

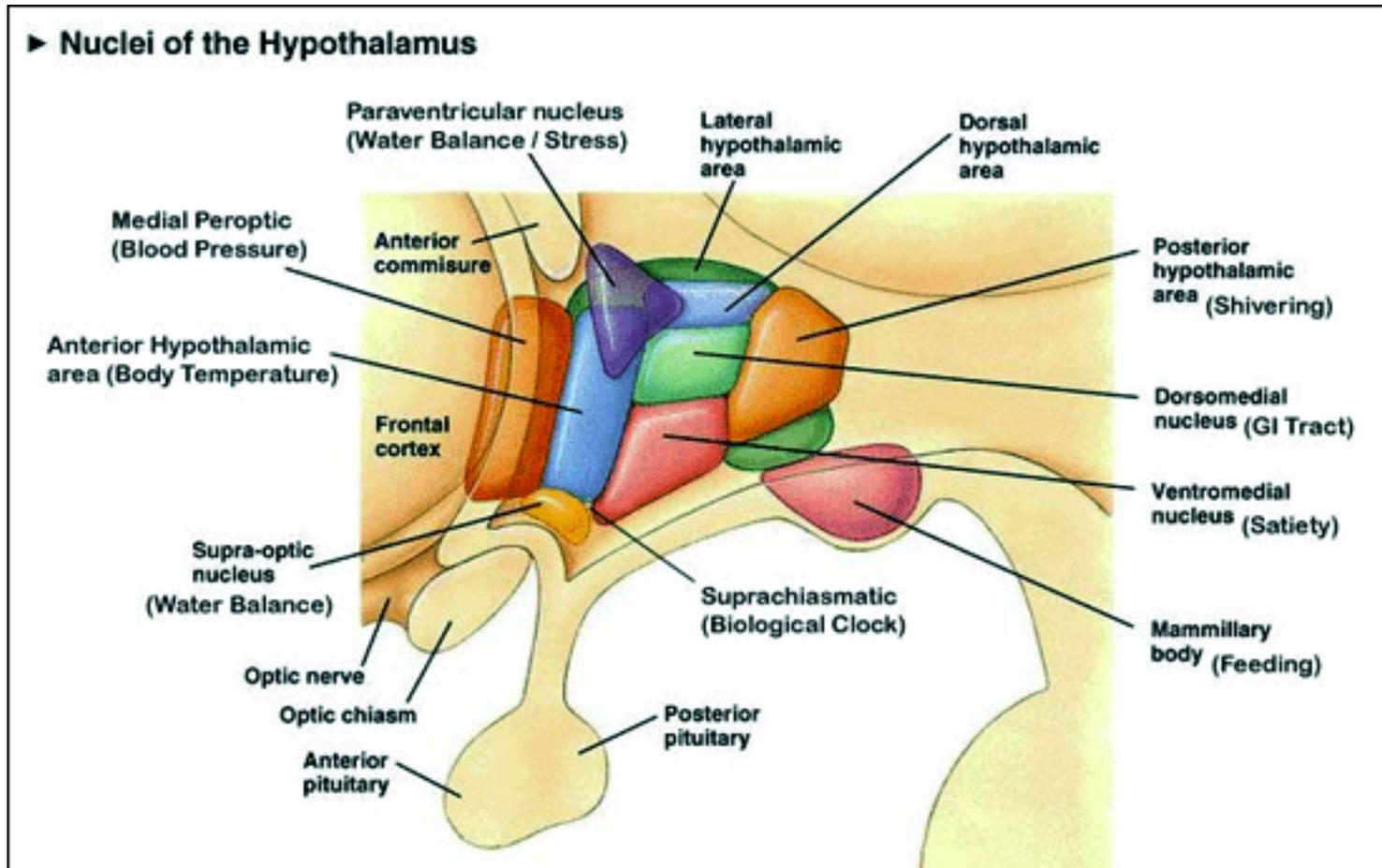
Lecture 9

# Sexual Development & Behavior



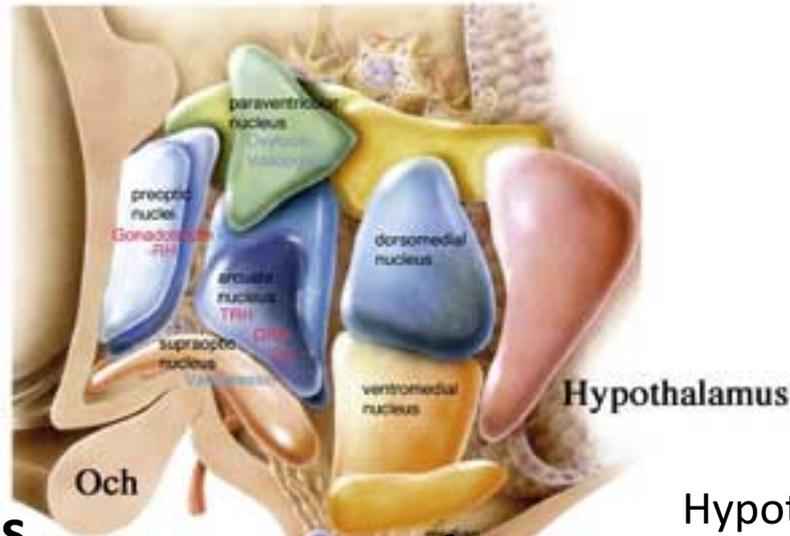
Cogs17 \* UCSD

# The Hypothalamus



Interface with Endocrine (Hormonal) System via  
**Pituitary (Master) Gland**

# Hypothalamus and Pituitary Gland



Hypothalamus produces **Releasing Hormones**, that flow via blood vessels to **Anterior Pituitary**

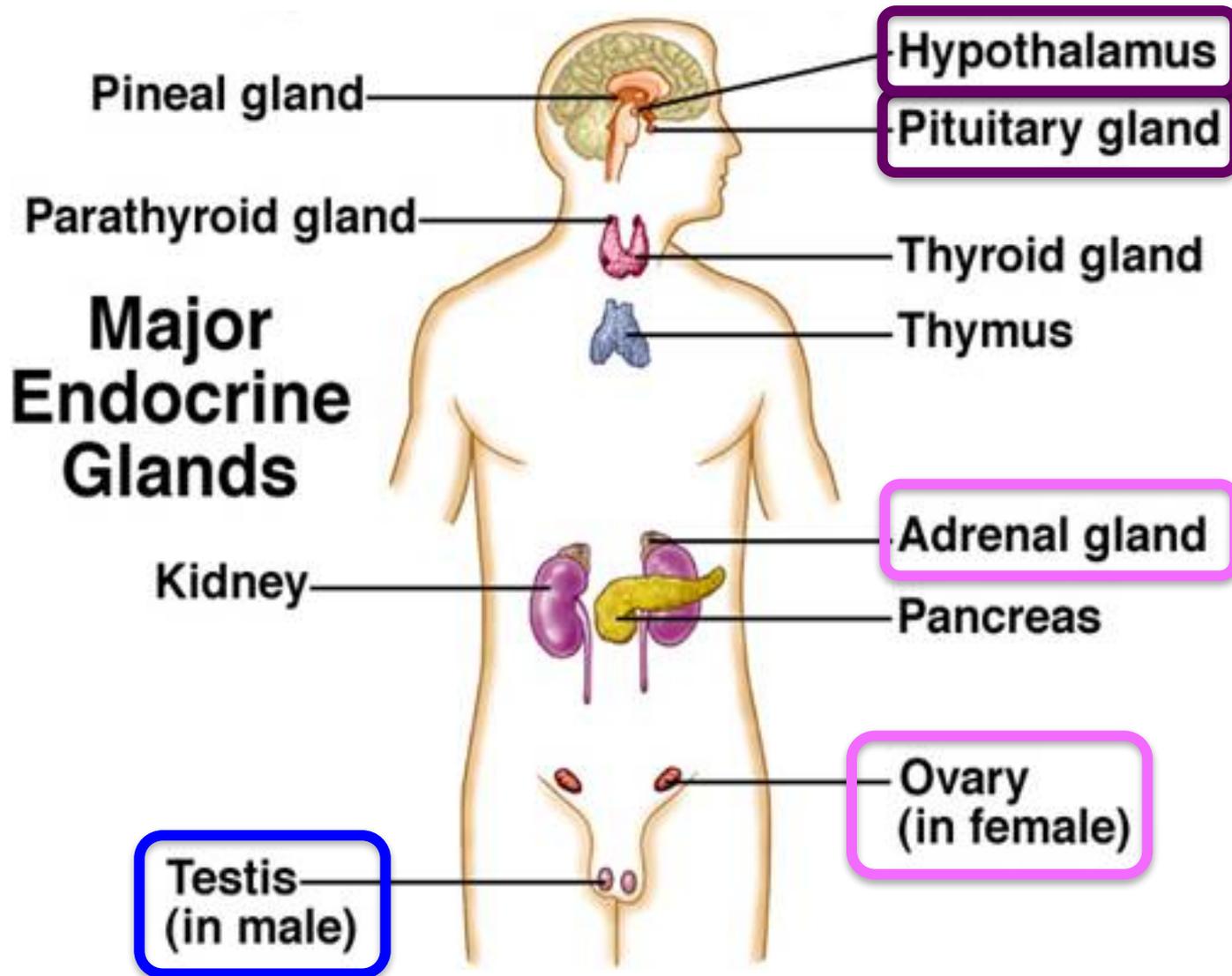
Hypothalamus releases other Hormones as Neurotransmitters via axons to **Posterior Pituitary**



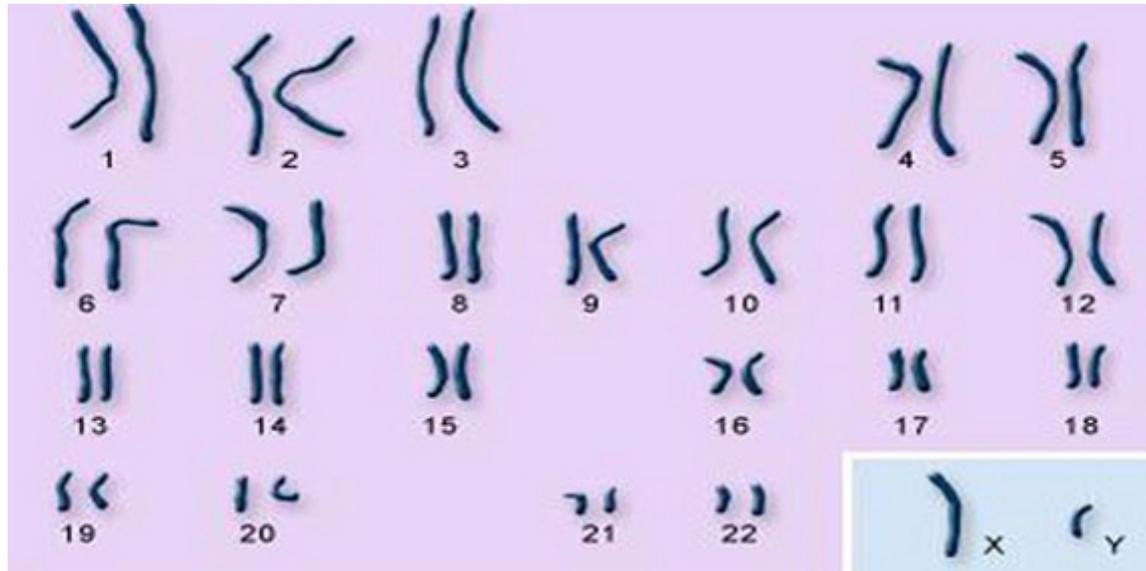
*Exempla Endocrinologica, Breckwoldt et al., 1991*

**Pituitary** then releases triggered hormones into the bloodstream of the body

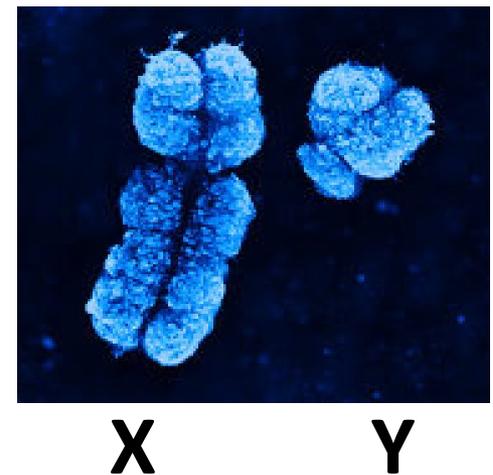
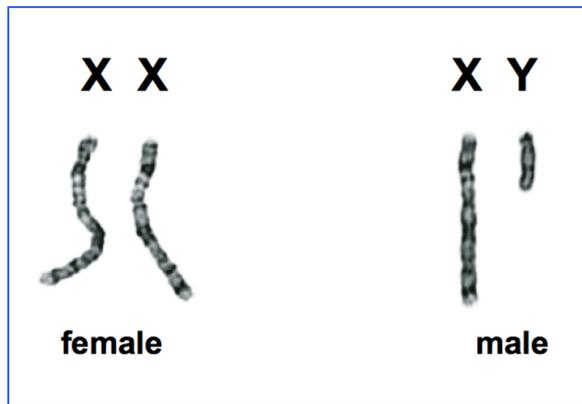
Pituitary Gland sends messages to other glands

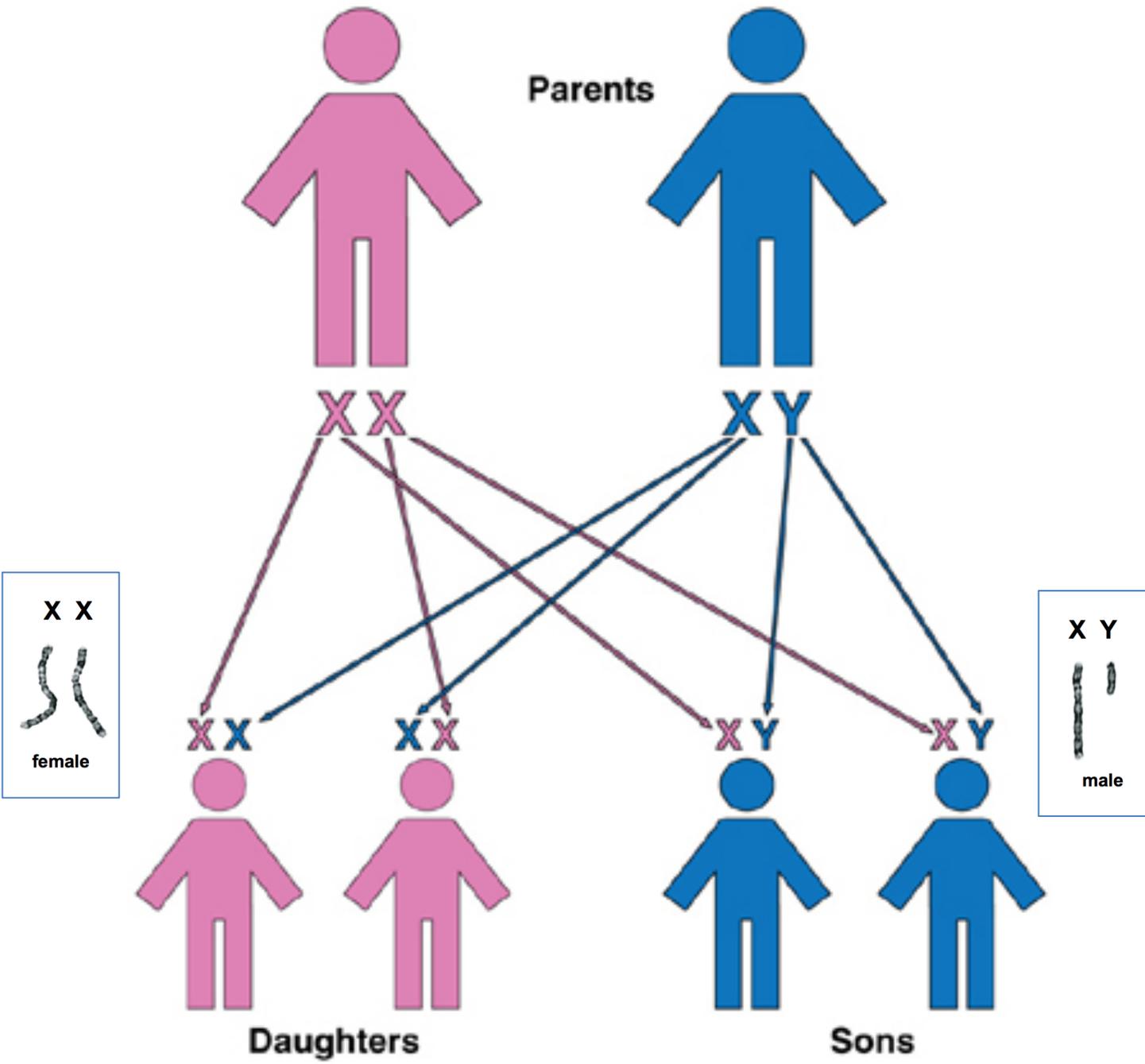


# Chromosomes

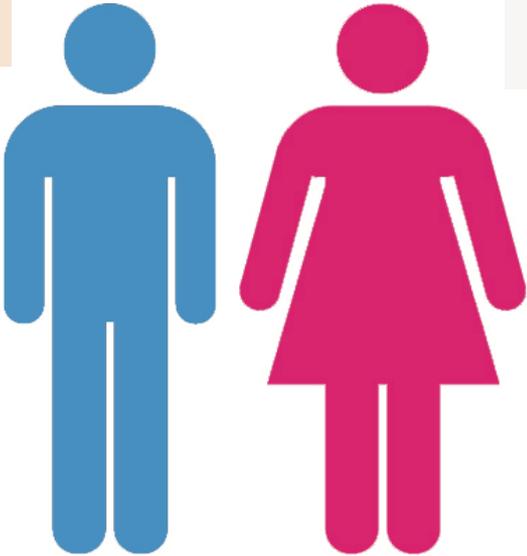
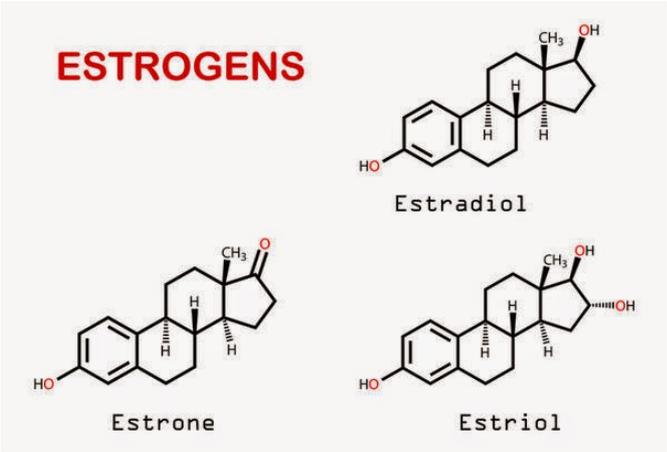
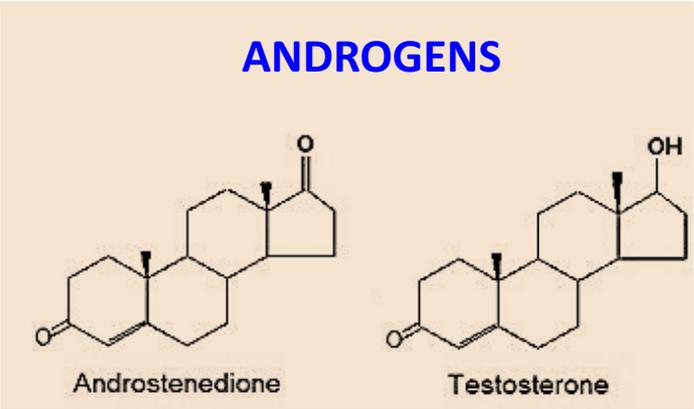
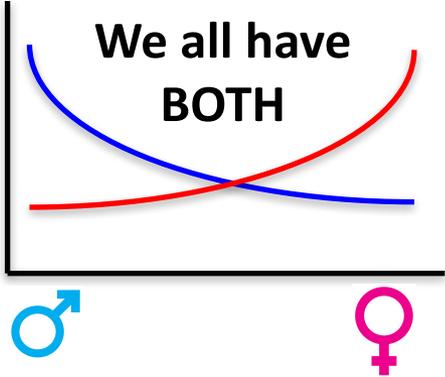


"Sex Chromosomes"



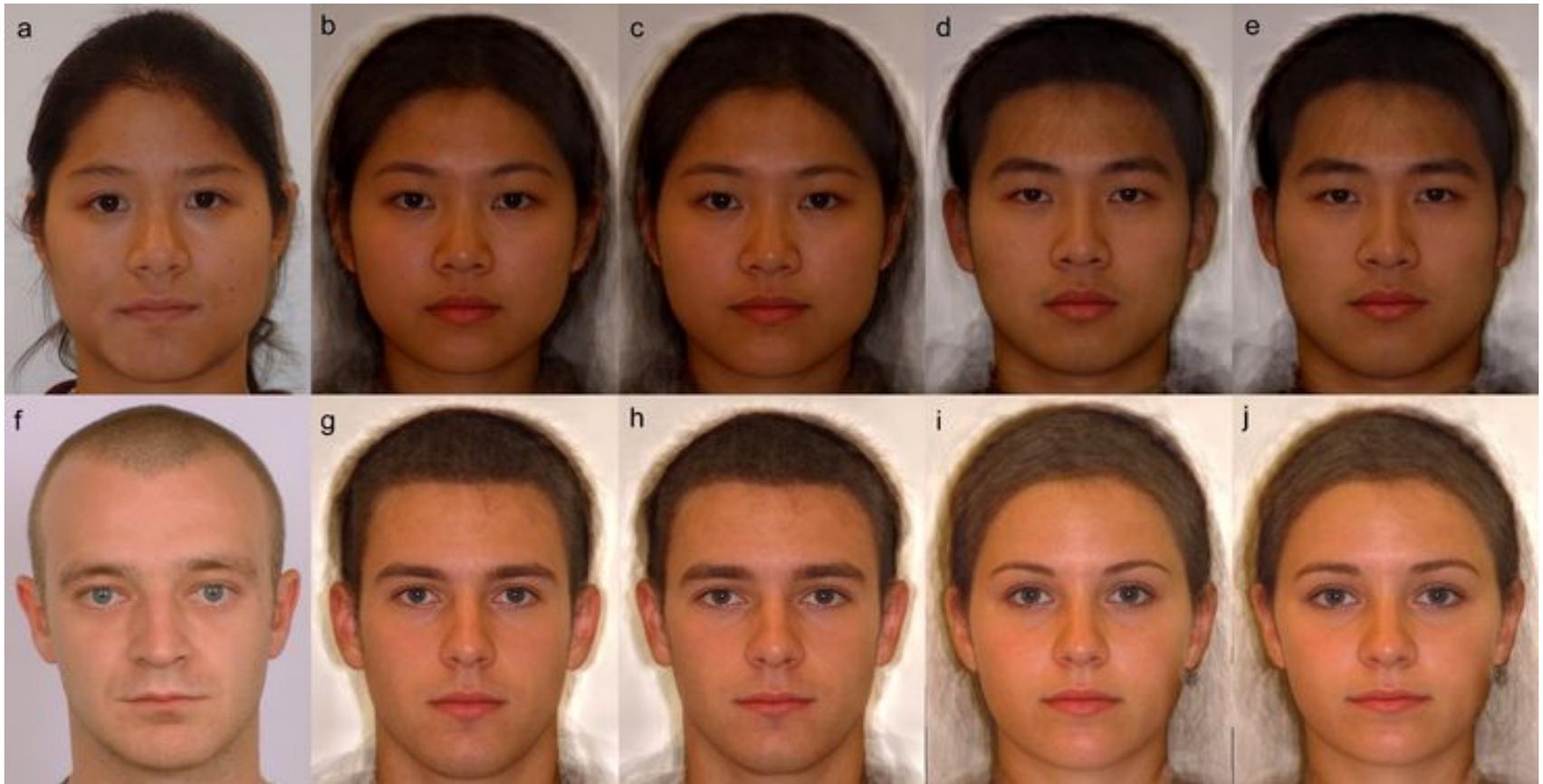


# Androgens (male) & Estrogens (female) Hormones



# Masculine & Feminine

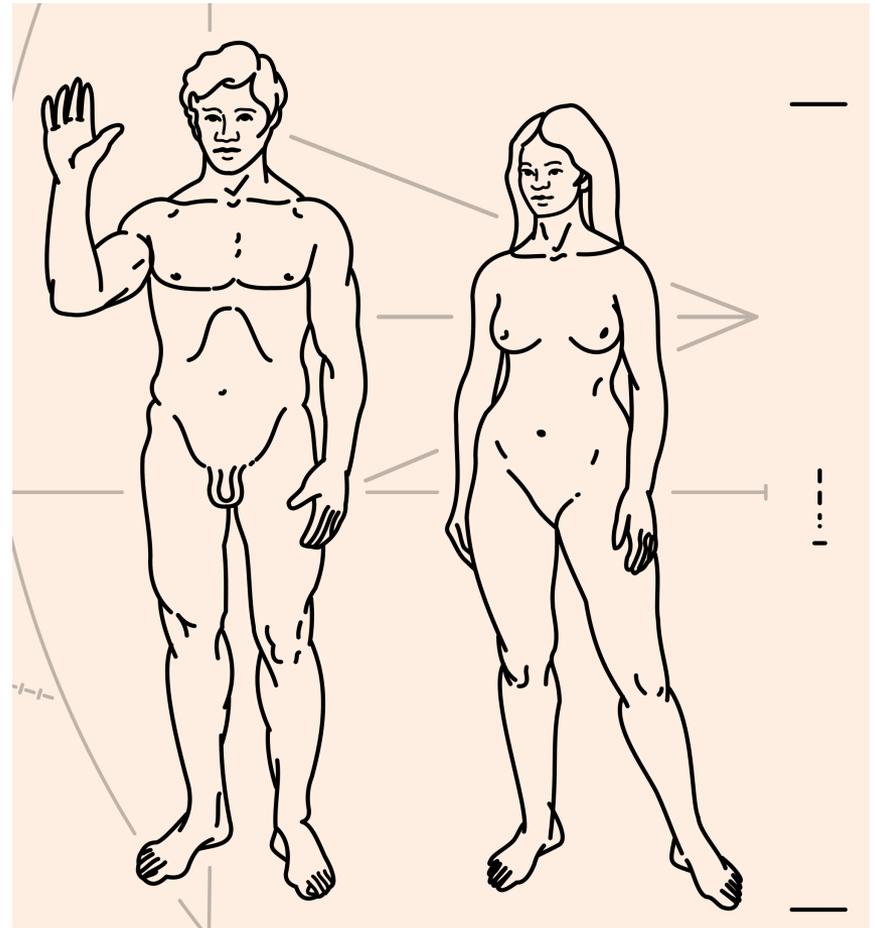
A complex set of factors influence gender



Including genes, neurotransmitters, hormones, and culture

# Organizing Effects

The development of sexual **anatomy**,  
including brain differences



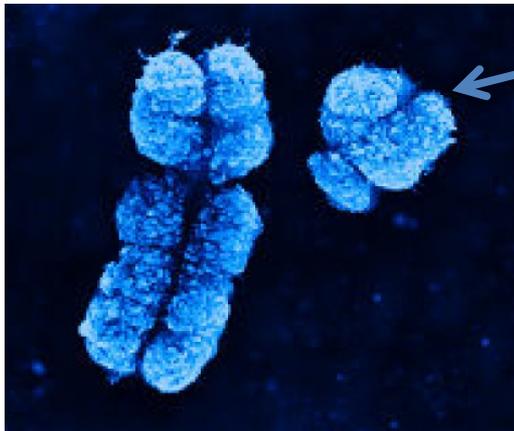
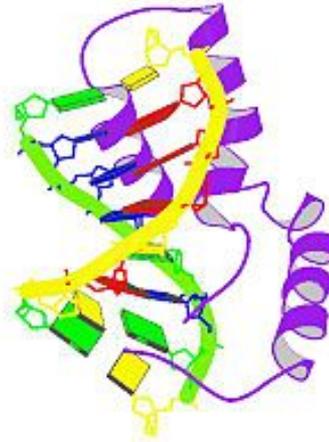
# Prenatal Development



# Role of genes in Organizing Effects - **TDF**

**TDF**

Testes  
Determining  
Factor



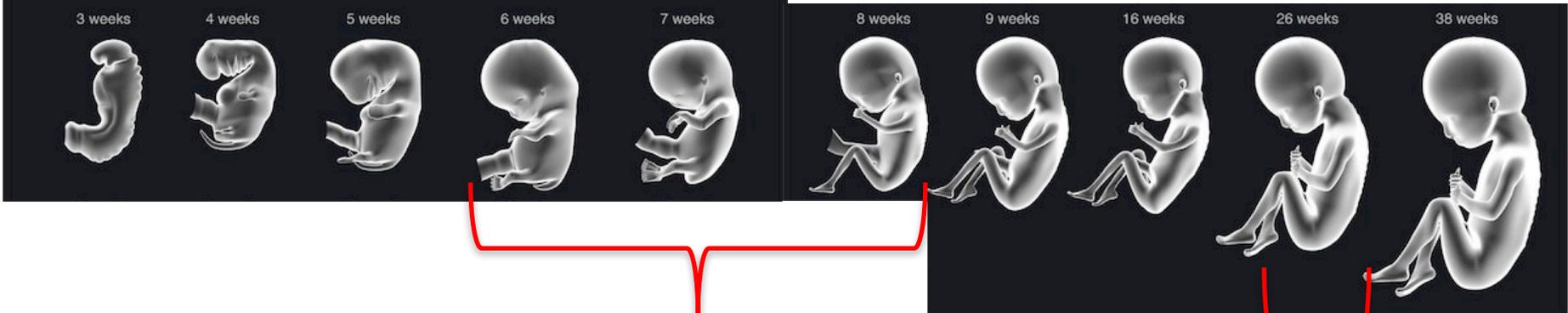
Found only on Y chromosome

An enzyme that appears at ~6-8 weeks

"Switch" that activates production of  
**Testosterone**

In absence of such Testosterone, development will default to Female form

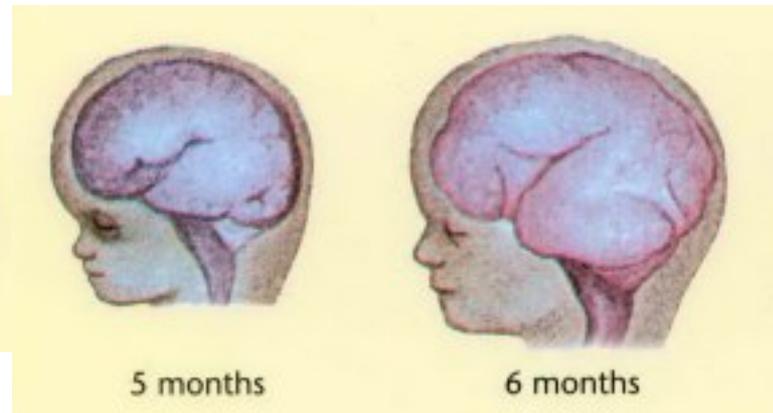
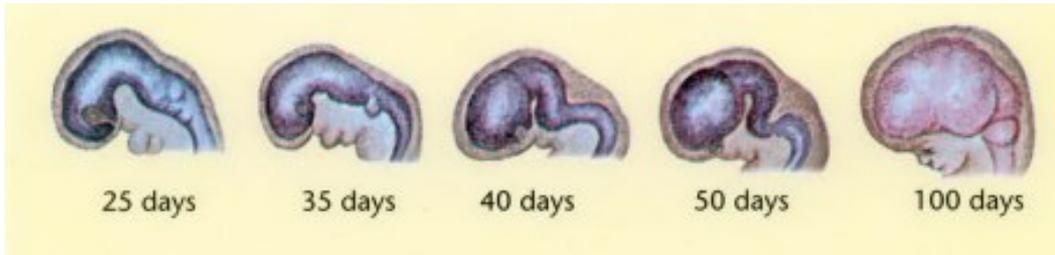
### Human embryonic and fetal development



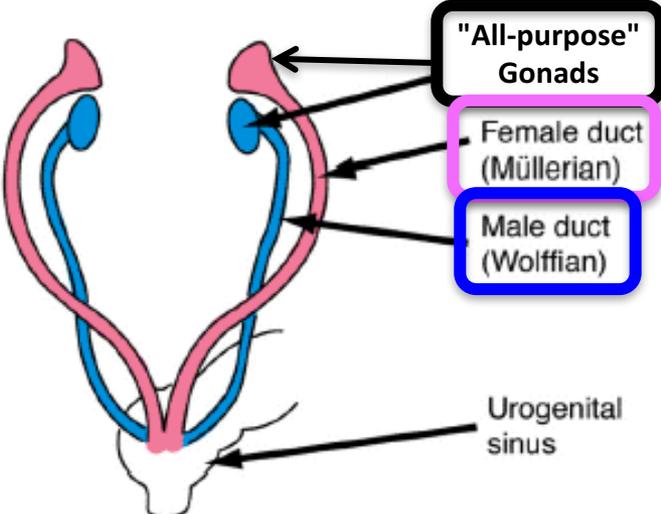
TDF appears between  
6<sup>th</sup> and 8<sup>th</sup> week

Sexual anatomy  
develops  
by 4<sup>th</sup> month

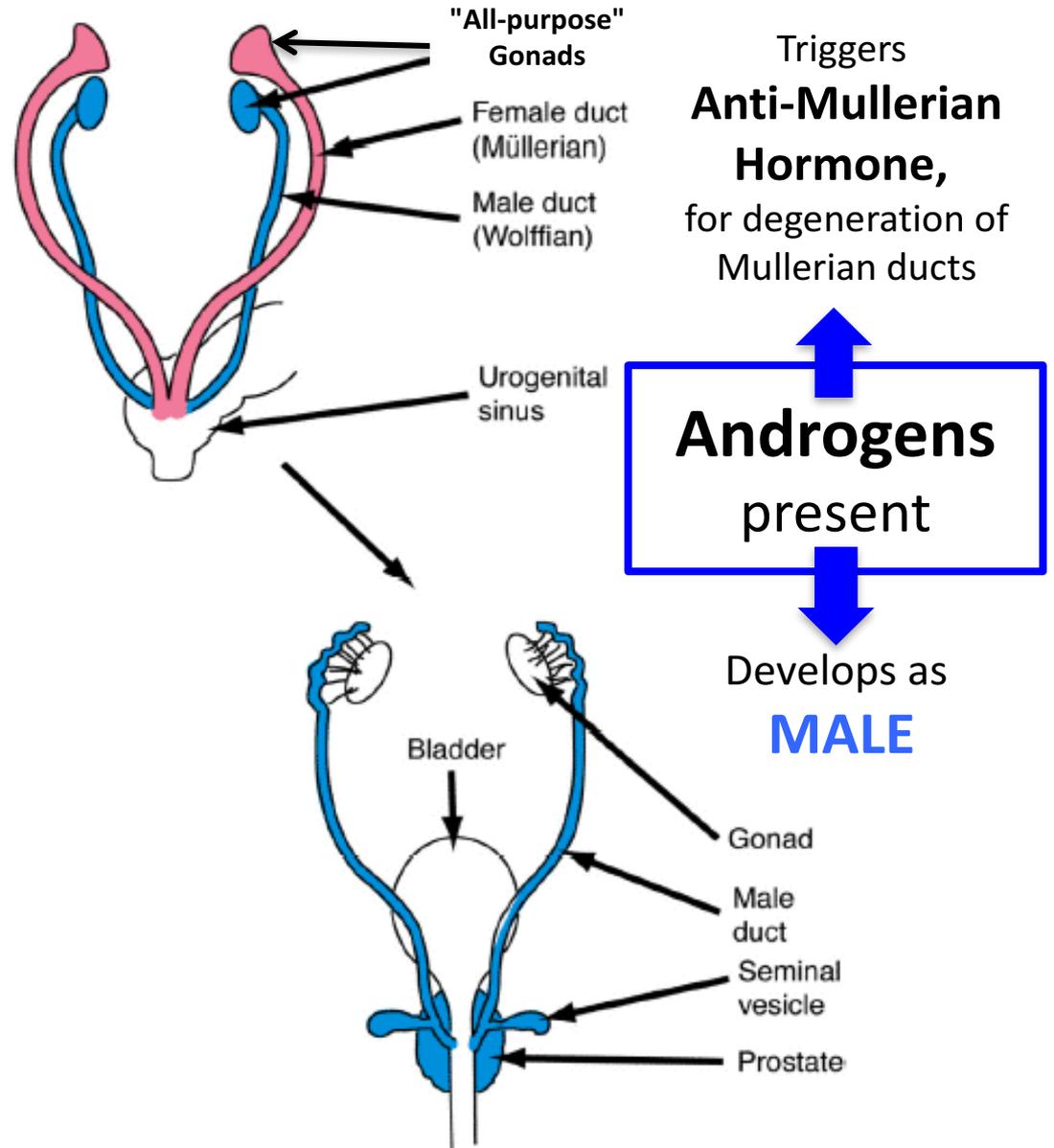
Meanwhile, brain is also developing



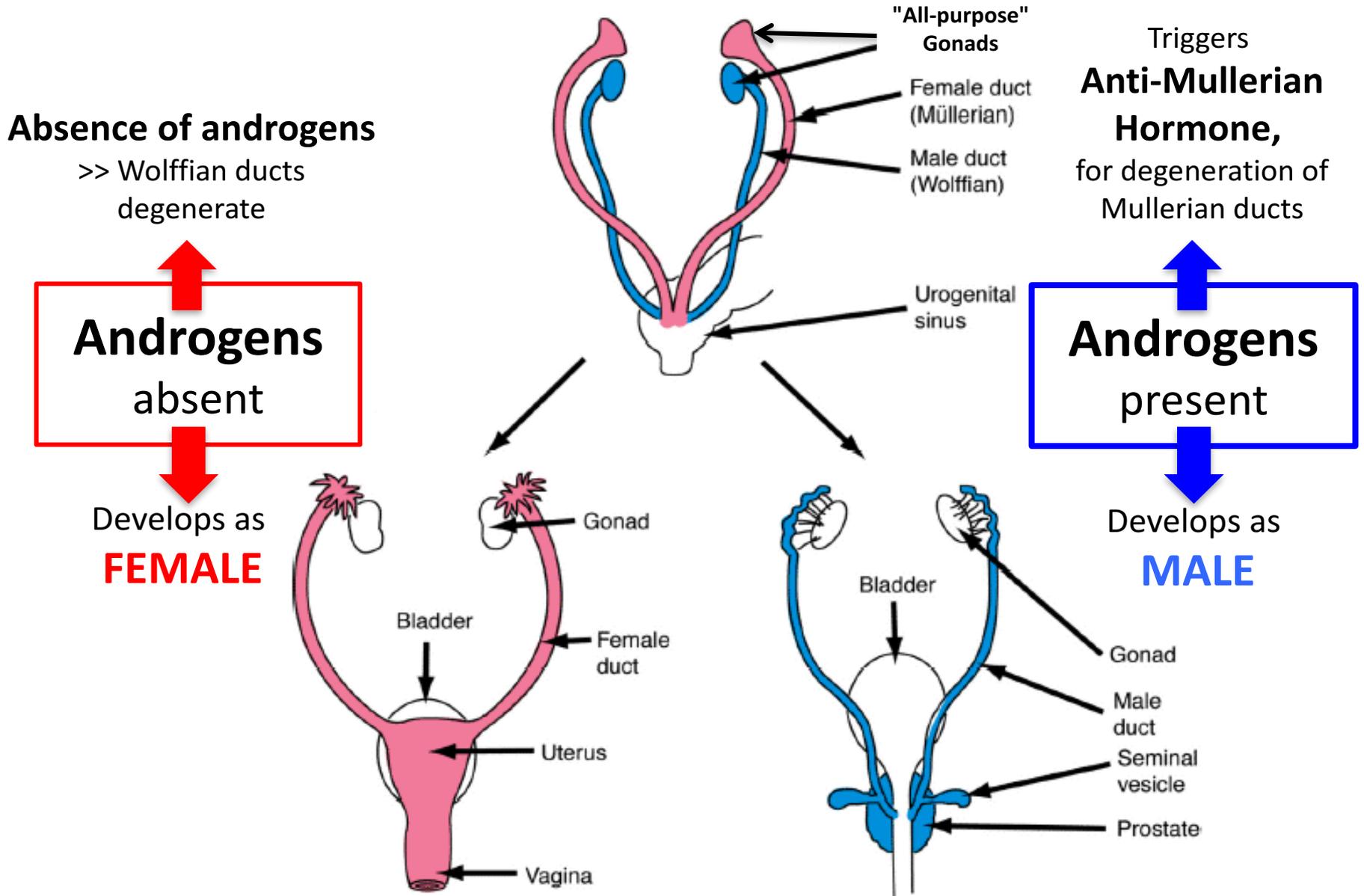
# Fetal Development of Internal Anatomy



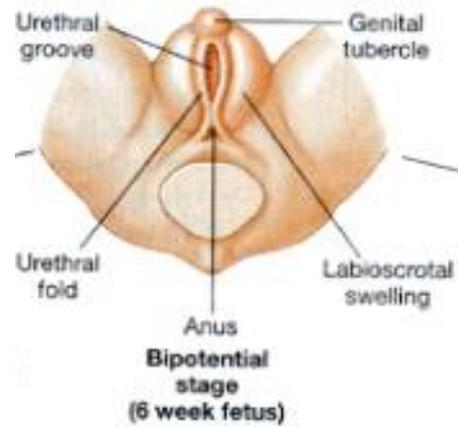
# Fetal Development of Internal Anatomy



# Fetal Development of Internal Anatomy

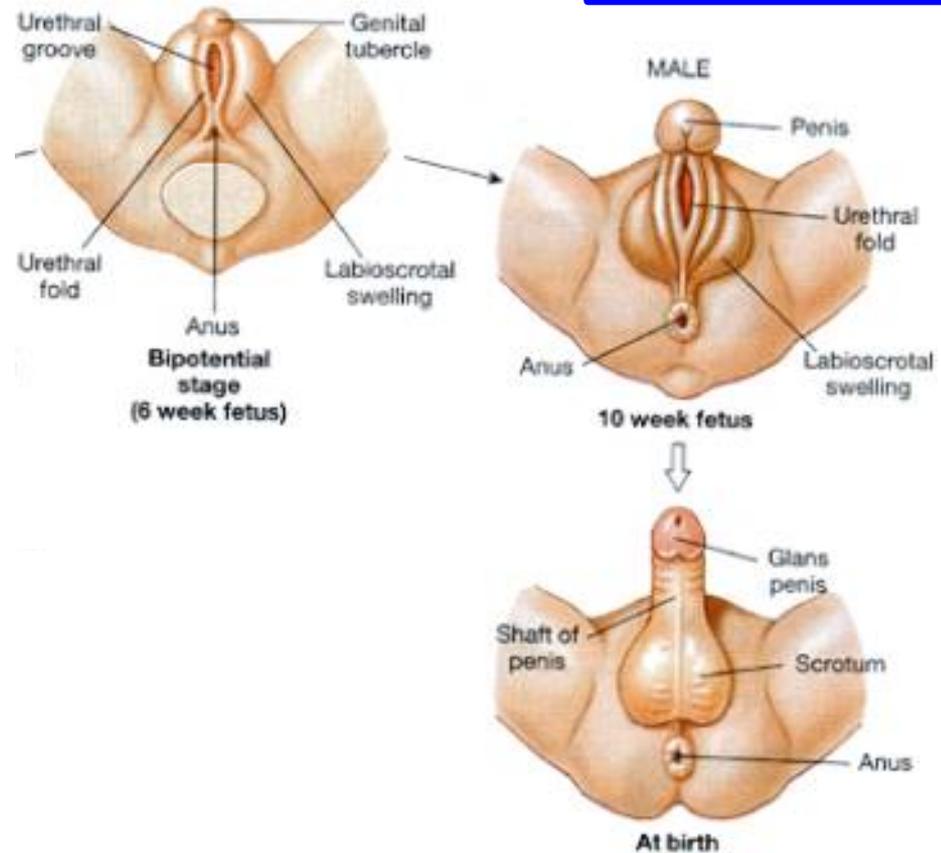


# Fetal Development of External Anatomy



# Fetal Development of External Anatomy

**Androgens  
present**

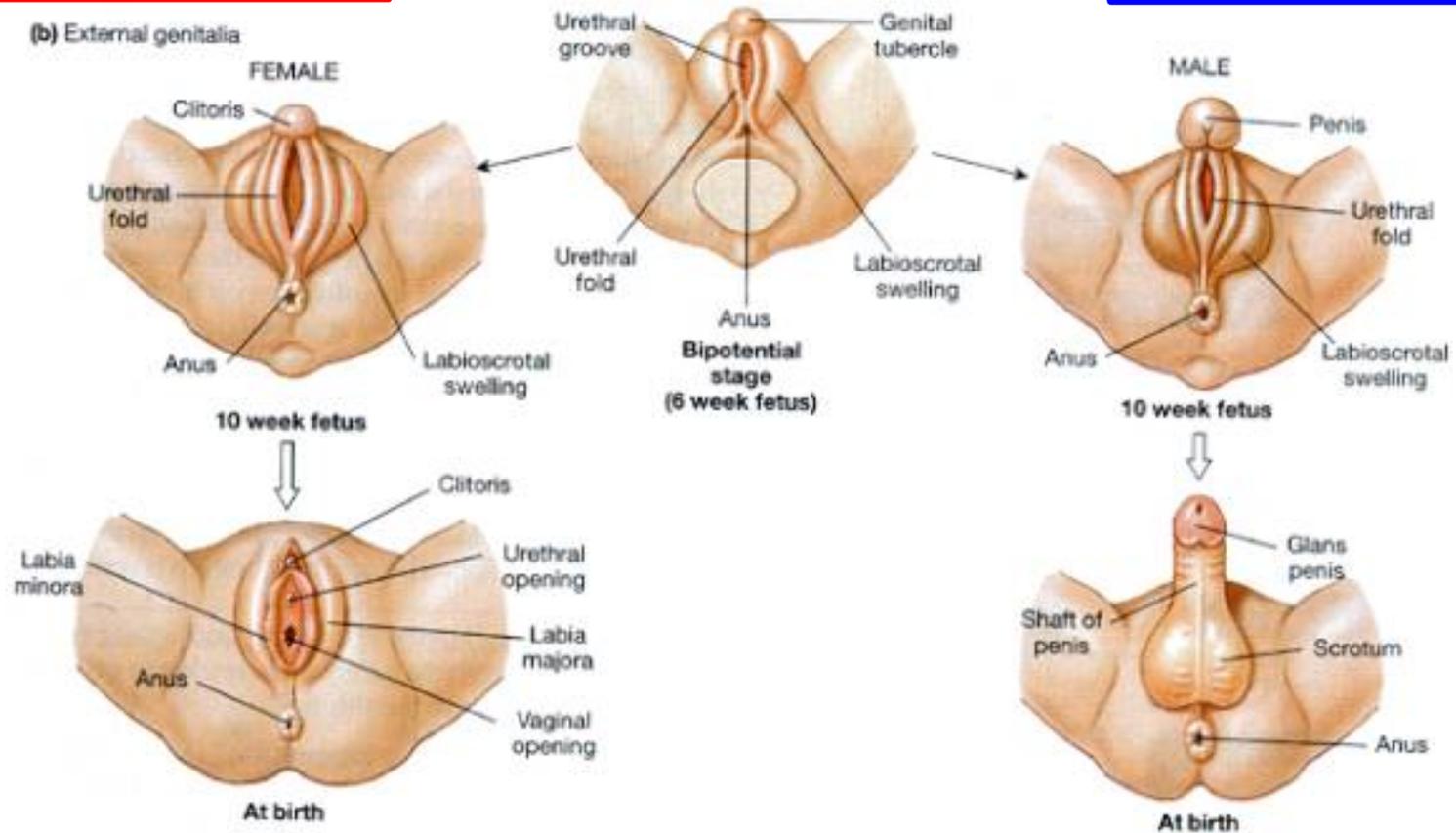


Develops as  
**MALE**

# Fetal Development of External Anatomy

**Androgens  
absent**

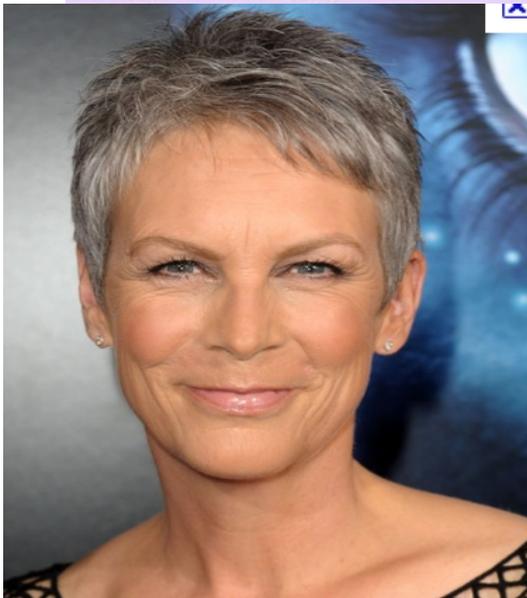
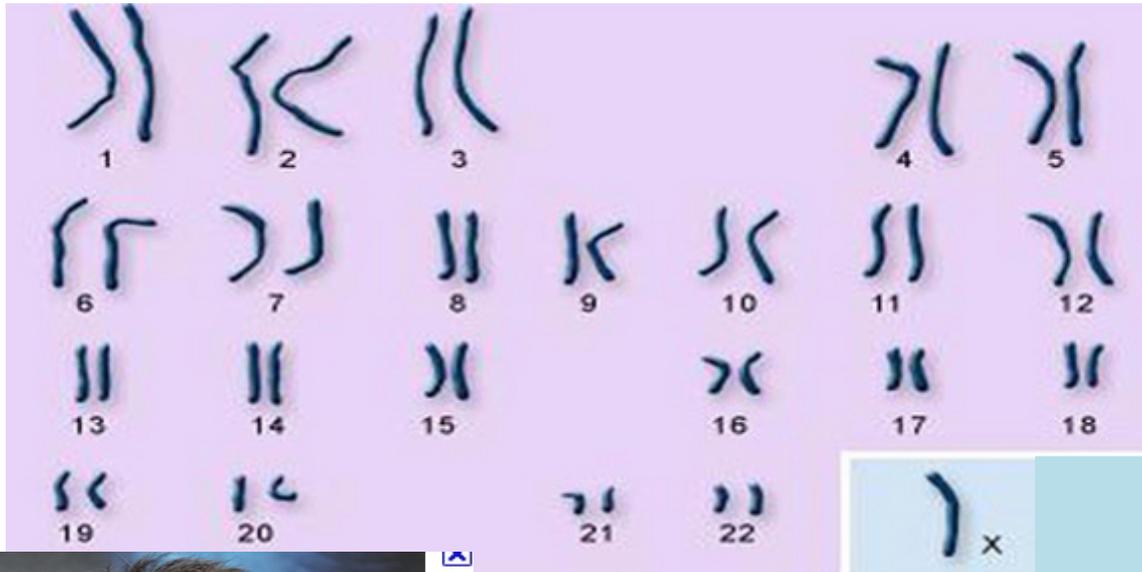
**Androgens  
present**



Develops as  
**FEMALE**

Develops as  
**MALE**

# Turner's Syndrome



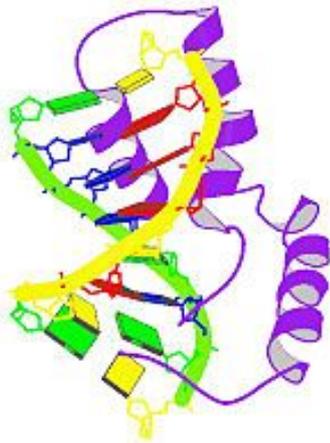
**XO**

Missing second  
sex chromosome

Develop as female, although infertile

# Androgen Insensitivity

Even if have TDF & produce Testosterone,  
cells may be insensitive to its effects



Again, body develops  
Internally and externally as female  
although no secondary hair growth  
and infertile



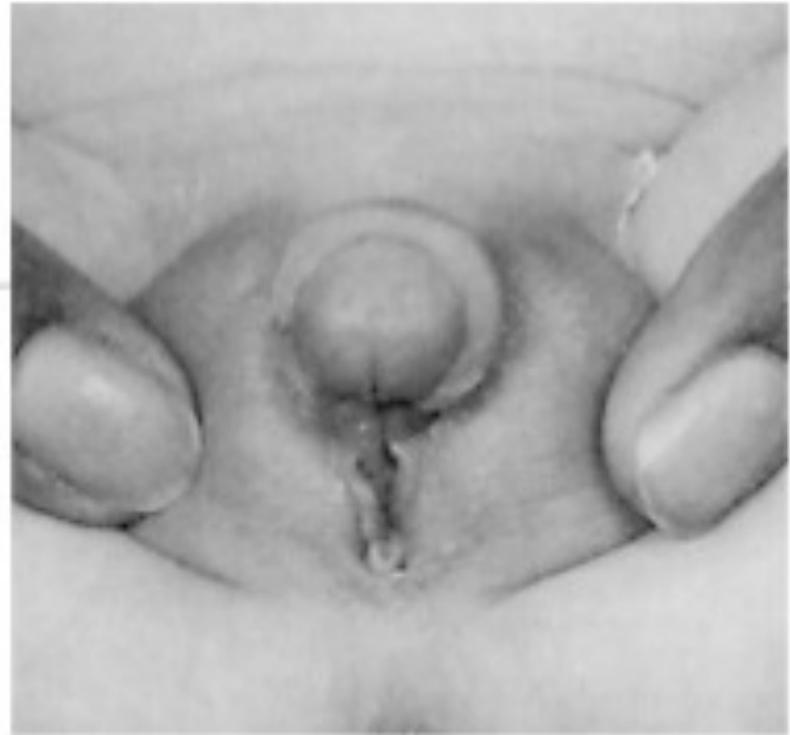
# Masculinizing effects of excessive Estrogens

As treatment for repeated miscarriage, pregnant women in 1950s received excessive Estrogens

(Still done today, but we have better knowledge of proportions of hormones required)

Could result in masculinized fetus (e.g. clitoris like head of penis, correctable by surgery)

But, if it is Testosterone that normally has masculinizing effect, why did these Estrogen treatments have such an effect???

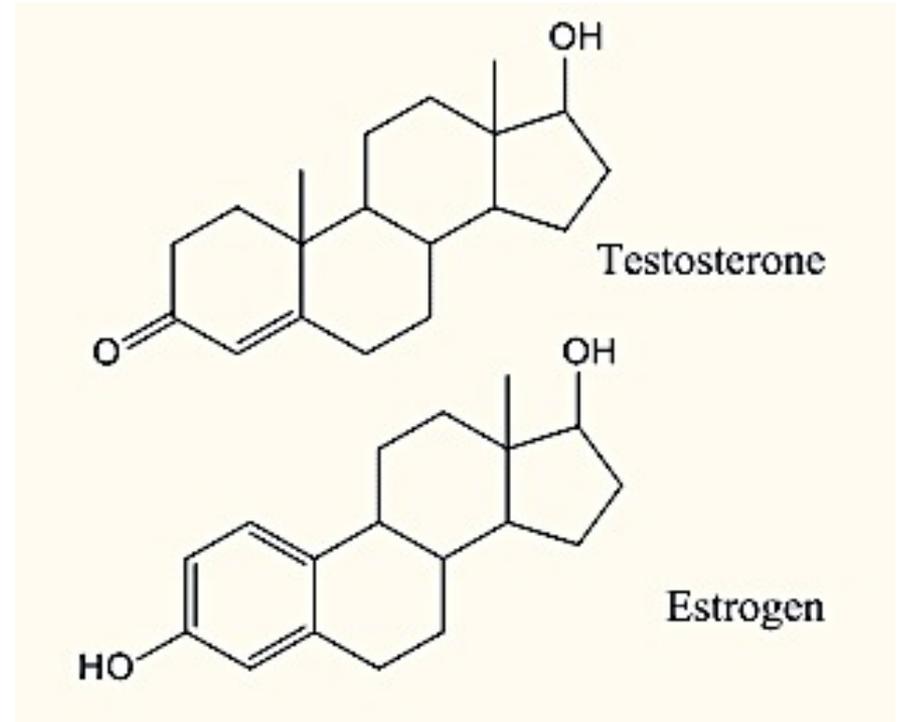


# How did mother's estrogen masculinize fetus??

Testosterone and Estrogen  
VERY similar!

In fact, when Testosterone  
enters cells, it is aromatized (converted)  
into Estrogen

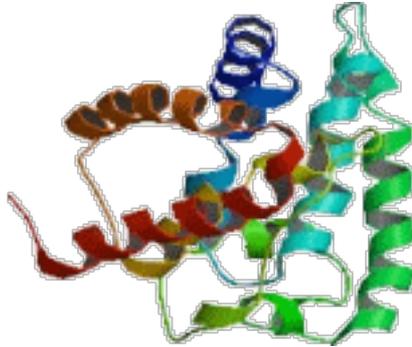
So, it is actually Estrogen that  
masculinizes ALL males!!



But, since pregnant women all have high levels of estrogens,  
why aren't ALL offspring males??!?

Why doesn't mother's estrogens masculinize every fetus?

Answer: **Alpha-Feto Protein**



Fetus produces Alpha-Feto Protein to BIND with mother's estrogens

This allows its own hormones to determine its gender

In medical treatment described above, excessive estrogens administered overwhelmed this safeguard, partially masculinizing fetus

# Post-natal Development

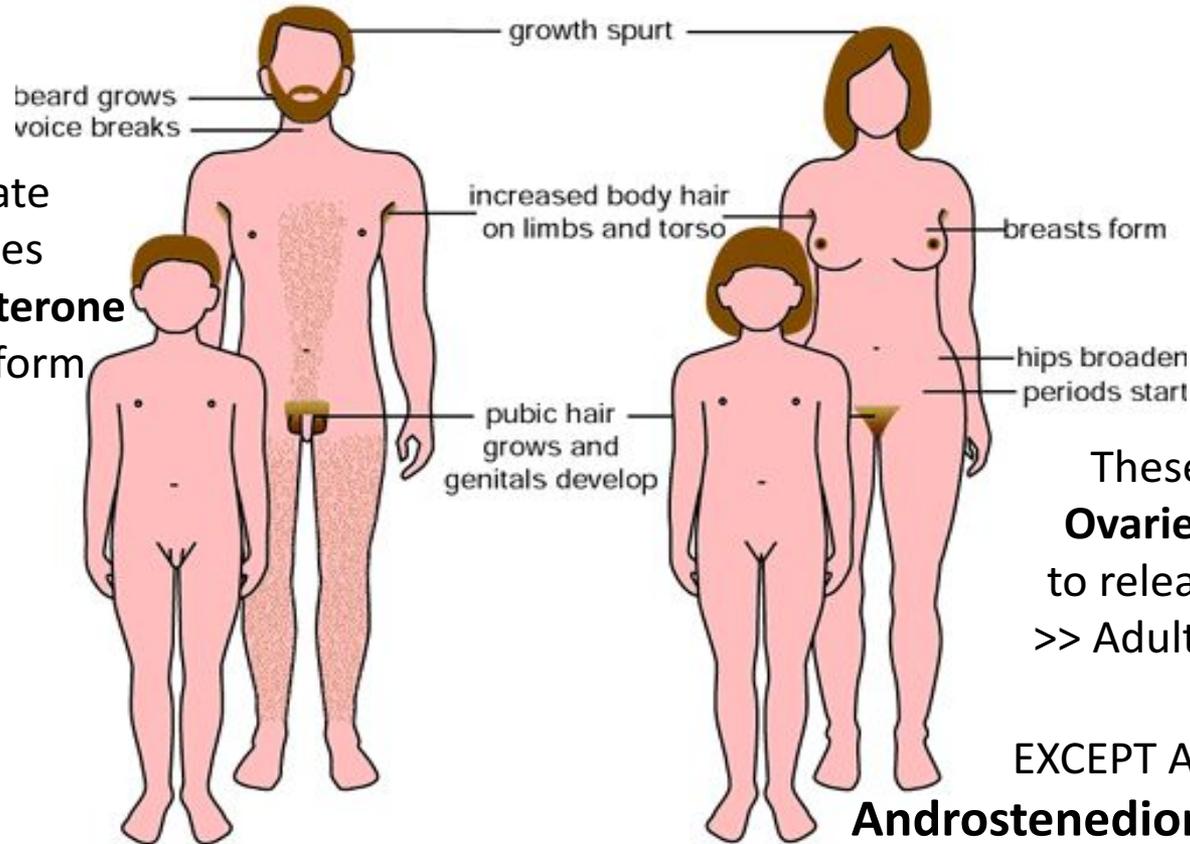


# Secondary Sexual Characteristics

In both sexes, at adolescence, Hypothalamus releases

**GnRH** (Gonadotrophin-Releasing Hormones)

These cause Anterior Pituitary to release Gonadotrophins **LH & FSH**  
(Leutinizing & Follicle Stimulating Hormones)



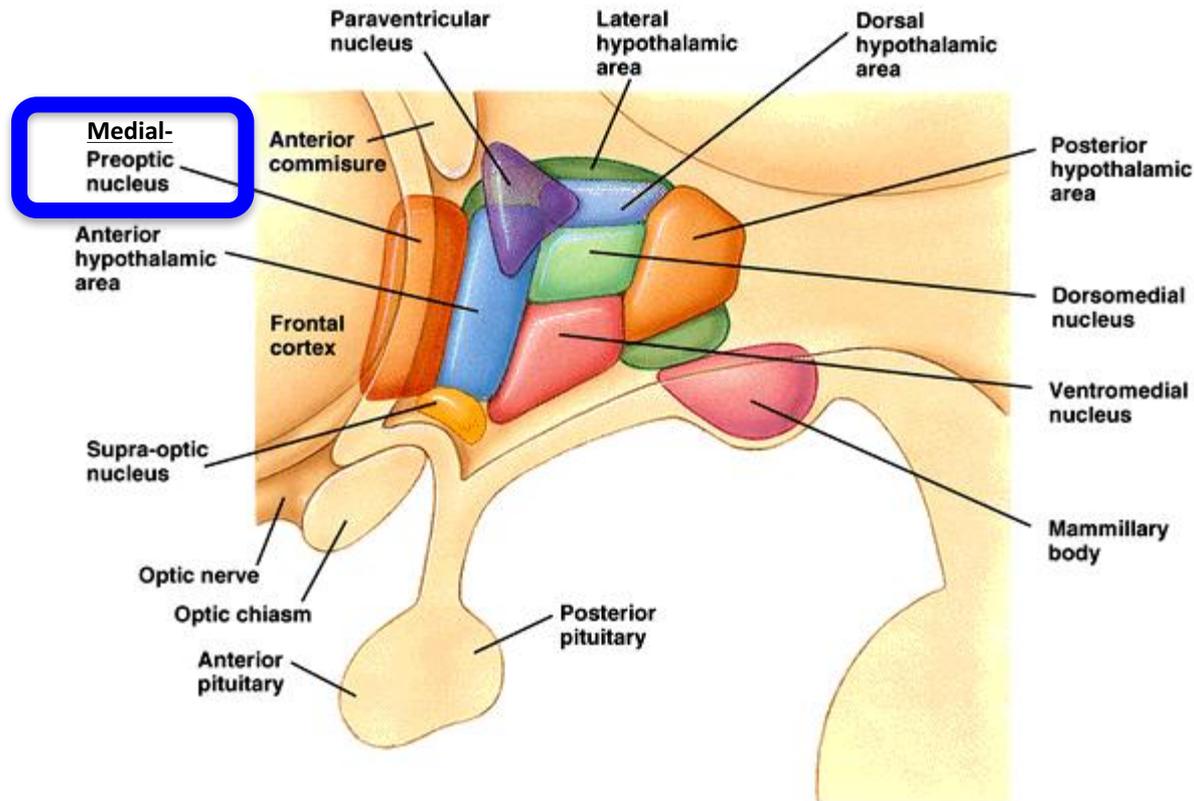
These stimulate  
**Testes** in males  
to release **Testosterone**  
>> Adult Male form

These stimulate  
**Ovaries** in females  
to release **Estrogens**  
>> Adult Female form

EXCEPT Androgen  
**Androstenedione** (from Adrenals)  
required for hair growth in Females

# Gender Differences in Brains – Hypothalamus in **MALES**

## ► Nuclei of the Hypothalamus



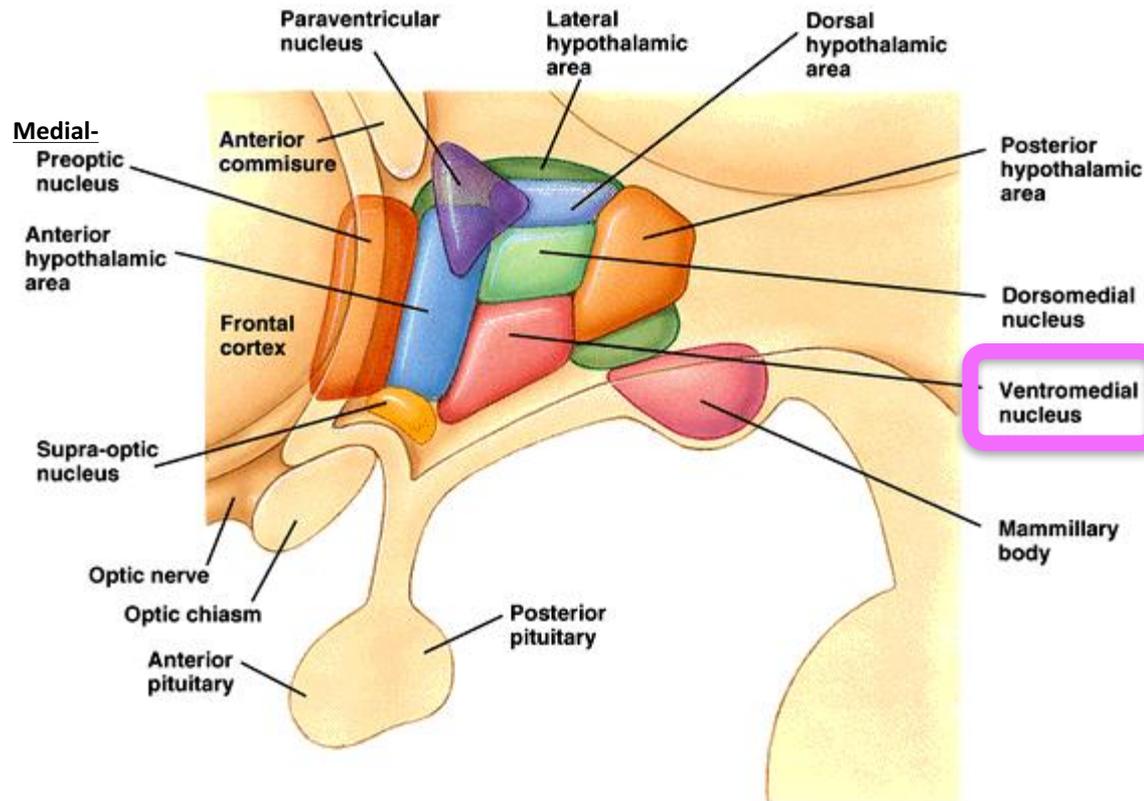
**MPOA**  
including  
"Sexually-  
Dimorphic  
Nucleus"

**SDN**  
(Straight  
Dudes  
Need)

2.5X larger  
in males

# Gender Differences in Brains – Hypothalamus in **FEMALES**

## ► Nuclei of the Hypothalamus



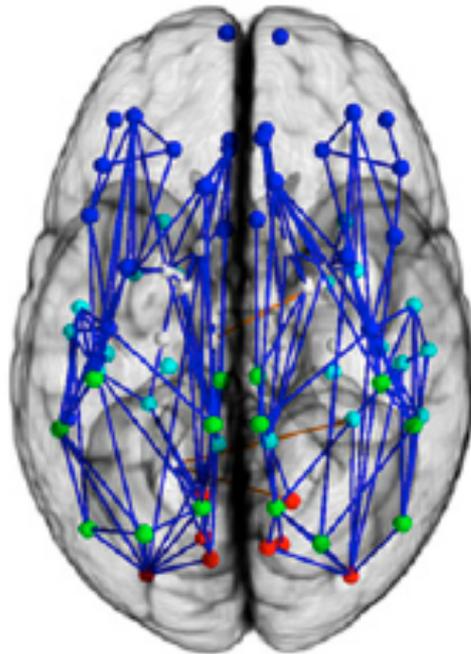
**VMH**  
(Venus  
Must  
Have)

Significantly larger in Females than in Males

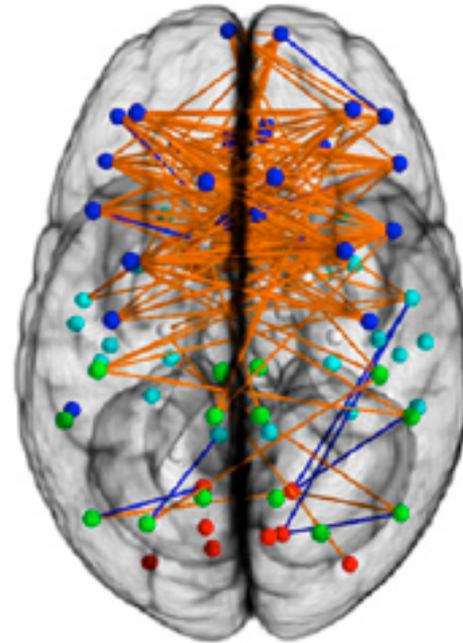
Area also regulates feeding behavior – esp critical in females "eating for two"

## Gender Differences in Brains

**Male** brains optimized for **intra-(within)-hemispheric** communication



**Female** brains for **inter-(between)-hemispheric** communication.



Suggests Male brains facilitate connectivity between perception and coordinated action, Female brains facilitate communication between analytical and intuitive processing modes.

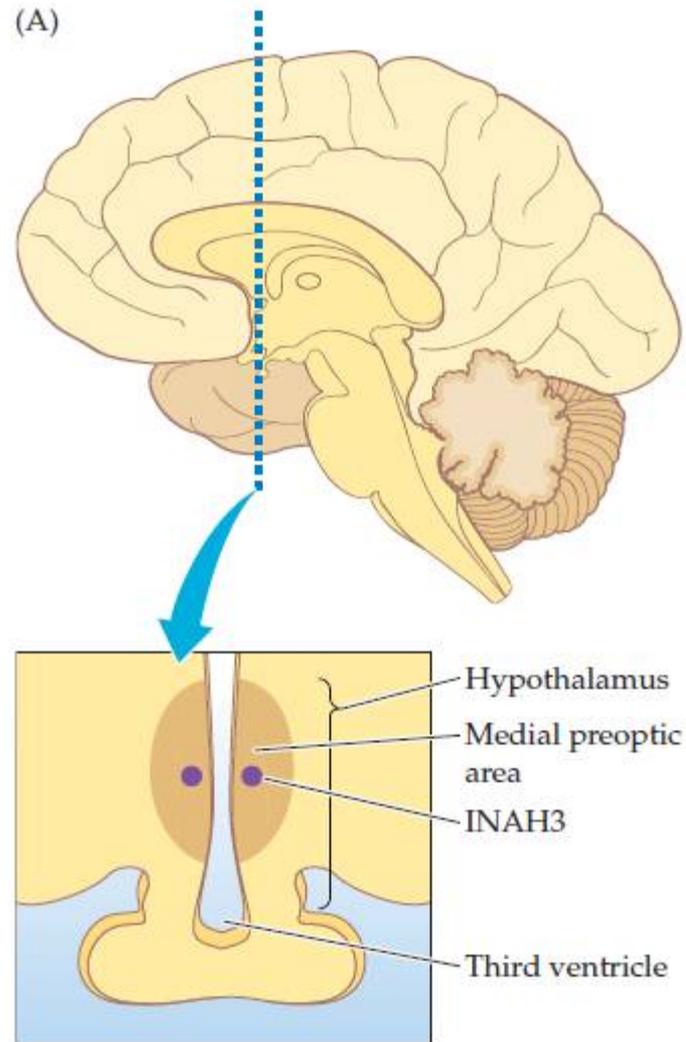
# Gender Differences in Brains

## INAH3

Enlarged portion of  
Sexually Dimorphic Nucleus  
of Hypothalamus MPOA

Larger in Heterosexual Males,  
smaller in Females  
AND  
in Homosexual Males

Including in Infants



# Activating Effects



The role of the nervous system  
in sexual/reproductive  
behavior



# Activating Effects

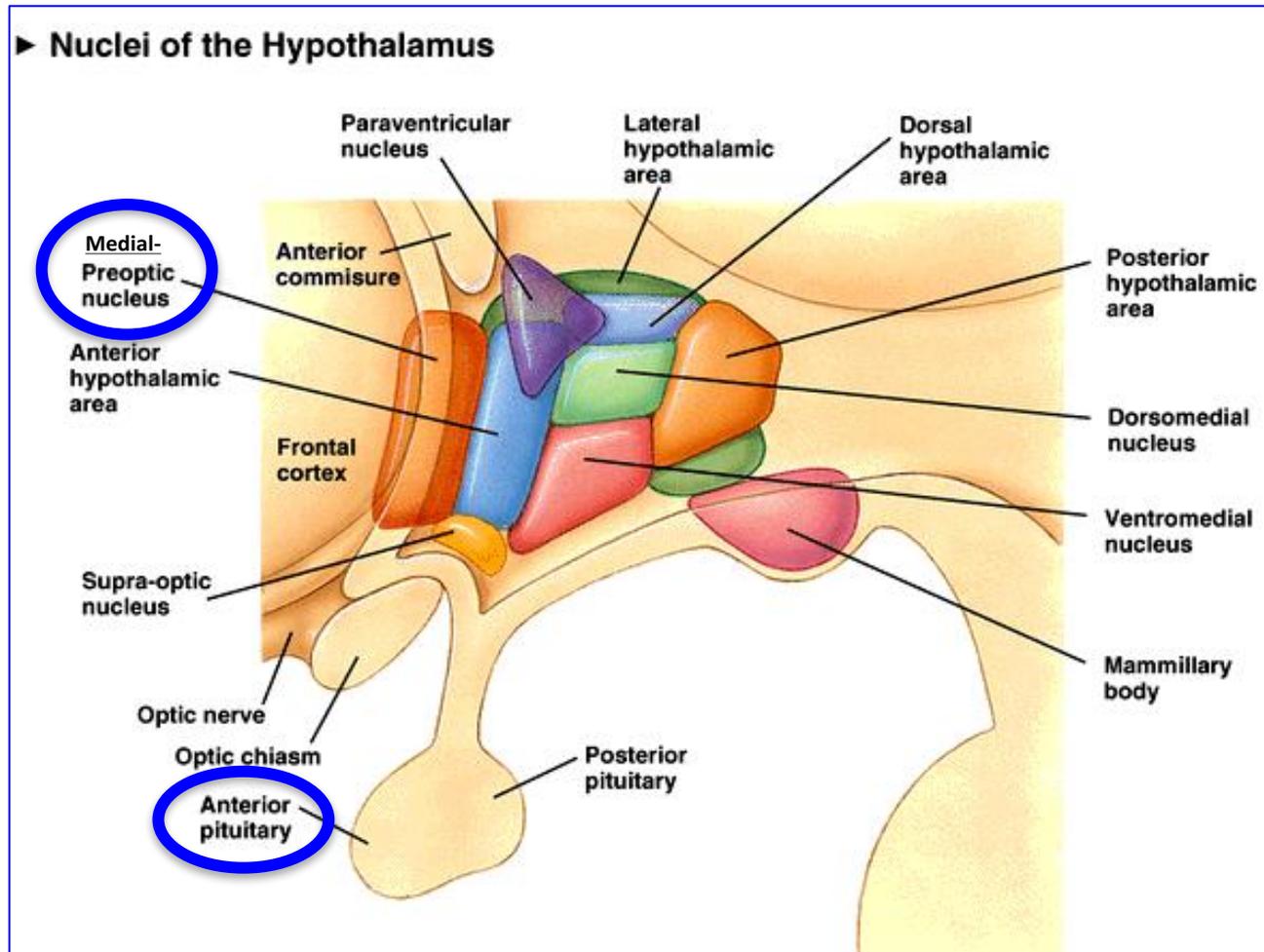
## MALE Sexual Behavior

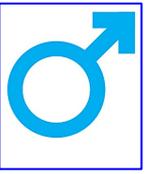
MPOA releases  
GnRH

Anterior Pituitary  
Releases  
LH & FSH

Circulate to  
Testes,  
release  
Testosterone

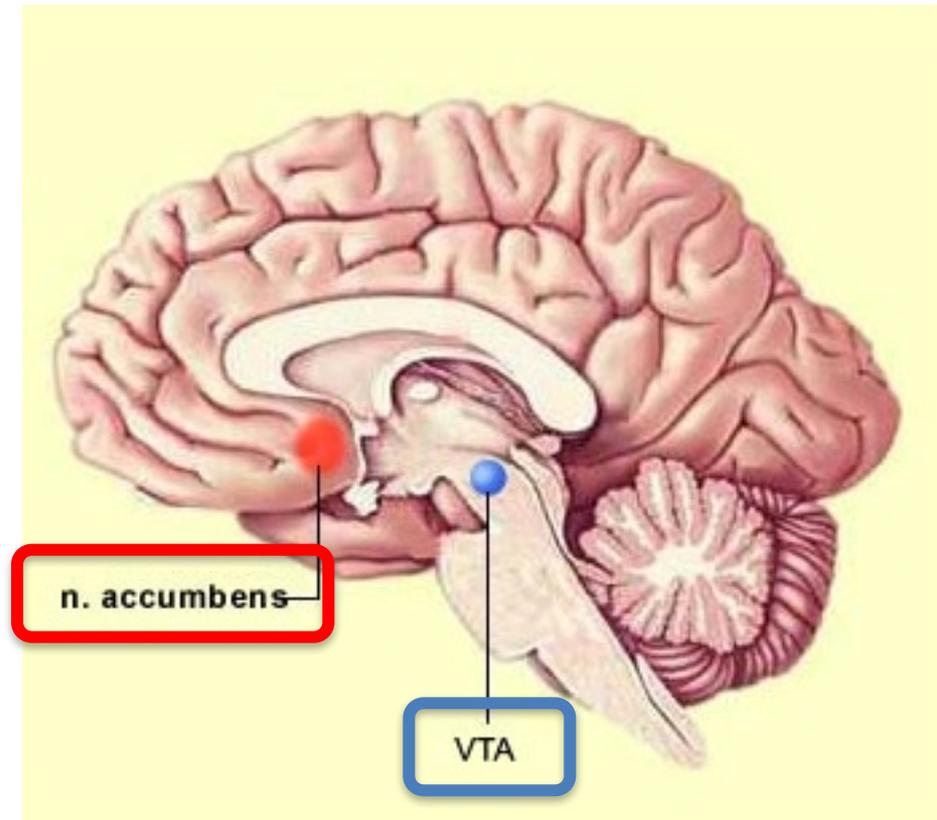
Testosterone  
feedback to MPOA  
escalating arousal





## Pleasure Circuits

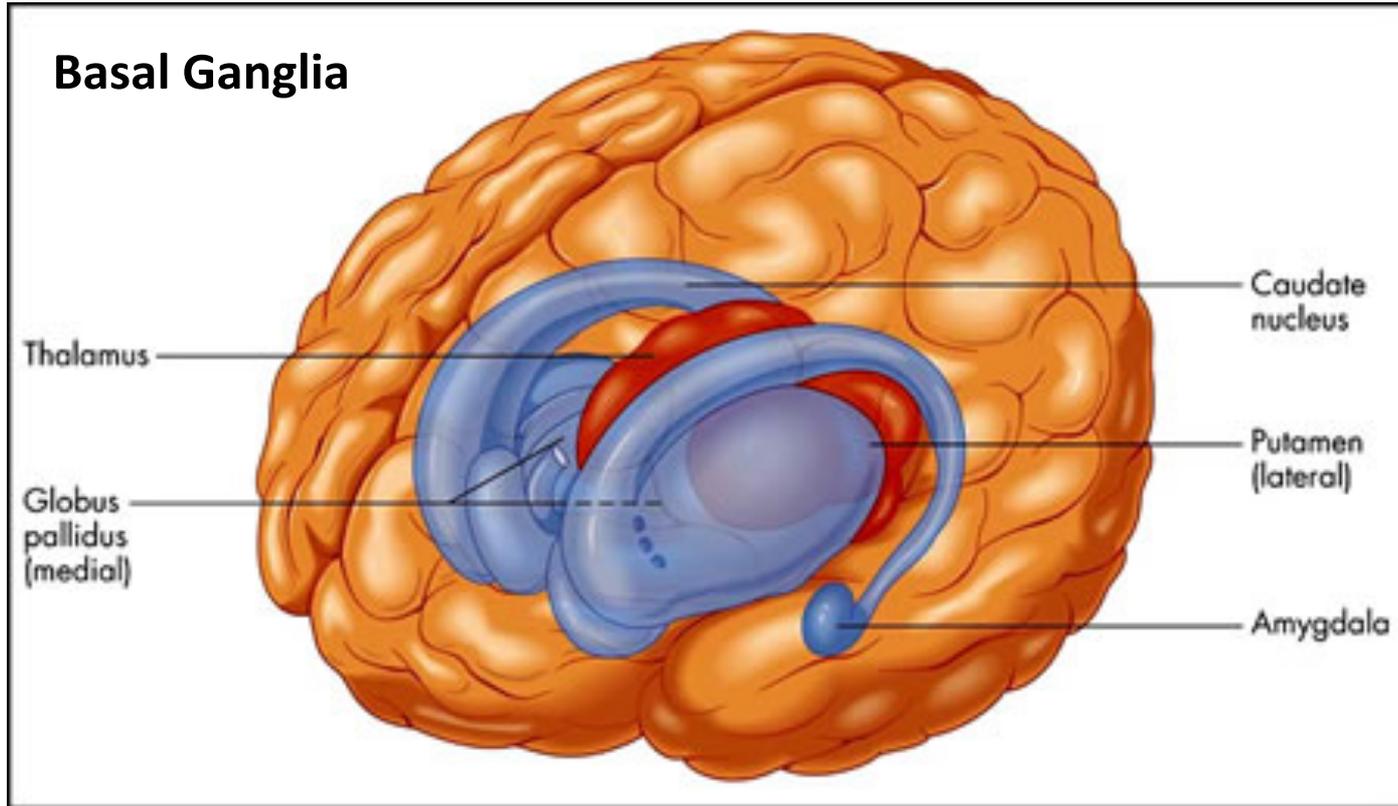
**VTA** (Ventral Tegmental Area) responds by releasing Dopamine to **Nucleus Accumbens**



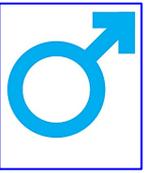
Nucleus Accumbens "**Reward Center**" – also implicated in addiction



MPOA also stimulates **Basal Ganglia**,  
which signals **SBN** (Spinal Nucleus of the Bulbocavernosus)



SBN causes rhythmic contractions for ejaculation

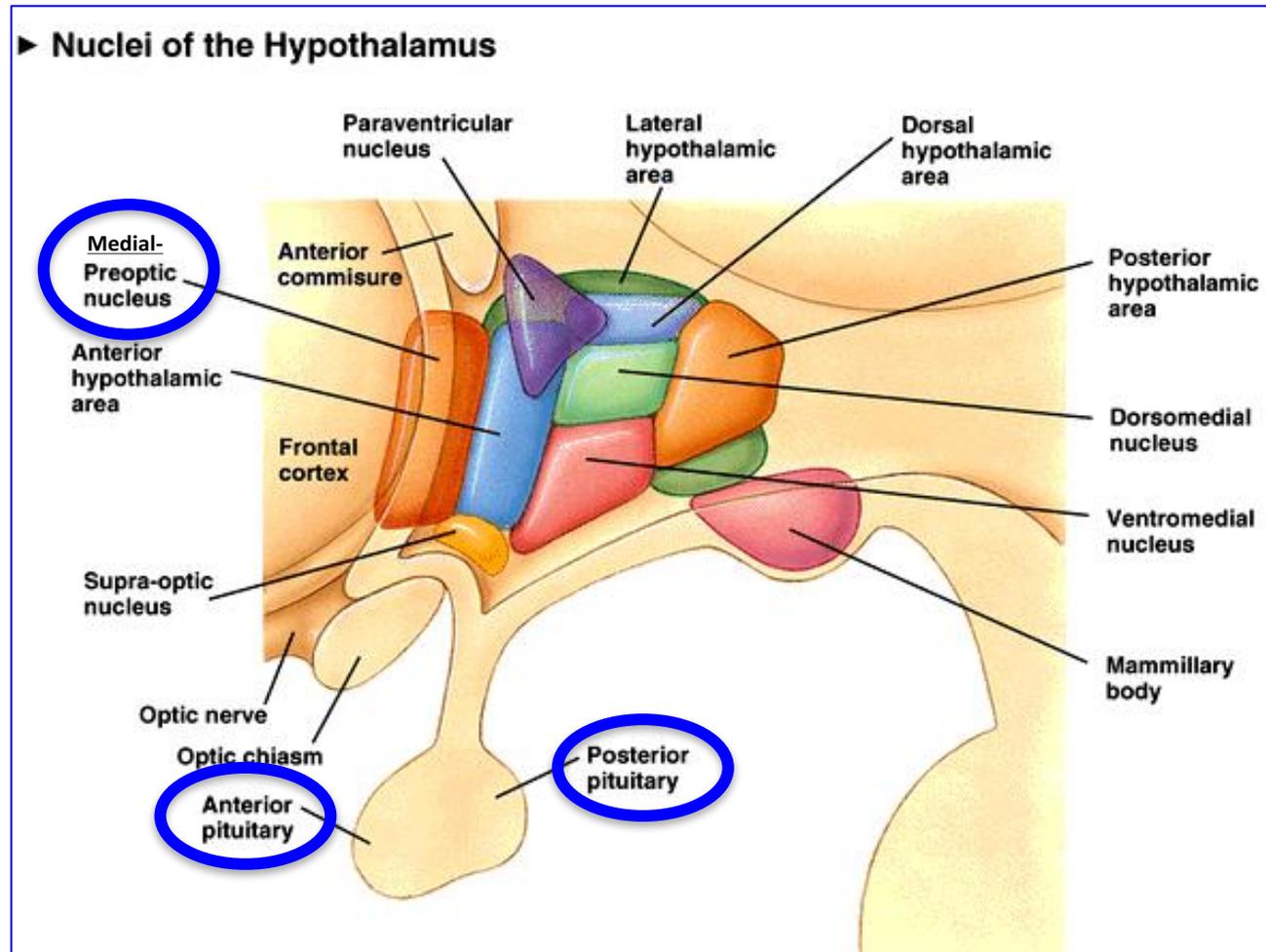


# Activating Effects: MALE Sexual Behavior

At orgasm,  
MPOA signals  
Posterior Pituitary  
to release  
**Oxytocin**

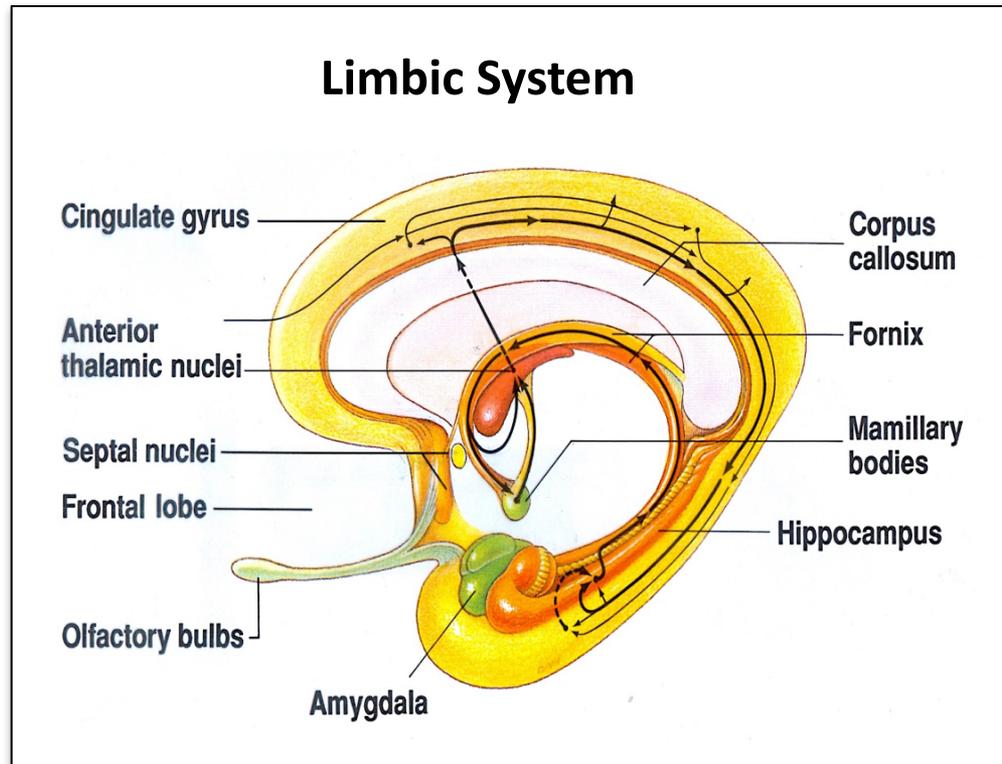
After ejaculation,  
Anterior Pituitary  
releases  
**Prolactin**

Causes  
"refractory period"  
during which  
Male cannot  
be aroused





**MPOA** also reciprocates interaction with **Medial Amygdala**  
and other parts of **Limbic System**



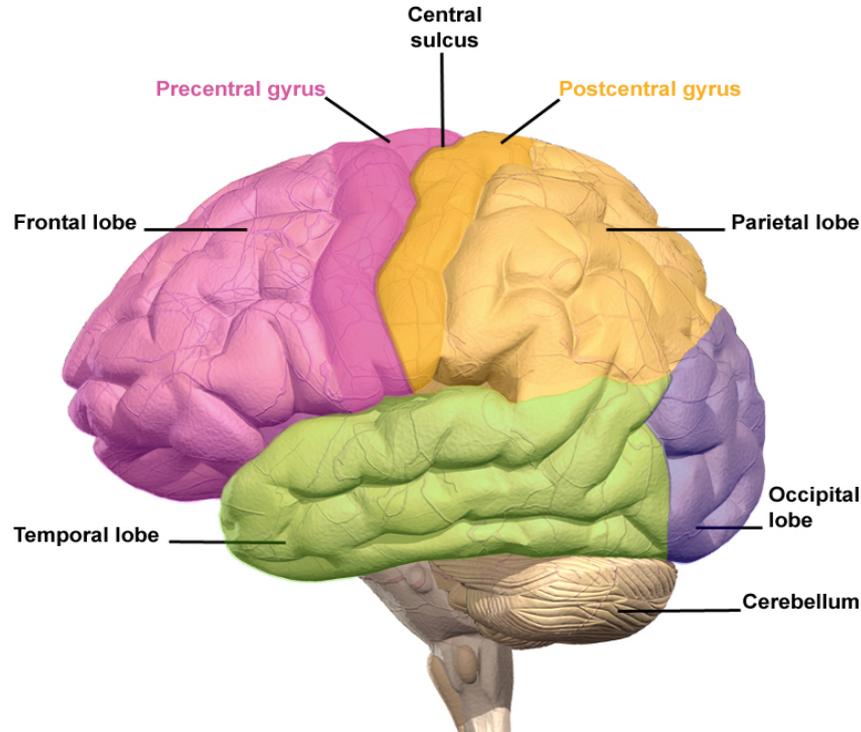
Plays a role in aggression effects of **Testosterone**

Also responds to **Pheromones** (more below)

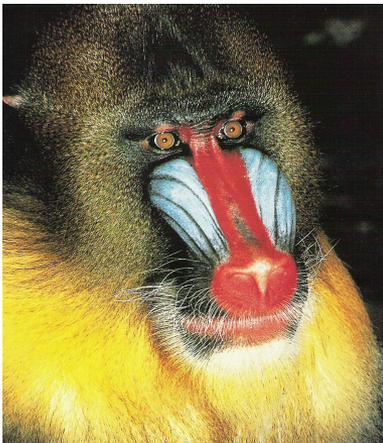
# Cortex also plays a role in sex in Humans

Learned associations can stimulate, mediate sexual response

Especially  
Prefrontal Cortex



But also  
Visual Cortex



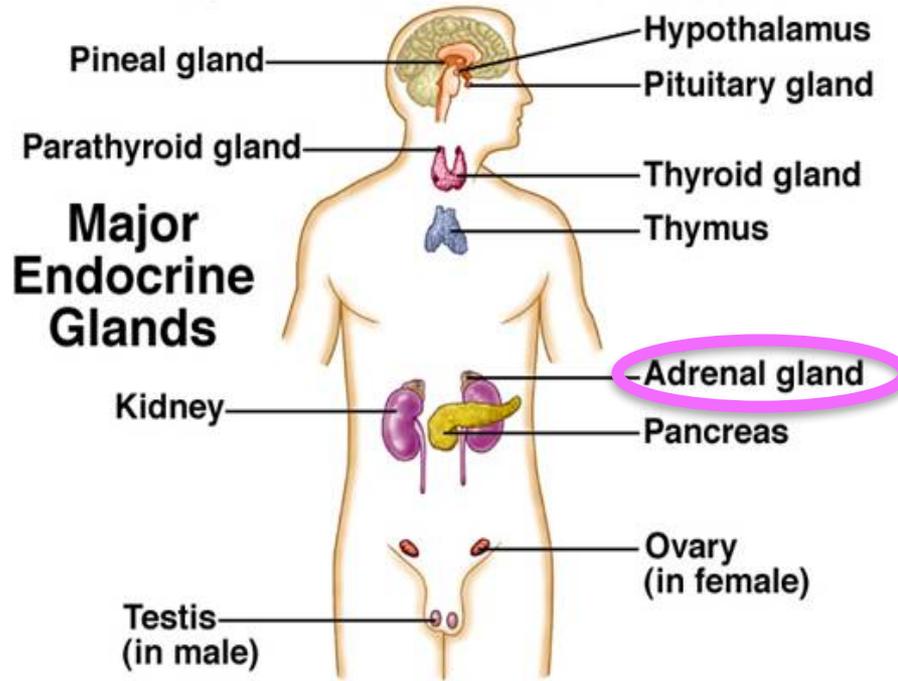
Unlike many  
smell-driven mammals,  
primate sexual signals  
tend to be  
visual





# Activating Effects

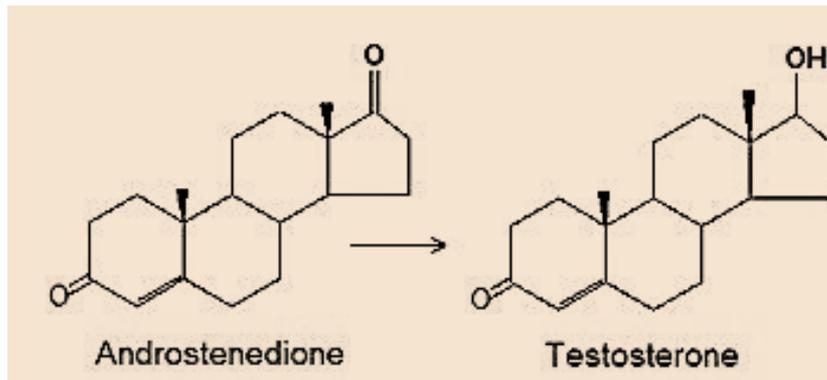
## FEMALE Sexual Behavior



Libido also a function of **Androgens**

But these originate from **Adrenal Glands** (not from MPOA)

In particular, **Androstenedione** released by Adrenals, gets converted in bloodstream to Testosterone



This circulating Testosterone then impacts on BOTH **MPOA** and **VMH**



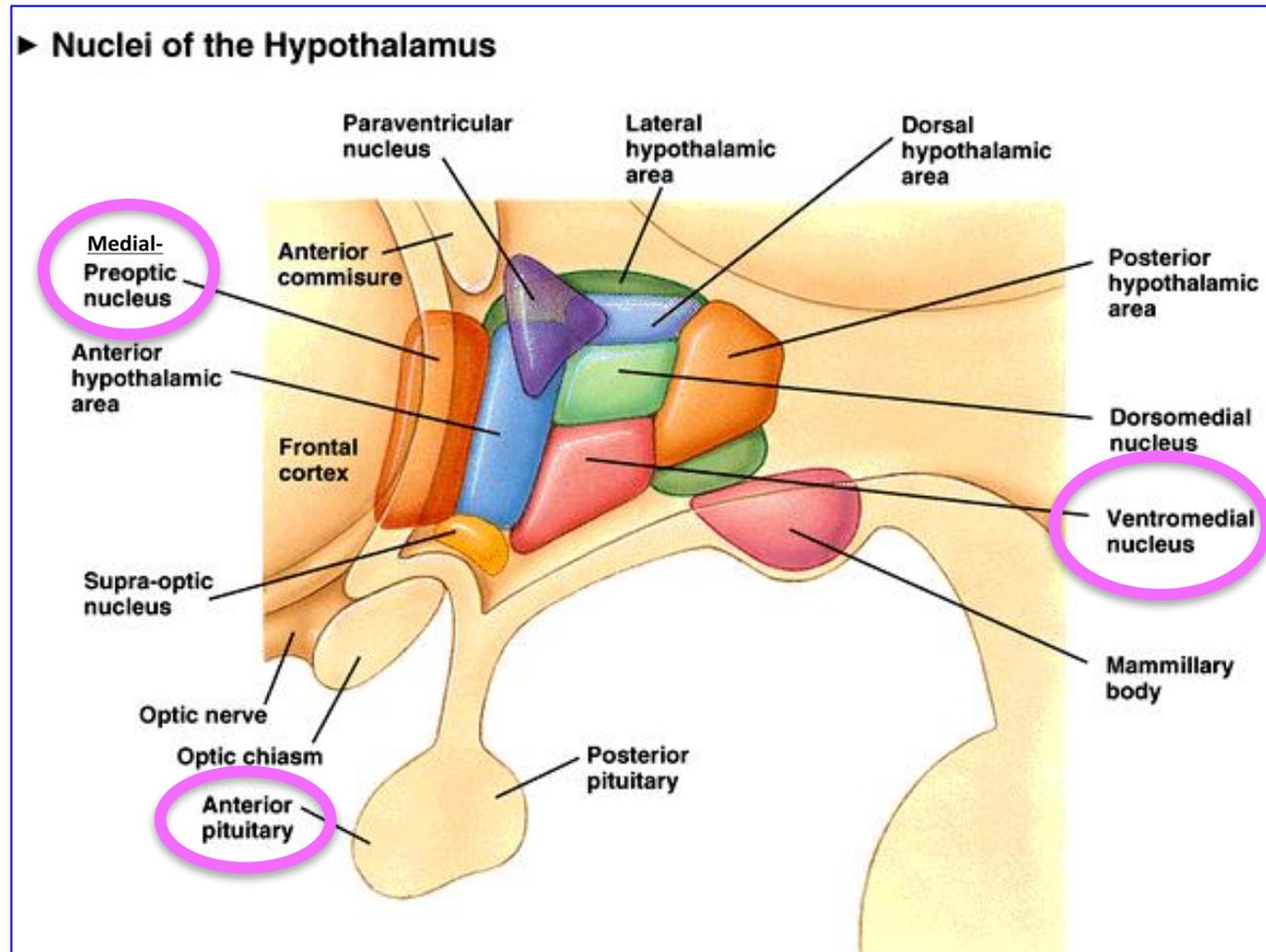
# Activating Effects

## FEMALE Sexual Behavior

Testosterone causes  
MPOA to release  
GnRH

Anterior Pituitary  
Releases  
LH & FSH

Circulate to  
Ovaries,  
release  
Estrogens



Estrogens feedback to VMH, escalating arousal

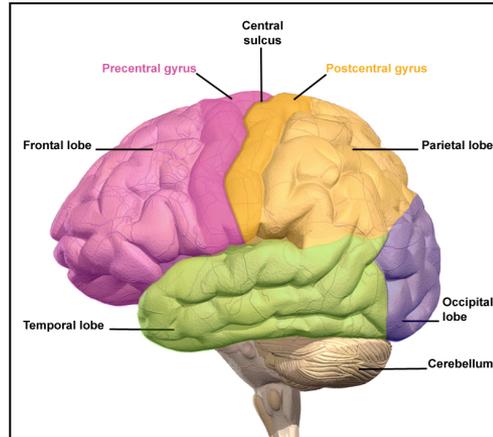
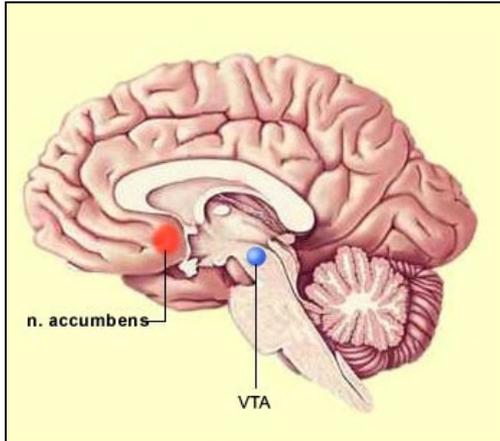


From there, Female response mediated by similar paths

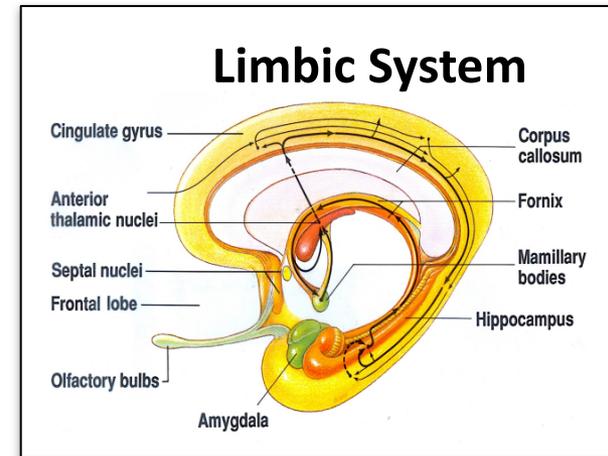
**VTA** (Ventral Tegmental Area)

responds by releasing

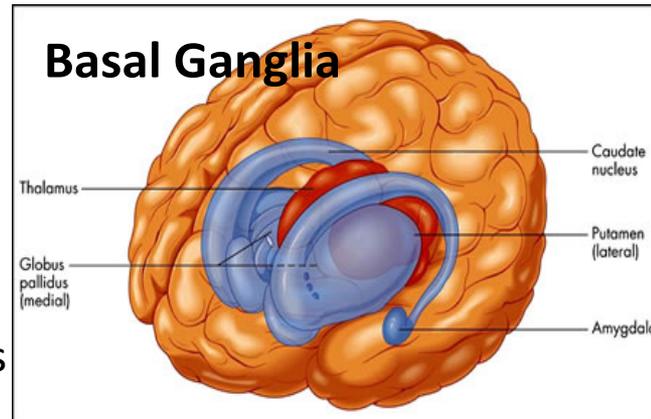
Dopamine to **Nucleus Accumbens**



**Cortex**  
plays role in  
learned responses



**Basal Ganglia,**  
signals **SBN**  
(Spinal Nucleus of the  
Bulbocavernosus)  
for rhythmic contractions



**Medial Amygdala**  
activated,  
including response to  
Pheromones



In addition, in Females...

## VMH

stimulates

Periaqueductal Grey (PAG)  
area of Midbrain

>> Endorphins

Endorphins add to pleasure,  
& help prevent (gate) Pain

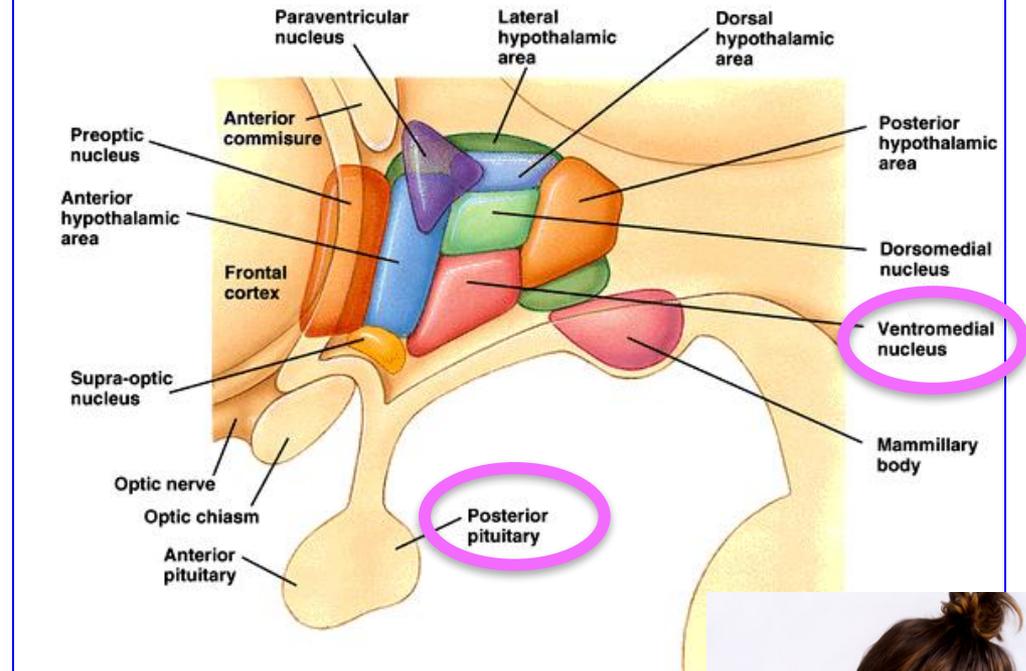
At Orgasm

Posterior Pituitary releases  
**Oxytocin**

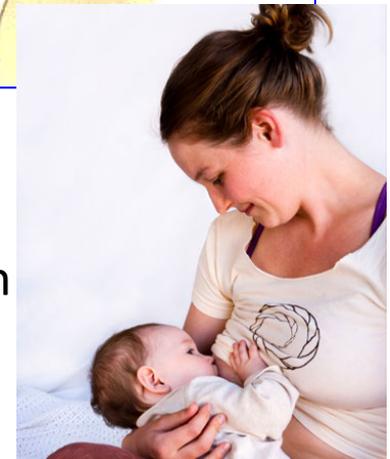
BUT

Unlike in Males,  
no follow-up release of  
**Prolactin**

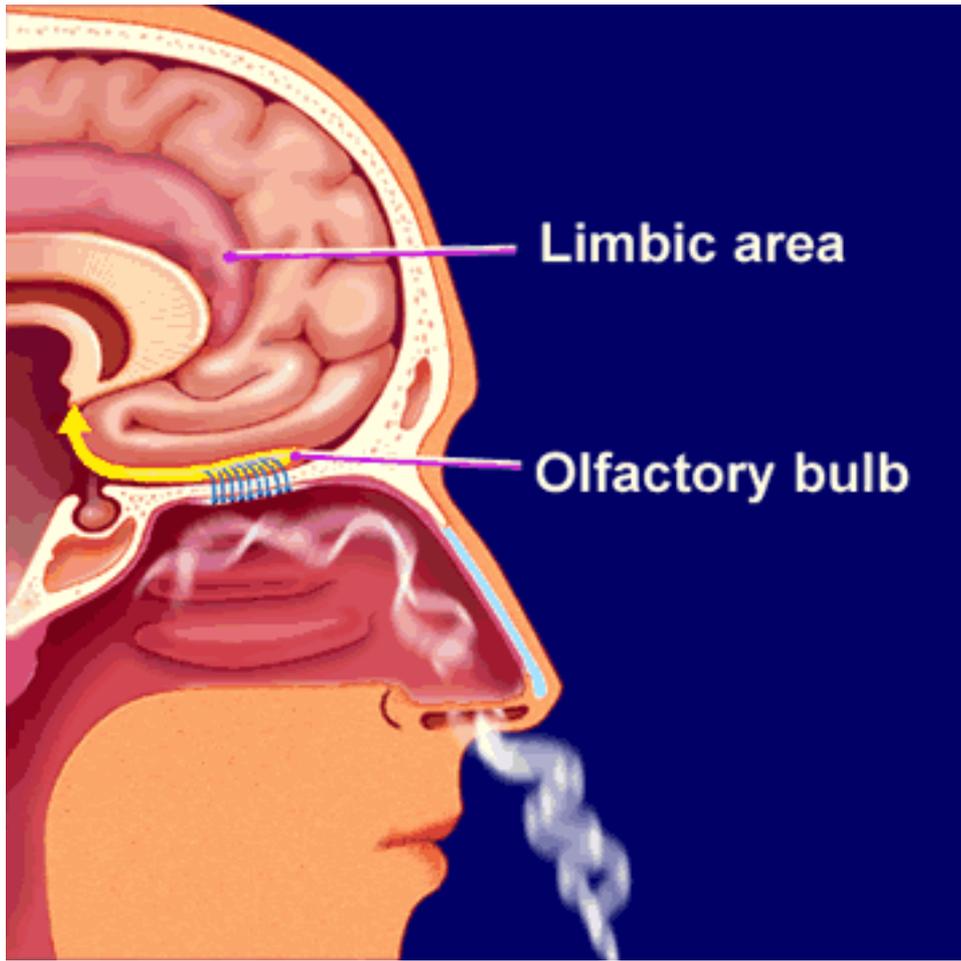
### ► Nuclei of the Hypothalamus



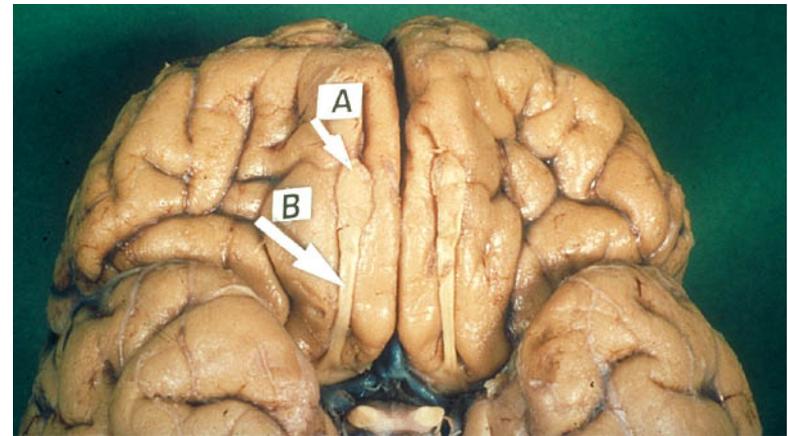
Altho note: **Prolactin**  
stimulates milk production in  
pregnant/lactating females



## Limbic (Emotional/Motivational) System plays major role



Including via SMELL  
through Olfactory Bulbs



One important class of smells:

### **Pheromones**

= Hormones in sweat,  
released into air to communication  
about reproductive state

# In most mammals, smell controls Limbic Responses

Specialized **VNO**  
(Vomeronasal Organ)  
detects Pheromones



Triggers many  
important reproductive  
behaviors



Male:Male  
Competition

Infant  
Care

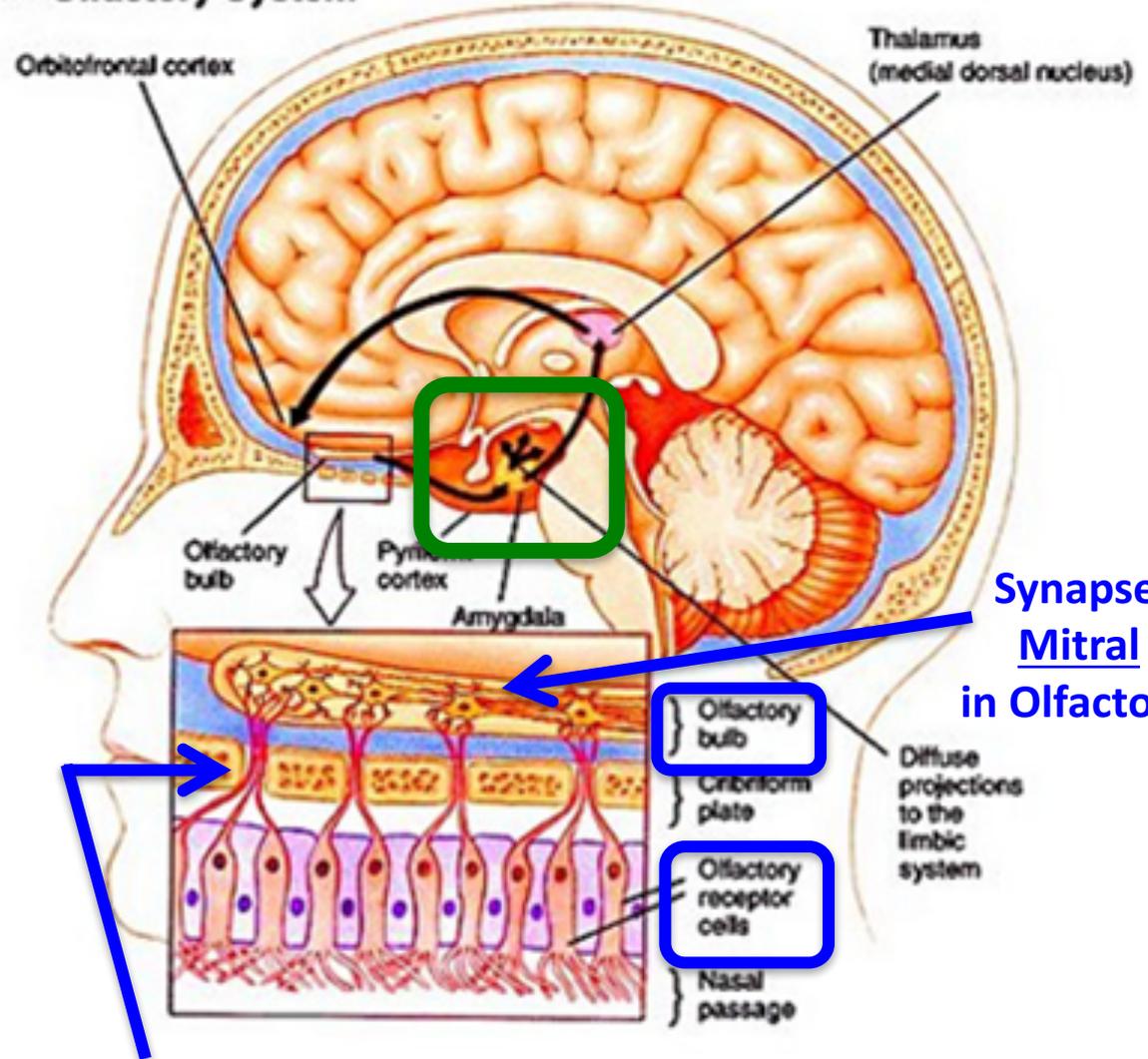


Mating



Unclear if Humans  
(or primates)  
have a VNO,  
but we still respond  
to Pheromones

## ► Olfactory System



Smell info goes directly to **Amygdala** and other parts of Limbic System

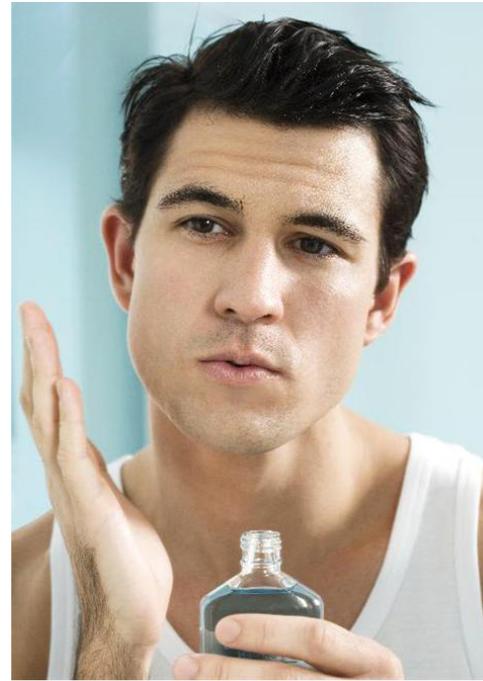
Limbic System also called

**"Rhinecephalon"**  
(Nose Brain)

Synapse onto Mitral cells in Olfactory Bulb

Axons pass through pores in skull

# Effects of Pheromones on Human male mating behavior



Aftershave  
spiked with male  
Pheromones

Dependent Measure:  
How many men did not go home alone?

Vs.  
regular  
aftershave

Results: More X than Y

## Effects of Pheromones on Human female behavior

e.g. Subjects had sweat of another female dabbed on upper lip,  
every day for 8 weeks

Those who stuck with program,  
ended up synchronizing their menstrual cycles with donor of sweat



Similar effect seen in female roommates

In primates, may help assure reproduce at similar times, to share child care