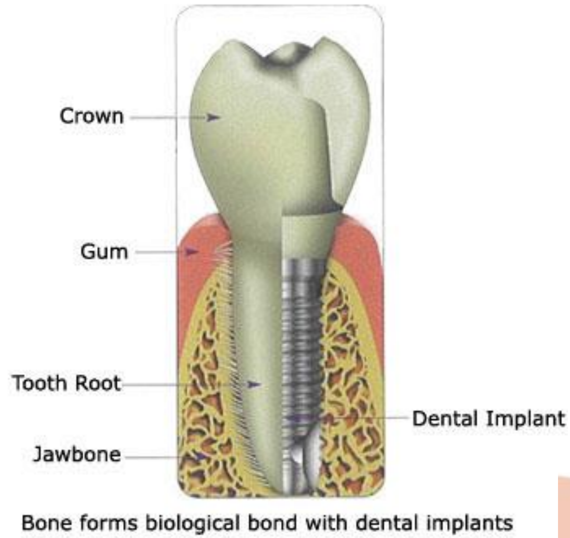
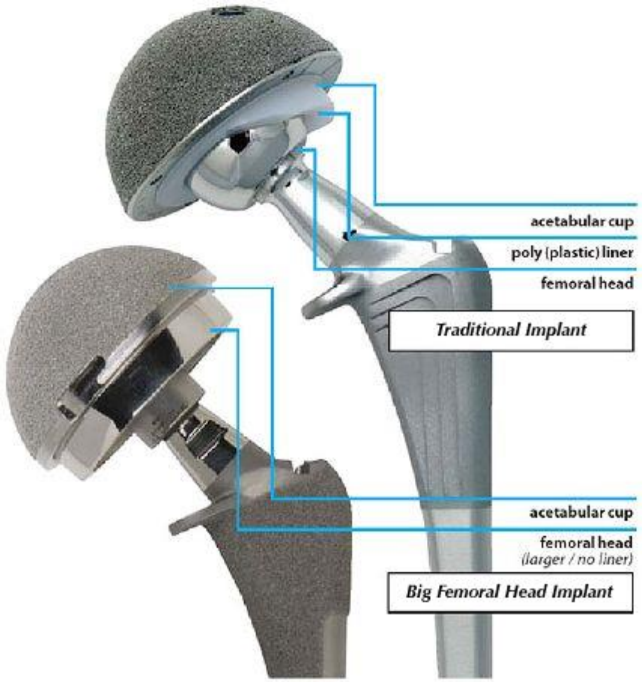
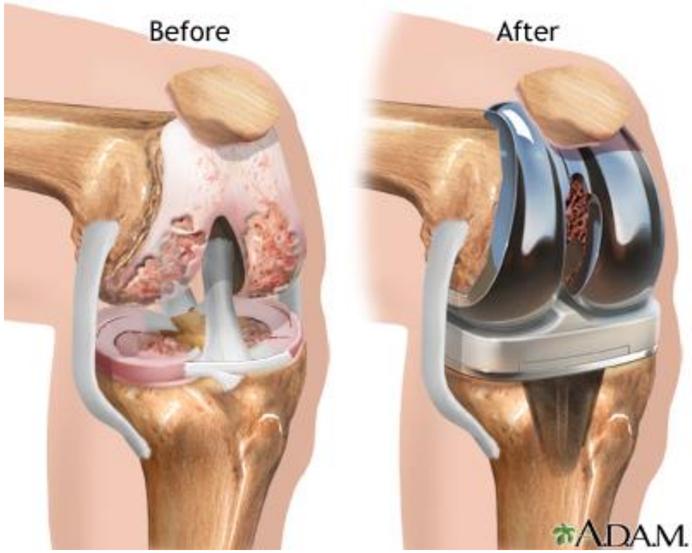
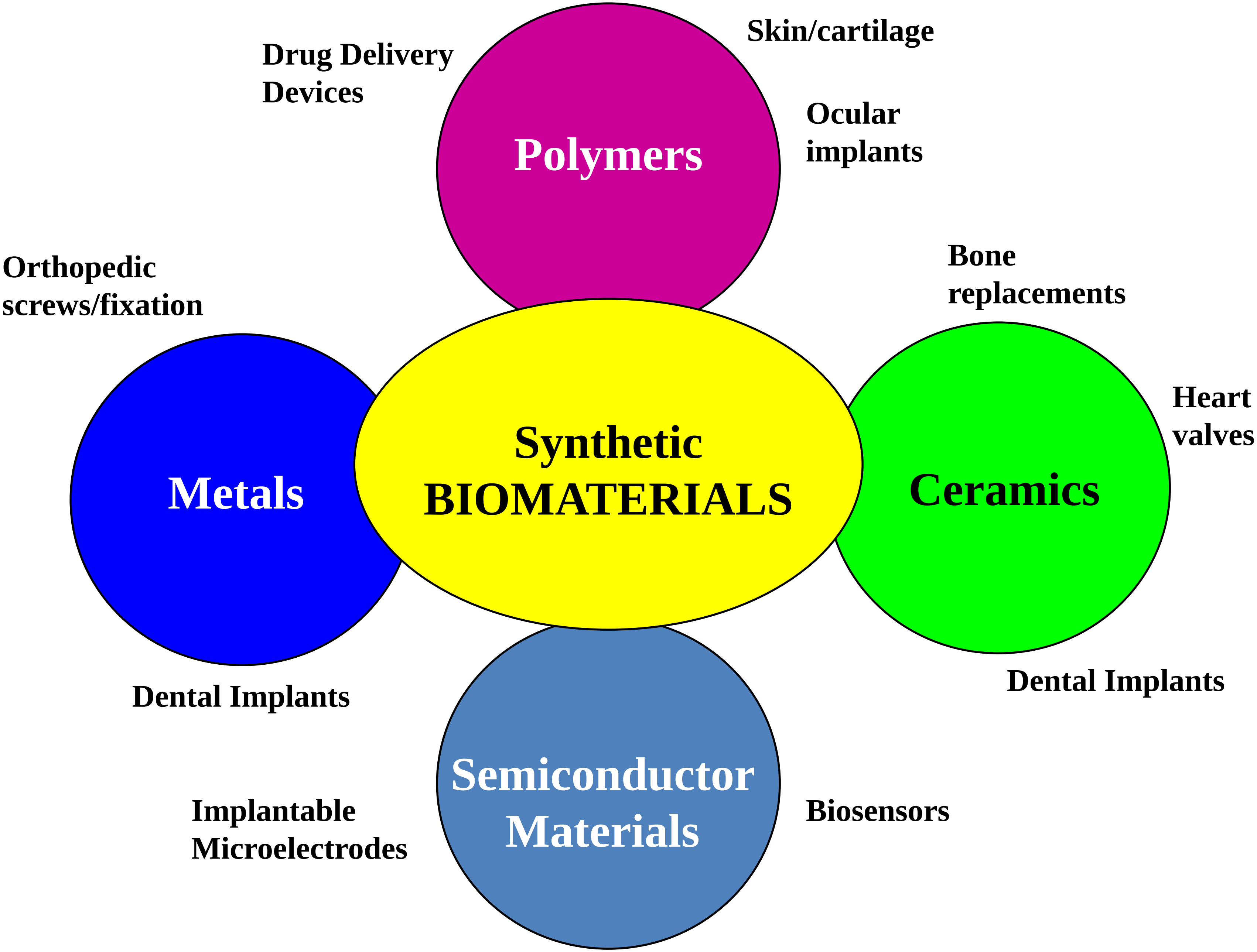
NEW MATERIALS FOR BODY IMPLANTS & PROSTHESES

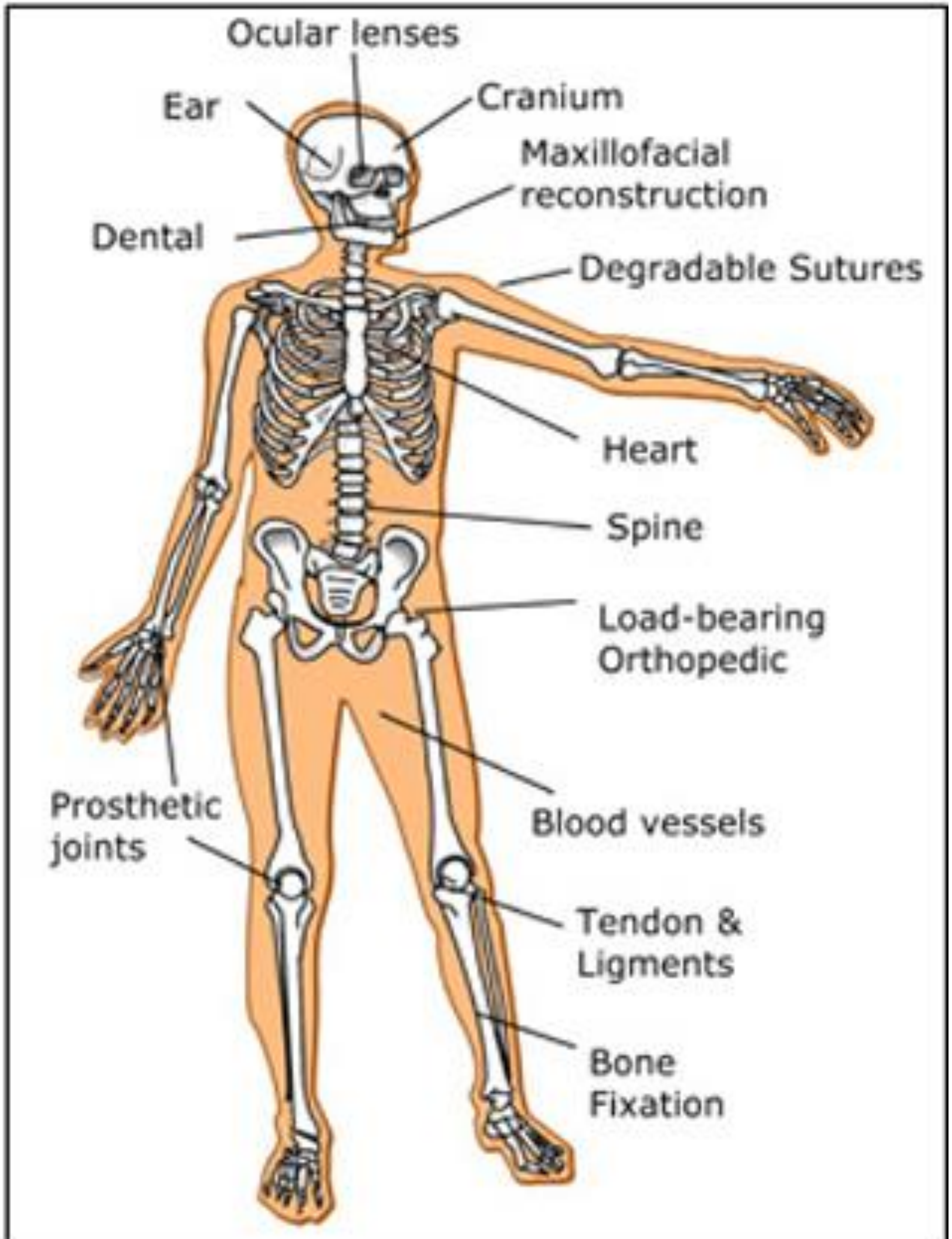






COMPILED BY HOWIE BAUM


Drug Delivery Devices
Skin/cartilage
Polymers
Ocular implants
Orthopedic screws/fixation
Bone replacements
Synthetic BIOMATERIALS
Metals
Ceramics
Heart valves
Dental Implants
Dental Implants
Semiconductor Materials
Implantable Microelectrodes
Biosensors



Biomaterials constructed of metals, ceramics, and polymers have many medical applications.

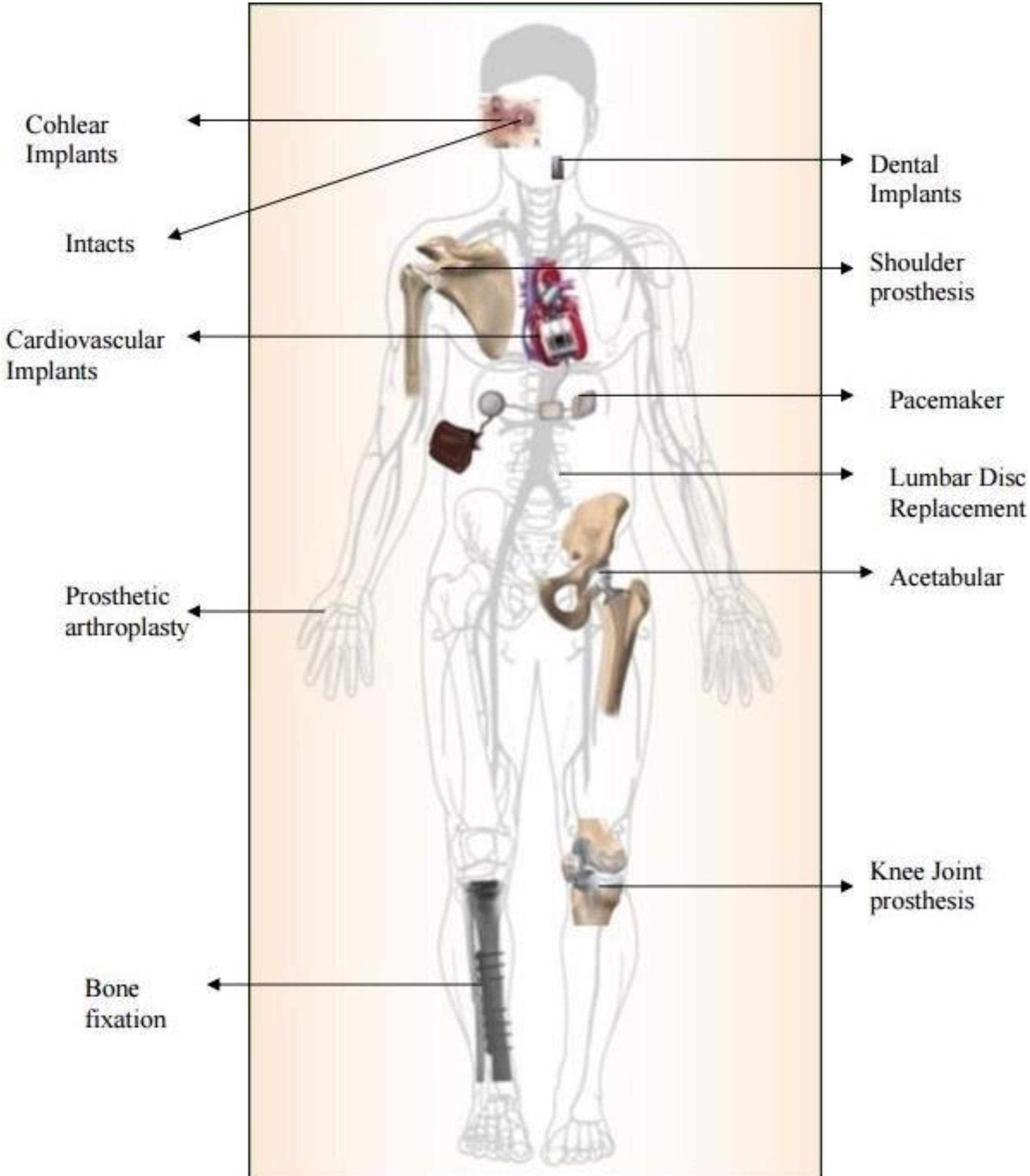
Replace component of living beings

Restores function

Harmonious interaction with the body

Bio-compatibility

Long-term strength


Cohlear Implants
Intacts
Cardiovascular Implants
Prosthetic arthroplasty
Bone fixation
Dental Implants
Shoulder prosthesis
Pacemaker
Lumbar Disc Replacement
Acetabular
Knee Joint prosthesis

Need for Replacement

- Skin - 3 million procedures per year
- Bone - 1 million procedures per year
- Cartilage - 1 million procedures per year
- Blood Vessel - 1 million procedures per year
- Kidney - 600 thousand procedures per year
- Liver - 200 thousand procedures per year
- Nerve - 200 thousand procedures per year

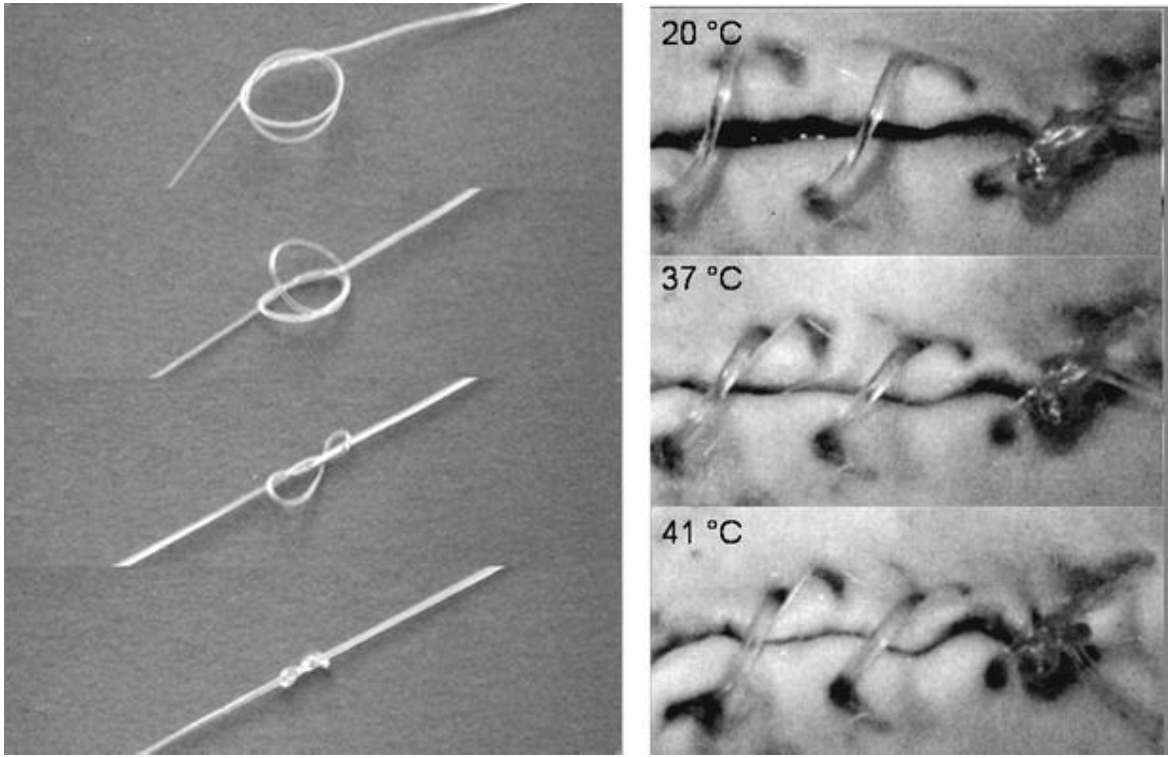
BIOMATERIAL CLASSES

- **METALS - Uses**: orthopedics, fracture fixation, dental and facial reconstruction, and stents.
- **CERAMICS - Uses**: orthopedics, heart valves, and dental reconstruction.
- **COATINGS - Uses**: orthopedics, contact lenses, catheters, and adhesives
- **POLYMERS - Uses**: orthopedics, artificial tendons, catheters, vascular grafts, facial and soft tissue reconstruction.
- **HYDROGELS - Uses**: drug delivery, eye implants, and wound healing.
- **RESORBABLES AND SCAFFOLDS - Uses**: sutures, drug delivery, in-growth, and tissue engineering.

SOME APPLICATION OF BIOMATERIALS

Application	Types of Materials
Skeletel system	
Joint replacement(Hip, knee)	Titanium , Stainless steel, Polyethylene
Bone plate	Stainless steel, Columbiam-Chromium alloy
Bone cement	Acrylic
Artificial tendon and ligment	Hydroxyapatite Teflon, Dacron
Dental implant	Titanium, alumina, calcium phosphate
Cardiovascalar sysem	
Blood vessel prosthesis	Dacron, Teflon, Polyurethane
Heart valve	Reprocessed tissue, Stainless steel, Carbon
Catheter	Silicone rubber, teflon, polyurethane
Organs	
Artificial heart	Polyurethane
Skin repair template	Silicone-collage composite
Artificial kidney	Cellulose, polyacrylonitrile
	Silicone rubber
Senses	
Cochlear replacement	Platium electrodes
Intraocular lens	Acrylic, Silicone rubber, hydrogel
Contact lens	Silicone-acrylate. Hydrogel
Corneal bandage	Collagen, hydrogel

Smart Sutures



(a) A smart surgical suture self-tightening at elevated temperatures (left). A thermoplastic shape-memory polymer fiber was programmed by stretching to about 200% at a high temperature and fixing the temporary shape by cooling. After forming a loose knot, both ends of the suture were fixed in place.

(b) The photo series shows, from top to bottom, how the knot tightened in 20 seconds when heated from 20 to 40°C. (b) Degradable shape-memory suture for wound closure (right).

Desirable Material Properties for Medical Applications

- Biocompatibilty
  - Non-carcinogenic, non-pyrogenic (non-burnable) , non-toxic, non-allergenic, blood compatible, non-inflammatory
- Sterilizability
  - Not destroyed or severely altered by sterilizing techniques such as autoclaving, dry heat, radiation, or with ethylene oxide
- Strong Physical Characteristics
  - Strength, toughness, elasticity, corrosion-resistance, wear-resistance, long-term stability
- Manufacturability
  - Machinable, moldable, or extrudable

Biocompatibility

The specific application must consider the time scale over which the host is exposed to the material:

Material	Contact Time
syringe needle	1-2 s
tongue depressor	10 s
contact lens	12 hr - 30 days
bone screw / plate	3-12 months (or greater)
total hip replacement	10-15 yrs
intraocular lens	30 + yrs

Hydrogels

- Water insoluble, three dimensional network of polymeric chains that are crosslinked by chemical or physical bonding

- Polymers capable of swelling substantially in aqueous conditions (eg hydrophilic – water loving)

- They have a foam network in which water is dispersed throughout the structure

ARE HYDROGELS USED IN ADULT DIAPERS ?

Artificial skin, which is grown in the laboratory, is used to treat patients with extensive skin loss or those that have burns.

The challenge with growing artificial skin is getting the cells to align properly.

Therefore a scaffold must be used for the cells.

The most successful scaffold is lactic acid - glycolic acid copolymer.

The **human skeleton** is the internal framework of the body.

It is composed of around 270 bones at birth – this total decreases to around 206 bones by adulthood after some bones get fused together.

The human skeleton performs six major functions;

1) Support of the body

2) Movement

3) Protection of our inner organs

4) Production of blood cells

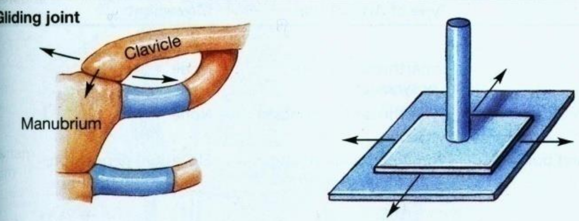
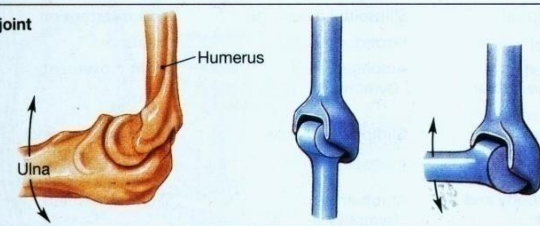
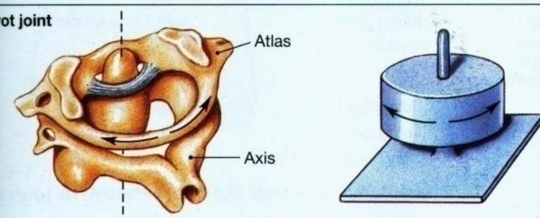
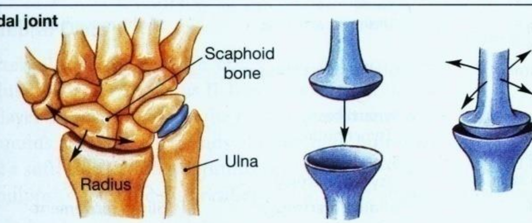
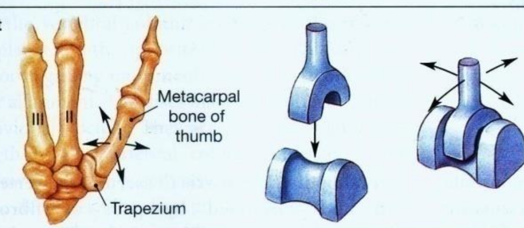
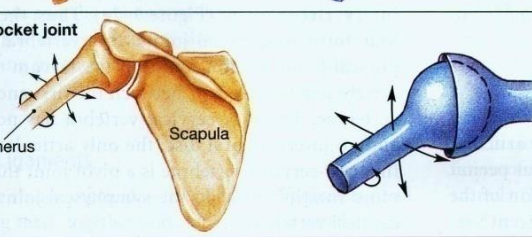
5) Storage of minerals

6) Endocrine regulation

(This is regulation of the glands that produce **hormones** which regulate body **metabolism**, **growth,** tissue function, sleep, and mood.)

TYPES OF BODY JOINT MOVEMENT

A Functional Classification of Synovial Joints

Types of Synovial Joints	Movement	Examples
Gliding joint 	Slight nonaxial or multiaxial	• Acromioclavicular and claviculosternal joints • Intercarpal and intertarsal joints • Vertebrocostal joints • Sacroiliac joints
Hinge joint 	Monaxial	• Elbow joint • Knee joint • Ankle joint • Interphalangeal joint
Pivot joint 	Monaxial (rotation)	• Atlas/axis • Proximal radioulnar joint
Ellipsoidal joint 	Biaxial	• Radiocarpal joint • Metacarpophalangeal joints 2–5 • Metatarsophalangeal joints
Saddle joint 	Biaxial	• First carpometacarpal joint
Ball-and-socket joint 	Triaxial	• Shoulder joint • Hip joint

Synovial Joints - There are 6 types of synovial joints.

They have varying shapes, but the important thing about them is the movement they allow. Joints determine what positions our bodies can take.

The 6 types of synovial joints are: Hinge, Pivot, Ball & Socket, Ellipsoid, Saddle, and Plane.

Hinge joint - The hinge is a very simple joint. It allows movement only on one axis.

The head of one bone wraps around the cylindrical head of the other, allowing a very stable rotation.

Like the hinges on a door, it’s only but important ability is to open or close.

The best example of it, is the elbow.

So if the elbow only allows flexion and extension, how is it that we are able to twist the forearm? Well, let's take a look at the next joint.

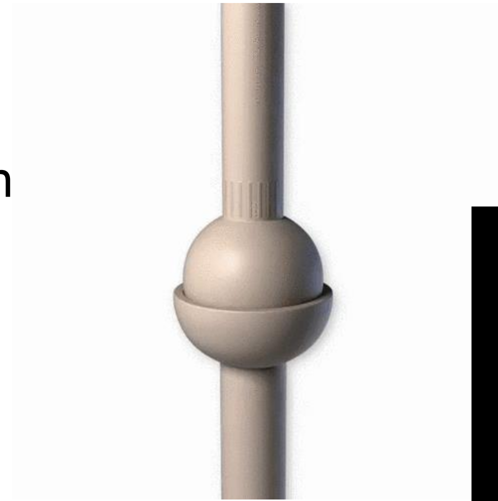
Pivot joint - The pivot joint also allows rotation at only one axis. However, it rotates along the long axis.

A cylindrical bone fits into a ring of bone and ligament, like with the joint just below the elbow.

The cap on the radius bone fits nicely into this notch on the ulna bone.

Ligaments complete the ring, holding the bone in place and allow the radius only to rotate inside of it.

Ball & Socket joint



The ball & socket is the champion of all joints.

It's structure is just like how it sounds. A ball inside of a socket.

This simple and effective structure allows it to move in all jjaxes

The two ball and socket joints of the body are at the hip and the shoulder.

The hip has a deep socket, which gives it stability, but limits some range of motion. The shoulder joint has a shallower socket, which gives it greater range of motion, but takes away some stability. Maybe that's why a dislocated shoulder is so common.

Ellipsoid joint

The ellipsoid joint is very similar to a ball & socket.

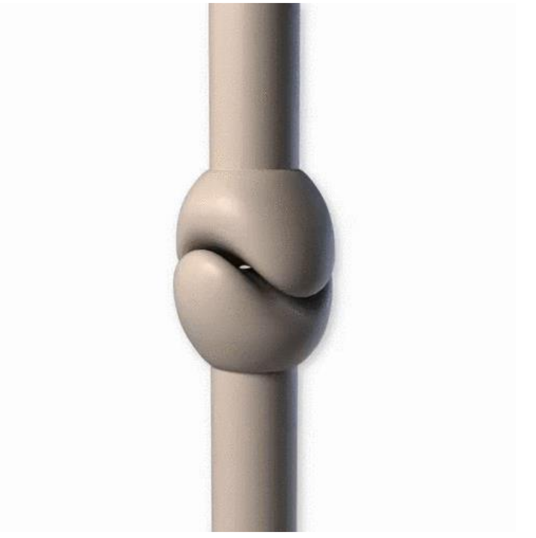
However, the ligaments and its oval shape prevent rotation.

But it still has the ability to rotate on two axes,
.
The ball, or oval head also slides inside the socket. When it rotates along the wider plane, it slides to stay inside the socket.

A great example of an ellipsoid joint is the wrist.

The group of carpal bones rotate inside the socket of the radius.

Saddle joint - The saddle joint is similar to the ellipsoid joint, but the rotation is limited mostly because of the bone structure.

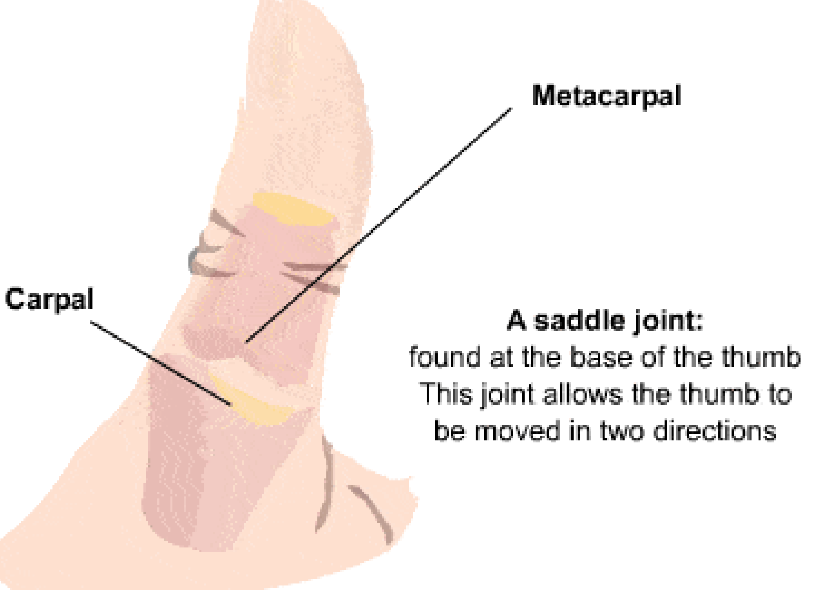


The structure of the saddle is very interesting. Both bones have a concave and convex surface.

Convex means the surface sticks out, like a hill. Concave means the surface curves in, like a hole or a cave.

The concave plane of one fits on the convex plane of the other.

The legs of the top piece, which wrap around the body of the bottom piece allow a rotation this way. The body of the top piece can glide inside of the legs of the bottom piece.



An example of a saddle joint on the body is the joint of the thumb.

Plane joint

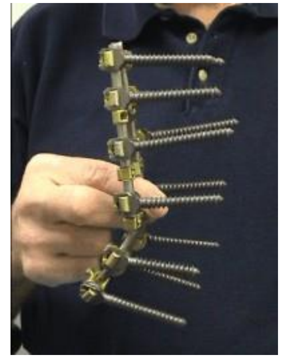
It’s basically two flat-ish surfaces, one on top of the other. These surfaces can glide or rotate.

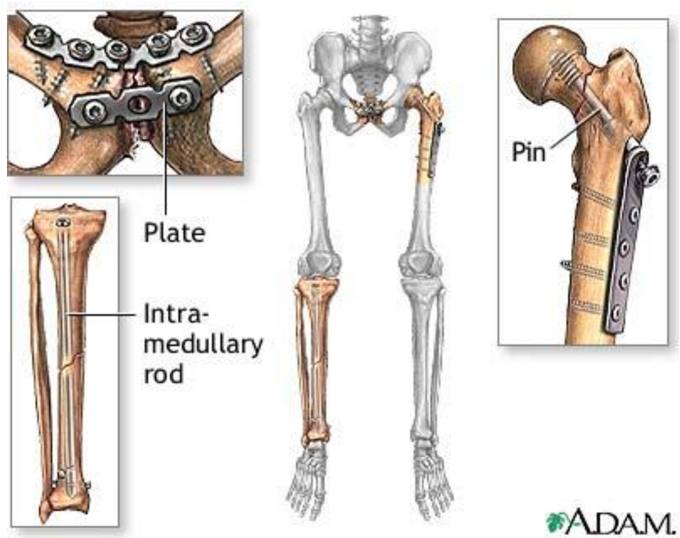
They usually come in groups, like the carpals of the hand and the tarsals of the foot

It is also part of the scapula bone in our shoulders, that lets us elevate our shoulders.

Ligaments hold these bones together, but might allow some rotation and gliding.

Biomaterials – Metals





Biomaterials – Metals

Material	Applications
316, 316L Stainless Steel	Fracture fixation Joint Replacement Spinal Instruments Surgical Instruments
Pure Titanium Titanium with small amounts of Aluminum and Vanadium	Bone and Joint Replacements Dental Implants
Columbium - Chromium Alloys	Bone and Joint Replacements Dental Implants Heart Valves
Gold Alloys	Heart Valves

Vitallium

- Cobalt, chromium, Molybdenum, nickel, manganese, and silicon for strength

- LOW Corrosion
  - Protective oxide film on the surface
  - Greatest tensile strength
  - Difficult to bend and shape

- Creates more of an artifact (image) on CT scan than stainless steel

- No magnetic properties

Gold


Contour Gold

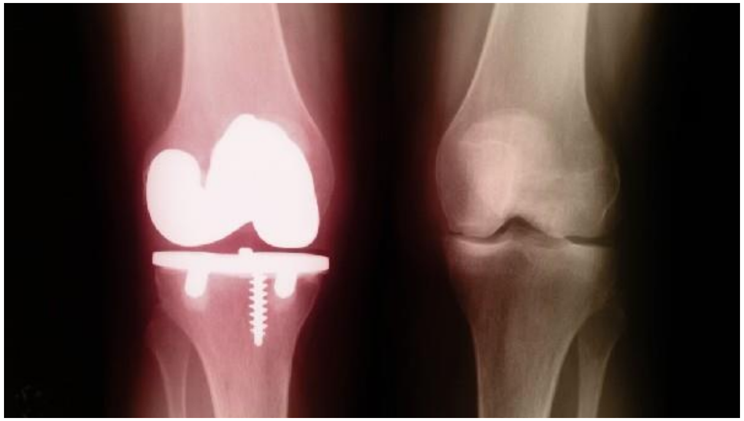
- Resistant to corrosion
- Poor strength
- High cost
- It’s only use outside of dentistry is in upper eyelid implantation for facial nerve dysfunction

BIOGLASS

Doctoring broken bones in the future could be easier and simpler – thanks to a **metallic glass material called Bioglass** that can be used to **make dissolvable screws, pins or plates.**

The components of the alloy were adjusted to **60% magnesium, 35% zinc and 5% calcium, molded in the form of metallic glass.** This is made by rapid cooling of the combined mixture of molten metals.

It's porous structure appears as bone to the body, so tissue will grow into the material and around it. As the bone re-grows and heals, the Bioglass safely degrades away, only leaving the new repaired bone.

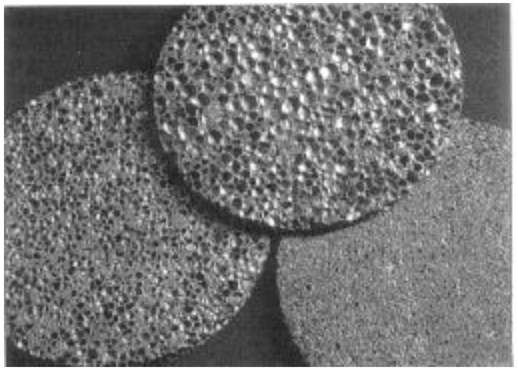


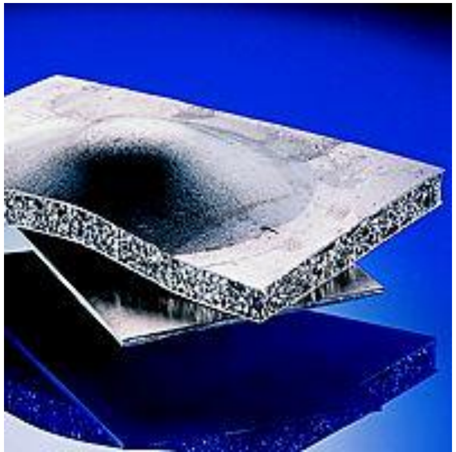
METAL FOAMS

When we design and build large load-bearing structures, we uses dense solids; steel, concrete, glass.

When nature does the same, she generally uses cellular materials; wood, bone, coral. There must be good reasons for it.

Metallic foams are a relatively new class of material that offer manufacturers significant potential for lightweight structures, for energy absorption and for thermal management.





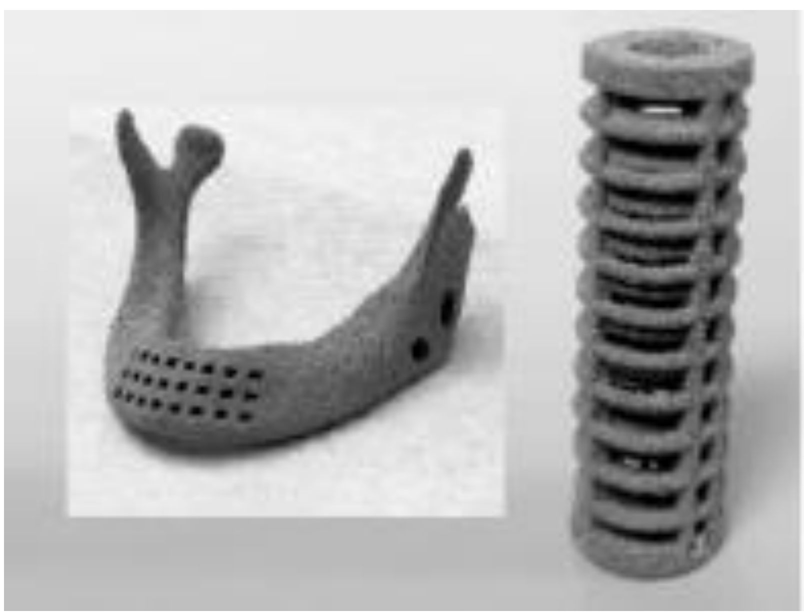
Metal foam is solid but very porous

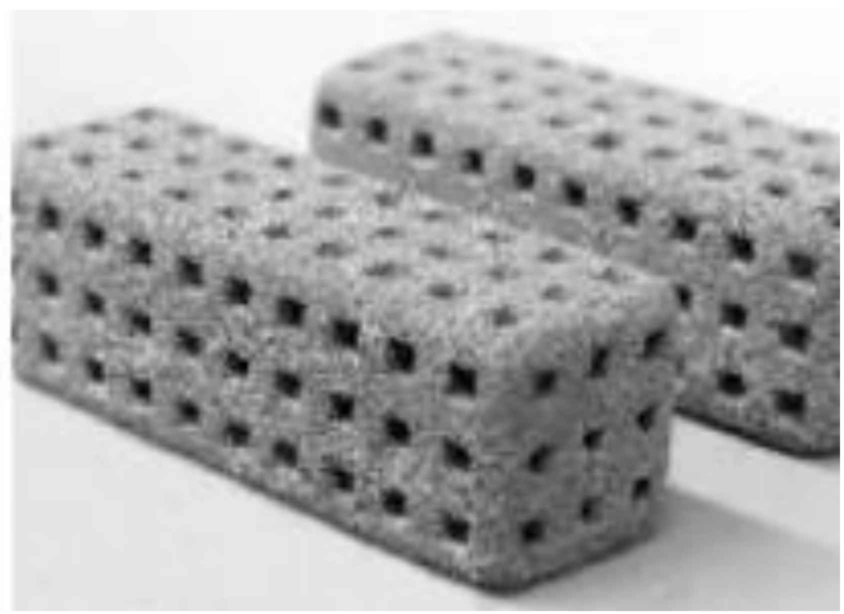
Current implants for cranio-maxillofacial bone (such as a jaw bone), reconstruction often require secondary removal surgeries.

Magnesium metal foams or 3D printed porous shapes can be formed into patient specific scaffolds, for bone regeneration. Over time, the bone grows into the scaffold and the Magnesium slowly dissolves away.

This can eliminate the need for secondary removal surgeries.

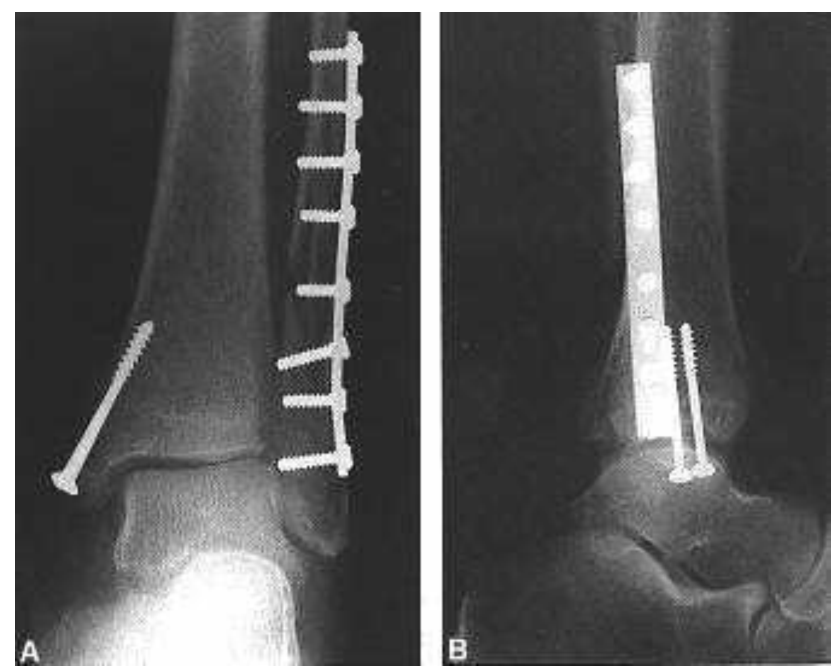
Magnesium alloys (mixtures) such as 98% magnesium and 2% calcium, have better mechanical properties and corrosion resistance, than pure magnesium by itself.





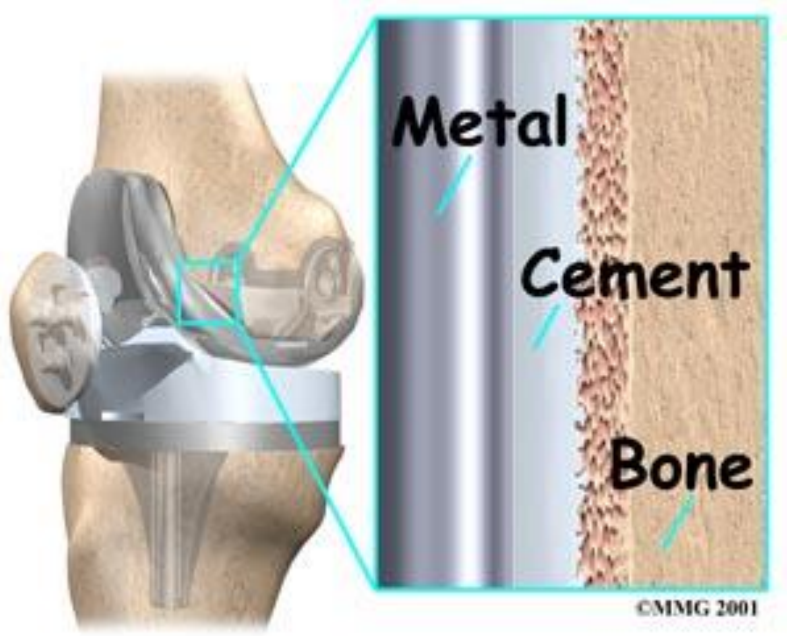
Implant Fixation Methods

- Screws – most are made of Type 316 Stainless Steel
  - Do not ensure tightness regardless of how many screws are present and can result in *loosening*
  - Only suitable for temporary fixation (e.g. fracture fixation)



Implant Fixation Methods

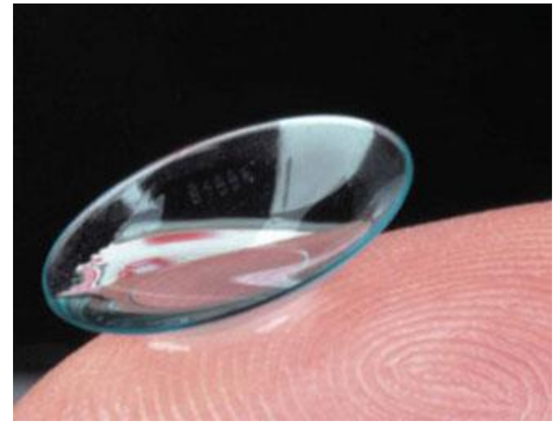
- Bone Cement
  - Gap filling agent
  - Polymethylmethacrylate (PMMA) (Acrylic) which is polymerized in place
  - Distributes load over largest possible area (low contact stresses)
  - Provides mechanically interlocking between implant and bone
  - <u>Problems</u>: monomers are toxic, polymerization process is exothermic (generates heat) and cement is generally brittle

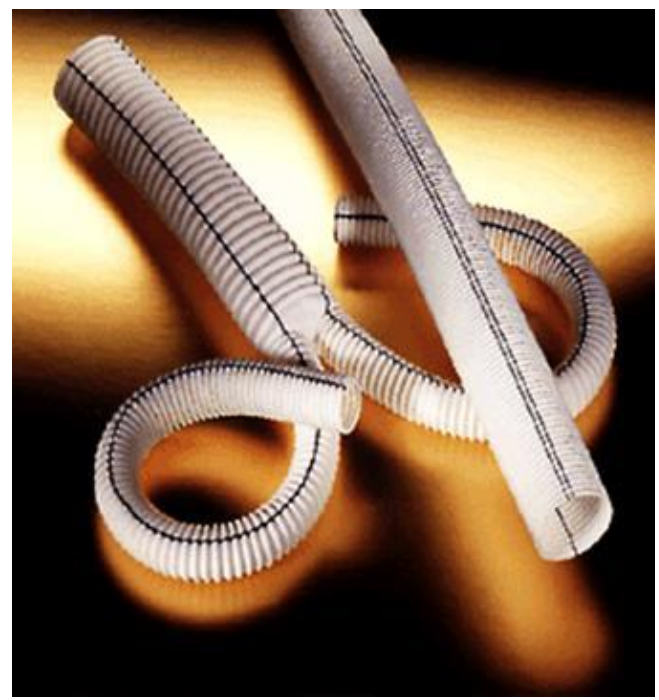


Implant Fixation Methods

- Bone Ingrowth
  - Porous coats, grooves and/or meshes
  - Good for long-term fixation
  - Relative motion must be restricted to ensure bone ingrowth
  - Pore size has a distinct effect on the amount of ingrowth
  - Common approach is to create a layer of partially sintered beads on the surface of the implant

Biomaterials – Polymers



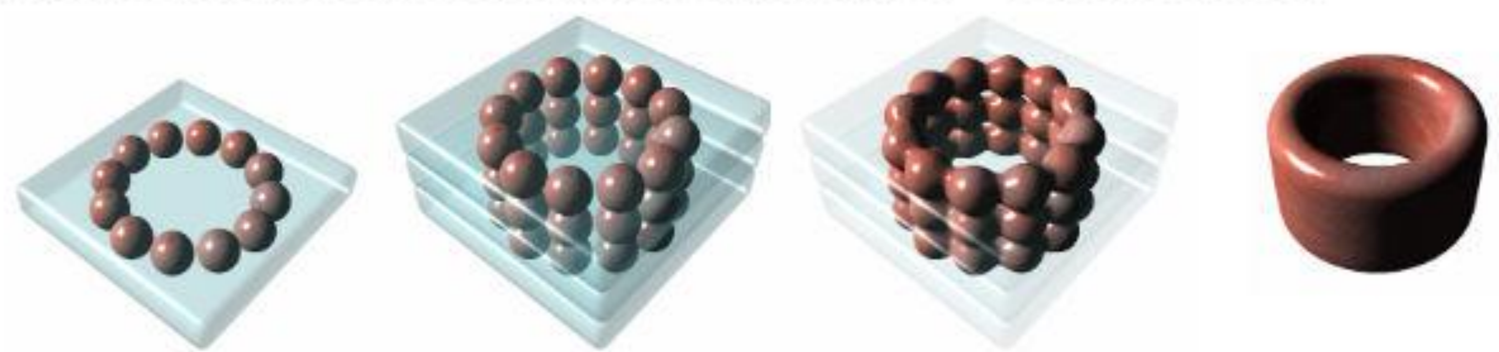


Biomaterials – Polymers

Material	Applications
Ultra High Molecular Weight Polyethylene (UHMWPE)	Joint Replacement Bearings
Polypropylene	Sutures, MCP Joints
Poly tetra fluoro ethylene (PTFE) (Teflon)	Vascular Prosthetics
Polyesters	Vascular Prosthetics, Drug Delivery, Sutures, Ligament Grafts
Polyurethanes	Vascular Prosthetics, Heart Valves, Catheters
Polyvinylchloride (PVC)	Catheters
Poly methyl methacrylate (PMMA)	Implant Fixation
Silicones	Ophthalmology
Hydrogels	Ophthalmology
Polylactic and Polyglycolic Acid	Resorbable Devices, Drug Delivery

What is 3D bioprinting?

- Bioprinters work in almost the exact same way as 3D printers, with one key difference. Instead of delivering materials such as plastic, ceramic, metal or food, they deposit layers of biomaterial, that may include living cells, to build complex structures like blood vessels or skin tissue.
- Well, every tissue in the body is naturally made up of different cell types. So the required cells (kidney cells, skin cells and so on) are taken from a patient and then cultivated until there are enough to create the 'bio-ink', which is loaded into the printer. This is not always possible, so, for some tissues, adult stem cells—which can develop to form the cells required in different tissues—can be used.



[A] Bioink spheroids printed into layer of biopaper gel

[B] Additional layers printed to build object

[C] Bioink spheroids fuse together and biopaper dissolves

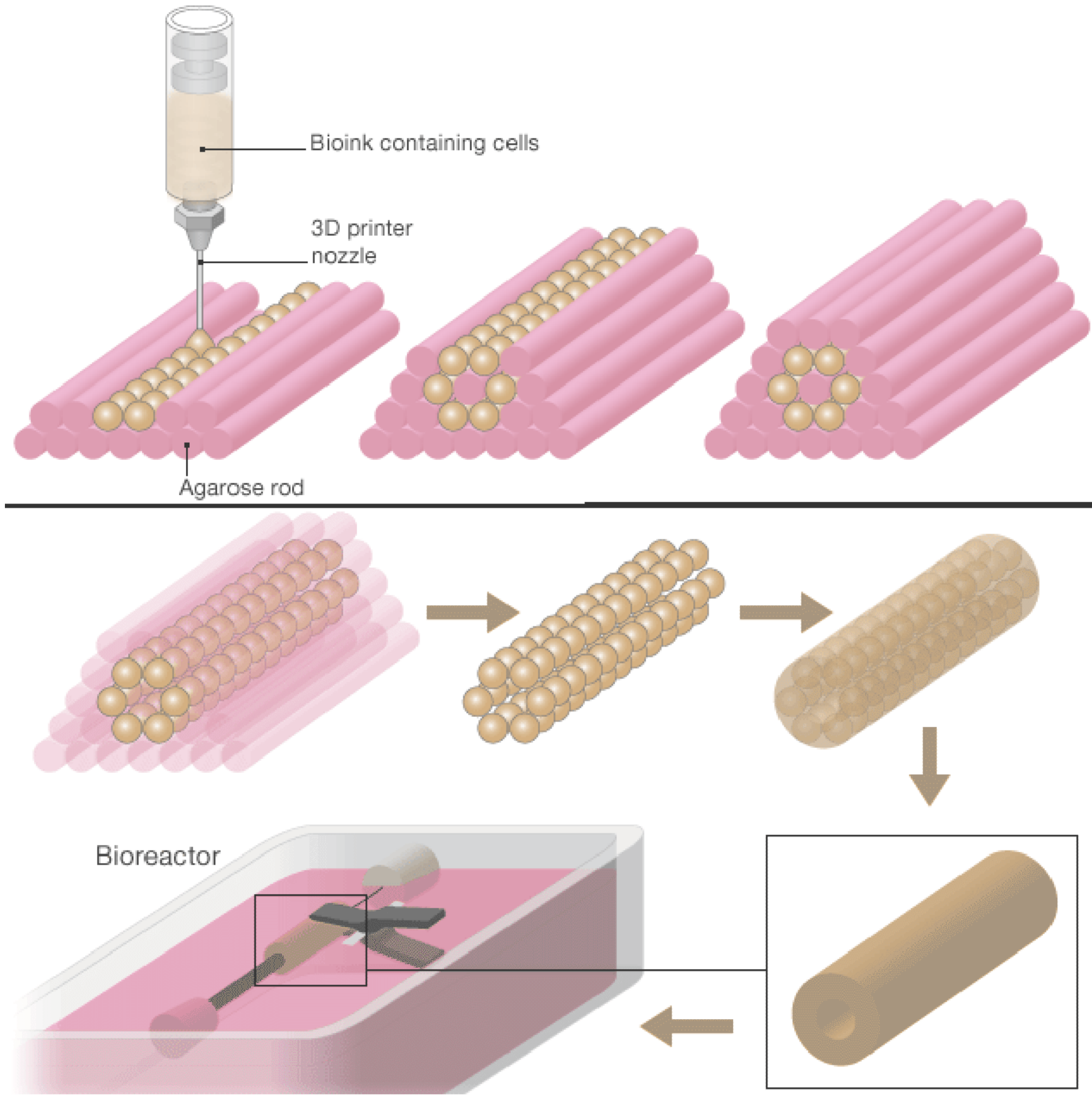
[D] Final living tissue

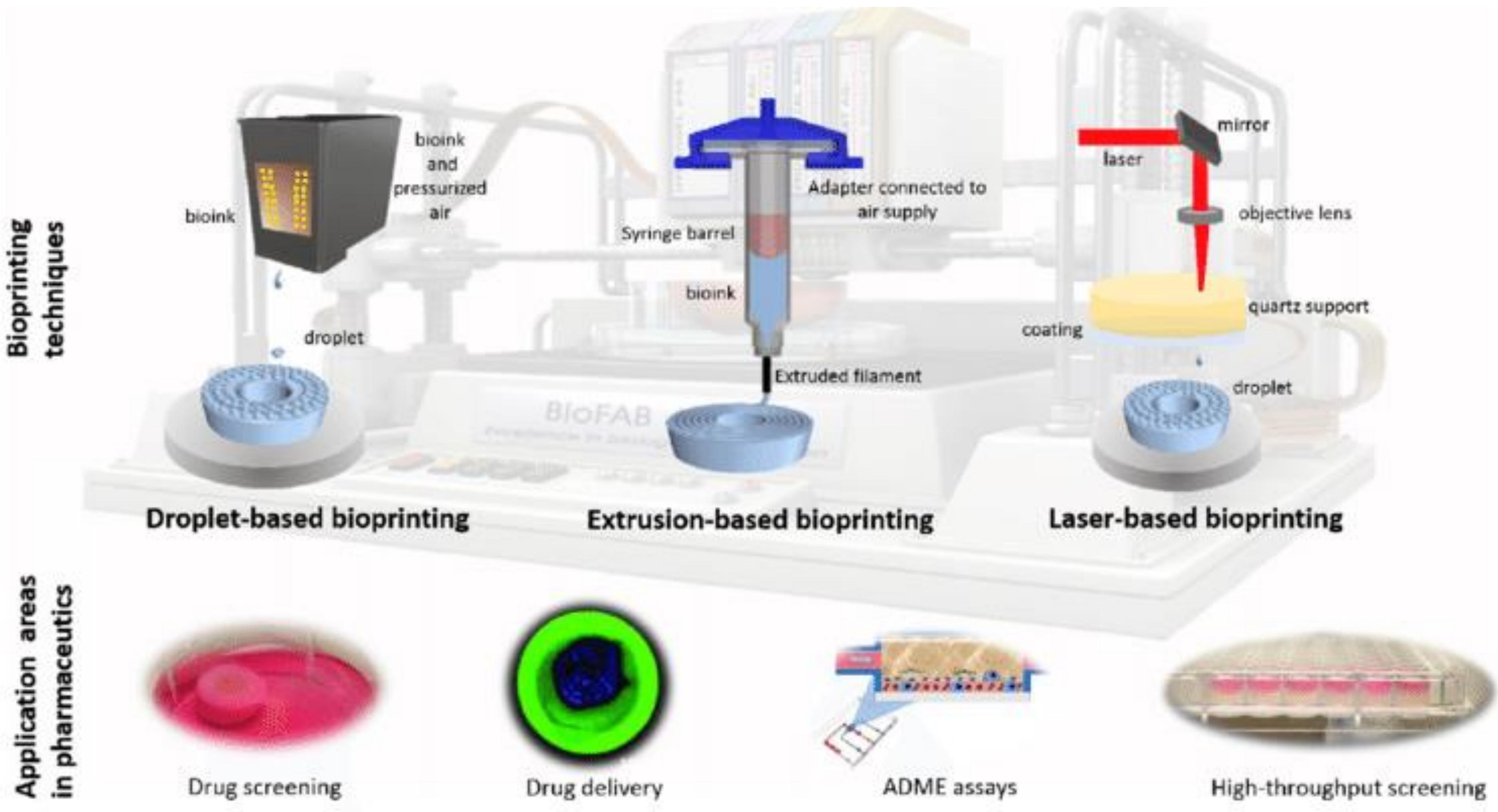
3D PRINTING OF BODY PARTS

One of the uses for 3D Printing technology is a printer that can build body parts from body (usually stem) cells, with a hydrogel material!

It is loaded with cartridges of “bio-ink” a substance that acts as a kind of scaffolding for the cells to retain their shape.

A sophisticated computer is linked to the printer that is pre-programmed with the 3D blueprint of whatever is being made. The computer instructs the printer to lay down two dimensional layers of bio ink and cells that eventually form into the 3D body part.





Bioprinting techniques
bioink
bioink and pressurized air
droplet
Syringe barrel
Adapter connected to air supply
bioink
Extruded filament
mirror
laser
objective lens
quartz support
coating
droplet
BioFAB
Droplet-based bioprinting
Extrusion-based bioprinting
Laser-based bioprinting
Application areas in pharmaceutics
Drug screening
Drug delivery
ADME assays
High-throughput screening

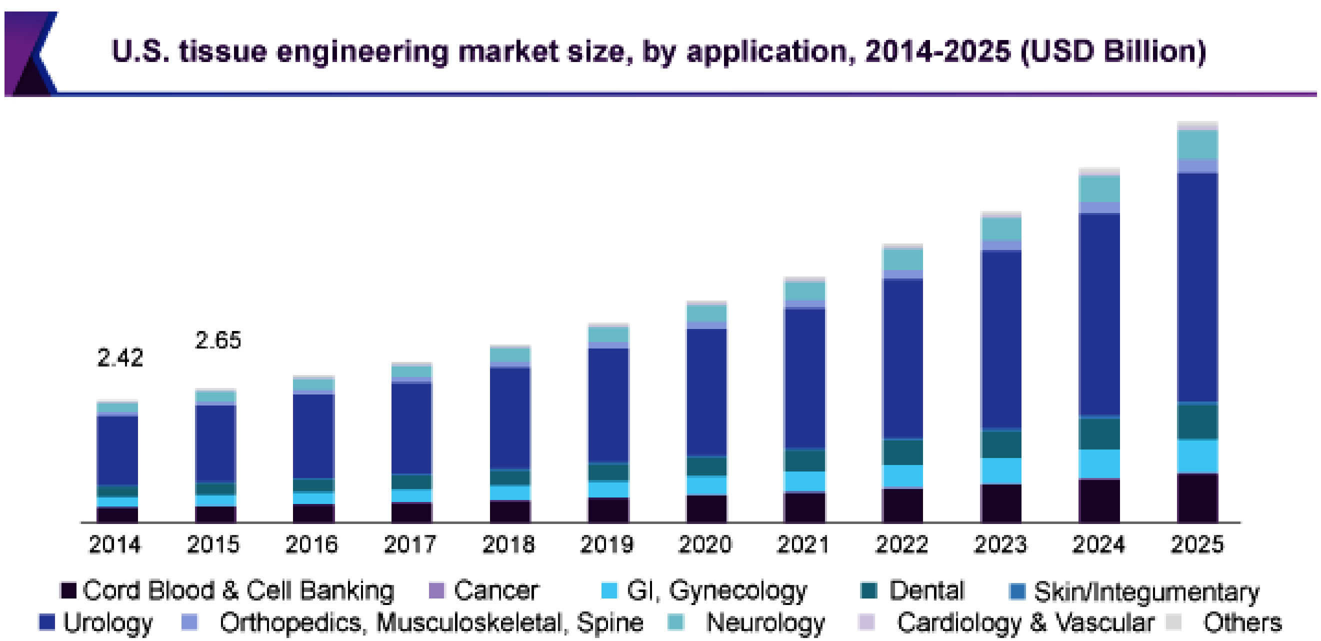
Scaffolds for tissue engineering - Future directions

The challenge of tissue engineering is to mimic what happens in nature. Attempts are being made to engineer, in the body, practically every tissue and organ in the body.

Work is proceeding in creating tissue-engineered liver, nerve, kidney, intestine, pancreas and even heart muscle and valves.

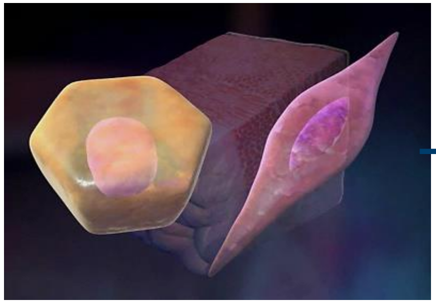
In the area of connective tissues, work has been ongoing worldwide for many years in the engineering of tendon, ligament, bone and cartilage.

To date the highest rates of success have been achieved in the areas of skin, bladder, airway and bone, where tissue-engineered constructs have been used successfully in patients

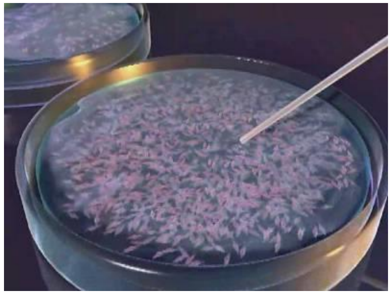


Neo-bladder – a commercial synthetic bladder

A surgeon takes a small, full-thickness biopsy from the patient's bladder.



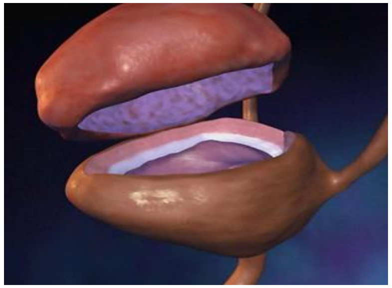
urothelial and smooth muscle cells that are capable of regeneration are isolated.



The isolated cells are cultured separately until there are a sufficient quantity.

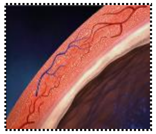
The cultured cells are properly seeded onto a biodegradable scaffold shaped like a bladder.

Quality assurance that the cells attach and grow properly throughout the scaffold. After about 8 weeks, the neo-bladder construction is returned to surgeon for implantation



The neo-bladder construct is implanted by the surgeon using standard surgical techniques.

The body uses the neo-bladder construct to regenerate and integrate new tissue, restoring the bladder's functionality.



The biodegradable scaffold dissolves and is eliminated from the body, leaving a functioning bladder made only of the patient's own newly regenerated tissue.

To grow an ear like the one on the mouse pictured here, tissue engineers mold a biodegradable scaffold into the proper size and shape of an ear.

Researchers then "seed" the scaffold with young cartilage cells and surgically implant the mold under the skin. The mouse, hairless and specially bred to lack an immune system that might reject the human tissue, nourishes the ear as the cartilage cells grow.

After the human ear is removed, the mouse will remain healthy.

Toddler Gets Synthetic Windpipe

Doctors culture a custom-made trachea from plastic fibers and human cells, and successfully implant it into a child who was born without the organ.

Hannah Warren and her parents

Hannah Warren, a 2.5-year-old girl born without a windpipe, has received a bioengineered replacement made with her own stem cells

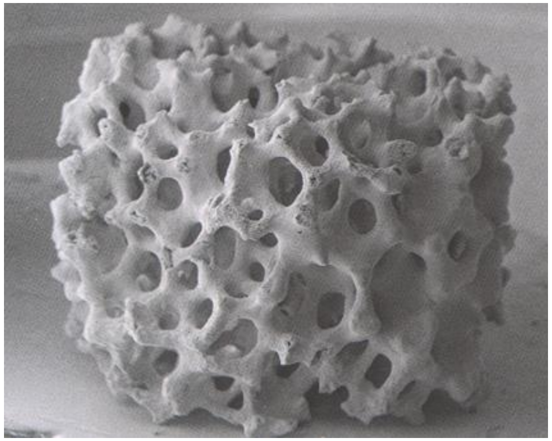
The scaffold and bioreactor in which the synthetic trachea was cultured with stem cells taken from bone marrow was custom-made for the patient.

Although she will need a new wind pipe every few years as she grows, the researchers behind the procedure have tried to limit such replacements by including biodegradable plastic fibers to allow the trachea to stretch.

BIOCERAMICS

Behavior of Ceramics in the Human Body

Ceramics employed within the body can fall into all **three biomaterial classifications i.e. Inert, resorbable and active,** meaning they can either remain unchanged, dissolve or actively take part in physiological processes.



What Forms Can Bioceramics Take?

Bioceramics are available as:

- Micro-spheres
- Thin layers or coatings on a metallic implant
- Porous networks
- Composites with a polymer component
- Large well polished surfaces

What Materials are Classified as Bioceramics?

Materials that can be classified as bioceramics include:

- Alumina
- Zirconia
- Calcium phosphates
- Silica based glasses or glass ceramics,
- Pyrolytic carbons

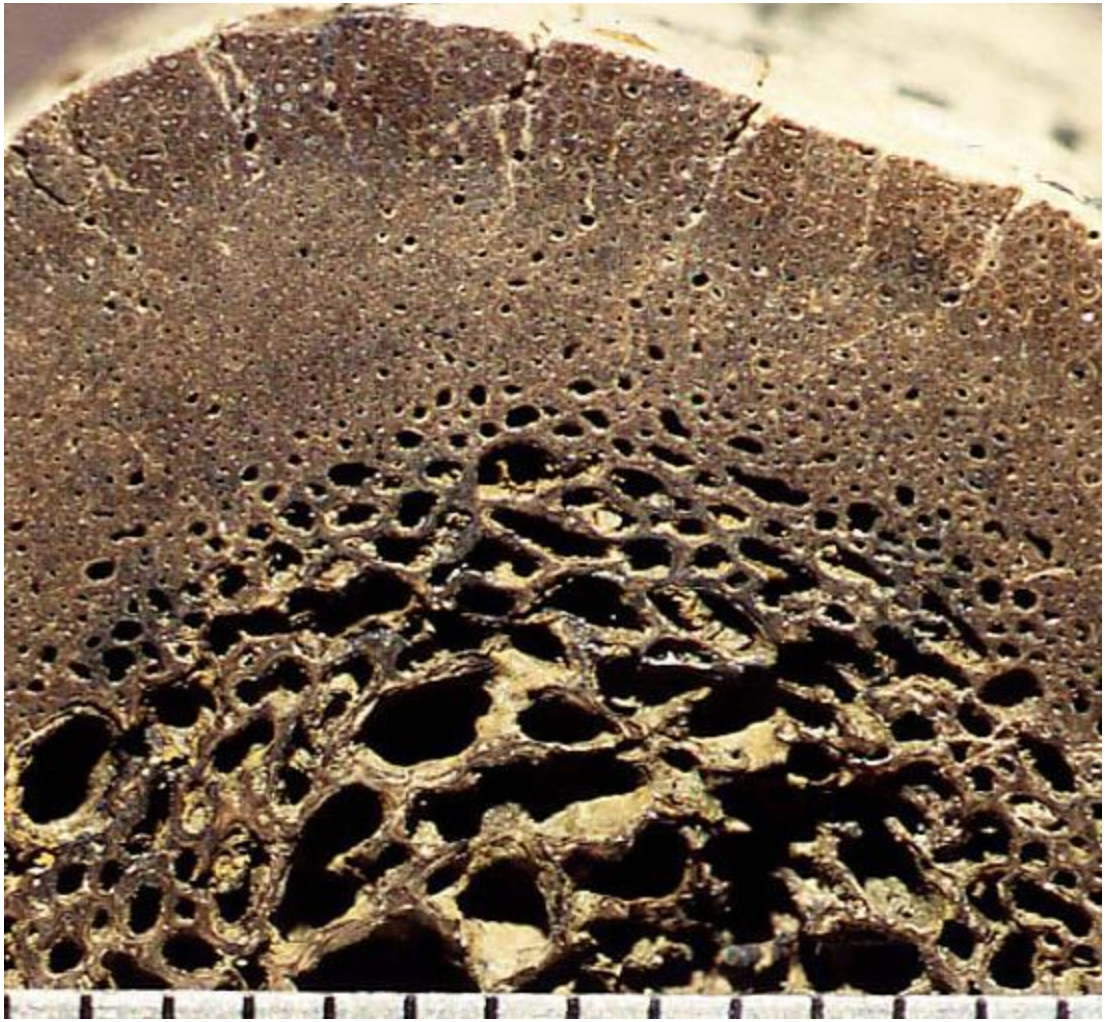
What Functions Do Bioceramics Fulfil?

Bioceramics satisfy needs as diverse as low coefficients of friction for lubricating surfaces in joint prostheses, surfaces on heart valves that avoid blood clotting, materials that stimulate bone growth and those that can harness radioactive species for therapeutic treatments.

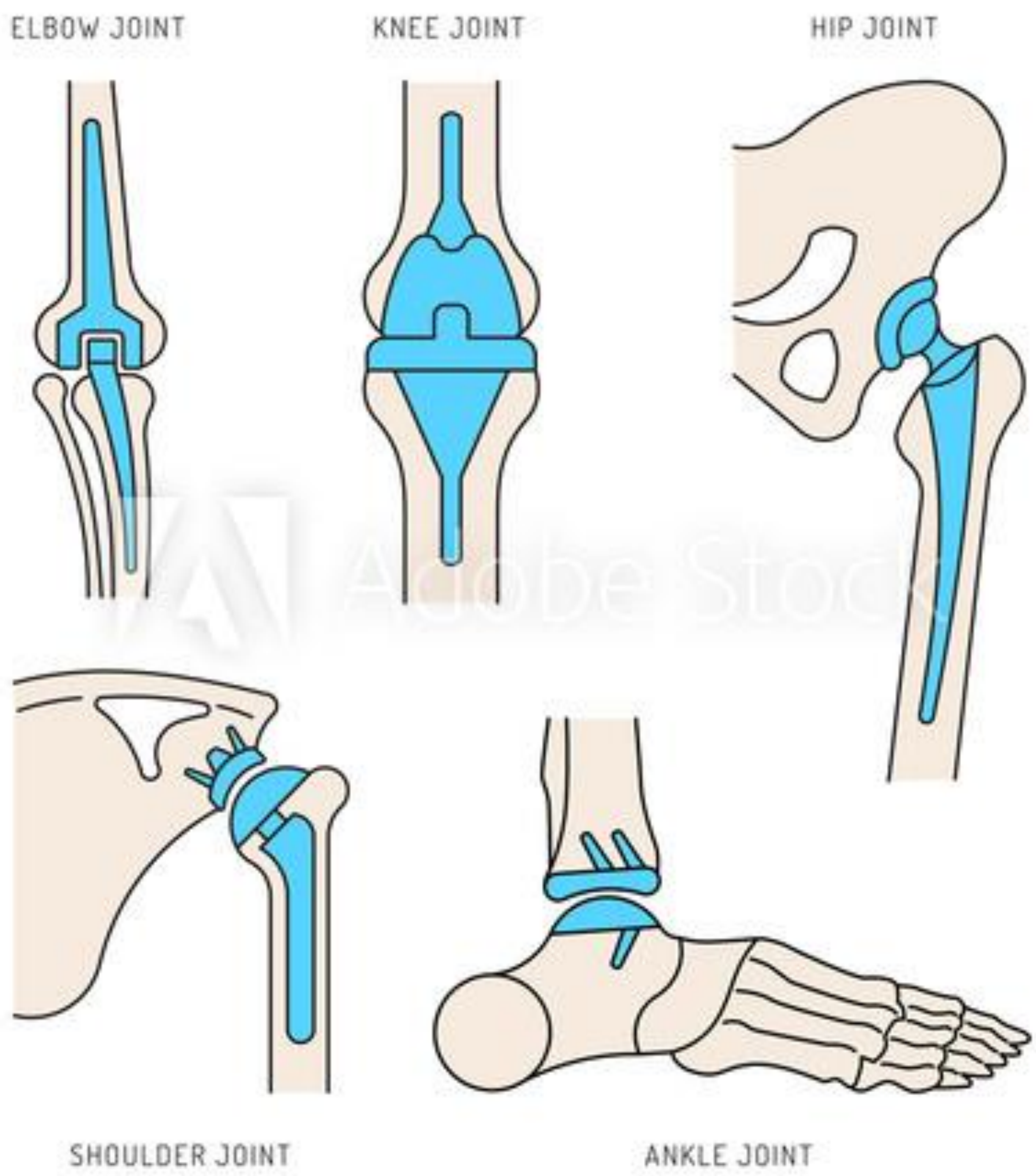
CERAMIC MATERIALS

Bone is a composite material of which the main inorganic component is a ceramic called **hydroxyapatite** .

The hydroxyapatite is combined in the bone microstructure with a natural biological polymer - *collagen.*



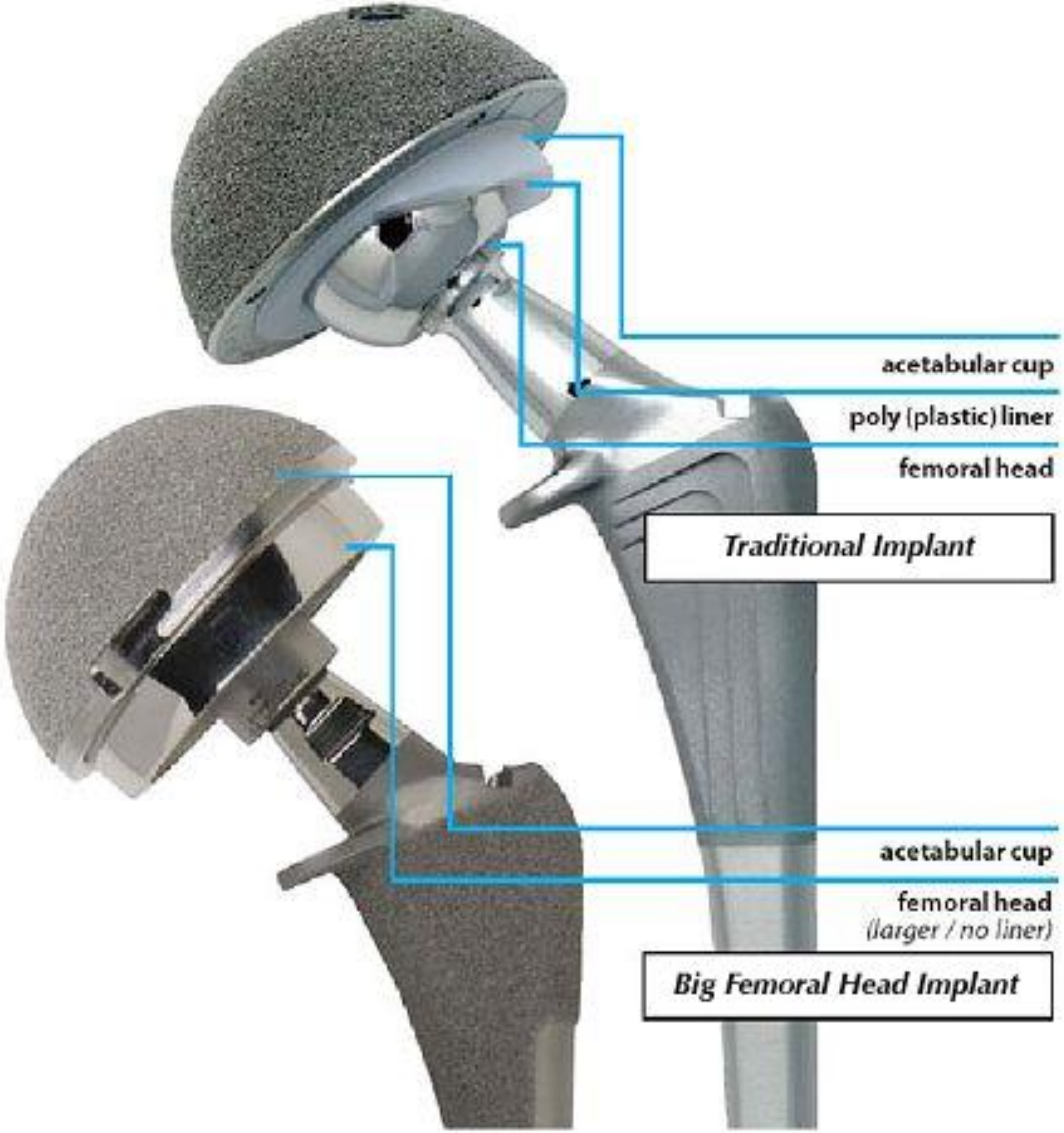
TYPES OF ORTHOPEDIC IMPLANTS



Hip Implant Options

Conventional Hip Implants

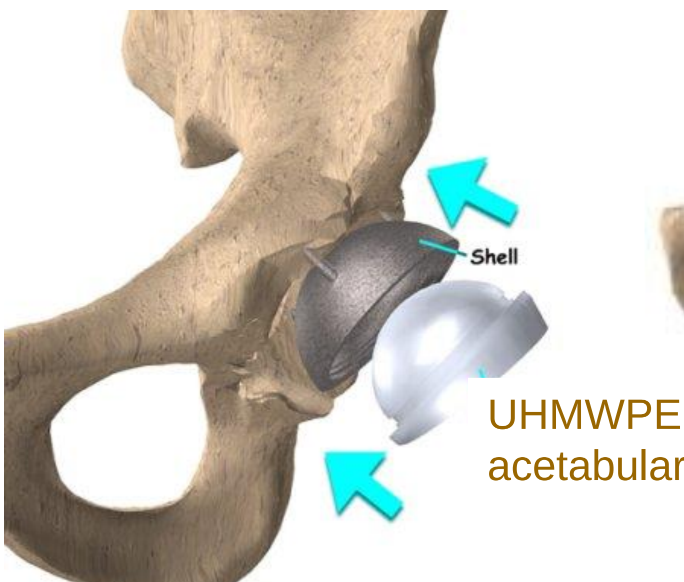
Ceramic Hip Implants

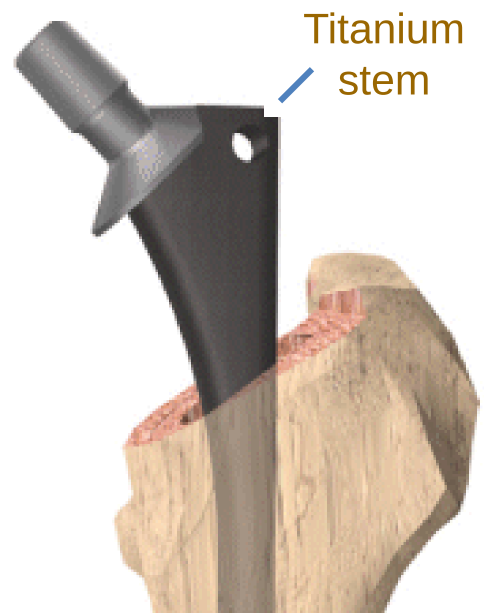

acetabular cup
poly (plastic) liner
femoral head
Traditional Implant
acetabular cup
femoral head
(larger / no liner)
Big Femoral Head Implant

Plastics are used extensively in the medical industry. One of the most interesting medical applications for plastics is the "artificial hip".

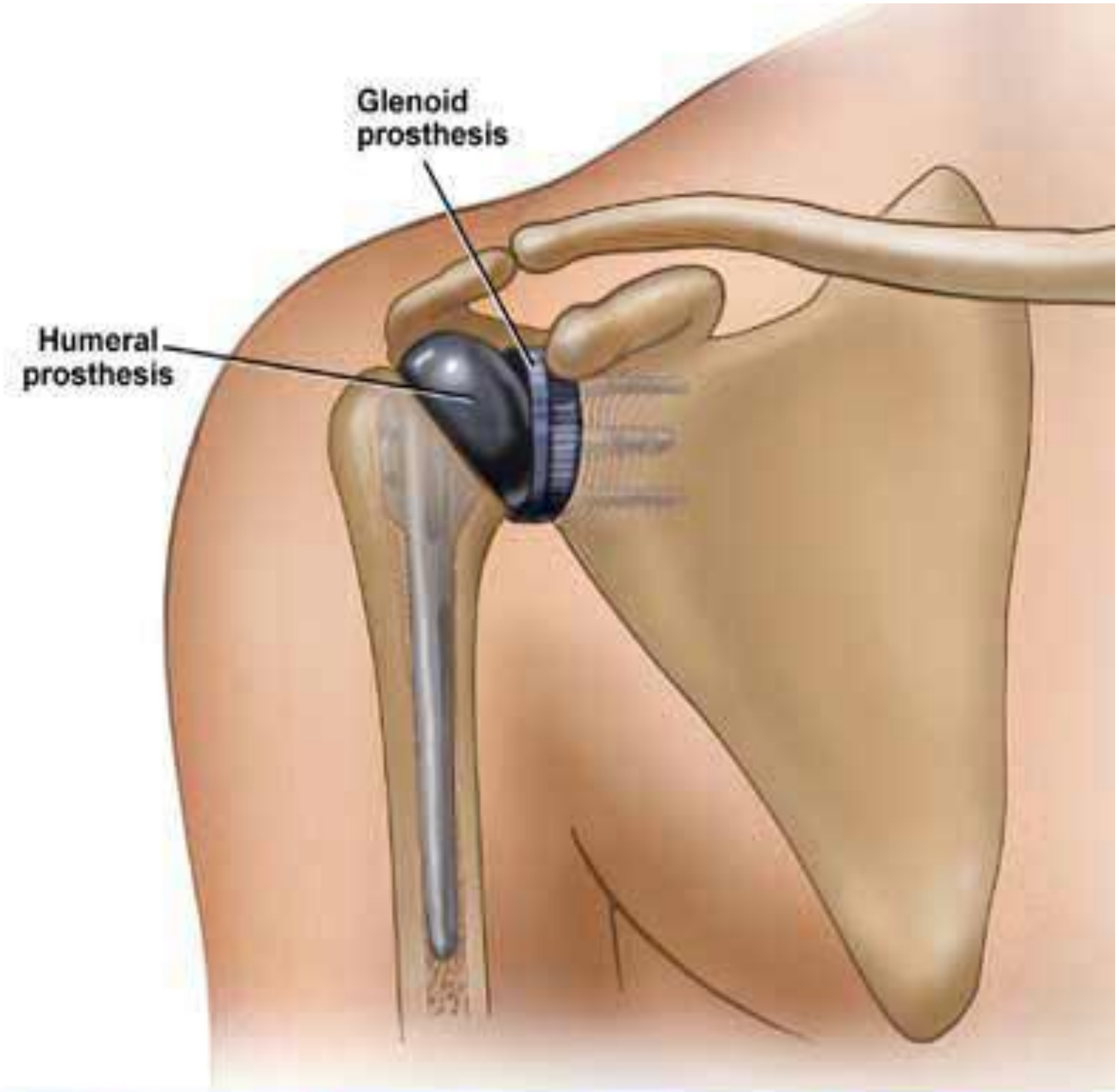
Each prosthesis is made up of two parts: the acetabular component (socket portion) that replaces the acetabulum, and the femoral component (stem portion) that replaces the femoral head.

The femoral component is made of titanium, while the acetabular component is made of a metal shell with a plastic inner socket liner. The plastic liner is molded from *Ultra High Molecular Weight Polyethylene* and acts like a bearing. The UHMWPE is extremely tough, abrasion resistant and has a very low coefficient of friction. This is a very good example of how plastics and metals work together to enhance our quality of life.






Shoulder Replacement - It is done for patients suffering from arthritis or a result of fracture where the head is split or broken into pieces - hemi-replacement (ball replacement only for fractures).

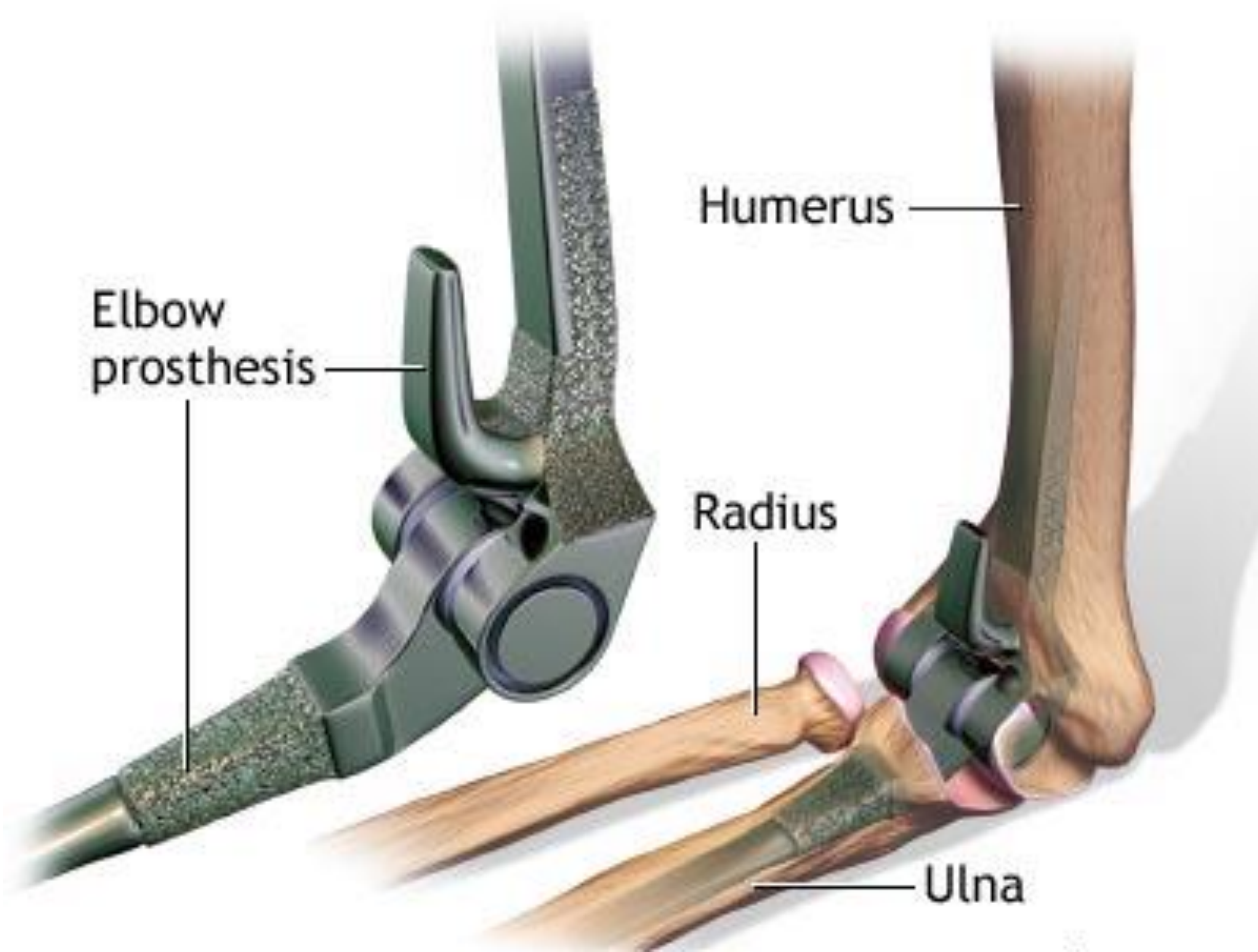


Carbon Clavicle Implanted in Lance Armstrong

The CarbonClavicle, available for both left and right shoulders in four male sizes and four WSD (Women's Specific Design) sizes, is an actual carbon fiber replacement of the clavicle. Developed with the aid of Sports Medicine Specialist Dr. Mark Timmerman, the inForm CarbonClavicle has greater shock absorption, greater impact strength, and a greater tensile strength—all while being grams lighter than the OEM bone.

The installation procedure is substantially quicker than the conventional collarbone repair procedures of stabilizing, drilling and pinning, as this is a full replacement. Essentially, the broken bone is completely removed and the CarbonClavicle is anchored in place. Armstrong's procedure took approximately 30 minutes and reduced his recovery time from 3 weeks, to 5-7 days for the sutures to fully heal.

Elbow replacement involves surgically replacing bones that make up the elbow joint with artificial elbow joint parts (prosthetic components). The artificial joint consists of two stems made of high-quality metal. They are joined together with a metal and plastic hinge that allows the artificial elbow joint to bend. The artificial joints come in different sizes to fit the patient.



There are **3 types of knee replacement** – a partial one for persons who have arthritis, a total replacement for more significant knee injuries, and a Revision knee replacement which includes metal stems that go into the main leg bones above and below the knee, for very significant injuries .

JOURNEY* UNI knee implant

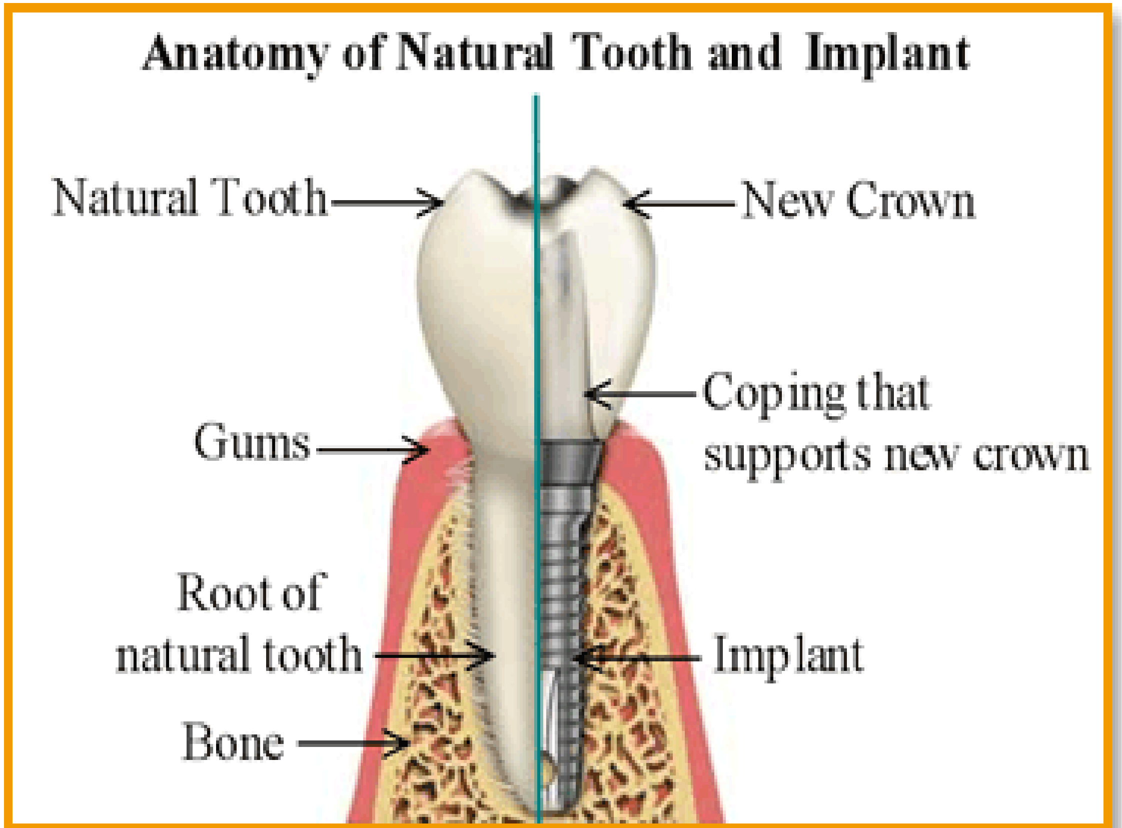
Total knee implant

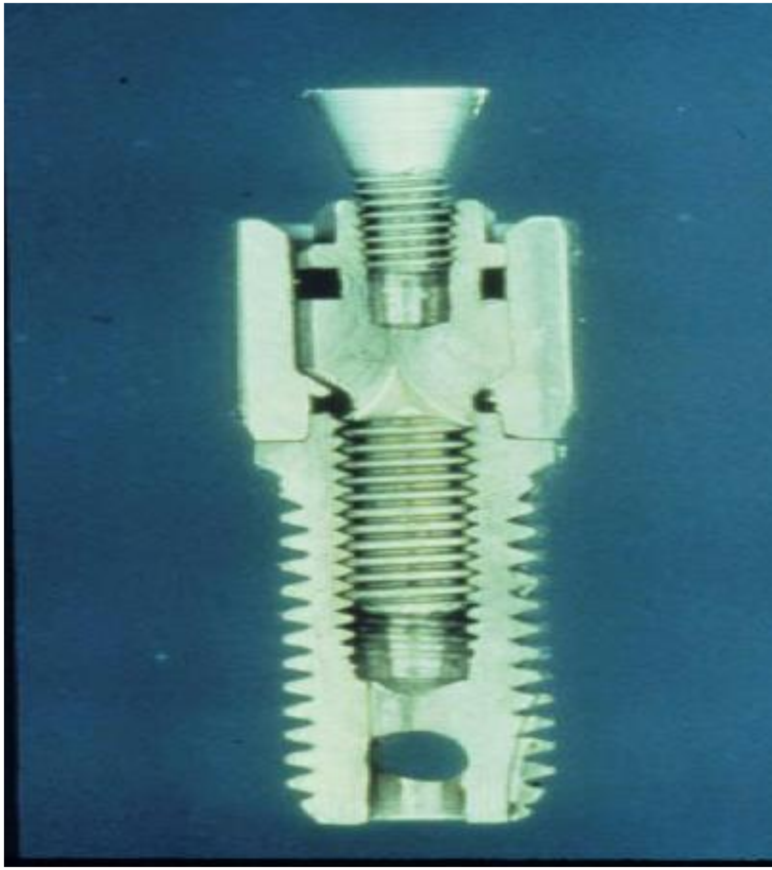
Revision knee implant

SPINAL DISC REPLACEMENTS

Left: Bryan Cervical Disc. Photo courtesy of Medtronic Sofamor Danek. Right: Charite Lumbar Artificial Disc. Photo courtesy of DePuy. Charite Lumbar Artificial Disc and Bryan Cervical Disc are approved for distribution in the United States by the FDA.

DENTAL IMPLANTS

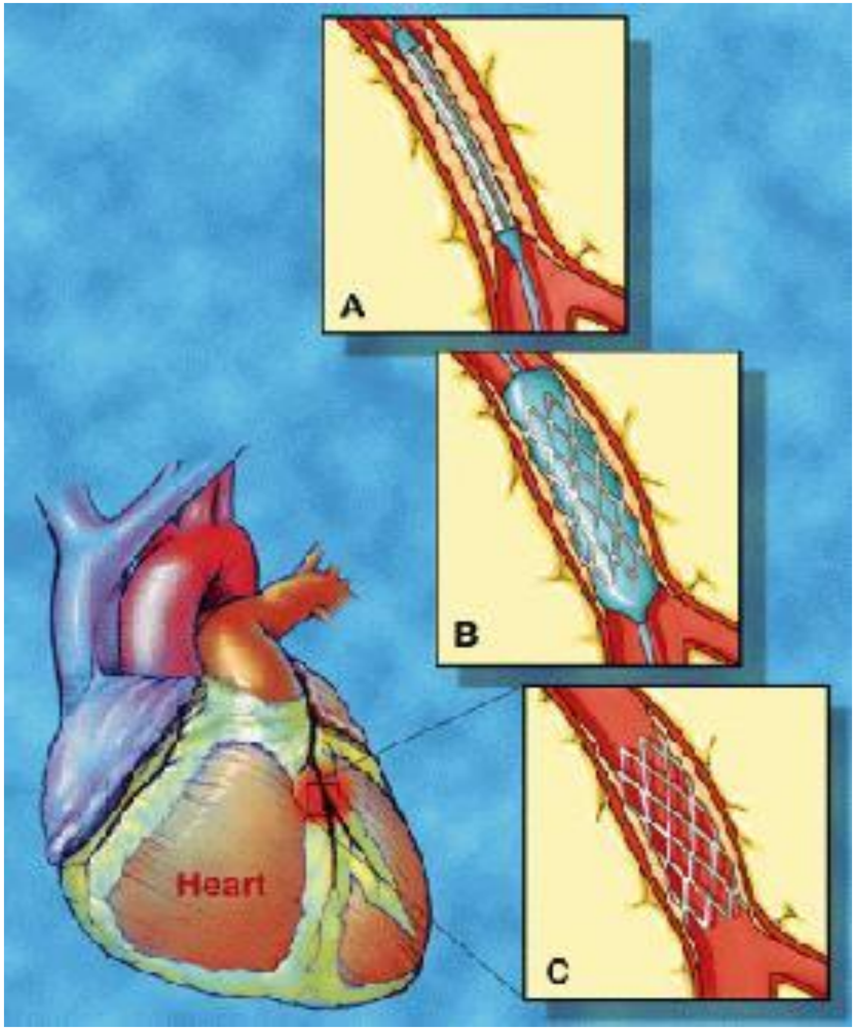


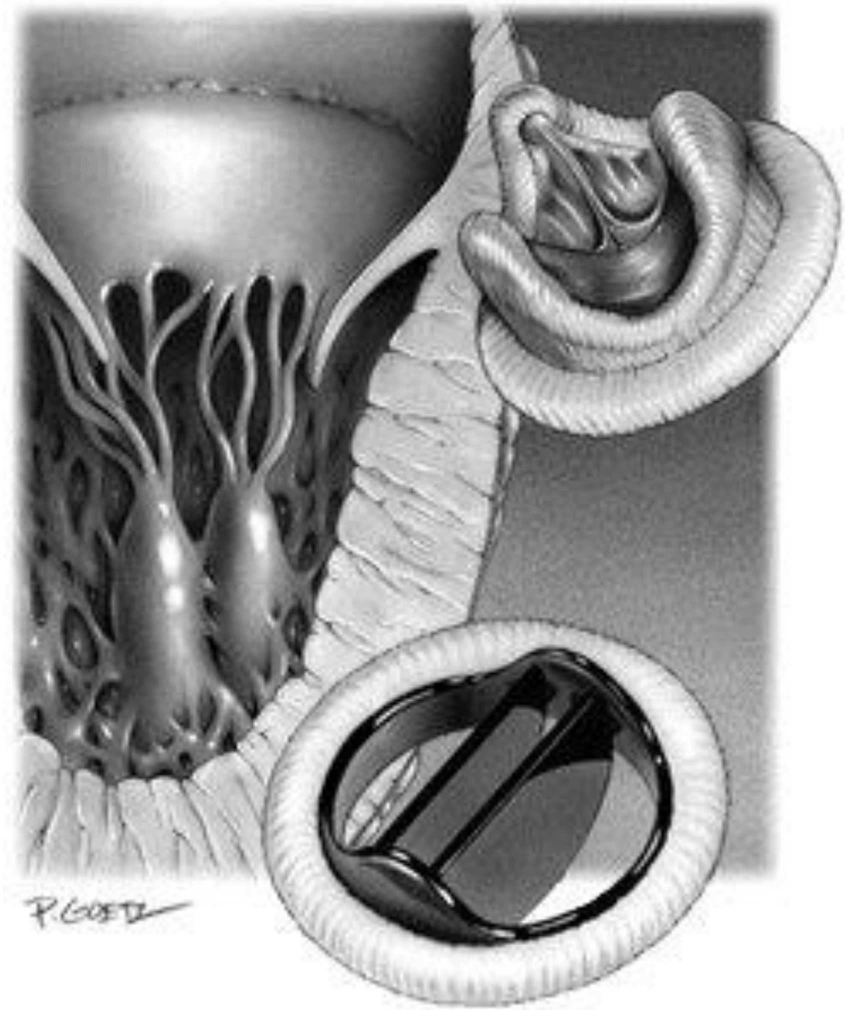


TITANIUM DENTAL IMPLANT

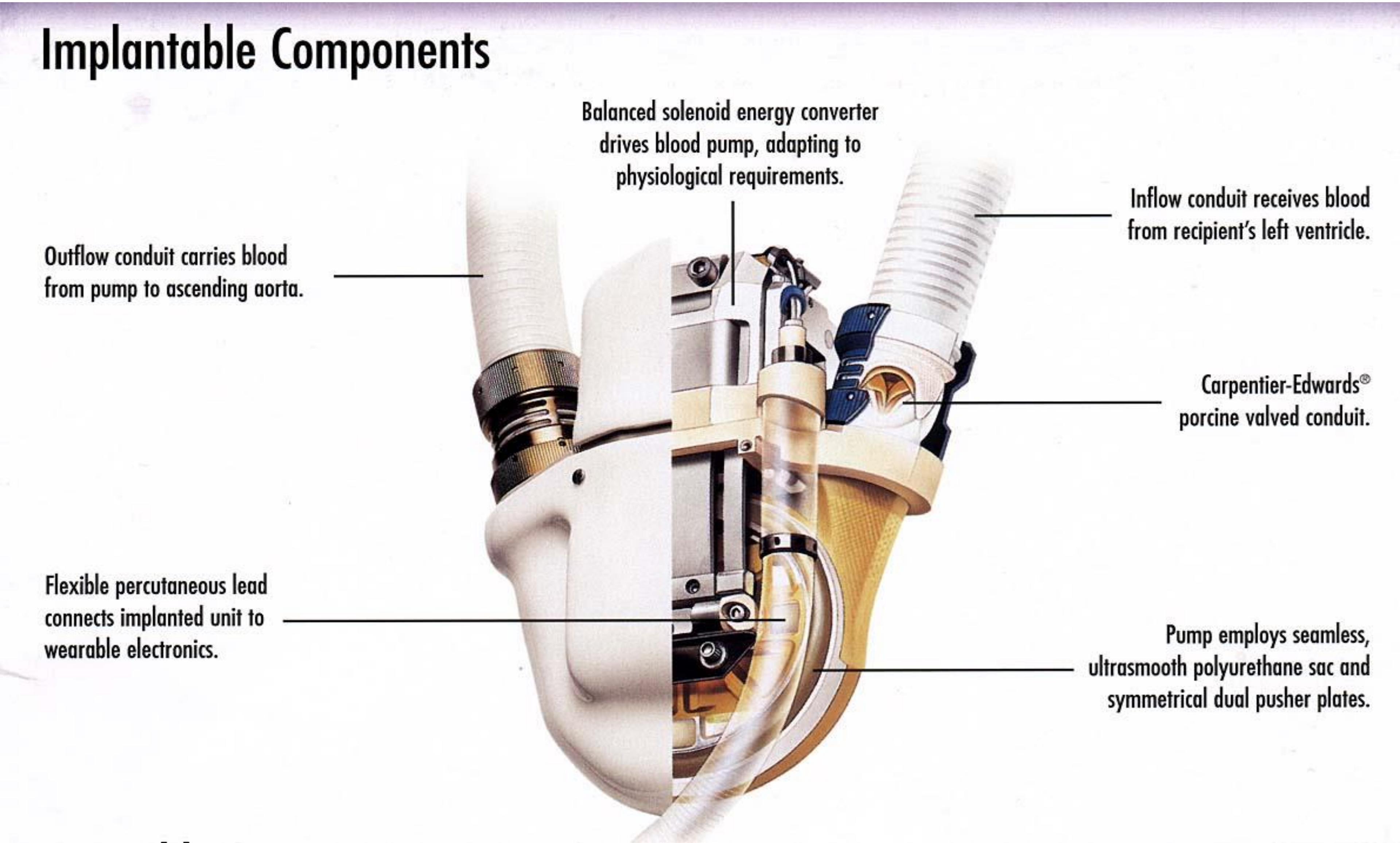
Tooth and jaw implants must look natural and must be resistant to degradation. They also need to be able to bond strongly to surrounding tissue. The typical root material is threaded titanium that is placed in the jaw bone. **Titanium is passive around** tissue, so it is very common in implants. These kinds of implants are commonly used, and have become very reliable.

Cardiovascular devices

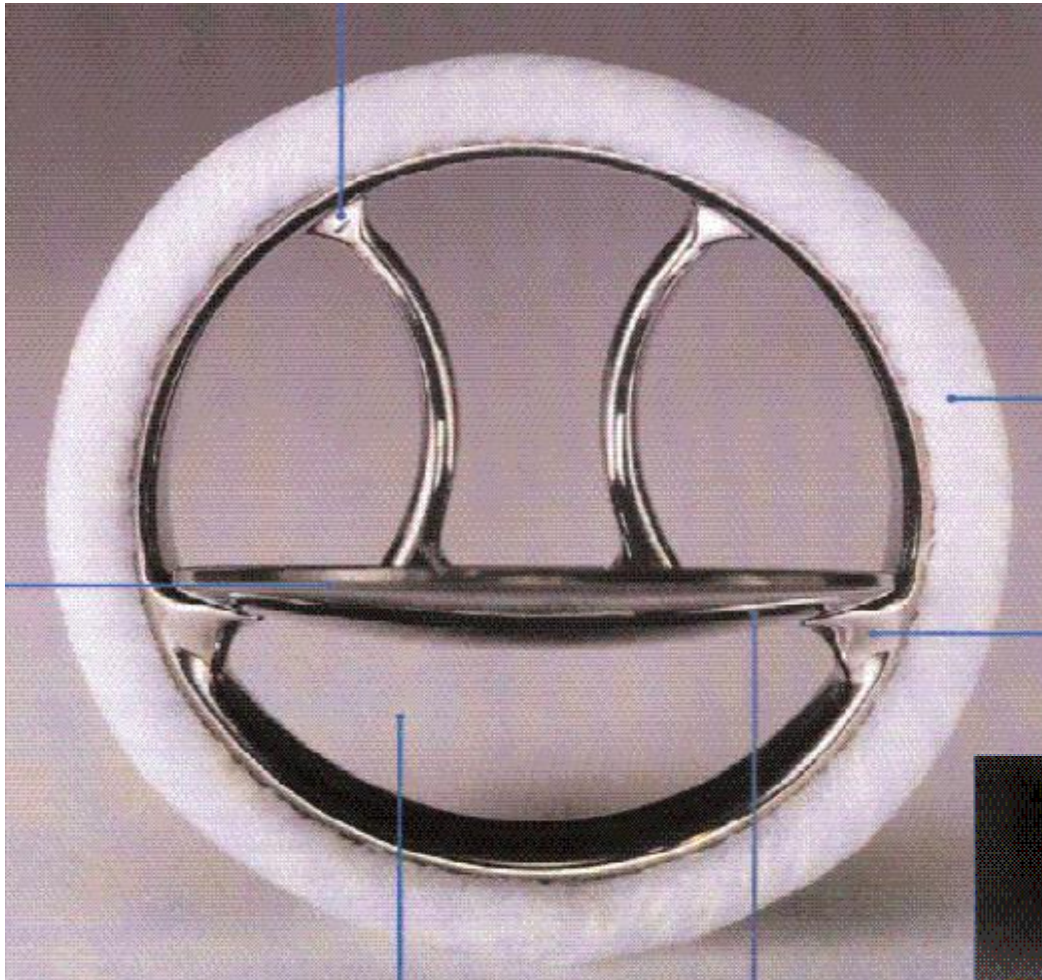


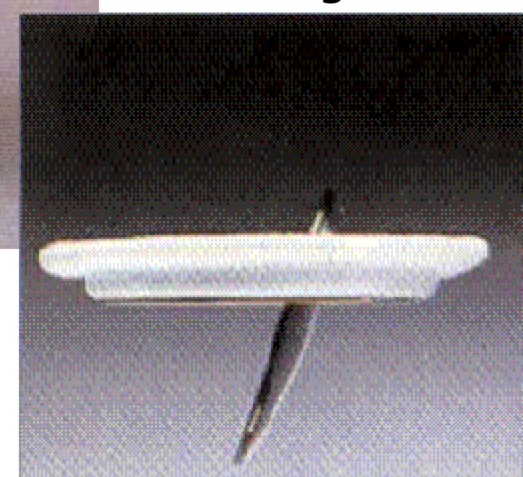


LVAS: Pump Drive Unit



AorTech Heart valve tilting disk prosthesis





Implantable Cardiac Pacemakers

Some of the most advanced plastic products being manufactured today are used in the medical industry.

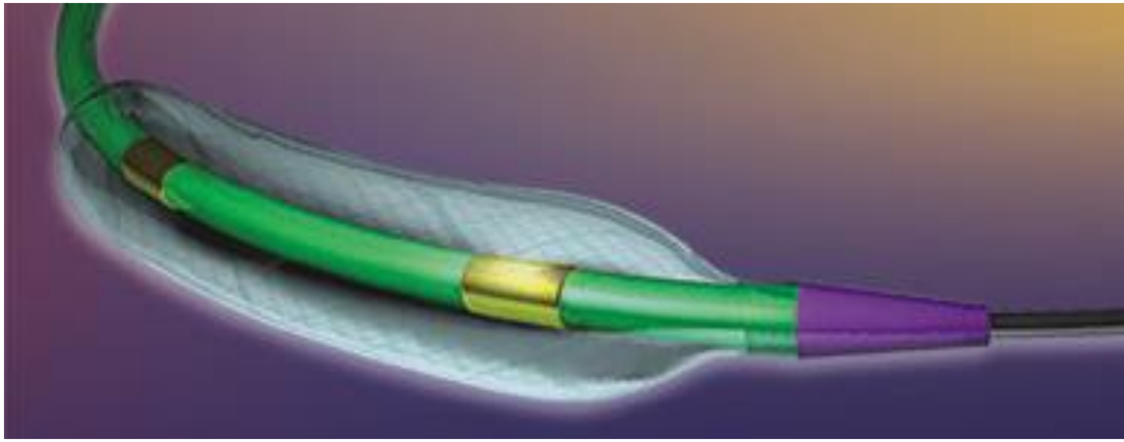
The angioplasty catheter is a good example of a life saving medical device that would not be possible without plastics.

Balloon angioplasty is a minimally invasive non-surgical alternative to coronary artery bypass grafting surgery. The angioplasty balloon is used to compress obstructing plaque in a clogged artery against the arterial wall so that blood can flow freely again.

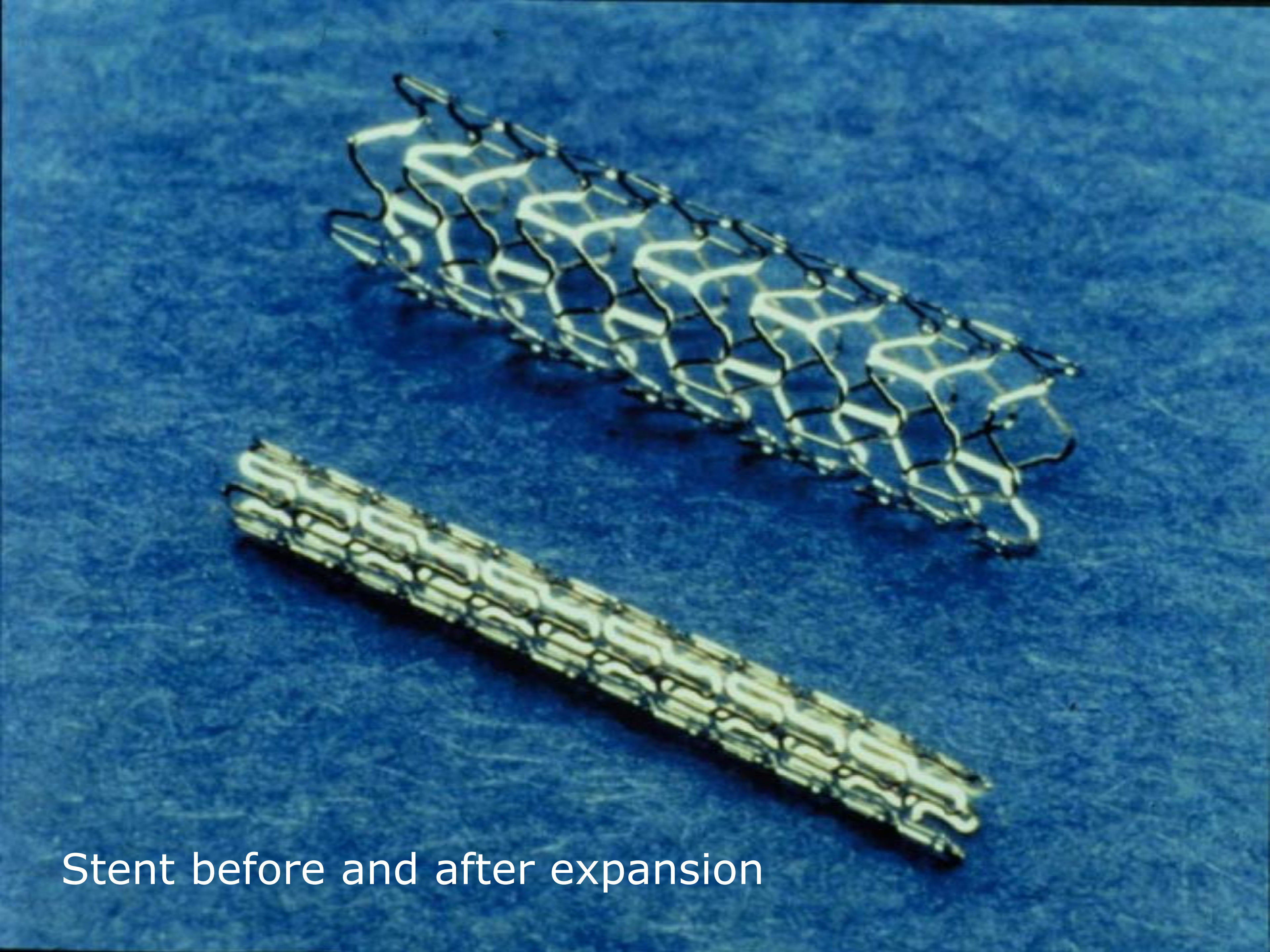
This procedure has a very high success rate and greatly reduces the chances of surgical complications.

Angioplasty balloons are made from a variety of plastics including Polyethylene Terephthalate (PET), nylon 11 or nylon 12.

https://www.youtube.com/watch?v=6yBp_u-Xo08



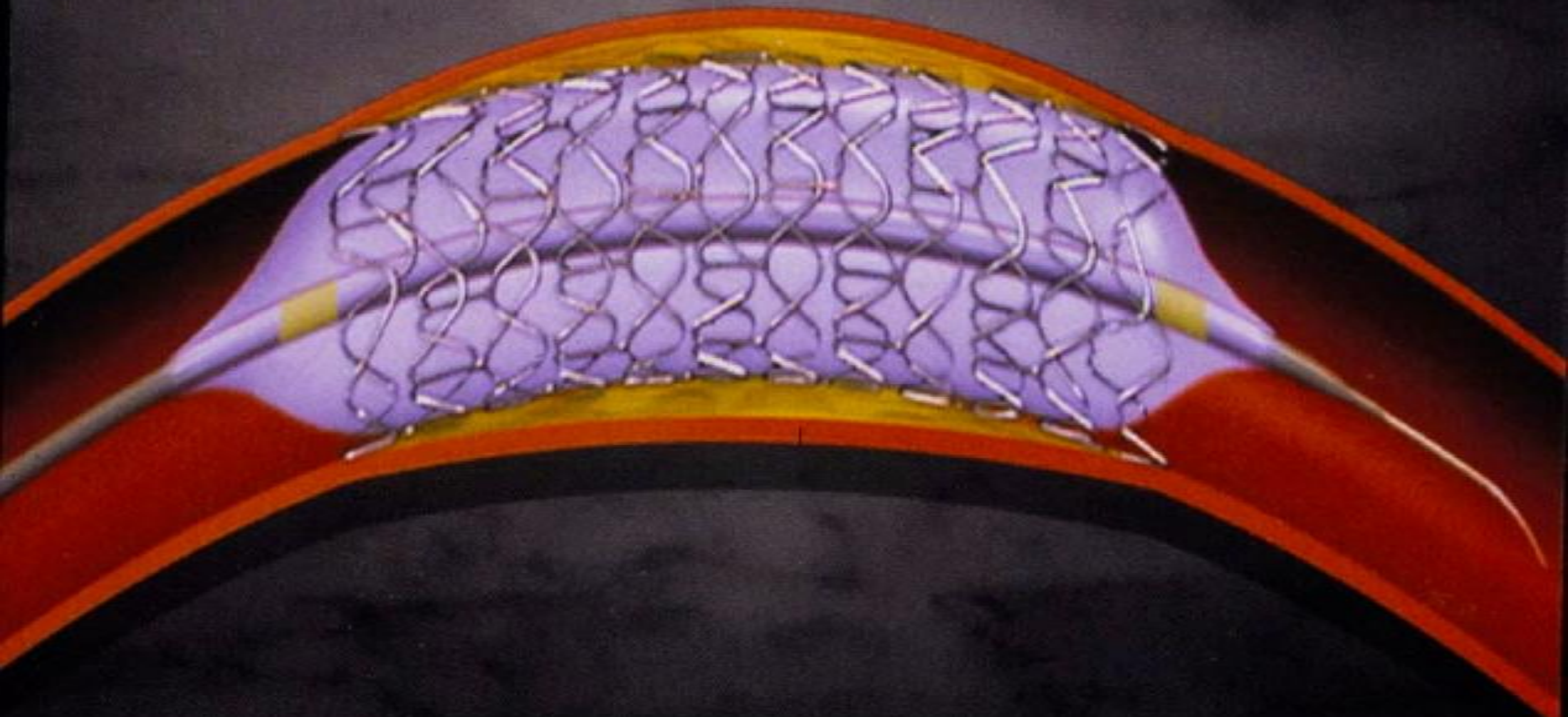
Balloon angioplasty in action:
Balloon and stent on catheter arrive at site of blockage.



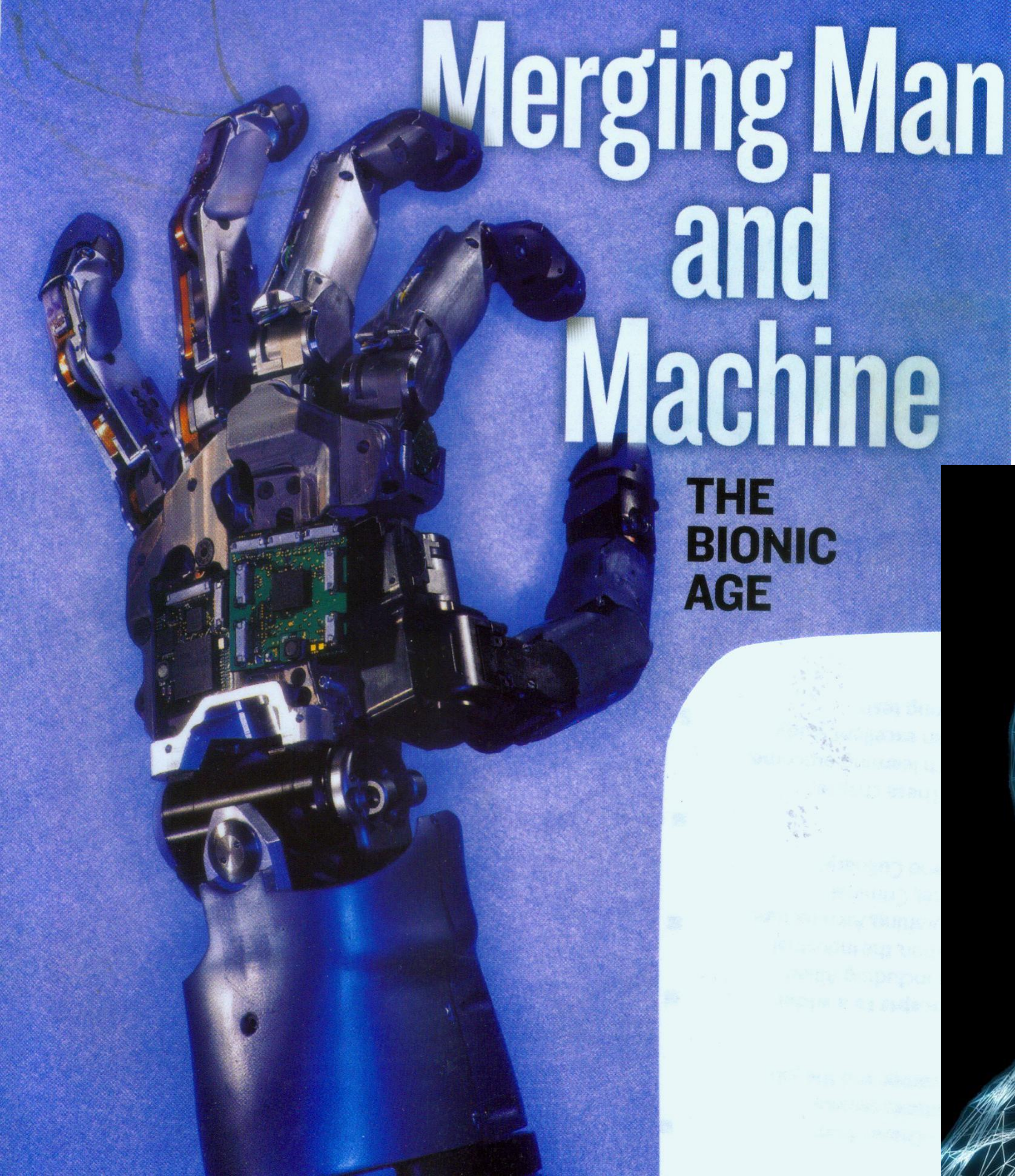
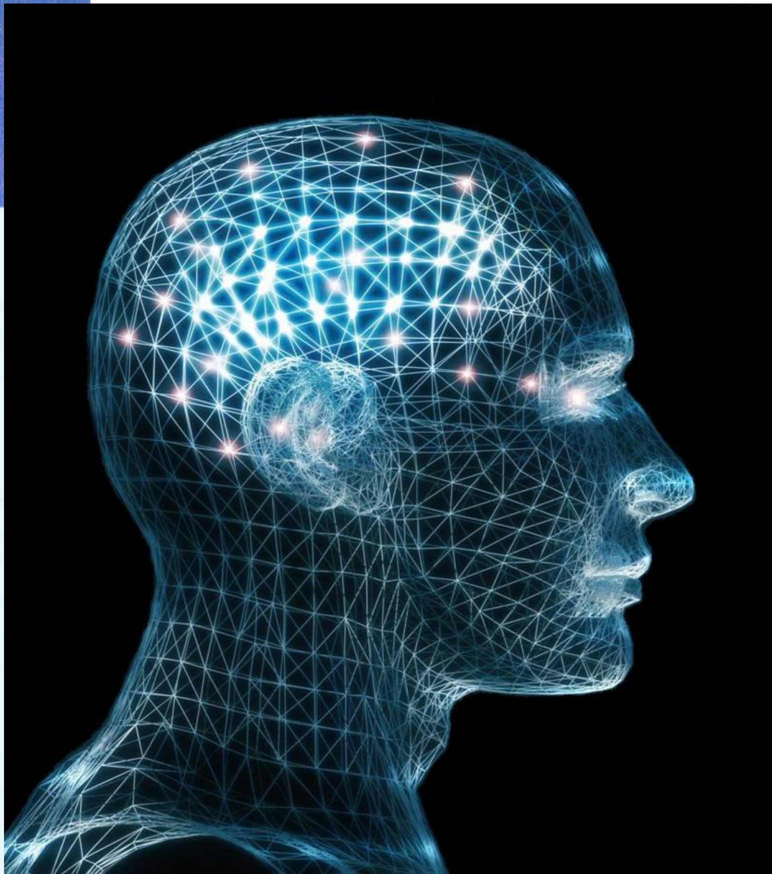
Stent before and after expansion

Balloon and stent partially expanded

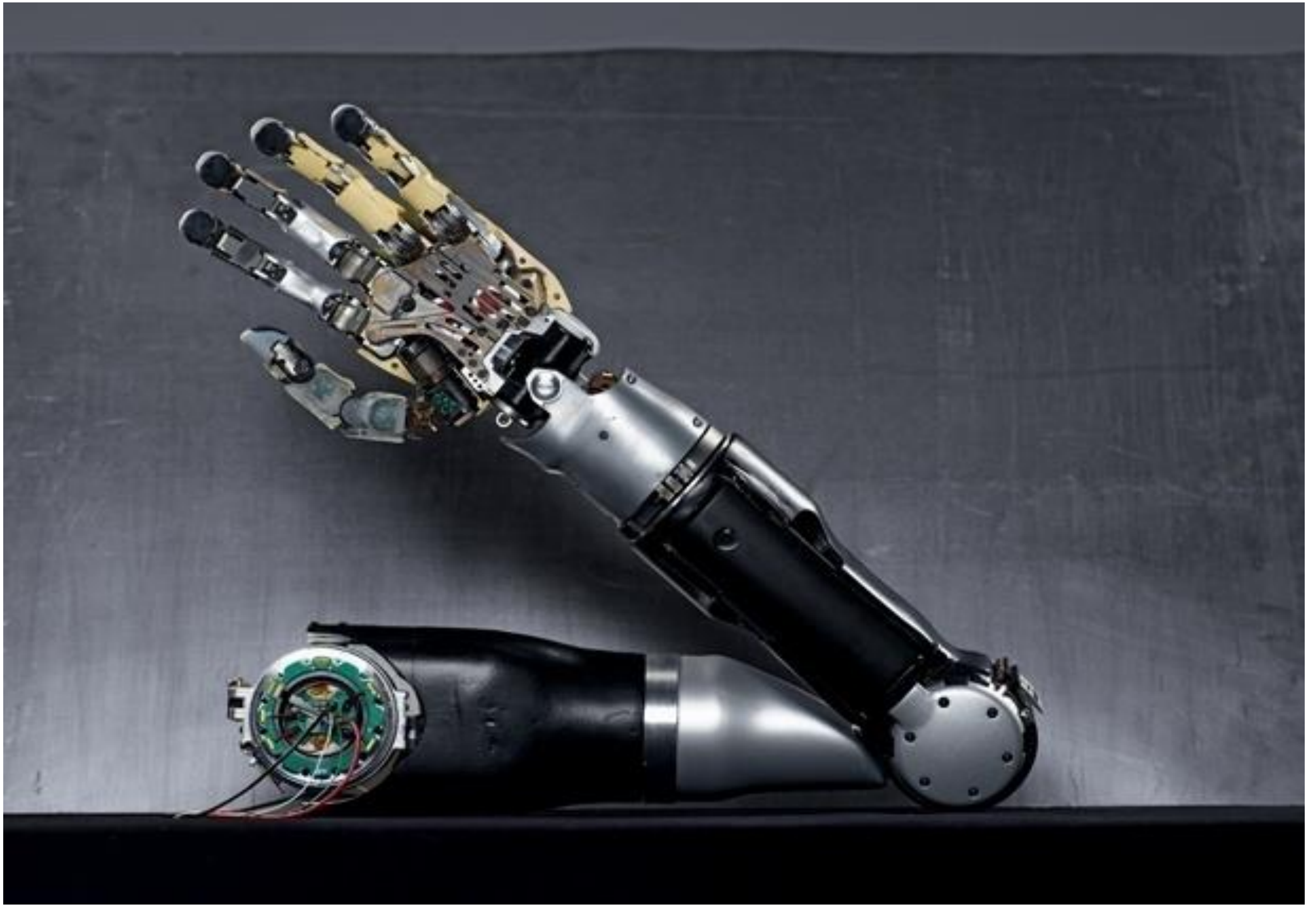
Balloon is inflated, expanding stent and compressing blockage



Balloon is deflated, catheter is removed, leaving stent behind to maintain good support of the blood vessel.


Merging Man and Machine
THE BIONIC AGE


MATERIALS FOR PROSTHESES



Closing In on a Lifelike Limb

THE ABILITIES OF TODAY'S PROTO 1 BIONIC ARM WILL TRIPLE IN THE NEXT PROTOTYPE.

HUMAN ARM

22+ MOVEMENTS

From the shoulder to a finger's last joint, an arm has at least 22 points of movement. Nerves carry the brain's instructions from the spinal cord to the muscles.

TRADITIONAL PROSTHESIS

3 MOVEMENTS

Still the only device available to most amputees, the pincer-hand prosthesis relies on cables moved by pressing levers on a harness with the chin or other arm.

PROTO 1

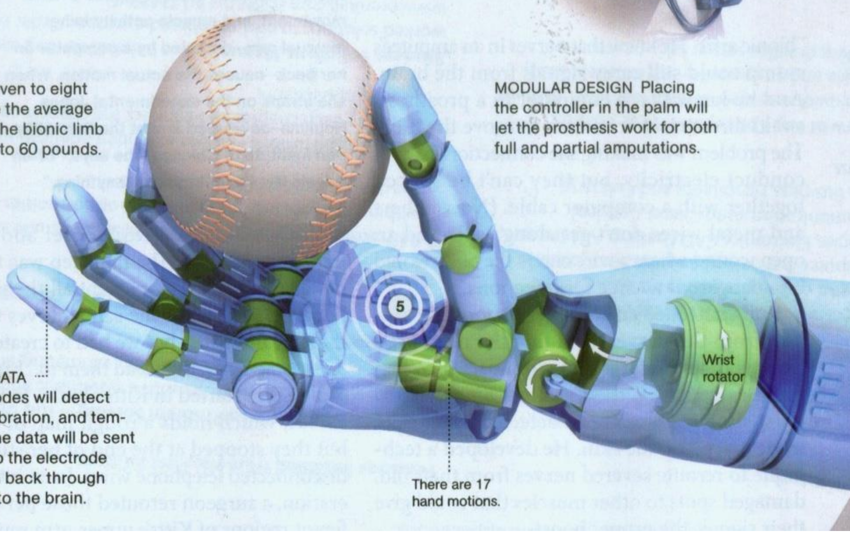
7 MOVEMENTS

Nerves that once reached the lower arm are rerouted into other muscles. Electrodes placed on those muscles capture the brain's commands and relay them by wires in the prosthesis.

WEIGHT Seven to eight pounds, like the average adult arm. The bionic limb can curl up to 60 pounds.

MODULAR DESIGN Placing the controller in the palm will let the prosthesis work for both full and partial amputations.

SENSORY DATA Fingertip nodes will detect pressure, vibration, and temperature. The data will be sent wirelessly to the electrode arrays, then back through the nerves to the brain.



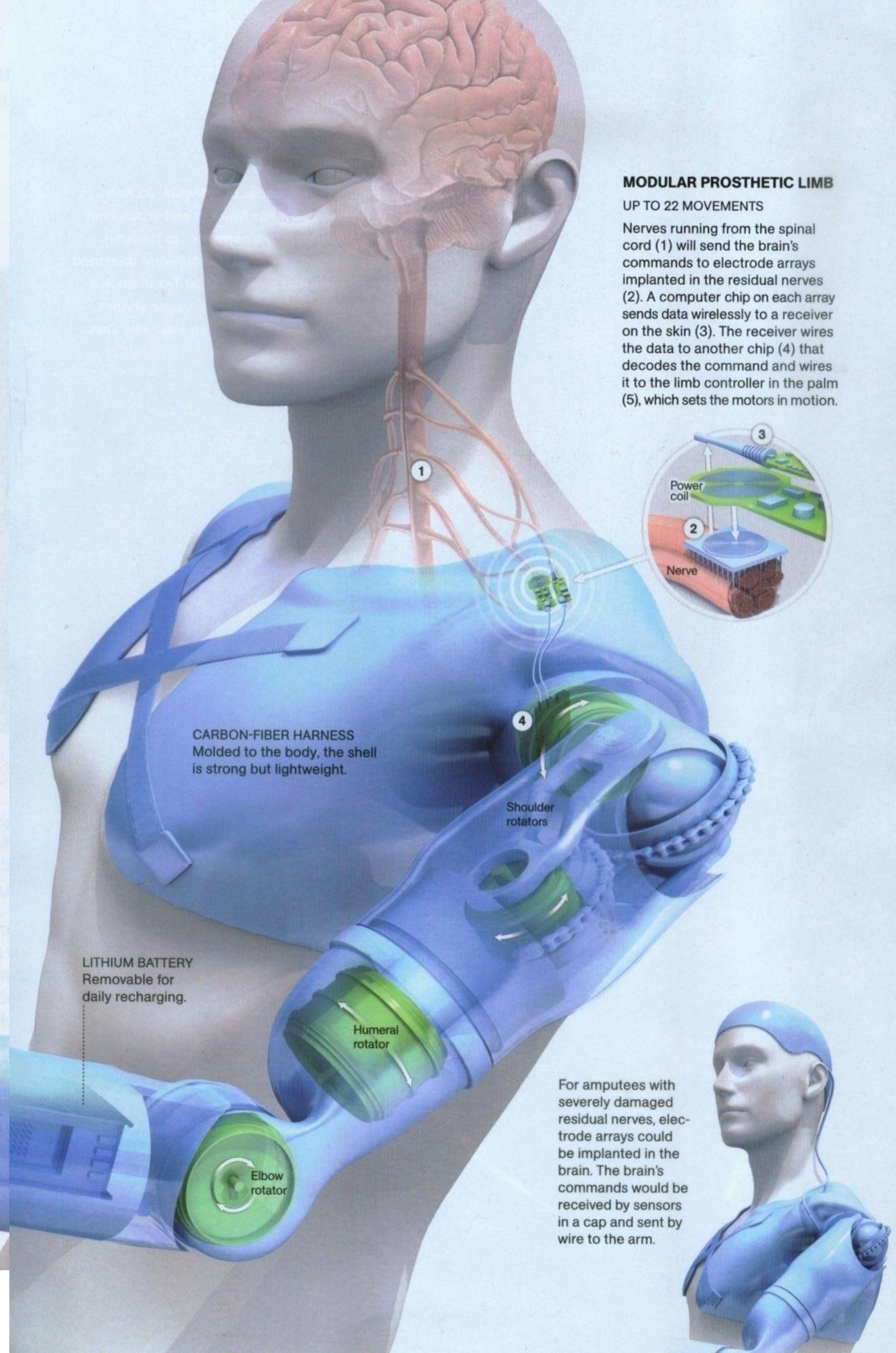
MODULAR PROSTHETIC LIMB

UP TO 22 MOVEMENTS

Nerves running from the spinal cord (1) will send the brain's commands to electrode arrays implanted in the residual nerves (2). A computer chip on each array sends data wirelessly to a receiver on the skin (3). The receiver wires the data to another chip (4) that decodes the command and wires it to the limb controller in the palm (5), which sets the motors in motion.

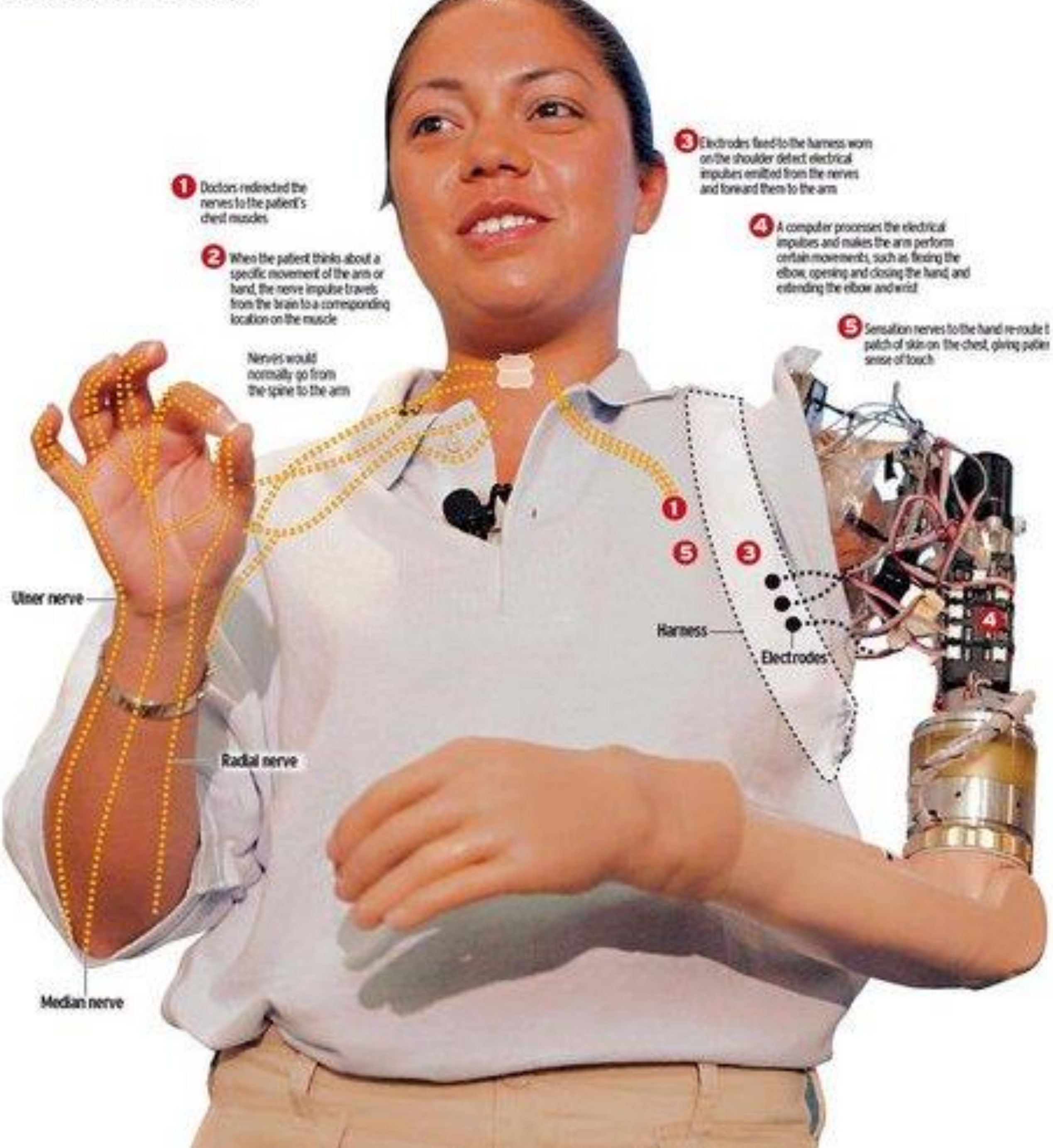
CARBON-FIBER HARNESS Molded to the body, the shell is strong but lightweight.

LITHIUM BATTERY Removable for daily recharging.



For amputees with severely damaged residual nerves, electrode arrays could be implanted in the brain. The brain's commands would be received by sensors in a cap and sent by wire to the arm.

How the arm works

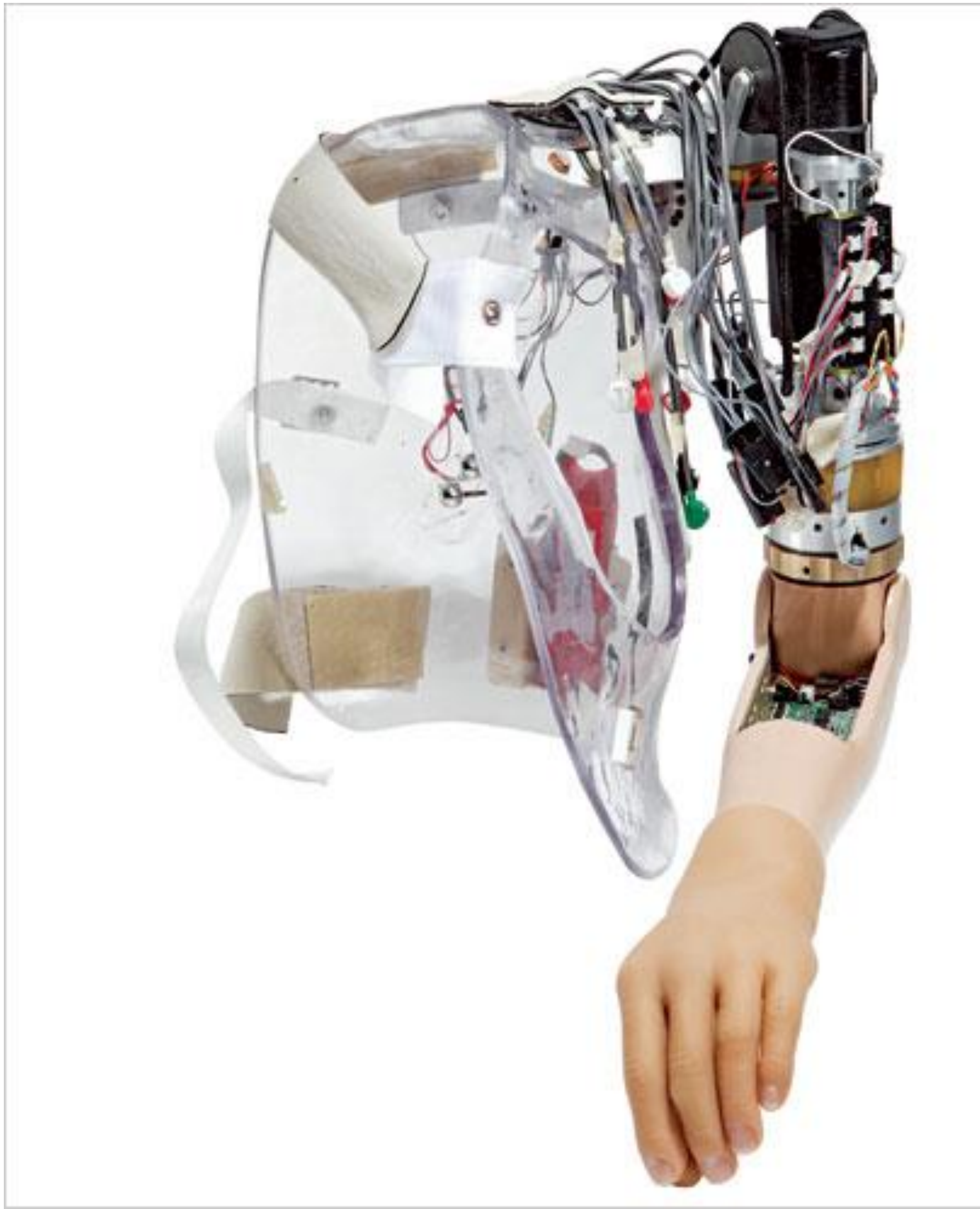


This bionic arm can do things like picking up fragile items such as a glass, just by the wearer just thinking about it.

The arm is connected directly to the wearer, Jesse Sullivan's brain, so he's able to use it like any other appendage. The device weighs 12 pounds.

Electrodes intercept the limb's residual nerve firings and feed them to a computer embedded in the forearm, which then commands six motors to move the device's shoulder, elbow and hand in unison.

Thanks to hand sensors, the wearer can even gauge pressure and fine-tune their grip.

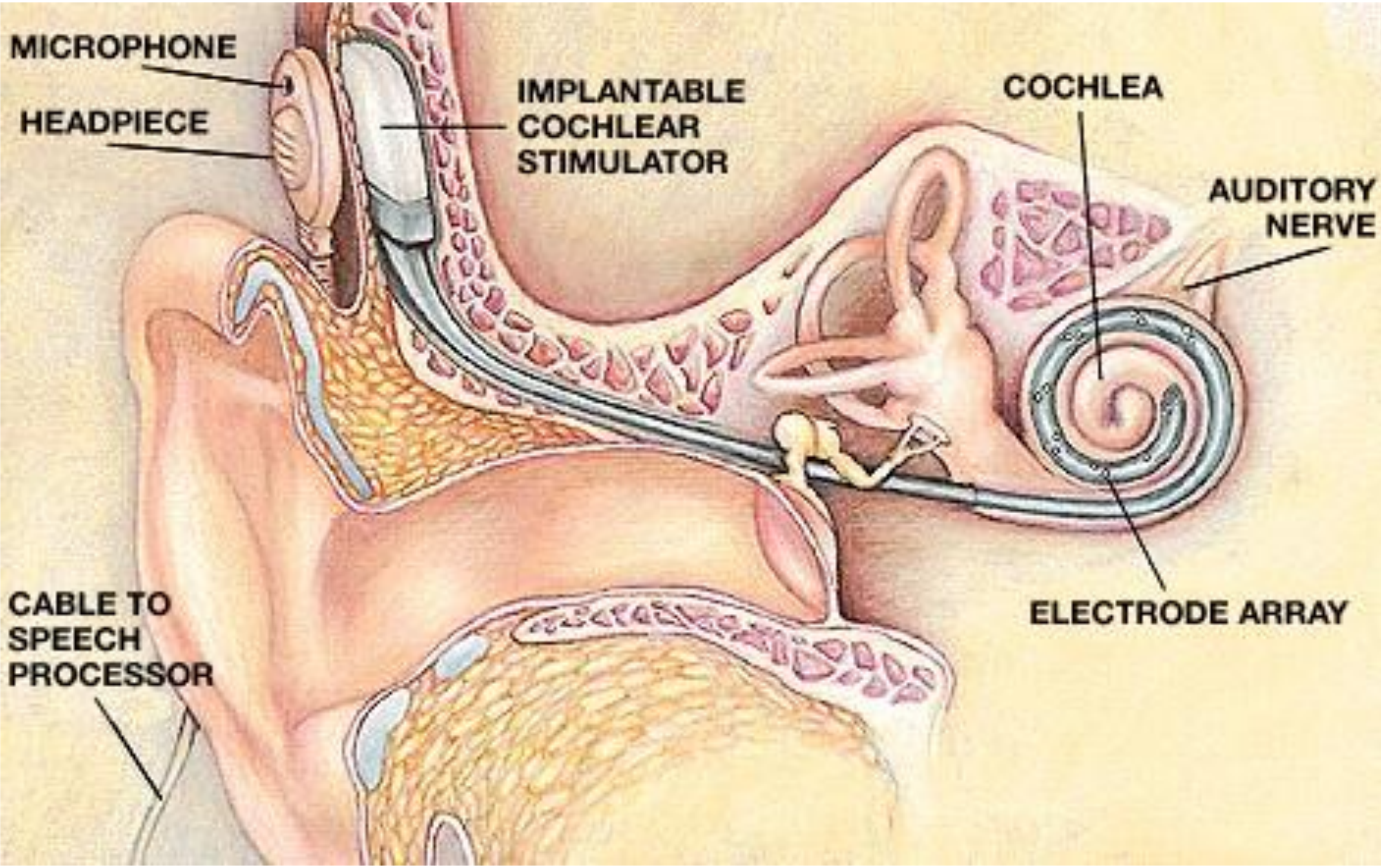


MIT assistant professor Hugh Herr is an advanced prosthetics researcher and a bilateral arm amputee, two conditions that have allowed him the rare experience of testing his gadgets on himself.

LINK TO A 19 MINUTE TED VIDEO
https://www.youtube.com/watch?v=CDsNZJTWw0w

COCHLEAR IMPLANTS TO ALLOW PERSONS TO HEAR

Cochlear Implant - Detail

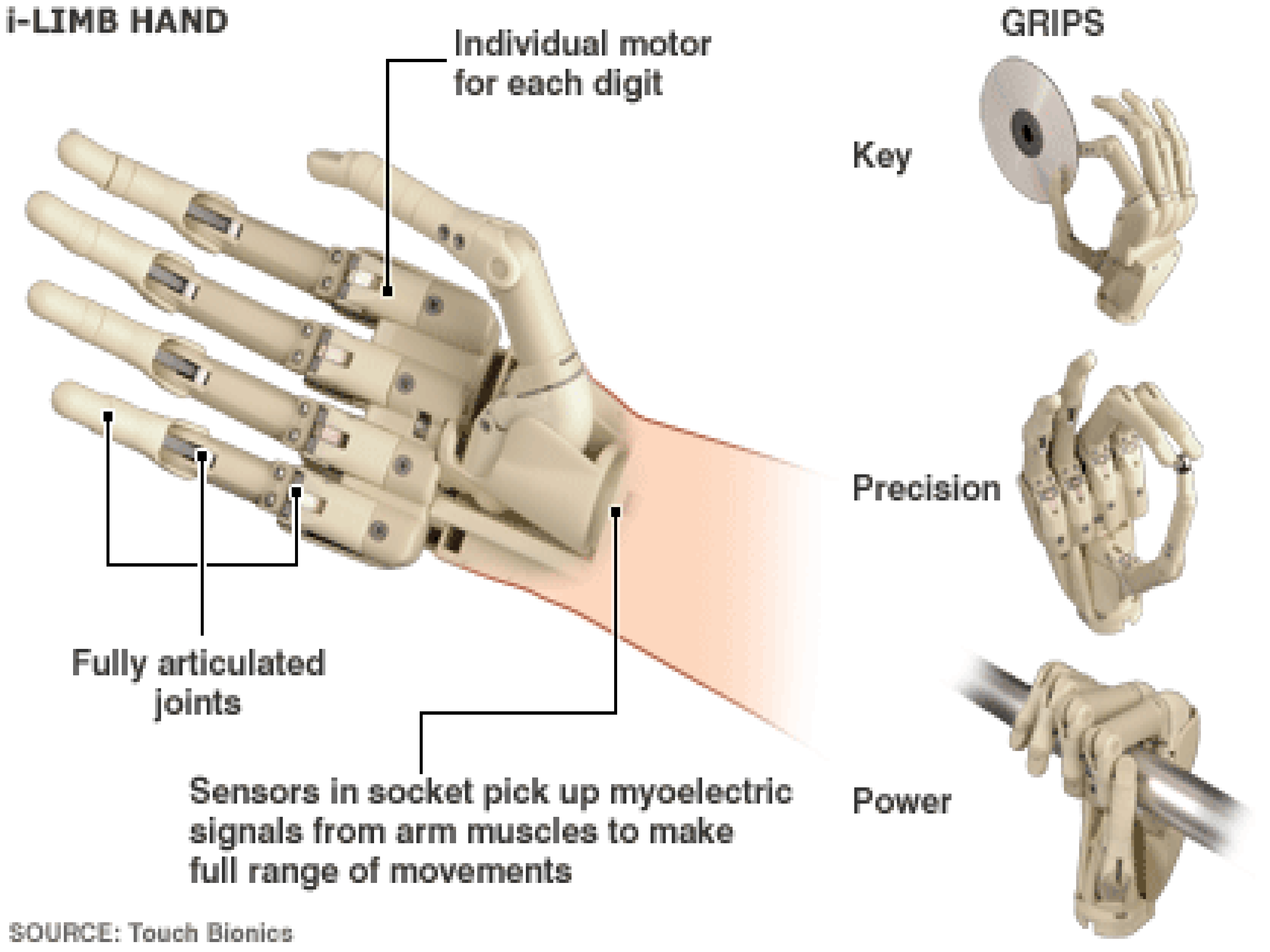


Oscar Pistorious wears the Ossur Cheetah Flex-foot Artificial Sprinting Leg. It is made of carbon fiber and manufactured in Iceland.

The prosthesis' 'J' curve shape resembles the hind quarter of a cheetah, the fastest animal on land. The spikes used on the bottom are taken from a Nike sports shoe.

The C-Leg is an innovative, completely microprocessor-controlled leg prosthesis system that helps people who have undergone trans-femoral amputation to achieve a new degree of safety and dynamics.

The C-Leg features a wireless remote control that lets users easily switch between different settings, e.g. for walking, bicycling or inline-skating, as well as make individual fine adjustments to the hydraulic system.

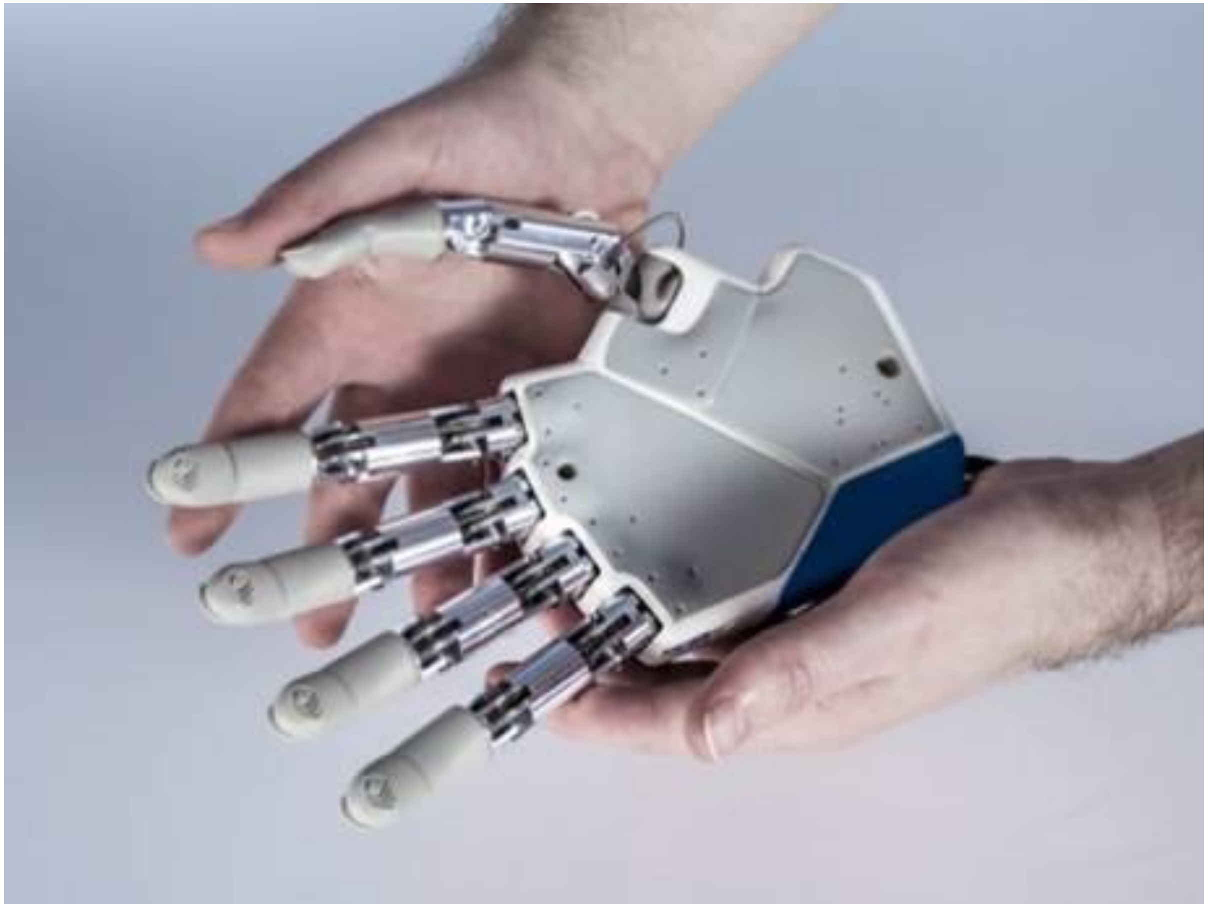


i-LIMB HAND
Individual motor for each digit
Fully articulated joints
Sensors in socket pick up myoelectric signals from arm muscles to make full range of movements
GRIPS
Key
Precision
Power
SOURCE: Touch Bionics

A sensational breakthrough: the first bionic hand that can feel

The first bionic hand that allows an amputee to feel what they are touching will be transplanted later in 2013, in a pioneering operation that could introduce a new generation of artificial limbs with sensory perception.

The wiring of his new bionic hand will be connected to the patient's nervous system with the hope that the man will be able to control the movements of the hand as well as receiving touch signals from the hand's skin sensors.



Cosmesis

Touch Bionics have made a break-through in the cosmesis of the i-LIMB™ Hand. Aesthetic improvements are evident in both the static and, importantly, the dynamic cosmesis.

Cosmesis is the flexible skin covering that covers the i-LIMB Hand and ProDigits. By applying in-house expertise and partnering with companies that specialize in cosmesis, Touch Bionics has achieved major breakthroughs in the aesthetic appearance of its prosthetic products, including being able to apply permanent hair.

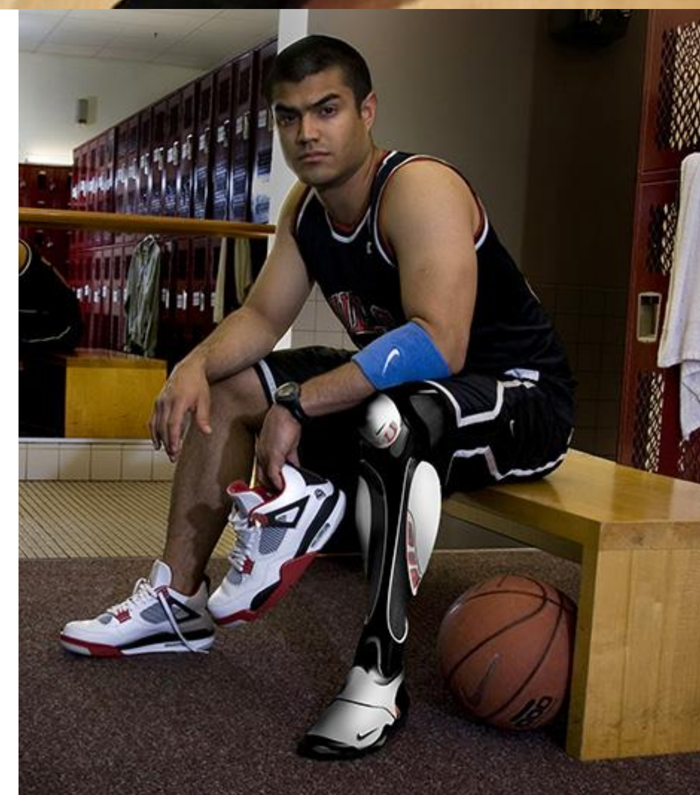
The Touch Bionics products are the first prosthetic hands to imitate the true movement and lifelike accuracy of a human hand. The challenge has been to find materials that can move and flex in the same way that human skin does.

FINTER DIGITS AND FEET COVERING FOR A PROSTHESIS, CAN ALSO BE MADE

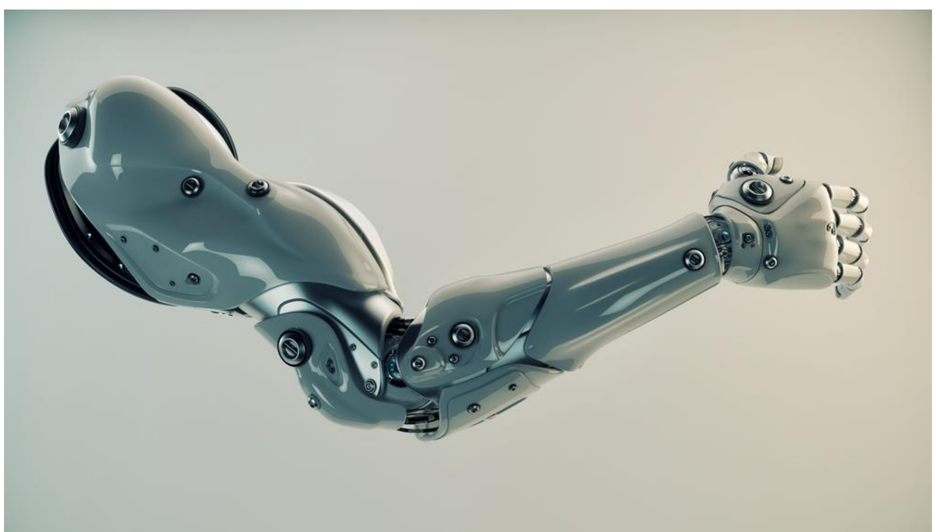
MODERN AESTHETIC DESIGNS FOR PROSTHES (MANY CAN BE 3D PRINTED)


MTV
EMA
FRANKFURT 2012
REPLAY
Windows



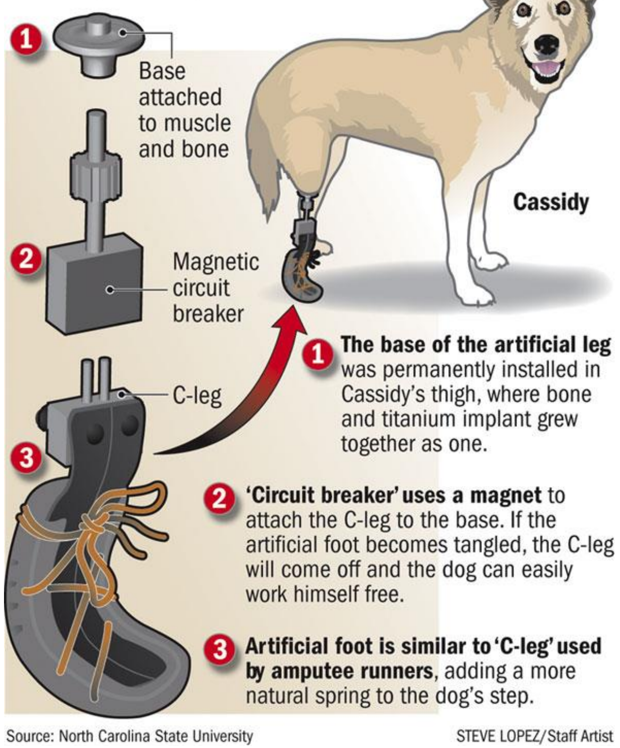

Nanocarbon
Dilatant
Composite Plating
CYBERNETIC LEG PROSTHESIS
5136_AC529
Mechanical Leg Replacement
WHAT IT DOES
TECH SPECS
SHARE THIS AUGMENTATION



This 3D-printed cast to help repair broken bones may be the future of medical orthopedic casts. 3D-printed casts also bring out the positive potential of this emerging technology.

Cassidy's artificial limb

N.C. State veterinarian Denis Marcellin-Little and engineering professor Ola Harrysson have developed an experimental artificial limb that may one day aid humans.



CHRIS P. BACON'S WHEEL ASSIST DEVICE

https://www.youtube.com/watch?v=r_FohCoYeWk

A British cat, Oscar, has made a full recovery from a farm accident, after being fitted with a pair of prosthetic feet in November.

The three-hour procedure, performed at an animal hospital in Surrey, England, by neuro-orthopaedic veterinary surgeon Dr. Noel Fitzpatrick, could serve as a model for human amputees. Oscar's custom-made implants, ITAPs (Intraosseous transcutaneous amputation prosthetics), were modeled after deer antlers, which have a honeycomb structure that bones can grow through and skin can grow over. **They are made of a Titanium-Aluminum material.**

By using computer-generated technology, a team of veterinarians and scientists designed a feline foot that mimics the way a cat walks and runs.
Oscar's implants were attached to his bones and then covered by hydroxyapatite, which allows bone cells to grow onto the metal. Skin can then grow over the ITAP to form a seal against bacteria and keep infections at bay.

https://www.youtube.com/watch?v=NqUEraHGHvI

THE END

3D PRINTING OF A WHOLE PERSON !!

https://www.youtube.com/watch?v=NMeODpNg_k8