Lectures 23, 20 Nov 2003
Chapter 15, Feeding and Digestion

Vertebrate Physiology
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Vertebrate Physiology 437

1. Feeding and Digestion (CH15)

2. Announcements...
   - Exams returned next week
   - Powerpoint preview
   - Eldon Braun Thanks
FEEDING
Feeding

Filter Feeding
- baleen whales
- flamingoes
- planktivorous fish with modified gill rakers
- amphibian larvae

Fluid Feeding
- lampreys
- vampire bats (analgesic and anticoagulants)
Seizing with mouth etc.

- Jaws, teeth, beaks
- Form and function matched

(a) Generalized placental mammal
(b) Squirrel
(c) African Lion
(d) Ox
(e) Beaver

Modification for diet
Seizing with mouth etc.

Modification for diet

-Form and function matched

-Darwin’s Finches in Galapagos
Seizing with mouth etc.

Most toothed non-mammalian vertebrates have **homodont** dentition

- Exception: Some snakes

Some snakes also with **venom**
- hemolytic, neurotoxic
Heloderma

(a)

Duct of venom gland
Venom gland

(b)

Figure 9-39. Venom gland and venom-conducting teeth of the Gila monster, Heloderma suspectum. (a) Location of the venom gland, with skin removed. (b) Medial view of mandible, showing grooved teeth that conduct the venom. (Source: (a) Based on Kochva 1978a.)

Pough et al. 2001

Front Fanged Hypodermic Duvernoy’s/Venom Gland

Solenoglyph Elapidae

Proteroglyph Viperidae
Joe Slowinski  
Myanmar, Burma  
*Bungarus multicinctus*  
Multibanded Krait  
alpha bungarotoxin  
nicotinic ACh receptor antagonist

*At 7:30 A.M., Joe lay down. At 8, his hand began to tingle, and he called the group together. The toxins would leave his system in 48 hours, he said. He'd be conscious the whole time.*
... Alethinophidia, Macrostomata, Caenophidia, Colubroidea

**Elapidae**
(62 genera, 300 species)

- Cobras, coral, and sea snakes
- venomous
- proteroglyph dentition
  - maxilla longer than that of vipers
  - may have teeth posterior to fang
  - relatively fixed
- some with biparental care
- most terrestrial are oviparous
- most marine are viviparous
- corals often mimicked by non-venomous sympatrics
Pit Organs
multiple origins -
  vipers, boas, pythons

infrared image

(pit sensitivity to 0.003 C)
Gastric Brooding Frog Etc.

Python regius

Rheobatrachus vitellinus
Figure 9–3  The mechanics of suction feeding. Skull, hyobranchial skeleton, and pectoral girdle of a larval tiger salamander (Ambystoma tigrinum) and the major muscles involved in the expansion phase. (a) Contraction of the muscles shown opens the mouth and lowers the hyobranchium (stippled), expanding the oral cavity. DM = depressor mandibulae, EP = epaxial muscles, GH = geniohyoides, RC = rectus cervicis. (b) Gill rakers of Ambystoma maculatum, a plethodontid salamander, in ventrolateral view, with the gills pulled forward. Note the interlocking gill rakers, GR. GB = gill bar, GF = gill filaments. (Source: (a) Redrawn from Lauder and Shaffer 1988; (b) modified from Lauder and Shaffer 1985.)

Figure 9–2  Suction feeding by a larval tiger salamander, Ambystoma tigrinum. Film frames from a high-speed movie record of a salamander offered a piece of earthworm from forceps. Frame numbers appear at upper left. Sequential frames are 5 milliseconds apart. Note the rapid depression of the hyobranchium during the expansion phase (frame 6). (Source: Shaffer and Lauder 1988.)
Suction Feeding

Salamanders

1. Jaws open
2. Hyoid apparatus (floor of mouth) drops
3. Muscles keep gills closed

A few genera asymmetrical - flexible mandible (cartilage)

Figure 9-5
Pough et al. 2001
Suction Feeding

Anurans

Tadpoles

unidirectional spiracle(s)

filter feeders
- strain
- mucus

Stebbins and Cohen, 1995

Pough et al. 2001

Figure 9-6f

Stebbins and Cohen, 1995
Turtle Suction Feeding

Bidirectional, no teeth
( keratinous beak )

1. Compensatory suction
   - displaced water

2. Inertial suction
   - modified hyobranchial
   - greater expansion

Esophogeal modifications
- prevent prey escape
- *Dermochelys*, 5 cm spines

Figure 9-13
Pough et al. 2001
Feeding

Chamaeleo jacksonii
Figure 9–20  The mechanism involved in tongue projection and retraction by the two-lined salamander, *Eurycea bislineata*, a hemidactyline plethodontid. Dorsal view of the hyobranchial skeleton and major muscles (shown only on one side). Note the relatively long epibranchial cartilages and the spiral fibers of the subarcualis rectus I muscle, which contracts to project the tongue. The rectus cervicis muscle retracts the tongue. The glandular tongue pad would lie around the radial, lingual, and anterior ends of the basibranchial cartilages. (Source: Modified from Lombard and Wake 1976.)
Snake Feeding

Scolecoptidians

Ancestral Group
- small gape
- short jaws
- many small prey

*Leptotyphlops* (teeth lower only)

Mandibular raking

![Diagram of Leptotyphlops feeding](image)
Snake Feeding

Cranial Kinesis

**Unilateral Feeding**

- two sides of lower jaw (dentary) unfused
- intramandibular hinge
- looser streptostylic quadrate

Fig. 9-33
Pough et al. 2001
Figure 9-25  Eyes of chameleons. (a) Eyes of Chameleo vulgaris, independently facing forward and down. (b) Chamaeleo jacksoni wearing spectacles to test binocular accommodation. (Source: (a) Photograph by Dwight R. Kuhn/Bruce Coleman; (b) photograph courtesy of L. Harkness.)
~Terrestrial Feeding

Turtles
-beak
  shape
  thickness (durophagic)
  motion (*Gopherus*)

*Alligator Snapping Turtle* (*Macrolemys temminckii*)

© Steve Barten
Egg Eating (e.g., *Dasypeltis*)
elastic neck skin, few teeth, vent. vertebral processes

*Figure 9–36*  The African egg-eating snake, *Dasypeltis scabra*, swallowing a bird egg. The egg is swallowed whole, and the shell is cracked in the throat. The contents are swallowed, and the shell is crushed and regurgitated. (Photographs by Michael and Patricia Fogden.)

*Figure 9–37*  Anterior vertebral column of the African egg-eating snake, *Dasypeltis*. Anterior is to the left, and the rear of the skull is shown. Note vertebrae with thickened hypapophyses (ventral processes) used for crushing eggshells and those with long, anteriorly directed hypapophyses that slit the egg membranes. (Source: Guns 1974.)
Digestive Systems

Three main types:

1. **Batch** reactors (in and out, not in vertebrates)

**Alimentary Canal**

2. **Continuous-flow/Stirred-tank** reactor
   (in, out when broken down)

3. **Plug-flow** reactor

Often 2,3 **combined**
   (e.g., stomach and small intestine)
Digestive Systems

Transit time (time to digest), cost, and anatomy variable:

- Food quality
- Body Size
- Temperature (ectotherms)
Generalized Digestive System

Salivary glands (mucin) to lubricate Tongue for chemoreception

Structure

- Ingestion
  - Headgut
  - Foregut
  - Midgut
  - Hindgut

Function

1. Receiving
2. Conducting Storage Digestion
3. Digestion (Acidic secretions)
4. Absorption→Assimilation (Basic secretions)
   - Storage of waste
   - Defecation
Generalized Digestive System

Salivary glands (mucin) to lubricate Tongue for chemoreception

Structure

- **Headgut**
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- **Midgut**
- **Hindgut**

Function

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   - Receiving
   - Conducting Storage Digestion

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3. **Absorption→Assimilation** (Basic secretions)

4. **Storage of waste**

Defecation

(15-13)
Foregut

-Conducting, Storage, Digestion
- Esophagus and Stomach
  ↓
  Crop in some for storage/regurgitation
  e.g., Some birds use to grind with pebbles and sand

Stomach
- food storage
- begins digestion (e.g., pepsin)
- mechanical mixing (muscular walls)
- Monogastric (1 chamber, carnivores and omnivores)
- Digastric (> 1 chamber)
Foregut

**Monogastric Stomach**
- strong muscular sac/tube
- sphincters at both ends
- **mucus** from goblet cells of gastric pit
- **HCl** from parietal cells of gastric gland
- **pepsinogen** from chief cells of gastric gland
Foregut

Digastic Stomach
- herbivores
- regurgitation

- digestive enzymes

Domestic cattle, 1L/min gas! (methane and CO₂)

- anaerobic fermentation by symbiotic bacteria and protozoans

( Carbohydrates -> sugars and gases )
sugars, amino acids, short FAs into blood