Standard Model of the Universe

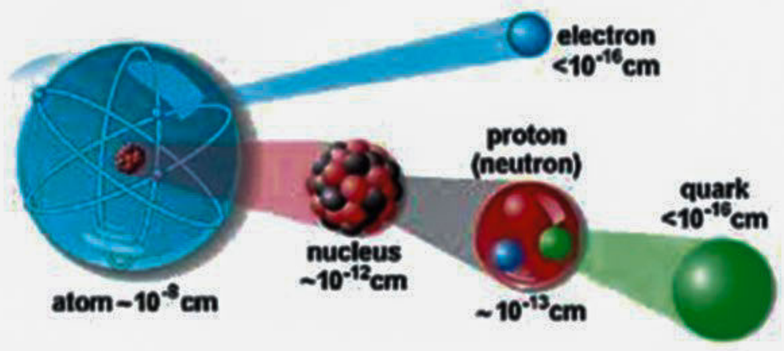
QUAMRUL HAIDER

THE Standard Model (SM) was developed in the late 1960s to answer the questions "What is the world made of? What holds the universe together?" It provides an elegant theoretical framework to study every particle in the universe and how these particles interact with each other.

At the beginning of the 20th century, J.J. Thompson suggested the "plum pudding" model of the atom, a mass of positive matter with little "plums" of negative electrons scattered throughout. Later in 1911, Rutherford's large angle scattering of alpha particles by gold foil led to the discovery of the nucleus containing neutrons and protons. In the 1950s muons were discovered in the cosmic rays and neutrinos were discovered in beta decay. With only four structureless point-like particles - proton, neutron, electron and electron neutrino, we could explain strong and weak nuclear forces together with the electromagnetic force.

In the late 1960s, Deep Inelastic Scattering of electrons by protons at SLAC revealed that protons have substructure. Neutrons and protons are no longer elementary particles, but made of "partons," a generic name for their constituents. Feynman and Gell-Mann later gave them the name quarks.

The SM started to take shape after the concept of quarks was introduced. It is a simple but comprehensive theory that describes all the hundreds of particles and their complex interactions using 17 fundamental particles. They are 6 "flavors" of quarks up, down, strange, charm, bottom and top, 6 leptons (Greek for "small mass")



From atom to quark

electron, muon, tau and their neutrinos, 4 bosons gluon, photon, W and Z particles, and the "hypothetical" Higgs boson. These 17 particles constitute the building block of the universe. There are also anti-particles of quarks and leptons.

The quarks and leptons are collectively known as fermions, named after Enrico Fermi. They are half-integral spin "unsocial" particles in the sense that no two fermions can exist together with the same set of quantum numbers. Bosons, named after Satyen Bose, are "social" integral spin particles with no such constraints.

Particles that are composed of quarks and anti-quarks are called hadrons. Hadrons are divided into two groups baryons (fermions) containing three quarks and mesons (bosons) made up of quark-antiquark pair. A proton is composed of two up quarks and a down quark, while a neutron has one up and two down quarks. A negative pion contains a down and an anti-up quark. Baryons are stable while the mesons are unstable.

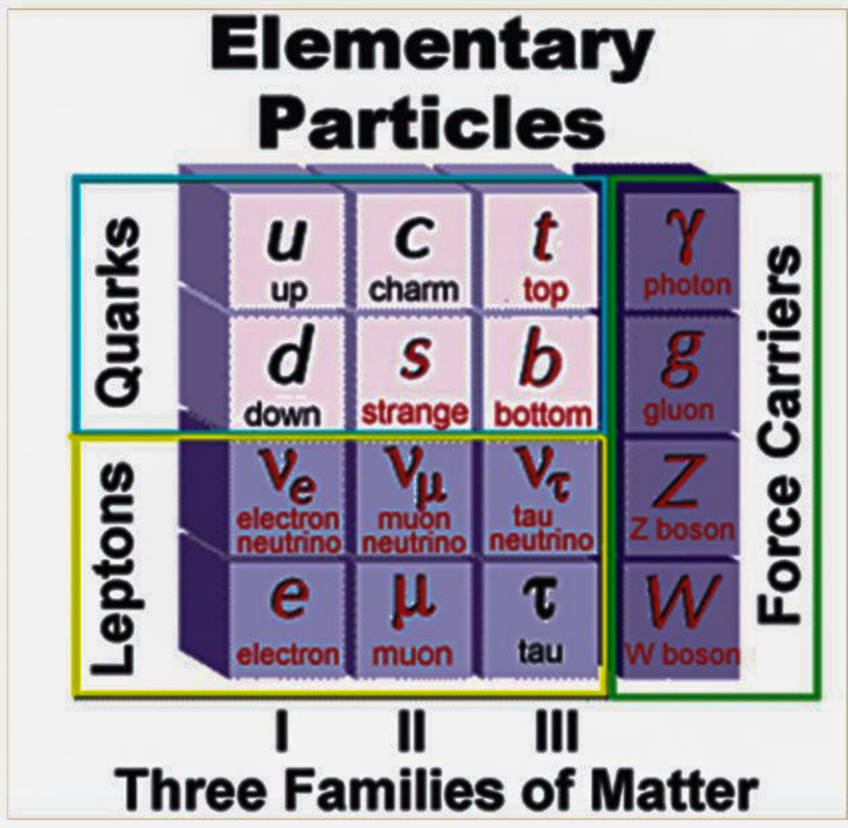
The SM particles are point-like and exhibit no internal structure. All the particles except the Higgs boson have been observed experimentally.

Isolated quarks have never been observed because they cannot exist singly. They can only exist inside hadrons and are confined by the strong force. The existence of seven of these particles - charm, bottom, top, tau neutrino, W, Z, gluon, were predicted by the SM before they were observed experimentally.

There are four fundamental forces in nature. Aside from gravity, the other three forces strong nuclear, weak nuclear and electromagnetic, are part of the SM. The strong nuclear force, mediated by gluons, holds the quarks together to form a hadron. The weak nuclear force is mediated by Z and W bosons, and is responsible for radioactive phenomenon. The photon is the carrier of electromagnetic force between charged particles.

Each of the 6 flavors of quarks can have three different "colors" red, green and blue. The quark forces are attractive only in the "colorless" combinations of three quarks, quark-antiquark pairs and possibly larger combinations such as the pentaquark that could also meet the colorless condition. Quarks can change color by emitting gluons.

Despite the success of the SM in explaining sub-nuclear physics and some aspects of cosmology in the earliest moments of the universe, it cannot explain what causes the fundamental particles to have masses. The elusive Higgs boson is crucial to understanding the origin of masses of the fermions and bosons. The SM does not include gravity which is mediated by "graviton." Although very weak as compared to the other forces, it cannot be explained by the SM.



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SPAN GENERATIONS | DIONE OF HOPE | CORAL EMBYOS

Lasting impact of toxicants

A woman spraying pesticides.

A Washington State University researcher has demonstrated that a variety of environmental toxicants can have negative effects on not just an exposed animal but the next three generations of its offspring.

The animal's DNA sequence remains unchanged, but the compounds change the way genes turn on and off -- the epigenetic effect studied at length by WSU molecular biologist Michael Skinner and expanded on in the current issue of the online journal PLoS ONE.

While Skinner's earlier research has shown similar effects from a pesticide and fungicide, this is the first to show a greater variety of toxicants -- including jet fuel, dioxin, plastics and the pesticides DEET and permethrin -- promoting epigenetic disease across generations.

"We didn't expect them all to have transgenerational effects, but all of them did," Skinner said. "I thought hydrocarbon would be negative but it was positive too."

This tells researchers that the ability to promote transgenerational disease is "not simply a unique aspect for a unique compound" but a characteristic of many environmental compounds.

Researchers tested a pesticide mixture (permethrin and insect repellant DEET), a plastic mixture (bisphenol A and phthalates), dioxin (TCDD) and a hydrocarbon mixture (jet fuel, JP8).

The field opens new ground in the study of how diseases develop. While toxicologists generally focus on animals exposed to a compound, Skinner's work further demonstrates that diseases can also stem from older, ancestral exposures that are then mediated through epigenetic changes in sperm.

The work also points the way to identify and diagnose exposures through the use of specific epigenetic molecular markers.

Source: Science Daily

Oxygen in Saturn's moon

LOS Alamos National Laboratory scientists and an international research team have announced discovery of molecular oxygen ions (O2+) in the upper-most atmosphere of Dione, one of the 62 known moons orbiting the ringed planet. The research appeared recently in Geophysical Research Letters and was made possible via instruments aboard NASA's Cassini spacecraft, which was launched in 1997.

Dione -- discovered in 1684 by astronomer Giovanni Cassini (after whom the spacecraft was named) -- orbits Saturn at roughly the same distance as our own moon orbits Earth. The tiny moon is a mere 700 miles wide and appears to be a thick, pock-marked layer of water ice surrounding a smaller rock core. As it orbits Saturn every 2.7 days, Dione is bombarded by charged particles (ions) emanating from Saturn's very strong magnetosphere. These ions slam into the surface of Dione, displacing molecular oxygen ions into Dione's thin atmosphere through a process called sputtering.

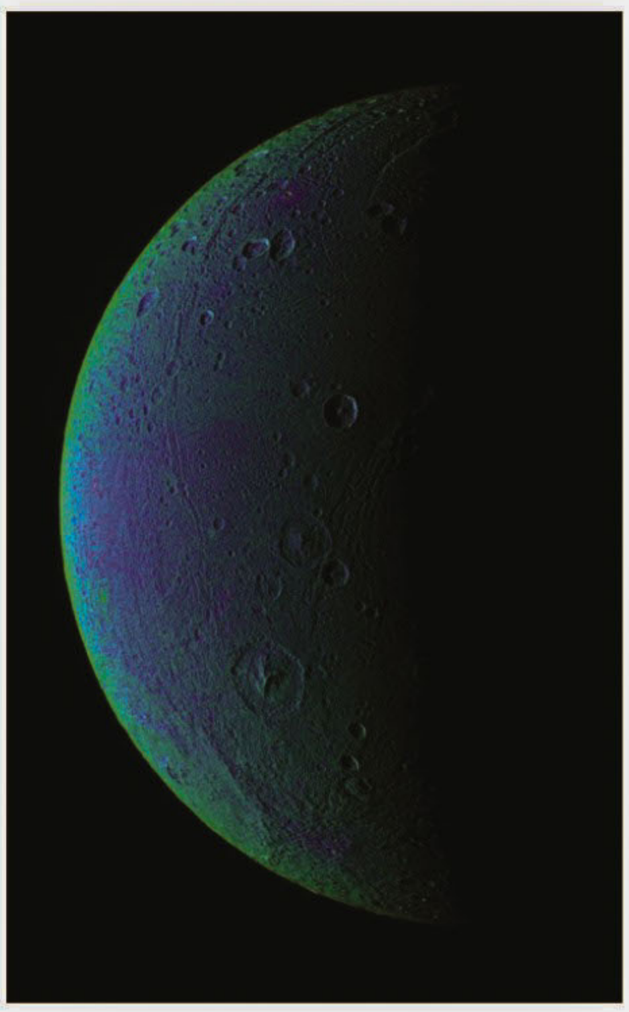
Molecular oxygen ions are then stripped from Dione's exosphere by Saturn's strong magnetosphere.

A sensor aboard the Cassini spacecraft called the Cassini Plasma Spectrometer (CAPS) detected the oxygen ions in Dione's wake during a flyby of the moon in 2010. Los Alamos researchers Robert Tokar and Michelle Thomsen noted the presence of the oxygen ions.

"The concentration of oxygen in Dione's atmosphere is roughly similar to what you would find in Earth's atmosphere at an altitude of about 300 miles," Tokar said. "It's not enough to sustain life, but -- together with similar observations of other moons around Saturn and Jupiter -- these are definitive examples of a process by which a lot of oxygen can be produced in icy celestial bodies that are bombarded by charged particles or photons from the Sun or whatever light source happens to be nearby."

Perhaps even more exciting is the possibility that on a moon with subsurface water, such as Jupiter's moon Europa, molecular oxygen could combine with carbon in subsurface lakes to form the building blocks of life. Future missions to Europa could help unravel questions about that moon's habitability.

Two sensors aboard Cassini built by Los Alamos National Laboratory are expected to come into play beginning later this month, and again in April and May, when the Cassini spacecraft flies by the moon Enceladus. The moon is one of the brightest objects in our solar system, reflecting back nearly all of the sunlight that strikes it, thanks to a shimmering surface of snowy ice crystals. The moon also unleashes plumes ofmaterial from its south polar region. Los Alamos' ion-beam spectrometer and ion-mass spectrometer may help answer key questions about the composition of these plumes.



False-color image of Saturn's moon Dione, imaged by the Cassini spacecraft in 2005.

Source: Science Daily

They break easy, die hard

CHOPPY waters and even mellow surf can knock drifting coral embryos to bits. But it takes more than shattering to kill these resilient young animals. The fragments turn out to have the power to keep on growing as clones.

Many corals start life adrift in open water, forming when eggs and sperm released by their settled parents float to the sea surface and mingle. The new embryos often face at least somewhat rough water on about half of the spawning nights in the central Great Barrier Reef. Lab tests mimicking these conditions split apart 45 percent of coral embryos just starting to divide, says Andrew Negri with the Australian Institute of Marine Science in Townsville. Yet checking on these remnants showed plenty of survivors that remained small but matured normally, Negri and Institute colleague Andrew Heyward of Perth report in the March 2 Science.

"A pretty cool observation," says coral biologist Nancy Knowlton of the Smithsonian Institution's National Museum of Natural History in Washington, D.C. "What makes it neat is not that the developing embryos can clone per se, but they are likely to do it under natural circumstances."

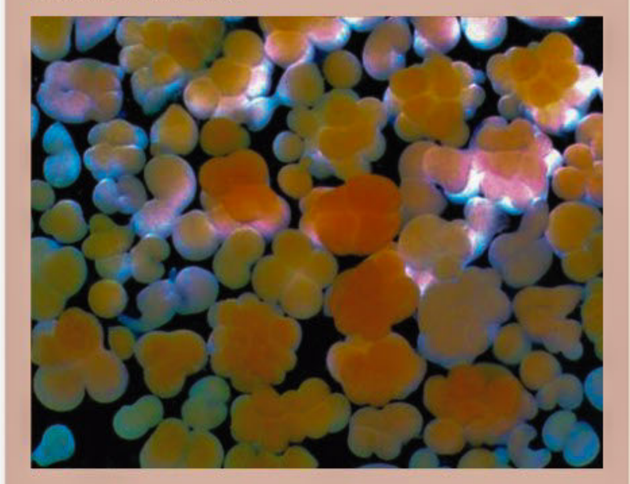
Undamaged, older larvae of sea stars and brittle stars (as well as some of their echinoderm relatives) sometimes clone themselves. In these animals, however, the very youngest larvae get some protection from their environment. Right after fertilization, a membrane forms around the echinoderm embryo as cells start to divide. Corals, in contrast, start naked.

Many coral species release their buoyant bundles of sex cells during highly synchronized mass spawnings. "It looks like upside-down, pink rain," Negri says. As for the odor, "I can't really describe it, but once you've smelled it, you never forget it."

To test very young corals under realistic conditions, Negri and his colleagues focused on moderate winds greater than 11 knots (12.7 miles per hour), which nudge water into waves at least 30 centimeters high. The researchers poured young embryos from that height twice. Studying the survivors, researchers found a mix of embryo sizes as smaller remnants kept on dividing. Like their intact brethren, if a smidge littler, these cloned bits developed into brisk swimmers and then selected places to settle down for some reef-building adulthood.

Finding normal development despite disaster opens up a new range for experiments, says Negri. Coral versions of human twin studies might compare some environmental effects on genetically identical individuals, or environmental tests might determine the vulnerabilities of youngsters of different sizes.

Source: Science News



Battered coral embryos three hours after fertilization show a mix of fragments and intact individuals.

TAGGED GIANT | DID YOU KNOW?

World's second largest fish

A basking shark

A basking shark the world's second largest fish tagged with a tracking device in June 2011 suddenly checked in near Hawaii after eight months of silence, researchers reported this week. The fish, tagged near San Diego, was one of only four basking sharks ever tagged in the eastern Pacific, and the lone shark to keep its tag for such a long time.

Basking sharks, the second-largest fish on the planet, were once plentiful along the Pacific coast of North America, gathering by the hundreds and even the thousands. Now, it's a rare treat to see even one of these ocean giants. Yet within the space of just a few days, satellite technology has offered scientists an unprecedented look at the mysterious wanderings of this elusive fish.

Source: Live Science

Which is the driest desert on Earth?

We all know that deserts are one of the driest places in the world but did you know that the Atacama desert in Chile is the driest? To understand what that really means let's take as an example the Sahara desert (the worlds largest hot desert) and note that it receives a meager 2mm of rain each year.

Just imagine how dry the Atacama is when it receives just 0.1mm per year. In fact some parts of the desert have not seen rainfall for over 400 years making it in most estimation the driest place on the planet earth.