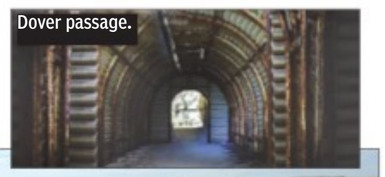
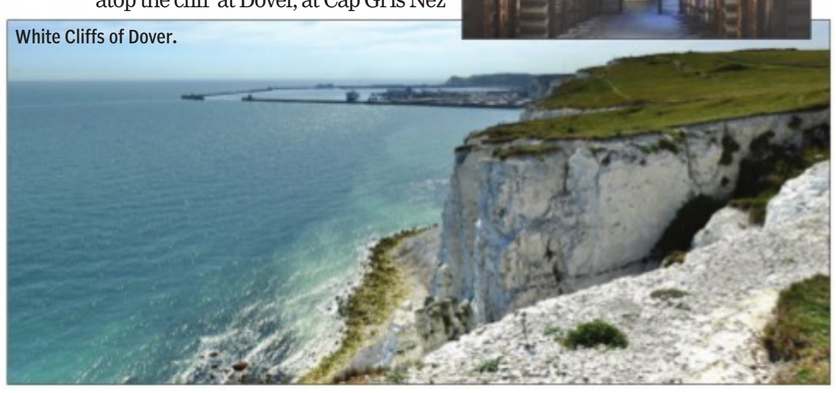
Seaweed and the great chalk mound

VEGETATION THAT GAVE RISE TO THE WHITE CLIFFS OF GREAT BRITAIN HAS BEEN FOUND TO TRAP CARBON IN THE SOUTHERN OCEAN, WRITES **S ANANTHANARAYANAN**

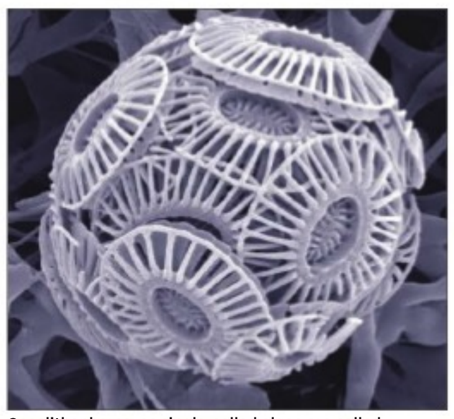
The first record of the white, southern face of the British Isles at Dover, and along the coast, is by Julius Caesar when he found this nearest entry from France to be too well guarded. The cliffs have long served England as a first defence against invasion and they now enclose a network of tunnels and chambers that housed a hospital during World War I and troops and a command station for the Battle of Britain during World War II. While a large part of the British Isles consists of the same chalk deposit, the chalk strata continues across the channel and can be seen from atop the cliff at Dover, at Cap Gris Nez on the French coast.


Dover passage.


White Cliffs of Dover.

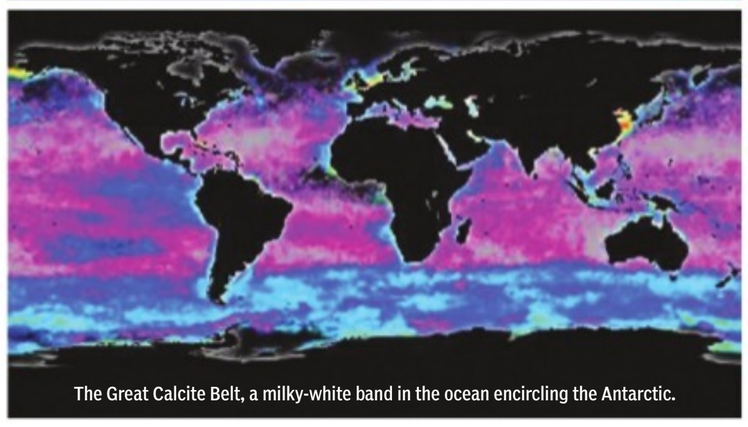
The chalk deposit is known to be the skeletal remains of algae, or phytoplankton, photosynthetic organisms found in the sea. Some hundred million years ago, this part of the earth was submerged by water and the hard, outer remains called *cocoliths*, of a variety of seaweed, descended and gradually formed a 500-metre mound on the seabed, a mound that rose above sea level, as the British Isles, due to movements of the earth's crust.

A group of scientists from Bigelow Laboratory for Ocean Sciences, Maine, the Bermuda Institute of Ocean Sciences, the University of Southampton, the Woods Hole Oceanographic Institution, California, and the Massachusetts Institute of Technology has studied a vast growth of cocolith-creating organisms, collectively called the *Great Calcite Belt*, in the Southern Ocean, the sea south of 38° South and till 60° South latitude. They describe in the American Geophysical Union journal, *Global Geophysical Cycles*, why the Belt arises and the conditions that allow the algae to flourish, which suggests the conditions in which calcite of the White Cliffs mound may have come to be.


Cocolithophores, as single-celled algae are called.

The *cocolithophores*, as the single-celled algae are called, create crystals of calcium carbonate that enclose the cells as an exoskeleton. The scale formation is by the reaction of calcium atoms with hydrogenated carbonate, an alkaline combination of carbon dioxide gas and water, a product of photosynthesis. Of the two carbon atoms consumed in the reaction, one gets fixed as calcite, and the other is released as carbon dioxide. While some of the CO_2 is again used for photosynthesis, reducing the alkalinity and releasing CO_2 has the effect of sending CO_2 back to the atmosphere. The net effect, however, is to fix carbon as calcite. The calcite shells are partly shed during cell growth and fully when the cell dies, and they sink to the seabed, effectively sequestering carbon.


Algal bloom, southern England.


The Great Calcite Belt, a milky-white band in the ocean encircling the Antarctic.

Great Calcite Belt

The oceans hold 50 times the quantity of CO_2 compared to the atmosphere, and 19 times more than all the biomass on land. Apart from carbon dioxide dissolved in seawater, the organisms in the oceans convert some one-third of the emissions by human activity into organic matter and also into inorganic particles. The organic matter enters the oceanic food chain and some comes back into circulation, but a good part of the carbon is released at great depths, where it remains, because water under pressure can hold more CO_2, and the rest sinks as dead tissue. The storing of carbon as calcium carbonate by some organisms, however, is in addition to organic matter, and this forms an important reservoir for carbon, so long as the calcite deposit is at moderate depths or covered by other sediment when it is at great depths.

Satellite images of the sea around the Antarctica reveal, during the summer months in the southern hemisphere, a milky white band covering a vast area equal to 16 per cent of the global ocean. William Balch, the lead author of the present study, and others in 2011, identified the band to be caused by sunlight being reflected by minute, shiny white spheres of algae covered by a calcite shell below the surface of the water. The imagery shows that 26 per cent of global particulate inorganic carbon is found in this area, which makes it the largest concentration of cocolith-producing algae. The study now undertaken, with two research cruises to the Southern Ocean, was to refine findings of the location, timing and magnitude of particulate inorganic carbon formation, ratio of the inorganic and organic carbon capture and the role of the process in the global carbon cycle.

The abundance of inorganic carbon particles in the region indicates that the algae that create cocoliths are able to dominate other kinds of algae in this area, the study reported in *Global Geophysical Cycles* says. The main competing form is that of diatoms, which create a silica shell and need silicon and nitrogen for growth. Cocolithophores would, hence, dominate in silicon poor waters. Another factor that affects growth of all algae is the supply of iron. In fact, there is a view that the oceans could be seeded with iron to promote growth of plankton, to draw down the CO_2 levels in the atmosphere.

Although low iron thus affects cocolith production and the Great Calcite Belt is deficient in iron, cocolithophores were less sensitive and could dominate iron-poor regions, the study says. The study also notes that the ocean currents meet along the calcite belt, which suggests that rising nutrients from deep waters, and the ratio of silicon to nitrogen content, at these places, affects the growth of cocolithophores.

The study also notes that the pace at which inorganic (ie, calcite) or organic (ie, plant tissue) carbon is produced affects the CO_2 concentration. Inorganic carbon production raises the CO_2 content of the water and hence diffusion into the atmosphere. Creating organic carbon, on the other hand, consumes CO_2 and reduces its level. The CO_2 content of the atmosphere is thus sensitive to seasonal variation of particulate inorganic carbon generation, the study says.

There are other studies that show there is actually a collection of calcite deposits directly below the Great Calcite Belt, which makes it clear that the study of Balch and others has arrived at the conditions that would have prevailed at the time the calcite deposits of the White Cliffs at Dover arose. There is no saying if a similar growth will arise in the Southern Ocean, but it would take many millions of years, in any case, the authors are reported to have observed.

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PLUS POINTS

Genomic treatment

Most of the DNA detectable in the genomes of modern humans can be traced back to a single migration of Homo sapiens out of Africa millennia

ago, according to three genomic studies published on 21 September 21 in Nature. "I think all three studies are basically saying the same thing," Joshua Akey of the University of Washington, who wrote a commentary accompanying the papers, told The New York Times. "We know there were multiple dispersals out of Africa, but we can trace our ancestry back to a single one."

While the three papers - which present the genome sequences of 787 people - all concluded that the vast majority of the modern human genome owed to a single out-of-Africa migration event, they differed in estimating the timing of that movement.

University of Copenhagen geneticist Eske Willerslev led a team that sequenced the genomes of 83 Australian Aboriginal people and 25 Papua New Guineans. Mait Metspalu of the Estonian Biocentre led a massive group of researchers, which sequenced 483 genomes from people in Europe, Asia, Africa and Australia. The third study, headed by Harvard's David Reich, considered 300 genome sequences from people all over the globe.

Willerslev's and Reich's teams concluded that the migration event occurred between 80,000 and 50,000 years ago. Metspalu's team, however, proposed an earlier migration - sometime between 140,000 and 120,000 years ago, based largely on DNA from people in Papua New Guinea. This earlier wave of humans died out quickly while the later wave survived to leave a more robust signal in the modern human genome, the researchers posited. "We see vestiges of an earlier out-of-Africa expansion," Metspalu told New Scientist.

Singing fish

Scientists will have you know that fish sing dawn choruses in the ocean just as birds do on land. Seven fish choruses have been identified by researchers from Exeter University and Curtin University in Perth, Australia, which varied from "foghorn" cries to "grunting" noises.

Using a pair of sea-noise loggers positioned at different points in the coastal waters of Port Headland in Western Australia, scientists monitored the ocean continually for 18 months and


Fish cries varied from 'foghorn' like to 'grunting' noises.

recorded distinct choruses occurring at different times of the day, particularly at dawn and at dusk, with songs predominantly heard between early spring and late summer. The study, led by Robert McCauley and published in the journal Bioacoustics, found the majority of this submarine soundscape was emitted through repetitive solo calls from fish, however these sounds also overlapped creating the choruses. "You get the dusk and dawn choruses like you would with birds in the forest," Steve Simpson, a marine biologist at Exeter University, told the New Scientist.

The sounds included a deep "foghorn call" made by the Black Jewfish, a chorus researchers said was comparable to the "buzzer in the Operation board game", emitted by a species of Terapontid, and a chorus consisting of a "ba-ba-ba" call. "Distinct diurnal patterns in the choruses were observed, associated with sunrise or sunset and in some cases, both," the study said. "While choruses were predominantly recorded on different days, there were a total of 80 days when more than one chorus was present at the same site. These choruses comprised calls of single or multiple acoustic pulses with varying pulse repetition frequencies."

Sound plays an important role in the behavioural functions and life stages of fish, it said, "such as spawning, feeding, territorial disputes or distress", and the catalogue of fish noises may help provide valuable ecological knowledge.

"We are only just beginning to appreciate the complexity involved and still have only a crude idea of what is going on in the undersea acoustic environment," said McCauley.

IT'S TIME TO DIE

TAPAN KUMAR MAITRA EXPLAINS THE PROCESSES BY WHICH CELLS ARE 'EXECUTED'

There are two main routes by which cells can activate caspases and enter the apoptotic pathway. In some cases, activation occurs directly. For example, when cells in the human body are infected by certain viruses, a population of killer lymphocytes is activated and induces the infected cells to initiate apoptosis.

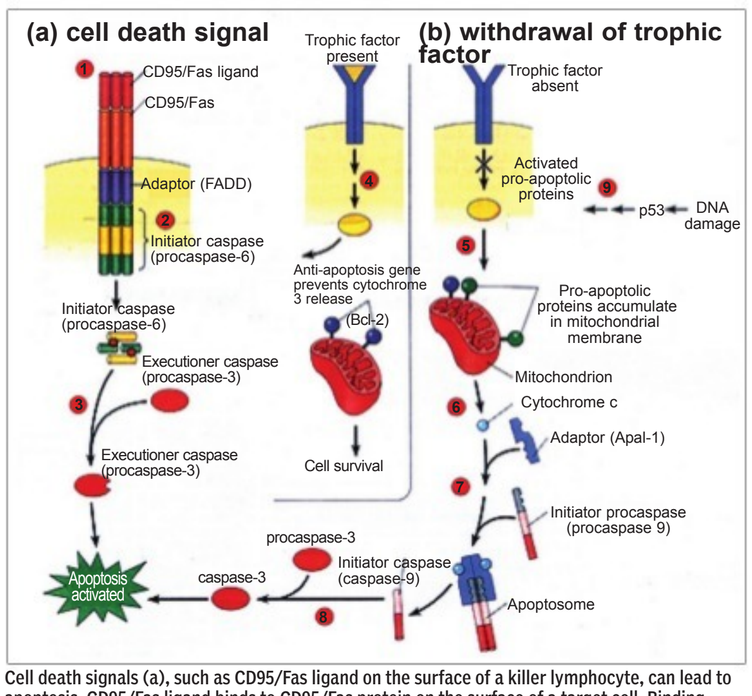
But how do lymphocytes induce cells to commit suicide via apoptosis? Typ-ically, such activation is triggered when cells receive cell death signals. Two well-known death signals are tumour necrosis factor and CD95/Fas.

Let's focus on CD95 — a protein on the surface of infected cells. Lymphocytes have a protein on their surfaces that binds to CD95, causing it to aggregate. The aggregation results in the attachment of adaptor proteins to the clustered CD95, which in turn recruits a procaspase (procaspase-8) to sites of receptor clustering. When the procaspase is activated, it acts as an initiator of the caspase cascade. A key action of such initiator caspases is the activation of an executioner caspase, known as caspase-3. Active caspase-3 is important for activating many steps in apoptosis.

In other cases, apoptosis is triggered indirectly. One of the best-studied cases of this second type of apoptosis involves survival factors. Survival factors mediate one of the many events associated with growth factors — cell survival. When such factors are withdrawn, the cell enters apoptosis. Surprisingly, a key site of action of this second pathway is the mitochondrion. The connection between mitochondria and cell death may be surprising, but it is clear that in addition to their role in energy production, mitochondria are important in apoptosis. If withdrawal of trophic factors is the sentence of execution, then the executioners are mitochondria.

How does the mitochondrion hasten cell death then? In a healthy cell that is not committed to apoptosis, there are several anti-apoptotic proteins in the outer mitochondrial membrane that prevent apoptosis, but only as long as a cell continues to be exposed to trophic factors. They are structurally related to a protein known as Bcl-2, the best understood of these anti-apoptotic proteins. Bcl-2 and other anti-apoptotic proteins exert their effects on counteracting other proteins that are also structurally. These proteins, however, promote apoptosis, and so they are collectively referred to as pro-apoptoth proteins. They can insert into the mitochondrial outer membrane but they only do so at high levels when trophic factors are no longer present. Thus, pro and anti-apoptotic proteins wage an ongoing battle in many cells; when the balance shifts toward pro-apoptotic proteins, a cell is more likely to undergo apoptosis.

Surprisingly, mitochondria trigger apoptosis by releasing cytochrome c into the cytosol. First, cytochrome c stimulates calcium release from adjacent mitochondria and from the endoplasmic reticulum, where it binds IP3 receptors. Second, it can activate an initiator procaspase associated with mitochondria, known as procaspase-9. It does this by recruiting a cytosolic adaptor protein (known as Apaf-1) that assembles procaspase-9 into a complex sometimes called an apoptosome; the apoptosome promotes the production of active caspase-9. Like other initiator caspases, caspase-9 activates the executioner caspase, caspase-3. Thus, in the end, both cell death mechanisms lead to the activation of a common caspase that sets apoptosis in motion.



Cell death signals (a), such as CD95/Fas ligand on the surface of a killer lymphocyte, can lead to apoptosis. CD95/Fas ligand binds to CD95/Fas protein on the surface of a target cell. Binding causes clustering of receptors and recruitment of adaptor proteins in the target cell, resulting in clustering of initiator procaspase (procaspase-8) protein. Initiator caspases then become activated. After they are activated, the initiator caspases in turn activate the executioner caspase, caspase-3, a key initiator of apoptosis. When trophic factors (b) are present, cell signalling results in inactivation of pro-apoptotic proteins, and the cell does not enter apoptosis. (5). When trophic factors are withdrawn, pro-apoptotic proteins are activated, and some accumulate in the outer membrane of the mitochondrion. The balance between pro-apoptotic and anti-apoptotic proteins (such as Bcl-2) at the mitochondrial outer membrane determines whether the mitochondrion releases cytochrome c. Cytochrome c forms a complex with other proteins, resulting in activation of an initiator caspase (caspase-9). The initiator caspase in turn activates the executioner caspase, caspase-3, triggering apoptosis. DNA damage can also lead to apoptosis through the activity of the p53 protein.

There is another situation that can trigger the mitochondrial pathway to apoptosis. When a cell suffers so much damage that it is unable to repair itself, it may trigger its own demise. In particular when a cell's DNA is damaged (for example, by radiation or ultraviolet light) it can enter apoptosis via the activity of a protein known as p53 — an important regulator of the cell cycle. Like the withdrawal of trophic factors, the p53 pathway can also activate pro-apoptotic proteins to trigger apoptosis.

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Phenomenal' skeleton discovery

BONES UNEARTHED IN A LONDON CEMETERY CAST NEW LIGHT ON ROMAN SOCIETY AND PROMPT EXCITEMENT AMONG ARCHAEOLOGISTS AND HISTORIANS. **JAMES SOMPER** REPORTS

Two ancient skeletons unearthed at a cemetery in London may be of Chinese origin, overturning long-standing assumptions about the history of the Roman Empire and Britain's capital city. Using cutting-edge techniques, a team of archaeologists and scientists examined dental enamel samples from over 20 sets of human remains dated from between the second and fourth centuries AD.

Dr Rebecca Redfern, curator of human osteology at the Museum of London, revealed that two of the skeletons found at the site in Lant Street, Southwark, had been identified as possibly being of Chinese origin. "This is absolutely phenomenal. This is the first time in Roman Britain we've identified people with Asian ancestry and only the third or fourth in the empire as a whole," she told BBC Radio 4's The World at One.

The find challenges the dominance of the traditional view that Roman Britain, and specifically "Londinium" as it was then known, was a relatively homogenous society. It also suggests the Roman and Chinese empires may have had more interaction than many historians had previously thought.

Crucially though, it raises the possibility that trade took place between Rome and China outside of the famous Silk Road.

While previous archaeological work has shown the multicultural nature of the ancient city and its importance as a major trading hub, this is only the second time the bones of an individual of possibly Chinese origin have been found at a Roman site, the first being the discovery of a possibly Asian man in Vagnari, Italy.

Writing in *The Journal of Archaeological Science*, Dr Redfern said, "The expansion of the Roman Empire across most of western Europe and the Mediterranean led to the assimilation and movement of many ethnically and geographically diverse communities. Its power and wealth meant that it also had trade connections for raw materials and products, such as silk throughout Europe, Africa and also to the east, including India and China. Many people travelled, often vast distances, for trade or because of their occupation, for example in the military, or their social status, for example if they were enslaved."


One of the skeletons found at the site in Lant Street, Southwark.

Archaeologists and historians are divided as to the explanation behind the possible presence of Chinese individuals in Roman Britain. The findings raise the possibility that Chinese traders settled in the area and may have even set up their own trading communities.

However, in her journal article Dr Redfern went on to add, "It may well be that these individuals were themselves or were descended from enslaved people originating from Asia, as there were slave-trade connections between India and China, and India and Rome."

THE INDEPENDENT