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: 1201.info

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 asap so the waitlist moves before the very end of the change of program period.

Special message for Fall 2020

- Be in touch about person situations / challenges
- Share your remote learning ideas with me
- Be flexible
- Use the chat window A LOT

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

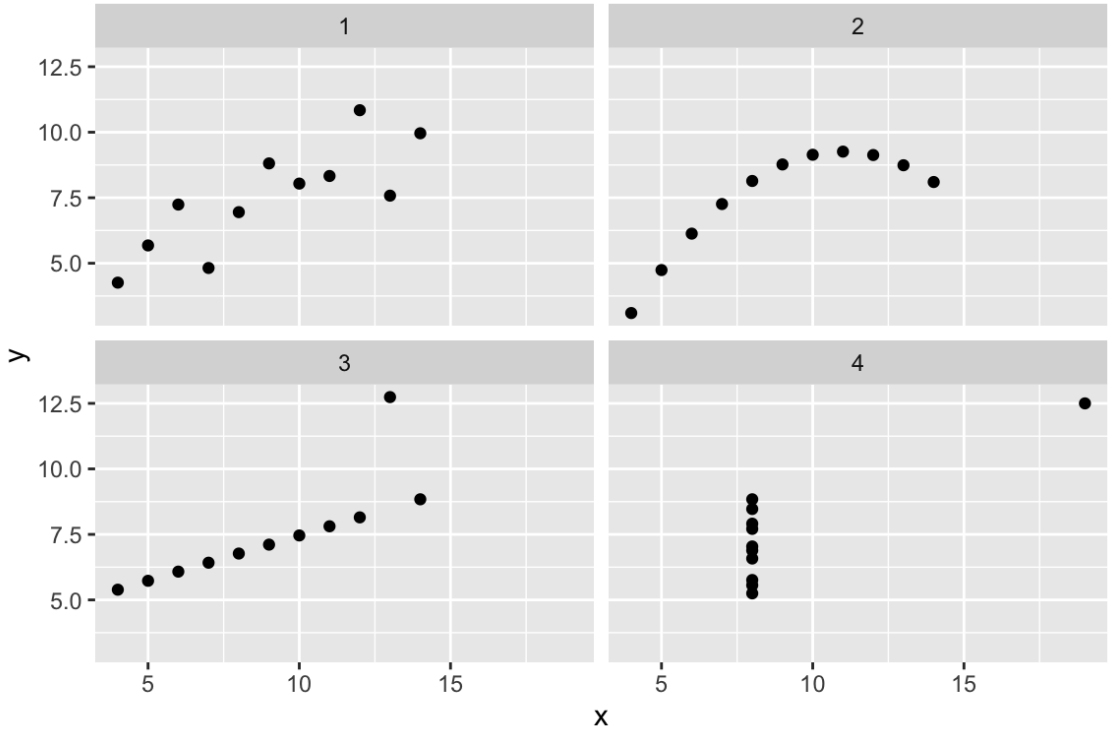
x1	x2	x3	x4	y1	y2	y3	y4
10	10	10	8	8.04	9.14	7.46	6.58
8	8	8	8	6.95	8.14	6.77	5.76
13	13	13	8	7.58	8.74	12.74	7.71
9	9	9	8	8.81	8.77	7.11	8.84
11	11	11	8	8.33	9.26	7.81	8.47
14	14	14	8	9.96	8.10	8.84	7.04
6	6	6	8	7.24	6.13	6.08	5.25
4	4	4	19	4.26	3.10	5.39	12.50
12	12	12	8	10.84	9.13	8.15	5.56
7	7	7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

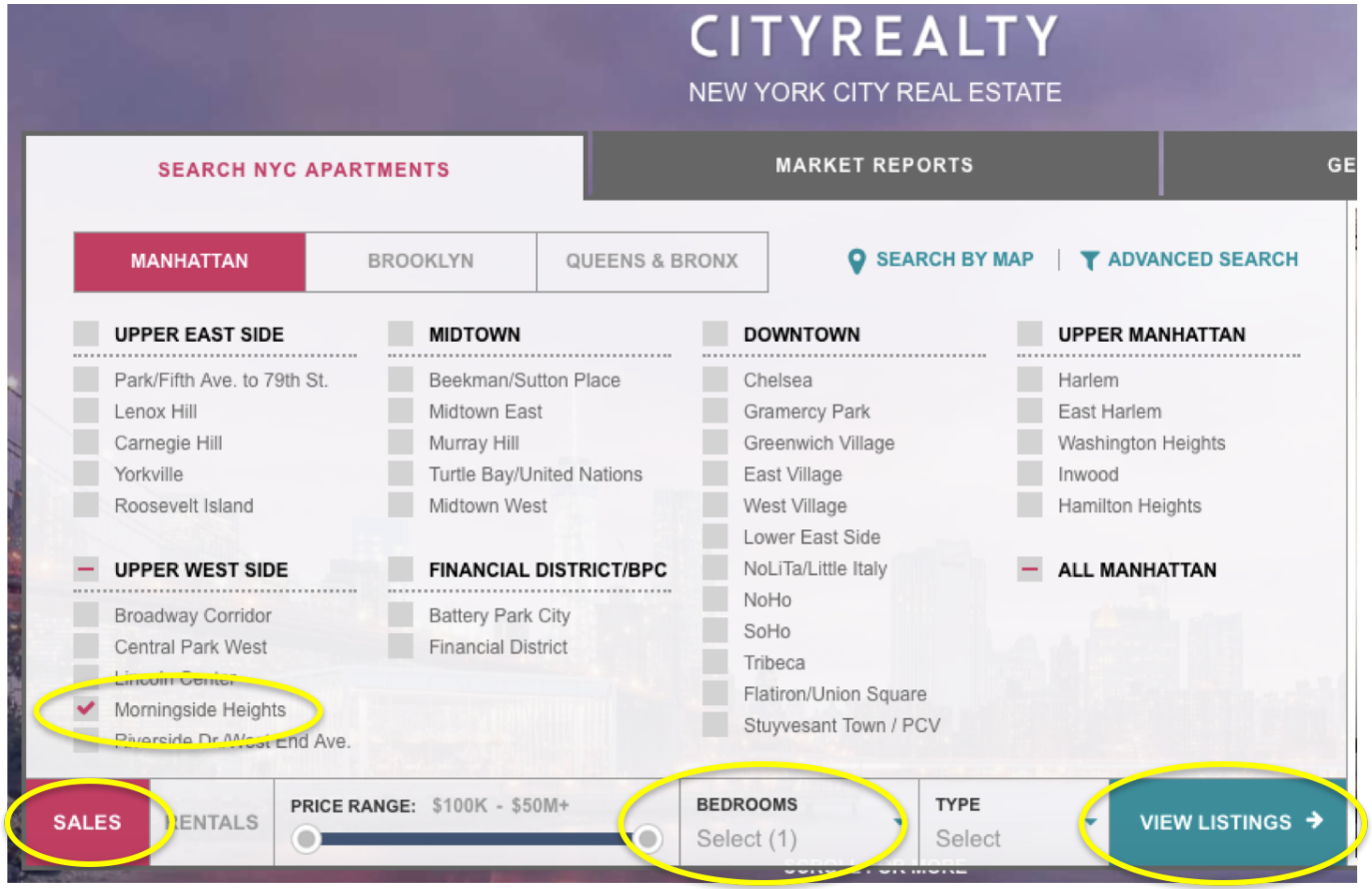
For each of the four data sets:

- 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

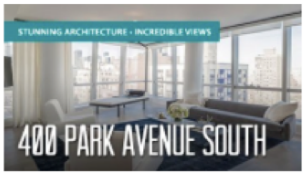


Collecting data

HIDE ALL PHOTOS SHOW ALL PHOTOS

ADDRESS	TYPE	NEIGHBORHOOD	BEDS / BATH / SIZE	PRICE	PRICE/FT²	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 ft²	$745K	$931	Jul 19, 2016
380 Riverside Drive, #8L	CO-OP	Morningside Heights	1 bd / 1 ba / 700 ft²	$725K	$1,036	Sep 06, 2016
535 West 110th Street, #6B	CO-OP	Morningside Heights	1 bd / 1 ba / 750 ft²	$725K	$967	Sep 07, 2016
535 West 110th Street, #6A	CO-OP	Morningside Heights	1 bd / 1 ba / 750 ft²	$699K (-4%)	$933	Apr 26, 2016
395 Riverside Drive, #2D	CO-OP	Morningside Heights	1 bd / 1 ba / 900 ft²	$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 ft²	$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 ft²	$535K	$892	Jun 22, 2016
80 La Salle Street, #21B	CO-OP	Morningside Heights	1 bd / 1 ba / 725 ft²	$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 ft²	$450K	$900	Jun 28, 2016

TURED NEW DEVELOPMENTS



510 West 123rd Street, #38	CO-OP	Morningside Heights	1 bd / 1 ba / 700 ft²	$450K	$643	Jul 02, 2016
3115 Broadway, #43	CO-OP	Morningside Heights	1 bd / 1 ba / 650 ft²	$425K	$654	Apr 18, 2016
3115 Broadway, #42	CO-OP	Morningside Heights	1 bd / 1 ba / 650 ft²	$379K (-5%)	$583	Mar 28, 2016

Cleaning / organizing data

	A	B	C	D	E	F	G	H
1		ADDRESS	TYPE	NEIGHBORH(	BEDS / BATH	PRICE	PRICE/FT2	LISTED
2	+							
3	3115 Broadw	CO-OP						
4	Morningside	1 bd / 1 ba /	$379K	$583	28-Mar-16			
5	+							
6	3115 Broadw	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 Broadw	CO-OP						
13	Morningside	1 bd / 1 ba /	$450K	$900	28-Jun-16			
14	+							
15	175 Claremo	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 (finite or can be listed in an infinite sequence)*
  - *Continuous (entire continuum of possible values)*
- Qualitative (categorical)

Visualizing one-dimensional continuous data

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

Stem-and-leaf plot

```
##  [1] 10 32 33 37 41 43 44 44 52 55 55 56 59 61 62
```

```
##
##   The decimal point is 1 digit(s) to the right of the |
##
##    1 | 0
##    2 |
##    3 | 237
##    4 | 1344
##    5 | 25569
##    6 | 12
```

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, in 1,000s, rounded to nearest 10,000:

```
##  [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, in 1,000s, rounded to nearest 10,000:

```
##  [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 | 333333333444444555555555555666666667777778888888888999999999
##   2 | 000000001111222223333333444444455555555666666679999
##   3 | 011122333333445678889
##   4 | 00111122455556677799999
##   5 | 0001222333355788
##   6 | 012344
##   7 | 6
```

Stem and leaf plot, change the length (scale)

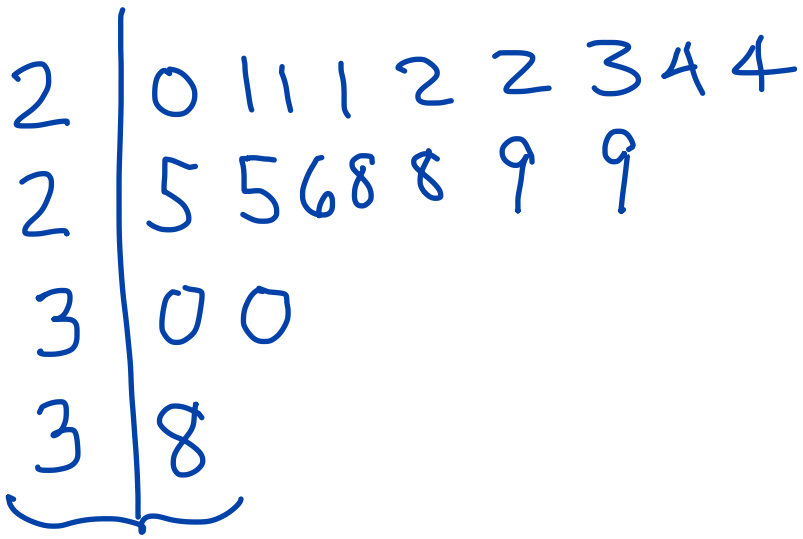
Total Fertility Rate

```
##
##   The decimal point is at the |
##
##   1 | 333333333444444
##   1 | 55555555555556666666677777788888888889999999999
##   2 | 00000000111122222333333344444444
##   2 | 555555556666666679999
##   3 | 01112233333344
##   3 | 567889
##   4 | 001111224
##   4 | 5555667779999
##   5 | 00012223333
##   5 | 55788
##   6 | 012344
##   6 |
##   7 |
##   7 | 6
```

Drawing a stem and leaf plot

Ages of top twenty ranked WTA players (8/31/20):

20 21 21 21 22 22 23 24 24 25
25 26 28 28 28 29 29 30 30 38



EXERCISE: Draw a stem and leaf plot

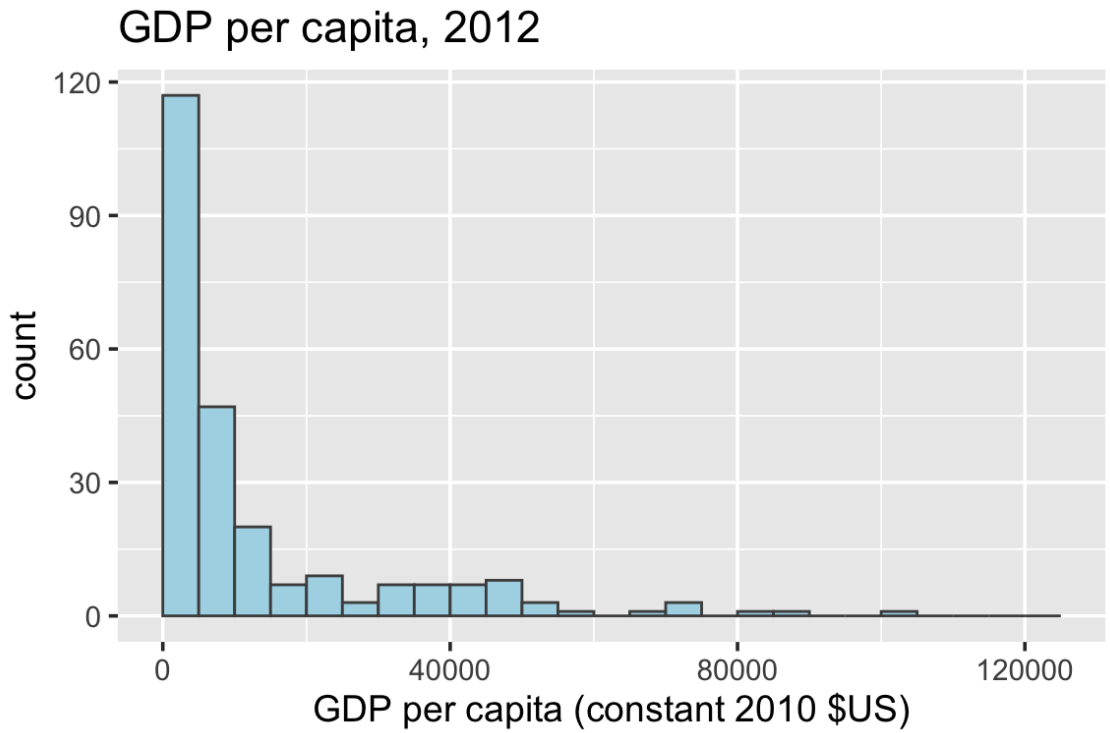
```
## [1] "Alert: Breakout rooms coming up."
```

Counts of various bird species in Big Bend National Park (R: `abd::DesertBirds`)

```
:   1   1   1   1   1   2   2   2   2   3
:   3   4   5   7   7  10  12  13  14  15
:  16  18  23  23  25  28  33  33  59  64
:  67  77 128 135 148 152 173 173 230 282
: 297 300 625
```

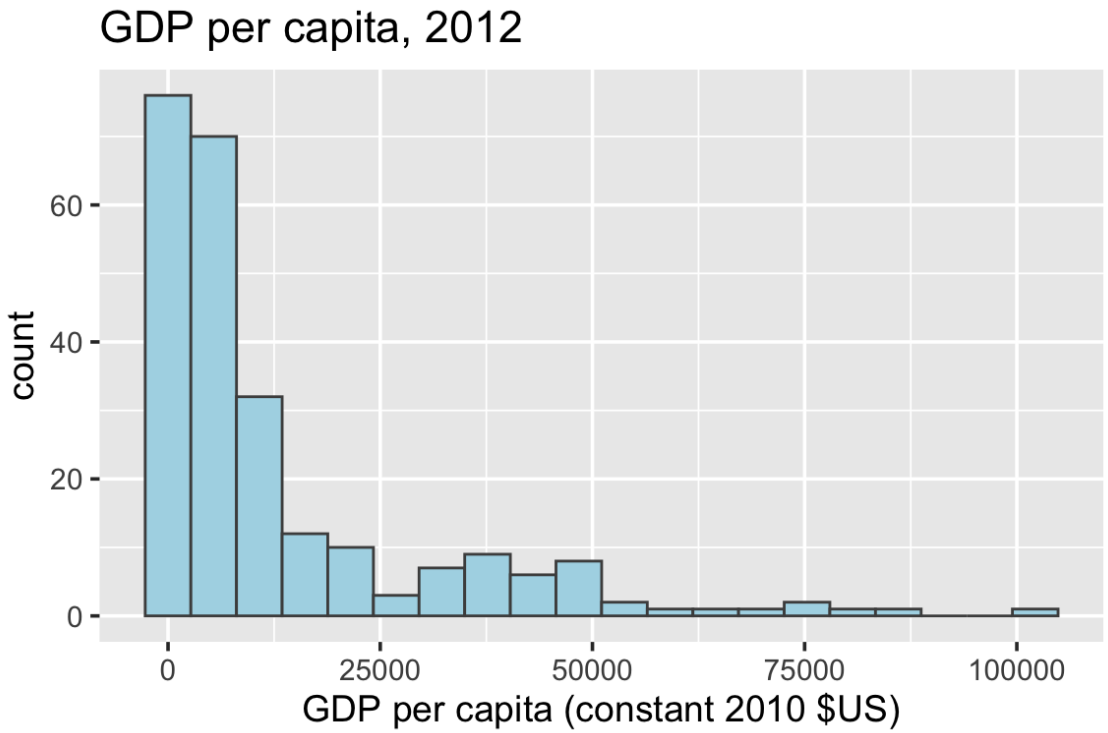
- When you're done, come back to the main room and post your answer in the chat.
- If you have questions use the "Ask for Help" feature.

Frequency histogram

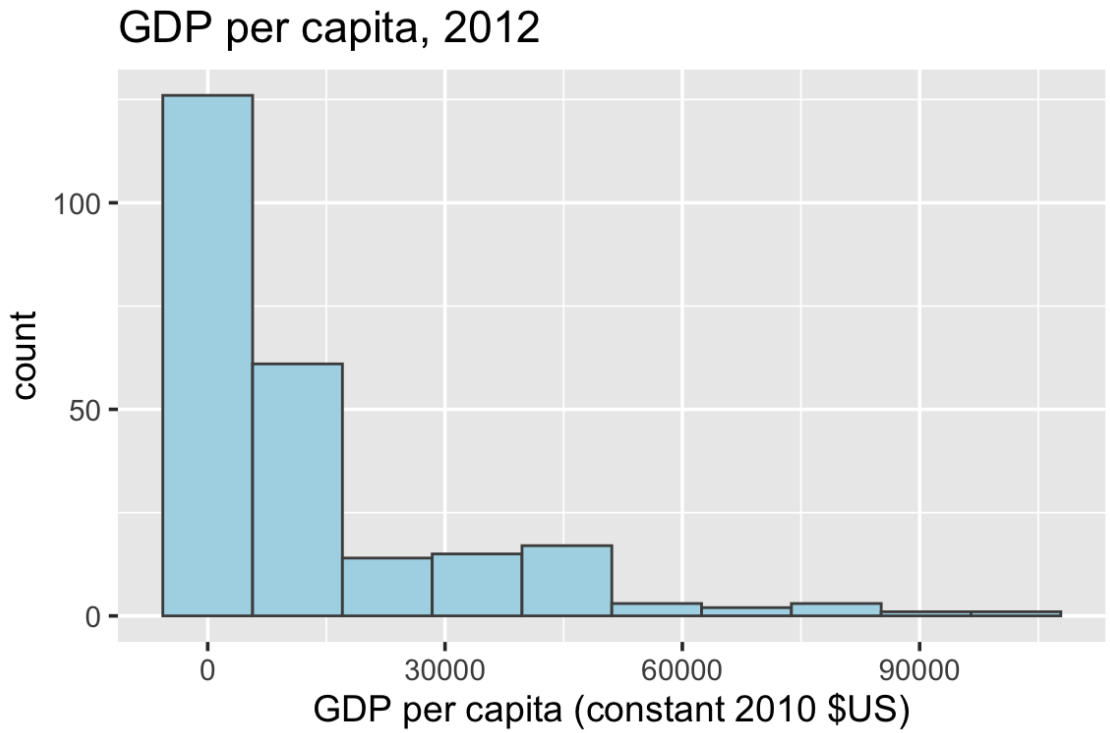


Source: World Bank

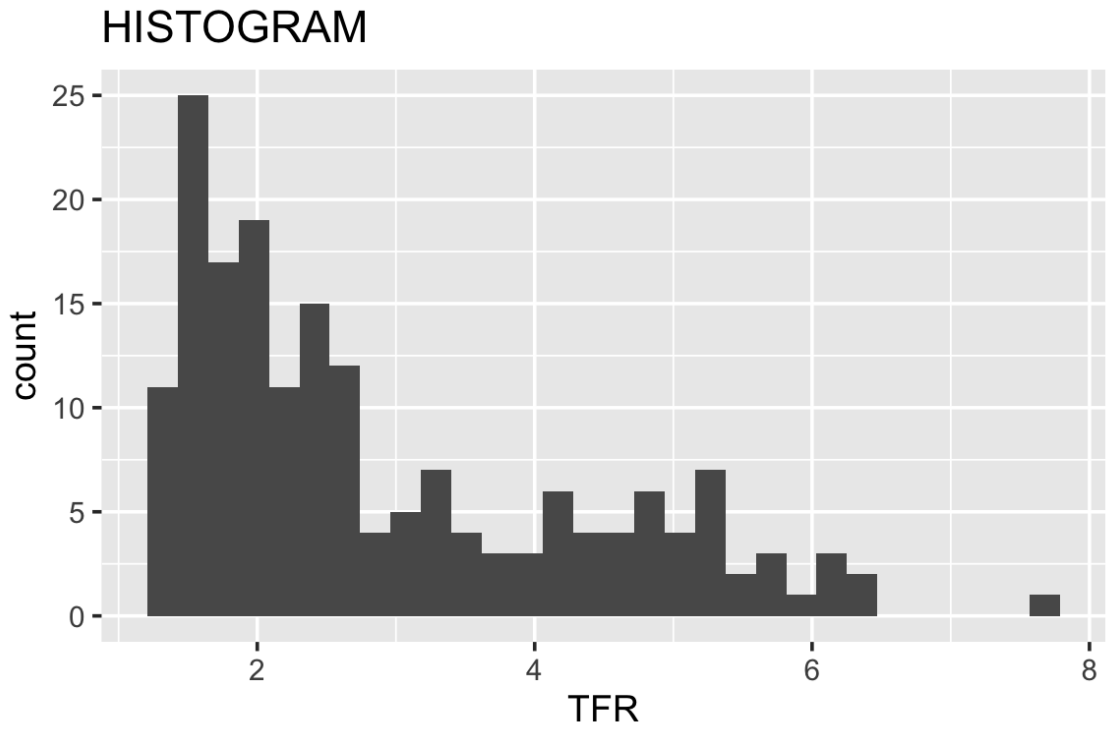
Change number of bins to 20



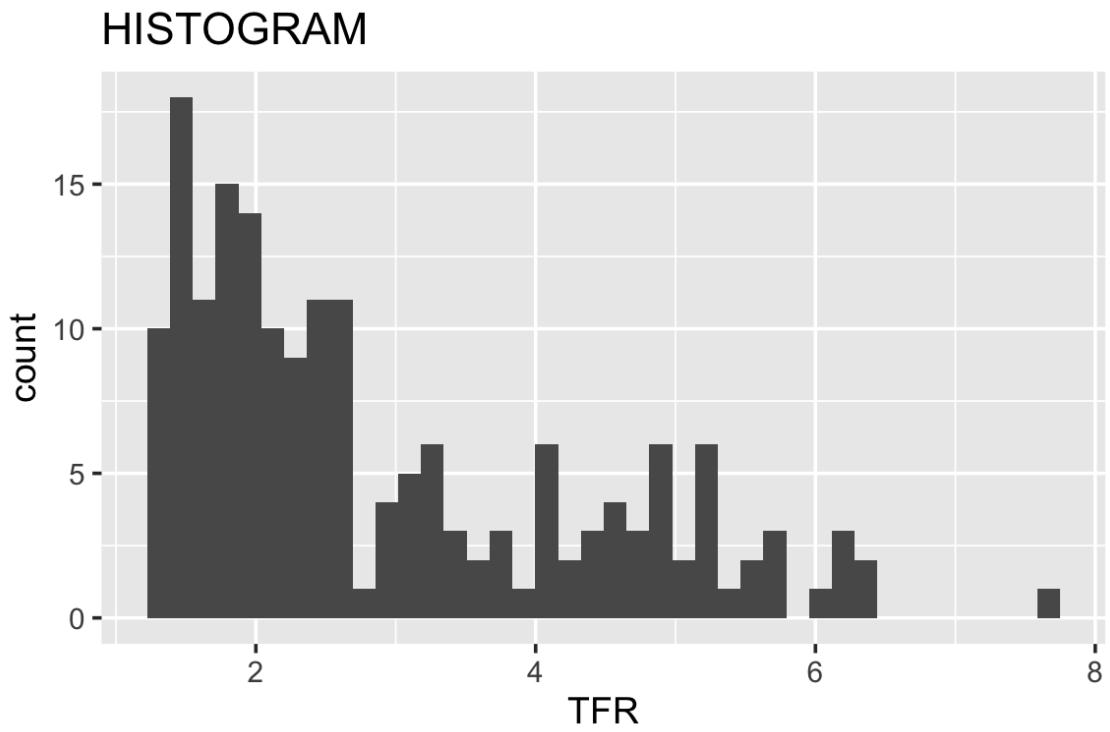
Change number of bins to 10



Total fertility rate



Change the number of bins to 40



Shapes of histograms

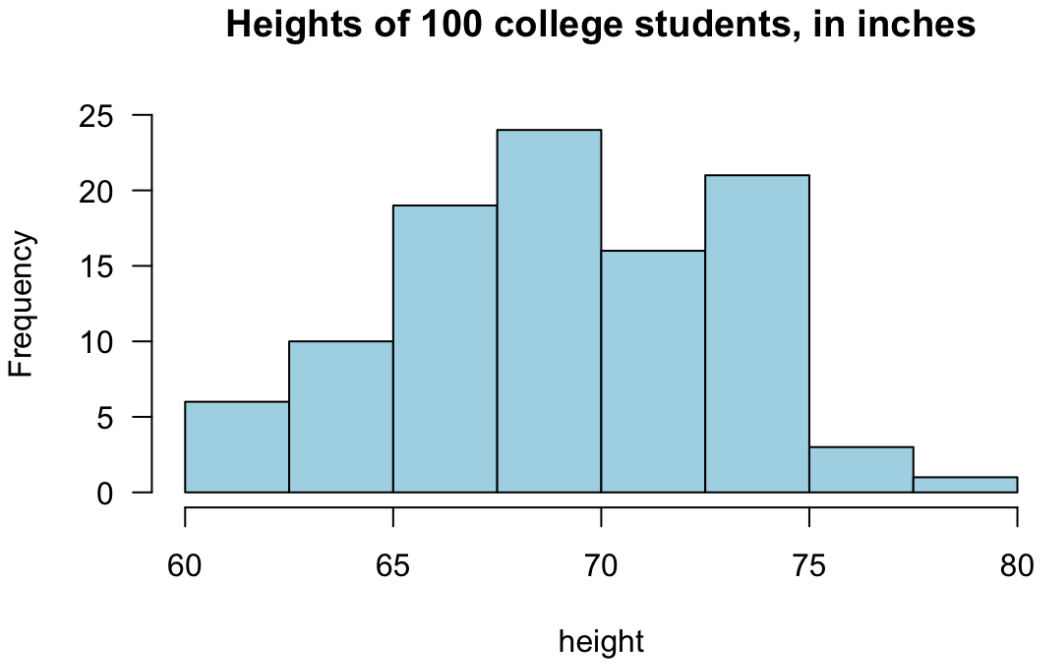
- Unimodal
- Bimodal
- Skewed left
- Skewed right

Discrete data

```
## [1] "Heights of 100 college students, in inches"
```

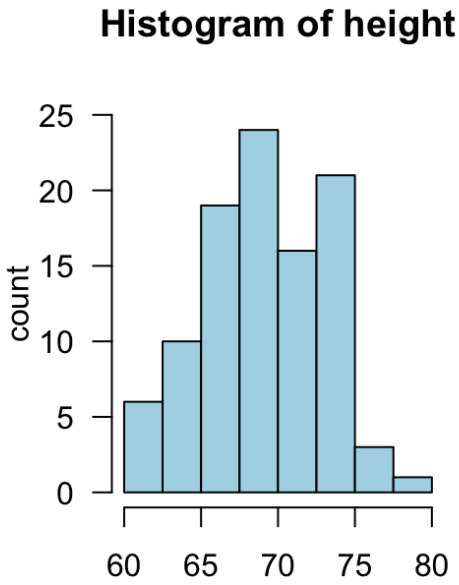
```
##   [1] 60 60 61 61 61 62 63 63 64 64 64 64 65 65 65
##  [16] 65 66 66 66 66 66 66 67 67 67 67 67 67 67 67
##  [31] 67 67 67 67 67 68 68 68 68 68 68 68 69 69 69
##  [46] 69 69 69 69 69 69 70 70 70 70 70 70 70 70 71
##  [61] 71 71 71 71 71 72 72 72 72 72 72 72 72 72 72
##  [76] 73 73 73 74 74 74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

Discrete data

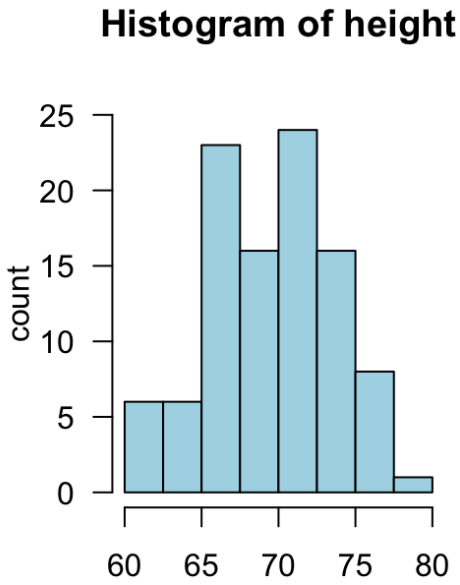



```
##   [1] 60 60 61 61 61 62 63 63 64 64 64 64 65 65 65
##  [16] 65 66 66 66 66 66 66 67 67 67 67 67 67 67 67
##  [31] 67 67 67 67 67 68 68 68 68 68 68 68 69 69 69
##  [46] 69 69 69 69 69 69 70 70 70 70 70 70 70 70 71
##  [61] 71 71 71 71 71 72 72 72 72 72 72 72 72 72 72
##  [76] 73 73 73 74 74 74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

Discrete data histogram



RIGHT CLOSED, LEFT OPEN



RIGHT OPEN, LEFT CLOSED

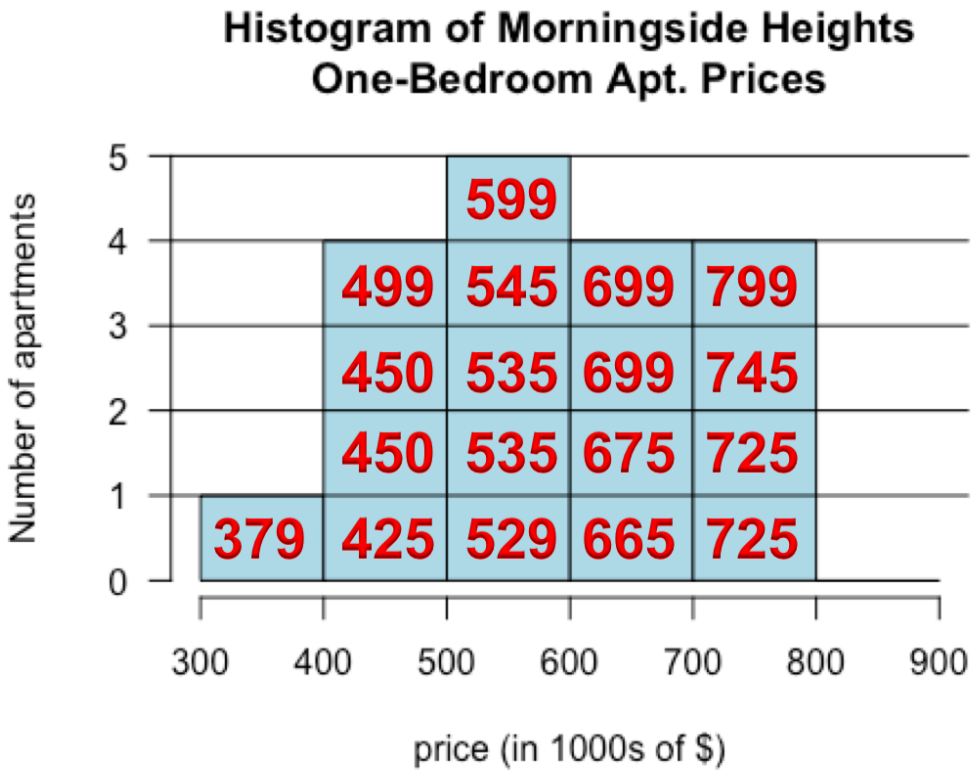
```
##   [1] 60 60 61 61 61 62 63 63 64 64 64 64 65 65 65
##  [16] 65 66 66 66 66 66 66 67 67 67 67 67 67 67 67
##  [31] 67 67 67 67 67 68 68 68 68 68 68 68 69 69 69
##  [46] 69 69 69 69 69 69 70 70 70 70 70 70 70 70 71
##  [61] 71 71 71 71 71 72 72 72 72 72 72 72 72 72 72
##  [76] 73 73 73 74 74 74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

EXERCISE

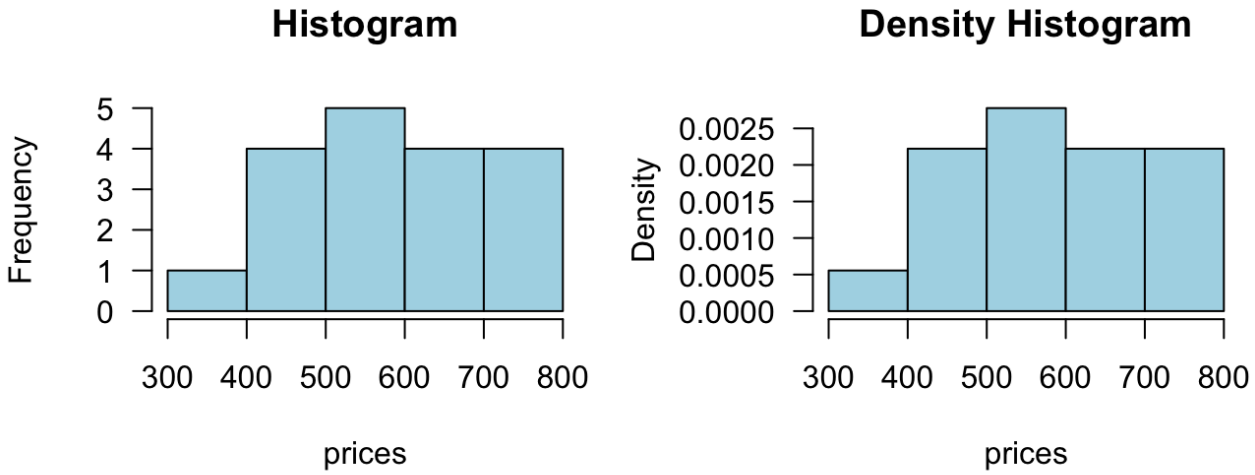
```
## [1] "Alert: Breakout rooms coming up."
```

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


Histogram of Morningside Heights
One-Bedroom Apt. Prices
Number of apartments
0
1
2
3
4
5
379
425
529
665
725
450
535
675
725
450
535
699
745
499
545
699
799
599
300
400
500
600
700
800
900
price (in 1000s of $)

Density histogram

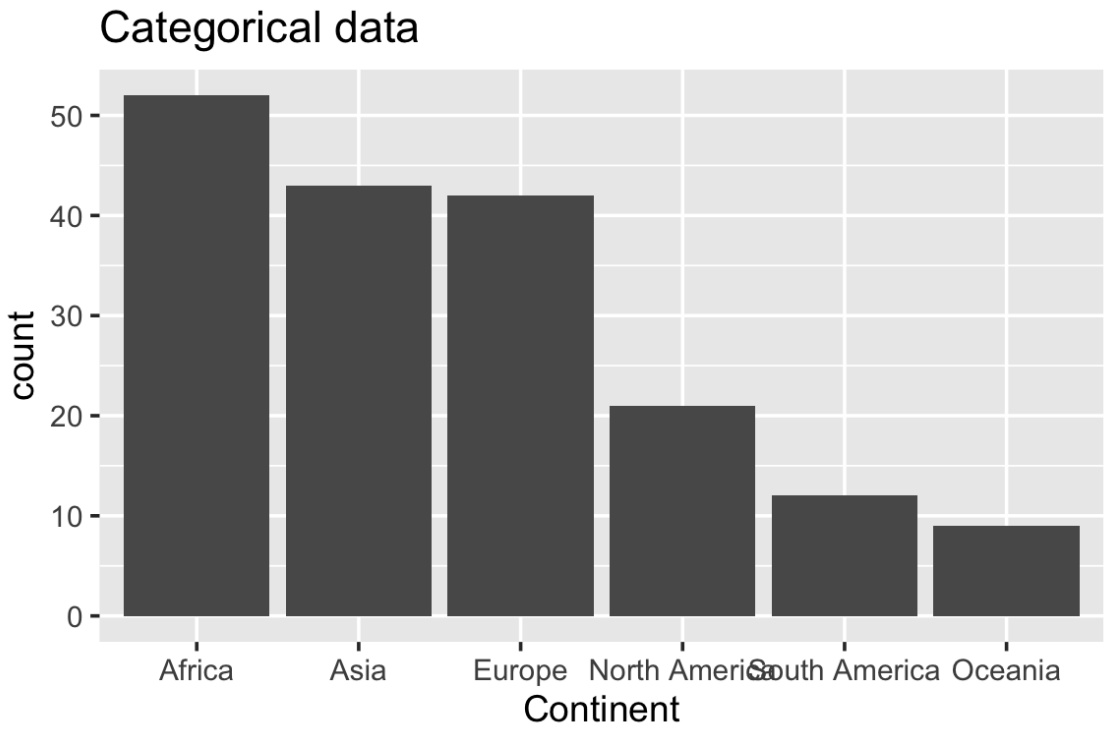


Class	Frequency	Rel. Frequency	Density
(300, 400]	1	.056	.00056
(400, 500]	4	.222	.00222
(500, 600]	5	.278	.00278
(600, 700]	4	.222	.00222
(700, 800]	4	.222	.00222

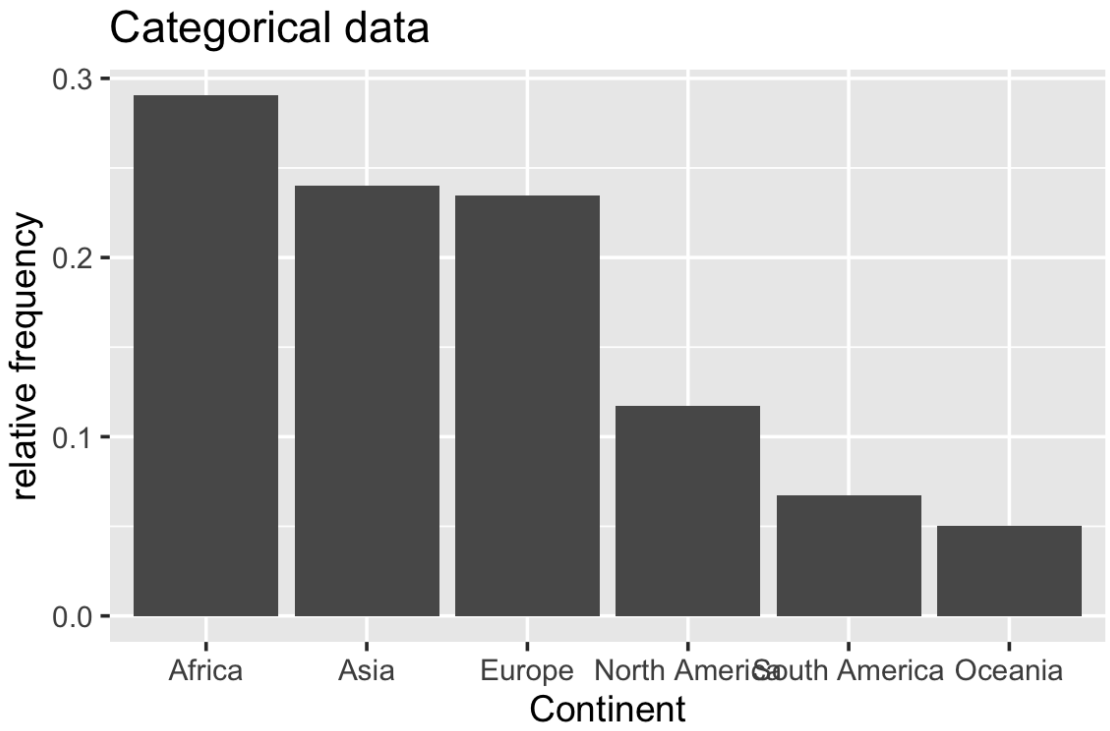
Categorical data

```
##                COUNTRY     CONTINENT   GDP  TFR
## 1          Afghanistan          Asia   691 5.27
## 2              Albania        Europe  4247 1.76
## 3              Algeria        Africa  5584 2.91
## 4               Angola        Africa  5532 6.25
## 5 Antigua and Barbuda North America 13526 2.10
## 6            Argentina South America 14357 2.35
##   LIFEEXP CHMORT
## 1    59.7   99.5
## 2    77.4   15.5
## 3    74.3   26.1
## 4    51.5  172.2
## 5    75.6    9.1
## 6    75.8   13.8
```

Frequency bar chart



Relative frequency bar chart



Five number summary

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

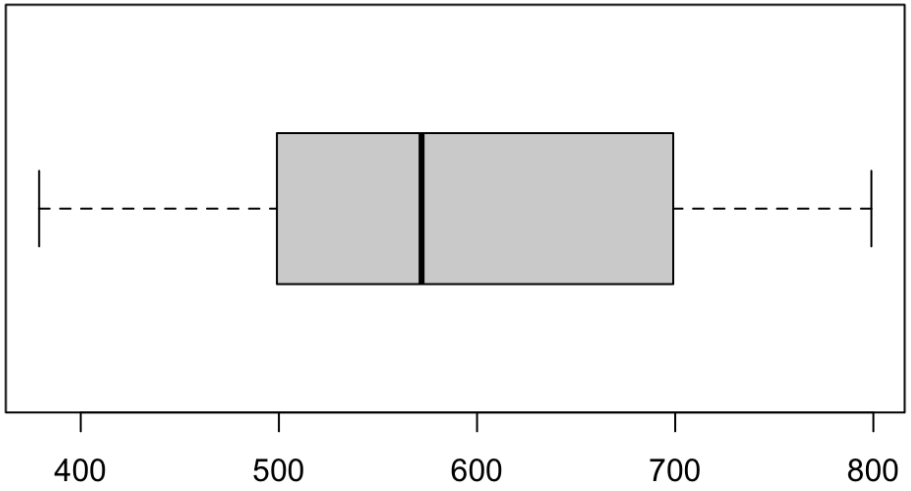
```
fivenum(prices)
```

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

Boxplot (no outliers)

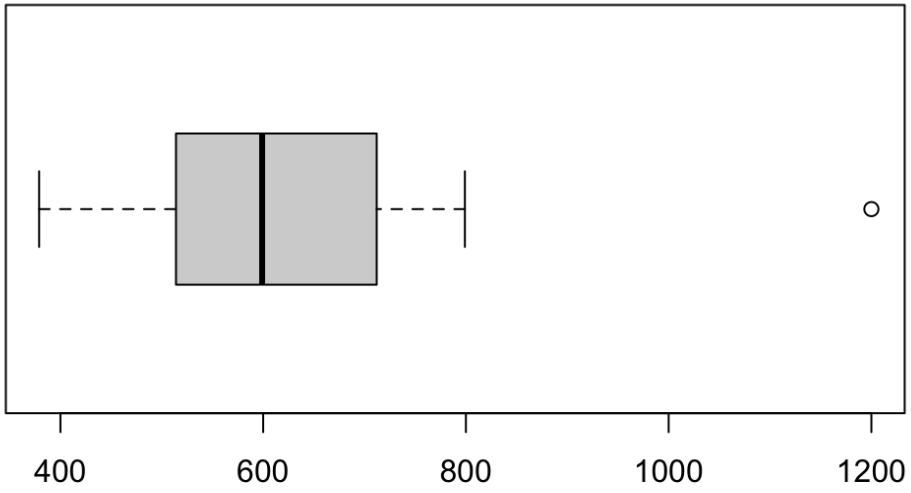
379, 425, 450, 450, 499, 529, 535, 535, 545,
599, 665, 675, 699, 699, 725, 725, 745, 799

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



Boxplot with outlier

```
##  [1]  379  425  450  450  499  529  535  535  545
## [10]  599  665  675  699  699  725  725  745  799
## [19] 1200
```



Box shows lower fourth, median, upper fourth

Whiskers show data within 1.5 times the *fourth spread* (f_s) of the nearest fourth

$$f_s = 712 - 514 = 198$$

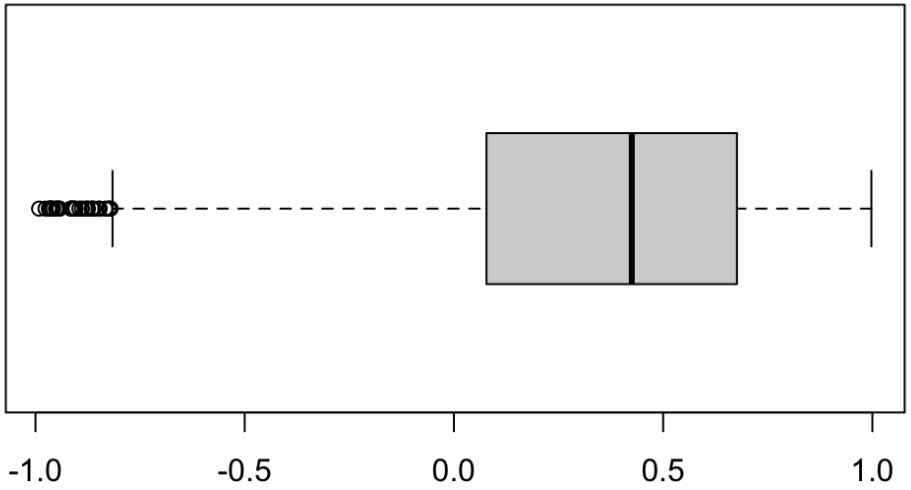
$$1.5f_s = 297$$

lower outlier boundary: lower fourth - $1.5f_s$ = 514 - 297 = 217

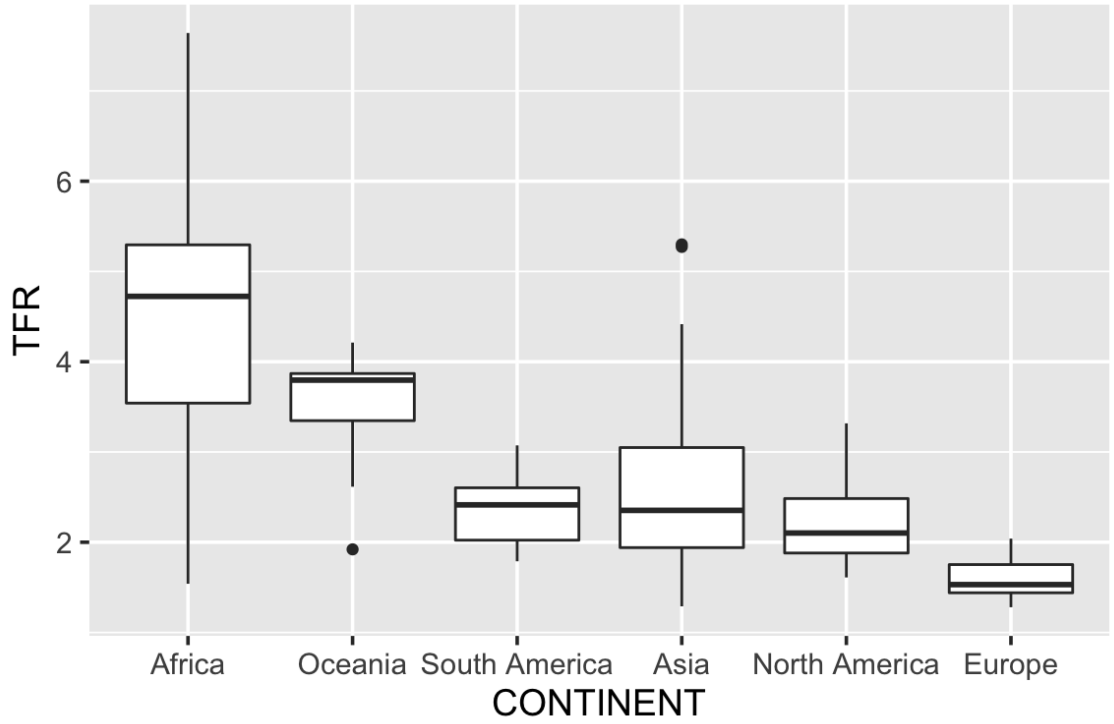
upper outlier boundary: upper fourth + $1.5f_s$ = 712 + 297 = 1009

Add outliers and then draw whiskers to the lowest and highest data values that are *not* outliers.

Boxplot with outliers



Multiple box plots



EXERCISE

(based on #72, p. 49)

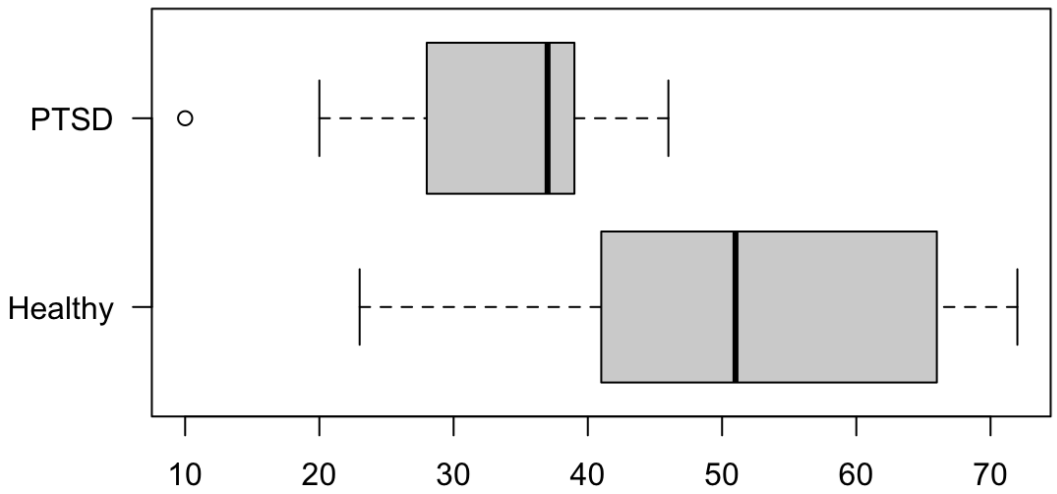
Data on a receptor binding measure:

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

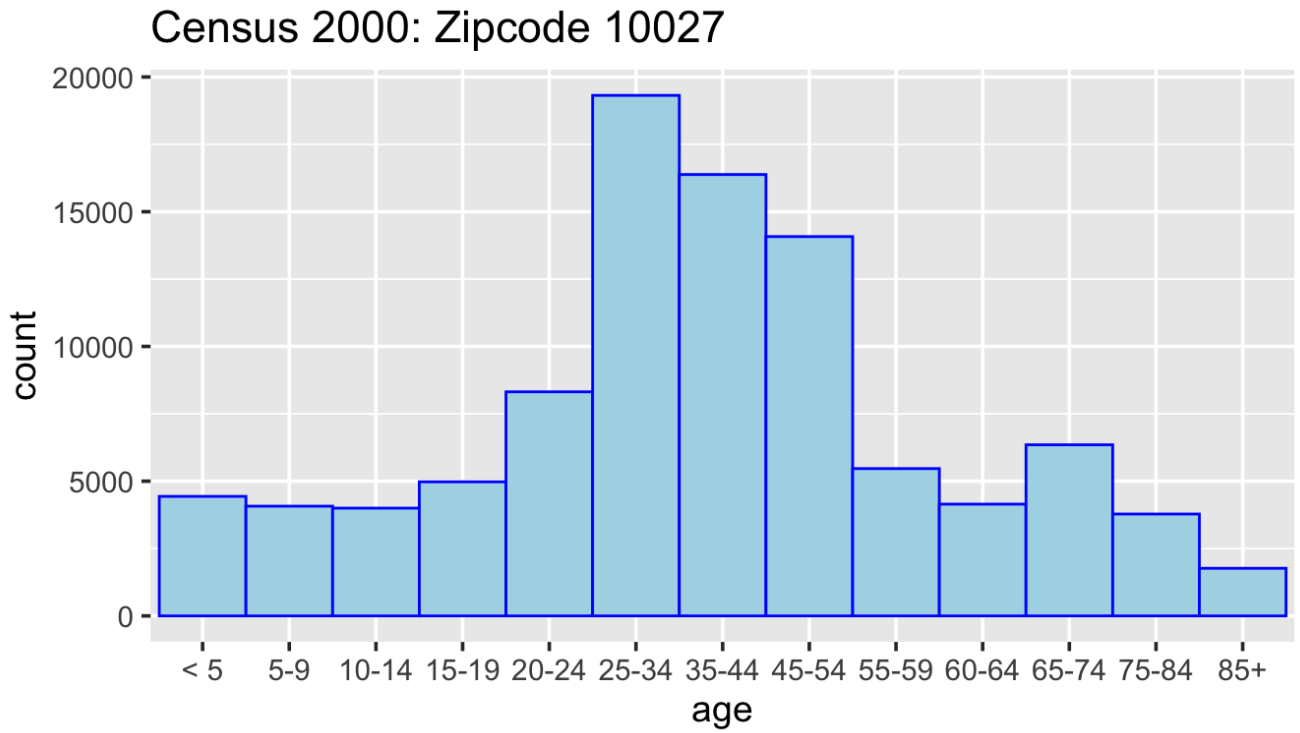
Healthy: 23, 39, 40, 41, 43, 47, 51, 58, 63, 66, 67, 69, 72

Draw a comparative boxplot.

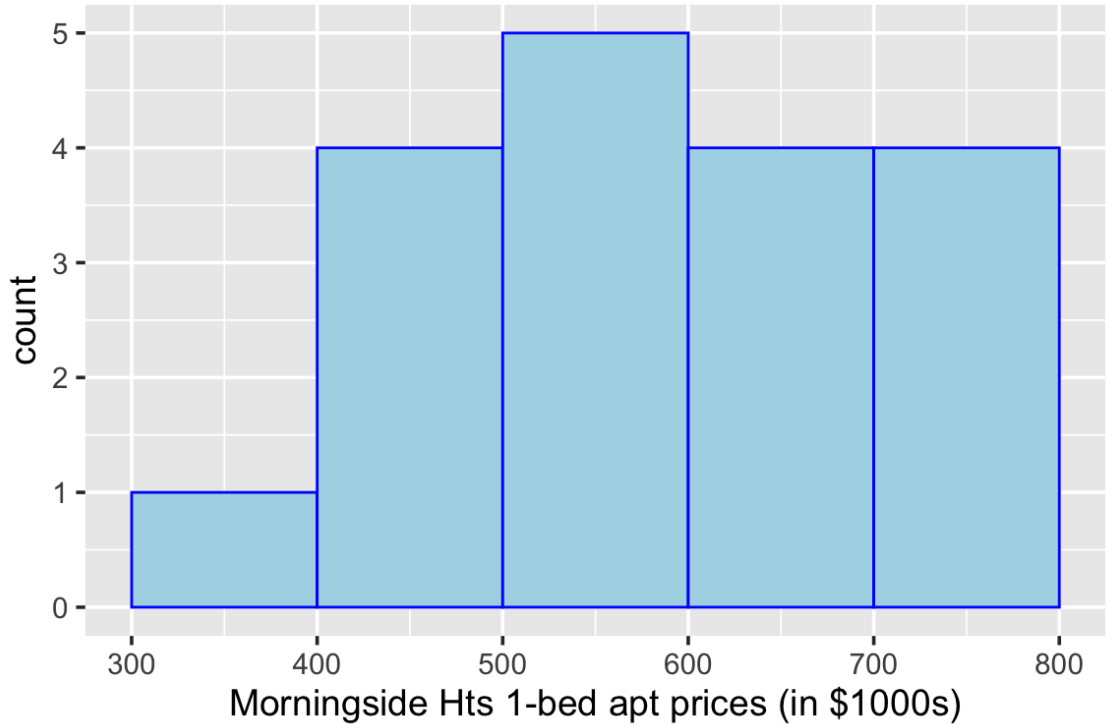
Comparative boxplot



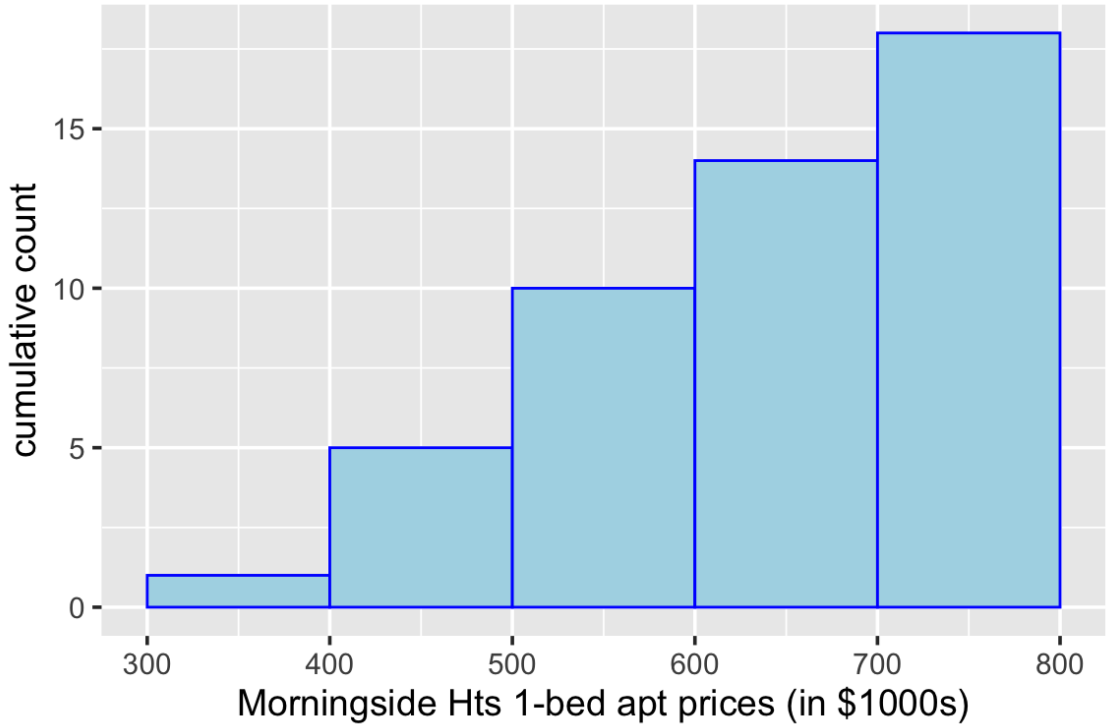
Histogram: what's wrong?



Frequency histogram



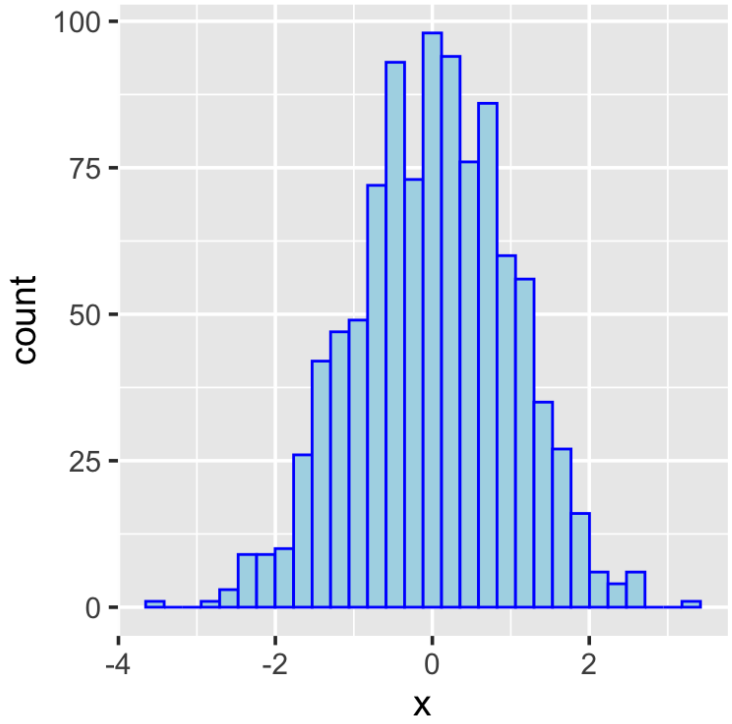
Cumulative frequency histogram

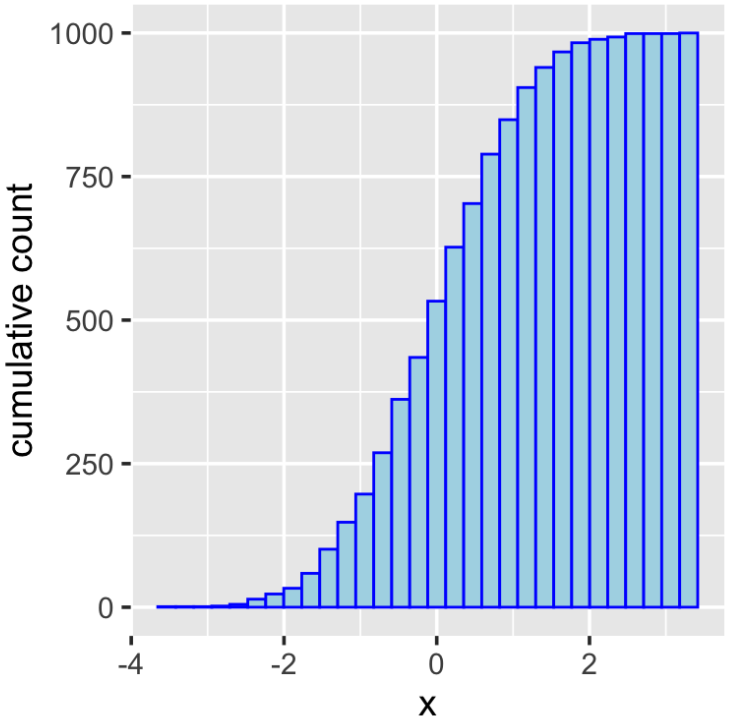


Cumulative frequency histogram

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:

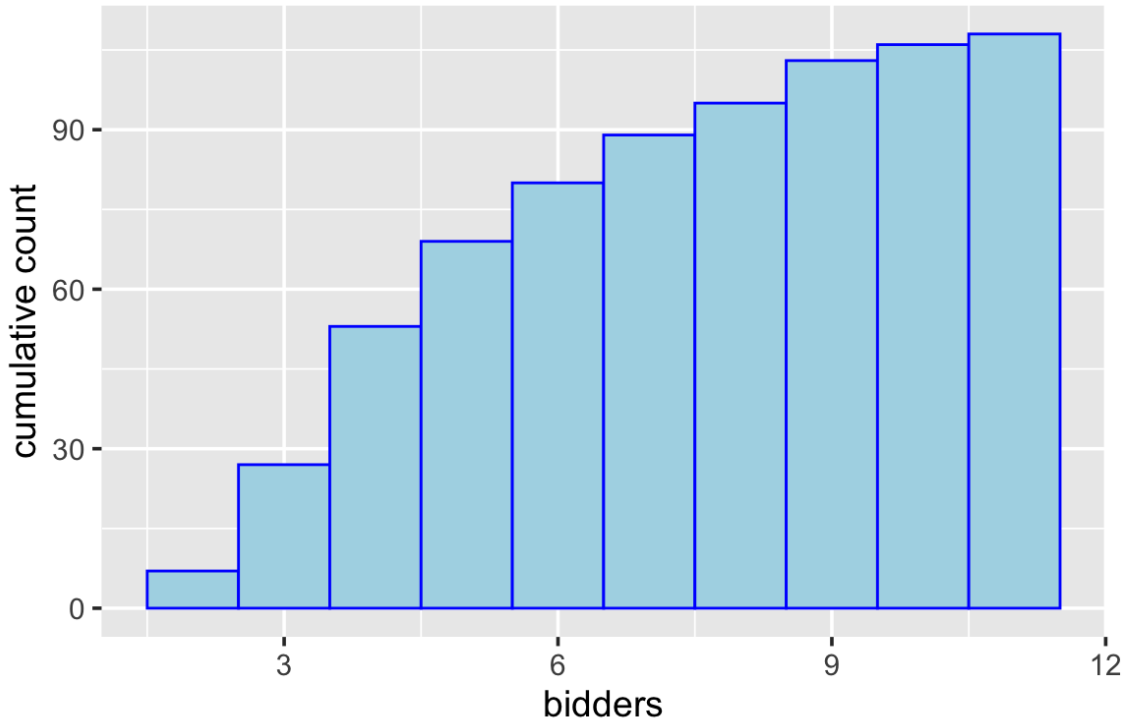
bidders	contracts
2	7
3	20
4	26
5	16
6	11
7	9
8	6
9	8
10	3
11	2

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: μ = sum of N population values / N

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

population median: $\tilde{\mu}$

sample median: $\tilde{x}$

Measures of variability

deviations from the mean

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

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

σ^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:

$\overline{x}$ = 76,831
s = 180
smallest x_i = 76,683
largest x_i = 77,048

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