WHAT SCIENCE IS *LIKE* AND WHAT SCIENCE *IS*—NON-PROFESSIONALLY EXECUTED ASTRONOMY AS A MEANS OF COMMUNICATING SCIENCE

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ABSTRACT

Astronomers and media professionals have formed very successful partnerships to communicate astronomy to the public through communications media of all sorts. However these efforts communicate what science is *like*, subject to the constraints of the communications medium. They do not communicate what science *is*. The missing and essential ingredient is public participation in an investigation, starting from uncertainty and proceeding to lesser uncertainty by means of organised enquiry. Science is a medium itself, and the medium is the message. We have started to communicate what science *is*, but the systems for doing so are sophisticated and we are only just beginning to implement them.

COMMUNICATING SCIENCE

The interaction between the scientist and the public usually takes the form of a dialogue in which the scientist tells what he has done and discovered and the member of the public says ‘These are my concerns about your work.’

The dialogue is asymmetric. The scientist is, in other circumstances, a member of the public and can readily exchange his roles. In the laboratory (or observatory, or computer room) a scientist can take the point of view of a scientist whereas in his home and in the street he is a lay person, perhaps someone who is informed in general about scientific matters but not an expert on topics outside his field. By contrast a member of the public usually finds difficulty in being a scientist.

Of course this conference is dedicated to breaking down this barrier, and to generating as many opportunities as possible for lay people to taste being a scientist. The opportunities are most often the following:

- The lay person learns about science in the media.
- The lay person hears the scientist lecture.
- The lay person simulates scientific enquiry.
- The lay person learns what science is *like*.

SCIENCE IN THE MEDIA

Communicating science through the everyday communications media is very important. The media provide channels by which busy and unique people can speak to huge audiences. The science is presented by interpreters skilled in communicating simply, clearly and interestingly. The science that is presented can be culled from the whole world, so everyone can learn about extremely important results no matter where they originate—the media have truly created a 'global village' of universal understanding.

Astronomers, in partnership with savvy media professionals, have done a really good job in accessing the media in order to tell about science. We owe a debt of gratitude to the astronomy media pioneers and to the sheer professionalism of groups like the HST Office of Public Outreach.

However, wonderful though I think these efforts have been, are and will remain in communicating some of the features of science, they are not enough. They do not communicate some absolutely essential features of science. The global village of universal understanding is incomplete.

The media communicate what they *can* communicate. They select what they communicate for reasons that are non-scientific, e.g. to attract viewers or to sell copies of newspapers. We, as scientists, have to learn how to cast our science into a form that is set by the media. The science is selected as a 'story' and is edited by the media. The story has to have a beginning and an end. It is an advantage if it has an associated dramatic picture, humour or some sort of record breaking fact. It has to have news value, perhaps to show an implied threat—that asteroids might destroy the world, for instance. It has to be important in news terms, for example to come from some expensive and politically relevant facility, or to have been carried out by a well-known person, or perhaps to contradict one. It has to have human relevance, a person or people with whom we can identify.

We as astronomers are learning how to cast our science into the form required by the communications media. In particular we are lucky enough to have both pictures and people who know how to display them, and we gain the front pages. If the launch of our spacecraft is successful or hits the target, our people are savvy enough to cheer, whoop, punch the air and jump up and down and show the emotion that gets our project on the TV news. Our press releases start with the superlative and carry witty turns of phrase. Our scientists show enthusiasm and make themselves into characters.

But it is difficult to get access to the media to describe an incremental advance, or one that is abstract, or one that is still uncertain. As we have heard people say at this conference, press releases can have no ‘wiggly lines’—no graphs, in other words, even though the business pages are full of them and this is the language of quantitative presentation. What is presented of science through the media is too literary and ‘too neat’.
Science as portrayed in the media may often be a distorted version of the real thing.

Lectures describe an authentic experience by a scientist, either talking about their own work or their understanding of other people’s work. Listening to a lecture is listening to an expert, and what is being said is ‘right from the horse’s mouth’.

However, the lecture is also edited science. Just as with a scientific paper, history is rewritten (for reasons of logic and understanding). The context in which the science is placed is selected to illuminate the science. As in a scientific paper or a media story, the lecture is too neat. It is also passive for the audience and they have to listen. Of course, lectures teach (but experience teaches better).

SIMULATED AND TAUGHT SCIENCE

Simulated science is an experience. The public can simulate science under controlled conditions relatively easily. School students do this every day in classroom learning experiences. In a science lesson they are given an instruction sheet and a selection of apparatus. Following the instructions they conduct an experiment, making measurements. In the data analysis phase of the lesson they may plot this against that, and attempt to replicate a result, for example to ‘Prove Ohm’s Law’.

The experience of simulated science is memorable. And simulated science teaches some of the methodology of science. However, the classroom is not the laboratory. A lesson is an activity that is similar to science, but it is not ‘real’ science. As students sometimes accurately sense, it may be boring. A lesson is what science is like, not what science is.

Science in education is an authoritarian structure of books, laws, right answers and proofs. As a result students have negative impressions of science. It is:

- Difficult
- Mathematical
- A long haul
- Impersonal
- Cautious.

They are told that science is certain: they are taught things discovered by dead people who were right. Simulated science misses out the essential feature of science, that it is a learning process of reducing uncertainty, not a learning process about what has already been discovered by hard work. The result is that science appears unattractive.

To counteract these impressions, teachers (including scientists themselves) may teach science as:

- Fun
- Visual
- Snappy
- Biographic
- Contains dramatic 'eureka moments'.

(However, teachers still pretend that science is correct.)

Science does indeed contain these features—but not only these features, so taught science and simulated science is certainly incomplete or possibly actually false.

WHAT SCIENCE *IS*

So: real science is different from simulated science. Science is only in part a commodity to be traded through the media. Science is, more importantly, a process. It is a medium in its own right. In science communication, the medium is also the message.

In science, the 'answer' is unknown. However, a working hypothesis comes before the results and the method of the study is defined by the scientist's anticipation of the results. In the data reduction phase, the scientist draws a conclusion about the result on the basis of incomplete data. Science is inherently uncertain, but it is post-validated by being reframed according to rules of 'scientific method'. Science is a method of thinking, not just a collection of commodities to be traded.

The reality of scientific enquiry, with its uncertainty and its human interaction, is at odds with common perception. Science is neither certain, nor completely reliable. It is constructed by people —who have, however, tried to remove themselves from it. To view science as infallible or certain is to misunderstand science.

HOW CAN WE OFFER A MORE REALISTIC SCIENTIFIC EXPERIENCE TO THE LAY PUBLIC?

The most direct way to experience science is through observational science. Observation often both was and remains a feature of non-professionally conducted natural history. Bird watchers and fossil hunters are examples of present day naturalists who still have the opportunity to make scientific discoveries. And of course amateur astronomers still exist in large numbers, viewing the sky through small telescopes or binoculars.

Observation need not be more than looking, seeing and recording. At some stages of science this might be enough of an end in itself. Robert Hooke looked through his microscope and drew a magnified and magnificent flea. James Nasmyth looked through his telescope and recorded and reconstructed the lunar mountains and craters in model form. But being a spectator is not really enough. What is missing is the flash of the idea, the progress of an investigation and the achievement of understanding.

In astronomy we do have scientific investigations through organised amateur astronomy, following the tradition of the great amateurs of individual astronomical research. I know those from Britain best, like the Herschels, Carrington, Rosse, W.H. Smyth, Lassell, Huggins... Societies like the British Astronomical Association and the American Association for Variable Star Observations continue to coordinate programmes of observations of variable stars, planetary features, etc. Some professionally run astronomy projects offer and manage real science opportunities that include amateurs, such as The Global Telescope Network, which is an optical backup programme for satellite gamma ray astronomy and the Small Telescope Science Program (STSP) of comet photometry for the Deep Impact mission. The Virtual Observatory and National Virtual Observatory projects make access to professionally archived data easy, so amateur scientists can make genuine astronomical discoveries, in the same way that the SOHO images of the Sun were used by an amateur astronomer to make discoveries of Sun-grazing comets.

Two exciting new projects that communicate astronomy beyond the community of amateur astronomers into the wider community of school students are the National School Observatory and the Faulkes Telescopes. Both use 2-metre class robotic telescopes. In the NSO, images are taken to order by a telescope on La Palma. In the Faulkes Telescope project, opportunities on telescopes on Maui, Hawaii, and Siding Spring Observatory, Australia, are offered for real-time observations. The essential point, however, is that both telescopes coordinate with scientific/educational projects. Example FT/NSO projects are:

- determining the light curve of a BL Lac object or gamma ray burster that has gone into outbreak,
- determining the size of an extrasolar planet from the light curve of its transit across its parent star,
- measuring and classifying the light profiles of galaxies for a catalogue
- determining the orbit of an asteroid to see if it will crash into the Earth.

These observations are of members of a population so large that professionals have found it impractical to devote enough time to them. Or they are of events that are transient, in the sky only briefly so that the student might be the lucky person with the telescope in the right place at the right time. This is democratic science.

Preparation for such projects is extensive and in particular the teacher training is pretty serious. A recent Faulkes Telescope teacher training course covered:

- Waves, optics, refraction, reflection, electromagnetic spectrum
- Colour imaging, human eye, colour pictures
- Photons, electrons, CCDs
- Mathematics, coordinate systems
- Robotics, weather, sensors, IT systems
- The scientific process.

It is easy to see the size of the task to communicate what science *is*. The NSO and FT projects consist of:

- A facility
- Some projects
- As few nerdy astronomy techniques as possible
- As much cool astronomy science as possible
- Some scientific principles
- A programme that maps onto ability-related educational objectives
- Knowledgeable and confident teachers
- Enthusiastic students, young or young at heart

Only the last is guaranteed: the rest has to be worked at. The promised outcome is that the telescope rises beyond being an optical instrument. It becomes an instrument for communicating science fully and generating human understanding.

CONCLUSION

The essential characteristic of science *is* not to hear stories about science that fit a predetermined media requirement or even to learn what is known. It is to enquire. The purpose of science communication is not only to teach facts or 'laws', or to entertain. It is to change heads. Coming to terms with what science *is*, not what it is *like*, is one of the biggest issues in science communication. It is a key to the public development of a realistic attitude to science. The challenge is to put entire systems in place to communicate science realistically in this way. Astronomy has the power to do it.