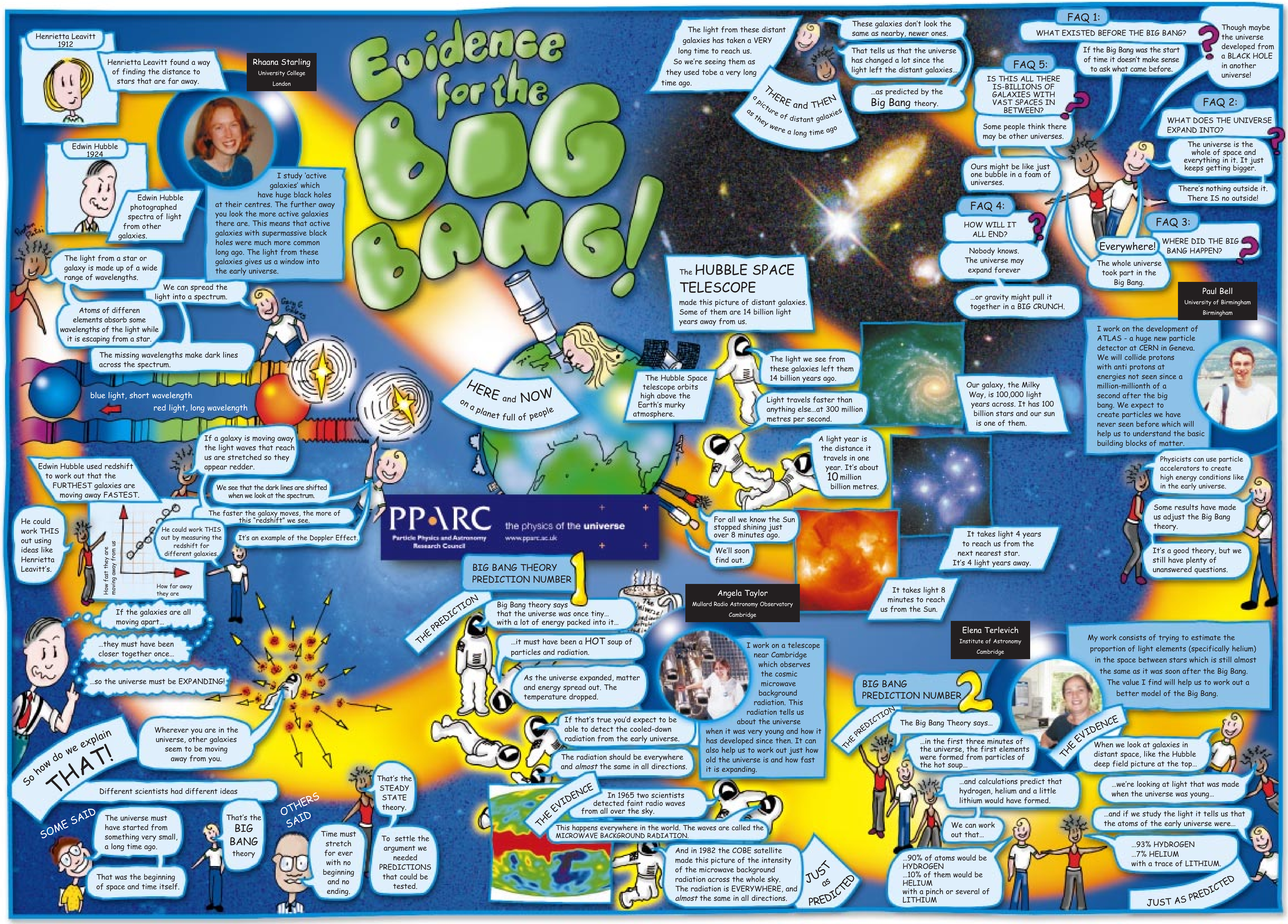

Evidence for the BIG BANG!
Henrietta Leavitt 1912
Henrietta Leavitt found a way of finding the distance to stars that are far away.
Rhaana Starling
University College London
I study 'active galaxies' which have huge black holes at their centres. The further away you look the more active galaxies there are. This means that active galaxies with supermassive black holes were much more common long ago. The light from these galaxies gives us a window into the early universe.
Edwin Hubble 1924
Edwin Hubble photographed spectra of light from other galaxies.
The light from a star or galaxy is made up of a wide range of wavelengths.
We can spread the light into a spectrum.
Atoms of differen elements absorb some wavelengths of the light while it is escaping from a star.
The missing wavelengths make dark lines across the spectrum.
blue light, short wavelength
red light, long wavelength
If a galaxy is moving away the light waves that reach us are stretched so they appear redder.
We see that the dark lines are shifted when we look at the spectrum.
Edwin Hubble used redshift to work out that the FURTHEST galaxies are moving away FASTEST.
The faster the galaxy moves, the more of this "redshift" we see.
It's an example of the Doppler Effect.
He could work THIS out using ideas like Henrietta Leavitt's.
He could work THIS out by measuring the redshift for different galaxies.
How fast they are moving away from us
How far away they are
If the galaxies are all moving apart...
...they must have been closer together once...
...so the universe must be EXPANDING!
Wherever you are in the universe, other galaxies seem to be moving away from you.
So how do we explain THAT!
Different scientists had different ideas
SOME SAID
The universe must have started from something very small, a long time ago.
That was the beginning of space and time itself.
That's the BIG BANG theory
OTHERS SAID
Time must stretch for ever with no beginning and no ending.
That's the STEADY STATE theory.
To settle the argument we needed PREDICTIONS that could be tested.
The light from these distant galaxies has taken a VERY long time to reach us. So we're seeing them as they used tobe a very long time ago.
These galaxies don't look the same as nearby, newer ones.
That tells us that the universe has changed a lot since the light left the distant galaxies...
...as predicted by the Big Bang theory.
THERE and THEN
a picture of distant galaxies as they were a long time ago
The HUBBLE SPACE TELESCOPE
made this picture of distant galaxies. Some of them are 14 billion light years away from us.
HERE and NOW
on a planet full of people
The Hubble Space telescope orbits high above the Earth's murky atmosphere.
The light we see from these galaxies left them 14 billion years ago.
Light travels faster than anything else...at 300 million metres per second.
A light year is the distance it travels in one year. It's about 10 million billion metres.
Our galaxy, the Milky Way, is 100,000 light years across. It has 100 billion stars and our sun is one of them.
For all we know the Sun stopped shining just over 8 minutes ago.
We'll soon find out.
It takes light 4 years to reach us from the next nearest star. It's 4 light years away.
It takes light 8 minutes to reach us from the Sun.
PPARC the physics of the universe
Particle Physics and Astronomy Research Council
www.pparc.ac.uk
FAQ 1:
WHAT EXISTED BEFORE THE BIG BANG?
If the Big Bang was the start of time it doesn't make sense to ask what came before.
Though maybe the universe developed from a BLACK HOLE in another universe!
FAQ 5:
IS THIS ALL THERE IS-BILLIONS OF GALAXIES WITH VAST SPACES IN BETWEEN?
Some people think there may be other universes.
Ours might be like just one bubble in a foam of universes.
FAQ 2:
WHAT DOES THE UNIVERSE EXPAND INTO?
The universe is the whole of space and everything in it. It just keeps getting bigger.
There's nothing outside it. There IS no outside!
FAQ 4:
HOW WILL IT ALL END?
Nobody knows. The universe may expand forever
...or gravity might pull it together in a BIG CRUNCH.
FAQ 3:
WHERE DID THE BIG BANG HAPPEN?
Everywhere!
The whole universe took part in the Big Bang.
Paul Bell
University of Birmingham
Birmingham
I work on the development of ATLAS - a huge new particle detector at CERN in Geneva. We will collide protons with anti protons at energies not seen since a million-millionth of a second after the big bang. We expect to create particles we have never seen before which will help us to understand the basic building blocks of matter.
Physicists can use particle accelerators to create high energy conditions like in the early universe.
Some results have made us adjust the Big Bang theory.
It's a good theory, but we still have plenty of unanswered questions.
BIG BANG THEORY PREDICTION NUMBER 1
THE PREDICTION
Big Bang theory says that the universe was once tiny... with a lot of energy packed into it...
...it must have been a HOT soup of particles and radiation.
As the universe expanded, matter and energy spread out. The temperature dropped.
If that's true you'd expect to be able to detect the cooled-down radiation from the early universe.
The radiation should be everywhere and almost the same in all directions.
THE EVIDENCE
In 1965 two scientists detected faint radio waves from all over the sky.
This happens everywhere in the world. The waves are called the MICROWAVE BACKGROUND RADIATION.
And in 1982 the COBE satellite made this picture of the intensity of the microwave background radiation across the whole sky. The radiation is EVERYWHERE, and almost the same in all directions.
JUST as PREDICTED
Angela Taylor
Mullard Radio Astronomy Observatory
Cambridge
I work on a telescope near Cambridge which observes the cosmic microwave background radiation. This radiation tells us about the universe when it was very young and how it has developed since then. It can also help us to work out just how old the universe is and how fast it is expanding.
Elena Terlevich
Institute of Astronomy
Cambridge
My work consists of trying to estimate the proportion of light elements (specifically helium) in the space between stars which is still almost the same as it was soon after the Big Bang. The value I find will help us to work out a better model of the Big Bang.
BIG BANG PREDICTION NUMBER 2
THE PREDICTION
The Big Bang Theory says...
...in the first three minutes of the universe, the first elements were formed from particles of the hot soup...
...and calculations predict that hydrogen, helium and a little lithium would have formed.
We can work out that...
...90% of atoms would be HYDROGEN ...10% of them would be HELIUM with a pinch or several of LITHIUM
THE EVIDENCE
When we look at galaxies in distant space, like the Hubble deep field picture at the top...
...we're looking at light that was made when the universe was young...
...and if we study the light it tells us that the atoms of the early universe were...
...93% HYDROGEN ...7% HELIUM with a trace of LITHIUM.
JUST AS PREDICTED