Feeding and diet

- Birds display an extraordinary variety of adaptations to obtain the food they need to survive
  - Physiological (last time)
  - Morphological
  - Behavioral

Morphological adaptations

- Bill structure is complex
  - Upper mandible is hinged to braincase by nasofrontal hinge, the lower by the quadrate. This allows bill to flex and make precise movements
  - No teeth
  - Rhamphotheca

Bill structure reveals food habits

Seed eaters
Grabbers and Stabbers

Gulpers

Filterers

Gleaners
Sippers

Bill size and shape reflect competition for food

- Sunbirds feed on mint flowers
  - Golden-winged bill is best match to flower and yields highest foraging rate

Bill size reflects resource availability

- Hummingbird bills match the size of their preferred flowers
- Galapagos drought changed average seed hardness, Ground Finch bills got larger

Evolution? (gene frequency)
Epigenetics? (gene expression)

Specialized tongues match specialized bills

<table>
<thead>
<tr>
<th>Bill length (mm)</th>
<th>Time per flower (s)</th>
<th>Nectar extracted (%)</th>
<th>Rate of nectar uptake (µl/s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Golden-winged</td>
<td>24</td>
<td>1.5</td>
<td>10.4</td>
</tr>
<tr>
<td>Malebica</td>
<td>29</td>
<td>1.8</td>
<td>82.1</td>
</tr>
<tr>
<td>Female</td>
<td>26</td>
<td>2.0</td>
<td>62.3</td>
</tr>
<tr>
<td>From Bill and Bred V151</td>
<td></td>
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</tbody>
</table>
Specialized feet adapted for feeding

- A, B: Duck, webbed or lobed for swimming and diving
- C: Ostrich, running
- D: Pheasant, scratching up dirt
- E: Ptarmigan, walking on snow
- F: Heron, wading
- G: Woodpecker, zygodactyl toe arrangement for climbing
- H: Eagle, holding prey
- I: Warbler, perching

Legs and feet specialized for diving

Digestive system

- Specialized for unmasticated food
  - Oral cavity (not shown)
  - Esophagus
  - Crop
  - Stomach
    - Proventriculus
    - Gizzard
  - Liver
  - Pancreas
  - Intestine
  - Cloaca

Oral cavity

- Tongue
  - Extracting, breaking up, holding, and manipulating food.
- Taste buds
  - Aid in food selection, not well developed.
- Salivary glands
  - Three major sets, provide lubrication and aid in digestion. Nest building.
**Esophagus**
- Lined with lubricating mucous glands
- Produces “pigeon milk” in Columbiformes
- Produces sound in Ostriches and Prairie Chickens
- Specialized fermentation chambers in Hoatzin

**Crop**
- Expanded section of esophagus
- Stores and softens food
- Regulates flow of food to digestive tract
- Shape varies with diet

**Proventriculus**
- Anterior glandular portion of stomach
- Secretes gastric juices and peptic enzymes necessary for digestion
- Source of “stomach oil” in Procellariiformes

**Gizzard**
- Posterior muscular portion of stomach
- For grinding and digesting tough foods
- Forms pellets
- May be bypassed by fruit and nectar feeders
Intestines

- Function of liver and pancreas similar to mammals
- Assimilation rates vary with type of food
  - Nectivores 97 – 99%
  - Carnivores 66 – 88%
  - Herbivores 30 – 70%

Recycled wax provides nutrition

- Seabirds, African Honeyguides, Yellow-rumped Warblers, Tree Swallows all digest wax
- Wax is recycled several times from the small intestine back to the gizzard
- An important source of energy when other foods are not available

Caeca

- Small side chambers near end of intestine
  - Aid in digestion of plant food
  - Common in fowl ostriches, similar to rumen in cows
  - Poorly developed in arboreal birds

Cloaca

- Anterior – waste from intestine
- Middle – waste from kidneys and released sperm and eggs
- Posterior – storage of excrement
Feeding behavior

- Birds make foraging decisions at different spatial scales
- Foraging often described by prey and patch models
- Learning
- Food caches
- Tools

Foraging choices are made at different spatial scales

A hierarchy of choices from coarse to fine scale


Prey and patch models

White Wagtails select medium-sized flies that yield the most energy per unit of handling time

Patch models look at movement between patches of food and costs and benefits of movement choices

Birds learn to feed

Practice make perfect

Chicks have a lot to learn

Caches store food

"Butcher-birds" cache their prey. Acorn Woodpeckers create communal "galleries".