ROGER PENROSE, with ABNER SHIMONY, NANCY CARTWRIGHT, and STEPHEN HAWKING. *The Large, the Small, and the Human Mind.* Cambridge: Cambridge University Press, 1997. 185 pp. $19.95.

Reviewed by Hollis R. Johnson, Professor Emeritus of Astronomy, Indiana University.

This accessible and stimulating book about modern science should be of interest to LDS thinkers. For those of us who did not make it through Penrose's previous books *(The Emperor's New Mind* and *Shadows of the Mind),* this book is a new opportunity to learn some of the key ideas of those at the frontier of the scientific quest to understand intelligence and human consciousness.

An advantage of this book is its panel-discussion format. The first three chapters are taken from the 1995 Tanner lectures by Penrose, and these are then critiqued by each of the associate authors listed above. In a final chapter, Penrose responds to their criticisms. The level of the book and the information density is high (the book is not easy!), but a thoughtful reading will surely provide new ideas about our fantastic minds.

An introductory chapter presents basic ideas about space-time, quantum physics, and cosmology. Combining the worlds of nature and mathematics, Penrose describes the world at the quantum level (the small: elementary particles and atoms) and the classical level (the large: people and stars), with some bridge between. This bridge becomes very important later. We meet light cones and general relativity. Penrose, who loves his subject, coaxes us to the world of gravitation and the curvature of space. Three possible geometries of space—open (hyperbolic), flat (Euclidean), and closed (elliptic)—are described. Penrose explains why he prefers the open geometry, and he likewise tells why he does not favor the popular "inflationary" scenario at the beginning of the universe. He emphasizes the incredibly small probability of the universe being exactly what it is by chance but leaves open the question of why it is so.

Chapter two presents some of the mysteries of quantum physics. After discussing the unreasonable effectiveness of mathematics in describing the real world, Penrose gives an impressive

list of experiments that can be explained only by quantum mechanics (QM)—from the stability of atoms to lasers and superconductors. He describes the famous double slit experiment as the archetypal experiment of quantum physics. Something strange happens when one makes a transition between the "quantum world" and the "classical world" (the "real" world), but not everyone agrees wherein that strangeness lies. Penrose divides the strangenesses of nature into two groups: Z and X, which he calls puZZles and paradoXes. "PuZZle" mysteries are those things we simply do not understand, and "ParadoX" mysteries are those things which do not make sense. The former (for example, the wave-particle duality and nonlocal effects) are real parts of nature. Penrose believes the latter (the measurement problem, illustrated by Schrodinger's cat paradox) indicates the lack of a proper theory—that QM as now understood is incomplete. Why he believes so and what additions are needed occupy much of the remainder of the book (as it did in the first two books).

Two puZZles are described by Penrose, the most important being the quantum nonlocality or quantum entanglement. A theorem by Bell, since substantiated by experiment, states that in the real universe, particles are not completely independent; they are "entangled." Somehow, completely contrary to normal expectations, each particle seems to "know" what other particles are doing. A second puZZle is the "null measurement" problem, which Penrose illustrates by a complicated "bomb-testing" experiment.

Regarding the nature and reality of the QM wave function, Wald is quoted: "If you really *believe* in QM, then you cannot take it *seriously*" (72). Penrose proceeds to classify famous physicists (with a figure!) as "believers in QM" (that is, they believe in QM because its application yields correct results) or as "serious about QM" (that QM is a correct description of the nature), and then he guesses at their reactions to later developments. Surely not all would agree with his classification, but it provides a starting point for a useful discussion of the reality of the wave function, the "many worlds" idea, and the question of whether any new effects might arise from additional QM parameters. Such considerations finally lead Penrose to propose that a new (now missing) theory is needed between the quantum level and the classical level of

reality. As a start, Penrose considers the relations between various fundamental theories of nature.

In chapter three (likely even more interesting to LDS readers), Penrose calls upon Popper's world of culture in addition to the world of the physical and the world of the mind. Penrose then defines consciousness as consisting of awareness, activity (exercise of free will, for example), and understanding. He distinguishes four viewpoints on the nature of consciousness, ranging from "purely computational activities" to "something that cannot be explained in physical or computational terms." He chooses the third alternative, that "physical action of the brain evokes awareness, . . . but this physical action is something which cannot even be simulated computationally" (101). This is the main point of the book. Some things cannot be computed (as Penrose repeatedly demonstrated in his first two books), and consciousness seems to be one of these. Penrose says something is lacking. He is not thinking of something outside the realm of modern physics. Penrose is simply saying that at present QM, which predicts so many incredible results that accord exactly with experiment, is incomplete. It is this new piece for which Penrose is searching, to which the responses of the panelists are interestingly varied. I was particularly fascinated by the responses of Shimony.

Of course, many questions remain: Where should intelligence be built into the theory? Will a pile of atoms produce intelligence? Reading the book should provoke much thought. For me, a final question remains about the future of LDS research into consciousness and intelligence. As is clear from this book, speculations about the operations of the human mind stand at the edge of the scientific frontier. What is our response as Church members? What do we bring to the discussion?

One of the singular contributions of the gospel is its teaching that each individual has, or is, an immortal spirit and a spirit child of our Heavenly Father. How can we incorporate this grand idea into scholarly thinking? What is the relationship of the human spirit to the human mind? Are consciousness and intelligence simply manifestations of the spirit? These are important questions, and here is an opportunity for LDS scientists and all similarly believing religionists to make an impact on scholarly thinking.

Unfortunately, although the existence of the spirit seems obvious, we have not demonstrated it in a scientific way, and we have no testable (falsifiable) theory of the relation of the spirit to the mind (to consciousness, say). There is work to do!

Science, a process through which we humans search for an understanding of nature, concerns itself with the entire world of matter and energy and their interactions—anything and everything that can be detected or measured. Scientists attempt to search out the facts of nature and find explanations for them in terms of natural processes. (As a cautionary note, we must carefully distinguish the facts of nature from theories about the facts.) In this regard, it is reassuring to recall that the Church has always taught that our Heavenly Father works by natural principles and processes in accomplishing his work. Thus science and the gospel share a basic premise that allows for mutual interaction and enrichment.

Because they are so subtle and elusive, spiritual matters present great difficulty for the scientific method as well as for religious thinkers. One way to try to avoid this difficulty is to deny the existence of spiritual phenomena. That is, if the matter-energy world is the complete world, there is nothing else to speculate about. I find that road a dead end. Another way out is to say that spiritual matters are real but belong to another or higher dimension—the spirit exists, but we can detect it only as God makes it manifest in transcendent ways. However, this answer does not increase our understanding of either spirit or mind. We must travel other roads to seek understanding.

Joseph Smith was an avid scholar, thinker, and teacher. There was power and enthusiasm in his attempts to understand all aspects of the world. I hope this attitude is as strong in the Church today as it was originally.