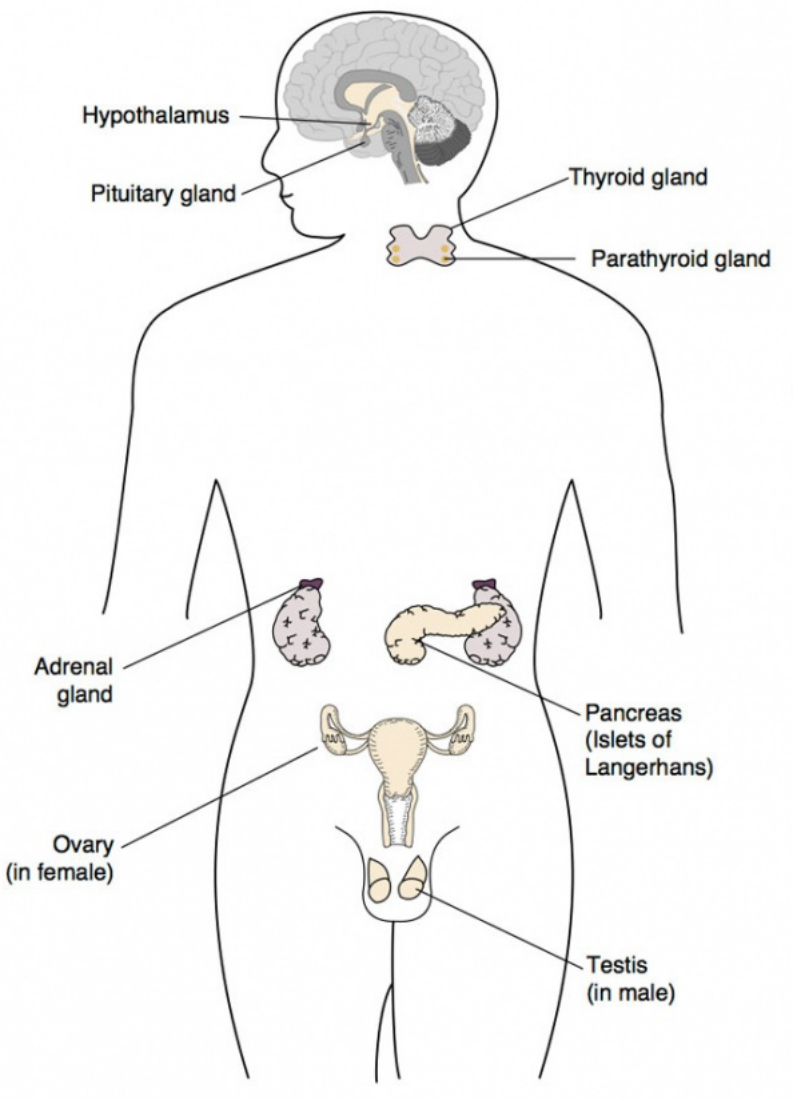
BGD Lecture - Endocrine Development

ExpandEmbryology - 20 May 2019 Expand to Translate
Google Translate - select your language from the list shown below (this will open a new external page)
العربية | català | 中文 | 中國傳統的 | français | Deutsche | עברית | हिंदी | bahasa Indonesia | italiano | 日本語 | 한국어 | မြန်မာ | Pilipino | Polskie | português | ਪੰਜਾਬੀ ਦੇ | Română | русский | Español | Swahili | Svensk | ไทย | Türkçe | | اردو ייִדיש | Tiếng Việt These external translations are automated and may not be accurate. (More? About Translations)

Introduction

BGDB has 2 endocrine related lectures. The first is on endocrine histology (mainly of the HPA axis), the second is endocrine embryology (on this current page).



Hypothalamus endocrine system

This lecture covers endocrine development, note that a better understanding can be made if you understand the adult function of each endocrine organ (though this will not be covered in the Lecture). Endocrine development is sometimes divided into neuroendocrine and endocrine and is also generally covered piecemeal in all embryology textbooks, so you may have to look in several different chapters to find supporting textbook information.

The endocrine system resides within specific endocrine organs and both organs and tissues with other specific functions. Epithelia (ectoderm and

endoderm) form the majority of the “ductless” endocrine glands like gastrointestinal and skin associated “ducted” glands. Differentiation of several organs also involves a epithelial/mesenchye interaction, seen in repeated in many differentiation of many different tissues. The endocrine glands produce hormones, which are distributed by the vascular system to the many body tissues, subsequently these organs are richly vascularized.

Hormones “orchestrate” responses in other tissues, including other endocrine organs, and these overall effects can be similar or different in different tissues. These signaling pathways are often described as "axes" the two major types are the: **HPA** (**H**yothalamus-**P**ituitary-**A**drenal) and **HPG** (**H**ypothalamus-**P**ituitary-**G**onad). These hormone levels and effects (like music) can be rapid, slow, brief, diurnal, or long-term. Hormone effects can be mimicked, stimulated, and blocked by therapeutic drugs, nutritional and environmental chemicals. Importantly, fetal endocrine development is required for normal fetal growth and differentiation.

2019 Lecture Notes (*This notice removed when update completed*)

ExpandEndocrine in the News
Ghassabian A & Trasande L. (2018). Disruption in Thyroid Signaling Pathway: A Mechanism for the Effect of Endocrine-Disrupting Chemicals on Child Neurodevelopment. *Front Endocrinol (Lausanne) , 9*, 204. PMID: 29760680 DOI. "Endocrine-disrupting chemicals (EDCs) are natural and synthetic substances with ubiquitous exposure in children and adults including pregnant women. EDCs interfere, temporarily or permanently, with hormonal signaling pathways in the endocrine system by binding to hormone receptors and modifying gene expression."
Vegas AJ, Veiseh O, Gürtler M, Millman JR, Pagliuca FW, Bader AR, Doloff JC, Li J, Chen M, Olejnik K, Tam HH, Jhunjhunwala S, Langan E, Aresta-Dasilva S, Gandham S, McGarrigle JJ, Bochenek MA, Hollister-Lock J, Oberholzer J, Greiner DL, Weir GC, Melton DA, Langer R & Anderson DG. (2016). Long-term glycemic control using polymer-encapsulated human stem cell-derived beta cells in immune-competent mice. *Nat. Med. , 22*, 306-11. PMID: 26808346 DOI.

Implanted in the intraperitoneal space of mice treated to chemically induce type 1 diabetes. Implants induced glycemic correction without any immunosuppression until their removal at 174 d after implantation. Human C-peptide concentrations and in vivo glucose responsiveness demonstrated therapeutically relevant glycemic control and retrieved implants contained viable insulin-producing cells.

Links: stem cells | pancreas

Oral Contraceptives A recent 2016 Danish study births from Danish registries between 1997 and 2011 identified that:

Charlton BM, Mølgaard-Nielsen D, Svanström H, Wohlfahrt J, Pasternak B & Melbye M. (2016). Maternal use of oral contraceptives and risk of birth defects in Denmark: prospective, nationwide cohort study. *BMJ , 352*, h6712. PMID: 26738512

Links: menstrual cycle | drugs

Ernest Henry Starling (1866-1927)

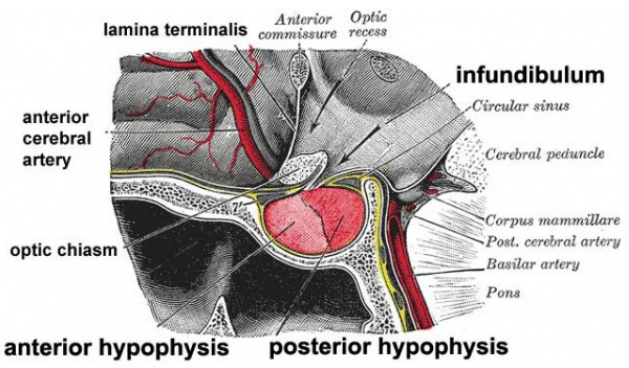
Interested in hormone history?

Listen ABC Radio Ockham's Razor 2005-07-31 Centenary of the word "hormone" (6.2 Mb mp3) Centenary of the word 'hormone', Sydney medical scientist and writer Dr John Carmody commemorates the centenary of the entry of the word 'hormone' into the English language.

-00:00

Lecture Objectives

- Understanding of hormone types
- Understanding of endocrine gland development
- Understanding of endocrine developmental functions
- Brief understanding of endocrine abnormalities



ExpandLecture Archive

2018 PDF | 2017 | 2017 PDF | 2016 | printable version | 2015 Lecture | 2014 Lecture | 2013 Lecture | 2012 Lecture | Endocrine System Development | BGD Lecture - Endocrine Histology | Practical - Virtual Slides

ExpandTextbooks

Hill, M.A. (2019). *UNSW Embryology* (19th ed.) Retrieved May 20, 2019, from https://embryology.med.unsw.edu.au

Endocrine Links: Introduction | BGD Lecture | Science Lecture | Lecture Movie | pineal | hypothalamus | pituitary | thyroid | parathyroid | thymus | pancreas | adrenal | endocrine gonad | endocrine placenta | other tissues | Stage 22 | endocrine abnormalities | Hormones | Category:Endocrine

ExpandHistoric Embryology - Endocrine

1903 Islets of Langerhans | 1904 interstitial Cells | 1908 Pancreas Different Species | 1908 Pituitary | 1908 Pituitary histology | 1911 Rathke's pouch | 1912 Suprarenal Bodies | 1914 Suprarenal Organs | 1915 Pharynx | 1916 Thyroid | 1918 Rabbit Hypophysis | 1920 Adrenal | 1935 Mammalian Hypophysis | 1926 Human Hypophysis | 1927 Hypophyseal fossa | 1932 Pineal Gland and Cysts | 1935 Hypophysis | 1937 Pineal | 1938 Parathyroid | 1940 Adrenal | 1941 Thyroid | 1950 Thyroid Parathyroid Thymus | 1957 Adrenal

Previous Lecture Audio - These are a live unedited recording from the endocrine development lecture and may contain errors in either descriptions or content. This 2012 lecture was recorded locally due to a problem with the iLecture system. These recordings are for University level students and may not be suitable for young students. For educational purposes only.

Dr Mark Hill Monday 22rd May 2012 9am Clancy

- listen Part 1 | download 1 (3.6 Mb MP3 28:27min)
- listen Part 2 | download 2 (3.3 Mb MP3 26:11 min)

Links: Medicine Audio

Embryology textbooks do not have a specific chapter for endocrine system, read the head and neck and renal chapters. This general endocrine online textbook shown below should also be helpful.

ExpandEndocrinology Textbook - Chapter Titles

Nussey S. and Whitehead S. **Endocrinology: An Integrated Approach** (2001) Oxford: BIOS Scientific Publishers; ISBN-10: 1-85996-252-1.

- Chapter 1. Principles of endocrinology
- Chapter 2. The endocrine pancreas
- Chapter 3. The thyroid gland
- Chapter 4. The adrenal gland
- Chapter 5. The parathyroid glands and vitamin D
- Chapter 6. The gonad
- Chapter 7. The pituitary gland
- Chapter 8. Cardiovascular and renal endocrinology

Full Table of Contents

Schoenwolf, G.C., Bleyl, S.B., Brauer, P.R., Francis-West, P.H. & Philippa H. (2015). Larsen's human embryology (5th ed.). New York; Edinburgh: Churchill

Livingstone.

UNSW students have full access to this textbook edition through UNSW Library subscription (with student Zpass log-in). Note that most embryology textbooks do no have specific chapter for endocrine development and this information is often found in other chapters (neural, renal, head, genital).

- Chapter 9 Development of the Hypothalamus
- Chapter 9 Development of the Pineal Gland
- Chapter 9 Development of the Pituitary
- Chapter 14 Development of the Pancreas
- Chapter 15 Development of the Suprarenal Gland
- Chapter 16 Development of the Gonad
- Chapter 17 Development of the Thyroid

ExpandLarsen's Human Embryology (5th edn)

UNSW students have full access to this textbook edition through UNSW Library subscription (with student Zpass log-in).

APA Citation: Schoenwolf, G.C., Bleyl, S.B., Brauer, P.R., Francis-West, P.H. & Philippa H. (2015). *Larsen's human embryology* (5th ed.). New York; Edinburgh: Churchill Livingstone.

> **Links:** PermaLink | UNSW Embryology Textbooks | Embryology Textbooks | UNSW Library

1. Gametogenesis, Fertilization, and First Week
2. Second Week: Becoming Bilaminar and Fully Implanting
3. Third Week: Becoming Trilaminar and Establishing Body Axes
4. Fourth Week: Forming the Embryo
5. Principles and Mechanisms of Morphogenesis and Dysmorphogenesis
6. Fetal Development and the Fetus as Patient
7. Development of the Skin and Its Derivatives
8. Development of the Musculoskeletal System
9. Development of the Central Nervous System
10. Development of the Peripheral Nervous System
11. Development of the Respiratory System and Body Cavities
12. Development of the Heart
13. Development of the Vasculature
14. Development of the Gastrointestinal Tract
15. Development of the Urinary System
16. Development of the Reproductive System
17. Development of the Pharyngeal Apparatus and Face
18. Development of the Ears
19. Development of the Eyes
20. Development of the Limbs

ExpandThe Developing Human: Clinically Oriented Embryology (10th edn)

UNSW Students have online access to the current 10th edn. through the UNSW Library subscription (with student Zpass log-in).

APA Citation: Moore, K.L., Persaud, T.V.N. & Torchia, M.G. (2015). *The developing human: clinically oriented embryology* (10th ed.). Philadelphia: Saunders.

Links: PermaLink | UNSW Embryology Textbooks | Embryology Textbooks | UNSW Library

1. Introduction to the Developing Human
2. First Week of Human Development
3. Second Week of Human Development
4. Third Week of Human Development
5. Fourth to Eighth Weeks of Human Development
6. Fetal Period
7. Placenta and Fetal Membranes
8. Body Cavities and Diaphragm
9. Pharyngeal Apparatus, Face, and Neck
10. Respiratory System
11. Alimentary System
12. Urogenital System
13. Cardiovascular System
14. Skeletal System
15. Muscular System
16. Development of Limbs
17. Nervous System
18. Development of Eyes and Ears
19. Integumentary System
20. Human Birth Defects
21. Common Signaling Pathways Used During Development
22. Appendix : Discussion of Clinically Oriented Problems

Se also - De Groot LJ, Chrousos G, Dungan K, Feingold KR, Grossman A, Hershman JM, Koch C, Korbonits M, McLachlan R, New M, Purnell J, Rebar R, Singer F, Vinik A, Tal R, Taylor HS, Burney RO, Mooney SB & Giudice LC. (2000). Endocrinology of Pregnancy. , , . PMID: 25905197

Endocrine Origins

- **Epithelia** - (ectoderm) covering embryo, (endoderm) lining gastrointestinal tract, (mesoderm) lining coelomic cavity
- **Mesenchyme** - (mesoderm) contribution, connective tissue, blood vessels

Hormones

Hormone Types

Amino acid	noradrenaline (norepinephrine), adrenalin

derivatives	(epinepherine) , thyroid hormone
Proteins, peptides	thyroid stimulating hormone, leutenising hormone, follicle stimulating hormone
Steroids (from cholesterol)	androgens, glucocorticoids, mineralocorticoids
ExpandSignaling Pathways	
Steroid biosynthesis pathway	Steroid hormone receptor signaling[1]
	G-protein coupled membrane receptors • Adrenergic signalling (α and β receptors, with several subtypes) • Thyroid stimulating hormone (TSH), leutenising hormone (LH), follicle stimulating hormone (FSH) signalling

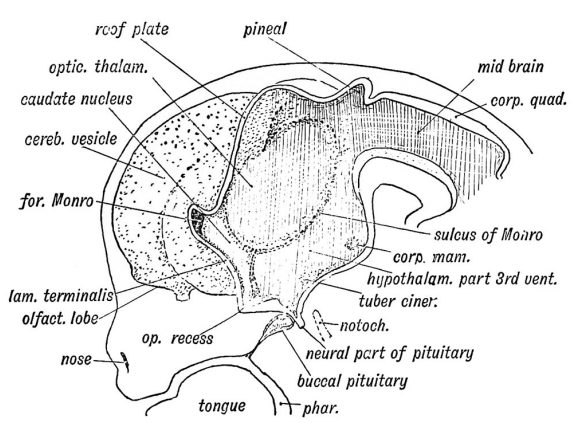
Hormone Actions

- **Autocrine** - acts on self (extracellular fluid)
- **Paracrine** - acts locally (extracellular fluid)
- **Endocrine** - acts by secretion into blood stream (endocrine organs are richly vascularized)

Hormone Receptors

- **Cell surface receptors** - modified amino acids, peptides, proteins
- **Cytoplasmic/Nuclear Receptors** - steroids

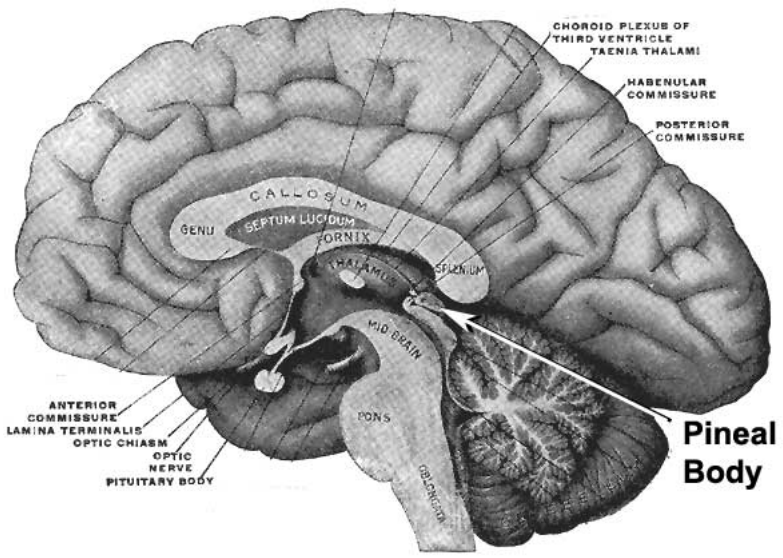
Pineal Gland



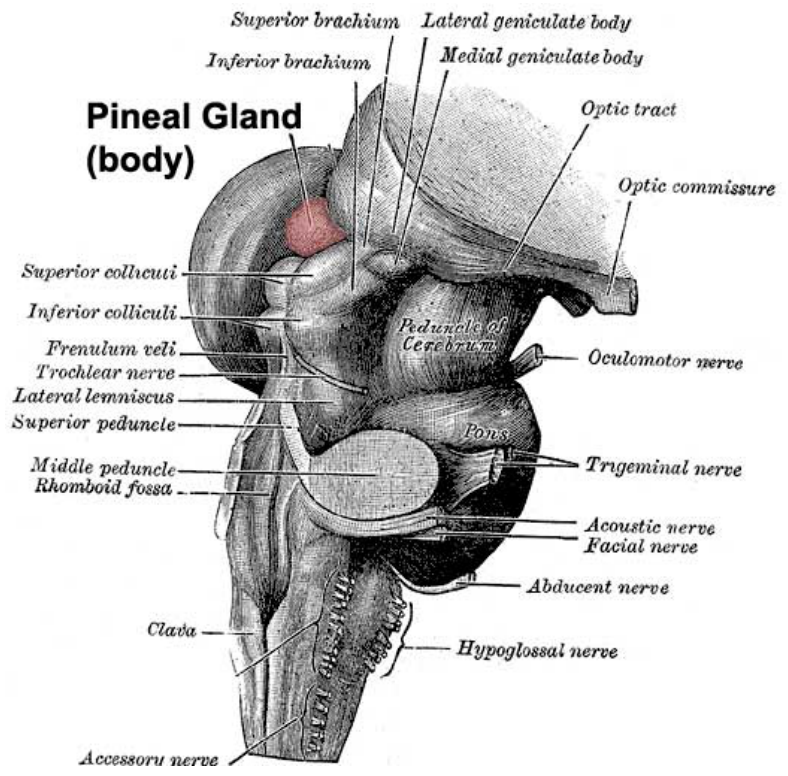
Pineal Development

- **Neuroectoderm** - prosenecephalon then diencephalon (evagination of neuroepithelium located at roof of the third ventricle)
- caudal roof, median diverticulum, epiphysis

- Initially a **hollow diverticulum**, cell proliferation to solid, pinealocytes (neuroglia), cone-shaped gland innervated by epithalamus

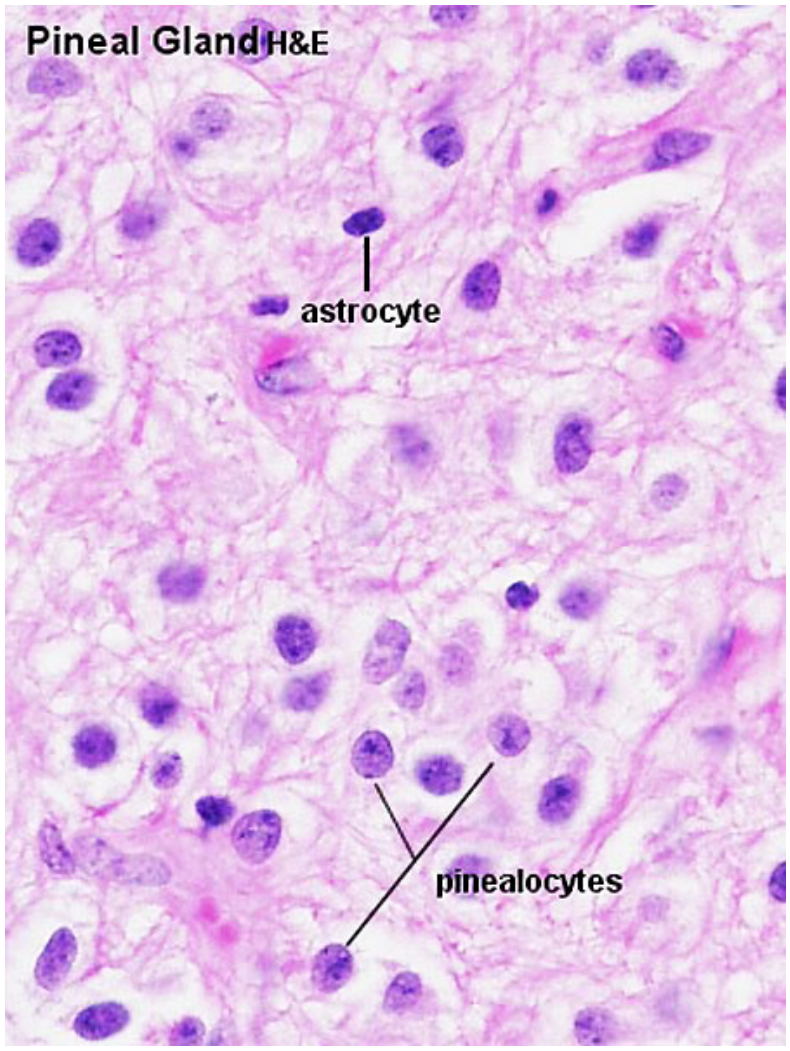


Adult pineal body



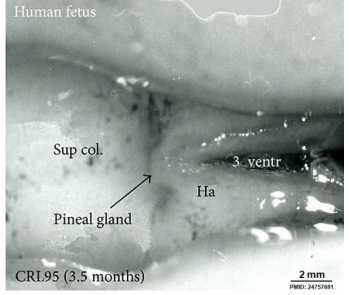
Pineal gland position

- part of **epithalamus** - neurons, glia and pinealocytes
- **pinealocytes** secrete melatonin - cyclic nature of activity, melatonin lowest during daylight
- maternal melatonin crosses the placental barrier
- inhibit hypothalamic secretion of GnRH until puberty, pineal gland then rapidly regresses.
- other activities - possibly gamete maturation, antioxidant effect, protect neurons?



Fetal Pineal Anatomy[2]

- Human fetus (3.5 month) superior (dorsal) view diencephalic-mesencephalic area.

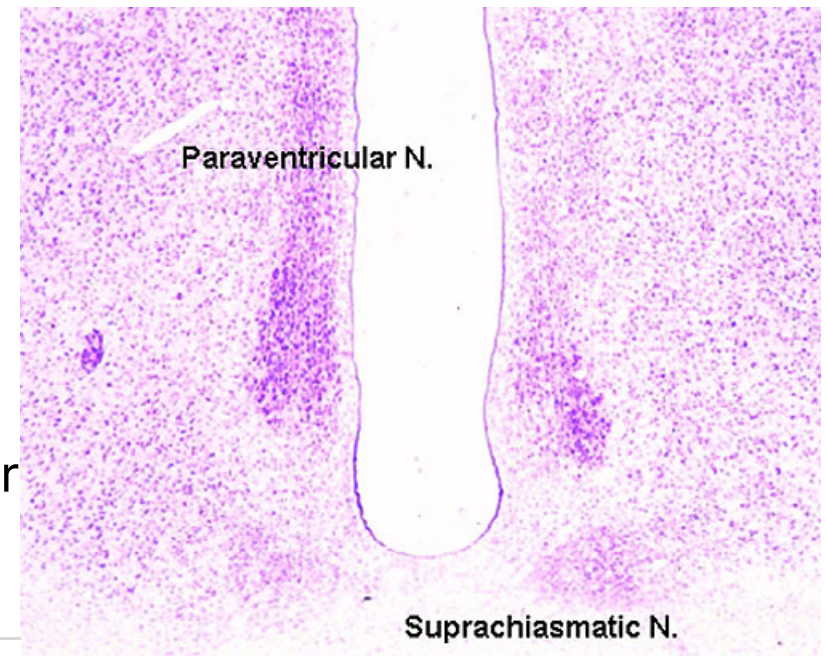


- Third ventricle (3 ventr) without pial covering is seen to the right.
- Pineal gland is a small protuberance (arrow) and merging via the broad stalk with the habenula (Ha). Superior colliculus (Sup col.)

Links: pineal | Endocrinology

Hypothalamus

Hormones - Corticotrophin releasing hormone (CRH), Thyrotrophin releasing hormone (TRH), Arginine vasopressin (AVP), Gonadotrophin releasing hormone (GnRH), Growth hormone releasing hormone (GHRH), Somatostatin, Prolactin relasing factor (PRF), Dopamine



Adult hypothalamus

ExpandHypothalamic H

Adult Hypothalamic Ho

Secreted hormone	Abbreviation	Produce
Thyrotropin-releasing hormone (Prolactin-releasing hormone)	TRH, TRF, or PRH	Parvocellul neurosecre neurons
Dopamine (Prolactin-inhibiting hormone)	DA or PIH	Dopamine neurons of arcuate nu
Growth hormone-releasing hormone	GHRH	Neuroendc neurons of Arcuate nucleus

Somatostatin (growth hormone-inhibiting hormone)	SS, GHIH, or SRIF	Neuroendc cells of the Periventric nucleus
Gonadotropin-releasing hormone	GnRH or LHRH	Neuroendc cells of the Preoptic ar
Corticotropin-releasing hormone	CRH or CRF	Parvocellul neurosecre neurons
Oxytocin		Magnocellu neurosecre cells
Vasopressin (antidiuretic hormone)	ADH or AVP	Magnocellu neurosecre neurons
Melanin-concentrating hormone	MCH	tuberal late nucleus (la hypothalar area)
Links: hypothalamus		

Hypothalamus Development

- Neuroectoderm - prosenecephalon then **diencephalon**

- ventro-lateral wall intermediate zone proliferation
- Mamillary bodies - form pea-sized swellings ventral wall of hypothalamus

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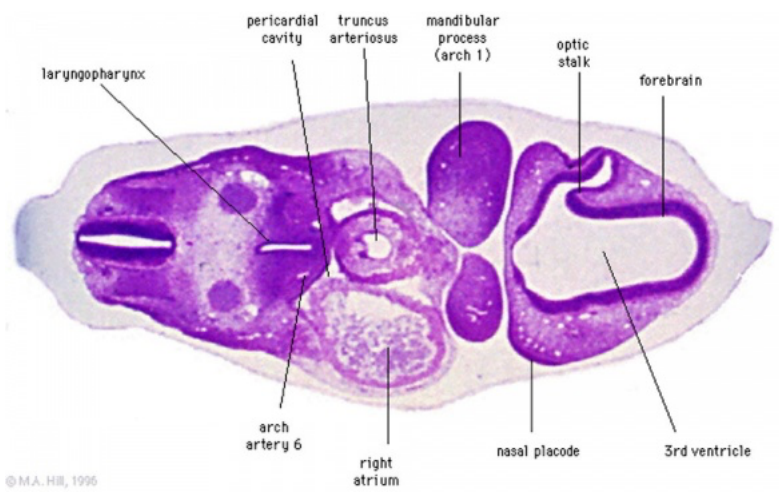
<td> 
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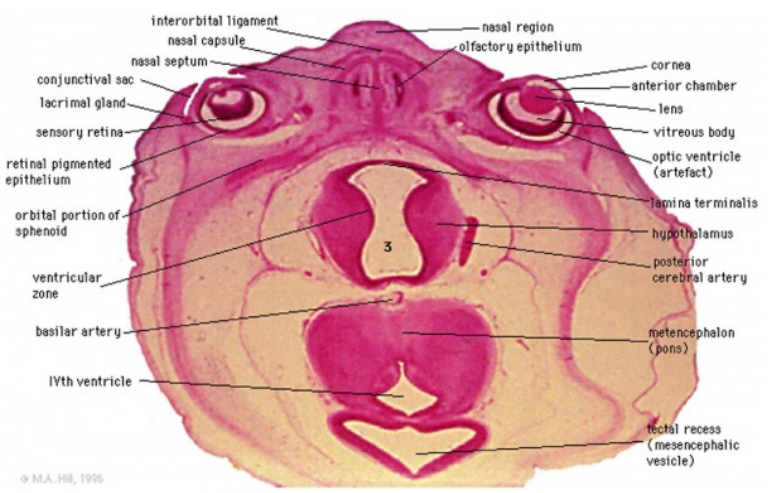
<td> 
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<td>Diencephalon region, shown by optic stalk
(Stage 13)</td>
<td>Late embryonic hypothalamus
(Stage 22)</td>
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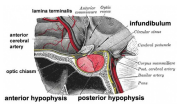
- Human Embryo Brain
  (week 4.5 exterior view)
- Human Embryo Brain
  (week 5 exterior view)
- Human Embryo Brain
  (week 5 interior view)
- Human Fetal Brain
  (3 months)
- Human Fetal Brain
  (4 months)

  Links: hypothalamus

Pituitary

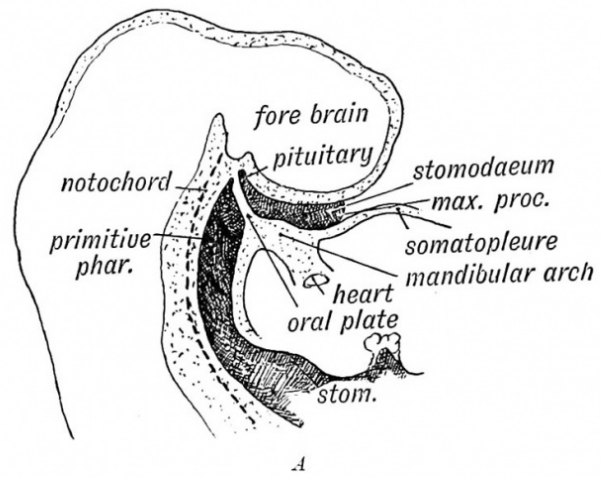
	The pituitary (hypophysis) sits anatomically within the sella turcica, a space within the sphenoid bone. **Anterior pituitary hormones** - Thyroid-stimulating hormone

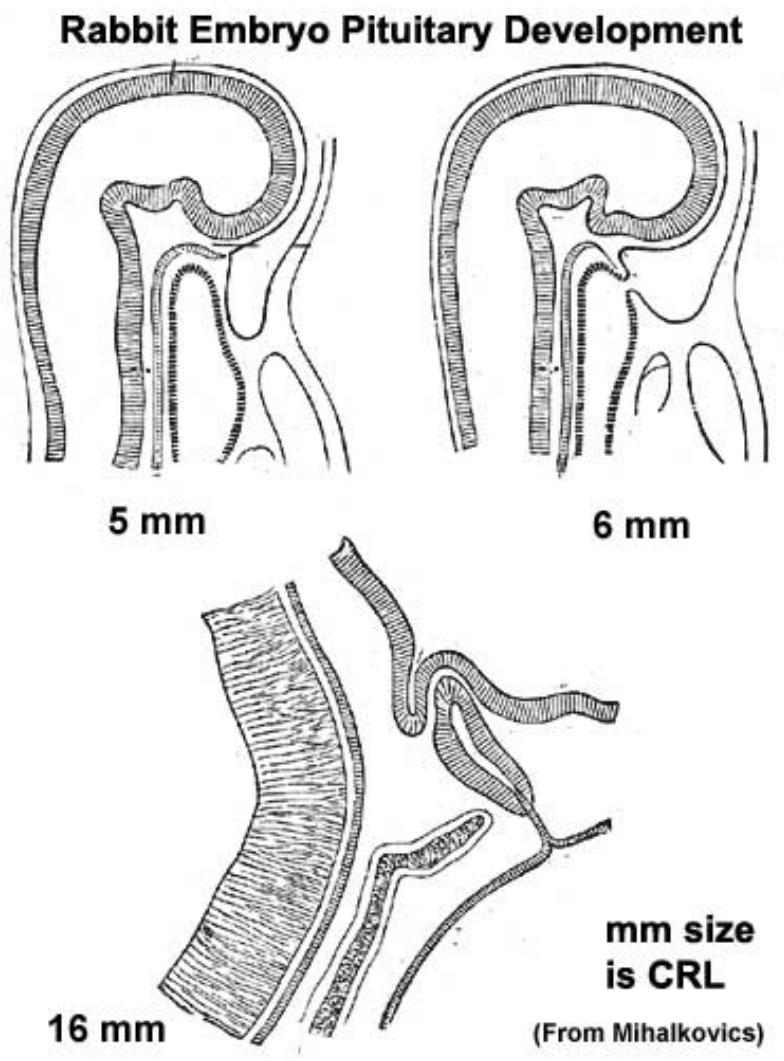


(TSH), Adrenocorticotrophic hormone (ACTH), Luteinizing hormone (LH), Follicle-stimulating hormone (FSH), Somatotrophin/growth hormone (GH), Prolactin (PRL), Melanocyte-stimulating hormone (MSH)

Posterior pituitary hormones - Oxytocin, Arginine vasopressin

Pituitary Development





Blue - neural tube ectoderm

Red - surface ectoderm

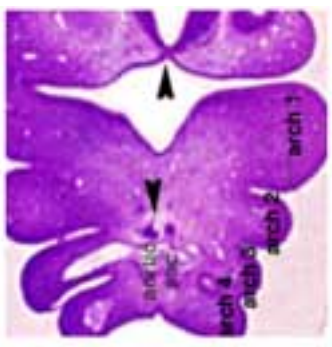
- Dual ectoderm origins
    - **Ectoderm** - ectoderm roof of stomodeum, Rathke's pouch, adenohypophysis
    - **Neuroectoderm** - prosenecephalon then diencephalon, neurohypophysis

Adenohypophysis

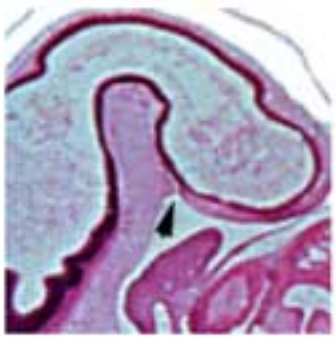
- Anterior wall proliferates - pars distalis
- Posterior wall little growth – pars intermedia
- Rostral growth around infundibular stem – pars tuberalis

Neurohypophysis

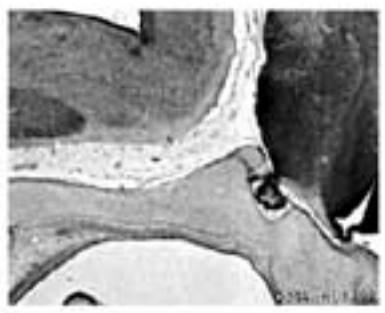
- Infundibulum – median eminence, infundibulum, pars nervosa



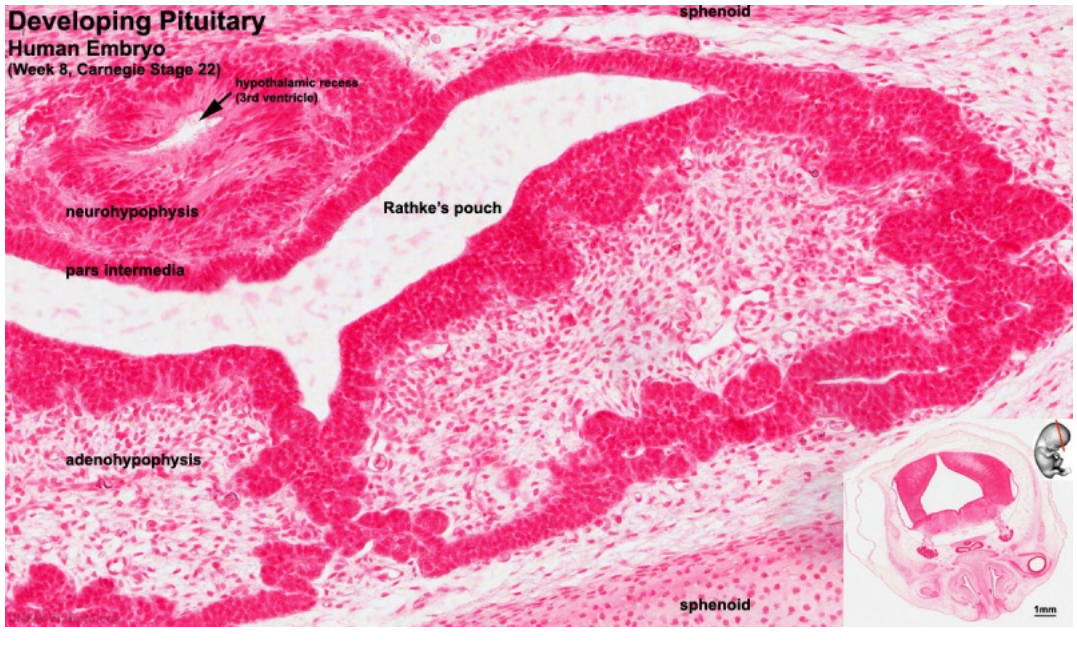
Rathke's Pouch
And Thyroid cells



Rathke's Pouch

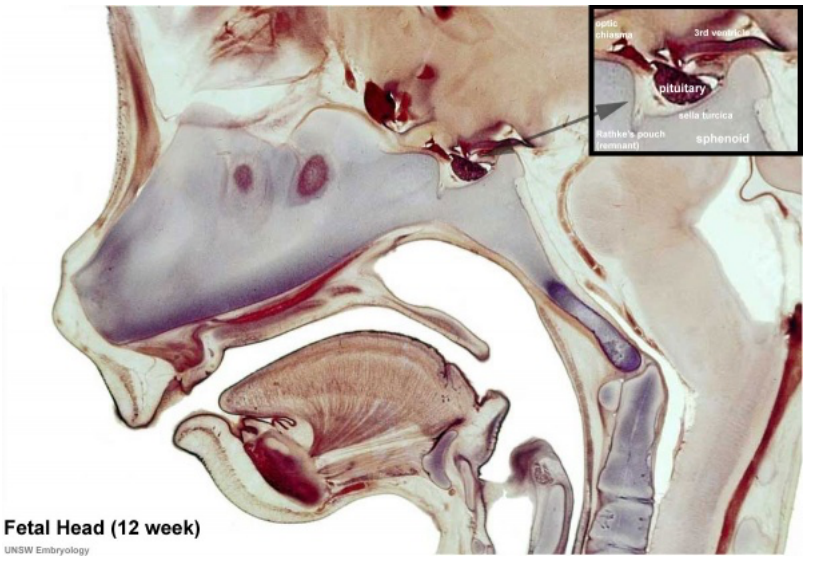


Fetal Pituitary



Pituitary Timeline

- **Week 4** - hypophysial pouch, Rathke's pouch, diverticulum from roof
- **Week 5** - elongation, contacts infundibulum, diverticulum of diencephalon
- **Week 6** - connecting stalk between pouch and oral cavity degenerates



Early Fetal (week 12)

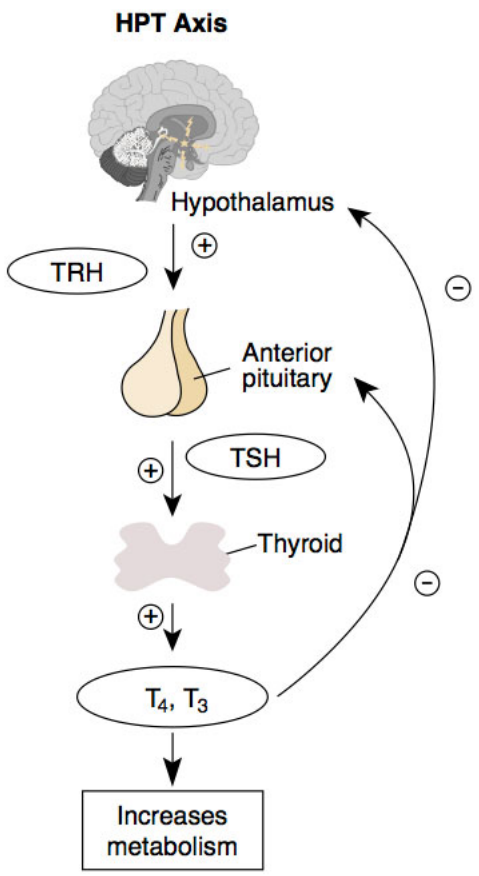
- **Week 8** - basophilic staining cells appear
- **Week 9** - acidophilic staining cells appear
- **Week 10** - growth hormone and ACTH detectable
- **Week 16** - adenohypophysis fully differentiated and TSH increases to peak at 22 weeks
- **Week 20 to 24** - growth hormone levels peak, then decline
- **Birth** - second TSH surge and decreases postnatally

Links: pituitary | Embryo Images - Pituitary | Endocrinology

Thyroid

- **Maternal thyroid hormone** - required for early stages of brain development
- **Fetal thyroid** - begins function from week10, (GA week 12) required for neural development, stimulates metabolism (protein, carbohydrate, lipid), reduced/absence = cretinism (see abnormalities)

Hormones - TH (amino acid derivatives) Thyroxine (T4), Triiodothyronine (T3)



Hypothalamus - Pituitary - Thyroid Axis

Thyroid Development

- thyroid median endodermal thickening in the floor of pharynx, outpouch – **thyroid diverticulum**.
- tongue grows, cells descend in neck.
- thyroglossal duct - proximal end at the foramen caecum of tongue.
- thyroid diverticulum - hollow then solid, right and left lobes, central isthmus.

Thyroid Timeline

- **24 days** - thyroid median endodermal thickening in the floor of pharynx, outpouch – thyroid diverticulum
- **Week 11** - colloid appearance in thyroid follicles, iodine and thyroid hormone (TH) synthesis. Growth factors (insulin-like, epidermal) stimulates follicular growth.
- **Week 16 - 18** - (GA 18-20 weeks) fully functional

Links: Box 3.21 Embryology of the thyroid and parathyroid glands

Fetal Thyroid Hormone

- Initial secreted biologically inactivated by modification
  - serum thyroid hormone levels are relatively low and tissue concentration of thyroid hormone is modified by iodothyronine deiodinases
- Iodine deficiency - during this period, leads to neurological defects (cretinism)
- Late fetal secretion - develops brown fat
- Birth - TSH levels increase, thyroxine (T3) and T4 levels increase to 24 h, then 5-7 days postnatal decline to normal levels
- Post-natal - TH required for bone development

Maternal TH - iodine/thyroid status can affect development.

- recent studies show that both high and low maternal thyroid

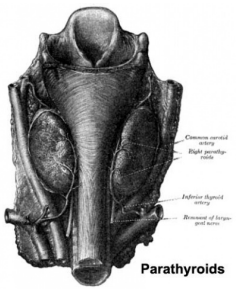
hormone impact on neural development (PMID 26497402)

Links: thyroid | Endocrinology |

Parathyroid

- Parathyroid Hormone - Increase calcium ions [Ca2+], stimulates osteoclasts, increase Ca GIT absorption (opposite effect to calcitonin)
- Adult Calcium and Phosphate - Daily turnover in human with dietary intake of 1000 mg/day
- secreted by chief cells

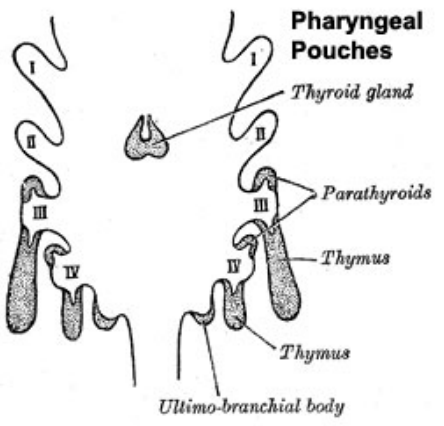
Principal cells cords of cells



Adult Parathyroid

Parathyroid Development

- Endoderm - third and fourth pharyngeal pouches, could also have ectoderm and neural crest
  - 3rd Pharyngeal Pouch - inferior parathyroid, initially descends with thymus
  - 4th Pharyngeal Pouch - superior parathyroid
- **Week 6** - diverticulum elongate, hollow then solid, dorsal cell proliferation
- Fetal parathyroids - respond to calcium levels, fetal calcium levels higher than maternal
- parathyroid hormone - (PTH, parathormone or parathyrin)



Pharyngeal pouches

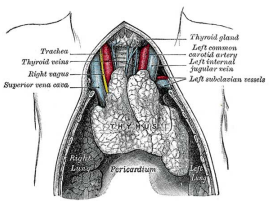
Links: parathyroid | Endocrinology

Thymus

- Thymus - bone-marrow lymphocyte precursors become thymocytes, and subsequently mature into T lymphocytes (T cells)
- Thymus hormones - thymosins stimulate the development and differentiation of T lymphocytes

Thymus Development

- Endoderm - third pharyngeal pouch
- **Week 6** - diverticulum elongates, hollow then solid, ventral cell proliferation
- **third pharyngeal pouch** - transient bilateral endodermal structures that generate both the thymus and parathyroid glands (some species also fourth pharyngeal pouch)
- **Thymic primordia** - surrounded by neural crest mesenchyme, epithelia/mesenchyme interaction
- **Week 7** (Carnegie stage 18-19) thymic component migrates ventrally
- **Week 8** (CS20-21) differentiation of the cortical and medullary thymic epithelial cells (TEC).

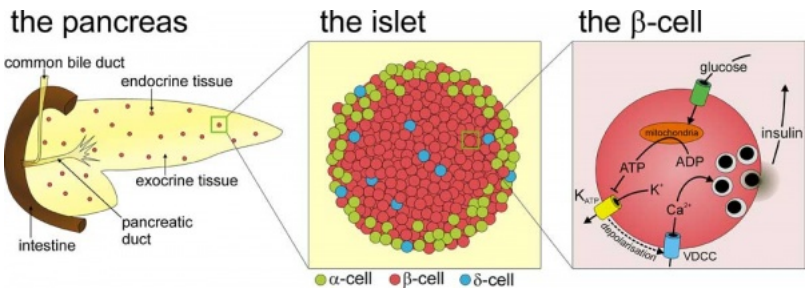


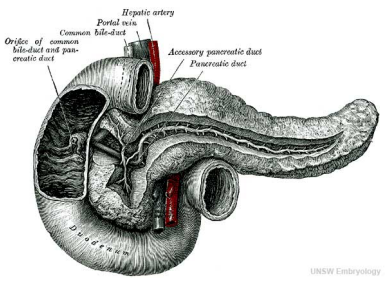
Fetal Thymus

Links: thymus

Pancreas

- Functions - exocrine (amylase, alpha-fetoprotein), 99% by volume; endocrine (pancreatic islets) 1% by volume
- Exocrine function - begins after birth
- Endocrine function - from 10 to 15 weeks onward hormone release
    - exact roles of hormones in regulating fetal growth?

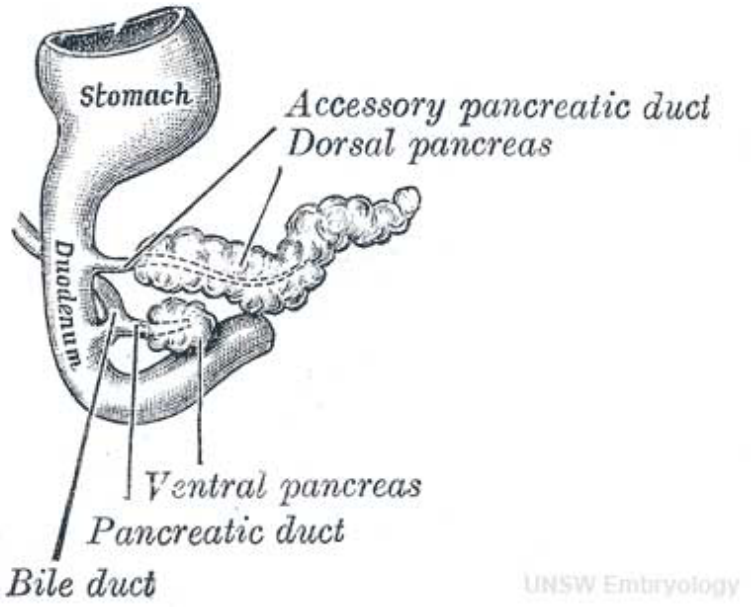
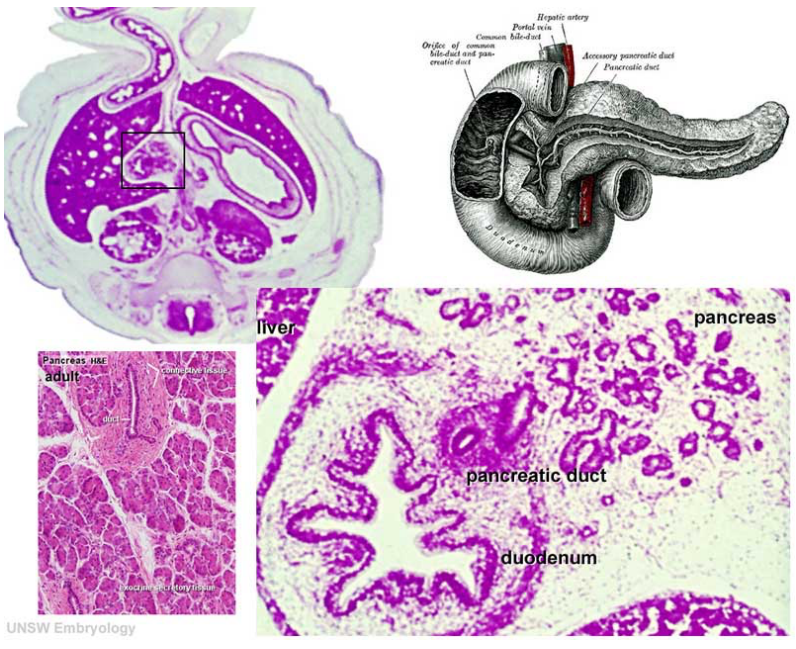




Pancreas Development

- Pancreatic buds - duodenal level endoderm, splanchnic mesoderm forms dorsal and ventral mesentery, dorsal bud (larger, first), ventral bud (smaller, later)
- Pancreas Endoderm - pancreas may be opposite of liver
    - Heart cells promote/notochord prevents liver formation
    - Notochord may promote pancreas formation

- Heart may block pancreas formation

	
Pancreatic buds and duct developing	Pancreas week 8 (Stage 22)

- Duodenum growth/rotation - brings ventral and dorsal buds together, fusion of buds See Figure 2.32
- Pancreatic duct - ventral bud duct and distal part of dorsal bud, exocrine function
- Islet cells - cords of **endodermal cells** form ducts, from which cells bud off to form islets

ExpandIslet
Arterial blood (from splenic, hepatic and superior mesenteric arteries) enters the core of each islet and capillaries then drain outwardly to the periphery where venous blood drains into the splenic and superior mesenteric veins. Histology image shows blood vessels injected with ink.

Pancreatic Islets

- Islets of Langerhans - 4 endocrine cell types
- **Alpha** - glucagon, mobilizes lipid
- **Beta** - insulin, increase glucose uptake
  - Beta cells, stimulate fetal growth, continue to proliferate to postnatal, in infancy most abundant
- **Delta** - somatostatin, inhibits glucagon, insulin secretion
- **F-cells** - pancreatic polypeptide

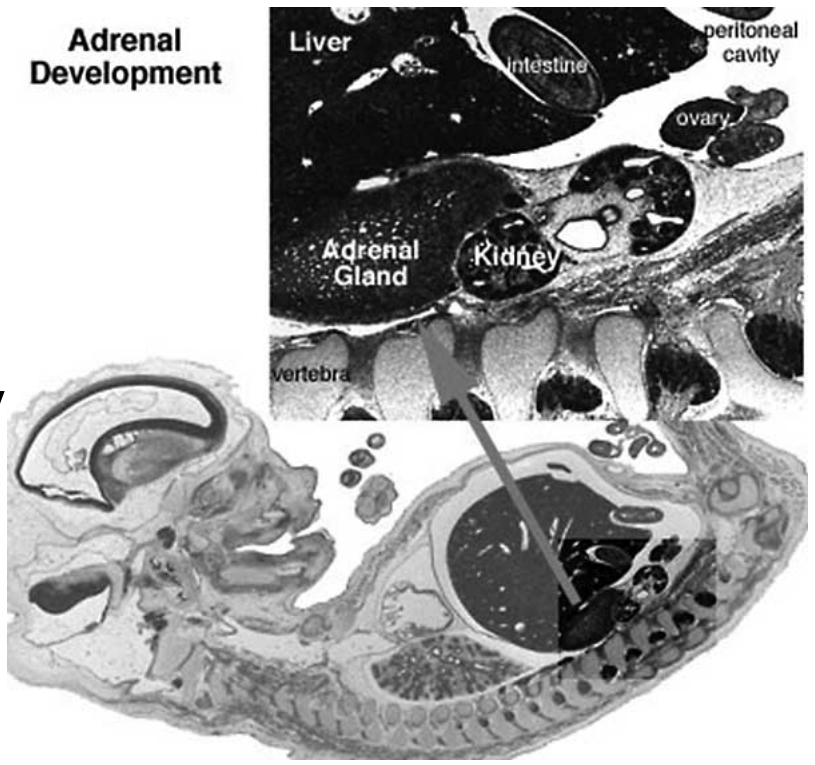
Pancreas Timeline

- **Week 7 to 20** - pancreatic hormones secretion increases, small amount maternal insulin
- **Week 10** - glucagon (alpha) differentiate first, somatostatin (delta), insulin (beta) cells differentiate, insulin secretion begins
- **Week 15** - glucagon detectable in fetal plasma

Links: [[Pancreas}} | Gastrointestinal Tract - Pancreas Development | Endocrinology

Adrenal

- Richly vascularized - arterioles passing through cortex, capillaries from cortex to medulla, portal-like circulation
- Fetal Cortex - produces a steroid precursor (DHEAS), converted by liver and then placenta into estrogen
- Adult Medulla - produces adrenalin (epinephrine), noradrenaline (norepinephrine)
- Fetal adrenal hormones - influence lung maturation



Fetal adrenal gland (Week 10, **GA** week 12

Adrenal cortical hormones - (steroids) Cortisol, Aldosterone, Dehydroepiandrosterone

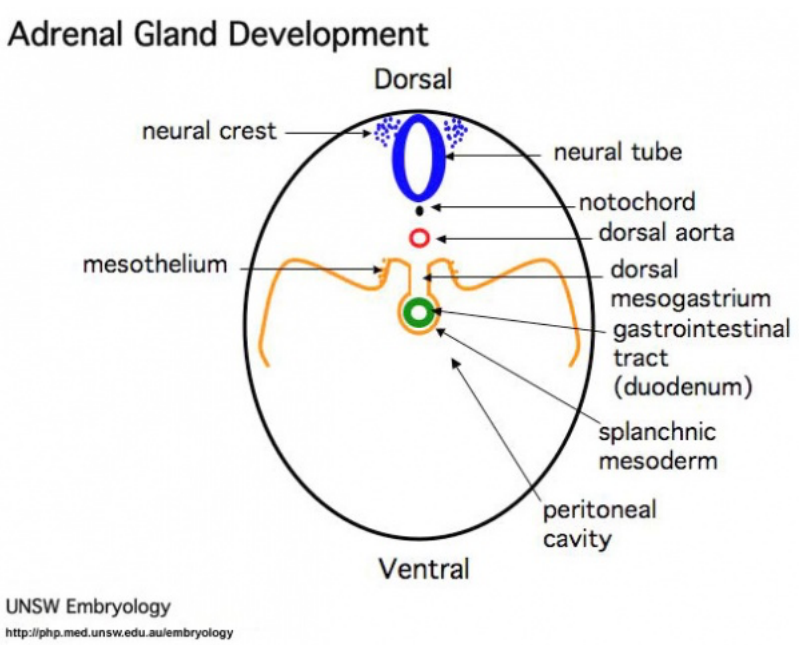
- zona glomerulosa - regulated by renin-angiotensin-aldosterone system controlled by the juxtaglomerular apparatus of the kidney.
- zona fasciculata - regulated by hypothalamo-pituitary axis with the release of CRH and ACTH respectively.

Adrenal medullary hormones - (amino acid derivatives) epinephrine,

norepinephrine

Adrenal Development

- **Week 6** - fetal cortex, from mesothelium adjacent to dorsal mesentery; Medulla, neural crest cells from adjacent sympathetic ganglia
- Fetal Adrenals - fetal cortex later replaced by adult cortex
- Adult cortex - mesothelium mesenchyme encloses fetal cortex

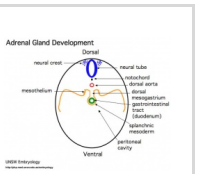


Adrenal Cortex

- Late Fetal Period - differentiates to form cortical zones
- Birth - zona glomerulosa, zona fasiculata present
- Year 3 - zona reticularis present

Adrenal Medulla

- neural crest origin, migrate adjacent to coelomic cavity, initially uncapsulated and not surrounded by fetal cortex, cells have neuron-like morphology
- 2 cell types - secrete epinepherine (adrenaline) 80%; secrete norepinephrine (noradrenaline) 20%

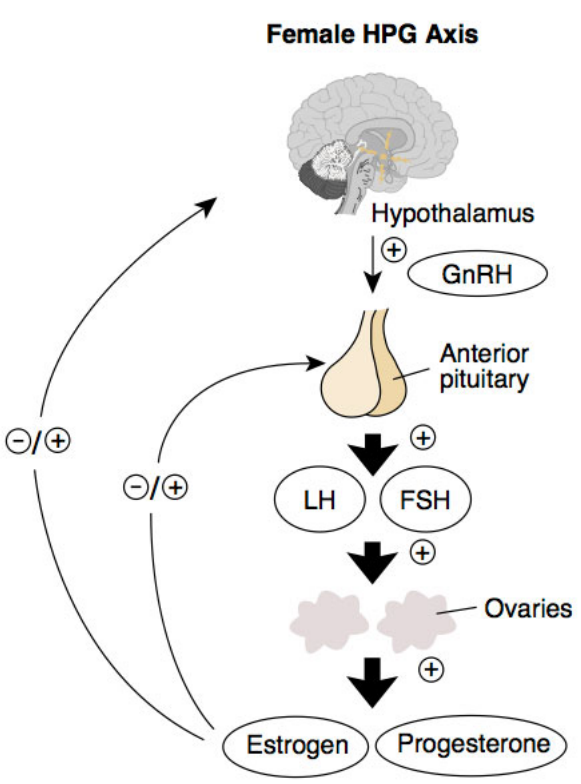


Adrenal Medulla

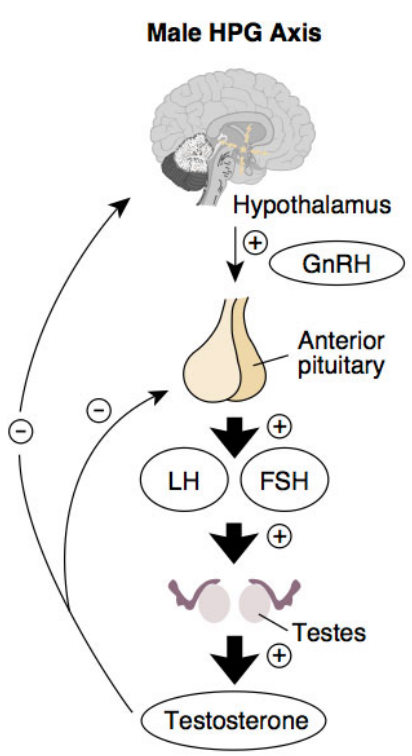
Page | Play

Links: Endocrine - Adrenal Development | Endocrinology - Adrenal Cortex Development | Endocrinology

Gonad



Adult Hypothalamus - Pituitary - Gonad (female)



Adult Hypothalamus - Pituitary - Gonad (male)

HPG Axis - [Endocrinology - Simplified diagram of the actions of gonadotrophins]

Gonad Development

- **mesoderm** - mesothelium and underlying mesenchyme
- **Gonadal ridge** - mesothelium thickening, medial mesonephros
- **Primordial Germ cells** - yolk sac, to mesentery of hindgut, to genital ridge of developing kidney

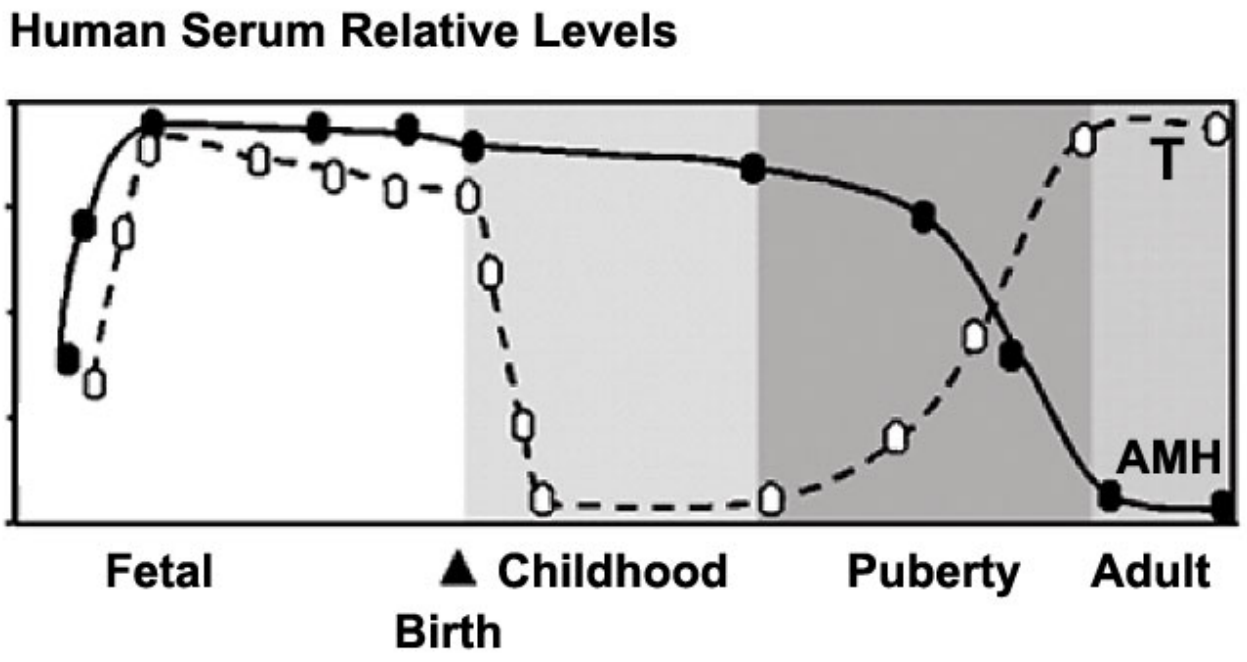
Differentiation

- testis-determining factor (TDF) from Y chromosome: presence (testes), absence (ovaries)

Testis

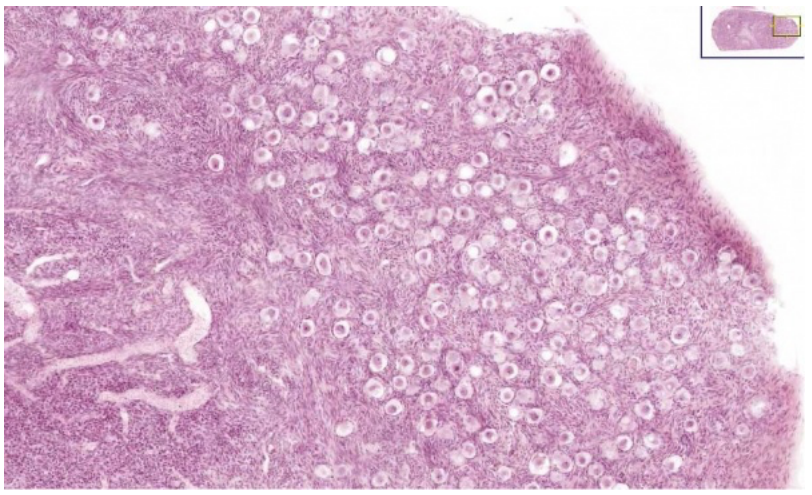
- **8 Weeks** - mesenchyme, interstitial cells (of Leydig) secrete testosterone, androstenedione.
- **8 to 12 Weeks** - hCG stimulates testosterone production.

- Sustentacular (Sertoli) cells - produce anti-mullerian hormone (AMH) to puberty.
    - **AMH** - anti-Müllerian hormone (Müllerian inhibiting factor (MIF), Müllerian-inhibiting hormone (MIH), and Müllerian-inhibiting substance (MIS)).



Ovary

- X chromosome genes regulate ovary development
- Hormone levels increase at puberty with follicle development.



Infant Ovary

I will cover this topic in detail again in sexual differentiation lecture/practical.

Links: Endocrine - Gonad Development | Endocrinology

Placenta

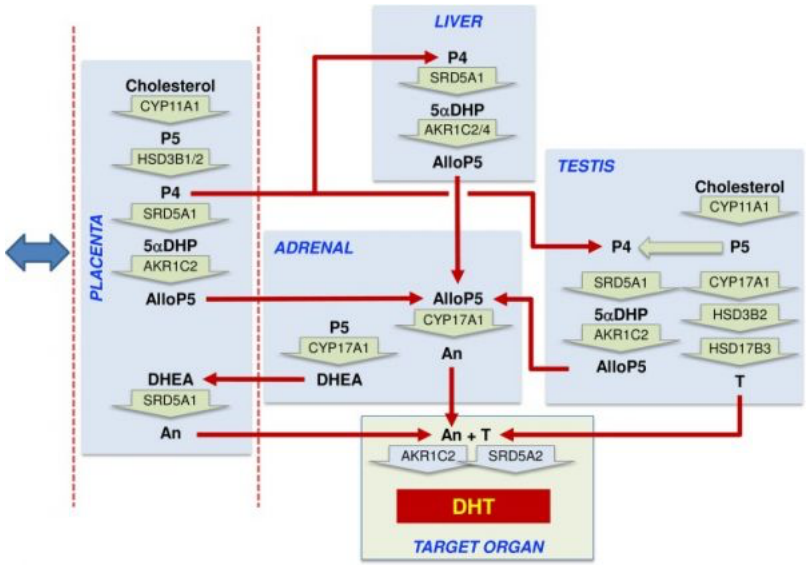
The corpus luteum provides initial support, when it degenerates in the embryonic period, placental estrogen and	

progesterone production increases exponentially to term.

- progesterone and estrogens - support maternal endometrium
- Human chorionic gonadotrophin (hCG) - like leutenizing hormone, supports corpus luteum in ovary, pregnant state rather than menstrual, maternal urine in some pregnancy testing
- Human chorionic somatommotropin (hCS) - or placental lactogen stimulate (maternal) mammary development
- Human chorionic thyrotropin (hCT)
- Human chorionic corticotropin (hCACTH)
- Relaxin

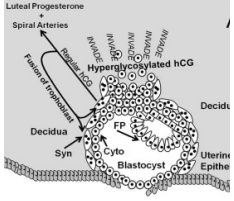
Placenta - Maternal (decidua) and Fetal (trophoblastic cells, extraembryonic mesoderm) components

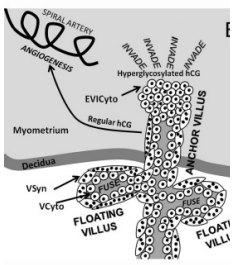
- Endocrine function - maternal and fetal precursors, synthesis and secretion
- Protein Hormones - chorionic gonadotropin (hCG), chorionic somatomammotropin (hCS) or placental

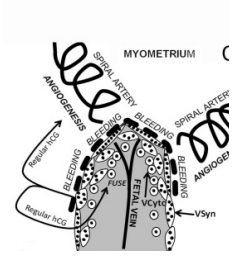


Alternate androgen synthesis pathway[3]

lactogen (hPL), chorionic thyrotropin (hCT), chorionic corticotropin (hCACTH)
    - hCG - up to 20 weeks, fetal adrenal cortex growth and maintenance
    - hCS – rise through pregnancy, stimulates maternal metabolic processes, breast growth
- Steroid Hormones
    - progesterone (maintains pregnancy), estrogens (fetal adrenal/placenta)
    - in Males - an alternate androgen synthesis pathway







Trophoblas hCG function

ExpandPlacental Estrogen?
Maternal late pregnancy estriol increases due to:[4] 1. fetal adrenal gland production of DHEAS 2. fetal liver conversion to 16α-OH-DHEAS 3. placenta sulphate removal to allow aromatization to estriol. - Uterus - stimulates growth of the myometrium, antagonizes the

myometrial-suppressing activity of progesterone.
- Mammary Gland - stimulates mammary gland ductal and alveolar growth.
- Fetal Ovary - stimulates development of female fetal ovary.[5]

Links: endocrine placenta

Other Endocrine

Endocrine Heart

- Atrial natriuretic peptide (ANP) - Increase Filtration rate / decrease Na+ reabsorption
- Endothelins - ET-1, ET-2, ET-3, Vasoconstriction / Increase NO
- Nitric oxide (NO) - Vasodilatation

Endocrine Kidney

- Renin - Increase Angiotensin-aldosterone system
- Prostaglandins - decrease Na+ reabsorption
- Erythropoietin - Increase Erythrocyte (rbc) production
- 1,25 (OH)2 vitamin D - calcium homeostasis
- Prekallikreins - Increase Kinin production

GIT Endocrine

Enteric control of digestive function

- Gastrin - Secreted from stomach (G cells), role in control of gastric acid secretion

- Cholecystokinin - small intestine hormone, stimulates secretion of pancreatic enzymes and bile
- Secretin - small intestine hormone (epithelial cells), stimulates secretion of bicarbonate-rich fluids from pancreas and liver

Adipose Tissue

- Leptin - polypeptide hormone produced in adipose and many other tissues with also many different roles
- Adiponectin - regulation of energy homeostasis and glucose and lipid metabolism, as well as acting as an anti-inflammatory on the cellular vascular wall
- Resistin - (for resistance to insulin, RETN) a 108 amino acid polypeptide and the related resistin-like protein-beta (Resistin-like molecule-beta, RELMbeta) stimulate endogenous glucose production

Links: Endocrine - Other Tissues

Endocrine Functional Changes

- **Puberty** - Increased activity.
- **Menopause** - Decreased activity.
- **Disease** - (diabetes, thyroid, kidney) suggested trends that genetics, health, nutrition, lifestyle may influence time that these events occur.
- **Pharmaceutical impact** - birth control, steroids, Hormone Replacement Therapy (HRT).

Abnormalities

NIH Genes & Disease Glands and Hormones

Pineal

- hypoplasia - associated with retinal disease.

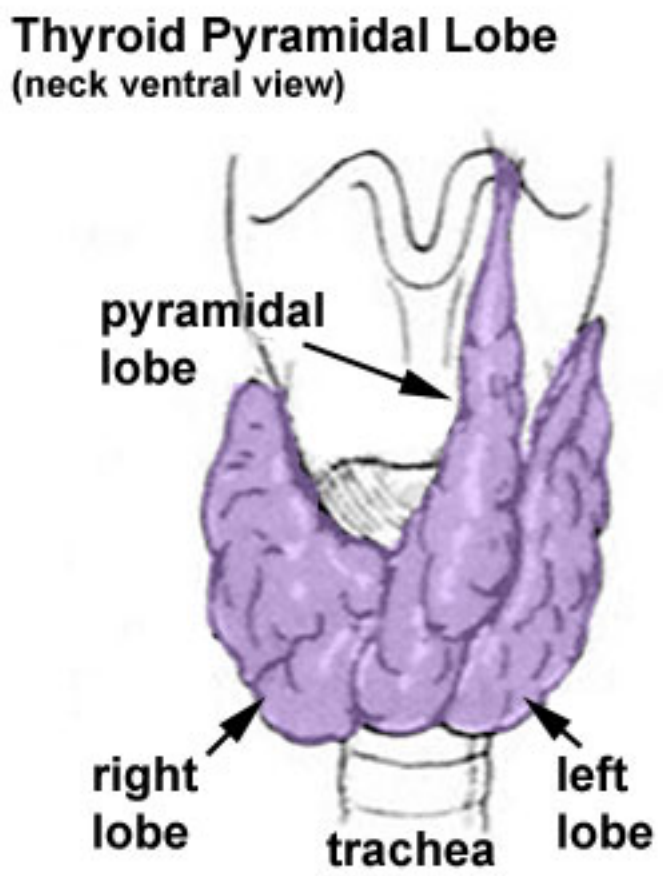
- tumours - in children are associated with abnormal puberty development.

Pituitary

- craniopharyngeal canal - Rathke's pouch abnormality, from the anterior part of the fossa hypophyseos of the sphenoid bone to the under surface of the skull.
- pituitary tumours (adenomas) - several abnormalities associated with abnormal levels of the hormonal output of the pituitary.
    - Growth hormone (GH) adenomas - benign pituitary tumors lead to chronic high GH output levels, that may lead to acromegaly.
- **Cushing's disease** - caused either by a pituitary adenoma produces excess adrenocorticotropic hormone (ACTH, corticotropin) or due to ectopic tumors secreting ACTH or corticotropin-releasing hormone (CRH).

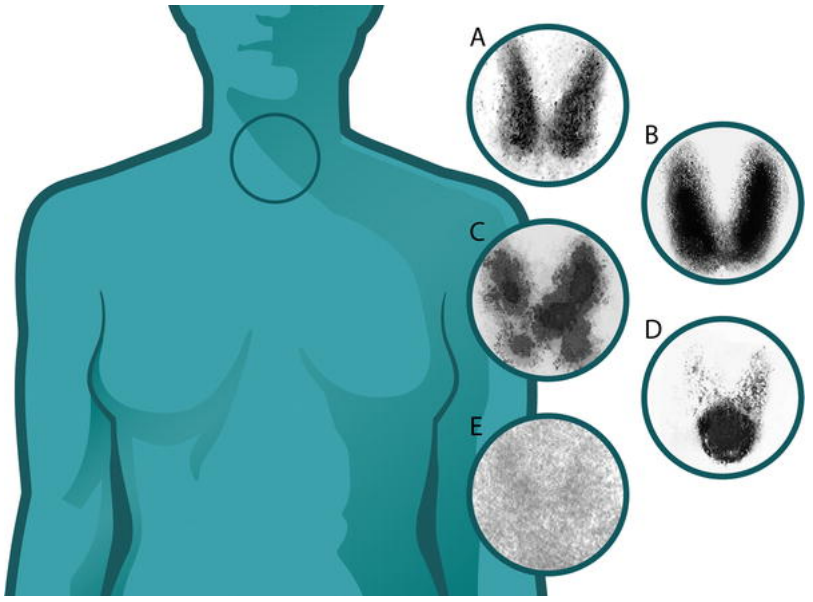
Thyroid

- Pyramidal lobe - from isthmus (50% of people) attached to hyoid bone distal end of thryoglossal duct.
- Congenital hypothyroidism - approximately 1 in 3000 births, associated with neurological abnormalities.
- Lingual thyroid gland - failure of thyroid descent.
- Thyroglossal cyst - persistance of thyroglossal duct. Image - thyroglossal duct
- Thyroglossal fistula - partial degeneration of the thyroglossal duct.
- Abnormal development of the thyroid - incomplete or excessive



Thyroid pyramidal lobe

descent.
- Childhood hypothyroidism delays ossification and bone mineralization.



Thyroid uptake scans

Iodine Deficiency

- A teaspoon of iodine, total lifetime requirement, cannot be stored for long periods by our body, tiny amounts are needed regularly
- Areas of endemic iodine deficiency, where soil and therefore crops and grazing animals do not provide sufficient dietary iodine to the populace
- food fortification and supplementation - Iodized salt programs and iodized oil supplements are the most common tools in fight against IDD

Parathyroid

- Usually four glands are present (2 on each side), but three to six glands have been found in human.
- Can have displaced parathyroid development with thymus.
- Lower parathyroid glands arise from the third pharyngeal pouch and descend with the thymus. Variable descent can lead to a range of adult locations, from just beneath the mandible to the anterior mediastinum.

Pancreas

- Type 1 Diabetes - juvenile onset diabetes, more severe form of illness, increases risk of blindness, heart disease, kidney failure, neurological disease, T-lymphocyte-dependent autoimmune disease, infiltration and destruction of the islets of Langerhans, Approx 16 million Americans
- Type 2 Diabetes - loosely defined as "adult onset" diabetes,

becoming more common cases of type 2 diabetes seen in younger people
- Risk of developing diabetes - environmental factors (food intake and exercise play an important role, either overweight or obese), Inherited factors (genes involved remain poorly defined)

Adrenal

- Congenital Adrenal Hyperplasia (CAH) - family of inherited disorders of adrenal steroidogenesis enzymes which impairs cortisol production by the adrenal cortex. Androgen excess leads newborn females with external genital ambiguity and postnatal progressive virilization in both sexes.
    - Enzymes most commonly affected: 21-hydroxylase (21-OH), 11beta-hydroxylase, 3beta-hydroxysteroid dehydrogenase.
    - Enzymes less commonly affected: 17alpha-hydroxylase/17,20-lyase and cholesterol desmolase.
- Pheochromocytomas (PCC) - Catecholamine-producing (neuro)endocrine tumor located in the adrenal medulla. Similar catecholamine-producing tumors outside the adrenal gland are called paragangliomas (PGL).

Endocrine Disruptors

Exogenous chemicals that interfere with the function of hormones. There are 3 main mechanisms: mimic, block or interfere.

Mimic - effects of natural hormones by binding receptors

- Diethylstilbestrol - (DES or diethylstilbetrol) a drug prescribed to women from 1938-1971 to prevent miscarriage in high-risk pregnancies. Acts as a potent estrogen (mimics natural hormone) and therefore a potential endocrine disruptor. Female fetus, increased risk abnormal reproductive tract and cancer. Male fetus, abnormal genitalia. Banned by USA FDA in 1979 as a teratogen,

previously used as livestock growth promoter.

Block - binding of a hormone to receptor or hormone synthesis

- Finasteride - chemical used to prevent male pattern baldness and enlargement of prostate glands. An anti-androgen (blocks synthesis of dihydrotestosterone) and therefore a potential endocrine disruptor, exposed pregnant women can impact on male fetus genetial development.
- Vinclozolin - a dicarboximide fungicide, perinatal exposure in rats inhibits morphological sex differentiation. In adult rats, shown to cause gonad tumours (Leydig cell) and atrophy. Chemical has androgen-antagonist (antiandrogenic) activity, metabolies compete with natural androgen

Interfere - with hormone transport or elimination

- Polychlorinated biphenyl pollutants - (PCBs) Rats exposed to PCBs have low levels of thyroid hormone. Compete for binding sites of thyroid hormone transport protein. Without being bound to this protein, thyroid hormones are excreted from the body (McKinney et al. 1985; Morse et al. 1996)

  Links: Endocrine Disruptors

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- **Genes and Disease**, Bethesda (MD): National Library of Medicine (US), NCBI Glands and Hormones

Search

- **Bookshelf** endocrine | pineal gland | hypothalamus | pituitary gland | thyroid gland | parathyroid gland | thymus gland | endocrine pancreas | adrenal gland
- **Pubmed** endocrine development

Embryonic

- Stage 22 - Pancreatic duct
- Stage 22 - Adrenal gland
- Week 10 - Adrenal gland

Terms

ExpandEndocrine Terms (expand to view)
• **adenohypophysis** - (anterior pituitary, pars distalis) anterior part of

pituitary embryonic development from surface ectoderm adenohypophyseal placode. Placode folds inward on the roof of the pharynx forming a transient structure Rathke's pouch.

- **adrenocorticotropin** - (ACTH or corticotropin) anterior pituitary, peptide hormone stimulates the adrenal cortex to produce corticosteroid hormones — primarily cortisol — as well as small amounts of female and male sex hormones.
- **androstenedione** - hormone precursor of testosterone and other steroidal androgens.
- **antidiuretic hormone** - (ADH) hypothalamus, peptide hormone renal
- **atrial natriuretic peptide** - (ANP) heart, peptide hormone regulates blood pressure. A study suggests that its activating enzyme corin, and ANP together, have a role in placentation, by promoting trophoblast invasion and spiral artery remodelling. (PMID 22437503)
- **basophil cell** - pituitary named by histological staining (deep blue, purple) different types produce different hormones: corticotrophs (ACTH, CRH), gonadotrophs (FSH, LH, GnRH), and thyrotrophs (TSH, TRH). See acidophil and chromophore cells.
- **C cells** - parafollicular cells of the thyroid.
- **calcitonin** - (CT) C cells of thyroid, peptide hormone thyroid
- **corpus luteum** - ovarian endocrine organ from ovulating follicle, stimulated by hCG and supports early pregnancy by secreting progesterone, 17β-progesterone, estradiol and androstenedione.
- **corticosteroid binding globulin** - (CBG) binds and transports glucocorticoids in the plasma. Globin is synthesised in the liver. adrenal
- **dihydrotestosterone** - (DHT) steroidal hormone made locally by 5-alpha reductase conversion of testosterone into a more active form in genital effects.
- **dehydroepiandrosterone** - (DHEA, androstenolone) adrenal cortex, gonads and brain make this steroid intermediate that may also have adult hormonal functions.
- **dehydroepiandrosterone sulphate** - (DHEAS, DHEA-S) fetal adrenal cortex makes this inactive precursor of a steroid hormone.
- **dydrogesterone** - clinical oral retrosteroid structurally related to progesterone, with a greater bioavailability and selectivity for the

progesterone receptor.

- **estrogen** (oestrogen) family of female steroidal hormones - estrone (E1), estradiol (E2), estriol (E3), and estetrol (E4) synthesised from testosterone and androstenedione, by aromatase. Also produced in male testis, and required for genital development (PMID 29438493)
- **estrone (E1)** - steroid hormone with weak estrogenic activity.
- **estradiol (E2)** - (oestradiol) estrogen steroid hormone with main estrogenic female activity.
- **estriol (E3)** - (oestriol) steroid hormone with weak estrogenic activity.
- **estetrol (E4)** (oestetrol) steroid hormone with weak estrogenic activity produced only during pregnancy.
- **follicle stimulating hormone** - (FSH) pituitary glycoprotein hormone secreted by gonadotrophs (basophilic cell subgroup) acts on gametogenesis and other systems in both males and females. Females, acts on the ovary to stimulate follicle development. Negative feedback by inhibin from the developing follicle decreases FSH secretion. Males, acts on the testis Sertoli cells to increase androgen-binding protein (ABP) that binds androgens and has a role in spermatogenesis.
- **growth hormone** - (GH) pituitary, peptide hormone that stimulates tissue and skeletal growth. In the ovary, growth hormone also increases granulosa cell FSH-dependent E2 production.
- **growth hormone releasing hormone** - (GHRH) hypothalamus, protein that activates growth hormone synthesis and release from the anterior pituitary.
- **human chorionic gonadotropin** - (hCG) glycoprotein hormone with 2 subunits (alpha and beta joined non covalently). Similar in structure to luteinizing hormone (LH), hCG exists in multiple hormonal and non-endocrine agents (regular hCG, hyperglycosylated hCG and the free beta-subunit of hyperglycosylated hCG). PMID 19171054
- **human chorionic somatommotropin** - (hCS, CSH, placental lactogen) Placental hormone is structurally similar to both growth hormone (GH) and prolactin (PRL} and binds strongly to PRL receptors but weakly to GH receptors. Role in stimulating maternal mammary gland development. endocrine placenta
- **interstitial cell** - (Leydig cell) Male testis cell secrete the androgen testosterone, required for fetal male genital tract differentiation and masculinisation after puberty.

- **Leydig cell** - (interstitial cell) Male testis cell secrete the androgen testosterone, beginning in the fetus. These cells are named after Franz von Leydig (1821 - 1908) a German scientist who histologically described these cells.

- **lutenizing hormone** - (LH, gonadotropin, lutropin, Interstitial Cell Stimulating Hormone, ICSH) pituitary, glycoprotein hormone acts on the gonad and has a role in male and female reproduction. Female, increase in concentration during the menstrual cycle triggers ovulation. Male, stimulates testis interstital cell production of testosterone. Gonadotrophins have been used clinically in humans for the treatment of female infertility.

- **melaocyte stimulating hormone** - (MSH) pituitary, peptide hormone pituitary

- **melatonin** - (N-acetyl-5-methoxytryptamine) pineal amino acid amino (precursor tryptophan) hormone involved with the diurnal cycle, melatoinin levels are high in dark, low in daylight. Also acts as an antioxidant, free radical scavenger, and anti-inflammatory molecule.

- **prolactin** - (PRL) pituitary, peptide hormone pituitary

- **parathyroid** - endocrine gland through parathyroid hormone (PTH) regulates calcium and phosphate levels in conjunction with parafollicular cells of the thyroid gland (calcitonin) and Vitamin D, dietary or synthesized in the skin. Develops from pharyngeal endoderm, in this case the 3rd and 4th pharyngeal pouches.

- **parathyroid hormone** - (PTH) parathyroid, peptide hormone parathyroid

- **synthetic ACTH test** = (synacthen test) A diagnostic test to both measure the amount of cortisol in the body and to determine the ability to produce cortisol.

- **testosterone** - testis ovary steroidal hormone. In males is the androgen which regulates genital (gonadal and tract), secondary sex characteristics and neural development. The steroid is converted to the active metabolite dihydrotestosterone (DHT) by the enzyme 5-alpha reductase for the genital effects and estradiol by the enzyme aromatase for the neural effects.

- **thyroid** - endocrine gland located in the neck with a developmental role in neurological development and metabolism.

- **thyroid diverticulum** - the primordium of the thyroid gland, beginning as an median endodermal thickening in the floor of pharynx between the pharyngeal pouch 1 and 2.

- **thyroid hormone** - (TH) thyroid amino acid derivative with two main forms (T3, T4) regulates tissue metabolic activity.
- **thyroid stimulating hormone** - (TSH) pituitary protein hormone
- **ultimobranchial body** - historic term for the embryonic structure that forms the parafollicular cells (C cells) of the thyroid.

ExpandOther Terms Lists

Terms Lists: ART | Birth | Bone | Cardiovascular | Cell Division | Endocrine | Gastrointestinal | Genital | Genetic | Head | Hearing | Heart | Immune | Integumentary | Neonatal | Neural | Oocyte | Palate | Placenta | Radiation | Renal | Respiratory | Spermatozoa | Statistics | Tooth | Ultrasound | Vision | Historic | Drugs | Glossary

Endocrine Development Interactive Component

ExpandAttempt the Quiz - Endocrine Development

Here are a few simple Quiz questions that relate to Endocrine development and abnormalities from the lecture. Some questions may require some additional research.

Additional Information: endocrine | BGD Lecture | Science Lecture | Lecture Movie | pineal | hypothalamus | pituitary | thyroid | parathyroid | thymus | pancreas | adrenal | endocrine gonad | endocrine placenta | other tissues | Stage 22 | endocrine abnormalities | Hormones | Category:Endocrine

BGDB: Lecture - Gastrointestinal System | Practical - Gastrointestinal System | Lecture - Face and Ear | Practical - Face and Ear | Lecture - Endocrine | Lecture - Sexual Differentiation | Practical - Sexual Differentiation | Tutorial

Glossary Links

Glossary: A | B | C | D | E | F | G | H | I | J | K | L | M | N | O | P | Q | R | S | T | U | V | W | X | Y | Z | Numbers | Symbols | Term Link

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What Links Here?