

STAT UN1201 – Chapter 1

Prof. Joyce Robbins

Waitlist

1. The waitlist moves in order as places open up.
2. Course materials are available here during change of program period:
<http://github.com/jtr13/1201>
3. It is strongly advised to keep up with the material if you are trying to get in the class.

EVERYONE: Once you've made a decision not to take the class, please be considerate and drop it from your schedule.

Very brief course outline

- Descriptive statistics (Chapter 1)
- Probability (Chapters 2 - 5)
- Inferential statistics (Chapters 6 - 9, 12 - 13)

Descriptive statistics

- numerical summaries: mean, median, etc.
- graphical summaries

Anscombe's Quartet

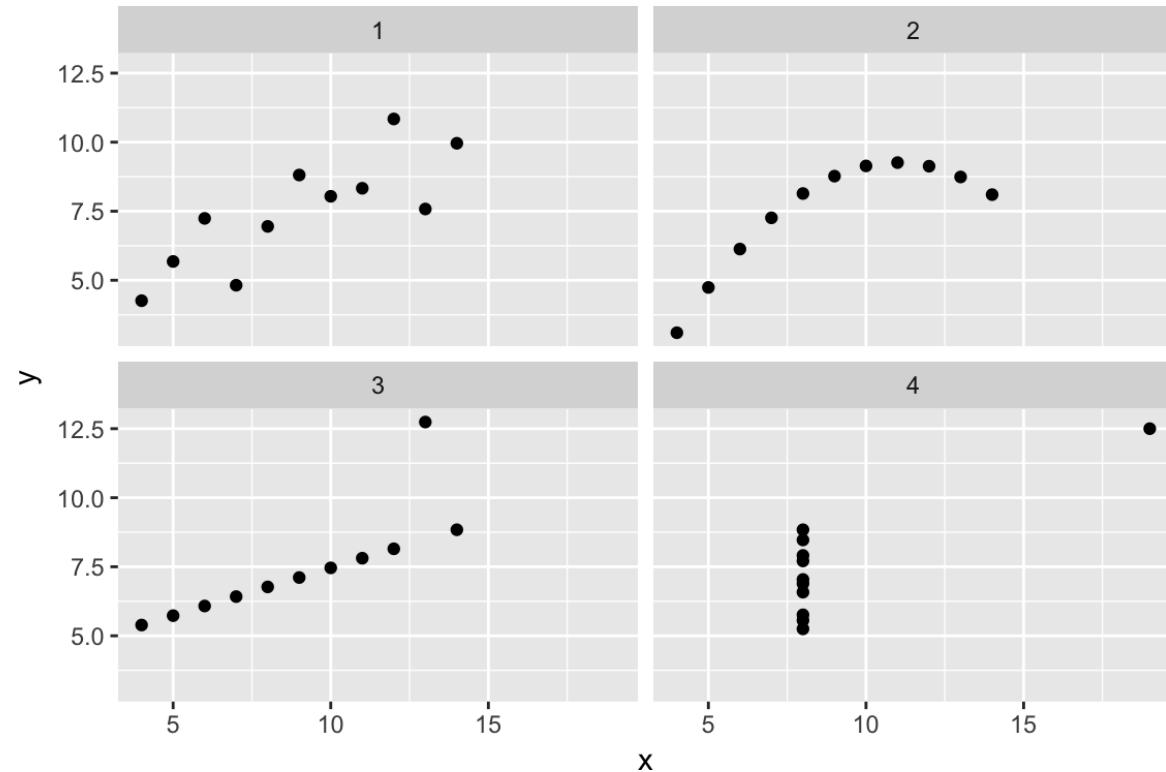
x1	x2	x3	x4	y1	y2	y3	y4
10	10	10	8	8.04	9.14	7.46	6.58
8	8	8	8	6.95	8.14	6.77	5.76
13	13	13	8	7.58	8.74	12.74	7.71
9	9	9	8	8.81	8.77	7.11	8.84
11	11	11	8	8.33	9.26	7.81	8.47
14	14	14	8	9.96	8.10	8.84	7.04
6	6	6	8	7.24	6.13	6.08	5.25
4	4	4	19	4.26	3.10	5.39	12.50
12	12	12	8	10.84	9.13	8.15	5.56
7	7	7	8	4.82	7.26	6.42	7.91
5	5	5	8	5.68	4.74	5.73	6.89

Anscombe's Quartet, numerical summaries

For each of the four data sets:

- Number of observations (n) = 11
- Mean of the x 's (\bar{x}) = 9.0
- Mean of the y 's (\bar{y}) = 7.6
- Equation of the regression line: $y = 3 + 0.5x$

Anscombe's Quartet, graphical analysis



Collecting data

The screenshot shows the CityRealty website's search interface. At the top, there are three main navigation tabs: "SEARCH NYC APARTMENTS" (highlighted in pink), "MARKET REPORTS", and "GE". Below these are three secondary tabs: "MANHATTAN" (highlighted in red), "BROOKLYN", and "QUEENS & BRONX". To the right are links for "SEARCH BY MAP" and "ADVANCED SEARCH".

The main content area is divided into four sections: "UPPER EAST SIDE", "MIDTOWN", "DOWNTOWN", and "UPPER MANHATTAN". Each section lists neighborhood names. In the "UPPER WEST SIDE" section, "Morningside Heights" is checked with a red checkmark and highlighted by a yellow oval. In the "DOWNTOWN" section, "Lincoln Center" is listed above "Morningside Heights".

At the bottom, there are several filters: "SALES" (highlighted in red and circled in yellow), "RENTALS", "PRICE RANGE: \$100K - \$50M+", "BEDROOMS" (set to "Select (1)" and circled in yellow), "TYPE" (set to "Select"), and a large teal "VIEW LISTINGS →" button (circled in yellow).

Collecting data

REFINE ALL RESULTS		SHOW ALL RESULTS				
ADDRESS	TYPE	NEIGHBORHOOD	BEDS / BATH / SIZE	PRICE	PRICE/FT ²	LISTED
395 Riverside Drive, #4E	CO-OP	Morningside Heights	1 bd / 1 ba	\$799K	-	Feb 22, 2016
390 Riverside Drive, #4G	CO-OP	Morningside Heights	1 bd / 1 ba / 800 ft ²	\$745K	\$931	Jul 19, 2016
380 Riverside Drive, #8L	CO-OP	Morningside Heights	1 bd / 1 ba / 700 ft ²	\$725K	\$1,036	Sep 06, 2016
535 West 110th Street, #6B	CO-OP	Morningside Heights	1 bd / 1 ba / 750 ft ²	\$725K	\$967	Sep 07, 2016
535 West 110th Street, #6A	CO-OP	Morningside Heights	1 bd / 1 ba / 750 ft ²	\$699K (-4% ▼)	\$933	Apr 26, 2016
395 Riverside Drive, #2D	CO-OP	Morningside Heights	1 bd / 1 ba / 900 ft ²	\$699K	\$777	Mar 03, 2016
528 West 111th Street, #24	CO-OP	Morningside Heights	1 bd / 1 ba	\$675K (-6.9% ▼)	-	Apr 15, 2015
545 West 111th Street, #9N	CO-OP	Morningside Heights	1 bd / 1 ba / 650 ft ²	\$665K (-9.5% ▼)	\$1,023	Mar 30, 2016
380 Riverside Drive, #6B	CO-OP	Morningside Heights	1 bd / 1 ba	\$599K	-	Oct 07, 2015
80 La Salle Street, #20C	CO-OP	Morningside Heights	1 bd / 1 ba	\$545K	-	May 19, 2016
609 West 114th Street, #36	CO-OP	Morningside Heights	1 bd / 1 ba / 600 ft ²	\$535K	\$892	Jun 22, 2016
80 La Salle Street, #21B	CO-OP	Morningside Heights	1 bd / 1 ba / 725 ft ²	\$535K	\$738	May 04, 2016
80 La Salle Street, #14D	CO-OP	Morningside Heights	1 bd / 1 ba	\$529K	-	Apr 14, 2016
175 Claremont Avenue, #3	CO-OP	Morningside Heights	1 bd / 1 ba	\$499K (-9.3% ▼)	-	Mar 30, 2016
3117 Broadway, #56	CO-OP	Morningside Heights	1 bd / 1 ba / 500 ft ²	\$450K	\$900	Jun 28, 2016

TURED NEW DEVELOPMENTS



510 West 123rd Street, #38	CO-OP	Morningside Heights	1 bd / 1 ba / 700 ft ²	\$450K	\$643	Jul 02, 2016
3115 Broadway, #43	CO-OP	Morningside Heights	1 bd / 1 ba / 650 ft ²	\$425K	\$654	Apr 18, 2016
3115 Broadway, #42	CO-OP	Morningside Heights	1 bd / 1 ba / 650 ft ²	\$379K (-5% ▼)	\$583	Mar 28, 2016

Cleaning / organizing data

	A	B	C	D	E	F	G	H
1		ADDRESS	TYPE	NEIGHBORHOOD	BEDS / BATH	PRICE	PRICE/FT2	LISTED
2	+							
3	3115 Broadway	CO-OP						
4	Morningside	1 bd / 1 ba /	\$379K		\$583	28-Mar-16		
5	+							
6	3115 Broadway	CO-OP						
7	Morningside	1 bd / 1 ba /	\$425K		\$654	18-Apr-16		
8	+							
9	510 West 12	CO-OP						
10	Morningside	1 bd / 1 ba /	\$450K		\$643	2-Jul-16		
11	+							
12	3117 Broadway	CO-OP						
13	Morningside	1 bd / 1 ba /	\$450K		\$900	28-Jun-16		
14	+							
15	175 Claremont	CO-OP						
16	Morningside	1 bd / 1 ba	\$499K	-		30-Mar-16		
17	+							
18	80 La Salle St	CO-OP						
19	Morningside	1 bd / 1 ba	\$529K	-		14-Apr-16		

Cleaning / organizing data

	A	B	C	D
1	Address		Price	IntPrice
2	3115 Broadway, #42	1 bd / 1 ba / 650 ft2	\$379K	379
3	3115 Broadway, #43	1 bd / 1 ba / 650 ft2	\$425K	425
4	3117 Broadway, #56	1 bd / 1 ba / 500 ft2	\$450K	450
5	510 West 123rd Street, #38	1 bd / 1 ba / 700 ft2	\$450K	450
6	175 Claremont Avenue, #3	1 bd / 1 ba	\$499K	499
7	80 La Salle Street, #14D	1 bd / 1 ba	\$529K	529
8	609 West 114th Street, #36	1 bd / 1 ba / 600 ft2	\$535K	535
9	80 La Salle Street, #21B	1 bd / 1 ba / 725 ft2	\$535K	535
10	80 La Salle Street, #20C	1 bd / 1 ba	\$545K	545
11	380 Riverside Drive, #6B	1 bd / 1 ba	\$599K	599
12	545 West 111th Street, #9N	1 bd / 1 ba / 650 ft2	\$665K	665
13	528 West 111th Street, #24	1 bd / 1 ba	\$675K	675
14	535 West 110th Street, #6A	1 bd / 1 ba / 750 ft2	\$699K	699
15	395 Riverside Drive, #2D	1 bd / 1 ba / 900 ft2	\$699K	699
16	380 Riverside Drive, #8L	1 bd / 1 ba / 700 ft2	\$725K	725
17	535 West 110th Street, #6B	1 bd / 1 ba / 750 ft2	\$725K	725
18	390 Riverside Drive, #4G	1 bd / 1 ba / 800 ft2	\$745K	745
19	395 Riverside Drive, #4E	1 bd / 1 ba	\$799K	799
20				
21				

Types of data

- Quantitative
 - Discrete âfinite or can be listed in an infinite sequenceâ
 - Continuous âentire continuum of possible valuesâ
- Qualitative (categorical)

Visualizing one-dimensional continuous data

- stem-and-leaf plot
- histogram
 - frequency
 - relative frequency
 - density
- boxplot

Stem-and-leaf plot

Prices:

```
## [1] 379 425 450 450 499 529 535 535 545 599 665  
## [12] 675 699 699 725 725 745 799
```

Prices, rounded to 2 significant digits:

```
## [1] 380 430 450 450 500 530 540 540 550 600 670  
## [12] 680 700 700 730 730 750 800
```

Stem-and-leaf plot

Prices:

```
## [1] 379 425 450 450 499 529 535 535 545 599 665  
## [12] 675 699 699 725 725 745 799
```

Prices, rounded to 2 significant digits:

```
## [1] 380 430 450 450 500 530 540 540 550 600 670  
## [12] 680 700 700 730 730 750 800
```

```
##  
##      The decimal point is 2 digit(s) to the right of the |  
##  
##      3 | 8  
##      4 | 355  
##      5 | 03445  
##      6 | 078  
##      7 | 00335  
##      8 | 0
```

Stem and leaf plot

Total Fertility Rate (average births per woman)

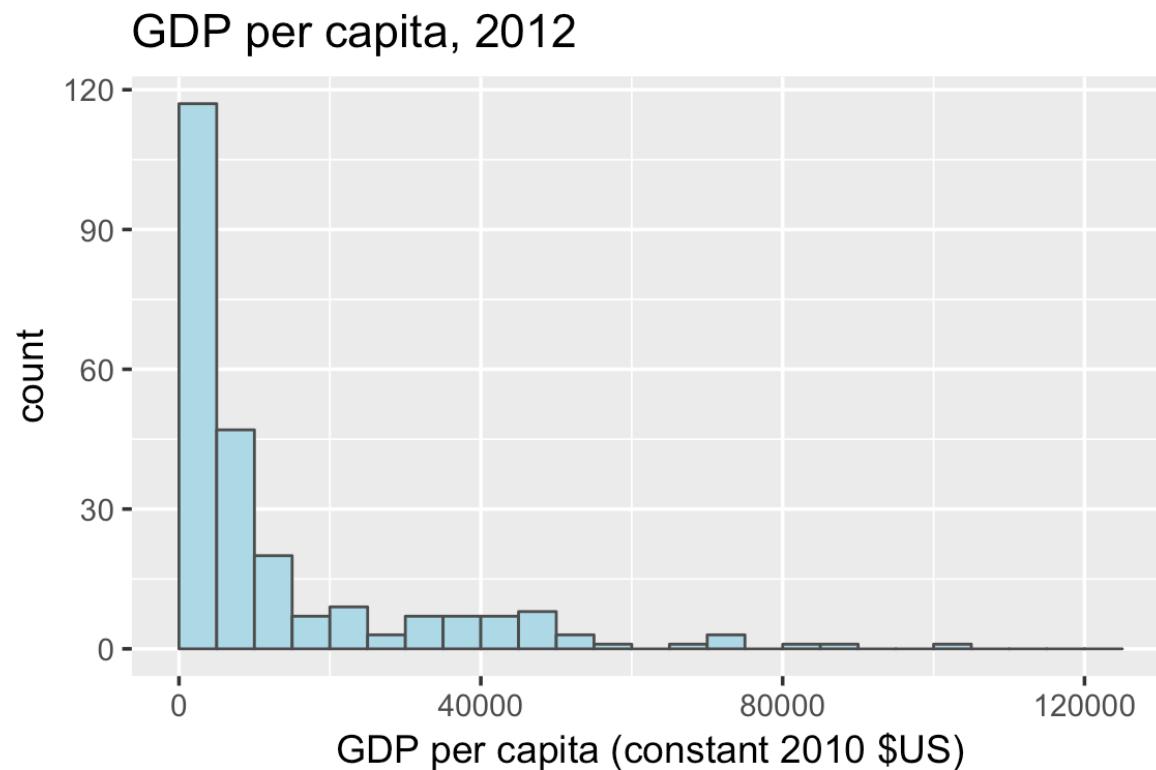
```
##  
## The decimal point is at the |  
##  
## 1 | 33333333444455555555566666667777888888889999999999  
## 2 | 000000011122223333334444445555555666666679999  
## 3 | 0111223333344567889  
## 4 | 0011112245555667779999  
## 5 | 0001222333355788  
## 6 | 012344  
## 7 | 6
```

Stem and leaf plot, change the length (scale)

Total Fertility Rate

```
##  
## The decimal point is at the |  
##  
## 1 | 33333333344444  
## 1 | 555555555555666666677777888888889999999999  
## 2 | 00000001112222333333444444  
## 2 | 55555556666666679999  
## 3 | 01112233333344  
## 3 | 567889  
## 4 | 001111224  
## 4 | 5555667779999  
## 5 | 00012223333  
## 5 | 55788  
## 6 | 012344  
## 6 |  
## 7 |  
## 7 | 6
```

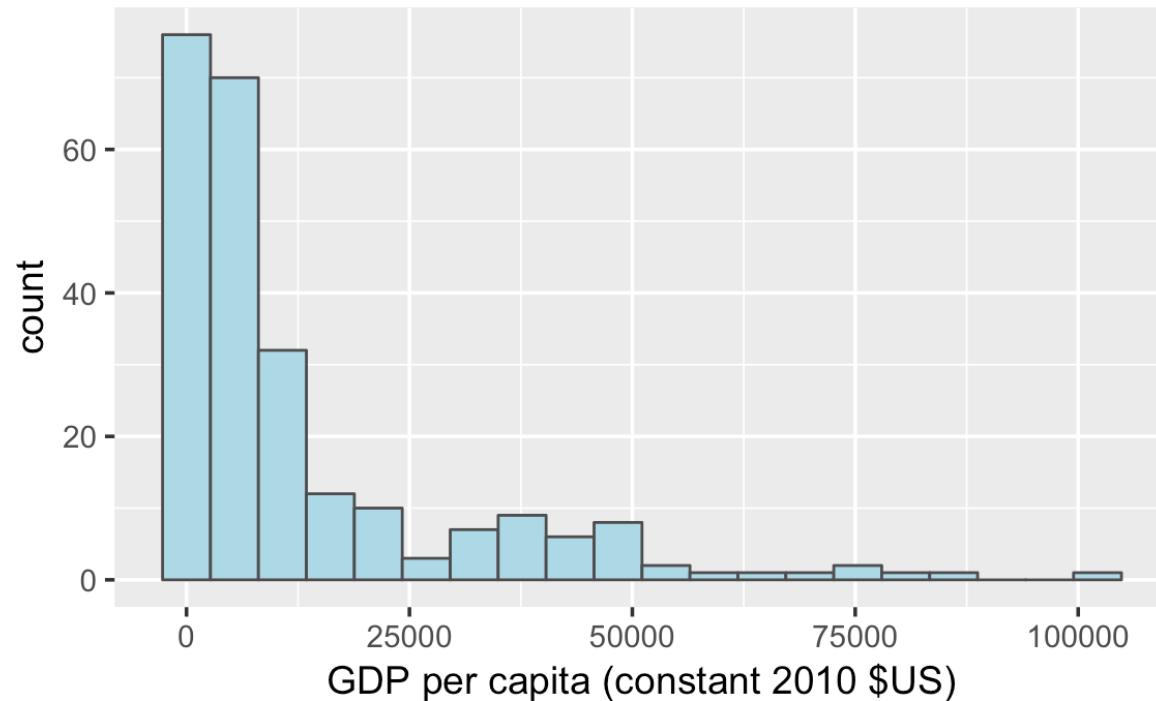
Frequency histogram



Source: World Bank

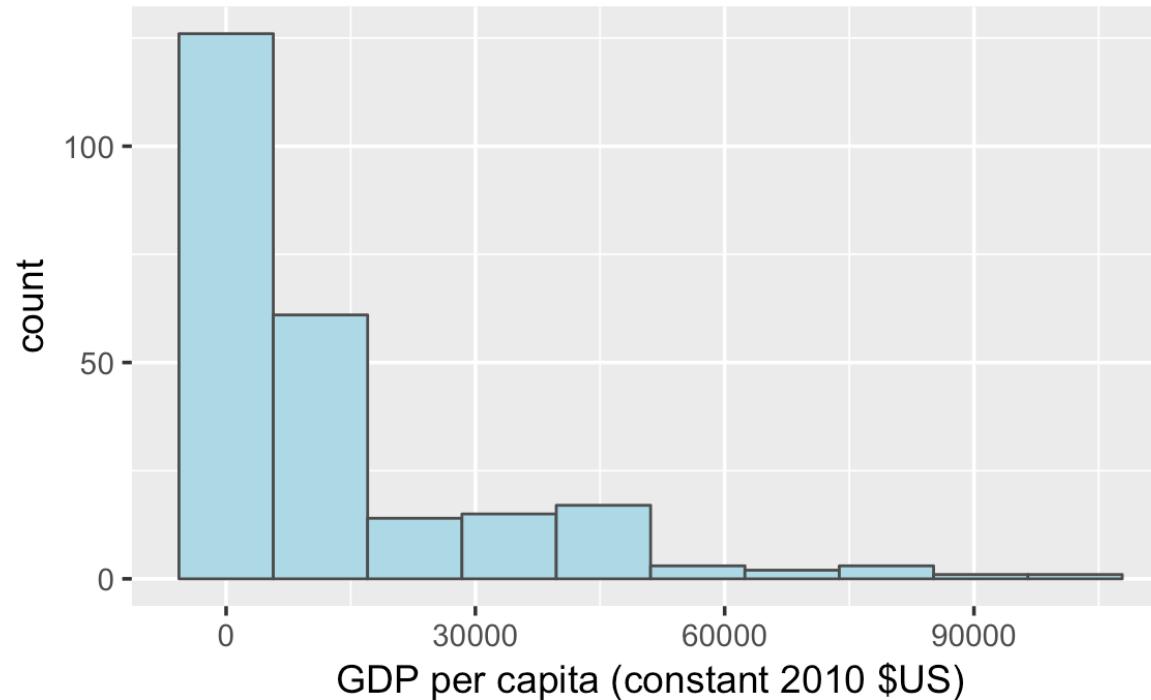
Change number of bins to 20

GDP per capita, 2012



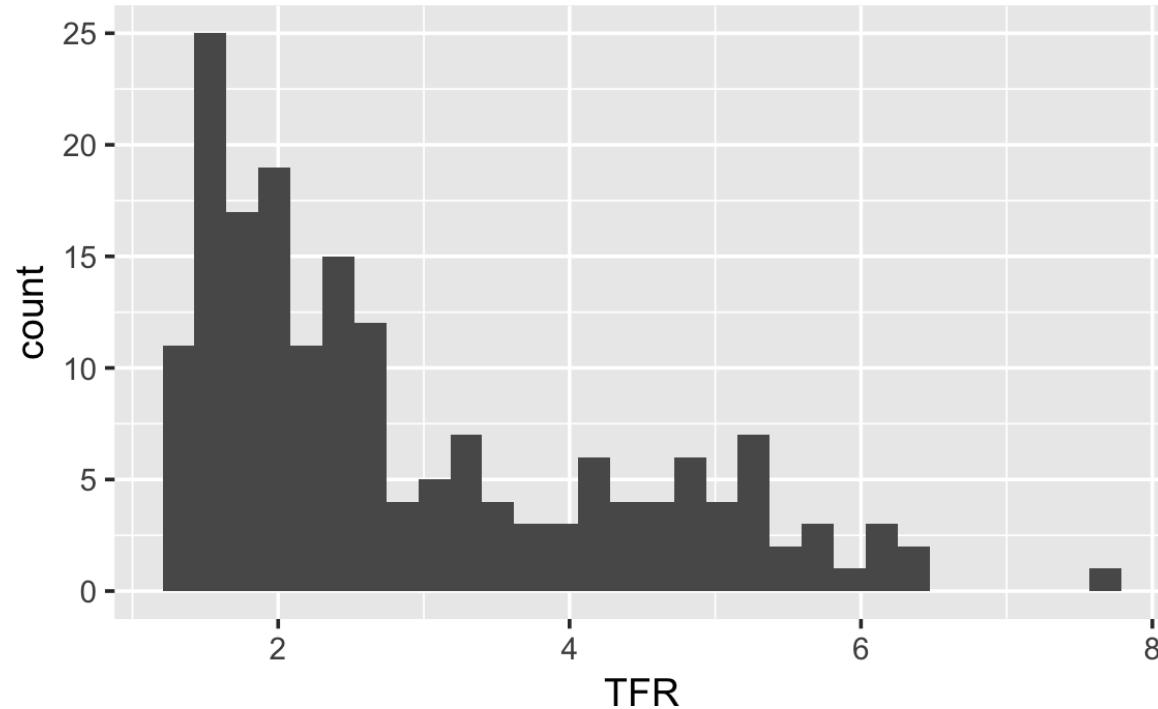
Change number of bins to 10

GDP per capita, 2012

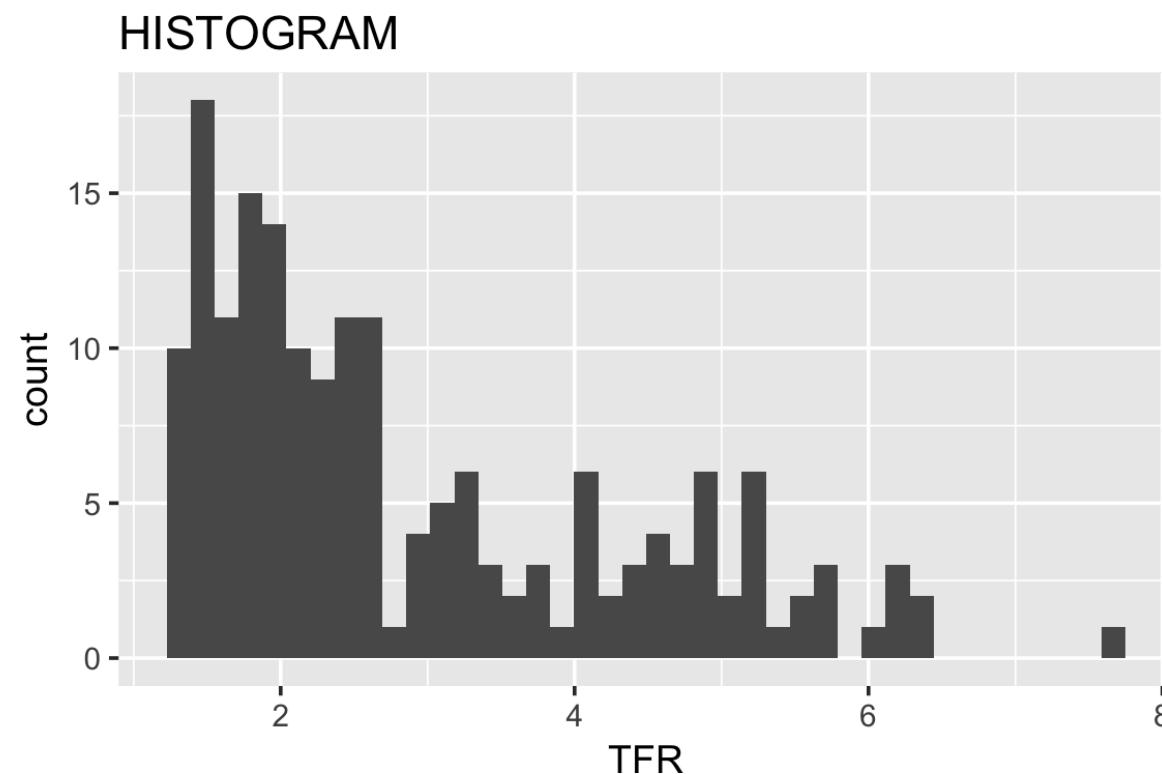


Total fertility rate

HISTOGRAM



Change the number of bins to 40



Shapes of histograms

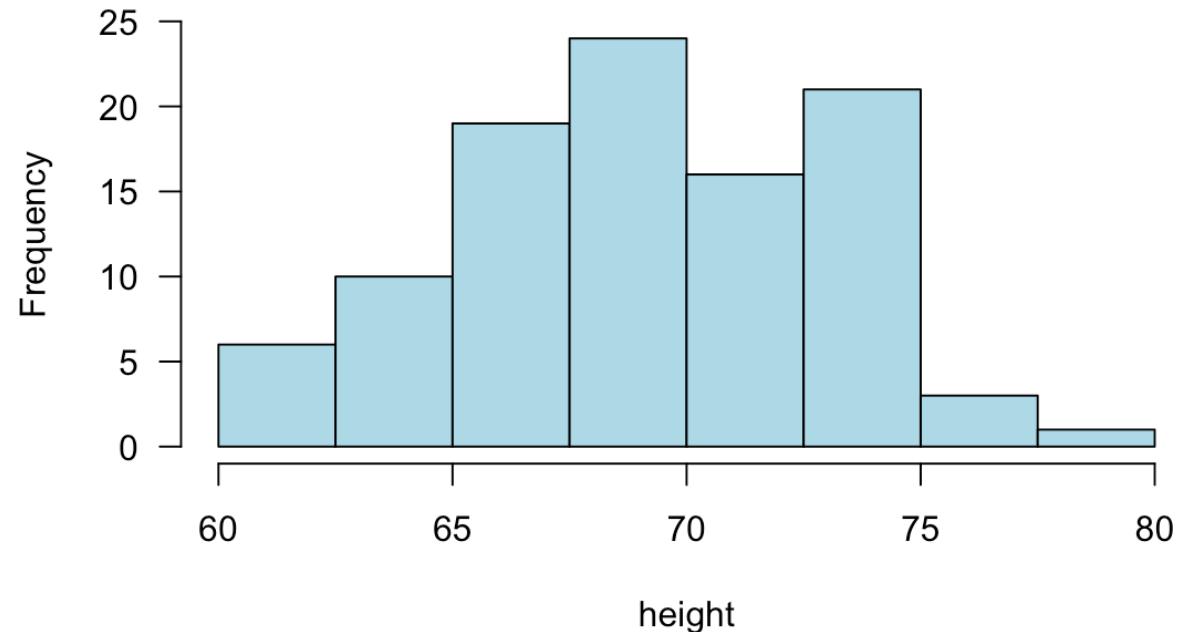
- Unimodal
- Bimodal
- Skewed left
- Skewed right

Discrete data

```
## [1] "Heights of 100 college students, in inches"  
  
## [1] 60 60 61 61 61 62 63 63 64 64 64 64 65 65 65  
## [16] 65 66 66 66 66 66 67 67 67 67 67 67 67 67 67  
## [31] 67 67 67 67 67 68 68 68 68 68 68 68 69 69 69  
## [46] 69 69 69 69 69 69 70 70 70 70 70 70 70 70 71  
## [61] 71 71 71 71 71 72 72 72 72 72 72 72 72 72 72  
## [76] 73 73 73 74 74 74 74 74 74 74 74 74 74 74 74  
## [91] 74 75 75 75 75 75 76 76 77 79
```

Discrete data

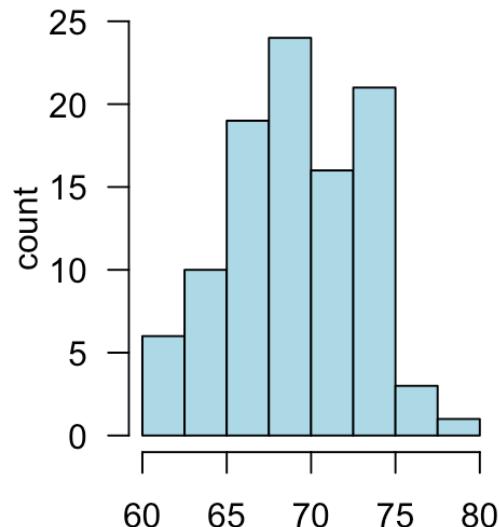
Heights of 100 college students, in inches



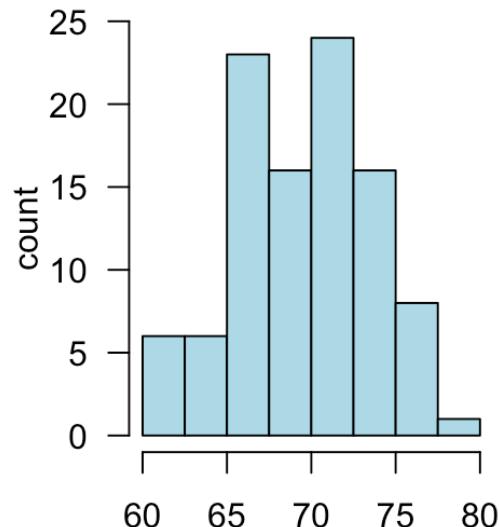
```
## [1] 60 60 60 61 61 61 62 63 63 64 64 64 64 64 65 65 65  
## [16] 65 66 66 66 66 66 66 67 67 67 67 67 67 67 67 67 67  
## [31] 67 67 67 67 67 67 68 68 68 68 68 68 68 68 69 69 69  
## [46] 69 69 69 69 69 69 70 70 70 70 70 70 70 70 70 70 71  
## [61] 71 71 71 71 71 72 72 72 72 72 72 72 72 72 72 72 72  
## [76] 73 73 73 74 74 74 74 74 74 74 74 74 74 74 74 74 74  
## [91] 74 75 75 75 75 75 76 76 77 79
```

Discrete data histogram

Histogram of height



Histogram of height



RIGHT CLOSED, LEFT OPEN

RIGHT OPEN, LEFT CLOSED

```
## [1] 60 60 61 61 61 61 62 63 63 64 64 64 64 65 65 65  
## [16] 65 66 66 66 66 66 66 66 67 67 67 67 67 67 67 67  
## [31] 67 67 67 67 67 67 68 68 68 68 68 68 68 68 69 69 69  
## [46] 69 69 69 69 69 69 70 70 70 70 70 70 70 70 70 70 71  
## [61] 71 71 71 71 71 71 72 72 72 72 72 72 72 72 72 72 72  
## [76] 73 73 73 74 74 74 74 74 74 74 74 74 74 74 74 74 74  
## [91] 74 75 75 75 75 75 76 76 77 79
```

EXERCISE

Draw a histogram of the asking prices for one-bedroom apartments in Morningside Heights (prices in thousands of \$)

Data source: cityrealty.com, 9/13/2016

379, 425, 450, 450, 499, 529, 535, 535, 545,
599, 665, 675, 699, 699, 725, 725, 745, 799

Drawing histograms

Asking prices for one-bedroom apartments in Morningside Heights, in thousands

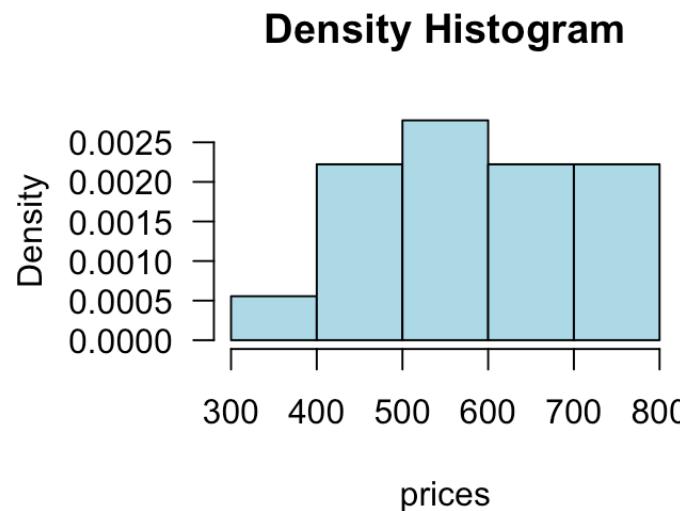
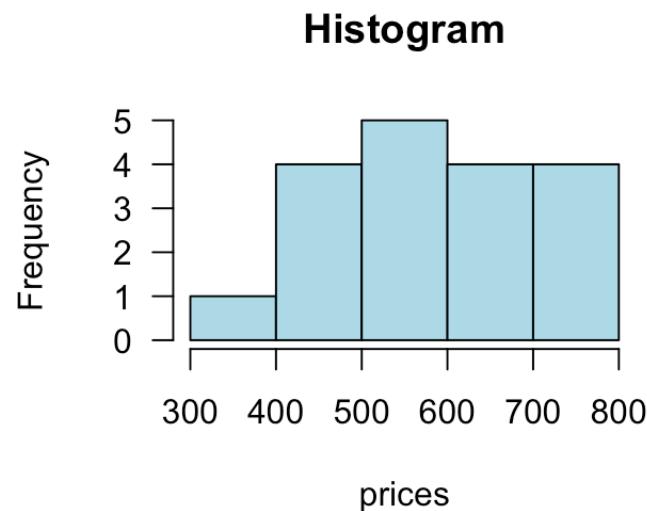
Data source: cityrealty.com, 9/13/2016

379, 425, 450, 450, 499, 529, 535, 535, 545,
599, 665, 675, 699, 699, 725, 725, 745, 799

Histogram of Morningside Heights One-Bedroom Apt. Prices



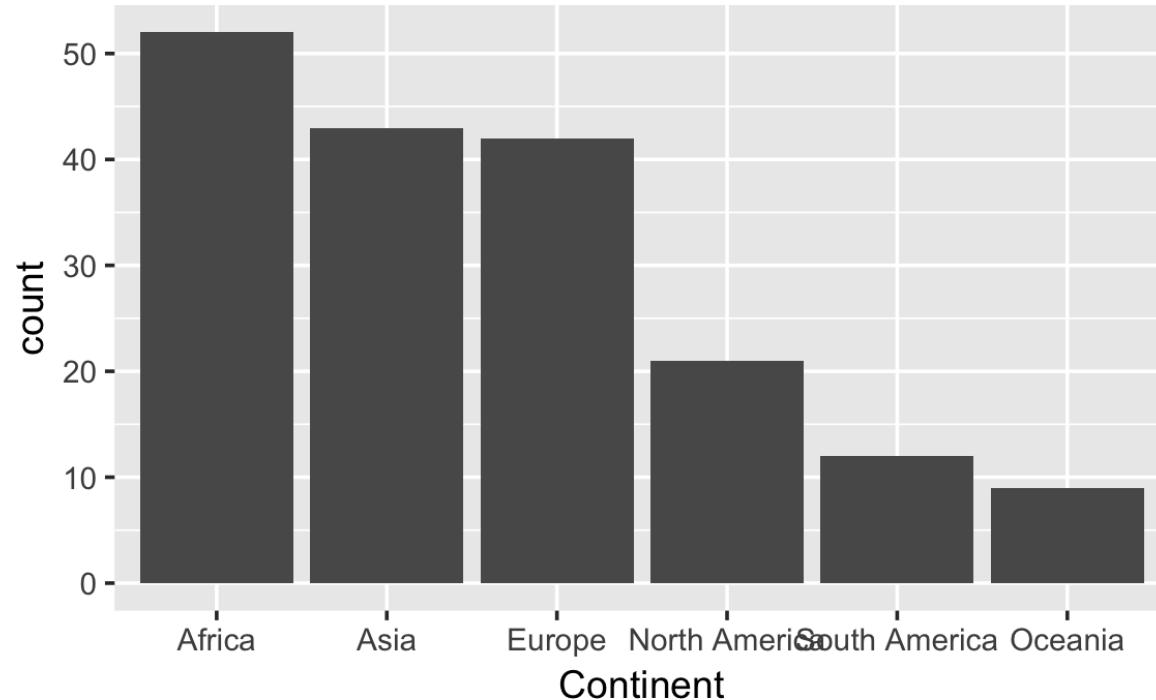
Density histogram



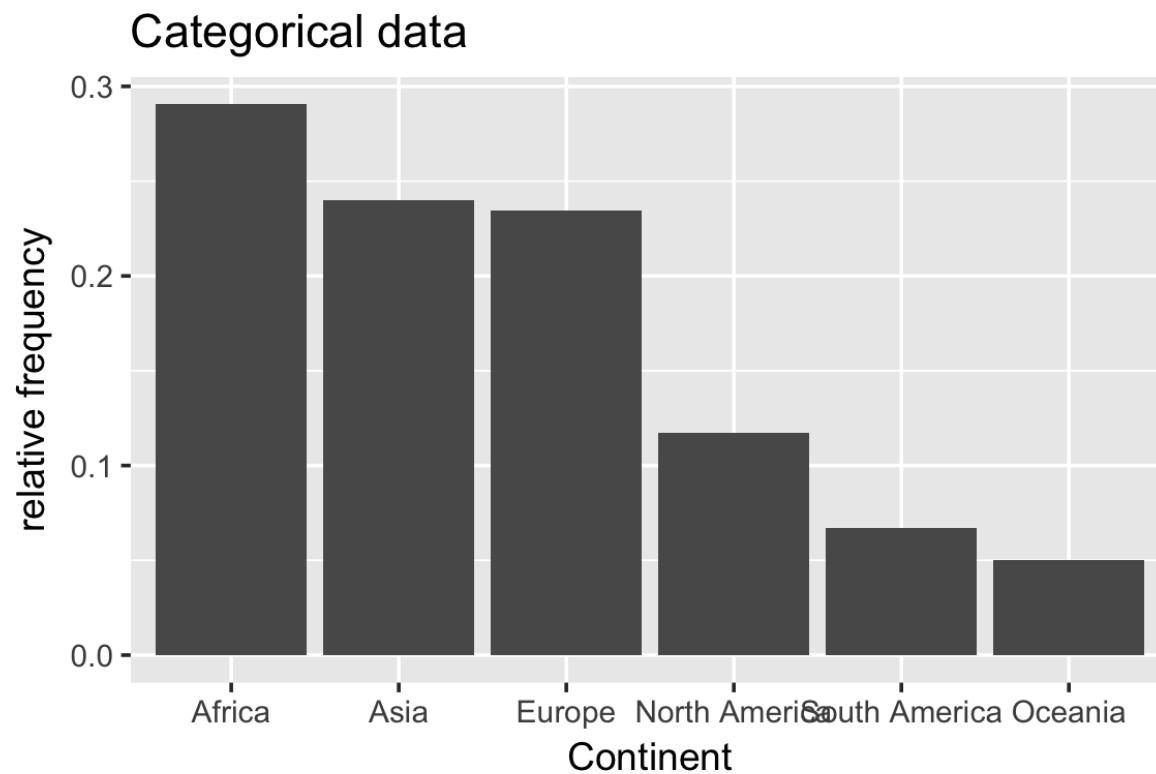
Class	Frequency	Rel. Frequency	Density
(300, 400]	1	.056	.00056
(400, 500]	4	.222	.00222
(500, 600]	5	.278	.00278
(600, 700]	4	.222	.00222
(700, 800]	4	.222	.00222

Frequency bar chart

Categorical data



Relative frequency bar chart



Five number summary

1. min
2. lower fourth
3. median
4. upper fourth
5. max

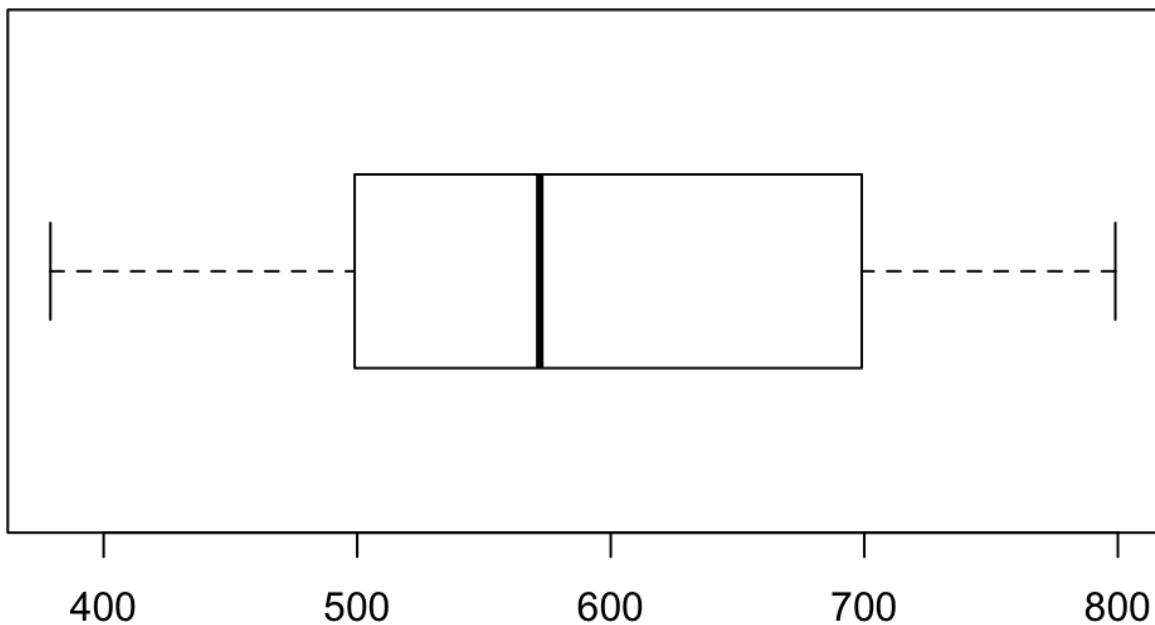
```
fivenum(prices)
```

```
## [1] 379 499 572 699 799
```

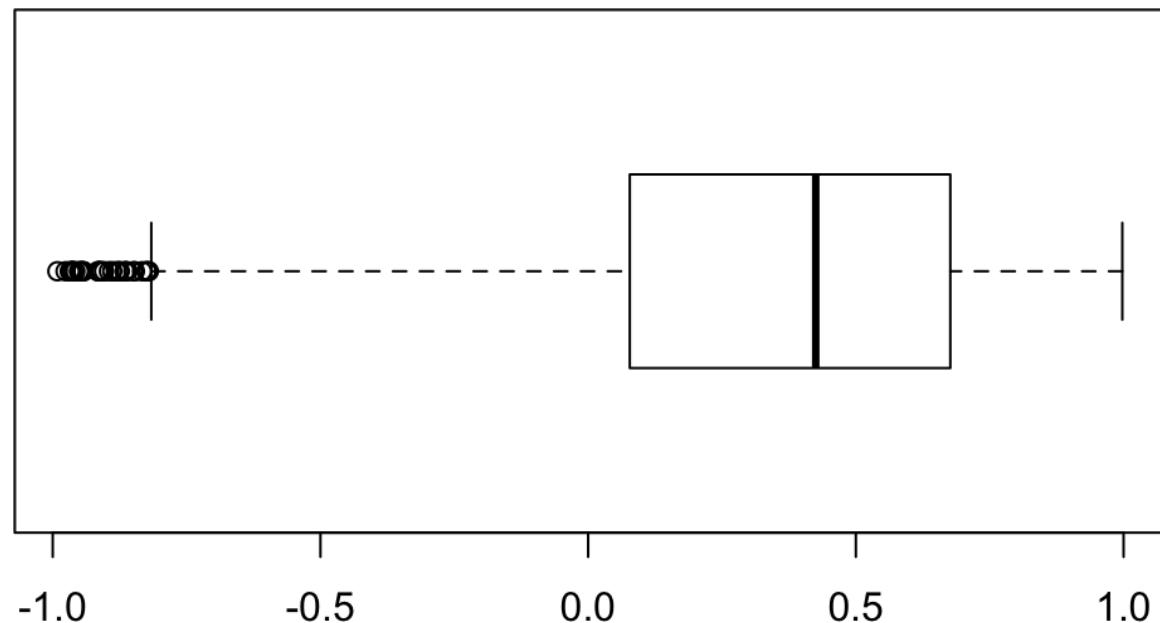
Boxplot

379, 425, 450, 450, 499, 529, 535, 535, 545,
599, 665, 675, 699, 699, 725, 725, 745, 799

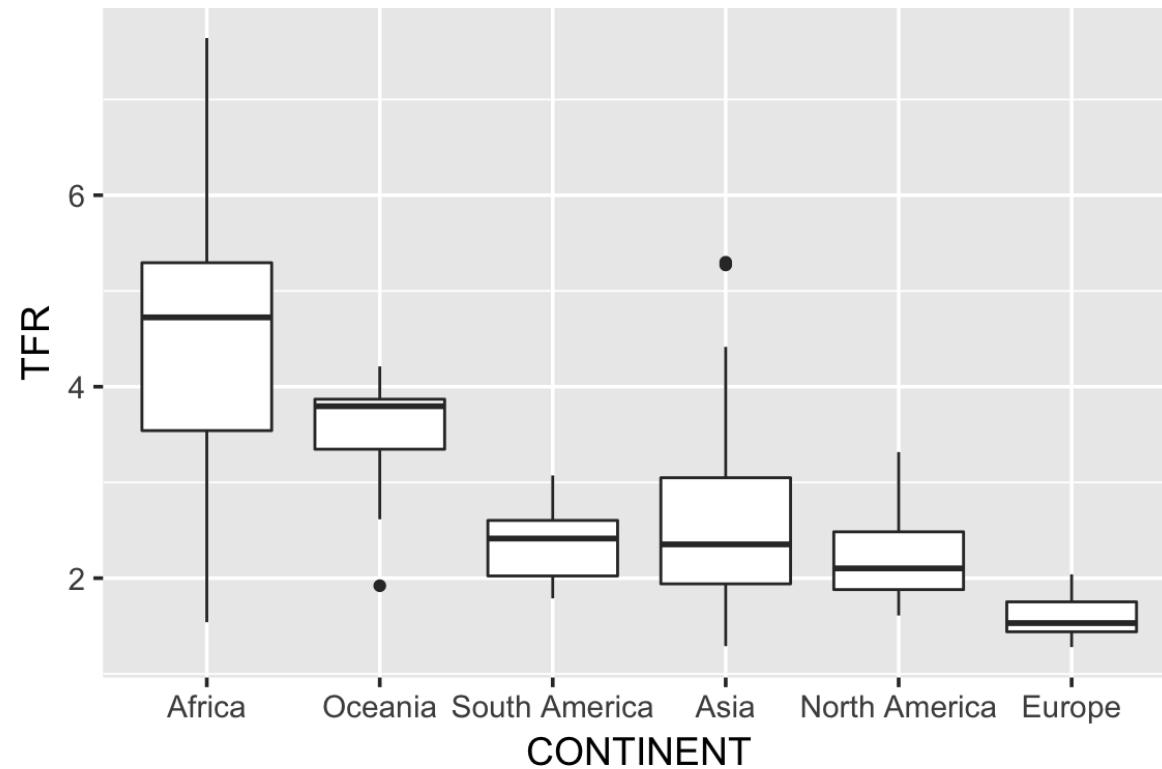
```
## [1] 379 499 572 699 799
```



Boxplot with outliers



Multiple box plots



EXERCISE

(based on #72, p. 49)

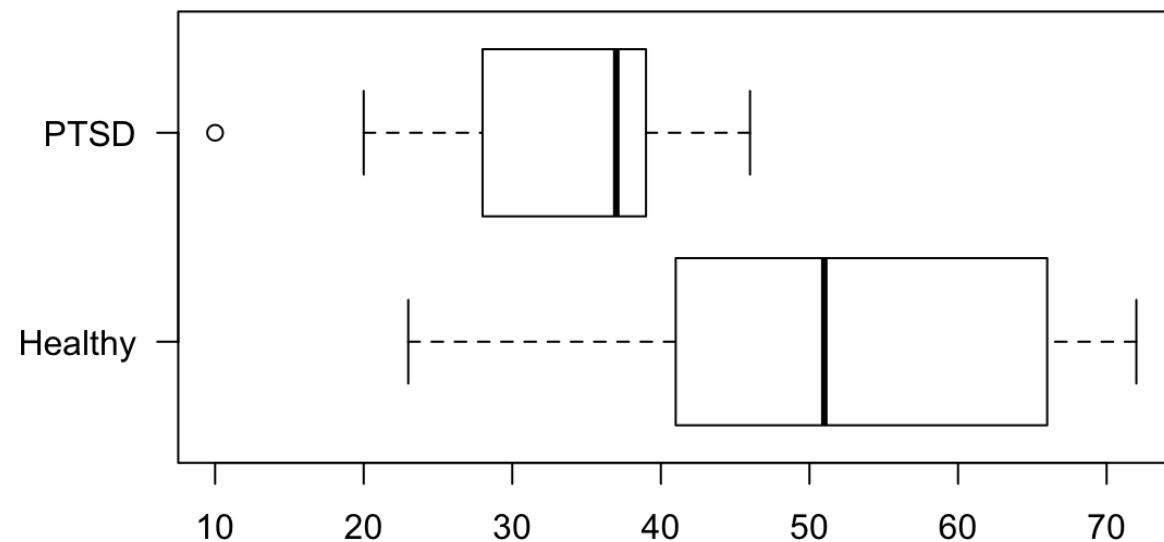
Data on a receptor binding measure:

PTSD: 10, 20, 25, 28, 31, 35, 37, 38, 38, 39, 39, 42, 46

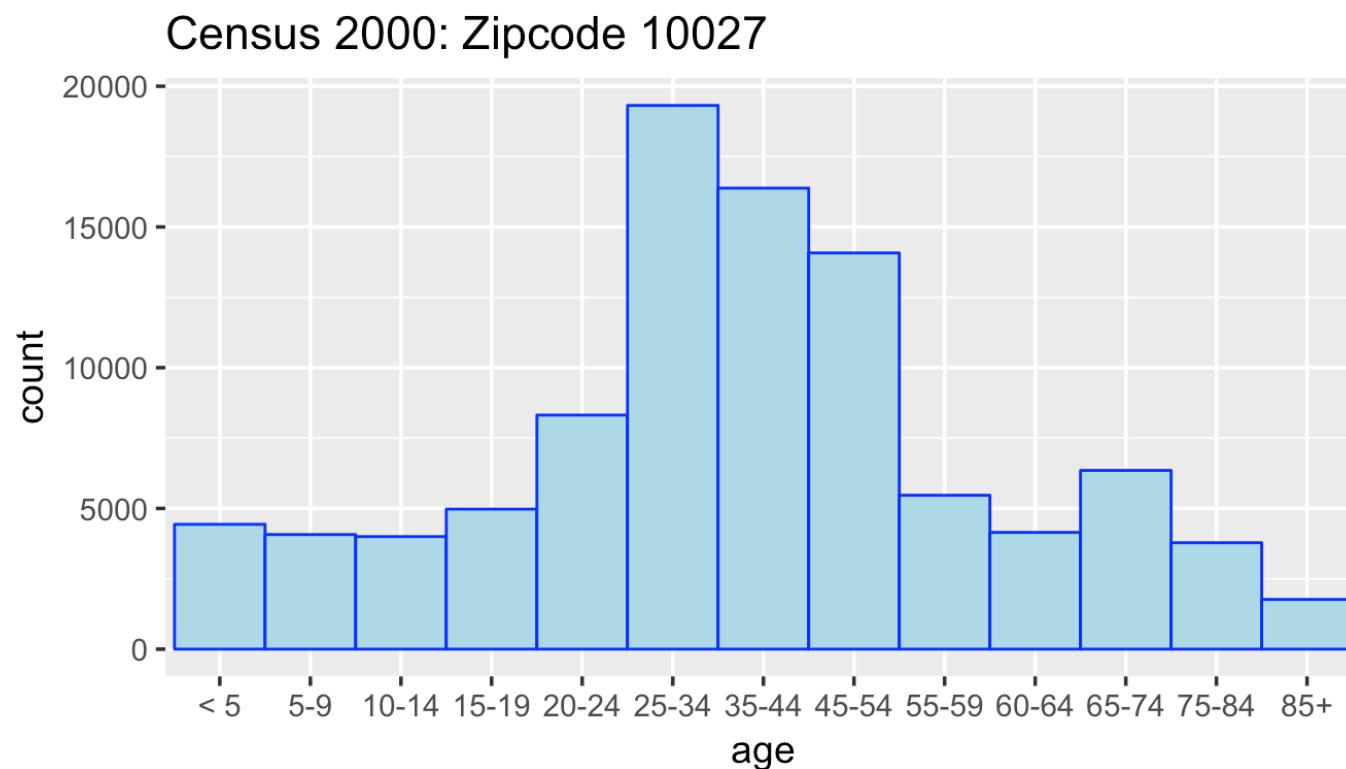
Healthy: 23, 39, 40, 41, 43, 47, 51, 58, 63, 66, 67, 69, 72

Draw a comparative boxplot.

Comparative boxplot



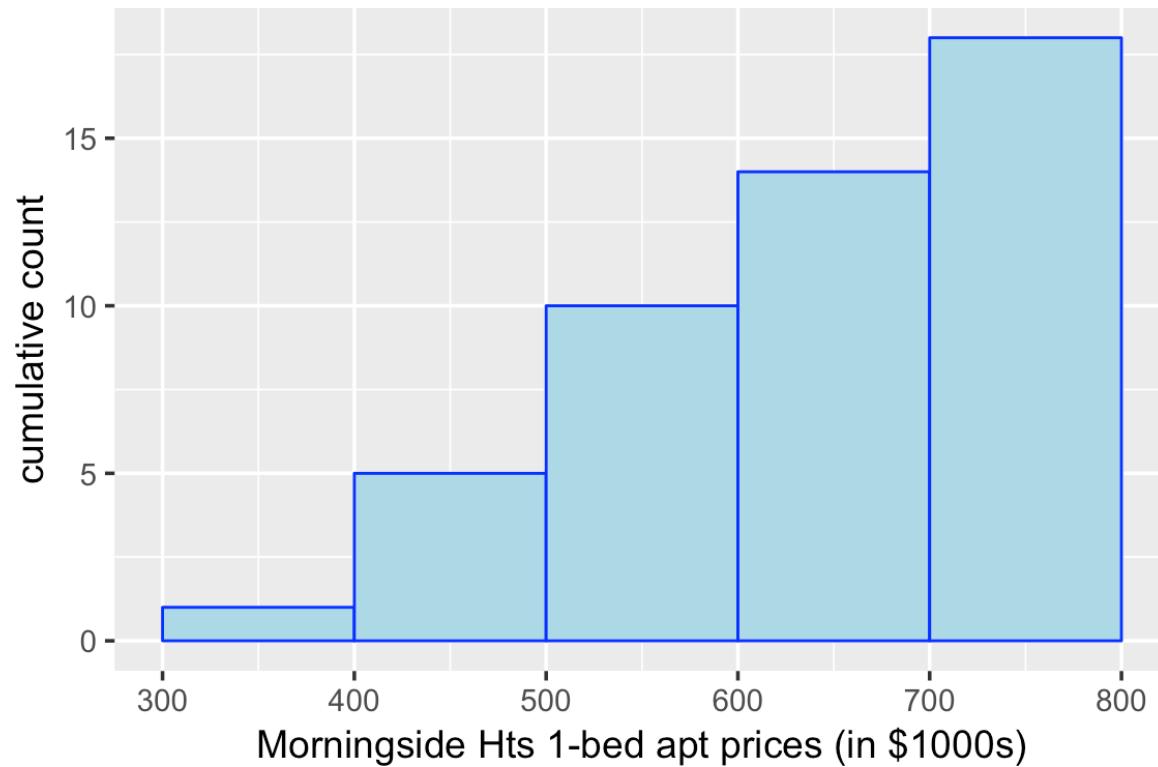
Histogram: what's wrong?



Frequency histogram



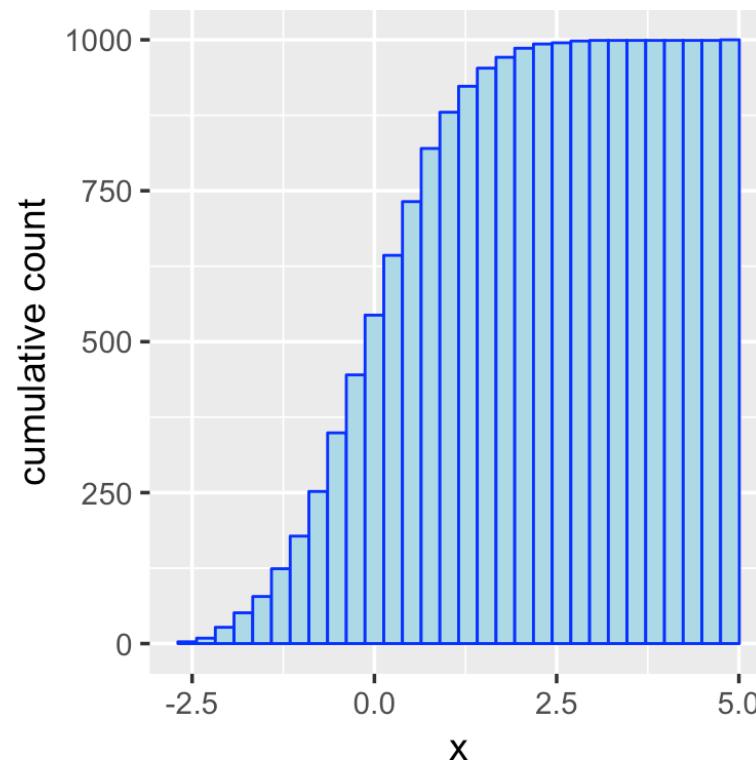
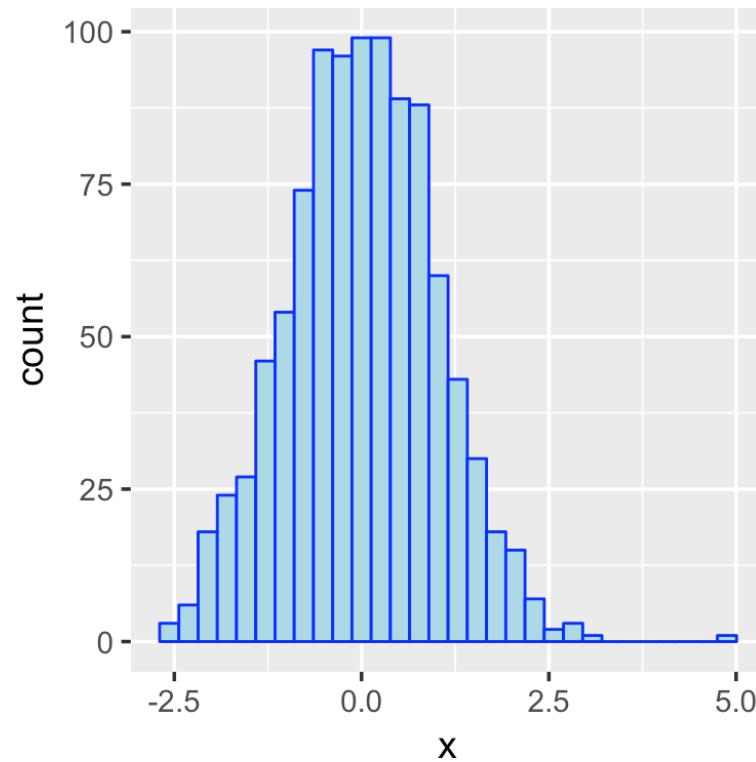
Cumulative frequency histogram



Cumulative frequency histogram

Class	Freq	CumulativeFreq
300-400	1	1
400-500	4	5
500-600	5	10
600-700	4	14
700-800	4	18

Cumulative frequency histogram



EXERCISE

(based on #17, p. 26)

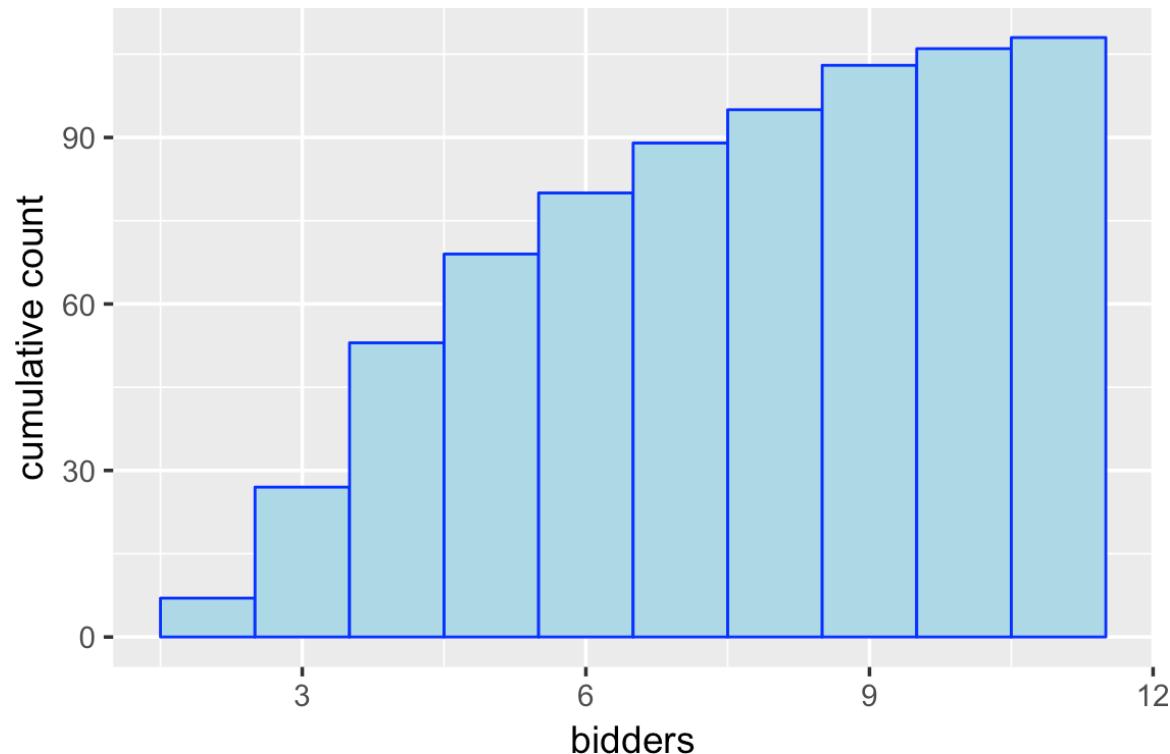
Construction industry data:

bidders contracts

2	7
3	20
4	26
5	16
6	11
7	9
8	6
9	8
10	3
11	2

- a) What proportion of the contracts involved at most five bidders?
- b) What proportion of the contracts involved between five and ten bidders, inclusive?
- c) Draw a cumulative frequency histogram.

Cumulative frequency histogram



Sample and population means

population mean: $\mu = \text{sum of } N \text{ population values} / N$

sample mean: $\bar{x} = \frac{x_1 + x_2 + \dots + x_n}{n} = \frac{\sum_{i=1}^n x_i}{n}$

population median: $\tilde{\mu}$

sample median: \tilde{x}

Measures of variability

deviations from the mean

$$x_1 - \bar{x}, x_2 - \bar{x}, \text{ etc.}$$

Data: 3, 8, 11, 14

Mean: 9

value	deviation	deviation ²
3	-6	36
8	-1	1
11	2	4
14	5	25

Sum of squared deviations

$$S_{xx}: 36 + 1 + 4 + 25 = 66$$

Population variance

$$\sigma^2 = 66/4 = 16.5$$

$$\sigma^2 = \sum_{i=1}^N (x_i - \mu)^2 / N$$

Sample variance

Sum of squared deviations:

$$S_{xx}: 36 + 1 + 4 + 25 = 66$$

Sample variance:

$$s^2 = 66 / 3 = 22$$

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

Why $n-1$?

Short answer: using n would result in an underestimation, since the values in the sample are closer to the sample mean than to the true population mean (which we don't know)

Standard deviation

Square root of variance

- Population s.d. = $\sqrt{\sigma^2}$
- Sample s.d. = $\sqrt{s^2}$
- same units as original values

EXERCISE (p. 47, #62)

Consider the following information on ultimate tensile strength (lb/in^2) for a sample of $n = 4$ hard zirconium copper wire specimens:

$$\bar{x} = 76,831$$

$$s = 180$$

$$\text{smallest } x_i = 76,683$$

$$\text{largest } x_i = 77,048$$

Set up equations to determine the values of the two middle sample observations. Do not solvez

EXERCISE: sd for n = 3

Find the sample mean, variance, and standard deviation:

X1 X2 X3 mean var sd

1 2 3

2 4 6

0 5 10

99 100 101

-8 -5 -2