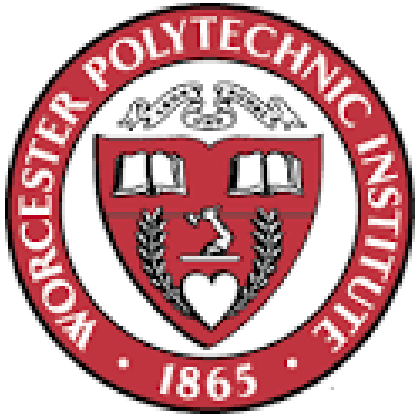
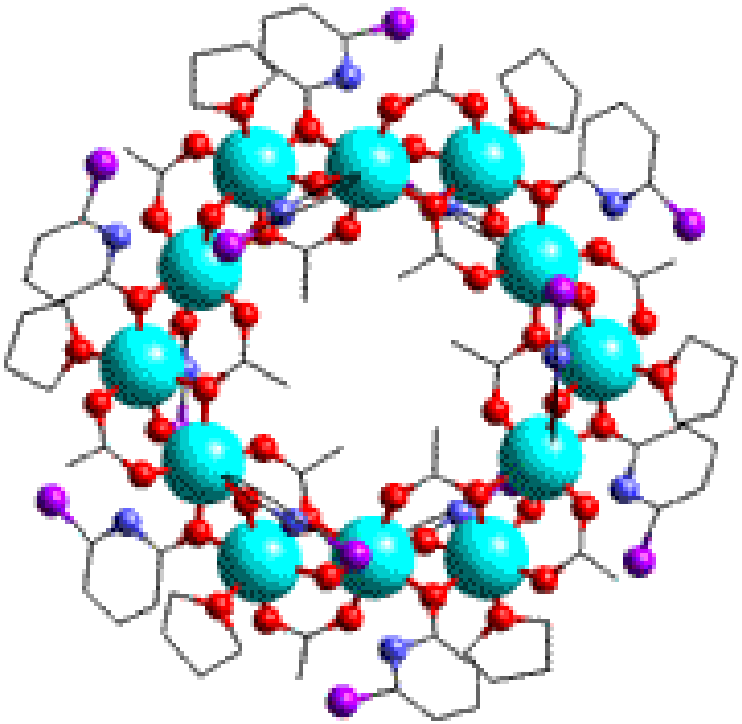


Mathematics and Science in Schools in Sub-Saharan Africa

MATERIAL SCIENCE

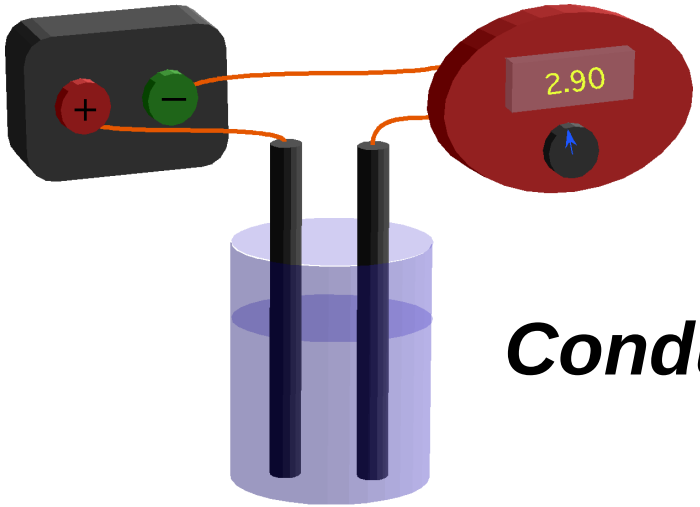


METAL ALLOYS

Metals have many advantages

Strong

Malleable



Conductors

Shiny

Metal Customizing

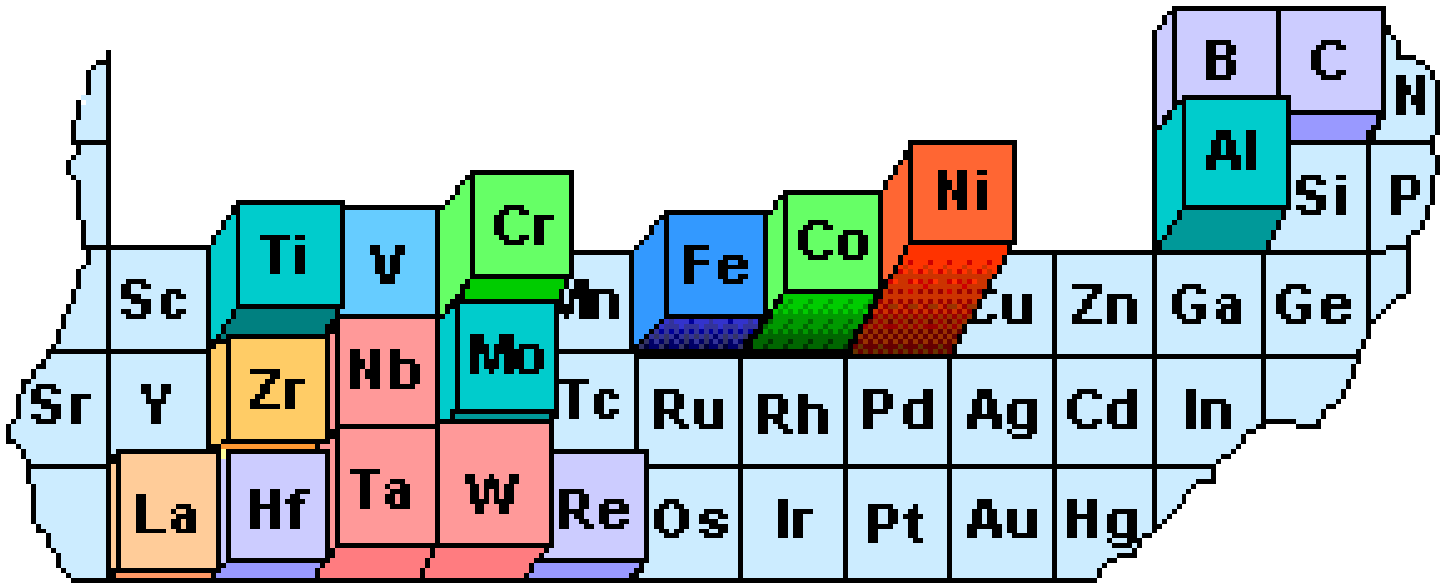
Cold-working and heat treating metals changes the strength & flexibility of metals.

Disadvantages

Alloys

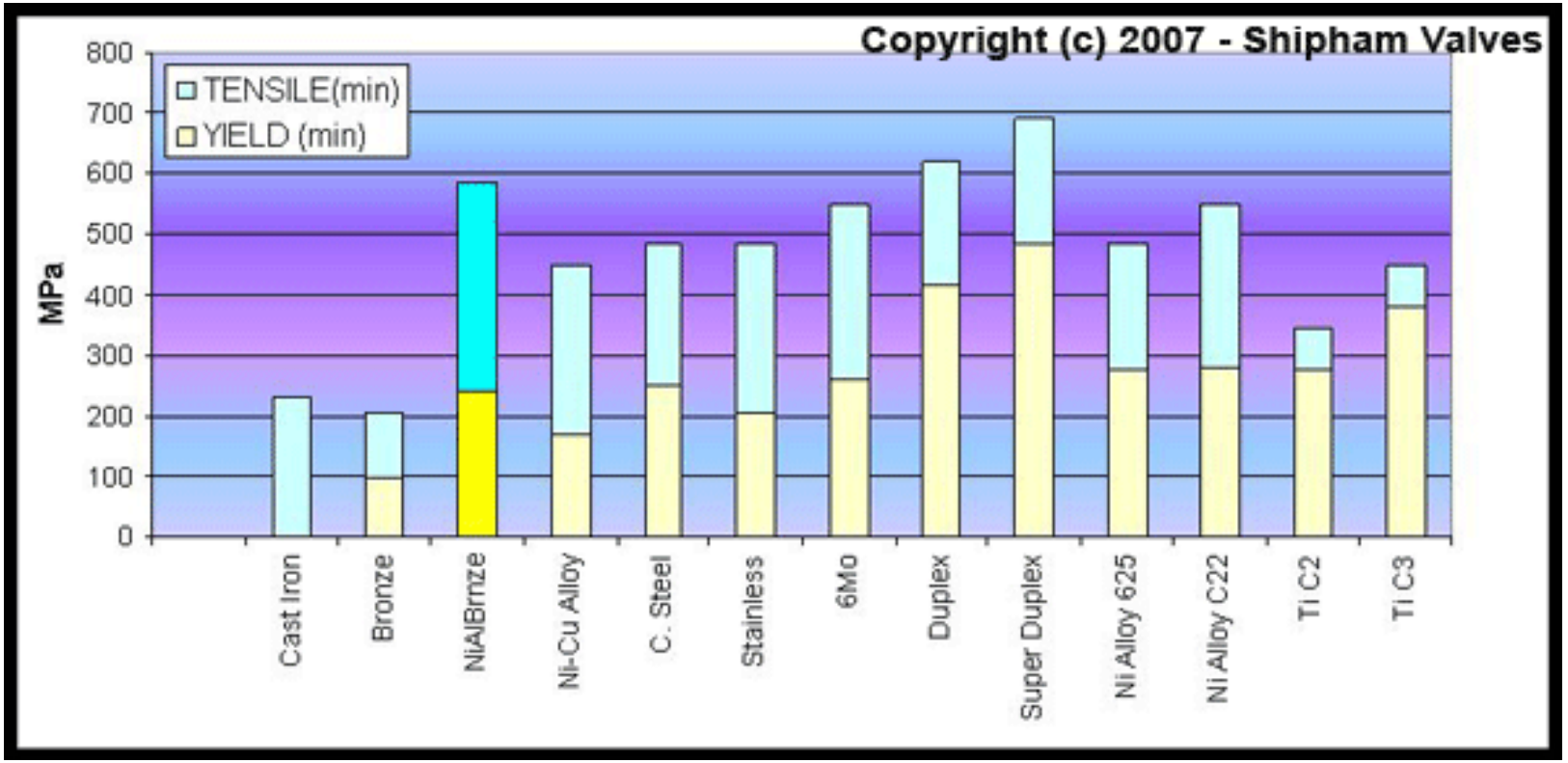
An alloy is a metal composed of more than one element.

Alloy Metals



Engineering alloys include the cast-irons, steels, aluminum alloys, magnesium alloys, titanium alloys, nickel alloys, zinc alloys and copper alloys.

Desirable Mechanical Properties



In pure form, most metals are not very strong!

99% Pure Aluminum

Very Light, Very Weak

Aluminum Alloy Wheels

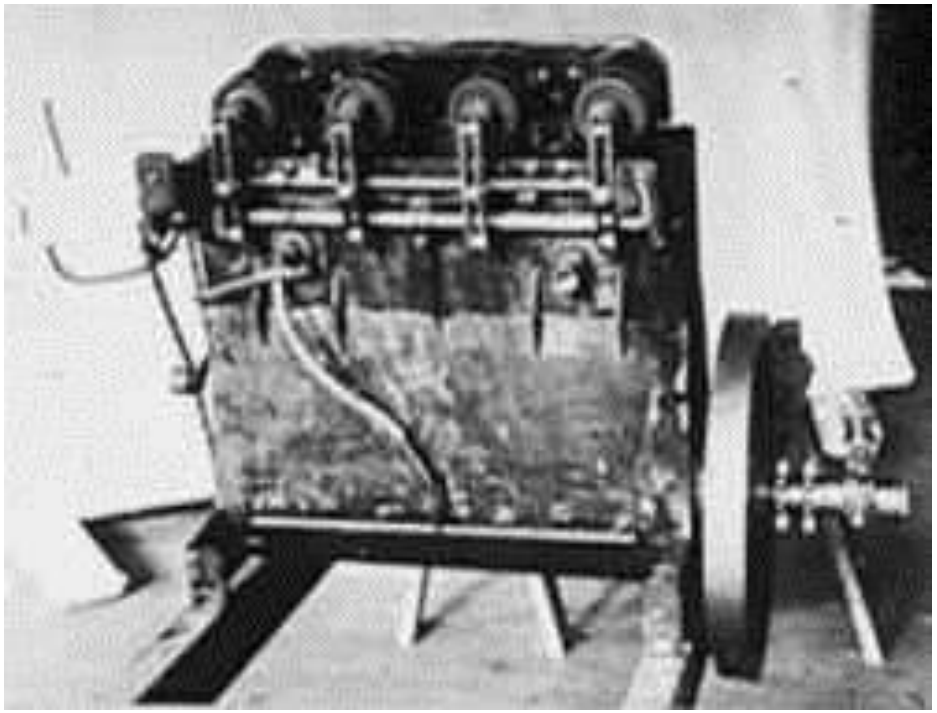
Light & Strong

Aluminum Alloys Make Flight Possible!

December 17, 1903

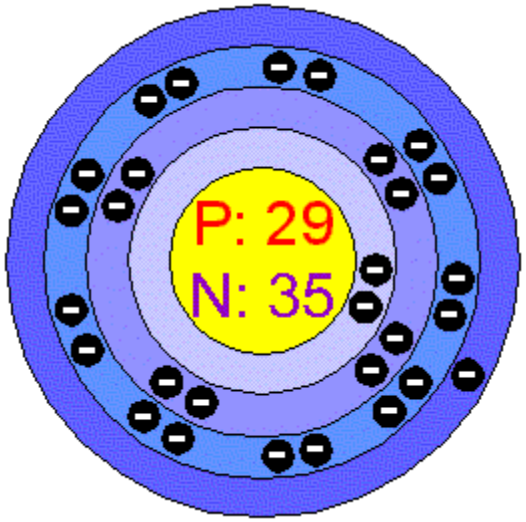
Wright Brothers

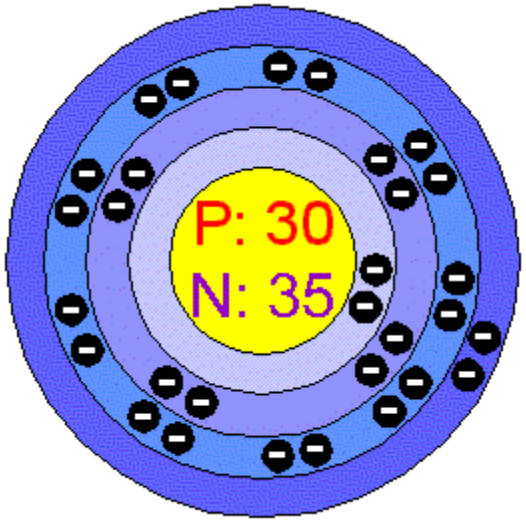
1st Aluminum Alloy Gas Powered Engine Block



Low Weight (<100 kg) High Power (~12HP)

Alloys Make Financial “Cents”!



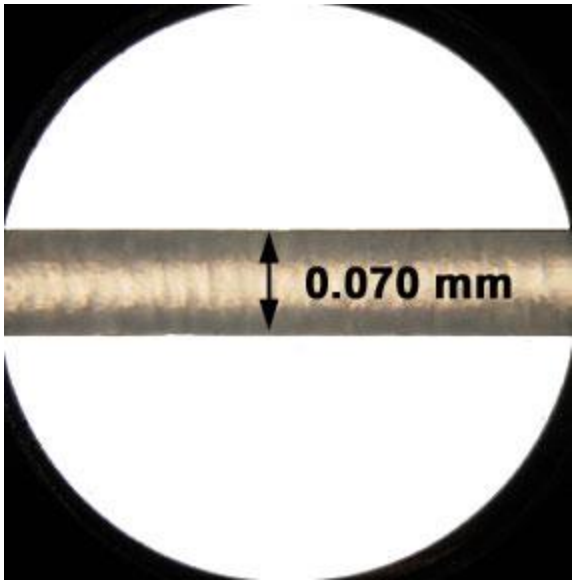


Pre 1982 = 95% Copper

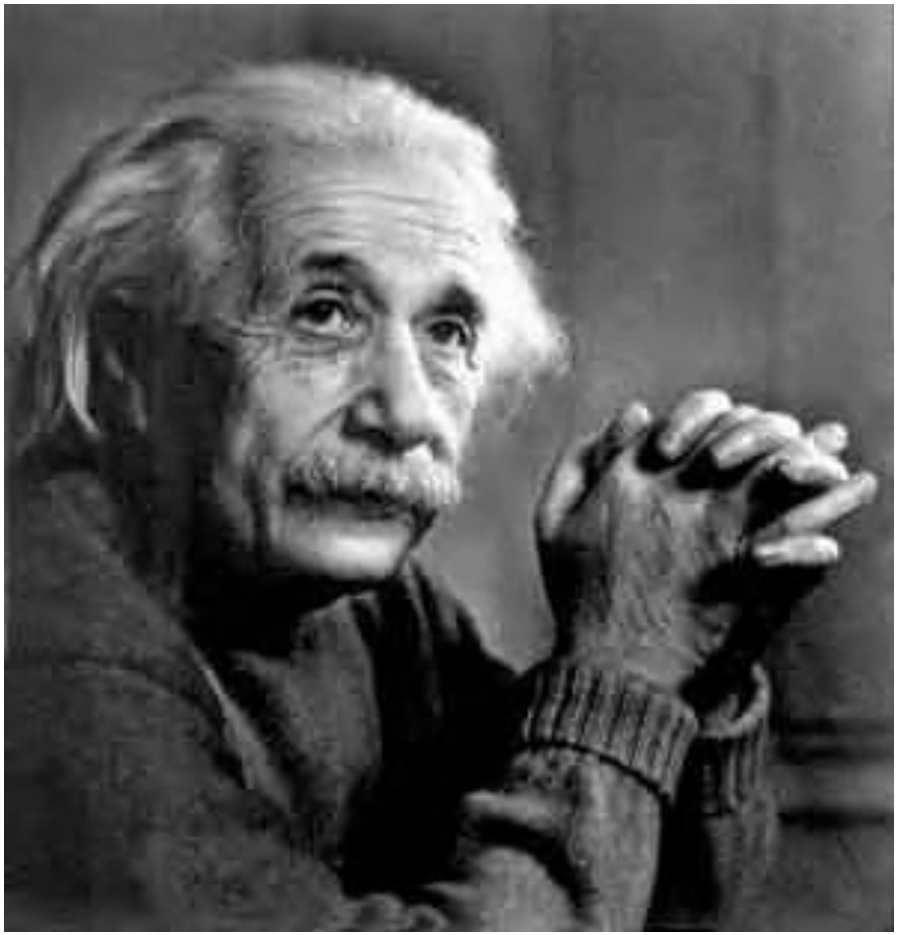
Post 1982 = 97.5% Zinc

Copper Coated

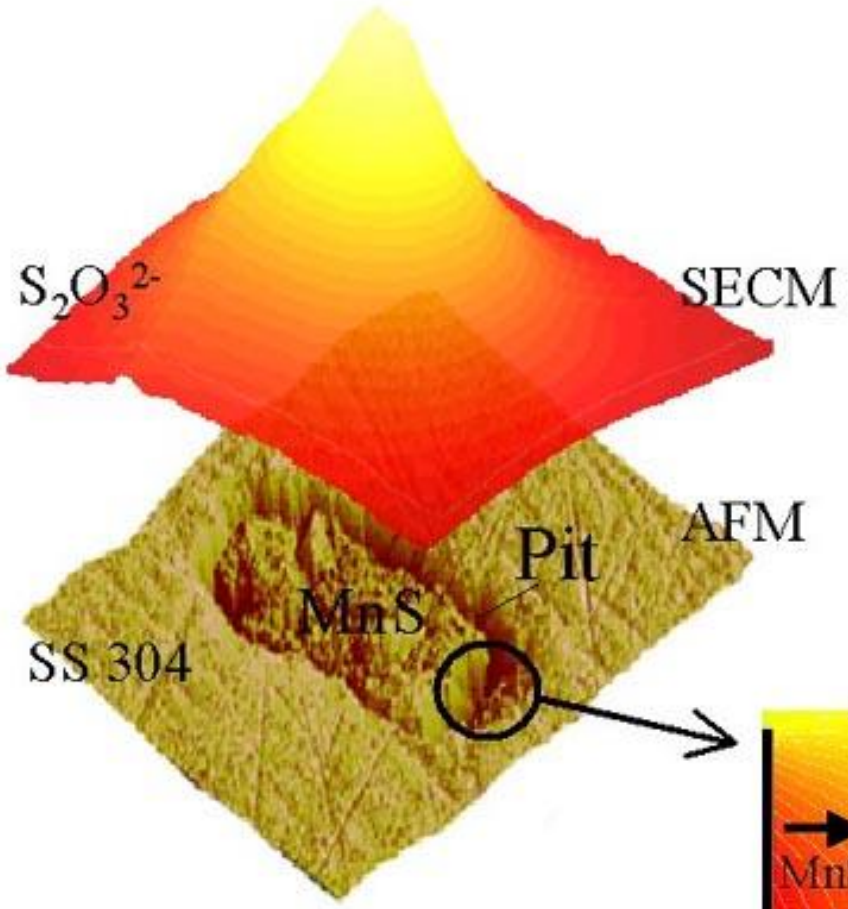
Coating = 10 micrometers

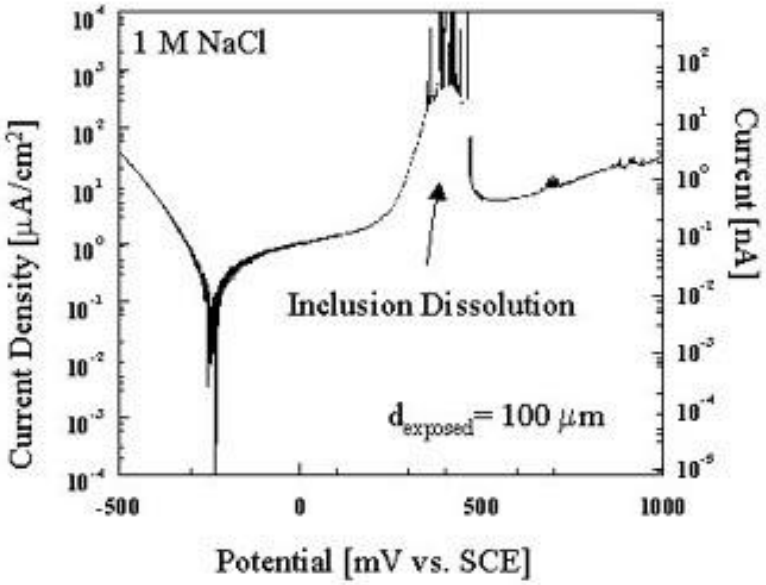


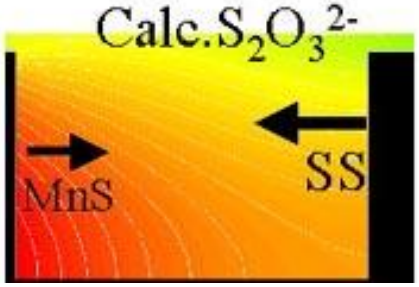
Lab: Floating Pennies



Corrosion Protection



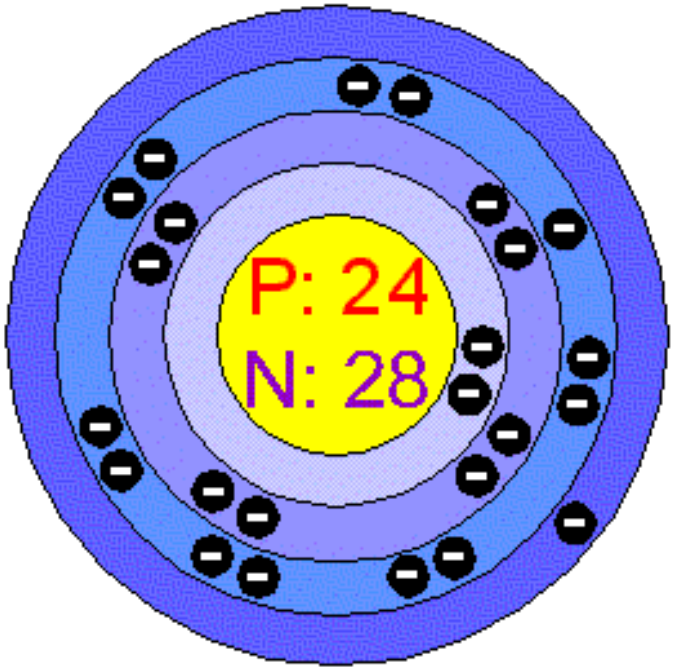




Stainless Steel

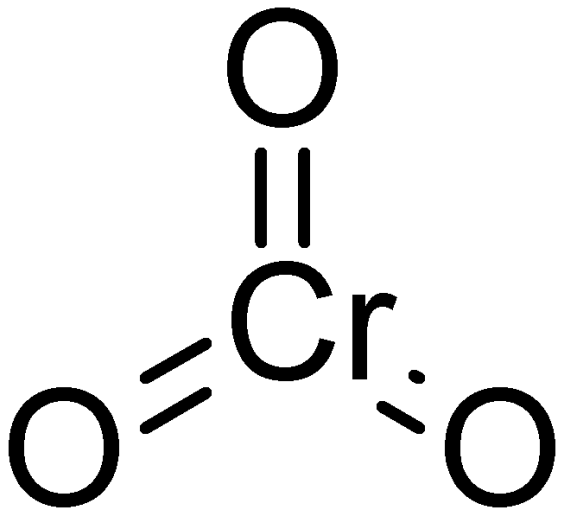
Stainless steel is "stainless" because it is more resistant to rusting than ordinary steel.

Stainless Steel



Stainless steel's chromium content is typically between 13-25%

Stainless Steel



The thin layer of chromium on the outside actually forms chromium oxide.

Stainless Steel

If the metal is scratched, the oxide forms in the scratch, which make it “self-healing.”

Most silverware is not silver!

This keeps silverware looking nice and new.

First Alloy Made?

Bronze

Bronze

Bronze is the traditional name for a broad range of alloys of copper.

Bronze is composed of copper with tin as its main additive.

Bronze

Earliest bronzes included arsenic which made it stronger than iron.

Modern Uses

Ductility

Machinability

Corrosion Resistant

Pewter

Pewter dates back at least 2,000 years to Roman times.

Ancient pewter contained about 70 percent tin and 30 percent lead.

Pewter

Ancient pewter was often called black metal because it darkened greatly with age,

The lead readily leached out in contact with acidic foods.

Modern Safer Pewter

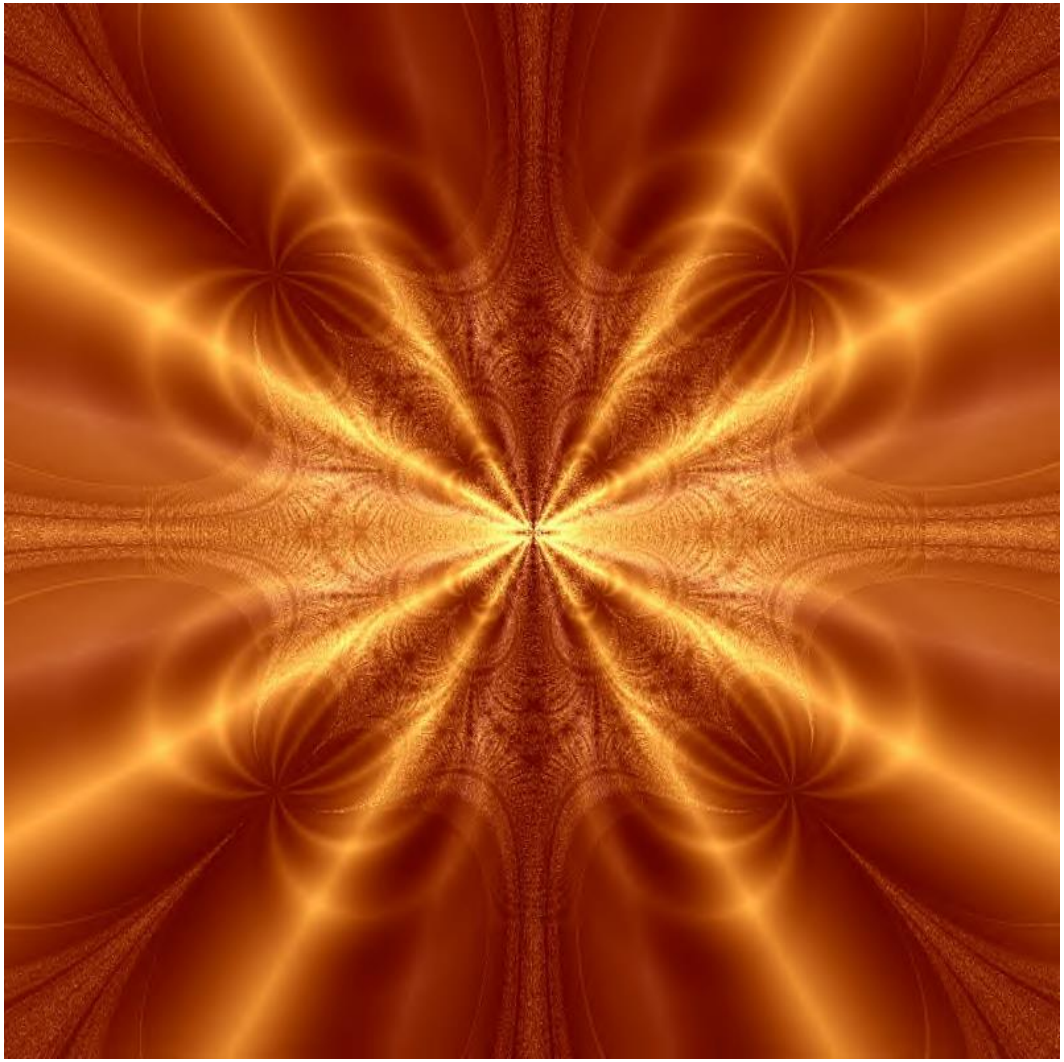
Today's functional pewter no longer contains lead.

Today's pewter is between 85% and 99% tin, with the remainder consisting of 1-4% copper, acting as a hardener.

Modern Uses

Some of today's lower grades of pewter have the addition of lead for a bluish tint.

Brass



Brass

Brass is an alloy of copper and zinc.

Typically brass is more than 50 % copper.

Some types of brass are incorrectly called bronzes, despite their high zinc content.

Material	Temper	Tensile Strength MPa	Hardness Vickers	Average Grain Size mm
Copper: TPC and DHP	Soft Anneal, O	205 - 250	55 max	0.040 - 0.060
	Light Anneal, OL	220 - 250	65 max	0.015 - 0.040
	Half Hard, HB	250 - 300	70 - 110	-
	Hard, HD	300 min	90 min	-
Brass: 65 B	Soft Anneal, O	290 - 370	80 max	0.025 - 0.060
	Half Hard, HB	370 - 450	105 - 150	-
	Hard, HD	450 min	150 min	-

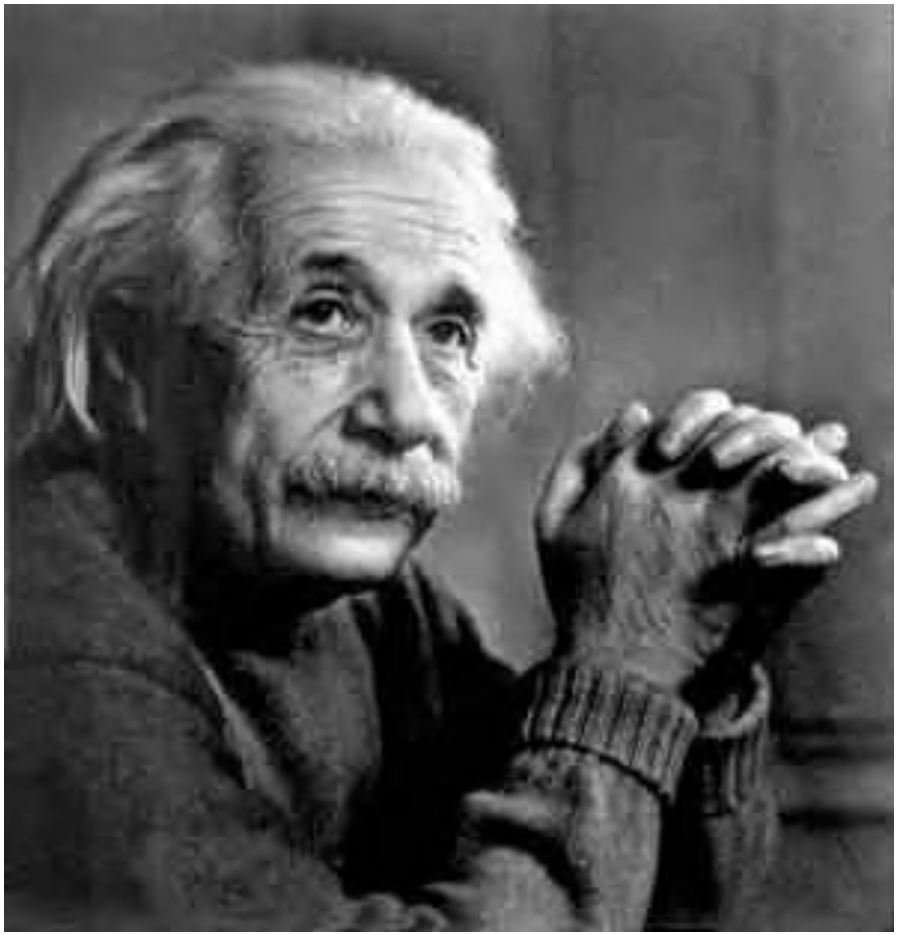
Brass is a versatile manufacturing material because of its hardness and workability.

Some types of brass have other metals added to modify their properties.

Brass is corrosion resistant.

Other Modern Uses

Lab: Making An Alloy



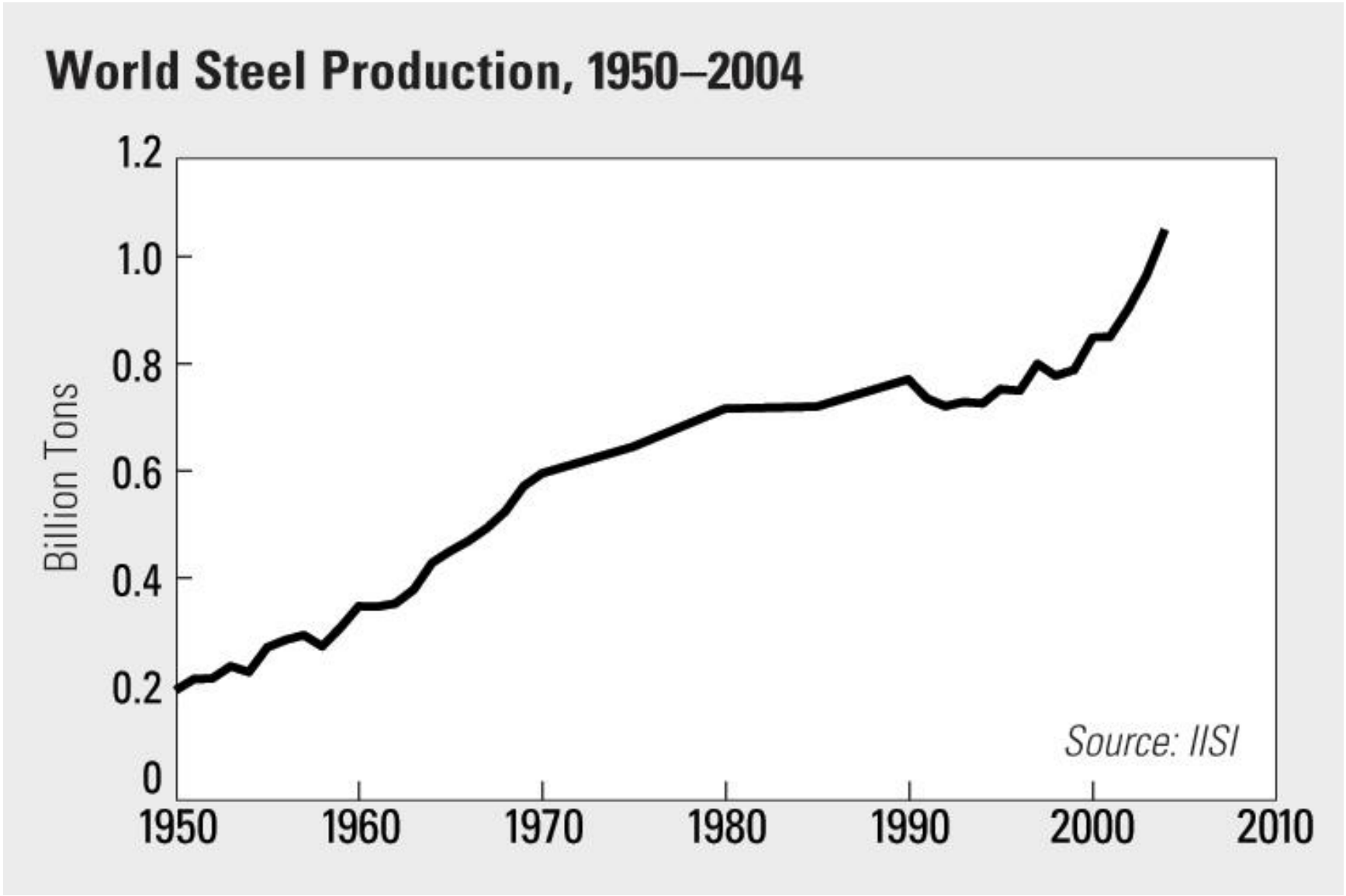
Lab: Making An Alloy

Data Chart

Lab: Making An Alloy

The most used alloy?

Steel


World Steel Production, 1950–2004
Billion Tons
1.2
1.0
0.8
0.6
0.4
0.2
0
1950
1960
1970
1980
1990
2000
2010
Source: IISI

Steel is the common name for a large family of iron alloys which are easily malleable after the molten stage.

Steel

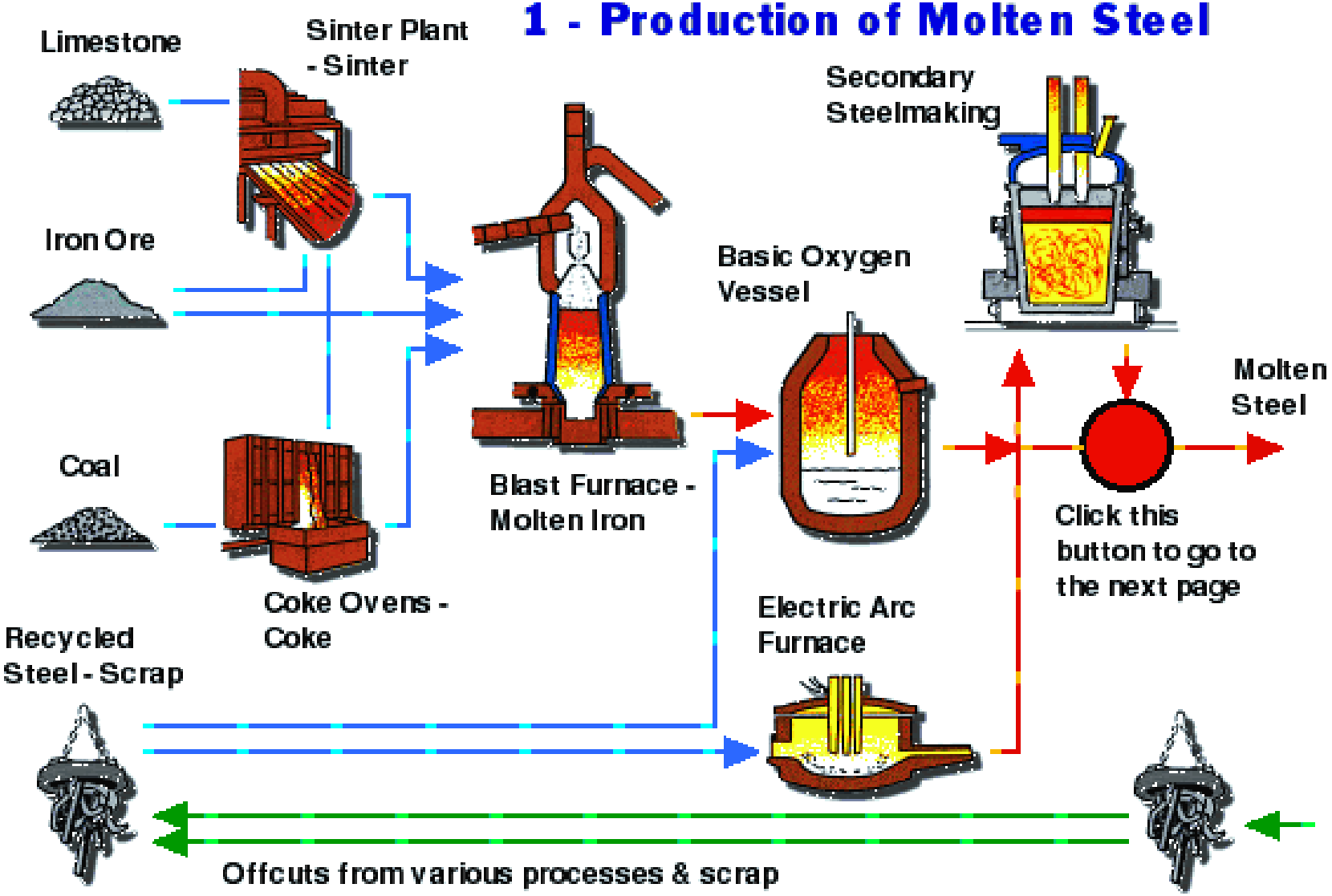
Steel is the worlds most recycled material.

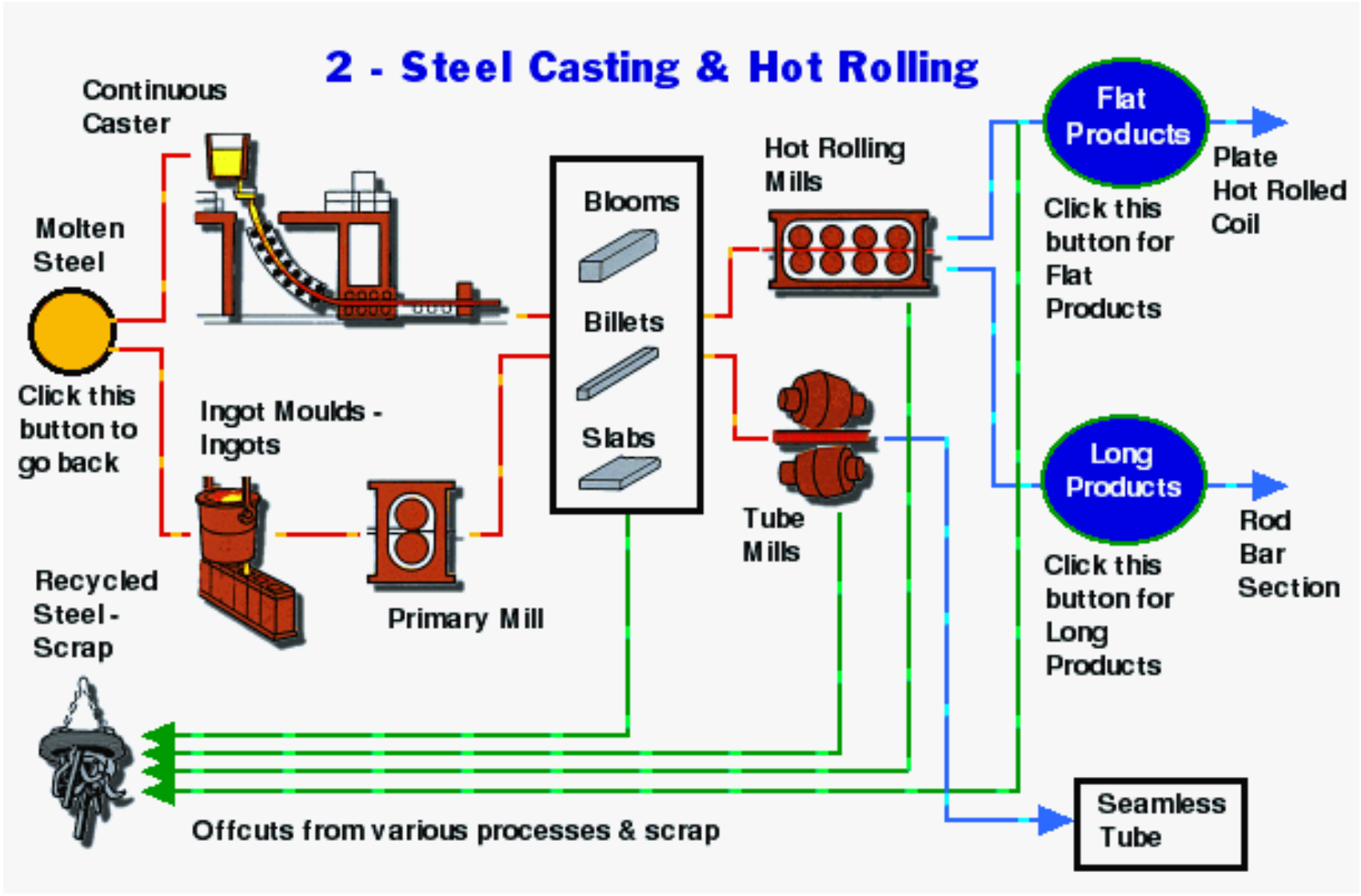
Henry Bessemer

Generally credited with the invention of an efficient steelmaking process in 1856.

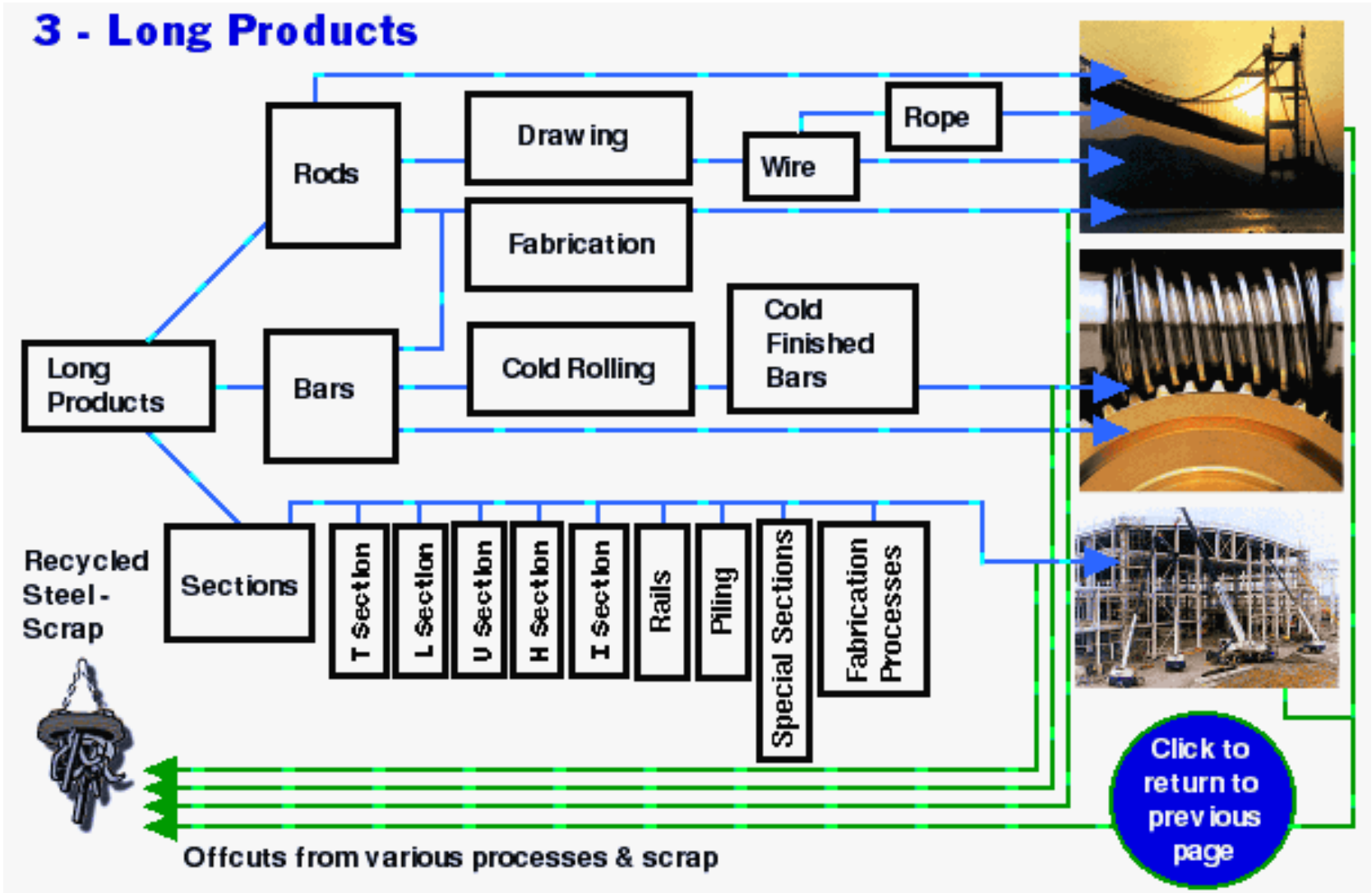
Steels are commonly made from limestone, iron ore & coal.

1 - Production of Molten Steel




2 - Steel Casting & Hot Rolling
Continuous Caster
Molten Steel
Click this button to go back
Ingot Moulds - Ingots
Recycled Steel - Scrap
Primary Mill
Blooms
Billets
Slabs
Hot Rolling Mills
Tube Mills
Flat Products
Plate Hot Rolled Coil
Click this button for Flat Products
Long Products
Rod Bar Section
Click this button for Long Products
Seamless Tube
Offcuts from various processes & scrap

3 - Long Products



4 - Flat Products

Plate

Tube Mills

Welded Tubes

Flat Products

Hot Rolled Coil

Cold Rolling

Tin Plating

Metallic Coating

Painting

Slitting

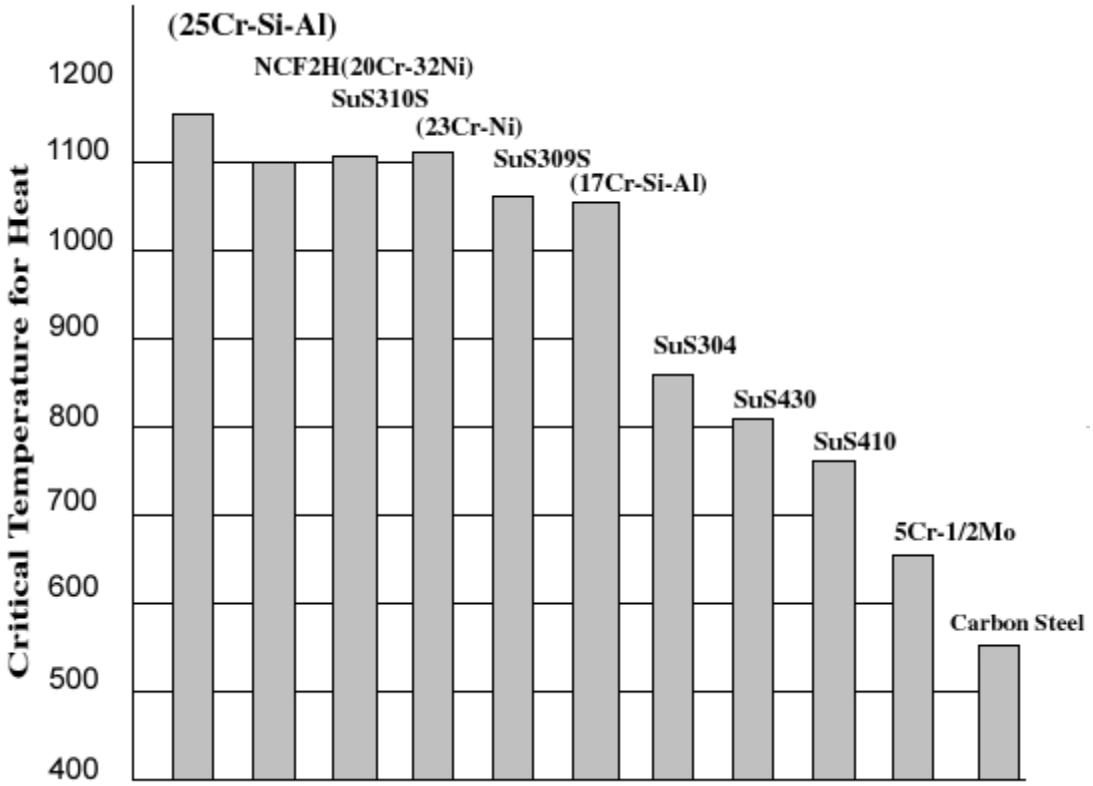
Profiling

Recycled Steel - Scrap

Offcuts from various processes & scrap

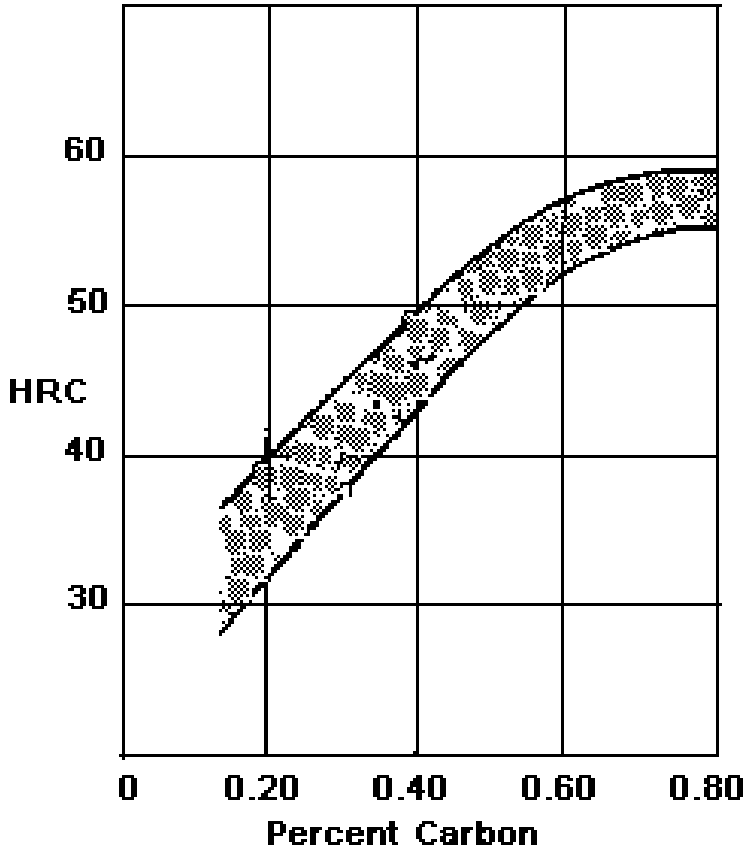
Click to return to previous page

Effects of Carbon



How hard steel is depends on the how much carbon is inside.

Effects of Carbon



Hardness and tensile strength increases as carbon content increases up to about 0.85% C!

Effects of Carbon

The scissors' steel contains ~20% times the carbon as the steel used in a soda can!

Effects of Carbon

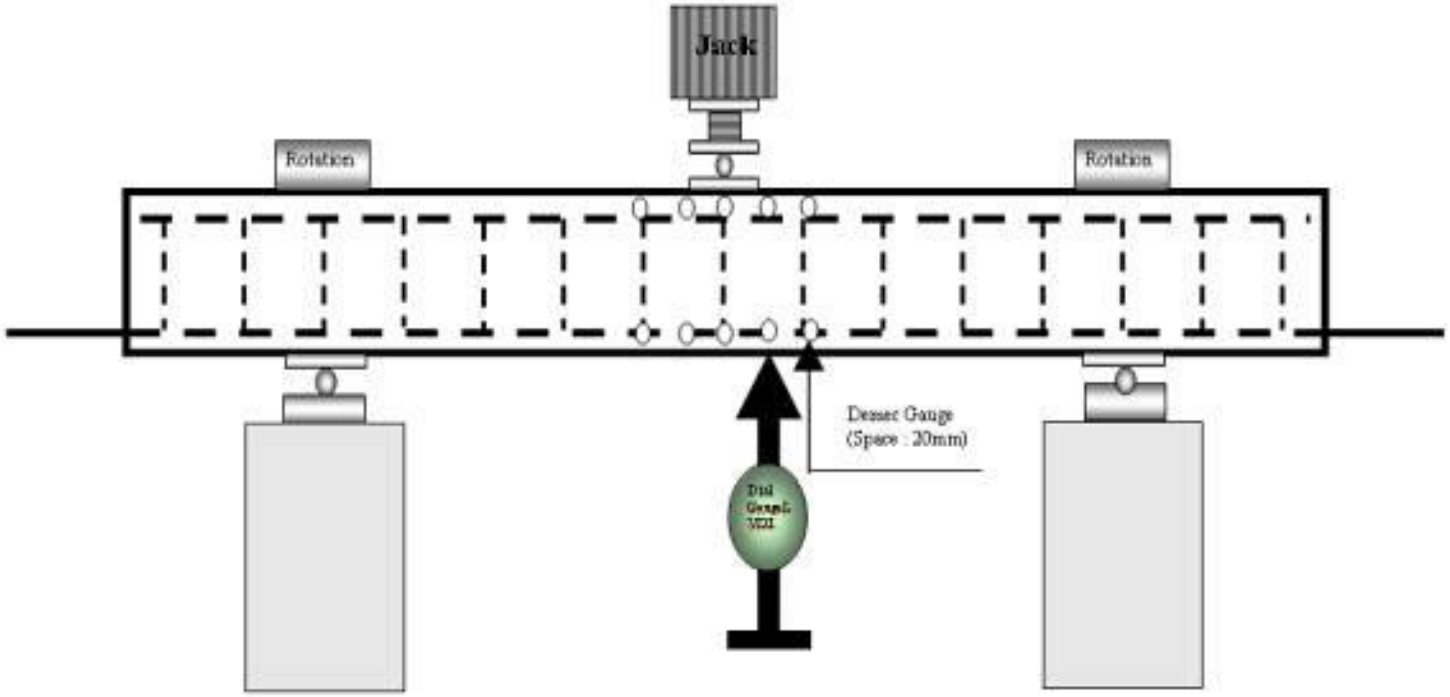


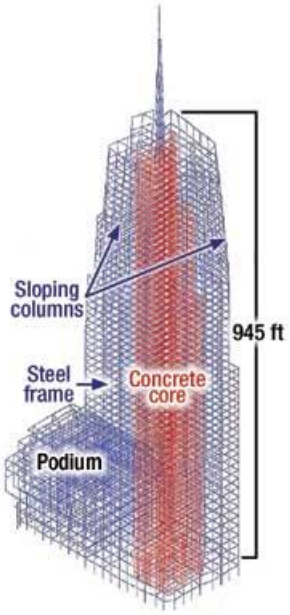
Figure 1. Beam specimens

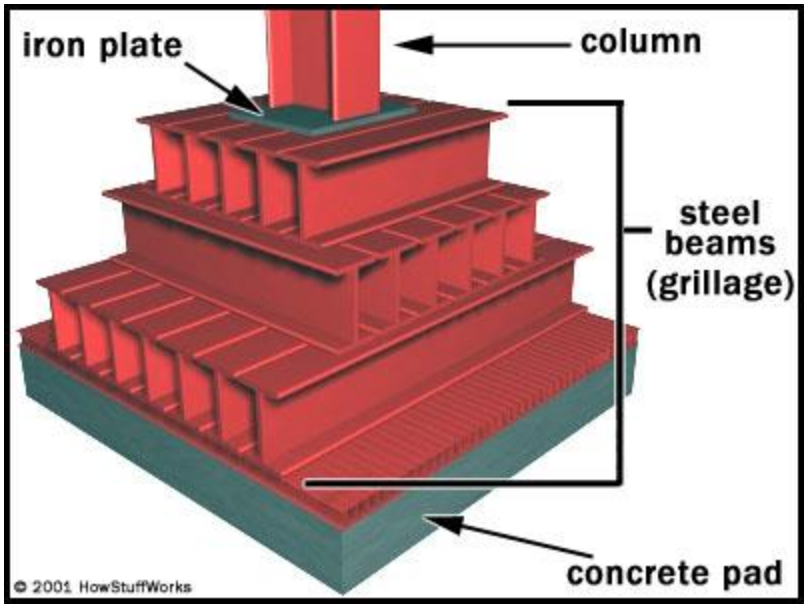
Ductility and weldability decrease with increasing carbon.

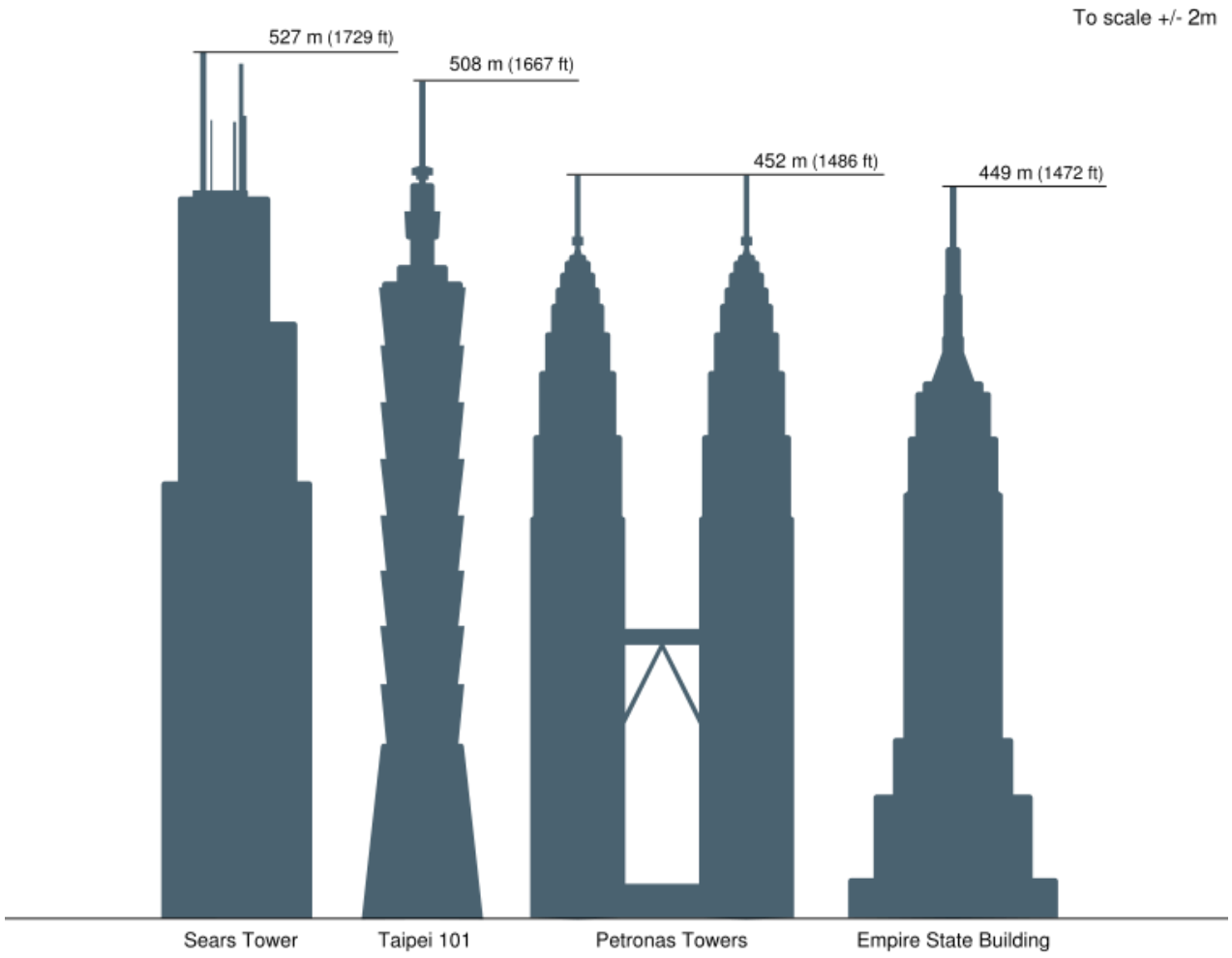
Types of Steel Alloys

There are more than 3500 different grades of steel with many different physical, chemical & chemical properties.

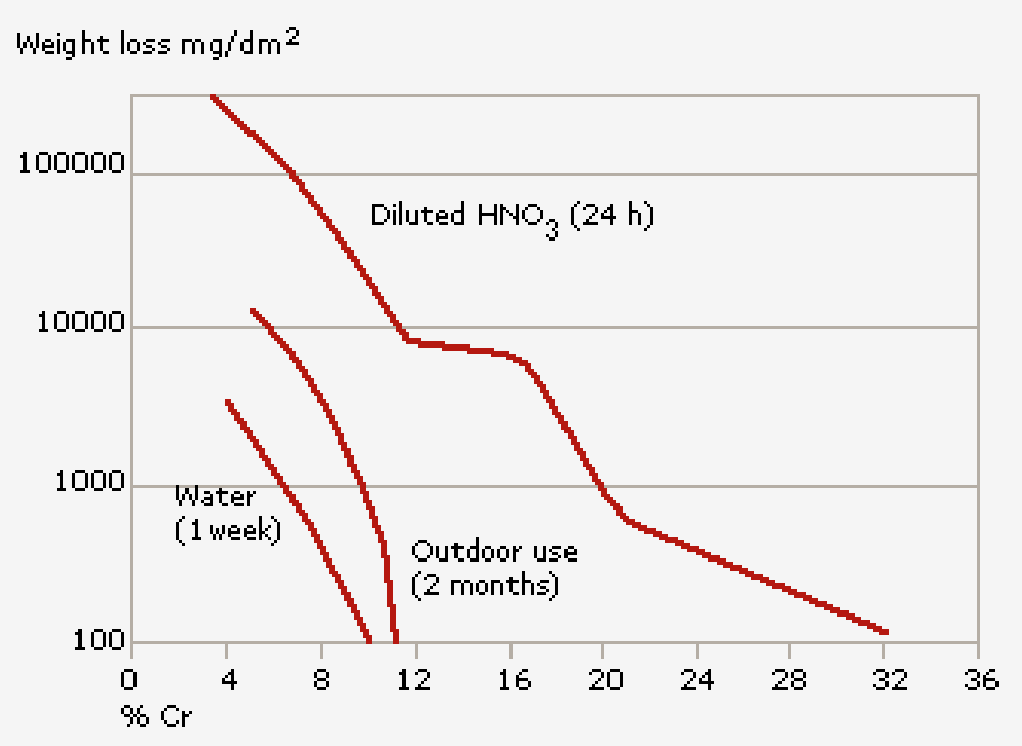
Carbon Steels


Sloping columns
945 ft
Steel frame
Concrete core
Podium


iron plate
column
steel beams (grillage)
concrete pad
© 2001 HowStuffWorks


To scale +/- 2m
527 m (1729 ft)
508 m (1667 ft)
452 m (1486 ft)
449 m (1472 ft)
Sears Tower
Taipei 101
Petronas Towers
Empire State Building

Chromium Steel



Chromium is commonly added to steel to increase corrosion resistance and oxidation resistance.

Chromium Steel

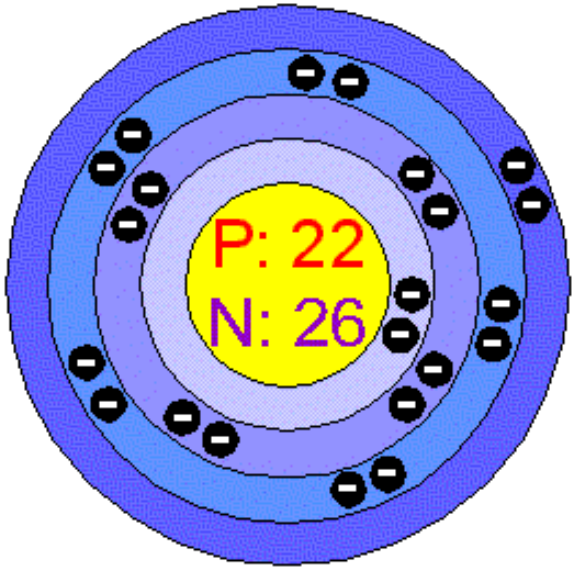
Chromium is commonly added to steel to increase corrosion hardness or to improve high temperature strength.

High Chromium Steel (17% Cr)

Used for pump shafts, values and fittings subject to high temperatures and pressure.

Unsuitable for acidic conditions.

Titanium Steel

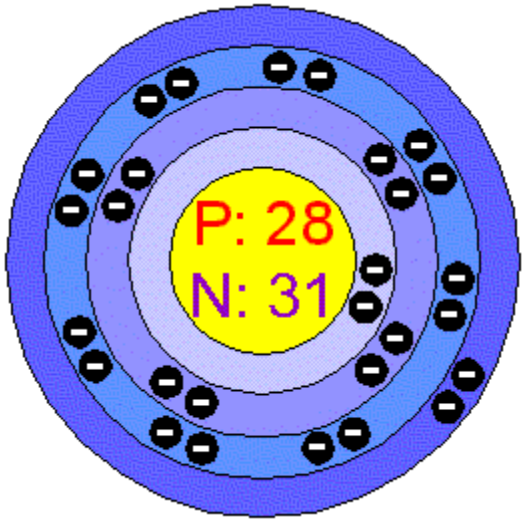


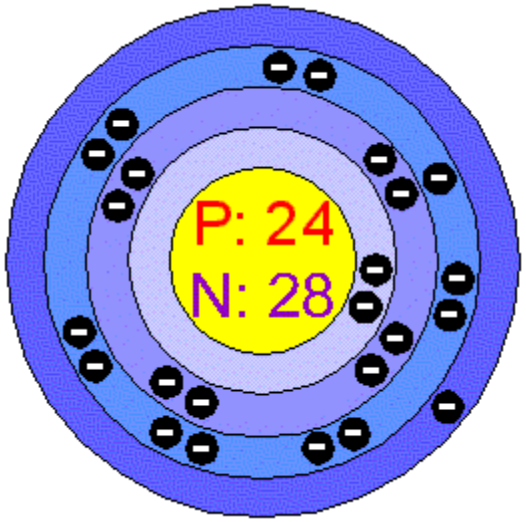
Titanium is used to retard grain growth and thus improve toughness.

Titanium Steel

Titanium causes sulfide inclusions to be globular rather than elongated thus improving toughness and ductility in transverse bending.

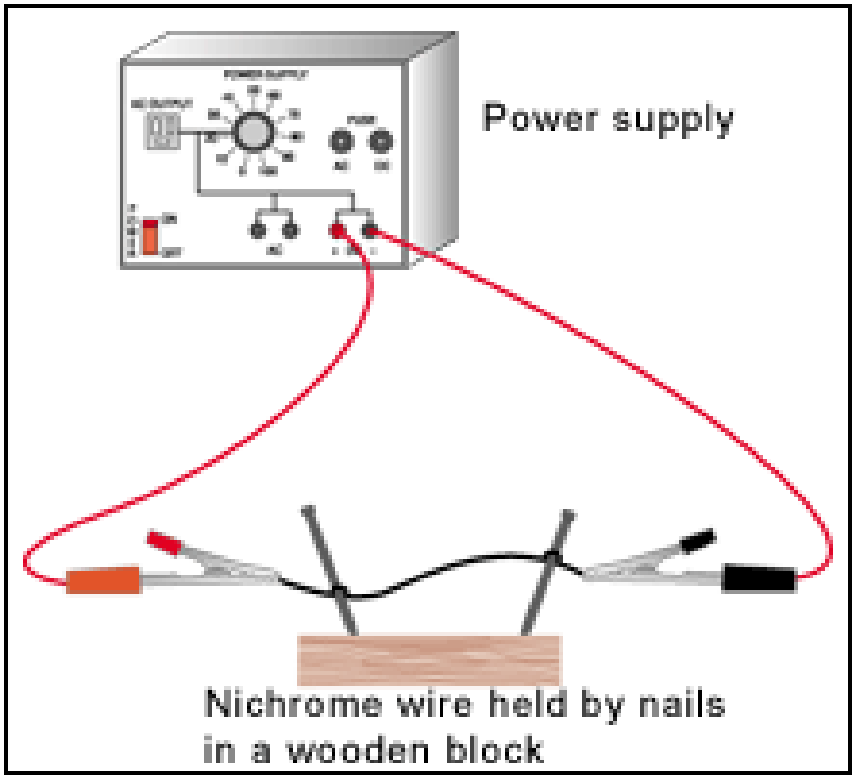
Nichrome





Nichrome is an alloy of nickel and chromium.

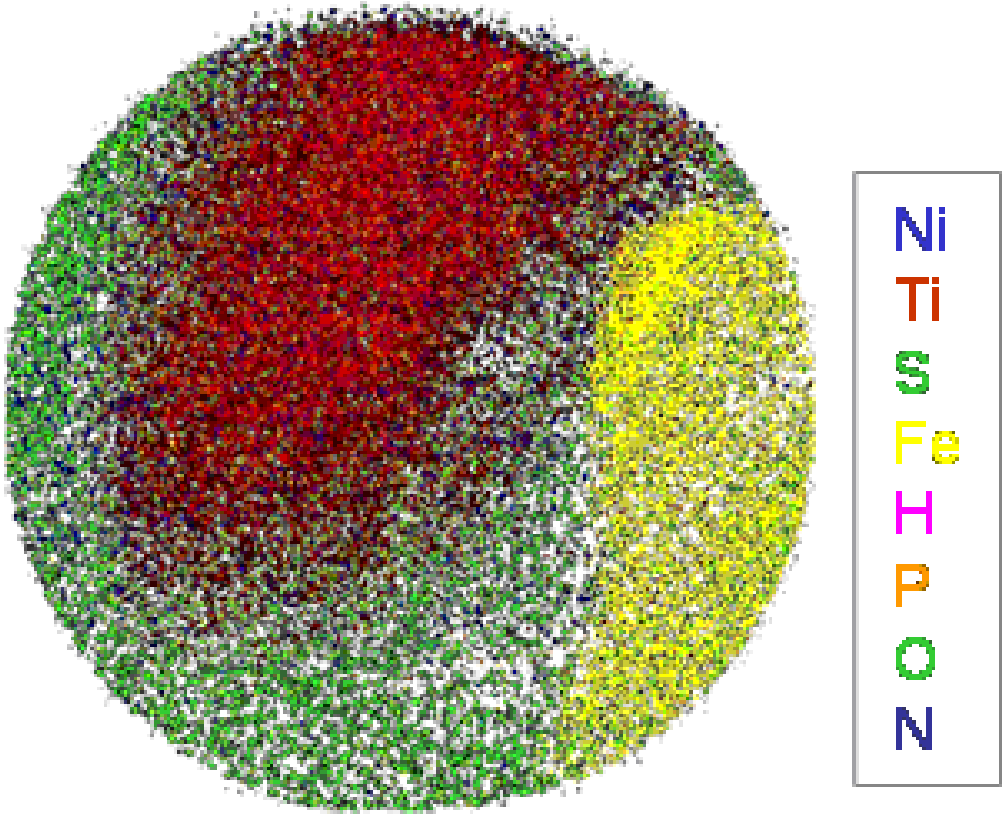
Nichrome



This alloy has a very high melting point and high electrical resistance.

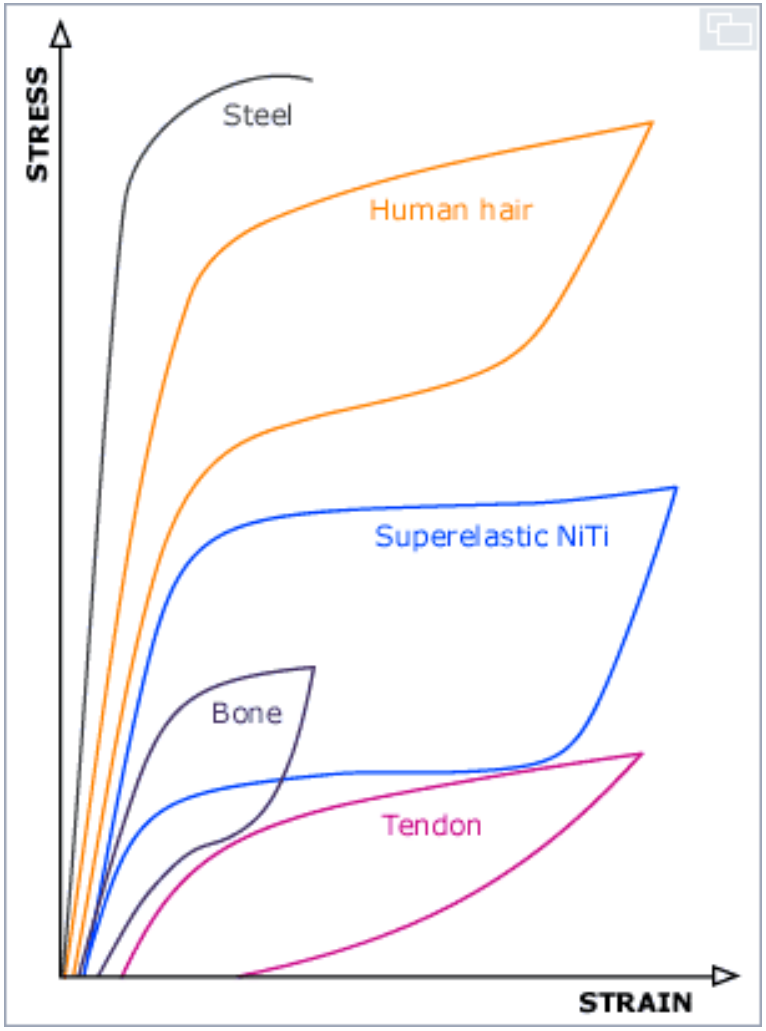
In 1965, the first of a series of metal alloys of nickel and titanium was produced by the Naval Ordnance Laboratory.

Nickel Titanium Naval Ordnance Laboratory



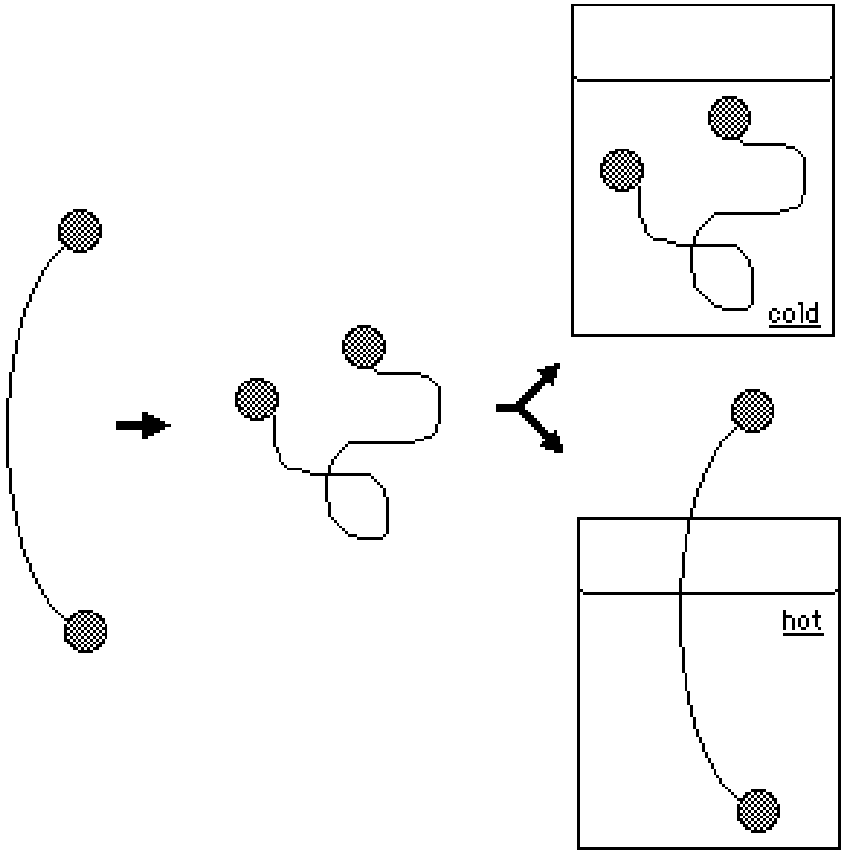
National

NITINOL's Unique Properties



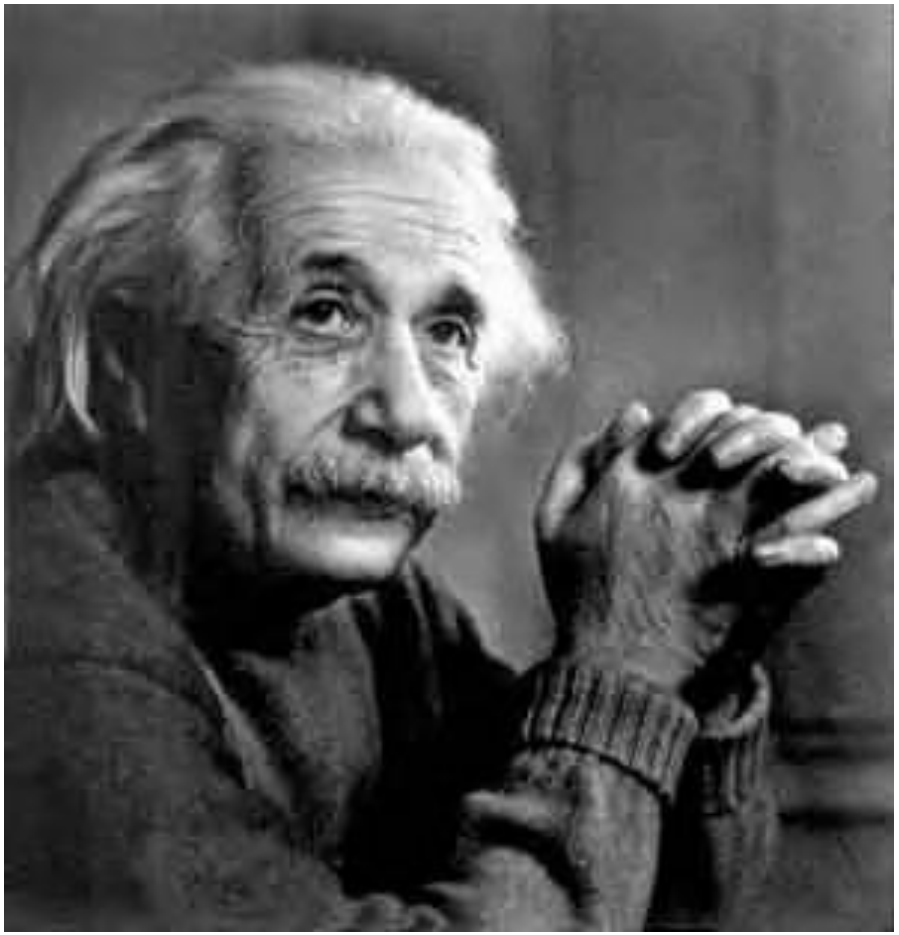
10X Elasticity of Stainless Steel

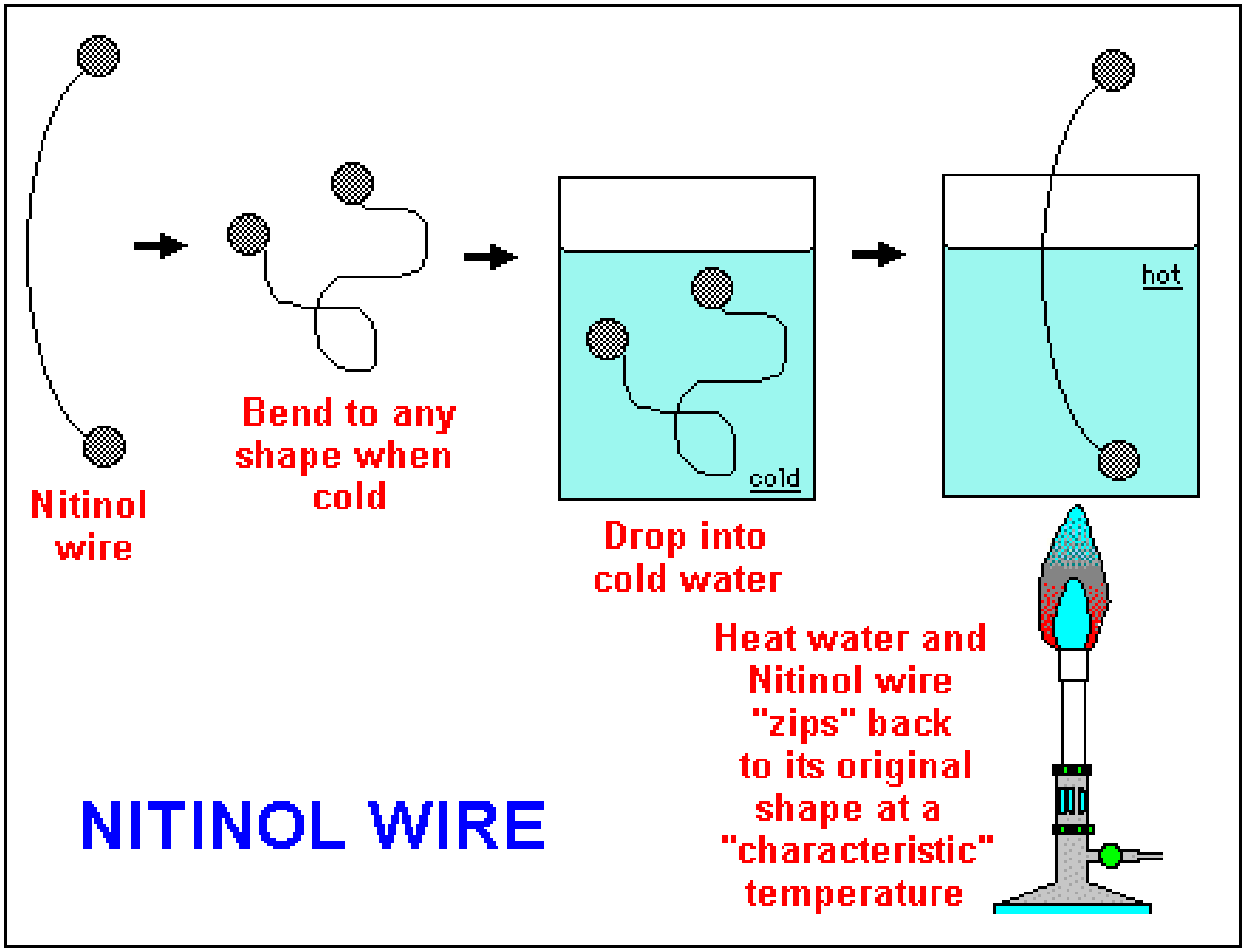
NITINOL's Unique Properties

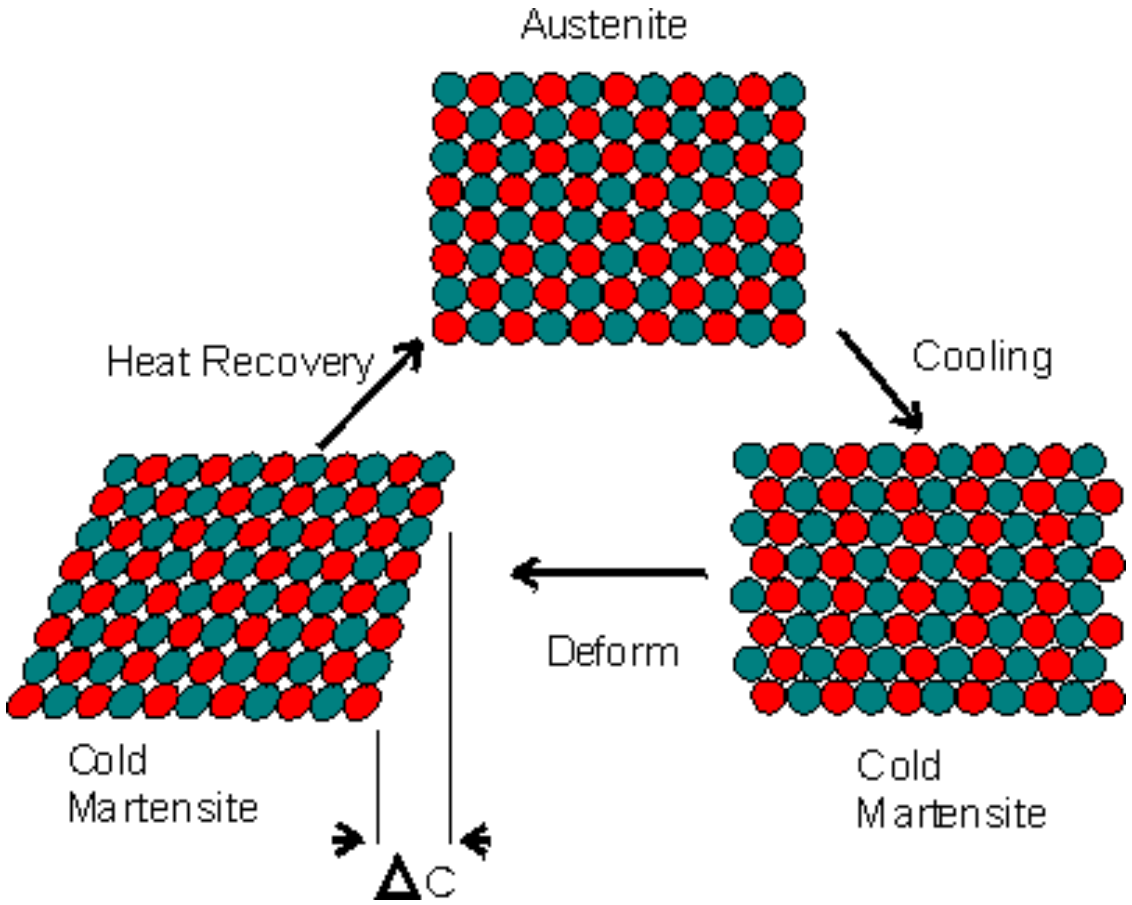


It "remembers" it's shape!

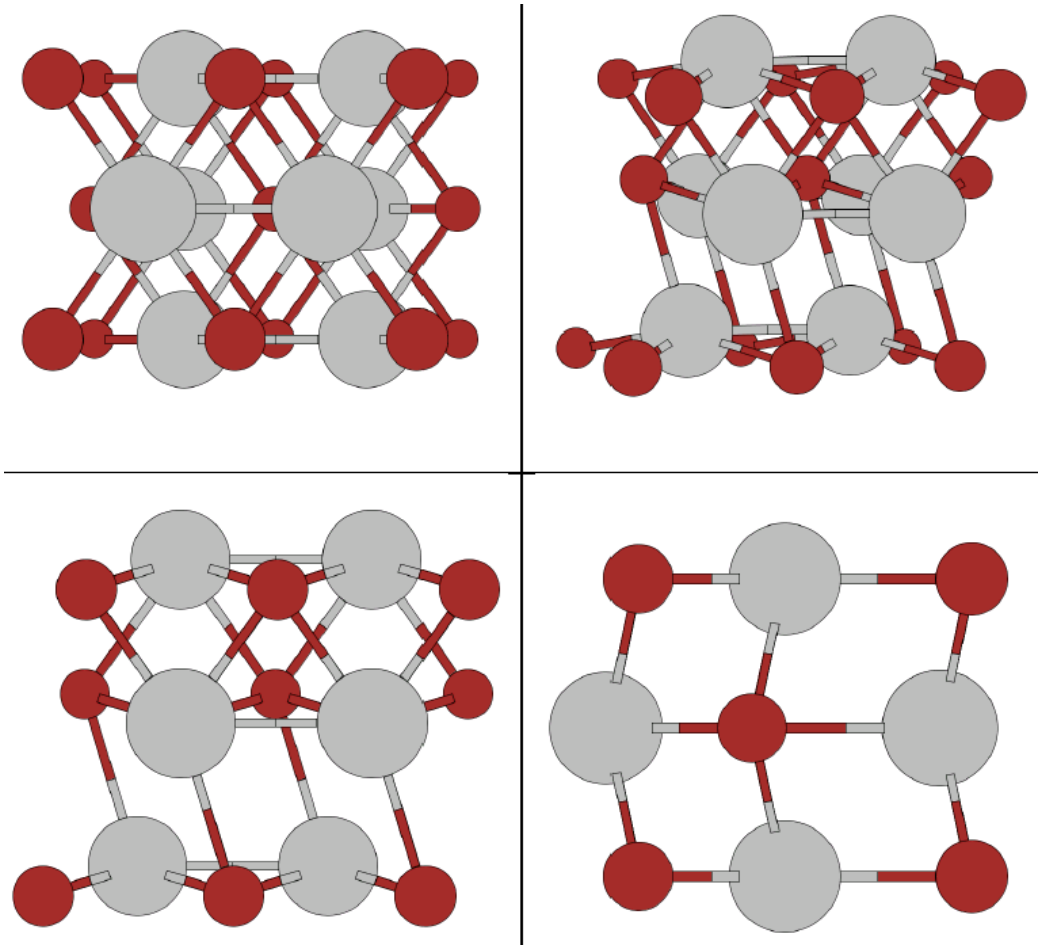
Lab: Memory Metal



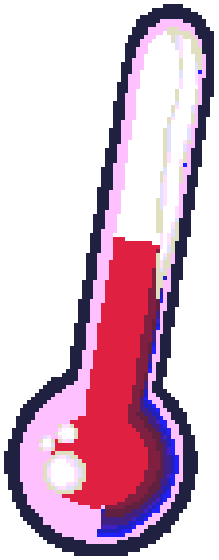

Nitinol wire
Bend to any shape when cold
cold
Drop into cold water
hot
Heat water and Nitinol wire "zips" back to its original shape at a "characteristic" temperature
NITINOL WIRE

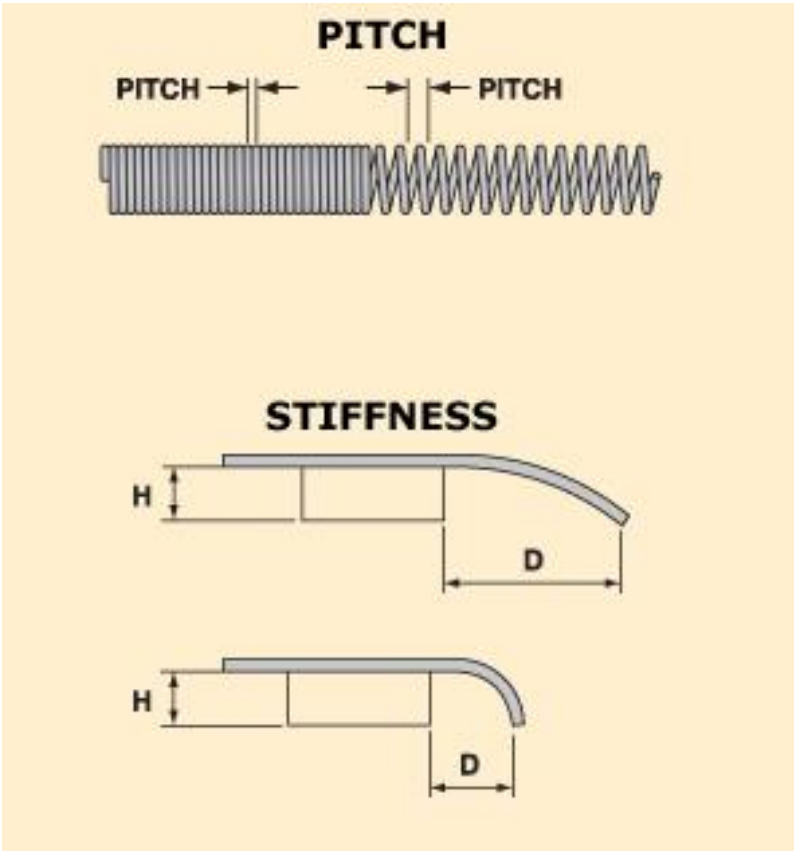


This "smart" property is the result of the substance's ability to undergo a phase change - a kind of atomic ballet in which atoms in the solid subtly shift their positions in response to a stimulus like a change in temperature.



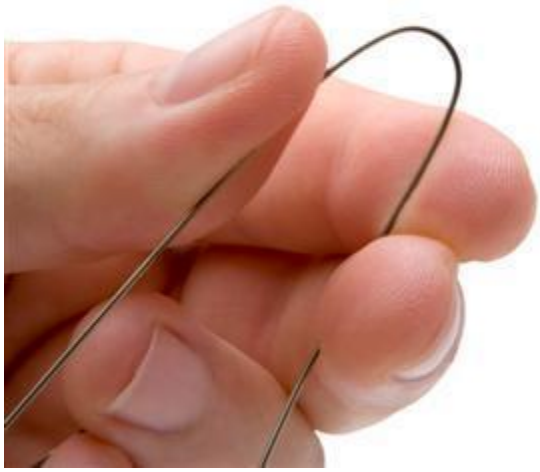
The sample recovers its original shape as its temperature is raised above the temperature corresponding to the phase change.



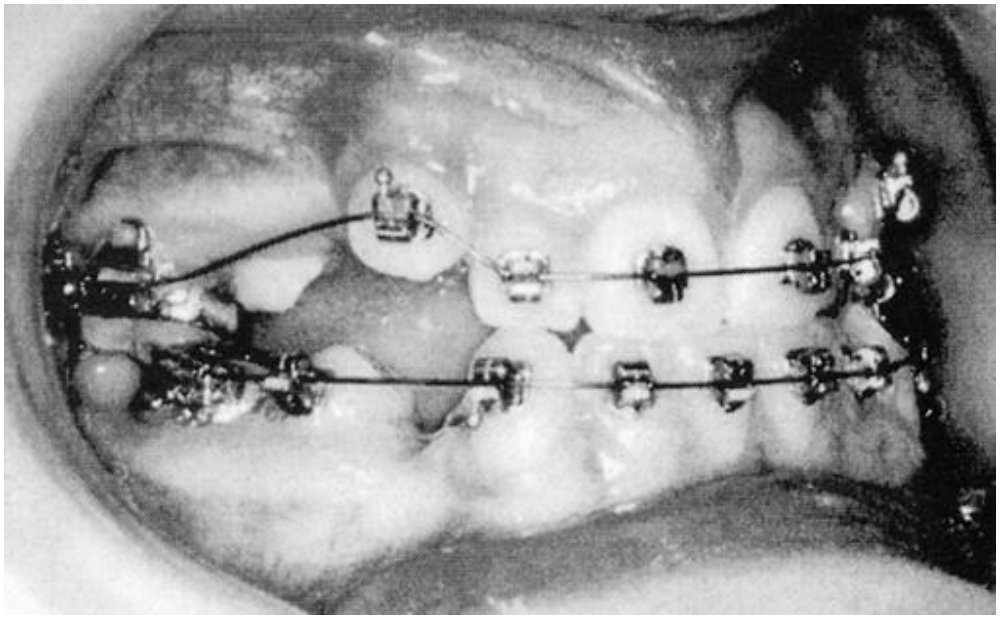


This temperature may be tuned by varying the ratio of nickel to titanium atoms in the solid by a few percent relative to a 1:1 ratio.

Commercial Applications

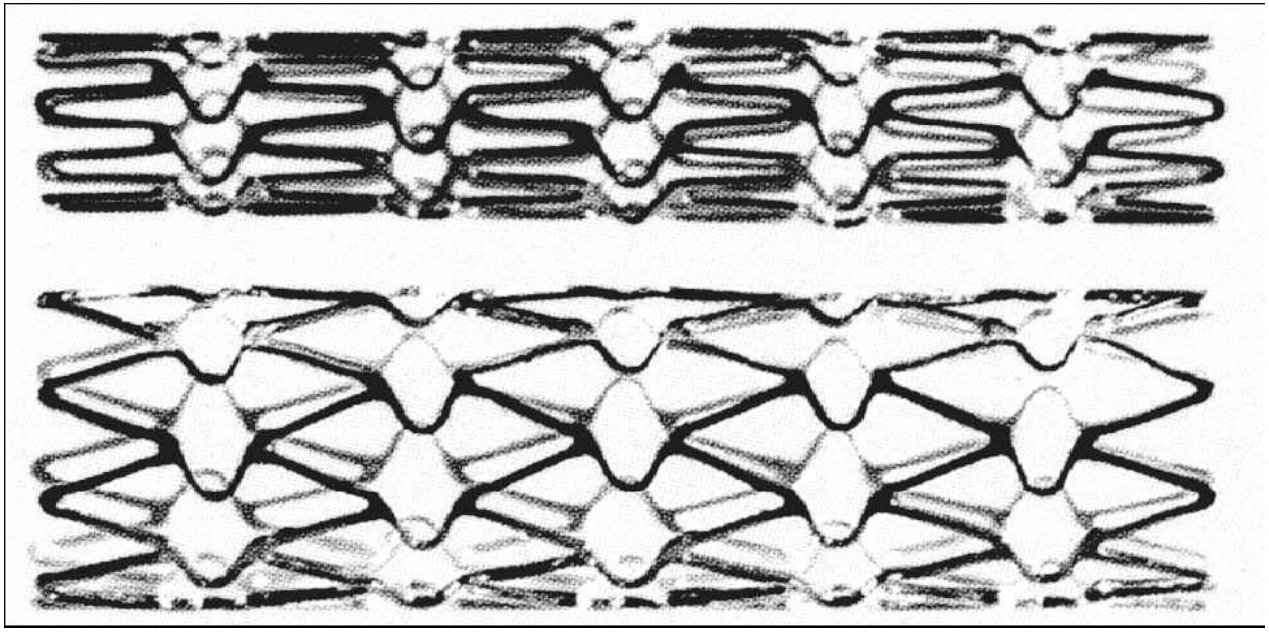


Medical Applications

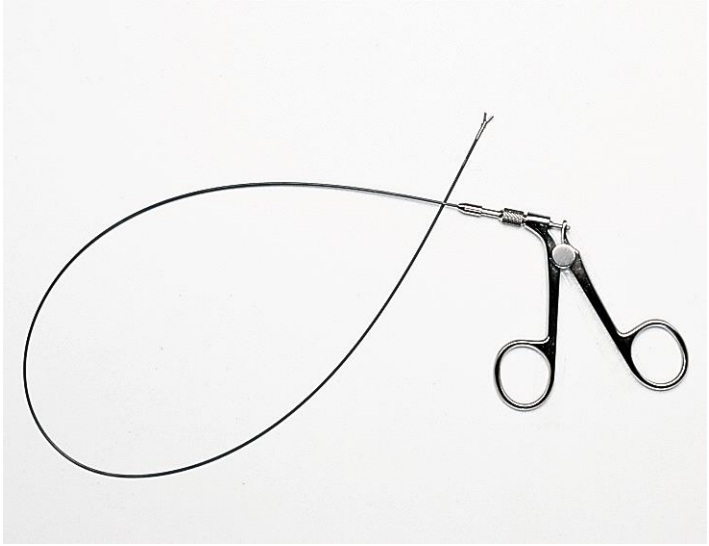


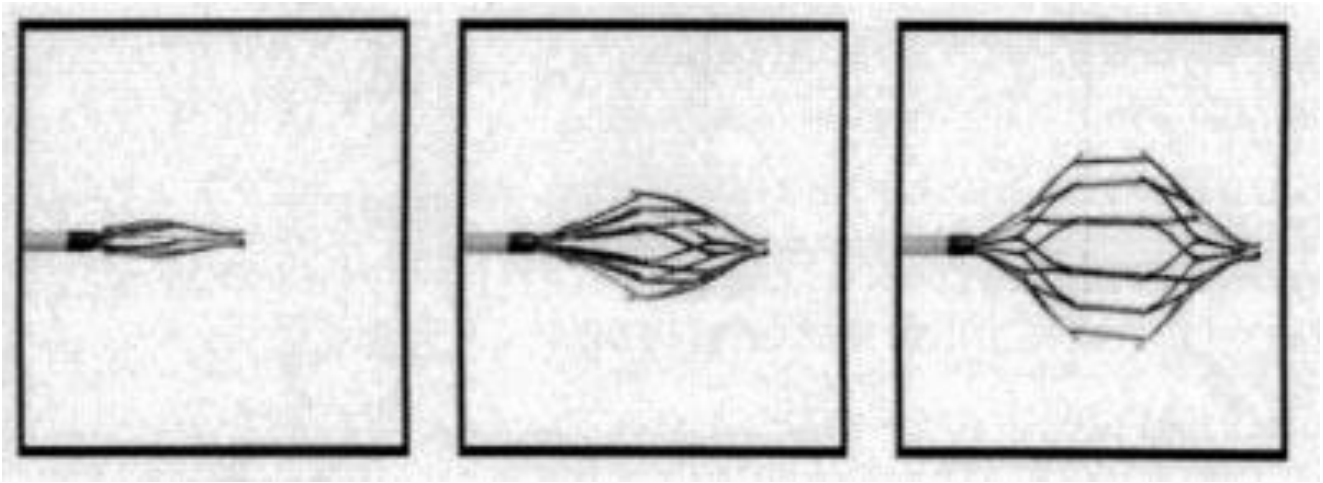
Nitinol can be designed to apply constant force or stress over a variety of shapes.

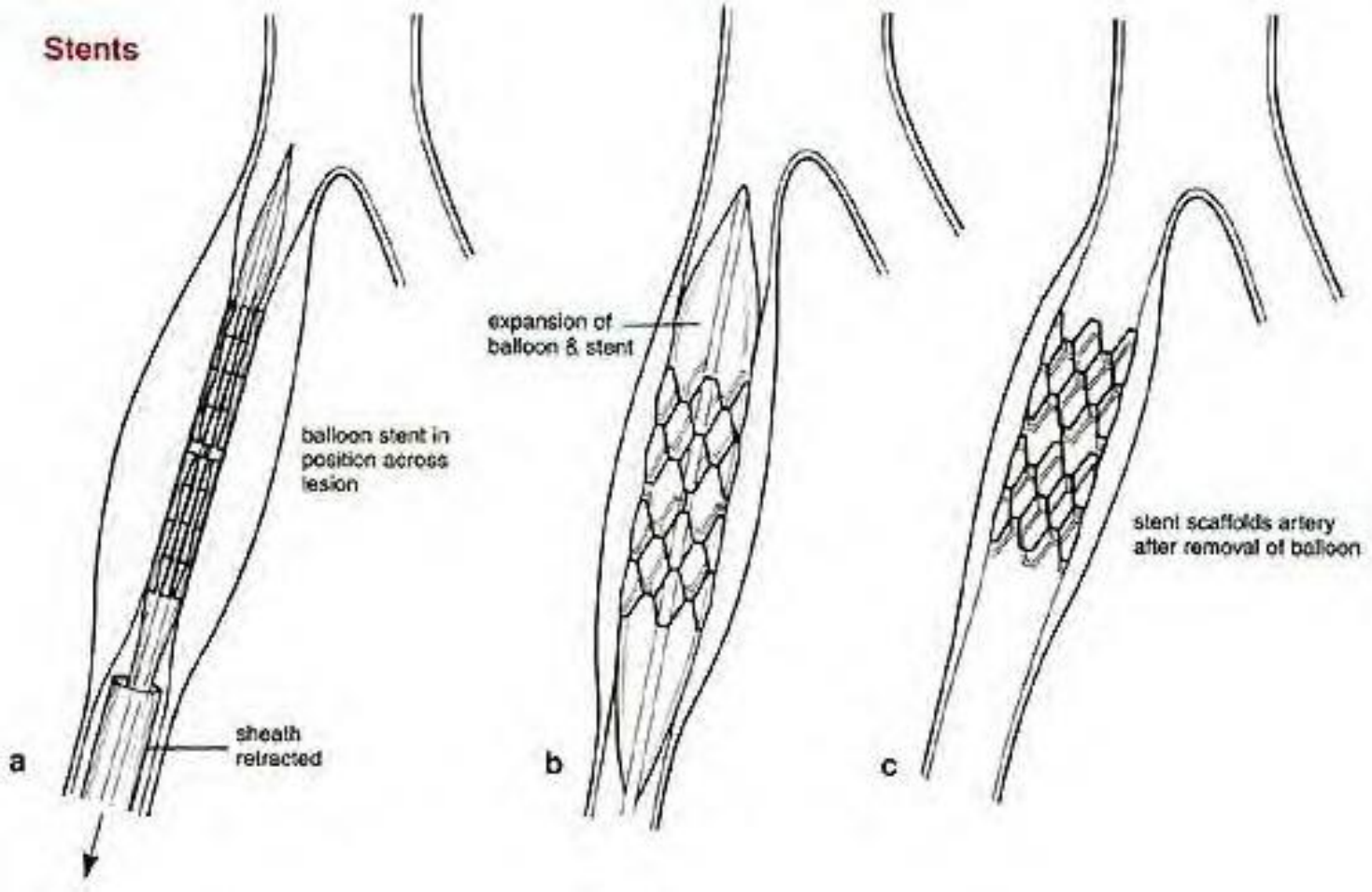
Medical Applications

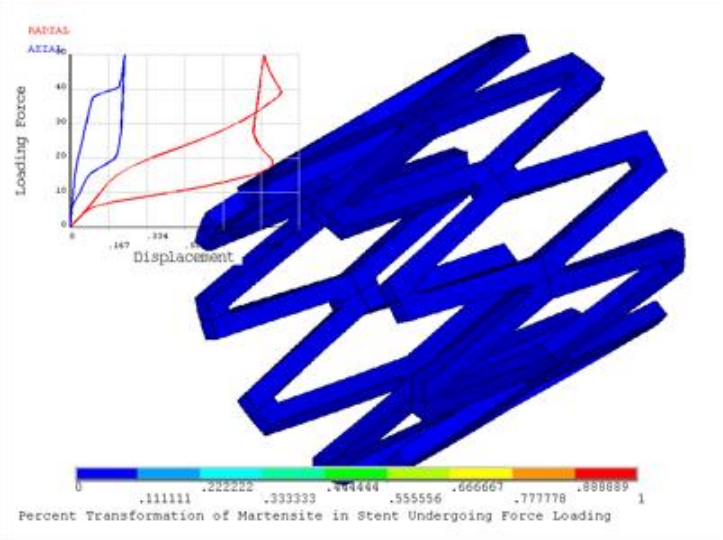


Nitinol can be designed to apply constant force or stress over a variety of shapes.





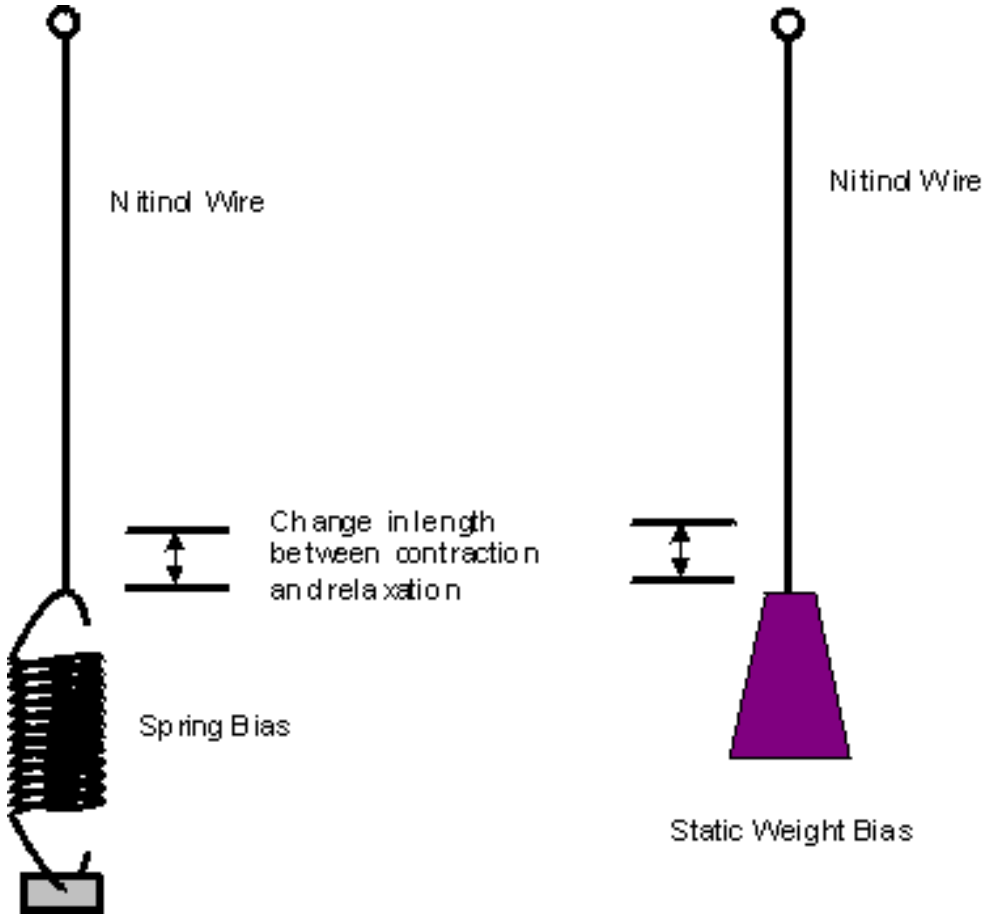

Stents
balloon stent in position across lesion
sheath retracted
a
expansion of balloon & stent
b
stent scaffolds artery after removal of balloon
c



More stable and less corrosive that stainless steel.

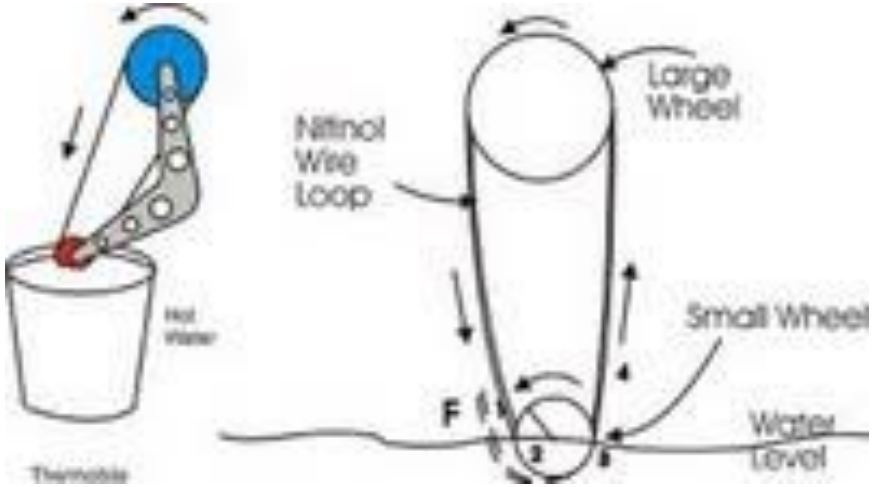
MRI compatible.

NITINOL's Unique Properties



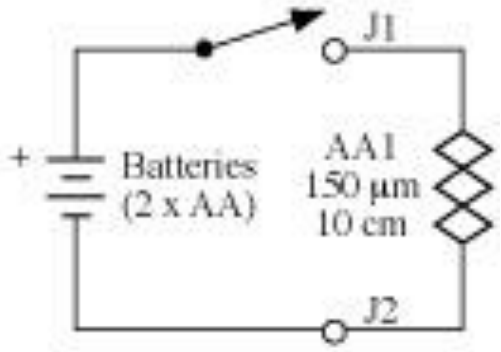
"Muscle" Metal

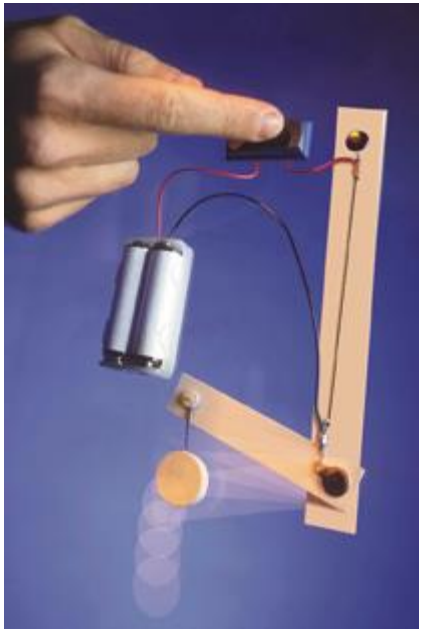
NITINOL's Unique Properties

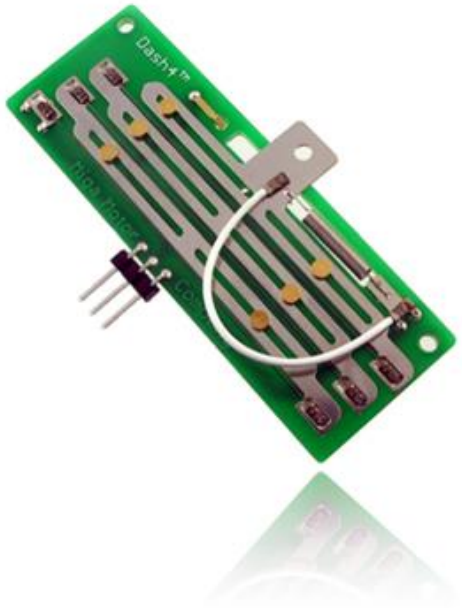


"Muscle" Metal

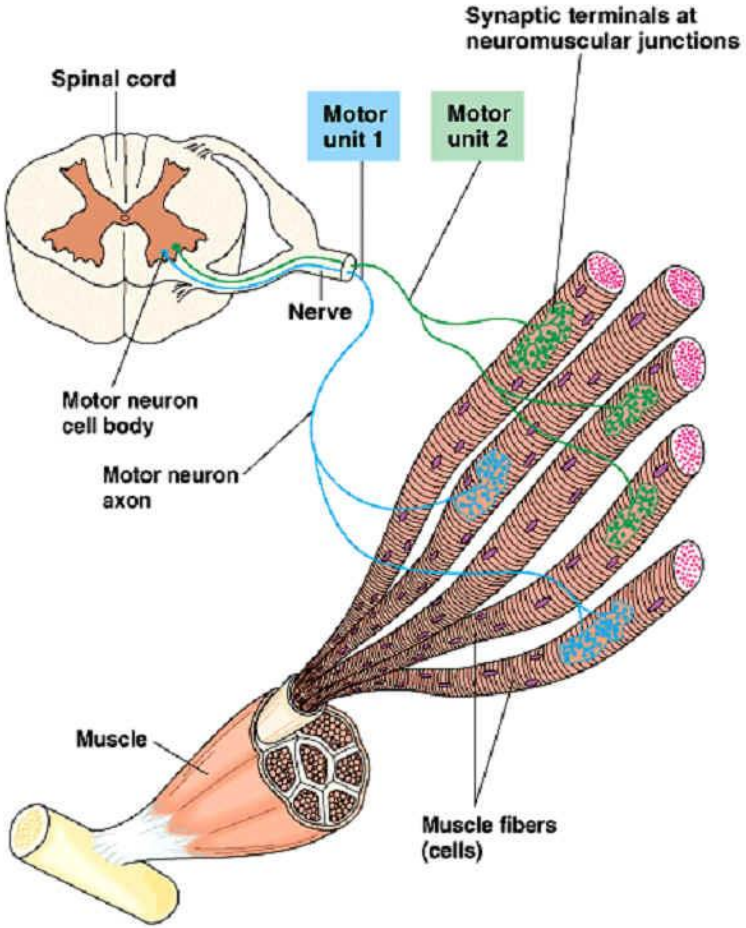
NITINOL's Unique Properties







NITINOL's Unique Properties



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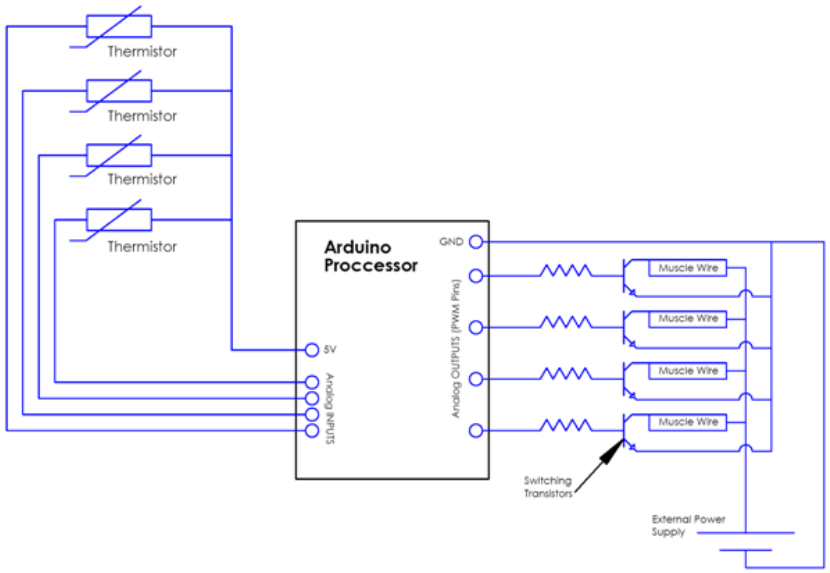
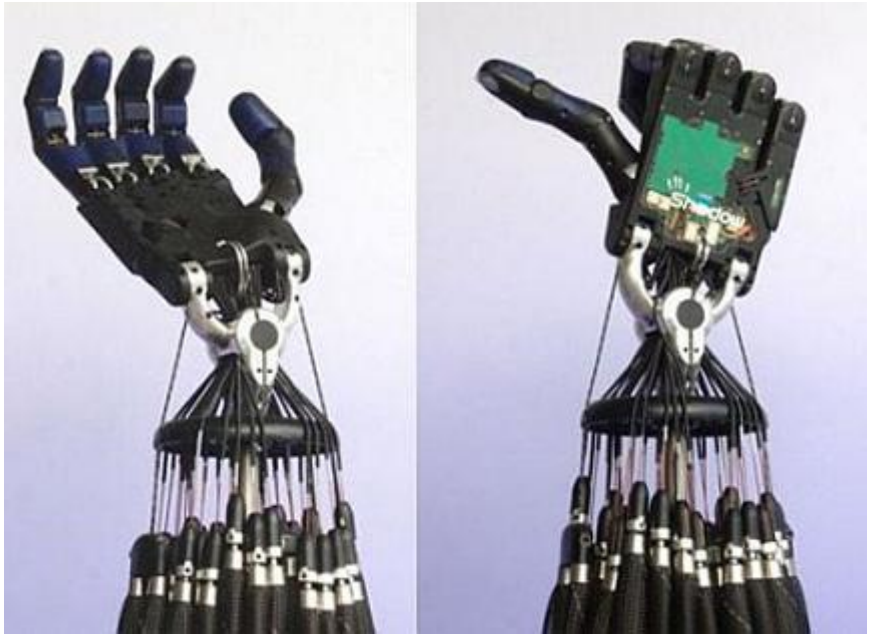
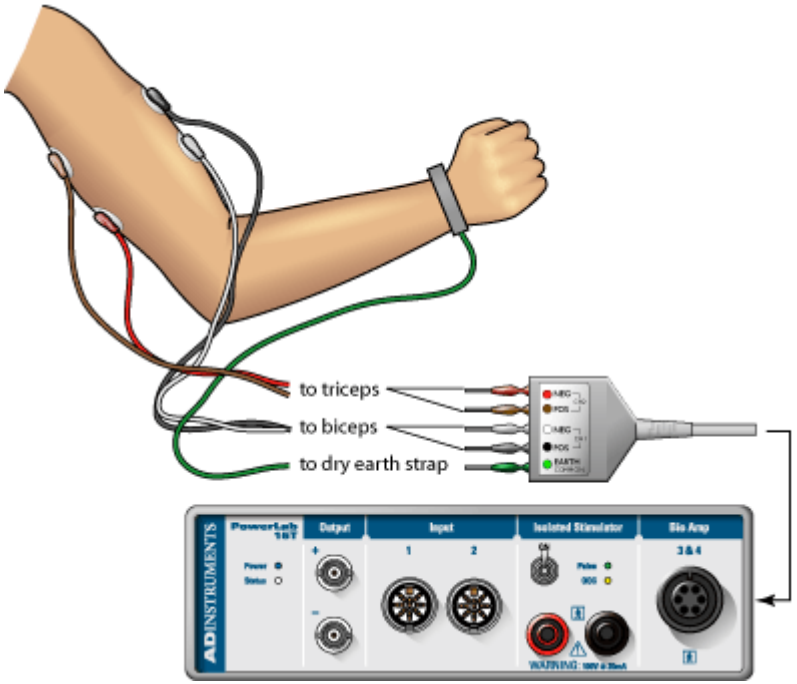
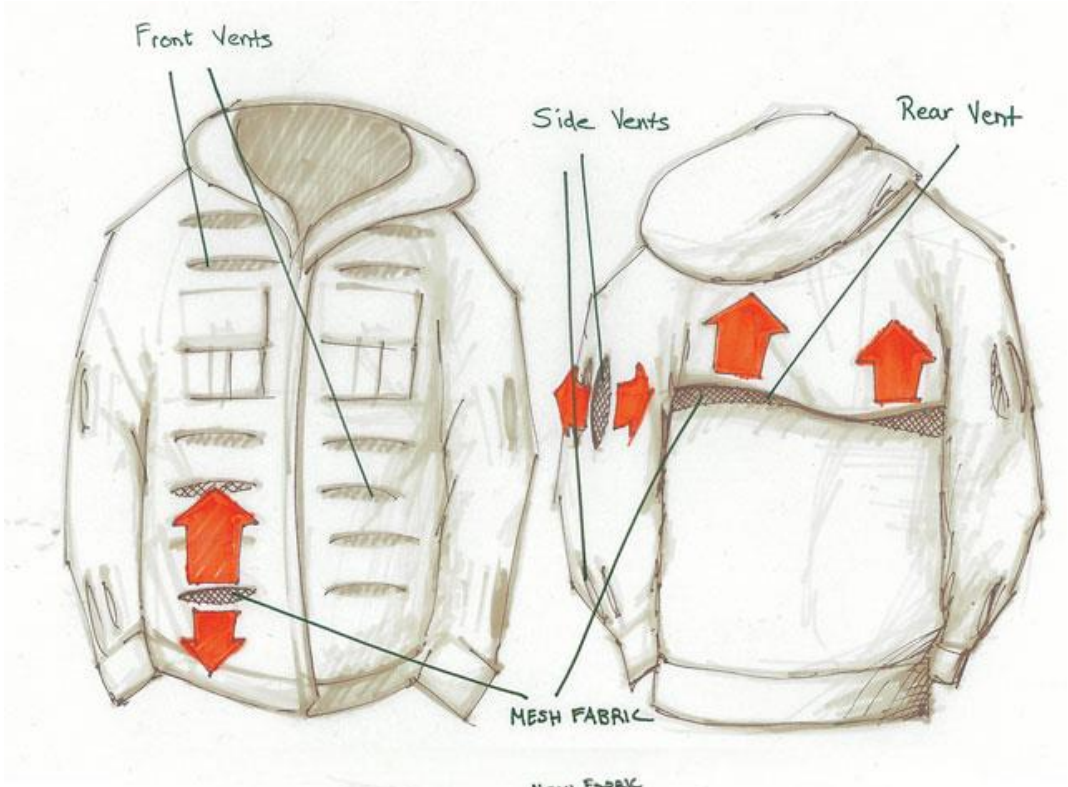
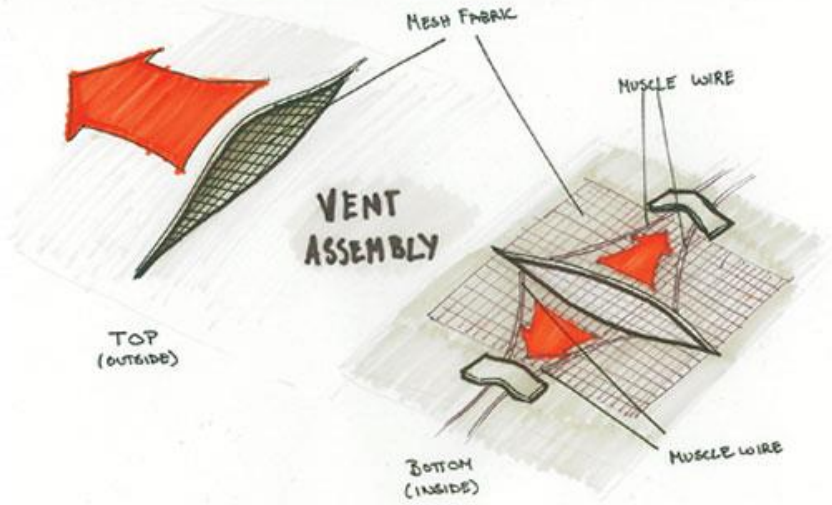


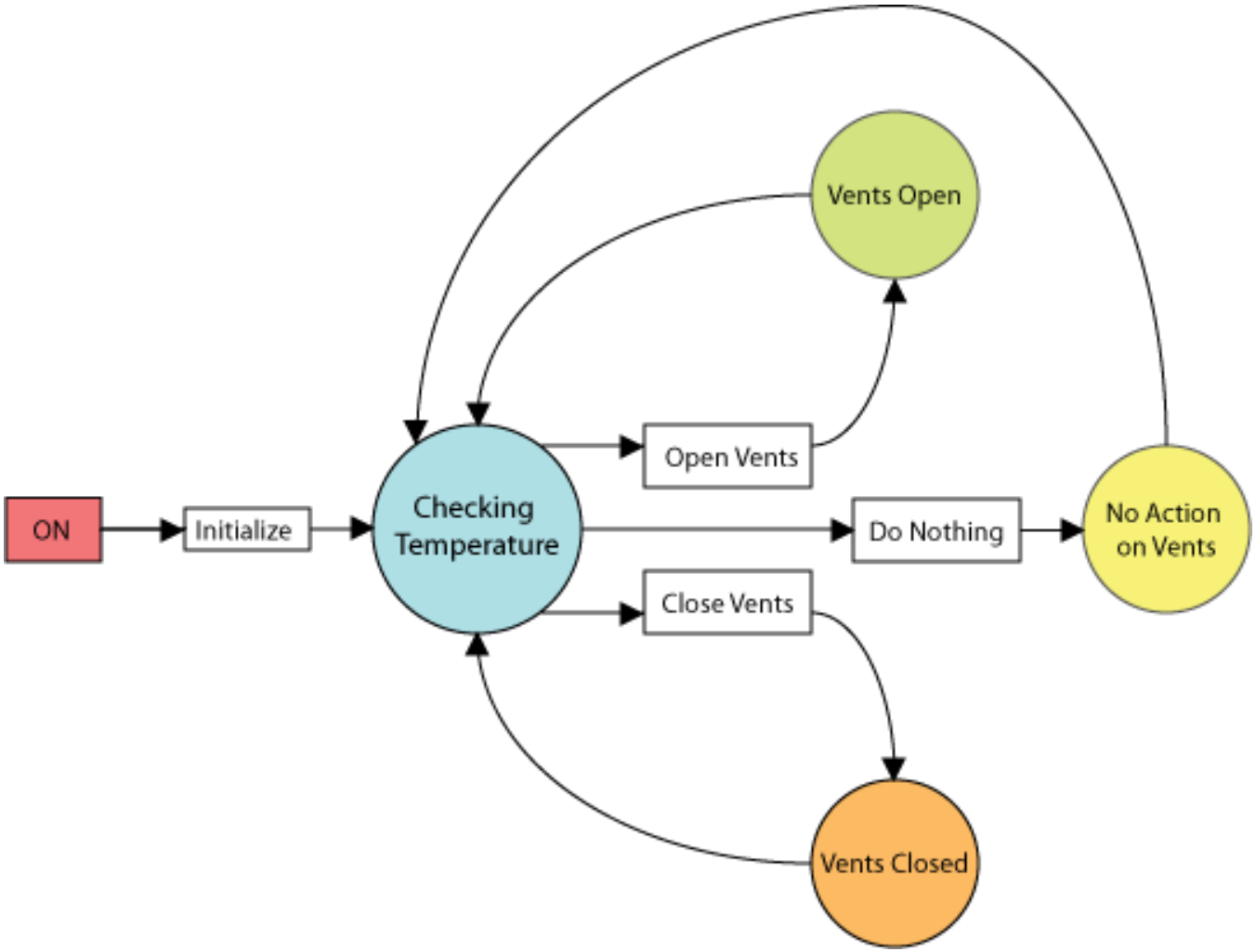


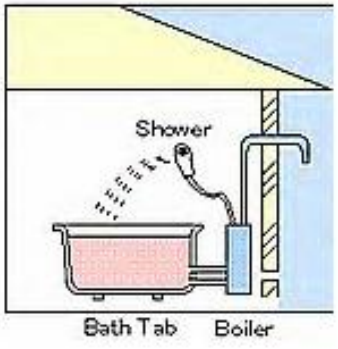

ULNA
RADIUS
WRIST


to triceps
to biceps
to dry earth strap
ADINSTRUMENTS
Output
Input
Isolated Stimulator
Bio Amp
1
2
3 & 4

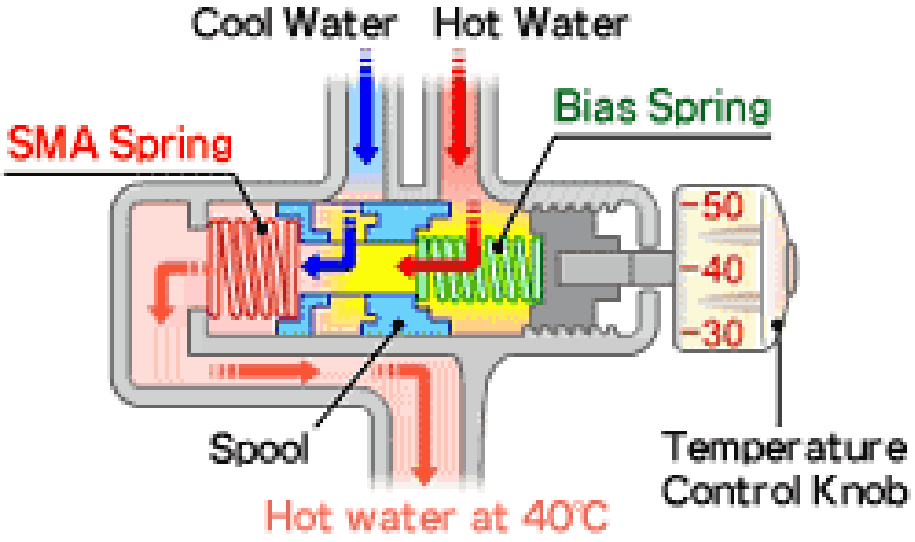

Front Vents
Side Vents
Rear Vent
MESH FABRIC


MESH FABRIC
MUSCLE WIRE
VENT ASSEMBLY
TOP (OUTSIDE)
BOTTOM (INSIDE)
MUSCLE WIRE


ON
Initialize
Checking Temperature
Open Vents
Vents Open
Do Nothing
No Action on Vents
Close Vents
Vents Closed

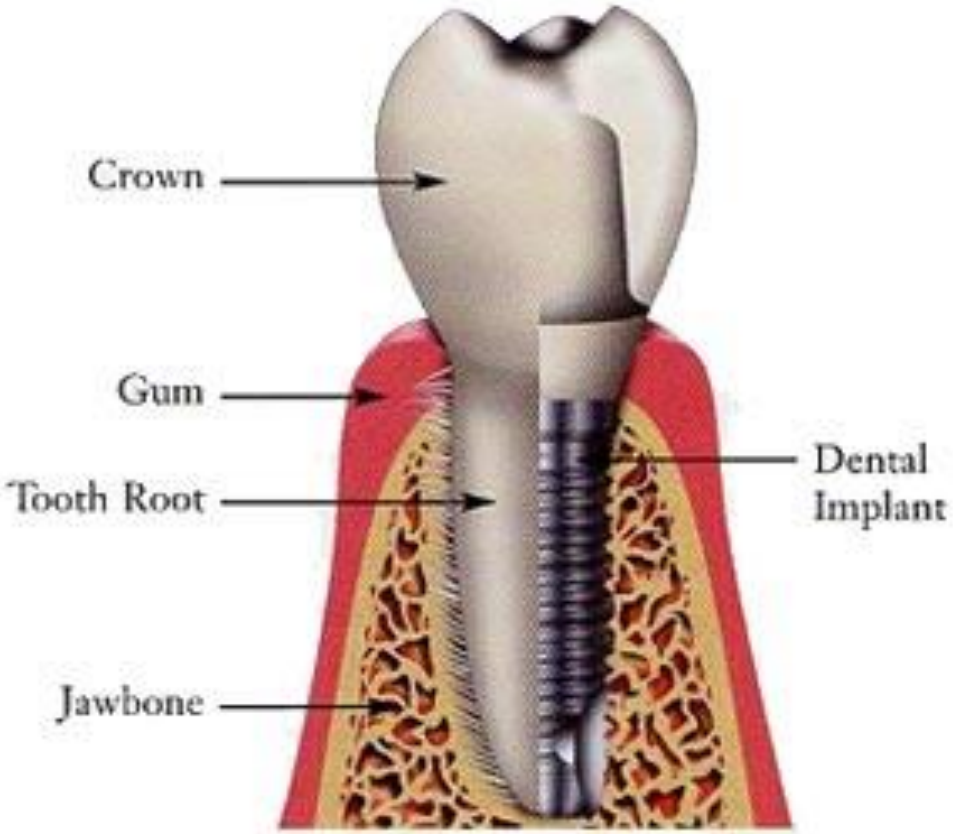


Home Applications



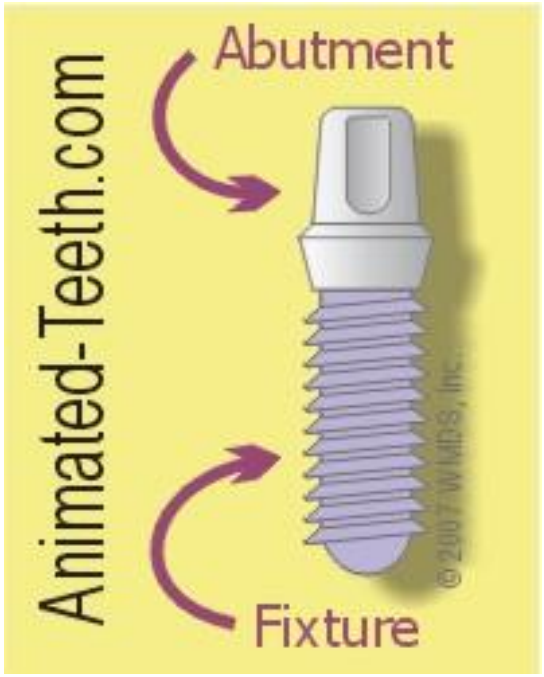
"Out of This World" Applications

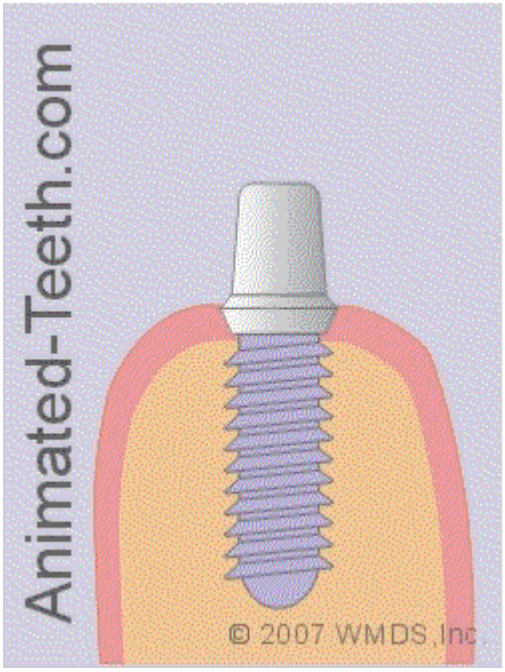
Metal Alloy Implants



Bone forms biological bond with dental implants.

Metal Alloy Implants



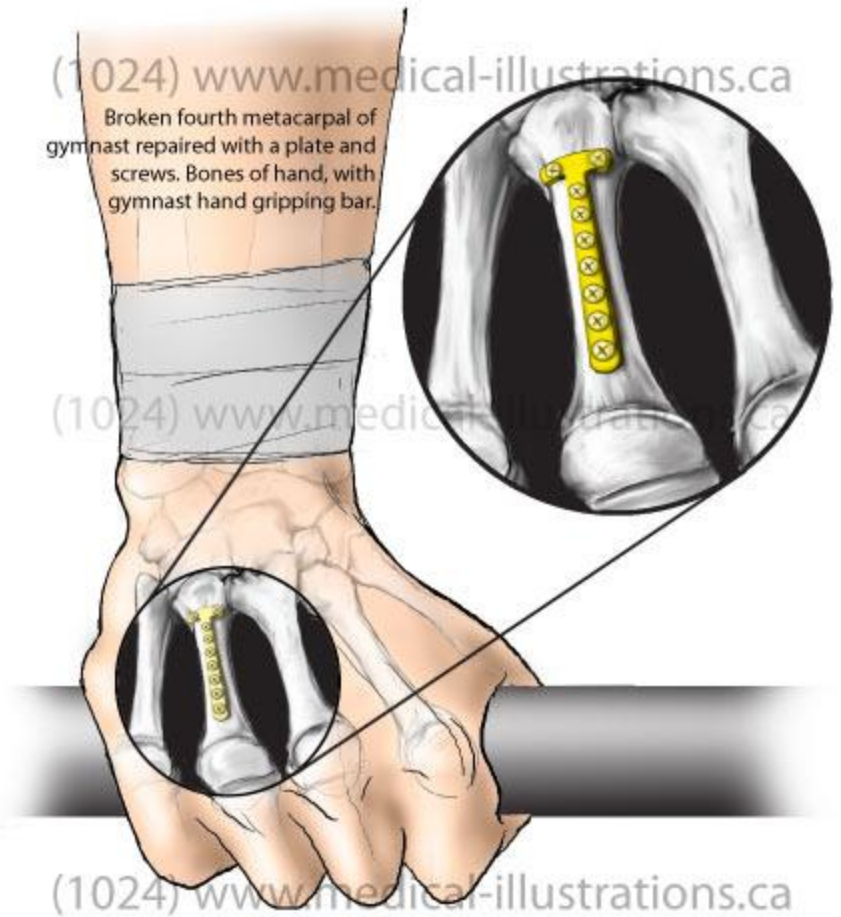


Titanium alloy implant fuses with the jawbone.

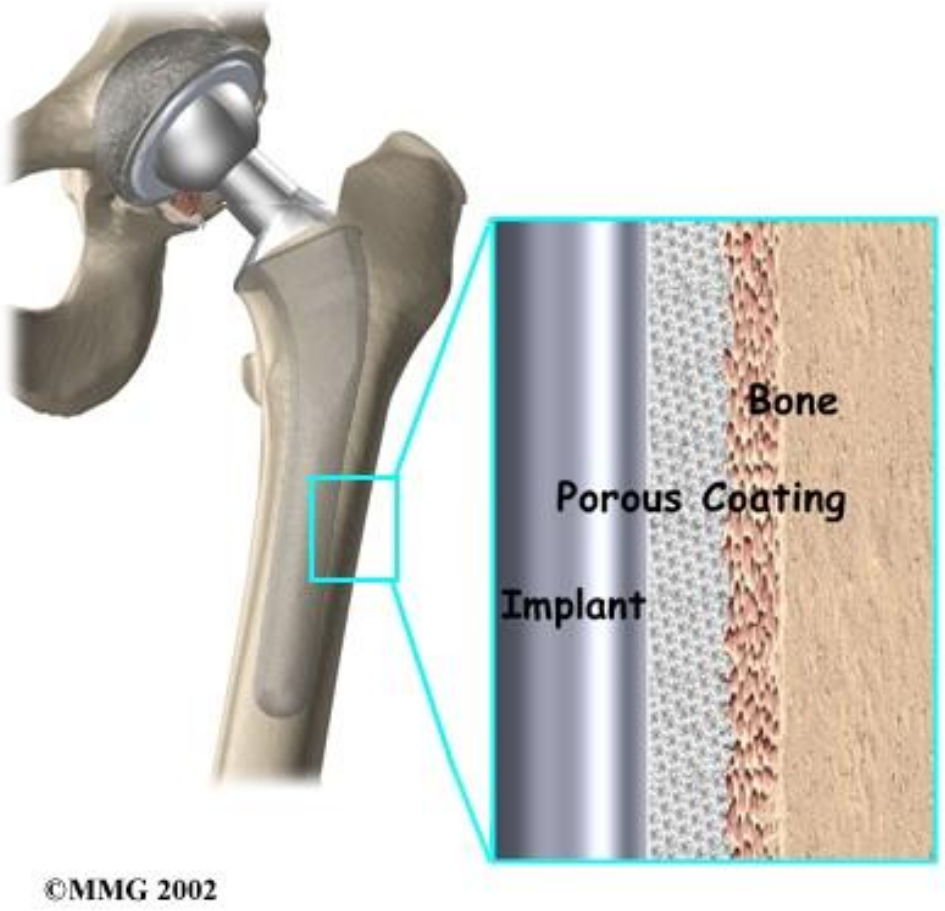
Metal Alloy Implants

Bone screws and plates made of surgical steel + titanium alloys.

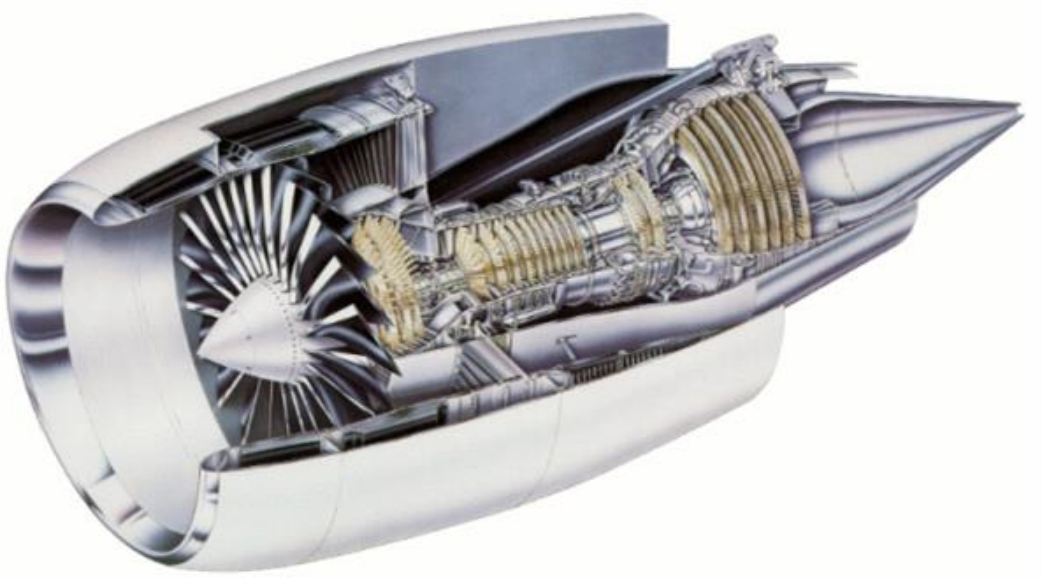
Metal Alloy Implants



Metal Alloy Implants

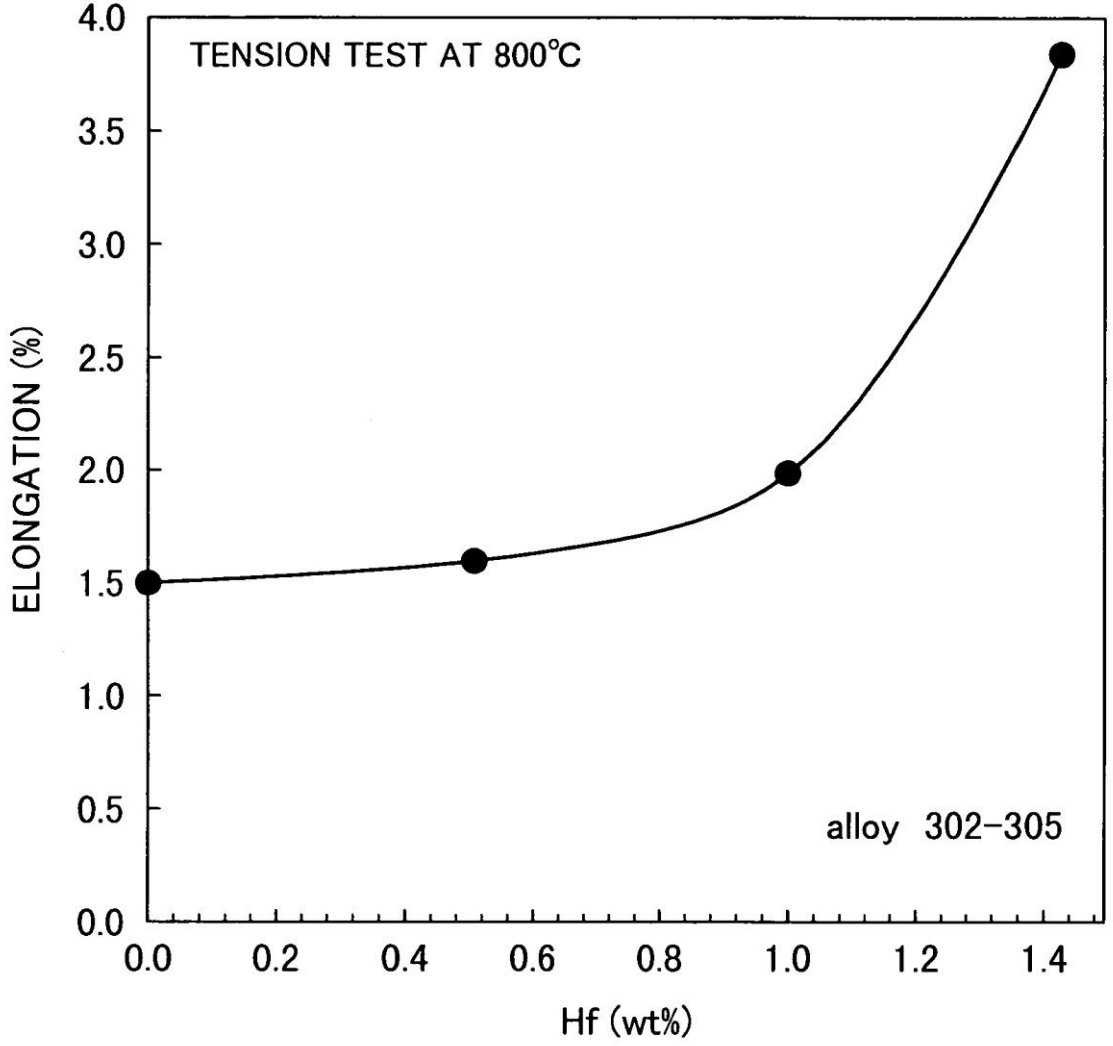


Super Alloys

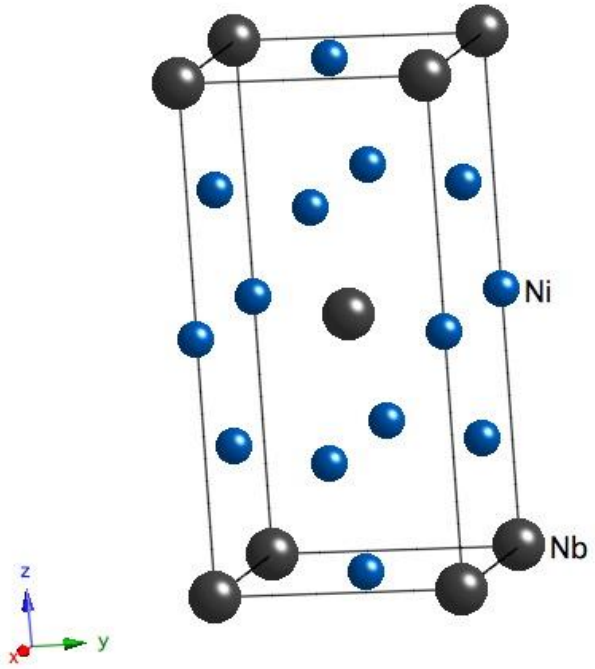


Super alloys are metallic alloys used for long service at elevated temperatures above 650° C (1,200° F).

Super Alloys

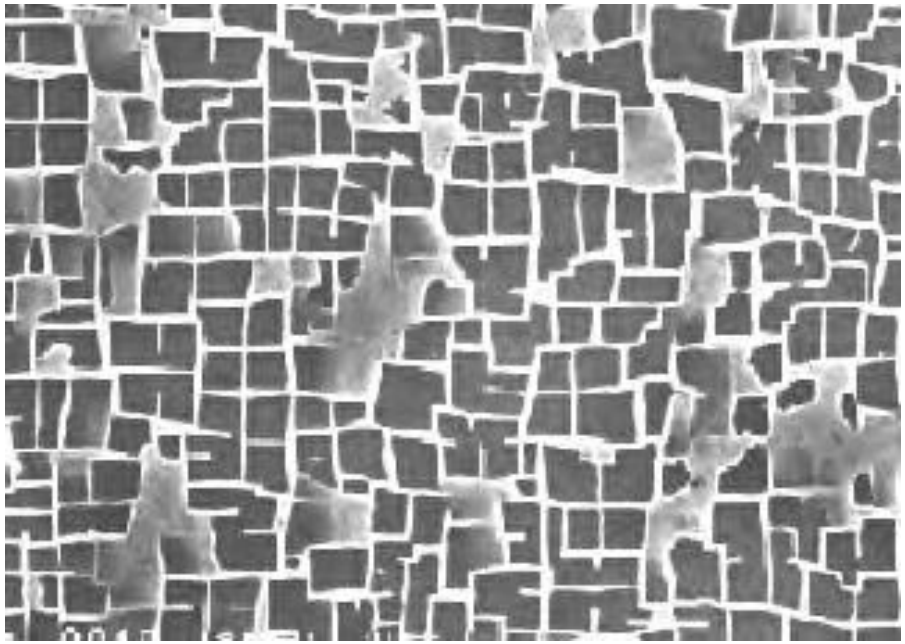


Super Alloys

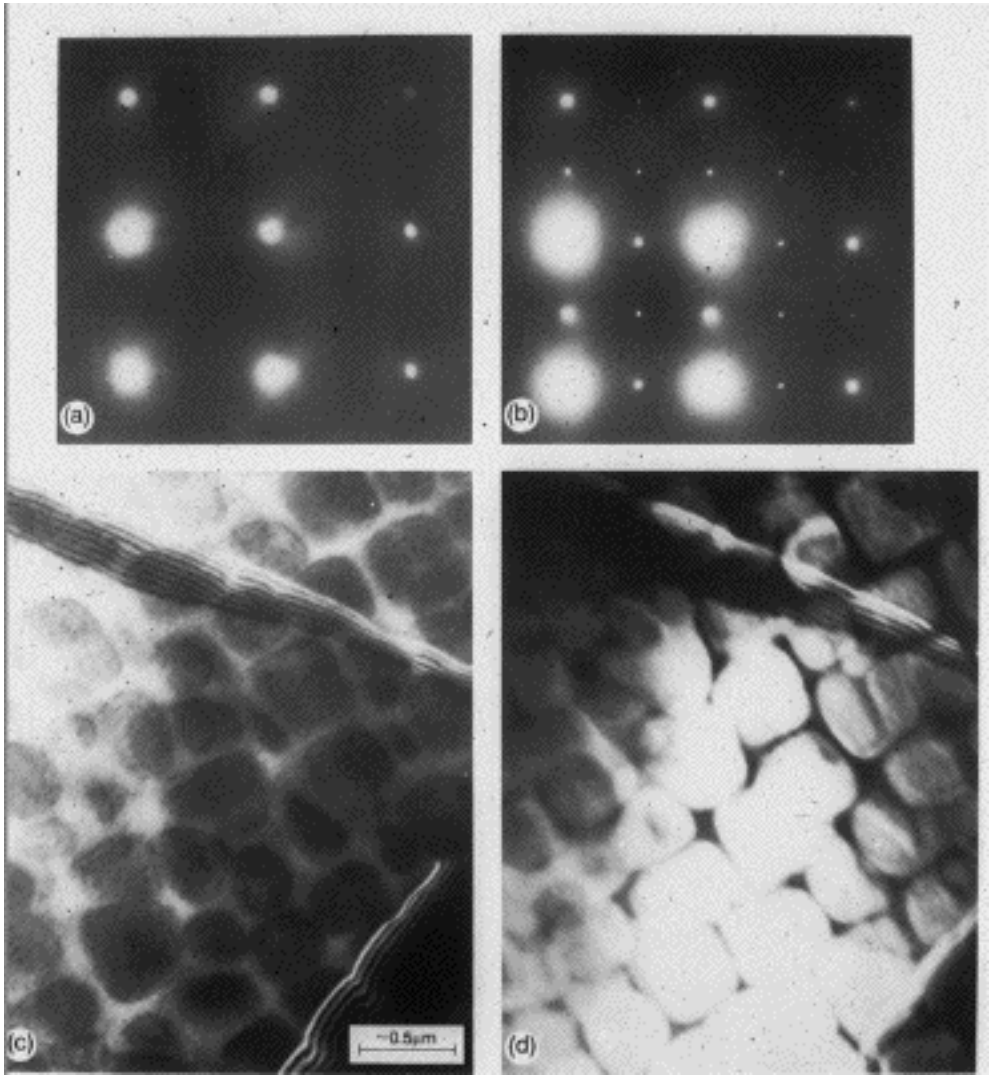


The common super alloys are based on nickel, cobalt or iron.

Super Alloys



Their versatility stems from the fact that they combine this high strength with good low-temperature ductility and excellent surface stability.

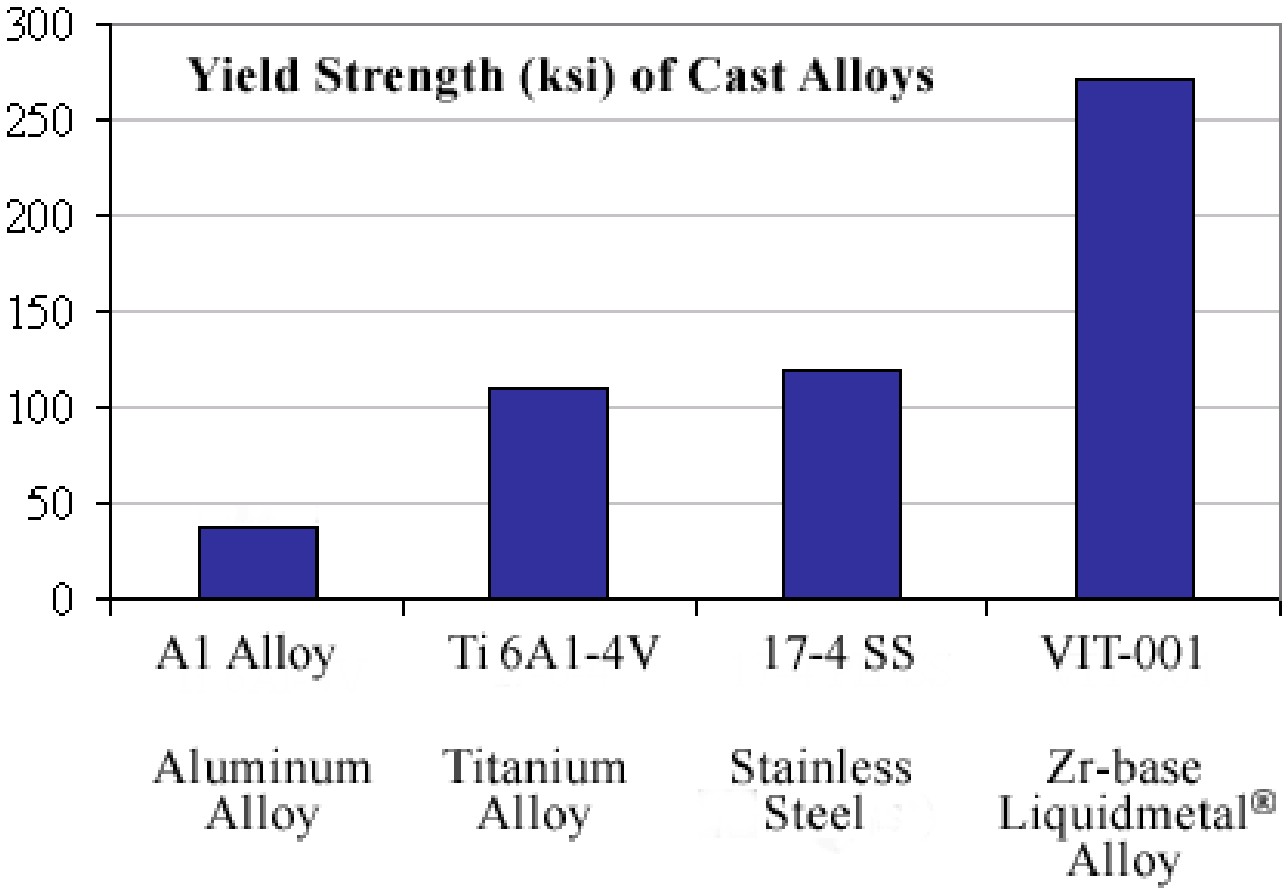


The creep life of the blades is limited by the grain boundaries.

Liquid Metal

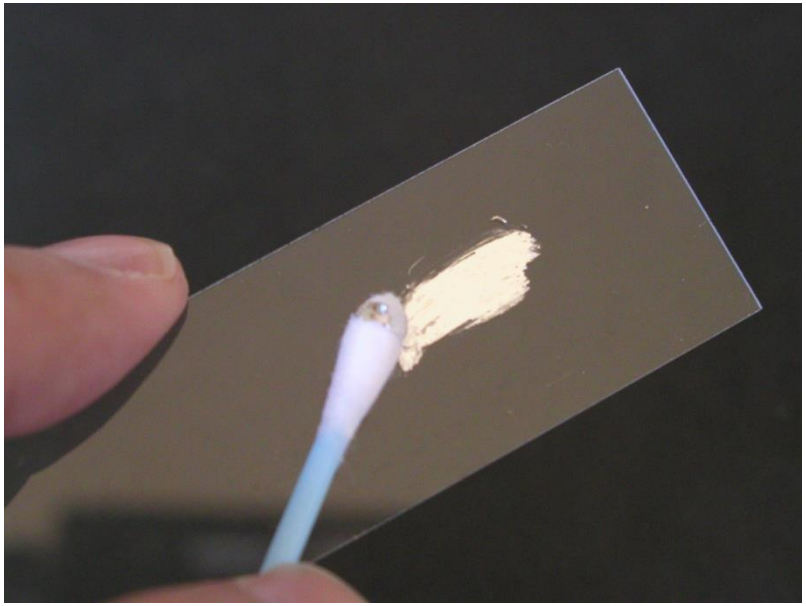
Liquid Metal alloys were conceived in 1992, as a result of a project funded by the California Institute of Technology (CalTech), NASA, and the U.S. Department of Energy.

Liquid Metal



More than twice as strong as titanium & steel!

Liquid Metal



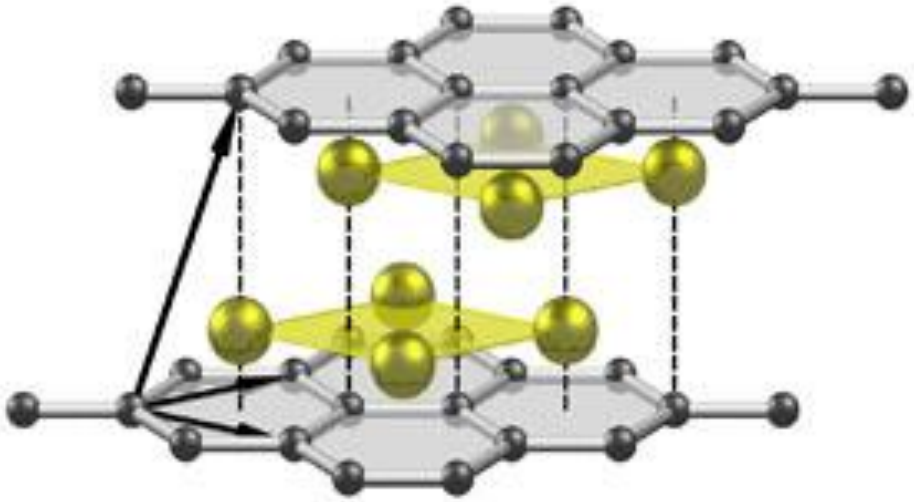
Liquid Metal doesn't rust and it can be cast like plastic and honed to an edge as sharp as glass.

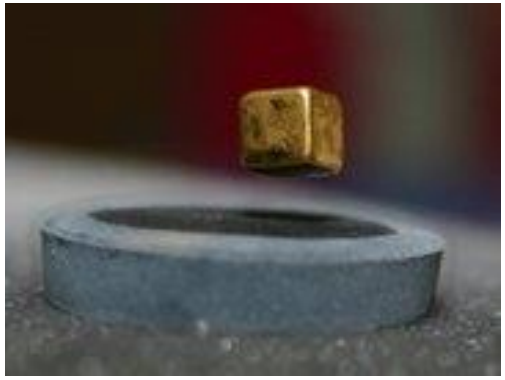
Liquid Metal

Its properties translate into a surface that is scratch, dent, and corrosion resistant, and at the same time provides a high gloss that can be polished to a luxurious jeweler's finish.

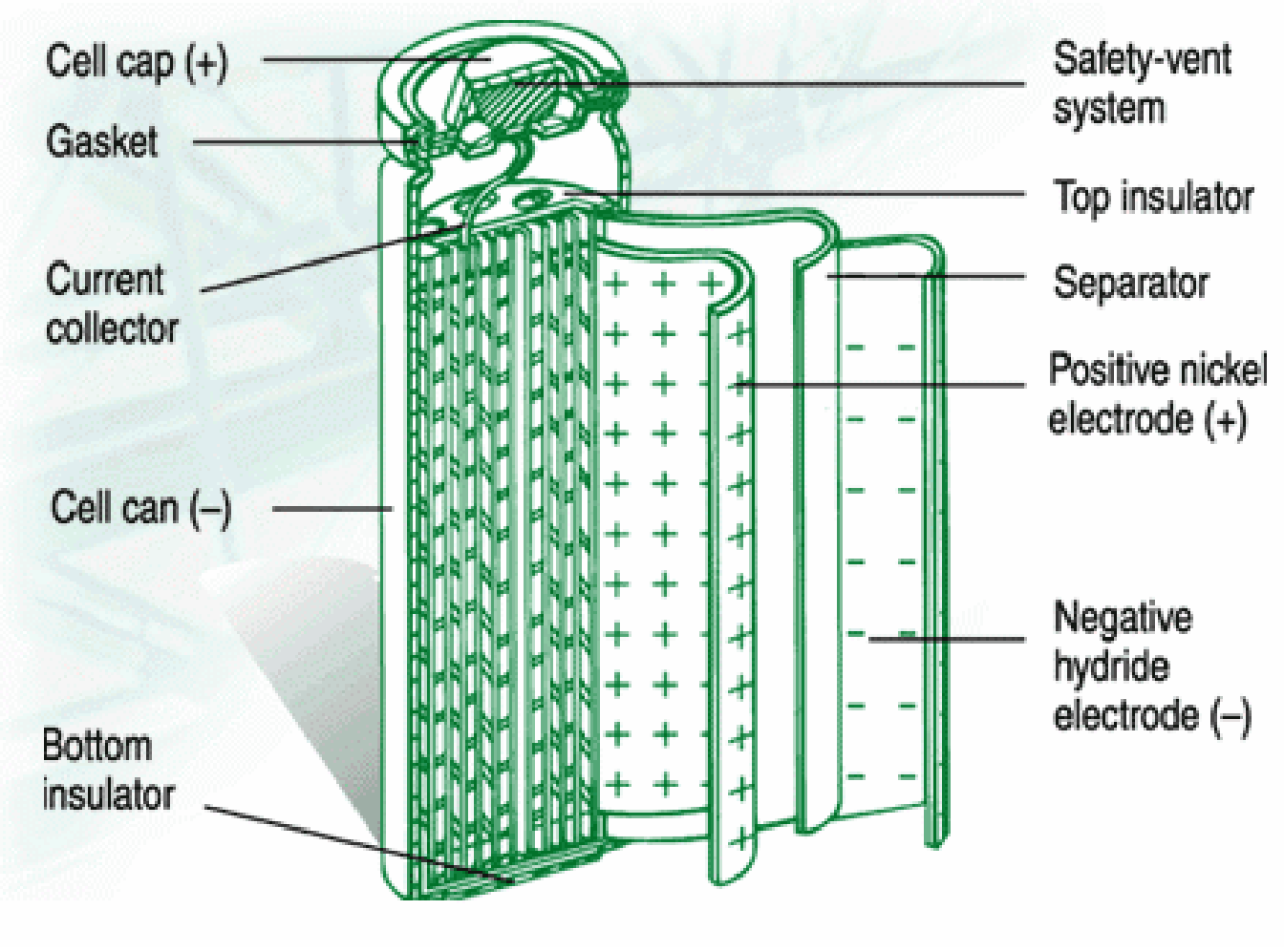

LIQUIDMETAL

Lithium Monoboride (LiB)





Super Battery Alloys



Superconductive Alloys