EFFECTS OF HORMONES

• Two major classes of hormone effects:
  — Organizational effects:
    • Occur during development
    • Help establish neural, muscular, and morphological basis for producing behavior

EFFECTS OF HORMONES

• Two major classes of hormone effects:
  — Activational effects:
    • Occur during adulthood
    • Involve modulating activity of existing neural, muscular, and morphological machinery

LEVELS OF ANALYSIS

• PROXIMATE CAUSES

<table>
<thead>
<tr>
<th>ORG</th>
<th>Genetic-developmental mechanisms</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Effects of genetic heredity on behavior</td>
</tr>
<tr>
<td></td>
<td>Effects of gene-environment interactions on behavior</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>ACT</th>
<th>Sensory-motor mechanisms</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Systems for detection of environmental stimuli (sensory)</td>
</tr>
<tr>
<td></td>
<td>Systems for adjusting responsiveness to stimuli (endocrine)</td>
</tr>
<tr>
<td></td>
<td>Systems for carrying out responses (motor)</td>
</tr>
</tbody>
</table>
EFFECTS OF PRE- AND PERINATAL STEROID EXPOSURE IN RODENTS

MALE MOUNTING BEHAVIOR

FEMALE LORDOSIS BEHAVIOR

MALE AND FEMALE RAT BEHAVIORS

- FEMALES
  - LORDOSIS
  - DON’T MOUNT
  - LESS AGGRESSIVE
  - PARENTAL

- MALES
  - NO LORDOSIS
  - MOUNT
  - MORE AGGRESSIVE
  - NOT PARENTAL
ORGANIZATION / ACTIVATION BY SEX STEROIDS

- Pre- and perinatal androgens masculinize and defeminize neuromuscular structures
  - Testosterone converted to estradiol in target tissues
  - Only effective at very early age
- Sex steroids activate circuits in adulthood
  - Androgens activate male-typical behaviors
  - Estrogens and progestins activate female-typical behaviors

RAT PUPS IN UTERO

UTERINE POSITION CAN AFFECT ADULT BEHAVIOR

- 2M INDIVIDUALS
  - More aggressive
  - More prone to mounting behavior
  - Females less sexually attractive to males
**True hermaphroditism in fish**

Simultaneous: possess both ovaries and testes
Sequential: first have testes then ovaries (protandrous)  
first have ovaries then testes (protogynous, below)

4.12 Urination postures of domestic dogs exhibit a clear sex difference that has been explored in studies of sexual differentiation. Adult male dogs usually raise a rear leg and orient the stream of urine toward a urine target on their penis. Adult females usually adopt a squatting posture. Puppies of both sexes usually assume a squatting posture during urination, although male dogs begin to show a “rear-forward” urinary posture around the time of puberty. After Becht 1974.
6.1.1 The sonic organs are used by Type I male amblyglyphid midshipmen fish to attract females to their males. (a) The sonic organs consist of a pair of sonic muscles attached to the swim bladder; contraction of the sonic muscles vibrates the swim bladder like the bell of a horn. (b & c) The sonic organs of Type II males are well developed compared with those of Type I males. (d) Females. The ratio of sonic muscle mass to total body mass is 6 times greater in Type II males than in Type I males. In contrast, the gonads or testes mass ratio is 6 and 20 times higher in Type II males and females, respectively, than in Type I males. After Bass, 1996.
Steroid-dependent auditory plasticity leads to adaptive coupling of sender and receiver. Science 305: 404-407.

See also Nelson Fig 3-18
4.16 Contributions of activational and organizational effects of hormones to behavior. Sexually dimorphic behaviors may be organized and activated, organized but not activated, activated but not organized, or not influenced by hormones.

<table>
<thead>
<tr>
<th>Activational effects</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>Refined sexual behavior</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Female body mass and mating behavior</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Male body mass and mating behavior</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Hormone gender role learning</td>
<td>Yes</td>
<td>No</td>
</tr>
</tbody>
</table>

(A) Testosterone (T) → Aromatase → OH Estradiol (E₂) → Target cell → OH Estradiol (E₂) → Estrogen receptors → Nucleus

(B) Time at window (seconds) vs. Test series

- Testosterone implanted
- Testosterone implant + aromatase inhibitor (at test 9)
- Controls (no testosterone implant)
General Adaptation Syndrome

- Alarm Phase
- Resistance Phase
- Exhaustion Phase

Pathological Effects of Stress Response

<table>
<thead>
<tr>
<th>Acute stress response</th>
<th>Pathological state associated with chronic stress</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shift from energy store to energy use</td>
<td>Fatigue, myopathy, stress, diabetes</td>
</tr>
<tr>
<td>Diminished cardiovascular tone</td>
<td>Hypertension</td>
</tr>
<tr>
<td>Inhibited digestion</td>
<td>Peptic ulcers</td>
</tr>
<tr>
<td>Inhibited growth</td>
<td>Psychosocial dwarfism</td>
</tr>
<tr>
<td>Inhibited reproduction</td>
<td>Impotence, amenorrhea, low of libido</td>
</tr>
<tr>
<td>Altered immune function</td>
<td>Impaired disease resistance, cancer</td>
</tr>
<tr>
<td>and inflammatory responses</td>
<td>Enhanced analgesia</td>
</tr>
</tbody>
</table>
Beneficial Effects of Stress Response?

- Chronic “mild” elevation of glucocorticoids
  - Positive effects on performance without obvious costs
- Acute (brief) stress response
  - Redirects behavior and physiology before homeostasis is threatened
  - Helps avoid chronic stress

11.6 Acute stress can improve immune function. Brief stress enhances a type of immune response in adrenal-intact rodents (A) and in animals receiving a sham adrenalectomy (B). This effect was abolished by adrenalectomy, suggesting that it was mediated by glucocorticoids (C). After Shearer and McEwen 2005.
Natural History

- Mountain chickadees cache food during late summer and early autumn
- Retrieve those food caches during winter to aid in survival
- Can have chronic modest elevation of corticosterone during cold, short days of autumn and winter
- How does mild elevation of corticosterone affect behavior and brain of mountain chickadees?


Figure 2. Mean number of pine nuts cached and mean number of nuts consumed (partly or fully) by corticosterone-implanted (filled bars) and placebo-implanted (hatched bars) mountain chickadees during unlimited cache-recovery trials.

Figure 3. Mean numbers of sites inspected by corticosterone-implanted (filled bars) and placebo-implanted (hatched bars) mountain chickadees to find previously made caches during unlimited and limited cache-recovery trials.

Figure 1. Mean numbers of sites visited by corticosterone-implanted (Cort) and placebo-implanted (Plac) mountain chickens to locate previously found food during one-trial associative learning tests (location, spatial versus, color, anti-spatial version).


Figure 1. Hippocampal volume of corticosterone-implanted (CORT) and placebo-implanted mountain chickens. Bars represent S.E. and whiskers represent 95% confidence interval.


Figure 2. Total number of hippocampal neurons in corticosterone-implanted (CORT) and placebo-implanted mountain chickens. Bars represent S.E. and whiskers represent 95% confidence interval.


Rapid Effects of Glucocorticoids

Figure 3. Total number of BrdU-labeled cells in the ventromedial area adjacent to the hypothalamus and to the midline in corticosterone-implanted (empty bars) and placebo-implanted (hatched bars) mountain newts. Bars represent S.E. and whiskers represent 95% confidence interval.

Fig. 3. Inhibition of male sexual behavior. (A) Latency of response to CORT. Males were injected with 25 mg/kg (11 μg) of CORT (○) or vehicle (○○), n = 14. Arrow indicates time of addition of females to tanks. Data are expressed as cumulative percentage of males at 1 min intervals. Males injected with CORT were significantly inhibited (†) within 3 min of testing (Fisher exact test, P = 0.021). (B) Linear relationship between potency of steroids in inhibition of (†)CORT binding (ordinate) and potency in inhibition of sexual behavior. Males were started with one of four in seven days of control or of vehicle (○ = 24 for each group). Data were measured as number of displays in 10-min time (abscissa), for which 60-min time was performed later in the breeding season. Half-maximal effective dose (ED50) values for inhibition of male displaying behavior versus controls were obtained by probit analysis (27).
Beneficial Effects of Acute Stress Response

- Mediate adaptive trade-off between current reproduction and long-term survival (for future reproduction)
  - Stress response induces animal to forego reproductive investment in favor of self-preservation

Development of Stress Response

- Effects of early experience on stress response later in life
1.1.2 Epigenetic influences of maternal behavior on offspring

Animals that adopt a maternal style of high licking and grooming in addition to wide-back nursing cause changes in the molecular pathways of the offspring. These changes are caused by DNA methylation and histone modification, both of which occur in the hippocampus, which involves expression of a transcription factor, NgF-A. It also causes demethylation of the GABA gene, as well as a change in histones, resulting in the GABA gene in the hippocampus. The net result of these changes is a GABA gene that is more readily accessible to the NGF-A transcription factor, which leads to more GABA synthesis in the hippocampus. This results in increased expression of this neural style by the offspring.