

16.400/453J

Human Factors Engineering

# Introduction

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# Outline

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- Introductions
- Human Factors Evaluation
- Syllabus
- Overview of Human Factors
- Case study presentation
- Questions

# Human Factors Evaluation

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- **Each Student** is to choose a Human Factors example and write down:
  - Some HF Issue (what is difficult or dangerous)
  - A potential solution to the problem
  - And what you would need to know to design a good solution.
  - **Put YOUR NAME and contact info on the card**
  - **They will be collected at the end of the case study presentation**

# Syllabus

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- Books
  - Proctor, R. W., & Van Zandt, Dismukes, et al., Bluman, A.G
- Readings
- Case studies
  - Presentations
- Online surveys (Daily Quizzes)
- P-sets (2) & Projects (3 UG +1 G)
- Quizzes
- Grad students

# Overview of Human Factors

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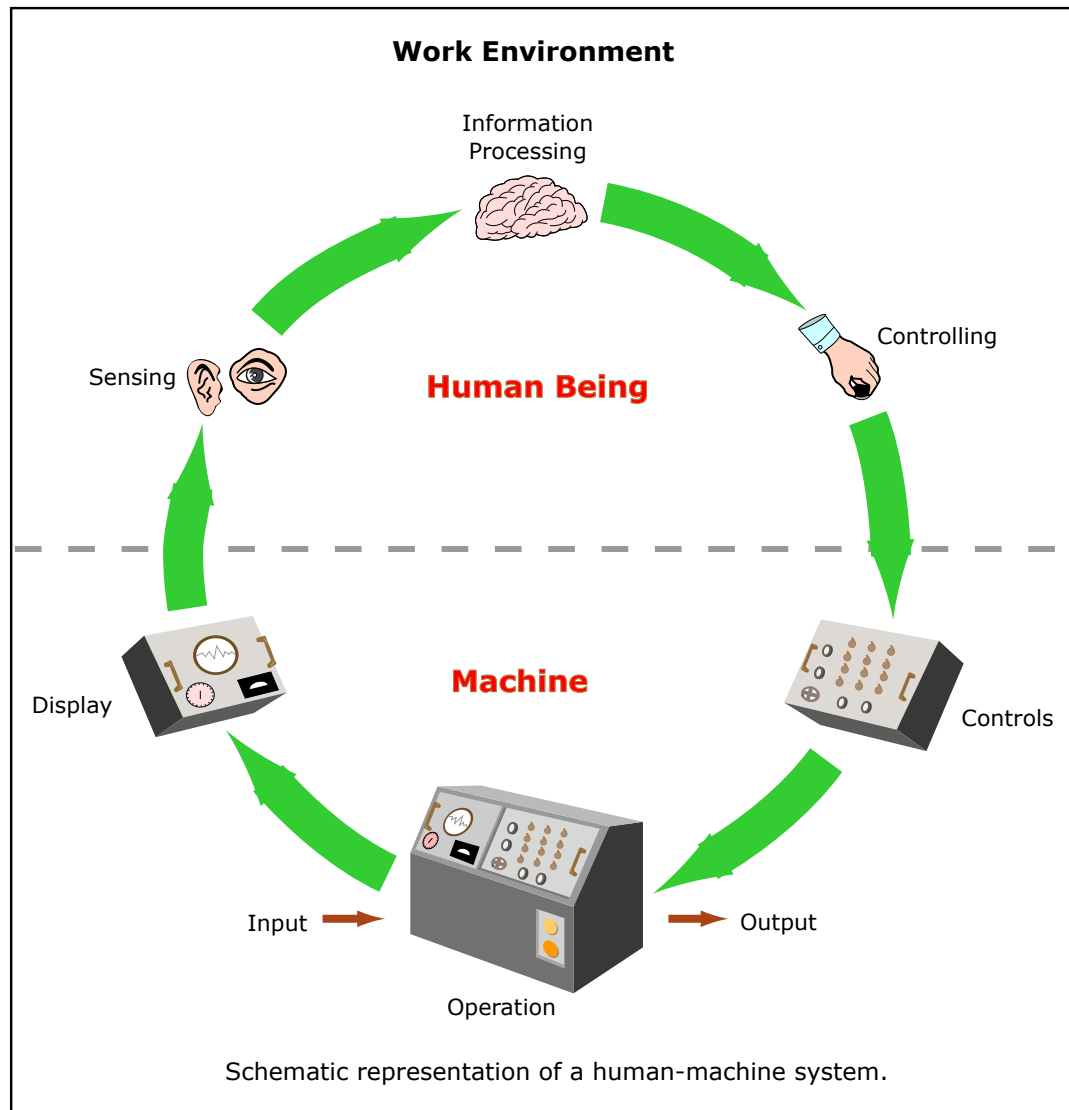


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# Case Study Presentation

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# Eastern Airlines Flight 401

Larry Young

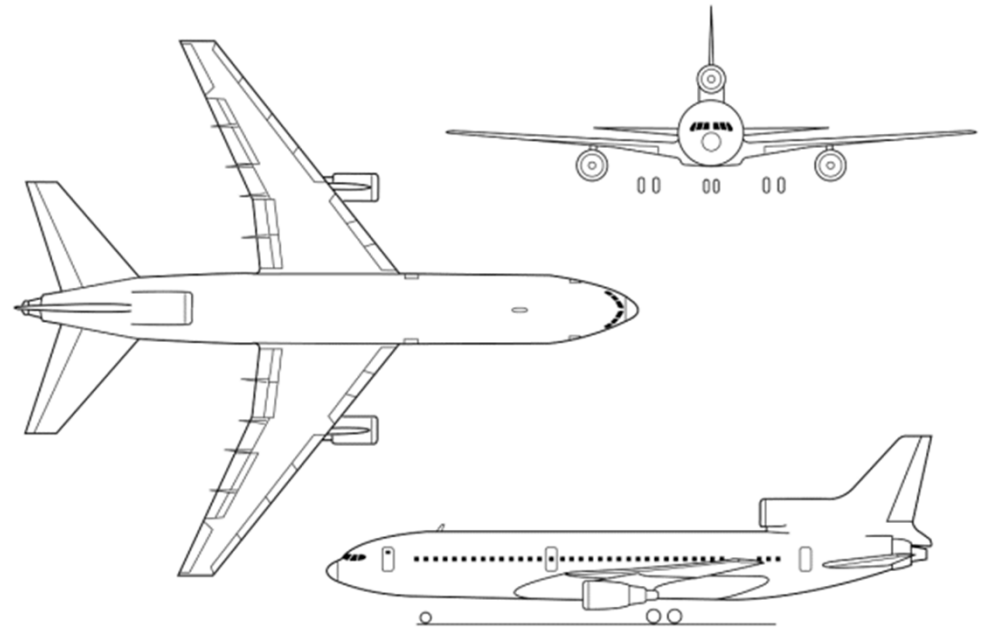
# Flight Summary

- Lockheed L-1011 Tristar
- Departed NY(JFK) -> Florida(MIA) 9:20pm, Dec29th, 1972
- Crashed 11:42pm ~18 miles from MIA
- 103/176 People on board died in the crash.
- Cause of the accident (NTSB):
  - Failure of crew to monitor instruments during final 4 minutes of flight, leading to CFIT
  - Distraction while dealing with failure of nose landing gear position light is a contributing factor



# Lockheed L-1011 TriStar

- Competitor of the DC-10
- Triple-engine configuration, 400 passengers max.
- Between 1968 and 1984, Lockheed manufactured a total of 250 TriStars.
- The L-1011 was advertised technologically largely ahead of its time.
- First widebody to receive FAA certification for Cat-IIIc autoland (no decision height, zero visibility).



This image is in the public domain. Source: NASA

# L-1011 Overview

- Direct Lift Control (DLC) system which allowed for smooth approaches when landing.
- Four redundant hydraulic systems (the DC10 and MD11 had only three).
- As of September 2006, 33 are in service with ad hoc charter and military carriers, as well as Hewa Bora Airways of the Democratic Republic of Congo, the sole remaining operator of scheduled TriStar flights.
- Most remaining L-1011's are now being sold for scrap.
- There has never been a crash of an L-1011 due to mechanical failure.

# Flight Narrative

- The flight crew was qualified, with >40,000 flight hours between the Captain and the First Officer.
- There was an experienced Flight Engineer, and a maintenance officer in the cockpit as well.
- The flight was essentially uneventful leading up to the approach to MIA.
- During the approach, the landing gear handle was lowered, but only 2/3 gear could be confirmed to be in the down position (via the cockpit indicator lights).

# L-1011 Cockpit

Images of Lockheed L-1011 cockpit removed due to copyright restrictions.

Images of Lockheed L-1011 cockpit removed due to copyright restrictions.

# Flight Narrative

- Unsure of whether the gear or the indicator was at fault, the Captain elected to abort the landing.
- The flight was directed by ATC to 2000ft and was given a course to hold while diagnosing the problem.
- The autopilot was engaged to hold course and altitude.
- The Captain ordered the F/O to fly the plane while he communicated with ATC and coordinated with the Flight Engineer to diagnose the problem.

# Flight Narrative

- Upon reporting that the hydraulics were online, the Flight Engineer was ordered down into the “hell hole”.
- The copilot pulled out the suspect light, inspected it, and jammed it back in the panel incorrectly.
- **Captain:** You got it sideways, then.  
**Co-pilot:** Naw, I don't think it'll fit.  
**Captain:** You gotta turn it one quarter turn to the left.  
**Captain:** Hey, hey, get down there and see if that damn nose wheel's down. You better do that.  
**Co-pilot:** You got a handkerchief or something so I can get a little better grip on this? Anything I can do with it?  
**Captain:** Get down there and see.  
**Co-pilot:** This won't come out, Bob. If I had a pair of pliers, I could cushion it with that Kleenex.  
**Flight Engineer:** I can give you pliers but if you force it, you'll break it, just believe me  
**Co-pilot:** Yeah, I'll cushion it with Kleenex

# Flight Narrative

- At 11:40:38 a C-chord was heard in the CVR, indicating a 250ft deviation from the selected altitude. This was apparently missed by the flight crew.

- **Co-pilot:** Naw that's right, we're about to cross Krome Avenue right now.

[Sound of click]

**Co-pilot:** I don't know what the # holding that # # # # in'

**Co-pilot:** Always something, we coulda make schedule'

[Sound of altitude alert]

**Captain:** We can tell if that # # # # is down by looking down at our indices

**Captain:** I'm sure it's down, there's no way it couldnt help but be

**Co-pilot:** I'm sure it is



# Flight Narrative

- The Flight Engineer in the hole reported that he couldn't see the gear through the viewing periscope, as it was too dark.
- The maintenance officer riding in the jumpseat attempted to help, but also couldn't see anything.
- The problem was discussed for another 30s before it was decided to turn back to the airport.

# Flight Narrative

- **Air traffic controller:** Eastern, ah 401 how are things comin' along out there?  
**Capt to air traffic controller:** Okay, we'd like to turn around and come, come back in.  
**Captain:** Clear on left?  
**Co-pilot:** Okay  
**Air traffic controller:** Eastern 401 turn left heading one eight zero  
**Co-pilot:** We did something to the altitude '  
**Captain:** What? '  
**Co-pilot:** We're still at two thousand right?'  
**Captain:** Hey, what's happening here? '

[Sound of click]

[Sound of six beeps similar to radio altimeter increasing in rate]

[Sound of impact]

# Flightpath, 29 DEC 1972, Eastern Tristar Everglades, FL

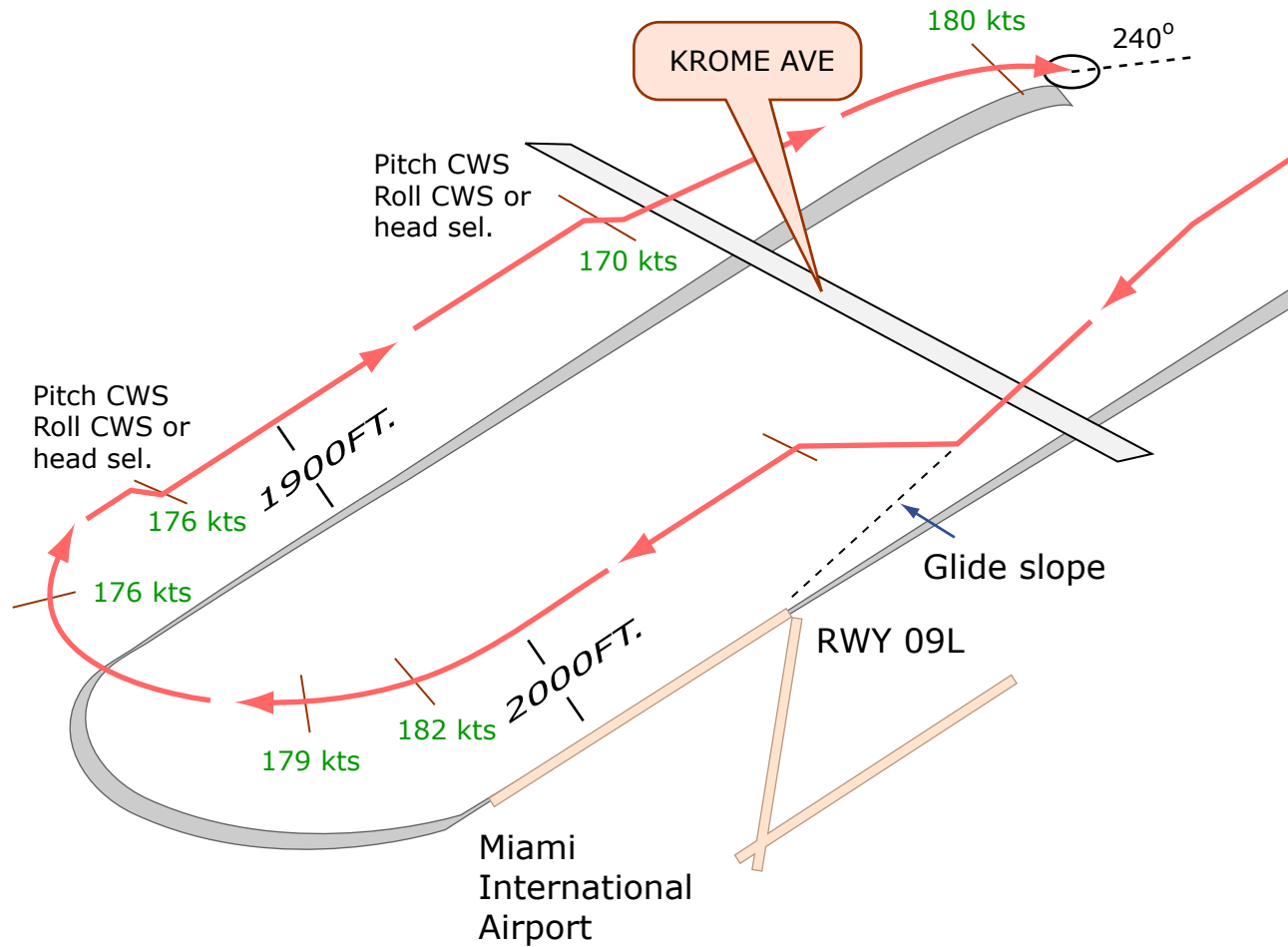


Image by MIT OpenCourseWare.

# Investigation

- Examination of the wreckage showed that the indicator bulb had been burned out, and that the gear was operational
- It was speculated that the pilot may have inadvertently bumped the control column, disengaging the autopilot from its altitude-hold mode, and that this went undetected by the flight crew
- The altitude had gradually decayed over a period of minutes before impact

# HF Issues

- Poor Crew Resource Management (CRM)
- Failure to maintain task priority: “**Aviate, Navigate, Communicate**”
- Overreliance on Automation, leading to loss of situational awareness
- Excessively cluttered and complicated cockpit layout

# Possible Solutions

- CRM training
- Simplified cockpit design (glass?)
- Improve training emphasizing **aviate** first
- More intelligent automation:
  - Better alarm for autopilot disengage

# References

- NTSB:AAR 73-14. 14 JUN, 1973. Retrieved 5 Sep, 2006, from <http://www.nts.gov/>
- “Eastern Airlines Flight 401 Memorial”. Retrieved 5 Sep, 2006, from <http://eastern401.googlepages.com/>

Questions?

# Syllabus Overview

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- Introduction and Vision I
- Vision II
- Space Bioastronautics
- Research Methods I
- Research Methods II
- Vestibular/Spatial Disorientation
- Displays
- Space Human Factors
- Auditory
- Attention/Workload
- PIO and Cooper Harper
- Handling Qualities
- Space Physiology
- Automation, Situation Awareness
- Decision Making
- Flight Deck Automation Working Group
- Manual Control I
- Manual Control II, FAA Regulations
- Fatigue/Circadian Rhythms
- Automobile HF
- Response Selection & Control of Movement
- Anthropometry/Environmental Ergonomics
- Volpe HF Lab Tour

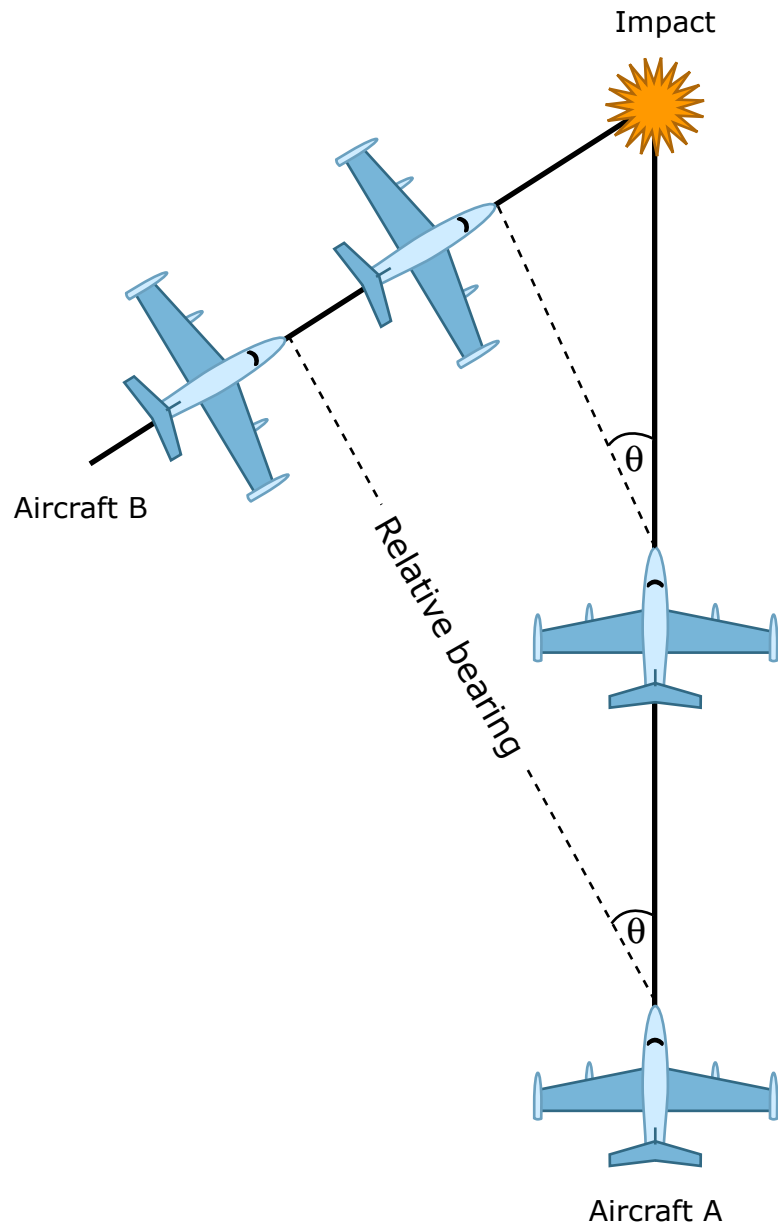


# Human Vision and Aircraft Displays

## Part 1 The Eye

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Prof. L. R. Young



Aircraft about to collide will remain at constant relative bearings.  
(i.e there will be no movement across the windshield)

Image by MIT OpenCourseWare.

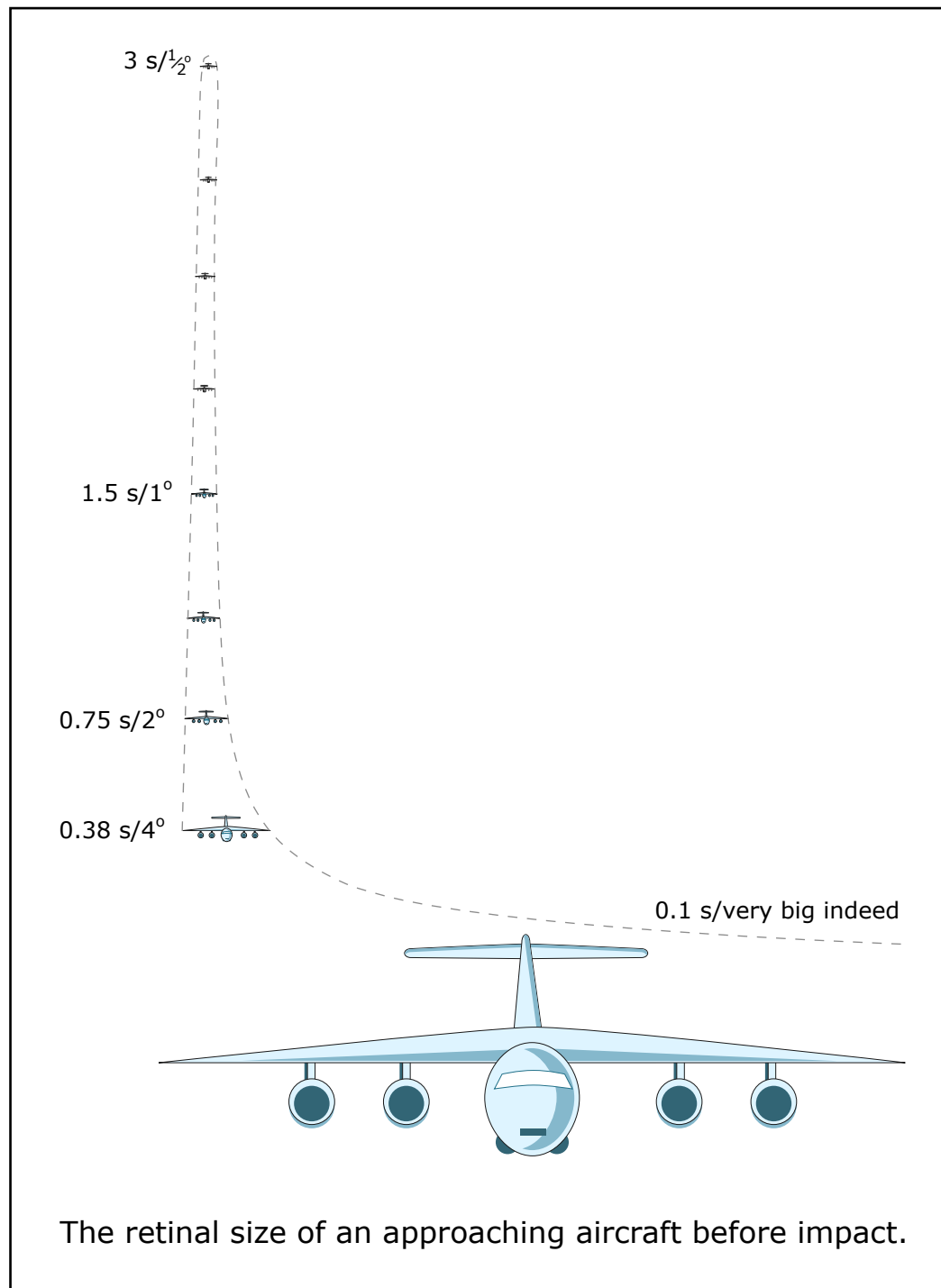


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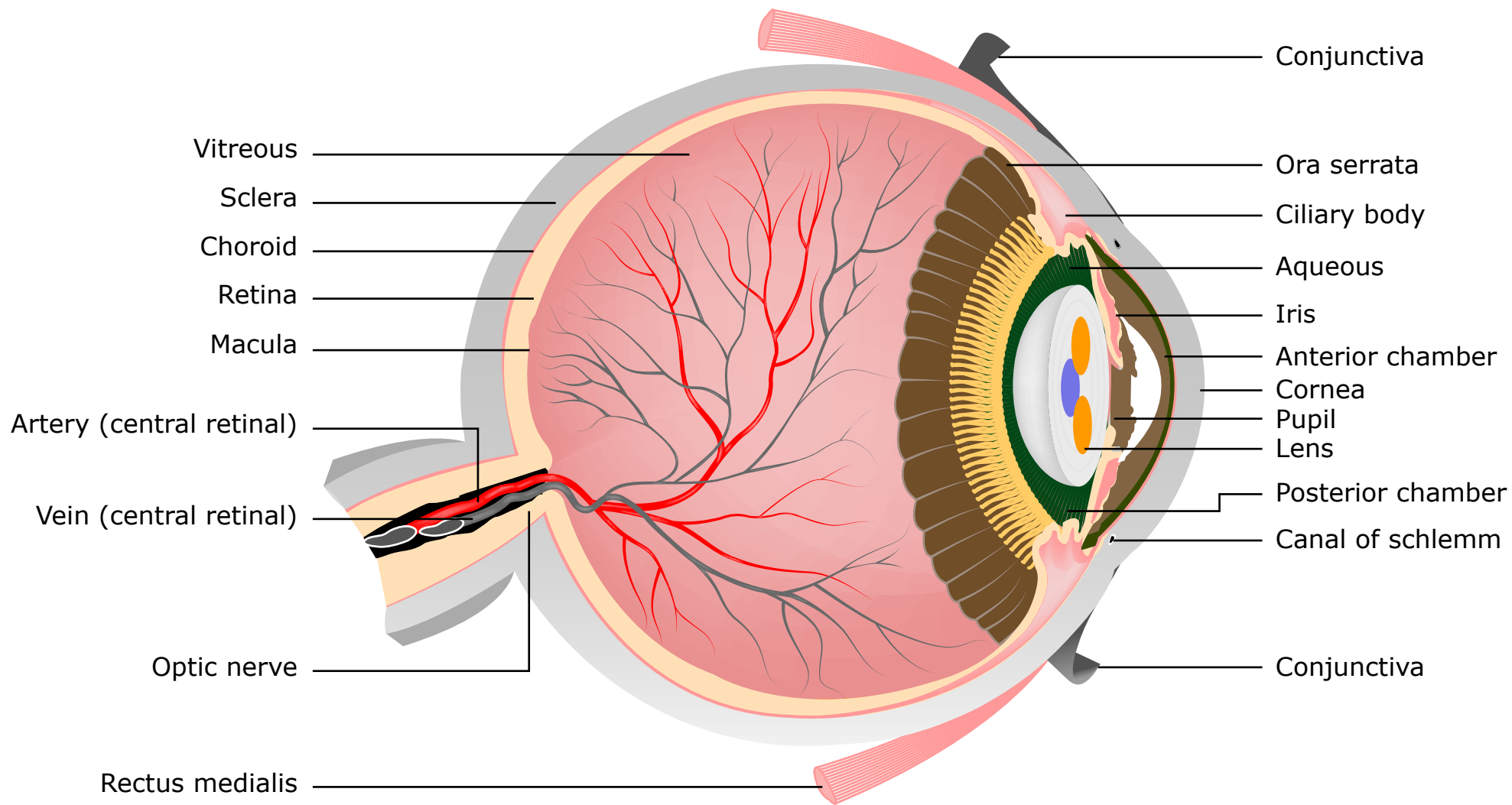
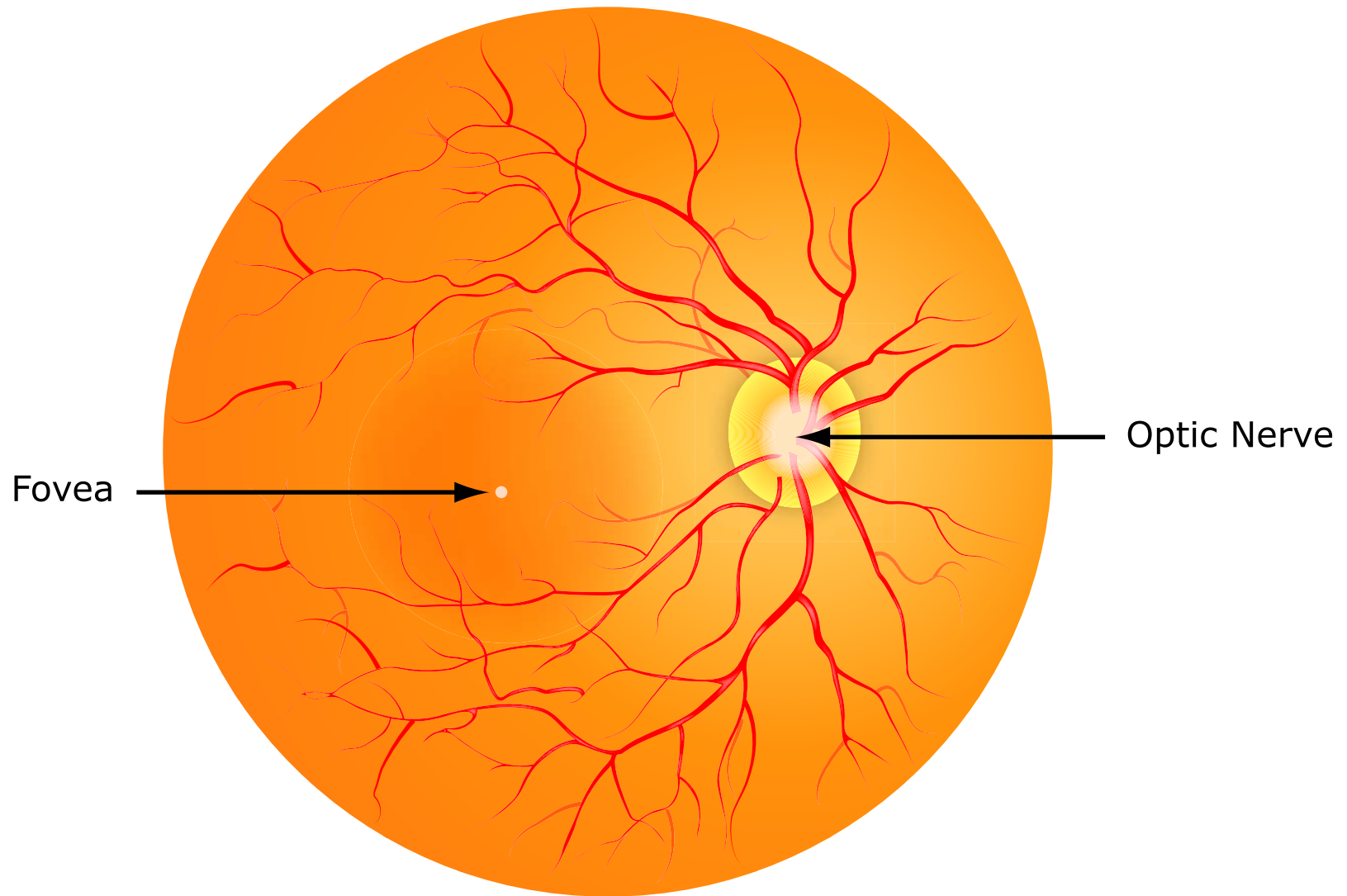


Image by MIT OpenCourseWare.

# Eye Movements

- Tracking (Versional)
  - Saccades
  - Pursuit
- Vergence
- Compensatory (VOR)
- Nystagmus
- Miniature
  - Drift
  - Flicks
  - Tremor

# The Retina



Human retina as seen through an ophthalmoscope.

# Retina Organization

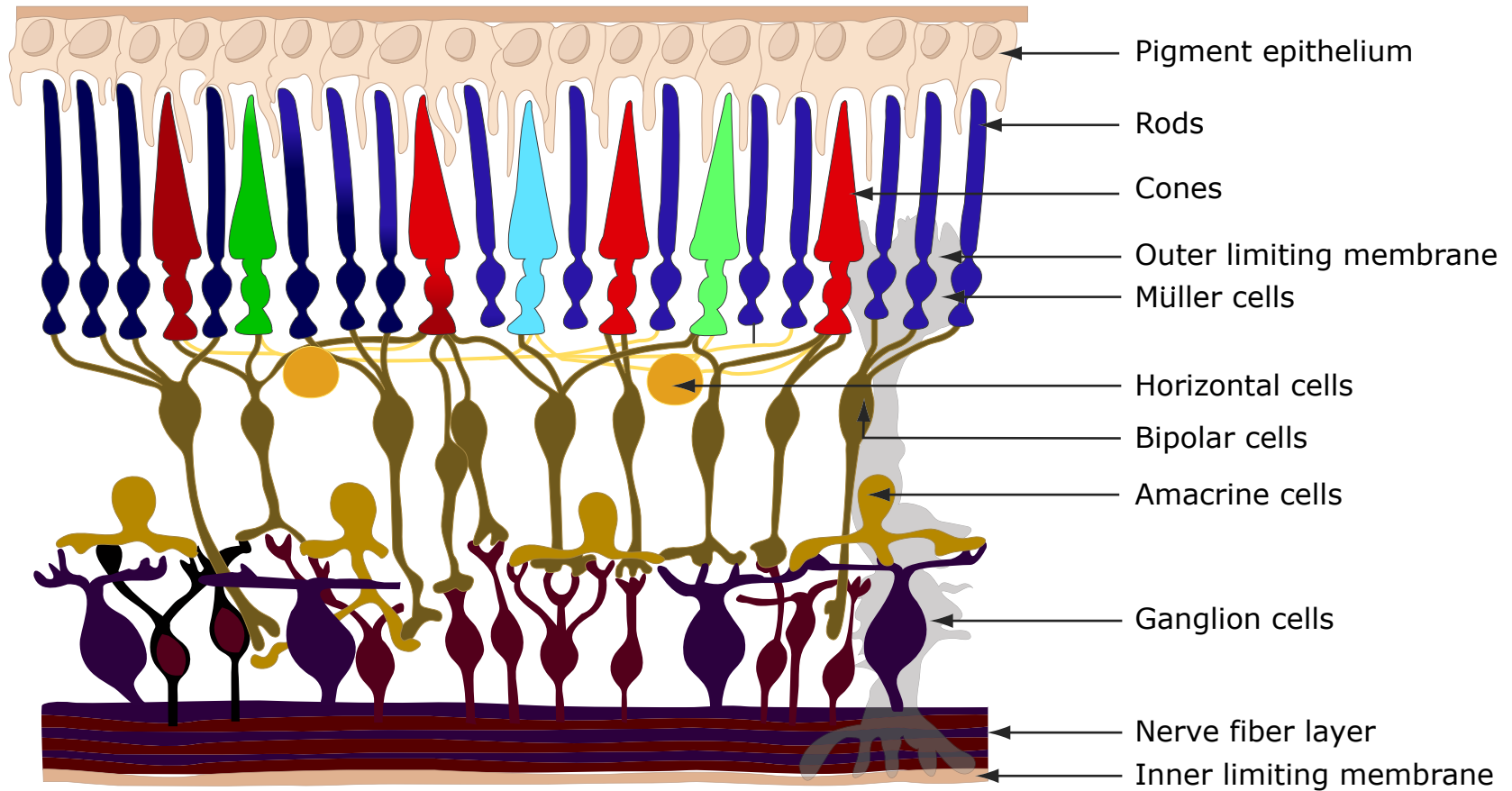
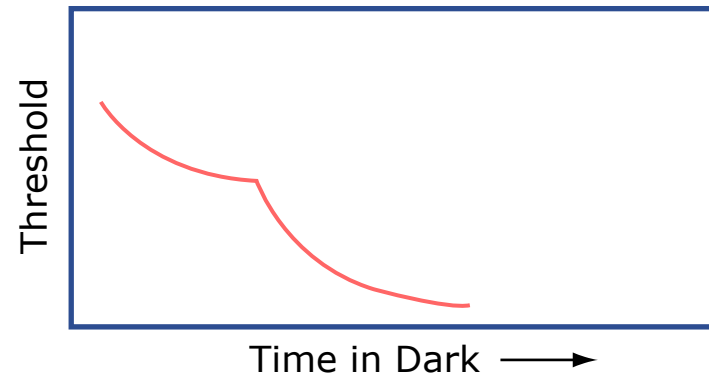
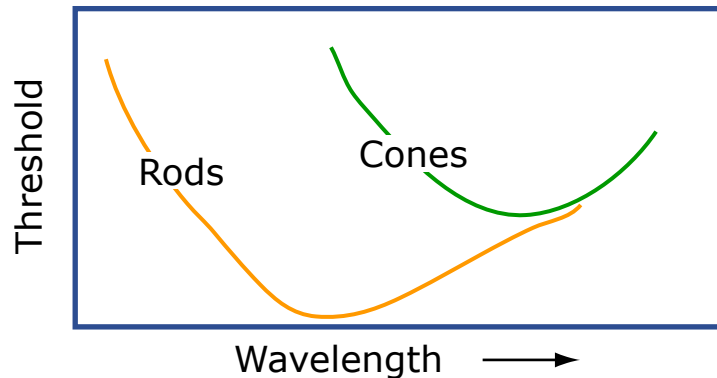


Image by MIT OpenCourseWare.

## Light - Sensitive Transducers :

- { Rods (Color insensitive, Max. concentration at 20°)
- { Cones (Color sensitive, Max. concentration at 0°)
- Foveal Acuity  $\sim$  1 Min. of arc
- { Max. Lumens - Sun (threshold of damage)
- { Min. Lumens - A few photons (Min. threshold)
- { Ratio of above  $\sim 10^{13}$
- Frequency range 340 - 760 nm wavelength
- Color adaption - "Visual purple"
- Temporal adaption - Flicker fusion 20 Hz  
- 20 Min. in dark.





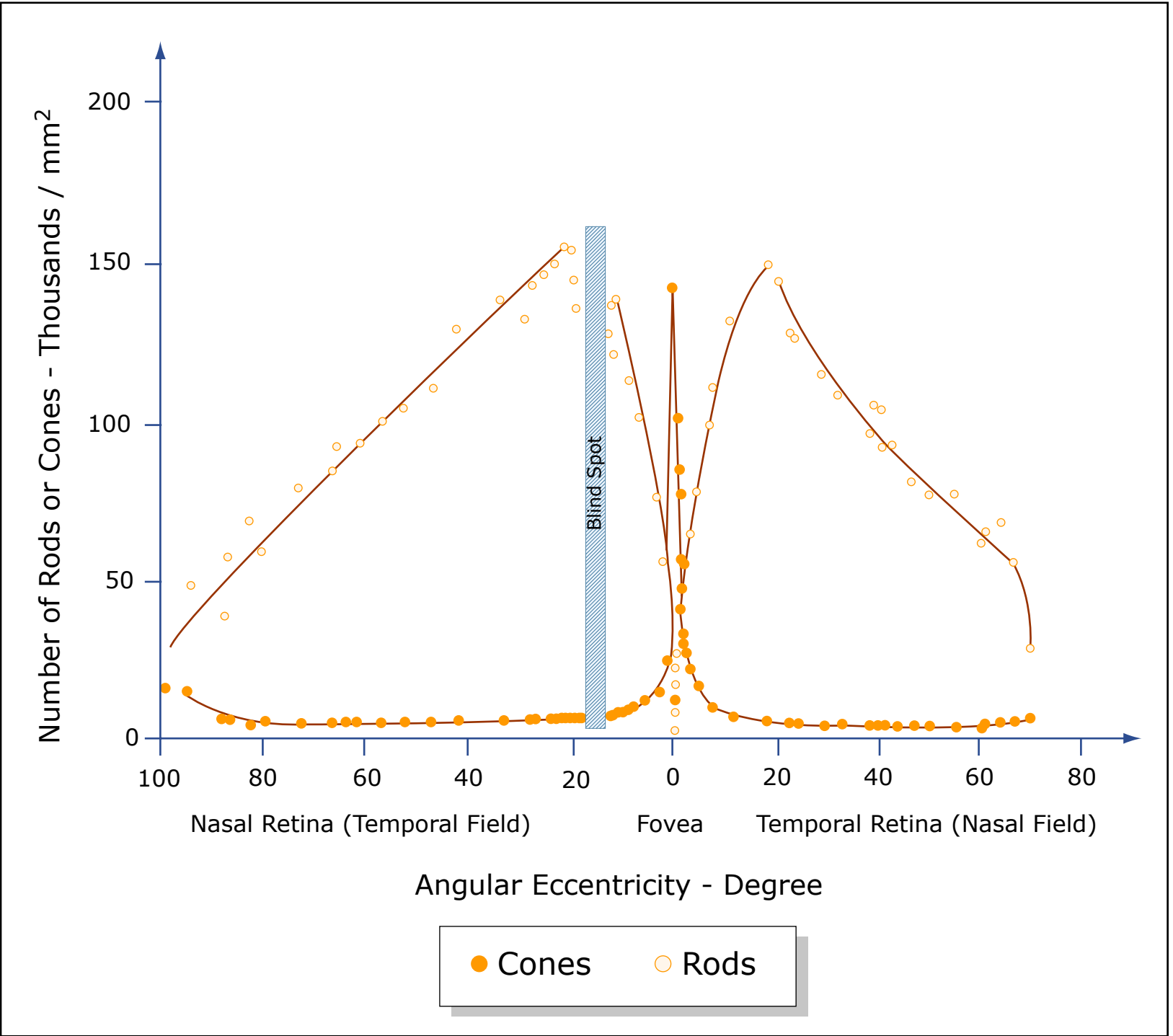


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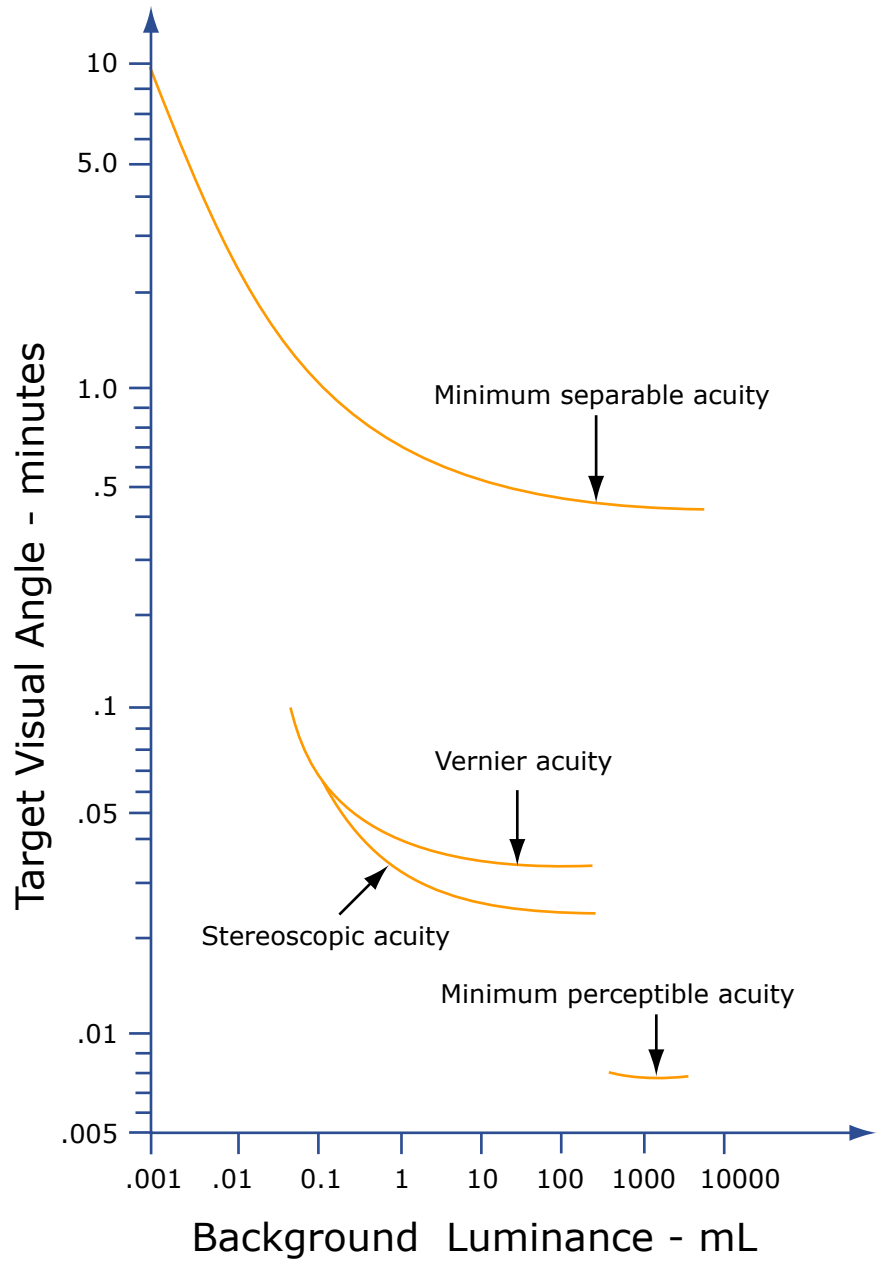
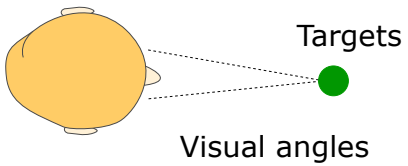
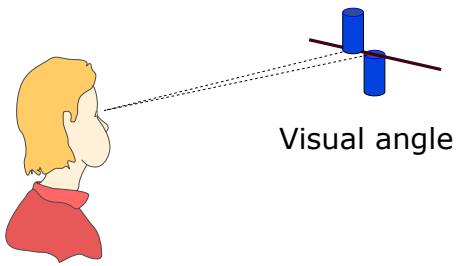
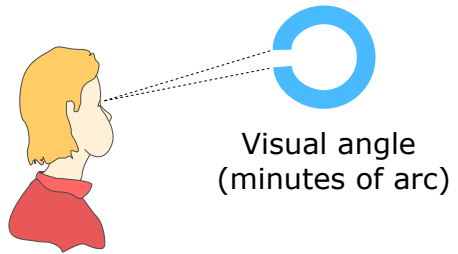
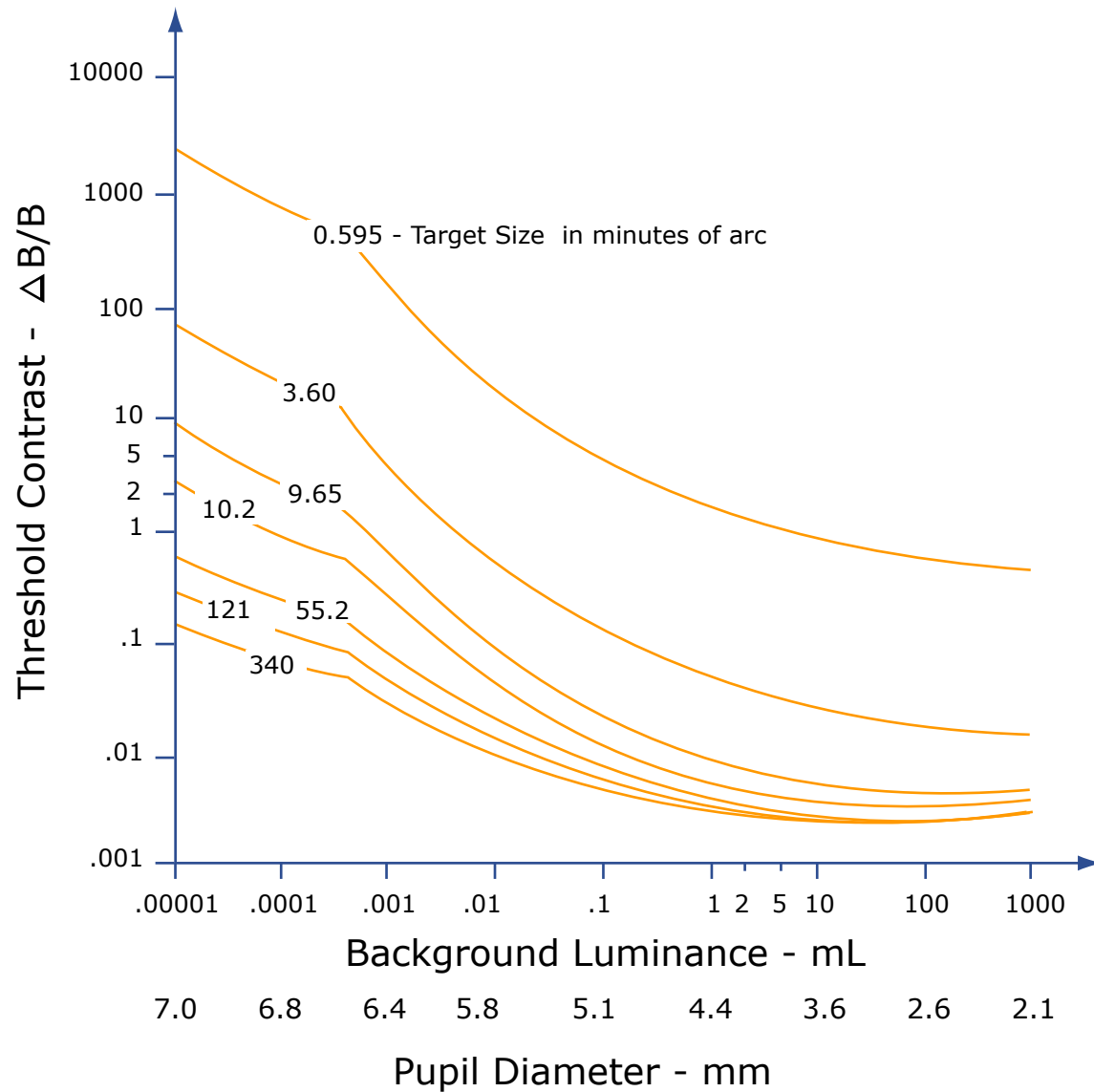


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Luminance contrast is a measure of how much target luminance ( $B_t$ ) differs from background luminance ( $B_b$ ). The equation for obtaining contrast is:

$$C_B = \frac{B_t - B_b}{B_b} \text{ or } C_B \times 100 = 100 C_B$$

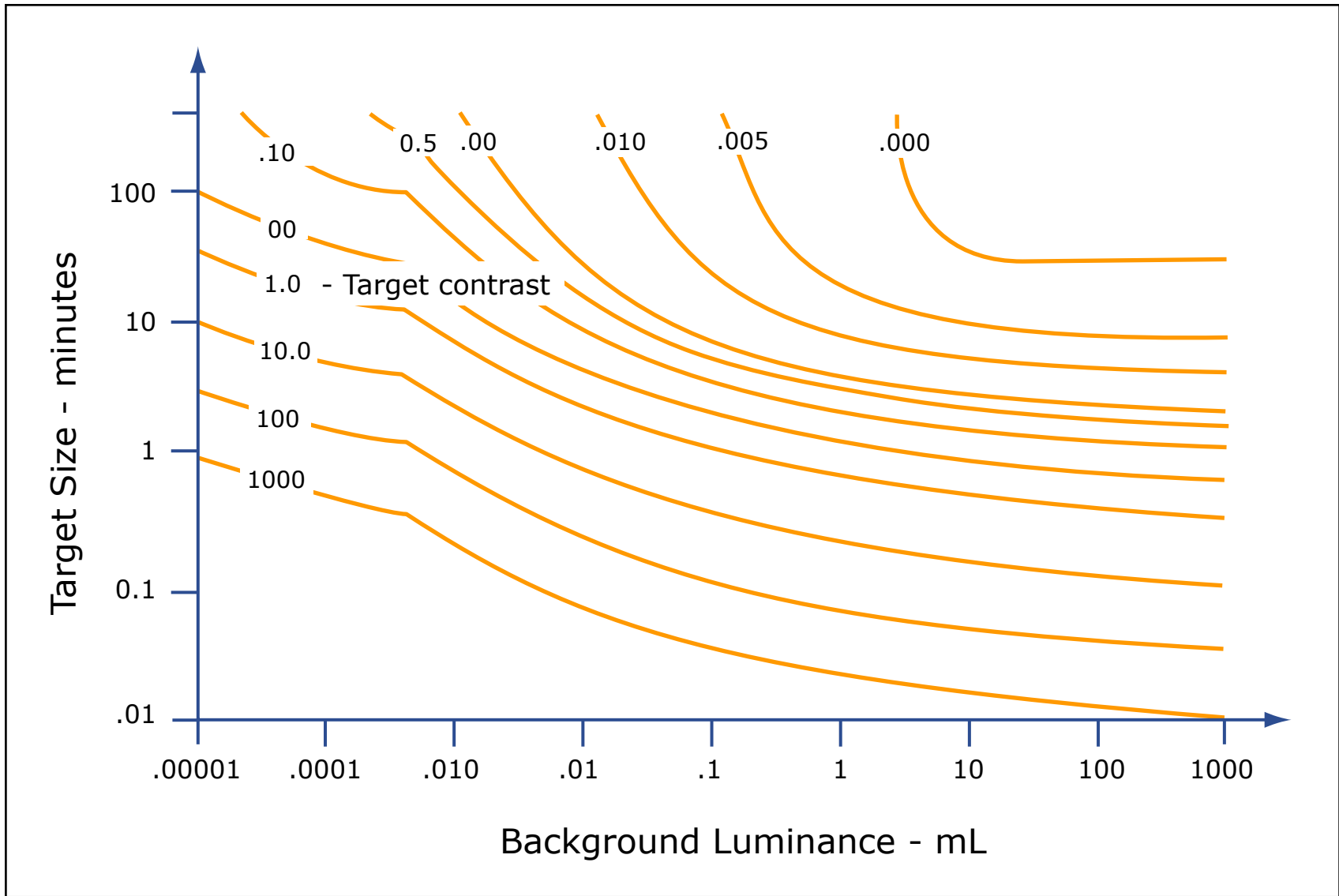


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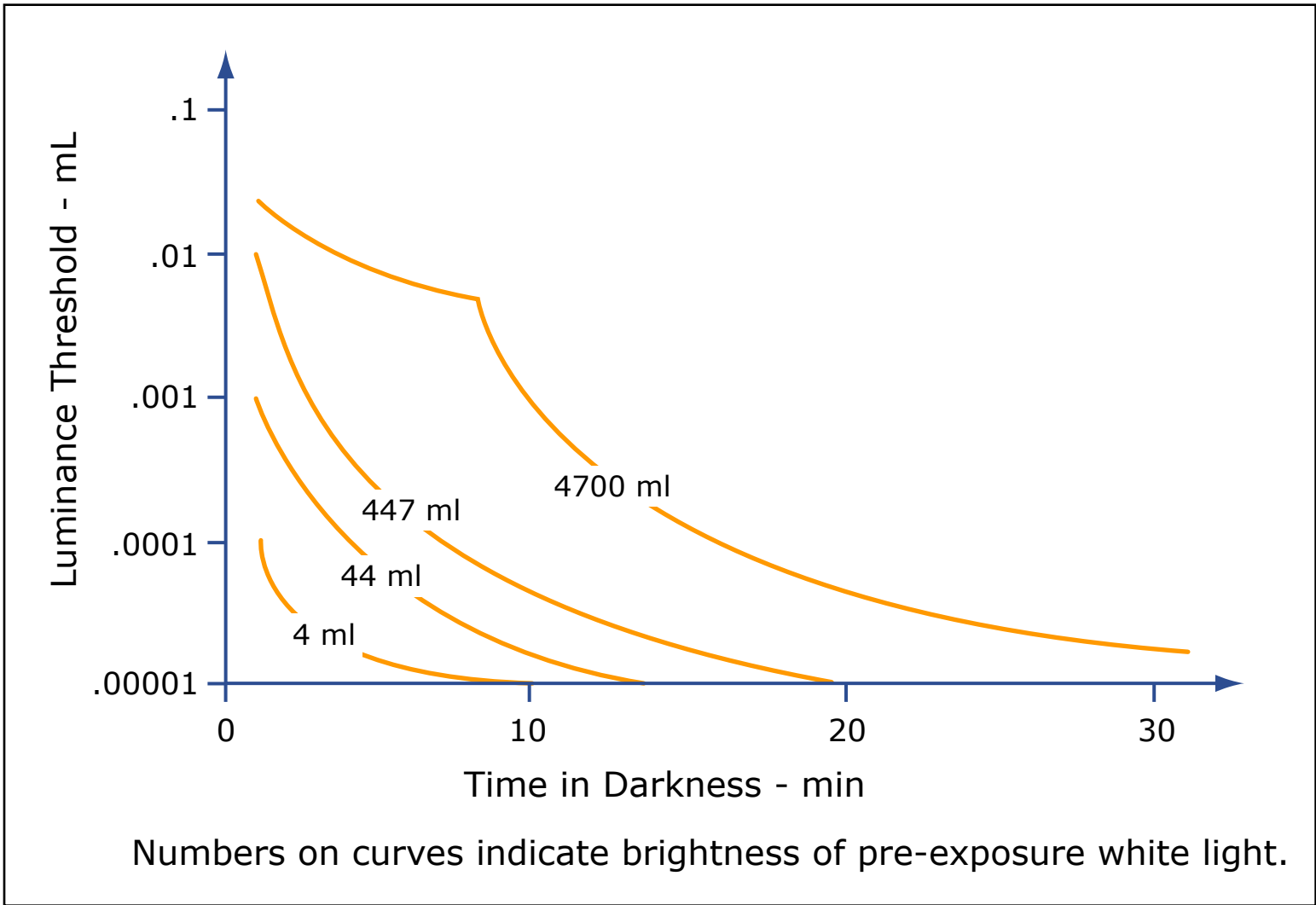
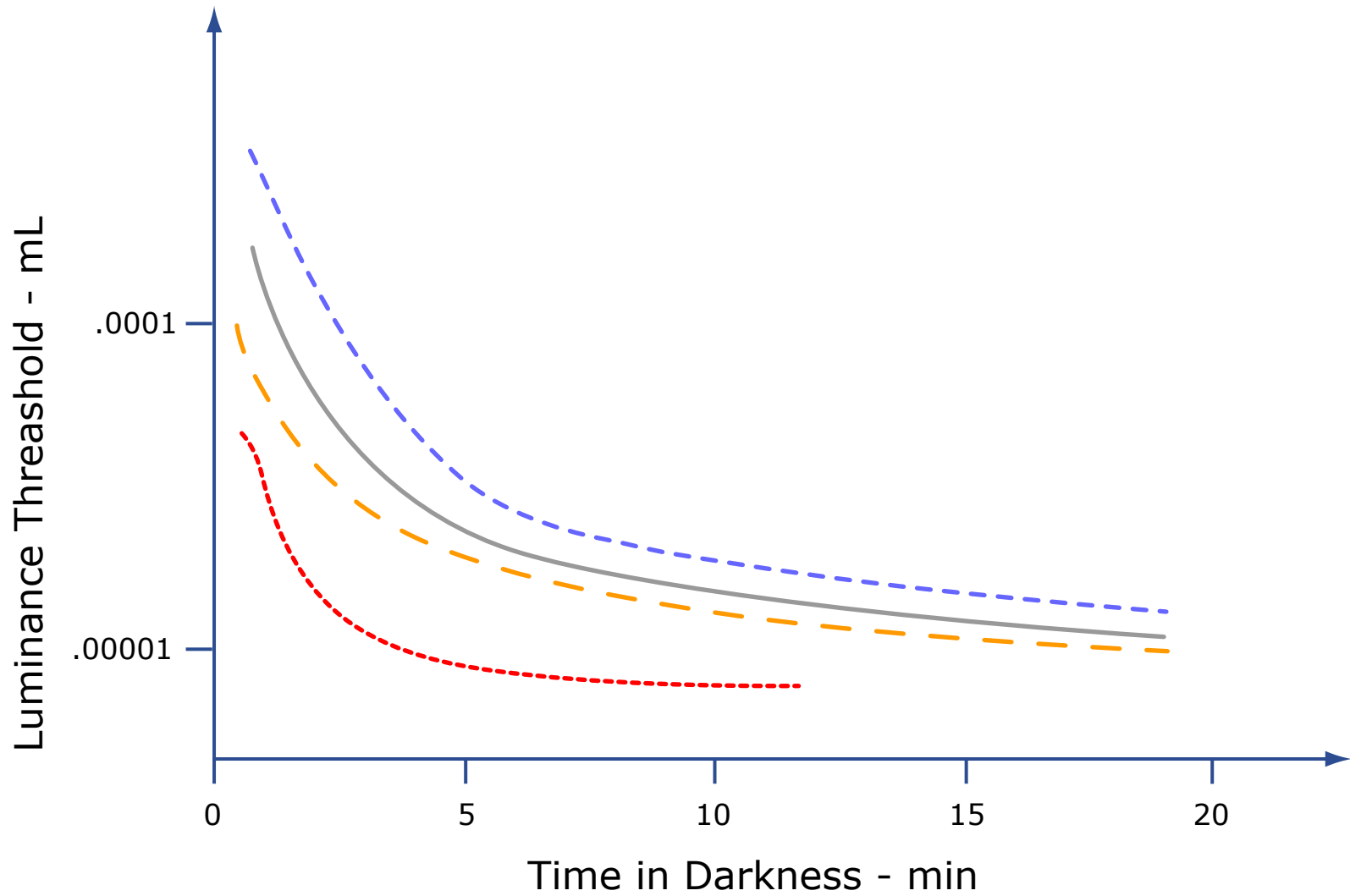


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Pre-exposure brightness of 1.1 - mL Light of the following Colors,  
 - - - Violet    — White    - - - Red    - - - Yellow

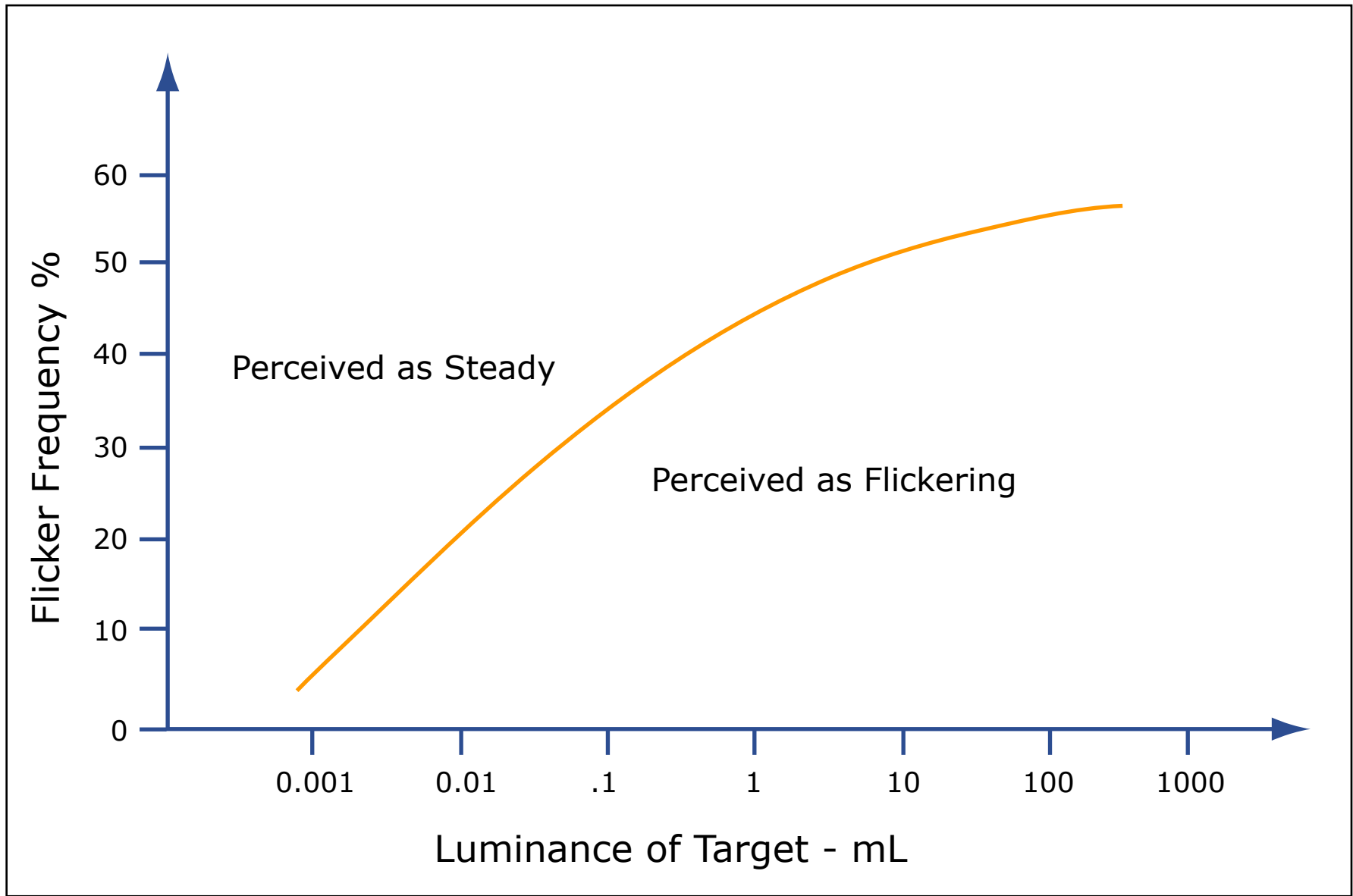


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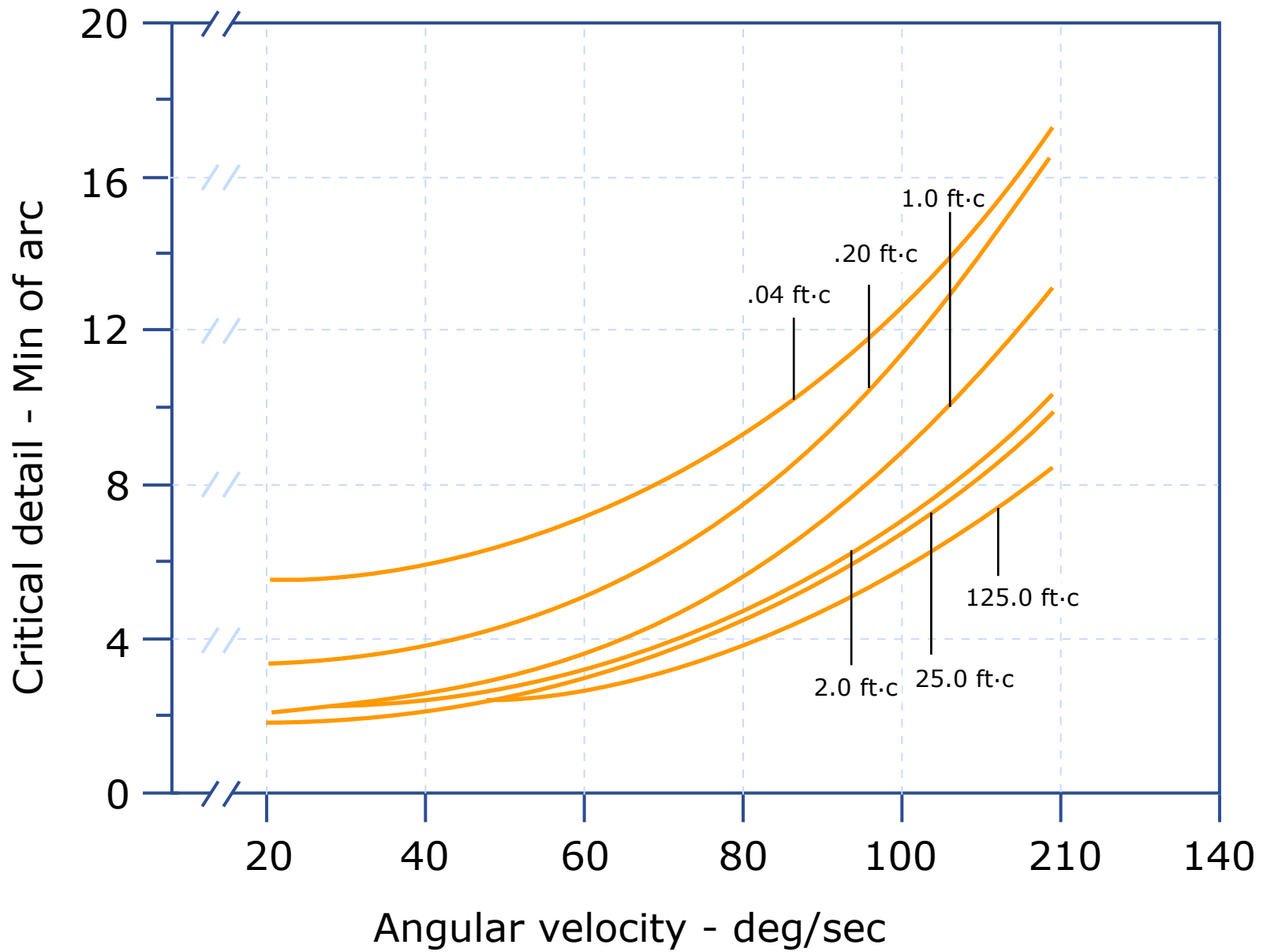


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