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

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

ΔΙΑΛΕΞΗ 2
“RESEARCHING AN IDEA”

Καθηγητής Στέφανος Κίλιας

2021

ΔΙΑΛΕΞΗ No 2

- Βιβλιογραφική έρευνα και “Ερευνητική Υπόθεση”.
- Συγγραφή δοκιμίου βιβλιογραφικής ανασκόπησης
- Η διεξαγωγή της έρευνας--Θεμελιώδεις αρχές.
- Εισαγωγή στη “Εναρκτήρια Έκθεση”--– Καθοδηγητικά βήματα για την παραγωγή της “Εναρκτήριας Έκθεσης”.

- Δειγματοληψία, Σχεδιασμός πειραμάτων, Συλλογή δεδομένων, Πειραματικές προσεγγίσεις.

Βιβλιογραφική έρευνα και “Ερευνητική Υπόθεση”

Literature research for proposals, reviews and discussions

Scientific Hypothesis

- Observation / research
- Construct a hypothesis
- Experiment
- Conclusion

Researching the Hypothesis

- What is known about the subject?
- What is known about the specific question?
- Who are the experts in the field?
- What direction is the research being taken?
- Is your question still valid?
- How will the current understanding help you to answer your question?
- How will the answer to your question advance understanding in the field?
- What are the current debates in the field?

Sources of Data

- Library: text books and Journals
- Lecturers
- Peers
- Internet databases to find: Peer reviewed journals, curated data archives, organization webpages, online analysis tools
  - Millions of science articles published each year so computer aided research is critical

Databases and search engines

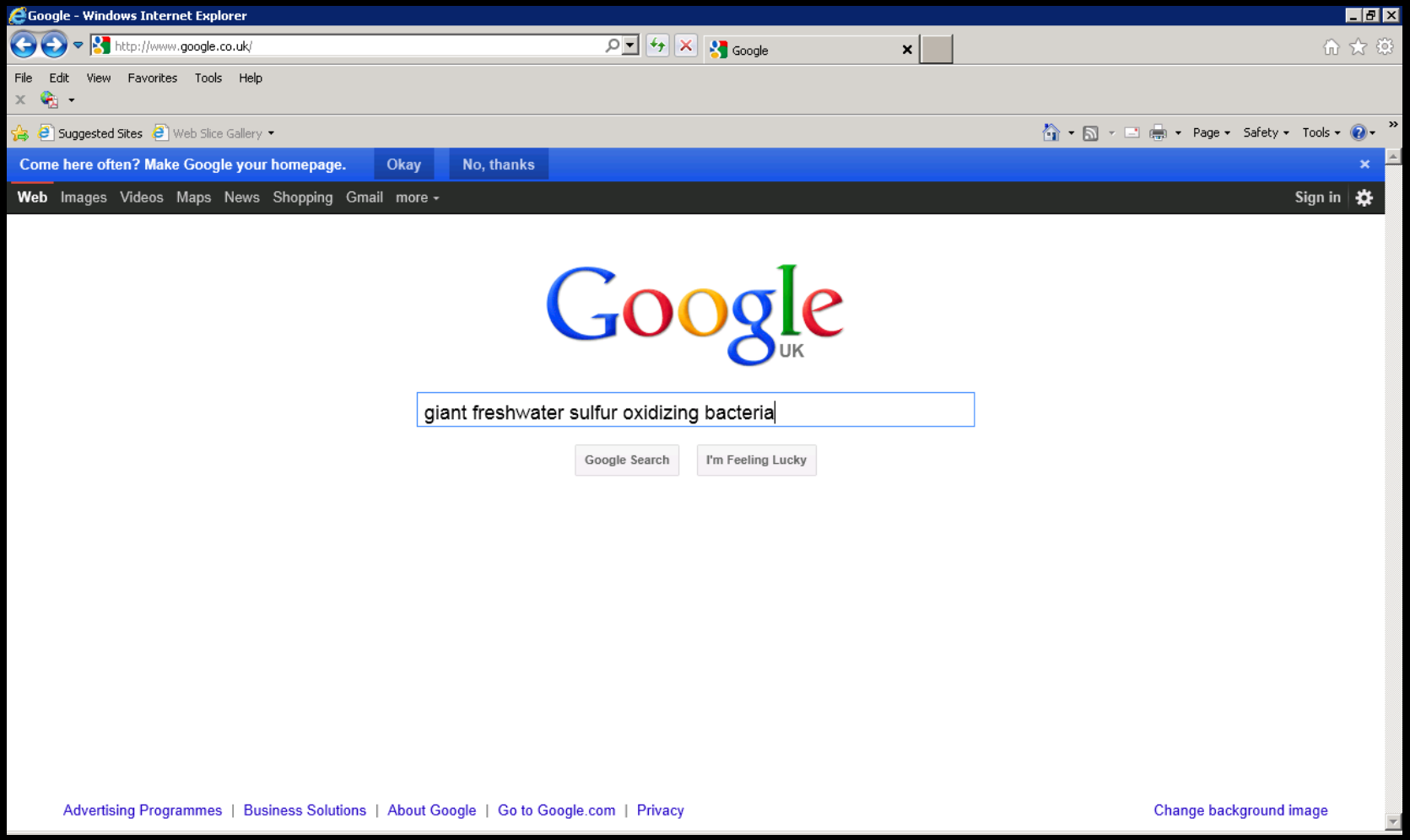
- Hellenic Academic Libraries Link {http://www.heal-link.gr/
- http://www.scopus.com/}
- https://www.google.com/?hl=el&gws_rd=ssl
  - Google scholar
  - Google Earth
  - Google maps

- Important When using these search engines and databases use University computers or search via University remote access routes because the University has online subscriptions to a wide range of electronic journals which generally charge for private users

Reputable information

- Peer reviewed articles (still by far the most important source of information because of the peer review process)
- What is the peer review process?
- Scientific Journal publications are obtained as PDF files downloaded via links followed from internet search tool e.g. google or web of knowledge

Reputable information



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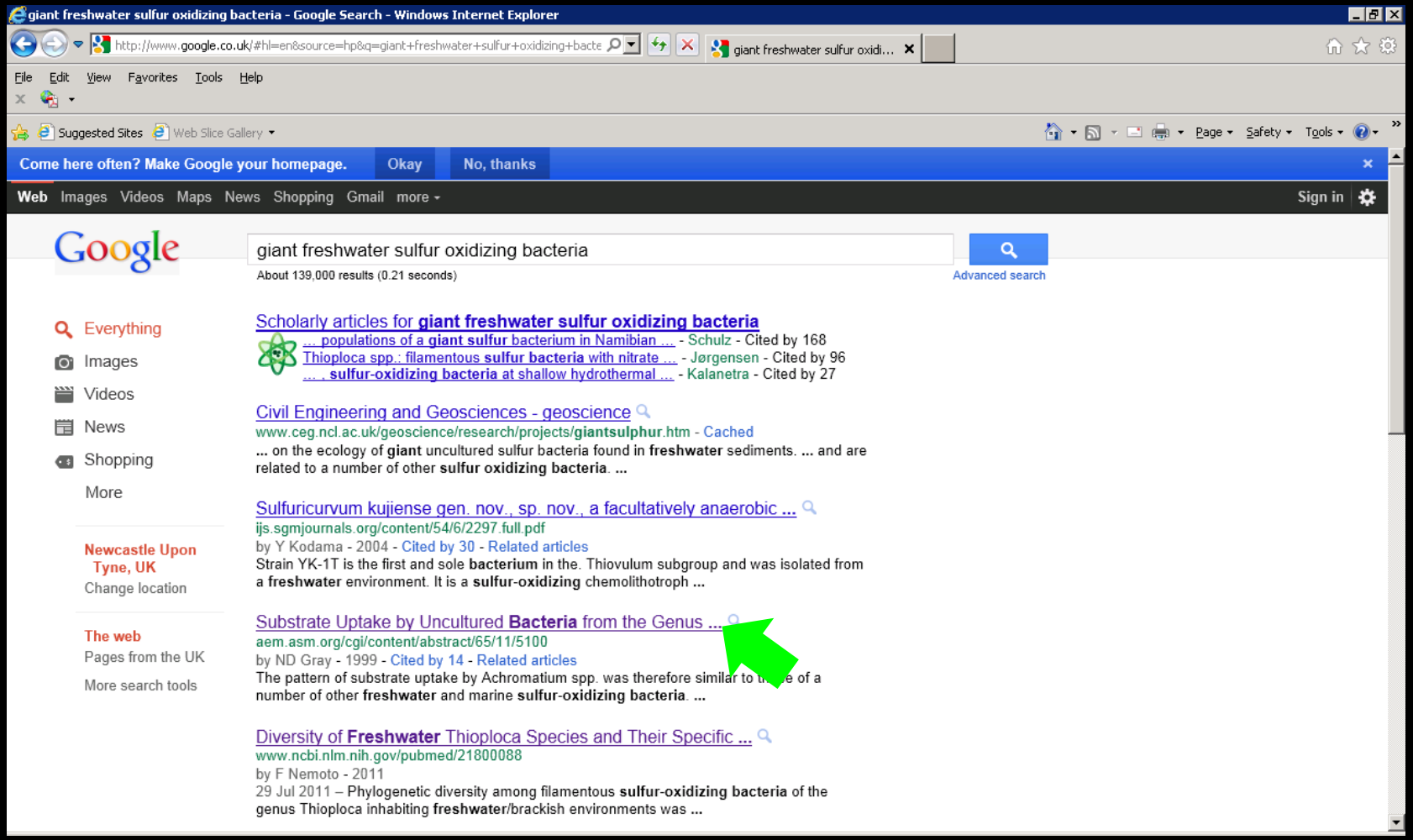

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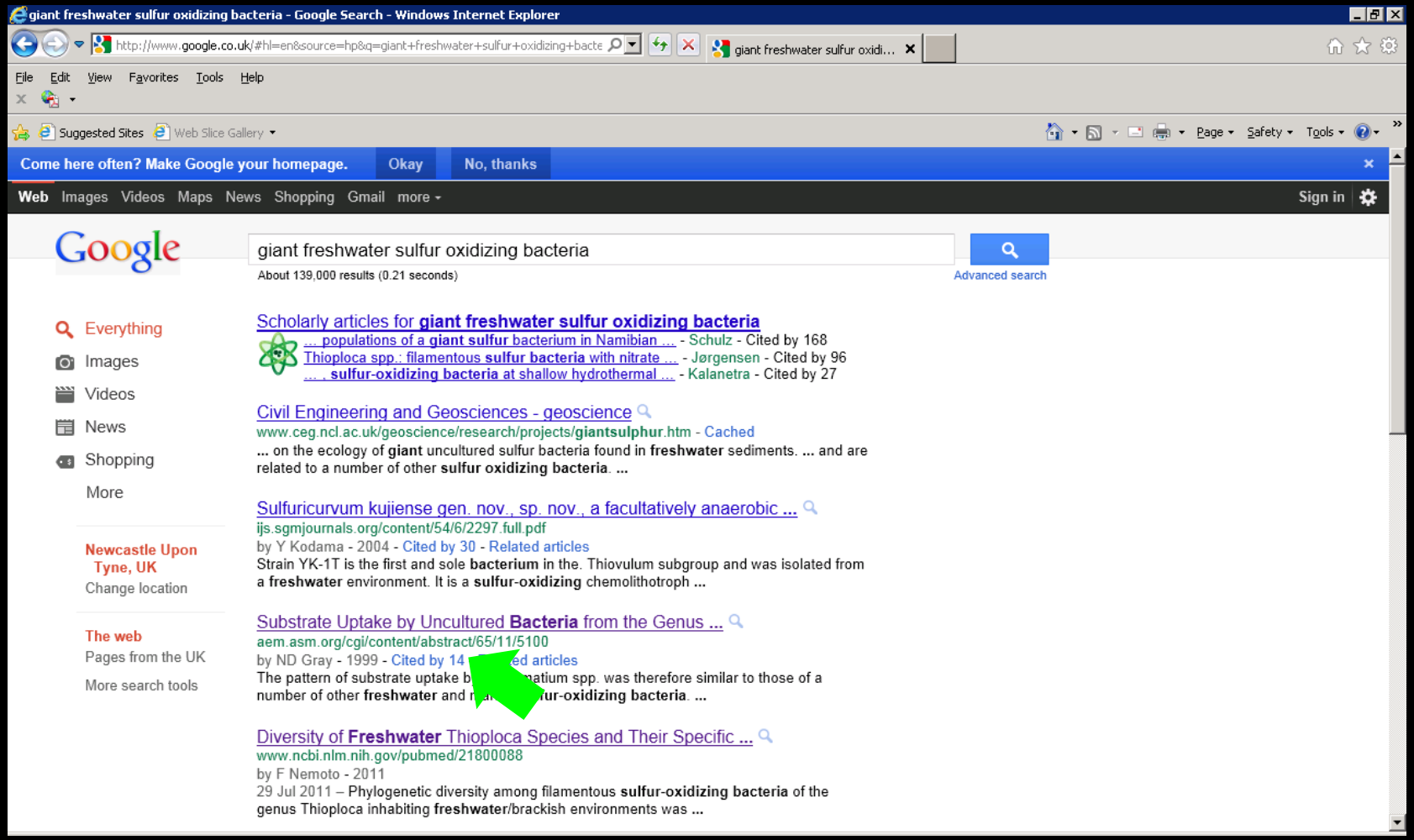

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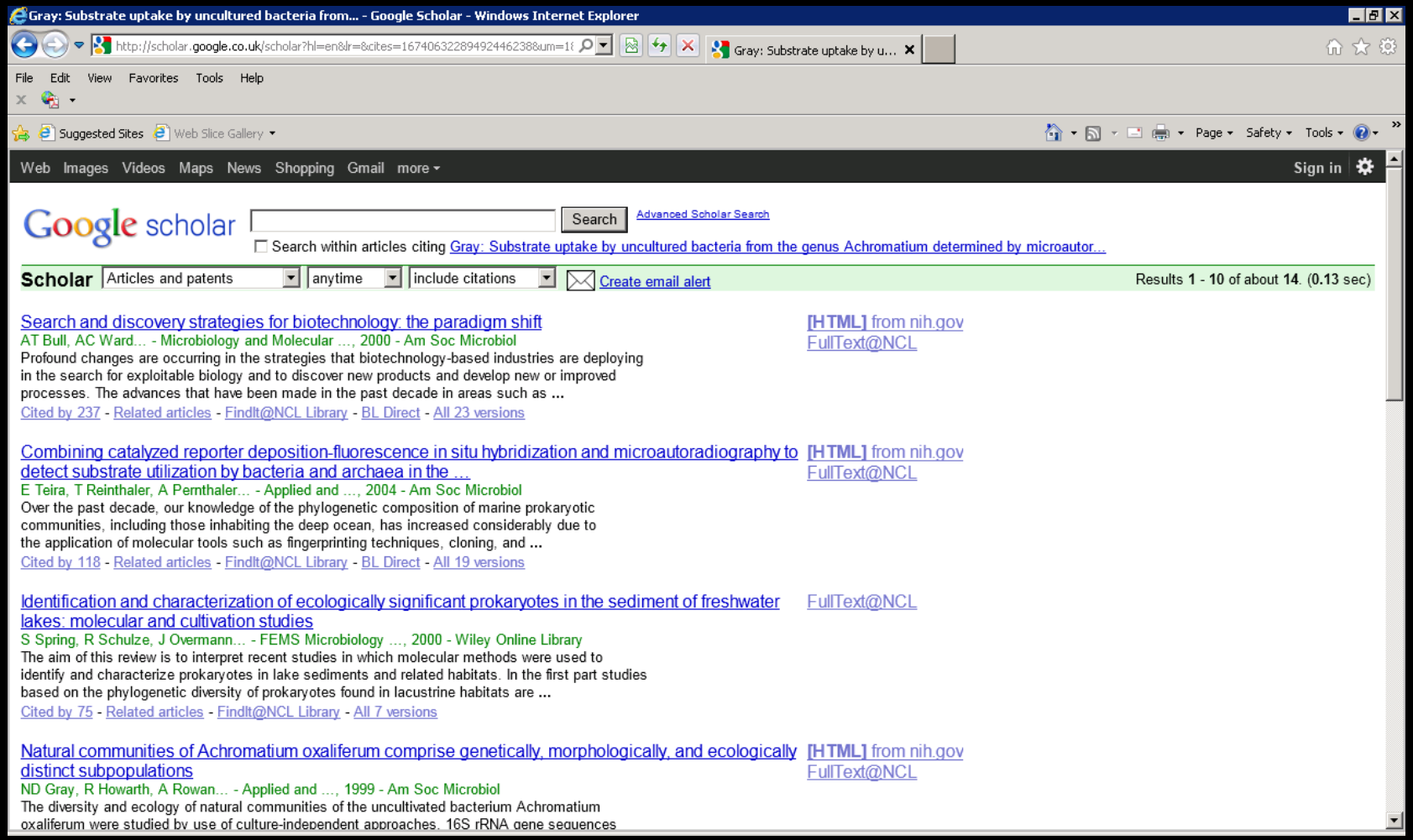

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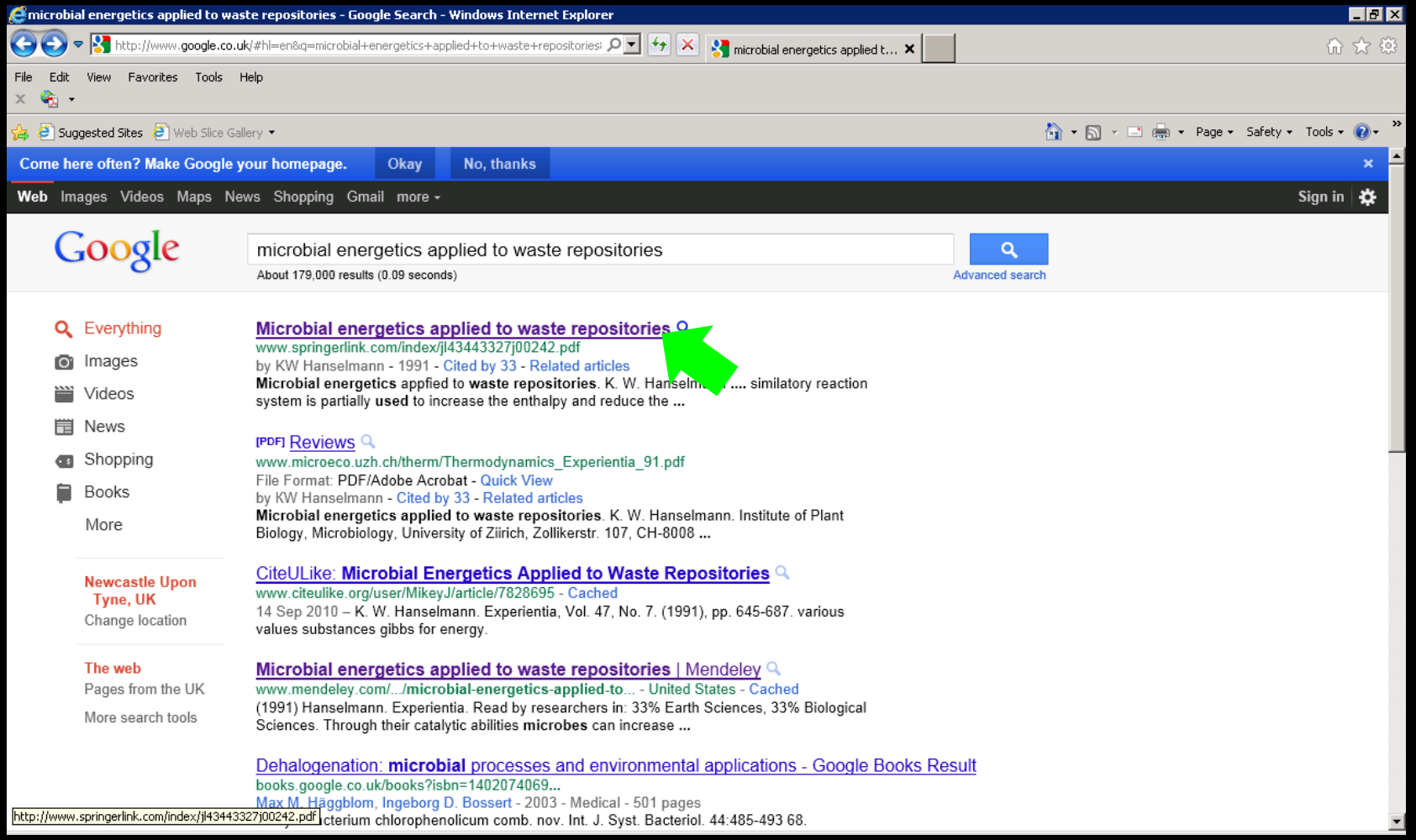

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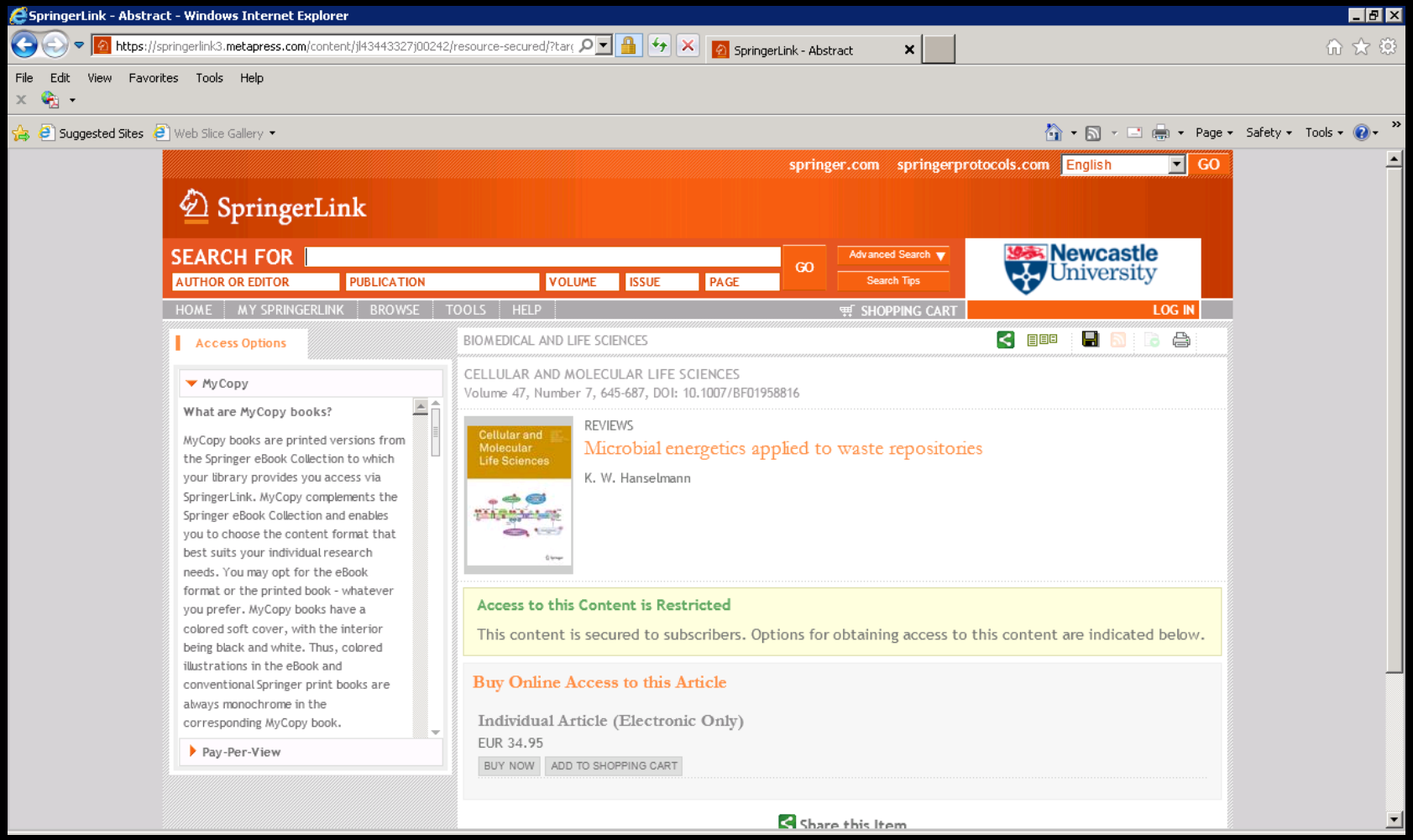

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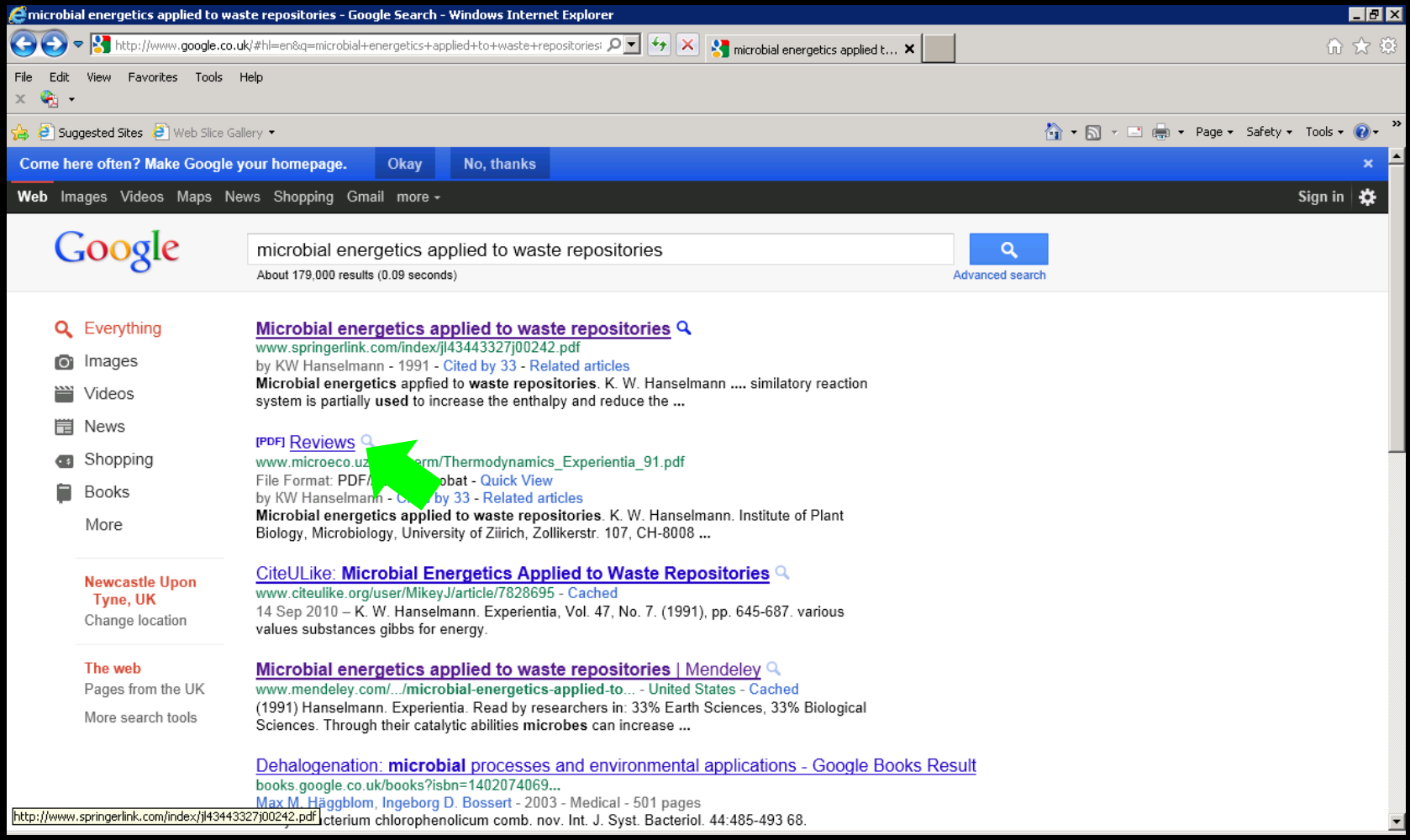

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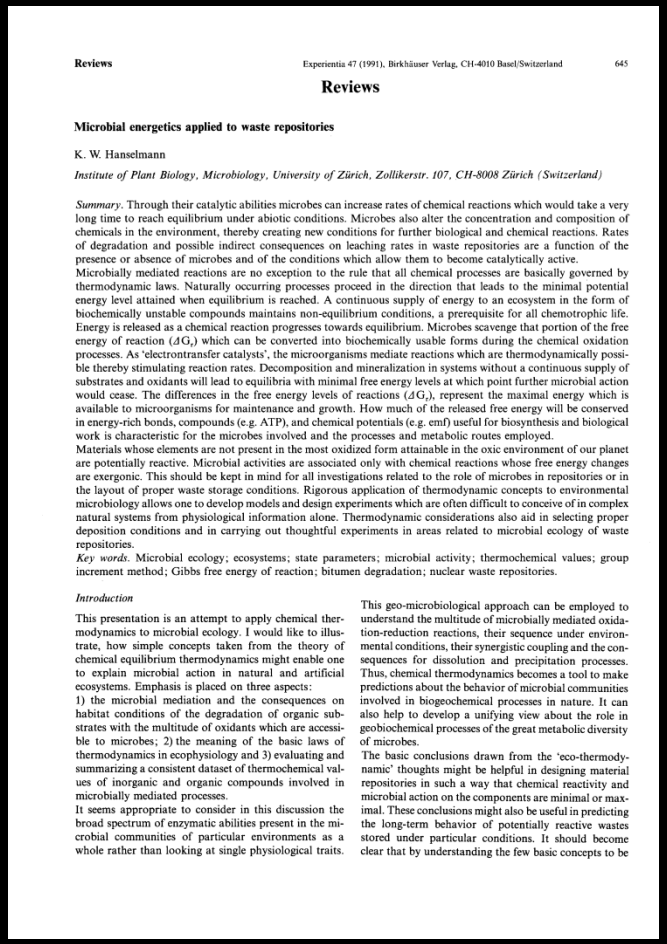


Reviews

Microbial energetics applied to waste repositories

K. W. Hanselmann

Institute of Plant Biology, Microbiology, University of Zürich, Zollikerstr. 107, CH-8008 Zürich (Switzerland)

Summary. Through their catalytic abilities microbes can increase rates of chemical reactions which would take a very long time to reach equilibrium under abiotic conditions. Microbes also alter the concentration and composition of chemicals in the environment, thereby creating new conditions for further biological and chemical reactions. Rates of degradation and possible indirect consequences on leaching rates in waste repositories are a function of the presence or absence of microbes and of the conditions which allow them to become catalytically active.

Microbially mediated reactions are no exception to the rule that all chemical processes are basically governed by thermodynamic laws. Naturally occurring processes proceed in the direction that leads to the minimal potential energy level attained when equilibrium is reached. A continuous supply of energy to an ecosystem in the form of biochemically unstable compounds maintains non-equilibrium conditions, a prerequisite for all chemotrophic life. Energy is released as a chemical reaction progresses towards equilibrium. Microbes scavenge that portion of the free energy of reaction (ΔG_r) which can be converted into biochemically usable forms during the chemical oxidation processes. As 'electrontransfer catalysts', the microorganisms mediate reactions which are thermodynamically possible thereby stimulating reaction rates. Decomposition and mineralization in systems without a continuous supply of substrates and oxidants will lead to equilibria with minimal free energy levels at which point further microbial action would cease. The differences in the free energy levels of reactions (ΔG_r), represent the maximal energy which is available to microorganisms for maintenance and growth. How much of the released free energy will be conserved in energy-rich bonds, compounds (e.g. ATP), and chemical potentials (e.g. emf) useful for biosynthesis and biological work is characteristic for the microbes involved and the processes and metabolic routes employed.

Materials whose elements are not present in the most oxidized form attainable in the oxic environment of our planet are potentially reactive. Microbial activities are associated only with chemical reactions whose free energy changes are exergonic. This should be kept in mind for all investigations related to the role of microbes in repositories or in the layout of proper waste storage conditions. Rigorous application of thermodynamic concepts to environmental microbiology allows one to develop models and design experiments which are often difficult to conceive of in complex natural systems from physiological information alone. Thermodynamic considerations also aid in selecting proper deposition conditions and in carrying out thoughtful experiments in areas related to microbial ecology of waste repositories.

Key words. Microbial ecology; ecosystems; state parameters; microbial activity; thermochemical values; group increment method; Gibbs free energy of reaction; bitumen degradation; nuclear waste repositories.

Introduction

This presentation is an attempt to apply chemical thermodynamics to microbial ecology. I would like to illustrate, how simple concepts taken from the theory of chemical equilibrium thermodynamics might enable one to explain microbial action in natural and artificial ecosystems. Emphasis is placed on three aspects:

1) the microbial mediation and the consequences on habitat conditions of the degradation of organic substrates with the multitude of oxidants which are accessible to microbes; 2) the meaning of the basic laws of thermodynamics in ecophysiology and 3) evaluating and summarizing a consistent dataset of thermochemical values of inorganic and organic compounds involved in microbially mediated processes.

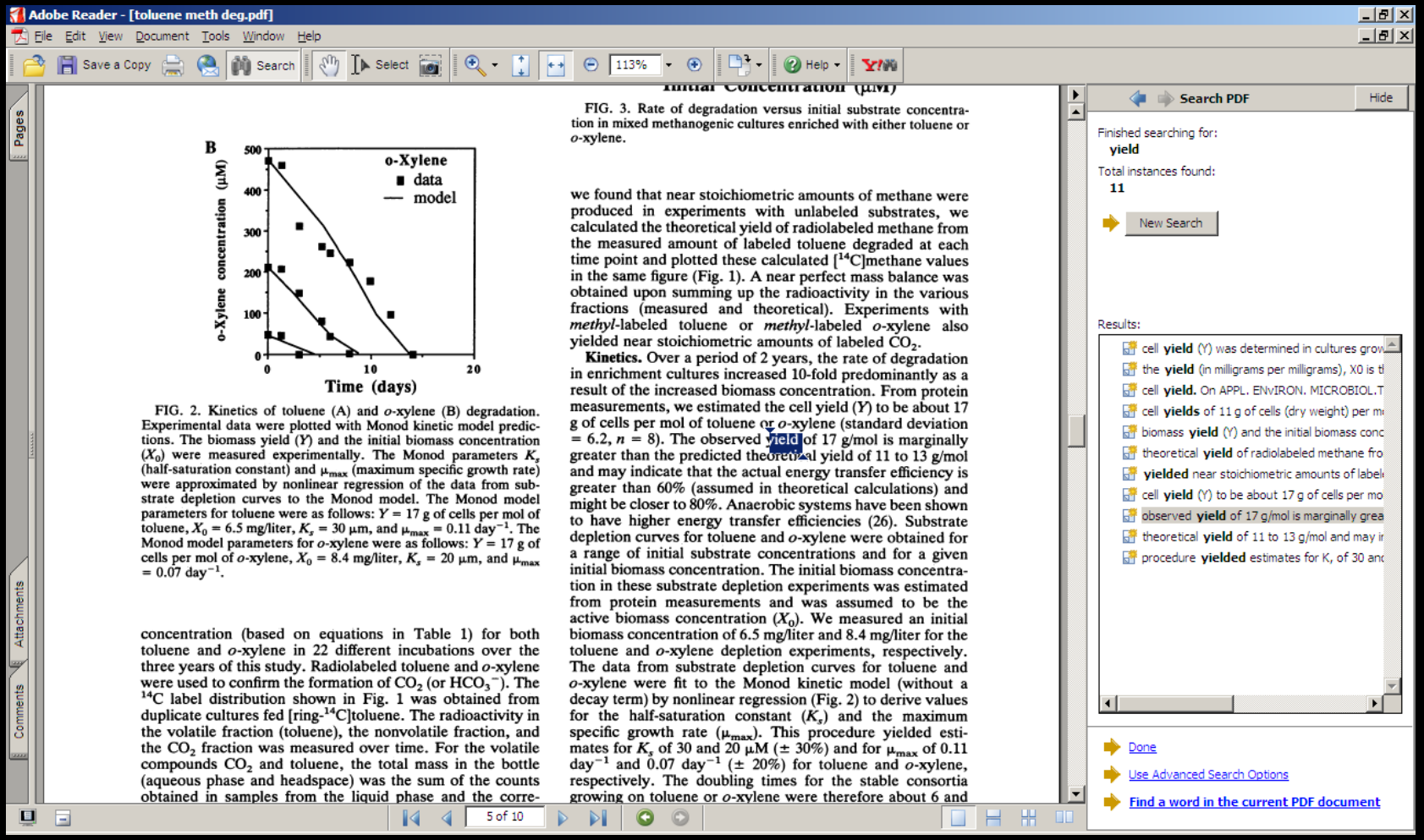
It seems appropriate to consider in this discussion the broad spectrum of enzymatic abilities present in the microbial communities of particular environments as a whole rather than looking at single physiological traits. This geo-microbiological approach can be employed to understand the multitude of microbially mediated oxidation-reduction reactions, their sequence under environmental conditions, their synergistic coupling and the consequences for dissolution and precipitation processes. Thus, chemical thermodynamics becomes a tool to make predictions about the behavior of microbial communities involved in biogeochemical processes in nature. It can also help to develop a unifying view about the role in geobiochemical processes of the great metabolic diversity of microbes.

The basic conclusions drawn from the 'eco-thermodynamic' thoughts might be helpful in designing material repositories in such a way that chemical reactivity and microbial action on the components are minimal or maximal. These conclusions might also be useful in predicting the long-term behavior of potentially reactive wastes stored under particular conditions. It should become clear that by understanding the few basic concepts to be

Downloaded
for free !

PDF searches

- The benefit of PDFs rather than printed copies of a paper is the use the search function



Other reputable Databases

- Respected organisations
  - National / government organisations
    - http://www.environment-agency.gov.uk/
    - http://www.jgi.doe.gov/
    - http://www.usgs.gov/
    - http://www.bgs.ac.uk/
    - And many many more

Sources to use with caution

- http://en.wikipedia.org/wiki/Main_Page
- http://www.bp.com/
- http://www.greenpeace.org.uk/

Sources to avoid

- http://www.creationism.org/
- Blogs and personal sites

Example

- Walker Riverside Park
- Contaminated land
- http://www.ncl.ac.uk/library
- http://wok.mimas.ac.uk
- http://edina.ac.uk/
- http://www.google.co.uk/
- http://www.chroniclelive.co.uk/
- http://www.environment-agency.gov.uk/
- http://www.jgi.doe.gov/ (joint genome institute)
- http://www.usgs.gov/
- http://www.bgs.ac.uk/
- http://www.newcastle.gov.uk/core.nsf/a/home

Tricks to finding data

- Which reference in the area has the most citations?
  - Obviously these citations will probably represent all the subsequent relevant research you should also look at
- Which author has published most work?
- Review papers are very good starting points
  - Especially if recent i.e. past three years
- Vary your search criteria as search engines are very stupid
  - Use different ways of describing the subject and you get surprisingly different but relevant products

Writing a Literature Review

- GETTING STARTED:
  - The usual purpose for a lit review is to identify existing literature on a topic that you plan to explore.
- NARROW YOUR SEARCH:
- ANALYZE YOUR ARTICLES:
  - Are the articles relevant, what are the key points, do the conclusions fit the data. Does it make sense to you
- WRITE IT:
  - Plan the review, don’t simple list the papers.
  - Beginning, middle and end
  - Group articles together
  - Reference everything you have said.

Quote references Correctly

- Innes et al. (1997) investigated the hopanoid signatures of the sediment from a fresh water lake, Priest Pot…..
- The hopanoid signatures of the sediment from a fresh water lake, Priest Pot (Innes et al., 1997)….
- What is the preferred reference style
- Different journals – different styles, be consistent
- Organic Geochemistry style
- Innes, H.E., Bishop, A.N., Head, I.M. Farrimond, P. 1997 Preservation and diagenesis of hopanoids in recent lacustrine sediments of Priest Pot, England. Organic Geochemistry 26, 565-576.

Summary

- Ensure you understand your idea
- Find a good start point
- Use reputable sources of data
- Plan you literature review based on what you have found out
- Get the references right

Carrying out research

Η διεξαγωγή της έρευνας-- Θεμελιώδεις αρχές

Scientific experiments

- Observation / research
- Construct a hypothesis
- Experiment or Laboratory Analysis
- Presentation of results (dissertation, papers…)

Analytical approaches

- The experimental approach you take will be dictated by the research type
- Exploratory research will likely focus on representative sampling and measurement of system properties perhaps compared to a benchmark system. e.g. Contaminated land assessment
- Hypothesis driven research: Once hypothesis (predictions!) are made, they can be sought by analyses with state-of-the-art analytical techniques.

State-of-the-art: the latest and most sophisticated or advanced stage of a technology, art, or science

- If the test results contradict the predictions, the hypotheses which entailed them are called into question and become less tenable. Sometimes the experiments are conducted incorrectly or are not very well designed, when compared to a crucial experiment. If the experimental results confirm the predictions, then the hypotheses are considered more likely to be correct, but might still be wrong and continue to be subject to further testing.

- The experimental control is a technique for dealing with observational error. This technique uses the contrast between multiple samples (or observations) under differing conditions to see what varies or what remains the same. We vary the conditions for each measurement, to help isolate what has changed. will focus on Document the micron-sized spheroid hematite occurrences
- Investigate for organic content with sensitive techniques (ToF-SIMS)
- Identify possible biomarkers:
- morphologic (i.e. fossil microbes, filaments, or biofilm)
- chemical (i.e. organic)
- Attempt to decipher the origin of hematite.
- experiments that make comparisons of replicated altered systems against unaltered

Analytical approaches

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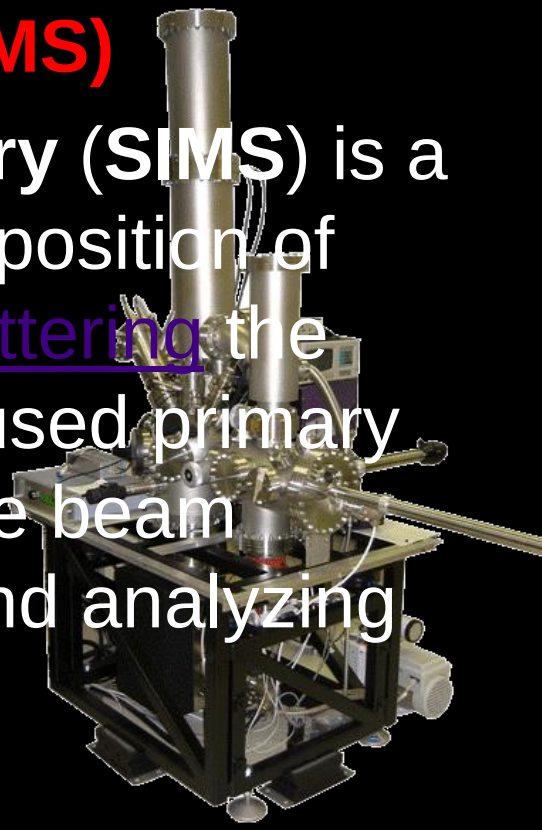
Materials & Methods

Time of Flight –Secondary Ion Mass Spectrometry (ToF-SIMS)

- **Secondary ion mass spectrometry** (**SIMS**) is a technique used to analyze the composition of solid surfaces and thin films by sputtering the surface of the specimen with a focused primary ion beam (a type of charged particle beam consisting of ions) and collecting and analyzing ejected secondary ions.



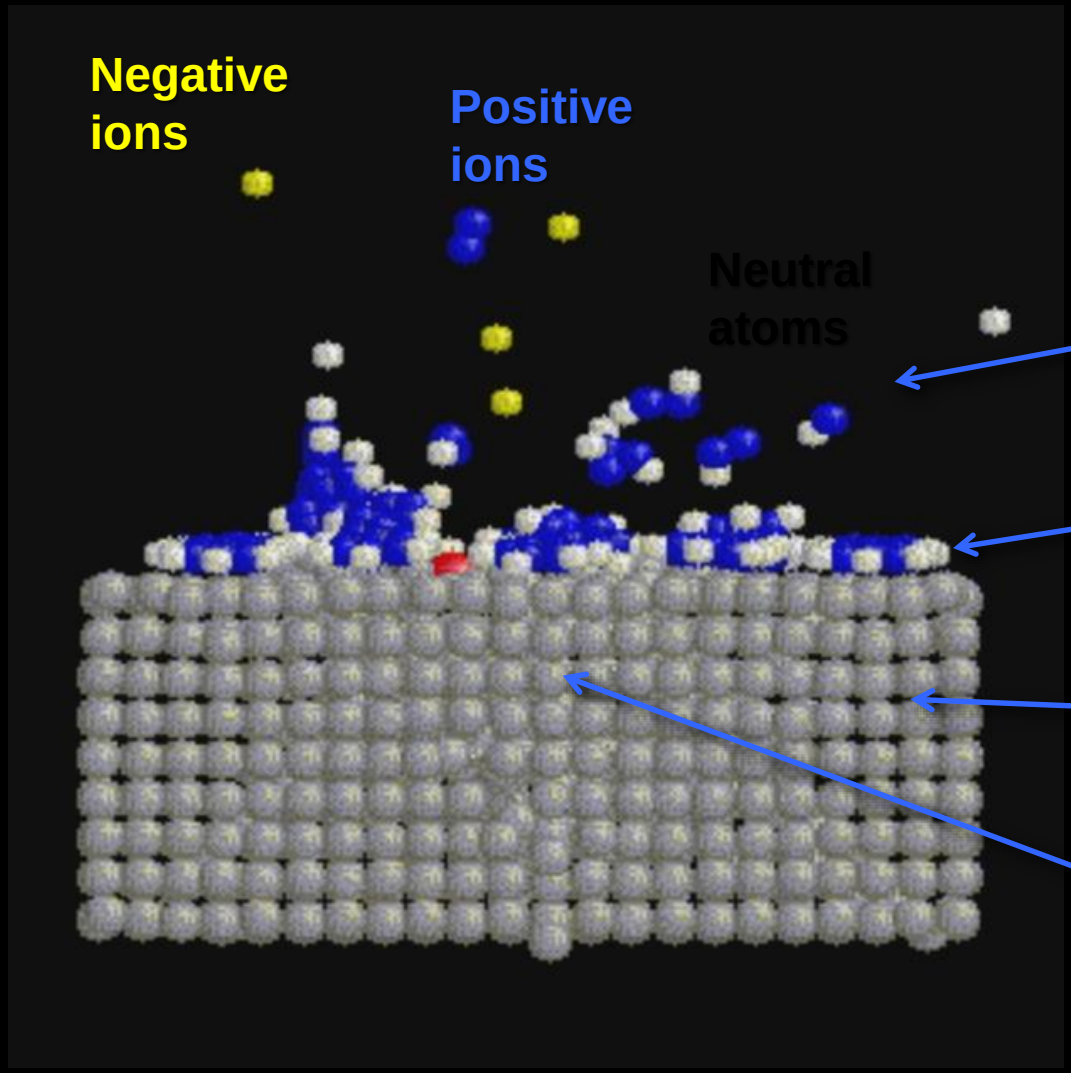
What is Time-of-Flight Secondary Ion Mass Spectrometry (ToF-SIMS)

- Time-of-Flight Secondary Ion Mass Spectrometry (ToF-SIMS) is a surface-sensitive analytical method that uses a pulsed ion beam (Cs or microfocused Ga) to remove molecules from the very outermost surface of the sample. The particles are removed from atomic monolayers on the surface (secondary ions). These particles are then accelerated into a "flight tube" and their mass is determined by measuring the exact time at which they reach the detector (i.e. time-of-flight). Three operational modes are available using ToF-SIMS: surface spectroscopy, surface imaging and depth profiling.

- Analytical capabilities of ToF-SIMS include:

- Mass resolution of 0.00x amu. Particles particles with the same nominal mass (e.g. Si and C2H4, both with amu = 28) are easily distinguished from one another because as Mr. Einstein predicted there is a slight mass shift as atoms enter a bound state.
- Mass range of 0-10,000 amu; ions (positive or negative), isotopes, and molecular compounds (including polymers, organic compounds, and up to ~amino acids) can be detected.
- Trace element detection limits in the ppm range.
- Sub-micron imaging to map any mass number of interest.
- Depth profiling capabilities; sequential sputtering of surfaces allow analysis of the chemical stratigraphy on material surfaces (typical sputtering rates are ~100 A/minute).
-

A few words on the ToF-SIMS analytical technique



ToF-SIMS instrument used in this work

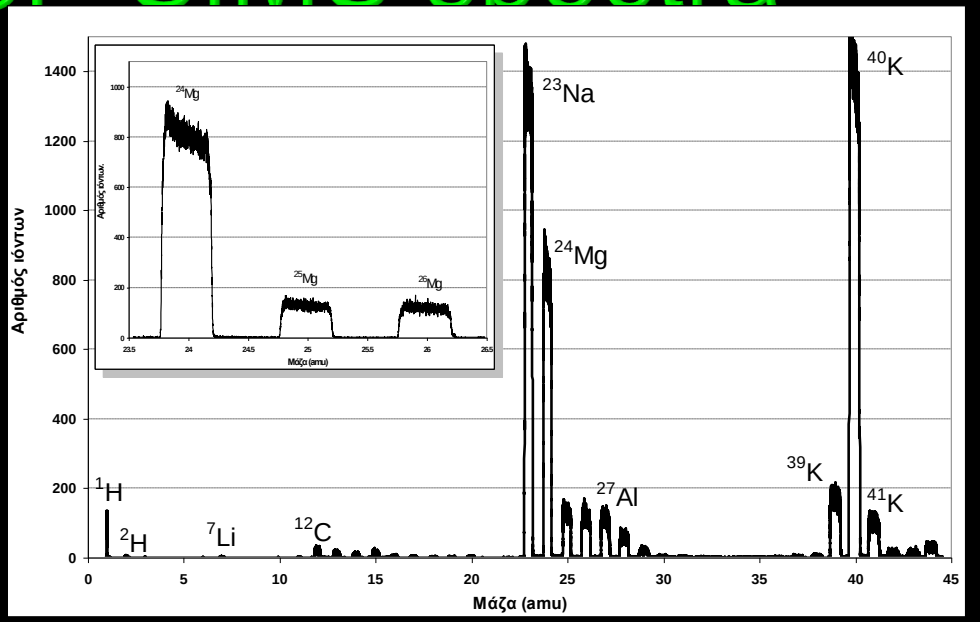
IDLE 1

IDLE 2

University of Manchester – School of Earth, Atmospheric and Environmental Sciences
Group of Isotope Geology

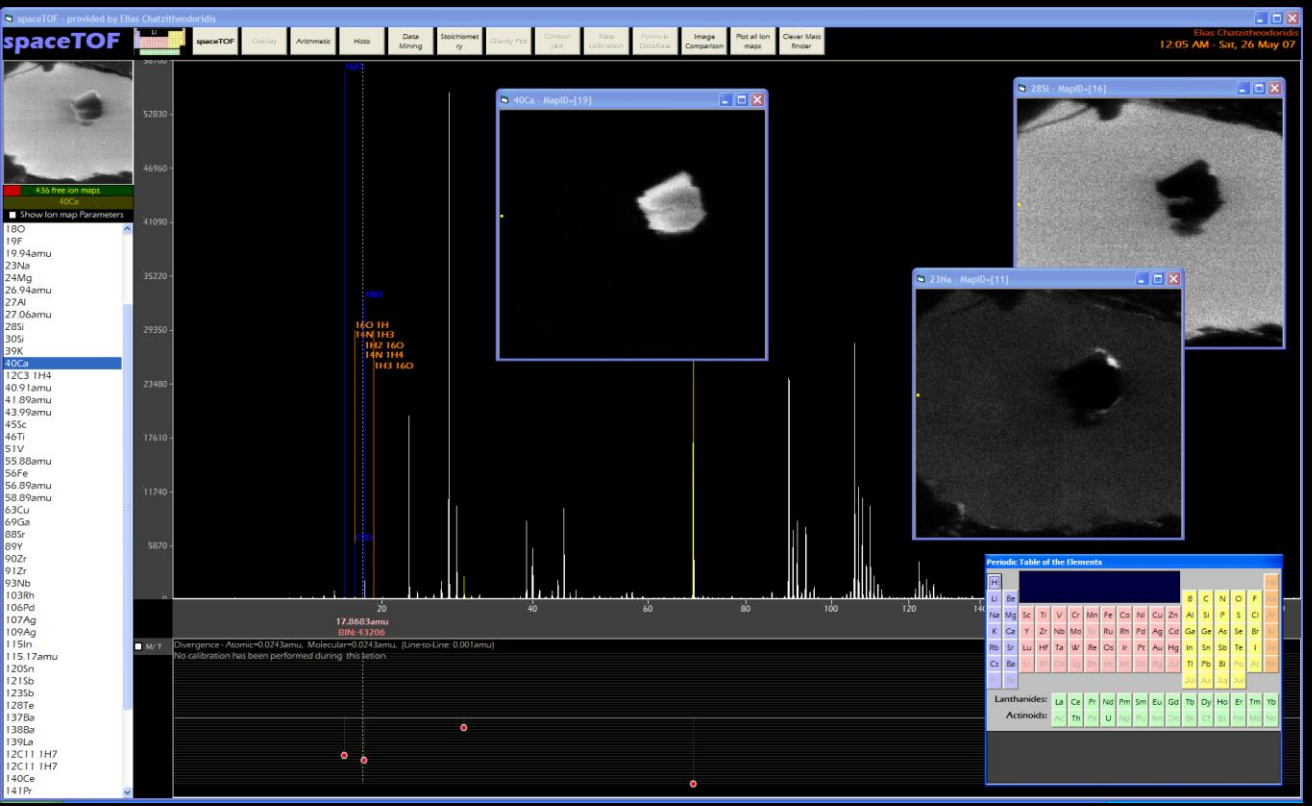
Examples of ToF-SIMS spectra

Magnification of a mass spectrum in the range of 1-45amu and on the Mg isotopes (inset)

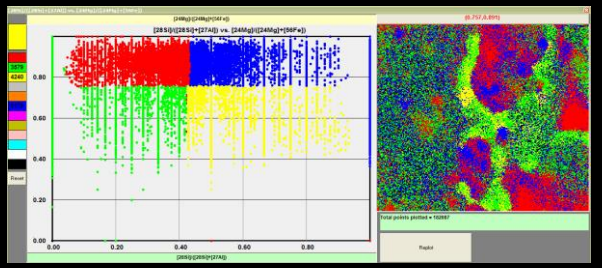


Total ion mass spectrum from a sample containing organic components

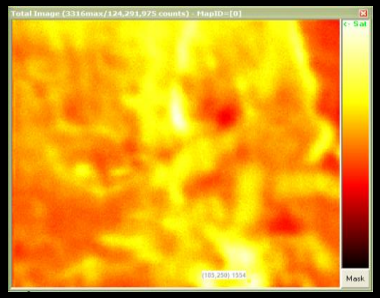
The "*spaceTOF*" software



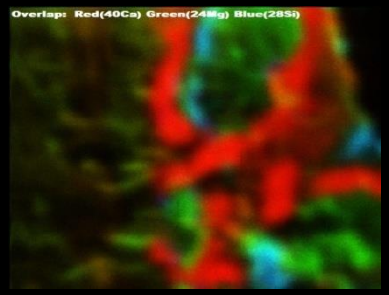
- **Interactive environment**
- **Database assisted interpretation**
- **Ion signatures patterns**
- **Image calculations**



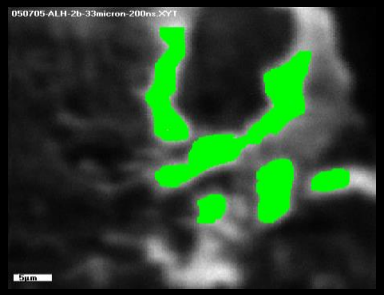
Data mining



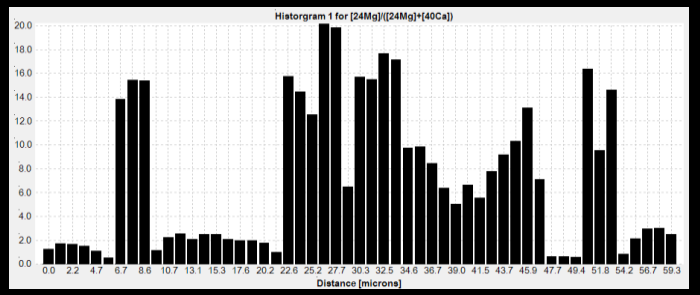
Ion mapping



Map overlaps



Masking



Profiling

What are you going to measure?

- Most important things that you need to do in planning an experiment are:
  - Find out which staff or technicians can help you
  - Work out how long it will take to complete an assay
  - Who else might want to use the machine
  - Therefore is the number of analyses planned realistic
  - Start in time to be able to carryout all work twice

Carrying out Research

- All research is time limited (i.e. 3 years or 3 months depending).
- Make sure that the work you intend to do can fit in to the available time
- Write a realistic plan with (if possible) key objectives along the way
- Make sure you know when your plan is going wrong and correct.
- BE IN CONTROL

Carrying out Research

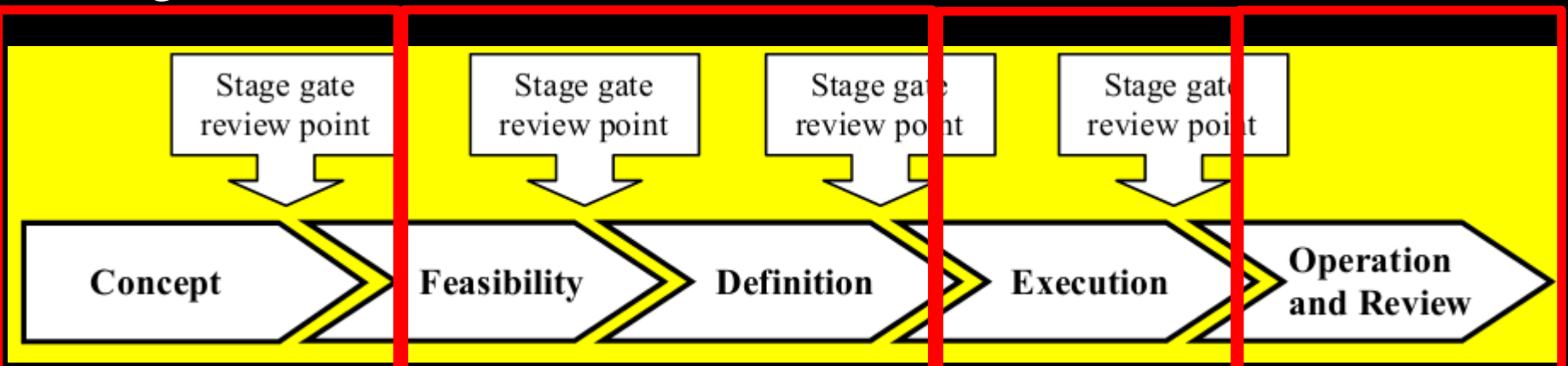
- Research rarely proceeds smoothly
  - Machines break down, samples don't arrive…..
- The trick is to be organised so that
  - You have time to cope with the problems
  - You have fully assessed risks and have backup ideas and plans

'They planned their campaigns just as you might make a splendid piece of harness. It looks very well; and answers very well; until it gets broken; and then you are done for. Now I made my campaigns of ropes. If anything went wrong, I tied a knot; and went on'.
Sir Arthur Wellesley

Project planning

'All projects have a project life cycle ' WG Morris "Science, objective knowledge, and the theory of project management"

The masters projects are just the same with stage gates throughout



Academics* will provide project ideas/questions just before Christmas which are chosen/allocated

Students complete project inception report by April 2014 and make short 15 minute presentation on research objectives and plan.

Projects start in May with thesis completion by mid August

Thesis assessment and presentation of findings in short talk

*ideas for projects are welcome from students

Project inception report

- The PIR is essentially a document that should facilitate the MSc/Diploma dissertation and is developed in consultation with the project supervisor. The primary purpose of the PIR is to:
  - Prevent delays in thinking about the specification, development, planning, and undertaking of the research involved in the project, and the writing-up of the project into a dissertation of an acceptable standard;
  - Allow time to develop the skills to undertake the project and to ensure that necessary resources (e.g. computational and/or experimental, consumables, etc.) are in place.
  - Allow any required equipment to be manufactured in time for the start of the project.
  - Allows laboratory space and technician support to be allocated and planned (e.g. a laboratory schedule) efficiently.

Εισαγωγή στη "Εναρκτήρια Έκθεση" (Project Inception Report)

Καθοδηγητικά βήματα για την παραγωγή της "Εναρκτήριας Έκθεσης"

Project inception report structure

- Supervisor:
- Student:
- Project title:
- Introduction:
- Aim:
- Objectives and hypotheses:
- Scope:
- Initial Literature Review
- Proposed Methods
- Skills requirements
- Resource requirements
- Programme of work
- Anticipated outcomes
- Risk Assessment
- Project risk assessment

Scope

- what will and will not be investigated.
- The project must be manageable, not too ambitious nor trivial.
- Since the aims and objectives indicate largely what will be covered, the importance of scope is to give bounds to the project and why certain aspects have **not** been investigated.
- Restrictions might be based on time for one sample set, access to samples, experimental design focus on a specific question

Methods -samples?

- Where from? Field location, archive…..
- What type? e.g. cores, water samples….
- When taken
- How many samples and their relationship?
  - Sample replication/spatial distribution (based on objectives and strategy)
- How samples will be or, were, removed
  - Sample handling (contamination)
  - Sample storage (cold room for live experiments, freezer for physico- chemical analysis)

Methods –experimental setup

- What will be the structure of your experiment or, field survey be
  - Different Treatments, locations and sampling times
  - Replication
  - Controls
- or, what is the structure of previously obtained data sets
- what will or was the ‘conditions’ and type and frequency of sub-sampling

Methods- measurements ?

- What and how are you going to measure
- e.g. Fe speciation, bulk chemistry of major, minor, trace and RE elements, stable isotopes $\delta^{13}C$ δD, $\delta^{18}O$, $\delta\ ^{34}S$, $\delta^{30}Si$..
- What method are you going to use LA-ICP-MS, EMPA, Synchrotron, ToF-SIMS
- What equipment do you need?
  - Do you need to build or buy anything?

Methods- data analysis ?

- Raw data will need some form of processing
  - How will you present and assess the accuracy and significance of your findings
    - Need to think about this before not after project e.g. data manipulation software, statistical tests and likely graph types
    - Follow lectures on data analysis (statistics) and presentation

Skills requirements?

- Hopefully many of the techniques and approaches required will be acquired during the course
  - What sampling and experimental skills do you need to learn to sample? (trench/chanel sampling, chip sampling, …..)
  - What analytical skills do you need to learn?
  - What computational and data analysis skills do you need to learn

Resource requirements?

- Staff support –who are key people
  - Academics, researchers, technicians, industry contacts

Analytically equipment and its availability	Other support equipment
GC	Sampling equipment
GCMS	Storage facilities (if unusual)
HPLC-MS	Glassware
ICP	Ovens
IC	Transport
Microbiological	Reagents
Titration techniques	standards
AA	
Porosimetry	
software	

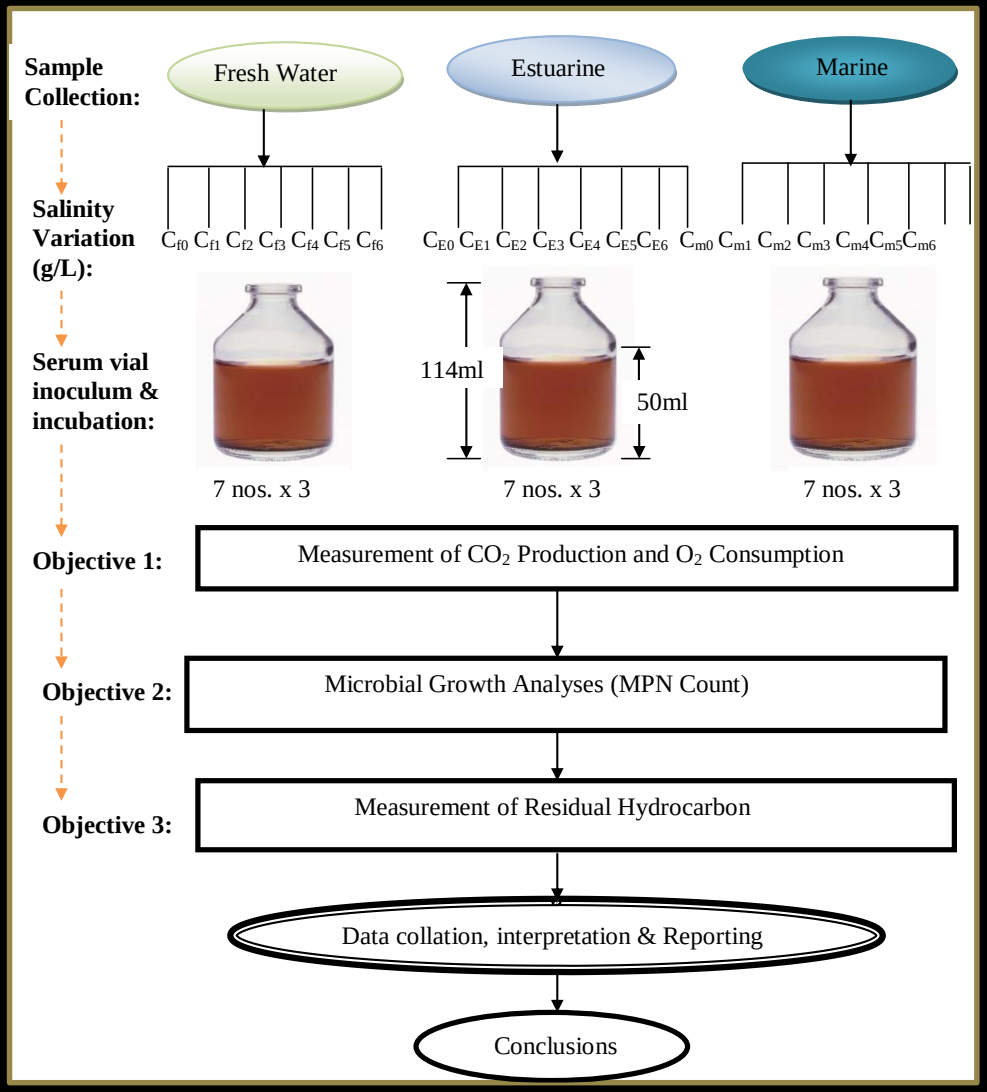
Work programme

- In what order should things happen in the project- Usually a logical flow to a research programme
  - Sampling (if necessary) or obtaining data
  - Analytical Method development (if necessary)
  - Experimental setup (if appropriate for project)
  - Analytical work (if appropriate for project)
  - Data analysis, representation, interpretation
  - Thesis writing
  - New research questions for next year from results

Work programme

- It is fundamental to good research that you have a plan.
- The plan links all the steps together.
- In some cases your plan will be wrong. The trick is to know when your plan goes wrong and compensate
- It is a bad plan that can not be changed
  - Publilius Syrus (1st centaury AD)

Work programme diagram



Timetable

For an MSc project there is a deadline – end of year 2.

- This is fixed, although in certain circumstances it can be moved
  - Illness
  - Problems that are out of your control
- The more in control you are the sooner you will know if you can hit your deadline.
- The earlier you tell us the more we can help you to make the deadline or get the extension.
- Extensions are bad as they are expensive and delay your career

Timetable

- producing a timetable ?
- Step 1 – how long will the different work programme components take to do
- Step 2 – cumulatively do these fit in with the allowed time
- Step 3 – if yes construct final timetable
- If no revise work programme and go back to step 1

Timetable

- Time table milestones - a **milestone** is the end of a stage that marks the completion of a work package or phase – a time for review and reflection
- Examples
  - Agreeing plan with supervisor
  - Obtaining samples
  - Completing experiments on samples
  - Submitting a chapter for review by supervisor
  - The timetable should include milestones and highlight likely bottlenecks.

Plans

- Gantt Charts (http://www.ganttproject.biz/)
  - A gantt chart is a bar chart that shows project schedule

									WEEK										
Project step		42	43	44	45	46	47	48	49	50	51	52	1	2	3	4	5	6	7
meet with supervisor to discuss plan																			
sample collection																			
sample storage																			
sample analysis																			
	extraction																		
	treatment																		
	analysis																		
analysis of results																			
meeting with supervisor																			
literature review																			
give lit review to supervisor for assessment																			
begin witing chapters																			
	method																		
	results																		
	discussion																		
	proof reading																		
hand in																			

Risk to human health

- Outline the key risks associated with conducting the work and the necessary precautions.
- Produce risk assessments for laboratory and field/site work. Produce COSSH forms for any hazardous substance to be used.
  - site specific sampling dangers (i.e. rivers in Africa have dangers not typical of the Tyne e.g. Crocodiles, hippos, buffalo….)
  - sample dangers
    - Inoculation to prevent disease
  - Reagents
    - Explosive, corrosive, toxic risks

Project risk

- Identify the risks that affect the management and completion of the project, giving possible solutions to avoid such risks e.g.
  - Difficulty getting samples (alternative sources)
  - Difficulty with access to equipment (prompt start to project, use of booking forms, cooperation)

Efficient execution of project plan

- Do pre-project equipment and consumables inventories
- Have an awareness (and use) of equipment booking sheets (talk to technicians)
- Get specialist software training early
- Where appropriate for experimental studies carry out data monitoring and rapid analysis to assess experimental progression
- Link project milestones\decision gates to supervisor meetings

Effective management of experiment and analyses

- Use of work programme developed in PIR to inform project progression
- Use of linked excel spread sheets to document and track systematically labelled samples, experiments, datasets, analyses
- Use of excel to carryout basic data summarization i.e. averages, errors calculation
- Use excel to provide basic graphical representations of the data and the data error
- Use excel to manipulate data for export to other data analyses packages

Effective management of experiments and analyses

Details of samples taken

Details of experimental microcosms to be setup

Details of analysis to be carried out on some microcosm samples

FLUXOGRAM

River Tyne
↓
Triplicate cores
↓
Sufate analysis
↓
2 depths chosen

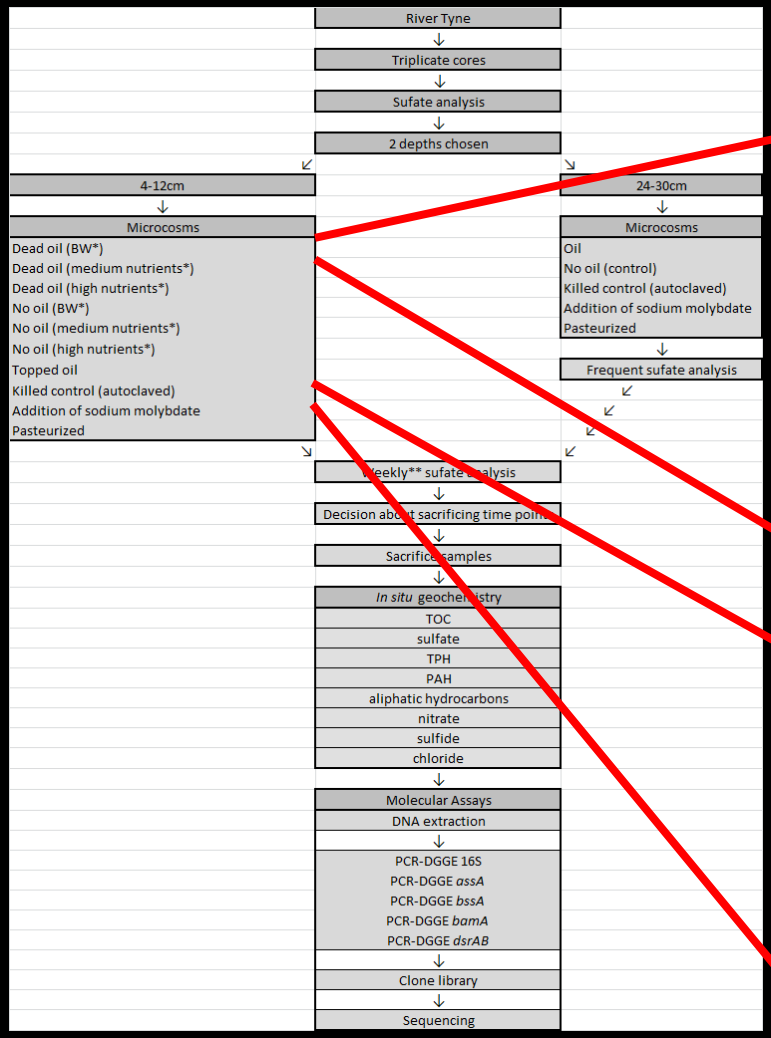
4-12cm	24-30cm
↓	↓
Microcosms	Microcosms
Dead oil (BW*)	Oil
Dead oil (medium nutrients*)	No oil (control)
Dead oil (high nutrients*)	Killed control (autoclaved)
No oil (BW*)	Addition of sodium molybdate
No oil (medium nutrients*)	Pasteurized
No oil (high nutrients*)	↓
Topped oil	Frequent sufate analysis
Killed control (autoclaved)	↙
Addition of sodium molybdate	↙
Pasteurized	↙
↘	↙

Weekly** sufate analysis
↓
Decision about sacrificing time points
↓
Sacrifice samples
↓
In situ geochemistry
TOC
sulfate
TPH
PAH
aliphatic hydrocarbons
nitrate
sulfide
chloride
↓
Molecular Assays
DNA extraction
↓
PCR-DGGE 16S
PCR-DGGE *assA*
PCR-DGGE *bssA*
PCR-DGGE *bamA*
PCR-DGGE *dsrAB*
↓
Clone library
↓
Sequencing

* We want to know if nutrient concentration can interfere in oil degradation.

** We will do frequent analyses for some of the samples, not for everyone. Analyses will be done at each 10 days aproximately.

KEYS	
1	Core 1
4	Core 4
5	Core 5
BW	medium prepared as Bak &Widdel
MN	medium nutrients medium
HN	high nutrients medium
TOC	Total Organic Compound
TPH	Total Petroleum Hydrocarbons
PAH	Polycyclic Aromatic Hydrocarbons
PCR	Polimerase Chain Reaction
DGGE	Denaturing Gradient Gel Electrophoresis
16S	16S rRNA
assA	Alkylsuccinate synthase gene
bssA	Benzylsuccinate synthase gene
bamA	6-OCH-CoA Hydrolase gene
dsrAB	dissimilatory (bi)sulfite reductase gene



4-12cm/dead oil/ BW/RT

Bottle	Depth	Oil condition	Nutrients	Temperature	Time zero	Sacrificed
1	4-12cm	dead oil	BW	RT	31/08/2010	17/08/2011
2	4-12cm	dead oil	BW	RT	31/08/2010	17/08/2011
3	4-12cm	dead oil	BW	RT	31/08/2010	17/08/2011
46	4-12cm	dead oil	BW	RT	01/09/2010	20/04/2011
47	4-12cm	dead oil	BW	RT	01/09/2010	20/04/2011
48	4-12cm	dead oil	BW	RT	01/09/2010	20/04/2011
91	4-12cm	dead oil	BW	RT	03/09/2010	11/02/2011
92	4-12cm	dead oil	BW	RT	03/09/2010	11/02/2011
93	4-12cm	dead oil	BW	RT	03/09/2010	11/02/2011
136	4-12cm	dead oil	BW	RT	07/09/2010	21/12/2010
137	4-12cm	dead oil	BW	RT	07/09/2010	21/12/2010
138	4-12cm	dead oil	BW	RT	07/09/2010	21/12/2010
181	4-12cm	dead oil	BW	RT	14/09/2010	08/11/2010
182	4-12cm	dead oil	BW	RT	14/09/2010	08/11/2010
183	4-12cm	dead oil	BW	RT	14/09/2010	08/11/2010
226	4-12cm	dead oil	BW	RT	16/09/2010	17/09/2010
227	4-12cm	dead oil	BW	RT	16/09/2010	17/09/2010
228	4-12cm	dead oil	BW	RT	16/09/2010	17/09/2010

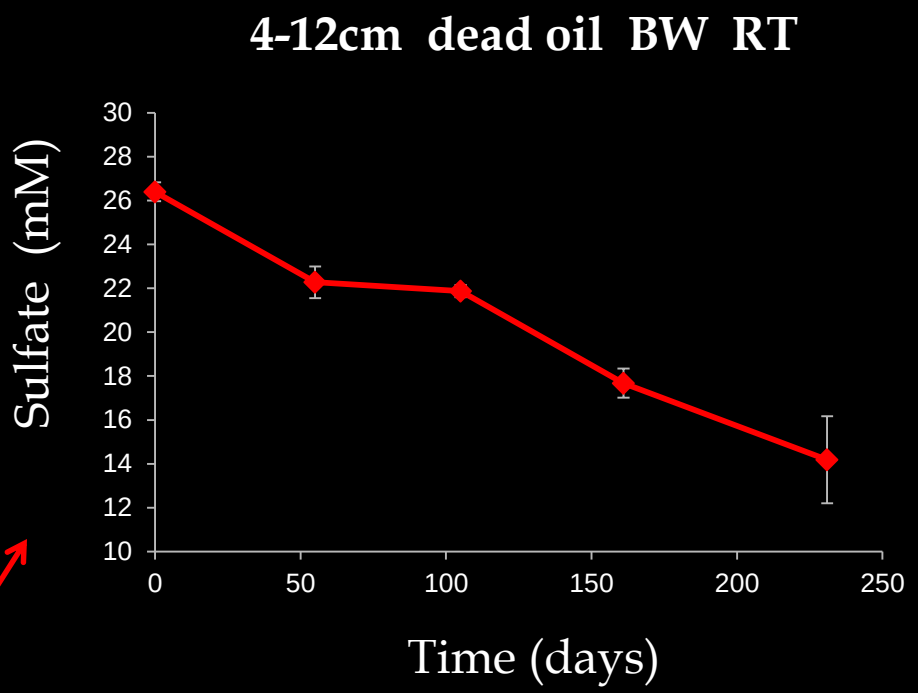
4-12cm/dead oil/ BW/killed

Bottle	Depth	Oil condition	Nutrients	Temperature	Time zero	Sacrificed
23	4-12cm	dead oil	BW	Killed	06/09/2010	17/08/2011
24	4-12cm	dead oil	BW	Killed	06/09/2010	17/08/2011
67	4-12cm	dead oil	BW	Killed	07/09/2010	17/08/2011
68	4-12cm	dead oil	BW	Killed	07/09/2010	20/04/2011
69	4-12cm	dead oil	BW	Killed	07/09/2010	20/04/2011
22	4-12cm	dead oil	BW	Killed	09/09/2010	20/04/2011
113	4-12cm	dead oil	BW	Killed	09/09/2010	11/02/2011
114	4-12cm	dead oil	BW	Killed	09/09/2010	11/02/2011
112	4-12cm	dead oil	BW	Killed	14/09/2010	11/02/2011
157	4-12cm	dead oil	BW	Killed	14/09/2010	21/12/2010
158	4-12cm	dead oil	BW	Killed	14/09/2010	21/12/2010
159	4-12cm	dead oil	BW	Killed	14/09/2010	21/12/2010
202	4-12cm	dead oil	BW	Killed	17/09/2010	08/11/2010
203	4-12cm	dead oil	BW	Killed	17/09/2010	08/11/2010
204	4-12cm	dead oil	BW	Killed	17/09/2010	08/11/2010

4-12cm/dead oil/ BW/RT

Bottle	Depth	Oil condition	Nutrients	Temperature	Time zero	Sacrificed	days	sulfate mM
1	4-12cm	dead oil	BW	RT	31/08/2010	17/08/2011	351	
2	4-12cm	dead oil	BW	RT	31/08/2010	17/08/2011	351	
3	4-12cm	dead oil	BW	RT	31/08/2010	17/08/2011	351	
46	4-12cm	dead oil	BW	RT	01/09/2010	20/04/2011	231	17.91
47	4-12cm	dead oil	BW	RT	01/09/2010	20/04/2011	231	13.52
48	4-12cm	dead oil	BW	RT	01/09/2010	20/04/2011	231	11.12
91	4-12cm	dead oil	BW	RT	03/09/2010	11/02/2011	161	17.45
92	4-12cm	dead oil	BW	RT	03/09/2010	11/02/2011	161	16.65
93	4-12cm	dead oil	BW	RT	03/09/2010	11/02/2011	161	18.94
136	4-12cm	dead oil	BW	RT	07/09/2010	21/12/2010	105	21.91
137	4-12cm	dead oil	BW	RT	07/09/2010	21/12/2010	105	22.34
138	4-12cm	dead oil	BW	RT	07/09/2010	21/12/2010	105	21.37
181	4-12cm	dead oil	BW	RT	14/09/2010	08/11/2010	55	20.84
182	4-12cm	dead oil	BW	RT	14/09/2010	08/11/2010	55	22.92
183	4-12cm	dead oil	BW	RT	14/09/2010	08/11/2010	55	23.07
226	4-12cm	dead oil	BW	RT	16/09/2010	17/09/2010	0	25.81
227	4-12cm	dead oil	BW	RT	16/09/2010	17/09/2010	0	27.24
228	4-12cm	dead oil	BW	RT	16/09/2010	17/09/2010	0	26.15

SACRIFICED SAMPLES	SACRIFICING TIME POINT				
	0	55	105	161	231
4-12cm dead oil BW RT	25.81	20.84	21.91	17.45	17.91
4-12cm dead oil BW RT	27.24	22.92	22.34	16.65	13.52
4-12cm dead oil BW RT	26.15	23.07	21.37	18.94	11.12
average	26.40	22.28	21.87	17.68	14.18
std error	0.43	0.72	0.28	0.67	1.99



Leave time to write up

- Finish the data acquisition/analysis stage early enough to allow ample time to write your thesis- it takes time to do your findings justice
- Negotiate with supervisors about their input i.e. chapter read through.
- Start writing some chapters e.g. methods and literature review before end of laboratory work