



Preserving Dark Adaptation – Dealing with lights, smoking & alcohol!

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Talk contents

- A bit about light & the eye
- The process of Dark Adaptation
- How we lose it
- How not to lose it!
- Some experimental results

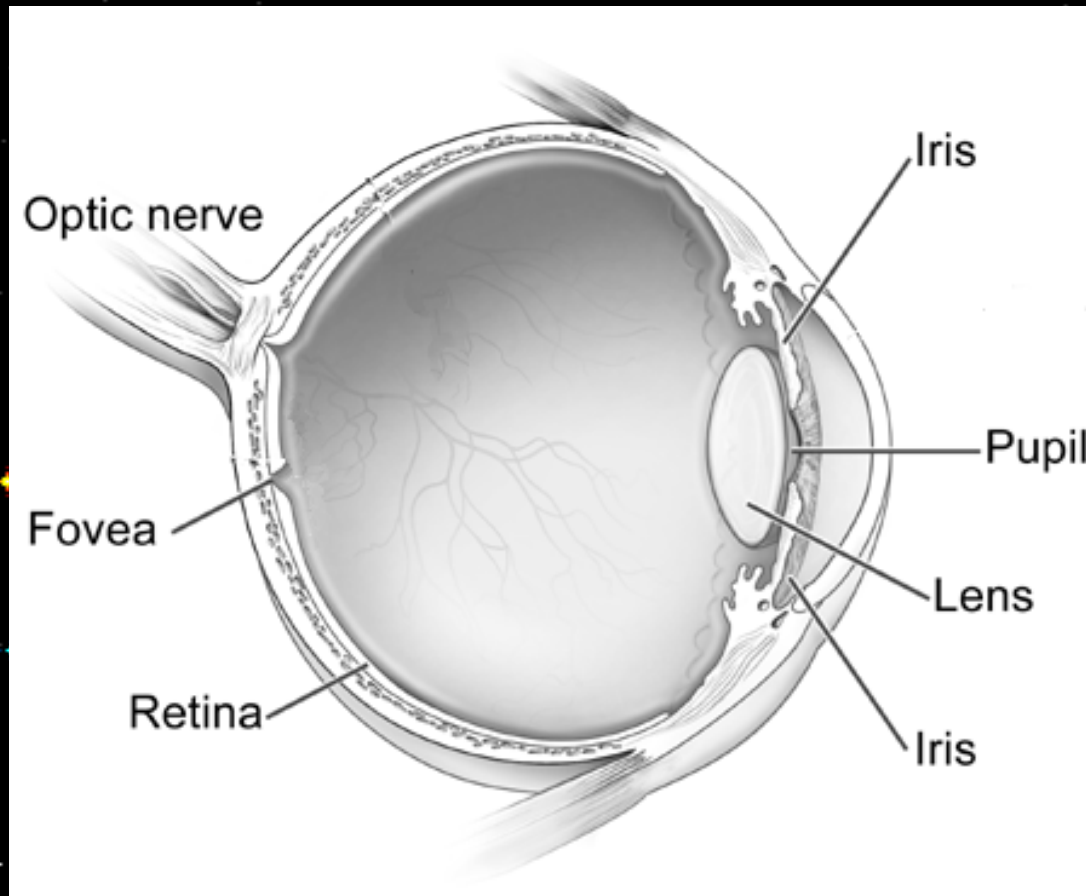
Visual Astronomy

The eye has evolved to be a superb imaging device, (compare it with the latest digital camera!)

- >100 million pixels
- >80 degree field of view
- Resolution of <1arcmin in the centre
- Sensitivity from 0.01 lux to 100,000 lux
- They come in pairs!

Sensitivity control

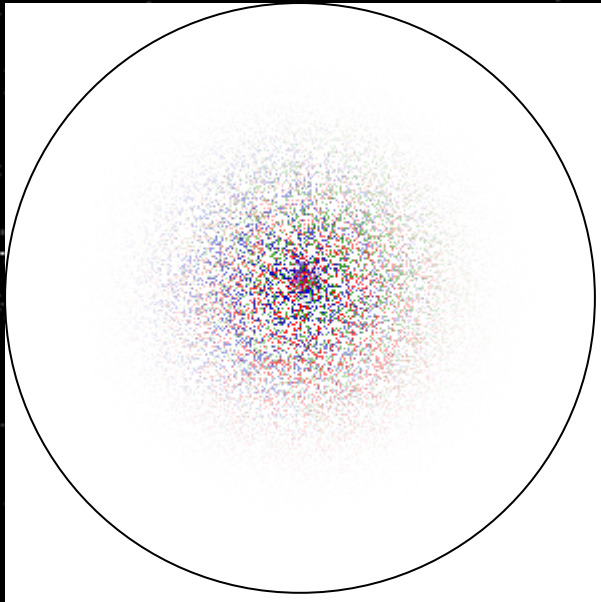
x10 sensitivity
control at cortex.
Very fast
response time
($<1\text{sec}$)



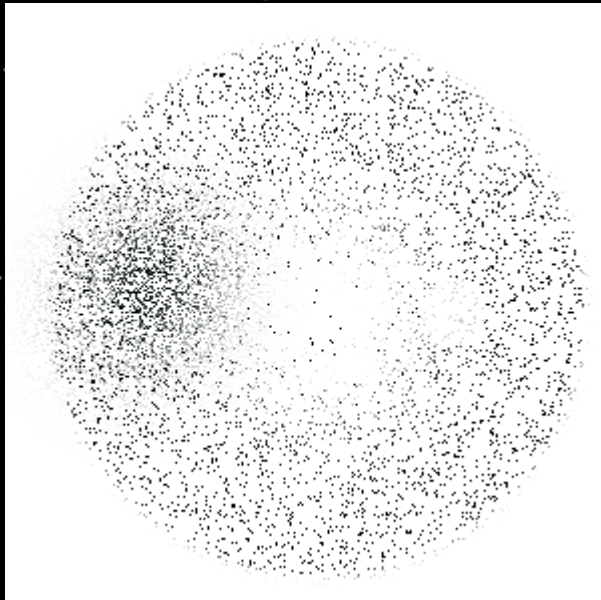
x10 sensitivity
control at iris.
Fast
response
time (secs)

x100,000 sensitivity control at retina.
Very slow response time (minutes)

The Retina



About 6 million cones.
Sensitive to Red, blue & green light
Grouped in the central region (fovea)
Respond to light levels $>0.03\text{cd/m}^2$
“Photopic Vision”



About 100 million rods.
Monochromatic
Denser in the outer regions
Respond to light levels $<0.03\text{cd/m}^2$
“Scotopic Vision”

Dark Adaptation time

- Typically it takes about 7 minutes to adapt from normal ambient to very dim coloured conditions.
- It takes around 30 minutes to adapt to full scotopic vision

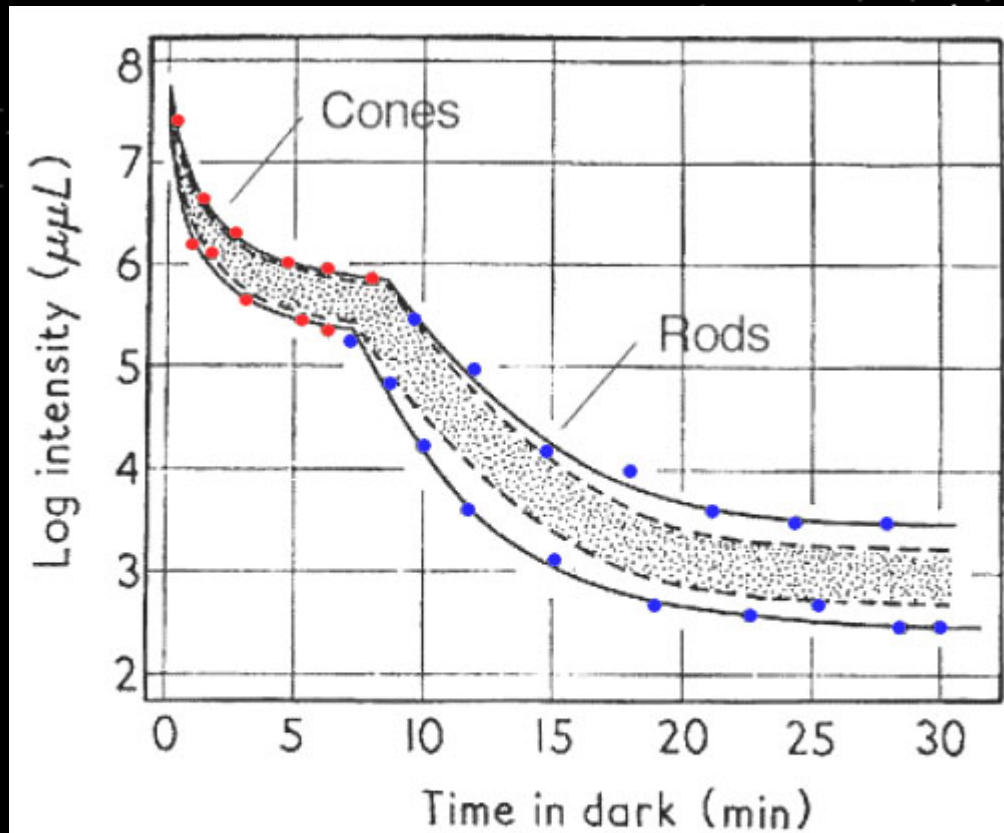


Figure 1. Dark adaptation curve. The shaded area represents 80% of the group of subjects. Hecht and Mandelbaum's data from From Pirenne M. H., *Dark Adaptation and Night Vision*. Chapter 5. In: Davson, H. (ed), *The Eye*, vol 2. London, Academic Press, 1962.

How bright the light?

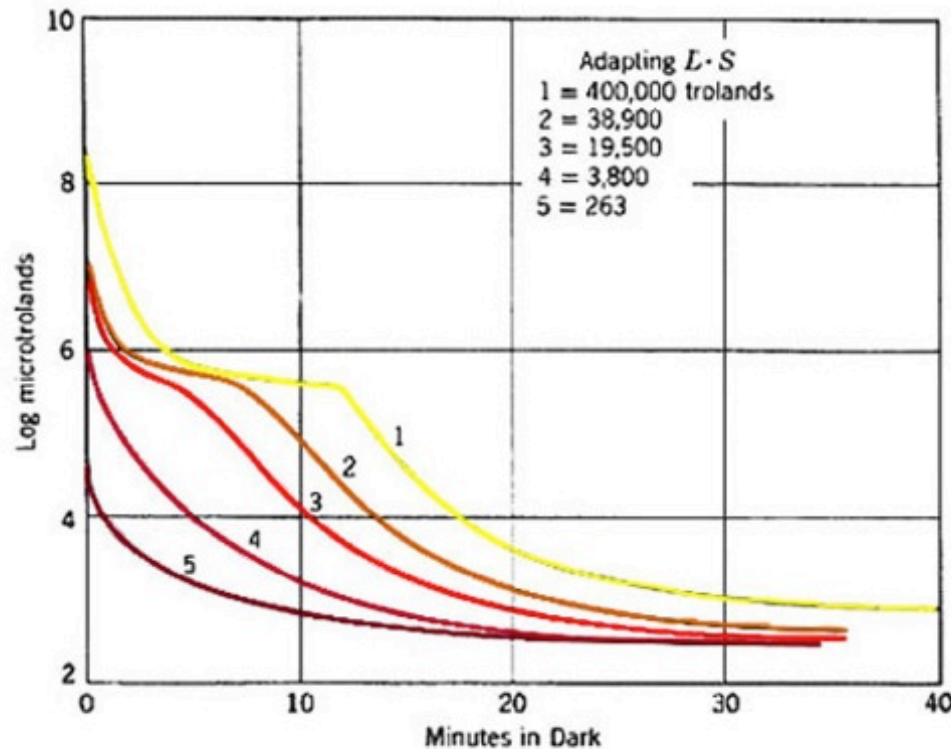


Figure 2. Dark adaptation curves following different levels of pre-adapting luminances. Hecht, Haig and Chase's data from Bartlett N. R., *Dark and Light Adaptation*. Chapter 8. In: Graham, C. H. (ed), *Vision and Visual Perception*. New York: John Wiley and Sons, Inc., 1965.

- After moderate light, our eyes can fully re-dark adapt in a few minutes.
- After bright illumination, many minutes are required.

How long the light?

After short durations of brighter light, our eyes re-adapt within minutes.

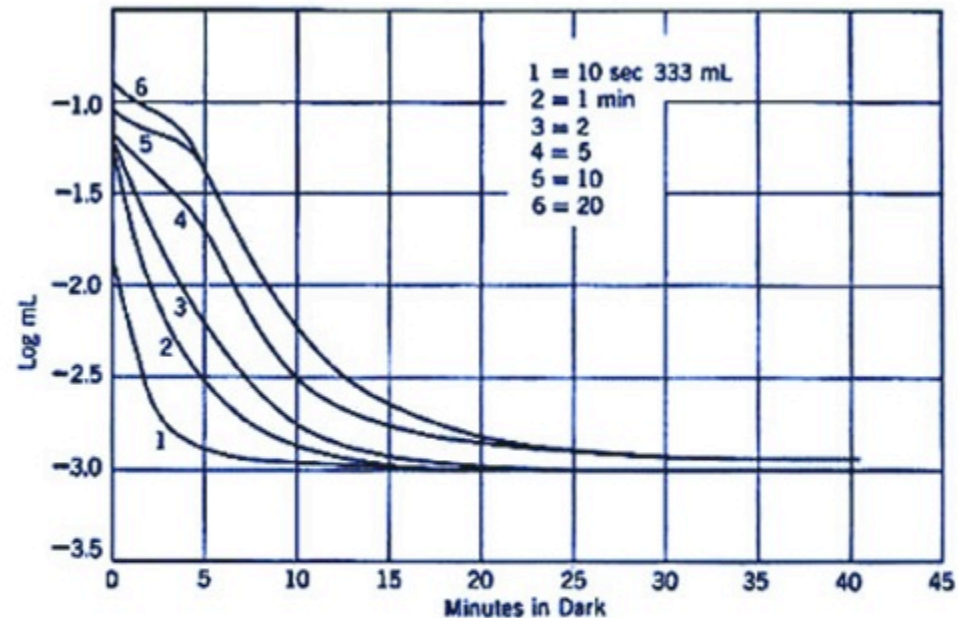
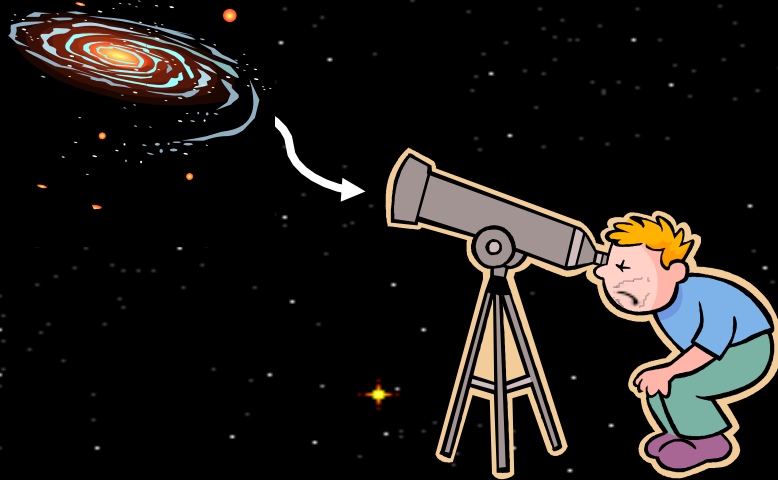


Figure 3. Dark adaptation curves following different duration of a pre-adapting luminance. Wald and Clark's data from Bartlett N. R., *Dark and Light Adaptation*. Chapter 8. In: Graham, C. H. (ed), *Vision and Visual Perception*. New York: John Wiley and Sons, Inc., 1965.

So what is going on?

- When dark adapted, a photosensitive protein in the rods called Rhodopsin, converts into Retinene under dim illumination.
- This conversion is signalled electrically to the brain and perceived as dim light.
- The Retinene can convert straight back to Rhodopsin using up Oxygen and Glucose if the exposure to light is for less than 5 minutes.
- If longer than 5 mins, the Retinene converts to Vitamin A. Conversion from Vitamin A to Rhodopsin takes 20-30 minutes.

Before Dark Adaptation



Rhodopsin

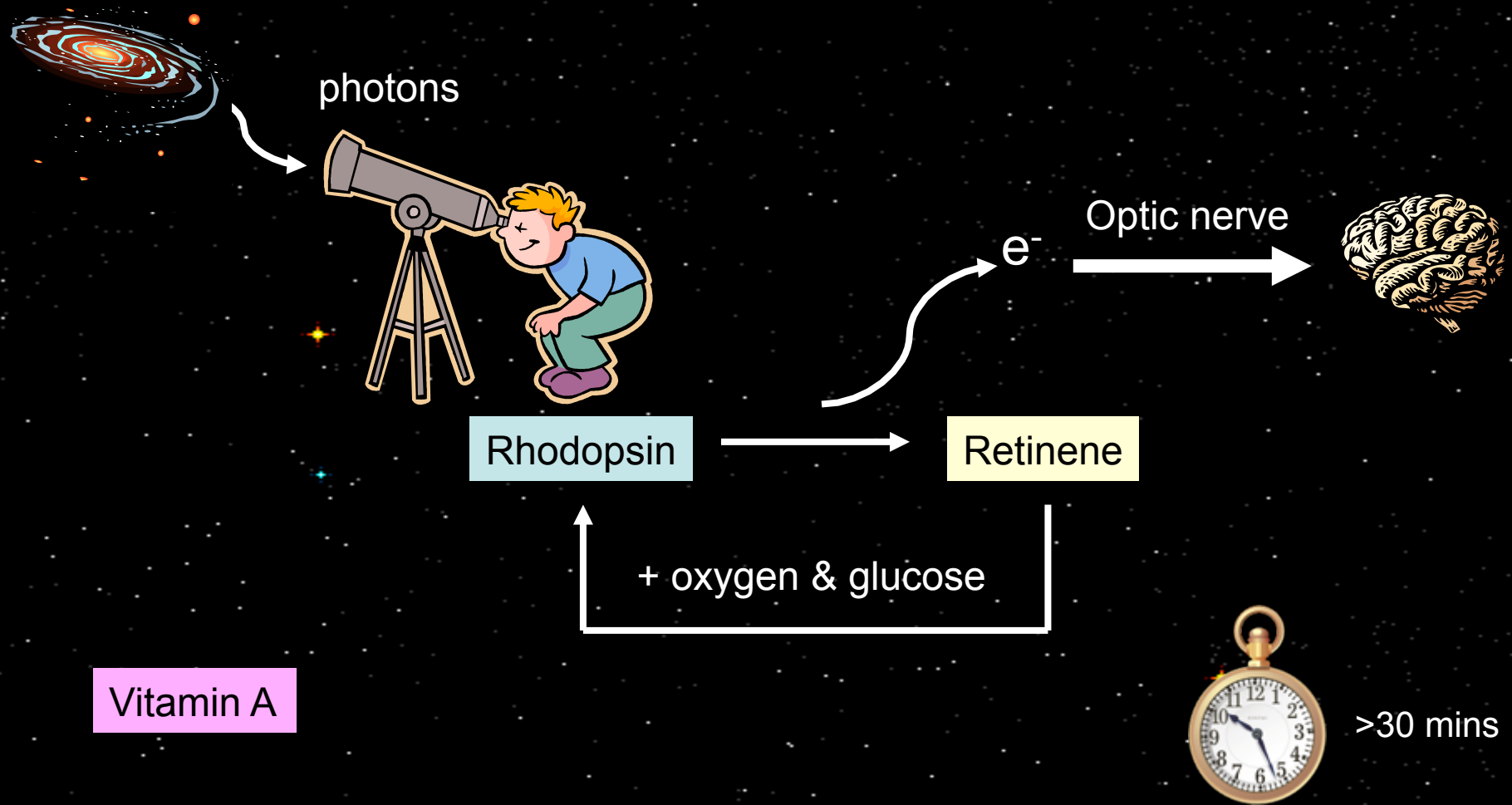
Maximum store of Rhodopsin
generated after at least 30 mins

Vitamin A



less than 30 mins

After Dark Adaptation

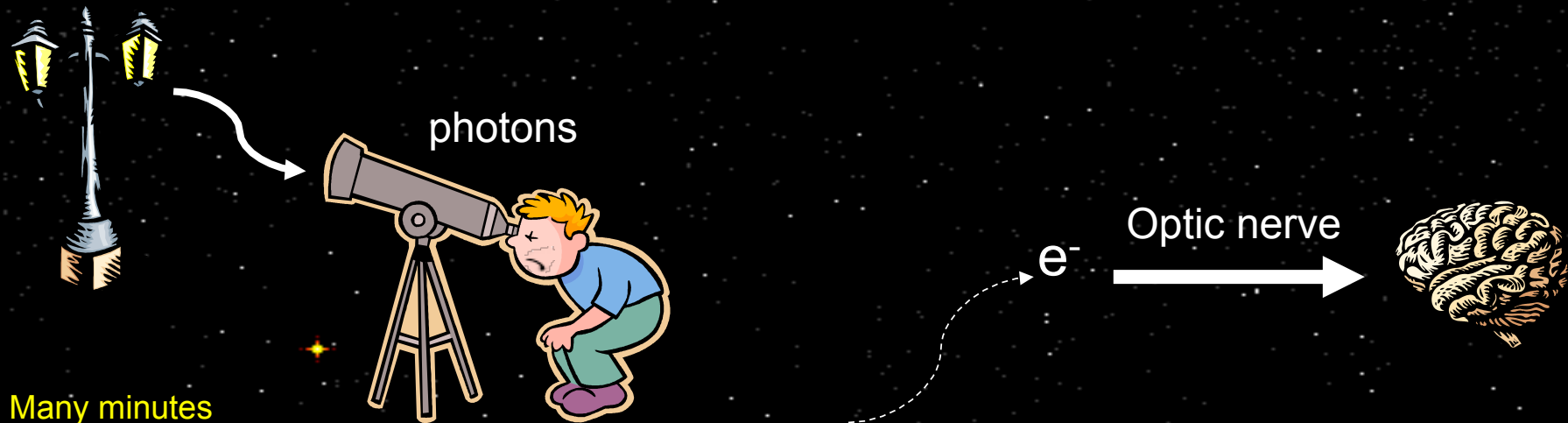


Vitamin A



>30 mins

After over-exposure



Many minutes
required again
to
generate
Rhodopsin

Rhodopsin

Retinene

Rhodopsin largely used up

Vitamin A

Retinene converts back into Vitamin A

And for astronomers?

- Therefore we need to make and maintain high levels of Rhodopsin in our retinas
- At the beginning of the session we take about 30 minutes to fully make Rhodopsin from vitamin A
- When using our rods, we need to constantly assist the conversion of Retinene back to Rhodopsin.
- We need to keep exposure to brighter lights to a minimum and for short periods.
- Note that each retina acts independently

and in practice?

- Maintain your oxygen & glucose levels at good levels
 - Smoking increases dark adaptation times by up to 20%
 - Smoking reduces light sensitivity by up to 50%
- Heavy drinking can reduce pupil dilation by 20%, and reduce signal at the cortex by a further 20%.
- Keep lights dim and on for short durations
- Keep blood sugar levels up!



Red lights

- Rods are less sensitive to far-red light
- Red LED torches & lights should be ideal, but
 - They must still be dim
 - They must emit beyond 650nm
- But, red light can be difficult to focus for some people.
- And, reading coloured maps and images can be tricky!

Question: How bright can a red LED torch be before we lose dark adaptation?

White lights

- Very dim white light does not effect dark adaptation.
 - ie staring at a galaxy in the eyepiece!
- Recovery from short exposures of stronger white light can be quite fast.

Question: What level of white illumination has little effect on dark adaptation?