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Communicating Astronomy with the Public

Publicising a Science Discovery
A case study of controversial stories

Beagle 2 and *Cassini–Huygens*
What happened?

WorldWide Telescope
A look under the bonnet!

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Cover: After a rainy day the sky becomes crystal clear on a pleasant spring evening, while diligent skygazers wait to seek the treasures of the night. The bright point just below the telescope tube is the dazzling planet Venus. Credit: Babak Tafreshi/twanight.org.

Editorial

FOR MANY OF US, the decision to pursue professional or amateur activities in astronomy was influenced by chance childhood contacts: an inspirational science teacher, a fantastic book, an engaging documentary, the first look through a telescope or even a piece of scientific software. When I was a kid, I used to play a lot with my Timex Sinclair 48K computer and simple astronomical BASIC code; somehow my engagement with astronomy grew with those small pieces of astronomical code. I'm pleased to see the amazing software available today. Nowadays community-driven content is a reality, and software developers and new media activists are having a field day. Digital universes like Stellarium, Celestia or Google Sky use astronomy activists to develop, produce and disseminate their products. The buzz of excitement generated around the latest product from Microsoft Research, the WorldWide Telescope, sets the standards so high that everyone at least wants to play with it. In this issue we are privileged to take a first look at the WorldWide Telescope and the concept behind it.

Diverse content is one of CAPj's core aspirations. In this edition the contributions cover the full spectrum of astronomy communication from forefront technology to the fine art of communicating controversy. Three of the topics discussed in this issue deal with communicating contentious topics: the cases of the meteorite ALH 84001, the TMR-C1 "protoplanet" and the UK spacecraft *Beagle 2* featured prominently in the media coverage of astronomy in 1996, 1998 and 2003 respectively. Two great articles examine the backstage drama and the media coverage of these remarkable stories thoroughly. There are many lessons to be learnt from these case studies.

Between issues you can stay in touch through our website, www.capjournal.org, where you will find the current issue in PDF format, a job bank, submission guidelines and back issues of CAPjournal. You can also post anything you have to say on the site or e-mail me at editor@capjournal.org. I'd like to know what you think about CAPj!

Happy reading,

Pedro Russo
Editor-in-Chief

Explained in 60 Seconds

A collaboration with *Symmetry* magazine, a Fermilab/SLAC publication

Best Practices

Gravitational Lenses

Gravitational lenses are a useful tool in the belt of the modern cosmologist. Massive bodies deflect light, focusing it towards the observer and causing distant objects to appear magnified and distorted, or even as multiple images. Einstein's General Theory of Relativity tells us exactly how light rays are affected by the warped space around a galaxy or cluster acting as a lens. Interestingly, the lensing effect is stronger than expected for the amount of mass we can see. This adds weight to the idea that the main constituent of galaxies and clusters is an unseen "dark matter".

The density of a galaxy increases towards its centre, much like the thickness of the base of a wineglass. In fact, a wineglass makes a good model gravitational lens: look into the glass from the top and through its stem toward a light to discern the effect. By seeing how it distorts the light, it is possible to work out the shape and thickness of the glass. In the same way, observing distant galaxies through gravitational lenses allows the density distribution of the clumpy, transparent dark matter to be mapped out. Gravitational lensing may not yet be able to tell us what the dark matter is, but it is telling us where to look.

Key Words

Written Communication
Case Study

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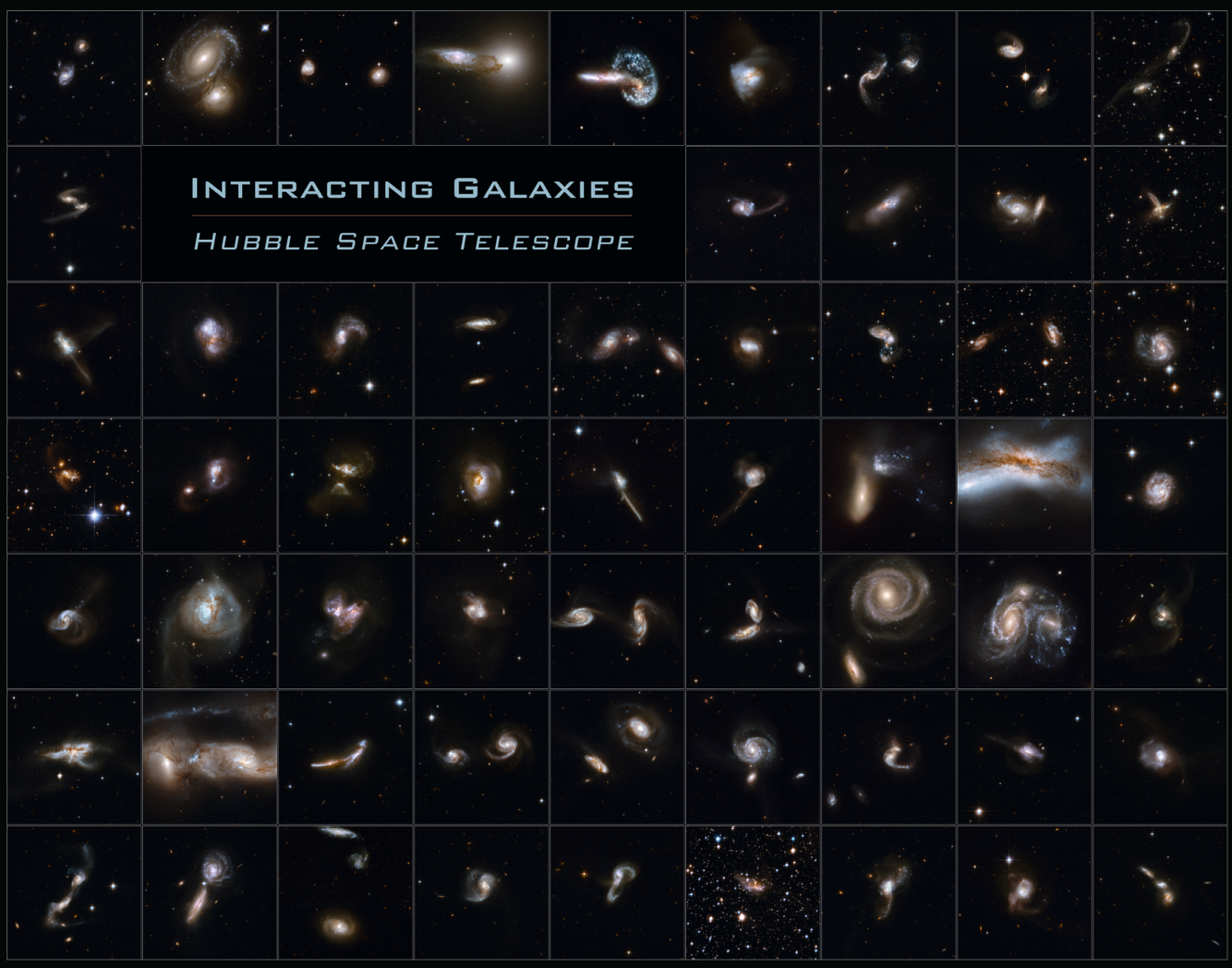
News

To mark the 18th anniversary of the *NASA/ESA Hubble Space Telescope* on 24 April 2008, 59 new images of colliding galaxies were released simultaneously. This is the largest collection of *Hubble* images ever released to the public at one time and was assembled over a period of more than a year from the several terabytes of archived raw images. Credit: NASA, ESA, the Hubble Heritage Team (STScI/AURA)-ESA/Hubble Collaboration and A. Evans (University of Virginia, Charlottesville/NRAO/Stony Brook University) — http://www.spacetelescope.org



Framing Space: UK Newspaper Reporting of the *Beagle 2* and *Cassini–Huygens* Space Missions

Research & Applications

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Key Words

Astronomy and the Media
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Summary

Relatively little scholarly work has been done on looking at the portrayal of astronomy and space science in the media. This short article examines the UK press coverage of two space missions: the *Beagle 2* mission to Mars and the *Cassini–Huygens* mission to Saturn and its moon Titan. In both cases, the leading scientists exerted a strong influence on what journalists reported, to the extent that some journalists appeared to be almost "embedded" in the mission. For the most part the coverage is positive in tone and the loss of the *Beagle 2* spacecraft does not reflect badly on the (later) *Cassini–Huygens* coverage. Most journalists only covered the actual mission events and, in the case of *Huygens*, did not follow up to cover the peer-reviewed scientific articles that appeared later. Off-the-cuff comments made by scientists at the time of the missions were widely reported. There appears to be an appreciation by journalists and (by inference) their readership that this was science in the making, and that allowances should be made if these comments later turned out to be inaccurate.

Introduction

Although it has little practical bearing on most people's day-to-day lives, astronomy is one of the physical sciences that seems to attract a great deal of public interest (e.g. Eurobarometer 55.2). As such, it could be used as a practical comparison for media studies of topics such as medicine — clearly of immediate interest and applicability; biotechnology — of immediate concern and possible applicability; and nanotechnology — of possible future concern and potential. One could hypothesise that astronomy might escape the increasingly critical stance that journalists and broadcasters, and perhaps the public at large, are adopting towards other branches of science and technology. For example, Weingart et al. (2003), looking at ethical concerns about science, have claimed that the media portrayal of astronomy is "mostly outside of this concern".

There have been relatively few studies of the way in which astronomical subjects are dealt with in the mass media. Gregory's (2005) recent biography of the British cosmologist Fred Hoyle traces the way in which he made use of all of the popular media to float ideas ahead of publication in the scientific literature or when he was prevented from access to peer-reviewed outlets for his science. The use of large and important metaphors in popularising astronomy and space science is particularly prevalent (Christadou et al. 2004). Miller (1994) and Bucchi (1998) have both looked at the presentation of cosmology to the general public, particularly in terms of the issues it raises *vis-à-vis* religion and the way in which religious metaphors ("knowing the mind/seeing the face of God") are often invoked. They also looked at the way embargoes work — or rather do not work — when big claims are at stake and many individual scientists are involved, an issue addressed in more detail in Kiernan's (2000) study of the Martian meteorite ALH84001. In that instance, presidential endorsement for Mars exploration on a massive scale was at stake. Although astronomical subjects are regularly covered in the media, Einseidel (1992), Bucchi and Mazzolin (2003) and Gopfert (1996) have each found that there is relatively little astronomy-related material in Canadian and Italian newspapers and on German television, respectively, when compared with other science and technology subjects, most notably medicine.

In this paper, we aim to address the relative paucity in media studies of the popularisation of astronomy with a largely qualitative investigation into the way that two space missions were presented to the British public through their press. In doing this we have been greatly assisted by the cuttings service provided by the then Particle Physics and Astronomy Research Council (PPARC — now the Science and Technology Facilities Council), the UK policy and funding body responsible for astronomy and space science. We are particularly interested in space missions since they are both events and research projects in and of themselves. This means that the mission scientists are often called on to make media-credible statements "on the hoof" about Solar System bodies of which they know little or nothing and certainly well prior to their ideas going through the peer-review process. So one question is: what extent do ideas put forward at the time of the mission events make it into subsequent scientific publications — what is the inter-influence between popular and scientific communications? Another, consequential, question follows from this and addresses the "well-known" finding of Nelkin (1987, 1995) that science journalists have often felt that their independence

is compromised, and that they have been co-opted "onto the team": is the production of "on the hoof" science a collaboration in which journalists are prepared to allow space scientists to be much less rigorous than they would medical researchers announcing a breakthrough discovery in the fight against headline conditions such as cancer, AIDS or Alzheimer's?

The Two Missions

The two missions we have considered reached their climaxes (or nadir, in one case) almost exactly a year apart. The UK *Beagle 2* lander, which hitched a ride on the European Space Agency's (ESA) successful *Mars Express* spacecraft (Figure 2), should have touched down on the surface of Mars on Christmas Day, 2003. By mid-January 2004 it had not called home and attempts to use Earth-based receivers, *Mars Express* and a Mars-orbiting NASA[1] mission to locate it had failed. In stark contrast, just over a year later, on 14 January 2005, the *Huygens* lander — part of the NASA/ESA/Italian Space Agency *Cassini–Huygens* mission to Saturn — touched down perfectly on the surface of Titan, the Solar System's second largest moon, exceeding all expectations. The two missions — one a failure, the other a great success — make for several interesting comparisons and contrasts.

Both missions involved landing on a Solar System body a great distance from Earth — in the case of Titan, 1.5 billion kilometres from Earth, a distance that requires over 80 minutes for electromagnetic signals such as light to cross it. Mars and Titan are also Solar System bodies that interest astronomers who are looking for signs of life off Earth. Mars may have had life in the past; it may even be present now. The atmosphere of Titan is often said to resemble that of the early Earth, fuelling speculation that life might one day evolve independently there. From the standpoint of the UK, both missions had charismatic British leaders: *Beagle 2* was identified inseparably with its champion, Colin Pillinger; and, although much more of an international team effort, *Huygens* was fronted by John Zarnecki, as far as the British and much of the European media were concerned. Both men are professors in the Planetary and Space Science Research Institute at the Open University, UK. But the similarities end there. *Beagle 2* was an opportunity-grabbing mission, put together on a relatively small budget. Exact figures are not available, but approximately £45 million has been quoted informally. Note that ESA's *Mars Express* mission, on which *Beagle 2* was travelling, cost around 300 million EUR, according to its official website. In contrast, *Huygens* was a long-planned part of a major, high budget project, costing ~$3 billion, depending on how the various international contributions are calculated. *Beagle 2* and *Mars Express* were "in competition" with NASA's *Mars Odyssey* and its *Spirit* and *Opportunity* rovers. *Cassini–Huygens*, on the other hand, saw Europe (including the UK) cooperating with America.

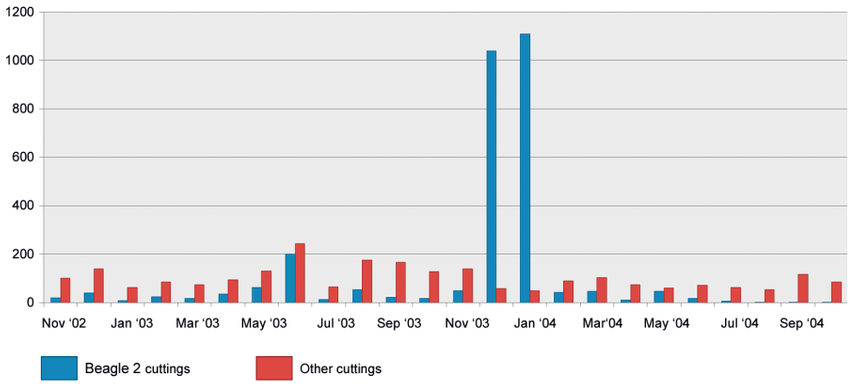

Figure 1. The number of Beagle 2 *press cuttings (blue) compared with the number of other PPARC cuttings (red). Credit: The authors.*

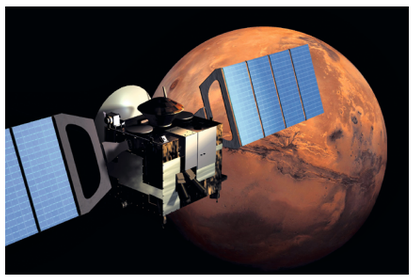

Figure 2. The Mars Express *spacecraft. Credit: ESA.*

Both *Beagle 2* and *Cassini–Huygens* received considerable press coverage during the period from 2003 to 2005: the total number of British newspaper articles runs into the thousands for both missions. Given that the two missions were only separated by a short time, it is interesting to ask how the print media treated the two of them: did attitudes to (the failure of) *Beagle 2* have a bearing on the coverage of the landing of *Huygens*? How were expectations maintained or tempered? Much coverage of astronomy is of the "amazing facts and discoveries" kind. Would the "new mood for dialogue" identified by the UK House of Lords (2000) lead to heated discussions about the wisdom of committing (reasonably) large sums of money to the task of throwing finely engineered pieces of metal at distant worlds? To investigate those questions, we now present a media analysis for several different short periods between November 2002 and December 2005.

UK Press Coverage of *Beagle 2*

The PPARC press cuttings service (see Figure 1) indicates that the *Beagle 2* space mission received continuous coverage on a monthly basis in the UK newspapers from November 2002 through to October 2004, and then on a less regular basis through to December 2005. The number of articles ranged from one or two per month to over 1000 in December 2003 and over 1100 January 2004, when the lander was supposed to be on the surface of Mars. The PPARC service culls articles from national, regional and local newspapers and from the BBC's online news service. Another — earlier — high point was the launch of *Mars Express* in June 2003, when there were about 200 individual cuttings included in the PPARC service. The number of articles published each month fell dramatically after it was realised that *Beagle 2* was not going to "phone home". Nonetheless, for each month of 2004 and sporadically throughout 2005, *Beagle 2* was the subject of articles in the press.

Of the total number of articles, 105 were sampled for a more detailed qualitative analysis. Nearly 60% of the articles sampled made use of quotes, largely from scientists. Tone was an important indicator. Right up until the failure of *Beagle 2* to call home, the newspaper coverage was either uniformly positive, or it was positive, but expressing anxiety. January 2004 saw about one third of the articles taking a critical line, as the realisation grew that the mission had failed. In February 2004 none of the articles had a good word to say for *Beagle 2*. Following this abrupt reversal in media image, the rest of 2004 saw a much more ambiguous attitude towards the project. Half the articles in our sample were accompanied by pictures or graphics, with images of Colin Pillinger, complete with mutton-chop whiskers, and cradling a mock-up of his spacecraft, a perennial favourite.

Two days before the June launch, the elite UK newspaper, *The Independent*, portrayed Pillinger as possessing "effusive enthusiasm, iron will and low cunning" and spoke of the care with which everything was being rehearsed for the eventual Mars landing (*The Independent*, 31 May 2003). Much was made of the decision that *Beagle 2* would be operated from the National Space Centre in Leicester in full view of the public. "NASA has

Figure 3. Beagle 2 *model. Credit: ESA.*

never done this. We are breaking new ground in the public presentation of space science," Leicester University's Director of Space Research, Alan Wells, was quoted as saying.

Much was made of the "Britishness" of it all. The ultra-chauvinistic, middle-order *Sunday Express* (20 July 2003) flushed with pride as it quoted Pillinger: "This is a British space project — make no doubt about it. The *Beagle 2* lander may be hitching a ride with the [ESA] *Mars Express*, but the design and the ingenuity comes primarily from the UK." And there was praise for the way Pillinger had raised support from the band Blur, who recorded the short tune that was to signal a successful landing, and BritArt guru Damien Hirst, whose sequence of painted dots would act as a colour calibrator for the *Beagle 2* cameras. With a certain amount of foreshadowing, there was also considerable emphasis on how little *Beagle 2* had cost. The elite *Guardian* (10 November 2003) described the mission as a "shoestring project".

The tone of the coverage became a little more tentative as the landing date approached. On 20 December 2003, *The Times* hinted at concerns as *Beagle 2* separated from *Mars Express* to begin its descent. "It's been a very tense morning," ESA Director of Science David Southwood was quoted as saying. The same day, *The Glasgow Herald*, an influential Scottish regional daily, spoke of the spacecraft passing the "most critical stage of its cosmic journey". Ironically, it was to be NASA's *Mars Odyssey* that would first hear from *Beagle 2* if the landing were successful; ESA's orbiting *Mars Express* would not be in position immediately. On 26 December 2003, *The Glasgow Herald* headlined: "Silent night as *Beagle* loses its voice." NASA's spacecraft had not heard from the lander. Jodrell Bank, the veteran radio astronomy centre, swung its giant antenna Mars-ward to listen for Blur's landing song, also to no avail. However, *The Herald* was still able to report that the bookmakers had shortened the odds on life being discovered on Mars by the end of 2004 from 500-1 to 100-1[2]. The next day, scientists were still being "hopeful" on regional agency wires.

But as the New Year (2004) dawned, hopes were fading. Pillinger was quoted in *The Times* (1 January 2004) as saying: "We'd have been incredibly accurate and incredibly unlucky to go right down this crater", as he speculated on where his lost lander might be. Matters were made to look worse by the successful landing of NASA's *Spirit* rover. "Dear NASA, if you spot our *Beagle* please call", jibed the tabloid *Daily Star* (5 January 2004). Typically, the *Financial Times* (8 January 2004) made the (wise-after-the-event) point: "There is no point in sending cut-price missions to Mars" — and what had previously been a great source of British pride became a cause for criticism. The paper went on: "With a curious lack of financial transparency the *Beagle* team and its chief backer, the UK government, have consistently refused to say just what the mission cost. Estimates are about £45 million, less than a tenth of the amount NASA spent on *Spirit* and its twin rover *Opportunity*. Of course, if *Beagle* comes unexpectedly to life it will be seen as a triumph of the gallant shoestring approach to space exploration. If not, a cut-price failure is still a total failure."

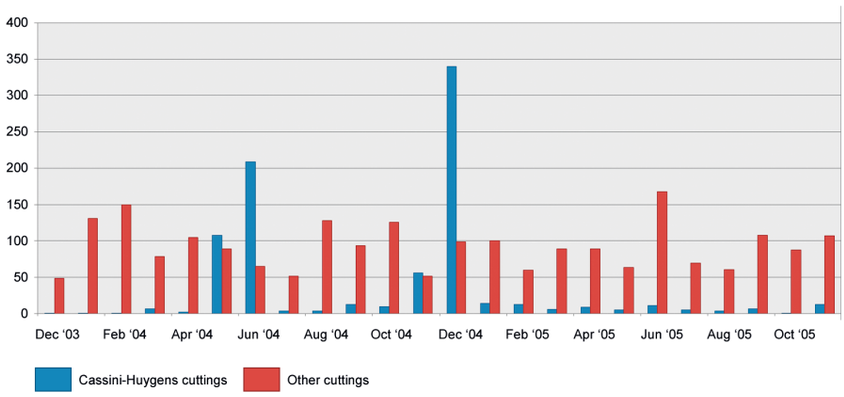

Figure 4. The number of Cassini–Huygens *press cuttings (blue) compared with the number of other PPARC cuttings (red). Credit: The authors.*

The same day's *Guardian* (January 8, 2004) had a more upbeat, footballing approach: "We must play to the final whistle. It only takes a fraction of a second to score a final goal. The *Beagle* project has demonstrated without doubt that we are playing in the Premiership[3]. We'll go for a second voyage of *Beagle 2*." By the end of January 2004, hope had evaporated. An inquiry, to be held jointly by ESA and the (even more unknown to the public) British National Space Corporation (BNSC), was announced. Blame was to be apportioned. When it reported in May 2004, there were 19 recommendations on how to do things better next time. But few of the inquiry's findings were made public. The *Weekly Telegraph* quoted scientists complaining of a cover-up: "Public still in the dark over *Beagle*," it said (2 June 2004).

Press Coverage of the *Huygens* Landing

While *Mars Express* (as its name suggests) carried *Beagle 2* to Mars in just over six months, the *Cassini–Huygens* mission to Saturn and its moons was a much more drawn out affair, taking seven years and involving "swing bys" of Venus (twice) and the Earth (once). Two key periods are important for this study (see Figure 4): June–July 2004, when the composite spacecraft finally went into orbit around Saturn after its epic journey; December 2004–January 2005, when the *Huygens* probe first separated from the mother ship and then landed on Titan. In June-July 2004 there were 317 articles across the spectrum of the UK press. For the period December 2004 to January 2005 the number was similar, 396. One thing to note is the growing importance of online publishing — roughly one third of the total collected by PPARC.

Once more, this output was sampled, with 50 articles taken from June–July 2004 and 50 for December 2004–January 2005. In this case, the general tone of the articles was 100% positive; the *Huygens* landing was successful, unlike *Beagle 2*, so no dramatic reversal of image was occasioned. Of the articles sampled, 68% employed quotations from scientists, with some quoting as many as five different researchers. Three quarters of the articles gave scientific details about Saturn and Titan and technical information about the mission. One change — compared with much coverage of other space missions — was that the European Space Agency (ESA) was regularly recognised, along with British scientists, as making a significant contribution. Roughly two thirds of the articles cited ESA along with the US space agency NASA; the complaint by many European scientists that they were barely recognised in comparison with their American counterparts during joint missions did not hold in this case. Although the general tone was positive, costs came up in about 34% of the articles, while 17% mentioned the riskiness of the mission — a cause for anxiety, particularly in the run up to the *Huygens* landing.

The press used a number of rhetorical devices and metaphors to explain the significance of the mission and its targets. Comparisons of Titan with the Earth were made in over a quarter of our sample, with Saturn's moon described as being on the "eve of life" in 18% of those articles. The timing of the mission meant that Christmas-related metaphors came into the press in about 20% of our sample. Nearly two out of three articles spoke of the secrets on the "alien world" and surprises that were in store for mission scientists. Our media samples were taken from articles that preceded any analysis of the scientific data from *Huygens* and hence any peer-reviewed scientific papers. So it is interesting to see to what extent the media and scientific discourses reflected one another.

Just like *Beagle 2*, the *Cassini–Huygens* mission had not been without its problems: its shuttle launch had been cancelled after the *Challenger* shuttle disaster; it had been "descoped" to fit a rocket launch; and it had run into some controversy as a result of the radio-isotope thermal generator it carried on board, particularly during the swing-by of the Earth. Newspaper coverage of the *Cassini–Huygens* mission carried on sporadically throughout the seven-year journey, such that it bracketed and overlapped that of *Beagle 2*. One might have expected press attitudes to the Mars failure to colour reporting of the Saturn-bound mission. But this happened in very few articles — just 8% of the sample. And three quarters of those articles were published after the successful landing, comparing *Huygens* positively to *Beagle 2*.

One key point at which a pessimistic comparison with *Beagle 2* could have been made was in the run-up to early July 2004, just two months after the secretive ESA–BNSC *Beagle 2* inquiry. *Cassini–Huygens* would commence orbiting Saturn on 1 July, going into Saturn Orbit Insertion, a tricky manoeuvre that involved flying through a division in the planet's extensive and spectacular rings, avoiding the larger rocks and icy stones that could inflict fatal injuries on the spacecraft. On 3 June, the BBC's online News UK ran an extended article on the mission under the heading "Probe keeps UK space hopes alive". It quoted *Huygens* mission scientist John Zarnecki — who had also been on Pillinger's *Beagle 2* team — commenting wryly: "I wish I could say that *Huygens* will be the second piece of UK hardware to land on a cosmic body, clearly that is now not the case."And he warned that *Huygens* could suffer a fate similar to that of *Beagle 2*: "Its survival on the surface [of Titan] is not guaranteed." In the print media less was made of the comparison with *Beagle 2*, but the warnings were there. *Cassini–Huygens* received a media boost later in June after its encounter with Saturn's distant moon Phoebe. "Stunning new images have been beamed back," the *Leicester Mercury* told its readers on 17 June — reminding them that the local Leicester University scientists were involved with the spacecraft.

Newspapers reported on 1 July that *Cassini–Huygens* had successfully gone into orbit around Saturn with a blaze of congratulations, expectations for the future and national and local pride. "Oxfordshire scientists were glued to satellite screens as a US spacecraft went into orbit around the giant planet Saturn," squealed the *Oxford Mail* over a picture of local space researcher Manuel Grande. Readers of *The Scotsman* were treated to an extensive primer on Saturn, together with such facts and figures as the diameter of the planet being 120 536 km (impressive accuracy considering the planet does not have solid surface but is a giant ball of gas) and a more reasonable size for Titan at 5150 km. Many newspapers (19% of articles analysed) carried the information that the spacecraft itself was the size of a bus/schoolbus/30-passenger bus, leaving readers to wonder if it were a single-decker bus, a double-decker, or one of the new 18-metre "bendy buses" that were making their appearance on the streets of London. For the moment, the disappointment of *Beagle 2* was put to one side. The *Leicester Mercury* gushed: "The *Cassini* project — which could reveal the origins of life — is being heralded as the new space project for Britain to cheer one after the failure of the *Beagle 2* Mars mission."

The *Huygens* probe was due to separate from the *Cassini* orbiter on Christmas Day, 2004, just one year after *Beagle 2*'s ill-fated Mars landing. As the press focused its attention on the event, the scientific community fed them a diet of startling results, which were often gobbled up almost untransformed. On 20 December 2004, five newspapers, the *Daily Express*, *The Scotsman*, the *Western Daily Mail*, *The Press and Journal* [Aberdeen], *The Irish News* (Belfast), ran stories with (almost) the same opening sentence: "Finding yourself in a thunderstorm on Saturn would be a truly shocking experience, scientists have found." *The Guardian* foreshadowed the *Cassini–Huygens* separation: "In its two and a half hour descent, [*Huygens*] will measure everything it can about the Titanic world… Everything about the ride will be a nerve-wracking test of plans and technology fashioned a decade ago." Glasgow's *The Sunday Herald* drew the parallel with Christmas 2003: "Last December and January [British researchers] were waiting for news of their ill-fated Martian lander, *Beagle 2*, which was eventually declared lost." Other writers invoked religious images. As *Huygens* approached Titan, the *Northern Echo* had it "Looking down on creation", adding: "By going to Titan we're studying the Earth's early history. It's like the Earth's early atmosphere, but stuck in a deep freeze." (4 January 2005) And the *Daily Telegraph* even claimed "Aliens 'could exist on Saturn's moon'", quoting American scientist Steven Benner: "This makes inescapable the conclusion that if life is an intrinsic property of chemical reactivity, life should exist on Titan." (10 January 2005)

Huygens was due to enter the atmosphere of Titan at 06:50 GMT on the morning of 14 January 2005. As well as intense newspaper interest, BBC television ran an all-night show live from the ESA tracking station in Darmstadt, Germany, featuring — among others — Zarnecki and ESA mission scientist Jean-Pierre Lebreton. *Huygens*' descent through Titan's atmosphere was a complete success, and it touched down gently on the surface undamaged. The next day's papers were full of pictures taken from the cameras on board *Huygens*, including an eerie beach-scape shot as the probe rested peacefully on the moon's surface. *The Sun* tabloid (15 January 2005) waxed poetic: "Excitin' sightin' of Titan", shrieked its triple-decker headline. Pillinger was reported to be among those scientists waiting at the headquarters of the Royal Society in London: the contrast from the previous year hardly needed to be drawn. Nonetheless *The Guardian* pointed out to readers who had not been following the plot that *Huygens* "was Europe's first landing on another celestial body". Zarnecki spoke for many European scientists: "Fifteen years of pent-up emotion were released… There is a tremendous mood of relief and anticipation." (*The Times*, 15 January 2005)

Science "On the Hoof" and "Normal" Science

In the run-up to the *Huygens* landing, there had been great speculation about what the lander would encounter. The atmosphere of Saturn's largest moon is a thick mixture of nitrogen and methane with a lethal cocktail of minor constituents, including hydrogen cyanide. That makes the atmosphere highly impenetrable to visible light and conditions on the moon's surface could only be modelled — or guessed at. The regional *Yorkshire Post* was typical in its coverage of the speculations. On 2 July 2004, it reported of *Huygens*: "The robot will think for itself as it parachutes down onto Titan. No one knows what it will find, but scientists believe there is a good chance it will make a splash landing in a sea of liquid methane or ethane." Two days later, the same paper had *Huygens* splashing "into a surreal sea of lighter fuel". Clearly these were ideas derived from scientists ahead of the landing and they continued to feature in the live and reported coverage of the landing itself on 14 January 2005. These were ideas derived from previous scientific studies, but in the next few weeks and months they were to be tested as never before. One question that arises from this, is why should normally sceptical journalists allow scientists to speculate in this unchallenged fashion?

More specialist publications were more cautious. Reporting on the first *Cassini* flyby of Titan in its July 2004 edition, the online *Spaceflight Now* magazine reported that scientists were getting a bit worried that they had not seen the glint of sunlight reflected off any sea, surreal or otherwise. Of course, *Cassini* had only had the opportunity to look at a small portion of Titan's surface. But the magazine quoted NASA mission scientist Kevin Baines to the effect: "If we go by 30 times and we haven't seen it [reflected sunlight], we're going to start getting worried." With increasing scepticism the article went on to quote another NASA scientist, Elizabeth Turtle on the images of Titan: "It's been hypothesised that the *dark* areas were regions where [hydrocarbons] had accumulated and that the *bright* areas might actually be cleaner water ice." But the article continued: "That was the theory until Friday night. 'Data from the infrared mapping spectrometer,' Baines said, 'indicates [that] the *brighter* areas have been contaminated in a sense with organics [hydrocarbons], the *dark* areas are more pure [i.e. cleaner] water ice.' Stay tuned."

Those who did stay tuned saw Zarnecki wondering out loud (*The Independent on Sunday*, 16 January 2005) if the images from *Huygens*' descent revealed waves in an "oily sea". To date, however, the only reports of waves, oily or otherwise, have been in the media. None of the peer-reviewed articles in the special editions of *Science* (25 February 2005; 13 May 2005) covering the mission, up to the end of 2005, claimed unimpeachable evidence for seas on Titan. That said, many Earth-like water features, such as drainage channels were reported both in the mass media (e.g. the Newcastle *Sunday Sun*, 16 January 2005) and in the peer-reviewed literature (e.g. Elachi et al. 2005). Eighteen months were to elapse before any real evidence of liquid hydrocarbons on Titan was to emerge. Not seas, but more modest lakes are now thought to exist.

Another of the "on-the-hoof" claims concerned the nature of the surface of Titan. The lander's penetrometer, a spring-loaded device designed to test surface strength, indicated an initial resistance that crumbled after a few milliseconds. At some point during the live television coverage, one of the team likened this to *"crème brulée"*, and the description made it both onto the official website of the UK's PPARC and that of the BBC's online news service (15 January 2005), as well as into the pages of *The Guardian* (15 January 2005). Yahoo! News also picked this up (16 January 2005). Zarnecki's own description of the surface was more prosaic — "wet sand or clay" (*Wall Street Journal Europe*, 17 January 2005). At a meeting of the Royal Astronomical Society (RAS) in London on 11 March 2005, Zarnecki explained that his penetrometer results were indicative either of a surface crust ("wet sand or clay") or a breaking "ice-pebble": the images from *Huygens* on the surface of Titan could even be interpreted as showing a broken pebble next to the lander.

Nature Special Issue on *Huygens* and Titan, 8 December 2005

In most Science Journalism 101 courses there is a discussion of the extent to which scientists should or should not wait until peer review has been completed before going public. Similarly, the discussion involves the extent to which science journalists and broadcasters should trust anything that has not been subject to peer review. So one of the purposes of this paper is to compare the comments made by space scientists during the events associated with their missions with what they have to say in the peer-reviewed literature, after careful data analysis and mature reflection. For scientists trying to publish in the high impact journals *Science* and *Nature* these issues are complicated by the rules of those two journals that say that they will not publish articles that have already received publicity elsewhere. Both journals send out their own weekly press releases, but with strict embargoes that ensure that a wider media coverage coincides with their own availability on the newsstands.

The first major publication of results from the *Huygens* probe came with a special issue of *Nature*, published on 8 December 2005, nearly one year after the landing. In *Nature*'s own commentary article, Mark Peplow (2005) reminded readers of the inevitable delay: "It is easy to forget that just over a year ago Titan was one of the most mysterious objects in our Solar System… But since the *Cassini–Huygens* mission arrived at the ringed planet last year, scientists have been clearing up Titan's mysteries at a tremendous pace." For NASA's Hasso Nieman, the surface of Titan was "a big surprise, it was totally new information" (Nieman 2005). Zarnecki's team also had an article in the special edition (Zarnecki et al. 2005). There was no mention of *crême brulée*. Instead the surface of Titan was likened to "wet clay, lightly packed snow and wet or dry sand" — similar to the descriptions given at the March RAS meeting. Titan's surface was elsewhere described as "neither hard, like solid ice nor very compressible (like a blanket of fluffy aerosol)". An article by Marti Tomasko of the Lunar and Planetary Laboratory in Arizona (Tomasko et al. 2005) contrasted expectations of "methane lakes" with what was actually observed. "Although these images [taken from the Descent Probe Imager] do not show liquid hydrocarbon pools on the surface, they do reveal the traces of once flowing liquid. Surprisingly like Earth, the brighter highland regions show complex systems draining into flat, dark lowlands. Images taken after landing are of a dry riverbed." Other articles supported this view (e.g Fulchignoni et al. 2005).

With the exceptions of the *crême brulée* metaphor and the lack of "seas" to "splash down" into, there were considerable similarities of both content and language between the articles in the special *Nature* edition and the previous press reports. At one point or another, both referred to secrets and surprises (e.g. Bird et al. 2005; Tomasko et al. 2005; Lebreton et al. 2005). As with the newspaper articles, many of the scientific articles compared Titan with the Earth: "An extraordinary world, resembling Earth in many aspects." ESA's Jean-Pierre Lebreton (2005) talked about the *Huygens* data as offering: "A new view of Titan, which appears to have an extraordinarily Earth-like meteorology, geology and fluvial activity (in which methane would play the role of water on Earth)… Titan is an extraordinary world having Earth-like geophysical processes operating on exotic materials under very alien conditions." The allusion to "alien" was not a throwaway. "Titan could be a place of astrobiological interest … a planetary-scale laboratory for studying pre-biotic chemistry, which confirms the astrobiological interest of Saturn's largest moon," the article concluded.

From the content of the *Nature* articles, it is clear that many of the on-the-hoof comments of scientists in January 2005 did stand up to the analysis of the *Huygens* data. In this instance, one might therefore argue that scientists had been vindicated in speaking out prior to peer review, and journalists had been right in believing and quoting them. At least, they had both "got away with it".

Press Coverage of the *Nature* Special Issue

There was none.

Other Space-Related Press Coverage in December 2005

It was not as if there was no coverage of space science in the British press during December 2005. But not even *New Scientist*, which is read by many people interested in science, as well as by scientists trying to keep up with all that is happening across the disciplines, carried a word about the *Nature* special issue. What the newspapers did cover included the threat from an asteroid that had been reported to be on collision course with the Earth, and likely to hit in 2036 (*Daily Express*, 8 December 2005; *The Guardian*, 16 December 2005), the cost of space missions (*The Independent*, 6 December 2005) and Mars. *The Sun* reported on 2 December that water on Mars gave a clue as to whether or not life could have flourished there. The cartoon accompanying its article depicted Martians worshipping at the wreckage of *Beagle 2*, while a NASA spacecraft flew overhead.

And then, on 20 December, the press reported that wreckage of the *Beagle 2* had been found in a crater on Mars (*Daily Express*, *Daily Mirror*, *Daily Record*, *Daily Telegraph*, *Financial Times*, *The Independent*, *The Sun*, *The Times*). NASA's *Mars Global Surveyor* had sent back some "grainy images" that looked as if there might be traces of where *Beagle 2* had first crashed down and even the remnants of its airbag. Speculation was that *Beagle 2* had hit the side of the crater it was aiming for, rather than landing safely on the bottom. Many of the papers quoted Colin Pillinger saying it was "a bit like hitting the side of the pocket in snooker". For the next few days a furious argument raged in the pages of *The Times*. On 21 December, its "Thunderer" column accused Pillinger of "radiating more enthusiasm than genius" and requested that he "shut up about *Beagle 2*". "We do not want to spend another Christmas thinking about such a dispiriting cock-up. By all means inform us about *Beagle 3*, but only after it has landed and made contact with mission control," the column finished.

Colin Pillinger and ESA's David Southwood both responded with letters defending *Beagle 2* against the "Thunderer". Southwood's support was somewhat double-edged: "I

deprecate most the attack on Colin Pillinger personally… it is a sad society where there is no role for the eccentric. Indeed, eccentrics can often inspire, almost always think laterally, and do not always fail." Reader Dan Green of Ewell was less supportive. "In the crater in which it is speculated that *Beagle 2* landed, it is also speculated that there is evidence of a 'possible gas bag'. It would be better to look here on Earth, where there is irrefutable evidence of the real thing," he wrote.

Models of Science Communication

Space missions are both scientific research programmes and potentially exciting media events: they are voyages of discovery, albeit often by robotic proxy; scientists gamble their careers on achieving millimetre accuracy over distances of a billion kilometres or more. So they are naturally concerned about how their efforts will come across to their fellow citizens. Hilgartner (1990) identified what he termed the "dominant model" of science communication: scientists did their research; it was published upstream after peer review, and it made it downstream to the public through the muddy channels of the mass media. In that way, the scientific community could retain control of what got into the public domain, Hilgartner explained. That model is clearly not applicable to either mission under discussion here: for obvious reasons, there were no peer-reviewed articles about the science beamed back from *Beagle 2*; for much less obvious reasons, there was no coverage of the special issue of *Nature* devoted to the *Huygens* landing. One of the news values often cited as enabling journalists to place their articles in their newspaper is that of co-option (e.g. Gregory and Miller 1998), the incremental development of an ongoing story. Maybe the gap between January 2005 and December 2005 was too long, but there seemed little co-option in evidence. On the other hand, the strong news value of negativity played its part in the continued fascination with *Beagle 2* nearly two years after it went AWOL.

When science is being made in real time, as it was for *Cassini–Huygens*, and might have been for *Beagle 2* had it been successful, there is no time for peer-review. In such circumstances, the Lewenstein (1995) web model is much more applicable. This model was developed to explain how scientists got information about claims for cold fusion made by Stanley Pons and Martin Fleischman. In that instance, however, the science being claimed had been conducted behind the closed doors of a laboratory to which the media and interested scientists were denied access. Indeed, with the refusal of the scientists involved to publish their data, other scientists were forced to resort to videoing the television news and freeze-framing it to get their hands on any data (Close 1992). Lewenstein's analysis shows how boundaries between scientific and public communication become blurred when such secrecy is involved. Both *Beagle 2* and *Cassini–Huygens* have been very open in terms of public access, and in terms of putting their data and analyses through the peer-review process. The web model, while useful, does not then fully capture what happens in many space missions in terms of the communication processes and relations.

So how are we to encapsulate what was going on? Once a scientist has made a public claim — methane seas or *crême brulée* in this case — is there pressure to put this into the peer-reviewed literature? The evidence from the *Huygens* issue of *Nature* is negative. Either these two ideas had been put forward and rejected by referees for the scientific journals or they had never been put forward. So to follow up this finding we held informal discussions with Baines and Zarnecki. Neither of them said that they felt constrained by what they had said on the hoof; they did not feel under any pressure to repeat informally expressed opinions in the formal setting of the scientific journal, if later interpretations and information showed their informed guesses to have been wrong.

In none of the newspaper reports that we looked at was there a sign of a caveat. Space scientists — reacting on the hoof — were reported as scientists speaking about scientific results every bit as reliable as medical researchers reporting the results of a medicine that had been through animal trials and full clinical trials. Nowhere did the journalists express scepticism, although the example of the specialist *Spaceflight Now* and in one or two other articles the views of scientists that were somewhat at odds with each other were presented. So how is the reader/viewer/listener to make sense of this and what does it say about the scientist–journalist relationship?

One conclusion that might be drawn from this is that scientists and journalists have come to an informal agreement that involves hoodwinking the general public; science journalists are "on the team" in Nelkin's terminology. Possibly. There certainly was strong scientific input direct into the media coverage: the — sometimes inappropriate — precision in numbers given to readers; the repetition of highly technical information about the mission; some of the densely annotated graphics. Journalists at mission headquarters during the *Huygens* landing or carrying out live interviews clearly shared the excitement of the scientists; they were almost "embedded" with the subjects of their articles in the same way as war correspondents were in Iraq or Afghanistan.

Our more charitable interpretation is that both journalists and the general public have a much more sophisticated understanding of science-in-the-making than they are often given credit for. If Zarnecki, Pillinger or Baines is filmed or recorded making a (hopefully) intelligent interpretation of real-time images or data, then maybe the media and their audience treat what is happening in the same way that they view an outside broadcast of a live sports event. That is to say they understand that the post-match analysis, with the benefit of action replays taken with a battery of cameras, may show that the referee "got it wrong". Annoying though that may be for the supporters whose team was "robbed", it is "par for the course". If we are right, those who despair of the level of public "scientific literacy" should take heart — your fellow citizens are more sophisticated than you thought!

Postscript

Among UK space scientists there was concern after the *Beagle 2* failure that their area of research would be given short shrift by the government and its funding agencies. *Huygens* was thus seen as a real shot in the arm. But, somewhat behind the scenes, Pillinger continued to play an important role, making use of his public image as the plucky, shoestring scientist who tried and went down fighting. Whoever wants to claim the credit, the UK government has signed up as the second-largest investor in ESA's ambitious Aurora programme of Mars and lunar exploration.

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Notes

1. We feel confident that readers will recognise the initials of the US space agency; ESA, on the other hand, is almost unrecognised by the majority of Europeans, let alone the citizens of other countries, and we felt obliged to spell it out.
2. The bookmakers will have done well out of those willing to take either set of odds.
3. The top UK football division.

Biographies

Blanka Jergovic lectures in journalism at the Universities of Zagreb and Dubrovnik in Croatia. She also works for Croatian Radio as a science journalist and programme editor. Her research interests are in science communication and media studies. She is a council member of the European Union of Science Journalist Associations.

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Both authors are members of the European Commission Framework 6-funded *European Science Communication* Workshops network (ESConet), which Professor Miller directs.

Opinion

Building a Wall-Free Digital Tomorrow

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Key Words

Collaboration
Web 2.0
New Technologies

I live a strange life. There is no way around it. I have contracts to work with universities and programmes in Sonoma (California), Swinburne (Australia), Washington DC and Edwardsville (Illinois) where I live.

This spread of employer locations wouldn't be possible if it weren't for this fabulous thing called the Internet. Across its high-wires and by-wires we shoot our lives across the world, meeting for lunch across the desk from one another, with a video camera bringing our collaborators' multi-continental faces to us.

This is an alternate reality that doesn't belong to all of us. As I find myself symbiotically connected to the Matrix, doing Education and Public Outreach (EPO) via a cellular broadband card from random corners of

this country, I know there are others who still linger in the land of landlines and dialup.

And there are those without computers.

The computer literacy of my collaborators and myself opens up a world that will make us EPO providers to a separate society. We will be part of a New Media tomorrow, where our video content goes up on YouTube, Google Video and other streaming content providers. We will brainstorm via Skype, and forego the telephone as a thing only called by telemarketers. We will set up iGoogle pages, write blogs, share our drives across the continents, and answer every "I wonder... who/where/how/when" with an instantaneous IMDB / Wikipedia / Google search. Our news will come from Fark and SlashDot as we read Digg and our collected RSS feeds more than we read the *Times* or the *Post*.

We will? No, actually, we have. We live in that tomorrow.

These amazing resources allow me to walk into work and talk to my colleagues about the latest outrage in funding allocations with world-weary knowledge gleaned from too much outraged Googling. These amazing resources allow me to learn at home every day, constantly experiencing life-long learning as I freely explore tutorials, learning videos, and even online classrooms in Second Life as I work to understand things beyond my astronomy degree (video editing anyone? No, how about German?).

But I am a freak of a high-speed, 10 Mbit/sec down and 1 Mbit/sec up, world.

"Did you see on Stumble Upon…?" I asked a colleague of a different generation. Blank stare.

"Did you see on Google Sky…?" I asked a student. Blank stare.

"I'll show you how to use that software later. Let's screen-share in BRIO", I said to a real-world associate. Blank Stare.

Just as there is a small segment of society that falls into the "richer than God category", there is a small segment of society that falls into the "more wired than Bill Gates" category. (I don't think anyone is more wired than Steve Jobs ;-) .) I'm not in either of these categories, but my household is definitely closing in on one of these boundaries faster than we're closing in on the other.

There is irony embedded in the markup language of the digital divide. Online content is largely free and ranges across almost all topics. Because I can access broadband, I can access the world's libraries, avoid international telephone charges, pay bills without buying stamps, and generally self-select to be a shut-in if I decide the real world is just way too scary. I can even order groceries, pizza, a freshwater fish freighted to my front step thanks to the likes of Amazon, Pizza Hut and Live Aquaria.

I suspect I save more money using the Internet than I spend on our broadband bill.

Let me say this again more clearly: Because I can afford the upfront expenditure — installation, hook-up, routers, computers — I can save money on life, learn effectively, live virtually and collaborate LAN-to-LAN as all boundaries are erased between my computer and yours.

As a Web 2.0 content provider, I have to wonder if podcasting is polo for the digital generation. We often gather around and root for our favourite ~~player~~ blogger, and occasionally try riding the ~~ponies~~ RSS. When we talk about our popularity (hey, *Spitzer's Hidden Universe* was a Best of 2007 podcast!), do the mainstream masses know what this means? Are we leading a tsunami of content over the LAN, or are we just a small crest created by a 2 ~~horsepower engine~~ MHz processor on a really small pond.

I understand why people still create television shows. Do you know anyone who wants a television and doesn't have one?

I understand why people still create radio shows. Do you know anyone without a radio?

Just as there are gestures designed to redistribute wealth in the US, there are also gestures designed to redistribute the Internet. Libraries give free access. Schools give free access. There are free hotspots for the laptop-lugging among us. Even McDonald's is in on the digital distribution of content with its free Internet.

But are there similar gestures in other countries? Can a kid in Kathmandu kill time in an internet café for free, for fun, for more than a few minutes at a time?

One of the Cornerstone projects of the International Year of Astronomy 2009 is the creation of a New Media Portal, The Portal to the Universe, that will allow the astronomy aficionados of the world to log in and lounge around in the stars. There will be links to live satellite feeds, twitter feeds, press feeds, pictures aplenty and widgets with which to wend your way around the sky. I am part of the Task Group that will be creating this portal, and as I sit here, working to learn how to program widgets, I wonder what segment of the world our worldwide portal will reach? Do I need to have different interfaces for high and low speed surfers? Is Flash fair on an international playing field?

Are there things I haven't anticipated — invisible digital walls that keep the surfers from breaching the content castle?

Yes. Yes there are.

I know there are many of you out there reading this online who are in other nations. Where are you reading? Can you reach all online content? What are your limitations? What do we, the content providers need to provide you with to make our world part of your world.

I want to know. Which digital walls need to be shattered?

Biography

Pamela L. Gay is an assistant research professor at Southern Illinois University Edwardsville. Her research interests include variable stars and assessing the impact of new media astronomy content on informal audiences. When not in the classroom or doing research, she co-hosts Astronomy Cast and writes the blog StarStryder.com.

Publishing Your Story in Astronomy Magazines: How to Solicit and Write Magazine Articles

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Key Words

Written Communication
Trades Magazines
Editing
Pitching

Summary

If you want to write a magazine article, here's some advice on how to pitch your article, how to write it and what you should expect once you have submitted your story.

Although their circulations are declining in the Internet Age, magazines remain one of the premiere outlets for communicating astronomy to a large audience. Publications such as *Sky & Telescope* and *Astronomy* in the United States, the *Tenmon Guide* in Japan, *Sterne und Weltraum* and *Astronomie Heute* in Germany, and *Astronomy Now* and the *BBC Sky at Night* in the United Kingdom reach tens of thousands of readers every month.

From 1991 to early 2007, I worked for four magazines, and have written, edited and commissioned many hundreds of articles on astronomy and related subjects. I started off as an editorial intern at *Sky & Telescope* in 1991. I next worked as a researcher/reporter at *Discover* from 1992 to 1995. I then moved to *Astronomy*, first as an associate editor and then later as a senior editor. In 2000 I left *Astronomy* to serve as editor-in-chief of *Mercury*, the bimonthly magazine of the Astronomical Society of the Pacific. In late 2003 I moved back to *Sky & Telescope* as a senior editor. I finally left the magazine business in early 2007, when I assumed my current job as a senior science writer at NASA's Goddard Space Flight Center. In the interest of full disclosure, I remain a contributing editor for *Sky & Telescope* and will be the new editor-in-chief in June.

As far as I know, I am the only person who has ever worked as a full-time editor at both *Sky & Telescope* and *Astronomy* — by far and away the two largest-circulation astronomy magazines published in the US. I wanted to share some of my experiences to help anyone interested in communicating their ideas and passion for astronomy in a magazine article.

I want to stress that all magazines are different. Even though *Sky & Telescope* and *Astronomy* have similar formats and reach a similar audience, a close examination will reveal subtle, but important differences. More importantly, each magazine has its own way of "doing business". So what follows is a generalised impression from my 15 years in magazine publishing.

The Pitch

If you are interested in publishing an article in a popular magazine, the first order of business is convincing a publication's editorial staff that your story is worth publishing. You may think you have the greatest idea in the world, but until the editors of a magazine agree, your concept represents unrealised potential.

There are two ways to approach a magazine. First, you can write your article, and send the draft to the magazine and hope for the best. Editors refer to such stories as "unsolicited manuscripts". Occasionally, a scientist or writer submits an outstanding article out of the blue and the staff decides to publish it. But this is the exception rather than the rule. Sending unsolicited manuscripts gives an author no contractual protection in terms of payment or kill fees and basically puts the writer at the mercy of the magazine's staff. In addition, the author may waste considerable time and energy writing an article that will never see the light of day.

I strongly advise taking a second route: writing a query letter. This involves much less effort than writing an entire article, and can lead to a contract that can guarantee at least a modicum of protection for the author. Writing a query letter rather than a full article in no way diminishes your chances of having your article published.

Before you write your query letter, I recommend taking three courses of action:

1. Read a recent issue of the magazine to get a feel for its style and the type of person it is trying to reach. With this knowledge, you can write a more effective pitch.
2. Try to find out if the magazine has published an article on your subject, or a closely related topic, sometime in the recent past. If it has, approach a different publication first.
3. Try to identify an individual editor at your target magazine who would handle query letters on a certain topic. For example, during part of my earlier tenure at *Sky & Telescope*, I would review query letters about science topics. Other colleagues would review queries related to observing projects and equipment reviews. Your chances of having an article published improve if you can make your pitch to a specific editor rather than sending a letter addressed to the magazine in general. You might even consider calling the editor on the telephone to establish a personal connection.

The letter, which can be sent via snail mail or e-mail, should be no longer than 500 words. The query must describe what your article will be about and why it would be of interest to the magazine's readers. Remember that you are competing for precious space in the magazine. If the editors run your article, it means they won't run someone else's.

Your letter should be clearly written and should convey excitement about your topic. If you're not enthusiastic about it, why would anyone else be excited? Before sending your query, let several friends or colleagues read it to see if you've made a persuasive case, and whether your letter is clear and well written. The letter should demonstrate good writing skills to the editorial staff.

I also recommend sending a list of possible images and illustrations that could run with the article. Magazine editors are always thinking about an article's visual impact, and not just the words. If you can convince the editors that your article will be visually appealing as well as intellectually stimulating, you've greatly improved your odds of being commissioned to write the story.

Suggest how long your article will need to be to cover your topic. Remember that most magazines are running short feature-length articles these days. A typical six-page feature in a magazine such as *Sky & Telescope* or *Astronomy* might run no longer than 2000 to 2500 words. Think about possible sidebar topics as well, since magazine editors like their articles to have "multiple points of entry".

Write a short bio, perhaps no more than one or two sentences, to demonstrate your background and qualifications for writing the article. Give the editor a realistic deadline of when you can submit your completed draft, and be prepared to meet it. I would advise setting a due date no later than three months into the future.

Have an idea what you expect to be paid, but if the magazine contacts you to commission your article, let the editor make the first offer. If you're dissatisfied, you can always try to negotiate for a higher pay rate. Unless you are a well-established writer, don't expect to get rich by writing for magazines, and remember that many magazines are experiencing financial pressures. Your primary motivation for writing an article should be the desire to disseminate your ideas.

Last but not least, if you and the editor agree on the topic, length, due date and pay rate, insist on receiving a contract specifying the terms of the agreement, and make sure the contract stipulates that you will be paid upon acceptance of the article, and not on publication. If the magazine declines to publish your article, make sure you will be paid a kill fee that is at least 25 percent of the pay rate.

Writing the Article

So let's assume the magazine's editorial staff commissions you to write the article. What comes next? Most magazines provide a guideline for authors, so check it out at the website. But here are some general recommendations for effective science writing.

First, the introductory three to five paragraphs of the article, known to journalists as "the lead" (sometimes spelled "lede"), must grab the attention of readers and motivate them to continue reading your article. The lead must be written in crystal-clear language, foreshadow exciting things to come and give readers a firm understanding of what your story will be about. People will be reading your article in their leisure time; you must convince them at the start that it's worth 20 minutes of their precious time. Use non-technical language and dispense with details and jargon — those can come later. If possible, use humour. In newspaper articles, the first paragraph almost always gets to the heart of the story. For magazine articles, it's usually acceptable to delay the lead to the third or fourth paragraph. But don't wait any later than that.

Here is an example of a lead I found particularly effective for its use of irony and humour. After reading this opening paragraph by Dutch science writer Govert Schilling in the December 1999 issue of *Astronomy*, just about anyone interested in astronomy would want to read the article:

Imagine a mirror the size of a basketball court — a vast expanse of glass, more than 30 meters in diameter, weighing some 150 tons and consisting of more than 250 hexagonal segments of two meters each. Got it? Okay, you're looking at the secondary mirror of next century's super telescope. That's right, the secondary. *The primary, matching the size of a football field, lies 100 meters below, near the base of a telescope structure as high as the Great Pyramid. Welcome to the 100-meter OWL, or OverWhelmingly Large Telescope, which has 10 times the collecting area of all existing telescopes put together.*

Ten-Point Checklist for Writers

1. Identify a topic you can write enthusiastically and authoritatively about.
2. Target a magazine and study its contents.
3. Go to the magazine's website and read any instructions for writers (for some magazines you might have to send a self-addressed stamped envelope).
4. Get an editor's name from the magazine masthead.
5. Don't write the article yet: first send the editor a preliminary letter pitching the article, with suggestions for illustrations and a two- or three-line CV.
6. Give the editor a realistic delivery date for copy and honour it.
7. Write simply and concisely, avoiding jargon and technical language, while keeping your sentences and paragraphs short.
8. Tailor the article to the style and readership of the magazine.
9. Expect to be paid for work accepted for publication in commercial magazines.
10. Use active voice and active verbs in your writing. Be yourself and try to have fun writing the article.

Adopt a conversational tone throughout your article. Pretend you're on an aeroplane on a transoceanic flight. The stranger sitting next to you asks what you do and you reply by telling her that you're a science writer (or scientist). As the conversation develops and she asks for more details about your profession, you realise she knows practically nothing about astronomy, but she's intelligent

and intellectually curious. Write the article as if you're talking to her.

A key to making your article conversational in tone is to use the active voice for 95 percent or more of your sentences. This is difficult for astronomers, since the scientific literature makes wanton use of the passive voice. But in popular articles, you should avoid the passive voice as you'd avoid sponge-bathing a diseased yak. In other words, say, "Astronomers discovered a new planet" rather than, "A new planet was discovered by astronomers".

Nothing makes writing come alive more than the use of active verbs (brandish, eviscerate, expunge, galvanise). If you are writing in English, avoid the various incarnations of "to be", the most boring verb in the language.

Keep most sentences short and avoid long run-on sentences. Read your words aloud. If your sentence sounds clunky, or like something nobody would ever say in conversation, rewrite it or break it apart into two or three shorter sentences.

Most magazines run their articles on two to four columns per page. Those columns are narrow, so long paragraphs look *really, really* long. A casual reader glancing at the page will be immediately turned off by the appearance of super-long paragraphs. So keep your paragraphs short, no longer than three or four sentences. If a paragraph goes over 150 words, considering breaking it up into two or more shorter paragraphs.

Avoid jargon as much as possible and minimise the use of needlessly complex terms. And when you must explain complex concepts, try to use analogies from everyday life. Here's an excellent example by science writer Chistopher Wanjek in the November/December 2000 issue of *Mercury*:

To visualize frame dragging, imagine the bowling ball rotating with something sticky on it. The ball pulls at a sheet as it spins. A marble rolling on the sheet not only curves around the ball, it also gets pulled forward a bit. Likewise, with frame dragging, the region of space-time close to the neutron star feels a tug. Any photon or matter in the region gets pulled along for the ride.

As a reader, there are a couple of things that really annoy me and often stop me in my tracks. One is an article that leaves an important question unanswered or contains a statement that seems to contradict a statement made elsewhere in the article. Anticipate questions that will be at the back of readers' minds and either provide an answer or tell the reader that the answer is unknown. And make sure to resolve any seeming contradictions quickly. The last thing you want is for readers to stop reading your article in the middle because they have become frustrated or confused.

If you use quotes in the article, make sure they are punchy and succinct. Quotes are particularly compelling if they convey a person's heartfelt emotion. Do not use long quotes to explain a concept. It's usually better to put lengthy explanations into your own words.

Last but not least, spice things up with the occasional use of amazing facts ("a billion neutrinos passed through your left pinkie in the time it took you to read this sentence") and humour. Whether or not you agree with this statement by *Sky & Telescope* editor-in-chief Rick Fienberg from the November 2006 issue, I bet you'll at least get a chuckle:

We got a definition that reads like it came from bureaucrats, not scientists. And now we need a new mnemonic to remember the order of the eight remaining planets. Here's one that works for me: Many Very Egotistical Malcontents Just Screwed Up Nomenclature.

Most of all, be creative, be yourself and try to have fun writing the article. If you have fun writing it, the chances are good that your audience will enjoy reading it. Always remember that you are telling a story.

What to Expect

So let's assume you have finished your article and you e-mail it to an editor. What happens after that?

During my earlier tenure at *Sky & Telescope* and *Astronomy*, we would often hold editorial meetings to decide on one of three possible outcomes. Perhaps about 30 percent of the time we would agree that the manuscript was in such good shape that we could accept it for publication. The large majority of the time, perhaps 65 percent, we would ask the author to make revisions based on our suggestions. Very rarely, perhaps 5 percent of the time, we would conclude that the manuscript was in such poor shape either in terms of writing style or accuracy (or both) that we would reject it and allow the rights to revert back to the author. We would also pay the kill fee specified in the contract.

The key point here is that just because you've submitted your article it doesn't mean your job is finished. You might have to go through several rounds of iteration with your editor, and even if your article is accepted, you will probably have to answer questions. Writing an article and seeing it through to publication is a big job, so before committing to write an article, make sure you're willing to spend the time and energy to make it happen.

Some editors are more aggressive than others about changing the text. Expect to be edited and be prepared for significant revisions. Try not to take it personally, since an editor's first priority is to serve the magazine's readers, not the author.

Sky & Telescope's standard operating procedure is to share the edited version of articles with authors. But other magazines and editors have different policies. It's fine to ask up front if you can see the edited version, but there is no guarantee that the editor will abide by your request unless it's the magazine's standard policy.

Also, magazines usually have to make last-minute changes to an article's text to make sure it fits properly in the layout. Do not expect to see these changes. Magazine staffers work under tight deadlines, and they simply cannot allow authors to micromanage the production of an article, especially during the latter stages of the process.

Most editors will welcome suggestions about images and illustrations, but art decisions are made by the magazine's staff, not by authors. Do not expect to see the layout of your article until you receive the printed copies in your mailbox (and yes, you should request several complimentary copies of the issue). In addition, you can suggest titles, teasers and captions, but these things are generally written by editors, not by authors.

The bottom line is that it's reasonable to ask to see the first edited version of your article, but don't expect to have any control after that. At some level, you have to trust that the magazine's editorial and art staff are competent. If you're worried about being embarrassed in print, don't write for magazines, or be careful about your choice of magazines.

Even after 15 years and hundreds of articles, I still feel a rush of excitement and satisfaction upon seeing one of my articles in print. If you want to communicate astronomy at an in-depth level, but without making the enormous effort it takes to write a book, magazines are still open for business and they're always on the look-out for new ideas and new writers.

Biography

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Astronomy Behind the Headlines at the Astronomical Society of the Pacific

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Summary

The Astronomical Society of the Pacific, as part of its mission to advance science literacy through engagement in astronomy, is starting a new online programme using podcasting and other web-based techniques to provide astronomy background to educational "intermediaries" — those who are the interface between astronomy and the public. This programme, entitled Astronomy Behind the Headlines, is designed to assist these intermediaries in quickly responding to and interpreting the latest astronomy and space science news.

Introduction

The science of astronomy — in addition to its innate appeal to the psyche and all the pretty pictures — has, arguably, two important claims to fame in the pantheon of sciences: that it is the oldest, and that it changes faster than any other. Just look at how quickly astronomy textbooks become out of date.

From the time of Galileo's discovery that much of the movable furniture of the heavens was in fact a set of other worlds, to today's heated argument among his professional descendants about what should be called a planet and what shouldn't, astronomy has been a no-holds-barred race to stay current with the latest discoveries and the ever-changing understanding of just what the cosmos is really like. With news of the latest comet whizzing past Earth and the newest extrasolar planet whizzing around another star, reports of the most recent exploits of *Hubble*, *Cassini*, the Martian rovers and other space missions, and the endless theoretical wrinkles put forth about how galaxies form, whether there's life elsewhere, what happens in a black hole, how we characterise dark matter and dark energy, and just how fast the Universal expansion is accelerating and what it means — how can anyone keep up?

If it is hard enough for those of us who dabble in this stuff for a living, where does that leave the public, and those charged with explaining it to them after the 30-second newsbite appears on the local news channel?

This is just the sort of challenge that we at the Astronomical Society of the Pacific (ASP) like to take on. And we are taking on a bit of it in a new grant-funded project designed to use podcasting and supporting web-based methods to provide background on the hot astronomy topics of the day for the educators who need to interpret the latest astronomical headlines for their public audiences.

The Rationale

It's about leverage, when you come right down to it. Since 1889, when the ASP was founded by a group of professional and amateur astronomers in San Francisco, California, it has been adding to the problem (described above) by adding its voice to those disseminating astronomical information. Our mission, recently rearticulated, is to increase public understanding and appreciation of astronomy through scientists, educators, enthusiasts and the public as a vehicle for science literacy and exchange. We publish a peer-reviewed journal, volumes of professional conference proceedings, a newsletter for classroom teachers, and a popular-level magazine for members. We hold a professional educational and public outreach conference of our own as part of our annual meeting. We conduct professional development opportunities for teachers, develop educational materials, and manage formal and informal education networks of national scope in the US, assisting formal and informal educators and amateur astronomers in doing good astronomy and science education and outreach. And we are international in scope, with members in more than 40 countries supporting the work we do.

We recognise that we cannot do it all, or reach everyone, through direct efforts, and so in recent years we have focused our

Figure 1. Participants at the Tucson Astronomy from the Ground Up workshop carefully follow the directions to create a scale model of the volumes of the planets, starting with three pounds of play dough. Credit: Kemper Barkhurst.

educational resolve more on serving what we call astronomy "intermediaries" — the classroom teachers, museum educators, planetarium staffers, amateur astronomers, after-school programme directors, and others who work at the interface between the astronomy (and astronomy researchers) and the public. By helping them to build their capacity to use and teach astronomy and related science concepts for their target audiences effectively, we can leverage our resources to reach out to many more people, in effect, than if we were out there working with one classroom or field trip group or museum audience at a time.

In addition, we have found it easier to leverage these intermediaries if we can find ways to link them together in efficiently managed learning communities. And we find that a good way to do that is to establish physical and electronic networks and partnerships with the help of our friends.

One of the results is a National Science Foundation-funded programme called Astronomy from the Ground Up (AFGU), which provides capacity-building and professional development opportunities for informal educators at small and medium-sized science and nature centres who are interested in bringing more astronomy to their audiences. This programme is accomplished in collaboration with the National Optical Astronomy Observatory (NOAO) which provides the science muscle, the Association of Science-Technology Centers (ASTC) which creates an online environment for distance learning via ASTC Connect, and the Institute for Learning Innovation (ILI) which provides evaluation and assessment expertise as we craft the programme to meet participant needs and learn what works best.

AFGU draws informal science educators into the joys of astronomy by conducting both on-site and online workshops, providing "toolkits" of activities covering three fundamental astronomical themes (size and distance, patterns and cycles, light and colour), and nurturing an online "community of practice" to encourage continued sharing, learning and support among workshop alumni as they apply their new knowledge and skills in their own programmes.

One important technique to encourage continued growth in astronomy education expertise is to demonstrate to participants that we are learning new things about the Universe all the time; all you have to do is watch the news or pick up a newspaper or magazine or surf the internet. As a consequence we emphasise interpretation of current astronomical events and discoveries in the AFGU programme. And the question we began to ask ourselves was whether there was a way that we could provide more specific preparation for these intermediaries in the dizzying world of hot topics and breaking astronomy news; if we could arm our intermediaries with more effective tools for sallying forth with confidence at the next new astronomical event, discovery, or controversy.

To answer this question, we went looking for another partner, and we found one in NASA's Initiative to Develop Education through Astronomy and Space science grant programme, administered by the Space Telescope Science Institute and more mercifully known as the IDEAS programme. And we went with a single word knocking around in our brains: podcasting.

If there's anything STEM-related that changes faster than astronomy, it's technology, and it's hard to imagine today that podcasting was a nonexistent term until 2004, when Apple introduced the iPod and a new way to communicate captured people's imaginations. Today, it's a form of communication used in clever ways by both children and adults, as described by Gay (2006). According to a report by Rainie (2005) for the Pew Internet and American Life Project, more than 22 million American adults own iPods or MP3 players and more than six million adults have listened to podcasts. And these podcastees are discriminating when it comes to astronomy. In a survey of *Astronomy Cast* listeners by Gay (2007), a weekly 30-minute podcast "that takes its listeners on a facts-based journey through the Cosmos", the survey found that listeners "desire focused, image-rich, fact-based content that includes news, interviews with researchers and observing tips".

We also found that while there were several astronomy-related podcasts available to consumers, the targeted audience tended to be the general public rather than, say, informal educators of the sort that we were trying to reach through programmes such as AFGU. Were we looking at a niche here that we could help to fill, while at the same time providing a new tool for us to use with our networks in bolstering educators? Educators are often without the training or resources to address new announcements or discoveries thoroughly, with little time or money for professional development, but toil on the front lines nonetheless, needing to communicate astronomy and answer public questions. Could we match the need with the technology in an effective way?

Building on these nascent thoughts, we approached the IDEAS grant programme with a proposal for Astronomy Behind the Headlines.

The Project

Astronomy Behind the Headlines builds on the online community that we have already established through AFGU, as well as initial results derived from working with distance learning methodologies. The core of the two-year project is to create a series of ten podcasts for informal educators on particular topics likely to be producing many of the headlines they will see — topics including sky events (eclipses, new comets, meteor showers, etc.), Solar System exploration, extrasolar planet discoveries, black holes, galaxy formation and evolution (and will the

Figure 2. Participants use squares of colour to create a temperature map of the inverted cookie sheet. To create differences, a heat pack and tray of ice are hidden below. Credit: Anna Hurst.

Andromeda Galaxy really hit us in several billion years?), dark matter, dark energy, cosmological questions, and the like. With the assistance of Dr Dana Backman, an infrared astronomer at the SETI Institute who runs the SOFIA education and public outreach programme for USRA and NASA, ASP staff will identify scientists and educators who are making the news, recruit them to participate in developing podcast scripts aimed at getting behind the snappy headlines to the real science and record their insights.

These podcasts will be posted on an interactive website — but the project hardly stops there. The recorded pieces will serve as the centrepieces of professional development modules that will focus on the specified topics and incorporate elements of the AFGU programme that we have found to be effective with our informal educator participants. After each podcast episode has been available online for two weeks, the ASTC Connect website will host an interactive online session on the topic in question — a forum stretching over 10–14 days with scheduled and moderated discussions with Dr Backman, ASP education staff, and the guest scientists featured on the podcasts. These follow-up sessions will include live interactive chats, often with live video and slide presentations to provide visual content, demonstrate hands-on activities and other means of interpreting the given topic — all to allow for the exploration of topics in greater depth and to provide additional resources and techniques for interpreting these topics for wider audiences.

These events will be accessible through the interactive website, which will include, in addition to the podcasts, supplementary resources relating to the topics and an archive of existing podcasts and related materials for reference when the big headlines hit. No strings — except that participants will need to participate in the evaluation of the effort by responding to short surveys and engaging in other means of determining how (and how many) participants are benefiting from the experience and if/how it has changed their education or outreach efforts in some tangible way. This assessment will be compared against the front-end assessment we will have conducted to survey the primary target audience about how to structure the project and products in the ways that best meet their needs and schedules and can most effectively engage a population of busy educators.

We expect that an immediate audience for the programme will be the expanding community of practice and workshop alumni from the AFGU programme. But since *Astronomy Behind the Headlines* is a programme independent of, if complementary to, the AFGU, we see it as a new way to engage informal educators as well and to swell that supportive community of practice as each programme recruits participants to the other.

Given the specialised nature of the podcasting project in comparison to those targeted at the general public, we expect initial educator audiences to be relatively small — perhaps 500 and growing. But that's where multiplication enters the equation. As educators use the information and tools they receive to interpret hot topics to their audiences, the numbers of members of the public served in the process can grow to hundreds of thousands per year. Remember, it's all about leverage, about finding those amplifiers that can take your effort to places that you can't always reach — there being only so many hours in a day and only so many resources to apply.

The Future

IDEAS-funded projects are designed to be start-up projects — efforts for which seed money is provided with an accompanying expectation that the programme will have legs beyond the initial funding period. The ASP has a history of sustaining the efforts and networks it starts, and our plan is for *Astronomy Behind the Headlines* to be incorporated into our longer-term plans to serve networks of astronomy intermediaries.

We are therefore very interested in what our evaluation will tell us — whether there is a measurable beneficial effect of the programme on the target audience. Through short follow-up surveys with participants, a

Figure 3. AFGU partners include NOAO and part of their Hands on Optics *toolkit. Here, participants test the resolution of their newly assembled telescopes. Credit: Paul "Pablo" Nelsont.*

more extensive online survey, the gathering of demographics and analysis of compiled statistics, we want to understand how best to implement the programme consistently and effectively, whether we're reaching the target population and how best to do it, and what refinements may be needed to achieve our goals. And most importantly, were there positive changes in the target audience in the interpretation and communication of headline astronomy for their own audiences, and can these changes be attributed to the project?

As the project proceeds, cool astronomy happens, and we assess the results, we will report those results in print and online publications and at professional meetings to share what we have learned.

Conclusion

Among the sciences, astronomy is a natural headline-grabber, as it has been since ancient kings nudged their court astrologers, hoping for favourable interpretations in the antics of the moving lights of the sky as their gods tossed the dice. Galileo grabbed more headlines when he made other worlds of those moving lights, and the press has been attentive ever since.

So is the public, and when their interest is piqued, whom do they call? They call the museum, the planetarium, the local astronomy club, a teacher, or others who they think can give them the details behind the pretty picture, the grabby headline, the 30-second sound bite on the evening news. *What is it? Where do I look? What does it mean?*

With Astronomy Behind the Headlines, we hope to equip some of those astronomy intermediaries with the answers, background, and tools to help them make the ever-changing cosmos a little clearer to their audiences. And in the process, perhaps a little more science literate than they were before.

It's a good and necessary thing. We'll let you know how it goes!

For more information on the Astronomical Society of the Pacific and its programmes, visit the ASP online at www.astrosociety.org.

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Biographies

James G. Manning is the Executive Director of the Astronomical Society of the Pacific, a member of the US Program Committee for the International Year of Astronomy 2009. He chairs the global Cornerstone Task Group for the Galileo Teacher Training Program and is the Principal Investigator for the National Science Foundation grant Astronomy from the Ground Up.

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The Incomparable Carl Sagan: Scientist, Presenter[1]

Opinion

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Key Words

Visual Communication
Presentations
Communicating Scientists

Figure 1. Carl Sagan. Credit: NASA/JPL.

Carl Sagan[2] (1934–96) was a famous and brilliant astronomer who was also a great speaker and presenter (Figure 1). If Carl Sagan had spoken at the Technology Entertainment Design Conference Series (TED)[3] — the annual series of conferences that brings together the world's most fascinating thinkers and doers, who are challenged to give the talk of their lives — I am sure he would have been one of the best presenters ever. I was a huge fan of Carl Sagan back in the 1980s and learned a lot from his famous TV series, *Cosmos*.[4] Sagan always spoke of complex issues in ways that were easy to understand and made you excited about science. He did not dumb down the issues, but he had an engaging and unique way of putting an issue in context, illuminating and illustrating his points in a way that listeners could comprehend. He was a scientist-presenter who cared about being clear and about being understood.

When Carl Sagan used statistics he usually followed the numbers with an illustration or comparison to put them in context. In Episode 13, "Who Speaks for Earth?", of *Cosmos* (Figure 2) you can watch Sagan using words to create the visuals in your head — a technique that is sometimes even more effective than the most graphic image or animation. How much is 20 tons of TNT? Enough for a single bomb to destroy an entire block. All the bombs used in World War II, Sagan says, amounted to two megatons of TNT or the equivalent of a hundred thousand "blockbuster" bombs. So now we can visualise the explosive, deadly destruction that took place in WWII (1939–45). We can "see" the horrible impact of two megatons of TNT. Two megatons of TNT is no longer an abstraction. Then Sagan drops a bomb of his own: "Today, two megatons is the equivalent of a single thermonuclear bomb — one bomb with the destructive force of the Second World War."

Perspective

It is always hard to see the wood for the trees. Good presenters will ask us to step back and examine the problem from another perspective to see what is true and what is not. In the clip above (Figure 2) Sagan asks, "How would we explain all this to a dispassionate extraterrestrial observer? What account would we give of our stewardship of the planet Earth?"

By asking the viewer to look at the problem from the point of view of an "extraterrestrial" (i.e. a dispassionate outside observer) the problem is freed from abstractions such as nation, political party, religion, etc. Sagan says: "From the extraterrestrial perspective, our global civilisation is clearly on the edge of failure and the most important task it faces is preserving the lives and well-being of its citizens and the future habitability of the planet."

Sagan's well-chosen words tell us that we, as a species, are the most remarkably intelligent, creative and innovative species on the planet, yet paradoxically and incomprehen-

Figure 2. Carl Sagan in Cosmos episode 13, "Who Speaks for Earth?". Credit: PBS.

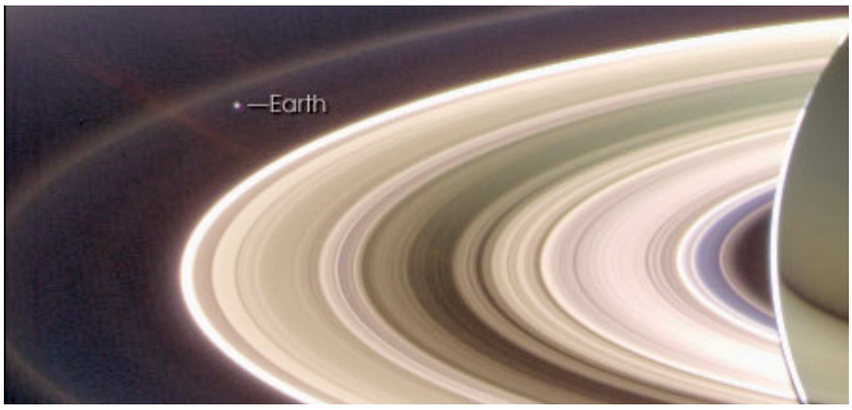

Figure 3. Saturn and the Earth (marked) as seen from the Cassini *spacecraft. Credit: NASA/JPL/Space Science Institute.*

sibly, we can also be the stupidest. Nonetheless, there is hope. Sagan says there is a new consciousness emerging that sees the Earth as a single organism and understands that an organism at war with itself is doomed. We know who speaks for the nations, Sagan says, but who speaks for the Earth? The answer, of course, is, we do. In the final chapter of *Cosmos*, available online,[5] Sagan makes the concluding comment: "Our loyalties are to the species and to the planet. We speak for Earth. Our obligation to survive and flourish is owed not just to ourselves, but also to that cosmos ancient and vast from which we spring!"

Pale Blue Dot

Below is a quote from Carl Sagan's *Cosmos* that goes very well with *Cassini's* photo of Earth (Figure 3): "Fanatic ethnic or religious or national identifications are a little difficult to support when we see our planet as a fragile, blue crescent fading to become an inconspicuous point of light against the bastion and citadel of the stars."

Figure 4 shows an excerpt from a slideshow set to Carl Sagan's narration. The message is wonderful and the simple photographic images amplify the message well. I think this is beautiful and puts "it" — our lives, our responsibilities, worries and our dreams — in perspective. It is this distant image of our tiny world — the only one we have — that underscores, says Sagan, "our responsibility to deal more kindly with one another", and to preserve and cherish our home, the planet Earth.

Figure 4. Excerpt of a slideshow set to Carl Sagan's narration. From http://www.youtube.com/watch?v=p86BPM1GV8M . Credit: PBS.

Metaphor

Some of the graphics in *Cosmos* will seem a bit dated (see, for instance, Figure 5), but the video clip is a good example of using a metaphor and simple graphics to help illuminate a complex issue. You can argue that it is too simple, but remember that this kind of calendar metaphor to explain the history of the Universe is not meant to be the end, but the beginning of the conversation. We have a choice, says Sagan, but what happens in the first second of the next cosmic year (i.e. now) depends on what we do with our intelligence and knowledge.

Figure 5. December of Sagan's Cosmic Calendar. From http://www.youtube.com/watch?v=FxoQTt-UiJw&feature=related . Credit: PBS.

Notes

1. Reproduced, with minor editorial changes, from Presentationzen.com, courtesy of the author.
2. http://www.carlsagan.com/
3. http://www.ted.com/
4. http://us.imdb.com/title/tt0081846/
5. http://www.cooperativeindividualism.org/sagan_cosmos_who_speaks_for_earth.html

Biography

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Contextual Narrative as an Information Architecture for the WorldWide Telescope

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Key Words

Digital Universes
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Interactive Learning

Summary

The evolution of the world wide web has enabled access to information about almost any topic conceivable. However, access to information is only one component of learning and understanding. How do people initially engage with unfamiliar or uninteresting subjects, where they do not know enough even to ask a question? How do educators and communicators make a topic sufficiently compelling to pique curiosity and sustain enough interest to facilitate learning?

This paper describes the underlying information architecture behind the WorldWide Telescope, called Contextual Narrative, as a model for interactive learning. Contextual Narrative seeks to integrate stories, contextual exploration and source information into a single environment to smooth the learning process, whether directed or self-directed. The WorldWide Telescope was designed to evaluate how Contextual Narrative can support exploration and understanding of a domain topic, in this case astronomy, by creating a compelling environment that facilitates the creation of linked stories in a multi-dimensional exploratory spatial environment with links to the rich information sources on the web.

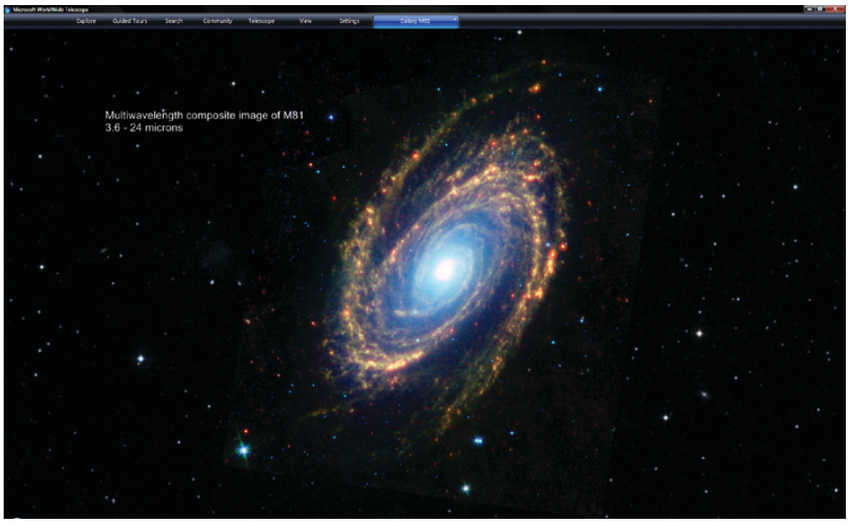

Figure 1. Screenshot of a multi-wavelength composite image of Messier 81. Credit: WWT.

What Is the WorldWide Telescope?

The WorldWide Telescope (WWT) is a web application analogous to Virtual Earth that allows seamless browsing, zooming and panning of a spatial environment — in this case the sky — across multiple wavelengths. In addition to several all-sky surveys such as the Digitized Sky Survey, NASA's *Wilkinson Microwave Anisotropy Probe*, X-ray surveys and others, WWT includes many high resolution images from *Hubble*, *Chandra*, *Spitzer* and other space- and ground-based telescopes.

The many terabytes of images and data are distributed on remote servers in different locations on the web and stream down to WWT on demand as the user browses.

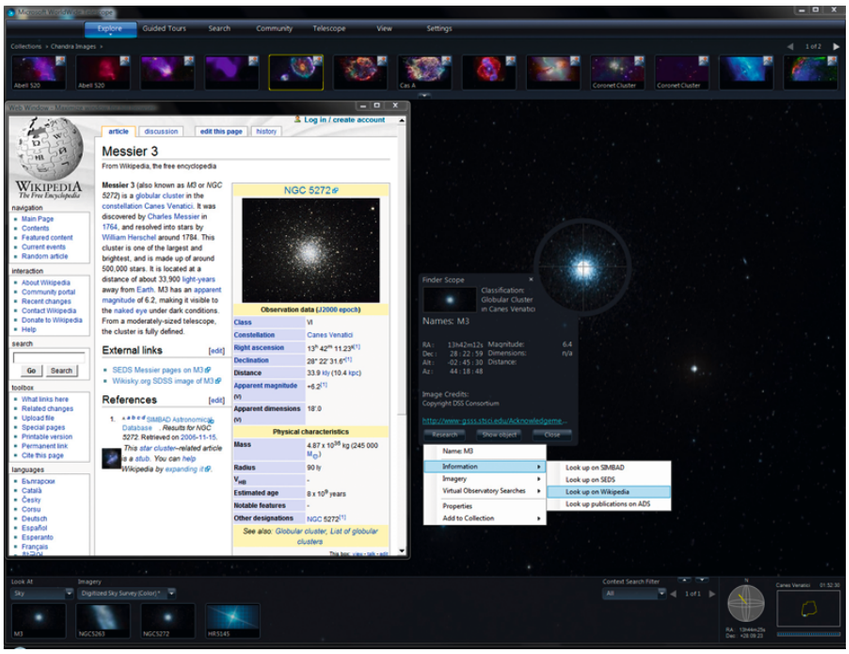

Figure 2. Screenshot of retrieved information on Messier 3 from Wikipedia. Credit: WWT.

The WWT has an integrated easy-to-use authoring environment that allows the novice to create guided tours of the Universe easily, using images of galaxies, nebulae, star clusters or other objects available within the WWT from any telescope, view or wavelength. It includes text, graphics, music, narration and other resources to enhance the experience. While the tours resemble video sequences, they are totally interactive, allowing the user to pause the tour and examine any detail of an object, to delve deeper into the information or simply to continue the tour.

All objects within the WWT have dynamic links to related source information, databases and source images that can be retrieved using simple menu choices. This seamless integration of tours, contextual exploration and dynamic links between objects and source information is based on the Contextual Narrative information architecture described in this paper.

Information Architecture

Contextual Narrative (CN) is an information architecture that has been developed and refined over the past 17 years as a model for creating engaging learning environments. CN consists of the following three linked layers.

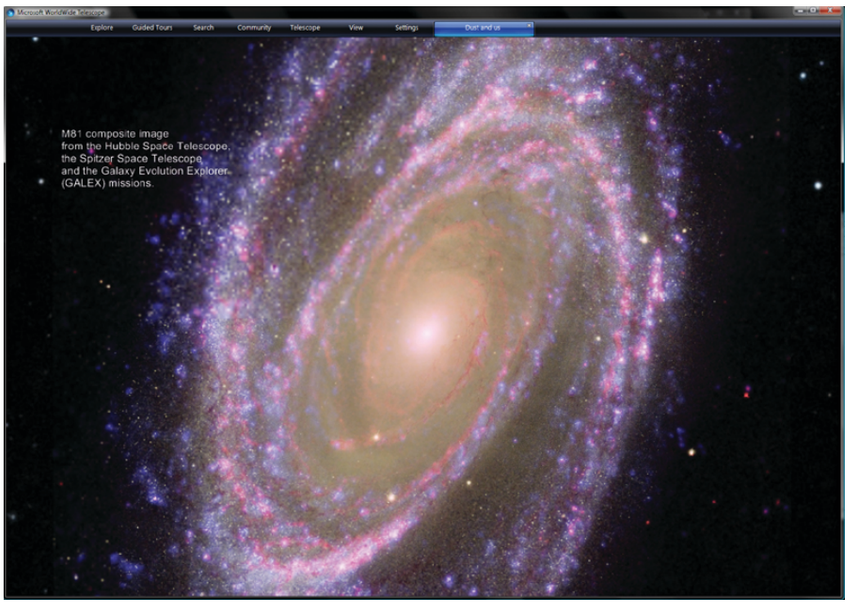

Figure 3. Screenshot from the Spitzer tour of Messier 81. Credit: WWT.

Stories

CN seeks to engage new learners through storytelling. Stories can engage the subject in a way that piques the curiosity and leads the learner into previously unknown subject areas, motivating them to go deeper into the linked Exploration layer.

Exploration

Stories told within the Exploration layer allow the user to engage interactively with the subject matter in multiple contextual ways. This Exploration layer can provide spatial and temporal simulation and other interaction models to help develop mental models that provide a framework for understanding accessed via different learning modalities.

Source Information

Objects in the contextual Exploration layer are linked to the Source Information layer, which provides the data that validate the new mental model. By providing a seamless link between stories, exploration and information, the user is drawn more quickly into a learning process that supports various learning modalities and constructs a framework for understanding.

Stories

- The focus of this CN environment is to engage the user and draw them into the subject matter. This is particularly important if the user is unfamiliar with the topic or is initially not particularly interested. The first narrative should establish a reason for the person to care about the subject.
- A framework for organising and remembering information about the topic is established. This has been the technique for preserving historical information since before recorded history. Stories were often memorised using songs that provided another memory augmentation mechanism to strengthen recall and structure large amounts of information.
- New stories can be created within the WWT using text or narration with music to introduce new topics and provide a framework within which to retain newly learnt information.
- Stories in the WWT take the form of Tours. These may be as simple as a PowerPoint presentation with text and graphics set within the virtual sky with automatic transitions between objects, surveys and study images. Tours can be created easily and shared as a file that can be played back by others using the WWT.

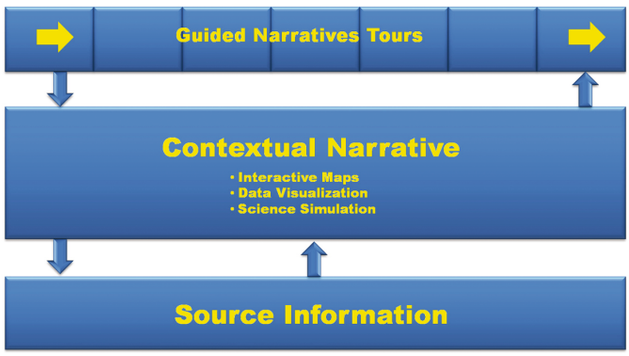

Figure 4. Contextual Narrative information architecture. Credit: Courtesy of the author.

- Stories are loosely clustered by domain, similarity, or by level (simpler narratives and overviews tend towards the top, whereas more specific, complex and deeper narratives on specific topics tend towards the bottom of this layer). Existing ontological organisation of the narratives may be useful to communicate the nature of the kind of narratives that are present, but the nature of Contextual Narrative is to enable deep cross-linking between related content so that pre-defined ontological relationships between content are just the beginning of the potential linkages.

Exploration

In the WWT the Exploration layer setting can be a virtual sky that explores a way to communicate spatial information related to the angular size or distance for objects within the sky. Stories from the layer above might be deconstructed or directly linked to objects so that the user can hear stories relevant to the object, much like audio guides in an art museum. This process of integrating stories within the environment establishes a spatial link between the stories and the context of that object, as well as providing a mental model and connection between stories, spatial information (size, location) and other associations for that object, such as another nearby memorable object. This process facilitates the development of a dimensional mental model of associations between stories, size, proximity, location and other contexts that will assist visual learners.

Within the WorldWide Telescope the Exploration layer consists of multiple sky surveys of different wavelengths and study images that are all registered in the virtual sky with high precision World Coordinate System metadata. The complete sky can be browsed in multiple wavelengths such as visible light, H-alpha, 2 Micron All-Sky Survey, X-ray, radio and others. Sliders can cross-fade between discrete wavelengths to compare objects and structural details that depend on wavelength. Detailed high resolution multi-wavelength study images from many telescopes are also available for each object. All of these resources are available for inclusion in a potential tour.

The process of interactive exploration within a virtual sky reinforces spatial associations between stories and objects and can directly map to an understanding of the real sky.

Figure 5. Screenshot of a hydrogen-alpha view of the constellation Cygnus. Credit: WWT.

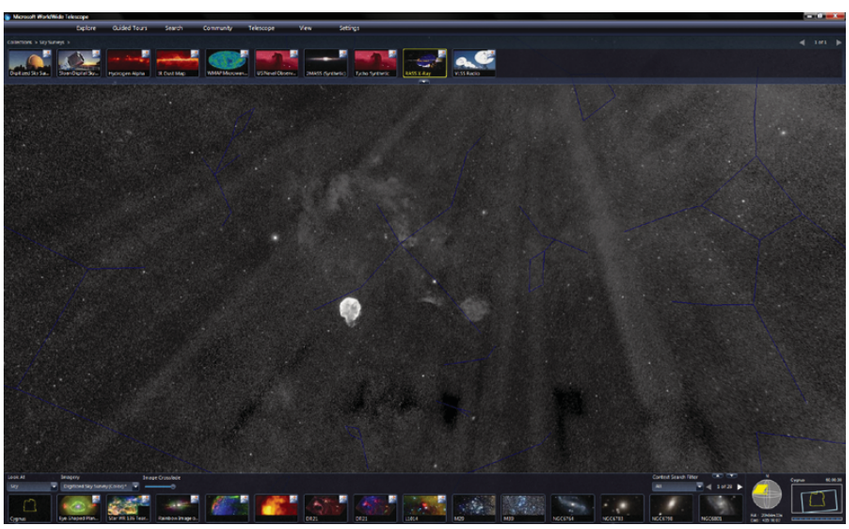

Figure 6. Cross-fade to an X-ray view of Cygnus. Credit: WWT.

This has been demonstrated anecdotally with children who have used the WorldWide Telescope and then gone out under the real sky. They often point out familiar constellations and recall the location, presence and stories about an object that they are familiar with from WWT even though the object cannot be seen with the naked eye. The purpose of the Exploration layer is to assist in the development of contextual mental models through interaction and elaboration of topics of interest raised by the stories. Stories told within the middle Exploration layer are such that the information from the stories can be retained in context.

Source Information

The purpose of the Source Information layer is to enable users to access source information about objects within the exploratory space easily.

Figure 7. Screenshot of Messier 31. Credit: WWT.

- Source Information within the WWT currently links to Simbad, Students for the Exploration and Development of Space, Wikipedia and astronomical databases of published papers, such as the Astrophysics Data System.
- The WWT also automatically provides links to retrieve a source image from DSS or SDSS as a JPEG file or a FITS file for specific objects.
- Other sources of information about objects can be added to the Source Information links in the future.

The WorldWide Telescope was designed with this information architecture to engage the curious by telling compelling stories. The stories link seamlessly between new and unfamiliar objects and areas in the sky and allow users the freedom to explore with the full resources of the WWT (multi-wavelength, multi-resolution, multiple telescope studies) coupled with links to deeper information resources from around the world. This allows new users to engage with the subject matter through the directed experiences of the tours and then branch off to self-directed experiences that allow them to go as deeply into the subject matter as they choose.

Rich though the WWT is, with its multiple terapixel multi-resolution image surveys linked to source information, the real power of the WWT will come when more and more stories are created within this environment that crosslink and form a hypermedia web. That web of stories will eventually allow people to move through the stories as easily as they move through hyperlinks on the web today and allow stories about the Universe to be created and shared.

Conclusions

The WWT was launched on 13 May 2008. Initial users of early versions have reported a high level of engagement among children of all ages and promising levels of retention based on the CN model. Once the application is established it will be interesting to conduct more rigorous, in depth and controlled studies of student comprehension of astronomy before and after using the WWT in contrast to other non-interactive media.

Notes

1. 1991: *Multimedia Beethoven*/Microsoft, 1995: *A Passion for Art*/Corbis, 1996: FDR/Corbis, 1997: *Leonardo da Vinci*, 1999: ArtMuseum.net/Intel, 1999: *Frank Lloyd Wright~The Poetry of Structure*/Ken Burns|PBS, 2002: *Commanding Heights*/PBS|WGBH|Microsoft Research, 2006: Frontline~*The Age of AIDS*/PBS|WGBH|Microsoft Research

Biography

Curtis Wong is the Principal Researcher of the Microsoft Next Media Research group responsible for future interactive media technologies to enhance the consumer media experience. His work has won numerous awards, including a 2002 British Academy Award and the first ITV Emmy nomination, four New York Festivals Gold Medals, and CA & ID awards. Curtis currently serves as a Trustee for the Seattle Art Museum and the Rhode Island School of Design, a member of the PBS Kids Next Generation Digital Media Advisory Board. He has previously served on the Advisory Boards for Ovation — The Arts Network, PBS Online, the Corporation for Public Broadcasting, the National Constitution Center, the Canadian Film Centre and the American Film Institute.

Publicising a Science Discovery: It's All in the Timing — Two Case Studies

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Key Words

Written Science Communication
Press Office Best Practices

Summary

Many factors are involved in deciding when a scientific result is ready to be presented to the news media and public. The most newsworthy science is often cutting-edge science and can inherently contain disagreement and controversy among scientists. Even results from peer-refereed papers are not free from criticism if scientists feel that the findings have been too widely publicised and lack caveats. How does a public information office balance these factors to ensure that newsworthy science is reported in a timely manner? This article presents two case studies from the research areas of exoplanets and astrobiology.

The common refrain from kids on a car trip is: "Are we there yet?"

Public Information Officers (PIOs) are sometimes viewed as being just as annoying when they ask a researcher, "Are we there yet?", when it comes to publicising a major scientific result.

The process of science publication is at odds with the process of news reporting. Research typically takes years of meticulous step-by-step analysis and advancement. The science news process is fuelled by stories that are exciting, relevant, colourful and succinct. The superlatives "biggest", "farthest" and "first" are the easiest to sell to news editors who are commonly uninterested in science, if not averse to it.

Truly profound discoveries that resonate with the public are few and far between. When one does come along it typically becomes a lightning rod for peer scrutiny. Over one hundred years ago the American author Mark Twain wrote: "The scientist will never show any kindness for a theory which he did not start himself."

The PIO, whose duty it is to serve as an agent for meeting the needs of the media and public for a good story and, in parallel, the needs of scientists to be properly acknowledged without antagonising their peers with suspicions of hype and self-promotion, is caught in the middle. It's a fine line to walk.

All PIOs fear that a major discovery could leak out without their parent institutions being involved. They don't want their directors learning about a discovery made by their observatory by reading about it in the newspaper.

Frequently this inner conflict is further aggravated by the final popular news reporting of a discovery that, simply because of limited word space, leaves out qualifiers, full acknowledgement and details. For example, we recently reported on a discovery by the *Hubble Space Telescope* and the *Spitzer Space Telescope* of one of the most distant galaxies ever seen. An exasperated Associated Press reporter told me he had to tell the story in 200 words.

Of course neither the scientist nor the PIO has any control over how a story is reported and is put into a social and cultural context for the readers, no matter how detailed or thorough the press release is.

In all sciences the road to Ultimate Truth is littered with results that were initially reported with great flourish, only to be proven wrong later. This is particularly true in reports on the search for exoplanets and will almost certainly be the case again as astrobiology experiments and observations are realised.

What's frequently lost in the debate about when a result should be reported is the simple fact that science is messy. Great discoveries in astronomy are often on the fringe of what a telescope can detect, whether it

Figure 1. NASA planetary scientist David McKay, at right, unveils the Martian meteorite ALH84001 as NASA Associate Administrator Wesley Huntress looks on during an August 1996 news conference at NASA Headquarters. Credit: NASA.

is the feeble trace of an exoplanet, the faint spectroscopic signature of extraterrestrial life, or a galaxy near the visible horizon of the Universe.

It is simplistic to assert, as some science and journalism critics do, that a result cannot be publicised until it is absolutely correct. Scientific research is a process of infinite mid-course corrections, so it should come as no surprise when the results are later modified or even retracted. The irony is that some critics have asserted that PIOs only issue results, but never describe the process of science. What could be more informative to the public than to discuss openly and honestly why a result was misinterpreted and what new information was learned from more recent data?

Occasionally new observations may come to light that are contrary to the results in a refereed paper about to be published and publicised in a press release. This presents an ethical dilemma for the PIO. Is it legitimate to publicise a refereed paper knowing that it will be challenged by research that will shortly be published?

The dilemma is that it is "double jeopardy" for a researcher to have work that has been accepted, and then "re-peer reviewed" by other scientists who may be serving in an advisory role to a news office. Also, it is not the job of a Public Affairs Office (PAO) to decide what is right or wrong in a story, but simply to report on the published work and its significance clearly and succinctly and in a timely manner. However, the institutions that PIOs serve, whether NASA facilities, universities, or research institutes, also worry about institutional embarrassment if a misleading story is issued.

It is specious to assert that doing a press release or press conference makes the science result "more real". Science journalists are flooded with astronomy press releases every day. They are astute enough to prioritise and, when needed, to separate the signal from the noise.

Lost in Space: the Terebey Planet

Between 1963 and 2005 (before the discovery of 51 Pegasi, the first bona fide exoplanet around a normal star), there were at least 15 reported discoveries of exoplanets that were later retracted. But probably no false detection of an exoplanet has been so criticised as the *Hubble* image of a suspected exoplanet that was later found to be a background star.

Entitled "Dangers of Publication by Press Conference", a lead editorial in the 4 June 1998 issue of *Nature* magazine criticised NASA for making "preliminary results by press release" official policy.

The editorial was prompted by a press conference on 28 May 1998 at which NASA released a *Hubble* photograph, obtained by Susan Terebey and her team at the Extrasolar Research Corporation in Pasadena, California, showing what they believed to be the first visible light from a planet outside our Solar System.

The paper had not been submitted for peer review in a journal, but Terebey was going to present the result at the 25–28 May meeting of the American Astronomical Society (AAS). NASA officials were alerted to this result and decided that it was so important they should call a press conference prior to the AAS meeting.

Over the years there have been a number of significant news announcements from the AAS, and they have all been presented as "works in progress". Very few science findings announced at the AAS are at the stage where a paper has been written and peer reviewed. In the context of the conference, this is acceptable among scientists and journalists.

Nature missed this point in criticising NASA for what normally transpires at the AAS meeting. "Unfortunately for those interested in the scientific details, there is only the abstract of a conference submission to turn to," they wrote. Such a sketchy presentation of new results, *Nature* argued, invokes the danger of adding to the pressures on journalists, which could leave them "with insufficient time to do much more than turn a press release into something comprehensible and sparkling, possibly excessively so".

In the rush to publicise, NASA had taken the unusual step of having selected scientists informally "peer-review" Terebey's work. NASA had undertaken an in-house review of the data reported at the 31 May press conference. "We had five PhD astronomers sit down with Susan and literally grill her...," said a leading NASA official.

At the televised press conference, Terebey reported that she thought the object, called TMR-C1, was a hot protoplanet that had been expelled from its star system and was hurtling into interstellar space. She and guest science experts at the press conference cautioned that astronomers needed to make further observations to confirm her theory.

On 29 April 1998 the *New York Times* dutifully reported this story with qualifiers: "The astronomers who participated in the meeting yesterday said a very small chance existed that the object in the picture was not a planet but was merely a background star almost directly behind the binary-star system called TMR-1. To rule out this possibility, Dr. Terebey said, her group must wait until the constellation Taurus rises in the sky in August. Then the astronomers will begin measuring the outward movement of the planet and will analyse its light spectrum with the big Keck II telescope in Hawaii."

Just as she had cautioned, in a paper published in the May 1999 *Astronomical Journal*, Terebey reported: "The new data do not lend weight to the protoplanet interpretation and the results remain consistent with the explanation that TMR-1C may be a background star."

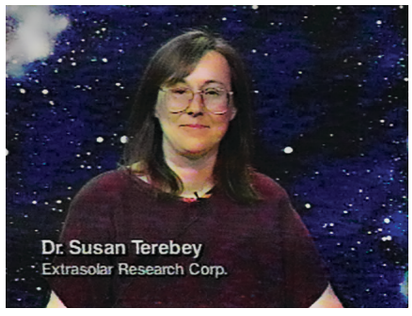

Figure 2. Dr Susan Terebey during a NASA Headquarters televised press conference on 28 May 1998 where she presented a Hubble *image of a suspected exoplanet that was later shown to be simply a background star. Credit: NASA.*

One inconsistency in the criticism of how the Terebey planet was publicised is that other tentative planet-hunting results have been accepted with appropriate qualifiers. For example, the European Southern Observatory reported a planet-detection story just like Terebey's in September 2004, and it was repeated by US investigators at the AAS meeting in January 2005. *Hubble* and the VLT telescopes had imaged a substellar companion object to the brown dwarf 2M1207.

The news articles that were written about that discovery were every bit as tentative as the Terebey planet story. The magazine, *Sky & Telescope*, in its 15 September 2005 is-

sue, reported, "Astronomers have unveiled the best candidate yet for the first direct image of an extrasolar planet. If confirmed, the object will also be the first planet-mass body found orbiting a brown dwarf rather than a true star."

In January 2006, *Space.Com* wrote: "The planet – still just a candidate, actually – is an odd duck in many respects. It does not orbit a normal star, and it is much more massive than the largest planets in our Solar System. Still, if confirmed, it represents a landmark in astronomy along the road to the ultimate goal of finding and photographing Earth-like planets around other stars."

What's been completely forgotten is that Terebey's paper was successfully refereed and was published in *Astrophysical Journal Letters* in August 1998 with the title, "A Candidate Protoplanet in the Taurus Star Forming Region".

In fact, it was cited by reviewers as bold and innovative research. The NASA PAO would have dutifully reported the result in the same manner in August 1998. Never mind, said the critics, the press conference jumped the gun. It propelled a questionable result into the news stratosphere via the televised NASA press event.

What's specious about this argument is that journalists have the same responsibility to assess and report a science new story accurately regardless of the venue, be it press release, press conference, or astronomical society presentation. Mainstream journalists do not have time to read the original science papers, much less find outside experts that have read the paper.

One major irony is that the first widely publicised exoplanet story also fell on its face despite being peer-reviewed and published in *Nature*. The 5 August 1991 issue of *Time Magazine* eagerly reported: "Now a team of three astronomers in Britain claims to have spotted solid evidence of a faraway world. Writing in the British journal *Nature*, Andrew Lyne and colleagues at the University of Manchester's Jodrell Bank radio observatory report an object between 10 and 15 times the mass of the Earth, orbiting a special kind of star called a pulsar that lies some 25 000 light-years away."

Numerous publications had reported that Lyne and his team had unequivocally discovered the first planet outside the Solar System. But the University of Manchester radio astronomer had changed his planned talk in the days before his scheduled slot at the American Astronomical Society meeting in Atlanta in 1992.

The 24 January 1992 issue of *Science* magazine reported: "Instead of telling a tale of triumph, he shocked the audience of several hundred with an anguished confession: The planet was a mistake. 'It was an artefact of the Earth's motion around the sun,' Lyne told the audience. His peers reacted sympathetically to his retraction, and even applauded. And, it did not sour them on the idea of pulsar planets — as their favourable reception of another talk, about a new crop of pulsar planets, showed."

Some theorists initially suspected that Lyne had been misled by some effect of the Earth's orbit, because the period of his pulsar planet was almost exactly six months I asked one of the referees if he had ever been suspicious about the six-month periodicity of the exoplanet. "No, I assumed they had done their math correctly," he shrugged.

Invaders from Mars?

The Terebey press criticism pales in comparison to the ongoing debate over NASA's decision to publicise the Mars meteorite findings in August 1996. A potato-shaped meteorite, labelled ALH 84001, found in Antarctica was suspected of containing fossilised Martian bacteria and other biotracers.

A science team from NASA'S Johnson Spaceflight Center (JSC) reported that "lines of evidence" pointed to the likelihood that a primitive form of microscopic life that flourished on the red planet three billion years ago had been found on board a meteorite that fell to Earth 13 000 years ago.

I have seen NASA endlessly lambasted for putting this out in a standing-room-only press conference at NASA Headquarters on 7 August 1996. Critics say that the announcement was premature. NASA should have waited until the finding had been fully vetted by the science community before making any public statement.

NASA was aware of the meteorite result months before the paper was to be published in *Science*. NASA PIOs knew it was only a matter of time before the results would leak out because the finding was so extraordinary. As a stopgap, the JSC scientists were told not to talk to reporters. But the NASA PAO knew that astute reporters would put the pieces together and build a coherent story.

Once the meteorite paper was successfully peer-reviewed, the NASA PAO asked *Science* to speed up publication for fear of a news leak. NASA Administrator Dan Goldin was even in direct communication with *Science* editors to facilitate an early publication date. The *Science* editors did not see the urgency or seem worried about news leaks.

In the meantime the NASA PAO put together a "Pearl Harbour" plan in case the story leaked to the news media. The press release and television graphics were prepared well in advance. NASA PAO had the JSC scientists on call to hop a plane on short notice and fly to NASA Headquarters in Washington DC, for a hastily called press conference.

Figure 3. The most infamous rock in NASA history is the Mars meteorite ALH84001. It caught the attention of the US President and made headlines around the world in 1996 when scientists announced that it might contain evidence for Martian bacteria — a claim that remains highly disputed even today. Credit: NASA.

Veteran aerospace reporter Leonard David picked up the Mars meteorite story at a science conference in Houston and published it in *Space News* a few days ahead of the embargo.

Two days before the 7 August NASA press conference, Leonard David told CNN: "Well, you know, I think the actual story's been evolving for a while, and there were certain indications even a year ago that something exciting had been found, but the clam doors of NASA kind of shut down on it, and rightly so, just to make sure that they believe that they have the correct evidence that they believe shows that this particular meteorite has biological indicators of life. I think we're at a point, too, where sort of a kind of an ounce of caution is worth about five pounds of Mars rocks, right now. You've got to be a little careful."

Veteran science reporter K. C. Cole of the *Los Angeles Times* picked up on the furore. "The team led by researchers from NASA's Johnson Space Center in Houston found what they say could be fossils of tiny extraterrestrial organisms stuck to the surfaces. They describe the findings in a paper to be published next week in the journal *Science*. But by Tuesday, word had spread around the world. Harried NASA officials have scheduled a news conference for today. 'NASA has made a startling discovery,' said NASA Administrator Dan Goldin. He called the evidence 'exciting, even compelling, but not conclusive'."

The debate over the nature of the meteorite will go on for years. In a meeting at NASA's Johnson Space Center in 2004, one participant said the presence of biotracers in the meteorite is a "definite maybe".

The bottom line, some researchers assert, is that the years of debate have been beneficial. Identifying what kinds of signatures of life are real and can be depended upon is crucial, particularly when spacecraft missions return the first Mars samples, or in trying to make on-the-spot judgments via instruments on the planet.

"A lot of people have done some exquisite work. This is going to be really useful to the community. This is all valuable stuff. In terms of being better prepared for handling Mars return samples in the future, it's a win-win situation for science," said Everett Gibson of the JSC Mars meteorite team. "This is an argument that's difficult for the person on the street to sort out, science is not accepted quickly."

Steven Kahn of the Kavli Institute for Particle Astrophysics and Cosmology at Stanford University believes that cultivating public interest and support for big astronomy programmes goes beyond simply listing science goals. "My belief is that a new transition will be required — a transition to beyond science. We must couple our field to goals that the public can viscerally attach themselves to, whether or not they understand the scientific measurements and analyses that will be performed."

This is more than hypothesis. The controversial 1996 report of biotracers in a Mars meteorite prompted US President Bill Clinton to reiterate US support for space exploration: "...the fact that something of this magnitude is being explored is another vindication of America's space programme and our continuing support for it, even in these tough financial times."

The "messy science" of exploration and discovery will be even more of a challenge in the coming decades. The diffusion of news across the internet in continuous news cycles, proliferation of blogs, and immediate scientist-to-scientist communication via publication sites like astro-ph will antiquate the practice of embargoed news and formal press conferences.

For example, the spectroscopic measurement of an Earth-like exoplanet with an atmosphere in disequilibrium will very probably see a replay of the Mars meteorite debate. There will be no consensus among scientists when the news of a planet with a possible biosphere is announced.

This news will be so extraordinary that it will be close to impossible to keep it secret for very long. There will very probably be allegations in the press of more NASA hype (since the result will likely come from an advanced NASA space observatory). But for the public it will be a tantalising "what if" that could at least open our society to thinking about the implications of finding life off-Earth. It could lead a future US president to make a public statement about the historic and cultural significance of the finding and to reiterate national support for the importance of astronomical research.

In summary, here is some conventional wisdom to be applied to the "Are we there yet?" question of when to publish a significant science result:

1. Big science stories can have a strong element of uncertainty and stand a reasonable chance of being significantly modified later or even proven wrong through subsequent observations.
2. Even if a result is later proven wrong, it can serve as a catalyst for further scientific investigation and enhanced public interest.
3. It is impossible for a major finding to be kept under wraps until it has been vetted to every scientist's satisfaction. Reporters will pick it up as "work in progress" from conference presentations, posters and general internet chitchat.
4. The question of whether to go public with a research finding without prior publication in a peer-reviewed journal is a judgement to be made on a case-by-case basis. There is much that scientists might say about their work that falls outside the scope of a refereed journal.
5. There will always be some discoveries that are clearly suited to immediate public disclosure, with or without full technical details. The 1994 *Shoemaker–Levy* comet impacts on Jupiter, or the ongoing exploration by rover vehicles on Mars, are just two examples.
6. By the time a science result is fully vetted it may be old news, because it has been surpassed by even more advanced findings.
7. It will take years or even decades for certain controversial scientific findings to be settled, especially when it comes to the emerging frontier of astrobiology. For example, the theory of plate tectonics was debated for nearly 50 years.
8. A science news story will find its proper buoyancy in the marketplace of daily news activities. The success of a news story is influenced more by the competing news of the day rather that what venue it was presented in, whether televised press conference or news release.
9. The public is largely understanding and forgiving if a science result is later retracted in the light of new information. Errors only have potentially serious consequences for the public in medical reporting and related health

Biography

Ray Villard is News Director for the Space Telescope Science Institute in Baltimore Maryland. For the past 35 years he has communicated astronomy to the public through popular articles, planetarium programmes and public seminars and courses. A 22-year veteran of the Hubble Space Telescope Project, he has received several NASA service awards for his contribution. His latest book, *Infinite Worlds*, is an illustrated survey of extrasolar planets.

Ten Tips for Communicating Astronomy with Children

Best Practices

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Key Words

Science Communication
Children
Best Practices
Outreach

Summary

Science communicators must tackle many difficult audiences as part of their jobs, but among the most challenging are audiences of young children. If you are not used to this type of work it can seem like a daunting task, but a few simple tips will help a great deal to prepare you. Get some experience now and you will also be in a good position to help with the International Year of Astronomy 2009.

Be Enthusiastic

Children will take their lead from you, so the most important tip is to be lively, engaged and interested. Your audience will follow suit, making it an enjoyable experience. If you are bored yourself then this will be reflected in their behaviour, and it will not be long before attention wanes. The danger is that if you act too enthusiastically, you will be seen as an entertainer figure. This might be what you are after, but usually you want to keep the children's respect! Remember to be enthusiastic about any work the children produce and questions that they ask.

Keep Things Simple

It is sometimes easy to forget that concepts adults take for granted can be lost on a younger audience and this is even more apparent with topics like astronomy. Almost every aspect will have to be simplified to some degree. As for how much you will need to simplify, just watch the children's faces as you speak — it will be obvious if they do not understand what you are saying! Detailed information and figures should be avoided as it will just confuse. Use analogies to help get your point across. For example, instead of saying that the average Earth/Mars distance is 225 million km, explain that Mars is so far away that even in a fast rocket ship it would take six months to get there.

Encourage Creativity

Astronomy is a brilliant topic for children to flex their creative muscles. They love to imagine advanced spaceships, strange planets and weird aliens. Although their ideas may not be the most scientific, avoid stifling their imaginations and gently direct them to more realistic notions. The children will be entertained and the activities memorable. When children are allowed some control over their work more pride is taken in what they do. Allowing children to be creative will also help them realise that science can be fun.

Be Prepared

A key to success when communicating astronomy to children is to be prepared. Make sure you know exactly what is expected of you. What age range will you be dealing with? How many children? Are you giving a ten-minute presentation or leading a whole day's workshop? Are there certain objectives you must meet? Ensure you have the whole picture before you begin. Having suitable materials will also make your life easier. Children appreciate visual aids, so any talk over ten minutes long should feature some large, colourful images. Luckily the field of astronomy has plenty of these! If you are required for an hour or more, prepare a lesson plan. This will provide structure and help you keep to time.

Figure 1. Children need visual aids to help them understand difficult concepts. Credit: Jennifer Barrett.

Figure 2. Allowing the children to work in groups is often an effective approach. Credit: Lee Pullen.

Know Your Stuff

It is important to do research before you present. If the relevant topic is unfamiliar you may be tempted to skip background reading as your audience will know very little, if anything, about the subject. However, children can be good at spotting when you are pretending to be an authority! Make sure you have a reasonable level of knowledge. You never know which questions you will be asked, so be prepared. Having a mental list of interesting facts and analogies will help.

Spark Discussions

An excellent way of keeping children involved is to encourage discussion and participation. A simple way of doing this is to avoid giving a straightforward presentation and ask questions instead. For example, if you are planning on giving a talk about the Solar System, start off by asking, "Hands up who can tell me something about the Sun?" You will probably get an answer like "it's hot". Build on that in your next question. "That's right, so would you be able to stand on the surface? Hands up who thinks yes."

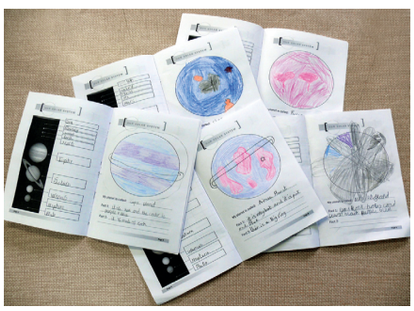

Figure 3. Let creativity flourish! Credit: Lee Pullen.

You will be guiding the discussion but the children will be providing information and will enjoy the opportunity to answer. They will be much more interested if you use this approach. Try not to completely dismiss any ideas or incorrect ideas, as this may knock their confidence, but compliment them on a good guess and gently offer a more sensible answer.

Encourage Friendly Competition

Children are naturally competitive and this can be used to our advantage. A good idea is to prepare an astronomy quiz based on the information that you will have given them. Select questions carefully, ensuring nothing is too obscure and that they have a chance to answer everything. If you are not sure of the ability level you may like to prepare easy and advanced questions, allowing you to use whichever is more appropriate. Children like rewards, so certificates (an A4 word processed sheet, for example) for winners are a cheap and easy way of congratulating them. If you can, prepare participatory certificates too, so no child feels left out. Mention at the beginning that there will be a quiz and then if any child becomes distracted during the session simply remind them that anything they learn could come up in the quiz, so they should best pay attention. This works every time!

Be Understanding

Individuals within a group of children will naturally vary greatly in ability, interests and learning styles. This may seem obvious, but if you ignore this fact you will become frustrated with anyone who lags behind the activities you set out. Every child will have an area that they are particularly good at. If they have trouble writing, then perhaps a drawing exercise will suit better. If that fails, maybe they have a good speaking voice and can explain information that way. Some children may have special educational needs and require much more attention than others. Try to arrange for specialists, such as the children's regular teacher, to be on hand if this is likely. Be as sensitive as you can to anyone having difficulties. For example, some children will have handwriting that is difficult to read. Asking "What does that say?" may hurt their confidence, so instead say, "Why don't you read this out loud to me?"

Be Aware of Legal Issues

These will vary depending on the country you are working in, but a few general tips are applicable to all. Make sure that you are fully insured, as this will give financial protection against any mishaps. If you are going to an institution like a school then it is quite possible that they will have their own insurance, but do check this. Organising insurance yourself can prove to be very costly, and is something to bear in mind if you will be working in a freelance capacity. Make sure you know about fire regulations and what to do in an emergency. It is very useful (and sometimes legally required) for someone usually in a position of responsibility such as a teacher or parent to be present at all times.

Realise That You Are Appreciated

By taking the time to help communicate astronomy to children you will not only educate, but also inspire the next generation to take an interest and perhaps study the Universe in which we live. For communicators not used to dealing with younger age groups it can be intimidating and difficult, but you will learn new skills and improve your own abilities. Ultimately, the children will greatly appreciate your efforts and will gain much from the experience.

Biography

Lee Pullen puts his astronomy degree and science communication master's to good use engaging a wide range of hard-to-reach audiences. He has taught several thousand children about the cosmos and also works as a science journalist. His website can be viewed at www.leepullen.co.uk.

Communicating Canadian Astronomy on the Eve of the International Year of Astronomy 2009

Best Practices

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Key Words

International Year of Astronomy 2009
Partnerships
Astronomy Education
Outreach
Communication in Canada

Summary

We describe the achievements of astronomy education, outreach and communication in Canada, past and present, and our hopes and dreams for the International Year of Astronomy 2009 (IYA2009): *To offer an engaging astronomy experience to every person in Canada and to cultivate partnerships that sustain public interest in astronomy*. Despite challenges such as the lack of major funding sources, much has been accomplished through volunteer efforts, especially in the last decade. These have been intensified by IYA2009 and have been facilitated by the "partnership approach" that includes professional astronomers in government and academia, amateur astronomers in both anglophone and francophone Canada, planetariums and science centres, astronomy communicators and other members of "the astronomical education community".

Canadian astronomy has a long and illustrious history for a country so young. It begins with the indigenous knowledge and practice of Canada's aboriginal populations. It continues with the practical astronomy needed for surveying the settlements and railways as they spread westward across the country. Within the last century it has included forefront research by university and government astronomers in fields ranging from meteorite impact craters to dark matter and dark energy. In international surveys of the past decade Canadian astronomy consistently ranks highly in productivity per astronomer or per dollar spent.

Canadians should be proud! But many — perhaps most — are under the misconception that most astronomy is done in the large country to the south of us. The problem is not one of interest: surveys show that most Canadians are interested in science, as much so as in sport or politics. Astronomers simply have to get the word out.

There are challenges. Canada has a small population spread over a large area. We have two official languages, English and French, and millions of people whose first language is neither of these two. We lack the "science culture" that is prevalent in Europe or in some Asian countries. Compared with the US, there is very little government funding available in Canada to support science outreach and communication. Nor have our funding agencies yet instituted policies requiring applicants to explain how they will share the results of their publicly funded research with the public other than through professional refereed astronomy research journals.

Nevertheless, much has been accomplished, largely on a voluntary basis.

Many Canadian astronomers are active — and indeed have distinguished themselves — in outreach and communication, and graduate students play a prominent role in organising non-technical lectures and tours of observatories. We are blessed with large numbers of active amateur astronomers and clubs, most of them associated with the Royal Astronomical Society of Canada (RASC) and the Fédération des Astronomes Amateurs du Québec (FAAQ). Both have very strong outreach programmes for schools and the public. The RASC was a 2003 winner of the Michael Smith Award, a prestigious national award for excellence in science promotion.

Canada has five large planetariums, as well as some major science centres. The planetariums have successfully cooperated in developing major shows on Canadian astronomy such as *The Quest for Origins* (2004) and *Is Anybody Out There?* (2006) and are proposing a new one, *Galileo Live!*, for the International Year of Astronomy 2009.

Canada has had some outstanding science communicators. When the Dominion Astrophysical Observatory (DAO) opened in May 1918, Director John Stanley Plaskett instituted regular open houses for the public, a tradition that continues 90 years later.

Through publications in professional and lay journals he and his small staff ensured the public was aware of scientific developments not only of their new observatory, but of astronomy more generally. Clarence A. Chant, the founder of the astronomy department at the University of Toronto, was a prolific writer and lecturer. His efforts led directly to the establishment of the David Dunlap Observatory which, when it opened in 1935, had the second largest telescope in the world (with the 1-cm smaller DAO telescope — now named the Plaskett Telescope — the third largest). Helen Sawyer Hogg, of the University of Toronto, wrote a weekly astronomy column in Canada's largest circulation newspaper for 30 years. Terence Dickinson's books have sold more than a million copies around the world. Comparable public outreach is a strong feature of astronomy in Québec too where professionals, amateurs (FAAQ), science centres and the media have achieved remarkable success as partners in communicating the latest astronomy news. In addition, the Canadian Astronomical Society (CASCA), which includes Canada's professional astronomers and graduate students, created the CASCA-Westar public lectures (patterned after the successful Shapley Lectures of the American Astronomical Society) to bring astronomy to smaller communities[1].

It would have been tempting to simply continue the impressive status quo. But in 2001, CASCA embarked on an "education initiative", funded in part by programmes of the federal and Ontario provincial governments. A broad-based advisory board recommended, as first priority, supporting astronomy in schools.

Astronomy is part of the elementary and secondary school science curriculum in most parts of Canada. The quality of science teaching is generally high, though teachers often shy away from astronomy because few of them have any background in astronomy or astronomy teaching.

Accordingly, a bilingual website was created[2], aimed at teachers and their students, but containing useful information for amateur astronomers and the general public. Since its inception, Heather Theijsmeijer, a high school science teacher with a background in astronomy, has maintained the site on a part-time basis, constantly adding useful new material and ensuring that all links are current. At about the same time RASC Vice-President Mary Lou Whitehorne wrote *Sky-Ways — Astronomy Handbook for Teachers.*

The next step was to create a website that would serve the mass media, taking into account the fact that most people (including teachers and students) get their astronomy information from that source. In response to a recommendation in Canada's Long Range Plan for Astronomy,[3] the CASCA Education and Outreach Committee developed a concept in 2005 for a website[4] that would provide high quality images, graphics and information in a form useful to the media. Fortunately, the chair of the committee, Jayanne English, has a background in art, design and media, as well as in astronomy. Unfortunately the project is stalled for lack of funding, but is still being slowly developed on a volunteer basis and efforts to secure funding continue.

Then the International Year of Astronomy 2009 came along. This is providing a catalyst for progress on three fronts: expansion and promotion of cascaeducation.ca, development of AstronomyCanada.ca, and organisation of countrywide IYA2009 activities, both local and national. Under the initial leadership of Dennis Crabtree and in collaboration with the authors, the IYA2009 Canada Committee was formed, representing all parts of the astronomical community — CASCA, university and government astronomy, the RASC and FAAQ, planetariums and science centres, science communicators, as well as Canada's aboriginal communities.

Our vision is "to offer an engaging astronomy experience to every person in Canada, and to cultivate partnerships that sustain public interest in astronomy". A subsidiary vision is that every amateur and professional astronomer in Canada will find (or develop) an IYA2009 activity that fits with their personal interests and expertise. We encourage "bottom-up" activities, not just "top-down" ones. Our evolving plans and their implementation may be tracked online.[5]

One of the arguments against simply maintaining existing activities through IYA2009 is that much of astronomy outreach and communication presently reaches a limited audience; we are "preaching to the converted", as the saying goes. Most astronomical hobbyists are middle-aged white males. What about women, young people, minority ethnic groups, including our aboriginal population? What about people whose primary interests are in the arts and literature? We need to reach out to new audiences.

We are therefore delighted that our partners from the aboriginal community, led by Cheryl Bartlett and Lindsay Marshall of Cape Breton University, are making steady progress towards achieving IYA2009 goals in two areas: bringing astronomy and other sciences to their people, especially young people and also collecting and disseminating information about indigenous astronomical knowledge and practice. In addition they are striving to increase the number of dark sky preserves in Canada.

And we are looking forward to imaginative partnerships with orchestras and other arts organisations; two major Canadian orchestras are already committed to imaginative astronomy-themed programmes in 2009.

Our committee has identified about two dozen possible IYA2009 projects and activities, many of them parallel to the international IYA2009 Committee's Cornerstone projects. Potentially they engage every part of our diverse population.

But challenges remain. We have few agencies and foundations which provide the type or amount of support that we need. In the 2000 Long Range Plan for Canadian Astronomy, it was recommended that 1.5 percent of the budget for any astronomical facility should go to related outreach. Only in one specific instance has that goal been indirectly achieved; in general, neither the funds nor an accepted mechanism have yet appeared. As for approaching corporate and private funding sources, Canadian astronomers are unfortunately amateurs at such fundraising. But with seed money from CASCA and other sources, we are making progress — and look forward to updating you soon.

An outline of astronomy education, outreach and communication in Canada, our plans for IYA2009[6] and our fundraising brochure[7] are all available online.

Notes

1. http://www.cascaeducation.ca/files/casca_westar.html
2. http:// www.cascaeducation.ca
3. http://www.casca.ca/lrp/front-back/en-index.html.
4. http://www.AstronomyCanada.ca
5. http://www.astronomy2009.ca or http://www.astronomie2009.ca/
6. http://www.astronomy2009.ca or http://www.astronomie2009.ca/
7. http://www.astro.utoronto.ca/~percy/finalastrodoc.pdf

Biographies

John Percy is a very active Professor Emeritus of Astronomy and Astrophysics, and of Science Education, at the University of Toronto. He is a past president of IAU Commissions 46 (Education and Development) and 27 (Variable Stars) and a member of the IYA2009 Canada Committee.

Jim Hesser is Director of the Dominion Astrophysical Observatory (National Research Council of Canada) in Victoria, Past President of the Canadian Astronomical Society, Chair of the IYA2009 Canada Committee, and a recipient of Canada's Michael Smith Award for outstanding contributions to science outreach.

Visualising Astronomy: The Astronomical Image, Part One

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Key Words

Visual Communication
Astronomical Images

Ask for an image to sum up visualising astronomy and most people think of an iconic Astronomical Image. By which I mean the glamour shot that appears on the glossy magazine cover or is enlarged to greater-than-human size to grace the wall of an art gallery or science museum.

Who isn't a fan of the latest, splashy *Hubble* or *Spitzer* or *Chandra*? Astro eye candy with crisp details psychedelically rendered from narrow band filters or wavelengths our eyes can never see… Don't we all just gobble up every swirl and sparkle? Aren't these images the reason the astronomers become astronomers, rather than physicists, poring over loopy particle tracks or dull plots?

The Astronomical Image provokes an aesthetic response that helps engage a variety of audiences. With the recent opening of the *Hubble* exhibition at the Walters Art Gallery[1] and similar exhibitions taking place or planned for IYA2009 worldwide, the "art" angle has obviously met with a certain high- or middlebrow recognition. As we attempt to capitalise on the public outreach potential,

Figure 1. Mountains of Creation from the Spitzer Space Telescope *reveals structure that we automatically recognise as naturalistic. Credit: NASA/JPL-Caltech/L. Allen (Harvard-Smithsonian CfA).*

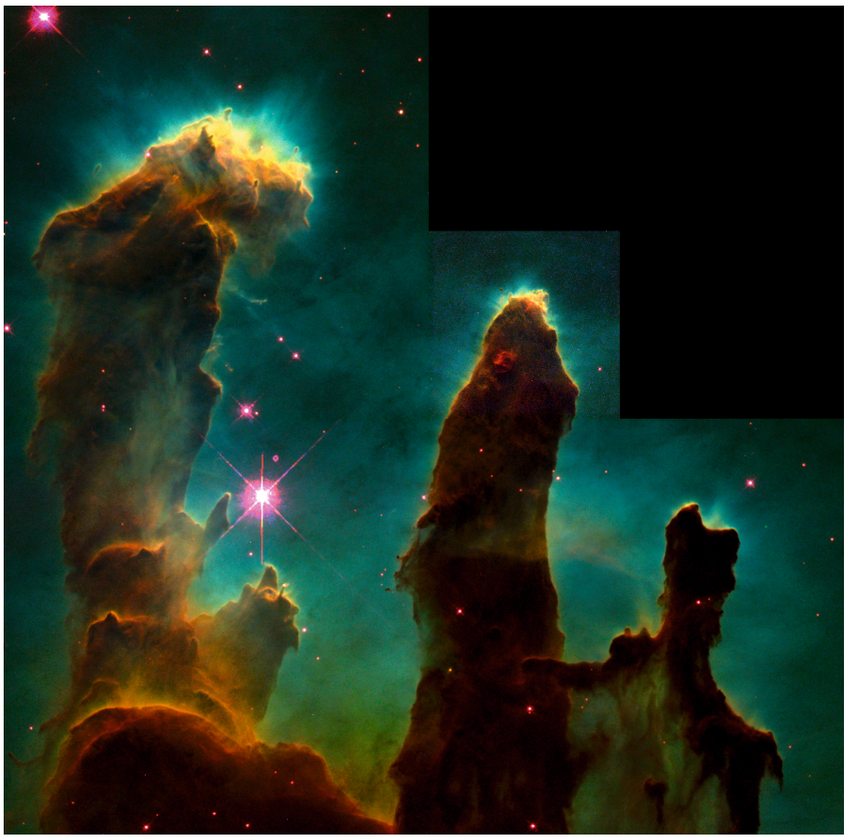

Figure 2. An old friend, the Pillars of Creation *image takes advantage of our inherent response to warm and cool colours to enhance its three-dimensional appearance. Credit: Jeff Hester and Paul Scowen (Arizona State University), and NASA/ESA.*

we should take a moment to consider the quality of people's aesthetic response.

In her study of *Hubble* imagery,[2] doctoral student Elizabeth Kessler compared *Hubble* imagery to paintings by members of the Hudson School, such as Albert Bierstadt or Thomas Moran: "The *Hubble* images are part of the Romantic landscape tradition — they fit that popular, familiar model of what the natural world should look like."

I suspect that part of the appeal lies in an intrinsic quality of the images themselves, namely the image statistics that underlie what we perceive to be natural images.[3] Real-world images contain structural information over a range of scales that communicates verisimilitude. Both the "*Mountains of Creation*"[4] of *Spitzer* (Figure 1) and Moran's "*The Teton Range*"[5] communicate something topographic that results from the manner in which the overall scale relates to its cragginess. Similarly, many high resolution astronomical images lock into our innate sense of what reality looks like. For much the same reason, I have long advocated the use of real data in planetarium presentations: the result simply looks more authentic than artwork and provokes an associated affective response.

It would be disingenuous to suggest that the naturalism and the appeal of an image can be reduced to a power spectrum. Take a look at the *Hubble* image that could be said to have started it all: Hester and Scowen's narrow-band interpretation of M16, dubbed the *Pillars of Creation*[6] (Figure 2). I know you will have seen it a million times before, but take another look. The warm oranges and yellows of the intricate pillars seem to reach out at you from the cool, almost aqueous background. This is not a new idea to visual artists — Leonardo da Vinci wrote in the 15th century: "You know that in such an atmosphere, the most distant objects, such as mountains, appear, because of the great quantity of air that lies between them and your eye, as blue as the air when the sun rises." The highly unnatural colour scheme in the *Pillars of Creation* results from assigning [OIII], Hα and [SII] narrow band images to blue, green and red channels respectively — but the resulting image happily capitalises on our sense of depth perception to give it a sense of dimensionality it would otherwise lack.

A must-read for anyone interested in the use of the Astronomical Image is Rector et al. (2007). Although the bulk of this lengthy article is devoted to techniques for manipulating digital images, it also touches on a philosophy of presentation in the abstract: "The use of visual grammar, defined as the elements which affect the interpretation of an image, can maximize the richness and detail in an image while maintaining scientific accuracy. By properly using visual grammar, one can imply qualities that a two-dimensional image intrinsically cannot show, such as depth, motion and energy. In addition, composition can be used to engage viewers and keep them interested for a longer period of time."

Amen. What they are saying is simple enough: give people what they want, and make it work for you!

But this gives us only half the aesthetic picture. There is something else our images have in common with the 19th century paintings of the American West: the sense of exploration. The Romantic landscape would not have existed without something to romanticise; similarly, the impact of the Astronomical Image relies on its looking outward to the Universe around us. More on that in my next column.

Notes

1. *The Aesthetics of Hubble Images Showcased at Walters Art Museum*, STScI Press Release 2008-10, available at http://hubblesite.org/newscenter/archive/releases/2008/10/full/.
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Biography

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