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# ASTROPHYSICS, COSMOLOGY AND ASTROBIOLOGY AT A POPULAR LEVEL AS A LEGACY OF IYA2009

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RESUMEN

Presento una cuidadosa selección de conceptos fundamentales e ideas básicas, con el fin de capturar la esencia de los asombrosos descubrimientos astrofísicos y hacerlos accesibles al público de todas las edades como un legado del IYA2009.

ABSTRACT

I present a careful selection of fundamental concepts and basic ideas, in order to capture the very essence of the amazing astrophysical discoveries and to make it accesible to the public of all ages as a legacy of IYA2009.

*Key Words:* education — outreach

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Ed. G. Magris, G. Bruzual, & L. Carigi

## 1. INTRODUCTION

In order to celebrate the 400th anniversary of the telescope, 2009 has been declared The International Year of Astronomy (`www.astronomy2009.org`). There will be thousands of special events worldwide that hopefully will enhance the relevance of Astronomy within the cultural fabric of modern societies. In the longer term, the legacy of IYA2009 would be naturally connected to elementary education and public outreach. Extra solar planets, the robotic exploration of Mars, Saturn and its moons, life and death of stars, particle cosmology, water and life in the solar system, super massive black holes, dark energy, transparent matterâ|. to capture the very essence of all these amazing discoveries and to make it simple and accessible to the citizens of planet Earth of all ages, is a major task towards building up such a legacy.

What do citizens of planet Earth need to know about the Universe in the 21st century? How to mitigate the effect of so many bizarre misconceptions and strange beliefs? Here is a careful selection of fundamental concepts and basic ideas in the shape of isolated core themes:

## 2. TINY BUILDING BLOCKS

To know that everything, absolutely everything we see in the Universe, from a flower or a child, to a mountain or a star is made out of the very same tiny building blocks. To know that all things are made out of smaller things put together, which in turn, are made from even smaller things. The building blocks of everything around us are so small that we can not see them. A useful analogy is a city made out of houses, which are made out of bricks, themselves made out of simple grains of sand. The concept could be introduced to audiences as young as five. No need (it could be even counterproductive) to go into details, just leave the concept as an amazing isolated fact to be explored in their future education. An interesting consequence of this is that the big things (like houses and buildings) may look very different from each other, while the smaller ones are more alike (like the grains of sand). The concept of an atom could follow for older kids (say, from 8 years old), by using building blocks like differently coloured plasticine balls or magnetic marbles to assemble the nuclei of atoms of well known chemical elements like hydrogen, helium, carbon, oxygen, calcium and gold. Hard work in this last case, to put together 79 red (proton) and 118 blue (neutron) marbles, but very useful to illustrate how each atom of the 90 or so chemical elements found in nature is made out of different numbers of the very same red and blue balls put together. The topic can be expanded to craft a very simple periodic table, where the positions of the selected elements are identified and enhanced.

## 3. ASSEMBLING THE BUILDING BLOCKS OF THE UNIVERSE

To know that assembling the Universe is necessarily a very long sequential process. That there cannot be big things without having small things first. In particular, to know that the Universe started with the smallest things possible called fundamental particles and that at that time there was nothing else. To know that far from coming from chaos, the early

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Universe was very simple and ordered. That little by little, those fundamental particles would join together to assemble the atoms that make absolutely everything we see around and above us.

To know that the assembly process can only happen at very high temperatures found only deep inside stars. Once again, going into details could be a distraction and dilution of the importance of the concept. To know that ever since the formation of fundamental particles at the early stages of the Universe, there has been nothing else new, but only the development of complexity by assembling those particles in clusters and that stars are fundamental in that process.

## 4. OUR PLACE IN THE UNIVERSE: A SENSE OF SCALE FOR DISTANCE AND TIME

In order to visualise and to get at least a rough idea of the vast distances in the Universe, it is essential to use a linear scale which allows direct comparison of relative dimensions. Linear scales attempting to represent both small and large dimensions may have severe practical limitations, but still worth displaying them. A couple of examples:

- Think of the Sun as a football, planet Earth as a peppercorn 25 m away, Jupiter a plum 150 m away, the nearest star another football 6,500 km away, nothing in between. An immediate conclusion is that the Universe is mainly vast empty space.

- A linear time model: Use a rope stretched 14 m as a time line. Any millimetre along it would represent one million years. Hang pictures from it illustrating the Big Bang, the first stars, the origin of the Solar System, the emergence of life on Earth, etc. The entire lifetime of humanity would fit in less than the thickness of a sheet of paper. Debate about the wide empty spaces along the rope and how recent the Solar System and life on Earth are. The last 4 metres along the rope will show the biological time, when chemistry had favourable conditions to develop extraordinary levels of complexity that triggered Darwinian natural selection of species around half a metre ago on that time line. This topic has a fortunate link to the 200th anniversary of Darwin's birth and brings the opportunity of merging astronomy and biology in more than one way, meaning scientific, philosophical and religious.

## 5. HOW DO WE KNOW? THE COLOURS OF THE RAINBOW

To know that across the wide ocean of empty space, light has been our only link with the Universe. Light is made out of colours and astronomers produce rainbows with the light from stars. To know that by just measuring these colours, they have found the age of the Universe, its chemical composition and hundreds of solar systems. To know that thanks to the rainbow, we know that the chemistry of the Universe is one and the same everywhere, a philosophical conclusion that links very well with the fundamental idea on the structure of the Universe described at the beginning of this paper.

## 6. CONCLUSION

To start with, it will be crucial to enhance the importance of the following core themes by keeping them isolated, independent, like detached islands of knowledge which in time, would slowly grow links between them:

- In the beginning, the Universe was very simple and organised, pure energy and no matter at all
- There was only one primordial event of creation. The rest has only been a long process of assembly following well known natural laws
- Everything we can see in the Universe is made out of the very same building blocks assembled in a multitude of stages of increasing complexity along time
- Stars play a fundamental role in this assembly process
- The rainbow is one of the main tools of modern science to unravel the secrets of the Universe

The core themes are aimed at audiences of all ages and backgrounds, so they should be delivered accordingly, using appropriate language and level of interactivity. As a legacy to IYA 2009, the fundamental concepts on building blocks, linear scales and the rainbow are intended for special inclusion (meaning as high priority core subjects) in the curricula of primary and secondary schools worldwide. Once treated as core subjects, these themes also deliver important cross curricular links to art, history, philosophy, mythology and religion, very valuable for productive discussions, debates and café scientifique events, aimed at more mature audiences. Some of these ideas are being piloted in the shape of school and public lectures as part of The Mind of the Universe, a series of lectures under a Science in Society Fellowship from the UK Science and Technology Facilities Council. Two of the main titles are What the Universe has done for us? and Astrobiology: Galileo and Darwin 2009. The Mind of the Universe project will also be part of the legacy of IYA2009.