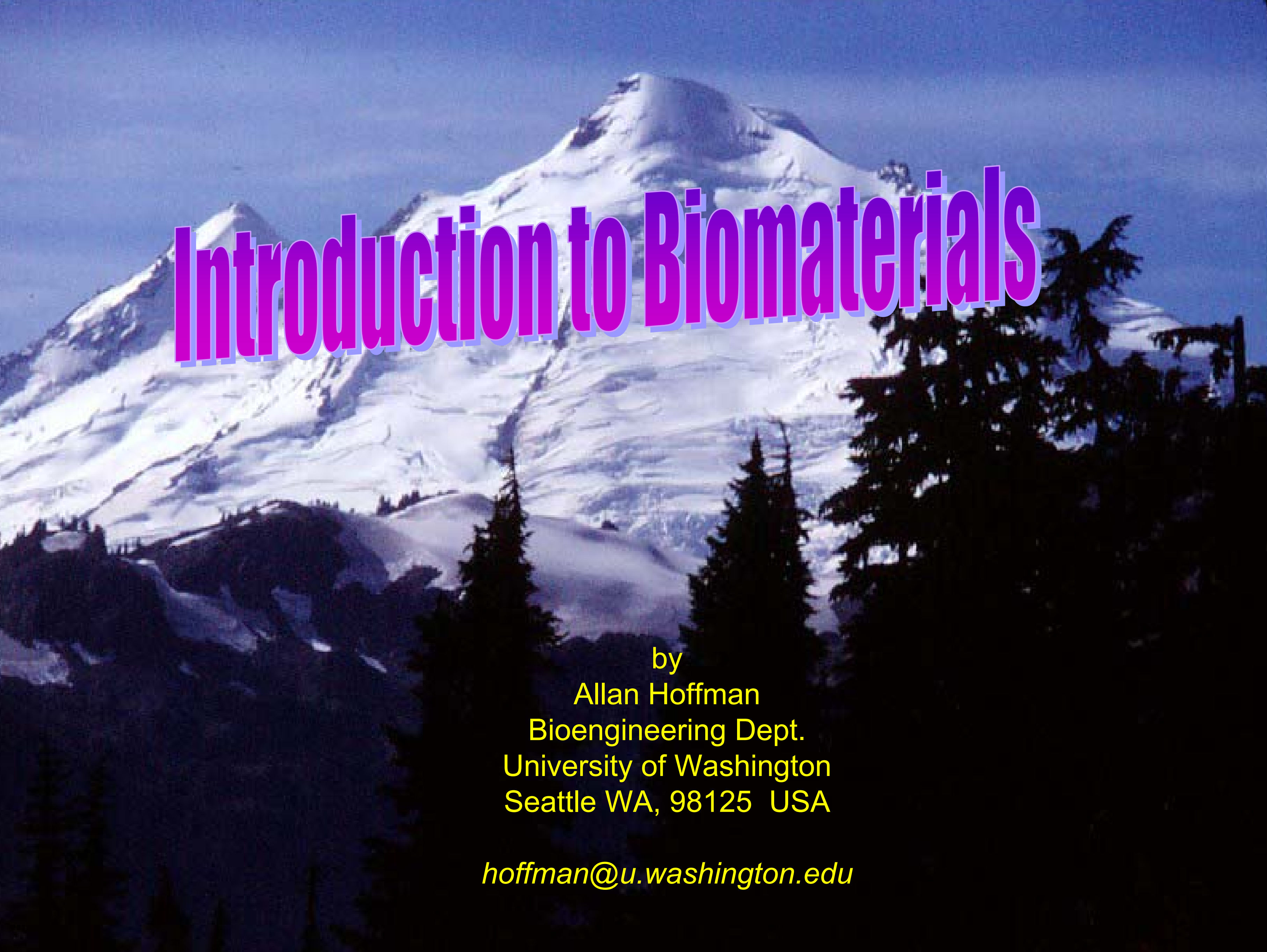

SWITZERLAND
MILAN
FRANCE
VENICE
HUNGARY
FLORENCE
VINCI
CORSICA
ROM
NAPLES
SICILY
BENVENUTTI
AL'ISCHIA!!



Introduction to Biomaterials

by
Allan Hoffman
Bioengineering Dept.
University of Washington
Seattle WA, 98125 USA

hoffman@u.washington.edu

Introduction

- Medical implants and therapeutic devices have had an immense impact on modern health care.
- This exciting and important field only began in earnest about sixty years ago.

Biomaterials

- Medical implants and devices are composed of a wide variety of materials, called "biomaterials", which include polymers, metals, ceramics, carbons and natural tissues.
- Where did they find the materials for the earlies devices?
- How did these "off the shelf" materials evolve into safer and purer forms, having a variety of novel designs and shapes?

We will see that in the beginning of the modern era of biomaterials and implants:

- Surgeons were the innovators in the 1940s-50s.

- They soon realized they needed help, and got it from materials scientists and engineers in the 1960s to 1980s.

- The materials engineers soon realized they needed help, and got it from biologists in the 1990s, and that continues today. Indeed, BIOLOGY is the driving force in our field today.

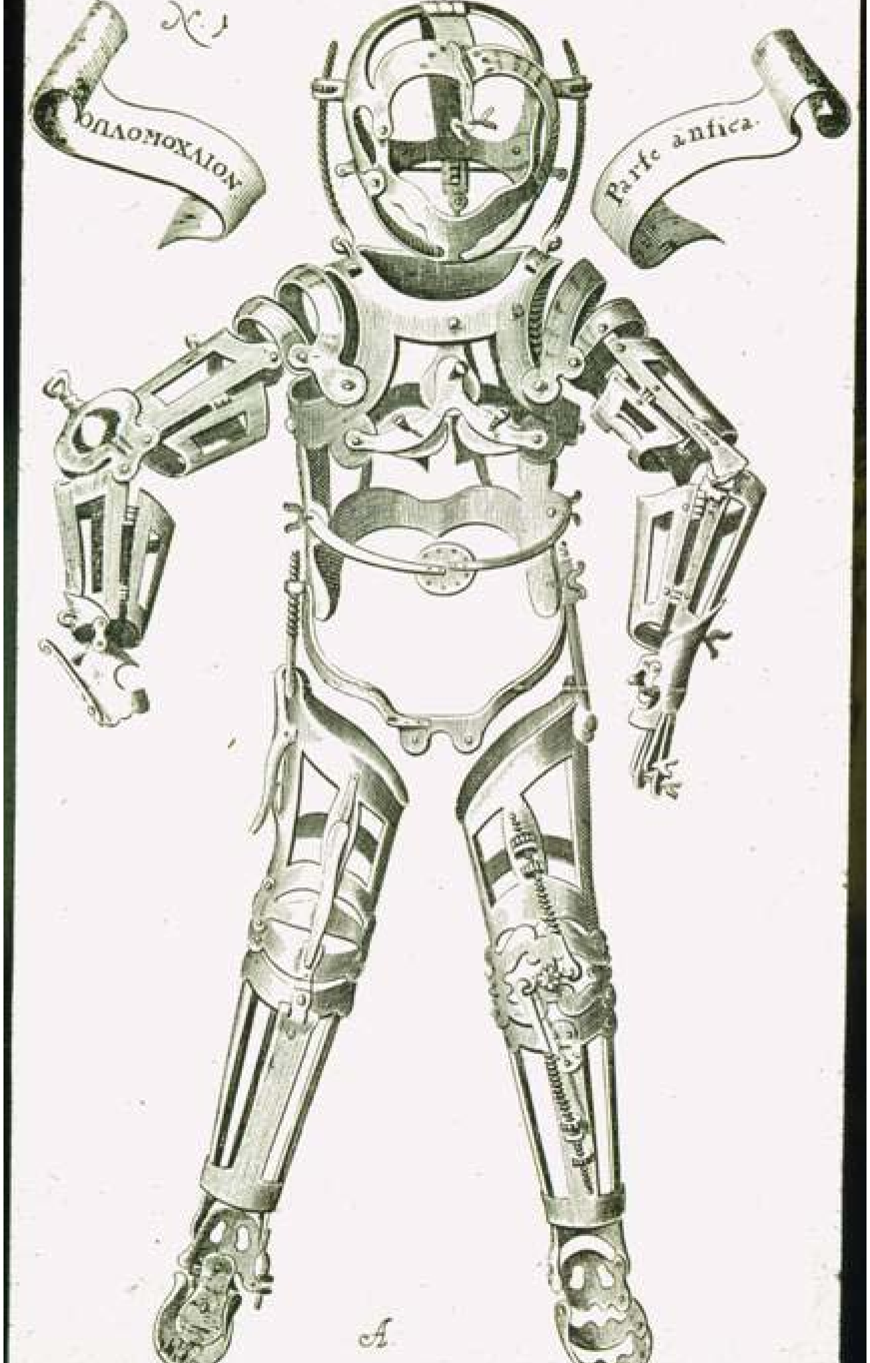
Here are some stories of how the earliest implants and devices were developed…..

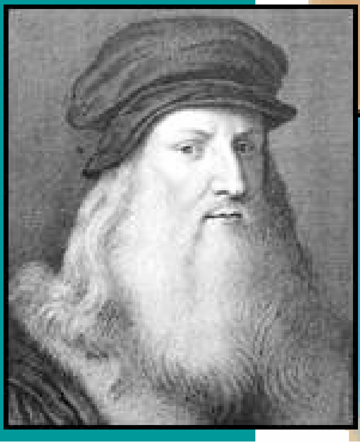
What are the earliest known uses of biomaterials?

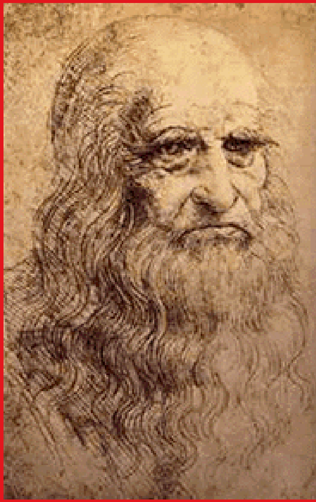
- Ancient Egyptians and Greeks used gold in dentistry.
- Around the time of Christ: Camel caravans used copper IUDs.
- 600 AD: Mayans used sea shells (nacre) as teeth implants.
- 1400S-1500S: **Da Vinci** and **Galileo** study "biomechanics" in **Italy**.
- 1600s-1900s: Iron was used in suits of armor and this led to its use in orthopedic supports.
- 1770s: George Washington, first President of USA, had a wooden tooth.

In WORLD WAR II, many new materials were developed--> polymers.

- 1940s: **Kolff** in The Netherlands develops artificial kidney using sausage casing.
- 1940/50s: **Ridley** in UK develops PMMA intraocular lens (IOL).
  Wichterle in Prague develops PHEMA soft contact lens.
  Failure of parachute Nylon® and Teflon® as vascular grafts leads **DeBakey, Cooley, etc.** in USA to develop Dacron® grafts.
- 1950/60s: **Charnley** (with **Smith**) develop the artificial hip in UK using Stainless® Steel, PE and MMA/PMMA as bone cement.
- 1960/70s: **Kolff, Nose, Akutsu, etc.** in USA and Japan develop LVADs and artificial heart.
  Yannas and **Burke** in USA develop collagen/chondroitin sulfate artificial skin for burn dressing.
- 1950/70s: Silicone injections (Japan) led to silicones in breast implants (USA).
- 1970-80s: **Schmitt and Frazza** in USA develop PLA degradable suture.
- 1980/90s: **Branemark** in Sweden discovers that bone binds to Titanium surface.
  Hench in USA develops ceramic glass the bonds to bone.
  Bottin in France develops alumina hip joint femoral head and cup.

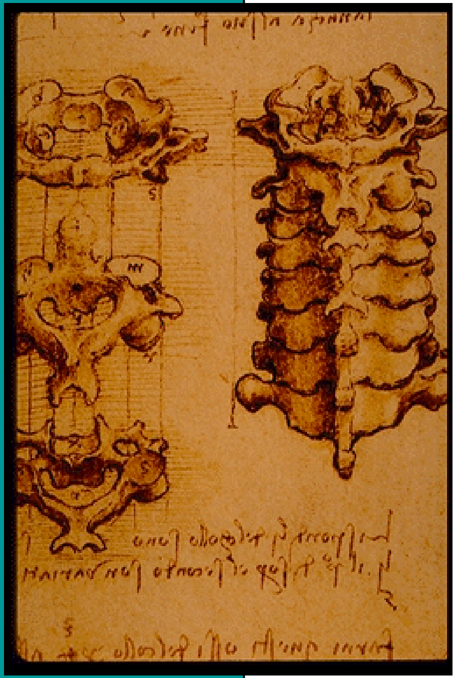

N. 1
ΟΠΛΟΜΟΧΛΙΟΝ
Parte antica
A

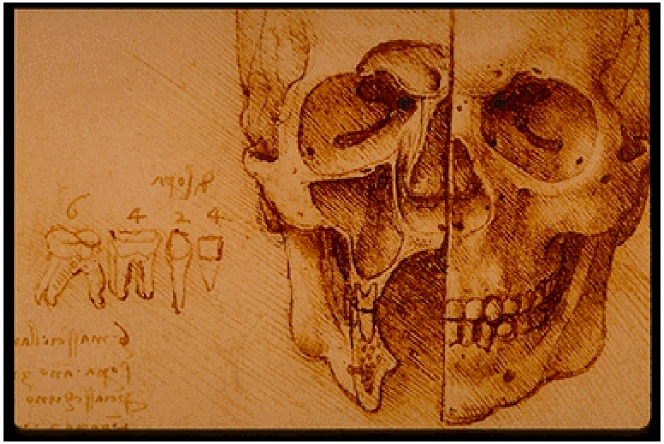


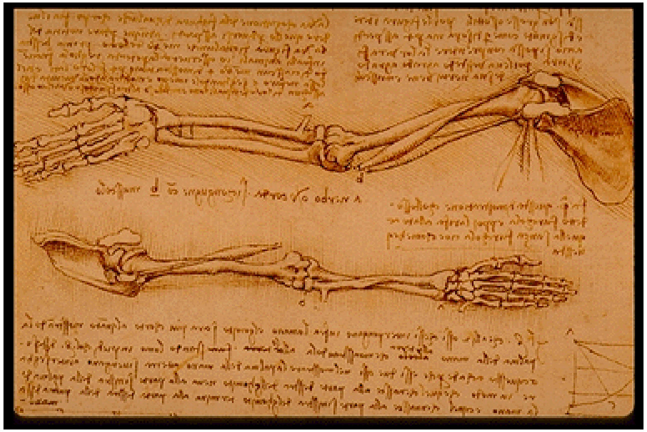


Perhaps Leonardo was the first bioengineer! (1452-1519)

Leonardo made many detailed anatomical drawings. The cadavers he used in these observations were often stolen from a nearby morgue.







Science

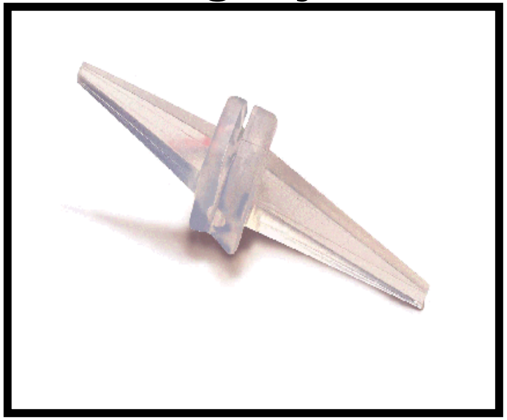
8 February 2002

Vol. 295 No. 5557
Pages 917–1180 $9

BODYBUILDING:
The Bionic Human

Common Medical Implants

Finger joint

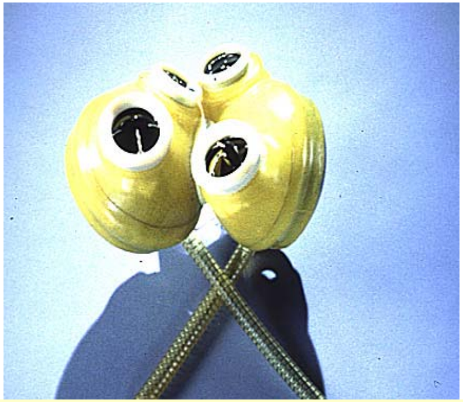


Breast implant

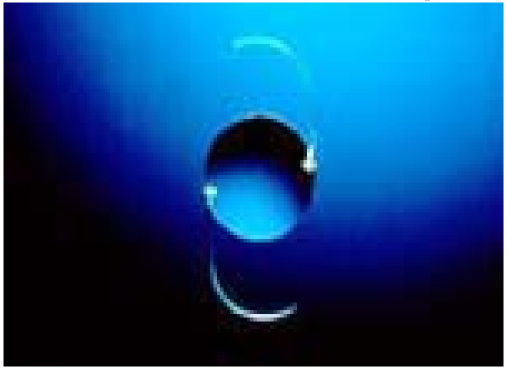
Heart valve

Hip joint

Artificial heart



Intraocular lens (IOL)



Medical implants save lives, improve quality of life -- but there are problems

Infection inflammation thrombosis longevity
fouling loosening scarring lubricity

Slide from Buddy Ratner

Implants and Devices
1999 U.S. Estimates

Implants

Hip and knee joints	6,500,000
Pacemakers	5,000,000
Intra-ocular lenses (IOLs)	2,500,000
Stents	1,750,000
Heart valves	1,500,000
Vascular grafts	700,000

Devices

Oxygenators	1,000,000
Dialysers	825,000

$250 billion = 7-9% of total US medical costs

CURRENT APPLICATIONS OF POLYMERIC BIOMATERIALS

IN VIVO

BIOMEDICAL

IMPLANTS

EX VIVO DEVICES

TOPICAL MATERIALS

DRUG DELIVERY SYSTEMS

ARTIFICIAL TISSUES
AND ORGANS

IN VITRO

BIOTECHNOLOGICAL

BIOSENSORS

DIAGNOSTICS

BIOSEPARATIONS

BIOPROCESSES

DIALYSIS
and
THE ARTIFICIAL KIDNEY

Willem Kolff, M.D.

He invented the
artificial kidney
and has been a pioneer in the
development of
the artificial heart.
He is called the
"Father of artificial organs"

At some moment in The Netherlands
during World War II, he got the idea o
the artificial kidney……

The Kidneys

One major function of healthy kidneys is removal of the end products of protein metabolism. Every 24 hrs. they must remove:

~15 g of urea

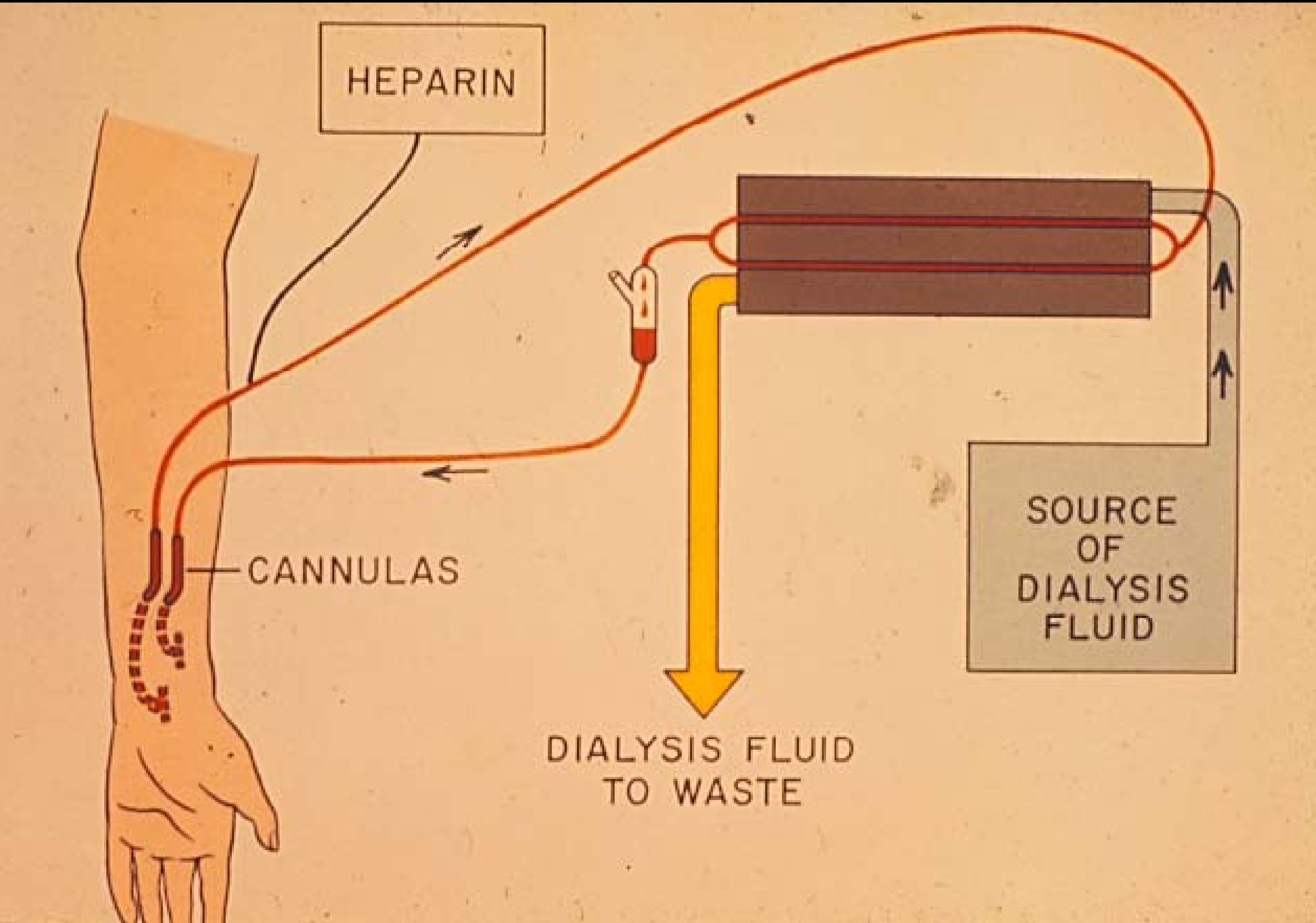
~ 3 g of creatinine

~ 1 g of uric acid

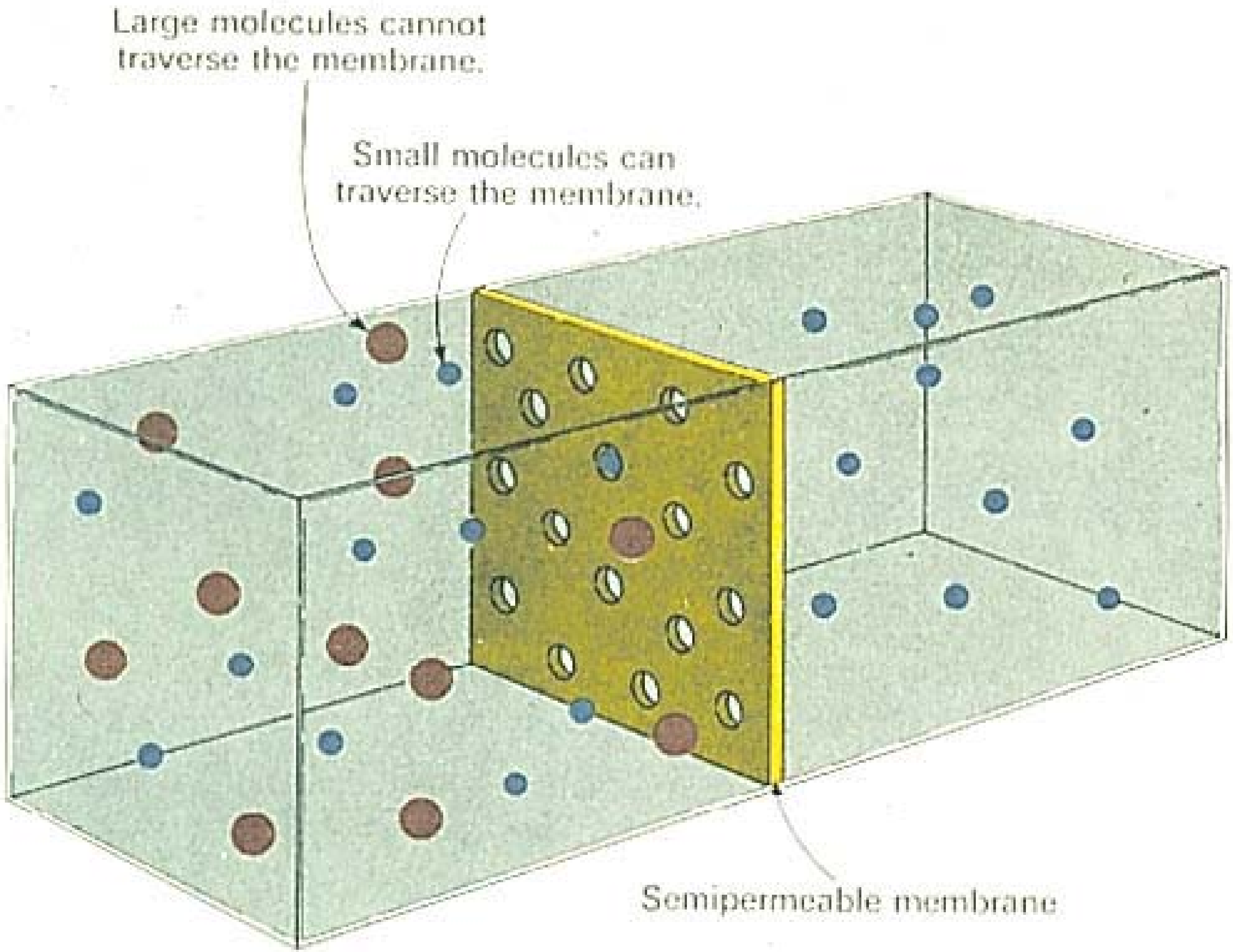
- The kidneys also balance electrolytes, remove fluid, and produce several hormones.

Mannekin-Pis
Brussels, Belgium

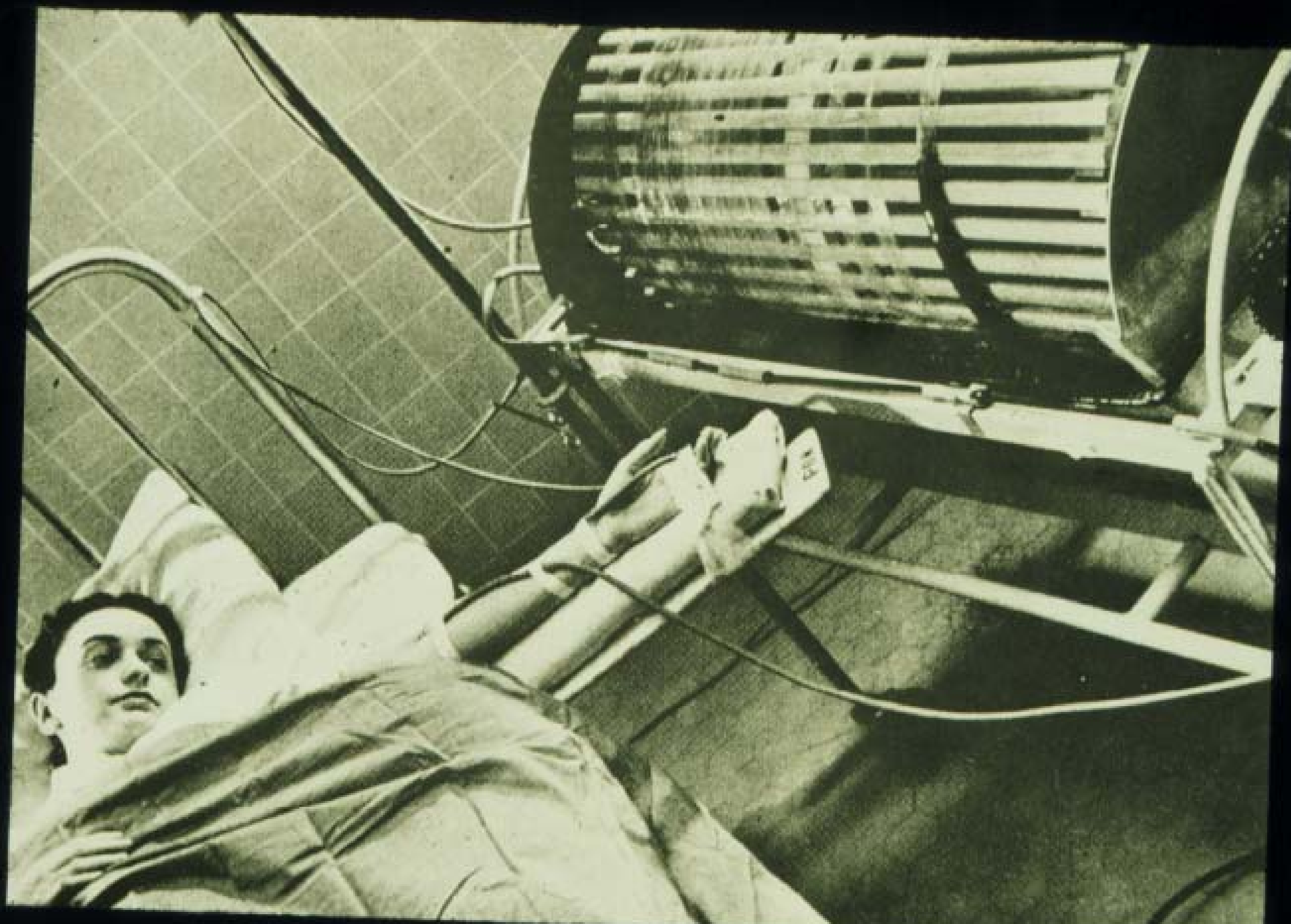
Schematic of the operation of an artificial kidney dialyser



Separation of molecules on the basis of size by dialysis



Kolff Dialysis in The Netherlands circa 1940s

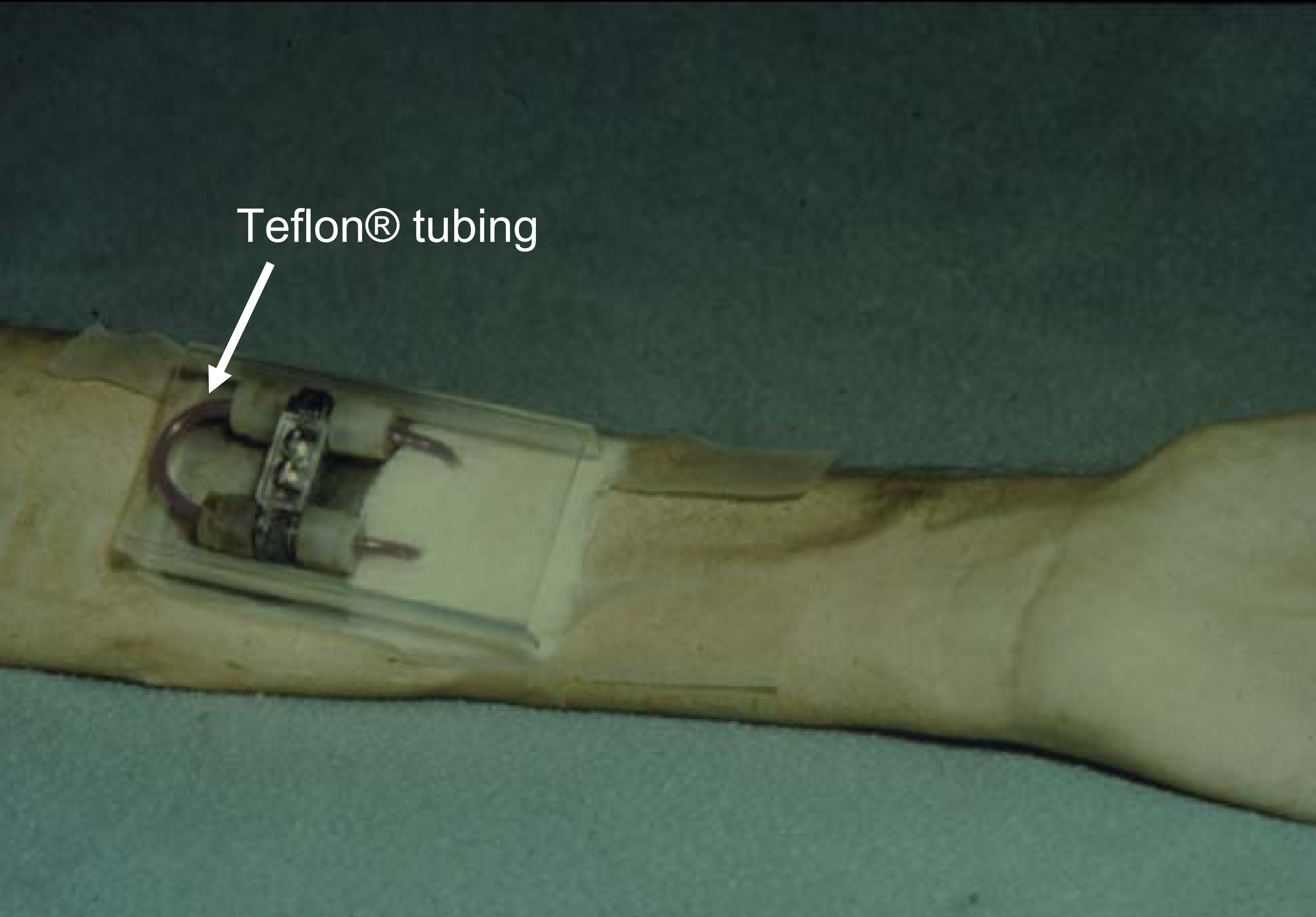


Willem Kolff, MD,and the washing machine dialyser (Cleveland Clinic, 1950s)

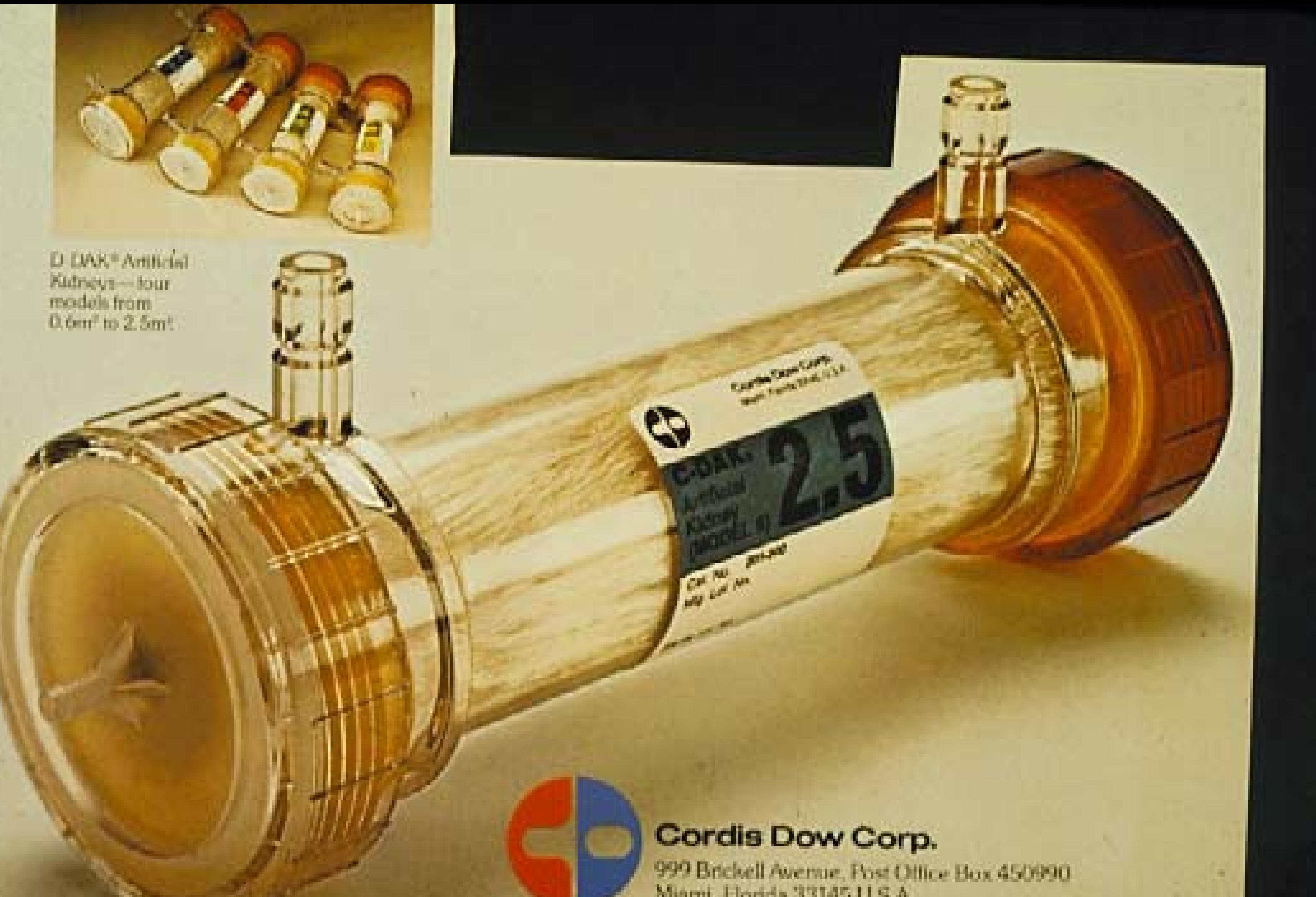
The Vessel Access Breakthrough

Dr. Belding Scribner, M.D.
University of Washington, Seattle, 1950/60s

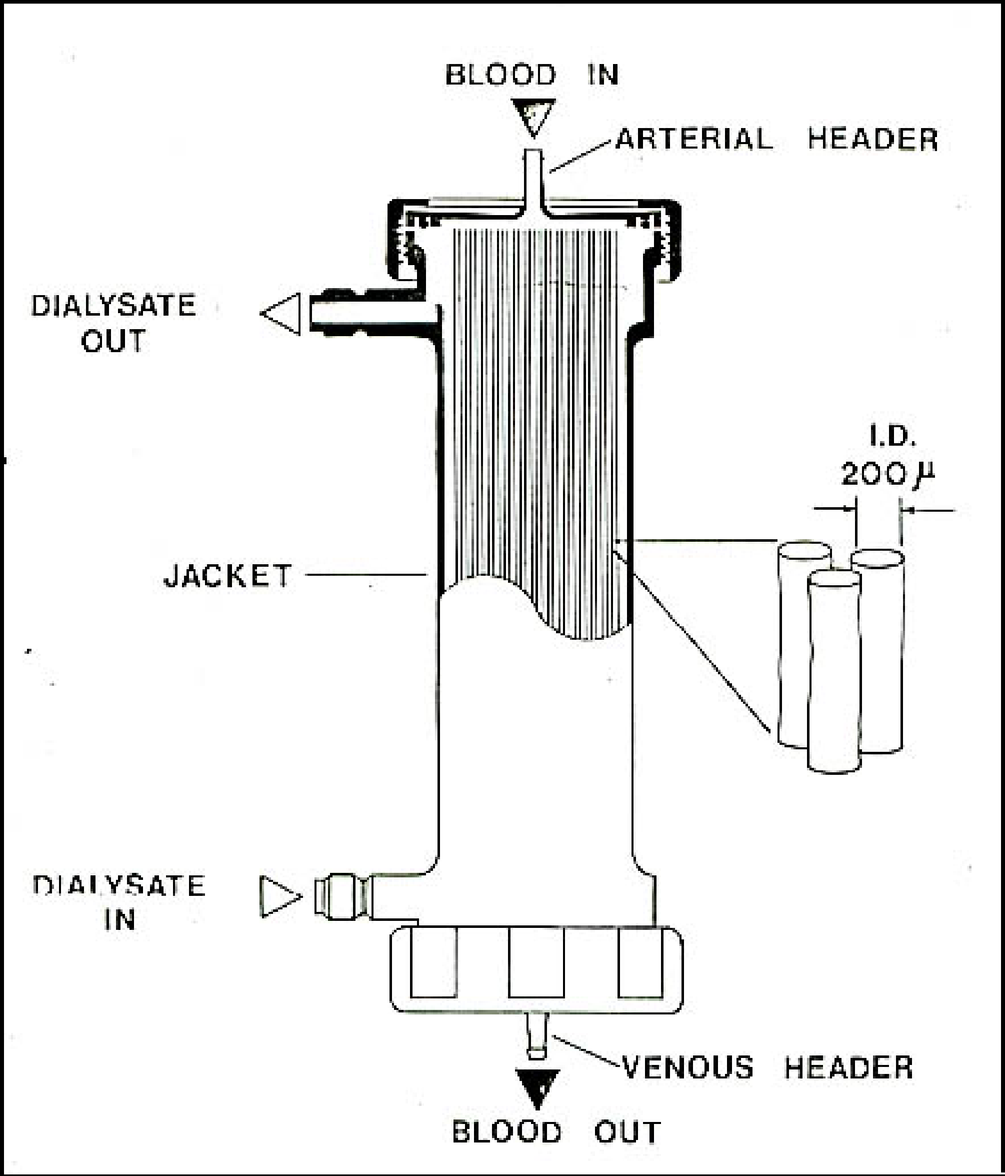
The Quinton-Scribner shunt circa 1950s-1960s



The hollow fiber artificial kidney (HFAK) with Cellulose Acetate hollow fibers, circa 1970s-1980s

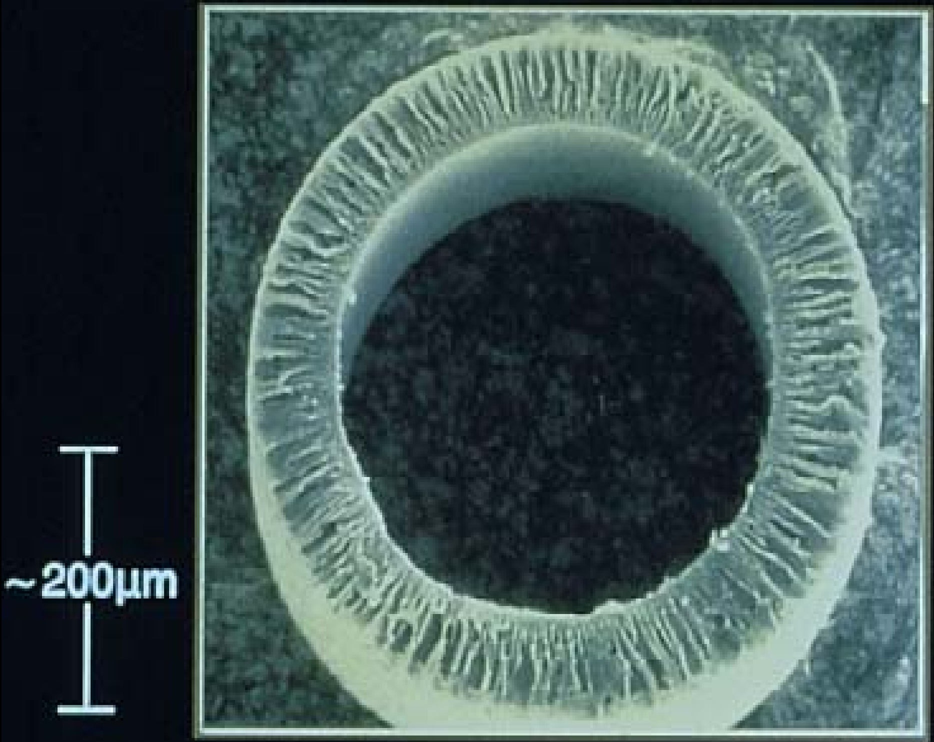


Schematic operation of HFAK



PERMSELECTIVE MEMBRANE

Inner Skin, Wall, Outer Surface



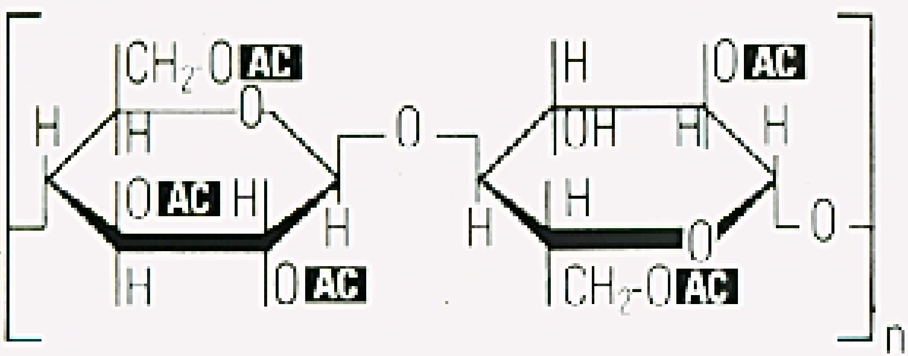
HOLLOW FIBER MADE OF CELLULOSE ACETATE

Cellulose Acetate

ENKA Cellulose Acetate membranes were particularly developed specifically for plasma fractionation, hemo-filtration and high-flux dialysis.

Figure 17

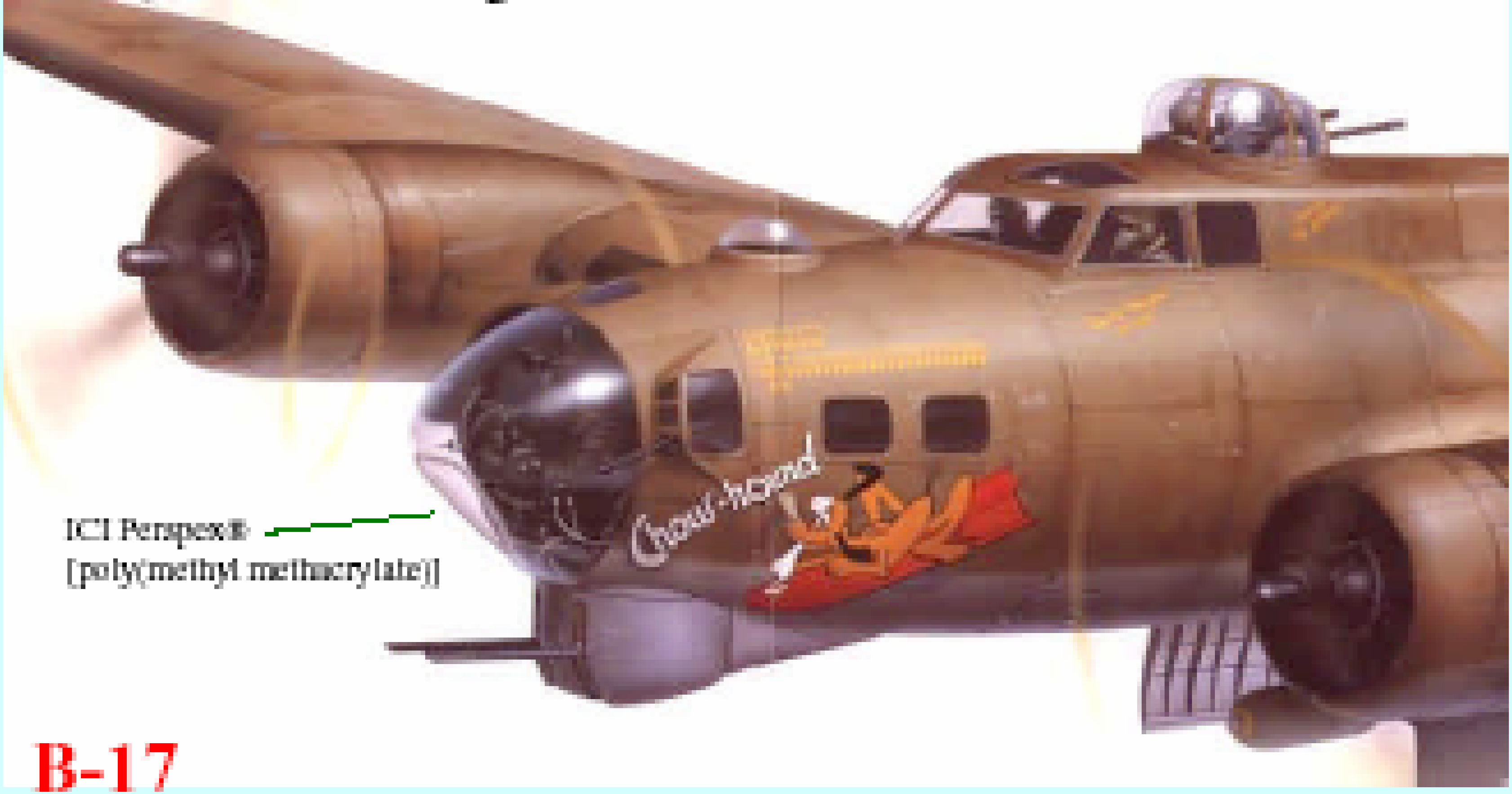
Structural formula

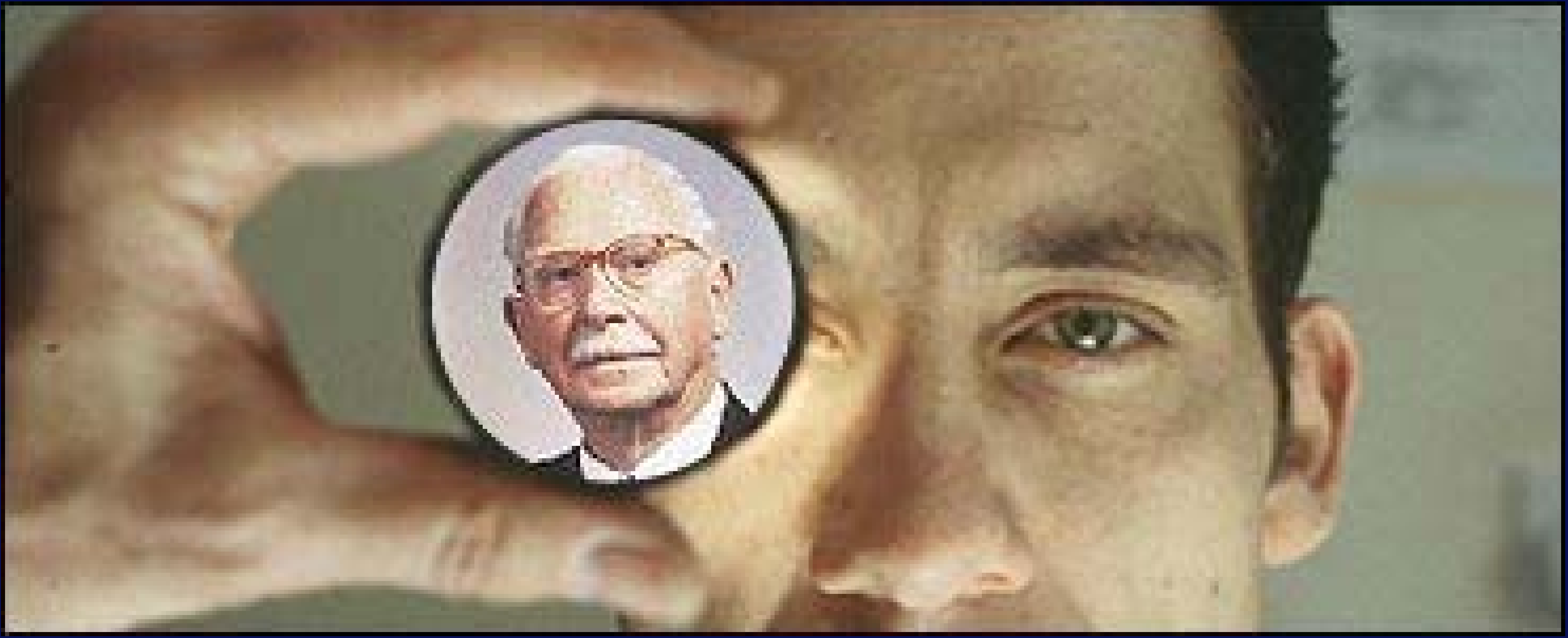


This is the polymer used to form thin skin, hollow fibers for the HFAK.

THE INTRAOCULAR LENS (IOL) AND THE CONTACT LENS

The “origin” of the modern biomaterials field:

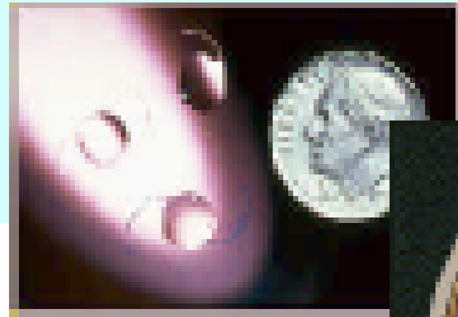




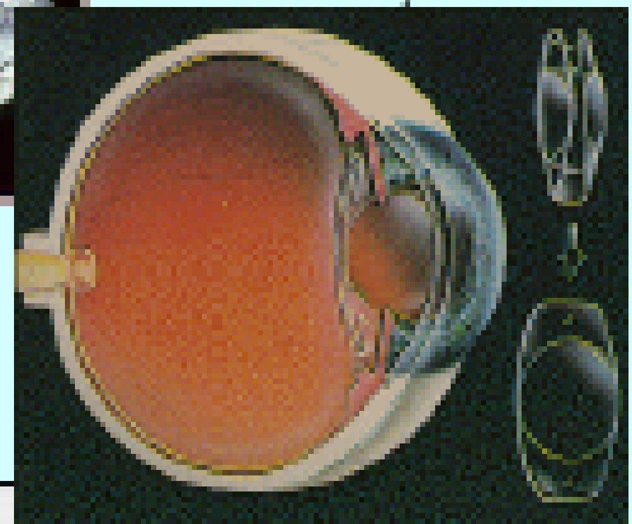
During the Second World War, the British opthalmologist Harold Ridley encountered several fighter pilots who had eye injuries caused by small plastic pieces from shattered cockpit windows. They did not inflame the eye and were not rejected. From these observations, Ridley got the idea of replacing a lens suffering from cataracts with a plastic lens, and on 29 November 1949 he performed the first intraocular lens (IOL) implantation at St Thomas's Hospital.

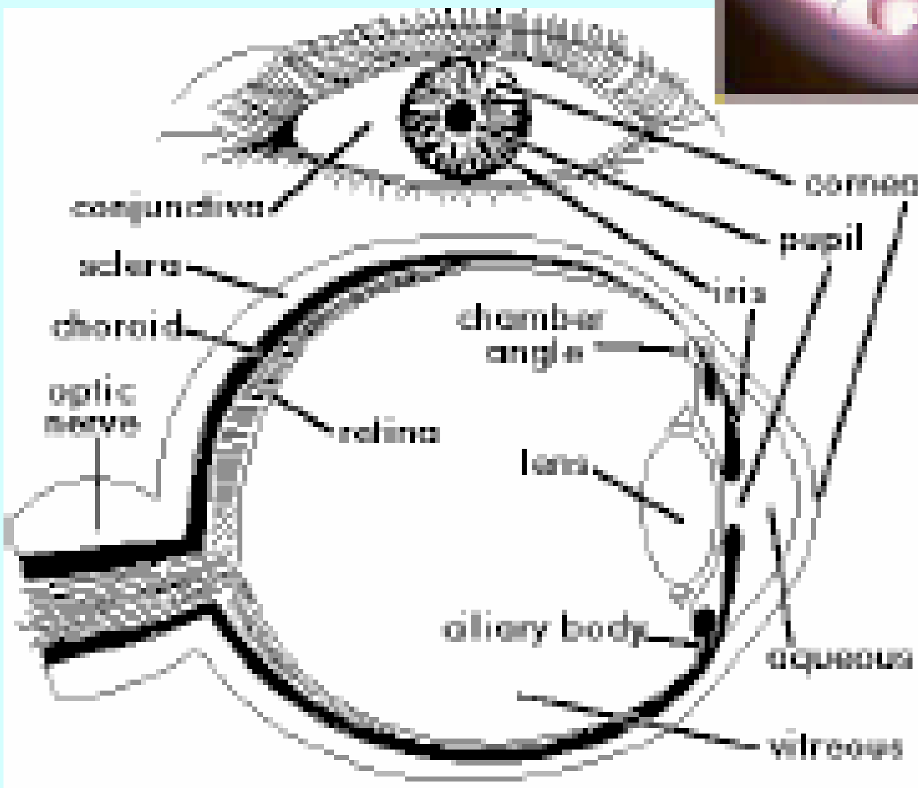
Intraocular Lenses (IOLs) - 7,000,000 worldwide/year

- Poly(methyl methacrylate)
- Silicone rubber
- Hydrogel
- Acrysoft®

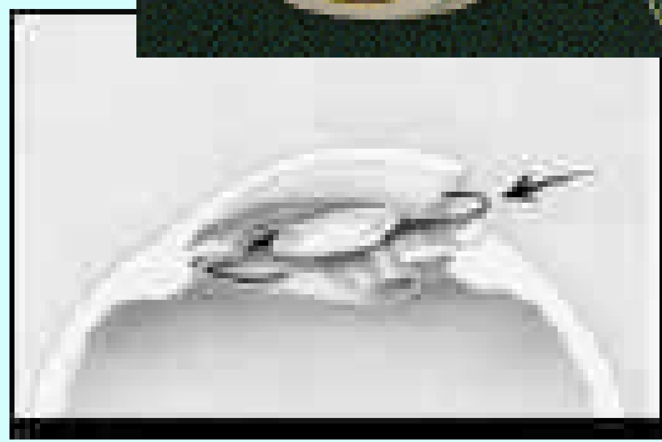


http://www.eyeclinicfbks.com/IntraocularLensImplant.htm

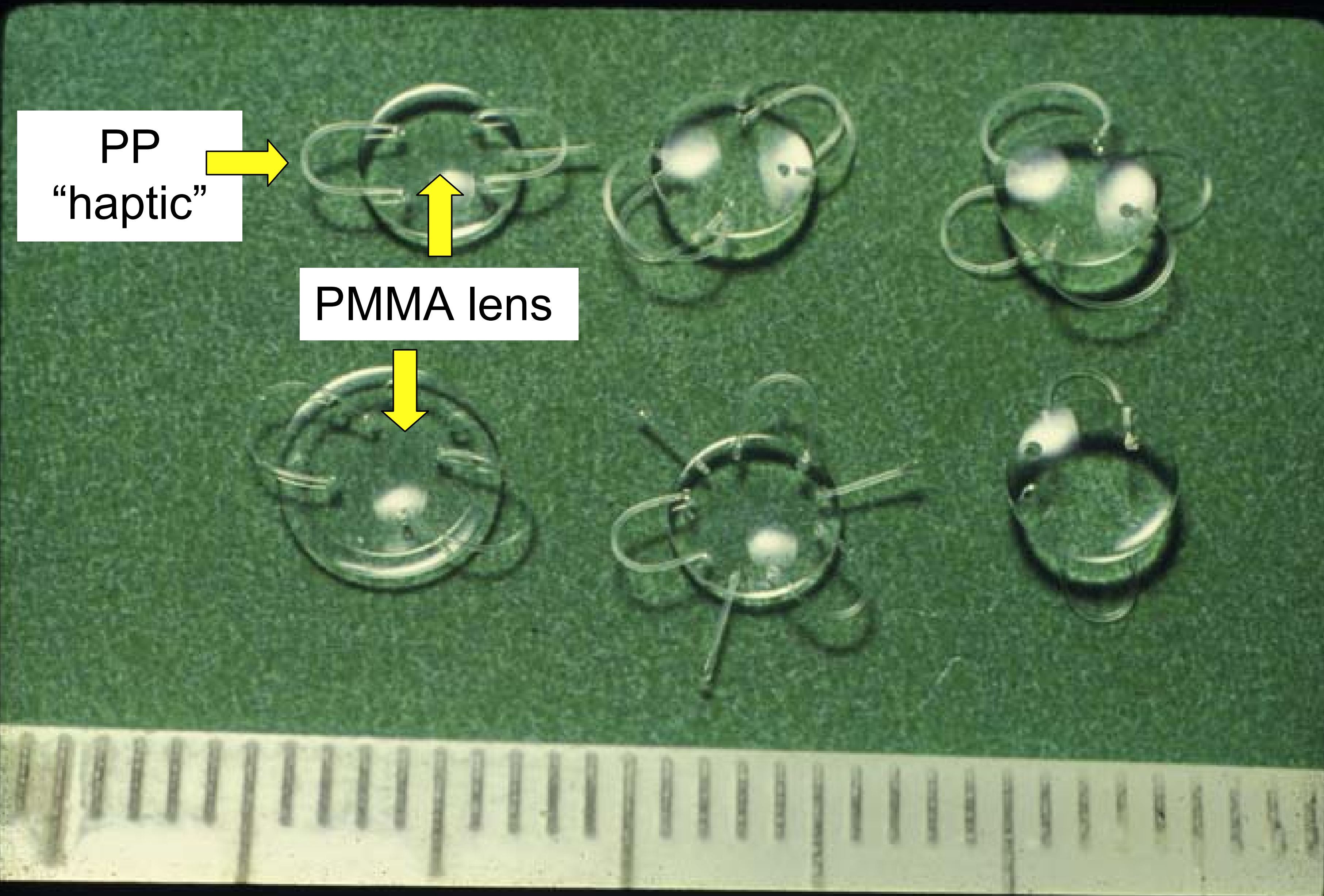




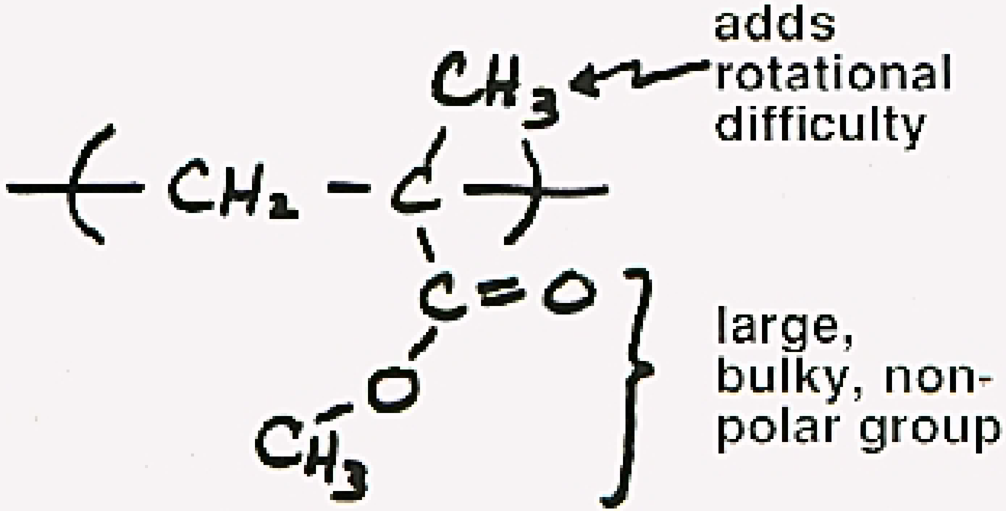
http://www.richmondeye.com/eyeanat.htm



http://www.eyenet.org/public/faqs/cataract/cataract_surgery_faq.html


PP
"haptic"
PMMA lens

The PMMA Molecule



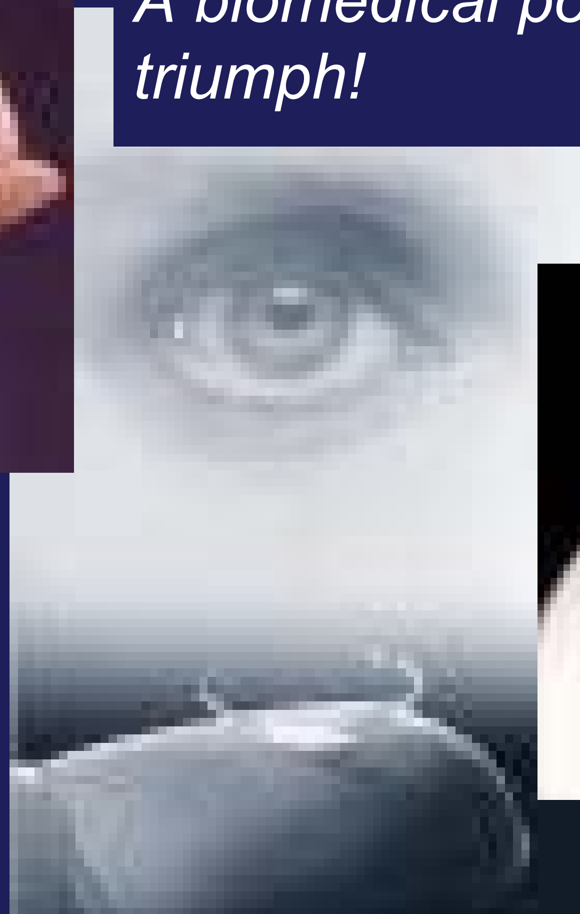
- Stiff chain
- Hydrophobic
- Irregular chain repeat unit

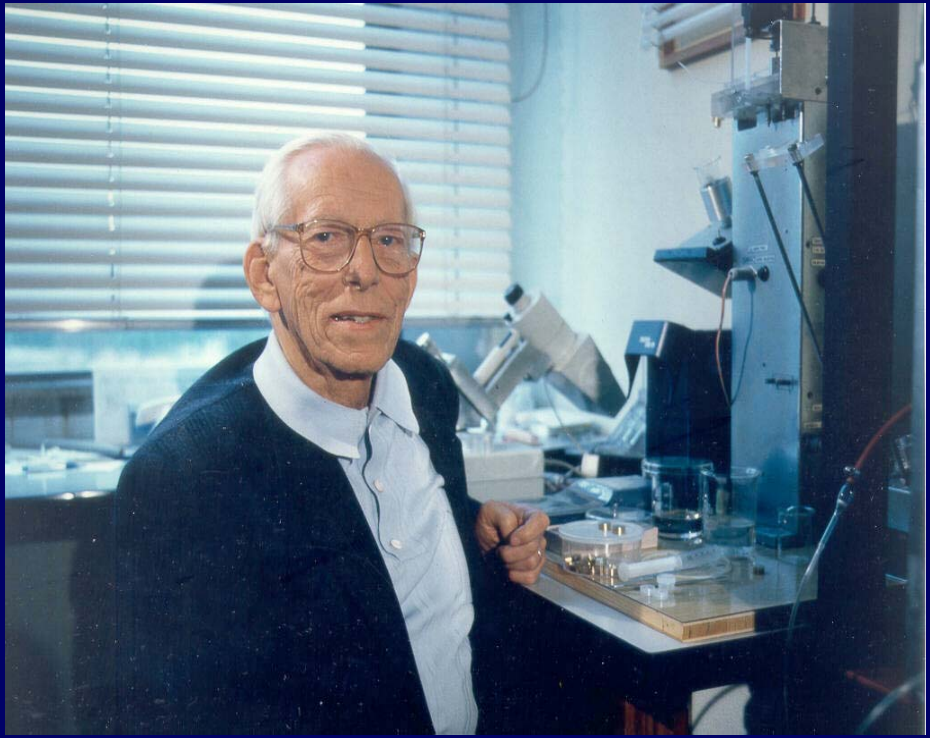
Uses
The hard contact lens, the IOL and bone and dental cement

All these lead to an amorphous, glassy, low water sorption polymer, useful as a molded plastic.

The hard contact lens...PMMA.
A biomedical engineering success story!

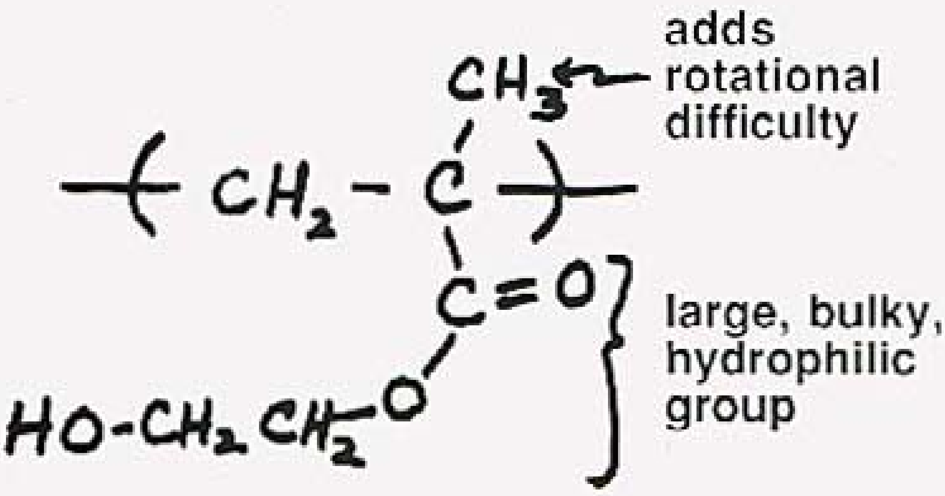
The soft contact lens….PHEMA.
A biomedical polymer chemistry triumph!





Elsewhere in the 1950s, a Czech polymer chemist named Otto Wichterle was working in his kitchen at home to polymerize a new monomer that he had synthesized in his Institute at work. It was HEMA, or hydroxyethyl methacrylate, and he had the idea to make it into a hydrogel, which he thought should be a more “compatible” contact lens than the hard contact lens, PMMA. PHEMA became the first “soft” contact lens, Prof. Wichterle patented and licensed it, and he became the richest man in Czechoslovakia.

The PolyHEMA Molecule

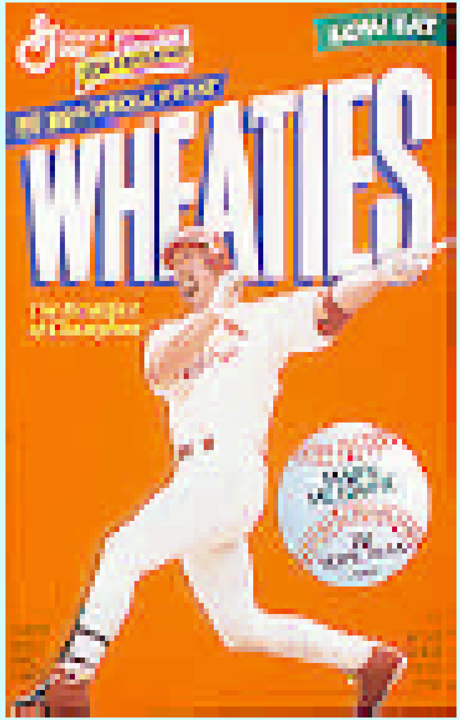


- Stiff chain when dry, but flexible when swollen with water
- Hydrophilic side group
- Irregular chain repeat unit

Uses
The soft contact lens

All these lead to an amorphous, glassy, polymer when dry, and a soft and flexible polymer when water swollen. When lightly crosslinked, it should be useful as a hydrogel.

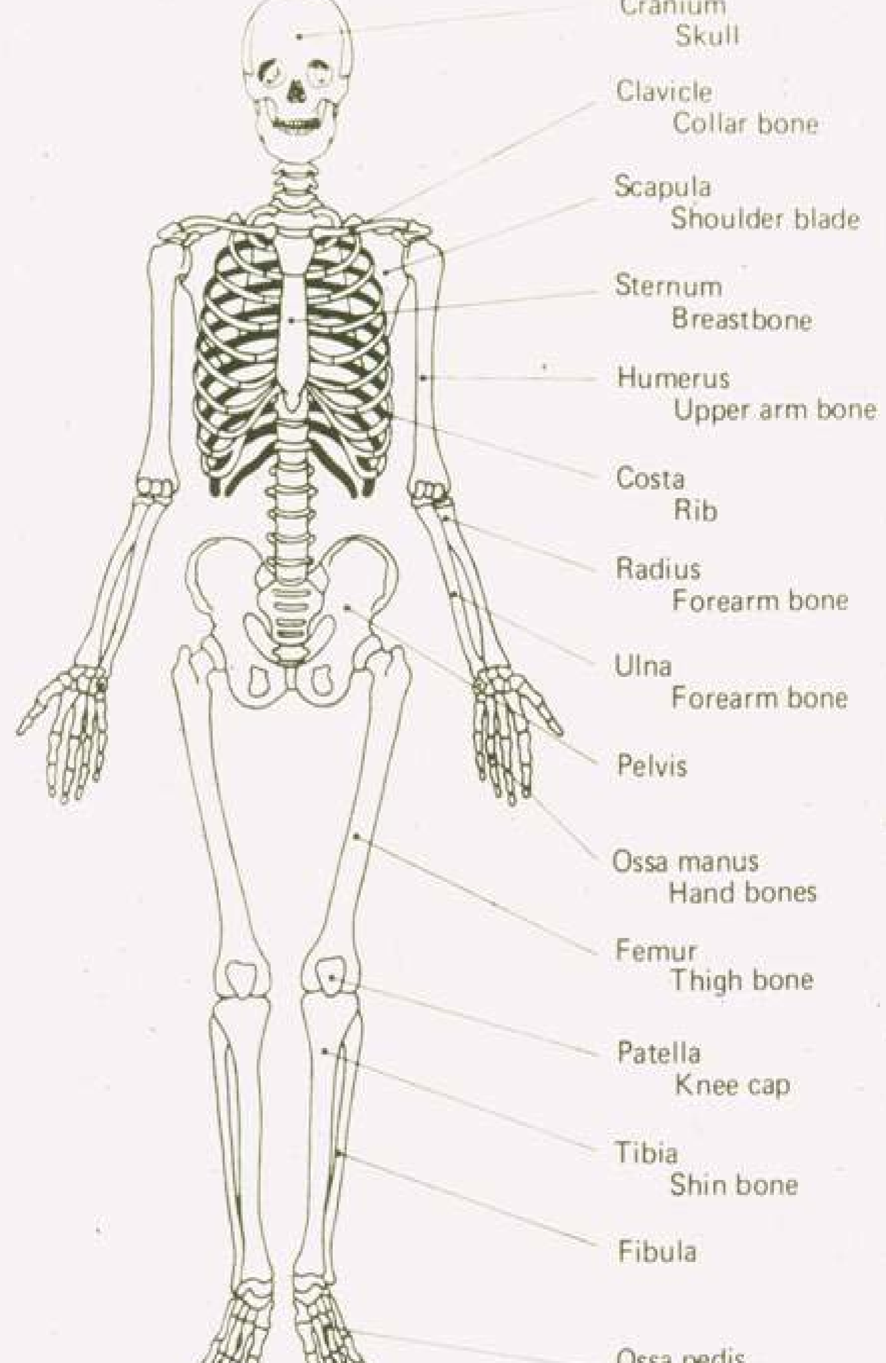
http://www.clarityvision.com/member/
contactlenses.html

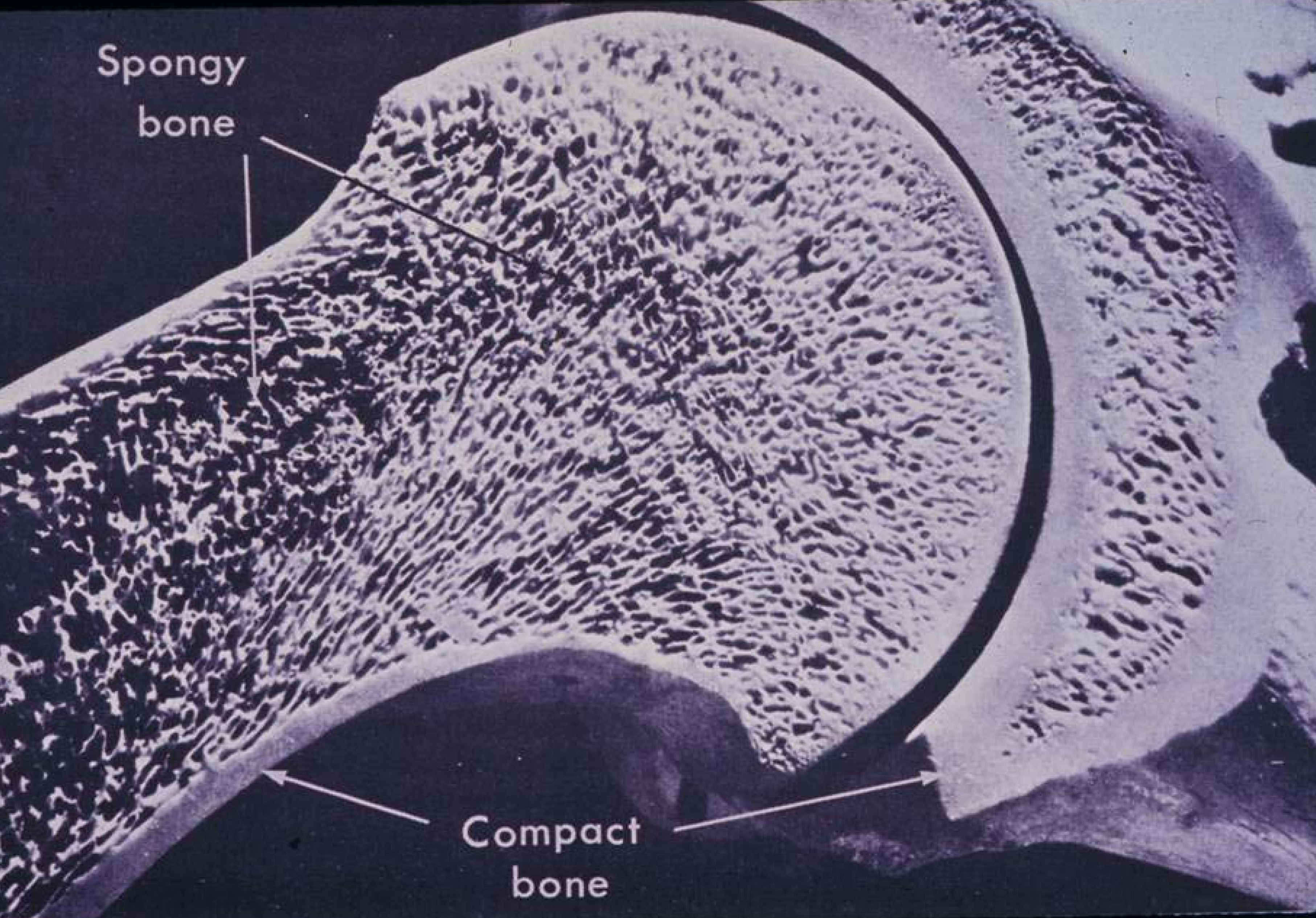


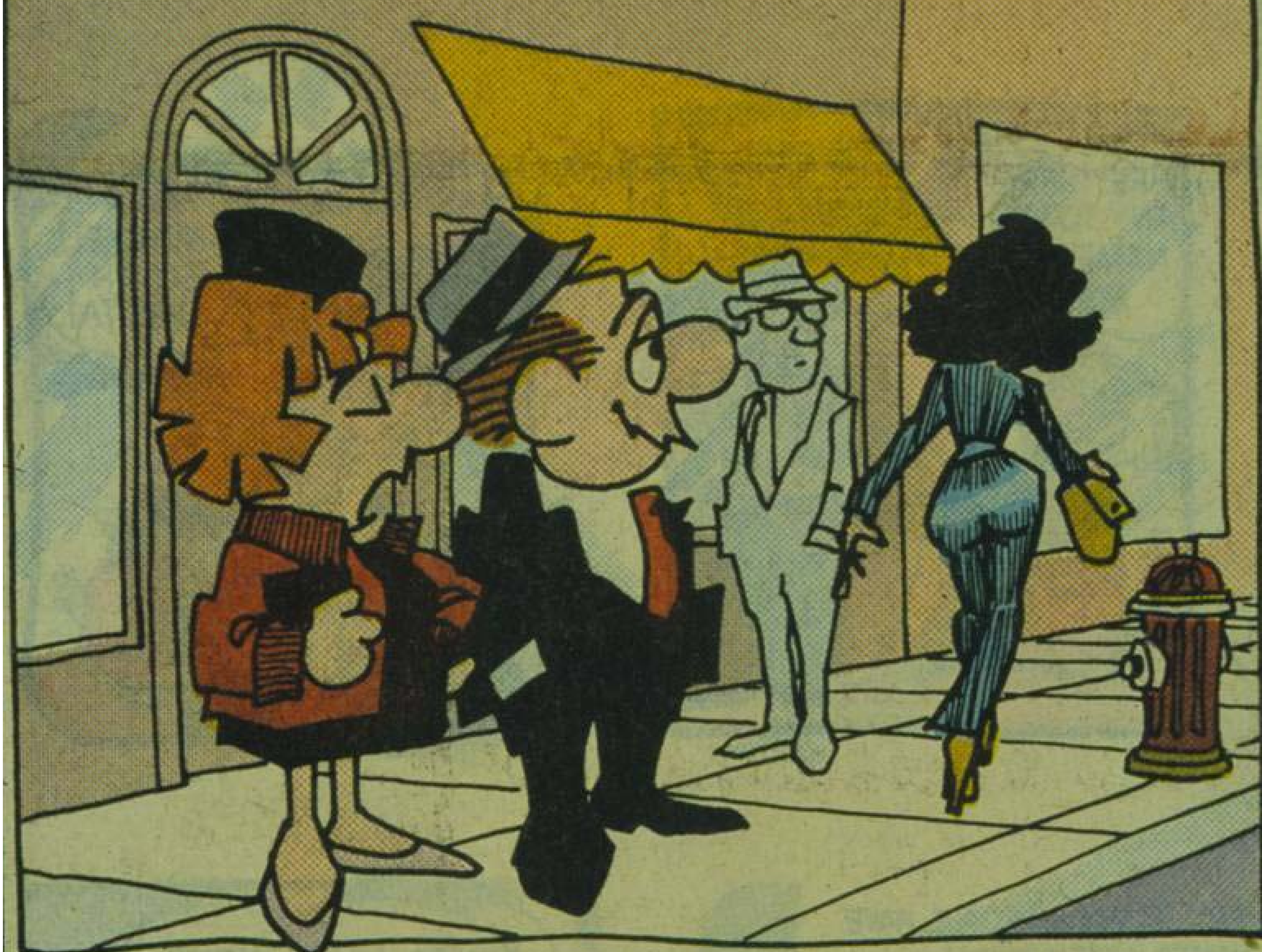
Contact Lenses and Mark McGwire

Mark McGwire is a contact lens wearer. McGwire is an uncorrected 20/500 and suffers from astigmatism and dry eye. In 1989, McGwire's existing lenses were replaced with custom designed soft torics. They're tinted yellow, like shooting glasses or ski goggles, to improve sharpness. Corrected, McGwire's vision is better than 20/10.

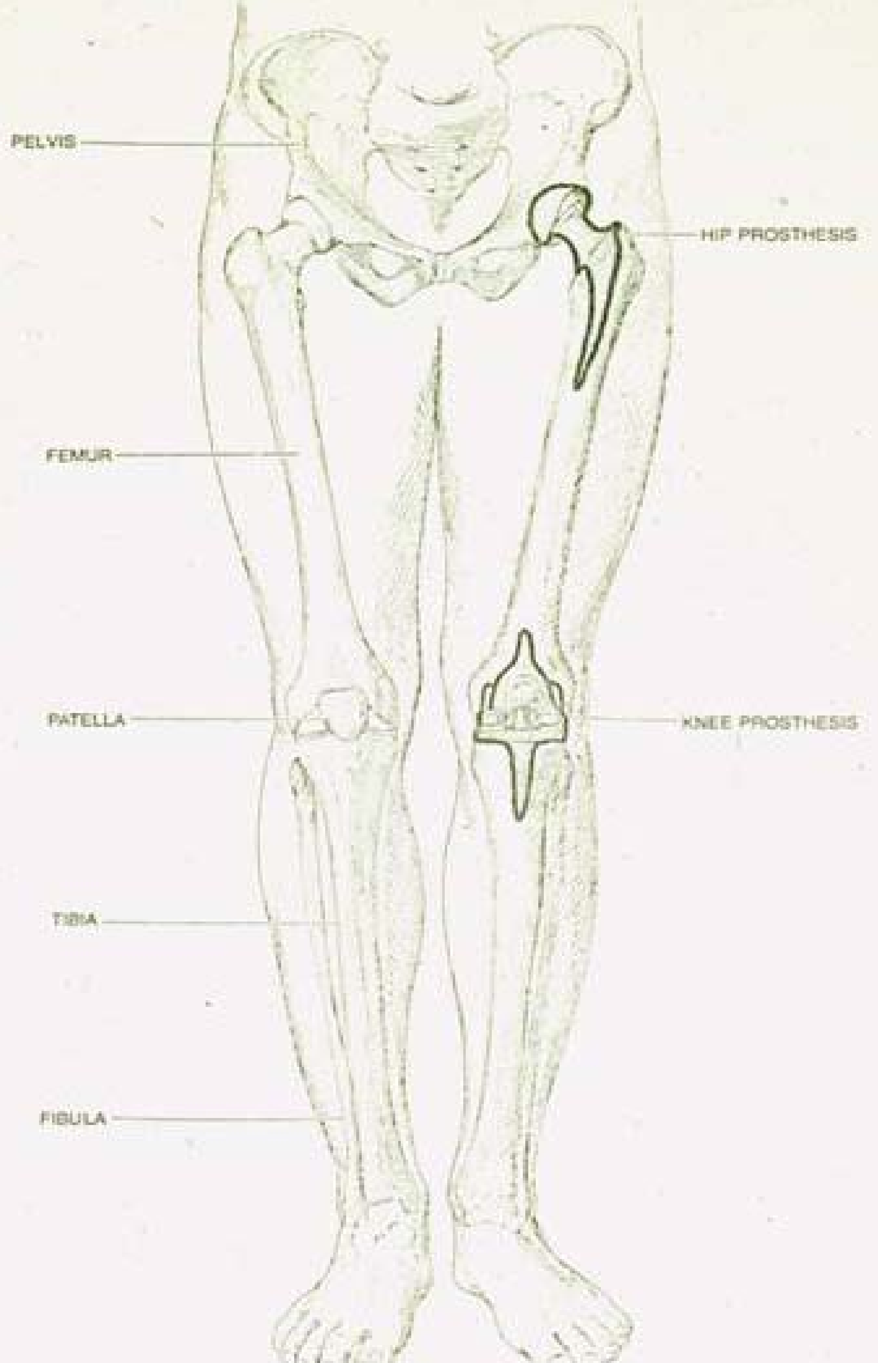
THE ARTIFICIAL HIP


Cranium
Skull
Clavicle
Collar bone
Scapula
Shoulder blade
Sternum
Breastbone
Humerus
Upper arm bone
Costa
Rib
Radius
Forearm bone
Ulna
Forearm bone
Pelvis
Ossa manus
Hand bones
Femur
Thigh bone
Patella
Knee cap
Tibia
Shin bone
Fibula
Ossa pedis


Spongy
bone
Compact
bone



"IN A FEW YEARS SHE'LL NEED A HIP OPERATION."


PELVIS
HIP PROSTHESIS
FEMUR
PATELLA
KNEE PROSTHESIS
TIBIA
FIBULA

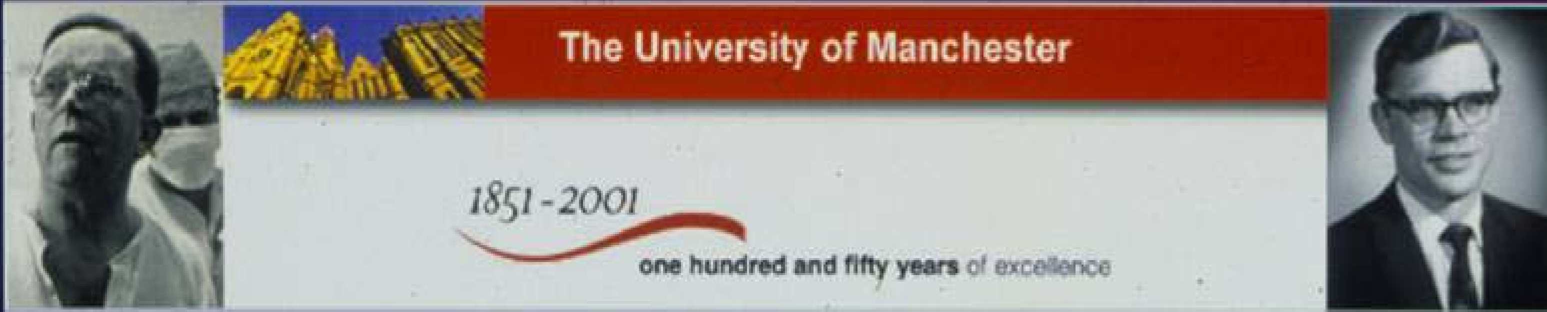
Sir John Charnley

One of the greatest surgical advances of the twentieth century has been the development of the hip replacement operation. The pioneer and innovator in the field was Sir John Charnley, an English orthopedic surgeon.

He invented the low friction hip replacement in the early 1960's at the Center for Hip Surgery at Wrightington, England. Surgeons from all over the world made their way to Wrightington to learn his techniques. He was a master surgeon, innovator and bioengineer.

Knee and shoulder replacement surgery developed directly out of his work on the artificial hip. His work has been an outstanding contribution to the relief of human suffering.


2 3 4 5 6 7 8 9 10



A 40th Anniversary Symposium on Acrylic Bone Cement in the New Millennium

May 13-14, 2002

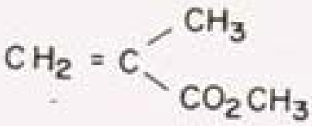
This academic year 2001-2002 we are celebrating the the 40th anniversary of the clinical use of acrylic bone cement following its development by Charnley and Smith at the University of Manchester. Many millions of patients have benefitted from cemented artificial joints, and currently more than 500,000 hip and knee joints are replaced every year.


STERILE
Sterilization indicator
SIMPLEX®
P
radiopaque
POWDER
(Mixture of Polymethyl methacrylate, Methyl methacrylate-Styrene copolymer and Barium Sulfate U.S.P.)
40g
Each packet contains 40g. of powder consisting of 6.0g. of Polymethyl methacrylate (15% w/w), 30.0g. of Methyl methacrylate-Styrene copolymer (75% w/w) and 4.0g. of Barium Sulfate U.S.P. (10% w/w).
WARNING:
See Package Insert for dosage and administration.
CAUTION:
Federal law prohibits dispensing without prescription.
Batch No: 043 IF
Sterilization No: 111172
Expiration Date: NOVEMBER 1973
Made by North Hill Plastics Ltd., London, N.16, England.
Distributed in the United States by
Howmedica Inc. Medical Division, Rutherford, New Jersey 07070.
OPEN HERE

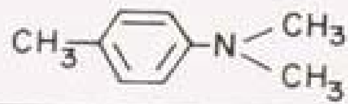

SURGICAL SIMPLEX
(Methyl methacrylate)
Sterile Liquid 20 ml.
SURGICAL SIMPLEX®
(Methyl Methacrylate)
Sterile Liquid 20ml.
Each ampul contains 20ml. of liquid consisting of 19.5ml. of Methyl methacrylate (97.4% v/v), 0.5ml. of N, N – dimethyl-paratoluidine (2.6% v/v), and 75 ± 15 ppm. of hydroquinone.
WARNING: 1. FLAMMABLE.
2. Store in a cool, dark place.
3. See Package insert for dosage and administration.
CAUTION: Federal law prohibits dispensing without prescription.
Distributed in the United States by
Howmedica, Inc. Medical Div.,
Rutherford, New Jersey 07070.
Batch No. 819 HF
Sterilization No. 121072
Expiration Date: JAN 74

ACRYLIC BONE CEMENT

LIQUID (20ml.)

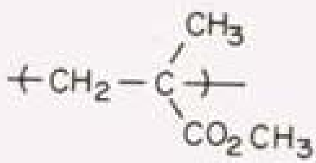
Methyl Methacrylate (MMA)  97.4% V/V

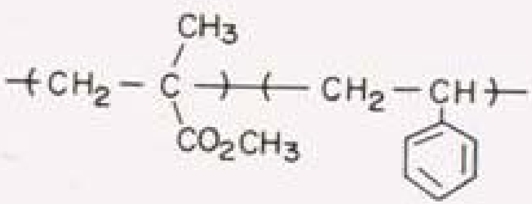
Hydroquinone  2.6% V/V

N-N dimethyl p-toluidine  ~75 ppm

---

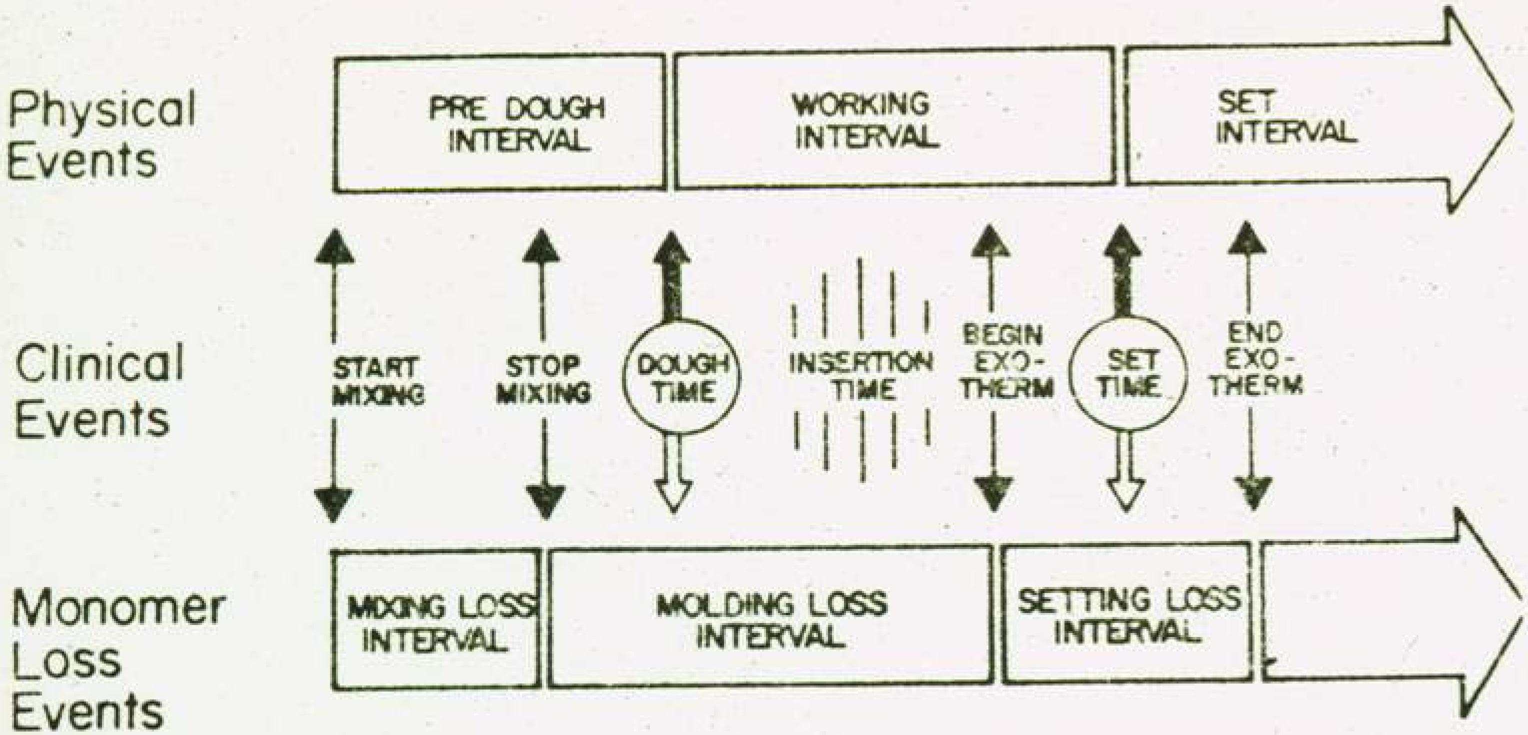
SOLID (40g)

PMMA  15% W/W

Copoly (MMA/sty)  75% W/W

Ba SO_4 10% W/W

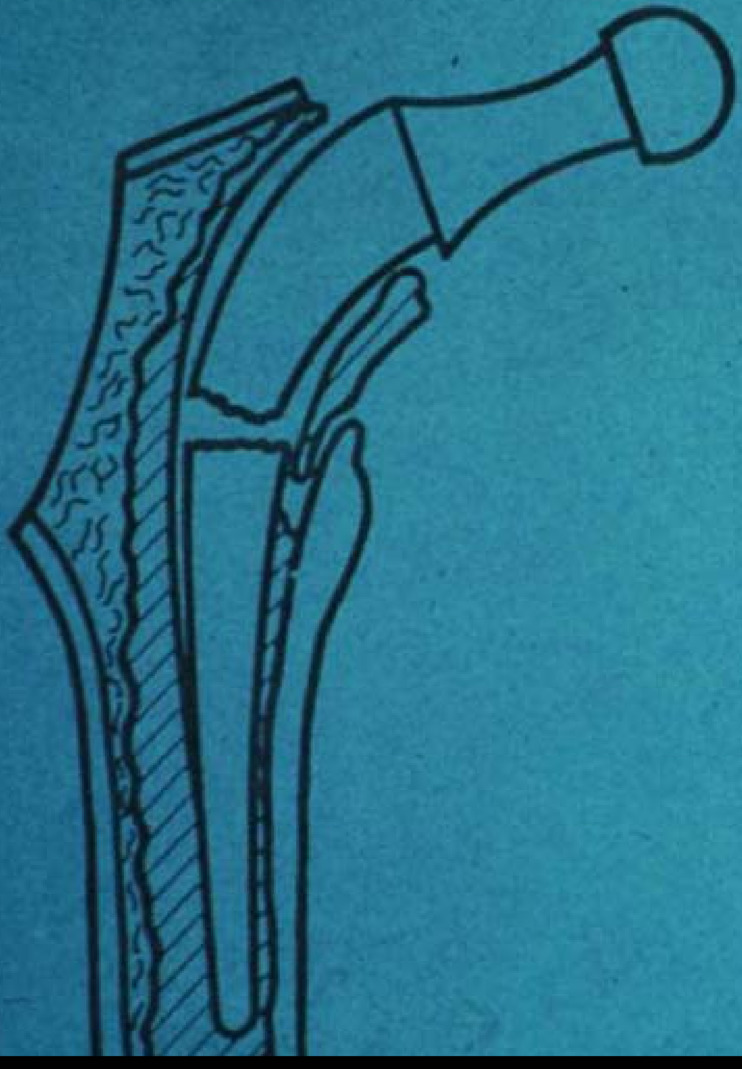
Benzoyl Peroxide 



Chronological comparison of cement terminology and clinical landmarks vs. monomer loss. (Beyne et. al., 1977)

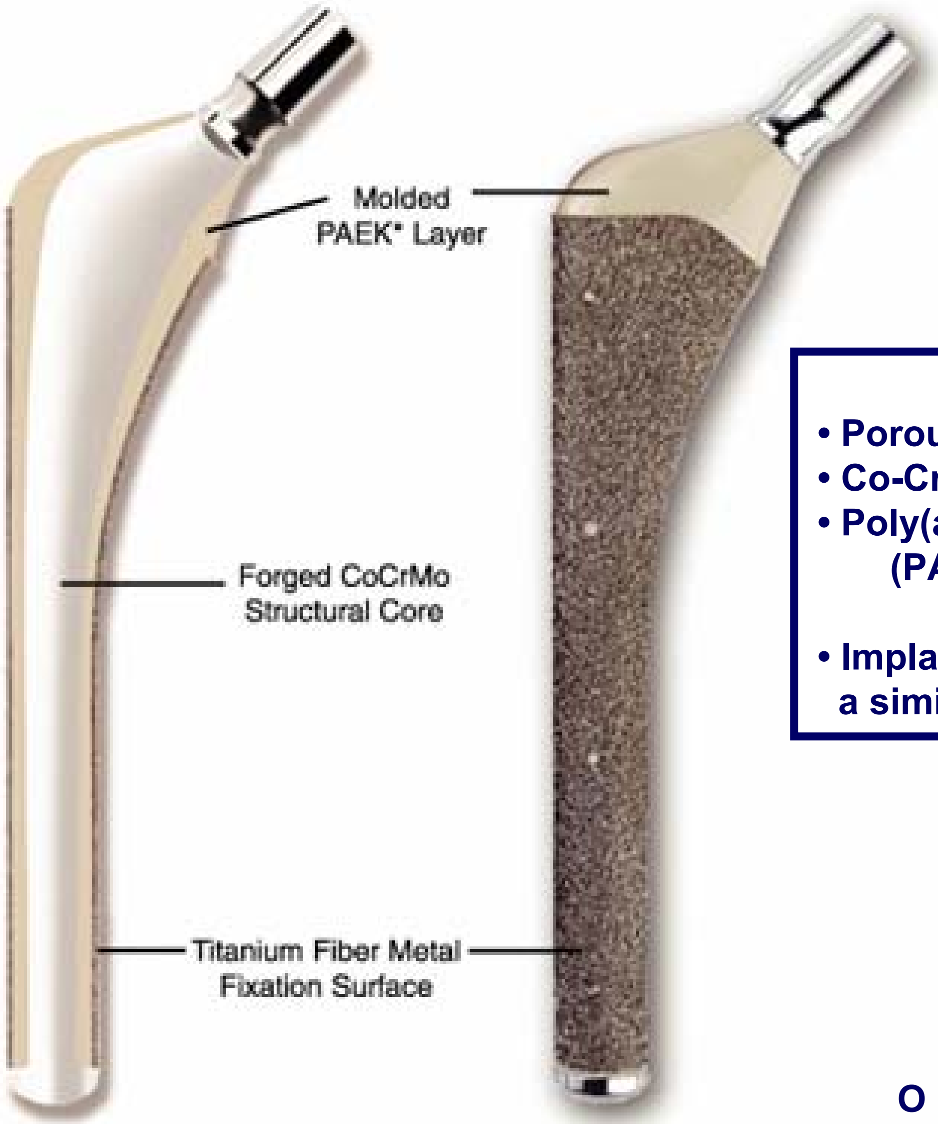

PE
Al_2O_3, a ceramic
Metals may be Stainless Steel, Co-Cr alloy, and Titanium

PROSTHESIS FAILURE.



Zimmer porous metal Co-Cr hip prothesis

Zimmer Epoch® Femoral Stem Implant



*polyaryletherketone polymer matrix

Composition

- **Porous Ti fixation surface**
- **Co-Cr-Mo core**
- **Poly(aryl-ether-ketone) (PAEK) matrix**

- **Implant is designed to have a similar density to bone.**

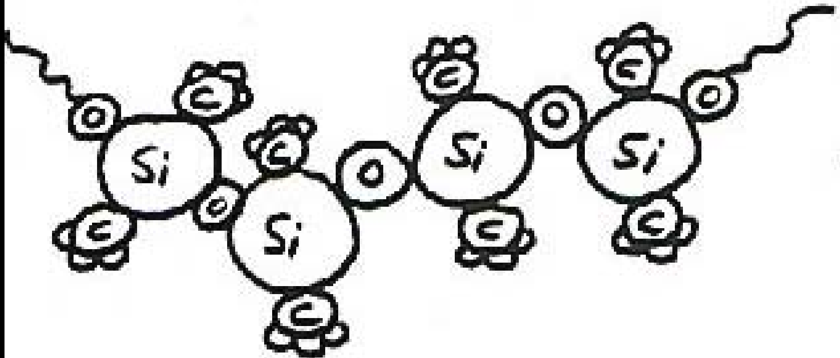
Modularity

- Offers flexibility
  - Leg length
  - Offset
  - Joint stability
  - Address bone loss or deformity
- Decreases inventory?

SILICONE IMPLANTS:

A case study involving polymer scientists, medical doctors, patients, lawyers, judges, politicians and the FDA.

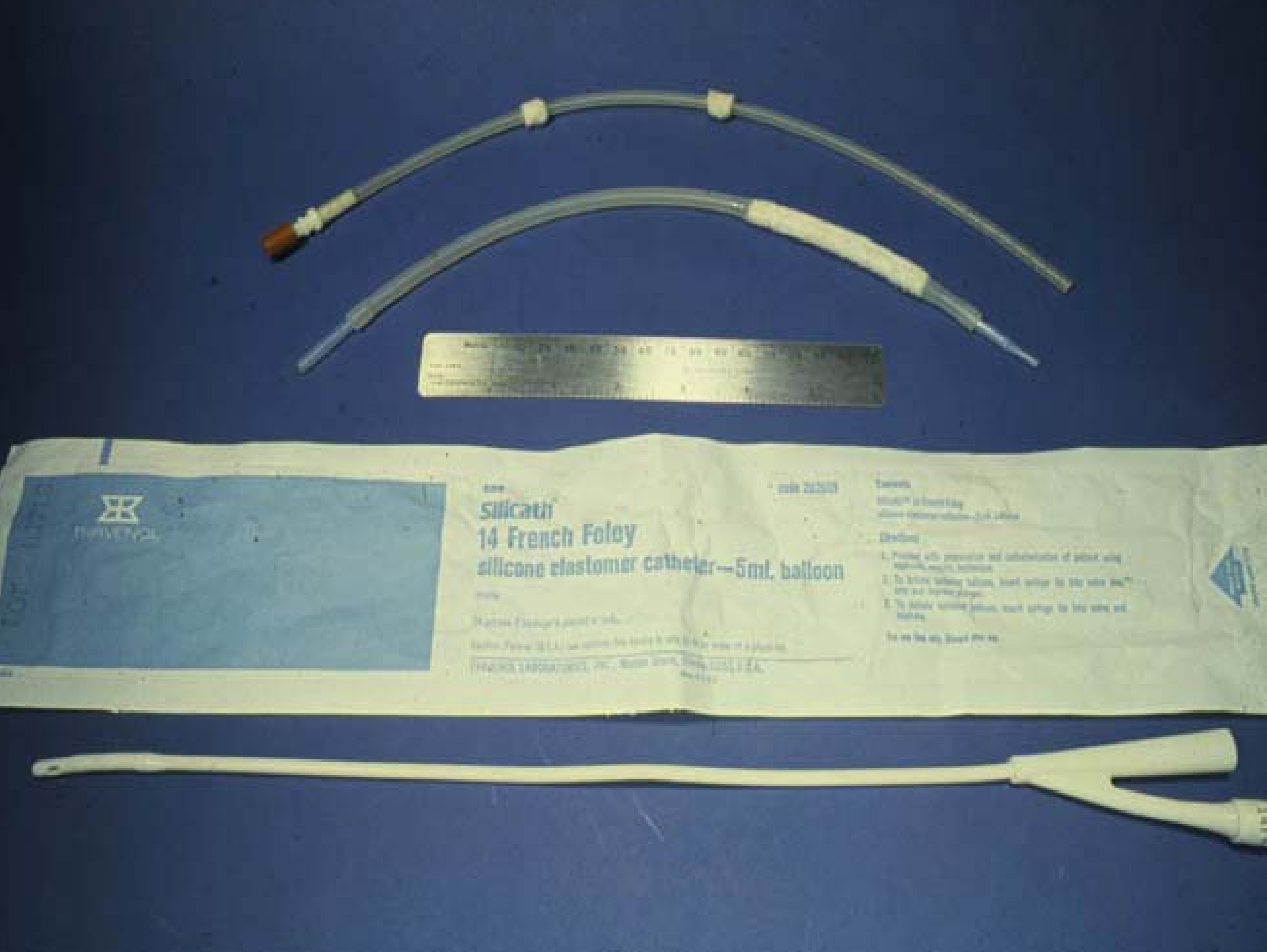
The Silicone Rubber Molecule



$$-\!\!\left[\begin{array}{c} CH_3 \\ | \\ Si - O \\ | \\ CH_3 \end{array} \right]_x\!\!-$$

- Flexible -O- group along main chain
- Hydrophobic -CH3 groups vs. polar -O- groups (hydrophobic groups dominate)
- Regular, streamlined main chain

All these should lead to a soft, crystalline, low water sorption plastic, but the very flexible chain (due to the large size of the silicon atom and the small, unhindered oxygens, which create large spaces between the -CH3 groups) makes the regularity less important, so this molecule is a useful rubber (with a crystalline melt temperature well below room temperature).


Silicath
14 French Foley
silicone elastomer catheter—5ml. balloon

Otoplasty Prosthesis

A soft, resilient otoplasty prosthesis molded to the shape of the natural external ear. Made of a SURGITEK medical grade silicone which closely approximates the normal variance in cartilage consistency from the center to the periphery of the external ear. The perforations in the prosthesis are covered with a very thin membrane of SURGITEK medical grade silicone which may be easily dissected according to individual case requirements. Available in left and right, with or without Dacron® Felt reinforcement.

Orbital Prosthesis

An orbital prosthesis of SURGITEK medical grade silicone designed to conform to the contours of the orbital floor, with Dacron® Felt attachment. Available in three sizes, individual left and right design.

SURGITEK PRODUCTS FOR SURGERY

Rhinoplasty Prosthesis

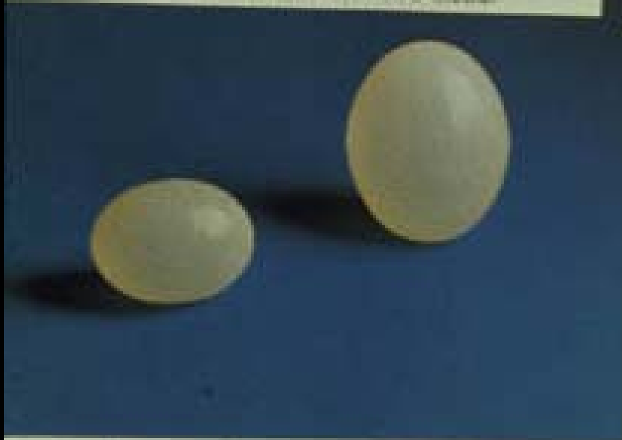
A rhinoplasty prosthesis made of a resilient SURGITEK medical grade silicone. Primarily designed for augmenting a concave bridge of the nose. Available in two sizes. Available with or without flared tip.

Chin Prosthesis

A smooth, pre-formed chin prosthesis of SURGI-TEK medical grade silicone shaped to follow natu-ral chin contours. Available in four sizes (differen center thicknesses) with or without cleft. Availabl with or without Dacron® Felt attachment.

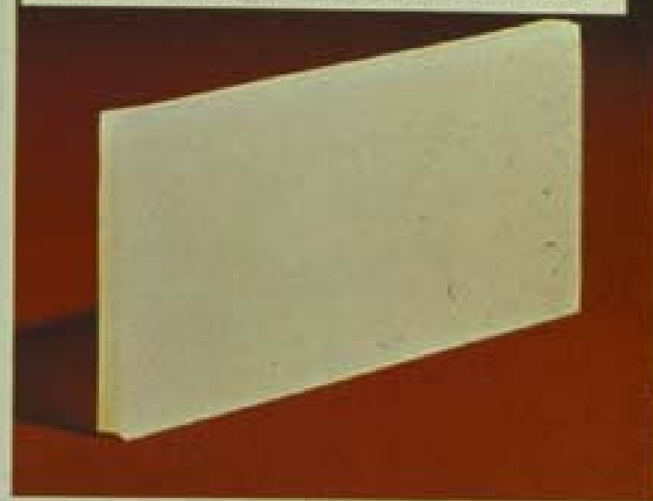
Testicular Prosthesis

A soft, smooth, testicle-shaped prosthesis of SURGITEK medical grade silicone filled with a SURGITEK medical grade silicone gel which closely simulates the weight and consistency of the natural testicle. Available in two sizes.



Block

A block of SURGITEK medical grade silicone which may be easily carved and shaped into required sizes for subdermal implantation. Blocks available in 3" x 3" sizes. Available in several consistencies.



Felt

Dacron® Felt material for use in conjunction with other implantable materials. Available in 2" x 4" pieces.

Adhesive/Sealant

SURGITEK medical grade silicone adhesive/sealant for use in bonding silicone to itself and to other materials.

The *Uni-Flate 1000*, from Surgitek, is the first fully assembled and pre-filled inflatable penile implant on the market.

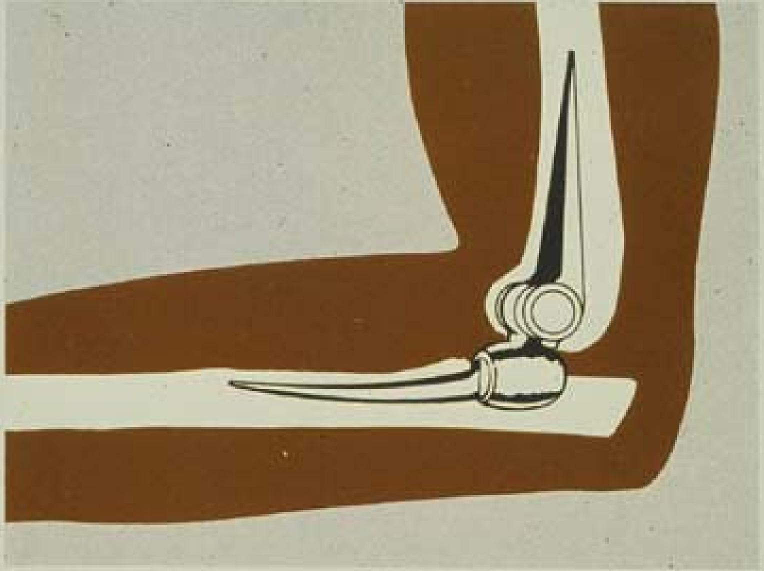


Figure 5. *Total elbow replacement. A simple hinge with high density polyethylene bearings.*

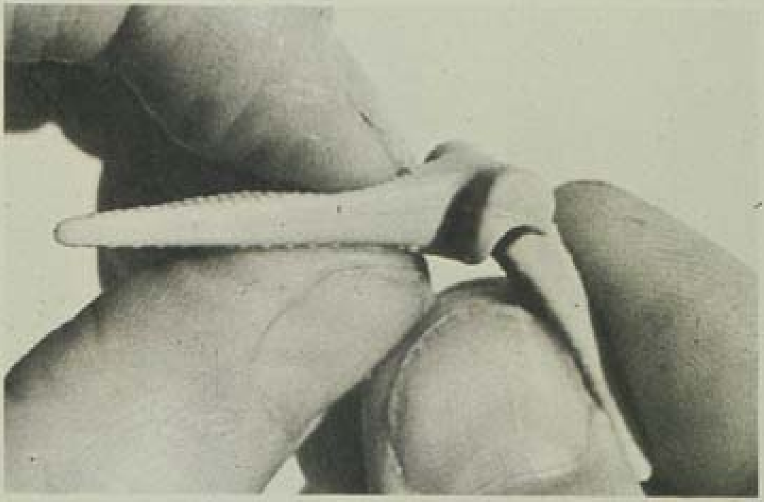
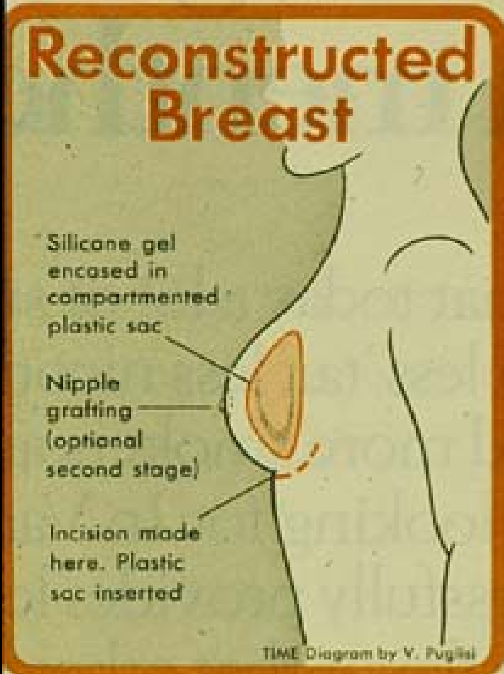


Figure 6. *Silicone rubber finger prosthesis. The stems are inserted down the shafts of the adjacent bones. The prosthesis is pliable to allow movement.*

are in varying stages of deterioration after prolonged use. The failures were the result of the absorption of lipids and cholesterol from body fluids by the silicone rubbers used in the prostheses. This absorption causes swelling, leading to surface cracks as demonstrated by the scanning electron micrograph (1400x). Stress concentrates in these cracks, accelerating the process of absorption and swelling, leading to the eventual dissolution of the prosthesis.

The first "hit" using the Google search engine with the term "breast implants"
(120,000 hits)

Time, 4/14/75



RANDOLPH GUTHRIE, M.D.

BREAST AFTER RECONSTRUCTION

JIM OLIVE

DR. THOMAS CRONIN WITH IMPLANT

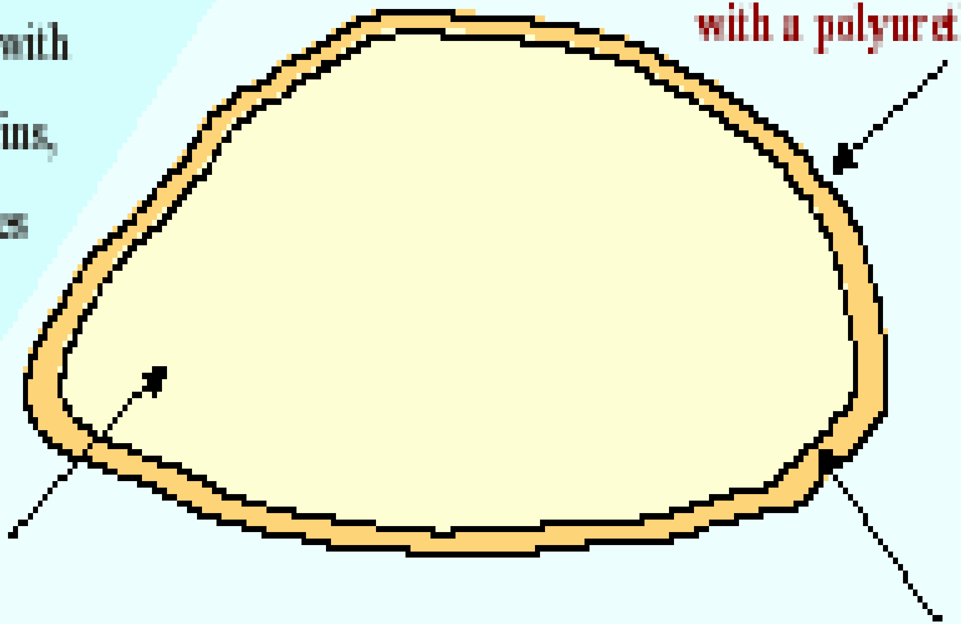

S72-172

Modern Breast Implants - General Description

<u>The Inspiration for the gel-filled bag</u>

In the 1950's, breast augmentations were performed in Japan with Injections of liquid paraffins, petroleum jelly or silicones contaminated olive oil

external surface can be textured silicone rubber or covered with a polyurethane foam



- gel filled
- saline filled
- soy oil filled
- (some implants have a silicone

envelope (shell) is usually crosslinked, filled PDMS

Lawyers

Santa Claus, the tooth fairy, an honest lawyer and a old drunk are walking down the street together when they simultaneously spot a hundred dollar bill. Who gets it?

A Woman with autoimmune disease was awarded by jury $7.3 Million (Dec. 1991)

Dow Corning and other breast implant companies settle for $4 billion
- the biomaterials crisis precipitated by liability concerns
- what is the impact on US competitiveness?

Conclusions

After many huge payments to lawyers and their clients,

and

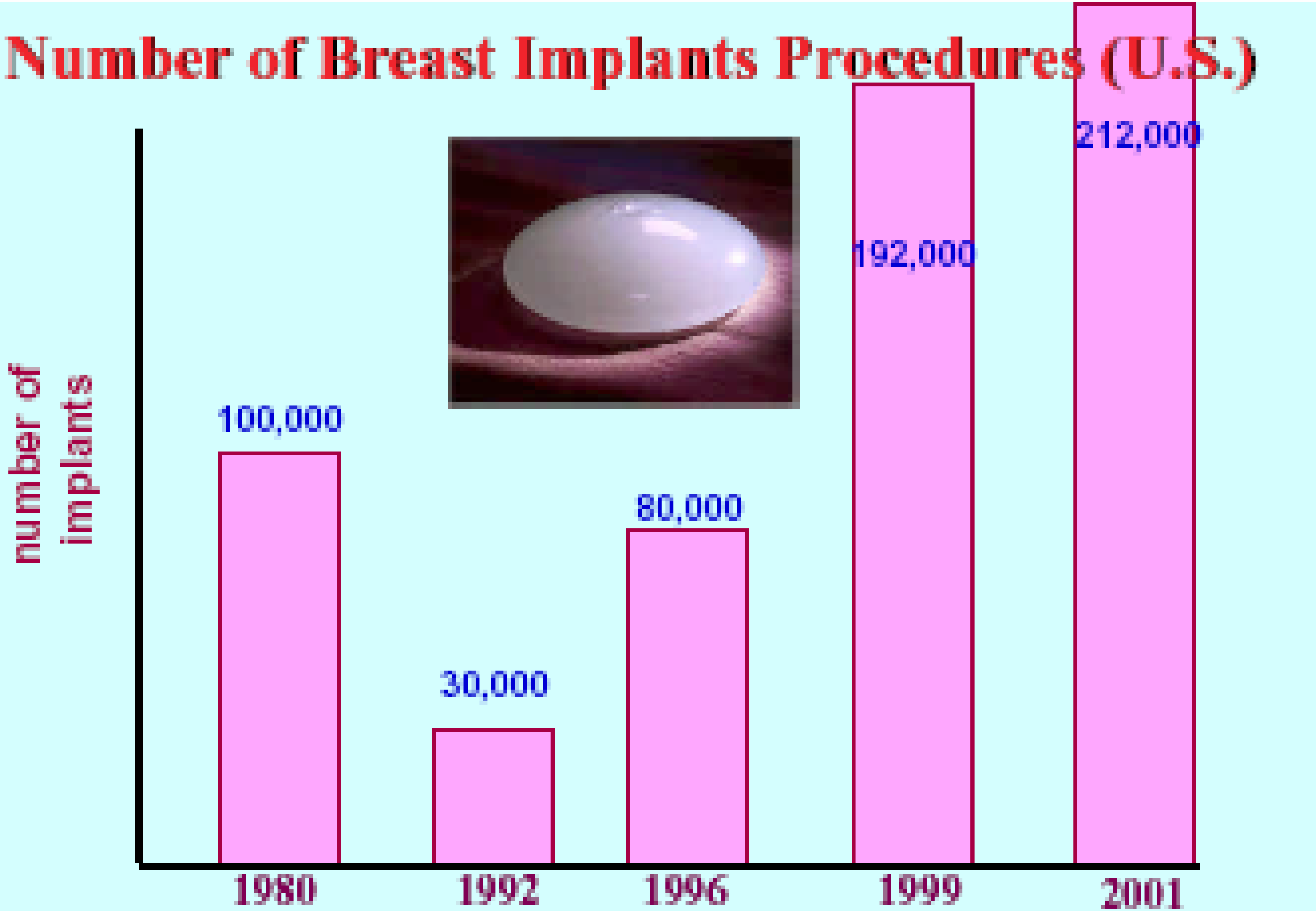
much additional biological and physiological testing,

there is no valid scientific evidence to show that silicone breast implants cause auto-immune disease or any other dangerous condition.

Failure of an implant...

- is NOT unexpected, because *every man-made implant and device will have a finite failure rate in a large population*.
- may or may NOT be due to materials, design, or handling.
- can be due to the patient's own abnormal physiologic responses, as usually seen in the "dose-response" statistics for a large population.
- has led to huge legal settlements to plaintiffs and their lawyers, which are having a significant negative impact on the future of medical implants and devices.
- There is a great need to alert the public to these facts.

Allan Hoffman


Number of Breast Implants Procedures (U.S.)
number of implants
100,000
30,000
80,000
192,000
212,000
1980
1992
1996
1999
2001

DEGRADABLE POLYMERS FOR USE AS SUTURES AND IN DRUG DELIVERY

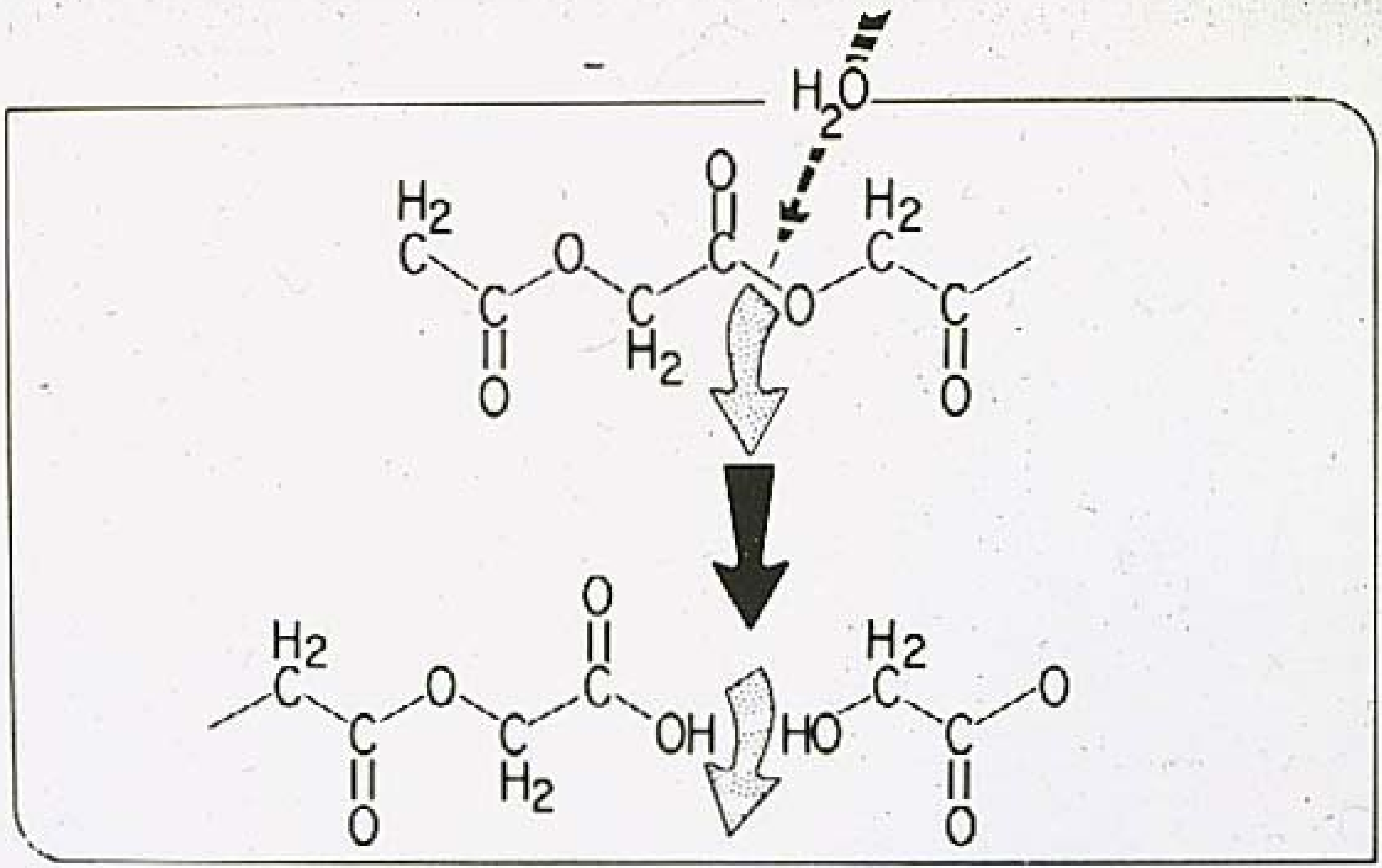
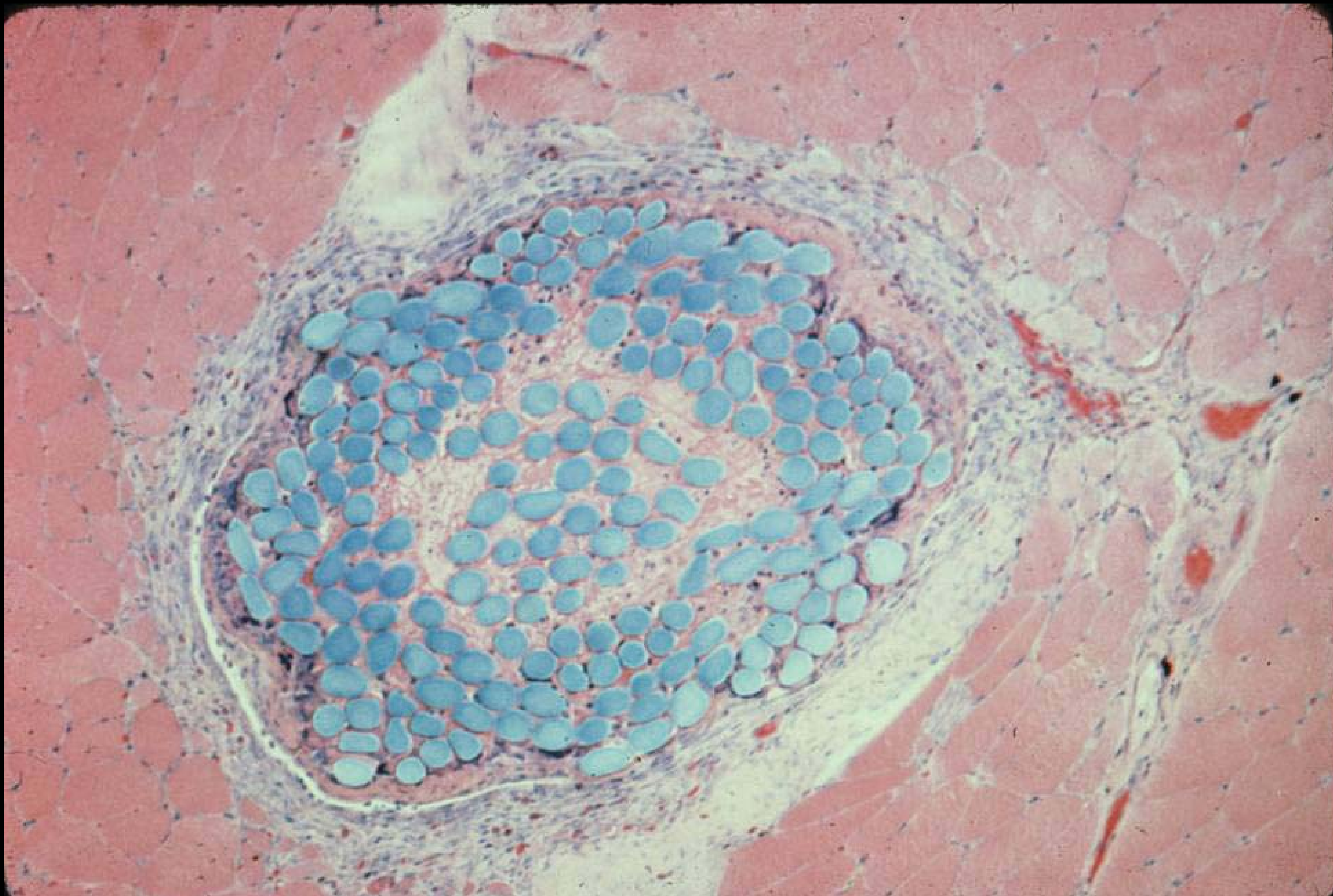
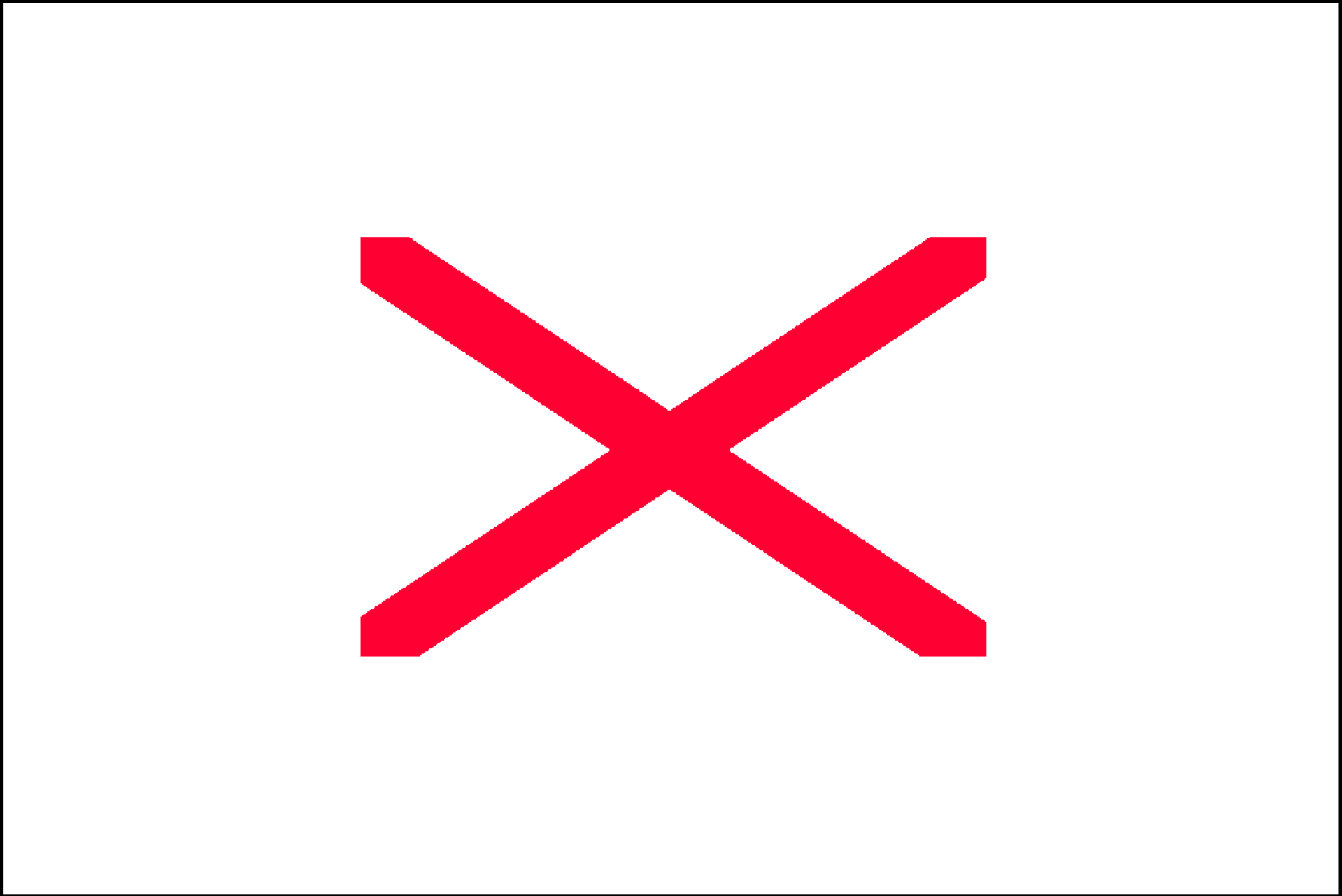


FIG. 11. Polyglycolic acid as a suture material. Chain scission by gradual hydrolysis of the ester linkage.

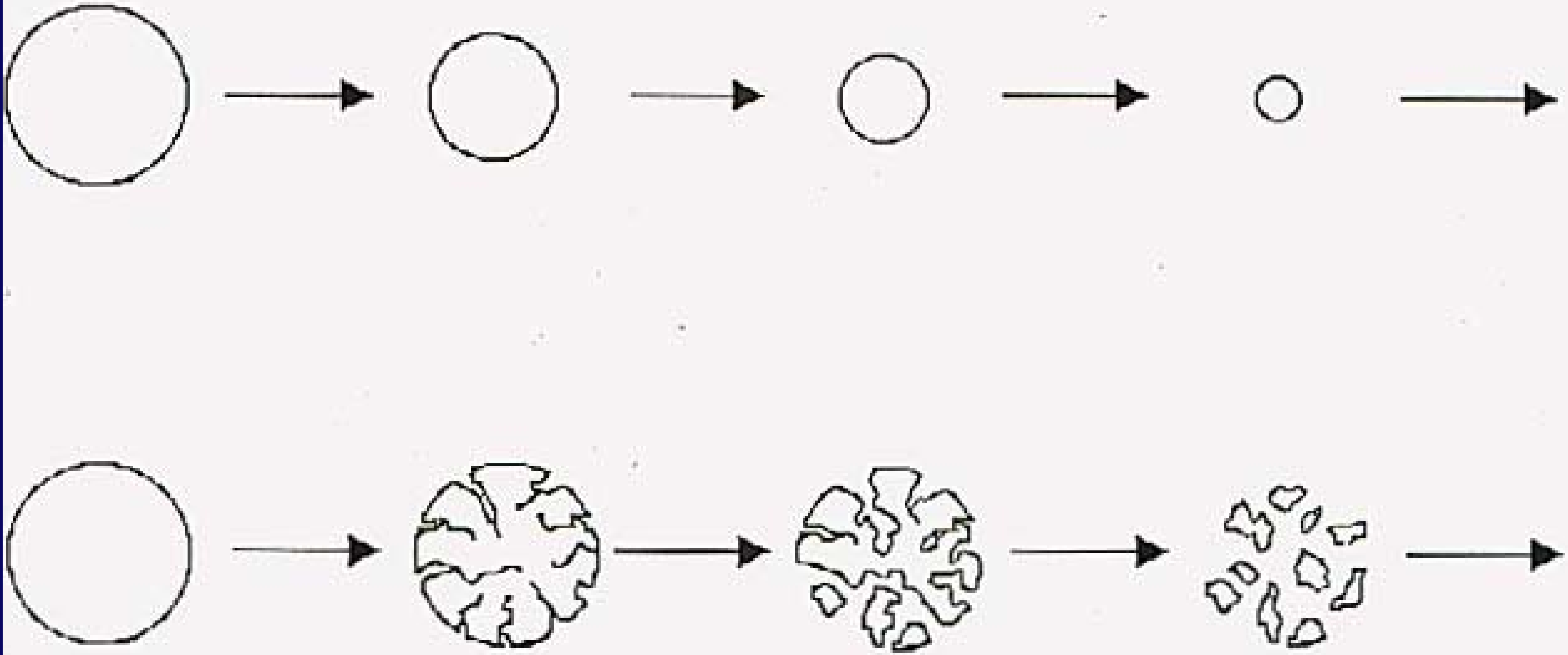
Vicryl® (PGA) after 7 days in rat muscle



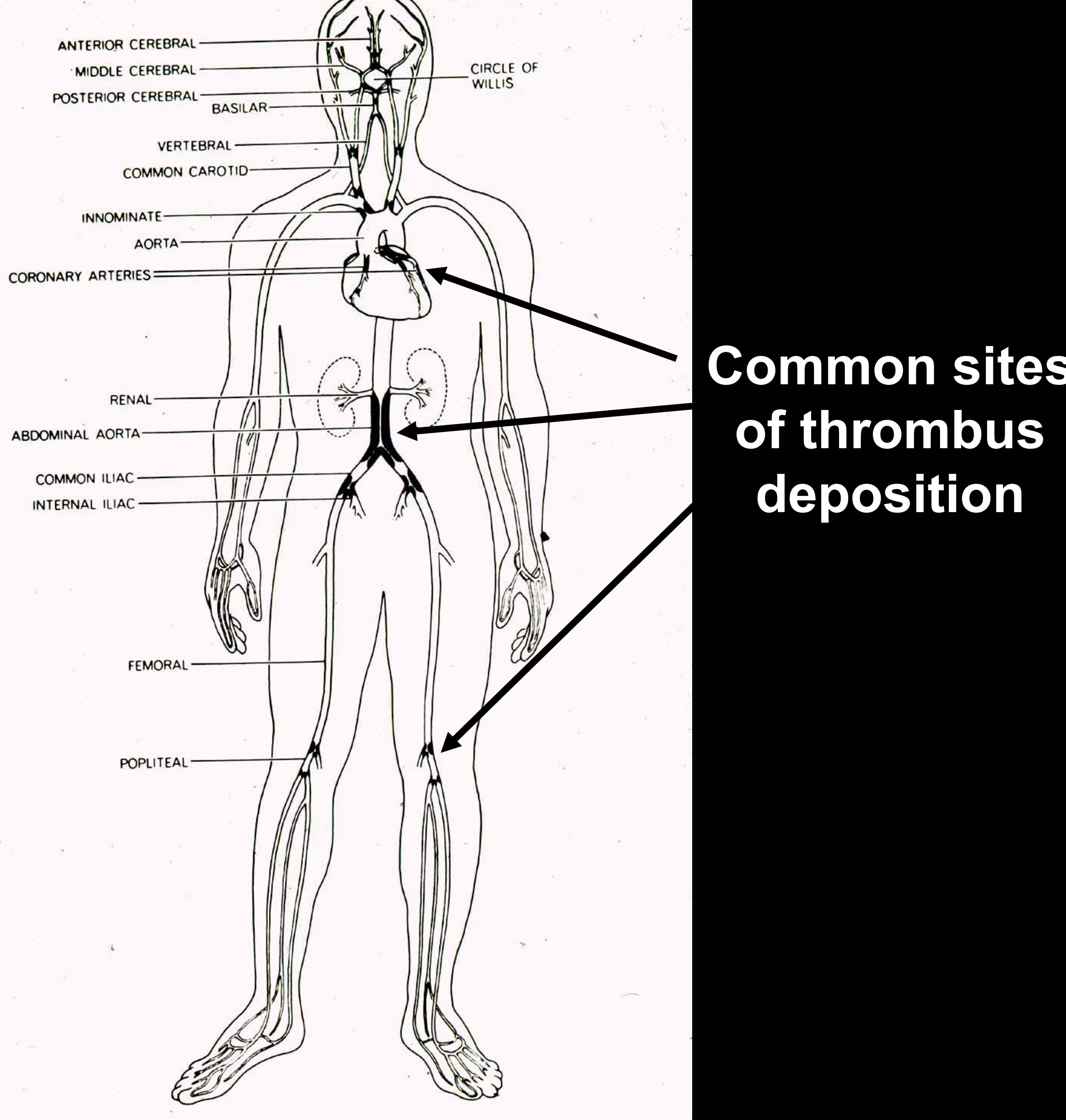
Vicryl® (PGA) after 56 days in rat muscle



BIODEGRADABLE MICROSPHERES

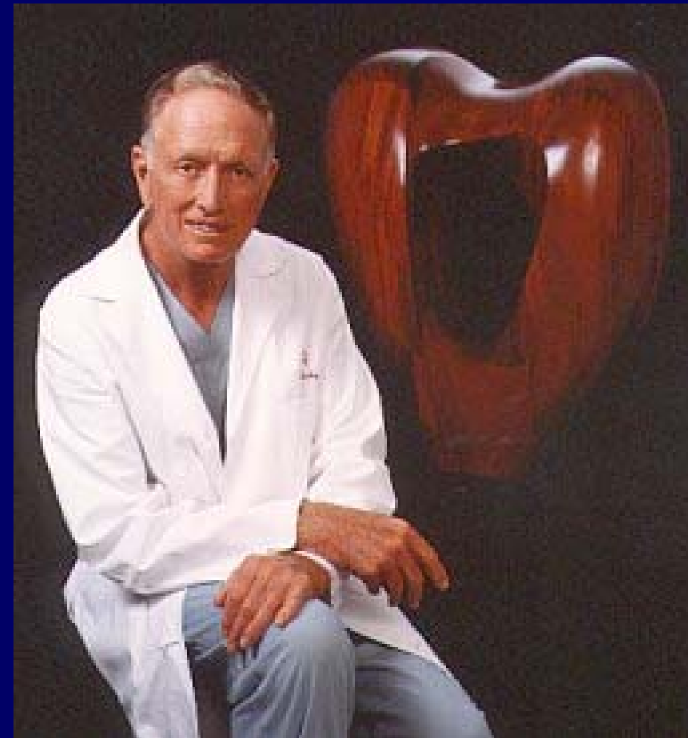


VASCULAR GRAFTS



FAVORED SITES of atherosclerosis are indicated in color in this diagram of the major

Dr. Michael E. DeBakey, M.D.



Dr. Denton A. Cooley, M.D.

Drs. DeBakey and Cooley, world famous surgeons, were pioneers (and competitors) in the development of Dacron® vascular grafts.

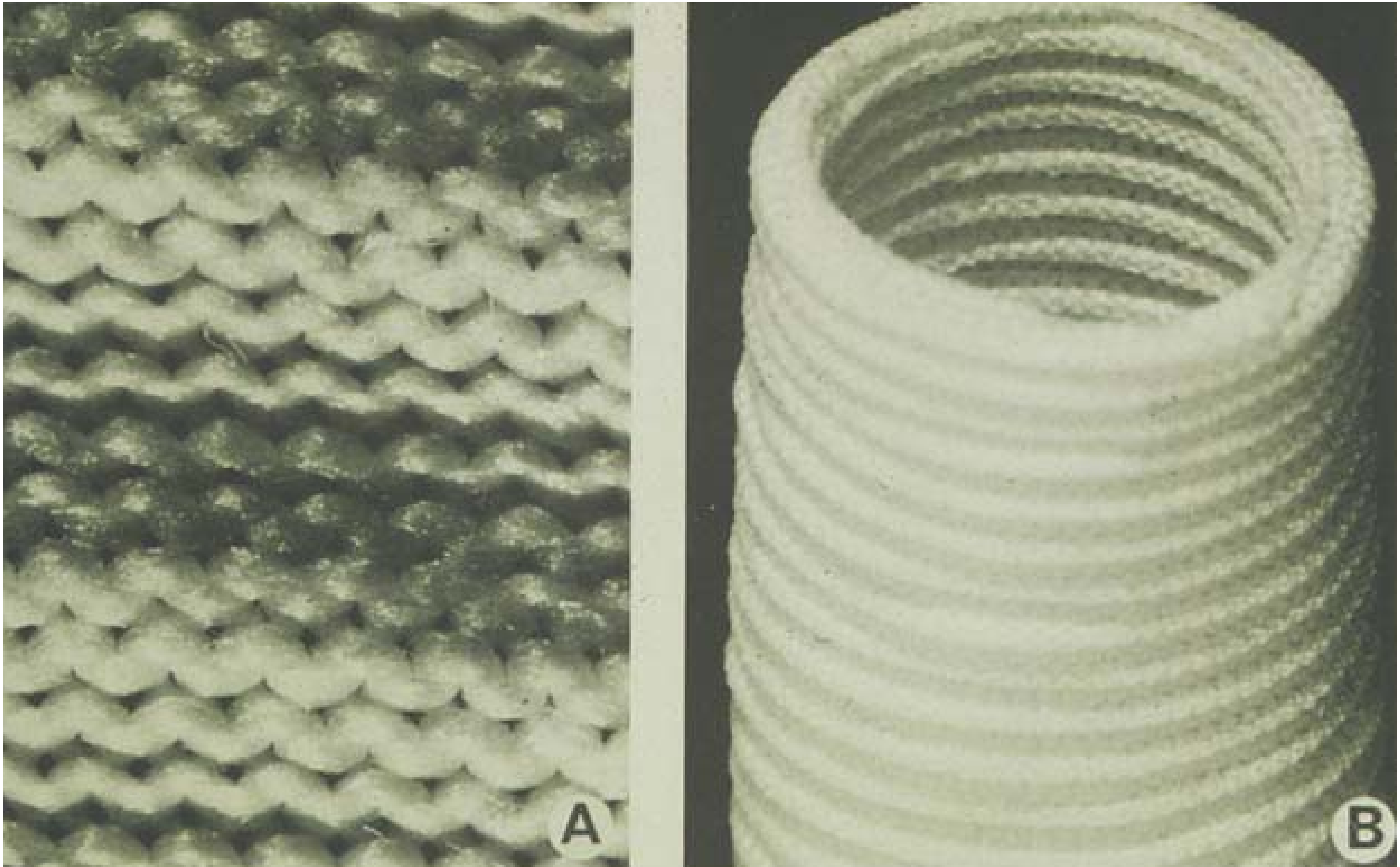


FIG. 3A. Appearance of knitted Dacron graft material ×85. B, Crimped tube graft.

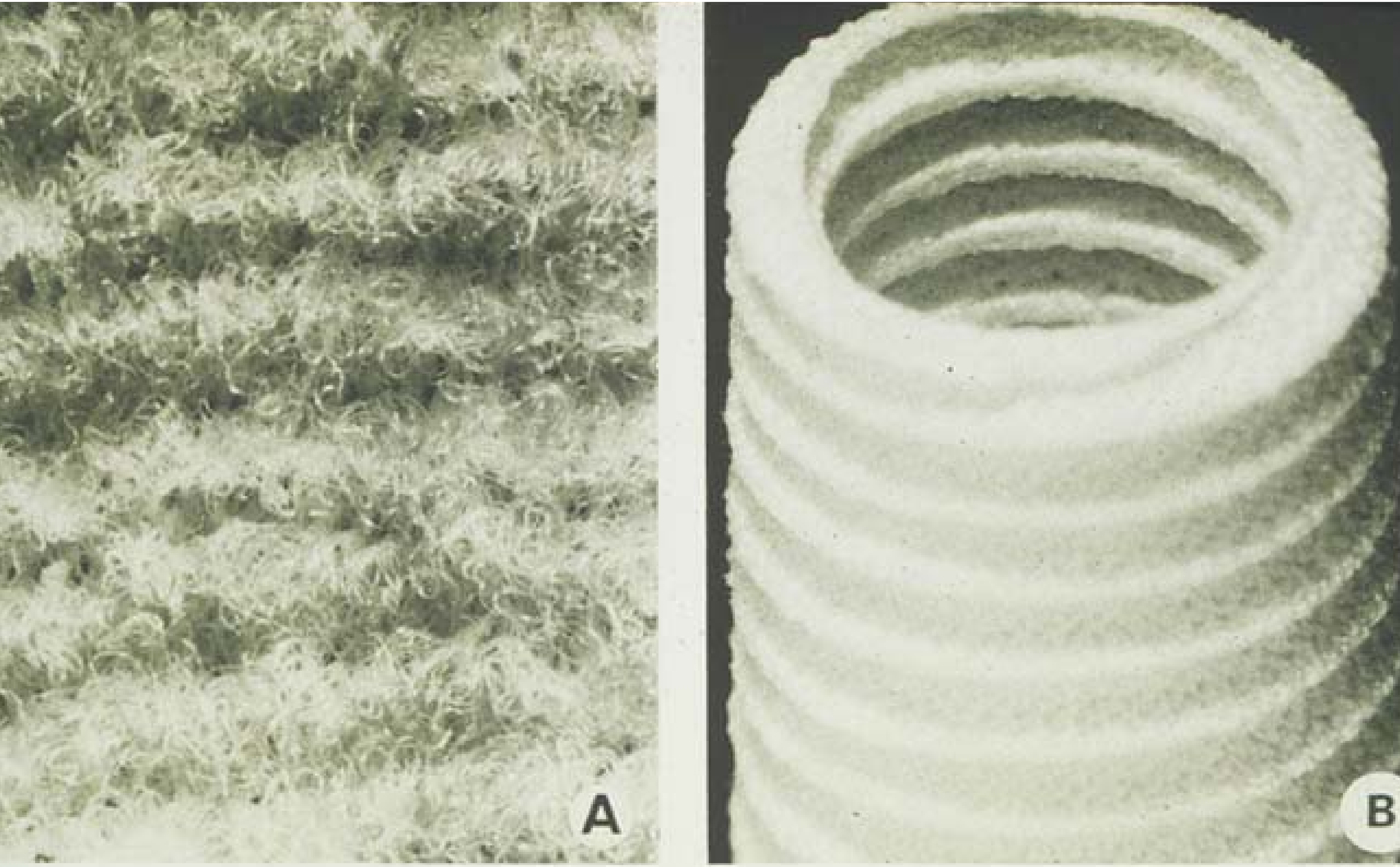
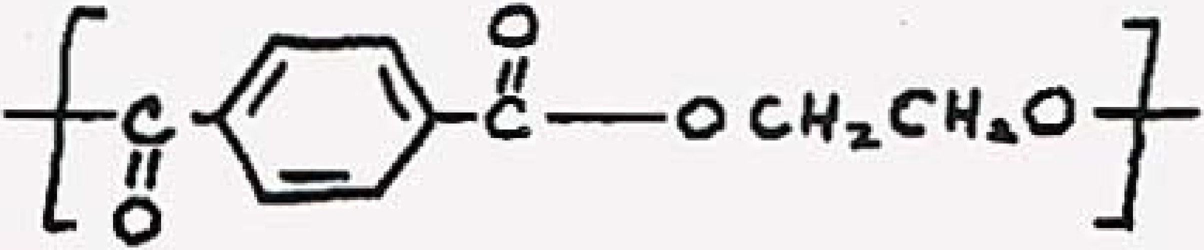


FIG. 4A. Appearance of Dacron velour graft material ×85. B, Crimped tube graft.

The PET Molecule



stiff group (dominates)

flexible group

- Stiff groups along main chain:
- Low polarity (electrons above and below stiff group)
- Regular, "streamlined" shape along chain

Uses
Vascular grafts,
Implant fixation
(e.g., sewing rings)
Ingrowth felts

All these lead to a crystalline, high melting, lowwater sorption polymer, useful as a fiber.

$$--(-CF_2-CF_2-)_x--$$

Poly(tetrafluoroethylene) Teflon®

A highly symmetrical chain, but very stiff, so it is both crystalline and high melting (327°C)

In the early days, *woven* Teflon® was used as a vascular graft. It was not strong enough and often burst under the blood pressure. Later, *expanded* Teflon® or e-PTFE has been successfully used as a vascular graft. It is widely known as Gore-Tex®.

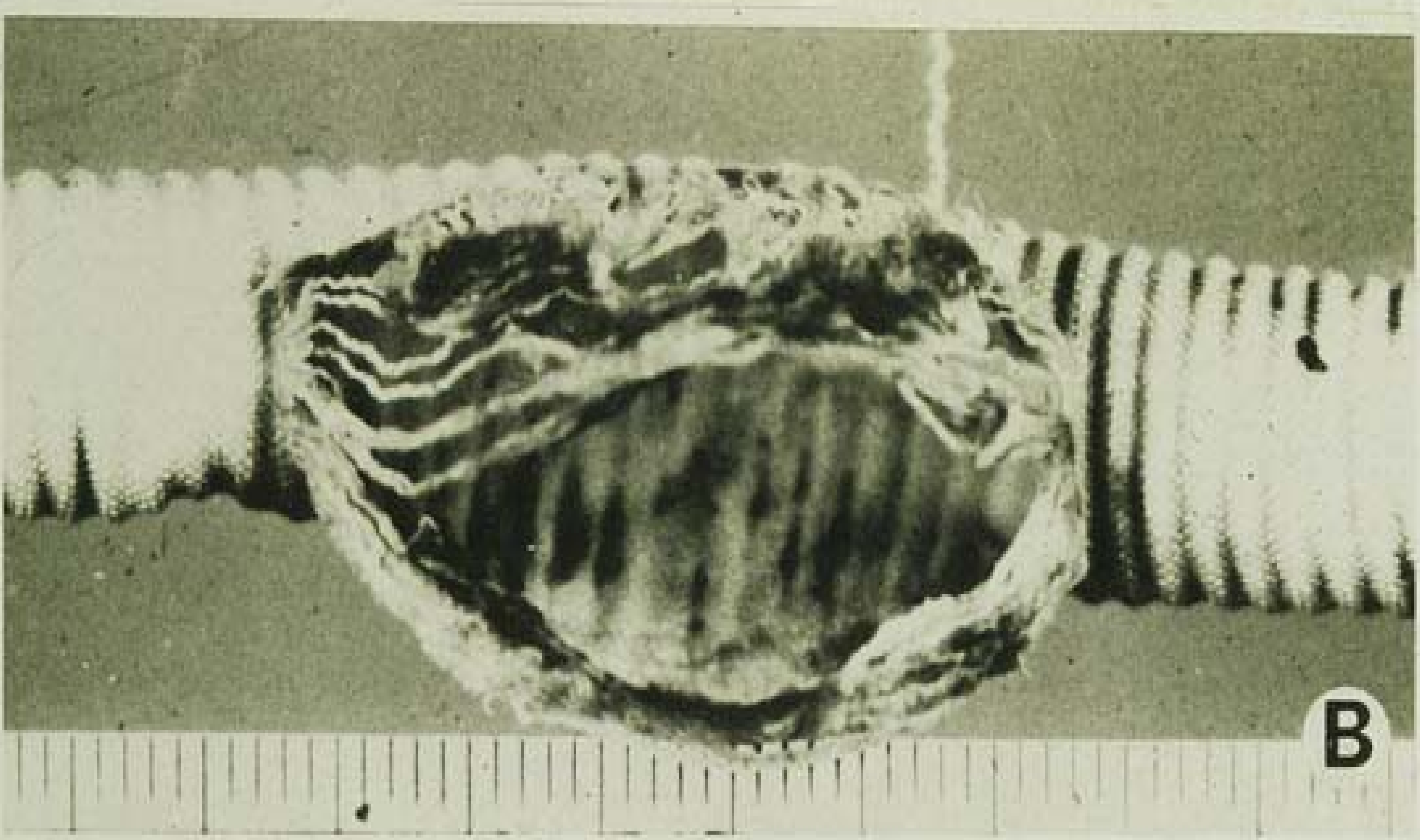
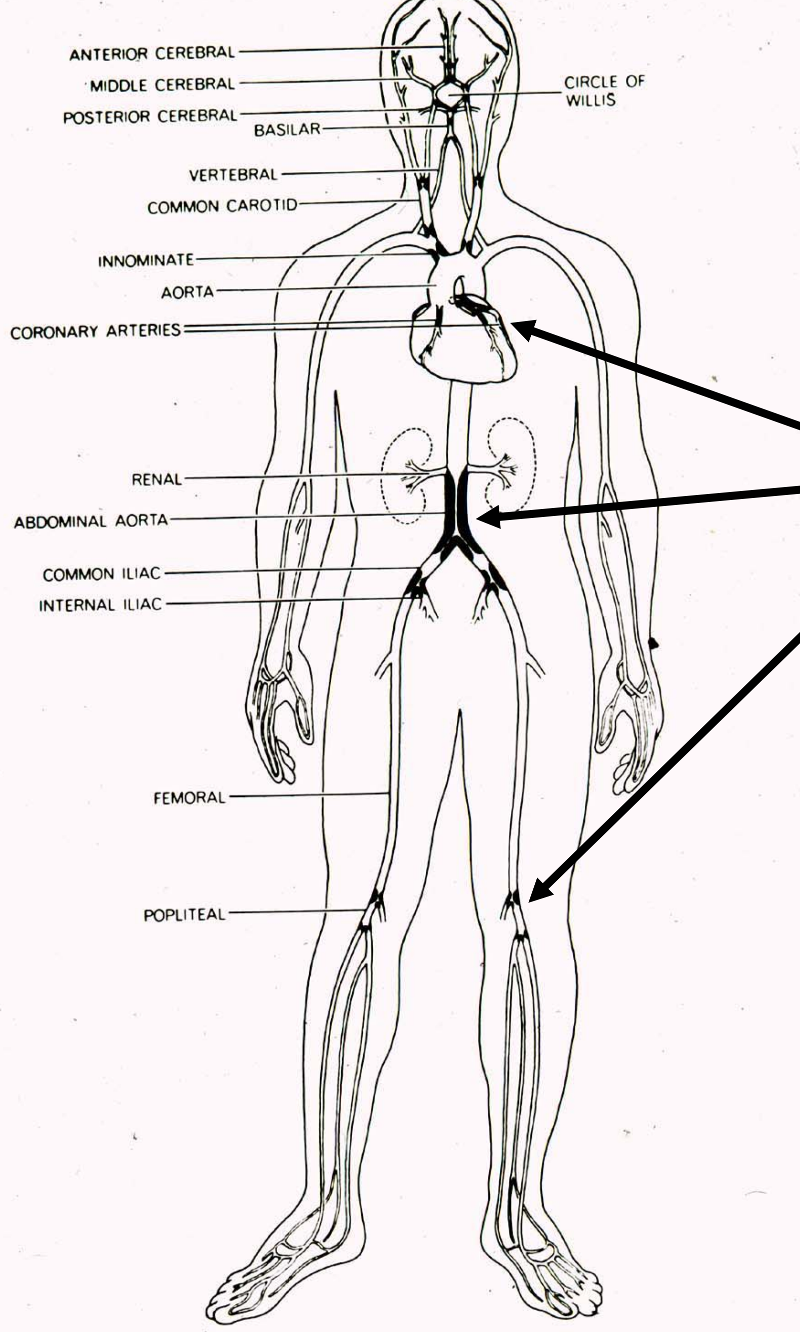


FIG. 1. Photographs of operative specimens showing two causes of delayed false aneurysm following arterial prosthetic implantation. A. Specimen at femoral anastomosis 7 years after implantation of a 40 needle-per-inch prosthesis with completely intact suture (arrow) attached to prosthesis. This false aneurysm resulted from progression of the patient's aneurysmal disease and was successfully repaired. B. Blow-out of a woven Edward's Teflon graft 8 years after implantation. Photograph kindly supplied by R.H. Hayward, M.D., Scott and White Clinic, Temple, Texas.[1] This aneurysm is the obvious result of deterioration of the Teflon yarn which has been widely advertised as indestructible in the body.



Common sites of thrombus deposition

FAVORED SITES of atherosclerosis are indicated in color in this diagram of the major

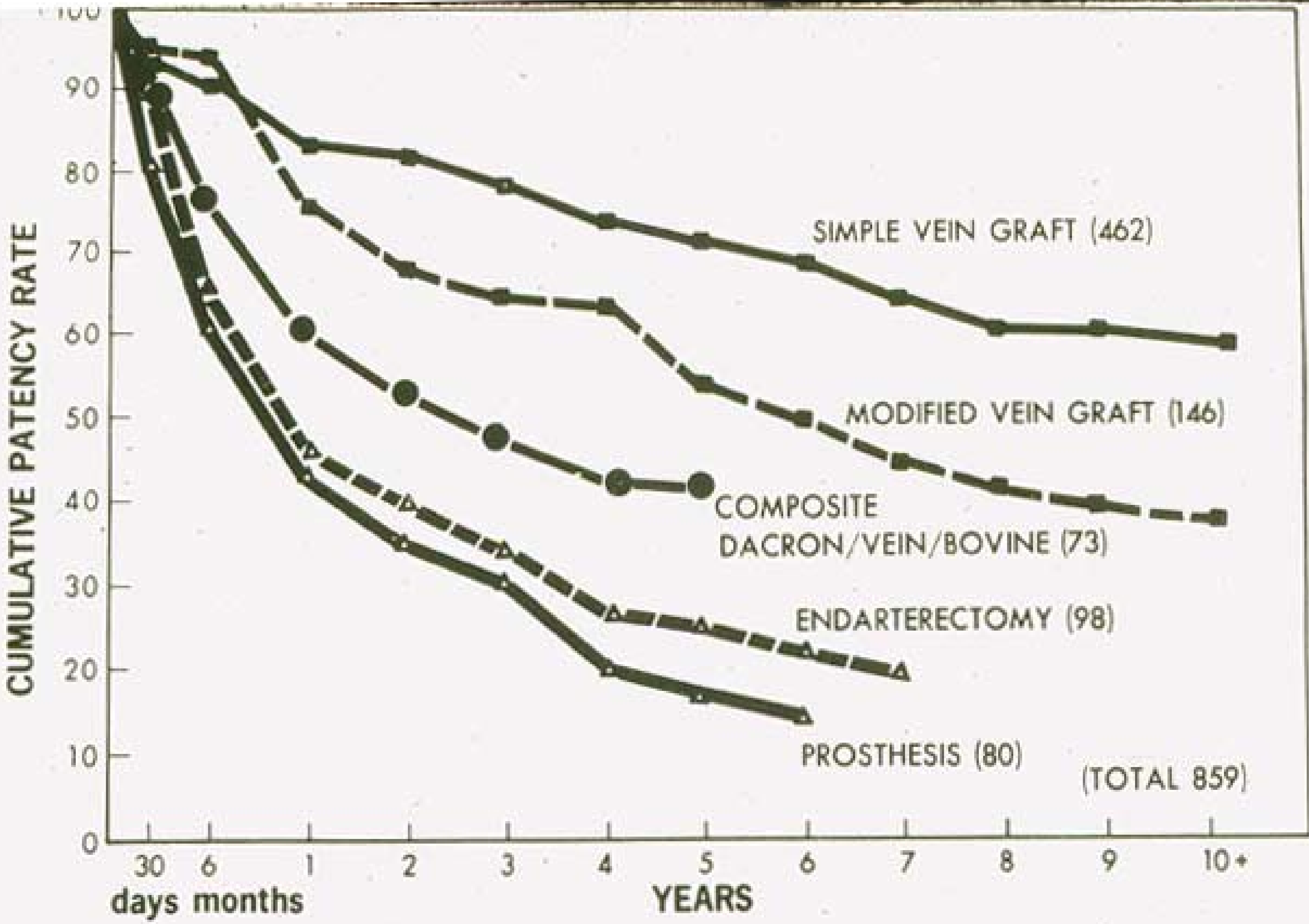
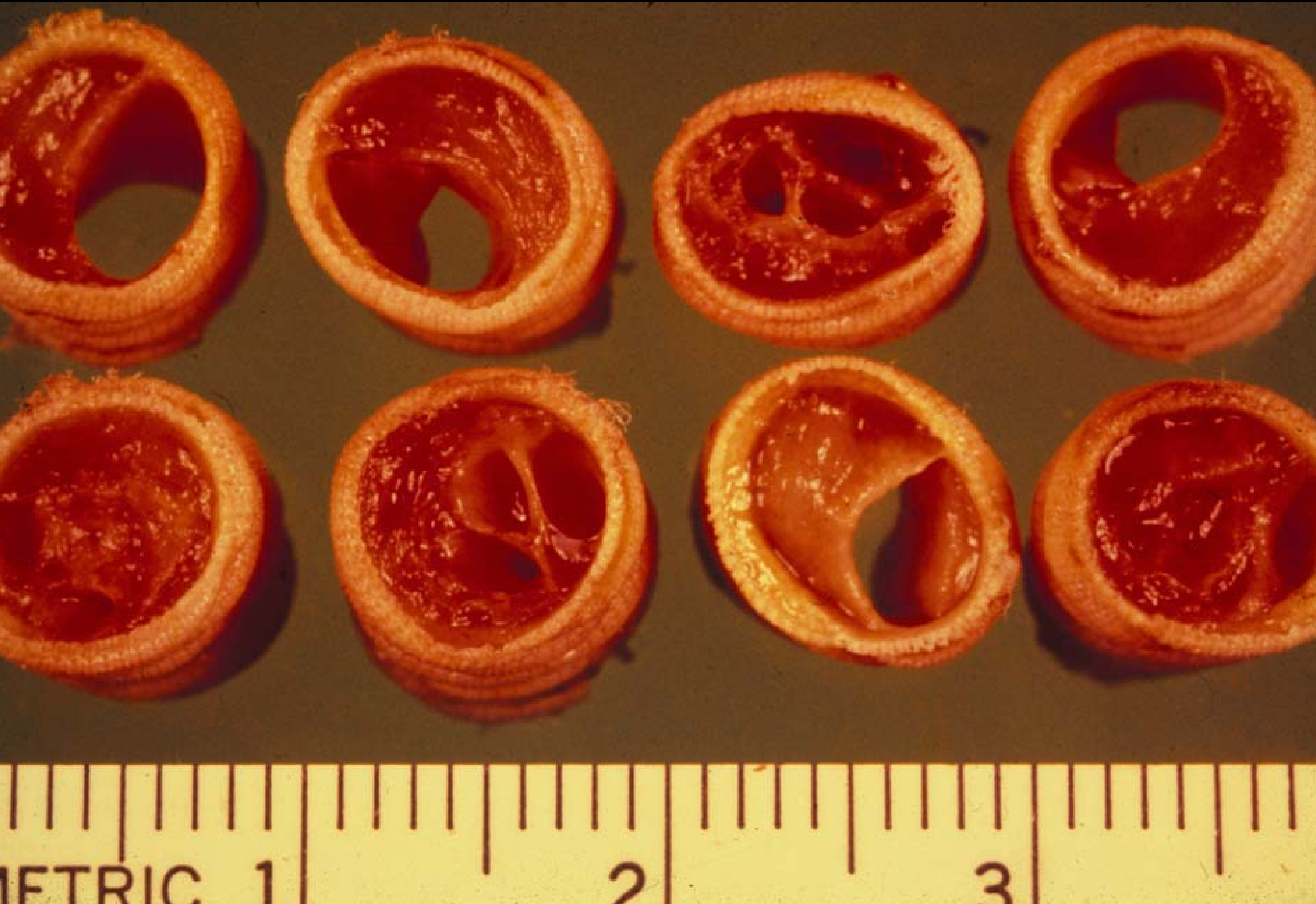


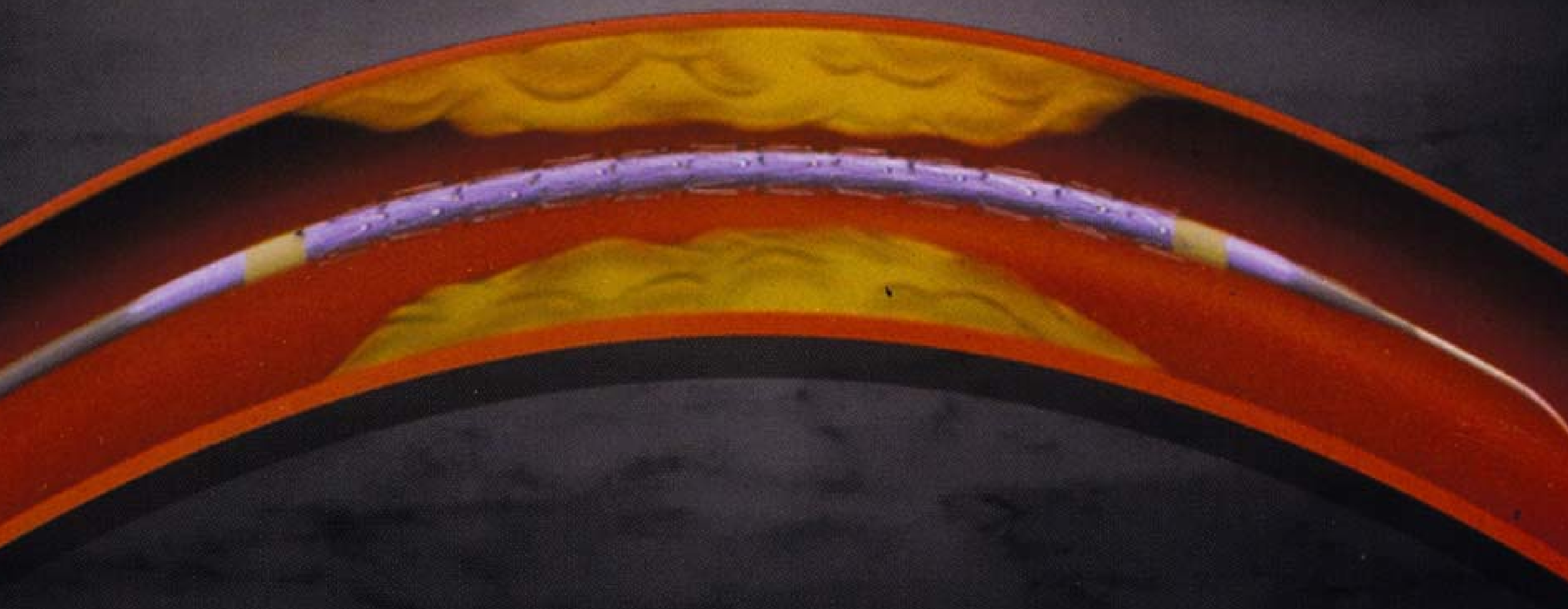
FIG. 3. Patency rates of 859 femoropopliteal grafts, as determined by life table method (1960–1974).

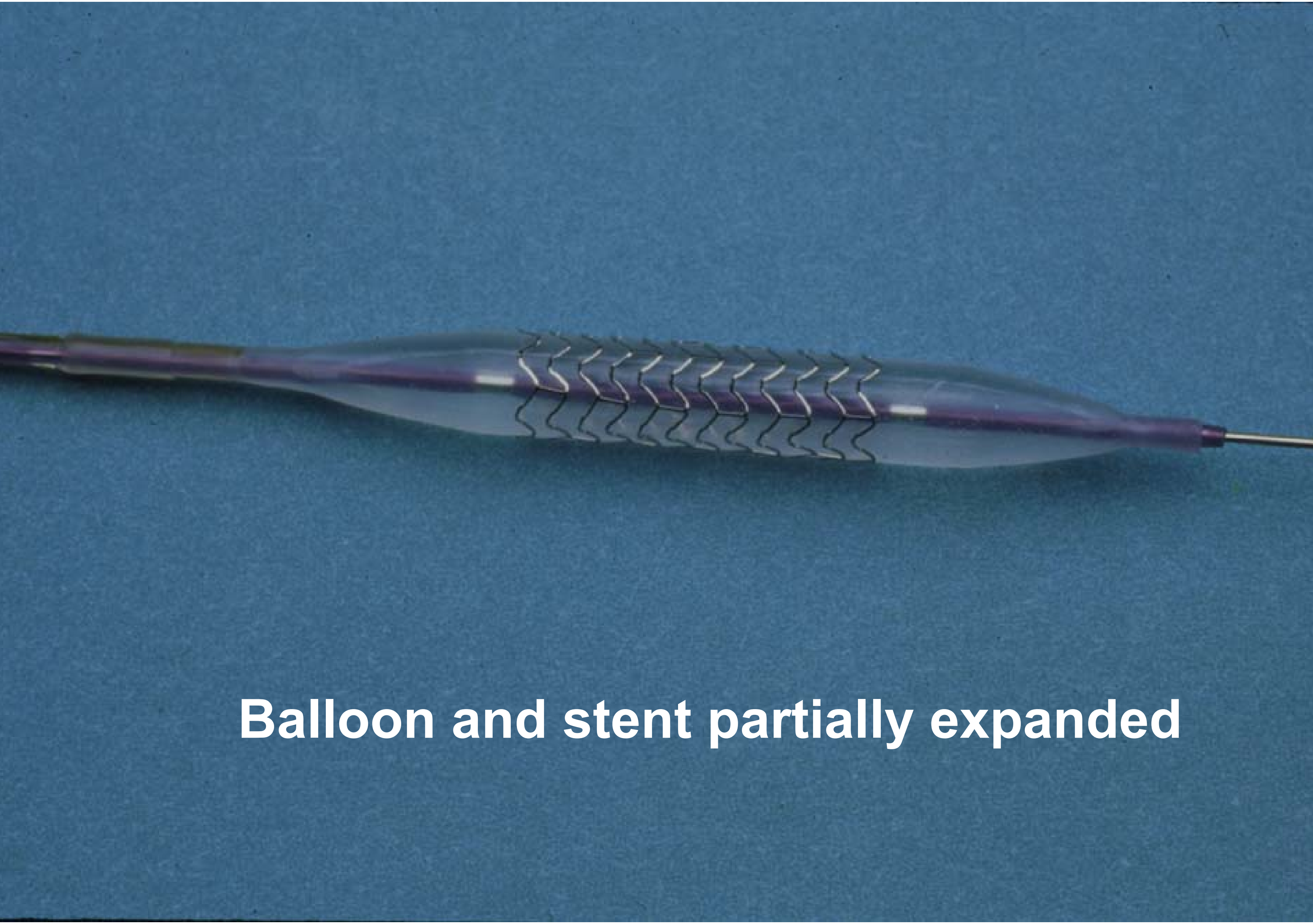
Thrombosed small diameter Dacron vascular grafts



ANGIOPLASTY AND STENTS

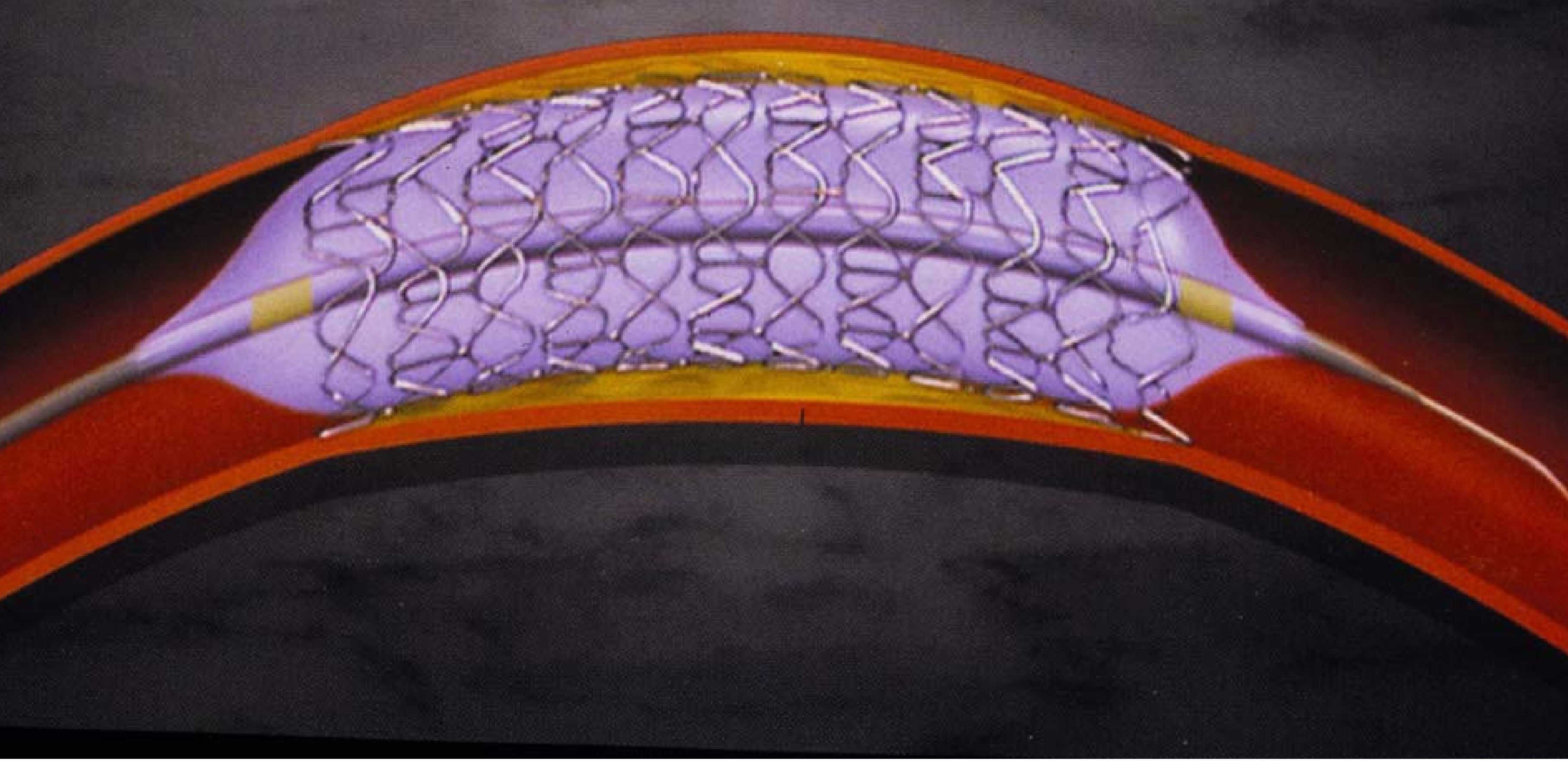
Angioplasty in action:
Balloon and stent on catheter arrive at site of blockage.

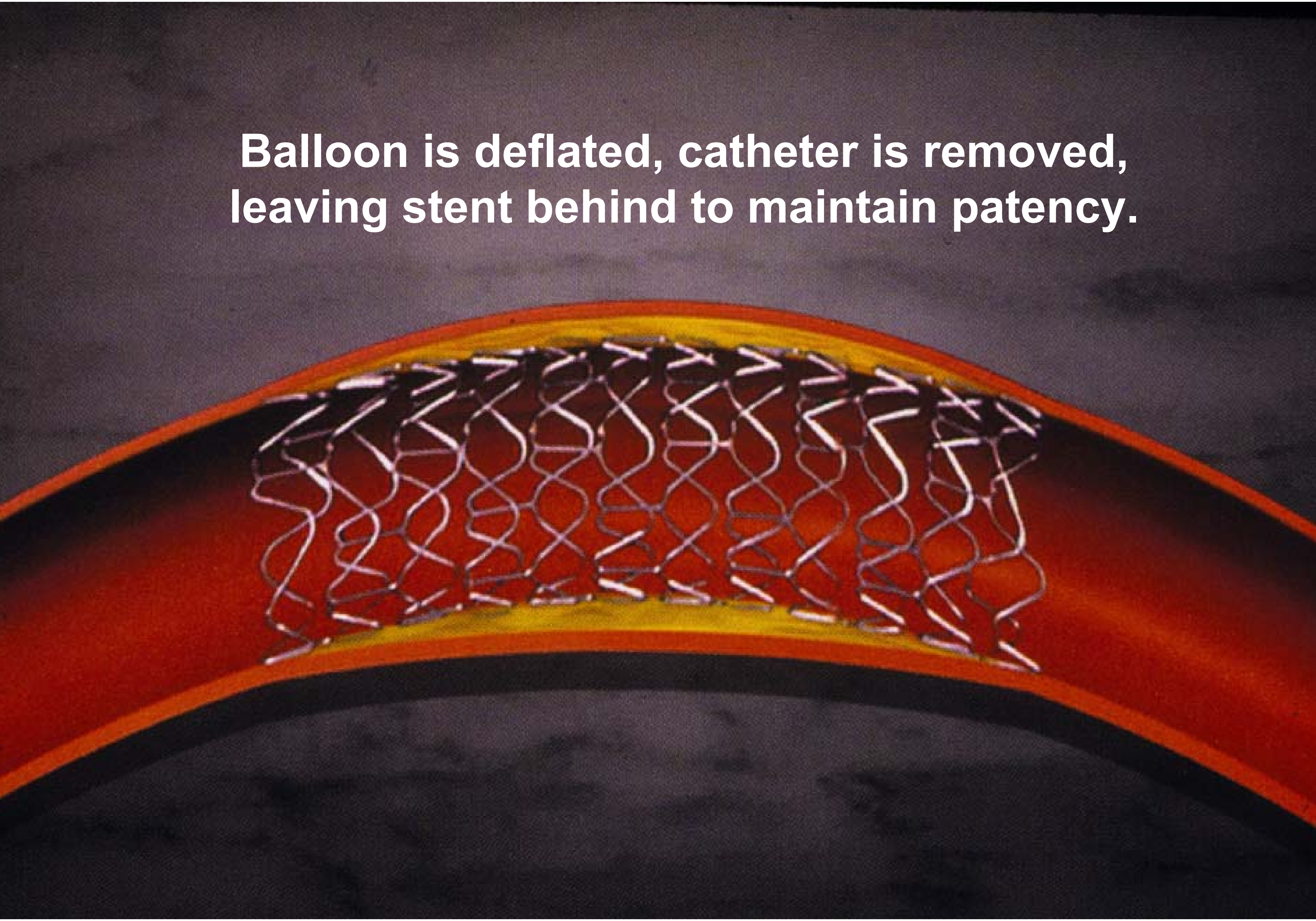


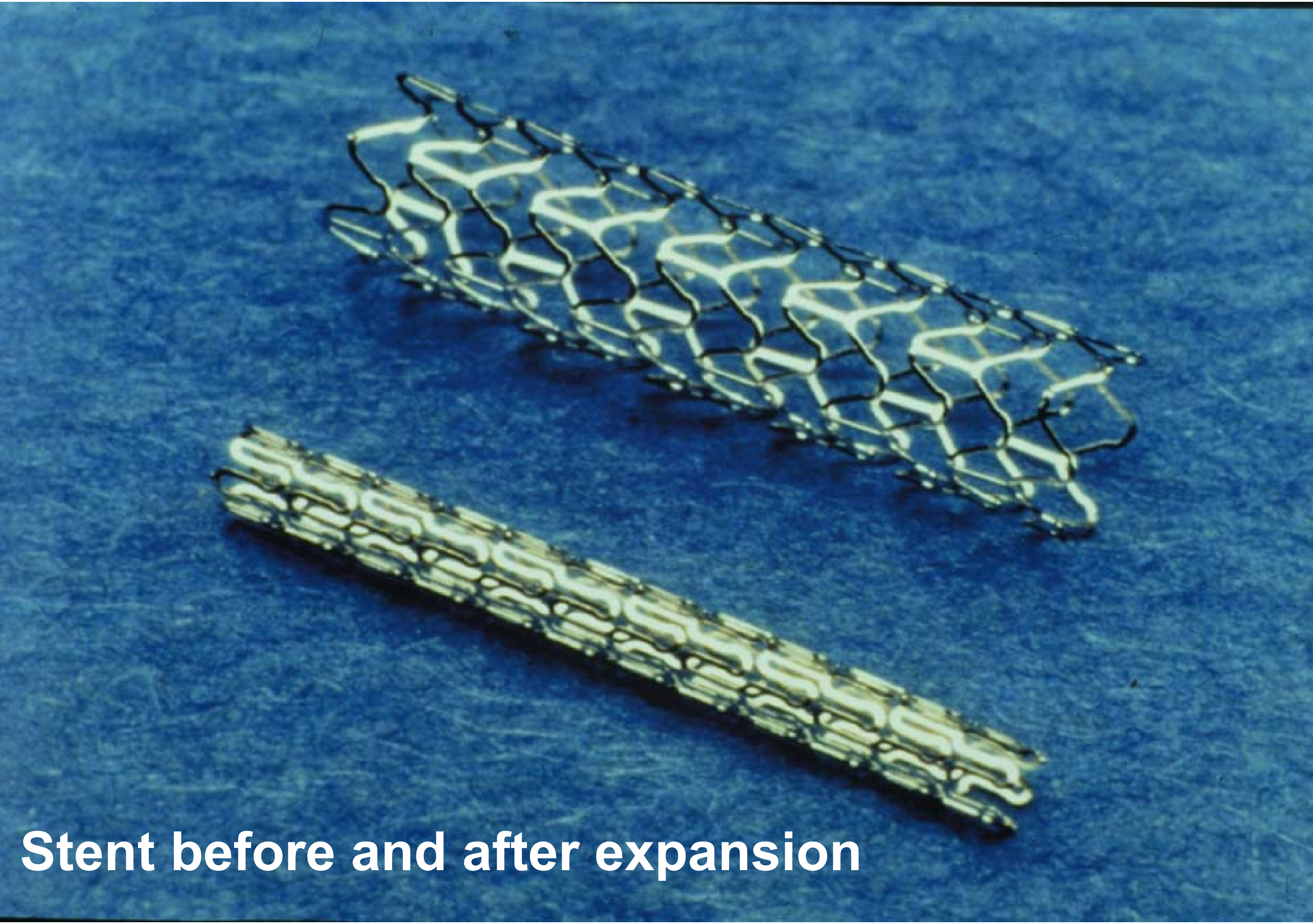


Balloon and stent partially expanded

Balloon is inflated, expanding stent
and compressing blockage

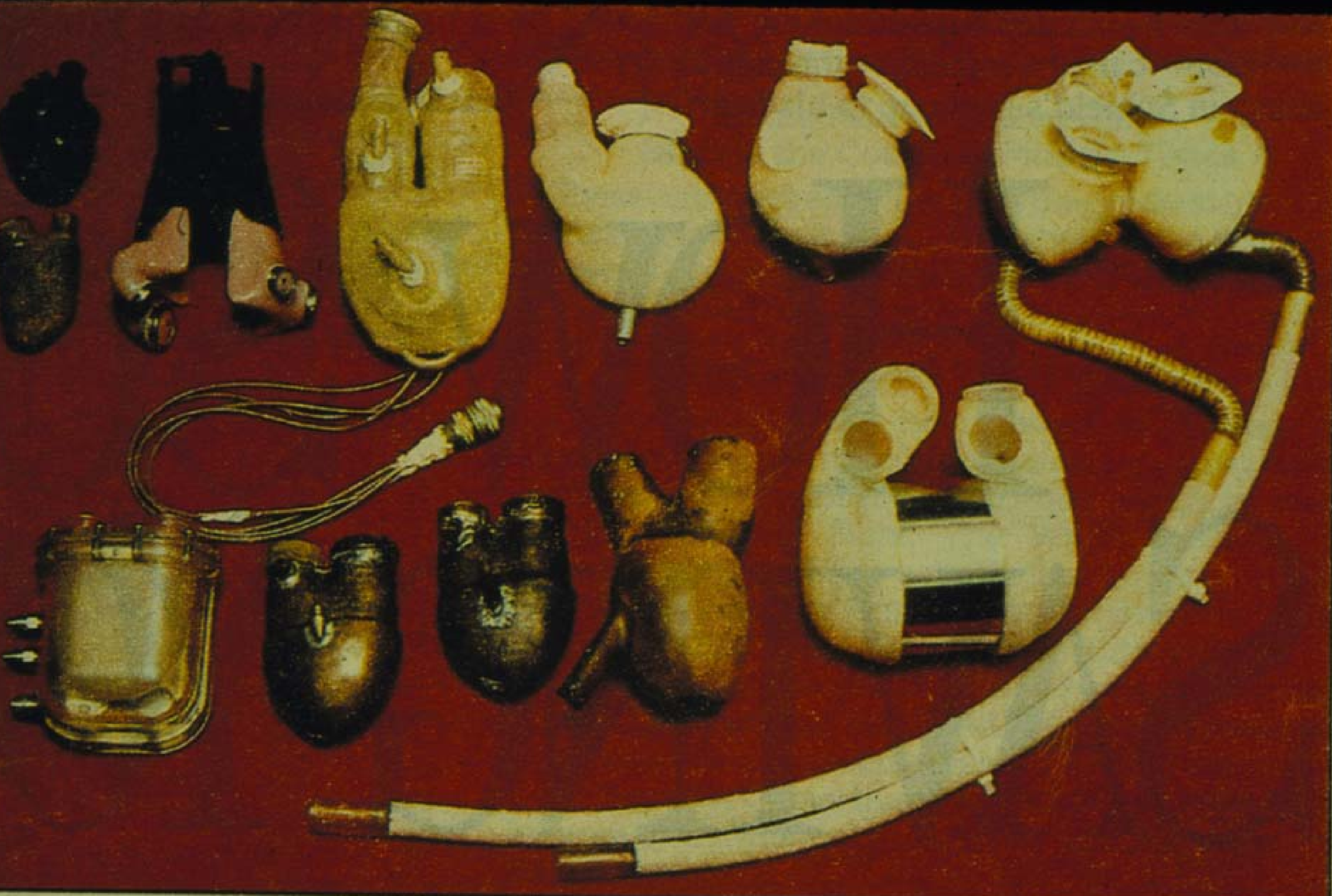



Balloon is deflated, catheter is removed,
leaving stent behind to maintain patency.



Stent before and after expansion

LVAD ASSIST DEVICES
AND
TOTAL ARTIFICIAL HEART



st models of artificial hearts: Doctors are seeking cheaper, simpler ones.

Willem "Pim" Kolff

Inventor of the artificial kidney and a pioneer in development of the artificial heart

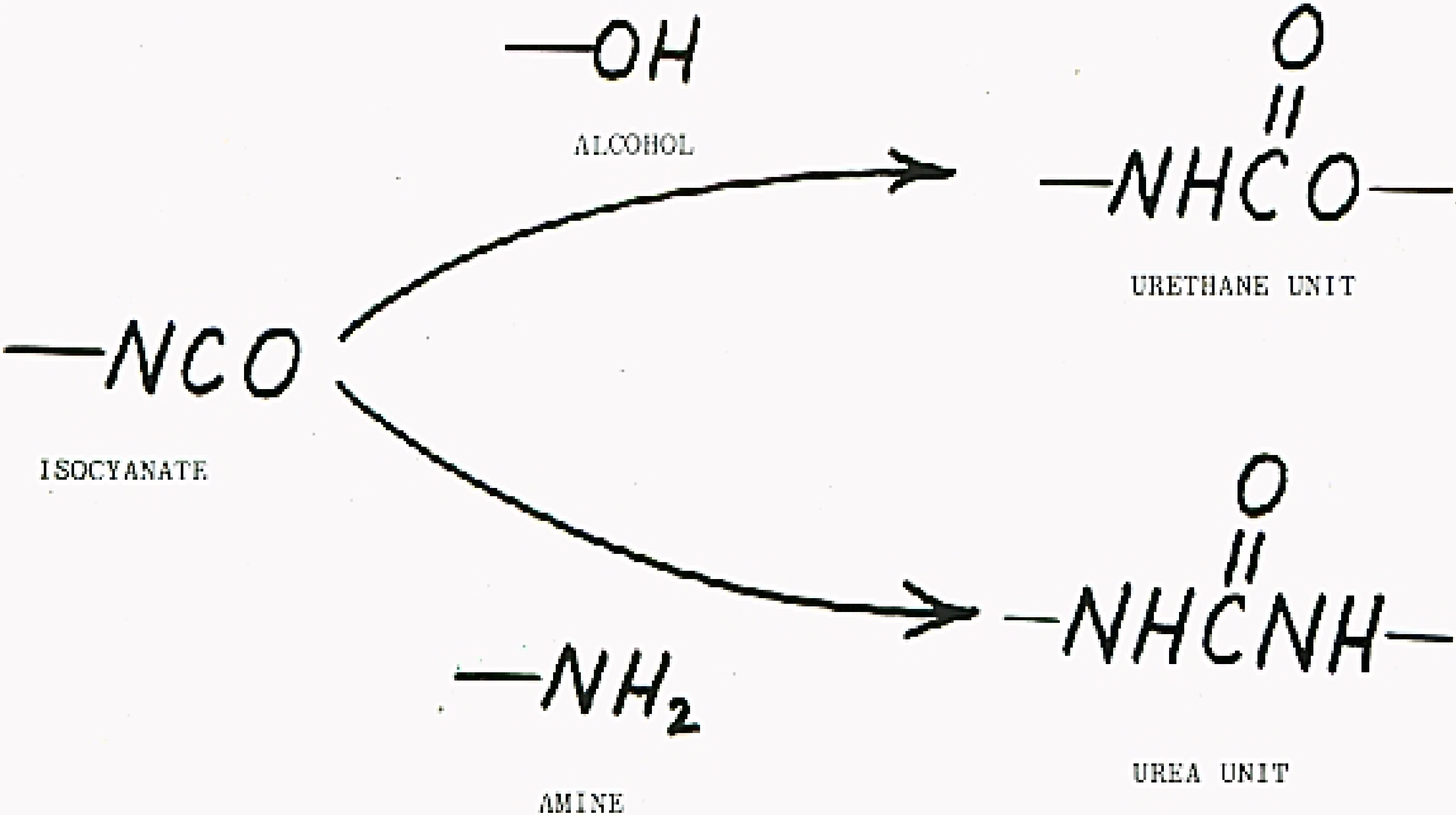
Evolution of the Total Artificial Heart

Kolff 1958	*Kolff 1965*	*Liotta 1969*	*Jarvik 1982*	*Abiomed 2001*

PVC **Silicone Rubber** **Lycra Spandex** **Purified TPU**

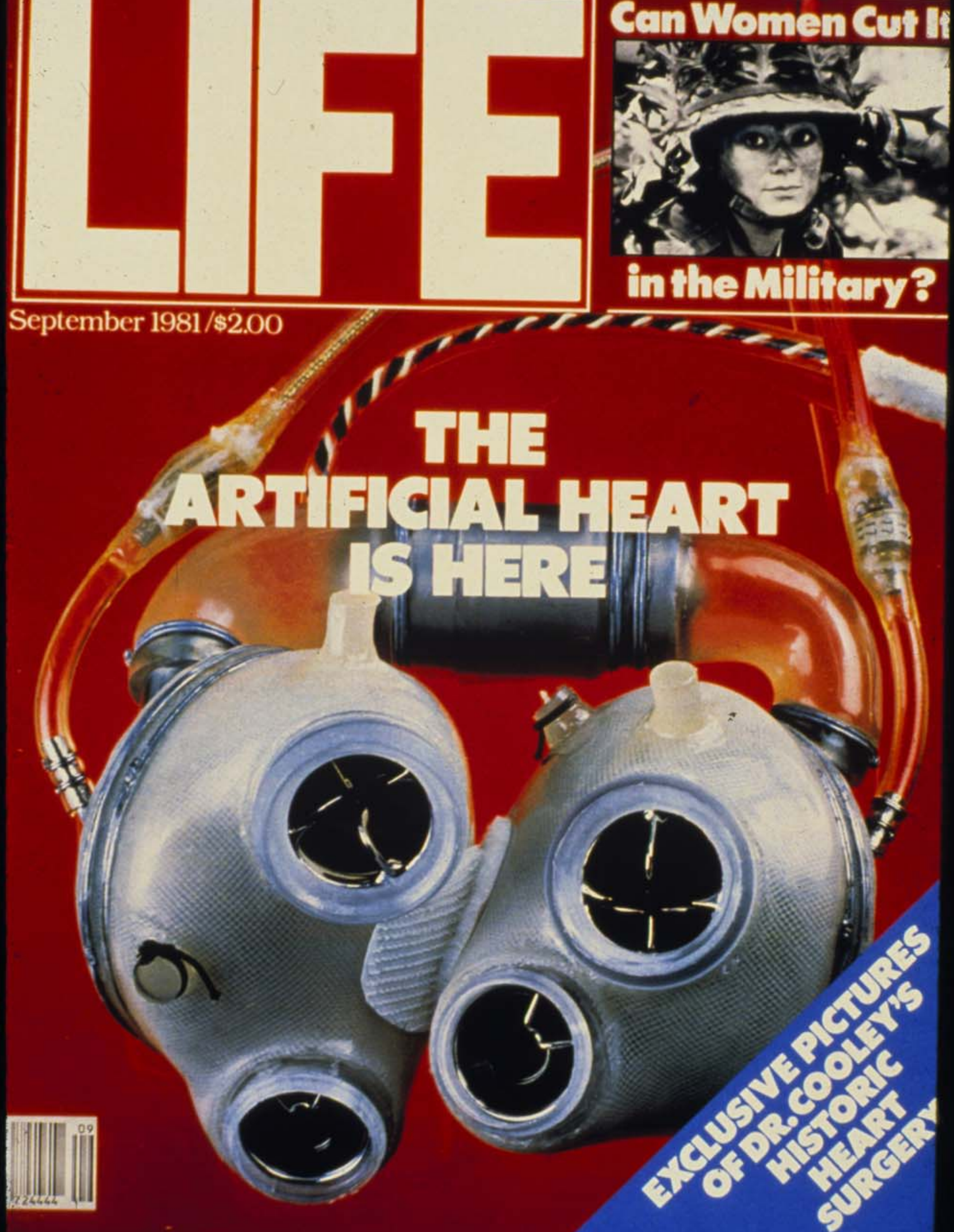
Courtesy of Bob Ward

POLYURETHANE BIOMATERIALS



PEU = POLY (ETHER-URETHANE)

PEUU = POLY (ETHER-URETHANE-UREA)


LIFE
Can Women Cut It in the Military?
September 1981/$2.00
THE ARTIFICIAL HEART IS HERE
EXCLUSIVE PICTURES OF DR. COOLEY'S HISTORIC HEART SURGERY

Orange County Edition

Late Sports

Los Angeles Times

Morning Final

culation: 1,081,050 Daily / 1,340,743 Sunday | Thursday, December 2, 1982 | MF / 252 pages / Copyright 1982, Los Angeles Times / Daily 25c

Man Given Artificial Heart

rn of Long Beach

His Campus s Also His Battlefield

MAURA DOLAN,
nes Staff Writer

group of 10 men and women sat d a conference table in a room ning the campus office of Ste- Horn, president of California University, Long Beach. gelical Christians and aides to rvative Republican legislators ed Horn to remove a book lesbian sex from a class read- t.

aide to Assemblyman Dennis n of Signal Hill tried to explain is dislike of the book did not he is naive or prudish.

e've all read books like this at me or another," said the aide, the kind of tone that is usually panied by a wink or a nudge.

rn, who was allowing his deans ice presidents to run the meet- uddenly perked up.

oung man, I am 50 years old have never read pornogra- participants quoted the be- acled, balding president as . "You are wrong to assume ve all read this kind of materi-

Los Angeles Times

Sen. Edward M. Kennedy as he bowed out of presidential race.

Tides Threaten Mobile Homes on Irvine Coast

By LEO C. WOLINSKY
and JACK JONES,
Times Staff Writers

Wind-blown waves accompanied by unusually high tides battered portions of Southern California's

Sen. Kennedy Won't Enter 1984 Race

By ROBERT SHOGAN,
Times Political Writer

WASHINGTON—Sen. Edward M. Kennedy took himself out of the 1984 contest for the White House Wednesday, setting off a scramble among the remaining Democratic presidential prospects for the support that had made him a principal contender.

The Massachusetts senator's withdrawal, which he attributed to concern for his children, appeared to make former Vice President Walter F. Mondale the front-runner, at least for the time being.

Kennedy indicated that he was bowing to the wishes of his children —Kara, 22; Edward Jr., 21, and Patrick, 15. They reportedly were concerned that another presidential campaign would bring more attacks on his character and perhaps further threats against his life.

Might Run in 1988

"My first and overriding obligation now is to Patrick and Kara and Teddy," Kennedy said. "I will not be a candidate for the presidency of the United States in 1984."

In announcing his withdrawal, Kennedy made it plain that he intends to maintain his role as the Democratic Party's most vigorous

Associated Press

Model of artificial heart implanted by Salt Lake City surgical team

Implant of Permanent Pump a First

SALT LAKE CITY (UPI) — Surgeons replaced the dying heart of a 61-year-old dentist today with the first permanent artificial heart implanted in a human.

The historic operation at the University of Utah was a last-ditch effort to save the life of Barney Clark of Seattle.

The second of two plastic pump chambers was snapped into place in his chest cavity about 3½ hours after the procedure began, officials said.

"Blood is actually flowing through the heart now," John Dwan, a spokesman for the University of Utah Medical Center, said as surgery drew to a close early today.

He said doctors had begun the painstaking process of weaning the patient from a heart-lung machine to the new heart.

Surgeons had to complete sewing up the connections to natural tissue before activating the artificial heart. That was to be done before the opening in the chest was closed.

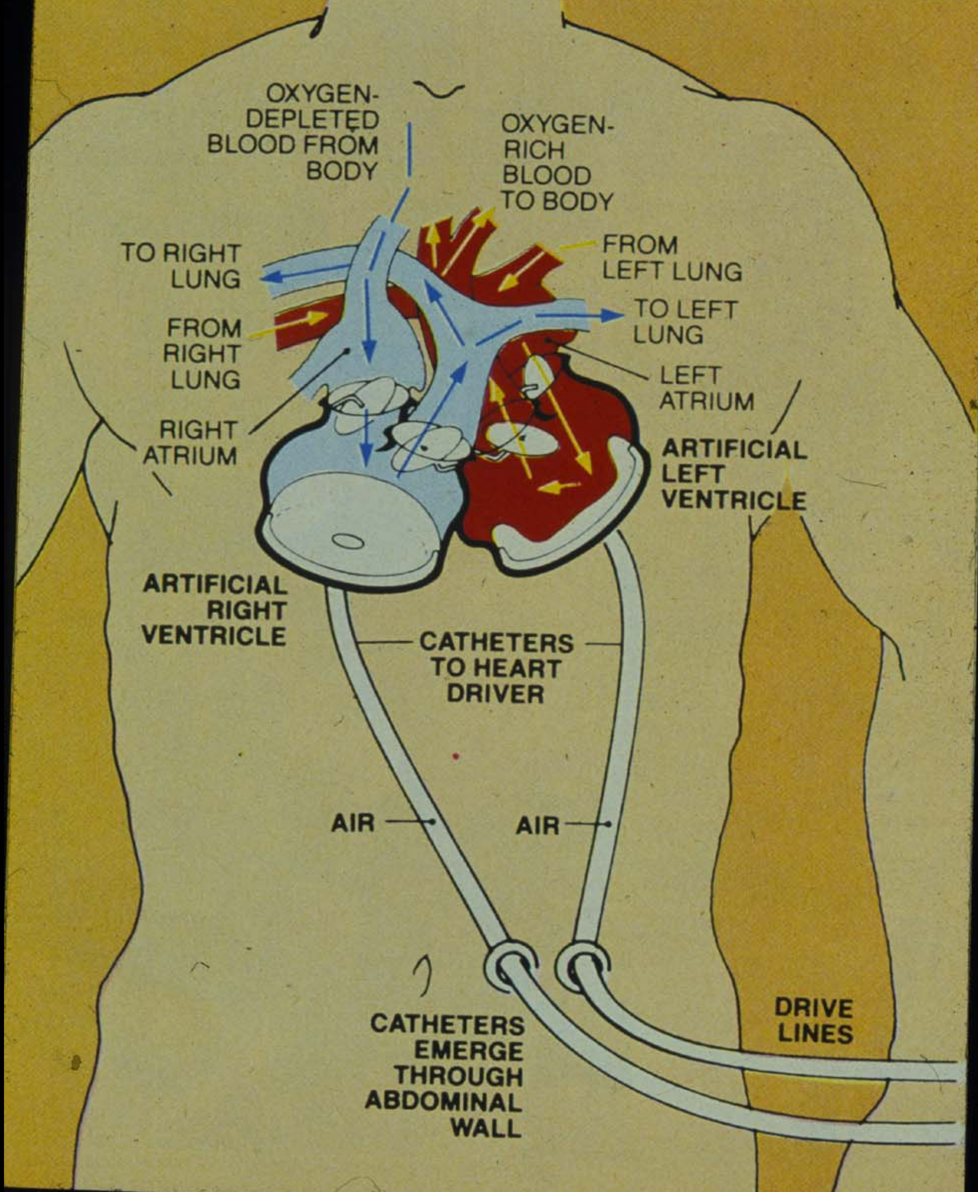
If successful, the operation would mean Clark must be connected for the rest of his life by two tubes to an external air compressor running the implanted device.

'Bound to Bed'

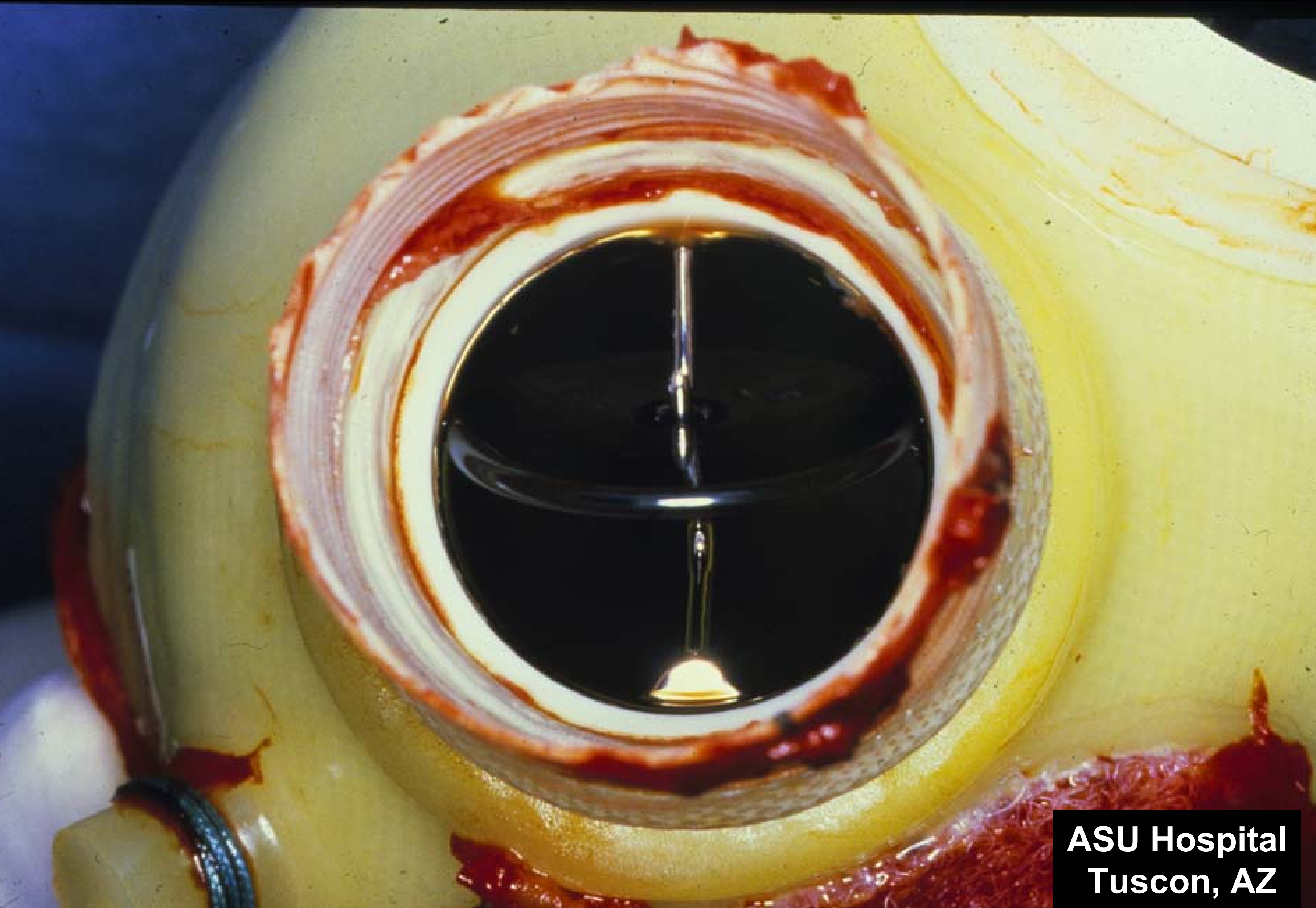
Dr. Chase Peterson, university vice president for medical services, likened it to "life tethered to a

THE IMPLANT

About the size of a normal male heart, the artificial device is sutured to the atria and assumes the function of the ventricles, pumping blood through the circulatory system. It is powered by pulses of compressed air fed through two permanent lines linked to the heart.



Thrombus on outlet from valve in Jarvik TAH



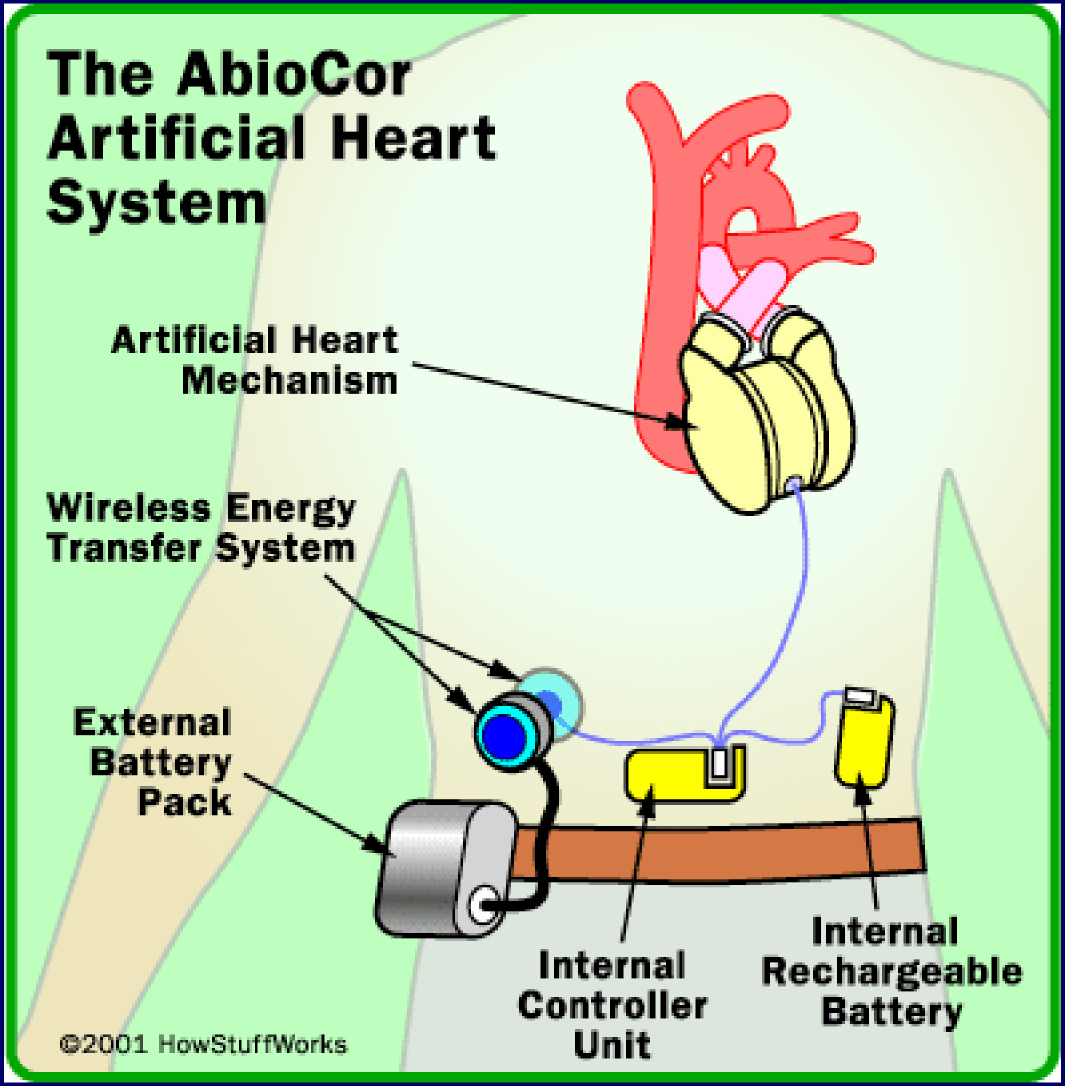
ASU Hospital
Tuscon, AZ

THE VALVE THAT BROKE

Open: The disc tilts down to let blood pour from the atrium into the ventricle

Closed: As the ventricle fills, the rising blood pushes the disc shut

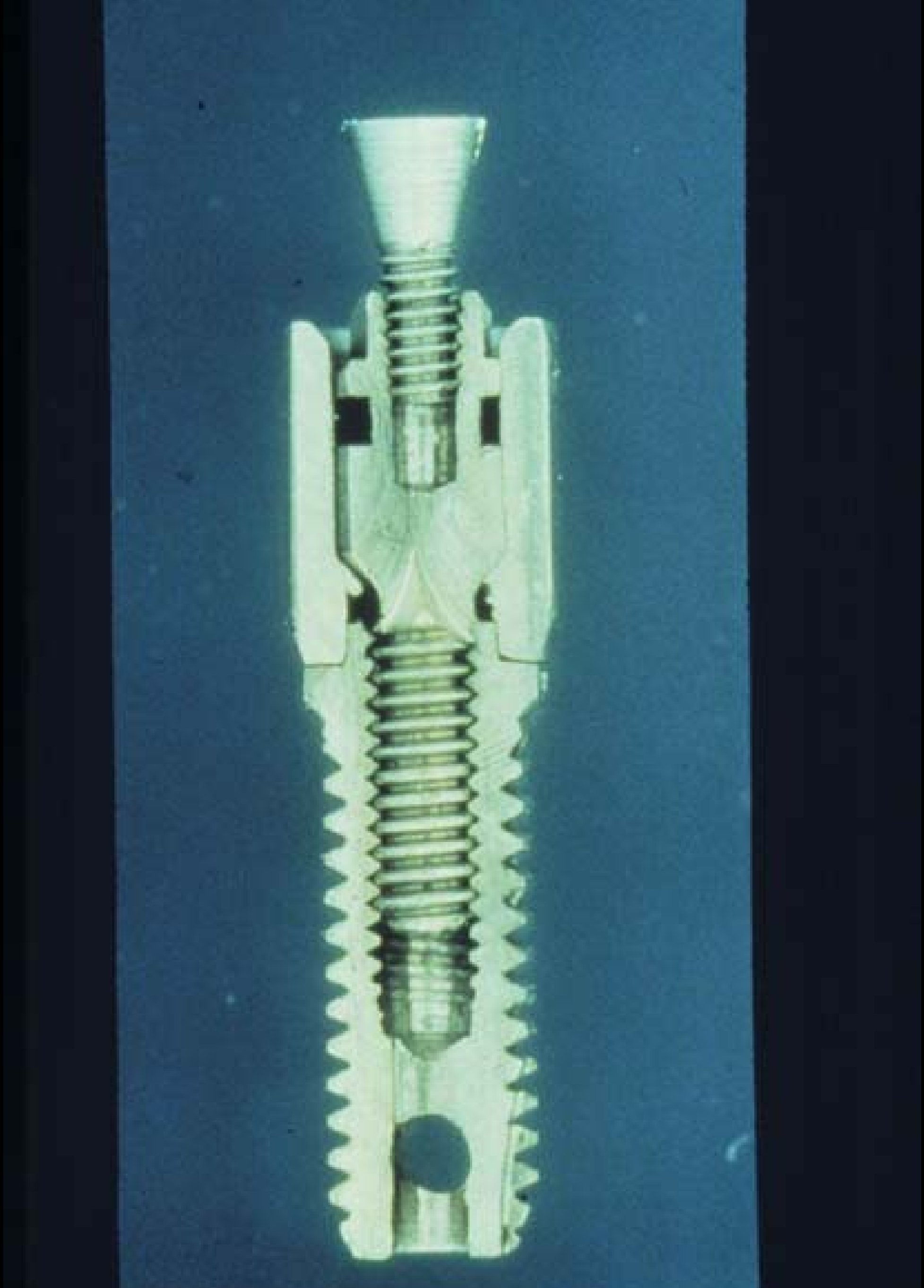
Broken: The disc will not seal properly; it can now slip out of the metal housing



The AbioCor Artificial Heart System
Artificial Heart Mechanism
Wireless Energy Transfer System
External Battery Pack
Internal Controller Unit
Internal Rechargeable Battery
©2001 HowStuffWorks

THE "MIRACLE" MATERIAL: TITANIUM

Some time in the 1980s, Branemark in Sweden noticed that titanium metal nails could not be easily removed from bone. This has led to the widespread use of Ti in dental and orthopedic implants. We are still trying to understand why Ti bonds so well to bone.



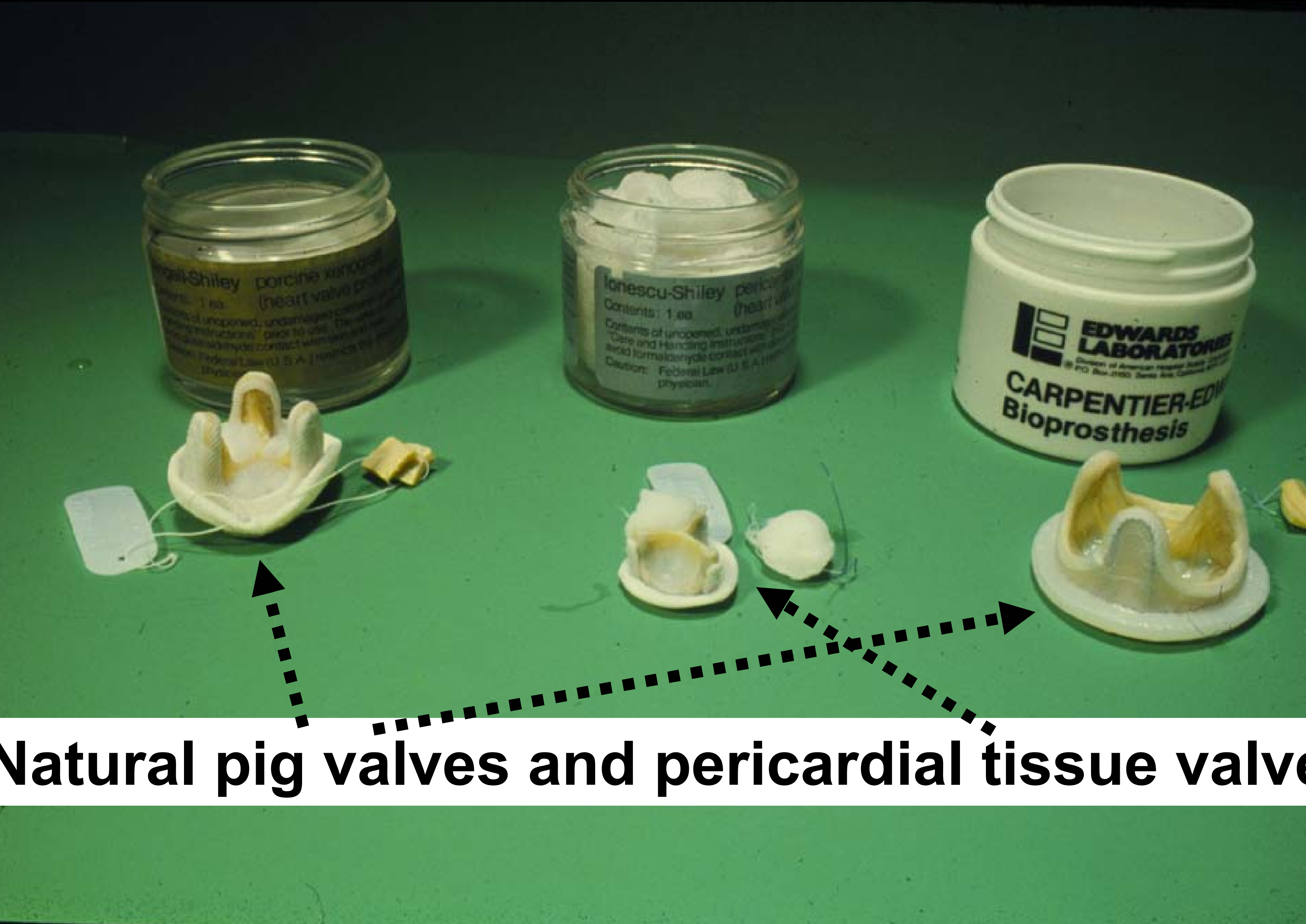
Titanium
Dental
Implant

BEFORE

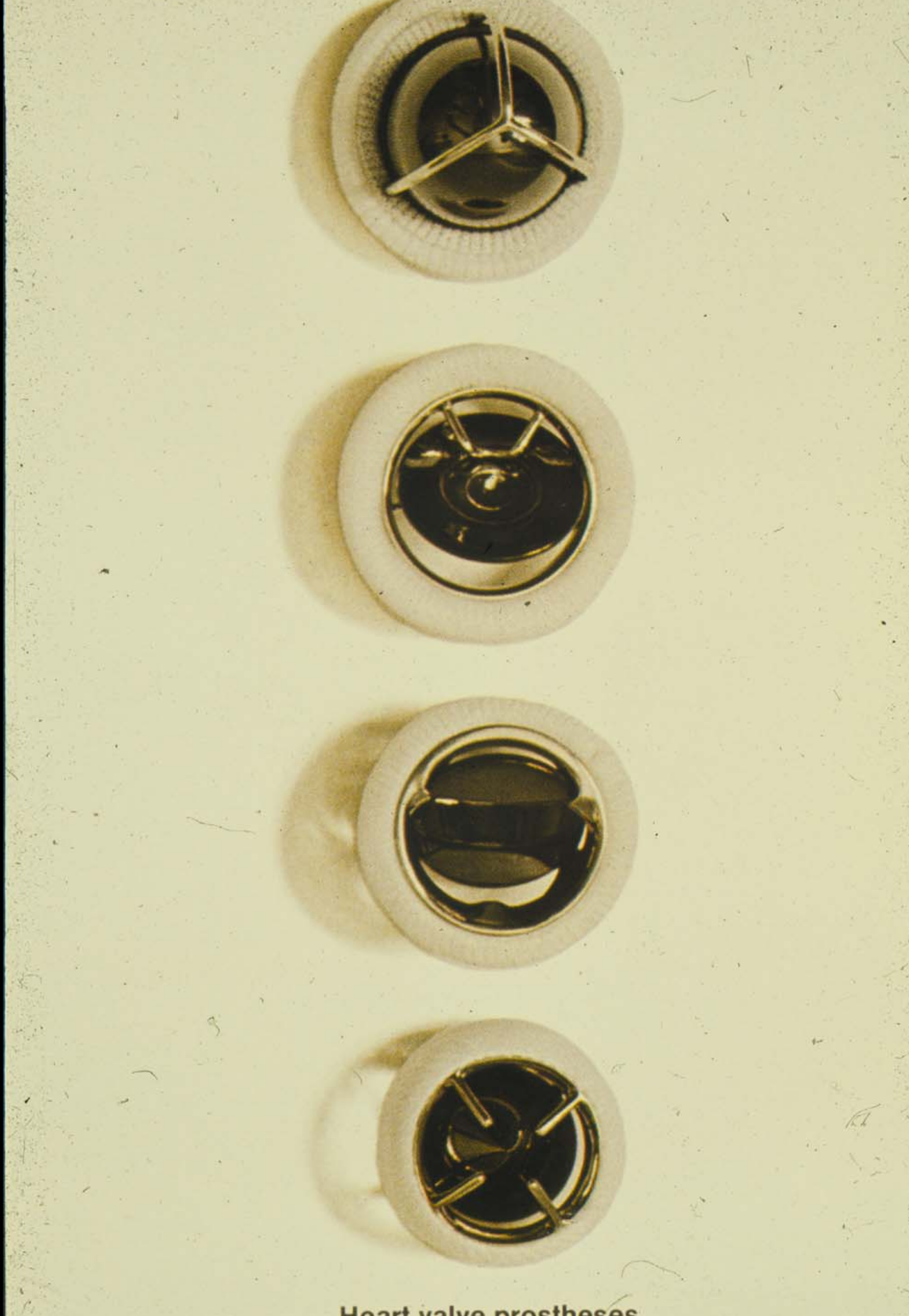
AFTER

HEART VALVES

Three Star-Edwards ("surgeon-company") silicone ball-in-cage heart valves



Natural pig valves and pericardial tissue valve



Pyrolytic Carbon® heart valves: (one ball-in-cage and three tilting disc valves)

BLOOD OXYGENATORS

Various designs of blood oxygenators

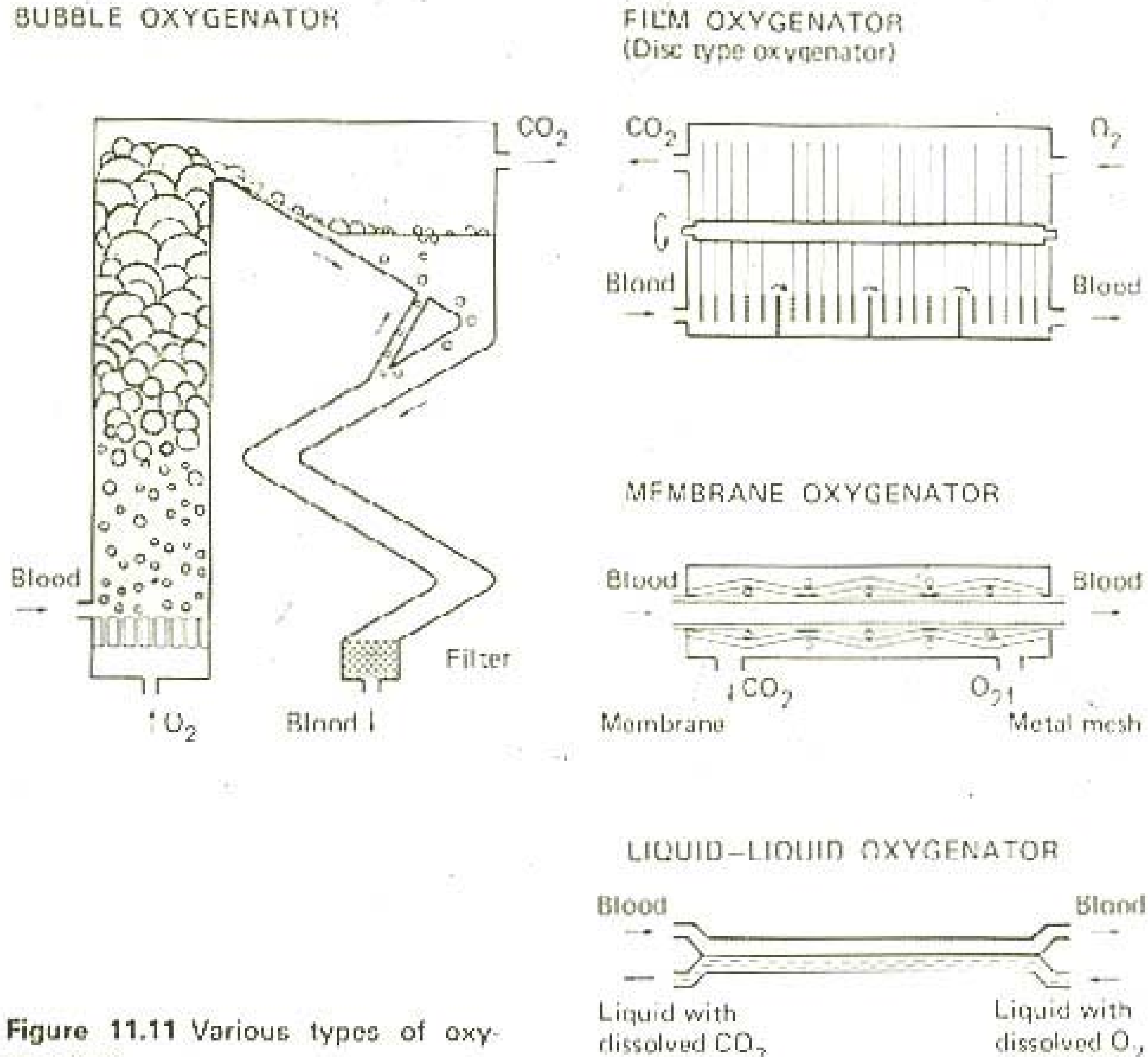
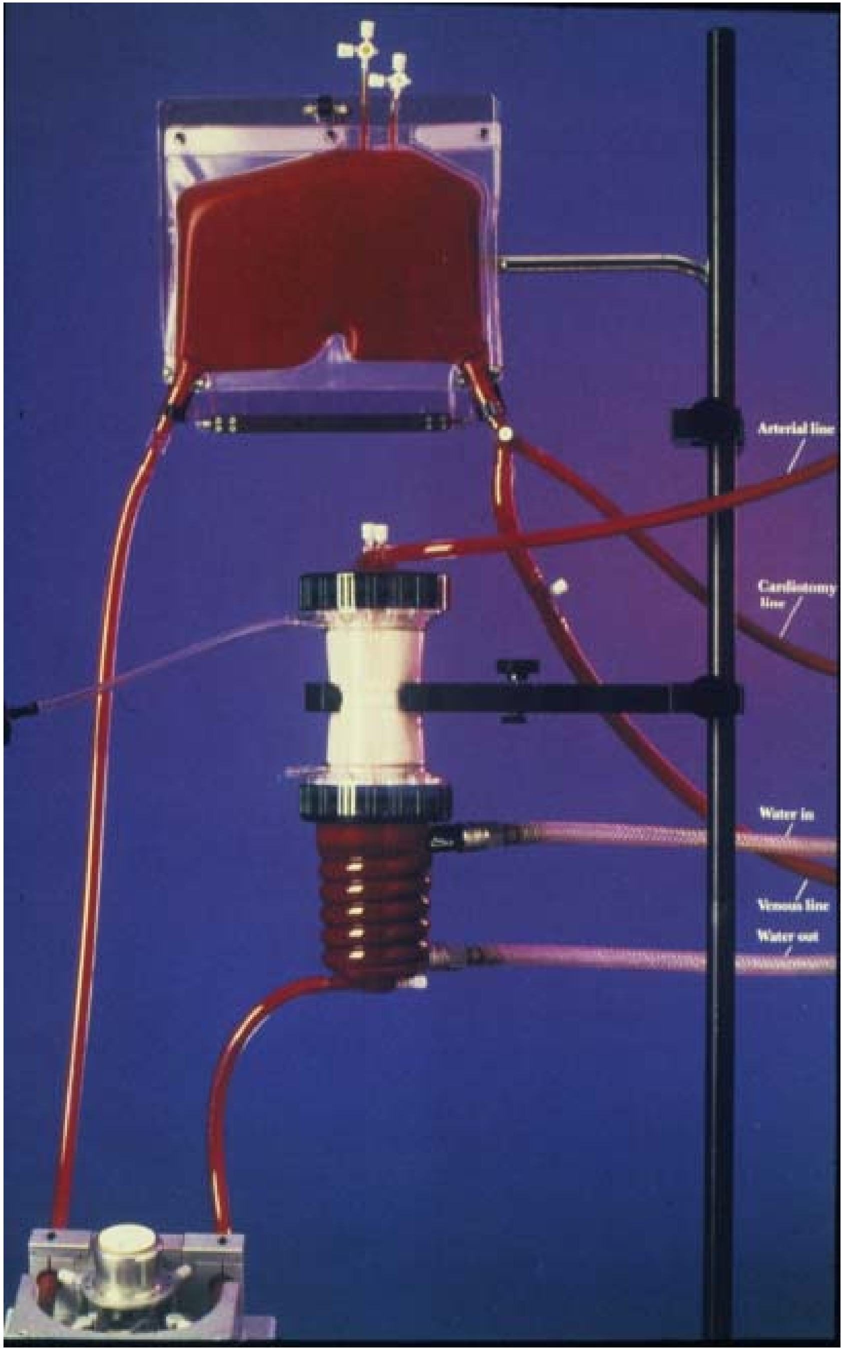


Figure 11.11 Various types of oxygenators.



HOLLOW FIBER MEMBRANE BLOOD OXYGENATOR (Uses porous PP hollow fibers)

Evolution of Tissue Engineering

Tissue injury, disease or failure

↓

Synthetic implant (if available)

↓

Implantation of biocompatible scaffold + cells ("*tissue-engineered*" tissue or organ)

↓

New tissue or organ

Organ injury, disease or failure

↓

Extracorporeal treatment (+/- cells)

↓

Transplantation (if organ available)

↓

Implantation of cells encapsulated in polymer ("bioartificial organ")

Tissue Engineering...

Ioannis V Yannas

Research on seeding cells in porous scaffolds started in the early 70's

Yannas,IV; Burke,JF; Orgill,DP; Skrabut,EM (1982): Wound tissue can utilize a polymeric template to synthesize a functional extension of skin. Science 215, 174-176.

Integra

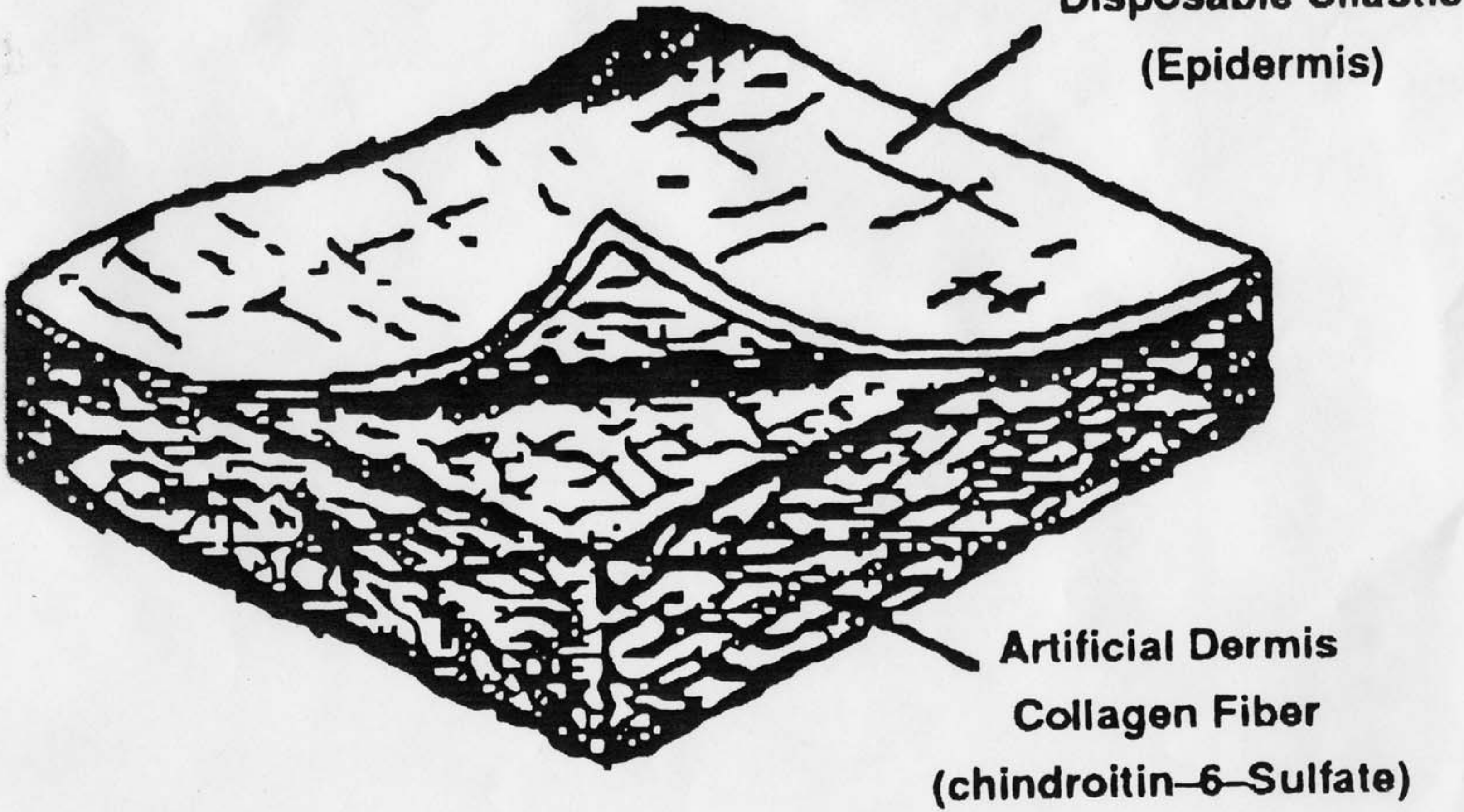
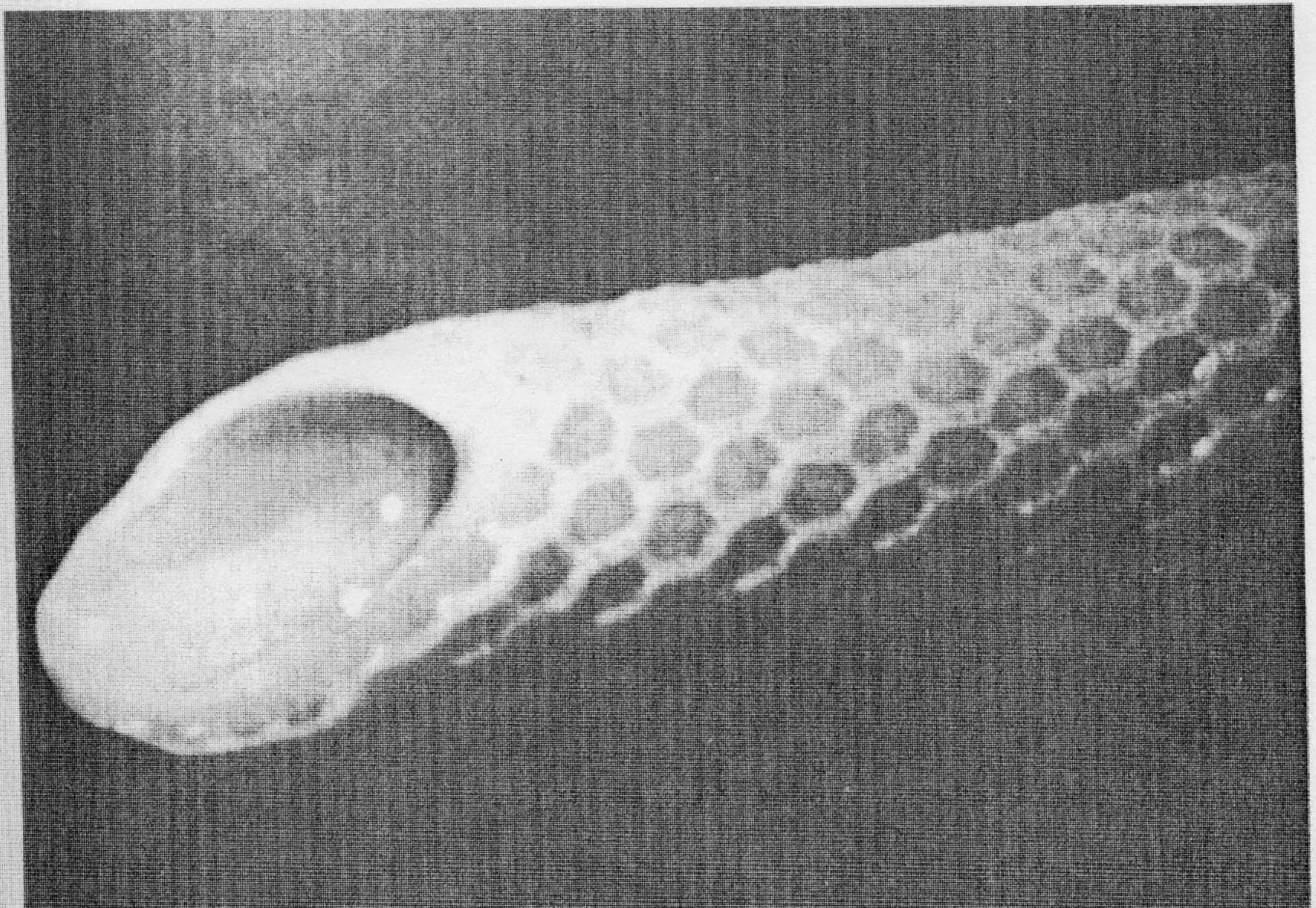


FIG. 8. Diagram of Burke and Yannas artificial skin (from Heimbach *et al.*, 1988).



REFERENCE: Dardik, H., "**Lower Extremity Revascularization with the Glutaraldehyde Stabilized Human Umbilical Cord Vein Graft,**" *Vascular Graft Update: Safety and Performance, ASTM STP 898,* Helen E. Kambic, Adrian Kantrowitz, and Pei Sung, Eds., American Society for Testing and Materials, Philadelphia, 1986, pp. 50-59.

Evolution of Tissue Engineering

Tissue injury, disease or failure

↓

Synthetic implant (if available)

↓

Implantation of *biocompatible scaffold* + cells ("*tissue-engineered*" tissue or organ)

↓

New tissue or organ

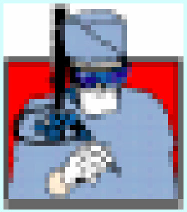
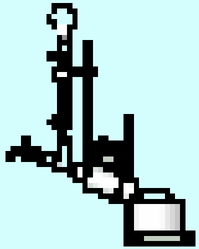
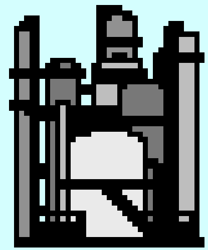
Organ injury, disease or f

ble)

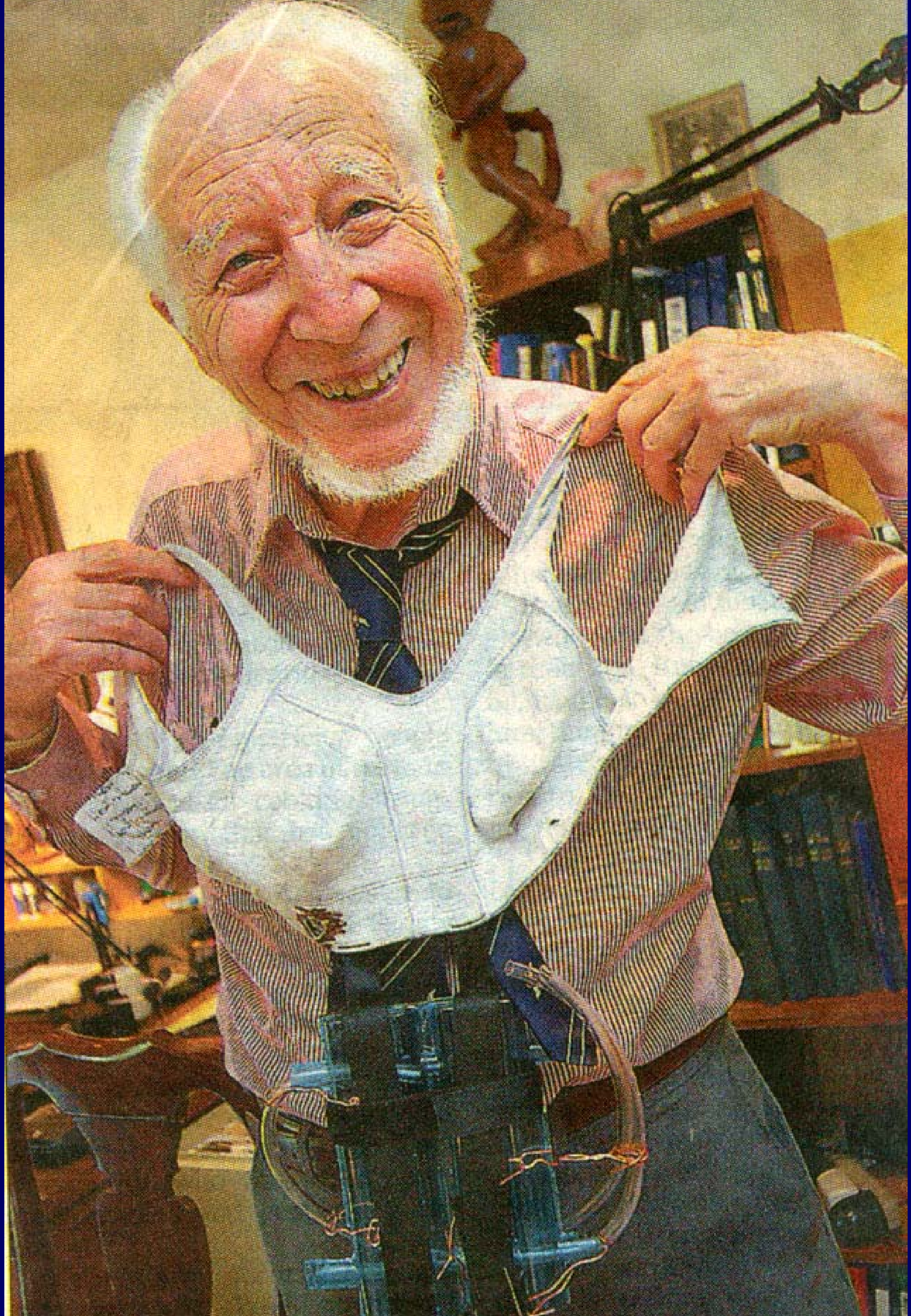
Implantation of cells encapsulated in polymer ("bioartificial organ")

Synthetic polymers such as PLGA, PHEMA and PEO, and natural polymers such as collagen, fibrin, silk fibroin, alginates, dextran and hyaluronic acid are currently being investigated as biocompatible scaffolds.

Careers Involving Biomaterials

Medicine	Science	Engineering	Business
Physician	Chemist	Bioengineering	Medical Device Company
Nurse	Biochemist	Chemical	Hospital
Bioengineer	Biologist	Mechanical	Venture Capital
Hospital Technician	Physicist	Electrical	Legal
	Lab Technician	Materials Science	



At 91, he's still working on ways to save lives

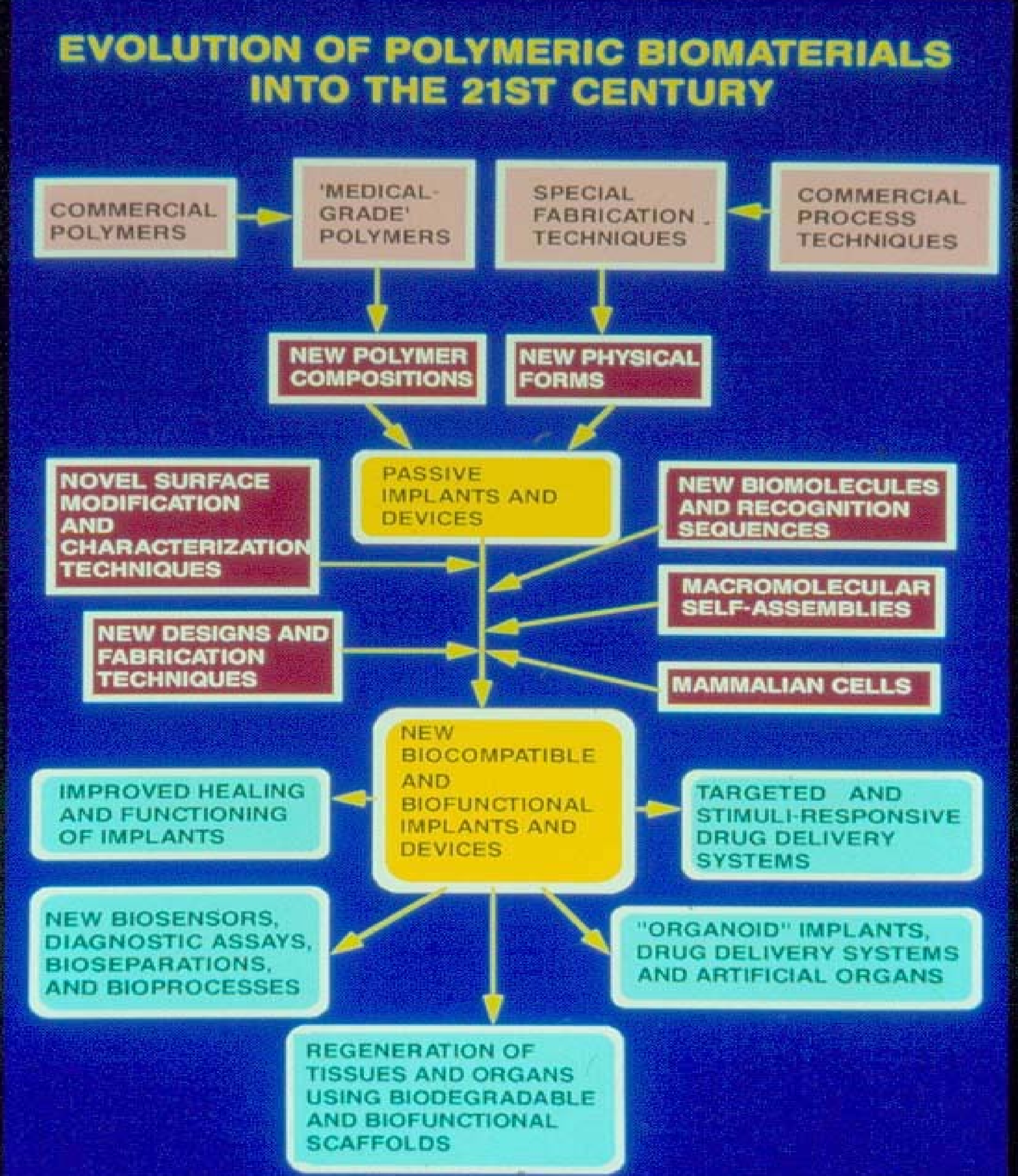
Dr. Willem Kolff has helped save millions of lives with his invention of the kidney-dialysis machine more than 60 years ago.

But at 91, the recent winner of a prestigious Lasker Award for medical research, is pushing his most recent invention. This time it's a portable artificial lung.

Bill Bergstrom in The Seattle Times, Nov. 3, 2002

Seattle, Washington is
one of the most beautiful and colorful
cities in America. Come and see for yourself!

Seattle is green for trees (and for $ from Boeing and Microsoft), brown for Starbucks coffee, blue for water (rivers, lakes, ocean…..and rain, very well red (for all the books we read) and purple and gold for the University of Washington!!


EVOLUTION OF POLYMERIC BIOMATERIALS INTO THE 21ST CENTURY
COMMERCIAL POLYMERS
'MEDICAL-GRADE' POLYMERS
SPECIAL FABRICATION TECHNIQUES
COMMERCIAL PROCESS TECHNIQUES
NEW POLYMER COMPOSITIONS
NEW PHYSICAL FORMS
PASSIVE IMPLANTS AND DEVICES
NOVEL SURFACE MODIFICATION AND CHARACTERIZATION TECHNIQUES
NEW BIOMOLECULES AND RECOGNITION SEQUENCES
MACROMOLECULAR SELF-ASSEMBLIES
NEW DESIGNS AND FABRICATION TECHNIQUES
MAMMALIAN CELLS
NEW BIOCOMPATIBLE AND BIOFUNCTIONAL IMPLANTS AND DEVICES
IMPROVED HEALING AND FUNCTIONING OF IMPLANTS
TARGETED AND STIMULI-RESPONSIVE DRUG DELIVERY SYSTEMS
NEW BIOSENSORS, DIAGNOSTIC ASSAYS, BIOSEPARATIONS, AND BIOPROCESSES
"ORGANOID" IMPLANTS, DRUG DELIVERY SYSTEMS AND ARTIFICIAL ORGANS
REGENERATION OF TISSUES AND ORGANS USING BIODEGRADABLE AND BIOFUNCTIONAL SCAFFOLDS