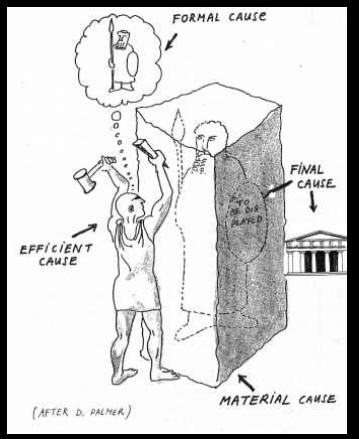
Aristotle's 4 Causes

1) **Efficient cause**: "is the trigger that starts a process moving" — x is what **produces** y
2) **Material cause**: "that from which," — x is what y is **[made] out of**.
3) **Final cause:** the goal or the purpose (**telos** in Greek) — x is what y **is for**
4) **Formal cause** "the essence of a thing" — x is what it is **to be** y.



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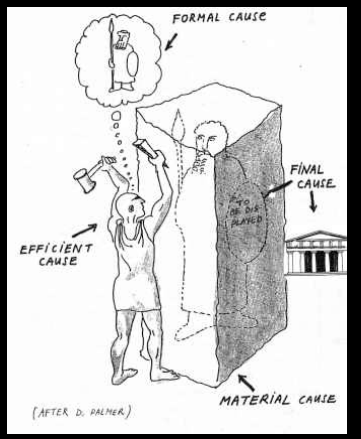
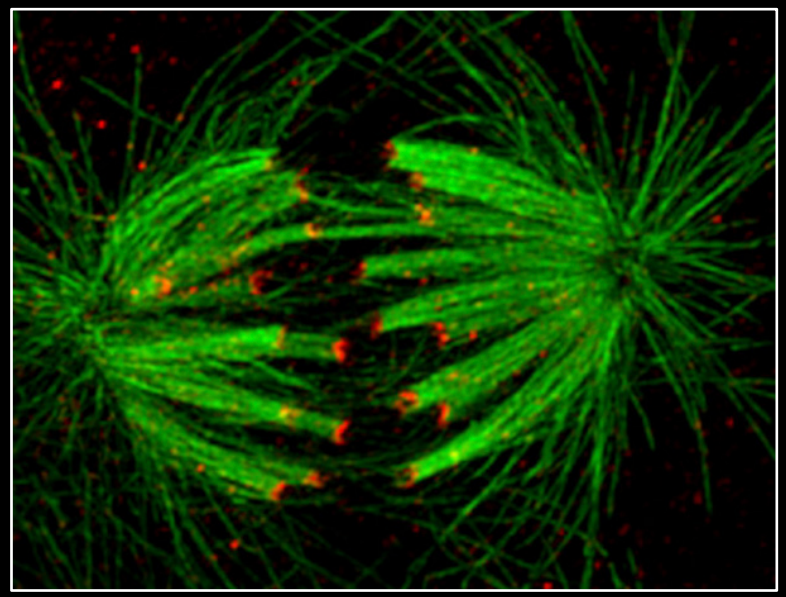


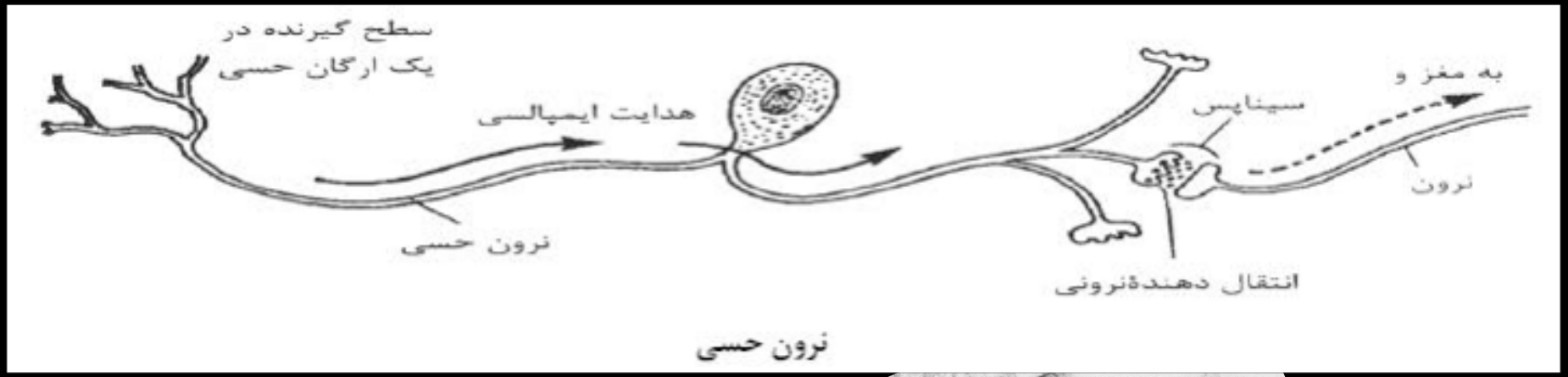
(Level) of question	Timeframe of study: Snap shot: An explanation of the current form of a behavior in terms of present-day	Timeframe of study: Story: An explanation of the current form of the behavior in terms of a sequence
Proximate (how): An explanation in terms of immediate factors, relevant and potentially measurable in current time.	**Mechanism** (a.k.a. causation) Causal explanations in terms of what the behavior is and how the behavior is constructed. These explanations can include physical morphology, molecular mechanisms or other underlying biological factors Aristotle: efficient cause	**Ontogeny** (a.k.a. development) Developmental explanations for sequential changes across the lifespan of an individual. Often these explanations are concerned with the degree to which the behavior can be changed through learning. Aristotle: material cause
Ultimate (why) An explanation in terms of the process and forces of evolution.	**Adaptive Value** (a.k.a. function) Functional explanations regarding the utility of the current form of the behavior with regard to increasing an organisms lifetime reproductive success. Aristotle: final cause	**Phylogeny** (a.k.a. evolution) Evolutionary explanations that describe the history of the behavior, such as which ancestor first possessed this trait, what was the antecedent to this behavior, and what selective pressures in the past have shaped this behavior. Aristotle: formal cause

Friday 4:10 September 14th B19

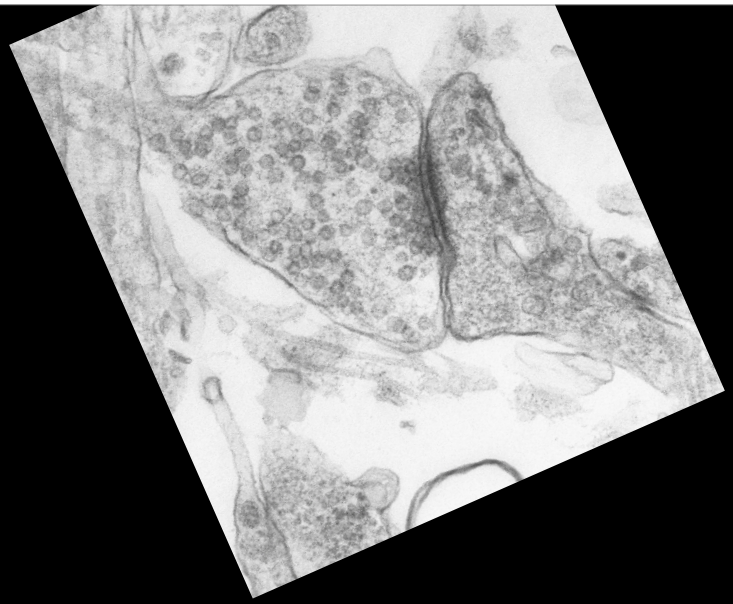
Dr. Derek Applewhite

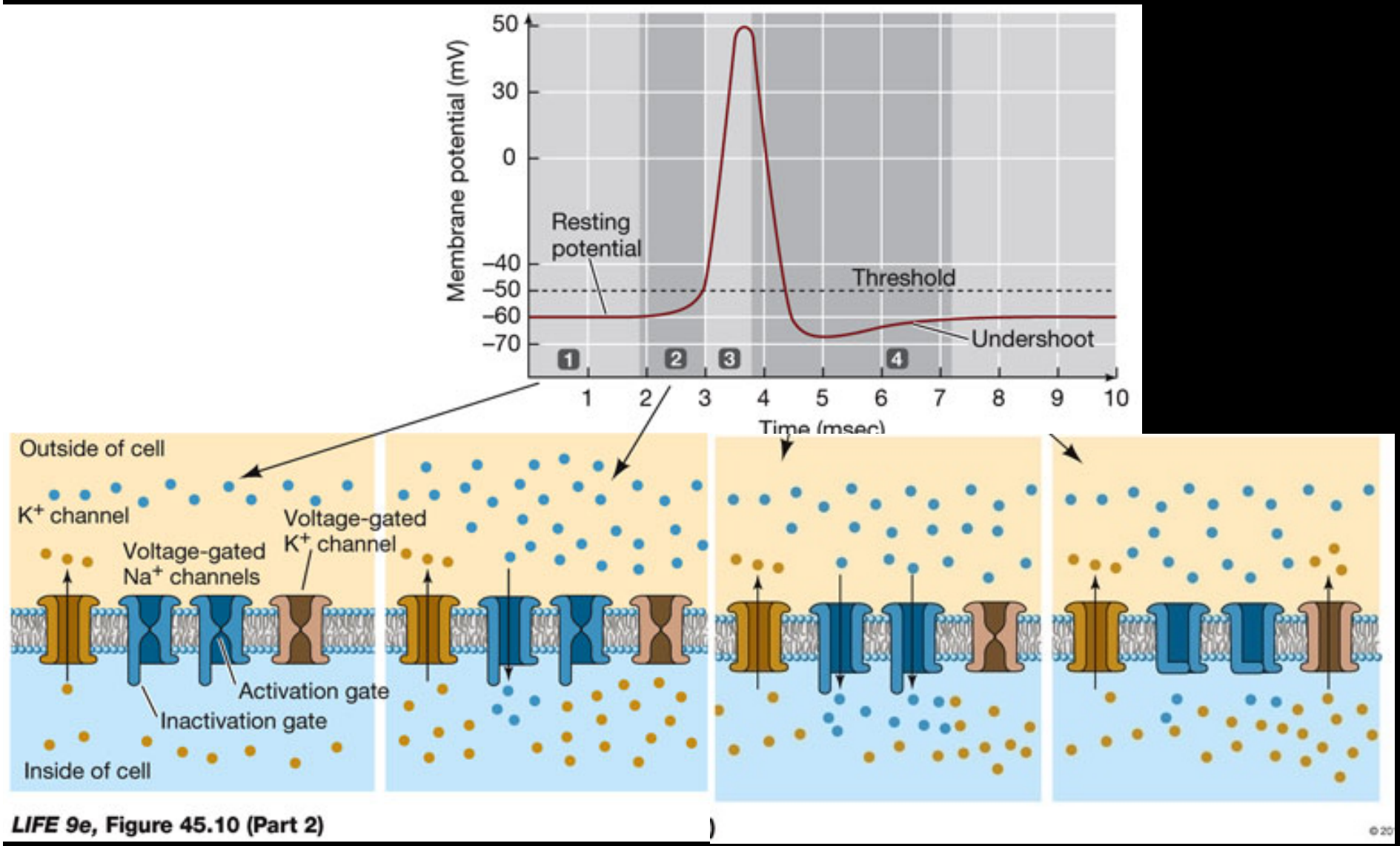
"*Understanding the regulation of the cytoskeleton.*"




سطح گیرنده در
یک ارگان حسی
هدایت ایمپالسی
نرون حسی
سیناپس
به مغز و
نرون
انتقال دهندهٔنرونی

نرون حسی





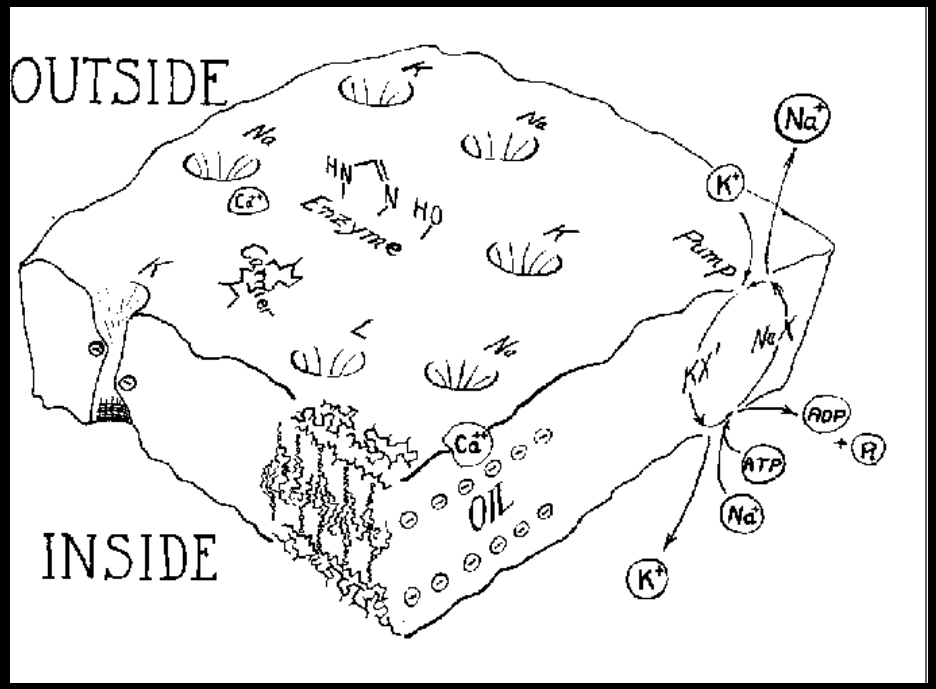
***LIFE 9e*, Figure 45.10 (Part 2)**

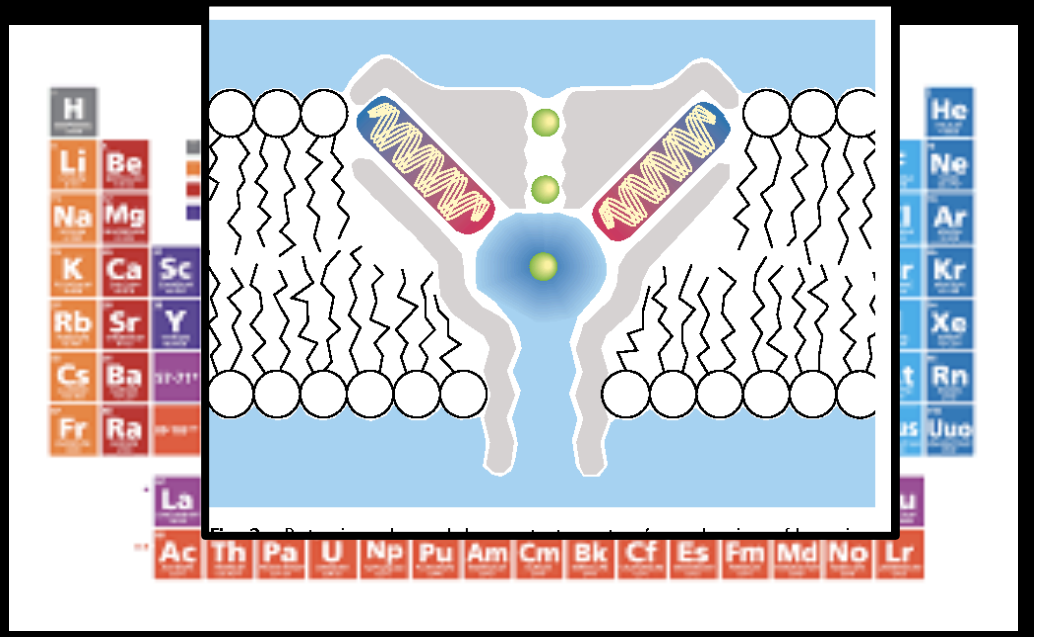
”rest”
leak K^+ open
all others closed
K^+ leaks out of cell
membrane potential ~-70mV

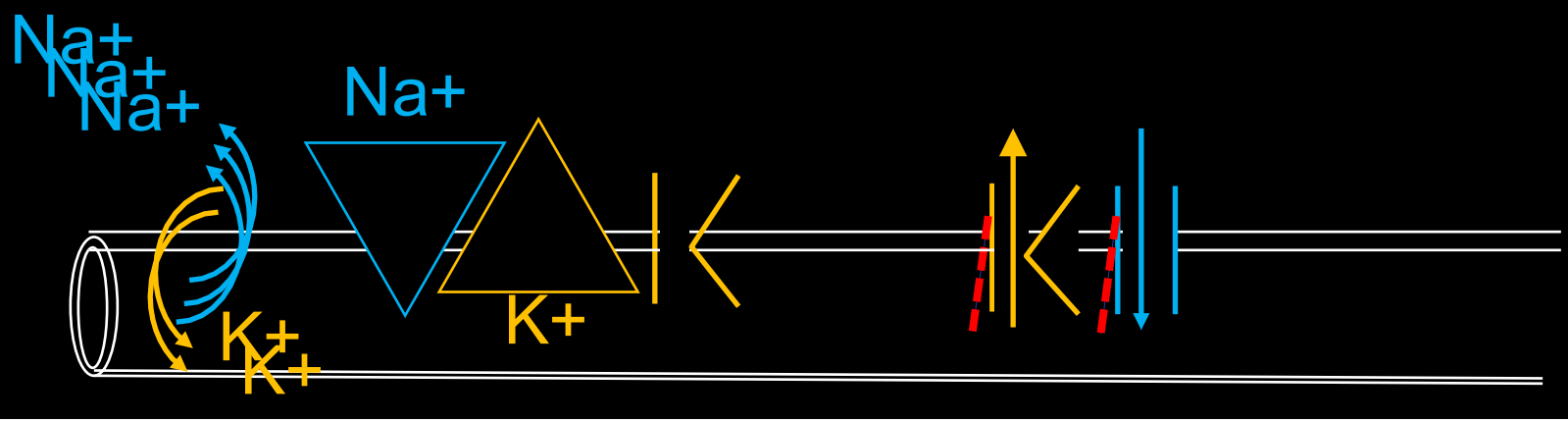
initial ”depolarization”
leak K^+ open
V-gated Na+ begin to open
Na begins to enter
other V-gated Na^+ still closed
V-gated K^+ closed
(while some K^+ leaks out)
membrane potential ~-50mV

rising phase of the action potential
leak K^+ open
V-gated Na^+ open @m.p. = -50mV
V-gated K^+ still closed
Na rushes into cell
(while some K^+ leaks out)
m.p. rises toward E_{rev} Na^+

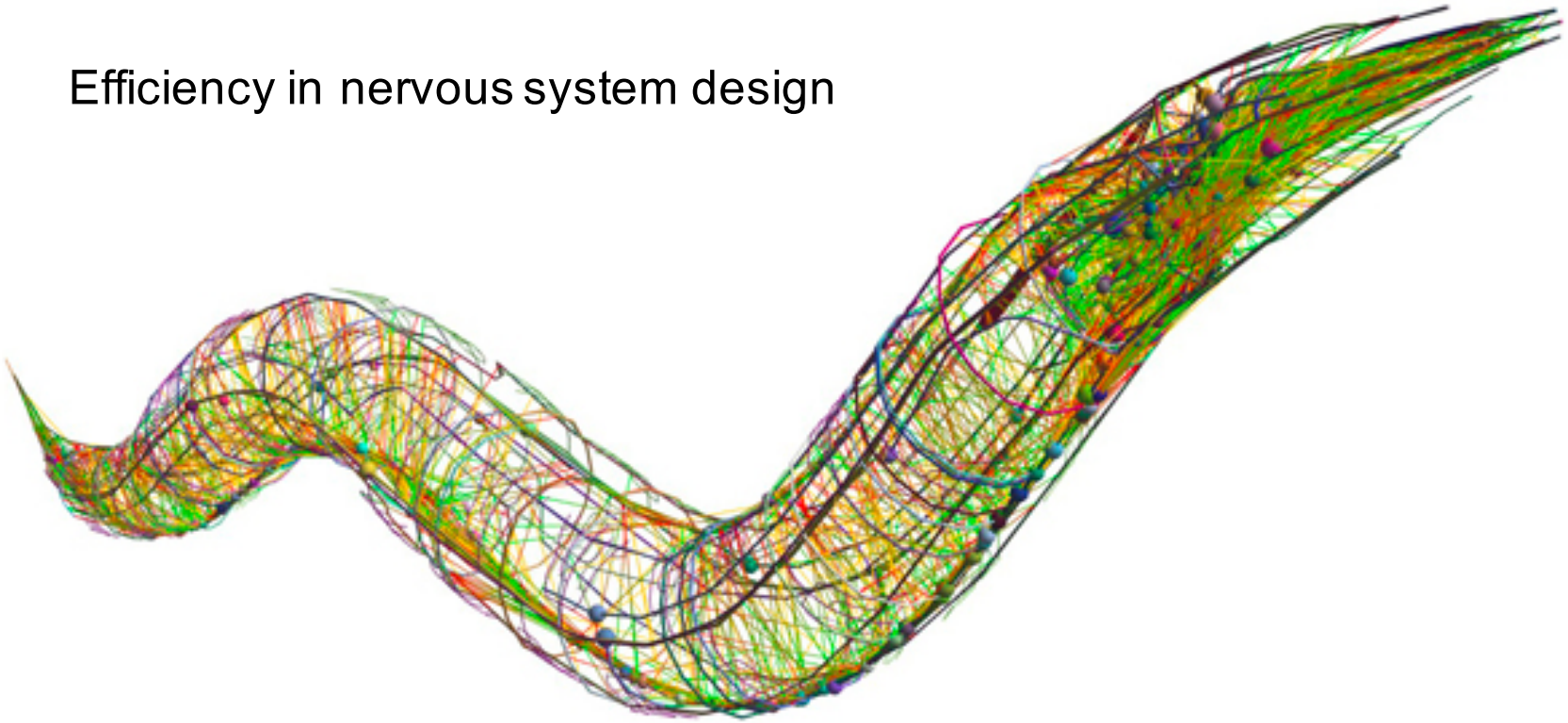
Falling phase of action potential
leak K+ open
V-gated Na+ begin to close (inactivate)
Na^+ no longer enters
V-gated K+ open at their threshold
K^+ rushes out taking + charge with it
(while some K+ leaks out)
membrane potential falls toward E_{rev} K


OUTSIDE
INSIDE
Enzyme
Carrier
Pump
ADP
ATP
Oil



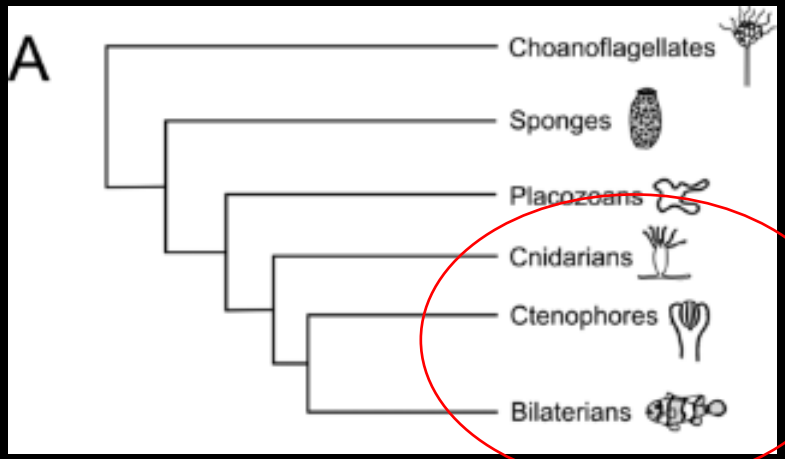

Na+
Na+
Na+
Na+
K+
K+

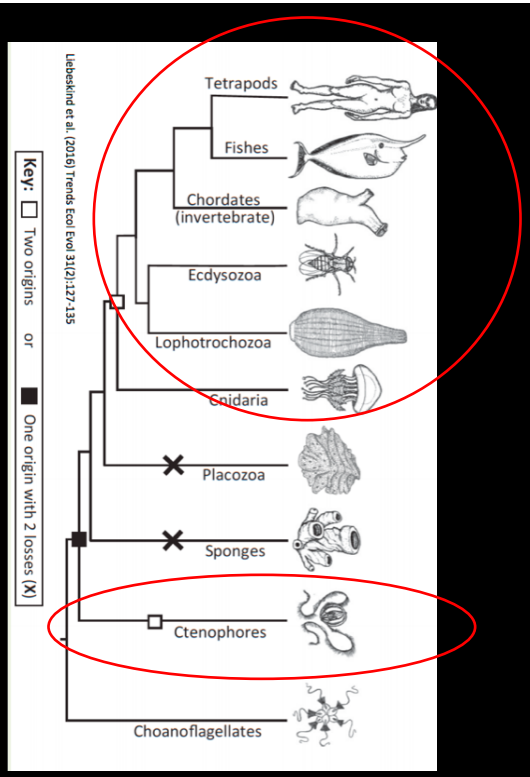
Efficiency in nervous system design



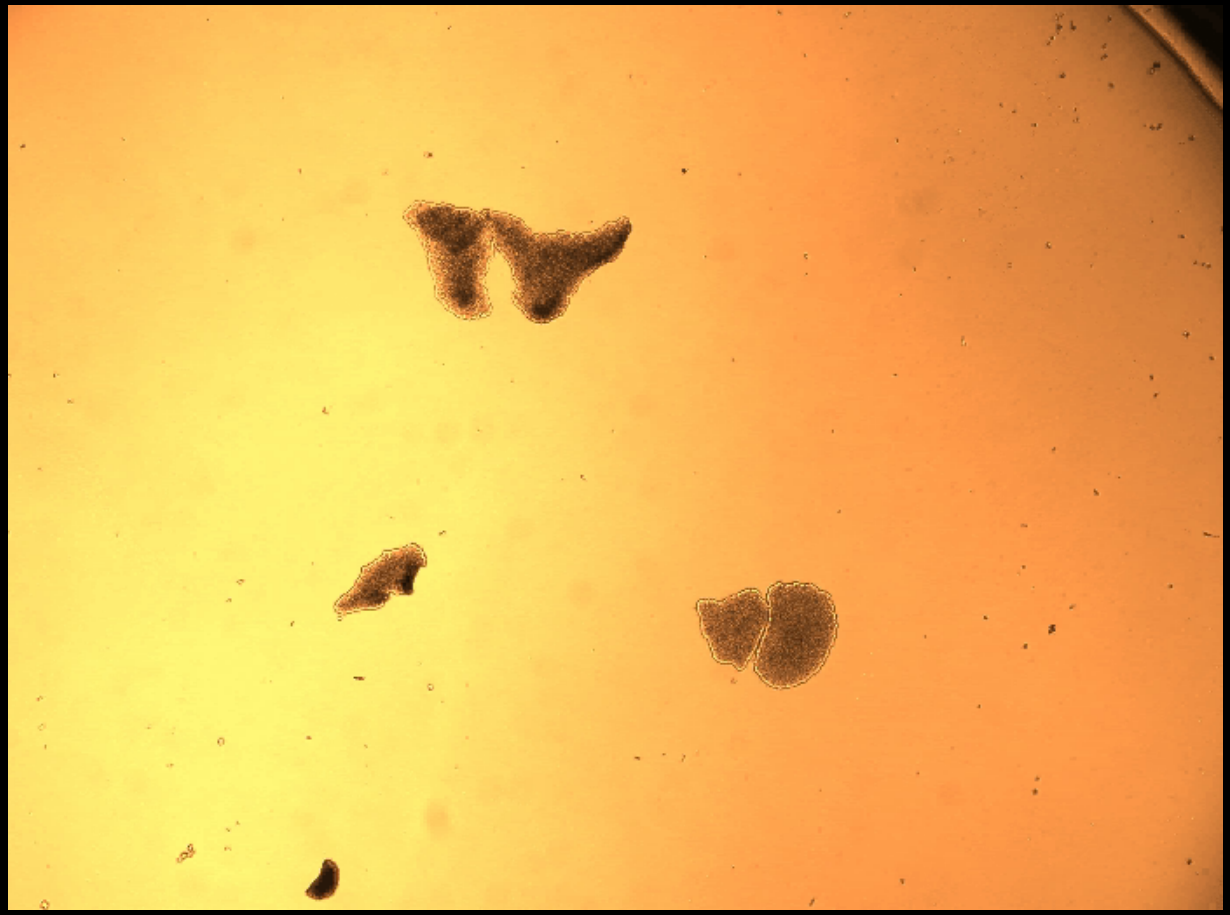
Big neurons = faster signals
more neurons = greater detail

N.S. for efficiency but not necessarily “optimal” there are trade offs with performance as well as evolutionary constraint

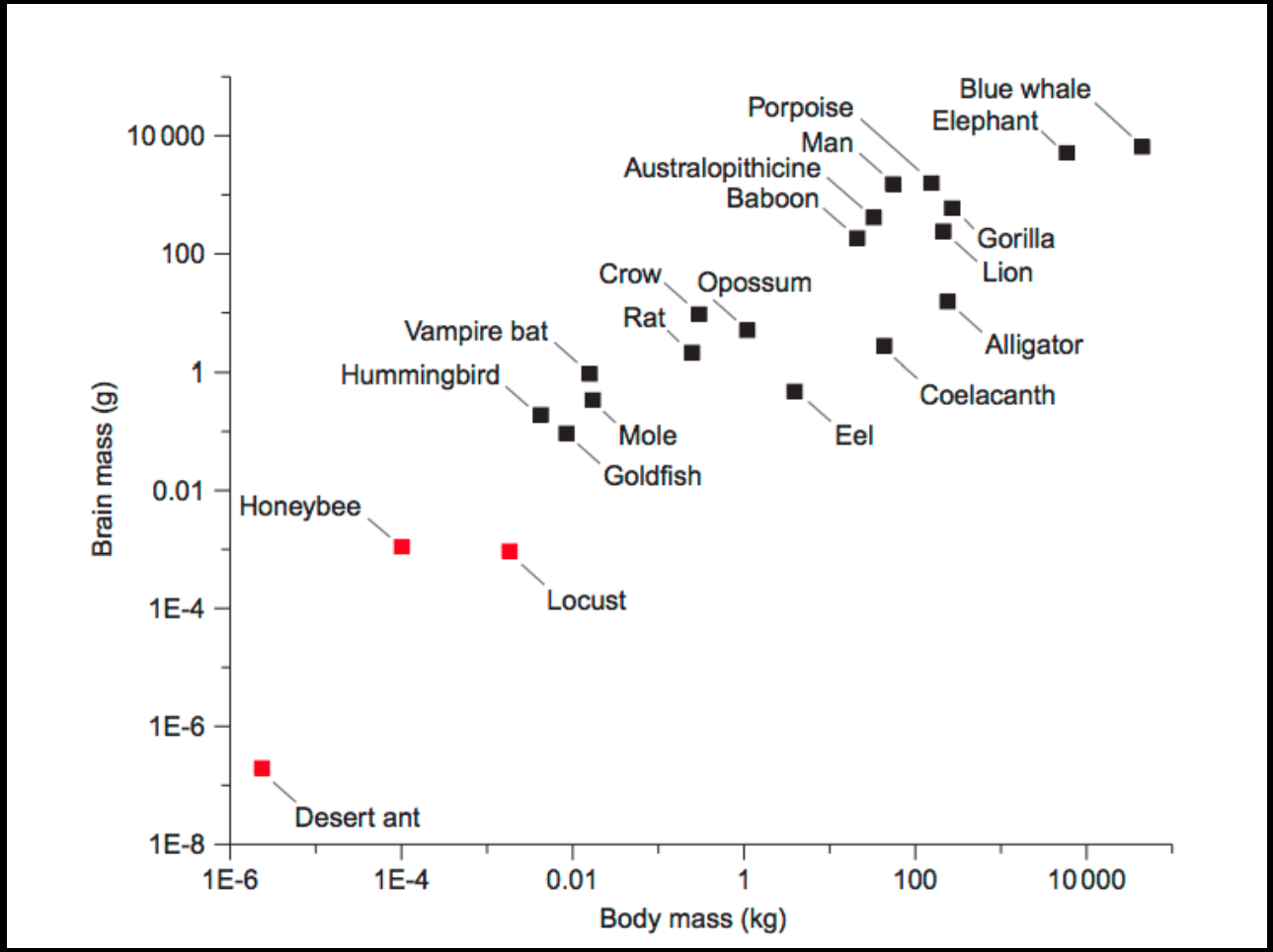


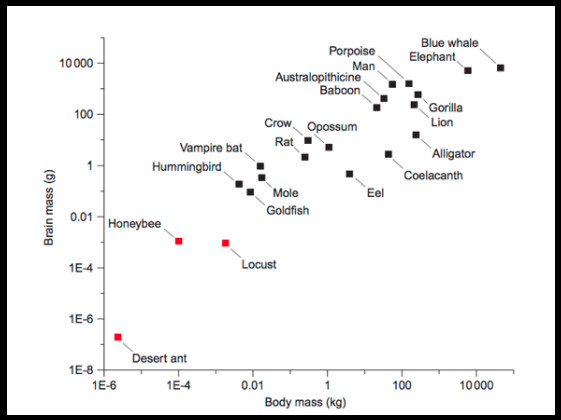


Evolution of Nervous Systems

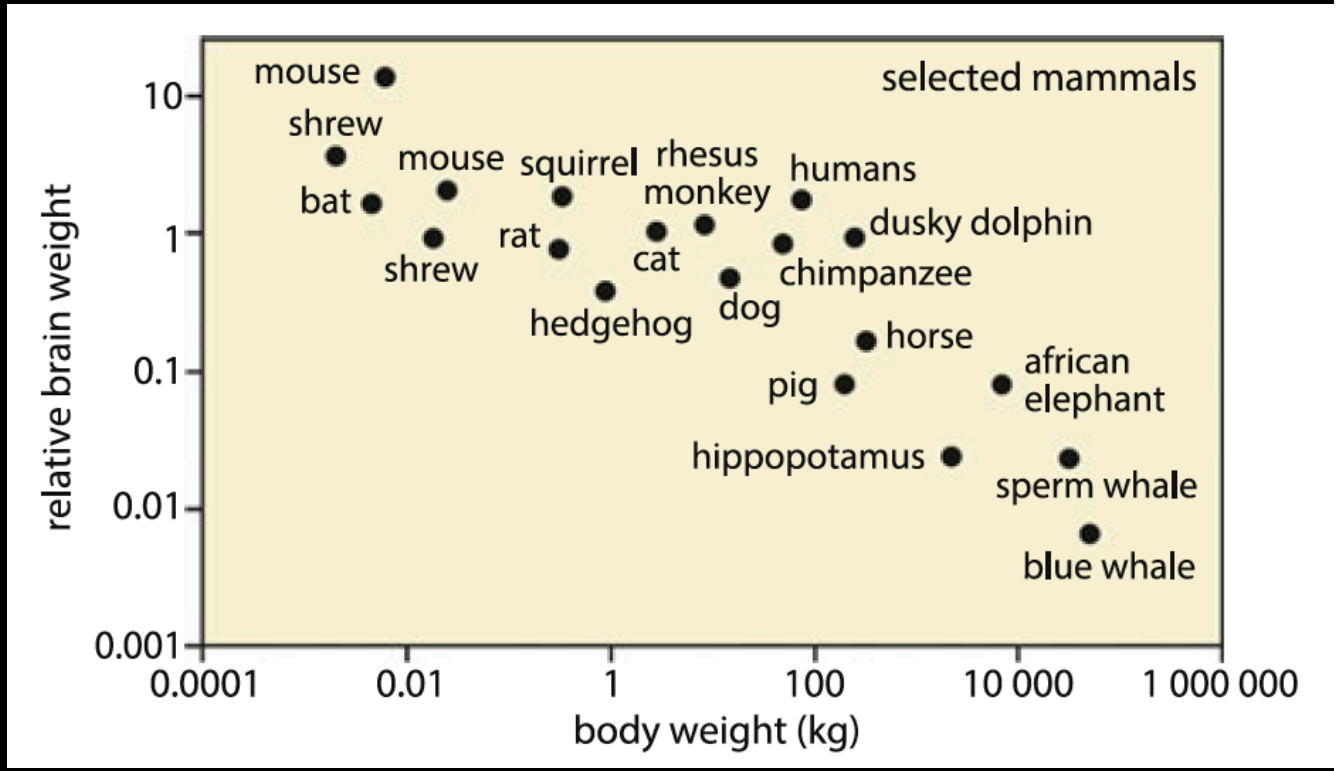


Absolute brain size scales positively with body mass





Relative brain size scales negatively with body mass



Big brains also have big problems, or problems associated with being big.
Longer connections, bigger axons, connective complexity, constraint…

Diversity of Sensory Modalities

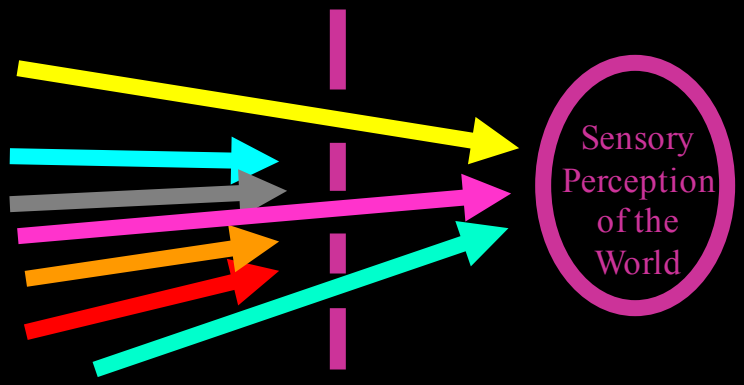
"Our senses do not deceive us. This is not because they always judge correctly, but because they do not judge at all."

- Immanuel Kant

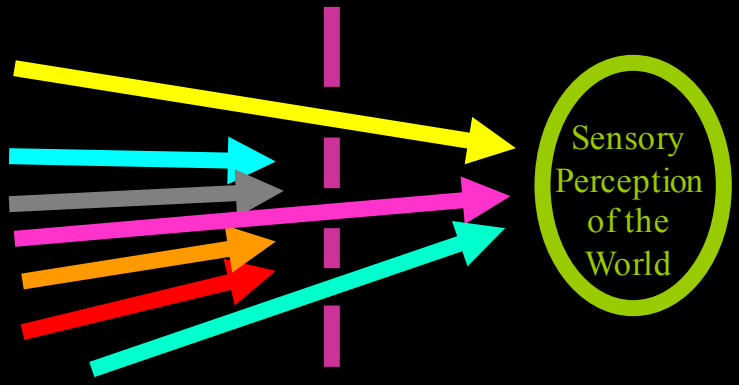
Umwelt or "sensory world"

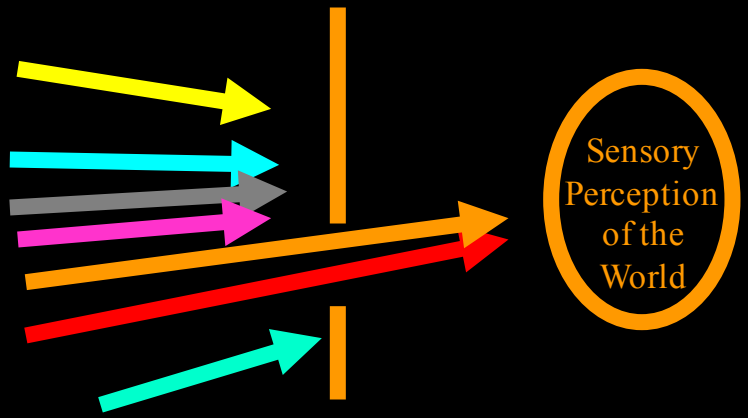
Species have their own unique worlds of sensory perception

Jakob von Uexküll, 1905

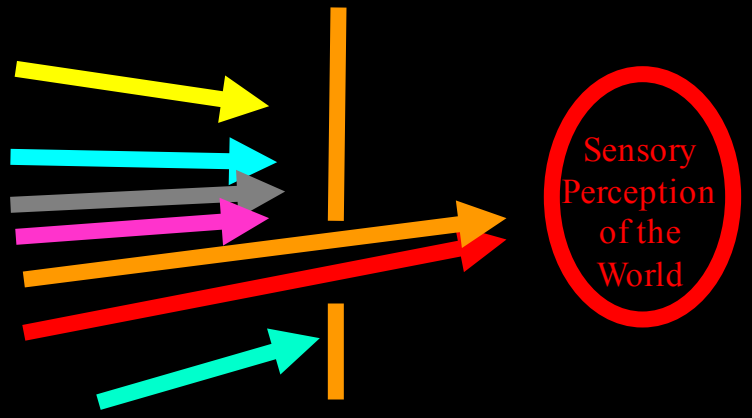


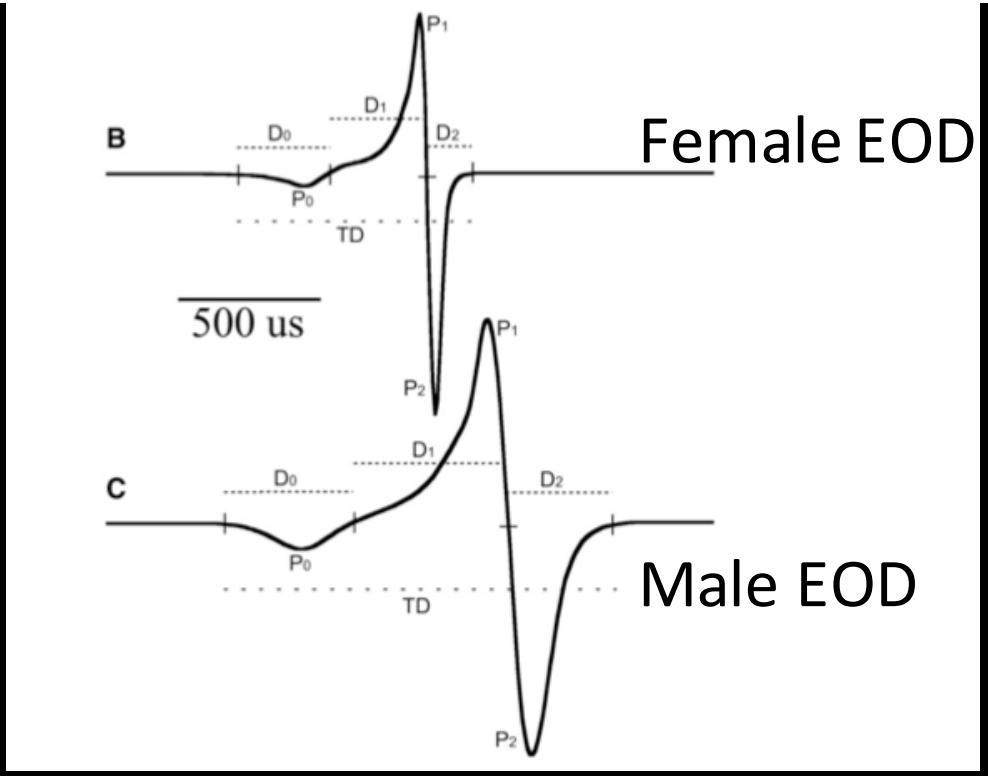
Species 1



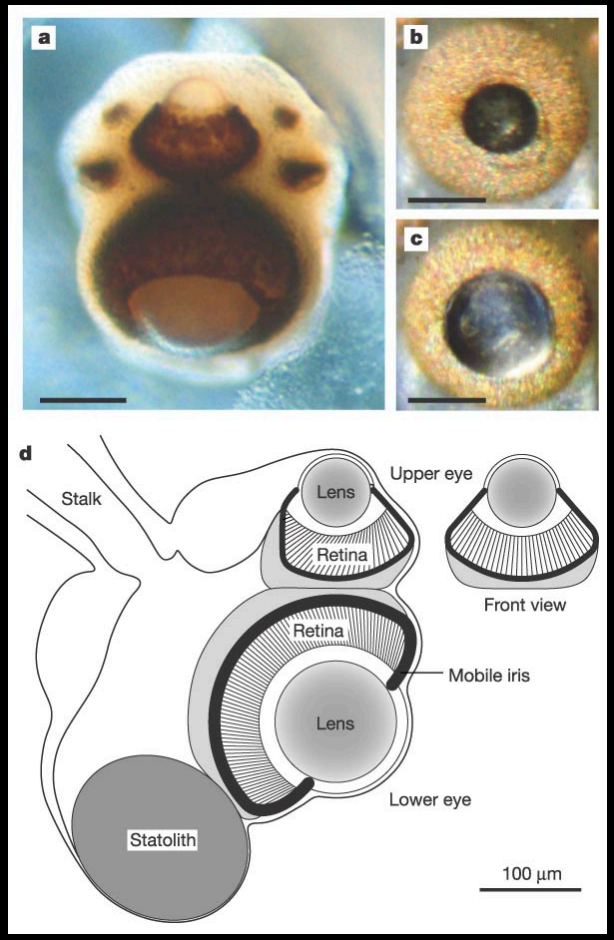


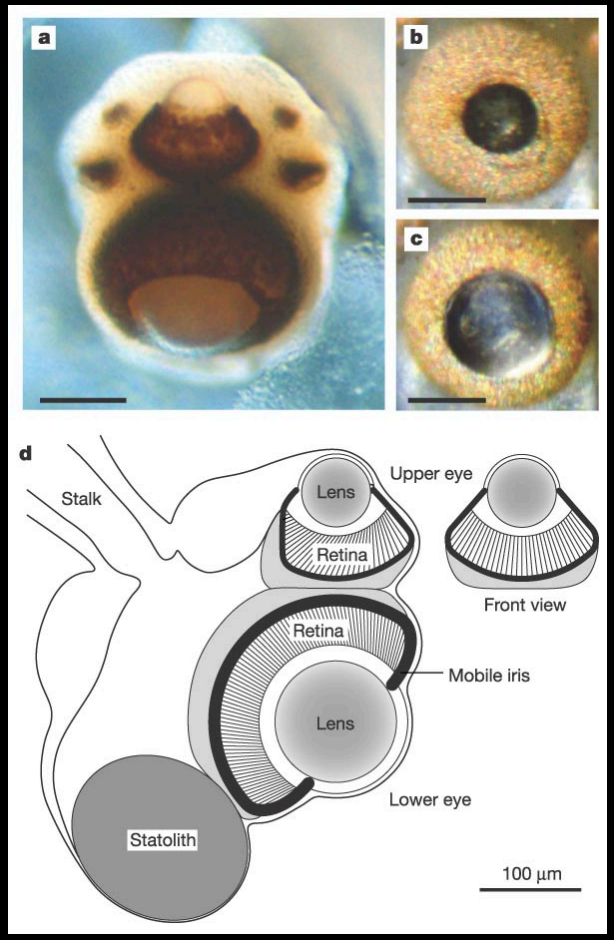
Species 2





EOD signals can communicate species, sex, and individual status


a
b
c
d
Stalk
Lens
Retina
Upper eye
Front view
Retina
Mobile iris
Lens
Lower eye
Statolith
100 µm


a
b
c
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Stalk
Lens
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Upper eye
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Retina
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Lower eye
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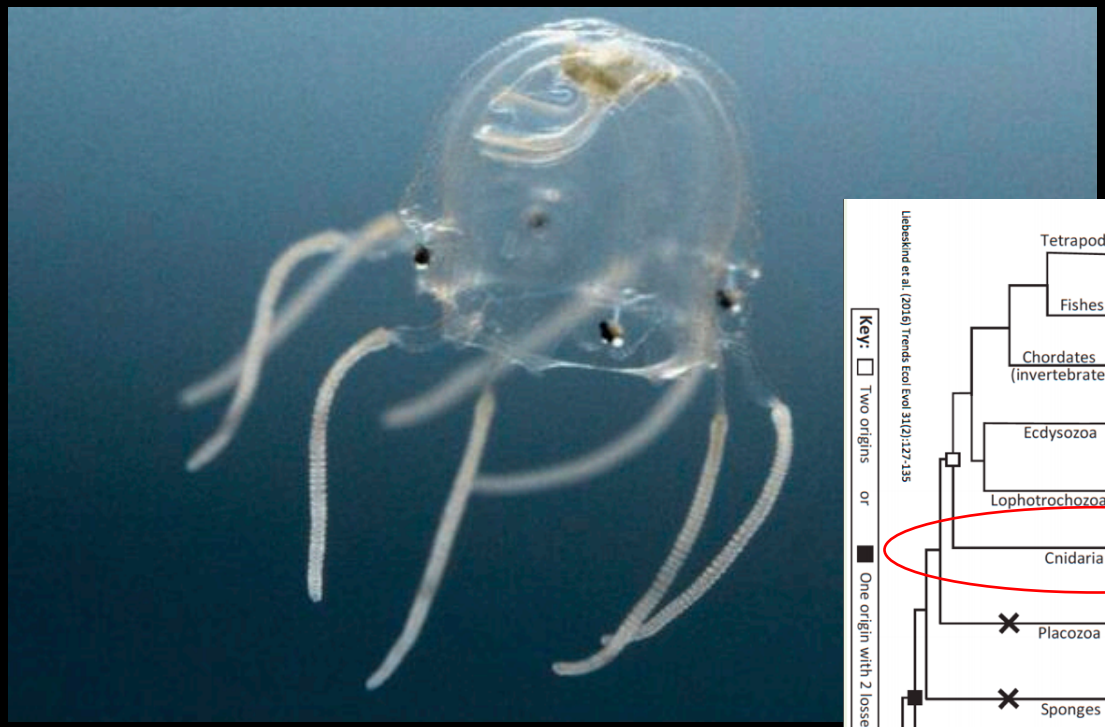
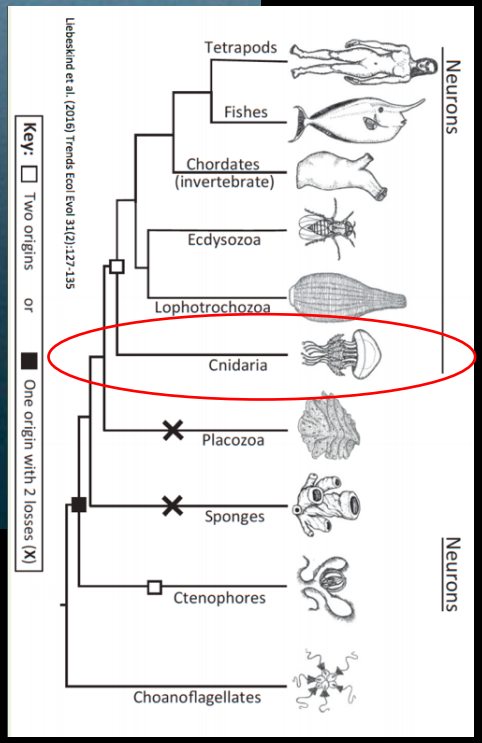
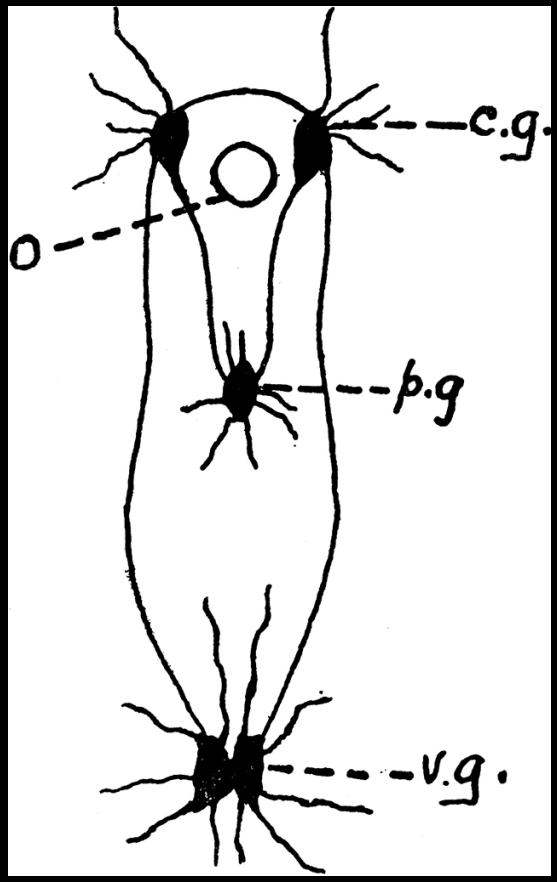
100 µm




Liebeskind et al. (2016) Trends Ecol Evol 31(2):127-135
Key: Two origins or One origin with 2 losses (X)
Tetrapods
Fishes
Chordates (invertebrate)
Ecdysozoa
Lophotrochozoa
Cnidaria
Placozoa
Sponges
Ctenophores
Choanoflagellates
Neurons
Neurons



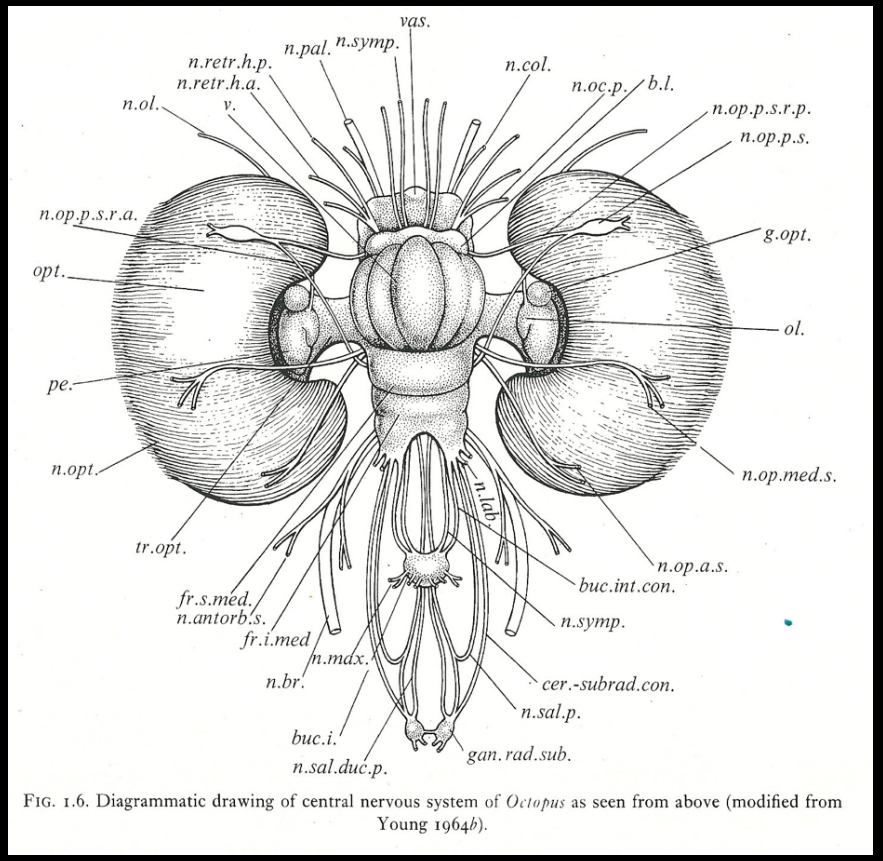
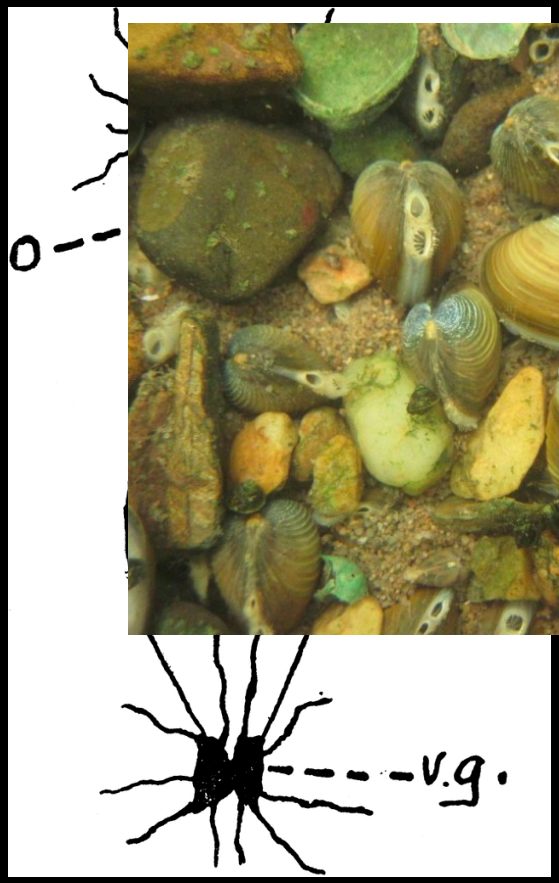
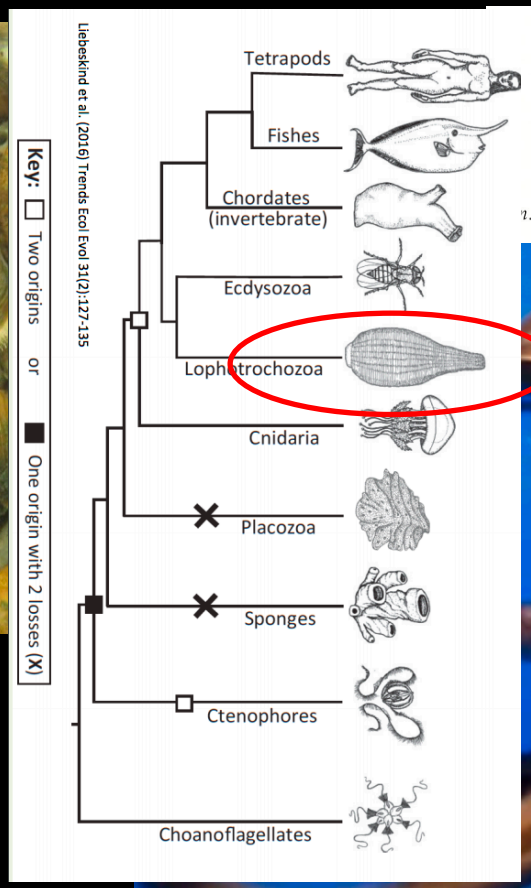
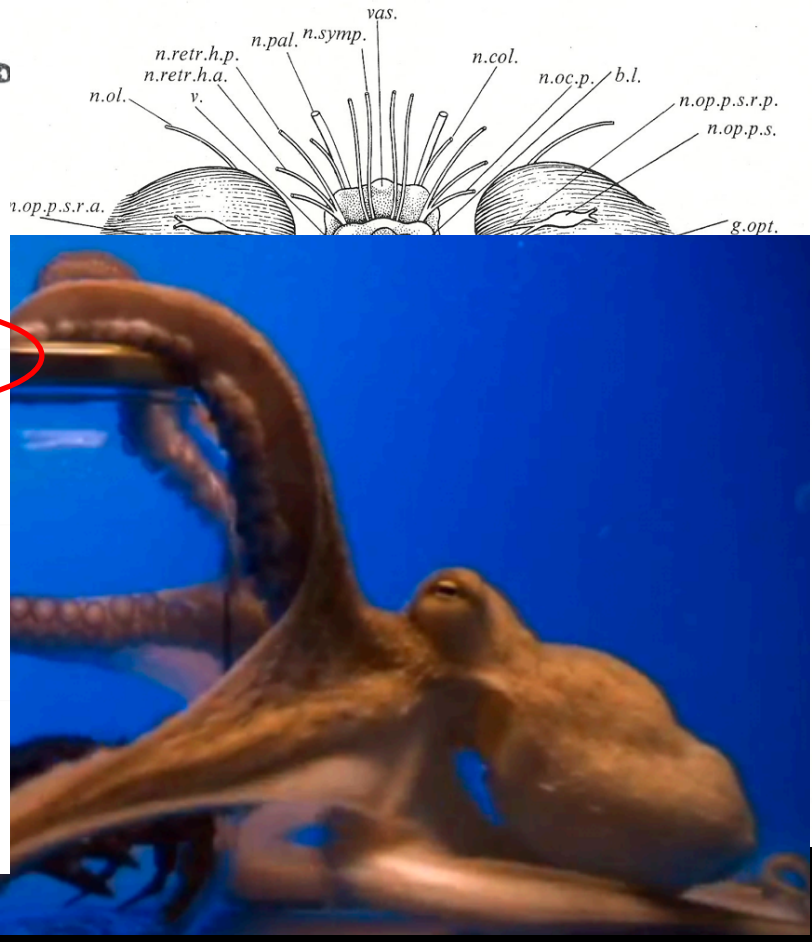
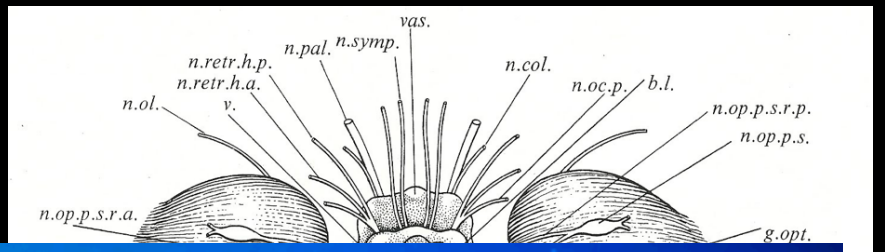


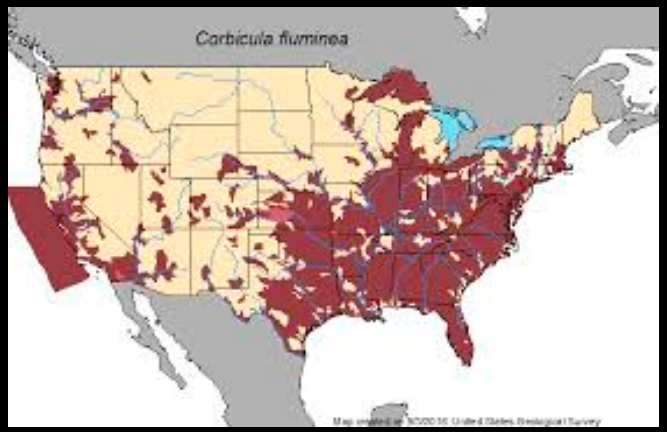
FIG. 1.6. Diagrammatic drawing of central nervous system of *Octopus* as seen from above (modified from Young 1964*b*).


v.g.


Liebeskind et al. (2016) Trends Ecol Evol 31(2):127-135
Key: Two origins or One origin with 2 losses (X)
Tetrapods
Fishes
Chordates (invertebrate)
Ecdysozoa
Lophotrochozoa
Cnidaria
Placozoa
Sponges
Ctenophores
Choanoflagellates


vas.
n.pal.
n.symp.
n.retr.h.p.
n.retr.h.a.
n.col.
n.ol.
v.
n.oc.p.
b.l.
n.op.p.s.r.p.
n.op.p.s.
g.opt.

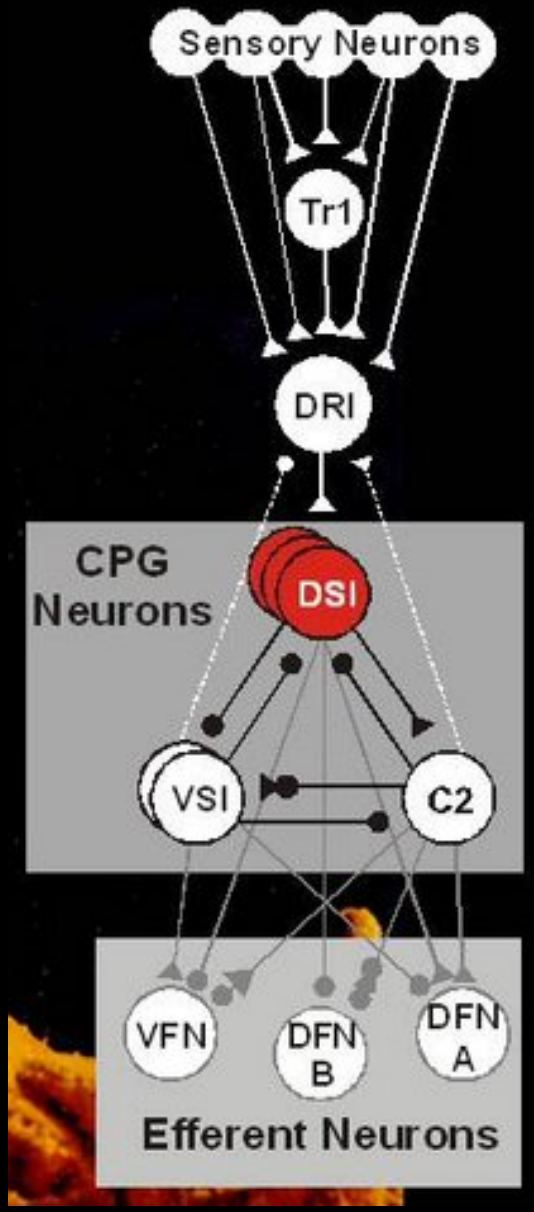

vas.
n.pal.
n.symp.
n.retr.h.p.
n.retr.h.a.
v.
n.ol.
n.col.
n.oc.p.
b.l.
n.op.p.s.r.p.
n.op.p.s.
n.op.p.s.r.a.
g.opt.

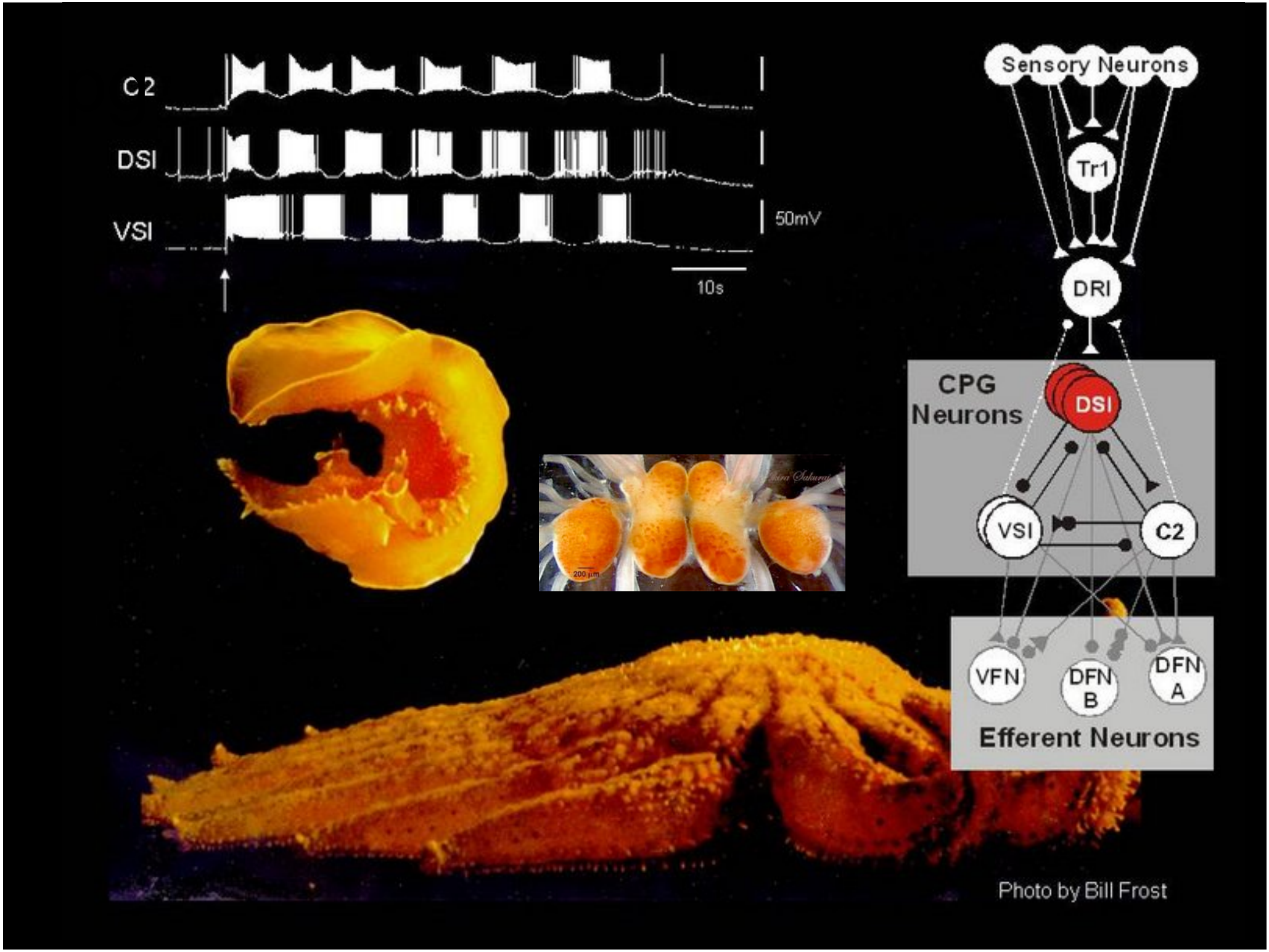

Corbicula fluminea

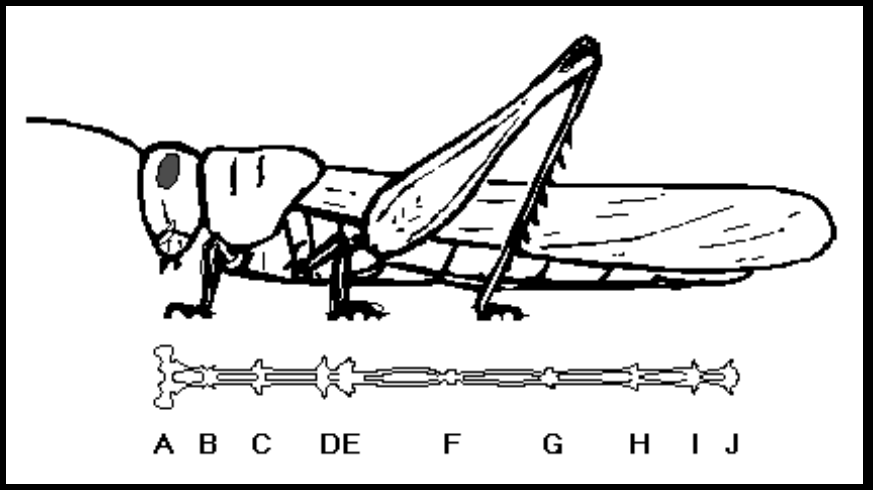
See: swim.mp4

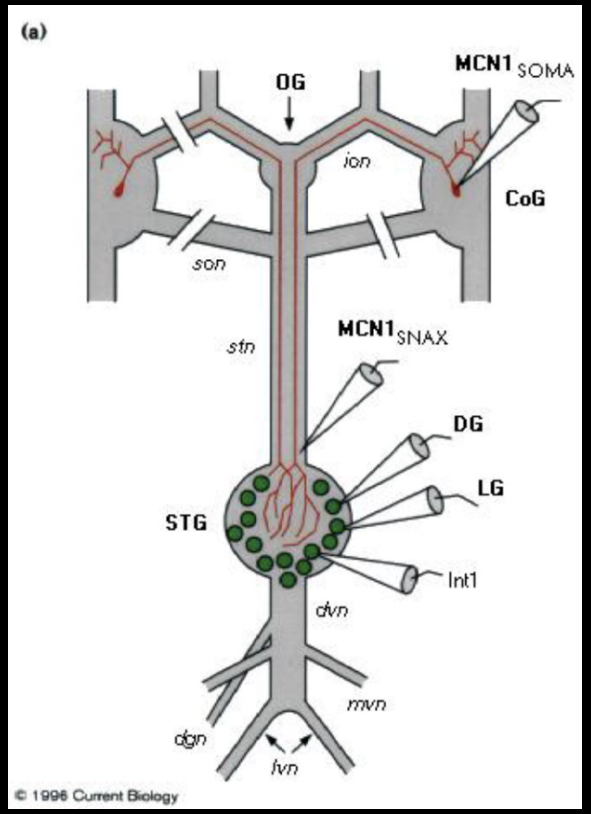
Fixed Action Patterns

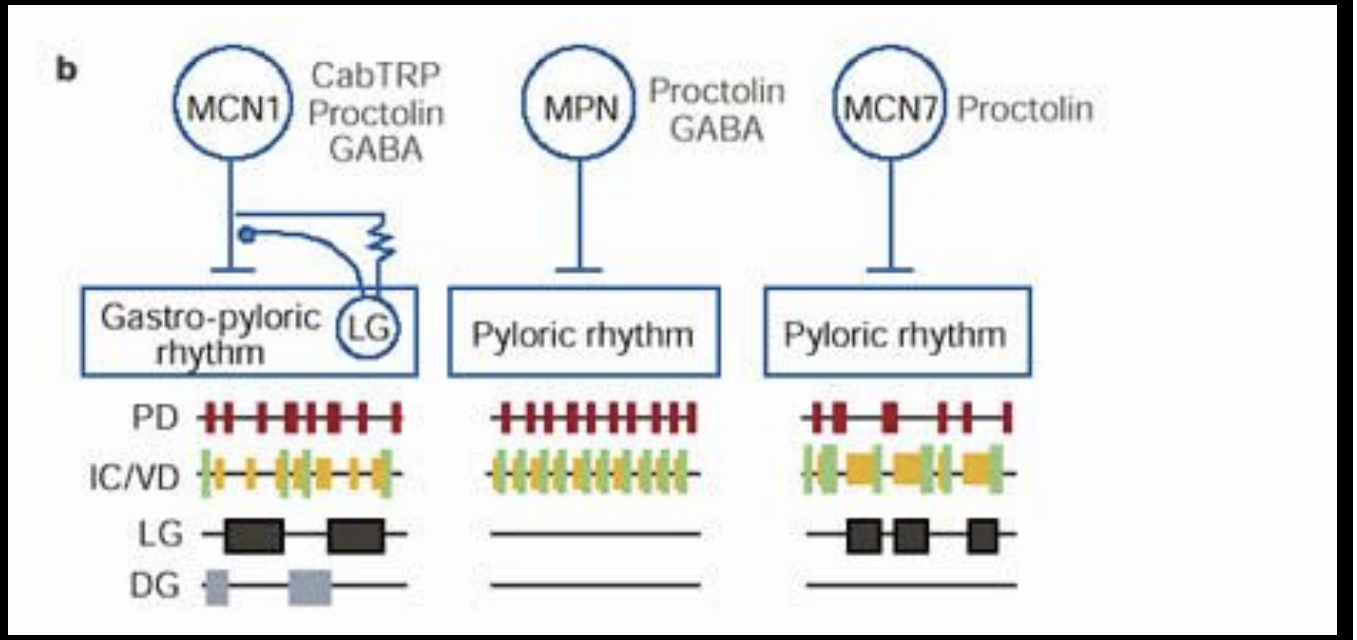
See: tritonia_E-physiology.mov




C2
DSI
VSI
50mV
10s
Sensory Neurons
Tr1
DRI
CPG Neurons
DSI
VSI
C2
VFN
DFN B
DFN A
Efferent Neurons
200 µm
Photo by Bill Frost

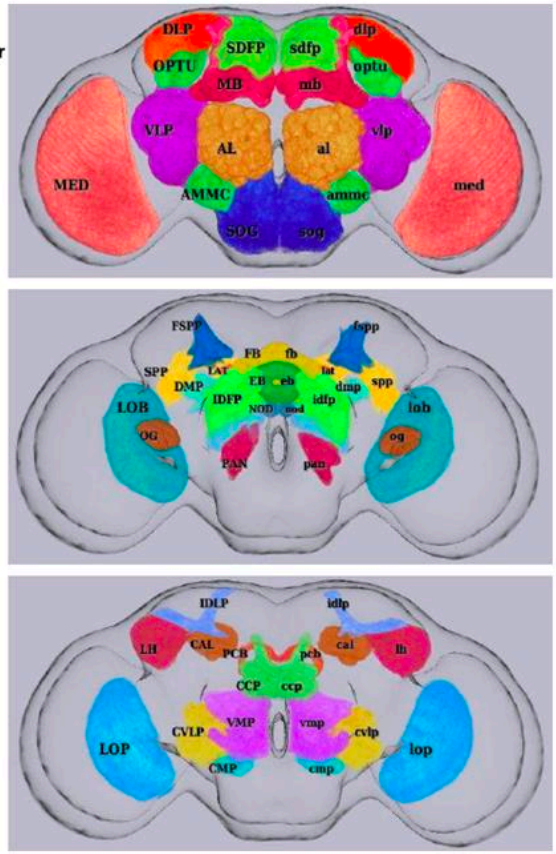

A B C DE F G H I J

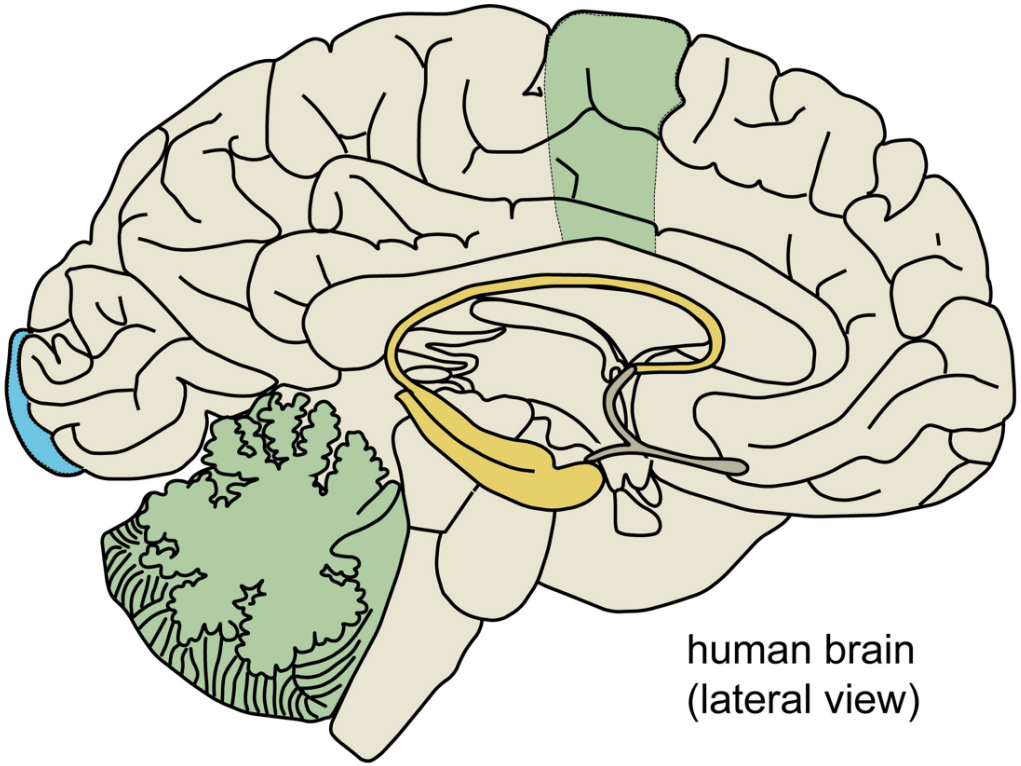




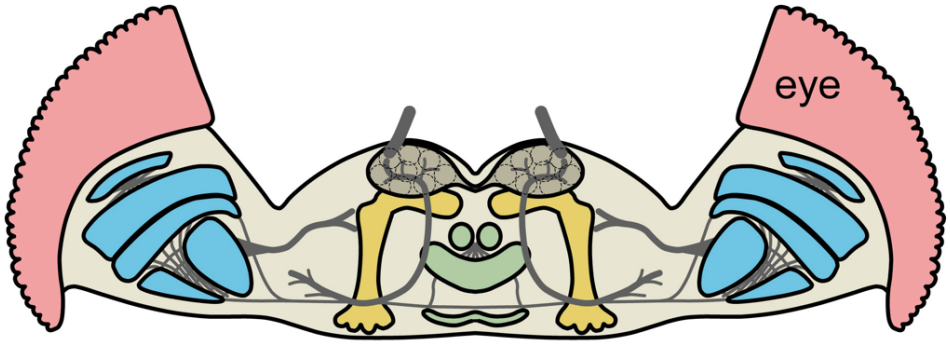
Stomatogastric system

- AL, Antennal Lobe
- AMMC, Antennal Mechanosensory and Motor Center
- Cal, Calyx
- CCP, Caudalcentral Protocerebrum
- CMP, Caudalmedial Protocerebrum
- CVLP, Caudal Ventrolateral Protocerebrum
- DLP, Dorsolateral Protocerebrum
- DMP, Dorsomedial Protocerebrum
- EB, Ellipsoid Body
- FB, Fanshaped Body
- FSPP, Frontal Superpeduncular Protocerebrum
- IDFP, Inferior Dorsofrontal Protocerebrum
- IDLP, Inner Dorsolateral Protocerebrum
- LH, Lateral Horn
- Lob, Lobula
- LoP, Lobula Plate
- Lat Tri, Lateral Triangle
- MB, Mushroom Body
- Med, Medulla
- Nod, Noduli
- OG, Optic Glomerulus
- OPTU, Optic Tubercle
- PAN, Proximal Antennal Protocerebrum
- PCB, Protocerebral Bridge
- SDFP, Superior Dorsofrontal Protocerebrum
- SOG, Subesophageal Ganglion
- SPP, Superpeduncular Protocerebrum
- VLP, Ventrolateral Protocerebrum
- VMP, Ventrolmedial Protocerebrum





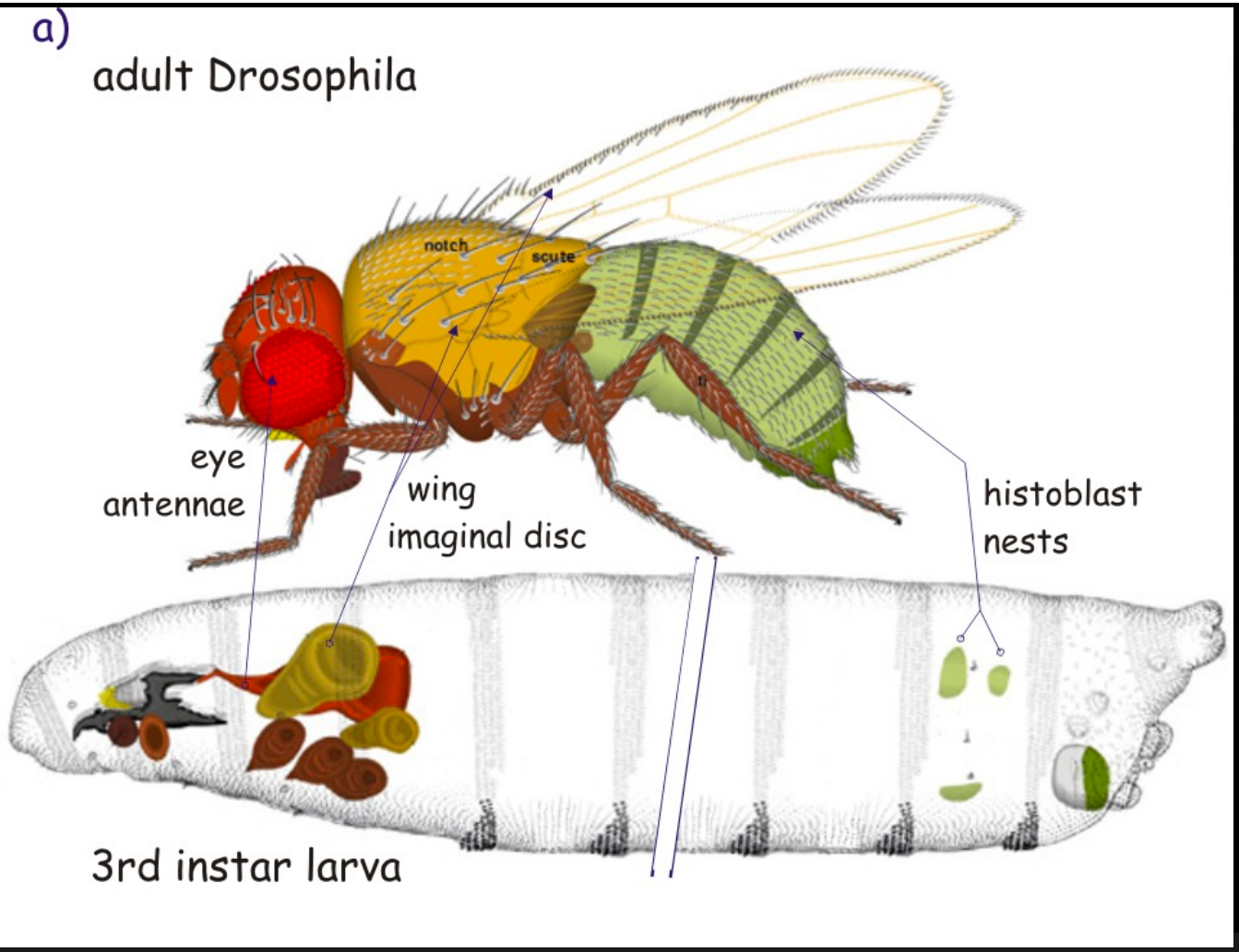
human brain
(lateral view)

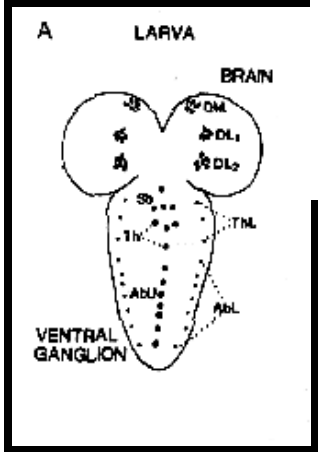


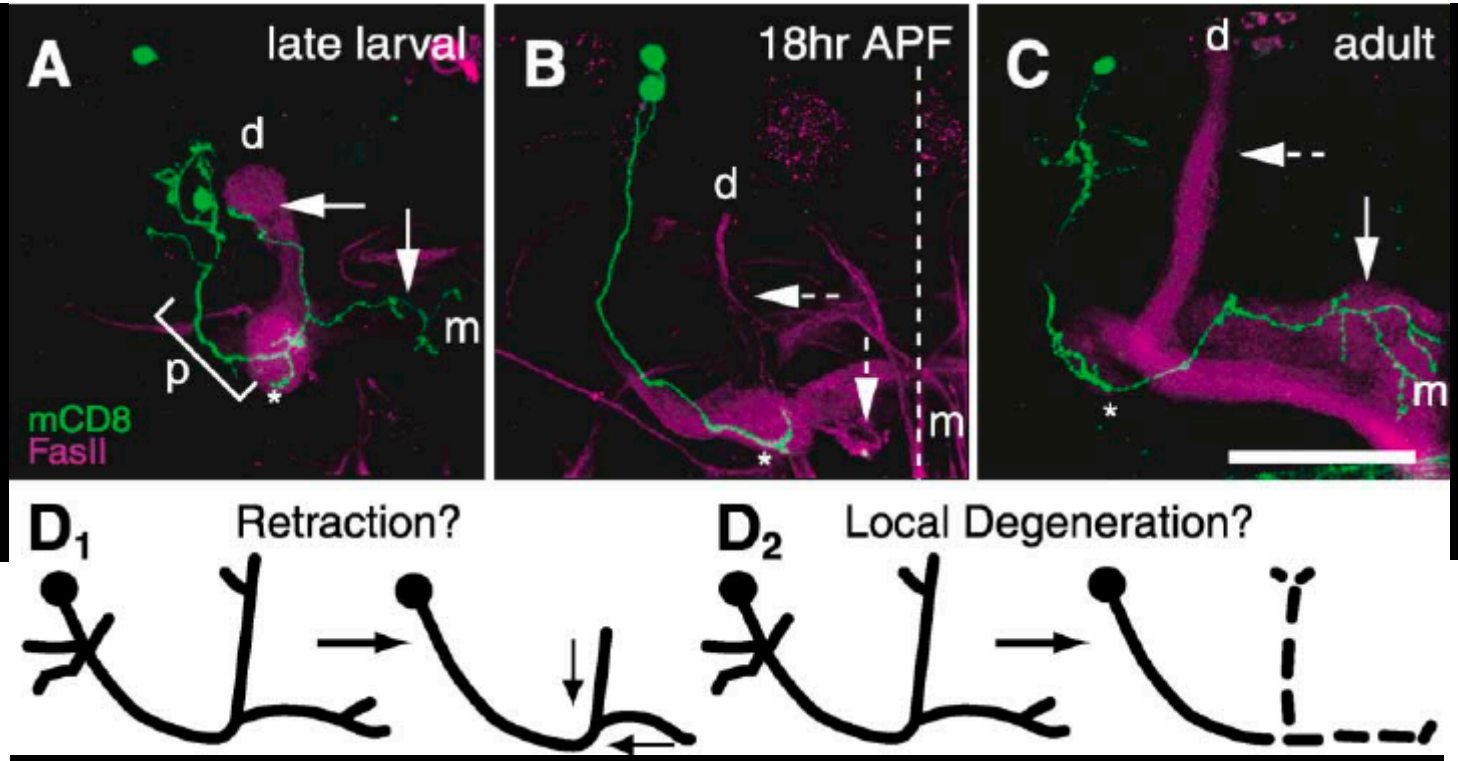
fly brain (horizontal view)

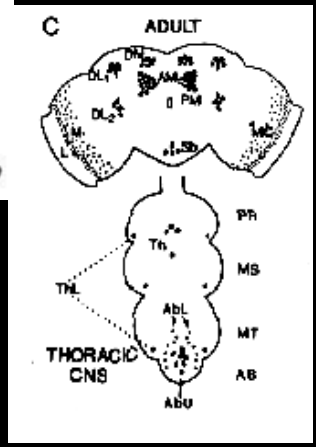
A. Prokop

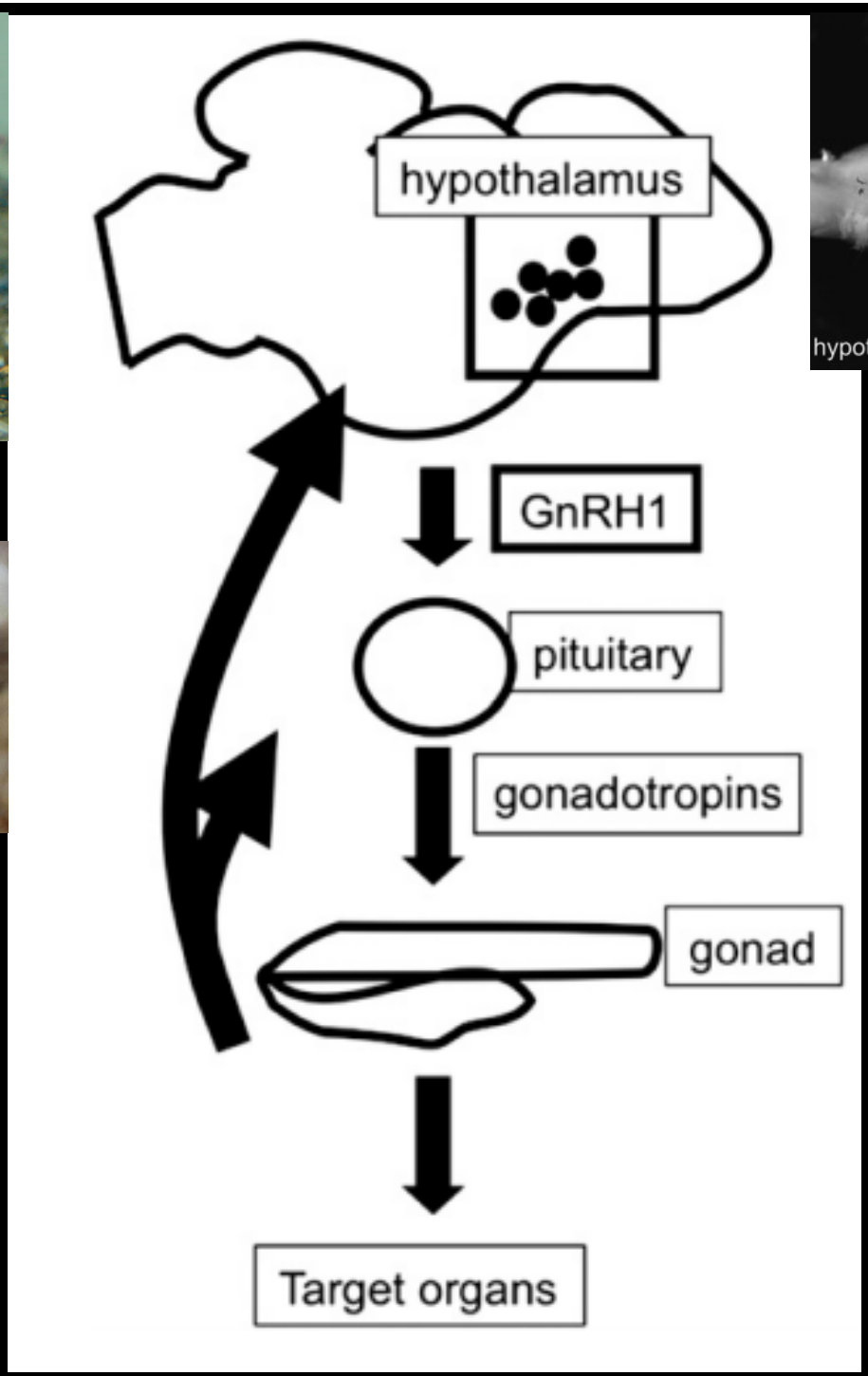
Analogous brain structures

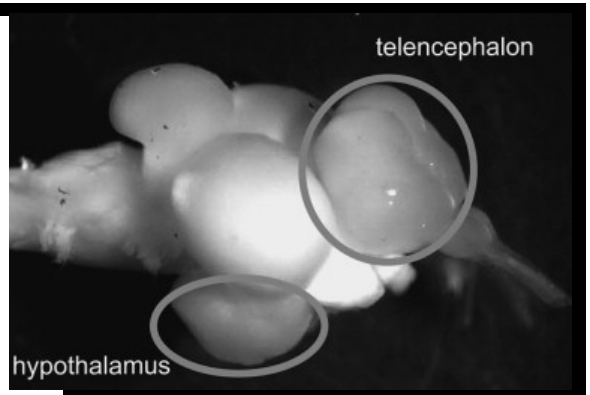

a)
adult Drosophila
notch
scute
eye
antennae
wing
imaginal disc
histoblast
nests
3rd instar larva

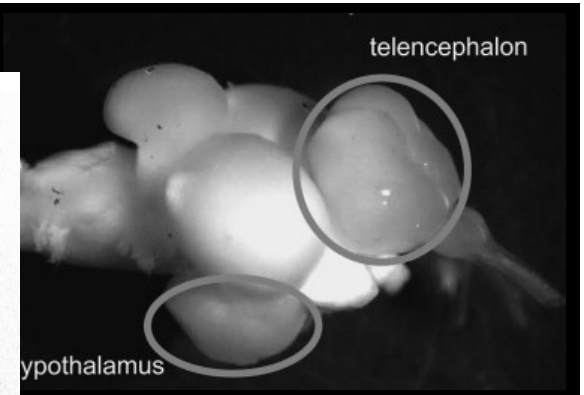

A
LARVA
BRAIN
VENTRAL GANGLION
Th
AbL

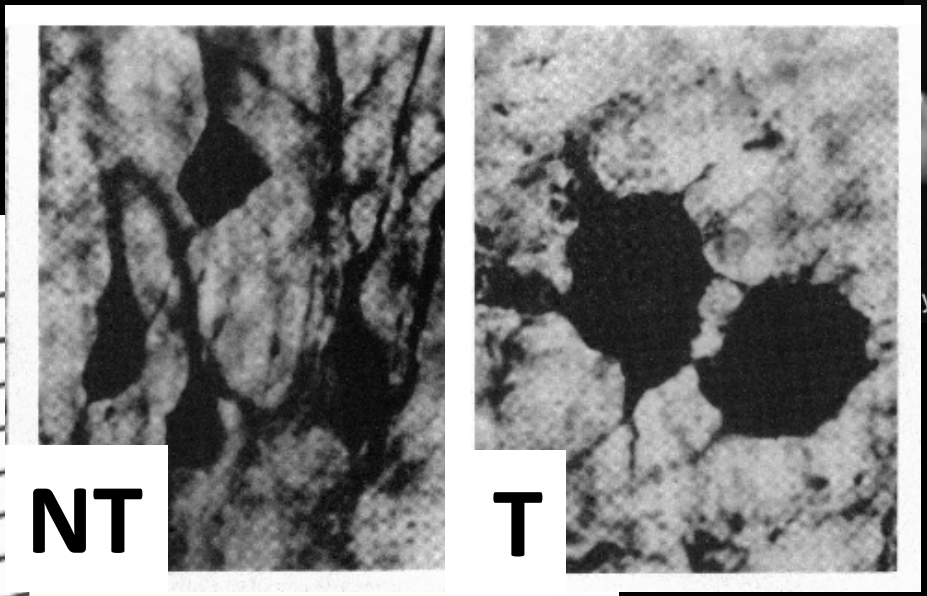

A
late larval
d
m
p
mCD8
FasII
B
18hr APF
d
m
C
d
adult
m
D1
Retraction?
D2
Local Degeneration?

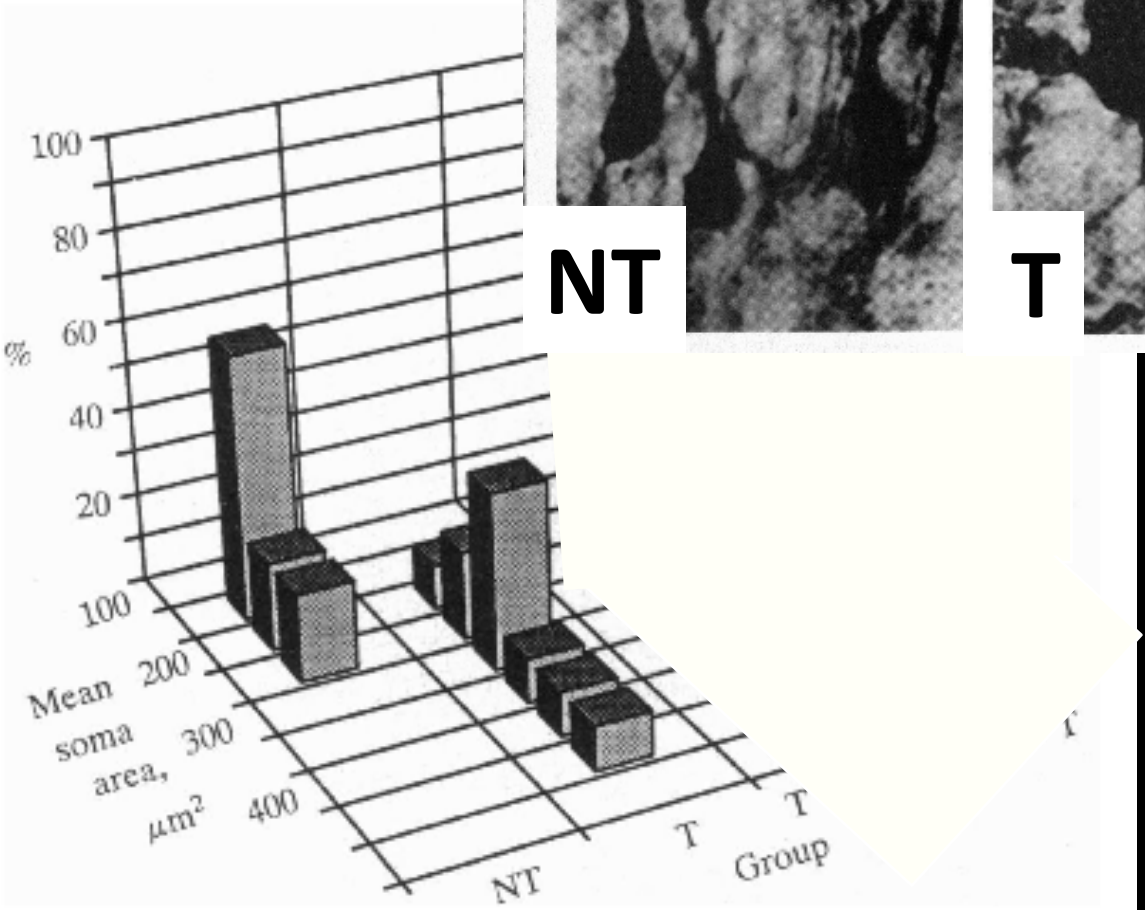

C
ADULT
PR
MS
MT
AB
Th
AbL
THORACIC CNS

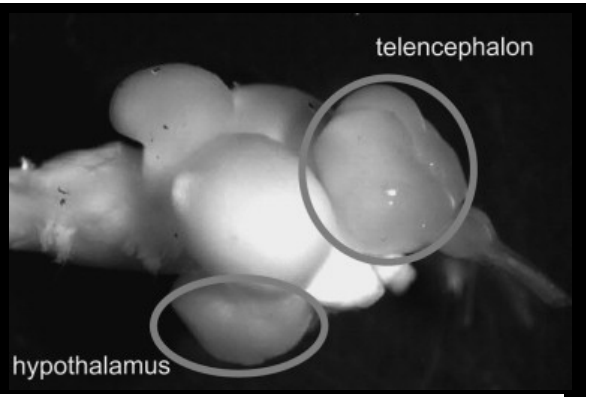

hypothalamus
GnRH1
pituitary
gonadotropins
gonad
Target organs

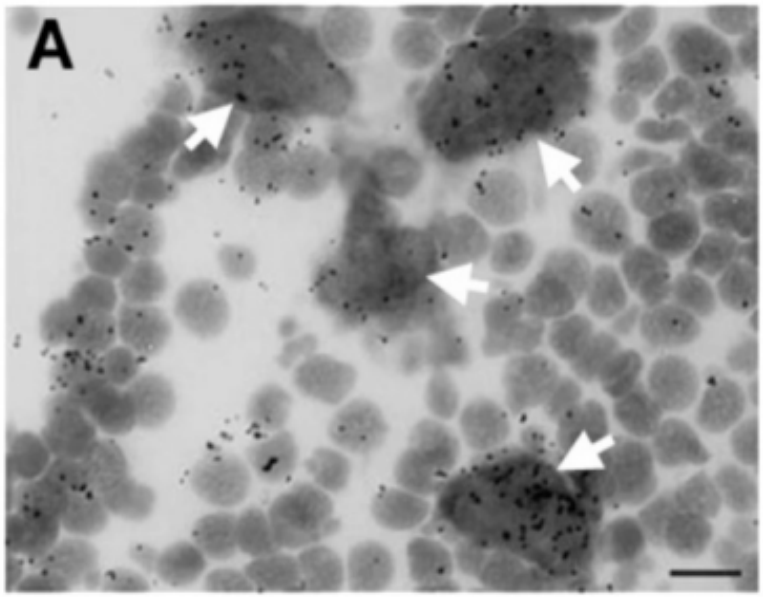

telencephalon
hypothalamus

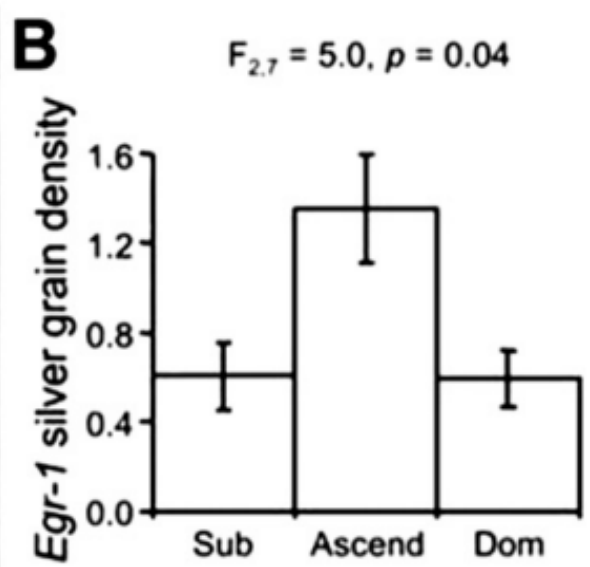

telencephalon
ypothalamus


NT
T

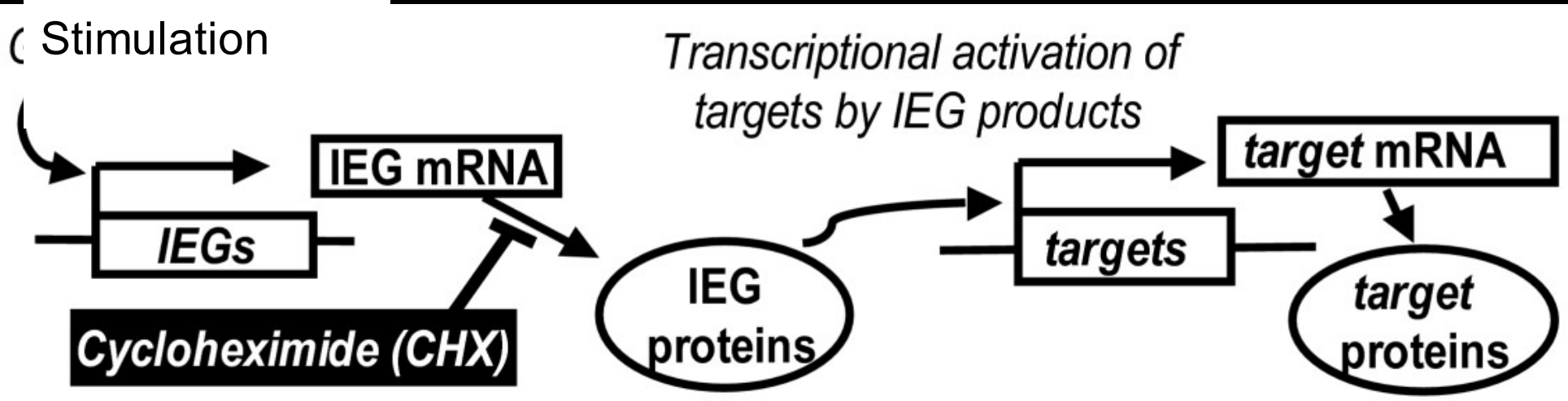

100
80
%
60
40
20
100
Mean
soma
area,
200
300
μm²
400
NT
T
T
Group

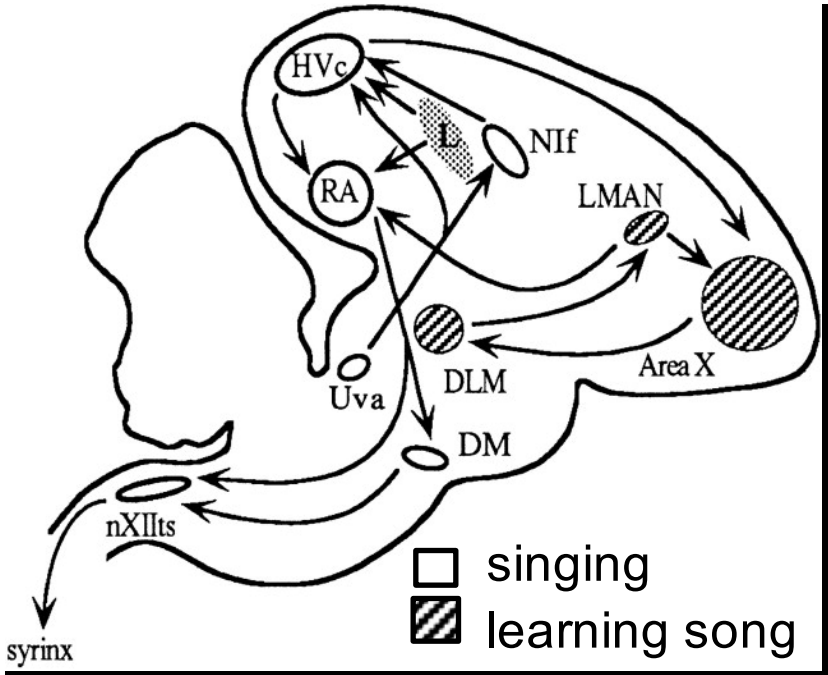


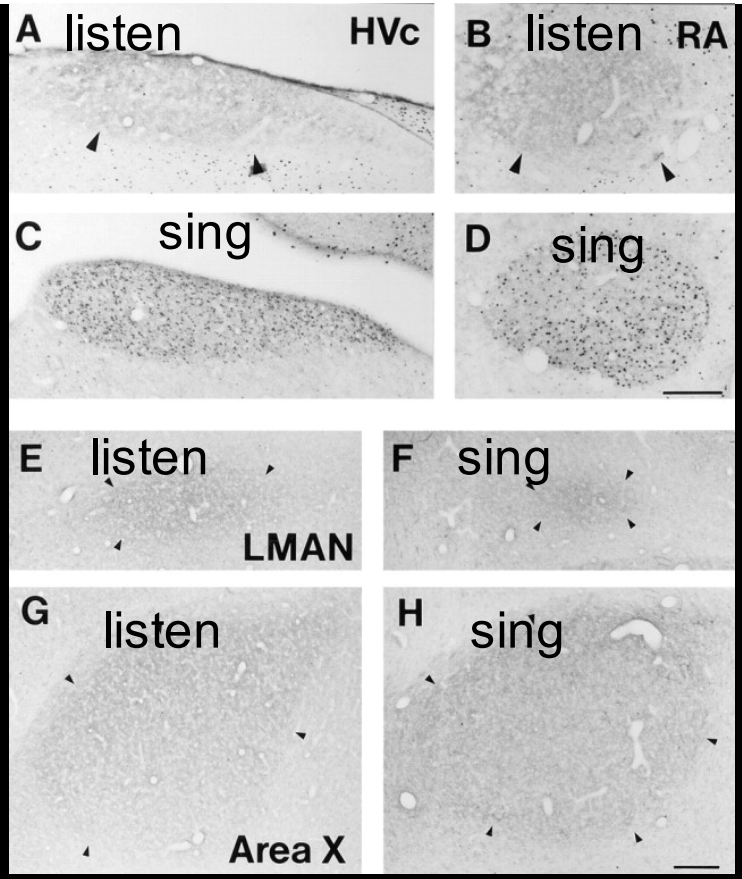


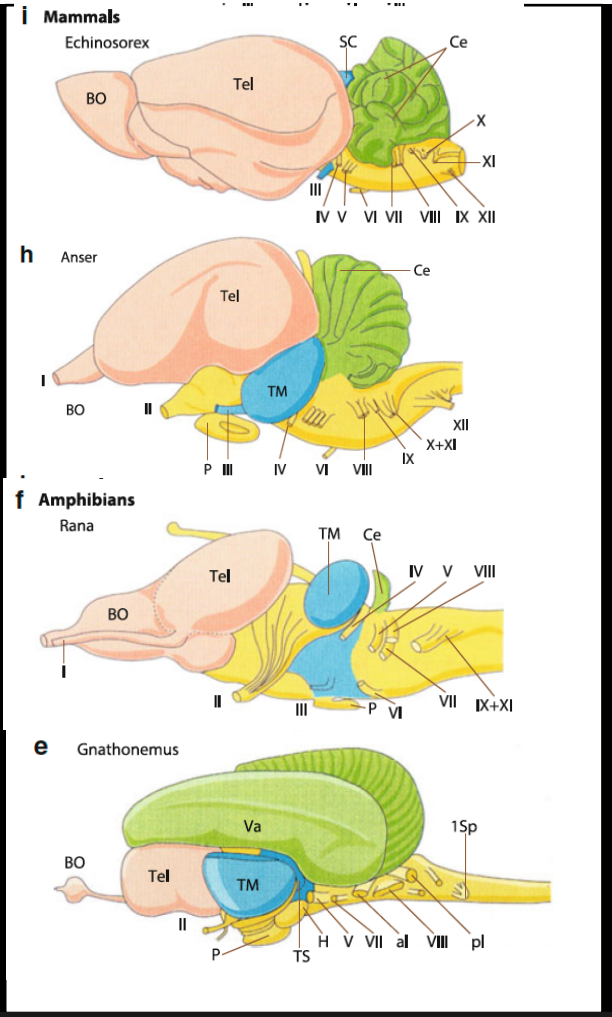


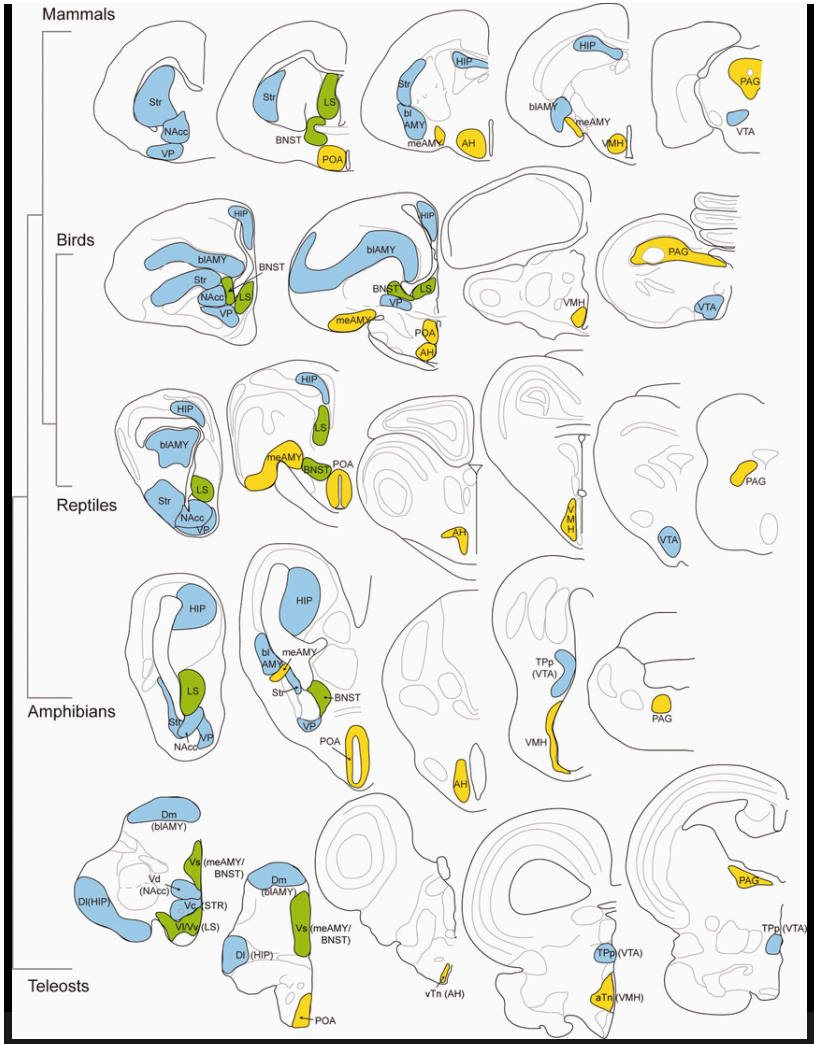
Increased "Immediate Early Gene" expression specifically in the GnRH neurons of the hypothalamus


Stimulation
Transcriptional activation of
targets by IEG products
IEG mRNA
IEGs
Cycloheximide (CHX)
IEG
proteins
target mRNA
targets
target
proteins


HVc
L
NIf
RA
LMAN
Area X
Uva
DLM
DM
nXIIts
syrinx
singing
learning song

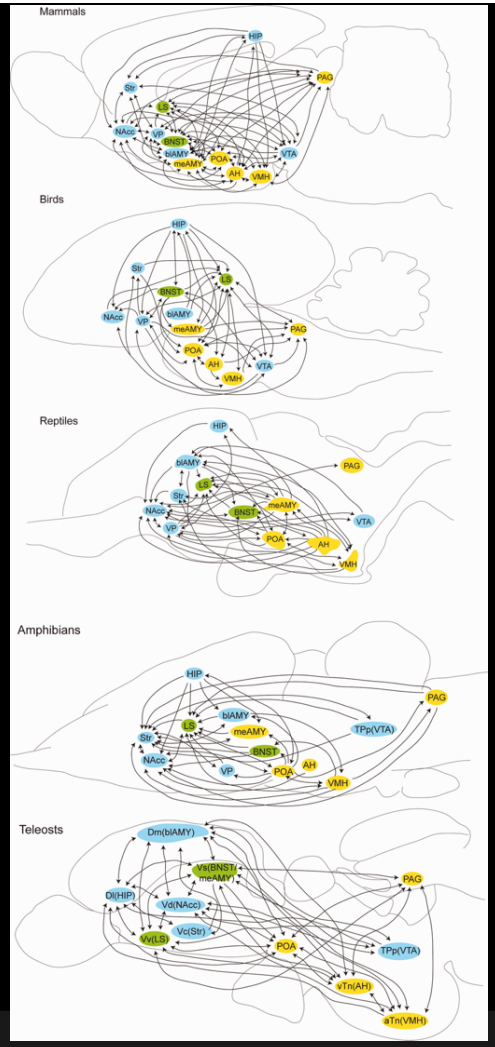

A listen HVc
B listen RA
C sing
D sing
E listen LMAN
F sing
G listen Area X
H sing


i Mammals
Echinosorex
SC
Ce
Tel
BO
X
XI
III
IV V VI VII VIII IX XII
h Anser
Ce
Tel
I
TM
BO
II
XII
X+XI
IX
P III IV VI VIII
f Amphibians
Rana
TM
Ce
Tel
IV V VIII
BO
I
II
III
P
VI
VII
IX+XI
e Gnathonemus
Va
1Sp
BO
Tel
TM
II
P
TS
H V VII al VIII pl



social behavior network
mesolimbic reward system
shared by both networks

Homoplasy or Deep Homology?



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O'Conne1l & Hofmann (2011) Frontiers in Neuroscience