Imperial College
London

A Memo on Doubt

A note from the editor

Just as Calvino wrote about the future of literature in his *Six Memos for the Next Millennium,* so here we will think about the future of science. Italo Calvino (1923-1985), one of Italy's finest post-war writers, was deeply interested and inspired by science. His work deftly combines elements of science fiction, fantasy and fable. As Calvino did, we will move swiftly, hopping across millennia and geographies, drawing from the words of poets - and of scientists - with literary freedom and gusto.

In science, as in life, doubt is usually thought of as something uncomfortable, to be weeded out and cast aside. But what if doubt were a good quality in science, a virtue to be practised in our daily lives scientific? Here, we are not talking about doubt in the sense of uncertainty, something quantifiable that we might read about in the *Limitations* section of a paper. In this Memo, we will take doubt to be something less tangible and more ethical in nature - more existential. We will examine doubt as an agent of the good life and of good science.

In this way, we will reflect on how doubt may relate to science and scientists. As our resources, reliably guiding us in ethical matters, we will turn to Greek myths and philosophy, with some input from mediaeval poetry along the way. In doing so, we will attempt to trace the outline of an essential ethics for science.

CREDITS

Editorial vision by
Dr Stephen Webster, Imperial College London, leader of the Good Science Project

Words and editing by
Dr Anthea Lacchia, independent writer

Illustrations by
Claudia Cannon, Imperial College London

Design and layout by
Keeping the wolves at bay

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the Imperial Design and Editorial team

A welcome from Dr Stephen Webster, leader of the Good Science Project

Imperial College welcomes you to The Day of Doubt. It is part of a College-wide project we are running on research culture, as a collaboration between the Office of the Vice-Provost (Research and Enterprise) and the Science Communication Unit. In this conference and in this Memo, scientists, sociologists, Greek heroes and poets come to our aid as we search for a research culture that supports our ideals. To that end, for a brief moment here in the precincts of Imperial College, we will let doubt flow over our science. In doing so we can look forward to good debate, good ideas, and some new directions.

THE DAY OF DOUBT, 27 SEPTEMBER 2023

The Good Science Project's first conference, the Day of Doubt, will bring together leading scientists to debate today's research culture and the values needed for today's science. In particular we discuss the relationship that must exist between the stern necessities of laboratory life and the emerging habits of the good scientist.

A wonderful group of speakers will join us. In the morning Sir Paul Nurse FRS and Professor Ian Walmsley FRS will consider what we mean by 'good science' and its relationship to doubt, in a session introduced by Daksha Patel. We will then split into two parallel sessions: one on doubt in research culture, with Dame Ottoline Leyser FRS and Professor James Wilsdon, and the other on doubt in innovation, with Professor Andy Stirling, Dr Kanta Dihal and Ehsan Masood.

Reflective sessions in the afternoon will provide an opportunity for delegates to move into smaller discussion groups. Each will cast doubt on one aspect of research culture. Katherine Mathieson and Professor Ken Arnold will help us question public engagement; Dr Isabella von Holstein and Alyssa Gilbert will look at interdisciplinarity. Professor Stephen Curry and Professor James Wilsdon will look at the concept of excellence as a descriptor of good science, while Professor Steve Fuller and Dr Stephen Webster will discuss ideas about scientific truth and progress. Kat Harris, Professor Oscar Ces, and Professor Roger Kneebone will consider how the many forms of expertise to be found in Imperial College can best work together.

The ideas generated by the reflection sessions will be shared and discussed when we all come together for the final plenary session, chaired by Professor Mary Ryan CBE, Vice-Provost, Research and Enterprise, and Dr Felicity Mellor, Director of the Imperial Science Communication Unit.

This booklet is intended as a memento of the day. It is a keepsake to encourage further thought and discussion. We hope you will continue these conversations and keep in touch with us by signing up to the Good Science Project mailing list.

TO LEARN MORE ABOUT THE GOOD SCIENCE PROJECT, VISIT:

www.imperial.ac.uk/about/leadership-and-strategy/provost/vice-provost-research/the-good-science-project/

Creeping doubt in science

"Doubt is the father of invention."

Galileo Galilei (1564-1642)

"Who gets funded, why did they get funded? Is it their project that is so significant or are they super-talented or is it because they've worked in the lab of Professor X, or is it because they are working on a research project that aligns with the views of Professor Y?"

Late-career researcher[1]

"Religion is a culture of faith; science is a culture of doubt."

Richard P. Feynman (1918-1988)

"Who is wise enough for all this? Who knows the meaning of anything?"

Ecclesiastes 8, v1

Criteria for research career progression have become narrower and "...less and less relevant or properly concordant with the values people had in coming into these careers in the first place. [...] We've got to do something about this."

Dame Ottoline Leyser FRS, Croonian Prize Lecture 2023, The Royal Society

"If we begin with certainties, we shall end in doubts; but if we begin with doubts, and are patient in them, we shall end in certainties."

Sir Francis Bacon, 1605

"The postdoc structure disadvantages those who cannot keep moving for family reasons, which particularly affects women."

Researcher/Lecturer[2]

"There lives more faith in honest doubt, believe me, than in half the creeds."

Alfred Tennyson, 1849

"Everything is false, everything is possible, everything is doubtful."

Guy de Maupassant, 1885

"Science is a very human form of knowledge. We are always at the brink of the known; we always feel forward for what is to be hoped. Every judgement in science stands on the edge of error and is personal. Science is a tribute to what we can know although we are fallible. In the end, the words were said by Oliver Cromwell: I beseech you, in the bowels of Christ, think it possible you may be mistaken."

Jacob Bronowski, 'The Ascent of Man', BBC, 1973

"Technical staff make vital contributions to research and innovation, but historically, their input can often go unrecognised. Research is a team sport – it's critical we recognise the diverse roles and skills that collectively enable excellence."

Kelly Vere, Director, Technician Commitment[3]

"I am aware of others who have been tempted to edit their data to get the 'right' results. I am also aware of data-trawling exercises to 'find' interesting results."

Reader[2]

"If you would be a real seeker after truth, it is necessary that at least once in your life you doubt, as far as possible, all things."

René Descartes, 1644

"Research should be evaluated in such a way that it ignores simple metrics like impact factors and numbers of papers and instead tries to take a better overall account of all outputs arising from the research."

Reader[2]

"In these times I don't, in a manner of speaking, know what I want; perhaps I don't want what I know and want what I don't know."

Marsilio Ficino, c.1460

"Peer review assumes freedom from politics and bias which is often not the case."

Professor[2]

A NOTE ON CONTEMPORARY SCIENCE

Look closely, and you will find that doubt resides in every corner of the scientific enterprise. It is in the open plan office where a PhD student receives an email from their advisor suggesting which journal they should publish their research in, it is in the seminar room where a postdoc is unsure whether to raise their hand to question a result, it is in the technician's expression when they look at a paper and see they have been left out of yet another author list.

From power struggles, to job insecurity, pressure to publish, secrecy, bullying, and intense competition, we know the issues in research culture. Our environment can be harsh and sometimes we need shelter. The pleasures we take in our work – surely the root of our creativity – often centre on our daily practice. Scientists report their enjoyment in intellectual autonomy and in the quiet development of their skills and their knowledge, sometimes slowly, sometimes quickly. And the institutions are noticing. From grants[4] dedicated to the enhancement of research culture, to codes of conduct and guidelines, to global initiatives dedicated to promoting responsible use of metrics in research evaluation,[5] there is much effort to ease the suffering that exists in science. But what does 'good' research culture look like? Where does it reside? Perhaps it is found in scientists' desire to improve conditions for society and the planet, or simply for their lab. Maybe it is found in the curiosity that drives our research. Could doubt help direct us in our quest?

1 Interviewee, Wellcome Trust survey on research culture, 2020: **wellcomeopenresearch.org/articles/5-201**

2 Survey respondent, The culture of Scientific Research in the UK, Nuffield Council on Bioethics, 2014: **www.nuffieldbioethics.org/publications/the-culture-of-scientific-research**

3 **hidden-ref.org**

4 Research England, Enhancing Research Culture grant allocations 2022-23 **www.ukri.org/wp-content/uploads/2022/09/RE-20092022-EnhancingResearchCulture-2022-23.pdf**

5 DORA, The Declaration on Research Assessment (DORA): **sfdora.org/**

Could doubt be a virtue?

αὐτὰρ ἐγώ γε
ἐγρόμενος κατὰ θυμὸν
ἀμύμονα μερμήριξα,
ἠὲ πεσὼν ἐκ νηὸς ἀποφθίμην
ἐνὶ πόντῳ,
ἦ ἀκέων τλαίην καὶ ἔτι
ζωοῖσι μετείην.

...And I woke up with a start, my spirit churning – should I leap over the side and drown at once or grit my teeth and bear it, stay among the living?

Odysseus speaking in Book 10 of the *Odyssey*, lines 49-50

"Honesty, [is the] number one [virtue]. It's a belief that, even though you may be absolutely convinced that you're right, you may be wrong. It's very important to accept that the frame in which you're operating is not the total frame."

Emeritus Professor[1]

Let's begin with a myth. Homer's Odysseus is standing at the helm of his ship, as it is battered by fierce, unforgiving winds. As the waves crash in, he stares out to sea, pondering what course of action to take. During his epic, ten-year wanderings from the ruins of Troy back home to the shores of Ithaca, this Greek hero is constantly reworking problems in his mind.[2] Though we often see him filled with doubt, Odysseus does not remain paralysed in a state of inaction for long. Indeed, doubt is a tool that enables him to consider all the possibilities that lie ahead. He adapts to the obstacles he's faced with. In this way, doubt is liberating. It is a strategy that brings us closer to the good life, to our Ithaca of research culture.

RESEARCH CULTURE AND THE GREEKS

Aristotle (384-322 BC), whose philosophy encompassed all branches of knowledge including the natural sciences, is often regarded as the first scientist. His ethical theory, articulated in the *Nicomachean Ethics*, puts at centre stage the character of a person rather than their actions.

According to Aristotle, in order to be good, we should cultivate the virtues: traits of character such as honesty, generosity, reticence and humility. Scientific virtues might also include integrity, openness and trust. Should doubt be added to this list? If, in science, we accept and examine the waylessness and doubt, as Odysseus does several times in his journey, can we better find our moral compass?

1 Interviewee in: Anthea Lacchia & Stephen Webster. 2021. La Commedia Scientifica – Dante and the scientific virtues, *Geoscience Communication*, 4(2), 129-145.

2 Michelle Zerba. *Doubt and Skepticism in Antiquity and the Renaissance*. Cambridge University Press, 2010. According to Zerba, Odysseus' handling of doubt, as well as his capacity to adapt without jumping to conclusions, make him the first sceptic.

Doubt has its roots in the Greek word aporia (ἀπορία), often translated as waylessness or impassibility. Odysseus, during his voyage back to Ithaca, is no stranger to this feeling.

Self-doubt and hesitation

E qual è quei che disvuol ciò che volle
e per novi pensier cangia proposta,
sì che dal cominciar tutto si tolle,
tal mi fec' ïo 'n quella oscura costa,
perché, pensando, consumai la 'mpresa
che fu nel cominciar cotanto tosta.

And like someone who no longer
wishes what he once did,
and changes his intention due
to new thoughts,
so that he backs out from what
he had started,
such I became upon that dark hillside,
because, in thinking, I brought to an
end the plan,
which I was so eager to adopt
in the beginning.

Dante, *Inferno*, 2(37-42)

"That's something that worries me, that once I leave and we have publications coming out of the study, for which I have done every single patient visit, collected every bit of data, I might not get first author. I might not even get co-authorship."

PhD student[1]

1 Interviewee in: Anthea Lacchia & Stephen Webster. 2021. La Commedia Scientifica - Dante and the scientific virtues, *Geoscience Communication*, 4(2), 129-145.

The year is 1300. Dante sets out on his fictional journey through Hell (*Inferno*), Purgatory (*Purgatorio*) and Paradise (*Paradiso*). In the Divine Comedy (*Divina Commedia*), which is widely regarded as an ethical masterpiece, late-medieval Italian poet Dante Alighieri (1265–1321) imagines himself making a metaphorical journey into the afterlife. Through this exploration of a moral universe, he comes to understand himself and the modern world he inhabits. And it all starts from a moment of doubt. The very first line of the *Commedia* highlights the poet's existential problem: *Nel mezzo del cammin di nostra vita, mi ritrovai per una selva oscura ché la diritta via era smarrita* (In the mid point of my life, I found myself in a dark wood, as the way forward was lost), *Inferno,* 1(1-3).

Scientists are no strangers to self-doubt and inner turmoil. If we take doubt to be the opposite of complacency, it is associated with pause, with thoughtful hesitation. Yet this act of questioning, of taking necessary time before making a decision, seems at odds with the push for success, publications, and the need for high-impact results. In truth, science is full of conflicts, some internal, some relating to wider culture. Questions proliferate over the proper handling of research metrics, the use of animals in research, scientists' relationships to funders and industry partners, co-authorship disputes, or the open sharing of knowledge and its benefits. So let us ask once again: where does good science reside? Could it be in the office where a PhD student and their supervisor are having an honest discussion? Or in the pause a researcher takes before submitting a grant proposal or adding their signature to a research agreement? Or in a simple quiet hour, alone with an experiment?

In the *Divine Comedy,* Dante, when the time comes for him to follow the Roman poet Virgil down into the depths of Hell, is full of doubt and anguish.

Looking both ways

The verb 'to doubt' has its roots in the Latin *duhibitare,* from *duhibeo,* to hold or have as two, which can be taken to mean 'to be of two minds', moving to and fro in opinion or decision.

ἔνθα καὶ ἠματίη μὲν ὑφαίνεσκεν
μέγαν ἱστόν,
νύκτας δ' ἀλλύεσκεν, ἐπὴν δαΐδας
παραθεῖτο.

So by day she'd weave at her great and growing web - by night, by the light of torches set beside her, she would unravel all she'd done.

Odysseus' wife Penelope is weaving and unweaving a web, The Odyssey, 2(104-15)

"The [emotionally] disinterested scientist is a myth. Even if there were such a being, he probably wouldn't be worth much as a scientist. I still think you can be objective in spite of having strong interests and biases."

Scientist[1]

Penelope, unsure whether Odysseus will return home or whether he has perished at sea, promises her suitors that she will remarry once she has finished weaving a funeral shroud for Odysseus' father, Laertes. Unbeknownst to them, she is warding off their advances through weaving by day and unweaving by night. Her reticence towards the suitors, which permeates the Odyssey,[2] is a quality that allows her to survive and continue to wait for a better outcome.

Scientists are no strangers to mixed feelings. Is having to work quickly at odds with integrity? How does the push towards collaboration impact on how we see our community, or individual work? Is personal attachment to a theory at odds with scientific rigour and objectivity? In his study[1] of the scientists working on the Apollo lunar missions, the sociologist Ian Mitroff described a deep ambivalence, a sense that the scientists were 'looking both ways'. For instance, on one hand they were fierce supporters of the impersonal, objective character of science, while at the same time firmly believing scientists ought to possess a strong, dogged, emotional commitment to their ideas.

As Mitroff found, conflicting perspectives are everywhere in science. They lurk also under the shiny facades of institutional websites and communications. Consider the complexities of a Research Excellence Framework (REF) always under reform, university rankings that can be interpreted in so many ways, the immediate exposure of high-impact science to political forces, and the policies of our institutions and funders that attempt to triangulate all of this. With all the messiness of contemporary science, could it be that a healthy dose of ambivalence, even confusion, may actually be conducive to good science? And could it be that institutions, in admitting the existence of doubt, can better encourage debate on research culture? In other words, in sitting with the discomforts of ambivalence, won't an institution be energised, as it seeks out good science? Could this be what we mean by success in science?

1 Ian Mitroff. 1974. Norms and counter-norms in a select group of the Apollo moon scientists: a case study of the ambivalence of scientists, *Am. Sociol. Rev.,* 39, 579–595.

2 See: Michelle Zerba. 2009. What Penelope Knew: Doubt and Scepticism in the 'Odyssey', *The Classical Quarterly, New Series,* 59(2), 295-316.

Janus bifrons is a Roman god associated with duality, decisions, and beginnings. His two faces, pointing in opposite directions, indicate an ability to hold different perspectives, and tolerate ambivalence.

A picture of happiness in science

I

...οὕτω τοι τόδε σῆμα πιφαύσκομαι:
οὐδέ τι οἶδα,
ἦ μοι ἔτ᾽ ἔμπεδόν ἐστι, γύναι,
λέχος, ἦέ τις ἤδη
ἀνδρῶν ἄλλοσε θῆκε, ταμὼν ὕπο
πυθμέν᾽ ἐλαίης.
ὣς φάτο, τῆς δ᾽ αὐτοῦ λύτο γούνατα
καὶ φίλον ἦτορ,
σήματ᾽ ἀναγνούσῃ τά οἱ ἔμπεδα
πέφραδ᾽ Ὀδυσσεύς:
δακρύσασα δ᾽ ἔπειτ᾽ ἰθὺς δράμεν,
ἀμφὶ δὲ χεῖρας
δειρῇ βάλλ᾽ Ὀδυσῆϊ, κάρη δ᾽ ἔκυσ᾽...

...There's our secret sign, I tell you,
our life story!
Does the bed, my lady, still stand
planted firm?-
I don't know- or has someone
chopped away
That olive-trunk and hauled our
bedstead off?"
Living proof
Penelope felt her knees go slack,
her heart surrender,
recognizing the strong clear signs
Odysseus offered.
She dissolved in tears, rushed to
Odysseus, flung her arms
Around his neck and kissed his head...

Odyssey, Book 23(201-207)

“It’s a bit like being a mountain climber,
a polar explorer or a deep-sea diver.
You go and explore somewhere, you go
somewhere nobody has been before. [...]
You are exploring uncharted territory.
There is that tremendous excitement
that you get”

Professor[1]

We began with the Odyssey. Let us end where it also ends. Having reached the shores of his beloved Ithaca, Odysseus, previously disguised as a beggar, finally reveals his identity to his wife Penelope. But neither tears, nor hugs are forthcoming. Penelope, like Odysseus, is both cunning and doubtful.[2] She looks at the man seated before her and needs to be sure it really is her long lost husband. Only then will she allow herself to make the move from doubt to happiness. Penelope has had to survive for 20 years without knowing whether her husband was alive or dead, whether he would return or meet his fate elsewhere. Her handling of doubt, in this scene and in the Odyssey at large, is on a par with that of Odysseus. For these heroes, doubt is more than anxious turmoil. It is a path leading to resolution and completion, even *happiness*.

A LIFETIME'S WORK

Aristotle believed that humans should strive for εὐδαιμονία, which loosely translates as happiness, or flourishing. In order to reach this happy state, we must spend our lives cultivating and practising the virtues. Applying virtue ethics to science means asking ourselves what character traits make someone a good scientist, instead of focusing on the right action to take in ethical matters. Practise the scientific virtues, and good science will inevitably flow. Indeed, Aristotle's word for virtue, ἀρετή, can be taken to indicate the cultivation of excellence, which simply equates to being good at what you do. In other words: if you do your job well, in conformity with the virtues, then you will flourish and your science will be fine. Could this be the kind of excellence the REF should encourage? And, if we accept that the virtues can help us in our quest for good science, how can scientific institutions foster them and make possible a scientific εὐδαιμονία? These are questions which endure.

1 Interviewee in: Anthea Lacchia & Stephen Webster. 2021. La Commedia Scientifica - Dante and the scientific virtues, *Geoscience Communication*, 4(2), 129-145.

2 Michelle Zerba. 2009. What Penelope Knew: Doubt and Scepticism in the 'Odyssey', *The Classical Quarterly, New Series*, 59(2), 295-316.

Penelope tests her husband's identity by asking her maid to take their bridal bed out of the bedchamber. Only her husband Odysseus would know that the bed is built around the trunk of an olive tree, firmly rooted in the ground, for he is the one who constructed it.

A starry future for science

"One thing only I know, and that is that I know nothing."

Socrates

The Athenian philosopher Socrates (c. 470-399 BC) is the main Greek figure we associate with doubt. He devoted his life to critical inquiry, writing nothing. His incessant questioning threatened the values and beliefs central to the polis, leading him to be sentenced to death. His fate can serve as a warning: when doubt is banished and complacency sets in, bad things happen.

Doubt challenges us. It exposes questions and it brings choices. The pleasure of being a scientist - our eudaimonia - comes also from that. Enjoying our work in this way, we inch closer to good science. Perhaps this is how, as we battle the waves, we can emerge to see the stars.

E quindi uscimmo
a riveder le stelle.

And then we emerged and once again beheld the stars.

The last line of Dante's *Inferno*, 34(139)

SIX GREAT REFERENCES ON DOUBT

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5. Alasdair MacIntyre. *After Virtue*. University of Notre Dame Press, Indiana, USA, 1984.
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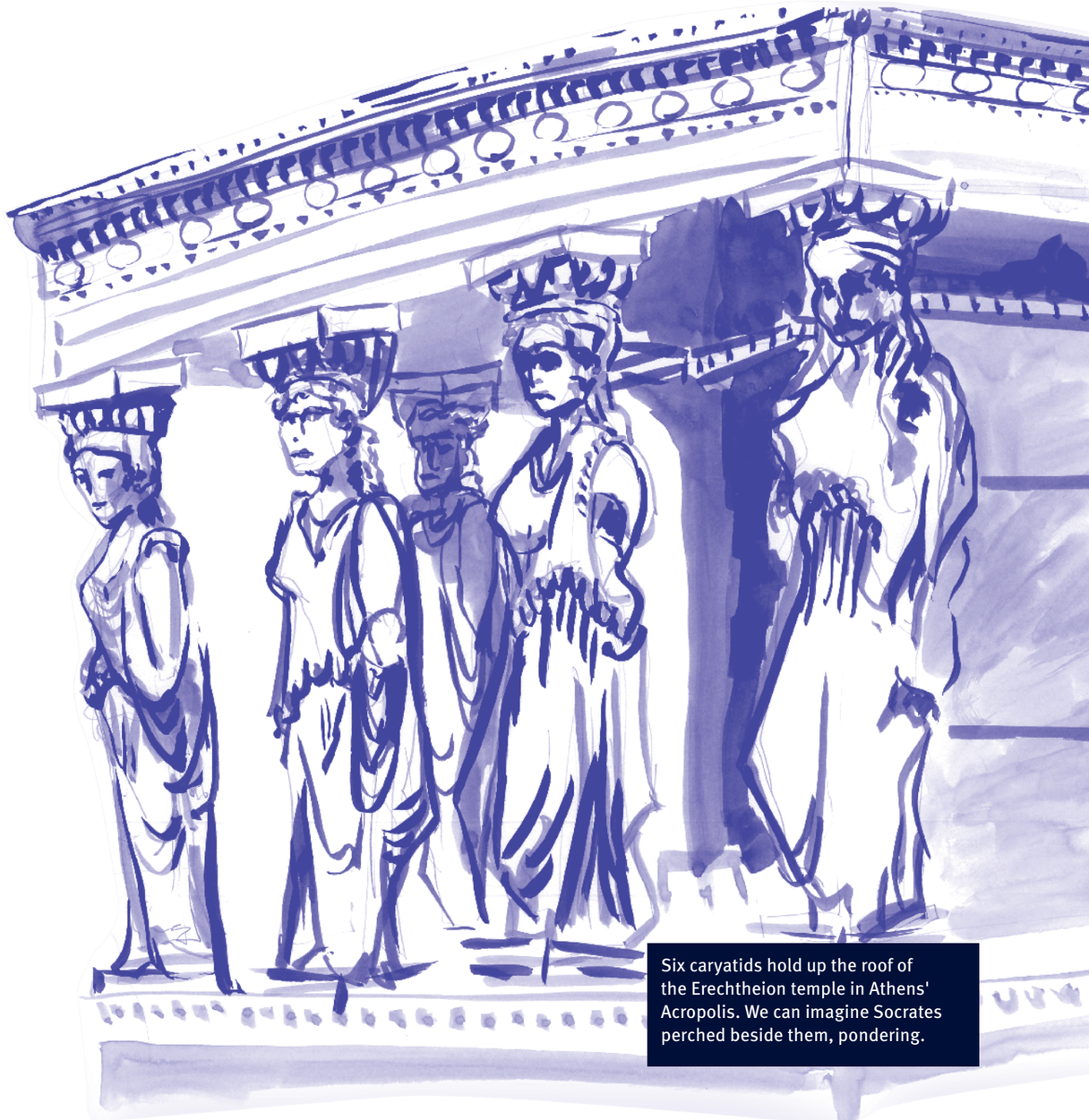

Six caryatids hold up the roof of the Erechtheion temple in Athens' Acropolis. We can imagine Socrates perched beside them, pondering.

Imperial College London

non men che saver, dubbiar m'aggrata

Doubting pleases me no less than knowing

Dante, *Inferno*, 11(93)

This Memo accompanied The Day of Doubt conference, held at Imperial College on September 27th 2023. Drawing from interviews, history, literature and myth, the Memo raises questions about the relationship between doing science, and being a good scientist.