

Belief in Science and Religion

Lecture 2: Scientific Methods



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Belief in Science and Religion

Lecture 2: Scientific Methods

- **What science is not like**
- **What science is like**
- **What science is**

What Is Science Like?

Science is...

- **Experimental**
- **Objective**
- **Hypotheses – Prove / Refute**
- **Applicable, Useful**
- **General,**
- **Person-independent, shared**
- **Models**
- **Predictive**
- **Dependable**

Science is ... Universal

Scientific statements are

- Universal
- Timeless
- Necessary

$$\mathbf{F = m a}$$

- Everywhere
- Always
- For everyone

Science is ... ~~Deductive~~

Deductive logic: from general to specific.

All swans are white

+

This animal is a swan



This animal is white

Premises

Conclusion

**If the premises are true,
the conclusions are *necessarily* true.**

Science is ... ~~Certain~~

“Few philosophers or scientists still think that scientific knowledge is, or can be, proven knowledge...”

but few realize that with this the whole classical structure of intellectual values falls in ruins and has to be replaced.”

I. Lakatos *Methodology of Scientific Research Programmes*



Science is ... Not Verifiable

Scientific statements can be falsified, but not verified.

e.g. “All swans are white”



Verified?



Falsified?



Science is ... Not Verifiable

Scientific statements can be falsified, but not verified.

e.g. “**Not** all swans are white”



Verified?



Falsified?



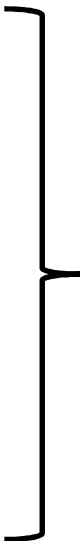
Science is ... Not Verifiable

Scientific statements can be falsified, but not verified.

Scientific statements
can be falsified
But not verified.

+

The statement
“Not all swans are white”
can be verified.

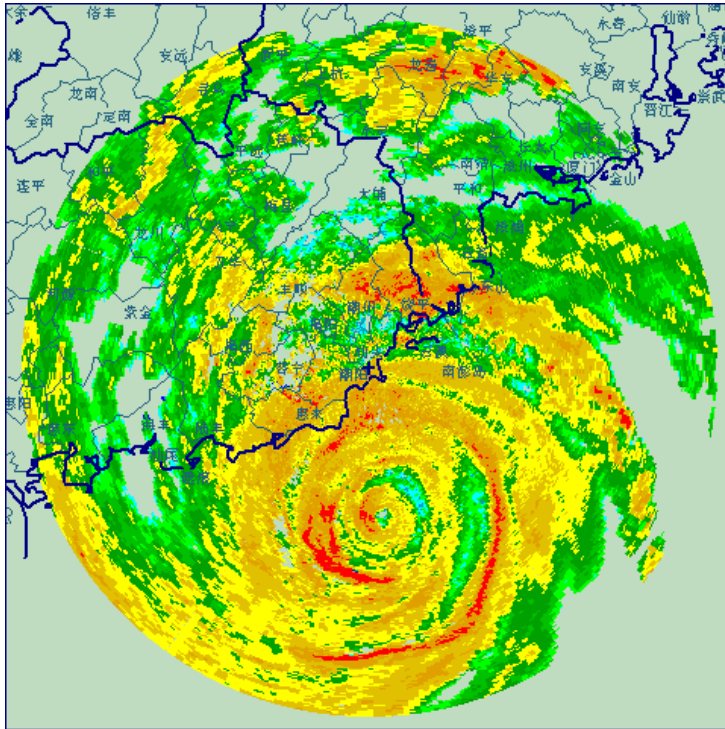


The statement
“Not all swans are white”
Is not scientific.

Scientific statements are universal, timeless and necessary

Science is ... Not Verifiable

Scientific statements are universal, timeless and necessary

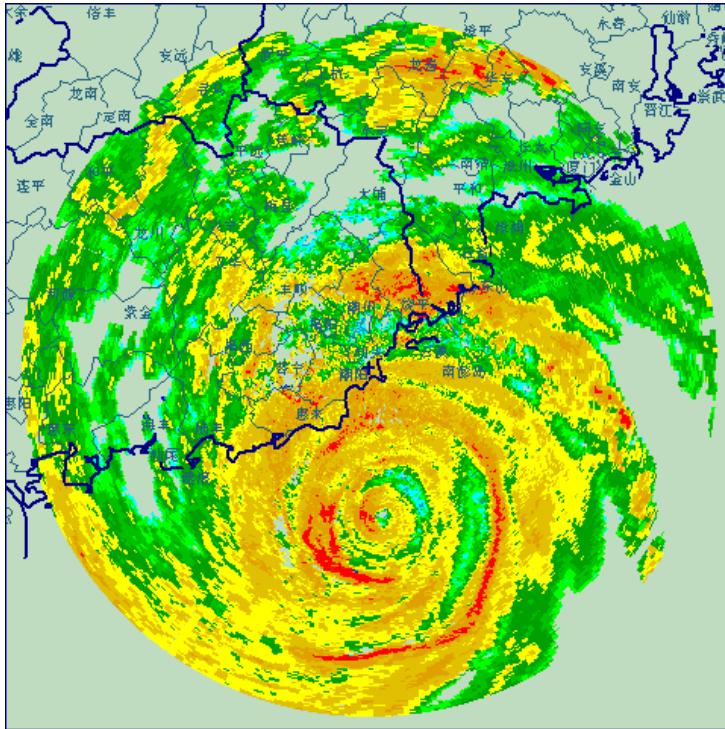


$$F = m a$$

“It will rain tomorrow”

Science is ... Not Verifiable

Scientific statements are universal, timeless and necessary
~~are~~ can be



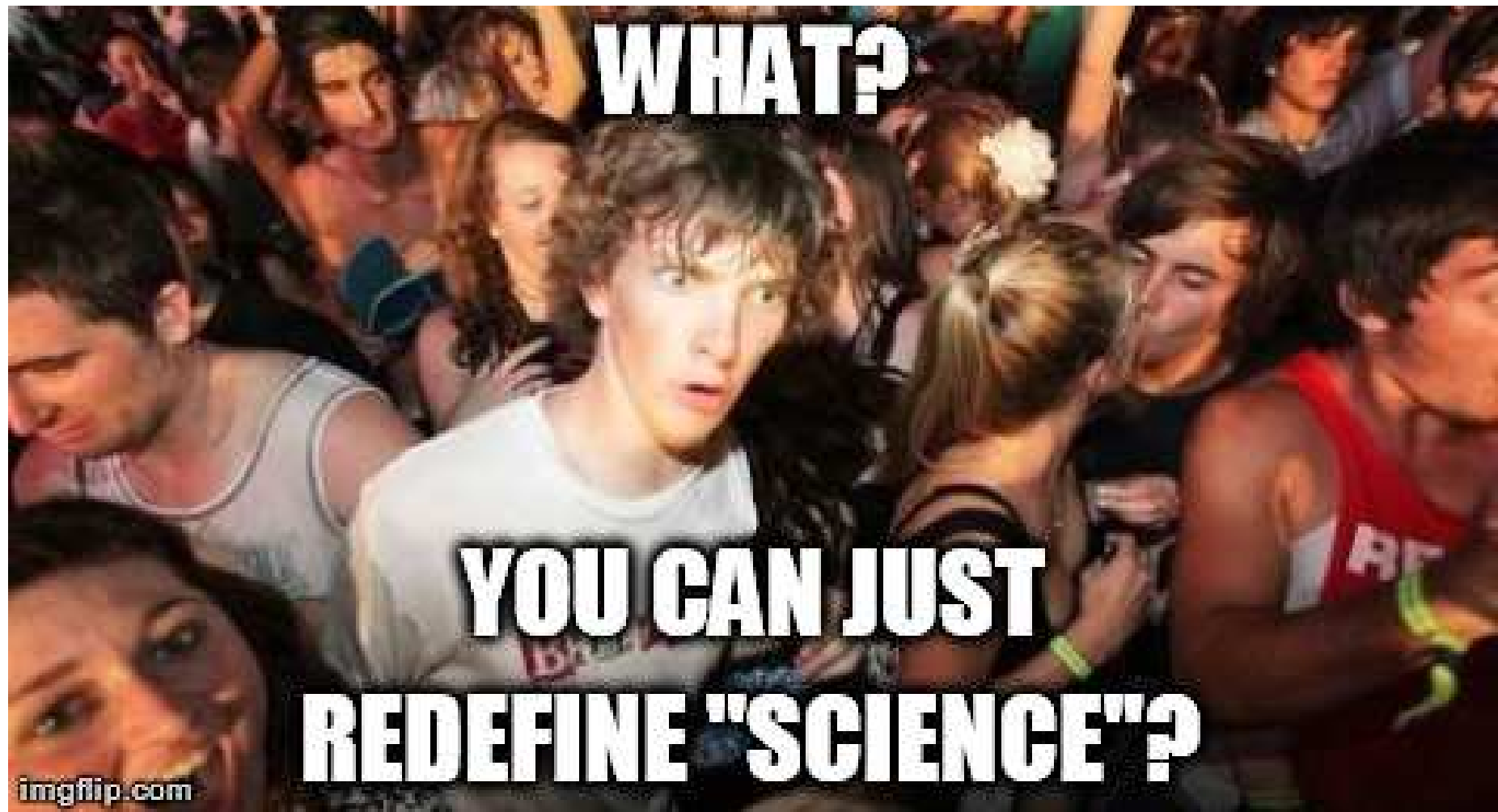
$$F = m a$$

“It will rain tomorrow”

but can also be specific, temporal, and contingent.

Science is ... Not Verifiable

Scientific statements ~~are~~ universal, timeless and necessary
can be, but do not have to be



Science is ... Falsifiable

State, in advance, what event would constitute a falsifying instance of a particular theory.

If this event occurs, the theory is falsified, and must be rejected.

Science is ... Falsifiable

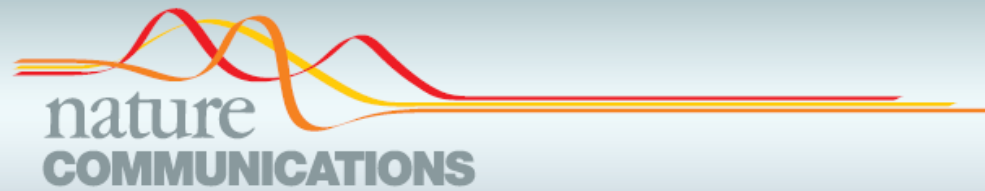
Falsifying evolution



A perfect example of adaption to the environment

Science is ... Falsifiable

Falsifying evolution



ARTICLE

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OPEN

Mid-Pliocene warm-period deposits in the High Arctic yield insight into camel evolution

Natalia Rybczynski¹, John C. Gosse², C. Richard Harington¹, Roy A. Wogelius³, Alan J. Hidy² & Mike Buckley⁴

Science is ... Falsifiable

Falsifying evolution

“We report ... the first evidence of a High **Arctic camel**... It is likely that modern camels are derived from a lineage that was originally adapted to living in Late Neogene, northern forests, and some traits seen in modern camels may reflect this heritage... **specialized traits seen in modern camels may also have served well in an Arctic realm.** For example their **wide flat feet** function well on soft substrates, such as **sand or snow**. Their iconic **hump(s)**, containing fat, also may have been adaptive. [They] could have been critically important for allowing populations to survive and reproduce in harsh climates characterized by 6-month **long, cold, winters.**”



Feet

Humps

Nostrils

Eye lashes

Lips

Fur

Science is ... ~~Falsifiable~~

Science must be falsifiable

+

Evolution does not get falsified



Evolution is not
science

Evolution is science

+

Evolution is not falsifiable

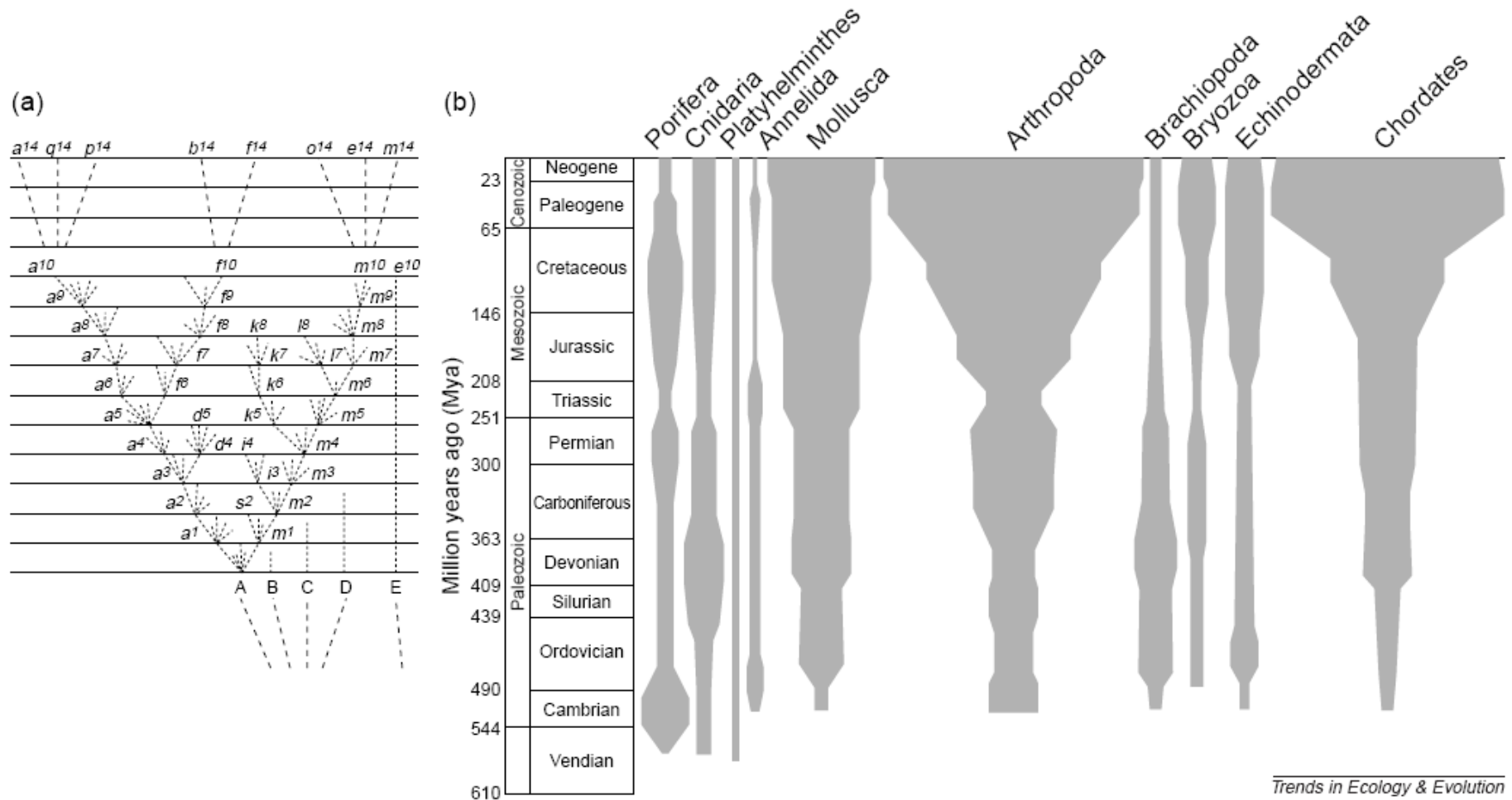


Science does not have to
be falsifiable

Science is ... ~~Falsifiable~~

Falsifying evolution

“New concepts need to be integrated into an expanded evolutionary synthesis.”



Trends in Ecology & Evolution

Too Many Ways To Be Wrong



Too Many Ways To Be Wrong



This bull is a boy

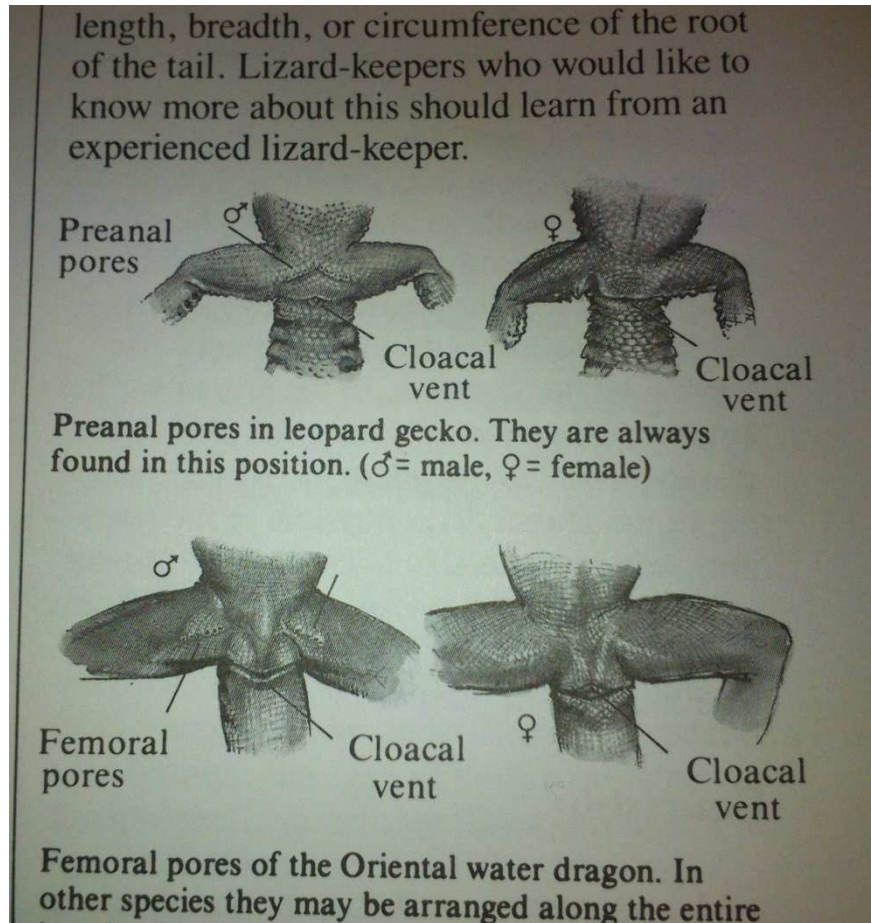
Too Many Ways To Be Wrong



All dinosaurs are girls

Too Many Ways To Be Wrong

Sexing reptiles



Even if a dinosaur had a penis, you might not see it

Too Many Ways To Be Wrong



Too Many Ways To Be Wrong



“Daddy, my pirate is a dinosaur.”

Too Many Ways To Be Wrong

Duhem Quine hypothesis

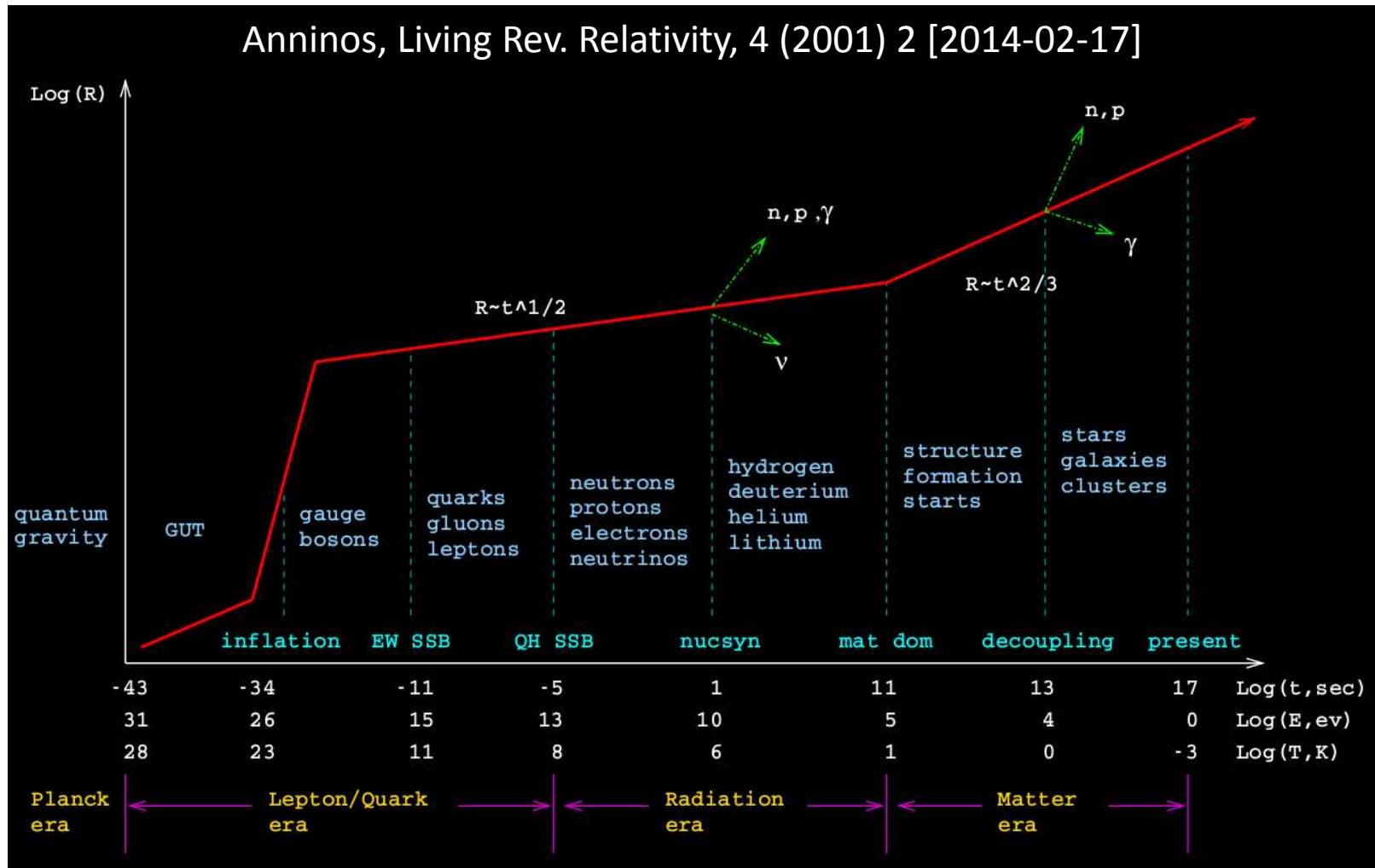
**“Our statements about the external world
face the tribunal of sense experience not individually
but only as a corporate body.”**

For any finite set of observations or statements
there exist an infinite number of theories
with which they are entirely consistent.

**Scientific statements are not
falsifiable**

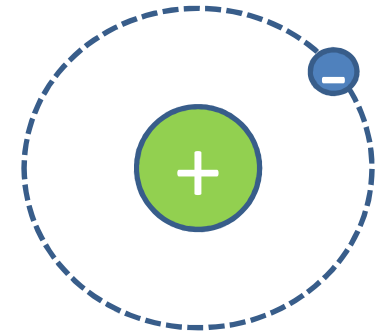
Science is... ~~Reproducible~~

Standard cosmological model



Science is ... Explanatory

Quantum mechanics: Bohr model



Classical problems:

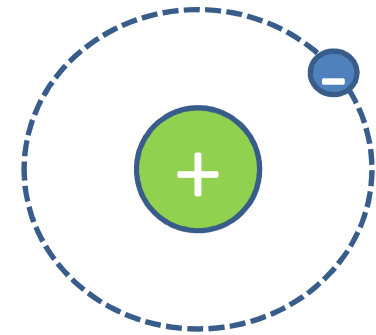
Quantum answers:

- Why doesn't the electron fall into the nucleus?
- Electrons orbit the nucleus without falling in.
- Why do you get narrow emission / absorption lines?
- Electrons moves between stable states by emitting or absorbing narrow linewidth radiation.
- Why are the absorption lines distinct?
- The energy levels of the electrons are discrete.

Science is ... ~~Explanatory~~

Science is ... Predictive

Quantum mechanics: Bohr model



Theory: Bohr

Phil. Mag., 26 (1913) 1-25.

Experiment: Lyman

Astrophys. Jour., 23 (1906) 181-210.

Science is ... ~~Explanatory~~

Science is ... ~~Predictive~~

Science is ... Unifying

Quantum mechanics: Bohr model

Bohr:

Atomic hydrogen (just about)

Not Bohr:

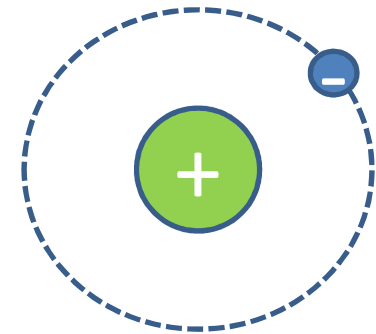
Helium, Lithium,

Molecular hydrogen,

Classical mechanics,

Classical electrodynamics...

Everything except atomic hydrogen.



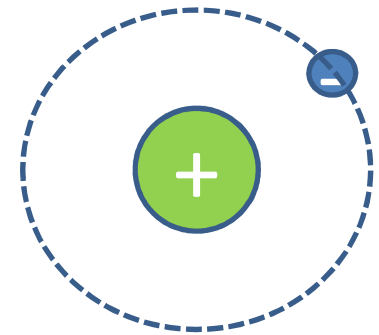
Science is ... ~~Explanatory~~

Science is ... ~~Predictive~~

Science is ... ~~Unifying~~

Science Makes Progress

Quantum mechanics: Bohr model



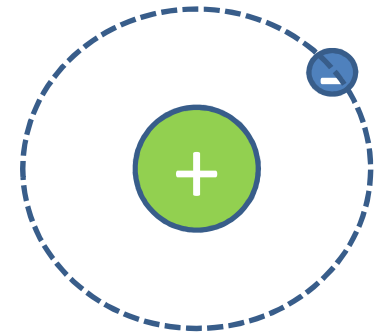
Science is ... ~~Explanatory~~

Science is ... ~~Predictive~~

Science is ... ~~Unifying~~

Science ~~Makes Progress~~

Quantum mechanics: Bohr model



Science Works

If it is scientific then it works

Having problems with your teeth?

Bruise easily?

Blurred vision?

Bad complexion? Pale? Spotty? Yellow?

Feeling grumpy?

Fever?

At death's door?

Science Works

If it is scientific then it works

If it works then it is scientific



Having problems with your teeth?

Bruise easily?

Blurred vision?

Bad complexion? Pale? Spotty? Yellow?

Feeling grumpy?

Fever?

At death's door?

Vitamin C!

Science Works

If it works then it is scientific

Acne,
Alcoholism,
Arthritis,
Dysentery,
Haemorrhagic fever,
Hay fever,
Headaches,
Infertility,
Insomnia,

Lactation deficiency,
Malpositioning of the foetus,
Nicotine addiction,
Obesity,
Sciatica,
Schizophrenia,
Stroke,
Whooping cough,
possibly Coma.

Science Works

If it works then it is scientific

Sir Isaac Newton:

Gravity,

Optics,

Transmutation.

When Science Won't Let Go

The universe follows rules

Science is Not Alone

The greatest good is served by
the individual maximising profit

Science is Not Alone

God is good

Summary

- “The scientific method” is not well defined.
- At pragmatic root, applied science does whatever works.
- Pure science does whatever is necessary to protect the claim “the universe follows rules”.
- Other subjects also have a “hard core” they protect at all costs.