

# Galileo's Solution to Dante's Riddle

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Dante's Lucifer in the *Inferno* is a gigantic hairy creature trapped by ice and rock at the earth's center. To accentuate this archangel's size, Dante poses a series of riddles for the reader to solve, one of whom just happened to be Galileo. Although we discuss some lesser and greater giants for added context with respect to the relative sizes of giants appearing in literature, we focus on Dante's riddle.

## Prelude: ordinary giants

Giants, as they appear in folklore and literature throughout the ages, seem to come in three sizes: ordinary giants, big giants, and bigger giants.

Ordinary giants are simply very tall men, such as professional basketball centers or wrestlers like André the Giant. Before the conception of the basketball court, perhaps the greatest assemblage of tall people was due to Frederick Wilhelm I (1688–1740) of Prussia who, in a mania for collecting tall people from around the world, assembled a regiment of 3000 men called the Potsdam Giants, some of whom were over seven feet tall. Frederick probably drooled over the report of Moses's vanguard that reconnoitered the promised land: "There we saw giants, and we were as grasshoppers in their sight" (Numbers 13:33). A well-known descendant of these larger-than-life strongmen was Goliath of Gath whose height was six cubits and a span, about ten feet (I Samuel 17:4). In 1752, as an item on his list of promising endeavors for the scientific community of his day to pursue, Pierre de Maupertuis, President of the Berlin Academy, proposed looking for giants in Patagonia, the southernmost region in South America, as the Royal Society had exhibited a skull from there which, arguing by proportion, should belong to a human ten to twelve feet tall [3, p. 152]. Grendel of *Beowulf* fame illustrates (in part xi of the poem) what an ordinary giant can do to an ordinary man:

Straightway [Grendel] seized a sleeping warrior  
as the first [victim], and tore him fiercely asunder,  
the bone-frame bit, drank blood in streams,  
swallowed him piecemeal: swiftly thus  
the lifeless body was clear devoured,  
even feet and hands.

## Interlude: big giants

Although ordinary giants are roughly twice the size of an ordinary man, big giants are an order of magnitude larger: about ten times the size. Pliny the Elder (23–79), some of whose

*Natural History* reads like Ripley's *Believe It or Not* files, says that [4, book vii, section xvi, p. 553],

When a mountain in Crete was cleft by an earthquake a body 69 feet in height was found.

In literature, Homer's Ulysses encounters the one-eyed Cyclops when sheep-stealing while finding his way home from the victory at Troy. An eyewitness castaway from Ulysses's crew describes the giant (*Aeneid*, book iii, lines 802–810):

The towering Cyclops  
is tall enough to strike the high stars—gods,  
keep such a plague away from earth.  
I myself have seen [Cyclops]  
snatch up a pair of us in his huge paw,  
then, bash both of them against a boulder.

In Greek mythology, a group of big giants, the Titans, were sired by the gods. Eventually most of them were incarcerated in the underworld lest they destroy the gods themselves. Dante picks up on this story in the *Inferno* and describes their height, using a sequence of three clues. Figure 1 is an early depiction of these giants showing the Titans ensconsed in the earth up to about their hips; Dante and Virgil, on the left side of the illustration, appear to be more than half the size of the giants.



Figure 1: The Titans, from the Holkham manuscript (c. 1375)

From canto xxxi, here are Dante's three clues about the height of Nimrod (who, although not a Titan, is of similar height to the Titans; he's the one blowing the horn in Figure 1):

**Clue I:** As large and long [Nimrod's] face seemed, to my sense,  
As Peter's Pine at Rome, and every bone  
Appeared to be proportionately immense.

**Clue II:** So that the bank which aproned him [Nimrod] from zone  
To foot, still showed so much, three Friesians  
Might vainly boast to lay a finger on  
His hair.

**Clue III:** For from the place at which a man's  
Mantle is buckled, downward, you may call me  
Liar if [Nimrod] measured not full thirty spans.

In clue I, Peter's Pine, shown in Figure 2, refers to a bronze casting made in the first century BC of a pine-cone that once adorned a fountain in the Baths of Agrippa in Rome, and was later moved to a fountain in front of St. Peter's Basilica in the early Middle Ages; it now stands in the Cortile della Pigna, a courtyard within the Vatican Museums. The pine-cone is 7.5 feet tall (or twelve feet inclusive of its pedestal).



Figure 2: Peter's pine at Rome

When Galileo was twenty-four, he gave his first public lecture in which he used clue I to find Nimrod's height [6, pp. 26–27]. Galileo took the height of Peter's Pine as  $5\frac{1}{2}$  armlengths, and said that

Because men normally are eight heads tall, even though painters and sculptors, among them Albrecht Dürer in his book on human proportions, hold that the most proportioned bodies must be nine heads tall, although due to the very rare number of bodies found with these proportions [of 9 heads], we will suppose that the height of the giant [Nimrod] must be eight times that of his head. [1, p. 42]

Thus Galileo's estimate for Nimrod's height is  $(8)(5.5)=44$  armlengths, or about 75 feet since Galileo assumed that a body was three armlengths long, and since a man was about five feet tall in his day.

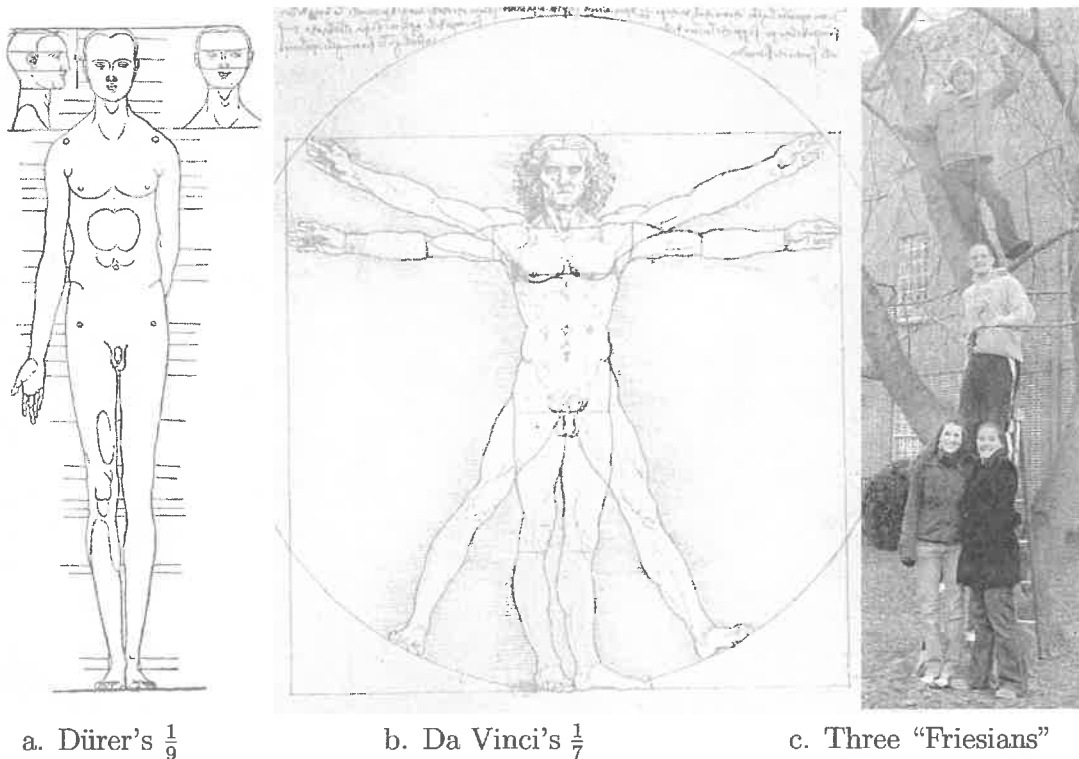


Figure 3: Human proportions

The particular woodcut from Dürer's book, *The Art of Measurement* (1524), referred to by Galileo is Figure 3(a). The man with an apparent crew-cut is indeed about nine heads tall. However, the more classic and normative proportion  $1/7$  of head to body length is illustrated by Leonardo da Vinci's *Vitruvian man* from about 1492 in Figure 3(b). If we use da Vinci's  $1/7$  proportion, and use only the 7.5 feet of the pine-cone itself (rather than some of the base as Galileo apparently did), then clue I gives Nimrod's height as about  $7(7.5 \text{ ft})$  or somewhat more than fifty feet.

What about clue II? In Dante's day, the Friesians were Dutchmen, reputed to be a fairly tall people. Dante imagines that if three of these Dutchmen stood on each other's shoulders, forming a human tower, the top-most fellow would yet be unable to reach Nimrod's hair (while the bottom-most fellow stood on the bank in which Nimrod was embedded to his hip area—the *zone*). Figure 3(c) is a photo of one of the author's classes recreating this clue. Thus the human tower plus Nimrod's head would measure about half the giant's body. Taking the human tower as about 15 feet and adding two feet for his reach gives Nimrod's height as  $2(15 + 2 + 7.5) = 49$  which we round to 50 feet.

What about clue III? A span is the distance between the tip of the thumb and little finger when the hand is fully spread out, about nine inches. From the hips to the shoulder, the place where the mantle is buckled, is 30 spans. Thus clue III gives Nimrod's height as  $2\left(30\left(\frac{9}{12}\right) + 7.5\right) = 60$  feet.

Fortuitously, all three of Dante's clues give roughly the same height.

## Main-lude: bigger giants

Although intimidatingly large, big giants are in turn dwarfed by bigger giants, who are at least 100 times as large as ordinary men. Dante's Lucifer is such a creature—as depicted in Allesandro Vellutello's image in Figure 4—for he describes the archangel's height in canto xxxiv, lines 29–33:

**Clue IV:**                      Out of the girding ice [Satan] stood breast-high,  
    And to his arm alone the [Titan] giants were  
    Less comparable than to a giant I;  
    Judge then how huge the stature of the whole  
    That to so huge a part bears symmetry.

Let  $H$  be the height of a typical human, about 5 feet. Let  $G$  be the the height of a Titan, 45 to 75 feet or Galileo's 44 armlengths. Let  $A$  be the length of Satan's arm. Dante's passage translates to

$$\frac{G}{A} \leq \frac{H}{G}, \quad (1)$$

or  $A \geq G^2/H$ . Since a body is about three armlengths, Galileo concluded that Satan's height,  $3A$ , was about 1936 armlengths, and rounded it up to 2000 armlengths [1, p. 42], over 3000 feet. Of course, if we use 50 ft as the estimate of the Titan's height, then Dante's Lucifer is only about 1500 feet tall.

A later imposing example of a bigger giant comes from Rabelais who wrote his stories about Gargantua and son Pantagrue starting in 1532. However, Rabelais' giants are unusual in that their size varies according to the convenience of the narrative. That is, at times they seem to be ordinary giants, and at others big giants, or bigger giants. As merely an ordinary

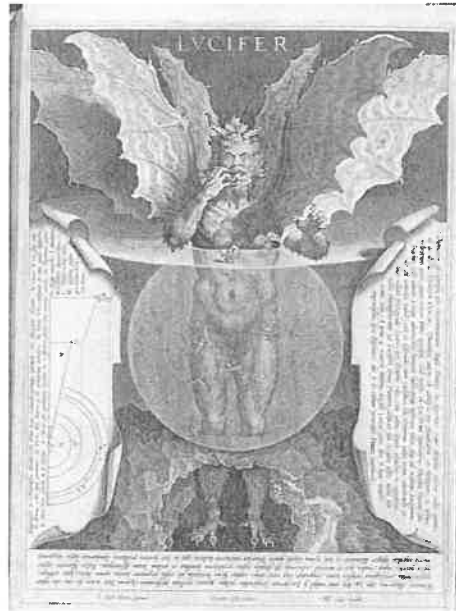


Figure 4: Dante's Lucifer by Allesandro Vellutello (c. 1544)

giant, Rabelais portrays Gargantua as slightly larger than life, allowing him “to skip over a ditch at one leap, spring over a hedge, climb up trees like a cat, and leap from one to another like a squirrel.” As a big giant, Rabelais says that Gargantua rode a steed that “was as big as six elephants.” As a bigger giant, Gargantua grooms his hair using a comb 900 feet long. Since a comb should be less than one head length long, then Gargantua is probably at least 4500 feet tall. Rabelais’ giant once ate a salad in which were hiding six pilgrims, who, upon being ingested, managed to avoid Gargantua’s grinding molars until being spat out. In passages wherein Rabelais satirizes the pollution levels of the River Seine, Gargantua relieves himself “in copious measure,” producing rivers in which drowned a quarter of a million men, not counting women and children [5, pp. 36–37, 51, 77–79]. Therefore, Gargantua is anywhere from being an unusually tall person to being a mile or more tall.

### Postlude: a biggest giant

In 1752, Voltaire wrote a story—based upon a French scientific expedition of 1736–7 to the arctic circle whose purpose was to test Newton’s theory about a flattened earth—featuring a giant 23 miles tall who wanders the universe as an exile from the star Sirius. Why so tall? one simplistic reason is Voltaire’s ego. In particular, of Dante, Voltaire said, “His reputation will last because he is little read” [8, vol. viii, *Dante*, p. 55], and of Rabelais, he said, “[He is] a drunken philosopher, writing only when he was unable to stand” [8, vol. xxxi, *Dean*

*Swift*, p. 90]. Therefore to outdo both Dante and Rabelais, Voltaire's giant Micromégas is a biggest giant, at least ten times as large as Dante's Lucifer or Rabelais' giants. But a deeper reason was that Voltaire used his giant's stature as a visual symbol of the expanse of man's knowledge in the Enlightenment. Voltaire wanted at least the same size ratio between Micromégas and earthlings as between scientists like Anton van Leeuwenhoek and Nicolas Hartsoeker and the micro-organisms they discovered, such as the sperm cell, about the smallest body that could be resolved with microscopes of their day. Since the human sperm cell is about 40 microns in length, the proportion of a two meter tall man to such a cell is 50,000, a figure on the same order of magnitude as 24,000, Voltaire's proportion of Micromégas to man. Voltaire also wanted vivid imagery for the sizes of the stars imagined by Jacques Cassini who in 1717 estimated the star Sirius's diameter as about 100 times that of our sun. (In actuality, Sirius's diameter is only about 1.75 as large as the sun's.) In this same spirit, Voltaire gave his giant a home world with radius of a little more than 1 astronomical unit (a.u.), the distance of the earth from the sun. That is, the diameter of the Sirian's world was about 24,000 times that of earth's diameter. Today's astronomers have discovered supergiant stars whose radii are up to 7 a.u. If Voltaire had written his story with this information, he would have been tempted to make his giant in excess of  $7^{*23}=161$  miles tall.

Finally, we point out two disclaimers about giants. First, our classifications of big, bigger, and biggest giants are relative terms. What happens if the ordinary people are other than five feet tall? For example, in Jonathan Swift's *Gulliver's Travels* of 1726, the Lilliputians are a race whose height is but six inches. Thus Gulliver would be classified as a big giant in their lore. However, Gulliver in turn is dwarfed by the Brobdingnagian race who are as tall as "an ordinary spire-steeple" [7, part ii, p. 97].

Secondly, in an essay "On being the right size," biologist J. B. S. Haldane points out a physical problem for a human body scaled upwards by a factor of ten. In particular, of the Giant Pope and the Giant Pagan from an illustrated version of John Bunyan's *Pilgrim's Progress* (1678), he says that while the weight of such a giant would be a thousand times that of a man, the cross-sectional area of the giant's thigh bone would increase only a hundred times.

As the human thigh bone breaks under about ten times the human weight, Pope and Pagan would have broken their thighs every time they took a step. This was doubtless why they were sitting down in the picture I remember. [2, pp.18-19]

In this discussion and when we read tales involving giants in general, we tacitly ignore these physical impossibilities. Just as with any fisherman and their fish stories, we need the language of the gigantic to convey important or even vacuous ideas and events. If we failed to have such traditions, we would of necessity invent them. After all, wasn't it Newton who said—in reference to how he accomplished so much—"I stand on the shoulders of giants"?

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