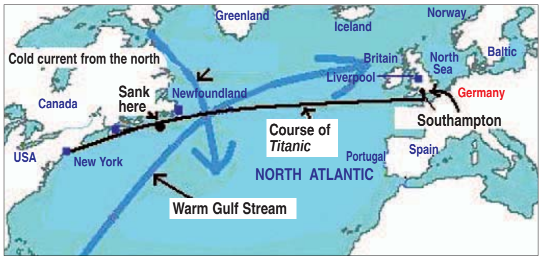
And then the Titanic sank

After everything went wrong, material failure was found to be critical, writes s ananthanarayanan



IT'S been a century since the legendary 46,000-tonne *Titanic* went down in the Atlantic off Newfoundland, with 2,224 passengers and crew on board. Science writer David Corfield has reviewed the circumstances and reasons leading to the disaster in his article, *The Perfect Storm*, carried in the journal *Nature* this week. The iconic *Titanic* was state-of-the-art in 1912 and had been touted as the "ship that could never sink". The hull was made of quality mild steel sheets held together by three million rivets of steel and wrought iron and the body was divided into 16 watertight compartments that had electrically operated doors. In the event of a puncture of the hull at one place, the rest of the ship could thus be sealed off. There was a 5,000-watt radio transmitter on board, a hand-picked crew and all reports of fair weather. But at 11.40 pm on Sunday, 14 April 1912, on her very first voyage from Southampton to New York, the *Titanic* struck an iceberg, damaged over a third of her hull plates and sank within three hours, losing more than two-thirds of those on board.

The enquiry reports filed at the time agree on the main circumstances that may have led to the disaster. Captain Edward J Smith, who was in command, was going too fast, he had not heeded iceberg warnings and the ship had lifeboats only for a third of the passengers. Corfield adds that the shortage of lifeboats carried was defended as the number carried being more than what was "legally required", as if this made a difference to passengers left behind. While shipbuilding technology is not much different today than at that time, the legal requirement for lifeboats is now, logically, at least "enough to evacuate all passengers and crew". But in 1912, the enquiry was necessarily formal, based on available records and reports as the wreckage, at a depth of 12,400 feet, had not been discovered.

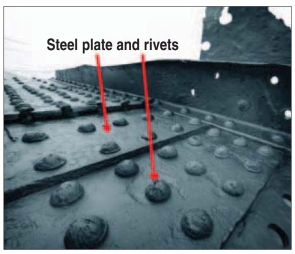
Added to the captain's mandate to prove the *Titanic's* reputation by making good speed, were "accidental" events — one almost comical, if it were not somber one being that the ship's binoculars, with which icebergs that dotted the sea may have been spotted before dark, were locked in a cupboard and the key was not at hand! The other was that an iceberg warning received from another ship in the area, of icebergs only 50 miles away and dead ahead, was not recognised as meriting the captain's personal attention and the wireless operator went back to dealing with passengers' messages to family and friends!

Iceberg population

In recent times, more thinking has gone into other bad fortune that affected the *Titanic*. One is how icebergs position themselves in the Atlantic off Newfoundland. The icebergs in the North Atlantic arise from glaciers or ice formations on the northwest coast of Greenland and then circle east and southward, through the Labrador Sea, to enter the North Atlantic near Newfoundland. Just around here, they meet the Gulf Stream, a warm ocean current that comes from the west and flows northward. The meeting of the cold drift from the north and the warm stream from the south creates troughs of lower salinity and density, which herd icebergs into approximately a straight line along the south-north interface — in other words, a barrier of ice. It is on record that the Caribbean had an unusually warm summer in 1912, which created an intense Gulf Stream that April, which in turn concentrated icebergs just where the star-crossed *Titanic* crossed their path.

The other circumstance that arose the same year is that on 4 January, or three months before the disaster, the sun and moon were aligned to create high "spring tides". On top of that, on the same day the moon was closest to earth in more than 1,400 years! And as if this was not enough, on the previous day the earth had been at its closest approach to the sun. The triple combination made for a record high spring tide that week in January 2012. But what should tides in January have to do with icebergs in April?

The answer is that many icebergs that break off glaciers or other formations and float in the sea do not reach the high seas; they are beached before they get very far. It is the high tide that can set them free and afloat again. With the extra high tides that January, this iceberg launching action would have taken place with twice redoubled vigour. And that fateful April evening, the North Atlantic was teeming with icebergs jostling to get in the *Titanic's* way.



Titanic's *shipyard in Belfast.*

Designed to take it

For all the reasons that may have caused the collision, the design of the ship's hull catered for such an impact, at full speed, with an object like the iceberg. The resilience of the design was expressed in the quality of steel plates that made up the hull and the way they were put together. After seven decades of speculation, hard evidence of how the steel plates and joints behaved during the *Titanic* disaster became available when the wreckage was discovered in 1985. It was found by a deep sea exploration craft called the *Alvin*, a version of the *Argo-Jason system*, an arrangement of cameras and sensors that are dragged along the seabed by a mother ship at the surface. And with the help of the facilities of the *Alvin*, images and samples of the wreck, more than 12,000 feet below, and under pressure of over 6,500 pounds per square inch, were brought up for analysis.

In the mid-2000s, two US metallurgists — Tim Foecke at the US National Institute of Standards and Technology and Jennifer Hooper McCarty, then at Johns Hopkins University — turned their attention to the composition of the rivets used to join the plates of the *Titanic*. Along with metallurgical analysis of the rivets, they searched through the records of the Harland and Wolff shipyard at Belfast where the *Titanic* had been built.

The result of the investigations is that the rivets used in the middle sections of the ship were of the very best quality steel or wrought iron and had been inserted by hydraulic presses, which make for the best insertion.

The rivets used in the region of the bow and the stern, however, were not the very best quality and had been inserted by hand. The difference in manner of insertion appears to be that the hydraulic presses could not be deployed where the hull was curved, as in the front and rear. But the reason for the lesser quality is not as clear. Only the best quality material is "slag free" and the use of lesser quality is seen as the reason for the rivets having sheared and popped off.

Lab tests have shown that the kind of forces generated in the impact could have had this effect — opening six chambers in the front of the ship to the entry of water. The ship was designed to stay afloat with as many as four of the chambers filled with water. If the rivets had stayed intact in any two of the chambers, the *Titanic* would not have gone down!

Why this compromise was made in a project of such "first time" importance is not clear. One speculation is cost. As Corfield has not indicated what the cost implications may have been, it is difficult to appreciate the possibility. There is also the possibility of supply shortfall and project deadlines. The shortfall in safety regulation of procedures and facilities, like lifeboats, has resulted in stringent safety norms in current day practices. The discovery that discipline in design and materials could have still averted the disaster, it is hoped, would impact the need to ensure use of quality materials.

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Ahoy! Meet the real-life pirate scientist

steve connor **discovers uncanny parallels between a swashbuckling pioneer and a new animated hero**

HE was a swashbuckling buccaneer who was the first person to circumnavigate the globe three times during his life as a pirate. He landed in Australia nearly 100 years before it was "discovered" by Captain James Cook and was the first Englishman to describe avocados, bananas, cashew nuts and chopsticks — among many other exotic sightings.

Although William Dampier, born in 1651, turned out to be a pretty hopeless pirate, he was a brilliant observer and natural historian and his exploits as an amateur scientist have led some to draw parallels with the fictional pirate captain in the latest film by Aardman Animations, of *Wallace and Gromit* fame.

Aardman's *The Pirates! In an Adventure with Scientists*, which opened at cinemas in the UK this week, tells the story of a blundering pirate who accidentally kidnaps Charles Darwin.

A scene from Aardman's The Pirates! In an Adventure with Scientists.

Darwin, meanwhile, recognises that the captain's "parrot" is in fact an extinct dodo and persuades him to come to the "Scientist of the Year" competition at the Royal Society in London.

The film's makers came closer than they might have realised to describing a true story. It turns out that there was indeed a pirate scientist, and although he lived nearly 200 years before Darwin he nevertheless had a strong connection with the man whose name in inextricably linked with the theory of evolution.

Darwin's own voyages in the 1830s closely followed those of Dampier at the end of the 17th century. They both travelled to South America, rounded Cape Horn and visited the Galapagos islands before going on to Australia.

Perhaps the strongest parallel between film and real life stems from Dampier's informal connections with distinguished fellows of the Royal Society, such as diarist Samuel Pepys and botanist Hans Sloane, who marvelled at his detailed descriptions of faroff places.

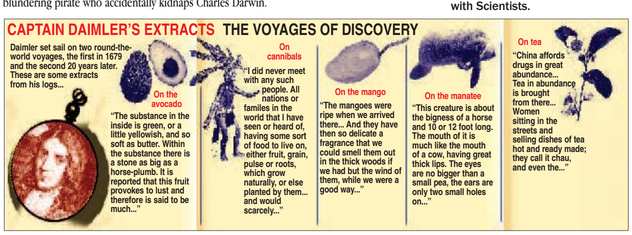
Keith Moore, head librarian at the Royal Society, said, "We know that Darwin had access to Dampier's book. We know that Dampier visited the Galapagos islands and described them in just the same way as Darwin, and it's the same voyage around the world."

Dampier became a meticulous note-taker, describing for instance how to make the avocado more palatable by adding sugar and lime juice – probably the first recipe in English for sweet guacamole.

In addition to describing the mango and the Chinese habit of drinking dishes of tea, Dampier wrote about the giant tortoise or "land turtle" of the Galapagos, saying there were enough on the islands to feed up to 600 men for several months.

Despite many raids on Spanish galleons aboard privateer vessels, Dampier did not seem to have had much success as a pirate, dying in penury in London in 1715 with debts of £677.

The Independent, London



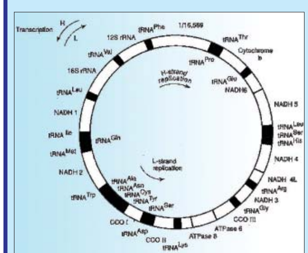
Mitochondrial genomes

tapan kumar maitra **explains a model of economy**

NUMEROUS mitochondrial DNAs have been sequenced, including the human mitochondrial DNA, which is 16,569 base pairs long. It is a model of economy, with very few non-coding regions and no *introns*. Each strand of the duplex is transcribed into a single RNA product that is then cut into smaller pieces, primarily by freeing the 22 transfer RNAs interspersed throughout the genome. Also formed are a *16S* and a *12S* ribosomal RNA.

Although proteins and small molecules such as ATP and tRNAs can move in and out of the mitochondrion, large RNAs cannot. Thus, the mitochondrion must be relatively self-sufficient in terms of the RNAs needed for protein synthesis.

Oxidative phosphorylation, the process that occurs within the mitochondrion, requires at least 69 polypeptides. The human mitochondrion has the genes for 13 of these: cytochrome b, two subunits of ATPase, three subunits of cytochrome-c oxidase and seven subunits of NADH dehydrogenase. The remaining polypeptides needed for oxidative phosphorylation are transported into the mitochondrion; they are synthesised in the cytoplasm under the control of nuclear genes. Proteins targeted for entry into the mitochondrion have special signal sequences.



Gene map of the human mitochondrial chromosome. All but nine loci are on the heavy (H) strand. The light-strand (L) loci are labelled inside the circle; the H-strand loci are labelled on the outside. Also shown are the origins of H-and L-strand.

These signal sequences range up to 85 amino acids long. Signal sequences examined so far do not have consensus amino acids but do have certain attributes, including a somewhat regular alternation of basic (positively charged) and hydrophobic (negatively charged) residues. In addition, they form a helices with opposite hydrophobic and hydrophilic faces that must somehow be important in the protein's ability to enter the mitochondrion.

Lynn Margulis.

When a signal sequence is attached to non-mitochondrial proteins by DNA manipulations, those proteins are transported into the mitochondrion.

The mitochondrial ribosomal RNA is more similar to prokaryotic ribosomal RNA than to eukaryotic ribosomal RNA. The mitochondrial ribosome, although constructed of imported cellular proteins, is sensitive to prokaryotic antibiotics; for example, streptomycin and chloramphenicol inhibit their function. This affinity (close resemblance) between mitochondria and prokaryotes is strong support for the symbiotic origin of mitochondria. That is, we now accept the model advocated by Lynn Margulis that organelles such as mitochondria and chloroplasts were originally free-living bacteria and cyanobacteria, respectively. These prokaryotes invaded or were eaten by early cells and, over evolutionary time, became the organelles we see today. Since they arose as prokaryotes, these organelles retain certain evolutionary similarities to other prokaryotes.

Among the mitochondrial DNAs that have been sequenced from different organisms, we see a great variation in content and organisation. Yeast mitochondrial DNA, for example, is not as economical as human mitochondrial DNA. Yeast mitochondrial DNA, about five times larger than human mitochondrial DNA, has non-coding regions as well as introns.

Because mitochondria are similar in structure to prokaryotic cells, given the general lack of introns in prokaryotic genes, it was surprising to find introns in yeast mitochondrial DNA. These genes most probably arose later as nuclear genes that were then "captured" by the mitochondria, possibly by recombination with nuclear DNA.

Of the many mitochondria sequenced to date (about 175 at the beginning of 2001), the sizes range from less than six to more than 200 kilobases and from three to 97 genes. With this wide range of genes present, the only generality we can make about mitochondrial DNA is that the large and small segments of the mitochondrial ribosomal RNA, as well as most of the mitochondria's transfer RNAs, are usually coded by the mitochondria's own genome, as are several proteins in respiratory complexes III and IV (cytochrome c oxidase and cytochrome c oxidoreductase).

Once the interaction within the mitochondrial-nuclear genetic system is clearly understood, we might expect to see several different inheritance patterns — following either cytoplasmic or nuclear lines — for the genetic defects that lead to interruption of cellular respiration. Among the best-studied phenotypes with such inheritance patterns are the petite mutations of yeast.

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