

this low neutron density implies that significant revisions of present low-mass AGB models are required.

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Of Whirls and Molten Gold

An Introduction to Fontenelle's "Entretiens" (1686)

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Whereas everybody agrees that there has been enormous progress in many areas of astronomy and astrophysics during recent years, nobody knows for sure which contemporary achievements of our science will be considered particularly important by scientists in a distant future. It is therefore sometimes interesting to place yourself in that privileged position by looking backwards in time and to judge the ideas of our forefathers in the light of our present knowledge.

Some time ago, when I glanced through A. Pannekoek's "History of Astronomy", I happened to come upon the name of Fontenelle. According to Pannekoek, whose text is one of the best introductions for non-specialists to the accomplishments of our predecessors, "Great popularity was won by Fontenelle's *Entretiens sur la pluralité des mondes* (Conversations on the Plurality of Worlds) 1686." I must admit that I had never heard of this author, but I became intrigued about the "plurality" and decided to find out what this was about. First I asked some of my colleagues about Fontenelle, but none of them seemed to know him. "At which observatory does he work?" was one of the kind, but not very helpful replies.

Calling the Bavarian State Library in Munich, I learned that no less than three editions of Fontenelle's book were available there, although it was slightly puzzling that the first was from 1687, the second from 1750 and the third from 1796! So I decided to have a closer look and soon entered a fascinating world, so different from our modern one, and yet in some regards so similar that it might also interest those readers of the *Messenger* who are not familiar with "Entretiens". Since I am not a specialist in the history of astronomy, the following account must of course only be taken as reflections of a modern astronomer when confronted with the thoughts of a popular writer in the late 17th century.

Popularization and Fontenelle

Any scientist, who has written articles that are destined to be read by a wider circle, knows that they have to be quite different from those that appear in professional journals. With the increasing importance of popularization of the sciences, in particular within the "natural" ones, more and more scientists go through this experience. Many of them do so because they feel that it is useful to call attention to the research at the institute where they work – in some countries the regular reporting in the media may even have a decisive influence on the funding. Some of their colleagues feel that they have a moral obligation to inform the taxpayers on whose money they subsist and others simply think it is great fun to tell about the work in which they are currently engaged.

The information flow from scientists to the media and onwards to the public is not a new phenomenon, although it may have become more intense in our days. We have all read the books by the fathers of modern science fiction, like Jules Verne and H.G. Wells, who based their thrilling stories on the science and technology of their epoch. Further back in time, the public interest in the natural sciences was often satisfied by dramatic accounts of journeys to distant continents. In astronomy, the so-called Broadsheets played an important role in conveying news about celestial phenomena, although they were not always to be trusted; see for instance the article by P. Véron and G. Tammann in the *Messenger*, **16**, 4, 1979.

Fontenelle's book, which was first published in 1686, is in retrospect a significant milestone in the noble art of science popularization and it contains elements from which even modern members of this trade may learn. The author was born in Rouen, France, on February 11, 1657 and he died in Paris on January 9, 1757, after a long and

busy life. His full name was Bernard le Bovier, sieur de Fontenelle; his mother was a sister of the famous Pierre Corneille. He was educated by the Jesuits in Rouen. Having unsuccessfully tried his luck as a lawyer (he lost his first court case and left in disgust!), he then turned towards the sciences and later became one of the most read philosophers of his time. Voltaire described him as the most universal mind produced by the era of the "Sun King" Louis XIV.

Still in his twenties, he wrote libretti to two tragic operas and in 1683 he became well known by some philosophical treatises, followed by the "Entretiens", three years later. In 1697, he became permanent secretary of the French Academy of Sciences, a position that

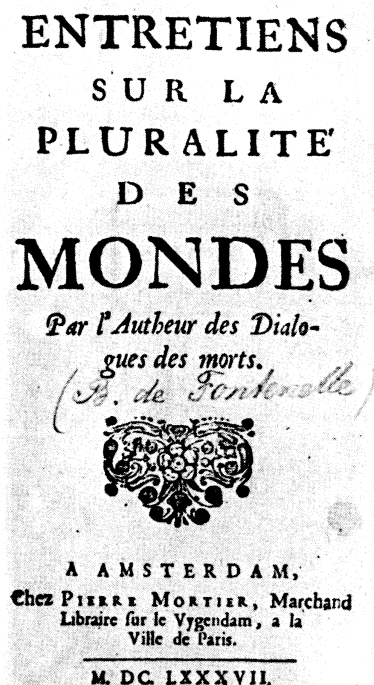


Figure 1: Title page of the French edition in 1687.

brought him into contact with many of the leading scientists in the age of Enlightenment, including Newton and Leibnitz, whose obituaries he later wrote. During his lifetime a major revolution took place in the attitude towards the natural sciences and their importance for progress in human society was recognized.

The Publication of "Entretiens"

There is little doubt that Fontenelle's "Entretiens" was his most successful publication. From the bibliographic sources available in Munich, it can be seen that the demand in Fontenelle's home country continued, and new French editions were published in 1687, 1694, 1698, 1703, 1707, 1708, 1714, 1733, 1745, 1750, 1793, 1796, 1800, 1812, 1818, 1820, and finally in 1824! How many popular works can show such a series over so many years?! The book was immediately translated into English in 1687 and there were about thirty English editions until 1803. The German edition appears to have been somewhat slower in coming; the famous astronomer J.E. Bode wrote a voluminous commentary to the first one in 1780. There was a Greek edition in 1794 and a Russian one in 1802. In Denmark the readers had to wait until 1748, before they could read it in their own language. There may have been other translations, which I have not been able to trace.

The book is concerned with the "World System" of 1686 and it is one of the very first examples of serious science popularization, readily accessible to the literate public. With the exception of Galileo's "Dialogo sopra i due massimi sistemi del mondo" from 1632, which was quickly banned by the Church and led to its author's forced abjudication of the heliocentric system, "Entretiens" is probably the first major attempt to bring Copernicus' thoughts to a wider public in their own language, almost 150 years after the death of the revolutionary in 1543. It took a long time before the heliocentric system of Copernicus was accepted by more than a few daring scientists – witness the resistance by the great observer Tycho Brahe at the end of the 16th century. When Fontenelle wrote his book, common people in Europe firmly believed that the Earth was at the centre of the Universe. The fact that it was written in France testifies to a more liberal attitude in that country.

Tricks of the Trade

When you hold the edition from 1687 in your hand, you first of all remark its

tiny size, only 9 × 13 cm. It is clearly a "pocket" book and was intended as such. The language is easy to read and there is no doubt that Fontenelle went into some trouble to ensure this. The words are simple and the arguments are well explained. It is divided into a Preface, an Introduction and five Chapters: "First Evening", "Second Evening", etc. A "Sixth Evening" was added in 1694, in order to explain a number of additional phenomena.

Let us have a closer look at the content in order to understand what was of concern to people in those days and also how Fontenelle presents the astronomical "results". Already in the Preface, he defends his decision to write in his mothertongue and not to use Latin, the international, scientific language of that time. Like Cicero, who wrote in Latin (and not in Greek, the language of science in his time), Fontenelle would like to tempt those who "are not philosophers" (i.e. those who do not know about the natural sciences) to read the book, because it is easy for them to read their own language. "The philosophers", who already know it all, might still find some interest in seeing it exposed in another language. Fontenelle explains that he has introduced a lady into the narrative – "who has never heard about these matters" – hoping to encourage "les Dames" to read his Book. He has tried to make it more interesting by the inclusion of "digressions", but he regrets that it may still be less interesting than Ovid's "The Art of Love"!

Fontenelle realizes of course that there will be resistance against his ideas from certain quarters, in particular from the religious authorities. He mentions a special problem in connection with the lunar inhabitants. According to the dogma, the forefather of all people is Adam, but since you cannot travel from the Earth to the Moon, the lunar people cannot be descendants of Adam! This is embarrassing for the theologians. However, "c'est vous qui mettez des Hommes dans la Lune, je n'y en mets point – J'y mets des Habitans qui ne sont point du tout des Hommes." Yes, Fontenelle is clever, his lunar beings need not be human after all!

The Introduction is directed to Monsieur de L***, and Fontenelle tells about some pleasant days spent in the country house of Madame La Marquise G***. Surely L***, who expects to hear about parties, hunting and card games, must be surprised to read about "planets, worlds and vortices; the talk was almost only about such things". And here commences the narrative about how Fontenelle (the "I" in the book) and Madame La Marquise G*** spent five evenings in



Figure 2: Portrait of Fontenelle from the luxury edition in 1796.

the park, discussing philosophical themes under the starry skies. The dialogue form is well known from the classics and Madame is rather intelligent, in any case she puts many clever questions to the author. Only once or twice does she become stubborn and Fontenelle has to use all his powers of persuasion to convince her that his ideas are correct. No doubt the readers had little difficulty in identifying themselves with Marquise G***.

The Copernican System

During their first walk in the park, on the First Evening, Fontenelle explains how the light from the stars disappears in the bright sunshine during daytime, but that the stars are still there all the time. He continues to compare Nature with a theatre; everything is controlled by invisible ropes and counterweights. "So the whole thing is just mechanical?" asks the Marquise and Fontenelle, who is pleased to see that his didactical method works, replies that it is indeed so and also that the explanation of what we observe in Nature is always the simplest possible one. He tells about the five major planets and that they, contrary to the fixed stars, move in the sky. He mentions that the cradle of astronomy can be found with the Chaldeans, and that Geometry was born in Egypt. We must not think that everything in the sky is just there for our sake, as some philosophers believe. In the same way, it is not the Earth, but the Sun which is the centre of the Univers, as we have been told by Copernicus, "qui fait main-basse sur tous ces Cercles differens, & sur tous ces Cieux solides, qui avoient esté imaginez par l'Antiquité. Il detruit les uns, il met les autres en pieces" (who takes away all those

different circles and all those solid skies which have been invented by Antiquity . . .).

Now the Earth is just the third planet in the system, among five others. Fontenelle feels obliged to excuse himself, but Madame answers: "Do you think that you have humiliated me by telling me that the Earth orbits the Sun? I swear that I feel no smaller!" Later Fontenelle argues that although the Earth is big and heavy and it would therefore appear difficult to let it turn around an axis in only 24 hours, it would certainly be even more incredible if the entire Universe, so much bigger and heavier, would turn around the Earth. Now the Earth floats freely in space and this might of course give rise to some feeling of dizziness; well, Madame believes that she will manage and she goes on "I do not want to say stupid things, but there is a difficulty. If the Earth turns, we change the air all the time and we always breathe that of a different country." Fontenelle explains how the atmosphere is like a silk-cocoon, a thin envelope and that it turns with the Earth. He then goes on to imagine that he and Madame are out in space, watching the rotating Earth below. They see Englishmen discussing politics, Indians who devour their prisoners alive, Japanese ladies who spend all their time cooking for their husbands, towers of porcelain in China, tartars, beautiful Circassian ladies and finally Turks.

And when they come back to the house, Fontenelle mentions the Tychoonian system (supposedly to avoid criticism from many of his friends), but Madame rejects it "vif & prompt", and they happily agree that Copernicus must indeed be right.

Life Outside the Earth?

Next morning, the Marquise is happy to tell Fontenelle that she has slept very well, despite the Earth's rotation. And later, when they again meet in the garden at the beginning of the Second Evening, Fontenelle discusses the Moon and its possible inhabitants. He asks Madame to imagine that she is standing in the outskirts of Paris and looks towards the nearby town of Saint Denis (now a part of the city of Paris). Although she cannot see the people in Saint Denis, she can be reasonably sure that it must be inhabited, since it resembles Paris with its houses, church towers, etc. So, as the Moon resembles the Earth with its mountains and abysses, it must also be inhabited. The Sun shines by itself, but both the Moon and Earth shine by reflected sunlight. The lunar inhabitants can therefore observe the Earth, as we see the Moon, although the

Earth shines brighter than the Moon. Fontenelle explains the Moon's phases and also the principle of solar and lunar eclipses. "I am very surprised that there is so little mystery to the Eclipses and that they are not understood by all people!" (Henceforth, the self-respecting reader will find it very difficult to show any ignorance.)

At this point, Fontenelle deviates from his rather scientific approach and tells the story about Astolfe, who with the help of St. Jean travelled to the Moon in order to recuperate the good humour of his friend Roland (here the reader will have time to relax). What do the lunar inhabitants look like? Fontenelle is honest enough to say that he knows little about this. He compares the space between the Earth and its satellite with the ocean that separates the known landmasses from the mythical Terra Australis and he recalls how little we knew about America before the voyage of Columbus, less than 200 years earlier. Imagine how the Indians felt when they first saw the white sails and heard the thunder of the guns! "Après cela, je ne veux plus jurer qu'il ne puisse y avoir commerce quelque jour entre la Lune et la Terre . . . L'art de voler ne fait encore que de naistre, il se perfectionnera, & quelque jour on ira jus'qu'à la Lune". (. . . some day we shall travel to the Moon). Like the Indians who knew the art of sailing before the arrival of Columbus, perhaps the lunar inhabitants have already visited Venus?

During the Third Evening, Fontenelle has to admit that the Moon nevertheless is different from the Earth: it has no clouds. There are no "exhalations" from the Moon which must therefore be "infinitely more hard and solid than our Earth". The lunar "mare", which were earlier taken to be seas of water, are possibly just cavities. "But must we then abandon our belief in lunar inhabitants?", worries Madame. Surely not, maybe the lunar air is different from ours and cannot be seen. And the moment we observe some motion on the lunar surface, the inhabitants must be there. But if the air around the Moon is different, it might not be so easy to travel to the Moon. It is difficult to breathe on the highest mountains on the Earth, so there appears to be a natural barrier.

Then Fontenelle continues to Venus and talks about the variety of life. He mentions the mini-fauna on a leaf and feels that the further away a planet is from the Earth, the more different must be the life-forms it harbours. "My imagination is overcome by the infinite multitude of inhabitants of all these planets!", exclaims Madame. "Perhaps the inhabitants of other worlds have a sixth sense beyond the five we have",

says Fontenelle and he goes on to ask whether Madame is now satisfied? Indeed she is and she looks forward to happy dreams about extraordinary creatures on other worlds.

The Fourth Evening Fontenelle continues the fictive journey in the solar system. He makes a mistake in stating that Venus is 40 times smaller than the Earth, although astronomers at that time already knew that they are of about the same size. The talk centres on the inhabitants on Venus and Mercury (who must feel hot, so near the Sun). Sunspots are described and the solar surface is compared to molten gold. There are probably no inhabitants on the Sun; "anyhow the poor people would not be able to see the planets and the stars" adds the Marquise. Then onwards to Jupiter with a description of Galileo's observations of the moons. Fontenelle imagines, how Jovian astronomers discover the Earth. One of them believes that it is inhabited and his colleagues laugh at him. The rings of Saturn must be a beautiful sight to those who live there.

Cosmology

At this point, Fontenelle introduces the Cartesian theory of vortices, which was put forward by Descartes around 1640: "Ah! Madame, répliquayje! Si vous sçaviez ce que c'est que les Tourbillons de Descartes, ces Tourbillons dont le nom est si terrible, & l'idée si agreable". (According to this theory, the universe is filled with a thin fluid which rotates in whirls (tourbillons) around the sun and the stars; the rotation carries the planets along.)

Coming now to the stars on the Fifth Evening, which according to Fontenelle must be at least 50 million miles ("lieuës") from the Earth, the Marquise wishes to know whether they are also inhabited. But her teacher explains that they are suns like our own and that each has its own vortex. There are small and large vortices and sometimes a new star can be seen in the sky. The Milky Way consists of myriads of stars and our solar system is just a small part of the Universe. In some places, the stars must be quite near each other and there the poor people live in eternal daylight and cannot sleep! And others may live in big vortices, far from their central star, in "les tenebres tres-profondes" (deep shadows).

Madame wants to know if a star, itself a source of light, may die and again Fontenelle refers to Descartes, who thought that sunspots may grow and ultimately cover the entire surface of the unlucky Sun – "Adieu le Soleil!". Indeed the Sun seems to have been rather faint

