Feeding & Food Processing

1. Structure (review)

2. Function (behavior, physiology)

3. Nutritional needs

4. Digestive efficiency

Food capture

- Mouth and pharyngeal cavity
  - Jaws
  - Teeth - jaw, mouth, pharyngeal
  - Gill rakers

Fish Feeding - function

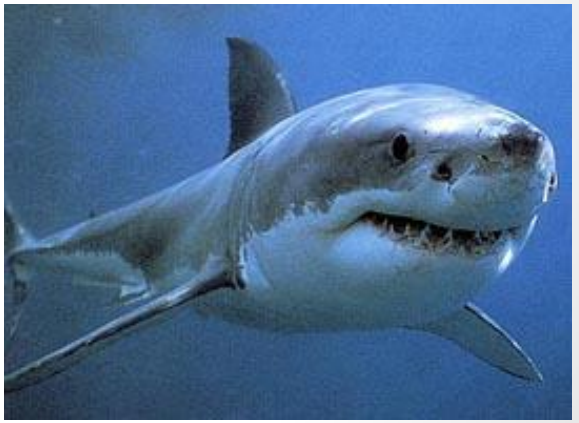
- Herbivores
  - < 5% of all bony fishes, no cartilaginous fishes
    - browsers - selective - eat only the plant
    - grazers - less selective - include sediments
- Detritivores
  - 5 - 10% of all species
  - feed on decomposing organic matter

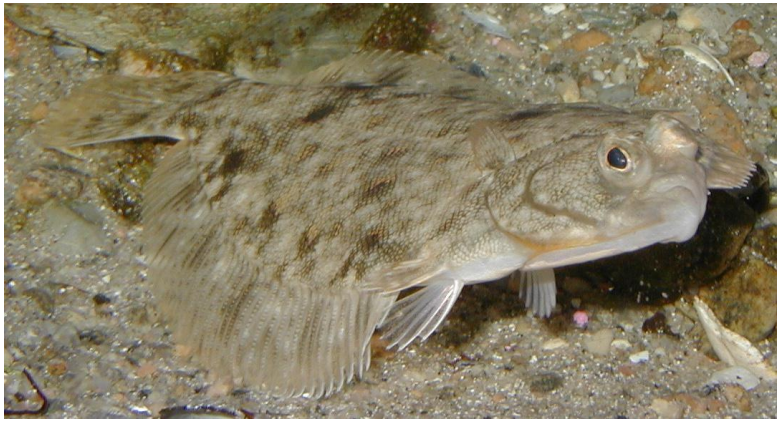
Fish Feeding – function

- Carnivores
  - zooplanktivores
    - suction feeding
    - ram feeding
  - benthic invertebrate feeders
    - graspers
    - pickers
    - sorters
    - crushers

Fish Feeding – function

- **More Carnivores**
  - **fish feeders**
    - **active pursuit**
    - **stalking**
    - **ambushing**
    - **luring**





Fish feeding behavior

- **Fish feeding behavior integrates morphology with perception to obtain food:**
  - **Search --> Detection --> Pursuit --> Capture --> Ingestion**

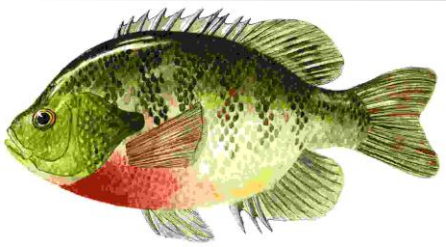
Feeding behavior

- **Fish show versatility in prey choice and ingestion**
- **Behavior tightly linked to morphology (co-evolution)**

Fish feeding behavior

- **Behavior tends to be optimizing when choices are available**
  - **Optimal = maximize benefit:cost ratio**
  - **More for less!**
  - **Select the prey that yields the greatest energetic or nutrient "return" on the energy invested in search, pursuit, capture, and ingestion**

Fish digestive physiology



- **After ingestion of food, gut is responsible for:**
  - **Digestion - breaking down food into small, simple molecules**
    - **involves use of acids, enzymes**
  - **Absorption - taking molecules into blood**
    - **diffusion into mucosal cells**
    - **phagocytosis/pinocytosis by mucosal cells**
    - **active transport via carrier molecules**

Digestive Apparati

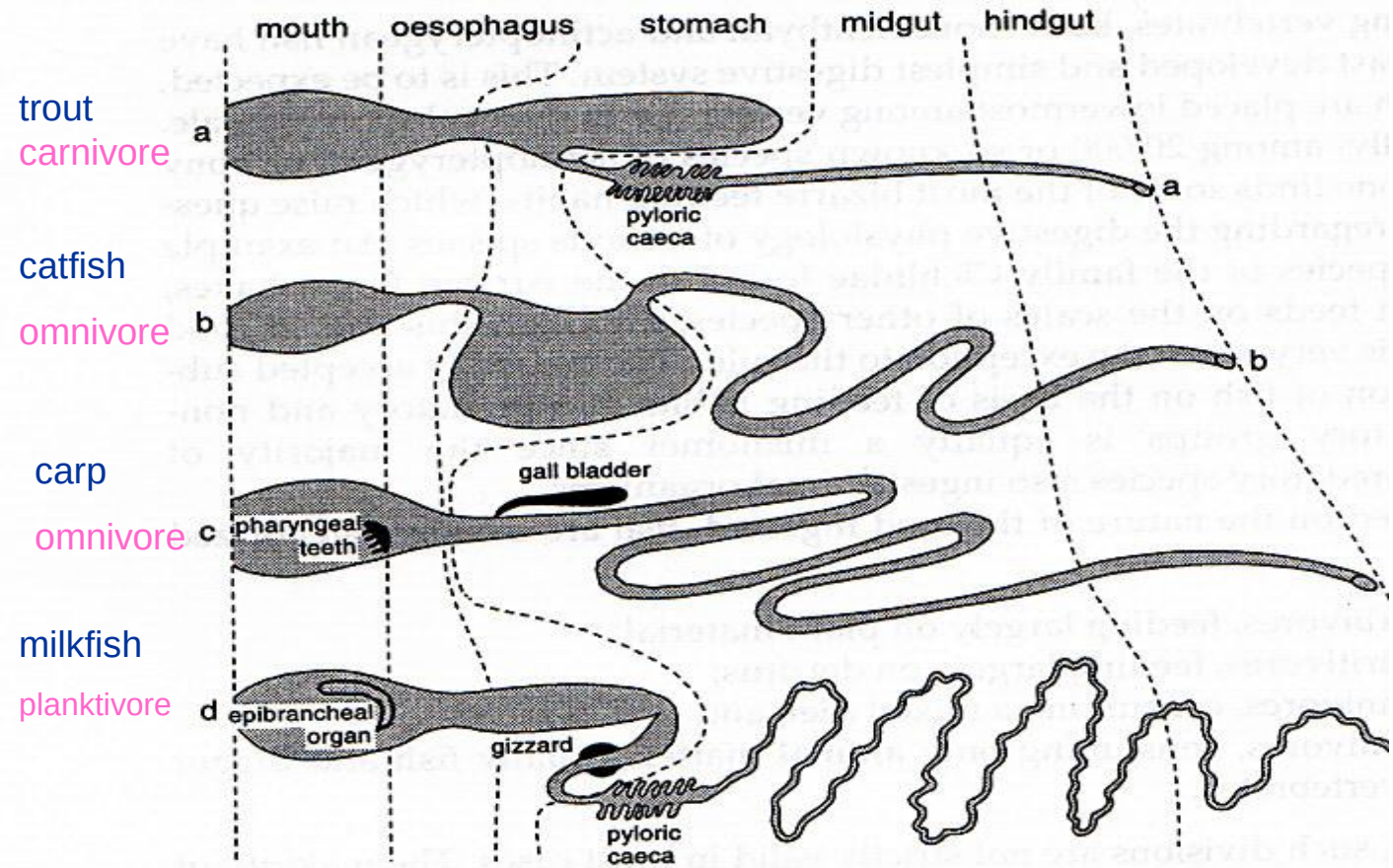


Figure 4.1 The digestive systems of four fish described in the text, arrang order of increasing gut length. (a) Rainbow trout (carnivore). (b) Catfish (omnivore emphasizing animal sources of food). (c) Carp (omnivore, emphasizing plant sources of food). (d) Milkfish (microphagous planktivo (From Smith, 1980.)

Fish Digestion

- Two major groups: w/stomach, w/out
- w/out stomach: cyprinids (carps)
- w/stomach: cold-water salmonids, warm-water catfish, tilapia, eels, grouper
- note: all “pure” predators have a stomach and teeth
- **relative gut length (RGL):** gut:body length
- high RGL = species consuming detritus, algae (high proportion of indigestible matter)

Relative Gut Length

Species	Feeding	RGL
Labeo horie	Algae, detritus	15.5
Garra dembensis	Algae, inverts	4.5
Barbus sharpei	Plants	2.8-3.1
Chelethiops elongatus	Zooplankton	0.7
Chela bacaila	Carnivorous	0.9

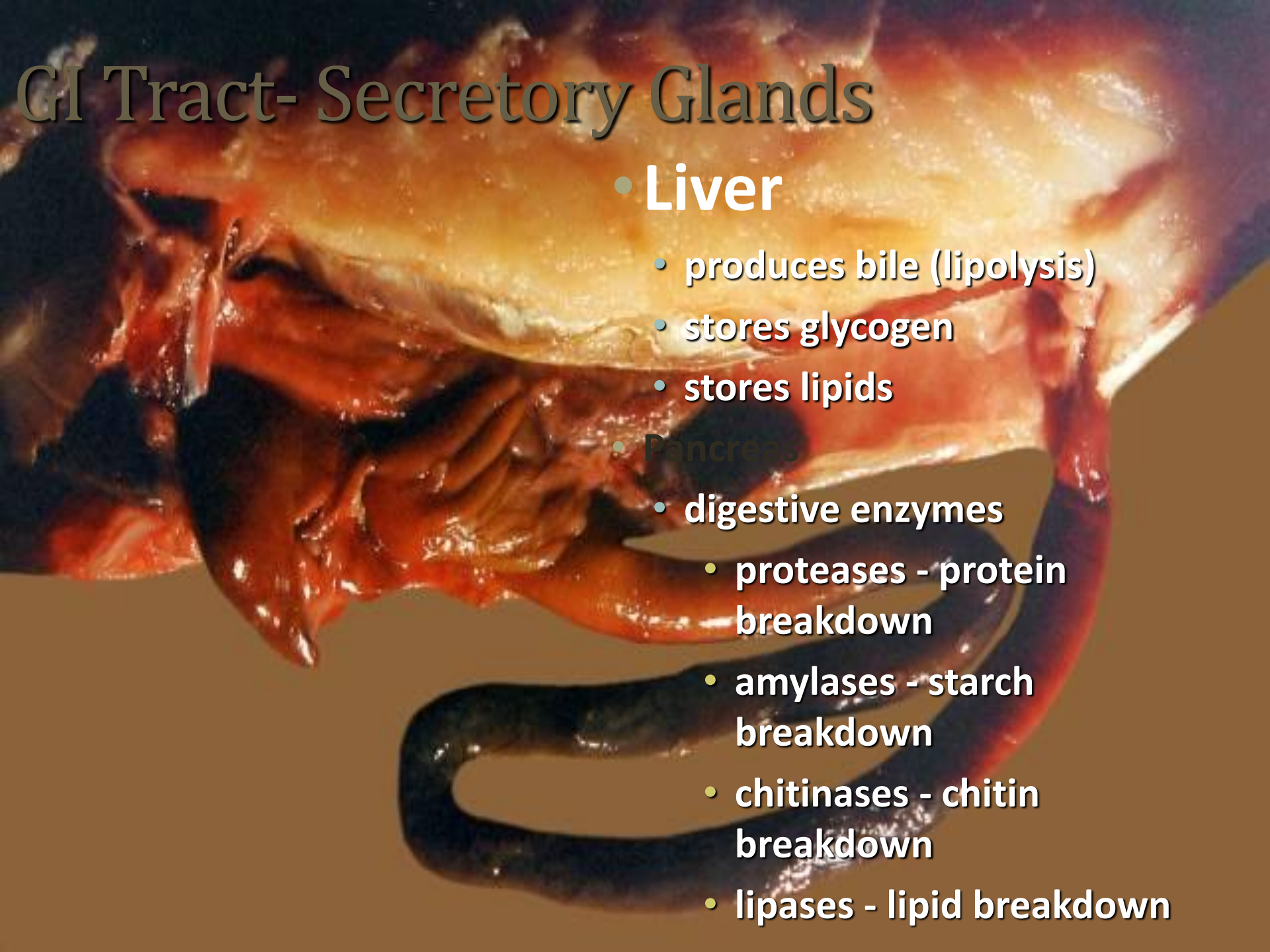
Fish Digestive Morphology: Major Divisions

- Mouth
- Esophagus
- Pharynx
- Stomach
- Intestine
- Rectum
- Secretory glands (liver and pancreas)
- often difficult to distinguish

Gastrointestinal Tract

- Esophagus
- Stomach
  - large in carnivores, small in herbivores/omnivores
- Pyloric caeca
- Intestine
  - short in carnivores, long in herbivores-omnivores
- Anus - separate from urogenital pore

GI Tract- Secretory Glands



- **Liver**
  - produces bile (lipolysis)
  - stores glycogen
  - stores lipids
- Pancreas
  - digestive enzymes
    - proteases - protein breakdown
    - amylases - starch breakdown
    - chitinases - chitin breakdown
    - lipases - lipid breakdown

Digestive Anatomy: Mouth/Esophagus

- *Channel catfish:* large mouth/esophagus, capture prey, slightly predaceous, mouth has no teeth, no gizzard/cardiac sphincter

- *Common carp:* small mouth for bottom feeding, pharyngeal teeth, grinds food

- *Tilapia:* combination of bottom feeder, predator, efficient plankton feeder, uses gill rakers, pharyngeal mucous

Digestive Anatomy: Stomach

- *Channel catfish:* have true stomach that secretes HCl and pepsinogen (enzyme)
- *Common carp:* no stomach; however, "bulb" at anterior end of digestive tract, bile and pancreatic secretions empty into intestine posterior to cardiac sphincter, no secretion of gastrin (low pH)
- *Tilapia:* modified stomach, secretes HCl, well-defined pocket, pH varies w/digestal flow, has pyloric sphincter

Fish Nutritional Needs

- **High protein diet:**
  - **Carnivores - 40 - 55% protein needed**
  - **Omnivores - 28 - 35% protein needed**
  - **Birds & mammals - 12 - 25% protein needed**
  - **10 essential amino acids (PVT. TIM HALL)**

Fish Nutritional Needs

- **High protein diet**

- **Why so high?**
  - **Proteins needed for growth of new tissue**
  - **Proteins moderately energy-dense (don't need dense source - ectotherms, low gravity)**
  - **Few side-effects - ease of NH_4^+ excretion**

Nutritional efficiency in fishes

- **Fish more efficient than other vertebrates:**
  - **Conversion factor = kg feed required to produce 1 kg growth in fish flesh**
    - **Fishes: 1.7 - 5.0**
    - **Birds & mammals: 5.0 - 15.0**

Nutritional efficiency in fishes

- **Fish more efficient than other vertebrates**
- **Why?**
  - **Ectothermy vs. endothermy**
  - **Energy/matter required to counterbalance gravity**
  - **Bias of a high-protein diet**

Nutritional efficiency

- **Maintenance ration (MR) = the amount of food needed to remain alive, with no growth or reproduction (% body wt./day)**

- **MR is temperature-dependent**
  - **MR increases as temperature increases**

- **MR is size-dependent**
  - **MR decreases as size increases**