Our Ocean Backyard — *Santa Cruz Sentinel* columns by Gary Griggs, Director, Institute of Marine Sciences, UC Santa Cruz.

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A Primitive Earth and A Near Disaster

Life on Earth as we know it came about because of a number of events in the early history of the planet that could easily have gone quite differently. Earth has been called the Goldilocks planet, not too hot and not too cold. While the average temperature on Earth is about 61 degrees F. (16 C.), temperatures vary greatly around the world depending upon the time of year, weather conditions, elevation, ocean currents and wind patterns.

Temperatures tend to be higher near the equator and lower near the poles, and summers tend to be warmer and winters colder. California holds the world record for heat, with a high of 134 degrees F. on July 10, 1913, at Death Valley. This is where people test their mettle or intelligence by trying to hike across a burning desert in July to see if they can survive.

At the other extreme, Vostok Station in Antarctica has the all time cold record, minus 128.6 degrees F. on July 21, 1983. That’s a total global temperature range of 262 degrees Fahrenheit.

Stepping back in time about 4.5 billion years, had the mass of dust and gas that gradually coalesced to form the Earth been a bit closer to the Sun, Earth would have been more like Venus, which has a surface temperature around 750 degrees Fahrenheit. Or our primordial cloud of debris might have collected into a planet with an orbit a bit farther away, closer to Mars, which has an average temperature of minus 80 F. Personally, I’m quite content being the Goldilocks planet.

Another event in very early Earth’s history also continues to exert a profound effect on our home planet, particularly on our oceans and our climate, and that has to do with our closest astronomical neighbor. There has always been a bit of mystery about the Moon and its formation. Ideas have come and gone over the centuries, but with the Apollo missions, we brought back real rocks to analyze and compare with rocks on Earth. At one point during my first year at UCSC, I actually weighed out a small sample of Moon dust for some chemical analyses, so for a few minutes I held some of that expensive and mysterious stuff.

We believe the Moon formed about 30-50 million years after the origin of the Solar System, give or take a few million years. The leading theory today, bolstered in part by the composition of those rocks brought back by Apollo astronauts, is that the Moon formed from a catastrophic collision between early proto-Earth and another early proto-planet. That second heavenly body, about the size of Mars, has even been given a name, Theia. This event has been called the "Giant Impact Hypothesis", or the "Big Splash".

The large amount of debris splashed away from this impact gradually coalesced to form the moon, which was held by Earth's gravitational attraction and began to orbit the evolving Earth.

At first the moon spun much faster on its axis than today, but because it is flattened a bit and bulges out at its equator, its rotation slowed (think of a spinning ice skater moving their arms in and out to speed up and down) and eventually locked into a position where the same side always faces Earth.

Several other dramatic things happened with that Big Splash. It knocked our home planet off balance so that it doesn't spin on a vertical access relative to the Sun. The angle of tilt, averaging about 23°, was retained and gives us our seasons.

Without this tilt, life on Earth would be considerably different. There would be no seasons or seasonal temperature differences, and the length of days would the same all year around. Without the axial tilt, the poles would be colder on average and their frigid impact would extend further towards the equator. Without seasons there would be no need for animals to migrate to warmer climates in winter months, and life on Earth would probably be less diverse.

That long-ago impact also created a wobble in the Earth's motion, much like a top, and altered our orbital path around the sun, from a circle to an ellipse. These disruptions in what started out as a very regular and predictable rotation for the Earth: the axial tilt, the wobble on its axis, and eccentricity of its orbit, with periods of tens of thousands of years, and which bring us closer to the sun and take us farther away, gave us long-term climate change.