a short course on

Scientific Writing

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Coverage

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

1

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.

2

Scientists

The Merton-Ziman norms (Anderberg, 1998)

Shared by members of the scientific community.

Communalism

Universalism

Disinterestedness

Originality

Organized **S**kepticism

3

CUDOOS (after Anderberg, 1998)

Communalism

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

Universalism

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

4

CUDOOS (after Anderberg, 1998)

Disinterestedness
Not subject to personal profit; ideology; expediency; *i.e.* honest and objective.

Originality
Requires research to be novel.

Organized Skepticism
No acceptance on word of authority; free questioning; truth rests on comparison with observed fact.

5

Universal Intellectual Standards

(Elder & Paul, 1996)

- Clarity
- Accuracy
- Precision
- Relevance
- Depth
- Breadth
- Logic

6

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.

7

Critical Thinking 2

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.

8

Critical Thinking 2 (Scriven & Paul, 1996)

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.

9

The Scientific Method

(based on material from Wilkinson, 1991 and others)

Observation, hypothesis, and experimentation

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

10

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.

11

Observation 2

Commonly-held belief *vs.* established fact

Consider . . .

12

Observation 3

Jean Louis Théodore Géricault (1821) “The Epsom Derby”

13

Observation 4

J. Cameron (1890) “Great Horses in a Great race”

14

Observation 5

Chinese print

15

Observation 6

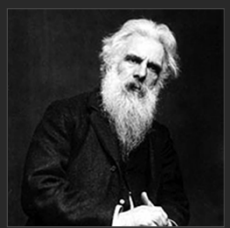
Palo Alto, 1872

Much debated question of the time:

Is a galloping horse ever completely aloft?

- Stanford (later to found Stanford University), 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

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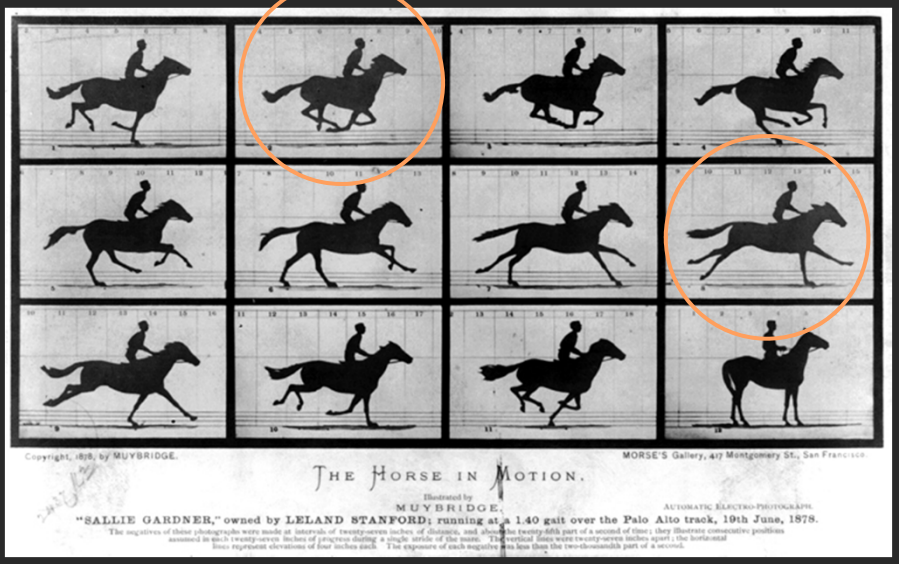
Observation 7



17

Observation 8

Eadweard Muybridge (1878) “The Horse in motion”

18

Observation >>> hypothesis

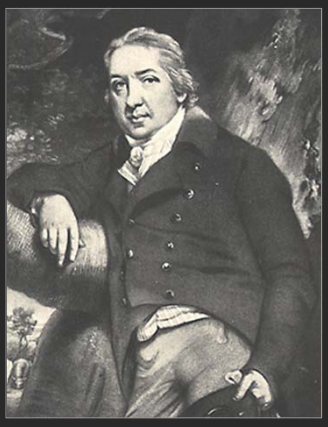
A prick in the arm

1979
The WHO declared smallpox an eradicated disease.

Edward Jenner
(1749-1823)

Pioneer of vaccination

"Father of immunology"



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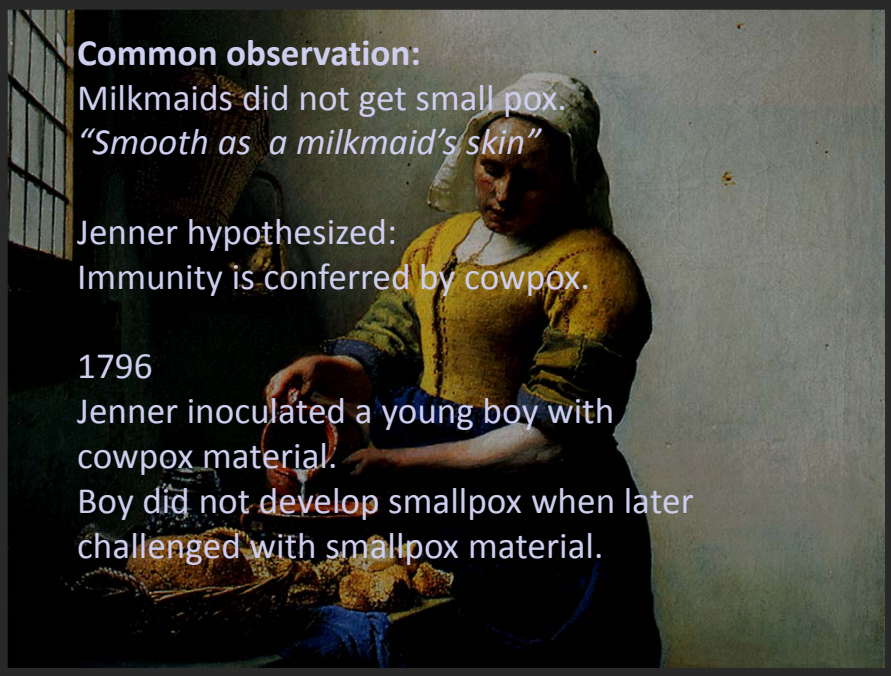
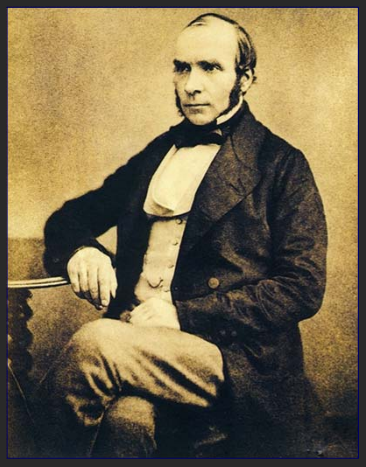


Observation >>> hypothesis

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



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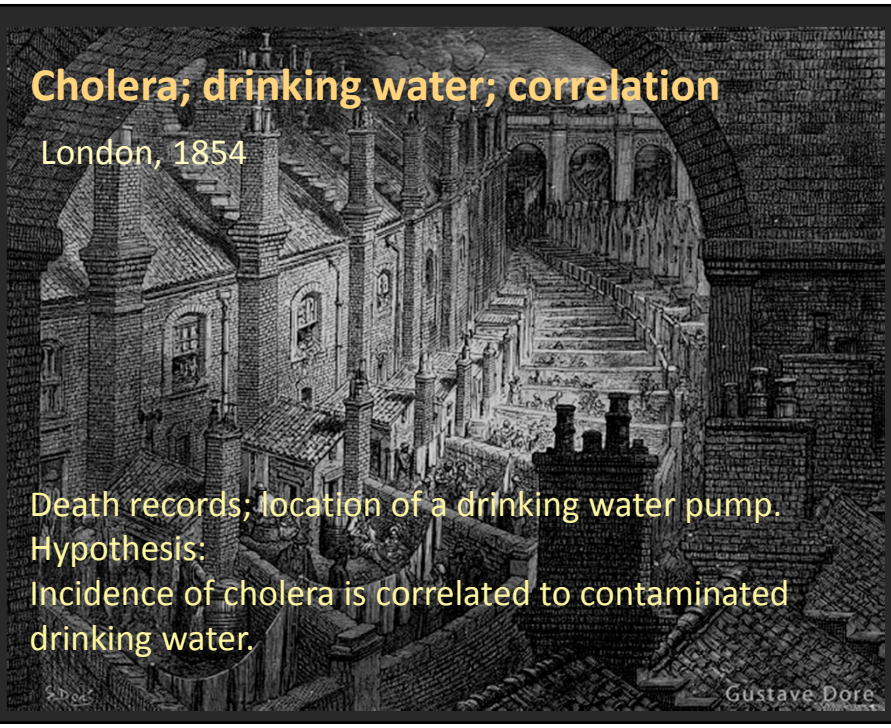
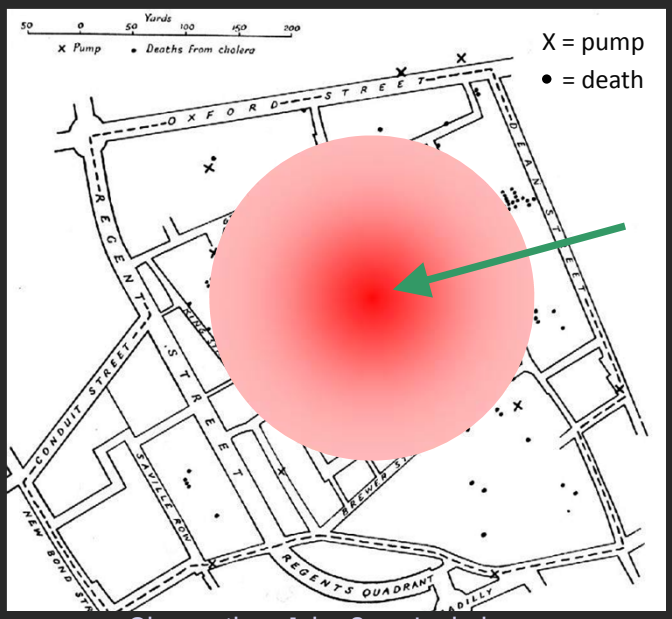


Cholera; drinking water; correlation

London, 1854

Death records; location of a drinking water pump.
Hypothesis:
Incidence of cholera is correlated to contaminated drinking water.



Observation: John Snow's cholera map

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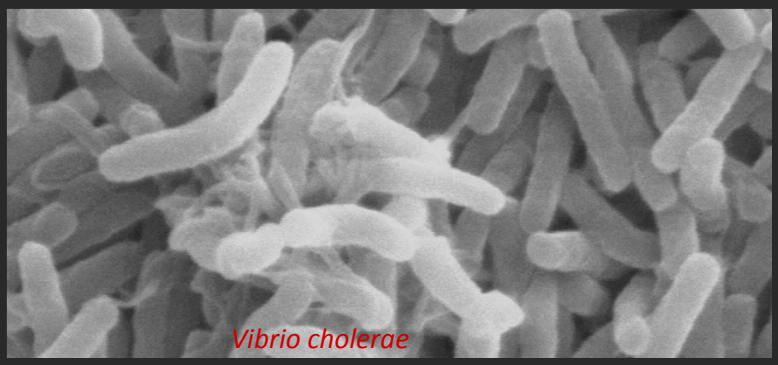
When the pump was **disabled**, number of deaths dropped dramatically.

The causative agent of cholera (*Vibrio cholerae*) was not widely known until 30 years later.



Vibrio cholerae

24

Replica pump on
Broadwick St., London

The John Snow pub, Broadwick St.

25

Observation >>> hypothesis

A pain in the gut

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

26

Helicobacter pylori associated with gastric mucosa

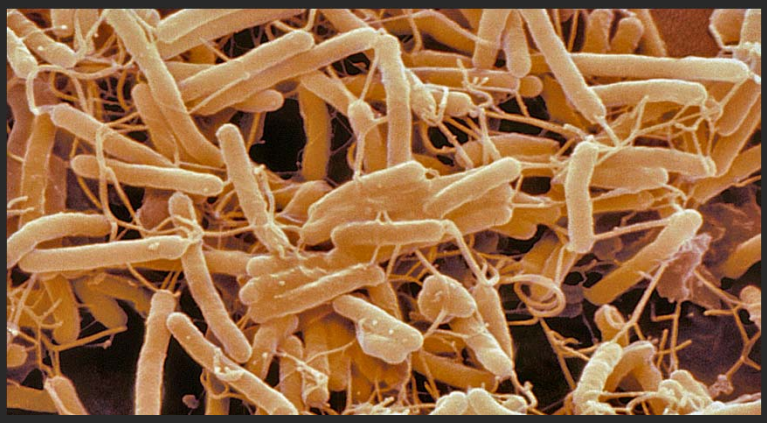
27

Warren's critical observation:

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

28

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



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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 *Helicobacter 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.

30

For their work, Marshall & Warren were awarded the 2005

Nobel Prize in Physiology or Medicine

31

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.

32

Hypotheses

Hypotheses are generally derived by inductive and deductive reasoning.

Deduction

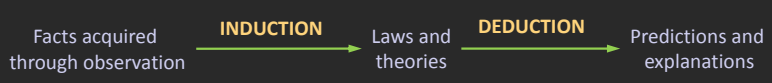
- *Inference by reasoning from general to the particular (Oxford dictionary).*
- *Application of a proven and accepted law to a specific situation (Lindsay, 1995).*

33

Hypotheses 2

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).*



34

Hypotheses 3

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).

35

Hypotheses 4

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.

36

Hypotheses 5

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.

37

The nature of hypotheses 2

38

Hypotheses 6

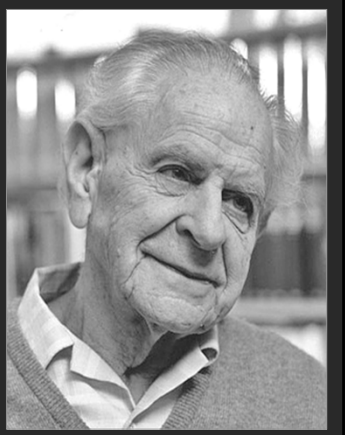
Hypotheses and experiments

- Experimental findings do not prove hypotheses. Hypotheses are confirmed, supported, substantiated, or verified.
- Confirmation can be accepted only as long as the hypothesis continues to be confirmed. Therefore, hypotheses are forever open to disconfirmation.
- Therefore science is constitutionally provisional and uncertain. No generalization, conclusion or finding is immutable.

39

Hypothesis 7

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.

40

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.

41

Consider . . .

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

Is this proposition falsifiable?

42

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.

43

Are hypotheses always required? 2

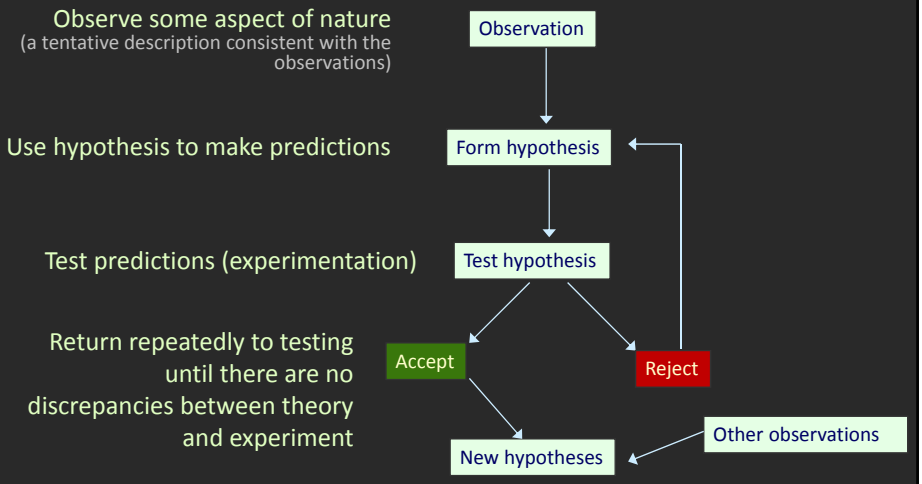
Consider:

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.

44

The Scientific Method



45

Characteristics of the Method

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

46

Sources

Anderberg, L. (1998) CUDOOS.
http://www.scicom.lth.se/fmet/cudoos.htm

Wilkinson, A.M. (1991) "The Scientist's Handbook for Writing Papers and Dissertations"; Prentice Hall, Englewood Cliffs.

47