511-2018-09-28-hormones

Rick Gilmore

Today's Topics

- Wrap-up on monoamines
- Hormones

Hormones

- Chemicals secreted into blood
- Act on specific target tissues via receptors
- Produce specific effects

Examples of substances that are both hormones and NTs

- Melatonin
- Epinephrine/adrenaline
- Oxytocin
- Vasopressin

Behaviors under hormonal influence

Behaviors under hormonal influence

- Ingestive (eating/ drinking)
  - Fluid levels
  - Na, K, Ca levels
  - Digestion
  - Blood glucose levels

Behaviors under hormonal influence

Behaviors under hormonal influence

- Reproduction
  - Sexual Maturation
  - Mating
  - Birth
  - Care giving

Behaviors under hormonal influence

Behaviors under hormonal influence

- Responses to threat/ challenge
  - Metabolism
  - Heart rate, blood pressure
  - Digestion
  - Arousal

What do these behaviors have in common?

- Biological imperatives
- Proscribed in space and time
- Foraging/hunting
  - Find targets distributed in space, evaluate, act upon
- Often involve others

Principles of hormonal action

- Gradual action
- Change intensity or probability of behavior
- Behavior influences/influenced by hormones
  - +/- Feedback
- Multiple effects on different tissues

Principles of hormonal action

- Produced in small amounts; released in bursts
- Levels vary daily, seasonally
  - or are triggered by specific external/internal events
- Effect cellular metabolism
- Influence only cells with receptors

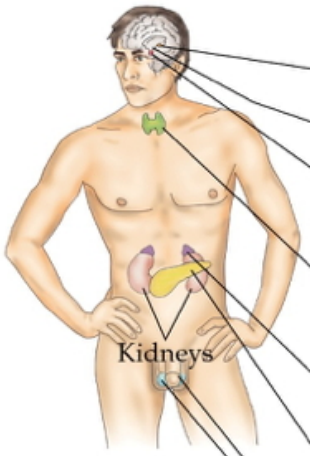
Differences between neural and hormonal communication

- Point to point vs.“broadcast”
  - Wider broadcast than neuromodulators
- Fast vs. slow-acting
- Short-acting vs. long-acting
- Digital (yes-no) vs. analog (graded)
- Voluntary control vs. involuntary

Similarities between neural and hormonal communication

- Chemical messengers stored for later release
- Release follows stimulation
- Action depends on specific receptors
- 2nd messenger systems common

Where are hormones released

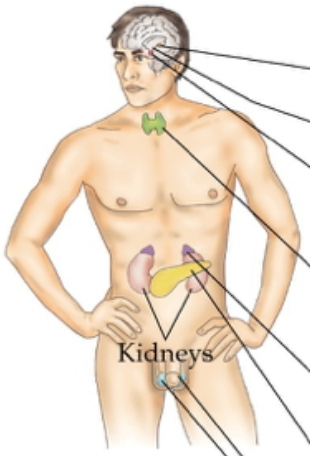


Main endocrine glands	Some main functions regulated by secretion
Pineal gland	Reproductive maturation; bodily rhythms
Hypothalamus	
Pituitary gland:	
Anterior pituitary	Hormone secretion by thyroid, adrenal cortex, and gonads; growth
Posterior pituitary	Water balance; salt balance
Thyroid	Growth and development; metabolic rate
Adrenal glands:	
Adrenal cortex	Salt and carbohydrate metabolism; inflammatory reactions
Adrenal medulla	Emotional arousal
Pancreas	Sugar metabolism
Gonads	Body development; maintenance of reproductive organs in adults

Where are hormones released?

- CNS
  - Hypothalamus
  -
    -
    -
  - Pineal gland

Where are hormones released



Main endocrine glands	Some main functions regulated by secretion
Pineal gland	Reproductive maturation; bodily rhythms
Hypothalamus	
Pituitary gland:	
Anterior pituitary	Hormone secretion by thyroid, adrenal cortex, and gonads; growth
Posterior pituitary	Water balance; salt balance
Thyroid	Growth and development; metabolic rate
Adrenal glands:	
Adrenal cortex	Salt and carbohydrate metabolism; inflammatory reactions
Adrenal medulla	Emotional arousal
Pancreas	Sugar metabolism
Gonads	Body development; maintenance of reproductive organs in adults

Where are hormones released?

- Rest of body
  -
  -
    -
    -
  - (testes/ovaries)

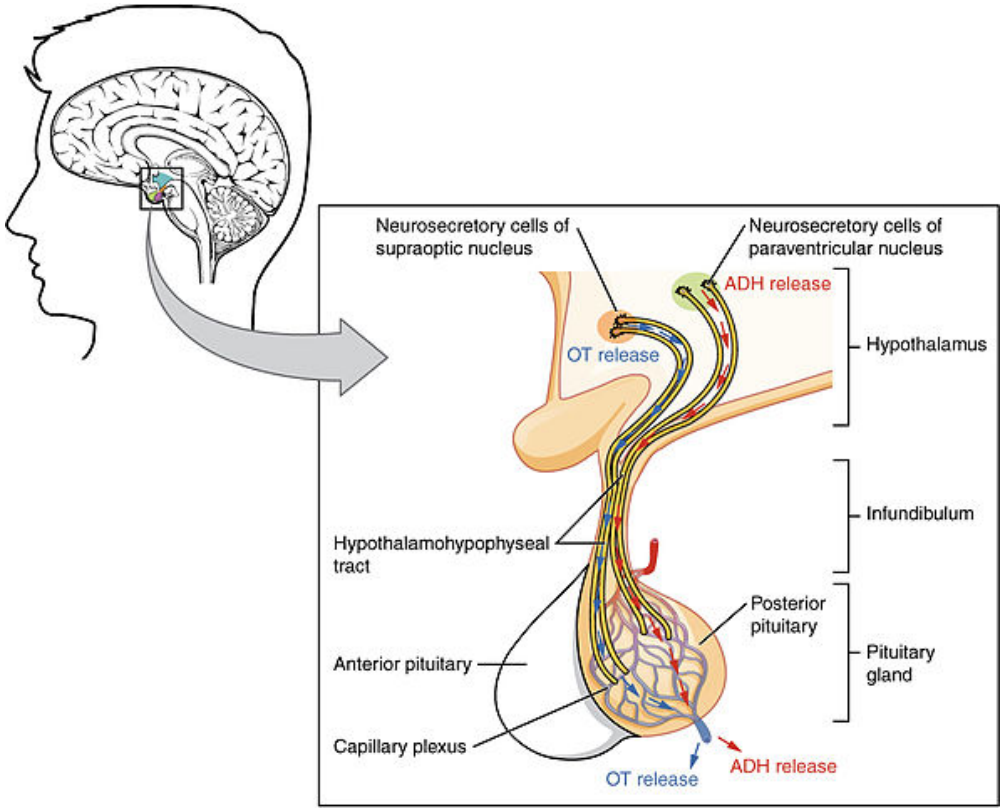
Two release systems

- Direct
- Indirect

Direct hormone release into bloodstream

- Hypothalamus (paraventricular, supraoptic nucleus) to
- Posterior pituitary
    -
    -

Direct release

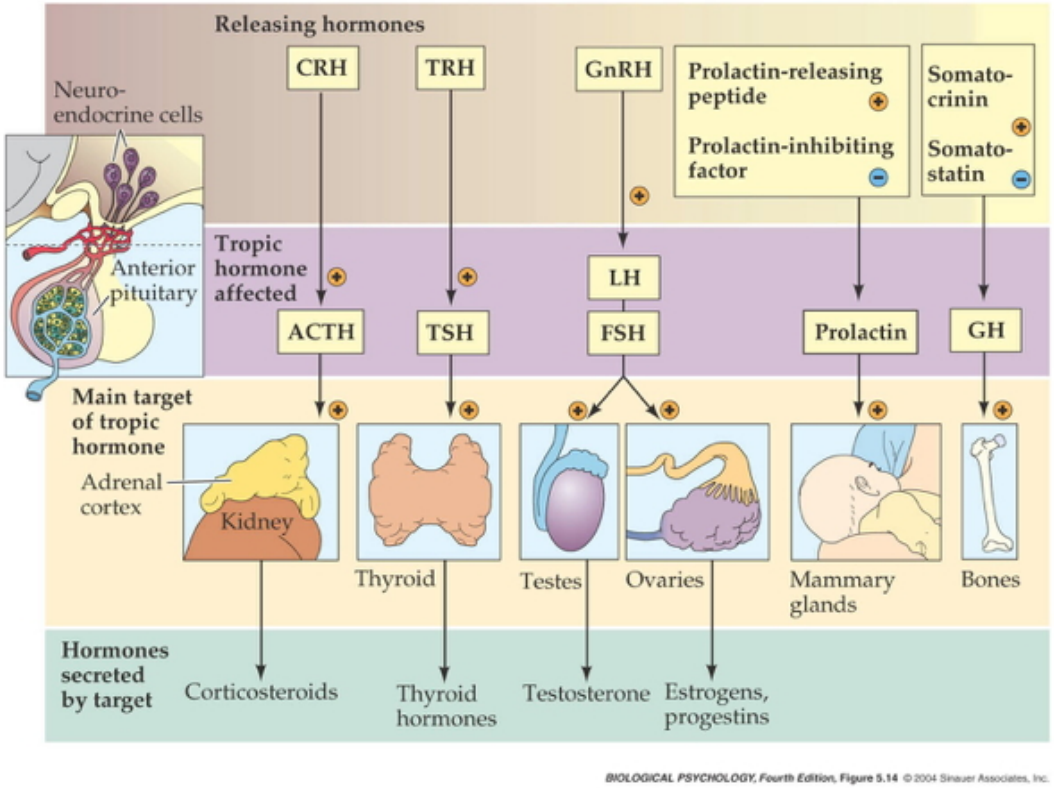


https://upload.wikimedia.org/wikipedia/commons/thumb/7/70/1807_The_Posterior_Pituitary_Complex.jpg/594p1807_The_Posterior_Pituitary_Complex.jpg

Indirect release

- Hypothalamus ->
- Anterior pituitary ->
- End organs

Indirect release

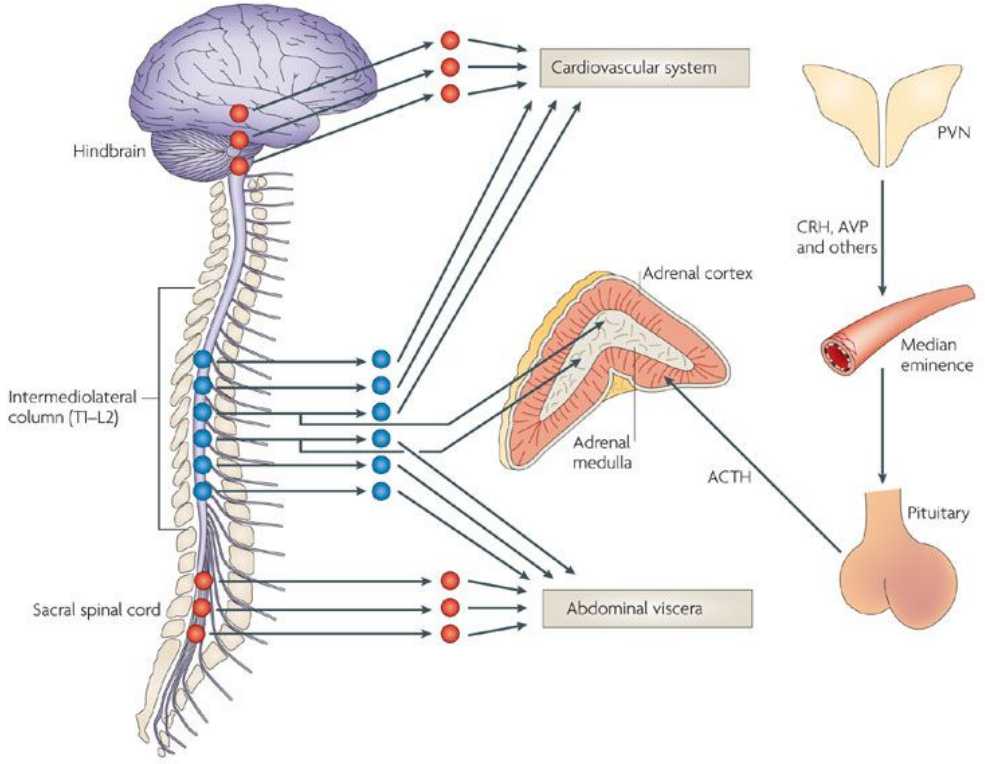


Case studies

Case 1: Responses to threat or challenge

- Neural response
  -
  - Sympathetic NS activation of adrenal medulla, other organs
  - Releases NE and Epi

(Ulrich-Lai & Herman, 2009)

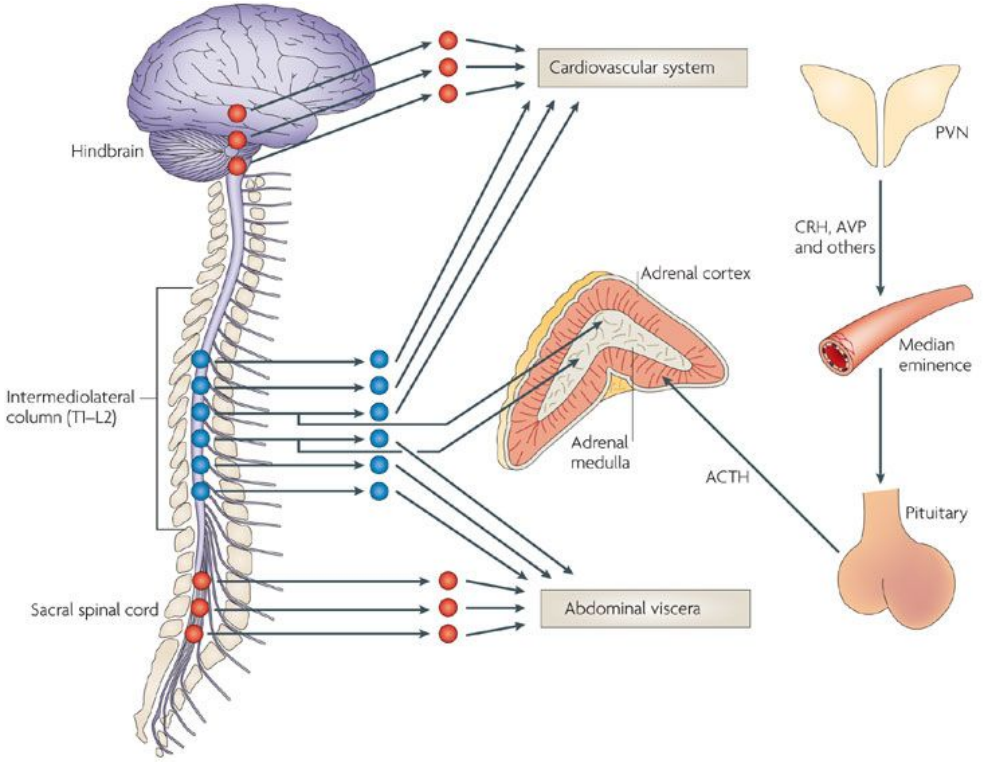

Cardiovascular system
Hindbrain
PVN
CRH, AVP
and others
Adrenal cortex
Median
eminence
Intermediolateral
column (T1–L2)
Adrenal
medulla
ACTH
Pituitary
Sacral spinal cord
Abdominal viscera
Nature Reviews | Neuroscience

Case 1: Responses to threat or challenge

- Endocrine response
  -
  - Adrenal hormones released
- Hypothalamus
  -
- Anterior pituitary
  -

Case 1: Responses to threat or challenge

- Adrenal cortex
  -
  -


Cardiovascular system
Hindbrain
PVN
CRH, AVP
and others
Adrenal cortex
Median
eminence
Intermediolateral
column (T1–L2)
Adrenal
medulla
ACTH
Pituitary
Sacral spinal cord
Abdominal viscera
Nature Reviews | Neuroscience

Adrenal hormones

-
  - Derived from cholesterol
-
  - increases blood glucose, anti-inflammatory effects
  - negative consequences of prolonged exposure
-
  - Regulates Na (and water)

Case 2: Reproductive behavior – the milk letdown reflex

- Supraoptic & Paraventricular nucleus (PVN) of hypothalamus releases oxytocin
  - Into bloodstream via posterior pituitary (endocrine)
  - Onto neurons in nucleus accumbens (neurocrine), amygdala, brainstem

Milk letdown reflex

Oxytocin's role

- Sexual arousal
- Released in bursts during orgasm
- Stimulates uterine, vaginal contraction
- Links to social interaction, bonding (Weisman & Feldman, 2013)
- Alters face processing in autism (Domes et al., 2013)
- May inhibit fear/anxiety-related behaviors by gating amygdala (Viviani et al., 2011)

Oxytocin

Melatonin

- Diurnal rhythm
- Night time peak, early morning low
- Secretion suppressed by "blue" light (< 460-480 nm)
- Rhythm irregular until ~3 mos post-natal (Ardura, Gutierrez, Andres, & Agapito, 2003)
- Peak weakens, broadens with age

SCN/pineal gland pathway.

Melatonin circuitry

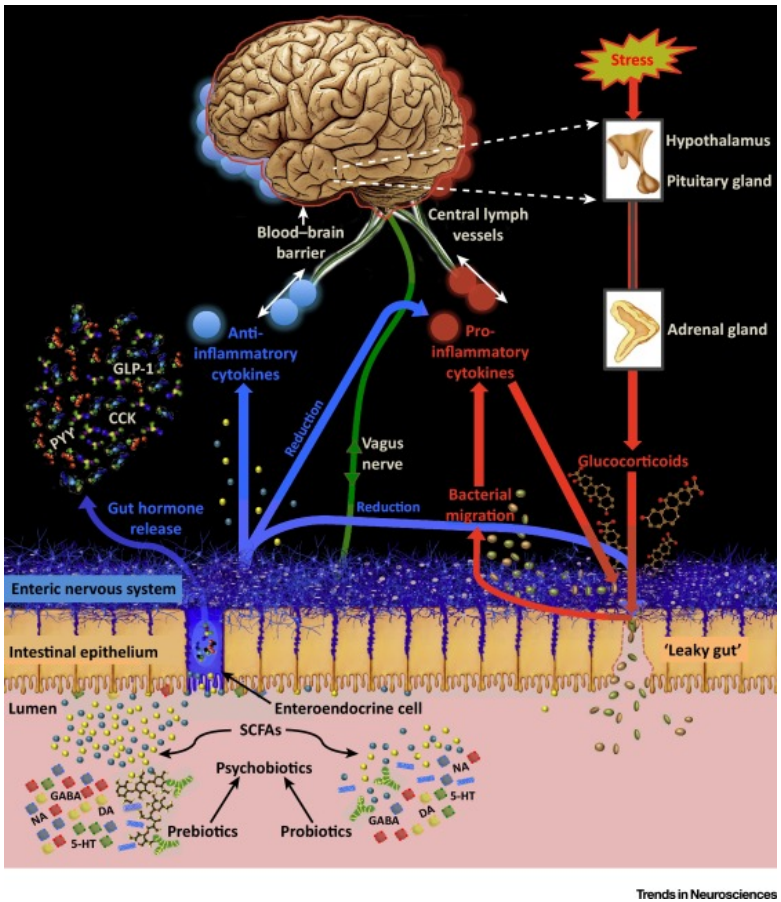
- Suprachiasmatic nucleus of the hypothalamus
- Paraventricular nucleus of the hypothalamus
- Spinal cord
- Superior cervical ganglion
- Pineal gland

How to think about neurochemical influences

- Measure hormones in blood, saliva; can't effectively measure NTs
- Multivariate, nonlinear, mutually interacting
- Varied time scales
    - Phasic (e.g., cortisol in response to challenge)
    - Periodic (e.g., melatonin; diurnal cortisol)

How to think about neurochemical influences

- Peripheral effects + neural feedback
- State variables and behavior
  - Are your participants sleepy, hungry, horny, distressed…
  - Endogenous & exogenous influences



Sarkar, A., et al. (2016). , (11), 763–781.

Next time…

- How the human brain got this way…

References

Ardura, J., Gutierrez, R., Andres, J., & Agapito, T. (2003). Emergence and evolution of the circadian rhythm of melatonin in children. , (2), 66–72. https://doi.org/68571

Domes, G., Heinrichs, M., Kumbier, E., Grossmann, A., Hauenstein, K., & Herpertz, S. C. (2013). Effects of intranasal oxytocin on the neural basis of face processing in autism spectrum disorder. , (3), 164–171. https://doi.org/http://dx.doi.org/10.1016/j.biopsych.2013.02.007

Ulrich-Lai, Y. M., & Herman, J. P. (2009). Neural regulation of endocrine and autonomic stress responses. , (6), 397–409. https://doi.org/10.1038/nrn2647

Viviani, D., Charlet, A., Burg, E. van den, Robinet, C., Hurni, N., Abatis, M., … Stoop, R. (2011). Oxytocin selectively gates fear responses through distinct outputs from the central amygdala. , (6038), 104–107. https://doi.org/10.1126/science.1201043

Weisman, O., & Feldman, R. (2013). Oxytocin effects on the human brain: Findings, questions, and future directions. , (3), 158–159. https://doi.org/http://dx.doi.org/10.1016/j.biopsych.2013.05.026