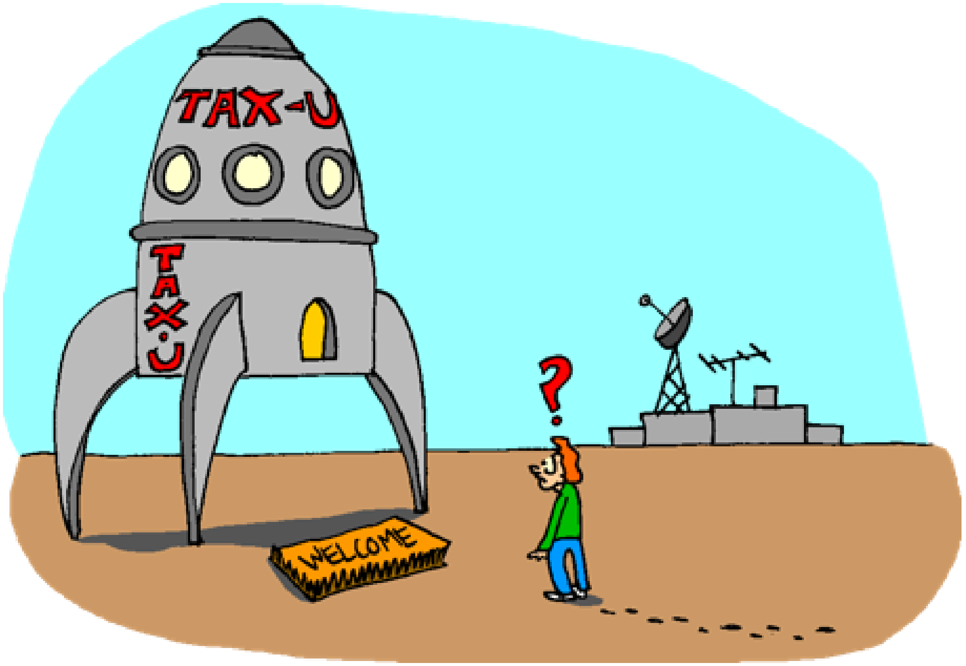
Costs, Risks, and Benefits: Science and the Citizen



Summary

In this Activity, we will discuss:

- the financial environment of space science;
- the risks and benefits of space exploration; and
- some aspects of the public perception of space exploration.

Expect the Unexpected

In scientific research projects, unknown factors mean that costs, risks, and benefits are not necessarily understood or accurately quantifiable.

For example, the early work in studying the phenomenon of radioactivity led ultimately to unexpected benefits.

Yet it led also to unforeseen tragedy, price tags beyond belief, a continuing ethical dilemma, and legal action by survivors of nuclear weapons testing.

Marie Curie-Sklodovska, who discovered radium in 1897, died in 1934 of aplastic pernicious anaemia caused by prolonged, repeated exposure to radioactive substances.

Credit: Swinburne

A Waste of Money?

To some people, the exploration of space means that staggering sums of money have been dissipated in - quite literally - a vacuum.

So, before we examine some of the ethical and legal issues of space exploration (in Activity 2), it is important to consider the broader context of space science, how it is funded, and what kind of chance the non-scientist has of understanding it all.

Examining Space Science

Why?

Because we live in a society which depends on science and technology, yet those very essentials seem undervalued — perhaps because they are not understood.

There is great concern in some quarters about the inadequacies and shortcomings in science funding, science education, and the way science is communicated to the public.

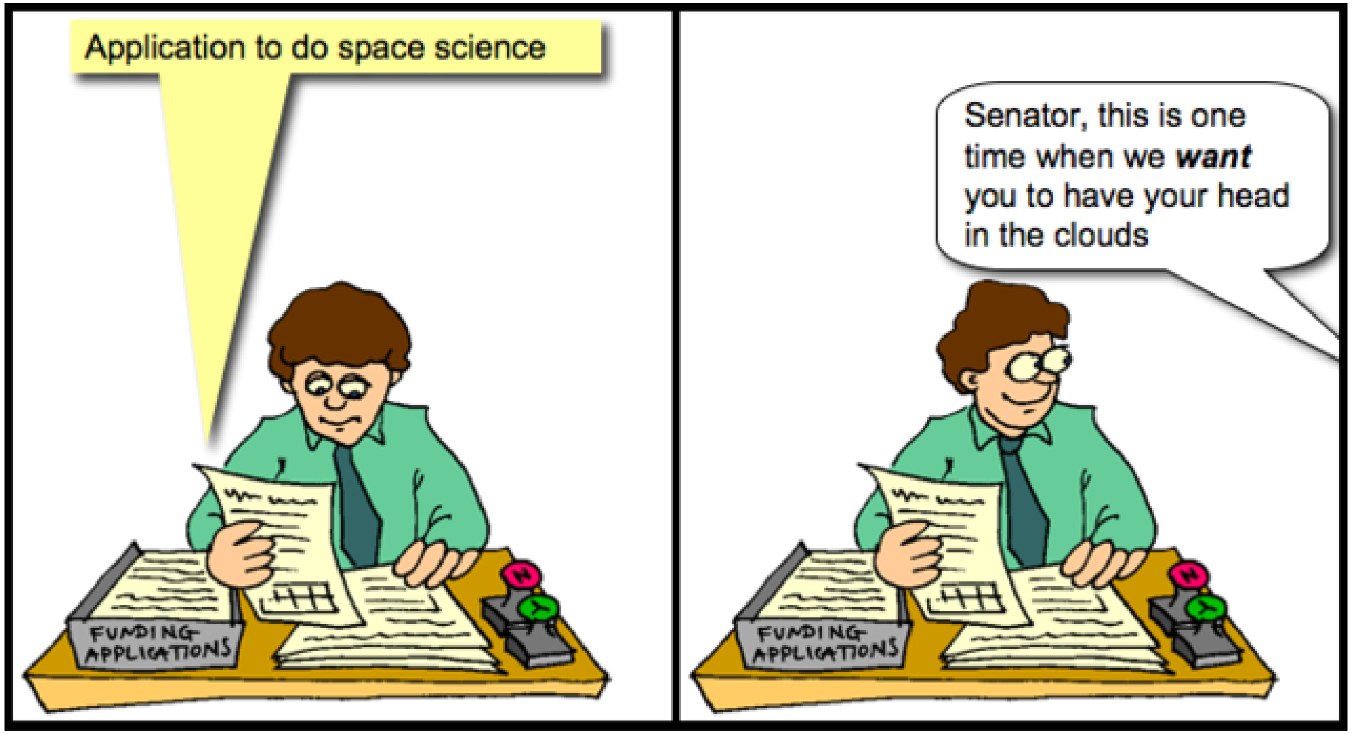
Again, it comes back to the public: because **people vote**.

The Communication of Science

It is beyond our scope to go deeply into the broader situation, but the communication of science certainly warrants some attention.

If people do not understand science - space science, medical science, or whatever - then they are not equipped to vote knowledgeably on science issues.

Politicians are people. If they are not equipped to debate science issues knowledgeably, are they equipped to decide science issues - such as funding and education policies?

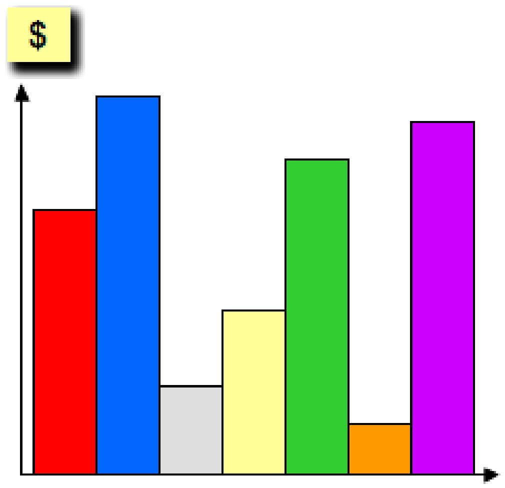


Science in Action

Normally, when discussing how science works, we start with the process of science: the scientific method.

For our purposes here, though, we shall start with the bottom line of just about everything else in society - **money**.

Governments allocate budgetary amounts, generally annually, to the things regarded as essential to the people they represent: health and welfare, defence, transport, and so on.



Introducing R&D

In science, there are two main but not necessarily separate avenues for spending, sometimes referred to collectively as **research and development** (R&D).

- ***Research*** *is the acquisition of new knowledge.*
- ***Development*** *is the application of existing knowledge to new or improved uses.*

Obviously, in R&D, new knowledge can pop up in all sorts of unexpected ways, and possible applications may reveal themselves even before the knowledge has been fully digested.

However, there is no way of knowing where or when new knowledge will find a practical application.

Electricity

Consider electricity, for example. Experimenters such as Galvani and Volta were in the vanguard of a developmental process that is still continuing two centuries later.

Yet who, in the 18th century, could have had the foresight to give money to Galvani to continue his work with dead frogs' legs?

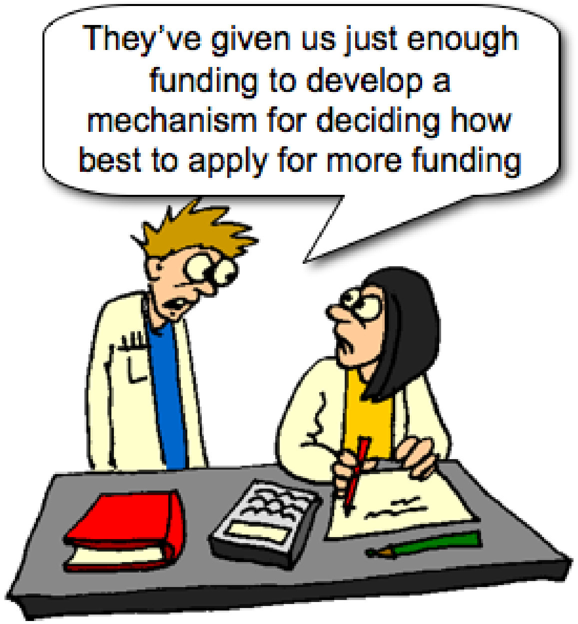
Money is usually only forthcoming when there is an obvious **commercial windfall** in the offing, such as the telegraph, telephone, electric motor, and electric light. Once again, we have reached the bottom line!

The Scramble for Funds

Little has changed. Whether in a university, private corporation, or a huge government organisation such as NASA, R&D is impossible without **approval** and **funding**.

It is safe to say, then, that some of the most vital work done by scientists is in preparing their funding applications!

Space science is a crowded field, with a very limited number of resources for cutting-edge research. Come up with an idea for research and there is a fair chance that someone else has already thought of it or is already working on it.



Prove Your Project's Worth

A proposal for research must therefore show how the work will build on or augment existing knowledge, and what the possible outcomes might be.

Finally, we again reach the bottom line. **Money**.

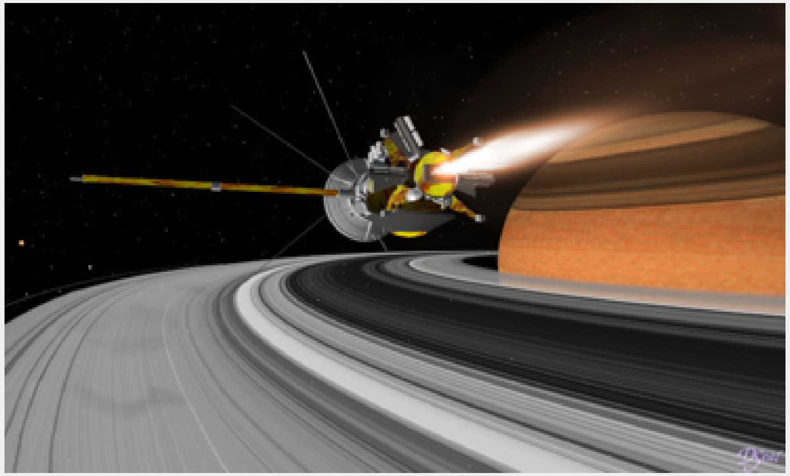
- How much is it going to cost you to fly over to the testing facilities?
- How much is it going to cost to modify an existing spectrometer to suit your purposes?
- And do you *really* need to test it for five days on the beaches of Tahiti?

Opening the Wallet

NASA's budget for 2005 is around **16 billion US dollars** . That's for everything from launching missions to conducting educational programs.

Human space flight, which includes the shuttle and space station, gets around **6.7 billion** of that.

Space missions are cheaper today than in earlier times, because the technology is in general cheaper and methods have been streamlined.



Computer rendered image of Cassini during the Saturn Orbit Insertion.

Credit: NASA

Day-to-day Benefits

Billion-dollar figures naturally keep a lot of people in work, and have an enormous economic influence, but are there tangible returns that the ordinary citizen can identify with?

Considered over the entire range of space-based activities, **yes**.

One of the first and most obvious results of the space age was the rapid progress in **satellite and communications technology**, evident today in so many aspects of life that our interface with them is virtually seamless.

The Value of Satellites

From weather reports, sports broadcasts, and communication networks, to geographic information systems, geophysical research, and the Global Positioning System, we reap the benefits of the space age every day of our lives.

If nothing else had come of the space race, we would still have ample reason for gratitude, for the fact that satellite technology has become a commercial enterprise means that it can pay its own way.

There, at least, the bottom line is undeniably healthy.

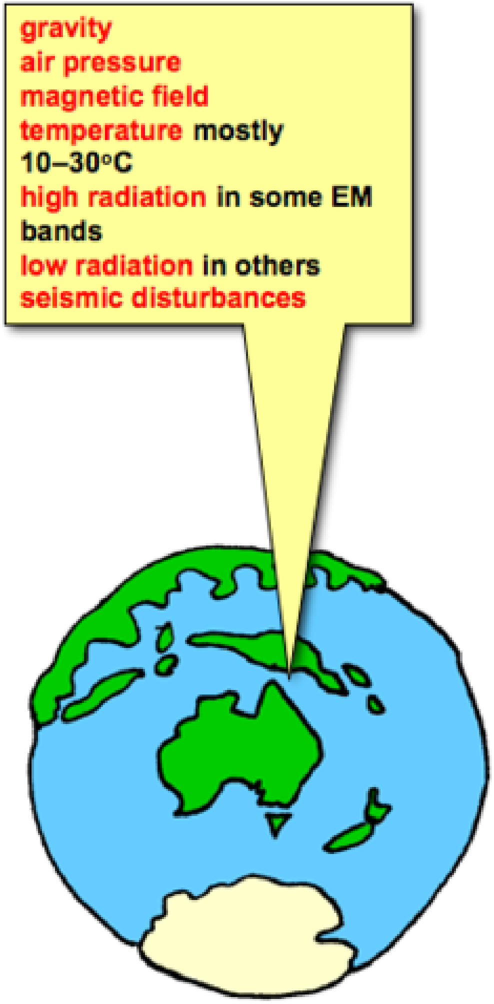
A Good Return

What else do we get for our investment in space?

The space environment offers conditions of microgravity, vacuum, and temperature extremes, which hold promise for experiments and processes not possible on Earth.

The vacuum of space, for example, is better than the best vacuum attainable on Earth.

The harsh conditions of space, including radiation, stimulate progress in developing more versatile and efficient materials and engineering methods.



A Healthy Push

We cannot say for sure that at least some of these developments would not have occurred regardless of space exploration, but they have almost certainly been hastened.

Computers, **medical equipment**, and **electronics** in general have all benefited from the impetus of the space age.

There is, too, the **feedback effect** which sees an advance in one field trigger an advance in another, which in turn may help the first.

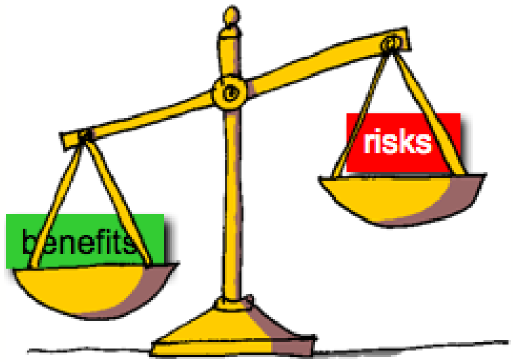
To some people, of course, that will undoubtedly seem a rather vague argument.

What Can Go Wrong?

An analysis of the likely **risks** and **benefits** would be a necessary part of a research proposal.

Your employer would undoubtedly be interested to know, for instance, that your ideas would almost certainly have commercial applications, but unsettled to learn that testing would require a layer of lead shielding around the lab.

In a successful proposal, however, there must at some stage come a point where the benefits outweigh the risks and the financial outlay can be justified.



Acceptable Risks

Deciding whether a risk is acceptable is necessarily subjective.

Obviously, the most hazardous part of an unmanned mission, from the point of view of those on the ground, is the liftoff. Rocket testing is done in isolated areas, and launch paths are usually over wide stretches of ocean or sparsely populated land.

Costly though a failure is, the risks in unmanned missions are relatively slight, involving fire or pollution from rocket fuel, and falling space junk.

Onboard radioactive substances can certainly give valid cause for concern, but once a craft has left Earth orbit, we are out of danger.

Launch of the Pathfinder/Sojourner mission to Mars, 1997.

Credit: Courtesy NASA/JPL-Caltech

Radioactive Debris

Since 1964, there have been at least nine failures of satellites or craft with **radioactive substances** on board.

Apollo 13, for example, has been on the bottom of the ocean off **New Zealand** since 1970, with about 3.5 kg of plutonium in it. More recently, the Russian Mars 96 craft burned up in the sky over **South America**.

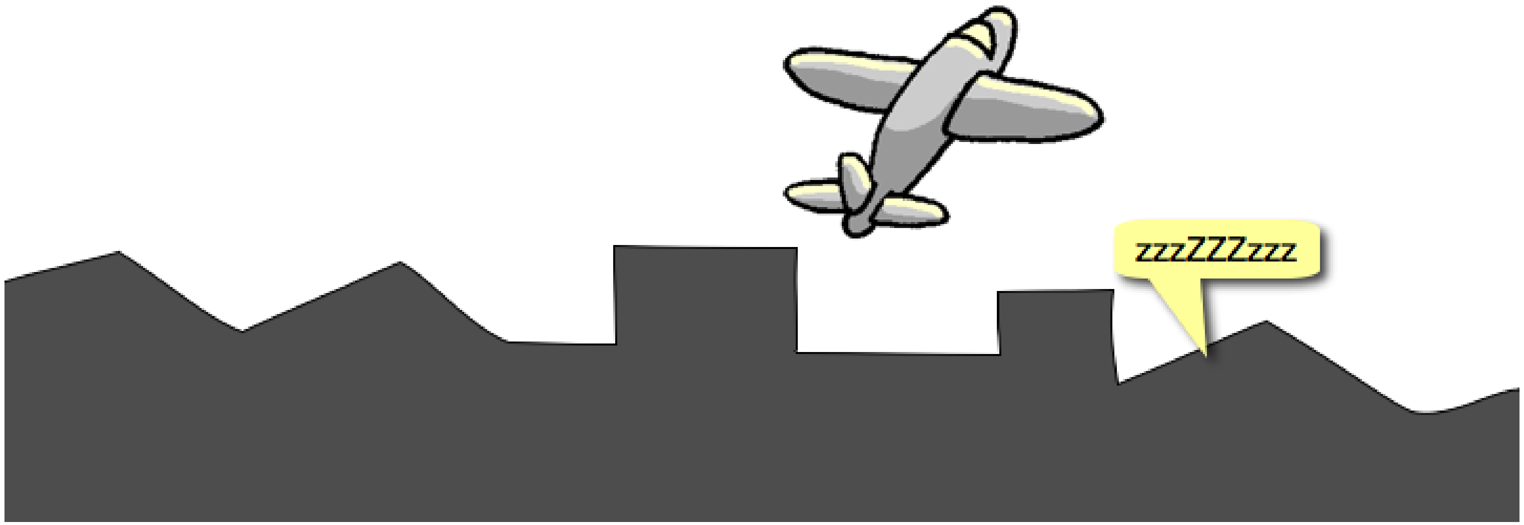
When such accidents happen, the nuclear material is, ideally, relatively safely contained. In principle, it can be retrieved, and this was actually done after a **US** mishap in 1968. In practice, though, it is likely to be lost into the environment.

Plummeting Junk

By comparison with radioactivity, if you say"rocket fue" and"space jun" quickly, the risks do seem minimal. Probably, they are.

One day, though, a launch vehicle may go drastically out of control and cause a minor catastrophe in Florida or Kazakhstan. Or, one day, a lump of space junk the size of a refrigerator may survive its fiery plunge and demolish a building.

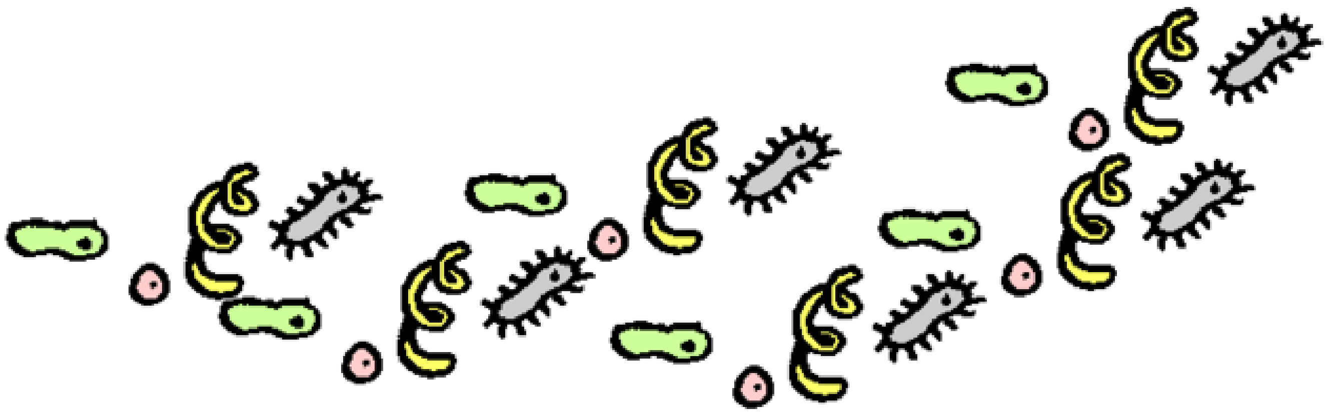
We should put those possibilities into perspective, though. Tens of thousands of people live in close proximity to airports, and face the prospect of having a burning airbus coming down on top of them. It is something we live with.



Microscopic Menace?

Other risks are more difficult to ponder. It is known, for instance, that microscopic organisms can survive and mutate in the microgravity and higher radiation levels of space stations such as Mir.

What would happen if they came back to Earth as passengers on an astronaut's clothing?

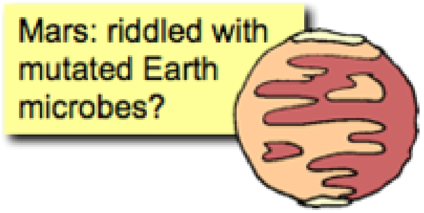


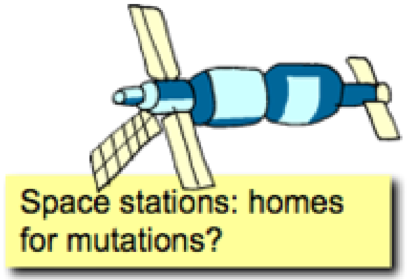
Unwelcome Passengers

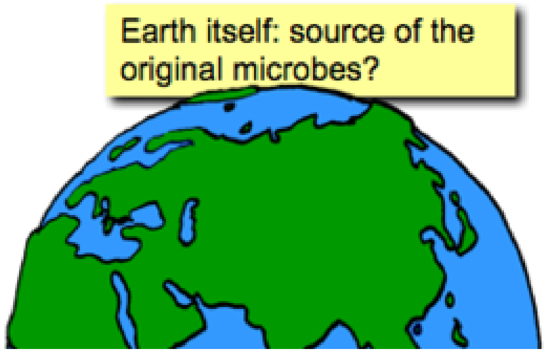
Moreover, we must rightly consider the possibility of dangerous Martian microbes arriving on Earth in samples returned by robot explorers. Will quarantine conditions devised around known standards be sufficient?

Now, consider this. Suppose some of our own bacteria travel to Mars on our spacecraft, survive on the surface, but mutate in the intense UV radiation.

What kinds of diseases could they cause when human explorers arrive?





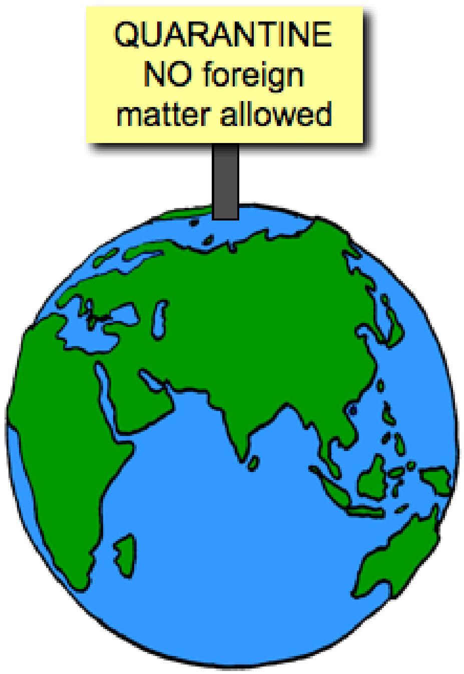


Tiny Livestock Not Welcome

Mutant Earth bacteria will have to be dealt with if and when they are encountered.

The possibility of native microbes from Mars arriving, though, is already taken seriously enough by some people that an organisation dedicated to seeing that samples are not returned is already in existence.

It is called the International Committee Against Mars Sample Return, and you can visit its web site by following this link.



What the Public See

Research has to have specific aims.

You don't get a few precious hours of telescope time just to admire the view, and - unless you have a lucky streak - you will probably not discover anything new by pointing a telescope at the sky and hoping for the best.

Nor will your Mars probe get funding if you can't be more specific than wanting to send back images of the surface.

The acquisition of the Hubble Deep Field images was a notable exception: according to legend, only loud voices in high places allowed the Hubble Space Telescope to stare, not for hours but for ten days, at an unremarkable patch of sky near Ursa major... with remarkable results.
Credit: NASA, ESA, S. Beckwith (STScI) and the HUDF Team

Constraints on the Profession

Yet those are some of the very things that non-scientists often do not understand.

For example, typical of the sorts of questions that this writer has been asked during community lectures on astronomy is this:

Since there are so many professional astronomers looking out at space, why is it that so many comets are discovered by amateurs?

Science Fact, Science Fiction

Can we really blame people for their own ignorance on scientific matters? How much a person knows and understands depends not just on what they were taught at school, but whether they have read the right kinds of books and magazines, and watched the right kinds of TV programs.

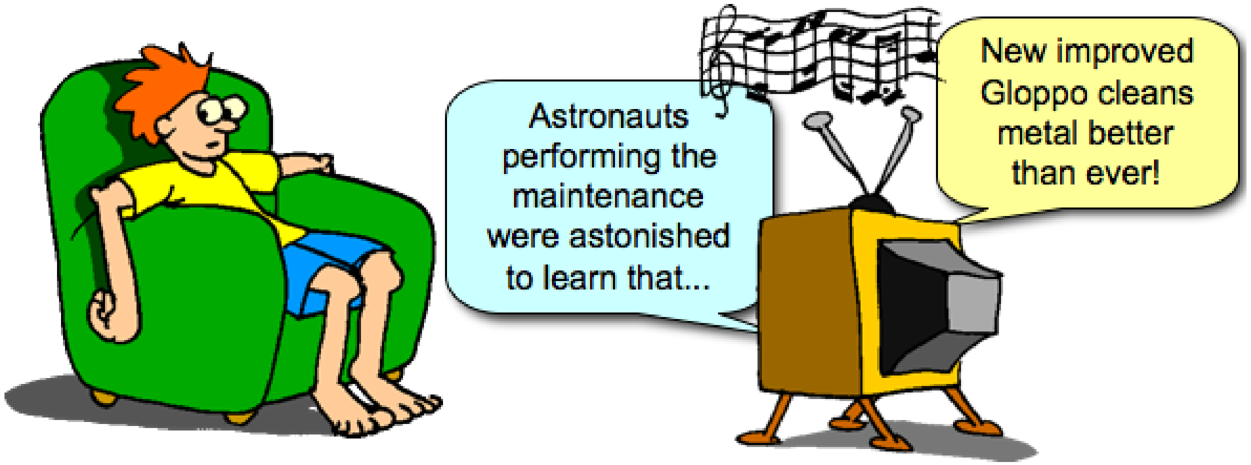
Walk into a bookstore, and pseudoscience is likely to nestle beside science without any distinction between the two. Settle down to watch TV, and science fiction blurs with science fact in any of a dozen programs.

Zero Value

What annoys many people about television depictions of space news is the way a lightweight, thirty-second story is accompanied by a series of quick video grabs.

Three seconds of the shuttle viewed, presumably, from a window on the space station; five seconds of helmet-cam showing an astronaut's hands working on some unexplained mechanical gizmo.

It sometimes boils down to nothing more than a meaningless time filler that we are expected to accept as informative.



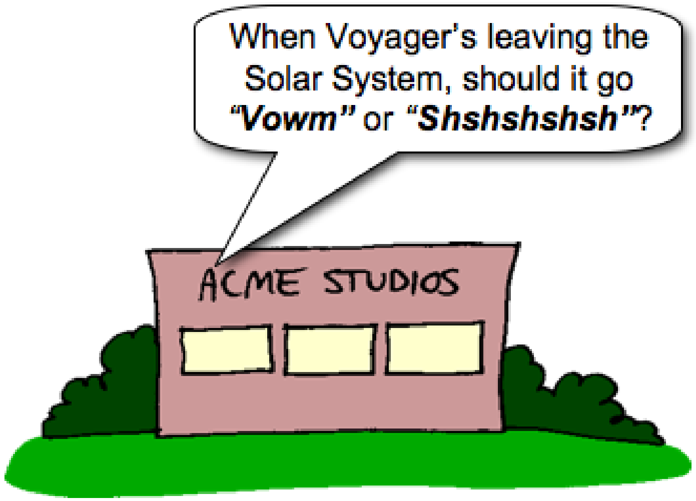
Unsound Astronomy

TV documentaries, in their own way, can be just as bad.

Simulations are often not labelled as such, and given the quality of video animation, may be indistinguishable from reality to the untrained eye, and confusing even to viewers who know what is happening.

And has the populace been so weaned onto a low attention span that every space scene must be accompanied by a low, droning background sound?

Yes, apparently, as if, perhaps, the utter silence of space would be too much for modern city dwellers to endure!



Public Education

Aesthetics aside, the point is that part of the way science works, or how it ought to work, should include the clear communication to the public of how and why a particular piece of research is being done.

Part of that responsibility falls on the group doing the work. Then, somewhere, we have to squeeze in at least a token role for government science and education policy.

The rest of the responsibility falls on the print and electronic media that claim to be there to keep us up to date on what is happening around us.

Enter the Web

The advent of the World Wide Web has made the provision of comprehensive information easy.

From NASA, the ESA, observatories, university departments and individual researchers, there is more and better information freely available than one would have dared dream of just a decade ago.

If only there were time to read it all!

Bad News is Good Media

The news media, however, are always very much preoccupied with sensationalism, for sensationalism sells.

For something scientific to be sensational, however, it generally has to be a **flop**, or at least pose some **risk to public safety**.

The failure of the Mars Polar Lander mission in 1999 probably gained more publicity than the success of the Mars Global Surveyor.

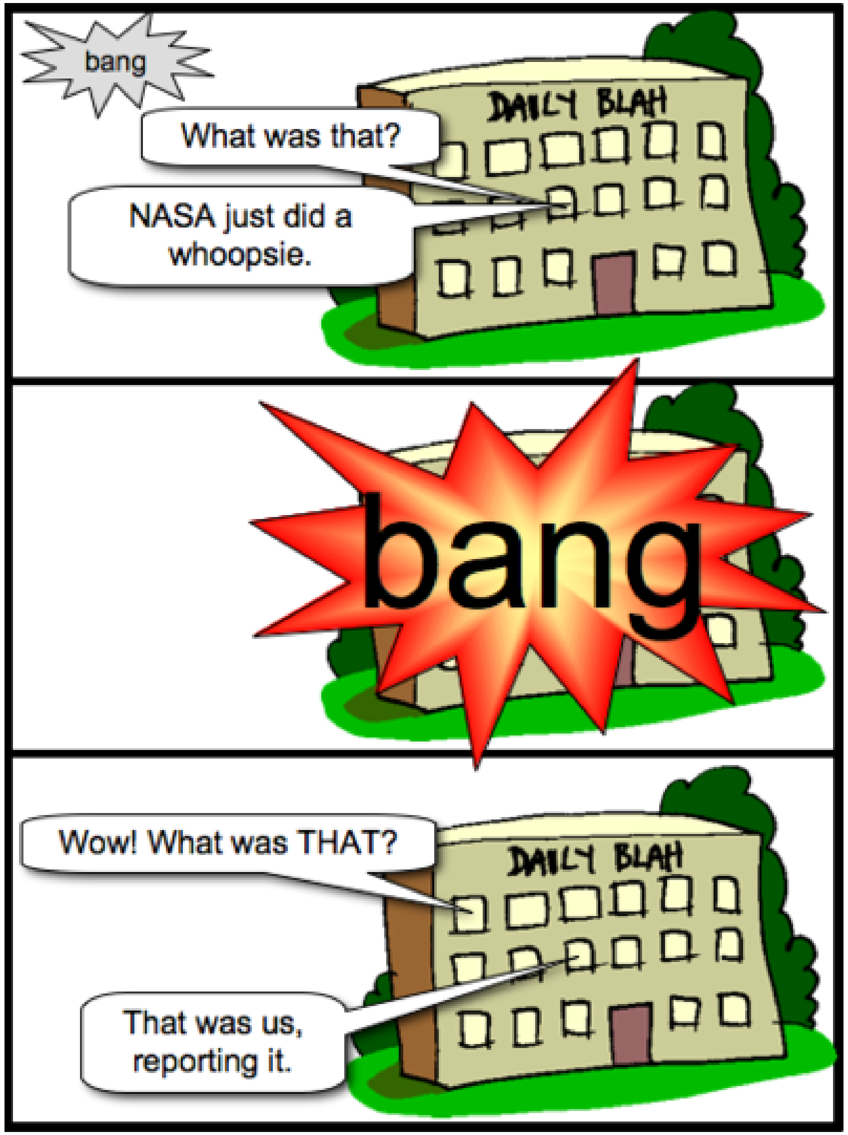
The tragic loss of the Challenger shuttle gained more media coverage than every passenger jet crash in the history of aviation.

No Small Mistakes

The loss of the Mars Polar Lander was apparently due to a confusion of metric and imperial units between groups involved in construction and mission control. If so, it was an incredible blunder that never should have happened.

Yet mistakes do happen in all aspects of society, and always will. There is an old saying: Engineers' mistakes fall down, doctors' mistakes get buried, and lawyers mistakes get hanged.

NASA's mistakes, however, get blown out of all proportion.



Pointing the Finger

Perhaps that is because we like to see the mighty humbled. We like to see politicians get caught with their pants down. We like to see experts made to look silly.

That aspect of human nature may never change, but we should hope that it never influences policy decisions unduly.

The way to try to ensure that it does not is to try to ensure that people understand the how and why of endeavours that are being attempted.

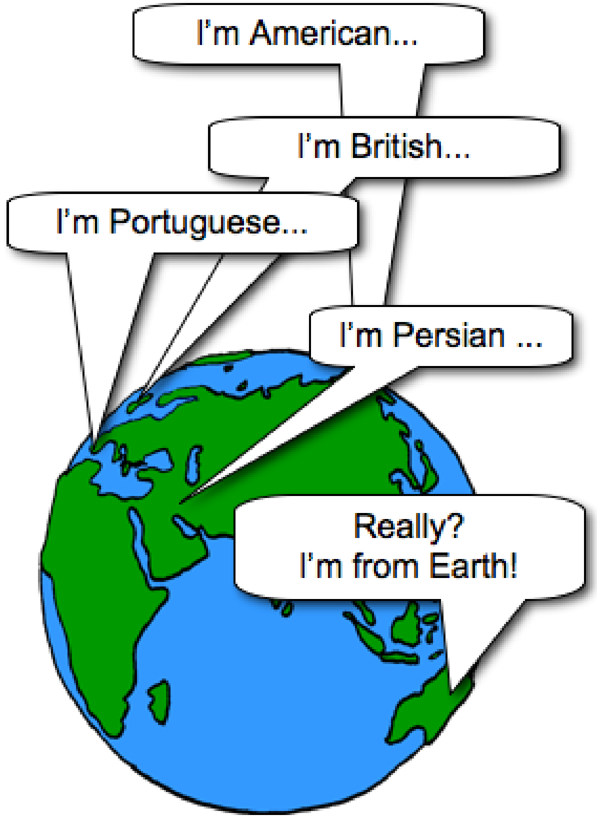
Keep the Earth Round

If there is one superlative reason for space exploration, then perhaps it is that it keeps the human cultural horizons expanding.

It can help us to see ourselves as a single species, not as a group of tribal factions.

If we do not actively pursue knowledge, we risk allowing our culture to degenerate into a “flat earth” way of thinking.

The greatest risk associated with the exploration of space would be in abandoning it, or limiting it so greatly that it became a mere curiosity on the periphery of our cultural vision.



Summary

In the next Activity… Coming up now are introductions to the legal and ethical dimensions of life in the space age.