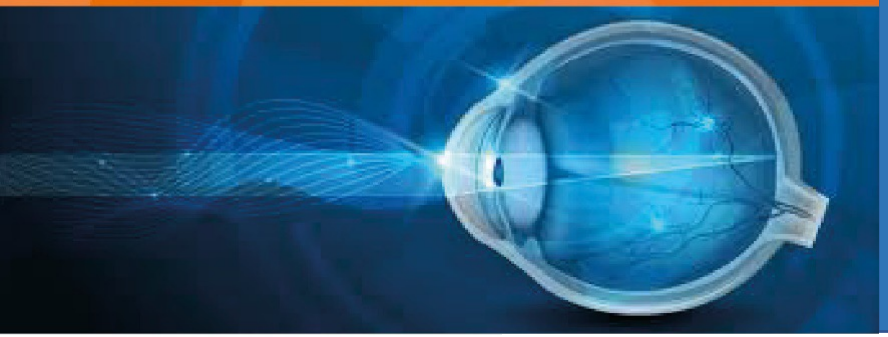
Eye Banking & Corneal Transplantation in Aotearoa



Nigel Brookes

Eye Banking Specialist
New Zealand National Eye Bank

UNIVERSITY OF AUCKLAND Waipapa Taumata Rau NEW ZEALAND

nz national eye centre

NZ National Eye Bank

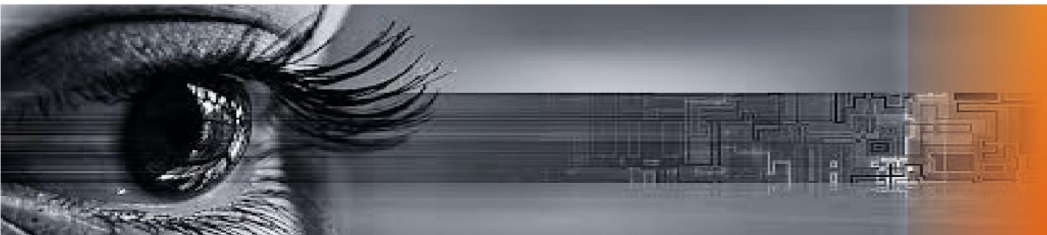
EBAANZ

New Zealand National Eye Bank

NZ National Eye Bank

EBAANZ

"The acquisition, evaluation & supply of high-quality corneal and other tissues to all New Zealanders needing a transplant to restore their sight"

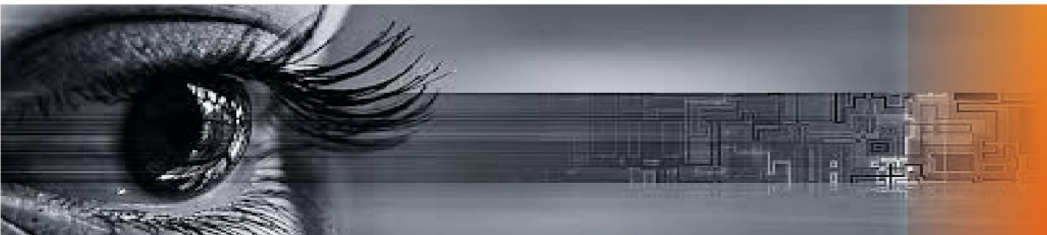


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NEW ZEALAND

- Overview
- History of Eye Banking
- Corneal Structure
- Corneal Transplantation
- Corneal Disorders
- Eye Donation
- Eye Banking in Aotearoa



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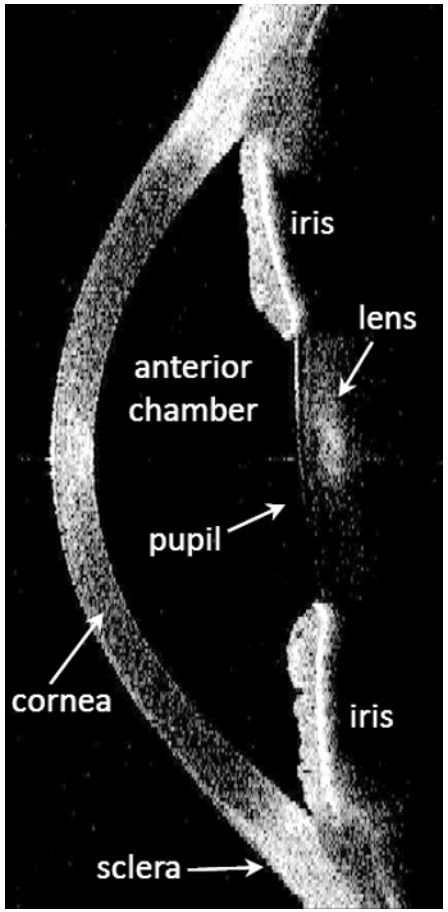
The Cornea

- The cornea is a unique transparent tissue
- A clear cornea with a normal shape is required for good vision
- A diseased cornea leads to functional blindness even if the rest of the visual system is normal



The Cornea

- **OCT** Image (**O**ptical **C**oherence **T**omography)



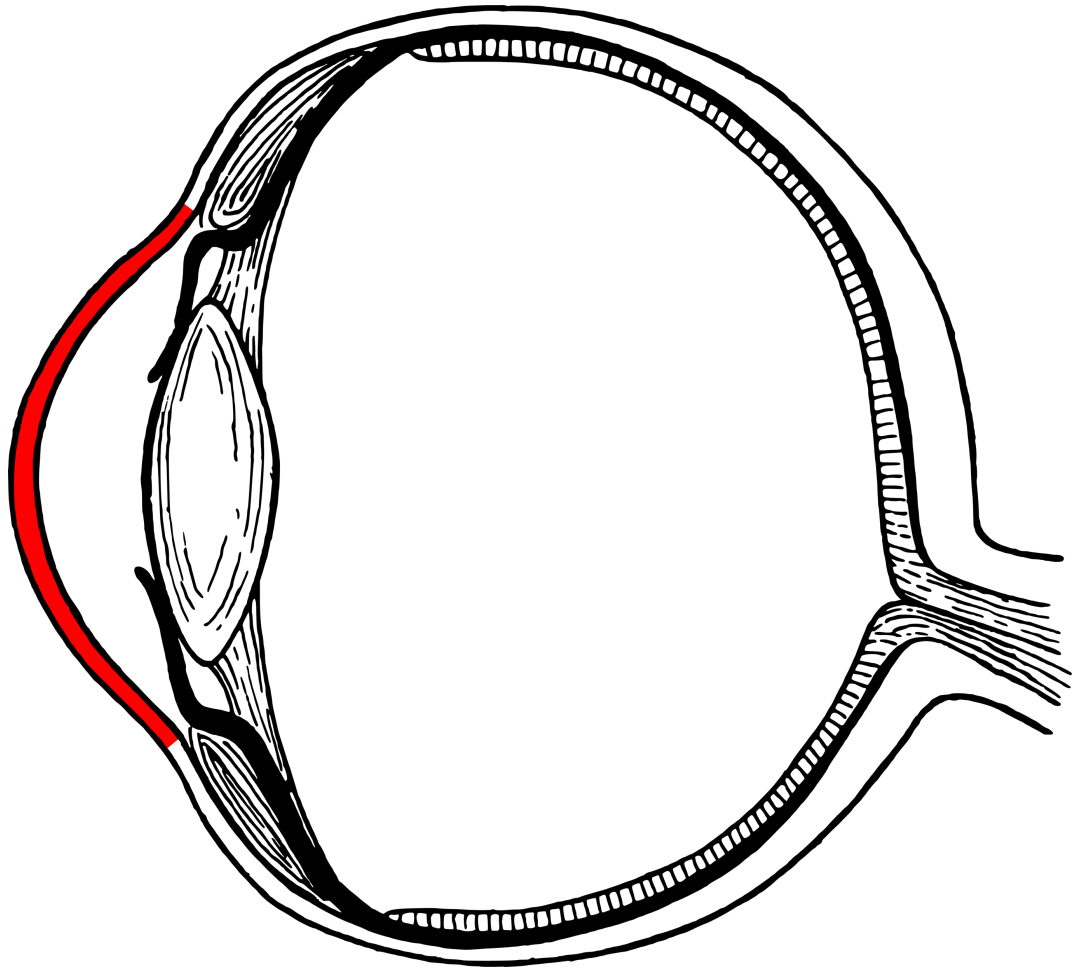


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What Tissues Can Be Stored?

Cornea

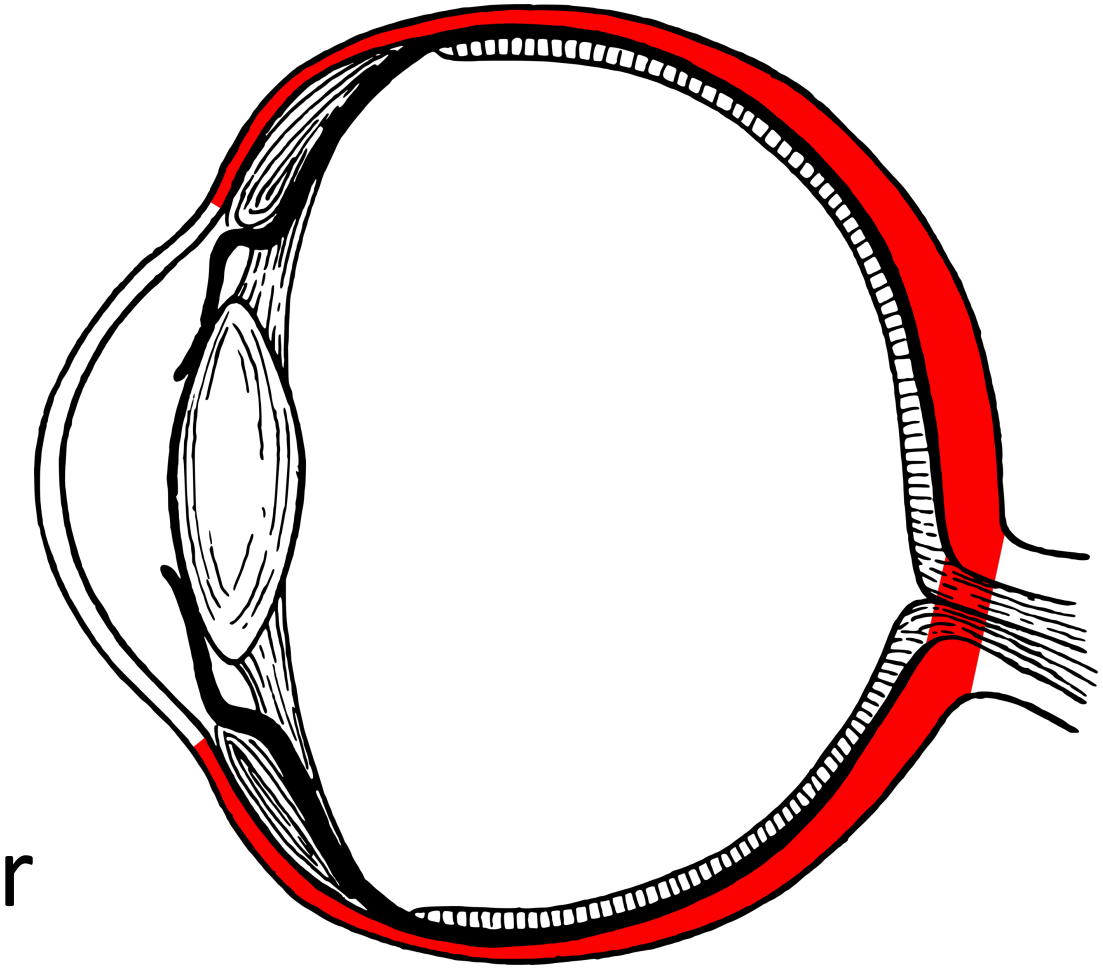
- Stored as living intact sight-restoring tissue
- Organ culture (34°C for < 28 days)
- ~ 350 transplants per year



What Tissues Can Be Stored?

Sclera

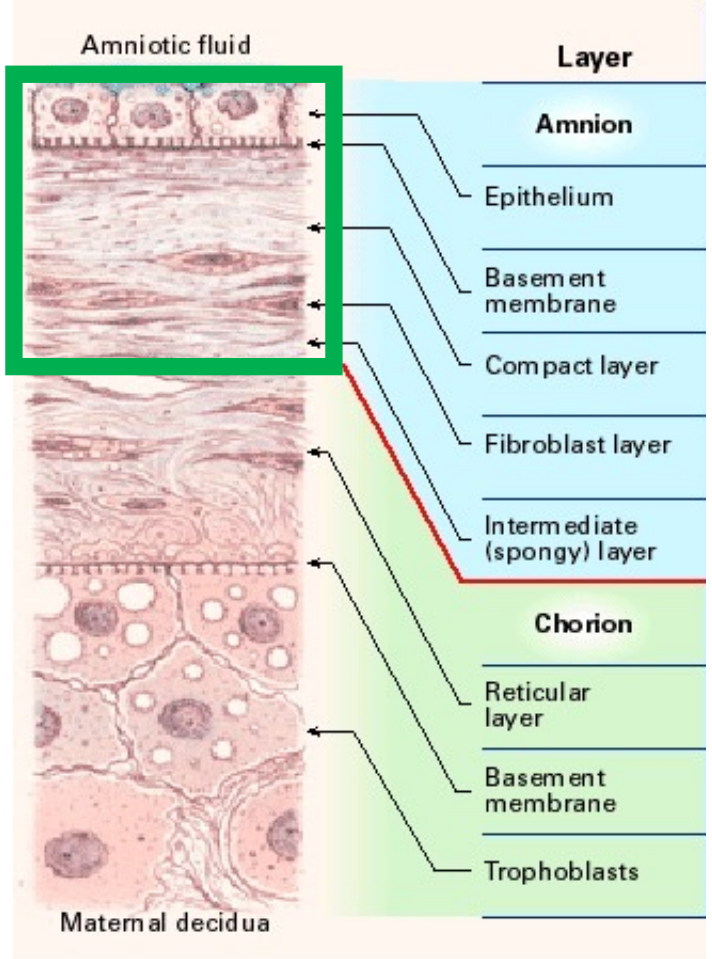
- Structural/reconstruction *e.g.* implants, patches, glaucoma surgery
- Refrigerated in glycerol for < 1 year
- ~ 150 transplants per year



What Tissues Can Be Stored?

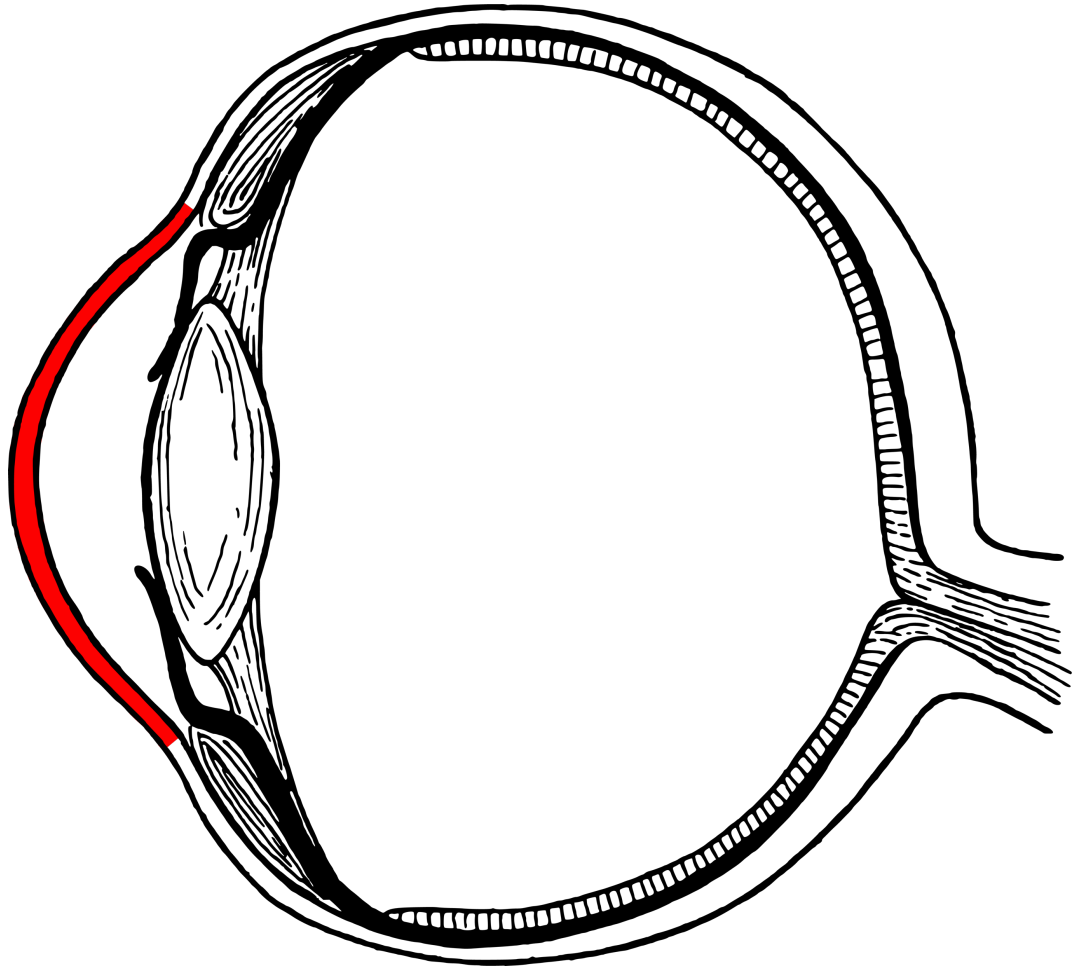
Amnion

- Placental surface
- Biological ‘bandage’
- Growth factors, cytokines, protease inhibitors
- -80°C for < 2 years
- ~ 50 transplants per year



Research Tissues

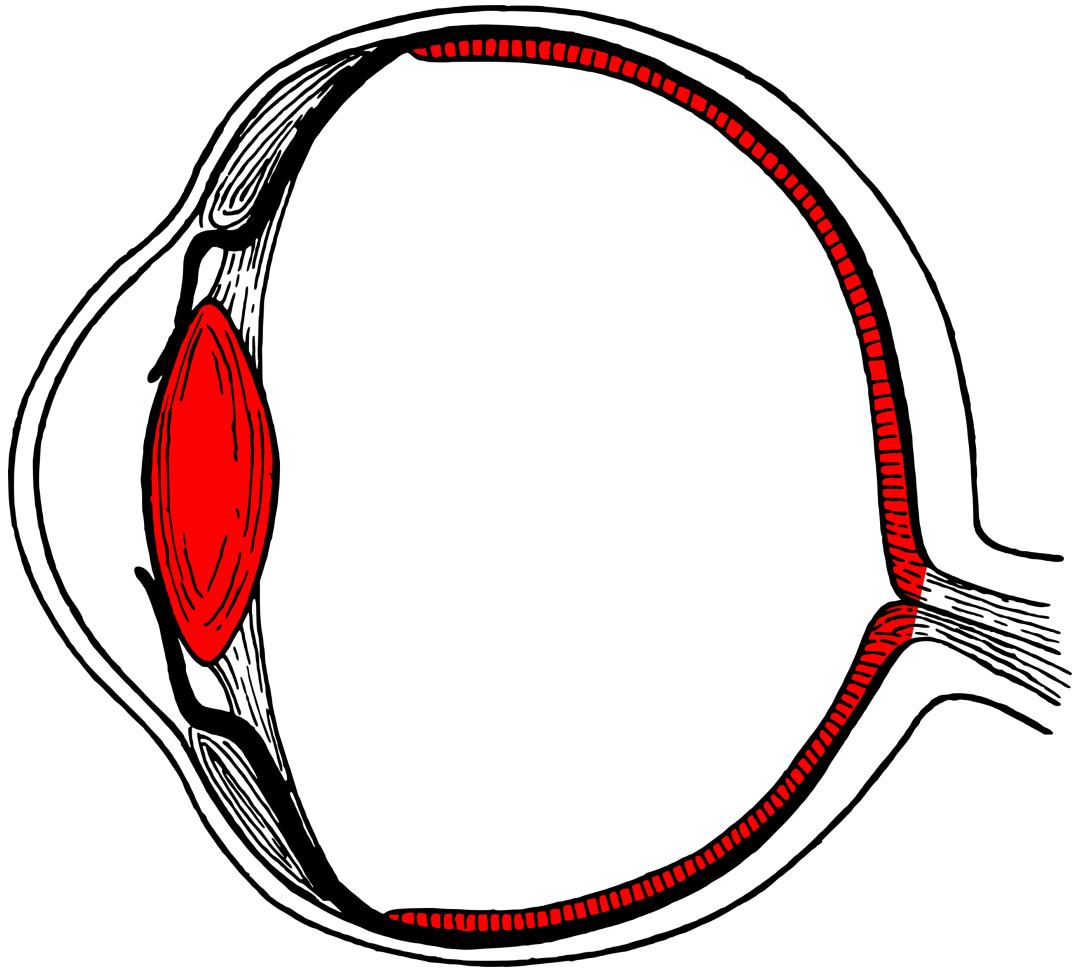
- **Cornea**
  - Unsuitable for transplant
  - Failed testing
  - Defective recipient tissue after surgery
- Lens
- Retina
- Limbal stem cells



Research Tissues

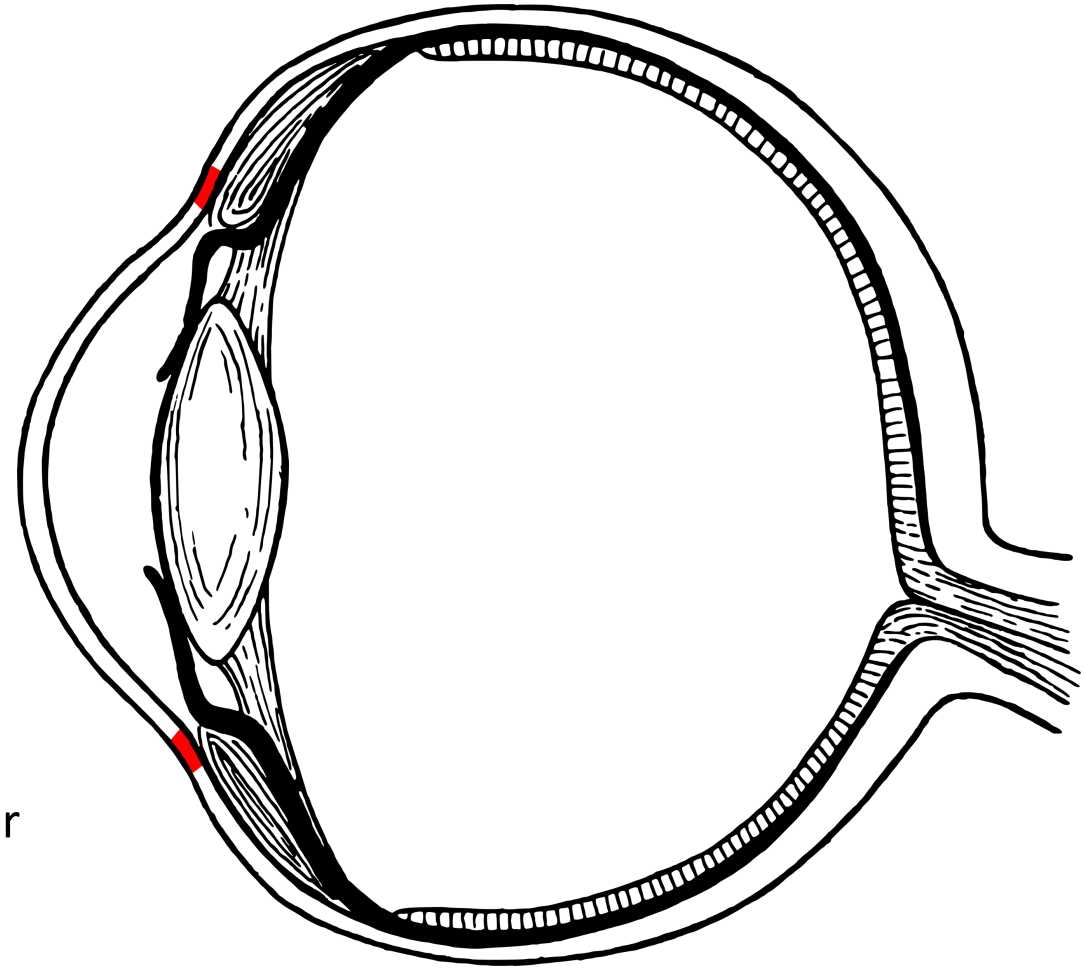
- Cornea
- **Lens**
- **Retina**
- Limbal stem cells

- Not transplanted



Research Tissues

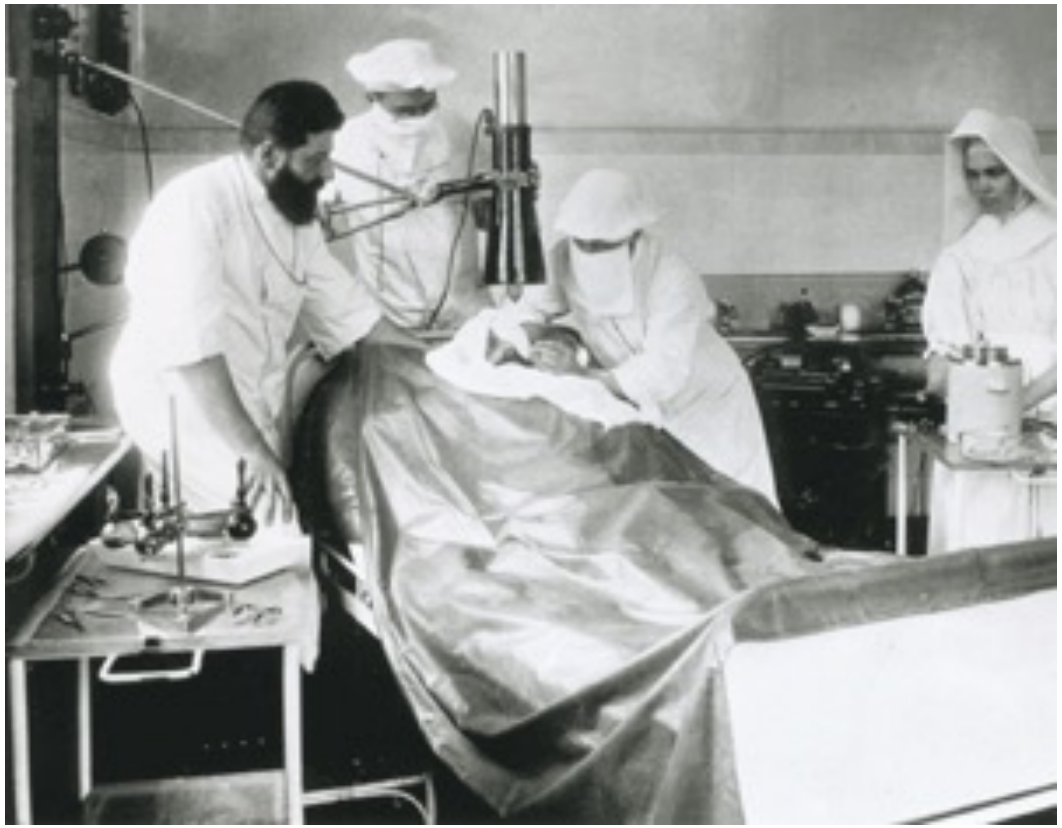
- Cornea
- Lens
- Retina
- **Limbal stem cells**
  - Corneoscleral ‘rim’ after surgery



History of Eye Banking

1905 First Full-thickness Keratoplasty

- Eduard Zirm – Austria



History of Eye Banking

1920-40 Keratoplasty Improvements

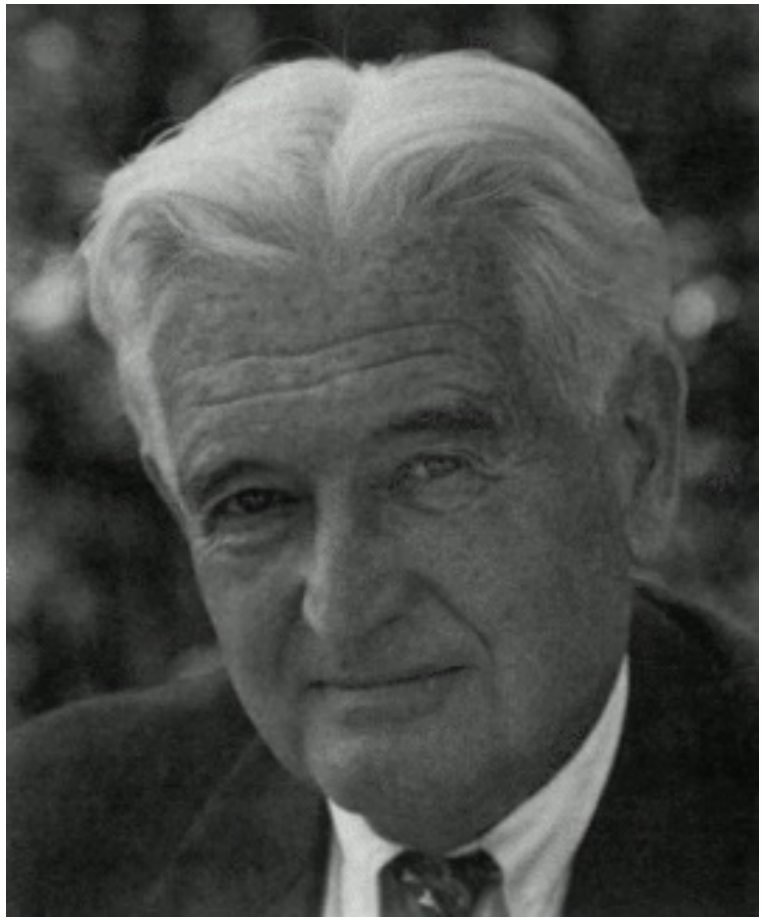
- Ramón Castroviejo – Spain



History of Eye Banking

1944 First Eye Bank

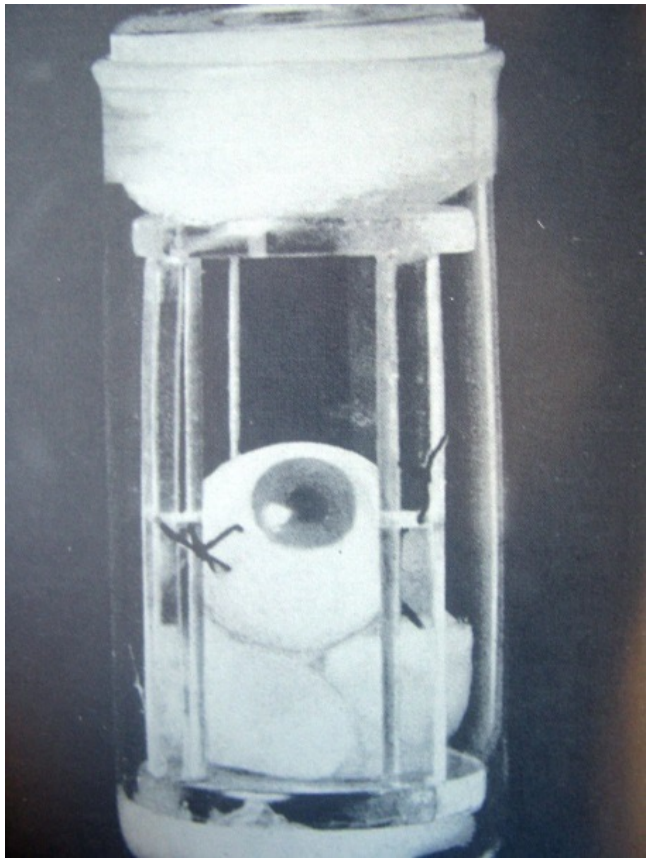
- R. Townley Paton
- Eye-Bank for Sight Restoration at the Manhattan Eye, Ear and Throat Hospital



History of Eye Banking

1944-1970's Whole Globe Storage

- 'Moist Pot'
- Vladimir Filatov USSR 1935



History of Eye Banking

1950-1990 Cold Storage Media

- Corneoscleral ‘button’
- M-K Media (McCarey-Kaufman 1974), Chondroitin sulphate (K-Sol, Dexsol, Optisol)
- Main storage media in USA
- NZ 1988-1991



History of Eye Banking

1991 Organ Culture Storage

- 34°C for < 28 days
- 1972 USA ‘Minnesota system’
- Europe, UK, NZ, Australia



History of Eye Banking

1991 Organ Culture Storage

- Separate storage and transport (thinning) media



History of Eye Banking

1991 Organ Culture Storage

- Separate storage and transport (thinning) media
- Assessment of graft suitability



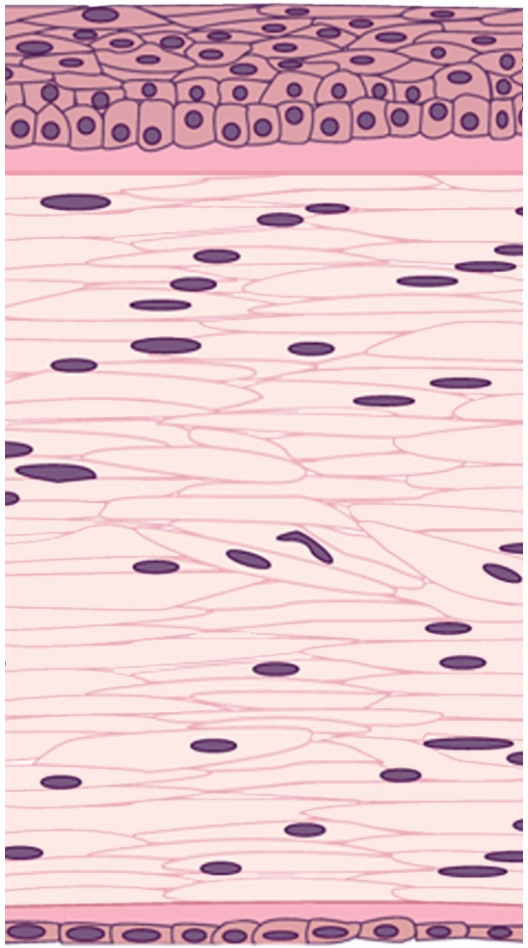


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Structure of the Cornea



Epithelium

Bowman's Layer

Stroma

Descemet's Membrane
Endothelium

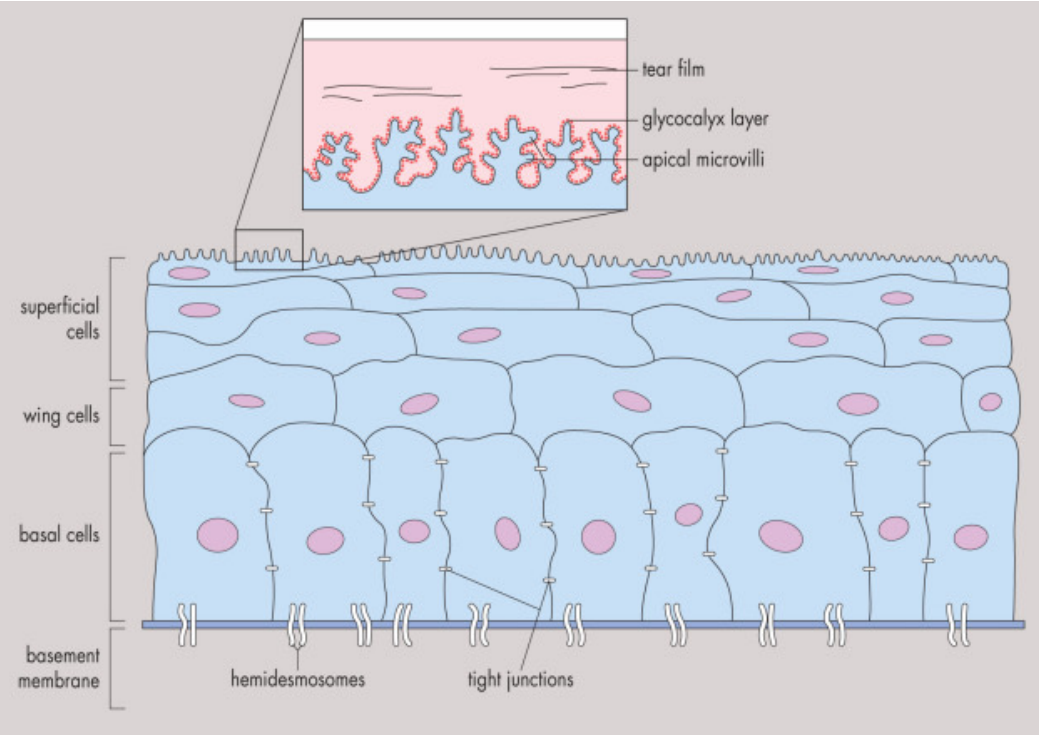


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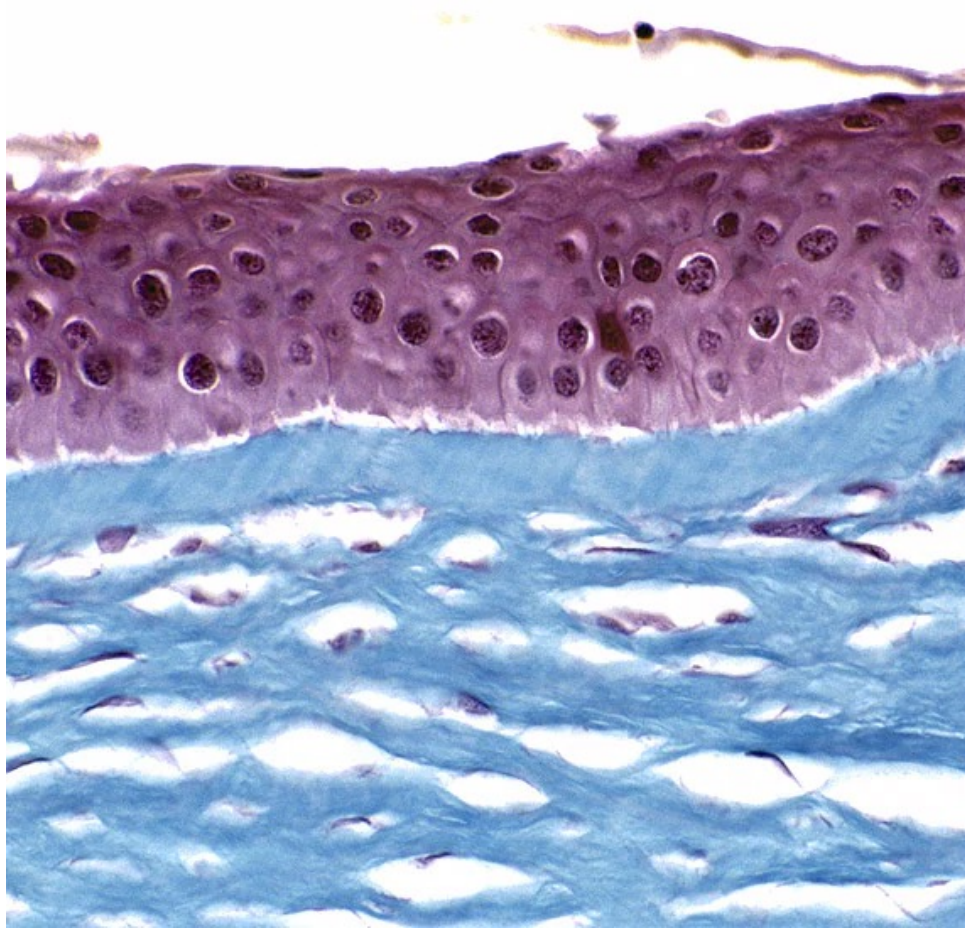
Epithelium



- Squamous
- 5-7 layers (50µm)
- 7-10 days basal to superficial
- Sloughed by eyelids/tear film

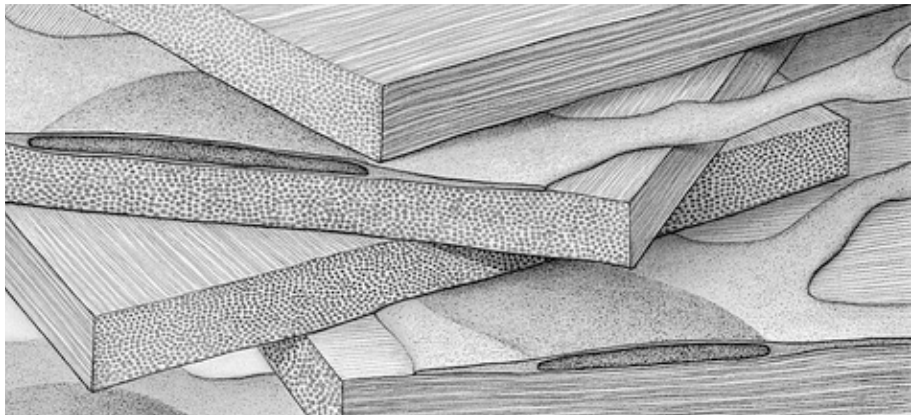
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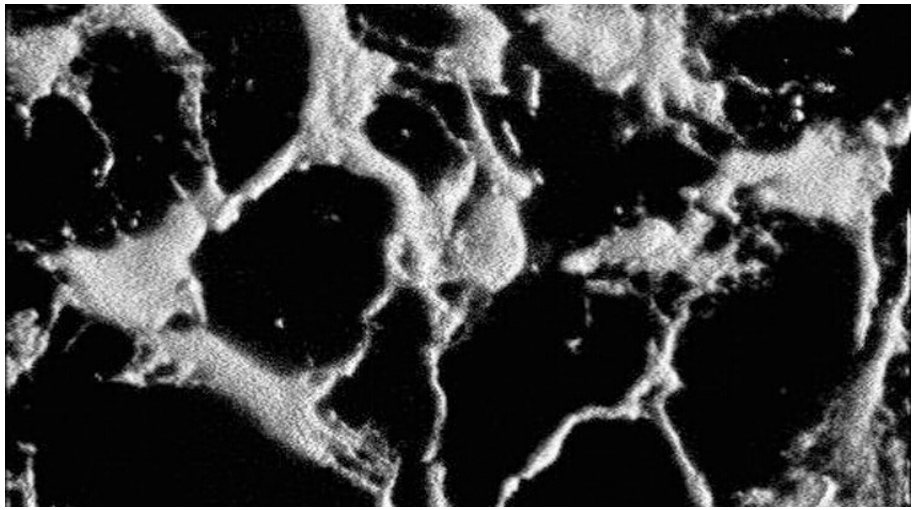
Bowman's Membrane



- Acellular (except for nerves)
- Unique to humans
- 12µm
- Collagen I/V

Stroma

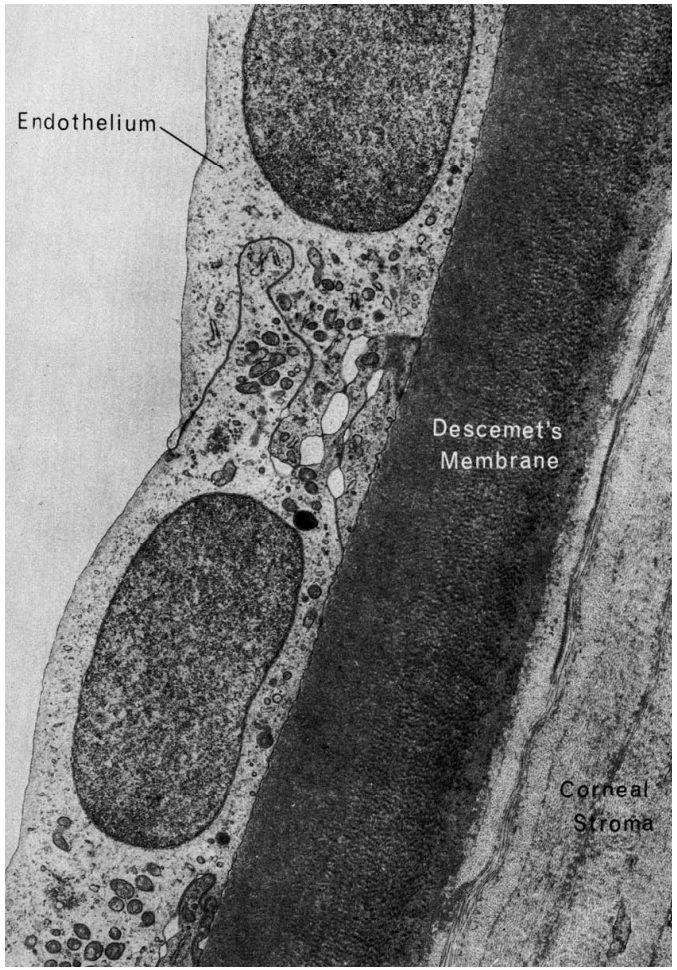




- 80-85% of corneal thickness
- Flattened collagen (Type I) / proteoglycan bundles
- Fibril spacing determines transparency
- Keratocyte syncytium

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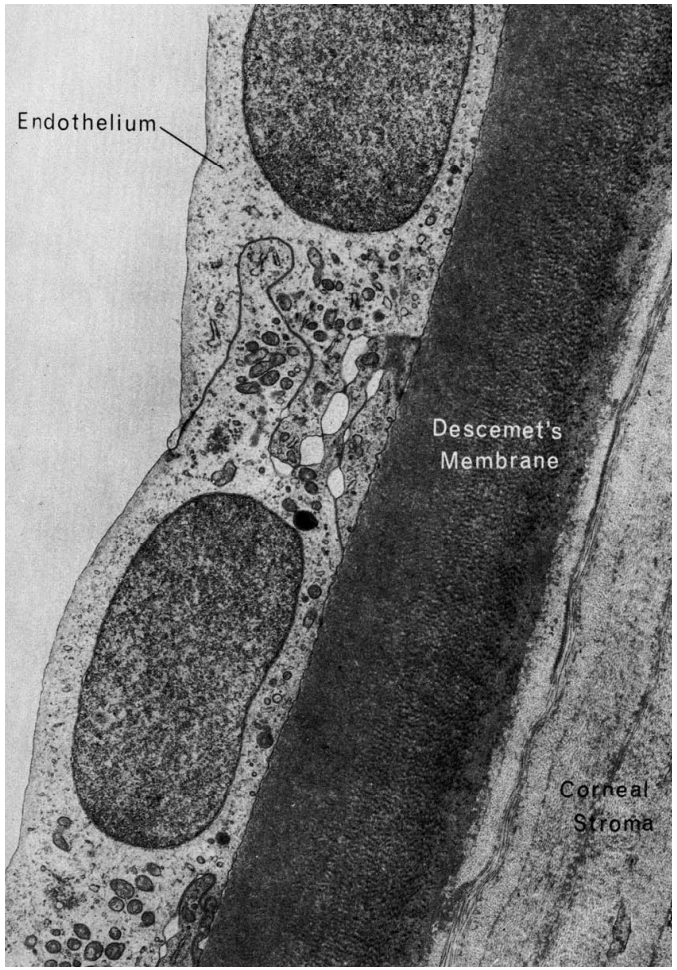
Endothelium



- 5µm monolayer
- Descemet's membrane (Collagen Type VIII) created by endothelium
- Endothelium pumps fluid out to maintain transparency

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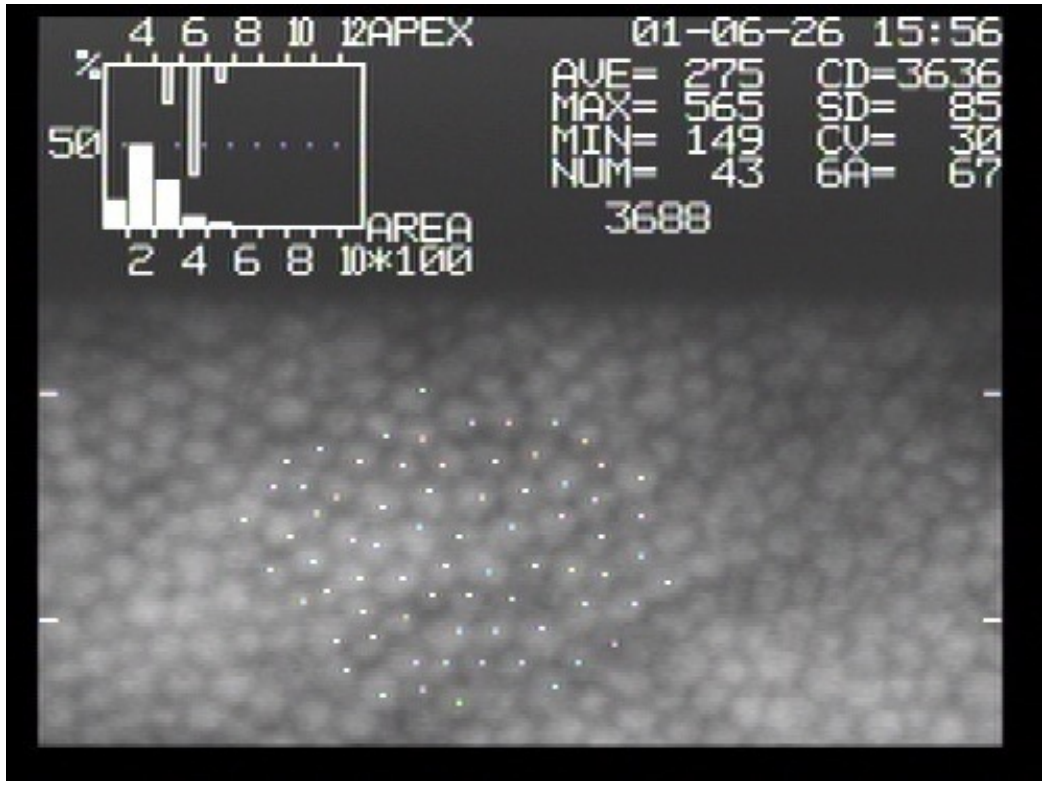
Endothelium



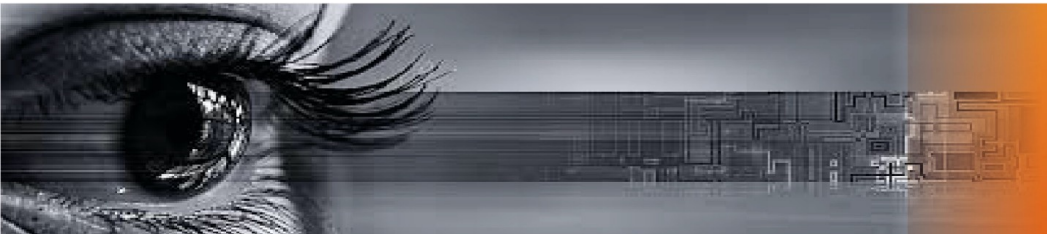
- **A functioning endothelium is critical for good vision**
- Endothelial dysfunction is the leading indication for corneal transplantation

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Endothelium



- Specular (reflectance) imaging
- Density decreases with age
- Minimum 2000 cells/mm^2 (typically 2500-3500 cells/mm^2)

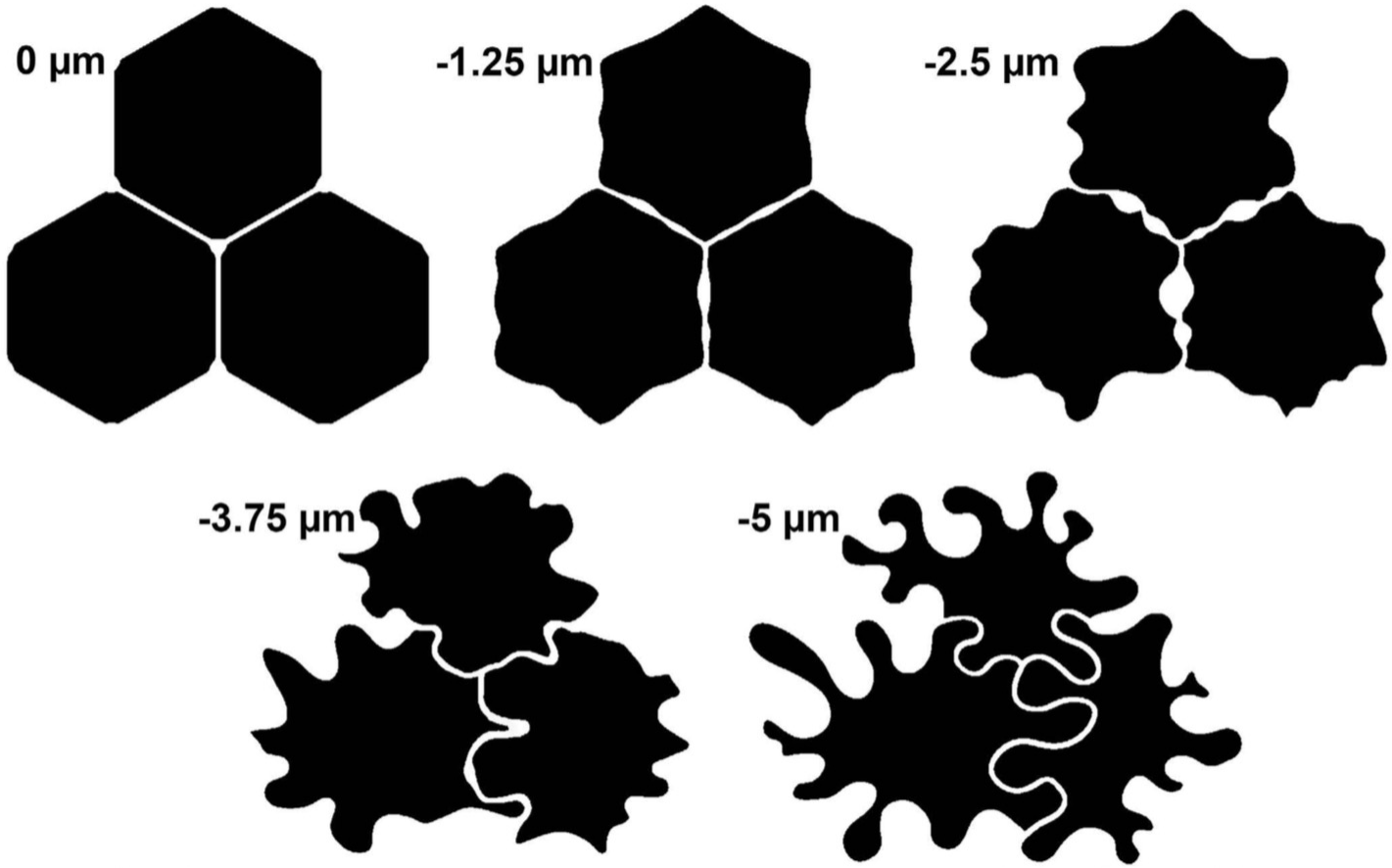


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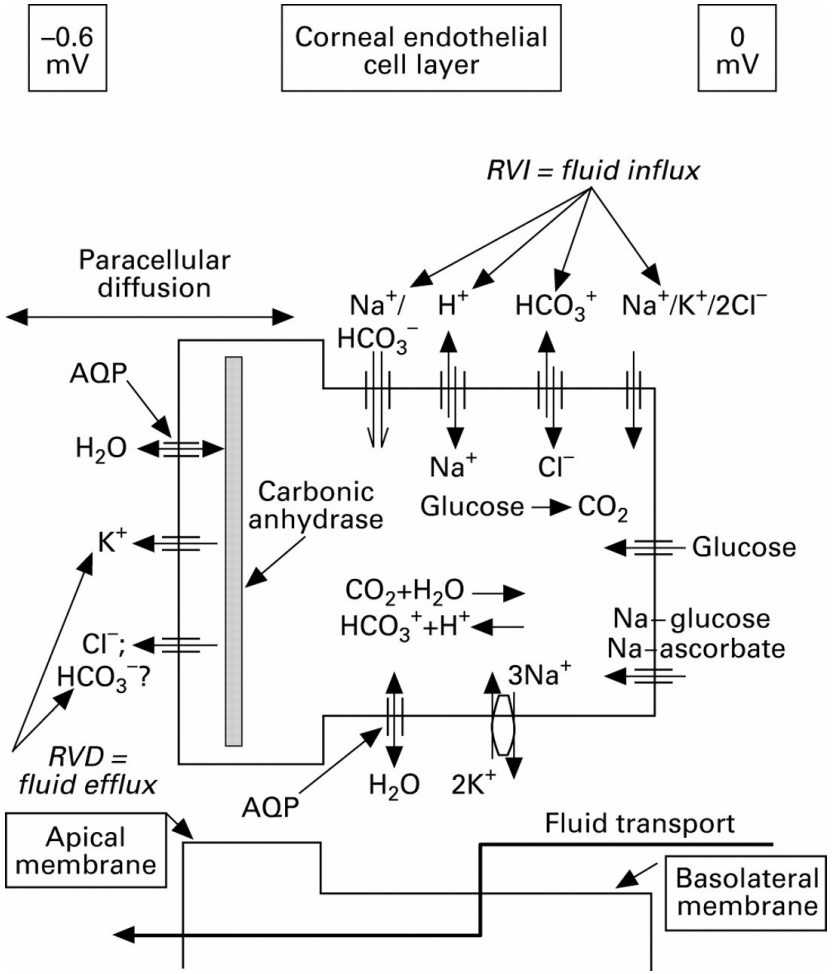
Endothelium



- Multipolar
- **Apical** – hexagonal
- Intercellular spaces for storage
- **Basolateral** – large surface area for molecular pumps

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Endothelium

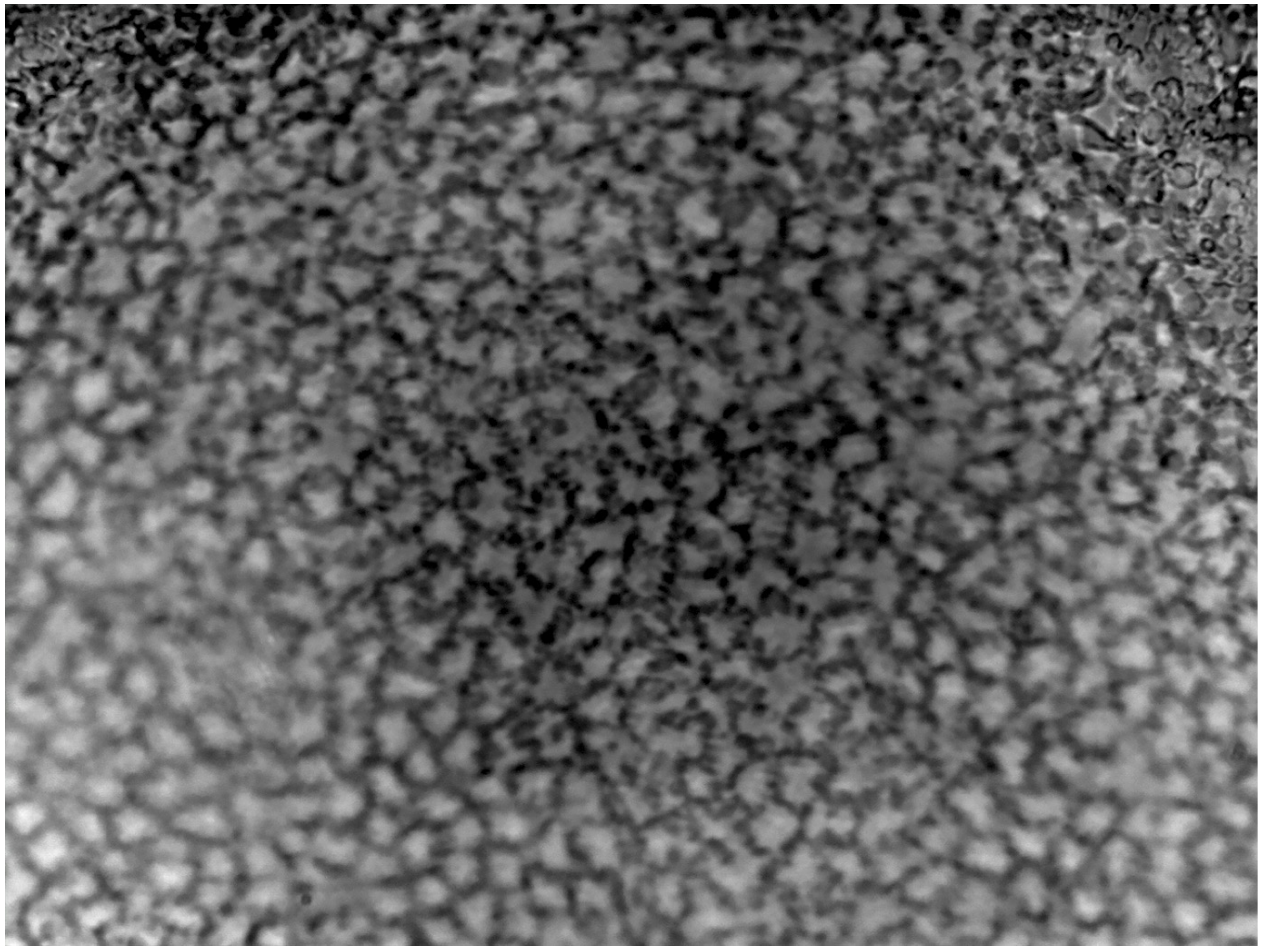


- Passive fluid flow into the stroma causes stromal oedema (cloudiness)
- Fluid actively pumped out to maintain transparency

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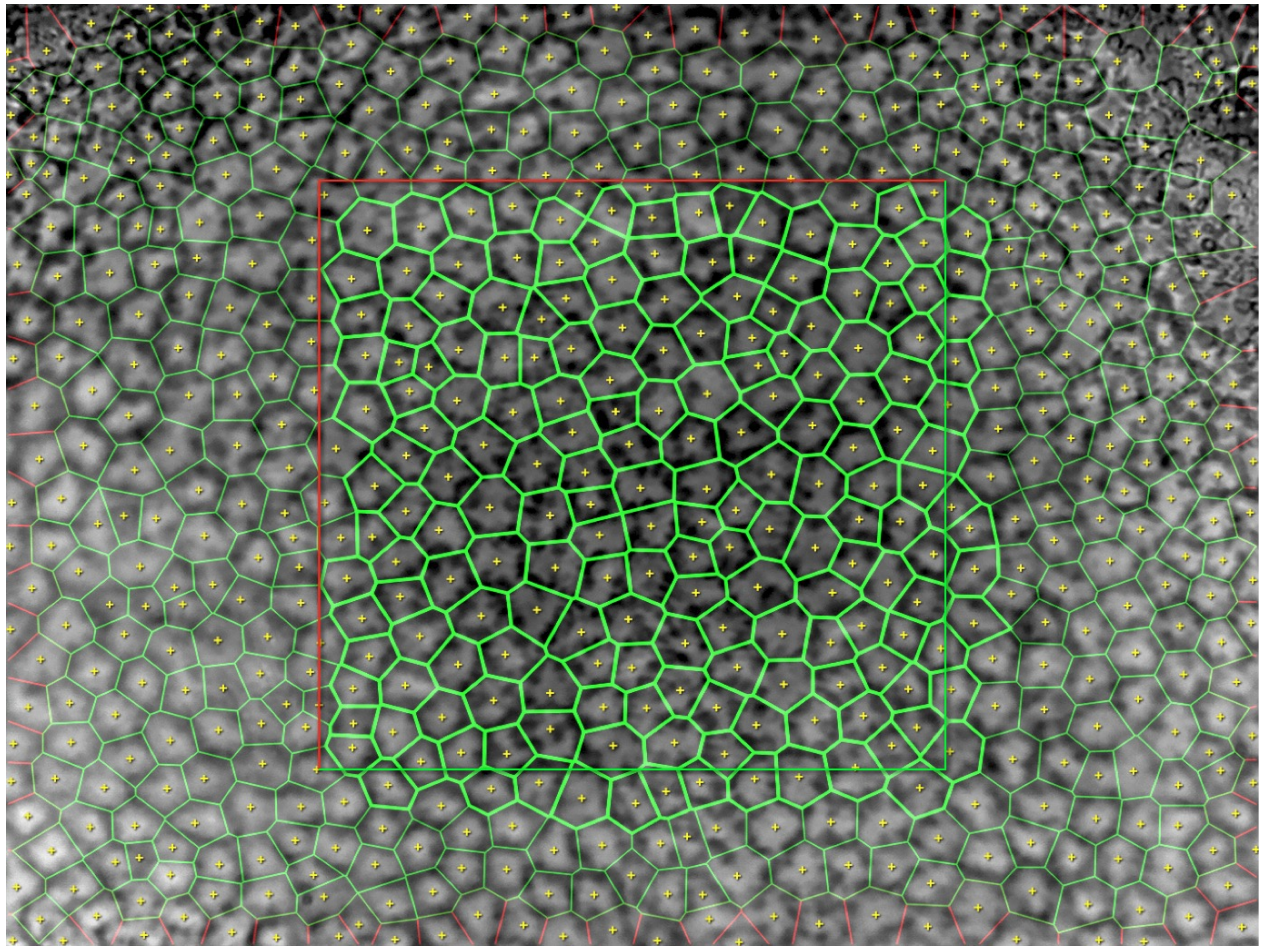
Endothelial Analysis

- Endothelium after Organ Culture storage
- Intercellular spaces swollen with hypotonic sucrose for visibility

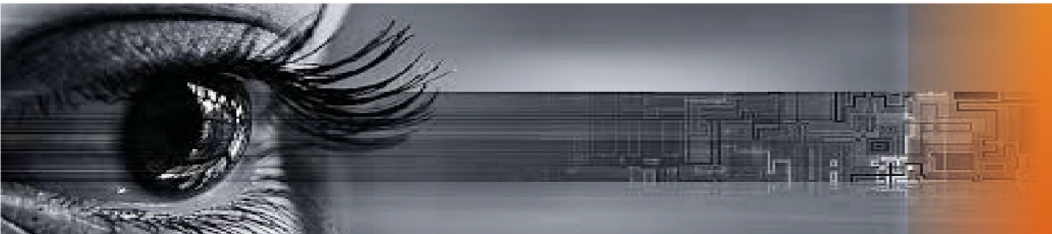


Endothelial Analysis

- Calibrated Voronoi tessellation using cell centroids
- Map of endothelial cell size, shape, and arrangement



POLYMEGATHISM		μm^2	cells/mm^2
Smallest		165.84	6029.96
Largest		497.93	2008.33
Mean		322.82	3097.67
± SE		4.77	54.72
Total		53265.83	
Perimeter		11347.60µm	
CoV Size		18.97%	
PLEOMORPHISM	**#**	**μm^2**	**%**
4-sides	3	668.43	1.25%
5-sides	34	9023.29	16.94%
6-sides	96	31566.01	59.26%
Regularity		90.43 ± 0.76%	
7-sides	27	10223.78	19.19%
8-sides	5	1784.32	3.35%
9-sides	0	0.00	0.00%
Total Cells	165		
Pleomorphs	5		
Mean Sides	5.98 ± 0.06		
CoV Sides	12.55%		
Shape Index	3.85 ± 0.01		
Topo Charge	3		



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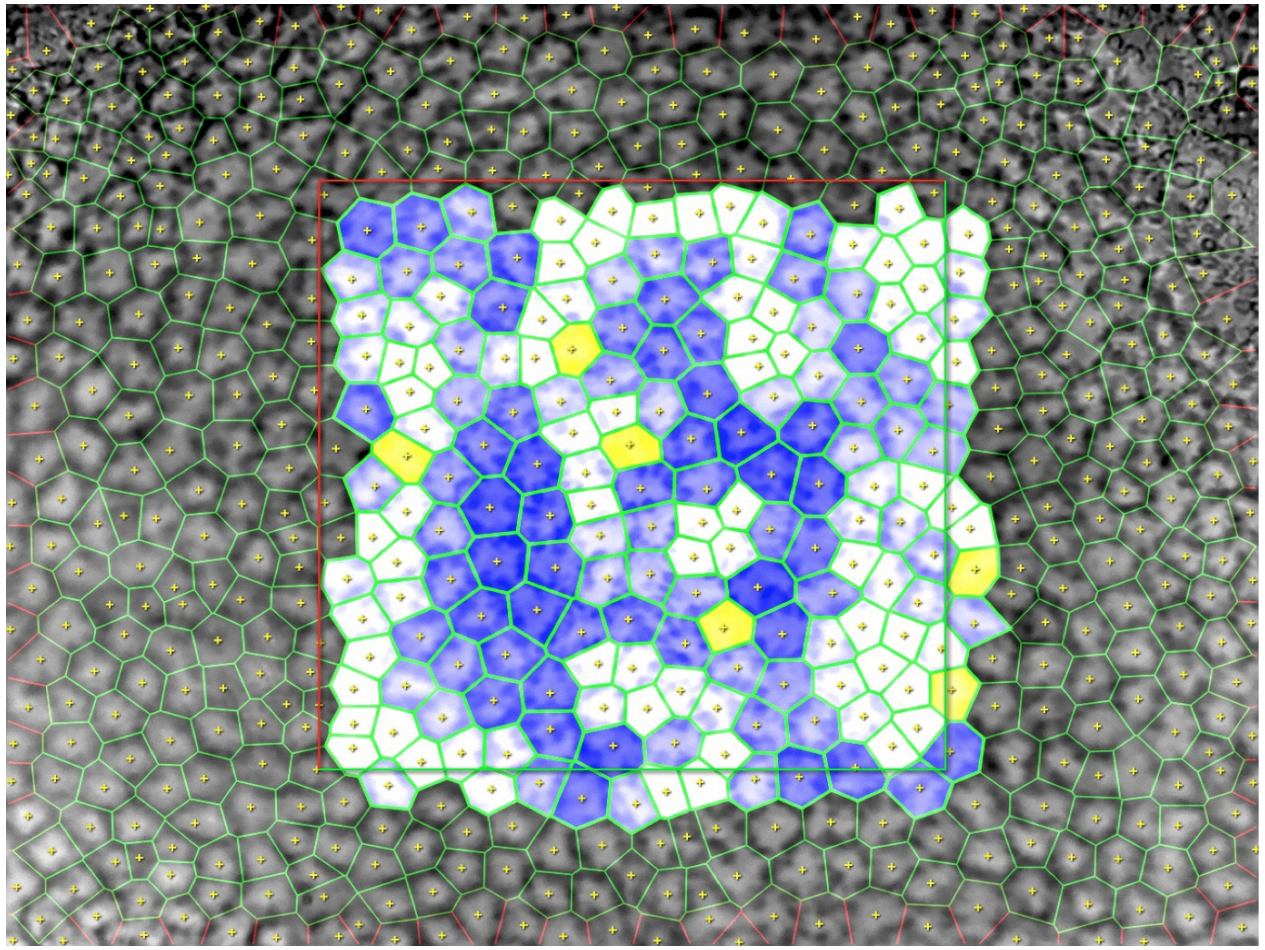
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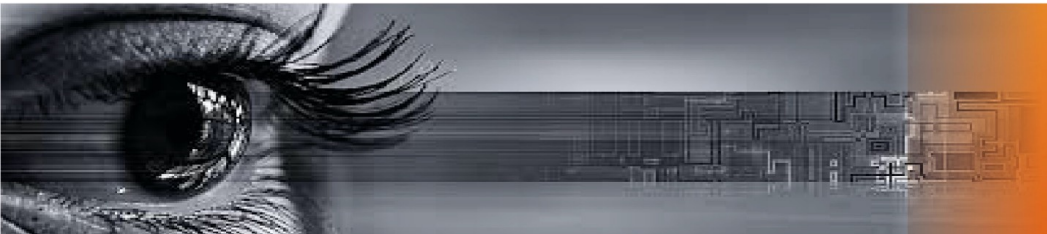
Endothelial Analysis

Cell Size / Density

- Small (white) to large (blue)
- Turing patterning



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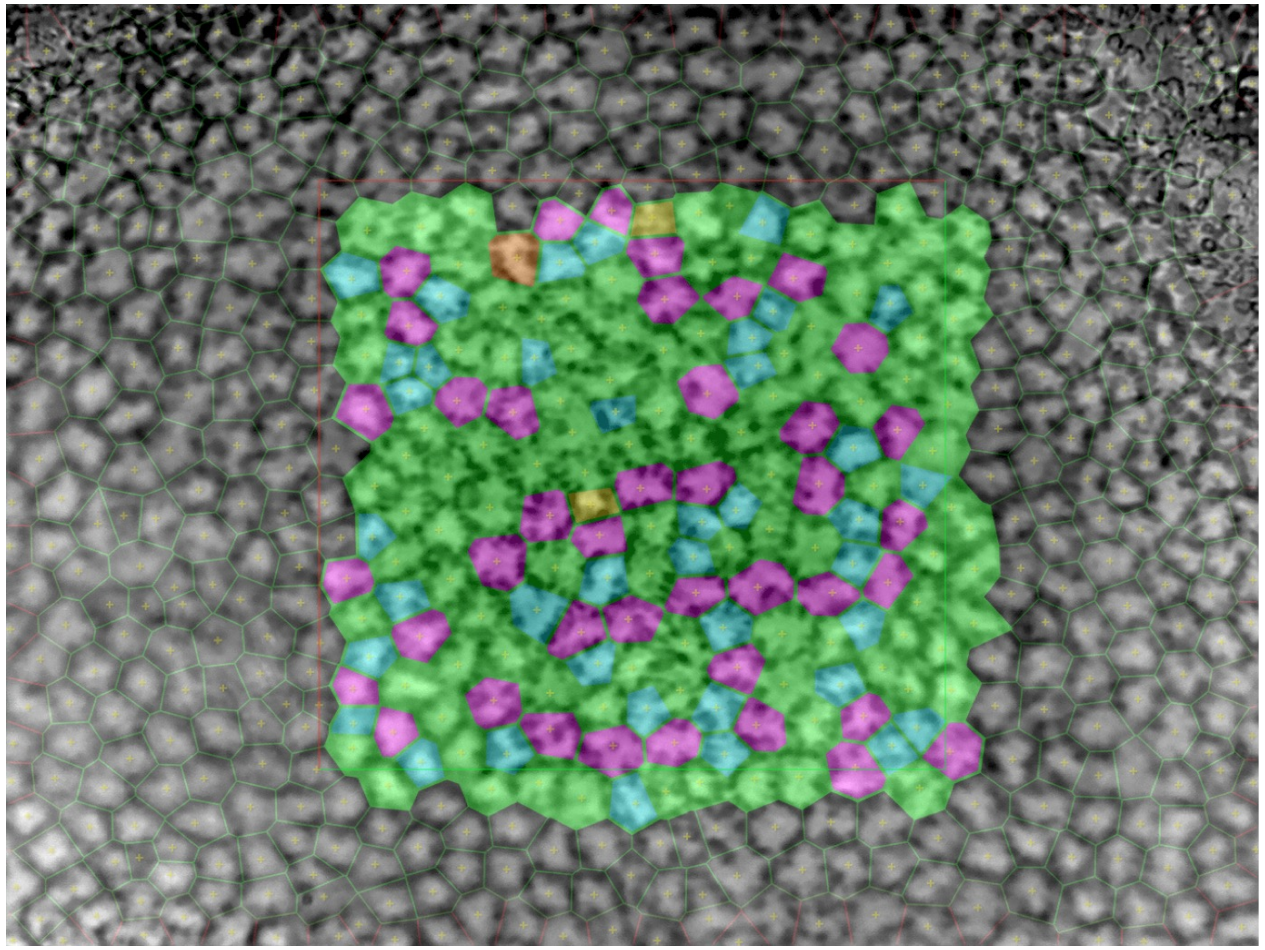
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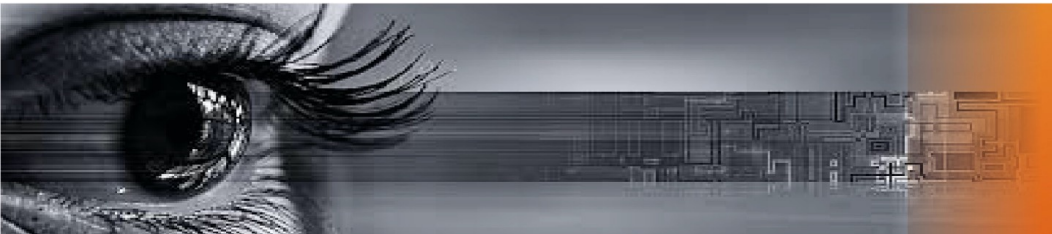
Endothelial Analysis

Cell Shape

- Mostly hexagonal
- Some 5/7 sided cells
- Very few 4/8 sided cells



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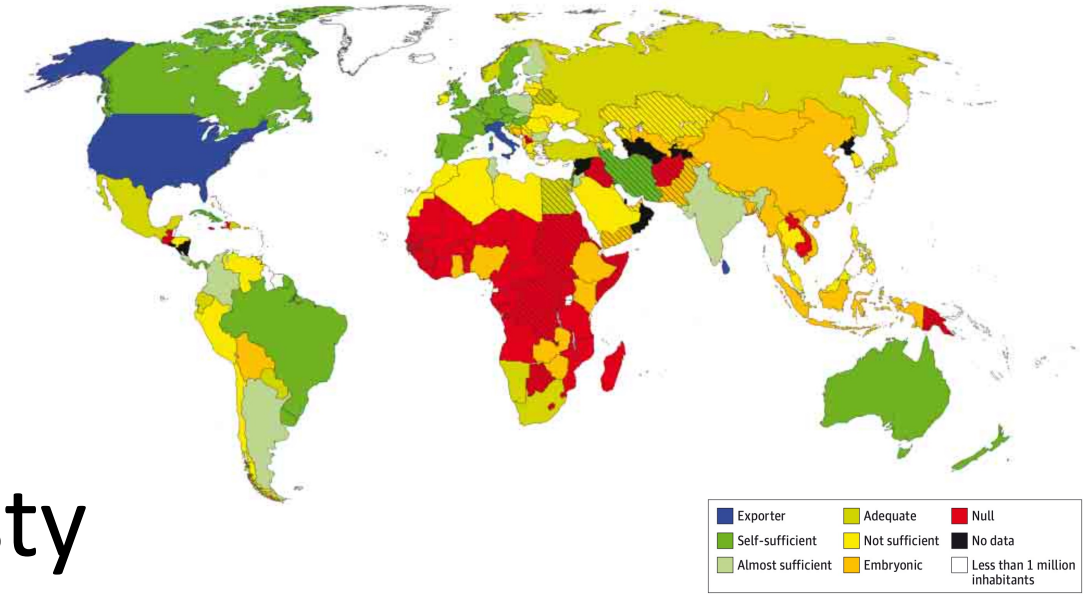
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Corneal Transplant (Keratoplasty)

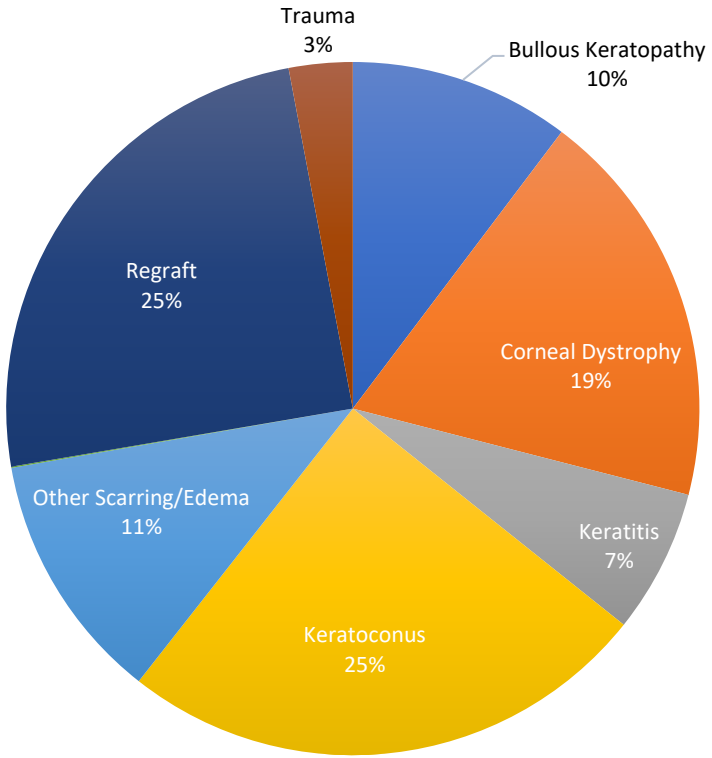
- Global transplant wait list: 12.7M
- 185,000 transplants in 116 countries
- 90% Penetrating Keratoplasty

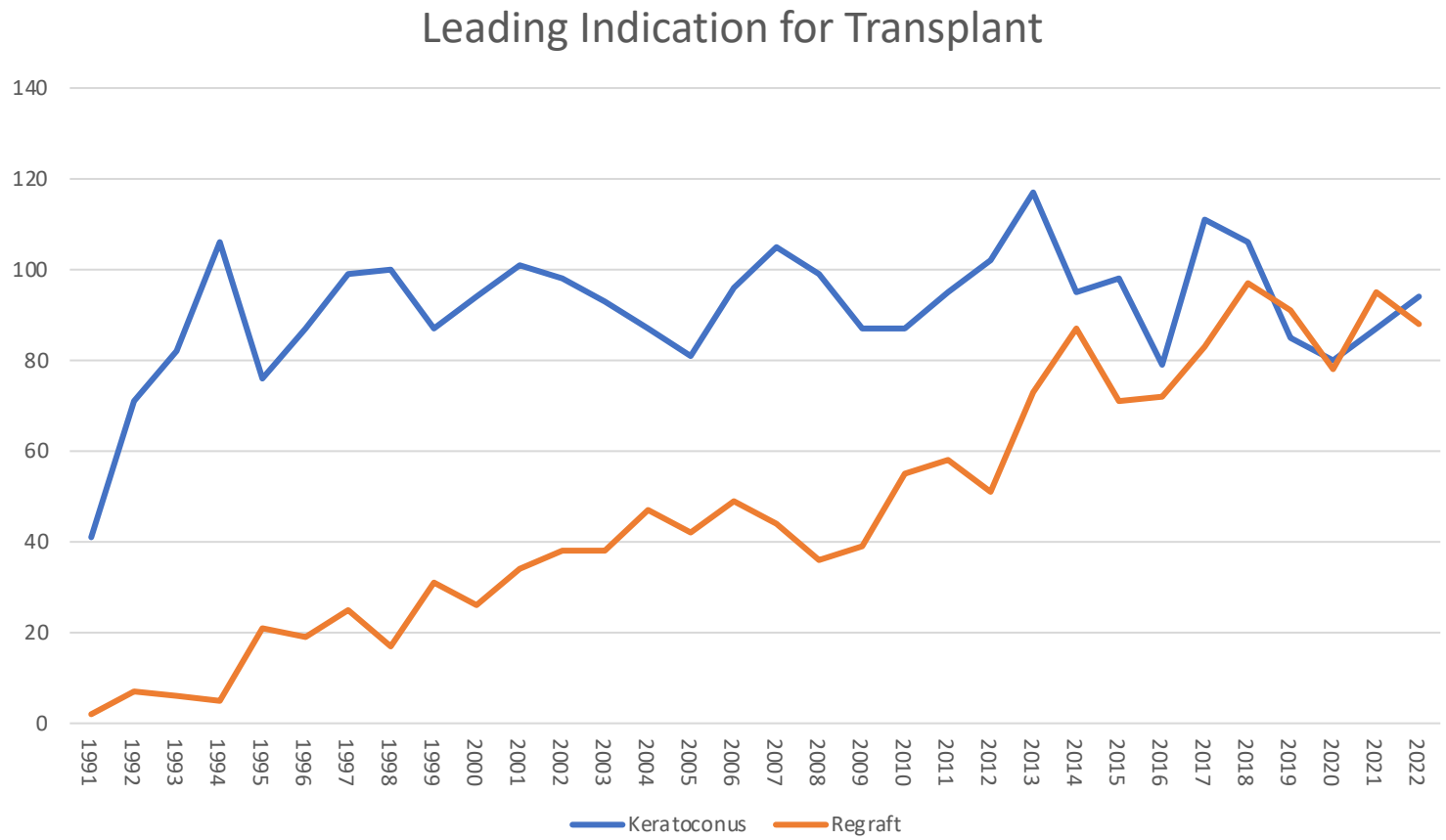


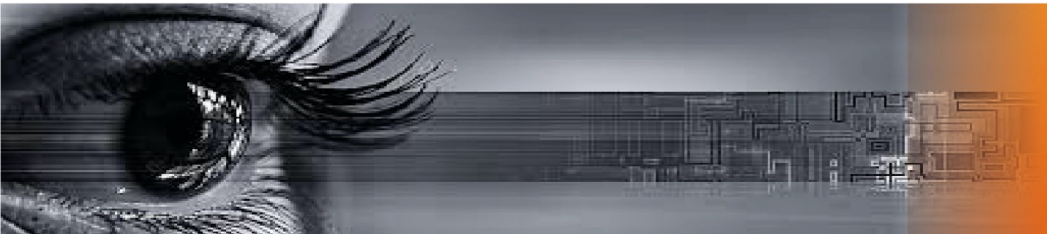
Gain P et al., Global Survey of Corneal Transplantation and Eye Banking, JAMA Ophthalmol. 2016; 134(2): 167-173. doi: 10.1001/jamaophthalmol.2015.4776

Indications for Corneal Transplant

2018 – 2022





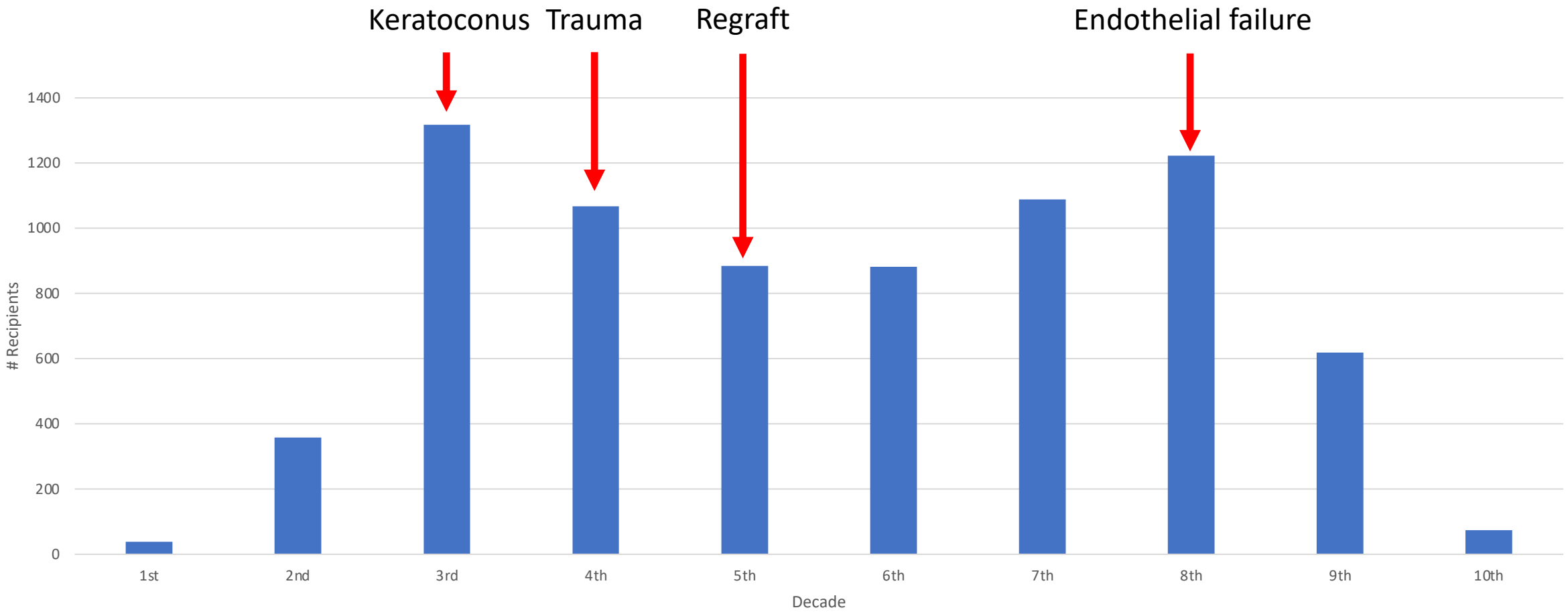


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Recipient Age

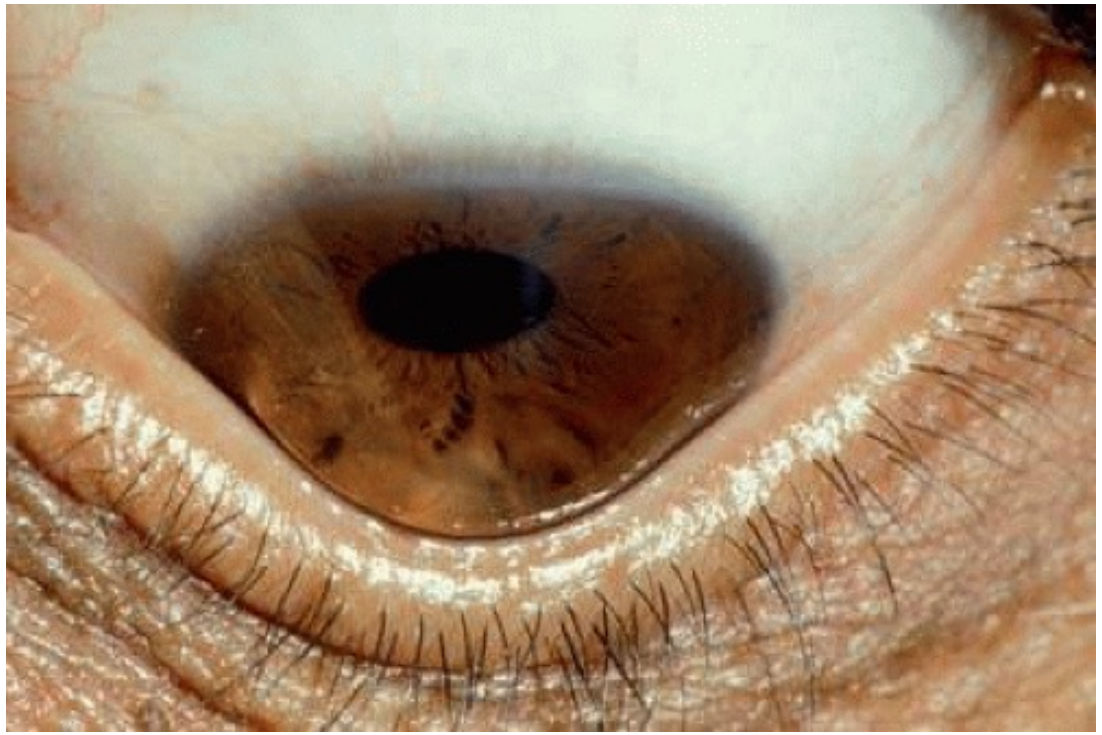


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Indications for Corneal Transplant

Keratoconus

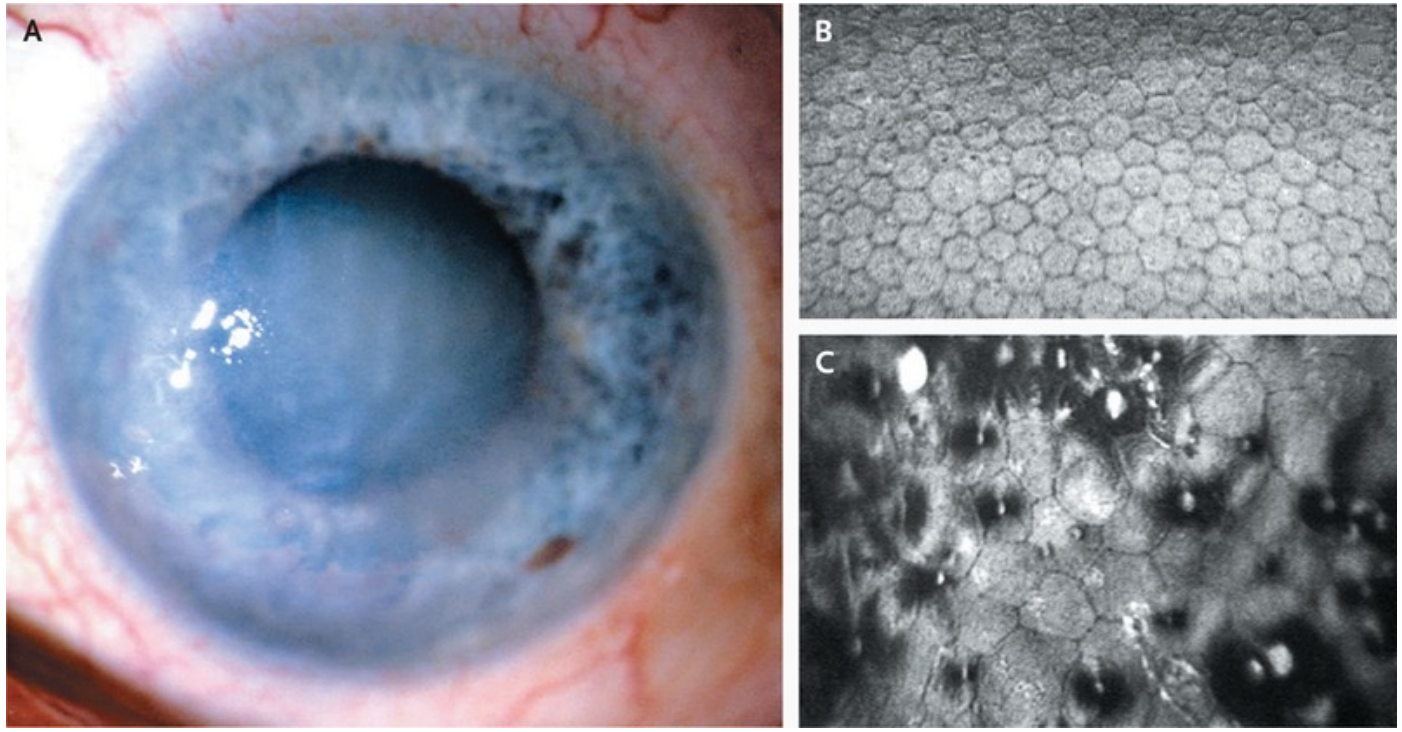
- Cornea protrudes / thins / distorts (“Munson’s sign”)
- Bilateral, progressive, occurs teens / twenties
- High prevalence in NZ / Maori / Pacifika
- UV light / Eye rubbing
- Also treated with cross-linking



Indications for Corneal Transplant

Fuch's Endothelial Dystrophy

- Can be inherited
- Older age
- Corneal oedema
- Guttae

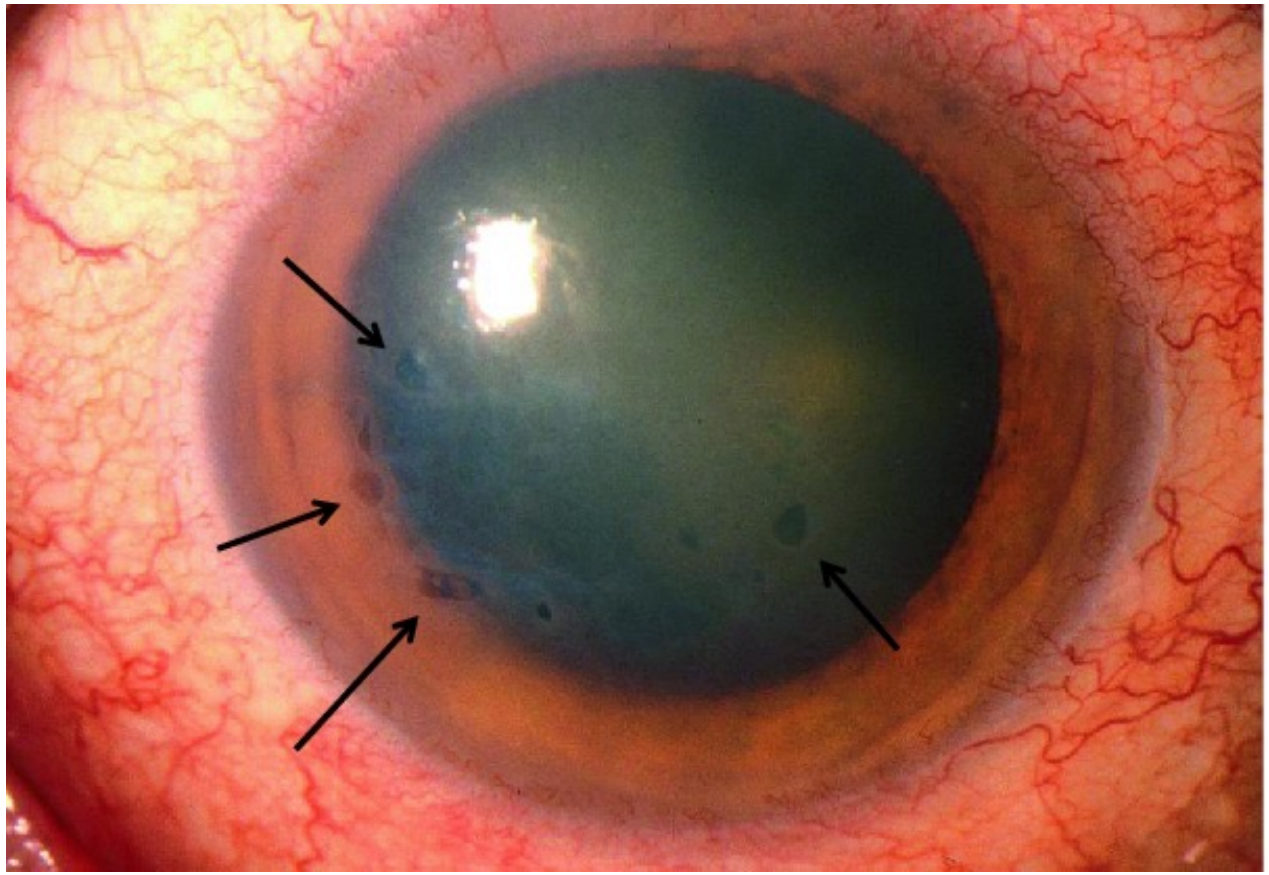


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Indications for Corneal Transplant

Bullous Keratopathy

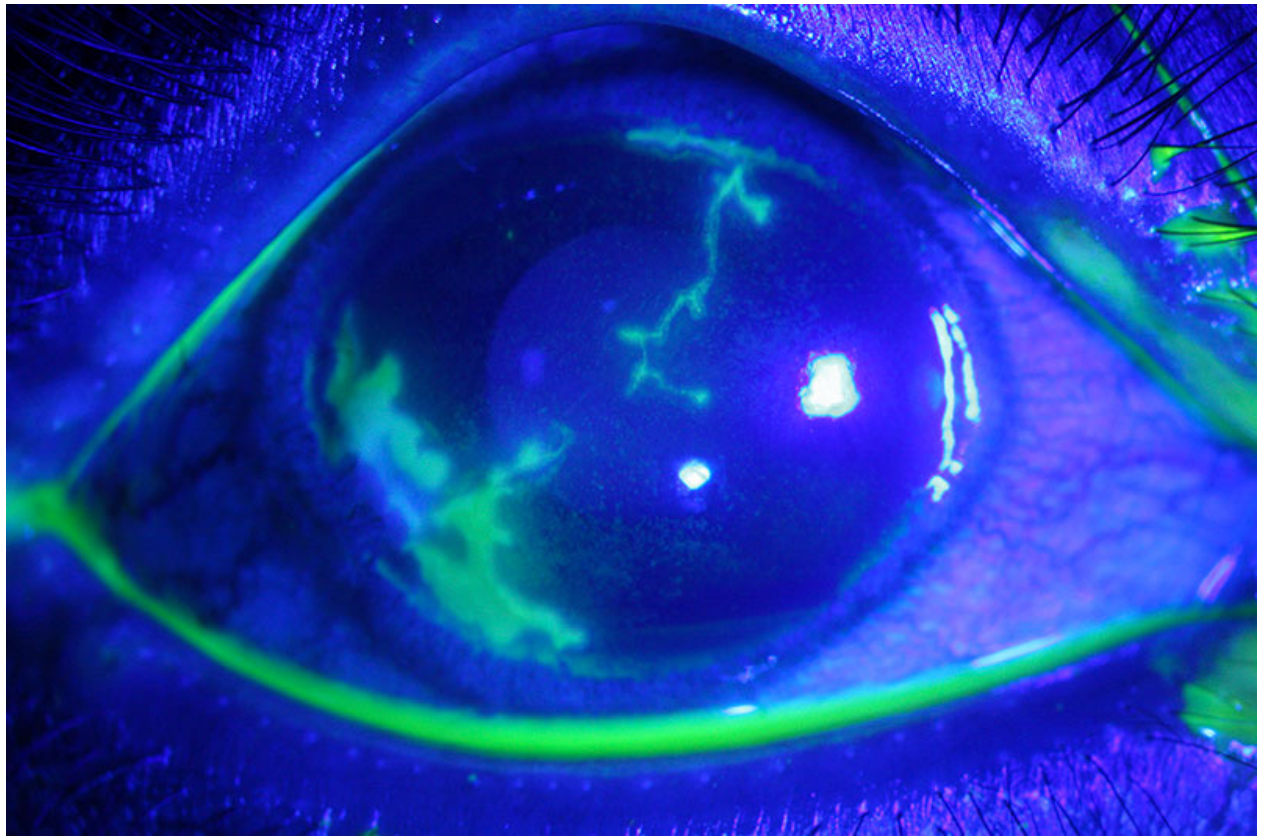
- Painful epithelial blisters, scarring caused by endothelial failure and corresponding oedema
- Associated with glaucoma & following cataract surgery



Indications for Corneal Transplant

Keratitis

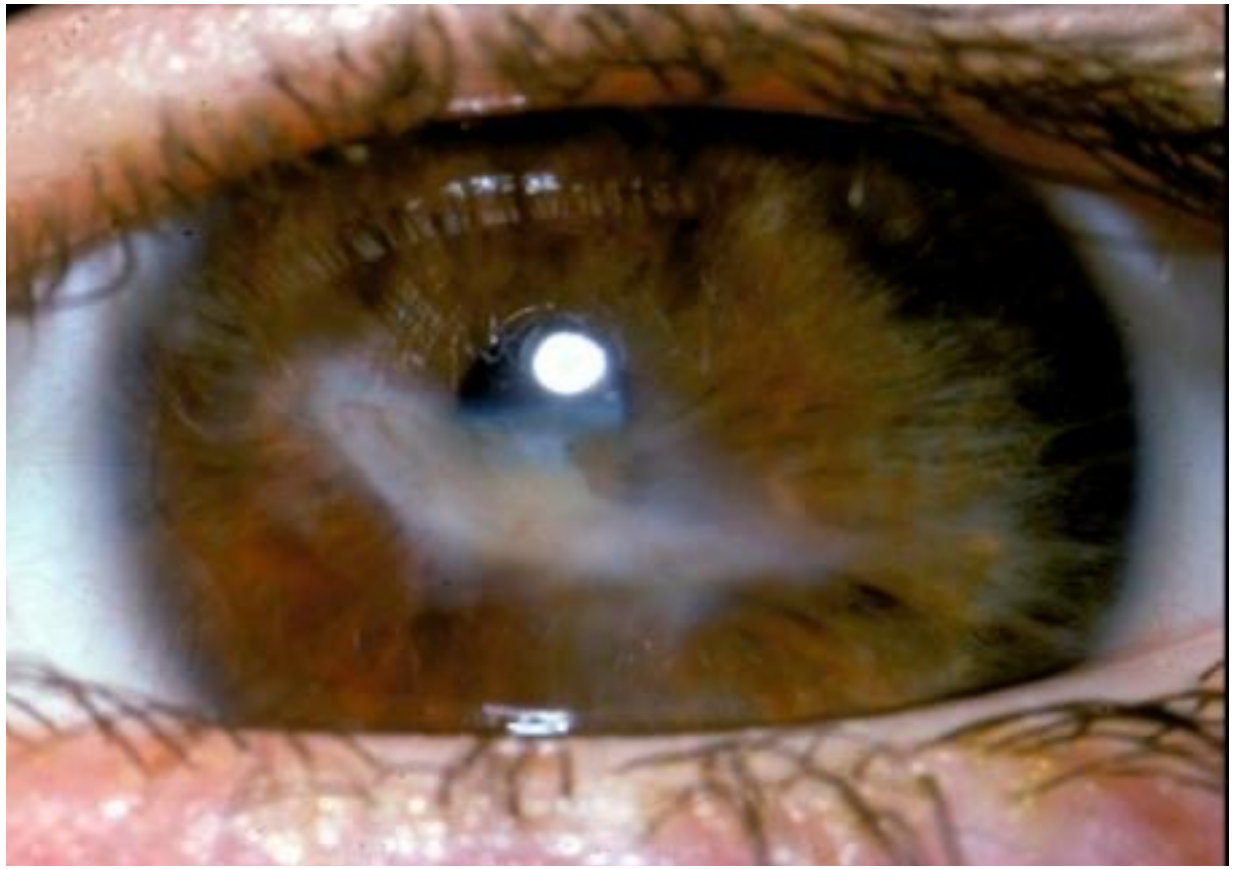
- Viral, bacterial, amoebic
- Inflammation, opacification, vascularisation, ulceration, scarring
- Risk of graft rejection



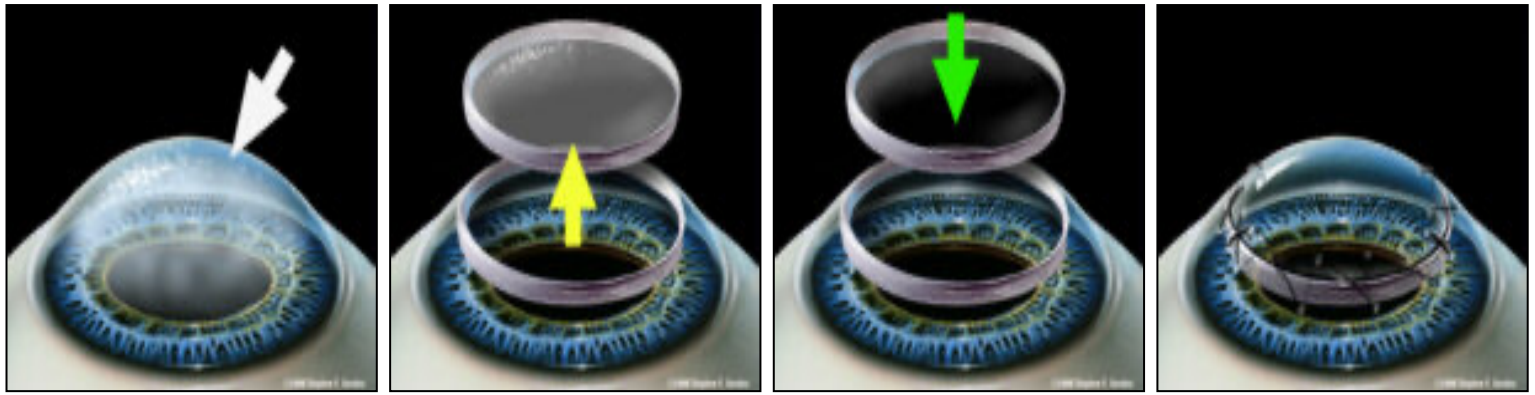
Indications for Corneal Transplant

Trauma

- Penetrating / chemical
- Scarring
- Male preponderance



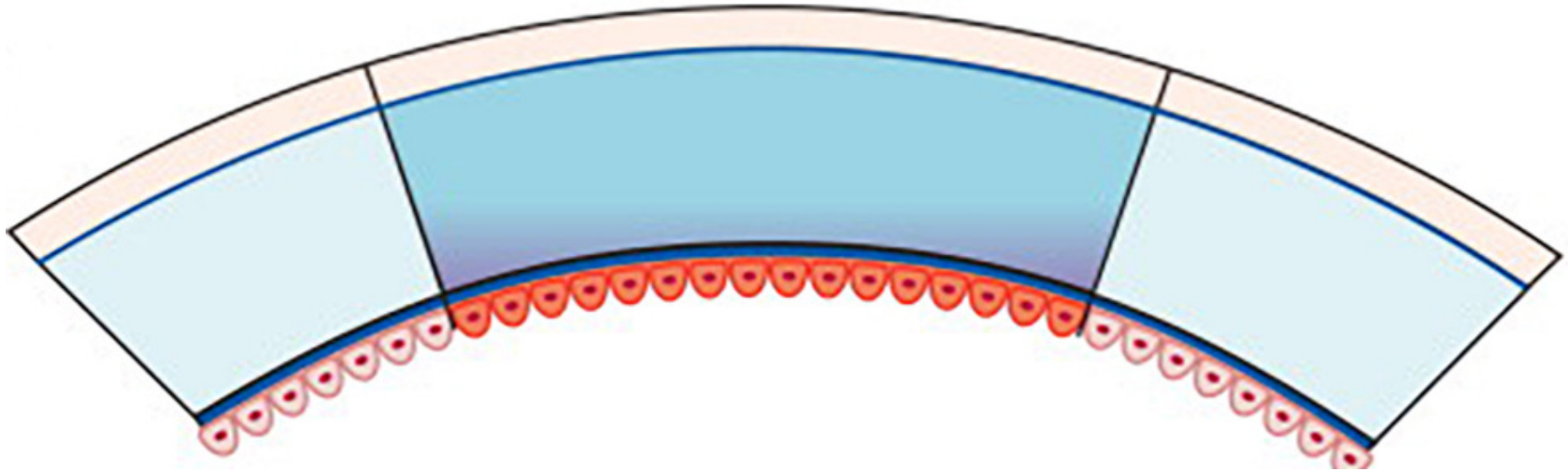
Corneal Transplant (Keratoplasty)



- 12-18 months for optimal vision

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Corneal Transplant (Keratoplasty)



PK (**P**enetrating **K**eratoplasty)

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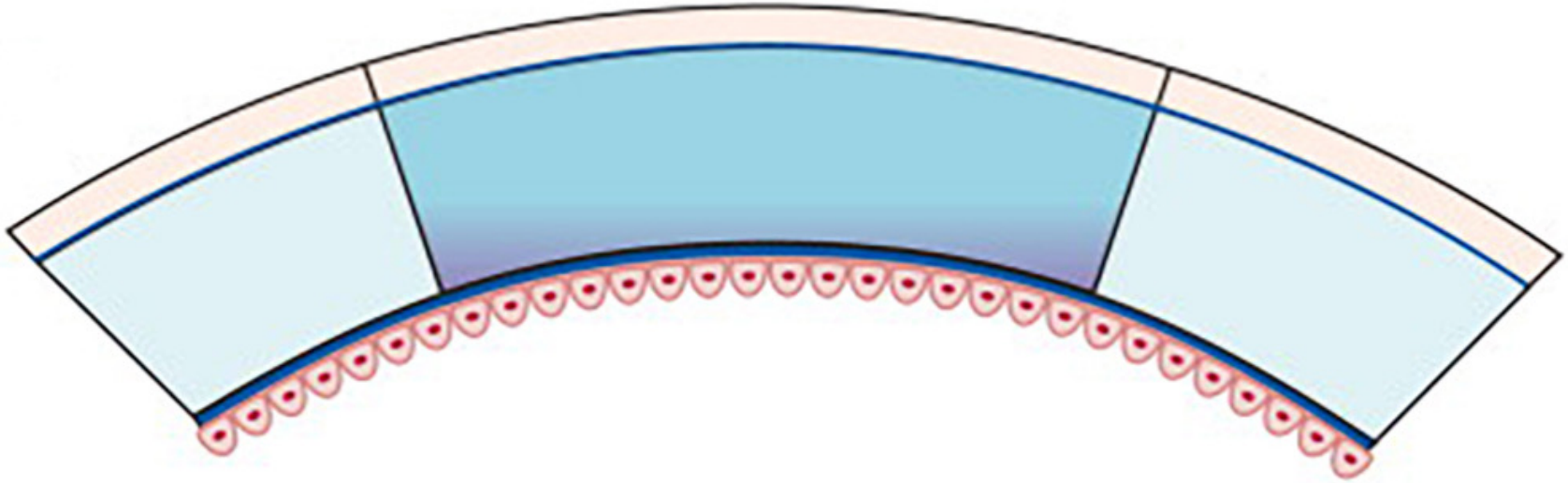
Corneal Transplant (Keratoplasty)



PK (**P**enetrating **K**eratoplasty)

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Corneal Transplant (Keratoplasty)

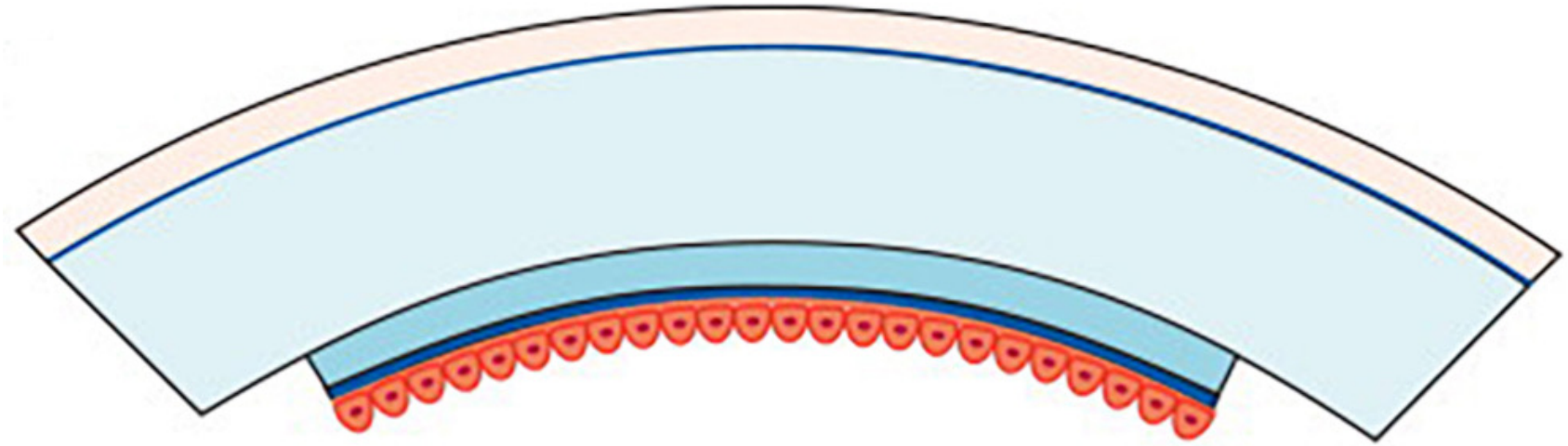


DALK (**D**eep **A**nterior **L**amellar **K**eratoplasty)

- *E.g.* early-stage keratoconus

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Corneal Transplant (Keratoplasty)



DSAEK (**D**escemet's **S**tripping **A**utomated **E**ndothelial **K**eratoplasty)

- *E.g.* Fuch's endothelial dystrophy

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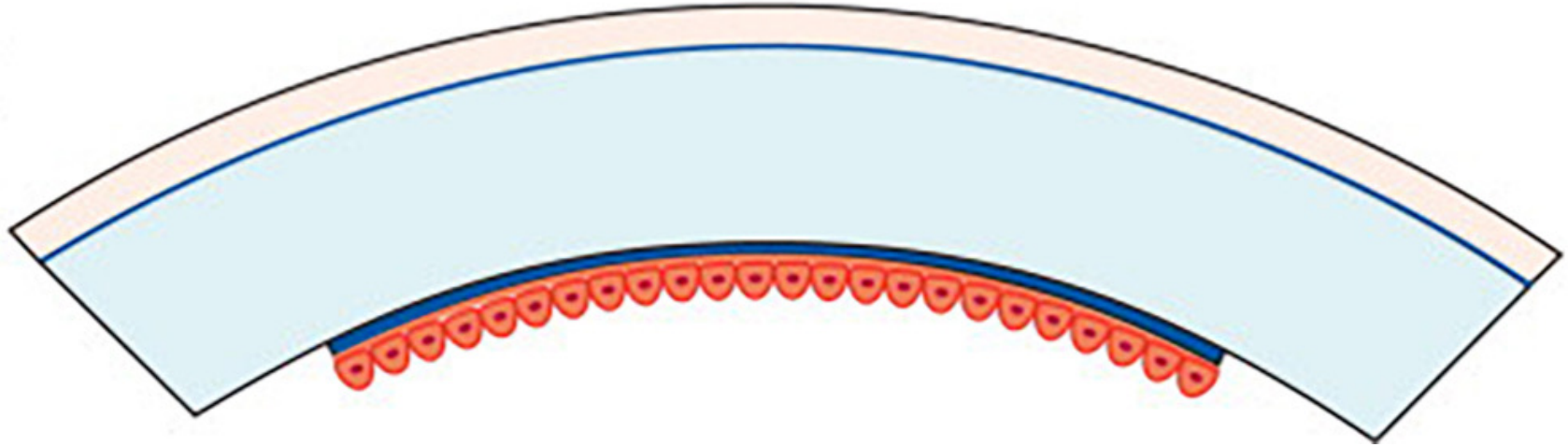
Corneal Transplant (Keratoplasty)

DSAEK

- Prepared in Eye Bank
- Centralise purchase cost
- Technical proficiency
- Surgeon and theatre time saved
- No cancellation of surgery with preparation problem



Corneal Transplant (Keratoplasty)

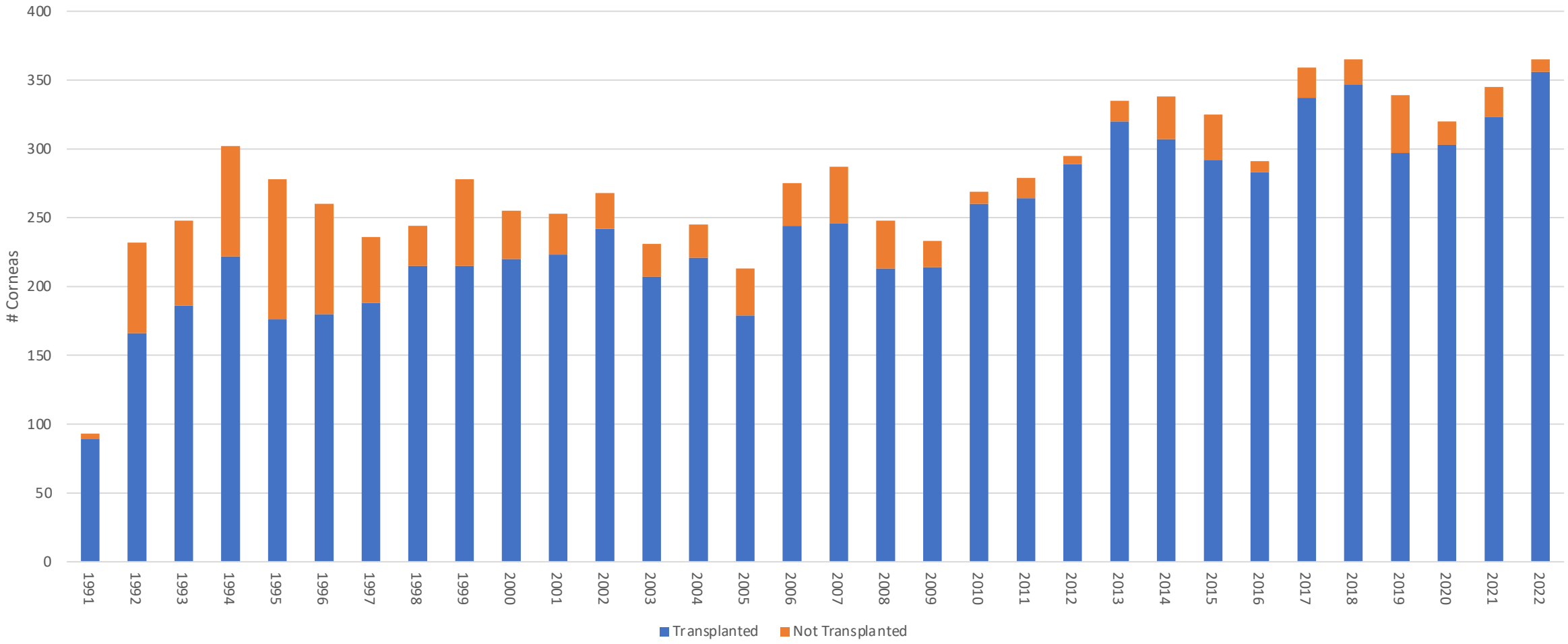


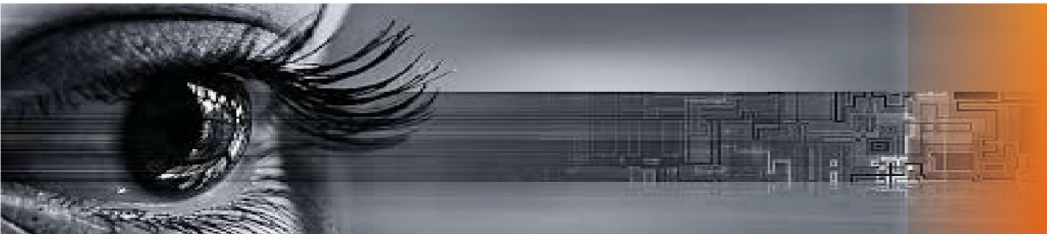
DMEK (**D**escemet's **M**embrane **E**ndothelial **K**eratoplasty)

- *E.g.* Endothelial failure

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Corneal Transplant (Keratoplasty)





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NEW ZEALAND

Tissue Safety

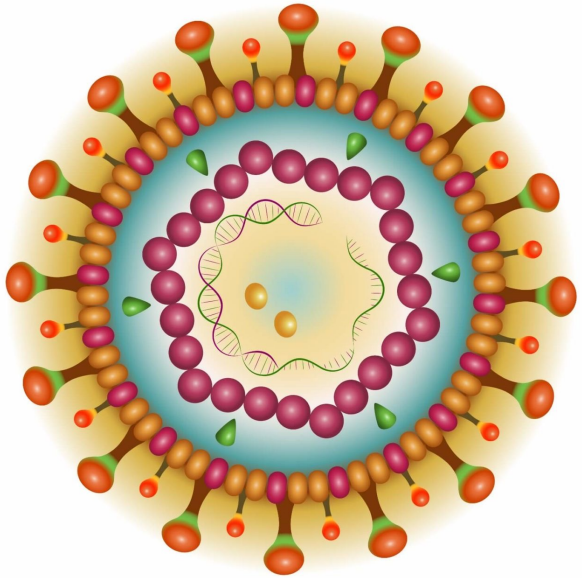


- Cornea is immuno-privileged and an inefficient transmitter of disease
- No cases of sclera/amnion transmission
- Medical Standards - EBAANZ
- Sensitive serological (NAT) testing
- Microbiological screening

Tissue Safety

Viruses

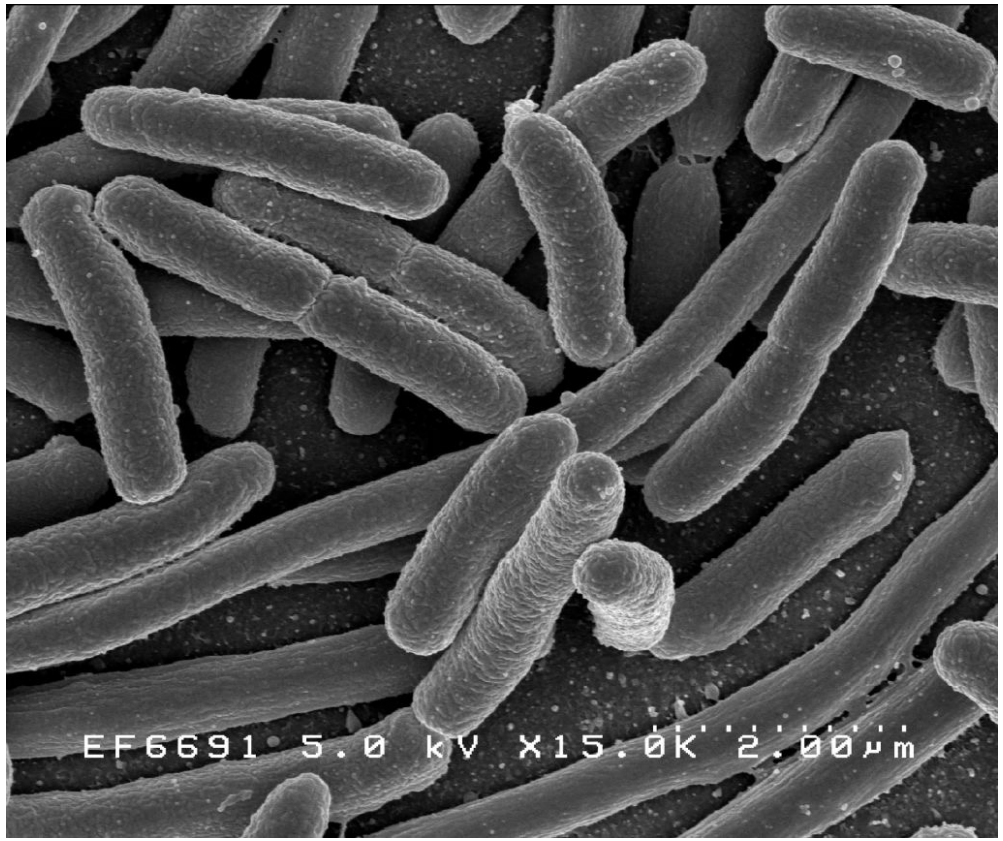
- Hepatitis B (2 cases) / C (no cases)
- HIV (no cases)
- Rabies (9 cases)
- COVID-19 (0 cases)



Tissue Safety

Bacteria and Fungi

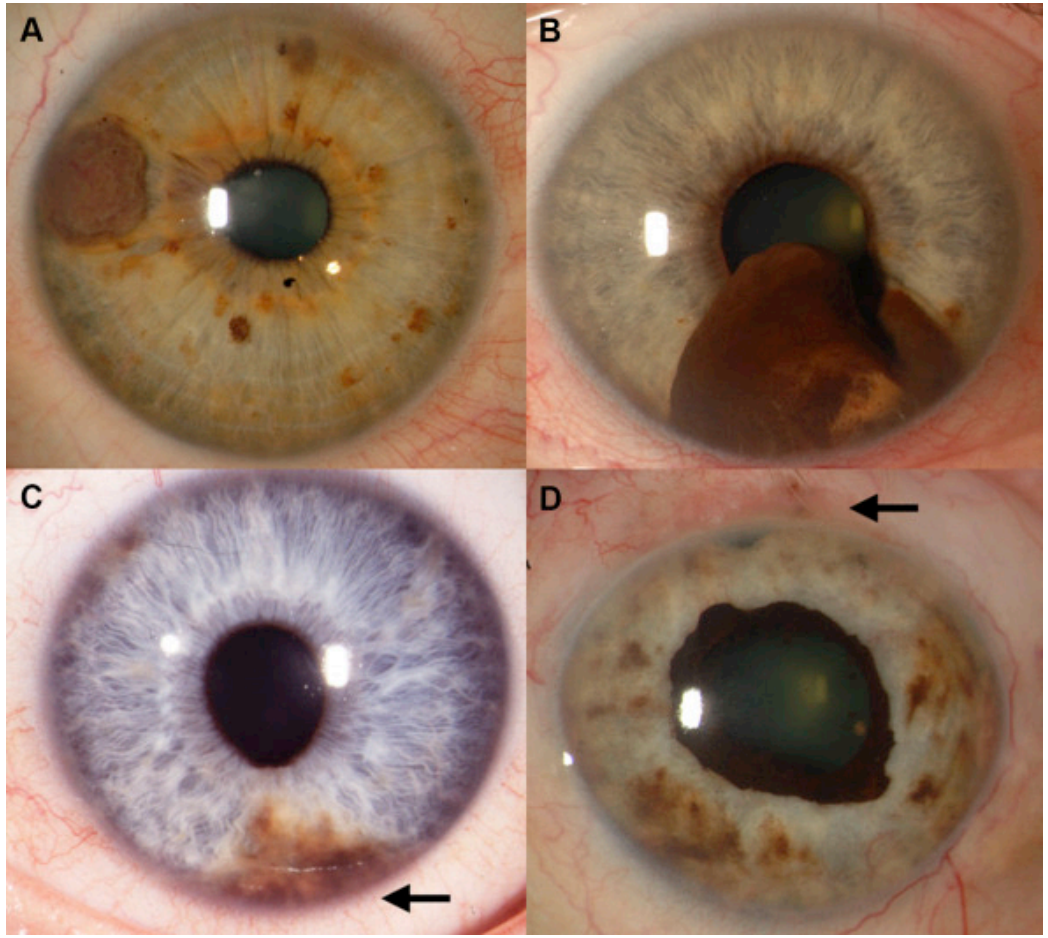
- Endophthalmitis
- Microbial Keratitis



Tissue Safety

Cancers

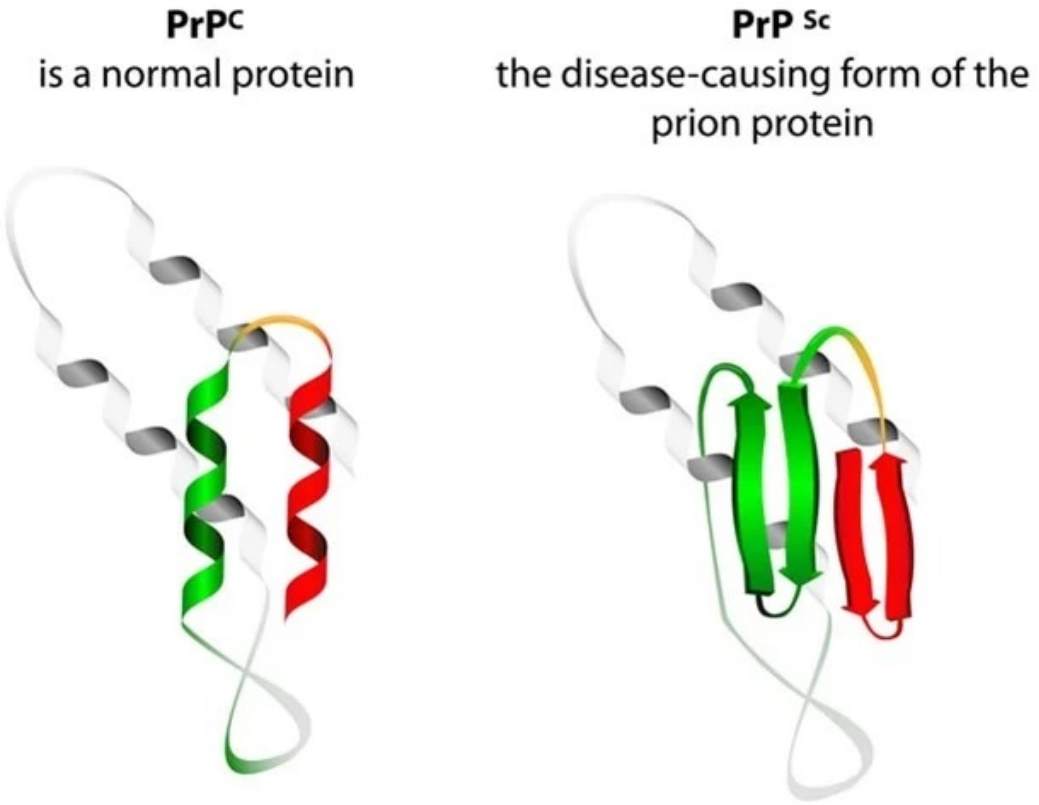
- 2 cases
- Adenocarcinoma NZ 1994



Tissue Safety

Creuzfeldt-Jakob Disease

- 1 case (1974)
- ‘Mad Cow’ UK 1980-1996
- Donor exclusions
  - Systemic viral infection
  - CNS diseases, progressive dementia



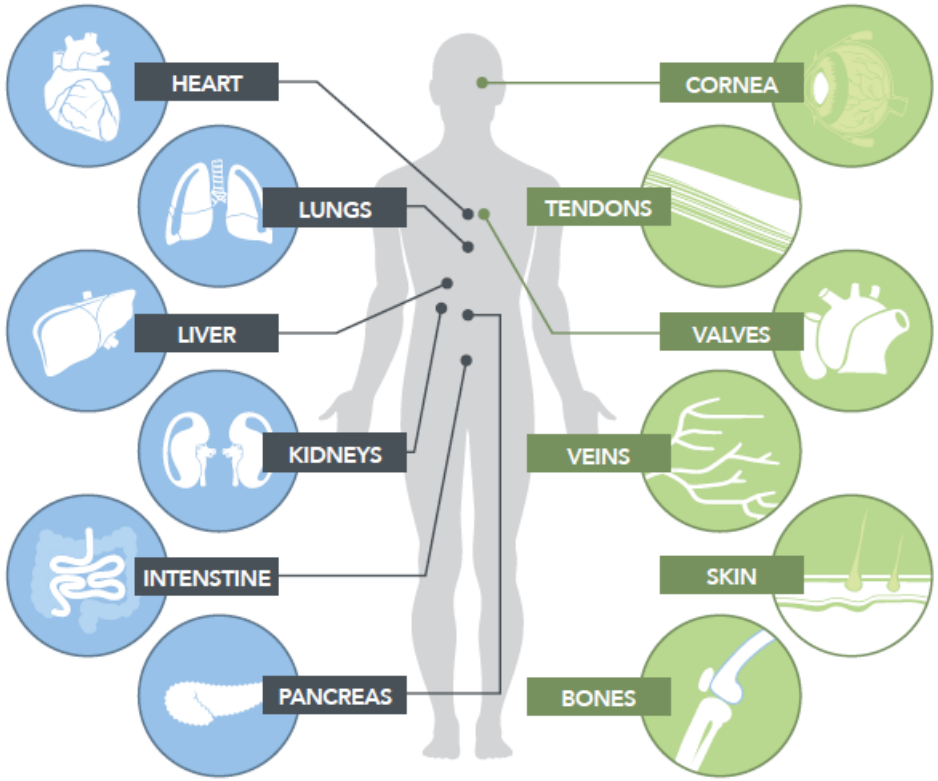
Tissue Safety

Dystrophies/Degenerations

- Undetected disease
  - Recurrent keratoconus
  - Fuch's dystrophy
- Donor exclusions



Donation – Organs, Tissues, Eyes



	ICU	Autopsy	Community
Organs	✓	✗	✗
Tissues	✓	✓	✗
Eyes	✓	✓	✓



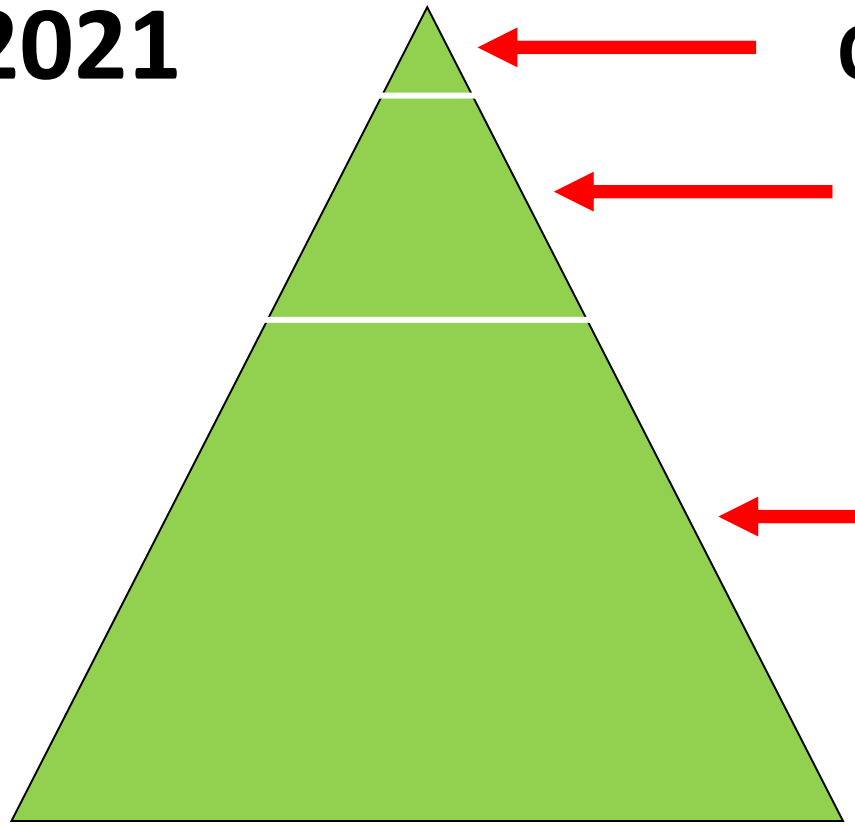
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nz national eye centre

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Donation – Organs, Tissues, Eyes

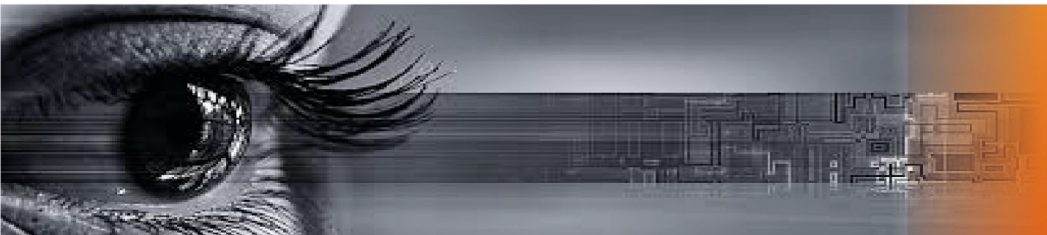
2021



ORGANS – 66 Donors / 203 Transplants

TISSUES

EYES – 202 Donors / 323 Cornea Transplants / 209 Sclera Transplants

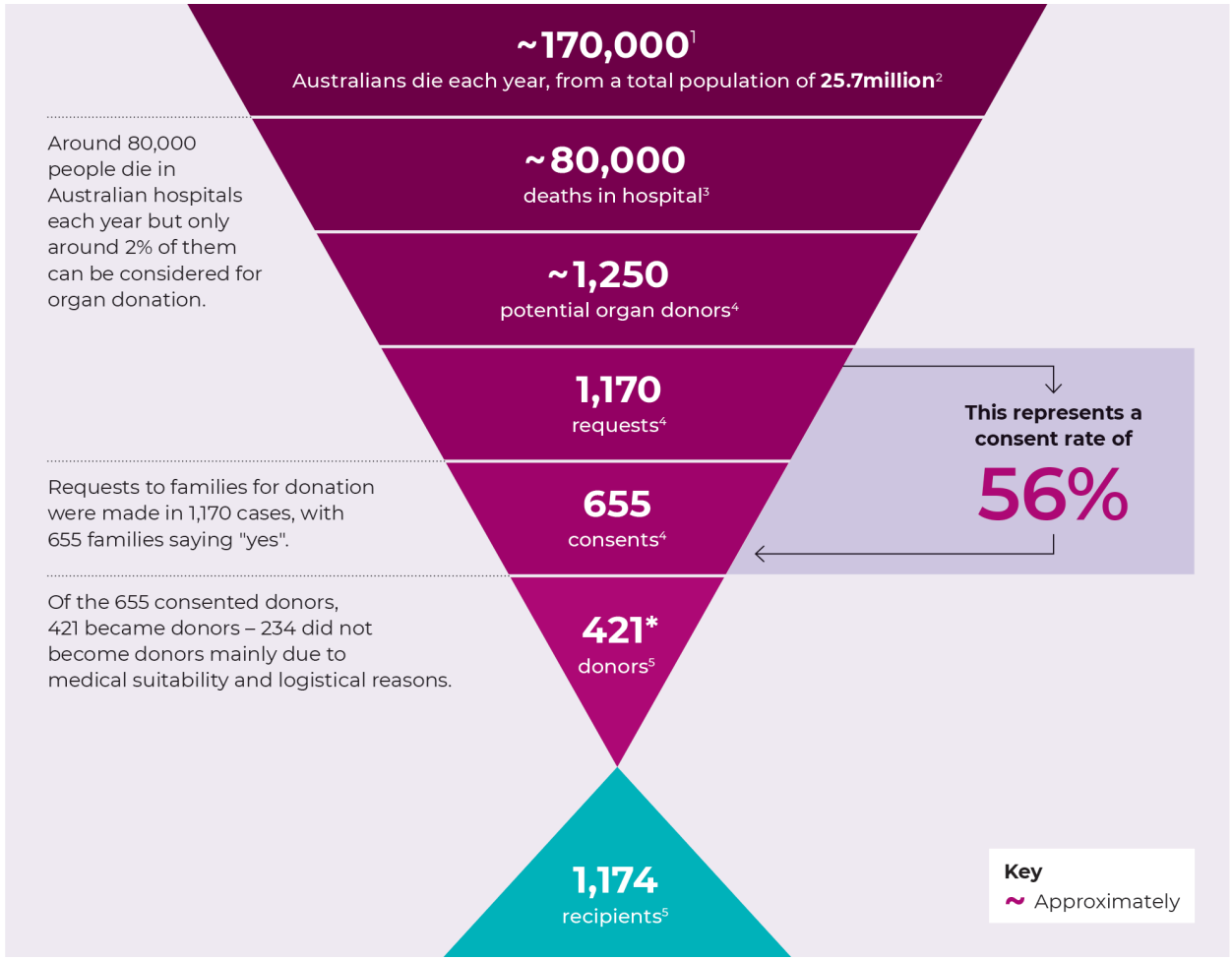


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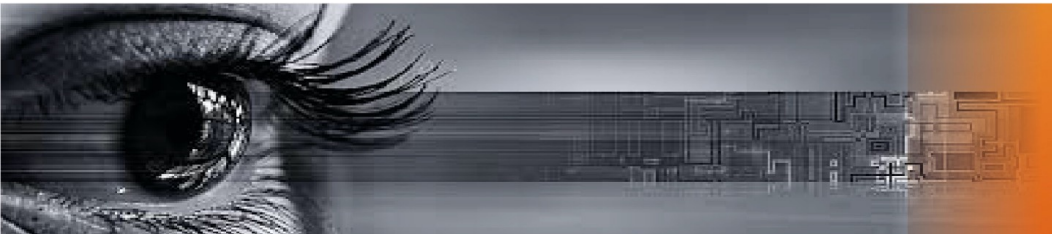
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Donation – Organs, Tissues, Eyes



- Very few potential donors actually end up donating

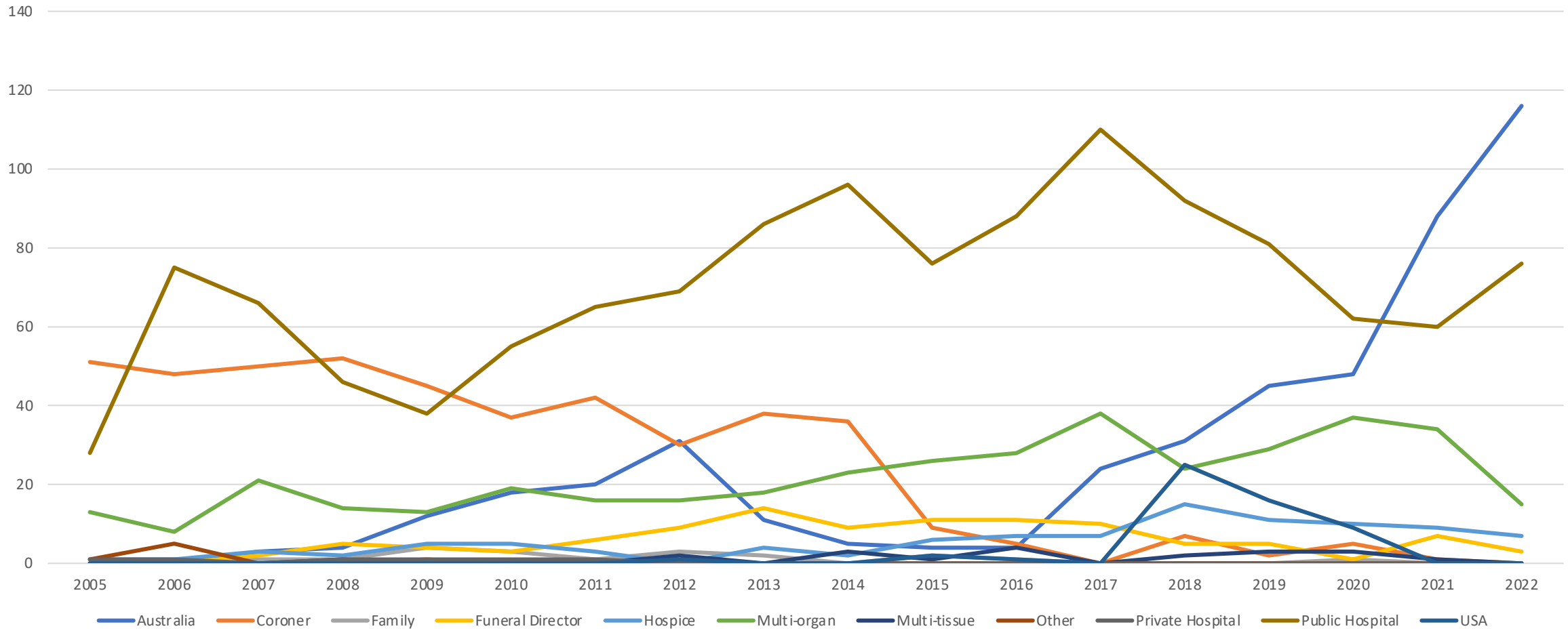


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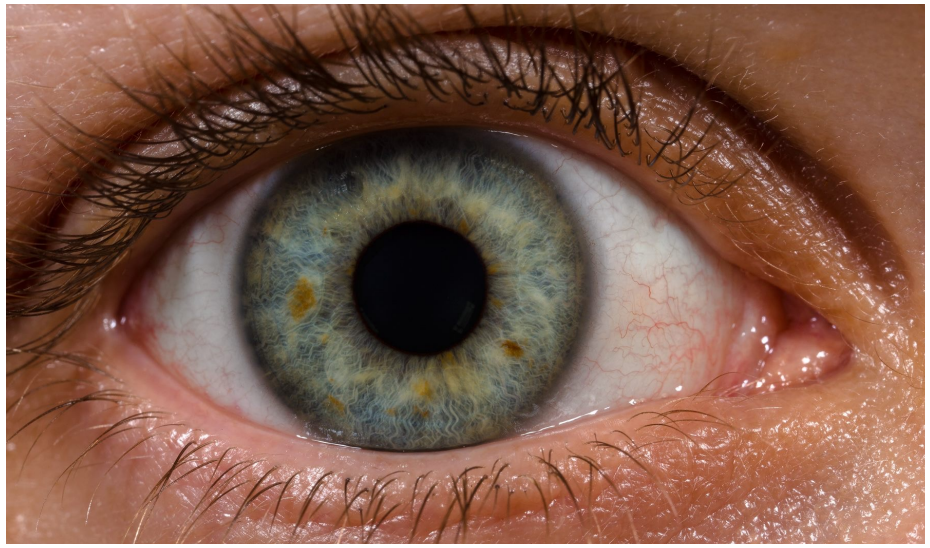
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Donation - Source



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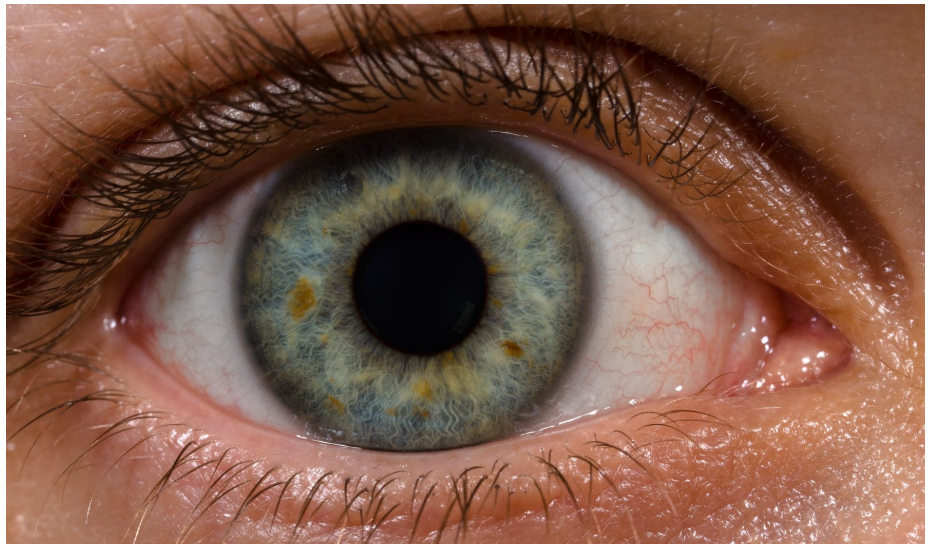
Donation - Criteria & Contraindications



Age: 10 – 85 years

Time: < 24 hours pm

Donation - Criteria & Contraindications



Generally Suitable

- Cancers
- Heart disease, Respiratory disease
- Bacterial infection / septicaemia
- Diabetes, Arthritis
- Vision problems or common eye disorders *eg*. Cataract, Glaucoma, Retinopathy
- LASIK (DSAEK/DMEK only)

Donation - Criteria & Contraindications



Medical Contraindications

- Death of unknown cause
- Infectious disease *eg*. Hepatitis B/C, HIV, Meningitis
- Systemic viral infection
- CNS diseases, Progressive dementia
- Leukaemia, Lymphoma
- Previous corneal disease or surgery
- Various congenital disorders
- Lifestyle risk factors

Donation - Process

Suitable donor identified → Next-of-kin contacted → Retrieval

Referral from

- Medical staff
- Transplant coordinators
- Referral from families



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Donation - Process



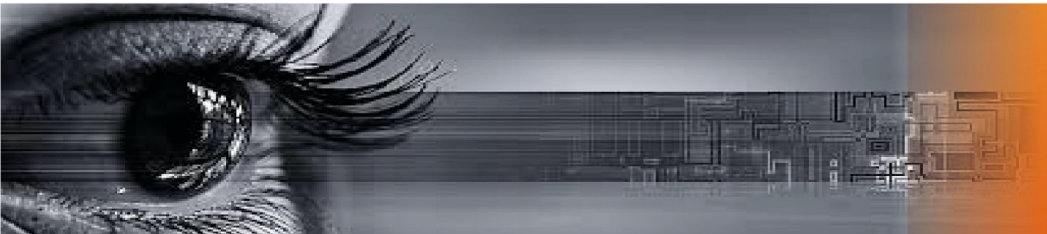
Informed Consent

- Human Tissue Act 2008
- No coercion
- Retrieval explained once consent granted

Donation - Process

Suitable donor identified → Next-of-kin contacted → Retrieval

Driver's licence is an indication of wish only – it's important to discuss your intention to donate with family/whanau.



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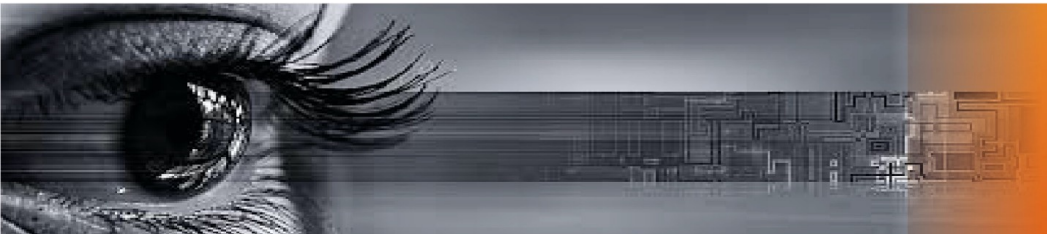
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Donation - Process

Suitable donor identified → Next-of-kin contacted → Retrieval

Retrieval

- Careful surgical procedure in hospital / mortuary / funeral home
- Donor treated with dignity and respect
- No delay to funeral arrangements
- No visible difference, viewing can occur



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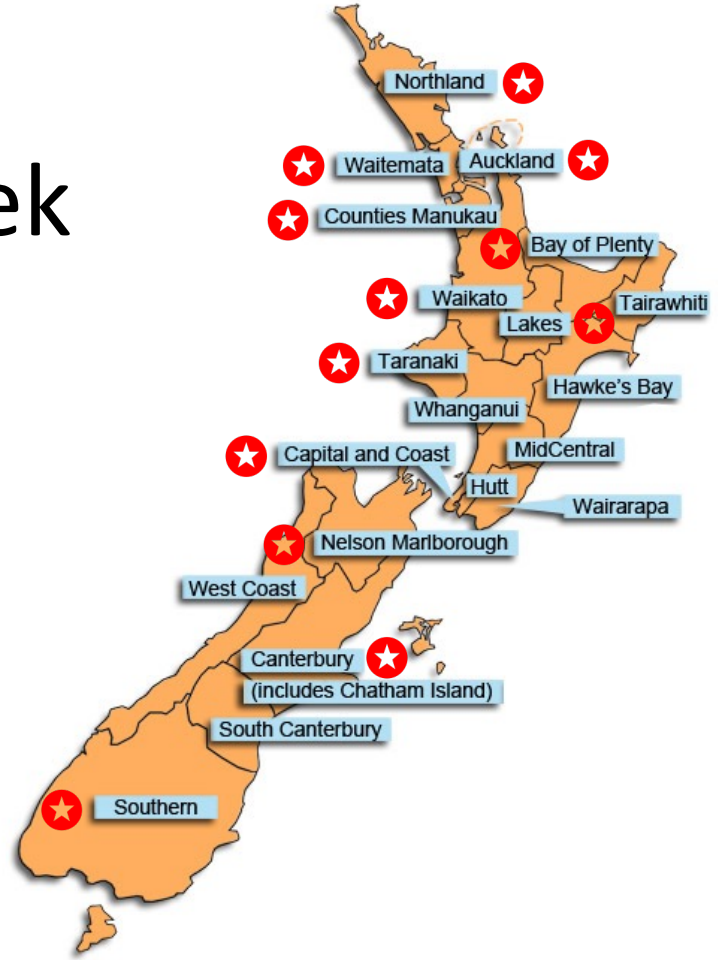
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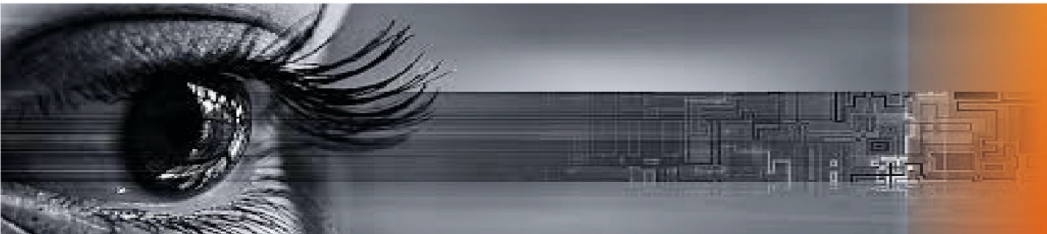
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Distribution

2018-2022

- 6-7 cornea transplants per week
- 29 Corneal Surgeons
- 30 Hospitals / 12 Regions
- 75% Public / 25% Private
- 85% Scheduled / 15% Emergency



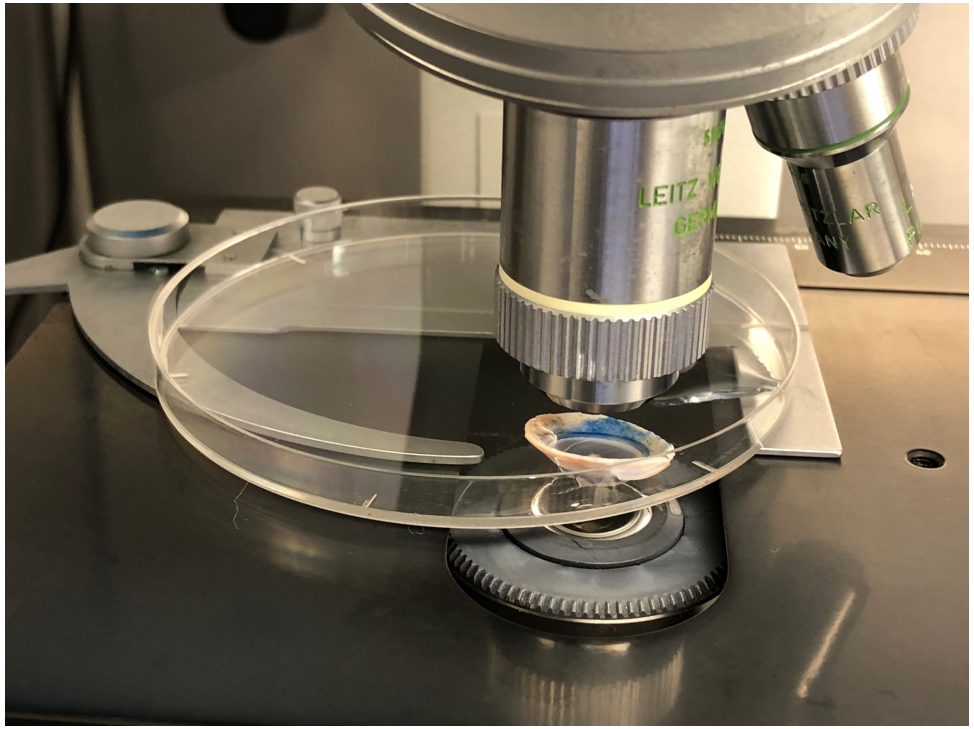


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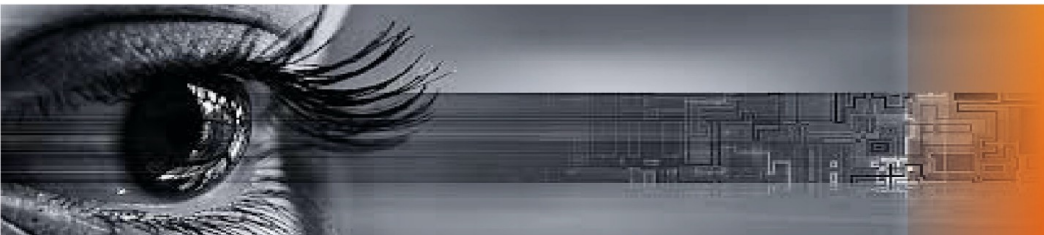
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New Zealand National Eye Bank



- 24 Hours – 365 Days
- Donor screening and consent
- Donor acquisition within 24 hours
- Storage, preparation, quality control
- Distribution throughout NZ
- Data collection and publication



NZ National Eye Bank

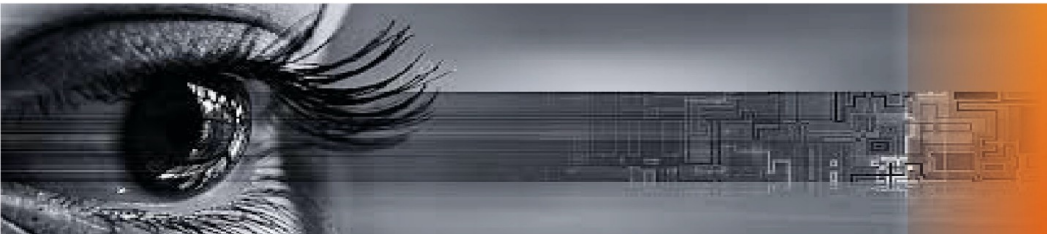
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Eye Bank People



NZ National Eye Bank



NZ National Eye Bank

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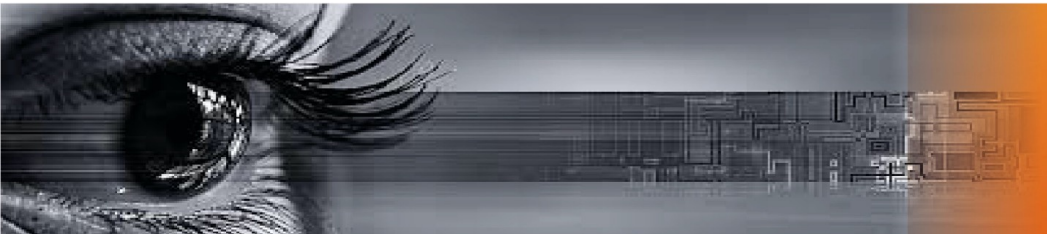
New Zealand National Eye Bank

NZ National Eye Bank

https://eyebank.nz

EBAANZ

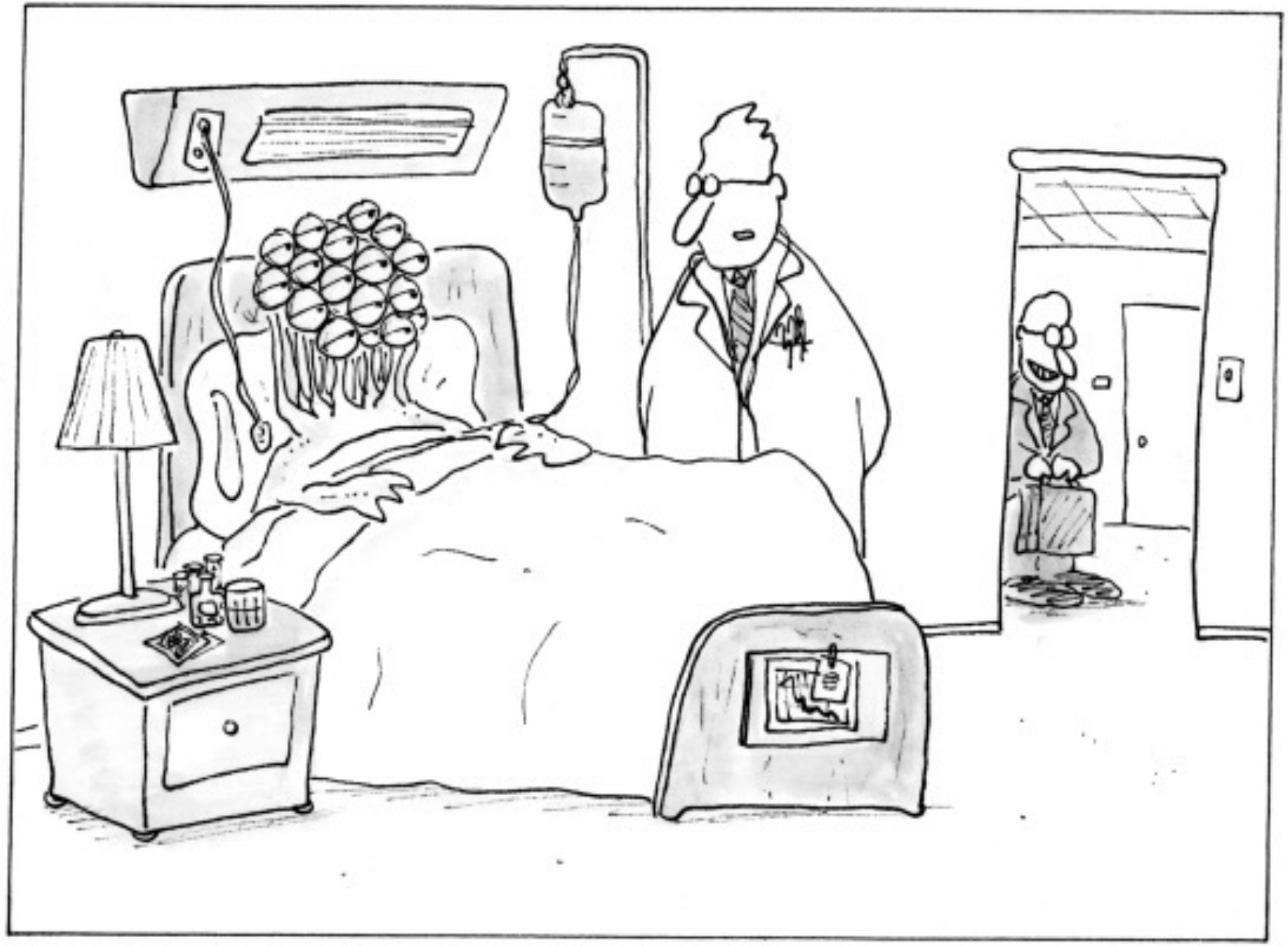
https://ebaanz.org



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"The man from the eye bank would like to see you."