Testing Hypotheses


Are these fingernail lengths extreme?

Testing Hypotheses

1. Hypotheses and Testing Philosophies
2. Introducing the Frequentist P-Value
3. Test Statistics and All That
4. You're Doing it Wrong (or are you)

What is a Hypothesis? (in a statistical sense)

- **Point**: Mean Fingernail Length == 5cm
- **Model**: If I increase Kelp, Biodiversity increases
- **Explanatory**: Fertilizers explain more variation in the data than Pesticides

Three Flavors of Statistical Inference

1. **Frequentist:** What's the chance we observed something like the data given our hypothesis?

2. **Likelihoodist:** What's the likelihood of our hypothesis relative to others?

3. **Bayesian:** How much do we believe our hypothesis given our data?

Frequentist Inference: the probability of observing this data, or more extreme data, given that a hypothesis is true

P-value
or
Confidence Interval

Our Hypothesis

‘Extreme’ fingernail lengths are not different from standard fingernail lengths

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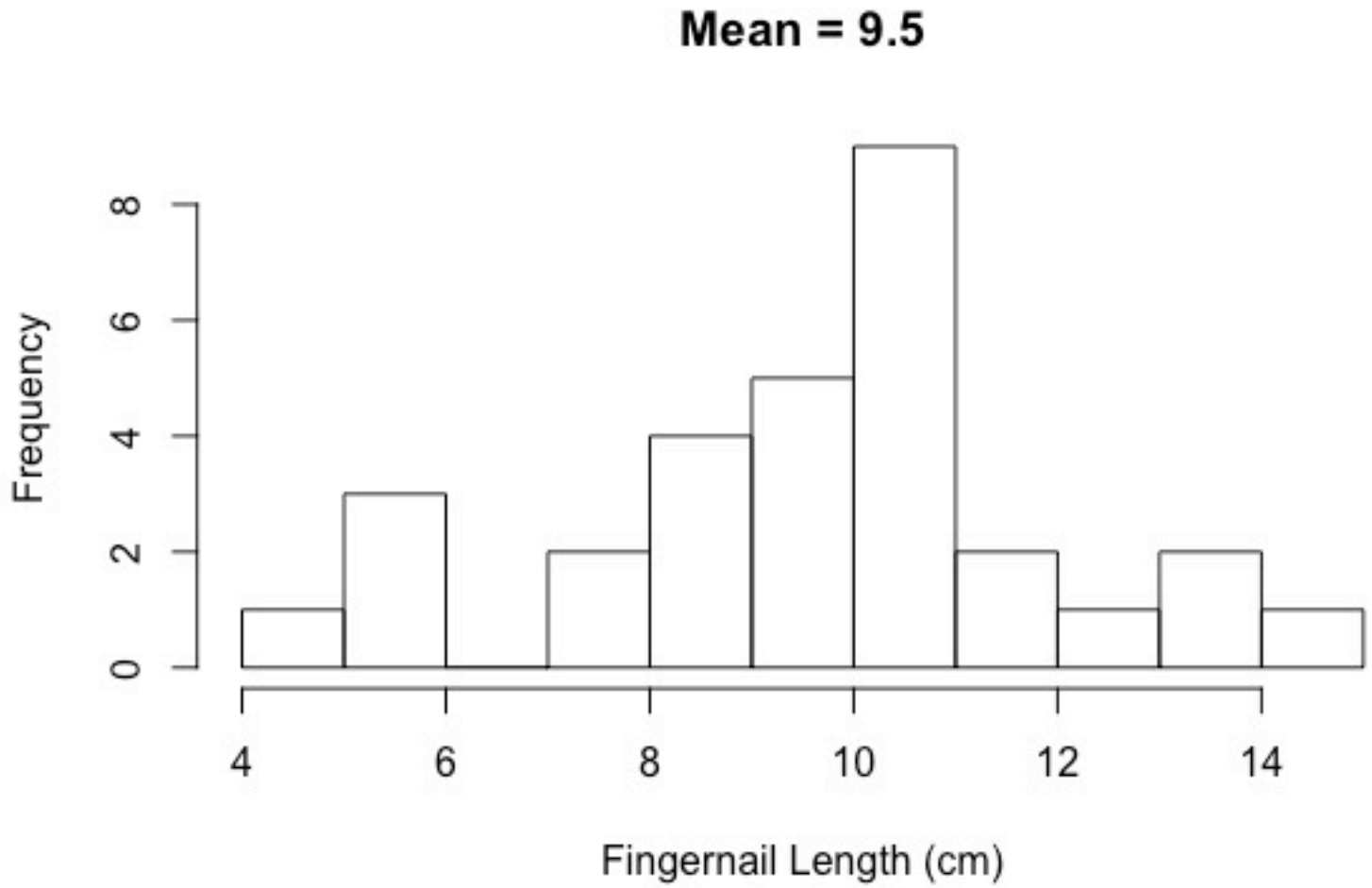
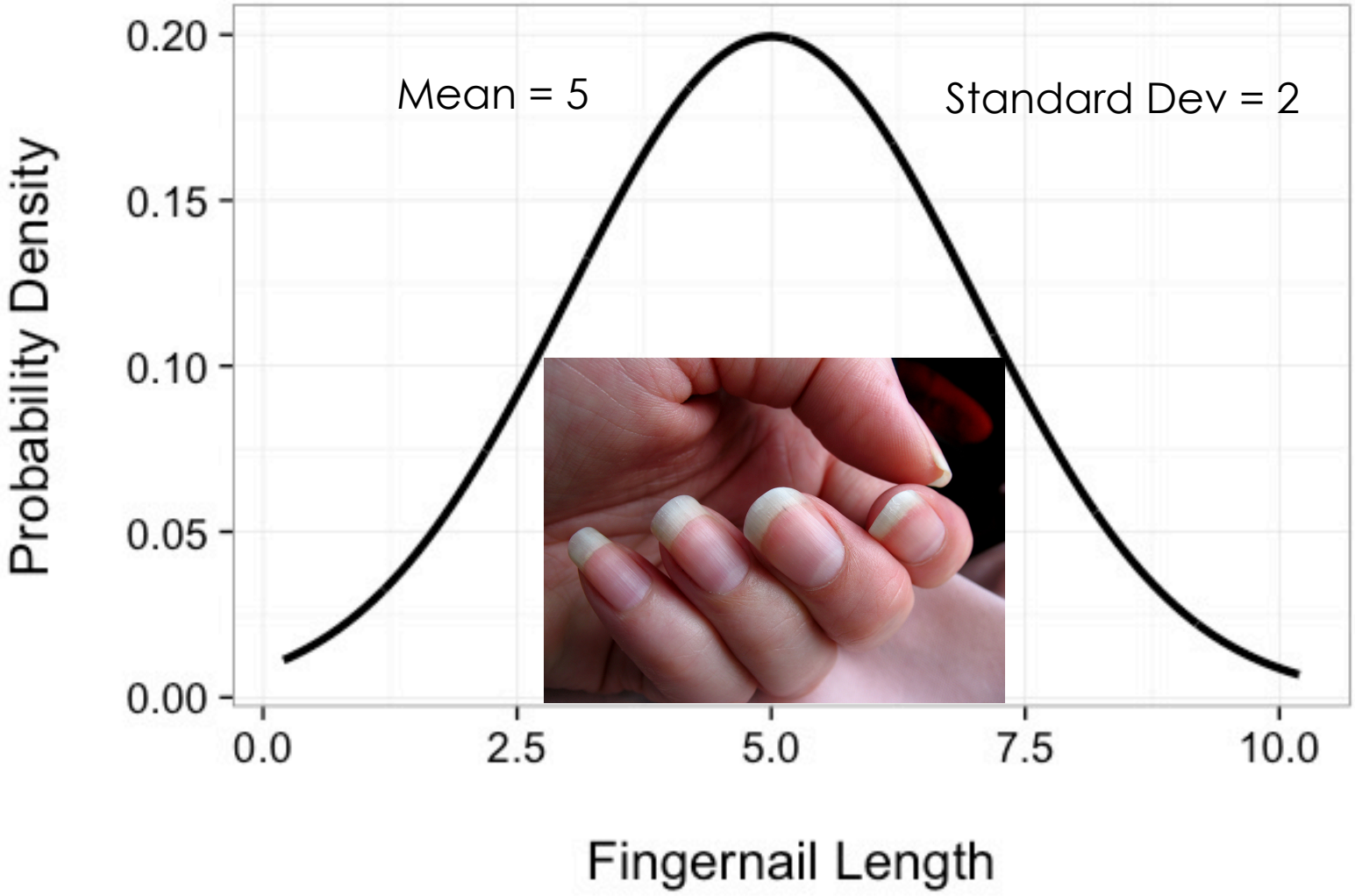
Our Sample



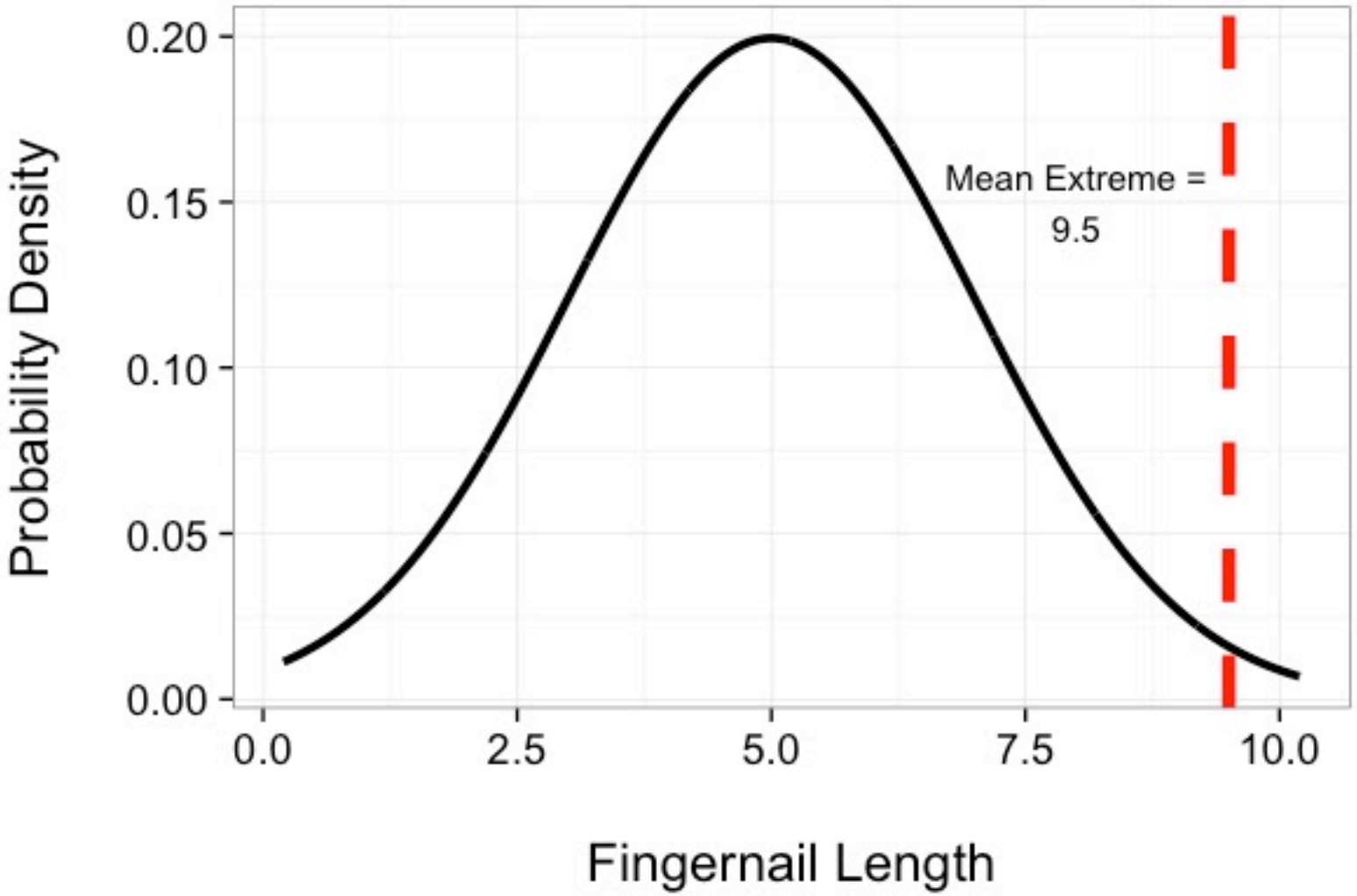
Assume a Distribution of Fingernail Sizes



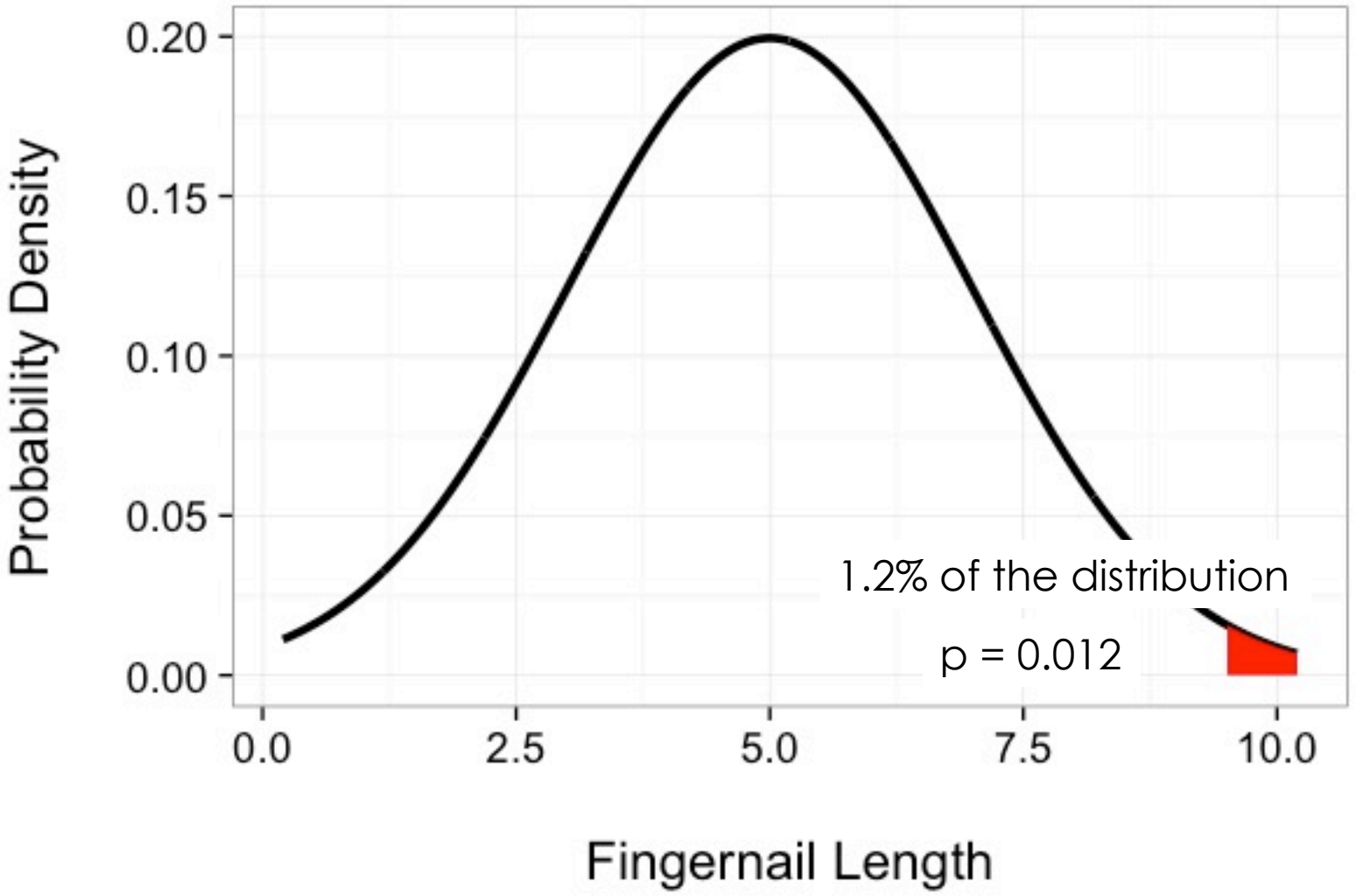
Our Hypothesis

‘Extreme’ fingernail lengths are from a distribution with mean of 5 and SD of 2.

Is our size extreme?



What about even more extreme values?




Extreeeeeeme!

P-Values: Fisher

R.A. Fisher

The probability of observing a value or more extreme value given a specified hypothesis.

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Null Hypothesis Testing

- Frequentist testing of whether ***something*** is different from a null expectation

- Example uses:
  - An estimate is not different from 0
  - The difference between two groups is not different from zero
  - A predictor provides no additional explanation of patterns in the data

Test Statistics: Making the World Sensible (and Null)

1. Create a null distribution

2. Use your data to calculate a test score

3. Calculate the p-value for your data in the context of that null distribution
   - $P(D|H_0)$:

Testing Fingernails Against a Normal

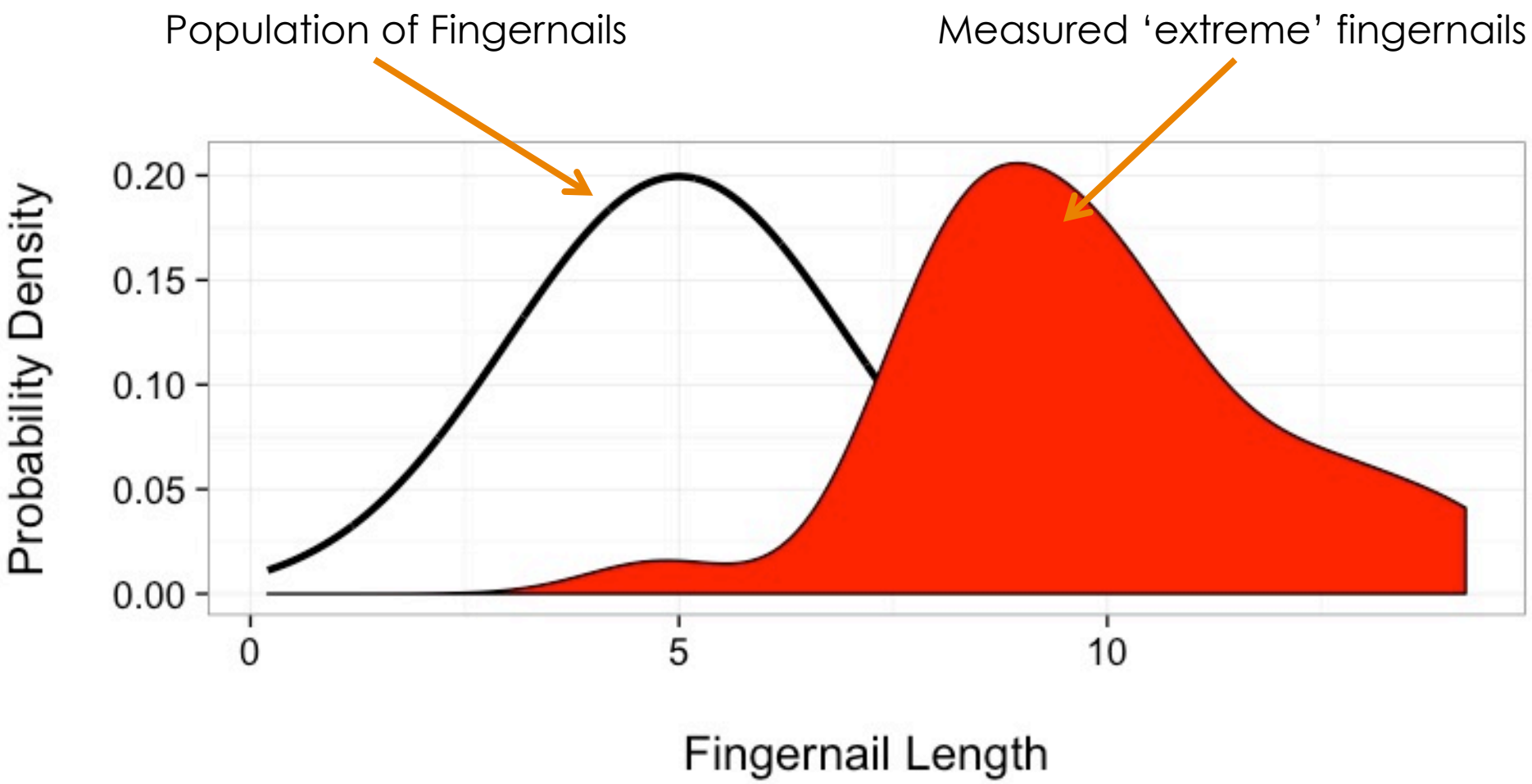
H_0 = Mean of sample is not different from the rest of the population

1. Assume a normal distribution with an SD of 2

2. Calculate the difference between the mean of our sample and 5 = 4.5

3. Assess the p-value of 4.5 against the normal distribution with mean 0

But…this is my data



The Arrival of a Test Statistic

H_0 = Mean of sample is not different from the rest of the population

1. Assume a normal distribution with an SD of 1 (standard normal curve)

2. Calculate the difference between the mean of our sample and 5 = 4.5

3. Divide by the Standard Deviation of the population and the square root of the sample size (assumed SE of a population Sample) – z score!

- Z-Score

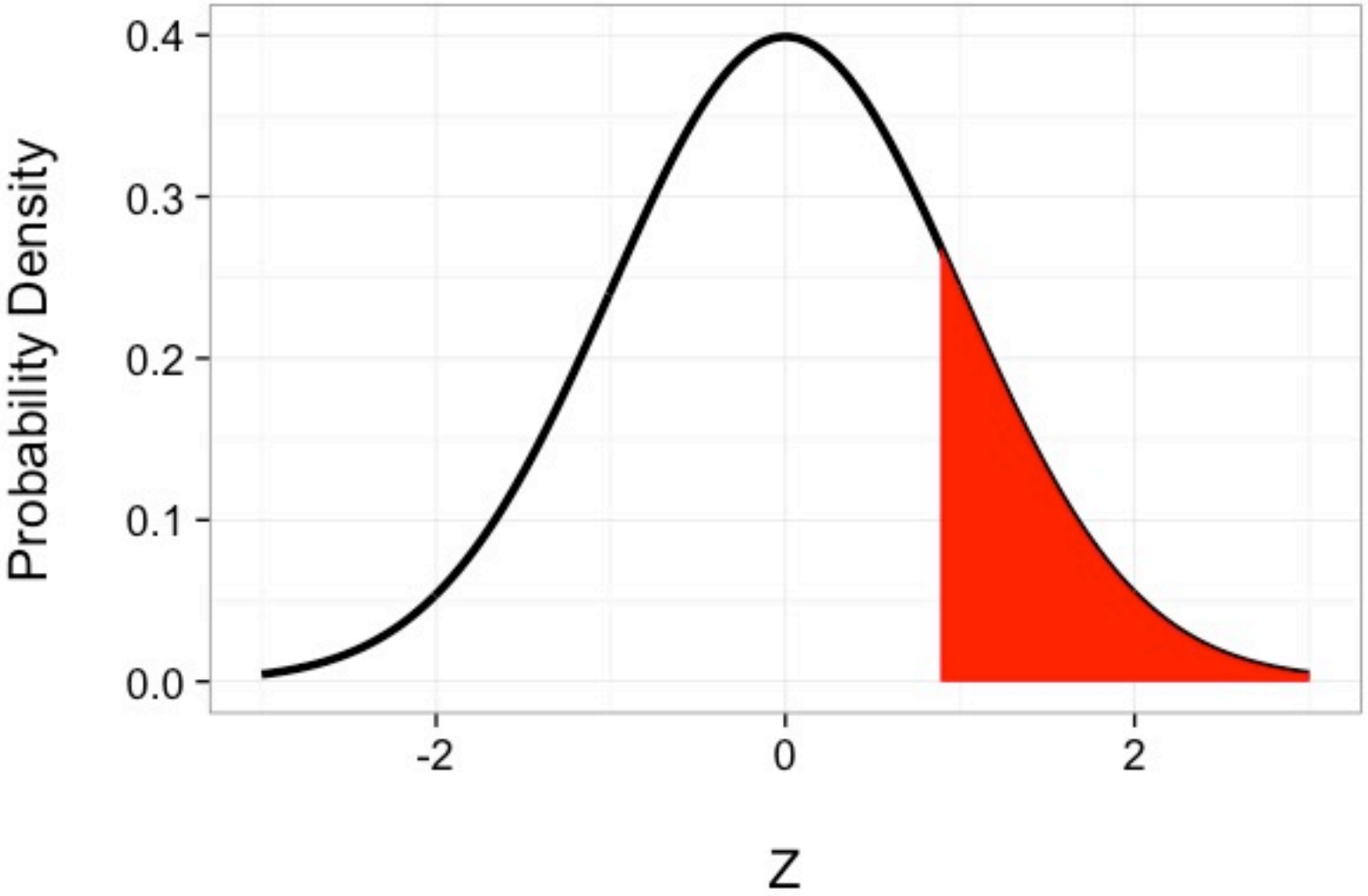
$$z = \frac{\bar{x} - \mu}{\sigma / \sqrt{n}}$$

z = 4.5 / (2/sqrt(30))

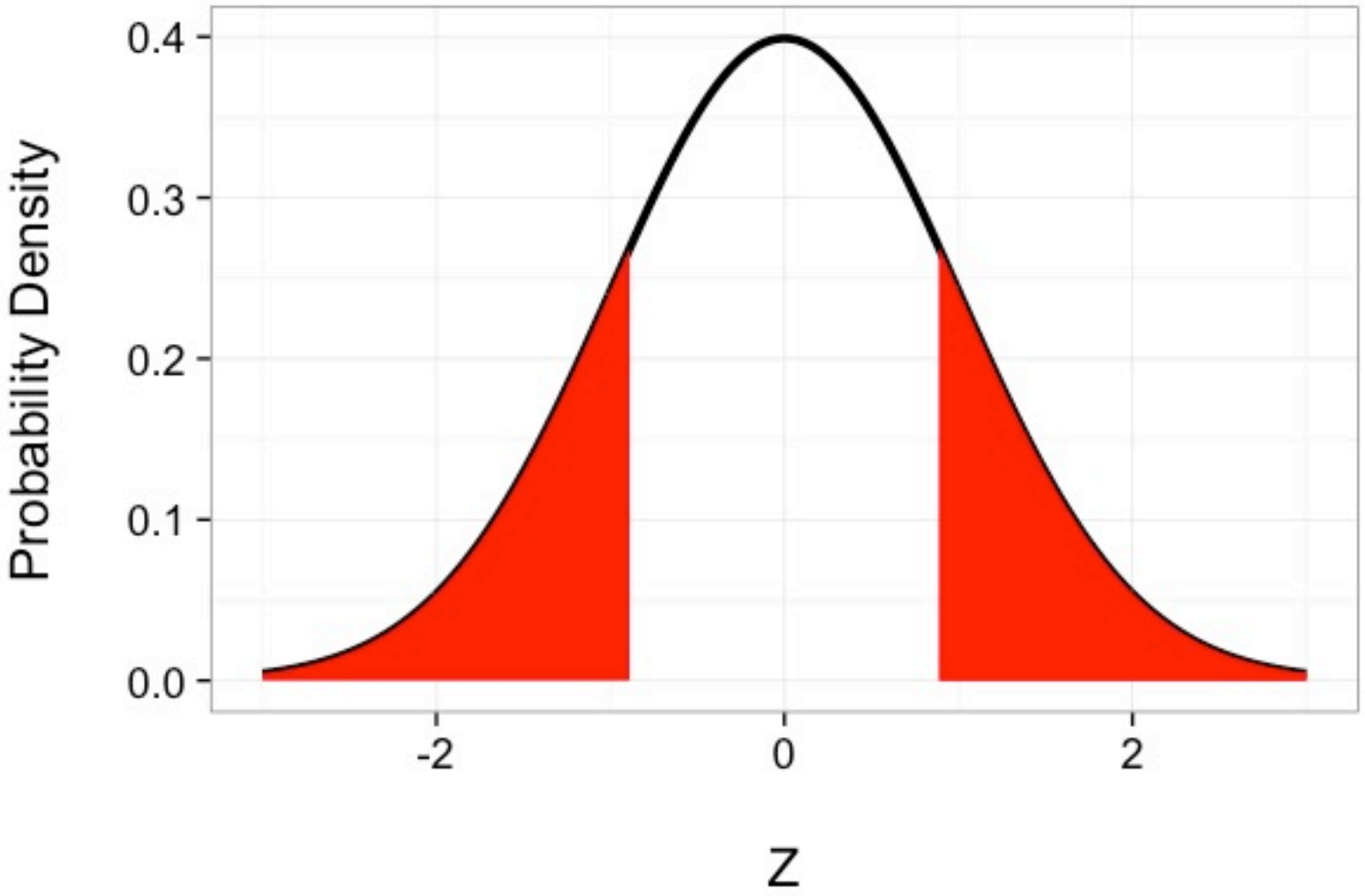
= 12.32

p(12.32|μ=0) < 0.0001

Z-Test



There Are Two Tails




Yes. These are super odd.

What do you do with a p-value?

- P-values give the evidence for the probability of your data, or more extreme data, given a hypothesis

- As the scientist, ***you*** decide whether it is grounds for rejecting a hypothesis

- In a frequentist framework, you can only reject a hypothesis – never `accept`

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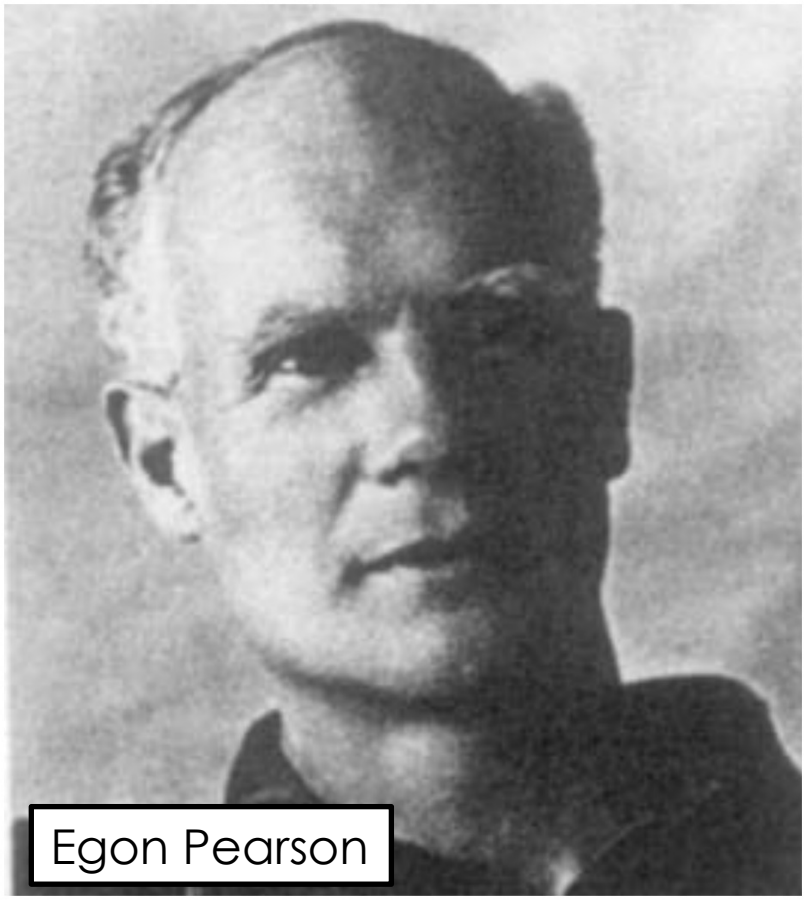
How We Can Screw This Up

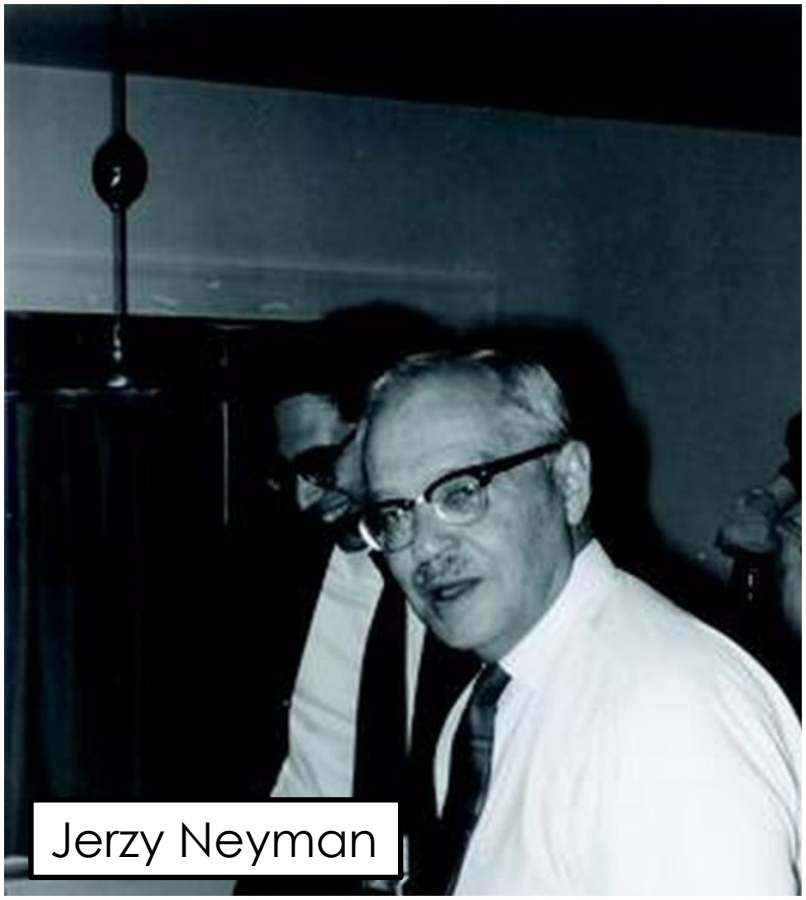
		Is the Hypothesis True or False?	
		True	False
Test Result Against Hypothesis	Hypothesis Not Rejected	☺	Type I error
	Hypothesis Rejected	Type II error	☺

Probability of a type I error = α

Probability of a type II error = β

Null Hypothesis Significance Testing


Egon Pearson


Jerzy Neyman

Problem: What is an acceptable α?

Answer: 0.05. You have a 1 in 20 chance of committing a type I error

Problems with NHST

- A realistic alpha can depend on your study design
  - E.g., Large sample size = lower p value
- Ignores β
  - Tradeoff between α and β
- Conflation of scientific significance and statistical significance
  - File-drawer effect
- We are human
  - If $p \leq 0.05$ makes your career, you will do a lot to obtain it!