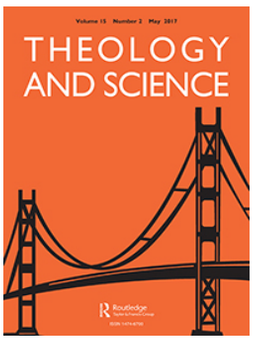

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Thomas: The Apostle of Scientists

Wilson C. K. Poon

ABSTRACT
Richard Dawkins suggests that the way "doubting Thomas" demanded evidence for Jesus' resurrection should endear him to scientists. A close reading of Chapter 20 of John's Gospel suggests that Thomas' confession of Jesus' divinity does indeed resonate with how scientists make progress, but not because he demanded evidence. Rather, the similarity lies in the way he went beyond the immediate evidence to reach a bold conclusion, the implications of which took a lifetime to work out. A comparison with the way J. J. Thomson discovered the first sub-atomic particle, the electron, shows that this is also how breakthroughs in science happen.

KEYWORDS
Faith; evidence; Thomas; Dawkins; Polanyi; electron; discovery

The militant atheist, Richard Dawkins, once nominated Thomas the apostle as a patron saint of scientists:

> Science is based upon verifiable evidence. Religious faith not only lacks evidence, its independence from evidence is its pride and joy, shouted from the rooftops. Why else would Christians wax critical of doubting Thomas? The other apostles are held up to us as exemplars of virtue because faith was enough for them. Doubting Thomas, on the other hand, required evidence. Perhaps he should be the patron saint of scientists.[1]

Apparently, Thomas' demand for visual and tactile evidence after the first Easter—"unless I see … and put my finger in … I will not believe" (20:25)[2]—sets him apart from the other apostles and allies him with the scientist. In this article, I explore whether there is any sense in which Thomas' behaviour recorded in Chapter 20 of John's Gospel can legitimately be compared to the way scientists go about their work. Through a close reading of the relevant passage (20:24–29), I conclude that Thomas bears comparison with the scientist *not* because he "saw" before he "believed", but because of *what* he believed on the basis of what he saw. This comparison is illustrated by an episode in the history of science, J. J. Thomson's discovery of the first subatomic particle, the electron.

John Chapter 20

I start with an exposition of the chapter in John's Gospel in which the narrative about Thomas (20:24–29) is found. This chapter occurs at the end of what was probably the last chapter of the original Fourth Gospel.[3] This chapter narrates the discovery of the empty tomb and a series of resurrection appearances. "Seeing and believing" is a major theme (see vv. 8, 25, 29).[4]

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In the opening pericope, Peter and John ("the other disciple") were told by Mary Magdalene of the empty tomb. They ran to it. John got there first, but did not go in. Peter arrived, went in and saw "the linen wrappings" and the head cloth. "Then the other disciple … also went in, and he saw and believed." (v. 8) The singular "he" refers to John. Commentators differ on what we are meant to infer about Peter. Bultmann thought that "clearly … Peter … was likewise brought to faith … "[5] Barrett, however, says that "Peter had not been convinced … of the resurrection by the sight of the empty tomb and the grave-clothes,"[6] so that it is possible to "see and not believe".[7] Either way, the next verse is the important one for my purposes here: "for as yet they did not understand the scripture, that he must rise from the dead." (v. 9) In other words, Peter and John had to rely on visual evidence at this point because the Jewish scriptures (what we now call the Old Testament)[8] did not yet have any evidential force for them.

In the next pericope Mary also looked into the tomb and saw the same sight that greeted Peter and John (with the addition of two angels). But she persisted in her conviction (vv. 1–2) that "they have taken away my Lord." (v. 12) Even seeing the risen Jesus (v. 15) did not help. It was only Jesus saying, "Mary!" (v. 16a) that brought recognition: the sheep knows the good shepherd's voice (10:1–5). Hearing Jesus enabled Mary to make sense of what she saw, and she answered, "Rabbouni!" (v. 16b) This was probably Mary's "regular designation for [Jesus]."[9] Thus, at the moment of recognition, Mary simply "picked up where she left off" in her previous relationship with Jesus. The physical "holding on" implied by verse 17 implies as much. Jesus had to explain to Mary that a mere resumption of the previous relationship was inappropriate, because "I am ascending to my Father and your Father."

Mary then went and told the disciples, "I have seen the Lord (*kurios*)." (v. 18) Mary, on the strength of auditory and visual evidence, had also come to believe that Jesus was risen. Some, like Bultmann,[10] hear in v. 18 something of the full Christological pathos associated with *kurios* as found in later Christian creedal confession. I disagree. "*Kurios* is a frequent designation of Jesus in John."[11] Before the resurrection, we find it so used by Mary and Martha, Peter, Thomas, Philip and Judas (not Iscariot) in Chapters 11–14. Probably, then, the *kurios* in v. 18 is, like the Rabbouni in v. 16, another of Mary's "regular designations" for the pre-resurrection Jesus (cf. the coupling of *kurios* and teacher in 13:13). What she came to believe was that the self same Jesus that she knew before was now alive again. No less; but no more.

Mary's report apparently had little effect on the disciples: in the third pericope in Chapter 20, we find them fearful and hiding. Jesus appeared, greeted and commissioned them. In the beginning of the next periscope, these disciples told Thomas, who was absent: "We have seen the Lord." (v. 25) These are (apart from substituting "We" for "I") identical to the words used earlier by Mary to report her experience (v. 18), and carry the same import: on the basis of their visual experience, the disciples believed that the Jesus they knew was alive again, no less, but no more.

To summarise, the first three pericopes in Chapter 20 tell us how the rest of the apostles together with Mary Magdalene came to believe, on the basis of visual evidence, that the Rabbouni and *kurios* they knew had indeed been raised from the dead. This was surely remarkable for them; but in the narrative framework of John's Gospel, this was not *sui generis*. They had seen Lazarus raised from the dead not so long ago (11:1–45).

Thomas

By now, Thomas was the only one of the "inner circle" who had not seen for himself any of the visible evidence of Jesus' resurrection (empty tomb, grave clothes, the Lord himself). He famously demanded, "Unless I see the mark of the nails in his hands, and put my finger in the mark of the nails and my hand in his side, I will not believe." (v. 25) It is important to be precise about what it is that he refused to believe without visual and tactile evidence. I think it is that which John believed on seeing the grave clothes, what Mary Magdalene suddenly recognised when she heard Jesus say her name and what the other disciples meant when they told Thomas, "We have seen the Lord."—that the Jesus the man, whom they had known for three years, had indeed risen.

A week later, Jesus appeared again, invited Thomas to see and touch, and challenged him: "Do not doubt but believe." (v. 27b). The NRSV's "doubt" and "believe" translate two words otherwise unknown in the Fourth Gospel, *apistos* and *pistos*. Elsewhere in the New Testament, these terms often mean "unbeliever" and "believer" respectively. If that is the import here, then although the precise force of Jesus' challenge is obscured by a "rather clumsy expression"[12] in the Greek, the choice on offer is between different kinds of beliefs (believing in the gospel or in something else), and not between exercising and not exercising faith.[13] John did not say that Thomas availed himself of the opportunity to touch; instead, he said to Jesus, "My Lord and my God!" (v. 28)

Thomas' confession led to the dominical saying: "Have you believed because you have seen me? Blessed are those who have not seen and yet have come to believe." (v. 29) It is easy to hear an element of accusation in the first part of this saying, whether it is rendered as a question or a statement.[14] Such a reading of this verse presumably lurks behind two millennia of Christian comments that (in Dawkins' words) "wax critical of doubting Thomas", such as the Collect for Saint Thomas the Apostle in the *Book of Common Prayer*.[15] But with Barrett, many commentators agree that "the words do not convey a reproach to Thomas."[16] After all, the other *dramatis personae* in this chapter also believed because they saw (see particularly v. 8), but were never reproved for it. Moreover, the content of their belief (that the crucified Jesus had indeed risen) was at best partial from John's point of view. Thomas was the only one whose sight had led to a fully adequate belief in Jesus' divinity. Whatever we conclude about this issue, however, the main message of this saying is that for post-apostolic generations (which includes most if not all of John's original audience), sight would no longer be the basis of belief.

How was Thomas distinctive?

John 20:24–29 lies behind Richard Dawkins' nomination of Thomas as the patron saint of scientists: "The other apostles are held up to us as exemplars of virtue because faith was enough for them. Doubting Thomas, on the other hand, required evidence." But he could not have read the text. If he *had* read John 20, he would have found that *everyone* in the chapter believed on the strength of visual evidence (plus hearing in the case of Mary). It is true that Thomas alone *demanded* to see. But verse 9 (that John saw and believed because he did not yet understand scripture) suggests that none of the others would have believed at this stage without sight either (because *no one* had yet understood

scripture), whether they overtly demanded visual evidence or not. On this score, there is, *contra* Dawkins, little to distinguish Thomas from the others.

The text, however, *does* clearly distinguish Thomas from the others on one matter: he uniquely confessed Jesus to be divine. Upon seeing Jesus, Thomas alone said, "My Lord *and my God*!" (v. 28, italics mine). As one commentator has said, the sight of Jesus "would justify Thomas saying 'My Lord' [= the human teacher he had known], but it could hardly justify him saying 'My God'."[17] In making this confession, therefore, Thomas went *considerably beyond* what he thought he could believe upon seeing and touching. Not only did he recognise the crucified Jesus in the risen one ("My Lord"; the others, based on similar visual evidence, had concluded as much), but that this Jesus was divine ("My God").[18] The conclusion that Thomas arrived at was all the more striking because of his Jewishness (with all that it entails about belief in the invisibility of God and the prohibition of all visual representations of the divine)

How did Thomas arrive at this bold conclusion? Our passage does not tell us explicitly. We are, of course, supposed to infer that Thomas, like the others, had witnessed all that had gone before in this Gospel, especially Jesus' seven "signs" (*sēmeia*), beginning with turning water into wine at the wedding in Cana. (2:1–11) Interestingly, however, John also gave us the only two other canonical stories about Thomas. First, he told us that Thomas was willing to go with Jesus to the tomb of Lazarus despite the risk posed by his enemies—"Let us also go, that we may die with him." (11:16) Second, in response to Thomas' honest question: "Lord, we do not know where you are going, how can we know the way?" (14:5), Jesus answered, "I am the way, the truth and the life." (14:6a) In other words, the Johannine Thomas had already concluded, before Jesus' death, that here was a teacher with whom he was willing to bind his fate. It was this Thomas who now reached beyond the data presented by his eyes to confess that the risen Jesus was divine.

Remembering the terms of Jesus' challenge to Thomas: "Do not be *apistos*, but be (or become) *pistos*," we must conclude that Thomas is now a full-blooded believer; indeed, in the narrative structure of the Fourth Gospel, we may go as far as saying that the Johannine Thomas is the first Christian believer: "My Lord and my God" is the first fully adequate confession of faith made by any disciple. Jesus' saying, "You believe because you have seen me," acknowledges as much. The original ending of the work makes this abundantly clear: the book was written "so that you may come to believe that Jesus is the Messiah, the Son of God … " (v. 31), in other words, to bring readers to the same point that Thomas has just reached.

Thomas the scientist

This account of Thomas resonates deeply with my experience as a practising scientist, but *not* because he demanded visual evidence. Instead, the resonance pertains to the way he went beyond what he saw—that the man Jesus he knew had indeed risen—to reach a much more profound conclusion: that this Jesus was divine. To see why this should resonate with a scientist, we turn to authors who have reflected on the scientific *process*, in particular the process of discovery. A good description of this process has been given by Michael Polanyi, a distinguished physical chemist turned philosopher of science.[19] In his 1951-2 Aberdeen Gifford Lectures, Polanyi says that

> true discovery is not a strictly logical performance … we may describe the obstacle to be overcome in solving a problem as a 'logical gap' … 'Illumination' is then the leap by which the logical gap is crossed. It is the plunge by which we gain a foothold at another shore of reality. On such plunges the scientist has to stake bit by bit his entire professional life.[20]

The philosopher of science George E. Smith has recently put the matter in another way: "the fundamental problem in doing science is turning data and observations into evidence," because "data rarely carry their evidential import on their surface."[21] In other words, "data and observations" rarely compel assent to any particular way of seeing things. To make progress, the scientist has to "take the plunge" across the "logical gap" separating "data" and "evidence" to reach "another shore of reality". Polanyi stresses that "taking the plunge" is not something that one could learn from a text book, but only by apprenticeship.[22] In my experience of taking scientific apprentices (PhD students!), this is one of the hardest things they have to learn. Indeed, some find the whole process so scary that even by the end of their training, their only experience of getting to that "other shore of reality" is by being carried on other people's shoulders.

The reason for the Thomas story resonating with me as a practising scientist should now be apparent. There was a "logical gap" separating what Thomas was seeing (Jesus the man was risen) and what he concluded (Jesus was divine). He took the plunge! None of his friends did that when confronted by the same visual data. Thomas was indeed unique, and in his uniqueness he was rather like a scientist making a breakthrough.

The electron: from electrical corpuscle to atomic constituent

George Smith made his point about "turning data and observations into evidence" in an essay on J. J. Thomson's role in the discovery of the electron.[23] I now turn to consider this episode to make concrete the similarities between Thomas' confession of faith and how scientists make breakthroughs.

Thomson was working on the conduction of electricity between two metallic electrodes sealed inside a partially evacuated tube. Visually, conduction was correlated with a green glow, dubbed "cathode rays", extending from the negative electrode (cathode) to the positive electrode (anode). Thomson made a specific assumption about the nature of cathode rays: they were streams of negatively charged "corpuscles" (rather than excitations in the all pervasive "luminiferous ether" as many of his contemporaries thought), and measured the ratio of their charge to their mass. In a 1897 paper, he announced values that were about a thousand times larger than the corresponding ratio typical for charged atoms (or "ions"), independent of the different materials making up the cathode. He suggested that the large charge to mass ratio was due to the extreme lightness of these corpuscles (rather than a high charge).

Thomson's conclusion that his data provided evidence for the existence of light, negatively charged corpuscles (later called "electrons" after tortuous nomenclature disagreements) and that these were responsible for the conduction of electricity through gases was uncontroversial. Emil Wiechert had reached similar conclusions in Germany. As a reviewer said in 1901, "[w]e have in the cathode rays the electrons … bodily before us so to speak."[24]

But Thomson went much further. He concluded that these very light corpuscles were universal atomic constituents, and that electrical conduction in his apparatus was due to these corpuscles being stripped from the gaseous atoms and propelled from cathode to anode. In other words, Thomson saw his data as evidence for atomic divisibility. Nothing in his data required this interpretation. Indeed, between data for the charge to mass ratio of the negative corpuscles making up cathode rays and the electron-as-atomic-constituent laid a logical gap. Of all the experimentalists working with cathode rays, Thomson alone[25] took the plunge to reach "the other shore of reality". That "Thomson's daring hypothesis of corpuscles as constituents of atoms was more controversial than his conclusion about the nature of cathode rays"[26] is evidence for the existence of the "logical gap" and the need for taking a plunge. Many of Thomson's contemporaries thought that the data provided evidence for no more than the existence of electricity particles ("free electrons") that had nothing to do with atoms. Thus, George Fitzgerald[27] preferred this interpretation because "it does not assume the electron to be a constituent part of an atom, nor that we are dissociating atoms, nor consequently that we are on the track of the alchemists."[28] For Fitzgerald, Thomson, in taking his plunge from cathode ray data to atomic divisibility, was edging towards the occult (hence "alchemists").

Thomson did not arrive at the logical gap and take the plunge "out of the blue". He had been interested for a long time in chemistry, including the chemical effects of electricity.[29] He was thus completely familiar with long-standing *chemical* speculations about atomic divisibility. These were traceable back to William Prout's suggestion, based on his measurement of atomic weights of the elements, that all chemical elements were made up of multiples of hydrogen atoms. Thomson's previous exposure to and engagement with these chemical ideas laid behind his daring plunge from cathode rays to atomic divisibility.

Thomson's is not an isolated example. Thus, Galileo took a rotating sun (inferred from his observation of periodicity in sun spot motion) to be evidence for the earth moving round it; but the observations were at best suggestive of heliocentrism, and certainly not compelling.[30] Many have seen animal and plant breeders at work before, but Charles Darwin saw their work as evidence for the origin of species by natural selection.[31] Philip Lenard's observation that the kinetic energy of electrons ejected from metals by ultraviolet light was independent of the light intensity need not be taken (and indeed was not so taken by most physicists) as evidence for the existence of photons (quanta of light)—but that was exactly what Einstein proposed as a "heuristic principle" for a new quantum mechanics.[32]

Faith in science and religion

The similarities between Thomas and Thomson should now be clear. Each turned data and observations (seeing Jesus; the mass to charge ratio of putative negative corpuscles) into evidence (for Jesus' divinity; for the divisibility of atoms). In each case, the conclusion was consistent with but not compelled by the data and observations—Thomas' friends merely concluded that the man Jesus they had known (*Rabbouni*, *kurios*) was alive again; many of Thomson's colleagues thought that the newly discovered particles of electricity had an independent existence from atoms. Their respective moves involved making a "leap" (Polanyi's term) across a "logical gap"; but it was not a "blind leap". Besides

consistency with observations and data, we also saw the rationality of the "leap" in terms of antecedent experience—Thomas' prior commitment to the earthly Jesus, and Thomson's engagement with chemistry.

Thomas' confession was described by Jesus as an act of "believing". (20:29) In other words, Thomas took a step of *faith*. The close parallel between Thomas' confession and Thomson's discovery suggests that every time a scientist takes a leap across a logical gap and turns data and observations into evidence, she or he also takes a step of faith. Thus, as Michael Polanyi has emphasised before,[33] faith is required equally of a follower of Jesus, and of an investigator of nature who wants to rise above the level of a mere cataloguer of facts, i.e. a scientist.

Acts of faith involve far from than mere intellectual ascent. Thomson called his set of ideas linking electrical conduction and atomic constitution a "working hypothesis".[34] It seems to me this terminology does not do full justice to what is involved in taking the plunge to "gain a foothold at another shore of reality". Einstein's nomenclature of a "heuristic principle" (which he used to refer to his "leap" to the idea of a "light quantum", the photon) is better, because it explicitly acknowledges that such an "act of faith" commits one to a journey of searching and finding (Gk. *euriskein*, to find (out), to discover). In Polanyi's terms, taking the plunge has the nature of a "personal commitment" with "universal intent", which is nevertheless open to development in the light of further reflection and praxis.[35] The rest of Thomson's research career was spent expounding, defending and elaborating the idea of a subatomic electron in countless ways, some fruitful, some less so. The confession of Jesus as Lord and God, a step first taken by Thomas, transformed the apostles' lives. The "appendix" to John's Gospel, Chapter 21, intimates as much, with its challenge issued by the risen, divine Jesus to follow him. (21:22) Canonically, John's Gospel is followed by the Acts of the Apostles (*Praxeis Apostolōn*), in which faith-led action (*praxis*) is narrated on the broadest then-known canvas—from Jerusalem to Rome.

As Thomas and Thomson worked out the consequences of their respective "leaps of faith", the objects of their faith did not remain static. Thomson's electron had mass and charge; later Wolfgang Paul endowed it with "spin" in an *ad hoc* manner to explain splits in atomic spectral lines induced by magnetic fields, and then Paul Dirac demonstrated that "spin" was in fact a consequence of marrying quantum mechanics and special relativity. Many years later, John Bardeen, Leon Cooper and John Robert Schrieffer taught us that negatively charged electrons, which *in vacuo* are mutually repulsive, can *attract* each other inside solids at low temperatures, giving rise to the phenomenon of superconductivity. Similarly, believers' understanding of the divine Jesus did not remain static after Thomas, but continually developed through early creedal formulations[36] to Nicea and Chalcedon and beyond. The developments in each case "flesh out" (a metaphor with obvious theological overtones) the initial "leap" without repudiating it.

Christian theology, especially in the various Protestant traditions, has always insisted that faith is a gift of God. This is not explicit in the story of Thomas' confession; but the thematically parallel story of the confession of Peter at Caesarea Philippi as recorded by Matthew makes this point directly. In response to Peter's declaration that he was "the Messiah, the son of the living God", Jesus said, "Blessed are you, Simon son of Jonah! For flesh and blood has not revealed this to you, but my Father in heaven." (Matt. 16:17) In other words, at the heart of what looks like the active step of "taking the plunge" is a certain passivity, because ultimately, it is a gift.

It may be thought that this characteristic of Christian faith sets it apart from the scientist's leap to a bold conclusion; but the way Polanyi describes the process suggests otherwise: "we may describe the obstacle to be overcome in solving a problem as a 'logical gap' … 'Illumination' is then the leap by which the logical gap is crossed." It is true that Polanyi uses the *active* metaphor of a "leap"; but in the same sentence, he balances it out by the *passive* metaphor of being illuminated. In this matter of "illumination", the testimonies of numerous scientists concur. It is striking how often scientists recounting their road to discovery would switch to passive language at the moment when data became evidence: "it came to me," etc. It appears that passivity lies at the heart of scientific leaps of faith as well—a scientific discovery is also a gift.[37]

From sight to testimonial

Although Thomas came to believe in the resurrection of Jesus and his divinity based on the evidence of sight, our text is clear that this would not be the norm for those coming after him. Jesus' saying in v. 29 tells us as much: "Blessed are those who have not seen and yet believe." However, this merely informs us that the basis for belief will be something other than sight without saying what the new basis should be. That is the function of the verse standing at the very end of original Fourth Gospel: "These are written so that you may come to believe that Jesus is the Messiah, the Son of God, and that through believing you may have life in his name." (v. 31) In other words, the normative basis for post-apostolic faith will be the written testimony of those who have seen. This claim needs to be read in the light of John's earlier commentary on "seeing and believing": "for as yet they did not understand the scripture, that he must rise from the dead." (v. 9) John's Gospel, as scripture, provides the basis for believing *without* seeing, because it was written by someone who *had* seen: "And the Word became flesh and lived among us, *and we have seen his glory* … " (1:14; italics mine).[38]

That post-apostolic Christian belief has to rely on apostolic testimony makes it fundamentally distinct from science in the eyes of many (including, presumably, Dawkins). But even on this score, the similarities with science are closer than one might expect at first sight. Historians of science have shown that when experimental science was in its infancy, its pioneers had to invent a new *genre* of testimonial-style writing aimed at those who had neither done nor witnessed firsthand the same experiments themselves.

> If one wrote experimental reports in the correct way, the reader could take on trust that these things happened. Further it would be as if that reader had been present at the proceedings. He could be recruited as a witness and be put in a position where he could validate experimental phenomena as matters of fact.[39]

The parallels between the purpose of this new scientific writing and John's avowed intention of writing his Gospel, "so that you may come to believe," are striking. Moreover, the similarities between the testimonial style developed by Robert Boyle and other pioneer experimentalists as a tool of science and the justification of religious beliefs from scriptural texts has been noted by Steven Shapin.[40] Today, four centuries later, scientific progress still depends on the trustworthy testimonials given by scientists in their publications. Thus stated, this crucial link in the scientific process appears almost banal; nevertheless,

scientists are periodically reminded of its importance when putatively truthful testimonials turn out to be fraudulent.[41]

Summary and conclusions

When presented with the visual data of the risen Jesus, Thomas the apostle concluded that this was evidence for Jesus' divinity. J. J. Thomson turned his data for the charge to mass ratio of cathode rays into evidence for atomic divisibility. I have drawn out some rather striking similarities between these episodes. In both cases, what breached the "conceptual gap" was a "leap of faith". The "leap" in neither case was "out of the blue"; on the contrary, we have been able to discern significant preparation in the respective prior biographies.

These similarities do not mean that there are not important differences as well. Perhaps most importantly, the electron was open to Thomson's manipulation at will, while the risen Jesus was (and is) an active agent who chose when and how to disclose himself. Noting this contrast, however, also discloses a further aspect of similarity. Thomson was a seeker, seeking for understanding of conduction and of the atom. Thomas was a seeker, too (see particularly 14:5). Although the object of his search is not open to passive manipulation by the seeker, we should recall Jesus' words, "Search, and you will find … for … everyone who searches finds … " (Matthew 7:7–8)[42]

Thus, the similarities between Thomas and the scientist indeed run deep. Richard Dawkins is right, but for the wrong reasons. I support the nomination of Thomas as patron saint of scientists, but not because he demanded evidence. Instead, Thomas went beyond what he saw: he, like the scientist, was able to "turn data and observations into evidence" by taking a leap of faith across a logical gap to reach "the other shore of reality".

Notes

1. R. Dawkins, *The Humanist* 97:1 (January/February 1997), 26–29.
2. Chapter and verse without book reference refer to John's Gospel; unless otherwise stated, all biblical quotations are from the New Revised Standard Version (NRSV).
3. See, *inter alia*, C. K. Barrett, *The Gospel According to St. John*, 2nd edition (London: SPCK, 1978), 576–577.
4. John Marsh suggests that "seeing and believing" is a major theme of the whole Gospel. See his *Saint John* (Harmondsworth: Pelican, 1968), 626–628.
5. R. Bultmann, *The Gospel of John*, trans. G. R. Beasley-Murray (Oxford: Basil Blackwell, 1971), 684.
6. Barrett, *John*, 563–564.
7. F. F. Bruce agrees with Barrett. See his *The Gospel of John* (Grand Rapids: Eerdmans, 1983), 386.
8. The singular "scripture" does not necessarily refer to an unnamed single verse; see e.g. Barrett, *John*, 564. The much earlier "forward reference" to scripture and resurrection in this Gospel (2:22) supports the interpretation I adopt here.
9. Bruce, *John*, 389.
10. in Bultmann, *John*, 689 (footnote 2). My use of "pathos" is Bultmannian.
11. Barrett, *John*, 443.
12. Barrett, *John*, 572. It turns on how one construes the force of *ginesthai*. The ambiguity can be seen, e.g. by comparing the NRSV with the AV: "Do not *become* unbelieving but believing." (italics mine).

13. Paul in 1 Cor. 11:27f makes this clear: "If an unbeliever (*apistos*) invites you to a meal … eat whatever is set before you … But if someone says to you, 'This has been offered on sacrifice,' then do not eat it … " An *apistos* is clearly a *believer* in another religion (which involves, amongst other things, animal sacrifices).
14. Question: the Revised, Revised Standard and New Revised Standard Versions, the New American Standard and Good News Bible, Moffat, Philips and Barclay, following the punctuation in the Nestle-Aaland Greek text. Statement: the Authorised and New International Standard Versions, The New English, Jerusalem and Living Bibles.
15. "Almighty and everliving God, who for the more confirmation of the faith didst suffer thy holy Apostle Thomas to be doubtful in thy Son's resurrection: grant us so perfectly and without all doubt, to believe in thy Son Jesus Christ … "
16. Barrett, *John*, 573. Rudolf Schnackenburg argues for a statement, but insists on hearing an element of "accusation", see his *Gospel according to John*, Vol. III (London: Burns & Oates, 1982), 333–334.
17. Marsh, *John*, 647.
18. C. H. Dodd also makes this distinction between "Lord" (*kurios*) and "God" (*theos*); see his *The Interpretation of the Fourth Gospel* (Cambridge: Cambridge University, 1953), 430. Barnabas Lindars similarly hears the pre-resurrection meaning of *kurios* here, but suggests that in this context, it also points to Jesus' exaltation. See his *The Gospel of John* (London: Marshall, Morgan & Scott, 1981), 614–615. Other commentators argue against any distinction (see, e.g. Barrett, *John*, 573), and essentially equate *kurios* with *theos* here. On either interpretation, however, Thomas went considerably beyond what he saw!
19. It is worth pointing out that Polanyi (1891–1976) was a *very* distinguished scientist. He made pioneering contributions to the theoretical treatment of the rates of chemical reactions and the understanding of X ray diffraction from fibres, the latter playing a key role three decades later in deciphering the structure of DNA. He was also one of the three independent proposers of the concept of a "dislocation" to explain the ductile behaviour of metals. It is probably because spectacular experimental verification came only years later in each case that these distinguished theoretical contributions were not rewarded by a Nobel Prize (or two!).
20. Michael Polanyi, *Personal Knowledge* (London: Routledge & Kegan Paul, 1962), 123.
21. George E. Smith, *J. J. Thomson and the Electron, 1897–1899*, in Jed Z. Buchwald and Andrew Warwick, eds., *Histories of the Electron: The Birth of Microphysics* (Cambridge and London: MIT, 2001), 24.
22. Michael Polanyi, *Science, Faith and Society* (London: Oxford University, 1946), Chapter II, especially 44–46. In this book, the metaphor of "taking a plunge" is replaced by the talk of "intelligent guessing"; the essential idea is the same, though.
23. In my account, I rely heavily on Smith's article, as well as other contributions in Buchwald and Warwick's edited volume, *op. cit.* especially chapters 1 to 6.
24. W. Kaufmann, "The Development of the Electron Idea," *Electrician* 8 (November 1901), 95–97; the quotation is on p. 97. I learnt this quotation from Isobel Falconer, *Corpuscles to Electrons*, Chapter 2 in Buchwald and Warwick, *Electron*, 92.
25. Smith, *Thomson and the Electron*, in Buchwald and Warwick, *Electron*, 45.
26. Helge Kragh, *The Electron, the Protyle and the Unity of Matter*, in Buchwald and Warwick, *Electron*, 205.
27. Fitzgerald later proposed that moving objects contract in the direction of movement, a result that Einstein subsequently deduced as part of his special theory of relativity.
28. Kragh, *Unity of Matter*, in Buchwald and Warwick, *Electron*, 204.
29. For electrochemistry, see Falconer, *Corpuscles to Electrons* in Buchwald and Warwick, *Electron*, 84f. For Proutean atomism, see Kragh, *Unity of Matter*, in Buchwald and Warwick, *Electron*, 196f.
30. For a concise discussion of the adequacy or otherwise of Galileo's belief in heliocentrism, see John Brooke and Geoffrey Cantor, *Reconstructing Nature* (Edinburgh: T & T Clark, 1998), 115–118.

31. Charles Darwin, *The Origin of Species*, edited with an introduction by J. W. Burrow (Harmondsworth: Penguin, 1968), Chapter 1.
32. For an account of the history of the "light quantum" and Einstein's role, see A. Pais, *Subtle is the Lord—the Life and Work of Albert Einstein* (London: Oxford University, 1982), Chapter 19.
33. Michael Polanyi, *Science, Faith and Society* and *Personal Knowledge*. See also T. F. Torrance, editor, *Belief in Science and in Christian Life: The relevance of Michael Polanyi's thought for Christian faith and life* (Edinburgh: Handsel, 1980).
34. Smith, *Thomson and the Electron*, in Buchwald and Warwick, *Electron*, 57 *et passim*.
35. Polanyi, *Personal Knowledge*, Chapter 10.
36. See, for example, J. N. D. Kelly, *Early Christian Creeds*, 3rd edition (London: Longman, 1972)
37. A theological way of putting this is to say that one could discern the work of the Holy Spirit in the process of scientific discovery. Time Gorringe's phenomenology of "revelation outside the church" applied to science would lead exactly to his conclusion; see his *Discerning Spirit* (London: SCM, 1990). On the whole subject of passivity, see the illuminating account in W. H. Vanstone, *The Stature of Waiting* (London: Darton, Longman & Todd, 1982). Vanstone mentions the work of scientists in the last chapter of his book.
38. The claim made in passing in John 1:14, namely, that the author was declaring to his readers what he himself had seen, is drawn out and made quite explicit in the beginning of the First Epistle of John: "We declare to you what was from the beginning, what we have heard, what we have seen with our eyes, what we have looked at and touched with our hands … " (1 John 1:1)
39. Steven Shapin and Simon Schaffer, *Leviathan and the Air-Pump: Hobbes, Boyle and the Experimental Life* (Princeton: Princeton University, 1985), 62–63.
40. Simon Shapin, *A Social History of Truth: Civility and Science in Seventeenth-Century England* (Chicago & London: University of Chicago, 1994), 209–211. Shapin argues (on p. 210) that the approach used by seventeenth-century writers, including many early scientists, to "secure religious testimony" (i.e. scripture), "was equally valuable within [the] specialized culture [of the new experimental science]."
41. A well-documented case is that of Hendrik Schön, the physicist who fabricated data on organic ("plastic") and carbon transistors. The whole episode is documented in Eugenie Samuel Reich, *Plastic Fantastic* (New York: Palgrave McMillan, 2009).
42. Compare also the Old Testament version of this promise, beautifully and memorably set to music by Mendelssohn in his *Elijah* oratorio, "If with all your heart ye truly seek me, ye shall ever surely find me." (Jeremiah 29:13, in the version used by Mendelssohn for his libretto)

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