

The Scientific Method

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Penmaenmawr –
Thursday Session 2

MODELLING:

- Science is the quest to develop MODELS of the real world.
- A model is a short description of what happens in the world, which can also be used to answer “what-if” questions.
- Experimental science tests out the “what-if” questions to see whether the model gives the right answer.





MODELS OF THE SOLAR SYSTEM:

- Aristotle (geocentric) – Earth in the centre, everything goes round it in circles.
- Ptolemy (geocentric) – Earth in the centre, everything goes round it in circles with epicycles.
- Copernicus (heliocentric) – Sun in the centre, circles with (fewer) epicycles.
- Tycho (hybrid) – Sun goes round Earth, planets go round sun.
- Kepler (heliocentric) – planets go round the sun in ellipses.
- Centre of Gravity – Sun and planets go round a common centre.



MODELLING THE SOLAR SYSTEM:

- All these systems can offer the maths to give the right answers.
- “The Sun goes round the Earth”? Adequate to describe what we see, but the Sun is clearly the hub of the system.
- “The Earth goes round the Sun?” – better, but the Sun is not fixed in its place.
- “The Earth and Sun go round the centre of gravity of the system.” Mathematically the neatest, and rotation is absolute!



MODELLING:

- No model is perfect, unless it matches reality in every possible circumstance.
- A model is good if it matches reality in a well-defined range of circumstances.
- A model is better when it applies to a wide range of circumstances, or when it can explain the same results in a simpler way (one ellipse better than many epicycles!)



REVISING MODELS:

- The Greeks thought objects stayed still until something pushed them. No good for understanding planets!
- Isaac Newton develops laws of motion which are good for planets, but break down at about $1/3$ of the speed of light.
- Albert Einstein develops special relativity which works up to the speed of light.
- Was Newton right or wrong?



PHILOSOPHY OF SCIENCE:

- Induction: David Hume considered whether you could work out a general principle from a few examples.
- Verifiability – the idea that we test models to see if they are true. But how can we test in all possible ways?
- Falsifiability – Karl Popper suggests that the method of science is to attempt to find where models don't work,
- Revolutions – Thomas Kuhn notes that scientists are a conservative bunch and won't let go of cherished but wrong ideas until there's a bandwagon.



WHEN MODELS CONFLICT:

- General Relativity is a superb theory of gravity. It predicts that nothing gets out of black holes.
- Quantum Physics is a superb theory of very small objects. It predicts that you can't confine an object in too small a space.
- So what happens in very small black holes?



WHEN MODELS CONFLICT:

- We see distant galaxies rotate, and we estimate their mass by using our theory of gravity.
- But we can only see less than 10% of that matter, and if the rest is there, it ought to be giving off light or at least heat.
- Options:
 - Our theory of gravity is wrong.
 - Our theory of matter is wrong.
 - There's a new kind of matter that doesn't obey the rules: we call it **DARK MATTER**.



WHEN MODELS CONFLICT:

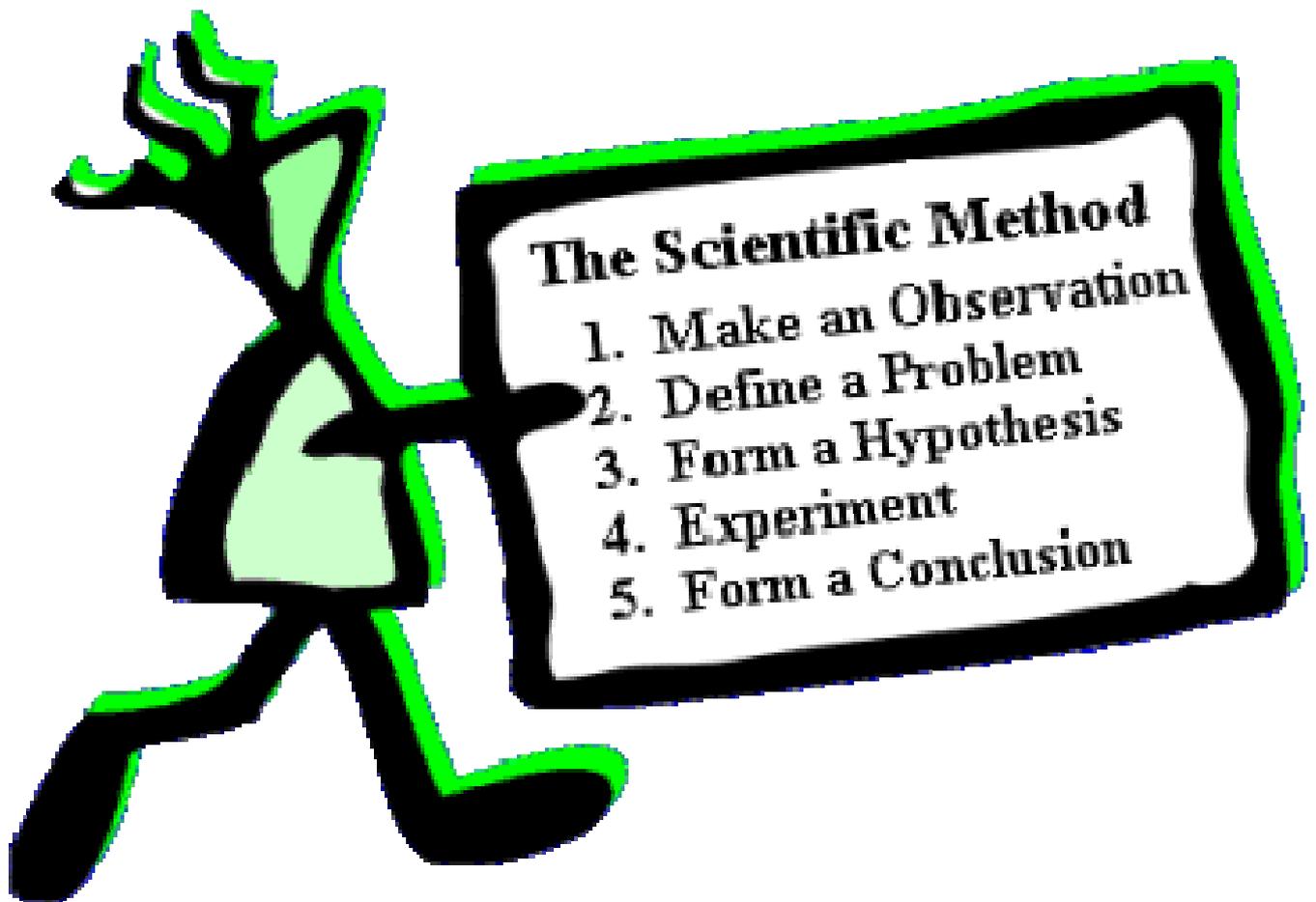
- We see radiation from the Big Bang (15 billion years ago), geological evidence of plate tectonics (over 5 billion years), and fossils of extinct species.
- A literal reading of the Bible suggests the Earth and its creatures are all about 6000 years old.
- Options:
 - Our scientific theories are wrong.
 - Our literal reading of Scripture is wrong.
 - There's a resolution we haven't thought of yet.



ALL MODELS HAVE ASSUMPTIONS

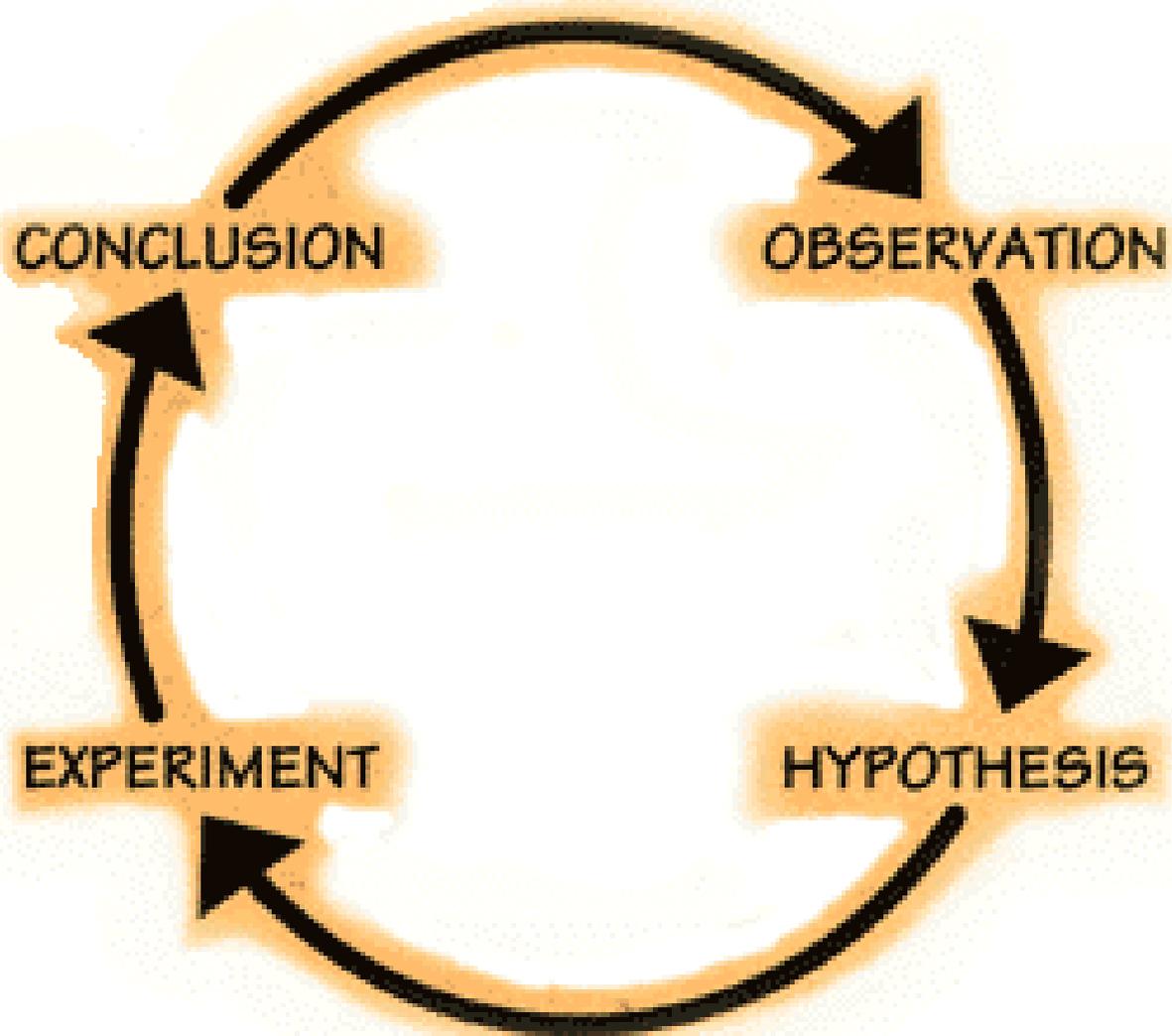
- That the universe here and now works the same way as the universe there and then.
- That the measuring equipment is OK (think of the Hubble Space Telescope fiasco...)
- That we have thought of all the factors we need to control.
- That God isn't going to intervene and do something different today.

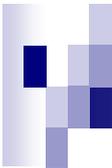
THE SCIENTIFIC METHOD:



- Testing out reality...
- And having reached a conclusion, think of more tests you can do!

THE MODELLING CYCLE:

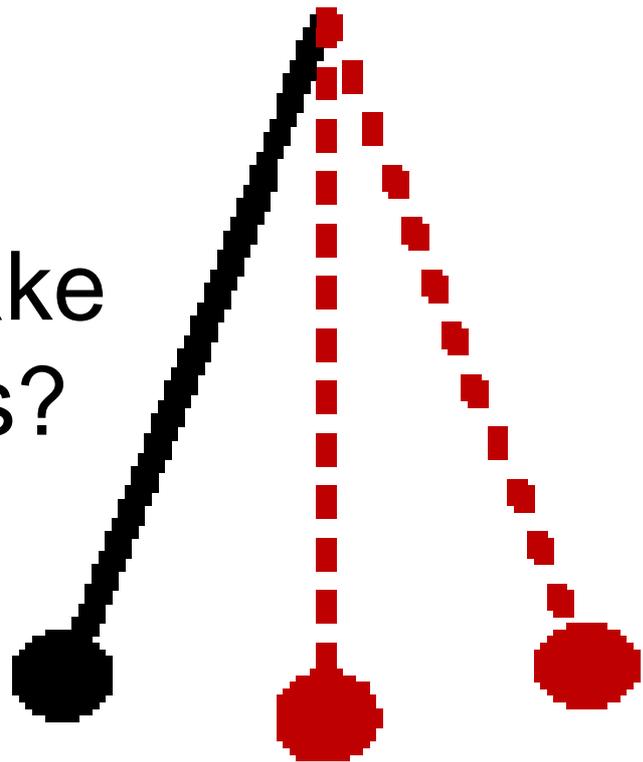




Let's do an
experiment...

How many
swings will a
pendulum make
in 30 seconds?

What factors
might this
depend on?



The 'control': a
dessert spoon on
a 45 cm string.



MIRACLES BY JESUS: The Skeptic's List

- PHYSICAL HEALING (blind, deaf, dumb, lame...)
 - *Psychosomatic?*
- RAISING THE DEAD
 - *If they were really dead!*
- CASTING OUT EVIL SPIRITS
 - *Mental illness and epileptic fits.*
- PHYSICAL MIRACLES
(multiplying bread, water into wine, walking on water)
 - *Folk tales which become attributed to Jesus.*
- CALMING THE STORM
 - *Lucky timing!*



MIRACLES IN THE 20th CENTURY

■ PHYSICAL HEALING

- *Lourdes. Charismatic churches. Many beatification cases.*

■ RAISING THE DEAD

- *Claimed by some African charismatic churches.*

■ CASTING OUT EVIL SPIRITS

- *See “An Exorcist Tells His Story” by Fr Gabriel Amorth, Chief Exorcist of the Diocese of Rome.*

■ PHYSICAL MIRACLES

- *Multiplication of food at Juarez, Mexico, under Fr Rick Thomas. Sr Maria Petkovic’s submarine hatch!*

■ CALMING THE STORM

- *Youth 2000 Trinidad’s hurricane.*



RESPONSES TO MIRACLE CLAIMS

■ DENIAL.

- *The witnesses were gullible or simply mistaken.*

■ NATURAL EXPLANATION

- *Science will figure it out one day, and the religious context is a coincidence or psychological requirement.*

■ SUPERNATURAL EXPLANATION

- *God is at work!*



A THEORY OF MIRACLES

- In Matthew, Mark and Luke, miracles are literally called *dynameis* – works of power.
- In John, they are called SIGNS.
- These signs accompany preaching about the Kingdom of God.
- Miracles take place as a response to FAITH – of the one healed, the one healing, or third parties like the friends of the paralytic.
- Jesus teaches that his followers will do greater works than He Himself.
- So the New Testament expects that God will continue to work miracles.



A THEORY OF MIRACLES

- It is not putting God to the test, to pray for what He has commanded us to do – e.g. to heal the sick.
- Nevertheless, *God cannot be forced to deliver a result on any particular occasion.*
- Failure to produce a miracle is not automatically an indictment of weak faith.
- **HYPOTHESIS:** if a Christian proclaims the Kingdom and prays for healing, God will sometimes be seen to deliver!