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3 Examples of shells used in mechanics and biomechanics – structures, materials, manufacturing

Shells of dreams

- one of the main activities that distinguishes humans is the exploration of nooks and crannies of the Earth and the universe

NAUTILUS



Twenty Thousand Leagues Under the Seas
book: **1870**
plot: 1866-1868 (**19th century**)

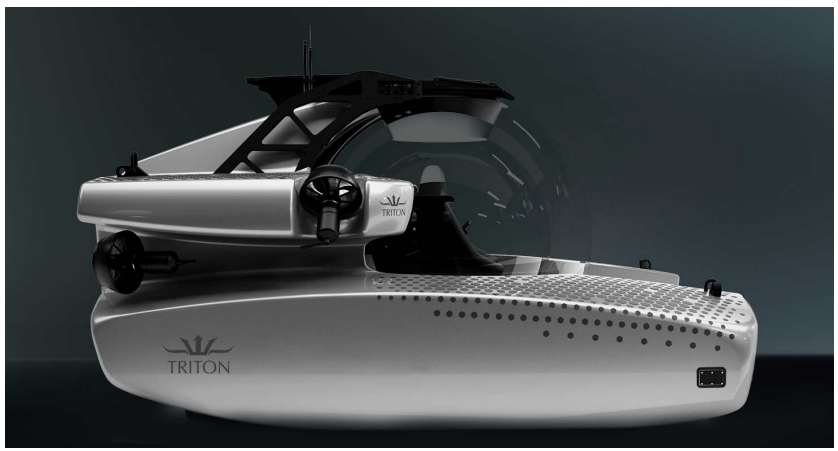
Star Trek: The Motion Picture. A Novel
book: **1979**
plot: 2266-2269 (**23rd century**)



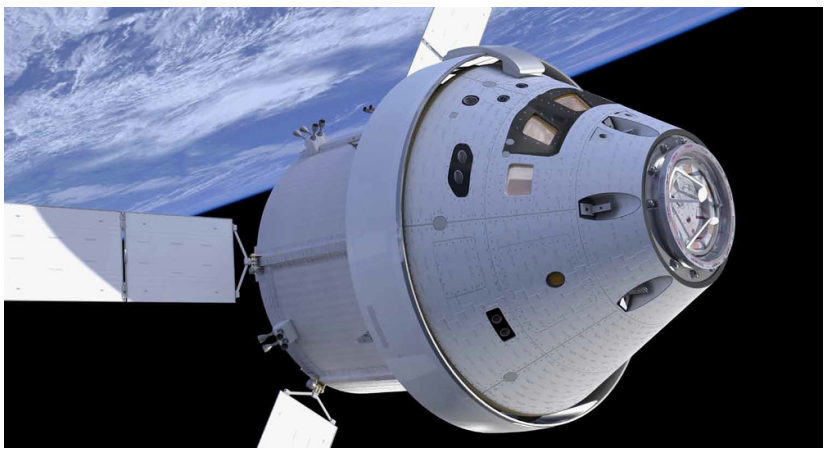
ENTERPRISE

Shells of dreams

- part of the dream of conquering the depths of the sea and space has been partly realised
- however, looking at the possibilities, there is still a great deal of work to be done
- to achieve this, new technologies, new materials and new structures have to be developed
- one of them are multi-layered shells



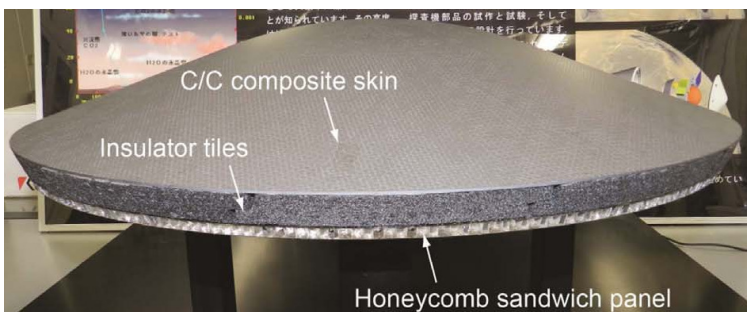
Limiting Factor - Triton 36000/2
certified for Full Ocean Depth (11,000 m)
crew: 2 man

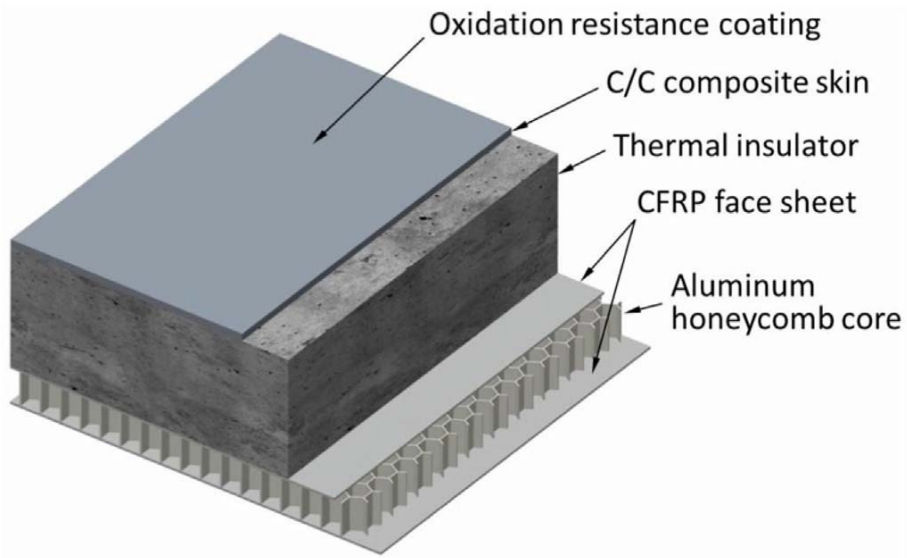


Orion
a manned flight around the Moon
crew: 4 man

Shells of dreams

- to make such exploration possible a proper equipment needs to be available being able to survive in unfavourable conditions such as high external pressure, a vacuum, salt water and low temperature
- if manned structures are considered, a large pressure hull must be designed which, is usually a light, shell-like structure capable of accommodating the crew and equipment
- a typical solution is a multi-layered shell



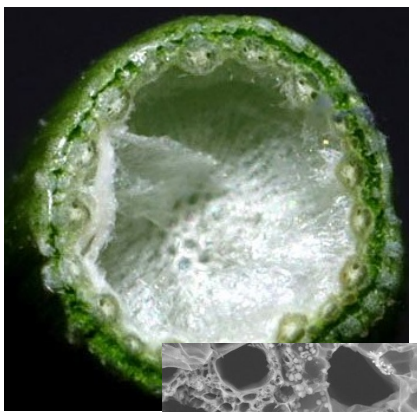


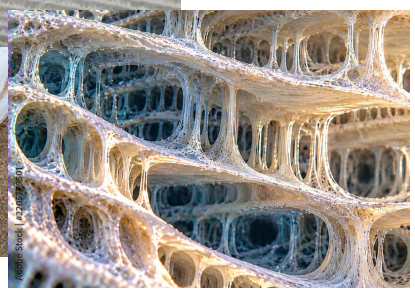
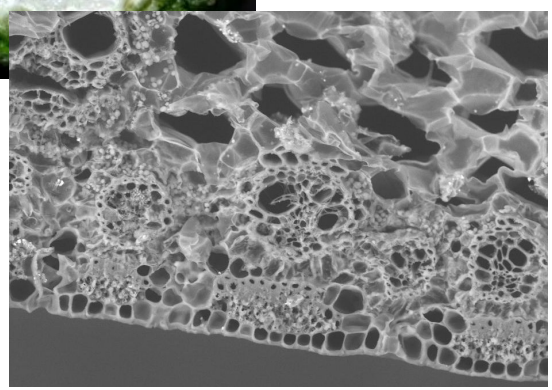
Suzuki T, Aoki T, Ogasawara T, Fujita K. *Nonablative lightweight thermal protection system for Mars Aeroflyby Sample collection mission*. Acta Astronaut 2017;136:407–20

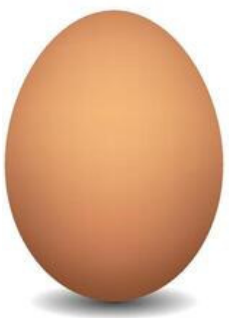
How to find perfect solution?

Natural shells

- one of the approaches in engineering is to mimic natural solutions – to use the existing forms of natural structures resulting from a long-term evolution
- characteristic features of natural solutions include
  - smooth curvatures, porous structures, multi-layered nature





Shells in engineering

- human-made shells are characterised by their variety of applications and shapes







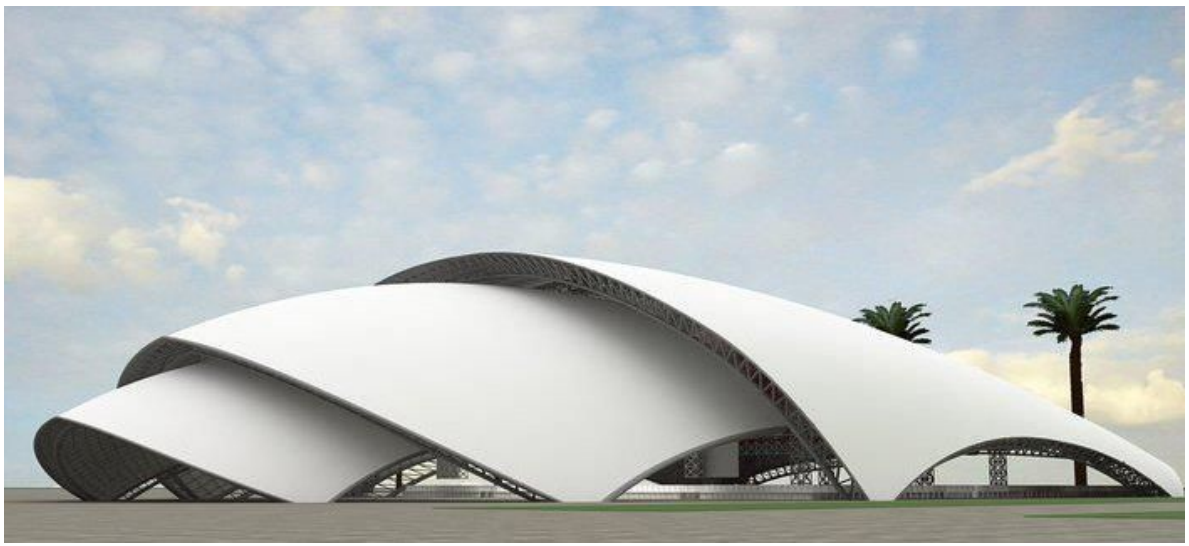





Properties of shell's structures

The broad application of shells comes from their many advantages, which are:

- effective load carrying mechanism – membrane forces
- high strength-to-mass ratio – lightness
- covering large spaces
- high stiffness
- aesthetics



Modern applications of shells

Architecture and civil engineering

- large space can be covered without internal supports
- low mass when compared to the size of the structure
- aesthetic appearance

EDEN PROJECT



Modern applications of shells

Storage and transport

- low mass when compared to the size of the structure
- large, airtight enclosed space
- ease of shaping







Modern applications of shells

Flying and space vehicles

- low mass when compared to the size of the structure
- large, airtight and comfortable space
- temperature insulation
- ease of shaping



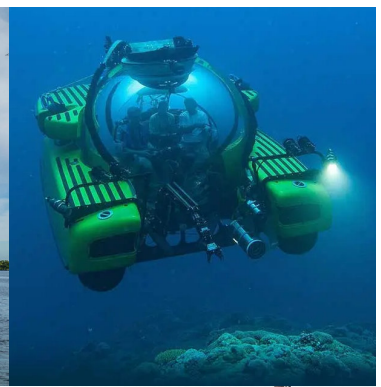




Modern applications of shells

Ships and submersibles

- low mass when compared to the size of the structure
- high strength and lightness
- temperature insulation
- large and safe space
- easy shaping



Modern applications of shells

Other

- many other applications of shells can be found in everyday life
- these applications are the result of their
  - lightness, aesthetics, functionality, mechanical properties, etc.



