COMS BC1016
Introduction to Computational Thinking and Data Science

Lecture 6: Charts and Histograms

Sept 22, 2025

Reminders

- Questions about the assignments? Please post on the EdStem!
  - Clarification questions are helpful for everyone :)
  - If it’s specific to your submission, you can post to instructors-only
- HW 1 is due on Wednesday
- HW 2 is out today, due next week Wednesday

Lecture Outline

- Table Review
  - Manipulating Tables
  - Operating on Tables
  - Functions
- Line Plots and Scatter Plots
- Bar Charts and Histograms

Table Review

Prof Lee's Cat Census

Professor Lee is in a cat picture group chat. She has collected data on the cats shared in this chat:

Name	Age	Weight	Coloring	Sex	Owner
Ruby	14	8	tuxedo	F	Alice
Gertrude	15	12	tuxedo	F	Alice
Hamby	8	16	tabby	M	Bob
Fig	3	7	tabby	F	Bob
Corina	6	10	tortie	F	Carol
Frito	2	8.5	tabby	M	Carol

Manipulating Tables

Keep or remove by columns:

- `tbl.select(c1 ,c2, ...)`
- `tbl.drop(c1, c2, …)`

Keep or remove by row:

- `tbl.where(c, predicate)`
- `tbl.take(row_indices)`

Reorder table entries:

- `tbl.sort(c[, descending=False])`

Operating on Tables

Organize table entries by values in column `c`:

- `tbl.group(c)`
- `tbl.group(c, func)`

Apply a function `func` to all entries in a column `c`:

- `tbl.apply(func, c)`

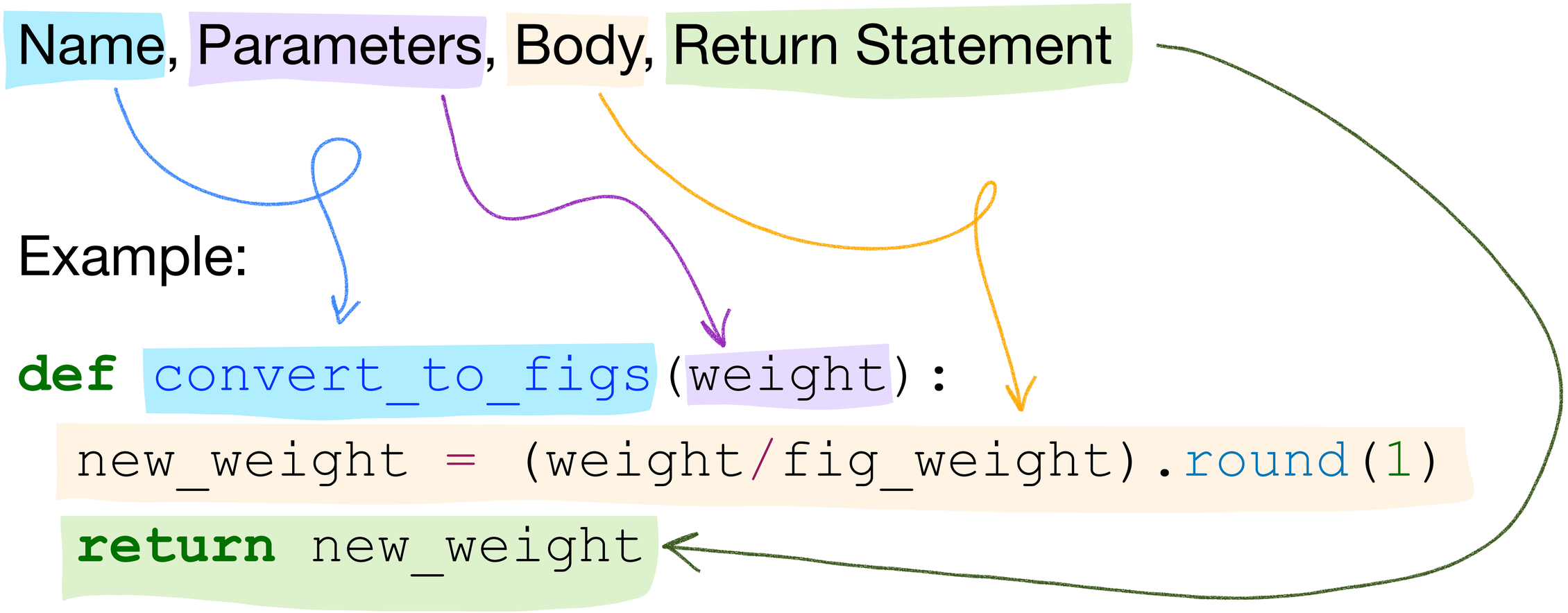
Anatomy of a Function

Name, Parameters, Body, Return Statement

Example:

```
def convert_to_figs(weight):
    new_weight = (weight/fig_weight).round(1)
    return new_weight
```

Anatomy of a Function



apply

Use **apply** to call a function on each element in a column

```
def convert_to_figs(weight):
    new_weight = (weight/fig_weight).round(1)
    return new_weight

cat_tbl.apply(convert_to_figs, 'Weight')
```

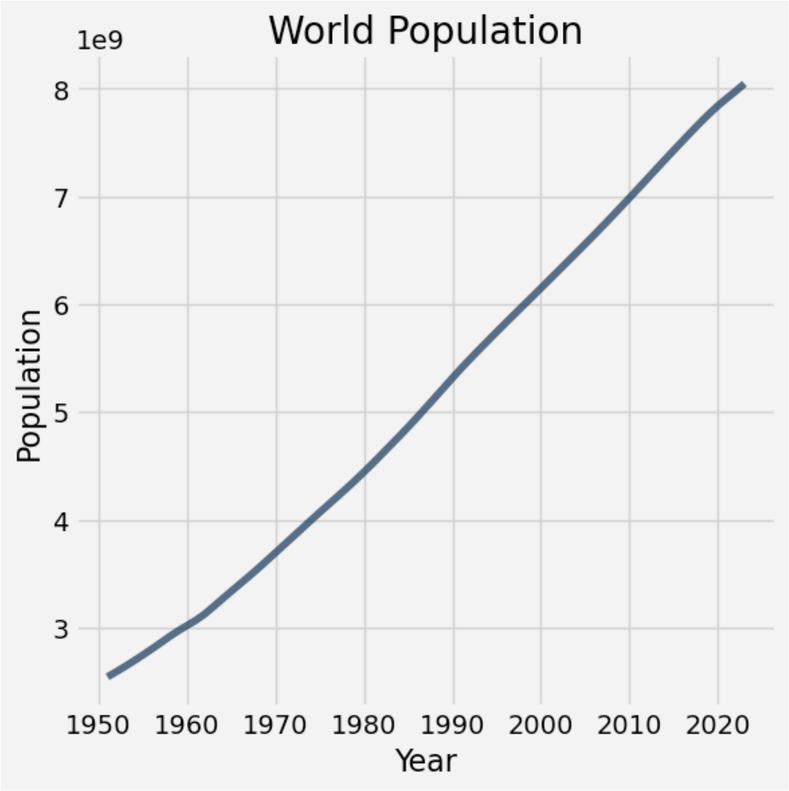
Returns an array with convert_to_figs called on each element in the 'Weight' column

Plotting Relations Between Numerical Values

Line and Scatter Plots

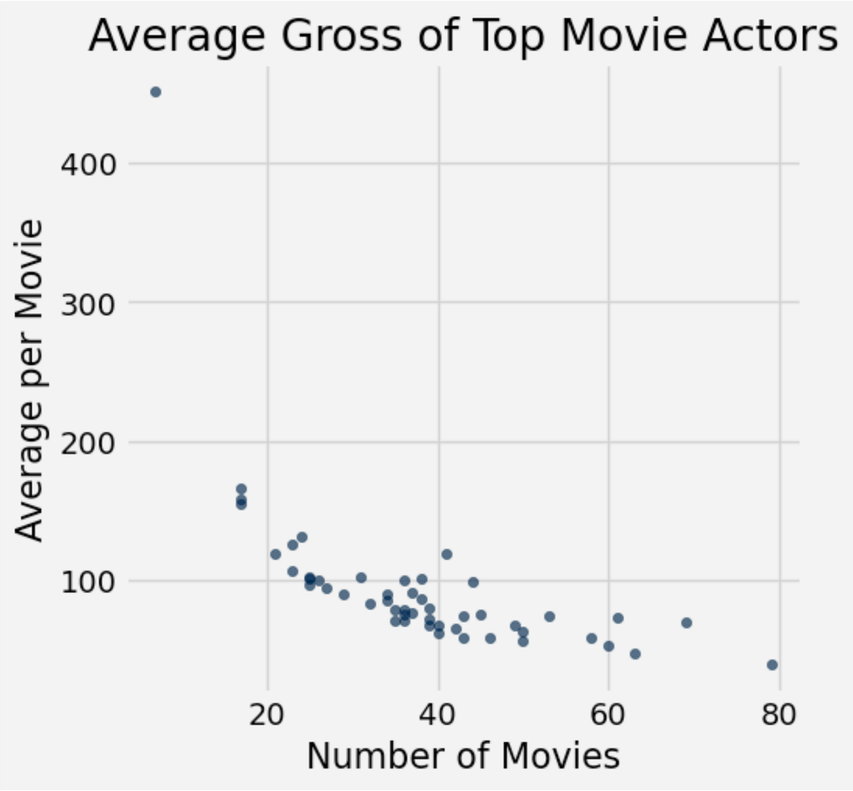
Line Plot

`plot`



Scatter Plot

`scatter`



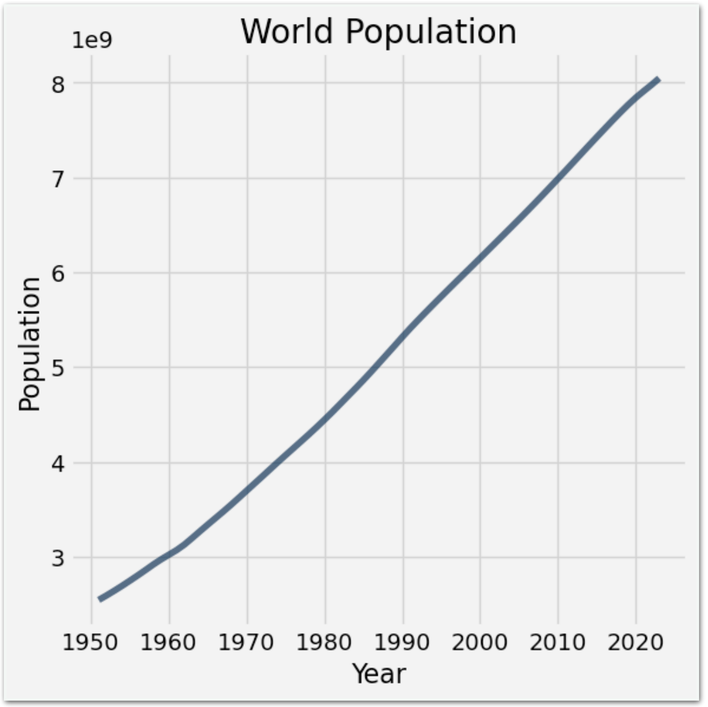
Line Plots

Line plots: good for sequential data if

- x-axis has an order (e.g., time, years, distance)
- sequential differences in y value are meaningful
- there's only one y-value for each x-value

Year	Population
1951	2.54313e+09
1952	2.59027e+09
1953	2.64028e+09
1954	2.69198e+09
1955	2.74607e+09
1956	2.801e+09
1957	2.85787e+09
1958	2.91611e+09
1959	2.97029e+09
1960	3.01923e+09

... (63 rows omitted)




```
tbl.plot(x_axis, y_axis)
```

- `pop_data.plot('Year', 'Population')`

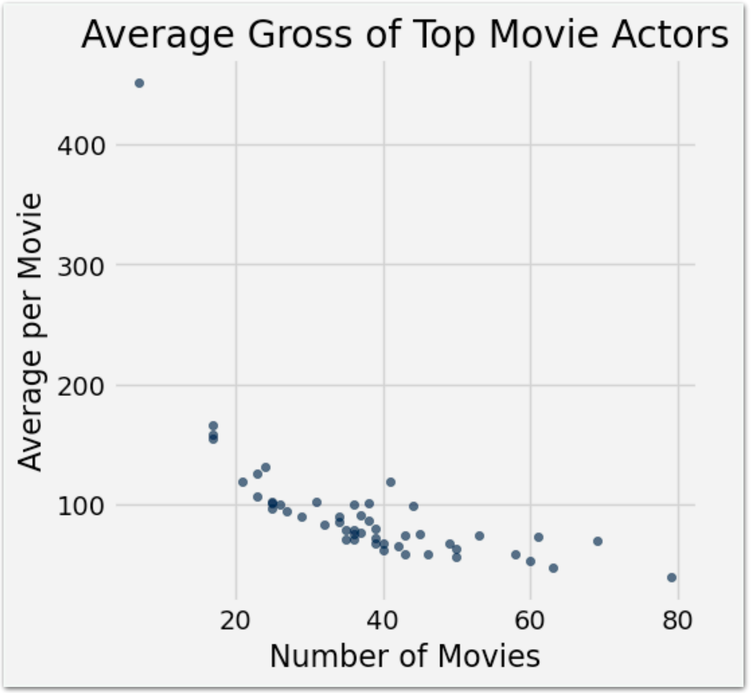
Scatter Plots

Scatter plots: good for non-sequential quantitative data

- Great for looking for associations

Actor	Total Gross	Number of Movies	Average per Movie	#1 Movie	Gross
Harrison Ford	4871.7	41	118.8	Star Wars: The Force Awakens	936.7
Samuel L. Jackson	4772.8	69	69.2	The Avengers	623.4
Morgan Freeman	4468.3	61	73.3	The Dark Knight	534.9
Tom Hanks	4340.8	44	98.7	Toy Story 3	415
Robert Downey, Jr.	3947.3	53	74.5	The Avengers	623.4
Eddie Murphy	3810.4	38	100.3	Shrek 2	441.2
Tom Cruise	3587.2	36	99.6	War of the Worlds	234.3
Johnny Depp	3368.6	45	74.9	Dead Man's Chest	423.3
Michael Caine	3351.5	58	57.8	The Dark Knight	534.9
Scarlett Johansson	3341.2	37	90.3	The Avengers	623.4

... (40 rows omitted)




```
tbl.scatter(x_axis, y_axis)
```

- `actor.scatter('Number of Movies', 'Average per Movie')`

Plot Notebook Demo

Visualizing Categorical Data

Recall: Types of Attributes

- Attributes are the names of columns in tables
- All values in a column should be the same type and comparable to each other
  - **Numerical -** Values are on a numerical scale (e.g., years)
    - Values are *ordered*
    - Differences are meaningful
  - **Categorical -** Each value is from a fixed inventory (e.g., material)
    - May not have an ordering
    - Categories are either the same or different

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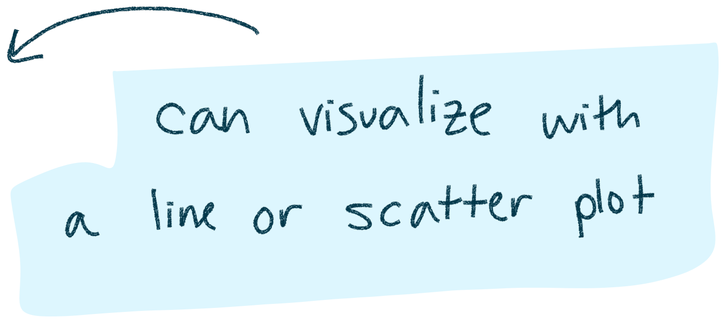


Is this a numerical or categorical attribute?

Track and field: The **distance a shotput** is thrown (in feet)

[77, 54, 63, 70]

Is this a numerical or categorical attribute?

Gymnastics: **Events that gymnasts can perform in**

[‘floor exercise’, ‘pommel horse’, ‘rings’, ‘parallel bars’]

Is this a numerical or categorical attribute?

Swimming: **Race distances (in meters)**

[50, 100, 200, 400, 800]

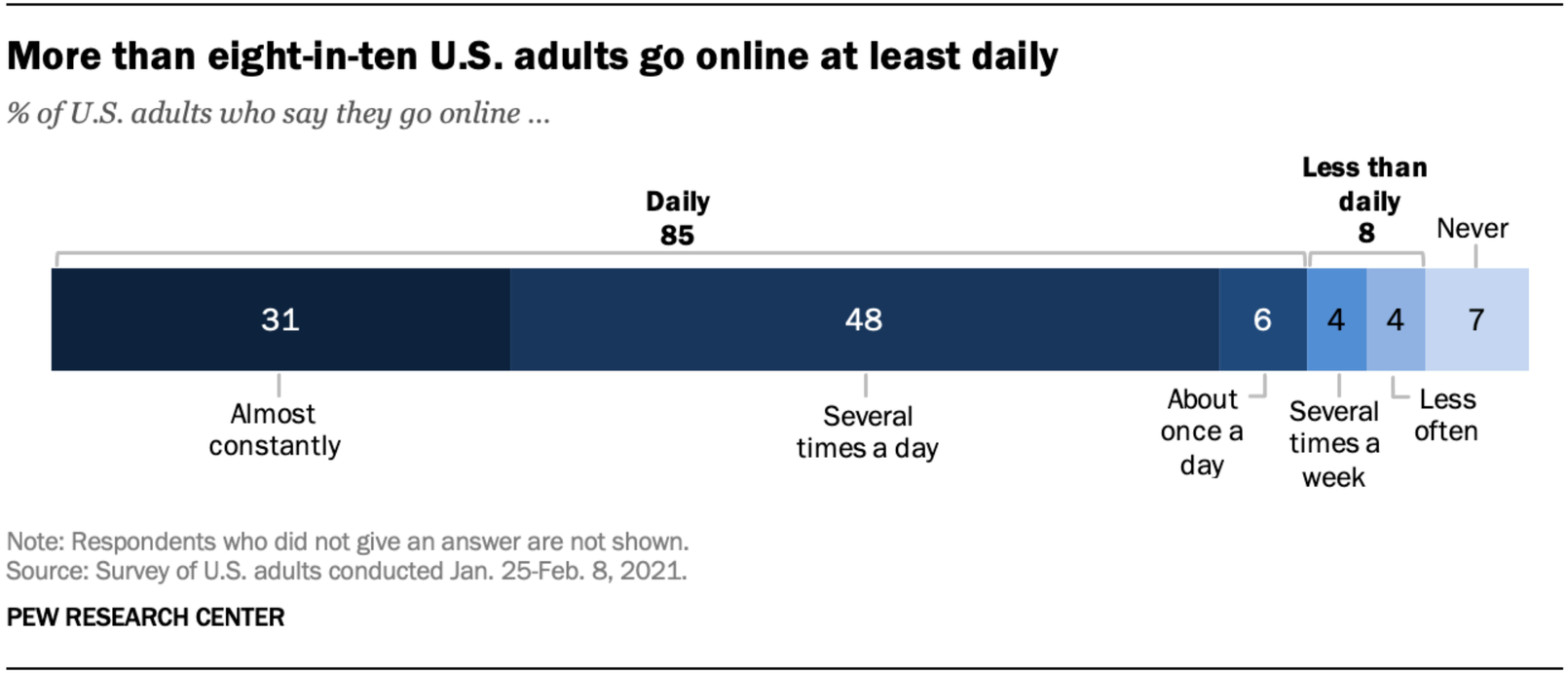
Terminology

- Individuals are rows in a column (instances of data)
- Categorical Variable are attributes (columns)
  - Each individual has exactly one value
  - Has a distribution
    - For each different value of a variable, there is a frequency of individuals that have that value

Distribution

Each individual has exactly one category

- Percents add to 100



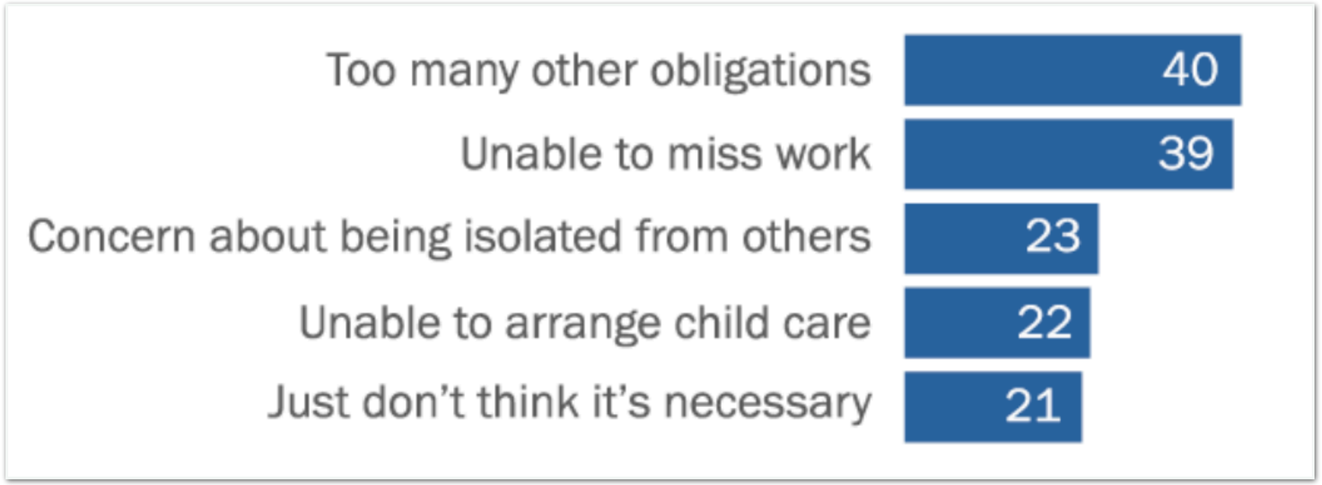
Source: Pew Research

Not a distribution

When individuals can pick more than one answer

- Percents don’t necessarily add up to 100

Survey question: “A major reason you would find it difficult to quarantine for 14 days”



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Bar Chart: Categorical Distributions

Bar charts: display categorical variables and frequencies

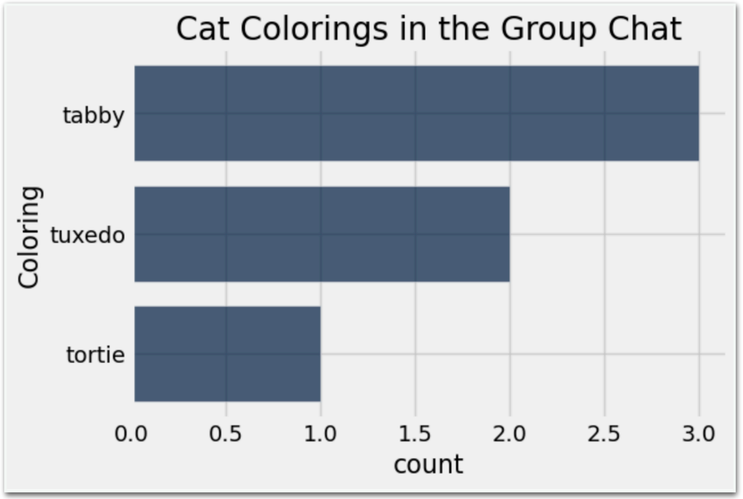
- One bar for each category
- Ordering of the bar can be specified (e.g. `.sort`)
- Length of bar is either count or % of individuals in that particular category

category ↓ frequency ↓

Coloring	count
tabby	3
tuxedo	2
tortie	1

```
tbl.barh(category_label, freq_label)
```

- `cat_tbl.barh('Coloring', 'count')`
- `cat_tbl.barh('Coloring')`



Categorical Bar Chart Demo

Creating Histograms for Numerical Distributions

Visualizing Numerical Distributions

Let's say we have a data set containing grades students scored on an exam:

```
array([ 56,  83,  99,  87,  90,  73,  82,  88,  88,  90,  72,  77,  75,
        85,  83,  88,  75,  93,  94,  86,  85,  87,  78,  63,  97,  96,
        87,  66,  90,  91,  81,  81,  85,  70,  58,  77,  92,  66,  85,
        93,  79,  85,  79,  90,  98,  75,  83,  76,  86,  82,  90,  67,
        72,  90,  85,  91,  69,  94,  92,  99,  92,  92,  80,  72,  82,
        91,  96,  90, 100,  90,  84,  80,  64,  71,  99,  92])
```

What if we want to know generally how students on the exam?

- Useful to sort these into groups (bins)
- Compare the size of these bins

Grouping Numerical Values into Bins

Binning is counting the number of numerical values that lie within a range (which is called bins)

- Bins are defined by their lower bounds (inclusive)

- The upper bound is the lower bound for the next bin)

  - Example: [10, 20)

Binning: Example

[1, 5, 7, 3, 2, 11, 18, 16, 15, 10, 22, 27, 4]

Binning: Example

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Let’s say we decide to use a bin size of 5

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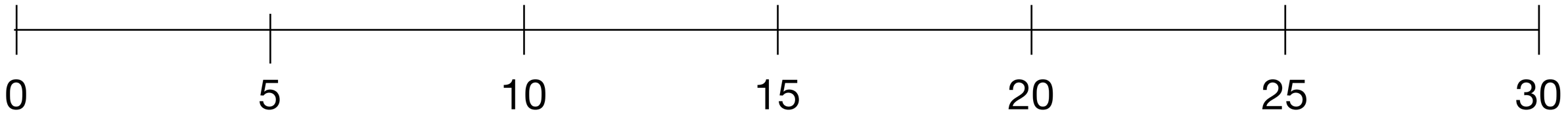
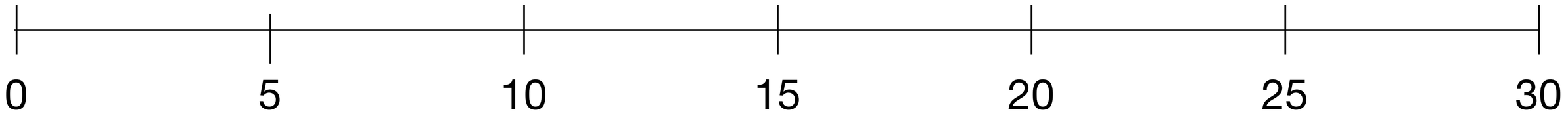


Binning: Example

[1, 5, 7, 3, 2, 11, 18, 16, 15, 10, 22, 27, 4]

What bin would 5 fall into?



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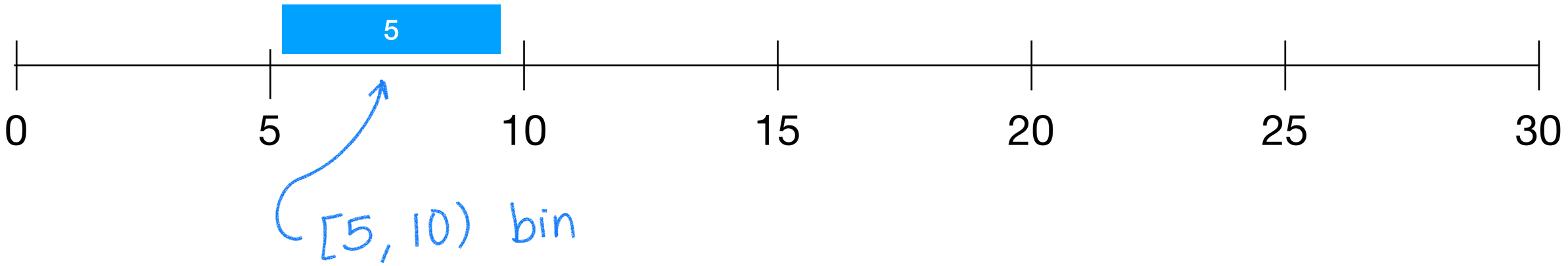
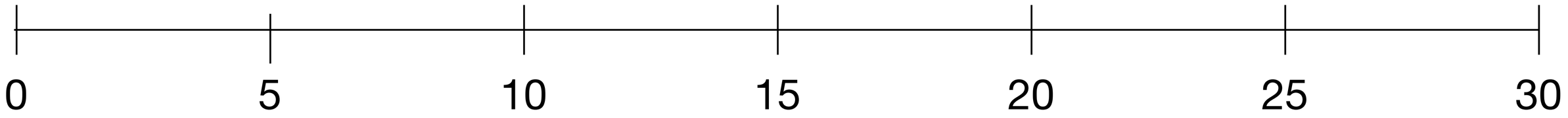


Binning: Example

[1, 5, 7, 3, 2, 11, 18, 16, 15, 10, 22, 27, 4]

How many individuals fall into bin 15-20?



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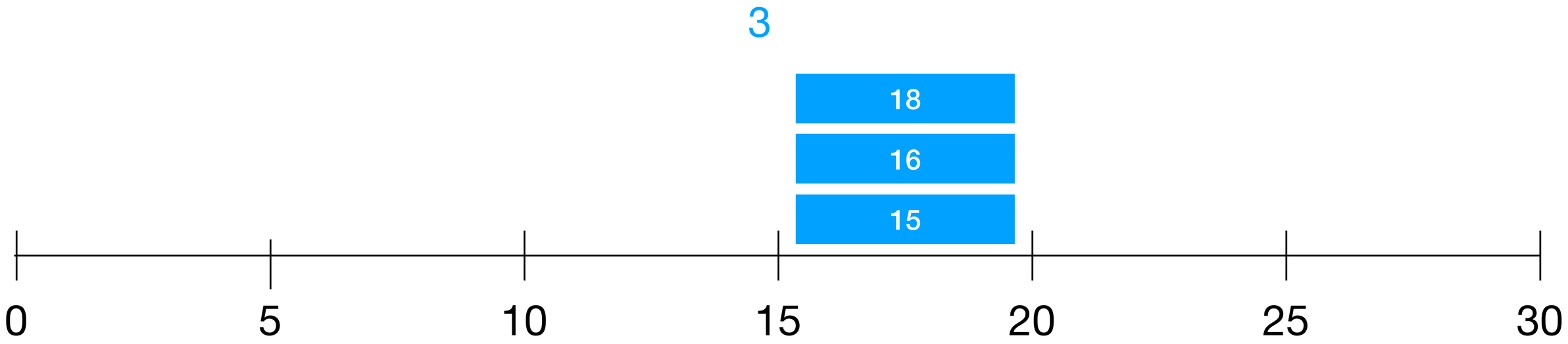

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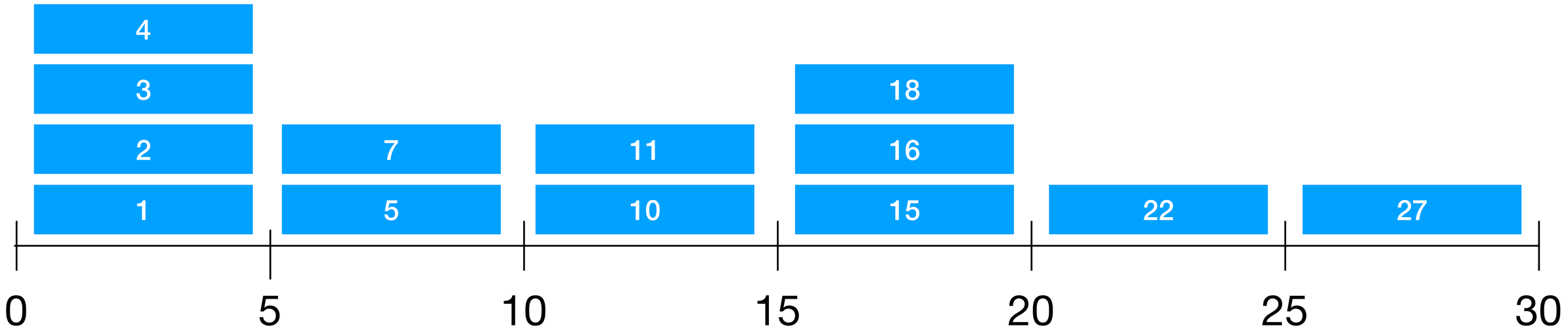

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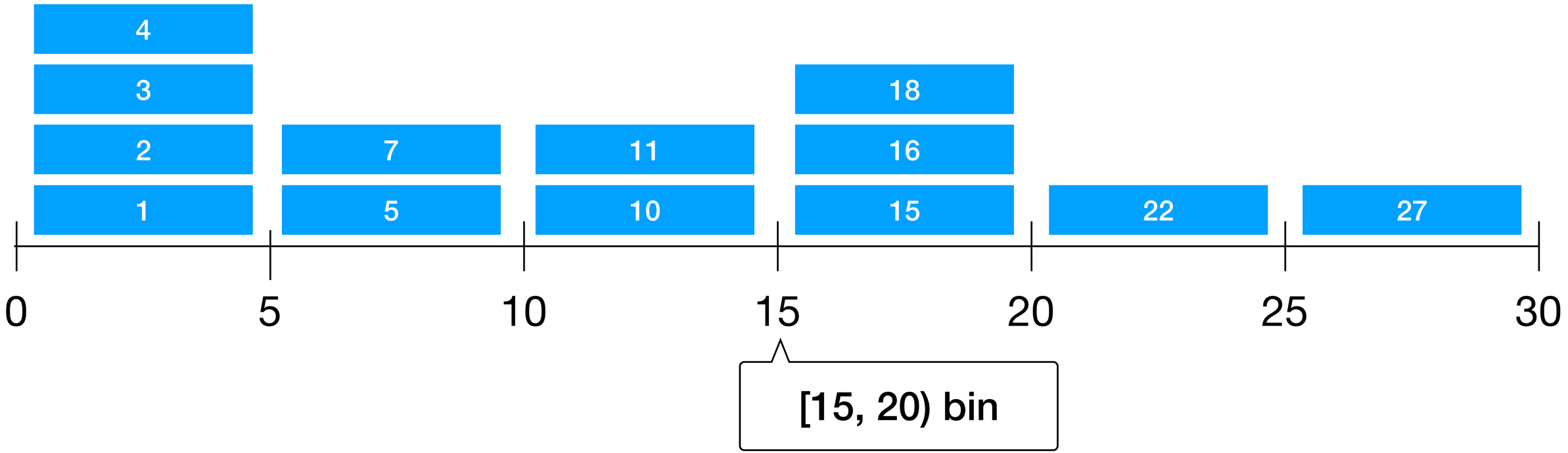

Choosing Bin Size

Let’s go back to our data from before:

```
array([ 56,  83,  99,  87,  90,  73,  82,  88,  88,  90,  72,  77,  75,
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        93,  79,  85,  79,  90,  98,  75,  83,  76,  86,  82,  90,  67,
        72,  90,  85,  91,  69,  94,  92,  99,  92,  92,  80,  72,  82,
        91,  96,  90, 100,  90,  84,  80,  64,  71,  99,  92])
```

Choosing Bin Size

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```
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        93,  79,  85,  79,  90,  98,  75,  83,  76,  86,  82,  90,  67,
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        91,  96,  90, 100,  90,  84,  80,  64,  71,  99,  92])
```
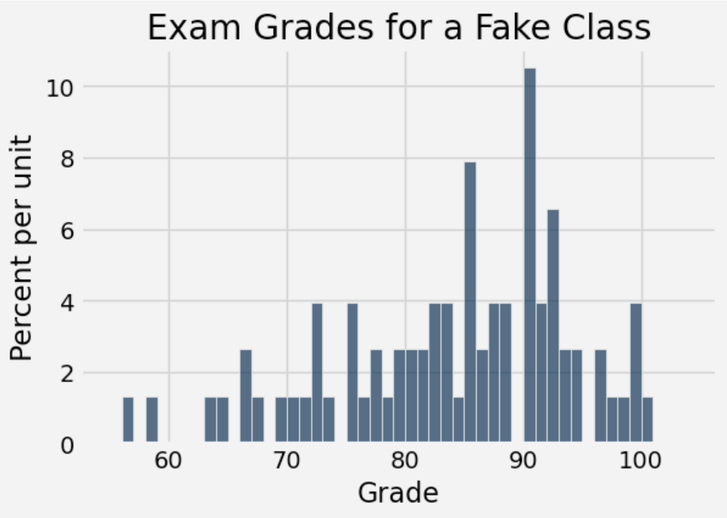
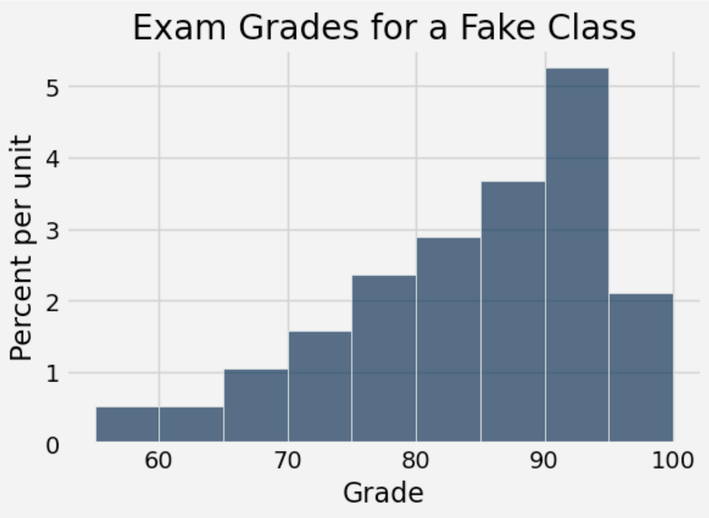
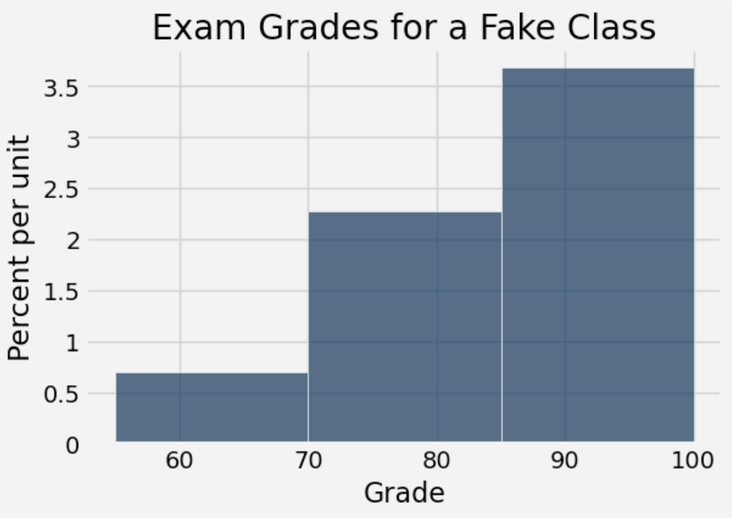

Bin size = 1



Bin size = 5

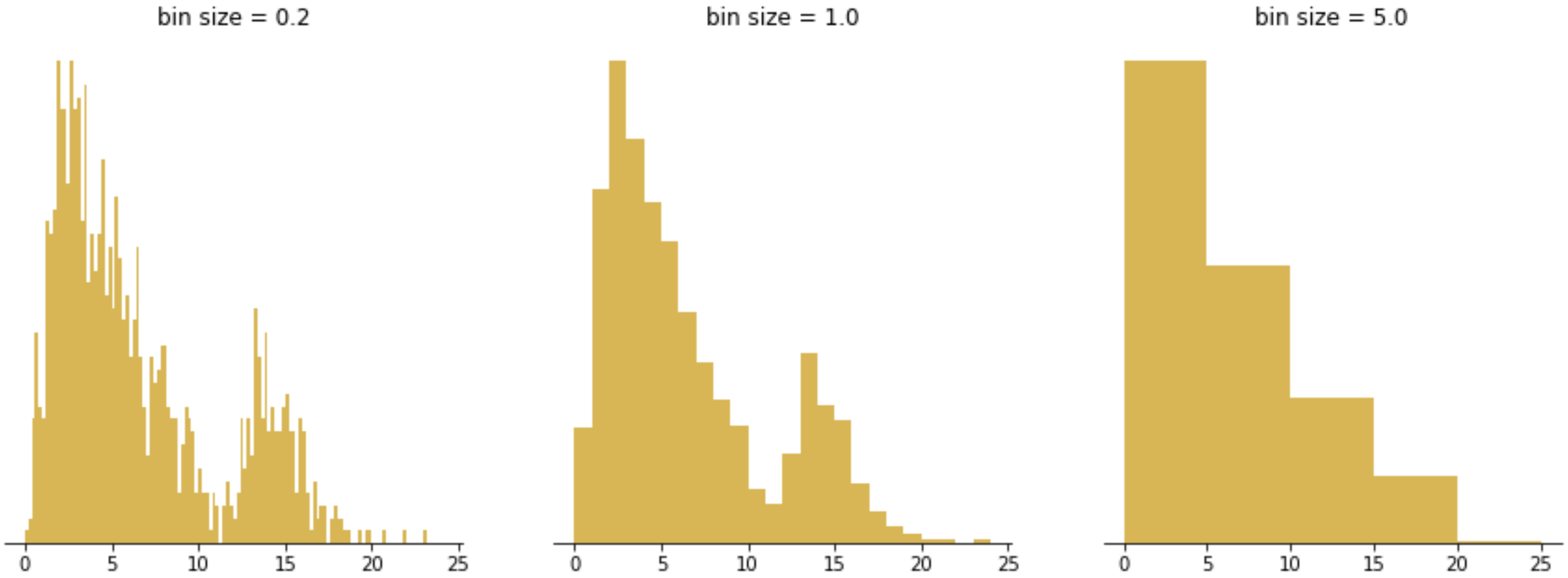


Bin size = 15



Choosing Bin Size

Chose so that it’s representative of your data



https://www.atlassian.com/data/charts/histogram-complete-guide

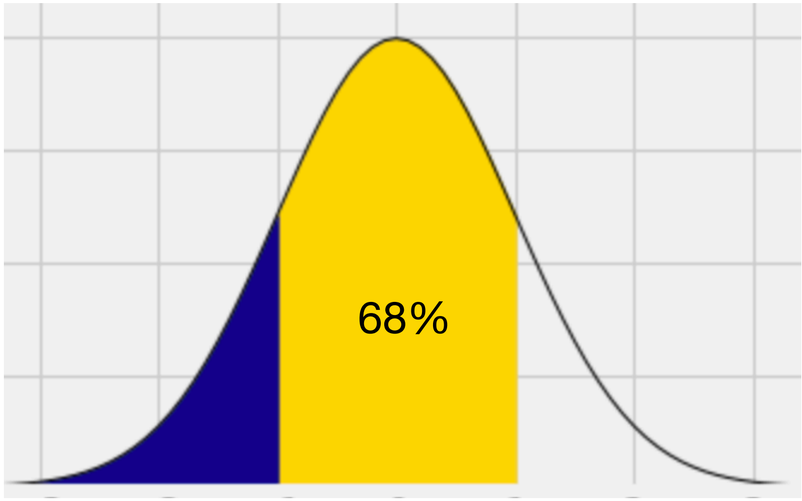
Histogram Notebook Demo - Bins

Area Principle

Areas should be *proportional* to the values they represent

In a histogram, the area of each bar is the percent of individuals in the corresponding bin

(Later on in the course, we will approximate histograms with smooth curves)



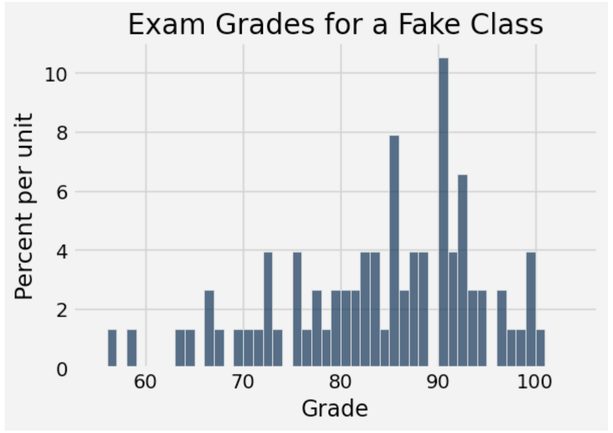
Area Principle

$$\text{area of bar} = \text{percent of entries in bin}$$

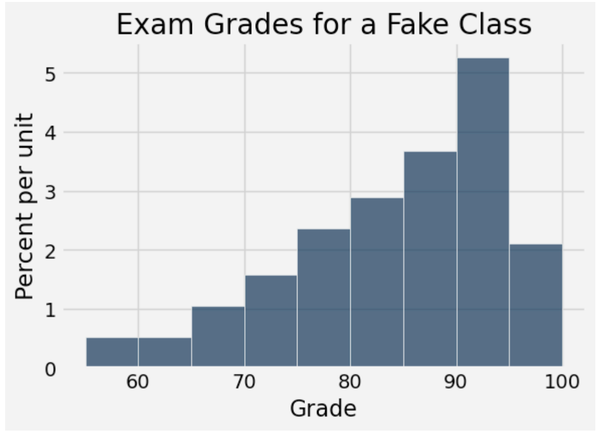
$$\text{area of bar} = (\text{height of bar}) \times (\text{width of bin})$$

$$\text{height of bar} = \frac{\text{area of bar}}{\text{width of bin}} = \frac{\text{percent of entries in bin}}{\text{width of bin}}$$

Bin size = 1



Bin size = 5



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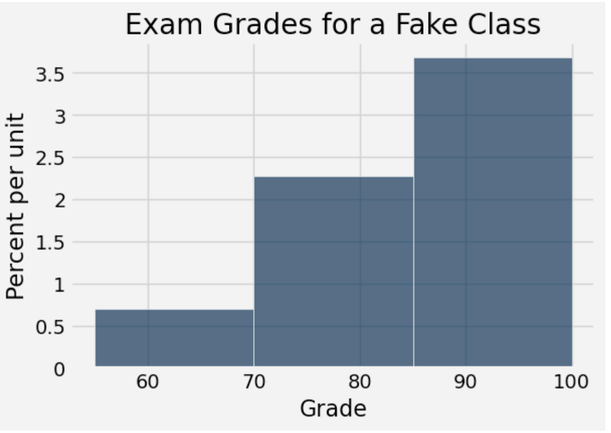

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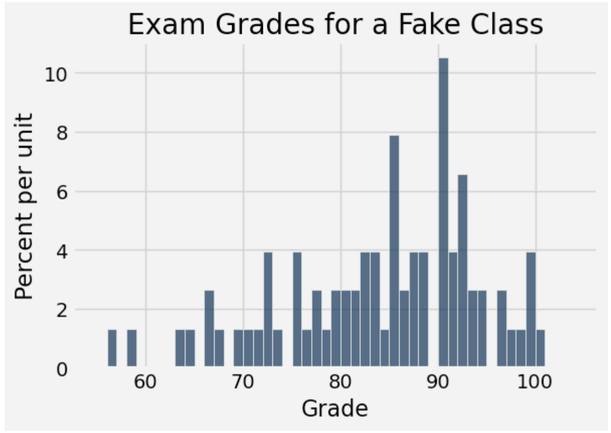
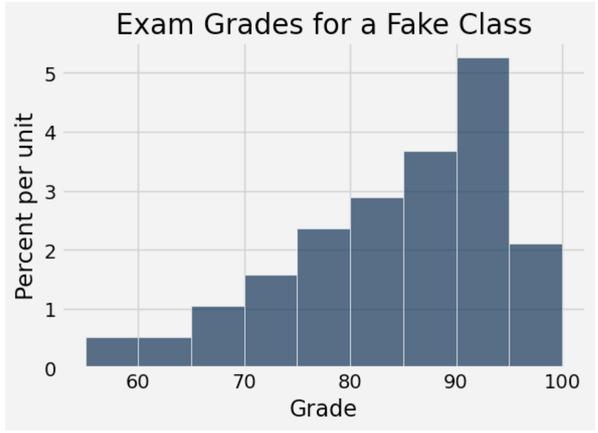
when bin size is 1:

$$\text{height} = \frac{\text{area of bar}}{\text{width of bin}} = \frac{\text{area of bar}}{1} = \frac{\%\text{ of entries in bin}}{1}$$

Bin size = 1



Bin size = 5



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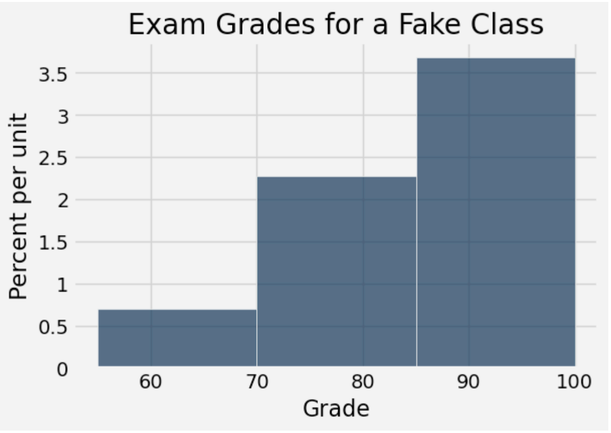

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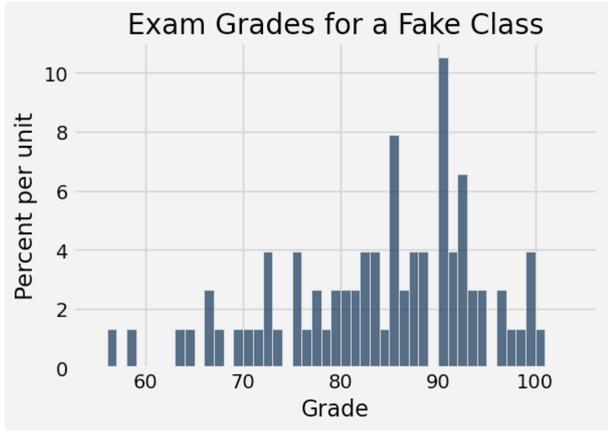
When bin size is 5:

$$\text{height} = \frac{\%\text{ entries in bin}}{5}$$

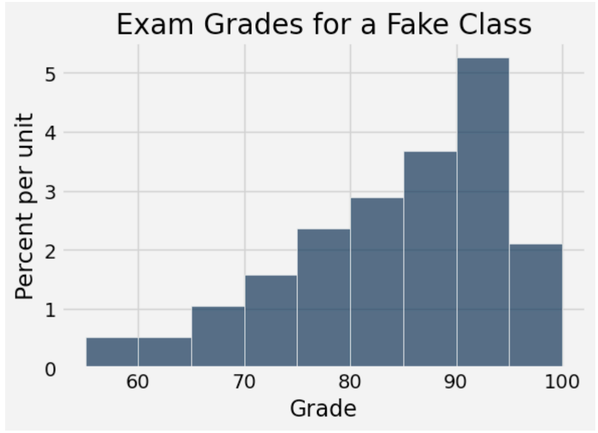
When bin size is 15:

$$\text{height} = \frac{\%\text{ entries in bin}}{15}$$

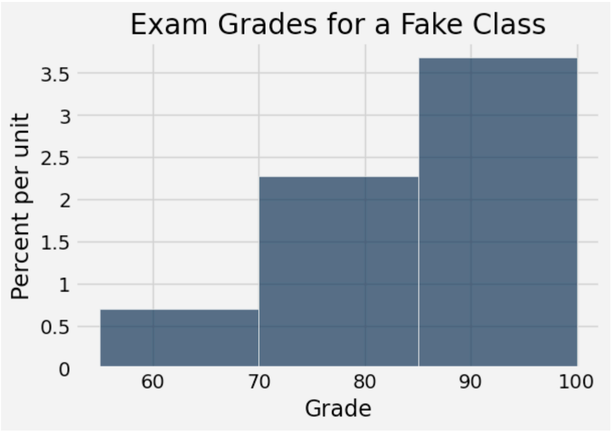
Bin size = 1



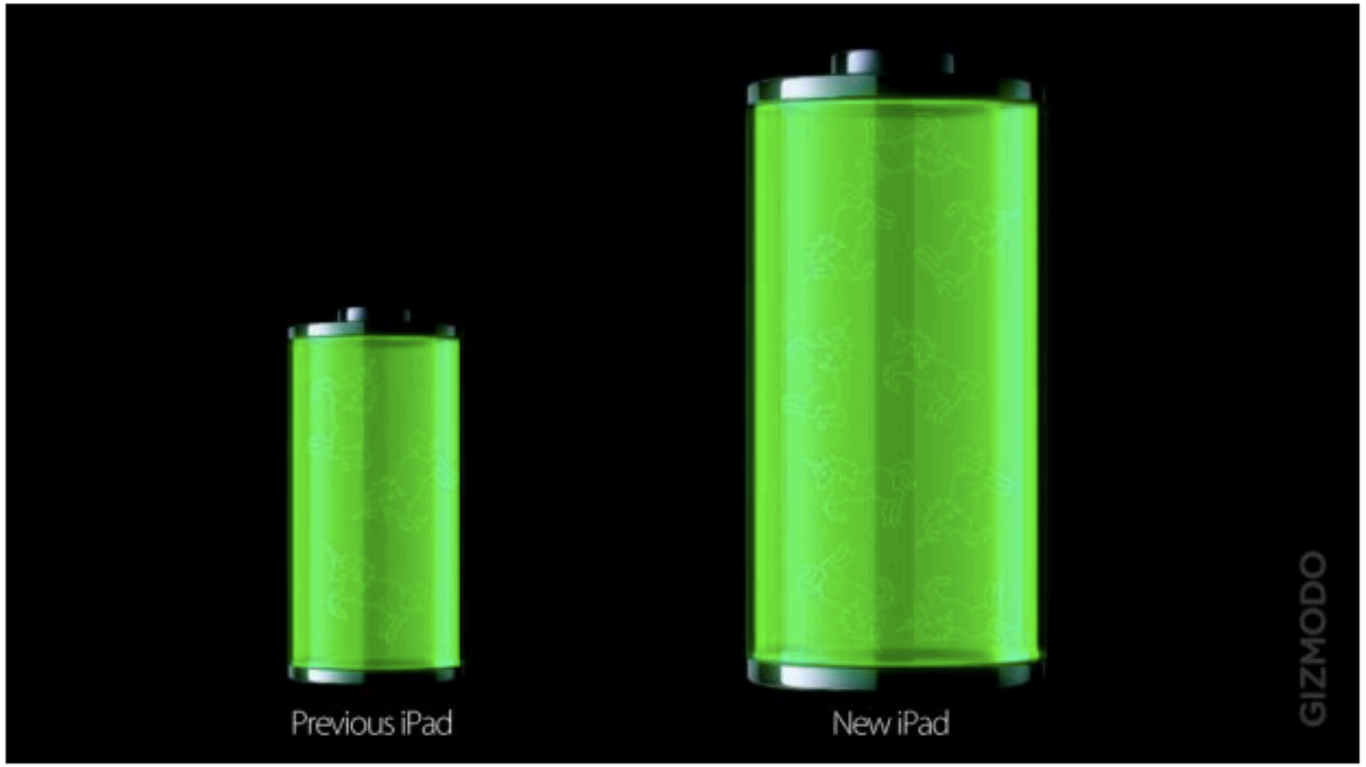
Bin size = 5



Bin size = 15

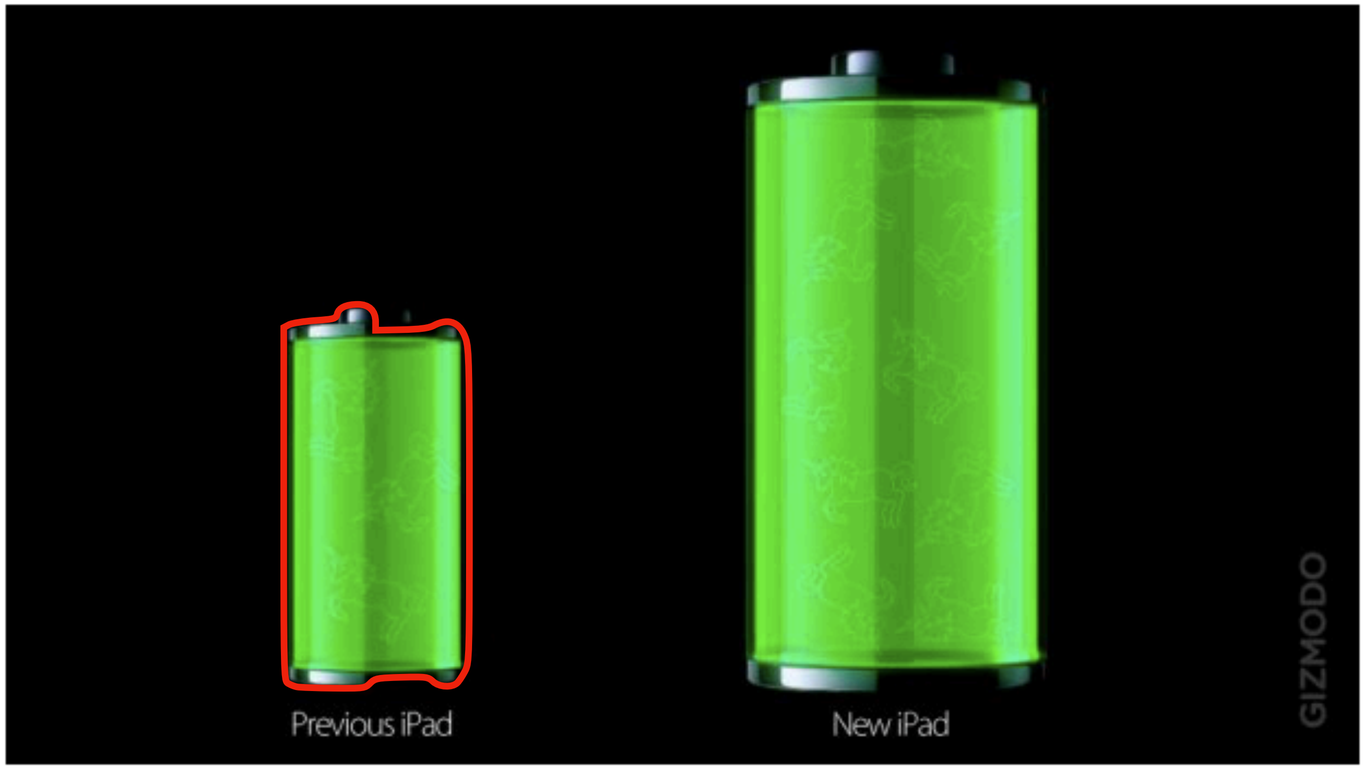


Area Principle



From Gizmodo, this shows battery size in the new iPad versus that of the iPad 2. The battery in the former is 70 percent bigger than that of the latter. Something's not right here.

Area Principle



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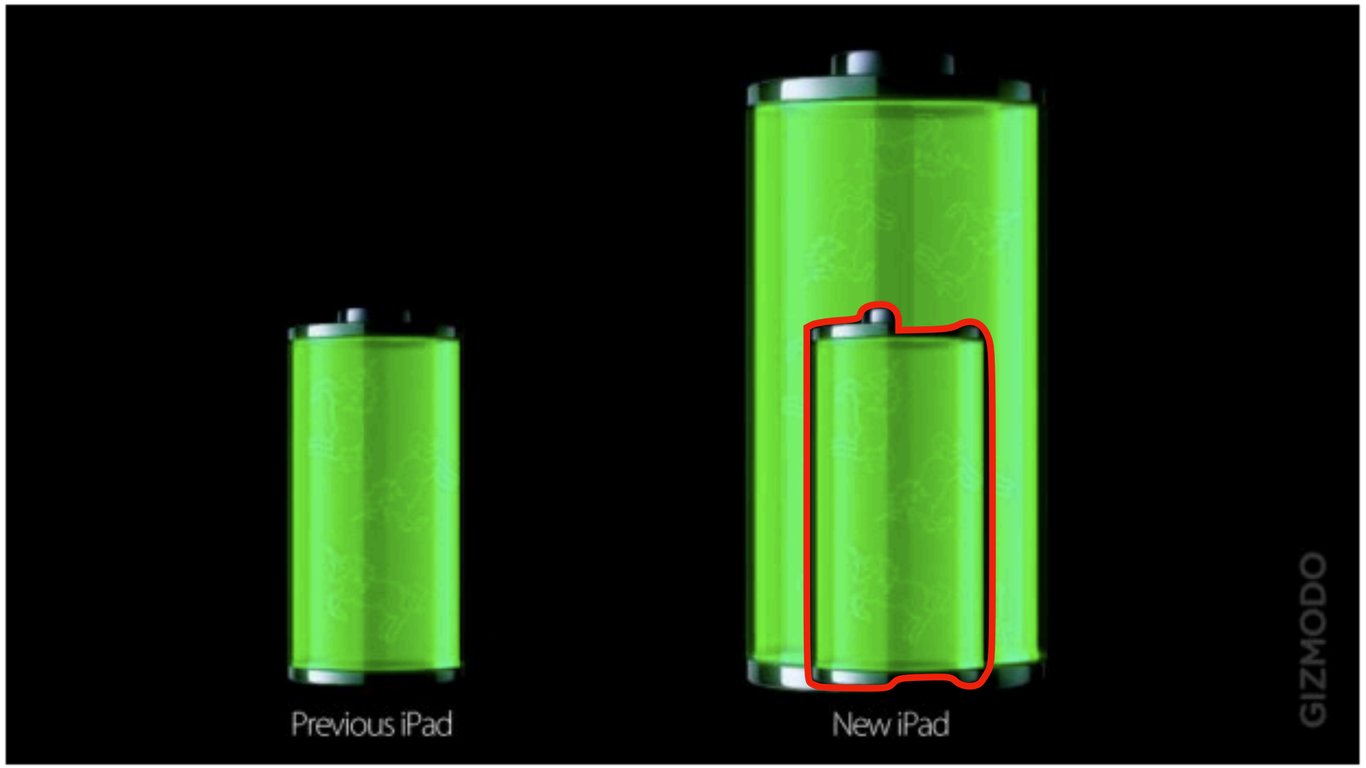
Area Principle



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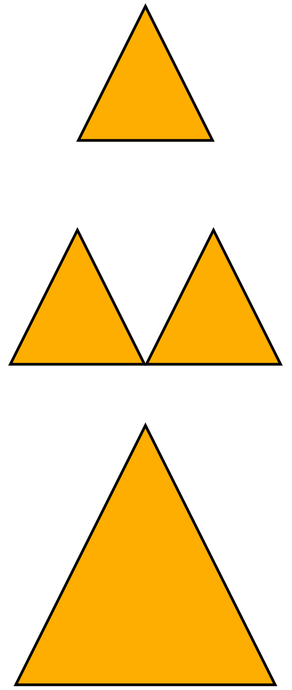
Area Principle

Areas should be proportional to the values they represent

- For example
  - If you represent 20% of a population by:
  - Then 40% can be represented by:
  - But not by:



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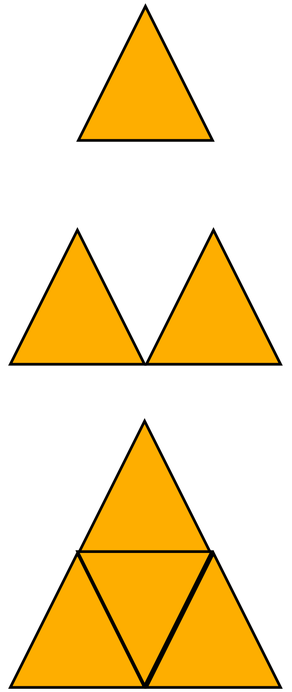
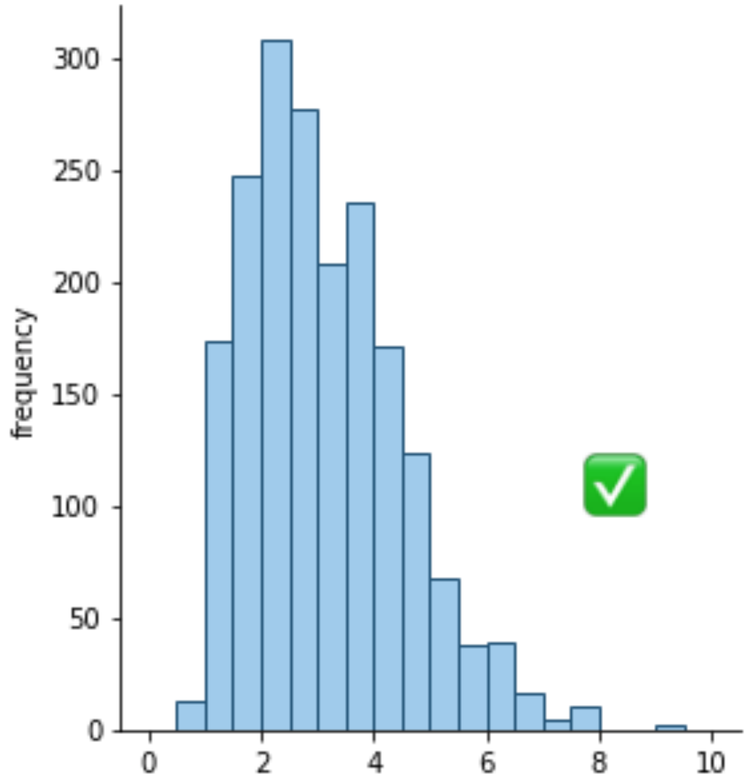


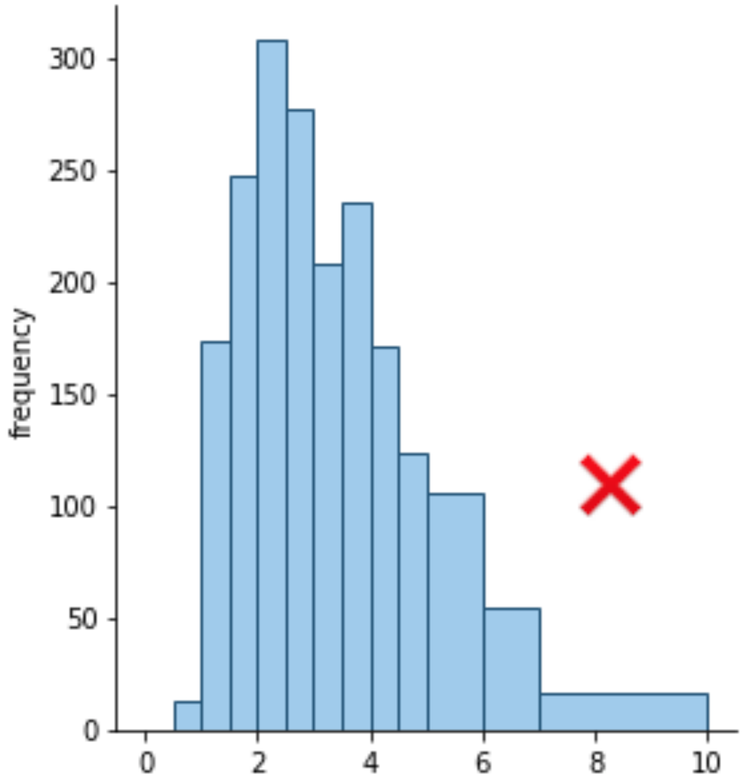
Unequal Bin Sizes

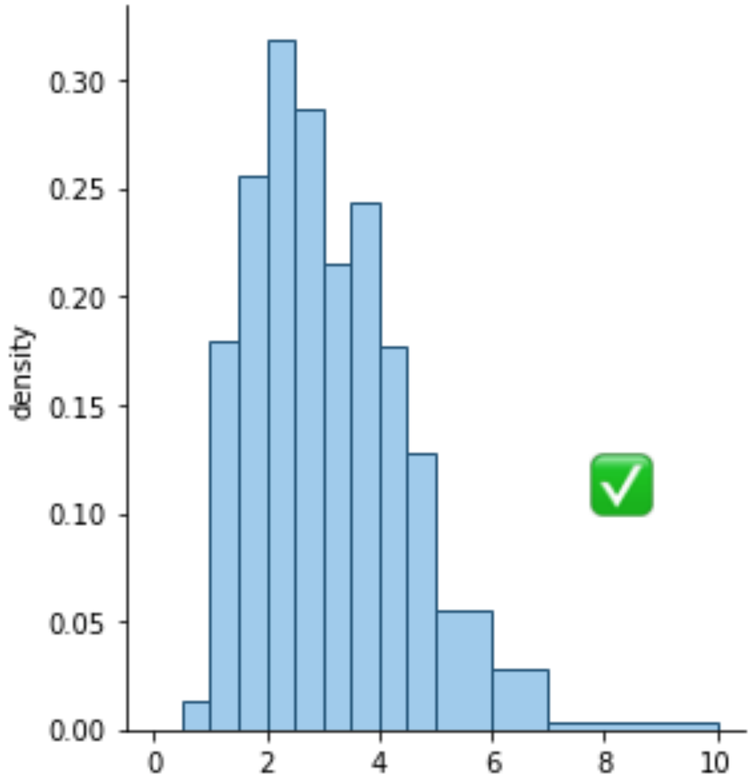
Bin sizes don’t need to be equal

- unequal bin size is often used for better representing tails

For unequal bin sizes - vertical axis now represents ***density*** rather than frequency







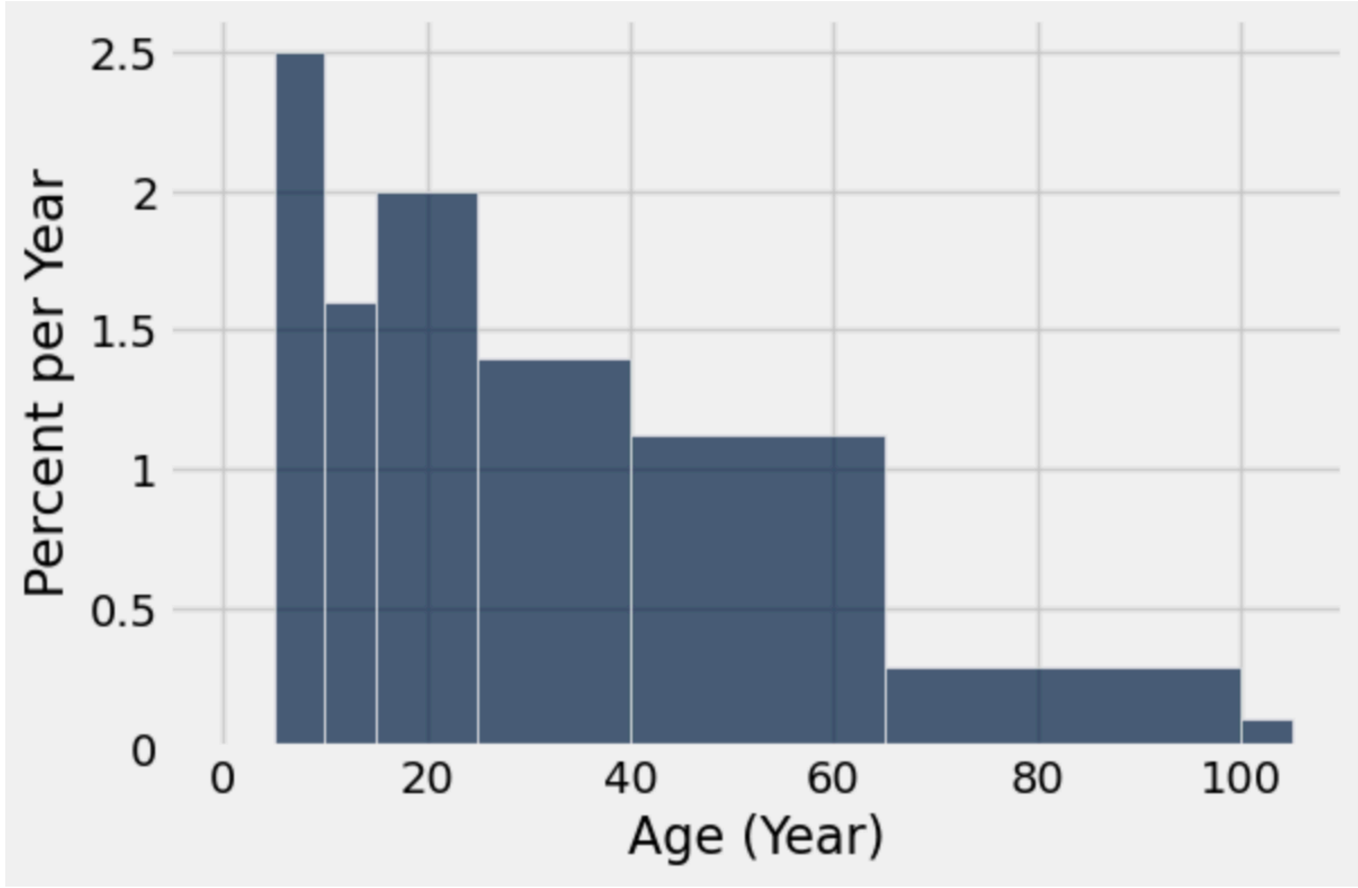
https://www.atlassian.com/data/charts/histogram-complete-guide

Histograms

The area of each bar is a percentage of the whole

The horizontal axis is a numerical distribution - the bins don’t need to be of equal size

The vertical axis is a rate (e.g., percent/year) - density



Calculating Heights

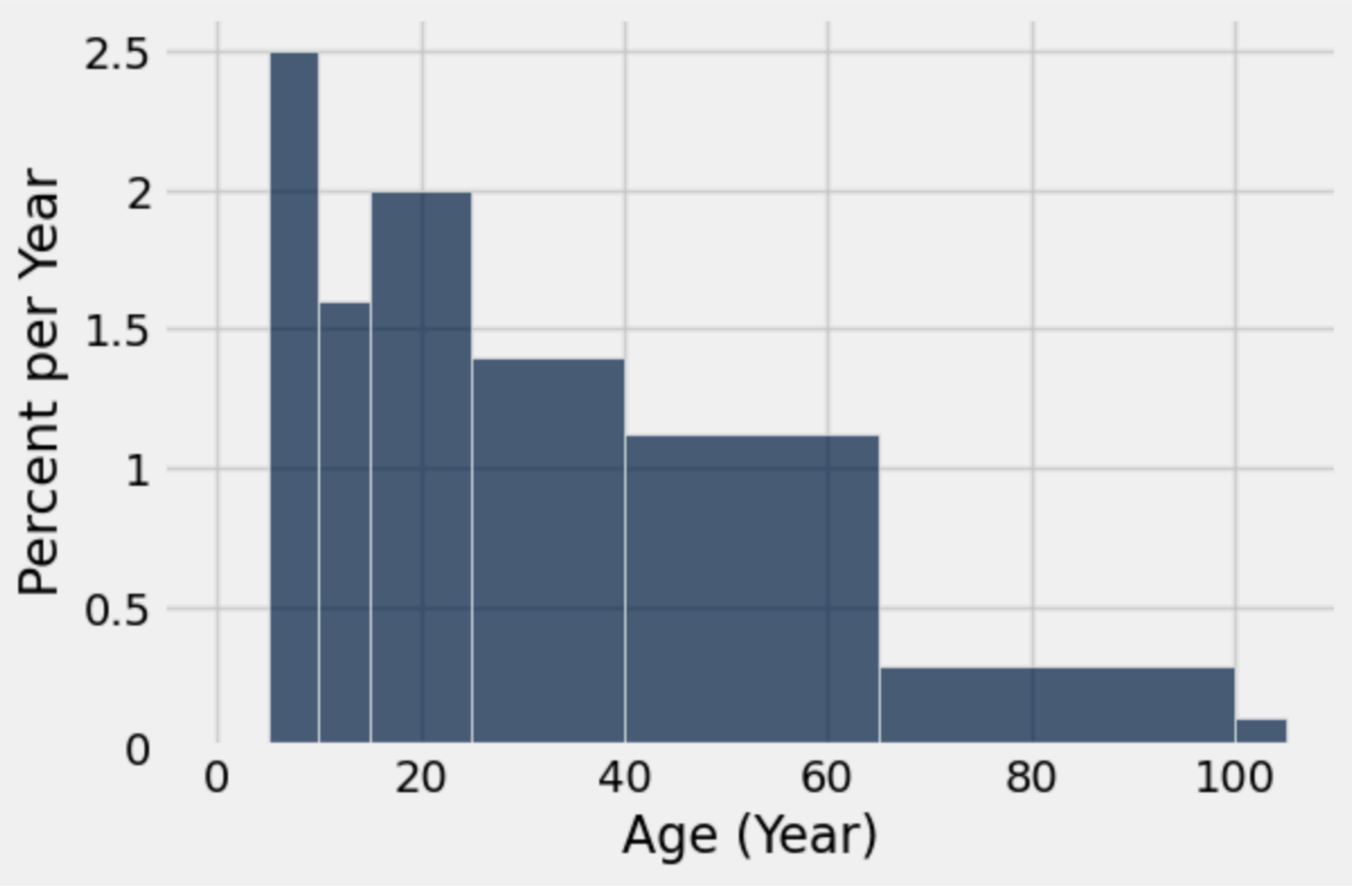
The [40, 65) bin contains 56/200 items

- The bin is 28% (56/200) of the whole

- The bin width is 65-40 = 25 years

- Height = $\frac{\text{28 percent}}{\text{25 years}}$

$$= 1.12\% \text{ per year}$$



Area Notebook Demo

Bar Chart vs Histogram

Bar Chart

- Distribution of categorical variable
- Length of bars is proportional to the frequency / percent of individuals

Histogram

- Distribution of numerical variable
- Horizontal axis is numerical, bins can be unequal
- Area of bars is proportional of percent of individuals, height measures density

Next Class

- More charts