The Earth

The Earth is a spinning top

The Earth is not motionless in space, but is subjected to different movements. The most well-known are the rotational movement around its own axis, which determines the alternation of day and night and the apparent movement of the sky above our heads, and the revolution around the Sun in a slightly elliptical orbit. The two main units of time, days and years, derive respectively from the rotation and revolution movements.
The length of a day can be measured as the time interval between two consecutive transits of the Sun or of a given star on the same meridian. The former is called solar day and lasts 24 hours; the latter is known as sidereal day and lasts about 4 minutes less. The difference between the two periods derives from the fact that the Earth rotates around its own axis as it is moving along its orbit. In doing so, it varies the alignment with the Sun and this entails an additional time to reach the same Earth-Sun orientation once again; this does not occur for the other stars that are so distant that they can be considered fixed.
When measuring a year, things get more complicated. In fact, the sidereal year measures the time interval between two successive alignments of a given star with the Earth, and it corresponds to a complete revolution of our planet around the Sun respect to the “fixed” stars. There is also the solar year which represents the time interval between two successive passages of the Sun through the vernal equinox. The latter is one of the two points of interception of the ecliptic and the celestial equator, an extension of the plane of the terrestrial equator into space. If the Earth’s orbit were immovable in space, these two definitions would coincide. However, in actual fact, bodies have a reciprocal influence on each other within the Solar System; hence, the gravitational attraction of the Sun and the planets modifies the terrestrial movements in relation to their mass and the distance away from the Earth. As a consequence, the Earth’s rotational axis describes a slow movement in the opposite sense respect to the orbital one, tracing a cone-shape in the lapse of time of 26,000 years. This cone-shape is also influenced by nutation, an oscillation with a period of 18 years generated by the Moon’s gravity. The sum of movements causes the slow migration of the North Celestial Pole, currently pointing at the Pole Star in the Little Bear constellation, towards different stars; in 15,000 years, for example, the Vega Star in the Lyre constellation will indicate the North. As the axis wobbles, so does the equatorial plane that is perpendicular to it, modifying some of its orbital parameters; as a result, every year the Earth reaches the equinoxes, i.e. the intersections of the equatorial and ecliptic planes, earlier. Hence the solar year differs from the sidereal year by about 6 hours and for this reason it has been necessary to introduce one day every four years to make up for the difference. This explains leap years and February 29. Time can also be measured in months, which are tied to the cycle of phases of our satellite. In fact, the Moon’s orbit around the Earth is inclined by 5° respect to the plane of the ecliptic. This implies that we can observe the different phases in which our satellite is illuminated by the Sun’s rays; as it changes from new moon to full moon, the lunar phase cycle takes a lunar month (28 days). In the points in which the lunar orbit intersects the Earth’s, the Sun, Earth and Moon are aligned and eclipses occur. There is a solar eclipse when the Moon passes between the Sun and the Earth: it is a coincidence that the small lunar disc is at the right distance in perspective to cover the gigantic Sun. If the Earth is in between the other two bodies instead, a lunar eclipse occurs.

The origin of the Moon

All the satellites of the Solar System are small: from 25 to thousands of times smaller than their relative planets. The only exceptions are the Earth-Moon and the Pluto-Charon systems; our Moon has a diameter that is only 1/3 the Earth’s diameter. This implies that maybe the processes that brought to the formation of the Moon were different from those of the other satellites. To date, four hypotheses have been advanced regarding the origin of the Moon:
1) The Moon might be a fragment that separated from the Earth shortly after its formation (fission hypothesis);
2) After having being formed in some part of the Solar System, the Moon might have been captured by Earth’s gravity (capture hypothesis);
3) The Moon might have formed from dust and debris orbiting around Earth (accretion hypothesis);
4) The Moon might be the result of the aggregation of many planetesimals orbiting around our planet, resulting from the

collision of the Earth with a planetary body the size of Mars (collision hypothesis).
Currently, the most favoured hypothesis seems the last one. After the gigantic “slap”, the Moon must have formed as a result of the mutual gravitational attraction of the remains of the collision, bringing about further re-fusion and differentiation of the layers and matter and a consequent cooling. During this process, the surface must have been subjected to an intense meteorite bombardment that transformed the rocks on the surface into a layer of dust and debris. Subsequently, the internal heating must have caused the eruption of matter, creating the basalt lava flows called maria, and the other characteristic tectonic and volcanic activities that are present on the surface.
This sequence of events would explain why the Moon is very similar to the Earth as far as some characteristics are concerned, but not respect to others that it might have “inherited” from the body that collided with our planet.

The seasons

The alternation of the seasons is caused by the inclination of the Earth’s axis and by the revolution of our planet around the Sun.
The Earth follows a slightly elliptical trajectory with respect to its orbital plane. During its revolution, the Earth’s axis of rotation maintains a constant inclination respect to the ecliptic and the Earth’s two hemispheres do not receive the same amount of radiation, which is dependent on the position of the planet respect to the Sun. The variation of the angle of incidence of the Sun’s rays on the Earth’s surface results in a consequent difference in the amount of heat received. Hence, seasonal variations in temperature are not due to a greater or shorter distance from our star: in fact, the Earth’s orbit is closest to the Sun during the winter solstice and furthest from it during the summer solstice. The inclination of the Earth’s axis respect to the orbital plane also explains the change in the length of day and night during the year.
It must be mentioned that the Moon has had an important role in stabilising the Earth’s rotation axis and therefore favouring the development of life. The more inclined the rotation axis is on the ecliptic plane, the more marked are the differences between the seasons. Had there been no Moon, the gravitational attraction of the Sun and the other planets could have made the tilt of the Earth vary in the course of time. In this case, temperatures would have been more extreme, making the evolution of life on Earth more difficult.