Principal Characteristics of Science

- Hypotheses
  - Falsifiable (hypotheses capable of being tested and refuted/supported)
- Logical deduction
- Objective observation:
  - Measurement and data (possibly although not necessarily using mathematics/statistics as a tool)
- Empirical evidence
- Experiment and/or observation as benchmarks for testing hypotheses

Principal Characteristics of Science

- Induction: reasoning to establish general rules or conclusions drawn from facts or examples

- Repetition (replicable results)

- Critical analysis

- Verification and testing: critical exposure to scrutiny, peer review and assessment

- Precision in data collection and analysis

Principal Characteristics of Science

- Systematic/organised – argument can be followed from hypotheses to experimental findings, and through to conclusions – logical

- Controllable

- Defensible

- Contributes to body of scientific knowledge

- Findings are communicated

- Generalisable

A definition of science

- "Science is the pursuit and application of **knowledge** and **understanding** of the natural and social world following a **systematic methodology** based on **evidence**"

Demarcation Criteria

- The demarcation criteria
  - What is enough to distinguish genuine science from pseudoscience?
    - e.g. astrology, whilst generating a body of knowledge empirically, is not considered a genuine science
  - Why should astrology be seen differently from other sciences?
- Pseudoscience
  - Theories are compatible with all results
  - Does not recognise anything that its theories cannot explain
  - Is not falsifiable (Karl Popper)

Revolutionary Science

- Theory by Thomas Kuhn
- Normal science
  - Use of a paradigm to solve puzzles, with assumption that paradigm is incorrect
  - Anomalous results build up
- Paradigm shift
  - New paradigm which subsumes old results and anomalies (e.g. quantum mechanics)
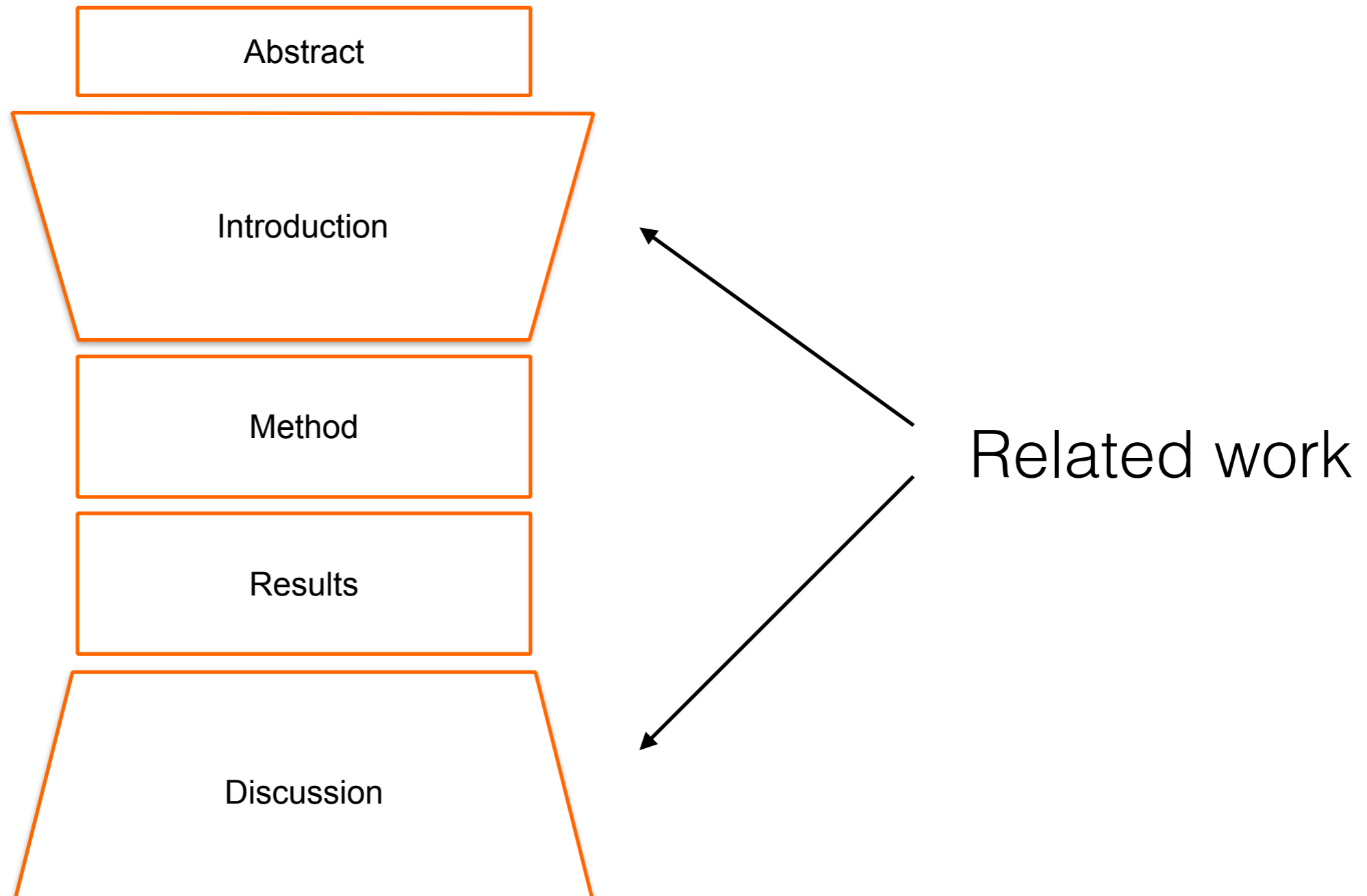
Scientific Method
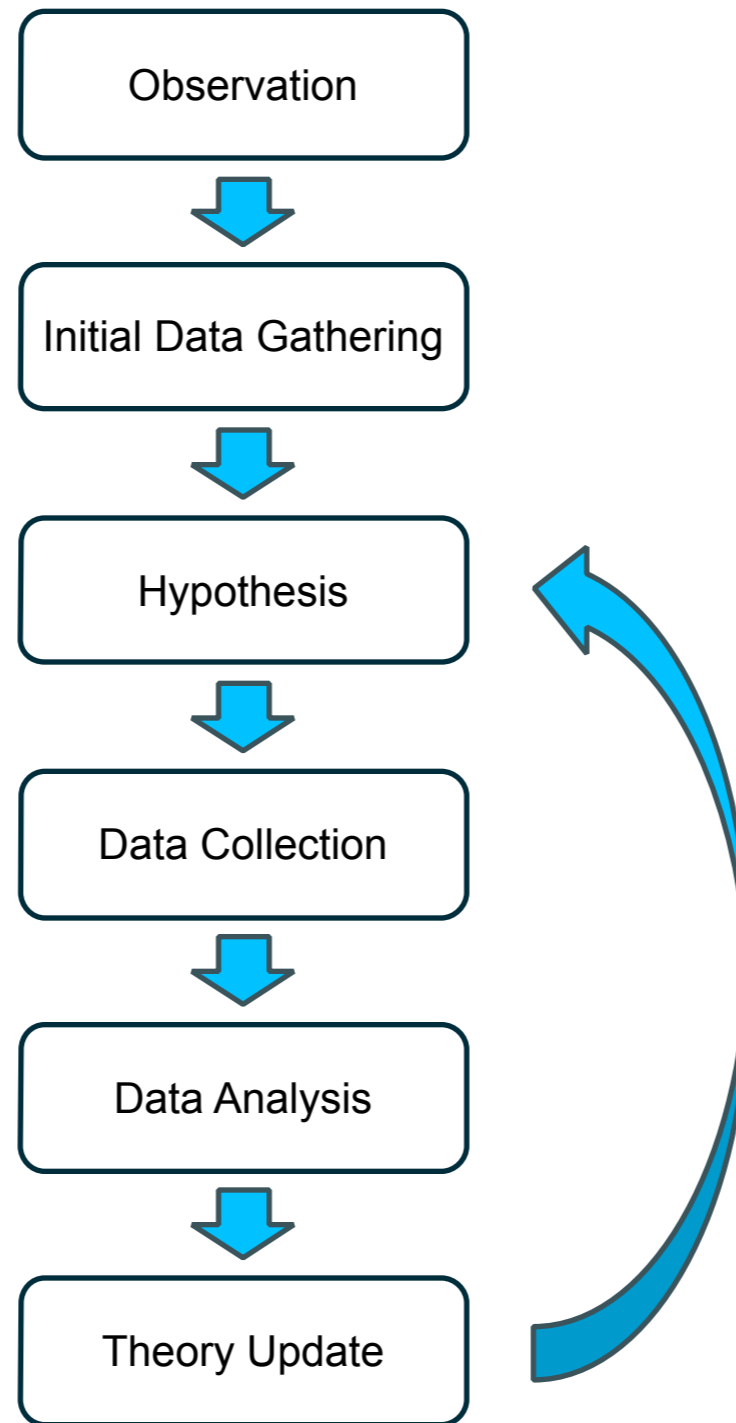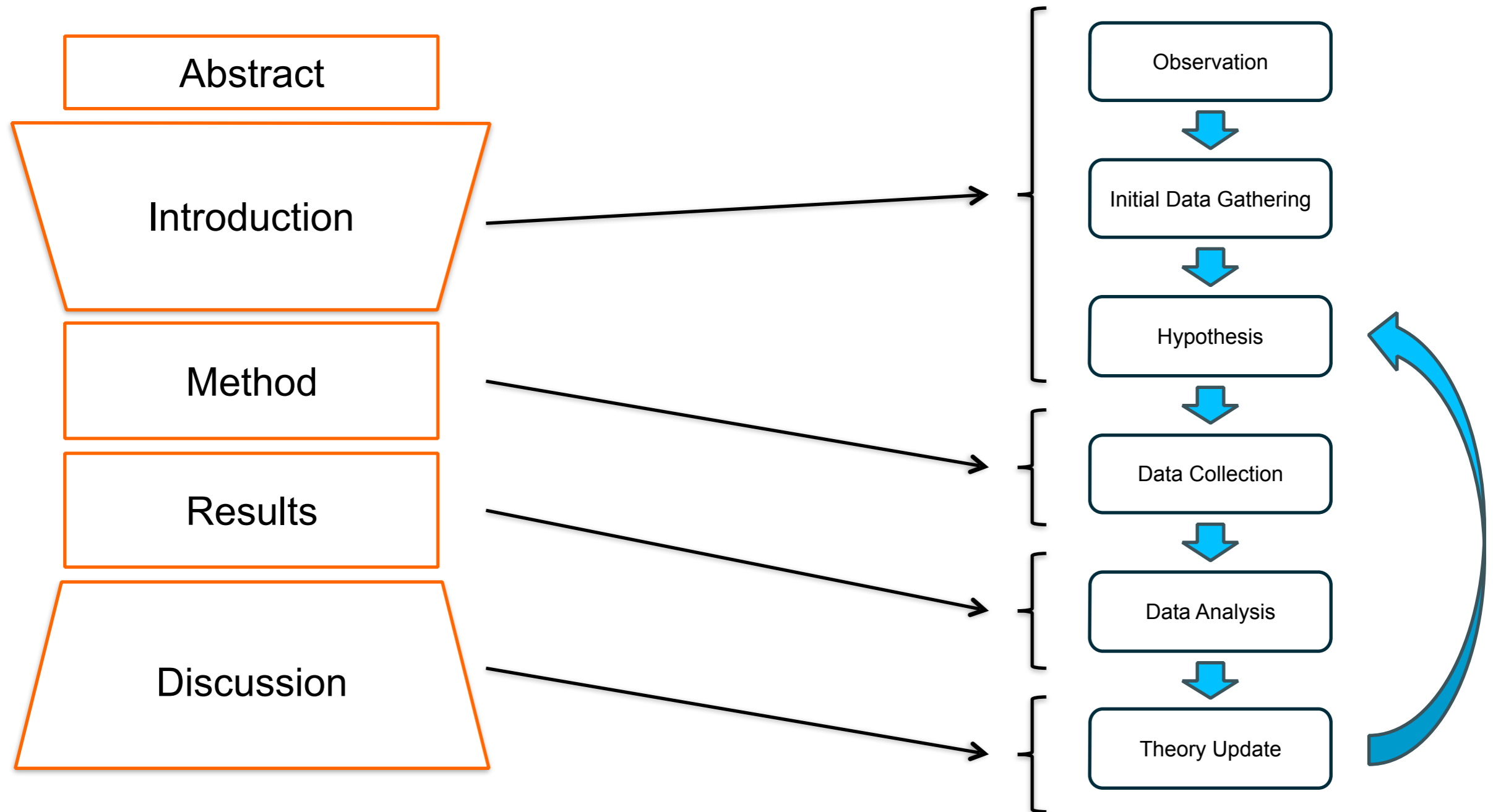
Scientific Paper

- Document written by researcher
- Usually describes a research study
- Goal is to communicate to other researchers:
  - objective;
  - methods; and
  - findings
- of the study
- May be written before and in-parallel to research
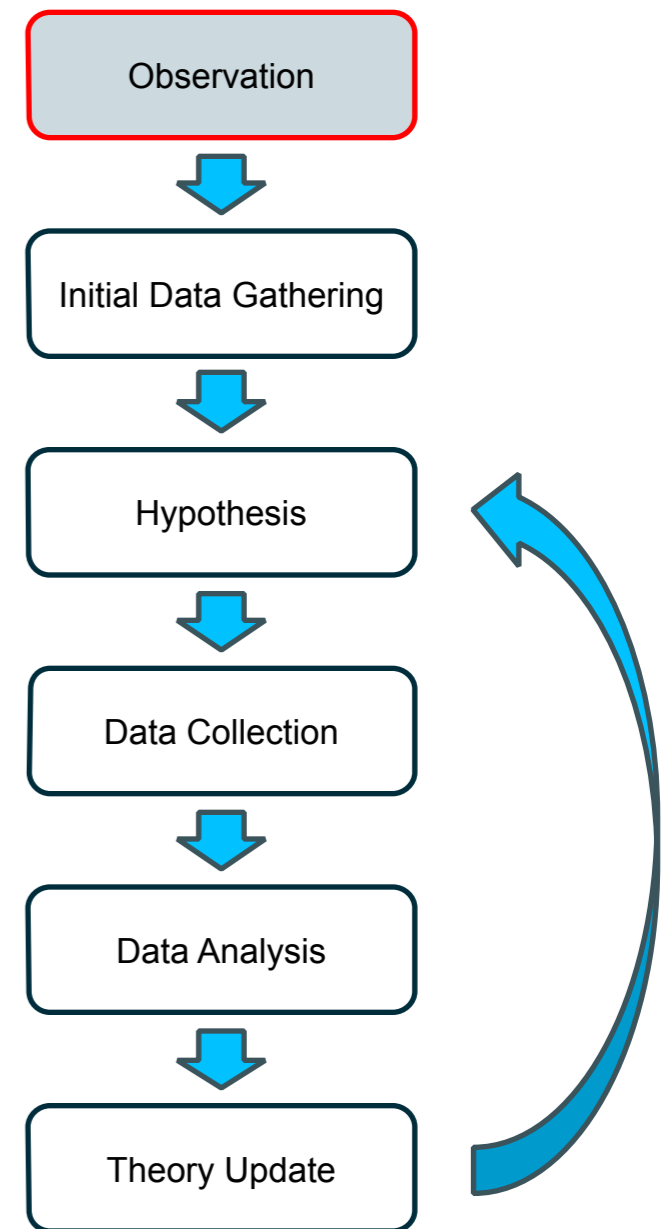
Typical structure

# Scientific Method & Scientific Paper

Observation

- Start by observing something you want to understand
  - Anecdotal
    - e.g. your friends tend to write their passwords on 'post-it' notes when they are complex, but not when they are simple
- Based on data
  - e.g. a diary study in an organisation revealed most employees write their passwords on 'post-it' notes

Initial Data Gathering

- Collect data to validate initial observation
  - Exploratory study collecting relevant variables
    - e.g. survey at organisation asking employees how frequently they write their passwords on 'post-it' notes
- Review of other research focused on same phenomena
  - journal articles, conference papers, PhD theses, etc.
  - Literature review

Observation

↓

Initial Data Gathering

↓

Hypothesis

↓

Data Collection

↓

Data Analysis

↓

Theory Update
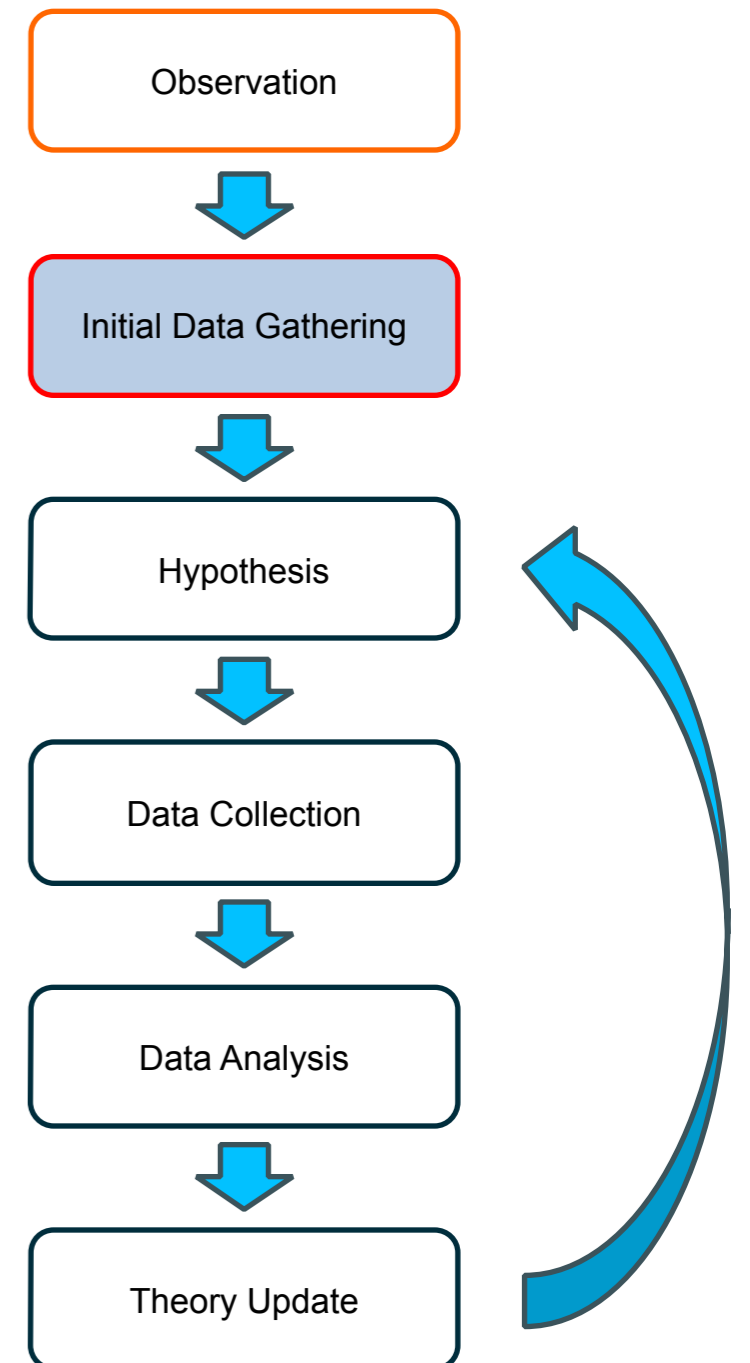
Hypothesis

- Attempts to explain observed phenomenon

  - e.g. password policies at organisations are too complex for employees to memorise

- Scientific hypotheses are empirically testable

  - e.g. the proportion of employees who write down their passwords is positively correlated with the complexity of the organisation's password policy
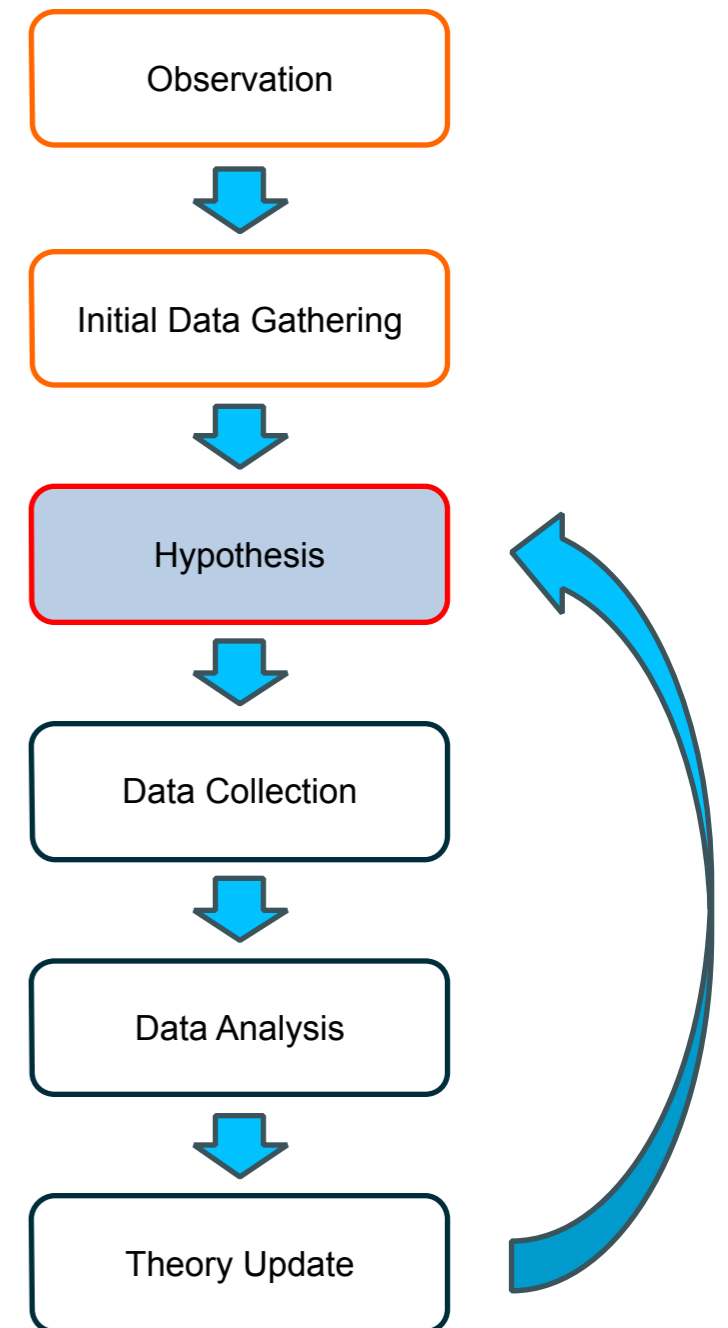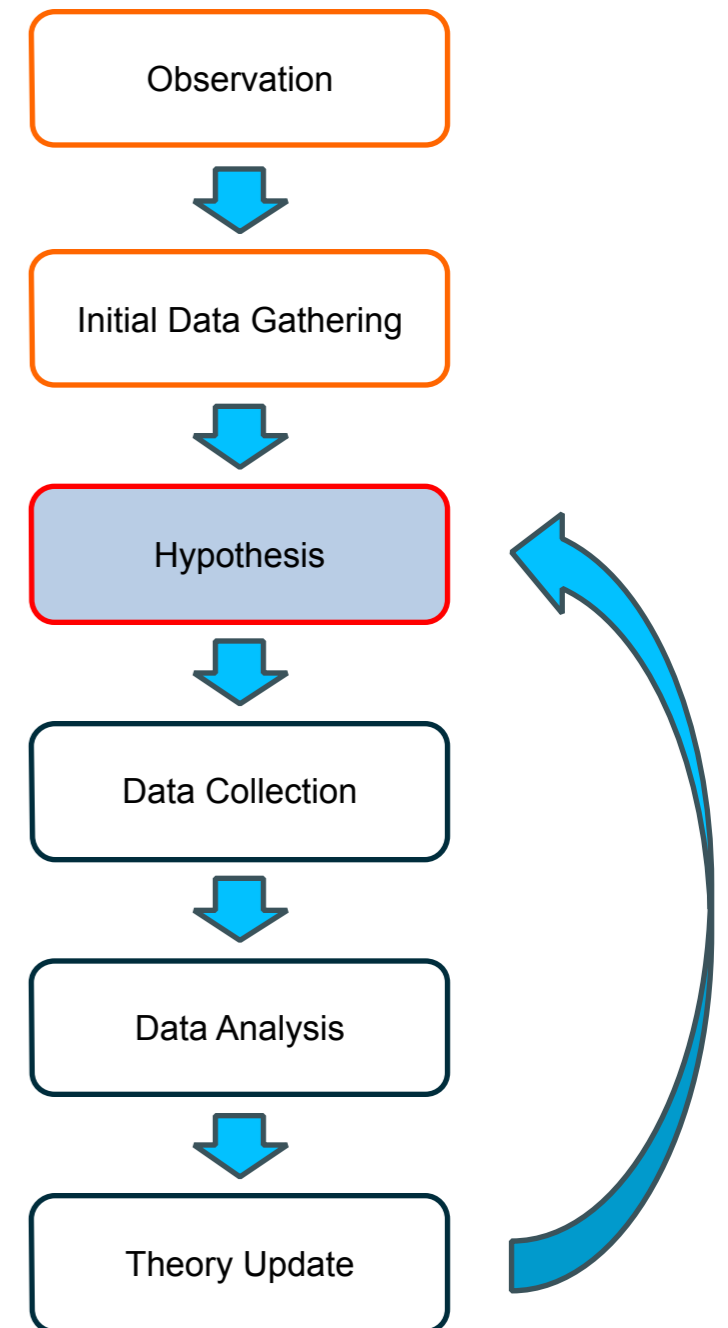
Hypothesis

- Scientific hypotheses
  - make predictions that can be disconfirmed by evidence
  - Popper's demarcation criteria: falsifiability
- Null hypothesis (H_0)
  - Reverse of experimental hypothesis
  - Represents default position where there is **no** relationship between the variables being observed
  - If data rejects H_0, then it gives support to experimental hypothesis
  - e.g. no correlation between password policies and proportion of employees writing passwords down

Observation

Initial Data Gathering

Hypothesis

Data Collection

Data Analysis

Theory Update
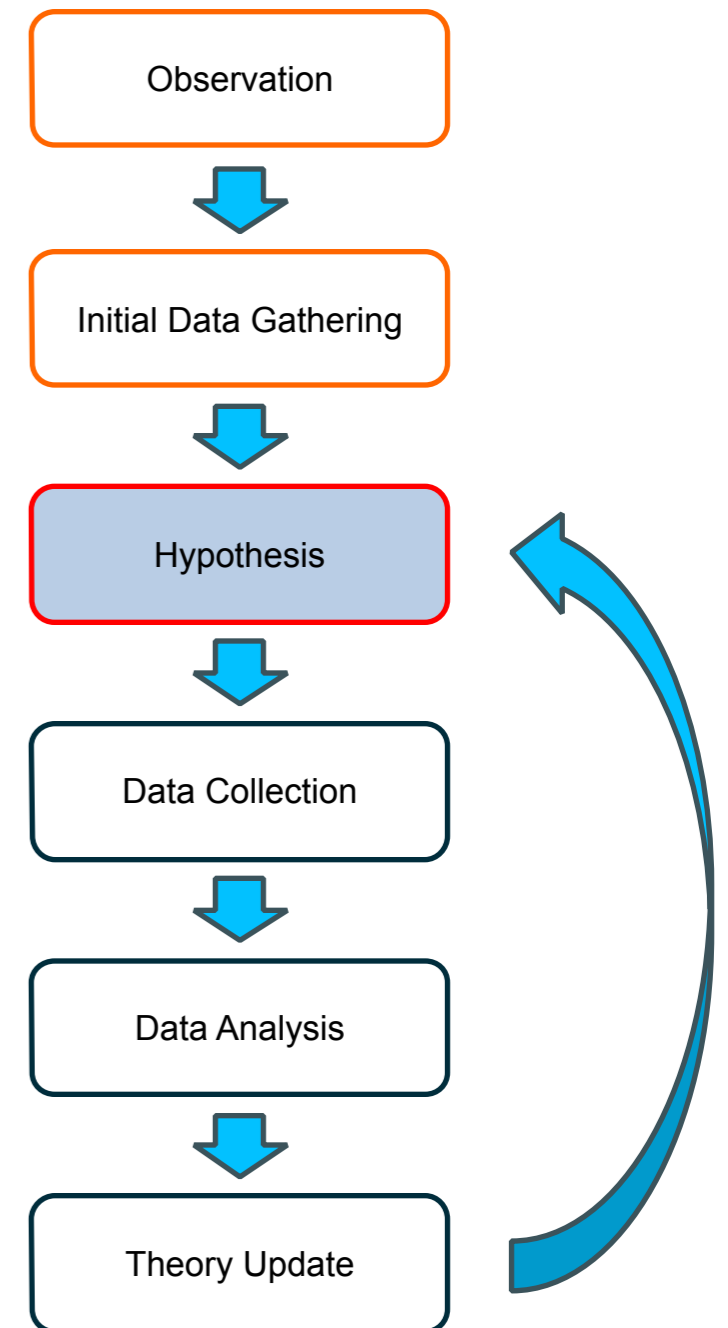
Hypothesis

- An untestable hypothesis is not a hypothesis

- Non-hypothesis:
  - e.g. "Citizen Kane is the best film ever"

- Hypothesis
  - e.g. "Avatar was the highest-grossing film of all time"

Observation

Initial Data Gathering

Hypothesis

Data Collection
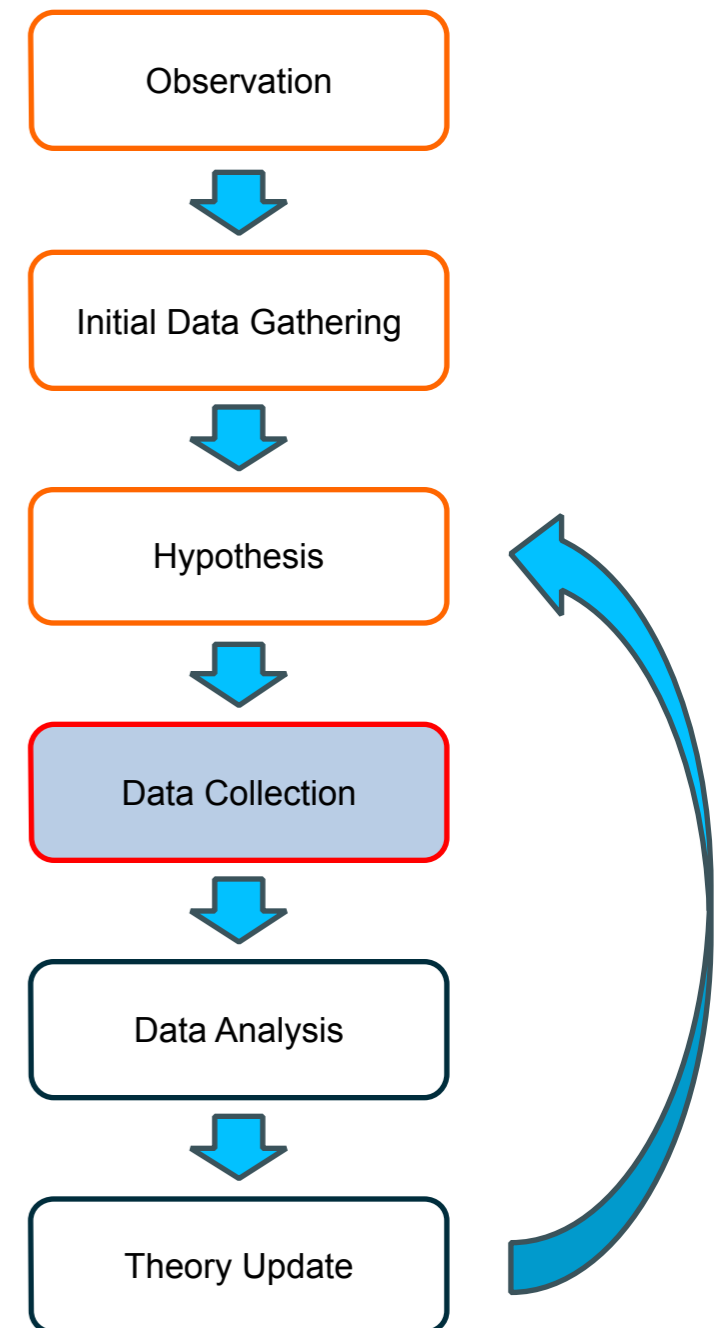
Data Analysis

Theory Update

Hypotheses – Exercise 1

- Which of the following statements are hypotheses?
  - Longer passwords are more difficult to memorise.
  - The Beatles were the most influential band ever.
  - Facebook wants to control your personal data.
  - www.google.com is the web's most visited website.
  - My neighbour's internet connection is faster than mine.

Data collection

- Collect data to test hypotheses
- What to measure
  - Independent variable (cause)
  - Dependent or outcome variable (effect)
- How to measure it
  - Correlational research (observation without interference)
  - Experimental research (manipulation of variables)

Observation

Initial Data Gathering

Hypothesis

Data Collection

Data Analysis

Theory Update

Data Analysis

- Quantitative data
  - Graphically representing the data
  - Fitting statistical models to the data
    - i.e. testing the null hypothesis
- Qualitative data
  - Thematic analysis
  - Grounded theory
- Very easy to confuse
  - Tip: think of "quantity"
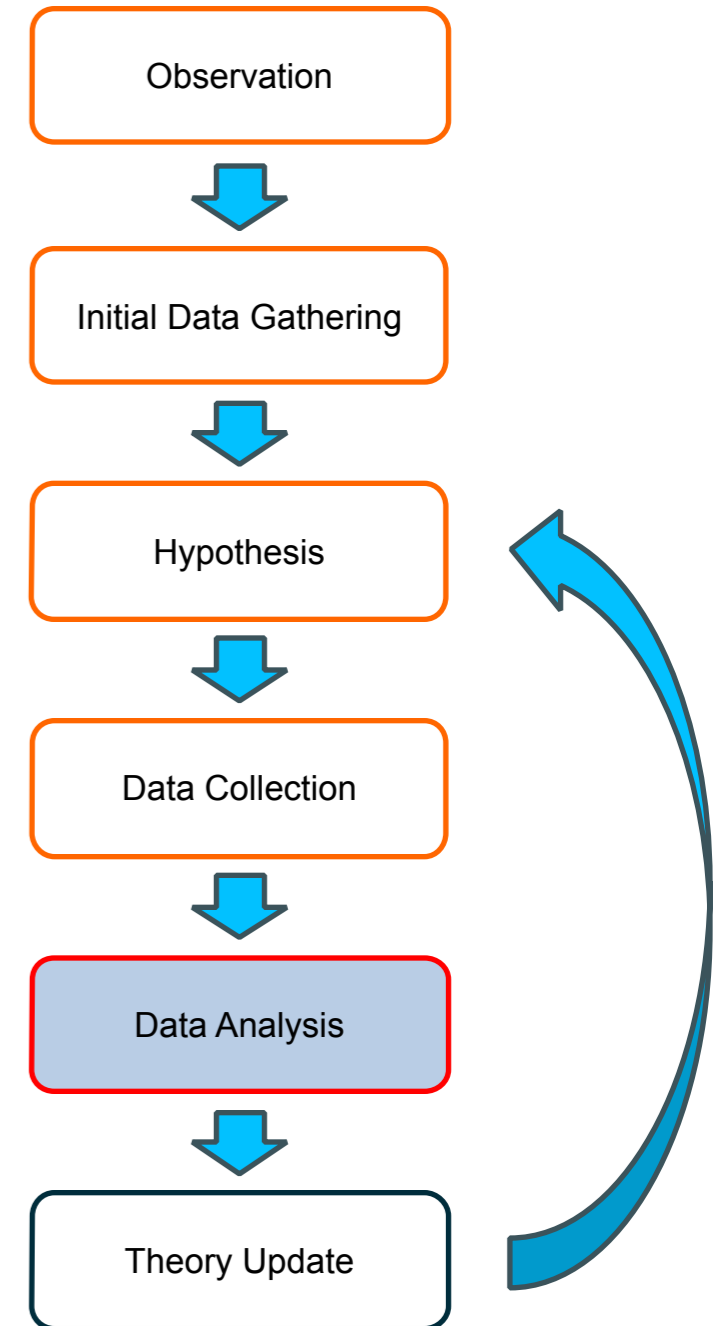
Theory Update

- Results of analysis may either:
  - support hypotheses; or
  - reject hypotheses.
- In case of rejection you may modify your theory
  - Generate new hypotheses
  - New research required to test new hypotheses
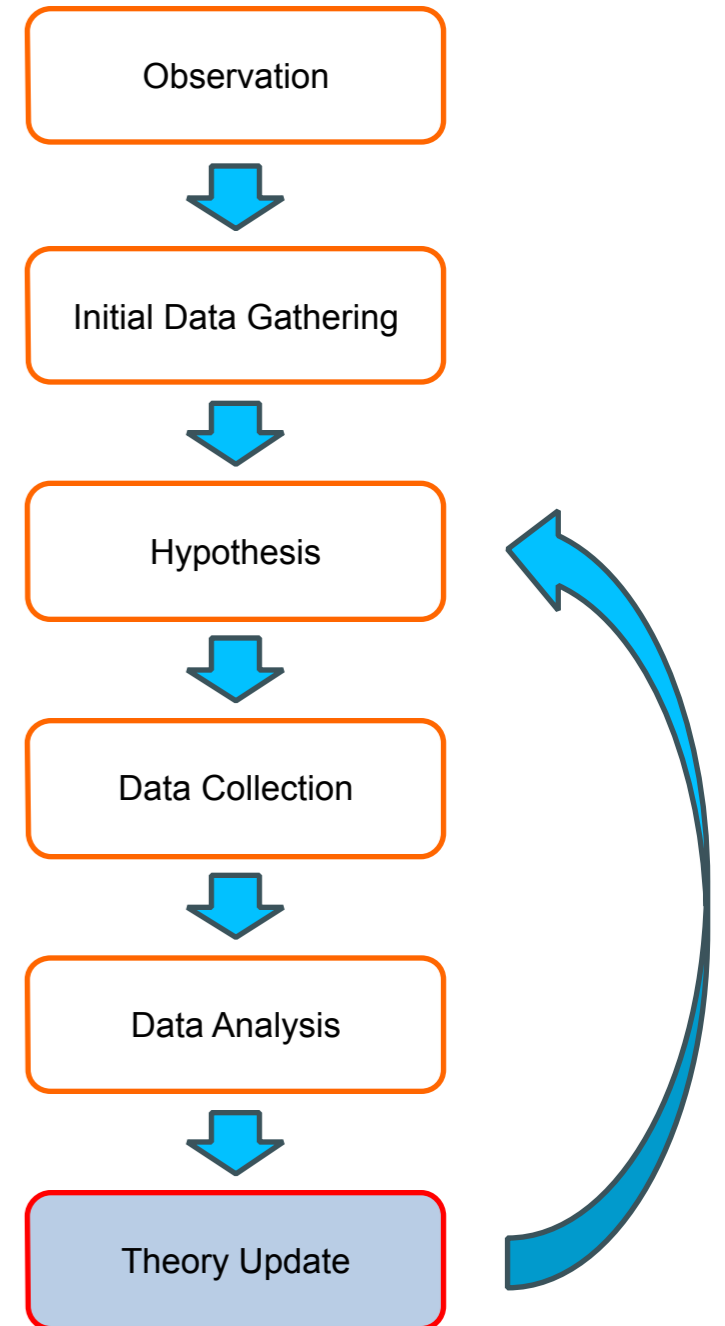
Scientific Paper - Abstract

- Brief summary of paper
  - Background information
  - Purpose of study
  - Methods
  - Most important findings
  - Conclusions and recommendations
- Includes elements from all sections

Abstract

Introduction

Method

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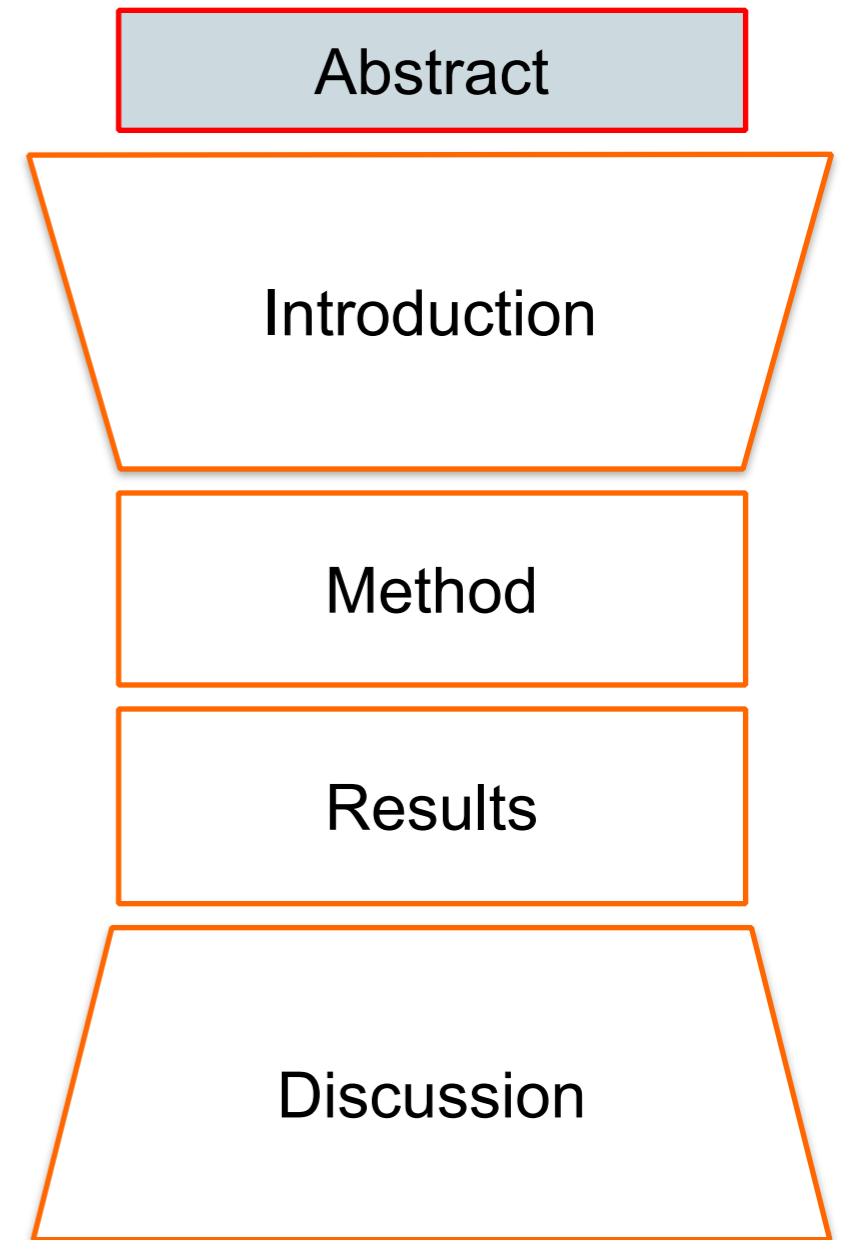
Scientific Paper - Abstract

- Usually last part to be written
- Readers will decide whether to read a whole paper based on it
- Very difficult to write
- Has a word limit
  - Usually 150 to 300 words

Abstract

Introduction

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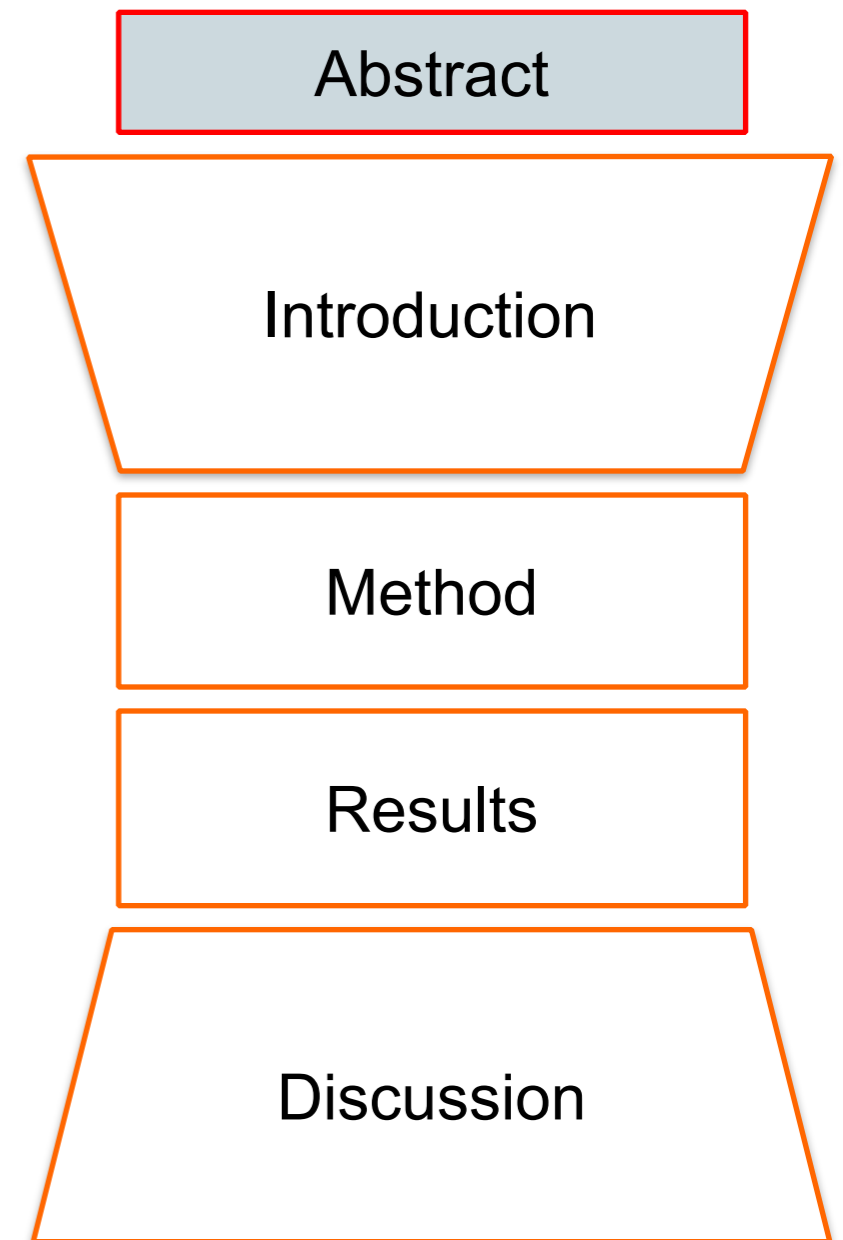
Example medical abstract

Drinking well water and occupational exposure to Herbicides is associated with chronic kidney disease, in Padavi-Sripura, Sri Lanka. Channa Jayasumana, Priyani Paranagama, Suneth Agampodi, Chinthaka Wijewardane, Sarath Gunatilake and Sisira Siribaddana. Environmental Health 2015, 14:6 doi:10.1186/1476-069X-14-6. Published: 18 January 2015

Background

The chronic kidney disease of unknown etiology (CKDu) among paddy farmers in was first reported in 1994 and has now become most important public health issue in dry zone of Sri Lanka. The objective was to identify risk factors associated with the epidemic in an area with high prevalence.

Methods

A case control study was carried out in Padavi-Sripura hospital in Trincomalee district. CKDu patients were defined using health ministry criteria. All confirmed cases (N = 125) fulfilling the entry criteria were recruited to the study. Control selection (N = 180) was done from people visiting the hospital for CKDu screening. Socio-demographic and data related to usage of applying pesticides and fertilizers were studied. Drinking water was also analyzed using ICP-MS and ELISA to determine the levels of metals and glyphosate.

Results

Majority of patients were farmers (N = 107, 85.6%) and were educated up to 'Ordinary Level' (N = 92, 73.6%). We specifically analyzed for the effect modification of, farming by sex, which showed a significantly higher risk for male farmers with OR 4.69 (95% CI 1.06-20.69) in comparison to their female counterparts. In the multivariable analysis the highest risk for CKDu was observed among participants who drank well water (OR 2.52, 95% CI 1.12-5.70) and had history of drinking water from an abandoned well (OR 5.43, 95% CI 2.88-10.26) and spray glyphosate (OR 5.12, 95% CI 2.33-11.26) as a pesticide. Water analysis showed significantly higher amount of hardness, electrical conductivity and glyphosate levels in abandoned wells. In addition Ca, Mg, Ba, Sr, Fe, Ti, V and Sr were high in abandoned wells. Surface water from reservoirs in the endemic area also showed contamination with glyphosate but at a much lower level. Glyphosate was not seen in water samples in the Colombo district.

Conclusion

The current study strongly favors the hypothesis that CKDu epidemic among farmers in dry zone of Sri Lanka is associated with, history of drinking water from a well that was abandoned. In addition, it is associated with spraying glyphosate and other pesticides in paddy fields. Farmers do not use personnel protective equipments and wears scanty clothing due to heat when spraying pesticides.

Example CS abstract

Secure Multiparty Computations on Bitcoin. Marcin Andrychowicz, Stefan Dziembowski∗, Daniel Malinowski, Łukasz Mazurek

Bitcoin is a decentralized digital currency, introduced in 2008, that has recently gained noticeable popularity. Its main features are: (a) it lacks a central authority that controls the transactions, (b) the list of transactions is publicly available, and (c) its syntax allows more advanced transactions than simply transferring the money. The goal of this paper is to show how these properties of Bitcoin can be used in the area of secure multiparty computation protocols (MPCs).

Firstly, we show that the Bitcoin system provides an attractive way to construct a version of "timed commitments", where the committer has to reveal his secret within a certain time frame, or to pay a fine. This, in turn, can be used to obtain fairness in some multiparty protocols. Secondly, we introduce a concept of multiparty protocols that work "directly on Bitcoin". Recall that the standard definition of the MPCs guarantees only that the protocol "emulates the trusted third party". Hence ensuring that the inputs are correct, and the outcome is respected is beyond the scope of the definition. Our observation is that the Bitcoin system can be used to go beyond the standard "emulation-based" definition, by constructing protocols that link their inputs and the outputs with the real Bitcoin transactions.

As an instantiation of this idea we construct protocols for secure multiparty lotteries using the Bitcoin currency, without relying on a trusted authority (one of these protocols uses the Bitcoin-based timed commitments mentioned above). Our protocols guarantee fairness for the honest parties no matter how the loser behaves. For example: if one party interrupts the protocol then her money is transferred to the honest participants. Our protocols are practical (to demonstrate it we performed their transactions in the actual Bitcoin system), and can be used in real life as a replacement for the online gambling sites. We think that this paradigm can have also other applications. We discuss some of them.
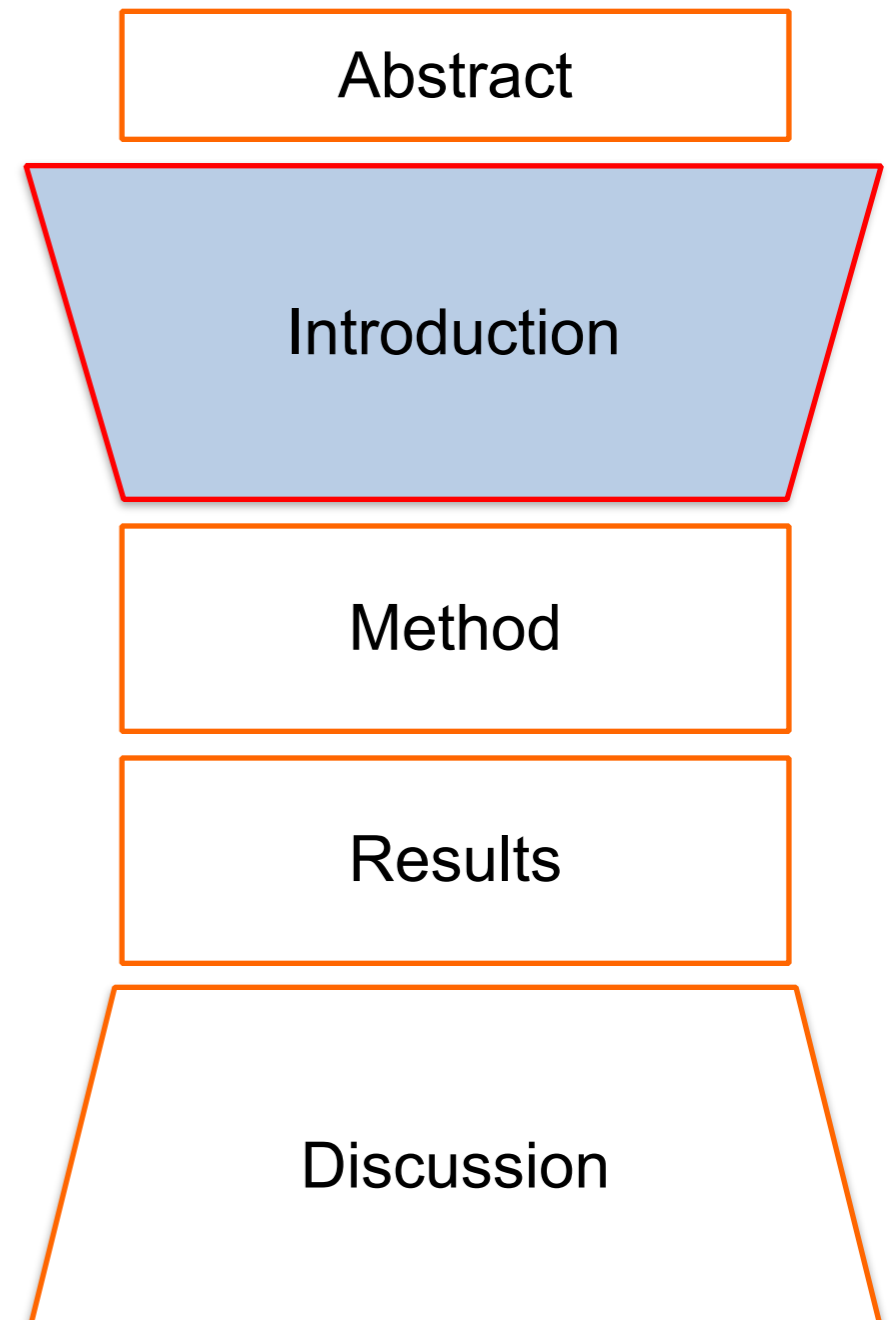
Scientific Paper - Introduction

- Provides information needed to understand rest of the paper
- Has several parts:
  - The setting
  - Literature review
  - Need for more research
  - Purpose of current study
  - Value of current study
  - Contribution to field

| Abstract |
| :---: |
| Introduction |
| Method |
| Results |
| Discussion |
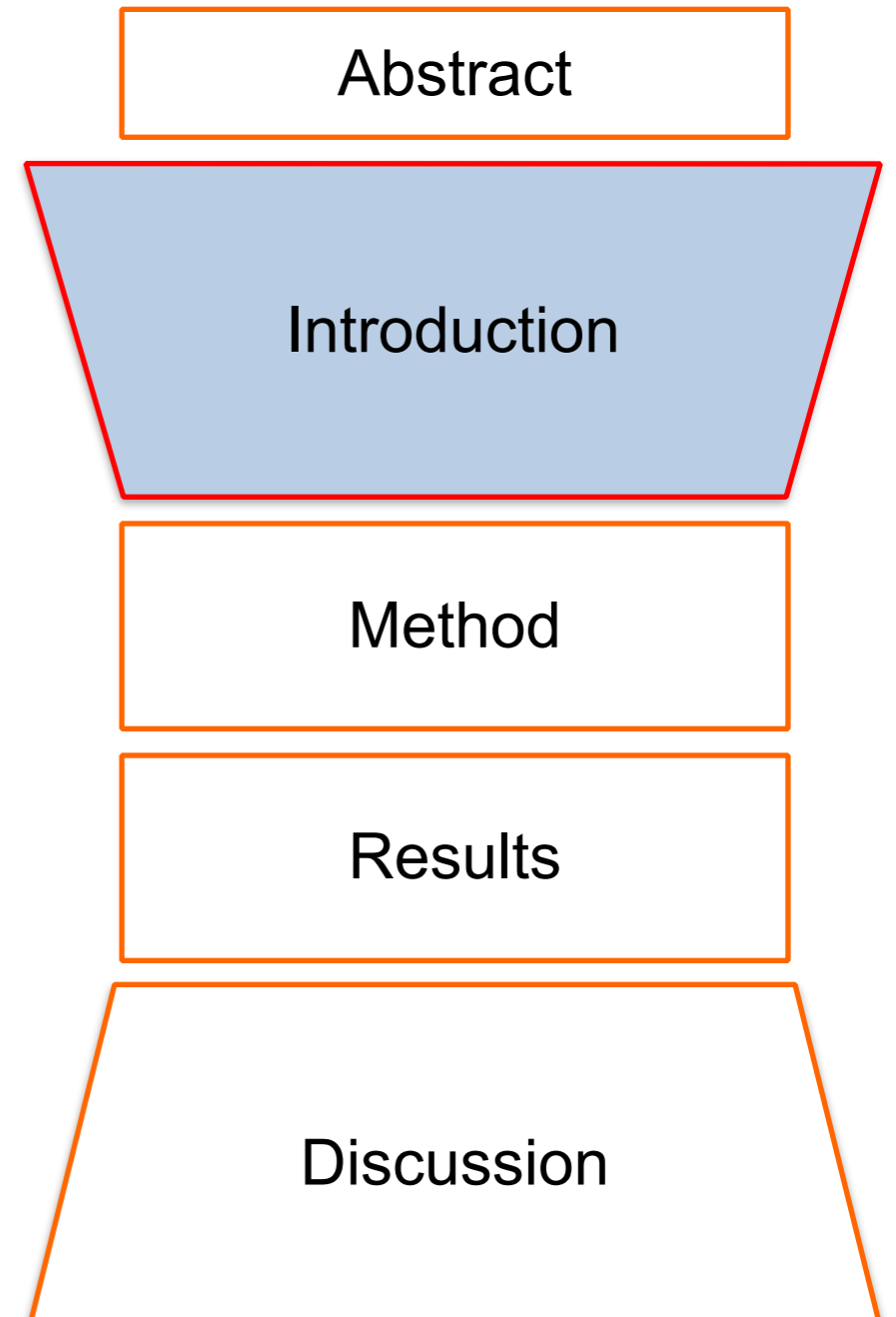
Scientific Paper - Introduction

- Purpose of current study
  - Follow-up from gap identified in past research
  - Describes which research questions the study set out to answer
- May also be a separate background section

Scientific Paper - Method

- Describes steps taken in conducting study
  - Materials used at each step
  - Techniques used e.g. qualitative, quantitative, structural equation modelling etc.
  - Allows other researchers to replicate your study
    - Validate your results

Abstract

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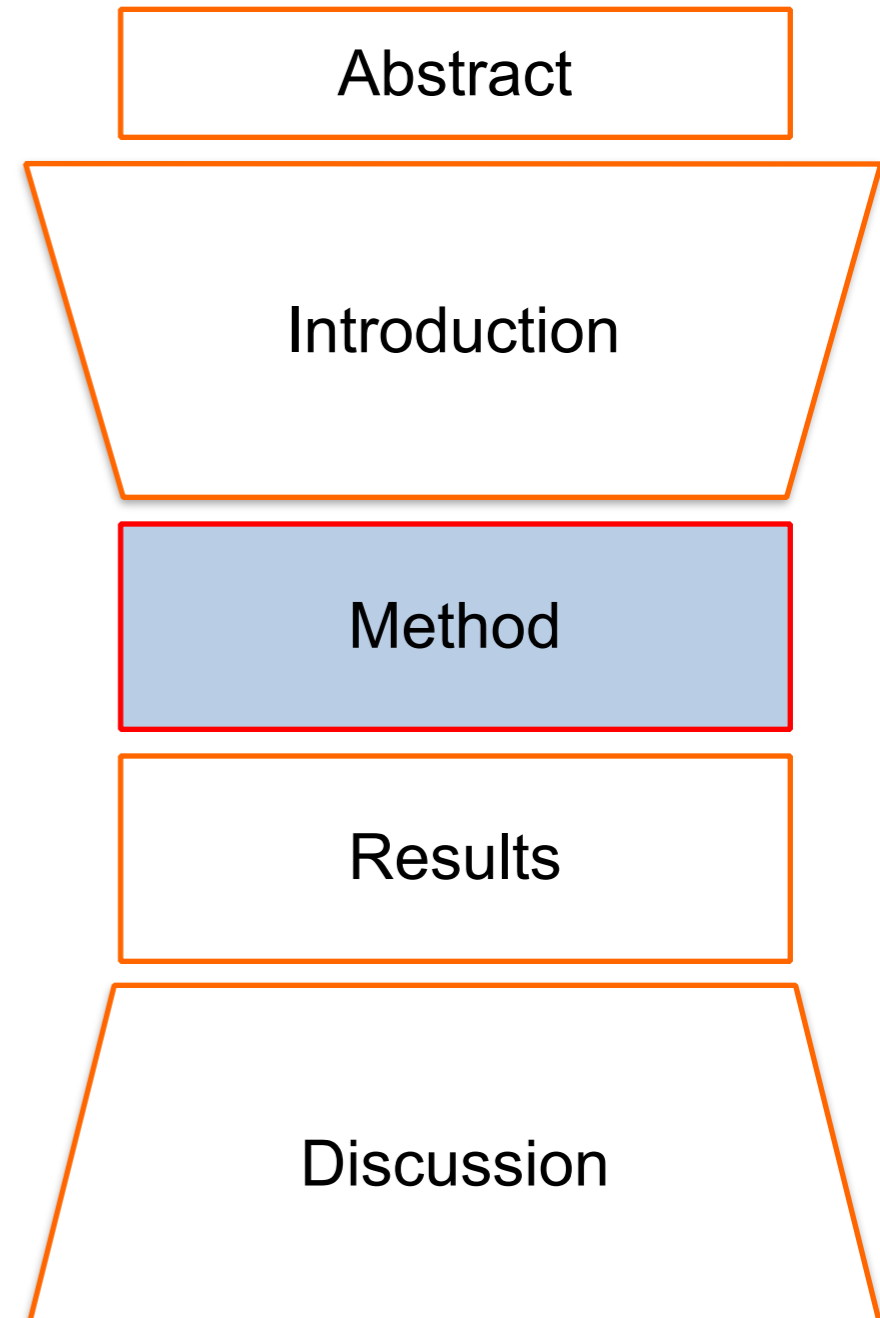
Scientific Paper - Results

- Describes steps taken in conducting study
  - Materials used at each step
- Presents the findings of your study
  - Includes figures and text
  - Descriptive statistics
  - Relationships between variables
    - Hypotheses supported?
  - Themes identified in qualitative data
- Claim – Evidence vs. Fact – Conclusion

| Abstract |
| Introduction |
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| Discussion |
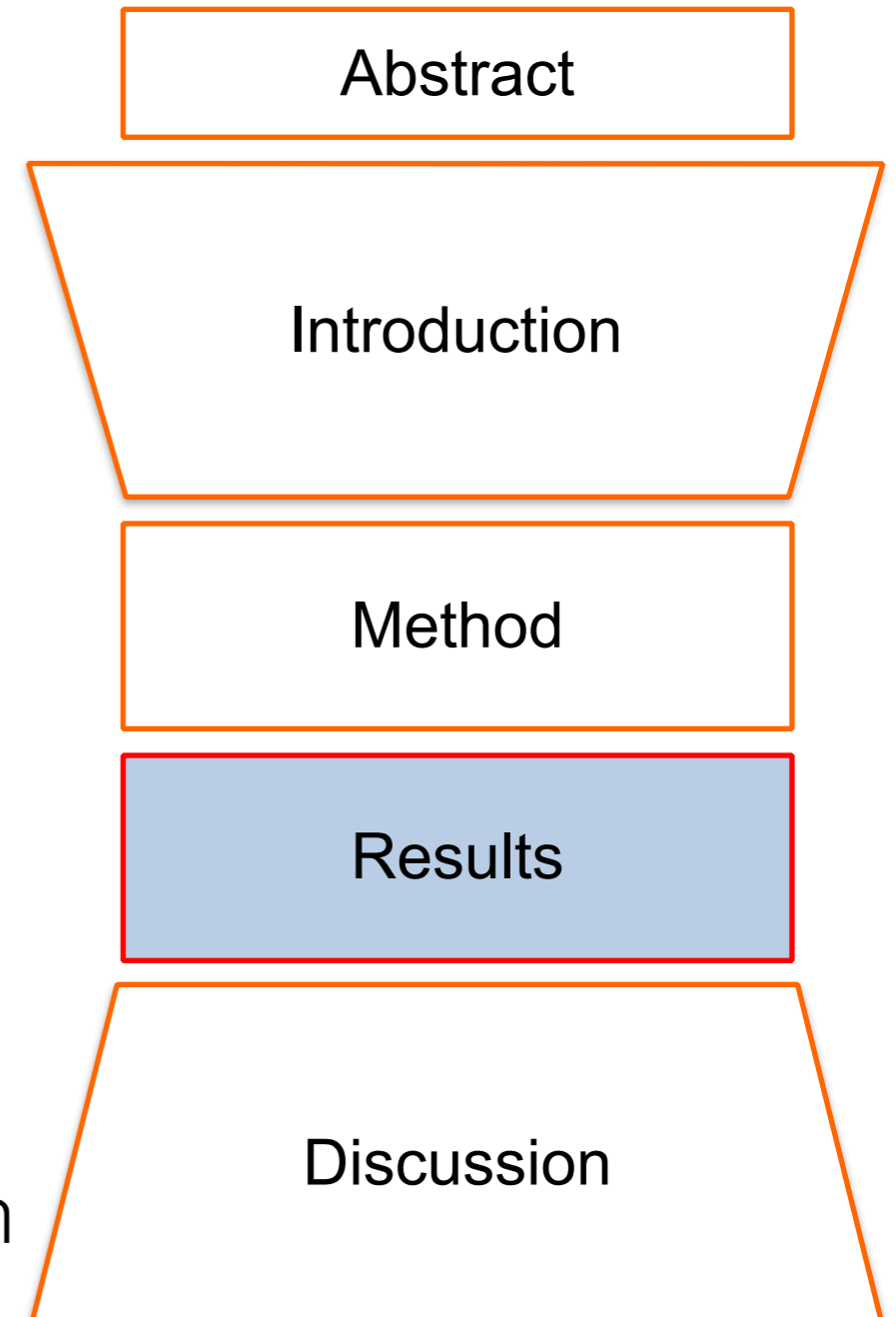
Scientific Paper - Discussion

- Interprets the findings
  - Explains what findings imply
  - Tries to explain or speculate about the results obtained
- Can include conclusions
  - Summary of main findings
  - Recommendations
  - Contribution of research
    - Substantive
    - Methodological
  - Limitations of research
  - Future research

Abstract

Introduction

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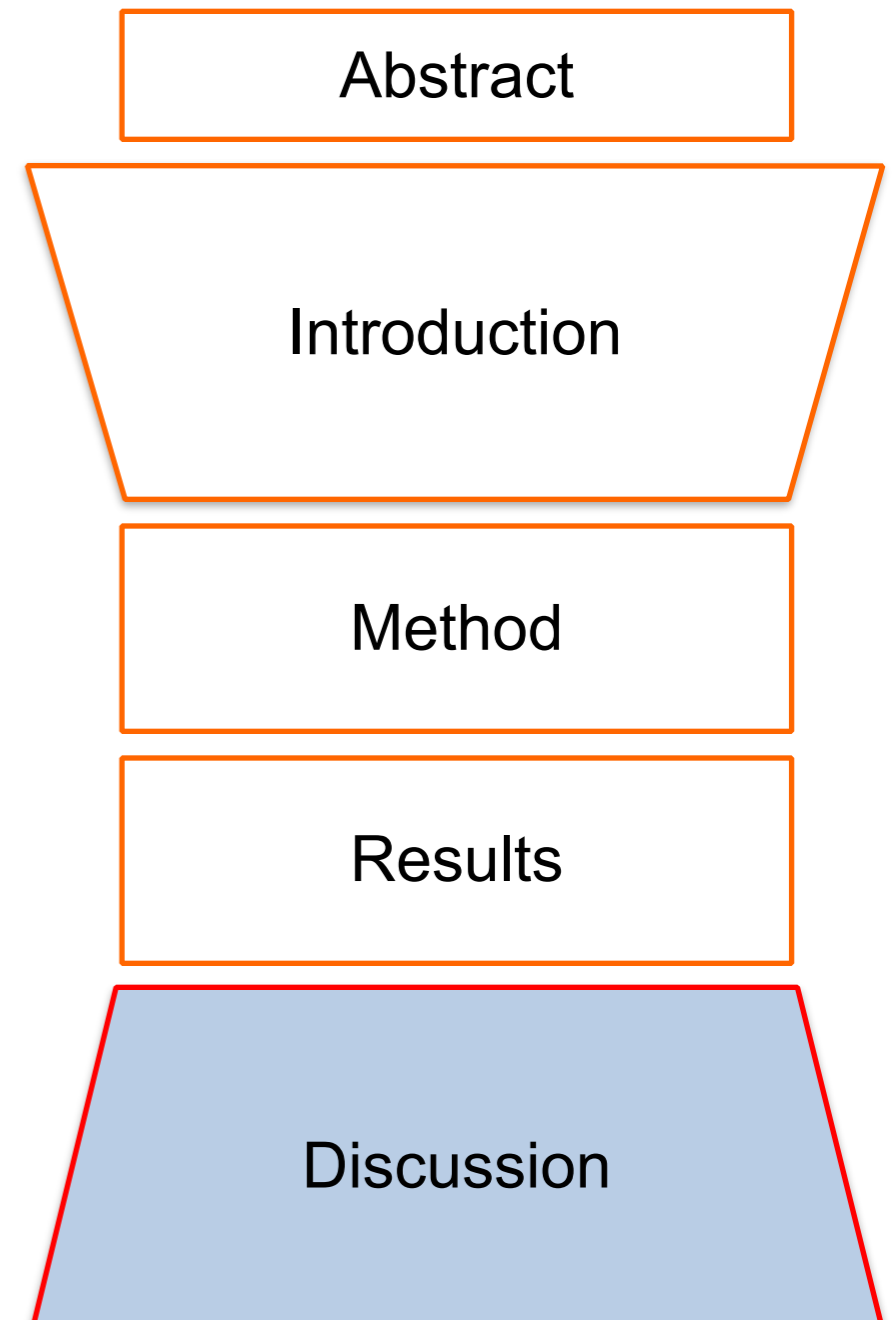
Presentations

- Many possible goals for a presentation
  - To inform
  - To persuade
  - To cover your back
- Typical goal of academic presentation is to encourage the right people to find out more

Formats of presentations

- Powerpoint has become dominant and expected style
  - Nested bullet lists
- Much to criticise
  - Low amount of information per slide
  - No context
  - Hides narrative
- See work by Edward Tufte

Review Of Test Data Indicates Conservatism for Tile Penetration

- **The existing SOFI on tile test data used to create Crater was reviewed along with STS-107 Southwest Research data**
  - **Crater overpredicted penetration of tile coating <mark>significantly</mark>**
    - **Initial penetration to described by normal velocity**
      - Varies with volume/mass of projectile(e.g., 200ft/sec for 3cu. In)
    - **<mark>Significant</mark> energy is required for the softer SOFI particle to penetrate the relatively hard tile coating**
      - Test results do show that it is possible at sufficient mass and velocity
    - **Conversely, once tile is penetrated SOFI can cause <mark>significant</mark> damage**
      - Minor variations in total energy (above penetration level) can cause <mark>significant</mark> tile damage
  - **Flight condition is <mark>significantly</mark> outside of test database**
    - **Volume of ramp is 1920cu in vs 3 cu in for test**

Columbia Accident Investigation Report (p191)

Alternative approaches

- No Powerpoint
  - or just as "decoration"
- Something different
  - e.g. Prezi
- Handouts
  - Potential to be far richer in terms of information content (see Tufte, Cognitive Style of Powerpoint)
- Risk is that focus will be on style rather than content

Larry Lessig

zoom outside the slide and

give your ideas

space

Assertion-Evidence style

- Begin each body slide with a sentence-assertion headline that is left justified and no more than two lines

- Support the assertion headline with visual evidence (photographs, drawings, graphs, films, or words and equations arranged visually)—avoid bullet lists

- In the body of the slide, use words only when necessary—design your slides so that the audience reads no more than 20 words per minute

Checklist for Assertion–Evidence Slides (College of Engineering, Penn State)