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HEADLINE: Mind-boggling new worlds Emma Crichton-Miller discovers what a garden hose has to do with the hottest topics in particle physics

BYLINE: By Emma Crichton-Miller

BODY:

IN 1900 THE British physicist Lord Kelvin announced at a meeting of fellow scientists: "There is nothing new to be discovered in physics now. All that remains is more and more precise measurement." Five years later Einstein's theory of special relativity exploded all such certainties. Alongside the fledgling theories of quantum mechanics and, 10 years later, Einstein's most conclusive legacy, general relativity, the formulation of special relativity ignited one of the most intense and fruitful phases of scientific discovery in all history.

With a creative power analogous to Big Bang, these foundation-shaking principles have driven an exponential growth in the search for accurate pictures of how our universe is put together, and pushed our understanding far beyond the safe confines of what we can actually envisage into the dizzying mathematical realms of superstring theory, multiple universes, braneworlds and warped, hidden dimensions.

We all need a guide here. And Lisa Randall, besides being one of the world's leading theoretical physicists, the first tenured woman in the Princeton physics department and the first tenured woman theorist at MIT and Harvard, is also, in her spare time, a mountain climber with an impressively cool head for heights. In *Warped Passages* she leads us by the hand authoritatively but genially, negotiating first the bumpy anomalies of the Standard Model of particle physics, which describes all known particles and non-gravitational forces and their interactions, before attempting an assault on the sheer north face of contemporary theory. Just as in climbing, it is gravity that has always been the problem.

In explaining this, Randall introduces us to an endlessly proliferating array of minuscule particles - from the more familiar electrons, neutrons, protons, photons and quarks to the stranger gluons, leptons, muons, gravitons, Higgs particles and so on; to entities such as the Planck length and features such as supersymmetry, before she reveals the logical possibilities opened up by superstring theory and extra-dimensional worlds.

All the time, Randall's careful choice of analogies and conversational tone, and even her rather whimsical sci-fi chapter prologues, coax your understanding.

However, although it is disguised in many ways as tempting summer reading - the most advanced physical theories explained with the help

of a garden hose and a determination not to patronize - Randall's scrupulous refusal not to compromise on complexity makes this book a sometimes chewy read. For Randall is herself at the forefront of new discoveries and is keen to share her excitement.

In 1998 she and a colleague, Raman Sundrum, began their forays into the brand-new physics of extra dimensions over coffees in an ice-cream shop at MIT. Since then, they have made several key theoretical breakthroughs, including the construction of a warped five-dimensional world in which our world appears as a four-dimensional "Weakbrane", a kind of self-contained slice in what physicists now call "the Bulk". Within the next five years, when the Large Hadron Collider particle accelerator near Geneva is switched on, experimental data may start to provide concrete evidence for the truth or otherwise of such extraordinary ideas.

What distinguishes Randall's book from the many other excited surveys of this mind-boggling terrain is that Randall is, as she tells us, a model-builder and a particle physicist first and foremost, with a scrupulous regard as much for what is possible as for what is imaginable.

As she says of one of her own most recent theoretical contributions, "I like the way localized gravity concentrates on what we can explicitly verify." So while other accounts may give you a smoother ride from theoretical advance to theoretical advance, Randall immerses you in the difficult to and fro between what might be and what can be tested, building up models of how the whole might work from observed phenomena, rather than freewheeling in the higher realms of mathematics.

Even so, there is nothing pedestrian about her conclusions. As one physicist Randall quotes put it when he first came upon the particle called a muon, which has the same charge as an electron but is 200 times heavier: "Who ordered that?"

Emma Crichton-Miller was a producer of science programmes for Channel 4

Warped Passages: Unravelling the Universe's Hidden Dimensions by Lisa Randall