GNOMON

Newsletter of the Association for Astronomy Education

Vol. 20 No. 3 | ISSN 0952-326X | SPRING 2001

Primary school's QCA astronomy curriculum

Below are the Qualifications and Curriculum Authority lesson plans for the topic Earth, Sun and Moon in Key Stage 2. Eight lessons are proposed, say about 12 hours work all told. The topic is recommended for Year 5 and is to be done in the late Autumn so that the lengthening of shadows may be used in the afternoons. The children at that point will mostly be 9 with some 10-year olds.

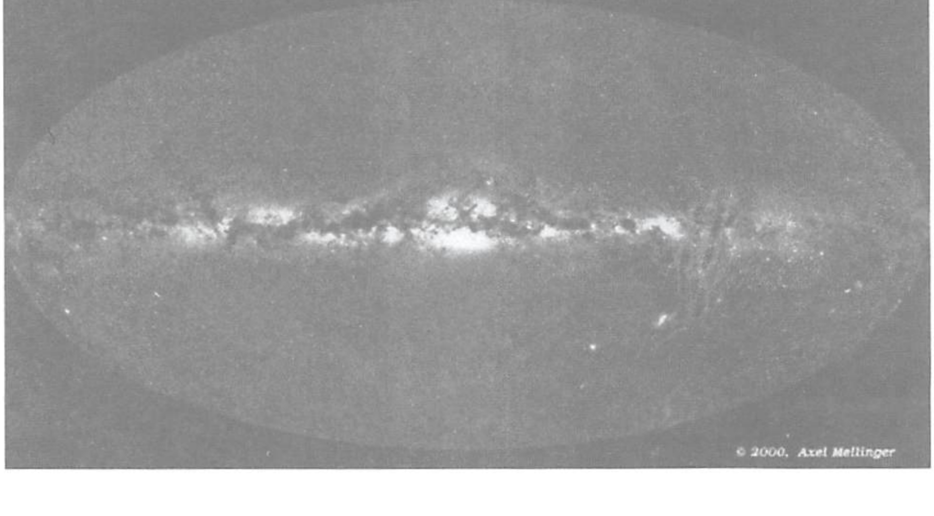
The children will obviously have to revise it about 18 months later because this is a compulsory topic in the SAT exams at age 11. But basically this is the sum total of the astronomical education of English children in primary schools. Peter Corbally(peter.corbally@btinternet.com) asks if there are any comments or suggestions for improvement?

The tabular presentation of the original is too large for *Gnomon*'s format, so it is rearranged here under each of the nine numbered units, followed by the learning objective in italics, the teaching activities in roman type, then the learning outcomes in italics.

Earth, Sun and Moon: Expectation: most children will recognise that the Earth, Sun and Moon are spherical and support this with some evidence. They will explain in terms of the rotation of the Earth why shadows change and the Sun appears to move across the sky during the course of the day. They should recognise that it is daylight in the part of the Earth facing the Sun, that the Moon orbits the Earth and identify patterns in secondary data about sunrise and sunset. ☞

Our galaxy, from the inside

This stunning panorama of the entire sky is a mosaic of 51 wide-angle photographs. Made over a three-year period from locations in California (USA), South Africa, and Germany, the individual pictures were digitised and stitched together to create an apparently seamless 360 by 180° view. The image is oriented so that Galactic Equator is the horizontal centre line, with the Galactic centre at the image centre and Galactic north at the top. Almost everything visible here is within the Milky Way Galaxy, but the two external fuzzy patches in the lower right quadrant of the mosaic are the Magellanic Clouds. http://canopus.physik.uni-potsdam.de/~axm/images.html ***is the address to see this in full colour***



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Advertising Charges:

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Publication Dates:

These are at the equinoxes and the solstices, that is four times a year.
Copy deadlines are two months *before* these dates.

☞ 1. *Review existing knowledge and undersanding of Earth, Sun and Moon*:
Find out what children know by asking them to draw and explain a picture showing how these would look to a traveller in space. Ask children questions about their drawings eg Is the Earth flat? Is the Sun bigger than the Moon? Does the Sun move?
Level of knowledge and understanding established

2. *The Sun, Earth and Moon are approximately spherical and it is sometimes difficult to collect evidence to test scientific ideas and that evidence may be indirect:*
Following discussion, use secondary sources and models like videos, CD-ROM, a globe, photographs of the Earth, Sun and Moon taken from space and ask children whether these suggest the bodies are flat or spherical. Point out to children that it is only in the last 40 years that we have photographic evidence from space about the Earth being spherical, and ask them to find out some earlier ideas about whether the Earth was flat or spherical and what evidence people used to support their ideas.
Recognise that the Earth, Sun and Moon are spheres, and describe some indirect evidence that the Earth is spherical - ships sailing round the world, ships appearing and disappearing over the horizon.

3. *The relative sizes of the Sun, Moon and Earth.*
Remind children of the pictures they drew earlier and the photographs they saw and ask them to put Earth, Moon and Sun in order of size by selecting from a range of spheres such as a football, beachball, tennis ball, pea, ball bearing, peppercorn, tiny beads about ¼ size of pea, table tennis ball. Explain to children that if a pea represents the Earth then the beach ball represents the Sun and the bead the Moon. Ask three children to hold the three spheres and position them in the classroom to give an idea of their relative distances apart.
Select three spheres to represent the Earth, Sun and Moon recognising which is largest and which is smallest and making a reasonable match to relative size.

4. *The Sun appears to move across the sky over the course of a day. Evidence of this may be interpreted in more than one way:*
Ask children about where the Sun shines into the school (or their homes) at different times of day. Remind them of earlier work on shadows and ask them to suggest what this evidence shows. If necessary observe the length and position of the shadow of a stick set up in the playground at different times of day over successive days.
Describe how the apparent position of the Sun changes over the course of a day and clarify that this does not mean that the Sun is moving.

5. *It is the Earth that moves, not the Sun, and the Earth spins on its axis once every 24 hours. It is daytime in the part of the Earth facing the Sun and night-time in the part of the Earth away from the Sun*
Use secondary sources, such as video, CD-ROM to illustrate the Earth spinning on its axis. Show children a model of the process, such as using a globe and a strong light source to represent the Sun. Ask children to show others by modelling or using themselves as Sun and Earth, or by drawing or using other models, how night and day arise from the Earth spinning on its axis. Talk with children about the different representations.
Illustrate using models or drawings to show that different parts of the Earth face the Sun during the course of the day and where it is day and night. Explain that the apparent movement of the Sun is a result of the Earth rotating or spinning

6. *The Sun rises in the general direction of the east and sets in the general direction of the west. Make observations of where the Sun rises and sets and to recognise the patterns in these. Present times of sunrise and sunset in a graph and to recognise trends and patterns in the data.*
Ask children to use a compass to observe and record, on several days in the winter, the direction of the Sun or of shadows from the Sun when it has just risen and just before it sets. Provide children with secondary data about times of sunrise and sunset and help them to present this data as a graph and to identify patterns in the data. Discuss with children whether it is dark or light when they get up in the winter and summer and what sorts of activities they can do on winter and summer evenings.
Generalise that the Sun rises in the East and sets in the West. Draw simple graphs and identify patterns such as that sunrise gets earlier and earlier up to June and then it starts getting later; when sunrise gets earlier, sunset gets later so it is daylight longer

7. *The Earth takes a year to make one complete orbit of the Sun, spinning as it goes. It is not always easy to gain information about phenomena such as the length of a year using first-hand experience.*
Ask children to use secondary sources like CD-ROMs, reference books to find out what a "year" is. Discuss with children their understanding of a "year" such as from birthday to birthday, or through all the seasons. Model the Earth's orbit of the Sun for example with a child moving round a central "Sun" ie either a lamp or a large group of children, rotating at the same time
State that a year is the time taken for the Earth to make one complete orbit of the Sun, showing that they know this from secondary sources such as reference books, CD-ROMs, information provided by the teacher.

8. *The Moon takes approximately 28 days to orbit the Earth. The changing appearance of the Moon over 28 days provides evidence for a 28-day cycle.*
Use secondary sources (video, CD-ROMs, reference books etc.) to illustrate that the appearance of the Moon changes in a regular manner over a period of approximately 28 days. Model the Moon's orbit round the Earth for example by asking a child to walk round a group of children representing the Earth so that the child representing the Moon always faces the Earth. Ask children to describe the movement of the Moon as it goes round the Earth so that it revolves but the same side always faces the Earth.
Explain that the pattern and time-scale of the changes in the Moon's appearance over 28 days is evidence that the Moon orbits the Earth once every 28 days

9. *Review and consolidation*
Review work done on the Earth, Moon and Sun by asking children to devise questions for a quiz (together with the answers). Ask children to pose questions to each other and help them to judge the [***continued on page 4***] ☞

Curriculum Corner

In the "Curriculum Corner" of *Gnomon Vol. 18 No.2* (Winter 1999) I gave a procedure for calculating the "age" of the Moon (days since New Moon) for any date. I gave no derivation for this procedure. Why did I exclude it? Quite simply, I had never bothered to try and find out how it worked. I also made a serious error in the instructions given, so if you had tried it out, you would have found it rarely worked at all!

So when one of my class of adult students this term took the trouble to investigate the process, and arrived at a very convincing and laudable result, I felt duty-bound to admit my laziness, and sloppiness, and reprint his results here!

How *really* to find the age of the Moon

A procedure for calculating the phase of the Moon from the calendar date given in the form CCYY/MM/DD (e.g. 1996/08/30) was presented without its derivation or origins as follows. It is said to give the age of the Moon since new, in days, to within about 24 hours, but usually better than that:

	Procedure	*Example (for 1996/08/30)*
Step 1	Divide CCYY by 19 and keep the remainder (i.e. reject multiples of 19).	RM [1996/19] = 1
Step 2	Multiply that remainder by 11	1 X 11=11
Step 3	Divide by 30, if divisible, and keep the remainder (i.e. reject multiples of 30).	RM [30] = 11
Step 4	Add CC/3 (ignoring remainders)	11 + integer [19/3] = 17
Step 5	Add CC/4 (ignore remainders)	17 + integer [19/4] = 21
Step6	Add 6	21 + 6 = 27
Step 7	Add MM, and then add DD	27 + 8 + 30 = 65
Step 8	Subtract CC.	65 - 19 = 46
Step 9	Divide by 30 and keep the remainder (reject multiples of 30)	RM [30] = 16 days

Since Full Moon is (nearly) at 15 days, this gives the answer that the Full Moon should be 1 - 2 days earlier than the 30th. In reality the Full Moon was August 28d 18hr.

There is a certain mystique in this procedure and it was fascinating to apply it to predict a New Moon for the total eclipse dates of 1999/08/11, 2001/06/21 and 2151/6/14 and a Full Moon for the Passover dates of 1998/4/11 and 2001/4/8.

Why does it work?

I was also intrigued to investigate why it works. I have been unable to find who devised this specific algorithm and the particular reasoning behind it and therefore can only offer the following attempt at a rationalisation.

Mathematics is a valuable tool for understanding our universe but the numbers are not always as convenient to use as we might like - just think of $\sqrt{2}$ from the diagonal of a unit square, or π from a circle.

The age-old problem with the calendar is that relative lengths of day, month and year involve fractions, not whole numbers. It is not easy, therefore, to synchronise the cycles of Moon and Sun.

I month (period of Moon's phase) = 29.53059 days

This approximates to 30 days [1]

1 year (calendar / tropical / seasonal) = 365.2422 days

Each year the Moon's cycles lead the sun by 10.875 days.

This approximates to 11 days [2]

Each month, the Moon's cycle gains 0.906 day

This approximates to I day [3]

It has long been recognised (by Meton of Athens and others) that after a period of 19 years the Moon will return to its phase at the start [4]

These four approximations can be used to explain the algorithm.

The Metonic cycle (statement [4]) explains step 1, the discarding of 19-year blocks.

Each year left over represents a gain of 11 days (from statement [2])

The justification for discarding 30-day blocks at any step is to account for the lunar cycle (statement [1]).

Approximations [1] and [3] are applied in step 7.

Steps 4, 5 and 8 are not so obvious.

Gathering terms, CC/3 + CC/4 - CC gives $-\frac{5}{12}$CC. This could be viewed as a correction to the Metonic cycle because 235 lunar months do not exactly match 19 years. There is an error of some 2 hours, or $\frac{1}{12}$ day. So $\frac{5}{12}$ day per century will be significant when dealing with the term CC. The 19 year slices we took were slightly too thin, giving too much of the 'Metonic cake' left over. Hence, subtraction is called for in the algorithm.

Step 6 involves a constant term of 6 (days). It might be simplest to see this as a calibration constant, tuning the origin of our scale with a given phase of the Moon.

This investigation has introduced me to a fascinating literature on the "calendar" and to other rules of thumb, like those for predicting the day of the week from the calendar date. Determination of the date of Easter is also frequently discussed - no one task better exemplifies the principles involved.

Some references:

Cambridge Illustrated History of Astronomy (edited by Michael Hoskin)

Mapping Time - the Calendar and its History by Richards [Oxford]

The Calendar by Duncan [Fourth Estate Ltd]

Questioning the Millennium by Stephen Jay Gould [Mackays]

Anglican Book of Common Prayer - older editions

Internet - searches on "calendar", "Metonic", "Easter", "ephemerides", "astronomical algorithms" etc.

Colin Woolcock

☞ *[continued from page 4]*
appropriateness of the answers.

Children show knowledge and understanding of Earth, Sun and Moon through quiz activities

Any comments?

Please let Peter know your views. He has already had comments from Eric Jackson in New Zealand, who wrote:

Thank you for your effort in setting out the series of lesson plans. John Dunlop, education officer at the Auckland Observatory recently completed his Master's degree using children's expression of the relationship of the Sun, Earth and Moon. I'll forward your e.mail on to him for comment as well! I have gone through the lesson plans a couple of times and have comments to make on some of the units.

Unit 4.

1. It says "Remind them of earlier work on shadows . . . ". When would this occur in your schooling system?
2. "If necessary observe the length and position . . . ". I suggest that you say "record" rather than "observe". Recording will have been the result of their observation and can be used later.

My research in the UK, USA, Australia and here (NZ) comparing the use of shadow sticks and children's own shadows has shown that in all cases the children were more interested in what their own shadow was doing than shadow stick observations. May I suggest that the activity be retained but with the children working in pairs and drawing around their partner's shadow, including shoes, so that they can stand back in the same place for recording later in the day. (I have a series of these shadow activities that I could send you).

A very telling activity is to take a globe of the Earth out in the sun. Stand a 15 - 20mm figure (Blutak or Plasticine) of one of the children in class, on your place in the UK. Move the globe around so that the figure casts a shadow towards the north pole. By turning the Globe eastwards and westwards the figure can be made to replicate on the Globe the children's shadows on the playground as the day progresses. This demonstrates that the Earth's turning makes the shadows move.

Unit 6.

A good source of sunrise and set times is the weather section in a daily newspaper. I find that children have short memories when it comes to the sort of activities that they did last summer or winter. They should record what they are currently doing morning and evening and the time of daylight and dark. Then do this again in say a month's time and repeated again later.

They now have their own record to which they can refer. The learning objective states "generalise that the Sun . . .". The globe/figure activity showing that the Earth turns towards the east is a good model for developing several understandings. "draw simple graphs . . ." is a great way to "personalise" maths. When the children record their shadows they also run a string from the top of their head to the end of the shadow of their head and measure and record the angle. If this is done around noon they will it fact be measuring the height of the Sun at its highest point in the day. By repeating this at monthly intervals the relationship of lengthening/shortening days and Sun's height is easily seen.

In the last *Gnomon* I asked if there were any UK schools interested in email exchanges with schools in NZ. My idea was that children could compare the sort of observations and records that you have suggested in these units. I didn't get one reply. May be your units may stimulate some.

Unit 9.

This is a great idea. Have you done it? I have used it - great results! I would like to explore this evaluation technique with you. Do you have any further ideas?

Keep up the good work. Eric Jackson.

Not long to NAM

The University of Cambridge is hosting the next National Astronomy Meeting (NAM) 2001 from Monday April 2 to Friday April 6 inclusive. The annual UK Solar Physics (UKSP) Meeting will be held concurrently with NAM and there will be some joint sessions.

Details of both meetings can be found at: http://www.ast.cam.ac.uk/~nam2001

These web pages are being updated regularly. If you would like to receive future mailings, please complete the online preliminary booking form. There is also a link to the UKSP web site from this web page.

Hurry to go to Space School

The University of Leicester has published its planned dates for its popular "five days in space" at the Space School for young people of 14 to 18 years old. Book your place now at any of these dates.

2001 April 8 to 12, or July 29 to August 2.
2002 March 24 to 28 or July 28 to August 1
2003 April 13 to 17 (provisional) or August 3 to 7.
2004 April 4 to 8 or August 1 to 5
2005 March 20 to 24 or July 31 to August 4

There is a £40 registration fee when booking, including a non-refundable £10 administrative charge. The cost this Easter is £199. This Summer, and future events will be £225.

A regular feature of the course is the essay competition. This year's subject is "Should the Moon or Mars be the next place for a manned mission?". Students are invited to write a discussion paper of up to 2000 words. The male and female winners will win an all-expenses paid trip to Space Camp in Huntsville USA in July.

Details of the programme can be found at

http:www.star.le.ac.uk/spaceschool/.

Teachers Online Space Odyssey Week.

This event took place in February, but *Gnomon* was not informed in time. But the Becta web site is still in operation with the ongoing space activities pages still available.

Becta is a UK Government Agency responsible for promoting the use of Information and Communications Technologies (ICT) in schools and colleges. The Teachers Online Project involves a "virtual community" of 10,000 teachers who are demonstrating how being online can improve classroom practice, management and administration. The Space Week was just one of a new set of theme weeks aimed at encouraging teachers to integrate ICT into their teaching. During the week in February (and for a while to come yet) the Becta web site has been promoting useful web sites and software to teachers. The Space Week site highlights places to visit and relevant activities. Other features include information on teachers' resource packs, competitions and projects, and directions for getting further information. If you look hard you may even find some links to the AAE websites!

Another Space Week may be run in October if there is enough interest, so get planning and find our more from the Becta site: http://teachersonline.ngfl.gov.uk

Spot the gaffes 4 (The biter bit)

Puzzled readers of "The Things People Ask" in the last issue please blame my crummy desk top publishing program. The penultimate paragraph (talking about the Moon) should have begun:

It usually will not be overhead, so make an estimate of the elevation angle of the Moon taking the horizon to be 0° and overhead 90°. (Small children would not usually apply this much sophistication) . . . . ." (Sorry Mike! **Ed.**)

Useful web sites

A question dealt with by Query: When will I be able to see the Space Station from my house, Is there a site that gives the stations trajectory over the next 24 hours?

To which Query replied: Yes, there is an excellent site http://www.heavens-above.com

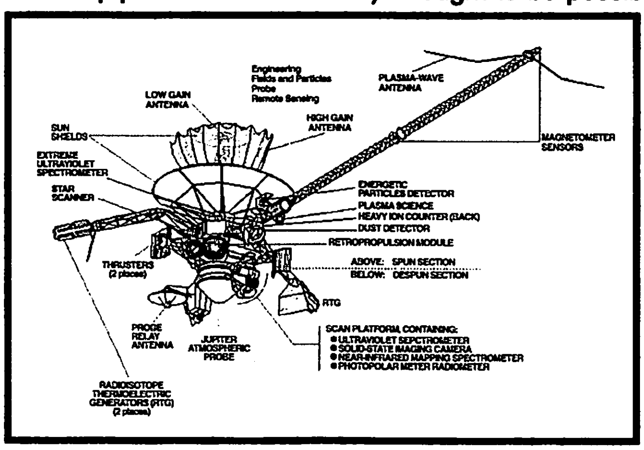
This is a very comprehensive site that gives local predictions of bright Earth satellites, operated by a commercial offshoot of the German space agency. There are also similar sites at the NASA website in the USA, but for ease of use the Heavens-Above site gets my vote.

For Your Library

RedShift 4. Astronomical software . Focus Multimedia. £19.99 incl. VAT

The popular RedShift astronomy programs have been introduced for PCs following a licensing deal with Maris Multimedia. RedShift 4 contains new features and, it is claimed, its functionality is a major advancement in the "most popular and user-friendly" desktop planetarium ever created. Its vast database now makes the program of serious use even for professional astronomers.

The program now offers all the planetarium type operations for which it is well known, including the on-screen identification of any objects by pointing with the mouse, which gives the name of the object (chosen from classical names, catalogue references, or Bayer names) and directly coupled to the detailed database. In addition, the programs offer a new multiple window mode allowing simultaneous viewing of events from multiple locations (see what an Earth-based eclipse of the Sun looks like from the Moon!).



A diagram of the Galileo Jupiter orbiter, one of the extensive gallery of diagrams and photographs in RedShift 4 (NASA Illustration)

In addition to the aspects of the night sky, the program takes the user on tours of the solar system and galaxy through its multimedia tutorials and the user options of where to view and at what zoom level. Have a look at Saturn from the surface of Mimas, or answer for yourself some of the questions that Query receives!

RedShift 4 includes the full Tycho-2 catalogue with the data for over 2.5 million stars down to 11th magnitude. The Principal Galaxies Catalogue contains information on over 70,000 galaxies, and the Asteroid Orbit Elements Database giving the positions of 15,000 asteroids. It also offers the 13th edition of the Catalogue of Cometary Orbits presenting over 1,700 comets and the latest algorithms for plotting the positions of the planets and moons in the Solar System. It also has a gallery of over 450 photographs.

Nearly all the snags with the new edition are related to the operation of the program, which is a pity when the astronomical capability is so good in almost all cases. The print out of the main sky map is good, with one minor niggle: the azimuthal directions are marked with a solid circular symbol that is identical to a bright star, but in green. When this map is printed in black, it looks as if there are first magnitude stars on the horizon at 45° intervals!

You have to print out the map and scan it if you want to use it iin another way (in *Gnomon*, for example, see page 8). It ought to be possible to save the map in a graphics format file for use in other programs. This was obviously once intended, since it is an option described in the Help menus, but the publishers have confirmed this reference should have been removed. Only the map screens are printable: there is no way of printing out the monthly Diary, nor the ecliptic chart of planetary visibility offered under the Diary options, for example. These limitations are very important when it comes to the usefulness of the programs to teachers, editors and other professionals. Maris Multimedia programmers, please note.

In the RedShift monthly events Diary there are notes about when planets reach conjunction, and even quadrature (which is not usually very significant) but the most important event of all as far as observing the superior planets are concerned, opposition, is left out completely! Neither is this given in the advanced data available by clicking on a planet on the sky map.

But these are small niggles, and can be put right for the next edition. RedShift 4 comes as a two CD-ROM set and at £19.99 inc. VAT must be unbeatable for value. For further information contact Gail Treadwell, PR & Marketing Manager at

g.treadwell@focusmm.co.uk or 01889 570156

RedShift 4 is a bargain for its data bases alone. Or for the sky diary alone. Or for the desk-top planetarium alone. Or for the dictionary and multimedia alone. It's a serious accessory for learning and practising your astronomy. **RAK**

THE THINGS PEOPLE ASK!

Why don't you get a solar eclipse every New Moon? Vanora Appleby, a school teacher from Australia asked.
For an eclipse of the Sun to occur at every New Moon, the Moon would have to be directly lined up with the Sun as seen from Earth. If it were just a little bit above or below no eclipse would be possible. So the short answer is that the Moon usually misses, because its orbit around the Earth is inclined to the plane of the Earth's orbit around the Sun by an angle averaging about 5.14°. Most of the time at New Moon the required alignment does not occur.

As the Earth orbits the Sun, so the Sun appears to travel around the sky, once each year, covering about 30° per month. The two places where the Moon's path in the sky intersects the Sun's apparent path, the *ecliptic*, are known as the *nodes*. One is the *ascending node*, because the Moon crosses the Sun's path from south to north, and the other is the *descending node*. A total eclipse of the Sun cannot be seen anywhere on Earth unless the New Moon occurs when the relevant node is within about 11° either side of the Sun's position. Eclipses of the Sun (and Moon, come to that) will occur during eclipse "seasons" about six months apart when the New Moon occurs within the 22° span. But *total* solar eclipses do not necessarily have to happen each year (there was *four* eclipses of the Sun last year, all partial!).

Finally, in about half of all "central" solar eclipses (when the centres of the discs of the Sun and Moon line up), there is no total eclipse because the Moon is too far away in its orbit. Then, the apparent diameter of the Moon's disc is smaller than that of the Sun's. When this happens it is called an annular eclipse, because at maximum eclipse the Sun can still be seen, as a thin ring, or annulus, of brilliant light. For lots of detailed information on past and future eclipses, see the official NASA eclipse web site by Dr Fred Espenak's official NASA home page:

http://sunearth.gsfc.nasa.gov/eclipse/eclipse.html

He lists eclipses for the next 1000 years! **Query**

IAU discuss astronomy in developing countries

Developing countries often have rudimentary education systems compared with those enjoyed in, for example, Western Europe. As for research, many of these countries have no telescopes and no observatories. They may have only few, in any, physical scientists. Many have no professional astronomers to help bring the subject into the schools.

At the IAU General Assembly 24, held in Manchester last August, there was a special three-day discussion meeting on the problems of doing research and teaching astronomy in developing countries. Many active researchers from the USA, Britain, Canada, France, and other Western countries were present and taking an active part.

The amount of money a country spends on astronomy in all forms tends to depend on the Gross Domestic Product. The number of active astronomers, and their proportion to the total population was examined. In some very poor small countries, the amount of money involved is less than the price of one PC! Not per school - for the whole country! In some cases, regional pooling of resources can help.

The small nations of Central America, for example, are too small, individually, to mount successful astronomy programmes. But they have cooperated and combined to produce an ascent Astronomical Observatory in Honduras, where they are training the first few professional astronomers. It is regrettable that their observatory suffered a severe setback due to damage from Hurricane Mitch last year, just when it was starting to produce some results.

Work to bring astronomy into the school curriculum in science.In Vietnam, astronomy (and much else) came to a complete halt in the early 1960s during the war. Only recently has a new astrophysics textbook been prepared in Vietnamese and English for courses beginning in September. Meanwhile, the astronomers plan a new high-school course in astronomy, which until now has had a very low priority in a country trying to rebuild itself and survive in a modern world economy.

Their ingenuity in making observations without any expensive equipment was demonstrated during the 1995 solar eclipse, when they built a simple radio interferometer from two TV aerials, and combined 600MHz signals (wavelength 50cm) into a TV and fed the result into a detector attached to an old PC. The fringes recorded as the Sun gradually passed through the beams, and disappeared during totality, were very obvious. Radio astronomy might also be a good way forward in schools in the UK, using similar simple techniques.

Students learn about both astronomy and electronics. Janet Mattei from the USA described a way in which those who have computers and the Internet available can obtain real data on variable stars and analyse it using software provided free on the Web site of the American Association of Variable Star Observers. The project is called Hands-On Astrophysics (**http://www.aavso.org**) and includes instructional material such as videos and manuals for students and teachers. This material would be ideal for research projects in schools, and could be supplemented by observational work (which could be reported back to the AAVSO).

Mexican astronomers are blessed with a dynamic and personable education spokesperson in the form of Julietta Fierro, who described the new series of educational astronomy videos produced for schools in Mexico. Although the productions did not involve expensive special effects, they showed a lot of enthusiasm, originality and good humour much appreciated by their young audiences, and came across very well while maintaining factual rigour. By comparison, educational videos in the UK seem far too earnest and stuffy.

These were just a few examples taken from among 83 contributions at the conference. There were also many fascinating stories such as the observatory in India that was attacked by a herd of wild elephants. A lone astronomy enthusiast in Paraguay single-handedly begged and borrowed equipment to start a small national observatory which now forms the nucleus of a small but successful enterprise. He is now helping to educate teachers in the country, which has introduced astronomy as part of the curriculum. So reflect on the obstacles of poverty, official apathy, and isolation that our fellow science and astronomy teachers in these countries have to face and try to overcome. **Mike Dworetsky**

LETTER FROM DOWN UNDER

The small town of Narrabri in northwestern New South Wales could well be described as the Interferometry capital of Australia. Interferometry is the technique by which signals from two or more telescopes are combined in such a way as to replicate the resolving power (though not the sensitivity) achievable by a single telescope as large as their separation.

Its application to radio astronomy was pioneered by Martin Ryle at Cambridge, while in Australia, Robert Hanbury-Brown led the even more demanding effort to make interferometry work at optical wavelengths. In the mid-1960's, Hanbury-Brown and Robert Twiss used a pair of 6.7m diameter segemented mirrors on a circular rail track at Culgoora (near Narrabri) to measure the angular diameters of 32 bright stars, allowing their temperatures to be reliably determined for the first time. The Sydney University Stellar Interferometer (SUSI) at Culgoora is now beginning to extend these measurements to a wider range of stars.

Also in the mid-1960's, the Commonwealth Scientific and IndustrialResearch Organisation (CSIRO) Division of Applied Physics built a radioheliograph on the same Culgoora site. An array of 96 dishes, each 13.6m diameter (constructed mainly from metal pipes and chicken wire!) was placed around a circle 3km diameter, and used to produce a two-dimensional image of the Sun at a wavelength of 3.75m.

The radio heliograph ceased operation in 1984, as work began on the Australia Telescope Compact Array (ATCA). The ATCA consists of six identical antennas, each 22m diameter, five of which are located on a 3km rail track which runs east-west. The sixth antenna rests on its own short segment of track some 3km further west. Every two weeks or so, the five antennas on the main track are relocated to particular "stations".

When the antennas are packed close together, they have excellent sensitivity to faint, diffuse sources, such as the clouds of hydrogen in the halo of our Galaxy. When they are spaced far apart, they have the best ability to resolve fine detail in bright sources, such as the jets shooting out from radio galaxies. The ATCA is the only radio interferometer in the southern hemisphere working at wavelengths between 30cm and 3cm. However, the performance of the antennas so exceeded expectations that in 1995, the Australian government committed nearly A$11 million from the Major National Research Facilities program to upgrade the ATCA to work at even shorter wavelengths (as short as 3mm). The main enhancements include:

(a) replacing the perforated outer panels on each antenna with solid panels;
(b) constructing new receivers and amplifier circuitry to work at these high frequencies;
(c) a system which measures emission from water vapour in the atmosphere, to allow correction for the effects of the atmosphere on incoming waves
(d) a north-south "spur" rail track, to allow antennas to placed in configurations better suited to observing at these higher frequencies.

On the night of November 30 last year, the first two antennas fitted with the high frequency receivers were pointed toward the Orion star-forming complex (a region rich in molecules such as SiO and CN which radiate at these millimetre wavelengths). In what has become something of a tradition in radio astronomy, the first spectrum was printed out and then signed by all those who had laboured hard over the past five years to bring this moment to reality. For the first time, some of the prime pieces of real estate in the sky (such as the Galactic centre, which passes overhead from Narrabri, and the Magellanic Clouds) can be studied using the best tracers of star formation and gas dynamics

Although the Narrabri site may not be the best in the world for such studies (typically, only the driest winter nights will be suitable for observing at millimetre wavelengths), it will have the southern sky to itself until at least the end of the decade. By then, a European/USA/Canada/Japan collaboration expects to have completed the Atacama Large Millimetre Array (ALMA) in the high deserts of Chile, which will be much better suited to such work. In the meantime, both SUSI and the ATCA will be busy combining optical and radio waves, respectively, so that Narrabri will continue to be the home of interferometry in Australia for some time to come.

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SKY DIARY SPRING 2001

Highlights of the first Spring of the new millennium include an eclipse of the Sun at the northern summer solstice, for which intrepid eclipse chasers, frustrated by their abortive trip to Cornwall in 1999, will be found in southern Africa. Alas, there will be nothing to see from British latitudes.

The solstice is at June 21d 7h 38m UT, whereas the greatest eclipse is at 12h 03m 45.6s UT, a mere four and a half hours later, give or take a few minutes. This is the first total eclipse of the Sun this millennium, so that makes three coincidental features of this event.

One more very unusual feature of this eclipse is that the next total eclipse of the Sun is on 2002 December 4, and will be visible from almost the same places as this year's, except that this time the Moon's shadow starts its journey across the Earth closer to the shores of Africa, and continues across the Indian Ocean and just makes it into southern Australia before sunset.

Throughout April Jupiter and Saturn, which have been providing their double act for some years now, will give an evening finale as they sink into the brightening evening twilight with the Moon and Mercury joining them on occasions. So there will be potential photo opportunities all round: on April 25 soon after sunset, Saturn will appear 2° to the west of the slim crescent Moon with Jupiter above, and Aldebaran 8° to the north east and Jupiter about 11° above.

On April 30, the Sun, Mercury, Saturn and Jupiter are lined up along the steeply inclined ecliptic of the vernal equinoctial evenings all spaced at about 12 degrees apart. Once the Sun has drifted low enough below the horizon, if conditions are good the three planets will make a perfect marker for the ecliptic in the evening sky.

Approx. rising and setting times: lat. 52N; long 3W

	April 15		May 15		June 15	
	Rise	Set	Rise	Set	Rise	Set
Sun	05h 15m	19h 08m	04h 17m	19h 59m	03h 50m	20h 34m
Mercury	05h 12m	18h 15m	05h 01m	22h 09m	04h 25m	20h 13m
Venus	04h 05m	02h 58m	02h 58m	15h 46m	02h 00m	16h 13m
Mars	00h 31m	08h 09m	22h 54m	06h 13m	20h 34m	03h 29m
Jupiter	07h 06m	23h 17m	05h 29m	21h 52m	03h 53m	20h 25m
Saturn	06h 43m	22h 10m	04h 55m	20h 33m	03h 05m	18h 52m
Uranus	03h 36m	13h 11m	01h 40m	11h 17m	23h 34m	09h 15m
Neptune	02h 56m	11h 46m	00h 59m	09h 49m	22h 52m	07h 46m

April is also the month for the Lyrid meteors, and the Moon is very close to New at the time. Watch between April 19 and 25, with the peak predicted at April 22d 08h UT (remember that daylight saving time begins on April 1 - very appropriate!).

Venus has moved into the morning sky for its second spectacular spell. It is quite amazing how Venus' two-yearly (about) cycle always gets the same reaction from the General Public. As it passes through its maximum eastern elongation at the start of the Earth's year, it is resplendent in the northern evening sky. It is there for many weeks before it finally closes, apparently quite suddenly, with the Sun, passes through inferior conjunction (on March 30) and rapidly swings away from the Sun to its next maximum morning (western) elongation (June 8 this year). Then as the year wears on, the morning ecliptic assumes the greatest angle to the horizon, so Venus remains prominent in the morning sky for several months. (Watch this space next issue!).

By the time Venus finally closes with the Sun for superior conjunction (not till January next year) it is nowhere to be seen in our sky, of course, and it does not reach maximum elongation east until August, by which time the evening ecliptic is quite badly placed, so it is not noticed. By the time we enjoy another spectacular evening elongation such as we have just had, it will be the end of next year.

Venus is next at a winter eastern elongation in 2003 on January 11, by which time people have forgotten about the brilliant object they saw in the evening sky in 2000 and early 2001. Once more the UFO stories will return in force in the media!

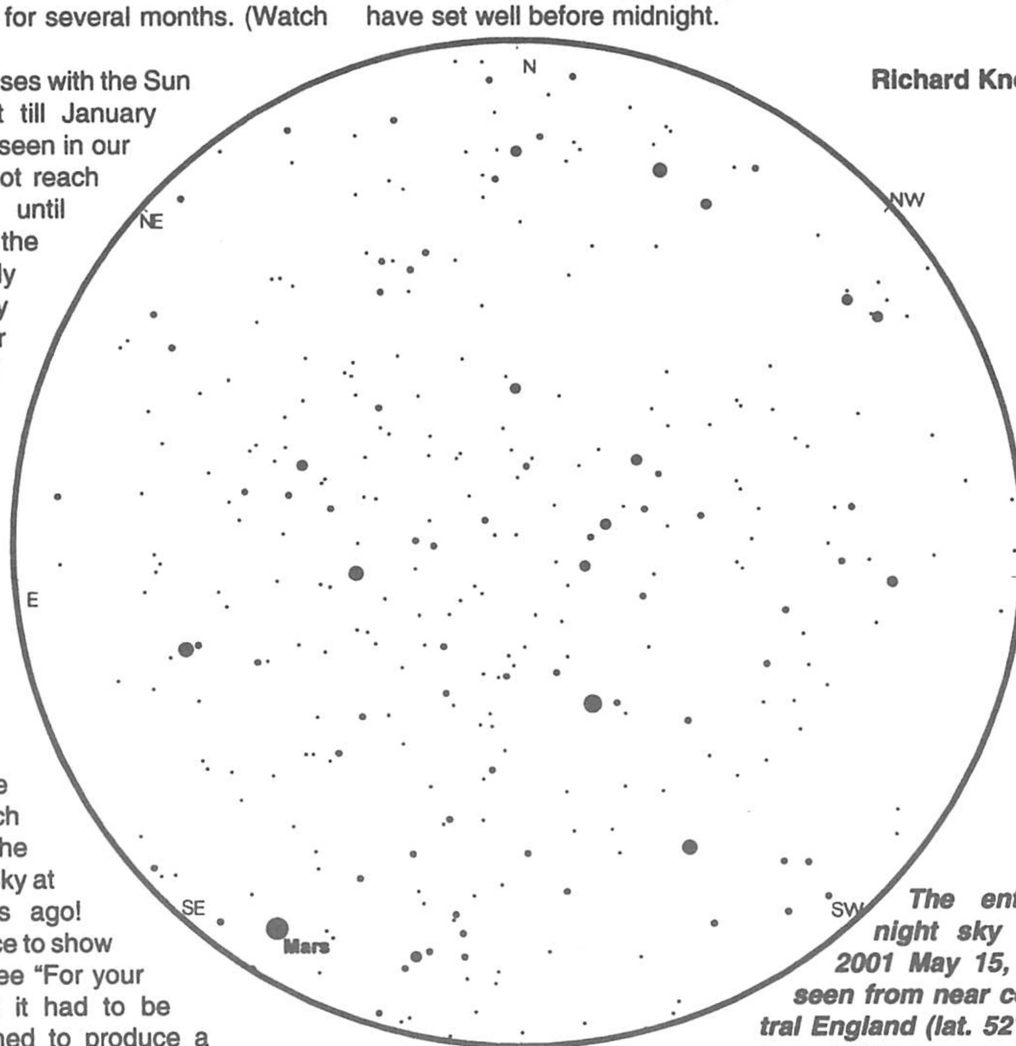
The star chart for once shows the entire sky, in much the same way that I criticised the daily press for doing in their "Sky at Night" columns some years ago! However, it does offer a chance to show a byproduct of RedShift 4 (see "For your Library") even though it had to be printed out and scanned to produce a computer-compatible format file. Near the centre of the chart is the Plough, with its handle directing "an arc down to Arcturus" and (loud groans!) continuing to "spike down to Spica". The main problem with a whole-sky chart is that the relative diametrical sizes of the different magnitude stars becomes silly, but it does make Arcturus and Spica stand out well! However, it is not intended to give a star atlas view of the sky, it is merely for use as a reminder of what is where in the night sky at that time.

The Summer Triangle is clearly seen in the east, while Leo is moving towards the western horizon where it will set roughly north west in about three hours time. Mars is boldly marked down near the Scorpion's Tail, with a respectable magnitude of -1.5. It will continue to brighten by another magnitude until its opposition on June 13. Alas, as the map shows, it will reach a culmination altitude of only 14° (from latitude 52° north) so will be poorly placed, as Mars always is at oppositions near its perihelion. Those with telescopes should keep a watch for planet-wide dust storms which have shown up fairly regularly when the planet makes its closest approaches to the Sun. Jupiter and Saturn are still just visible in the early evening low in the north west, but have set well before midnight.

Moon phases for the second quarter of 2001

Month	New Moon	First Quarter	Full Moon	Last Quarter
April	23	1/30	8	15
May	23	29	7	15
June	21	28	6	14

Richard Knox



The entire night sky on 2001 May 15, as seen from near central England (lat. 52° N, long. 3° W).