Physics : Part 2 : Video 9 : Conclusion

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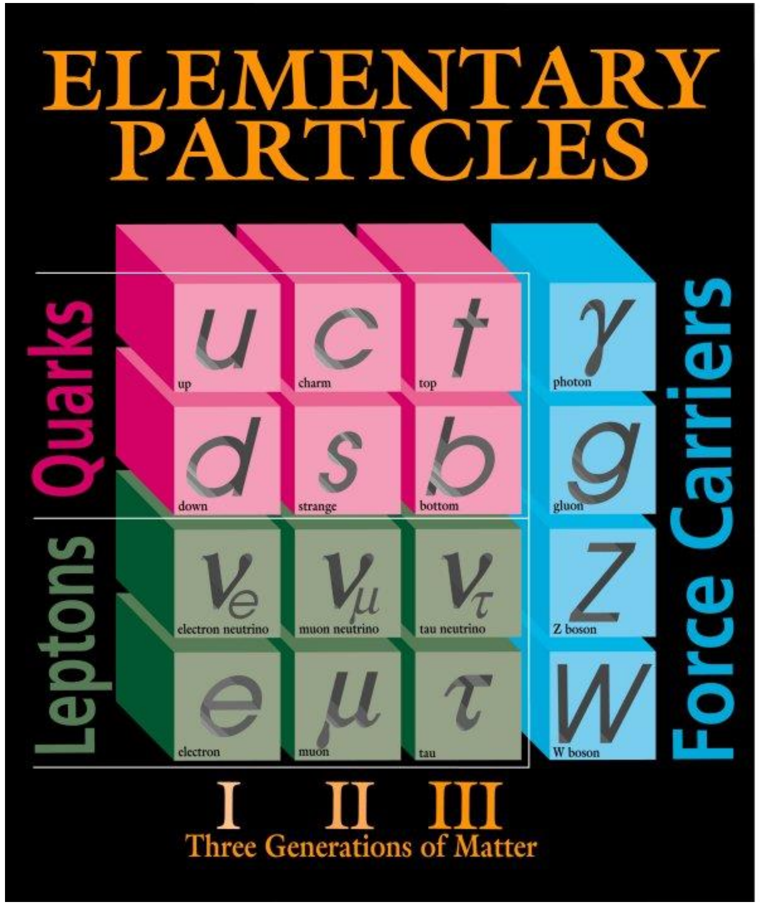
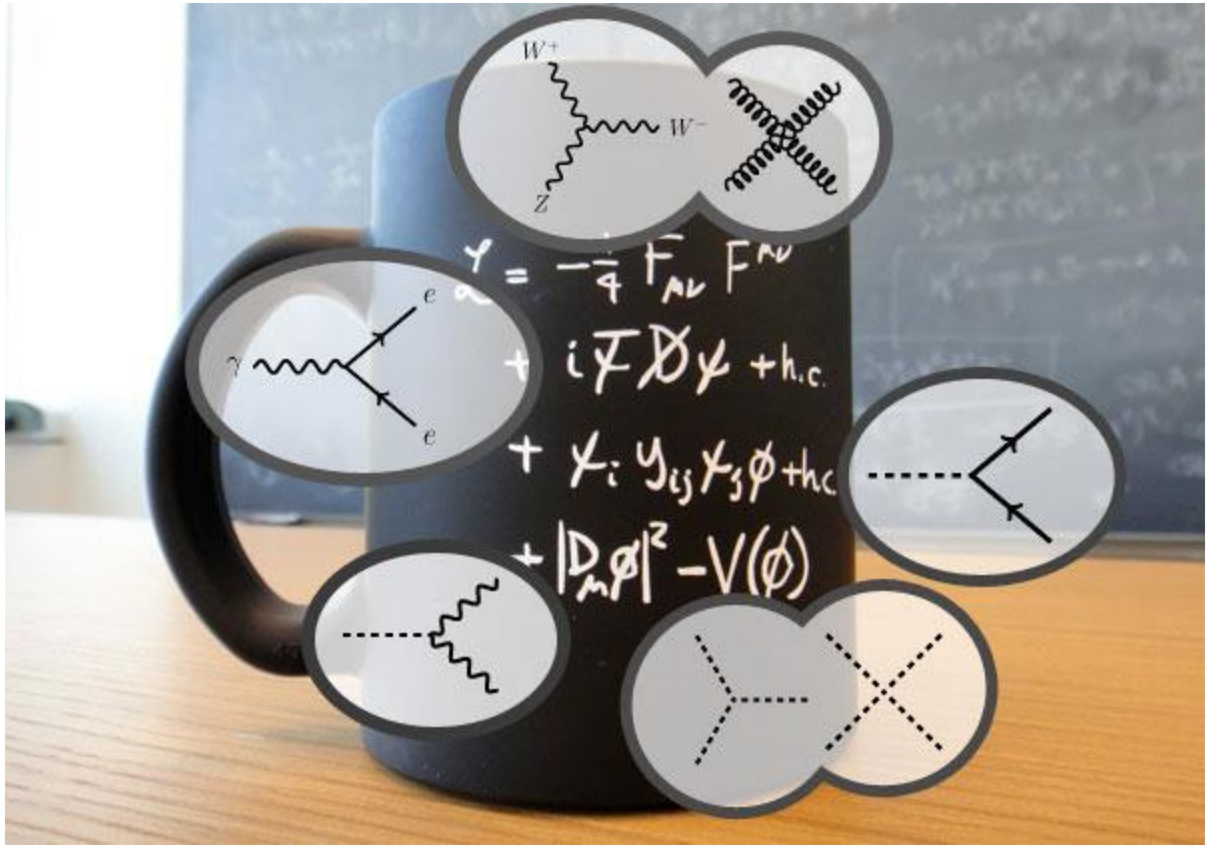
Department of Physics

Contents:

Questioning Nature … Reductionism:





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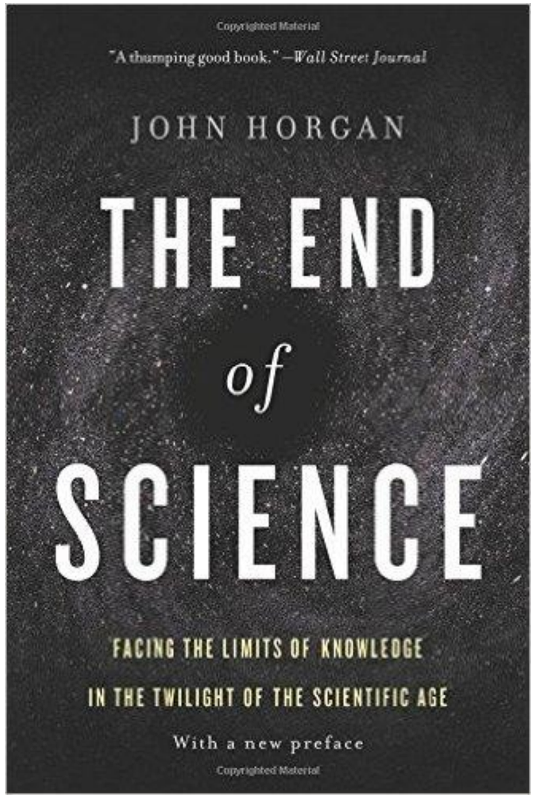
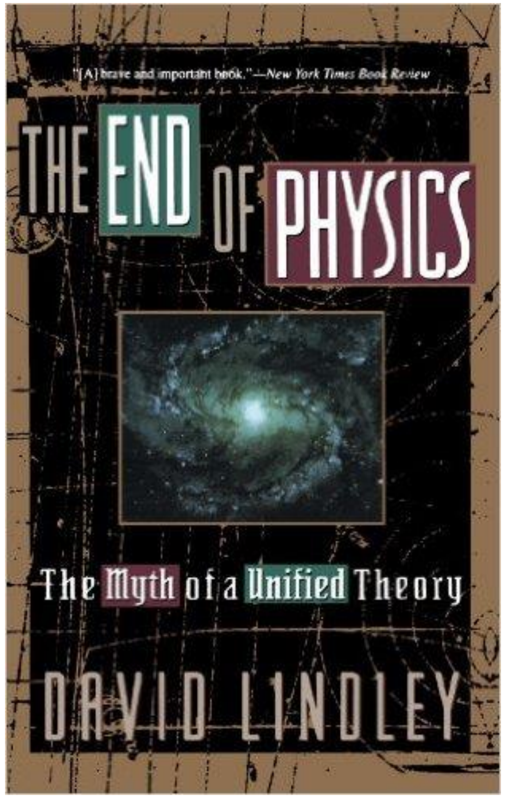
Is there an End to Science (Physics) ?



The "last" particle to be discovered is called the God particle or Higg's particle.

Why is this particle so important ? Because it gives other fundamental particles mass.

There is a 2015 edition.

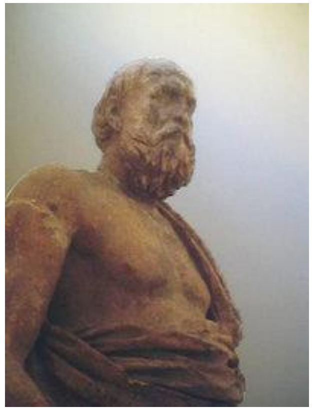


J. Horgan, *The End of Science*, 1996 Broadway Books.
D. Lindley, *The End of Physics*, 1993, Persus Book.

Reductionistic thinking

We can easily forgive a child who is afraid of the dark; the real tragedy of life is when men are afraid of the light. … … that one can never understand the Universe until the smallest components of matter are known.

Plato 427-347 BC



Heisenberg,
was influenced by this tenet of Plato
… but he changed his mind later.

By getting to smaller and smaller units, we do not come to fundamental or indivisible units. But we do *come to a point* where further division has no meaning.

Heisenberg

Is there a future for Physics Knowledge?

Physics has a future only to the extent that an existing theory is incomplete …

… But it is also useless ! It becomes philosophy. It cannot be tested. We will never know whether we know everything that exists. All we can ever know is everything we know ! This problem is, of course, insurmountable but it has an important implication that is often not appreciated. It is the fundamental tenet of science that we can never prove something to be true; we can only prove it to be false. This is a very important idea, one that is at the basis of all scientific progress.

L. M. Krauss, *Fear of Physics*, 2007, Basic Books.

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Is there an End to Science (Physics) ?

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What are these Emergence questions ?

Would it be better to seek mathematical questions ?

Godel’s Incompleteness Theorem

Is Science a Human and Cultural Activity ?

Against Reductionism :

Particle theorists say that they are discovering "the mind of God". It is not the mind of God at all … particle physics cannot explain things like superconductivity, life and consciousness.

P. Anderson
Nobel Laureate

M. Durrani, *Against Reductionism, Nov. 2006* Physics World.

Anti-Reductionism :

Anderson's dislike of particle physics stems in part from its strong reductionist tendencies, according to which all of science can, in theory, be derived from just a few fundamental principles. Follow any arrow of explanation, so the argument goes, and you end up at a common source: elementary particle physics. M. Durrani

M. Durrani, *Against Reductionism, Nov. 2006* Physics World.

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What is Emergence Theory ?

Emergence states that everything we observe at one level obeys the laws at a more primitive level, but those observations cannot necessarily be deduced from that level. Molecular biology, for example, does not violate the laws of chemistry yet contains ideas that probably could not have been deduced directly from those laws. Instead, emergence says that when certain systems reach a sufficient level of complexity, new phenomena “emerge” that do not exist for the elementary components of that system.

M. Durrani, *Against Reductionism, Nov. 2006* Physics World.
P. Anderson, *More is Different*, 1972, Science 177 393

Emergence :

Anderson points out that emergence is not simply a case of the whole being more than the sum of the parts, which is how some scientists – biologists in particular – tend to view the concept. “They see a hammer and a hammer handle, and then put them together to get new functionality,” he says. “That’s not my concept: emergence says that large systems become qualitatively different from small systems when you change the scale.

… other related questions about nature can be found in Complexity and Chaos Theories

M. Durrani, *Against Reductionism, Nov. 2006* Physics World.
P. Anderson, *More is Different*, 1972, Science 177 393

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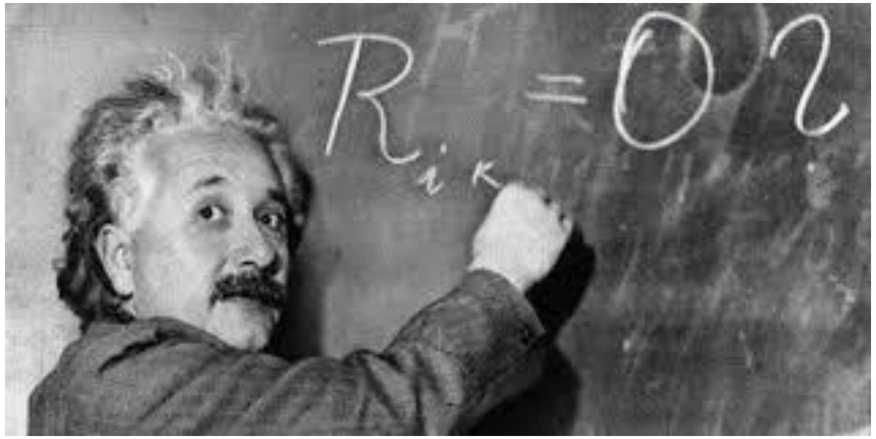
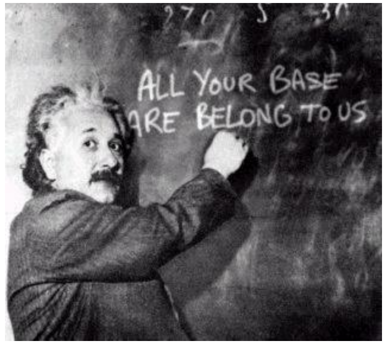
Have a glimpse of the new language ?

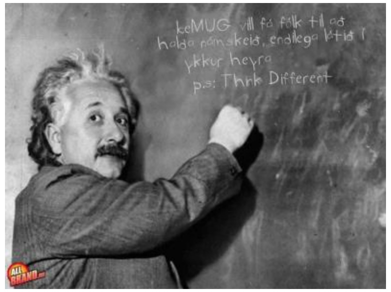


What is exactly R_{ik} , ?

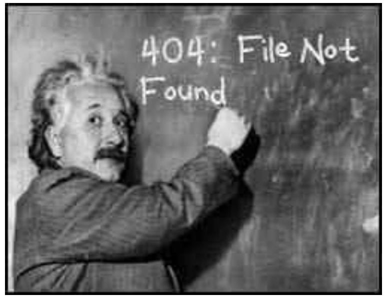
$$R_{ik} = \frac{1}{r}\frac{\partial V_{ik}}{\partial r} + \frac{1}{2}\frac{\partial^2 V_{ik}}{\partial r^2}$$



$$R_{ik} - \frac{1}{2} R g_{ik} = \frac{8\pi G T_{ik}}{c^4}$$



Famous Einstein Field's Equations !



I. Egdall, *Einstein*, 2014, World Scientific Pub.

The Genius : Einstein's Field Equation

$$R_{ik} - \frac{1}{2} R g_{ik} = \frac{8\pi G T_{ik}}{c^4}$$

$$\begin{pmatrix} R_{tt} & & & \\ & & & \\ & & & \\ & & & \end{pmatrix} - \frac{1}{2} R \begin{pmatrix} g_{tt} & & & \\ & & & \\ & & & \\ & & & \end{pmatrix} = \frac{8\pi G}{c^4} \begin{pmatrix} T_{tt} & & & \\ & & & \\ & & & \\ & & & \end{pmatrix}$$

Let's re-write using the notations below

$$(t, x, y, z) \longrightarrow (x_0, x_1, x_2, x_3)$$

$$\begin{pmatrix} R_{00} & - & - & - \\ - & - & - & - \\ - & R_{21} & - & - \\ - & - & - & - \end{pmatrix} - \frac{1}{2} R \begin{pmatrix} g_{00} & - & - & - \\ - & - & - & - \\ - & g_{21} & - & - \\ - & - & - & - \end{pmatrix} = \frac{8\pi G}{c^4} \begin{pmatrix} T_{00} & - & - & - \\ - & - & - & - \\ - & T_{21} & - & - \\ - & - & - & - \end{pmatrix}$$

This is the famous Ricci Curvature Tensor

What is a Tensor ? … Matrix

The Price to pay … for new ideas

It is not until we attempt to bring the theoretical part of our training into contact with the practical that we begin to experience the full effect of what Faraday called "*mental inertia*" … not only the difficulty of recognizing among the objects before us, the abstract relations which we have learned from books, but *the distracting pain of wrenching the mind away from the symbols to the objects, and from the objects back to symbols*. This, however, is the price we have to pay for new ideas.

J.C. Maxwell
Intro lecture at Cavendish Lab. 1871

Physics is not Mathematics

Mathematicians are only dealing with structure of reasoning, and they do not really care what they are talking about. They do not even need to know what they are talking about, or as they themselves say, whether what they say is true … In other words, mathematicians prepare abstract reasoning ready to be used if you have a set of axioms about the real world. But the physicist has meaning to all his phrases.

Physics is not mathematics, and mathematics is not physics. One helps the other. But in physics you have to have an understanding of the connection of words with real world.

R. P. Feynman (on Relation of Mathematics to Physics), *The Character of Physical Law,* 1967, MIT Press.

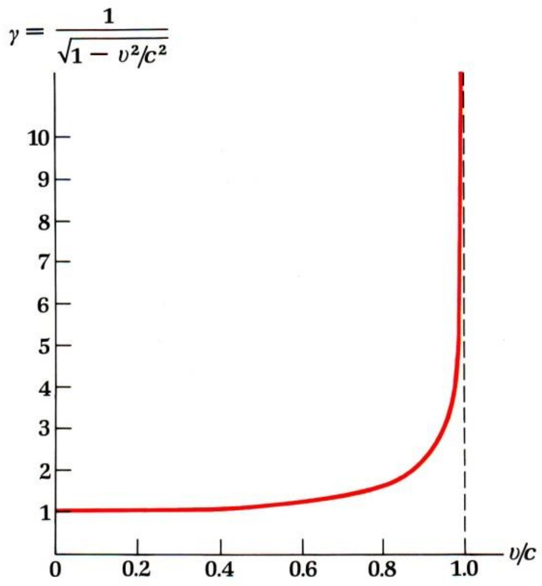
Example : Relativistic Mass

Does this mean that momentum (mass) can increase without any limit ?

Does this mean that speed can also increase without any limit ?

Caveat Emptor :

In Newtonian ideas, particles behave as if their masses increase with speed. Einstein initially favoured this interpretation but later changed his mind to keep mass as a constant, an intrinsic property of matter that is the same in all frames of reference. So it is gamma that changes with speed, not mass.



$$m = \frac{m_0}{\sqrt{1 - \frac{v^2}{c^2}}} = \gamma\, m_0$$

Physics vs Mathematics

Mathematicians like to make their reasoning as general as possible. If I say to them, ‘I want to talk about ordinary 3 dimensional space’, they say ‘If you have a space of *n* dimensions, then here are the theorems.

The Physicist is always interested in the special case; he is never interested in the general case. He is talking about something; he is not talking abstractly about anything. He wants to discuss the gravity law in 3 dimensions; he never wants the arbitrary force case in *n*- dimension.

The mathematical rigour of great precision is not very useful in physics.

R. P. Feynman (on Relation of Mathematics to Physics), *The Character of Physical Law,* 1967, MIT Press.

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Is Science a Human and Cultural Activity ?

David Hilbert (1862 – 1943) German

Hilbert believed that mathematics was unassailable, and that he had a plan to prove it. Few doubted Hilbert's assertion because he was the premier mathematician of his time.

Kurt Godel, a young mathematician in the 1930's, was one of the mathematicians who believed in Hilbert and he set out to prove Hilbert right. But what Godel found instead was that Hilbert was wrong.

Godel's discovery involved a long mathematical line of reasoning, but what he uncovered is not hard to understand. He discovered that there are always some mathematical truths in any mathematical system of sufficient complexity; algebra is an example that can't be proved true within that system. This was not only a loose end but a gigantic hole.

Most influential and universal mathematician of the 19th and early 20th centuries.

Kurt Friedrich Gödel (Austrian)

According to Godel, the elementary rules that we use in junior colleges to apply to solving arithmetic and mathematical problems are inconsistent and incomplete.

This leads to a profound implication that no matter what we prove, we will always have incomplete proof.

This applies to physics as well, as it uses a lot of mathematics.

https://en.wikipedia.org/wiki/Kurt_G%C3%B6del

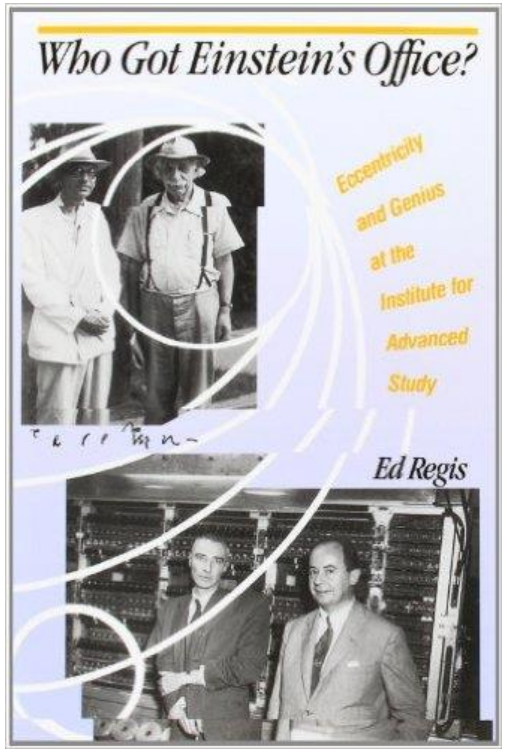
Austrian Logician
Mathematician and Philosopher

Kurt Friedrich Gödel (1906 – 1978)

Who was Godel ?

In 1933, Godel became a close friend of Einstein at Princeton. He used Einstein General Relativity Theory's field equation to address the many paradoxes of time and rotating Universes.

This great mathematician would *wear* warm, winter *clothing* in the middle of summer. ... Some say that he was dependent on his wife.



Austrian Logician
Mathematician and Philosopher

https://en.wikipedia.org/wiki/Kurt_G%C3%B6del

Implications of the Theorem

Godel fundamentally translated self-referential statements that led to ambiguity in the language domain, into their mathematical equivalents and proved that, as in language, there is also ambiguity in the mathematical way of reasoning.

This came as a rude shock to the scientific community in the same manner as Relativity and Quantum Theories did to Classical Physics.

Austrian Logician
Mathematician and Philosopher

S. Nalawade, *The Speed of time*, Wordizen Books, 2012

Self-reference Logic

Consider the following 2 statements

The following statement is not true.
The above statement is false.

https://en.wikipedia.org/wiki/Waterfall_(M._C._Escher)

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Science and Humanity

Science is an important part of the humanities because it is based on an essential human trait; curiosity about the “hows” and “whys” in our environment. We must foster wonder, joy of insight. Such attitudes are crucial not only in the natural sciences but in human relations, social issues, politics and art.

We must be concerned, ask questions and see things from different angles. There are no pat answers; there is no flat knowledge.

Science can foster an open attitude which is helpful in other human activities and culture. It can give us a much fuller, more meaningful life.

V. Weisskopf, *The Privilege of Being a Physicist*, 1989, Freeman

Science a Human Activity

It's not just that scientists have their normal share of human roguishness. The scientific enterprise at its best depends on very human prejudices and preconceptions. I know that I did some of my own best work because I had certain preconceptions about the way forces ought to work, and ignored experimental evidence to the contrary, and I did not succeed in taking the next step in this work because I was prejudiced against certain mathematical methods. It's not an atypical story. I know of no better way of teaching science to undergraduates than through its history. Science is, after all, a part of the history of humanity, and not, I think, the least interesting part.

S. Weinberg, *Facing Up*, 2003, Harvard U Press.

Science a Cultural Activity

Finally, I want to stress that physics is a human creative intellectual activity, like art and music. Physics has helped forge our cultural experience. I am not sure what will be most influential in the legacy we pass on, but I am sure that it is a grave mistake to ignore the cultural aspect of our scientific tradition.

In the end, what science does is change the way we think about the world and our place within it. To be scientifically illiterate is to remain essentially uncultured. And the chief virtue of a cultural activity - be it art, music, literature, or science - is the way it enriches our lives.

L. M. Krauss, *Fear of Physics*, 2007, Basic Books.

Summary : Final Comments 1:

Popper developed this insight into a full-scale theory of knowledge. According to him, physical reality exists independently of the human mind, and is of a radically different order from human experience - and for that very reason can never be directly apprehended. We produce plausible theories to explain it, and if these theories yield successful practical results, we go on making use of them for as long as they work. Nearly always, though, they run us into difficulties sooner or later by proving inadequate in some respect, and then we cast around for a better theory, a more ample one that explains everything the first one could explain without being subject to its limitations.

B. Magee, *The Story of Philosophy*, 2001 Dorling Kindersley.

Summary : Final Comments 2:

We do this not only in science but in all other fields of activity, including everyday life. It means that our approach to things is essentially a problem-solving one, and that we make progress not by adding new certainties to a body of existing ones but by perpetually replacing existing theories with better theories. The search for certainty, which obsessed some of the greatest Western philosophers from Descartes to Russell has to be given up, because certainty is not available.

B. Magee, *The Story of Philosophy*, 2001 Dorling Kindersley.