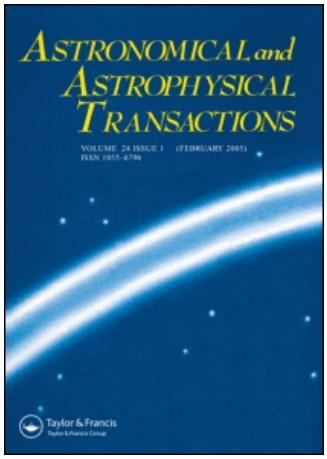

Astronomical & Astrophysical Transactions
The Journal of the Eurasian Astronomical Society
Publication details, including instructions for authors and subscription information:
http://www.informaworld.com/smpp/title~content=t713453505

George Gamow, science writer. A consideration of what science is and how it is done

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Online Publication Date: 01 June 1996
To cite this Article: Sabadell, M. A. (1996) 'George Gamow, science writer. A consideration of what science is and how it is done', Astronomical & Astrophysical Transactions, 10:1, 9 - 19
To link to this article: DOI: 10.1080/10556799608203240
URL: http://dx.doi.org/10.1080/10556799608203240

Astronomical and Astrophysical Transactions, 1996, Vol. 10, pp. 9–19
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GEORGE GAMOW, SCIENCE WRITER. A CONSIDERATION OF WHAT SCIENCE IS AND HOW IT IS DONE

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(Received October 28, 1994)

To George Gamow, whose book "Biography of Physics" made many young men, like me, begin to study Physics.

KEY WORDS The popularization of science, the scientific activity, the goals of science

1 INTRODUCTION

A memorial session honoring George Gamow would be incomplete if we did not mention one of the most fascinating sides of his life: his dedication to (good) popularization of science.

It's quite unusual to find scientists concerned to explain what they do, and what others do, to nonprofessionals. The reasons for this could be found in two main attitudes: "It is not worth doing that, it is a waste of time" and "I have not got enough time". Where do such positions come from? On one hand, some scientists feel that popularization is a complete waste of time, because people don't take an interest in their own work; others think that their research is too complicate to be explained; or that in popularization of science scientific accuracy and rigor are lost, and so the very outcome of the investigations is distorted. On the other hand, there is certain feeling of shortage of time. Competition has done scientists very worried about their own research and, thus, they usually consider popularization an accessory goal. In a few words: scientists don't feel it necessary, either professionally or personally.

Nevertheless, this has to do with Gamow. His literary production was truly significant. His excellent popular writings (see Table 1) made him the leader of scientific popularization in the 60's, and today he is considered one of the best

Table 1. Gamow's popular books on science

1939	Mr. Tompkins in wonderland, or stories of c, G and h
1940	The birth and death of the Sun: Stellar evolution and subatomic energy
1941	Biography of the Earth: Its past, present and future
1943	Mr. Tompkins explores the atom
1945	Atomic energy in cosmic and human life: Fifty years of radio activity
1947	One, two, three... infinity: Facts and speculations of science
1952	The creation of the Universe
1953	Mr. Tompkins learns the facts of life
1958	Puzzle–Math
1958	Matter, Earth and Sky
1961	Biography of Physics
1961	The atom and its nucleus
1962	Gravity: classic and modern views
1963	A planet called Earth: a biographical sketch of its past, present and future
1964	A star called Sun
1965	Mr. Tompkins in paperback
1966	Thirty years that shook physics: the story of quantum theory
1967	Mr. Tompkins inside himself
1970	My world line: an informal autobiography

Note. (Source: "My world line" (in its Russian edition), Moscow 1994)

science writers ever born. His outstanding contributions to popular science were awarded in 1956 with the Kalinga Prize of UNESCO.

In this talk, I will first analyse the popularization work of Gamow and, second, I will present some reflections on the value of bringing science closer to nonprofessionals.

2 THE SCIENCE WRITER

To do good scientific popularization is quite difficult. One must capture the reader's interest and attention. In addition, one must weigh up how much scientific accuracy (which requires to explain scientific mechanisms and theories in depth) can be missed just for clarity (the way to be understood by most people). We can find two different styles of doing popular science in the following excellent books: "Cosmos" by Carl Sagan and "The First Three Minutes of the Universe" by Steven Weinberg. The first one was written for everybody, and the second one belongs to the best books of high-level popularization. To write one or another depends on which is the aim of the book. If it is to generate interest to science, one must sacrifice accuracy. On the other side, if one wants to explain a particular field to people who are already interested in or have special interest in it, one must sacrifice clarity. But this problem has no trivial solution, and Gamow faced these difficulties. In his books we can observe a series of patterns that provides us some clues about how tried to solve them:

1) Drawings made by himself. – The profusion of drawings, portraits, and graphics by Gamow was one of the most characteristic features of his books. This gave him the opportunity of drawing what he wanted to explain. This may sound foolish, but if we consider it in depth, it is not so. His drawings yield to the reader a feeling of confronting a "different" book (the writer took the effort to make his own drawings), and to avoid a possible misunderstanding of graphics excerpted from a technical journal. Thus, the author can illustrate and make more intelligible a paragraph that, without it, would be abstruse and obscure. For example, in "The Creation of the Universe", the concepts of turbulence and the whirlpool hierarchy gain clarity after glancing at Figure 21 of that book (Figure 1 here). Also, it is important to remember the ability of Gamow to draw portraits of well-known physicists. Such portraits proliferate in his best-seller "Biography of Physics" (see Figure 2) even if he confessed having used an overhead. Finally, a marvellous Gamow's feature stands out: his making amusing graphics (I call this "the Gamow touch"). A good example appears in "The Creation of the Universe", in the curves of the relative abundances by R. Alpher and R. L. Herman (Figure 3).

2) Use of analogies. – This is one of the most useful tools in popularization of science, making concepts or complex reasoning easily explained. Gamow's use of analogies is quite subjective and obeys to his personal view of understanding science and always astonishes us. Thus in his book "The Creation of the Universe", Gamow explains the method developed by the British geologist Arthur Holmes to obtain the age of the Earth. It is rather difficult to see any relationship between the memory troubles of a cowboy, who could remember neither when he had released his cattle in the prairie nor when he had shut it up in the stable, with the relative isotopic abundances of lead found in different geological ages. But he did.

Gamow also used amusing drawings to fix some important ideas in the reader's brain or to help to explain them. We can observe this in his renowned book "One, Two, Three...Infinity", (Figures 4 and 5, to explain Brownian motion and thermal agitation, respectively). Also, in "Biography of Physics", Gamow illustrates the muon interchange drawing two dogs passing a bone; and in "The Creation of the Universe" (Figure 6) he shows the Wigner proposal to overcome the trouble of mass five (the bridge of nuclear chain method).

3) Use of tales and legends. – Gamow used folklore stories and tales excerpted from M. Twain, E. A. Poe and others. This is a very usual way in popularization of Mathematics, and Gamow made use of some of these classical resources in "One, Two, Three... Infinity", one of the best books on general science ever written. In this book we can discover the classical topological problem of the four colour map (one of the best treatments of this problem can be found in Gardner, 1966) and "The End of the World" problem that stands as follows: The Creation Day, God created three diamond sticks and put 64 gold rings in one of them. Since then, Brahman priests can only move one ring per second from one to another following this simple rule: they cannot put a big ring on a small one. The legend said that when the priests transfer all the rings from one stick to another, Doomsday will come (simple calculus shows that if one moves one ring per second, this process would take 58 billions of years).

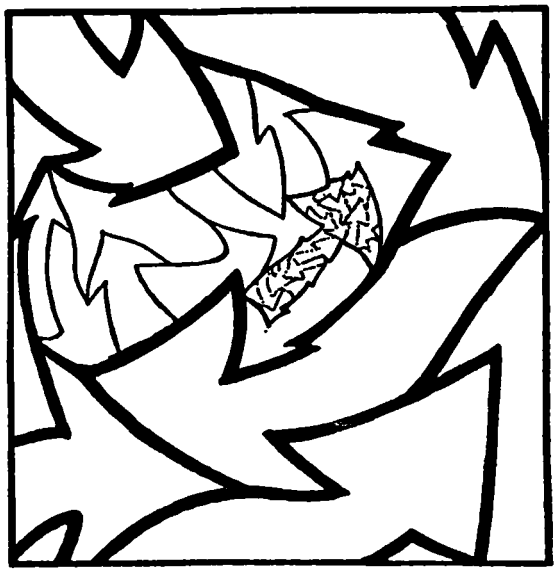

Figure 1 Turbulence and the whirpool hierarchy (from "The Creation of the Universe").

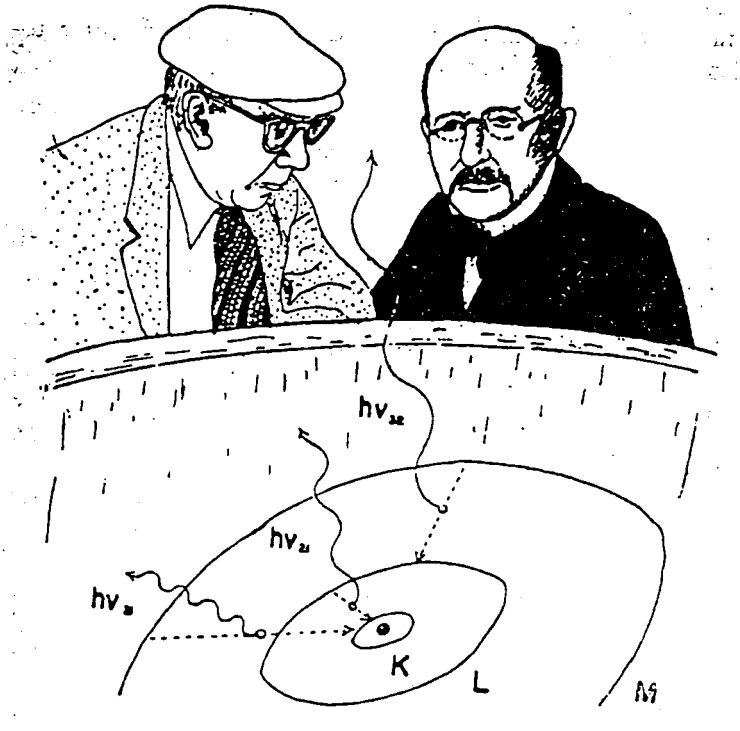

Figure 2 Portraits of Bohr and Heisenberg (from "Biography of Physics").

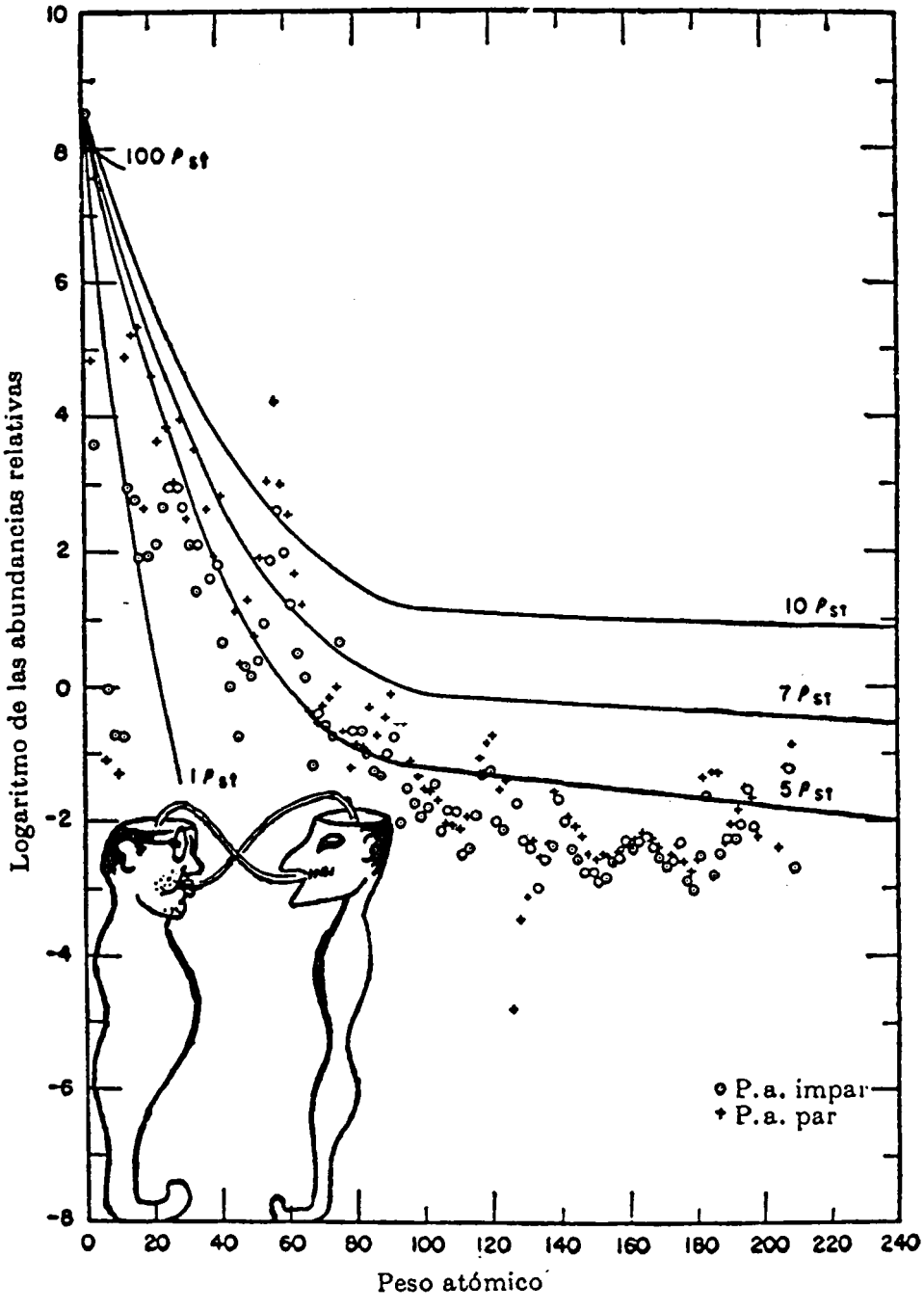

Figure 3 Curves of relative abundances (from "The Creation of the Universe").

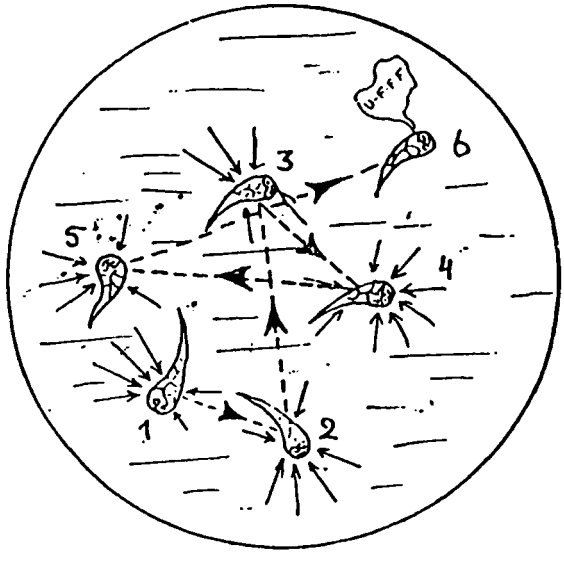

Figure 4 Representation of Brownian motion (from "One, Two, Three... Infinity").

4) A deep knowledge of how science works. – This is the most important point. The ability of explaining science depends equally strongly both on as the scientific background of the writer and on his capacity of expressing it in an understandable way. With no exception, great science writers had a deep interest in all fields of science, and most of them showed encyclopaedic knowledge (Jsaac Asimov comes to my memory). In my opinion, this eagerness to know more than their own speciality is absolutely necessary to be successful in scientific popularization. Reading Gamow's books one can learn, not only about physics, but about geology, mathematics, biology...

However, his peculiar style suggests something about his personality. In his books one is able to discover his optimistic point of view of the world and his rigorous and creative way to do science.

I have mentioned that the science writer must find an agreement between clarity and rigor. Using a mathematical simile, one must maximise the function Clarity–Rigor. Gamow betted on not to loose accuracy. His work is high-level popularization.

What we must learn from Gamow is that one do this high popularization without loosing an ounce of pleasantness and freshness. This is the greatness of his work.

3 POPULARIZATION OF SCIENCE

If you have read any of Gamow's popular books, you may have wondered whether scientific popularization is important or not. This second part of my talk will be

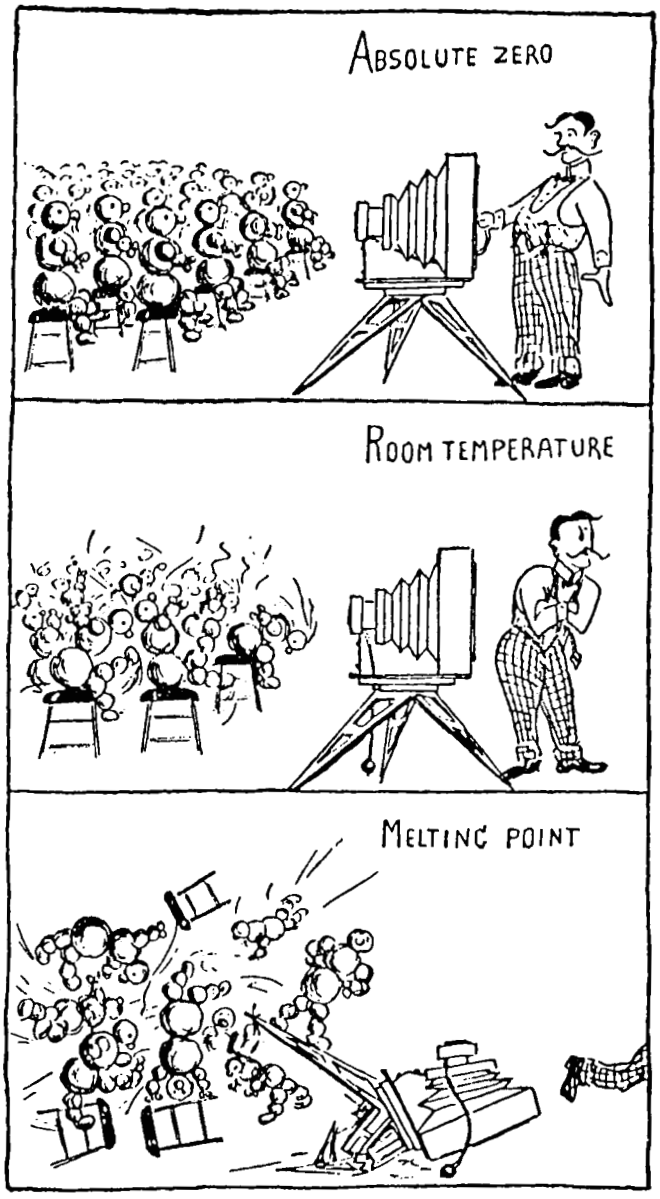

Figure 5 Representation of thermal agitation (from "One, Two, Three... Infinity").

devoted to convince you in the goodness of such an enterprise and the need in it. I will try to answer these three main questions: Why, What and How?

WHY?

We live in a technological and scientific world. Every day media announce a new discovery. Paradoxically, most people don't know what science is and how it is done.

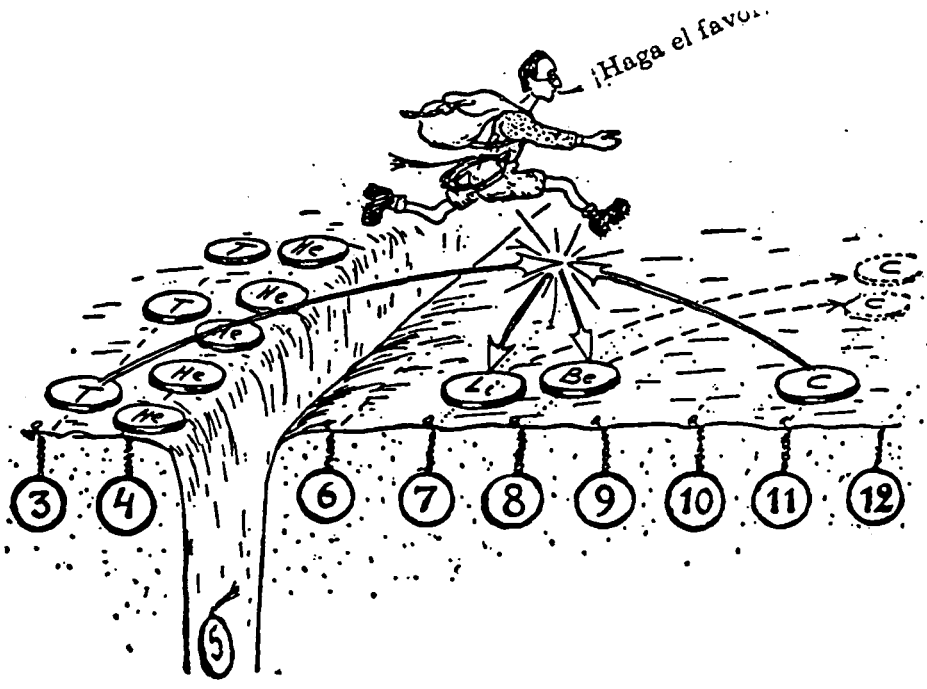

Figure 6 The bridge of nuclear chain method (from "The Creation of the Universe").

Kurtz (1992) pointed out that, according to a recent study, only thirteen percent of people in Europe have a clear notion of what scientific inquiry is. "This seems to me to point to a frontier for future development: THE NEED FOR PUBLIC EDUCATION ABOUT THE AIMS AND METHODS OF SCIENCE (emphasis added)" (Kurtz, 1992).

From this, the important question is not "what science is" but "what people think science is", Casti (1990) draws our attention to three quite distinct meanings of the term science in most general conversations: a set of facts and a set of theories that explain facts; a particular approach, the scientific method; and whatever is being done by institutions carrying on "scientific" activity. "As a general rule, non-scientific public usually opts for the third interpretation, occasionally the first, but virtually never the second". Casti (1990) thinks that the fundamental misunderstanding of what constitutes a scientific activity gives rise to an array of misperceptions about the goals of science, for example (my comments in Brackets):

The primary goal of science is the accumulation of facts (unfortunately, the mere cataloguing of data is not enough).

Science distorts reality and can't do justice to the fullness of human experience (so science is not different from religion, art, mysticism...).

Scientific knowledge is truth (science provides ultimate explanation of nothing).

Science is concerned primarily with solving practical and social problems (this is the Science=Technology equation).

The last notion has something to do with certain increasing disappointment that appeared at the beginning of the 70's, when society realized that science was unable to solve social problems. Confidence in science has been lost. Today we can find a rejection of reason and objectivity. "One hears over and over again that 'one belief is as good as the next' and that there is a kind of 'subjective truth' immune to rational or evidential criticism" (Kurtz, 1976). There is also another mood that is increasing today – an aversion to technology and science. Scientists are often viewed as a kind of demons and science is blamed for the present world situation. In a few words, science is "dehumanizing, brutalizing and destructive of human freedom and value" (Kurtz, 1976).

There are other cultural and sociological hypotheses that could be introduced to explain this denial. The influence of the mass media has been increasing during the last decades. The image of science and scientists has been drawn by journalists and novelists, not by scientists themselves. Dangers of a bad use of science and its marriage with political power, the control exerted by industries, and the fact that half of all support for scientific research is for weapons development, have given a bad reputation to science in newspapers, magazines, and TV programs. These have brought much confusion about the meaning of science. We have also witnessed a quick increase of different forms of irrationality, often antiscientific and pseudoscientific in character. A good illustration is the growth of astrology.

As an astrophysicist, I am very worried about the rebirth of this fringe science. Many people think that there is no difference between astronomy and astrology and ask me for horoscopes. It doesn't matter that in Spain 258 astronomers and astrophysicists signed the "Objections to Astrology" manifesto in 1990 (a translation from that issued in 1975 in the USA). Being one of the two promoters has allowed me to follow the reactions of people and, of course, astrologers. They accept everything uncritically. This also happens in pseudoscience in general. Humankind has always been fascinated with mystery, and imagination plays an important role in our lives. Pseudoscience offers a run-away our boring daily existence. Pseudoscientists offer salvation from the tribulations encountered in this life; they sell hope. This can be seen in pseudoscientific magazines or even in daily newspapers.

Science seems boring, close-minded and lacking imagination to people. We known that it is not true. Science doesn't appeal only to evidence, logical coherence, experimental prediction and replication by others scientists, but it is also creative, it is indeed among the most creative activities in the world. It is not dogmatic, as pseudoscientists claim, and always explores new ideas. A unique feature is that science is self-corrective, and one must be prepared to admit that good theories today can be overturned in the light of new discoveries. Science is intrinsically fallible. And the most important: SCIENCE IS AMUSING.

We need to develop appreciation for science as part of the culture. It should be learnt that one is not right only by affirming a truth claim but by supporting it by

evidence. We must teach that what is important in science is the method followed to reach some results and not the results themselves. Research involves ideas, not answers. This is why we have to do popularization of science.

Moreover, we need to do that because we are being paid (at least, many of us) with tax money: tax payers are entitled to know where their money goes...

WHAT?

If I was able to convince you that we have to do scientific popularization, the following questions are very easy to answer. George Gamow has taught us that everything can be explained, from 10^{-33} cm to 10^{10} light-years. It is not a difficult subject, but popularization itself really is. You have to realize that unscientific people don't know as much as you believe. This seems to be a foolish thing, but my own experience has taught me that when you sit trying to write some thing in an intelligible way you tend to think: "Well, they MUST know this". Of course, they do not.

HOW?

The best answer to this question was quoted by the French philosopher Voltaire: "A book must be anything but boring". Science is amusing, so why don't you insist in doing it so?

4 BY THE WAY OF A CONCLUSION

We need to disseminate appreciation for the adventure of the scientific enterprise. The breakthroughs in science are and will continue being astonishing, so we explore further inside the atom, into the secrets of life and Universe. Astronomy is the best subject to make people feel this swarming in the backbone that every scientist feels when he, as Pasteur said, "lifts up an edge of the veil with which God has covered his work".

We have to show that science is one of the most wonderful adventures of humankind. I am sure that Gamow would have loved this idea.

Acknowledgements

I am greatly in debt with Dr. Putstylnik. Very useful discussions about Gamow's character and life helped me to write down this paper. I also want to thank Dr. Flinn for our talk about what scientific popularization is, to Drs. A. F. Pacheco and C. Malo for their critical comments to this paper, to Drs. J. Sañudo and S. Abad for our discussions about science and pseudoscience and to LOC of the Conference for their efforts on making me feel at home in Odessa.

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