Thursday:  Hypothalamic and Pituitary Hormones

Monday:  Adrenal Corticosteroids

Tuesday:  Thyroid Drugs

Wednesday:  Diabetes and Insulins

Thursday:  Oral Anti-Diabetic Agents

Spring:  Calcium and Bones, Sex Steroids, Contraception and Related Topics

ENDOCRINE PHARMACOLOGY
Frederick G. Hamel, Ph.D.
Veterans Affairs Medical Center R208A
346-8800 x3032
fghamel@unmc.edu
Toews Teaching Home Page
Nothing fancy; hopefully useful
At info.unmc.edu/toews/
Linked from Pharmacology Teaching Home Page

fghamel@unmc.edu
Contact me with questions, comments

Lecture Slides
PowerPoint slides as presented in class

Study/Review Questions
Essay/short answer style questions, with answers

Sample Questions from Previous Exams, MiniQuizzes
Multiple choice, with answers explained
A few previous MQ essay questions with answers
MY TEACHING STYLE

Syllabus very complete
- should contain all information for exam
- required drugs highlighted in bold
- Slides and lecture will follow syllabus
  - required drugs in blue
  - new information not in handout in brown
- Lecture slides and additional material on website

Questions
1. Mechanism of action
   a. Molecular
   b. Physiological
2. Uses
   a. When
   b. How
3. Contraindications
<table>
<thead>
<tr>
<th>Hypothalamic hormone</th>
<th>Pituitary hormone</th>
<th>Target organ</th>
<th>Target organ hormone(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corticotropin-releasing hormone (CRH) (+)</td>
<td>Adrenocorticotropic hormone (ACTH) (+)</td>
<td>Adrenal cortex</td>
<td>Glucocorticoids</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Mineralocorticoids</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Androgens</td>
</tr>
<tr>
<td>Thyrotropin-releasing hormone (TRH) (+)</td>
<td>Thyroid-stimulating hormone (TSH) (+)</td>
<td>Thyroid</td>
<td>Thyroxine (T₄)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Triiodothyronine (T₃)</td>
</tr>
<tr>
<td>Gonadotropin-releasing hormone (GnRH or LHRH) (+)</td>
<td>Follicle-stimulating hormone (FSH) (+)</td>
<td>Gonads</td>
<td>Estrogen</td>
</tr>
<tr>
<td></td>
<td>Luteinizing hormone (LH) (+)</td>
<td></td>
<td>Progesterone</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Testosterone</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Growth hormone-releasing hormone (GHRH) (+)</td>
<td>Growth hormone (somatotropin) (GH) (+)</td>
<td>Liver</td>
<td>Somatomedins</td>
</tr>
<tr>
<td>Somatotropin release-inhibiting hormone (somatostatin)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Prolactin-releasing hormone (PRH) (+)</td>
<td>Prolactin (PRL) (+)</td>
<td>Lymphocytes</td>
<td>Lymphokines</td>
</tr>
<tr>
<td>Dopamine (-)</td>
<td></td>
<td>Breast</td>
<td>Breast milk</td>
</tr>
</tbody>
</table>
Hypothalamus

Releasing hormone

Anterior pituitary

Tropic hormone

Target organ

Target hormone

End organ effects

Feedback regulation

Replacement therapy

Suppressive therapy

(+)

(-)

(+) (-)
Thyroid Hormone

Replacement Therapy

Inactive Thyroid

Suppressive Therapy

Enlarged Thyroid
Glucocorticoids

- Replacement Therapy
  - Adrenal Insufficiency
- Suppressive Therapy
  - Adrenal Hormone Excess
Adapted from Brenner, Fig 31-1

- Vasopressin
- Oxytocin
- ACTH
- LH
- FSH
- TSH
- Prolactin
- Growth hormone

Hypophysioporal vessel

Arcuate and other nuclei of the hypothalamus

Supraoptic and paraventricular nuclei of the hypothalamus

Anterior lobe of pituitary

Posterior lobe of pituitary
Adapted from Brenner, Fig 31-1

Vasopressin
Oxytocin
ACTH
FSH
TSH
Prolactin
Growth hormone
LH
Regulate target organ hormone production

Directly regulate end organ responses

Vasopressin
Vessels
Kidney

Oxytocin
Uterus
Breast

ACTH
Regulate target organ hormone production

LH
FSH
TSH
Prolactin
Growth hormone

Growth
End organs
Metabolism
T₃, T₄
Thyroid

Posterior lobe of pituitary
Anterior lobe of pituitary
Hypophysioportal vessel

Arcuate and other nuclei of the hypothalamus
Supraoptic and paraventricular nuclei of the hypothalamus

Adapted from Brenner, Fig 31-1
<table>
<thead>
<tr>
<th>Hypothalamic hormone</th>
<th>Pituitary hormone</th>
<th>Target organ</th>
<th>Target organ hormone(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corticotropin-releasing hormone (CRH) (+)</td>
<td>Adrenocorticotropic hormone (ACTH) (+)</td>
<td>Adrenal cortex</td>
<td>Glucocorticoids Mineralocorticoids Androgens</td>
</tr>
<tr>
<td>Thyrotropin-releasing hormone (TRH) (+)</td>
<td>Thyroid-stimulating hormone (TSH) (+)</td>
<td>Thyroid</td>
<td>Thyroxine ($T_4$) Triiodothyronine ($T_3$)</td>
</tr>
<tr>
<td>Gonadotropin-releasing hormone (GnRH or LHRH) (+)</td>
<td>Follicle-stimulating hormone (FSH) (+) Luteinizing hormone (LH) (+)</td>
<td>Gonads</td>
<td>Estrogen Progesterone Testosterone</td>
</tr>
<tr>
<td>Growth hormone-releasing hormone (GHRH) (+)</td>
<td>Growth hormone (somatotropin) (GH) (+)</td>
<td>Liver</td>
<td>Somatomedins</td>
</tr>
<tr>
<td>Somatotropin release-inhibiting hormone (somatostatin) (-)</td>
<td>Prolactin-releasing hormone (PRH) (+) Dopamine (-) Prolactin (PRL) (+)</td>
<td>Lymphocytes Breast</td>
<td>Lymphokines Breast milk</td>
</tr>
</tbody>
</table>
### Hypothalamic, pituitary, and target hormones (by hormone receptor type)

<table>
<thead>
<tr>
<th>Hypothalamic hormone</th>
<th>Pituitary hormone</th>
<th>Target organ</th>
<th>Target organ hormone(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corticotropin-releasing hormone (CRH) (+)</td>
<td>Adrenocorticotropic hormone (ACTH) (+)</td>
<td>Adrenal cortex</td>
<td>Glucocorticoids, Mineralocorticoids, Androgens</td>
</tr>
<tr>
<td>Thyrotropin-releasing hormone (TRH) (+)</td>
<td>Thyroid-stimulating hormone (TSH) (+)</td>
<td>Thyroid</td>
<td>Thyroxine (T₄), Triiodothyronine (T₃)</td>
</tr>
<tr>
<td>Gonadotropin-releasing hormone (GnRH or LHRH) (+)</td>
<td>Follicle-stimulating hormone (FSH) (+), Luteinizing hormone (LH) (+)</td>
<td>Gonads</td>
<td>Estrogen, Progesterone, Testosterone</td>
</tr>
<tr>
<td>Growth hormone-releasing hormone (GHRH) (+)</td>
<td>Growth hormone (somatotropin) (GH) (+)</td>
<td>Liver</td>
<td>Somatomedins</td>
</tr>
<tr>
<td>Somatostatin release-inhibiting hormone (somatostatin) (-)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Prolactin-releasing hormone (PRH) (+), Dopamine (-)</td>
<td>Prolactin (PRL) (+)</td>
<td>Lymphocytes, Breast</td>
<td>Lymphokines, Breast milk</td>
</tr>
</tbody>
</table>
# Hypothalamic, pituitary, and target hormones (by chemical class of hormone)

<table>
<thead>
<tr>
<th>Hypothalamic hormone</th>
<th>Pituitary hormone</th>
<th>Target organ</th>
<th>Target organ hormone(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corticotropin-releasing hormone (CRH) (+)</td>
<td>Adrenocorticotropic hormone (ACTH) (+)</td>
<td>Adrenal cortex</td>
<td>Glucocorticoids Mineralocorticoids Androgens</td>
</tr>
<tr>
<td>Thyrotropin-releasing hormone (TRH) (+)</td>
<td>Thyroid-stimulating hormone (TSH) (+)</td>
<td>Thyroid</td>
<td>Thyroxine (T&lt;sub&gt;4&lt;/sub&gt;) Triiodothyronine (T&lt;sub&gt;3&lt;/sub&gt;)</td>
</tr>
<tr>
<td>Gonadotropin-releasing hormone (GnRH or LHRH) (+)</td>
<td>Follicle-stimulating hormone (FSH) (+)</td>
<td>Gonads</td>
<td>Estrogen Progesterone Testosterone</td>
</tr>
<tr>
<td></td>
<td>Luteinizing hormone (LH) (+)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Growth hormone-releasing hormone (GHRH) (+)</td>
<td>Growth hormone (somatotropin) (GH) (+)</td>
<td>Liver</td>
<td>Somatomedins</td>
</tr>
<tr>
<td>Somatotropin release-inhibiting hormone (somatostatin) (-)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Prolactin-releasing hormone (PRH) (+)</td>
<td>Prolactin (PRL) (+)</td>
<td>Lymphocytes</td>
<td>Lymphokines</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Breast</td>
<td>Breast milk</td>
</tr>
<tr>
<td></td>
<td>Dopamine (-)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Problems with peptides as drugs

- Hard to identify initially
  - trace amounts, local action
- Expensive to purify
- Immune reactions if animal products used
- Human form may be required
- Difficult to synthesize chemically
- Generally ineffective orally
  - poorly absorbed, rapidly hydrolyzed
- Generally require injection
  - unpleasant
  - still rapid hydrolysis, short half-life
Technical advances for peptides as drugs

- Production by recombinant DNA technology
  - large amounts, pure, human
- Novel amino acids to prevent hydrolysis
  - D-isomers, other analogs
- Routes of administration
  - nasal, transdermal
  - needle-free delivery devices (GH, insulin)
  - one oral, more coming
- Identify synthetic analogs from combinatorial libraries by high-throughput screening
- Optimize for potency, duration, specificity
- Oral non-peptide mimetics

Peptides are becoming increasingly useful as drugs
<table>
<thead>
<tr>
<th>Hypothalamic hormone</th>
<th>Pituitary hormone</th>
<th>Target organ</th>
<th>Target organ hormone(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corticotropin-releasing hormone (CRH) (+)</td>
<td>Adrenocorticotropic hormone (ACTH) (+)</td>
<td>Adrenal cortex</td>
<td>Glucocorticoids, Mineralocorticoids, Androgens</td>
</tr>
<tr>
<td>Thyrotropin-releasing hormone (TRH) (+)</td>
<td>Thyroid-stimulating hormone (TSH) (+)</td>
<td>Thyroid</td>
<td>Thyroxine (T₄), Triiodothyronine (T₃)</td>
</tr>
<tr>
<td>Gonadotropin-releasing hormone (GnRH or LHRH) (+)</td>
<td>Follicle-stimulating hormone (FSH) (+)</td>
<td>Gonads</td>
<td>Estrogen, Progesterone, Testosterone</td>
</tr>
<tr>
<td><strong>Growth hormone-releasing hormone (GHRH) (+)</strong></td>
<td><strong>Growth hormone (somatotropin) (GH) (+)</strong></td>
<td>Liver</td>
<td>Somatomedins</td>
</tr>
<tr>
<td><strong>Somatotropin release-inhibiting hormone (somatostatin) (-)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Prolactin-releasing hormone (PRH) (+)</strong></td>
<td><strong>Prolactin (PRL) (+)</strong></td>
<td>Lymphocytes, Breast</td>
<td>Lymphokines, Breast milk</td>
</tr>
<tr>
<td><strong>Dopamine (-)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Questions on physiology or peptides as drugs??
Hormones/Drugs that you DON'T need to know (for now)
CRH, ACTH, corticosteroids

- Corticosteroids preferred for therapy
  - Glucocorticoids, mineralocorticoids

- Adrenocorticotropic hormone (ACTH)
  - Porcine ACTH (corticotropin)
  - Synthetic human ACTH[1-24] (cosyntropin)
  - Diagnosis of H-P-A function, tumors

- Corticotropin releasing hormone (CRH)
  - Sheep or recombinant human hormone
  - Diagnosis of H-P-A axis function
TRH, TSH, thyroid hormones

- Thyroid hormones used extensively for therapy

- Thyroid stimulating hormone (TSH)
  - Bovine pituitary or recombinant human
  - Diagnosis of thyroid function, esp. tumors

- Thyrotropin releasing hormone (TRH)
  - Synthetic TRH (Protirelin)
  - Diagnosis of thyroid disease
- GnRH, gonadotropins, sex steroids
  *(Covered in more detail next semester)*

- Sex steroid hormones used extensively
  - HRT, contraception, menstrual control

- Gonadotropins used therapeutically
  - diagnosis and treatment of infertility

- GnRH analogs used extensively
  - to mimic or to block GnRH responses
  - good examples of synthetic peptide analogs with altered pharmacokinetic and pharmacodynamic properties
Hormones/Drugs that you **DO** need to know
The growth hormone system (pituitary level)

- Growth hormone (GH)--191 a.a. pituitary peptide
  - Useful for treating GH deficiency
    - promoting growth in children (1/4000)
    - body maintenance in adults
  - Preparations
    - only human hormone works
    - human cadaver product used until 1984
      ✤ withdrawn due to Creutzfeldt-Jakob
    - recombinant hormones used now
The growth hormone system (pituitary level)

- Growth hormone (GH)
  - Recombinant hormone preparations
    - **Somatropin** (Nutropin®, others)
      - human sequence
    - **Somatrem** (Protropin®)
      - human sequence plus extra methionine
      - IM or SC, 3-7/week
    - Depot somatropin (Nutropin Depot®)
      - IM 1-2/month
    - New "Cool.Click" needle-free delivery device
◆ The growth hormone system (pituitary level)

☐ Growth hormone (GH)

- Effective
  - increased linear growth
  - decreased fat, increased muscle, bone
  - increased sense of well-being

- Expensive ($20,000/yr)
The growth hormone system (pituitary level)

- Growth hormone (GH)
  - Approved uses
    - GH deficiency, Turner’s syndrome, Prader-Willi syndrome, renal insufficiency, AIDS cachexia
    - approved 2003 for "normal short stature" (NGHD, non-GH-deficient)
  - Efficacy and safety in other conditions under investigation
    - delayed growth, wound healing in severe burns
  - Some abuse by athletes, body-builders for anabolic effects
◆ The growth hormone system (hypothalamic level)

- Growth hormone-releasing hormone (GHRH)
  - **Sermorelin** (Geref®)
    - Synthetic human GHRH[1-29] (of 44 total)
    - Approved 1998 for GH deficiency
    - Stimulates release of GH \( \rightarrow \) IGF-1
    - Requires pituitary function
    - IV, SC, nasal administration
    - Somewhat cheaper than GH ($10,000/yr)
    - Somewhat less effective than GH?
    - Long-term effects not known
    - Used more diagnostically than therapeutically
The growth hormone system (pituitary level)

- Pegvisomant (Somavert®)
  - first GH receptor antagonist
  - blocks actions of released GH
  - in clinical trials, orphan status for acromegaly (GH excess)
  - Approved 2003
The growth hormone system (hypothalamic level)

- **Somatostatin (SS)**
  - 14- and 28-amino acid cyclic peptides
  - Hypothalamic SS inhibits GH release (and TSH and prolactin)
  - Pancreatic SS inhibits release of insulin, glucagon
  - Gut SS inhibits release of VIP, others
  - Not useful therapeutically
    - action too short, too much insulin effect

- **Octreotide** (Sandostatin®)
  - Clinically useful synthetic SS analog
  - 8-amino acid cyclic peptide
Somatostatin

Octreotide
The growth hormone system (hypothalamic level)

- Octreotide
  - Longer-acting than somatostatin
  - Less effect on insulin than with somatostatin
    - 10-20X selectivity
    - some receptor subtype selectivity
    - prefers SSTR-2 and -5 receptors, those expressed on tumors
  - Regular octreotide
    - given SC, 2-3X/day
  - Newer long-acting depot preparations
    - Sandostatin LAR®: IM every 4 wks
The growth hormone system (hypothalamic level)

Octreotide

- Uses
  - metastatic carcinoid (5HT-secreting tumor)
  - VIP-secreting tumors
  - inhibit GH secretion (acromegaly)
  - inhibit TSH and glucagon secretion
  - treating GI secretion disorders

- Mostly GI side effects (GI SSTRs)
  - diarrhea, nausea, flatulence, malabsorption
  - gallstones
Pharmacological strategies for growth hormone system therapy

- **Short stature, GH deficiency**
  - **Sermorelin**: hypothalamic hormone
    - stimulate GH release
  - **Somatropin, Somatrem**: pituitary hormones
    - replacement GH

- **Acromegaly, excess GH**
  - **Octreotide**: hypothalamic hormone
    - inhibit GH release
  - **Pegvisomant**: GH receptor antagonist
    - block actions of released GH
Questions on growth hormone system drugs??
The prolactin system

- Prolactin (pituitary hormone)
  - No drug preparations

- Dopamine (hypothalamic level)
  - Endogenous inhibitor of PRL release
  - Numerous DA drugs alter prolactin
    - DA agonists inhibit prolactin secretion
      - anti-Parkinson drugs, bromocriptine
    - DA antagonists cause hyperprolactinemia
      - antipsychotics, antidepressants
  - Dopamine itself not useful pharmacologically
    - dopamine agonist analogs used instead
The prolactin system

Dopamine agonist analogs

Bromocriptine (Parlodel®)
- Pergolide (Permax®) also used
- D1 and D2 receptors
- non-peptide, orally effective
  - vaginal tablets also used
- for hyperprolactinemia (infertility)
- for suppression of lactation
- to decrease prolactinoma tumor mass
- for acromegaly
  - inhibits GH too (in acromegaly only)
- side effects: GI, nausea, lightheadedness
  - tolerance generally develops
The prolactin system

- Dopamine agonist analogs
  - **Cabergoline** (Dostinex®)
    - same uses as bromocriptine
    - highly D2-selective analog
      - D2 is the target for prolactin
      - but also for side effects
    - fewer side effects than bromocriptine
      - due to pharmacokinetics (slower absorption and longer action), not due to D2 selectivity (?)
    - longer half-life
      - 70 hr, *vs.* 7 hr for bromocriptine
      - allows 1/d dosing
    - slightly more effective
Questions on prolactin-related drugs??
Posterior pituitary hormones

- Vasopressin (antidiuretic hormone, ADH)
  - 9-amino acid peptide
  - Released in response to ↑ osmolarity or ↓ blood pressure
  - Actions
    - increase renal water absorption to ↓ osmolarity
    - vasoconstriction to ↑ blood pressure
Posterior pituitary hormones

- Vasopressin
  - Acts on G protein-coupled receptors
    - V1 receptors
      - vascular smooth muscle: constriction
    - V2 receptors
      - kidney: water absorption
      - endothelial cells: clotting factors
  - Deficiency leads to diabetes insipidus
  - Used to treat diabetes insipidus (V2) and certain bleeding disorders (V1 and V2)
Posterior pituitary hormones

- Vasopressin preparations
  - Arginine vasopressin (AVP, Pitressin®)
    - synthetic human vasopressin
    - IV, IM, SC, nasal
    - short-acting
    - acts on V1 and V2 receptors
    - agent of choice for V1 effects or for short-term uses (whether V1 or V2)
      - local bleeding artery, hemorrhage (V1); e.g. esophageal varices, colonic diverticula
      - temporary post-surgical DI (V2)
Posterior pituitary hormones

Vasopressin preparations

Desmopressin acetate (DDAVP, Stimate®)
- stable peptide analog (10-20 hr)
- highly V2 selective (~4000-fold)
- IV, SC, inhaled
- new oral prep, first oral peptide drug!!
- DDAVP is the preparation of choice for diabetes insipidus

An improved peptide drug
- stability, selectivity, administration
Cys-Tyr-Ile-Gln-Asn-Cys-Pro-Leu-Gly  Oxytocin
Cys-Tyr-Phe-Gln-Asn-Cys-Pro-Arg-Gly  Vasopressin
Cys•Tyr-Phe-Gln-Asn-Cys-Pro-\textit{d}Arg-Gly  Desmopressin
Cys-Tyr-Phe-Gln-Asn-Cys-Pro-Lys-Gly  Lypressin
\textit{(Lysine vasopressin, no longer available)}
◆ Posterior pituitary hormones
  □ Vasopressin preparations
    ➤ Desmopressin acetate
  • Uses
    – treatment of choice for diabetes insipidus
      ✿ nasal has been; oral may be soon
    – nocturnal enuresis, to concentrate urine
    – to increase clotting factor synthesis in hemophilia, von Willebrand’s
    – all are V2 effects
Posterior pituitary hormones
- Vasopressin preparations
  - Side effects
    - V1 receptors: increased blood pressure, GI cramps, headache
    - oxytocin receptor: uterine contractions, cramps
    - occur with AVP, minimal with DDAVP
Posterior pituitary hormones

- Oxytocin
  - 9-aa peptide, two different from AVP
  - used to control labor, post-partum bleeding, and lactation
  - *Covered in more detail next semester*
Questions on posterior pituitary drugs??
Surprise MiniQuiz!
1. Which of the following drugs is recombinant human growth hormone-releasing hormone?

a. Sermorelin  
b. Somatropin  
c. Somatrem  
d. Somatostatin  
e. Somavert  
f. Somalia  
g. Somany similar-sounding drug names!
1. Which of the following drugs is recombinant human growth hormone-releasing hormone?

a. Sermorelin
b. Somatropin (GH)
c. Somatrem (GH with extra methionine)
d. Somatostatin (GH release inhibitory hormone)
e. Somavert (will be trade name of GH antagonist pegvisomant)
f. Somalia (country on east coast of Africa)
g. Somany similar-sounding drug names! (True!)
2. Octreotide

a. is recombinant human somatostatin.
b. has similar potencies for inhibiting growth hormone and insulin release.
c. is available as a once-per-month depot preparation.
d. is the only agent available to inhibit growth hormone release.
e. mediates its effects by activating dopamine D$_2$ receptors.
2. Octreotide

a. is recombinant human somatostatin. *(a synthetic shortened and stabilized analog)*
b. has similar potencies for inhibiting growth hormone and insulin release. *(quite selective for GH over insulin)*
c. is available as a once-per-month depot preparation.
d. is the only agent available to inhibit growth hormone release. *(bromocriptine is effective also)*
e. mediates its effects by activating dopamine D$_2$ receptors. *(bromocriptine acts on D$_2$ receptors, octreotide on SS-Rs)*
3. Which of the following statements comparing arginine vasopressin with desmopressin is TRUE? Desmopressin

a. has a more selective effect on vascular smooth muscle.
b. has a shorter duration of action.
c. is an agonist whereas arginine vasopressin is an antagonist.
d. has a greater selectivity for the V2 receptor vs. the V1 receptor.
e. is an orally-effective non-peptide analog of the arginine vasopressin peptide.
3. Which of the following statements comparing arginine vasopressin with desmopressin is TRUE? Desmopressin

a. has a more selective effect on vascular smooth muscle. (on kidney, not VSM)
b. has a shorter duration of action. (longer-acting)
c. is an agonist whereas arginine vasopressin is an antagonist. (both are agonists)
d. has a greater selectivity for the V2 receptor vs. the V1 receptor.
e. is an orally-effective non-peptide analog of the arginine vasopressin peptide. (is now available orally but is still a peptide)
REQUIRED DRUG LIST REVIEW

- somatropin
- somatrem
- sermorelin
- octreotide
- bromocriptine
- cabergoline
- arginine vasopressin (AVP)
- desmopressin (DDAVP)
KEY CONCEPTS REVIEW

- Hypothalamic-pituitary regulation
  - feedback inhibition
  - replacement vs. suppressive therapy

- Peptides as drugs
  - problems and solutions
  - advantages and disadvantages
  - examples