

Hot Science Cool Talks

UT Environmental Science Institute

75

Your Eye, My Eye, and the Eye of the Aye – Aye: Evolution of Human Vision from 65 Million Years Ago to the Present

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Your Eye, My Eye, and the Eye of the Aye-Aye



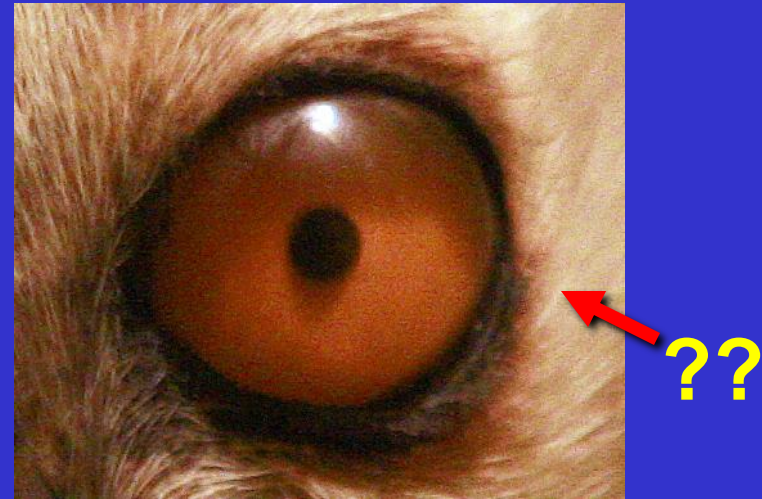
**Evolution of human vision from 65
million years ago to the present**

Your Eye, My Eye, and the Eye of the Aye-Aye



Two main topics: Evolution of our
visual perception of depth and detail

Your Eye, My Eye, and the Eye of the Aye-Aye



But first...

Meet the Aye-Aye: your weirdest primate relative



Aye-Aye:



Aye-Aye Grub Foraging

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What could human and aye-aye visual systems possibly have in common?

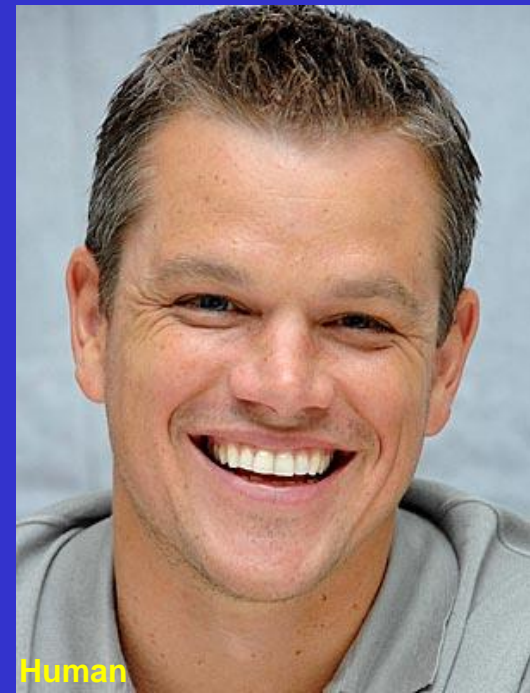


Would you like a hint?

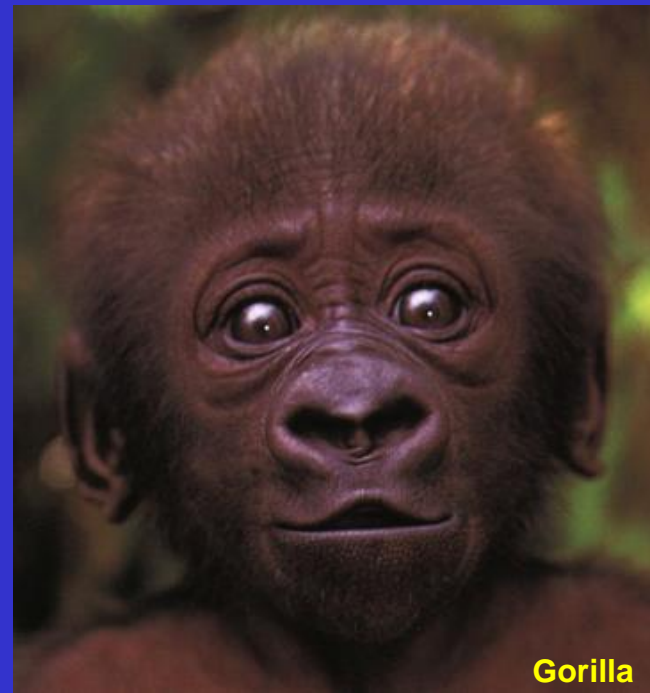
What could human and aye-aye visual systems possibly have in common?



All living primates have forward-facing eyes!



Human



Gorilla



Owl Monkey

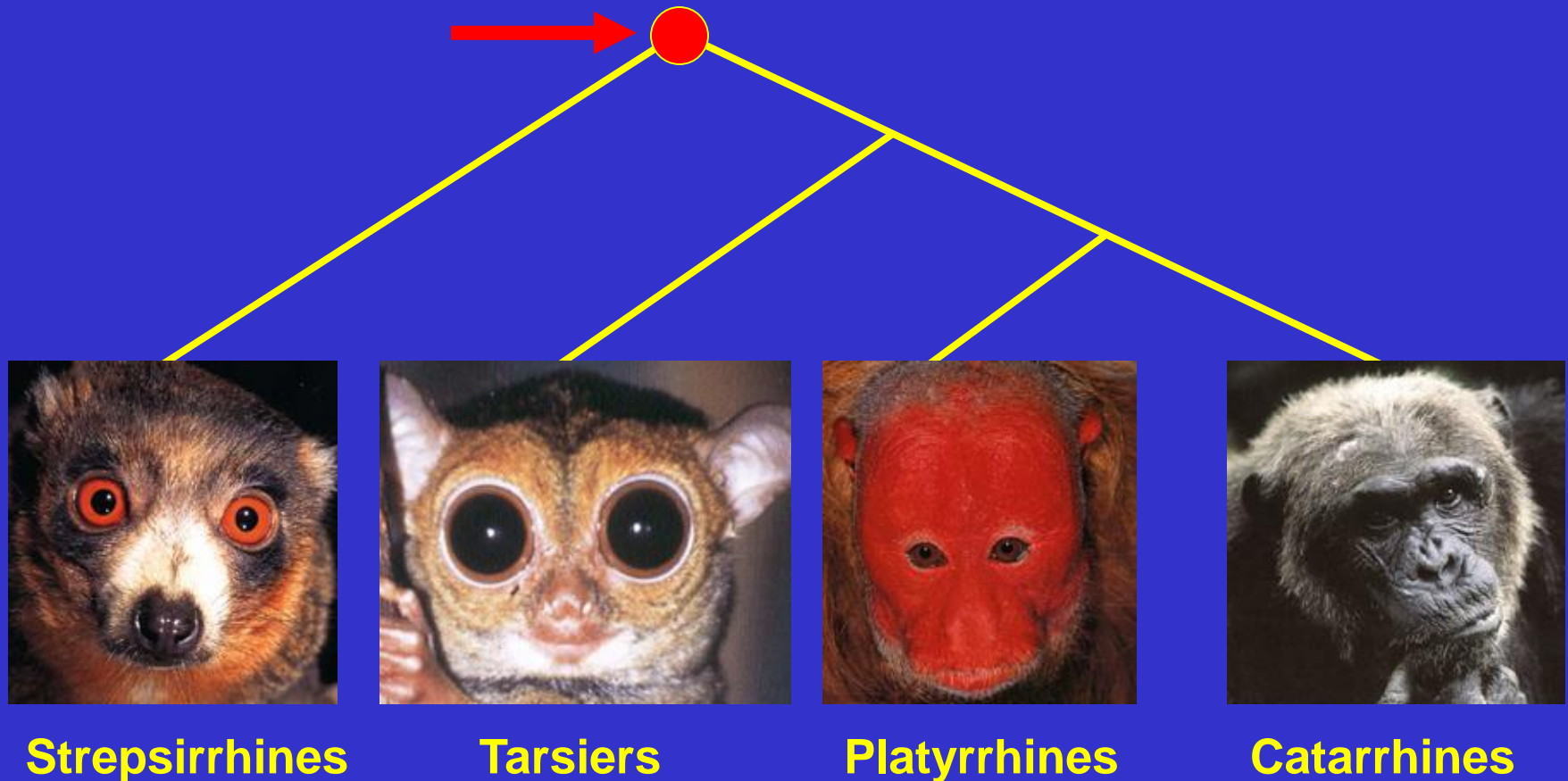


Bushbaby

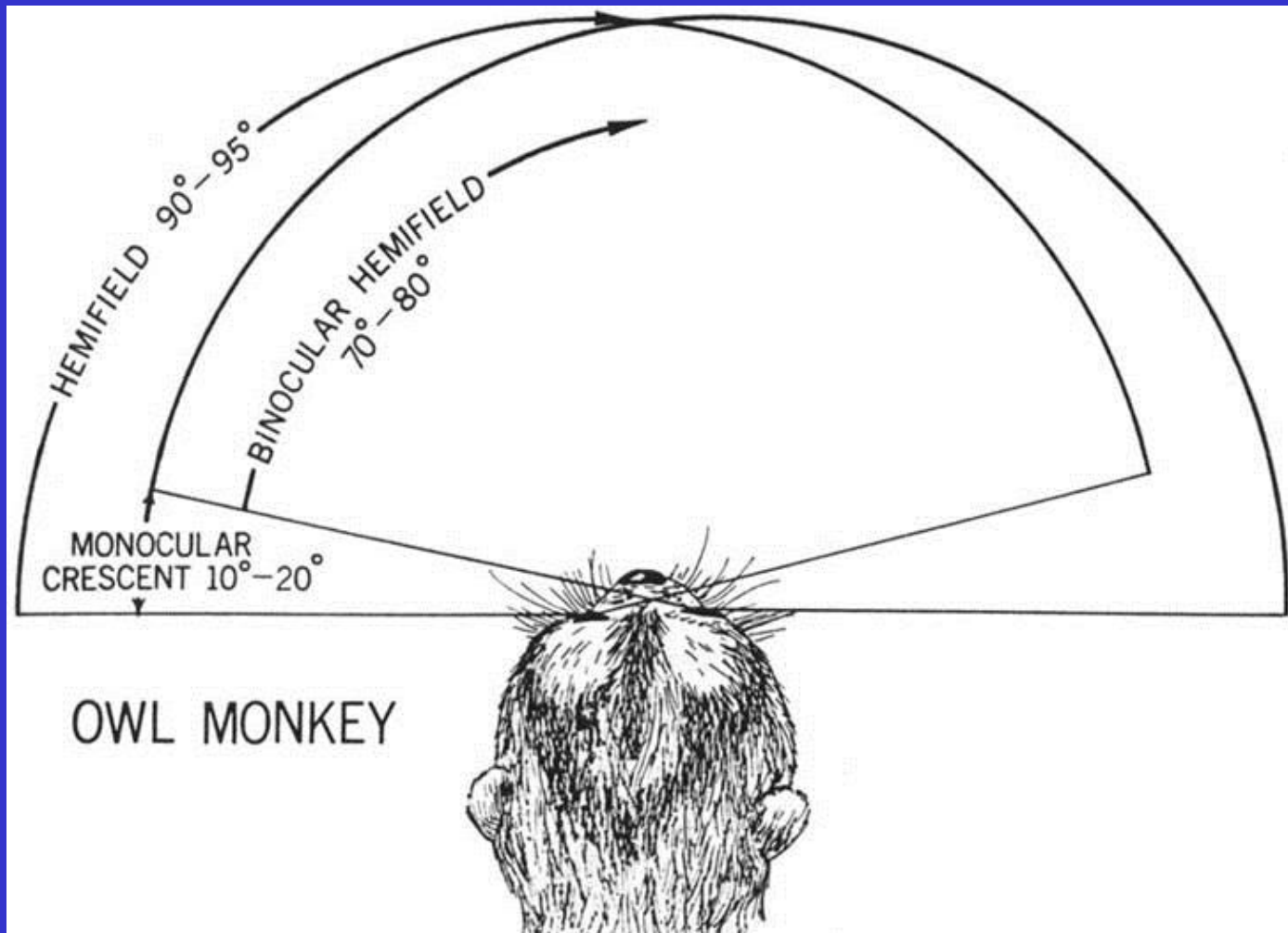
Why?

[several ways to answer this question...]

1. Phylogenetic Answer: Forward-facing eyes were present in the last common ancestor of living primates



2. Functional Answer: Forward facing eyes give you a wider field of binocular vision and stereopsis



Who has Stereopsis?

Demo:
Floating Hot Dog
(binocular fusion)



Binocular Vision and Stereopsis
Critical for Fine Depth Judgement

Demo



3. Ecological
Answer:
Much less
obvious

Q: Why might
primates benefit
from having
improved depth
perception?

The Older Idea:

Forward-facing eyes and improved depth perception necessary for life in the trees



**Can anyone think of any problems
with this hypothesis?**

Hint: Something here on campus...

Can anyone think of any problems with this hypothesis?

Hint:



Tree Shrew

In fact: *Most arboreal mammals don't have forward-facing eyes*



Squirrel

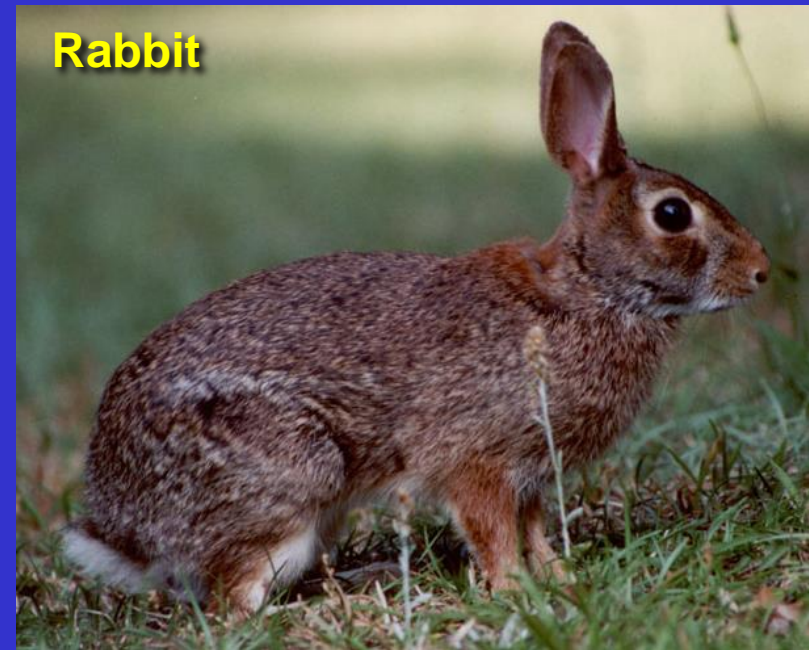


Colugo

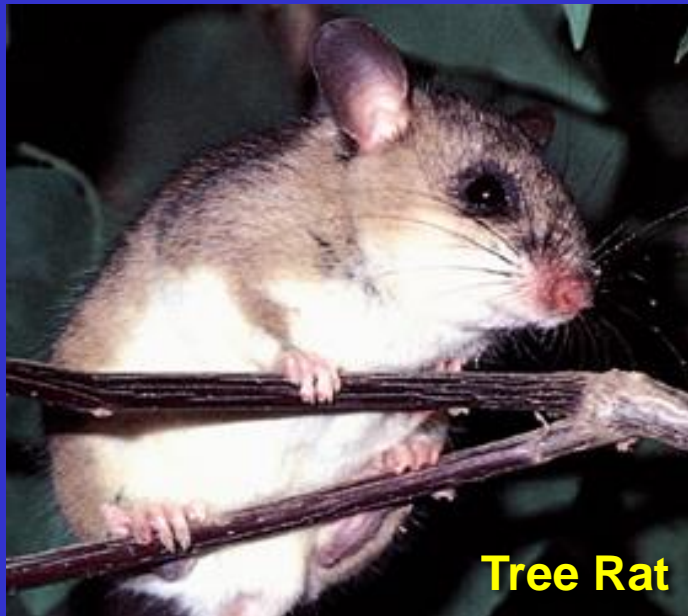
Also true for mammals generally



Tapir



Rabbit



Tree Rat



Elephant Shrew

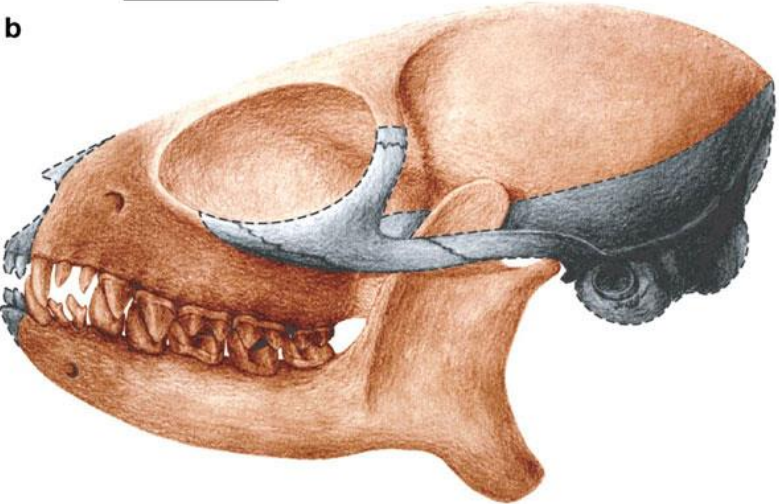
**Q: So who does have
forward-facing eyes?**

The big two: Owls and Cats

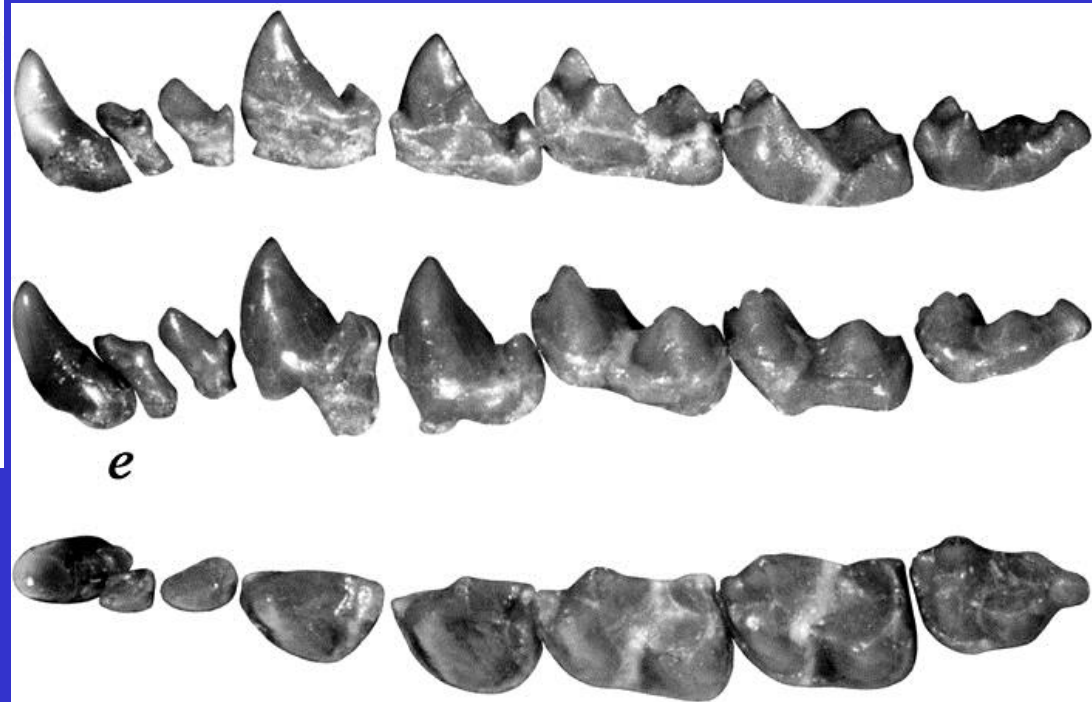


Predators that hunt at night & reliant on vision

Like owls and cats, the earliest fossil primates were nocturnal, predatory, and had big forward-facing eyes...

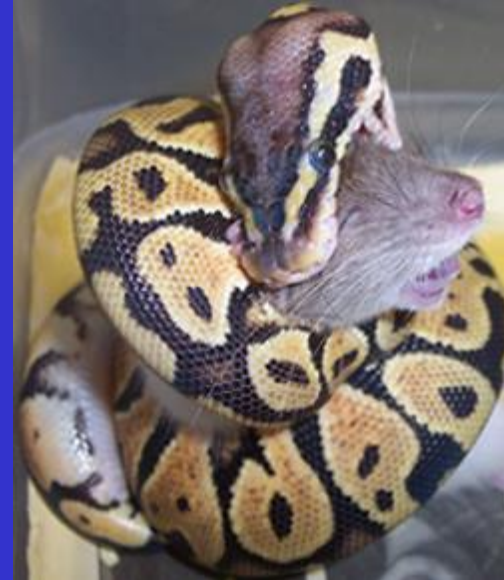


Teilhardina asiatica



e

Key: Many predators capture prey with their mouths...



... But some predators do things very differently

Meet the Tarsier – a small, nocturnal, predatory primate



Tarsier Hunting

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How primate predators get the job done:



Scan



Pounce

How primate predators get the job done:



Snatch



Bite

**Similar to
primates:
Cats stalk &
nab with a
paw...**



... or trip their prey

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Owls: Swoop...



... and snatch with talons



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By the way...

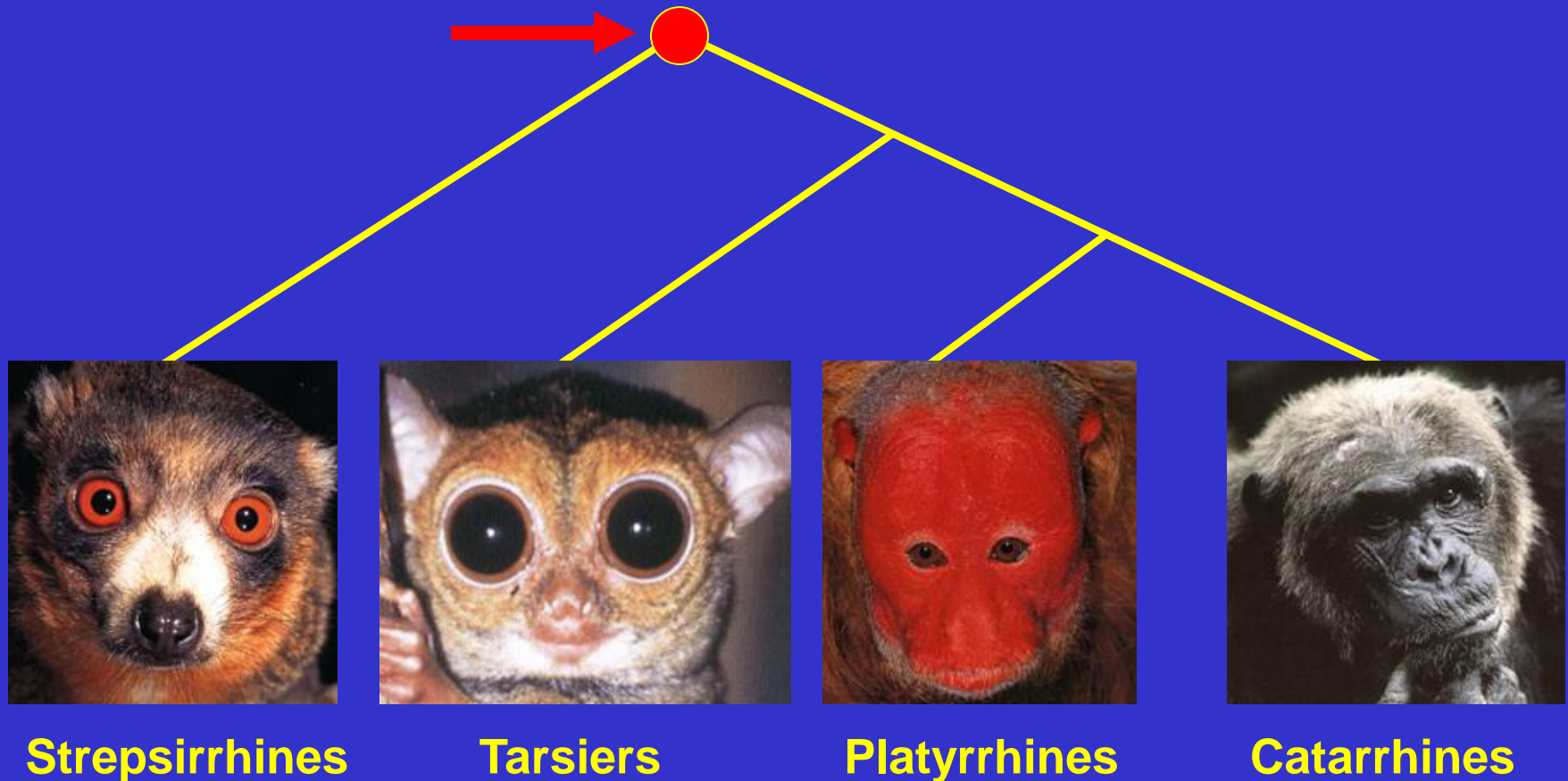




Each of these species requires fine visual depth perception to catch prey with an appendage



These comparisons show that forward-facing eyes present in the last common ancestor of primates as a predatory adaptation; F-F eyes are retained by the living descendants of that common ancestor



So the next time you see someone doing this:



Or this:



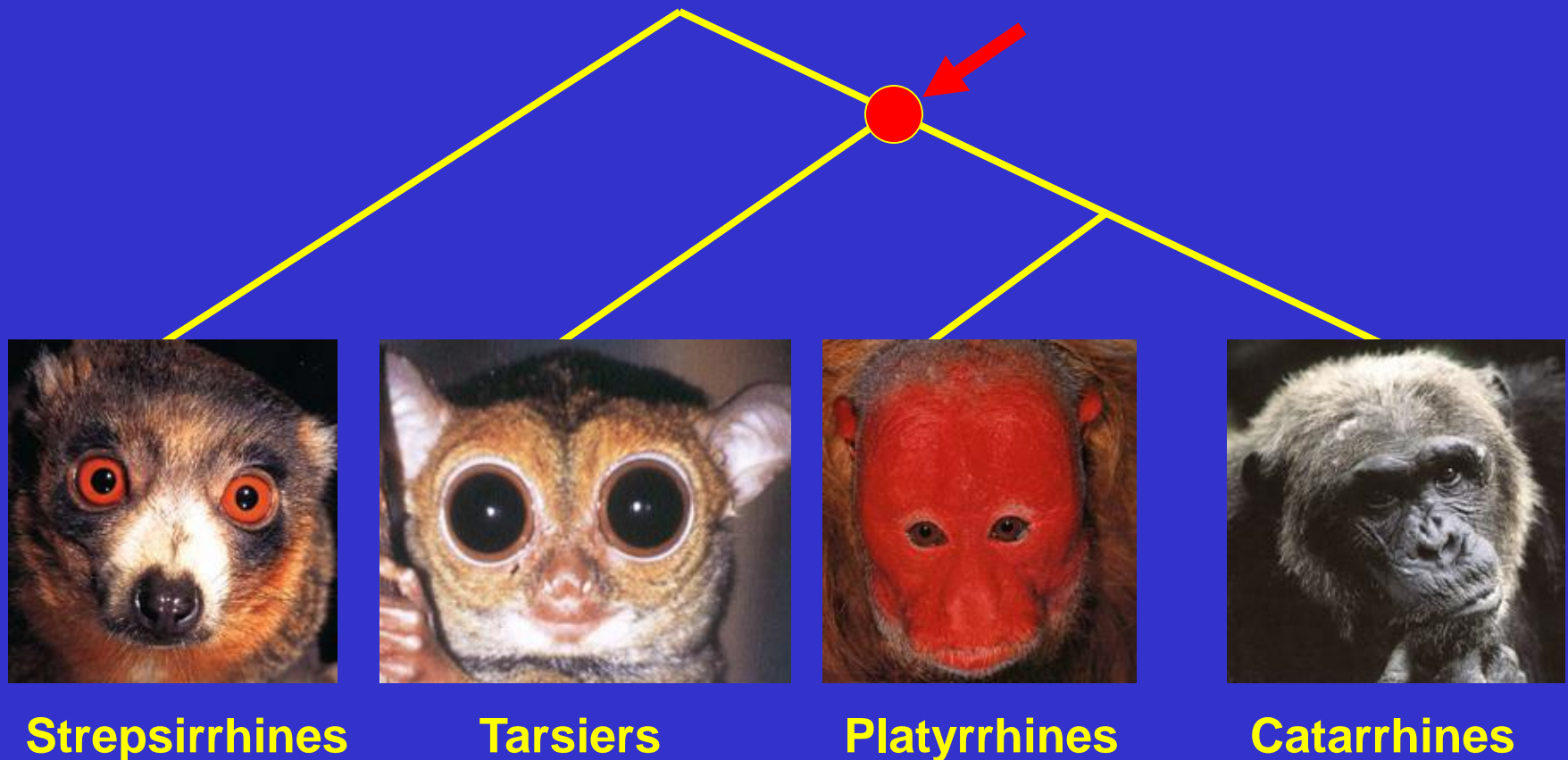
Or anything that requires fine depth perception



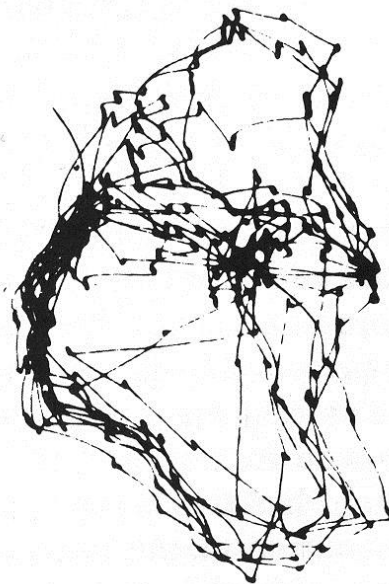
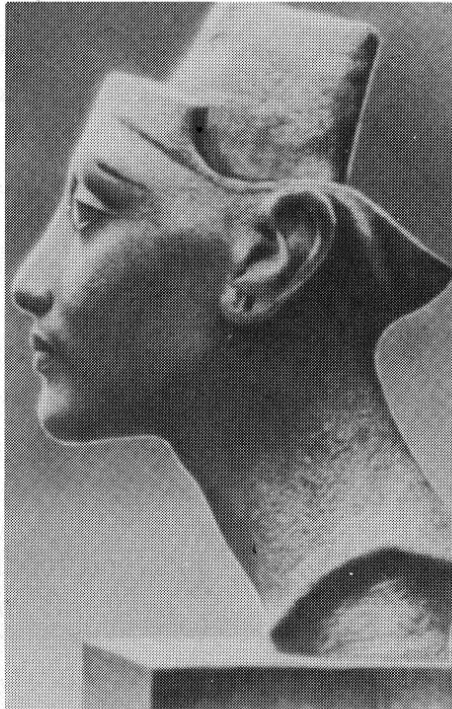
**Remember
that the
ability to
precisely
judge
distance
using vision
first evolved
for this:**



**Part 2 - an amazing ability that evolved
in the last common ancestor of
tarsiers, monkeys, apes, and humans:**







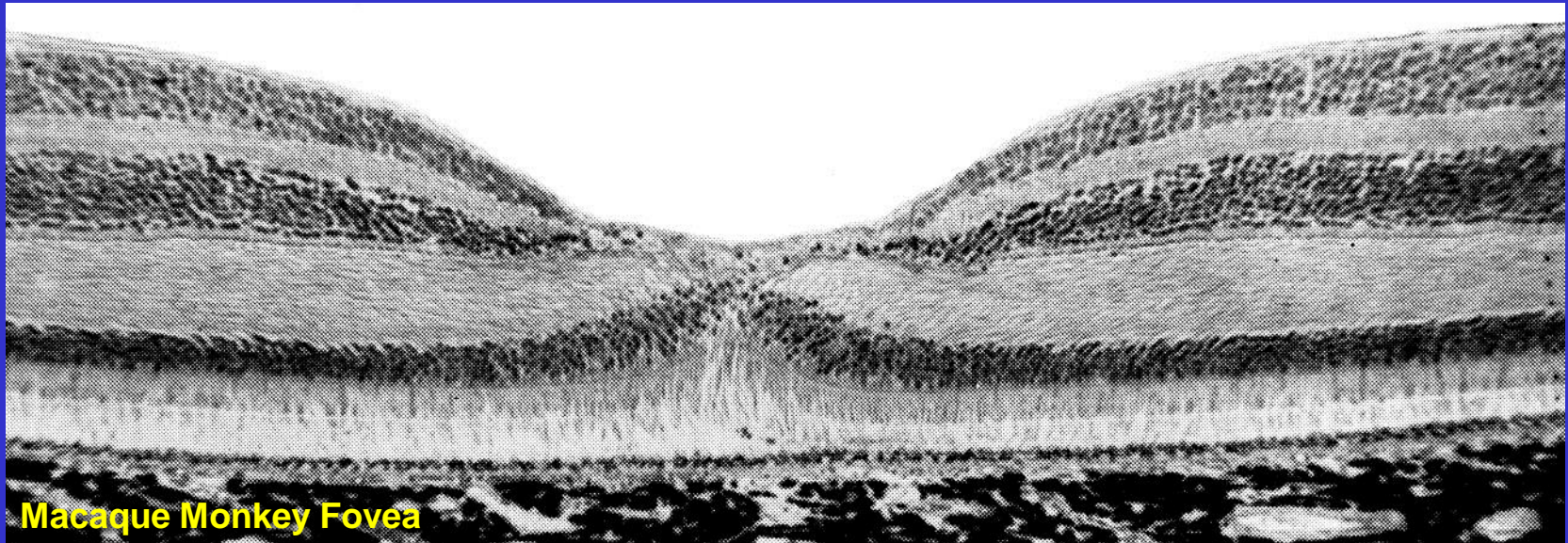
Saccades -

**Reflexive,
ballistic eye
movements**

**Tracks of
the retinal
FOVEA**

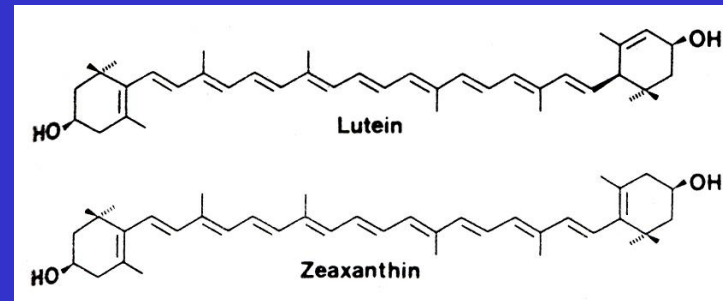
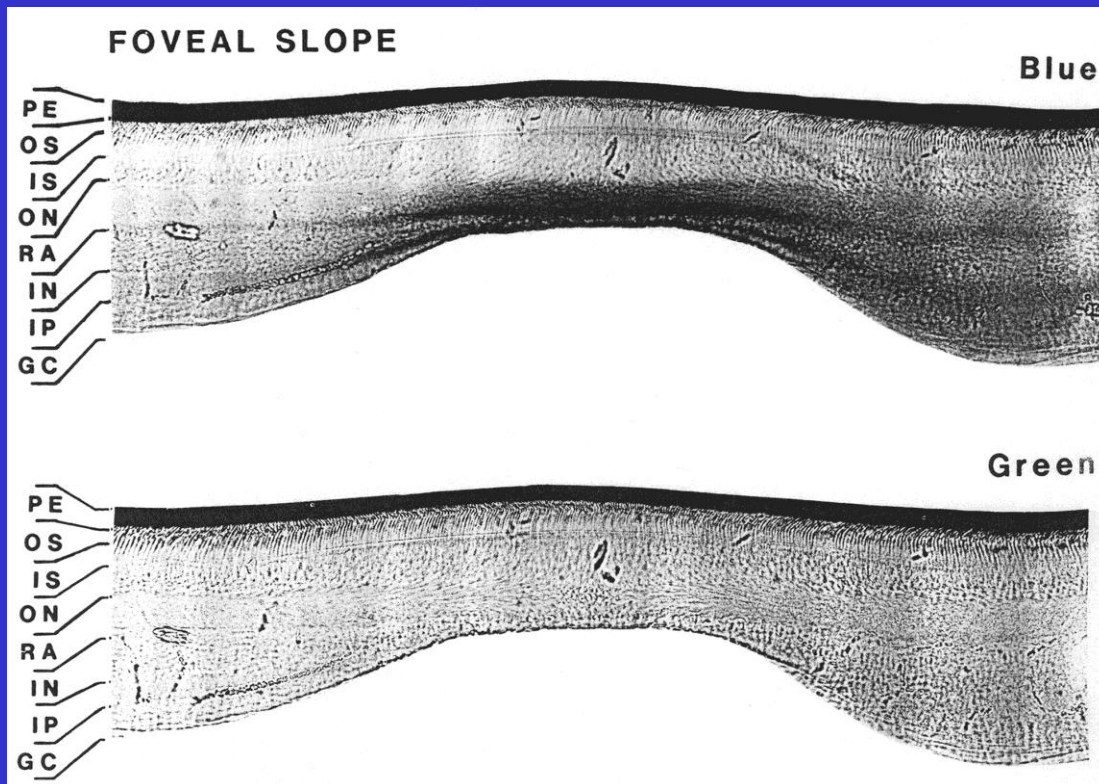


FOVEA - Pit in the center of the retina



- What you use to “look at” things
- Adaptation that provides an unobstructed path for light to reach photoreceptors

Fovea has its own yellow filter to screen out (blurring) blue light: Macula Lutea



And in the center of the fovea - a dense hexagonal lattice of cone photoreceptors

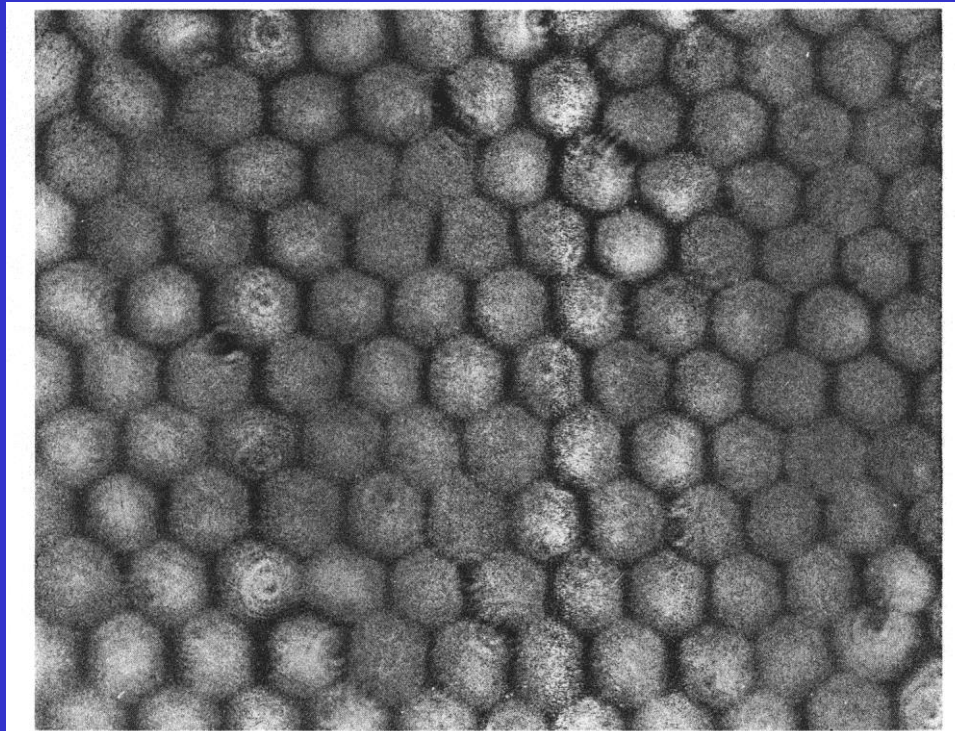
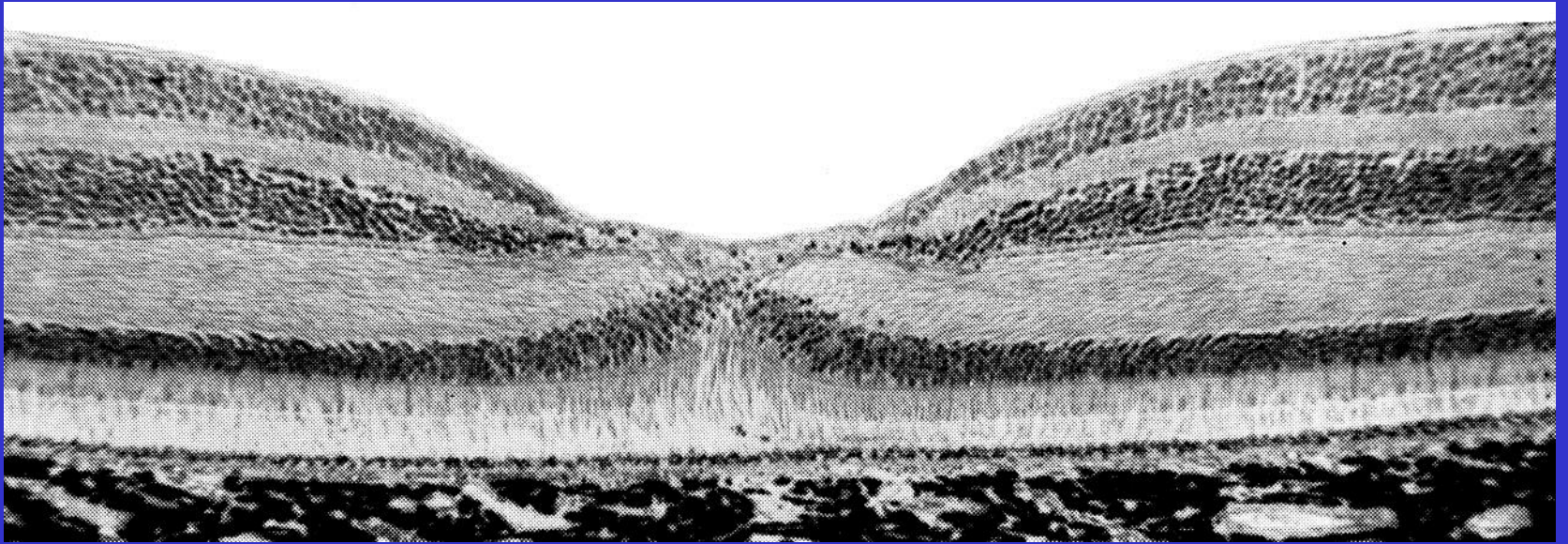


Fig. 1. Cone inner segments at the central fovea in the retina of the monkey, *Macaca fascicularis*, shown in a photograph of a $1\ \mu\text{m}$ thick section tangent to and on the scleral side of the external limiting membrane. Center-to-center distance of cones is $3\ \mu\text{m}$. From Miller (1979) with permission.

What does all of this do for you??

**With all due respect to the benefits
of peripheral vision, without your
fovea you cannot perform most
tasks involving visual *details***

**Can I have another volunteer
please?
(preferably with 20/20 vision)**



**Here's the most astonishing
consequence of having a fovea:**

Foveas give humans the highest visual acuity of any living mammal:

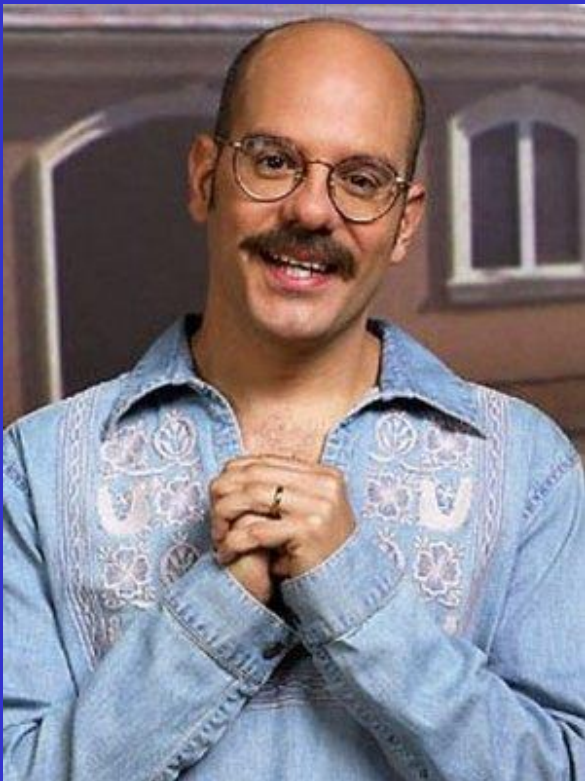
PRIMATES

Anthropoids (D):	40-80
Owl Monkey:	10
Tarsier:	9
Ringtailed Lemur:	6-7
Bushbaby:	5-6
Mouse Lemur:	5
ALL PRIMATES:	5-80

NONPRIMATES

Horse:	23
Camel:	10
Carnivorans:	1-9
Cetaceans:	0.6-5
Marsupials:	0.5-5
Elephant:	4
Rodents:	0.5-4
Flying Fox:	3.5
Rabbits:	1.5-3
Tree Shrew:	1-2
Microbat:	0.05-2

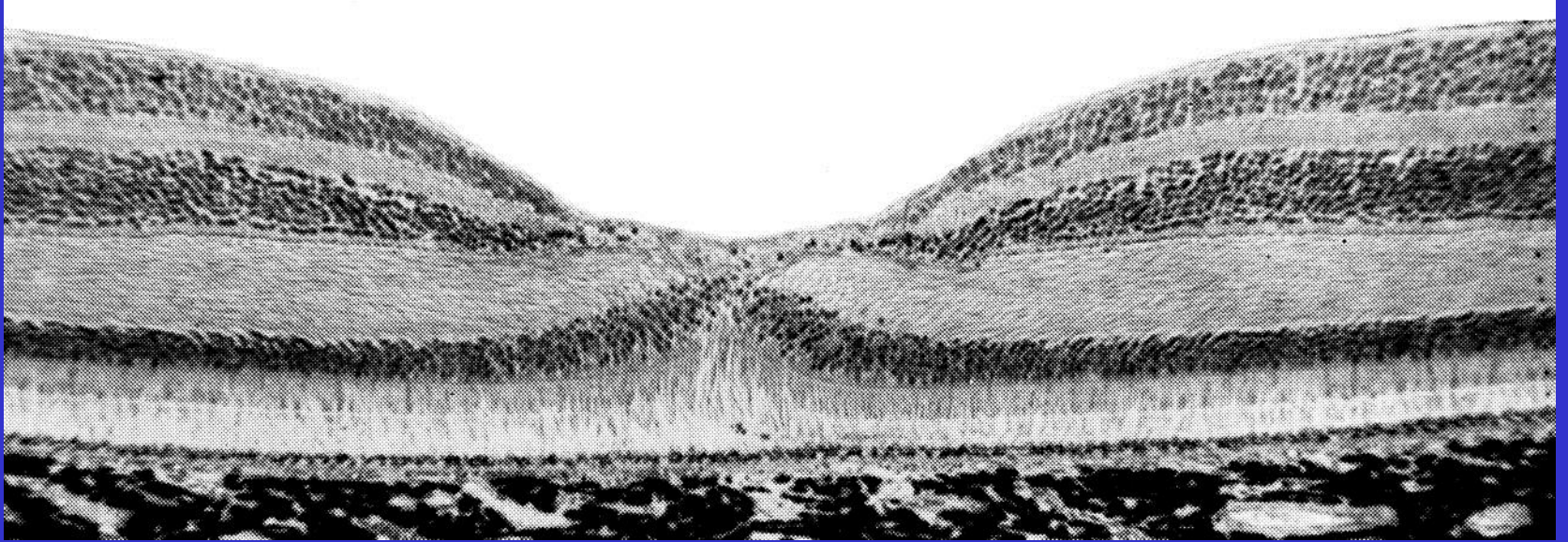
Q: Anyone know the only vertebrates with higher visual acuity than humans?



Q: Anyone know the only vertebrates with higher visual acuity than humans?

A: Large eyed diurnal birds of prey

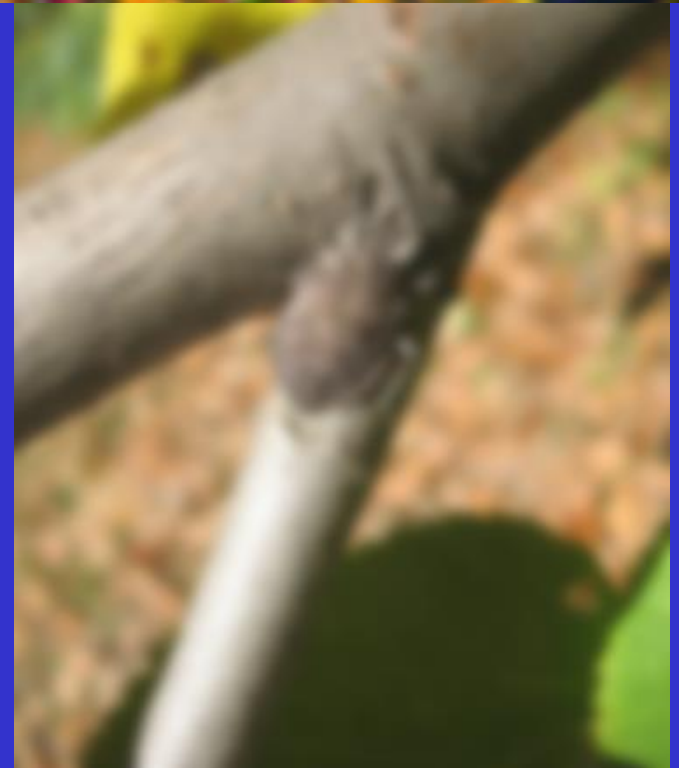




So what are foveas and extremely high acuity *good for*?



Low acuity limits your options





High acuity enhances them



Many living non-primates with foveas are:



1. diurnal
2. predatory
3. hunt by sight



Foveas evolved as another predatory adaptation?

Two very important consequences of high acuity in primates:

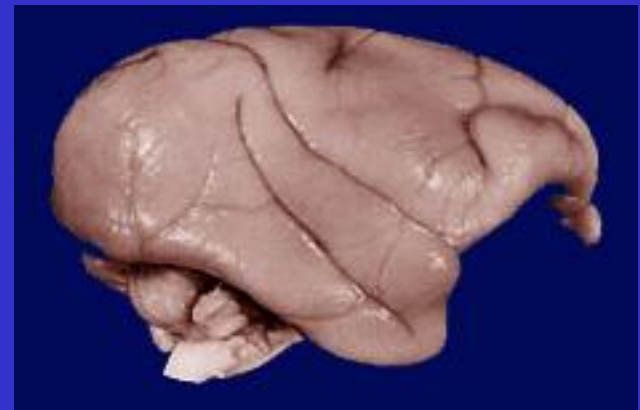
1. - High acuity requires more visual input to the brain
 - Brain has to process all the added input



Opossum

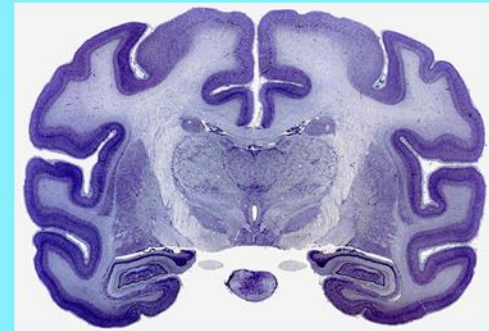
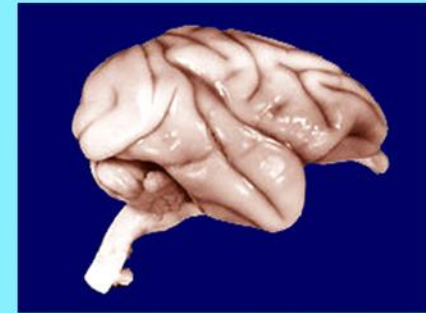
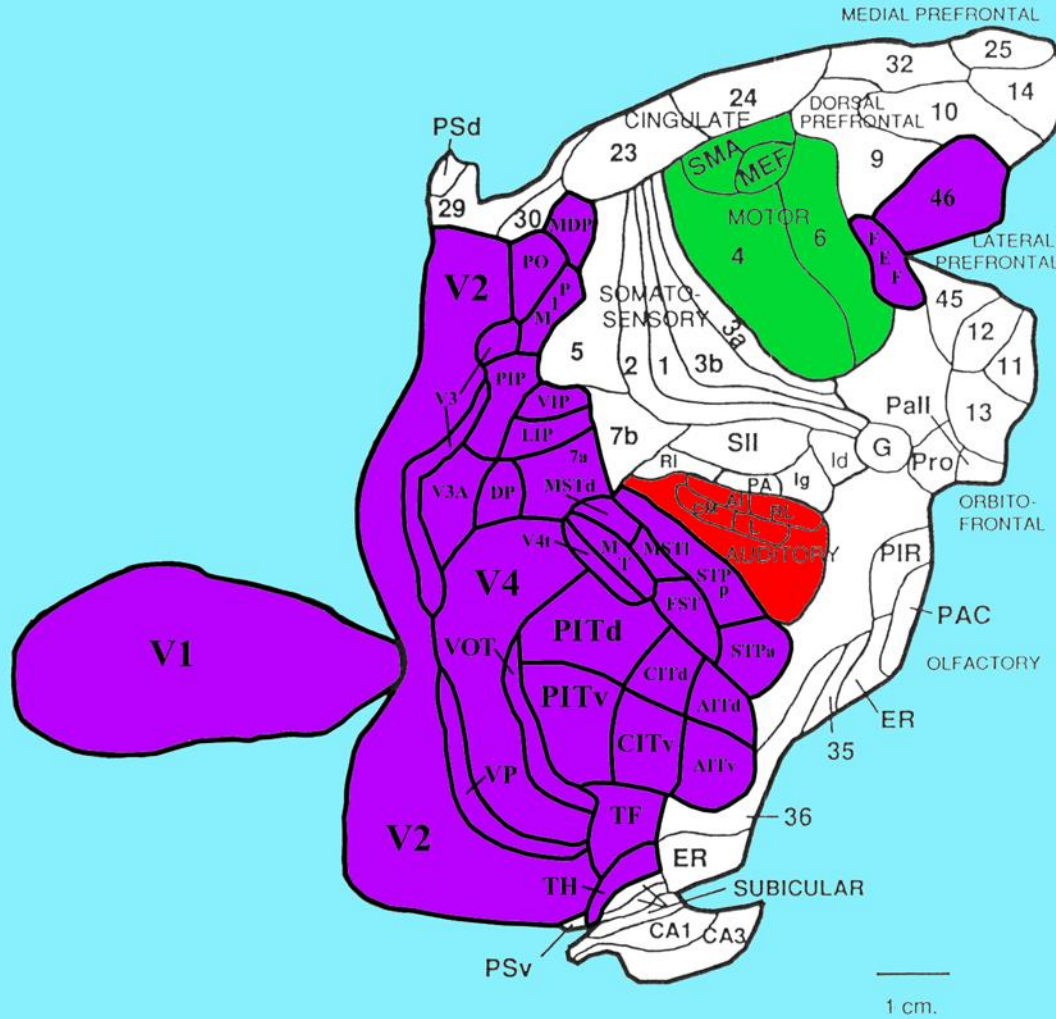


Bushbaby

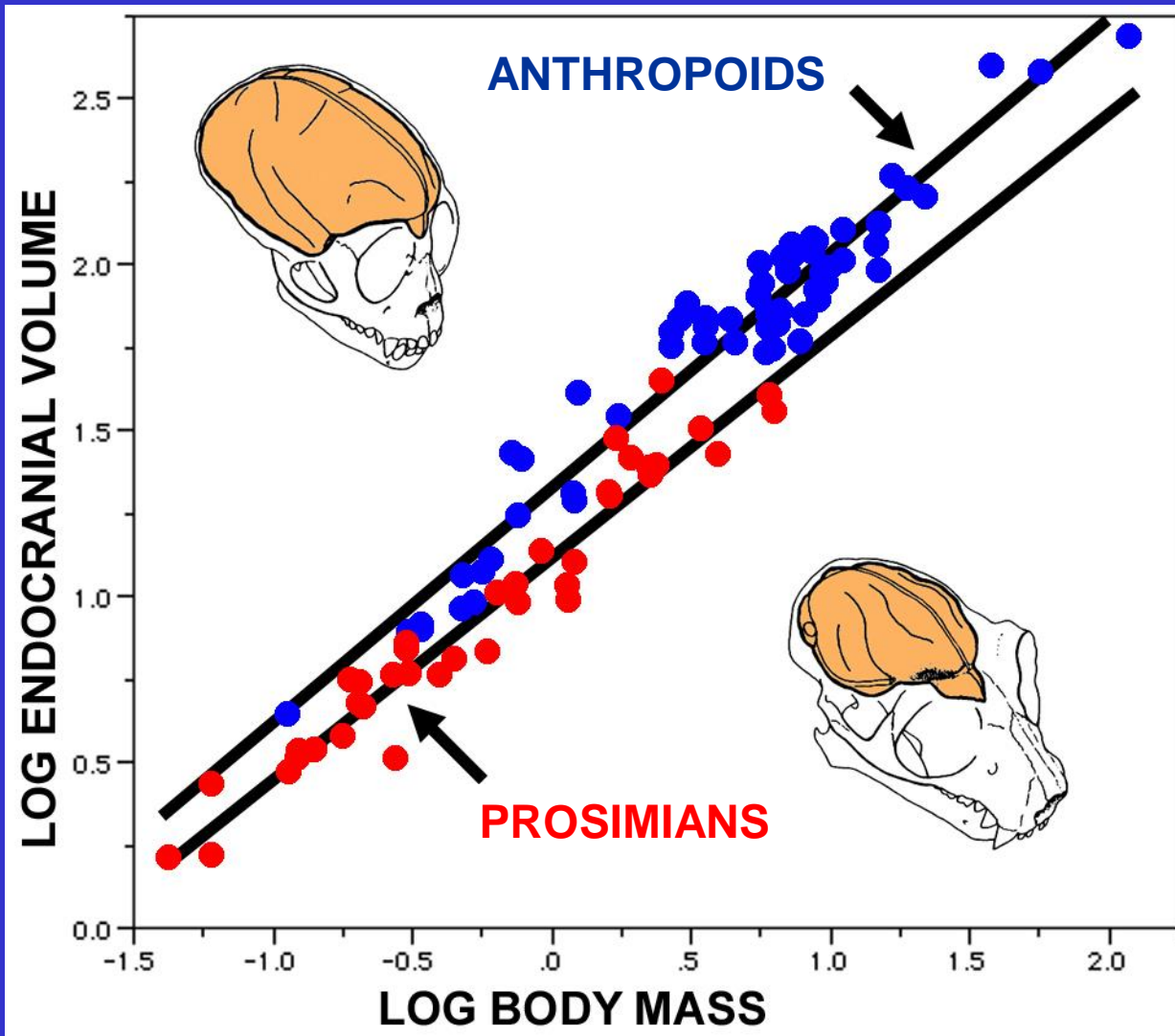


Squirrel Monkey

CORTICAL VISUAL AREAS (Macaque)



Van Essen, Anderson, & Felleman, 1992

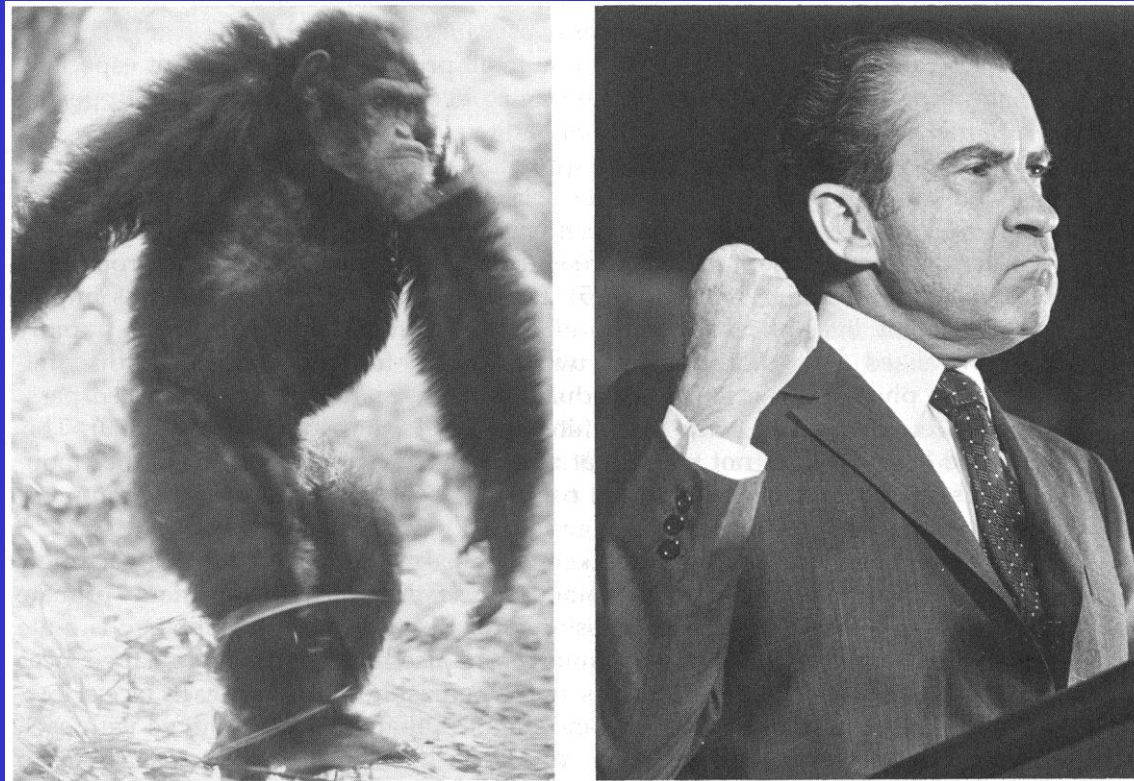


***Anthropoidea includes all haplorhines (monkeys, apes, humans) except tarsiers**

~ 50% of variation in primate encephalization can be explained by differences in visual input alone

Two very important consequences of high acuity in primates:

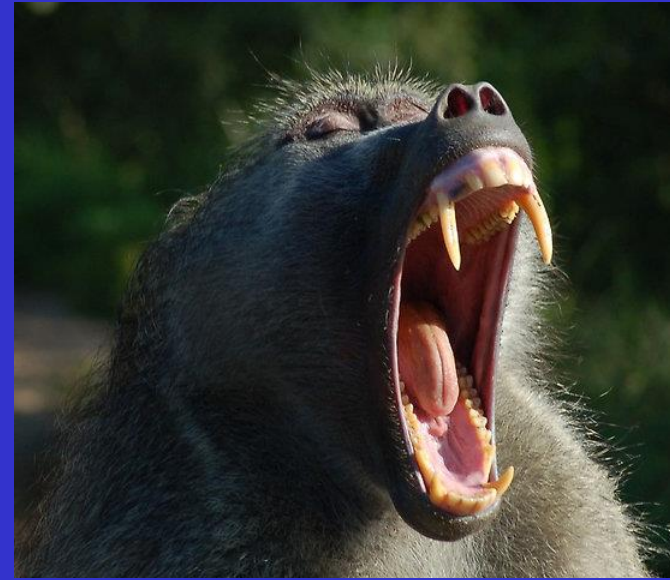
2. High acuity readily co-opted for other other functional contexts, esp. social communication based on visual signals



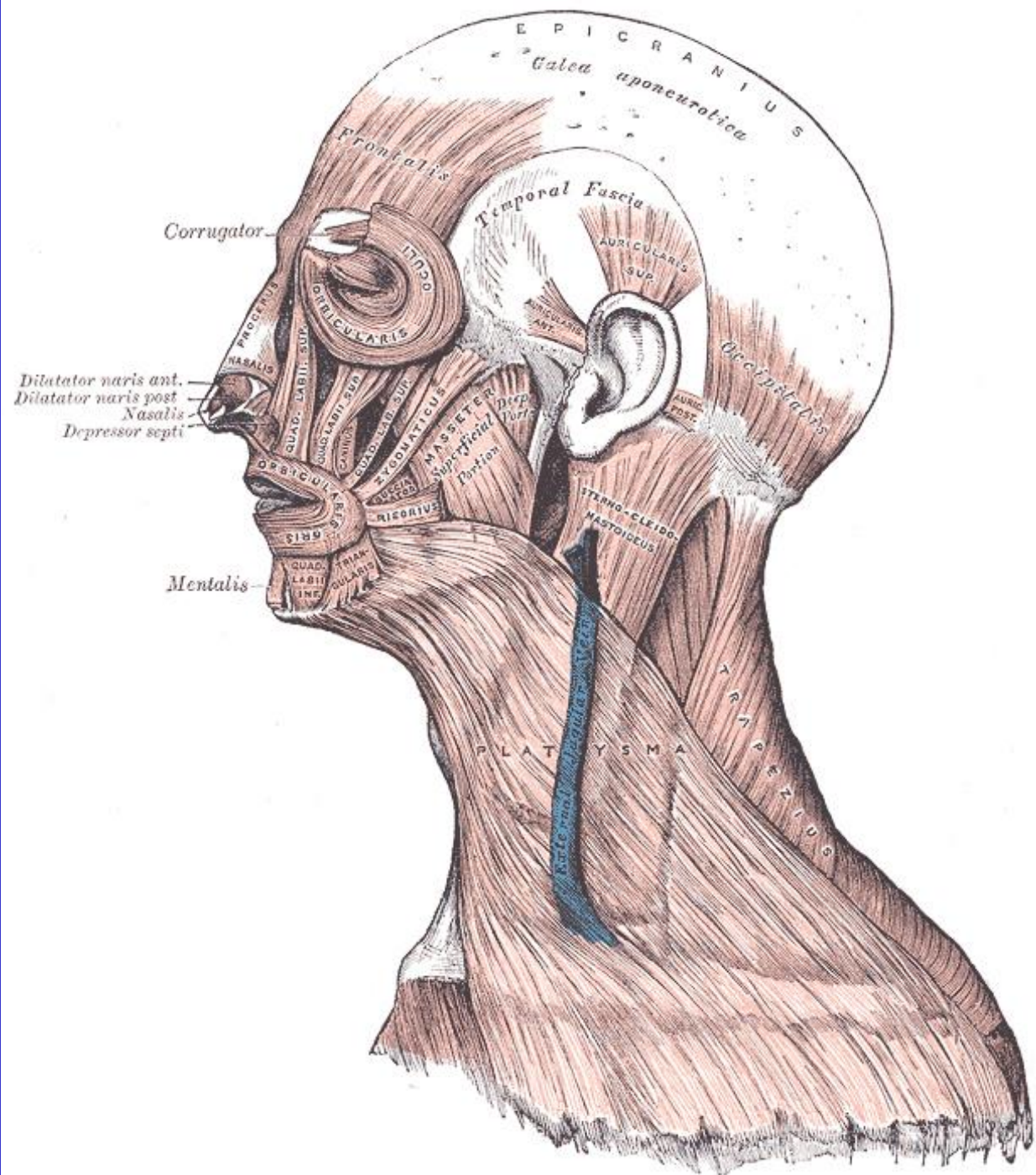
**In most mammals,
social communication
dominated by
olfactory signals**



Visually-mediated signals fundamental for social communication in monkeys, apes, & humans



Anthropoid primates even have a complex set of superficial facial muscles that have evolved mainly for the purpose of social communication



The Big Picture: Just as you learned that this ability related to nocturnal predation...



**The next time you use a facial expression
to tell that a toddler is happy...**



That someone is angry...



**Or you sense that
something is slightly
amiss...**





Recall that this ability stems from the fact that you have eagle eyes





**Because
your distant
anthropoid
ancestors
liked to
wake up
during the
day to eat
bugs**



**Thanks
Very
Much!**

Dr. Christopher Kirk



Dr. Chris Kirk is an Associate Professor in the Department of Anthropology at The University of Texas at Austin. Dr. Kirk teaches undergraduate and graduate courses in physical anthropology, is a member of the American Association of Physical Anthropology and Society of Vertebrate Paleontology, and is the author of numerous professional publications, including papers published in the *Journal of Human Evolution*, the *American Journal of Primatology*, and *Proceedings of the National Academy of Sciences*.

Dr. Kirk has a broad array of research interests in physical anthropology, including sensory ecology, functional morphology, and paleontology. His primary research interest is the evolution of primate sensory systems, important to physical anthropology because many of the major adaptive shifts that occurred during the course of primate evolution involved key changes in sensory anatomy and ecology.