YOUR EYES-A USERS GUIDE FOR VISUAL ASTRONOMY

Presented by Myron E. Wasiuta O.D, F.V.A.O
Almost Heaven Star Party, Spruce Knob, West Virginia
July 22,2017

Myron Wasiuta Biography

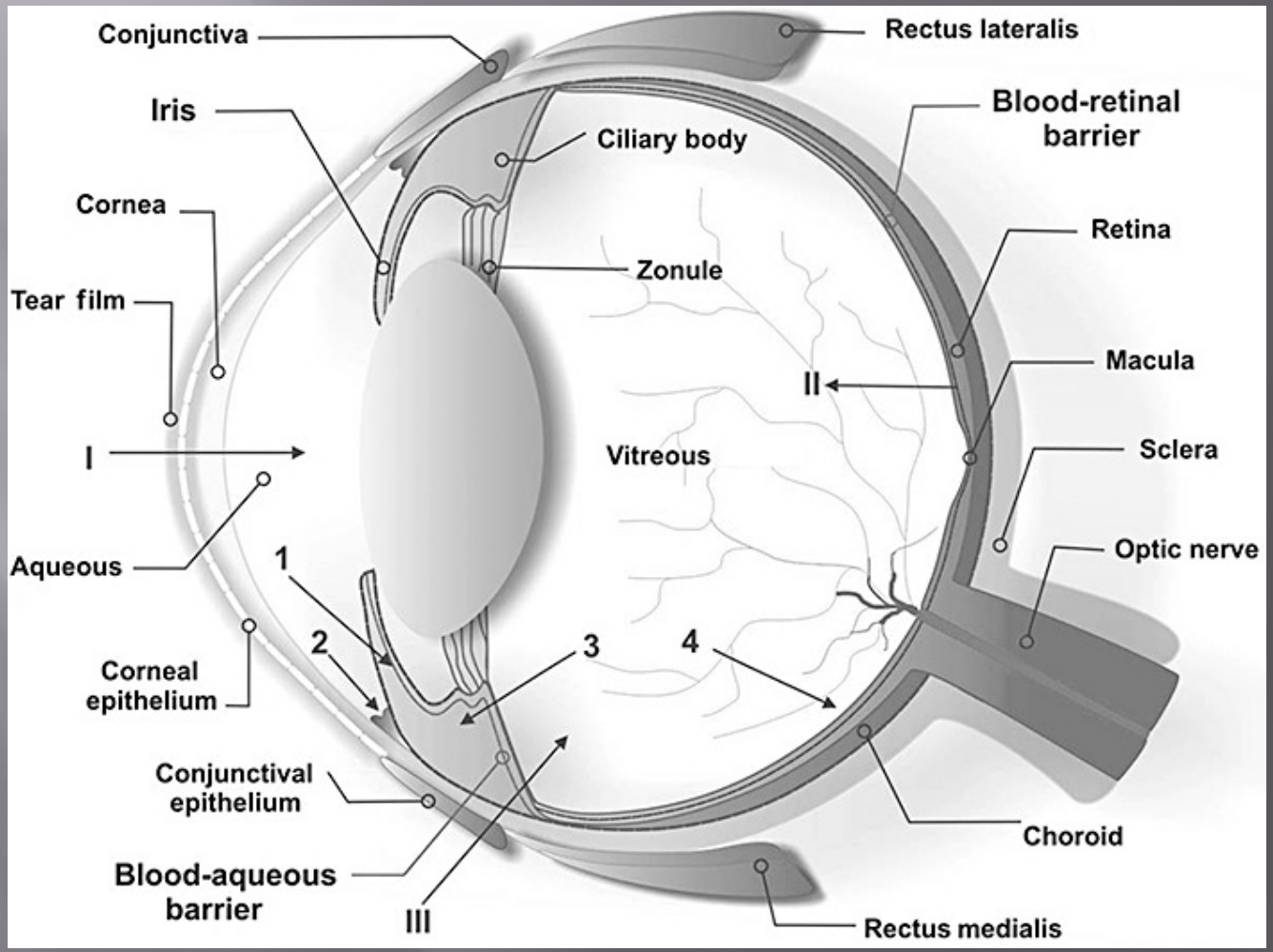
PROFESSIONAL

- Optometrist in private practice 27 years
- MyEyeDr Culpeper, Virginia 2016
- Member American Optometric Assoc.
- Member Virginia Optometric Assoc.
- Fellow Virginia Academy of Optometry
- Adjunct Lecturer Univ. of Mary Washington-Astronomy
- Past- President Battlefield Optometric Society

PERSONAL

- Amateur astronomer for over 40 years with interests in visual, ccd, and telescope collecting, remote observing
- Past-President NOVAC
- Past President Birmingham Astronomical Society
- Past President Rappahannock Astronomy Club
- Observing privileges at USNO 1991-2001
- Developed StarPoint astigmatism lens (see Sky and Telescope, September 1995)
- Married 24 years with 4 children

General Eye Anatomy



Normal Eye-Visual Acuity

- Normal Vision is 20/20, but many people see better than this.
- This means at 20 feet away, a person can see a letter subtending 5 arc-minutes with smallest detail 1-arc-minute in size. Called 20/20 letter.
- Only true in bright light (photopic conditions)
- In dim light (scotopic conditions), visual acuity is much less and may not be able to see color.
- 20/40 means a person with normal vision can identify at 40 feet but you must come into 20 feet to identify
- 20/10 means a person with normal vision must approach to 10 feet a letter that the person with 20/10 can see at 20 feet

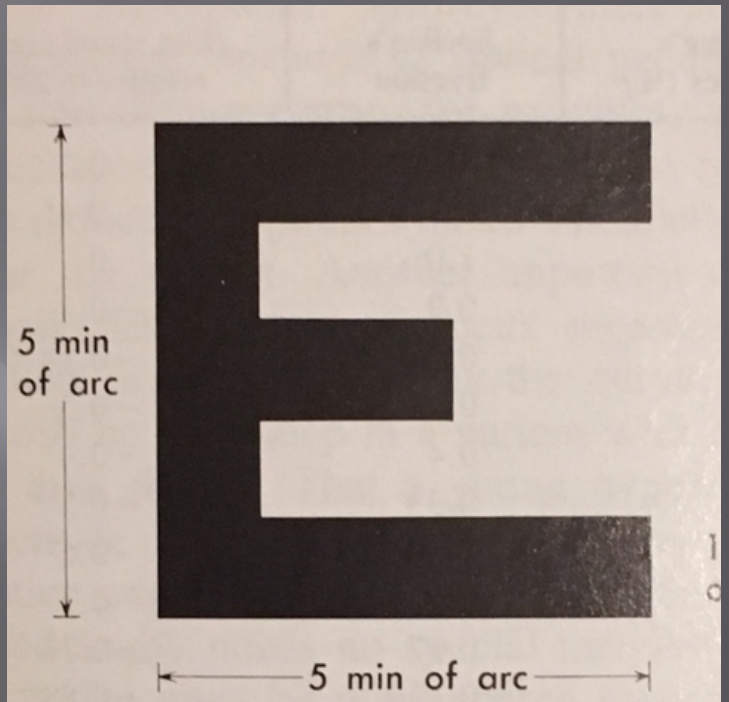


Fig. 17-6. 20/20 Snellen's letter.

- Photo credit :Adlers Physiology of the Eye, p421

Visual Acuity as a function of age and viewing eccentricity

ACUITY DECLINES WITH AGE

WEYMOUTH,F.W. THE EFFECT OF AGE ON VISUAL ACUITY VISION OF THE AGING PATIENT, RADNOR,1960

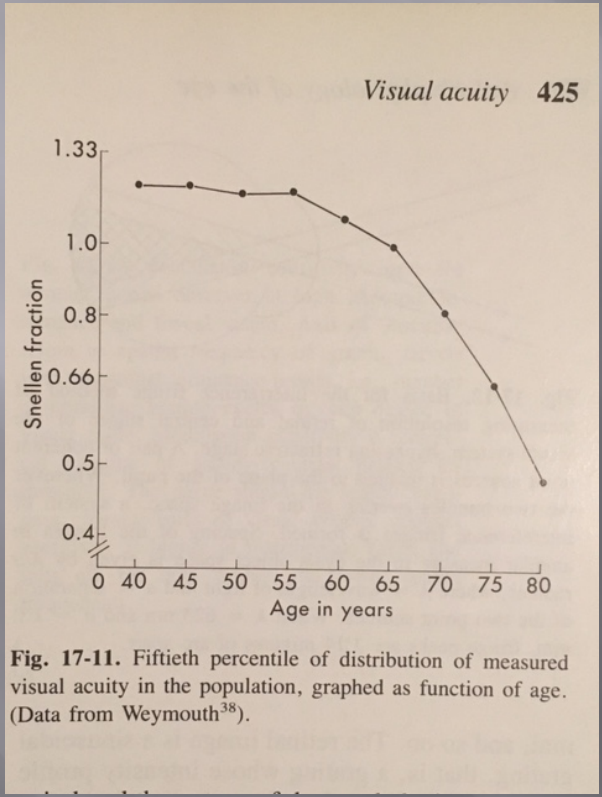


Fig. 17-11. Fiftieth percentile of distribution of measured visual acuity in the population, graphed as function of age. (Data from Weymouth[38]).

ACUITY DECLINES WITH VIEWING RETINAL ECCENTRICITY

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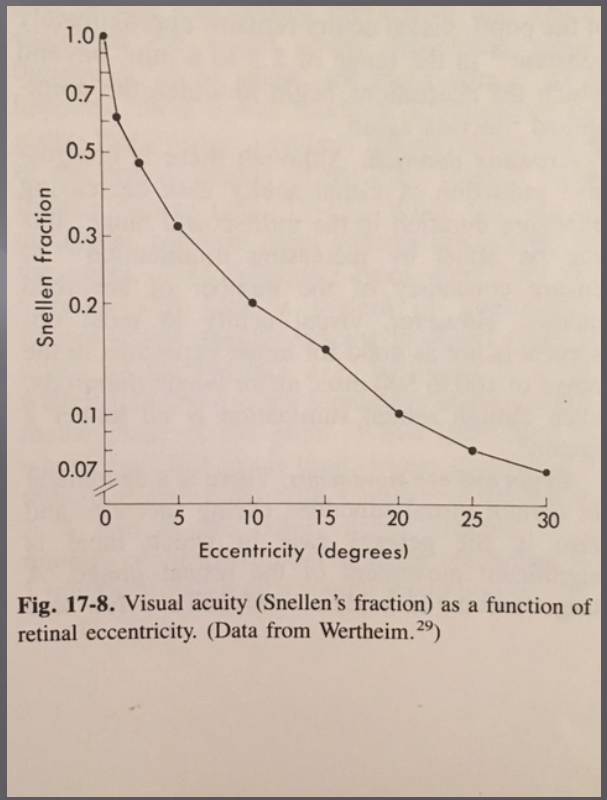
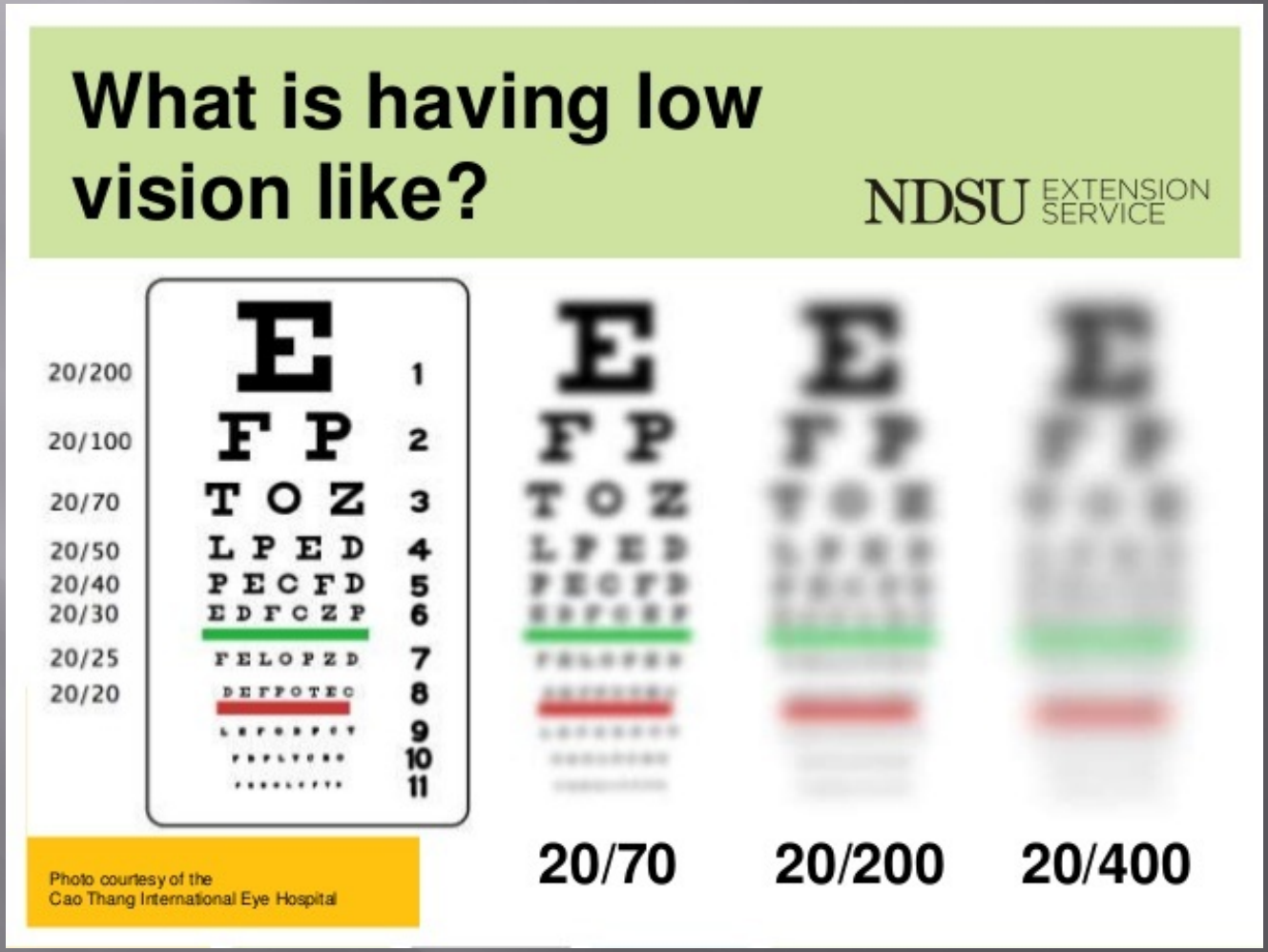


Fig. 17-8. Visual acuity (Snellen's fraction) as a function of retinal eccentricity. (Data from Wertheim.[29])

Visual acuity depends on many factors

- Uncorrected Ametropia
- Degree of high order aberrations present
- Quality of pre-corneal tear film (primary refracting surface of eye)
- Degree of lens transparency (cataract)
- Degree of vitreous floaters/syneresis
- Retinal health (macular drusen or degen)
- Density of foveal cone photoreceptors
- Optic nerve/neurologic health

Simulation of reduced acuity



Major structures through which light passes on way to retina

- Pre-Corneal Tear Film
- Cornea
- Aqueous humor (anterior chamber)
- Pupil
- Lens
- Vitreous humor (posterior chamber)
- Retina inner segment
- Photoreceptors-retina outer segment

Normal Eye-Color Vision

Human eye has two types of photoreceptors:

Rods-very sensitive to light (can detect a single photon) but can not discriminate color.

Cones- not very sensitive to light but can discriminate color.

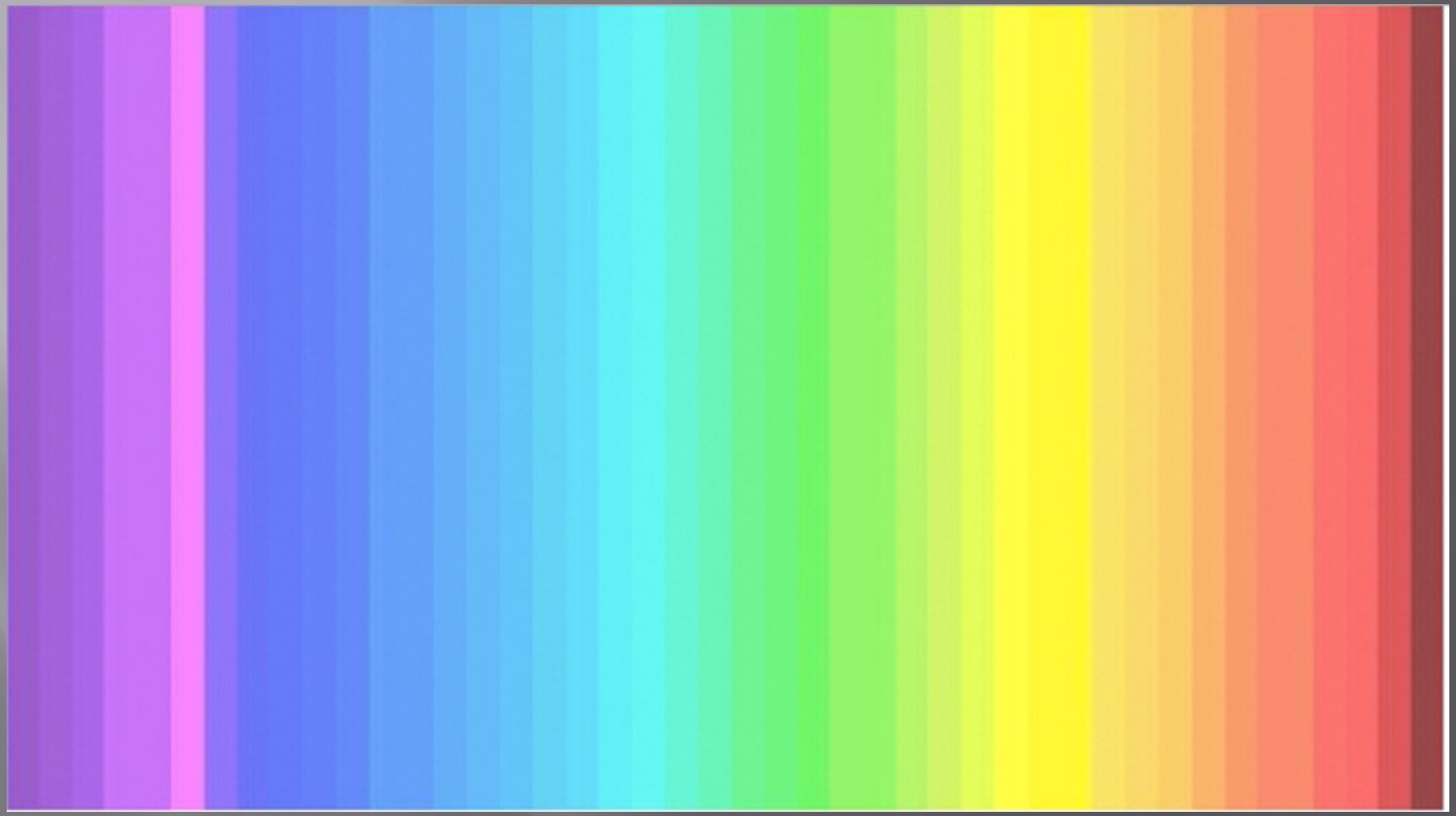
Three classes of cones: Blue (peak sensitivity 440-450nm), Green (535-555nm), Red (570-590nm)

Most people with normal color vision can differentiate wavelength changes as small as 1-4nm.

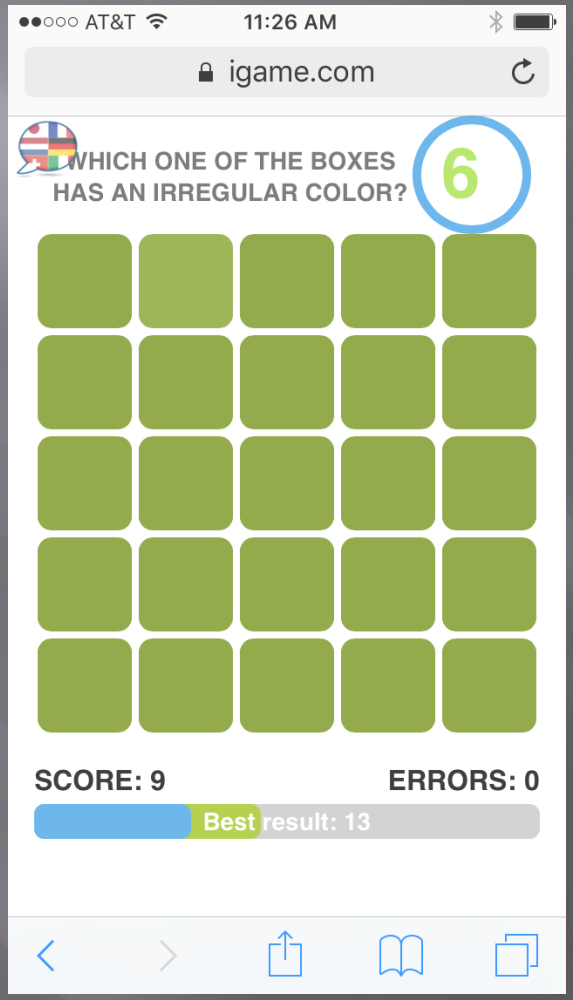
Color vision carried on X-Chromosome-if defective leads to a Red-Green color deficiency

Like VA-color vision decreases with increased viewing angle

How many colors can you see?



Online iGame color discrimination test



Color Vision Continued

- R-G color vision defect common in males (1 per 15) and rarer in females (1 per 200
- Being color deficient can affect the appearance of planets, bright DSO, star colors

Color Vision-Continued

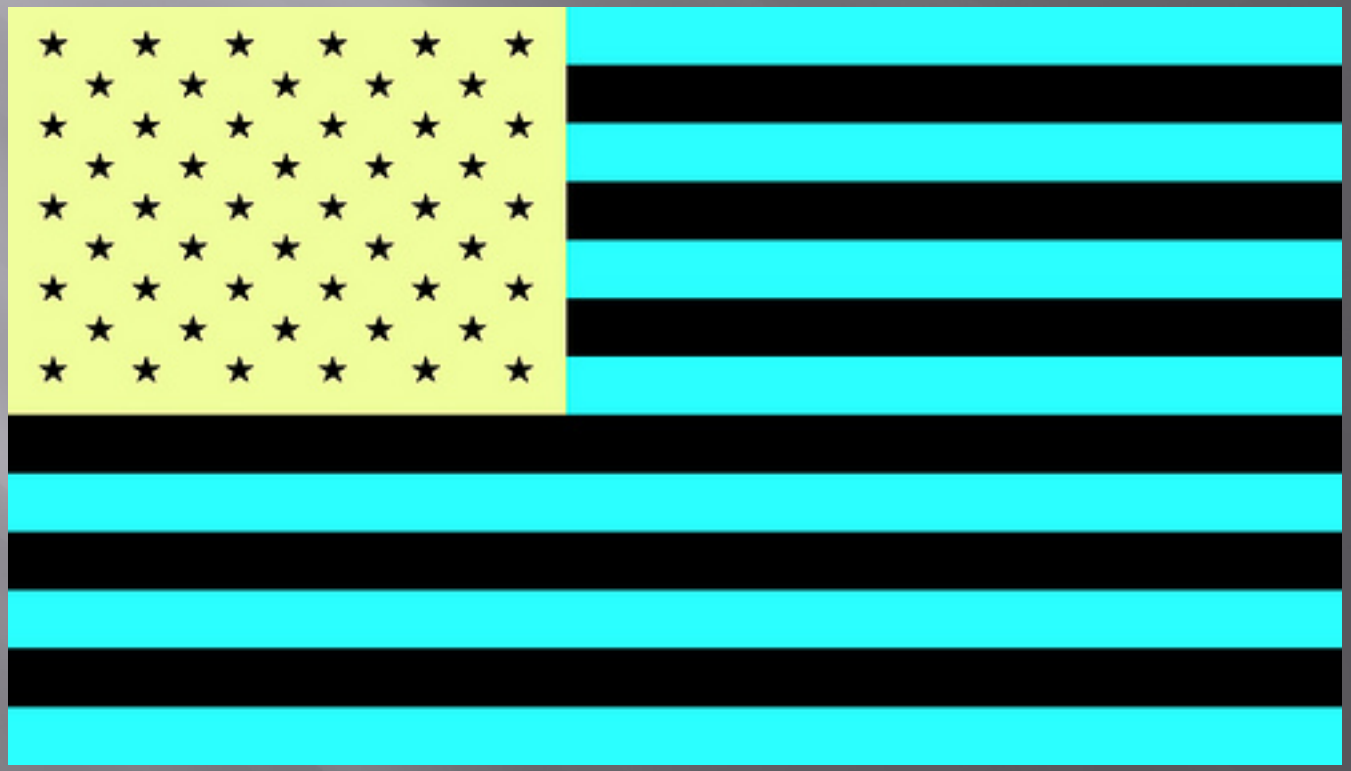
- Color sensation is subjective-depends on numerous parameters including:
- Wavelength or band of wavelengths reflected or emitted from object
- The wavelengths of other objects in the field (simultaneous color contrast)
- The intensity of light (must be above threshold)
- The wavelength of light from the object the observer looked at just prior to looking at new object (successive color contrast)

Remember this controversy?

BLUE AND BLACK?

WHITE AND GOLD?

Successive Color Contrast



Normal Eye-Sensitivity

- The eye adjusts its gain based on local lighting conditions-called light/dark adaptation.
- Difference in brightness from a bright daytime scene to a dark starry night is about 100 million fold!
- At its most sensitive-the rods in a young eye can detect a single photon of light!
- The eye actually bins its rods allowing summation of multiple receptors which increases sensitivity but also lowers resolution.

Maladies of the Eye

DRY EYE

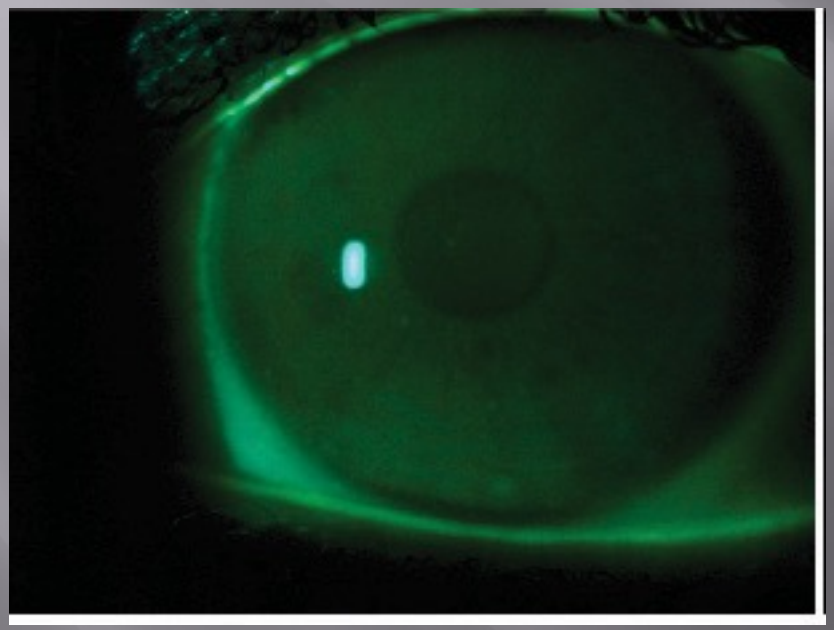
- 50% prevalence over age 50
- Symptoms include blurred vision, fluctuating vision, burning, scratchy, tired eyes.
- Reduces contrast sensitivity
- Causes are numerous- medications are often culprits, but inflamed eyelids (blepharitis/roseacea) and thyroid and auto-immune disease common causes. Contact lenses also a factor.

TREATMENT/PREVENTION

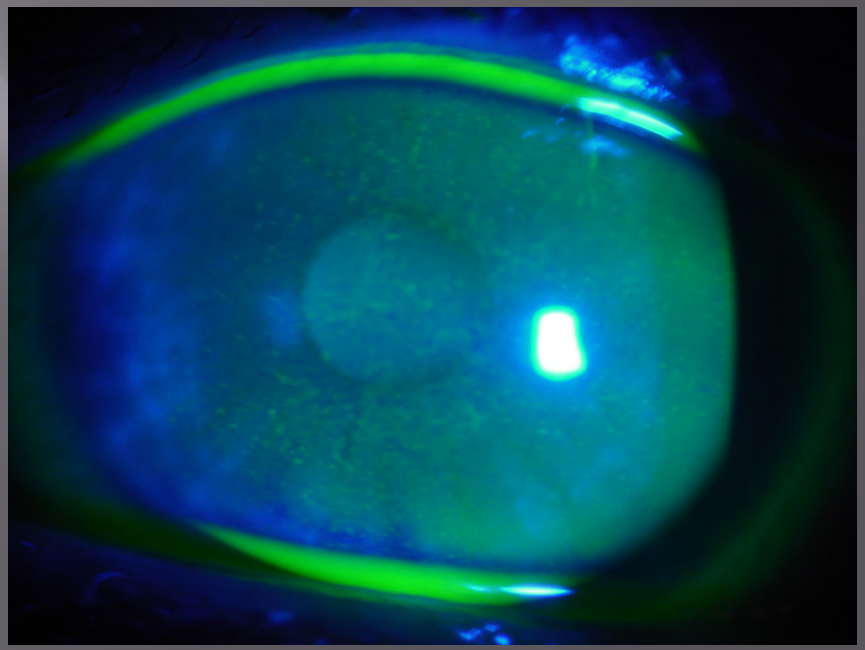
- Artificial tears such as Systane(Balance or Ultra), Refresh Optive Advanced
- Hi Purity Omega-3
- Restasis/Xiidra
- Lid Hygeine (Johnson Baby Shampoo,Cliradex or Ocusoft Lid Wipes)

Dry Eyes

NORMAL TEAR FILM



ABNORMAL WITH CELL DAMAGE



Maladies of the Eye

CORNEAL DYSTROPHY

- Irregularity in corneal structure
- Outer surface can be affected (EBMB),middle, or inner surface (Fuch's)
- Often these are hereditary
- Results in the corneal surface scattering light- reduces both acuity and contrast sensitivity.
- Can be progressive

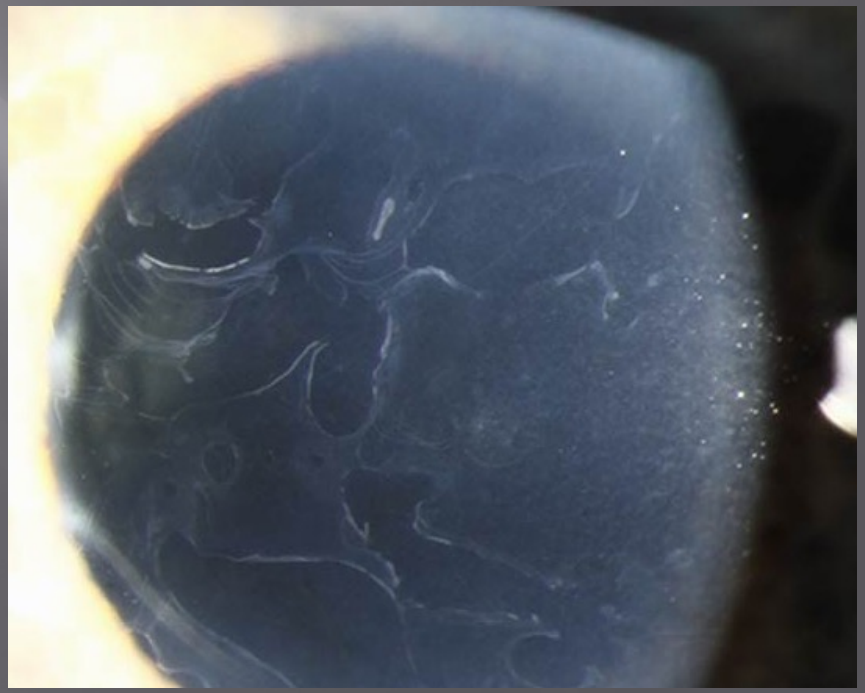
TREATMENT/PREVENTION

- Artificial tears/lid hygeine
- Hyperosmotic solutions and ointments (Muro 128 5%)
- Gas Perm CL or Scleral Contacts
- Corneal surgery

Corneal Dystrophies

FUCH'S GUTTATA

ANTERIOR DYSTROPHY



Maladies of the Eye

CATARACT

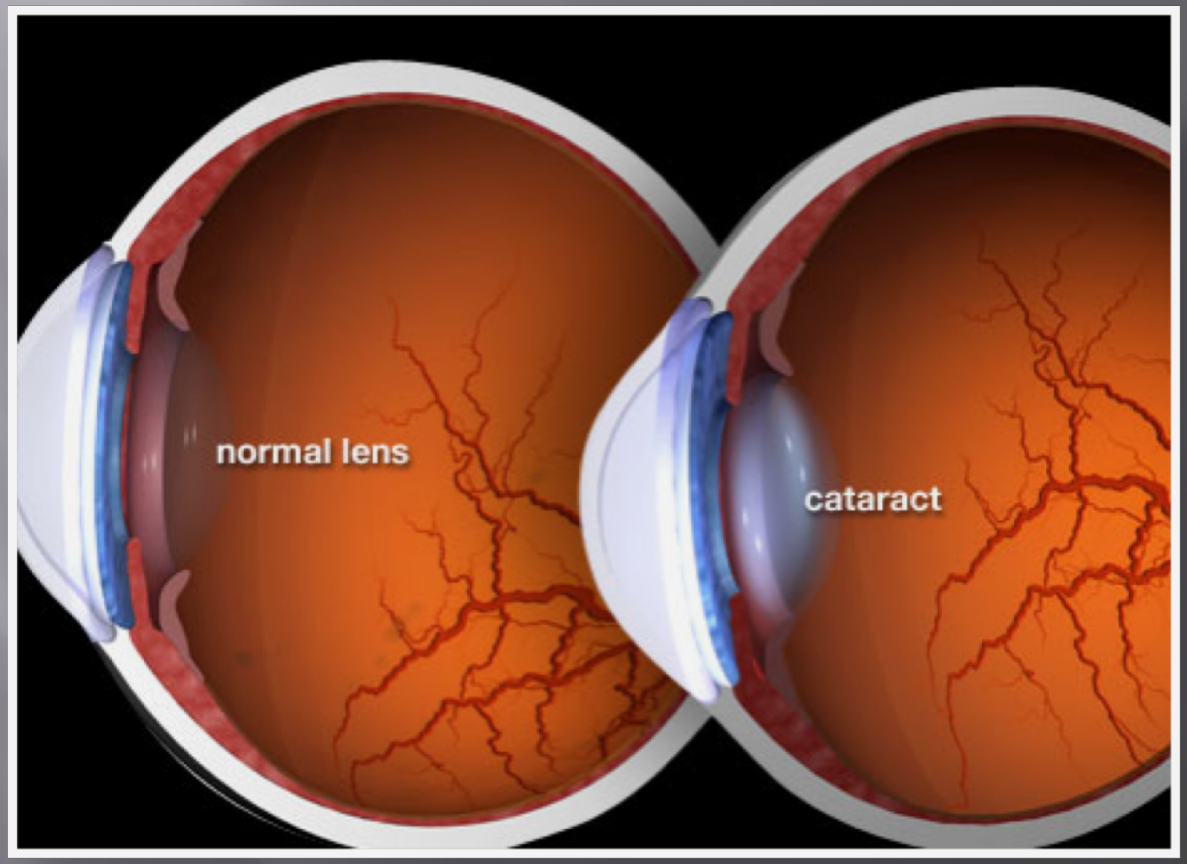
- A clouding of the crystalline lens
- Nuclear Sclerosis(clouding of innermost region of lens)
- Cortical Cataract (clouding of outer shell)
- Posterior Subcapsular (clouding of back surface usually on or near visual axis)

TREATMENT/PREVENTION

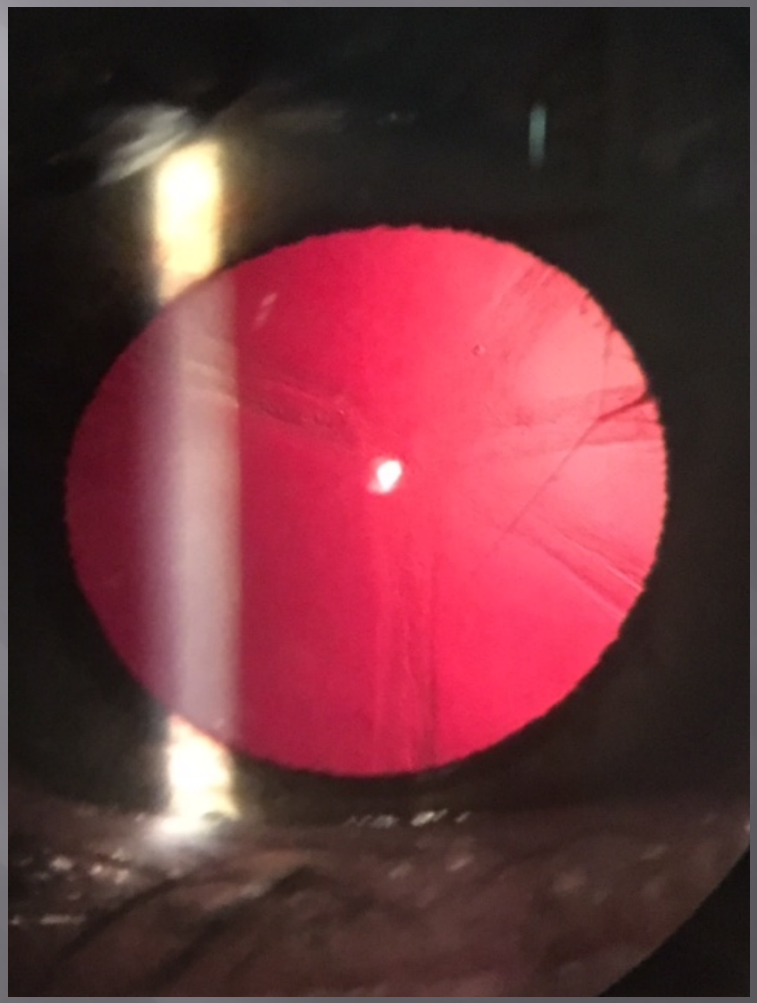
- Wear sunglasses when outdoors that block UVA/B rays.
- Don't smoke
- Cataract Sx (monofocal IOL, bifocal, diffractive-recommend Symphony for astronomers)

Schematic of eye with cataract

Courtesy of WebMD



Cortical cataract



Maladies of the Eye

MACULAR DEGENERATION

- A deterioration of the rods/cones in the central retina
- Two main types: Dry-no blood or fluid leaking into retina. Wet-blood or fluid causing damage and scarring

TREATMENT/PREVENTION

- Protect eyes from sun when young-wear sunglasses
- Don't smoke-doubles risk of getting macular degen. It is the single biggest modifiable risk factor!
- Dark green leafy veggies!
- Eye injections can help with wet form, but no treatment for dry form.

Macular Degeneration

DRY

WET

Maladies of the Eye

GLAUCOMA

- A painless loss of initially peripheral visual field contrast sensitivity, which progresses to loss of central visual contrast sensitivity and finally loss of acuity and light perception.
- Causes destruction of the optic nerve which carries visual impulses to the brain's visual cortex.
- Main mechanism believed to be damage to nerve axons from either too much pressure in the eye or poor perfusion from supply blood vessels.
- Several types-most common form is open –angle glaucoma. Hereditary component, as well as race (African-Americans at increased risk)

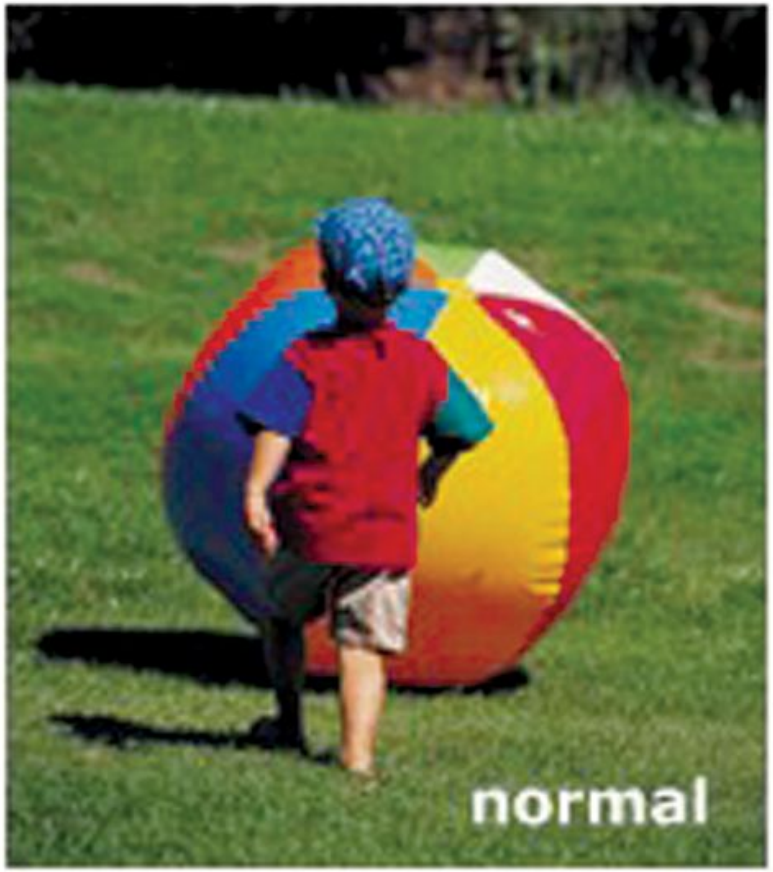
TREATMENT/PREVENTION

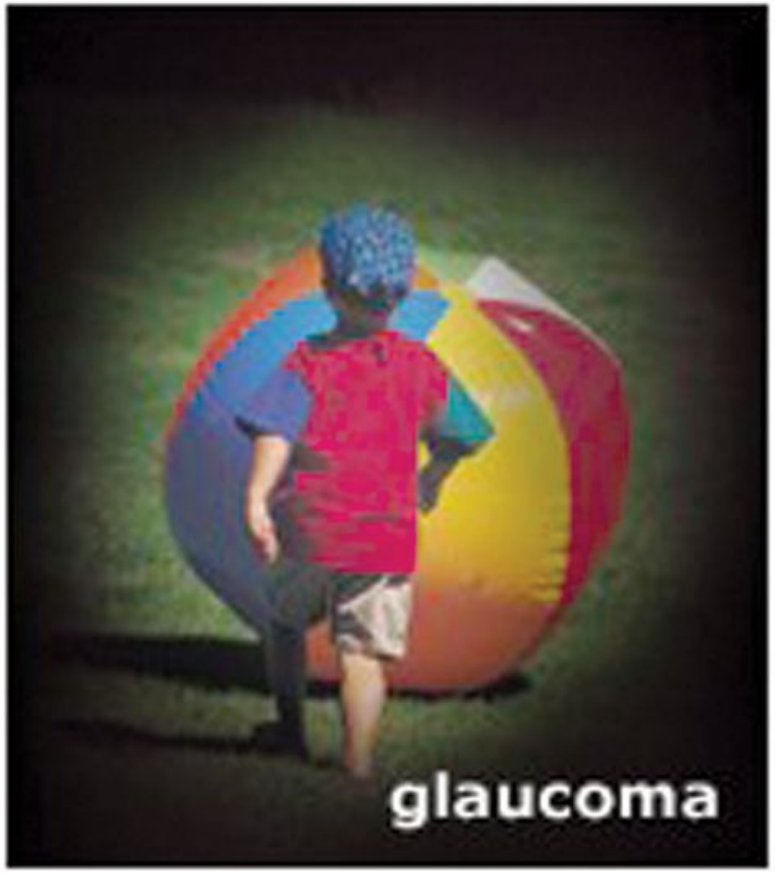
- As genetics and race are important risk factors prevention centers on routine eye exams to detect and treat while still in early stages.
- Treatment includes eye drops, medications,laser, surgery.

Normal

Glaucoma

Simulated effect of glaucoma on vision-note loss of contrast sensitivity and color saturation





Comparison between Rods and Cones (Curcio et al)

RODS

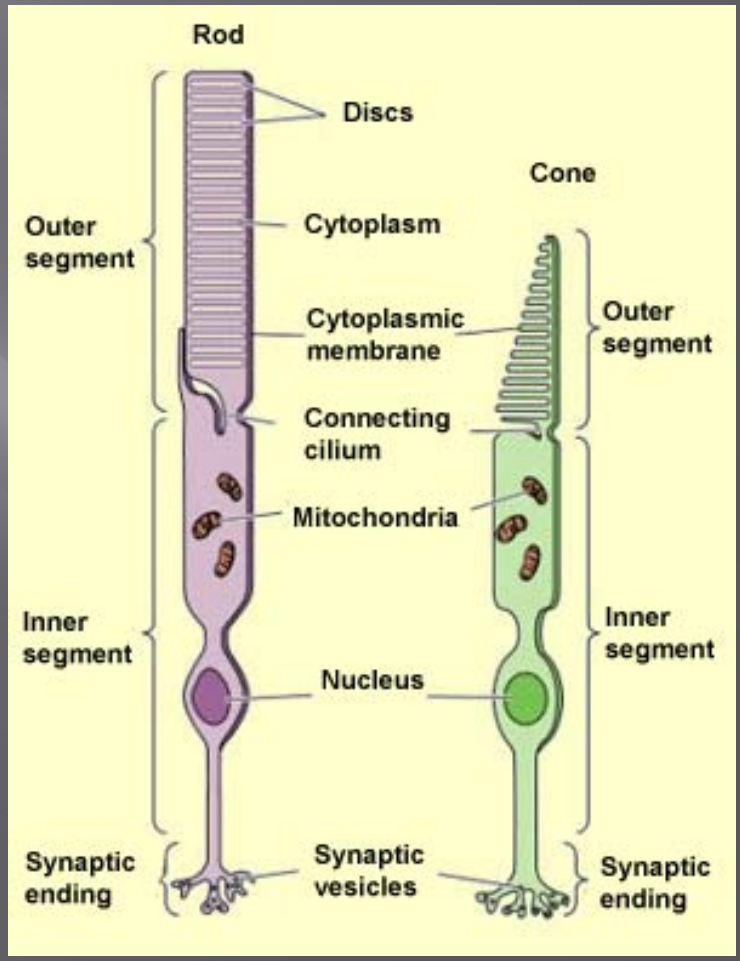
- More photopigment
- Slower response-can integrate
- Saturating response (6%bleached)
- Not directionally sensitive
- Highly convergent retinal pathways
- Hi sensitivity
- Low acuity
- Achromatic-one type of pigment

CONES

- Less photopigment
- Fast response-short integration
- Non-saturating (except blue cones)
- Directionally sensitive
- Less convergent retinal pathways
- Lower sensitivity
- Hi acuity
- Chromatic-3 types of color sensitive pigments

Primer on Human Dark Adaptation

- Provides 100 million X increase in sensitivity allowing us to see from a bright sunny day to a dark WV night.
- Most effect within 30 minutes, continues for up to 2 hours.
- Two factors-increase in pupil (16X) and neuro-chemical (6 million X)
- Two light sensitive cells-rods and cones both undergo dark adaptation.
- Cones dark adapt much quicker than rods, but don't achieve as high sensitivity as rods



Dark Adaptation

- There are about 100 million photoreceptors in human retina- 95 million rods,5 million cones
- Cones are most dense at center (fovea) where there are up to 150,000 /mm2.
- No rods in fovea, but increase to maximum density of 150,000/mm2 about 15-20 degrees away from fovea.
- No rods or cones at optic nerve- which is about 15 degrees nasal from fovea in each eye (projects temporal).
- Very few cones in retinal periphery

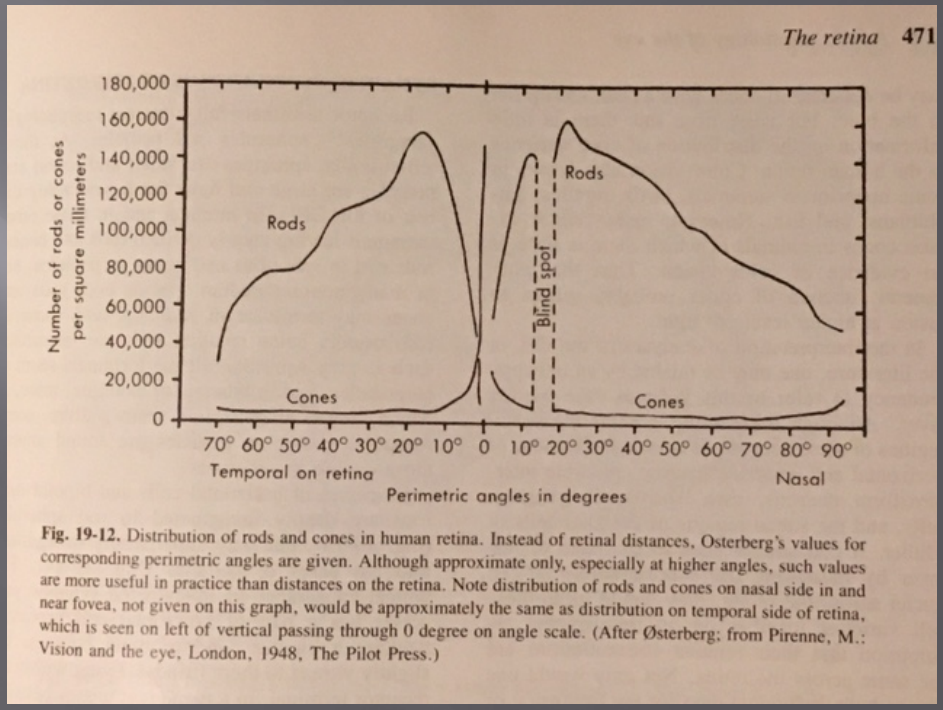
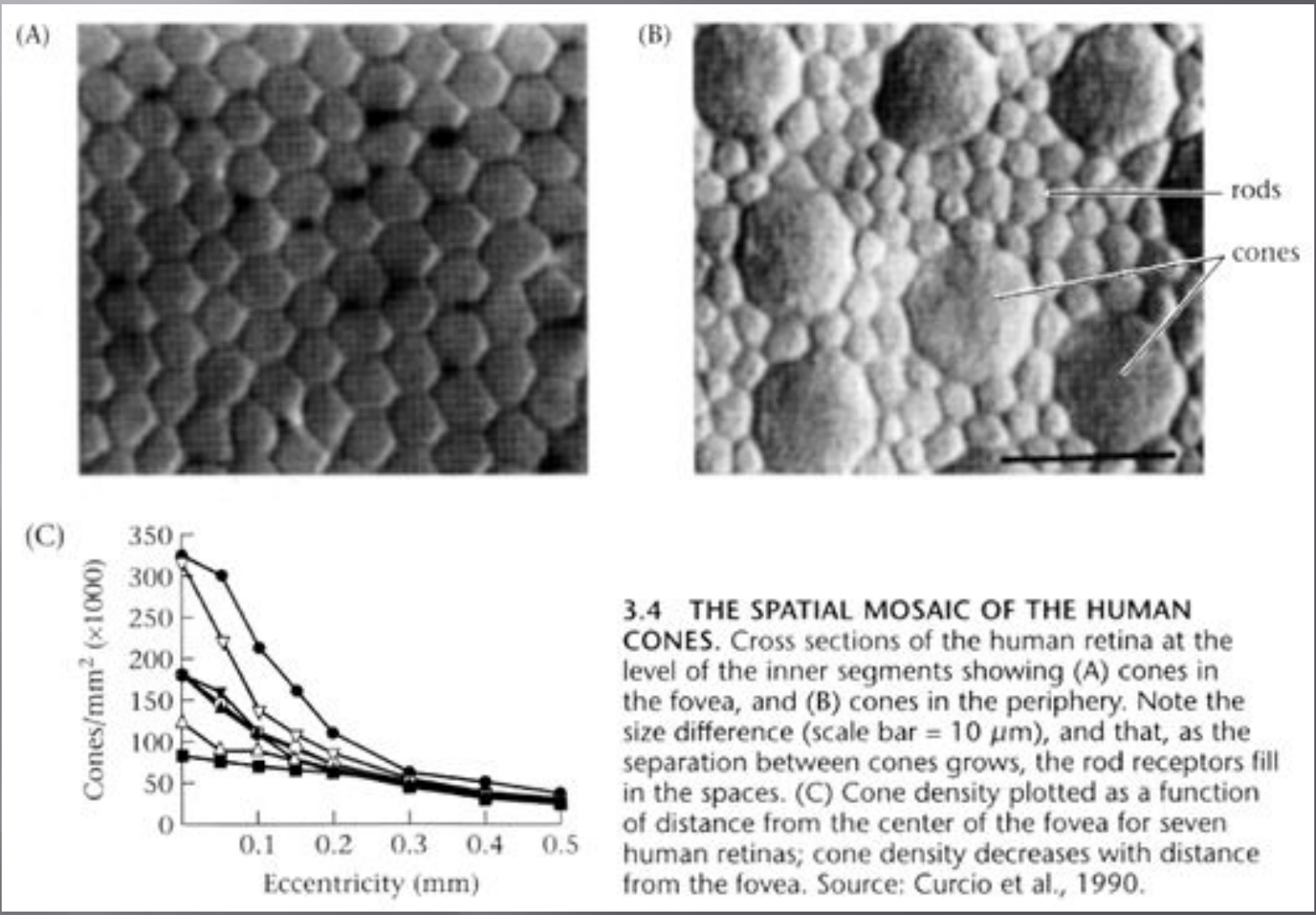


Fig. 19-12. Distribution of rods and cones in human retina. Instead of retinal distances, Osterberg's values for corresponding perimetric angles are given. Although approximate only, especially at higher angles, such values are more useful in practice than distances on the retina. Note distribution of rods and cones on nasal side in and near fovea, not given on this graph, would be approximately the same as distribution on temporal side of retina, which is seen on left of vertical passing through 0 degree on angle scale. (After Østerberg; from Pirenne, M.: Vision and the eye, London, 1948, The Pilot Press.)

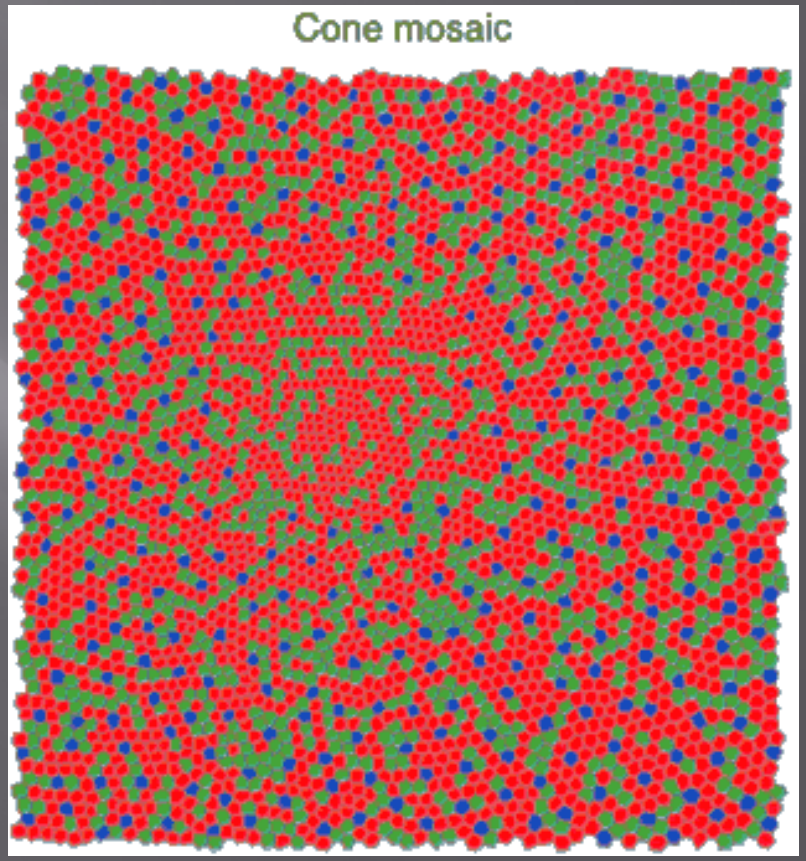
Photomicrograph of human retina showing rods and cones (Curcio et al, 1990)



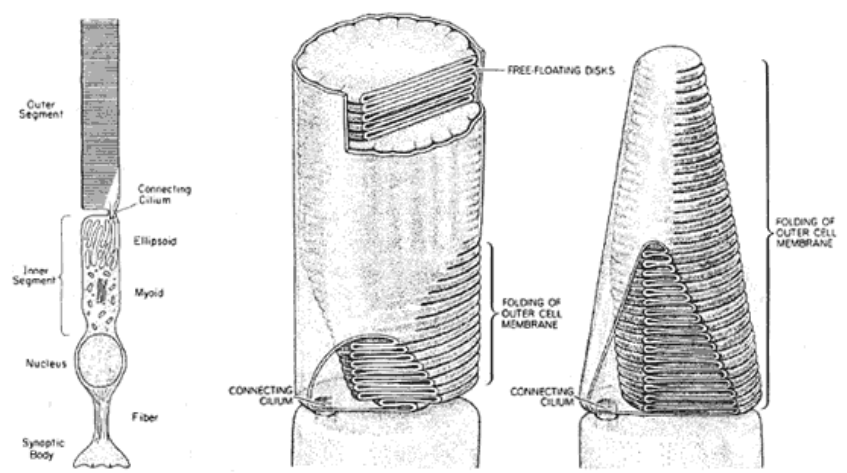
3.4 THE SPATIAL MOSAIC OF THE HUMAN CONES. Cross sections of the human retina at the level of the inner segments showing (A) cones in the fovea, and (B) cones in the periphery. Note the size difference (scale bar = 10 μm), and that, as the separation between cones grows, the rod receptors fill in the spaces. (C) Cone density plotted as a function of distance from the center of the fovea for seven human retinas; cone density decreases with distance from the fovea. Source: Curcio et al., 1990.

Distribution of cones in human fovea

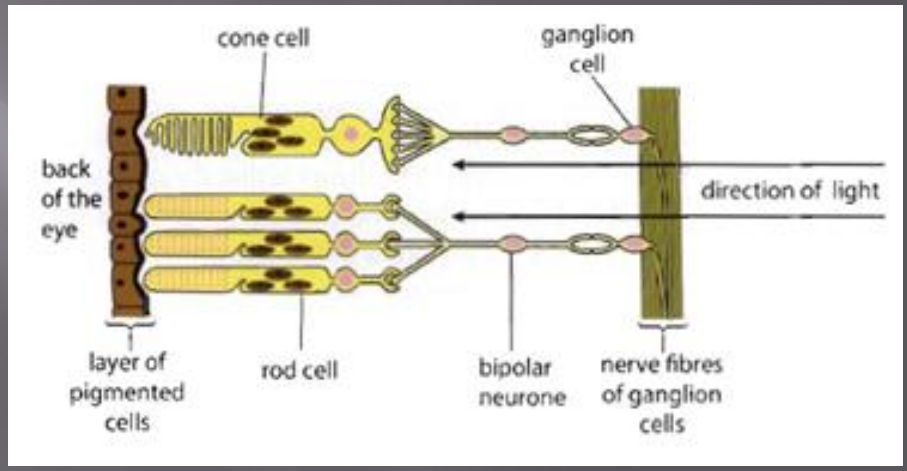
- Cone density peaks at fovea
- Estimated 150,000 per square millimeter
- Size is about 7 microns in diameter
- Even here cones are not distributed randomly- very few blue cones at very center
- Ratio of R+G to B cones is 100/1



Rods are more sensitive to light because they have both more light sensitive pigment collecting surface and are wired in groups (binned) to increase light collecting area (Young and Young 1970-1971)



At the left is a generalized conception of the important structural features of a vertebrate photoreceptor cell. At the right are shown the differences between the structure of rod (left) and cone (right) outer segments. These diagrams are from Young (1970) and Young (1971).



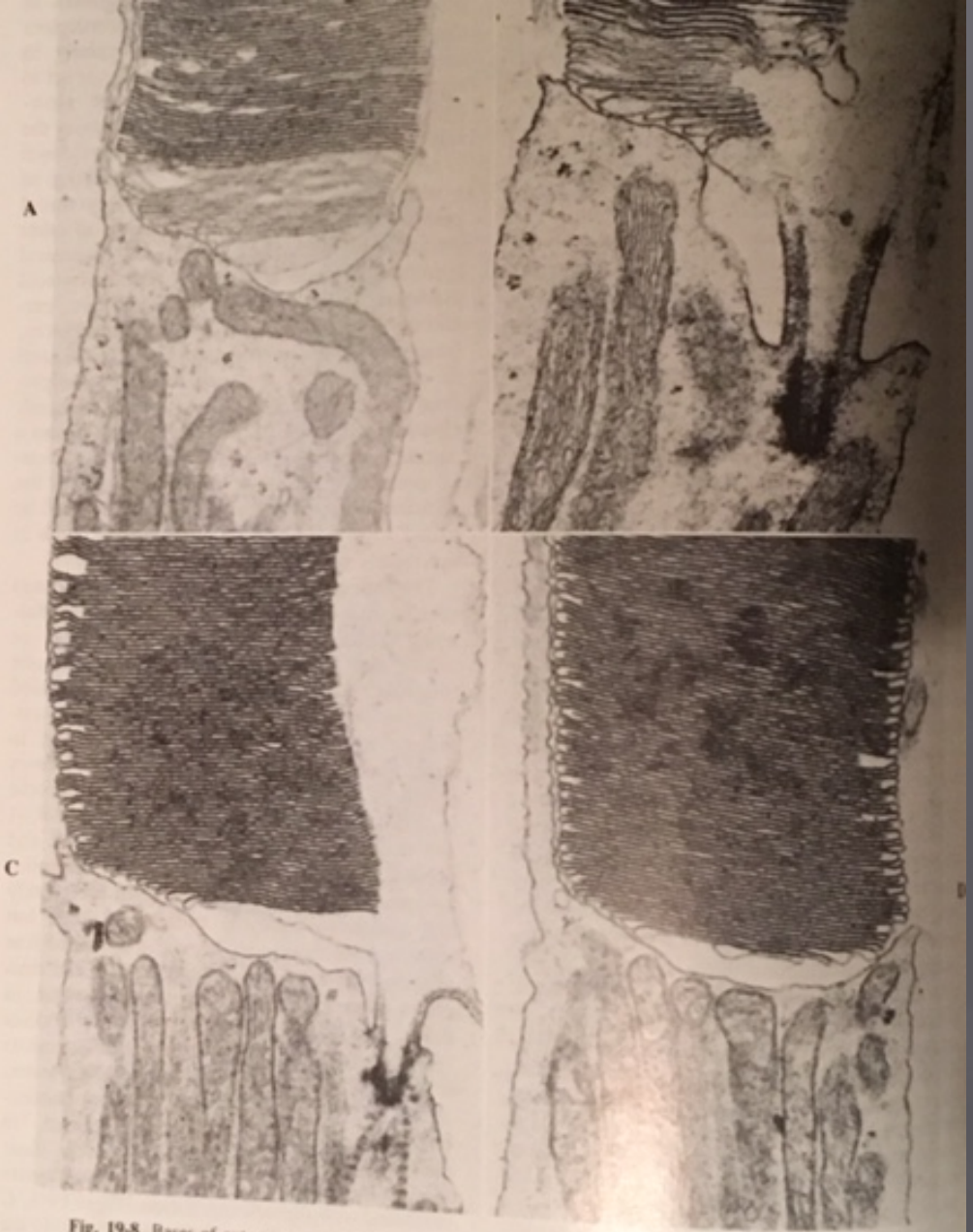
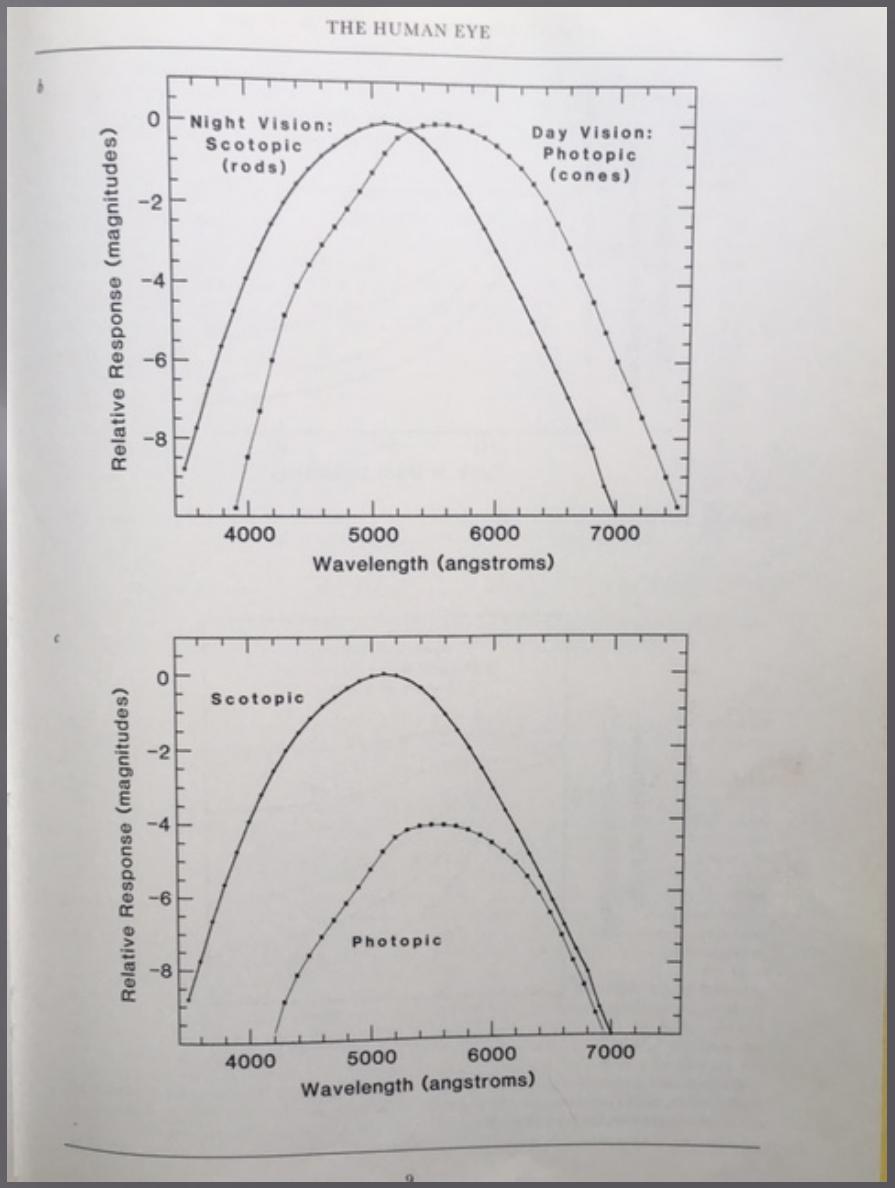


Fig. 19-8. Bases of outer segments of rhesus rods. **A** and B, and ... **D**. **A** and **C** are cut at right angles to **B** and **D**. Note plasma membrane infolding to form sacc... separation of outer and inner segments in **B** (magnification ×30,... ...gnification ×37,000) and total (magnification ×22,500) and **D** (magnification ×25,000) except ... phenomena are observed in **C** with the plasma membrane. ... all saccules are seen to connect

Rods and Cones respond to different wavelengths

- Cones averaged together are most sensitive to 5600nm (yellow-green), while rods are most sensitive to a slightly shorter wavelength of 5000nm (green).
- This is known as the Purkinjee Shift
- Graph taken from Visual Astronomy of the Deep Sky-Roger Clark-data from Kingslake (1965) and Crossier and Holway (1939)



Dark adaptation takes time

- Two phases of dark adaptation-cones adapt first, then rods.
- Cones take about 8 minutes to adapt and achieve a 1-2 magnitude gain, then rods begin adapting and take up to 30-60minutes with another 4 magnitude increase in sensitivity
- From VAOTDS-data by Middleton,1958 and Hecht et al (1935) and Bartley (1951)

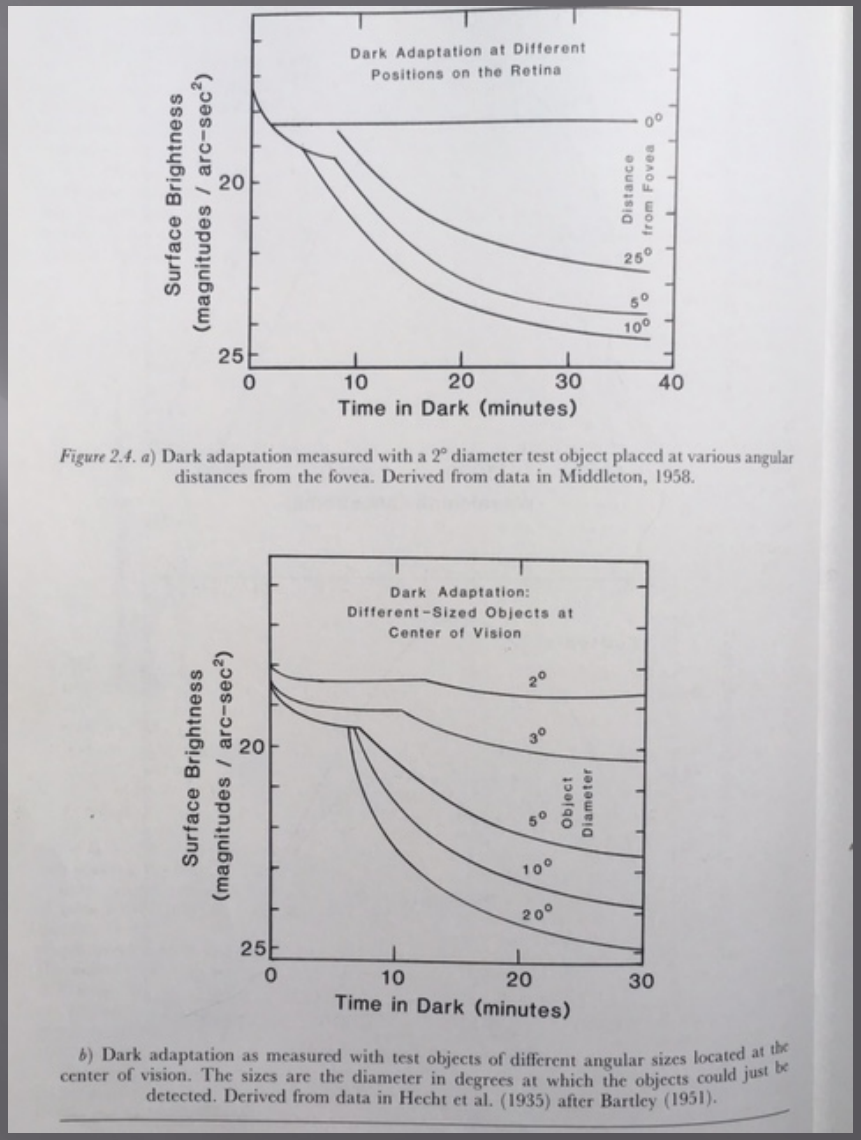


Figure 2.4. a) Dark adaptation measured with a 2° diameter test object placed at various angular distances from the fovea. Derived from data in Middleton, 1958.

b) Dark adaptation as measured with test objects of different angular sizes located at the center of vision. The sizes are the diameter in degrees at which the objects could just be detected. Derived from data in Hecht et al. (1935) after Bartley (1951).

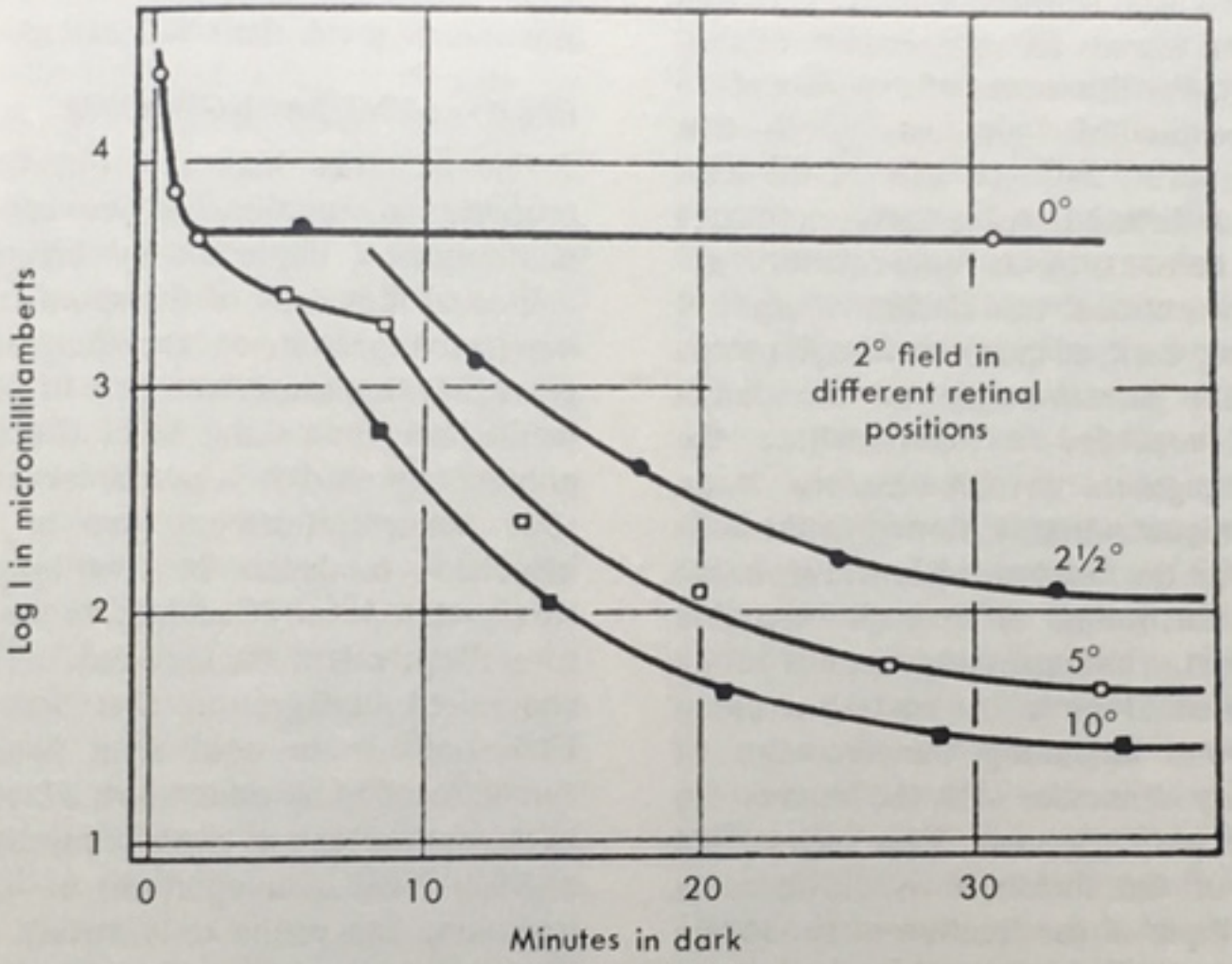


Fig. 16-10. Dark adaptation as measured with a 2-degree field placed at different distances from center. (From Hecht, S., Haig, C., and Wald, G.: J. Gen. Physiol. **19**:321, 1935.)

Principles and Techniques to Maximize Night Vision

Maximize Dark Adaptation

- In general-live healthy lifestyle. Exercise, eat healthy, consider smoking cessation if smoke
- Day before observing-make sure you are well rested, wear sunglasses with UV/Blue protection. Don't feel wearing red goggles that helpful. Avoid excessive alcohol as it sedates nervous system.
- Evening of observing stay hydrated, eat a good dinner, then allow fully 30-60 minutes before beginning your critical observing.
- Use dim red lighting to look at charts if needed, but even better is to avoid this as much as possible because even slightest amount of light raises threshold detection significantly.
- For maximum effect-can drape cloth over head while observing.
- Take your time-observe slowly and carefully.
- No benefit of pharmacologic dilation, or breathing pure O2 unless at high altitude.

Principles and Techniques to Maximize Night Vision

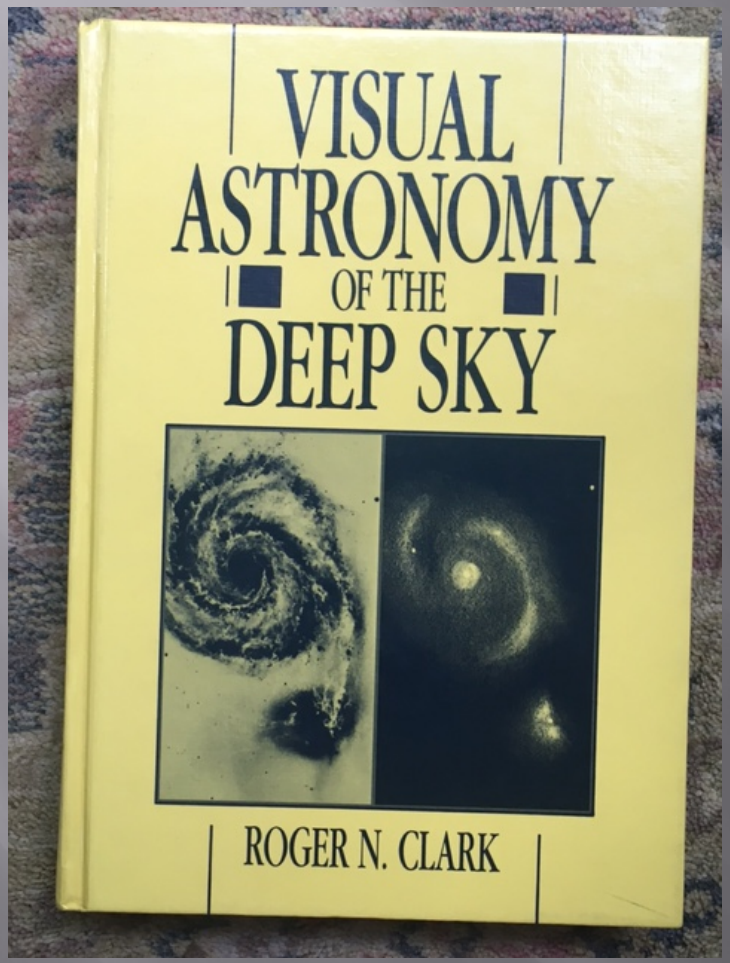
Maximize Contrast Sensitivity

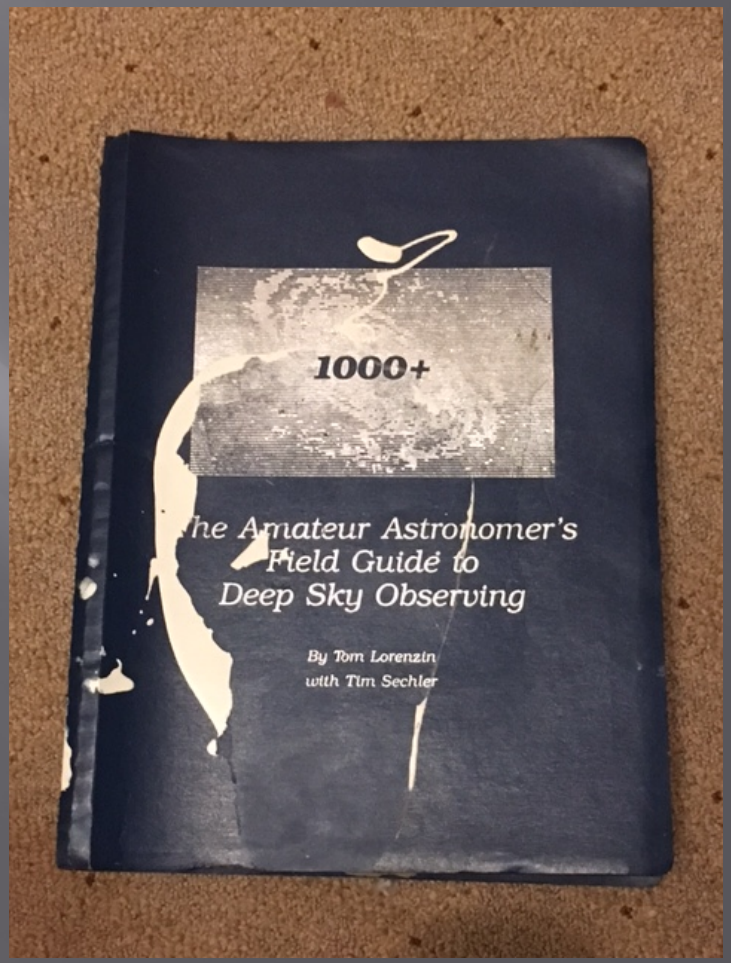
- Wear glasses with high efficiency anti-reflective coatings, especially if you have astigmatism. For telescope use may be able to remove them. Experiment. Use artificial tears to lubricate eyes-remember must keep that pre-corneal tear film intact as that's the PRIMARY refracting surface of the eye.
- If you wear contacts-consider observing without them as they tend to dry at end of day thus blurring vision and reducing contrast sensitivity.
- If you must wear contacts-use rewetting drops. Refresh Optive Advanced/Systane Balance.
- Don't let your eyes dry out!

Learning to “See” at Night

- Vision is a dynamic, and continuous ballet between the eyes seeing something and the brain interpreting what that something is. MEW
- “Millions of items of the outward order are present to my senses which never properly enter into my experience. Why? Because they have no interest for me. My experience is what I agree to attend to…without interest, experience is an utter chaos.”William James-American Philosopher/Psychologist

Two Great Books that help us Learn to See

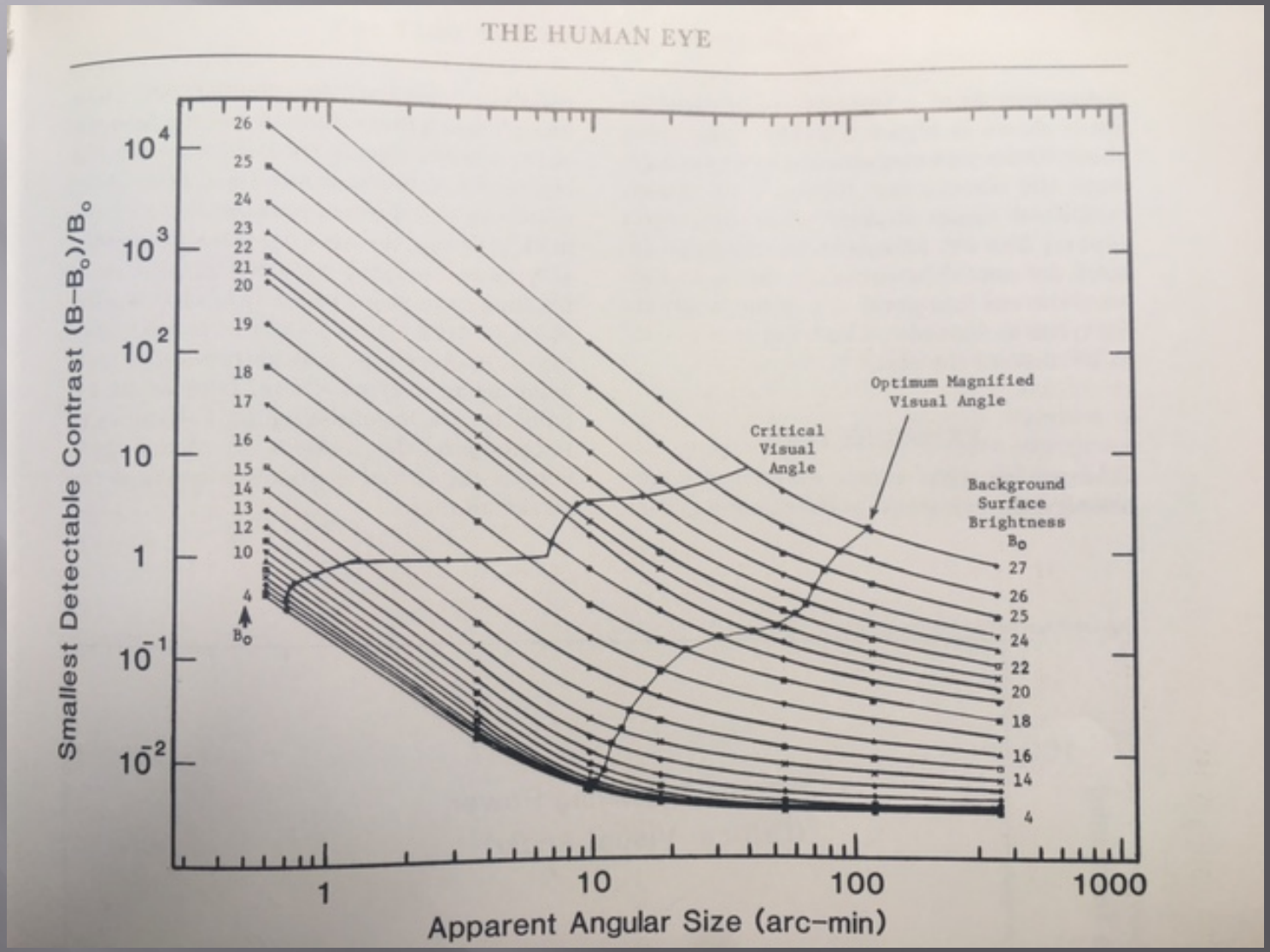




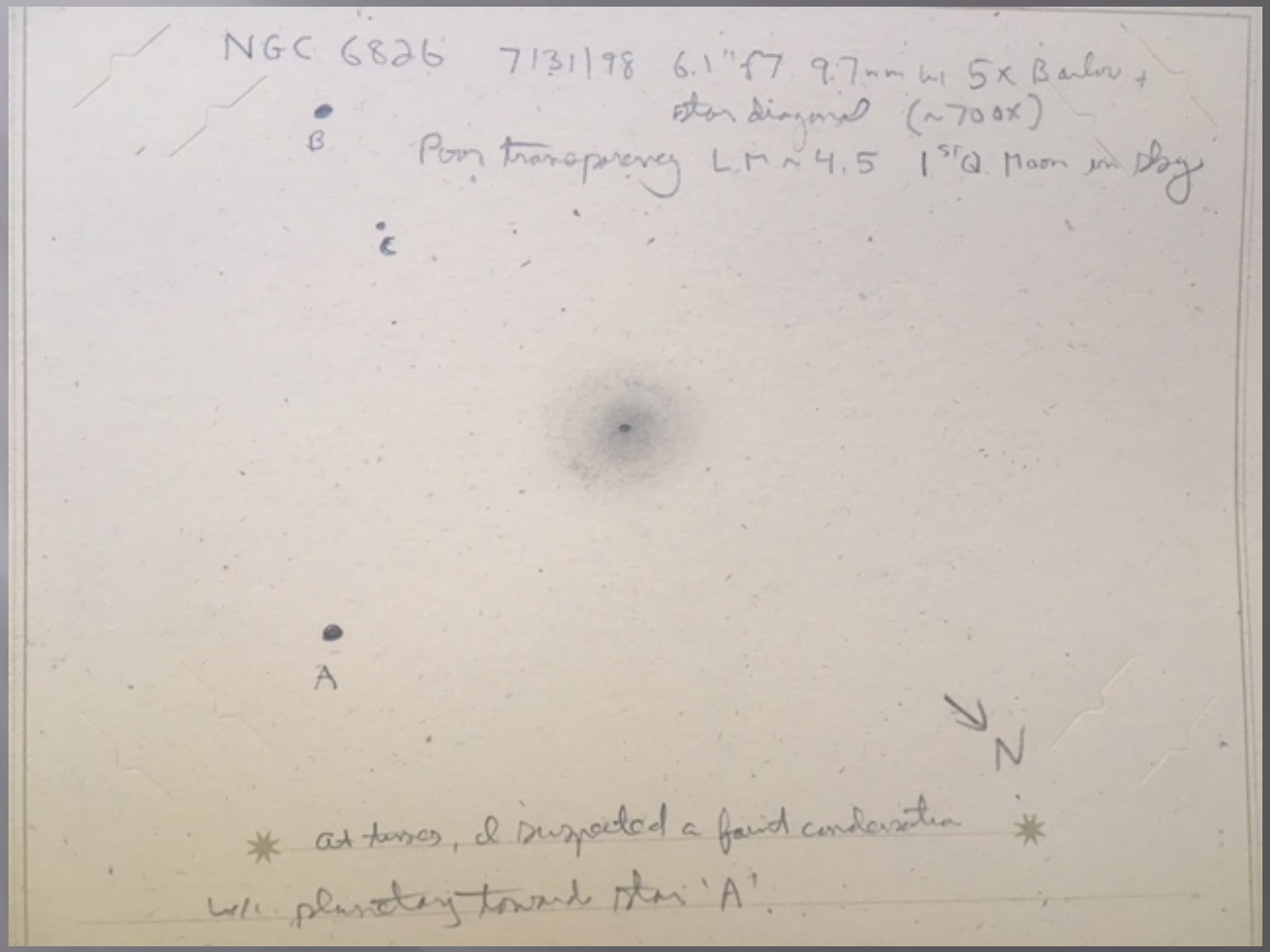
Tips from Visual Astronomy of the Deep Sky

- By Roger N. Clark
- Published 1990
- Available on Amazon
- Use averted vision-look about 5-10 degrees to right or left of object to increase visibility
- Observe carefully,slowly.
- Can slowly move telescope to enhance detection of faint objects
- Increasing magnification does not increase contrast of **an extended** object with sky background, but can improve visibility.
- Don't be afraid to use medium or even high magnification (depending on surface brightness). This increases chance of detecting object or feature by increasing apparent size which at any given sky background brightness lowers eye threshold contrast detection limit (up to a point)
- See Clark's Fig. 2.6, p.13 and read Chapter 6.
- Sketch what you are looking at! One of best ways to learn to see! Or SKETCH AN EGG.

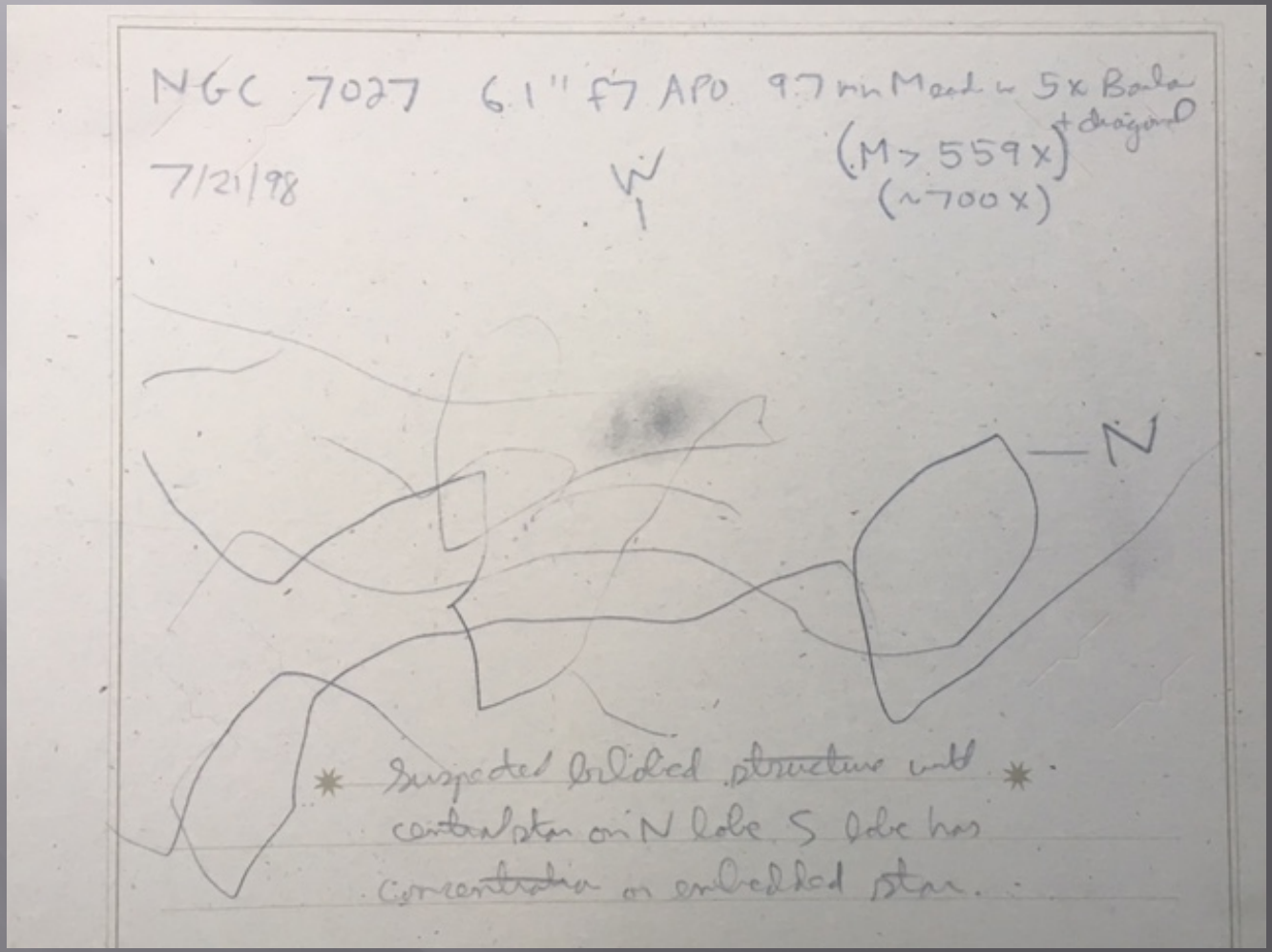
The “most important diagram “in the book Lets look at what it means



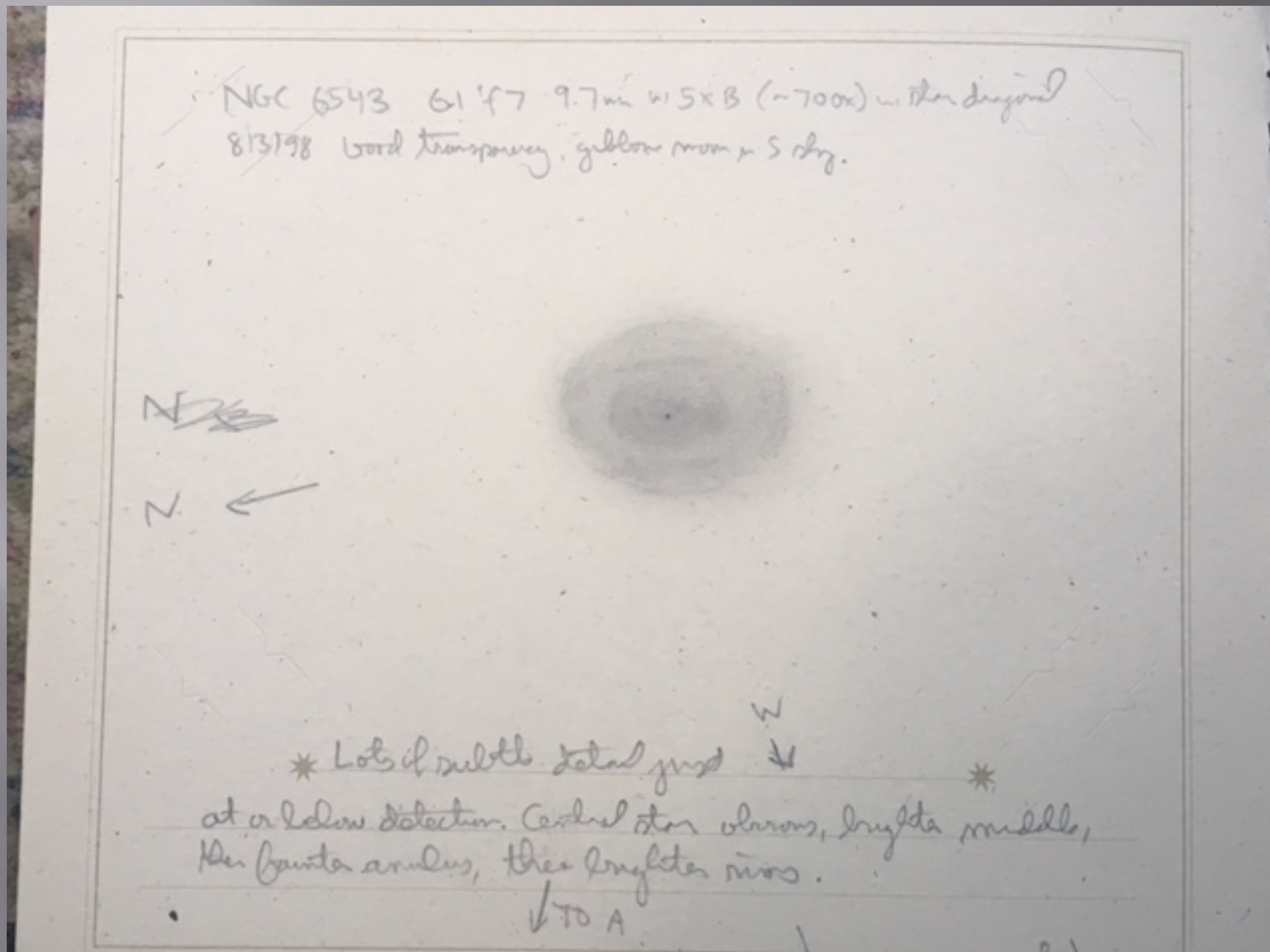
NGC 6826 700X (way above OMVA)



NGC 7027 700X (Way above OMVA)

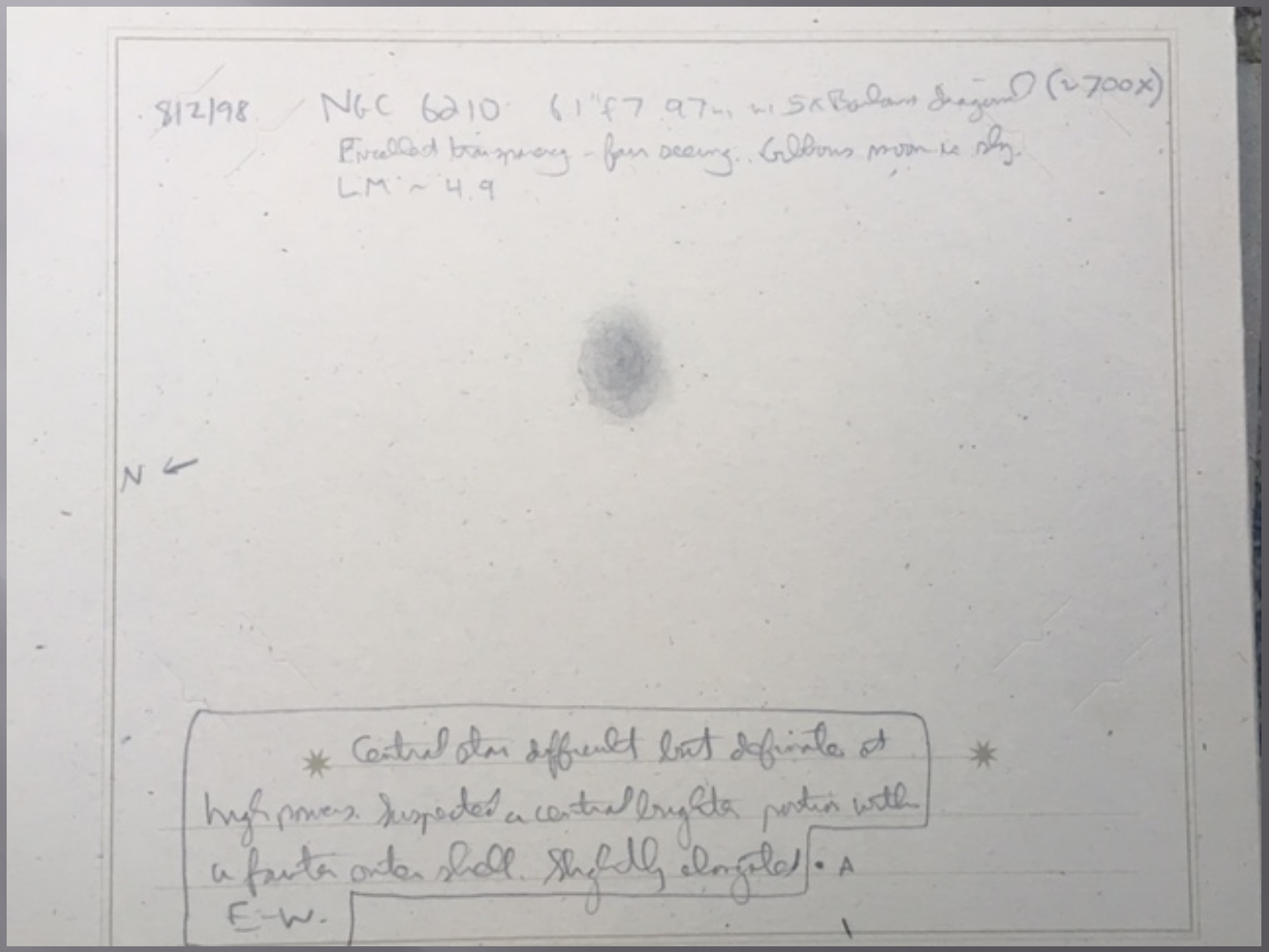


NGC 6543

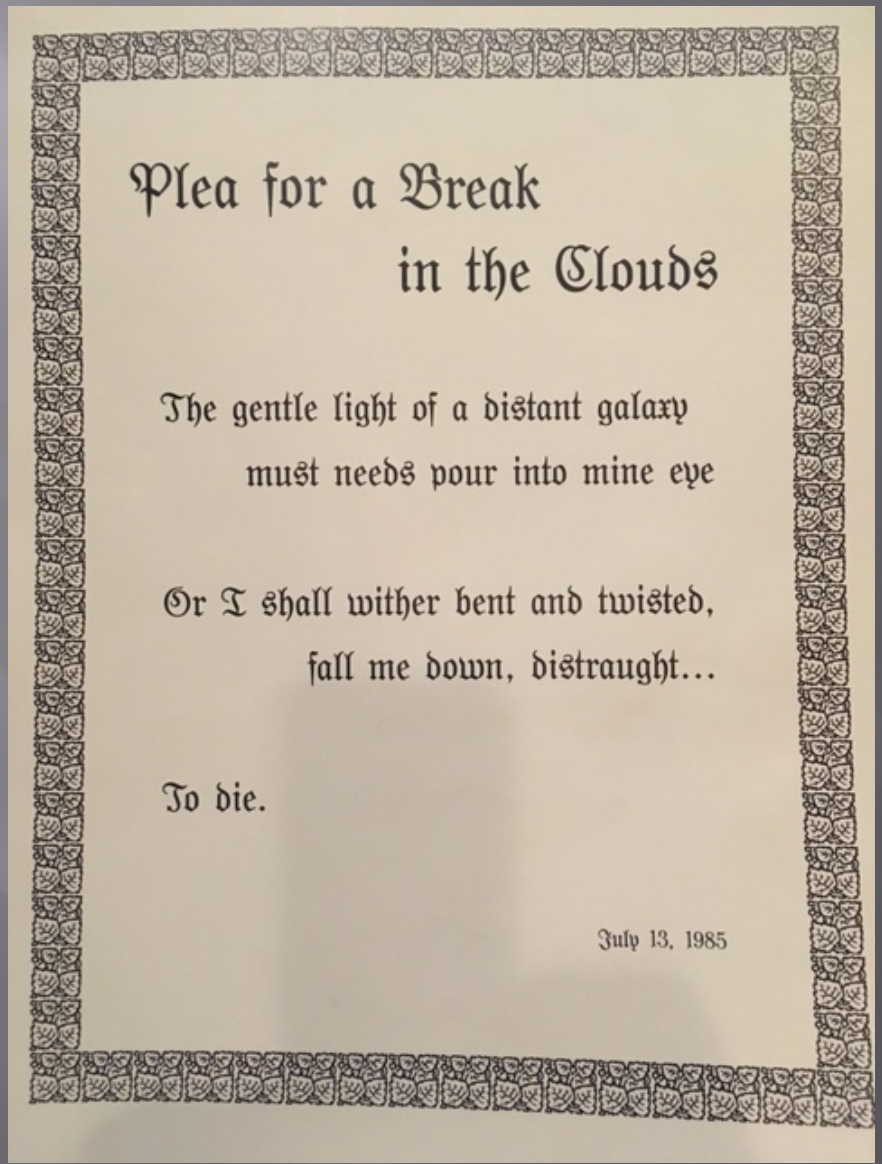


NGC 6543 61" f7 9.7mm w 5xB (~700x)
8/3/98 Good transparency, gibbous moon in S sky.
N
W
Lots of subtle detail just
at or below detection. Central star obvious, brighter middle,
then fainter annulus, then brighter rims.
TO A

NGC 6210 (Turtle Nebula) 700X



Thank You!
Plea by Tom Lorenzin



Plea for a Break in the Clouds

The gentle light of a distant galaxy
must needs pour into mine eye

Or I shall wither bent and twisted,
fall me down, distraught...

To die.

July 13, 1985