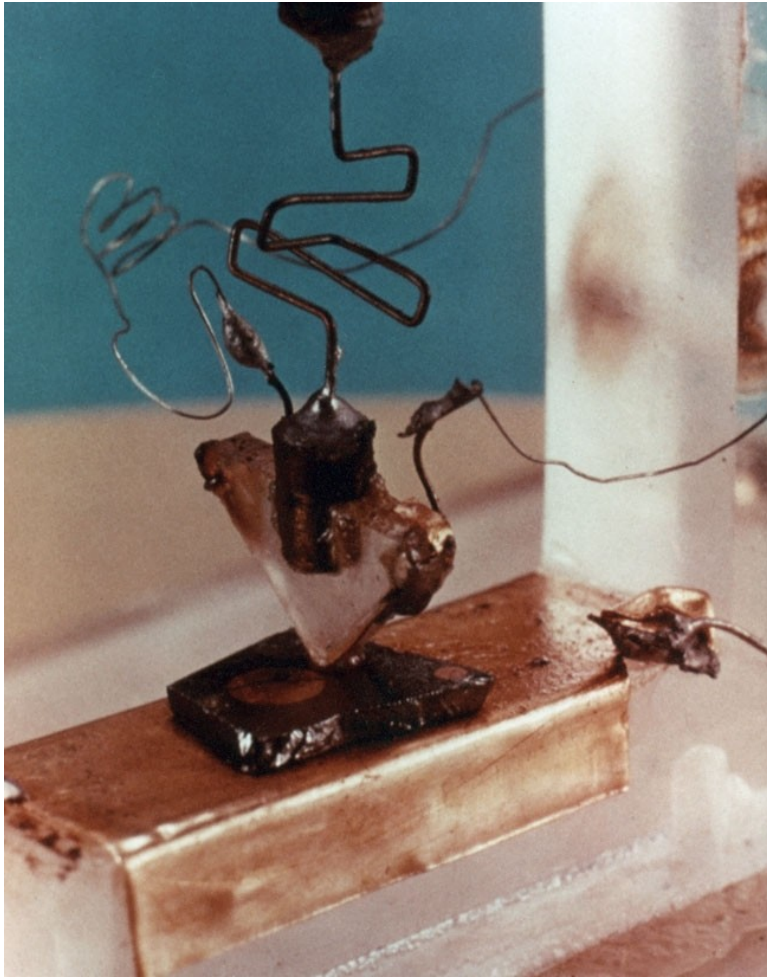


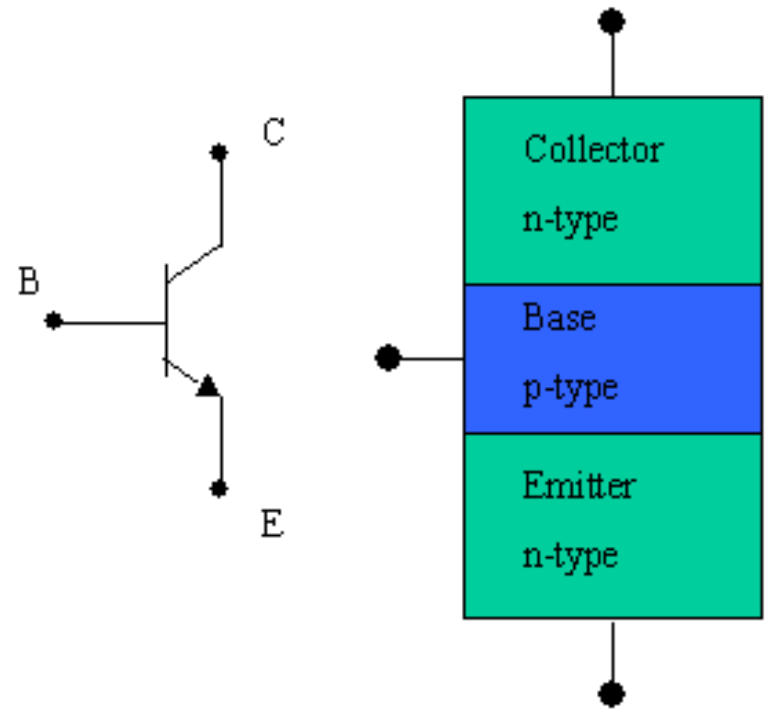
Dia 5:

- Um pouco mais sobre microeletronica-
- Concreto: material banal ou nao?
 - Nosso corpo-

Conclusoes:

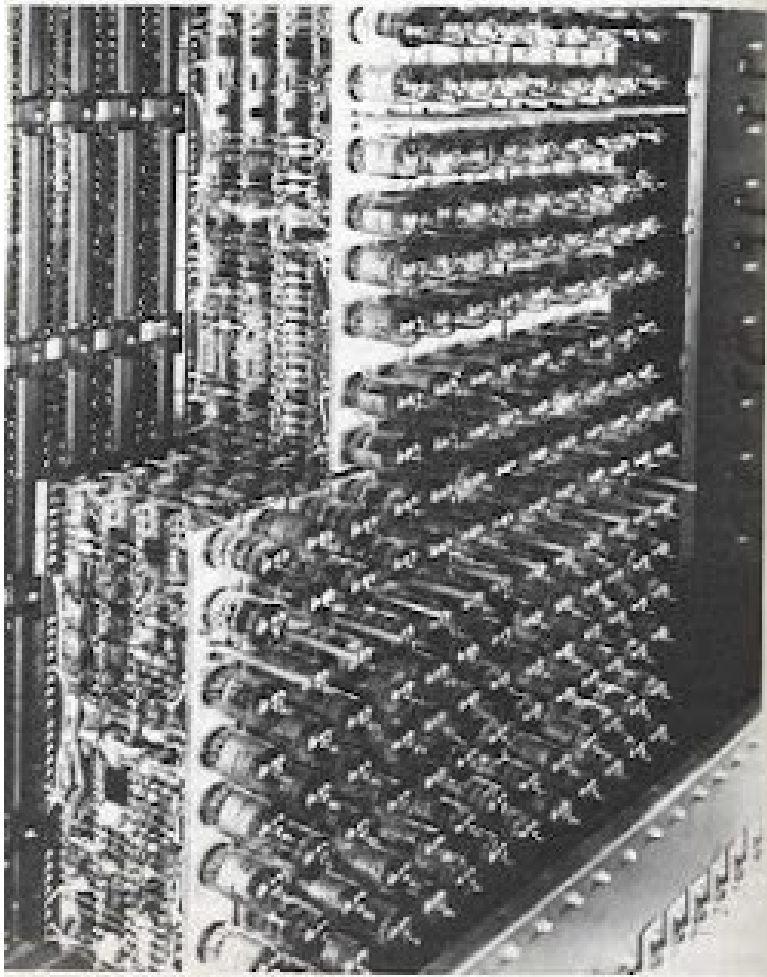


The first, point-contact transistor invented by John Bardeen and Walter Brattain in December 1947.

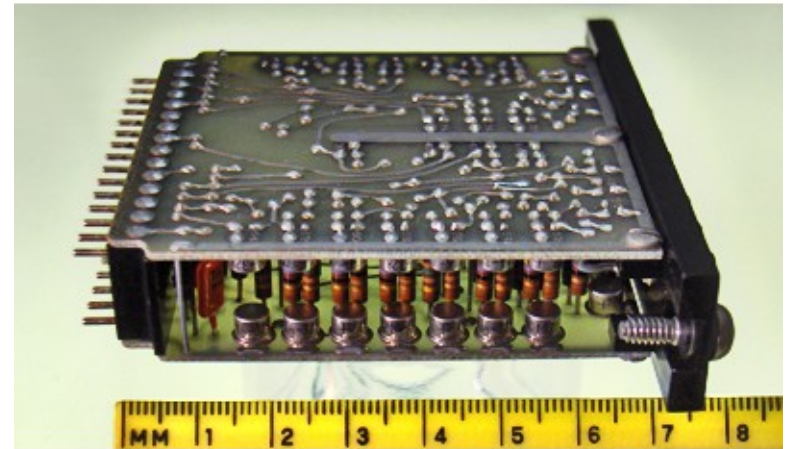


Today it seems so simple: the emitter-to-base voltage controls the emitter-to-collector current, permitting a signal voltage/power amplification. It is a solid state analog to the 1930's vacuum tube triode amplifier.

The CEO of IBM thought (1950) that there might be a world market of ~10 mainframe computers. The semiconductor (r)evolution has resulted in a world computer population of the same order as the human population.



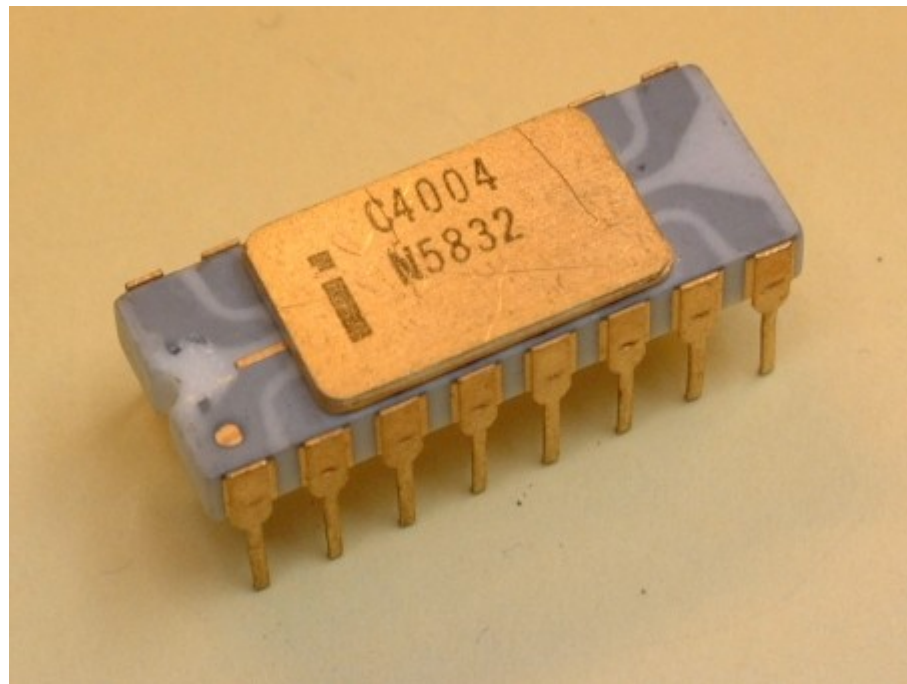
Rack after rack of hot, glowing vacuum tube amplifiers and diodes- IBM 1950's



Replaced by high density discrete transistors- Cray 1960's

Replaced by integrated circuits, starting in the
1970's

- (1978) Intel 4004: 2,300 transistors, cycle rate up to 108 KHz, 4-bit processor, **minimum feature size of 10 μm**



- (2008) Intel Core i7: 781 million transistors, cycle rate up to 3.6 GHz, 64-bit processor, **minimum feature size of 45 nm**, 4 physical cores, Hyper-Threading, QuickPath up to 6.4GT/s



Meanwhile, back in the Macro world: Composite Materials

- A combination of two or more materials (reinforcing elements, fillers, and composite matrix binder), differing in form or composition on a macroscale. The constituents retain their identities, that is, they do not dissolve or merge completely into one another although they act in concert. Normally, the components can be physically identified and exhibit an interface between one another. Eg,
 - Reinforced concrete
 - Metal-matrix composite
 - Cermet
 - Carbon fiber cloth, cables,...

Reinforced concrete

- Concrete is a mixture of coarse (stone or brick chips) and fine (generally sand or crushed stone) aggregates with a binder material (usually Portland cement). When mixed with a small amount of water, the cement hydrates to form microscopic opaque crystal lattices encapsulating and locking the aggregate into a rigid structure. Typical concrete mixes have high resistance to compressive stresses (about 4,000 psi (28 MPa)); however, any appreciable tension (e.g., due to bending) will break the microscopic rigid lattice, resulting in cracking and separation of the concrete. For this reason, typical non-reinforced concrete must be well supported to prevent the development of tension.
- If a material with high strength in tension, such as steel, is placed in concrete, then the composite material, **reinforced concrete, resists not only compression but also bending and other direct tensile actions**. A reinforced concrete section where the concrete resists the compression and steel resists the tension can be made into almost any shape and size for the construction industry.



The Great Pyramids were capped (and maybe grouted) with a limestone cement, 2470 BC, Egypt

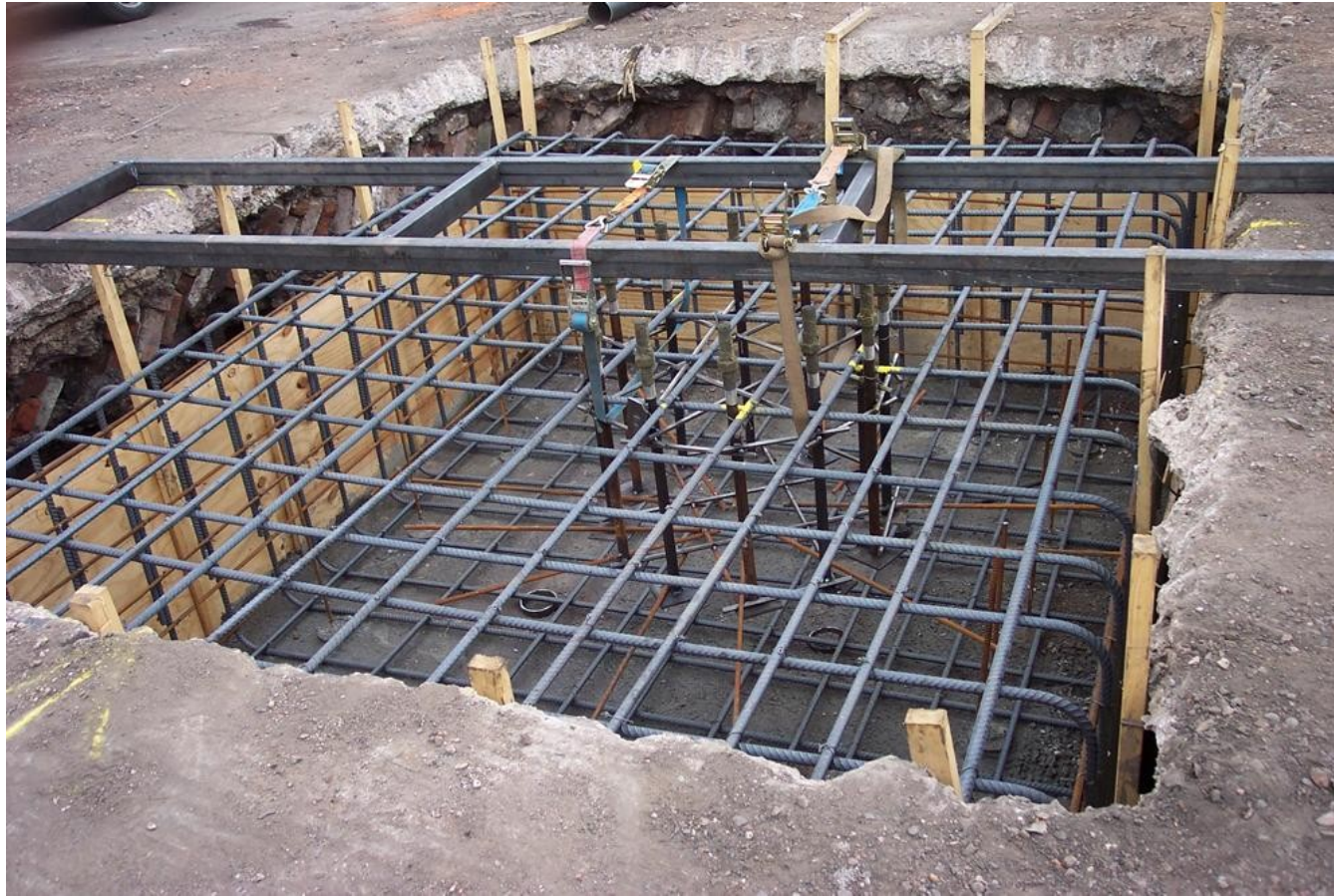


Hadrian's rebuilt Pantheon: Rome, 126 AD used a powerful cement made by grinding together lime and a volcanic product found at Pozzuoli.



The Assyrians and Babylonians used clay as the bonding substance or cement. The Egyptians used lime and gypsum cement. In 1756, British engineer, John Smeaton made the first modern concrete (hydraulic cement) by adding pebbles as a coarse aggregate and mixing powdered brick into the cement. In 1824, English inventor, Joseph Aspdin invented Portland Cement, by burning ground limestone and clay together, which has remained the dominant cement used in concrete production.

Reinforced concrete was invented (1849) by Joseph Monier, a Parisian gardener who made garden pots and tubs of concrete reinforced with an iron mesh. He exhibited his invention at the Paris Exposition of 1867. Besides his pots and tubs, Joseph Monier promoted reinforced concrete for use in railway ties, pipes, floors, arches, and bridges.



- Required properties for internal grid structure:
- High strength
- High toleration of tensile strain
- Good bond to the concrete, irrespective of pH, moisture, etc
- Thermal compatibility, not causing unacceptable stresses in response to changing T
- Durability in the concrete environment, irrespective of corrosion or sustained stress.

Reinforced concrete is concrete in which the material's undesirably **low tensile strength and elasticity are counteracted by the inclusion of reinforcing structures** that have high tensile strength. The structures usually, though not necessarily, are reinforcing bars of steel (rebar) and also usually, though also not necessarily, are embedded passively in the concrete before it sets. Such reinforcing structures are designed primarily to take up working stresses that otherwise would have placed regions within the concrete mass under unacceptable tension.



Modern Brazilian architecture, embodied in works of Oscar Niemeyer, depends totally upon reinforced concrete as the basic construction material.

“I am not attracted to straight angles or to the straight line, hard and inflexible, created by man. I am attracted to free-flowing, sensual curves. The curves that I find in the mountains of my country, in the sinuousness of its rivers, in the waves of the ocean, and on the body of the beloved woman. Curves make up the entire Universe, the curved Universe of Einstein”



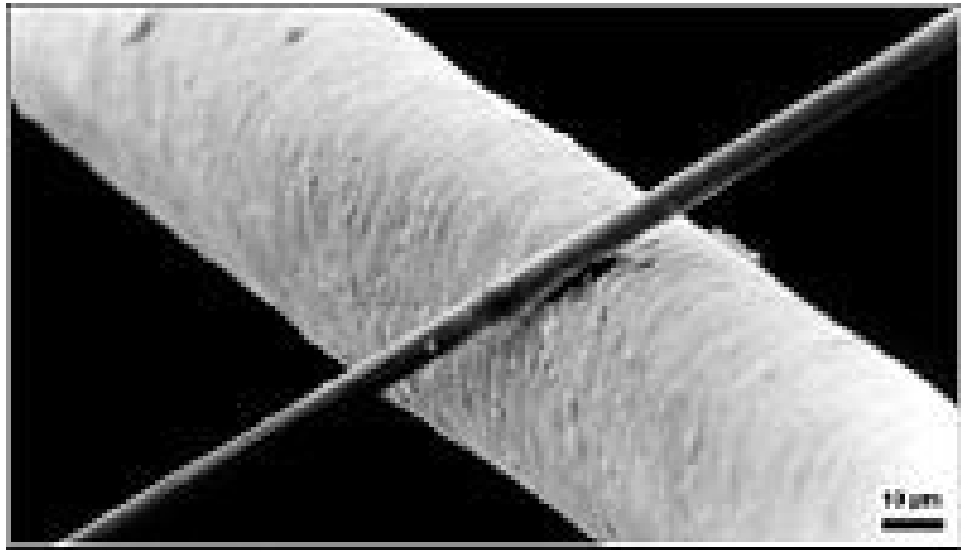
Basilica Sagrada Familia, by
Antoni Gaudi`, Barcelona 2010

Detail of Basilica roof construction

Carbon fiber/fiber composites: E pluribus unum...

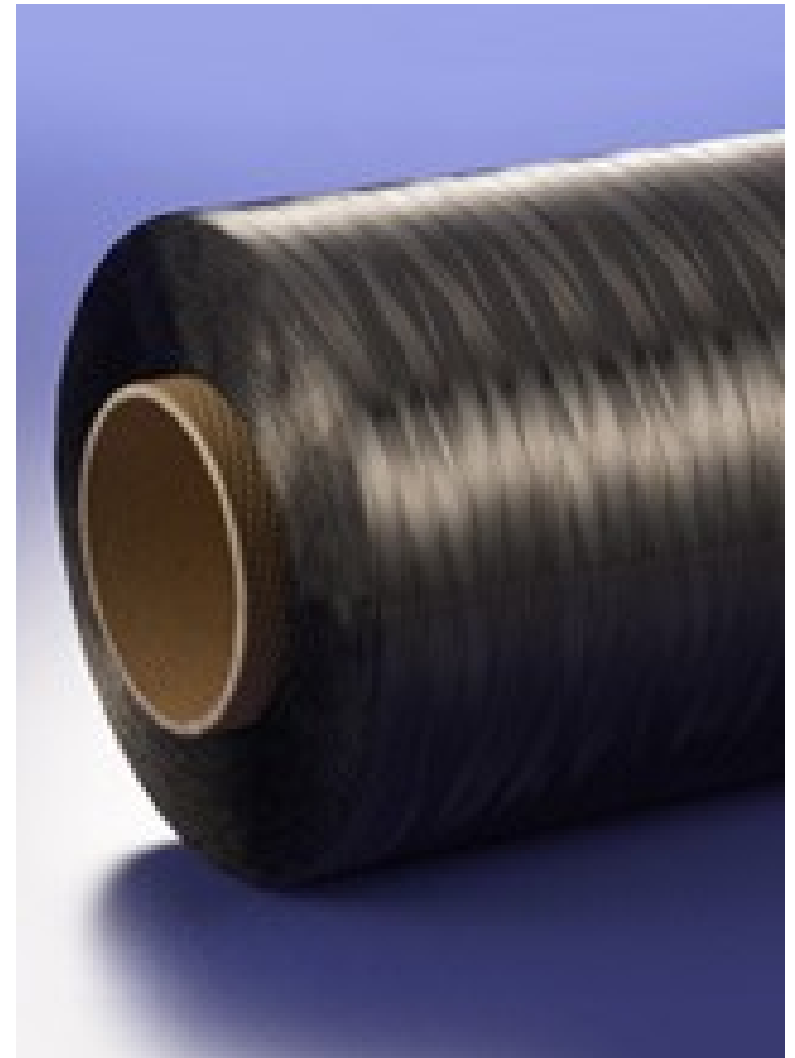
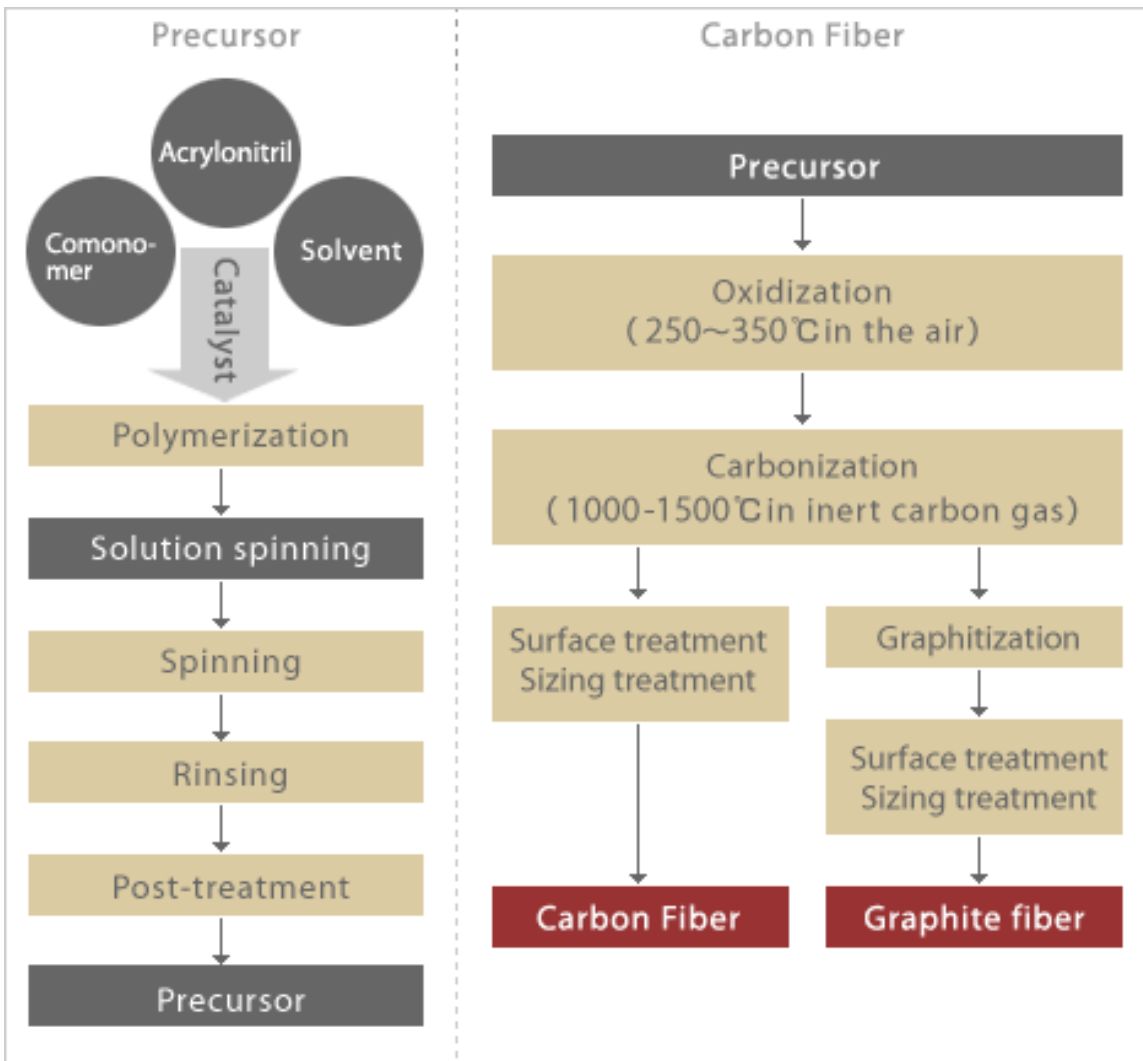
The atomic structure of carbon fiber is similar to that of graphite, consisting of sheets of carbon atoms (graphene sheets) arranged in a regular hexagonal pattern. The difference lies in the way these sheets interlock. Graphite is a crystalline material in which the sheets are stacked parallel to one another in regular fashion. The intermolecular forces between the sheets are relatively weak Van der Waals forces, giving graphite its soft and brittle characteristics.

Depending upon the precursor to make the fiber, carbon fiber may be turbostratic or graphitic, or have a hybrid structure with both graphitic and turbostratic parts present. In turbostratic carbon fiber the sheets of carbon atoms are haphazardly folded, or crumpled, together.



6 μm carbon fiber resting on human hair.

Carbon fiber production

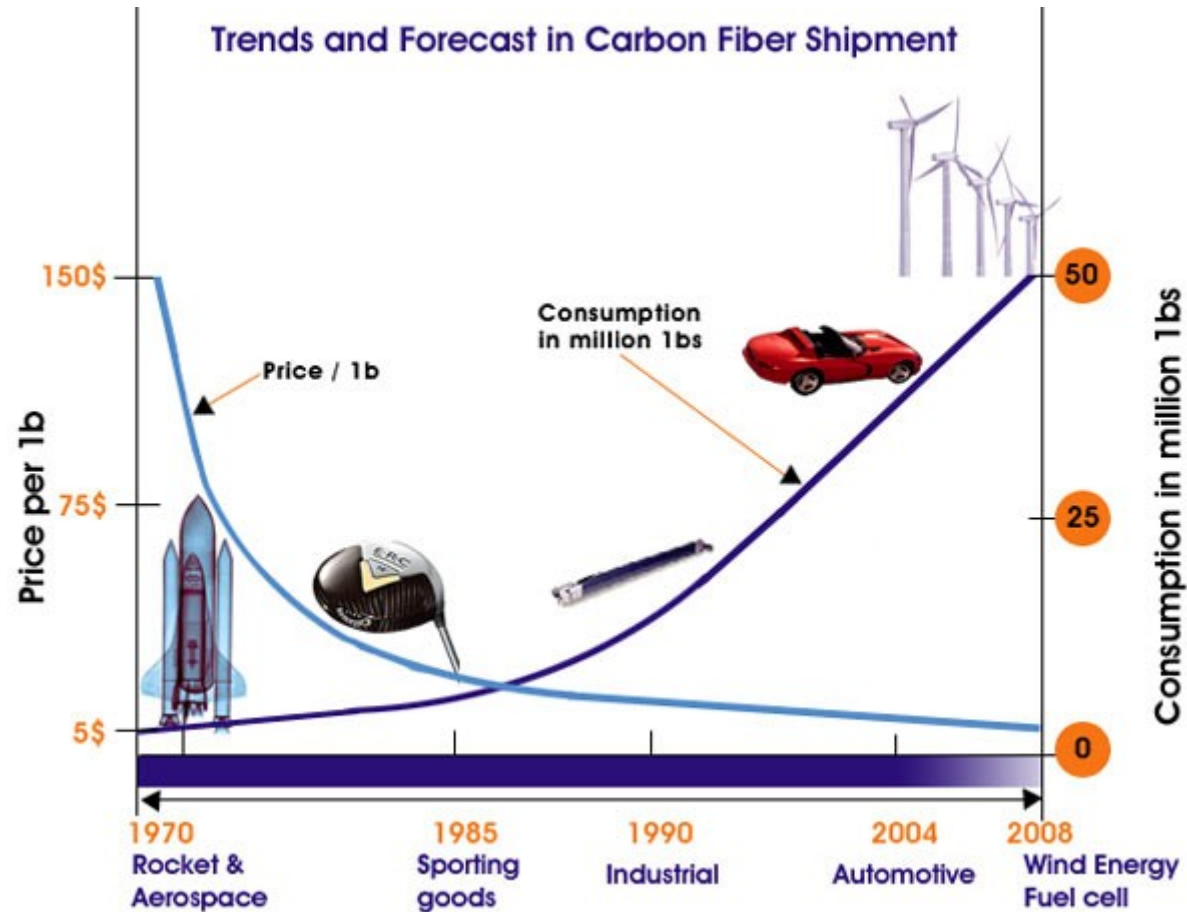


Carbon fiber is made by carbonizing a special acrylic fiber (precursor) as a raw material. Resulting fibers are ~5-7 μ m diameter.

Toho-Tenax Corp: Filament
... strands made with 1,000-, 3,000-, 6,000-, 12,000-, and 24,000- filaments

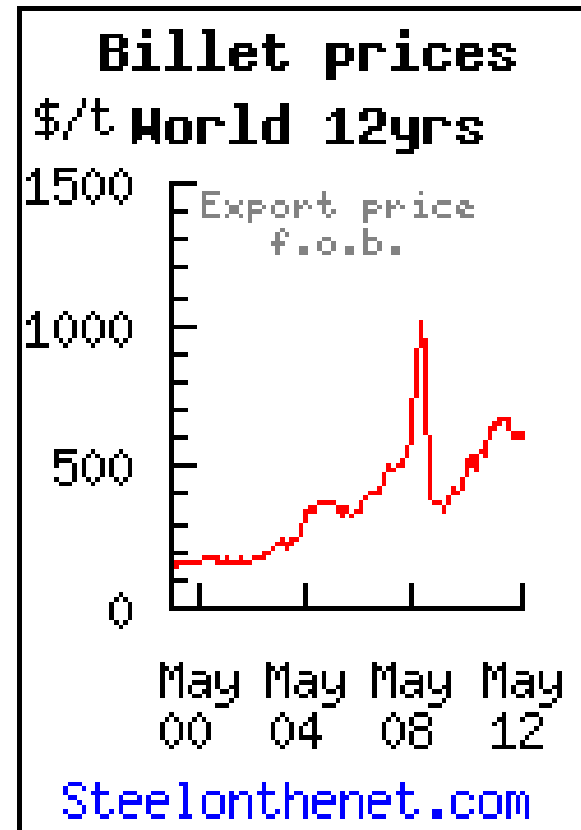
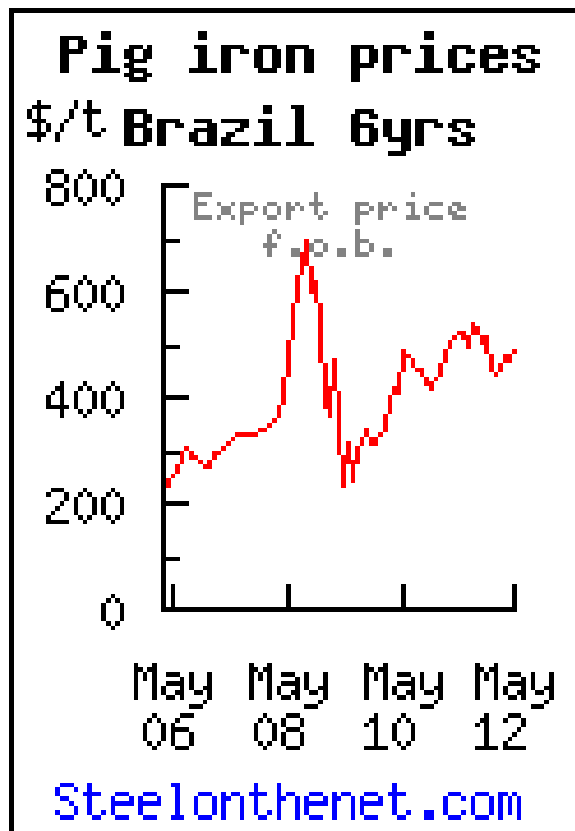
Production/demand of carbon fiber is still ramping upward rapidly...

In 2010, Red and Roberts showed a demand of 6,390 metric tonnes (14.09 million lb) for **aerospace**; 7,000 metric tonnes (15.43 million lb) for **consumer and recreation**; and 25,850 metric tonnes (56.99 million lb) for **energy and industrial**. Red and Roberts forecast that by 2019 those demand figures will increase, respectively, to 18,100 metric tonnes (39.90 million lb); 11,100 metric tonnes (24.47 million lb); and an eye-popping 105,080 metric tonnes (231.66 million lb). A large majority of the energy and industrial demand is expected to come from wind, which Red and Roberts peg at 9,990 metric tonnes (22.02 million lb) in 2010 and 64,190 metric tonnes (141.51 million lb) by 2019.



Econ 101: Rapidity and extent of applications will depend upon equilibrium between material's advantages in use (density, strength, heat resistance, formability...) and cost\$\$

- The price of aluminum is still much cheaper than carbon fiber. When you compare the cost per pound, aluminum is around \$1.50 while carbon fiber is closer to \$10.50. On a large scale, the price of carbon fiber can come down to about \$8, but still nowhere near aluminum. In comparison pig iron and basic steel are 'dirt cheap'.



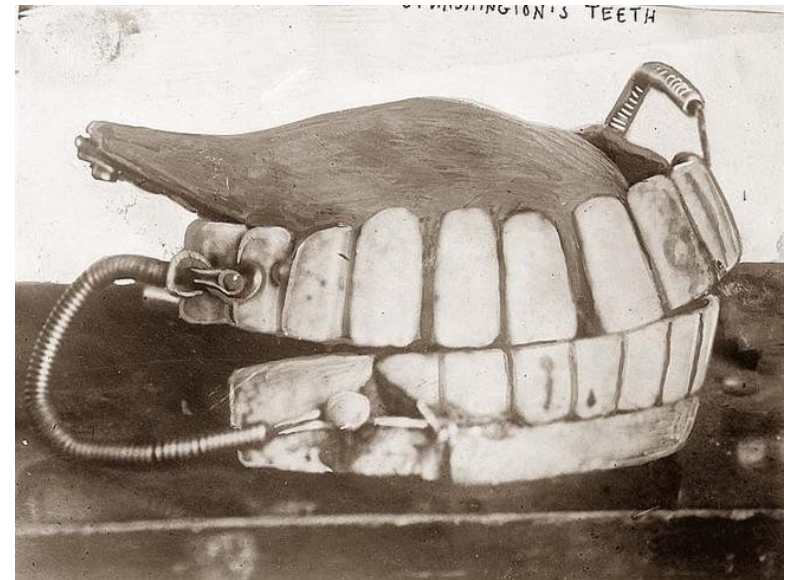
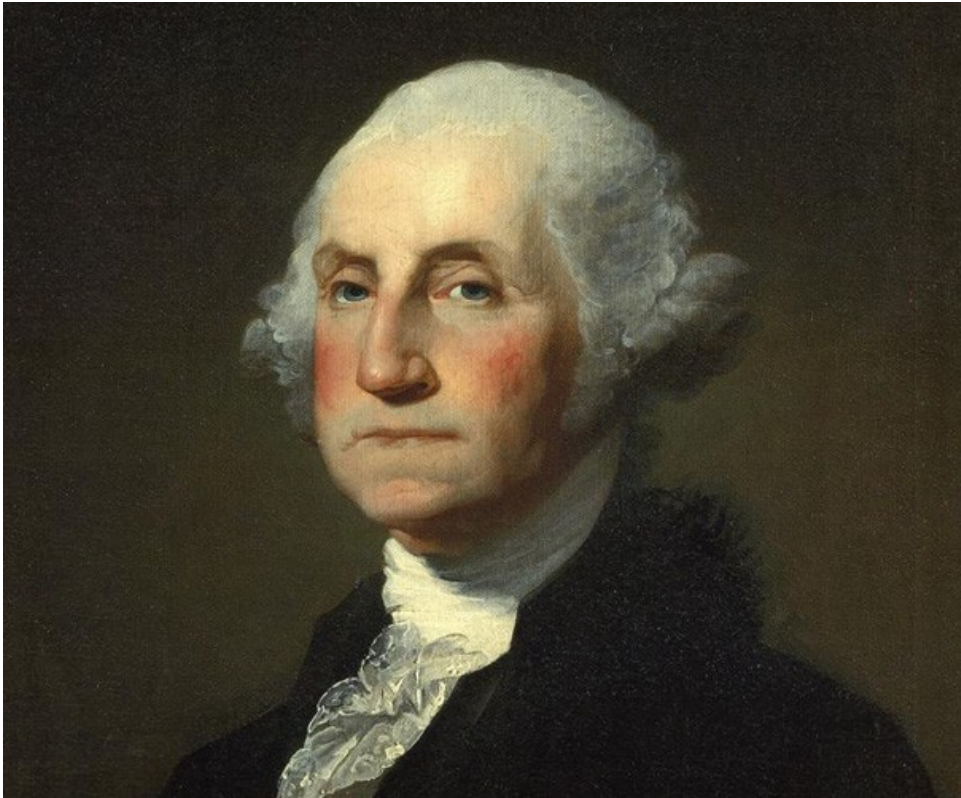
What materials are tolerated by the human body?

From prostheses to tissue engineering: starting with the tooth fairy



Replacements for decayed or lost teeth have been produced for a few thousand years. The Etruscans (people from the ancient country of Etruria in western Italy) made skillfully designed false teeth out of ivory and bone. These false teeth were secured in the mouth by gold bridgework as early as 700 B.C. Unfortunately, the skills and artistry that went into these efforts were lost until the 1800s.

Why were George Washington's speeches always short?



In the 18th century, animal and cadaver tooth, ivory, and other natural products were in use. Mechanics of dentures was very poor...either the mouth wouldn't open, or wouldn't close, or the denture would pop out at an inconvenient time...

Engraving hand coloured on paper by Thomas Rowlandson(1811). Towards the end of the 18th century, people were becoming dissatisfied with ivory dentures and experiments began with porcelain and the production of "incorruptible" dentures. The whole of the denture, teeth and gums, were made of china. In their favor they were more hygienic, however they were brittle, the colors weren't very realistic and generally they did not fit well. They were the subject of a good deal of hilarity at the time. People made much fun of them as depicted in this picture by Thomas Rowlandson. It shows the French dentist, Nicholas Dubois de Chemant, demonstrating his porcelain dentures on a buxom lady to a potential client who inspects them through his double lorgnette.



Nicholas Dubois de Chemant (1753-1824) was an important dentist in Paris before the revolution of 1789. He perfected the manufacture of his mineral paste, or porcelain dentures, which he claimed were an improvement on the more usual ivory teeth as they did not decay in the mouth. Alexis Duchateau (1714-1792) invented the process in 1744, but De Chemant was able to overcome the problem of shrinkage during firing. King Louis XVI granted him an inventor's patent. However, in 1792 he fled to England to escape the French Revolution.

The earliest attempts at dental implant tooth replacements on record were discovered in the Mayan civilization dating back to 600 A.D. Archeologists have recovered ancient skulls in which teeth were replaced by materials ranging from carved stones, such as jade, to fragments of seashells. Despite primitive methods and materials, some of these early implants actually fused to the jawbone.

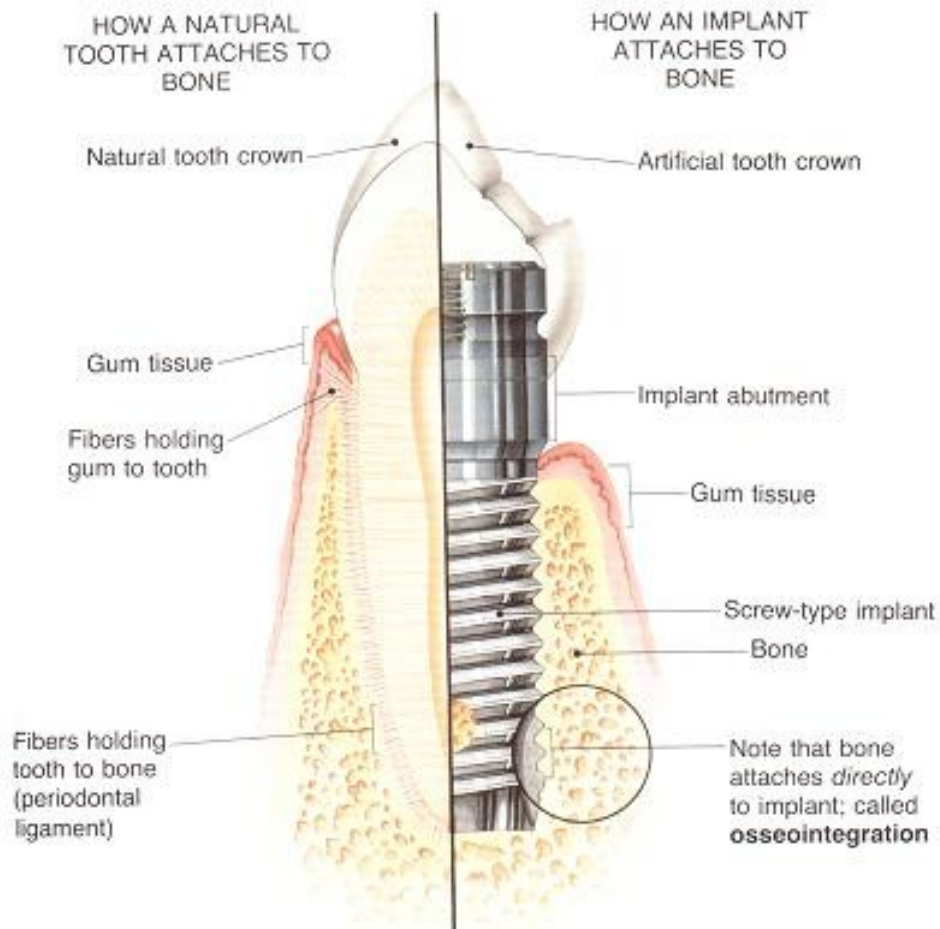


Obsidian tooth implant.



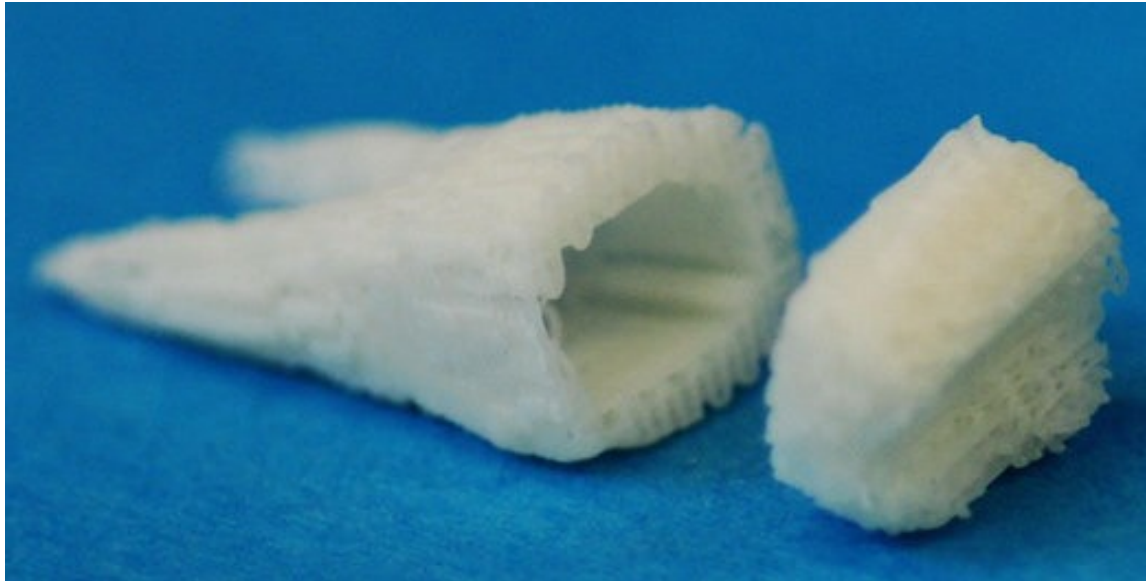
Mayan royalty enjoyed jade insets.

As with many scientific advances, the discovery of what makes current dental implants successful was serendipitous. In 1952, an orthopedic surgeon noted that he could not remove a small titanium cylinder he had placed in a bone to study how bone healed. The special property that titanium has of fusing to bone, called osseointegration, is the biological basis of modern implants' success. Became commonplace in the 1980's.



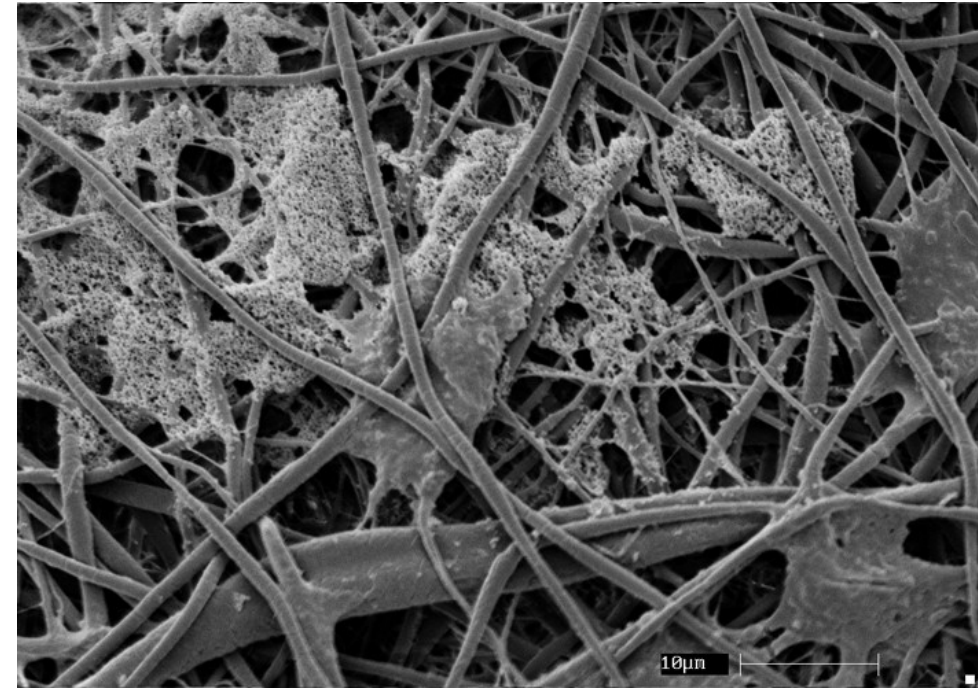
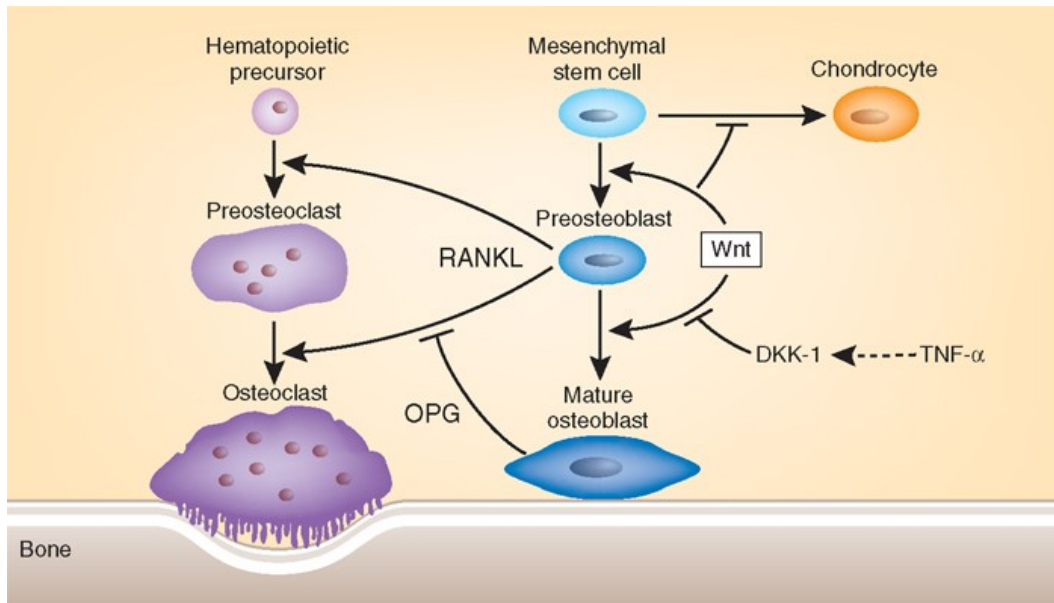
Ti screw surface has been machined and Al_2O_3 blasted and irradiated by 30 ns pulses of Nd:glass laser at 1064 nm wavelength with 0.5–3 J pulse energy. Surface topology and chemistry is critical to osseointegration.

Why not just grow a new tooth? Sharks do it all the time!!



Human molar scaffolding A technique has been developed that directs the body's **stem cells** into a scaffolding that will aid in the regeneration of a new tooth. (Dr. Jeremy Mao, Columbia University Medical Center, 2010). Polymer scaffold is made from a resorbable polymer already used in surgical procedures.

Osteoblasts build bone; osteoclasts eat bone



Lots of signaling goes on to tell cells to form bone, or to resorb it.

Osteoclasts colonizing a polymer scaffold

So, where can I get my new teeth?

- The NSU (Nova Southeastern University) researchers' approach is to extract stem cells from oral tissue, such as inside a tooth itself, or from bone marrow. After being harvested, the cells are mounted to a polymer scaffold in the shape of the desired tooth. The polymer is the same material used in bioreabsorbable sutures, so the scaffold eventually dissolves away. Teeth can be grown separately then inserted into a patient's mouth or the stem cells can be grown within the mouth reaching a full-sized tooth within a few months. (5/2012)
-
- So far, teeth have been regenerated in [mice and monkeys, and clinical trials with humans are underway](#), but whether the technology can generate teeth that are nourished by the blood and have full sensations remains to be seen. Teeth present a unique challenge for researchers because the stem cells must be stimulated to grow the right balance of hard tissue, dentin and enamel, while producing the correct size and shape

But, be careful what you ask for...



Now for a few arms, legs, hands and feet...Greek: prósthesis, "addition, application, attachment"



Madame has a new toe: 3,000-year-old mummified remains of an Egyptian noblewoman. This wood and leather prosthesis dates back to between 950 and 710 B.C.

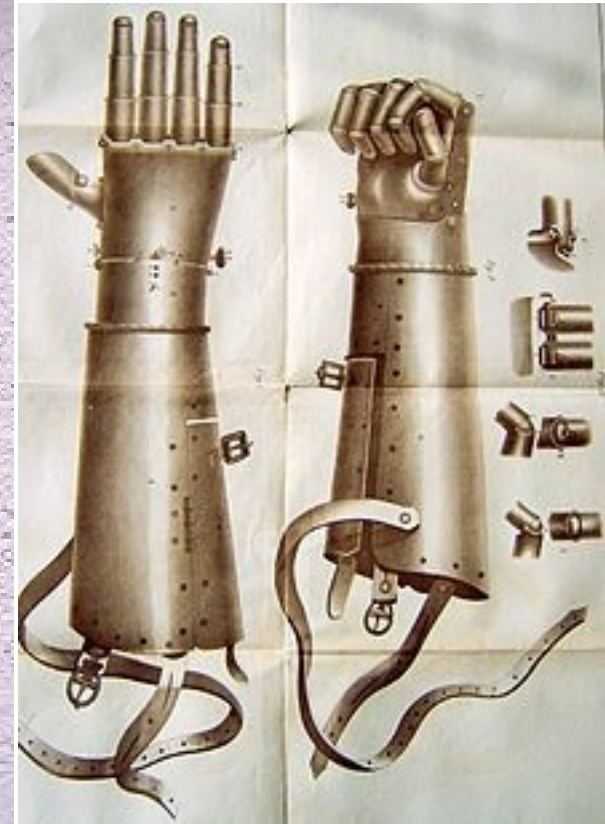


Quiz: Why was Peg-Leg Pete always mad at Mickey?

A roman prosthesis from 300 BC (during the Samite wars) was unearthed in Capua, Italy about 1858 and made from a wooden core, bronze shims and leather straps.



By the 15th century, metal prostheses of considerable complexity were available.



Captain Hook, more famous than Peg-Leg Pete

Gottfried "Götz" von Berlichingen (c. 1480 – 23 July 1562) and also known as Götz of the Iron Hand, was a German (Franconian) Imperial Knight (Reichsritter) and mercenary.

In 1800 James Potts of London designed a prosthesis that consisted of a wooden shin and socket, a steel joint and an articulated foot that was controlled by catgut tendons from the knee to the ankle. It was subsequently used by the Marquis of Anglesey who had lost his leg during the battle of Waterloo, and it became known as the Anglesey leg. Flexion of the knee caused the foot to dorsiflex and extension of the knee caused the foot to plantar flex, it has also been referred to as the 'Clapper Leg' because of the noise it made with the wooden 'foot stops, or the 'Cork Leg' because it was widely used in county Cork, Ireland. In 1839 William Selpho introduced the Anglesey limb to the USA. The Anglesey leg became known as the American leg when an A A Marks in 1856, gave it knee, ankle and toe movements and an adjustable articulation control.



The latest drive towards the development of advanced prosthetics includes this new microchip-controlled artificial knee joint that's opening up an unprecedented level of freedom of movement for above-knee amputees and allowing amputee servicemen to remain active in their jobs if they so choose. The US\$30K hydraulic C-LEG's CPU "brain" automatically adapts to changes of speed and direction, and can be pre-programmed into up to 10 switchable "modes" to enable natural driving, cycling and other programmable activities that require different leg actions to normal walking and stair climbing.

THE MICRO-PROCESSOR C-LEG

L-wrench adjustment tightens or loosens leg fit.

Hinged connection links to absorber piston.

Processor regulates the fluid flow into the absorber.

Carbon-fiber leg socket is custom-made to patient's leg size.

Plug connects computer to the micro processor. Settings are fed into the processor to adjust the swing of the knee joint. These settings tell the processor how much fluid to feed into the absorber.

Plug accepts charge for lithium-ion batteries. Batteries must be charged every 48 hours.

Height adjustment made for leg.

Foot like rubber sock fits over metal pedestal.

ABOUT THE C-LEG

The manufacturer: Otto Bock

Cost: \$70,000

15 patients in Hawai'i use this technology.

It has been in use in the U.S. for about 6 years.

Tension in the C-Leg can be adjusted to allow the patient to walk, ride a bicycle, climb stairs and golf.



American sprinter April Holmes isn't your typical runner. Holding world records in 100m, 200m and 400m, she does it all on one leg.

try this:pistorius_runs



Noticias de 27/07/12:O velocista sul-africano Oscar Pistorius, 25 anos, único atleta que conseguiu se classificar para disputar a Olimpíada e a Paralimpíada de Londres, desembarcou nesta sexta-feira no Aeroporto de Heathrow com um sorriso no rosto e uma "sensação surreal" por poder entrar para a história mundial do esporte. Conhecido como "Blade Runner", apelido que ganhou graças à velocidade que alcança sobre as "pernas de aço", o atleta disse acreditar ter chances de conquistar uma medalha.

try this: [azimo_2011](#)



Robotics research at Honda and elsewhere, leads to improved (powered) prostheses.



2008: Honda produces a practical powered walking assist, based upon Azimo experience.



Your friendly local Defense Department has other plans.....

Conclusions- if any

The universe of 'materials' consists of an intimate mix of physics, chemistry, engineering, politics, economics... including the human response to challenges of climate and culture. By studying the past, we have clues to the future.

But as the great Yogi Berra once said: **“It's tough to make predictions, especially about the future”**