Reports from the RSC Secondary & Further Education Group – 5th National Conference for Chemistry Teachers & Educators

Inspiring the Next Generation of Chemists

1. Report on exhibitors – DP
2. Report on Holly Carter – Apprentice of the Year JF
3. Report on Breakout Session– Lakshmi Hughes, RSC Careers – 'How to use RSC career resources to deliver Gatsby Career benchmarks.' JF
4. Report on breakout session – Space Chemistry TB
5. General Report by SW

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1. Report on exhibitors – David Paterson

A range of exhibitors attended the conference with interesting resources for teachers and educators to peruse and discuss with the company representatives.

- DataHarvest had a set of their latest hardware, including pH and temperature probes. Of particular interest was the backwards compatibility of some of the modern BlueTooth sensors with previous generations of the data recording hardware.
- The Association of Science Education has a range of books to peruse, including the Teaching Secondary Science series and Language of Measurements, and a Field Officer was on hand to discuss the benefits of joining the organisation.
- Grundon, a waste collection company, had the most interesting freebie as a pen holder in the shape of an oil barrel! The representative discussed the range of collection services offered, including that of chemical and radioactive waste.
- Better Equipped were present with a range of apparatus available from their catalogue, including differently shaped plastic delivery tubes, balances, glassware and data loggers.
- YPO had a very interesting range of scientific toys and games to increase the learning and discovery in the classroom, including Knex STEM kits and Educational Advantage's Food Chains Game.
- TIMStar had a wide range of equipment to looks at and discuss, including datalogging hardware, and a modern oscilloscope that is significantly simpler and easier for teachers and students to use.
- Philip Harris had a wide range of equipment available to investigate and try out, including an interested method for calculating the gravitational field strength based on a falling magnet through coils of wire.

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2. Report on Holly Carter – Apprentice of the Year John Firnham

A comprehensive talk about her education, work experience background and the advantages her more vocational approach had given her.

She studied the academic route to GCE A levels. Chemistry was her favourite subject and she wanted to help people in the medical field. During her GCE A levels she managed to get a work placement at Astra –Zeneca, decided to take a more vocational approach instead of going to university and managed to secure an apprenticeship at Astra-Zeneca in 2016. She continued to study at Manchester Metropolitan on a chemical sciences degree course and her fees were paid for through her apprenticeship scheme.

Her job involves catalysis and flow reactions, researching solubility in organic solvents and she is currently working to enable AI robots to carry out the experiments.

She is a STEM ambassador, spoken to MPs about her experience and gives talks around the country.

Holly Carter – My Journey from School to Award Winning Apprentice of the Year 2018

Introductory session

For those who are not so familiar with the apprenticeship route to a degree and a career in the chemical sciences, Holly Carter gave an inspiring talk on her journey from school to work at Astra Zeneca gaining 'Apprentice of the Year 2018' along the way. What sparked her interest in chemistry? In her younger years' influences included a chemistry set, a site visit and work experience at Astro Zeneca. She always enjoyed the practical aspects so an apprenticeship was ideal and gave her the opportunity to achieve a degree in 5 years whilst also getting valuable work experience. She discussed the advantages over the traditional university route in that she could achieve a degree whilst being paid and without incurring the student debt. As well as the in-company training, some work is by distance learning but she also attends university for live lectures, seminars and practical lab. experience with apprentices from other companies. Additionally, she has valued the wider experience and opportunities it has given her, for example, she is a STEM ambassador involved in outreach activities, has addressed a conference of around 250 people and has been involved in training a robot!

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3. **Afternoon Breakout Session – Lakshmi Hughes, RSC Careers – 'How to use RSC career resources to deliver Gatsby Career benchmarks.'**

Lakshmi introduced the session by outlining the Gatsby benchmarks which all schools and colleges will have to implement by 2020 and discussed the value of good careers guidance in pupils achieving better outcomes and not ending up without employment, education or training. She highlighted that the main challenges are benchmarks 5 and 6 – the encounters with employers and experience in the workplace. The delegates discussed ideas and Lakshmi challenged their preconceptions about specific careers and the amount of science involved. There was a wider discussion on what good careers guidance should look like and what employers are looking for when taking on employees. She talked through the various resources that are available from the RSC including teacher workshops run by the Education coordinators, posters, other RSC publications and online resources. Lastly, she explored various ideas and gave examples of what schools are doing. All the delegates went away better informed and with lots of ideas to put into practice.

4. **Report on Space Chemistry - Trevor Birt**

Presented by Caroline Molyneux – Deputy Head, Sharple School, Bolton and Lead Educator for the National Space Academy.

Caroline gave her presentation in an entertaining way and was very enthusiastic about the topic. At the outset, and after a brief introduction, it was apparent that this session was going to involve tasks and team work.

The content was linked to KS 4/5 science and relating current space exploration and discoveries to chemistry, physics and biology. Several video clips were used throughout.

Topics included minerals, tests for ions, volumetric analysis, organic compounds such as amino acids, survival and states of matter.

The information provided by Mars rovers was discussed and we had to choose from a list of minerals two that we thought would be useful and essential to astronauts when they land on Mars. An informative handout was provided that gave a list of common minerals and their uses on Earth. This brought in the tests for ions, and the expected observations, to assist in the identification of these minerals.

How life may have started on Earth brought up the topic of amino acids and the Miller-Urey experiments with 'primordial soup'. It also looked at the Rosetta mission to Comet 67P and the data sent back which recorded the detection of organic molecules etc. A suggested practical exercise was to provide students with artificial comet samples doped with amino acids and get them to carry out amino acids tests.

Looking much further into the future we considered the idea that Jupiter's moon Europa might be a place for humans to inhabit. This gave an opportunity to compare the states of matter of a variety of elements and compounds, such as water, nitrogen, oxygen etc., as they are on Earth at 20_oC and Europa at -160_oC.

The session ended with 'particle motion' in the different states of matter. We were *persuaded* to get on our feet and mimic these movements. With the accompanying music we were literally 'dancing in the aisles'.

An excellent session.

Twitter @molymolyneux

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5. **General Report by Sam Walker on the day-**

<u>PT of Videos</u>

Also do videos on what is in the news/world cup etc.

Began with BD Shaw doing public engagement @ Nottingham, now award a medal in his name to people involved in public engagement. Supercritical fluids on test tubes site is where it all started.

<u>Holly Carter</u> – Apprentice of the year 2018

Lab scientist, 3-year foundation degree, 2 more years for top up to BSC. Salary, RSciTech and uni fees paid too. FdSc Chemical Science. A lot of distance learning using Moodle, one day a week in work dedicated to this watching webinars.

<u>AQA Feedback from 2018 Exams</u>

Comparable outcomes, E.g. 2018 Grade 5 will equal a 2022 grade 5.

The standard shouldn't change but numbers of those reaching standard can change. Lower grade boundaries for one particular spec doesn't make it easy.

20-30% of questions are common between F and H. "chained equipercentile equating" allows grade 4 on both tiers to be at the same standard.

At A level, there is a decrease in the overall A Level entries but Chemistry is increasing.

Keynote – Helen Sharman

Helen was amazing, such an inspirational lady and very engaging. Related her time in space in the early 90's to modern space issues and everyday Chemistry.

Early in life she decided to study science as it opened more doors. In space all elements are created. She worked in display screen technology being the only Chemistry. The she worked for MARS in ice creams as research technologist working on the new ice cream mars bar, developing flavour and sweetness perception at low temperatures.

Then she moved to chocolate department and involved in tasting. Listening to the car radio one day on her way home from work she heard an advert on the car radio wanting an astronaut. UK government didn't fund UK space flight at that time but Russia had offered a seat. The mission was to be 2 years from the date of the advert. Helen was excited by the prospect of the training but almost didn't apply as thought a military guy would get it. Timothy Mace (Army air corp) was also chosen for training at Star City in Moscow. One would go up the other was back up. She had 3 months to learn Russian as all training was conducted in it. In 1989 she had theoretical lessons, then 18 months of training and simulators. Helen and two Russian planned to go up for 8 days, the Russians would stay and Helen would return with returning crew. Flew up on Soyuz rocket fuelled by Kerosene with liquid oxygen. Take 530s to use all the fuel (max 3.5G) to get 3.5km above the earth. 2.5 hours after leaving Earth they can removed their spacesuits. She felt congested and her head was fatter due to lack of gravity. Body balanced out after a few days due to expelling 2.5L of urine. This can cause problems as other chemicals e.g. Ca and K also lost. Kidney stones and muscle loss is an issue. They think that ion exchange through the muscles is messed up by weightlessness. Also, some drugs like ibuprofen don't have the same effect on the body in space. There are no convection currents in space so you end up breathing in what you have just breathed out, so CO_2 conc increases and becomes dangerous so need to circulate and filer the air.

It took two days to get to the space station and in 1991 only method of communication with Earth was via radio. Her role was to carry out some experiments and looked at how potatoes grow in space. To this day they have still not managed to grow potatoes or fruit from seed in space. Green chlorophyll pigment is affected by radiation. Plants that don't have hormones for their roots grow in all directions so they had to use strong magnets to force the direction.

They can grow salad, e.g. basil though. Sense of taste diminishes in space.

She also looked at crystal growing, protein crystals. These are difficult to grow on Earth but in space they grew bigger and better.

For water they condensed the water vapour on cold panels. They produced oxygen by heating Lithium Chlorate. LiOH crystals were used to remove CO_2. NH_3, from the breakdown of sweat, was removed by passing over charcoal filters, which also removed CH_4. Heat passed into liquid NH_3 pipes on outside of station to radiate the heat in to space. Space toilets were air flushed. You don't want to waste anything in space so they used reverse osmosis and distillation. Add Ag^+ and then reheat so urine can be drunk. Electrolyse the water to get O_2 but the H_2 was wasted and vented in to space. Looking at ways today of how to use the hydrogen.

Current crew in space station are working on where do we go next = Mars.

Issues though are radiation could blind the astronauts and give them cancer, they think they will develop drugs to prevent this. Also, growing fruit for Martian astronauts not possible at mo.

Periodic table breakout

This was slightly disappointing for me though I don't know what I expected. There were some fabulous demonstrations but the talk was about the data behind the periodic videos and how many viewers and videos etc. they had which was interesting but not particularly useful.

GCSE 2018 reports breakout

Discussed how questions and mark schemes are written then about the fact that AO2 is 40% and is a fundamental part of science, the ability to apply knowledge. AO2 most maths skills are included in it.

Importance of being aware of the maths skills, listed in spec, was made. Then we had discussions on some of this years issues.

GCSE Chemistry: AO2, Maths and practical questions

Peter Rupkus

Summer 2019

Welcome

This meeting will be recorded

Exam boards have an Ofqual requirement to record event audio.

Recordings are kept for the lifetime of the specification and not shared as an accompaniment to session resources.

The recording will begin now.

Outline for the session

- Mark schemes and how we apply them
- AO2-focused questions in GCSE sciences
- Maths-related questions in GCSE sciences
- Practical related questions in GCSE sciences
- Using exam questions to improve student performance

Mark schemes and how we apply them

- What is the mark scheme for?
- Our GCSE Science mark schemes
- Points-based mark schemes
- Levels of response mark schemes

What is the mark scheme for?

- To evaluate the evidence from each student fairly
- To reward positive achievement
- To differentiate purely on evidence of subject knowledge, understanding and skills
- To fully and consistently reflect the agreed interpretation of command words
- To fully reflect the purpose of each assessment
- To credit appropriate responses that reflect the different ways in which learners may demonstrate what they know, understand and can do

Our GCSE Science mark schemes

- The ‘Information to examiners’ section:
  - general guidance on the parts of the mark scheme
  - explicit guidance on what parts of the mark scheme mean and how they should be applied
  - marking levels of response questions
  - exactly the same for all GCSE Sciences.

- Detailed mark scheme for each question:
  - specific guidance on what is/is not acceptable
  - points or levels of response marked.

Points-based mark schemes

- Marks given for each correct point a student gives
- Explicitly define correct (and incorrect) answers
- Emphasis is on the correctness of the response, not the quality
- Usually used for lower-tariff questions (<10 marks)
- If well-written are very reliable

Levels of response mark schemes

- Used for open questions where there is a variety of ways for students to arrive at a mark
- Reward the overall quality of the answer
- Divide performance into chunks of marks (levels) on a continuum
- Describe the performance at each level
- Generic level descriptors linked to specific command words
- Same descriptors apply to all GCSE sciences
- Section of indicative content specific to each question

AO2-focussed questions in GCSE sciences

- What is AO2?
- Regulatory requirements
- How do we assess AO2?
- Common issues with AO2 questions in Summer 2018

What is AO2?

- AO2 is the skill of being able to apply knowledge and understanding to provide meaning and explanation to observed phenomena
- It involves making links between theory and data to make sense of observations
- This skill is a fundamental part of science
- It is not an ‘add on’ but something scientists do all the time

Regulatory requirements for AO2

GCSE Subject Level Guidance for Single Science (Biology, Chemistry, Physics)

<table>
<tr><th colspan="3">AO2: Apply knowledge and understanding of:
▪ scientific ideas
▪ scientific enquiry, techniques and procedures.</th><th>40%</th></tr>
<tr><th>Strands</th><th>Elements</th><th>Coverage</th><th>Interpretations and definitions</th></tr>
<tr><td>1 – Apply knowledge and understanding of scientific ideas.</td><td>This strand is a single element.</td><td rowspan="2">▪ Full coverage in each set of assessments (but not in every assessment).</td><td rowspan="2">▪ Scientific ideas are aspects of the subject content. They include the subject-specific requirements and the requirements for Working Scientifically as set out in the Content Document – for example, theories, models and the use of relevant mathematics.
▪ Scientific enquiry, techniques and procedures encompasses, but is broader than, knowledge and understanding of the core practical activities. In the context of this assessment objective, it involves applying such knowledge and understanding to a given context.
▪ The emphasis in this assessment objective is on Learners applying their knowledge and understanding to provide meaning or explanation – for instance, to connect theory with particular contexts, stimuli or materials. This application should relate principally to:
▫ novel situations that are not clearly indicated in the specification;
▫ developing further material that is covered in the specification;
▫ making links between such types of material, which are not signalled in the specification.
▪ Application of knowledge should also involve determining how to make sense of connections and linkages within data, information and detail – although not to the extent of drawing conclusions or making judgements.</td></tr>
<tr><td>2 – Apply knowledge and understanding of scientific enquiry, techniques and procedures.</td><td>This strand is a single element.</td></tr>
</table>

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Contexts and making links

- We must assess application of knowledge and understanding gained by doing the required practicals primarily in a context that is not given in the specification
- Students need to develop further material that is given in the specification
- Students need to be able to make links between material in the specification, which are not signalled in the specification

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What do we assess as AO2?

- Most maths skills: calculations, using equations or formulae, plotting, interpreting and using graphs
- Applying knowledge from an area of the specification to a context (which might not be a familiar one)
- Understanding the use of models and theories
- Practical skills such as reading scales or taking measurements
- Understanding of variables, errors, uncertainties
- Using scientific vocabulary and terminology
- Using/interpreting specialist diagrams

Maths-related questions in GCSE Sciences

- What is Maths in the context of Science GCSE?
- Regulatory requirements
- How do we assess Maths skills?
- Common issues with Maths-related questions in Summer 2018

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What is Maths in the context of GCSE Science?

Assessment of mathematical skills

"The Content Document sets out the mathematical skills which must form part of each GCSE Qualification in Combined Science (the 'Mathematical Skills') in the 'Use of Mathematics' sections and individual content statements for biology, chemistry and physics, the mathematical forms of Working Scientifically and the appendices addressing different aspects of the mathematical requirements."

Extract from Ofqual: GCSE Subject Level Conditions and Requirements for Combined Science

Regulatory requirements

On page 6 of the content document it is states:

“The mathematics [outlined in the Content document] should be at levels up to, but not beyond, the requirements specified in GCSE mathematics for the appropriate tier.”

Regulatory requirements

In designing and setting the assessments for each GCSE Qualification in Combined Science which it makes available, or proposes to make available, an Awarding Organisation must ensure that, taking the assessments for that qualification together:

- the number of marks used to credit the relevant mathematical skills is no less than 20% of the total marks for the qualification
- those marks are allocated to questions and tasks related to biology, chemistry and physics in a ratio of 1:2:3

Regulatory requirements

- the questions and tasks used to target Mathematical Skills are at a Level of Demand which:
  - is appropriate to the subject
  - will allow effective differentiation between a range of attainments by Learners in relation to the subject content being assessed
  - in respect of assessments for the foundation tier, is not lower than that which is expected of Learners at Key Stage 3 as outlined in the ‘Mathematics programmes of study: key stage 3,’ document reference DFE-00179-2013

Regulatory requirements

  - in respect of assessments for the higher tier, is not lower than that of questions and tasks in assessments for the foundation tier in a GCSE Qualification in Mathematics.
- Mathematical Skills are assessed at an appropriate range of Levels of Demand in each set of assessments and over the lifetime of the qualification.

Content Document requirements

Appendix 3

Mathematical skills required for biology (B), chemistry (C), physics (P) and combined science (CS)

	Mathematical skills	Subject			
1	**Arithmetic and numerical computation**				
a	Recognise and use expressions in decimal form	B	C	P	CS
b	Recognise and use expressions in standard form	B	C	P	CS
c	Use ratios, fractions and percentages	B	C	P	CS
d	Make estimates of the results of simple calculations	B	C	P	CS
2	**Handling data**				
a	Use an appropriate number of significant figures	B	C	P	CS
b	Find arithmetic means	B	C	P	CS
c	Construct and interpret frequency tables and diagrams, bar charts and histograms	B	C	P	CS
d	Understand the principles of sampling as applied to scientific data	B			CS
e	Understand simple probability	B			CS
f	Understand the terms mean, mode and median	B		P	CS
g	Use a scatter diagram to identify a correlation between two variables	B		P	CS
h	Make order of magnitude calculations	B	C	P	CS
3	**Algebra**				
a	Understand and use the symbols: =, <, <<, >>, >, ∝, ~	B	C	P	CS
b	Change the subject of an equation		C	P	CS
c	Substitute numerical values into algebraic equations using appropriate units for physical quantities		C	P	CS
d	Solve simple algebraic equations	B		P	CS
4	**Graphs**				
a	Translate information between graphical and numeric form	B	C	P	CS
b	Understand that y=mx+c represents a linear relationship	B	C	P	CS
c	Plot two variables from experimental or other data	B	C	P	CS
d	Determine the slope and intercept of a linear graph	B	C	P	CS
e	Draw and use the slope of a tangent to a curve as a measure of rate of change		C		CS
f	Understand the physical significance of area between a curve and the x-axis and measure it by counting squares as appropriate			P	CS
5	**Geometry and trigonometry**				
a	Use angular measures in degrees			P	CS
b	Visualise and represent 2D and 3D forms including two dimensional representations of 3D objects		C	P	CS
c	Calculate areas of triangles and rectangles, surface areas and volumes of cubes.	B	C	P	CS

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Practical related questions in GCSE sciences

- Regulatory requirements
- How do we assess practical skills?
- Common issues with practical related questions in Summer 2018

Requirements for assessment of practical skills

Assessment in relation to practical work:

- the number of marks is no less than 15% of all the marks allocated.
- all three assessment objectives must be covered
- questions and tasks must draw on the theoretical and practical aspects of experimentation
- students are required to show and apply:
  - knowledge and understanding of practical activities
  - scientific thinking
  - use experimental skills and strategies
  - analyse and evaluate information.

How do we assess practical skills?

- Planning, explaining and evaluating procedures
- Knowledge and understanding of how to use apparatus and techniques
- Understanding of sampling techniques
- Safety and risk management in practical contexts
- Understanding and appropriate use of scientific terminology, eg accuracy, precision, variables, uncertainty
- Reading scales or taking measurements
- Appropriate mathematical procedures and analysis

Common issues in Summer 2018

Common issues with AO2 in Summer 2018

- Confusion in using practical terminology
- Basic maths skills
- Choosing appropriate scales for graphs
- Basic graph plotting
- Lines of best fit
- Interpreting graphical data
- Applying knowledge and skills in an unfamiliar context
- Linking ideas across the specification

Common issues with Maths questions in Summer 2018

- Basic maths skills
- Graphs and data manipulation
- Applying mathematical skills in an unfamiliar context
- Significant figures and decimal places
- Standard form and large numbers
- Lack of working, calculator errors
- Calculating percentages and percentage increases and percentage decreases
- Substitution into and re-arrangement of equations

Graph skills

- Graphs should be plotted and drawn with a sharp pencil choosing an appropriate scale which uses most of the paper − use crosses rather than dots (this is easier for the examiner to see), check the scale of the axis when reading values and plot all data points given.
- Students need to make use of the data provided, either in a table or in a chart or graph, to answer the question which has been asked.

Common issues with practical questions in Summer 2018

- Lack understanding about the science underlying the practical's - model of osmosis cell and transects chemicals that make a salt and electrolysis acceleration and density.
- Didn’t fully understand why they had carried out each step in the practical.
- Unclear why they had taken specific measurements and the equipment needed to do this.
- Use of vague terms such as ‘amount’, ‘fair’, ‘results’.

Common issues with practical questions in Summer 2018

Areas of working scientifically in the context of the required practicals:

- repeatable or its significance
- identify control variables and other variables
  term 'fair' is always inadequate unless suitably qualified
  types of errors
- how to improve accuracy - improves inaccuracy is insufficient for a type of experimental error, human error is insufficient.

Using exam questions to improve performance

- Use as examples in the classroom
- Look at key points in the response that gain marks
- Discuss mark scheme requirements with students
- Students mark their own or each other's work
- Group discussions on how a response could be improved to gain more marks

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Get in touch

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Thank you

Incorporating good career guidance into chemistry teaching

Lakshmi Hughes

Royal Society of Chemistry

In this session

1. Does good career guidance make a difference to young people's lives and choices
2. Outline of the Gatsby good career guidance benchmarks
3. Careers resources from the Royal Society of Chemistry linked to the Gatsby benchmarks
4. Some examples of what other schools are doing
5. Exploring ideas on linking curriculum learning to careers (over to you)

GATSBY

The value of good career guidance

Diagram from report commissioned by Gatsby into costs and benefits of good career guidance Apr 2014

Areas chemists work in

- Pharmaceuticals
- Environment – clean up and protection
- Energy - gas and oil, alternatives, battery storage
- Materials sciences - nanomaterials
- Food industry
- Forensics
- Cosmetics, household and personal-care goods
- Colour chemistry

Where a chemistry qualification can lead

Analytical chemist: you check the chemical nature of substances e.g. blood at a crime scene

Laboratory Technician: you might collect samples, study and perform tests on chemicals, materials or products.

Medicinal scientist: you design and develop drugs to treat disease

Production chemist: you develop and improve products made from chemical reactions, such as oil, cosmetics and fertilisers

Research chemist: you study chemical compounds to create and improve processes and products, from new medical treatments to cosmetics, electrical goods and food and drink

Environmental chemist: you monitor what is in the air, water, and soil to find out what affects they have, and how human activity affects the environment.

Employers

- Private pharmaceutical, food, energy, materials, polymers, biotechnology, or chemicals company
- Hospital
- Environmental agency
- Consultancy
- University
- Government agency
- Public health laboratory
- Testing company

Where else a chemistry qualification can lead

From teaching and writing to the law and banking, employers value a chemistry qualification.

ROYAL SOCIETY OF CHEMISTRY

The eight benchmarks are a simple list to assess a school's careers and enterprise provision.

1 A STABLE CAREERS PROGRAMME	2 LEARNING FROM CAREER AND LABOUR MARKET INFORMATION	3 ADDRESSING THE NEEDS OF EACH PUPIL	4 LINKING CURRICULUM LEARNING TO CAREERS
5 ENCOUNTERS WITH EMPLOYERS AND EMPLOYEES	6 EXPERIENCES OF WORKPLACES	7 ENCOUNTERS WITH FURTHER AND HIGHER EDUCATION	8 PERSONAL GUIDANCE

The Vision Of Each Benchmark

1

Every school and college should have an embedded programme of career education and guidance that is known and understood by pupils, parents, teachers and employers.

2

Every pupil, and their parents, should have access to good-quality information about future study options and labour-market opportunities. They will need the support of an informed adviser to make best use of available information.

3

Pupils have different career guidance needs at different stages. Opportunities for advice and support need to be tailored to the needs of each pupil. A school's careers programme should embed equality and diversity considerations throughout.

4

All teachers should link curriculum learning with careers. Science, technology, engineering and mathematics (STEM) subject teachers should highlight the relevance of STEM subjects for a wide range of future career paths.

5. *Every pupil should have multiple opportunities to learn from employers about work and employment and the skills that are valued in the workplace. This can be through a range of activities such as visiting speakers, mentoring, enterprise schemes and a range of other enrichment activities.*

6. *Every pupil should have first-hand experiences of the workplace through work visits, work shadowing and/or work experience to help their exploration of career opportunities, and expand their networks.*

7. *All pupils should understand the full range of learning opportunities that are available to them.This includes both academic and vocational routes and learning in schools, colleges, universities and in the workplace.*

8. *Every pupil should have opportunities for guidance interviews with a careers adviser, who could be internal (a member of school staff) or external, provided they are trained to an appropriate level. These should be available whenever significant study or career choices are being made and should be expected for all pupils, but should be timed to meet their individual needs.*

Careers resources from the Royal Society of Chemistry linked to the Gatsby benchmarks

Gatsby benchmarks the RSC can support directly		
Gatsby Benchmark 2	Learning from career and labour market information:	Every pupil, and their parents, should have access to good quality information about future study options and labour market opportunities. They will need the support of an informed adviser to make the best use of available information.
Gatsby Benchmark 4	Linking curriculum learning to careers	All teachers should link curriculum learning with careers. For example, STEM subject teachers should highlight the relevance of STEM subjects for a wide range of career pathways.
Gatsby Benchmark 5	Encounters with employers and employees	Every pupil should have multiple opportunities to learn from employers about work, employment and the skills that are valued in the workplace. This can be through a range of enrichment opportunities including visiting speakers, mentoring and enterprise schemes.
Gatsby Benchmark 6	Experience of Workplaces	Every pupil should have first-hand experiences of the workplace through work visits, work shadowing and/or work experience to help their exploration of career opportunities, and expand their networks. By the age of 16, every student should have had at least one experience of a workplace, additional to any part-time jobs they may have

Learning from career and Labour Market Information: benchmark 2

vital to inform information about jobs and career paths

1. Biennial RSC report on employment and job satisfaction
    - Information comes straight from working chemists
    - Includes salary medians by qualification and sector on earning potential
2. Career information before and after GCSEs
3. EiC: News and analysis of career-related info, trends, landscape

ROYAL SOCIETY OF CHEMISTRY

Addressing the needs of each student benchmark 3

gathering accurate data for each pupil on their education

- EiC: articles highlighting issues of inclusivity
- Regional careers events specific to needs of local area
- Support for apprenticeships and technical education in the chemical sciences

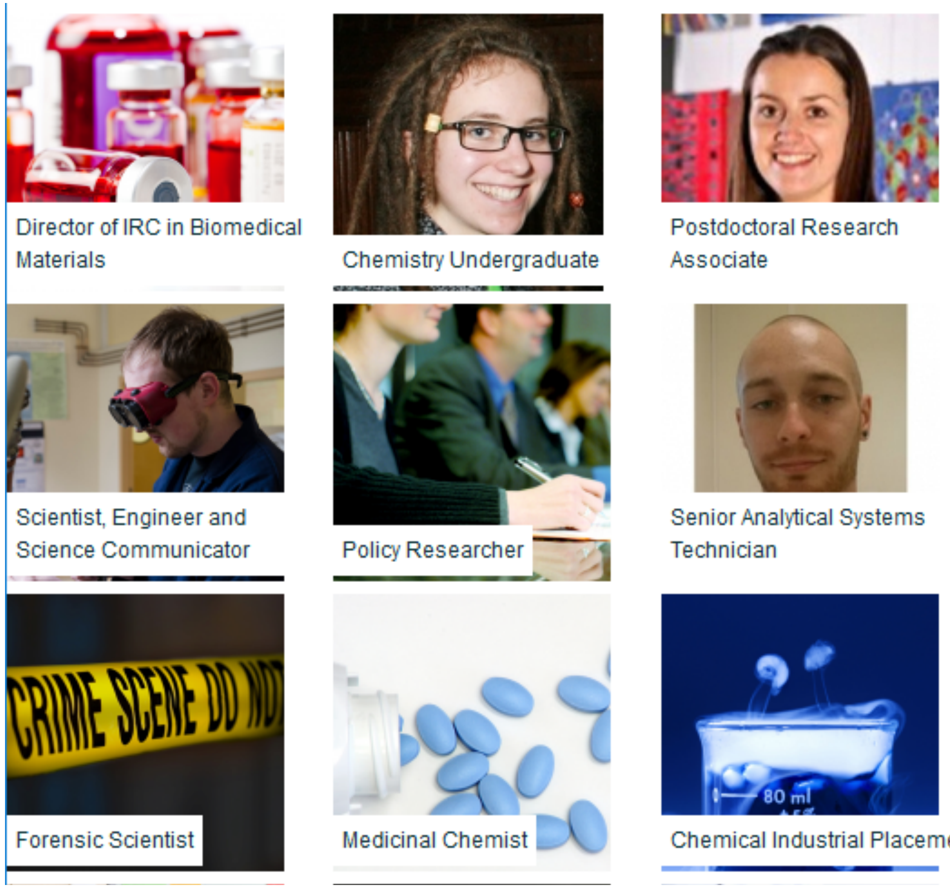
Linking curriculum learning to careers Benchmark 4

1. **Career profiles of real chemists linked directly to exam board topics at A-level**

Use case studies in lessons to:

- introduce topics: e.g. forensic scientist for chromatography
- check for learning: acids and alkalis, use the household goods scientist

2. Learn Chemistry Partnership events and Education Coordinator consultations with teachers, providing links to teachers to link curriculum learning to careers



Encounters with employers and employees Benchmark 5

1. We work with STEM Learning to connect RSC members to schools (~800) through STEM Ambassador programme
2. We incentivise RSC chemists to volunteer in schools
   - “Giving back” attribute required for chartered status for individuals and companies

3. RSC education coordinator network working directly with teachers and members broker links between schools and industry (varies per area)

4. Local section-organised events with schools (varies per section)

Experience of Workplaces
Gatsby Benchmark 6

Currently

Local section and education coordinators work experiences between schools and member-employers

Coming up

- Work experience guidance: off the shelf available to hosts, to facilitate meaningful work experience for students and remove pressure for SMEs
- For T levels (in development) it's required to have work experience

What schools are doing: some examples

<u>Benchmark 1: A Stable Careers Programme</u>

- Career guidance and benchmarks are built into the appraisal and performance review of staff at all levels, including headteacher. **Excelsior Academy**

<u>Benchmark 2: Learning from Career and Labour Market Information</u>

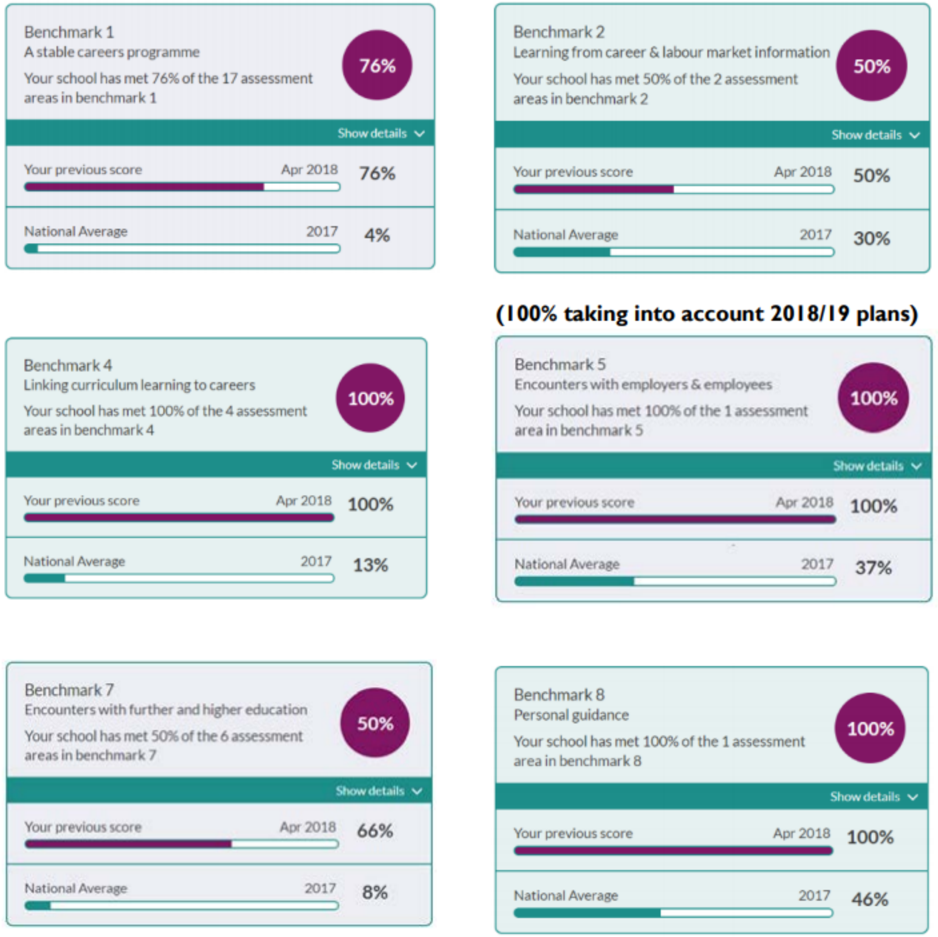
- The career leader reads the local economic plan documents produced by the Local Enterprise Partnership (LEP) and/or the local authority to understand labour market in the local area. **Bishop Auckland College**

<u>Benchmark 3: Addressing the needs of each pupil</u>

- We look at destinations data of former students. We saw that former students take up apprenticeships. Now we have more support about apprenticeships and the routes into them. **Castle View Enterprise**

<u>Benchmark 4: Linking Curriculum Learning to Careers</u>

<u>Benchmark 5, 6, 7, 8</u>



Source: Gatsby Good Career Guidance

ROYAL SOCIETY OF **CHEMISTRY**

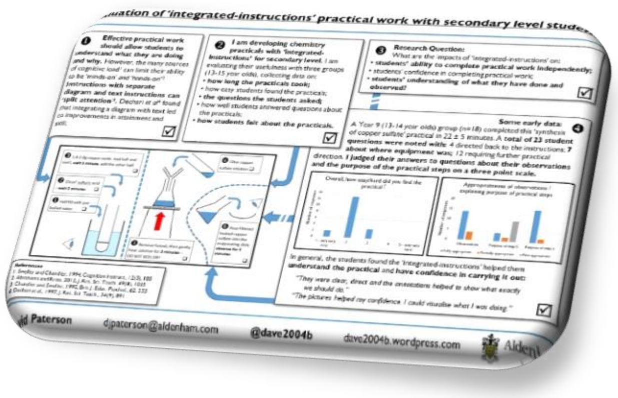
Over to you: Linking careers to the curriculum Benchmark 4

Form two or three groups

One person from each group to feedback on the discussion

Discuss and note down ideas for:

- What you do (or would like to do) to meet benchmark 4
- What RSC resources (if any) does it use
- What you think the RSC most usefully provide



Integrated instructions in practical work
RSC SaFE Conference, Bolton School
2nd July 2019

David Paterson, Aldenham School, Elstree

@dave2004b | dave2004b.wordpress.com
davidjamespaterson@yahoo.co.uk

Acknowledgements

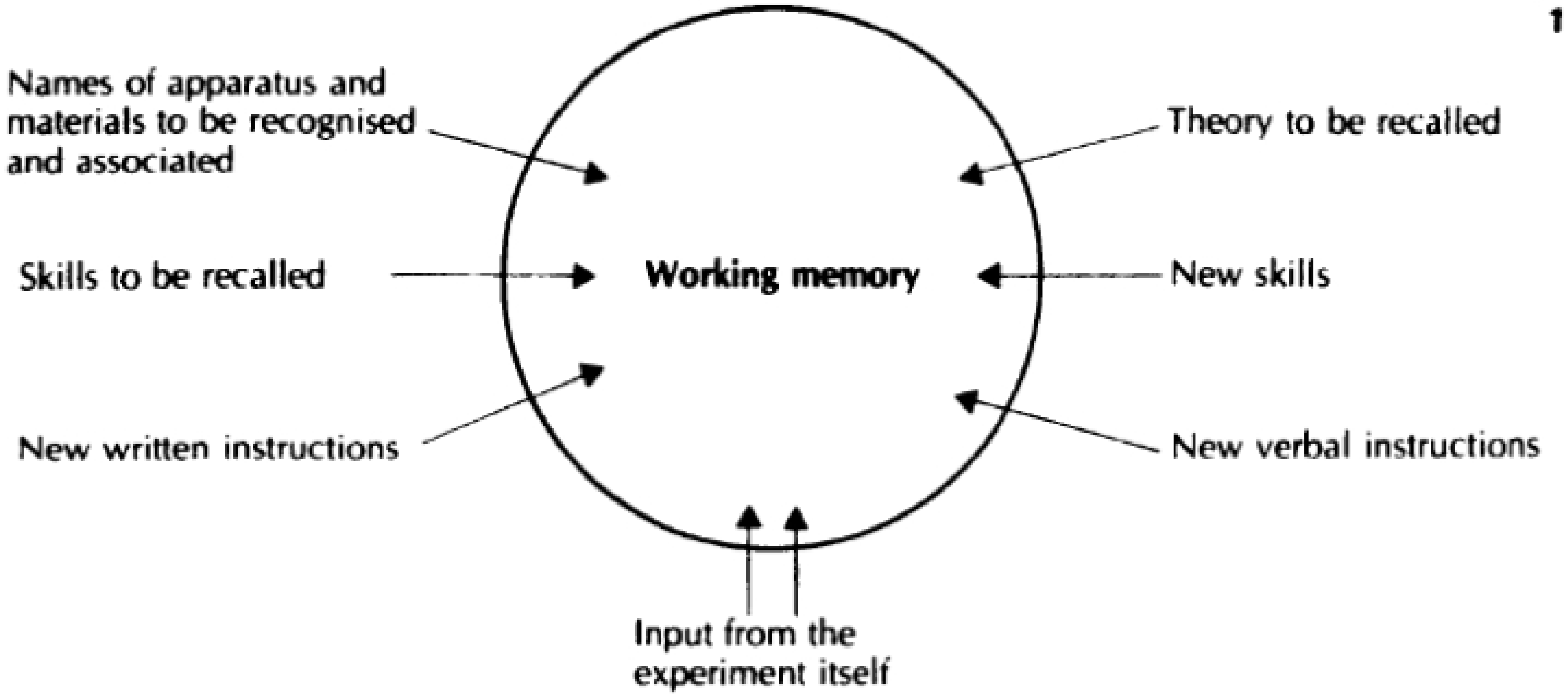
RSC Chemical Education Research Group Teacher-Researcher Fellowship Scheme 2018

Suzanne Fergus & Michael Seery.

Staff and students at Aldenham School

Steve Jones and Bob Worley, CLEAPSS

Practical work – a hard ask for students



Information overload in a lab environment (from Education in Chemistry, 1982)

From http://michaelseery.com/home/index.php/2016/02/practical-measures-for-practical-work/; A. H. Johnstone, A. J. B. Wham, The demands of practical work, *Education in Chemistry*, 1982, **19**, 71-73

Practical work – the pyramid model

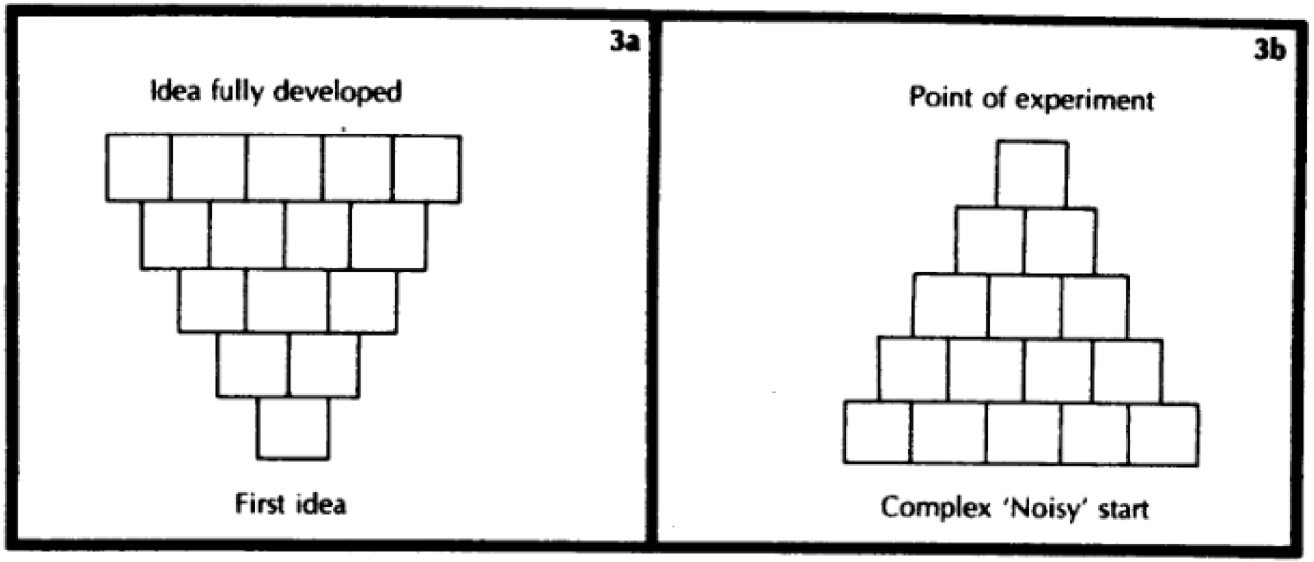
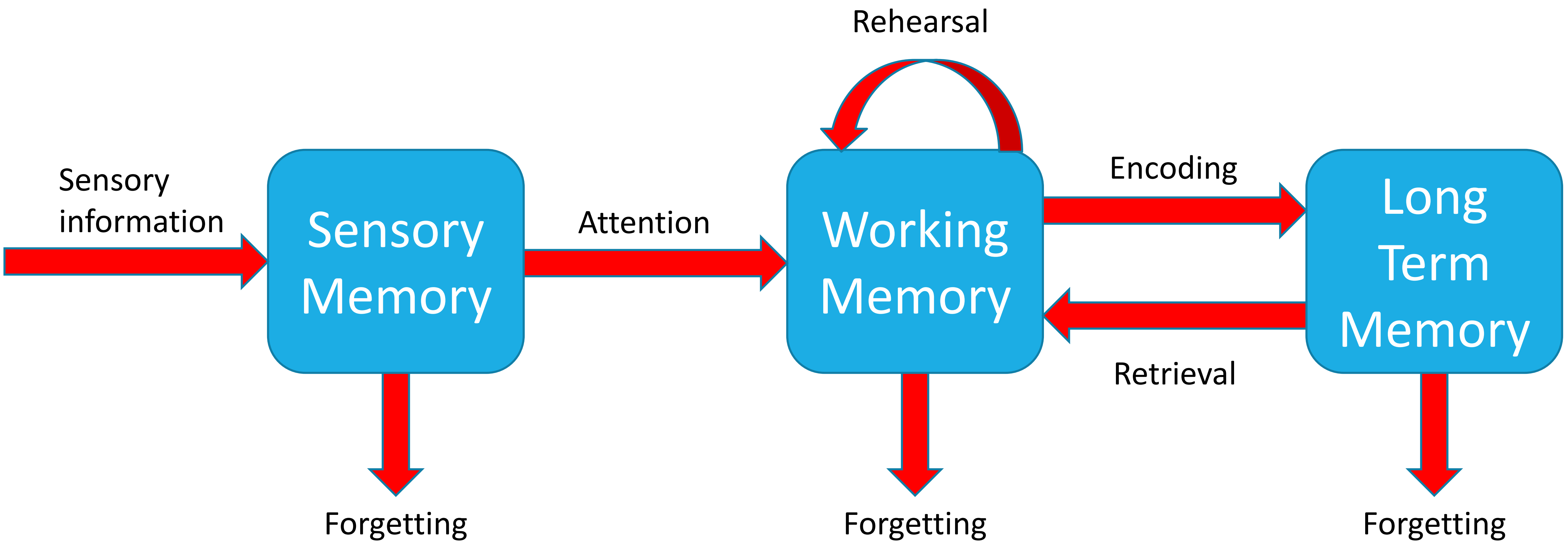


Fig. 3. Class teaching often begins with a single idea which is elaborated (3a). Often it seems that, in practical work, the pyramid is inverted (3b), obscuring the point we are trying to make.

Different approaches in class work and practical work (Johnstone and Wham, from Education in Chemistry, 1982)

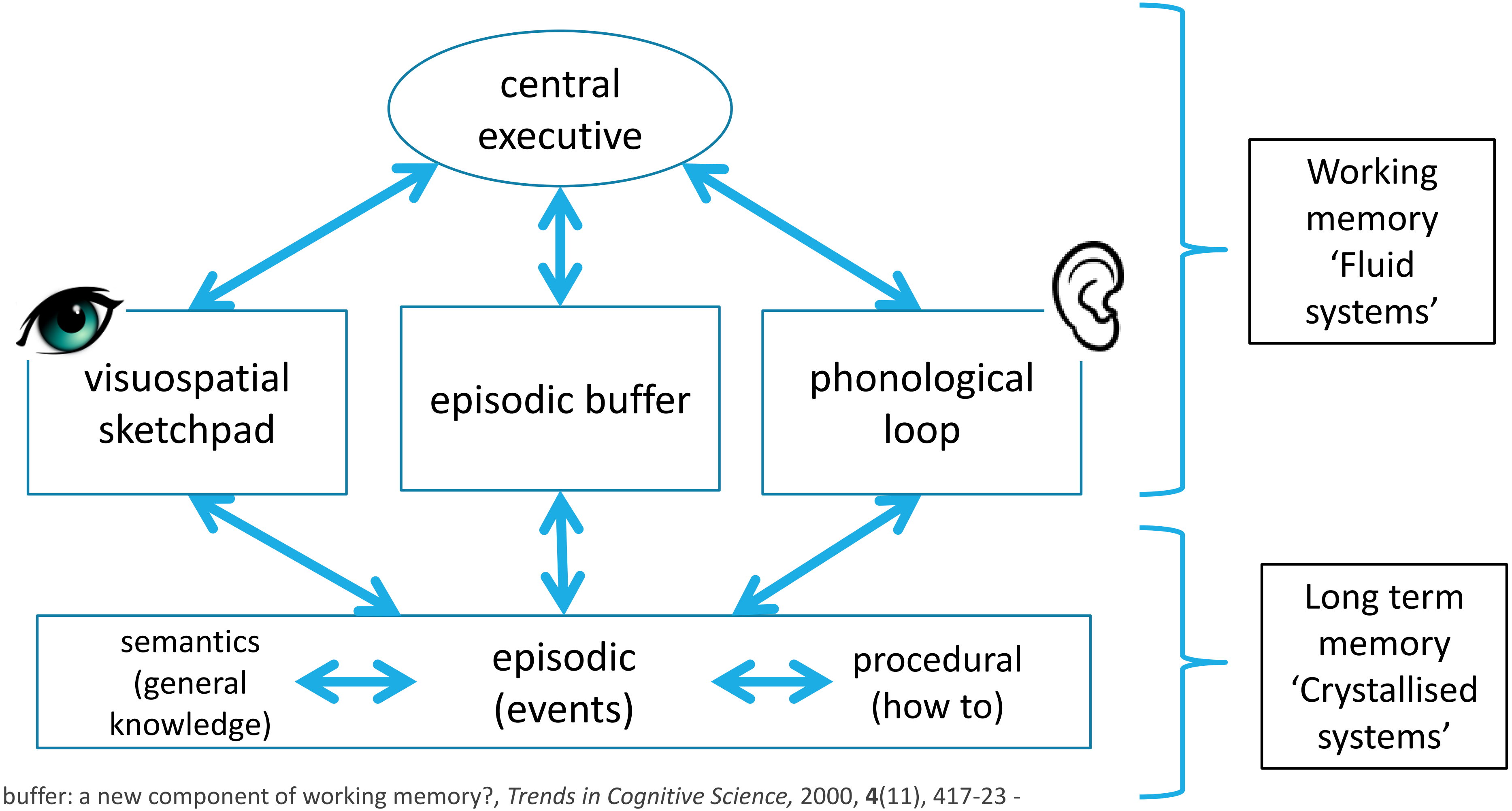
From http://michaelseery.com/home/index.php/2016/02/practical-measures-for-practical-work/; A. H. Johnstone, A. J. B. Wham, The demands of practical work, *Education in Chemistry*, 1982, **19**, 71-73

Working and Long Term Memory



Atkinson–Shiffrin memory model (1968) / Baddeley (1992) for WM rather than STM

A model of memory



Baddeley. A., The episodic buffer: a new component of working memory?, *Trends in Cognitive Science,* 2000, **4**(11), 417-23 - http://www.sciencedirect.com/science/article/pii/S1364661300015382

Working Memory

Where you ‘consciously think’

Limited capacity

If it is overloaded, task completion/learning is impeded

Working Memory – a test

Remember as many of the following as you can:

149 219 181 945 199 720 102 019

Working Memory – a test

Write down as many as you can remember.

How many did you manage?

Working Memory – a second test

Remember as many of the following as you can:

1492 1918 1945 1997 2010 2019

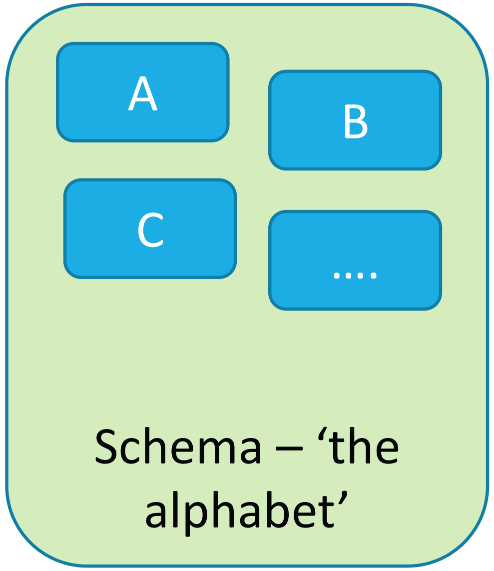
Working memory – a second test

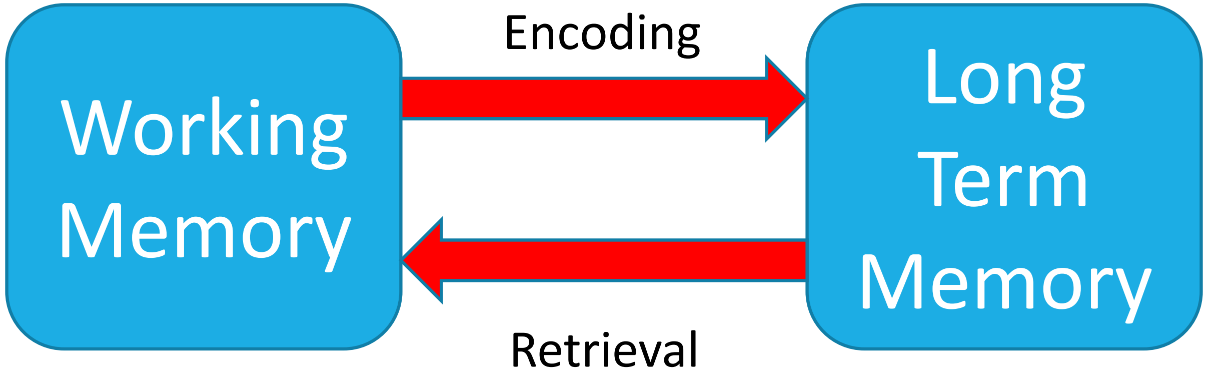
Why was is easier the second time?

- Bigger ‘chunks’ of information
- Use schema (pre-existing knowledge) – famous dates.
- Relies on prior knowledge – the more you know, the easier it is to learn!

After Piaget 1923; Bartlet 1932

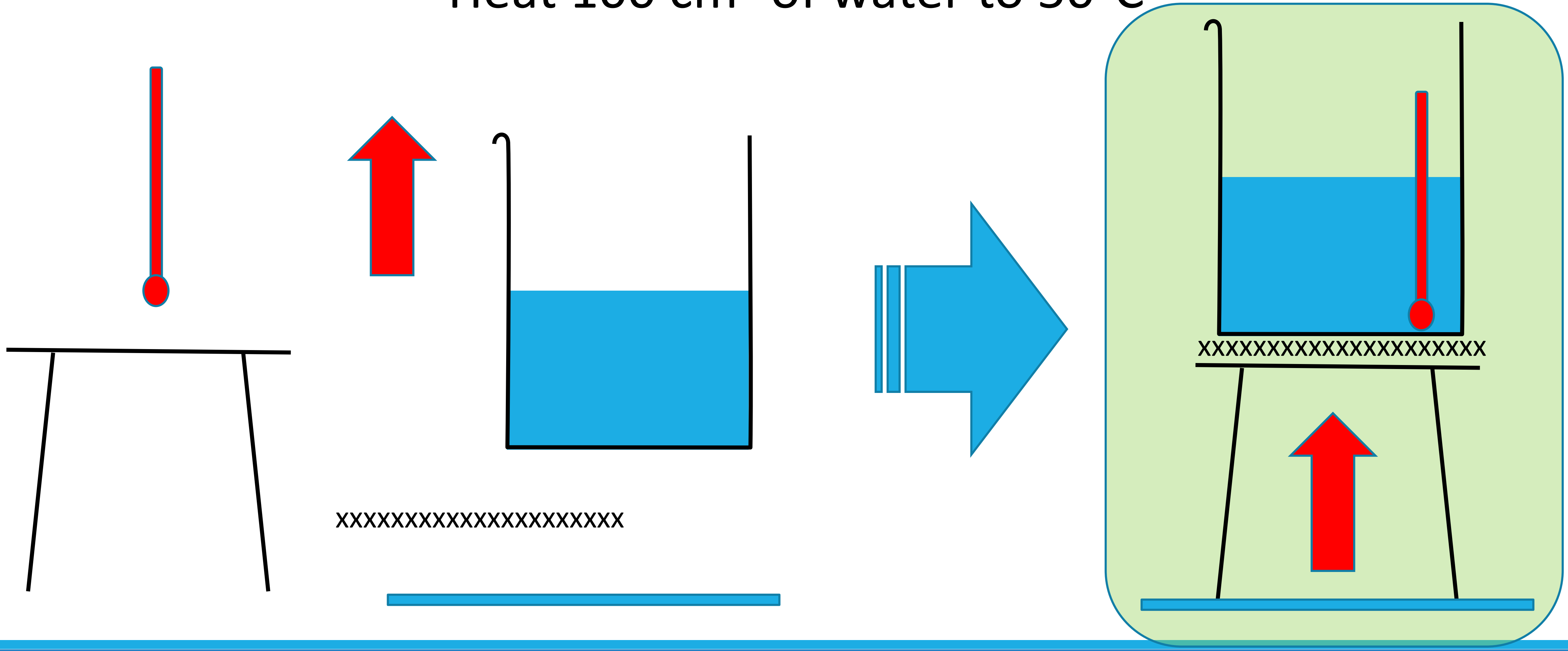
Long-term Memory: Schema





Long term Memory: A science schema

Heat 100 cm^3 of water to 50°C



Problem solving

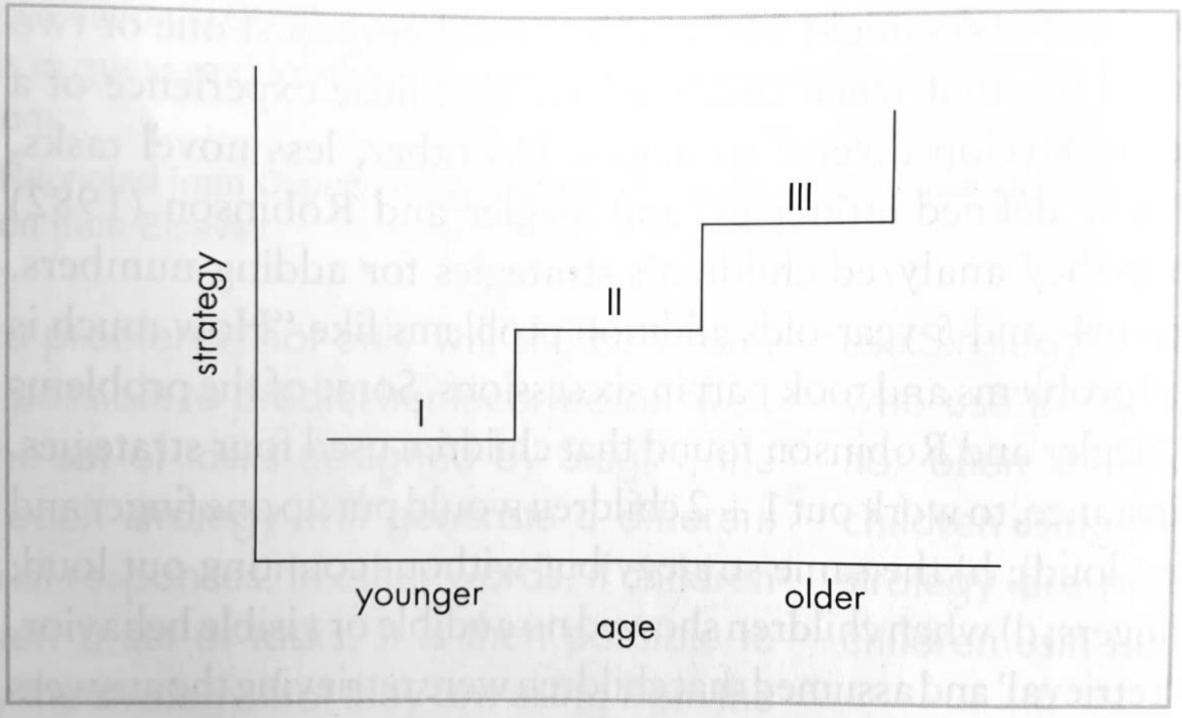


Figure 14.4 A graphical representation of children's strategy development as distinct steps or stages. This example represents the distinct stages implied in the development of better strategies in tasks like the balance scale task.

Source: Adapted from Siegler, 1996.

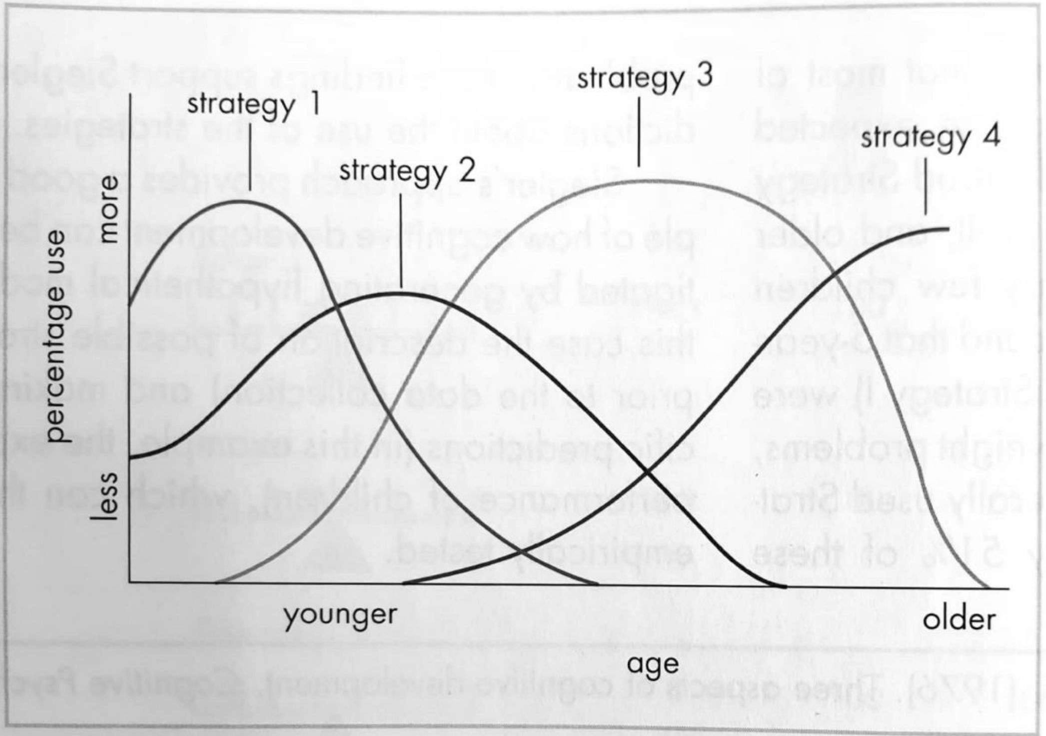


Figure 14.3 A graphical representation of the overlapping waves metaphor used by Siegler to describe children's strategy use over time, At any specific age children might be using two or more strategies.

Source: Adapted from Siegler, 1996.

Siegler, R.S. (1996). *Emerging minds: The process of change in children's thinking.* New York: Oxford University Press

Cognitive Load Theory (CLT)

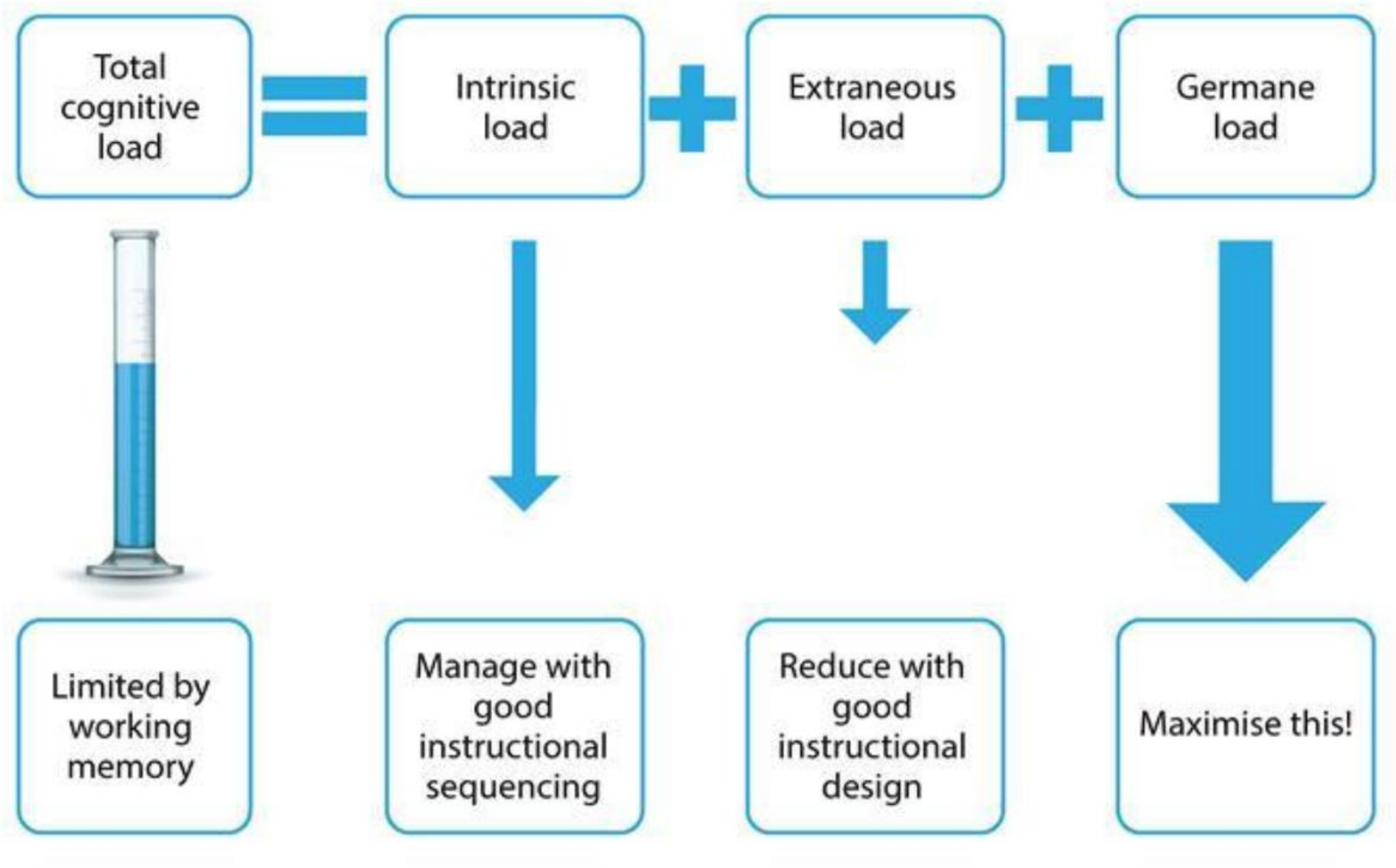
What are they thinking about in the Working Memory?

Intrinsic
- complexity of concepts
- inter-relatedness of ideas

Extraneous
- complexity of the instructional materials
- external influences

Germane
- building the mental models (schema) about the concepts

Cognitive Load Theory (CLT)



Greer, D.L., *et al*, Cognitive theory of multimedia learning..., *Journal of Education*, 2013, 193(2), 41-50
https://www.researchgate.net/publication/269112838

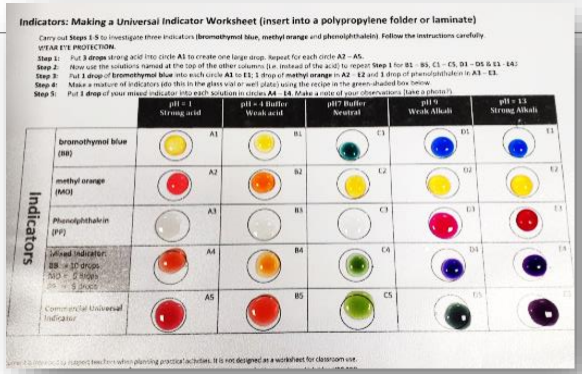
Example: Titration

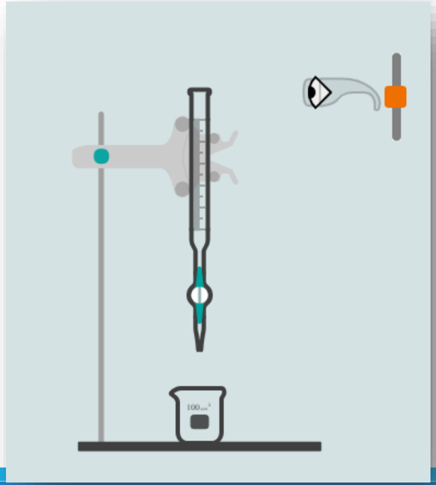
An intrinsically complex activity

- New equipment
- Recalling prior knowledge
- Making and understanding observations
- Accurate measurement
- Calculation

Good instructional sequencing

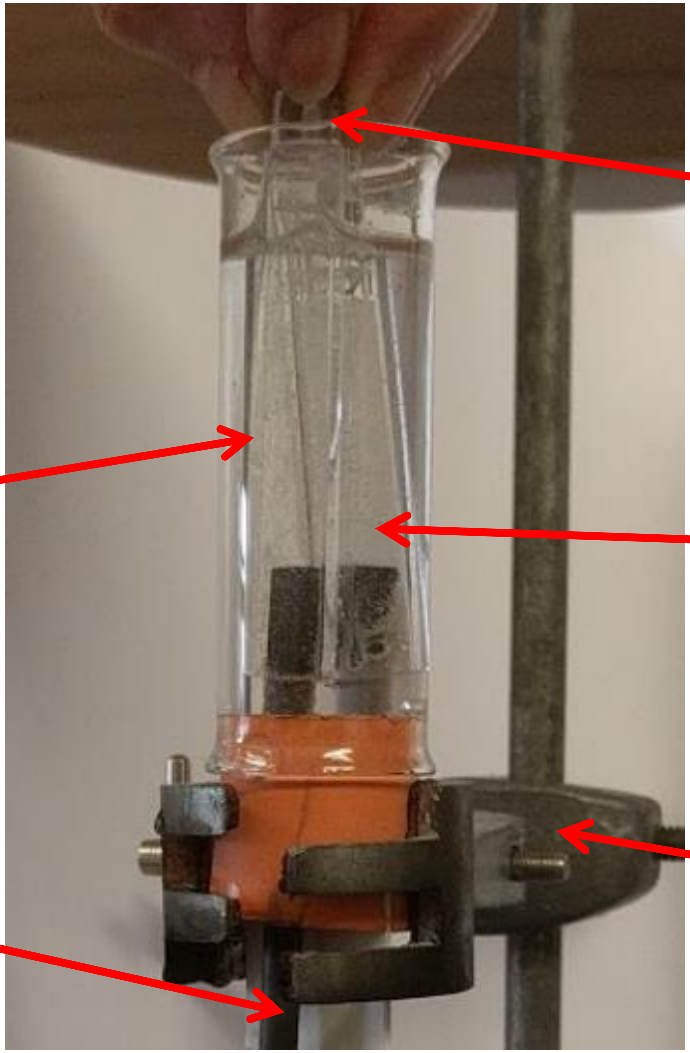
- Recap neutralization and indicators
- Simple (gravimetric) titration
- Introduce new equipment
- Simulation of titration
- Simple volumetric titration
- Data analysis – lots of examples
- Strong and weak acids
- Develop investigative skills





http://www.rsc.org/learn-chemistry/resources/screen-experiment/titration

Extraneous load - electrolysis



Collecting enough gas

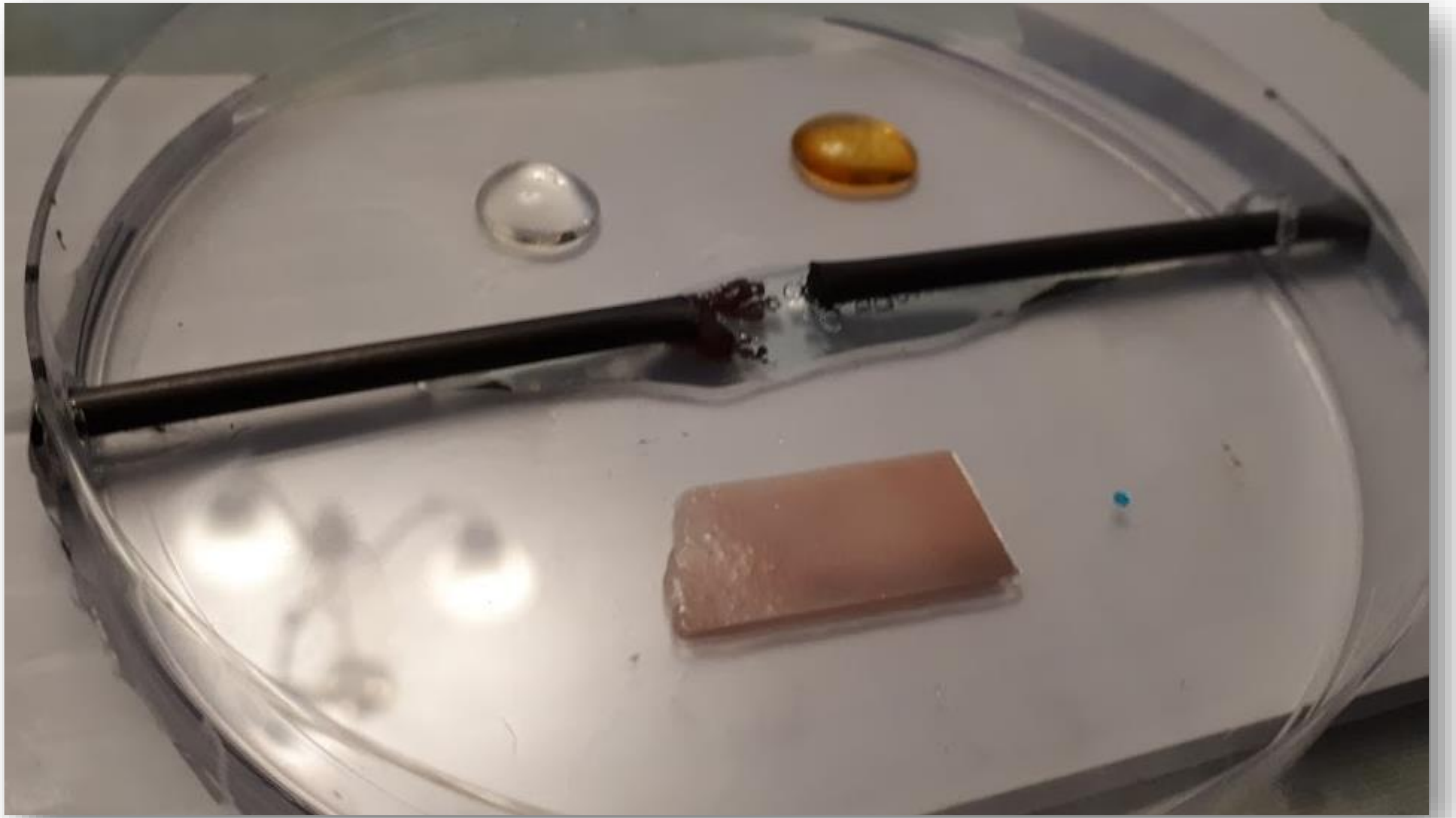
Spillages in setting up the test tubes

Getting the test tubes filled

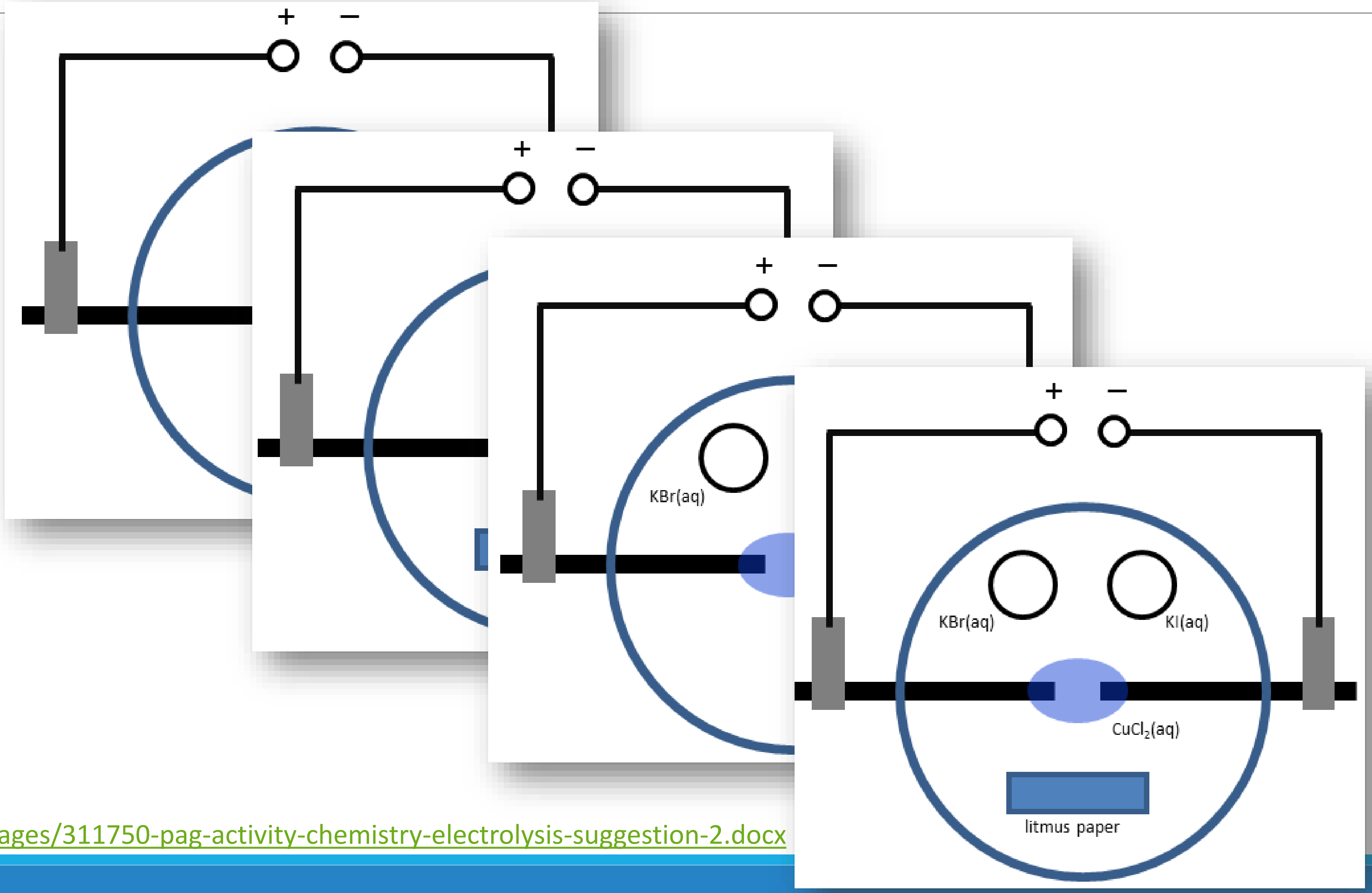
Connecting powerpack and getting it working

Getting the boss and clamp right

Simplifying equipment



Instructional design - progression



http://www.ocr.org.uk/Images/311750-pag-activity-chemistry-electrolysis-suggestion-2.docx

Extraneous load – the split-attention effect

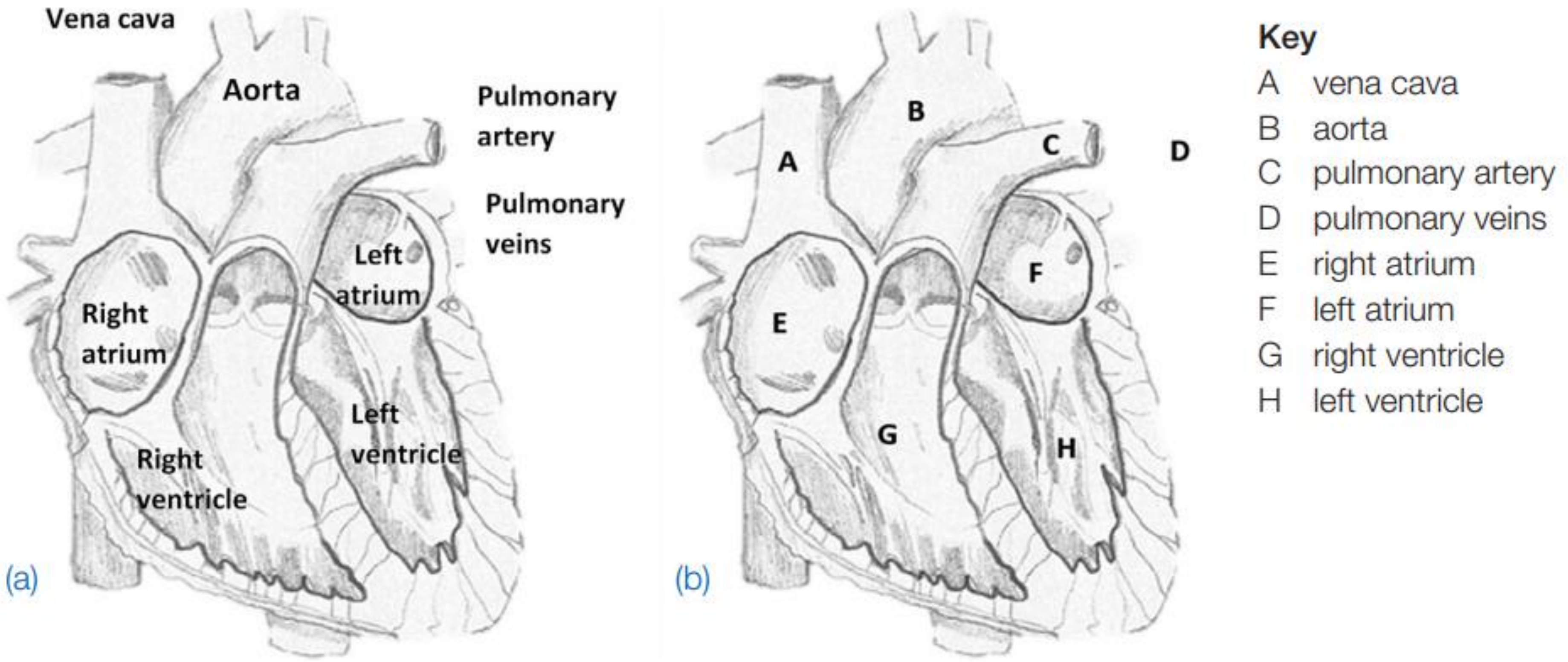


Figure 2 The spatial contiguity principle: (a) reducing extraneous load by integrating labels with visualisation; (b) extraneous load is increased when labels are not integrated with visualisation

Rebecca Torrance Jenkins, *Using educational neuroscience and psychology to teach science Part 1*. **SSR December 2017**

Split attention – a demonstration

Time how long it take you to:

Write out all the numbers from 1 to 26 in order, left to right.

---THEN---

Write out all the letters from A to Z in order, left to right.

Make a note of how long that took.

Split attention – a demonstration

Without looking at your previous work…

Time how long it takes you to:

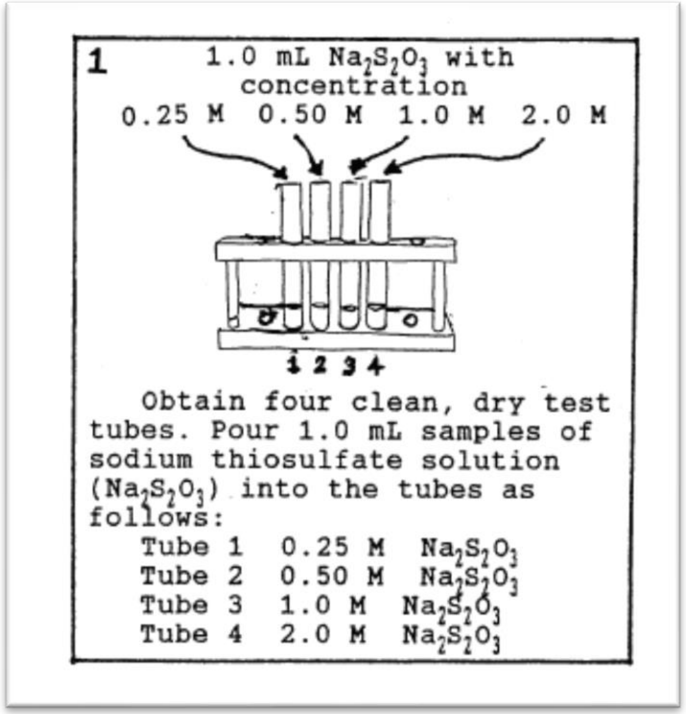
Write out A1, B2, C3 through to Z26, in order, left to right.

Compare with your previous time.

Integrated Instructions – Deschri *et al*

1. Obtain four clean, dry test tubes. Pour 1.0 mL samples of sodium thiosulfate solution ($Na_2S_2O_3$) into the tubes as follows:

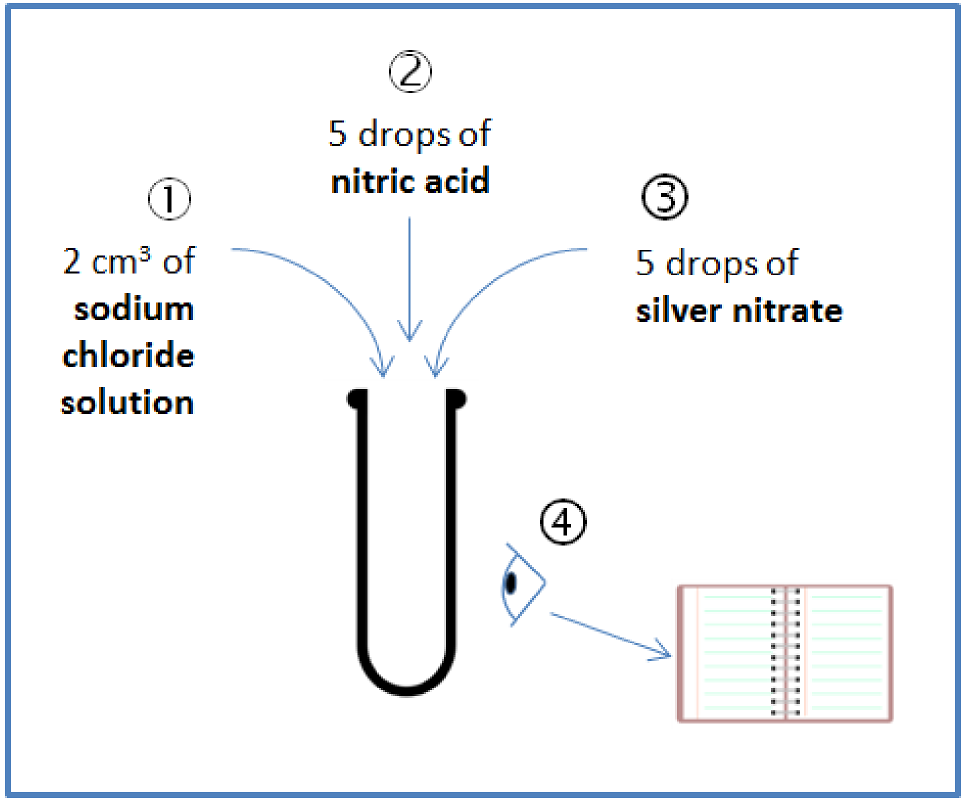
   Tube 1 0.25 M $Na_2S_2O_3$
   Tube 2 0.50 M $Na_2S_2O_3$
   Tube 3 1.0 M $Na_2S_2O_3$
   Tube 4 2.0 M $Na_2S_2O_3$



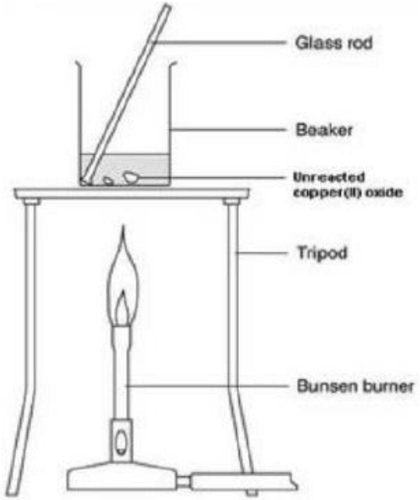
Deschri *et al* (1997), J Res Sci Teach, 34(9), 891-904: Effect of a Laboratory Manual Design Incorporating Visual Information-Processing Aids on Student Learning and Attitudes

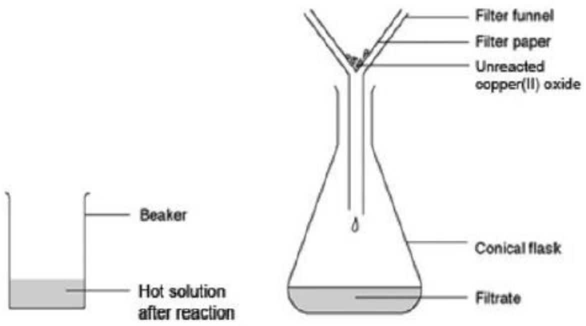
Integrated Instructions

1. Add 2 cm^3 of 0.2 M sodium chloride solution to a test tube.
2. Add 5 drops of 0.5 M nitric acid to the same test tube.
3. Add 5 drops of 0.1 M silver nitrate solution to the same test tube.
4. Make and record your observations.



Split attention in practical work

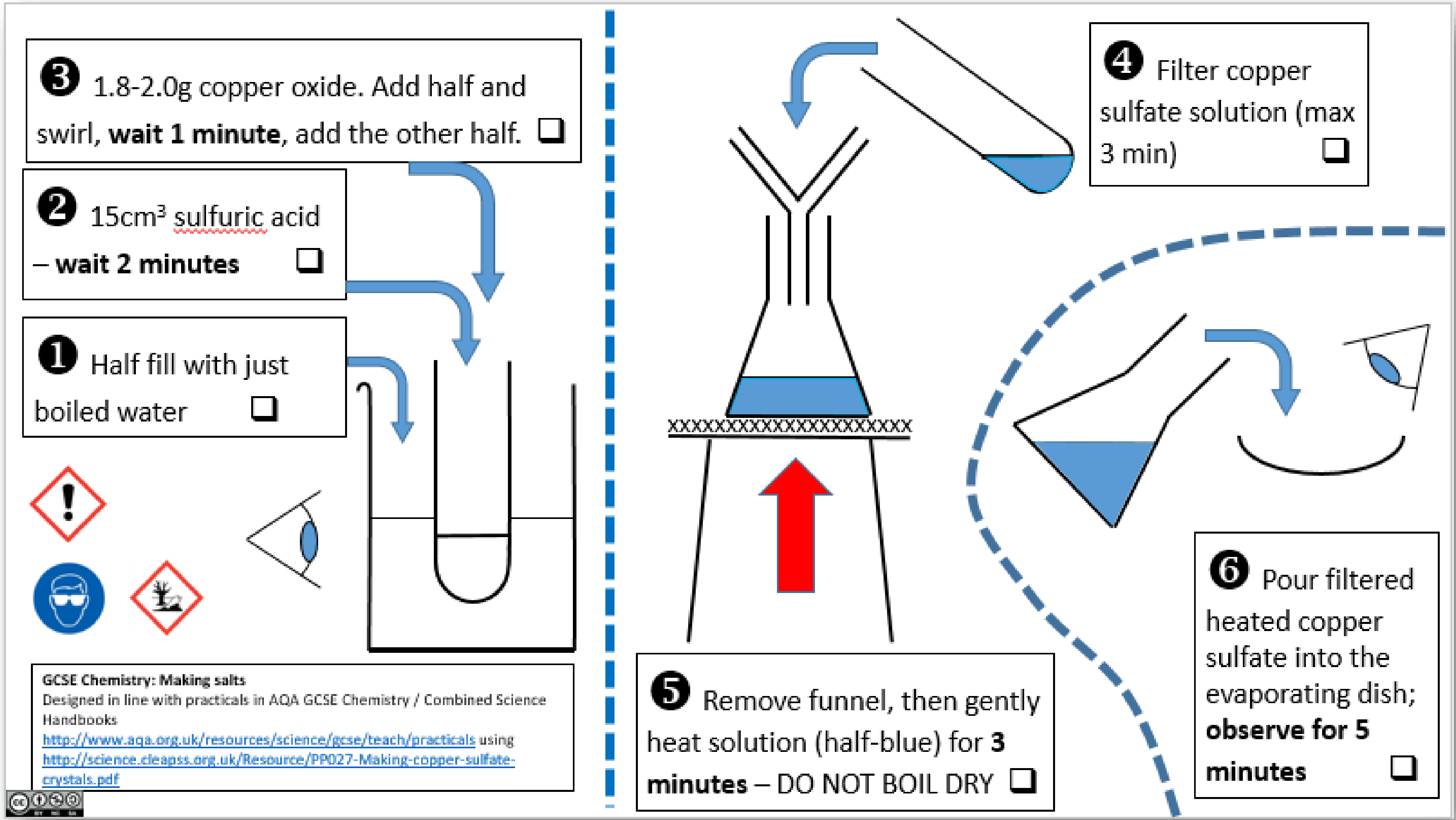




a Add 20 cm3 of the 0.5 M sulfuric acid to the 100 cm3 beaker. Heat carefully on the tripod with a gentle blue flame until nearly boiling.
b When the acid is hot enough (just before it starts to boil), use a spatula to add small portions of copper(II) oxide to the beaker. Stir the mixture gently for up to half a minute after each addition.
c When all the copper(II) oxide has been added, continue to heat gently for 1 to 2 minutes to ensure reaction is complete. Then turn out the Bunsen burner. It may be wise to check (using pH or litmus paper) that no acid remains. If the acid has not been hot enough, excess acid can co-exist with copper oxide.
d Allow the beaker to cool slightly while you set up Stage 2.
Stage 2
e Place the filter funnel in the neck of the conical flask.
f Fold the filter paper to fit the filter funnel, and put it in the funnel.
g Make sure the beaker is cool enough to hold at the top. The contents should still be hot.
h Gently swirl the contents to mix, and then pour into the filter paper in the funnel. Allow to filter through.
i A clear blue solution should collect in the flask. If the solution is not clear, and black powder remains in it, you will need to repeat the filtration.
Stage 3 (optional)
j Rinse the beaker, and pour the clear blue solution back into it. Label the beaker with your name(s). Leave the beaker in a warm place, where it won't be disturbed, for a week or so. This will enable most of the water to evaporate. would fill with toxic fumes.
k Before all the water has evaporated, you should find some crystals forming on the bottom of the beaker. Filter the solution. Collect the crystals from the filter paper onto a paper towel.

http://www.rsc.org/learn-chemistry/resource/res00001917/reacting-copper-ii-oxide-with-sulfuric-acid?cmpid=CMP00006703

Integrated-instructions in practical work



Student practical work

Data collection

Questions
What observation(s) did you make that showed you a chemical reaction had occurred?
What was the purpose of step 5 – gently heating the solution for 2 minutes?
Describe the purpose of step 6.

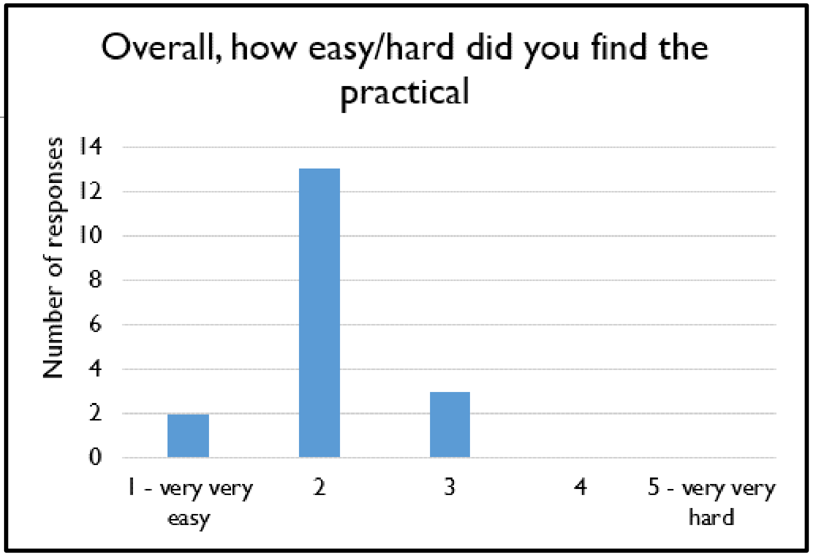
Evaluation	Response (thinking a
Overall, how easy/hard did you find the practical (circle one number)	**1** very very easy **2**
How did the instructions help you **understand** what you were doing?	
How did the instructions help your **confidence** in completing the practical?	

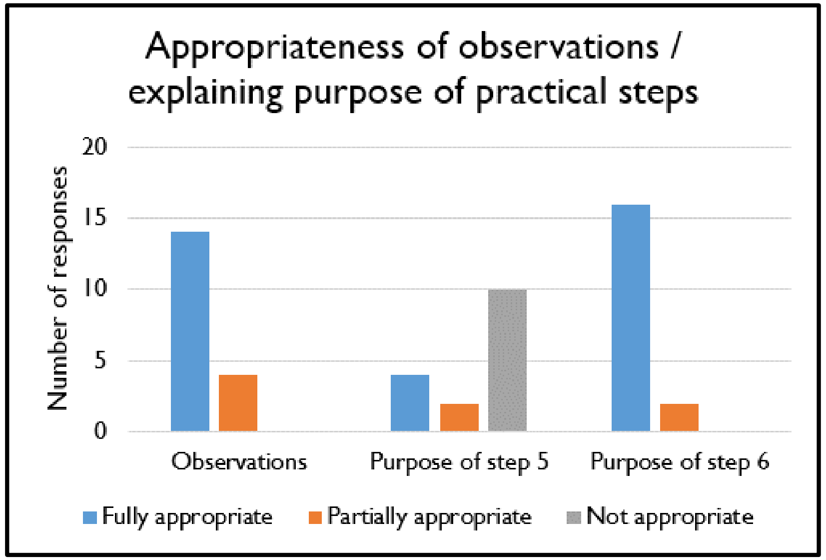
Early data

- Year 9 teaching group (18 students)
- Completed in 22 ± 5 minutes
- 23 student questions (12 required additional guidance)

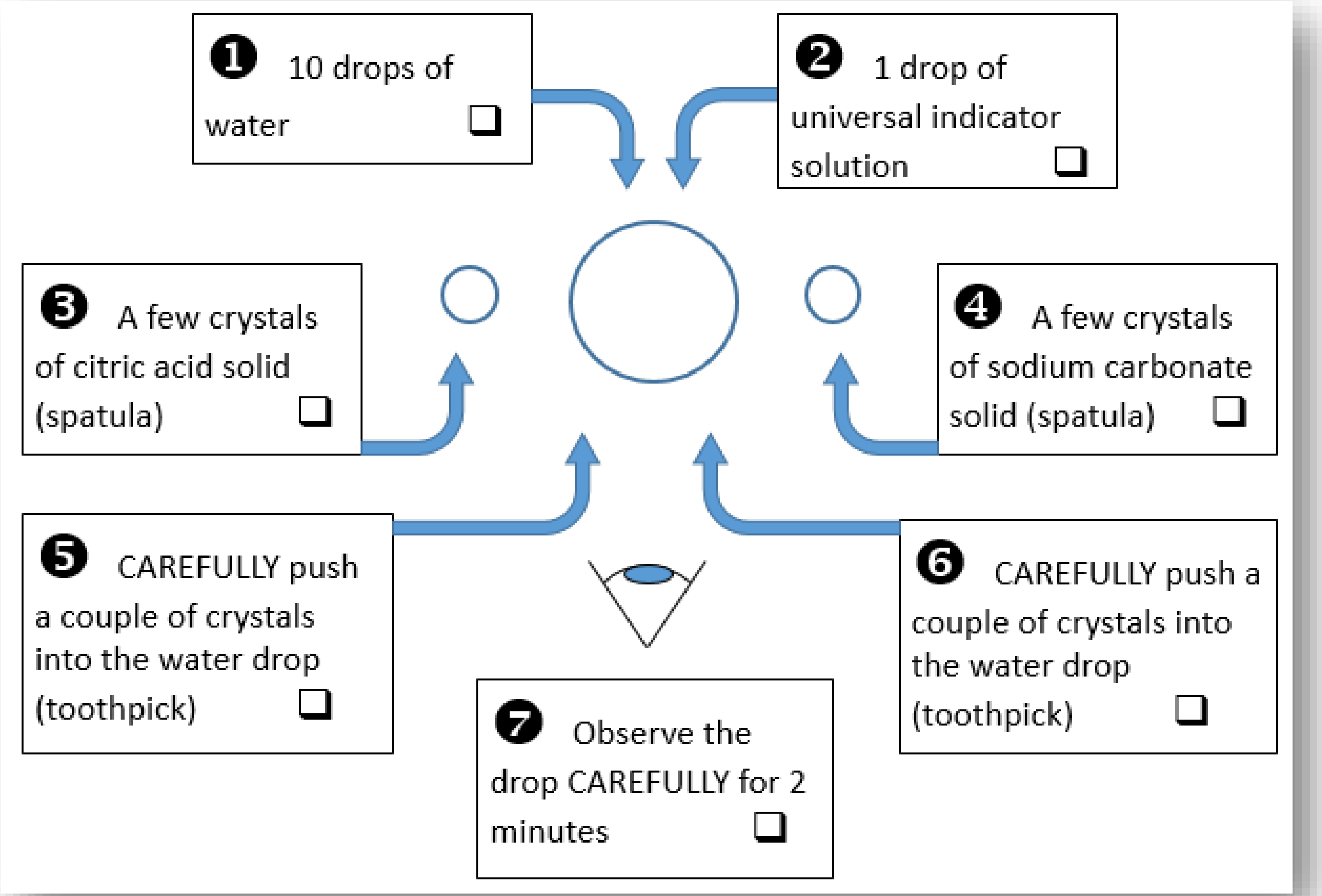
“[The instructions] were clear, direct and the annotations helped to show what exactly we should do.”

“The pictures helped my confidence. I could visualise what I was doing.”



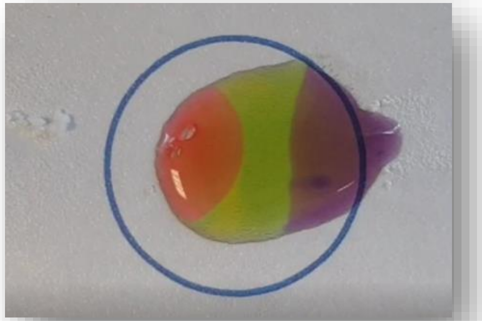


Microscale neutralisation

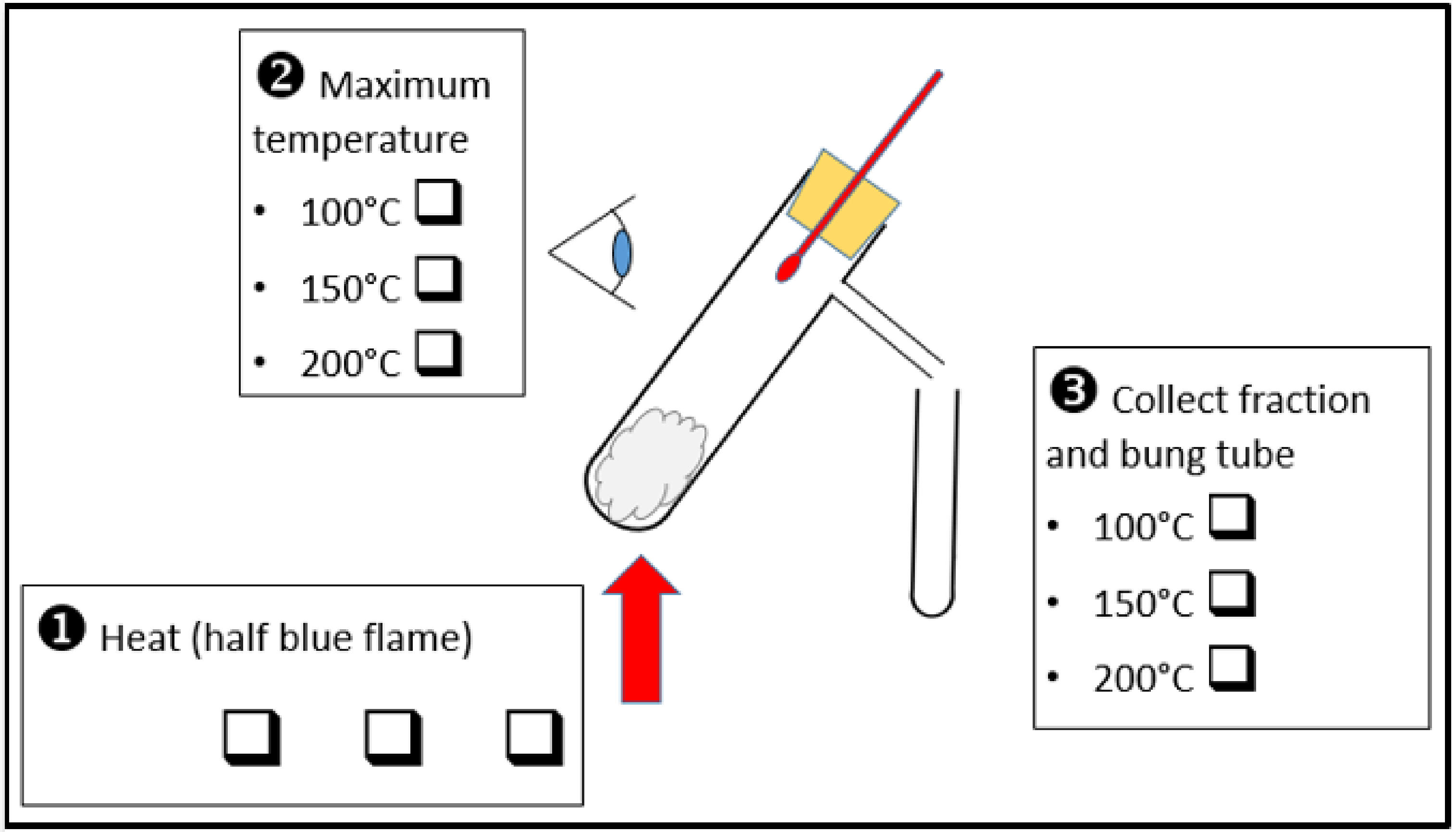


Questions:

- Describe the sequence of observations – what happened first, second etc.
- What observations did you make that solutions were formed?
- What observations did you make that showed a neutralisation has occurred?



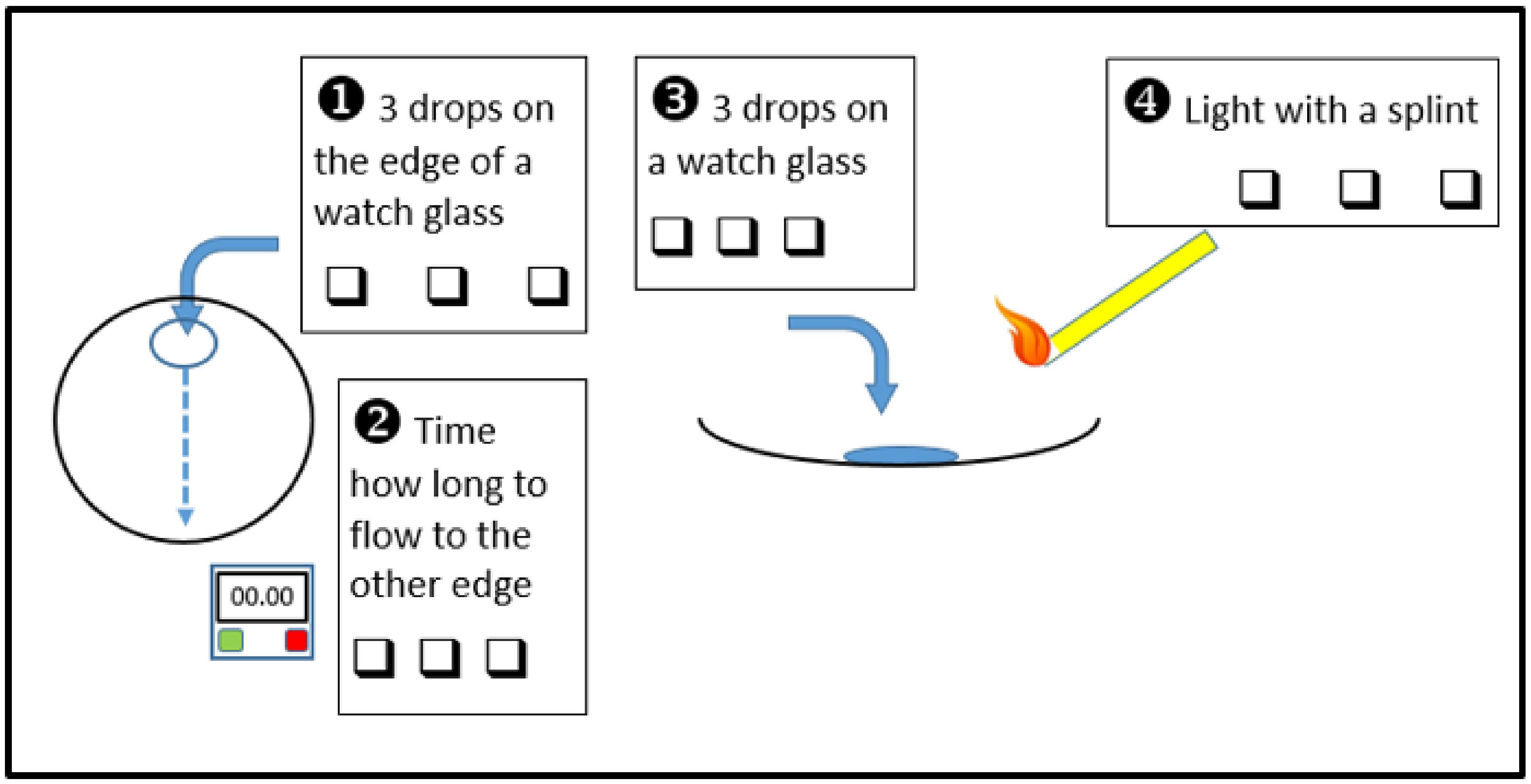
Distillation of crude oil



Questions:

- ❑ Describe the change in temperature you observed as you heated the crude oil.
- ❑ What observations did you make that showed distillation was occurring?
- ❑ What was the purpose of the tube between the **boiling tube** and **the collection test tube**?

Properties of crude oil fractions



Questions:

- Describe how the viscosity changed between the fractions.
- Describe how the ease of setting light to the fractions changed between the fractions.
- Describe how the odour changed between the fractions.

Student task completion and learning

- All students completed all practical
- On average only one in-practical question per two students
- Most questions referred back to instructions
- Most students gave at least ‘partially appropriate’ answers to ‘observation’ questions
- Variable responses to ‘reason for practical step’ questions

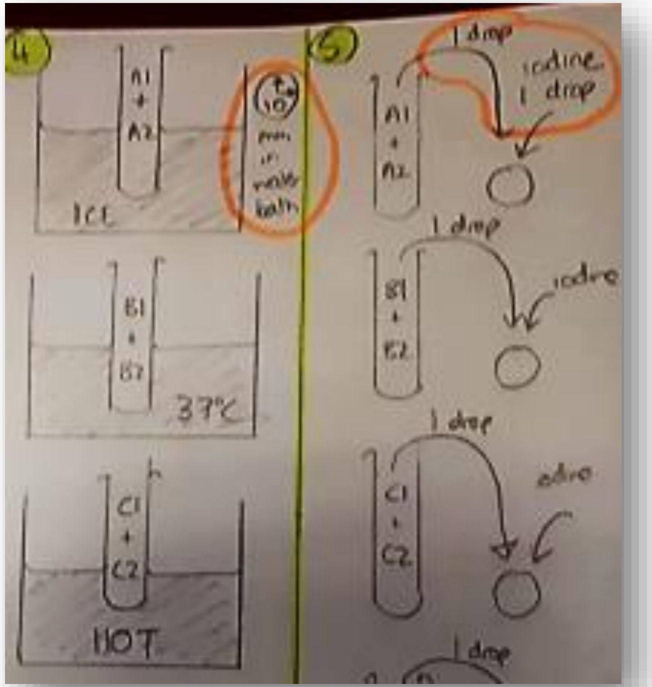
Students’ opinions of integrated instructions

- All students ranks all practical 1-3 on the Likert scale for ‘how easy was the practical’
- Students like the ‘clarity’ of the instructions – they could ‘see’ what they were supposed to so.
- *“It helped me do the practical without asking the teacher”*
- *“They gave me more confidence because I knew I was doing the right thing”*

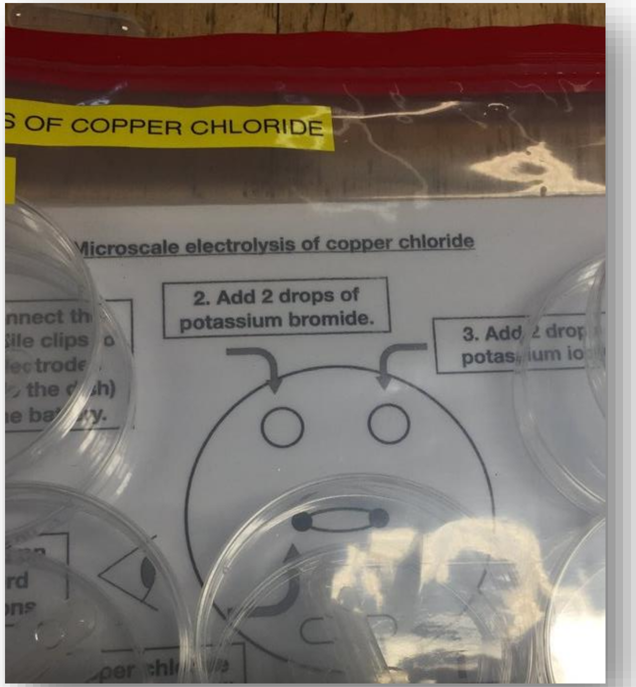
My reflections at the time

- Allowed me to have a better overview of the whole lab – less time dealing with 'thoughtless questions'
- Students quickly started self/peer correcting by reference to instructions – increased independence
- Gave a useful visual cue during and after the practical

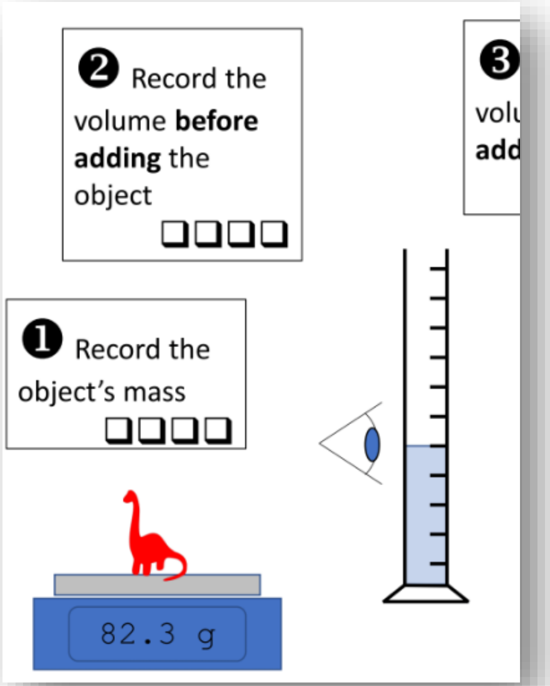
Other integrated instructions
bit.ly/integratedinstructions



Biology – food tests
(R. Kirsten, Aldenham School)

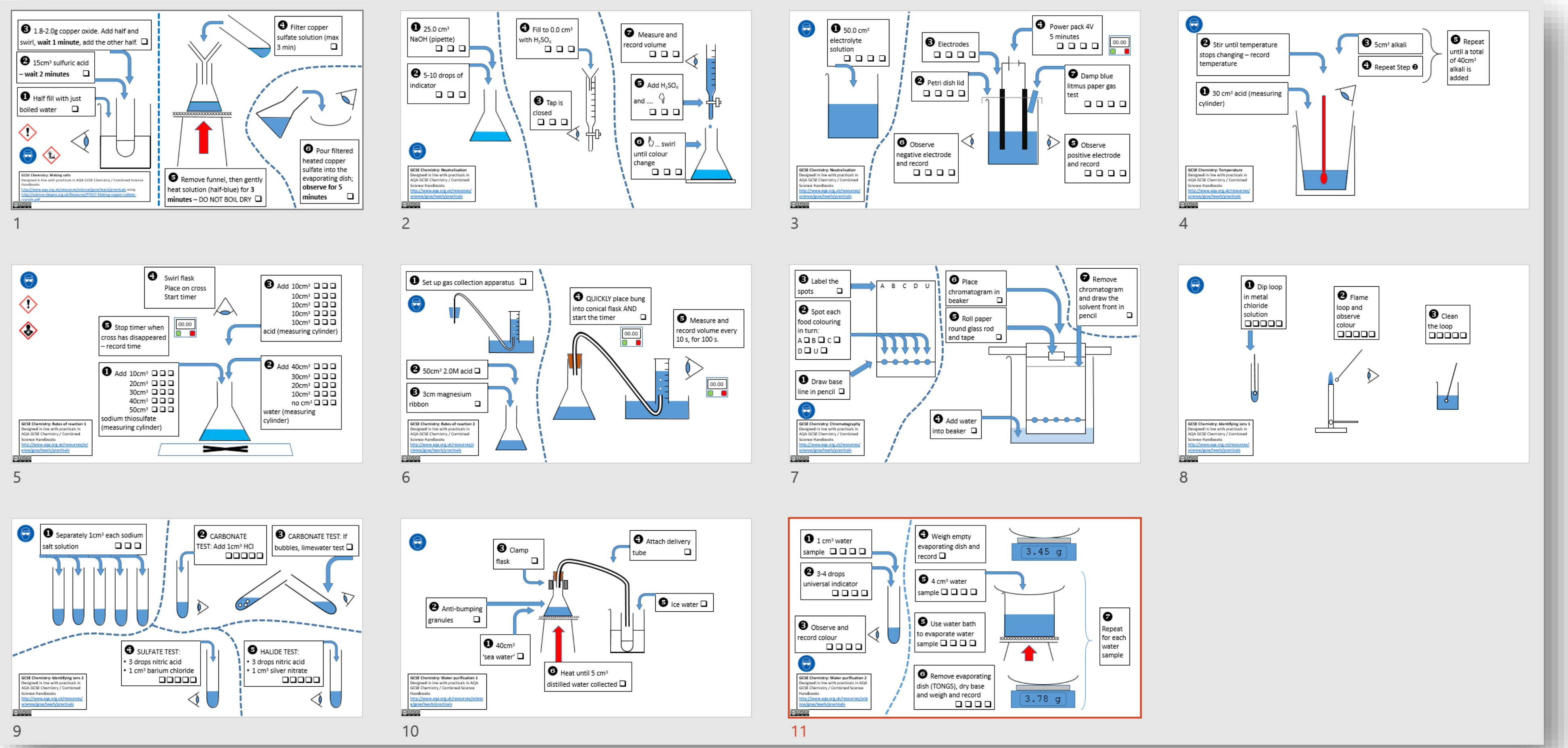


Chemistry – electrolysis
(H. Lord, Haslingden High School)



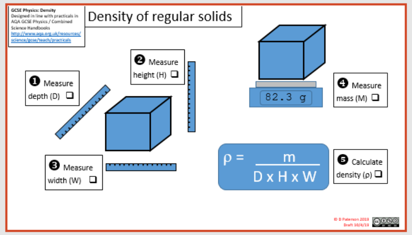
Physics – density
(B. Cook)

Chemistry 'Required' Practical (AQA)



All at http://bit.ly/integratedinstructions

Physics ‘Required’ Practicals (AQA)



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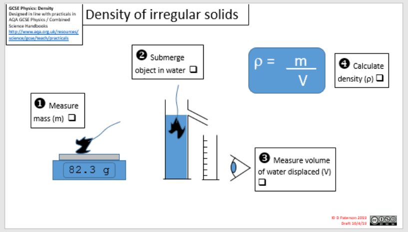

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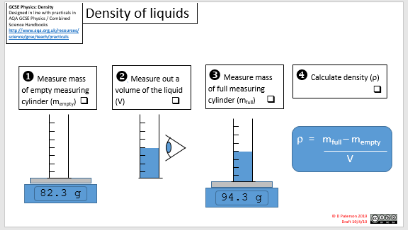

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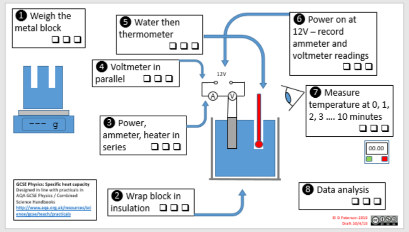

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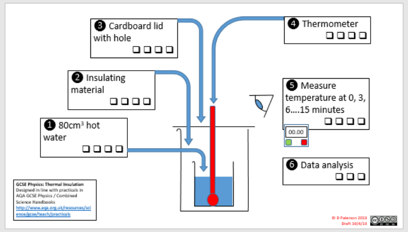

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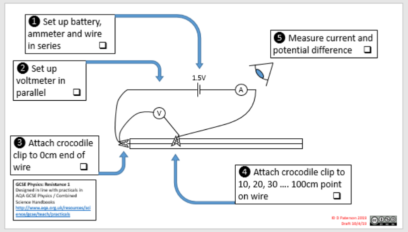

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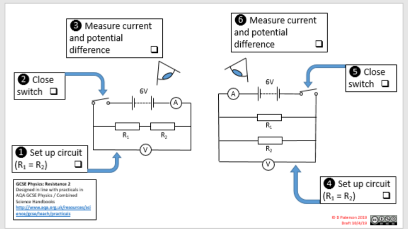

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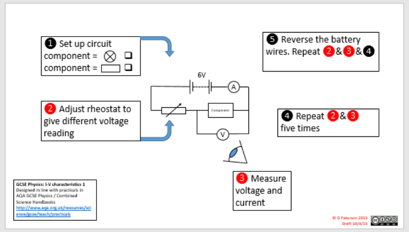

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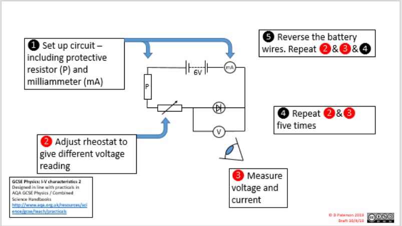

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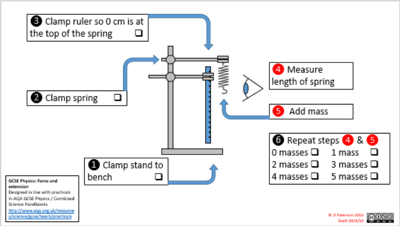

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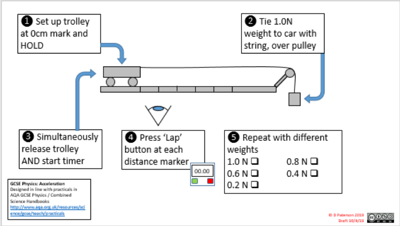

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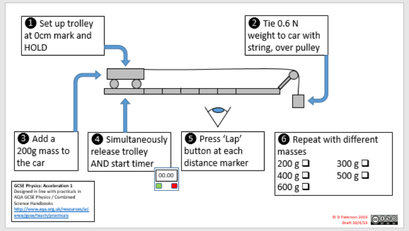

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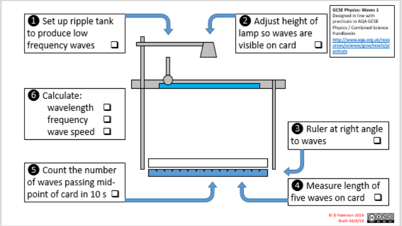

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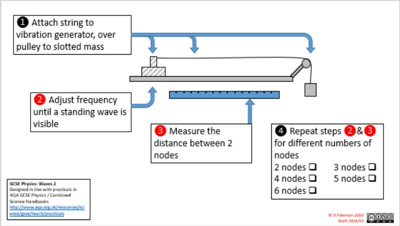

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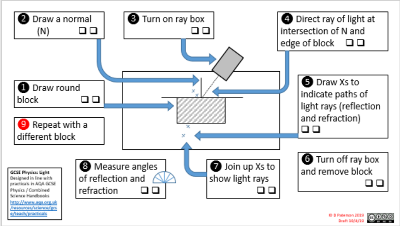

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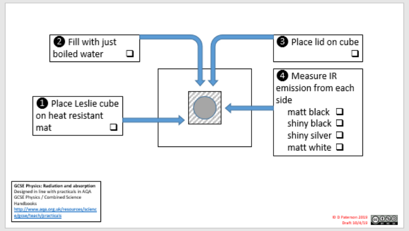
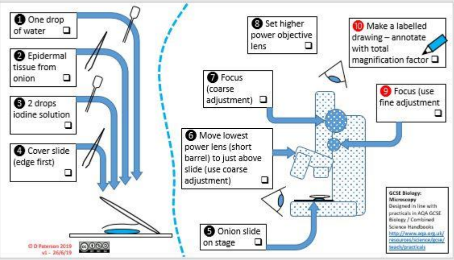


16

Biology ‘Required’ Practical(s) (AQA)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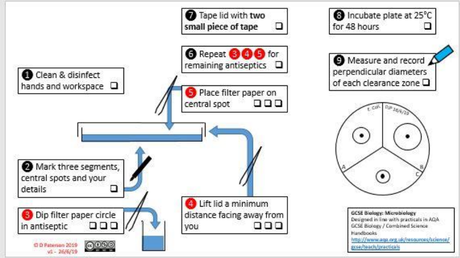
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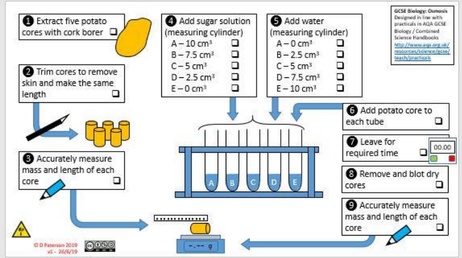
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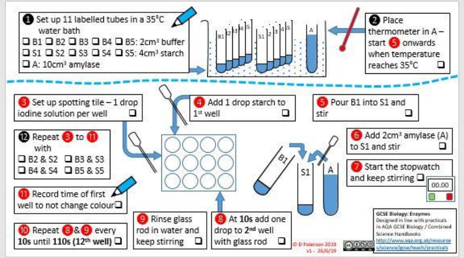
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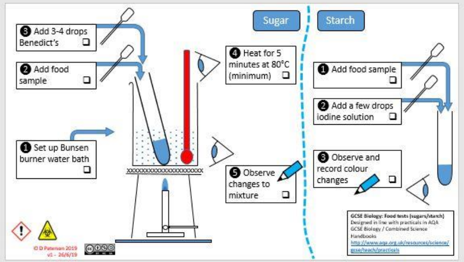
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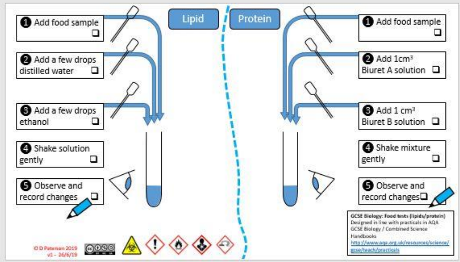
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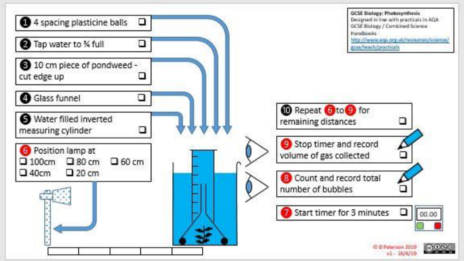
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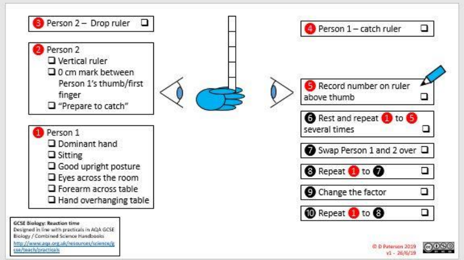
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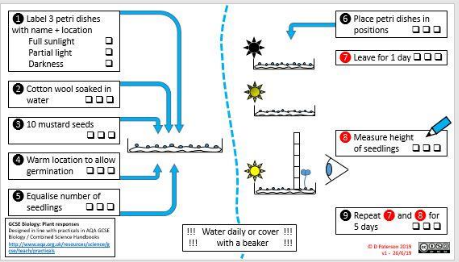
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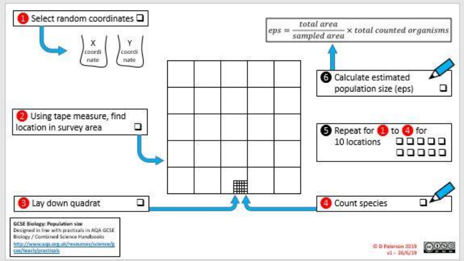
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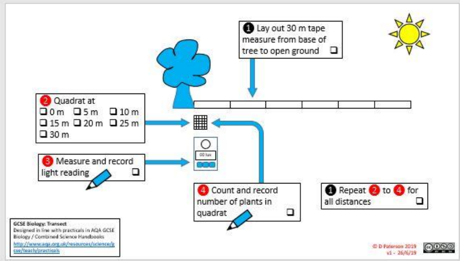
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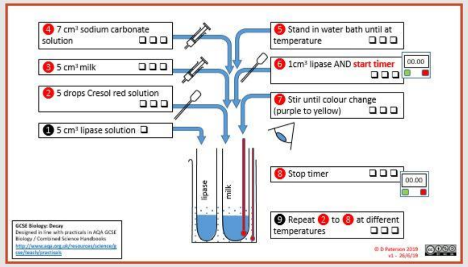
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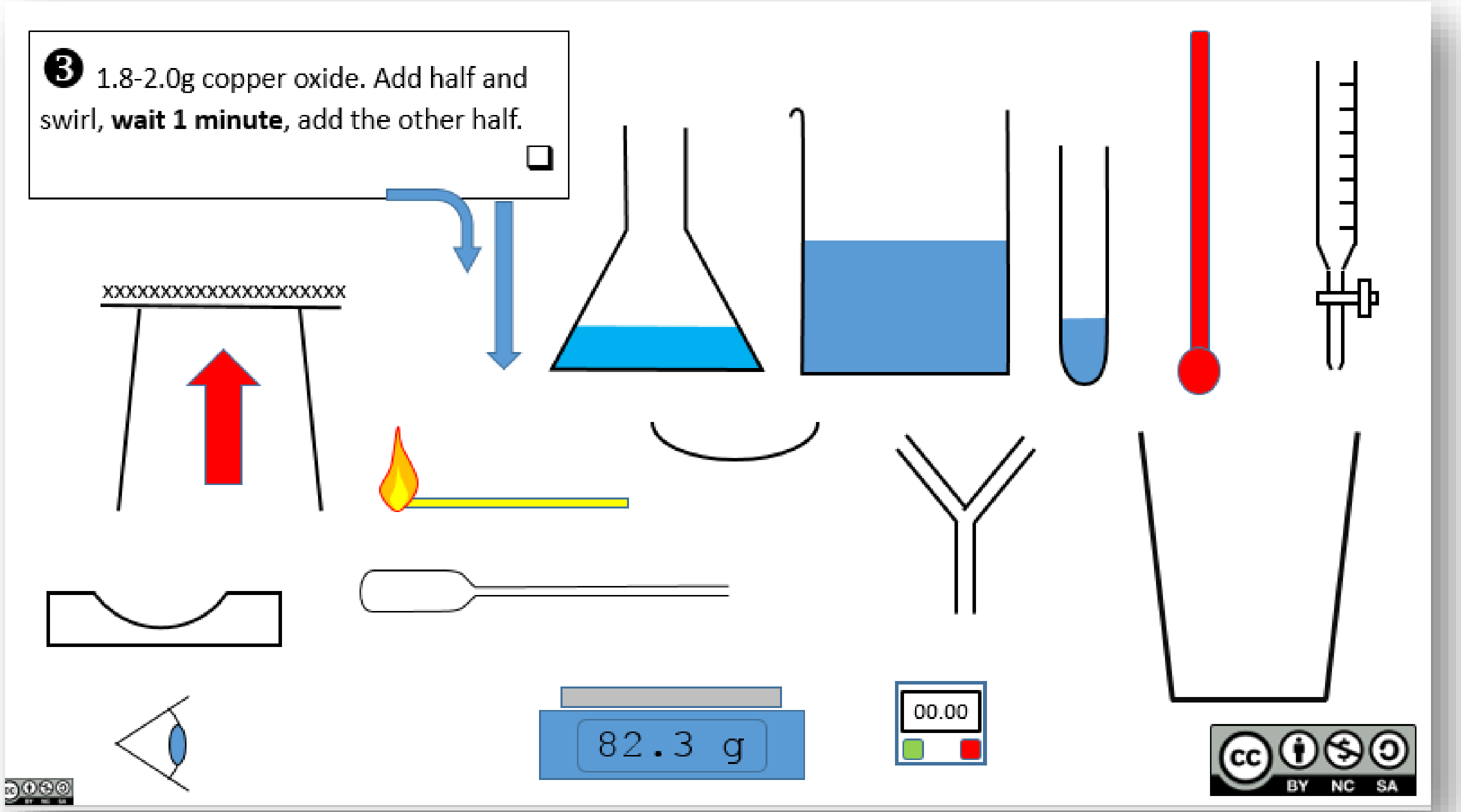
Making integrated instructions



https://dave2004b.wordpress.com/2018/02/25/integrated-instructions-templates/

Making integrated instructions

educationinchemistry

FEATURE

Improving practical work with integrated instructions

28 NOVEMBER 2018

Do your students struggle to follow written instructions?

https://eic.rsc.org/feature/improving-practical-work-with-integrated-instructions/3009798.article

EQUIPMENT	INSTRUCTIONS	FLOW	PICTOGRAMS	IN LESSON
Consider what the minimum required equipment is	Use clear numbering	Try to arrange instructions clockwise or anticlockwise	Use of 'eyes' to direct observation	Project the diagram on screen
	Minimum text necessary		Use of 'clocks' to indicate timings	Issue paper copies to all students
	Use of arrows to direct movement			
	Use tick boxes so students can track their progress			

Now…

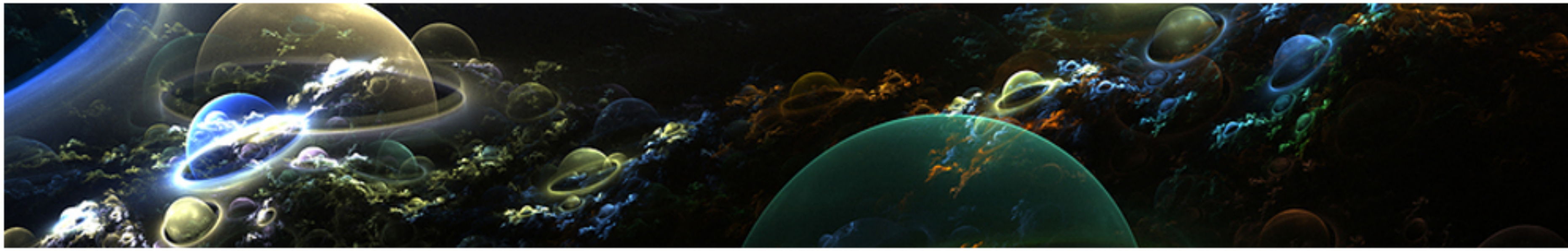
- Have a look at a couple of traditional vs integrated instructions.
- Annotate your copies – good points / constructive criticism.
- Any questions…

End notes

Plenty more at **dave2004b.wordpress.com**

@dave2004b

davidjamespaterson@yahoo.co.uk



Space Chemistry

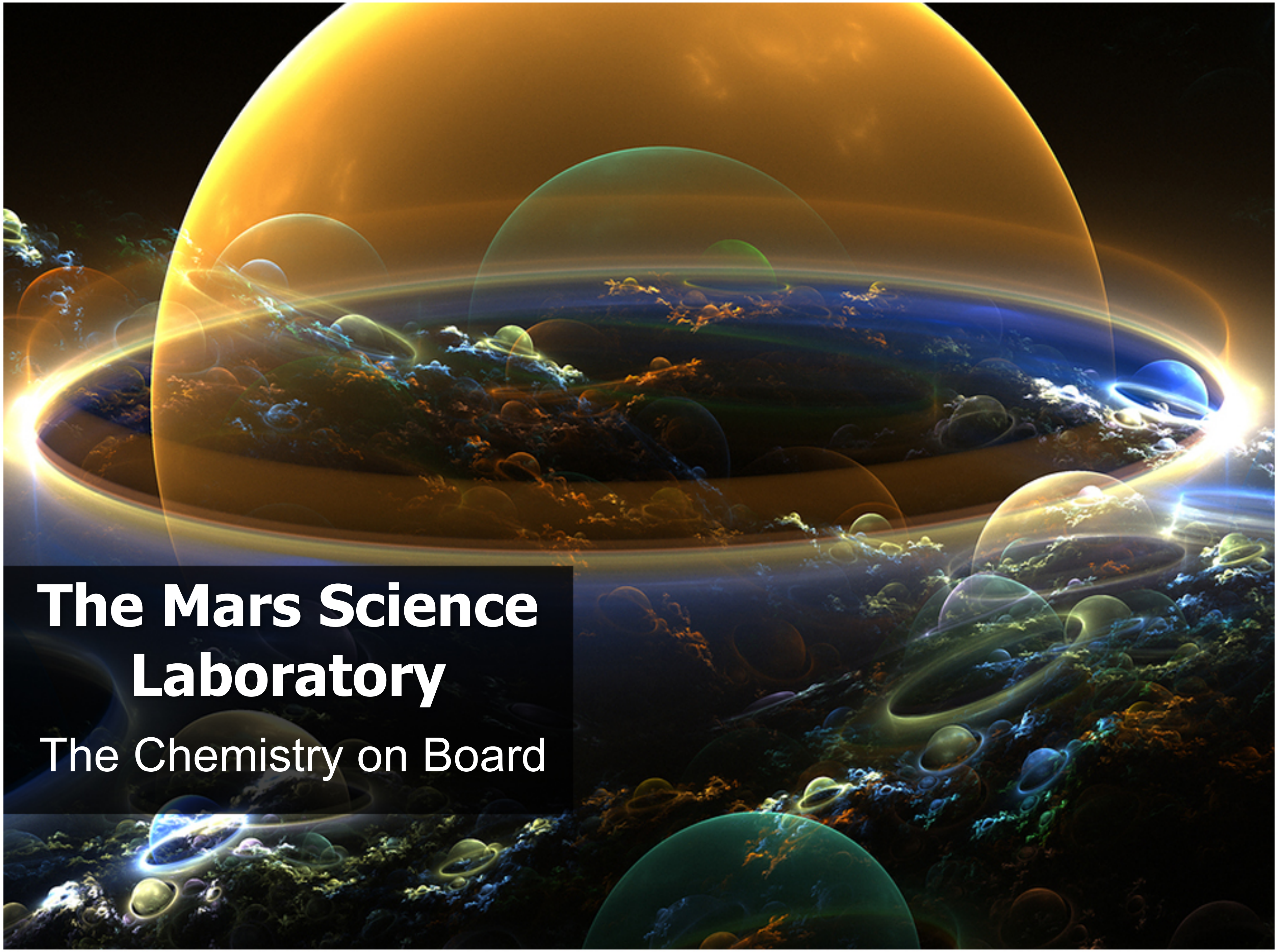
Caroline Molyneux

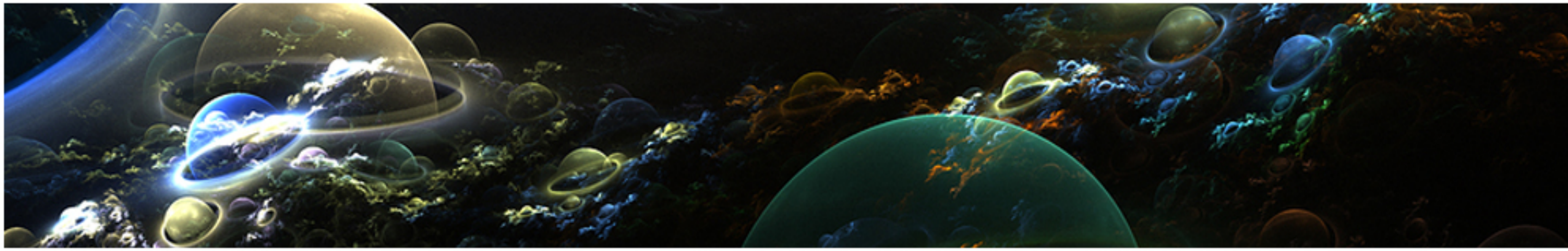
Lead Educator

National Space Centre, Leicester

Deputy Headteacher, Sharples School, Bolton

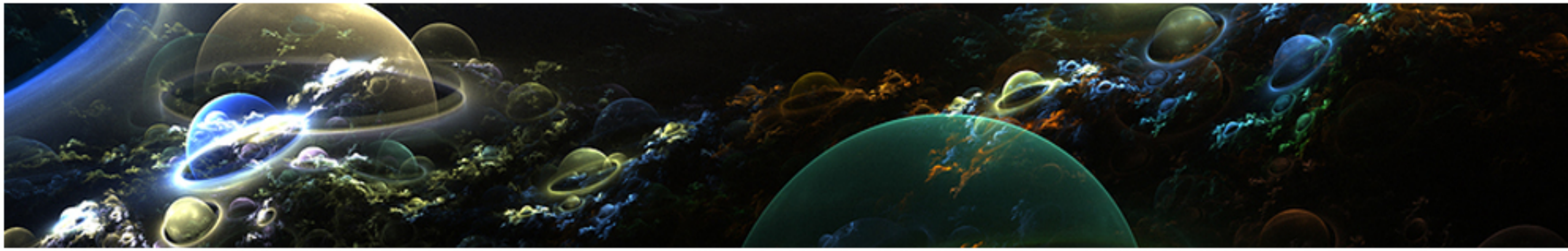
@molymemolyneux


The Mars Science Laboratory
The Chemistry on Board



Your Mission...

- Identify possible experiments on board the laboratory
- Select possible useful materials that might be found on Mars with reasons for your selections
- Explain how the Mars Science Laboratory might identify these materials once on Mars



What do YOU think those ten experiments could be looking for?

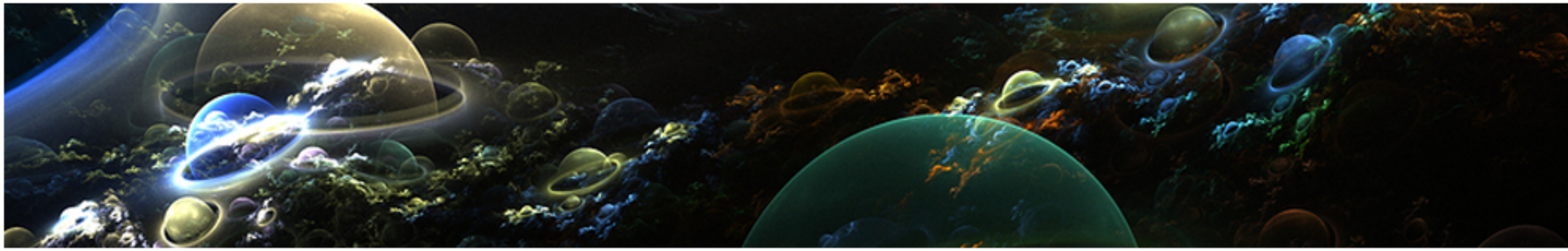
THINK OF YOUR OWN IDEAS

NOW SHARE THEM WITH A PARTNER

DECIDE ON ONE TO WRITE ON A POST IT NOTE

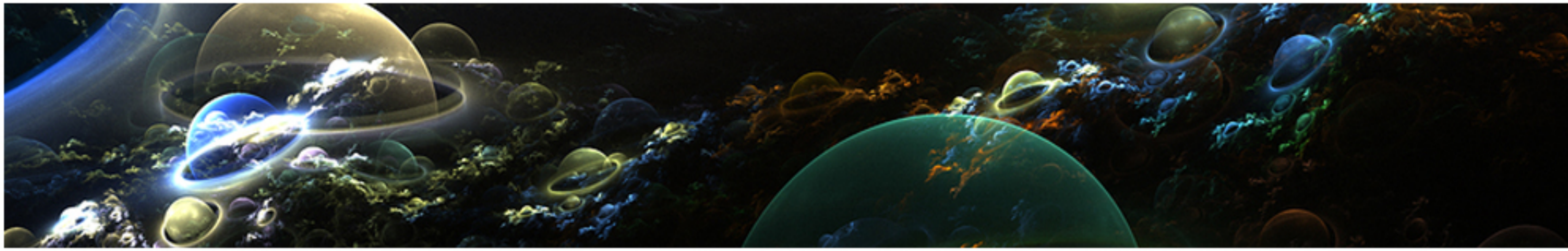
The MSL mission has four scientific goals:

- Determine whether Mars could ever have supported life
- Study the climate of Mars
- **Study the geology of Mars**
- Plan for a human mission to Mars



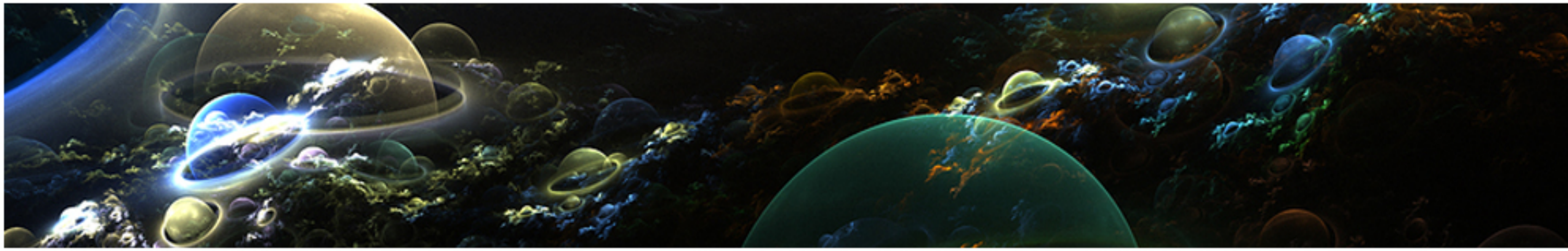
What to look for?

- Choose TWO substances to look for using the MSL
- Why would they be useful to us?
- Use YOUR knowledge and the information given to you
- You must justify your reasons for looking for these substances on Mars



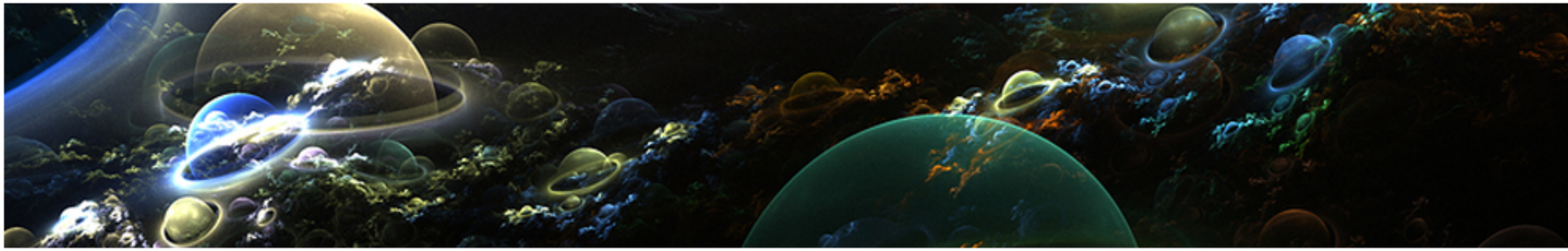
Finding your substances…

- Using the reagents provided work out what tests will need to be on board the MSL in order to find out if your chosen substances are on Mars



Equipment/Reagents

- Nitric Acid (dilute 1M)
- Hydrochloric Acid (dilute 1M)
- Barium Chloride
- Limewater
- Silver Nitrate
- Sodium Hydroxide (Dilute 1M)
- Wire Loops for Flame Tests
- Spatulas for solubility testing
- Access to water
- Test Tubes

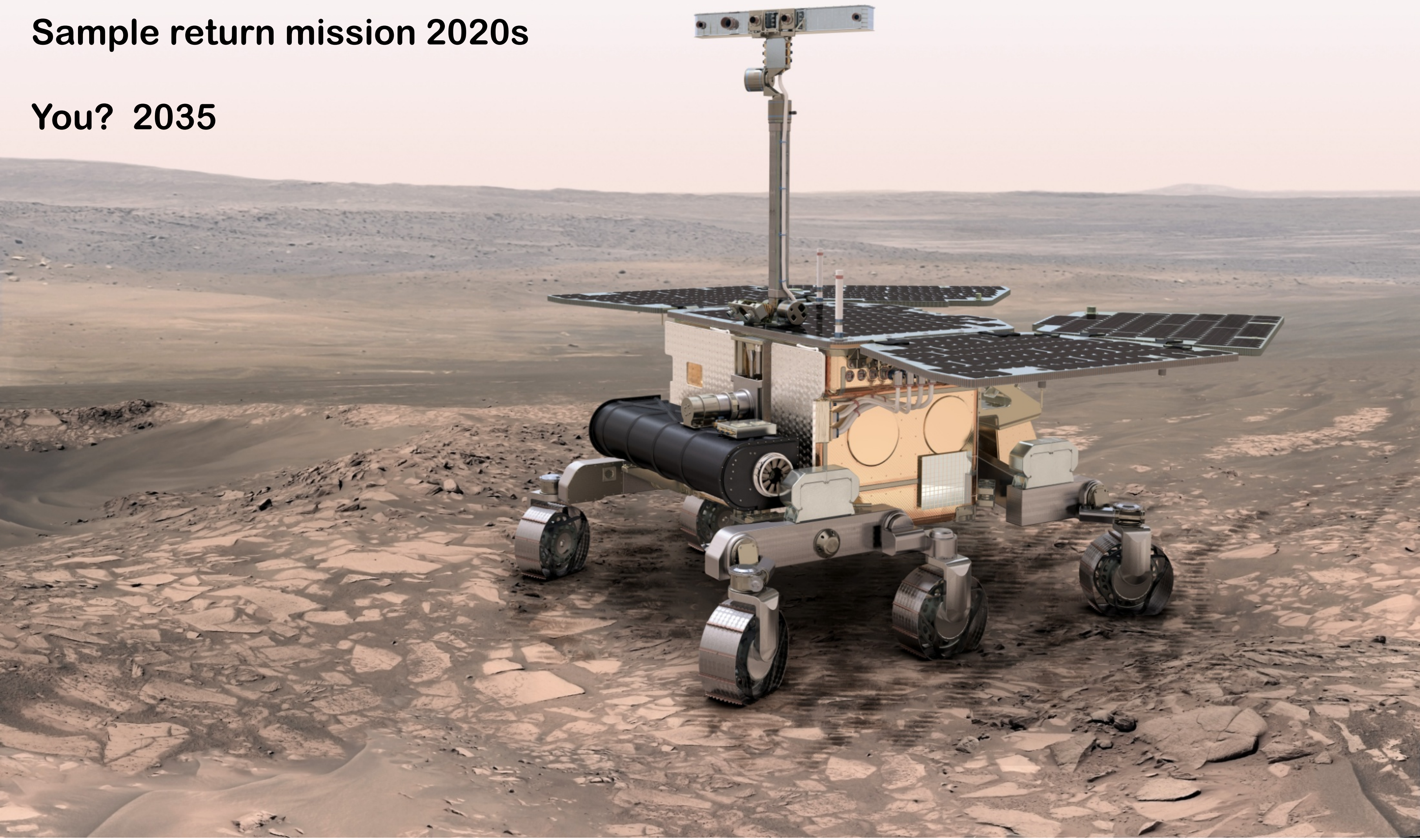


Quantitative analysis of martian soil

ExoMars Rover - launch date 2018

Sample return mission 2020s

You? 2035



Rosetta Explores a Comet

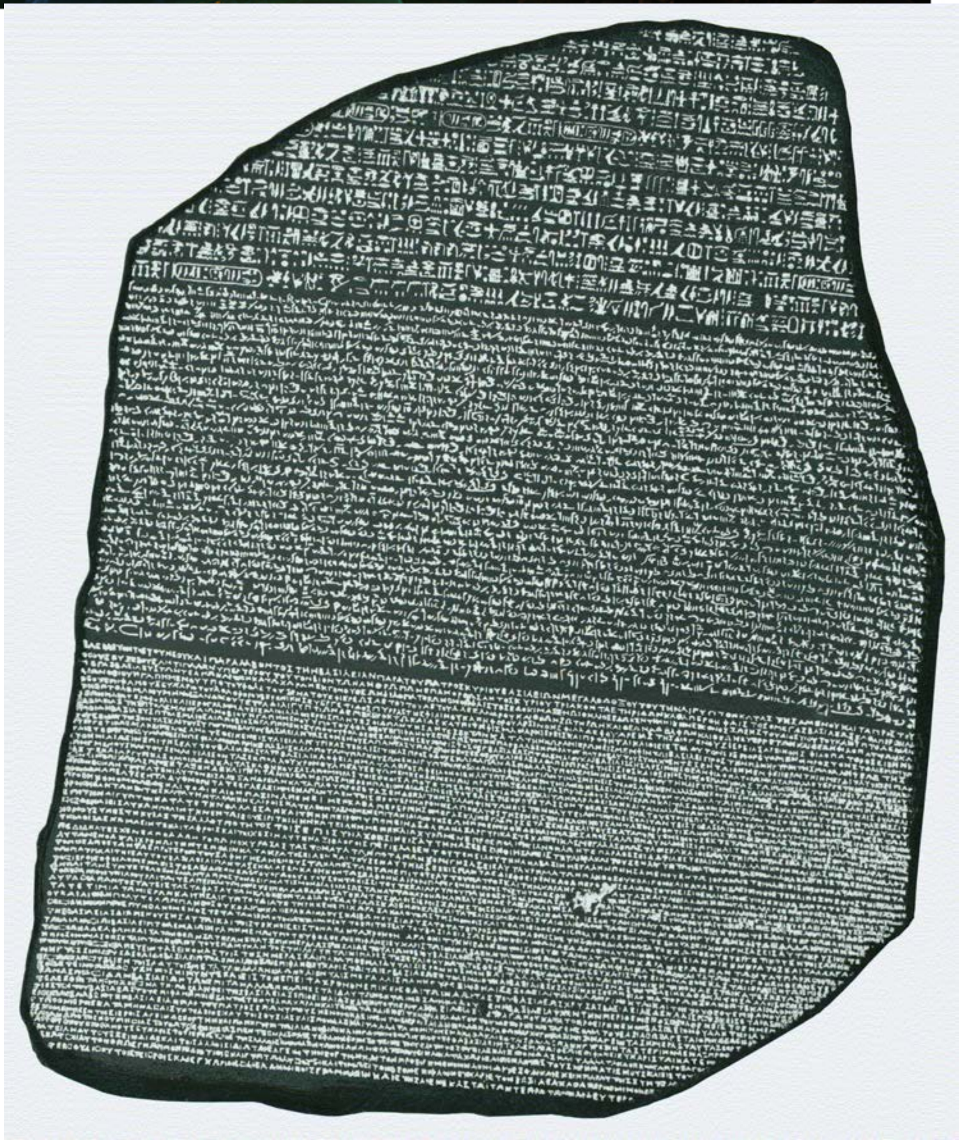
- European Space Agency (ESA)
- Launched 12 years ago, 5 Earth flybys to save fuel and weight

Rosetta ESA-Cornerstone

- Rosetta has been the first mission :
  - To orbit a comet nucleus.
  - To fly alongside a comet as it heads closer to the Sun.
  - To observe from very close proximity how the frozen comet nucleus is transformed by the heat of the Sun.
  - To send a Lander for controlled touchdown on the comet nucleus surface.
  - To obtain images from a comet’s surface and to perform in-situ analysis
  - To fly near Jupiter’s orbit using solar cells as power source.
  - To close encounter two asteroids of the asteroid belt

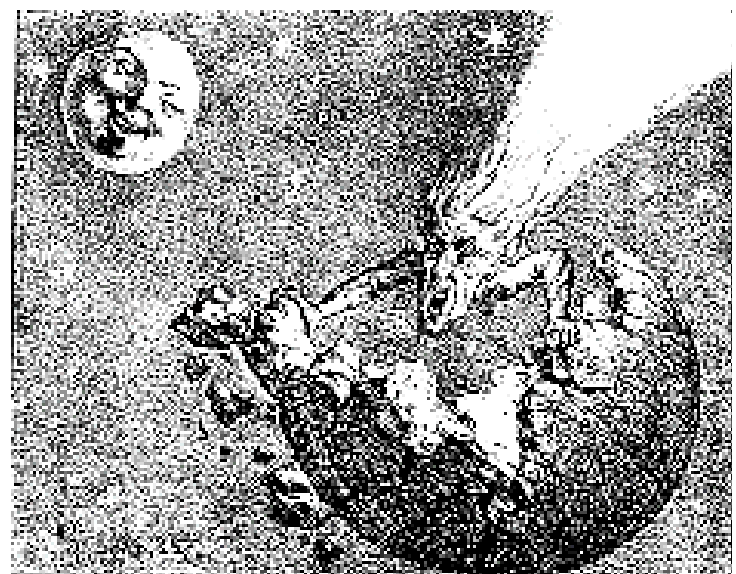
Why the name Rosetta?

- The Rosetta stone (1799) was the key to deciphering the old hieroglyphics writing of ancient Egypt.
- Obelisk from Island of Philae (1815)



Why to go to a comet?

- Comets have always attracted the attention of mankind. The apparitions are recorded in documents going back millennia.
- Comets appear suddenly and have been interpreted as good signs or as bad omens announcing great disgraces.
  Battle of Hastings (1066 AD)



Why to go to a comet?

- Are comet dangerous for us?.
  What happens if a comet hit the Earth?.
  Dinosaurs extinction event Chicxulub impact crater in Yucatan (discovered 1991).

Why to go to a comet)

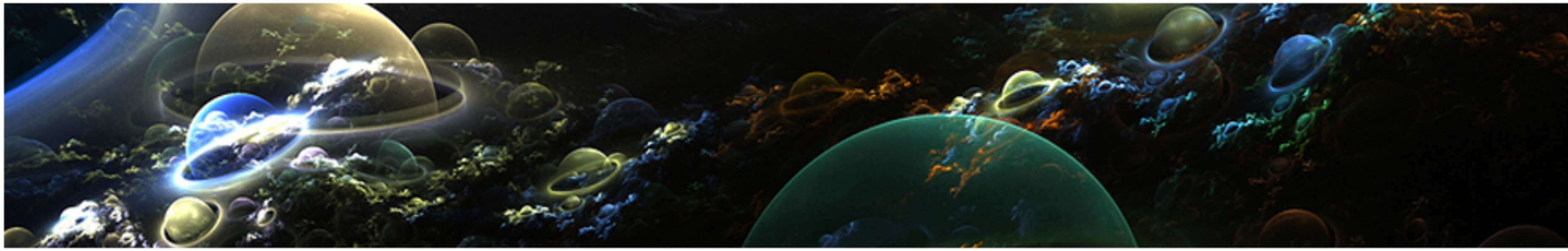
- A comet is a celestial body originating very far away from the Sun
  - Oort cloud, far beyond Pluto (50000 AU)
  - Kuiper Belt, beyond Neptune (30-100 AU)

- nucleus composed of ice, dust, of a size between a few hundred m up to a few km. Carbon compounds.

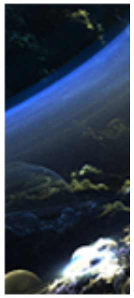
  Near the Sun it develops a coma (~ 100000 km), and tails (dust, ion) several Mkm

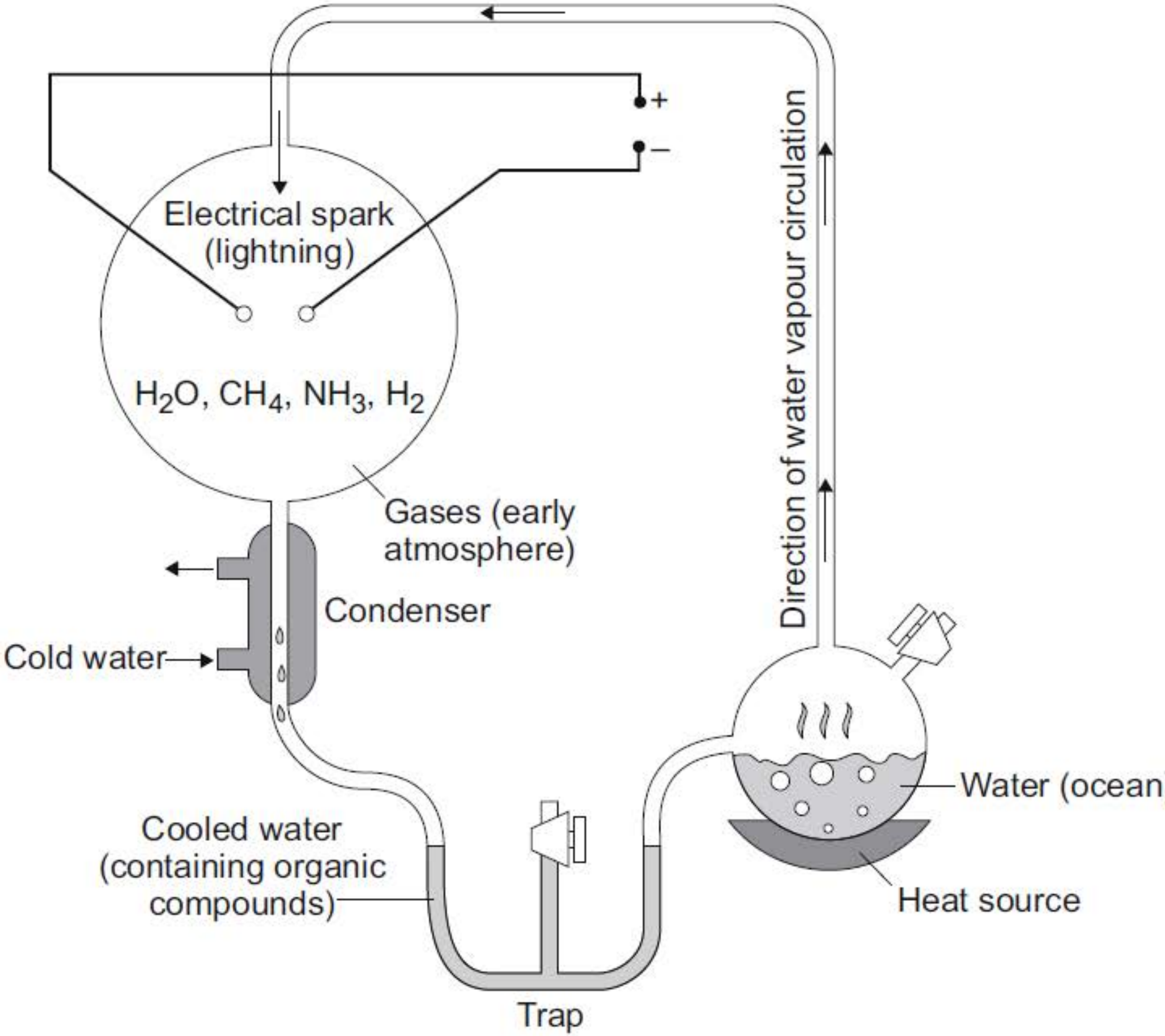
Why to go to a comet?

- Scientist wants to study comets because these are what is left of the "primitive cloud". They are time capsules preserving the physical and chemical conditions that existed when the planets were formed 4.5 billions of years ago.
- Comets could have provided water and organic material to the Earth.
- Comets can help to understand conditions of formation of the solar system



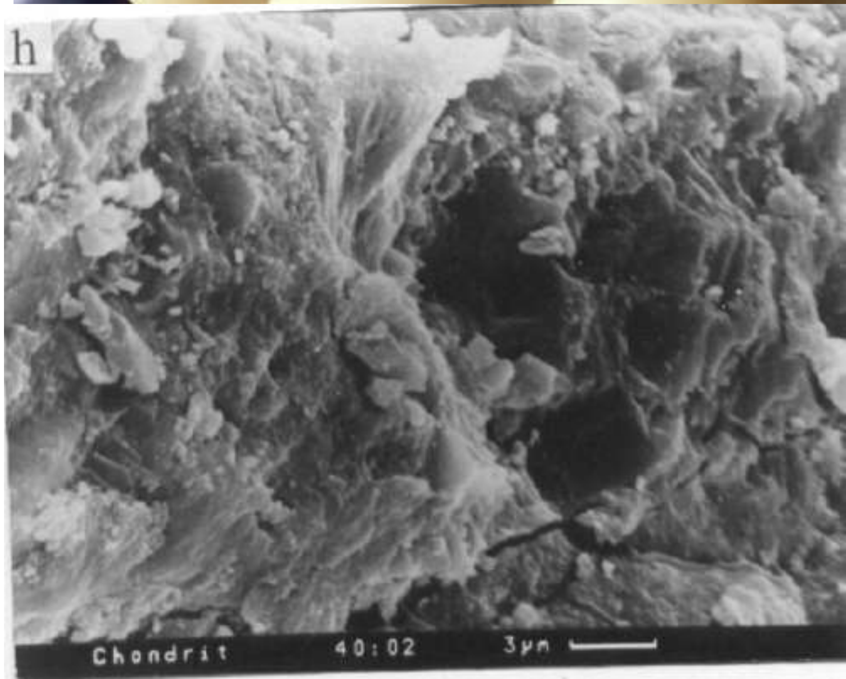
Life on Earth




Electrical spark
(lightning)
+
–
H_2O, CH_4, NH_3, H_2
Gases (early
atmosphere)
Direction of water vapour circulation
Condenser
Cold water
Cooled water
(containing organic
compounds)
Trap
Water (ocean)
Heat source

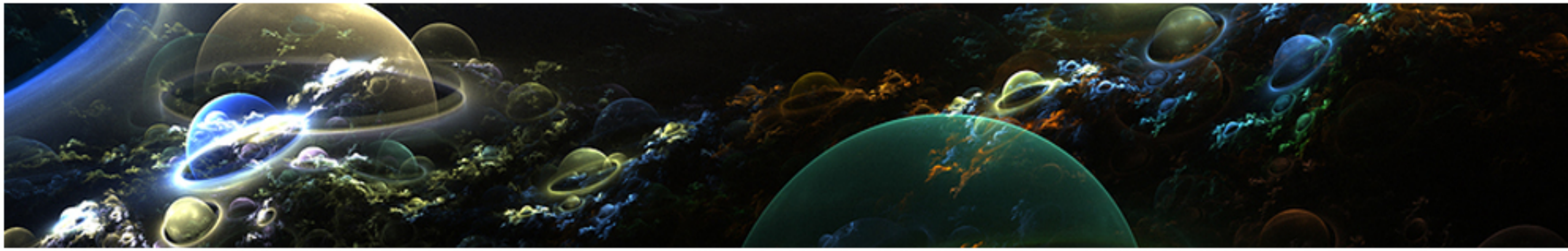
Murchison Theory

- In 1969 a meteorite fell from the sky above Australia. It weighed over 100kg.
- We have identified over 70 amino acids on the fragments.
- Extraterrestrial seeding?



Primordial Soup

- The organic molecules arrived somehow, from what ever source.
- These could have all been in the seas
- React together somehow to make the first primitive cells.



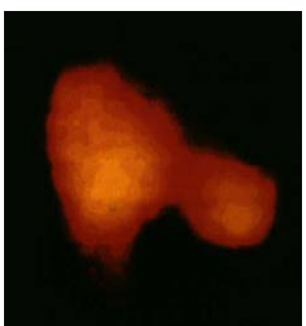
Comet samples

1. Using a microscope
2. Using the biurets test for protein
3. Using the iodine test for starch

Is there any evidence of the building blocks of life?

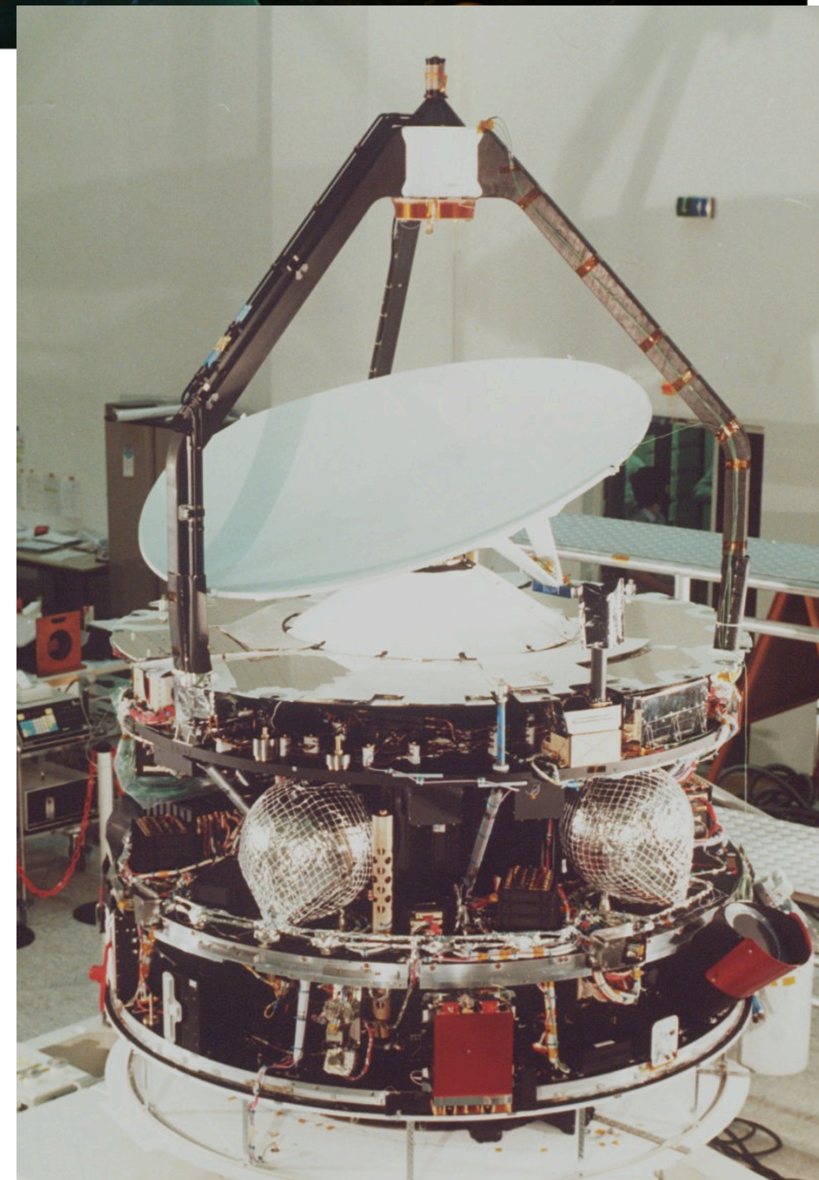
Space Missions to Comets

- To Halley
  - Giotto, 1986, 600 km, 68 km/s and comet Grigg-Skjellerup, 1992, 200 km. (ESA)
  - VEGA-1 & VEGA-2, 9000 km, 78 km/s1986. (RUS)
  - Sakigake & Suisei, 7 Mkm, 150000 km,1986. (JAP)



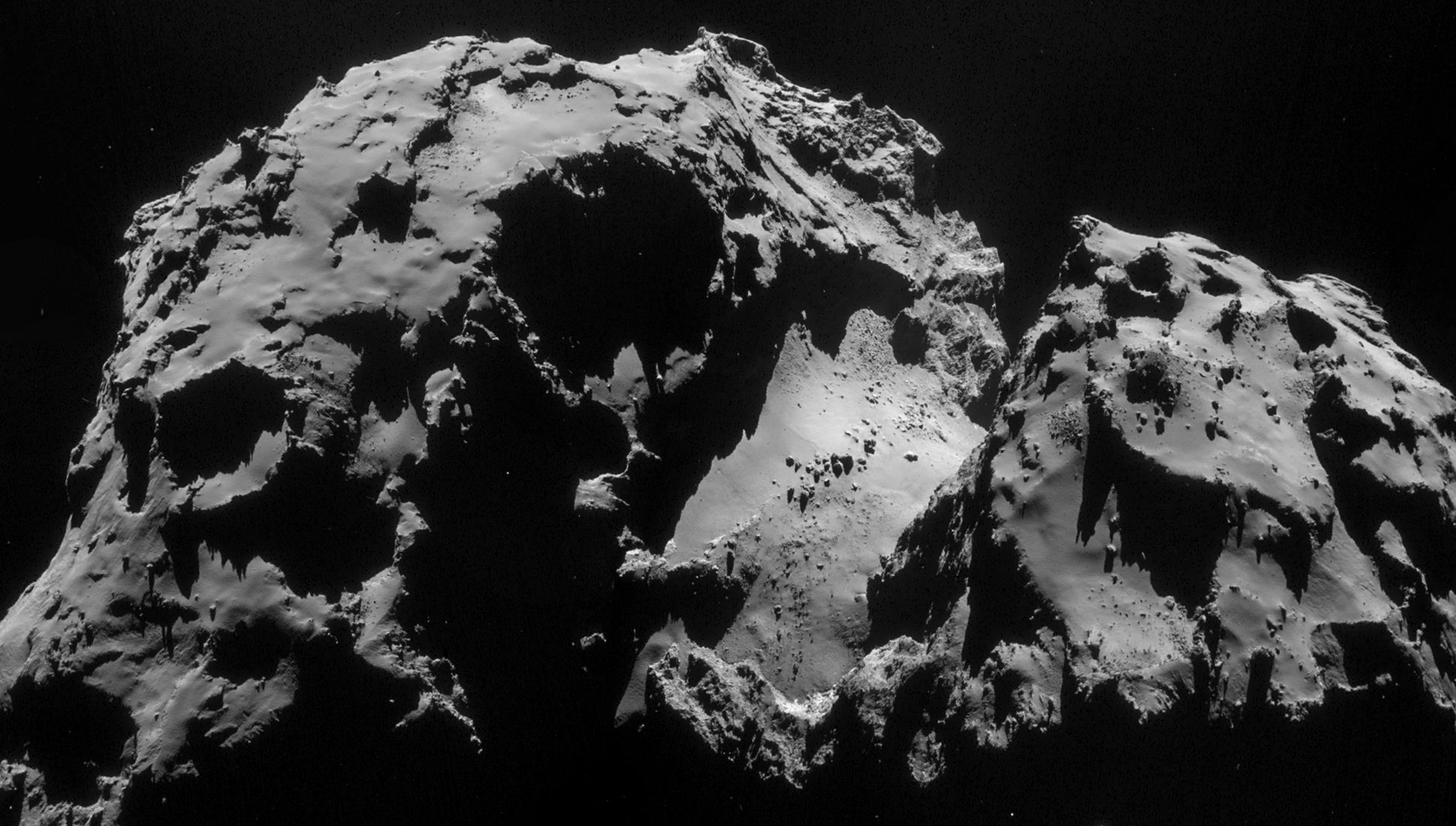
VEGA

Giotto



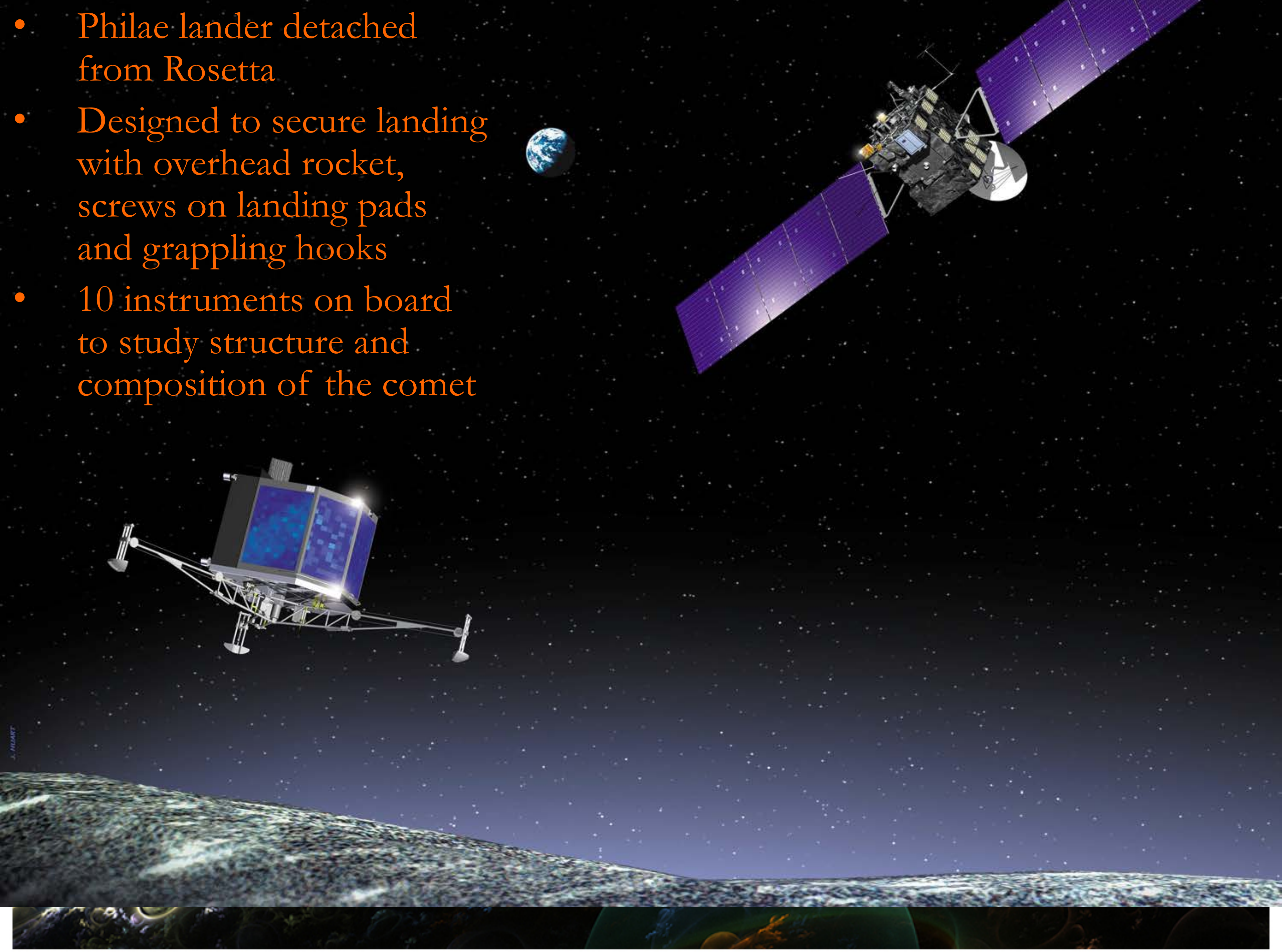
Rosetta Explores a Comet

- Comet 67P or Churyumov-Gerasimenko (after who found it)
- 4x4.5 km – here with Los Angeles for scale
- Very low density (0.05 g/cm3!) like talcum powder

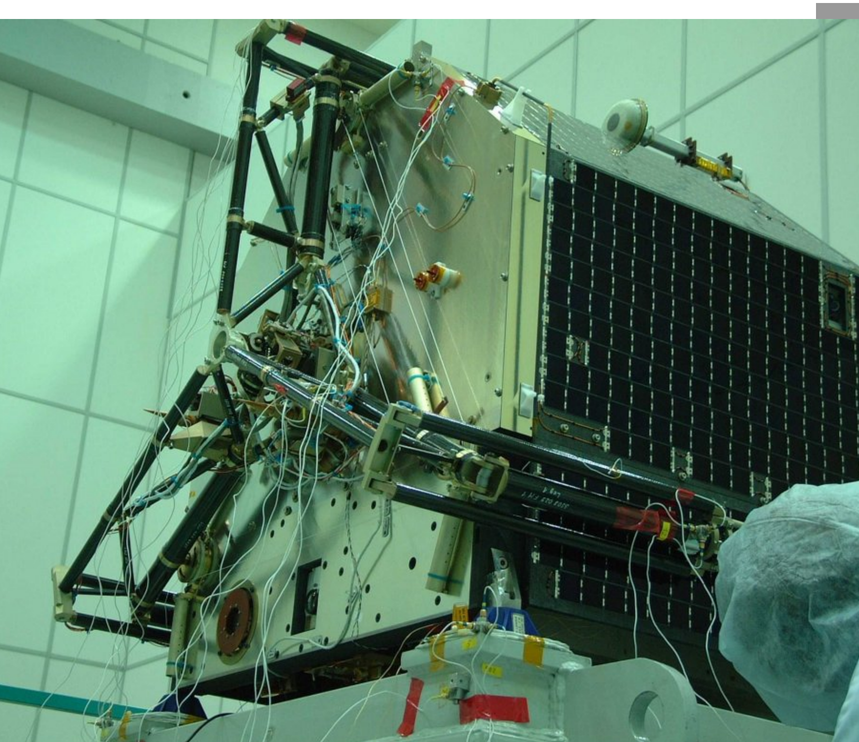


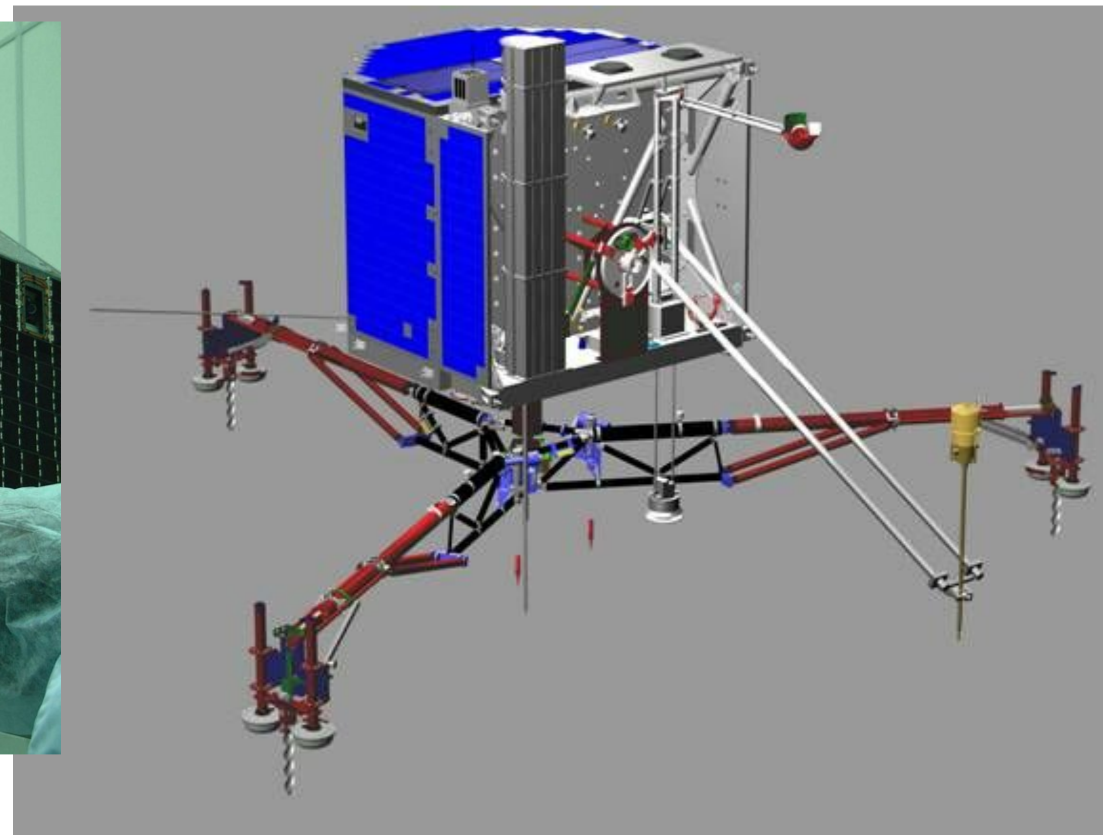
- Made of ice (the ridges?) and fine dust from the birth of the solar system
- One of the blackest objects in the solar system – stretched here so you can see it
- Lots of varied geology – blocks, dust, plateaus, ridges
- You could walk across it in a few hours/day, but if you walk faster than a house spider, you'll put yourself in orbit!

- Jets!!
- Ices in comets vaporize as they approach the sun
- ESA decided not to put the lander in the "neck" region – why?


• Philae lander detached from Rosetta
• Designed to secure landing with overhead rocket, screws on landing pads and grappling hooks
• 10 instruments on board to study structure and composition of the comet

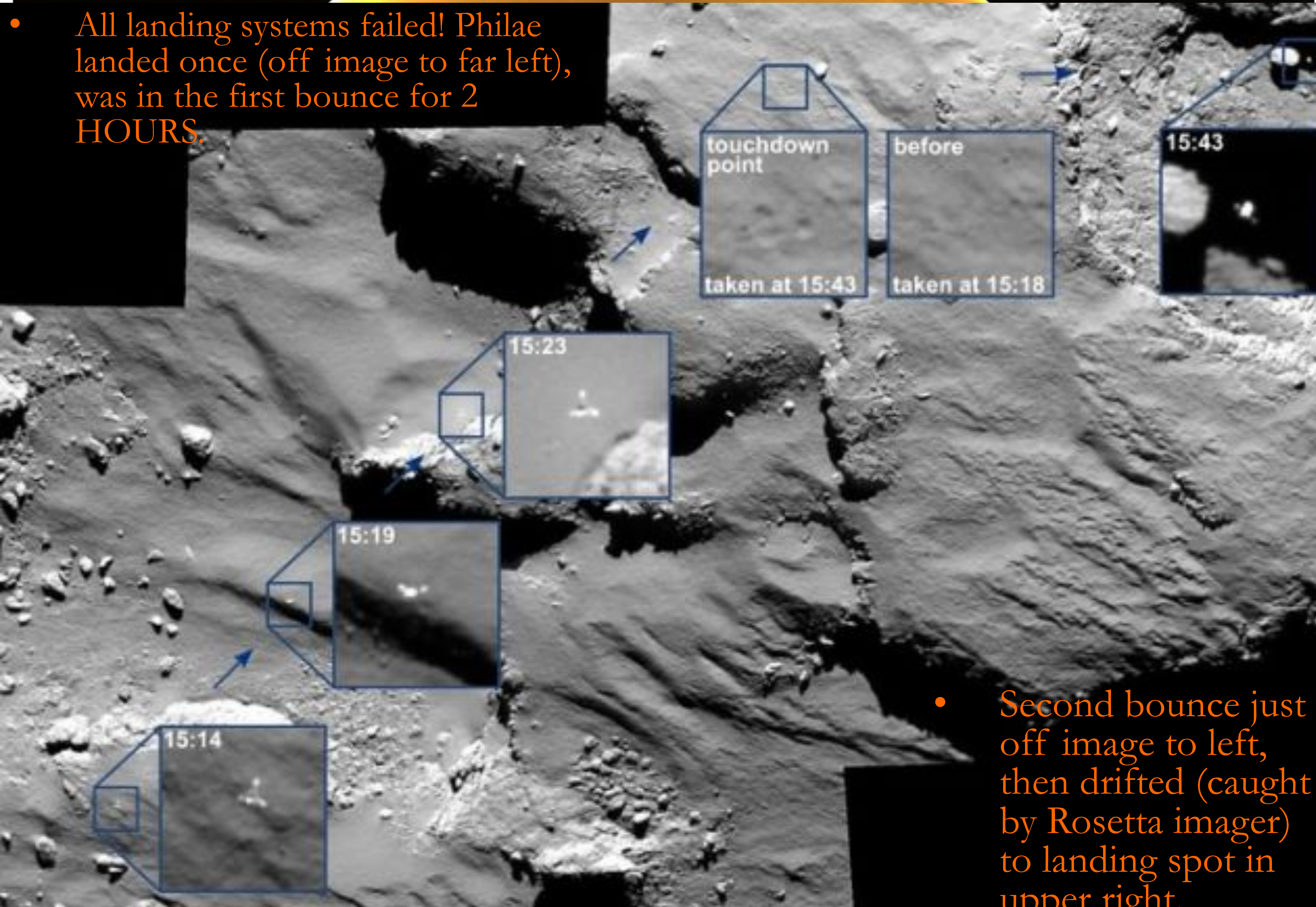
Philae Landing





Philae Landing (5)

- All landing systems failed! Philae landed once (off image to far left), was in the first bounce for 2 HOURS.



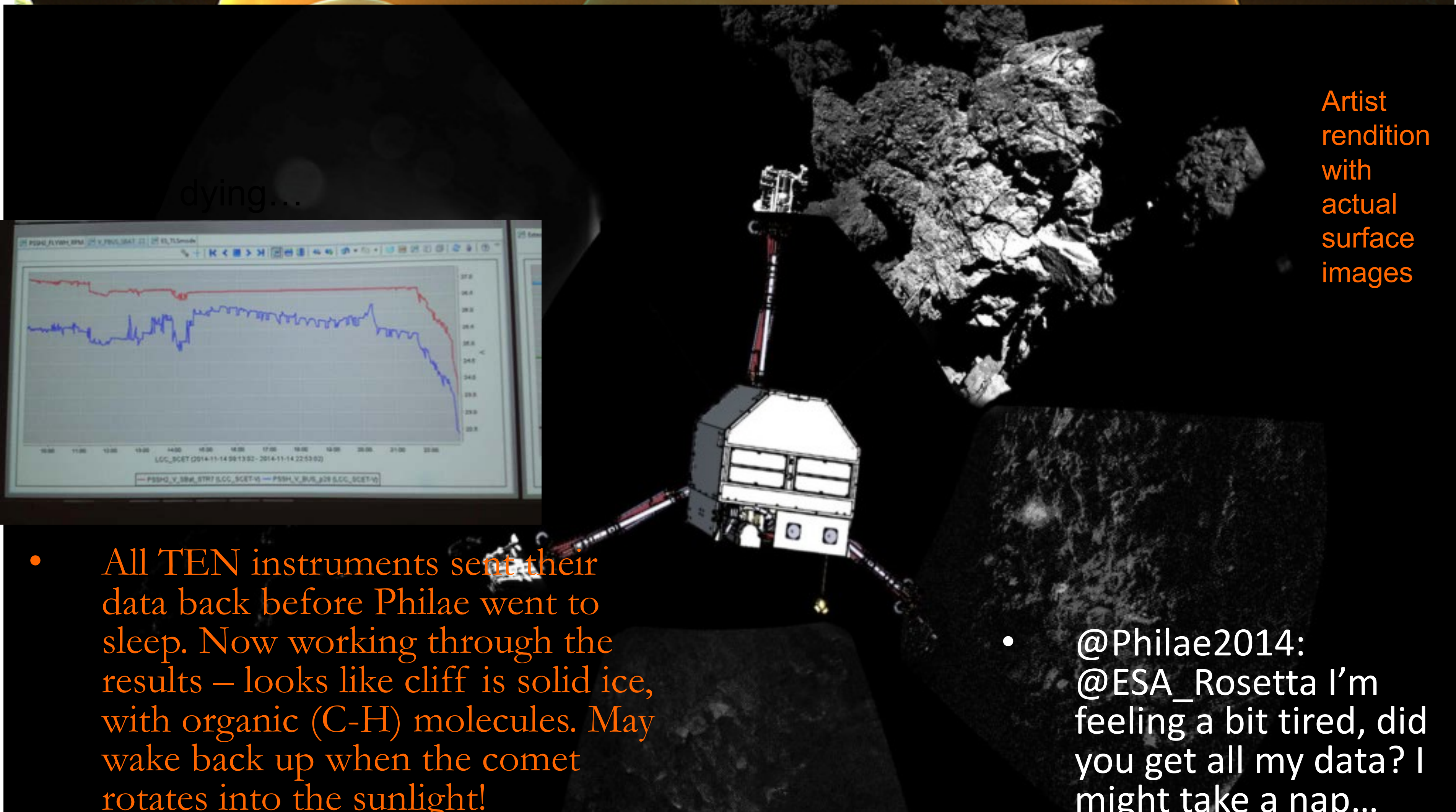
- Second bounce just off image to left, then drifted (caught by Rosetta imager) to landing spot in upper right.

- Philae rested right side up (!), is now on a cliff (2 pads on, one off), at a 30 degree angle, IN THE DARK.

Artist rendition with actual surface images

- Batteries need the sun to charge, only had 40 hours of life.

- Philae rested right side up (!), is now on a cliff (2 pads on, one off), at a 30 degree angle, IN THE DARK.
- Batteries need the sun to charge, only had 40 hours of life.

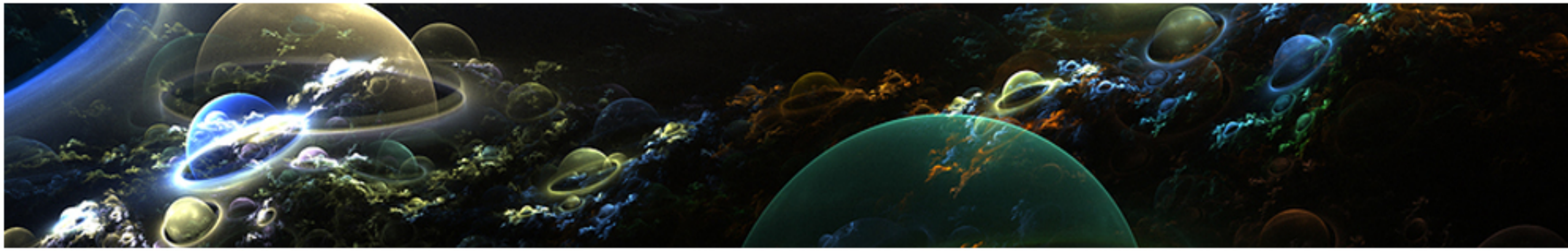


dying…

Artist rendition with actual surface images

- All TEN instruments sent their data back before Philae went to sleep. Now working through the results – looks like cliff is solid ice, with organic (C-H) molecules. May wake back up when the comet rotates into the sunlight!

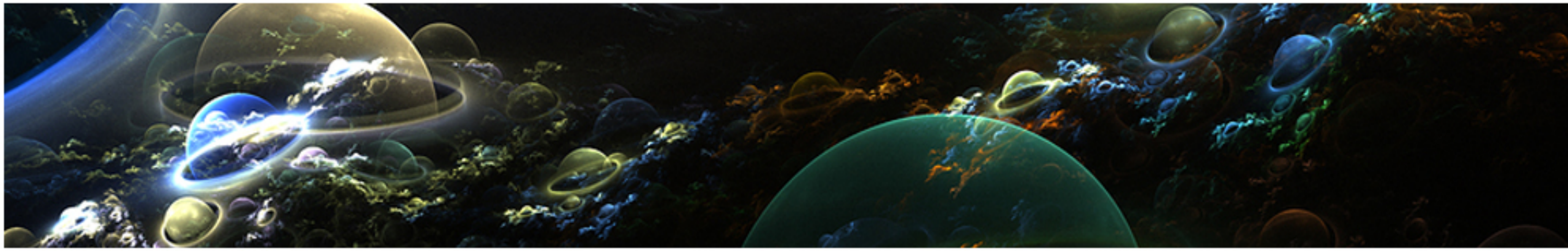
- @Philae2014: @ESA_Rosetta I'm feeling a bit tired, did you get all my data? I might take a nap…



What has Rosetta detected?

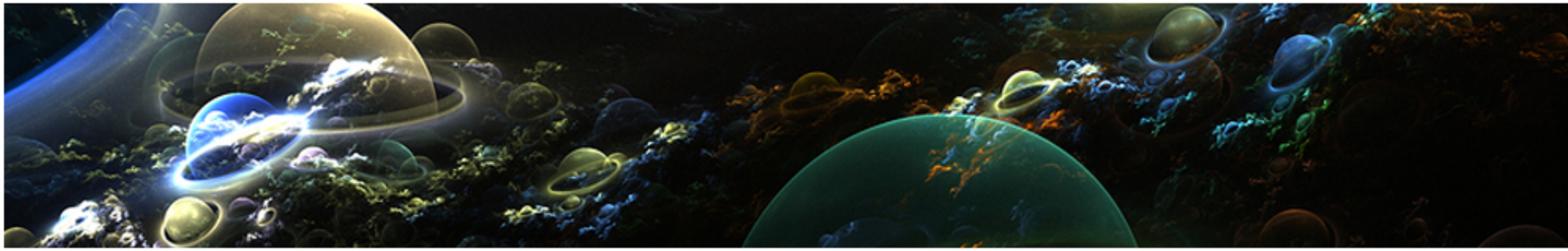
- Amino acids have been found in meteorites that fell to Earth,
- But Rosetta made the first measurement of the polymer-like compounds on a comet. The signal detected by Rosetta indicates complex organic molecules were abundant in the material that formed the comet’s nucleusin Italy.

Polymers



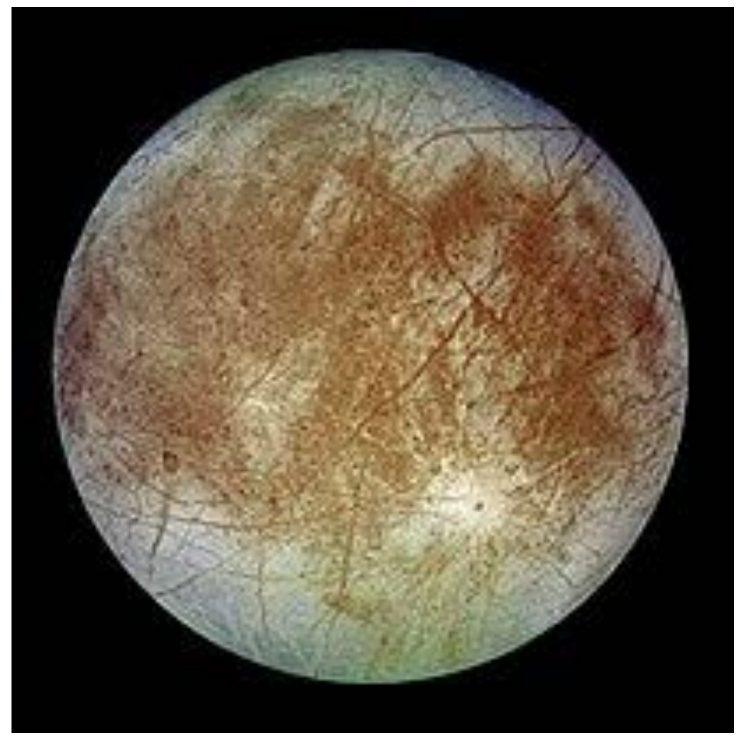
Isotopes

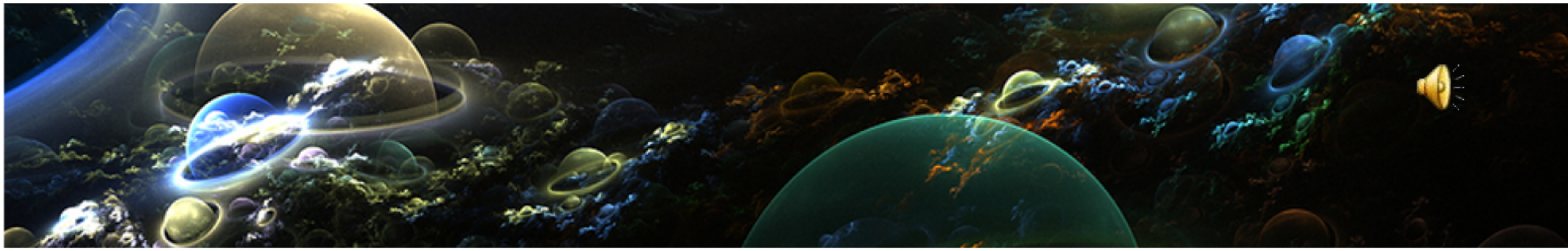
- The ROSINA instrument on Rosetta measured the proportion of deuterium — a form of hydrogen with an additional neutron — to normal hydrogen in the comet's water, according to ESA.
- It turns out the deuterium to hydrogen ratio on Churyumov-Gerasimenko is more than three times higher than the figure for water on Earth, hinting that Earth's oceans were seeded by many types of objects — not just a certain kind of comet or asteroid.



Europa

- Smallest of the 4 large Galilean moons of Jupiter
- Rock and a water ice crust
- Possibly a place for life to exist

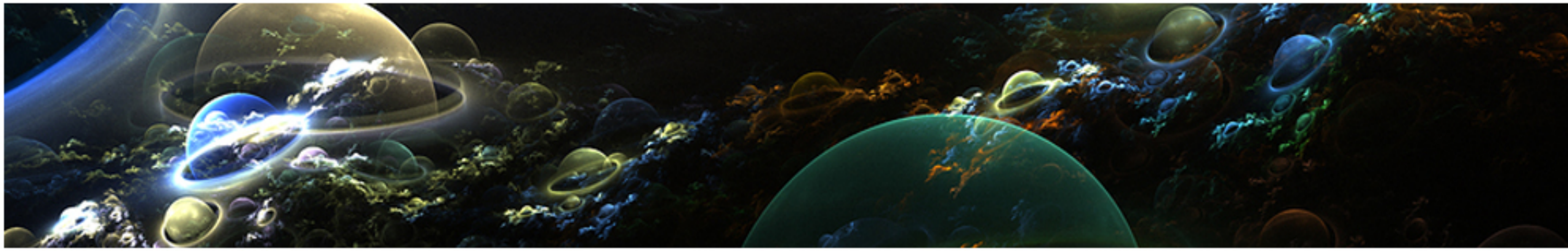




Particles Dance

gas

solid



oxygen

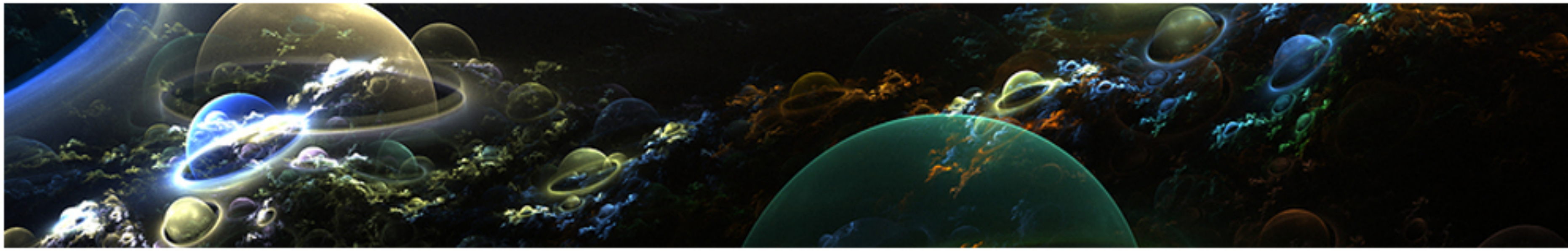
gold

water

brick


500 mL
±5%
400
300
200


FreeFoto.com



Thank you for attending

c.molyneux@sharplesschool.co.uk

Darren Walsh
Associate Professor of Physical Chemistry

To celebrate the International Year of the Periodic Table, we described our Periodic Table of Videos project (www.youtube.com/periodicvideos), a collaboration between staff in the School of Chemistry at the University of Nottingham and video-journalist Brady Haran (www.bradyharan.com). The Periodic Table of Videos began as a collection of 120 videos (one for each of the 118 elements of the Periodic Table, plus an introduction and a trailer). Quickly, it gathered momentum and by 15th February 2018 it comprised 649 uploaded videos, with 1.14 million YouTube subscribers and a total of 193.3 million views in over 200 countries. In this talk, we explained how the Periodic Table of Videos was conceived and suggested tentatively how the channel came to be successful.