Your students have read about the universe in which they live. I'm sure that they have some concept of scales and significance. By completing the activities in this module they can experience the universe through three stunning virtual tours. What was once just intellectual property will become a gut feeling.

They will make a journey that will change their view of the universe and their place in it. This will be achieved through creative activities and the sharing of ideas with others.

As their teacher you will find the assessment rubric and background information invaluable as a means of levelling your students progress.

TEACHER USE

Background Information

These sheets are for teachers. They provide information to pass on to their students before, during or after their visit.

What is Cosmology?

Cosmology can be defined as the scientific study of the large-scale properties of the universe. It is an attempt, using the scientific method, to explain the origin, evolution and ultimate fate of the universe. These 'big questions' fascinate students, and hopefully their visit to the GDC will allow them to understand how we have arrived at our current understandings.

Like any other field of scientific study, cosmology relies on the formulation of theories and hypotheses about the universe that make specific predictions for phenomena that can be tested with observations. Depending on the outcome of the observations, the theories will need to be abandoned, revised or extended to accommodate the data. The exciting thing about this area of scientific pursuit, for your students, is that world-class work is being done here in WA, and it is possible that they can become involved in research that will change forever how humans view their universe.

While at the GDC your students will be able to conduct a virtual-tour of the universe, whereby they can get a feel for the scale of size of our universe. They should soon find that the units of measurement for length, that are adequate for Earth based distances, are less useful when looking at even distances between stars. Some commonly used astronomical distance units are:

Light year	the distance that light travels in one year. i.e. 9.46×10^{15}m
Parsec (pc) kiloparsec (kpc) megaparsec (Mpc)	3.26 light years (or 3.086×10^{16}m) 1,000 parsecs 1,000,000 parsecs
Astronomical Unit (AU)	the average separation of the earth and the sun i.e. 1.496×10^{11}m

Below are some representative astronomical distances:

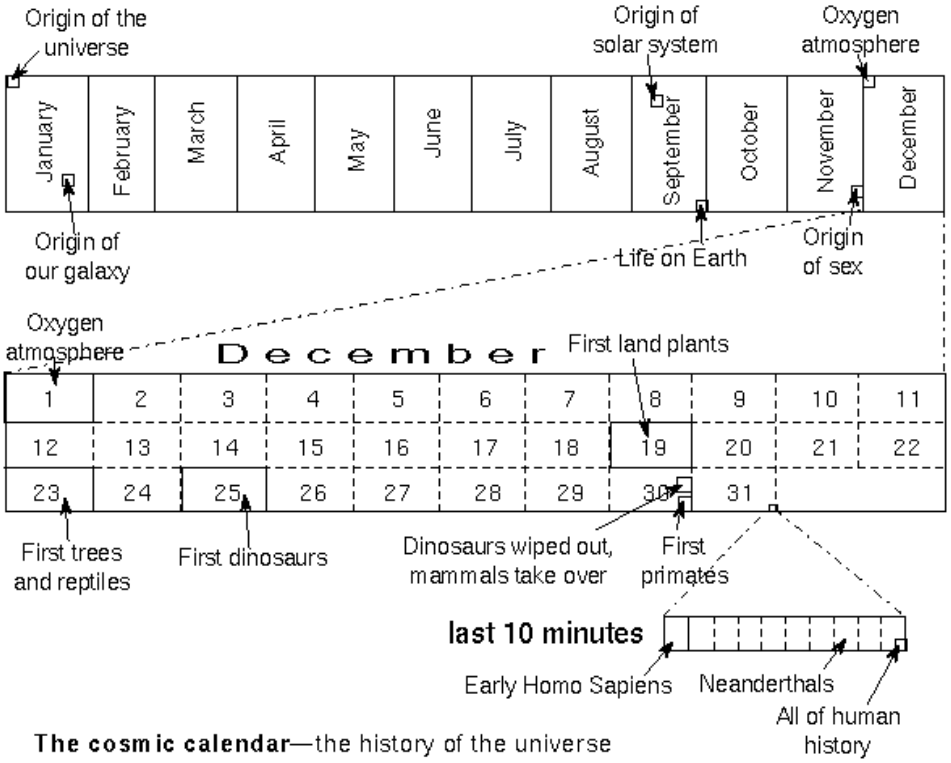
The Solar System is about 80 Astronomical Units (AU) in diameter.
The nearest star (other than our sun) is 4.27 light years away... Proxima Centauri.
Our Galaxy (the Milky Way) is about 100,000 light years in diameter.
Diameter of local cluster of galaxies is about 1 Megaparsec.
Distance to M87 in the Virgo cluster: 50 million light years.
Distance to most distant object seen in the universe: about 18 billion light years

(A fantastic web site that your students should visit, to get a good feel for scale, is http://micro.magnet.fsu.edu/primer/java/scienceopticsu/powersof10/index.html
By using the Java applet, your students will 'View the Milky Way at 10 million light years from the Earth. Then move through space towards the Earth in successive orders of magnitude until you reach a tall oak tree just outside the buildings of the National High Magnetic Field Laboratory in Tallahassee, Florida. After that, begin to move from the actual size of a leaf into a microscopic world that reveals leaf cell walls, the cell nucleus, chromatin, DNA and finally, into the subatomic universe of electrons and protons.')

If looking at time, rather than distance, with relation to the universe, the following scale (found at Nick Strobel's Astronomy notes web site http://www.astronomynotes.com) puts astronomical time into perspective.

If you use the classical number of 15 billion years for the age of the universe, you can squeeze the universe's entire history into one 'cosmic calendar' year (recent measurements place the age closer to 13 billion years). On the 'cosmic calendar' the universe starts in the early morning of January 1 at midnight and our present time is at December 31 at 11:59:59.99999 PM. The scale of the 'cosmic calendar' is that every second in the 'cosmic calendar' corresponds to 475 real years (i.e. 24 'cosmic calendar' days is equivalent to 1 billion real years).

A diagram of this 'cosmic calendar' appears on the next page.



The cosmic calendar—the history of the universe compressed to one year. All of recorded history (human civilization) occurs in last 21 seconds!

Here are some important dates in this super-compressed cosmic calendar relevant to us humans:

Origin of the Universe--Jan. 1
Solar system origin--Sept. 9
Life on Earth--Sept. 30

Oxygen atmosphere--Dec. 1

Land plants & insects--Dec. 19, 20
First reptiles & trees--Dec. 23
KT impact, mammal age, birds—10:00 AM Dec. 30
Australopithecines (Lucy, etc.)—10:00 PM Dec. 31
Homo erectus--11:40 PM Dec. 31
Neanderthal man--11:57 PM Dec. 31
Homo sapiens sapiens--11:58:57 PM Dec. 31

Ancient Greeks to now--last five seconds

Origin of our galaxy--Jan 24
Earth Solidifies--Sept. 14
Sexual reproduction advent--Nov. 25
Cambrian explosion (600 mil years ago when most complex organisms appear, fish, trilobites)--Dec. 17
First amphibians--Dec. 22
First dinosaurs--Dec. 25
First primates--Dec. 30

Homo habilis--11:25 PM Dec. 31

Early Homo sapiens--11:50 PM Dec. 31
Cro-Magnon man--11:58:38 PM
Human history--11:59:39 PM
Average human life span--0.15 seconds

You will be able to view a sculpture that represents the history of the universe in a similar sort of time line when visiting the GDC.

SCHOOL ACTIVITIES

Walk and Talk

These sheets describe activities to be undertaken by students at school, either before or after their visit to the GDC.

Your teacher will describe the steps involved in the Walk and Talk protocol. Record a description of each stage below. You can then refer to these instructions as you do your walk and talk:

1 Information gathering (approx 1 hour)

2 Pairing (2-3 minutes)

3 Presentation (5 minutes)

4 Questioning and Feedback (5 minutes)

5 Role reversal (10 minutes)

6 Regrouping (10 minutes)

7 Response and open conversation

Below are some sites that may help you research some of the questions that you'd like answers to. Tick the 'Visited' column if you had a look at them. Good luck. If these sites don't provide you with stimulation for discussion, then look for others. Remember, though, that time is limited.

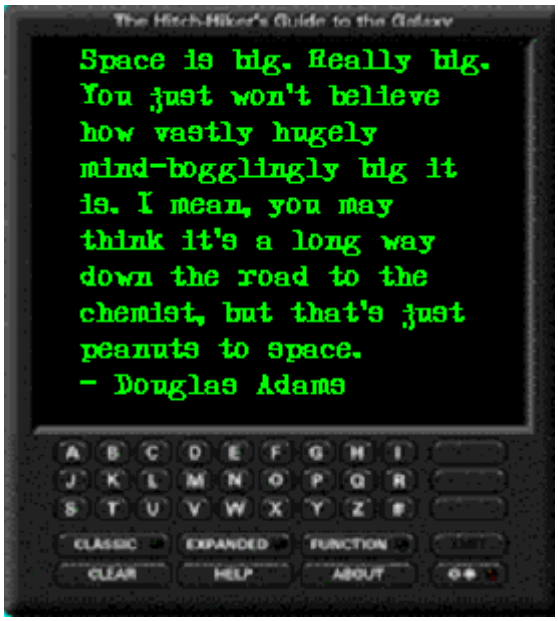
Web site description and URL	Visited
Hitchhikers guide to the Hubble telescope. Great site full of information, from the Discovery pay TV channel: http://www.discovery.com/area/specials/hubble/hubble1.html	
Dark matter tutorial. What is dark matter? This site should help you find some answers. http://www.astro.queensu.ca/~dursi/dm-tutorial/dastroed.html	
Interactive physics applets (these pages takes a while to load, but are worth the wait.) http://jersey.uoregon.edu/vlab/hubble/Hubble_plugin.html http://jersey.uoregon.edu/vlab/parallax/Parallax.html http://jersey.uoregon.edu/vlab/GalCrash/GalCrash_plugin.html	
Steps to Hubble constant. http://www.astronomynotes.com/galaxy/s16.htm	
Cosmology notes. http://www.astronomynotes.com/cosmolgy/s2.htm	
Scales of distance. Go from a volume of space 12 light years across up to 15 000 000 000 light years across! http://www.electrickiva.com/lessons/index_1st_9wks.htm	
Powers of ten. Excellent site that gives a feeling of scale by moving through distances from **** to the interior of an atom, by a factor of ten each time. http://micro.magnet.fsu.edu/primer/java/scienceopticsu/powersof10/index.html	
Space-time wrinkles. What is space? What is time? What is space-time!? http://archive.ncsa.uiuc.edu/Cyberia/NumRel/NumRelHome.html	
The Hubble project. View images collected by this instrument. http://hubble.nasa.gov/ http://hubblesite.org/newscenter/archive/category/cosmology/	
Classifying galaxies. Look at images of different galaxies and begin to classify them. http://www.smv.org/hastings/galaxy.htm	
Unit of study for solar system, galaxy and universe. For tertiary students, but some interesting information. http://www.michigan.gov/scope/0,1607,7-155-13497_13510_13513-36271--,00.html	

Quote from T.H. Huxley (1887), **"The known is finite, the unknown infinite; intellectually we stand on an islet in the midst of a limitless ocean beyond comprehension. Our business in every generation is to reclaim a little more land".**

VIRTUAL TOURS

Notes and Recording

These sheets describe activities for students to complete. They provide space to record their results from activities.



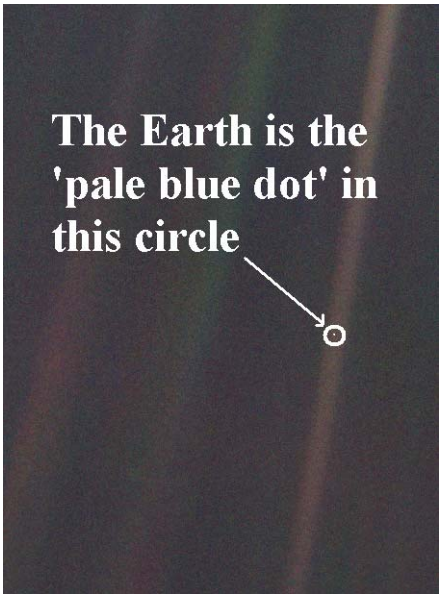
When thinking about the dimensions of the universe, our mind does indeed get 'boggled'! The sizes involved are just so vast, and bear very little relation to everyday measurements that we have difficulty comprehending them.

By completing the activities described on these sheets you should develop a feel for these scales of measurement. You will be able to take virtual walks across our solar system, galaxy and around the universe

You may already have visited:
http://www.electrickiva.com/lessons/index_1st_9wks.htm

This internet site contains information that illustrates the vastness of space. (It shows regions of space ranging from 10 light years across to 15 000 000 000 light years across.) The walks you will take while you are here, at the GDC, will allow you to get a feeling in your 'gut' (and legs!) for the sizes involved.

Voyager 1 captured the image on the right on February 14, 1990. The spacecraft was approximately 24 AU (i.e. roughly 3600 million km) away from the Earth when it turned its cameras toward the Sun. This is a distance between the orbits of Uranus and Neptune…. not even outside our solar system! The Earth appears as a tiny point of light (only 0.12 pixels in size) caught in the scattered light rays of the Sun.



'Look again at that dot. That's here. That's home. That's us. On it everyone you love, everyone you know, everyone you ever heard of, every human being who ever was, lived out their lives.' Puts our planet in perspective, doesn't it!?

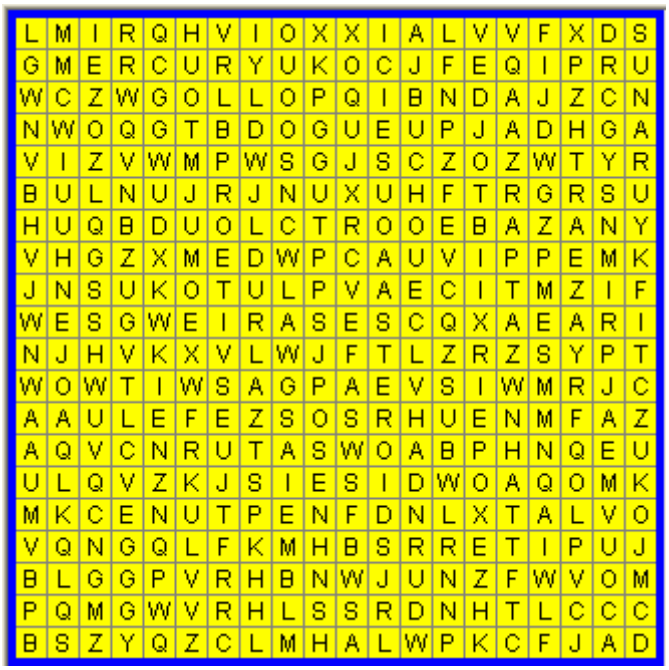
- An excerpt from '*A Pale Blue Dot*'' by Carl Sagan Co-founder of The Planetary Society

You will now be undertaking three separate ‘virtual tours’ of our universe. All of these ‘tours’ begin at the paved area outside the Southern Cross Cosmos Centre (SCCC). Every great journey begins with one step. Before you take your first step, make sure that you are carrying some food and drink with you. You will be travelling to the ends of the universe!

Our Solar System

Form yourselves into pairs for this trip. Once your Solar System trek is completed you will compare notes with another pair of explorers.

1. This journey will take the two of you outwards from the Sun, through our solar system. The path you will take is from the paved area towards Eshcot springs. As well as taking in the local flora and fauna, you will pass scale models of the following on your journey:



L	M	I	R	Q	H	V	I	O	X	X	I	A	L	V	V	F	X	D	S
G	M	E	R	C	U	R	Y	U	K	O	C	J	F	E	Q	I	P	R	U
W	C	Z	W	G	O	L	L	O	P	Q	I	B	N	D	A	J	Z	C	N
N	W	O	Q	G	T	B	D	O	G	U	E	U	P	J	A	D	H	G	A
V	I	Z	V	W	M	P	W	S	G	J	S	C	Z	O	Z	W	T	Y	R
B	U	L	N	U	J	R	J	N	U	X	U	H	F	T	R	G	R	S	U
H	U	Q	B	D	U	O	L	C	T	R	O	O	E	B	A	Z	A	N	Y
V	H	G	Z	X	M	E	D	W	P	C	A	U	V	I	P	P	E	M	K
J	N	S	U	K	O	T	U	L	P	V	A	E	C	I	T	M	Z	I	F
W	E	S	G	W	E	I	R	A	S	E	S	C	Q	X	A	E	A	R	I
N	J	H	V	K	X	V	L	W	J	F	T	L	Z	R	Z	S	Y	P	T
W	O	W	T	I	W	S	A	G	P	A	E	V	S	I	W	M	R	J	C
A	A	U	L	E	F	E	Z	S	O	S	R	H	U	E	N	M	F	A	Z
A	Q	V	C	N	R	U	T	A	S	W	O	A	B	P	H	N	Q	E	U
U	L	Q	V	Z	K	J	S	I	E	S	I	D	W	O	A	Q	O	M	K
M	K	C	E	N	U	T	P	E	N	F	D	N	L	X	T	A	L	V	O
V	Q	N	G	Q	L	F	K	M	H	B	S	R	R	E	T	I	P	U	J
B	L	G	G	P	V	R	H	B	N	W	J	U	N	Z	F	W	V	O	M
P	Q	M	G	W	V	R	H	L	S	S	R	D	N	H	T	L	C	C	C
B	S	Z	Y	Q	Z	C	L	M	H	A	L	W	P	K	C	F	J	A	D

Sun

Mercury
Venus
Earth
Mars
asteroids
Jupiter
Saturn
Uranus
Neptune
Pluto
Oort cloud

2. As you find these on your walk then cross them out in your word search. Also record your observations, with words and pictures, in the space that follows. (Include information

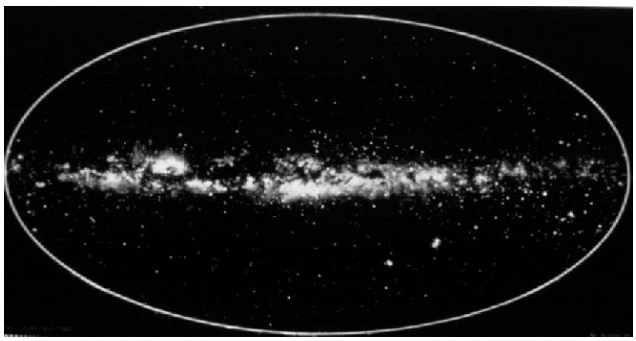
(continued over)

Now journey back to where your Solar System adventure began. Compare your observations with another pair of explorers, that have also completed the same trip. Make additions or alterations to your notes based on your discussions with the other pair.

Get ready for your next adventure. It will take you across our entire galaxy!

Our Galaxy – the Milky Way

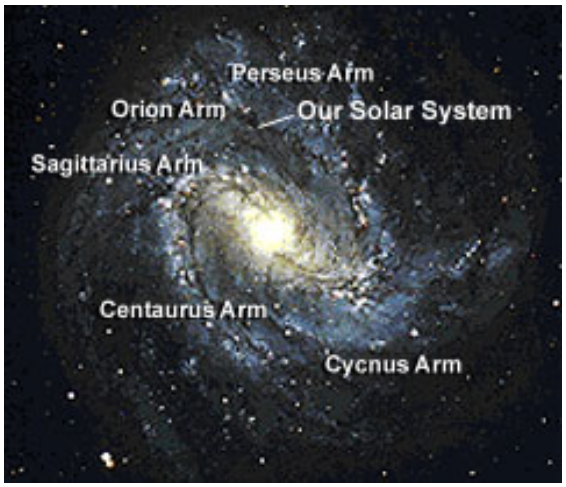
If you are in Perth, or another large town, you don't get to see the Milky Way very clearly at night. This is due to the amount of light coming from buildings, streetlights and other artificial sources that interfere with your view of the night sky. If you were here at the GDC tonight you would clearly see a band of billions of stars stretching across the sky.

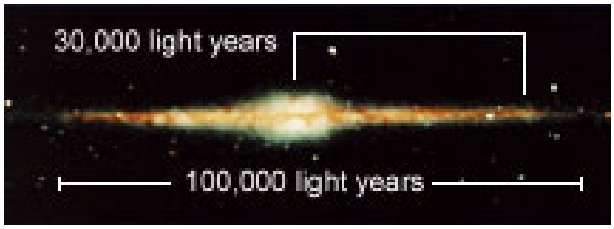


Milky Way photo mosaic, contributed to the Usenet group alt.binaries.pictures.astro by Lloyd Johnson

This band of stars is our galaxy – the Milky Way.

The view that we get from Earth is side on to the Galaxy. It is difficult to picture its true structure, since we are in it. It's like trying to imagine the shape of the bush-land that you are standing in by looking through the trees.





These images show how we believe our galaxy would appear to someone viewing it from outside the Milky Way, from the top and from the side.
These images came from http://school.discovery.com/schooladventures/universe/galaxytour/milkyway.html

3. Your assignment, along with your fellow travellers, for this tour is to prepare a segment for the future lifestyle/travel program **'Getaway –Getfarfaraway!'** . As you journey from the paved area to the GDC entrance you will pass models of objects found in the Galaxy. You are to choose one of these objects and prepare a short, informative presentation for your television viewers that describes it as a great holiday destination. Your viewers will need to be given scientifically accurate information that tells them:

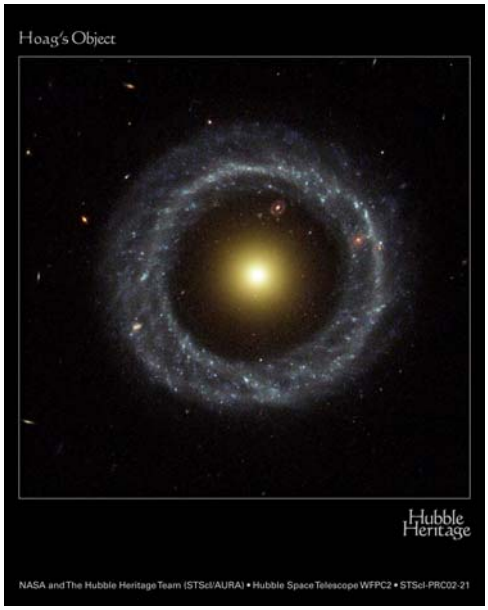
- where it is (how long will it take to travel to, and what other holiday destinations are nearby),
- what it is (describe its nature including aspects like size, temperature, radiation, gravitational field strength etc),
- why you found it such a 'delightful' destination, and
- any other information that you feel is relevant to prospective travellers.

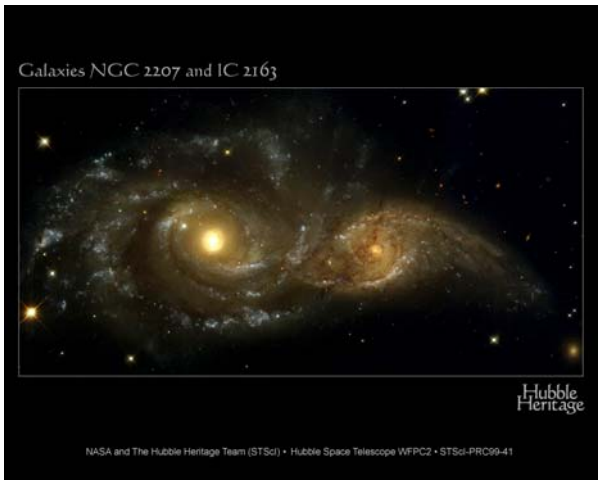
Make notes below as you travel throughout the galaxy to assist you to make your presentation. You may be using a computer, and presentation software (such as Microsoft PowerPoint) to do this, and completing it back at school. Therefore make sure that your notes will be meaningful and complete, as it would be difficult to come back and check your information. You could however contact us to check on any data, and we'd love you to send us a copy of your completed presentation (******@*****.****) so that we can use it as an example for future students.)

The Universe

Your final journey will be taking you around the whole universe. You thought that the solar system was large. The dimensions of our galaxy then astounded you. Well now be prepared to be totally blown away by the size and wonders of 'everything'!

Stars are born in stellar nurseries and spectacularly die. Galaxies collide. Objects that appear like art works abound. The Hubble telescope has opened our eyes and improved our knowledge of the universe greatly since it came into operation. Have a look at the HDF poster inside the GDC and the images below for an idea of the views it gives us. Imagine what other wonders and improvements in understanding await us when we can view gravity waves from our universe.





These are some of the work produced by NASA and AURA/STScI using the Hubble telescope. (More images can be found at http://oposite.stsci.edu/pubinfo/pictures.html).

Before you begin this final journey we would like you to sit quietly and jot down some of your knowledge of and personal thoughts on the universe. What is it? What is space? What is time? When did it begin? How will it end – or will it continue to exist? How big is it? Are humans close to understanding it? How much importance do you place in understanding it? Does it have a purpose? What is your place in it? Do you have any personal theories or beliefs about the universe and its significance? All these questions, and more could be considered as you write down your ideas.

4. After your journey you will look at what you have written or drawn and see if the trek has altered any of your ideas and/or beliefs, and then compare your thoughts with others.

Now begin your journey. You may make the trip by yourself and reflect on your currently held beliefs as you proceed. Or you may decide to walk with a group and discuss your ideas as you stroll through the 'universe'.

5. When you return all of you will need to sit and quietly assimilate new ideas with your old ones. The table on the next page will assist you as you organise all these facts and ideas.

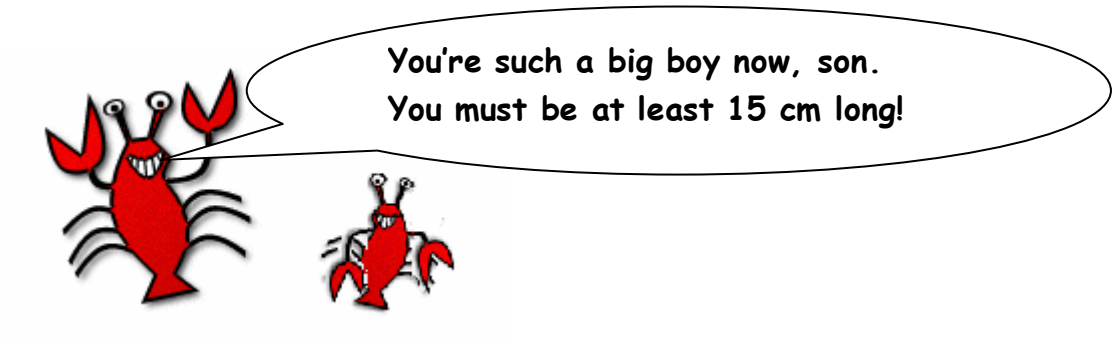
Ideas and thoughts that have not been changed by your virtual journey/s	Ideas and thoughts that have been changed by your virtual journey/s	Interesting facts or ideas that you didn't know of or even consider before your virtual journey/s

Extra for those that have been moved:
Has your view of the universe changed today? How does that make it make you feel? If you have time now, or later, you could do a piece of art, a drawing, a poem or story that expresses your feelings.

GETTING INFORMATION FROM THE PAST

Notes and Instructions

These sheets describe an activity to be completed by students, and provide space for their observations and calculations.



Centimetres would be an adequate unit of measurement for these crayfish. We wouldn't use centimetres to describe the distance that you travelled to get here today. It wouldn't be an appropriate unit. We would use kilometres. A distance from school to the GDC would have meaning if expressed in kilometres.

When we talk about astronomical distances kilometres prove to be inadequate. We need a larger unit of length to make sense of the enormous distances.

Einstein's theories state that the speed of light in a vacuum is an unchanging value. Astronomers make use of this fact when describing huge distances.

This speed for light is the ultimate speed that can be achieved in our universe. It is 3×10^8 ms^{-1}. Imagine that. It travels 300,000 km every second! How far would it travel in a year? Work it out. How many seconds are in one year? Multiply that value by 300,000 and you will know how far light would get in one year.

1. Write your answer below and check it with your guide, or teacher.

_____ km

This distance is known as one light year.

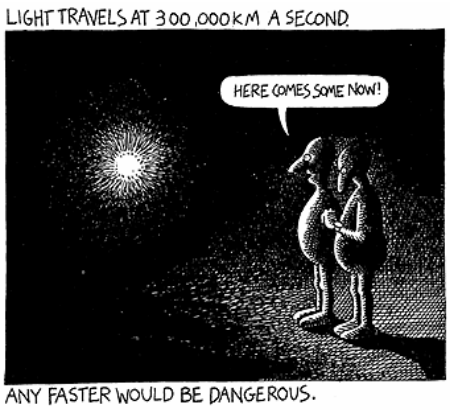


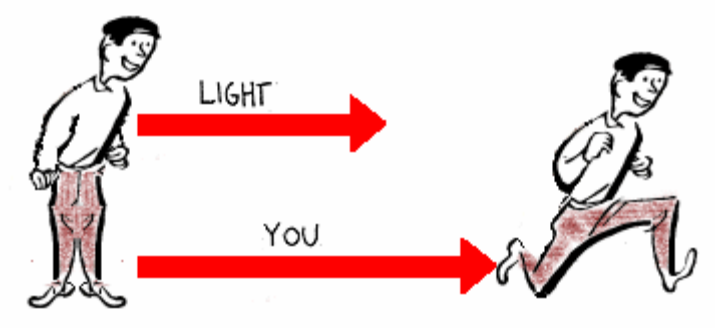
Image by B. Kliban
(http://www.coldbacon.com/pics/kliban/bklight.gif)

The nearest star to the Earth is our sun, Sol. It is approximately the distance that light travels in 8.3 minutes away. (i.e. 8.3 light minutes.)

2. How far is that in km?

The closest star after the sun is Proxima Centauri (also known as Alpha Centauri C). It is only 4.2 light-years (ly) away. When we observe Proxima Centauri we are seeing light that left it 4.2 years ago. We are actually seeing what it looked like 4.2 years ago. We are in fact observing the past!

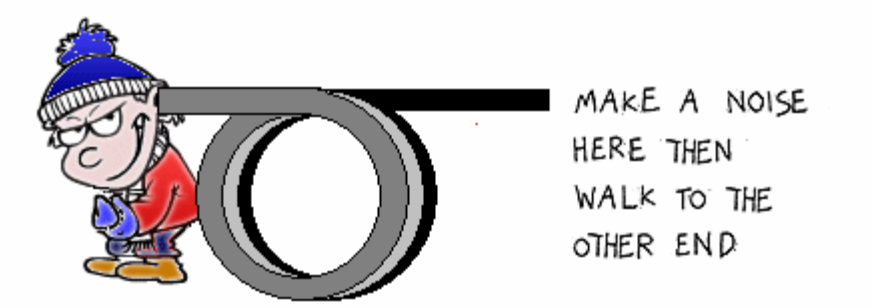
In fact everything we see is a view of the past. It takes light some time to travel from every object or event to us. When we look at a tree or watch a movie this time lag is so small that we don't notice it. However most objects that we view in the sky are at distances far greater than 4.2 ly away. The time that it takes the light to travel to us is important. Light may be just reaching us from objects that no longer exist!



Imagine if you could run faster than light speed. You can't of course. But if you could, after running and then looking back you would see yourself in the past! Would this mean that you travelled back in time?!

We don't have displays that would allow you to see yourself in the past. However if you perform the following activity you will be able to hear yourself in the past! Sound doesn't ravel at anything like the speed of light. Its speed is approximately 340 ms^{-1} in air. We've arranged a way for you to 'outrun' your sound!

There is a 1km length of coiled plastic pipe at the building's entrance. If you make a sound at one end of the pipe you can walk to the other end and get there before your sound does. If you put your ear to the other end you will hear the sound when it arrives.



You are hearing the past!

SCHOOL ACTIVITIES

Walk and Talk

These sheets describe activities to be undertaken by students at school, either before or after their visit to the GDC.

"The known is finite, the unknown infinite; intellectually we stand on an islet in the midst of a limitless ocean beyond comprehension. Our business in every generation is to reclaim a little more land." quote from T. H. Huxley (1887)

Your students will want some answers to the 'big' questions. Why is the universe here? What are the universe, dark matter, space-time etc? The types of questions that cosmology attempts to answer. There is so much information available to your students, and yourselves, that to wade through it all is an impossible task.

There are many strategies that can be employed in the classroom that will assist your students in assimilating volumes of information in an collaborative manner. The technique used for this activity is called 'Walk and Talk'. (Your students will be doing a lot of walking and talking at the GDC, when they undertake their virtual tours of the universe.) Completing this activity before the visit may enable the onsite activity to be more productive. However it will still be useful if done after the visit as they will be able to introduce information from their 'tours'.

The strategy is designed to stimulate discussion by encouraging purposeful questioning, active listening and focus on specific information. The time frame may vary according to you class and situation, but adhering to a set time foe each segment is advised.

1 Information gathering (approx 1 hour)

You explain the process to the class, provide them with their worksheets and access to computers/internet. Allow them to visit the sites provided and any others in order to research a cosmological area of interest, that they will have to talk about to their partner.

2 Pairing (2-3 minutes)

You assign the pairs. (It works well placing students together that normally don't share ideas with each other. This is not essential.) Recap the process.

3 Presentation (5 minutes)

Participant 1 speaks on the topic while participant 2 listens. Only **non-verbal** communication is allowed by participant 2 during this time.

4 Questioning and feedback (5 minutes)

Participant 2 asks up to three clarifying questions, and provides up to two elements of 'warm' feedback. ('I didn't know…. , You explained … very clearly etc)

5 Role reversal (10 minutes)

Roles are reversed and steps 3 and 4 are repeated.

6 Regrouping (10 minutes)

Each pair joins with another pair. Each person has two minutes to give a brief synopsis of their partners presentation.

7 Response and open conversation

This is an opportunity for the class to discuss their response to the process and information gathered.

TEACHER AND/OR STUDENT USE

Rubric

These sheets are for teachers and students to assist in the levelling of student work completed while doing the 'Cosmology, Time and Space' module.

Overarching Learning Outcomes

There are opportunities within the activities in this package for students to demonstrate the following outcomes:

OLO 1

Students use language to understand, develop and communicate ideas and information and interact with others.

OLO 2

Students select, integrate and apply numerical and spatial concepts and techniques.

OLO 3

Students recognise when and what information is needed, locate and obtain it from a range of sources and evaluate, use and share it with others.

OLO 10

Students participate in creative activity of their own and understand and engage with the artistic, cultural and intellectual work of others.

OLO 12

Students are self-motivated and confident in their approach to learning and are able to work individually and collaboratively.

Science Conceptual Strand – Earth and Beyond

These activities could be used to assist you in the levelling of your students in the 'Earth & Beyond' conceptual strand.

The following pointers could be used to determine the level at which your students have performed the activities.

Level		Pointer/s	Demonstrated
EB4	The student understands processes that can help explain and predict interactions and changes in physical systems and environments.	• can compare components, processes and features of our universe • can identify similarities and differences between planets	
EB5	The student understands models and concepts that explain Earth and space systems and that resource use is related to the geological and environmental history of the Earth and universe.	• can identify similarities and differences in the orbit and characteristics of planets, such as atmosphere, intensity of solar radiation, rotational speed and tilt of axis.	
EB6	The student understands how concepts and principles are used to explain geological and environmental changes in the Earth and large-scale systems in the universe.	• can use principles to explain systems within and beyond our solar system • can present relevant evidence to describe the possible future of the universe and its components • can provide reasons why astronomical features are studied	
EB7	The student understands the role of science in exploiting resources, assessing human impact on environments and developing theories of the evolution of the universe.	• can compare different theories on the evolution of the universe • can outline evidence for accepted theories	
EB8	The student uses concepts, models and theories to understand holistic effects and implications involving cycles of change or equilibrium within Earth and space systems.	• can explain current theories about the nature of the universe • can research and report on instances where astronomical discoveries have changed an accepted view	

This sheet could be reproduced and provided to your students before they conduct the activities, or used by you to assess their performance, once the activities have been completed.