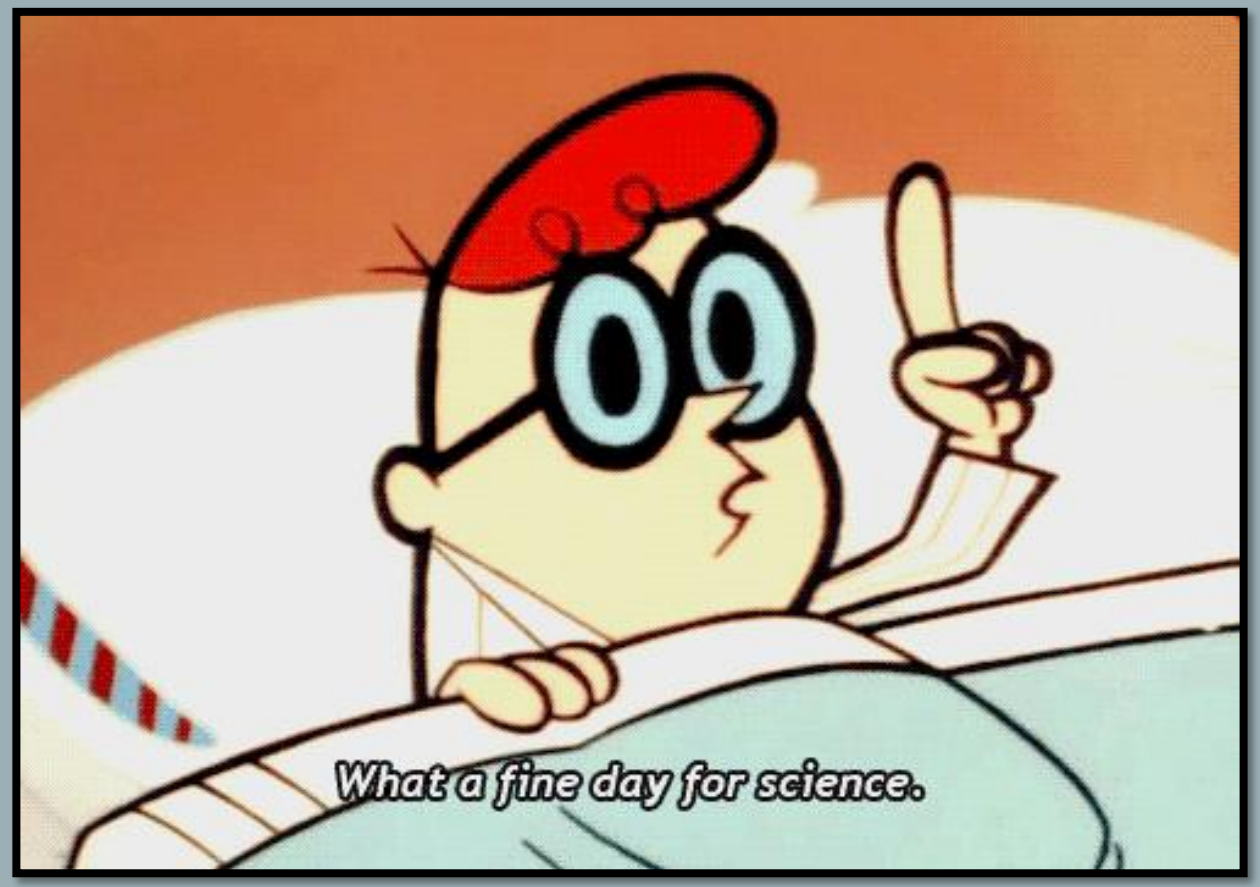
SCIENTIFIC METHOD



SCIENTIFIC METHOD

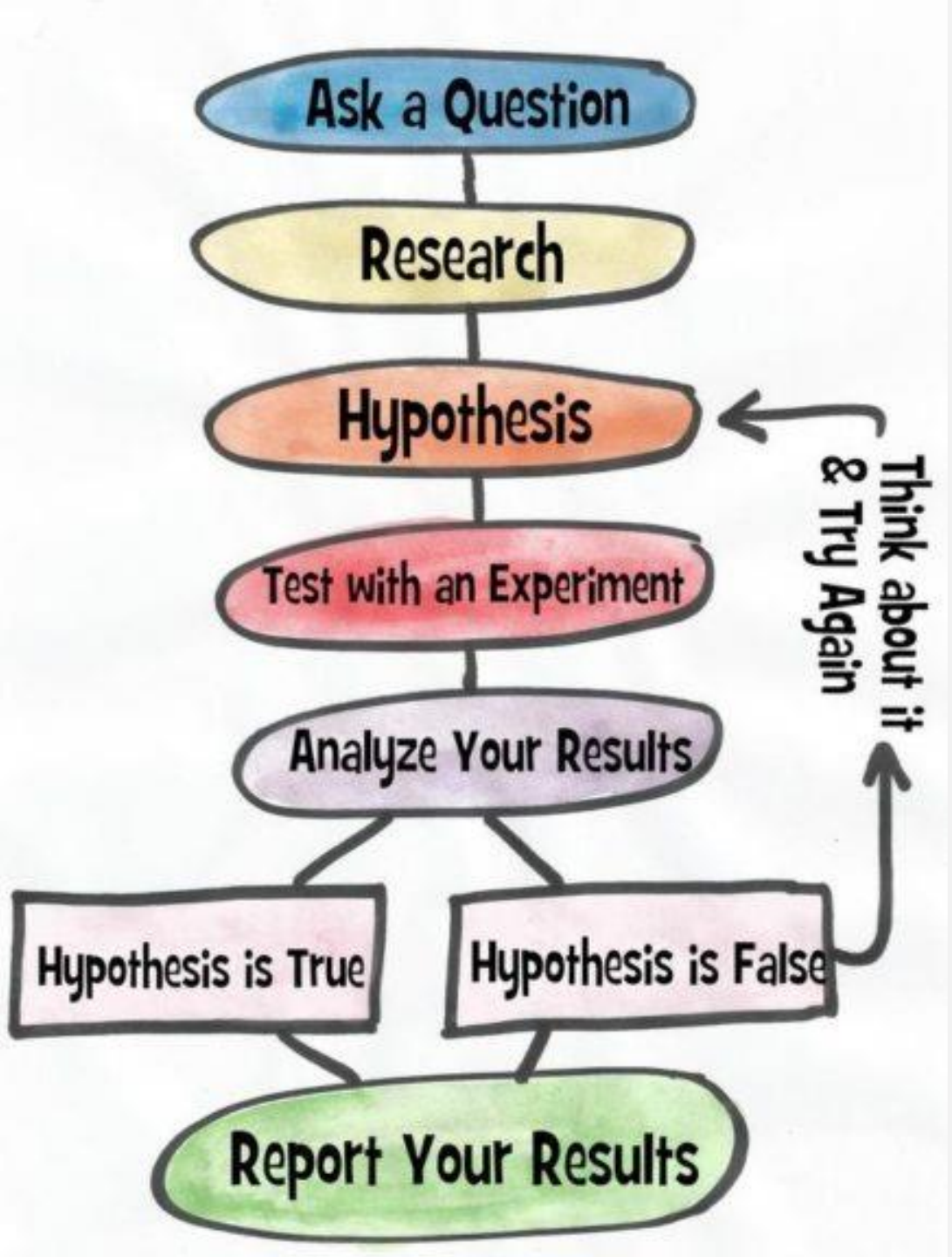
What is the Scientific Method?

SCIENTIFIC METHOD

- What is the **Scientific Method**?
  - **How scientists study and learn about the world** around them

SCIENTIFIC METHOD

- In reality, there is **no such thing as ONE Scientific Method**
  - It depends a lot on the type of Science you are doing
  - BUT in general, **all scientists follow a similar set of steps**; the order might just change


Ask a Question
Research
Hypothesis
Test with an Experiment
Analyze Your Results
Hypothesis is True
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Report Your Results
Think about it & Try Again

SCIENTIFIC METHOD

- **Step 1 – Question**
  - Starts when you **ask a question about something that you observe**:
    - How, What, When, Who, Which, Why, or Where?

SCIENTIFIC METHOD

- Examples:
  - Why do dogs & cats have fur?
  - Why do the tornadoes form?
  - When does thunder and lightning occur the most?
  - Why do spiders spin webs?
  - How do different buildings stand up to earthquakes?
  - How do crystals form?

SCIENTIFIC METHOD

- **Step 2 – Research**
  - In order to design an appropriate experiment, you need to **research the topic including the best techniques and equipment for investigating it**.
  - To help you along, identify the key words in your question to research.

SCIENTIFIC METHOD

- Researching your experiment beforehand is the difference between guessing and having a hypothesis.
- Where can you find information?
  - The internet, library (books, magazines, journals, etc…), text book etc.

SCIENTIFIC METHOD

- **Step 3 – Hypothesis**
- A hypothesis is an **educated guess** about how things work **based on research and observations.**

SCIENTIFIC METHOD

- **Step 4 – Experiment**
  - Your **experiment provides evidence to help you decide whether your hypothesis is true or false.**
  - You should also repeat your experiments several times to make sure that the first results weren't just an accident.

SCIENTIFIC METHOD

- **Variables**
  - The things (factors, traits, measurements) that could change in an experiment

SCIENTIFIC METHOD

- **Independent Variable**
  - A variable that is NOT affected/changed by the other variables you are trying to measure. It is often the one that is changed by the scientist
  - Try to have only ONE independent variable because if you change more than one thing, it could be difficult to know which factors caused the change

SCIENTIFIC METHOD

Dependent Variables

- A variable that changes in response to other factors (like the independent variable)

SCIENTIFIC METHOD

Controlled Variables

- Factors that could change but that the scientist wants to keep constant (don't change) so that they don't affect the results of the experiment

SCIENTIFIC METHOD

- **Examples:**
  1) Let's say you wanted to see if the size of a dog affects how much it eats.

What is the independent variable? **The size of the dog**

What is the dependent variable? **Amount of food eaten**

SCIENTIFIC METHOD

- **Examples:**

1) Let's say you wanted to see if the size of a dog affects how much it eats.

What are some variables you would need to control?

- **Making sure you always feed at the same time of day**
- **Making sure you always give them the same food**
- **Making sure you are comparing dogs of the same breed**
- **etc**

SCIENTIFIC METHOD

- **Examples:**
  2) Does amount of light affect how much algae grows in an aquarium

What is the independent variable? **Amount of light**

What is the dependent variable? **How much algae is present**

SCIENTIFIC METHOD

- **Examples:**

2) Does amount of light affect how much algae grows in an aquarium

What are some variables you would need to control?

- **Temperature of the water**
- **Other species present in the water**
- **How much food is being fed to the fish**
- **Type of food being given to the fish**

SCIENTIFIC METHOD

- **Control Groups**
  - The "base" group that you use for comparison to see if the factor you are changing has an effect
- **Experimental Groups**
  - The group where you modify the factors (independent variables)

SCIENTIFIC METHOD

- **Example**

  You usually keep your microwave popcorn in the cupboard but you read an article online that says that cold kernels pop better than room temperature ones. So you decide to test this out by placing some popcorn in the fridge and keeping some in the cupboard.

SCIENTIFIC METHOD

- **Examples:**

What is the independent variable? **Temperature**

What is the dependent variable? **Amount of kernels that popped**

What is the control group? **Popcorn in cupboard**

What is the experimental group? **Popcorn in fridge**

SCIENTIFIC METHOD

- **Examples:**

  What are some variables you would need to control?

  - **Brand of popcorn**
  - **Batch (from same box)**

SCIENTIFIC METHOD

- **Observation**
  - Information that you gather through the five senses: what you can see, smell, taste, hear, feel.
- **Inference**
  - Conclusions that you draw based on your observations

SCIENTIFIC METHOD

- **Example:**

SCIENTIFIC METHOD

- **Observation**
- There is a liquid on the pavement

- **Inference**
  - Water is on the pavement
  - It must have rained

SCIENTIFIC METHOD

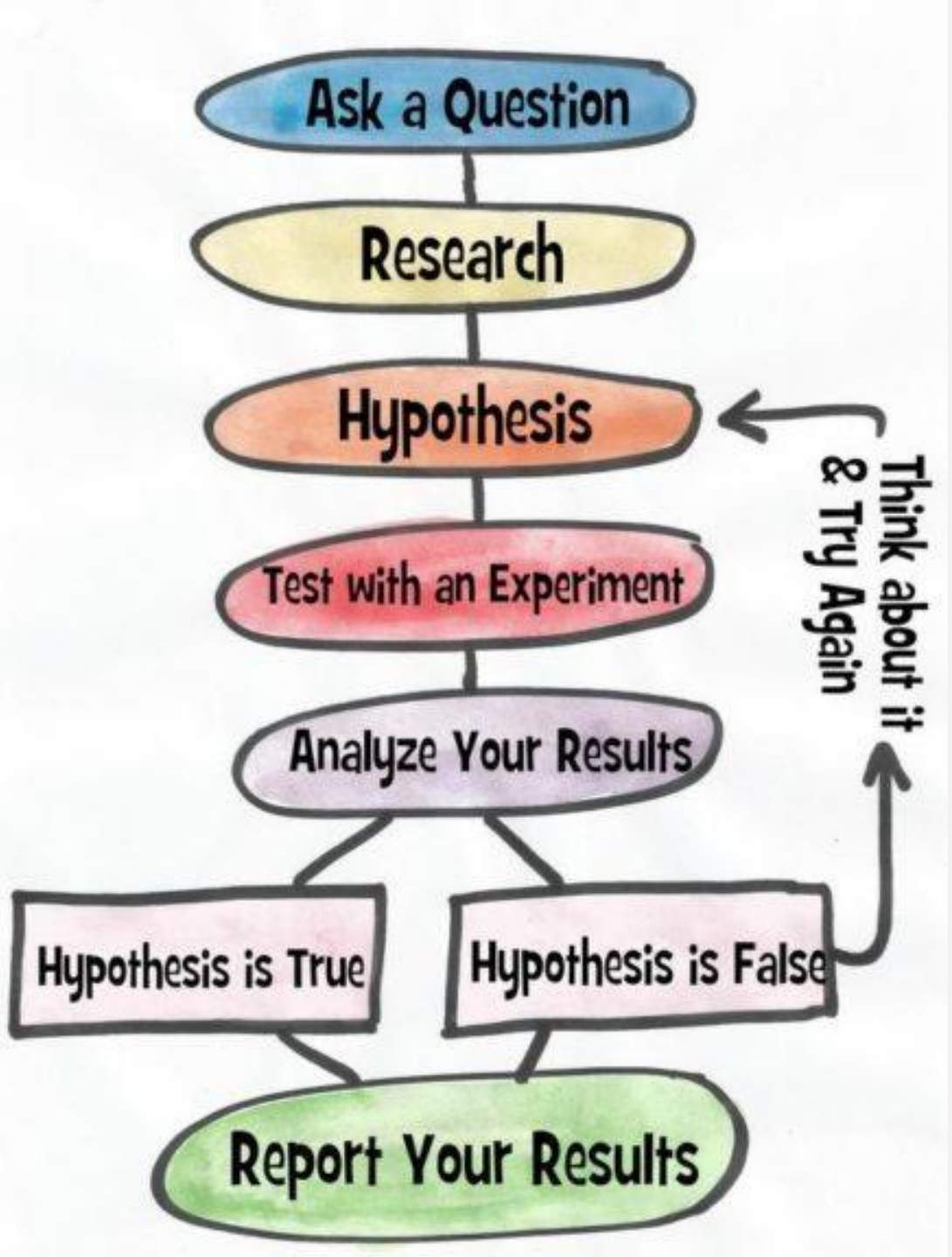
- **Step 5 – Collect and Analyze Data**
  - Once your experiment is complete, you **collect your results and analyze them to see if your hypothesis is true or false**

SCIENTIFIC METHOD

- **Make a table**
- Maybe chart your results through **a graph** to help find a pattern

SCIENTIFIC METHOD

- **Step 6 – Conclusions**
  - To complete the scientific method, you must **communicate your results to others in a final report.**
  - Professional scientists do almost exactly the same thing by publishing their final report in a scientific journal or by presenting their results on a poster at a scientific conference.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LAB SAFETY

BEFORE THE LAB

- 1) **Read all the instructions** and make sure you understand what you are supposed to do
  - I will often demonstrate what you will be doing - so **pay close attention**
  - **Take extra notes** to help you out later
  - **Ask questions** if anything is unclear!

BEFORE THE LAB

- 2) **Prepare** your self for the lab:
  - **Tie back long hair**
  - **No loose clothes**
  - **No dangling jewelry or wires**
  - **No open-toed shoes**
  - **Goggles!**

BEFORE THE LAB

- 3) **Clear your workspace**
  - Make sure your books are off to the side and that your tabletop is clean
  - **No food** in the lab!

DURING THE LAB

- 1) **Good behaviour**
  - There is to be no pushing or shoving or any other "horseplay" during the lab
  - If you are misbehaving **I can revoke your lab privileges**
    - You will still be responsible for the **lab report**!

DURING THE LAB

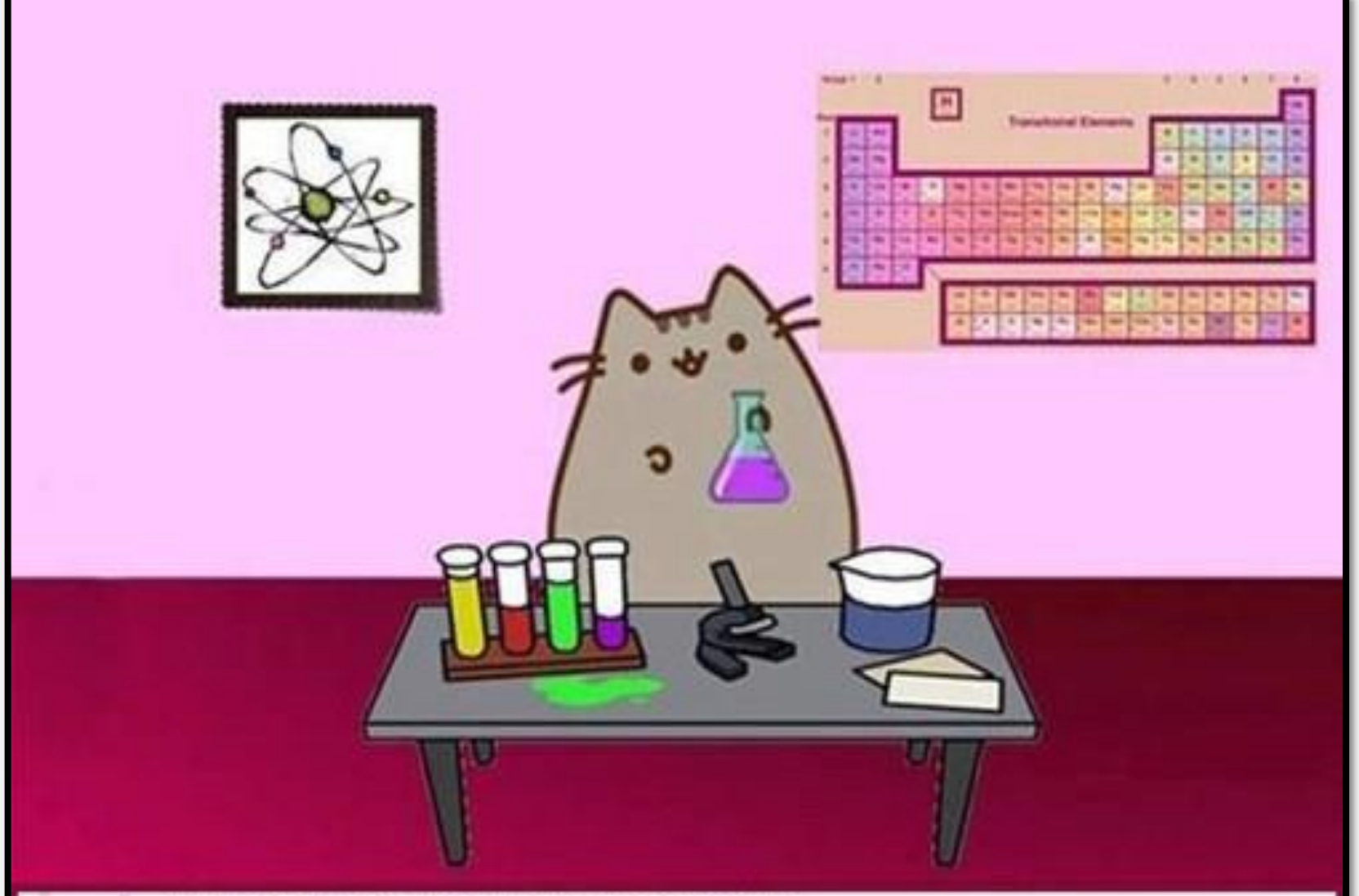
- 2) **Health Safety**
  - **Never eat or drink** anything during a lab unless otherwise instructed
  - Do not directly smell substances; always use the **wafting technique**
  - **Avoid touching your face and eyes**
  - If you are **hurt**, let me know ASAP

DURING THE LAB

- You may **only perform the experiments** that I have **pre-authorized**
- If you would like to try something different: ask!

DURING THE LAB

- 3) **Material Safety**
  - Pay attention to any **handling instructions**
  - Keep materials away from table edges
  - **Report any broken equipment**
  - **Report any chemical spills**
  - **Dispose of materials where instructed**



> Pusheen the cat making some chemistry.

That cat is not wearing safety goggles, he hasn't even bothered to clean up that spilled solvent, and he is holding that Erlenmeyer flask way to close to his face.

Pusheen the Cat, more like Pusheen the limits of lab safety

AFTER THE LAB

- **Clean up**
  - Most chemicals will go into a waste container – **NOT the sink**
    - Make sure to pay attention to where things are to be disposed of
  - **Clean and dry** all equipment
  - All equipment must **go back to where you got it from**

AFTER THE LAB

- **Clean up**
  - Clean your **tabletop** and **pick up any trash**
  - **Wash your hands**!

ACCIDENTS AND INJURY

If you get **chemicals in your eyes**:

- Inform me right away
- Use emergency **eyewash** station for **10 minutes** with eyes open

ACCIDENTS AND INJURY

If you spill **chemicals on your skin** or get **burned**:

- Inform me right away
- Rinse area under **cold water** for **10 minutes**

ACCIDENTS AND INJURY

If a fire occurs:

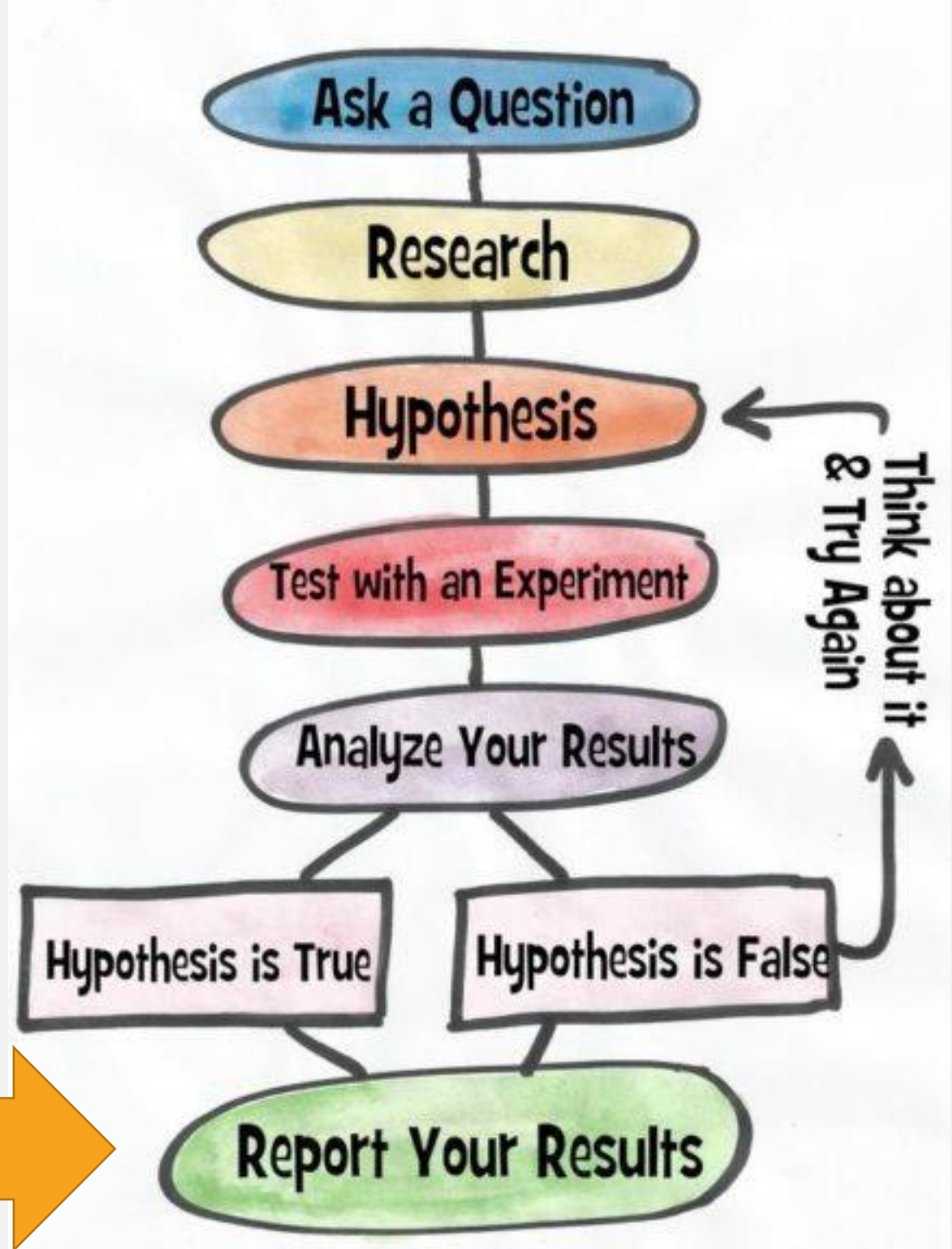
- Throw the **fire blanket** over the fire

WHAT'S WRONG WITH THIS PICTURE?

WHAT'S WRONG WITH THIS PICTURE?

WHAT'S WRONG WITH THIS PICTURE?

LAB REPORTS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LAB REPORTS

Title

- Tells you **what the lab is about**
- *Ex: Determining the Effects of Light on the Growth of Plants*

LAB REPORTS

Aim

- the **purpose** of the experiment
  - starts with the word "To…"

Ex: To determine how light quantity affects a plant's growth rate

LAB REPORTS

Hypothesis

- an **educated guess** about what will happen in the experiment
- is a **testable** statement justified using scientific reasoning (often ‘if… then…because…’)
-

LAB REPORTS

Hypothesis

- *Ex: **If** sunflower A is placed on a windowsill and a sunflower B is placed in a closet, **then** sunflower A should grow the most in 10 days **because** plants require light in order to complete the process of photosynthesis and thereby grow.*

LAB REPORTS

Materials

- **list** in point form of all materials used in the lab (columns)
  - **indicates size and quantity**

Ex: *- 3 x 100mL volumetric flask*

- 12-well spot plate

- Unknown solid A

LAB REPORTS

Procedure

- Provides a **step-by-step** plan that precisely describes how the experiment will be conducted
- Each step is **numbered**

Ex: 1) Pour 50mL of water into the 100mL graduated cylinder

2) Weigh unknown A on the electronic balance

3) Record results.

LAB REPORTS

Results

- data is presented in **table** or chart format
  - all tables, charts and graphs should be **labelled appropriately** with titles, headings and units of measurements

LAB REPORTS

Results

- **observations** noted during the experiment must be recorded, **just the facts not any interpretation of what the facts mean**

QUANTITATIVE VS QUALITATIVE

Quantitative Data

- Data that can be **counted** or **measured**
  - Represents a quantity (amount)
- Expressed using **numbers**

Ex: 250mL of water

23 cm in diameter

12 drops of acid

QUANTITATIVE VS QUALITATIVE

Qualitative Data

- Data that **cannot be counted** or measured
- **Characteristics or descriptions**

Ex: colour, relative size, shape

REVIEW: AVERAGES

Calculating Averages

$$Average = \frac{Sum\ of\ values}{Number\ of\ values}$$

REVIEW: AVERAGES

Calculating Averages

Example:

Let's say we wanted to determine on average, how many students take the bus, car or walk to get to school. So we survey three classes.

REVIEW: AVERAGES

Calculating Averages

Example

Table 1. Number of students getting to school by car, bus or walking

Category	Class 1	Class 2	Class 3	Average
Car	8	3	4	?
Bus	20	24	22	?
Walk	2	2	5	?

REVIEW: AVERAGES

Calculating Averages

$$Average = \frac{sum\ of\ values}{number\ of\ values}$$

Example Average for Car

$$Average = \frac{8 + 3 + 4}{3}$$

$$Average = \frac{15}{3}$$

$$Average = 5$$

REVIEW: AVERAGES

Calculating Averages

Example Results

Category	Class 1	Class 2	Class 3	Average
Car	8	3	4	5
Bus	20	24	22	?
Walk	2	2	5	?

REVIEW: AVERAGES

Calculating Averages

$$Average = \frac{sum\ of\ values}{number\ of\ values}$$

Example Average for Bus

$$Average = \frac{20 + 24 + 22}{3}$$

$$Average = \frac{66}{3}$$

$$Average = 22$$

REVIEW: AVERAGES

Calculating Averages

Example Results

Category	Class 1	Class 2	Class 3	Average
Car	8	3	4	5
Bus	20	24	22	22
Walk	2	2	5	?

REVIEW: AVERAGES

Calculating Averages

$$Average = \frac{sum\ of\ values}{number\ of\ values}$$

Example Average for Walking

$$Average = \frac{2 + 2 + 5}{3}$$

$$Average = \frac{9}{3}$$

$$Average = 3$$

REVIEW: AVERAGES

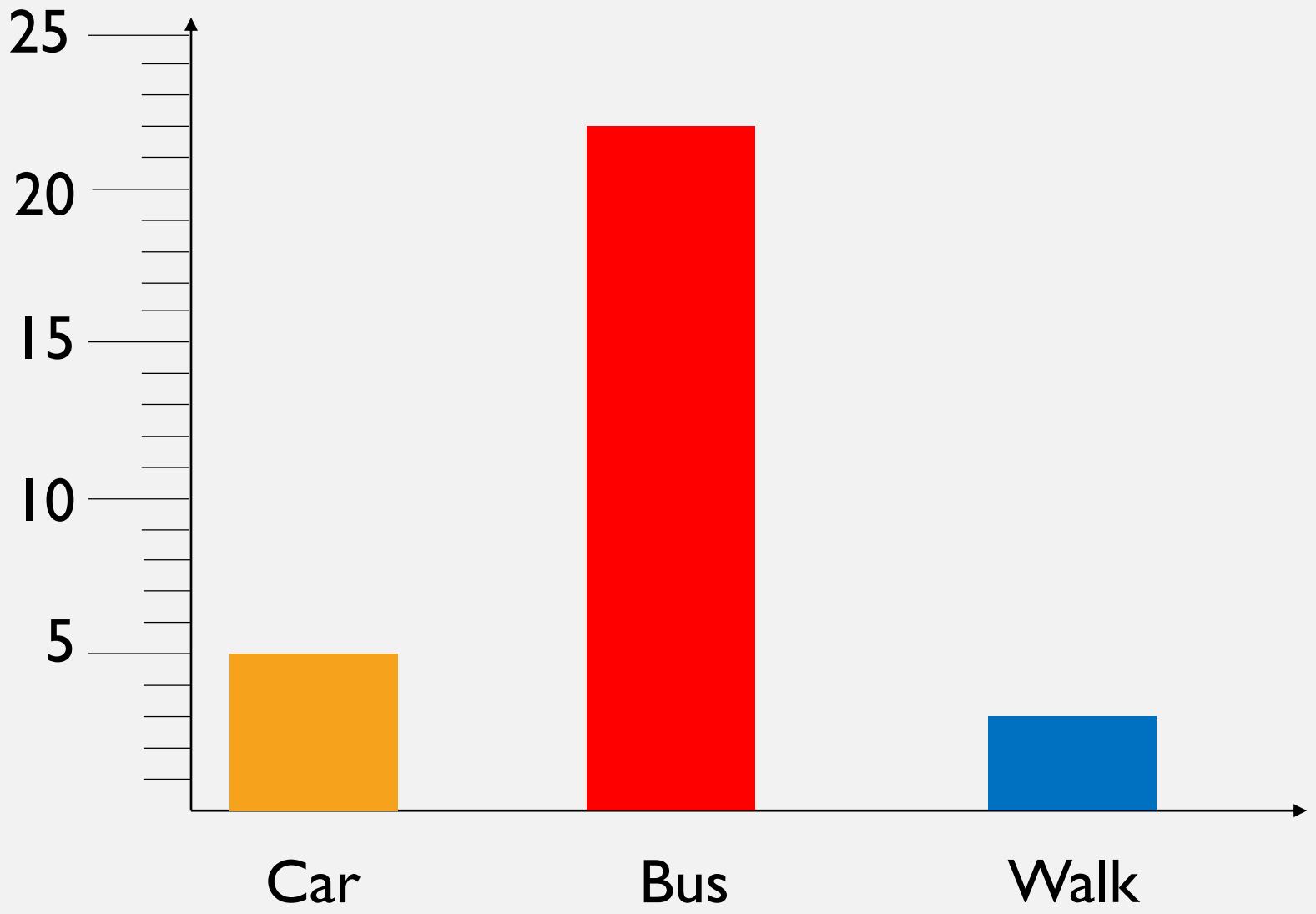
Calculating Averages

Example Results

Category	Class 1	Class 2	Class 3	Average
Car	8	3	4	5
Bus	20	24	22	22
Walk	2	2	5	3

REVIEW: BAR GRAPHS

REVIEW: BAR GRAPHS



LAB REPORTS

Analysis

- Answer any questions given while referring to the results obtained

LAB REPORTS

Conclusion

- **Summarizes the findings** of the experiment
- Made up of 5 parts

LAB REPORTS

Conclusion

1. Restate the aim of the lab “The aim was…”

2. Restate the hypothesis of the lab “The hypothesis was…”

LAB REPORTS

Conclusion

3. State and explain the results

4. Indicate if the hypothesis was correct or incorrect

LAB REPORTS

Conclusion

5. Sources of errors and/or suggestions to improve the lab

- sources of error:

- **discuss** possible errors that **could have** occurred in the collection of the data (material error, human error … **specific to the experiment**)
- these should be things that are out of your control