

Frank Close

NOTHING

A Very Short Introduction

OXFORD

Nothing: A Very Short Introduction

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OXFORD
UNIVERSITY PRESS

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UNIVERSITY PRESS

Great Clarendon Street, Oxford OX2 6DP

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and education by publishing worldwide in

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Published in the United States
by Oxford University Press Inc., New York

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First published in hardback as *The Void* 2007
First published as a Very Short Introduction 2009

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British Library Cataloguing in Publication Data
Data available

Library of Congress Cataloguing in Publication Data
Data available

ISBN 978-0-19-922586-6

1 3 5 7 9 10 8 6 4 2

Typeset by SPI Publisher Services, Pondicherry, India
Printed in Great Britain by
Ashford Colour Press Ltd, Gosport, Hampshire

For Lizzie and John

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Contents

	Acknowledgements	xi
	List of illustrations	xiii
1	Much ado about nothing	1
2	How empty is an atom?	22
3	Space	41
4	Waves in what?	53
5	Travelling on a light beam	65
6	The cost of free space	74
7	The infinite sea	90
8	The Higgs vacuum	112
9	The new Void	128
	Notes	147
	Further reading	149
	Index	151

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Acknowledgements

I am grateful to my editor Latha Menon for encouraging me to research and write about nothing, and to Ian Aitchison, Ben Morison, and Ken Peach for their comments that helped me to produce this something.

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List of illustrations

- | | |
|---|---|
| 1 Air is something 7 | 8 Electron waves in atoms 98 |
| 2 The Magdeburg Hemispheres 14
Mary Evans Picture Library | 9 The quantum pendulum 101 |
| 3 Pressure, winds, and weather maps 32 | 10 Pair creation 109
© Lawrence Berkeley
Laboratory/Science Photo Library |
| 4 Pythagoras' triangle 72 | 11 The Dirac Sea 110 |
| 5 Light beams in a gravitational field 77 | 12 Snowflakes and symmetry 116
© Kenneth Libbrecht/Science Photo
Library |
| 6 A triangle containing three right angles 79 | 13 Microwave background radiation as seen by COBE and WMAP 135
NASA/WMAP Science Team |
| 7 The perihelion of Mercury 81 | 14 Imaginary time 142 |

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Chapter 1

Much ado about nothing

At some early stage in our lives most of us are suddenly hit by the question: 'Where did everything come from?' We may also wonder where our conscious self was before our birth. Can you identify your earliest memory? When I first started school, I had clear memories of the previous two or three years, especially of summer holidays at the seaside, but when I tried to recall earlier events the visions became more hazy, disappearing into nothingness. I was told that this was because I had only been born five years previously, in 1945. Meanwhile my parents spoke of a war, and of things that had happened to them before the war, but it all meant nothing to me. The world that I knew had not existed then and appeared to have been created at my birth, filled with ready-made parents and other adults. How could they have existed 'before' my conscious universe?

The weird void that was everything until 1945 continued to trouble me; then in 1969 an event occurred that was to give me a new perspective on this problem.

Apollo 10 was skimming just above the surface of the Moon, which the marvels of communications were revealing as a desolate wasteland of rock and gravel. This desert of grey dust stretched to the lunar horizon, which arced against a black void that was

dotted with occasional stars, lifeless balls of hydrogen that had erupted into light. Suddenly, into this barren picture arose a beautiful blue jewel with white clouds and green continents of vegetation: for the first time humans witnessed Earthrise. There is one place at least in the universe where there is life, collections of vast numbers of atoms that have become organized such that they are self-aware and can gaze into the universe with wonder.

What if there were no intelligent life? In what sense would any of this exist if there were no life to know it? Ten billion years ago it is possible that that is how it was: a lifeless void littered with clouds of plasma and barren lumps of rock orbiting in the vastness of space. Although this epoch of 'pre-consciousness' contained no life, and must have been like some grand extension of my egocentric pre-1945 universe where gravity's dance played on without anyone being aware, nonetheless the same atoms that existed back then are what we are made of today. Once inert, complex combinations of these atoms have become organized to create what we call consciousness and are able to receive, from far across the universe, light that had set out in those earlier lifeless times. We in our 'now' can bear witness to that earlier lifeless epoch, which after the event gives it some sort of a reality. We have not been created out of nothing, but from a primeval 'ur-matter', atoms formed billions of years ago that have for a brief while been gathered into collections that think they are us.

This led to my final question: what if there were no life, no Earth, no planets, Sun, or stars, no atoms with the potential to be reorganized into future somethings; what if there were just emptiness? Having removed everything from my mental image of the universe, I tried to imagine the nothing that remained. I discovered then what philosophers have known throughout the ages: it is very hard to think about the void. As a naive child I had been wondering where the universe had been before I was born, now I was trying to imagine what there would be had I not been born at all. 'We are the lucky ones for we shall die,' as there is an

infinite number of possible forms of DNA all but a few billions of which will never burst into consciousness. What is the universe for the never-to-be-born or for those now dead? All cultures have created myths about those that have died, so difficult is it to accept that consciousness can just disappear when the oxygen pumps fail to power the brain, but what means consciousness for those combinations of DNA that never started, nor ever will be?

It is as hard to understand how consciousness emerges and dies as it is to comprehend how something, the stuff of the universe, erupted out of nothing. Was there a creation or was there always something? Could there even be nothing if there were no one to know there was nothing? The more I tried to understand these enigmas, the more I felt that I was at the edge of either true enlightenment or madness. Years later, having spent my life as a scientist trying to understand the universe, I have returned to such questions and taken a journey to find out what answers there are. The result is this little book. I am flattered to know that in having asked such questions, I am in good company, as in one form or another they have been asked throughout the ages by some of the greatest philosophers. Furthermore, no answer has been agreed. At various times, as one philosophy has dominated over others, the received wisdom also has evolved. Can there be a vacuum, a state of nothing? Like questions about the existence of God, it seems that the answers depend on what you mean by nothing.

Much ado about nothing

In addressing these questions through the power of logic the philosophers of ancient Greece came to contrary opinions. Aristotle claimed that there could not be an empty place. This was even raised to a principle that 'Nature abhors a vacuum'; what this means and why it was believed for 2,000 years is one of the first questions that I shall address. In short summary we will see that it was not until the seventeenth century, with the emergence of the experimental method, that Galileo's students showed belief in the abhorrence of a vacuum to be due to a misinterpretation of phenomena; the apparent abhorrence was the result of 10 tonnes

of atmosphere weighing down on each square metre of everything on the ground, squeezing air into every available orifice.

As we shall see, it is possible to remove the air from containers and make a vacuum. Aristotle was wrong. At least, that is the conclusion if there is only air, such that removing air has removed everything. And as science has advanced, and we have extended our senses with ever more sophisticated instruments, it has become clear that there is a lot more than just air to remove before we are left with a true void. Modern science suggests that it is impossible in principle to make a complete void, so perhaps Aristotle was not wrong after all. Nonetheless, modern scientists are happy to use the concept of the vacuum, one interpretation of modern physics being that it is focused completely on trying to understand the nature of the vacuum, of time and space in their various dimensions.

Nothing The question that I so innocently asked myself is even more enigmatic given that today we know what no one did then: the universe is expanding and has been doing so for some 14 billion years since the eponymous Big Bang. As neither the solar system, the Earth, nor the atoms that make us are expanding, the received wisdom is that it is 'Space itself' that is growing. Leaving until later the question of 'what is it expanding into', we have a further coda to my original question: if I have removed everything, then is space still expanding? In turn this begs the question of what defines space when everything is taken out. Does space exist independent of things, in the sense that if I had mentally removed all those planets, stars, and assorted pieces of matter, space would remain, or would the removal of matter do away with space as well? So let's begin our quest to see what insights wiser heads from history can offer as we try to answer questions such as: could we empty space of everything and if so, what would result? Why did the Big Bang not happen sooner? What was God doing the day before creation? Or was there always something that turned into us?

Early ideas on No-thing

The paradox of creation from the void, of Being and Non-Being, has tantalized all recorded cultures. As early as 1,700 years BC, the Creation Hymn of the Rigveda states that

There was neither non-existence nor existence then.
There was neither the realm of space nor the sky which is beyond.
What stirred? Where?

Such questions were debated by the philosophers of ancient Greece. Around 600 BC, Thales denied the existence of No-thing: for Thales, something cannot emerge from No-thing, nor can things disappear into No-thing. He elevated this principle to the entire universe: the Universe cannot have come from No-thing.

The concept of No-thing was confronted with the laws of logic, Thales posing the question: does thinking about nothing make it something? The answer, according to the Greek logician, is that there can *only* be nothing if there is no one to contemplate it. My question whether there could be nothing if there was no one to know there was nothing had apparently been answered in the affirmative 3,000 years earlier, though it seems to me to have been an axiomatic assertion rather than established by argument. My quest continued but it appeared that no one after Thales defined nothing other than as an absence of something.

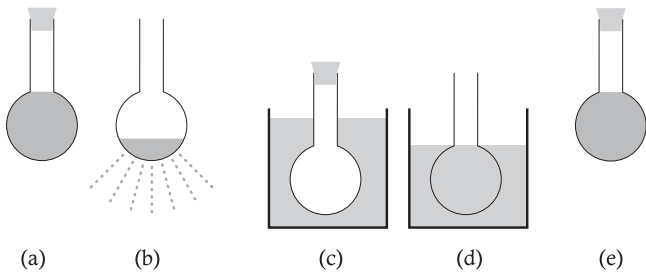
Much ado about nothing

Having disposed of No-thing Thales then moved on to the nature of things. He successfully predicted the eclipse of the Sun of 28 May 585 BC, which was a remarkable achievement and bears testimony to his ability. No wonder that his ideas were held in such high regard. He argued that if things cannot come from No-thing, there must be some all pervading essence from which all things have materialized. The question 'where did everything come from?' has inspired another: suppose that we removed everything from a region of space, would what is left be the

primeval 'No-Thing'? Thales offered his solution of this mystery too: his prime suspect was water. Ice, steam, and liquid are three manifestations of water and so Thales supposed that water can take on an infinity of other forms, condensing into rocks and everything. As puddles of water seemingly disappeared, later to fall as rain from above, the idea of vaporization emerged and with it the recognition of the cycle that water provides. Space for Thales is as empty as it can be when all matter in it has been turned into its primeval form, liquid water like the ocean. Water thus contains every possible form of matter. 3,000 years later this idea is defunct but modern ideas of the vacuum maintain the conceptual nomenclature by supposing it to contain an infinitely deep 'sea' of fundamental particles (see Chapter 7).

After seventy-eight years of consciousness Thales returned to the permanent void in 548 BC but the idea that there is an ubiquitous primeval essence or 'ur-matter' lived on. The nature of the ur-matter, however, was debated. On the one hand Heraclitus insisted it to be fire. So where does fire come from? Answer, it is eternal, and as such could be identified with ideas on a deity, creator of the world. By contrast Anaximenes argued that it is air. Air can be conceived of as extending infinitely, unlike water, its very ubiquity making it the preferred candidate for the universal source of all matter.

In the middle of the fifth century BC, Empedocles was faced with the question whether air was a substance or empty space. The tentative beginnings of experimental methods were brought to bear with a device known as a hydra – a glass tube, open at one end and with a spherical bulb at the other, the bulb containing holes out of which water can pour – so long as the open end of the tube remains open. If you place your finger over it, no water flows. If you empty the water from the hydra and then submerge it, water will pour in and refill it so long as the open end remains open. However, if the end is covered with your finger, no water



1. (a) A bottle with holes in the large bulb contains water. When the tube at the top is closed, water will stay in the bulb but if the tube is opened, (b), water will leak out of the holes. (c) The empty bottle has its tube closed and is immersed in a tank of water; no water enters. (d) Open the tube and water enters through the holes in the bulb. (e) Close the tube again and a water-filled bulb can be lifted out of the container without any liquid leaking from its bulb

enters the holes and no air escapes either. This demonstrated that air and water coexist in the same space; no water can enter until the air leaves; air is a substance and not empty space. It would not be until the seventeenth century that Toricelli explained what was happening.

Much ado about nothing

Empedocles extended the concept of ur-matter to four elements: air, water, fire, and earth. He also introduced primitive ideas on forces: for him they were love and discord, forerunners of attraction and repulsion. He was certainly the first to differentiate between matter and forces, but he still insisted that there can be no such thing as empty space.

Many forms of matter are granular. When spheres are packed together they leave spaces. So that there is no possibility of a void occurring in the 'empty' space thus created, Empedocles introduced the ether, lighter than air, which fills those spaces, indeed all space. Ether gets into everywhere, and prevents a vacuum occurring. He even imagined this ubiquitous ether being

able to transmit influence from one body to another. In modern thought this is like a gravitational field.

Anaxagoras also denied the possibility of empty space and of creation of something from nothing. For him creation was order emerging from chaos rather than a material universe appearing from nothing. Order from chaos admits that things can evolve and change, as when food turns into us. This permanence of basic elements while changing their overall structure gave the idea of seeds and the birth of atomism. For Anaxagoras, there was no smallest atom, no limit to the divisibility of matter, and so no need to worry about the spaces between touching spheres, no need for gap-filling ether.

Epicurus (341–270 BC), with Leucippus and Democritus, continued the denial that something can come from nothing. They are regarded as the originators of the idea of atoms, small basic indivisible seeds common to matter. Here is born the idea that there can be a void, an empty space through which atoms move. The thinking was that if there is something already at some point, then an atom cannot move into that place; in order for motion to be possible there must be empty space into which atoms can move. They even imagined an infinite evacuated universe filled with moving atoms, which were too small to see individually but which cluster into visible macroscopic forms. Atoms are in motion but their whole is a blur, seemingly at rest. The image is like an ant hill; seen from afar it is a static mound but in close-up would be revealed to consist of millions of tiny individuals in seething motion.

Although the ideas of the atomists are more similar to our modern picture of matter, it was Aristotle's contrarian ideas that held sway for 2,000 years. For Aristotle, a void would have to be utterly uniform and symmetric, unable to differentiate front from back, right from left, or up from down. This concept

had also appeared in the Creation Hymn of the Rigveda which mused:

Was there below?
Was there above?

Within such a philosophy an object cannot fall or move, it can only exist in a state of rest, an idea which would eventually form a basis of Newton's mechanics. However, for Aristotle such properties denied the existence of nothing and he brought the logical arguments for the absence of a void to their clearest form. If empty space is something, and if now you place a body in this empty space, you would have two 'somethings' at the same point at the same time. If that were possible, then it would generalize to allowing any something to be in the same place as any other something, which is nonsense. So for Aristotle, logic seemed to require that empty space cannot be something and therefore is non-existent. He defined the void as where there is no body, and since the basic elements of things exist eternally, there can be no place that is completely empty.

Much ado about nothing

All in all, Aristotelian logic denied the existence of the void and led to the received wisdom that nature abhors a vacuum. This was regarded as self-evident; nonetheless it was wrong, as we shall now see.

Why so abhorrent?

The aphorism that nature abhors a vacuum was the accepted wisdom for 2,000 years, well into the Middle Ages, because it was the simplest, seemingly obvious, explanation of a whole range of everyday phenomena. Try sucking the air out of a straw: air rushes in at the other end; it is like trying to suck the air out of the whole room. So close one end by putting a finger over it and suck the air from the other end: no vacuum occurs as the straw will collapse. Or put one end of the straw in a glass of juice and suck: you end up

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