Earth is a spectacular world. It is surely a pinnacle of creation within the Universe, and if our planet is not the Universe's crowning achievement, then an even more breath-taking Universe awaits us.

Our planet has thrived and developed persistently throughout its entire history. Despite events that have on occasion virtually obliterated all life and radically altered its surface, our world has emerged as one of exquisite balance between the gargantuan forces of the surrounding Universe and its own inner make-up, the result of which is the beautiful blue-green globe we now inhabit (Figure 11).

We have already encountered one of the grandest forces of all to affect our world—its quarter-of-a-billion-year journey around the galaxy. But there are many others, including a number of celestial cycles that alter the orientation and movement of our planet in relation to the Sun over timescales of thousands of years. These are known collectively as the Milankovitch Cycles in honor of the Serbian astronomer Milutin Milankovitch who determined many of their characteristics.

The best known of the Milankovitch Cycles is a precession of Earth’s axial tilt where, over approximately 26,000 years, a gravitational pull by the Sun and Moon upon Earth’s slight equatorial bulge will cause the orientation (but not the size) of the axial tilt with respect to the Sun to vary, just as a spinning-top slowly wobbles when rapidly spinning. For example, where currently the Earth’s northern hemisphere tilts most toward the Sun at some particular point along its orbit, in approximately 13,000 years (or half of a precession cycle) the northern hemisphere will tilt away from the Sun at that same orbital position. Hence, as regular and small adjustments will be required to maintain our calendar over an entire precession cycle, the precession affects the position along Earth’s orbit where particular calendar events occur. Another Milankovitch Cycle is called orbital precession where, over a period of approximately 70,000 years, the distant gravitational pull from the other planets causes Earth’s orbit about the Sun to precess. This, coupled to axial precession, induces a 41,000-year cyclical change in the
size of Earth’s axial tilt, called its obliquity, from a minimum of about 22 degrees to a maximum of approximately 24 degrees. Perturbations in the gravitational pull of the other planets also affect the roundness or eccentricity of Earth’s orbit over a timescale of about 100,000 years, changing the shape of the orbit from a near perfect circle to an ellipse of about 5% eccentricity.

When combined, the various axial and orbital cycles can affect Earth’s surface conditions quite significantly. Changes in obliquity, for example, affect the distribution of solar radiation upon the northern and southern hemispheres over time. Changes in eccentricity, on the other hand, affect the amount of solar energy each hemisphere receives along its orbit. At maximum eccentricity, a given hemisphere can receive up to 20% more