Pearls: irritants, iridescence and industry

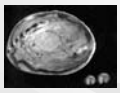
Which Critters Make Pearls ?

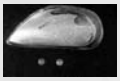
However, pearls can also be made by many other bivalves (e.g. mussels), as well as some gastropods (e.g. conchs), and even cephalopods (*Nautilus*).

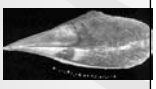
Basically, any mollusc that secretes a shell is capable of producing a pearl, but high-lustre (nacreous) pearls are limited to molluscs with a nacreous (aragonitic) layer.

The conchs and blue mussels do not secrete nacre, so their pearls are not nacreous.


Queen conch (a gastropod)


Abalone (a gastropod)


Edible blue mussel (a bivalve)


Pen shell (a bivalve)

Pearl Oysters vs. Edible Oysters

Most people know that precious pearls are made by pearl oysters (which, by the way, are different from the common edible oyster--more closely related to scallops than to true oysters).

Edible oysters (true oysters) can also produce pearls, but these are not nacreous (edible oysters do not secrete nacre--calcitic shells produce lustreless calcareous concretions).


Pearl oyster


Edible oyster

Largest Pearl (from Philippines; collected 1934)

The largest known pearl comes from the world's largest Giant Clam (*Tridacna gigas*).

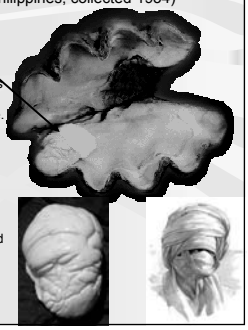
It is known as the "Pearl of Allah" as it was found by a Muslim diver and though to resemble a turbaned face.

It is not nacreous.

Irregular, brain shaped, blister pearl (hemispherical pearls attached to shell).

The pearl measures 23 cm long and weighs 6.35 kg (14 lbs).

The clam itself weighed 160 lbs.



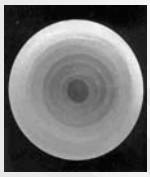
How a Pearl Forms

It is no coincidence that the characteristics of pearls, such as colour and lustre, match the characteristics of the nacreous layer in the molluscs that make them.

Nacreous pearls, like mother of pearl, are composed of nacre and are built by the epithelial (surface) cells of mantle tissue.

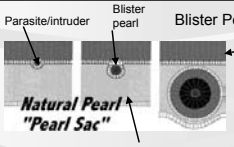
Any foreign body that irritates the mantle tissue and cannot be expelled by the mollusc can form the nucleus of a pearl (the mollusc reduces irritation by surrounding the irritating body with smooth layers of nacre).

Rarely do grains of sand form the nucleus of a pearl (oysters are quite efficient at expelling sediment particles)


Cross section of natural pearl showing layers of aragonite (separated by layers of conchiolin).

Note that light penetrates through the pearl, giving it a warm glow throughout.

Blister Pearls



In this case, nacre was secreted around a clam that managed to bore into an abalone shell from the outside of the shell.


In this remarkable specimen, a fish somehow got trapped between the mantle and nacreous surface of a pearl oyster. The fish has been covered with nacre, forming a blister.

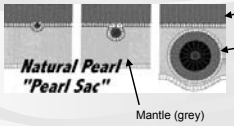
Blister Pearls

The most common type of pearls in nature are blister pearls (pearls adhering to the nacreous layer of the shell).

Blister pearls form when an irritant (often a parasite) becomes trapped between the shell and the mantle tissue or tries to drill through the shell from the outside.

The oyster (or other mollusc) simply covers over the irritant with nacre, forming a blister.

Free pearls



Free pearls are formed less readily than blister pearls.

This is because the irritant must be completely surrounded by nacre-secreting epithelial cells of the mantle and held away from the nacreous layer of the shell.

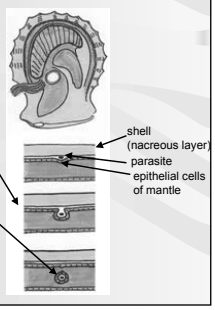
Free Pearls

In most cases, natural free pearls form by the intrusion of a parasite. Movement of a parasite stimulates an invagination of the epithelium.

Epithelial tissue completely surrounds the invader, forming a pearl sac in deeper levels of the mantle.

Nacre is secreted on all sides of the invader, forming a free pearl.

Natural free pearls are formed deep within mantle tissue or in the gonad (if epithelial cells are moved there by the invading parasite).



How rare are natural pearls ?

One out of about 10,000-15,000 pearl oysters will produce a natural free pearl

Most of these lack the desired spherical shape, but large, irregular pearls (called Baroque pearls) have commanded high prices throughout history.

Baroque pearl set in gold

Note the term "Baroque" (originally from the Portuguese term *barroco*, meaning unpredictable or elaborate), was used to describe pearls long before it gained meaning in a art or music.

Properties of Pearls

The same properties valued in mother of pearl are valued in pearls: lustre, colour and orient.

As for mother of pearl, high reflectivity and internal reflection determine the lustre of pearls.

The basic colour of a pearl (colour body) is dependent on pigments in conchiolin (dark pearls tend to have thick layers of dark-coloured conchiolin, whereas white pearls have thin layers of light-coloured conchiolin). Conchiolin colour varies among various species of pearl oysters.

As in mother of pearl, the orient (iridescence) in a pearl is caused by the breakup of white light into colours of the spectrum by surface relief and the refractive/reflective properties of aragonite crystals.

Black pearls are produced by oysters that have a black nacreous layer (the black colour results from high concentrations of black pigment in the conchiolin)

Fossil pearls

As the nacreous layer of shells can sometimes be preserved in the fossil record, so too can pearls (although these are extremely rare).

These are fossil pearls of pen shells from Eocene (50 million years old) London Clay – they retain their nacreous lustre due to exceptional conditions of preservation (most importantly, lack of dissolution)

Pearls in fossil pen shell

Modern pen shell with pearls

Cultured Pearl Industry

The practise of perliculture has greatly increased the availability of pearls to the general public.

Wild pearl oysters have been nearly driven to extinction in Hawaii and Tahiti. Extensive pearl farming takes the pressure off these natural sources.

Populations of wild pearl oysters are also threatened by pollution.

Some advantages of perliculture include:

- Better pearl count to oyster ratio
- Some control over pearl shape
- Control over pearl size.

It is, however, a very labour-intensive industry

Epithelial mantle tissue of donor oysters are cut into small strips.

In each recipient oyster, a slice of mantle tissue, plus a nucleation bead (generally made from nacre of freshwater clams), is inserted into the gonad (far removed from nacreous layer of shell).

The latter ensures that the pearl remains free (separate from the shell nacreous layer).

A technician cuts epithelial mantle tissue to be implanted in a cultured pearl oyster.

Shells of freshwater mussels are cut and polished to make nucleation beads for cultured pearls.

A nucleation bead and a strip of donor tissue are inserted in the gonad of the pearl oyster

The Cultured Pearl Industry : Oyster Surgery 101

Oysters, raised in cages or nets (mostly to prevent predation by other animals), are anaesthetized so that the oysters relax their adductor muscle and open their shell.

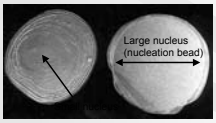
They are now ready for tissue implant.

A pearl sac forms in the gonad.

The epithelial mantle tissue continues to secrete nacre and, if all goes well, covers the bead with nacre to form a free pearl.

Natural pearls generally have a large amount of nacre, relative to the diameter of the nucleus.

Cultured pearls only have a thin rind of nacre surrounding a larger nucleus (the thickness of the nacreous rind must be at least 15 % of the total diameter of the pearl to be worth selling).



Natural pearl Cultured pearl

Success Rate of Perliculture

The ratio of pearls per number of oysters is higher in cultured oysters than wild oysters, but the yield is still surprisingly low.

Under the best circumstances, out of every 1,000 oysters grown at a Japanese pearl farm:

500 die during the culturing period
250 produce poor-quality pearls
200 produce saleable pearls of low to medium quality
50 produce top-grade, gem-quality pearls (so 1 out of 20 oysters).

We must assume that the surgery, presence of the nucleation bead and close-quarters environment of the nets have a highly detrimental effect on oyster viability. Of course those that produce high quality pearls are generally also killed in the extraction process.

It takes about 2 years to produce a marketable pearl with a layer of nacre about 0.4 millimetres thick (pearl size varies according to the size of the nucleation bead inserted in the oyster). The average diameter of Japanese pearls is about 7 millimetres.

Mabé Pearls

A fairly new type of cultured pearl, technically a blister or cavity pearl, is called the Mabé pearl.

To produce mabé pearls, hollow, flat-bottomed, plastic domes are inserted in the space between the mantle and nacreous layer of the pearl oyster shell (adhered to the nacreous layer). The oyster secretes nacre on these domes.

In a year or less, the mabés are cut from the oyster shell and the plastic domes removed.

The hollow interior of each pearl is filled with wax (sometimes coloured to give the pearl a slight colour tint) for support, and a disc of mother of pearl is glued to the bottom.

Major Pearl-Culturing Centres
(not to be memorized- just for general interest):

Pearl Oysters (various species)
- Japan
- Australia
- South Sea Nations (Papua New Guinea, Indonesia, Philippines, Thailand)
- French Polynesia (e.g. Tahiti)
- Mexico

Freshwater Clams (various species)
- China
- Japan
- Thailand
- India

Mabé pearls are typically used in pieces of jewellery that do not necessitate a perfectly spherical shape (e.g. earrings). Obviously, many different pearl shapes are possible in this technique through use of variably shaped plastic "nuclei".

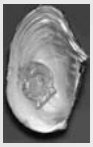
Prototypes of Mabé Pearls

Although Mabé pearls are a relatively recent invention, it is interesting to note that the same basic method of blister pearling bivalves was used by the Chinese as early as the 5th century A.D.

Blister pearl Buddhas (5th century)

Carved pieces of ivory, ceramic and shell were inserted in freshwater clams to "pearlize" the object.

Elaborate blister pearls are still being made in China today.



Modern blister pearl of Chairman Mao

END OF LECTURE