Radiation Effect on Eye Lens

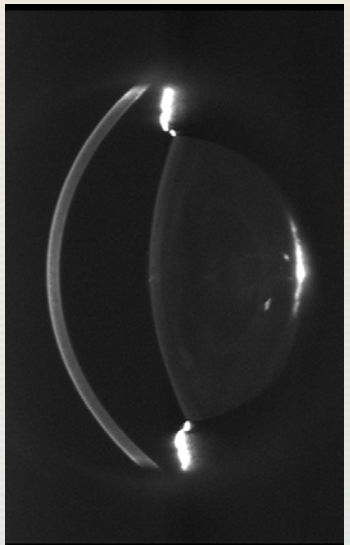
Madan Rehani

Radiation Protection of Patients Unit, IAEA

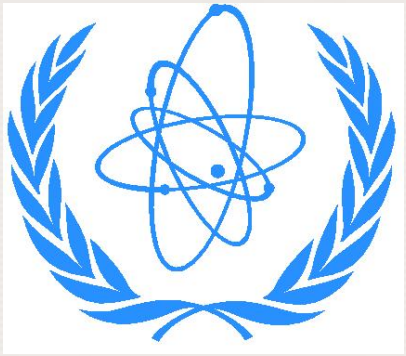
M.Rehani@iaea.org

IAEA

Atoms for Peace: The First Half Century
1957–2007



Major international organizations

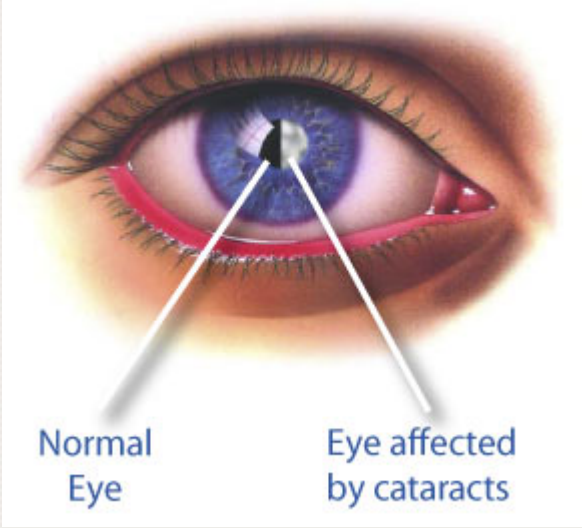


ICRP

- More BASIC that the Basic Safety Standard,
- More BASIC than the basic recommendation

HOT Topic in Occupational Radiation Protection

- Cataract



Unlike Patients where……..

Goal

- **100% protection of staff against cataract**
- **Is it achievable: Yes**
- **Is it documentable: Yes**

Is there any other goal that is achievable with this much success?

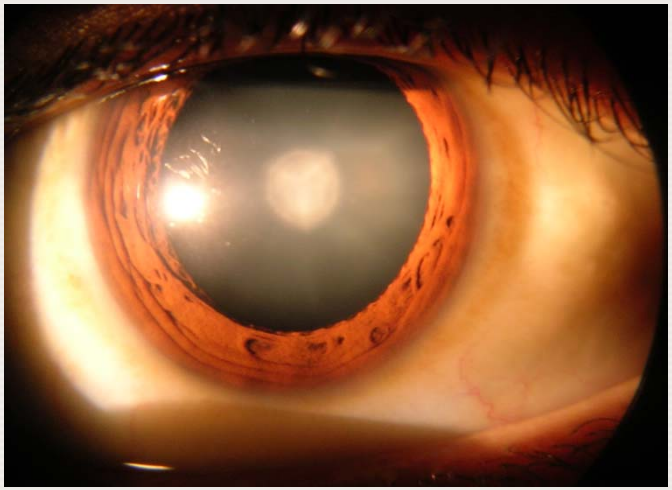
Goal in effect, not in steps & actions

Radiation effects- 100% success

- **Carcinogenic: No**
- **Genetic: No**
- **Skin injuries: May be ??**

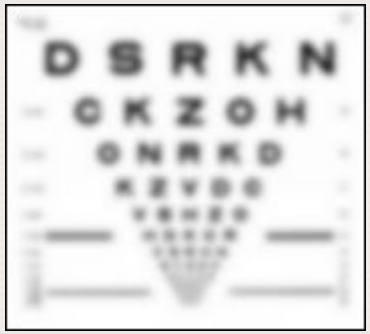
What is cataract

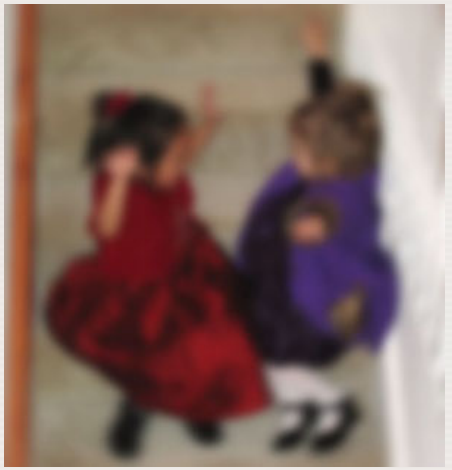
Clouding or opacification of the natural lens of the eye and obstructing the passage of light



What effect does it have?

- When light passes through the cataractous lens, it is
- diffused or scattered, resulting in blurred or defocused vision

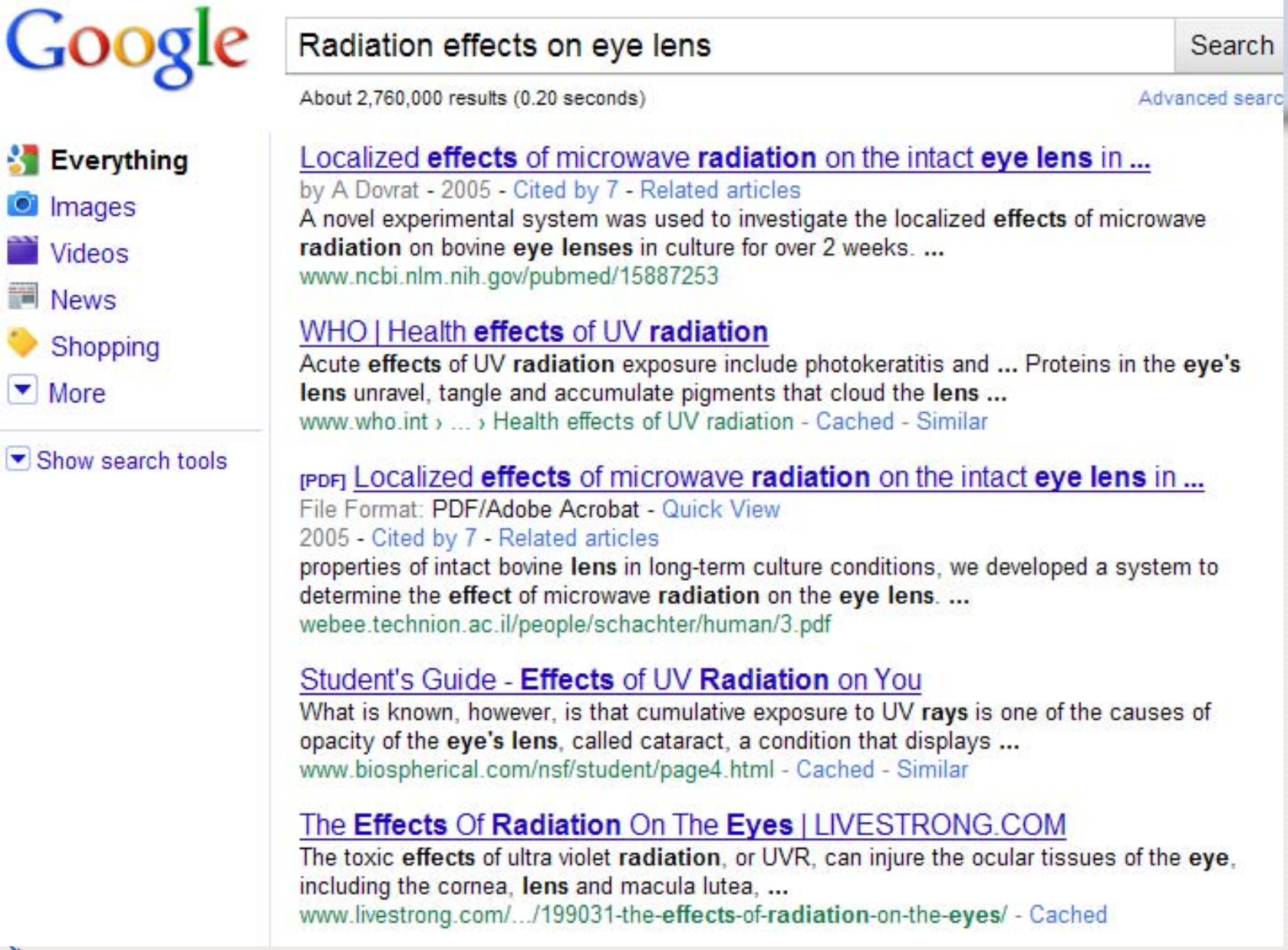




Easily treatable condition -surgery

Cataract- Age related

- Most cataracts appear with advancing age after 45 years.
- Smoking, diabetes, and excessive exposure to sunlight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Localized effects of microwave radiation on the intact eye lens in ...
by A Dovrat - 2005 - Cited by 7 - Related articles
A novel experimental system was used to investigate the localized effects of microwave radiation on bovine eye lenses in culture for over 2 weeks. ...
www.ncbi.nlm.nih.gov/pubmed/15887253
WHO | Health effects of UV radiation
Acute effects of UV radiation exposure include photokeratitis and ... Proteins in the eye's lens unravel, tangle and accumulate pigments that cloud the lens ...
www.who.int › ... › Health effects of UV radiation - Cached - Similar
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properties of intact bovine lens in long-term culture conditions, we developed a system to determine the effect of microwave radiation on the eye lens. ...
webee.technion.ac.il/people/schachter/human/3.pdf
Student's Guide - Effects of UV Radiation on You
What is known, however, is that cumulative exposure to UV rays is one of the causes of opacity of the eye's lens, called cataract, a condition that displays ...
www.biospherical.com/nsf/student/page4.html - Cached - Similar
The Effects Of Radiation On The Eyes | LIVESTRONG.COM
The toxic effects of ultra violet radiation, or UVR, can injure the ocular tissues of the eye, including the cornea, lens and macula lutea, ...
www.livestrong.com/.../199031-the-effects-of-radiation-on-the-eyes/ - Cached

Mechanism: Photochemical or Thermal

- High frequency microwave electromagnetic radiation from mobile phones and other modern devices has the potential to damage eye tissues, but its effect on the lens epithelium is unknown at present.

- E. Bormusov et al., Non-Thermal Electromagnetic Radiation Damage to Lens Epithelium. ***Open Ophthalmol J.* 2008; 2: 102–106**

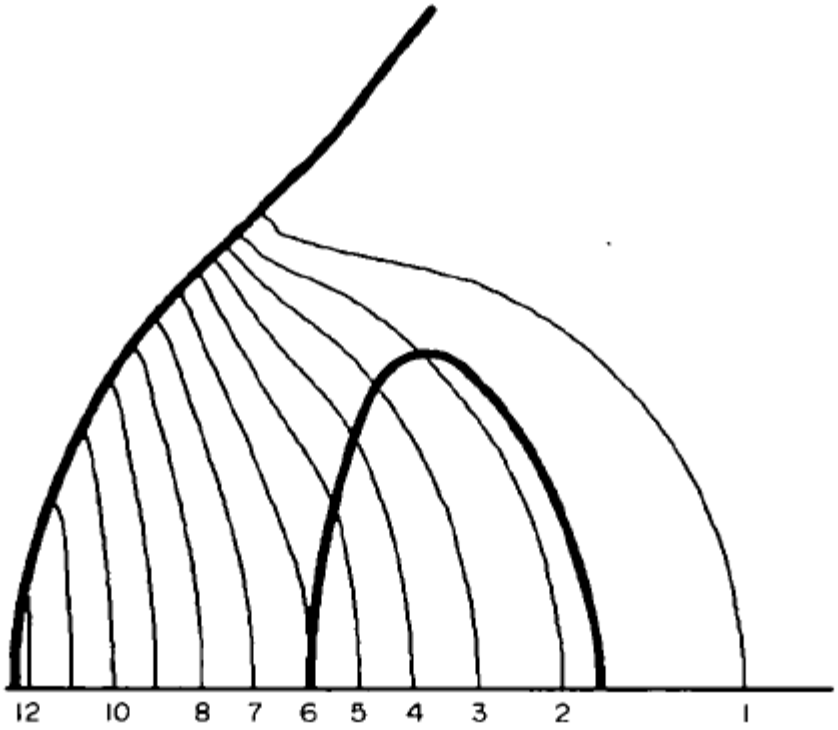
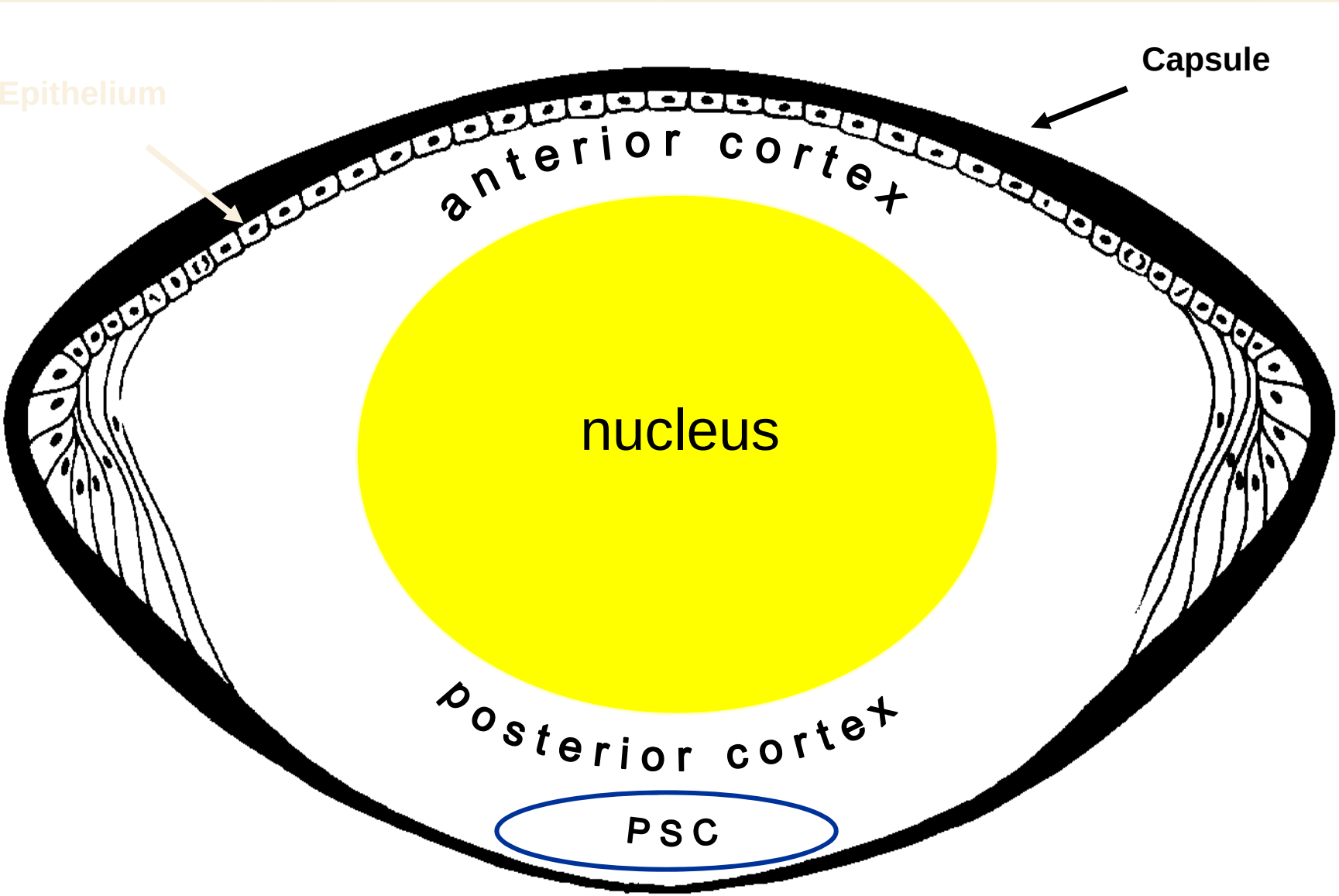
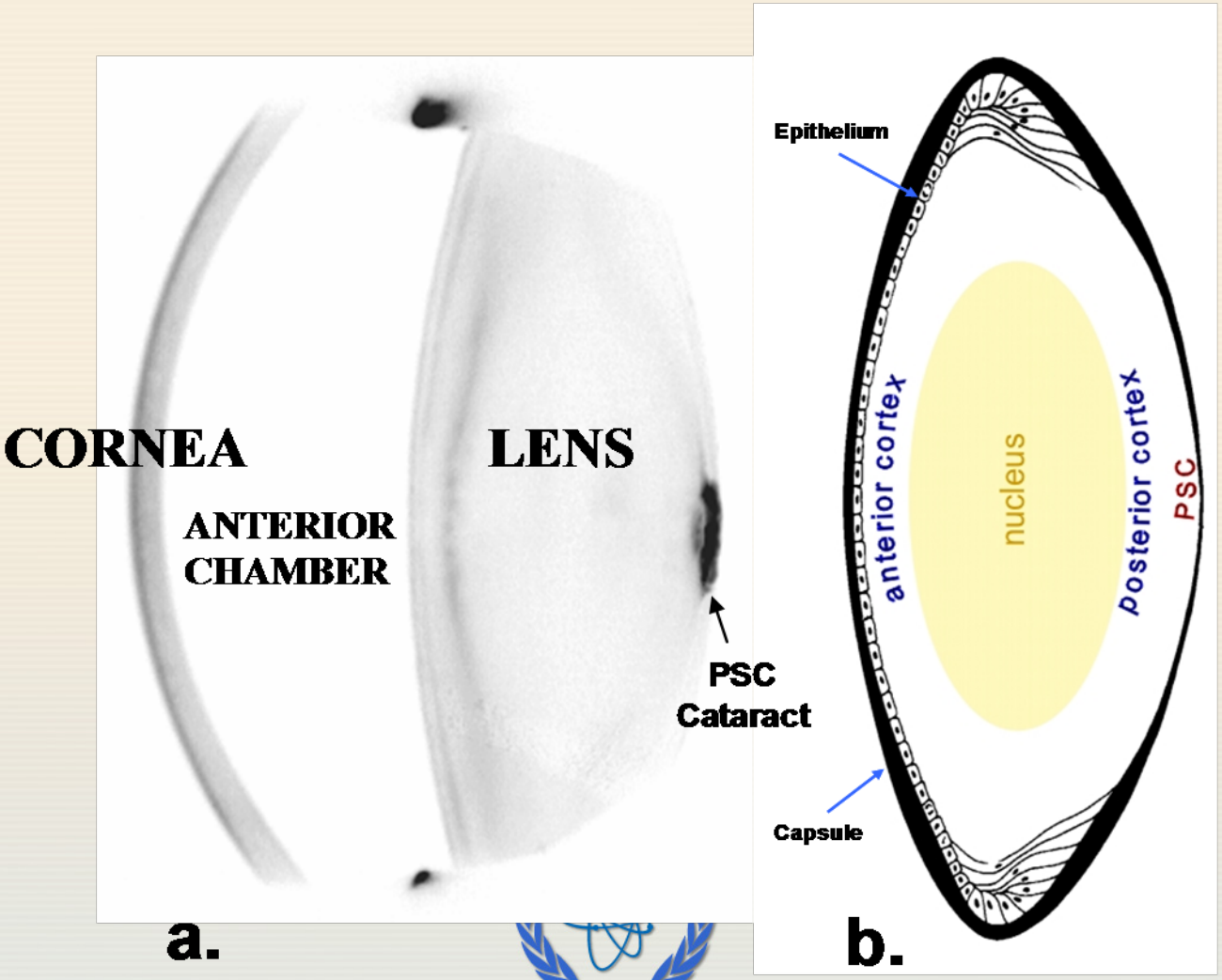


FIG. 6. The distribution of temperature rises within the anterior part of the eye after an exposure of 10 min for radiation of 1200°C, normal lens, pupil diameter of 2 mm and brown iris, expressed by isothermal contours. The incident irradiance is 200 mW cm^{-2}. This distribution will not vary if the exposure continues further.


Capsule
Epithelium
anterior cortex
nucleus
posterior cortex
PSC


CORNEA
LENS
ANTERIOR CHAMBER
PSC Cataract
a.
Epithelium
anterior cortex
nucleus
posterior cortex
PSC
Capsule
b.

Major Cataract Subtypes

- Cortical
- Nuclear
- Posterior SubCapsular (psc)
- Mixed

Eye Lens

- It is a unique organ in that it is nonvascular
- Has no loss of cells over the lifetime,
- Thus there is no mechanism for the removal of damaged cells.

History of radiation cataract

- **Documented within 1 year of Roentgen's discovery of X rays**
- **H. Chalupecky, Ueber die wirkung der Roentgenstrahlen. Centralblatt fuer praktische Augenheilkunde (J. Hirschberg Ed.), pp. 386–401. Veit, Leipzig, 1897.**

- However, cataract was long thought to result from only high doses of radiation to the lens of the eye.
- This was based on data from early cyclotron workers with cataract after substantial neutron doses and
- with early Japanese A-bomb studies that reported excess cataracts among those who received over 2–3 Gy.

Up to early 1950's

- W. Rohrschneider, Beitrag zur entstehung und morphologie der ro¨ntgenstrahlenkatarakt. *Klin. Monatsbl. Augenheilkd.* **81**, 254–259 (**1928**).
- A. U. Desjardins, Action of Roentgen rays and radium on the eye and ear. *Am. J. Roentgenol.* **26**, 643–679 (1931).
- P. J. Leinfelder and H. D. Kerr, Roentgen-ray cataract: An experimental, clinical, and microscopic study. *Am. J. Ophthalmol.* **19**, 739–756 (**1936**).
- D. G. Cogan and K. K. Dreisler, *Minimal amount of x-ray exposure causing lens opacities in the human eye*. *AMA Arch. Ophthalmol.* **50**, 30–34 (**1953**).

Radiation can cause cataract at High dose

- G. R. Merriam and E. Focht, A clinical study of radiation cataracts and the relationship to dose. Am. J. Roentgenol. Radium Ther. Nucl. Med. 77, 759–785 (1957).
- G. R. Merriam and E. F. Focht, A clinical and experimental study of the *effect of single and divided doses of radiation on cataract production*. *Trans. Am. Ophthalmol. Soc.* **60**, 35–52 (1962).

Beliefs based on data in late 1950's

- Cataract has a dose threshold
- The severity increased and the latency decreased as the radiation dose increased above that threshold
- Latent period was strongly inversely correlated with dose and that there was no cataract induction below 2 Gy.

Other major papers that influenced

- M. D. Nefzger, R. J. Miller and T. Fujino, Eye findings in *atomic bomb survivors* of Hiroshima and Nagasaki: 1963–1964. Am. J.Epidemiol. 89, 129–138 (1969).
- M. Otake and W. Schull, Radiation-related posterior lenticular opacities in Hiroshima and Nagasaki *atomic bomb survivors* based on the DS86 dosimetry system. Radiat. Res. 121, 3–13 (1990).

ICRP Guidelines on Minimal Lens Doses for Cataract Induction (*15*, *16*)

End point	Brief exposures (Sv)	Fractionated or protacted exposures (Sv)	Annual dose rate (Sv)
Detectable opacities	0.5–2	5	>0.1
Visual impairment	5	>8	>0.15

What is New?

Lens opacities being reported at dose levels below the currently mentioned threshold in ICRP

- Inspection of the Merriam and Focht papers shows that the observation periods after irradiation were mostly quite short (average of 8 years)
- They studied only 20 individuals who had estimated lens doses under 2 Gy,

More Recent Studies

- A. Minamoto, H. Taniguchi, N. Yoshitani, S. Mukai, T. Yokoyama, T. Kumagami, Y. Tsuda, H. K. Mishima, T. Amemiya and M. Akahoshi, *Cataract in atomic bomb survivors*. *Int. J. Radiat. Biol.* **80**, 339–345 (2004).
- F. A. Cucinotta, F. K. Manuel, J. Jones, G. Iszard, J. Murray, B.Djojonegro and M. Wear, *Space radiation and cataracts in astronauts*. *Radiat. Res.* **156**, 460–466 (2002).

More Recent Studies

- E. Nakashima, K. Neriishi and A. Minamoto, *A reanalysis of atomic bomb cataract data, 2000–2002: A threshold analysis. Health Phys.* **90**, 154–160 (*2006*).

Most Recent Papers 2010

- **Shore RE, Neriishi K, Nakashima E. Epidemiological studies of cataract risk at low to moderate radiation doses: (not) seeing is believing. Radiat Res. 2010 Dec;174(6):889-94.**

- **Blakely EA, Kleiman NJ, Neriishi K, Chodick G, Chylack LT, Cucinotta FA, Minamoto A, Nakashima E, Kumagami T, Kitaoka T, Kanamoto T, Kiuchi Y, Chang P, Fujii N, Shore RE. Radiation cataractogenesis: epidemiology and biology. Radiat Res. 2010 May;173(5):709-17.**

- a second AHS study examined the prevalence of cataract surgeries among 3,761 study subjects 55–57 years after the bombings, in which 479 surgical-cataract cases were documented (33). The study subjects were primarily 0–35 years old at exposure

Strength of newer studies over earlier ones

- Negative aspects of earlier studies:
  - short follow-up periods,
  - failed to take into account increasing latent periods with decreasing doses,
  - relatively few subjects with doses below a few Gy.
- Positive aspects of newer studies: Long follow-up, larger numbers, lower doses

Why longer follow-up?

- The latent period is dependent on the rate at which damaged epithelial cells undergo aberrant differentiation (fibergenesis) and accumulate in the PSC region of the lens cortex .

IONIZING RADIATION

Damage to the Lens Epithelium

[*dividing cells*] → [*differentiating cells*]

↓

ABNORMAL LENS FIBERS

↓

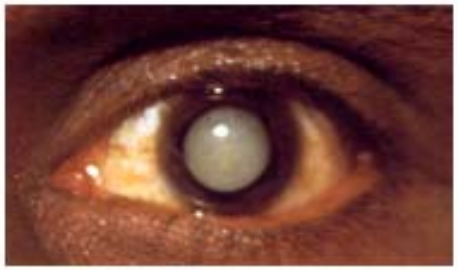
Loss of Transparancy

CATARACT

Information for
Health Professionals
Member States
Patients

Member Area
- Member States Area
- Drafts Management Area

IAEA Cataract study



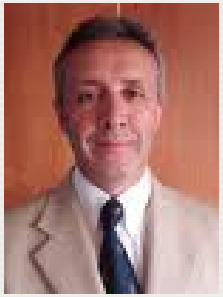
IAEA activity on Retrospective Evaluation of Lens Injuries and Dose (RELID)

The lens of the eye is one of the radiosensitive tissues in the body. Radiation induced cataract has been demonstrated among staff involved with interventional procedures using X rays [ICRP 85; Vano et al., 1998]. A number of studies suggest there may be significant risk of lens opacities in populations exposed to low doses of ionizing radiation. These include those undergoing CT scans [Klein et al., 1993], astronauts [Cucinotta et al., 2001; Rastegar et al., 2002], radiologic technologists [Chodick et al., 2008] radiotherapy [Hall et al., 1999] besides data from atomic bomb survivors [Nakashima et al., 2006; Neriishi et al., 2007] and those exposed in Chernobyl accident [Day et al., 1995]

These observations have clear implications for those working in interventional rooms. Interventionalists and paramedical staff (nurses and to some extent radiographers) remain near the X ray source and within a high scatter radiation field for several hours a day during interventional procedures. During typical working conditions and if radiation protection tools are not routinely used, x-ray exposure to the eyes of interventional physicians and paramedical personnel working in interventional and catheterization laboratories can be high.

The cataract has so far been considered to be a deterministic effect with threshold. The International Commission on Radiological Protection (ICRP) and the U.S. National Council on Radiology Protection

Active collaborators



IAEA Cataract

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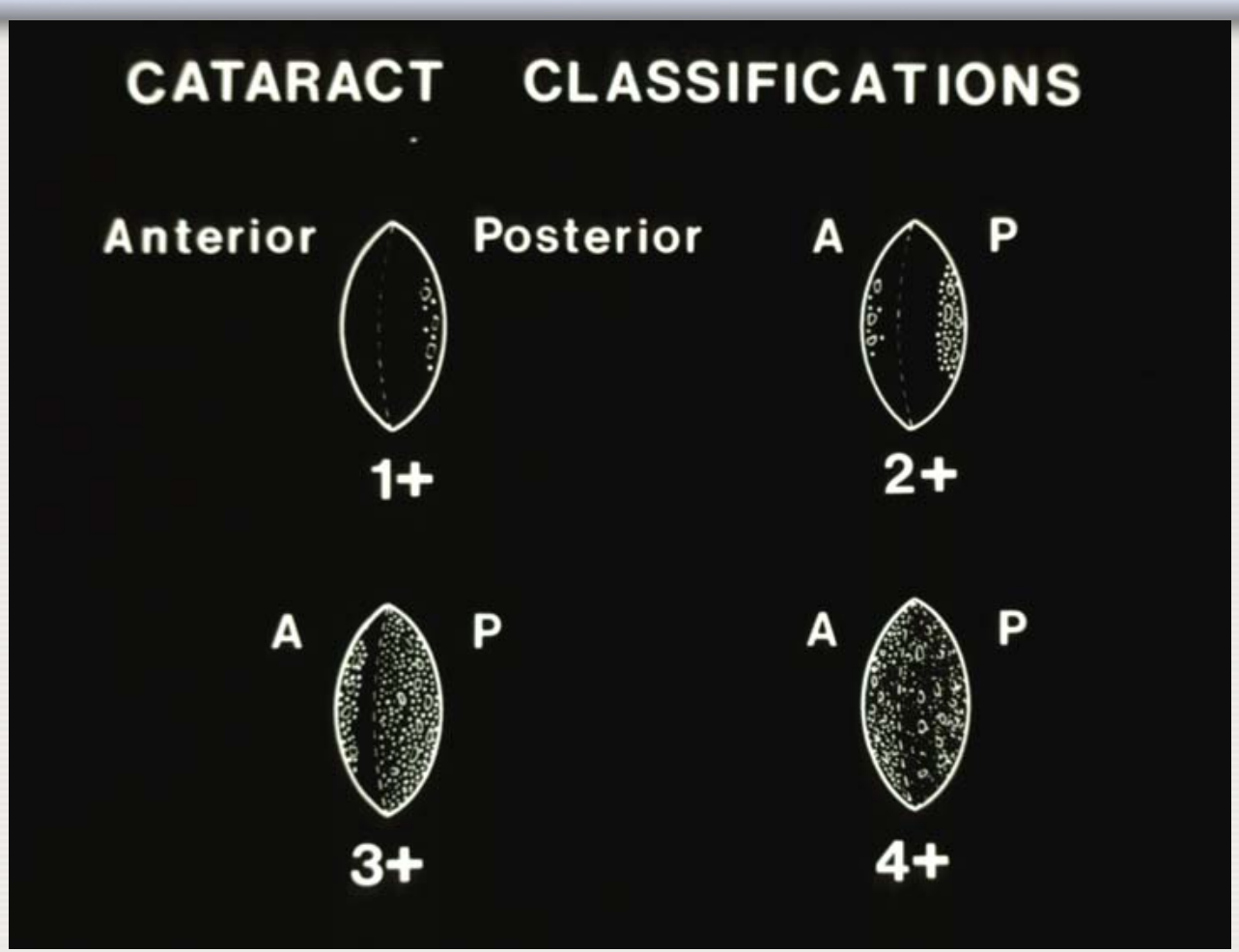
IAEA Cataract study - List of Eye testing exercises conducted

No	Place (City, Country)	Dates	Regional/National organization	Links
1	Bogota, Colombia	25-26 Sept.2008	SOLACI[1]	RELID report Colombia [English], [Español]
2	Kuala Lumpur, Malaysia	17-19 April 2009	NAHM[2]	RELID report Malaysia
3	Montevideo, Uruguay	16-17 April 2009	SOLACI[1]	RELID report Uruguay [English], [Español]
4	Varna, Bulgaria	11-12 July 2009	NCRRP[3]	RELID report Bulgaria
5	Sofia, Bulgaria	13-15 July 2009	NCRRP[3]	RELID report Bulgaria
6	Bangkok, Thailand New!	23-24 December 2009		RELID report Thailand
7	Buenos Aires, Argentina New!	11-13 August 2010	SOLACI[1]	RELID report Argentina [English], [Español]

Overview of studies

- A-Bomb survivors- Not in occupational settings
- Chernobyl workers- acute exposure
- Air Crew
- Medical occupational
  - NIH
  - IAEA studies
  - Unpublished from others

Cataract Staging: *Merriam & Focht &, 1962*



Epidemiological evidences

American Journal of Epidemiology
Published by the Johns Hopkins Bloomberg School of Public Health 2008.

Vol. 168, No. 6
DOI: 10.1093/aje/kwn171
Advance Access publication July 29, 2008

Original Contribution

Risk of Cataract after Exposure to Low Doses of Ionizing Radiation: A 20-Year Prospective Cohort Study among US Radiologic Technologists

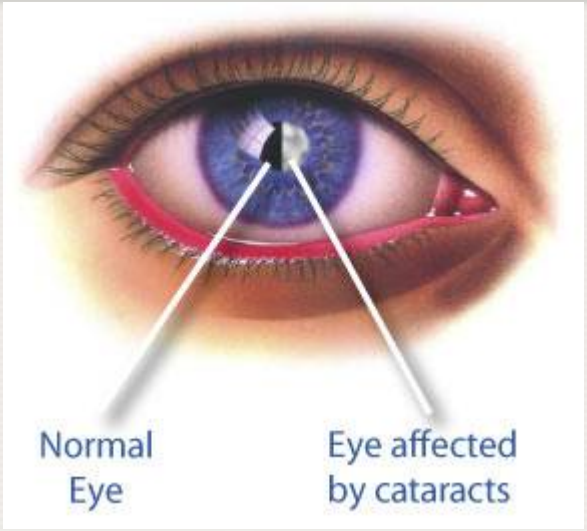
Gabriel Chodick[1], Nural Bekiroglu[2], Michael Hauptmann[3,4], Bruce H. Alexander[5], D. Michal Freedman[1], Michele Morin Doody[1], Li C. Cheung[6], Steven L. Simon[1], Robert M. Weinstock[1], André Bouville[1], and Alice J. Sigurdson[1]

and nonoccupational exposures to ionizing radiation and to personal characteristics. A ... cohort of 35,705 cataract-free US radiologic technologists aged 24–44 years was followed ... years (1983–2004) by using two follow-up questionnaires. During the study period, 2,382 cat... cataract extractions were reported. Cigarette smoking for ≥5 pack-years; body mass inde..., and history of diabetes, hypertension, hypercholesterolemia, or arthritis at baseline were ... ≤ 0.05) associated with increased risk of cataract. In multivariate models, self-report of ≥3 x-rays ... neck was associated with a hazard ratio of cataract of 1.25 (95% confidence interval: 1.06, 1.47). For ... kers in the highest category (mean, 60 mGy) versus lowest category (mean, 5 mGy) of occupational dose to the lens of the eye, the adjusted hazard ratio of cataract was 1.18 (95% confidence interval: 0.99, 1.40). Findings challenge the National Council on Radiation Protection and International Commission on Radiological Protection assumptions that the lowest cumulative ionizing radiation dose to the lens of the eye that can produce a progressive cataract is approximately 2 Gy, and they support the hypothesis that the lowest cataractogenic dose in humans is substantially less than previously thought.

Median eye lens dose: 28 mGy

cataract; radiation; technology, radiologic; x-rays

- Lens opacities which may or may not lead to cataract
- Surgically operated cataracts among medical occupational group ???



Epidemiologists

Occupational risks
(difficulty with dose)

Radiation Protection professionals

- Good at dose estimations
- Training to prevent
- Capability to solve the problem
- Monitoring of effectiveness of RP actions
- Regulatory support
- -ve: not good in epidemiological context

Few tens of thousands

Summary

- Clear that cataract is possible at doses below the currently accepted threshold
- Larger scale studies in occupational settings
- Actual cataract demonstration
  - With typical doses in occupational settings
  - With dose estimates
  - Long term follow up

CHALLENGE to this group!!!!!!

ORAMED workshop barcelona

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Optimization of Radiation Protection of Medical Staff.
rpop.iaea.org/RPOP/RPoP/.../international-**workshop-oramed**.htm - Cached

Work in progress / WP5 / Workpackages / **ORAMED** - SCK•CEN
The venue, scope and general organization of the **ORAMED workshop** were agreed in September 2009. The **workshop** will be held in **Barcelona**, from 20th to 22nd of **...**
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events.emagister.co.uk/congresses/**oramed**...**workshop**.../26143 - Cached

International **Workshop ORAMED** 2011 Optimization of Radiation **...**
19 Apr 2010 **...** International **Workshop ORAMED** 2011. Optimization of Radiation Protection of Medical Staff. Dates: 20-22 January 2011. Location: **Barcelona ...**
www.euradnews.org/fullstory.php?storyid=230375 - Cached

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