PUPIL
RESEARCHER
INITIATIVE

# Cosmic Web Site

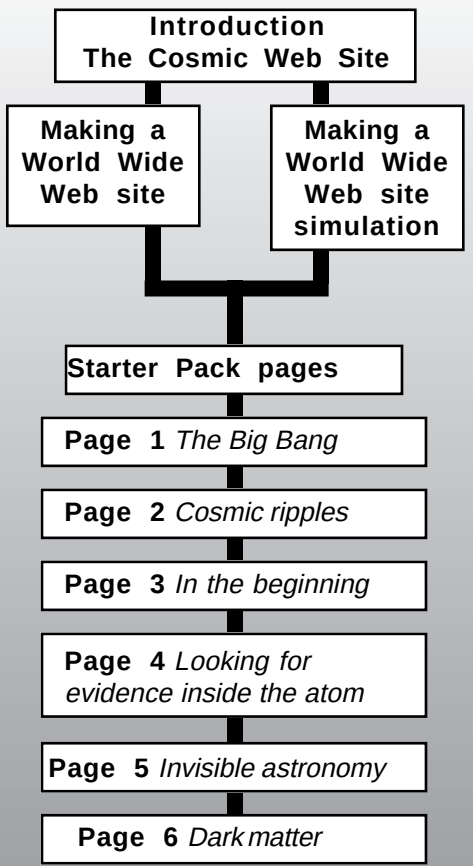
# Pupil Research Brief

## Teachers' Notes

### Syllabus Coverage *Subject Knowledge and Understanding*

- ❑ theories of the origin of the Universe have to take into account:
  - that light from other galaxies is shifted towards the red end of the spectrum
  - that the further away the galaxies are, the bigger the 'Red Shift'
- ❑ one way of explaining this is:
  - that other galaxies are moving away from us very quickly
  - that the further away from us a galaxy is, the faster it is moving away from us
- ❑ this suggests that the whole Universe is expanding and that it might have started, billions of years ago, from one place with a huge explosion, or 'big bang'

### Route through the Brief




### Introduction

In this Brief pupils learn how to create a Web-site to explain the theory of the origin of the Universe known as the Big Bang.

They are provided with the basic text and are asked to:

- provide illustrations to go with the text
- identify words and phrases that need further explanations, and so one task will be to compile a glossary page for the text. Other words and phrases also may require explanations. Pupils are to identify these and allocate the tasks of providing hypertext pages between themselves. They are required to look for the information to be put onto these pages and to find suitable images to accompany the text. This information may come from textbooks, magazines and video programmes, or from the Internet itself. The whole exercise should provide a comprehensive explanation of the Big Bang theory and how research work currently being conducted is helping to shed light on the likely fate of the Universe.

This task is obviously not suitable for all, but some of the work can be carried out successfully by lower achieving pupils. The text that is provided can be trimmed to make the Brief shorter and more manageable.

The work can be done as a paper exercise, but the Brief was designed to be carried out using material

# Teachers' Notes continued

downloaded from the Internet, and it is hoped that this is how pupils will do it wherever possible.

**Prior knowledge**

Before attempting the Brief, pupils should have a basic knowledge of stars and galaxies. An understanding of the structure of the atom would be a great advantage, as would having some experience of using the Internet.

## Running the Brief

**Pupil grouping**

Pupils could work in a number of groupings during this Brief. Suggestions are:

| | | |
|---|---|---|
| *Initial briefing and introduction* | - | whole class; teacher introduces the topic and allocates tasks |
| *Pages 1 to 6* | - | individuals, pairs or small groups; pupils are allocated the tasks of finding illustrations or creating hypertext pages |

**Timing**

The Brief may require 3 or more hours of classroom time, depending on whether the work is done as a paper exercise or on computers, and also on the enthusiasm and ability of the pupils.

**Activities**

The teacher should issue the pupils with the **Study Guide** which provides pupils with a summary of what they should produce as they work through the Brief. It can also act as a checklist for pupils to monitor their own progress. The Brief is intended to provide a context for pupils to carry out background research using textbooks and any other resources available in school. The tasks they are to carry out can vary depending on the time available, but at the very least they should create hypertext pages for the following topics:

*Galaxies*
The information pupils might supply would be the size of a typical galaxy, the number of stars in a galaxy, details of the Hubble Classification of galaxies and clusters of galaxies, and the average mass of a galaxy.

*Red Shift*
Hubble measured the shift in the absorption lines in a galaxy's spectrum. As white light from a star's interior passes through the cooler, lower pressure gases of the stellar atmosphere dark lines appear in the spectrum. When stars or galaxies move away relative to another body all the absorption lines shift towards the red end of the spectrum. The more higher achieving pupils should be able to understand this.

*The Hubble Space Telescope*
This page may include general information about the telescope as well as details of some of the discoveries made using the telescope. This could include any up-to-date news at the time the Brief is being run.

*Albert Einstein*
Einstein's contribution to the understanding of cosmology should be acknowledged and details about his life and achievements can be included on a separate page.

*The Places where stars are formed*
A page can be given over to an explanation of how stars are formed, and possibly the classification of stars (including the Hertsprung-Russell diagram) and details of the nuclear fusion process that goes on inside a star.

*CERN*
Pupils may have a go at creating a page about the work of CERN and some of the discoveries made there.

*Electromagnetic spectrum*
The opportunity could be taken to get pupils to review work already done about the electromagnetic spectrum on a separate page, explaining the properties and uses of the different types of electromagnetic waves.

*Radio telescopes*
Pupils here could include information about the discoveries made over the years that radio telescopes have been used. They could mention specific telescopes, such as Jodrell Bank, Arecibo and the Very Large Array telescopes.

*Quasars*
Quasi-stellar radio sources were discovered in 1963. They are probably the most distant objects known, but some astronomers dispute that they are as far as their red-shift would suggest.

*Pulsars*
Jocelyn Bell (later Burnell) was a graduate student at Cambridge University in 1967 when she discovered pulsars. She and Professor Anthony Hewish at first thought that these regular pulses were signals from extraterrestrials, which is why they were at first called LGMs (for Little Green Men)! They are now known to be rotating neutron stars.

# Pupil Research Brief

## Teachers' Notes continued

*Black holes*
Pupils could explain that black holes are so called because they do not allow light to escape from them. They may also give information about where black holes may be located.

*Fate of the Universe*
The three main theories of what will happen to the Universe depend on how much mass there is. If there is less than a critical mass the Universe will continue to expand forever. A critical mass will lead to a situation where gravitational forces will slow down the expansion of the Universe until it comes to a halt. If the mass is greater than this, the Universe will eventually go into reverse; galaxies will begin to move back and the Universe will collapse back to a single point. This is the Big Crunch. Pupils should be asked to find a way of representing these three cases diagrammatically.

The text also contains other words and phrases that could be given separate pages to themselves, or a glossary of terms could be compiled, defining these words and phrases briefly.

### Scottish syllabus coverage

Standard Grade Physics - *Space Physics*

### Further pupil research opportunities

The results of cosmology research are regularly being published in magazines, newspapers, television and on the Internet. Pupils can update and extend their work on this topic using these sources of new information.

PUPIL RESEARCHER INITIATIVE

# Cosmic Web Site

## Setting the Scene

*You will create a World Wide Web site which explains the science behind the Big Bang theory of the origin of the Universe. Starting with a set of ready-made pages, called the Starter Pack, you will research the information needed to produce links to other pages which you design.*

# Pupil Research Brief

## Study Guide

### Syllabus Targets *Science you will learn about in this Brief*

- ❑ theories of the origin of the Universe have to take into account:
  - that light from other galaxies is shifted towards the red end of the spectrum
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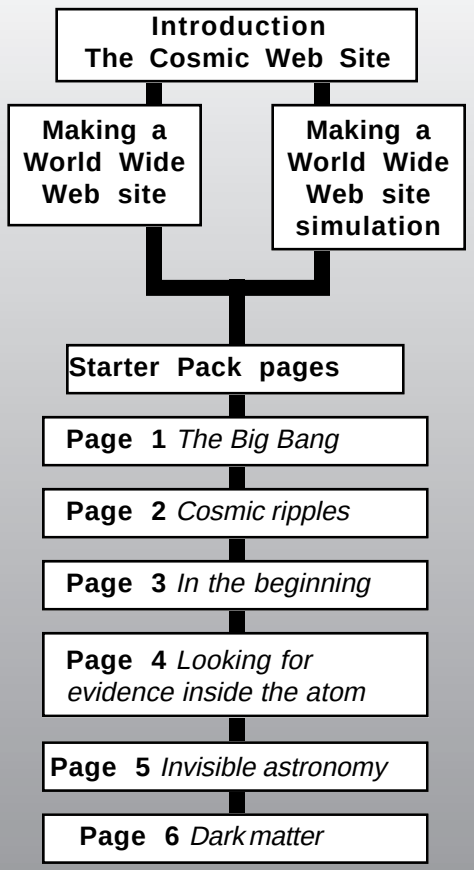



### Outcome Checklist

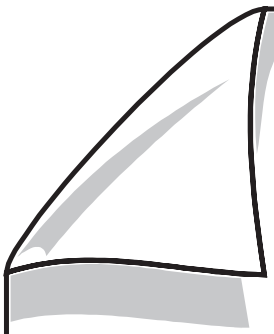
You will learn about the World Wide Web, and how hypertext links are used. You will produce a World Wide Web site using the Starter Pack. You can use either the paper version, or the version on the World Wide Web. You will produce linked pages using hypertext hot links. You could include pictures as well as text to make the site more interesting and informative. You should make sure you produce the following items as you work through the Brief.

**Starter Pack pages 1-6**

- ❑ linked pages explaining the meaning of the words or phrases already highlighted in Starter Pack pages 1-6
- ❑ a list of new words or phrases for which you can write linked pages
- ❑ linked pages for the words or phrases you have identified

# The Cosmic Web site

## Introduction



On April 23rd, 1992, George Smoot, a US scientist addressed a meeting of the American Physical Society on the results of the COBE (Cosmic Background Explorer) research programme. During the questions after his talk, one of his answers was: "If you're religious, it's like seeing God". What had he and the scientists working on the COBE project discovered which would make him say this? In George Smoot's own words, they had "observed the oldest and largest structures ever seen in the early Universe. These were the primordial seeds of modern day structures such as galaxies, clusters of galaxies, and so on. Not only that, they represented huge ripples in the fabric of space-time left from the creation period".

COBE had discovered evidence of something which scientists had predicted would be necessary to explain the Big Bang theory of the origin of the Universe. Scientists looking at the largest structures in the Universe (astronomers) and those looking at the smallest (particle physicists) have in recent years worked together to explain the origin of the Universe, a subject called cosmology. The search for further evidence to prove that the Big Bang Theory is correct (or not) is one of the most exciting scientific projects currently taking place.

In this Pupil Research Brief, you will have the opportunity to share in some of the excitement, by getting involved in a project to create a World Wide Web site for your school which aims to tell all visitors to your site what is going on in Big Bang Science. In doing this you will not only learn some science, you will also be contributing to the public understanding of this important and expanding area of human knowledge. You will find Frank Close's article *Inside the Atom* (*PRISM*, Issue 1, September 1996) useful background reading.

There are two versions of the activity.

1. Setting up a World Wide Web site and making it available on the Internet. Go to the sheet *Making a World Wide Web site*.

2. Setting up a World Wide Web site simulation. This is useful for schools which do not have Web site facilities linked into the Internet. Go to the sheets *Making a WorldWide Web site simulation* 1 and 2.

# The Cosmic Web site

## Making a World Wide Web site

In this Pupil Research Brief you will be doing what a growing number of science and engineering researchers are doing - using the Internet, and particularly the World Wide Web to communicate with others. Don't worry - if you haven't got a computer linked to the Internet you can still carry out the activites in the Brief (see the sheets *Making a World Wide Web site simulation* 1 and 2).

The World Wide Web was the idea of Tim Berners Lee, a scientist at CERN (the European particle physics laboratory in Geneva, Switzerland), in 1989. The purpose was to provide an efficient means of communication between particle physicists across the world. Now the World Wide Web is the fastest growing method of communication. In this Brief you will create a Web site on the topic of the Big Bang theory. This will cover the recent developments in astronomy and particle physics that support the theory which attempts to explain the origin of the Universe. The study, linking the smallest and the largest structures in the Universe, is called cosmology.

You are provided with a *Starter Pack*, which is available on paper, as well as electronically on the PRI Web site. The *Starter Pack* includes a number of screens which relate the current knowledge about the Big Bang theory.

Your job is to:

- produce hypertext links from the words and phrases identified on the screens to new pages which you create to explain the meaning of the words;
- read through the text carefully and decide what other hypertext links could be created, particularly for any terms or topics which you feel need explanation. You should provide the necessary linked pages for these terms or topics. You will need to carry out some research using books, magazines, CDs and the WWW itself;
- identify any links to other useful and interesting Web pages which already exist on the WWW;
- add any images, perhaps using those found on other Web sites, or create your own by scanning existing photographs (you will need to get the permission of the person who produced the photograph).

There will be an opportunity to enter your Web site in a PRI competition.
See your teacher for details.

# The Cosmic Web site

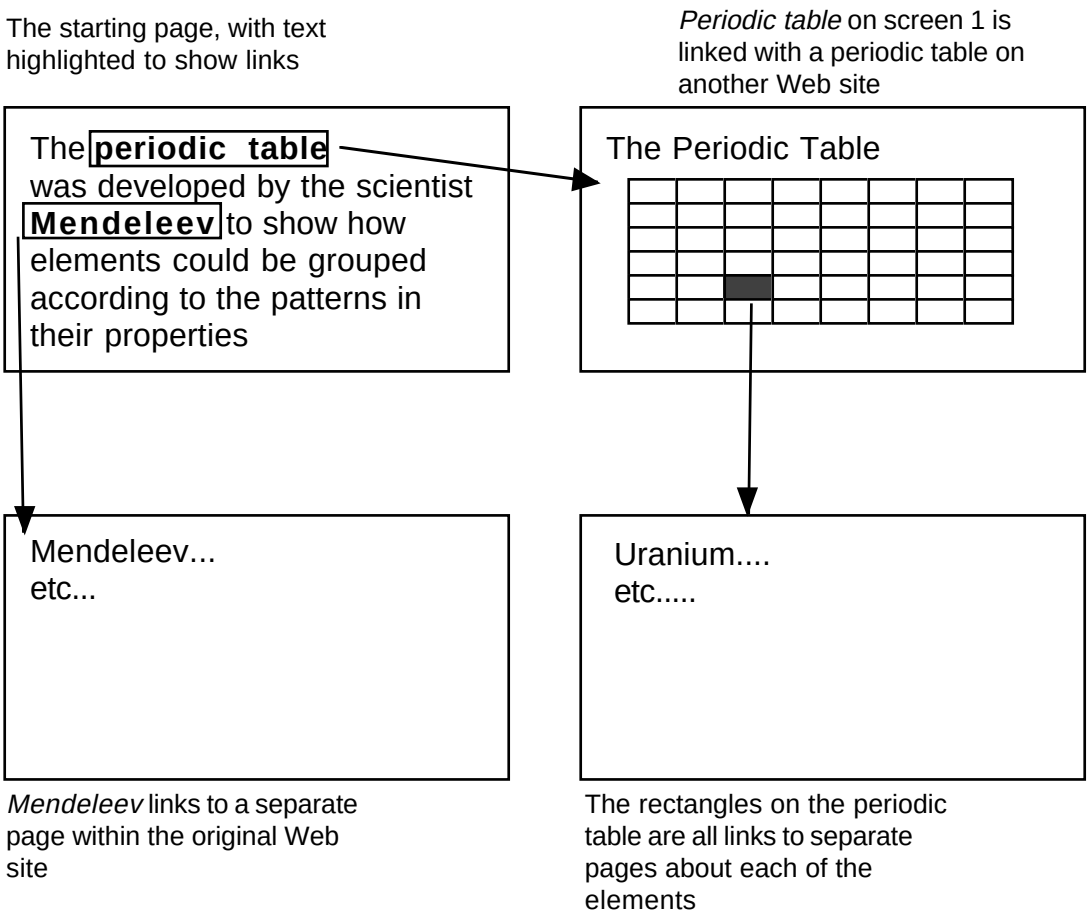
## Making a World Wide Web site simulation 1

It is possible to create a World Wide Web site on paper. Some of you may not be familiar with how the WWW works, and so the first thing is to explain what it involves. Have a look at the PRI Web site simulation disk supplied with Pack 2 of the PRBs - see your teacher for a copy). This shows you what the WWW looks like. See how clicking the mouse on highlighted words takes you from one screen to another.

### Hypertext

The ability to link one screen with one or more others uses an idea called hypertext. This is a system which allows the creator of the Web page to build in links to other parts of the same Web site or to the relevant bits of other Web sites.

*Figure 1. How hypertext links screens, using hot links (highlighted words or graphics) - click on the word and you go to the linked page*



# The Cosmic Web Site

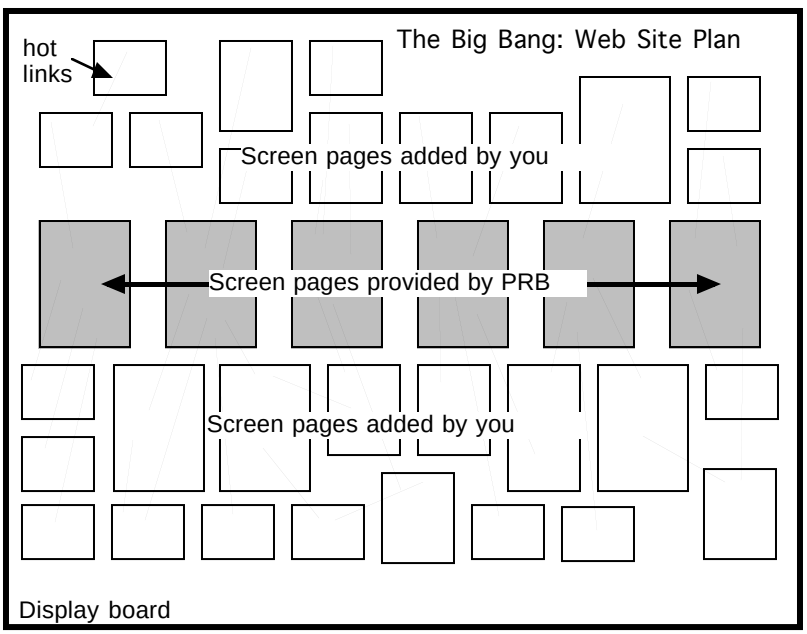
## Making a World Wide Web site simulation 2

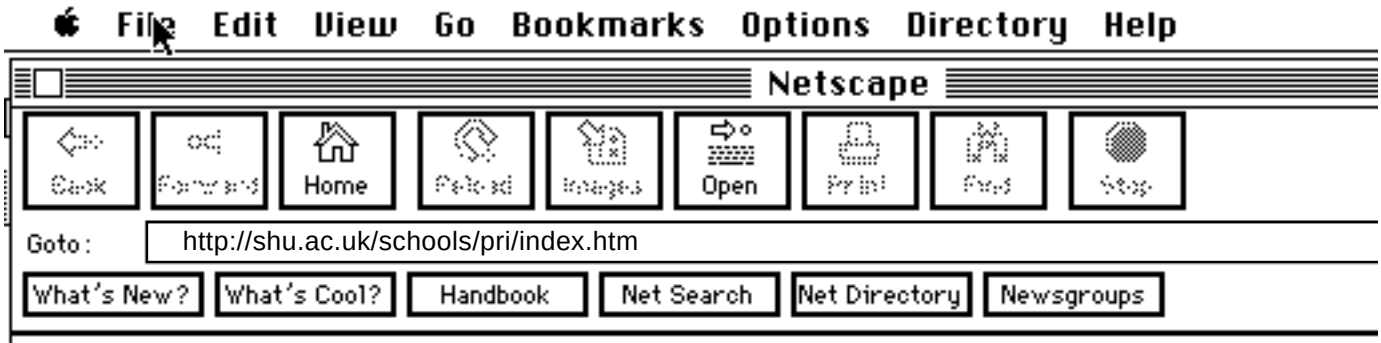
**Simulating a WWW page.**

This Pupil Research Brief includes paper versions of six screens of information, all about the Big Bang theory. You should:

- lay out the pages on a table or stick onto a display board, in order. The words which are underlined are ones to make hot links to new pages which you create;
- stick a pin in each hot link word or phrase;
- read through the text carefully and identify using pins which other words or phrases could become hot links, particularly any terms or topics which you feel need explanation. You will need to carry out some research using books, magazines, CDs and the WWW itself;
- make a list of all the hot link words;
- allocate the hot link words to the members of your class or group, and research the information to write the page which explains the hot link words;
- identify any photographs or other graphics (you may have to photocopy or re-draw diagrams from books, magazines, worksheets or CD printouts);
- stick the photographs or graphics onto the pages;
- put the new pages onto the display;
- put pins in the title words of each of the new pages;
- join the pages to the original hot links by coloured thread;
- identify any new hot links which can be made between the words and phrases of the new pages.

*Figure 2. Display board set out as Web site*








# The Big Bang

### The expanding Universe

In 1929 American astronomer Edwin Hubble published details of work he had carried out at Mount Wilson Observatory in California.

He had observed many galaxies beyond our own and he discovered that all of them are moving away from each other - in other words, the Universe is expanding. If you draw dots on a balloon and blow it up you can see how the Universe expands. If you imagine each dot is a galaxy, as you blow up the balloon each dot, or galaxy, moves further away from all the others. Hubble knew that galaxies were moving away from one another by analysing light from the galaxies and measuring the Red Shift. He also noticed that the further away a galaxy is the faster it recedes, according to the equation $z = v/c$

z = the fractional amount of red shift
v = speed the galaxy is receding
c = speed of light

and he related the distance of the galaxy (d) to its speed (v) by the equation **$v = H \times d$**

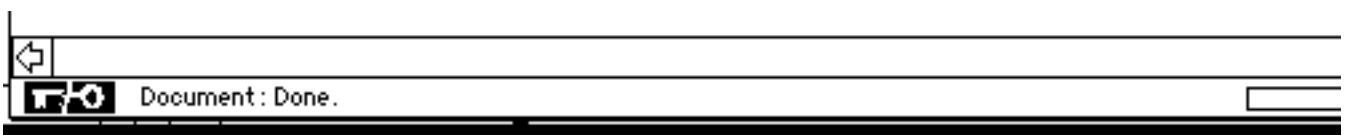
d = distance of the galaxy from Earth
v = the speed a galaxy is moving away from Earth
H = the Hubble constant. No-one knows yet the exact value of this number.

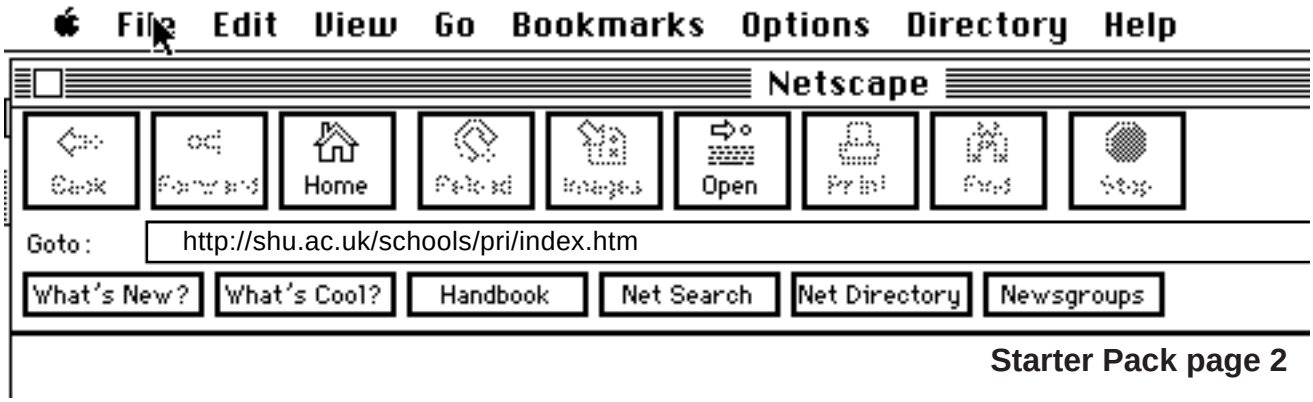
Hubble also introduced a system for classifying galaxies into spirals, barred spirals, ellipses and irregular types. The space telescope launched into orbit by NASA in 1990 is named after Edwin Hubble.

### The Hubble Constant

The Hubble equation, $v = H \times d$, seems so simple, but it could help astronomers to calculate the size and age of the Universe.

We don't yet know the precise value of the Hubble Constant, H, but the most commonly accepted value by cosmologists is 80±17 km/s/million parsecs. Appropriately, the Hubble Space Telescope is helping to get more accurate values of H by measuring the distance variable stars are from us.







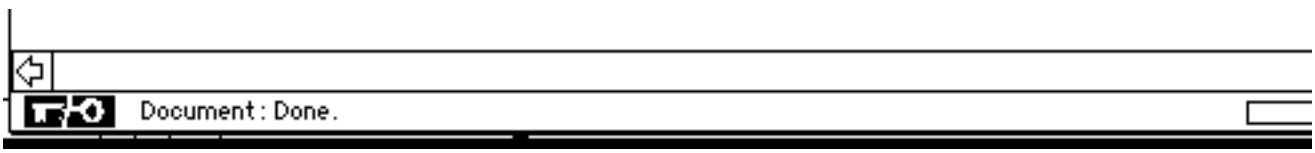

## Cosmic ripples

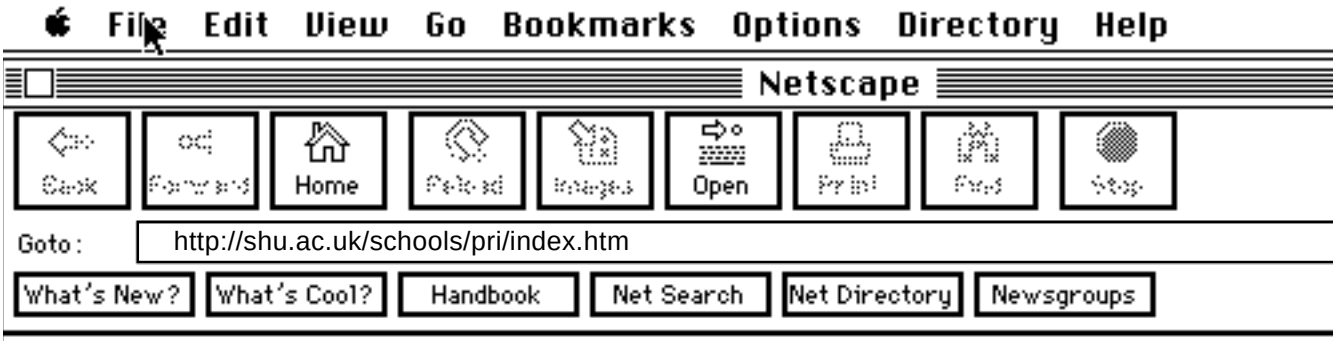
If galaxies are hurtling away from one another at tremendous speed, the Universe is expanding. In the past it must have been smaller. If you go back far enough in time there must have been a moment when the whole Universe was concentrated in one spot. Then something like an explosion (the `Big Bang') flung them apart. When the explosion occurred an enormous amount of energy and matter was released.

Over the billions of years since the 'Big Bang' this energy would have become more and more dispersed, but traces of it should still be there. In the 1960's American scientists discovered that there were faint traces of microwave radiation coming from everywhere in space. This is called the cosmic background radiation**.** This radiation is very cold, only 2.73 degrees Kelvin on average, but it was calculated that the energy from the Big Bang would be as cool as this, and so it is further evidence to support the Big Bang theory.

Astronomers also realised that for galaxies to have formed, in the time they did, there must be 'hot-spots' - tiny fluctuations in density where galaxies could grow. In 1992 the COBE (Cosmic Background Explorer) satellite detected very slight variations in the temperature of the cosmic radiations. This shows that there were 'hot-spots' in the Universe, making the Big Bang theory seem even more likely.

Although most cosmologists believe that the Big Bang theory is probably correct not all of them are convinced. Even those who agree with the theory acknowledge that there are many questions still to be answered. The enormous amount of research work being carried out may well supply these answers in years to come. On the other hand there may be even more problems to solve as a result of the outcomes of this work.








## In the beginning

Once the scientists knew that the Universe started with a Big Bang they could work on the complex theory of what happened and when, using Einstein's Theory of Relativity.

The theory is extremely complicated and the explanation of what happened at the beginning is very difficult, and scientists haven't worked out all the answers yet.

They have worked out what possibly happened, down to $10^{-43}$ seconds after the beginning! At this time the Universe would have been incredibly hot ~ $10^{32}$ K and concentrated into a space no bigger than the size of a hydrogen nucleus! From this moment until $10^{-34}$ seconds the Universe suddenly inflated to a diameter of 10 cm and the temperature dropped to $10^{27}$K.

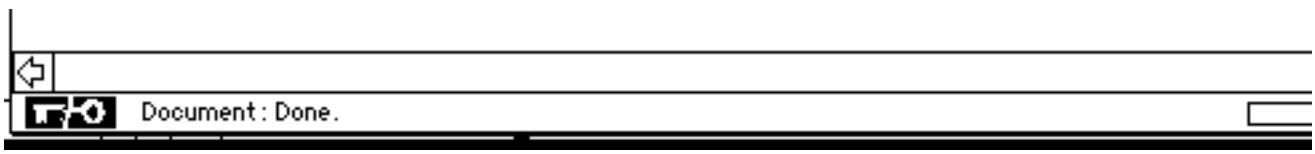
This is when the Big Bang occurred. Particles called quarks and leptons appeared and gravity came into being. At about 1 second the quarks came together to make protons and neutrons. The temperature was $10^{10}$K.

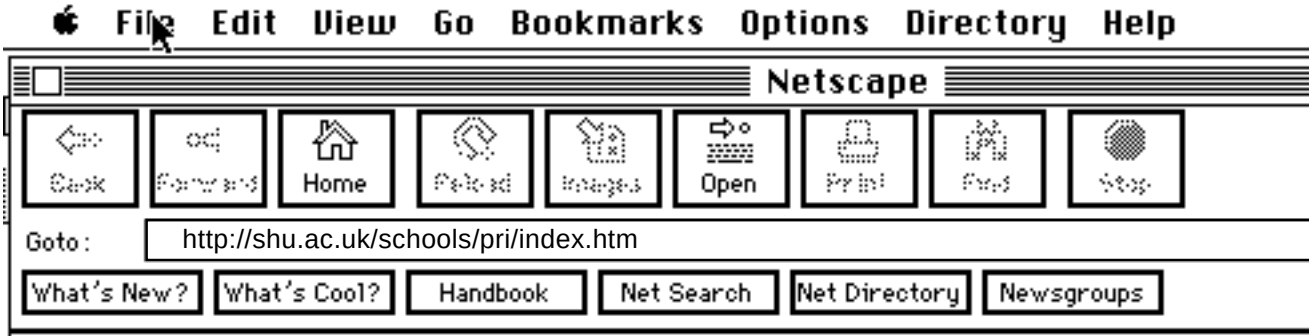
When the Universe was three minutes old it was already light years in size and its temperature was down to $10^{9}$ K (1 billion degrees Kelvin). Now protons and neutrons began to stick together to form nuclei of helium and other light elements.

At 300 000 years the Universe was cool enough (about 3000K) to allow atomic nuclei to bind with electrons to form atoms.

The Universe was now filled with a cloud of gas, mainly hydrogen and helium.

As the Universe expanded it cooled down. The gas cloud split up and these clumps eventually began to collapse under their own gravity. They became the places where stars are formed. These stars grouped together into galaxies and the Universe continued to expand and cool down, as it has been doing for about 15 billion years.



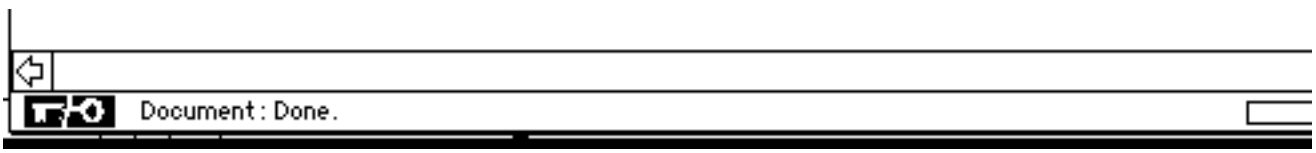


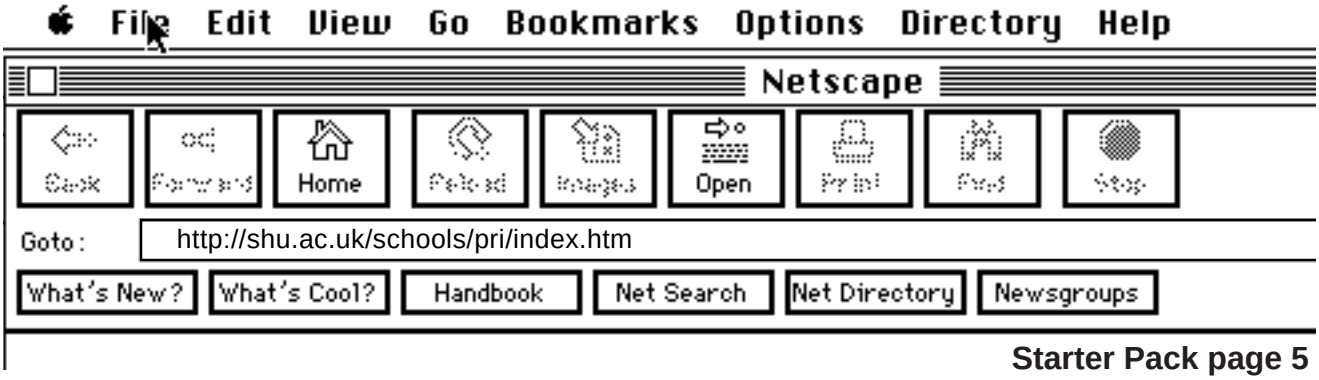



## Looking for evidence inside the atom

Theories are all very well, but we need evidence that the theories are correct. Looking for evidence that the 'Big Bang' theory is correct involves not only astronomical research, but also research into particle physics**.**

If quarks and leptons exist, it should be possible to find them. To do this you need to recreate the conditions that existed in the early Universe. So, massive machines called particle accelerators were built, like the one at CERN in Geneva. These smash together particles like electrons and positrons to investigate what happens. Particle physicists have discovered six quarks and are now looking for other 'exotic' particles. They are also investigating the forces that bind quarks together. The machines that are used are enormously expensive to build and use and so they are financed by several countries and staffed by scientists from these countries.








# Invisible astronomy

Until this century astronomers learned about the Universe by observing the light from distant stars and galaxies. Now they also use instruments that can detect waves from the whole electromagnetic spectrum to study bodies that are invisible to us.

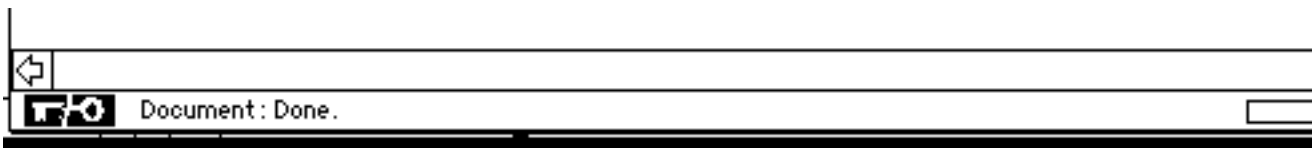
Radio telescopes were used to discover quasars and pulsars.

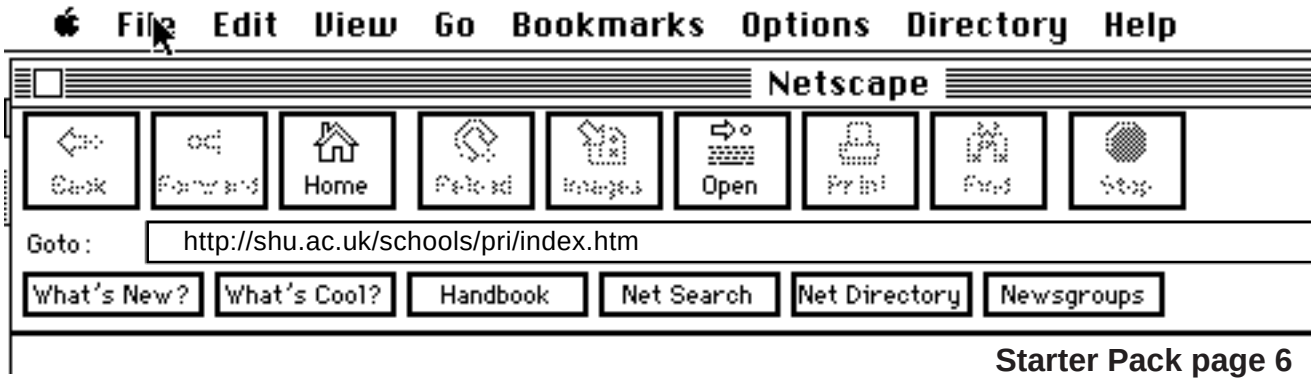
Infrared dectectors allow us to see inside molecular gas clouds to learn more about how stars form.

Ultraviolet rays and X-rays are given out by extremely hot objects such as quasars and pulsars. U.V. and X-ray telescopes can only be used in satellites, since these waves are absorbed by our atmosphere, and so would not get through to a telescope on the surface of the Earth.

Ultraviolet rays are absorbed by cold interstellar gas, and so can be used to study this material. X-rays are given out when material falls into black holes**.**

Gamma rays are produced by violent energetic sources, such as supernovae, pulsars and quasars. There are also very powerful sources, called gamma-ray bursters which mysteriously appear and then vanish after a few seconds. No one knows what generates these bursts of energy.








## Dark Matter

It is estimated that there are 300 billion galaxies in the Universe. If you take this figure and multiply it by the average mass of a galaxy, the total mass of all the matter we can see adds up to less than 1% of the mass of all the matter there should be in the Universe according to the Big Bang theory.

So there must be a vast amount of matter we cannot see - which is why it is called “Dark Matter”. Some mass can be accounted for by black holes and brown dwarfs. Some matter is in the void between galaxies, and yet more must be inside galaxies themselves. Astronomers have calculated that the spiral arms of galaxies would break up if they only contained the matter we can see. This means that the visible material must be surrounded by matter we cannot see. Yet more mass may be contained in ‘exotic’ particles such as neutrinos and WIMPS (Weakly Interacting Massive Particles). Research into these is being carried out at the Rutherford Appleton Laboratory and in a deep salt mine in Boulby, North Yorkshire.

It is important to find out the total mass of the Universe, since from this we can determine the fate of the Universe: will it be the Continous Expansion Theory or the Steady State Theory or the Big Crunch Theory that is correct? This is one of the most important questions in science that is yet to be answered.