ΕΘΝΙΚΟ ΚΑΙ ΚΑΠΟΔΙΣΤΡΙΑΚΟ ΠΑΝΕΠΙΣΤΗΜΙΟ ΑΘΗΝΩΝ
ΤΜΗΜΑ ΓΕΩΛΟΓΙΑΣ ΚΑΙ ΓΕΩΠΕΡΙΒΑΛΛΟΝΤΟΣ
‘ΠΜΣ –Ειδίκευση‘
"Ορυκτοί Πόροι - Πετρολογία και Διαχείριση Περιβάλλοντος"

“ **ΟΠΠ-Ε08** ΜΕΘΟΔΟΛΟΓΙΑ ΕΡΕΥΝΑΣ ΚΑΙ ΣΥΝΤΑΞΗ ΕΠΙΣΤΗΜΟΝΙΚΩΝ ΚΕΙΜΕΝΩΝ”

ΔΙΑΛΕΞΗ 1
“HYPOTHESIS”

Καθηγητής Στέφανος Π. Κίλιας
2021

Aims (Σκοπός)

- To provide students with the skills necessary to pursue academic or industry based research by developing their planning, writing, laboratory, data analysis and reporting skills

Aims (Σκοπός)

- Methodology: a set or system of methods, principles, and rules for regulating (ρυθμίζω/εξυπηρετώ) a given discipline(κλάδος/τομέας/επιστήμη), as in the arts or sciences
- Method: a procedure, technique, or way of doing something, especially in accordance with a definite plan

Learning Outcomes (Μαθησιακά Αποτελέσματα)

- The ability to analyse and interpret data using appropriate numerical techniques supported by relevant software
- The ability to design, plan and carryout research projects
- The ability to write scientific or consultancy reports
- The ability to use scientific databases and efficiently find key findings in research literature

Learning Outcomes (Μαθησιακά Αποτελέσματα)

Skills (Ικανότητα/Επιδεξιότητα) required or to be acquired

- planning and organisation
- problem solving
- numeracy(ability to do arithmetic)
- computer literacy
- data analysis, presentation and interpretation
- oral scientific communication skills

Teaching

- Lectures will cover
  - Research Ideas
  - Researching an idea
  - Project design
  - Project safety
  - Scientific writing
  - Communication and presentation skills
  - Data manipulation
- Practicals
  - Basic statistics and data presentation

Assessments

Τρόπος αξιολόγησης φοιτητών-
Ο βαθμός του μαθήματος προκύπτει με βάση

- 100% course work
  - Προφορική παρουσίαση –due this semester (ΗΜΕΡΟΜΗΝΙΕΣ ΣΥΜΦΩΝΑ ΜΕ ΤΟ ΠΡΟΓΡΑΜΜΑ) 50% of total
  - Δοκίμιο/ “Εναρκτήρια Έκθεση” (περίπου 6 σελίδες) [Project inception report (PIR)] –due next semester (ΜΗΝΕΣ) 25% of total
  - Project inception presentation –due next semester (ΜΗΝΕΣ) 25% of total

Hypotheses driven and exploratory research

What is research?

- Scientific research is simply finding out facts which collectively answer a specific question about a study subject.
- What? Measurable properties of a given system (presence and dimensions of properties)
- Where? Distribution of a measurable property
- When? Frequency and longevity of a studied phenomenon (prediction)
- How? Mechanism for a given observed or induced phenomenon (understanding the mechanics of processes e.g. pathways or consecutive reactions)
- Why? (e.g. cause or motivation for a phenomenon (climate warming, sexual reproduction)

The Scientific Method

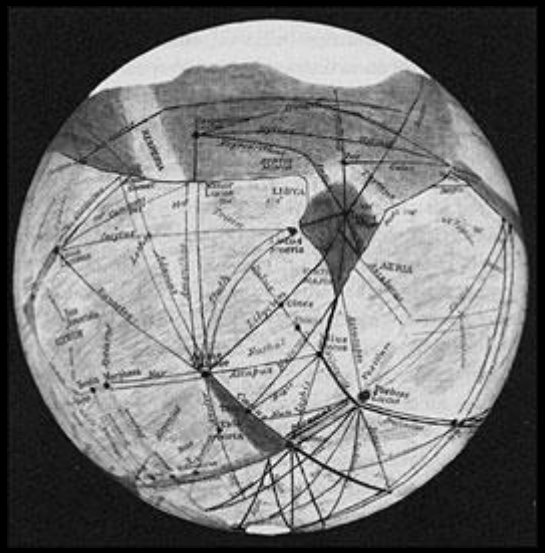
- A step by step way of designing an experiment to obtain a specific answer (probably familiar to all here)
- Step 1. Observation prompting a question
- Step 2. Background research (has the question already been posed and answered?)
- Step 3. Construct a hypothesis
- Step 4. Experiment and/or analysis to test hypothesis
- Step 5. Conclusion (i.e. reject or accept hypothesis)
- If hypothesis not proven produce new hypothesis and experiment
- Report findings

The Scientific Method

- If you don’t use the scientific method for testing an idea then your research will
  - lack focus, unfortunately It is insufficient these days for research to be quite Interesting
  - will not prove anything anyway
  - Nobody will pay for it or your next experiment
  - Nobody will publish it

Step 1: Observation/question

- This first step is the framing of a question
- This often based on an observation
- E.g. Structures on mars that reassemble canals
- Is or was there water on Mars?
- If so is or was their intelligent life on Mars?



Percival Lowell 1855-1916

Step 2: Background

- This second step is simply finding out what is known about the question and importantly unknown.
- There is no point in re-inventing the wheel, however, sometimes the findings of others are potentially flawed and need testing (e.g. Cold fusion)
- Therefore need to do critical review
- We will discuss this in much more detail in another lecture i.e. searching the academic literature

Step 3: Construct a research hypothesis

- A hypothesis is not a question.
- It is a statement that you are about to either accept or disprove.
- E.g. Question. What shape is the world?

Hypotheses

1. The world is round.
2. The world is flat.
3. The world sits on top of 4 elephants that stand on top of a turtle that swims through space.
4. The world is an oblate spheroid

The Scientific Method-first steps

- Observations / past research

  (1) Tomato plants need sunshine to make food through photosynthesis, and logically, more sun means more food, and;

  (2) Through informal, exploratory observations of plants in a garden, those with more sunlight appear to grow bigger.

- Question

  "Does the amount of sunlight a tomato plant receives affect the size of the tomatoes?“

- Hypothesis

  the more sunlight a tomato plant receives, the larger its tomatoes will grow

The Scientific Method-first steps

- Observations / past research

  (1) Soluble Fe^{2+}, supplied from mid-ocean ridges and hydrothermal vents, was oxidized by various processes to Fe^{3+} deposited in association with varying silica ratios as Banded iron formations BIFs, the bulk of which was formed in the late Archaean/Palaeoproterozoic marine basins and;

  (2) lab experiments have suggested that biotic, anoxygenic photoferrotrophic precipitation according to the equation

  $4Fe2+ CO_2 + 11H_2O + light = [CH_2O] + 4Fe(OH)_3 + 8H^+$

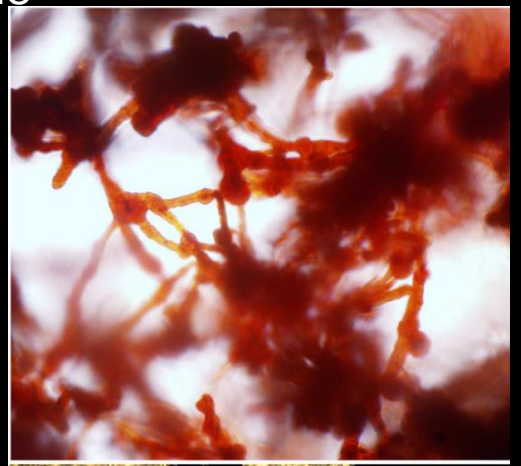
  Is responsible for BIF deposition

- Question

  "how biological processes could have accounted for vast-scale biological BIF deposition deposition in late Archaean/Palaeoproterozoic marine basins?“

- Hypothesis

  “Biology (Photoferrotrophy) is responsible for BIF deposition in stratified water columns deep in the ocean and on continental shelf margins in late Archaean/Palaeoproterozoic marine basins”

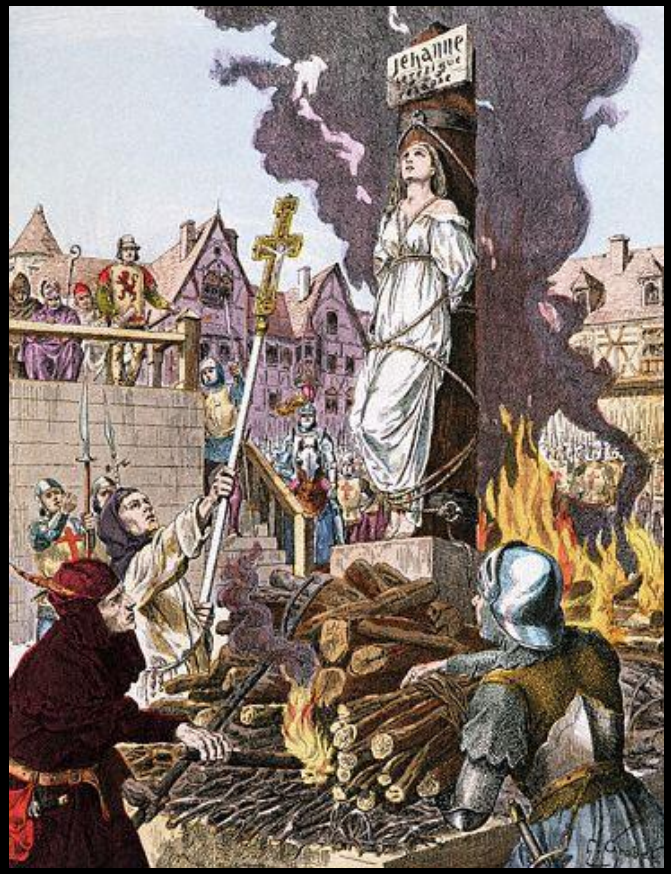


Predicting the answer

- A research hypothesis is used by scientists to help frame experiments by predicting their outcomes
  - so hypotheses are more focused than a question
- What is the point of carrying out the experiment if we already think we know the answer?
- The job of a scientist is to prove the hypothesis.

Predicting the answer

- Without proof there is only faith which leads to superstition and ignorance (e.g. breaking mirrors gives 7 years bad luck, eccentric old women living on their own are probably witches
- Science doesn't deal in faith, only in facts
- Facts need proof.



Not a witch. This is a Masters student who did not use hypothesis in her Project inception report

Step 4: Carryout experiments

- The hypothesis is tested experimentally.
- Bad experiments (laboratory analyses) will yield answers that are inconclusive, or give rise to an incorrect rejection of a true hypothesis or incorrect acceptance of a false hypothesis.
- Good experiments (laboratory analyses) change one parameter at a time and measure the effect compared to controls which are not changed .
- We will discuss good experimental (analytical) design in much more detail in the coming lectures

Carryout laboratory analyses

- The hypothesis is tested analytically.
- Unsuitable laboratory analyses will yield answers that are inconclusive, or give rise to an incorrect rejection of a true hypothesis or incorrect acceptance of a false hypothesis.
- Suitable laboratory analyses yield reproducible results.
- We will discuss good analytical design in much more detail in the coming lectures

Carryout experiments

- It is often very hard to prove a hypothesis so typically an experiment is set up to try to disprove it.
- For example a researcher in the UK poses the question. Are all swans white
- The hypothesis is: All Swans are white.
- To experimentally test this hypothesis he identifies the colour of a large number of Swans in the UK

Carryout experiments

- 10,000 Swans are counted and are all found to be white- Does this data constitute proof of the hypothesis?

No the observation of a single black swan on a trip to Australia (where they are native) is enough to disprove the hypothesis

Testing hypotheses- badly!

- Observations / research

  Elizabeth Clarke is was a one-legged widow and does not get on with her neighbours

- Question

  Is Elizabeth Clarke a witch?

- Hypothesis

  Elizabeth Clarke is a witch

- Experimental plan

  1. torture and sleep deprive a suspected Witch until she confesses
  2. bind suspect tightly and throw into pond. If drowned then not a Witch
     if not drowned then they are a Witch so drown them

Mathew Hopkins 17th centaury Witch finder general

Under critical review can we find flaws in this experimental plan?

Good hypotheses testing -

- Question

  "Does the amount of sunlight a tomato plant receives affect the yield of the tomatoes?“

- Hypothesis

  the more sunlight a tomato plant receives, the larger weigth of tomatoes it will grow

- Experimental plan

  Grow two tomato plants in separate pots (each with the same soil and water additions) but with different amounts of light and measure the size of crop

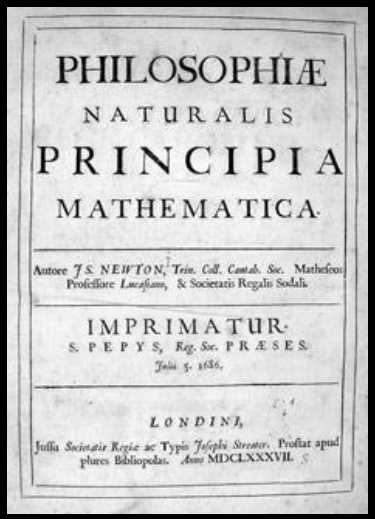
Under critical review can we find flaws in this experimental plan?

Step 5: Conclusions

- This is the summary of the results and how those results match to the hypothesis
- Conclusions can only be based on your results
- Hypotheses can be proved or disproved
- Badly designed experiments will not allow you to reach the correct conclusions

Publish or Perish?

- in academia there is no point in carrying out research and then keeping it secret
- Advancement of science and society is based on shared knowledge
  - ‘If I have seen further it is only by standing on the shoulders of giants’ a quote from perhaps the second most influential scientist of all time

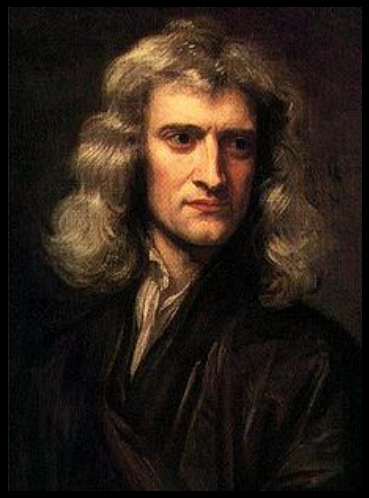

PHILOSOPHIÆ
NATURALIS
PRINCIPIA
MATHEMATICA.

Autore *Is. NEWTON*, Trin. Coll. Cantab. Soc. Matheseos Professore Lucasiano, & Societatis Regalis Sodali.

IMPRIMATUR.
S. PEPYS, Reg. Soc. PRÆSES.
Julii 5. 1686.

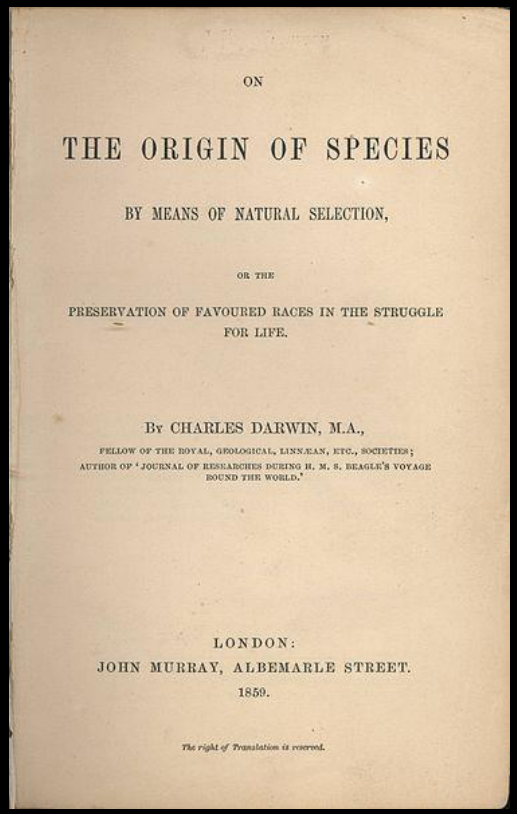
LONDINI,
Justu Societatis Regiæ ac Typis Josephi Streater. Prostat apud plures Bibliopolas. Anno MDCLXXXVII.

Sir Isaac Newton



Publish and be dammed?

- Darwin's dangerous idea-’the single best idea anyone ever had’ Dennett (American Philosopher)



ON

THE ORIGIN OF SPECIES

BY MEANS OF NATURAL SELECTION,

OR THE

PRESERVATION OF FAVOURED RACES IN THE STRUGGLE FOR LIFE.

By CHARLES DARWIN, M.A.,

FELLOW OF THE ROYAL, GEOLOGICAL, LINNÆAN, ETC., SOCIETIES;
AUTHOR OF 'JOURNAL OF RESEARCHES DURING H. M. S. BEAGLE'S VOYAGE ROUND THE WORLD.'

LONDON:
JOHN MURRAY, ALBEMARLE STREET.
1859.

The right of Translation is reserved.

- In a single stroke, the idea of evolution by natural selection unifies the realm of life, meaning and purpose with the realm of space and time, cause and effect, mechanism and physical law.

Publish in haste and repent at leisure?

- The impact of Darwin's idea (Evolution by natural selection) has changed the world but originally he delayed publication for 20 years. why?
  - Maybe through fear of controversy and societal reaction
  - So as not to upset religious friends and relatives
  - But most likely to get the idea (theory) and its communication right

Remember hypotheses are rarely unequivocally proven, however, this idea has now survived 150 years without rejection

Publish or Perish?

- More mundanely a scientists publication record justifies past investment and facilitates future research funding
- It is the mechanism by which your worth as a scientist is judged. No publications No job!

And Its all about numbers, impact factor and citation stupid

Publish or Perish?

- Best to publish in the best international journal in your subject area i.e. with the highest impact factor. This makes it more likely to be read and therefore cited by your peers
- Or publish in the top general science journals e.g. Nature, Science, PNAS with even wider readership
- Impact factor of a journal for a given year
- A = the number of times articles published in past three years were cited in journals during the given year
- B = the number of articles published in same three year period
- impact factor = A/B Journal Citation Report (JCR), Institute for scientific information (ISI)

Publish or Perish?

- The impact factor (IF) of an academic journal is a measure reflecting the average number of citations to recent articles published in the journal. It is frequently used as a proxy for the relative importance of a journal within its field, with journals with higher impact factors deemed to be more important than those with lower ones. The impact factor was devised by Eugene Garfield, the founder of the Institute for Scientific Information. Impact factors are calculated yearly starting from 1975 for those journals that are indexed in the Journal Citation Reports

Publish or Perish?

Impact Factor Calculation

- In any given year, the impact factor of a journal is the average number of citations received per paper published in that journal during the two preceding years.[1] For example, if a journal has an impact factor of 3 in 2008, then its papers published in 2006 and 2007 received 3 citations each on average in 2008. The 2008 impact factor of a journal would be calculated as follows:

- 2008 impact factor = A/B.

- where:

- A = the number of times that all items published in that journal in 2006 and 2007 were cited by indexed publications during 2008.
- B = the total number of "citable items" published by that journal in 2006 and 2007. ("Citable items" for this calculation are usually articles, reviews, proceedings, or notes; not editorials or letters to the editor).

- (Note that 2008 impact factors are actually published in 2009; they cannot be calculated until all of the 2008 publications have been processed by the indexing agency.)

Publish or Perish?

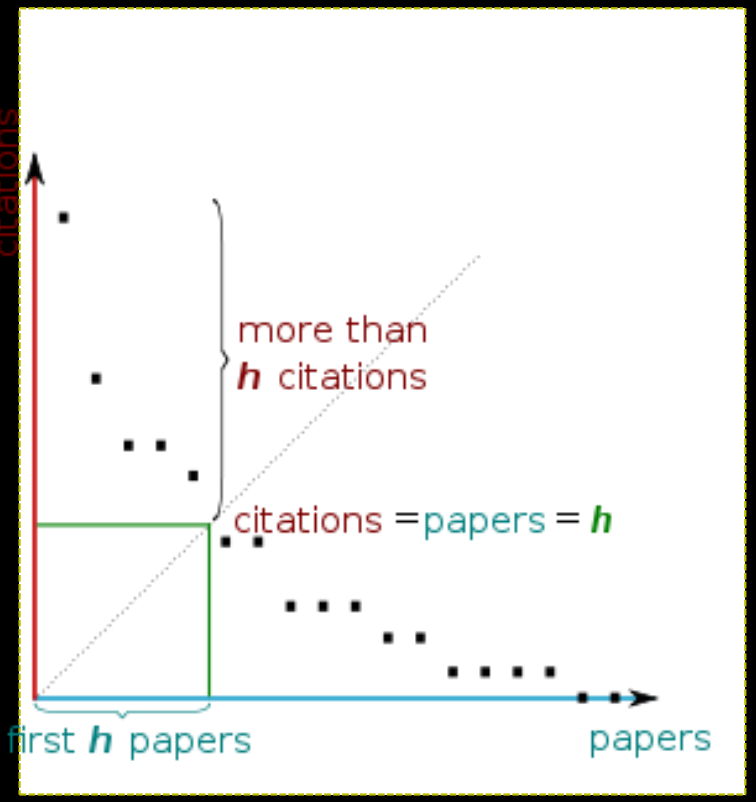
- Impact factor of a journal for a given year
- A = the number of times articles published in past three years were cited in journals during the given year
- B = the number of articles published in same three year period
- impact factor = A/B Journal Citation Report (JCR), Institute for scientific information (ISI)

Publish or Perish?

- With your papers in the best journals you will hopefully get cited (with modern search engines and electronic access this may not be so true)
- The number of citations by others is a judgment of the quality of the work
- Databases such as ISI Web of knowledge and Scopus document these citations for all to see
- Information then used to construct indices e.g. the H index

H index

- H index value is calculated when x papers of the total published by an author have at least x citations each
- E.g. you might have 13 papers which each have 13 citations or more
- This approach deemphasises the impact of a single highly cited paper



Patent or Perish?

- For industry there is no point in carrying out research and not keeping it secret
  - Protection of research output by patenting
  - More commonly nowadays first to market is best served
- This is why there is often an intellectual tension and mistrust between industrial and academic partners
- Why? Different objectives and philosophies, but, when it works can yield huge benefits to both e.g. petroleum geosciences in CEGS and oil companies
- Why make industry academic partnerships ?
  - validation of approach, technology or processes by publication in peer reviewed publications.
  - What better tool for reassuring buyers and stakeholders

Industry and academic partnership

- Tips for success

Academic

- Constant communication of plans progress
- confidentiality
- prior agreements about publication
- Awareness of the bottom line

Industry

- Clear objectives and requirements
- clear timelines
- Patience (results won’t come last week)

Publish

- Another way to maximize your paper citations (like a rock band) get yourself out on tour –

The importance of touring

The Beatles arrive in US for their first US tour (1964). Album sales soared and the rest is history

- For academics -conferences not concerts but the principle is the same (if not as cool)
  - Poster (lower impact)
  - Oral presentation (higher impact)

Scientific Sins

- Thou shall not plagiarise

- Thou shall not make up results
  - i.e. to make things more interesting i.e. accepting the hypothesis rather than rejecting – in a properly conducted experiment there is no such thing as a bad result!

These sins are unforgivable and will ruin your career

Be sure your sins will find you out

- Plagiarism (the antithesis of citation –see handbook for citation advice)
- = wrongful appropriation = passing someone else's work off as your own
  - For Students – essays and dissertations –if guilty thrown off course. No degree. This is taken very seriously by the University authorities
  - http://www.plagiarism.org useful web resource

I have cut and pasted the following from http://www.plagiarism.org

- 'to steal and pass off (the ideas or words of another) as one's own
- to use (another's production) without crediting the source
- to commit literary theft
- to present as new and original an idea or product derived from an existing source'.

Be sure your sins will find you out

- turning in someone else's work as your own
- copying words or ideas from someone else without giving credit
- failing to put a quotation in quotation marks
- giving incorrect information about the source of a quotation
- changing words but copying the sentence structure of a source without giving credit
- copying so many words or ideas from a source that it makes up the majority of your work, whether you give credit or not (see our section on "fair use" rules)
- I have copied the above word for word from http://www.plagiarism.org Do not do this !

Be sure your sins will find you out

- Most cases of plagiarism can be avoided, however, by citing sources. Simply acknowledging that certain material has been borrowed, and providing your audience with the information necessary to find that source, is usually enough to prevent plagiarism. See our section on citation for more information on how to cite sources properly.

One of the typical ways that students get caught out i.e. not removing incriminating inappropriate text pasted from e.g. http://www.plagiarism.org

How will your sins be found out

- The university and the wider world has sophisticated computer aided means of checking plagiarism and in the last few years a number of masters students on CEGS courses have fallen foul of plagiarism rules (see course handbook)
- For academics and students plagiarism is often detected because markers or peer reviewers are very familiar with the scientific literature and know what has gone before

Plagiarism and methods (a special case?)

- Lots of papers describe the same experimental procedure in a very similar way
- This is because the words used in each case used are the most “economical” way of describing what was done
- This is fine and methods sections often are flagged up as plagiarized using checking tools
- Even so do not cut and paste other’s methods sections

Plagiarism: tips for avoidance

- NEVER cut and paste sections of *text* from other sources into your final submitted coursework
- Never loan your coursework, either before of after you have personally submitted it
- No individual quotation should be more than two sentences, and usually much less. The quoted text must be *italicised* and preceded and followed by double open and closing quotation marks

Plagiarism: tips for avoidance

- The quotation must be immediately followed by a proper citation
- NO item of coursework must comprise more than 3% quotations in total
- When using ideas, conclusions, data, examples, or facts of others you must cite a reference to the source(s) within the sentence in which it appears
- The works you cite in your coursework should mainly be the things that you have actually read yourself

Fraud

- Science works on trust but occasionally major scientific fraud gets detected by peer review and attempted experimental replication by others
- Why? There are always others working in the same research area so if you make fraudulent claims they will be tested and questioned, eventually!
- Minor scientific fraud is more difficult to detect but what is the point of taking the risk

Fraud

- Jan Hendrik Schön was the perpetrator of the worst research fraud scandal to hit physics in living memory
  - Schön published eight papers in *Science* and *Nature*
  - Awarded Otto-Klung-Weberbank Prize for Physics in 2001, the Braunschweig Prize in 2001 and the Outstanding Young Investigator Award of the Materials Research Society in 2002
  - Found out eventually by unlikely patterns of duplicated data in publications
  - There are many other examples of fraud detection

Future Direction

- Is there mileage in your research?
- What can it be used for?
- Will someone pay for you to continue?