THE UNIVERSITY OF WAIKATO
Te Whare Wānanga o Waikato

Truth, its theory and its practice in science education

ABSTRACT:

This presentation argues that science education must embrace truth.

It draws upon the origins of modern science, particularly the work of Isaac Newton on optics, to show how truth is essential to science.

Newton wrestles with truth both in his early experiments and later as he attempts to present his work to a sceptical audience. The formulation of truth in this presentation is that of Martin Heidegger.

If we are to make science understandable to students, and inspire them, we must present them with an adequate account of science itself, and this can only be achieved if we embrace a concept of truth.

Open Polytechnic
KURATINI TUWHERA

Today

Intellectual tradition

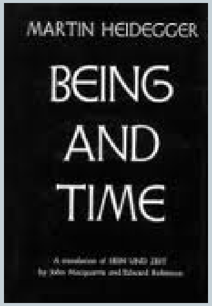
Truth
- Heidegger's theory
- Discovery as truth

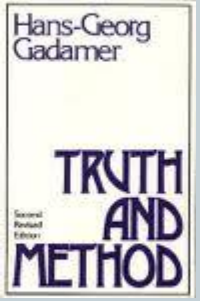
Truth in modern science
- Heidegger's characteristics
- Newton

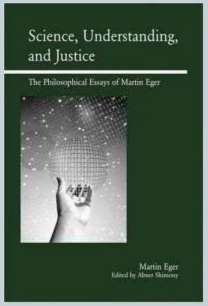
Implications
- Philosophy of science
- Science education

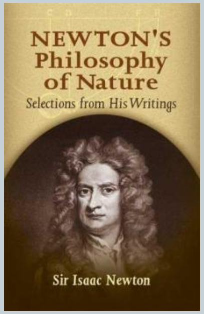
Hermeneutic philosophy of science

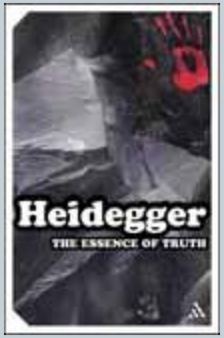
- Without truth
  - Heidegger
  - Gadamer
  - Eger
- With truth
  - Galileo 1610
  - Newton 1666
  - Kant 1782
  - Heidegger 1927
  - Heelan 1983

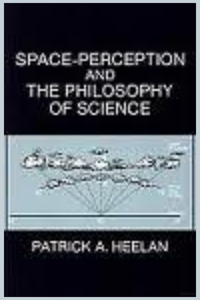






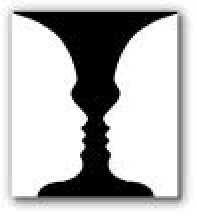






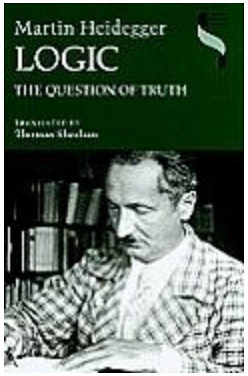
Heidegger's concept of truth

Correspondence 

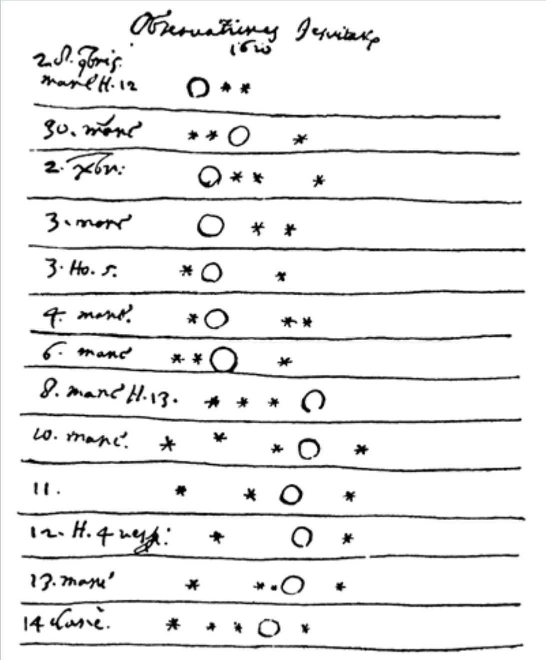
Disclosure 


Tongariro National Park
World Heritage Area
FINISH
Ketetahi
1450m
Te Mari
Mt Tongariro
Blue Lake
Emerald Lakes
Mangatepopo
START
Oturere
1360m
Mt Ngauruhoe

Three characteristics of modern science



- Framework / ground plan
  - Pre-logic
  - Perception
  - Measurable objects
  - The Real
- Force nature to reveal more of itself
  - Follow procedures
  - Equipment
  - Event of truth
  - Individual
  - Perception
- Consequences of disclosures
  - Literature
  - Institutions
  - Workforce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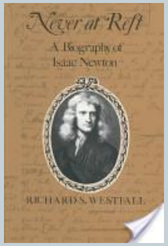
3. mane
3. Ho. s.
4. mane
6. mane
8. mane H.13.
10. mane.
11.
13. mane

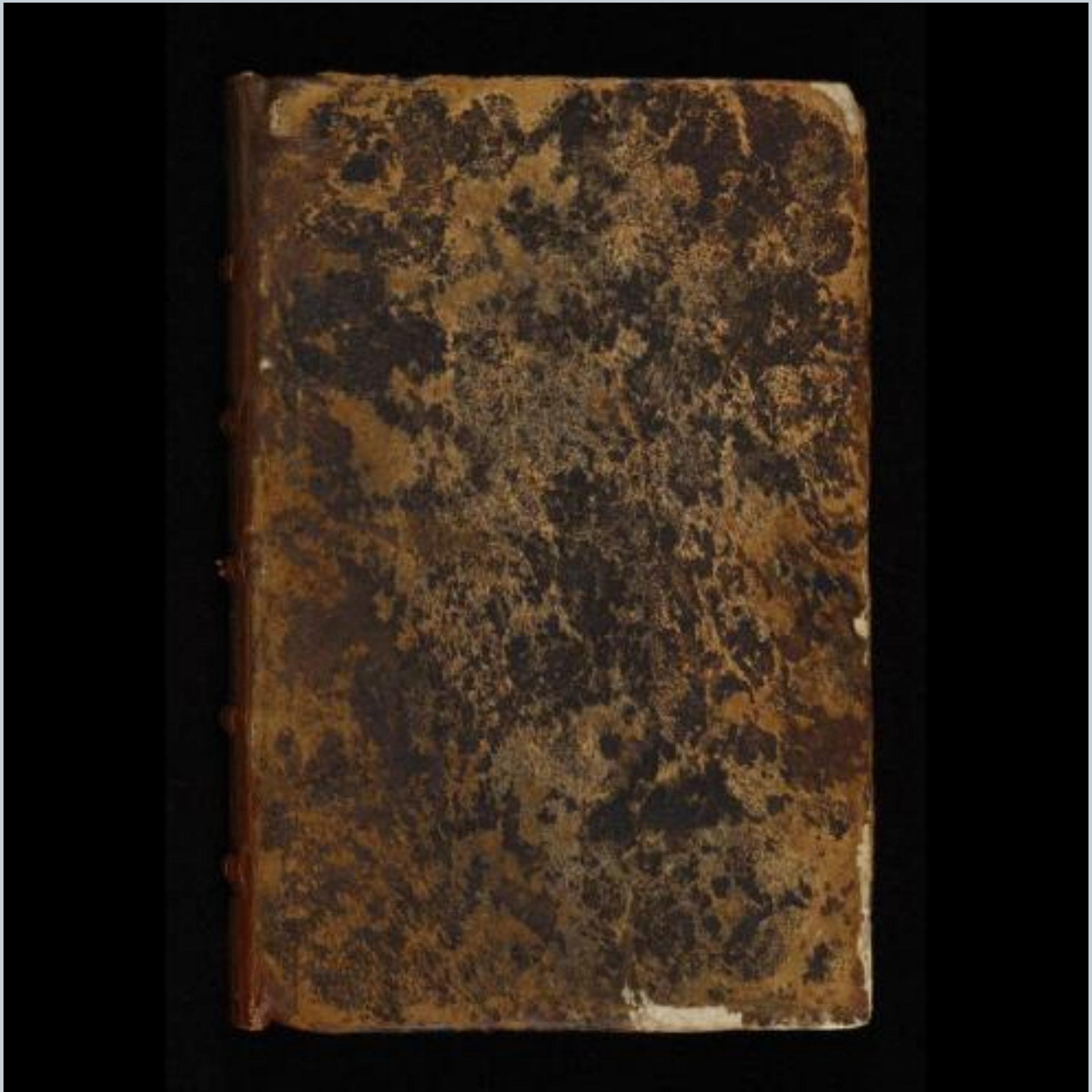
Newton's optics

1664
22 years-old
Trinity College

Questiones quædam Philosophiæ
Certain philosophical questions

Amicus Plato amicus Aristoteles magis amica veritas
Plato and Aristotle are my friends, but truth is a better friend





Amicus Plato amicus Aristoteles magis amica veritas.

1
88

Questiones quædam Philosophicæ

Off ye first mater

Whether it be mathematicall points: or Mathematicall points & parts: or a simple entity before division indistinct: or individualls i.e. Atomes.

Not of Mathematicall points since wt wants dimensions cannot constitute a body in theire conjunction Because they will sinke into ye same point. An infinite number of mathematicall points sink into one being added together & yt being still a mathematicall point is indivisible but a body is divisible. Besides a Mathematicall point is Nothing, since it is but an immaginary entity. &c

Not of parts & Math: points, for such a point is either something or nothing. if something tis a pt & so added betweene 2 pts will make a line of 3 pts. if nothing, then added betwixt two parts there is still nothing betwixt ye 2 pts & consequently ye line consists of nothing still but 2 pts. &c

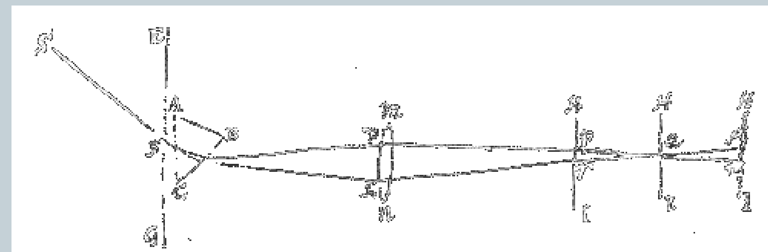
Not of simple entity before division indistinct for this must be an union of ye parts into wch a body is divisible since those parts may againe bee united & become one body as they were before at its creation, Now ye nature of union (being but a modall ens) is to depend on its pts (wch are absolute entities) therefore it cannot be ye forme of creation, or first matter for tis a contradiction to say ye first matter depends on some other subject ~~except God~~ since yt implys some former matter on wch it must depend.

Newton's optics
Truth as correspondence

1666 

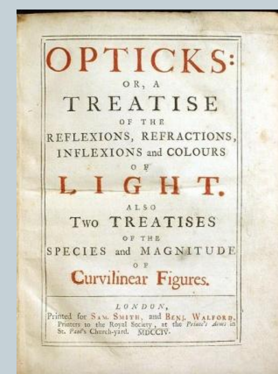
	white	& cdsr	blew	y^n e	~~yello~~ Red.
	black		blew		~~Greene~~ blewer.
	blew		black		Greene, or Red
	black		red		blew.
	red		black		redder.
If abdc be	red	& cdsr be	white	y^n eodc is	blew.
	white		red		redder.
	white		whiter		blew.
	whiter		white		redd.
	black		blacker		Greene or darke red
	blacker		black		blew.

1667
Fellow at Trinity College



1672 Royal Society

1692



OPTICKS:
OR, A
TREATISE
OF THE
REFLEXIONS, REFRACTIONS, INFLEXIONS and COLOURS
OF
LIGHT.
ALSO
Two TREATISES
OF THE
SPECIES and MAGNITUDE
OF
Curvilinear Figures.

LONDON,
Printed for SAM. SMITH, and BENJ. WALFORD, Printers to the Royal Society, at the Prince's Arms in St. Paul's Church-yard. MDCCIV.

1704

If abdc be blew & cdsv whi

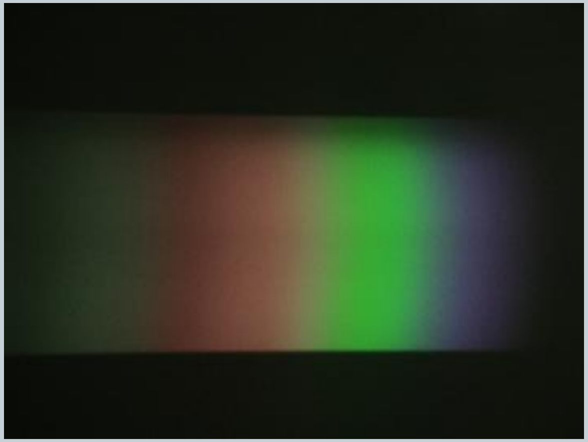
white
black
blew
black
red

If (abdc) be red & (cdsv) be

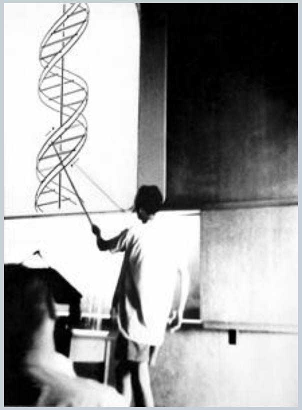
white

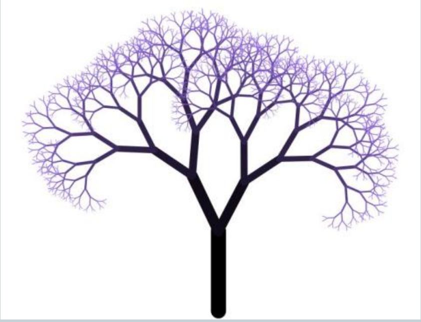
bl
bl
bl
re
bl
wh
red

Newton's optics
Truth as disclosure



Implications
- philosophy of science





Positivists & constructivists

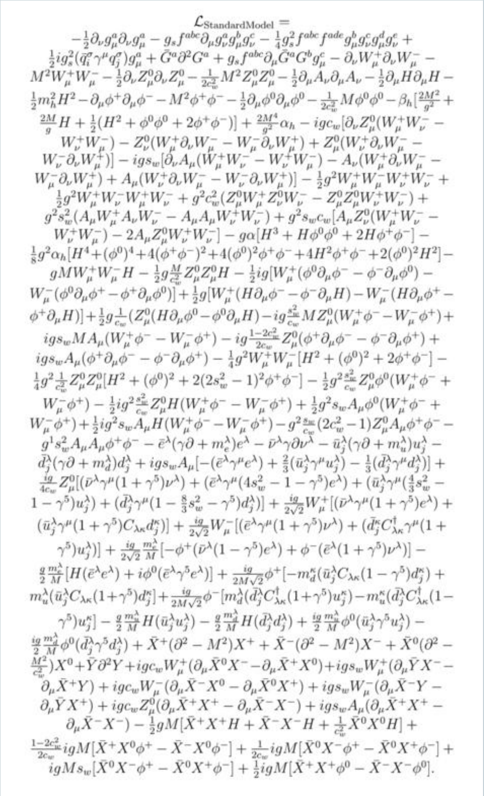
Relativism

Technology

Perpetuation of science

Biology

- DNA / Cold Spring Harbor
- Mandelbrot's fractals



Implications
- science education

Truth

Demonstrations ~~Experiments~~ ~~Simulations~~

~~Hypothesis~~

~~Mathematical models~~

Scientific method

Curriculum structure

Science literacy

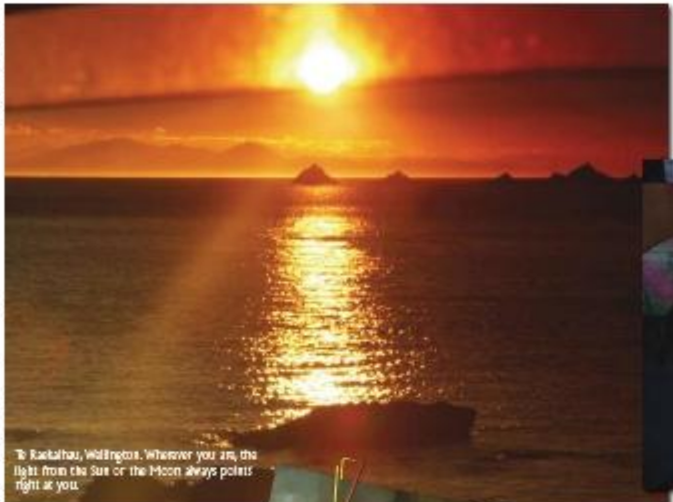
Nature of science

Astronomy and you

You are you. No one else can be you. What you think and do is yours alone. You are secret within yourself. You occupy a particular space. You are not somewhere else, just in this one place.

You are significant

You live in a particular time. You did not appear earlier on when the world was a different place. Nor will you appear later – right now is your time! You see things from where you are. Your view of everything is unique. It is not possible for anyone else to see what you see.



Te Raekaihau, Wellington. Wherever you are, the light from the Sun or the Moon always points right at you.

You are insignificant

Have you ever had that feeling that you are very tiny? You are in an enormous Universe. This is your brief moment in space and time. There were millions of people before you. There will be millions of people after you. No matter what you do, you cannot be significant in the long term.

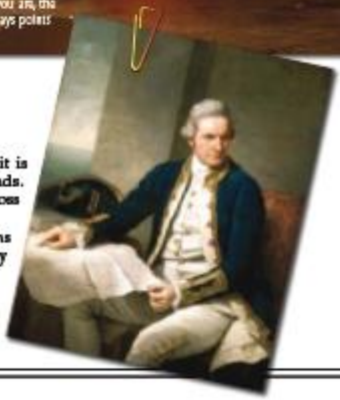
Our world has not always existed. Nor will it always exist. One day everything we know will be gone. Astronomy helps us all to see ourselves in perspective.

On the one hand we are important to ourselves, but on the other hand we are not important at all.

History and culture

Astronomy is important in the history of all cultures. However, it is particularly important for people who live on small, isolated islands. New Zealanders all originated as migrants, and they had to travel across a vast ocean to get to our islands.

In their journeys to Aotearoa, both the Maori and the Europeans depended on their knowledge of astronomy. Because of this, astronomy links you to your own history – wherever you came from.



Captain James Cook (1728–1779). Captain Cook's crews relied on astronomical observations for navigation on their voyages of discovery to the Pacific, as did the Pacific peoples generations earlier. (Painting by Nathaniel Dance, 1775)

Our future

If we are to enjoy a good standard of living, our country must earn money overseas. The only way to do this is by being a creative and intelligent nation. When you study – be it science or anything else – you make a contribution towards New Zealand's future. Science, the arts, and the humanities all offer ideas and insights that are important to our country.

The portable dome used by the Carter Observatory to teach children about space.

Using a globe and a light, a student from Palmerston North Intermediate Normal School demonstrates the reason for Earth's seasons to others in her group.

Exciting revelations in unsettled times

More is being revealed about our Universe all the time. Things out there are not as we thought they might be. New discoveries and new ideas always produce more questions. Once you learn the basics of astronomy, you will understand the importance of each discovery.

You happen to live in an age where there is a dramatic expansion in human knowledge. Scientific understanding is undergoing major change. Astronomy is a part of this, but all the sciences are included.

Beyond science there are also great conflicts of ideas, for example the global conflicts between religious and political ideas. In other words, you live in a time that is unsettled and uncertain, rather than stable and reliable – a time when there is debate about what is true.

New Zealand astronomers and observatories

New Zealanders have a long history of involvement in science. The first learned society, the Literary and Scientific Institution of Nelson, was founded on the emigrant ship *Whitby* whilst it was at sea in April 1841.

In 1851, English migrant Charles Rooking Carter gave the first recorded address to the New Zealand Society, which went on to become The Royal Society of New Zealand (the professional association of New Zealand scientists).

Present-day astronomy sites in New Zealand include:

- universities, particularly the University of Auckland and the University of Canterbury
- research observatories, particularly the Mt John University Observatory
- local observatories, such as the Stardome in Auckland, the R.F. Joyce Observatory West Melton, and the Beverly-Begg Observatory in Dunedin.

The *Astronomy Aotearoa* website (www.astronomyaotearoa.net) provides links to the New Zealand organisations.

John Hearnshaw – professional astronomer

John Hearnshaw is professor of astronomy at the University of Canterbury. He teaches students and carries out research in astronomy. He has written three books on astrophysics and is New Zealand's senior astronomer.

John Hearnshaw is also active in the administration of astronomy. As a member of the International Astronomical Union (IAU), he chairs a group that advances astronomy teaching and research in developing countries.

The IAU was formed in 1919. Today it involves over 9000 astronomers from 87 countries. It is important for New Zealand that our scientists are involved in international scientific organisations, because those scientists keep everyone in New Zealand informed about new ideas.

John Hearnshaw, New Zealand's senior astronomer

Beatrice Tinsley – woman of ideas

- Born in Chester, England, in 1941
- Came to New Zealand when she was five years old
- Father was mayor of New Plymouth
- Became an eminent cosmologist (someone who studies the origin, development, and nature of the physical Universe)
- Her thesis was entitled *The Evolution of Galaxies and its Significance for Cosmology*
- Was a theoretical astronomer (worked without a telescope)
- Became Professor of Astronomy at Yale University
- Died of skin cancer aged 40 years, in 1981.

Tinsley proposed and developed the idea of galactic evolution – how galaxies are formed, and how they change over long periods of time. Her work concerned groups of stars and how they age together. She developed the idea of the 'protogalaxy' – a cloud of dust that forms a galaxy. She related changes in the age of galaxies to how they looked.

Later, Tinsley carried out important work on whether the Universe is open or closed – whether or not space goes on forever.

William Pickering – peerless manager

- Born in Wellington, in 1910
- Mother died when he was six; lived at Havelock and later boarded at Wellington College
- Inspired by his mathematics teacher 'Pop' Gifford (see page 26)
- Studied engineering at the University of Canterbury and the California Institute of technology (Caltech)
- Returned to New Zealand in 1932 but, unable to find work, returned to Caltech and obtained a doctorate in physics
- Taught electrical engineering
- Became a US citizen in 1941
- Worked for NASA's Jet Propulsion Laboratory (JPL) during WWII
- Worked with van Allen (see page 71) and Wernher von Braun, the German rocket scientist who masterminded the V2 rockets that devastated London (see page 48)
- Appointed director of JPL in 1954
- Received many awards and honours, including the Order of New Zealand, an Honorary Fellowship of the Royal Society of New Zealand, and an honorary knighthood (1976)
- Was twice on the cover of America's *Time* magazine
- Died in 2004.

William Pickering with US President Lyndon B Johnson

Sir William Pickering was one of the world's leading space scientists and science managers.

In November 1957 the first Soviet *Sputnik* was launched (see page 49). Just 83 days later the Americans sent *Explorer 1* into space, under the direction of Pickering. This quiet, mild-mannered New Zealander was the man responsible for America's first satellite.

Amateur astronomers

Amateur (unpaid) astronomers do work that the professionals cannot do – they constantly monitor the sky. Because the sky is so vast, and looks different around the world, amateurs are important observers.

There are amateur astronomers hard at work all over New Zealand. They:

- build telescopes
- observe the sky
- collect data
- use the internet to exchange information
- support observatories and astronomy clubs.

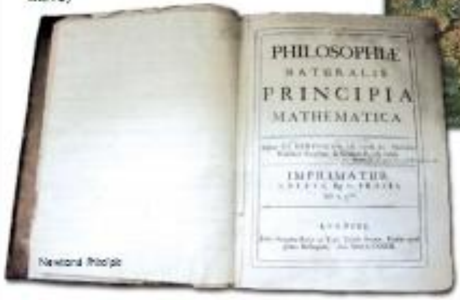
Some amateurs look for small changes that occur in the brightness of stars. Stars that change their brightness are called 'variable stars'. It is very difficult to notice changes in the brightness of stars – the changes are very small, and you need good judgement.

Many would say that Newton was the most important scientist of all time. He was what people today would call a workaholic. During his most productive years, his long hair was frequently dirty, and he avoided people for long periods of time.

Newton was the founder of modern physics. He based his books on what he saw, and on the experiments of others. In particular he studied Copernicus and Galileo.

Some of Newton's achievements were:

- the invention of calculus (Leibniz (1646–1716) also invented calculus, probably without knowing of Newton's work, and around 225 BC the Greek Archimedes had ideas about calculus)
- a book on optics (light, colour, mirrors, and lenses);
- the theory of gravitation (see below)
- his book entitled *The Mathematical Principles of Natural Philosophy*, published in 1687. (The old name for physics was 'natural philosophy'.) This book used mathematics to describe how things move;



Newton's Principia


William Blake's picture Newton, painted in about 1805, shows the 'divine geometer' – the God-like mathematician. Blake objected to Newton's 'disciplined thinking'.

- Newton's method, which is still the basic method of science. It states that in science you:
  - observe
  - measure
  - generalise (produce laws using mathematics)
  - experiment (predict results and try things out)
  - set your arguments in a logical order, starting with your assumptions and definitions
  - keep an open mind.

Newton believed that the laws he discovered were God's work. As he wrote (in Latin), 'God created everything by number, weight and measure'.

The important point is that Newton used mathematics to explain the things he saw: he measured things, then used mathematics to try to explain how different things were related.

Newton's *Principia*, published in 1687, is perhaps the most important book ever written. This photograph above shows Newton's copy of the first edition, and if you look closely you can see his corrections for the second edition.

Newton is famous for the idea of gravity. People say his theory was inspired while watching an apple fall off a tree around 1666. However, it is more correct to say that he worked on the theory for more than 20 years. Gravity was not a sudden 'bright idea'.

Gravity is the idea that everything (matter) in the Universe attracts everything else. Newton understood that when an apple fell off a tree, the Earth itself and the apple both pulled towards each other. Because the apple was lighter, it moved further. However, the Earth does move up a little to meet the apple.

Immanuel Kant

Kant was born in Prussia (now Kaliningrad, Russia), in 1724. He was brought up in a religious household. He studied science, and became a university lecturer. He died in 1804.

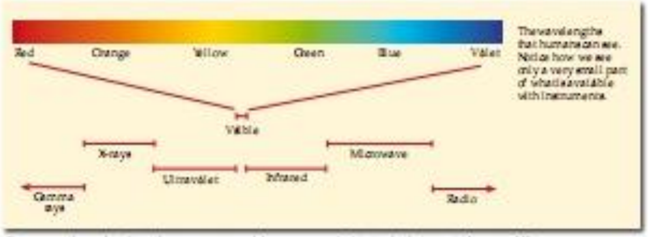
Kant began to ask basic questions about science itself. He asked:

- Why is Newton's physics so successful?
- What is reality?
- What is the Universe?
- What is the nature of the things that exist?

Kant rejected the use of 'God' as an explanation for these things.

Kant made a famous statement which is inscribed on his tombstone in both German and Russian. Translated into English, it reads:

> 'Two things fill the mind with ever new and increasing admiration and awe – the starry sky above me and the moral law within me.'



Electromagnetic wavelengths – those we can see, and those we can only detect using instruments (see page 44)

Kant's work in astronomy included:

- the nebula theory, about how our Sun and its planets came to form. Kant said that the solar system formed from a disk of gas and dust (called a nebula). Laplace (1749–1827) later developed this idea, which is broadly correct
- the idea that 'spiral nebulae' were galaxies beyond our own form
- the prediction of the existence of the planet Uranus. (The actual discovery of Uranus was made by Herschel in 1781)
- predictions about comets
- the claim that there must be intelligent life elsewhere in the Universe.

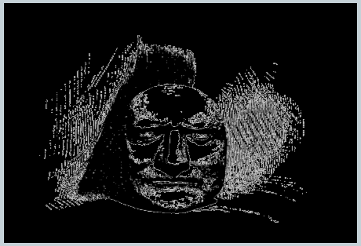
Although Kant's work in science was useful, his most important work is in philosophy. This includes work on the philosophy of science.

Some of Kant's key ideas were:

- Space and time may not really exist. They are perhaps generated within us by the action of our minds.
- The rules of mathematics are not certain. It is possible to have several forms (kinds) of mathematics. In Einstein's physics, for example, there is the idea that a straight line in space is not straight – that space is curved.
- We cannot ever imagine the Universe, because we cannot understand the idea of infinity.
- Human minds are only capable of certain kinds of understanding. There may be other forms of understanding that are always beyond us.
- Understanding is always based on our ability to think or reason, not on a reality that is 'out there'.

Perhaps Kant's most important idea was that human beings are limited by their own senses (sight, hearing, touch, smell, and taste), and by the way their minds are made and work.

Look at the diagram above. The upper part shows the wavelengths of light humans can see. The lower part shows the wavelengths that we know about only using instruments.



Truth, its theory and its practice in science education

THANK YOU

Heidegger’s phenomenology - enquire into human-ness

Ontological structure
- Ontological understanding
- Disposition
- Nomination

Abidance's of truth
- Disclosure
- Correspondence

Care structure
- Casting ahead
- Hermeneutic circle
- Equiprimordial
- Potentiality

Ontological kinetics
- Ways of being in the world
- For-the-sake-of-which cascades