Absorption of nutrients through the body surface

Feeding and Digestion
Chapter 15, pages 631 - 647
663 - 665
Feeding adaptations

Filter feeding mammal - Baleen whales use ram feeding

Suction feeding
Sucking insects

Netter, 1989
Teeth adapted for processing three principal kinds of foods.

Teeth adapted for grinding.

Alimentary systems

(a) Batch reactor
   Pulsed output
   Contents mixed
   Composition changes with time
   Mouth
   Gastrovascular cavity
   Hydra

(b) Continuous-flow stirred-tank reactor
   Continuous input
   Contents mixed
   Composition unchanging with time at steady state
   Esophagus
   First compartment
   Third compartment
   Hindstomach
   Ruminant forestomach

(c) Plug-flow reactor
   Continuous input
   Axial gradient in composition
   Composition uniform in cross-section at steady state, unchanging with time at any point along reactor.
   Small intestine
Batch reactors

Digestive systems of invertebrates

(a) Hydra
- Enzymatic gland cells
- Nutritive muscle cell
- Coelenteron
- Mesoglea
- Epidermis
- Interstitial cell
- Food vacuole

Gastrovascular cavity

(b) Flatworm
- Tentacle
- Mouth
- Pharynx
- Adhesive disk
- Lateral branch of enteron
- Main part of enteron

Gastrovascular cavity

(c) Mollusk
- Buccal cavity
- Salivary glands
- Esophageal glands
- Esophagus
- Gastric shield
- Cecum
- Sorting area
- Major typhlopole
- Duct of digestive gland

(d) Cockroach
- Pharynx
- Esophagus
- Crop
- Proventriculus
- Gastric ceca
- Malpighian tubules
- Midgut
- Hindgut
- Rectal pads
- Rectum
Digestive systems of vertebrates

<table>
<thead>
<tr>
<th>Region</th>
<th>Secretion</th>
<th>Daily amount (L)</th>
<th>pH</th>
<th>Composition*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Buccal cavity</td>
<td>Saliva</td>
<td>1+</td>
<td>6.5</td>
<td>Amylase, bicarbonate</td>
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<tr>
<td>Esophagus</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stomach</td>
<td>Gastric juice</td>
<td>1—3</td>
<td>1.5</td>
<td>Pepsinogen, HCl, rennin in infants, intrinsic factor</td>
</tr>
<tr>
<td>Pancreas</td>
<td>Pancreatic juice</td>
<td>1</td>
<td>7—8</td>
<td>Trypsinogen, chymotrypsinogen, carboxy- and aminopeptidase, lipase, amylase, maltase, nuclease, bicarbonate</td>
</tr>
<tr>
<td>Gall-bladder</td>
<td>Bile</td>
<td>1</td>
<td>7—8</td>
<td>Fats and fatty acids, bile salts and pigments, cholesterol</td>
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<tr>
<td>Jejunum</td>
<td>Succus entericus</td>
<td>1</td>
<td>7—8</td>
<td>Enterokinase, carboxy- and aminopeptidases, maltase, lactase, sucrase, lipase, nucleases</td>
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<tr>
<td>ileum</td>
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<tr>
<td>Cecum</td>
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<td>Colon</td>
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<tr>
<td>Rectum</td>
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</tbody>
</table>

*Excluding mucus and water, which together make up some 95% of the actual secretion.
Polypeptide hydrolysis

\[
\begin{array}{c}
\text{Peptide bond} \\
R - C \quad \text{H}_{2}\text{O} \quad R - C - \text{OH} + \text{HNH} - R
\end{array}
\]

Polysaccharide hydrolysis

\[
\begin{array}{c}
\text{Glycosidic bond} \\
\text{R} - \text{H} - \text{H} - \text{H} - \text{R} \quad \text{H}_{2}\text{O} \quad \text{R} - \text{H} - \text{OH} + \text{R} - \text{H} - \text{OH}
\end{array}
\]

(a) Hindgut (colon) fermenter

(b) Hindgut (cecal) fermenter

(a) Hindgut (colon) fermenter:
- Esophagus
- Stomach
- Cecum
- Right ventral colon
- Left ventral colon
- Left dorsal colon
- Rectum

(b) Hindgut (cecal) fermenter:
- Esophagus
- Stomach
- Cecum
- Proximal colon
- Distal colon
- Rectum
Foregut fermentation

Grazing
Plant material is chewed a little before being swallowed.
Part-digested food is stored in the rumen where it is broken down into sugars by bacterial action.

Ruminating
Cud is regurgitated and chewed again while the ruminant is lying down.
Food is swallowed for the second time and bypasses the rumen.
Food is finally processed by acids and digestive enzymes in the other stomach chambers.
Anatomy of small intestine.
Basal lamina

Absorptive epithelial cells

Microvilli

5 μm

1

× ~10

Cylindrical surface area of lumen

Surface area of lumen plus villi

Surface area of lumen plus villi plus microvilli

× ~50
Response of small intestine to periods of fasting in snakes, crocs, and turtles.

Feast and famine. Cells lining the python’s intestine have tiny projections that expand and shrink depending on food availability.

My diet is going to kill me.
In the United States, chronic illnesses and health problems either wholly or partially attributable to diet represent by far the most serious threat to public health. Sixty-five percent of adults aged ≥20 y in the United States are either overweight or obese (13), and the estimated number of deaths ascribable to obesity is 280,184 per year (14). More than 64 million Americans have one or more types of cardiovascular disease (CVD), which represents the leading cause of mortality (38.5% of all deaths) in the United States (15). Fifty million Americans are hypertensive; 11 million have type 2 diabetes, and 37 million adults maintain high-risk total cholesterol concentrations (>240 mg/dL) (15). In postmenopausal women aged ≥50 y, 7.2% have osteoporosis and 39.6% have osteopenia (16). Osteoporotic hip fractures are associated with a 20% excess mortality in the year after fracture (17). Cancer is the second leading cause of death (25% of all deaths) in the United States, and an estimated one-third of all cancer deaths are due to nutritional factors, including obesity (18).

Cordain et al., 2005

Our teeth, gut, and the diet of hunter-gatherers suggest an ancestral diet composed of low-calorie, high-fiber plant material, and low-fat animal protein.
-Drouillard had killed a deer.

"The seen when I arrived was such that had I not have had a pretty keen appetite myself I am confident I should not have taisted any part of the venison…. Each [Indian] had a piece of some discription and all eating most ravenously. Some were eating the kidneys the melt [the spleen] and liver and the blood running from the corners of their mouths, others were in a similar situation with the paunch and guts…. One of the last [to arrive] had provided himself with about nine feet of the small guts one end of which he was chewing on while with his hands he was squeezing the contents out at the other. I really did not untill now think that human nature ever presented itself in a shape so nearly allyed to the brute creation. I viewed these poor starved divils with pity and compassion."

Merriwether Lewis, 1805

Today, 50% of the world’s population lives on 2200 cal/day or less.

Famine

Russia -
From 971 - 1970 there were 121 years of famine.
The famine of 1921 left 9 million dead. Famine of 1933 left 4-7 million dead.

China -
Famines of 1810-1849 killed 45 million.
Famine of 1958-1961 killed between 14 and 40 million.

Individuals with a “thrifty phenotype” are the ones that survived to reproduce.