

Infrared Cataract And Temperature Elevation Within The Eye

Tsutomu OKUNO

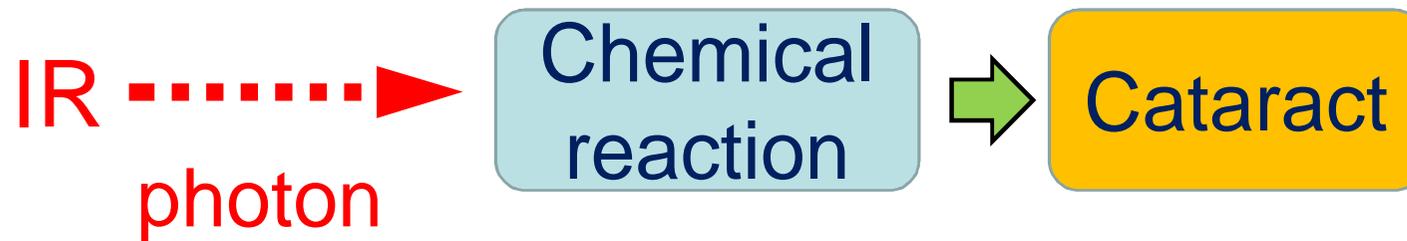
**International Commission on Non-Ionizing Radiation Protection
National Institute of Occupational Safety and Health, Japan**

What is infrared cataract?

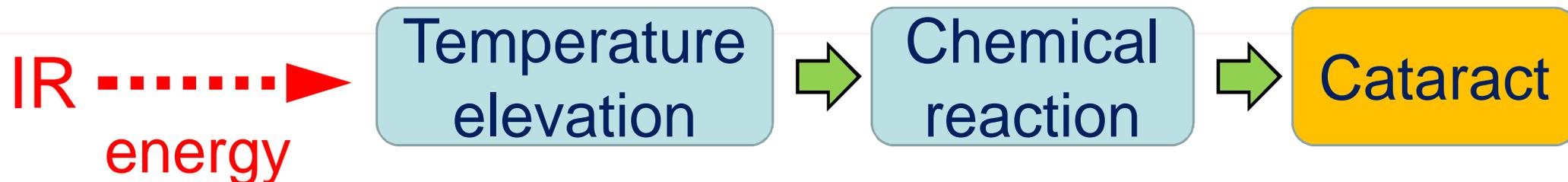
- IR cataract occurs in workers who have been engaged in the glass or steel industry for many years (e.g. glassblower's cataract).
- IR cataract is associated with exposure to intense IR emitted from molten materials and the inside of industrial furnaces.
- Recently, there is concern that infrared LEDs and diode lasers may cause cataract.

Interaction mechanism

➤ Photochemical mechanism



➤ Thermal mechanism

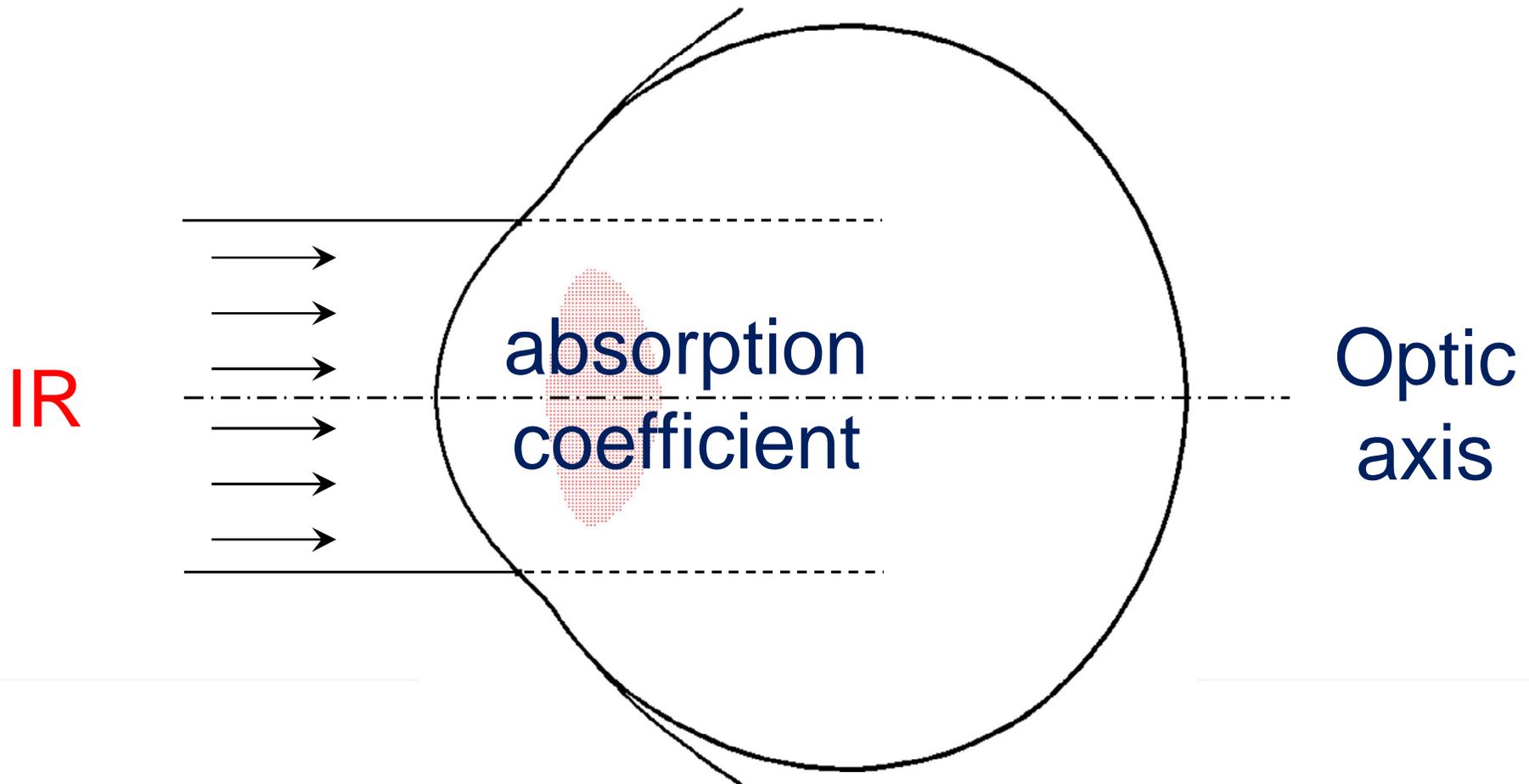


Temperature elevation within the eye

Calculation based on a model of IR absorption and heat transfer within the eye

- Tsutomu Okuno (1991) Thermal effect of infra-red radiation on the eye: a study based on a model, Ann. Occup. Hyg. 35, 1-12.
- Tsutomu Okuno (1994) Thermal effect of visible and infra-red radiation (i.r.-A, i.r.-B and i.r.-C) on the eye: A study of infra-red cataract based on a model, Ann. Occup. Hyg. 38, 351-359.

Assumptions about IR absorption (1)



Assumptions about IR absorption (2)

➤ Monochromatic radiation

Visible: 400 nm, 425 nm, ... , 775 nm

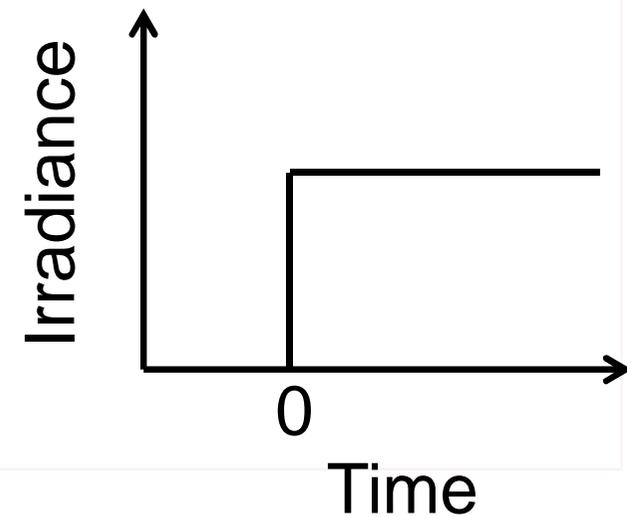
IR-A: 800 nm, 825 nm, ... , 1400 nm

IR-B: 1425 nm, 1450 nm, ... , 1900 nm

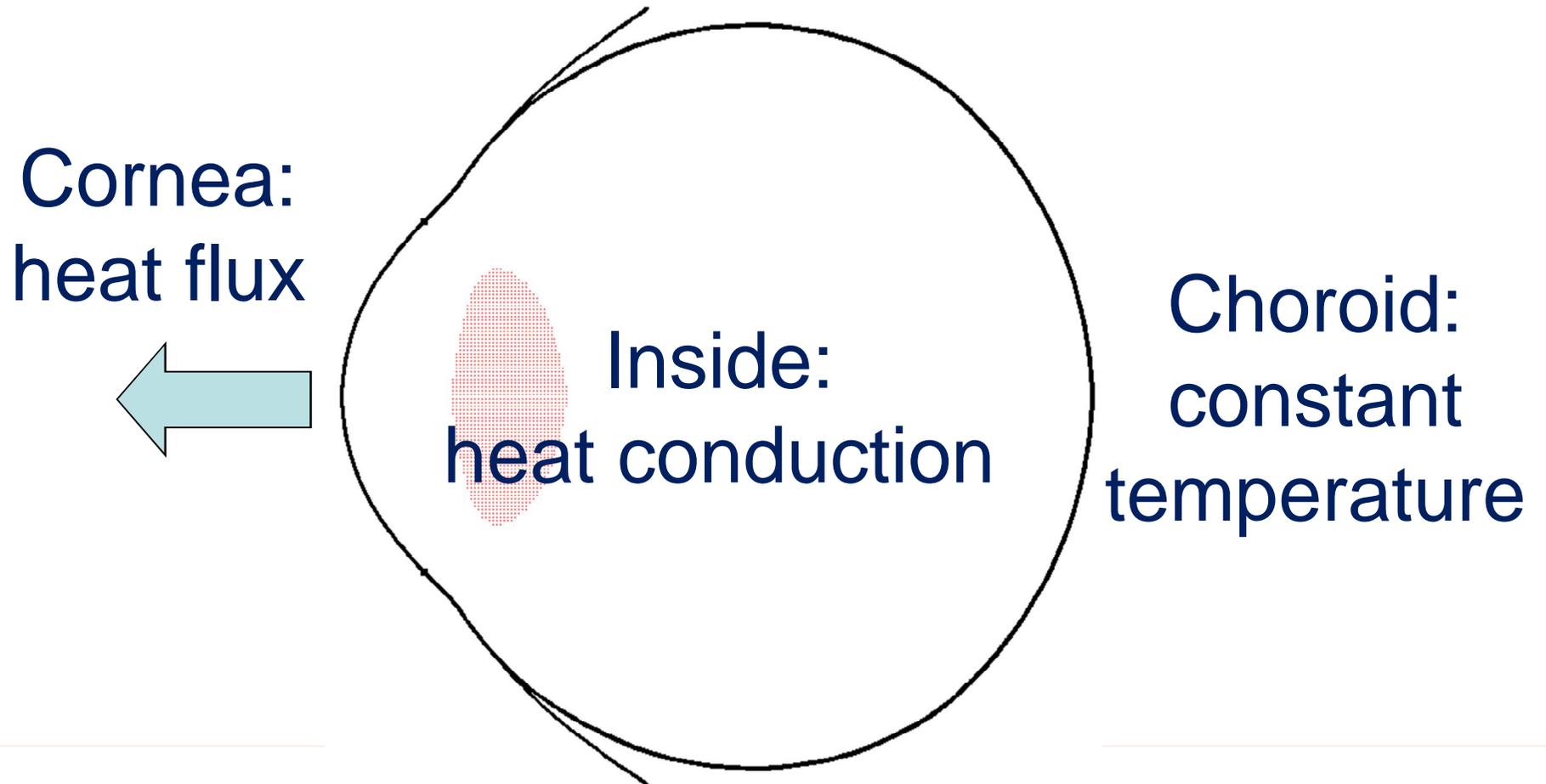
➤ Black-body radiation

1200°C: Working temperature of glass

1500°C: Melting point of iron

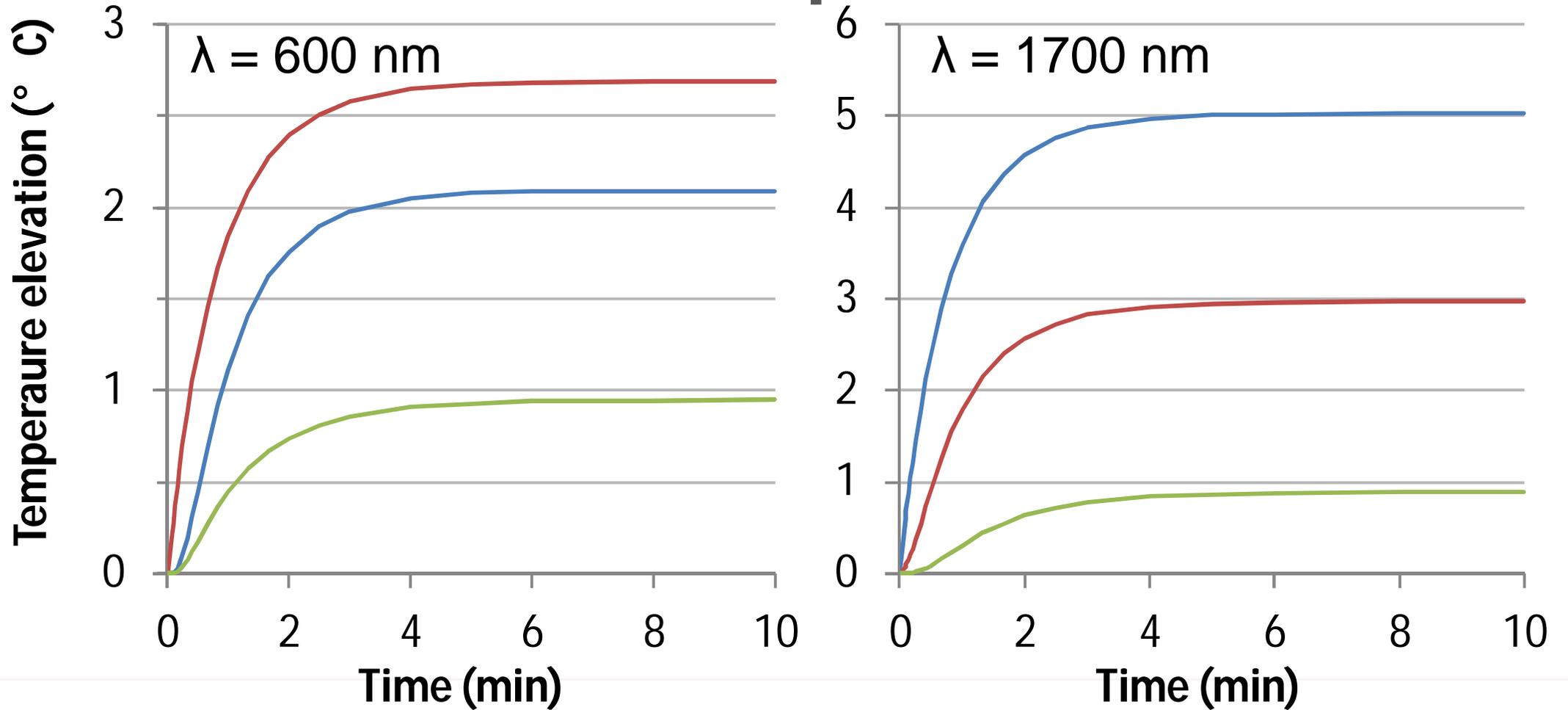


Assumptions about heat transfer



The relative temperature elevations above normal, unexposed conditions within the eye were calculated.

Time course of temperature elevation

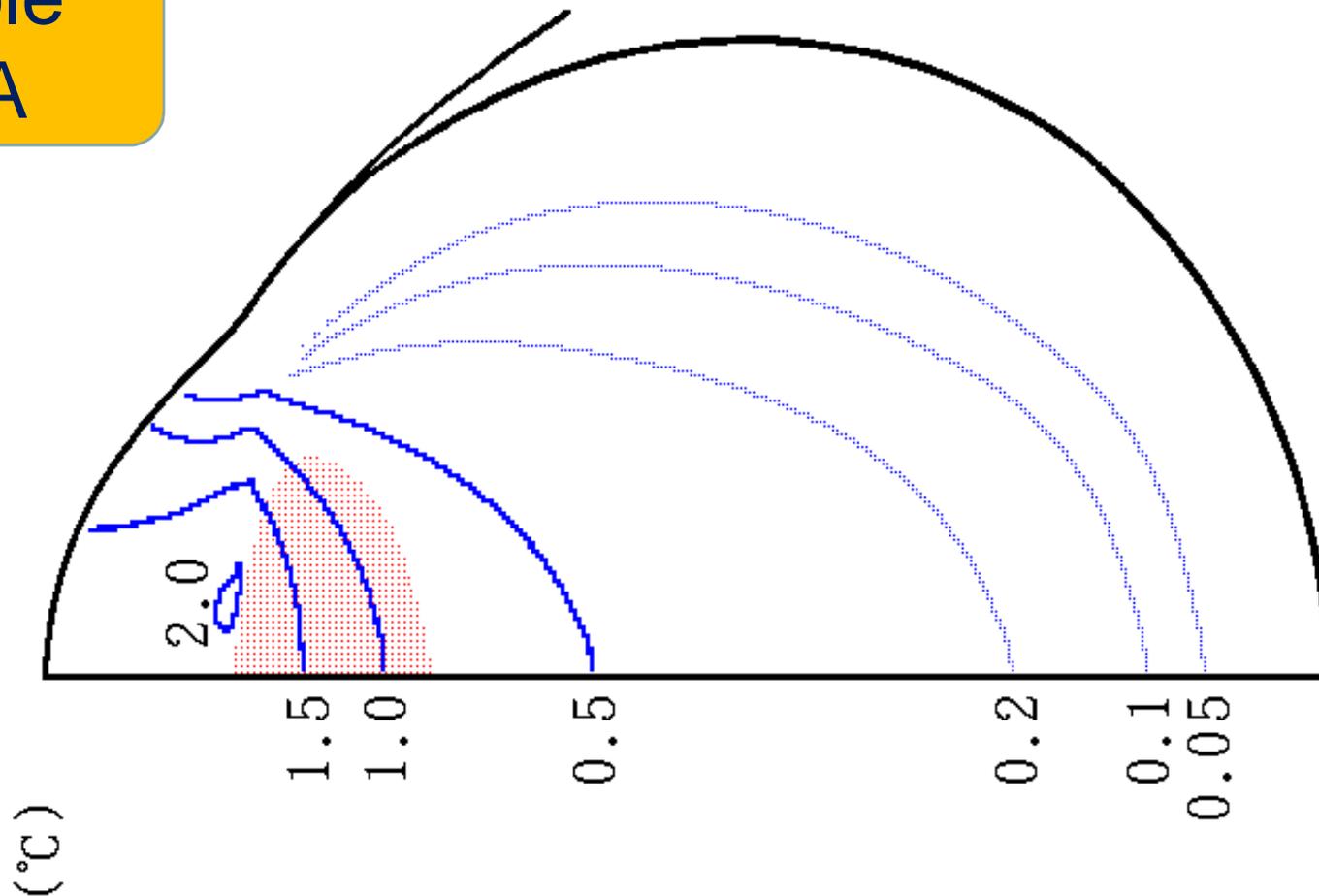


- Anterior surface of cornea
- Anterior surface of lens
- Posterior surface of lens

(100 mW/cm²)

Distribution of temperature elevation (1)

Visible
IR-A

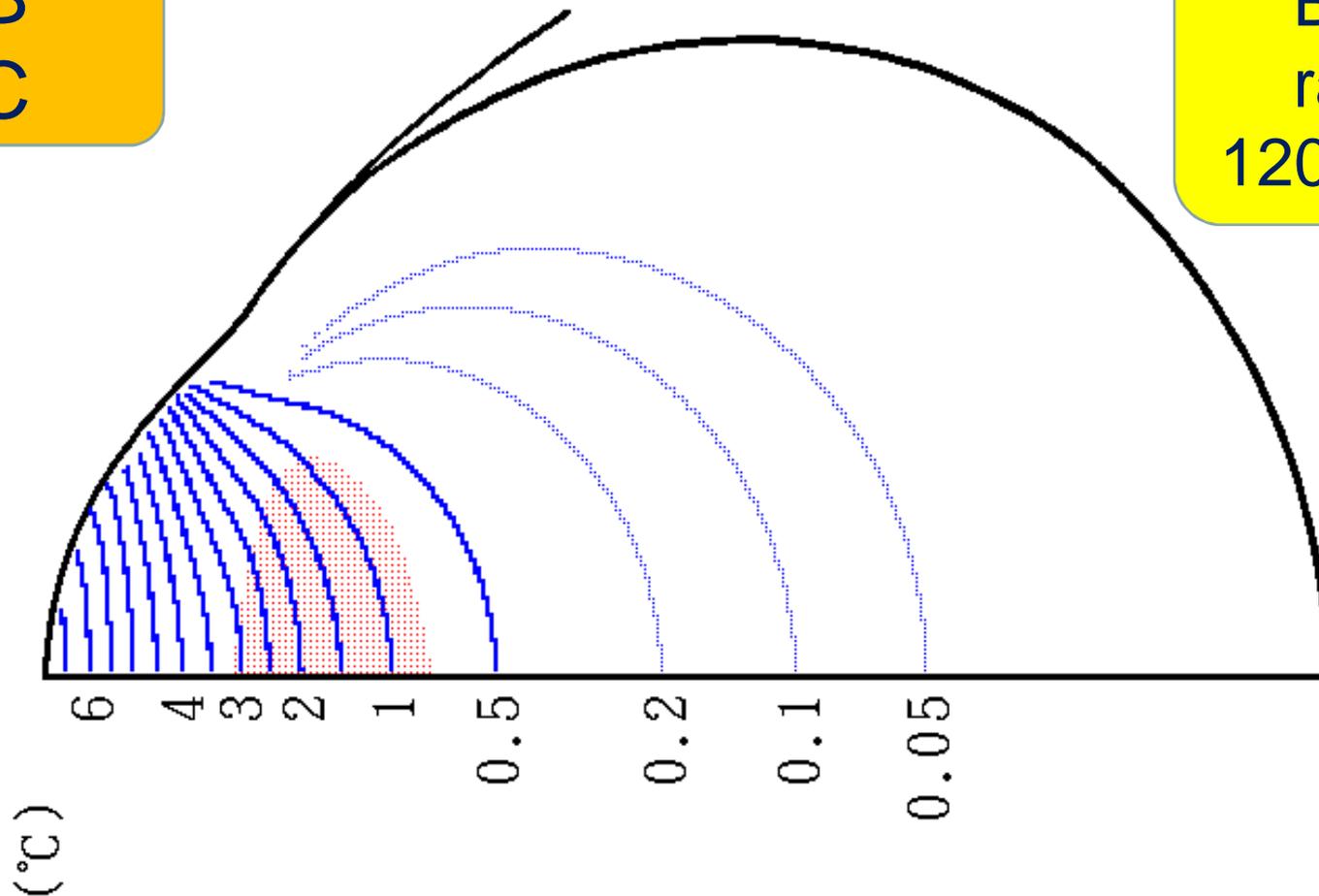


1000 nm
100 mW/cm²
10 min

Distribution of temperature elevation (2)

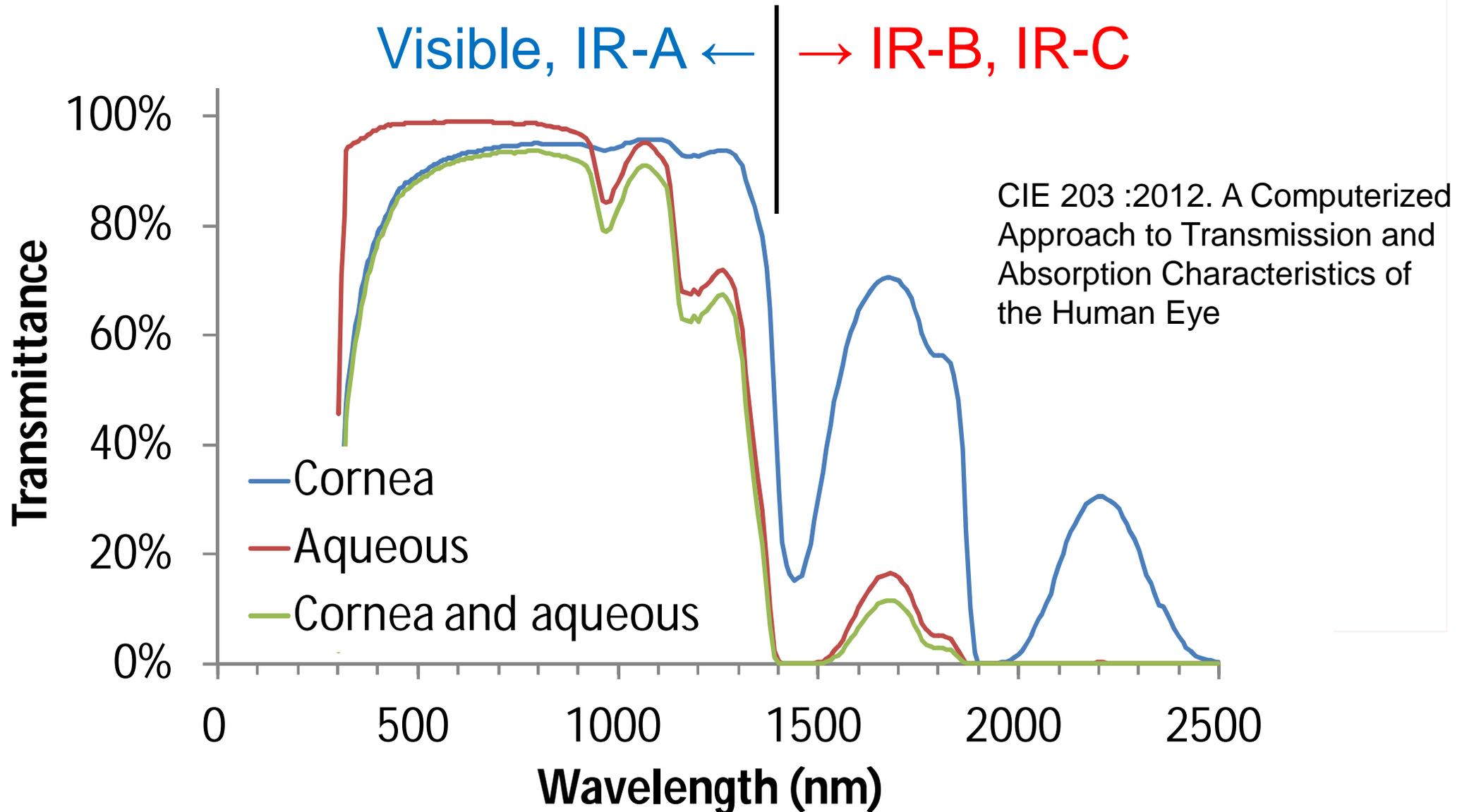
IR-B
IR-C

Black-body
radiation of
1200°C, 1500°C

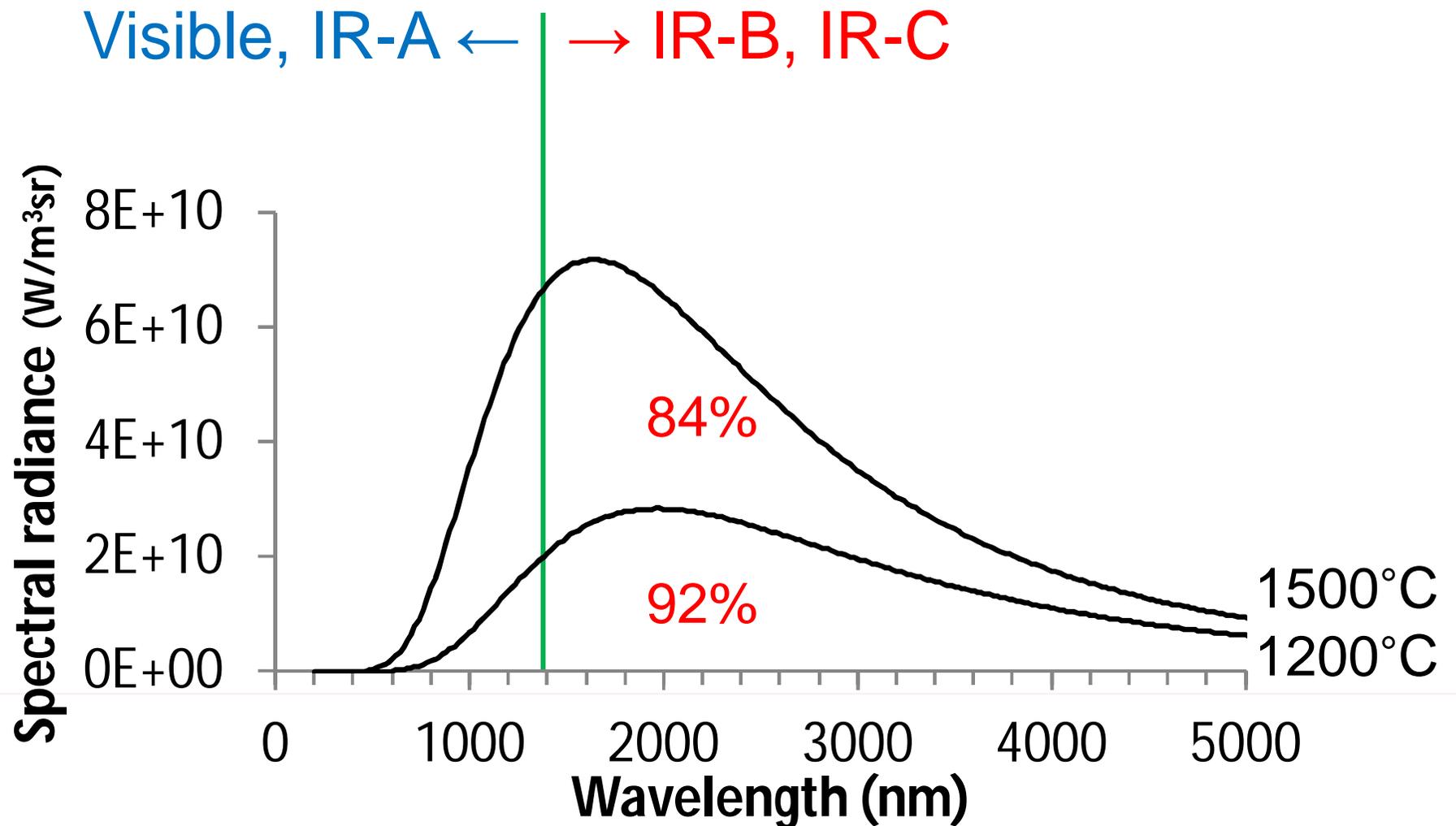


1500 nm
100 mW/cm²
10 min

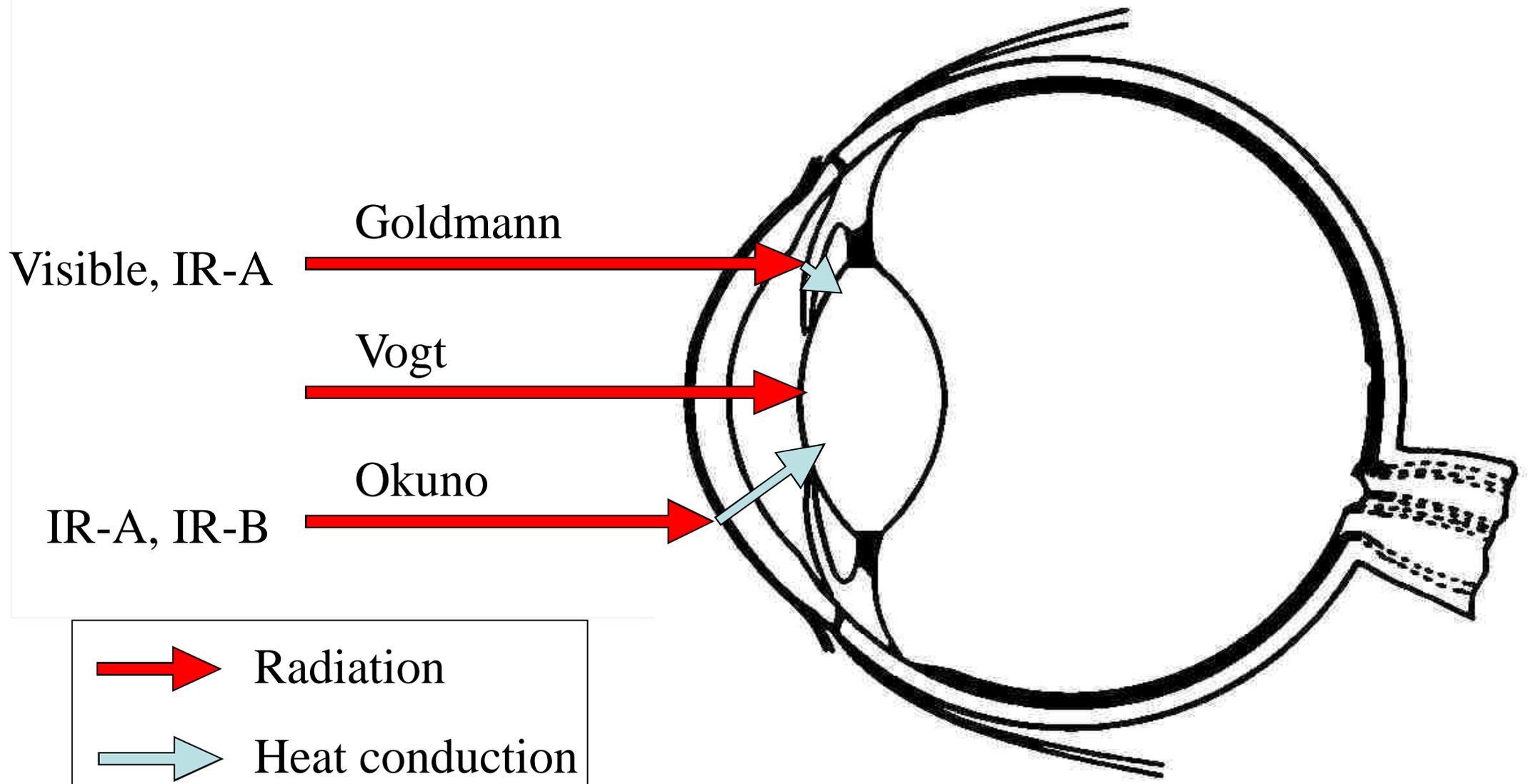
Transmittance of cornea and aqueous humor



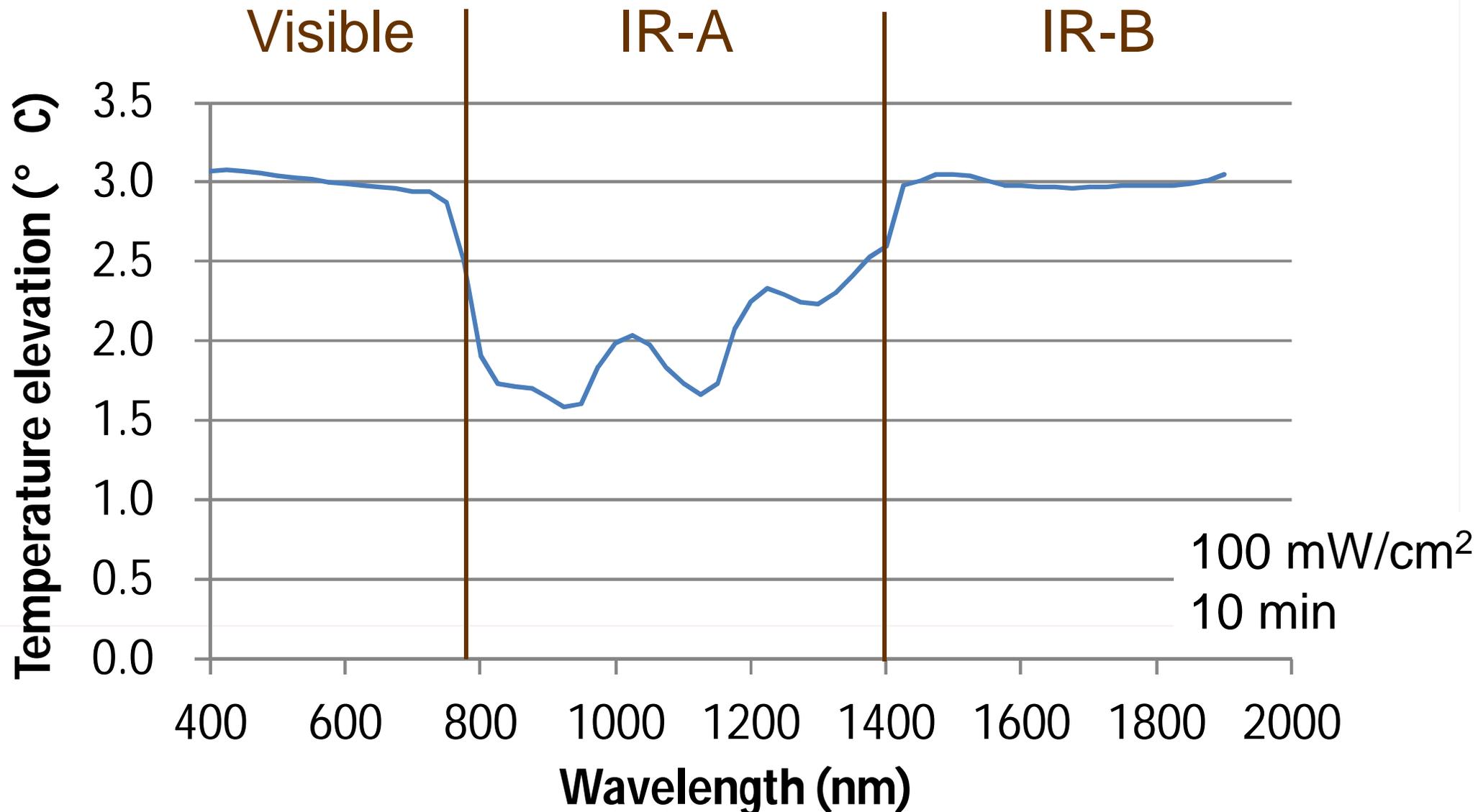
Spectral distribution of black-body radiation



Mechanisms of temperature elevation



Maximum temperature elevation in the lens



Summary on temperature elevation (1)

- The temperatures within the eye increase steeply with exposure for about 2 min, then level off and remain constant for exposures for more than about 5 min.
- For exposure to visible radiation and IR-A, the temperature elevation within the eye is the greatest at the iris.
- For exposure to IR-B and IR-C, the temperature elevation within the eye is the greatest at the center of the anterior surface of the cornea.

Summary on temperature elevation (2)

- For exposure to black-body radiation of 1200°C and 1500°C, the temperature elevation within the eye is the greatest at the center of the anterior surface of the cornea.
- Visible radiation and IR-B induce greater temperature elevations in the lens than IR-A, and are supposed to be more effective in causing cataract.

Summary on mechanisms

- For exposure to visible radiation and IR-A, the radiant energy is absorbed and converted into heat in the iris, which is then conducted to the lens.
- For exposure to IR-B and IR-C, the radiant energy is absorbed and converted into heat in the cornea, which is then conducted to the lens.
- For exposure to black-body radiation of 1200°C and 1500°C, the radiant energy is absorbed and converted into heat in the cornea, which is then conducted to the lens.

Cataract formation in rabbits exposed to IR-A

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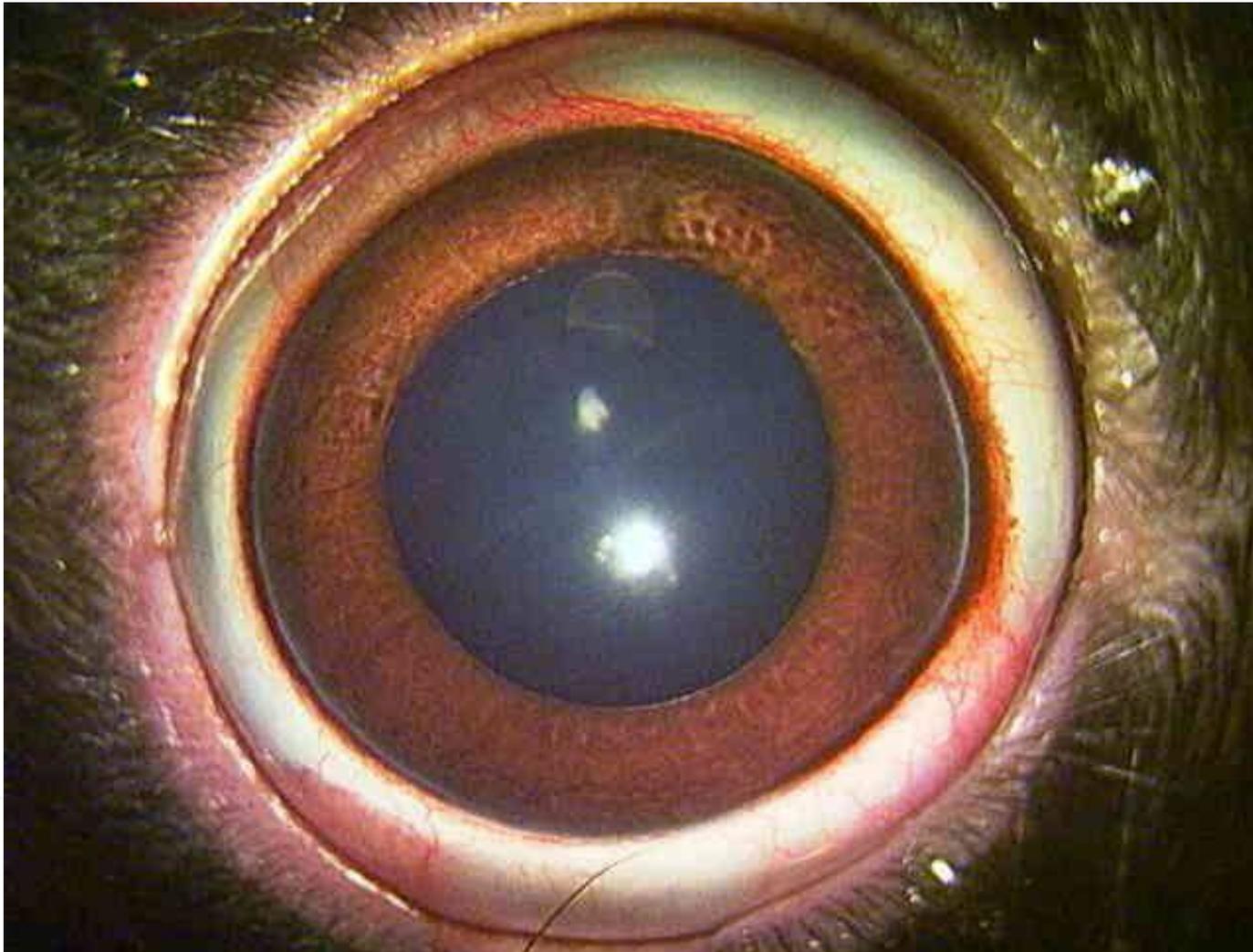
³ Yamamoto Kogaku, Co., Ltd.

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Exposure to 808 nm IR-A

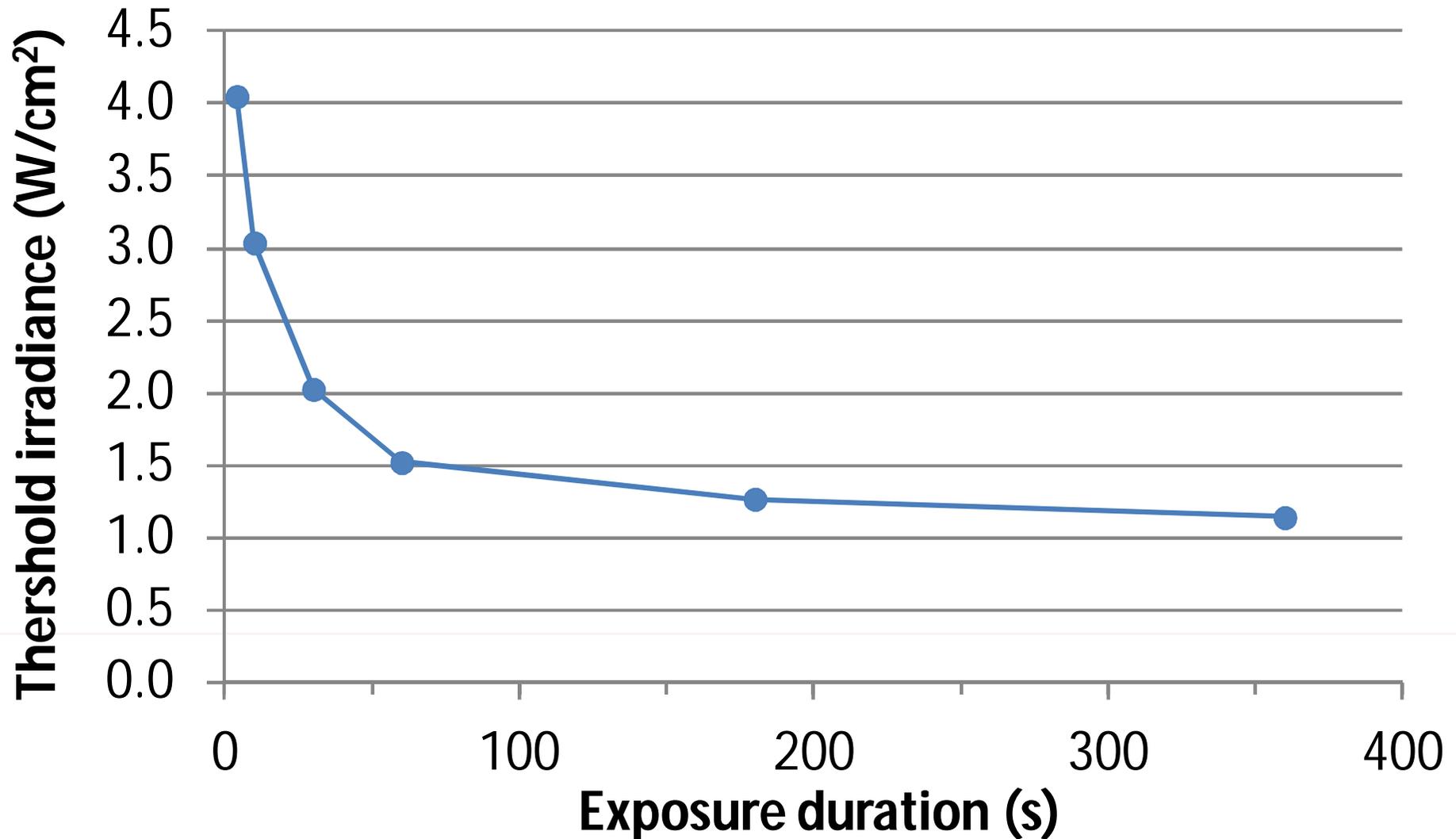


Results



After one day of exposure at 6.1 W/cm^2 for 4 s

Threshold irradiance vs. exposure duration



CIE technical report on infrared cataract

Okuno, T. (Chair)	Japan
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Shang, Y.-M.	Chinese Taipei
Sliney, D.	USA
Söderberg, P.	Sweden
Stuck, B.	USA
Suzuki, Y.	Japan
Tengroth, B.	Sweden