Statistical Learning: Introduction

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Intro: What is statistical learning?

What do you think data science is?

What about machine learning?

What about statistical learning?

Key definitions

- **Machine learning (ML)**: Development of models and algorithms from data
  - **Deep learning**: A subfield of ML focused on algorithms modeled after the human brain
- **Statistical learning**: Branch of applied statistics focusing on statistical models and uncertainty quantification
- **Data Science**: Extraction of knowledge from data using a toolbox made up of mathematical, statistical, engineering, and machine learning techniques

https://web.stanford.edu/~hastie/TALKS/SLBD_new.pdf

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Through different lenses, they all aim to **make sense of data**!

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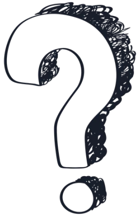
Why the differences?



Let's talk data

In the most familiar setting (i.e. **supervised learning**) data is made up of two primary ingredients:

1. **Outcome/Output/Target/Label(s)**: The variable(s) that you want to understand better

2. **Covariate/Input/Feature(s)**: The variable(s) that can potentially tell you something about your outcome(s)

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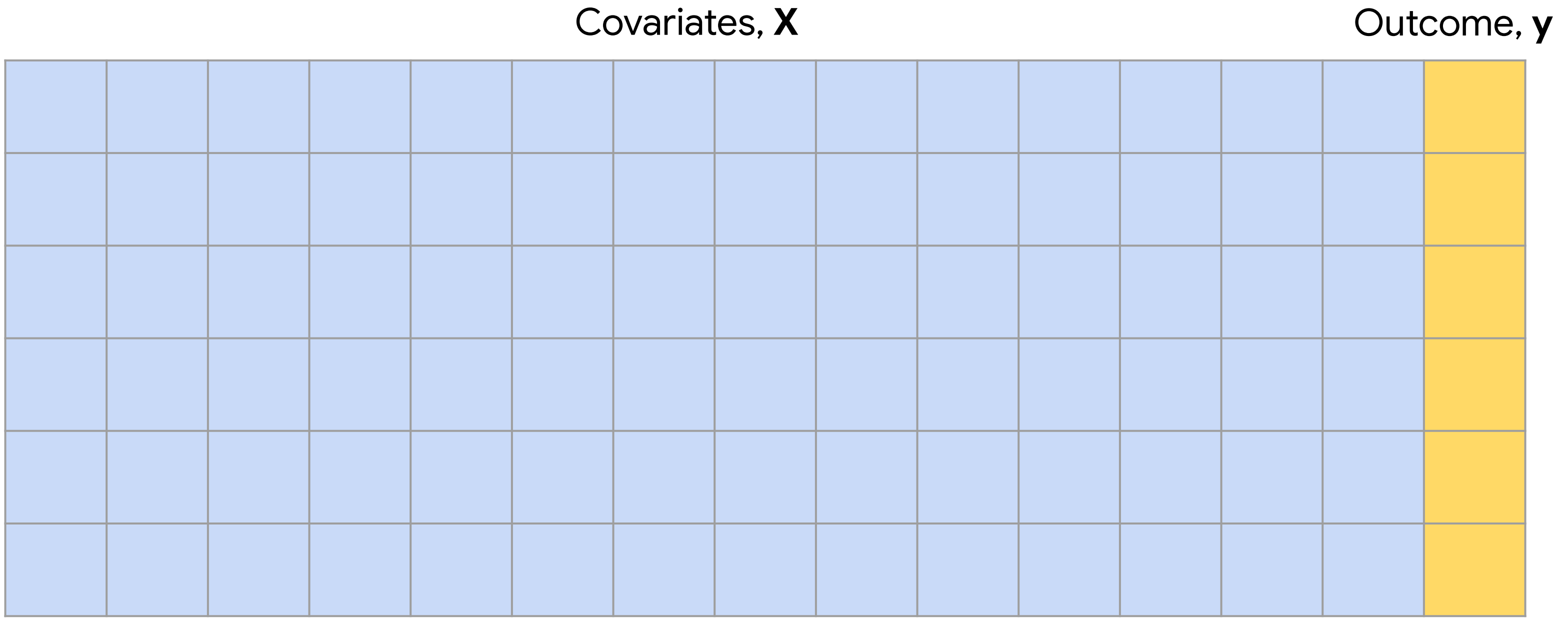
Outcome and covariate are most commonly used in statistics so we’ll use them!

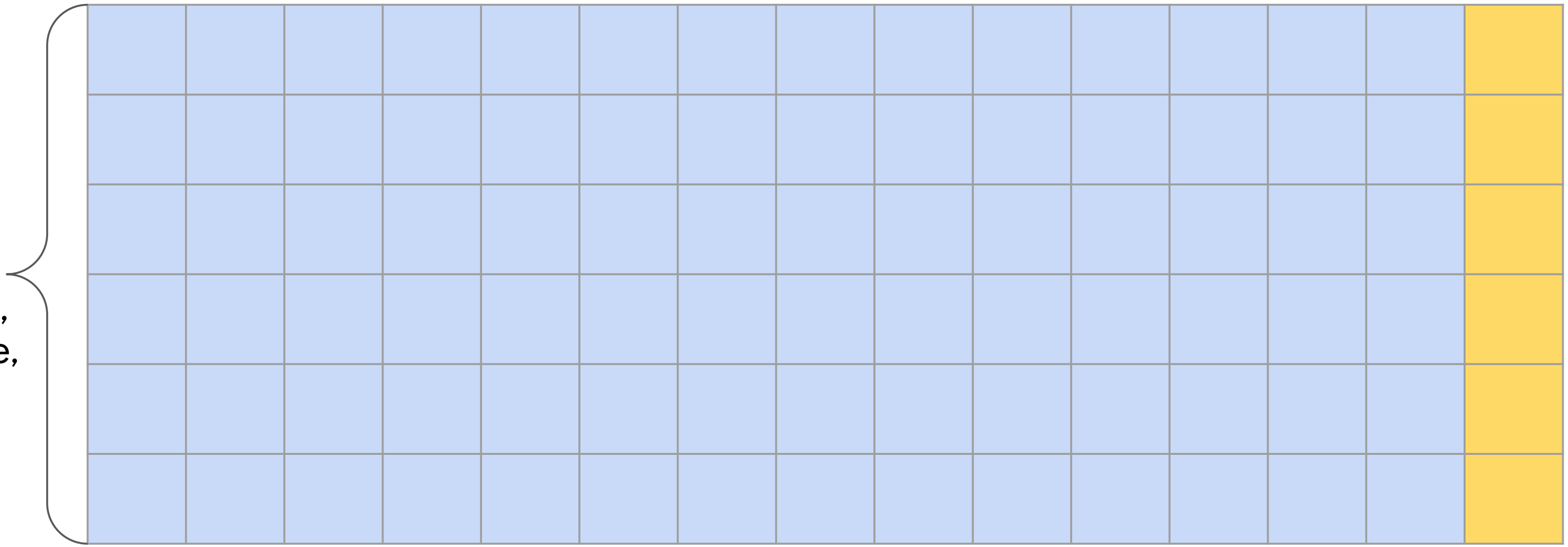
Let's look at a *data matrix*



Let's look at a *data matrix*

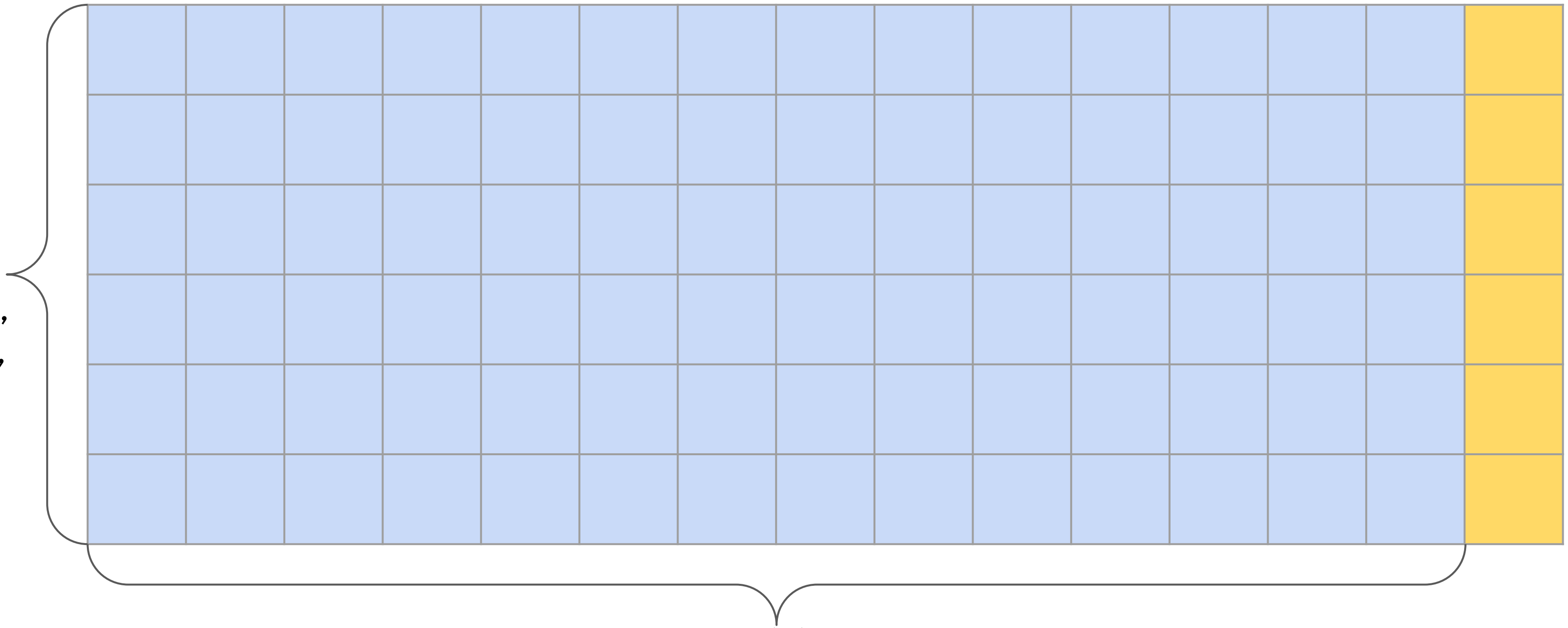
Covariates, **X**

Outcome, **y**



<u>Rows</u> (n): contain the units of analysis, e.g. people, images, sentences

Let's look at a *data matrix*



Example data matrix: Penguin dataset

	species	island	bill_length_mm	bill_depth_mm	flipper_length_mm	body_mass_g	sex	year
[1,]	3	1	42.0	13.5	210	4150	1	2007
[2,]	3	1	54.3	15.7	231	5650	2	2008
[3,]	2	2	42.4	17.3	181	3600	1	2007
[4,]	3	1	48.6	16.0	230	5800	2	2008
[5,]	2	2	47.0	17.3	185	3700	1	2007
[6,]	3	1	50.4	15.7	222	5750	2	2009
[7,]	1	2	36.0	17.8	195	3450	1	2009
[8,]	1	2	41.3	20.3	194	3550	2	2008
[9,]	1	2	39.6	18.8	190	4600	2	2007
[10,]	3	1	49.6	16.0	225	5700	2	2008
[11,]	3	1	46.9	14.6	222	4875	1	2009
[12,]	1	2	40.2	17.1	193	3400	1	2009
[13,]	3	1	46.8	16.1	215	5500	2	2009
[14,]	3	1	49.4	15.8	216	4925	2	2009
[15,]	1	1	38.2	18.1	185	3950	2	2007

p = ?
n = ?

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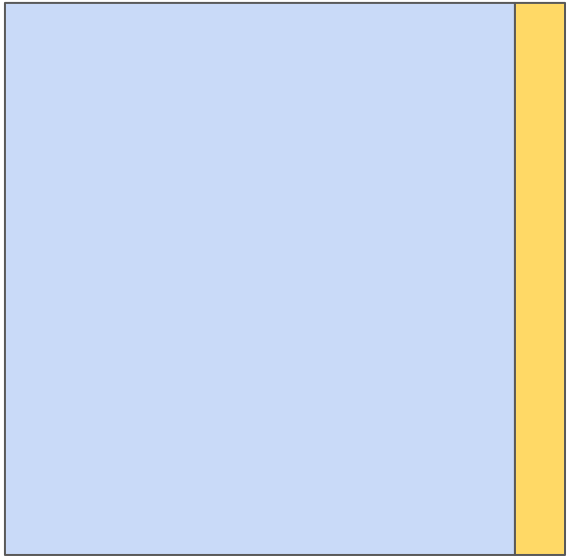
$p = 7$
$n = 15$

We need the terminology because data comes in many forms

Tall data

$p < n$

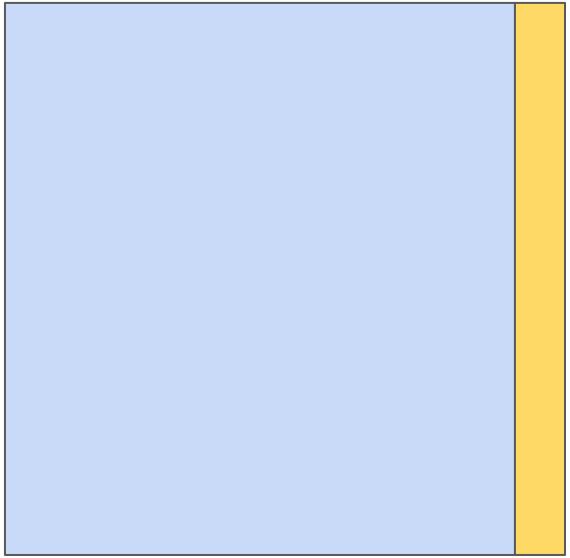


The data of early **statistical learning**

We need the terminology because data comes in many forms

Tall data

$p < n$



The data of early **statistical learning**

Wide data

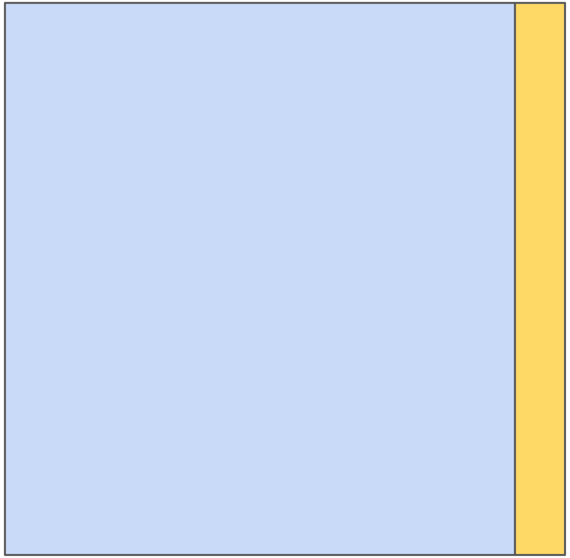
$p > n$

The data of later **statistical learning**

We need the terminology because data comes in many forms

Tall data

$p < n$



The data of early **statistical learning**

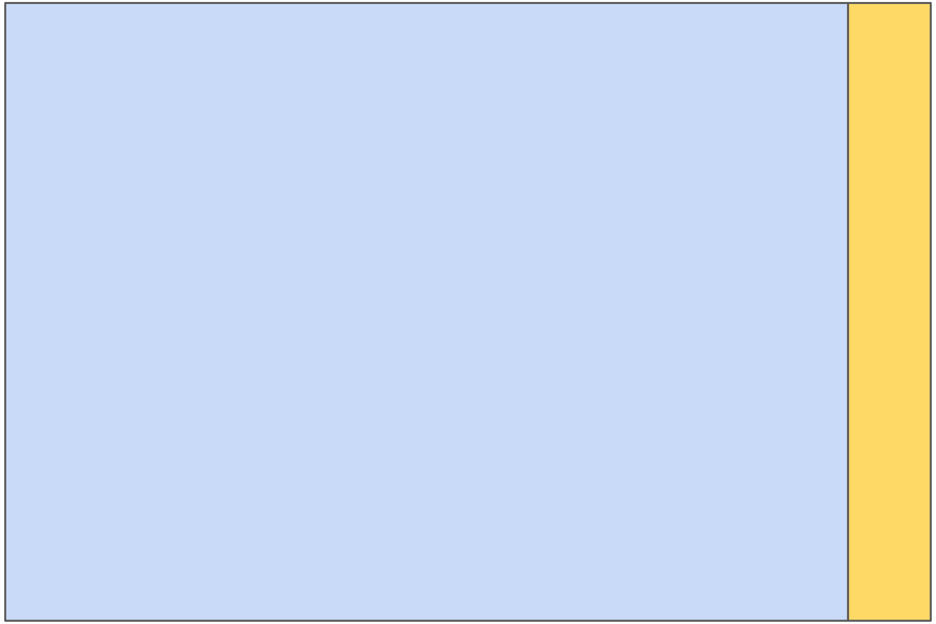
Wide data

$p > n$

The data of later **statistical learning**

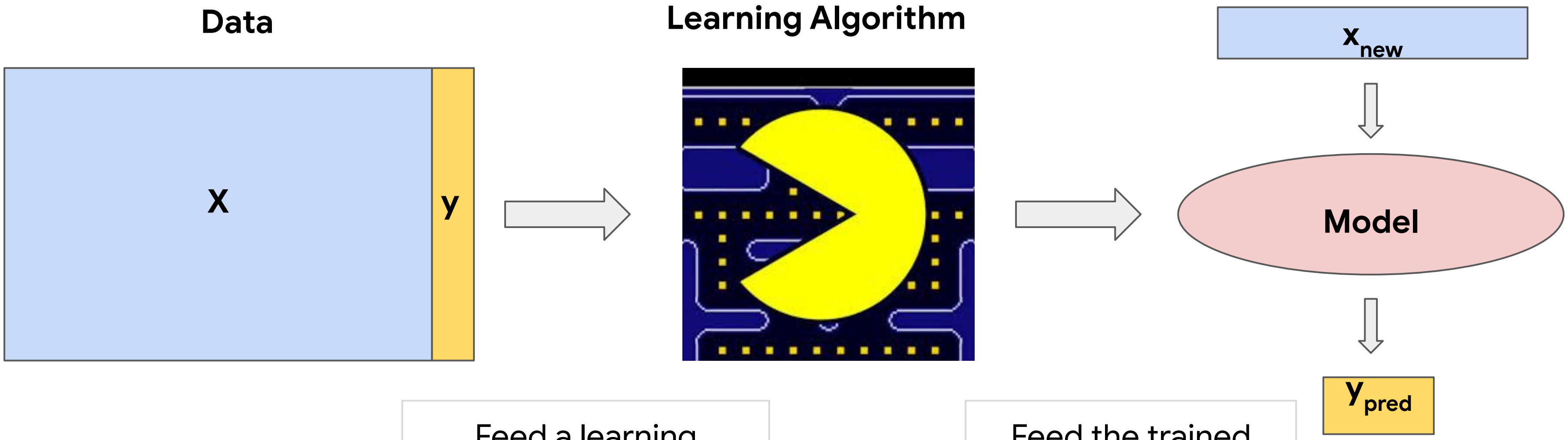
We need the terminology because data comes in many forms

The 'biggie'
big p and/or big n



The data of **modern statistical learning + machine learning + data science**

Now matter what you call it, this is what you do



Feed a learning algorithm your data for ***estimation*** or ***training*** of the model.

Feed the trained model new data to make a ***prediction*** about the outcome.

We are going to play with image classification

Chihuahua or blueberry muffin?

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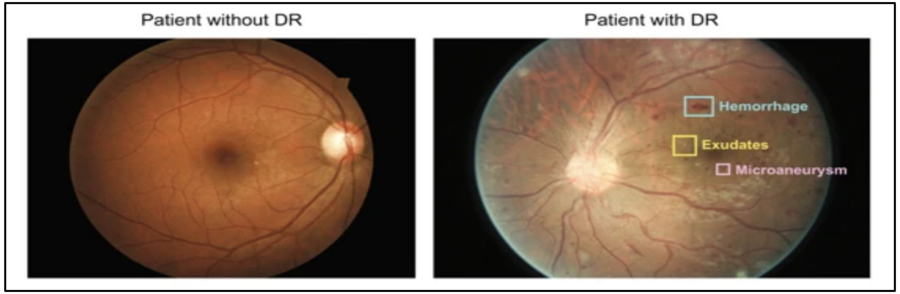
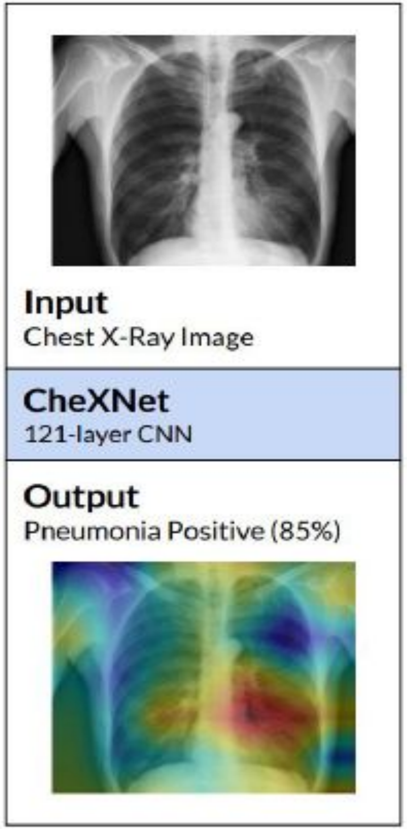
Chihuahua or blueberry muffin?

Labradoodle or fried chicken?

Many real life of examples of this...



Deep learning algorithm predicts diabetic retinopathy progression in individual patients



CheXNet: Radiologist-level pneumonia detection on chest x-rays with deep learning

How we’ll get there

- Learn the recipe for cooking up a statistical learning model
- Review some techniques for modeling
- Summarize methods for model evaluation