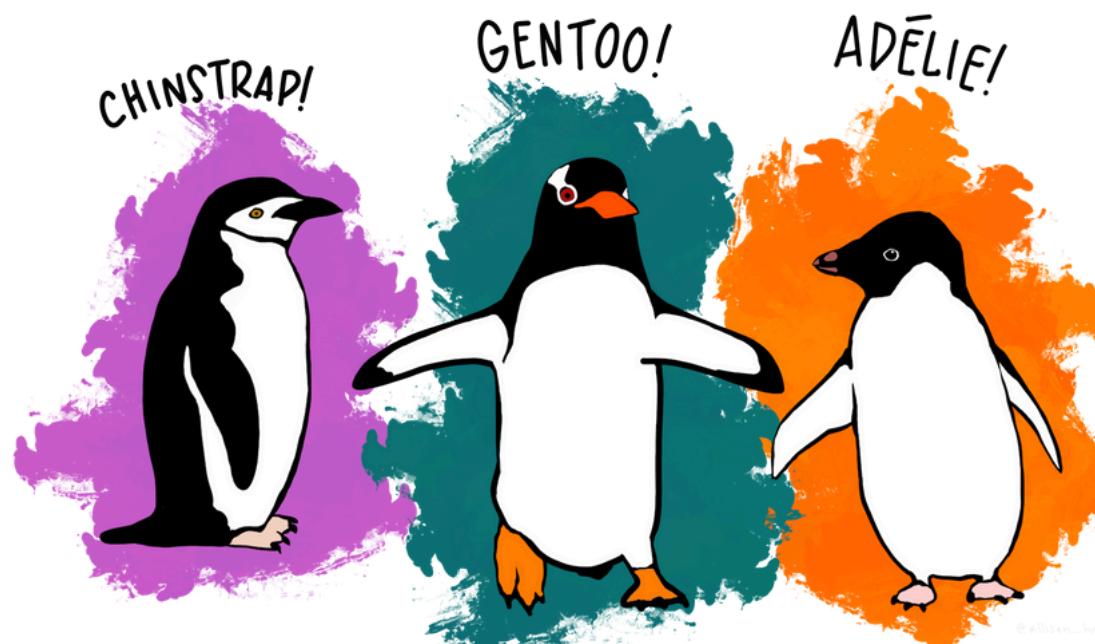
73 male Adelie penguins
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max body mass = 4775 g

HISTOGRAM



These data were collected from 2007 - 2009 by Dr. Kristen Gorman with the Palmer Station Long Term Ecological Research Program, part of the US Long Term Ecological Research Network.

NUMERIC VARIABLES



8 variables (n = 344 penguins)

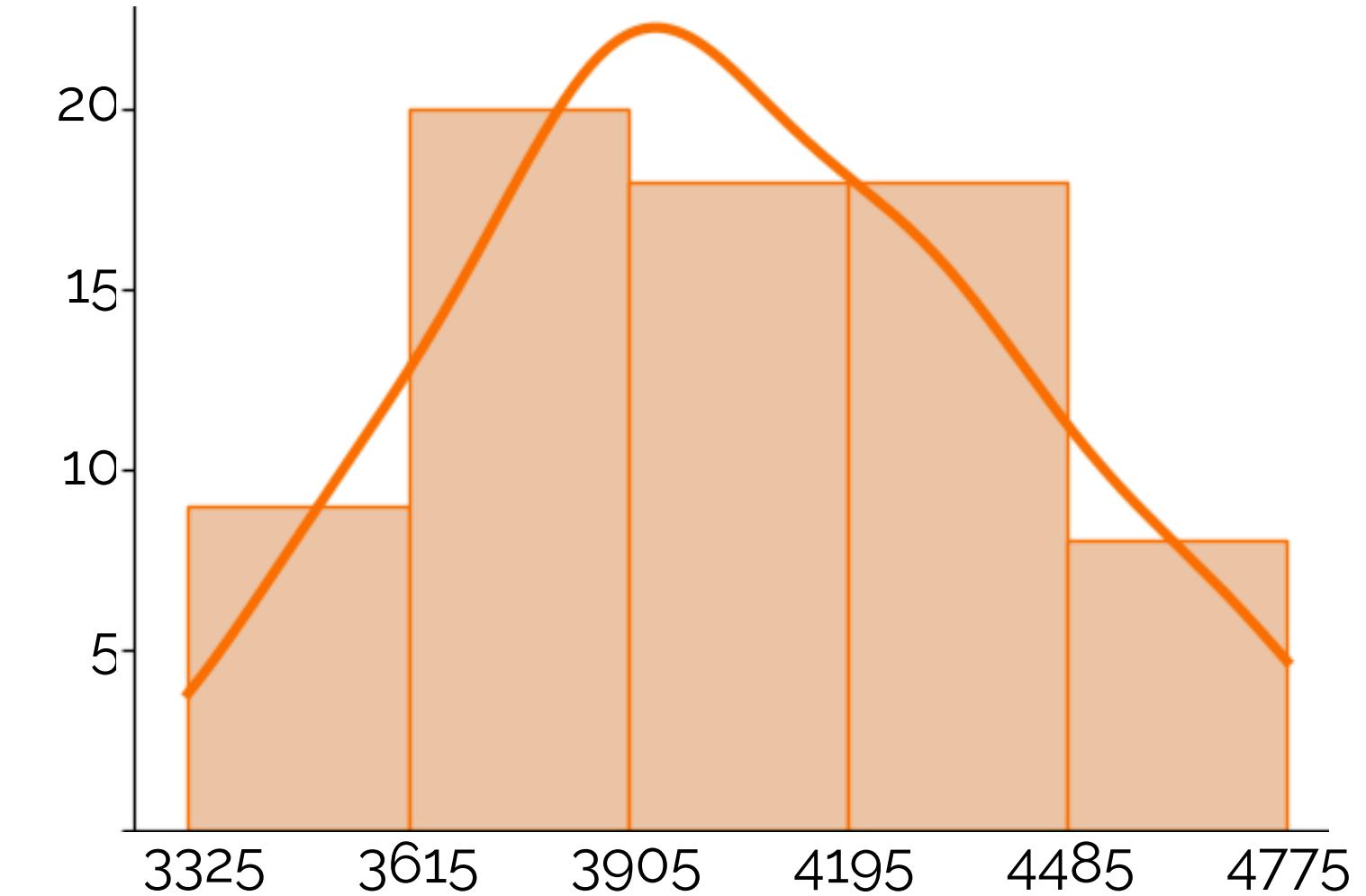
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KERNEL DENSITY (PLOT)



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ESTIMATES OF LOCATION MEASURE OF CENTRAL TENDENCY

MEAN

QUANTILES

MEDIAN

RANGE
&
IQR

MODE

VARIANCE
&
STD DEV

ESTIMATES OF LOCATION MEASURE OF CENTRAL TENDENCY

MEAN

QUANTILES

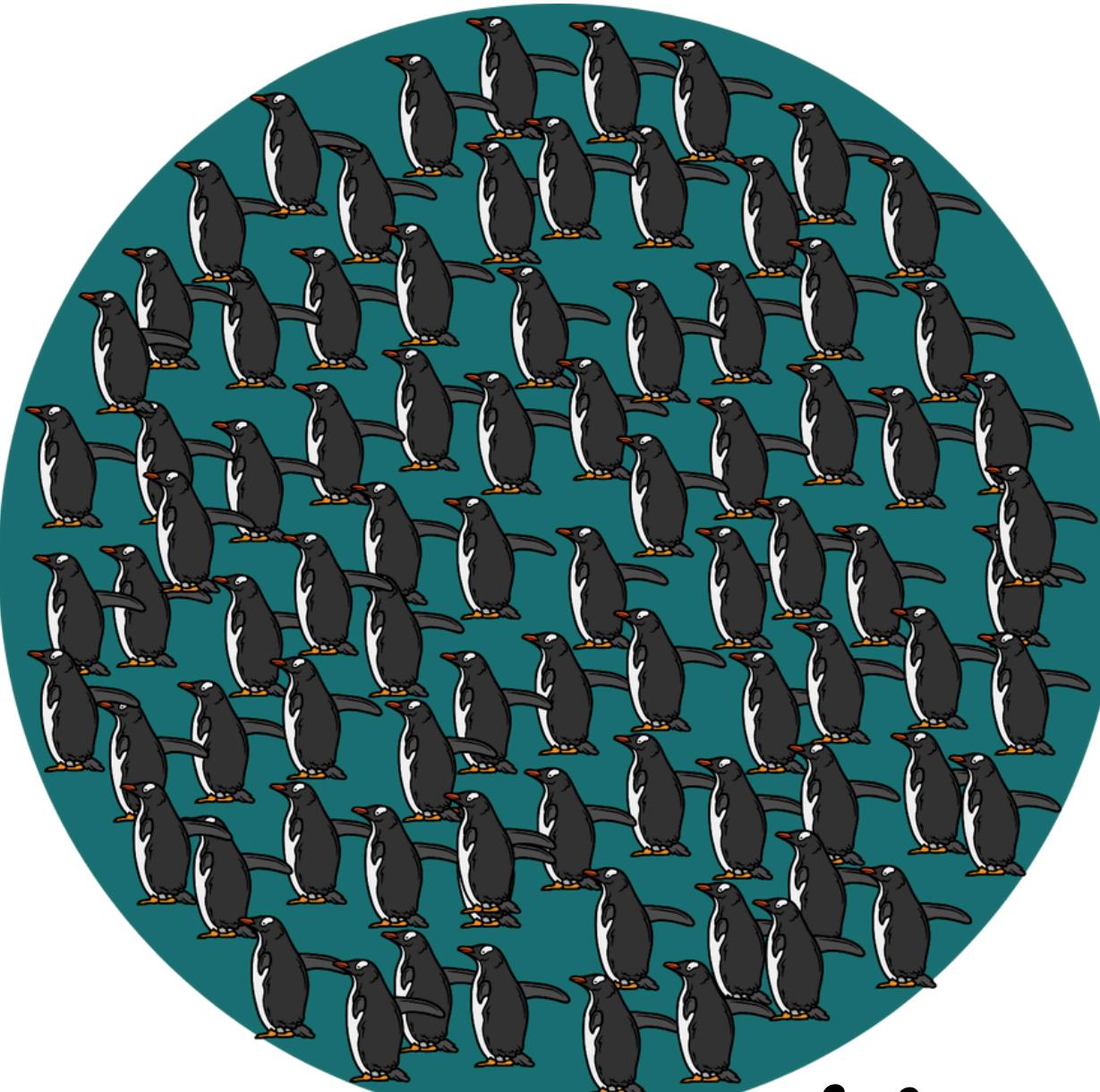
MEDIAN

RANGE
&
IQR

MODE

VARIANCE
&
STD DEV

ESTIMATES OF LOCATION MEASURE OF CENTRAL TENDENCY



POPULATION μ

MEAN

QUANTILES

MEDIAN

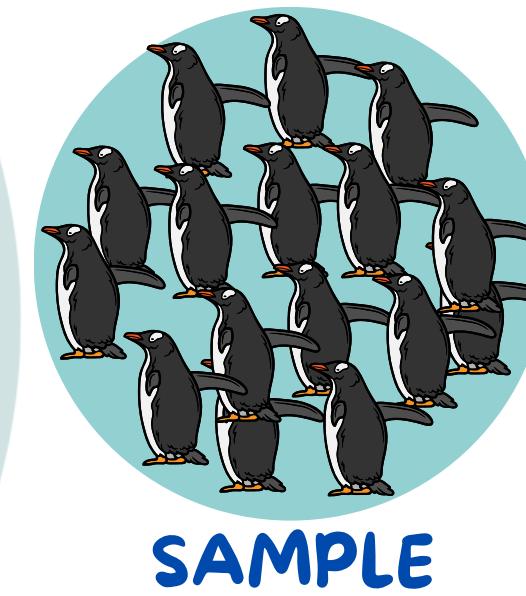
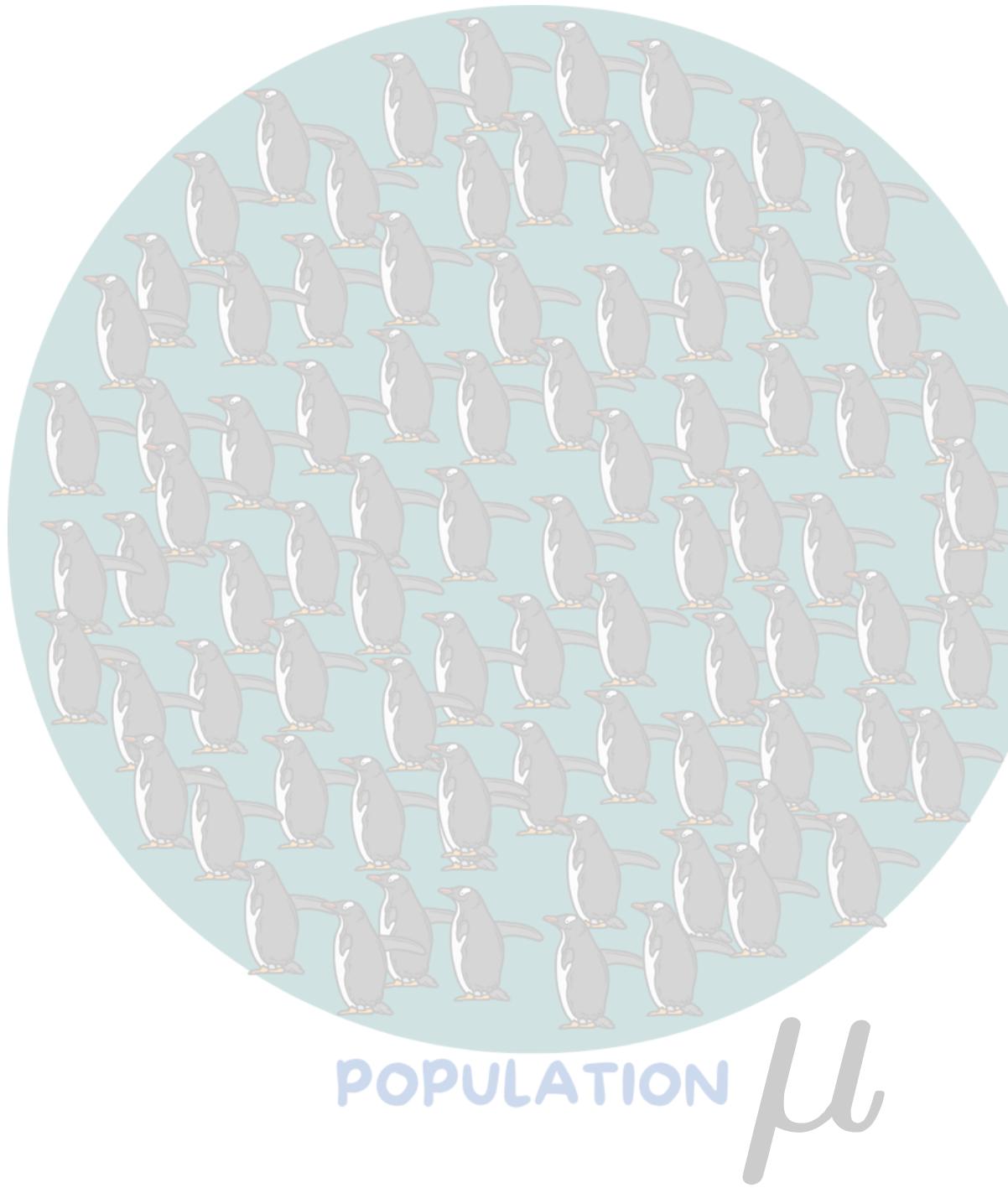
RANGE
&
IQR

MODE

VARIANCE
&
STD DEV

$$\mu = \frac{\sum x}{N}$$

ESTIMATES OF LOCATION MEASURE OF CENTRAL TENDENCY

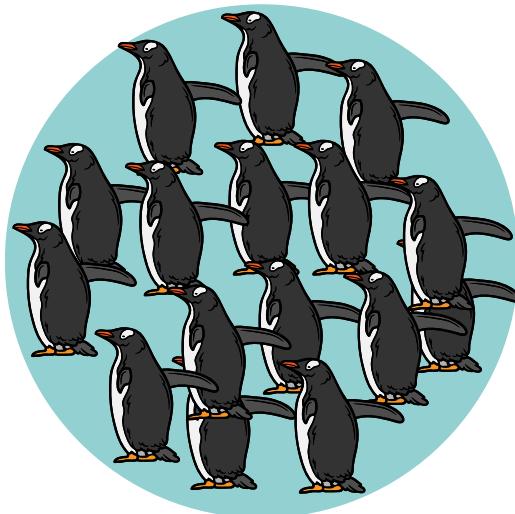


MEAN	MEDIAN	MODE
QUANTILES	RANGE & IQR	VARIANCE & STD DEV

$$\mu = \frac{\sum x}{N}$$

ESTIMATES OF LOCATION

MEASURE OF CENTRAL TENDENCY



SAMPLE

$$\bar{x} = \frac{\sum x}{n}$$

MEAN

QUANTILES

MEDIAN

RANGE
&
IQR

MODE

VARIANCE
&
STD DEV

ESTIMATES OF LOCATION

MEASURE OF CENTRAL TENDENCY

MEAN

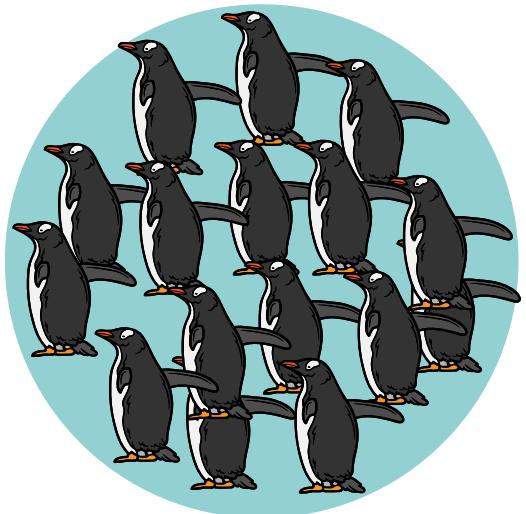
MEDIAN

MODE

QUANTILES

RANGE
&
IQR

VARIANCE
&
STD DEV



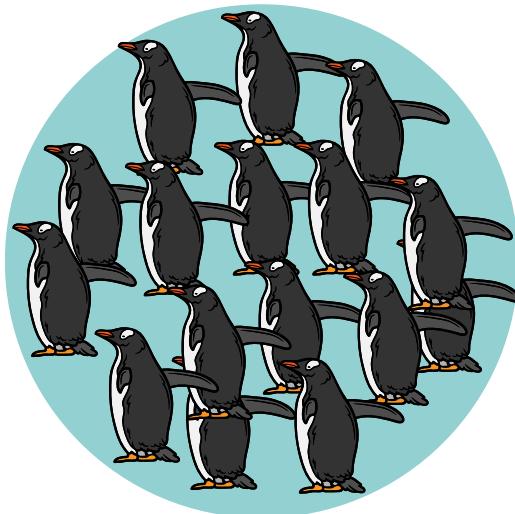
SAMPLE

$$\bar{x} = \frac{\sum x}{n}$$

[10, 28, 28, 33, 54]

$$\bar{x} = \frac{10 + 28 + 28 + 33 + 54}{5} = 30.6$$

ESTIMATES OF LOCATION MEASURE OF CENTRAL TENDENCY



SAMPLE

$$\bar{x} = \frac{\sum x}{n}$$

MEAN

QUANTILES

MEDIAN

RANGE
&
IQR

MODE

VARIANCE
&
STD DEV

MEAN OF CATEGORICAL VARIABLE?

[Male, Female, Female, Male, Female, Female]

ESTIMATES OF LOCATION MEASURE OF CENTRAL TENDENCY

MEAN

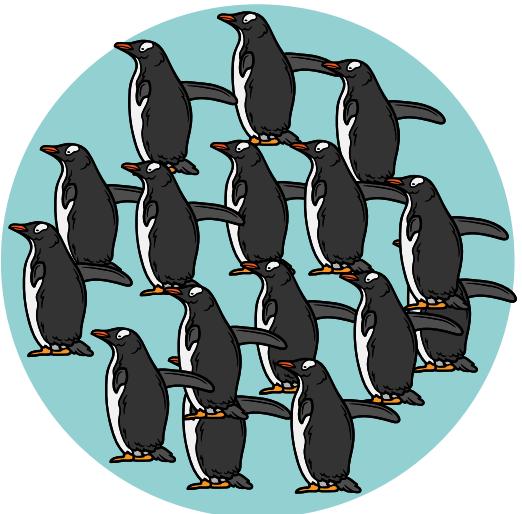
MEDIAN

MODE

QUANTILES

RANGE
&
IQR

VARIANCE
&
STD DEV



SAMPLE

$$\bar{x} = \frac{\sum x}{n}$$

MEAN OF CATEGORICAL VARIABLE?

[Male, Female, Female, Male, Female, Female]

[0, 1, 1, 0, 1, 1]

$$\bar{x} = \frac{0 + 1 + 1 + 0 + 1 + 1}{6} = 0.66\ldots$$

ESTIMATES OF LOCATION MEASURE OF CENTRAL TENDENCY

MEAN

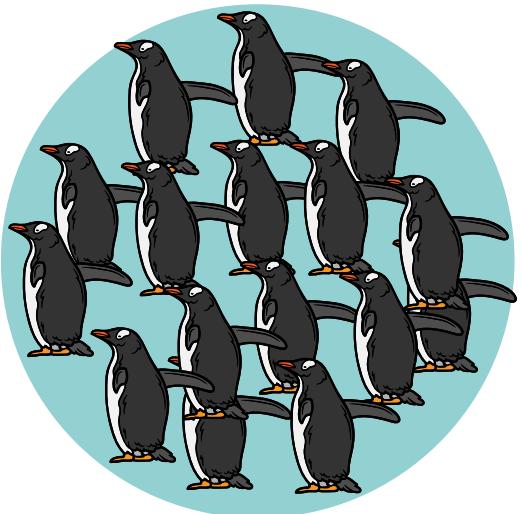
MEDIAN

MODE

QUANTILES

RANGE
&
IQR

VARIANCE
&
STD DEV



SAMPLE

$$\bar{x} = \frac{\sum x}{n}$$

MEAN OF BINARY VARIABLE > PROPORTION

[Male, Female, Female, Male, Female, Female]

[0, 1, 1, 0, 1, 1]

$$\bar{x} = \frac{0 + 1 + 1 + 0 + 1 + 1}{6} = 0.66\ldots$$

ESTIMATES OF LOCATION MEASURE OF CENTRAL TENDENCY

MEAN

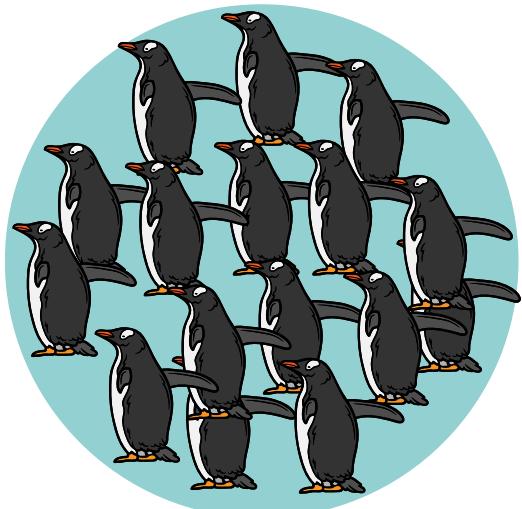
MEDIAN

MODE

QUANTILES

RANGE
&
IQR

VARIANCE
&
STD DEV



SAMPLE

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[10, 28, 28, 33, 54]

ESTIMATES OF LOCATION MEASURE OF CENTRAL TENDENCY

MEAN

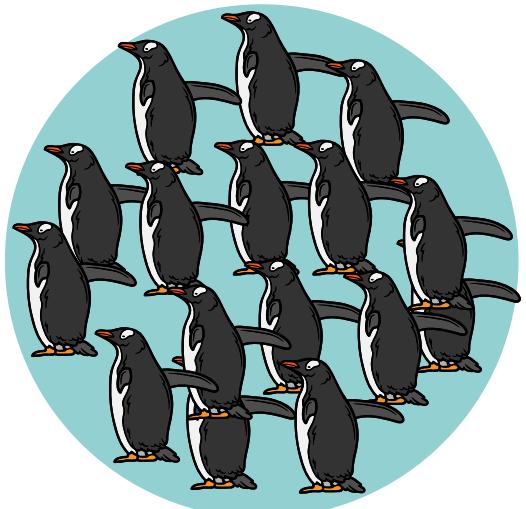
MEDIAN

MODE

QUANTILES

RANGE
&
IQR

VARIANCE
&
STD DEV



SAMPLE

$$\bar{x} = \frac{\sum x}{n}$$

[10, 28, 28, 33, 54]

$Med = 28$

ESTIMATES OF LOCATION MEASURE OF CENTRAL TENDENCY

MEAN

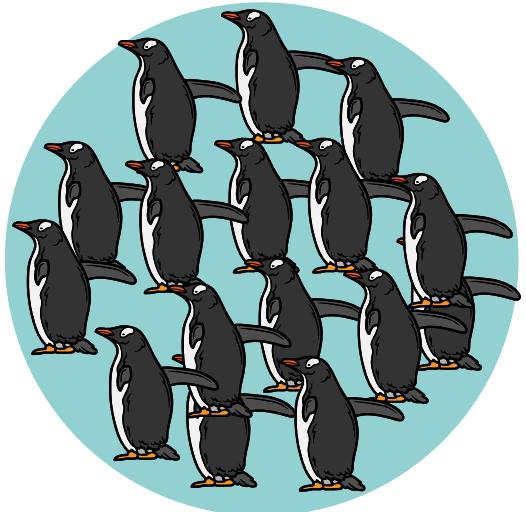
MEDIAN

MODE

QUANTILES

RANGE
&
IQR

VARIANCE
&
STD DEV



SAMPLE

$$\bar{x} = \frac{\sum x}{n}$$

[10, 28, 28, 33, 54, 59]

ESTIMATES OF LOCATION

MEASURE OF CENTRAL TENDENCY

MEAN

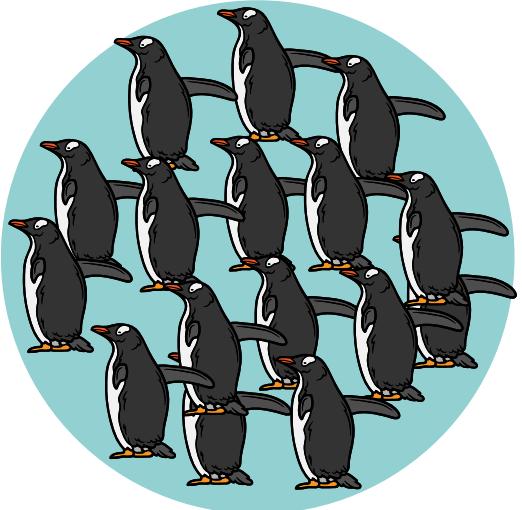
MEDIAN

MODE

QUANTILES

RANGE
&
IQR

VARIANCE
&
STD DEV



SAMPLE

$$\bar{x} = \frac{\sum x}{n}$$

Middle value of ordered observations (50% below, 50% above)

[10, 28, 28, 33, 54, 59]

$$Med = \frac{28 + 33}{2} = 14.5$$

ESTIMATES OF LOCATION MEASURE OF CENTRAL TENDENCY



$$\bar{x} = \frac{\sum x}{n}$$

MEAN

MEDIAN

MODE

QUANTILES

RANGE
&
IQR

VARIANCE
&
STD DEV

Mean:

- sensitive to outliers
- “balance” point

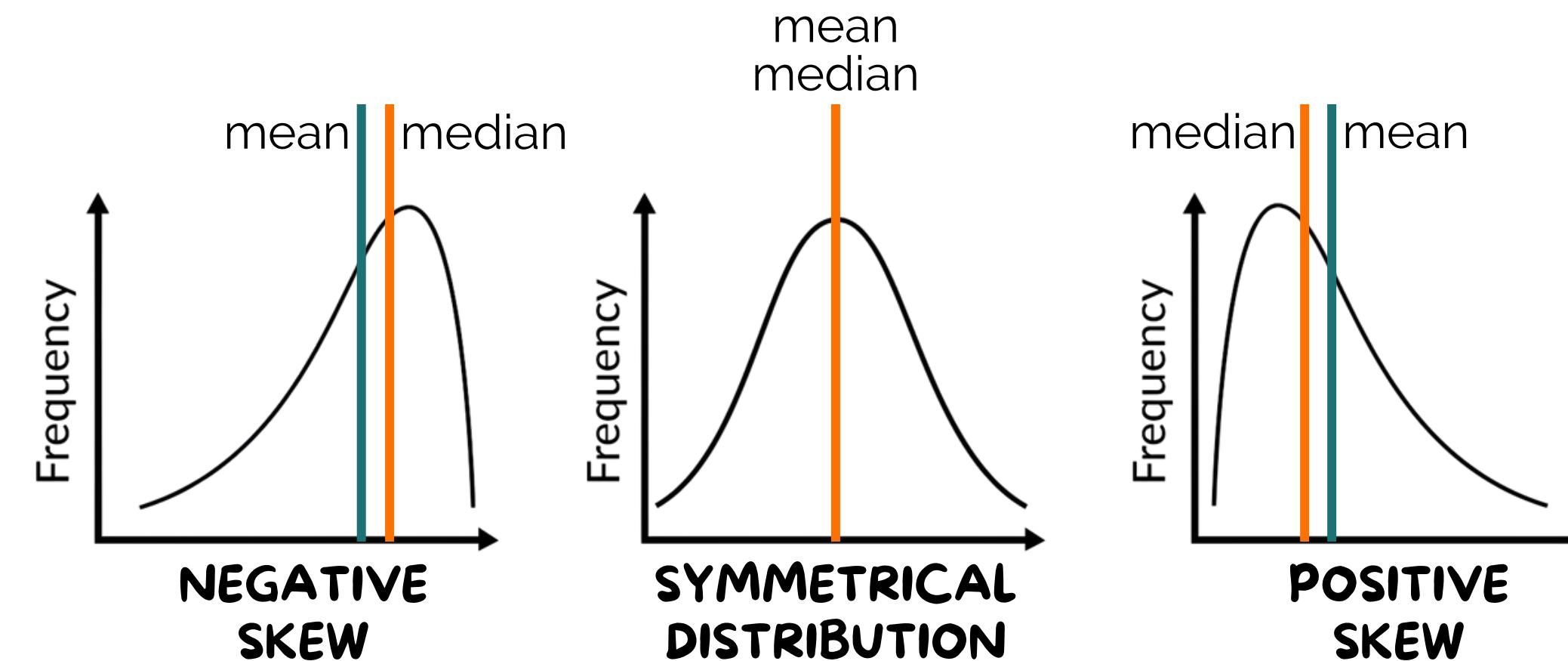
Median:

- not sensitive to outliers
- cuts data in half

[10, 28, 28, 33, 54]

$$\bar{x} = \frac{10 + 28 + 28 + 33 + 54}{5} = 30.6$$

$$Med = 28$$



ESTIMATES OF LOCATION MEASURE OF CENTRAL TENDENCY

MEAN

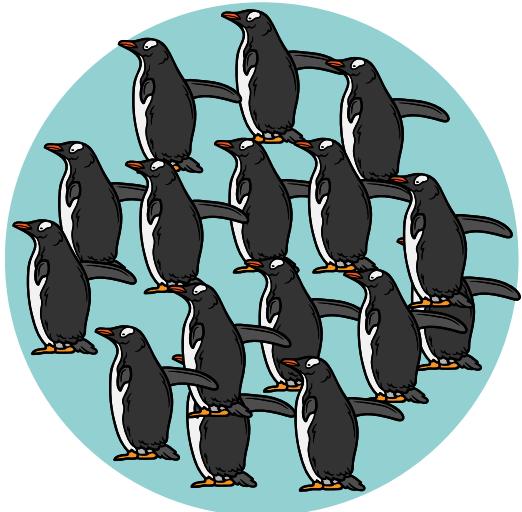
MEDIAN

MODE

QUANTILES

RANGE
&
IQR

VARIANCE
&
STD DEV



SAMPLE

$$\bar{x} = \frac{\sum x}{n}$$

The observation with the highest frequency

[10, 28, 28, 33, 54]

ESTIMATES OF LOCATION MEASURE OF CENTRAL TENDENCY

MEAN

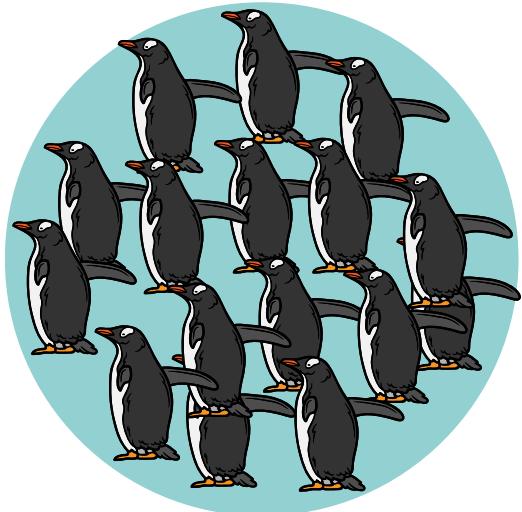
MEDIAN

MODE

QUANTILES

RANGE
&
IQR

VARIANCE
&
STD DEV



SAMPLE

$$\bar{x} = \frac{\sum x}{n}$$

The observation with the highest frequency

[10, 28, 28, 33, 54]

Mode = 28

ESTIMATES OF LOCATION MEASURE OF CENTRAL TENDENCY

MEAN

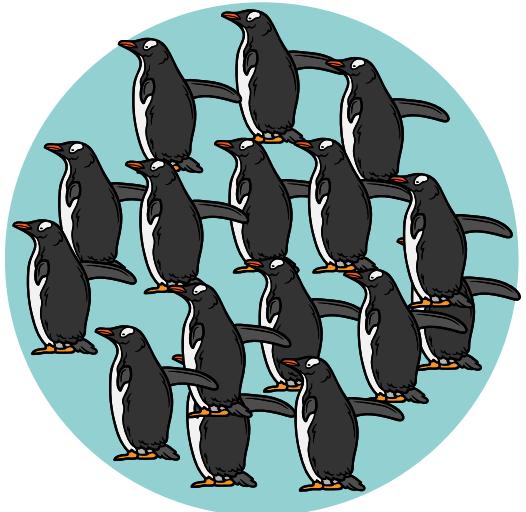
MEDIAN

MODE

QUANTILES

RANGE
&
IQR

VARIANCE
&
STD DEV



SAMPLE

$$\bar{x} = \frac{\sum x}{n}$$

The observation with the highest frequency

[10, 27, 28, 33, 54]

Mode = ?

ESTIMATES OF LOCATION MEASURE OF CENTRAL TENDENCY

MEAN

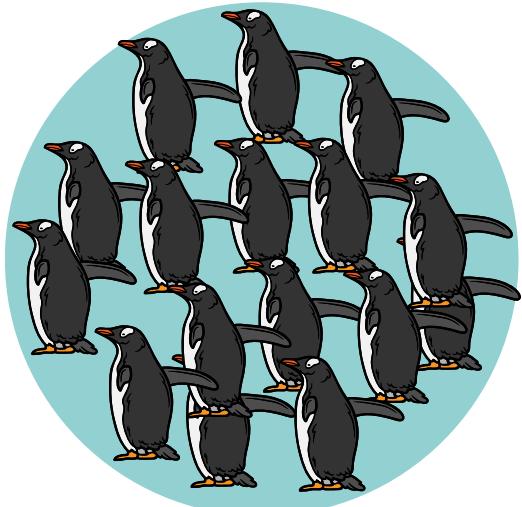
MEDIAN

MODE

QUANTILES

RANGE
&
IQR

VARIANCE
&
STD DEV



SAMPLE

$$\bar{x} = \frac{\sum x}{n}$$

The observation with the highest frequency

[10, 27, 28, 54, 54]

Mode = 54

Not suitable for small datasets

ESTIMATES OF LOCATION MEASURE OF CENTRAL TENDENCY

MEAN

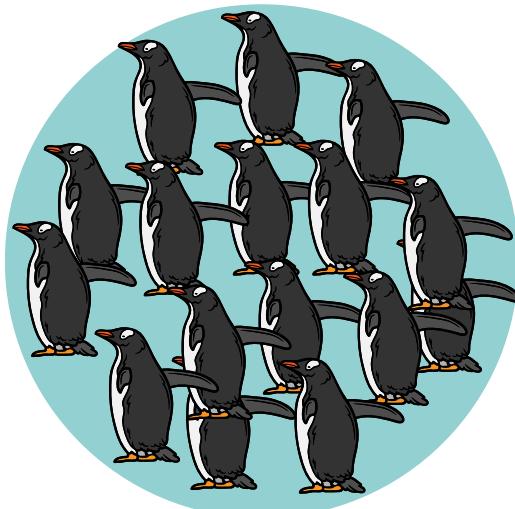
MEDIAN

MODE

QUANTILES

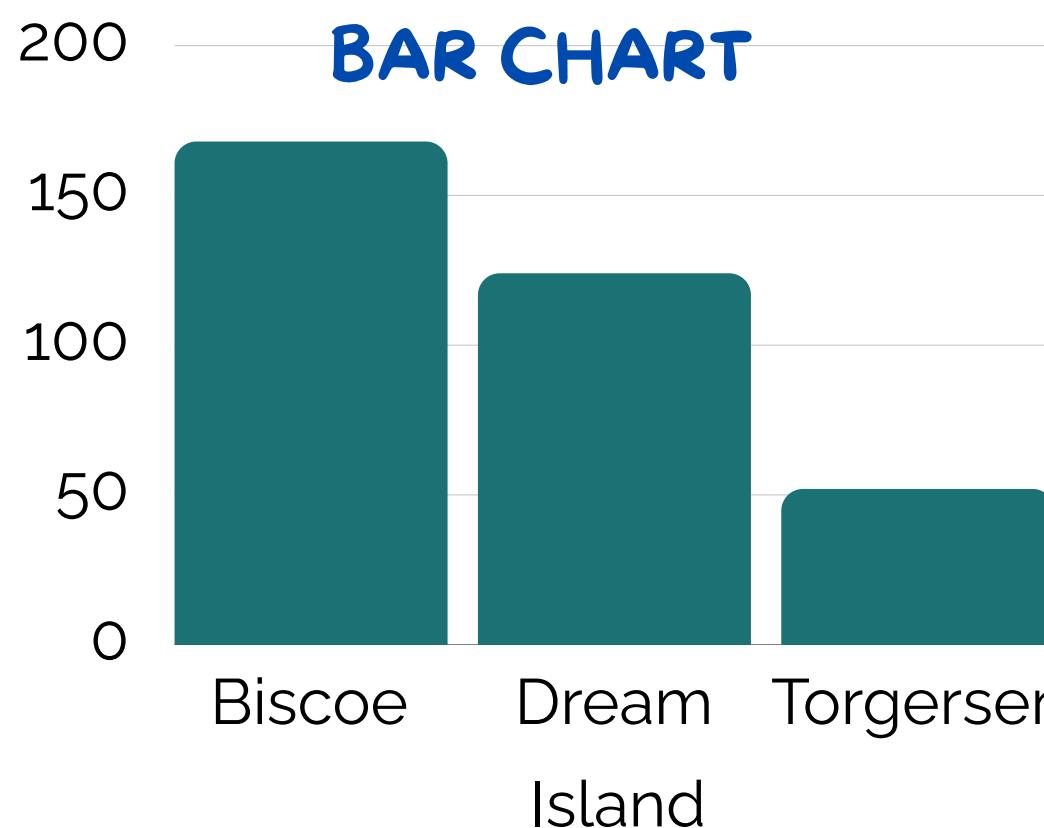
RANGE
&
IQR

VARIANCE
&
STD DEV



SAMPLE

$$\bar{x} = \frac{\sum x}{n}$$

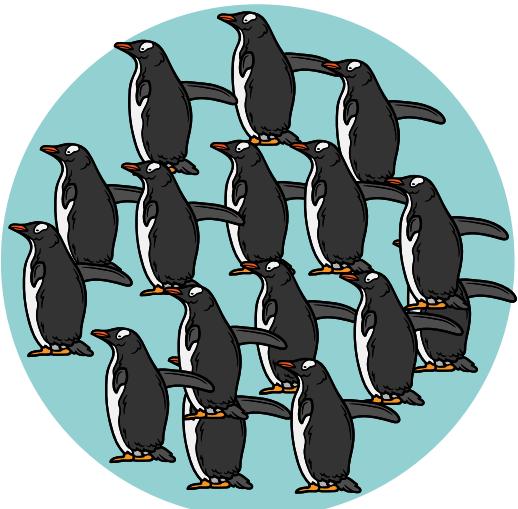


The observation with the highest frequency

Mode = Biscoe

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ESTIMATES OF LOCATION MEASURE OF CENTRAL TENDENCY



SAMPLE

$$\bar{x} = \frac{\sum x}{n}$$

Mean:

- sensitive to outliers
- “balance” point

Median:

- not sensitive to outliers
- cuts data in half

Mode:

The observation with the highest frequency

MEAN

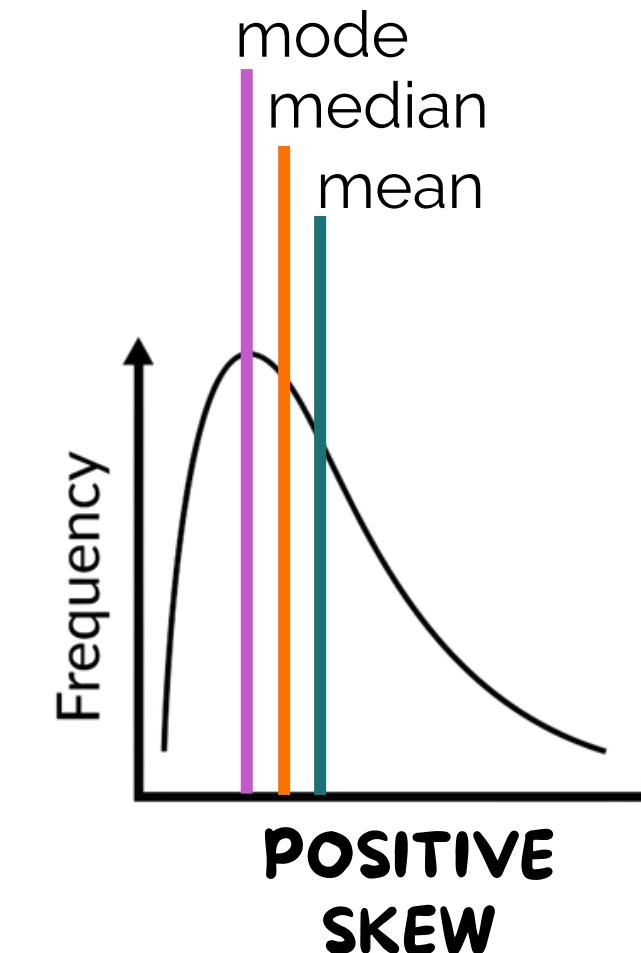
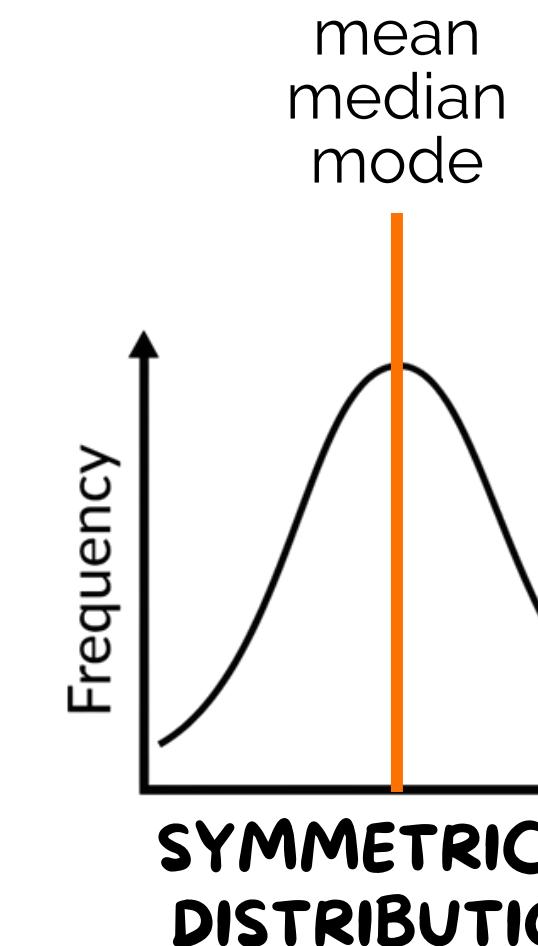
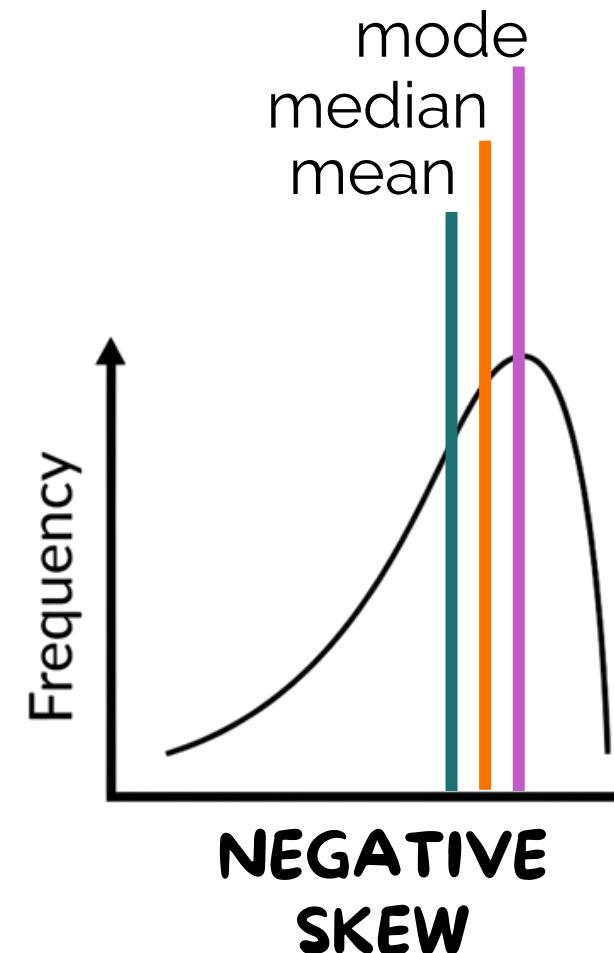
MEDIAN

MODE

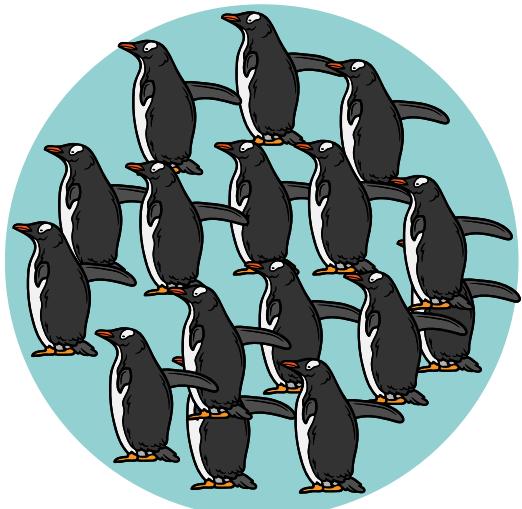
QUANTILES

RANGE
&
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STD DEV



ESTIMATES OF LOCATION MEASURE OF CENTRAL TENDENCY



SAMPLE

$$\bar{x} = \frac{\sum x}{n}$$

Mean:

- sensitive to outliers
- “balance” point

Median:

- not sensitive to outliers
- cuts data in half

Mode:

The observation with the highest frequency

MEAN

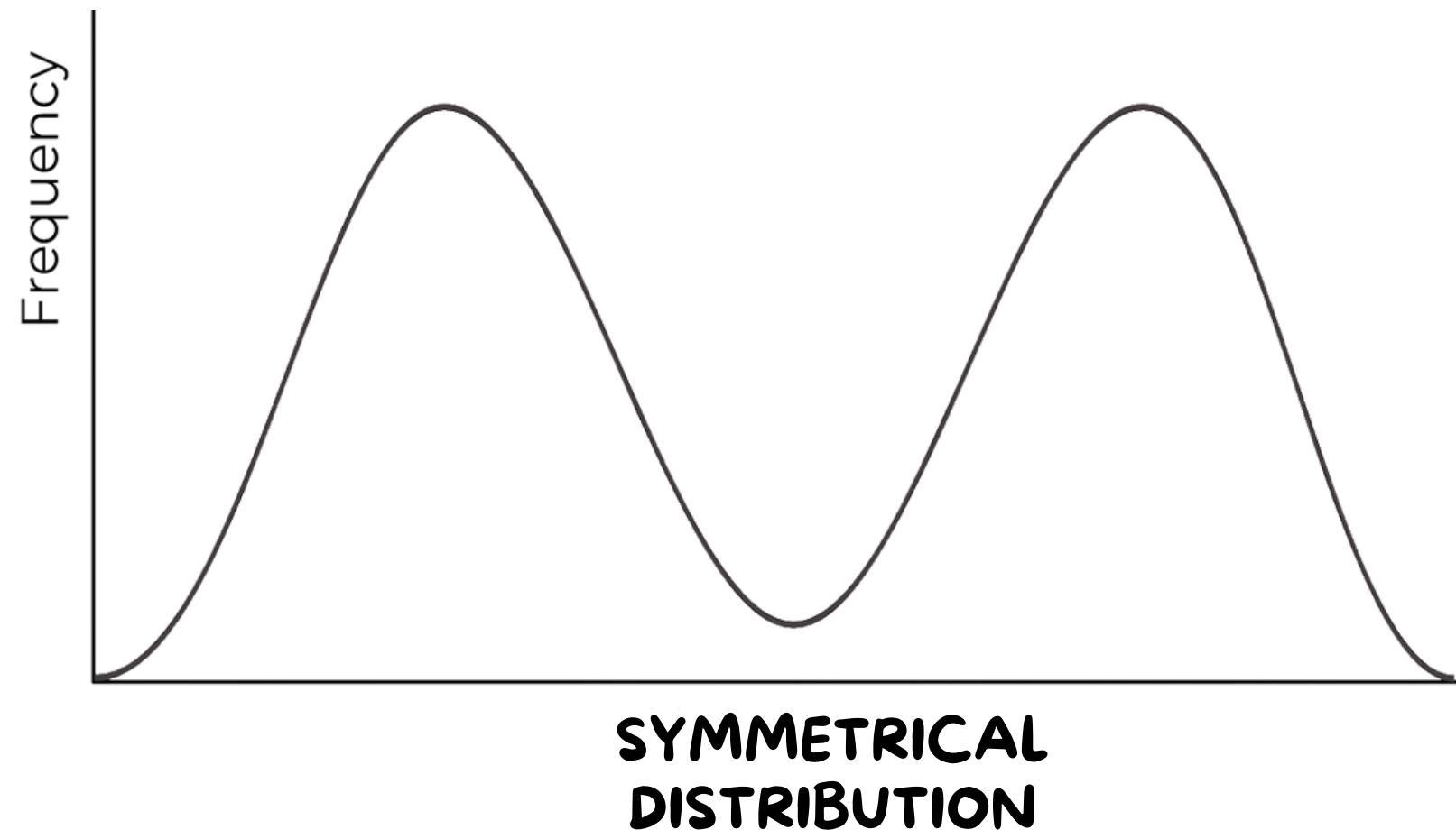
MEDIAN

MODE

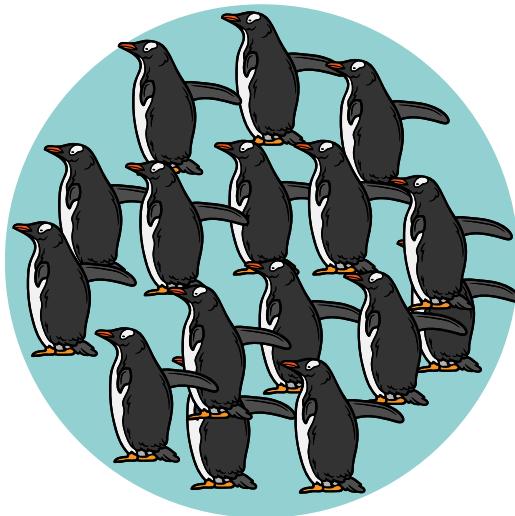
QUANTILES

RANGE
&
IQR

VARIANCE
&
STD DEV



ESTIMATES OF LOCATION MEASURE OF CENTRAL TENDENCY



SAMPLE

$$\bar{x} = \frac{\sum x}{n}$$

Mean:

- sensitive to outliers
- “balance” point

Median:

- not sensitive to outliers
- cuts data in half

Mode:

The observation with the highest frequency

MEAN

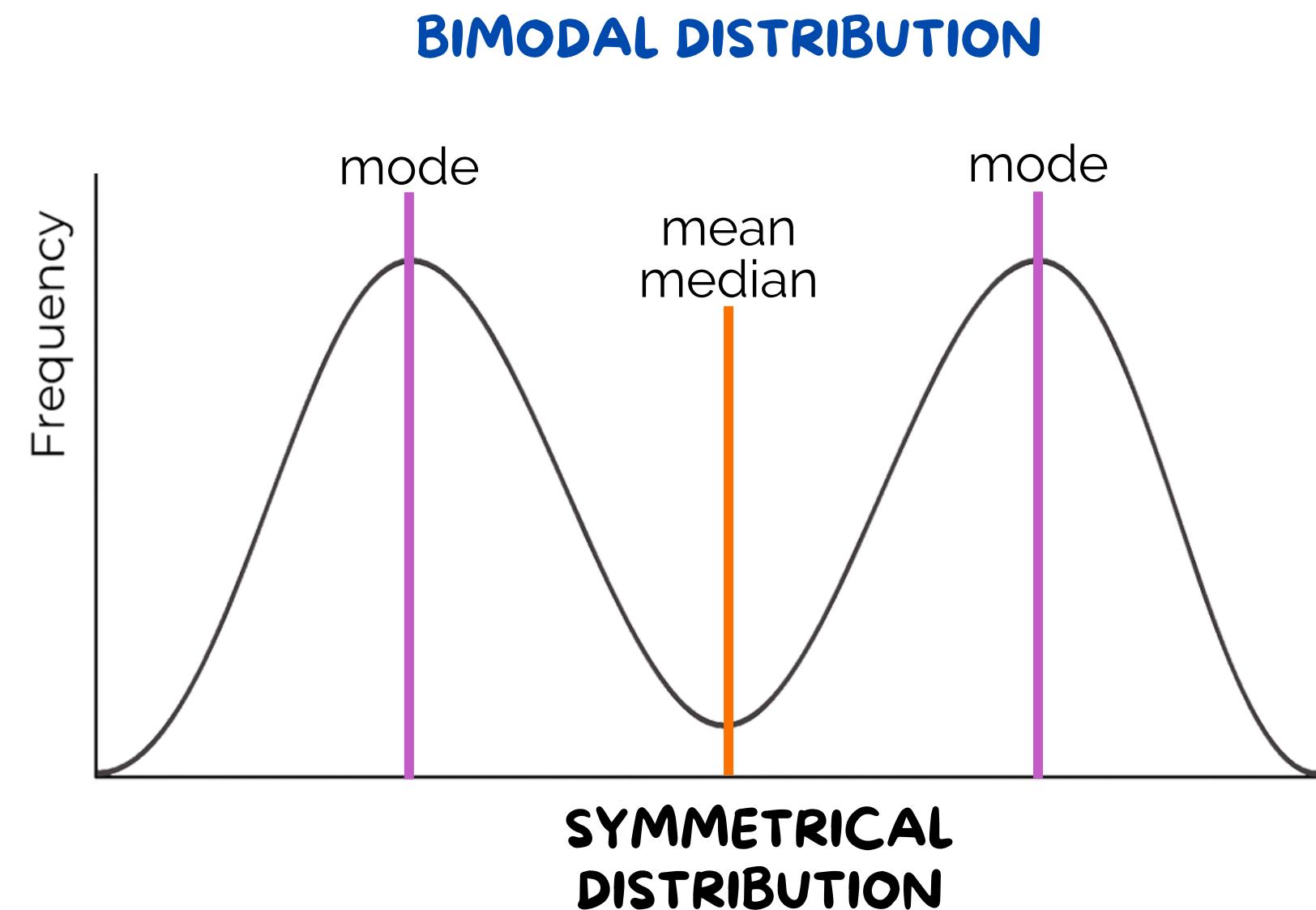
MEDIAN

MODE

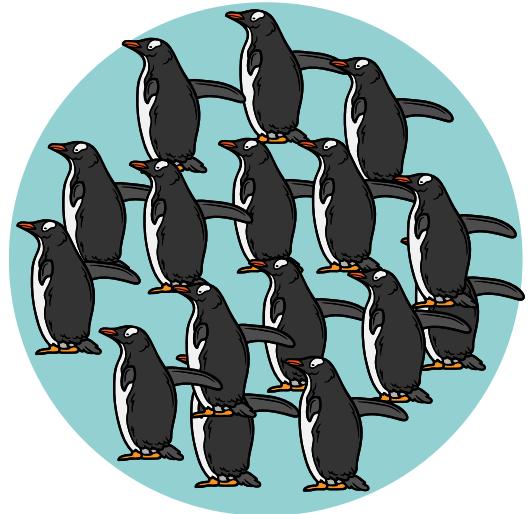
QUANTILES

RANGE
&
IQR

VARIANCE
&
STD DEV



ESTIMATES OF LOCATION DESCRIBING THE DISTRIBUTION



SAMPLE

[4, 7, 8, ..., 178, 180, 189]

$n = 23$



MEAN

MEDIAN

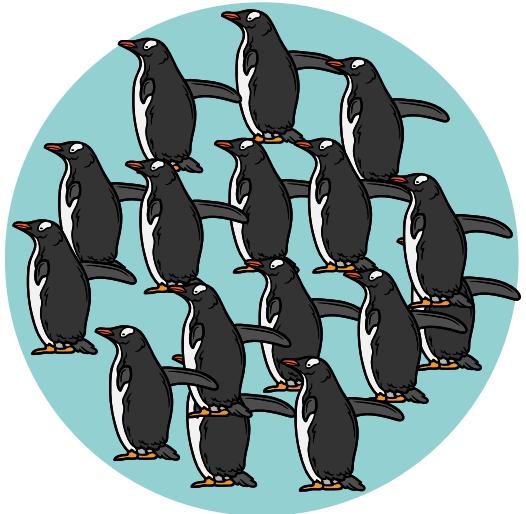
MODE

QUANTILES

RANGE
&
IQR

VARIANCE
&
STD DEV

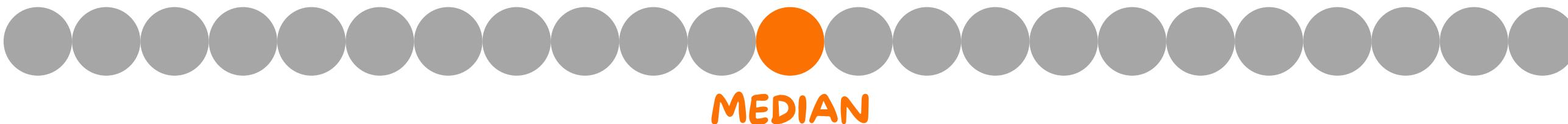
ESTIMATES OF LOCATION DESCRIBING THE DISTRIBUTION



SAMPLE

[4, 7, 8, ..., 178, 180, 189]

$n = 23$



MEAN

MEDIAN

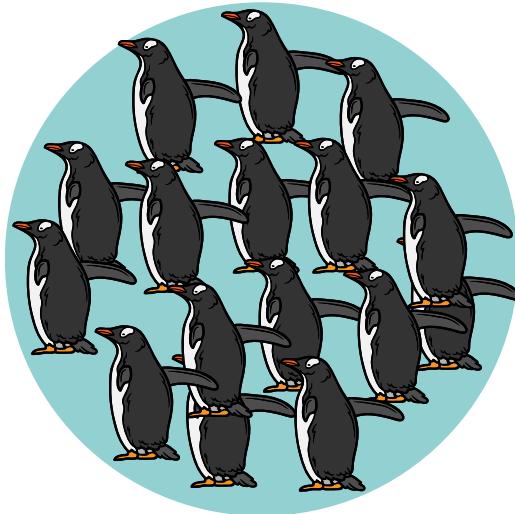
MODE

QUANTILES

RANGE
&
IQR

VARIANCE
&
STD DEV

ESTIMATES OF LOCATION DESCRIBING THE DISTRIBUTION



SAMPLE

MEAN

MEDIAN

MODE

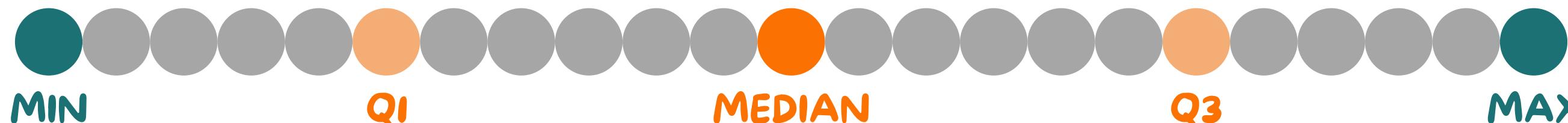
QUANTILES

RANGE
&
IQR

VARIANCE
&
STD DEV

[4, 7, 8, ..., 178, 180, 189]

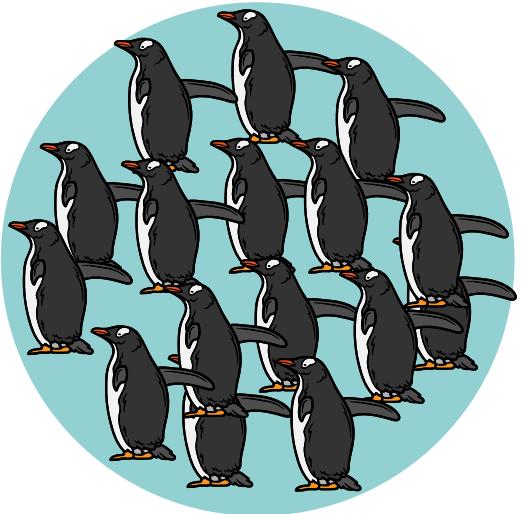
$n = 23$



First quartile (Q1) : 25% (1/4)
of observations below

Third quartile (Q3) : 75% (3/4)
of observations below

ESTIMATES OF LOCATION DESCRIBING THE DISTRIBUTION



SAMPLE

[4, 7, 8, ..., 178, 180, 189]

$$n = 23$$

MIN Q1 MEDIAN Q3 MAX

25th percentile 50th percentile 75th percentile

MIN Q1 MEDIAN Q3 MAX

First quartile (Q1) : 25% (1/4) of observations below

Third quartile (Q3) : 75% (3/4) of observations below

8

ESTIMATES OF LOCATION DESCRIBING THE DISTRIBUTION

MEAN

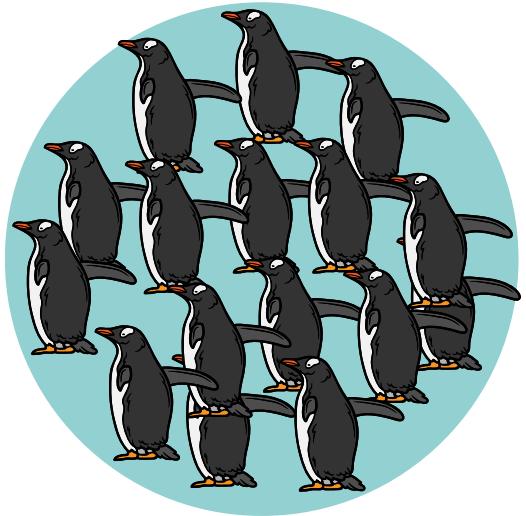
MEDIAN

MODE

QUANTILES

RANGE
&
IQR

VARIANCE
&
STD DEV



SAMPLE

[2, 2, 5, 6, 9, 10, 13]

2 2 5 6 9 10 13

ESTIMATES OF LOCATION DESCRIBING THE DISTRIBUTION

MEAN

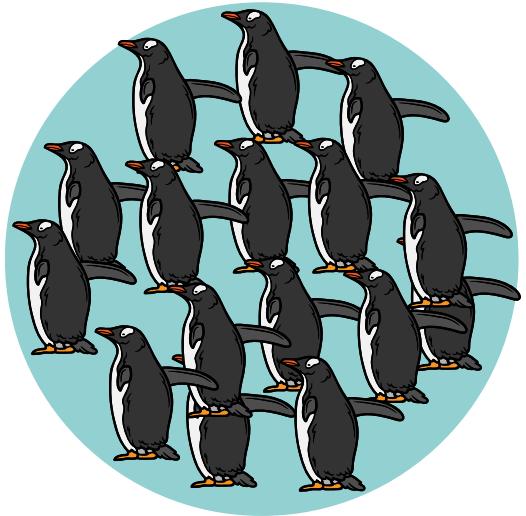
MEDIAN

MODE

QUANTILES

RANGE
&
IQR

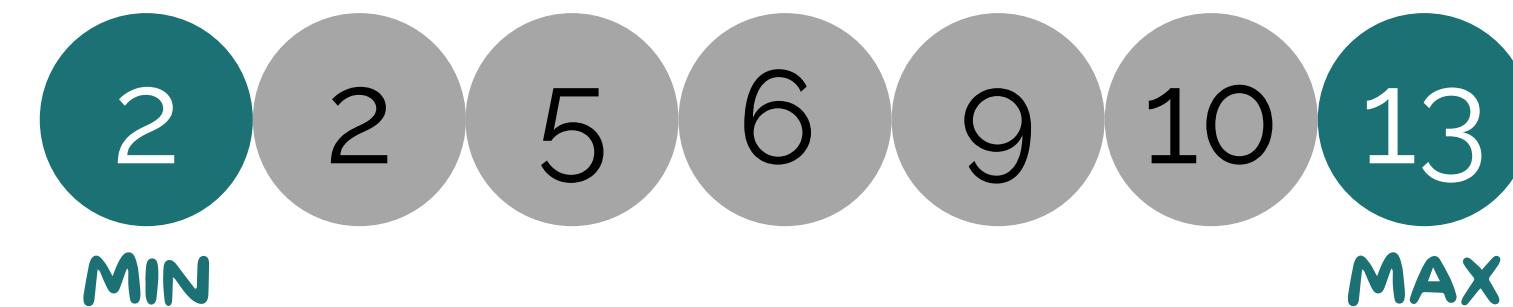
VARIANCE
&
STD DEV



SAMPLE

[2, 2, 5, 6, 9, 10, 13]

Range: MAX - MIN = 13 - 2 = 11



ESTIMATES OF LOCATION DESCRIBING THE DISTRIBUTION

MEAN

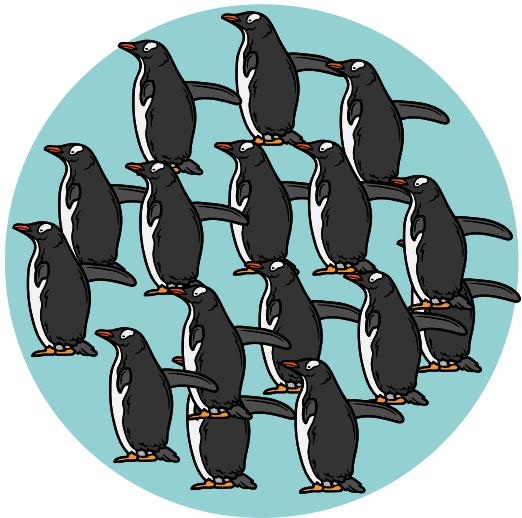
MEDIAN

MODE

QUANTILES

RANGE
&
IQR

VARIANCE
&
STD DEV

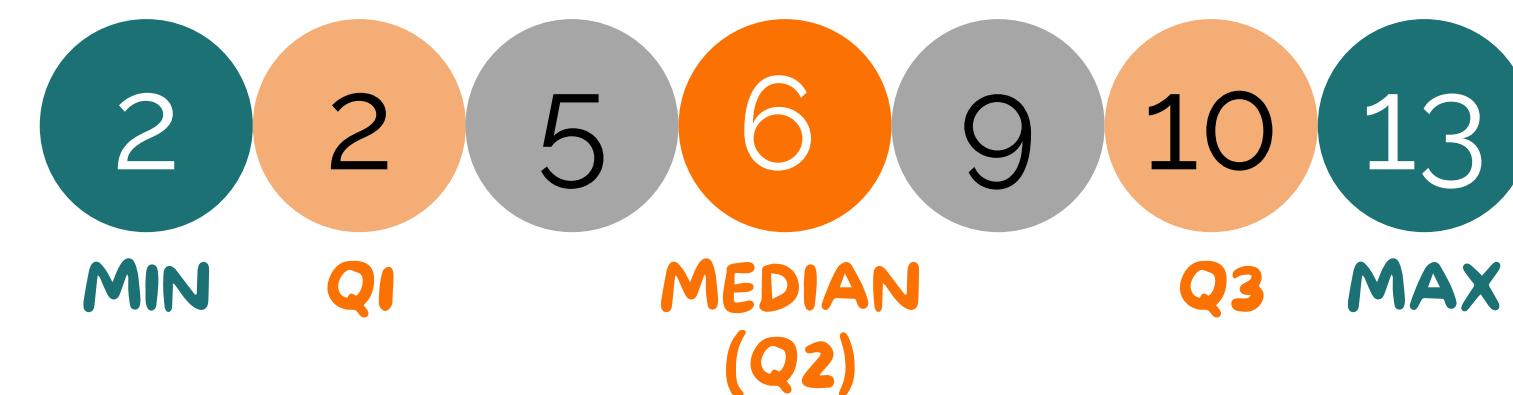


SAMPLE

[2, 2, 5, 6, 9, 10, 13]

Range: MAX - MIN = 13 - 2 = 11

IQR: Q3 - Q1 = 10 - 2 = 8



ESTIMATES OF LOCATION DESCRIBING THE DISTRIBUTION

MEAN

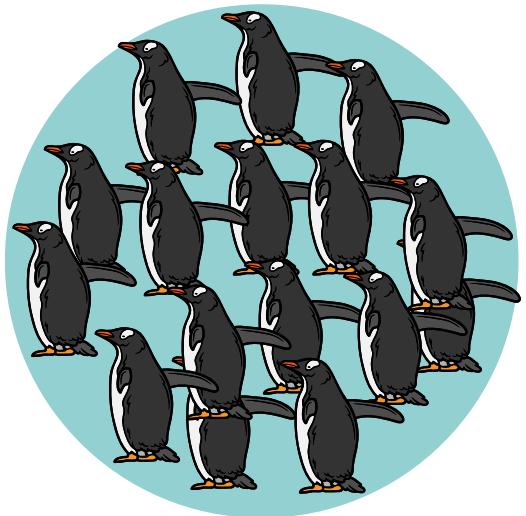
MEDIAN

MODE

QUANTILES

RANGE
&
IQR

VARIANCE
&
STD DEV

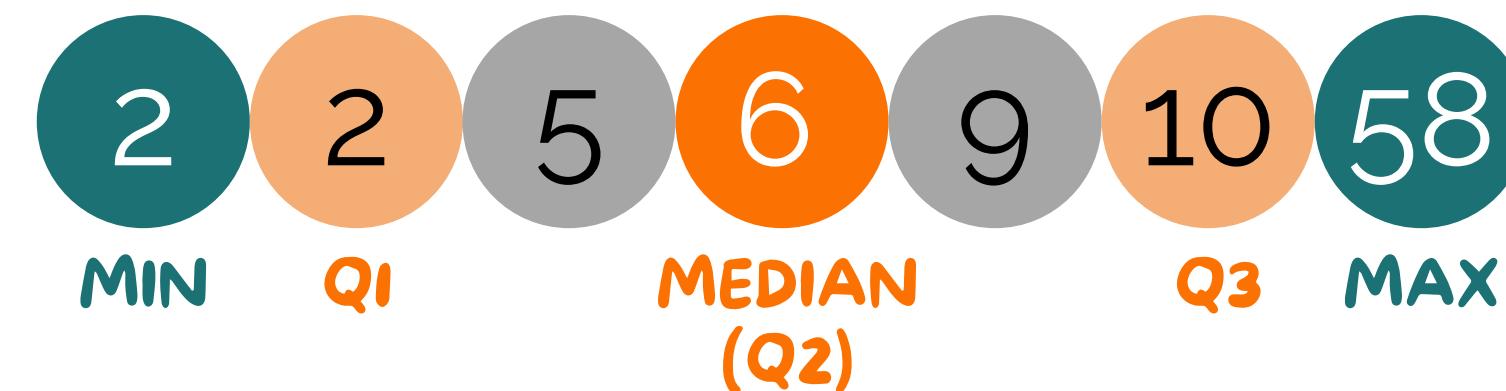


SAMPLE

[2, 2, 5, 6, 9, 10, 58]

Range: $\text{MAX} - \text{MIN} = 58 - 2 = 56$ Range is sensitive to outliers

IQR: $\text{Q3} - \text{Q1} = 10 - 2 = 8$ The middle 50% of the ordered data
Not sensitive to outliers



ESTIMATES OF LOCATION DESCRIBING THE DISTRIBUTION

MEAN

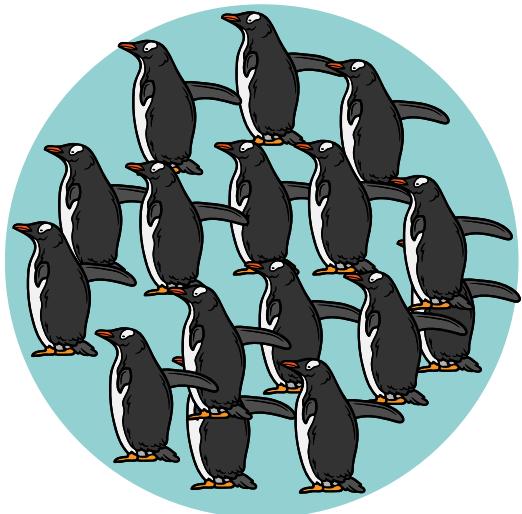
MEDIAN

MODE

QUANTILES

RANGE
&
IQR

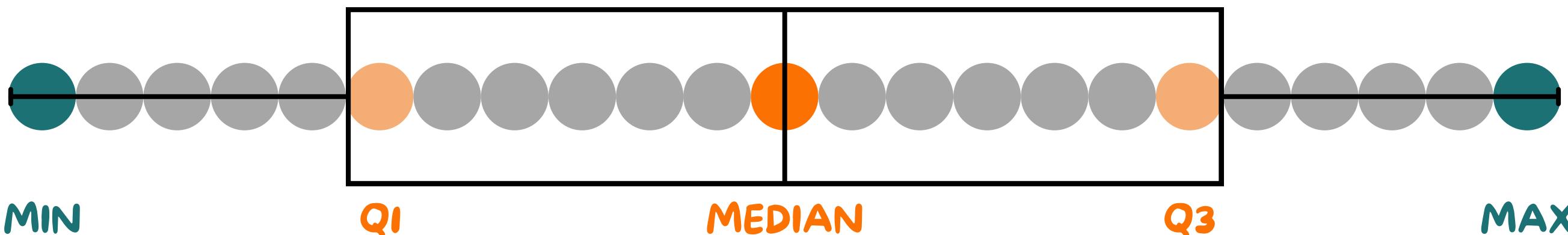
VARIANCE
&
STD DEV



SAMPLE

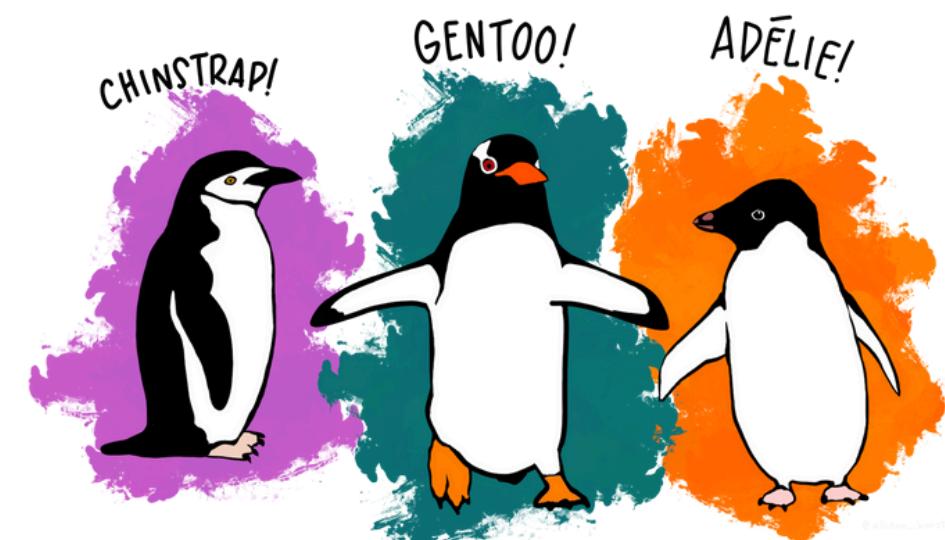
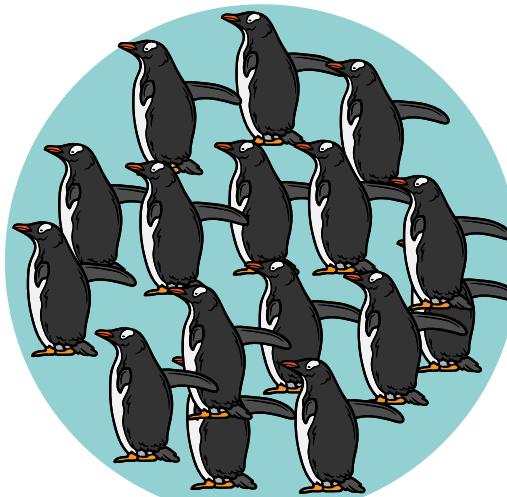
$n = 23$

BOXPLOT



The box-and-whisker plot was first introduced in 1970 by John Tukey

ESTIMATES OF LOCATION DESCRIBING THE DISTRIBUTION



SAMPLE

MEAN

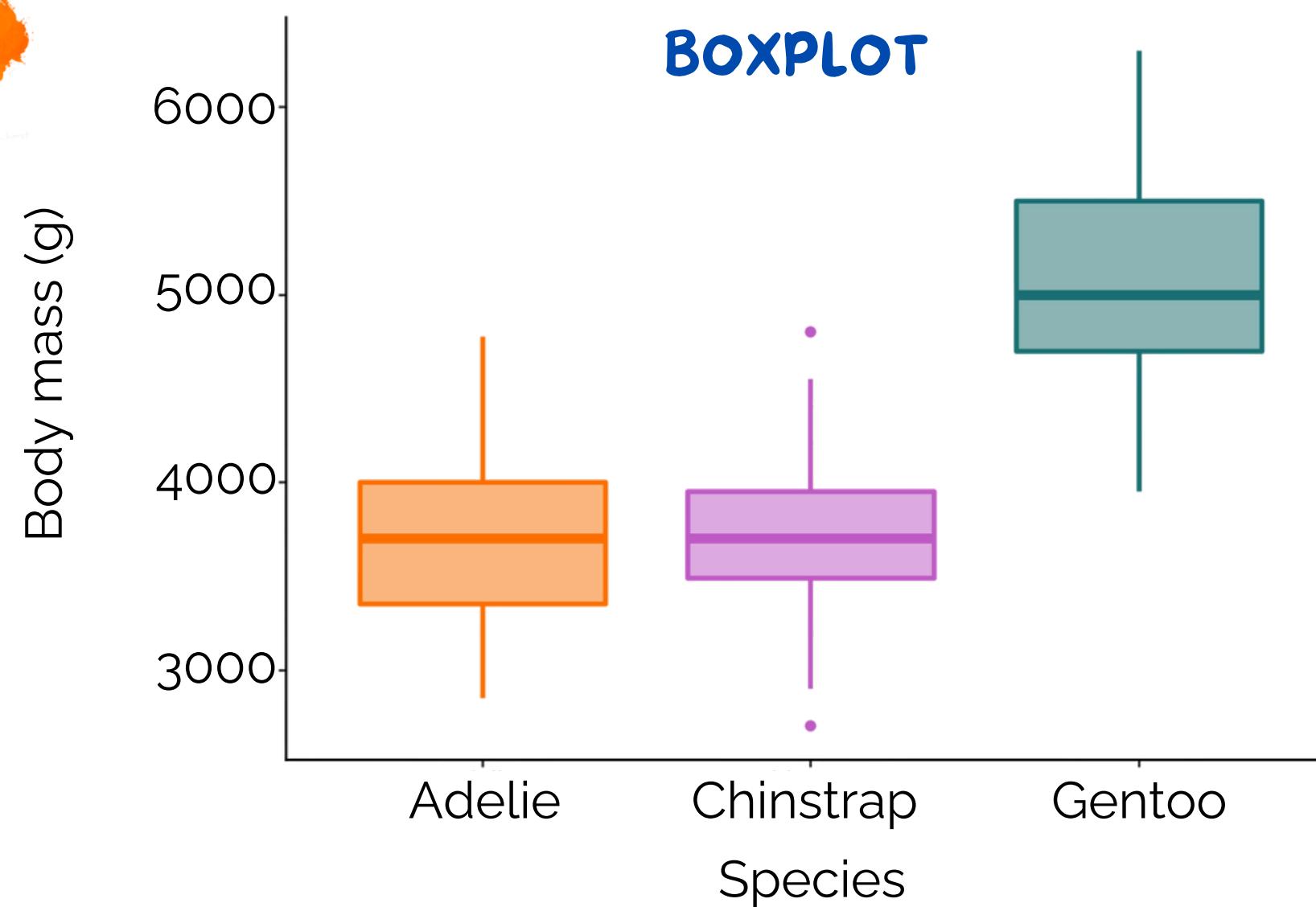
MEDIAN

MODE

QUANTILES

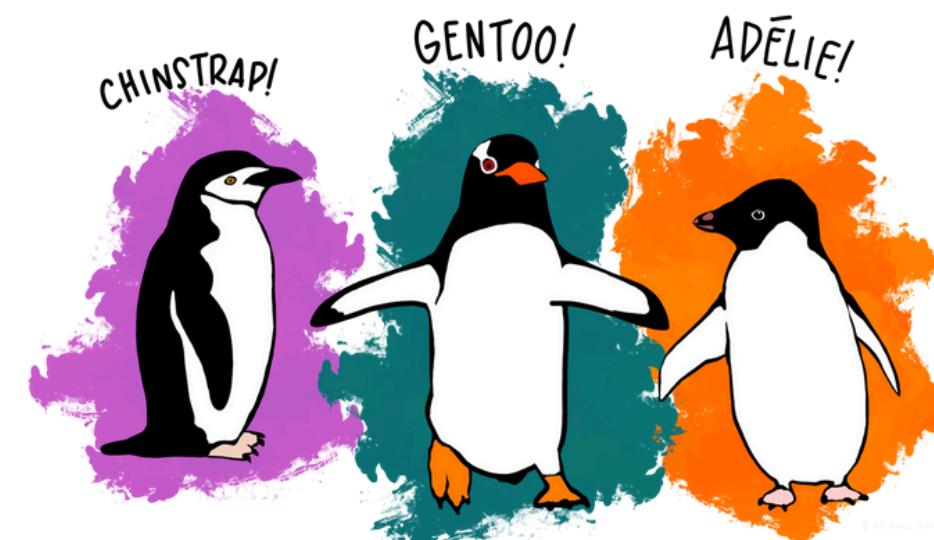
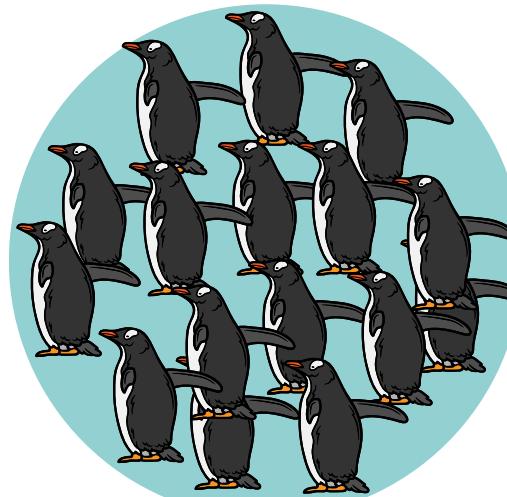
RANGE
&
IQR

VARIANCE
&
STD DEV

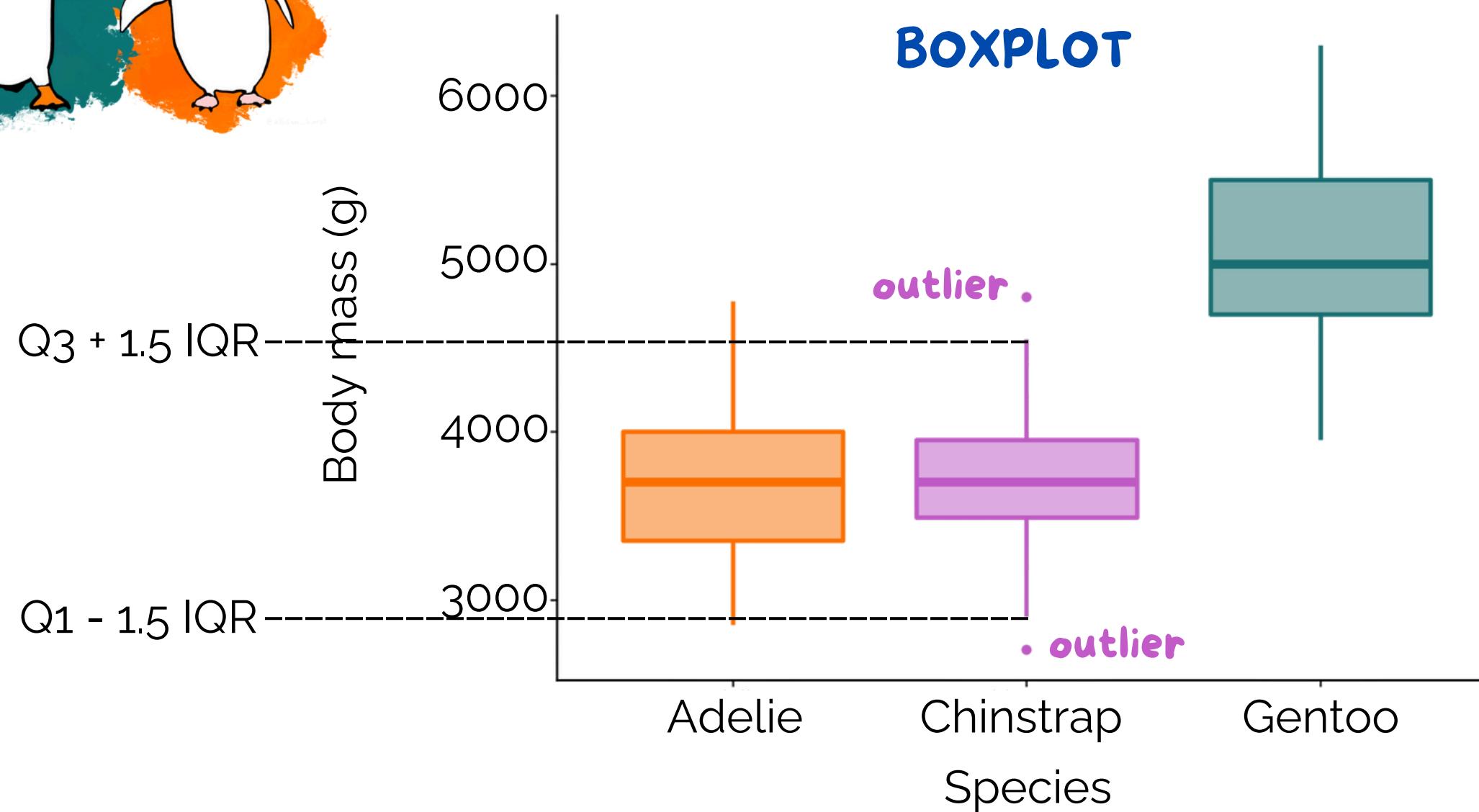


These data were collected from 2007 - 2009 by Dr. Kristen Gorman with the Palmer Station Long Term Ecological Research Program, part of the US Long Term Ecological Research Network.

ESTIMATES OF LOCATION DESCRIBING THE DISTRIBUTION



SAMPLE



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ESTIMATES OF LOCATION DESCRIBING THE DISTRIBUTION

MEAN

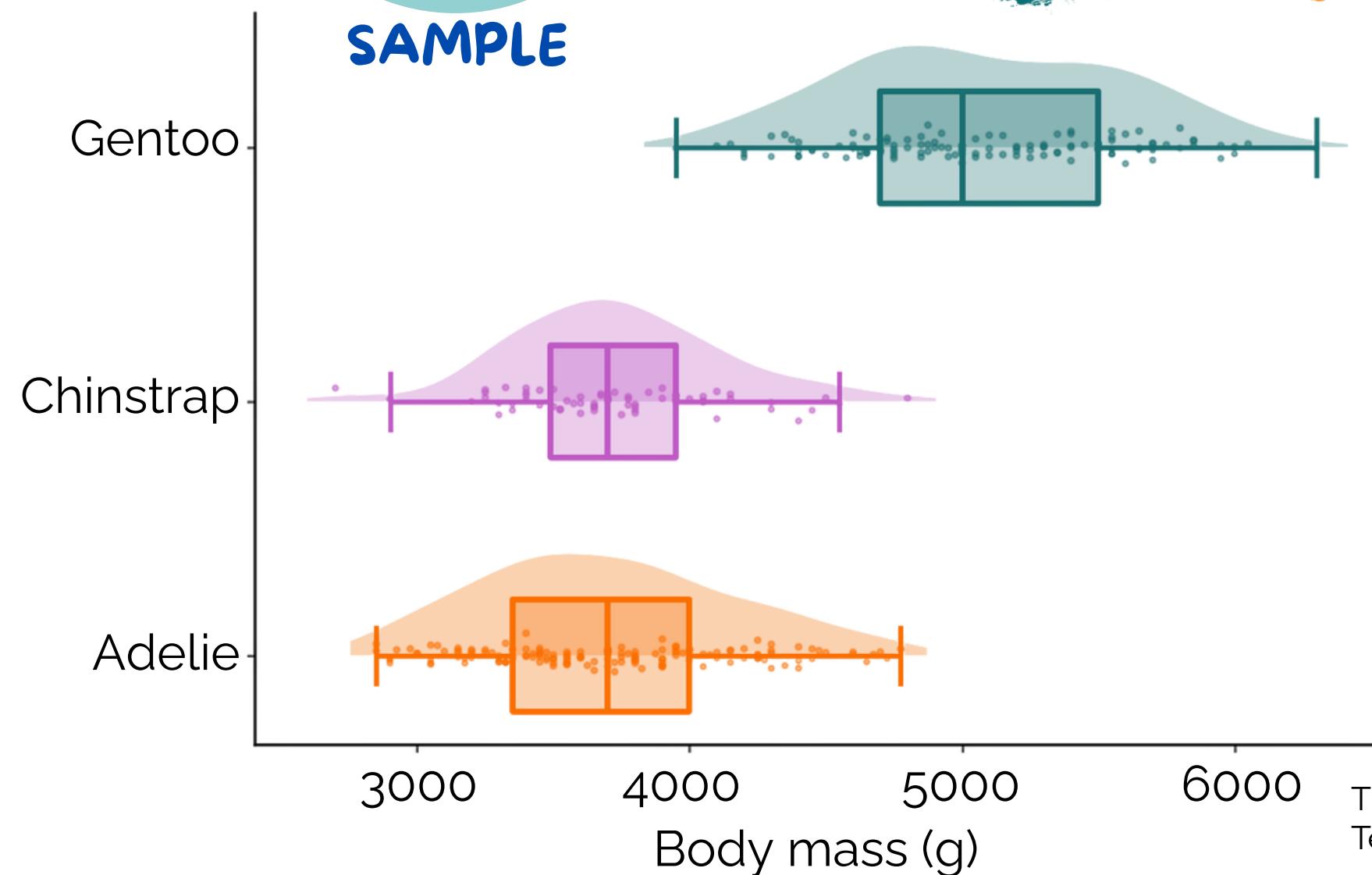
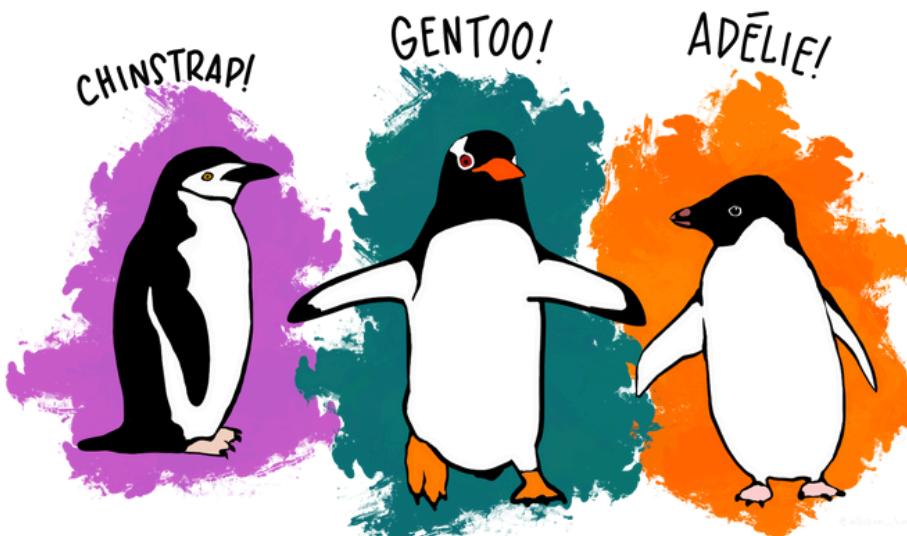
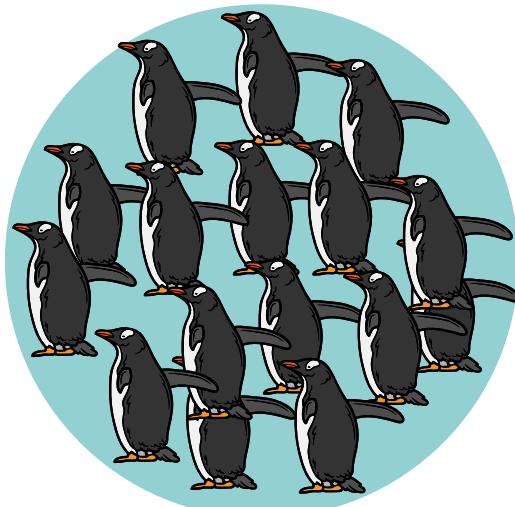
MEDIAN

MODE

QUANTILES

RANGE
&
IQR

VARIANCE
&
STD DEV



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ESTIMATES OF LOCATION DESCRIBING THE DISTRIBUTION

MEAN

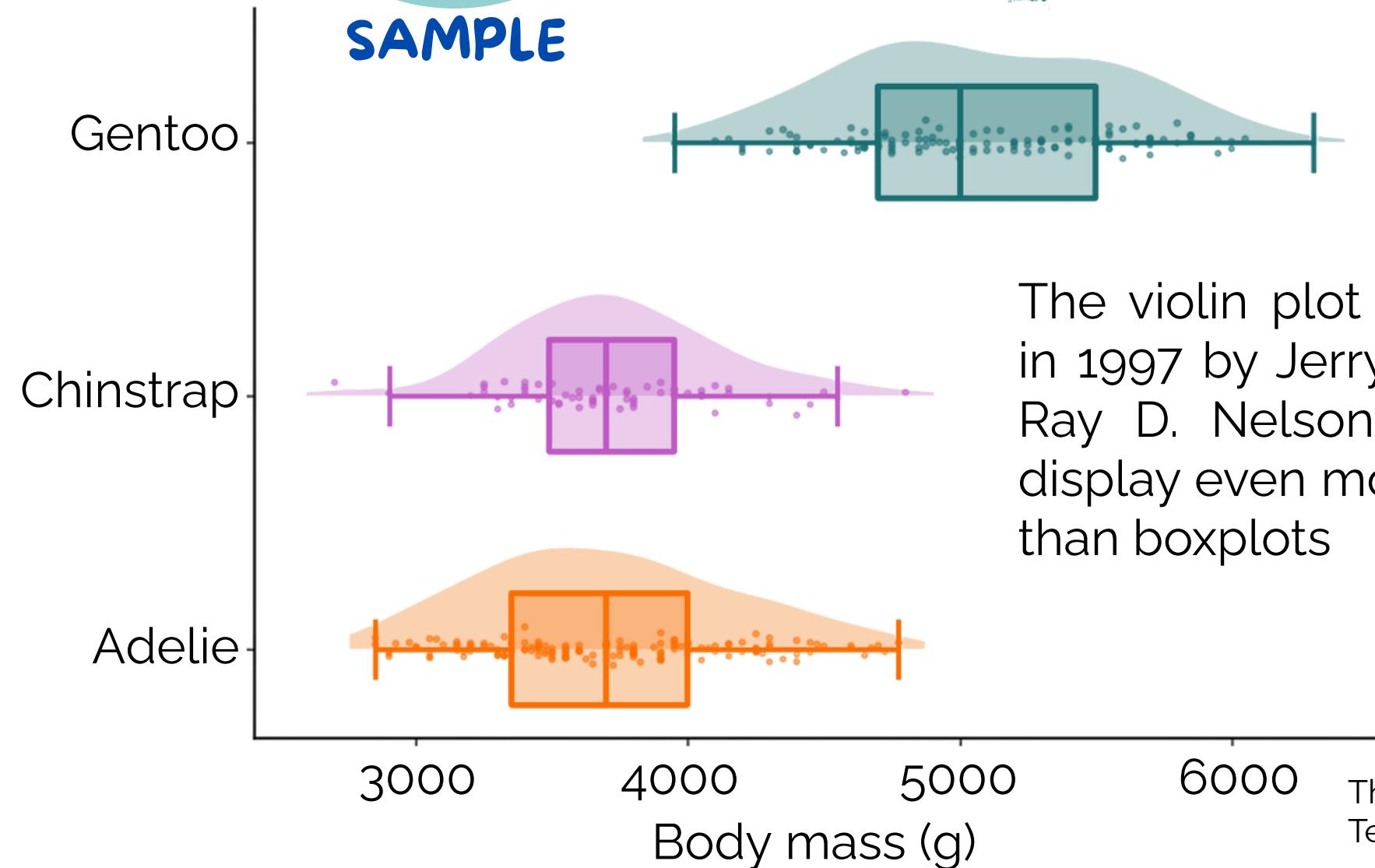
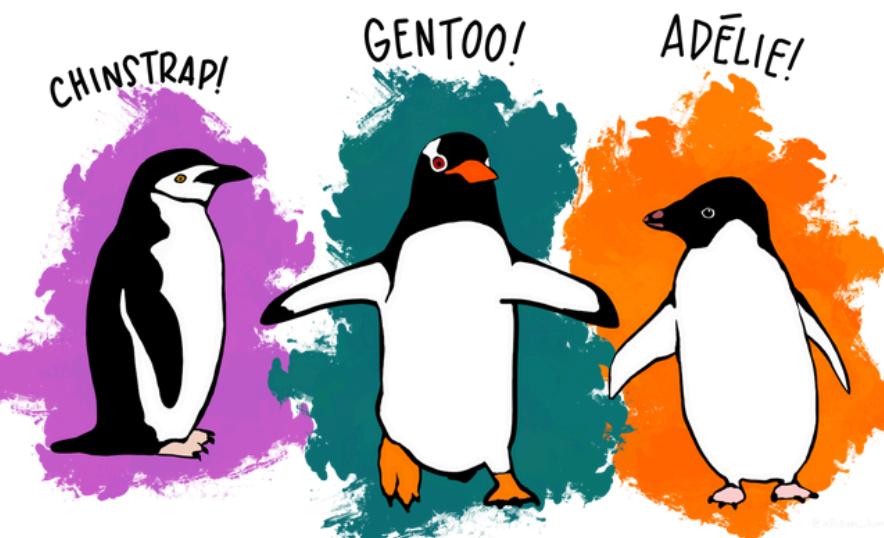
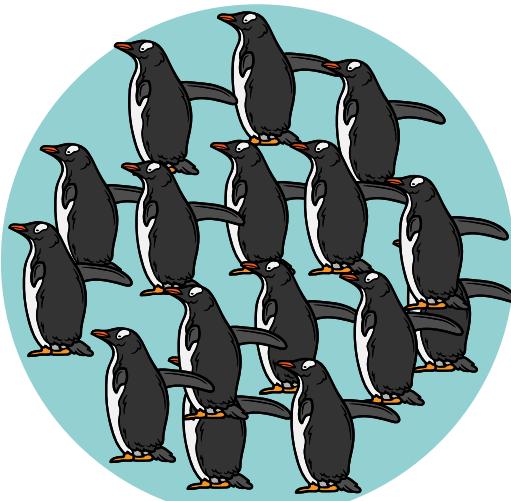
MEDIAN

MODE

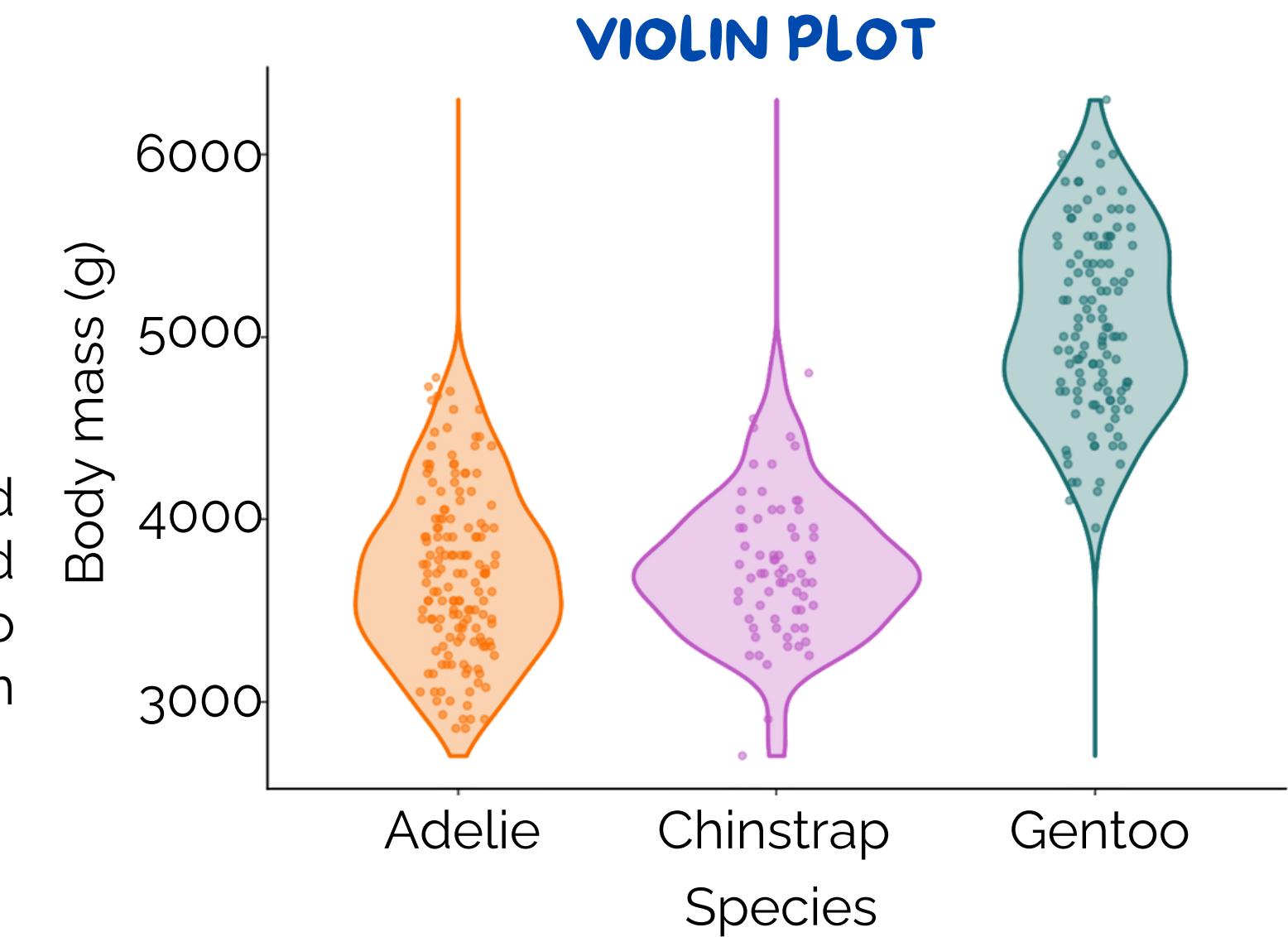
QUANTILES

RANGE
&
IQR

VARIANCE
&
STD DEV



The violin plot was proposed in 1997 by Jerry L. Hintze and Ray D. Nelson as a way to display even more information than boxplots



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ESTIMATES OF LOCATION DESCRIBING THE DISTRIBUTION

MEAN

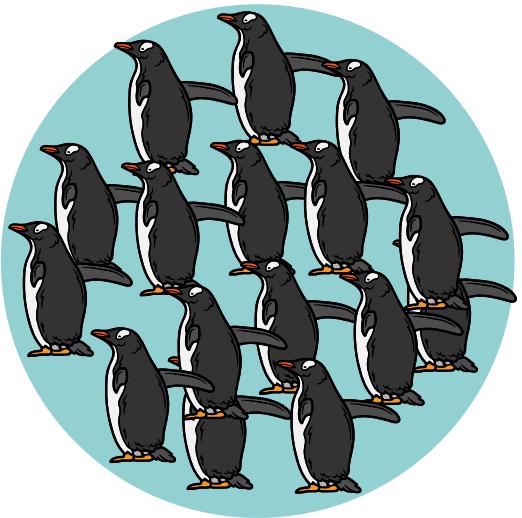
MEDIAN

MODE

QUANTILES

RANGE
&
IQR

VARIANCE
&
STD DEV



SAMPLE

$$\bar{x} = \frac{\sum_{i=1}^n x_i}{n}$$

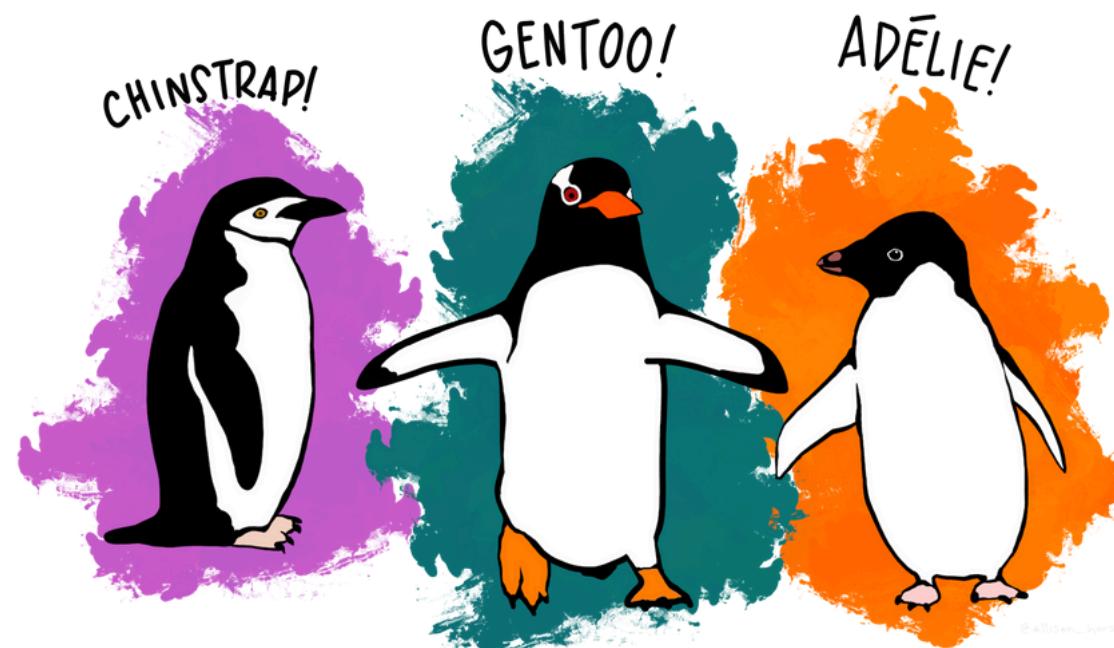
$$s^2 = \frac{\sum_{i=1}^n (x_i - \bar{x})^2}{n - 1}$$

VARIANCE

$$s = \sqrt{s^2} = \sqrt{\frac{\sum_{i=1}^n (x_i - \bar{x})^2}{n - 1}}$$

STANDARD DEVIATION

DATA VISUALIZATION



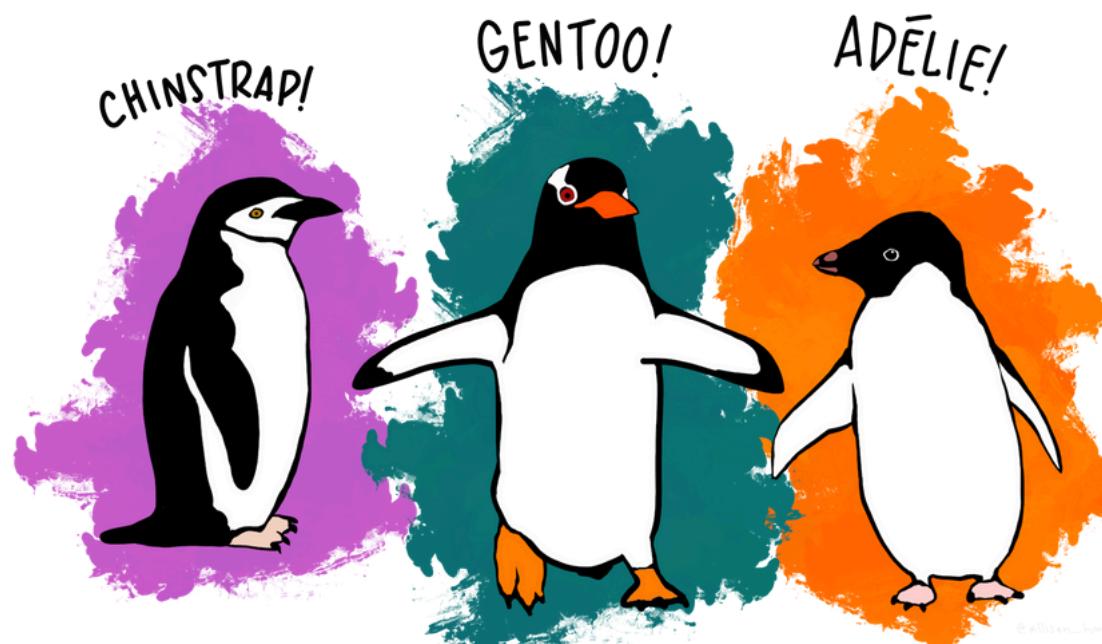
The **palmerpenguins** data contains size measurements for three penguin species observed on three islands in the Palmer Archipelago, Antarctica.

8 variables (n = 344 penguins)

Species	Penguin species (Adélie, Chinstrap, Gentoo)
Island	Island in the Palmer Archipelago where observed
Bill length (mm)	Length of the penguin's bill (mm)
Bill depth (mm)	Depth (thickness) of the penguin's bill (mm)
Flipper length (mm)	Length of the penguin's flipper (mm)
Body mass (g)	Body mass of the penguin (g)
Sex	Male or female (some values missing)
Year	Year of observation (2007–2009)

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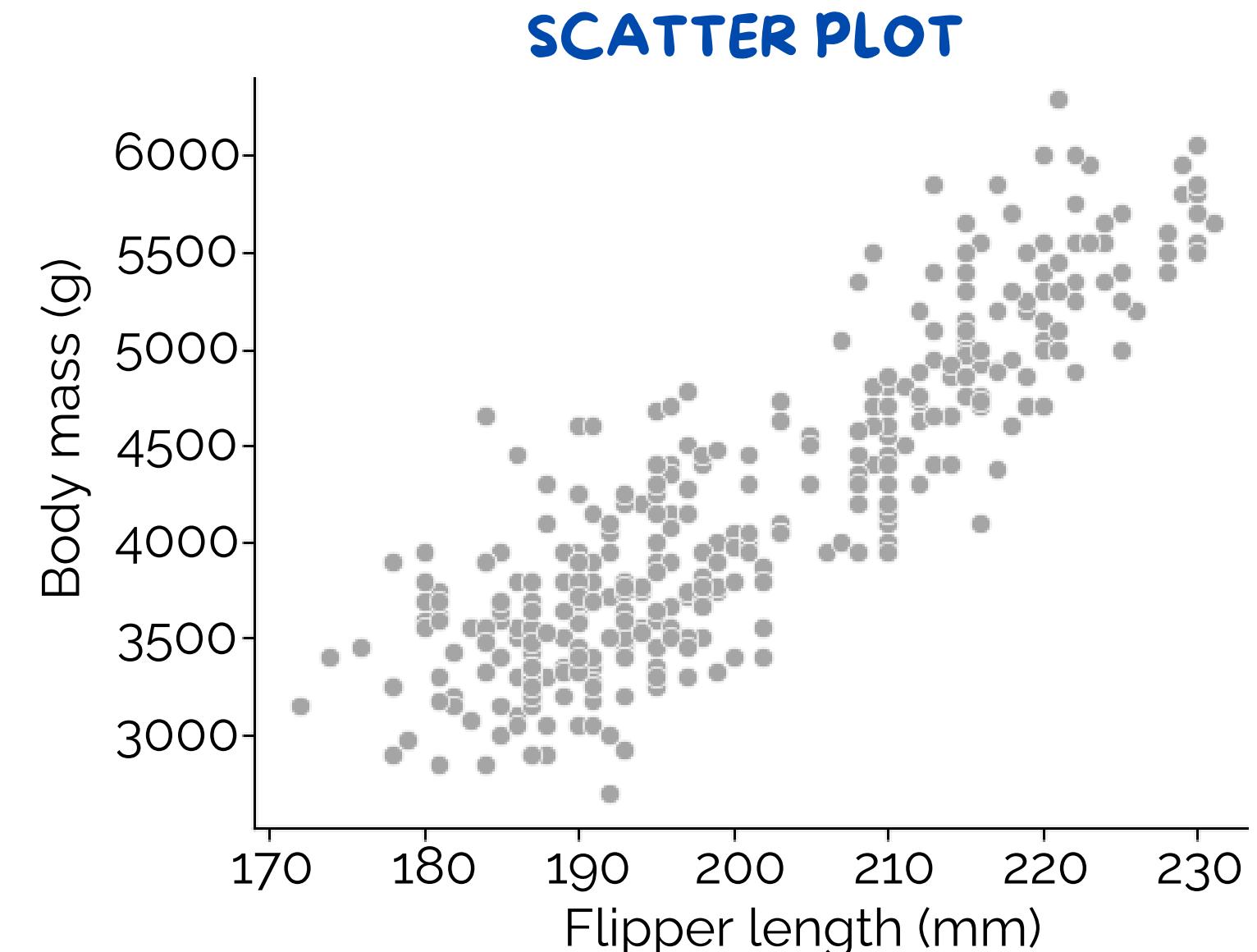
DATA VISUALIZATION



8 variables (n = 344 penguins)

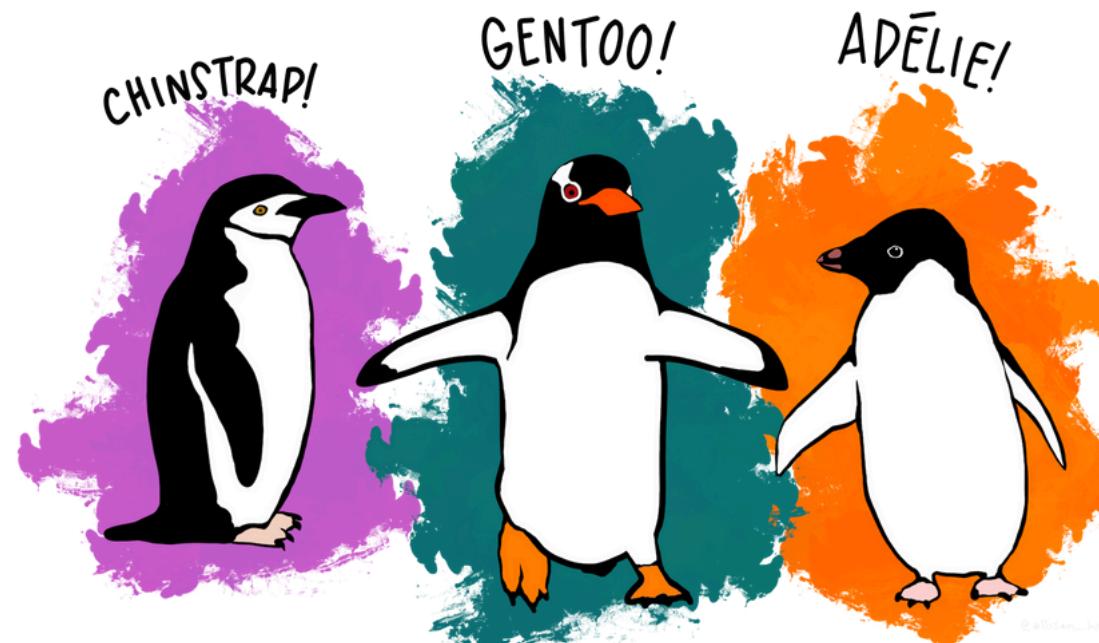
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DATA VISUALIZATION

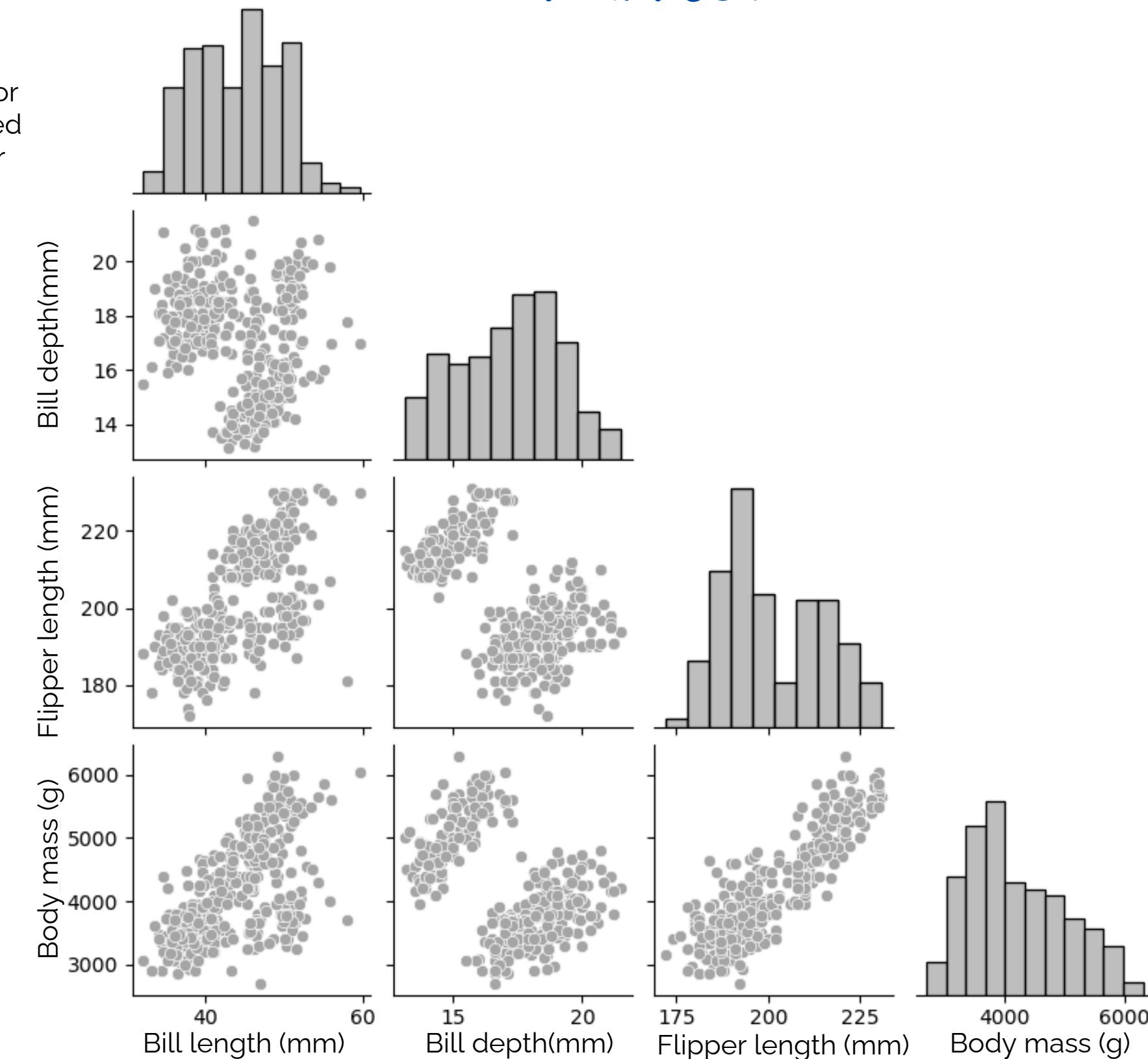


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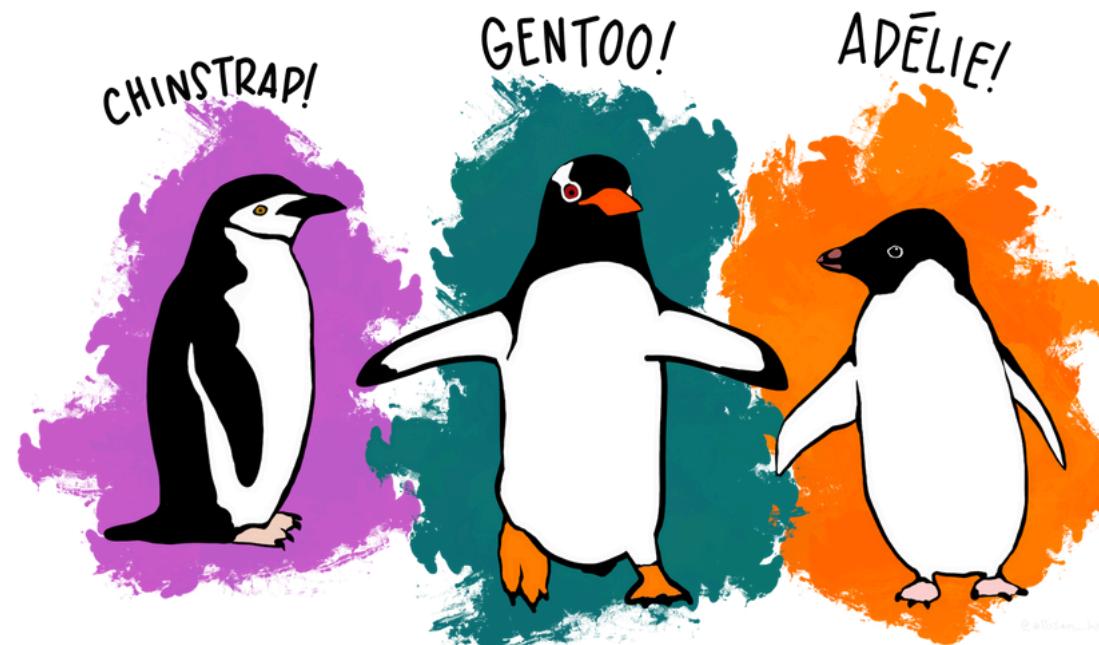
The **palmerpenguins** data contains size measurements for three penguin species observed on three islands in the Palmer Archipelago, Antarctica.

PAIRPLOT



These data were collected from 2007 - 2009 by Dr. Kristen Gorman with the Palmer Station Long Term Ecological Research Program, part of the US Long Term Ecological Research Network.

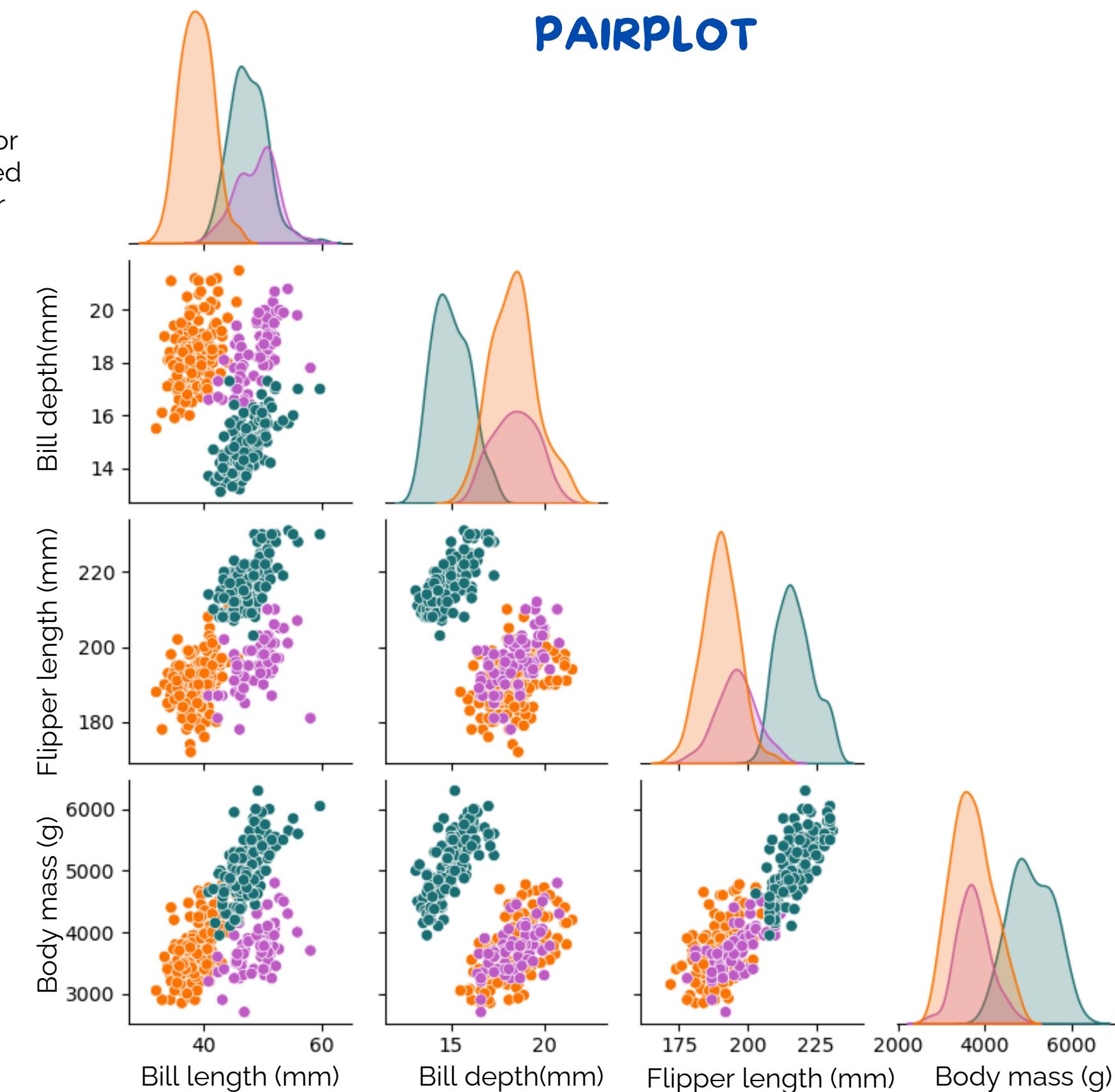
DATA VISUALIZATION



8 variables (n = 344 penguins)

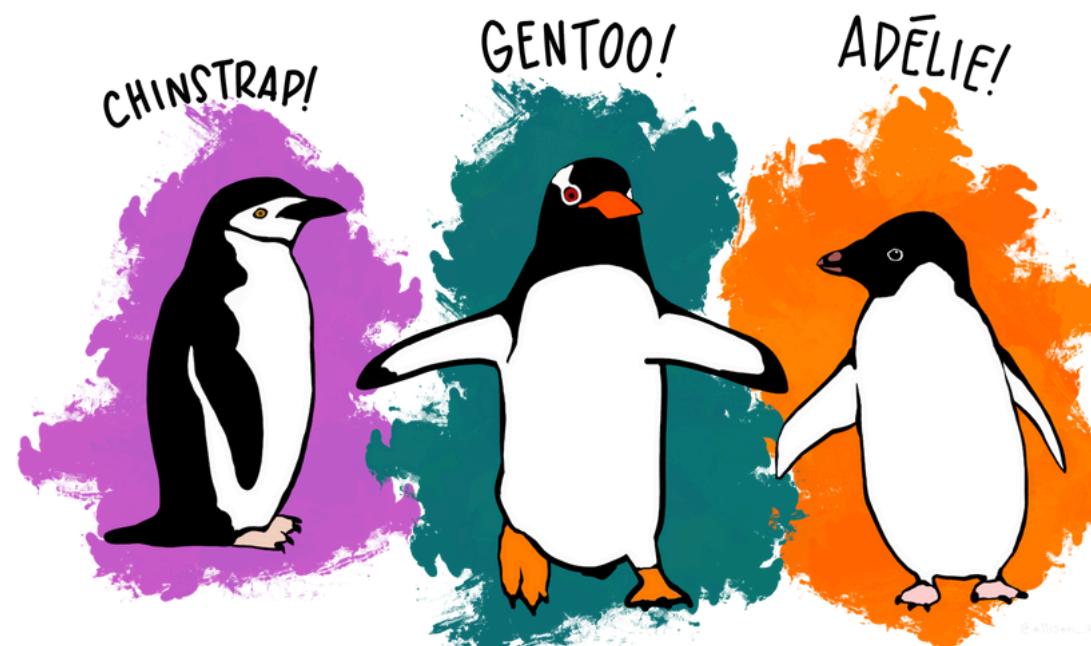
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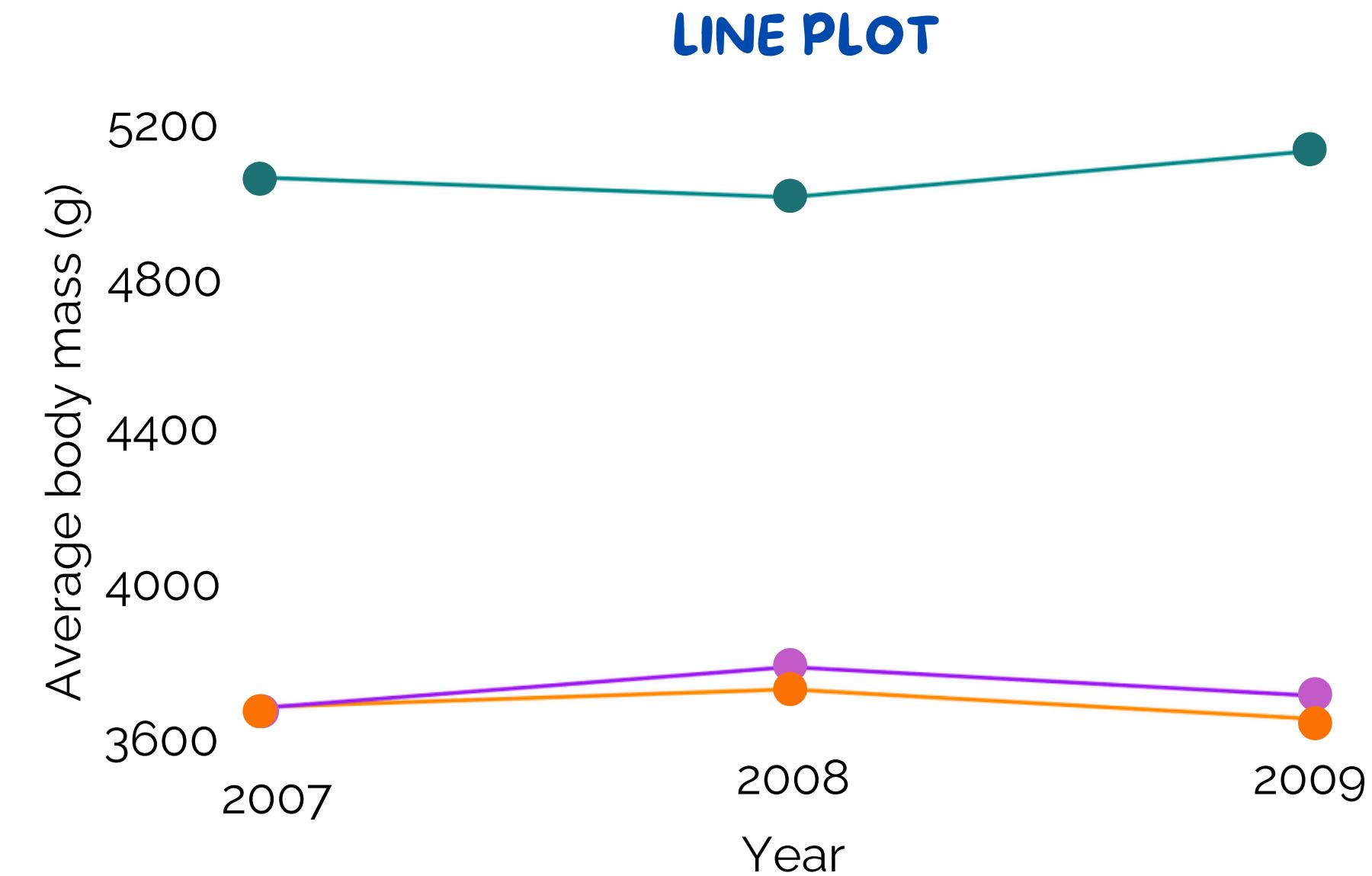
DATA VISUALIZATION



8 variables (n = 344 penguins)

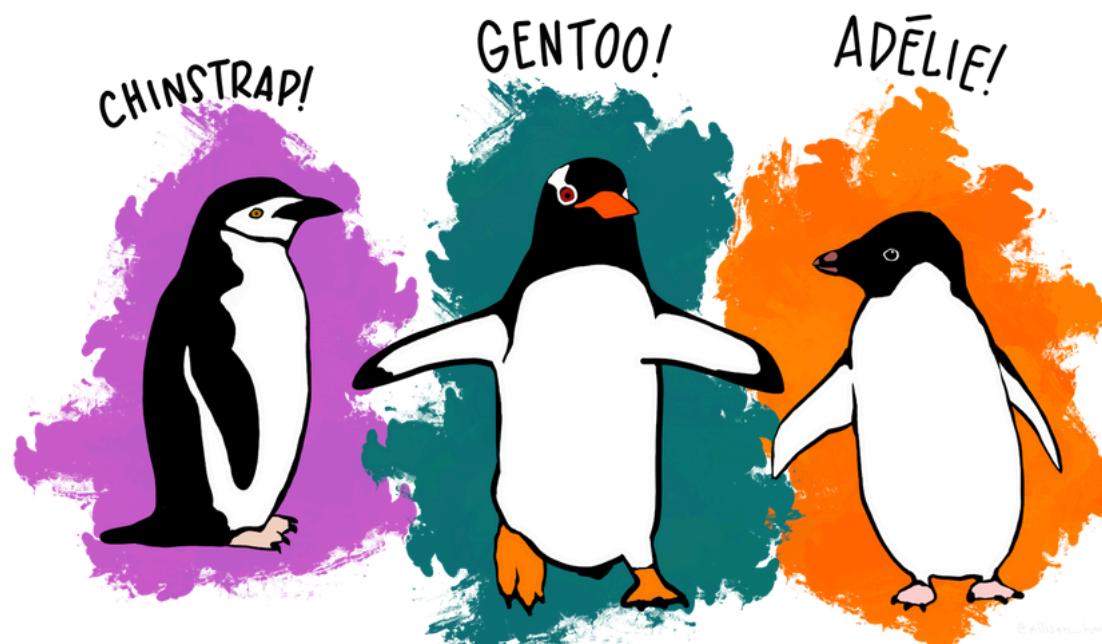
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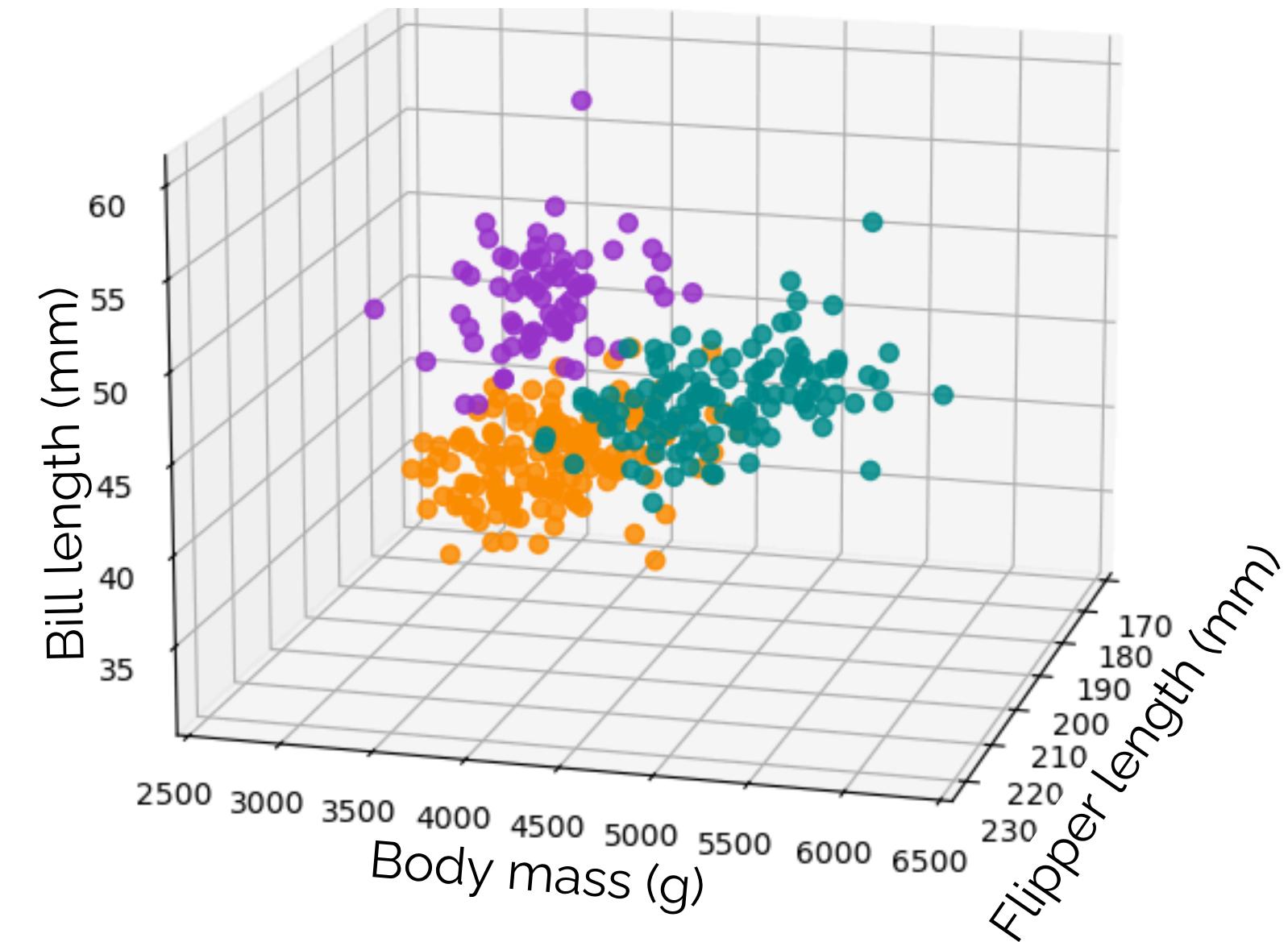
DATA VISUALIZATION



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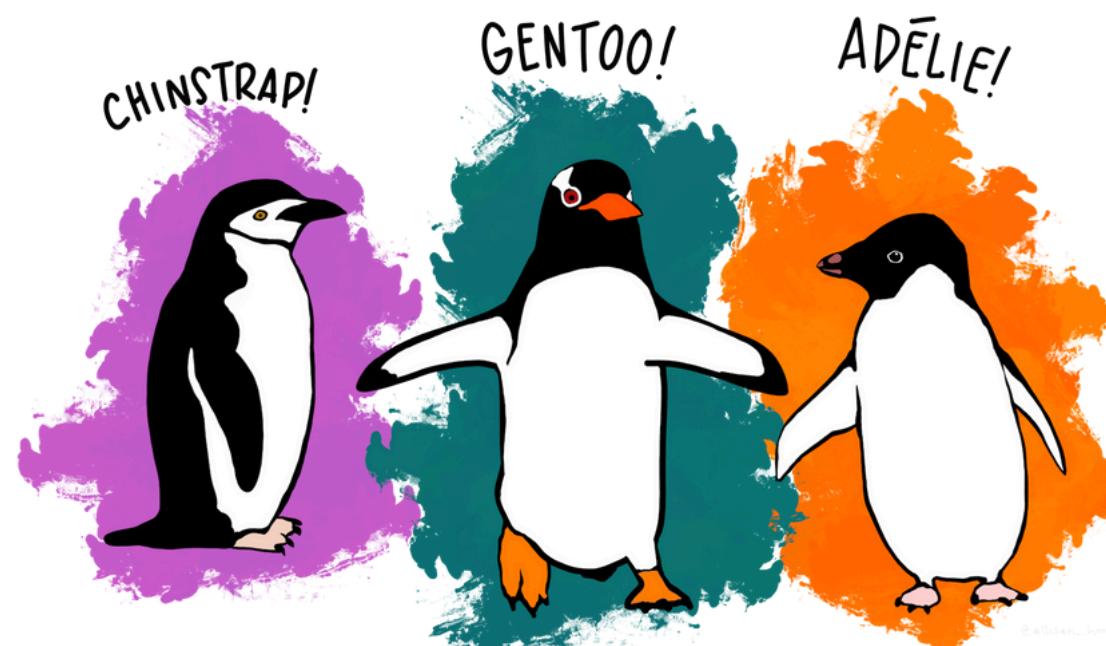
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DATA VISUALIZATION

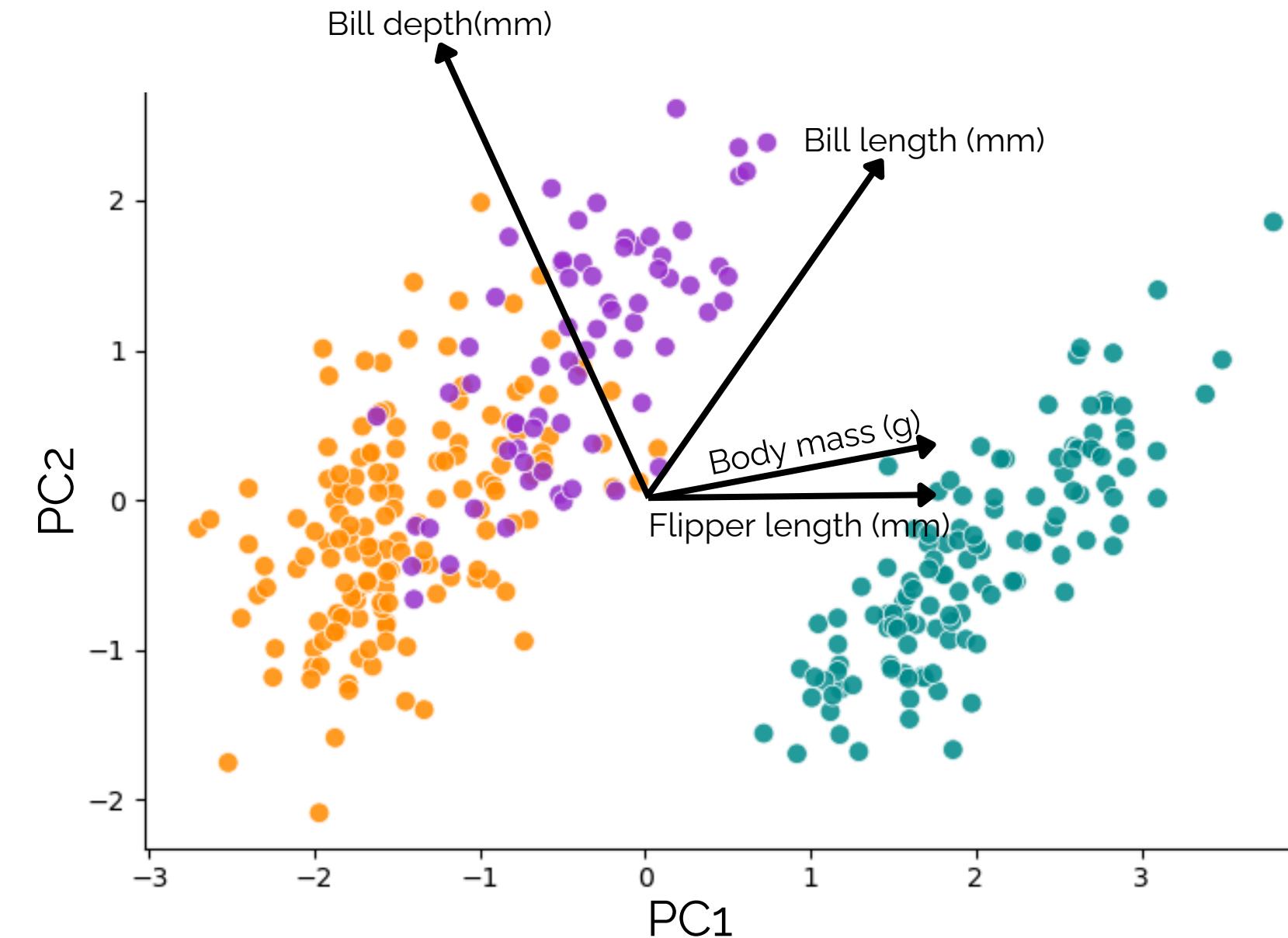


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DIMENSIONALITY REDUCTION



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