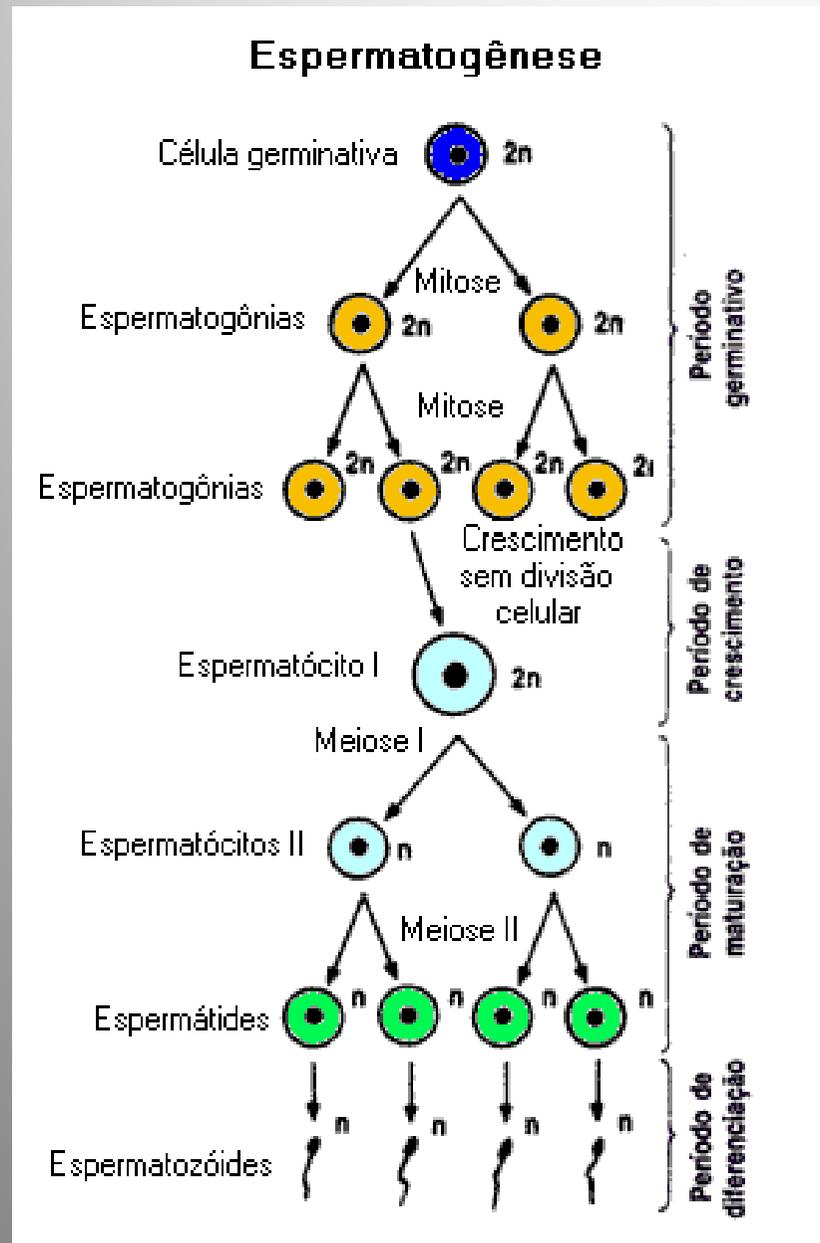




Eixo-Hipotálamo-Hipófise- Gônadas

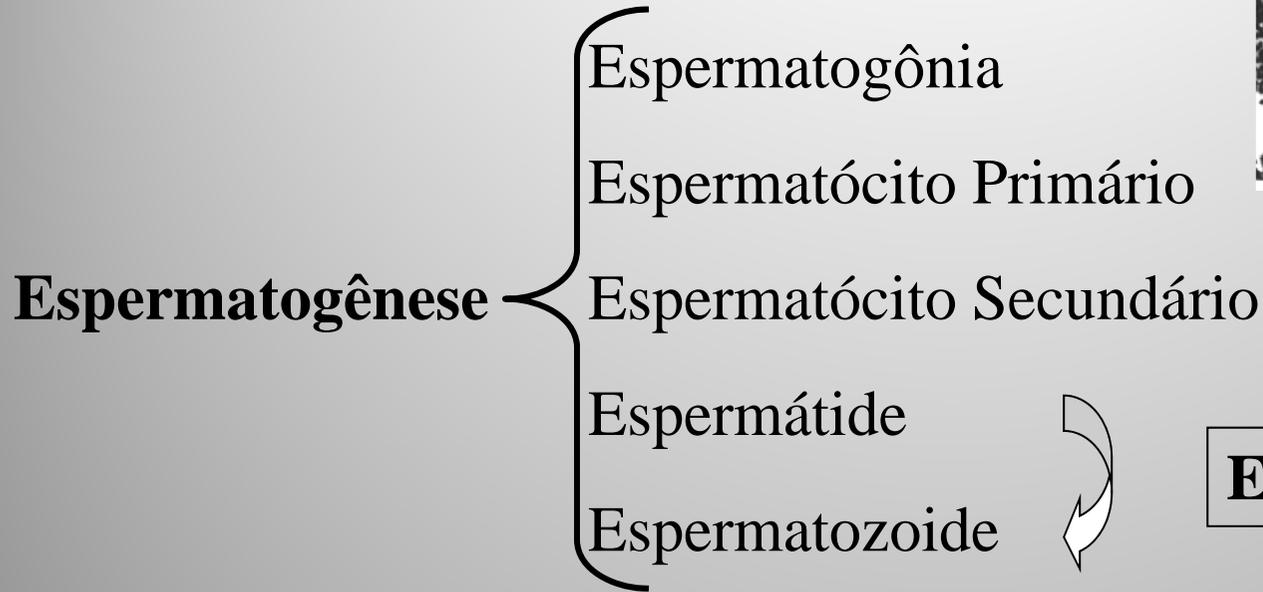
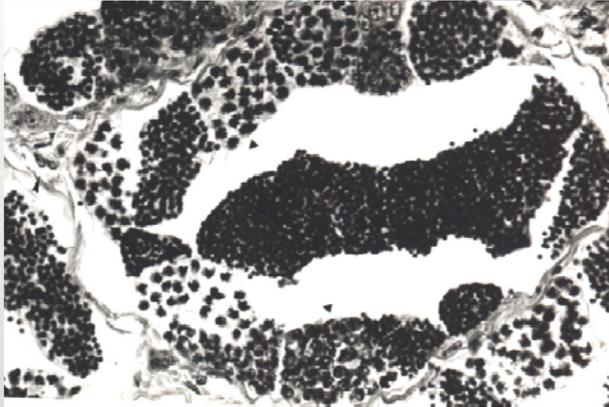
Reprodução sexuada: custo com formação de gametas



1 espermatogônia: 4 espermatozoides
($2n$) (n)

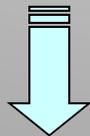


Espermatogênese



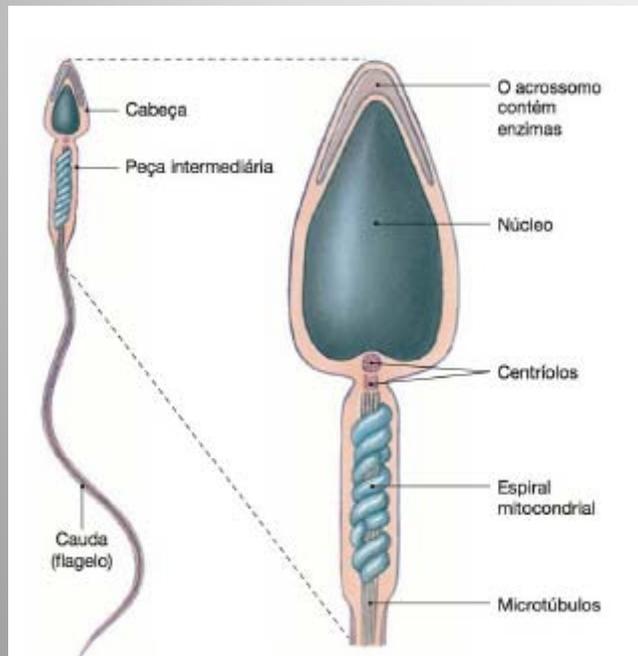
Espermiogênese

ESPERMIAÇÃO



Liberação de espermatozoides para o ducto espermático

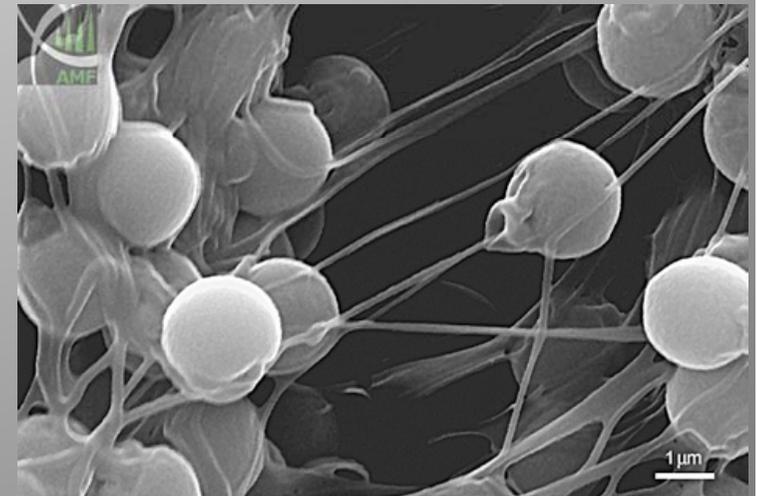
Variabilidade na estrutura do espermatozoide



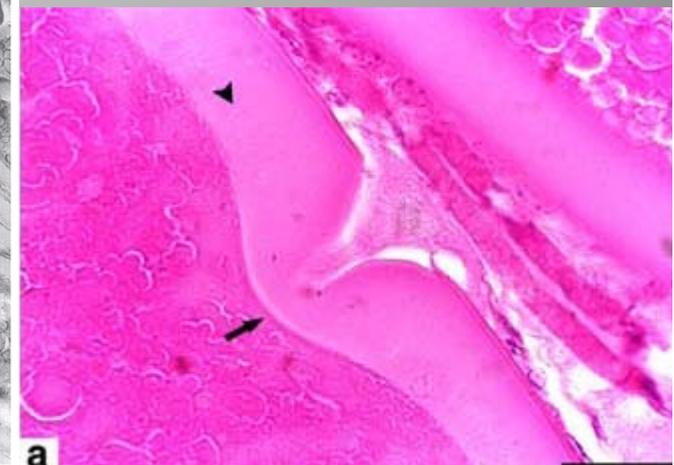
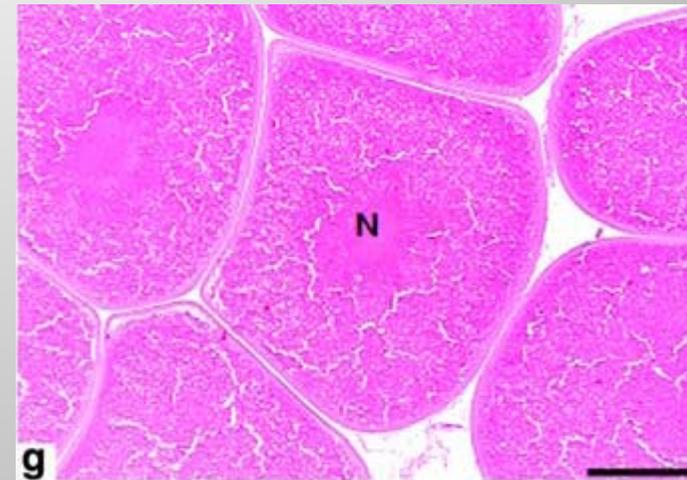
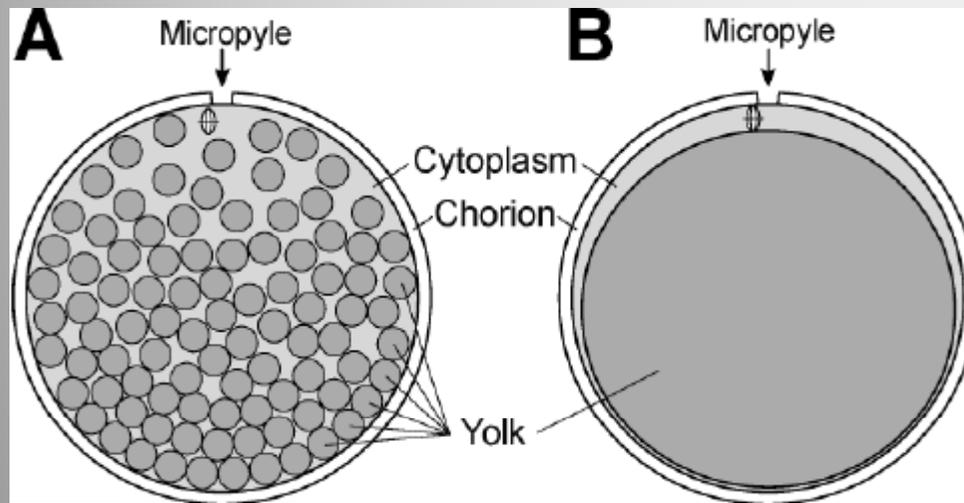
● **FIGURA 26-10** O espermatozoide consiste em uma cabeça com enzimas e DNA, uma cauda longa e mitocôndrias para produzir a energia usada para o movimento da cauda.

Acrossomo: enzimas

Em peixes, o espermatozoide não tem acrossomo



Teleósteos: presença da micrópila para a fertilização



**PRINCIPAIS
CARACTERÍSTICAS DO
CICLO REPRODUTIVO
EM VERTEBRADOS**

Peixes



Repertório comportamental : Corte, comunicação química, migração

Teleostei – Mais diversos padrões de reprodução

- Fertilização externa
- Predominância de oviparidade
- Número de ovos depende da estratégia reprodutiva

Chondrichthyes – diversos padrões

- Retenção dos ovos fertilizados : viviparidade

Viviparidade em peixes

- O termo vivíparo está relacionado com embriões que são nutridos diretamente pela mãe;
- Fecundação interna;
- Condrichthyes prevalece a viviparidade;
- Em teleósteos são estimadas 510 espécies vivíparas



Gonopódio



Clásper

HERMAFRODITISMO

Invertebrados – Platelmintos, hidras, anelídeos, moluscos pulmonados

Vertebrados - Peixes

Hermafroditismo sequencial



Badejo (protogínico)



Garoupa (protogínico)



Peixe-Palhaço (protândrico)

Anfíbios

Anuros



a corte e



o “abraço”

- Fertilização externa na maioria, mas a interna também ocorre, com desenvolvimento direto
- Repertório comportamental: vocalização, cuidado parental (local de desova, ninhos de espuma)

Urodelos



- Fertilização interna (externa em 2 famílias primitivas)
- Espermatóforo
- Repertório Comportamental: Corte com movimentos corporais que culminam na transferência do espermatóforo

LETTERS

Parental investment by skin feeding in a caecilian amphibian

Alexander Kupfer¹, Hendrik Müller^{1,2}, Marta M. Antoniazzi³, Carlos Jared³, Hartmut Greven⁴, Ronald A. Nussbaum⁵ & Mark Wilkinson¹

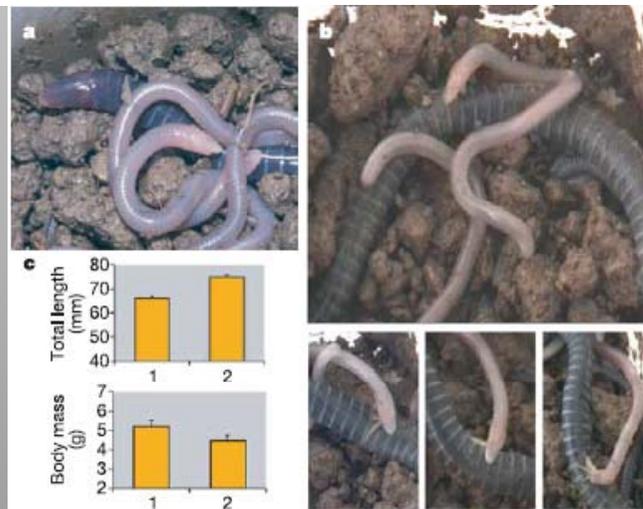


Figure 1 | Skin feeding in *B. taitanus*. **a**, Female with unpigmented young. **b**, Various stills from video footage of a young animal peeling and eating the outermost layer of its mother's skin. **c**, Changes in mean total length ($n = 66$, $P < 0.001$; t -test) of young (top) and mean body mass ($n = 15$, $P < 0.001$; paired t -test) of mothers (bottom) between a first (1) and a second (2) measurement after one week of parental care. Error bars show s.e.m.

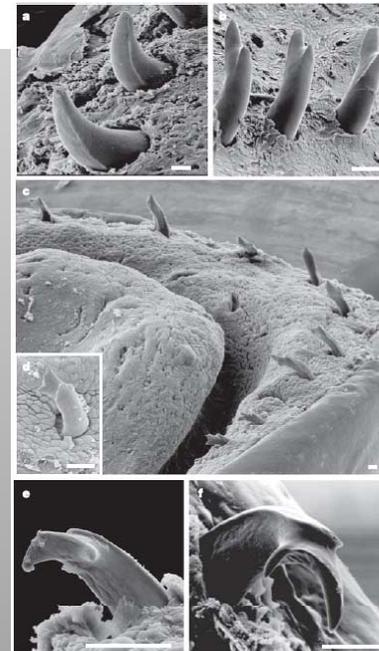
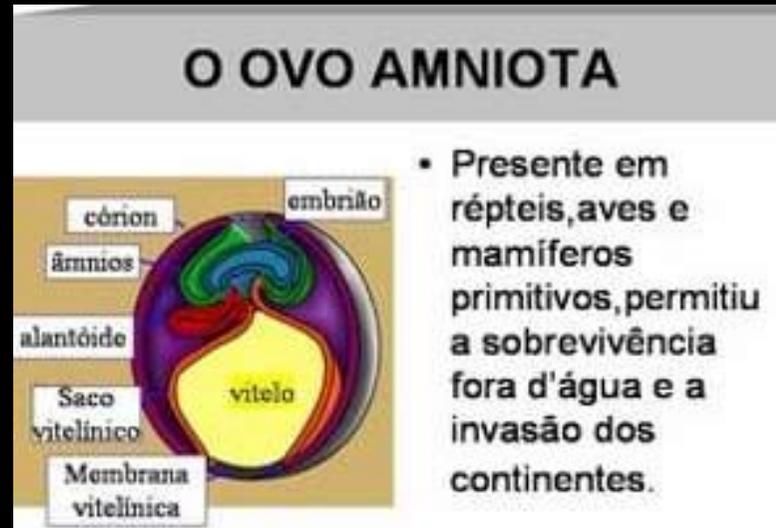
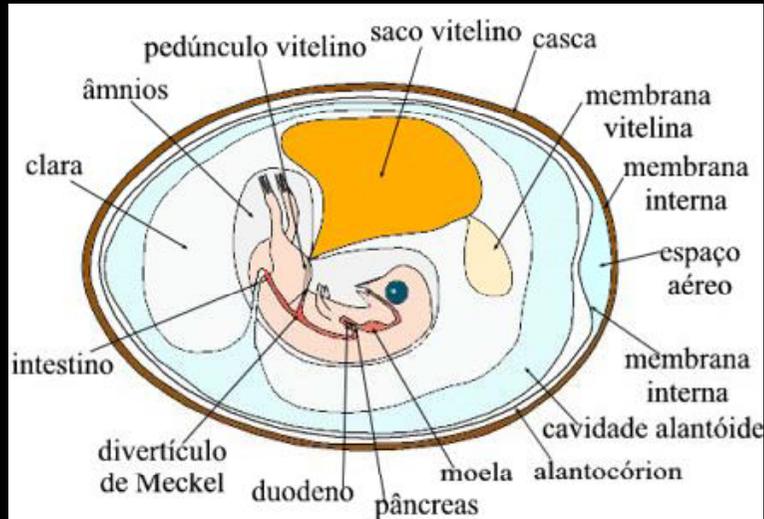


Figure 3 | Dentition of adult and young *B. taitanus*. **a**, Anterior view of two monocuspid, adult premaxillary teeth. **b**, Labial view of three bicuspid, adult vomerine teeth. **c**, Lateral view of a lower jaw of a young specimen (total length 69 mm), showing different dentary tooth crown morphologies. **d**, Labial view of a posterior dentary tooth of this young specimen. **e**, Anterior premaxillary tooth of the same specimen. **f**, Anterior premaxillary tooth of a smaller specimen (total length 57 mm) resembling a grappling hook. Scale bars, 30 μ m.

Répteis

O OVO AMNIÓTICO



Âmnio – simulação do ambiente aquático

Córion – proteção e trocas gasosas

Ovíparos com diferentes graus de ovoviviparidade

- Fecundação interna – órgãos copuladores
- Corte e produção de feromônios → identificação das espécies



Aves

Complexo comportamento associado à reprodução

- Vocalização
- Posturas associadas com coloração
- Exclusivamente ovíparas
- Pequeno número de ovos (até mesmo 1)
- Sistemas de acasalamento – monogamia (maioria) ou prosmicuidade
- Nidificação e Incubação

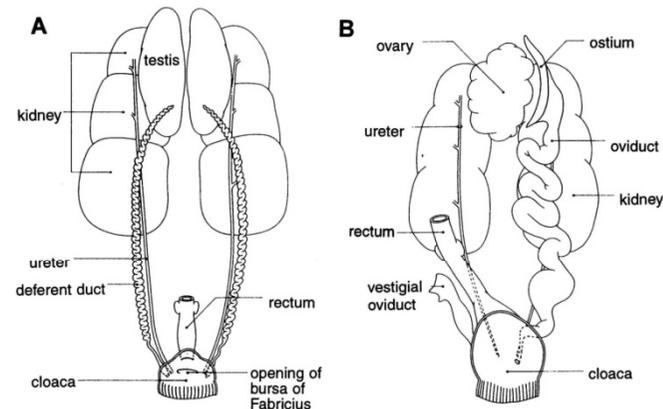


Figure 12-25. Reproductive organs of the pigeon. The top of the cloaca has been removed in both sexes. (A) The male. (B) The female: Note that the right ovary is absent in most birds (the left in others), as well as the corresponding oviduct. This regression is due to production of MIS in the embryo by the remaining ovary, which secretes estradiol locally and protects the müllerian duct on that side from MIS.

Mamíferos

Oviparidade



Viviparidade

- Fertilização necessariamente interna
- Fornecimento de alimento: placenta e lactação
- Útero (proteção térmica) - não necessitam do choco
- Cuidado Parental: número menor de filhotes

Monotremados

Os ovíparos persistem....



2 ovos



1 ovo

Marsupiais

- Nascimento precoce
- Presença do marsúpio



Prole numerosa

Placentários

- Útero único
- Transferência materna de nutrientes: placenta e lactação
- Ovos reduzidos: perda da importância do vitelo

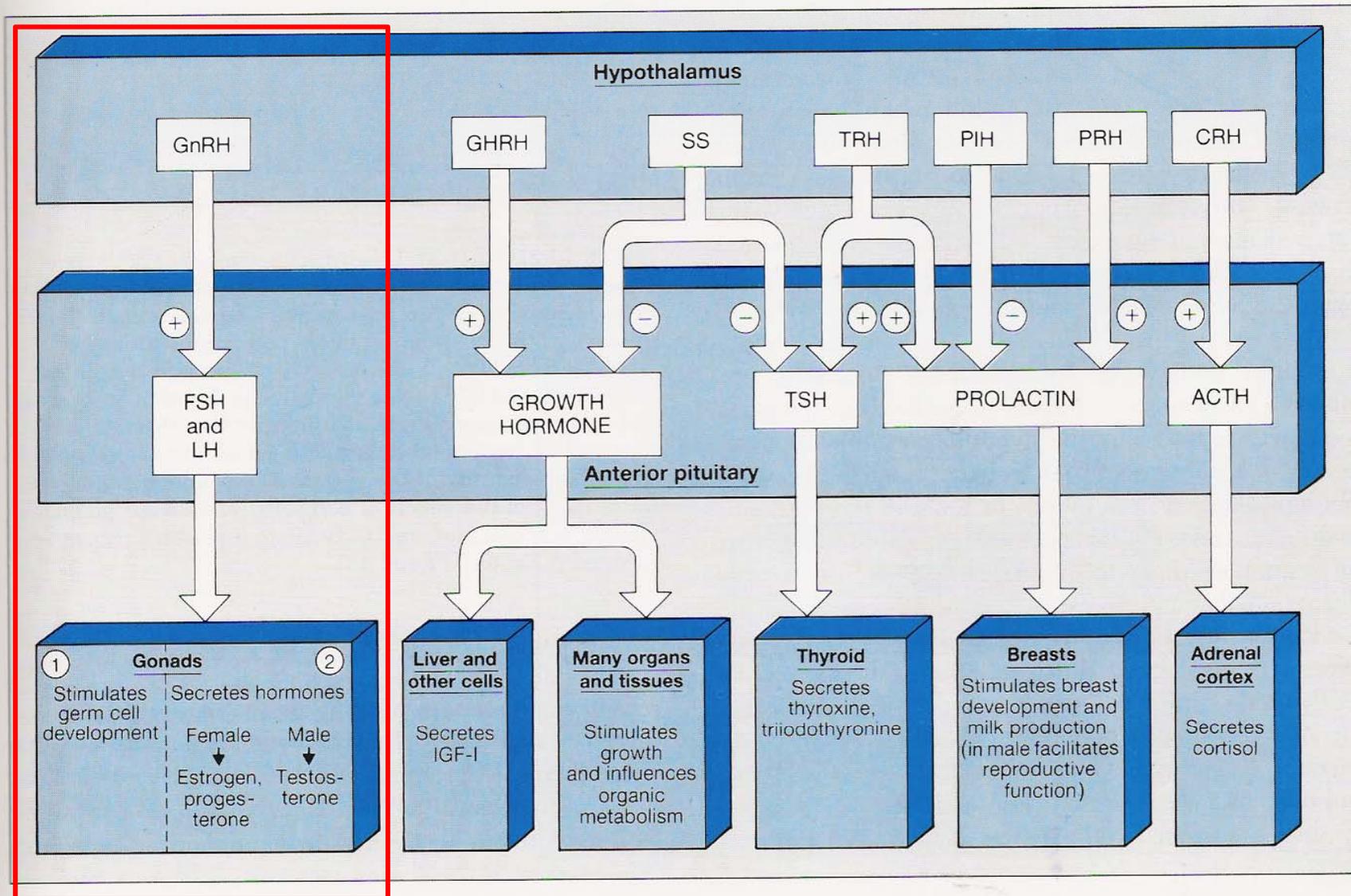


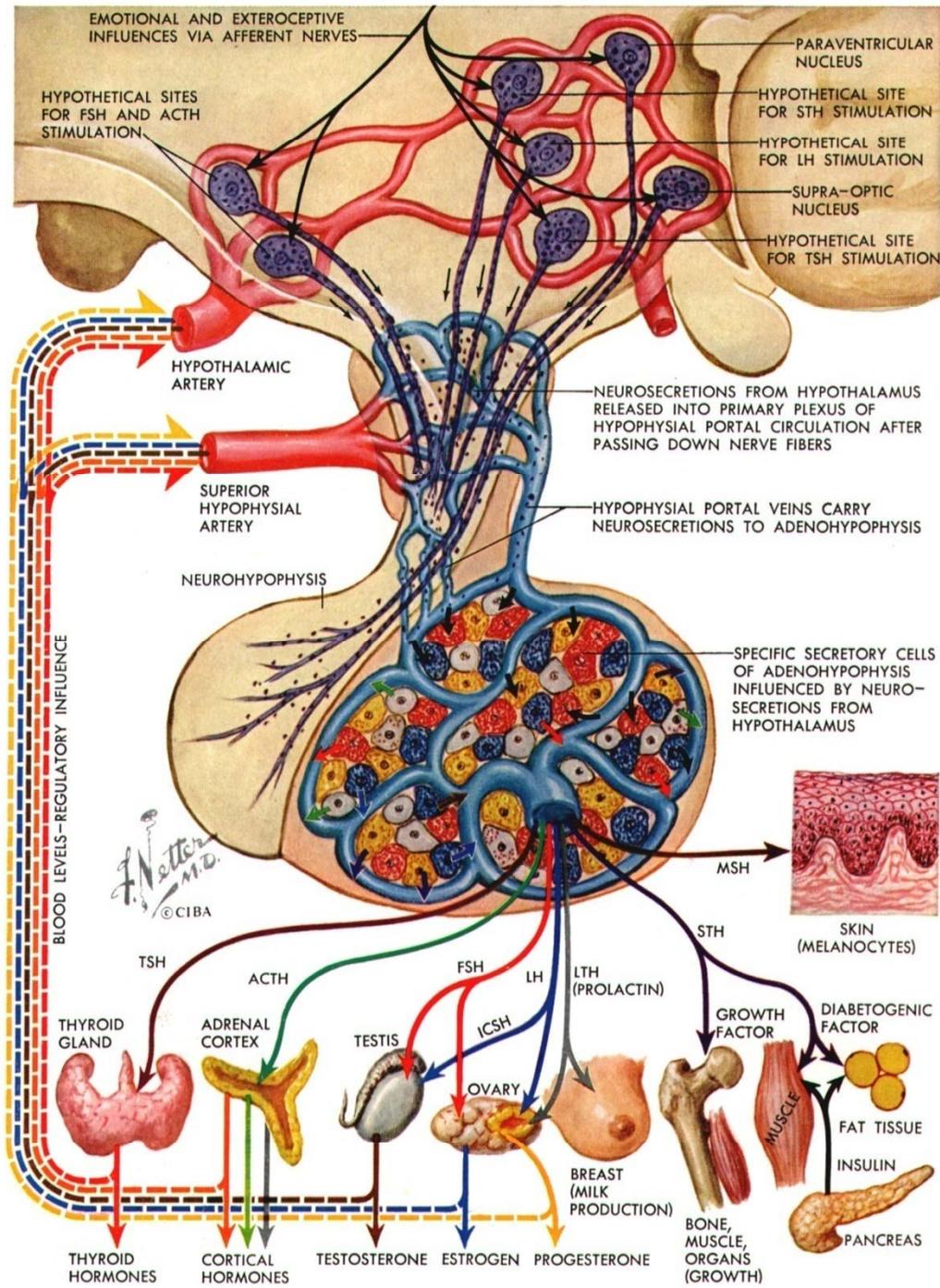


CONTROLE DO CICLO REPRODUTIVO EM VERTEBRADOS



FIGURE 10-20 A combination of Figures 10-17 and 10-19 summarizes the hypothalamic-anterior-pituitary system.





O CONTROLE DO DESENVOLVIMENTO DOS GAMETAS

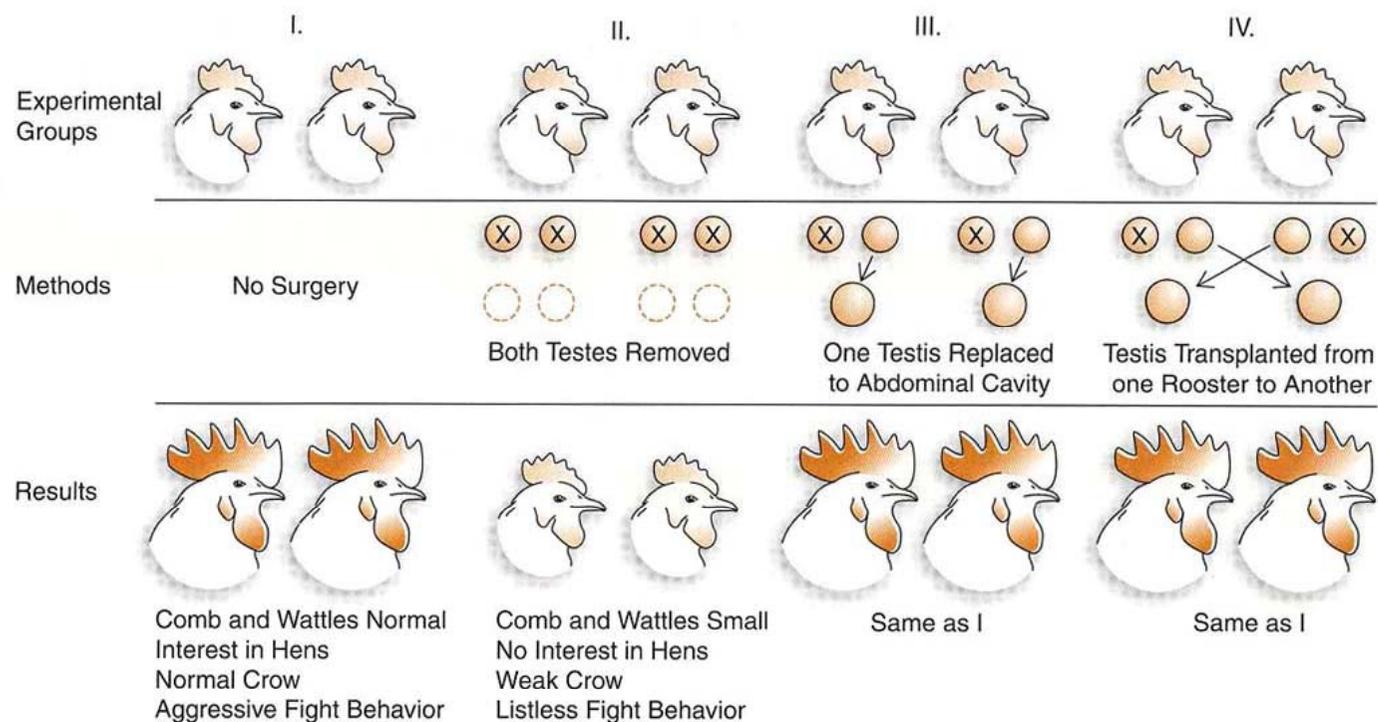


ESTEROIDES GONADAIS



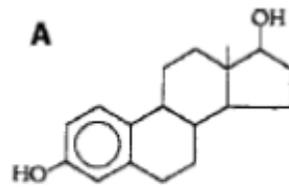
Arnold Berthold (1849) – Primeiro experimento em endocrinologia

Figure 1.1 Berthold's experiment: the first endocrine experiment.

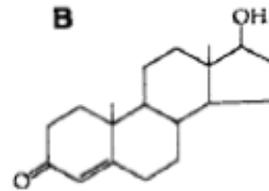


Papel dos testículos na definição das características sexuais secundárias de galos

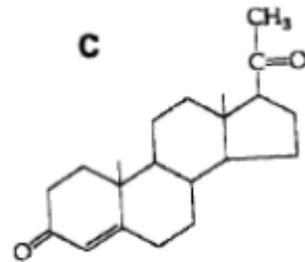
Principais esteroides gonadais



Estradiol

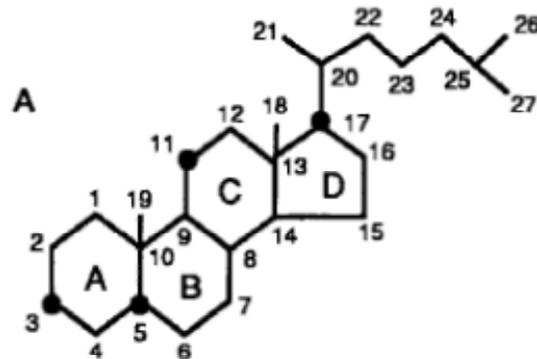


Testosterona



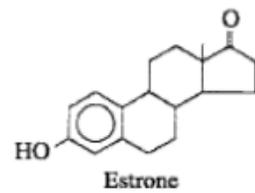
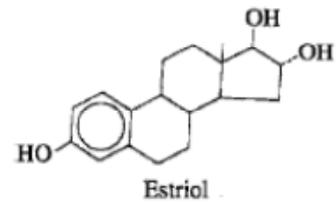
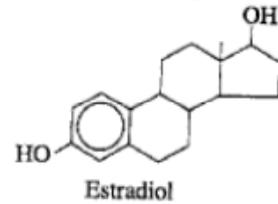
Progesterona

Estrutura do "núcleo" de um esteroide



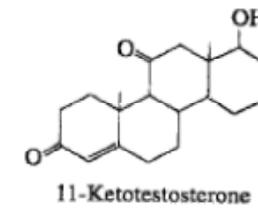
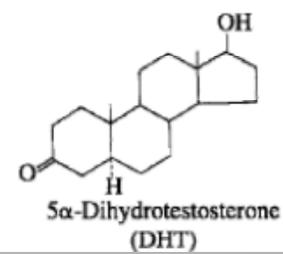
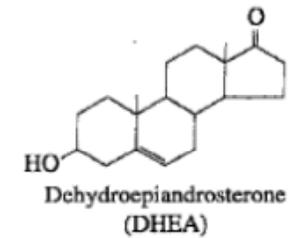
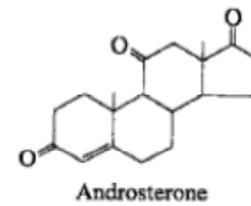
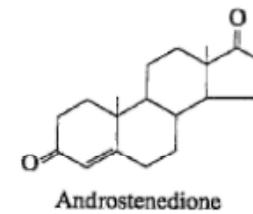
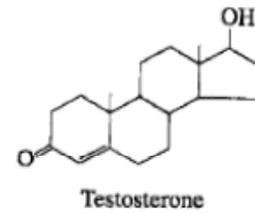
Estrógenos e andrógenos

A Estrogens



18C

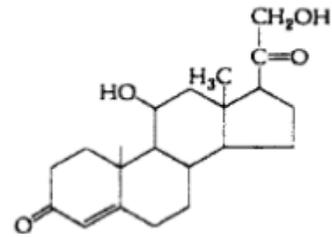
B Androgens



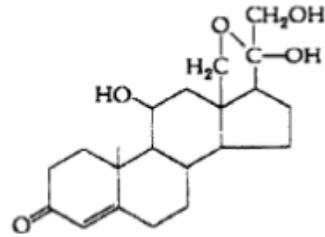
19C

Corticosteroides e Progestágenos

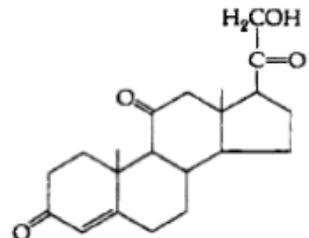
A Corticosteroids



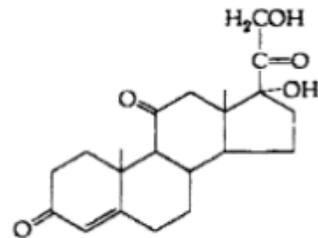
Corticosterone (B)



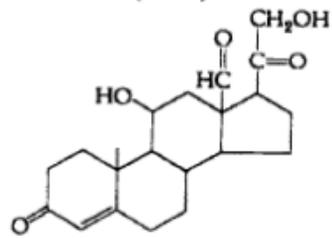
18-Hydroxycorticosterone



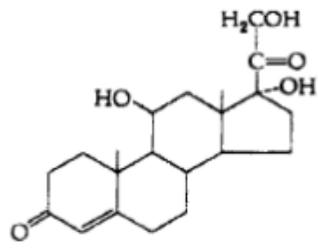
Dehydrocorticosterone (DOC)



Cortisone

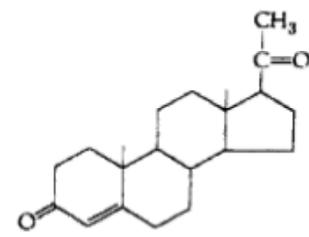


Aldosterone

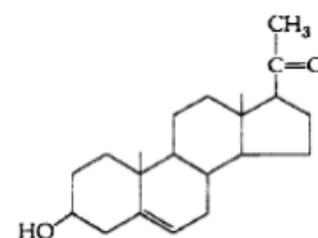


Cortisol (F)

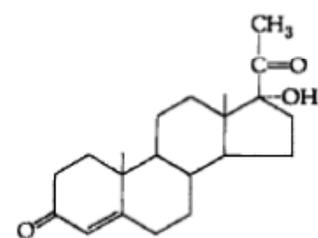
B Progestogens



Progesterone



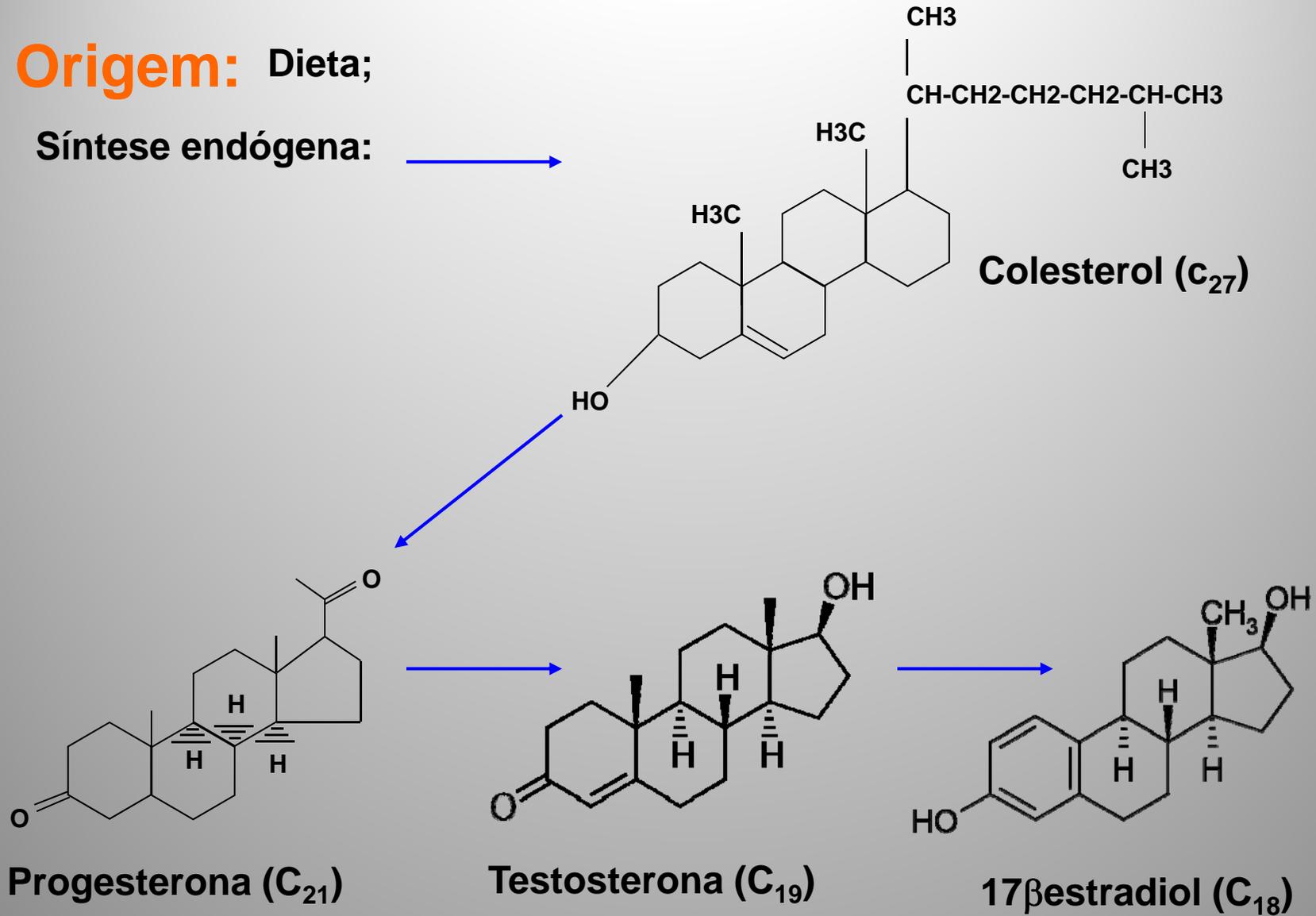
Pregnenolone



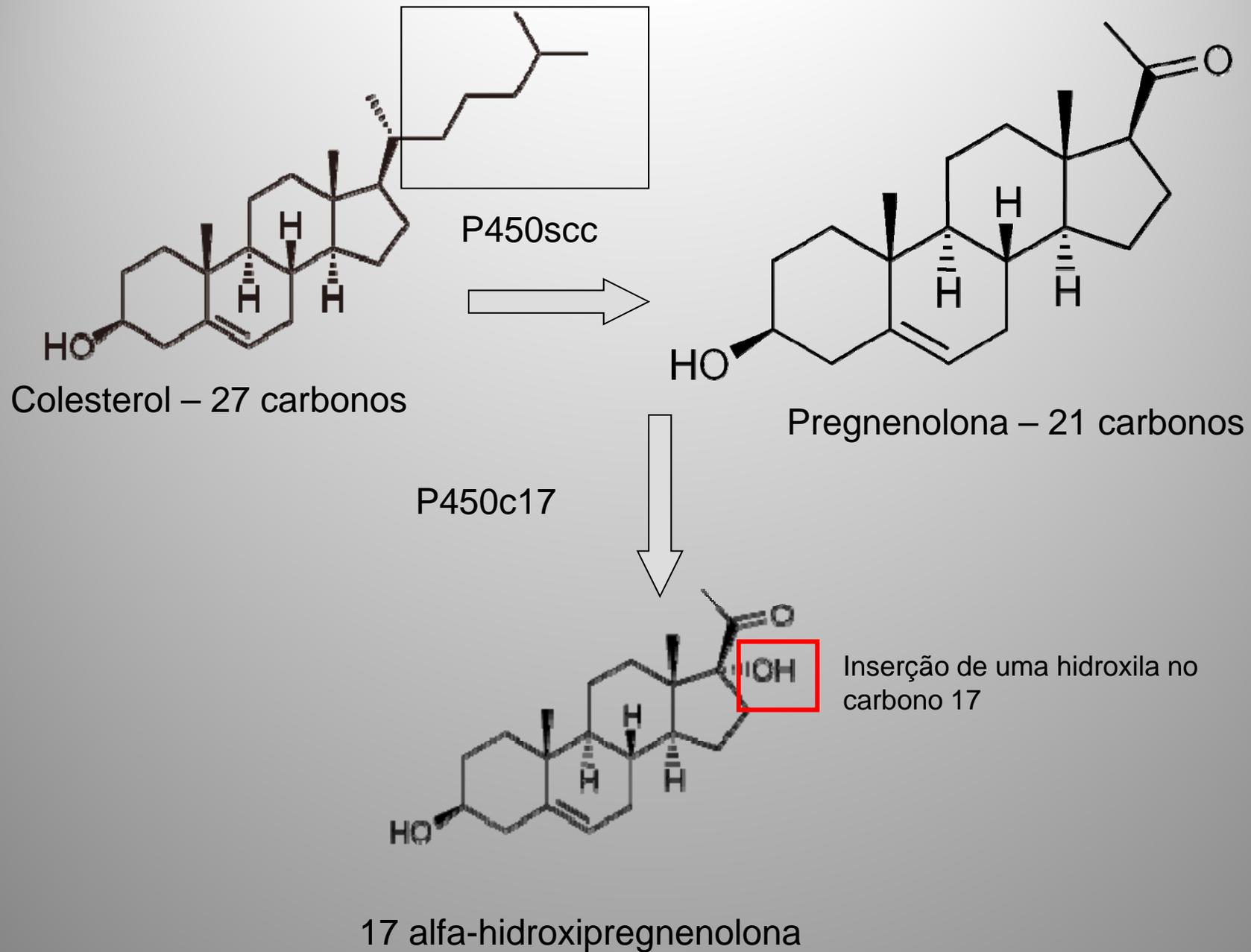
17 α -Hydroxyprogesterone

Origem: Dieta;

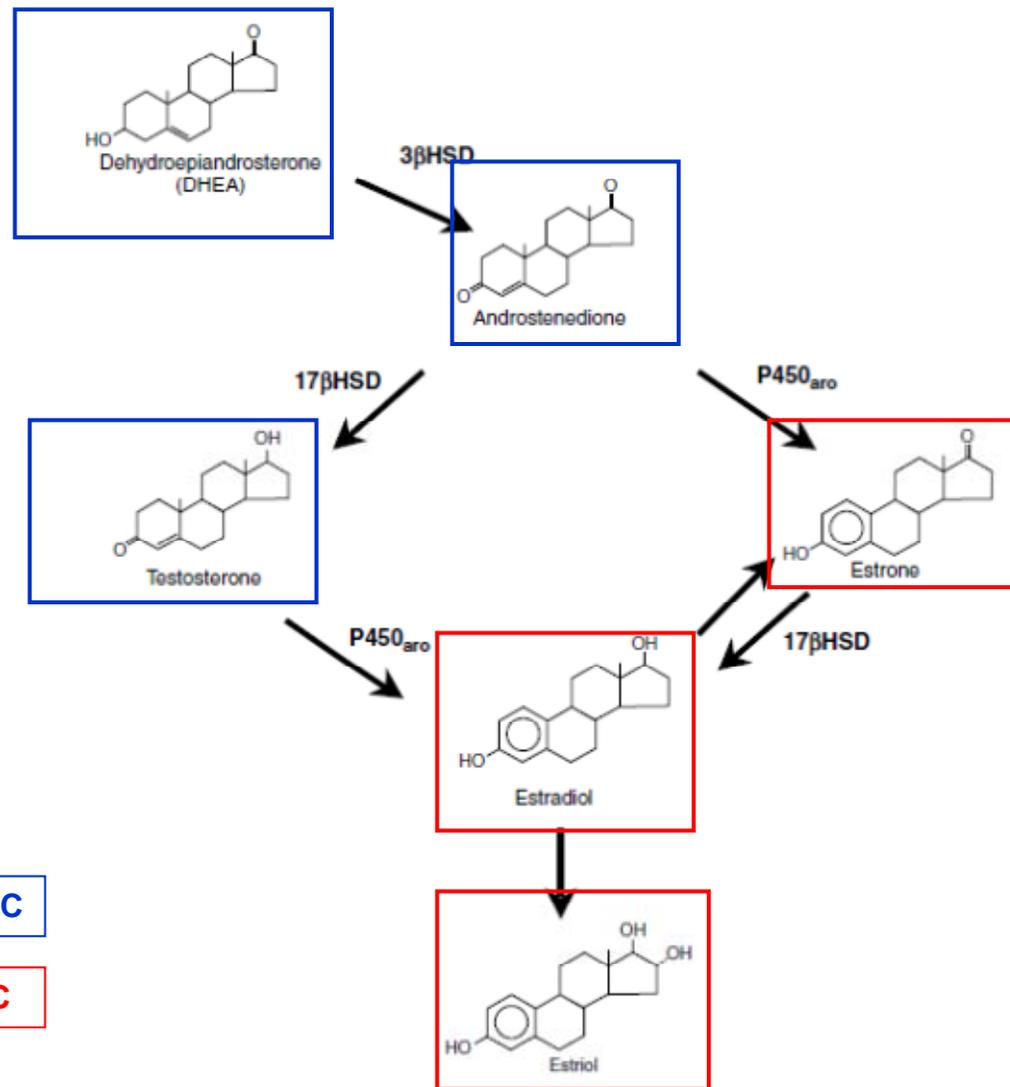
Síntese endógena:



“corte” de 6 carbonos



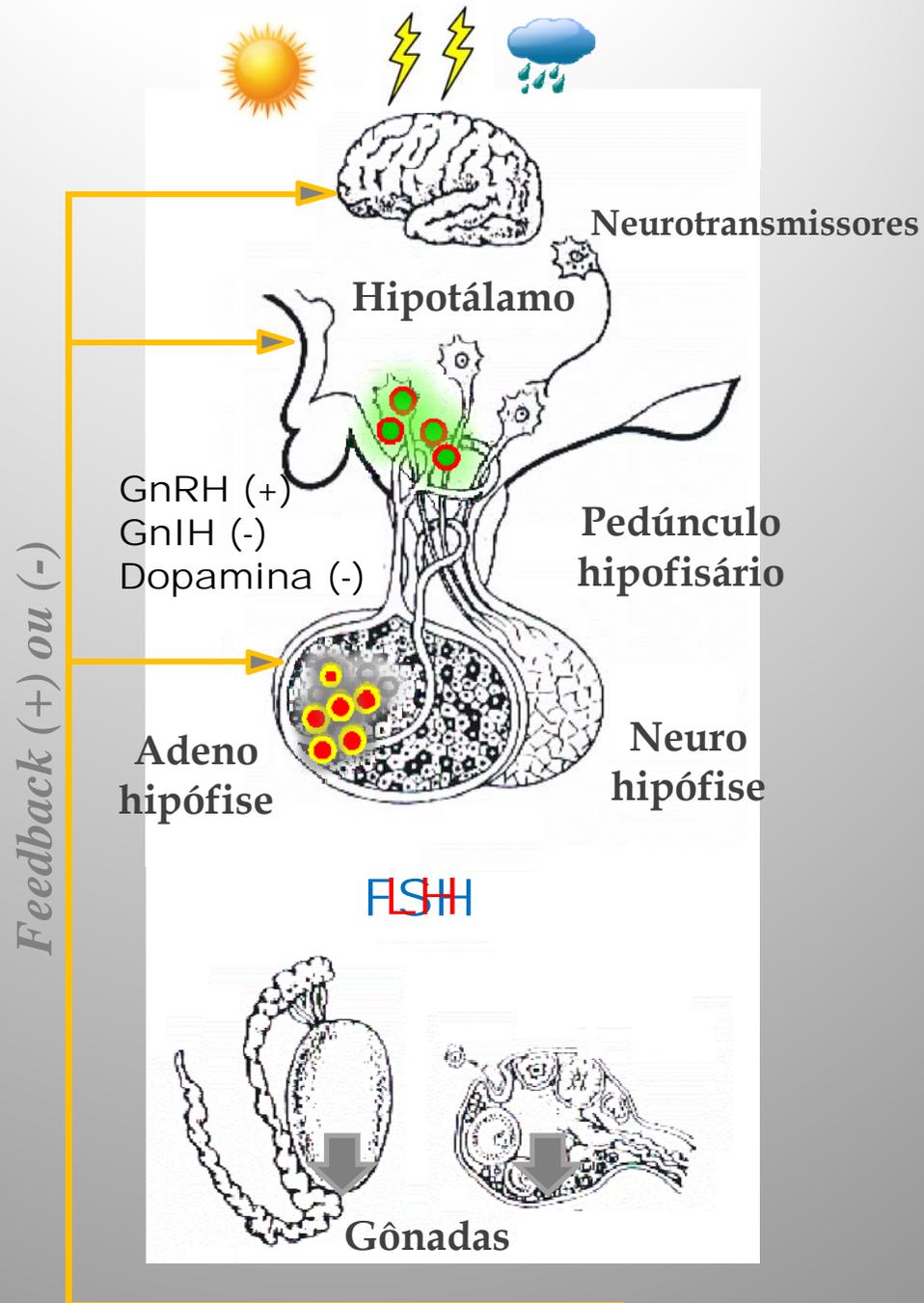
Síntese de estrógenos a partir de andrógenos



Andrógenos – 19 C

Estrógenos – 18 C

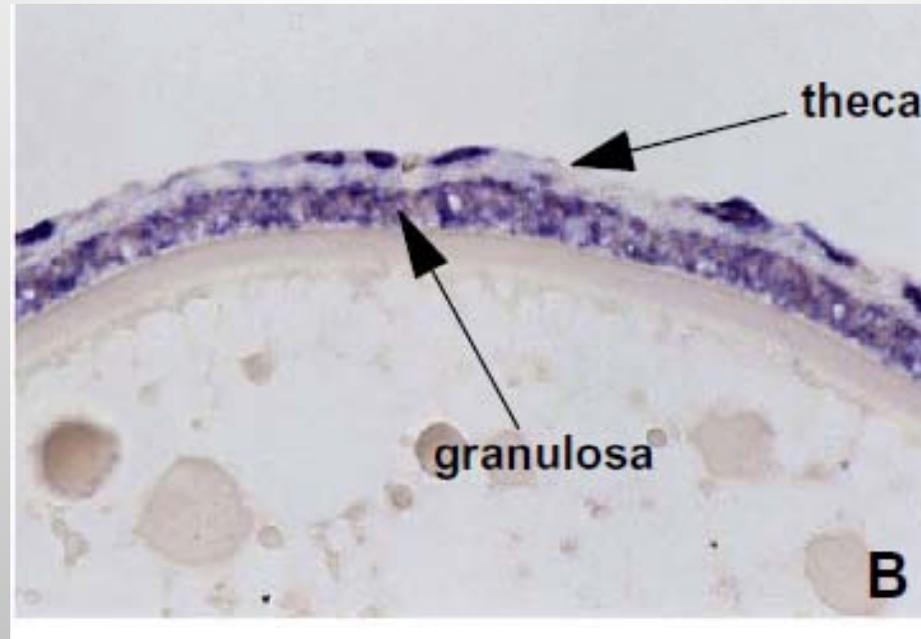
Eixo Hipotálamo-Hipófise-Gônadas no Controle da Reprodução em Vertebrados



Esteroides Gonadais

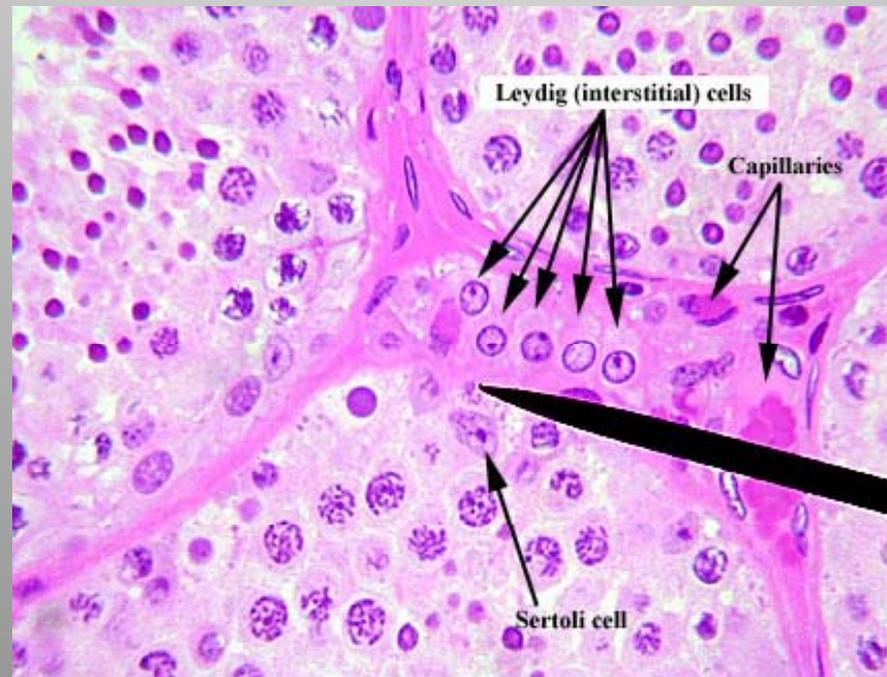
(Medrado, 2014)

Folículo ovariano



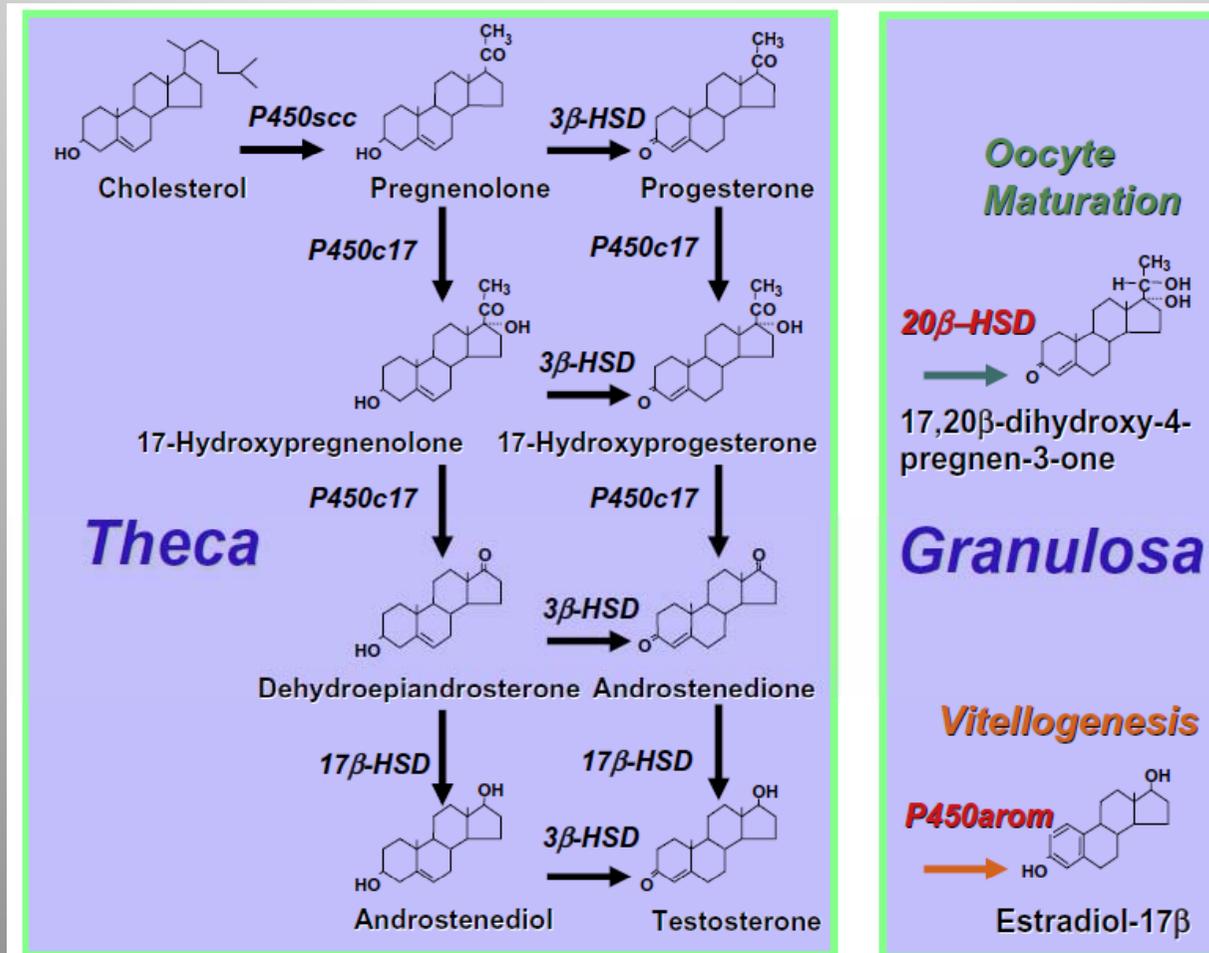
(Lubzens et al.,
2010)

Testículo



(www.pixgood.com)

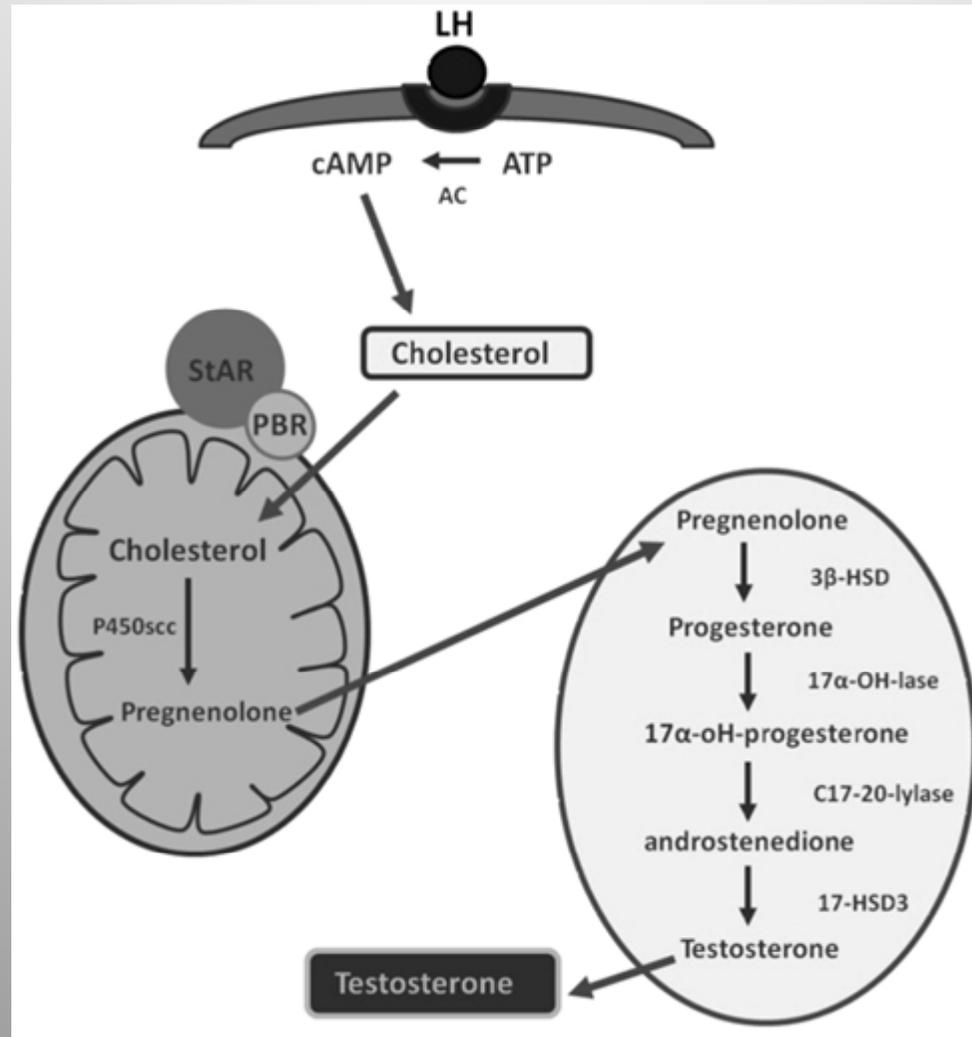
Esteroidogênese nas células foliculares



Processo conservado na escala filogenética

(Lubzens et al., 2010)

Esteroidogênese na célula de Leydig



Principais esteroides na gametogênese dos vertebrados:

Estrógenos

17 β - Estradiol é o estrógeno mais importante em todos os grupos

Andrógenos

Teleósteos – 11 ceto-testosterona

Anuros - 5 α - dihidrotestosterona

Urodélos - 11 β -hidroxitesterona

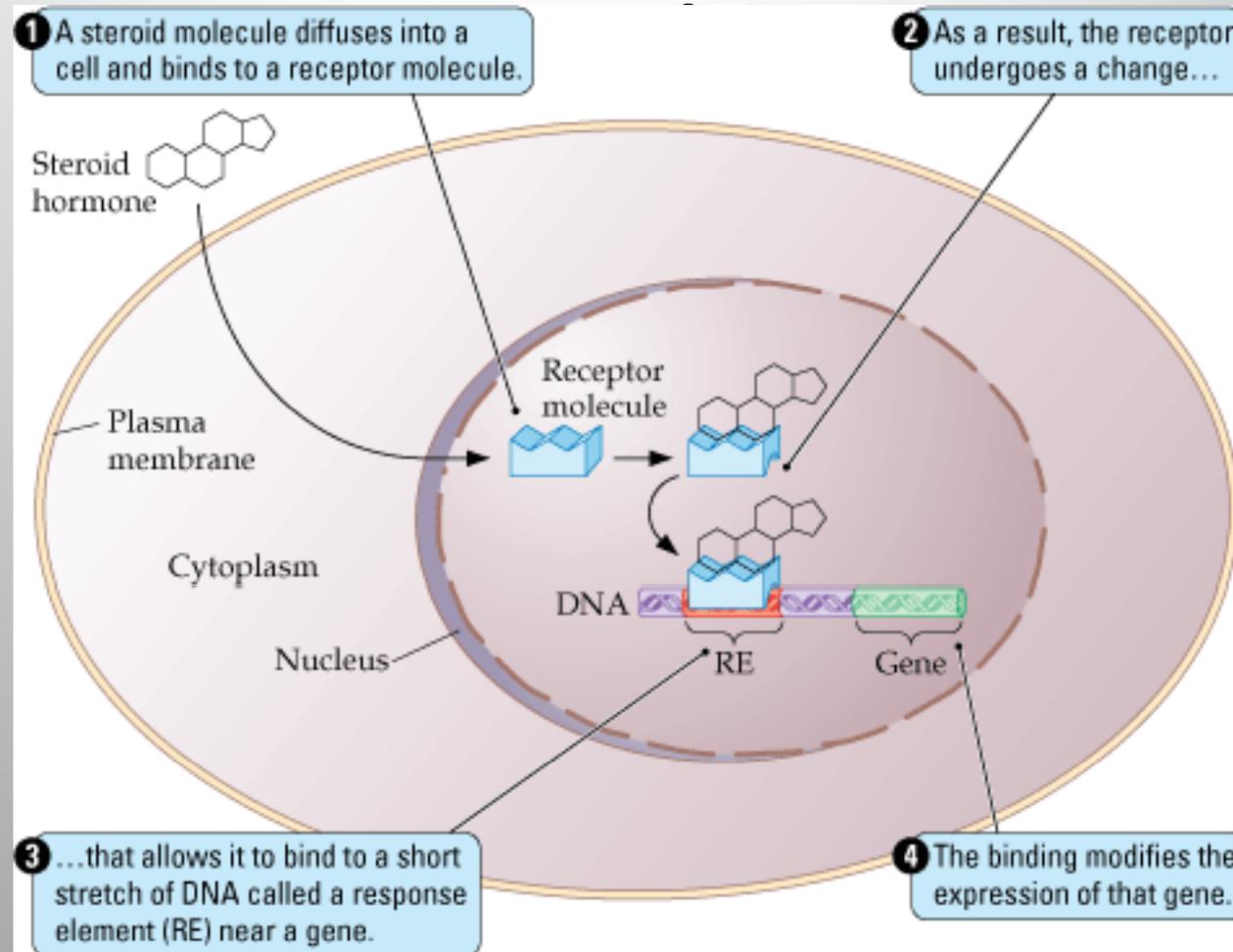
Em répteis, aves e mamíferos o andrógeno mais importante é a testosterona

Progestágenos

Teleósteos – 17 α -20 β dihidroxi-4-pregnen-3-one

Nos demais vertebrados o progestágeno mais importante é a progesterona;

Mecanismo clássico de ação dos esteroides



Hormônios esteroides formam complexos com seus receptores (no citoplasma ou no núcleo)

-Receptores intracelulares – Ashburner et al. (1974) estudando ecdisona em mosquitos (*Chironomus*) sugeriram a ação deste hormônio em genes



Paraskev
a

-Ações rápidas dos esteroides foram relatadas pela primeira vez em oócitos de *Xenopus* (Godeau et al. 1978).

Proc. Natl. Acad. Sci. USA
Vol. 75, No. 5, pp. 2353–2357, May 1978
Cell Biology

Induction of maturation in *Xenopus laevis* oocytes by a steroid linked to a polymer

(mechanism of progesterone action/meiosis/plasma membrane/immobilized hormones/polyethylene oxide)

J. FRANCOIS GODEAU*, SABINE SCHORDERET-SLATKINE†, PATRICK HUBERT‡,
AND ETIENNE-EMILE BAULIEU*



Tiegarten

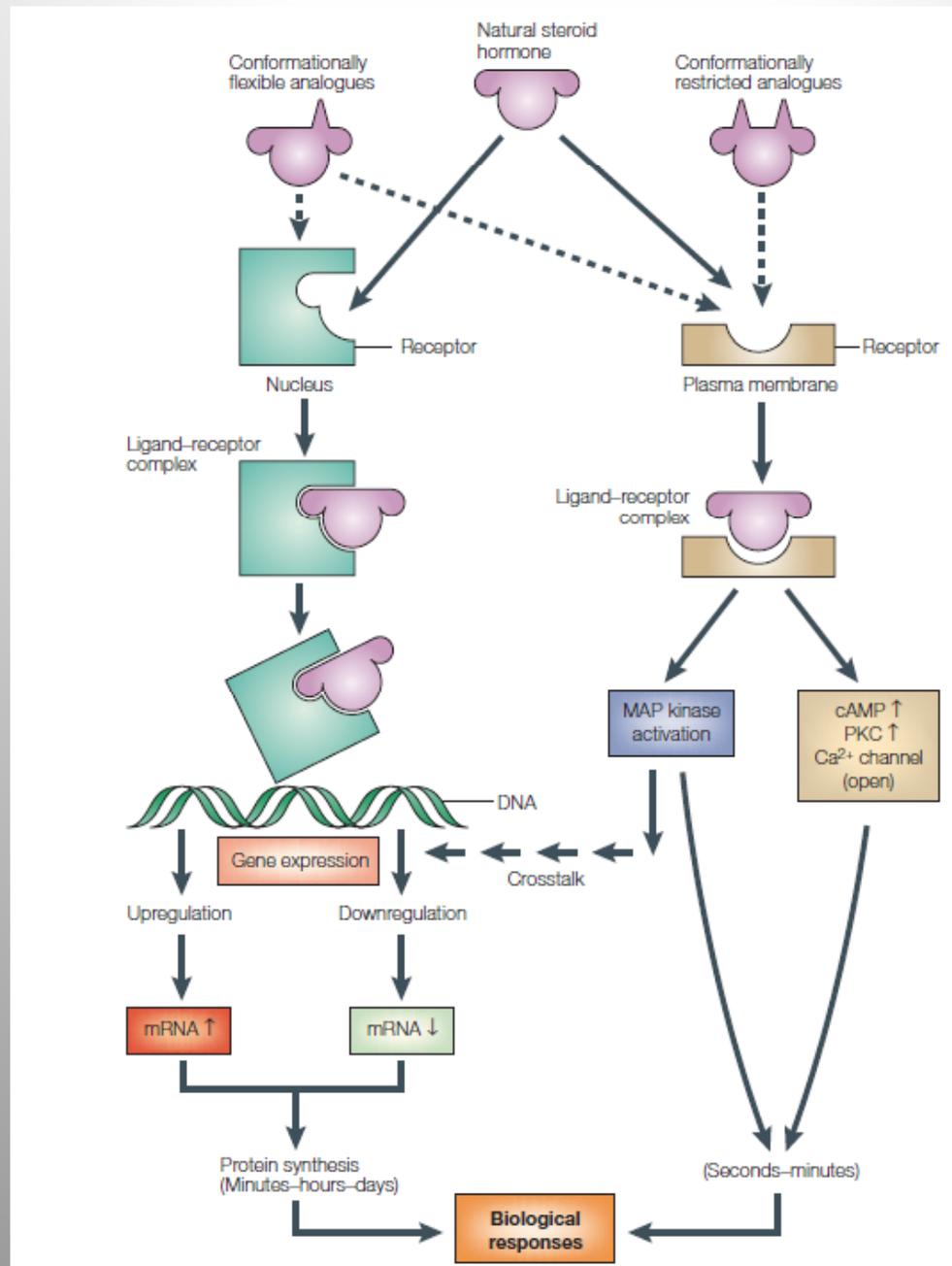
Receptores de membrana para corticosteroide sugeridos em neurônios de *Taricha granulosa* (1991)



A Corticosteroid Receptor in Neuronal Membranes

MILES ORCHINIK,* THOMAS F. MURRAY, FRANK L. MOORE

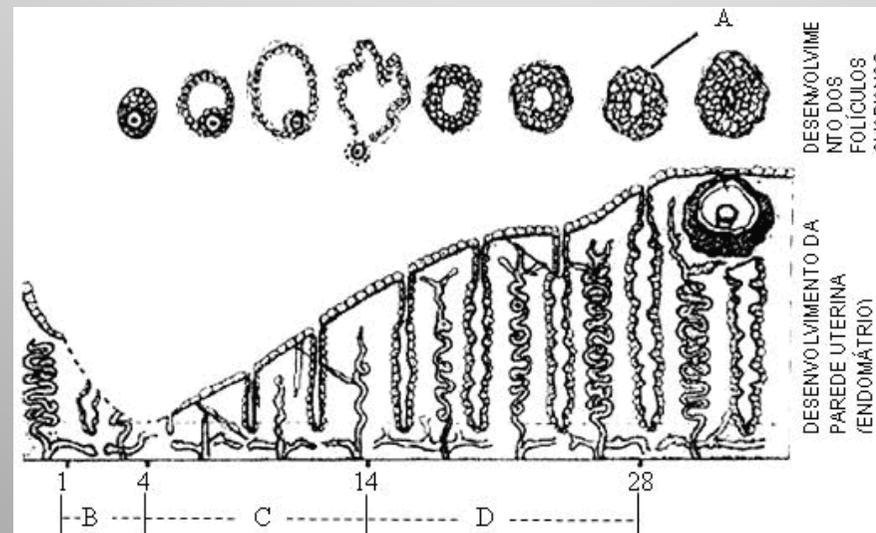
Steroids may rapidly alter neuronal function and behavior through poorly characterized, direct actions on neuronal membranes. The membrane-bound receptors mediating these behavioral responses have not been identified. [³H]Corticosterone labels a population of specific, high-affinity recognition sites (dissociation constant = 0.51 nanomolar) in synaptic membranes from an amphibian brain. These binding sites were localized by receptor autoradiography in the neuropil, outside the regions of perikarya. The affinities of corticoids for this [³H]corticosterone binding site were linearly related to their potencies in rapidly suppressing male reproductive behavior. Thus, it appears that brain membranes contain a corticosteroid receptor that could participate in the regulation of behavior.



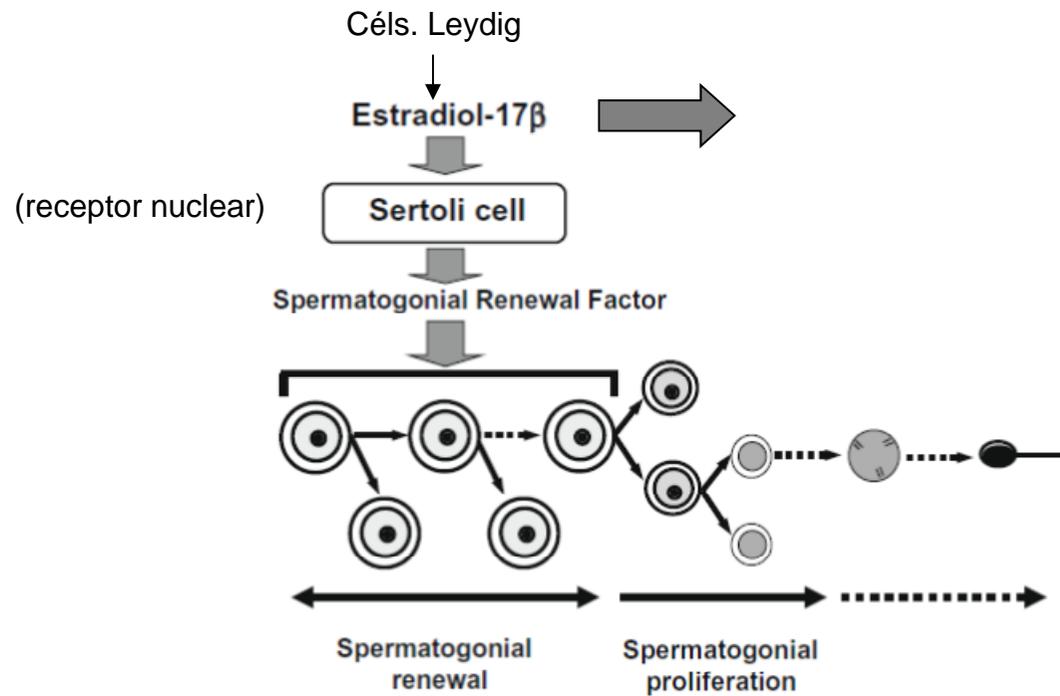
(Norman et al., 2004)

Funções dos estrógenos

- Estimula o desenvolvimento do endométrio;

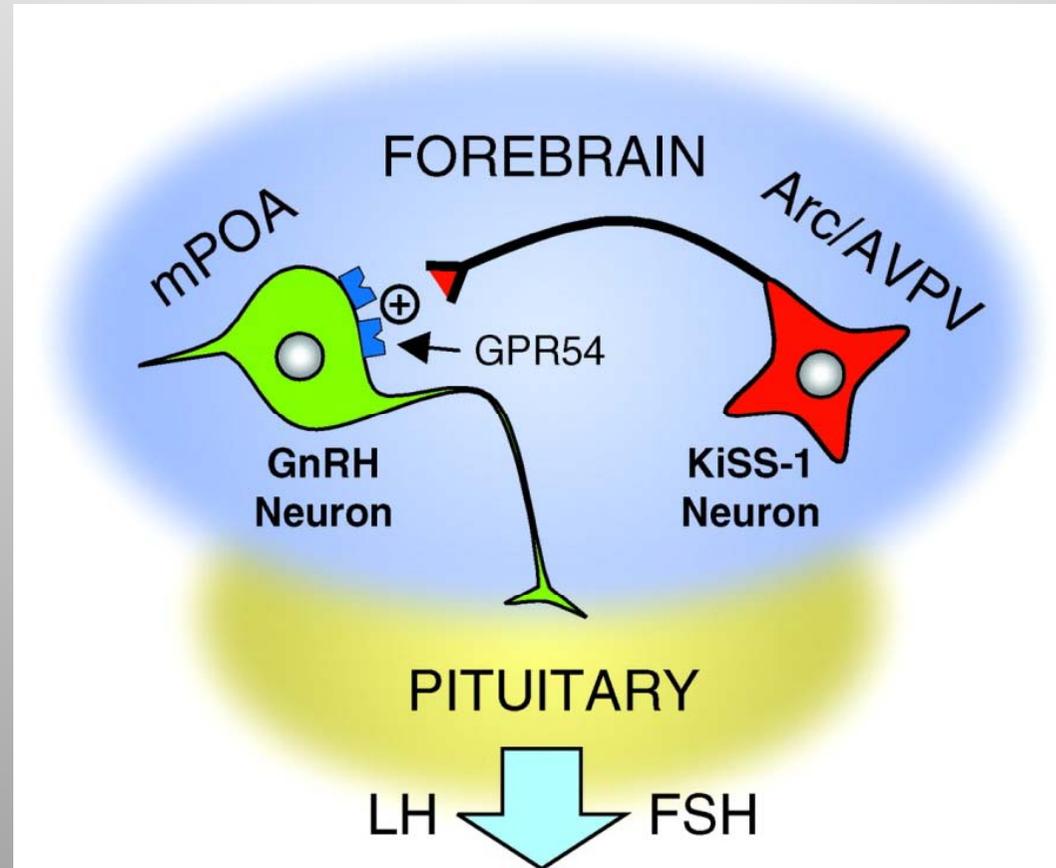


Papel dos estrógenos em machos



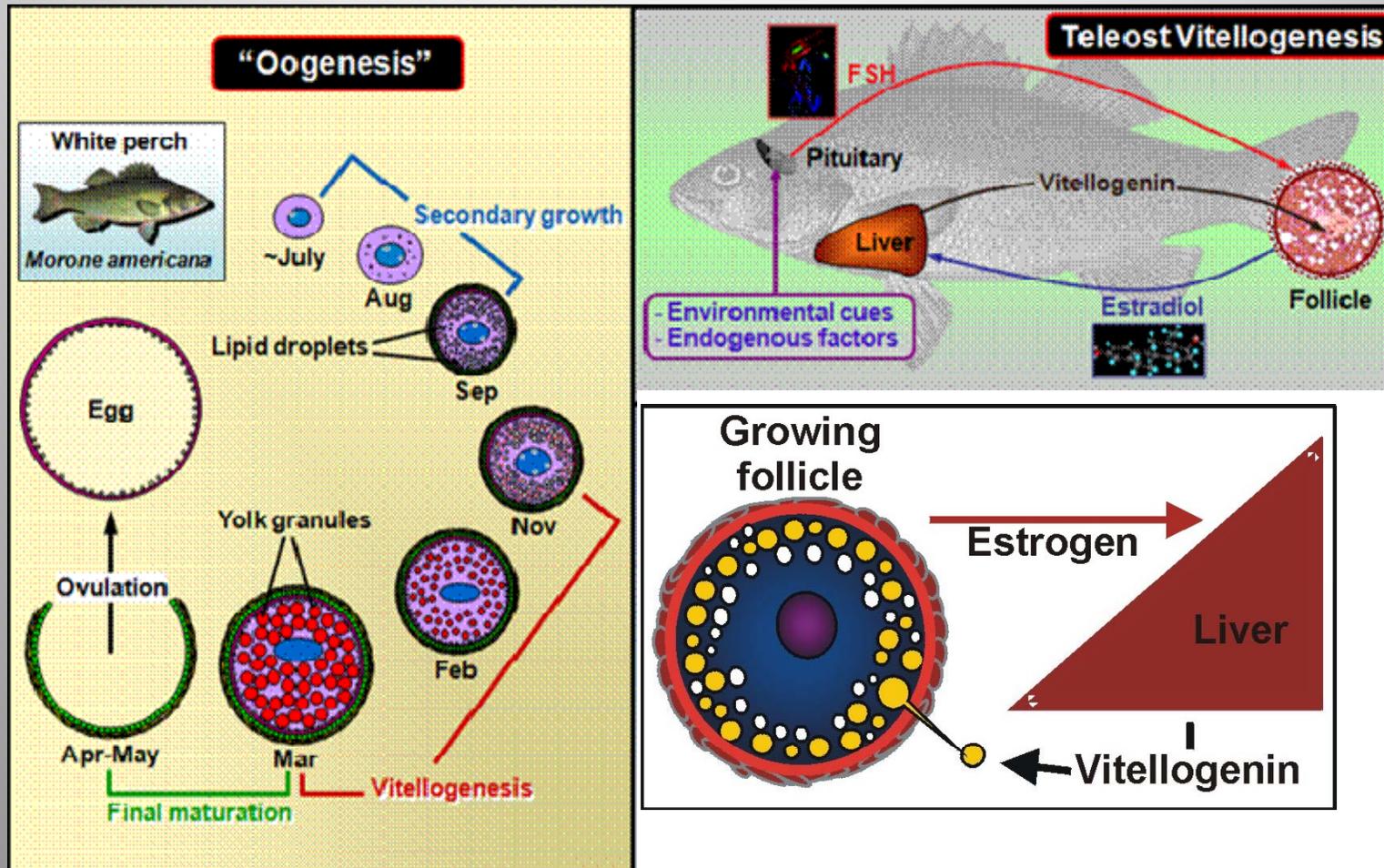
Schulz et al., (2010)

Modulação do eixo H-H-G via feedback negativo;



Feedback dos esteroides gonadais na modulação do eixo H-H-G

Estimula a síntese de vitelogenina hepática;



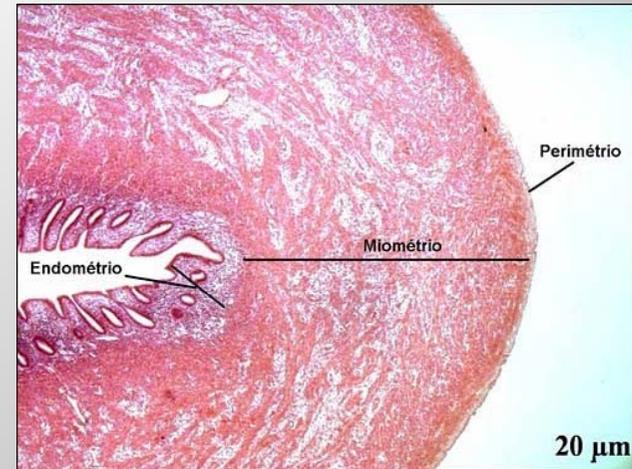
Estradiol estimula a vitelogenese em espécies ovíparas

(Jackson and Sullivan, 1995)

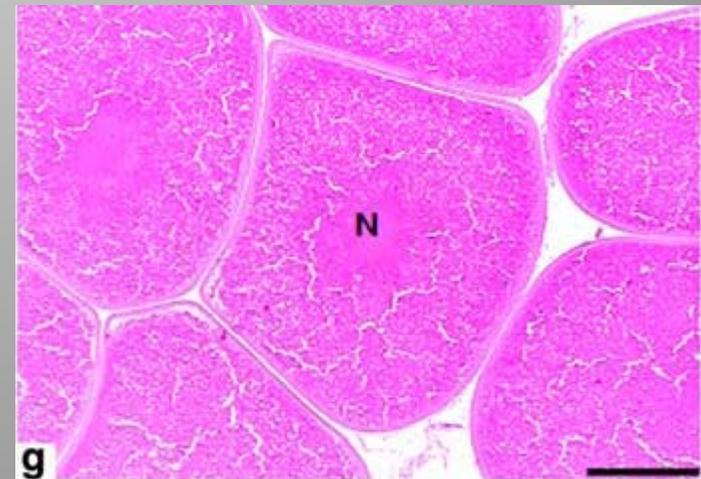
FUNÇÃO DO ESTRADIOL

- ÚTERO DE MAMÍFEROS

X

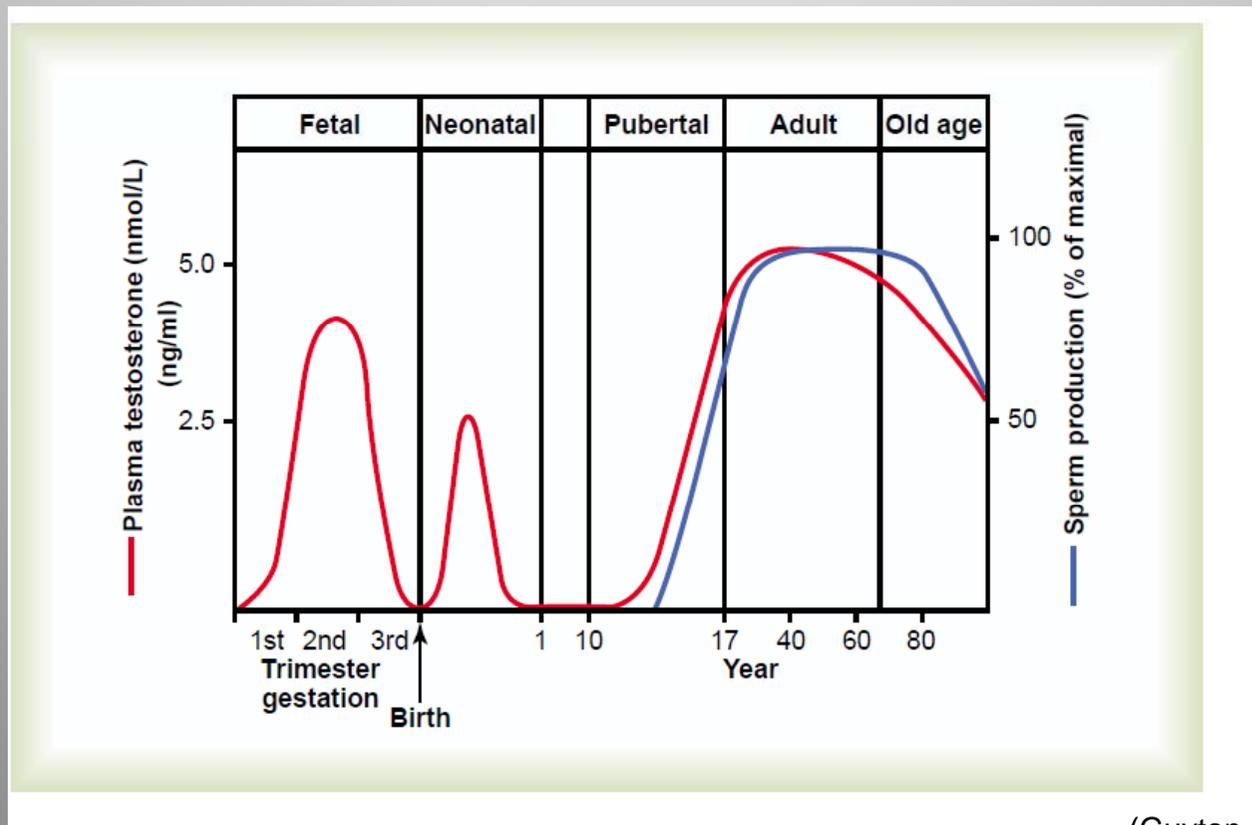


- VERTEBRADOS OVÍPAROS??



Função dos andrógenos

- Espermatogênese;
- Características sexuais secundárias;
- Modula o comportamento reprodutivo em machos;

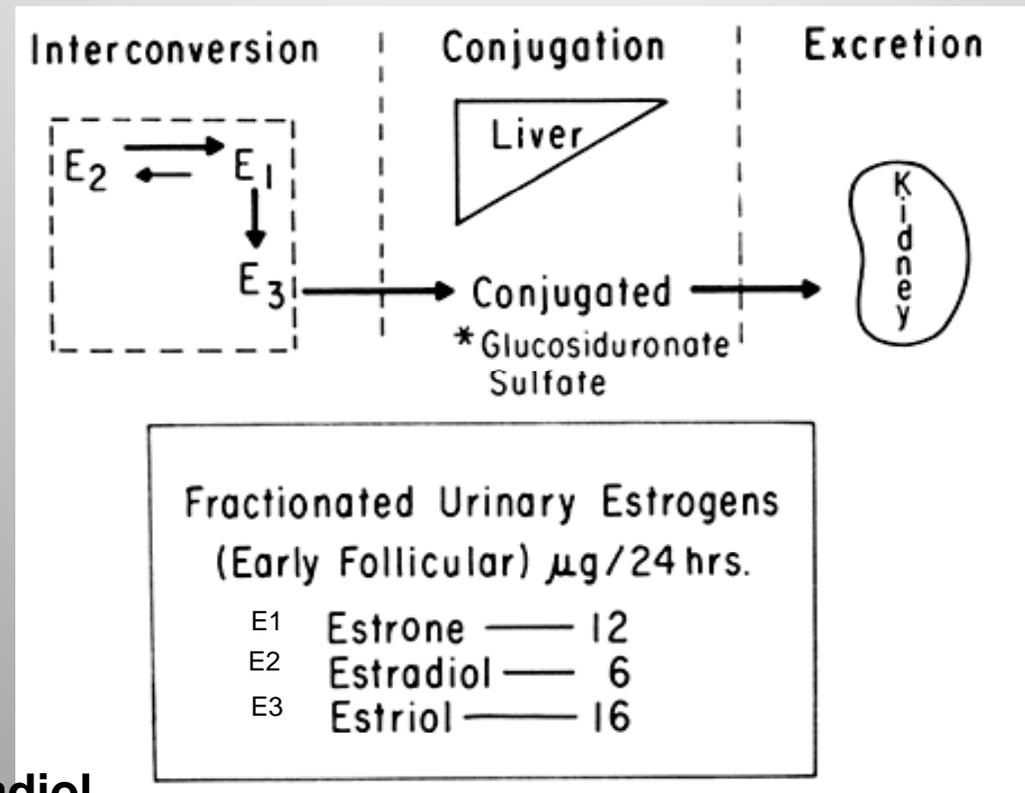


(Guyton and Hall, 2006)

Função dos Progestágenos

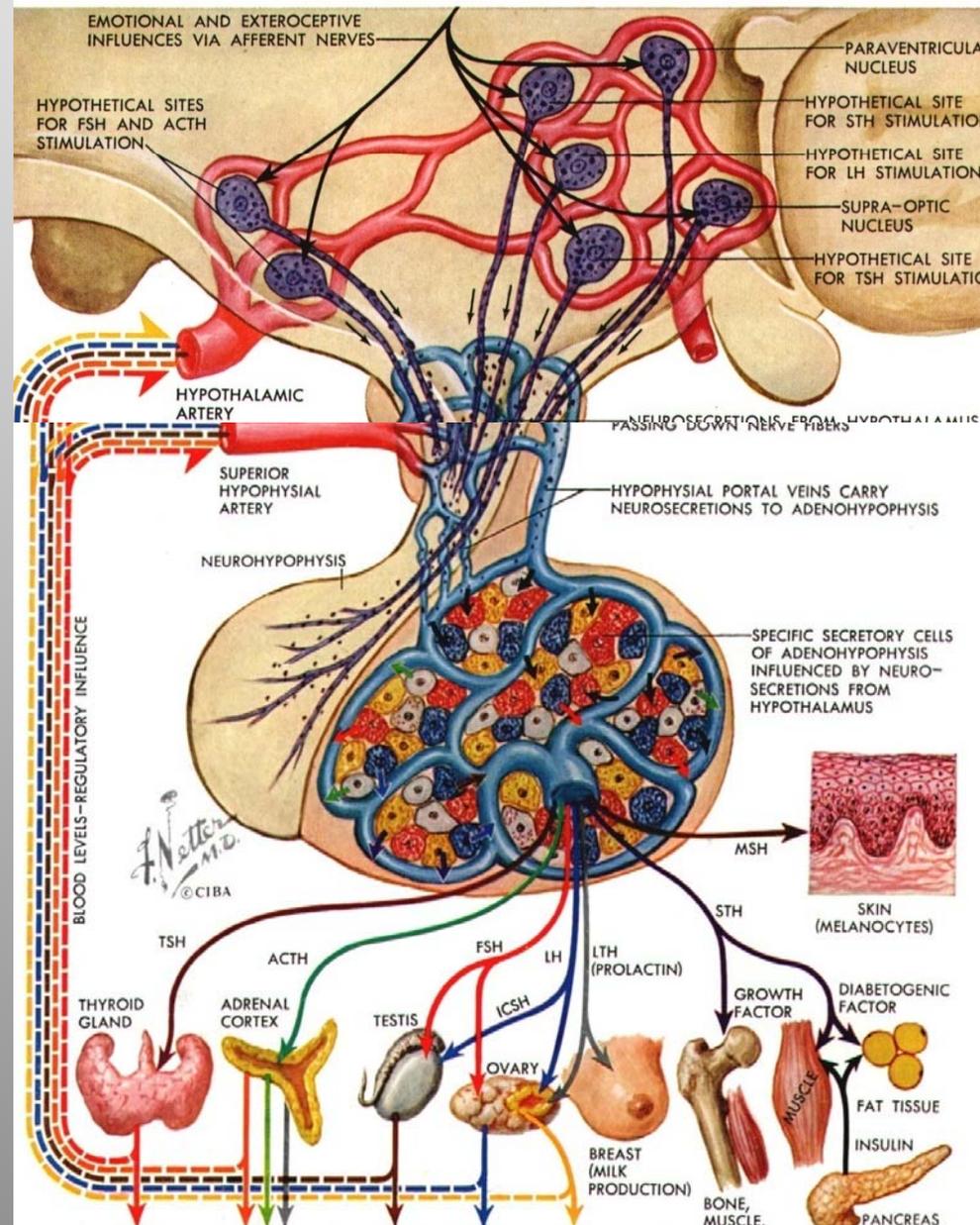
- Promove as alterações secretórias no endométrio durante a fase pós-ovulatória, preparando o útero para nidação;
- Motilidade dos espermatozoides e reação acrossômica;
- Cuidado parental

Excreção dos esteroides



Ex. estradiol

CONTROLE HIPOTALÂMICO



Hipotálamo

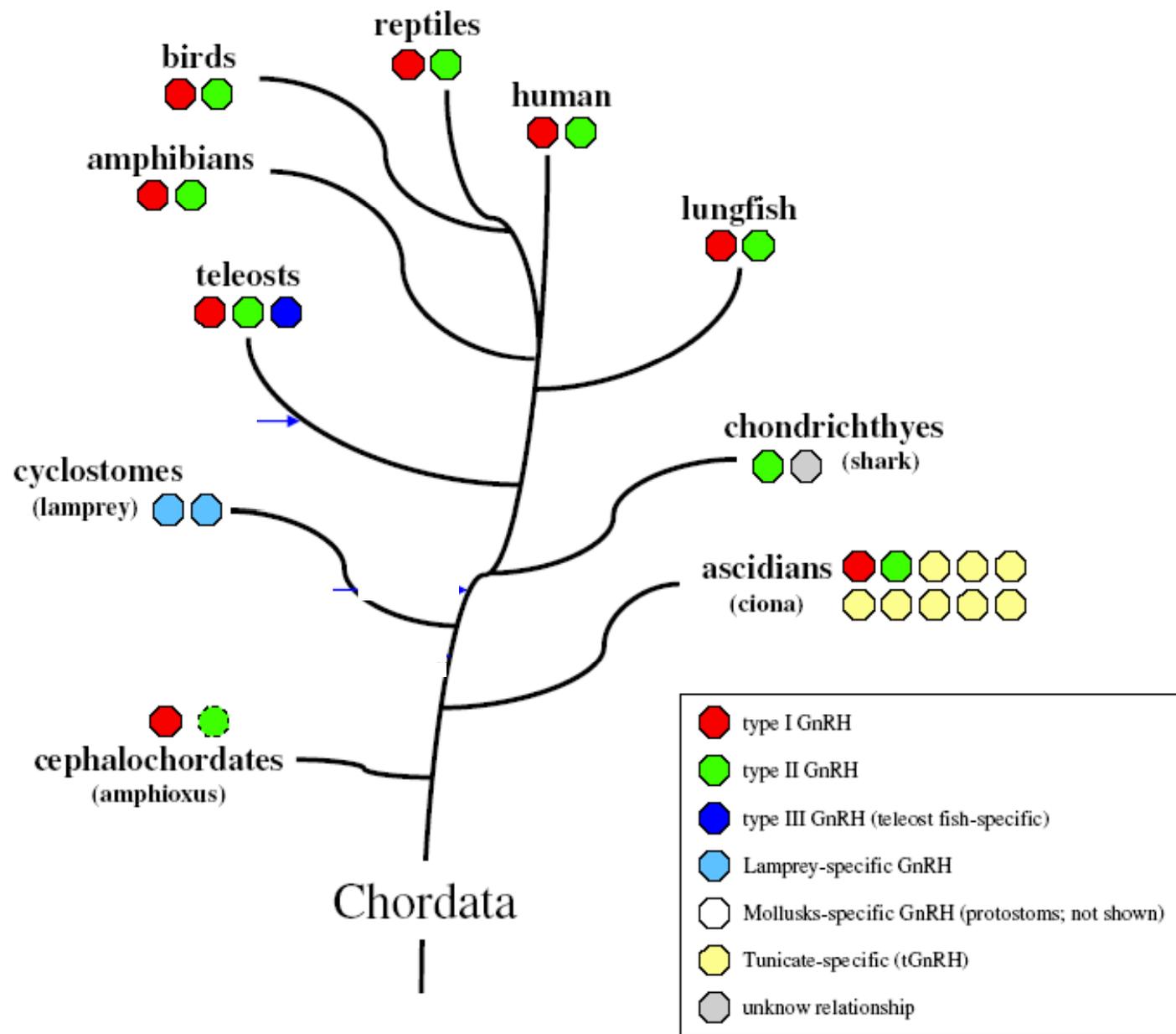
GnRH - Hormônio Liberador de Gonadotropina

Mamífero	pGlu	His	Trp	Ser	Tyr	Gly	Leu	Arg	Pro	Gly
<i>seabream</i>	pGlu	His	Trp	Ser	Tyr	Gly	Leu	Ser	Pro	Gly
salmão	pGlu	His	Trp	Ser	Tyr	Gly	Trp	Leu	Pro	Gly
enguia I	pGlu	His	Tyr	Ser	Leu	Glu	Trp	Lys	Pro	Gly
enguia III	pGlu	His	Trp	Ser	His	Asp	Trp	Lys	Pro	Gly
<i>dogfish</i>	pGlu	His	Trp	Ser	His	Gly	Trp	Leu	Pro	Gly
frango I	pGlu	His	Trp	Ser	Tyr	Gly	Leu	Gln	Pro	Gly
frango II	pGlu	His	Trp	Ser	His	Gly	Trp	Tyr	Pro	Gly

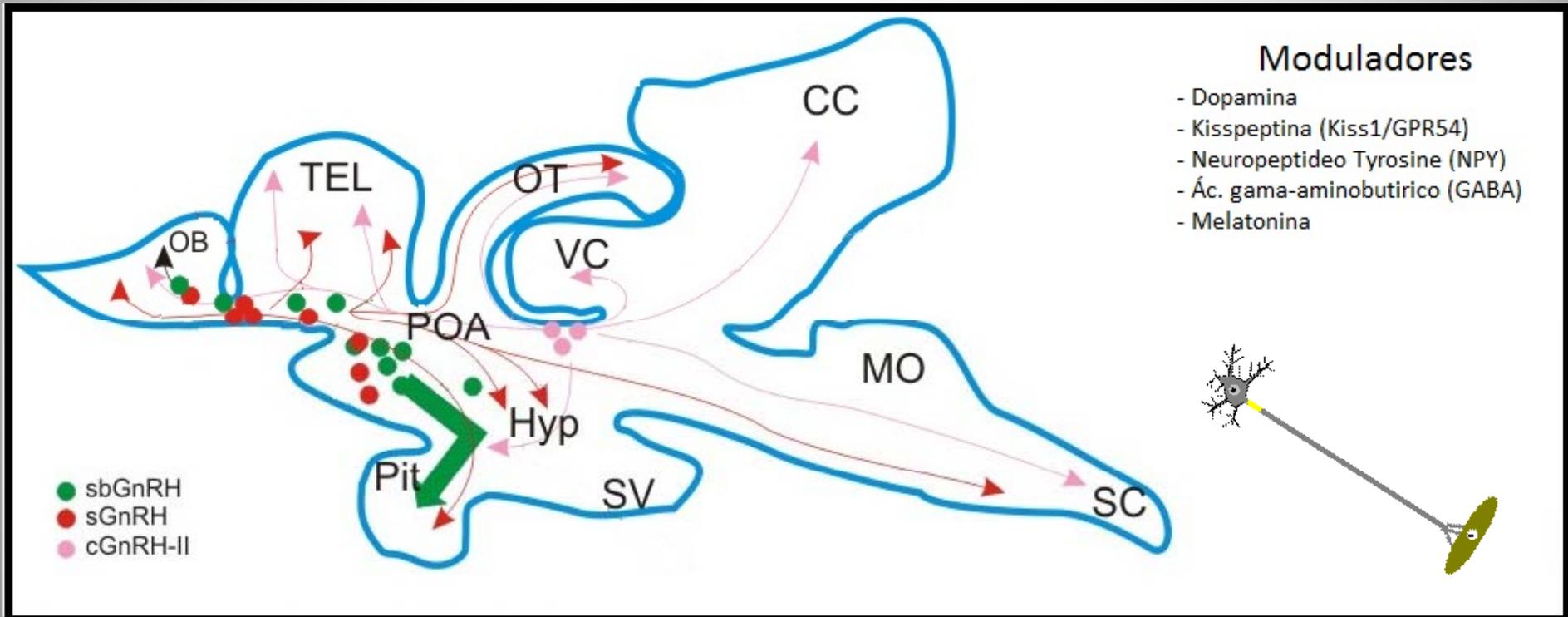
Sequência de aminoácidos de formas de GnRH conhecidos em Vertebrados e Urocordados

Animal	Aminoácidos												
	1	2	3	4	5	6	7	8	9	10			
Mamífero	pGlu	His	Trp	Ser	Tyr	Gly	Leu	Arg	Pro	Gly	NH ₂		
Whitefish	pGlu	His	Trp	Ser	Tyr	Gly	Met	Asn	Pro	Gly	NH ₂		
Salmon	pGlu	His	Trp	Ser	Tyr	Gly	Trp	Leu	Pro	Gly	NH ₂		
Sea Bream	pGlu	His	Trp	Ser	Tyr	Gly	Leu	Ser	Pro	Gly	NH ₂		
Pejerrey	pGlu	His	Trp	Ser	Phe	Gly	Leu	Ser	Pro	Gly	NH ₂		
Herring	pGlu	His	Trp	Ser	His	Gly	Leu	Ser	Pro	Gly	NH ₂		
Catfish	pGlu	His	Trp	Ser	His	Gly	Leu	Asn	Pro	Gly	NH ₂		
Dogfish	pGlu	His	Trp	Ser	His	Gly	Trp	Leu	Pro	Gly	NH ₂		
Chicken-II	pGlu	His	Trp	Ser	His	Gly	Trp	Tyr	Pro	Gly	NH ₂		
Lamprey-III	pGlu	His	Trp	Ser	His	Asp	Trp	Lys	Pro	Gly	NH ₂		
Lamprey-I	pGlu	His	Tyr	Ser	Leu	Glu	Trp	Lys	Pro	Gly	NH ₂		
Guinea Pig	pGlu	Tyr	Trp	Ser	Tyr	Gly	Val	Arg	Pro	Gly	NH ₂		
Chicken-I	pGlu	His	Trp	Ser	Tyr	Gly	Leu	Gln	Pro	Gly	NH ₂		
Frog	pGlu	His	Trp	Ser	Tyr	Gly	Leu	Trp	Pro	Gly	NH ₂		
Tunicata-1	pGlu	His	Trp	Ser	Asp	Tyr	Phe	Lys	Pro	Gly	NH ₂		
Tunicata-2	pGlu	His	Trp	Ser	Leu	Cys	His	Ala	Pro	Gly	NH ₂		
Tunicata-3	pGlu	His	Trp	Ser	Tyr	Glu	Phe	Met	Pro	Gly	NH ₂		
Tunicata-4	pGlu	His	Trp	Ser	Asn	Gln	Leu	Thr	Pro	Gly	NH ₂		
Tunicata-5	pGlu	His	Trp	Ser	Tyr	Glu	Tyr	Met	Pro	Gly	NH ₂		
Tunicata-6	pGlu	His	Trp	Ser	Lys	Gly	Tyr	Ser	Pro	Gly	NH ₂		
Tunicata-7	pGlu	His	Trp	Ser	Tyr	Ala	Leu	Ser	Pro	Gly	NH ₂		
Tunicata-8	pGlu	His	Trp	Ser	Leu	Ala	Leu	Ser	Pro	Gly	NH ₂		
Tunicata-9	pGlu	His	Trp	Ser	Asn	Lys	Leu	Ala	Pro	Gly	NH ₂		
<i>Octopus vulgaris</i>	pGlu	Asn	Tyr	His	Phe	Ser	Asn	Gly	Trp	His	Pro	Gly	NH ₂
<i>Aplysia californica</i>	pGlu	Asn	Tyr	His	Phe	Ser	Asn	Gly	Trp	Tyr	Ala	Gly	NH ₂

Asp: ácido aspártico; Glu: ácido glutâmico; Arg: arginina; Lys: lisina; His: histidina; Asn: asparagina; Gln: glutamina; Ser: serina; Thr: treonina; Tyr: tirosina; Ala: alanina; Gly: glicina; Val: valina; Leu: leucina; Ile: isoleucina; Pro: prolina; Phe: fenilalanina; Met: metionina; Trp: triptofano; Cys: cisteína.



Hipotálamo



CC: corpo do cerebelo; **Hyp**: hipotálamo; MO: medula oblonga; OB: bulbo olfatório; OT: teto óptico; Pit: hipófise;
POA: área preoptica; SV: saco vasculoso; Tel: telencéfalo; SC: medula espinhal; VC: valvula do cerebelo;

Retirado e modificado de Zohar *et al.* 2009

GnIH em vertebrados

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Minireview

Evolutionary origin and divergence of GnIH and its homologous peptides

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Table 1

Amino acid sequences of GnIH and its homologous peptides (LPXRFamide peptides) in vertebrates.

Animal	Name	Sequence	Reference
Rat	RFRP-1*	SVTFQELKDWGAKKDIKMSPAPANKVPHSAANLPLRFa	Hinuma et al. (2000)
	RFRP-3	ANMEAGTMSHFPSLPQRFa	Ukena et al. (2002)
Hamster	RFRP-1*	SPAPANKVPHSAANLPLRFa	Kriegsfeld et al. (2006)
	RFRP-3*	TLSRVPSLPQRFa	Kriegsfeld et al. (2006)
Bovine	RFRP-1	SLTFEEVKDWAPKIKMKNKPVVNMPPSAANLPLRFa	Fukusumi et al. (2001)
	RFRP-3	AMAHLPRLGKNREDSLSRWVVPNLQRFa	Yoshida et al. (2003)
Quail	GnIH	SIKPSAYLPLRFa	Tsutsui et al. (2000)
	GnIH-RP-1*	SLNFEEMKDWGSKNFMKVNTPTVNKVPNSVANLPLRFa	Satake et al. (2001)
	GnIH-RP-2	SSIQSLNLQRFa	Satake et al. (2001)
Sparrow	GnIH*	SIKPFNSLPLRFa	Osugi et al. (2004)
	GnIH-RP-1*	SLNFEEMEDWGSKDIIKMNPFASKMPNSVANLPLRFa	Osugi et al. (2004)
	GnIH-RP-2*	SPLVKGSSQSLLNLQRFa	Osugi et al. (2004)
Bullfrog	fGRP	SLKPAANLPLRFa	Koda et al. (2002)
	fGRP-RP-1	SIPNLQRFa	Ukena et al. (2003a)
	fGRP-RP-2	YLSGKTKVQSMANLPQRFa	Ukena et al. (2003a)
	fGRP-RP-3	AQYTNHFVHSLDTLPLRFa	Ukena et al. (2003a)
Goldfish	goldfish LPXRFa-1*	PTHLHANLPLRFa	Sawada et al. (2002b)
	goldfish LPXRFa-2*	AKSNINLPQRFa	Sawada et al. (2002b)
	goldfish LPXRFa-3	SGTGLSATLPQRFa	Sawada et al. (2002b)
Hagfish	Hagfish	ALPQRFa	Osugi et al., unpublished data

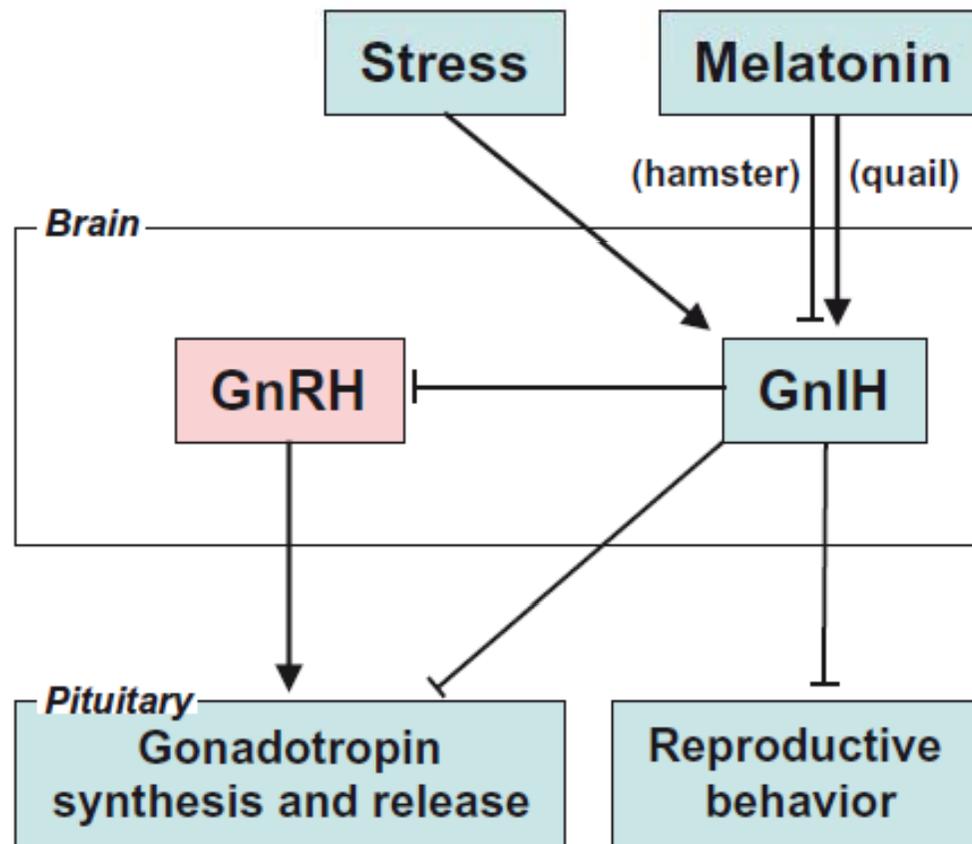


Fig. 1. GnIH actions within the brain and pituitary. GnIH inhibits gonadotropin synthesis and release by directly acting on the pituitary or by inhibiting the activity of GnRH neurons. GnIH can also inhibit reproductive behavior by possibly acting within the brain. Stress induces the expression of GnIH in birds and mammals. Melatonin induces the expression of GnIH in quail, whereas melatonin inhibits the expression of GnIH in hamsters.