

a short course on

# Writing in Research

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## Coverage

- Science/scientists
- The Scientific Method
- The Scientific Paper
- Some aspects of English in technical writing
- Authorship and publishing

©  
1

A naturalist's life would be a happy one if he had only to observe and never to write

Charles Darwin



## What is *research* ?

(from the Middle French *recherché*  
meaning "to go about seeking")



"**creative work** undertaken on a **systematic basis**  
in order to **increase** the stock of **knowledge**,  
including knowledge of man, culture and society,  
**and the use of this stock of knowledge to devise**  
**new applications**" (OECD, 2002)

The **Scientific Method** is used to conduct research in  
a scientific way

3

## What is *science* ?

(from the Latin *scientia*, meaning "knowledge")



Science refers to a **system of acquiring knowledge**  
based on the **scientific method**,  
as well as to the organized body of knowledge  
gained through such research

4

“Science is a particular way of knowing about the world. In science,

- explanations are limited to those based on observations and experiments that can be substantiated by other scientists.
- Explanations that cannot be based on empirical evidence are not part of science.”

National Academy of Sciences (1999)

## What science cannot do

(after University of California Museum of Palaeontology)



- Deal with supernatural explanations  
*Super* is beyond nature

6

## Characteristics of scientists

- **The Merton-Ziman norms**

(Merton, 1942; Ziman, 2000)

Shared by members of the scientific community

**C**ommunalism

**U**niversalism

**D**isinterestedness

**O**riginality

**O**rganized **S**kepticism

7

## CUDOOS

### **Communalism**

knowledge is public; results published; freedom of exchange of information; **responsibility for trustworthiness of works**

(*opp.* Solitariness)

### **Universalism**

science is independent of race, color or creed; essentially international

(*opp.* Particularism)

8

## Disinterestedness

Not subject to personal profit; ideology; expediency;  
*i.e.* honest and objective  
(*opp.* Interestedness)

## Originality

Requires research to be novel

## Organized Skepticism

No acceptance on word of authority; free  
questioning; **truth rests on comparison with  
observed fact**  
(*opp.* Dogmatism)

9

- **Universal Intellectual Standards**

(Elder & Paul, 1996)

- **Clarity**

How do we begin to assess if the issue is not clear?

- **Accuracy**

Are statements which are clear, accurate?

- **Precision**

Are statements which are accurate and clear, precise?

- **Relevance**

Are statements which are accurate, clear and precise, relevant to the issue?

10

- **Depth**

Do statements which are accurate, clear, precise and relevant to the issue cover sufficient depth?

- **Breadth**

Do statements which are accurate, clear, precise, relevant to the issue, and which covers sufficient depth consider sufficient points of view?

- **Logic**

When a series of thoughts are mutually supporting and make sense together, the thinking is logical

11

- **Critical Thinking**

(Scriven & Paul, 1996)



The intellectually disciplined process of actively and skillfully **conceptualizing, applying, analyzing, synthesizing,**

and/or

**evaluating** information gathered from, or generated by, observation, experience, reflection, reasoning, or communication, as a guide to **belief and action**

12

### **Critical thinking can be seen as having two components:**

- a set of **skills** to process and generate information and beliefs
- the **habit**, based on intellectual commitment, of using those skills to guide behavior

13

### **Critical thinking is thus to be contrasted with:**

- the mere acquisition and retention of information alone
- the mere possession of a set of skills
- the mere use of those skills

14

## The Scientific Method

“... is a body of techniques for investigating phenomena, acquiring new knowledge, or correcting and integrating previous knowledge”  
(Goldhaber and Nieto, 2010)

“A method of research in which a problem is identified, relevant data are gathered, a hypothesis is formulated from these data, and the hypothesis is empirically tested.”  
(Random House dictionary, 2014)

15

## Observation, hypothesis, and experimentation

- Observations are fundamental to the Scientific Method
- Formulation of hypotheses is fundamental to making sense of observations

16



## Observation

- Science begins and ends with observation
- Experimentation may follow upon observation, and it results in further observations *i.e.* the results of experimentation
- Research can be said to consist of systematic observation

17

## Commonly-held belief

vs.

## established fact

Consider . . .

18



Jean Louis Théodore Géricault (1821) "The Epsom Derby"

19



J. Cameron (1890) "Great Horses in a Great race"

20



Chinese print

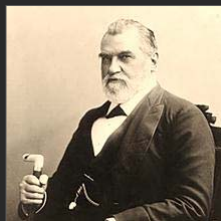
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Palo Alto, 1872

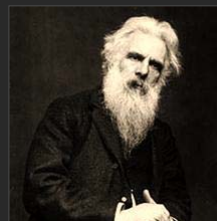
Much debated question of the time:

**Is a galloping horse ever completely aloft?**

- Stanford, a race-horse owner took a position on “unsupported transit” in horses
- Wanted it proven scientifically and hired the photographer Eadweard Muybridge to provide evidence

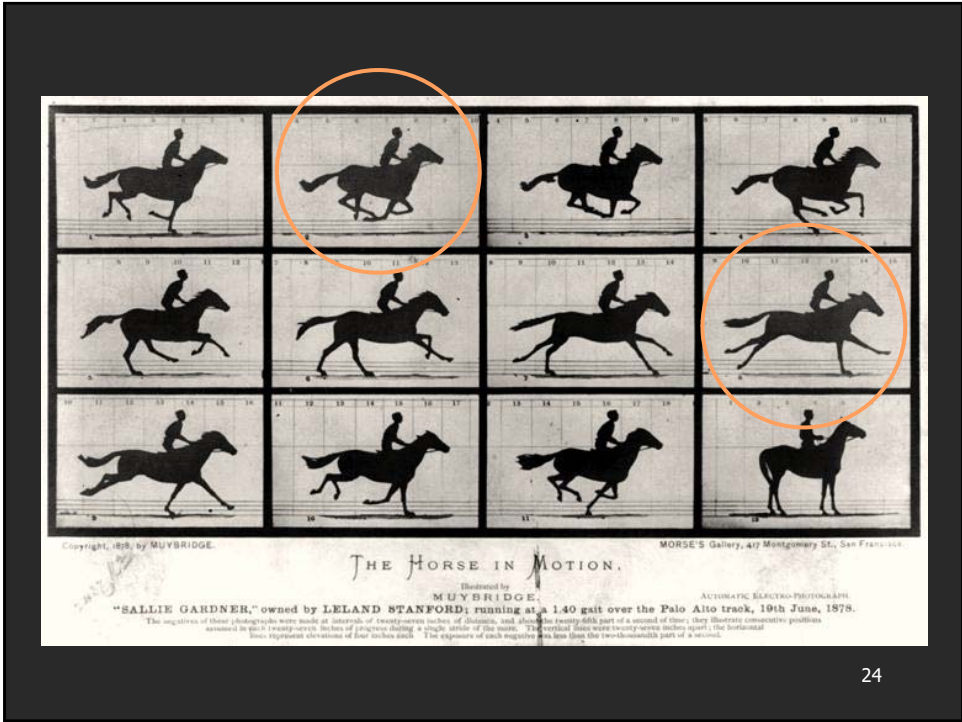
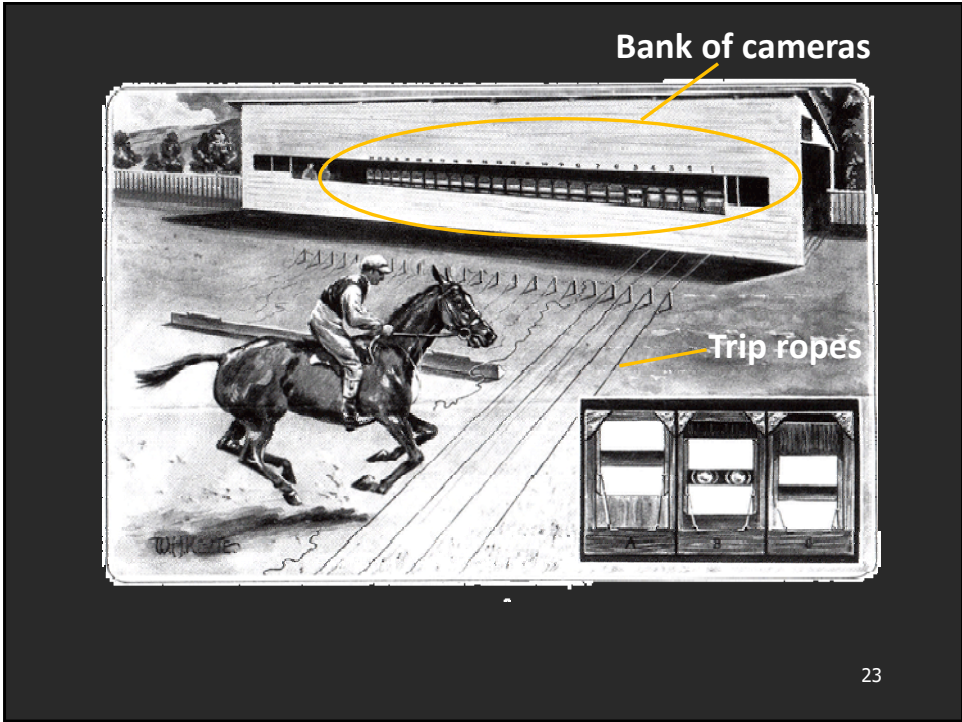


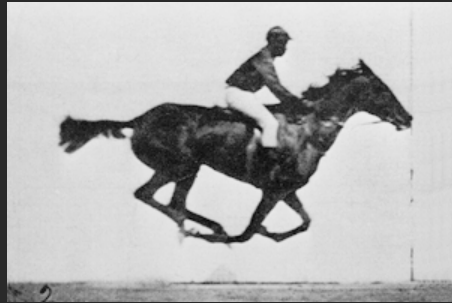
Stanford



Muybridge

22





Eadweard Muybridge (1878) "The Horse in motion"

25

## Observation >>> hypothesis 1

### A prick in the arm

1979

The WHO declared smallpox an eradicated disease.

**Edward Jenner**  
(1749-1823)

**Pioneer of vaccination**

*"Father of immunology"*



26



**Common observation:**

Milkmaids do not get smallpox.  
*"Smooth as a milkmaid's skin"*

**Jenner hypothesized:**

Immunity is conferred by cowpox.

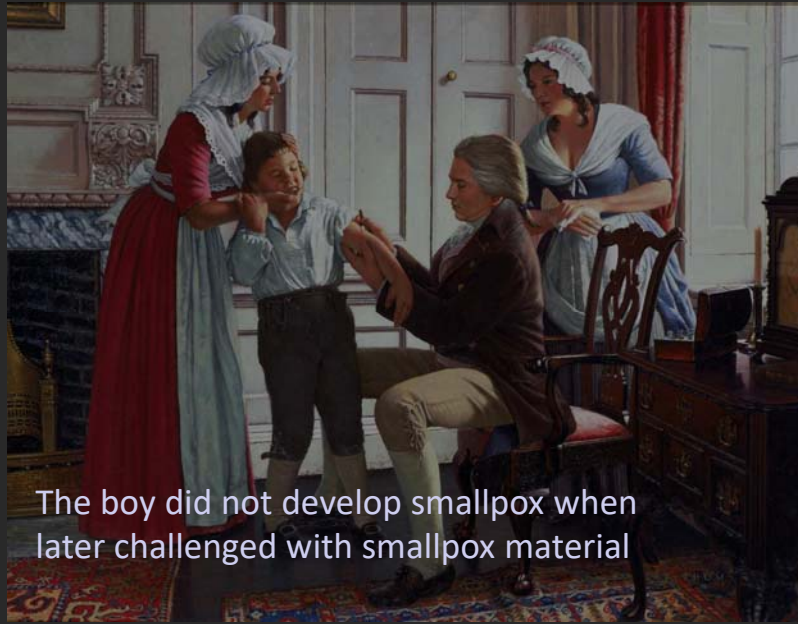
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**1796**

Jenner inoculated a young  
boy with cowpox material

28





The boy did not develop smallpox when later challenged with smallpox material

29

## Observation >>> hypothesis 2

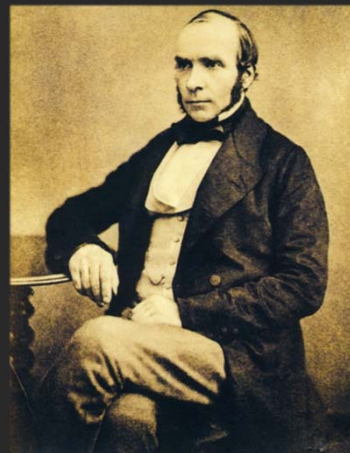
### Something in the water

#### John Snow

(1813-1858)

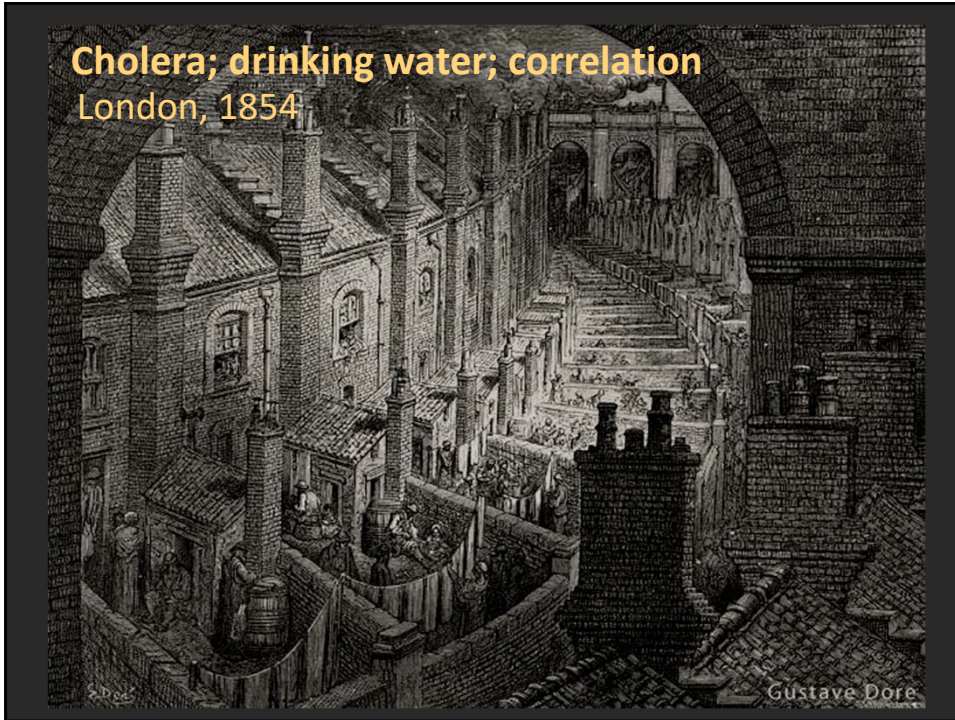
The Father of Epidemiology\*

\*The science that deals with the incidence, distribution, and control of disease in a population



30

**Cholera; drinking water; correlation**  
London, 1854



Death records;  
location of a drinking water  
pump

>>> Hypothesis:  
Incidence of cholera is  
correlated with contaminated  
drinking water

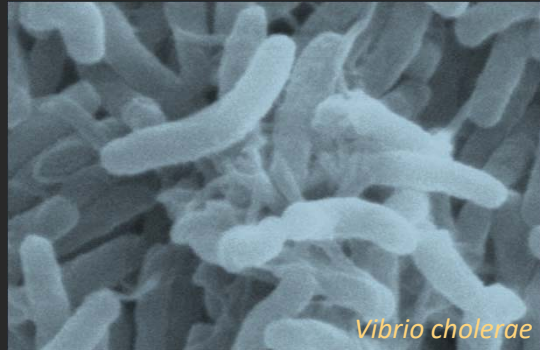
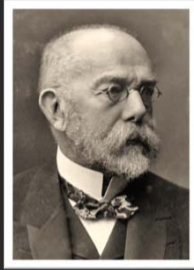




When the Broad St. pump was **disabled**, deaths dropped dramatically

Snow's observations and hypothesis was a **major achievement** because . . .

the causative microorganism (*Vibrio cholerae*) was not discovered until 29 years later by Robert Koch



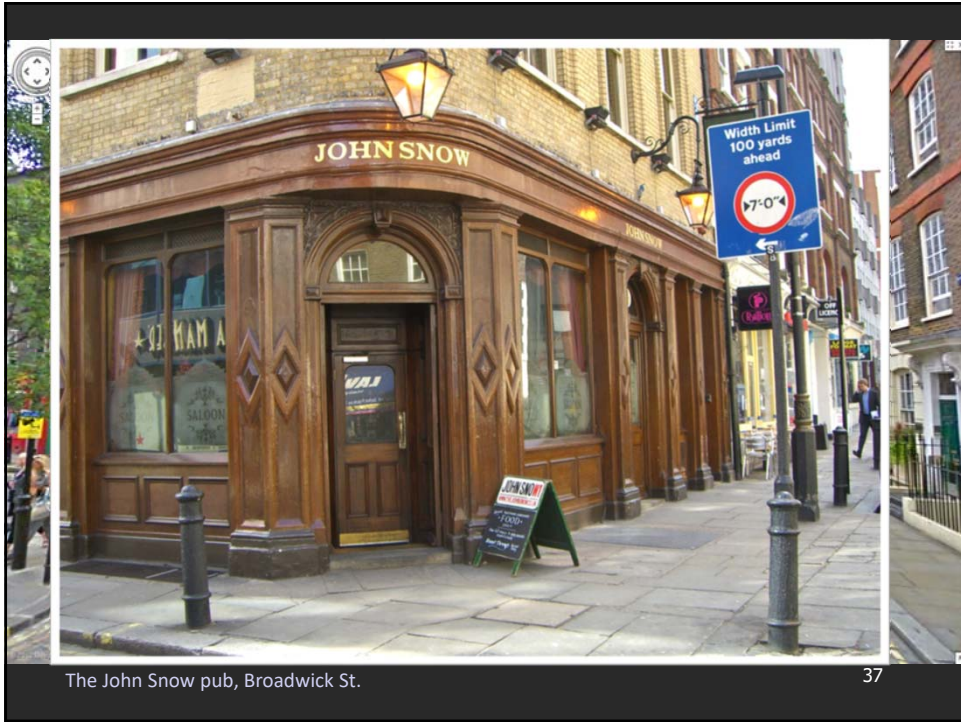
*Vibrio cholerae*

35



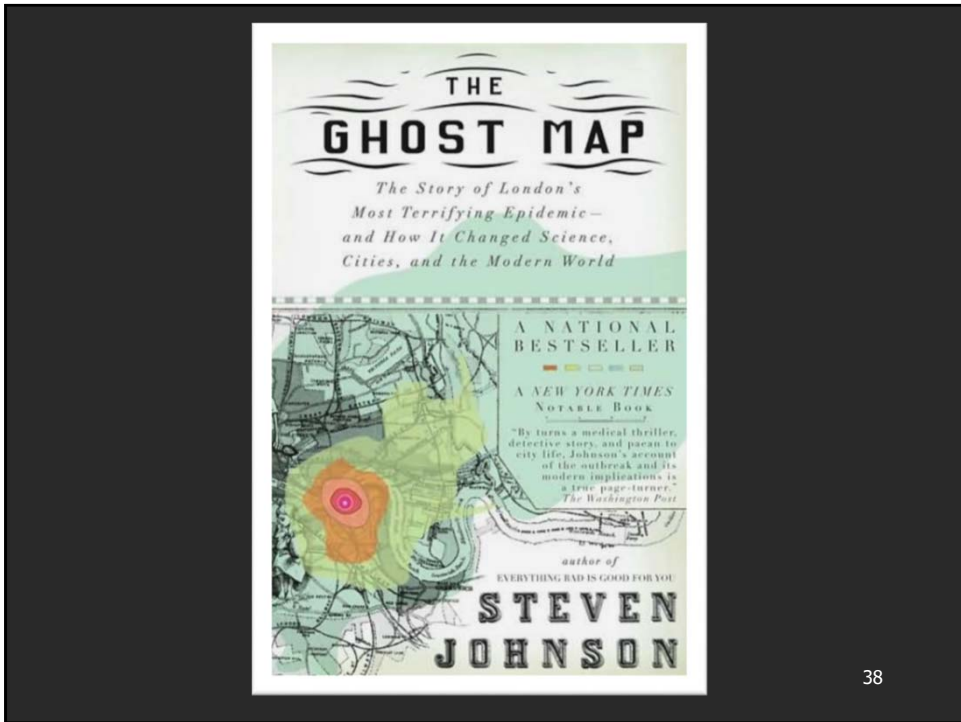
Replica pump on Broadwick St., London

36



The John Snow pub, Broadwick St.

37



38

## Observation >>> hypothesis 3

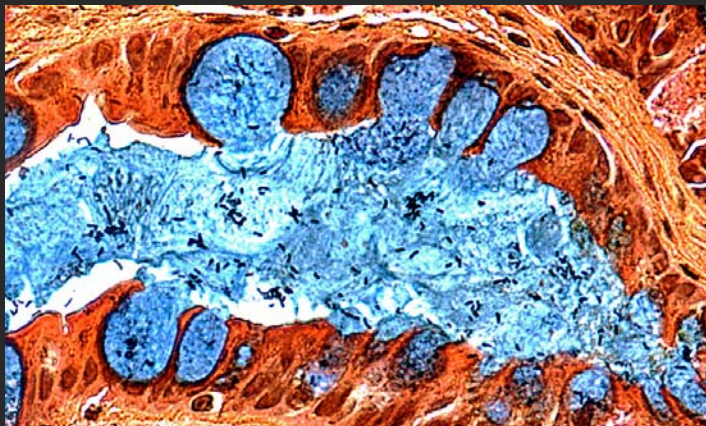
A pain in the gut

Perth, Western Australia



39

In the late 70s J. Robin Warren observed through biopsy, bacteria colonizing the stomach in about 50% of patients



*Helicobacter pylori* associated with gastric mucosa

40



Warren's critical observation:

. . . these bacteria were always associated with inflammation close to where the bacteria were seen

41

Barry Marshall joined Warren and eventually a previously unknown bacterium *Helicobacter pylori* was discovered in 1982



42



Clem demonstrating to microbiology students,  
QE2 Medical Centre, UWA; 1981

43

Marshall & Warren found:

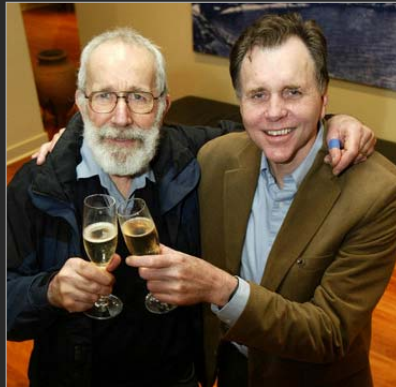
*H. pylori* present in almost all patients with gastric inflammation, duodenal ulcer or gastric ulcer

Based on these results, they proposed that *H. pylori* is involved in the aetiology of these diseases ...

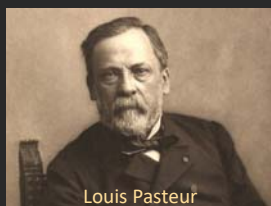
... in the face of the then idea that stress and lifestyle were the major causes of peptic ulcer disease

44

For their work, Marshall & Warren  
were awarded the 2005  
**Nobel Prize in  
Physiology or Medicine**



45



Louis Pasteur

“In the fields of observation,  
chance only favors the  
prepared mind” *L. Pasteur*

# Hypotheses and scientific enquiry

*hypo = under; thesis = an arranging*

Critical to the development of science.

- They bridge
- the known and unknown,
  - and past and future expected observations
- 
- Hypotheses are tentative, explanatory, interpretative generalizations about natural phenomena
  - They arise out of past or present observations, experimentation, and scientific thinking
  - They are subject to **confirmation** or **verification**, which is done by **testing**

47

## Hypotheses

**Hypotheses are generally derived by inductive and deductive reasoning**

### **Deduction**

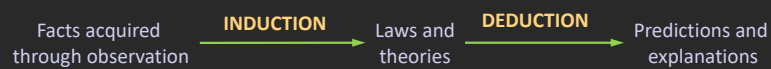
- *Inference by reasoning from general to the particular (Oxford dictionary).*
- *Application of a proven and accepted law to a specific situation (Lindsay, 1995)*

48



## Induction

- *Inferring a general law or principle from the observation of particular instances (Oxford dictionary)*
- *Logical process of assembling facts until a conclusion, usually a generalization, is reached (Lindsay, 1995)*



49

## Deductive or inductive reasoning?

“When I kick a ball in the air, it always returns to the ground. So whenever someone kicks a ball in the air, it will return to the ground”

“The rate at which a ball falls back to the ground depends on the force of gravity. On a planet with twice the gravitational force of earth, all things being equal, there will be less time to catch a ball before it hits the ground”

50

### **The null hypothesis**

Predicts no difference between comparison groups or association among tested variables

### **The alternative hypothesis**

Predicts either a simple difference

(two-tailed hypothesis)

or

a difference in a particular direction

(one-tailed hypothesis)

51

### **Examples**

#### **Null hypothesis**

There is no association between smoking and lung cancer

#### **Alternative hypotheses**

##### **Two-tailed**

There is an association between smoking and lung cancer

##### **One-tailed**

There is a positive association between smoking and lung cancer

52

## The nature of hypotheses

- Hypotheses set up expectations for subsequent observations
- They join given conditions to predicted consequences and are **inherently conditional** and predictive
- Therefore, when accurately stated, they are predictive **if-then statements**

53



54

## The testability of hypotheses

Consider the statement

“All swans are white”

If, from observation a bird-watcher:

- sees a white swan.
- and another, and another, and so on
- the bird-watcher may conclude that “All swans are white”



But it would not be possible to observe all the swans in the world.

So what do we make of the statement?

The statement is still **testable** because ...

... in continued observation,  
if a single **counterexample** (a black swan) were seen ...

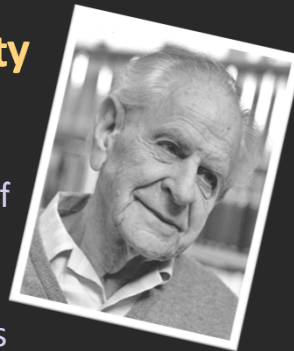


it can be concluded that the statement is not true  
*i.e.* NOT ALL swans are white

**The statement is falsifiable**

## Karl Popper and Falsifiability

The less possible it is to disprove a proposition the more it is capable of being believed



A scientific theory or hypothesis has the important characteristic that it is capable of being subject to experimentation that could show it to be untrue *i.e.* it is falsifiable

57

## Falsifiability

is the logical possibility that an assertion can be shown false by an observation or a physical experiment

That something is "falsifiable" does not mean it is false; rather, that *if* it is false, then this can be shown by observation or experiment

58

### Consider . . .

“There are little green men on the moon,  
but when as soon as they are observed,  
they turn invisible”

Is this proposition falsifiable?



59

### Are hypotheses always required?

**Not all experiments test hypotheses**

*e.g.* surveys; observations

**However,**

- there is a reason for, and expectation from the work
- a hypothesis lies within that reason and expectation

60

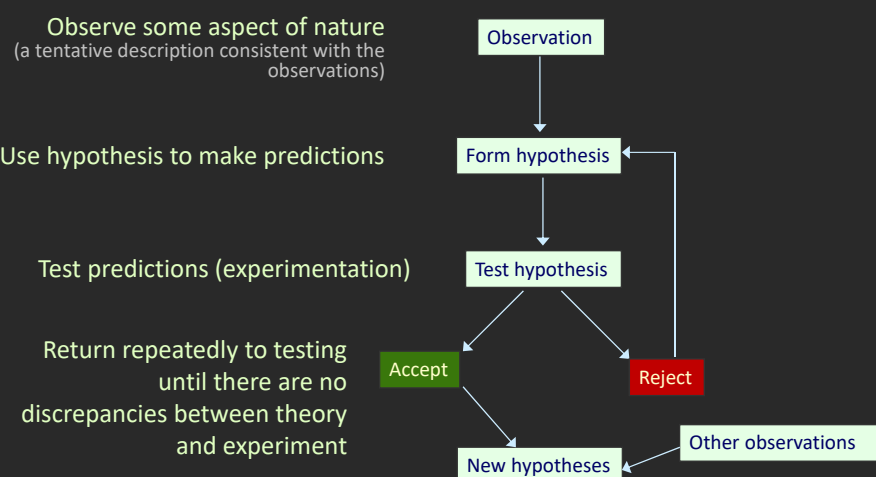
## Consider:

A survey of the birds in a particular bush environment

- Would a reader find a paper reporting this work interesting or easy to assess?
- What possible reasons were there for the study?
  - The possibility of finding new species?
  - Finding out if the crop you want to introduce in that area will be pollinated by the local bird population
  - A census to record variety prior to clear felling of the native trees in the area
- A purpose and direction for the work becomes clearer when a hypothesis is derived from the above

61

## Flow in the Scientific Method



62

## Characteristics of the Method

- Unprejudiced
- Repeatability
- Conclusions are not subject to influence by state of mind, religious belief, and/or subject of the investigation

63

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64