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Advanced Data Science

Topic 11b – Part 1

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1. What We'll Cover

This topic will introduce…

- **What is data science.**
- **Key concepts – the scientific method.**
- **Useful terminology.**

} **Part 1**

- **Important tools - Statistics.**
- **Data collection & Experiment Design.**

- **Probability basics.**
- **Data distributions.**
- **Hypothesis testing.**

The aim: to help you understand what it means to be a data scientist and to get you familiar with data science tools.

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2. What is Data Science

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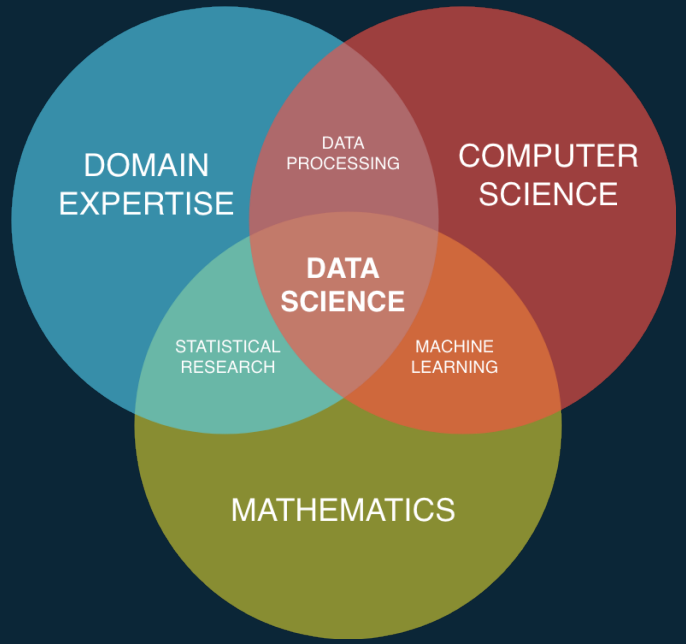
We can loosely define data science as follows:

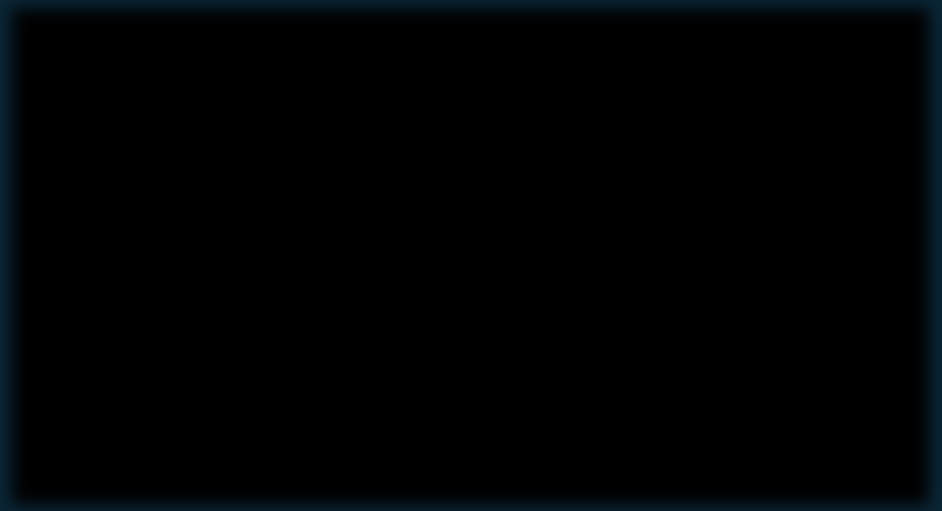
"Data science is a technical discipline concerned with the extraction of new knowledge from data, via application of the scientific method, in conjunction with the tools of mathematics and statistics."



Credit: Shelley Palmer & Crate.io

3. What is Data Science

- How do others see data science?
- There are many views depending on a individuals perspective.
- What is your perspective - perhaps you already have a view?



Credit: Society for Industrial and Applied Mathematics **(SIAM)**

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4. What is DS in Practice?

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- How we apply data science differs by domain.
- Data science may involve trying to solve problems such as:
  - Minimize company expenditure by using statistics to determine the area where savings can be most easily be made.
  - Segment customers into groups that accurate characterize their credit risk.
  - Determine which products a customer is mostly likely to buy based on past spending habits.
  - Determine if a drug is successful at treating a specific condition.

ID	Gender	Age	Var 1	Var 2	Class
x_1	Male	18	52	162	1
x_2	Male	23	75	186	0
x_3	Female	29	47	160	1
x_4	Male	34	80	179	1
x_5	Female	36	60	175	0
x_6	Male	38	80	189	0
x_7	Male	41	94	182	0
x_8	Female	45	52	173	1
x_9	Female	55	69	153	1
x_{10}	Male	62	75	167	0
x_{11}	Female	70	50	157	0
x_{12}	Female	80	45	156	1

Example data

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5. A New Discipline?

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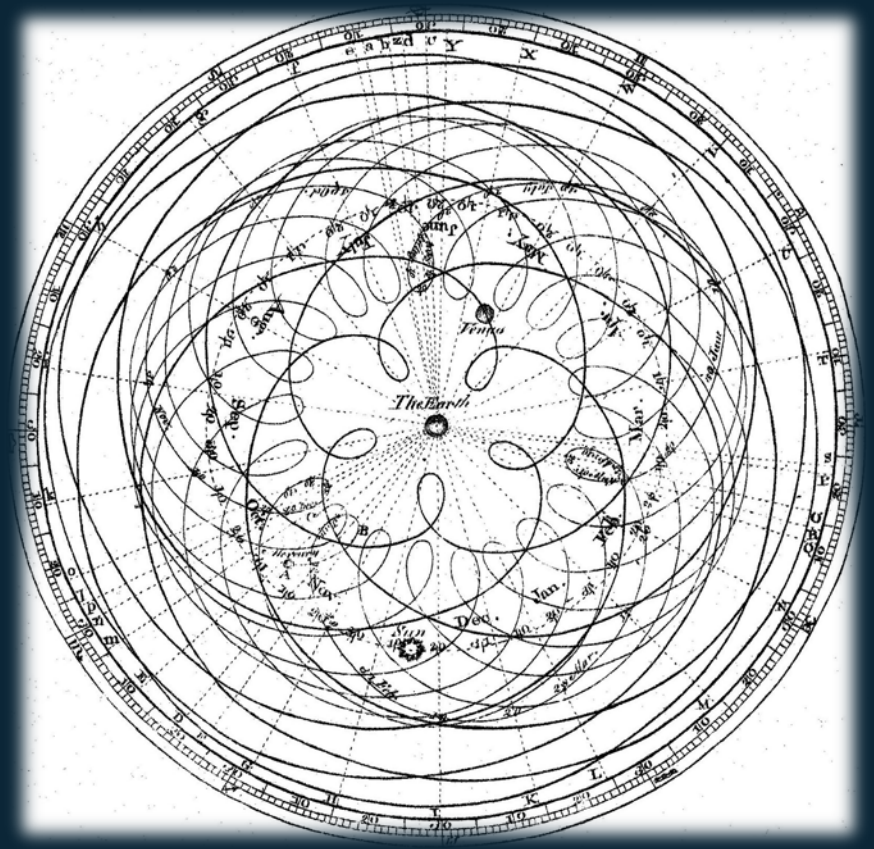
- Data Science is not a new discipline.
- Humans have been colleting/analysing data for centuries.
- Astronomy provides a famous example.



“Data science is a technical discipline concerned with the extraction of new knowledge from data, via application of the scientific method, in conjunction with the tools of mathematics and statistics.”

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6. What's Changed?

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- For most of history "data science" activities were undertaken by experimental scientists.
- Contrast this to the modern world we live in. Everything has changed - data is generated about us everyday.
- Clearly data is everywhere. But little of it was collected with the aim of revealing new knowledge.

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7. Rise of the Data Scientist

We are now living in a data-driven world. There are many challenges in this brave new world facing those working with data.

- **Data wasn't necessarily collected to answer any specific question or solve a specific problem.**

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8. Rise of the Data Scientist

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We are now living in a data-driven world. There are many challenges in this brave new world facing those working with data.

- **Data wasn't necessarily collected to answer any specific question or solve a specific problem.**
- **The types of questions we ask of our data are becoming more complex – requires more than just knowledge of statistics.**
- **Data volumes are increasing dramatically.**
- **Data is increasing in complexity.**
- **The domain knowledge required to stay on top off these issues is increasing over time.**
- **Until recently there was no role that covered all these areas. Hence the data scientist role emerged to fill the gap, and with great success.**

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9. Hype or Reality

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18,251 views | Oct 14, 2019, 07:15am

The Birth Of The Data Science Generation

Forbes

Ike Kavas Forbes Councils Member
Forbes Technology Council COUNCIL POST | Paid Program
Innovation

POST WRITTEN BY

Ike Kavas

Founder & CEO of Ephesoft, Passionate Tech Innovator, Supervised Machine Learning Advocate and Customer-Obsessed Entrepreneur.

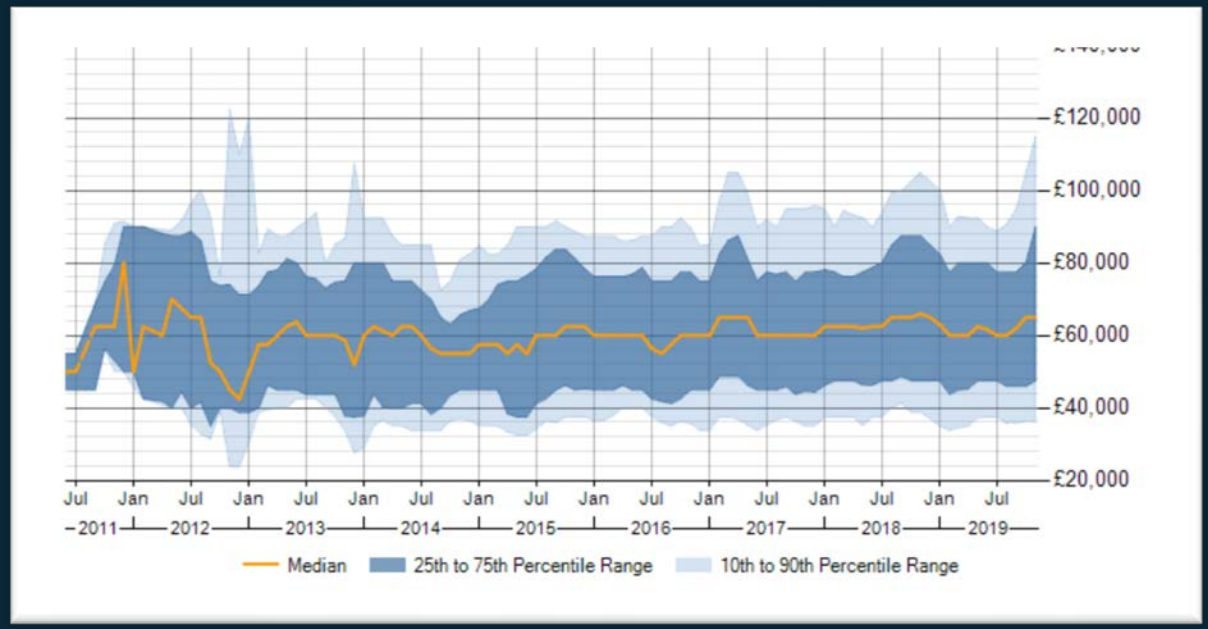
Bloomberg

Economics

These Are the Highest Paying Jobs for the Class of 2019

By Shelly Hagan
May 15, 2019, 1:01 PM GMT+1

- Starting pay for Data Scientist graduates reported at $95,000
- Physical therapist is the only non-technical job on the list



Credit: ITJobsWatch

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10. Hype or Reality

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Pertinent questions:

1. **How significant are these trends?**
2. **What are the data sources, are they trustworthy?**
3. **Is the data biased or skewed in some way?**

These questions can be tackled via applying the tools of data science.

Credit: ITJobsWatch

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11. “Typical” Data Scientist

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What key attributes does a typical data scientist have?

- **Competent programmers in one or more high-level programming languages (Java, Python, C++ etc).**
- **Knowledgeable of database systems, with some experience of relational and non-relational databases (MySQL, Postgres SQL, MongoDB etc).**
- **Statistical background and an understanding of data distributions.**
- **Experience of building/applying machine learning algorithms to data.**

PostgreSQL

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12. “Typical” Data Scientist

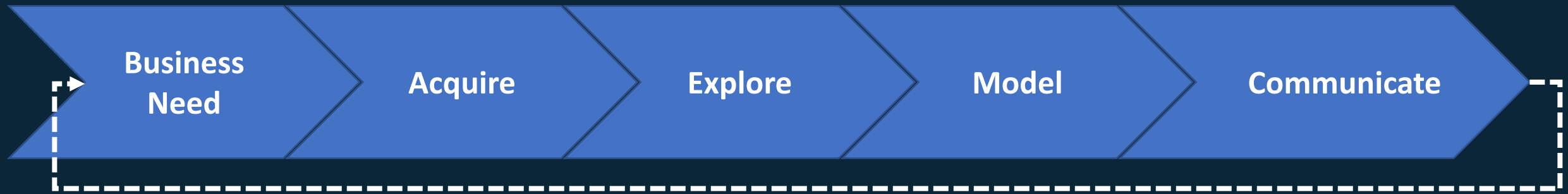
- It is possible to learn these skills – anyone can do this.
- Data scientists require non-technical skills that many people posses.
  - The ability to communicate effectively.
  - To present methods and results to non-technical people.
  - To problem solve.
  - To be rigorous and determined.
- Very few people are experts in everything!
- Data science is constantly evolving, so the technical skillset is always changing.

Credit: Springboard

13. Understanding the Role

There are some essential steps that all must carry out during the course of their work on a project. This begins with,

- **Identifying the business problem at hand.**
- **Data acquisition.**
- **Data pre-processing/Preparation follows.**
- **Data Exploration / Exploratory Data Analysis (EDA).**
- **Data modelling.**
- **Communication / visualisation.**



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14. Practical View

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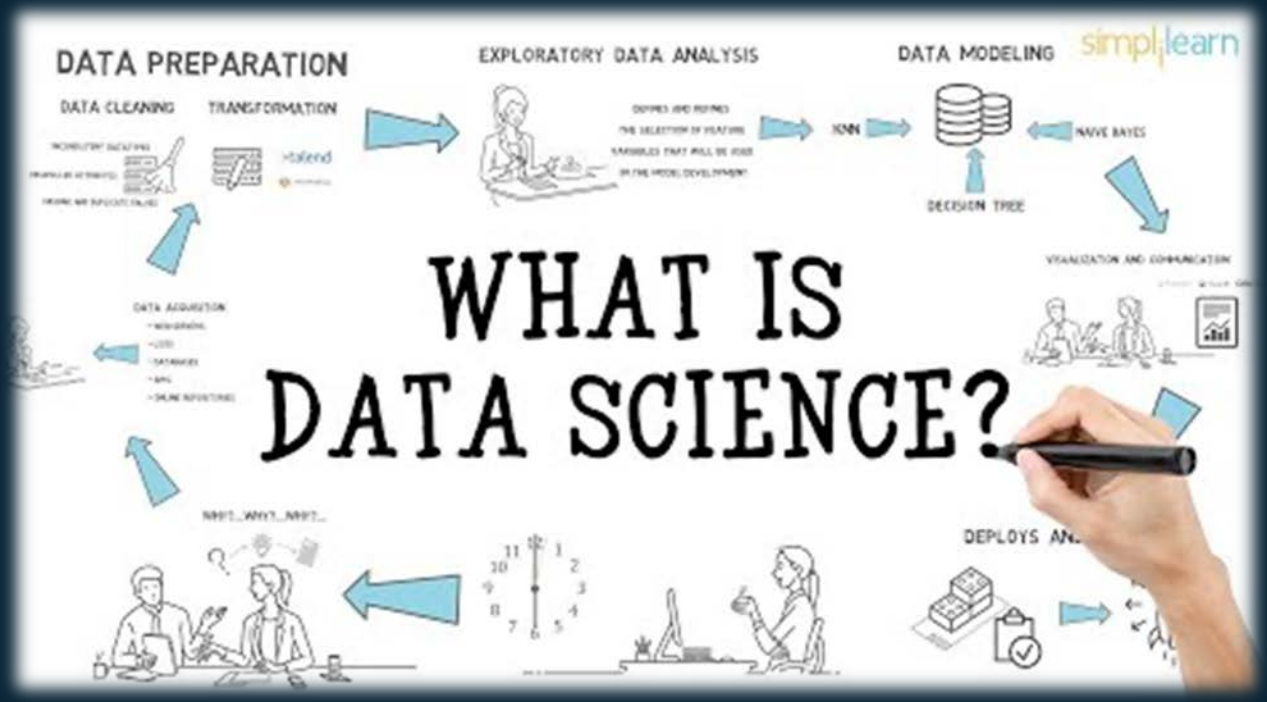

Credit: Simplilearn

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15. Practical View

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Credit: Chevron

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16. Why Important?

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- Data science is becoming an increasingly important discipline.
- As a society we continue to collect more and more data.
- This data is being used to make decisions. Such decisions can affect the lives of people in unforeseen ways, both good and bad.
- It is crucial that we train competent and professional data scientists capable of owning such responsibility.
- If we do this well, data scientists have the potential to help society in many.
- For all the positive possibilities there are an equal number of potentially negative outcomes
- This is why data science, and principled data science, is crucially important.

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17. Science

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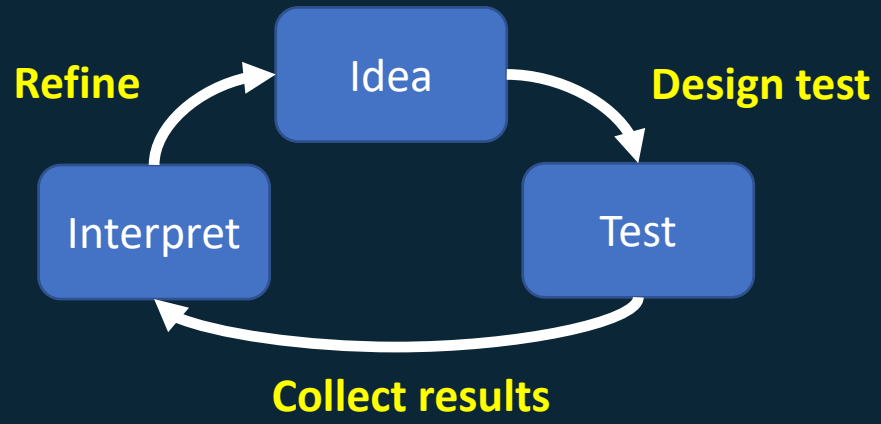

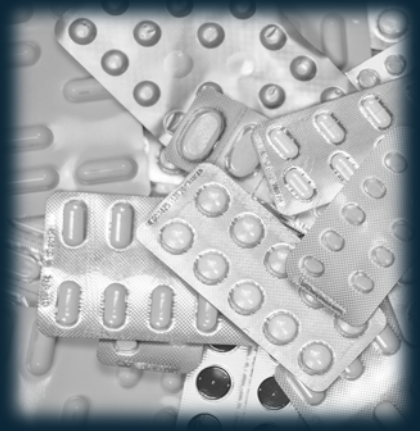

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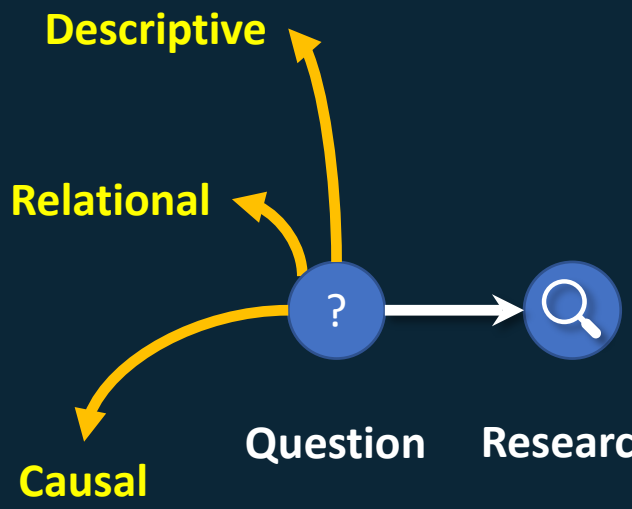
18. The Method

Credit: BBC

19. Scientific Method

- It consists of a number of a steps which if undertaken in order, help establish truth.
- We'll cover the main steps of the methodology here.



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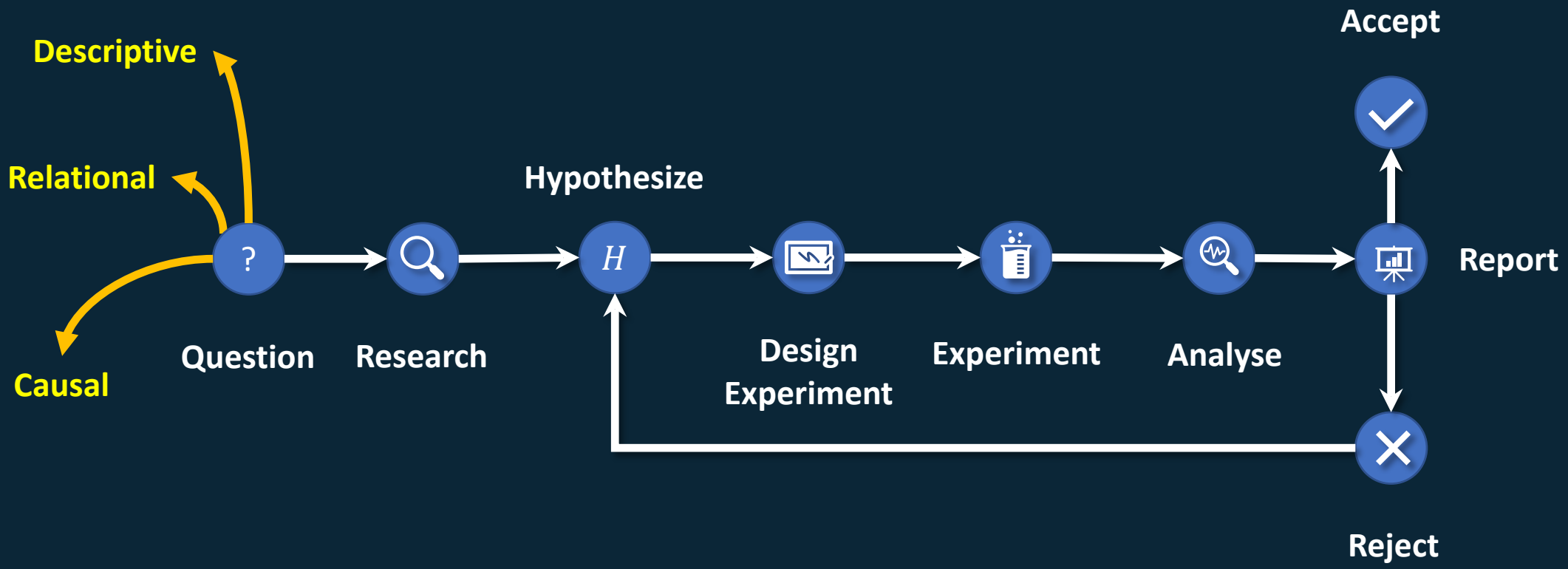
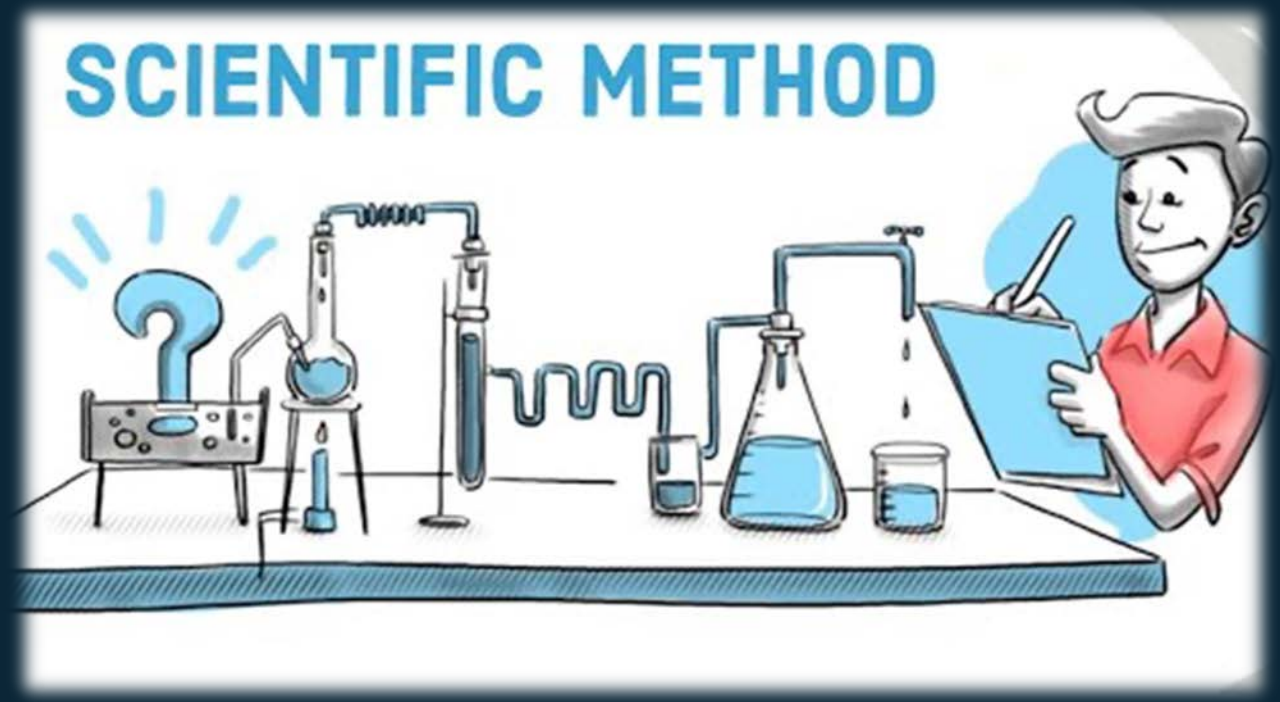


21. Scientific Method



Credit: Sprouts

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22. Hypotheses

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- A hypothesis is a proposed explanation for an observation, phenomena or relationship.
- You no doubt form such explanations each day.
- The null hypothesis is a proposed explanation that is assumed to be true until proven otherwise. It is normally the default position.
- We must form a null hypothesis as part of the scientific method. We normally denote the null hypothesis as H_0.
- The alternative hypothesis is a proposed explanation that directly contradicts the null hypothesis. We normally denote the alternative hypothesis as H_a or H_1.

Null Hypothesis

$$H_0$$

Alternative Hypothesis

$$H_a \quad \text{or} \quad H_1$$

23. Hypotheses

- **Hypotheses must be falsifiable, otherwise they can never be properly tested.**
- **In general, a falsifiable statement only needs one observation to disprove it.**

Null Hypothesis

$$H_0$$

Alternative Hypothesis

$$H_a \quad \text{or} \quad H_1$$

24. Hypotheses

Credit: 365 Data Science

25. Experiment Design

- Experiment design varies according to the hypotheses under consideration, but there are some general similarities between all experiments.
- Example – do website shoppers spend more if targeted ads are removed?
- We define our groups.
- We identify our variables.

Null Hypothesis

H_0= No effect

Alternative Hypothesis

H_a or H_1= Effect on sales

Independent Variable *= Targeted ads per user*

Dependent Variable *= Value of sales per user*

Targeted

Control Group

Only the Independent Variable altered between Groups.

Non-Targeted

Experimental Group

26. Experiment Design

- **Experiment design varies according to the hypotheses under consideration, but there are some general similarities between all experiments.**
- **Example – do website shoppers spend more if targeted ads are removed?**
- **We define our groups.**
- **We identify our variables.**

Null Hypothesis

H_0= No effect

Alternative Hypothesis

H_a **or** H_1= Effect on sales

Independent Variable *= Targeted ads per user*

Dependent Variable *= Value of sales per user*

Control variables *e.g.*
time of day, user age group etc

Not Targeted

Control Group

Only the Independent Variable altered between Groups.

Targeted

Experimental Group

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27. Experiment Design

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Credit: Khan Academy

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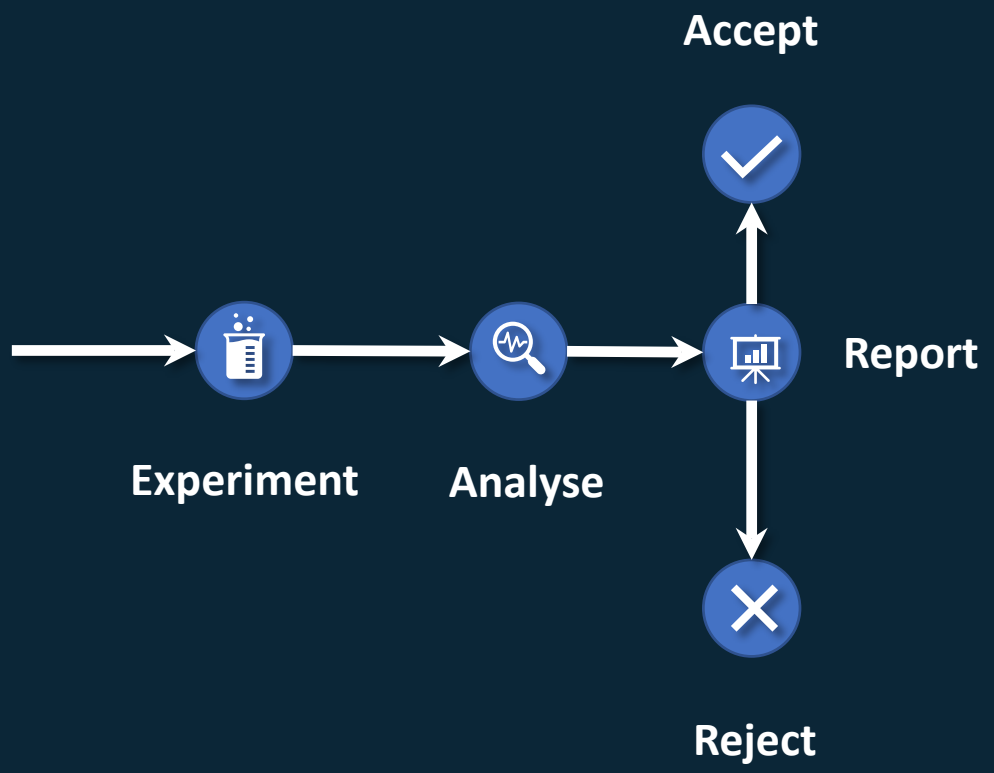
28. Remaining Stages

- Once you've designed your experiment, you ultimately prepare it and then carry it out.
- This usually involves first collecting / cleaning data. Then we can write code/use tools to run the experiment.
- Perhaps the most important part of the experiment involves analysis – Hypotheses evaluated against results.
- Eventually results are reported to various stakeholders.
- Traditionally negative outcomes have been viewed as failures – but not the case!



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29. Case Studies

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Credit: PwC

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30. Summary

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- What data science is.
- The nature of the data science role.
- The data science process.
- The scientific method in relation to data science.