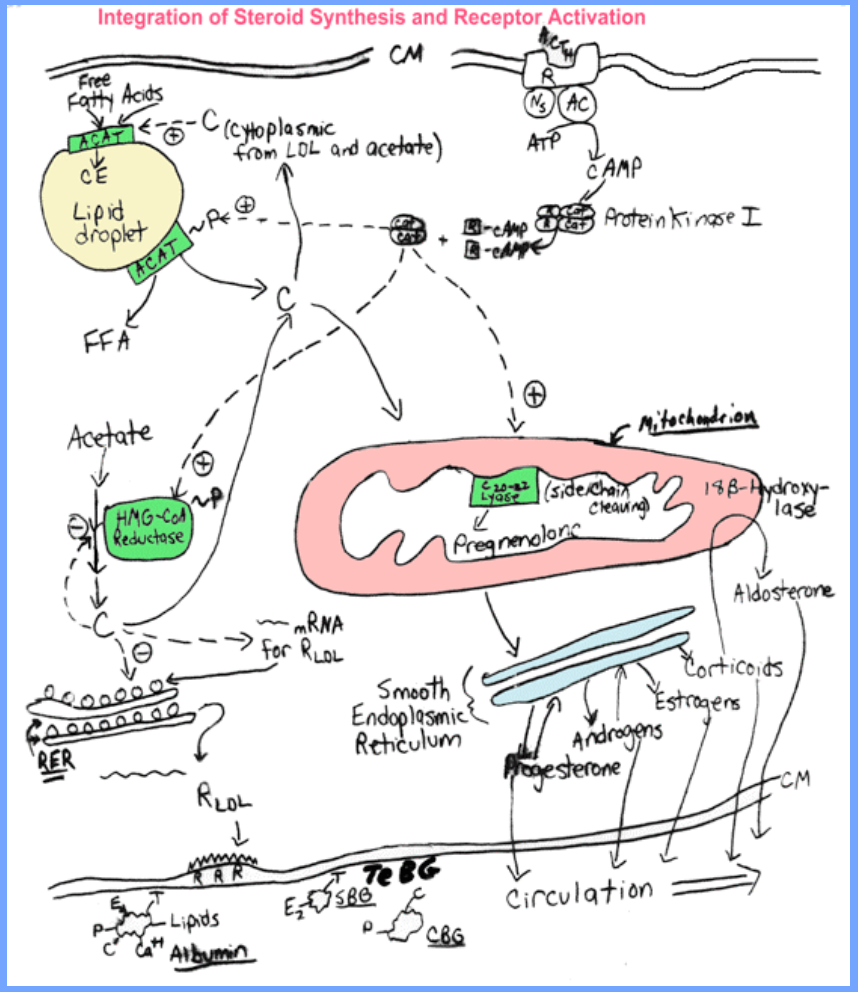
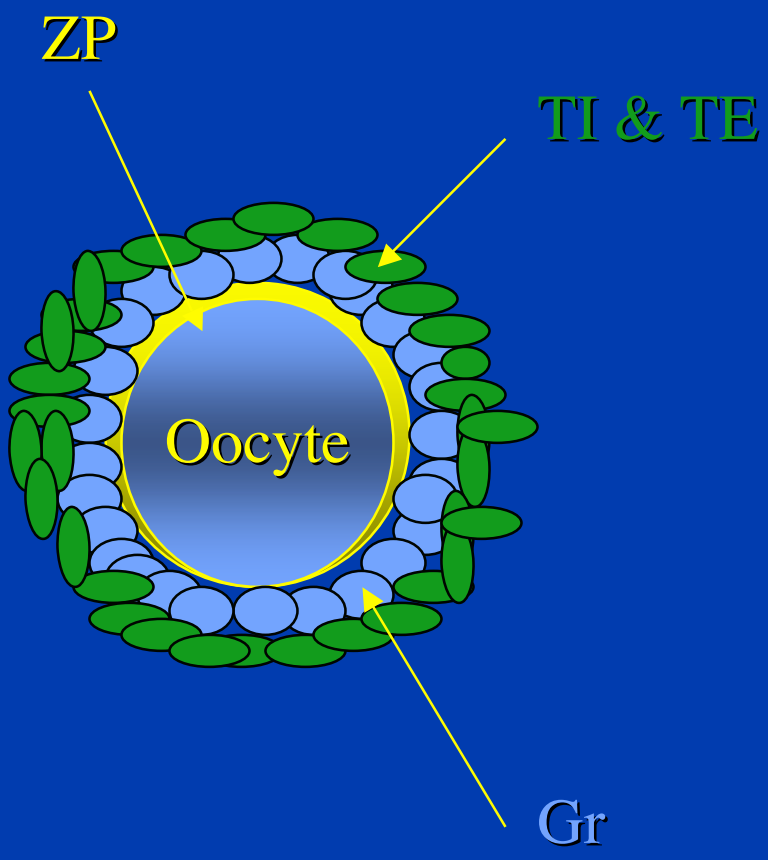
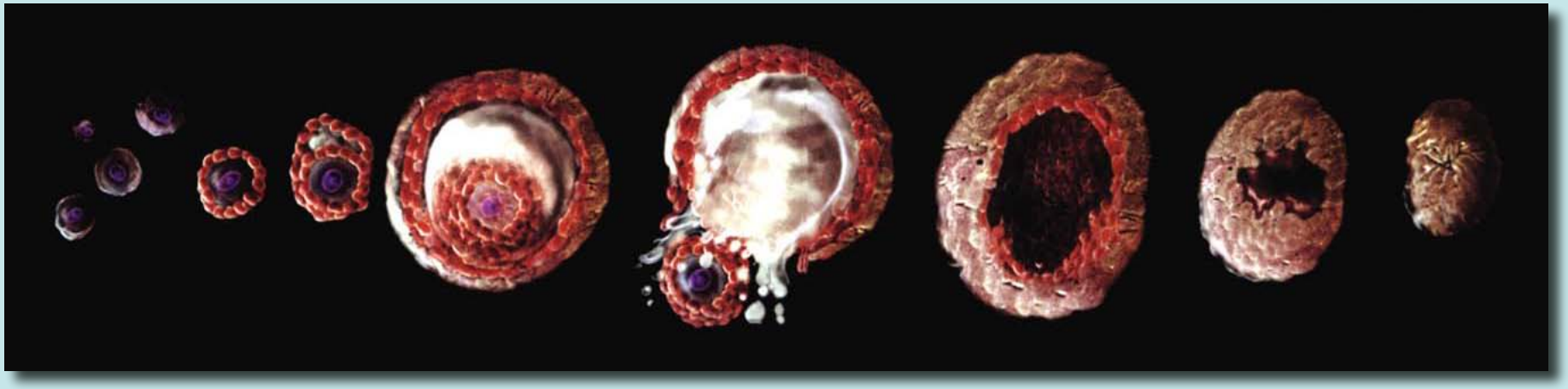
Oogenesis/Folliculogenesis
&
Ovarian Follicle Endocrinology



Ovarian Follicle



- **follicle** - composite structure that will produce mature oocyte
  - primordial follicle - germ cell (oocyte) with a single layer of mesodermal cells around it
  - as development of follicle progresses, oocyte will obtain a 'halo' of cells and membranes that are distinct:
    - 1. zona pellucide (ZP)
    - 2. granulosa (Gr)
    - 3. theca interna and externa (TI & TE)



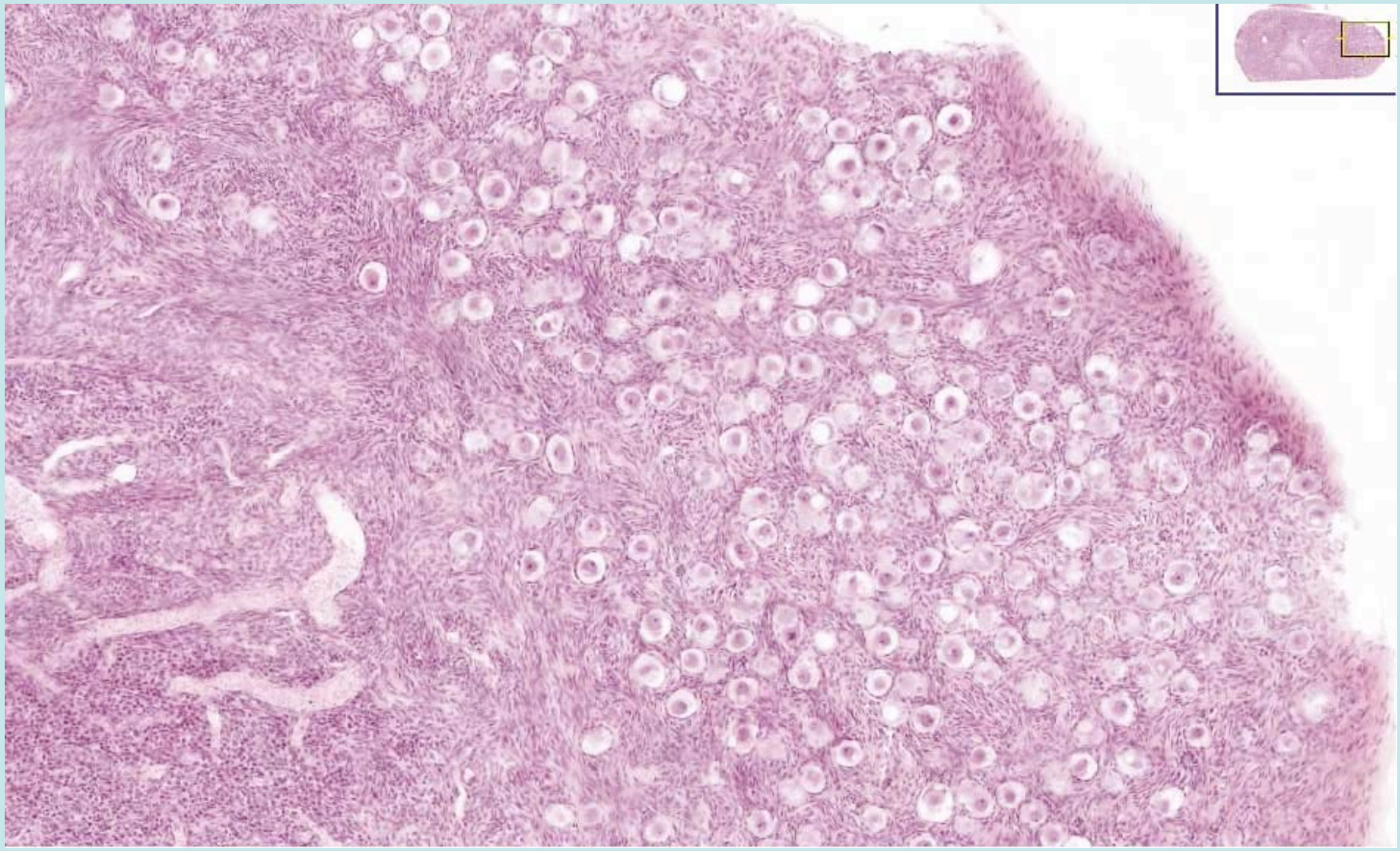
Summary:

The **follicle** is the functional unit of the ovary.

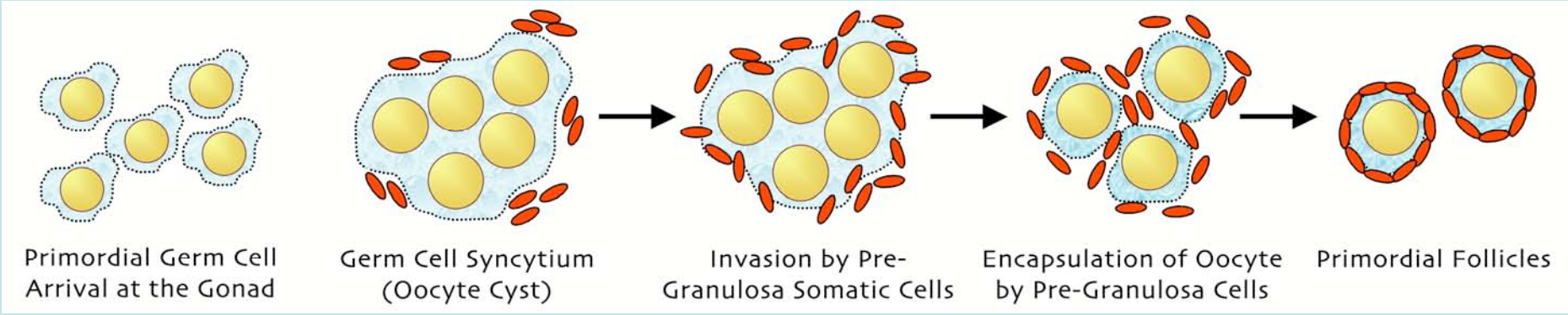
One female gamete, the **oocyte** is contained in each follicle.

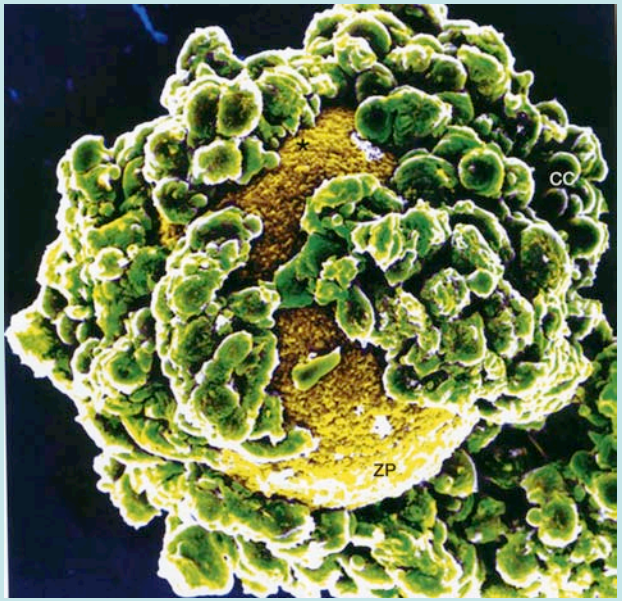
The **granulosa cells** produce hormones (estrogen and inhibin) that provide ‘status’ signals to the pituitary and brain about follicle development.

Mammal - Embryonic Ovary



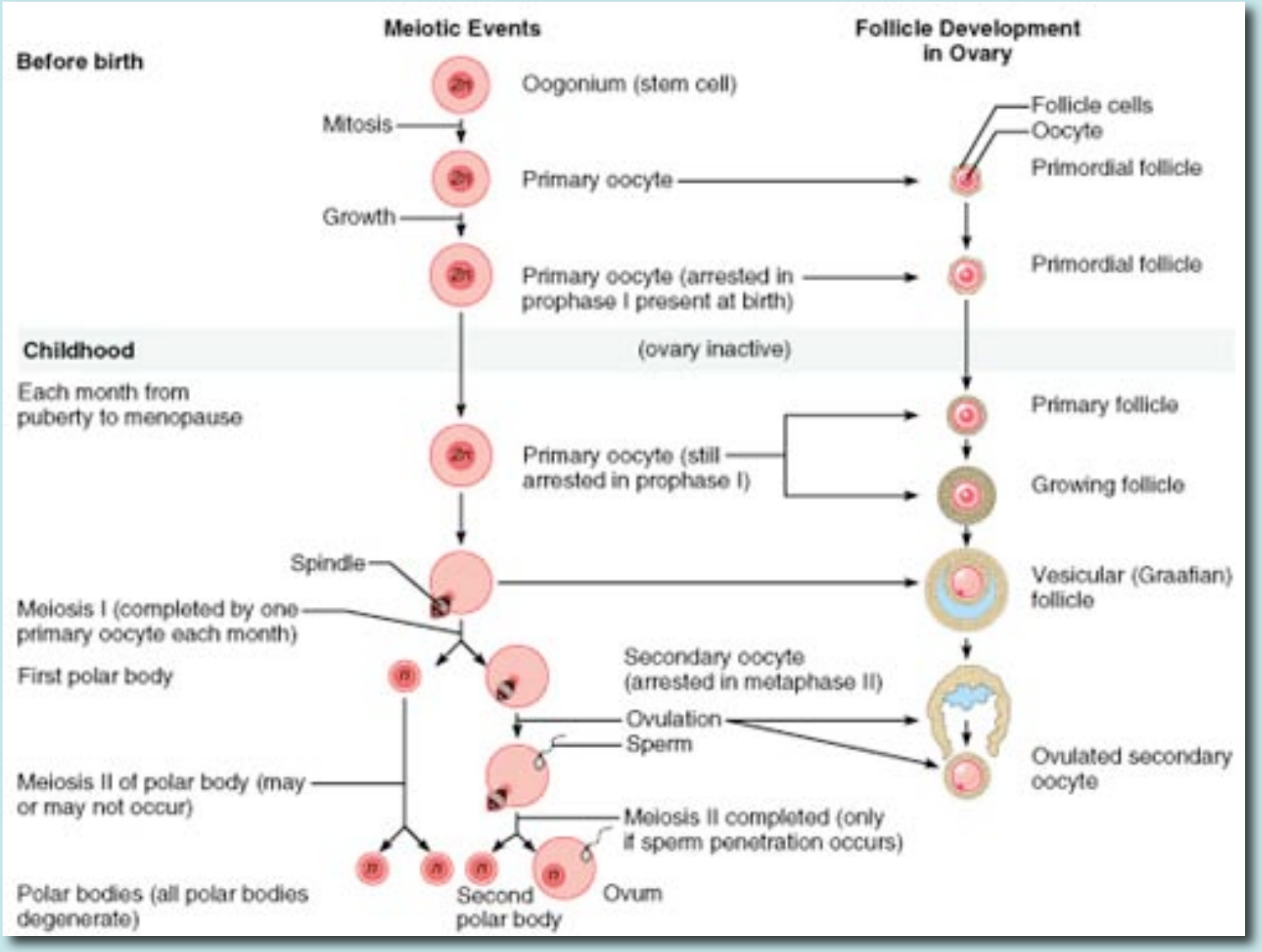
Germ Cells Division and Follicle Formation

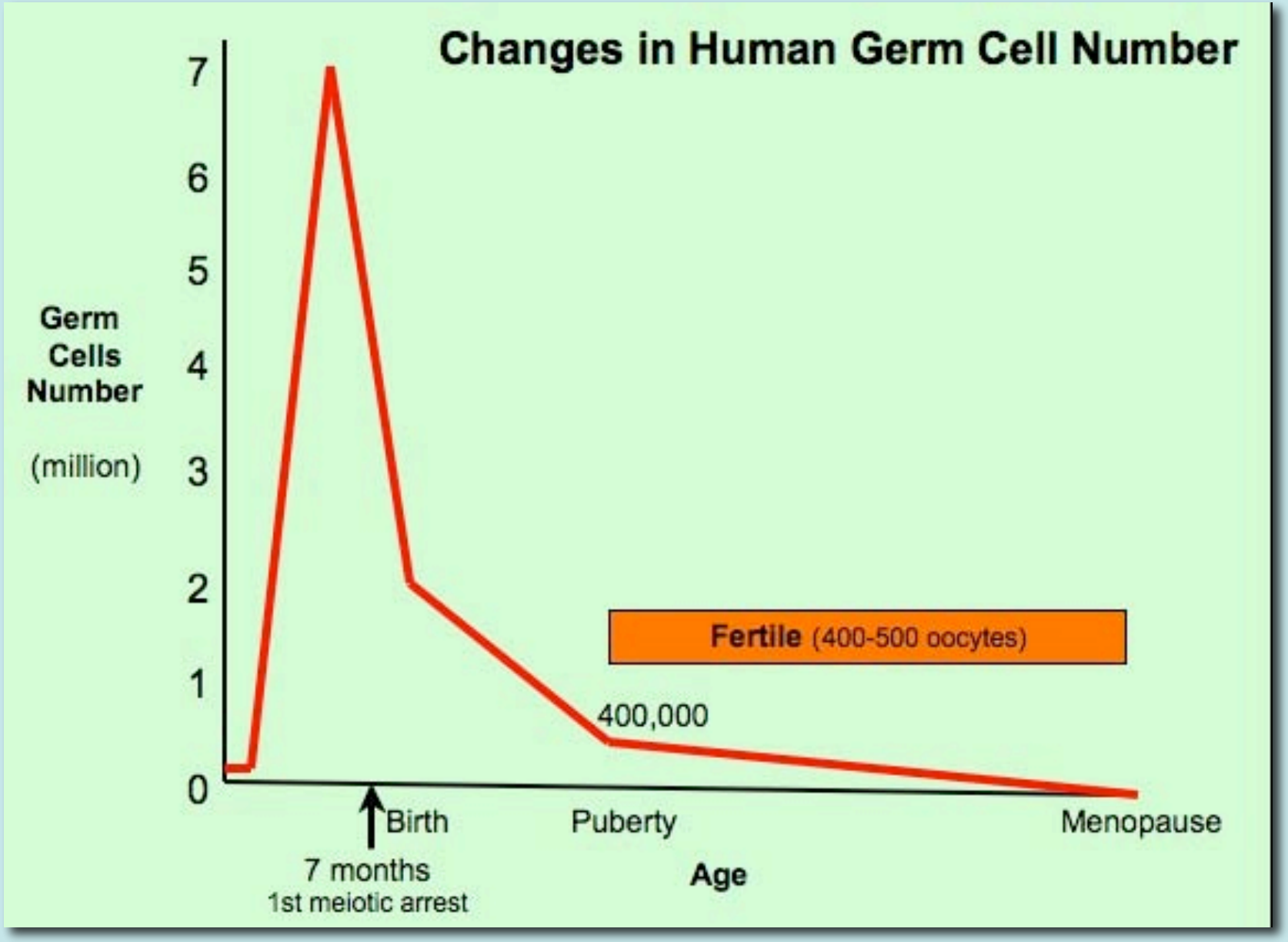




from Makabe and van Blerkom, 2006

Oogenesis and Folliculogenesis




Changes in Human Germ Cell Number
Germ Cells Number
(million)
7
6
5
4
3
2
1
0
Fertile (400-500 oocytes)
400,000
Birth
Puberty
Menopause
7 months
1st meiotic arrest
Age

Graafian Follicle Structure

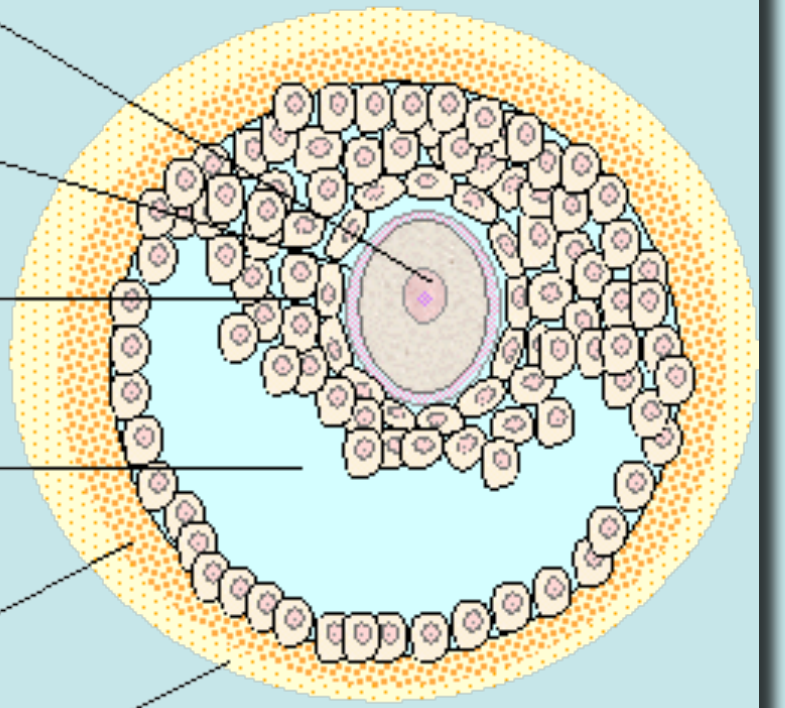
Secondary oocyte formed after Meiosis I is completed

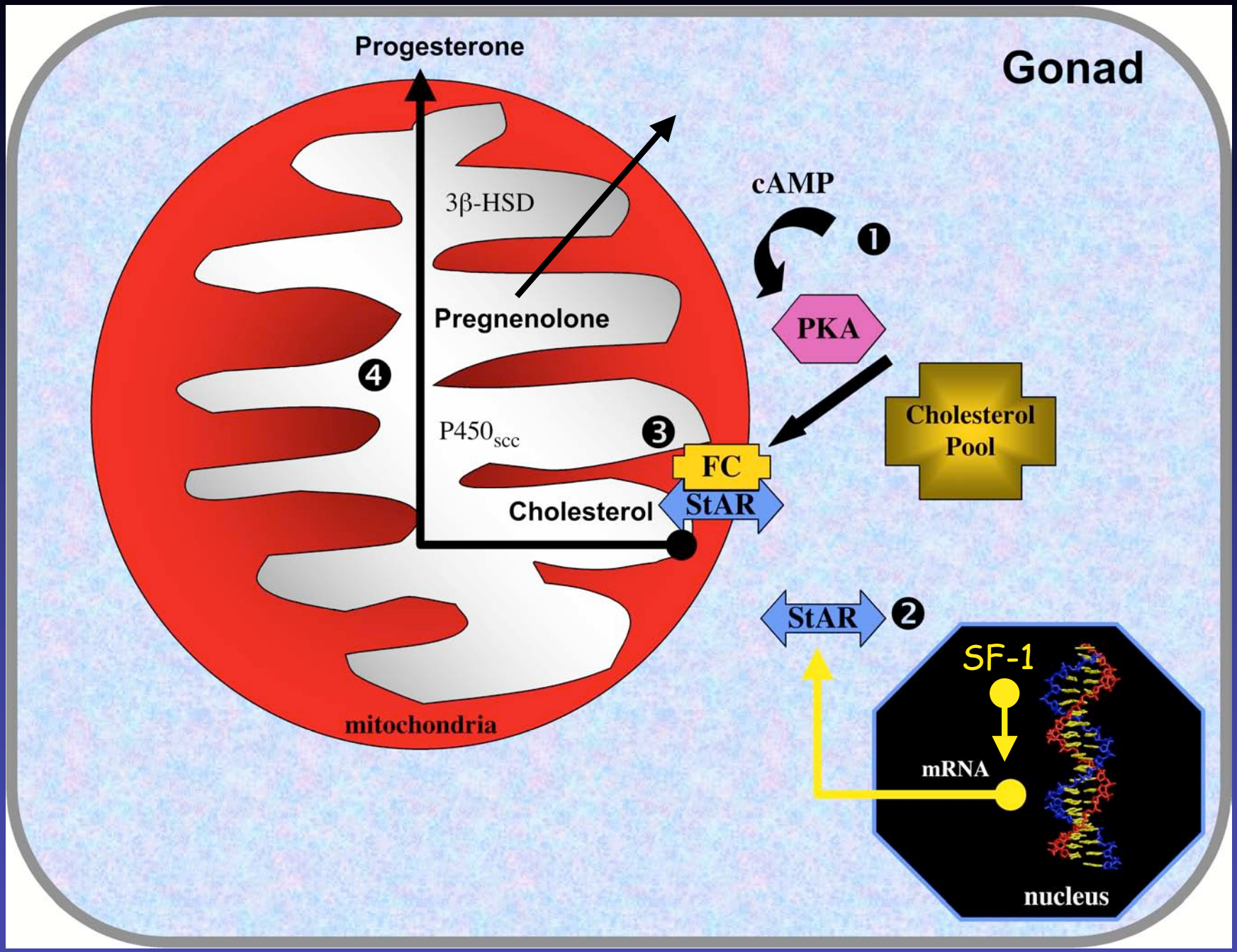
A zona pellucida surrounds the oocyte

Cumulus oophorus surrounds the oocyte

A fluid-filled antrum forms between the follicular cells

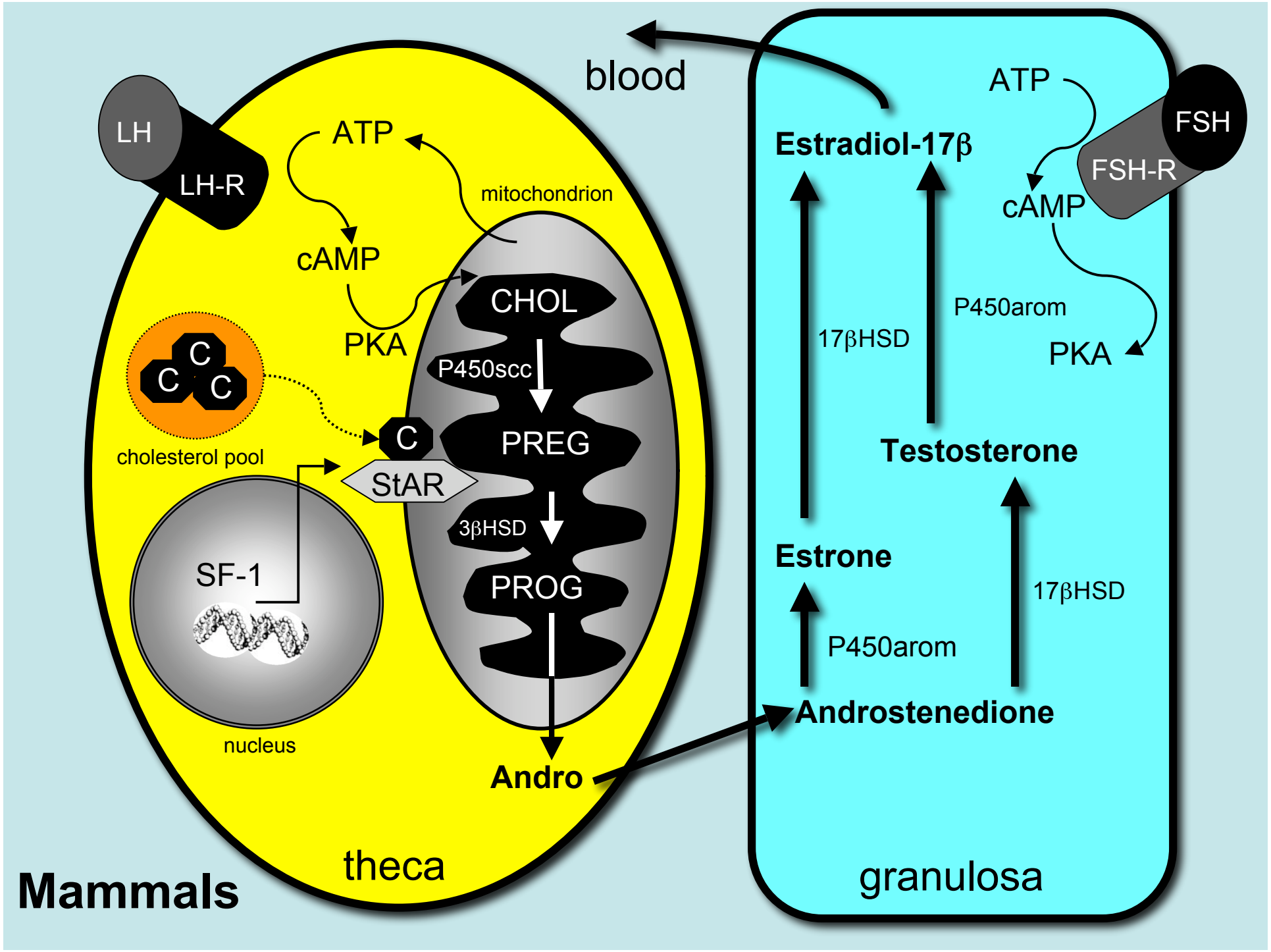
Two layers formed from the ovarian stoma:
Theca interna - vascular
Theca externa - connective tissue capsule




Progesterone
Gonad
cAMP
1
3β-HSD
Pregnenolone
PKA
4
Cholesterol Pool
P450scc
3
FC
StAR
Cholesterol
StAR
2
SF-1
mRNA
mitochondria
nucleus

Two Cell Steroidogenesis

- Common in mammalian ovarian follicle
- Part of the steroid pathway in
  - Granulosa
  - Theca interna
- Regulated by
  - Hypothalamo-pituitary axis
  - Paracrine factors


blood
LH
LH-R
ATP
cAMP
PKA
mitochondrion
CHOL
P450scc
PREG
StAR
3βHSD
PROG
Andro
C
C
C
C
cholesterol pool
SF-1
nucleus
theca
Mammals
ATP
FSH
FSH-R
cAMP
PKA
Estradiol-17β
17βHSD
P450arom
Testosterone
Estrone
P450arom
17βHSD
Androstenedione
granulosa

Activins & Inhibins

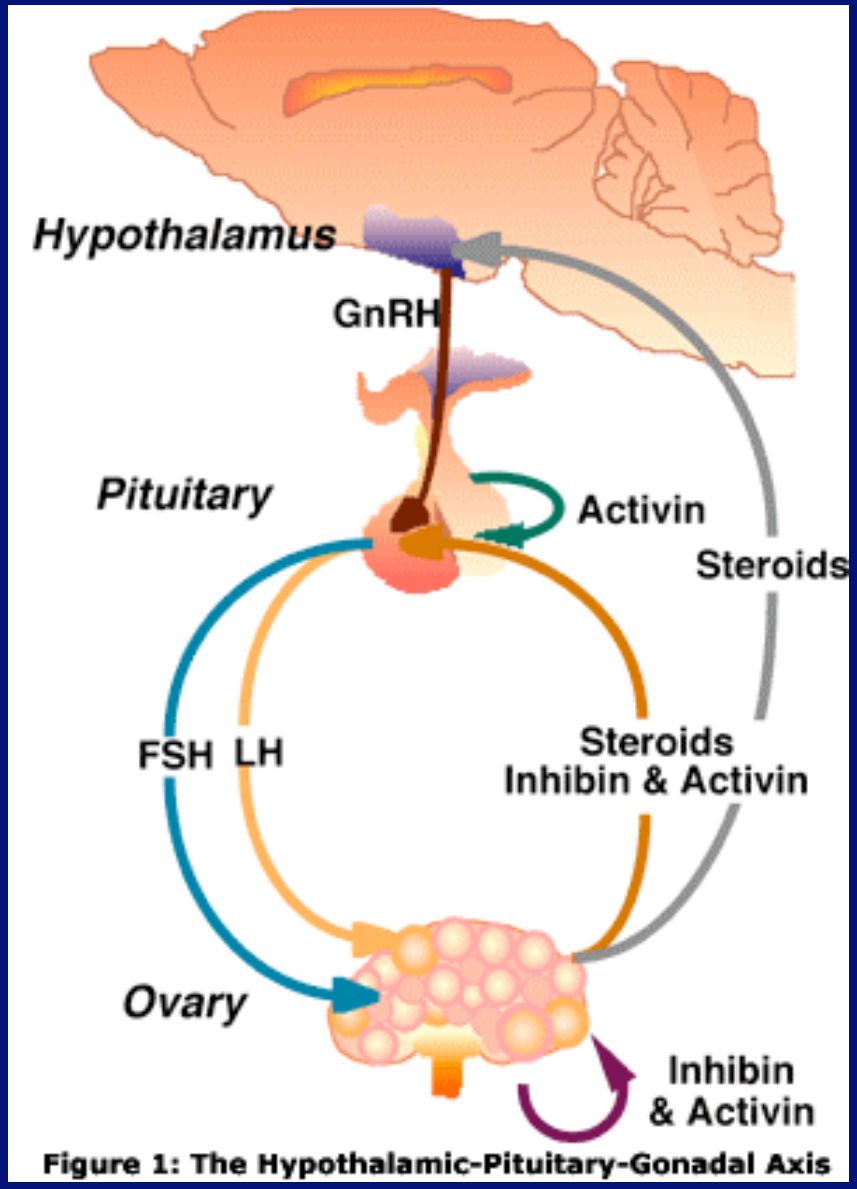
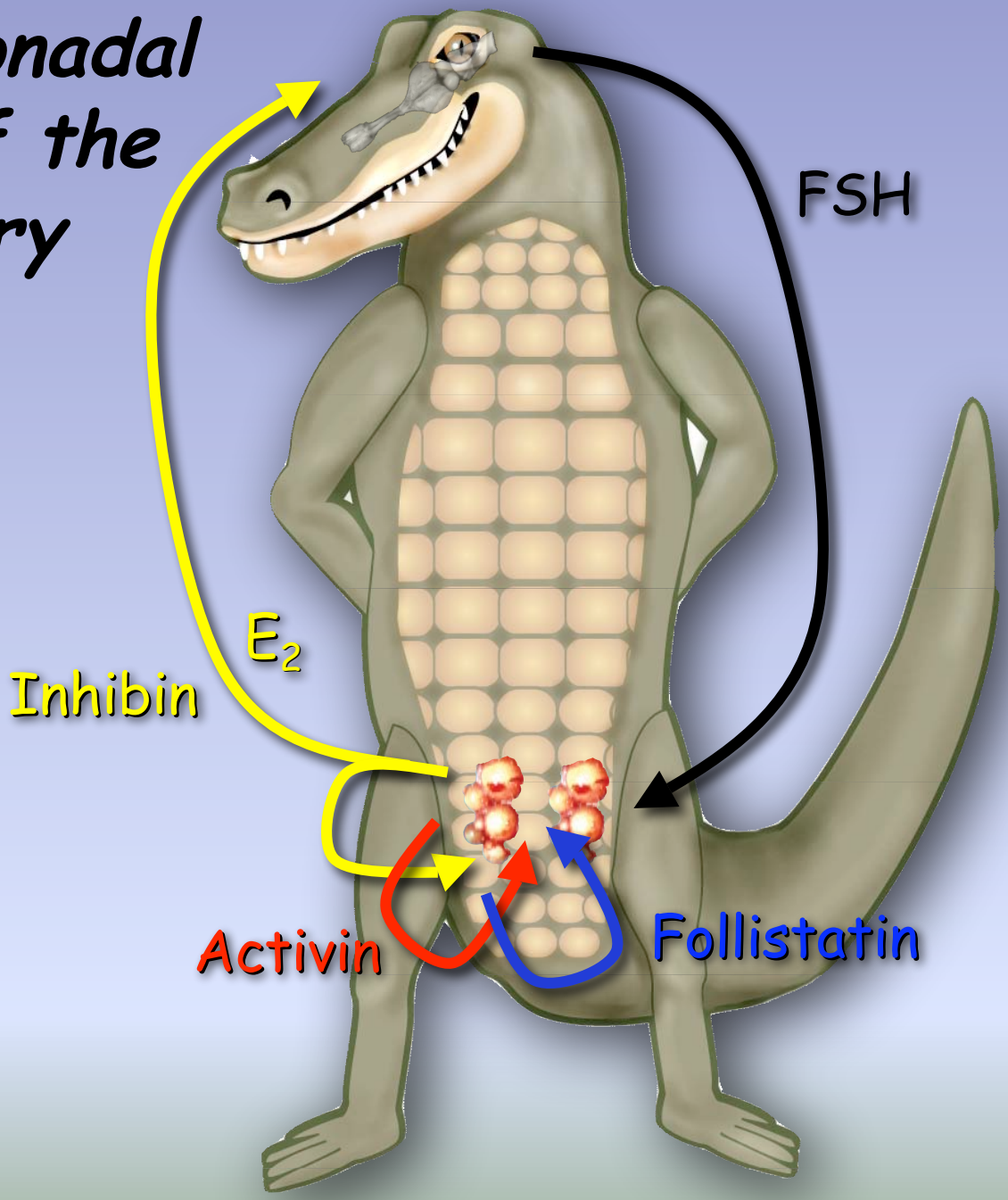


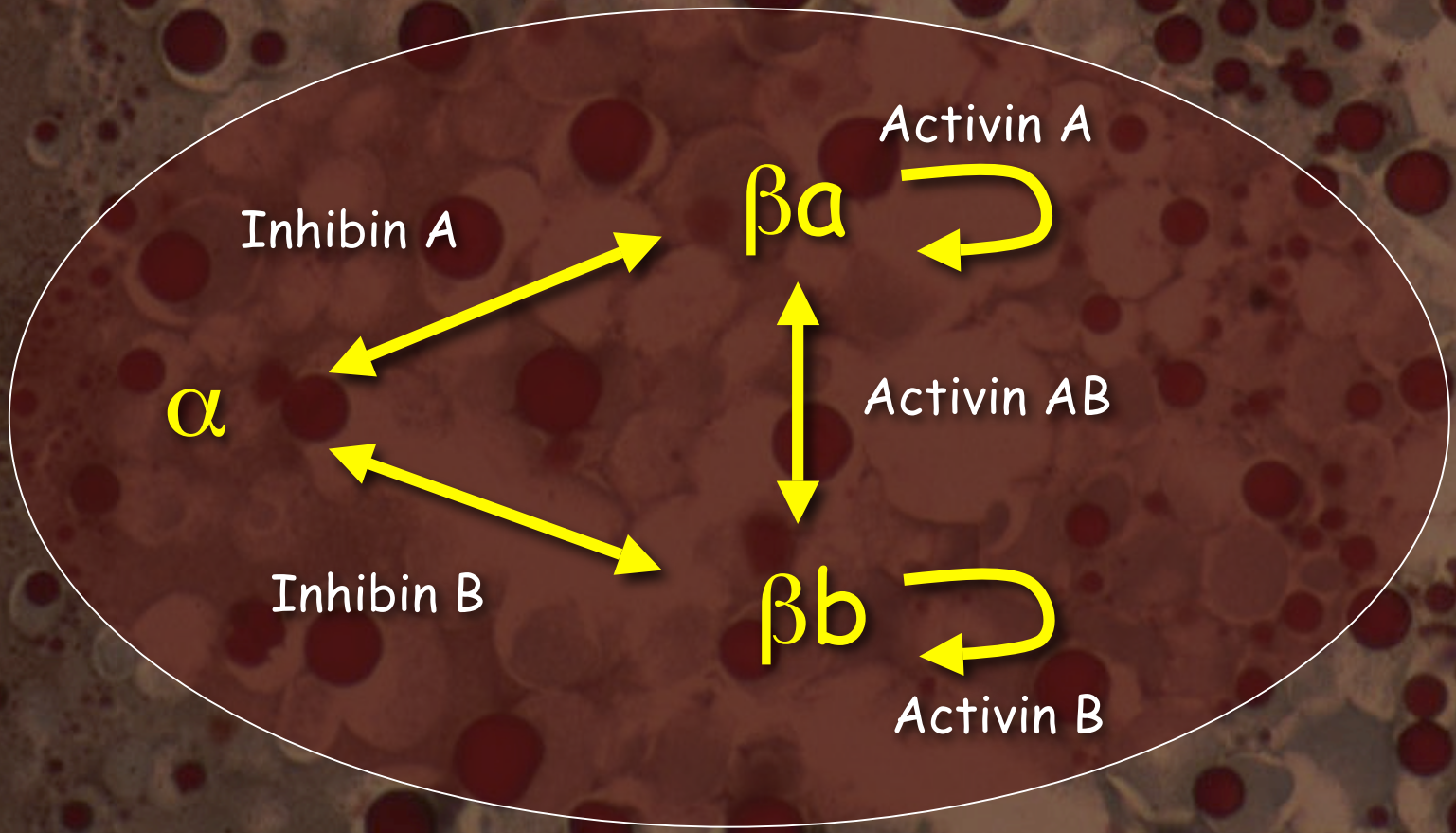
Figure 1: The Hypothalamic-Pituitary-Gonadal Axis

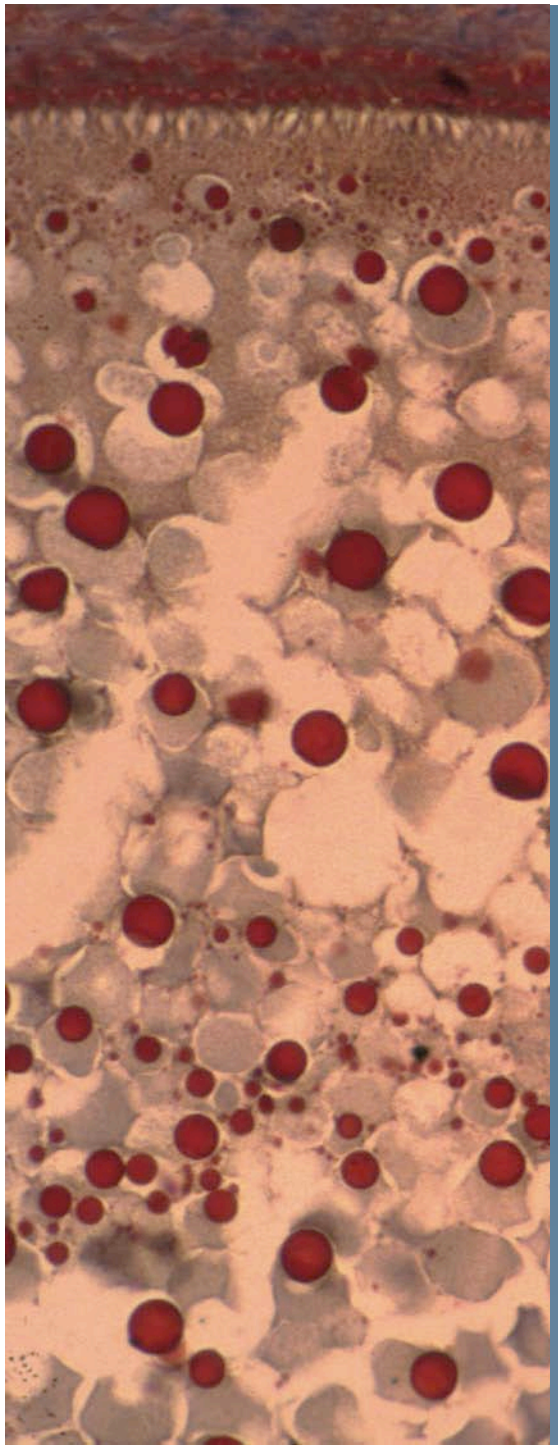
Pituitary - Gonadal Regulation of the Adult Ovary

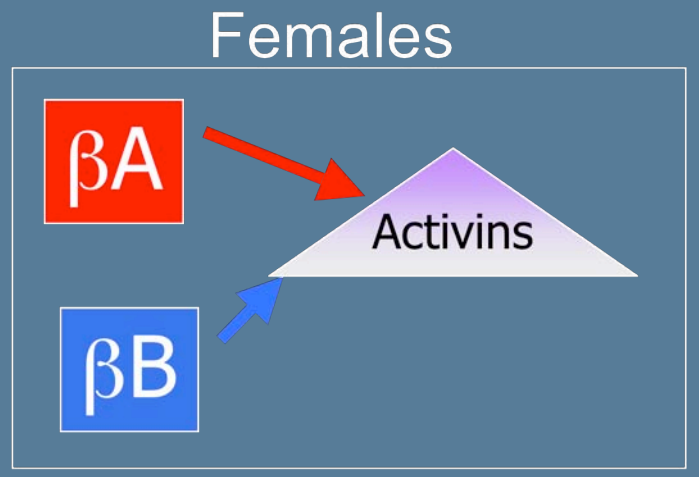


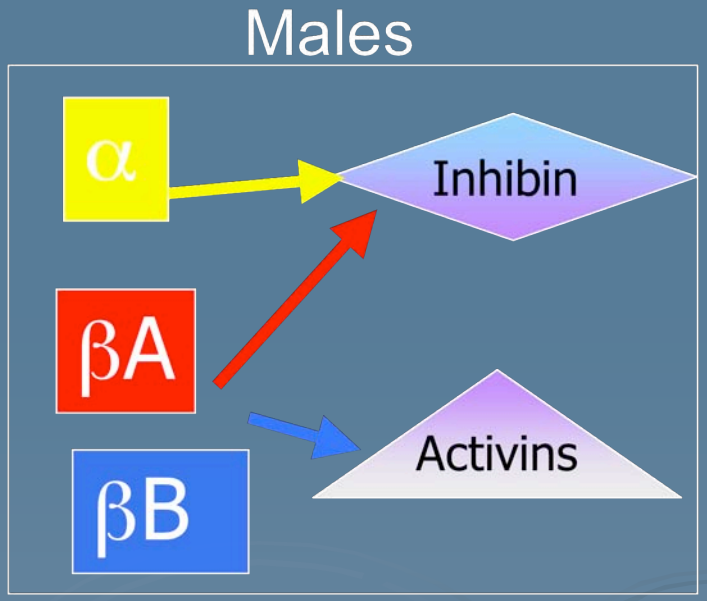
Inhibins and Activins

- Transforming Growth Factor -β (TGF-β) family
- Many gonadal cells produce β subunits
- In ovary - only granulosa produce α subunits
- At the ovary, inhibins antagonize the actions of activins

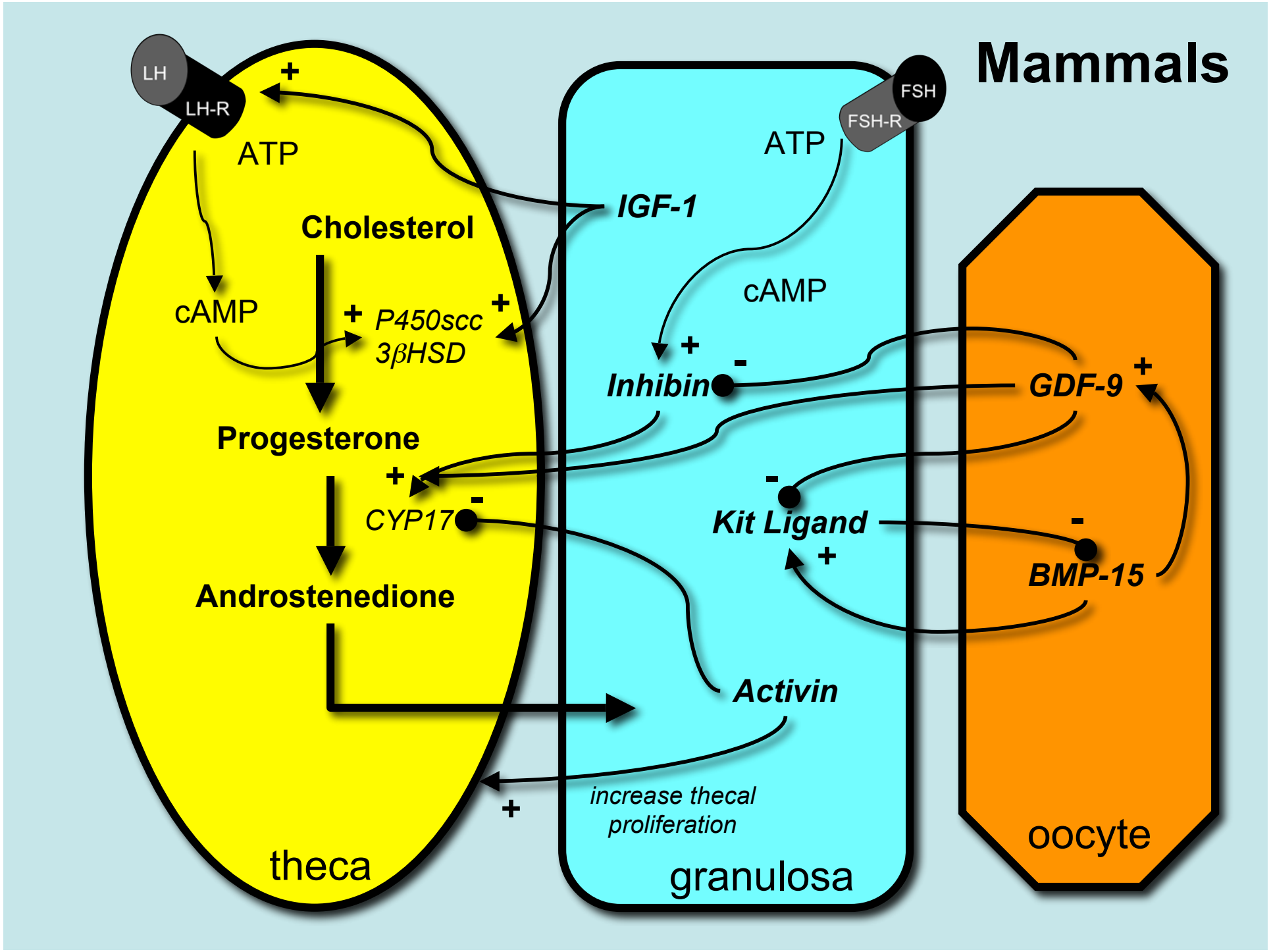






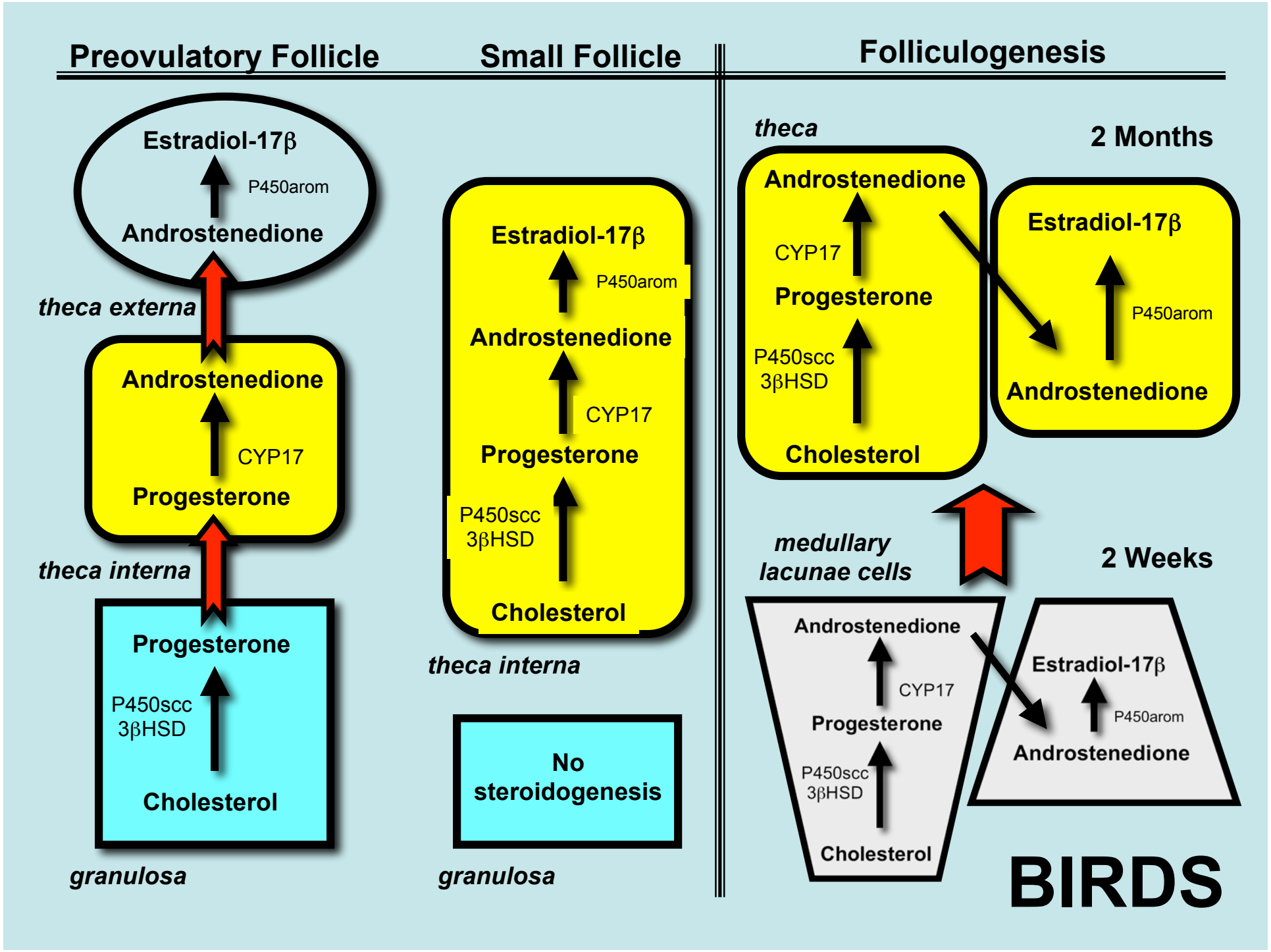


Moore et al. unpubl. data


Mammals
LH
LH-R
FSH
FSH-R
ATP
ATP
IGF-1
Cholesterol
cAMP
cAMP
P450scc
3βHSD
Progesterone
Inhibin
GDF-9
CYP17
Kit Ligand
BMP-15
Androstenedione
Activin
increase thecal proliferation
theca
granulosa
oocyte

Three Cell Steroidogenesis

- Common in avian/reptilian(?) ovarian follicles
- Part of the steroid pathway in
  - Granulosa
  - Theca interna
  - Theca externa
- Regulated by
  - Hypothalamo-pituitary axis
  - Paracrine factors


Preovulatory Follicle
Small Follicle
Folliculogenesis
Estradiol-17β
P450arom
Androstenedione
theca externa
Androstenedione
CYP17
Progesterone
theca interna
Progesterone
P450scc
3βHSD
Cholesterol
granulosa
Estradiol-17β
P450arom
Androstenedione
CYP17
Progesterone
P450scc
3βHSD
Cholesterol
theca interna
No
steroidogenesis
granulosa
theca
2 Months
Androstenedione
CYP17
Progesterone
P450scc
3βHSD
Cholesterol
Estradiol-17β
P450arom
Androstenedione
medullary
lacunae cells
2 Weeks
Androstenedione
CYP17
Progesterone
P450scc
3βHSD
Cholesterol
Estradiol-17β
P450arom
Androstenedione
BIRDS

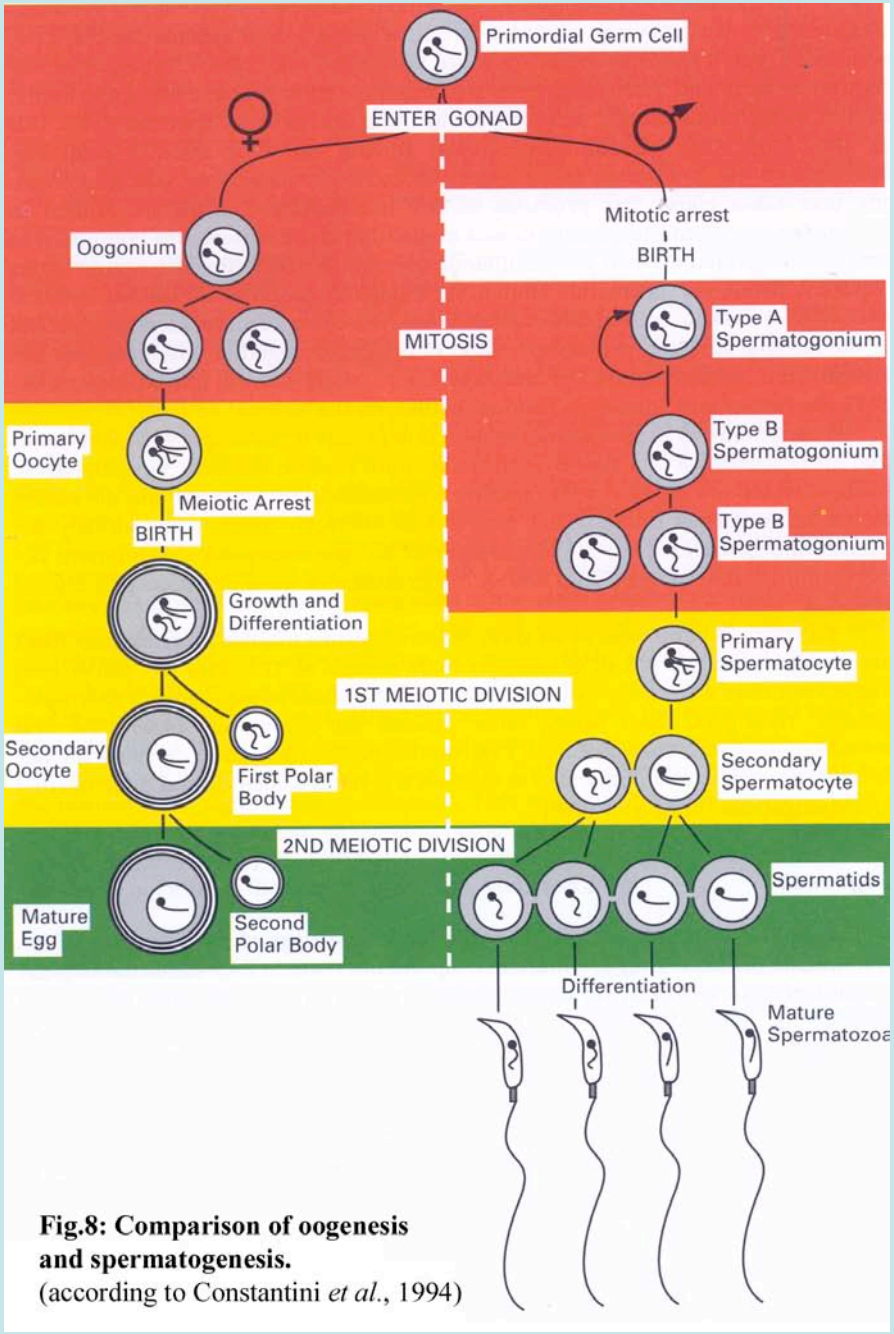


Fig.8: Comparison of oogenesis and spermatogenesis.
(according to Constantini *et al.*, 1994)

Review Mitosis/Meiosis

- What events are different?
- What events take place in utero in mammal versus later in life?
- How is spermatogenesis and oogenesis different?