بِسۡمِ ٱللَّهِ ٱلرَّحۡمَٰنِ ٱلرَّحِيمِ

A Briefer History of Time – Stephen Hawking

3 The Nature Of A Scientific Theory

- We shall take the simpleminded view that a theory is just a model of the universe, or a restricted part of it, and a set of rules that relate quantities in the model to observations that we make. It exists only in our minds and does not have any other reality (whatever that might mean). [Stephen Hawking with Leonard Mlodinow: ***A Briefer History of Time*** (Kindle Locations 157-159). Random House.]
- Any physical theory is always provisional, in the sense that it is only a hypothesis: you can never prove it. No matter how many times the results of experiments agree with some theory, you can never be sure that the next time a result will not contradict the theory. On the other hand, you can disprove a theory by finding even a single observation that disagrees with the predictions of the theory. [Stephen Hawking with Leonard Mlodinow: ***A Briefer History of Time*** (Kindle Locations 165-167). Random House.]
- As philosopher of science Karl Popper has emphasized, a good theory is characterized by the fact that it makes a number of predictions that could in principle be disproved or falsified by observation. Each time new experiments are observed to agree with the predictions, the theory survives and our confidence in it is increased; but if ever a new observation is found to disagree, we have to abandon or modify the theory. [Stephen Hawking with Leonard Mlodinow: ***A Briefer History of Time*** (Kindle Locations 167-170). Random House.]
- The general theory of relativity describes the force of gravity and the large-scale structure of the universe; that is, the structure on scales from only a few miles to as large as a million million million million (1 with twenty-four zeros after it) miles, the size of the observable universe. [Stephen Hawking with Leonard Mlodinow: ***A Briefer History of Time*** (Kindle Locations 194-196). Random House.]
- The discovery of a complete unified theory, therefore, may not aid the survival of our species. It may not even affect our lifestyle. [Stephen Hawking with

Leonard Mlodinow: ***A Briefer History of Time*** (Kindle Locations 222-223). Random House.]

6 Curved Space

- Just as we cannot talk about events in the universe without the notions of space and time, so in general relativity it became meaningless to talk about space and time outside the limits of the universe. [Stephen Hawking with Leonard Mlodinow: ***A Briefer History of Time*** (Kindle Locations 560-562). Random House.]
- the old idea of an essentially unchanging universe that could have existed forever, and could continue to exist forever, was replaced by the notion of a dynamic, expanding universe that seemed to have begun a finite time ago and which might end at a finite time in the future. [Stephen Hawking with Leonard Mlodinow: ***A Briefer History of Time*** (Kindle Locations 562-564). Random House.]

7 The Expanding Universe

- Our sun is just an ordinary, average-sized yellow star near the inner edge of one of the spiral arms. [Stephen Hawking with Leonard Mlodinow: ***A Briefer History of Time*** (Kindle Locations 581). Random House.]
- It was quite a surprise, therefore, to find that most galaxies appeared red-shifted: nearly all were moving away from us! More surprising still was the finding that Hubble published in 1929: even the size of a galaxy's red shift is not random but is directly proportional to the galaxy's distance from us. In other words, the farther a galaxy is, the faster it is moving away! And that meant that the universe could not be static or unchanging in size, as everyone previously had thought. It is in fact expanding; the distance between the different galaxies is growing all the time. [Stephen Hawking with Leonard Mlodinow: ***A Briefer History of Time*** (Kindle Locations 642-645). Random House.]
- This behavior of the universe could have been predicted from Newton's theory of gravity at any time in the nineteenth, the eighteenth, or even the late seventeenth century. Yet so strong was the belief in a static universe that it persisted into the early twentieth century. Even Einstein, when he formulated the general theory of relativity in 1915, was so sure that the

universe had to be static that he modified his theory to make this possible by introducing a fudge factor, called the cosmological constant, into his equations. [Stephen Hawking with Leonard Mlodinow: ***A Briefer History of Time*** (Kindle Locations 655-659). Random House.]

- We feel it would be most remarkable if the universe looked the same in every direction around us but not around other points in the universe! [Stephen Hawking with Leonard Mlodinow: ***A Briefer History of Time*** (Kindle Locations 706-707). Random House.]
- The universe will continue to expand at an ever-increasing rate. Time will go on forever, at least for those prudent enough not to fall into a black hole. [Stephen Hawking with Leonard Mlodinow: ***A Briefer History of Time*** (Kindle Locations 777-778). Random House.]

8 The Big Bang

- At some time in the past (about 13.7 billion years ago), the distance between neighboring galaxies must have been zero. In other words, the entire universe was squashed into a single point with zero size, like a sphere of radius zero. At that time, the density of the universe and the curvature of space-time would have been infinite. It is the time that we call the big bang. [Stephen Hawking with Leonard Mlodinow: ***A Briefer History of Time*** (Kindle Locations 782-785). Random House.]
- Correspondingly, if, as is the case, we know only what has happened since the big bang, we cannot determine what happened beforehand. As far as we are concerned, events before the big bang can have no consequences and so should not form part of a scientific model of the universe. We should therefore cut them out of the model and say that the big bang was the beginning of time. This means that questions such as who set up the conditions for the big bang are not questions that science addresses. [Stephen Hawking with Leonard Mlodinow: ***A Briefer History of Time*** (Kindle Locations 788-792). Random House.]
- Atoms are made of smaller particles: electrons, protons, and neutrons. The protons and neutrons themselves are made of yet smaller particles called quarks. [Stephen Hawking with Leonard Mlodinow: ***A Briefer History of Time*** (Kindle Locations 803-804). Random House.]

- Corresponding to each of these subatomic particles there exists an antiparticle. Antiparticles have the same mass as their sibling particles but are opposite in their charge and other attributes. [Stephen Hawking with Leonard Mlodinow: ***A Briefer History of Time*** (Kindle Locations 805-806). Random House.]
- The initial rate of expansion would have had to be chosen very precisely for the rate of expansion still to be so close to the critical rate needed to avoid collapse. It would be very difficult to explain why the universe should have begun in just this way, except as the act of a God who intended to create beings like us. [Stephen Hawking with Leonard Mlodinow: ***A Briefer History of Time*** (Kindle Locations 855-858). Random House.]
- Some scientists believe that advanced life is likely to evolve only in regions of galaxies in which there are not too many stars—"zones of life"— because in denser regions phenomena such as supernovas would be common enough to regularly snuff out any evolutionary beginnings. [Stephen Hawking with Leonard Mlodinow: ***A Briefer History of Time*** (Kindle Locations 975-976). Random House.]
- Our greatest hope for obtaining a complete understanding of the universe from beginning to end arises from combining these two partial theories into a single quantum theory of gravity, a theory in which the ordinary laws of science hold everywhere, including at the beginning of time, without the need for there to be any singularities. [Stephen Hawking with Leonard Mlodinow: ***A Briefer History of Time*** (Kindle Locations 1014-1016). Random House.]

9 Quantum Gravity

- The uncertainty principle tells us that, contrary to Laplace's belief, nature does impose limits on our ability to predict the future using scientific law. [Stephen Hawking with Leonard Mlodinow: ***A Briefer History of Time*** (Kindle Locations 1067-1068). Random House.]
- So the more accurately you try to measure the position of the particle, the less accurately you can measure its speed, and vice versa. [Stephen Hawking with Leonard Mlodinow: ***A Briefer History of Time*** (Kindle Locations 1078-1079). Random House.]
- Heisenberg's uncertainty principle is a fundamental, inescapable property of the world, and it has had profound implications for the way in which we view

the world. Even after more than seventy years, these implications have not been fully appreciated by many philosophers and are still the subject of much controversy. [Stephen Hawking with Leonard Mlodinow: ***A Briefer History of Time*** (Kindle Locations 1090-1092). Random House.]

- We certainly cannot predict future events exactly if we cannot even measure the present state of the universe precisely! [Stephen Hawking with Leonard Mlodinow: ***A Briefer History of Time*** (Kindle Locations 1093-1094). Random House.]
- We believe that the universe has not existed forever. [Stephen Hawking with Leonard Mlodinow: ***A Briefer History of Time*** (Kindle Locations 1230). Random House.]
- God may have originally decreed the laws of nature, but it appears that He has since left the universe to evolve according to them and does not now intervene in it. [Stephen Hawking with Leonard Mlodinow: ***A Briefer History of Time*** (Kindle Locations 1232-1233). Random House.]
- As long as we believed the universe had a beginning, the role of a creator seemed clear. But if the universe is really completely self-contained, having no boundary or edge, having neither beginning nor end, then the answer is not so obvious: what is the role of a creator? [Stephen Hawking with Leonard Mlodinow: ***A Briefer History of Time*** (Kindle Locations 1244-1246). Random House.]

- طالما اعتقدنا أن للكون بداية، فإن دور الخالق واضح، ولكن إذا كان الكون مكتفياً بنفسه بشكل كامل، وليس له حدود أو حواف، بدون بداية أو نهاية، فإن الإجابة تبدو غير واضحة: ما هو دور الخالق؟!

11 The Forces of Nature and The Unification of Physics

- The laws of science, as we know them at present, contain many numbers—for example, the size of the electric charge of the electron and the ratio of the masses of the proton and the electron—that we cannot, at the moment at least, predict from theory. Instead, we have to find them by observation and then insert them into the equations. Some call these numbers fundamental constants; others call them fudge factors. [Stephen Hawking with Leonard Mlodinow: ***A Briefer History of Time*** (Kindle Locations 1416-1418). Random House.]

- Whatever your point of view, the remarkable fact is that the values of these numbers seem to have been very finely adjusted to make possible the development of life. For example, if the electric charge of the electron had been only slightly different, it would have spoiled the balance of the electromagnetic and gravitational force in stars, and either they would have been unable to burn hydrogen and helium or else they would not have exploded. Either way, life could not exist. [Stephen Hawking with Leonard Mlodinow: ***A Briefer History of Time*** (Kindle Locations 1419-1422). Random House.]
- String theories, however, have a bigger problem: they seem to be consistent only if space-time has either ten or twenty-six dimensions, instead of the usual four! Of course, extra space-time dimensions are a commonplace of science fiction. [Stephen Hawking with Leonard Mlodinow: ***A Briefer History of Time*** (Kindle Locations 1569-1571). Random House.]
- With the advent of quantum mechanics, we have come to recognize that events cannot be predicted with complete accuracy: there is always a degree of uncertainty. If you like, you could ascribe this randomness to the intervention of God. But it would be a very strange kind of intervention, with no evidence that it is directed toward any purpose. [Stephen Hawking with Leonard Mlodinow: ***A Briefer History of Time*** (Kindle Locations 1656-1658). Random House.]
- The rate of progress is so rapid that what you learn at school or university is always a bit out of date. Only a few people can keep up with the rapidly advancing frontier of knowledge, and they have to devote their whole time to it and specialize in a small area. The rest of the population has little idea of the advances that are being made or the excitement they are generating. [Stephen Hawking with Leonard Mlodinow: ***A Briefer History of Time*** (Kindle Locations 1681-1684). Random House.]
- As we've said, no one can solve exactly the quantum equations for an atom consisting of a nucleus plus more than one electron. We can't even solve exactly the motion of three bodies in a theory as simple as Newton's theory of gravity, and the difficulty increases with the number of bodies and the complexity of the theory. [Stephen Hawking with Leonard Mlodinow: ***A Briefer History of Time*** (Kindle Locations 1691-1693). Random House.]

12 Conclusion

- Just as an infinite tower of tortoises supporting the flat earth is such a picture, so is the theory of superstrings. Both are theories of the universe, though the latter is much more mathematical and precise than the former. Both theories lack observational evidence: no one has ever seen a giant tortoise with the earth on its back, but then, no one has ever seen a superstring either. [Stephen Hawking with Leonard Mlodinow: ***A Briefer History of Time*** (Kindle Locations 1704-1707). Random House.]
- Gradually, however, it must have been noticed that there were certain regularities: the sun always rose in the east and set in the west, whether or not a sacrifice had been made to the sun god. Further, the sun, the moon, and the planets followed precise paths across the sky that could be predicted in advance with considerable accuracy. The sun and the moon might still be gods, but they were gods who obeyed strict laws, apparently without any exceptions, if one discounts stories such as that of the sun stopping for Joshua. [Stephen Hawking with Leonard Mlodinow: ***A Briefer History of Time*** (Kindle Locations 1714-1717). Random House.]
- Laplace's determinism was incomplete in two ways: it did not say how the laws should be chosen, and it did not specify the initial configuration of the universe. These were left to God. God would choose how the universe began and what laws it obeyed, but He would not intervene in the universe once it had started. In effect, God was confined to the areas that nineteenth-century science did not understand. [Stephen Hawking with Leonard Mlodinow: ***A Briefer History of Time*** (Kindle Locations 1722-1724). Random House.]
- At the big bang and other singularities, all the laws would have broken down, so God would still have had complete freedom to choose what happened and how the universe began. [Stephen Hawking with Leonard Mlodinow: ***A Briefer History of Time*** (Kindle Locations 1741-1742). Random House.]
- But if the universe is completely self-contained, with no singularities or boundaries, and completely described by a unified theory, that has profound implications for the role of God as creator. [Stephen Hawking with Leonard Mlodinow: ***A Briefer History of Time*** (Kindle Locations 1746-1748). Random House.]

- Einstein once asked, "How much choice did God have in constructing the universe?" If the no-boundary proposal is correct, God had no freedom at all to choose initial conditions. God would, of course, still have had the freedom to choose the laws that the universe obeyed. This, however, may not really have been all that much of a choice; there may well be only one, or a small number, of complete unified theories, such as string theory, that are self-consistent and allow the existence of structures as complicated as human beings who can investigate the laws of the universe and ask about the nature of God. [Stephen Hawking with Leonard Mlodinow: ***A Briefer History of Time*** (Kindle Locations 1748-1752). Random House.]
- Even if there is only one possible unified theory, it is just a set of rules and equations. What is it that breathes fire into the equations and makes a universe for them to describe? [Stephen Hawking with Leonard Mlodinow: ***A Briefer History of Time*** (Kindle Locations 1752-1754). Random House.]
- The usual approach of science of constructing a mathematical model cannot answer the questions of why there should be a universe for the model to describe. Why does the universe go to all the bother of existing? Is the unified theory so compelling that it brings about its own existence? Or does it need a creator, and if so, does He have any other effect on the universe? And who created Him? [Stephen Hawking with Leonard Mlodinow: ***A Briefer History of Time*** (Kindle Locations 1754-1756). Random House.]
- If we do discover a complete theory, it should in time be understandable in broad principle by everyone, not just a few scientists. Then we shall all, philosophers, scientists, and just ordinary people, be able to take part in the discussion of the question of why it is that we and the universe exist. If we find the answer to that, it would be the ultimate triumph of human reason—for then we would know the mind of God. [Stephen Hawking with Leonard Mlodinow: ***A Briefer History of Time*** (Kindle Locations 1763-1766). Random House.]

الحمد لله الذي بنعمته تتمّ الصَّالحات