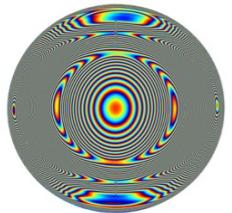


# Cataract risk at low radiation dose: *Seeing is believing*



# Cataract risk at low radiation dose: *Seeing is believing*

**Paul Jonkergouw**  
**Radboud University Nijmegen**



# ICRP recommendations (2007)

ICRP Publication 103

Table 6. Recommended dose limits in planned exposure situations<sup>a</sup>.

Type of limit	Occupational	Public
Effective dose	20 mSv per year, averaged over defined periods of 5 years <sup>e</sup>	1 mSv in a year <sup>f</sup>
Annual equivalent dose in:		
Lens of the eye <sup>b</sup>	150 mSv	15 mSv
Skin <sup>c,d</sup>	500 mSv	50 mSv
Hands and feet	500 mSv	—

<sup>b</sup> This limit is currently being reviewed by an ICRP Task Group.

# ICRP recommendations (2007)

ICRP Publication 103

Table A.3.1. Estimates of the thresholds for tissue effects in the adult human testes, ovaries, lens, and bone marrow (from ICRP 1984, *Publication 41*<sup>1</sup>).

Tissue and effect	Threshold		
	Total dose received in a single brief exposure (Gy)	Total dose received in highly fractionated or protracted exposures (Gy)	Annual dose rate if received yearly in highly fractionated or protracted exposures for many years (Gy y <sup>-1</sup> )
<b>Testes</b>			
Temporary sterility	0.15	NA <sup>2</sup>	0.4
Permanent sterility	3.5–6.0 <sup>3</sup>	NA	2.0
<b>Ovaries</b>			
Sterility	2.5–6.0	6.0	>0.2
<b>Lens</b>			
Detectable opacities	0.5–2.0 <sup>4</sup>	5	>0.1
Visual impairment (Cataract) <sup>5</sup>	5.0 <sup>5</sup>	>8	>0.15
<b>Bone marrow</b>			
Depression of hematopoiesis	0.5	NA	>0.4



INTERNATIONAL COMMISSION ON RADIOLOGICAL PROTECTION

ICRP ref 4825-3093-1464

## Statement on Tissue Reactions

Approved by the Commission on April 21, 2011

(2) The Commission has now reviewed recent epidemiological evidence suggesting that there are some tissue reaction effects, particularly those with very late manifestation, where threshold doses are or might be lower than previously considered. For the lens of the eye, the threshold in absorbed dose is now considered to be 0.5 Gy.

(3) For occupational exposure in planned exposure situations the Commission now recommends an equivalent dose limit for the lens of the eye of 20 mSv in a year, averaged over defined periods of 5 years, with no single year exceeding 50 mSv.

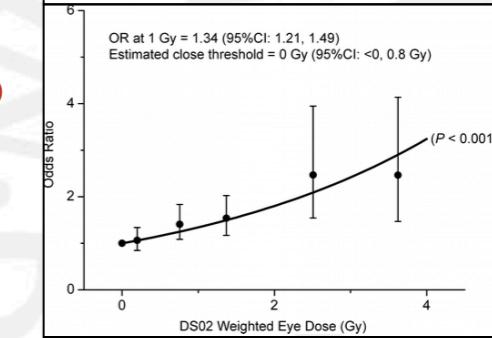
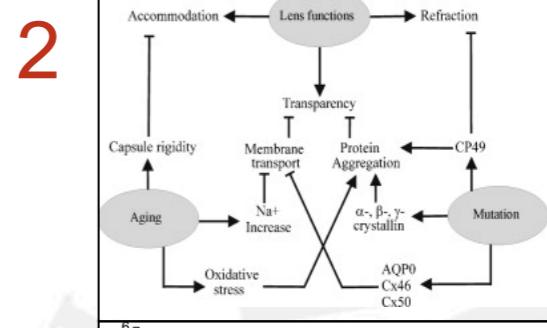
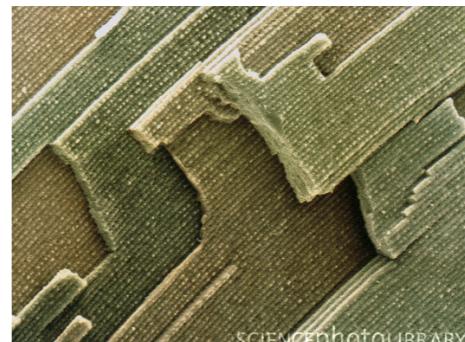
## ICRP statement on tissue reactions → lens

How come

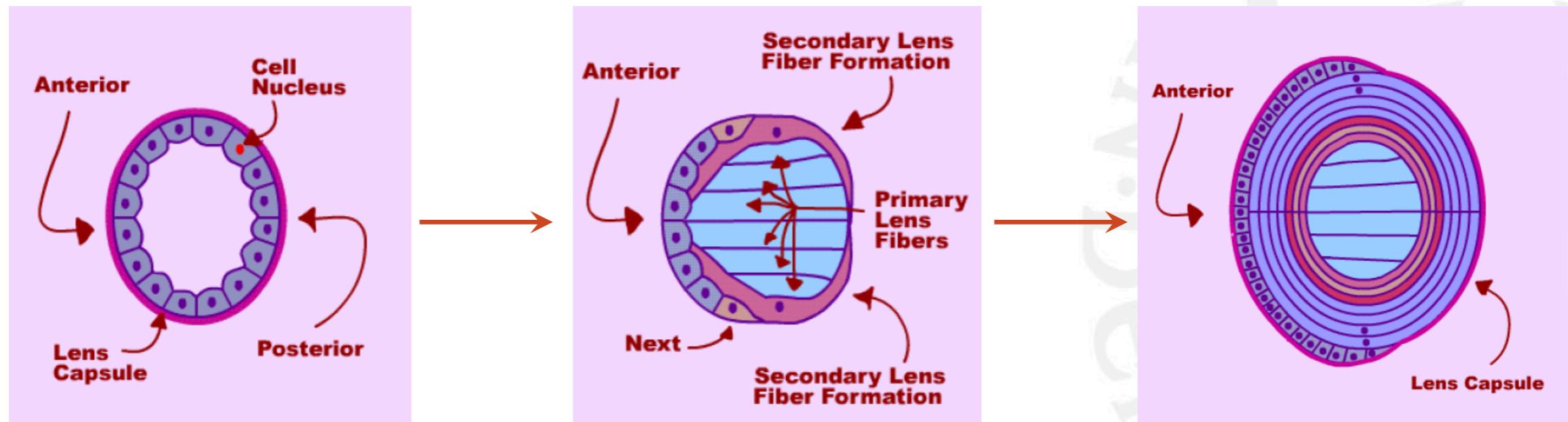


# Content

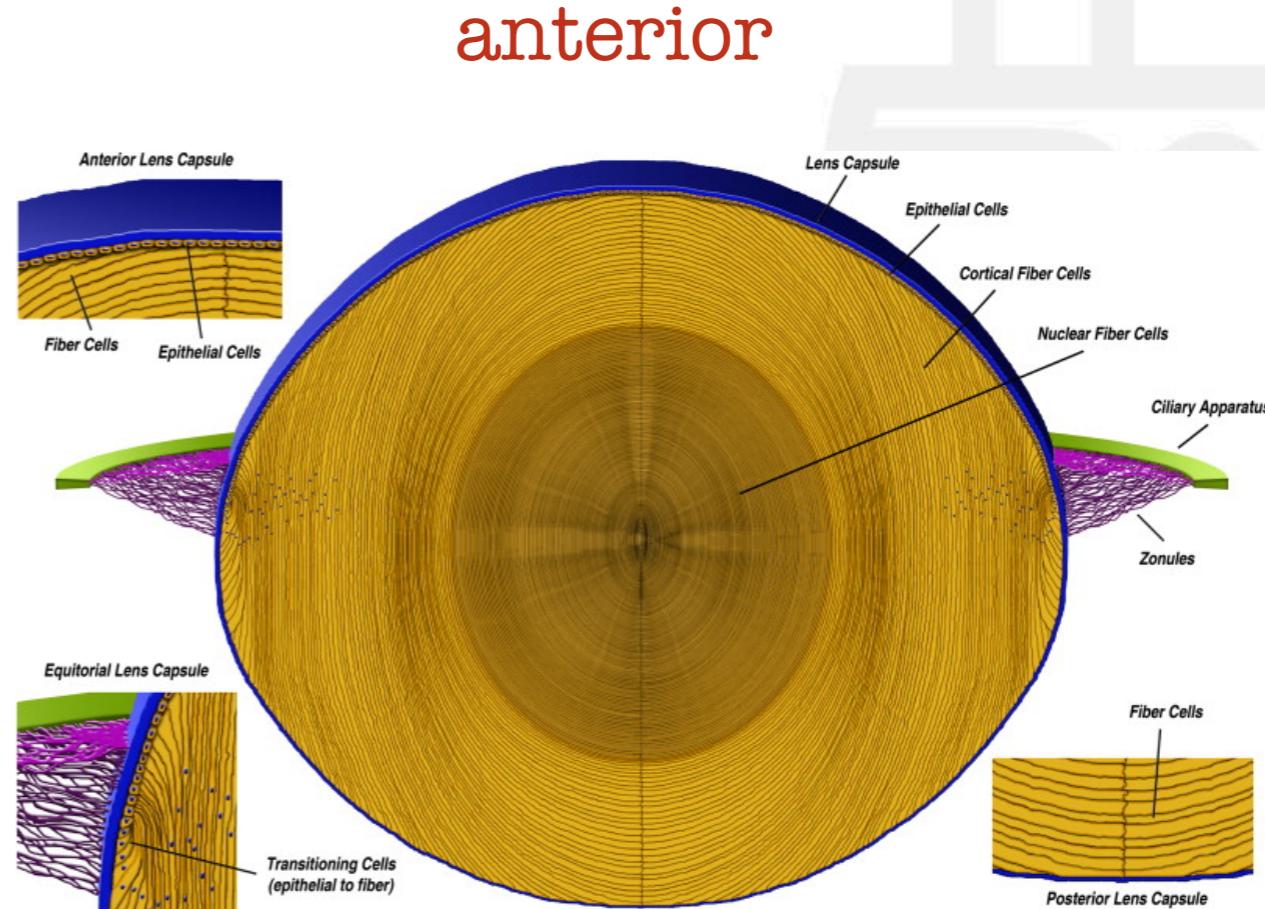
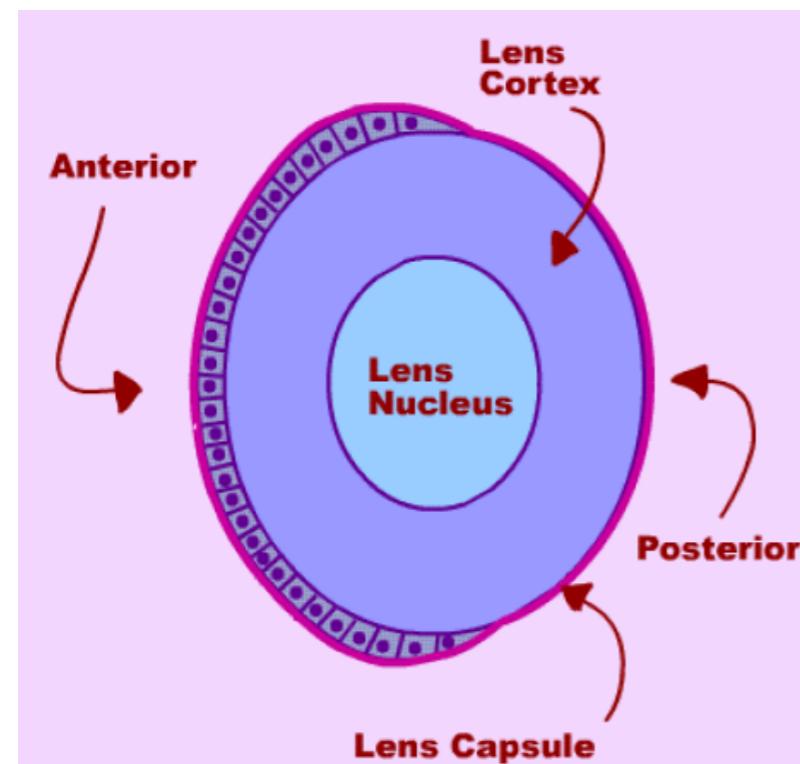
1. Lens structure
  2. Cataract / cataractogenesis
  3. Radiosensitivity of the lens
  4. Lens effects, recent literature
  5. O'LOC study results



# Lens structure development, embryonic phase



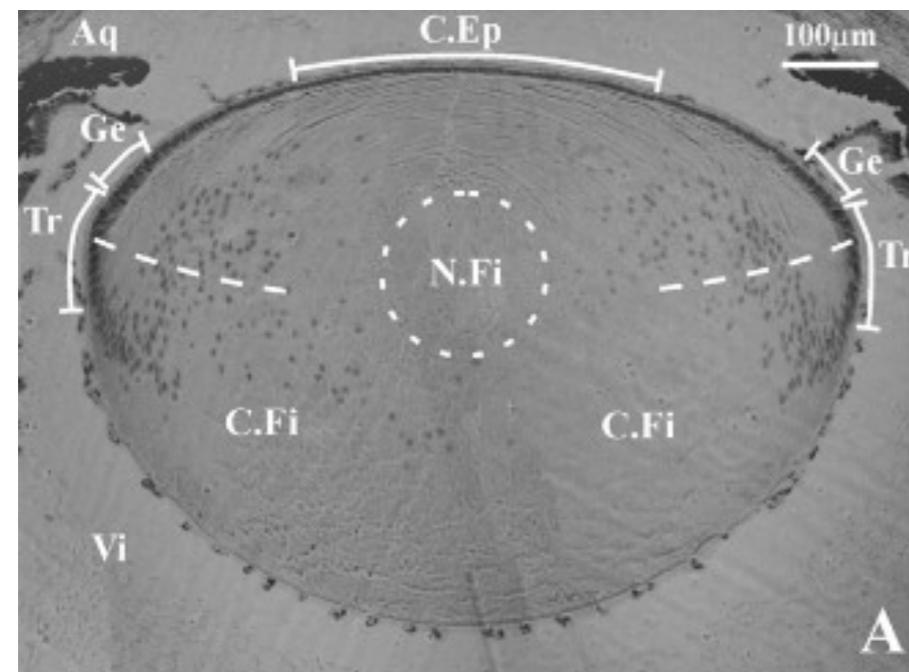
# Lens structure adult phase



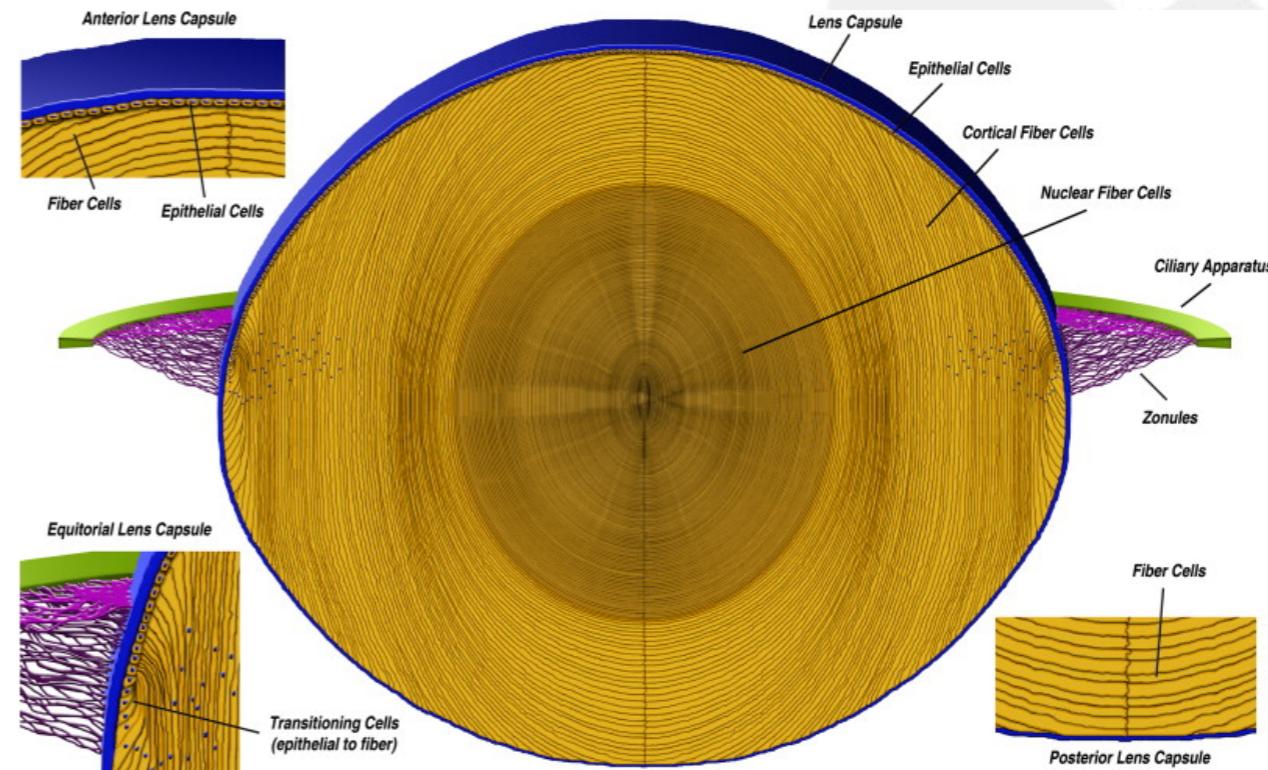
anterior

posterior

# Lens structure adult phase



anterior



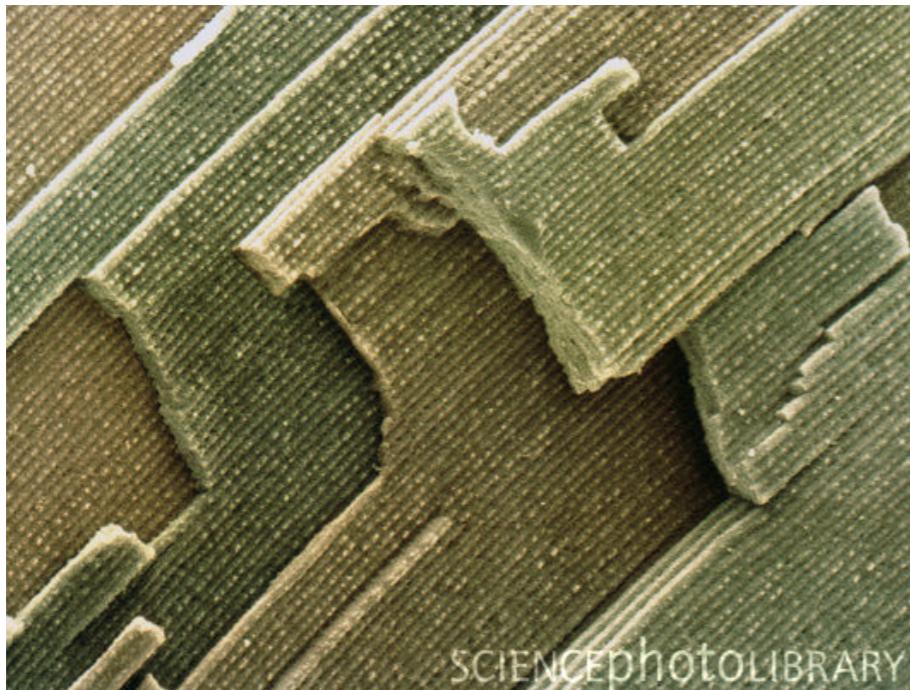
posterior

Frederique M.D. Tholozan , Roy A. Quinlan

**Lens cells: More than meets the eye**

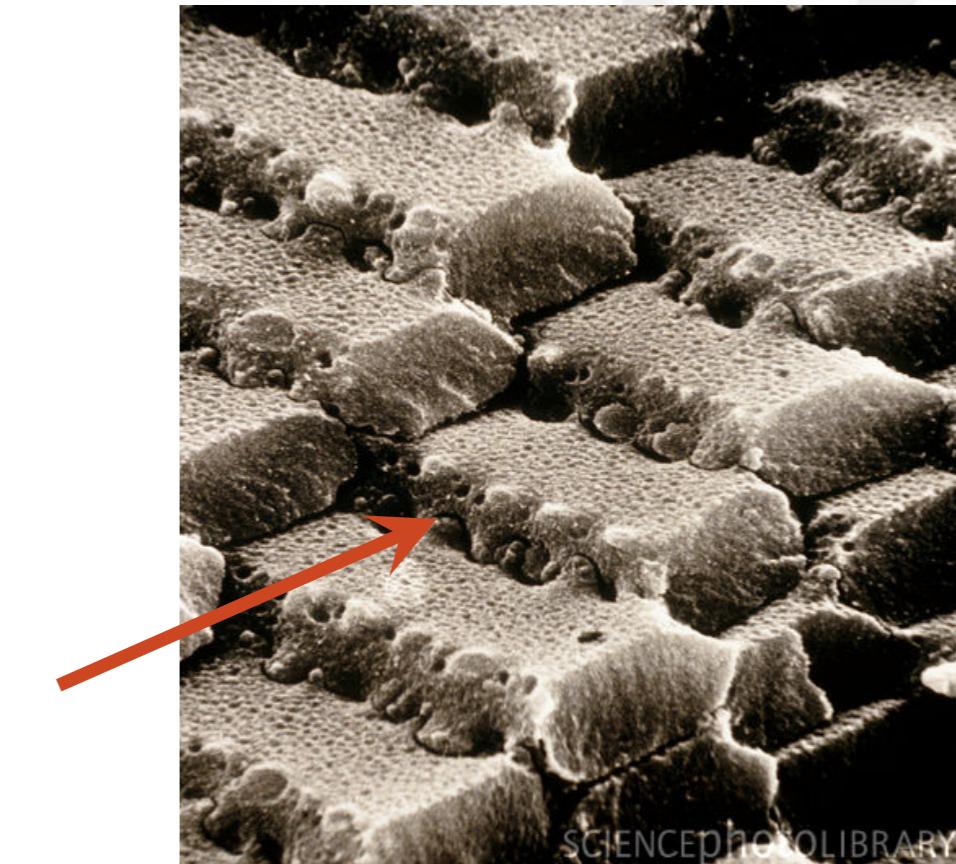
The International Journal of Biochemistry & Cell Biology Volume 39, Issue 10 2007 1754 - 1759

# Lens structure *fibre cells*



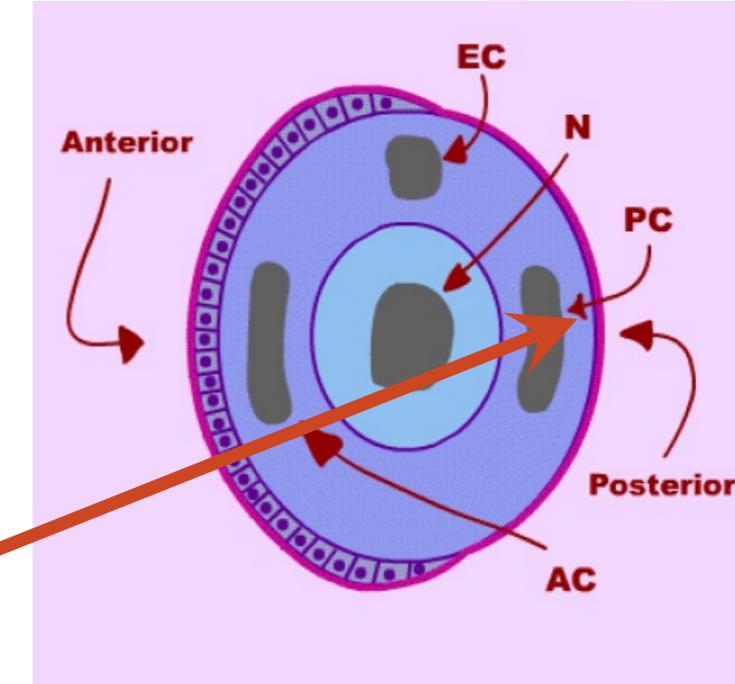
onion-like orientation

‘zipper’  
junction



# Cataract

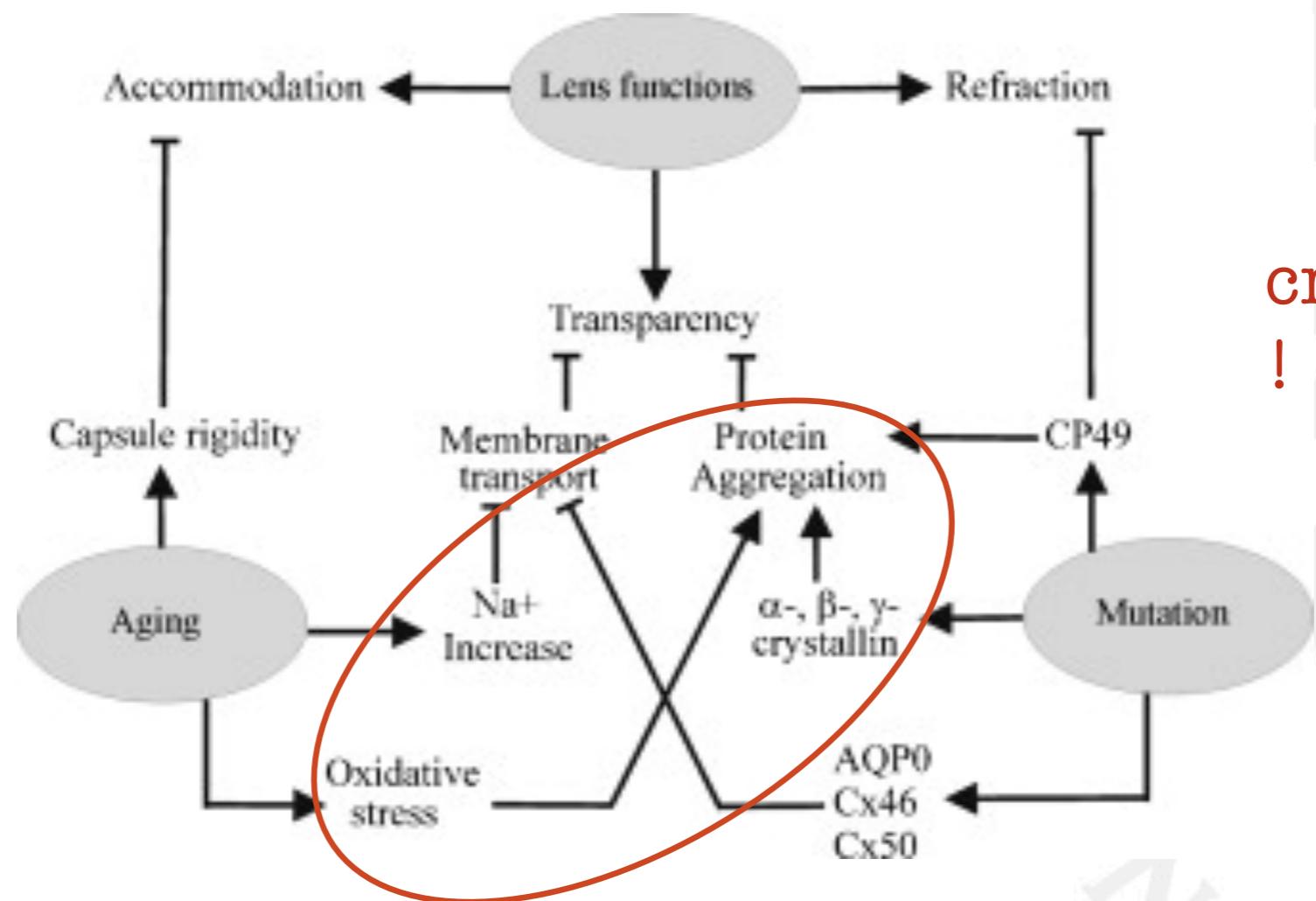
- Nuclear cataract (NC) → 70%
- Cortical cataract (AC) → 25%
- Posterior subcapsular cataract (PSC) → 5%



posterior subcapsular  
cataract (PSC)



# Cataractogenesis



crystallins  
!

Frederique M.D. Tholozan , Roy A. Quinlan

**Lens cells: More than meets the eye**

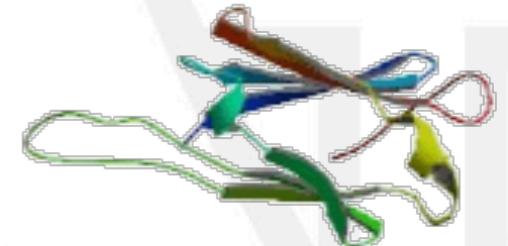
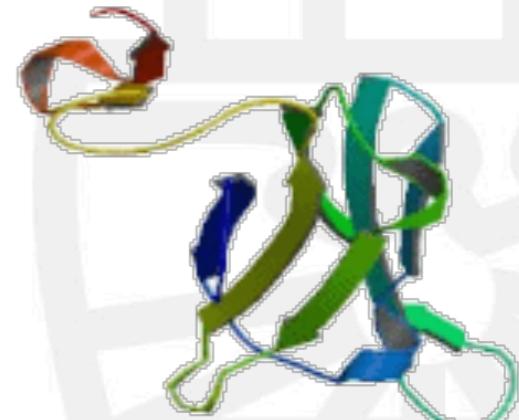
The International Journal of Biochemistry & Cell Biology Volume 39, Issue 10 2007 1754 - 1759

# Crystallins

- member of small Hsp
- in human lens: CRYaA : CRYaB = 3:1
- CRYaA found mainly in lens
- lens protein concentration: 450 mg/ml → refractive index  
→ transparency
- lens fibre cell: 90% crystallins
- main function: chaperone properties suppressing non-specific aggregation due to unfolded/denatured proteins

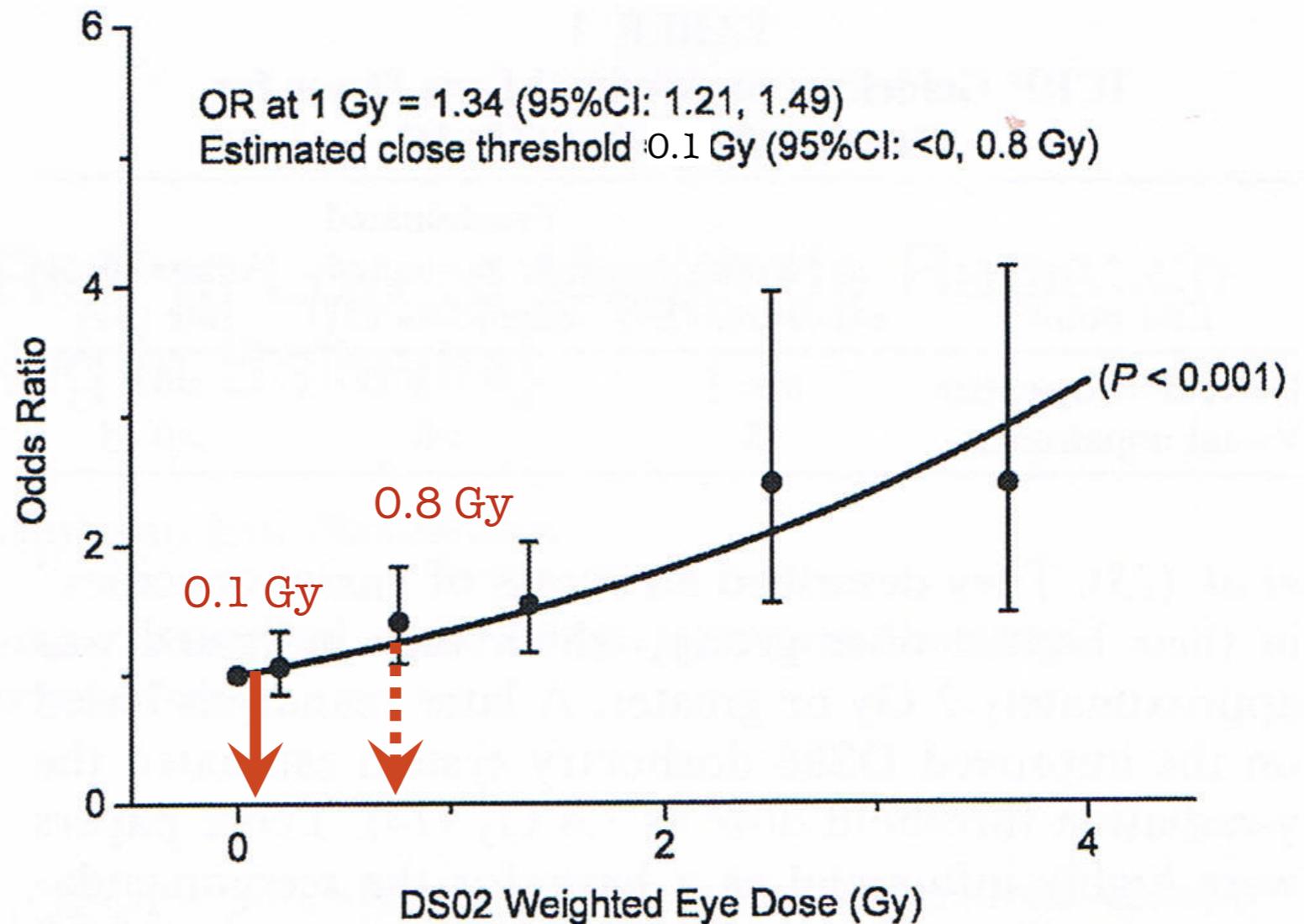


target molecules / mechanism ?



# Radiosensitivity A-bomb survivors

threshold or non-threshold ?

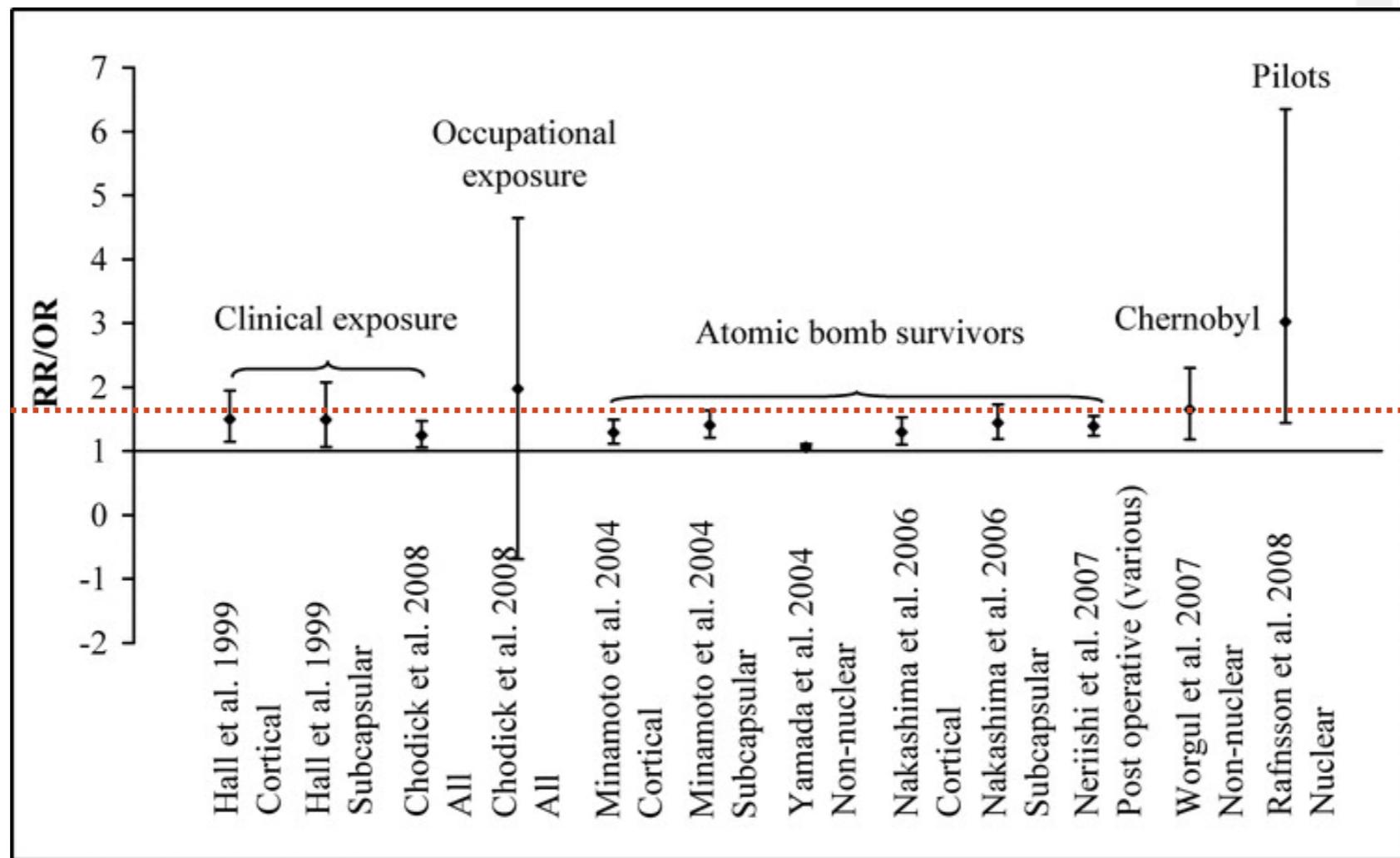


Roy E. Shore, Kazuo Neriishi, Eiji Nakashima

Epidemiological Studies of Cataract Risk at Low to Moderate Radiation Doses: (Not) Seeing is Believing

Radiation Research 174, 889-894 (2010)

# Radiosensitivity recent literature

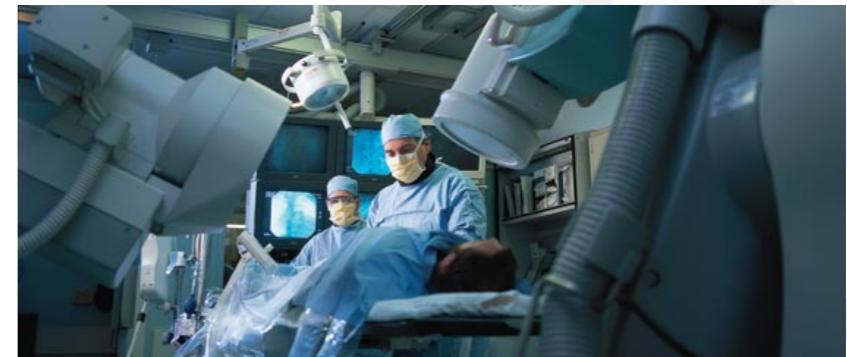


E.A. Ainsbury, S.D Bouffler, W. Dörr, J. Graw, C.R. Muirhead, A.A. Edwards, J. Cooper

## Radiation Cataractogenesis: A Review of Recent Studies

Radiation Research 172(1), 1-9 (2009)

# Occupational risk *interventional cardiology*



- Latin America (Vano et al. 2010):
  - case control: 116 exposed, 93 non-exposed
  - median lens dose:
    - cardiologist: 6 Sv
    - assistant: 1,5 Sv
  - 38% vs. 12% PSC (**RR= 3.2**, p<0.005)
  - 21% nurses/technicians had PSC
- Malaysia (Ciraj Bjelac et al. 2011):
  - 52% vs. 9% PSC (**RR= 5.7**, p<0.05)

dose-  
dependent

# O'CLOC study (France) *occupational cataract, IC*

	Exposed group of interventional cardiologists <b>N=106</b>	Unexposed group <b>N=99</b>	p-value*
<b>Age at interview (years)</b>	51.1 ± 7.3	49.6 ± 6.7	0.20
<b>Men</b>	99 (93%)	86 (87%)	0.11
<b>BMI</b>	23.7 ± 2.6	24.5 ± 3.1	0.13
<b>Smokers (past or present)</b>	40 (38%)	44 (44%)	0.39
<b>Diabetes</b>	1 (1%)	0 (0%)	1.00
<b>Myopia</b>	55 (52%)	58 (59%)	0.40
<b>Corrected visual acuity</b>	0.97 ± 0.09	0.98 ± 0.06	0.24
<b>Corticosteroids use</b>	1 (1%)	3 (3%)	0.35

courtesy Sophie Jacob, IRSN France

# O'CLOC study (France) occupational cataract, IC

during 22 year

Mean doses ( $\mu\text{Sv}/\text{procedure}$ )	Cumulative lens dose* (mSv)	Mean $\pm$ SD	p-val.
Coronarography	All cardiologists	$423 \pm 359$ (min 25; max 1658)	p=0.09
Angioplasty		$455 \pm 373$ (min 29; max 1658)	
PM or DEF: implantation		$343 \pm 308$ (min 25; max 1650)	
PM or DEF: resynchronization	CICs Electrophysiologists		
RF Ablation except AF			
RF Ablation of AF			

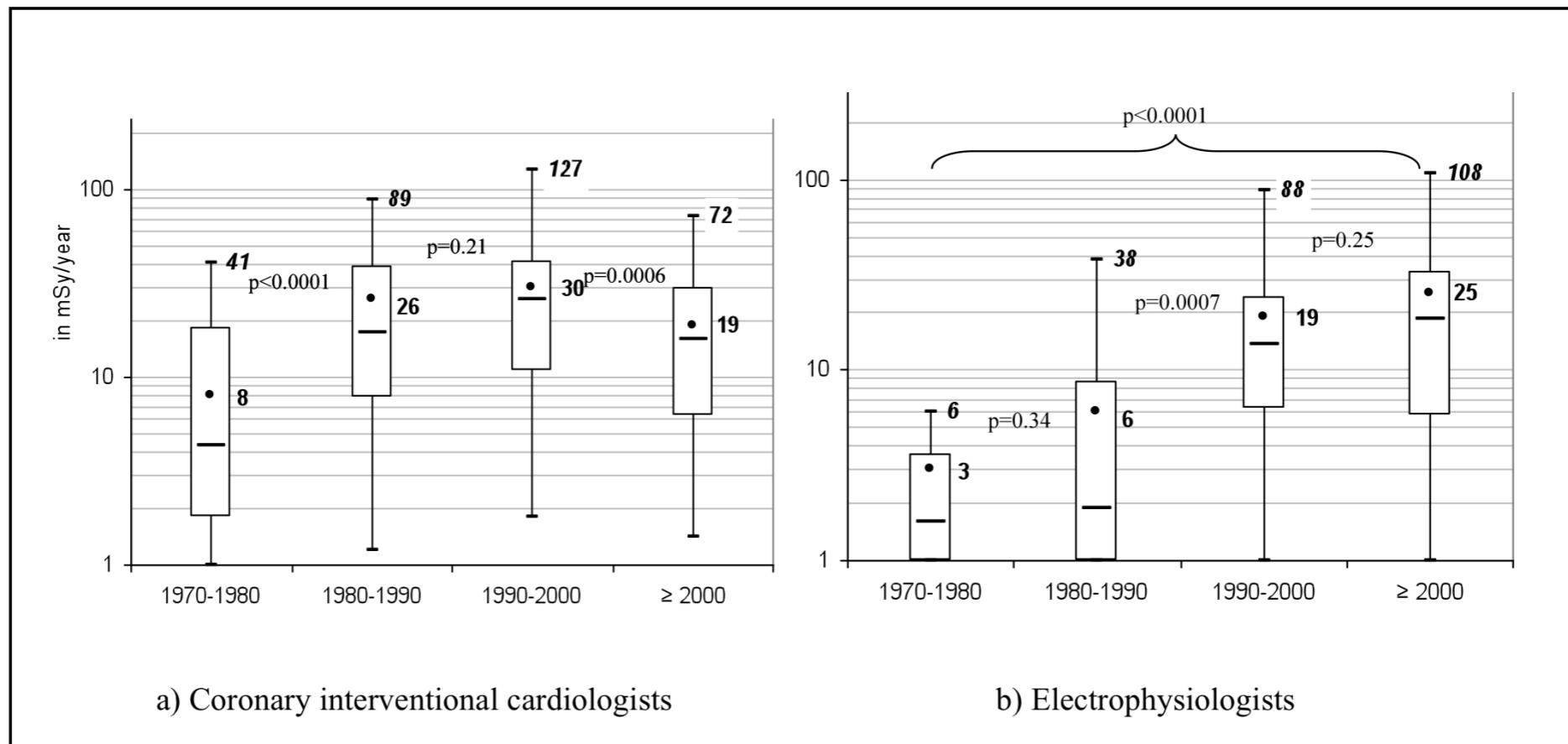
\* retrospectively assessed from ORAMED dataset

courtesy Sophie Jacob, IRSN France



# O'CLOC study (France) *occupational cataract, IC*

mean annual dose



courtesy Sophie Jacob, IRSN France

## O'CLOC study (France) *occupational cataract, IC*

	Interventional cardiologists N=106	Unexposed group N=99
	% (95% CI)	% (95% CI)
Nuclear	60% (51 - 69)	69% (60 - 78)
Cortical	23% (15 - 31)	29% (20 - 38)
<b>Posterior</b>	<b>17 % (10 - 24)</b>	<b>5% (1 - 9)</b>
<b>Subcapsular</b>		<b>OR adjusted = 3.8 (1.3 – 11.4)</b>

courtesy Sophie Jacob, IRSN France

# O'CLOC study (France) occupational cataract, IC

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**Results: 3**

[EYE LENS RADIATION EXPOSURE TO INTERVENTIONAL CARDIOLOGISTS: A RETROSPECTIVE ASSESSMENT OF CUMULATIVE DOSES.](#)

**Jacob** S, Donadille L, Maccia C, Bar O, Boveda S, Laurier D, Bernier MO. Radiat Prot Dosimetry. 2012 Jul 4. [Epub ahead of print] PMID: 22764175 [PubMed - as supplied by publisher] [Related citations](#)

[Interventional cardiologists and risk of radiation-induced cataract: Results of a French multicenter observational study.](#)

**Jacob** S, Boveda S, Bar O, Brézin A, Maccia C, Laurier D, Bernier MO. Int J Cardiol. 2012 May 17. [Epub ahead of print] PMID: 22608271 [PubMed - as supplied by publisher] [Related citations](#)

[Occupational cataracts and lens opacities in interventional cardiology \(O'CLOC study\): are X-Rays involved? Radiation-induced cataracts and lens opacities.](#)

**Jacob** S, Michel M, Spaulding C, Boveda S, Bar O, Brézin AP, Streho M, Maccia C, Scanff P, Laurier D, Bernier MO. BMC Public Health. 2010 Sep 8;10:537. PMID: 20825640 [PubMed - indexed for MEDLINE] [Free PMC Article](#) [Related citations](#)

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Occupational cataracts and lens opacities in in [BMC Public Health. 2010]

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# Conclusion

## *ICRP recommendations revisited*

ICRP Publication 103

Table 6. Recommended dose limits in planned exposure situations<sup>a</sup>.

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<sup>b</sup> This limit is currently being reviewed by an ICRP Task Group.

