Assessing contemporary science

About this free course

This free course is an adapted extract from the Open University course S350 *Evaluating contemporary science* www.open.ac.uk/courses/modules/s350.

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www.open.edu/openlearn/ocw/course/view.php?id=4295

There you'll also be able to track your progress via your activity record, which you can use to demonstrate your learning.

Contents

Introduction

Considered analysis is at the heart of good science. This free course, *Assessing contemporary science*, will introduce you to the assessment of reports on contemporary areas in science, allowing you to examine the scientific information that is available to members of the public in a range of forms. Additionally, you will explore the ways in which scientific knowledge develops and undergoes peer review, and learn how to apply key methods of critiquing and evaluating information. There will be a variety of activities throughout the course for practising these skills – as well as some optional activities that delve slightly deeper, or explore side topics. You are not required to complete these optional activities unless they particularly interest you.

This OpenLearn course is an adapted extract from the Open University course S350 *Evaluating contemporary science*. It was produced for OpenLearn by Richard Holliman (Sections 1–5), Phil Wheeler (Section 6) and Simon Collinson (Sections 7–9).

Learning Outcomes

After studying this course, you should be able to:

- critically evaluate statements, different viewpoints and data to reach informed judgements based on scientific evidence
- understand key aspects of areas of scientific knowledge that have personal relevance
- understand some of the wider implications associated with any scientific investigation
- have an appreciation of current thinking on uncertainty, ambiguities and the limits of scientific knowledge
- deploy transferable skills in assessing contemporary science.

1 Why science matters

Why should you care about the assessment of contemporary science? In our view, the main reason you should care is because science has the potential to change our lives, and those of future generations. As citizens, we need to keep abreast of the changes in scientific knowledge so we can have a say in how it can, and should, be applied in wider society (Holliman et al., 2009). To do this, we need to develop generic skills that can be applied across the sciences.

In practice, science is not just one thing. Scientific knowledge is produced by scientists working in a vast array of sub-disciplines (Schummer, 2009). In this short course you will encounter, among others: conservation biologists working to better understand how animals, plants and humans interrelate and influence each other; life scientists studying the microbiology of the heart, and Earth scientists who explore how metamorphic rocks are formed.

Despite the variations in working practices between scientists in different disciplines, there are some common purposes and beliefs that they adhere to. All scientists are trying to produce new knowledge. To achieve this end, they look to build on our current understanding of natural phenomena, following a set of underlying research principles. It follows that what is known about a given scientific **discipline** has the potential to change with the publication of each new piece of research.

The publication of new knowledge is not a given. For new knowledge to be published, it has to pass the assessment of peers working in the field (i.e. other expert scientists). Once agreed, this new knowledge can be shared more widely for further assessment among other scientists, and potentially for communication beyond the academic domain.

Understanding how such assessments are made by expert scientists, and how this can influence the ways that new knowledge becomes public, will help you to make informed judgements about what is (and is not) credible when studying the dynamic boundaries of scientific knowledge. In this light, it is also important to acknowledge that academic practices of openness (Weller, 2014) and **engagement** (Jensen and Holliman, 2016) are becoming more widespread. Together, they offer additional opportunities for scientists *and* citizens to scrutinise science, both at the point of publication and as this information circulates in wider society.

Study note 1 Accessing the glossary

The terms ‘discipline’ and ‘engagement’ are in bold in the paragraphs above to identify them as glossary terms. You can hover your cursor over the emboldened text to bring up the definition provided for these terms. You may need to click on the word(s) to read the full definition – this will take you to the glossary section appended to the course, which contains definitions for all the emboldened terms.

As you work through the remainder of the course, you will encounter further glossary terms. Take a moment now to familiarise yourself with this functionality.

It follows that science does not end with the production and publication of new knowledge. The potential for, and realisation of, new knowledge requires members of society to take account of the implications (Guston, 2014). The application of new knowledge has the potential to change our lives for the better or for worse. We all have just as much of a stake as scientists in determining the ways that science can and should influence our lives. Therefore, we need skills and competencies to assess science and its implications (Holliman, 2008).

This course explores some of the skills and competencies that can help scientists and citizens successfully navigate this ever-changing complexity. It introduces and applies concepts from the related fields of science communication and engagement, focusing in particular on digital and information literacy skills (Holliman, 2011). By completing this course you should have a better understanding of how contemporary science progresses and how ‘cutting edge’ scientific knowledge circulates in the **public sphere**.

2 What is contemporary science?

This course explicitly focuses on 'contemporary science' so it is worth exploring how this concept is defined.

First and foremost, it would be safe to assume that contemporary science means science that is 'up-to-date', or modern. In this course, however, the term is used more specifically than this, and relates particularly to 'cutting-edge' science. Indeed, here contemporary science is characterised as 'new' knowledge, meaning it is new to the scientific community *and* to wider society.

So how do we recognise contemporary science, and where does it first appear to the vast majority of the general public? The activity that follows will help you to explore these questions.

Activity 1 The excitement of contemporary science

Allow about 30 minutes

Think about the experiences of contemporary science that have interested, excited or concerned you, either professionally or in your personal life. This could have been in the past days or weeks, or possibly longer ago.

This should be something that you have encountered outside of formal education (i.e. sources of science where you are not formally being taught). Sources could include, for example, television programmes, news websites, blogs, books, magazines, newspapers, social media, museums and science centres.

In the light of your experiences, write a short summary (no more than 200 words) that addresses the following questions.

- Briefly, what is the example about?
- Where did you first learn about this new development in the sciences?
- What first attracted you to this information?

An example is then included in the discussion below, to give you an idea of the level of detail that you can cover in around 200 words.

Provide your answer...

Discussion

Philae lands on Comet 67/P

In November 2014, a robotic probe called Philae landed on Comet 67/P, 300 million miles from Earth. Funded by the European Space Agency (ESA), the Rosetta Mission that delivered the probe to the surface had taken more than 25 years in the planning.

The announcement was made at a meeting where scientists and journalists mixed freely; Professor Monica Grady's reaction to the landing captured the excitement of what had been achieved. You can view her response by watching the following video: 'Rosetta comet landing: Professor's excitement and tears'.

I found this information on the BBC News website, but it was also reported by other news providers. Given that Open University colleagues had worked on this mission for many years, I'd been following this story for some time. What really struck me about the story was the emotional response of Professor Grady – excitement mixed with relief. It provided the perfect counter to the stereotypical image of scientists as purely rational beings.

(165 words)

Your response to the previous activity is likely to be different from other people studying this course. As citizens we access contemporary science from a range of sources. Research has shown that the genre of news is a key source of new information about the sciences (Holliman, 2004), but that the ways we access news is changing (Holliman, 2010; 2007a; 2007b).

The example described in the previous activity also shows that as contemporary science enters the public sphere it can elicit a range of emotions. Over time, these announcements can affect how we perceive science in a more general sense, influencing how we interpret and contextualise new knowledge (Holliman, 2000).

Optional activity: imagining scientists

Allow about 15 minutes

Research has shown that if viewers receive consistent portrayals of scientists through popular media, such as television, this can influence how they interpret and contextualise science (Carr et al., 2009).

If you would like to explore why stereotypical images of scientists endure, have a look at our audio feature, Imagining Scientists. This discusses research conducted at The Open University through the (In)visible Witnesses Project. The project investigated gendered representations of people working in the fields of science, technology, engineering and mathematics (STEM), and how these images might affect the perception of children and young people.

2.1 The applications of contemporary science

One of the reasons this course focuses on contemporary science is because of the potential influence and impact that new knowledge can have on wider society. This can come in the form of novel challenges and opportunities.

In the case of the ESA Rosetta Mission, for example, it led to some unexpected developments when the technology initially developed by the Philae scientists was adapted by them for further use. The next activity provides more information on these developments.

Activity 2 The application of contemporary science

Allow about 20 minutes

Study the following video: 'How space science is making a difference on Earth', featuring Geraint (Taff) Morgan. Taff works in the Department of Physical Sciences at The Open University. Through his research he has contributed to a number of space missions.

View at: youtube:KBWFgXG4LdY

Video 1 How space science is making a difference on Earth.

Now answer the following questions, before revealing the discussion below.

- What other scientific areas have developed from this space research and associated technology?
- Who might be influenced by the development of the social and economic impacts of these technologies?

Provide your answer...

Discussion

The work has led to scientists developing methods to:

- Detect prostate cancer by 'smell', with the potential to perform more accurate diagnoses, thereby saving lives and expenditure in the National Health Service (NHS). Patients, carers and medical professionals, in particular, could benefit from the application of these technologies.
- Analyse the air quality in submarines, acting as an additional safety measure for submariners.
- Optimising perfumes, complementing the work of humans in producing scents, complementing and enhancing the work of companies and the professionals working for them. Consumers could also benefit from the production of better quality scents.

This video shows that one of the reasons scientists and other **stakeholders** (citizens, medical professionals, carers, patients, consumers, military personnel, business people, etc.) care passionately about the sciences is because they have the potential to influence our lives.

To use an oft-cited cliché, 'science matters', which is why the work conducted by scientists and other stakeholders can be linked with politicians and other policy makers. The next (optional) activity explores these ideas further.

Optional activity: why should scientists engage with policy makers?

Allow about 30 minutes

Study the following video: 'Why should scientists engage with policy makers?', featuring Ian Bateman. Ian is Professor of Environmental Economics and the Director of the Land, Environment, Economics and Policy Institute (LEEP) at the University of Exeter. As you watch, make notes on the questions that follow, before revealing the discussion below the text box.

View at: youtube:V-WkWTZmVfA

Video 2 Why should scientists engage with policy makers?

Questions:

- Why should scientists engage with policy makers?
- What are the biggest challenges to using scientific evidence in policy making?
- What practical steps should scientists take to engage with the policy making process?
- What examples does he offer to illustrate where science has influenced policy?

Provide your answer...

Discussion

Professor Bateman begins by arguing that science has the potential to change our lives. He calls on scientists to make active decisions about whether they want their research to benefit society. If they answer yes to this fundamental question, then scientists need to identify which decision makers connect with their science. This could include policy makers at an international, national, regional, and/or local level. It could also include a whole range of other stakeholders, including non-governmental organisations (NGOs), community groups, industry and members of the public.

Professor Bateman argues that one of the biggest challenges facing scientists is to understand the context that decision makers are working within. This includes multiple, and sometimes conflicting, demands on them. Decision makers rarely have the luxury of having a single, simple issue to debate at any given time, and they are routinely faced with limited resources.

In effect, decision makers have to prioritise. Scientists therefore need to communicate their science clearly and within the context of 'real-world' challenges. At times this may require them not to communicate, i.e. to be selective about which scientific evidence is essential to resolving a given issue. At other times, they will need to identify and present scientific evidence in shorthand. This approach can seem very different from communicating with other scientists in a research context, e.g. a laboratory, on location in the field, at academic **conferences**, or through **research papers**.

He argues that one of the most obvious ways to engage with the policy making process is to talk to decision makers. Crucially, this requires careful selection of information, packaged in a way that is equivalent to other forms of evidence that decision makers will receive.

Finally, Professor Bateman describes an example of this working in practice related to research into ecosystems. By engaging with policy makers he, working with other scientists and stakeholders, ultimately delivered a long-term, 25-year commitment to improving the environment.

3 Perspectives on contemporary science

Contemporary, ‘up-to-date’ knowledge can be compared to science that is ‘agreed’ knowledge – for example, something you might read in a textbook or a popular science book (Latour, 1987). How, then, do scientists make sense of the difference between new and agreed knowledge? And what are the characteristics that make an effective scientist? Complete the next activity to find out more.

Activity 3 Perspectives on contemporary science and scientists

Allow about 1 hour

Study the following audio interviews, featuring Open University scientists, Clare Warren (Senior Lecturer in Earth Sciences), Martin Bootman (Reader in Biomedicine), Claire Turner (Professor of Analytical Science) and Phil Wheeler (Senior Lecturer in Ecology). Each of the scientists is interviewed by Richard Holliman (Professor of Engaged Research).

These interviewees were selected because (at time of writing) they are current Open University scientists and are actively researching and producing new scientific knowledge. However, they also conduct research in different academic disciplines: life and health sciences; chemistry and analytical sciences; and environment, Earth and ecosystem sciences.

Compare and contrast all four (or at least two) of the audio interviews to explore where their perspectives are similar and different. To this end, you should listen to each of the interviews more than once, and consider the following questions. There is a box beneath the audio clips where you can make notes as you listen.

- What are the current topics of enquiry for each scientist?
- What do these scientists see as key characteristics of successful scientists?
- What scientific evidence do these scientists see as agreed knowledge in their discipline?
- What mechanisms do they describe for how this knowledge was evaluated?
- What would it take for agreed knowledge in science to be replaced with new knowledge?

Audio content is not available in this format.

Audio 1 Richard Holliman interviews Clare Warren.

Audio content is not available in this format.

Audio 2 Richard Holliman interviews Martin Bootman.

Audio content is not available in this format.

Audio 3 Richard Holliman interviews Claire Turner.

Audio content is not available in this format.

Audio 4 Richard Holliman interviews Phil Wheeler.

When you have completed your analysis of the interviews, compare and contrast the scientists' perspectives on the questions asked above. In particular, look for any consistency or diversity in the responses about the characteristics required of a successful scientist, the relative maturity of the knowledge that each scientist describes as 'agreed', and the mechanisms for evaluating provisional scientific knowledge.

Provide your answer...

Discussion

At the start of the respective interviews each of the four scientists describes their topics of enquiry. The topics are diverse with little obvious overlap:

- geology; mountain building and formation of metamorphic rocks (Clare)
- health sciences; the workings of the heart at the level of molecular biology (Martin)
- chemistry; breath analysis as a diagnostic tool (Claire)
- applied ecology and conservation biology; how humans and ecological systems interrelate and influence each other (Phil).

Where the work of these researchers *does* overlap is that they see similar characteristics in successful scientists.

- First, they discuss the need to be curious, enquiring and creative in identifying challenges.
- Second, they discuss the need to be observant, analytical and sceptical in researching the challenges that have been identified.
- Third, they argue for the need to be persuasive in convincing others that newly-published research has originality, rigour and significance.
- Finally, they talk of the need for determination, perseverance and hard work, with cooperation required between researchers when working in teams.

The interviewees share other similarities. They are all working at the frontiers of scientific knowledge in their respective disciplines. As they conduct their investigations, these scientists draw on existing evidence and interpretations published by other researchers to further scientific knowledge.

For Phil and Martin, the agreed knowledge they discuss in relation to their respective topics of enquiry is more than 150 years old. Clare Warren's comments about the science of plate tectonics point to more recent knowledge, but no less foundational in its importance to geologists.

Phil, Martin and Clare Warren accept that the agreed knowledge they discuss *could* be replaced, but it would be very unlikely given the respective bodies of evidence that support the three underpinning theories. In effect, scientists working in these respective disciplines have established a **scientific consensus** around what could be considered foundational knowledge for any entry-level researcher.

In contrast, Claire Turner discusses ancient knowledge about the links between smell and disease. She argues that it is only very recently that researchers have been able to analyse breath samples using scientific techniques (i.e. since the 1970s).

Further, she notes that her discipline has yet to develop agreed standards by which breath samples can be analysed consistently and rigorously. In essence, her discipline is working towards the foundational knowledge that Phil, Clare and Martin's disciplines already have in place.

What should be apparent is that for all four scientists, the process of knowledge production is fundamental to their research. Scientific knowledge progresses from what has been previously known or agreed through processes of investigation, evaluation and verification. This process of verifying results happens at the level of individual scientists, checking and repeating experiments until they are satisfied that their findings are valid, but also at the level of the wider scientific community.

Most of the time, scientific progress involves small, incremental gains in knowledge, with each gain being verified independently by other scientists. This is in contrast to more fundamental shifts in understanding like the one described by Martin Bootman in Audio 2.

The work Martin describes can be characterised as a paradigm shift (Kuhn, 1996) because this research successfully challenged the existing scientific consensus in this academic field. He notes the time it took for the new evidence to become agreed knowledge. This required an initial publication (Lipp et al., 2000), evaluated through a process called **peer review**. This initial research was then further supported by other researchers who tested the original theory, and found it to be supported by evidence they published following peer review.

The interviews in the previous activity were recorded in the summer of 2016. Given the nature of contemporary science, these researchers have continued to produce new knowledge. If you are interested to see what they have been up to in the intervening period, complete the following optional activity.

Study note 2 Keeping up to date with the research(ers)

If you are interested in the work of the scientists and the interviewer who featured in Activity 3, you can find out more about their research from the following links to their Open University profiles: Clare Warren; Martin Bootman; Claire Turner; Phil Wheeler, and Richard Holliman.

4 How contemporary science works

This discussion of contemporary science will now expand by exploring some of the key aspects of how science works. This will include some discussion about the different approaches scientists take when they research, and how they assess and communicate the products from research. You will develop your appreciation of key areas of scientific knowledge and of the limits of such knowledge, and learn about some of the wider implications of scientific investigation.

From your experience of completing Activity 3, where you compared the perspectives of four scientists, you should already be able to see that scientists work in diverse areas, producing new knowledge that is subject to evaluation by colleagues and peers. In essence, this is how scientists work and the sciences progress, regardless of the academic discipline in question. This section will explore these issues in more detail.

Activity 4 Trust in science

Allow about 15 minutes

Watch the first five minutes of Video 3: 'Sir Paul Nurse: Trust in Science' (open the link in a separate window so you can easily return to this page). Sir Paul is Chief Executive and Director of the Francis Crick Institute in London, and former President of the Royal Society. As you watch the video, make some notes below on what he says concerning the way science is performed, evidenced and developed. You may want to play the section through a couple of times to familiarise yourself with his views on important issues in science.

Provide your answer...

You can find many other interviews online where Sir Paul discusses these topics. Elsewhere, he has talked more expansively about how science works, discussing inductive and deductive approaches:

- *Inductive approaches*: put simply, an inductive approach is where we collect evidence, and then generate theories from it. Inductive approaches tend to be exploratory in nature. They are often adopted when scientists are looking to explore a new field of enquiry or phenomenon.
- *Deductive approaches*: if we adopt a deductive approach, we would start with a theory, develop a hypothesis, and then 'test' that hypothesis against a set of evidence. The test either proves or disproves the hypothesis and the original theory is adapted (or not) accordingly.

These two approaches to studying science are often conflated around the idea of a 'scientific method'. The scientific method is an idea, or set of ideas, which has been around for centuries. It describes the process by which scientific ideas are formalised into research questions for further investigation. Put simply, this involves four stages:

- observation
- development of hypothesis or research question

- investigation
- interpretation

Crucially, the more data you collect, the more confident you can be in your results and your interpretations.

At first glance, the scientific method is a linear process going from observation to the formation of research questions to investigation to interpretation. But in practice, the way science is carried out is iterative: observation leads to the formation of research questions and investigation, but part of the subsequent interpretation is identifying new questions or refining the original research question.

Activity 3 showed that there are different ways that different scientific disciplines interpret the same basic set of principles. Further, it is important to note that not all sciences rely on empirical observation to advance their ideas. Some theoretical areas develop through the exploration or creation of theoretical models, or exploring logical or theoretical inconsistencies in existing ideas or theories. Ultimately though, for these theoretical ideas to be validated, they must be supported by empirical observation.

In another instance, Sir Paul Nurse offers some advice to journalists:

> I think the important thing for a journalist looking at this is not to be naive. What they should do is look at the funding, look at the type of the research, look at what conflicts of interest there may be, and don't simply have a sort of tick-box approach, 'If it's funded commercially, therefore we should be deeply suspicious', because often that research is of the highest quality and it has been tested in the very highest standards, and don't think that because it's funded by an NGO, it's got to be whiter than white, because it may not be, and don't necessarily think just because it's funded by the government, it's completely without any value-driven stuff as well. Just don't be naive.
>
> BBC (2015)

Why is this so important, and how are findings from how science works shared with other scientists and wider society? These ideas are considered further in the next section.

5 Communicating contemporary science

Communication is a vital component in the process that enables citizens and other stakeholders to engage with and evaluate contemporary science. Indeed, it is at the heart of scientific progress and public debate.

Sir Paul Nurse's advice to journalists in the previous section came, in part, as a response to an example where the communication of scientific information was deemed to have gone badly wrong. That example involved a now discredited suggestion, made at a press conference in 1998 by former doctor Andrew Wakefield, that the combined measles, mumps and rubella (MMR) vaccination might be implicated as a cause of autism, as he had recently reported (Wakefield et al., 1998).

Study note 3 Further study about the vaccination controversy

If you wish to learn more about the MMR vaccination controversy that was fueled by Wakefield's comments, you can study another OpenLearn course ' The MMR vaccine: Public health, private fears'. (Be aware that studying this course in its entirety would involve around 20 hours of study time.)

How, then, do scientists communicate with other scientists and members of the public when debates about the science in question are less heated?

Activity 5 Communicating and engaging with contemporary science

Allow about 25 minutes

Listen now to another interview conducted by Richard Holliman, in which he speaks to Victoria (Vic) Pearson. In this interview, Vic discusses her involvement in science communication and engagement as a research scientist working in the School of Physical Sciences at The Open University.

As you listen, make some notes on the following questions, in the box below the audio clip.

- In what ways does Vic communicate science? Of these, which does she consider to be the most important, and why?
- How does Vic define the role of a reviewer of scientific papers and other forms of scientific output? How does she evaluate the quality of scientific evidence in her discipline?
- In what ways does Vic engage different stakeholders and members of the public with her science? Of these, which does she consider to be the most important, and why?
- What are some of the benefits and drawbacks that Vic discusses in relation to communicating her science to, and engaging with, various members of the public?

Audio content is not available in this format.

Audio 5 Richard Holliman interviews Vic Pearson.

Provide your answer...

Discussion

Vic Pearson is a senior scientist with a wide range of experience in science communication and engagement.

In terms of science communication, she emphasises the importance of peer-reviewed academic research papers, both as a vehicle for science to progress and as a driver for career progression.

She notes that some academic **journals** are considered better quality than others, arguing that *Science* and *Nature* are two of the most prestigious journals to publish findings from scientific research.

Vic also discusses other routine forms of science communication, including poster presentations at academic conferences, and technical reports. In each case, the form of communication is targeted at a particular **audience**.

Vic goes on to describe her role as a formal and informal reviewer of other scientists' work. You should be aware that scientists also informally review scientific information once it is published, as readers of newly-published research findings.

In essence, Vic goes through the same process whether she is formally or informally reviewing a paper. She systematically assesses each element of a scientific paper, starting with the methodology, matching this with the research design, and assessing the findings and the interpretations.

The discussion moves on at this point to consider how Vic engages non-academic groups with her science. Again, she lists a diverse set of activities, delivered to audiences that include school children and teachers. One of the key rationales for her work in this area is to keep young people and teachers up to date with cutting-edge research (Holliman et al., 2017), which is important because new research is being published all the time. In this respect, she reflects the findings of work conducted to explore the attitudes, culture and ethos of physical science researchers (Duncan et al., 2016).

Finally, Vic describes some of the benefits and drawbacks of her communication and engagement work. She is clearly passionate and enthusiastic about the need to work with public audiences, but also notes the time required to do this effectively. Again, this challenge reflects the findings of research conducted to explore the challenges and motivations of researchers as they seek to engage with members of the public (Grand et al., 2015).

This is made all the more challenging because this type of work doesn't generate the same level of funding as research. It follows that engagement activities can fall down the priority list. This challenge can be exacerbated because, unlike research, there are few widely accepted criteria for what counts as excellent work in this area (Holliman and Davies, 2015).

Vic's consumption of science news allows her to keep informed of developments outside of her specific scientific discipline. In this respect, she's acting less as a scientist and more as a citizen interested in the sciences. What role then does science news, and therefore journalism, play in keeping citizens up to speed with developments in the sciences? This will be explored in the next section.

Study note 4 Learning more about science promotion

If you are interested in Vic's research, you can use the following link to see her Open University profile and learn more about her recent work: Vic Pearson.

Similarly, if you are particularly interested in exploring approaches to science communication and engagement, you can study these issues in more detail with another OpenLearn course, 'Science promotion'. (Be aware that studying this course in its entirety would involve around 12 hours of study time.)

6 Interpreting science news

An important part of being a scientist or a scientifically-informed citizen is being able to interpret scientific information that is represented in the public sphere.

By choosing to study this course, you have expressed an interest in learning about how contemporary science is conducted, and this course aims to help you build the skills and confidence to critically evaluate scientific research. However, it is also useful to have an idea of how to judge the value of science as it is reported to members of the public. The next activity presents some approaches that can be applied to this task.

Activity 6 Using 'Score and ignore' to assess news reports

Allow about 1 hour 15 minutes

Part 1

Begin by listening to the following audio clip, taken from a 2013 episode of BBC Radio 4's *Inside Science*. Kevin McConway, Emeritus Professor of Applied Statistics at The Open University, discusses how he interprets science as it is reported on radio news bulletins. You do not need to make any notes on this interview, unless you particularly want to.

It's not explored in this short clip, but Kevin has developed a 12-point checklist for evaluating science news on the radio. You will have a chance to read this checklist shortly.

Audio content is not available in this format.

Audio 6 Adam Rutherford interviews Kevin McConway for Inside Science.

With his co-author, Professor David Spiegelhalter, Kevin expands on the points he makes in the audio feature in a written article 'Score and ignore: A radio listener's guide to ignoring health stories' (McConway and Spiegelhalter, 2012). Take a look at this article – you can use the box below to make your own notes about the content, if you wish, and it would be logical to focus on how he critically assesses the reports on science.

Provide your answer...

Part 2

Now you will use McConway and Spiegelhalter's checklist to evaluate two online news articles that report contemporary scientific research:

- McGrath, M. (2016) 'Men may have evolved better 'making up' skills', *BBC News website*.

- Johnston, I. (2016) ‘Nature videos seem to make maximum security prisoners less violent’, *Independent*.

First, read each story, and score it against the 12 points from the McConway and Spiegelhalter (2012) article.

Now answer the following questions based on your analysis:

- Which article scored highest?
- If you found one article to be particularly low scoring, what made it so?

When you’ve finished your evaluation, read the discussion provided below.

Provide your answer...

Discussion

Here are some thoughts on how each article can be assessed through McConway and Spiegelhalter’s checklist. (Don’t worry if your answers differ from these to some degree – evaluation of this sort is a subjective exercise.)

Analysis of McGrath (2016)

- *Just observing people?* Yes, just looked at recordings.
- *Original information unavailable?* No, it is mentioned that the paper was published in *Current Biology* and a link provided.
- *Headline exaggerated?* No, headline suggests it is only a possibility.
- *No independent comment?* No, independent comments included.
- *‘Higher risk’?* No, risks not really mentioned.
- *Unjustified advice?* Not really.
- *Might be explained by something else?* Yes, other explanations are possible, as correlation does not mean causation.
- *Public relations puff?* Yes, it is a sports and gender story that will attract attention.
- *Half the picture?* No.
- *Relevance unclear?* Yes, it is related to business but the data don’t apply to business situations.
- *Yet another single study?* Yes.
- *Small?* Yes.

Total score: 7/12

Analysis of Johnston (2016)

- *Just observing people?* No, there was a control group.
- *Original information unavailable?* Yes, the research was presented at the American Psychological Association’s annual convention. Therefore you would have to search for the associated publication which was only published much later in September 2017 in *Frontiers in Ecology and the Environment*: https://doi.org/10.1002/fee.1518
- *Headline exaggerated?* No, uses the word ‘seems’.

- *No independent comment?* Yes, only researchers quoted.
- *'Higher risk'?* No, risks not really discussed that would affect the public.
- *Unjustified advice?* No, advice not relevant to the public in this context.
- *Might be explained by something else?* Yes, and the authors acknowledge this.
- *Public relations puff?* Yes, the story is about criminals to attract people's attention.
- *Half the picture?* Yes, but hard to say for definite as the data are unavailable.
- *Relevance unclear?* No, relevance is clear for reducing violence in prison.
- *Yet another single study?* No, several studies are mentioned.
- *Small?* Possibly, study size not given.

Total score: 5/12, but note that the information is less clear in this second article and can't be easily verified, as the article refers to a presentation rather than a peer-reviewed paper.

Now that you've practiced some techniques for critically appraising information that is presented to you, the next few sections of the course will explore a scientific area in some closer detail. The topic is plastics in society. You don't need to worry if this topic is new to you, and you don't follow all of the science that will be explored. This will be an exercise in gauging your current knowledge of a subject, learning some new information, and examining how the subject relates to and impacts your own life, before using the skills you've just developed to evaluate some sources of information about plastics.

7 Introducing plastics in society

In recent years, the multifaceted issues around plastics in society have been widely reported in various media. One high profile example was in an episode of the BBC documentary series *Blue Planet 2* ('Our Blue Planet'), where Sir David Attenborough examines the impact of human life on life in the ocean, and especially the damage done by discarded plastic waste.

Study note 5 Blue Planet

If you're interested, you can find out more about *Blue Planet 2* and *Blue Planet Live* on our dedicated pages:

Blue Planet 2

Blue Planet Live

Despite this, it should be remembered that scientific knowledge does not stand still, and there is some positive news in this field of research. For instance, Austin et al. (2018) reported a novel enzyme that could degrade the most common type of polyester – so-called polyethylene terephthalate, or PET. As this course explores how scientific research is carried out and reported, we will now consider the science of this group of materials, which have become integral to our everyday lives.

Plastics are some of the most useful materials on Earth. They are almost entirely man-made, and the world around us would look very different without them. But they can also present challenges to the environment and human health. For example, there is growing concern about plastic materials (Eriksen et al., 2014) and microplastics (Vandermeersch et al., 2015; Welden and Cowie, 2017) in the oceans, and consequently the food chain. Therefore, anyone who is interested in science – from the fundamentals of chemistry, or the properties of materials, to human health and the future of the planet – needs to take an interest in plastics!

The first truly artificial synthetic plastic, Bakelite™, was developed in 1907 and since then, many more plastics have been introduced (Thompson et al., 2009). Today's plastics are everyday materials, but they represent a great many inventions by a huge number of scientists from a number of disciplines.

If you look up plastic on the Oxford Dictionaries website (2018), the entry returned is:

> A synthetic material made from a wide range of organic polymers such as polyethylene, PVC, nylon, etc., that can be moulded into shape while soft, and then set into a rigid or slightly elastic form.

Additionally, the entry for a bioplastic is:

> A type of biodegradable plastic derived from biological substances rather than petroleum.

And microplastics are:

> Extremely small pieces of plastic debris in the environment resulting from the disposal and breakdown of consumer products and industrial waste.

Scientific research into plastics and their many applications are ongoing, with many thousands of papers published on the subject each year. Exciting new applications appear daily, such as advances in 3D printing with plastics (Figure 1), novel antibacterial plastics and the development of new bioplastics that are not derived from petroleum.

Figure 1 A 3D printer producing a plastic bracelet.

The contemporary topic of plastics in society involves many multidisciplinary current research issues. These issues arise during their production, use, disposal and the development of materials with novel properties. For example, research teams are exploring concepts such as:

- novel plastic materials, like as bioplastics or gels (chemistry, biochemistry and materials science)
- the formation and properties of microplastics (chemistry and materials science)
- the environmental and ecological effects of plastics in the oceans (biology and environmental science)
- the health effects from the leaching of chemicals from plastics, for example bisphenol A (BPA), which has been a source of some debate in recent years, following concerns about its safety for use in food packaging and containers (health science, biology and biochemistry)
- the presence of plastic as an indicator in geological deposits, where they can exist for an extremely long time in sediment (environmental and Earth science)
- the science behind efficient recycling (chemistry and materials science).

Question 1 Plastics in everday life

Allow about 5 minutes

Try to identify ten items that you regularly use in everyday life that comprise a significant amount of plastic.

Provide your answer...

Answer

Your list might include, for example:

- a polyester jacket
- a milk bottle
- a polyethene bag
- a laptop
- a mobile phone
- the dashboard in a car

- a window frame made from PVC
- the coating on electric cable
- the coating on a tablet
- a yogurt pot.

Plastics are also ubiquitous in many workplace environments. For example, if you were working in a laboratory, it's likely your list would include the following (some of these are shown in Figure 2):

- sample bottle
- sample vial
- pipette tip
- syringe
- microscope slide
- Teflon™ stirrer bar
- dialysis tubing
- connecting tubing for a water supply
- well plate
- beaker.

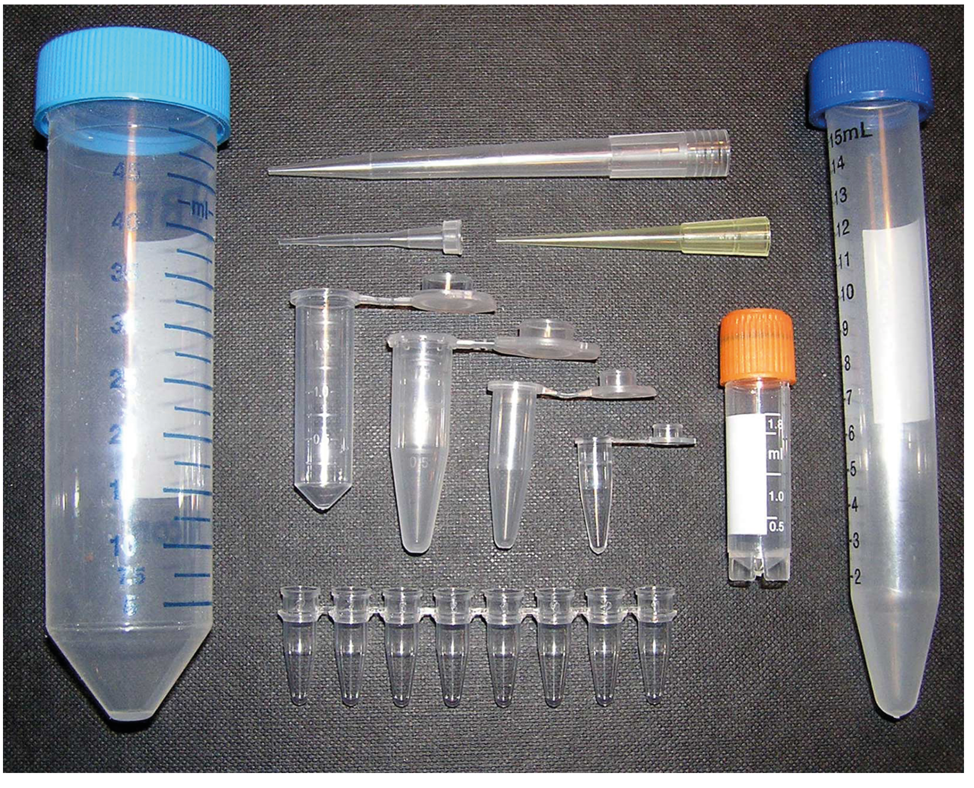

Figure 2 Several polypropylene laboratory items.

7.1 Some aspects of the science of plastics

Let's spend a few moments looking at some of the science that underlies plastics and their production.

Plastics are comprised of so-called polymer molecules, where a long molecular chain is formed from a repeating molecular unit. (This name derives from the Greek: *poly* + *meros* = 'many' + 'parts'). Furthermore, the term 'polymer' explains the use of the term 'poly' in the chemical names of plastics that you met in the previous section.

As an example, let us consider the relatively simple structure of polyethene, which is, at a basic level, the molecule $(CH_2CH_2)_n$, where n is a large number resulting in a molecule with a long chain (see Figure 3).

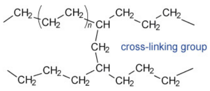

Figure 3 Illustration of a section of the chemical structure of polyethene.

The value of n, and how the individual chains are connected to each other (which is known as cross-linking; see the CH–CH_2–CH arrangement next to the blue label in Figure 3), largely determines the properties observed for the plastic. These properties include the plastic's density and melting temperature, which can be varied by altering the chemical production process.

This makes plastics like polythene highly versatile, and some everyday variations include:

- low density polyethene (LDPE), which is used in food packaging trays, wire insulation
- medium density polyethene (MDPE), which is used in carrier bags and shrink film
- high density polyethene (HDPE), which is used in milk bottles, soft drink bottle caps, pipes and some surgical implants.

Other chemicals may be added to the plastic to change the colour, act as antioxidants, improve how it wears or increase its plasticity or fluidity, where the latter chemicals are called plasticisers. However, additives in plastics sometimes cause health and environmental concerns if they leach out of the material, and this is an active area of research.

Question 2 Plastic degradation

Allow about 2 minutes

From your own observations, how easily do plastics degrade in the environment?

Provide your answer...

Answer

You will probably realise from the amount of plastic litter that is often observed in the outdoors (see Figure 4) that plastics are slow to degrade in the environment.

Figure 4 Plastic materials in the environment.

Polyethene is rather chemically inert; this is a property that may be either beneficial or problematic during the lifetime of a product made from it. Video 4, dating from September 2015, considers some aspects of polyethene in the environment, and one way that scientific research is progressing for plastics.

Video content is not available in this format.

Video 4 New biodegradable materials could replace plastic bags.

Question 3 Chemical inertness

Allow about 5 minutes

Considering the examples of everyday use given above, and the other information you've read so far, can you suggest when the chemical inertness of polyethene might be useful, and when it might be a problem?

Provide your answer...