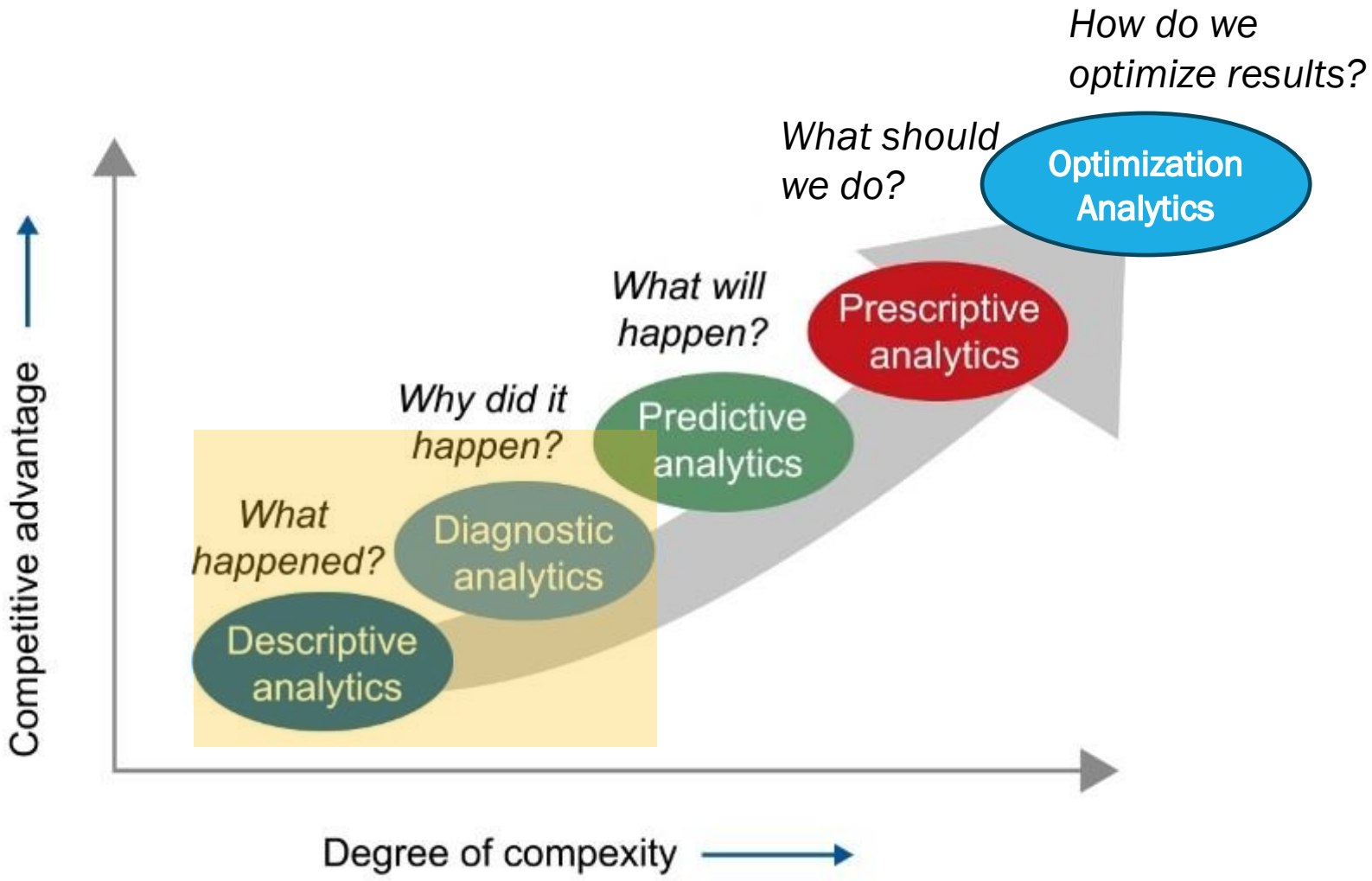
DATA SAMPLING

HIERARCHY OF DATA ANALYSIS TYPES



POPULATION VS SAMPLE

- Ideally, analyze all data for insights.
- Examples:
  - A mobile company wants to assess all potential customers.
  - A government must consider all citizens' needs for a new service.
- Full data collection is often impractical due to:
  - High costs of data acquisition
  - Time constraints
  - Computational and storage limitations
  - Increased complexity in processing large datasets
- Solution: Select a representative, make inference

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DATA SAMPLING

A ***Sampling Method*** is a process to select a subset of observations from the entire population. Ideally, the observations in the sample are representative of the population. Common methods include:

- **Random Sampling:** Each subset of n units is equally likely to be chosen.
- **Stratified Sampling:** The population is divided into meaningful groups (strata), and samples are drawn from each.
- **Cluster Sampling:** The population is divided into clusters (unrelated to key study features), and some clusters are randomly selected.
- **Systematic Sampling:** Every kth observation is selected from a random starting point, where $k \approx$ (population size) / n.
- **Convenience Sampling:** Easily accessible observations are selected (non-random).

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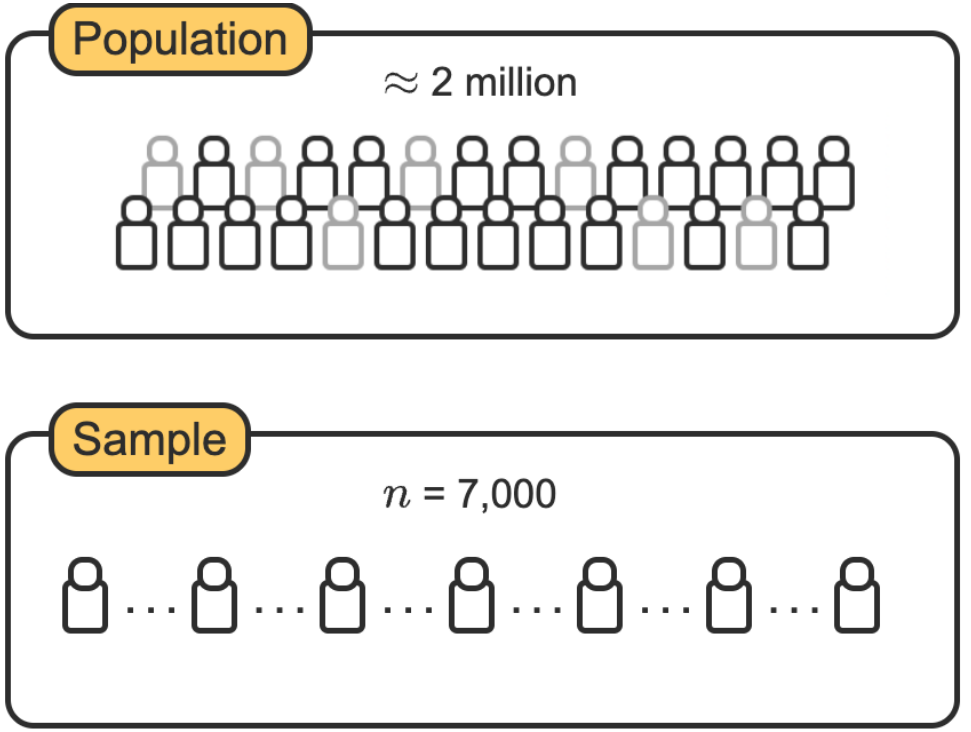
SAMPLING SCENARIO

- A ***population*** is the entire set of all individuals, items, or events of interest.
- An ***observational unit (aka observation)*** is an individual, item, or event of the population where data is recorded.
- A ***sample*** is a subset of observations from the population used for analysis.
- Example: Transportation satisfaction survey across 5 cities.



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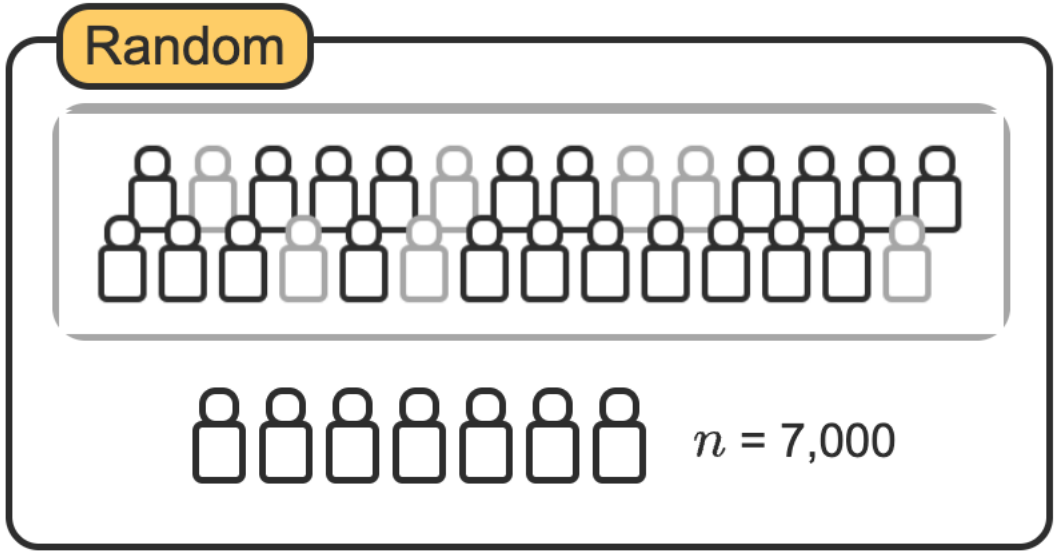
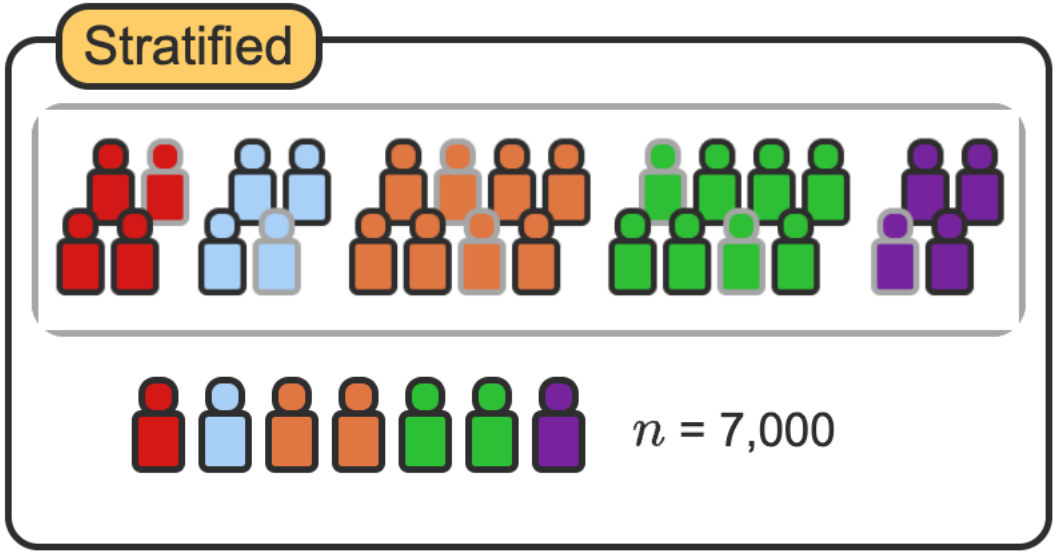
RANDOM SAMPLING

- In random sampling, passengers are selected at random from a list of all passengers in the five cities.
- Random sampling reduces the potential for sampling bias.
- But this could result in missing important events that occur less frequently.



STRATIFIED SAMPLING

- Passengers are first divided into groups based on city.
- Then from each group, passengers are selected at random.
- Unlike pure random sampling, stratified sampling ensures adequate representation from each city.
- This is especially important when working with data that includes events that are relatively rare (e.g., customer churn, network intrusion, cancer cell detection, etc.)



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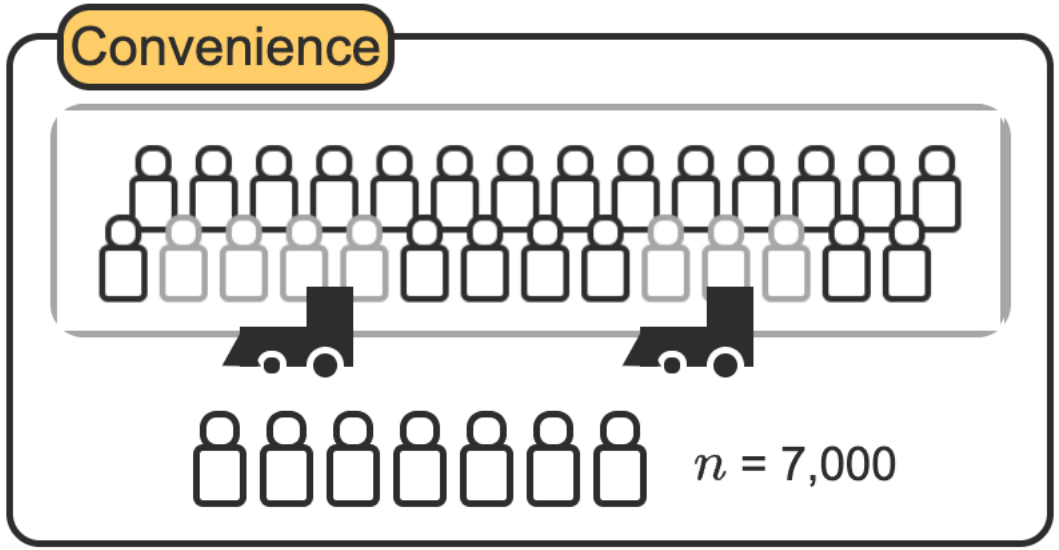
CONVENIENCE SAMPLING

- Select passengers waiting in the train stations uses convenience sampling.
- This method is easy and quick, but the sample is not likely representative of all train passengers.



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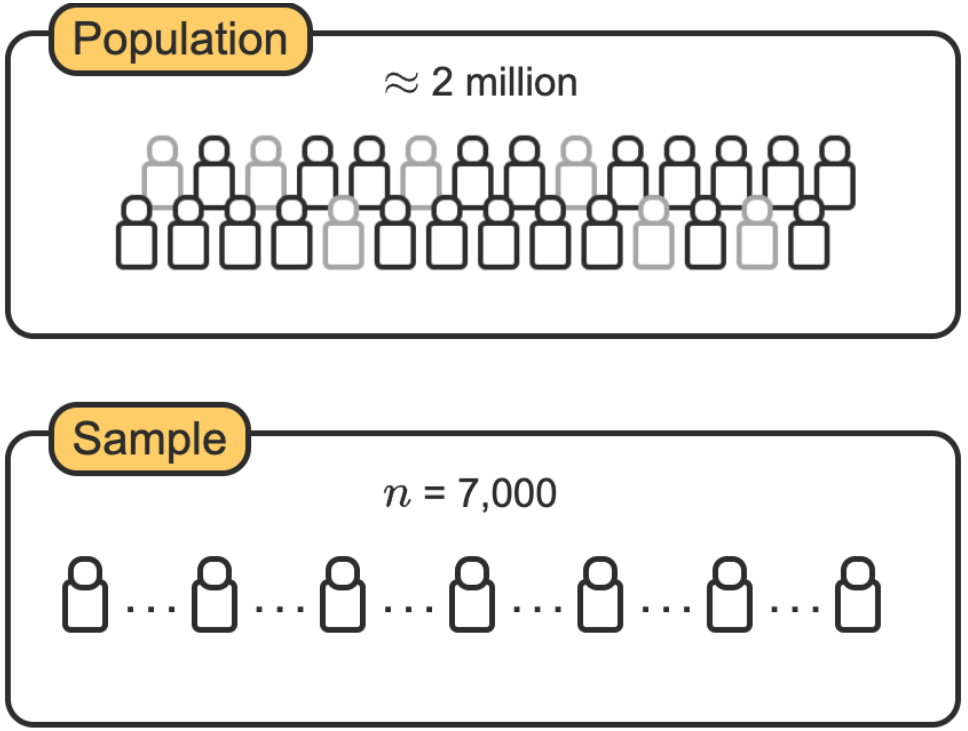
SYSTEMATIC SAMPLING

- Every 286th passenger from a list of all 2 million potential passengers is selected for the sample.
- Population / sample size = selection criteria
- Depending on ordering of the list, this could be close to random, or highly biased.

Select every 286th person



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SAMPLING IN PYTHON

- The pandas method DataFrame.sample(n=None, frac=None, replace=False, random_state=None) returns a random sample of items from a dataframe.
- n or frac specify the number, or fraction, of items to be returned in the sample.
- replace= parameter specifies whether sampling is done with (True) or without (False) replacement.
- random_state= parameter optionally sets the random number generator seed for reproducible sampling.
- weights controls the likelihood of each row (or column) being selected. Weights can be a list/array of values or a column name in the DataFrame. The weights do not need to sum to 1; Pandas normalizes them automatically.
- **axis**= The axis to sample
- **ignore_index**= reset the index to 0,1,2,3…

```
DataFrame.sample(n=None, frac=None, replace=False, weights=None,
random_state=None, axis=None, ignore_index=False)
```

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PYTHON EXAMPLES, SAMPLING

- https://colab.research.google.com/github/rhodes-byu/cs180-winter25/blob/main/notebooks/06-sampling.ipynb

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SAMPLING DISTRIBUTION – NOT ALL SAMPLES EQUAL

A **sampling distribution** is like taking many small samples from a big jar of jellybeans and calculating the average number of red beans in each sample. If you repeat this process over and over, you'll get a bunch of different averages.

Now, imagine plotting those averages on a graph—you'll notice that most of them cluster around the true average of the whole jar. This pattern of sample averages is the **sampling distribution**. It helps us understand how much the results can vary and lets us make better guesses about the whole jar without checking every single jellybean!

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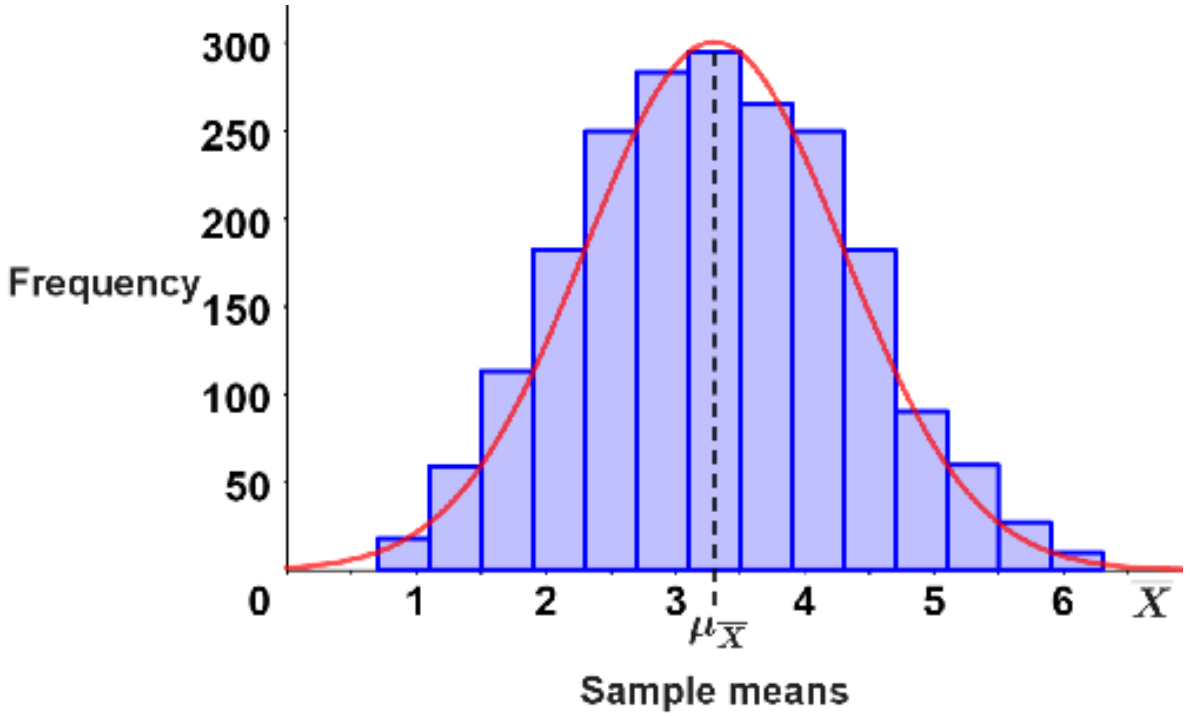
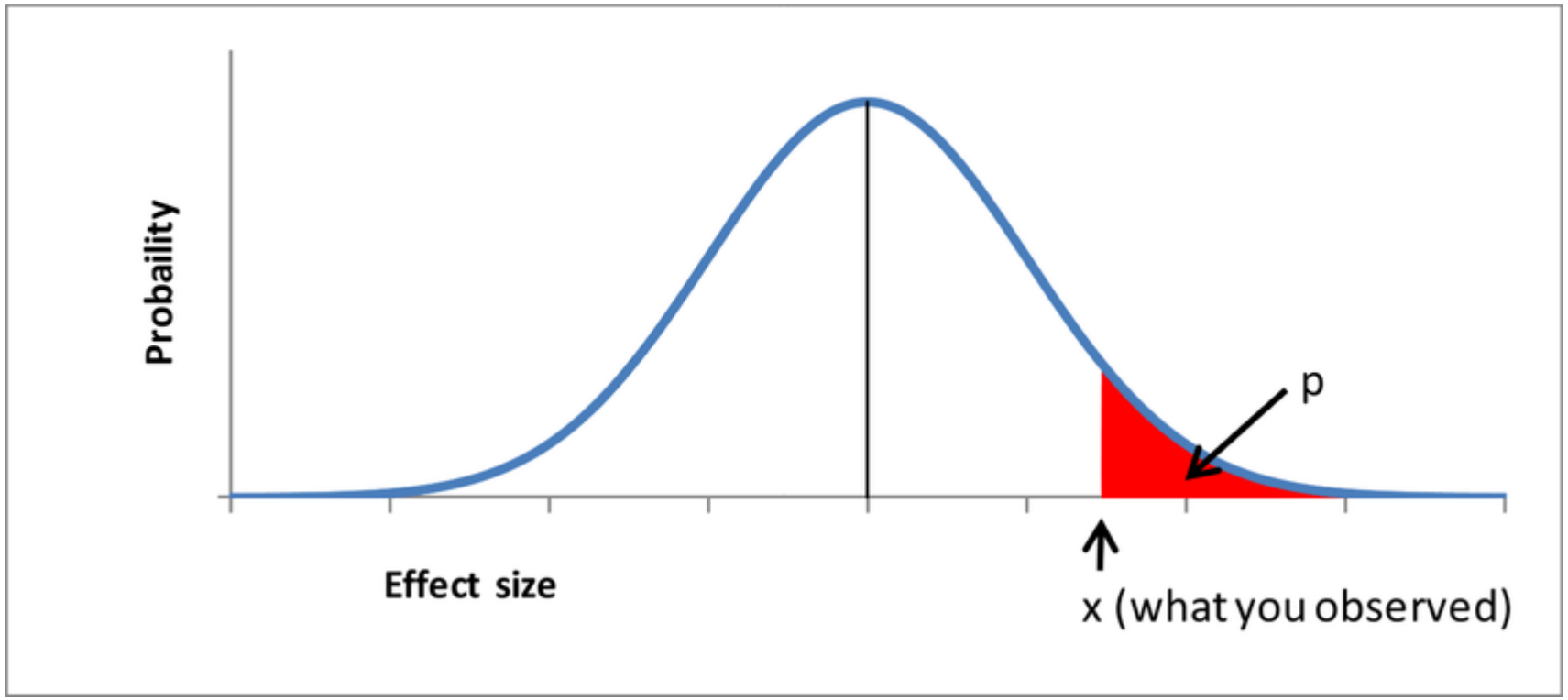
THE CENTRAL LIMIT THEOREM

- **The sampling distribution of the sample mean approaches a normal distribution as sample size increases, regardless of the population's original distribution** (assuming random sampling).
- Works well for large n (>30).



IS OUR SAMPLE SIGNIFICANTLY DIFFERENT THAN THE POPULATION?

Proportion of red beans…



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ONE-SAMPLE T-TEST

In the case of a **one-sample t-test** (where you are comparing the sample mean against a known population mean), the equation becomes:

$$t = \frac{\overline{X} - \mu}{\frac{S}{\sqrt{n}}}$$

Where:

- $\overline{X}$ is the sample mean,
- μ is the population mean,
- S is the sample standard deviation,
- n is the sample size.

This formula tests whether the sample mean $\overline{X}$ significantly differs from the population mean μ. The denominator represents the **standard error** of the mean.

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STATISTICAL SIGNIFICANCE IN PYTHON

- https://colab.research.google.com/github/rhodes-byu/cs180-winter25/blob/main/notebooks/07-stat-significance.ipynb

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