# 2019 HEALTH HACK COMPETITION

INNOVATION4 HEALTH

## Theme

# CHILD HEALTH & WELLNESS

## Data Science Workshop

# Data Science Workshop

Instructor - Philip Ciunkiewicz

# Before We Start

**Experience with data analysis**

- Organizing data in Excel
- Visualizing data in Excel
- Computing basic statistics
  - Mean, median, mode
  - Standard deviation, uncertainty
- More advanced analysis
  - Transforming columns
  - Operations between columns

**Experience with programming**

- Exposure to programming basics
  - Concept of variables
  - Concept of functions
- Working in Python / R / Matlab
  - Defining variables
  - Defining functions
  - Loading and saving data
  - Using external libraries

# Interactive Notebook

The interactive notebook for this workshop is available on GitHub

- Click the 

button to launch

https://github.com/PCiunkiewicz/I4H_Workshop

Presentation slides will also be on GitHub as PDF

# Presentation Flow

**Data Science Basics**

- What is data science?
- Applications of data science
- Statistics and analytics vs machine learning

**Data Preparation**

- Working with different types of data
- How data is structured
- How machines interpret data

**Machine Learning**

- Core principles of machine learning
- Machine learning project workflow
- Different machine learning tasks

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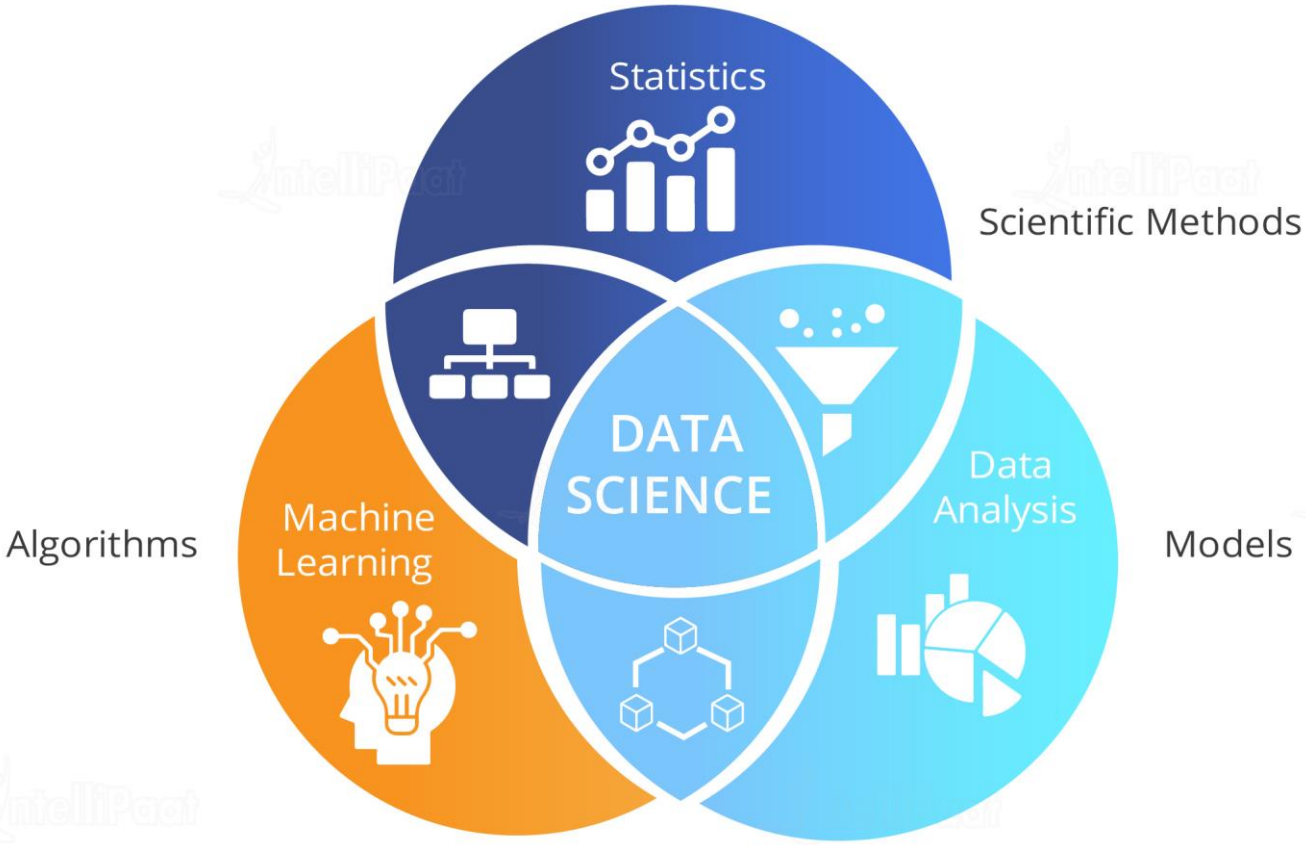
# Data Science Basics

Defining and understanding the field

# What is Data Science?




https://intellipaat.com/blog/what-is-data-science/

- No rigid / formal definition for data science
- Two popular ideas
  - Applying the scientific method to data
  - Transforming data into useful knowledge

# Applications of Data Science

**Types of Applications**

- Classification
- Regression
- Clustering

- Image and audio processing
- Natural language processing

**Fields of Use**

- Science
  - Experimental and theoretical
  - Clinical applications

- Engineering and Industry
  - Research and development
  - Business intelligence

# Applications of Data Science - Classification

- Classification problems focus on the prediction of a discrete variable

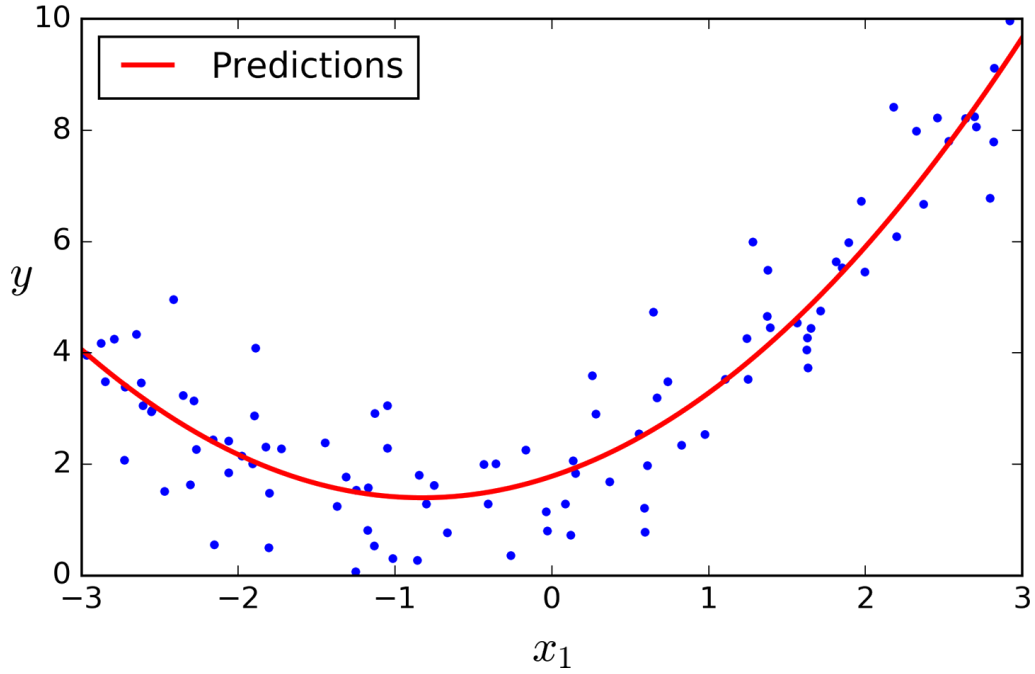
Dog

Cat

https://medium.com/@gnabr/machine-learning-c28daf3cf60a

# Applications of Data Science - Regression

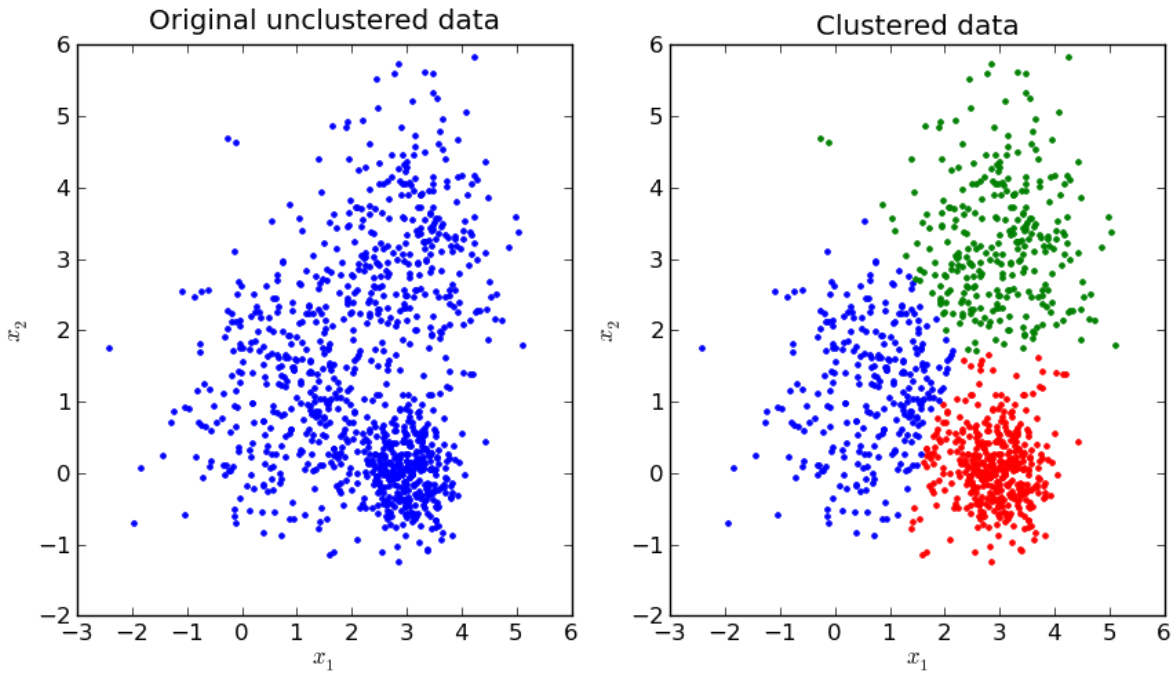
- Regression problems focus on the prediction of a continuous variable




https://learning.oreilly.com/library/view/hands-on-machine-learning/9781491962282/ch04.html

# Applications of Data Science - Clustering

- Clustering problems focus on identifying similarities in populations




http://mathalytics.blogspot.com/2015/04/k-means-clustering-machine-learning.html

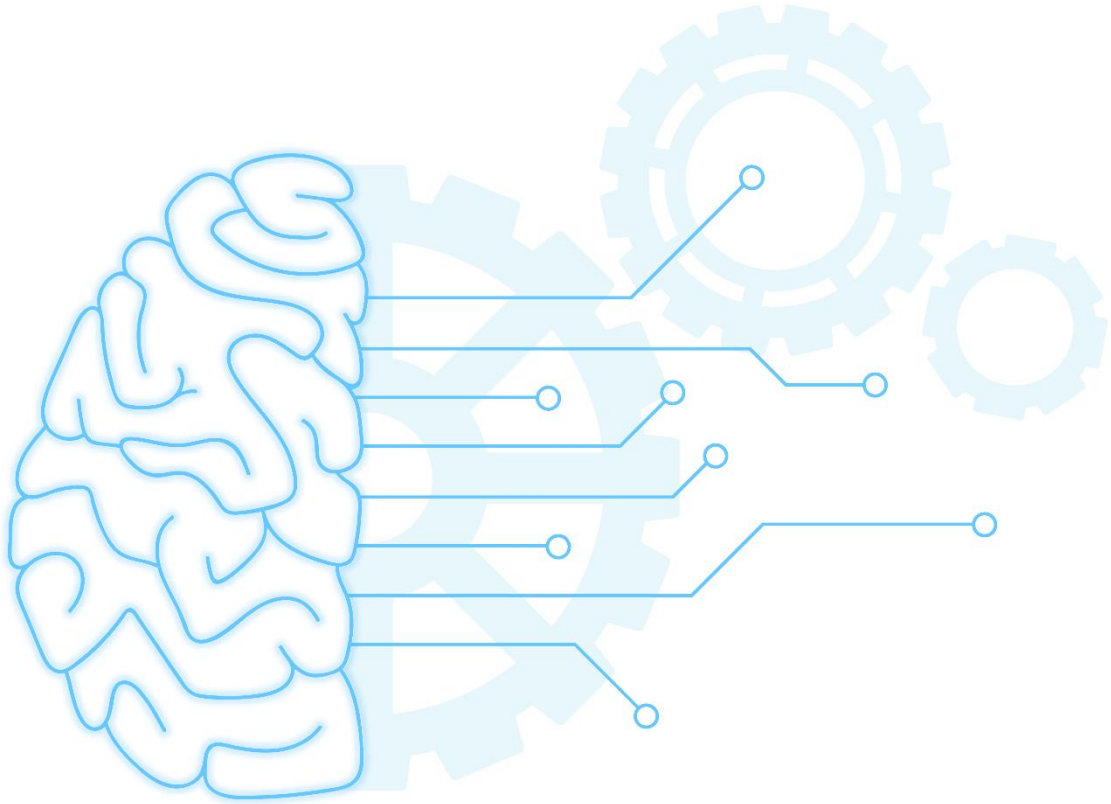
# Statistics and Analytics vs Machine Learning

**Statistics and Analytics**

- Subfield of mathematics
- Offers more insight than ML
  - Formalizes existing relationships
  - Offers less predictive ability than ML
- Results based on formal definitions
  - Explicit mathematical relationships
- Strong results from minimal data

https://www.iconfinder.com/icons/1828922/

# Statistics and Analytics vs Machine Learning



https://docs.microsoft.com/en-us/windows/ai/windows-ml/

**Machine Learning**

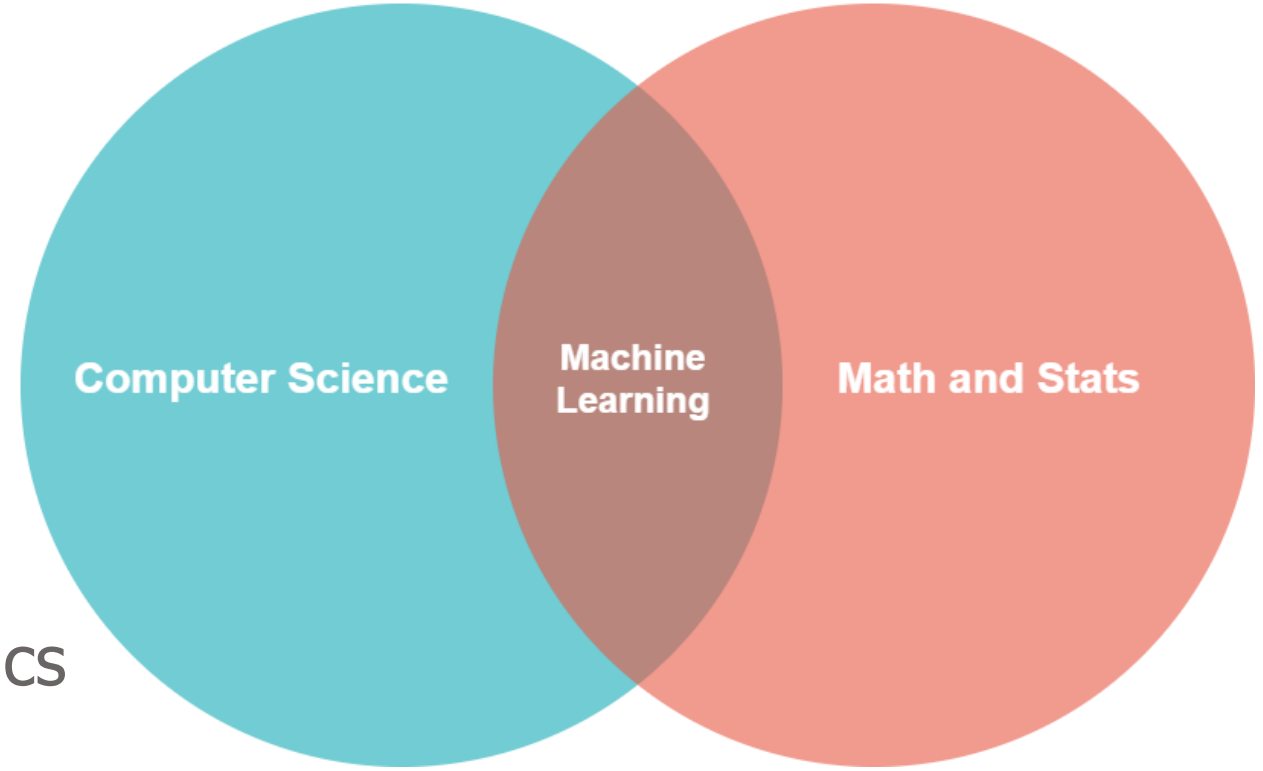
- Subfield of computer science
- Offers more predictive ability than stats
  - Predicts future relationships
  - Offers less insight than stats
- Results based on stochastic processes
  - Implicit relationships from optimization
- Requires lots of data for strong results

# However…

There are also many similarities

- Applications
- Required knowledge
- Overall complexity

Machine learning is built on statistics



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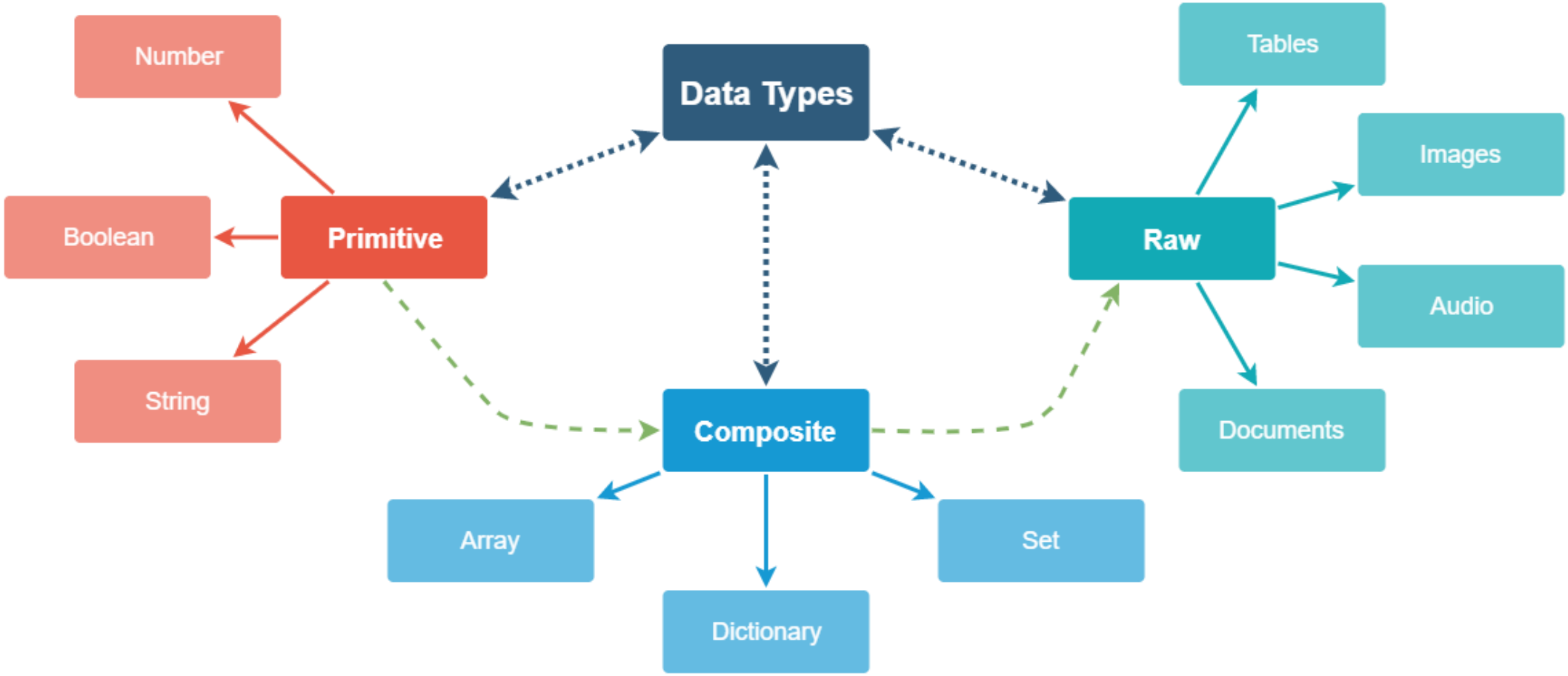
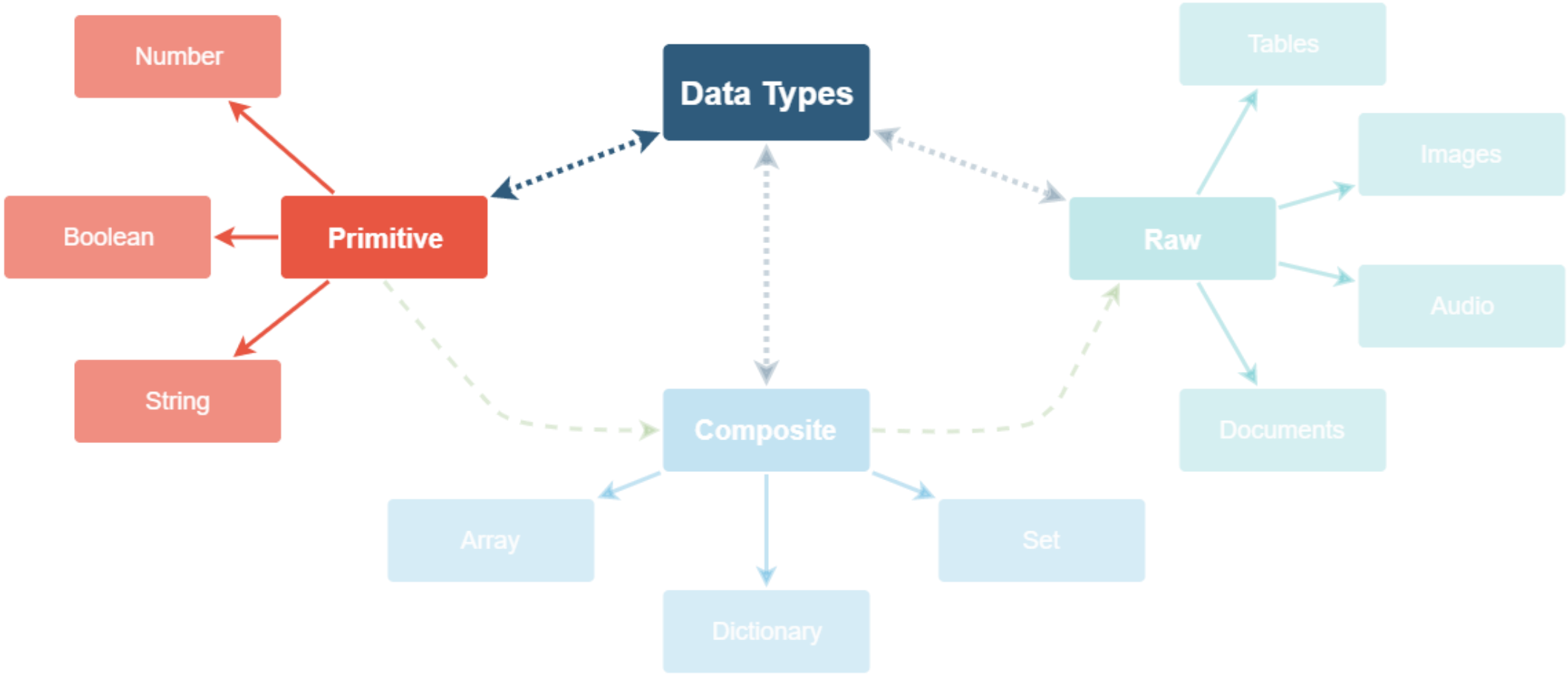
# Data Preparation

Making data “digestible” for machines

# Working with Different Types of Data



# Working with Different Types of Data



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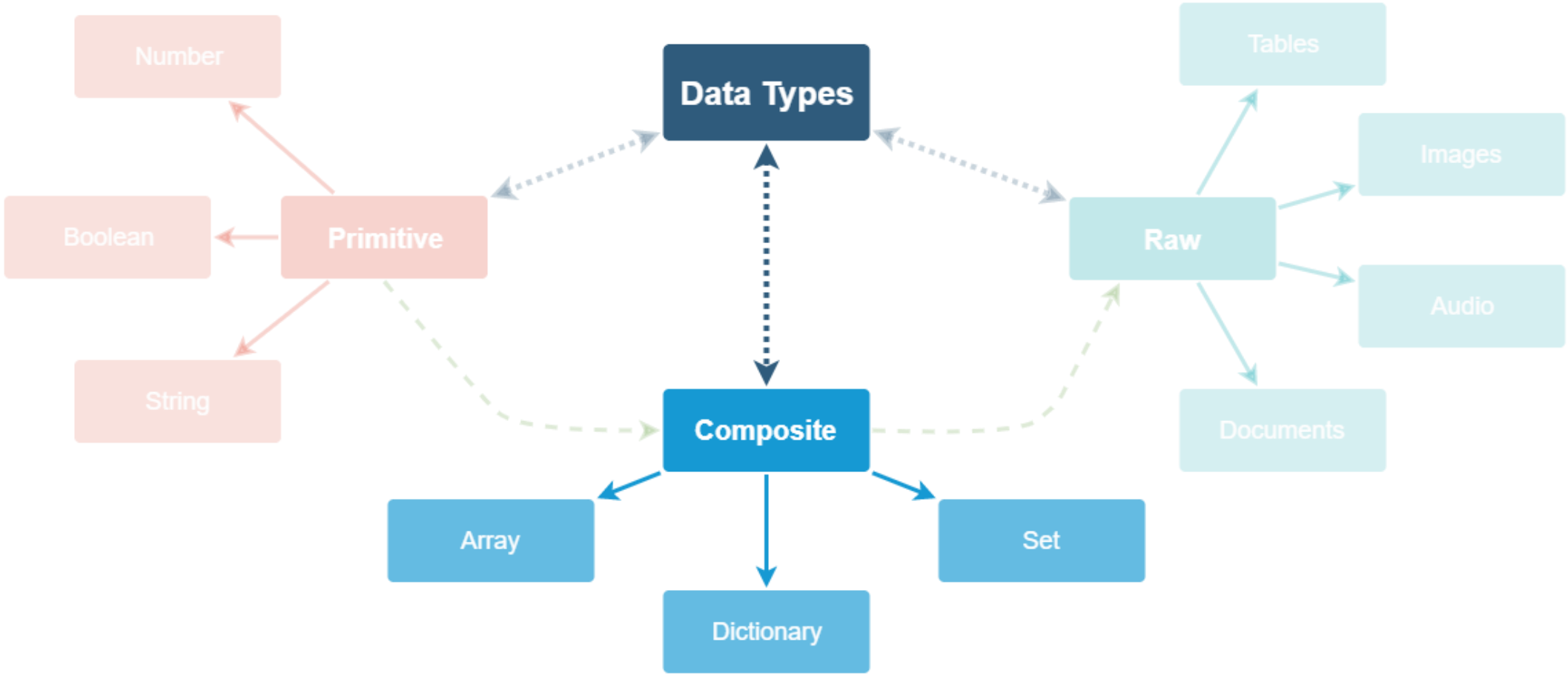

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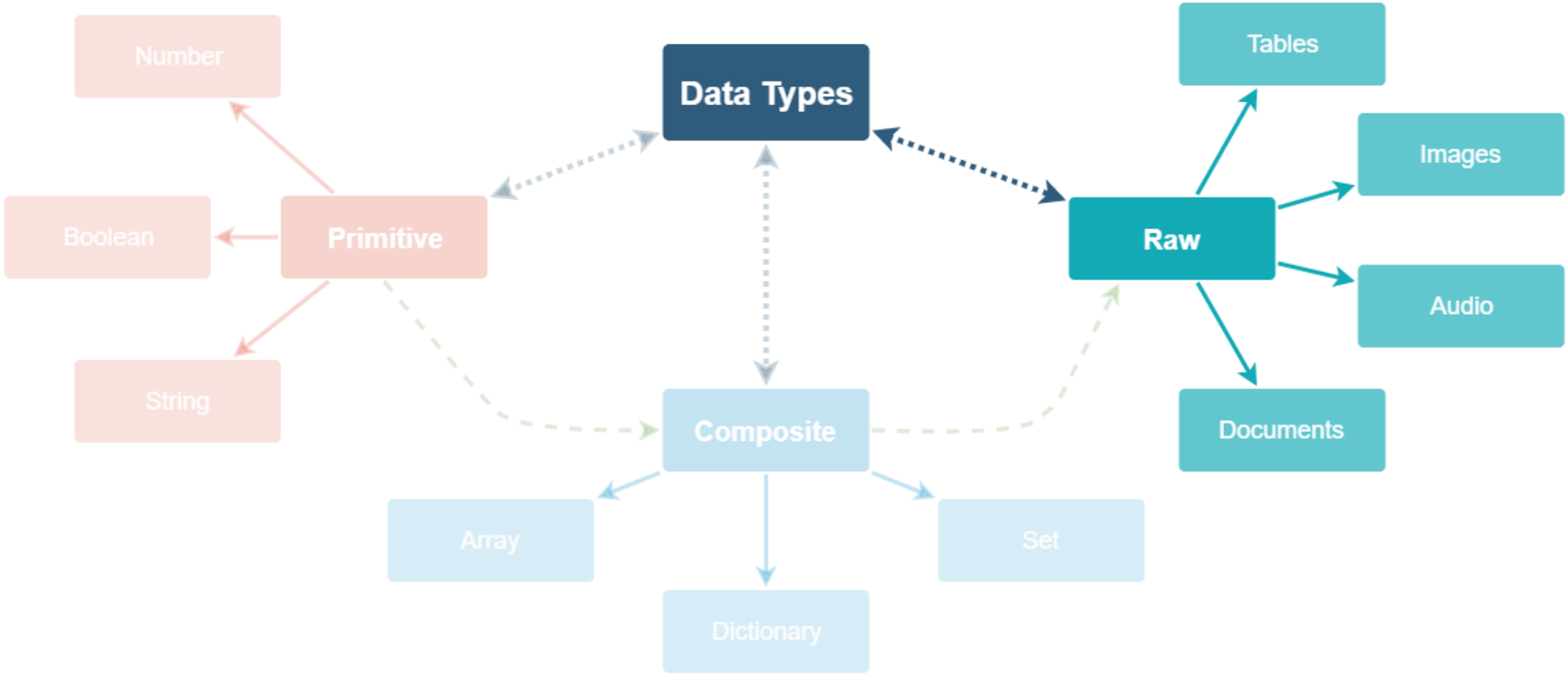
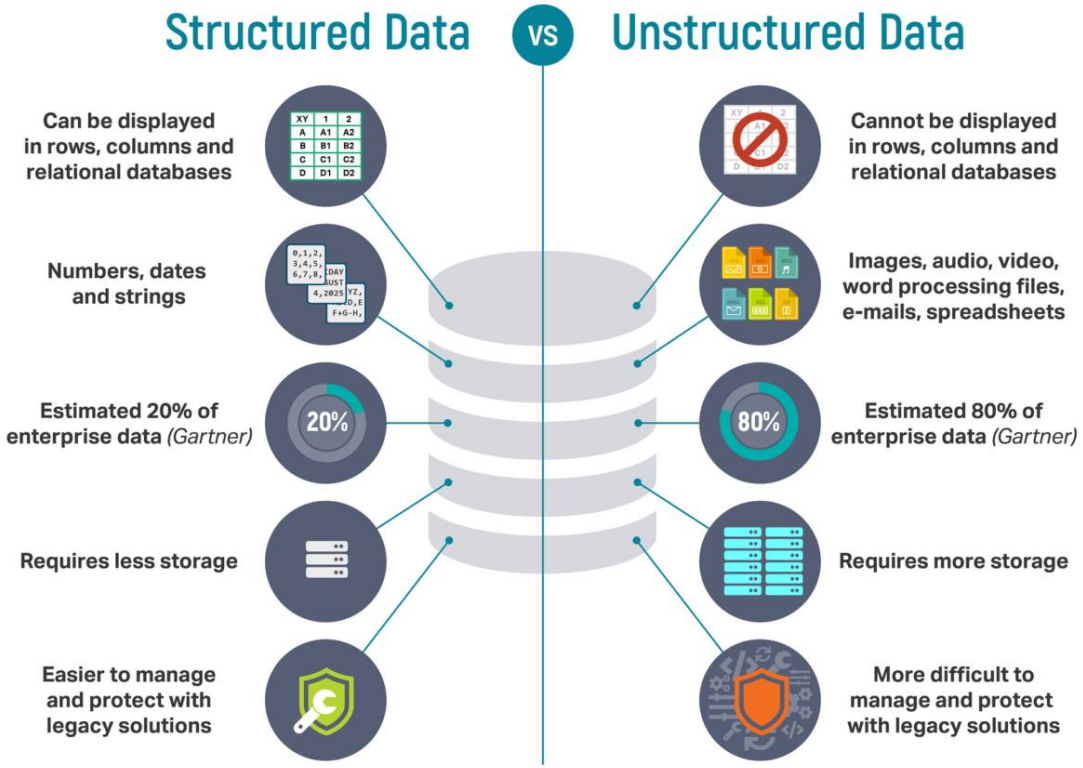


# How is Data Structured?

**Structured**

- Structured data follows "Schema"
  - Highly organized and consistent
- Easily interpretable by machines
- Basis for many databases
  - Structured Query Language (SQL)

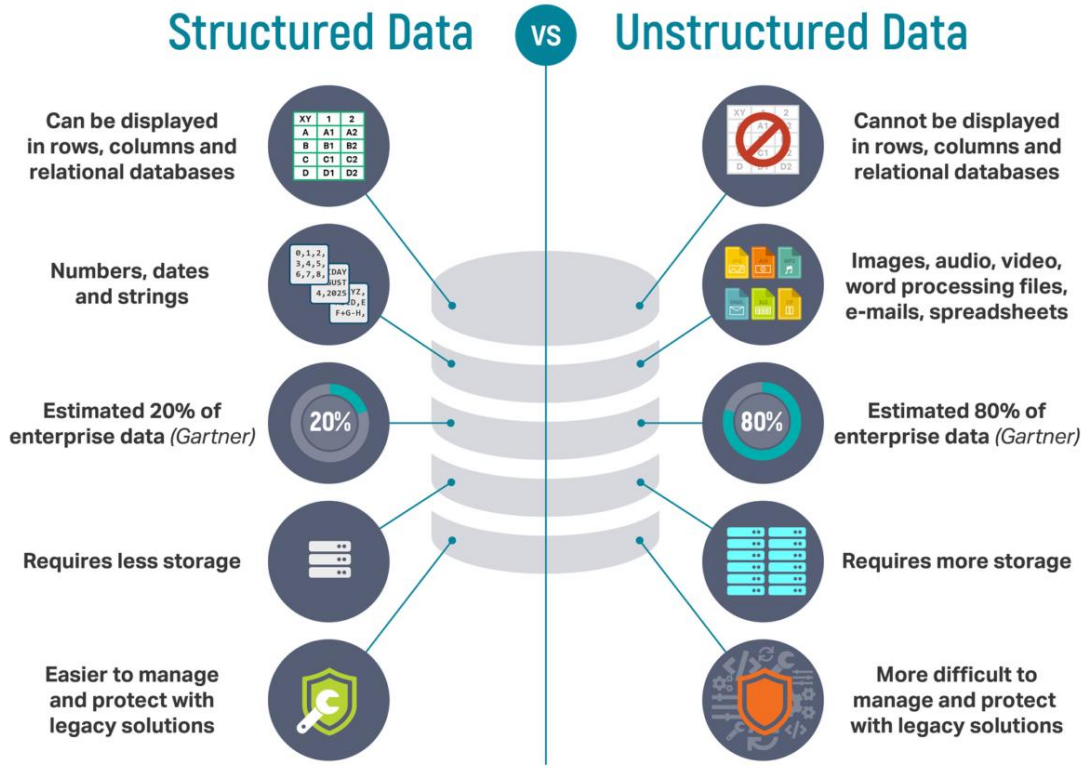



https://lawtomated.com/structured-data-vs-unstructured-data-what-are-they-and-why-care/

# How is Data Structured?

**Unstructured**

- Unstructured data can take any form
  - Potentially organized but inconsistent
- Not easily interpretable by machines
- The current state for >80% of data
  - Only expected to increase



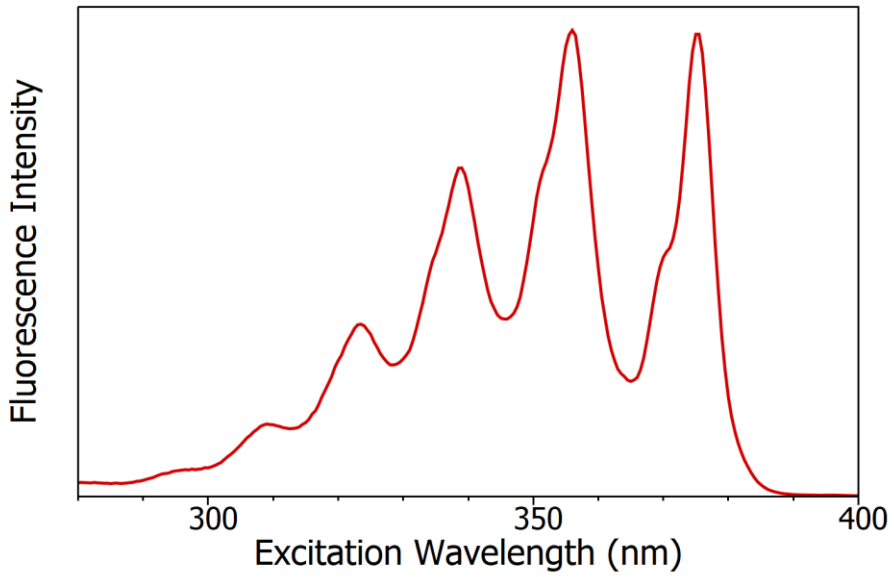

https://lawtomated.com/structured-data-vs-unstructured-data-what-are-they-and-why-care/

# Common Examples of Structured Data

- Tabular Data

| Feature 1 | Feature 2 | Feature 3 |
|---|---|---|
| 34 | 1.004 | AAB |
| 42 | 4.293 | BTY |
| 142 | 7.934 | XYZ |
| 23 | 4.143 | PWX |
| 98 | 0.391 | HRQ |
| 738 | 3.240 | TMG |
| 423 | 6.996 | KLO |

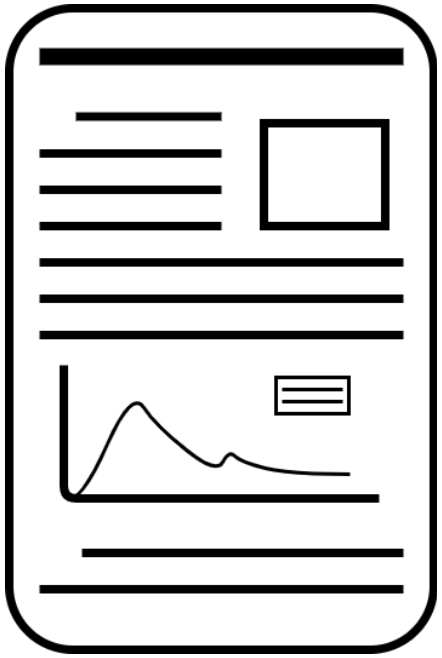
- Sensor Data




https://www.edinst.com/blog/what-are-absorption-excitation-and-emission-spectra/

# Common Examples of Unstructured Data

- Reports and Documents



- Other Text / Audio / Video / Images

https://techblogwriter.co.uk/wp-content/uploads/2016/01/text-video-audio-and-images..png

# How Machines Interpret Data

**Computer Processors**

- All data is interpreted as binary
- All operations are binary logic
- Requires consistent format

**Structured vs. Unstructured Data**

- Representation similar for both
  - Comprised of primitive data types
- Operations are very different
  - Structured data
    - Consistent and predictable results
  - Unstructured data
    - Inconsistent and often undefined results

# Preparing Data for Machine Learning

- Raw data must be converted into a structured form
  - Most machine learning algorithms ingest arrays
  - This step is generally different for all unstructured data

- Missing values and inconsistencies must be addressed
  - Many methods for this
    - Dropping missing rows
    - Imputation or interpolation

- Scaling and other preprocessing techniques must be applied

# Working with Missing Data

**1 - Imputation**

- Replace missing data
- Many methods
  - Mode/mean/median
  - Zero-fill
  - Random-fill
  - Interpolation
- Requires assumptions
  - Can introduce bias

| Feature 1 | Feature 2 | Feature 3 |
|---|---|---|
| 34 | 1.004 | AAB |
| | 4.293 | BTY |
| 142 | 7.934 | |
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→

| Feature 1 | Feature 2 | Feature 3 |
|---|---|---|
| 34 | 1.004 | AAB |
| 0 | 4.293 | BTY |
| 142 | 7.934 | 0 |
| 23 | 4.143 | PWX |
| 0 | 0 | HRQ |
| 738 | 3.240 | TMG |
| 423 | 6.996 | KLO |

# Working with Missing Data

**2 - Interpolation**

- Predict values
  - Within known range
    - Else extrapolation
- Multiple methods
  - Linear methods
  - Nonlinear methods
- Requires assumptions
  - Can introduce bias

| Feature 1 | Feature 2 | Feature 3 |
|---|---|---|
| 34 | 1.004 | AAB |
| | 4.293 | BTY |
| 142 | 7.934 | |
| 23 | 4.143 | PWX |
| | | HRQ |
| 738 | 3.240 | TMG |
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→

| Feature 1 | Feature 2 | Feature 3 |
|---|---|---|
| 34 | 1.004 | AAB |
| 88 | 4.293 | BTY |
| 142 | 7.934 | ??? |
| 23 | 4.143 | PWX |
| 357 | 3.624 | HRQ |
| 738 | 3.240 | TMG |
| 423 | 6.996 | KLO |

# Working with Missing Data

**3 - Removal**

- Drop incomplete rows
- Will result in less data
  - But higher quality data
- No assumptions
  - Will not introduce bias

| Feature 1 | Feature 2 | Feature 3 |
|---|---|---|
| 34 | 1.004 | AAB |
| | 4.293 | BTY |
| 142 | 7.934 | |
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# Scaling Input Features

- Scaling data is very important for certain models
  - Maintaining consistent data range equalizes all features

- Multiple available methods with various applications
  - Min-Max scaling
    - Rescaling all features to the same closed interval [min, max]
  - Standard scaling (z-score normalization)
    - Rescaling to zero-mean and unit-variance
  - Quantile scaling
    - Rescaling all features to match a target distribution

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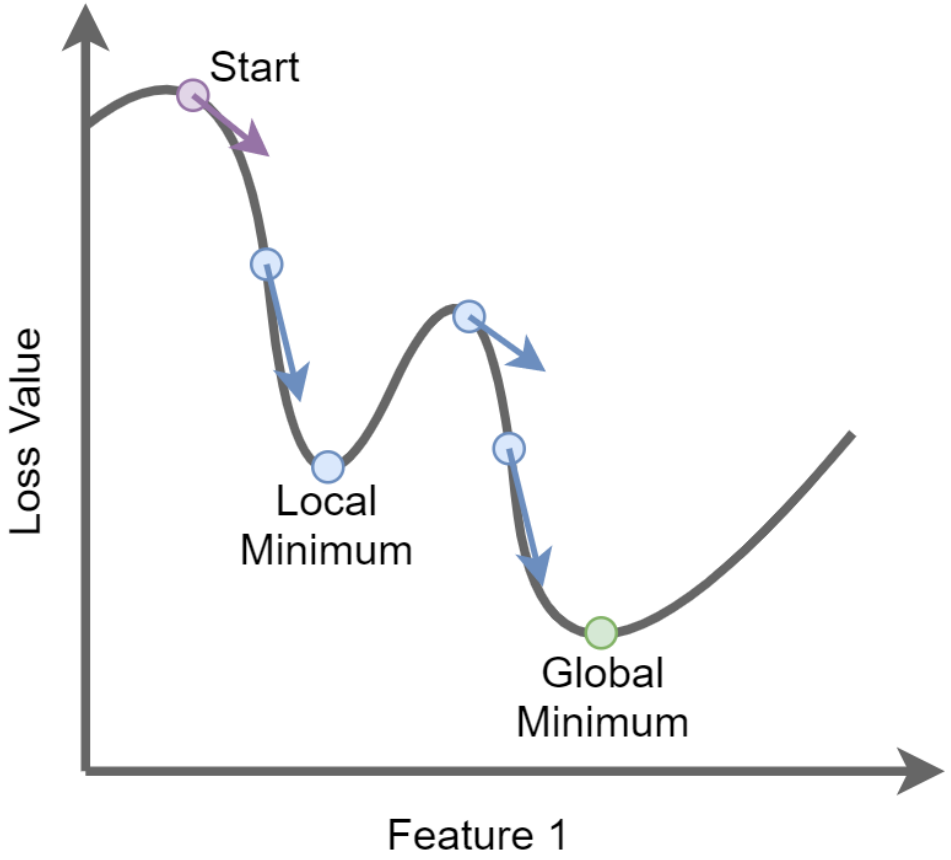
# Machine Learning

Problem solving by inference

# Core Principles of Machine Learning

- Minimizing a "loss" function
  - Mean squared error
  - Root mean squared error
  - Mean absolute error
  - Cross-entropy (log loss)
- Optimized via gradient descent
  - Analogy: rolling down a hill



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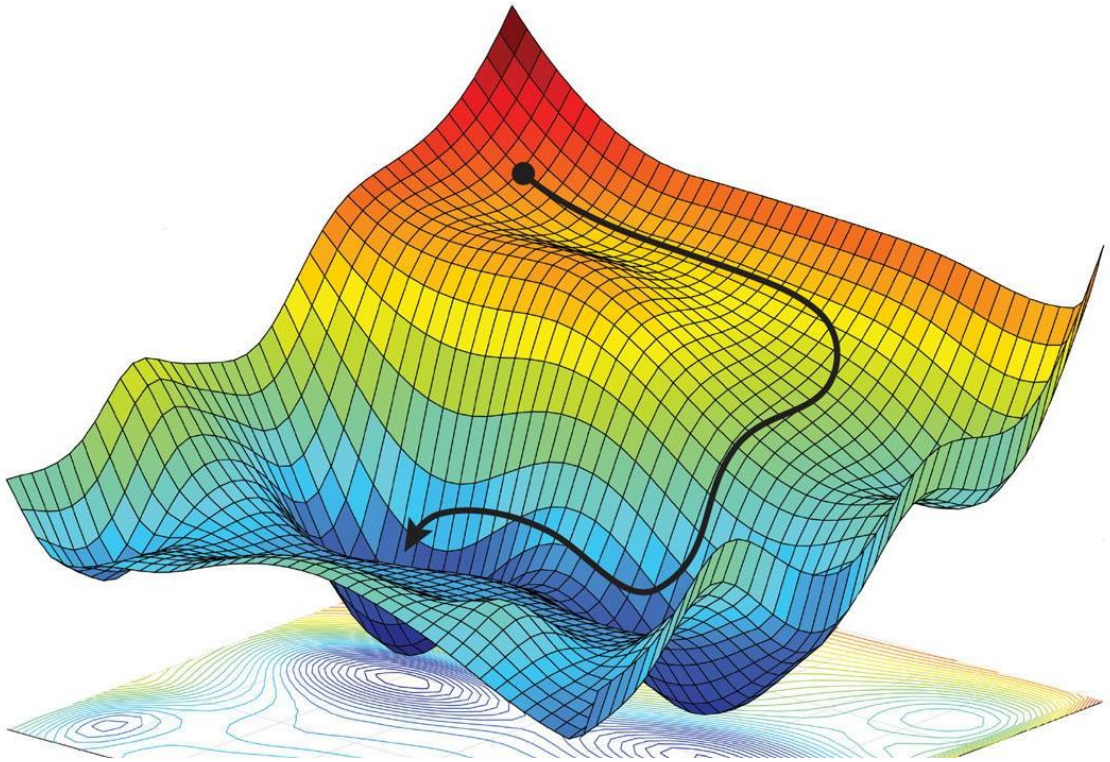
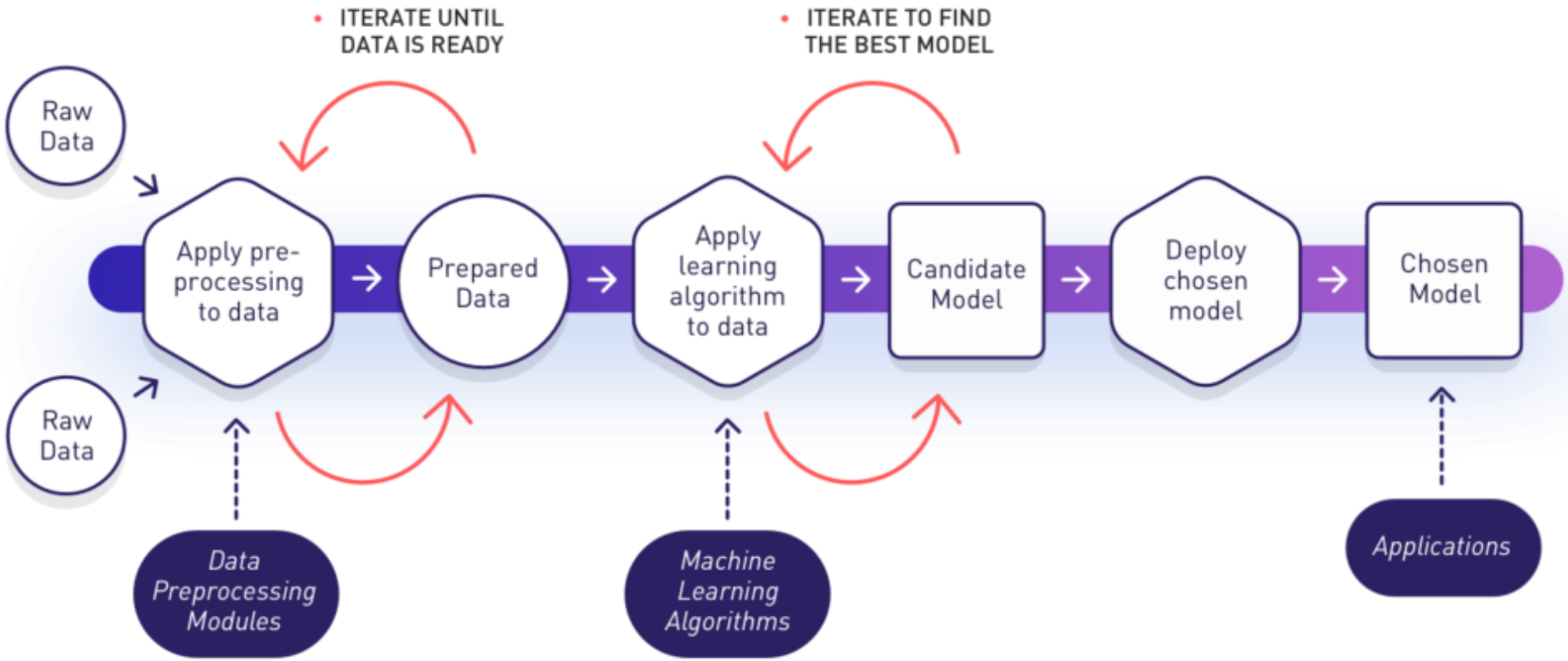


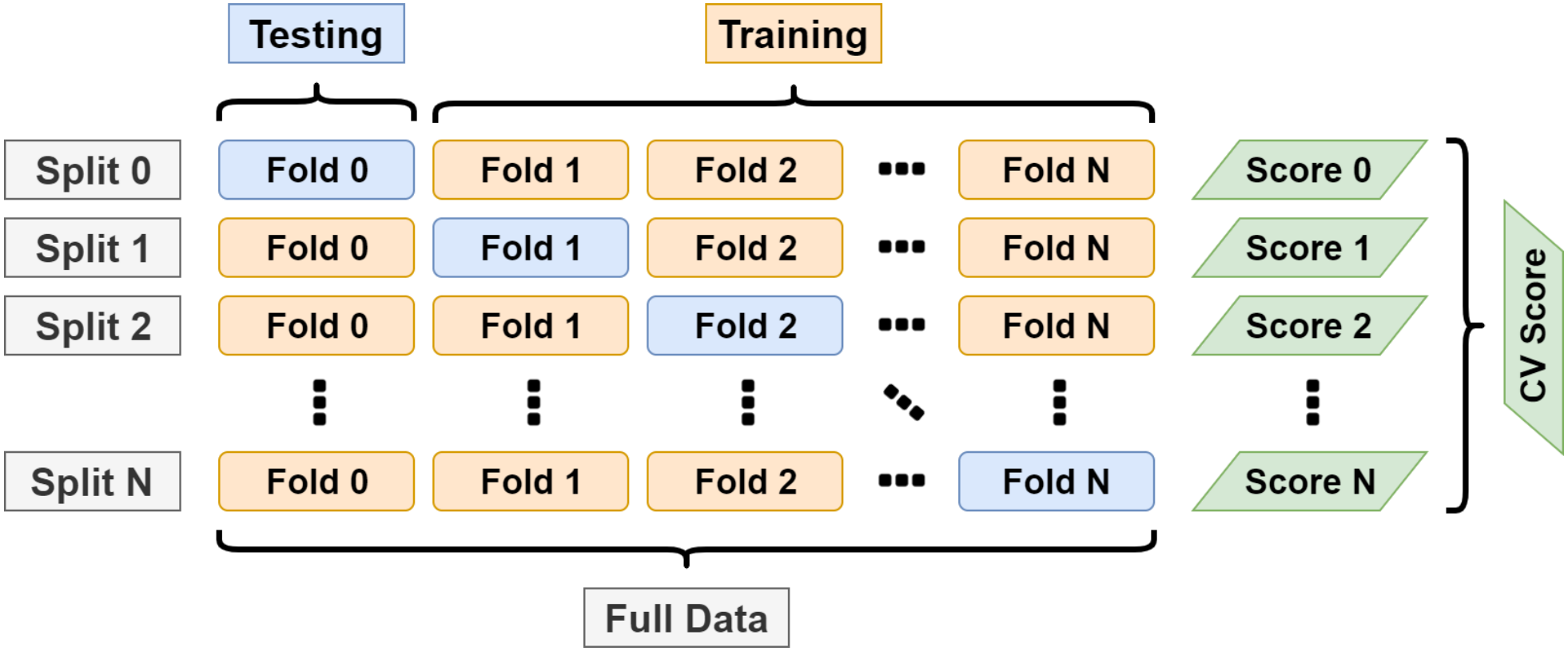
http://bioinformatics.org.au/ws18/wp-content/uploads//sites/22/2016/02/Marcus-Gallgher_2018-Winter-School.pdf

# Typical ML Project Workflow




https://www.uruit.com/blog/wp-content/uploads/2018/02/Diagram-1-1024x435.png

# Cross Validation



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