THE UNIVERSITY OF MELBOURNE

Melbourne Veterinary School

Consequences of gut stasis for fluid balance

Dr Nick Bamford

n.bamford@unimelb.edu.au

VETS30016 / VETS90120

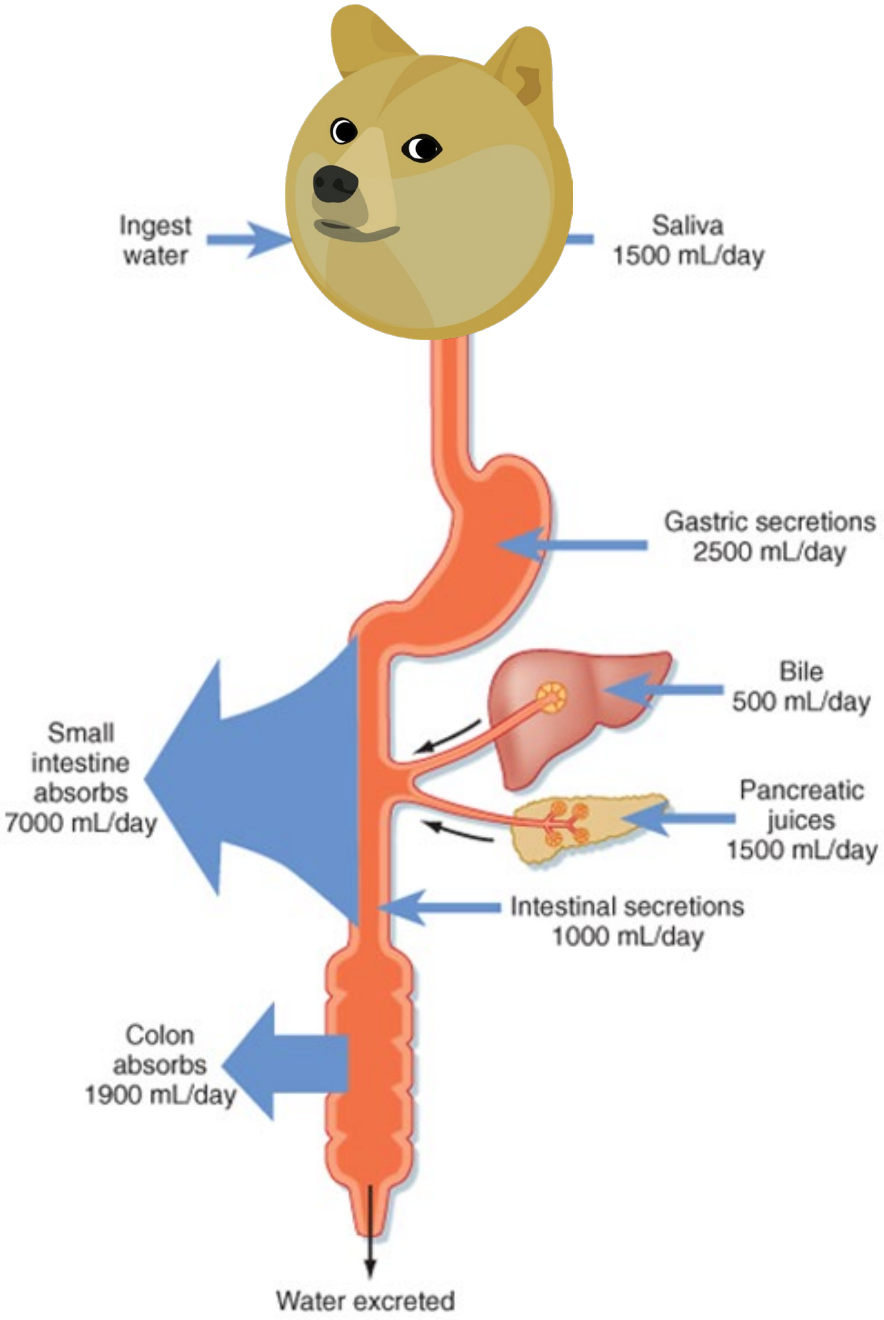
Intended learning outcomes

- Identify the fluids that are secreted into the gastrointestinal tract with a concept of their relative volume and composition in different animal species

- Apply an understanding of the enterosystemic fluid cycle in different animal species to explain the consequences of obstruction in different regions of the digestive tract for fluid and electrolyte balance

- Describe how the gastrointestinal tract can be clinically assessed in large animal species

GI secretions



Koeppen & Stanton: Berne and Levy Physiology, 6th Edition.

Case 1

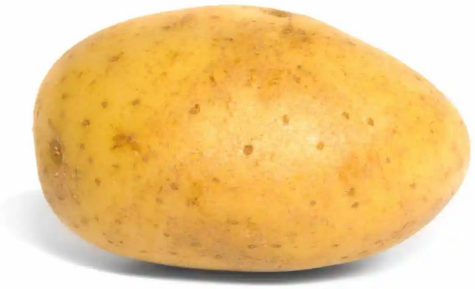
- 4 year-old dairy cow
  - Ptyalism
  - Bloating

Hint: Think back to the first case study!

Physical examination

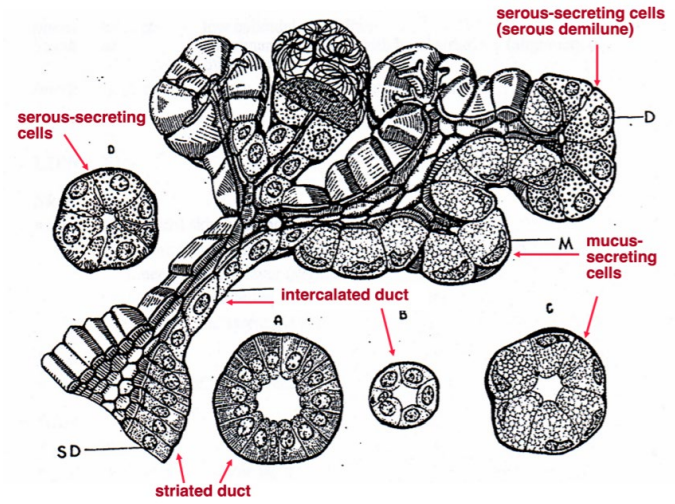
- Auscultation
  - No rumen contractions
  - Dull ping (“pong”) LHS
- Palpation
  - Per rectum
    - Gas-distended rumen
  - Oesophagus
    - Large foreign body
- Oesophageal obstruction

Image courtesy Blowey & Weaver, 2003

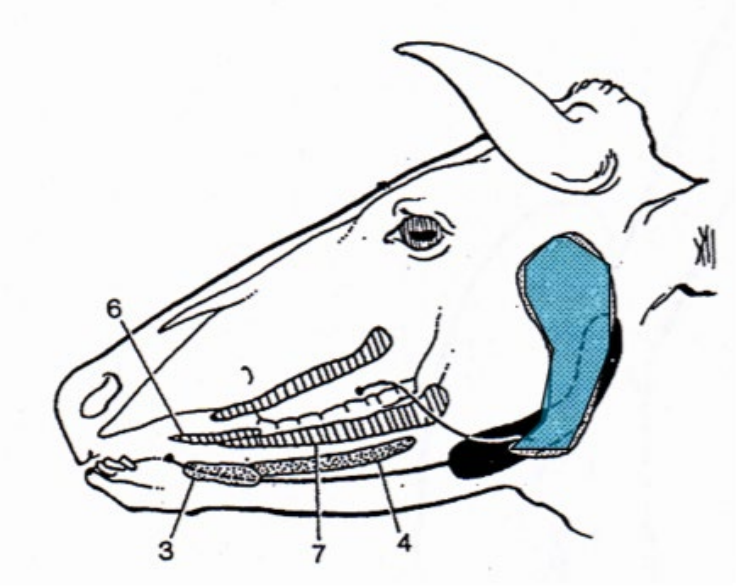


Saliva

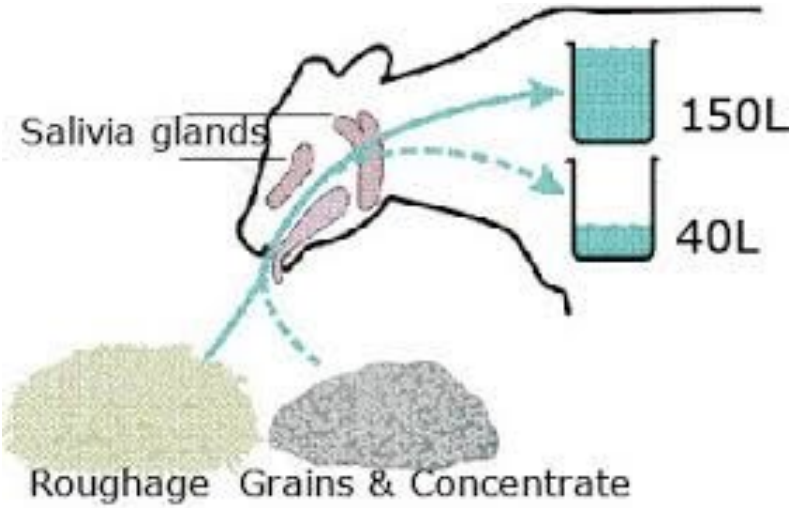
- Serous and mucus secretions
  - Moisten & lubricate food
  - Enzymes
  - Electrolytes



- Volume and composition vary with species/diet



Saliva

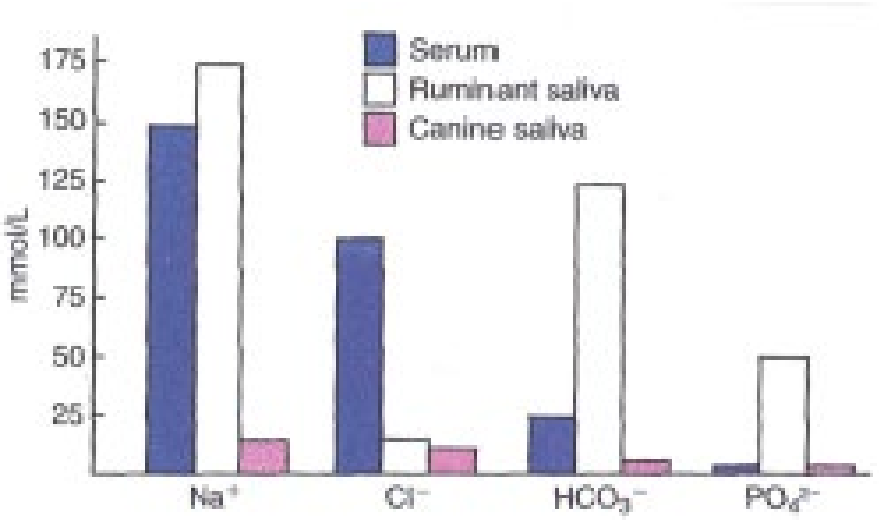


Cows

- Very large volumes serous secretions from parotid glands
  - Moisten/lubricate feed
  - Buffer VFAs in rumen

$$CO_2 + H_2O \rightleftarrows H_2CO_3 \rightleftarrows HCO_3^- + H^+$$

- Volume
  - Cattle: 100-150 L/day
  - Horse: 10-15 L/day (likely more)
  - Pig: 1-2 L/day
  - Dog: 2-3 L/day



From Cunningham & Klein, 2007

Role of saliva in acid-base balance

- Electrolytes affect acid-base status
- Strong ion difference (SID)

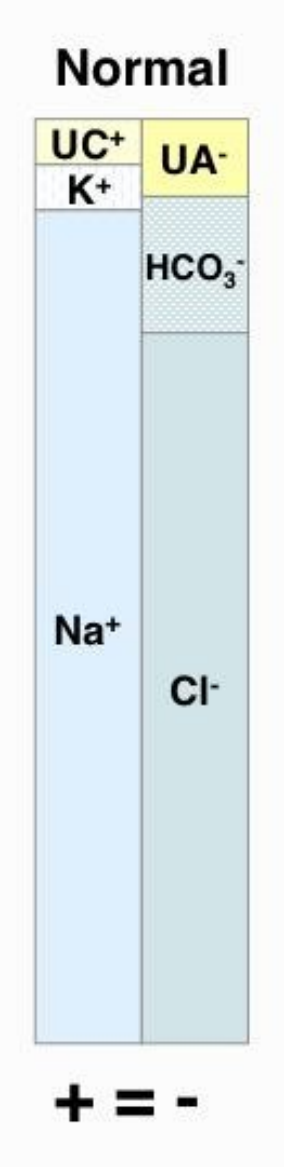
  $= (Na^+ + K^+) - Cl^-$

  Normal ≈ 40

  Acidosis <40

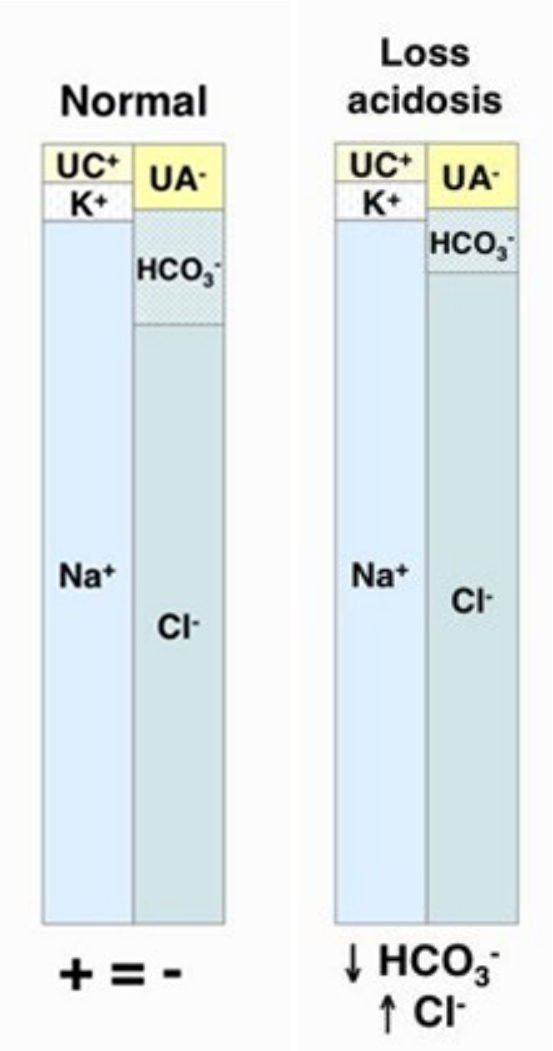
  Alkalosis >40

- Consequences for the animal



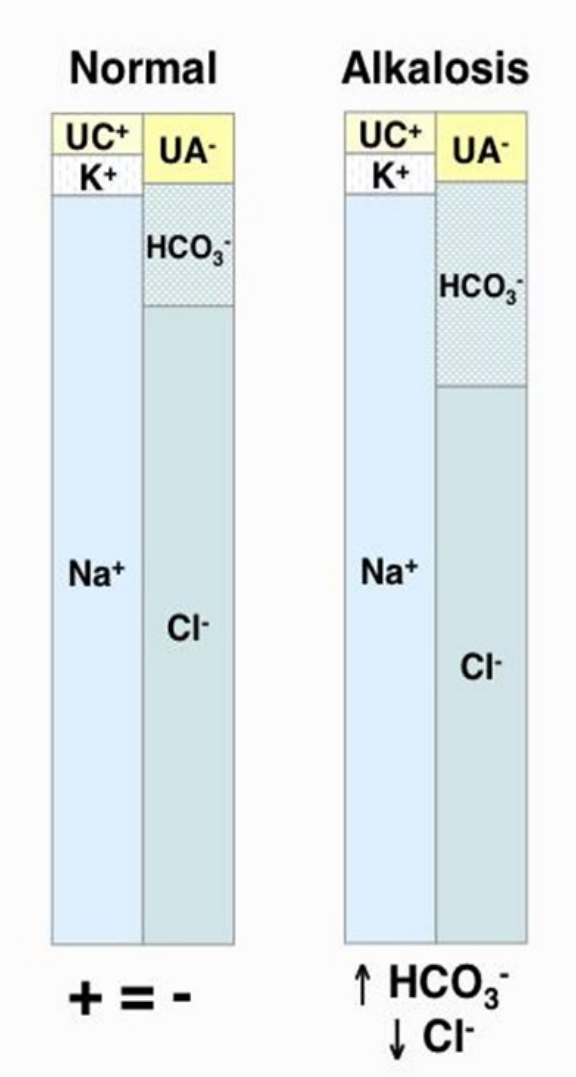
What happens to this cow?

- Cow saliva: high in Na^+ and HCO_3^-
- Loss of saliva = loss of Na^+ and HCO_3^-
- Loss of water
- Cow becomes:
  - Acidaemic (↓pH)
  - Hyperchloraemic (↑Cl^-)
  - Dehydrated (↓H_2O)



What if this was a horse?

- Horse saliva: high in Na^+ & Cl^-
- Horse becomes:
  - Hypochloraemic (↓ Cl^-)
  - Hyponatraemic (↓ Na^+)
  - Alkalotic rather than acidaemic



GI FLUID LOSS

↓

REDUCED FLUID ABSORPTION FROM GUT TO CIRCULATION

↓

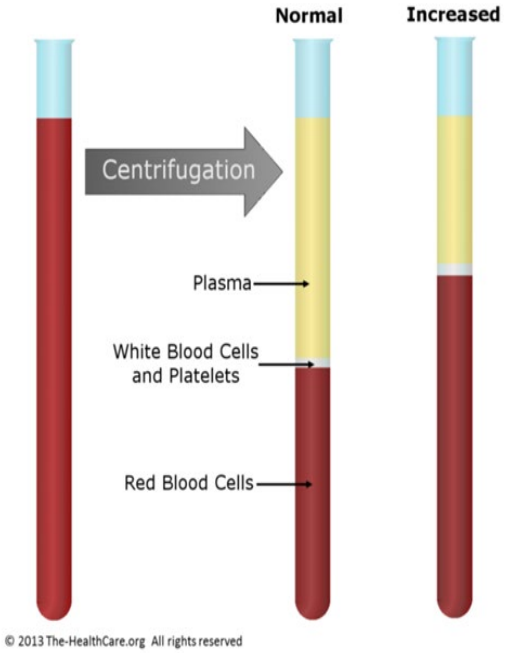
REDUCED VASCULAR VOLUME = "HYPOVOLAEMIA" → Water content in blood reduced, relative ↑ in RBCs and protein

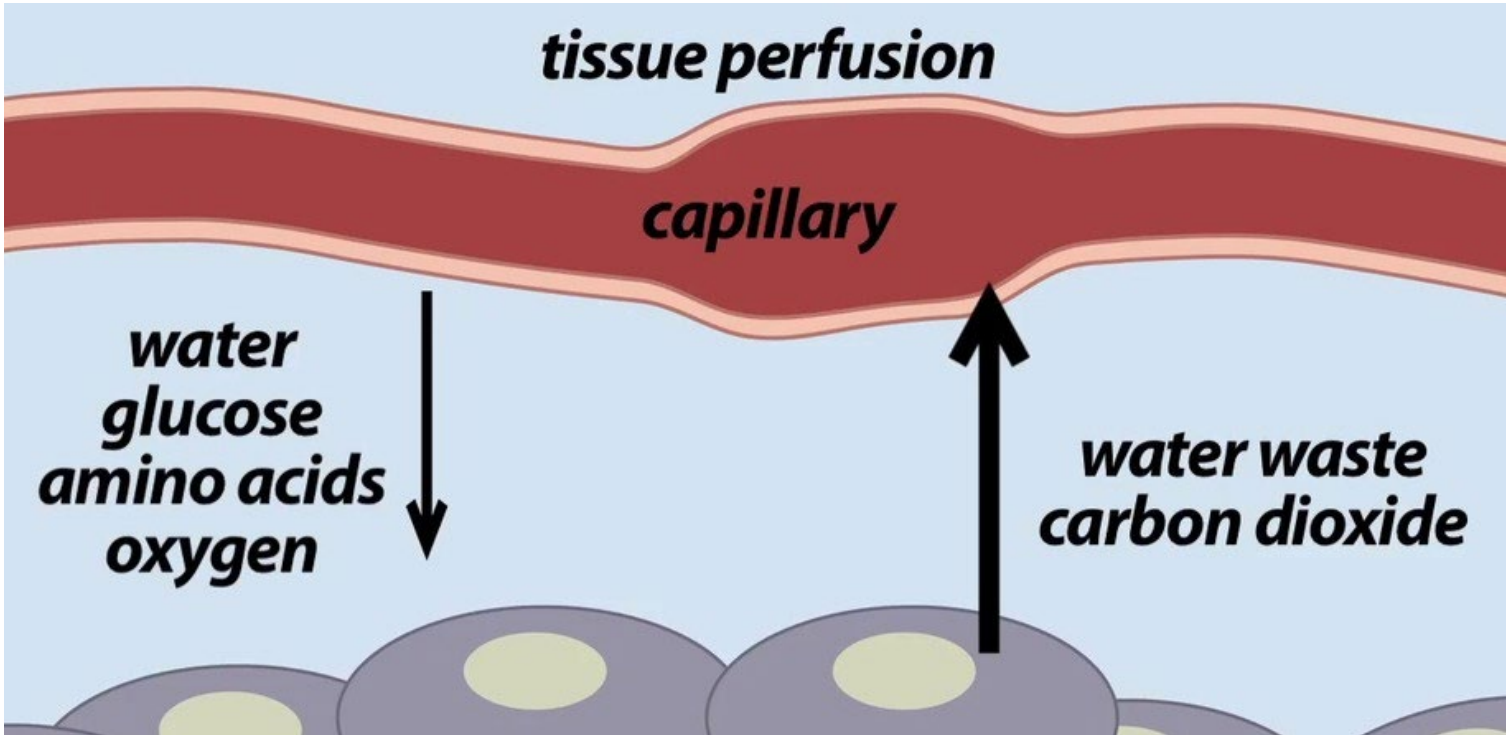
↓

PERIPHERAL VASOCONSTRICTION POOR VENOUS RETURN

↓

POOR PERFUSION ANAEROBIC METABOLISM → Lactate production




tissue perfusion
capillary
water
glucose
amino acids
oxygen
water waste
carbon dioxide

Case 2 - Freddy

Freddy

- Fine this morning, but this afternoon…COLIC!
  - Kicking at abdomen
  - Rolling
  - Pawing
  - Flank-watching

Freddy – Physical examination

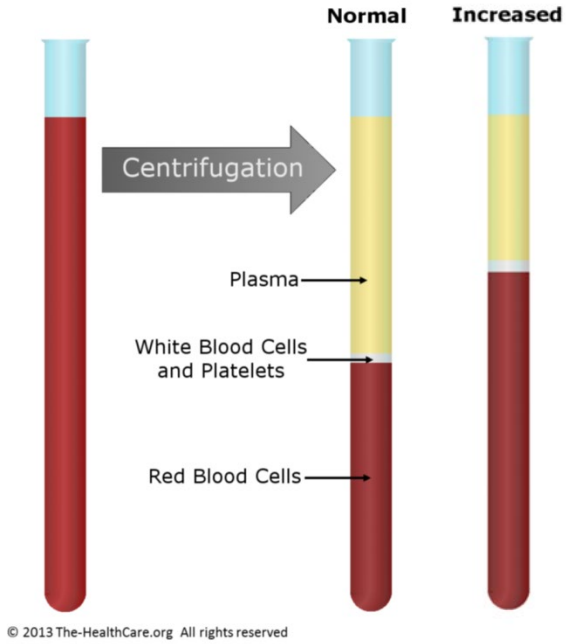
- Cardinal signs
  - Heart rate 80 beats/min
  - Cold extremities
  - Injected mucous membranes
- Auscultation
  - No sounds on abdominal auscultation
- Palpation per rectum
  - Distended small intestinal loops

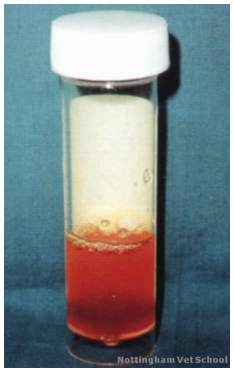
Freddy – Further diagnostics

- Nasogastric tube
  - 6L reflux
- Abdominocentesis
  - Serosanguinous fluid
- Ultrasound
  - Distended, amotile small intestine

Freddy – Laboratory results

- Blood test results
  - High PCV, high TS
  - High lactate
  - Electrolytes normal
- Peritoneal fluid analysis
  - High lactate

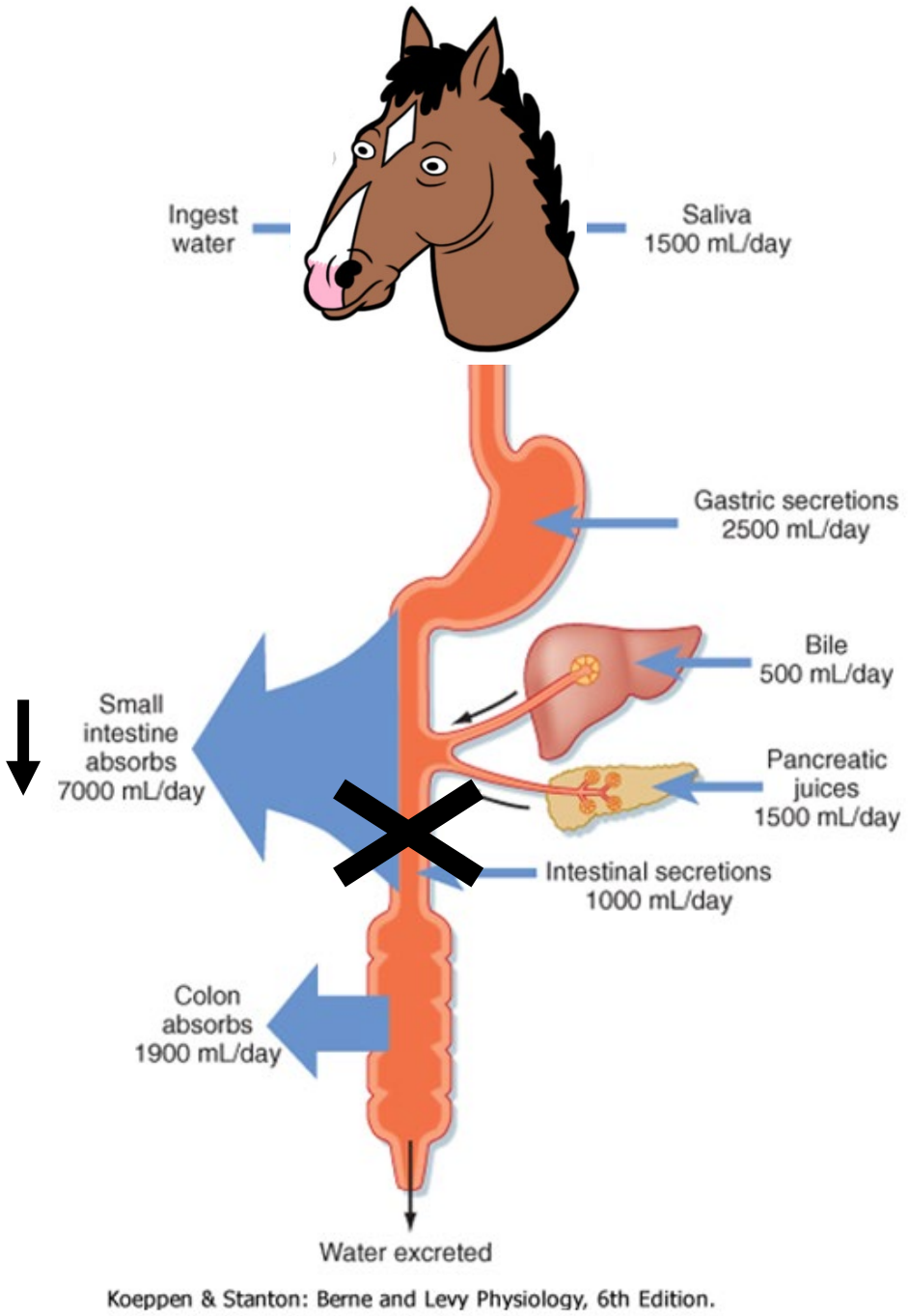




Freddy

- Problem list
  - Colic
  - Gastric reflux
  - No borborygmi
  - Distended small intestine
  - Abnormal peritoneal fluid
- Differential diagnoses?
  - Small intestinal obstruction/strangulation

- Where is the fluid coming from?



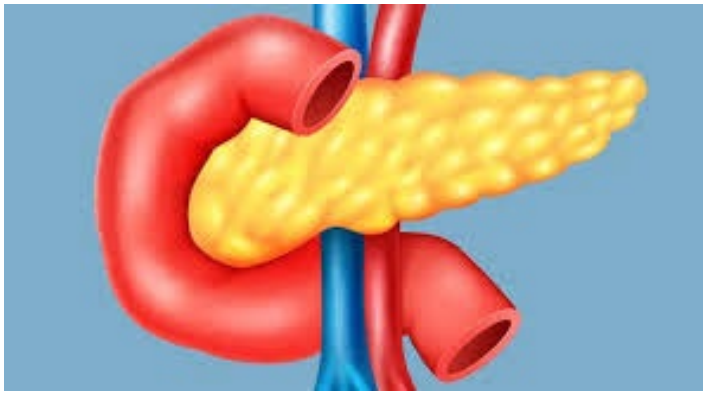
Koeppen & Stanton: Berne and Levy Physiology, 6th Edition.

Gastric secretions

- What comprises the fluid?
  - HCl (parietal cells)
  - Digestive enzymes (chief cells)
  - Mucous (mucous cells)
- Secretions vary with diet
- Gastric fluid secretion volumes
  - Horse: 26-62 L/day
  - Pig: 3 L/day

Pancreatic secretions

- Pancreatic secretion volumes
  - Pig: 5 L/day
  - Horse: 60 L/day
  - Cattle: 15-25 L/day
  - Sheep: 0.4-0.8 L/day
  - Dog: 0.2-1.5 L/day



- Pancreatic fluid composition
  - Na^+, HCO_3^- rich, alkaline
  - Buffers acidic gastric fluid
  - Enzymes

Biliary secretions

- Gall bladder allows concentration of bile
- Bile release from gall bladder stimulated by:
  - Food in duodenum (CCK)
  - Bile acid cycling
- No gall bladder?
  - Continuous secretion

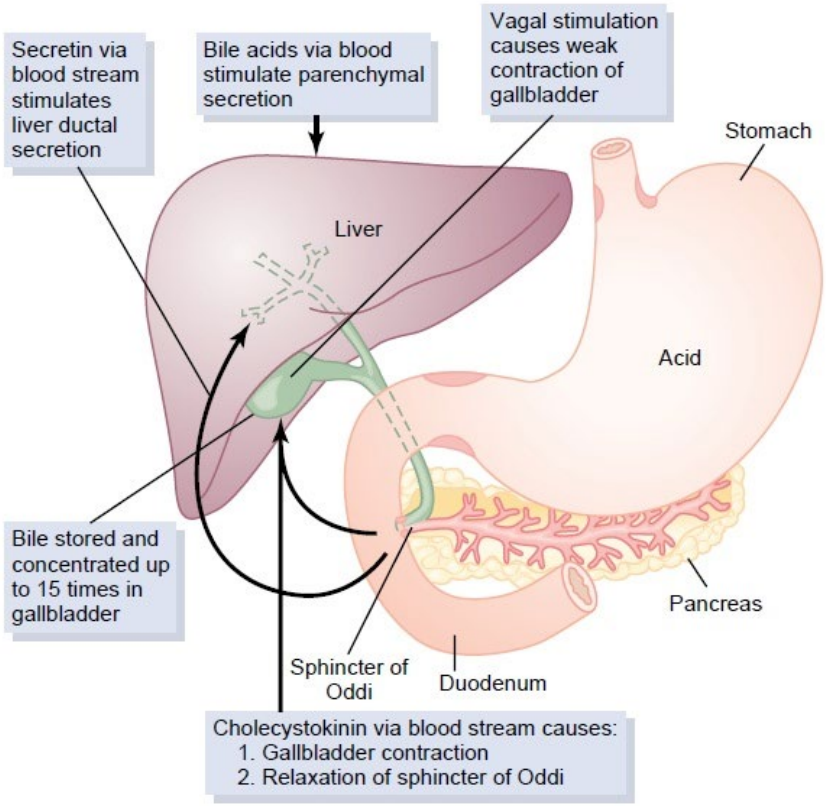
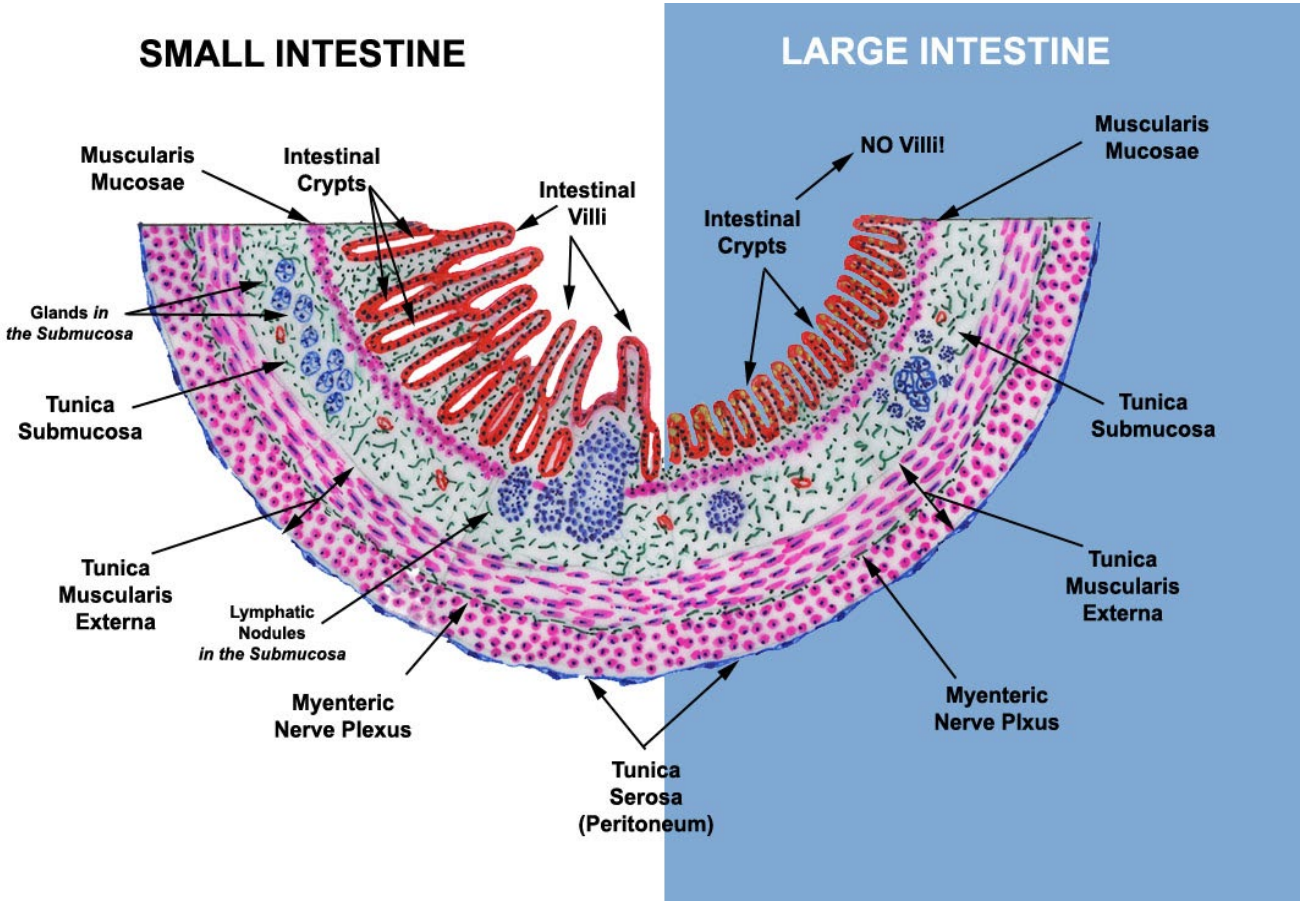


Figure 64–11

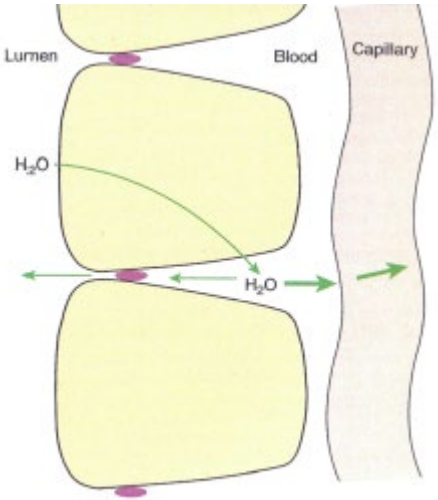
Liver secretion and gallbladder emptying.

Intestines


SMALL INTESTINE
LARGE INTESTINE
Muscularis Mucosae
Intestinal Crypts
Intestinal Villi
Glands in the Submucosa
Tunica Submucosa
Tunica Muscularis Externa
Lymphatic Nodules in the Submucosa
Myenteric Nerve Plexus
Tunica Serosa (Peritoneum)
NO Villi!
Intestinal Crypts
Muscularis Mucosae
Tunica Submucosa
Tunica Muscularis Externa
Myenteric Nerve Plxus

Small intestine – secretion

- Mucous (Brunner's glands – duodenum)
- Crypt cells – electrolyte secretion
  - Coupled Na^+ and Cl^- secretion
  - Large amount HCO_3^- secreted in ileum (horse)
- Water follows osmotic gradient
  - Transcellular/paracellular absorption
  - Enters vascular system



Small intestine – absorption

- Water absorption
  - Always simple diffusion
- Electrolytes
  - Na^+: co-transport proteins, Na^+/H^+ exchanger, diffusion
  - Cl^-: coupled Na^+/Cl^- absorption, paracellular, Cl^-/HCO_3^- exchange
  - HCO_3^-: much used for buffering gastric HCl, remaining reabsorbed (Na^+/HCO_3^- exchange)
  - K^+: simple paracellular diffusion
- Different mechanisms in different parts

Small intestine

- Peristalsis essential for unidirectional flow of fluid through the GI tract
- Obstruction
  - Structural (e.g. foreign body, mass)
  - Functional (e.g. ileus, inflammation)
- When bowel is obstructed:
  - **Absorption ceases and water moves into lumen**
  - **Sequestration of fluid, Na^+, K^+, Cl^- in small intestine**

Back to Freddy

- Why are the changes occurring in his blood results?
  - Net movement of fluid into GI tract → dehydration
    - High PCV
    - High TS
    - High lactate
  - Reflux
    - Loss of HCl
    - Loss of Na^+, Cl^-, K^+
    - Loss of intestinal fluid?

Freddy

- Surgery!

research.vet.upenn.edu

Case 3: Zippy

Zippy

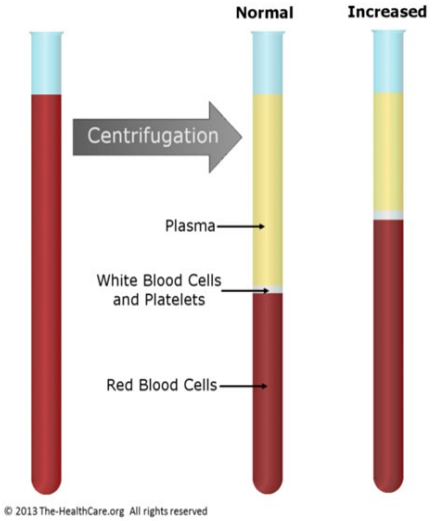
- 8 year-old Quarter Horse mare
- Escaped, gorged on grain in feed room overnight
- Now: Colic, profuse diarrhoea

- Consider pathogenesis
  - Remember Lecture 23?

Zippy – Physical exam

- HR = 72 beats/min
- Temp = 39.6°C
- “Washing machine” borborygmi
- Injected mucous membranes
- Cold extremities

- Blood results
  - ↑ PCV
  - ↑ lactate
  - ↓ Na^+, K^+, Cl^-



Zippy – Physical exam

- Problem list
  - Profuse watery diarrhoea
  - Colic
  - Hypovolaemia
  - Electrolyte derangements

- Differential diagnoses?
  - ~~Small intestinal disease?~~
  - Large intestinal disease
  - Remember: different functions in different species!

Large intestine

- Variable between species
  - Very large in horses (hindgut fermentation)
  - Dogs: Mainly H_20 absorption
  - Horses: Water, electrolytes, VFAs

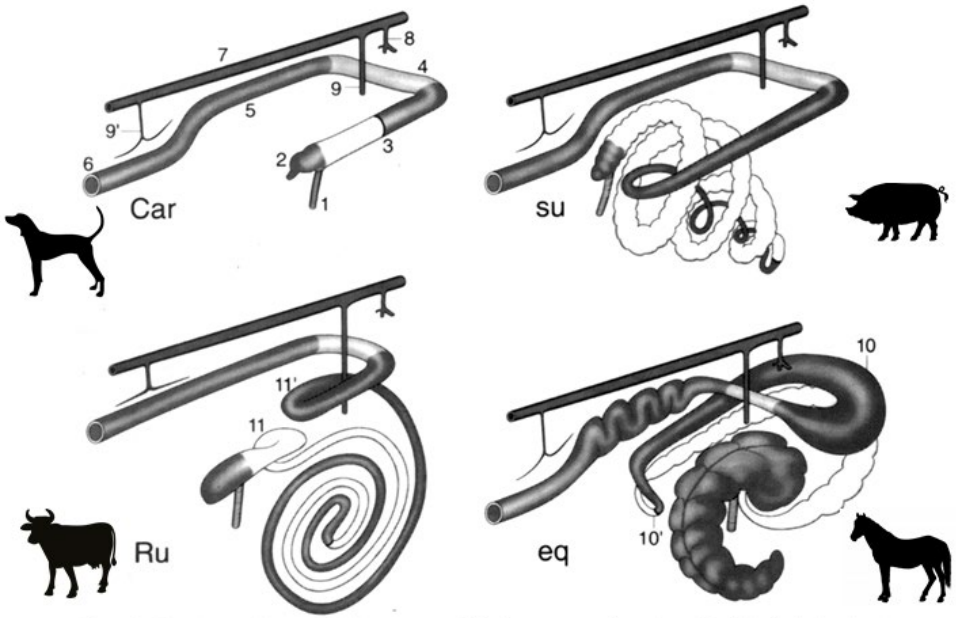


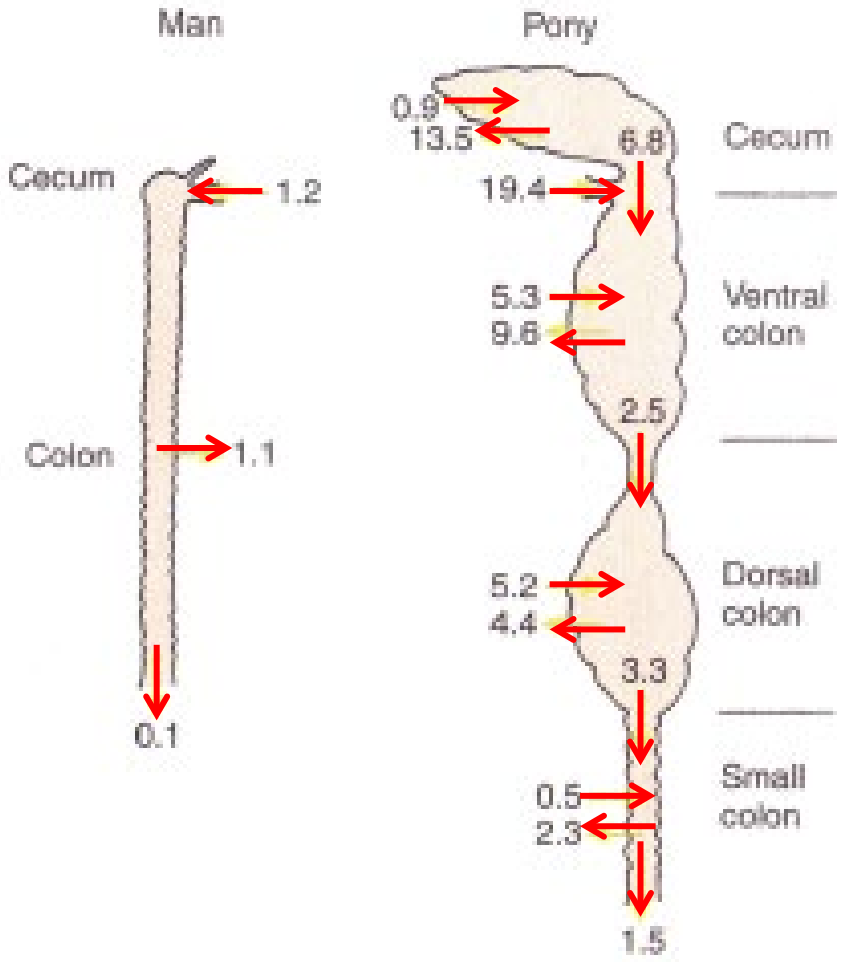
Figure 3–44. Schematic drawing of the large intestine of the domestic mammals: carnivores (Car), the pig (su), ruminants (Ru), and the horse (eq). Cranial is to the upper right.

1, Ileum; 2, cecum; 3, ascending colon; 4, transverse colon; 5, descending colon; 6, rectum and anus; 7, aorta; 8, celiac artery; 9, 9′, cranial and caudal mesenteric arteries; 10, 10′, dorsal diaphragmatic and pelvic flexures of ascending colon; 11, 11′, proximal and distal loops of ascending colon.

Large intestine - horses

- Secretion HCO_3^- , Na^+ and Cl^- added to colonic contents in horse from ileum
  - Buffer VFAs
- Water follows
  - Large fluxes between colon lumen and circulation
- Volumes of fluid absorption
  - Horse: 100-150 L/day

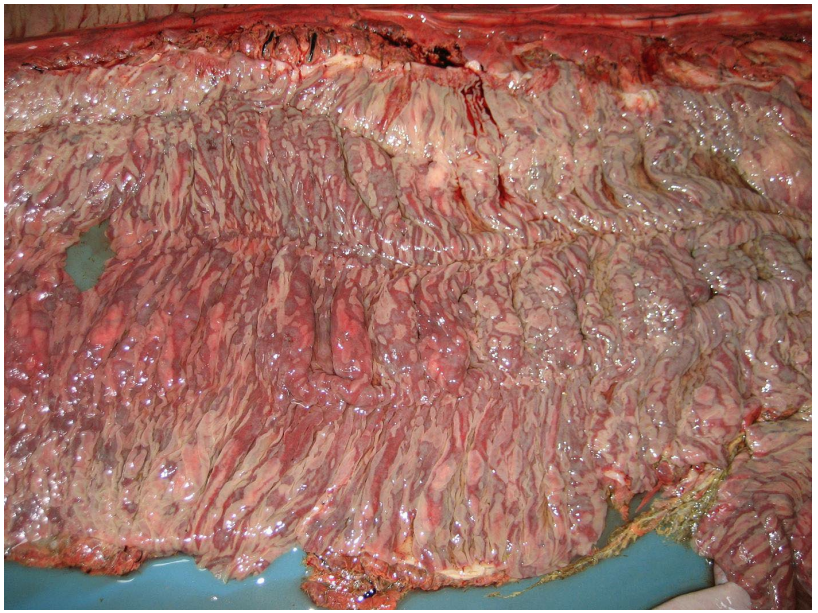
Large intestine



From Cunningham & Klein, 2007

Back to Zippy

- Inflamed colon, damaged colonic mucosa
  - Absorption & secretion disrupted
  - Loss of water and electrolytes in diarrhoea
    - Low Na^+, Cl^-, K^+
    - High PCV
    - High lactate
    - Acidosis



Summary

- Identify the fluids that are secreted into the gastrointestinal tract with a concept of their relative volume and composition in different animal species

- Apply an understanding of the enterosystemic fluid cycle in different animal species to explain the consequences of obstruction in different regions of the digestive tract for fluid and electrolyte balance

- Describe how the gastrointestinal tract can be clinically assessed in large animal species