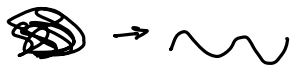
I. A. Digestion

- also some mechanical digestion (mastication) → different location for birds
- also some chemical digestion (denature proteins → HCl, heat, electrostatic
  ↳ unfolding 

B. Absorption - crossing the intestinal cell barrier

(apical cell membrane of intestinal epithelial cells)

(aka enterocyte)

crossing the cell membrane
- ↳ Simple diffusion
- ↳ Facilitated diffusion
- ↳ Active transport

II. Parts and functions (Brief)

A. Mouth
- ↳ lips, Tongue > sensation + acquisition
- Teeth - aquisition + mastication (Physical dig.)
- Saliva - lubrication + minor enzymatic dig. mostly our salivary amylase (digests carbs.)

II B. Esophagus
- Tube that's connects mouth to stomach
- Smooth muscle for peristalsis (less in ruminents) (need to regurgitate for rumination)

Birds
- crop
- Esophageal sphincter

C. Stomachs - great diversity
- Storage (carnivores = smaller stomach; less digestible diet = larger stomach)
- Chemical digestion (HCl)

- kill microbes (HCl)

- Some enzymatic digestion

autoenzymatic (minor)

alloenzymatic in some species

II C. 1. Non-ruminant "gastric" or "acid" Stomach

- acid denature proteins / detox bugs

- HCl - Parietal cells

- Enzymes:

↓zymogen, HCl autocatalysis

Pepsinogen → Pepsin > Chief cells

gastric lipase

- MUCUS - glycoproteins - protect from the acid

MUCUS cells

- Hormones - from the stomach to the blood

gastrin (G-cells)

Somatostatin (D-cells)

II C. 2. Birds

- 2 Chambers

- Proventriculus - acid Stomach

- Ventriculus - gizzard (grinding / mastication)

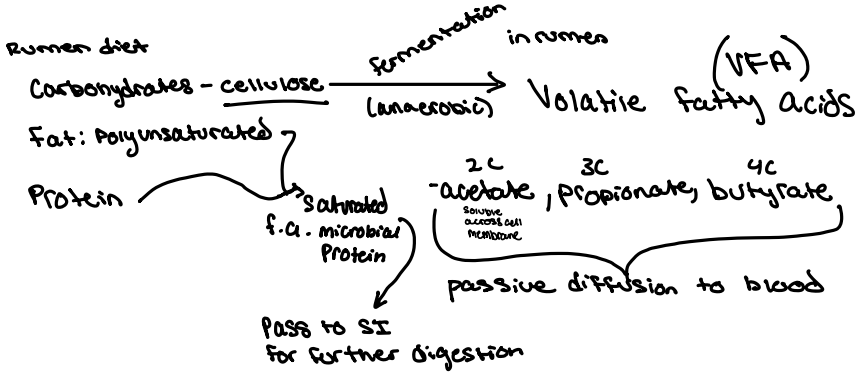
II. C. 3 Ruminant Stomach

- 3-4 "Chambers"

rumen > reticulorumen / rumenoreticulum

reticulum

= alloenzymatic digestion



Rumen: anaerobic, pH ~7, microbes 10^6 protozoa, 10^7 bacteria > per ml

up to 200L in big cow

II. D. small intestine - major site of autoenzymatic digestion and absorption

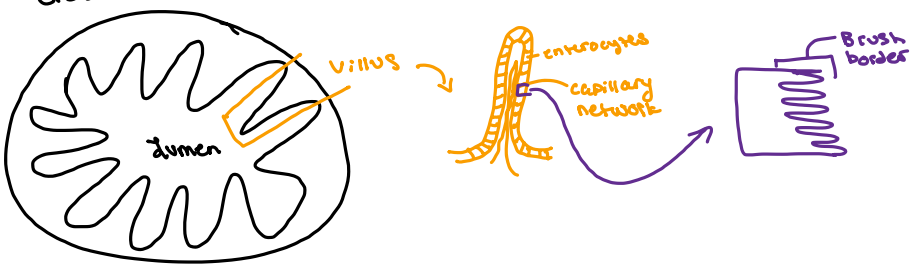
- duodenum, jejunum, ileum (most digesting occurs here; absorption)
- ileocecal sphincter @ end
- lots of surface area in SI, villi + microvilli (brush border)
- digestive enzymes enter @ beginning of duodenum

Hormones:

↳ Cholecystokinin (CCK) - I cells of the duodenum

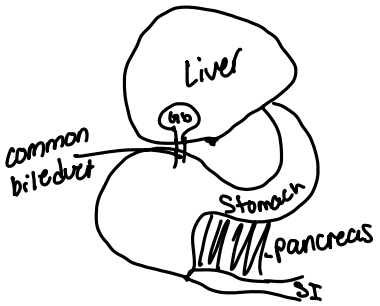
↳ Secretin - S-cells of duodenum

cross section of SI



Tuesday

II. E. Liver, Pancreas, etc.



Pancreas - endocrine (secreted into blood) + exocrine functions

β cells (more later)

exocrine - out of the body (into ducts; per. spray)
- acinar cells - digestive enzymes (secreted into common bile duct)
- duct cells - bicarbonate (buffer) $NaHCO_3^-$

- Liver
  - Chemical detox.
  - ↳ Portal Circulation - drains Stomach, SI, mos of L.I to liver 1st

Liver = Logistics warehouse of body

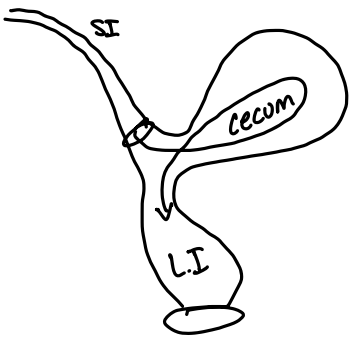
- makes and secretes bile (amphipathic like soap) that helps w/ fat digestion

bile is secreted into the gall bladder for storage.

- Pancreas and the gall bladder empty into the common bile ducts which connects to beginning of duodenum

- Common bile duct is closed off @ duodenum by Sphincter of Oddi

II.F. Cecum - variable importance depending on species



-Blind Sac.

-Site of alloenzymatic digestion

in cecal fermenting species (bunnies, iguana)

-alloenzymatic digestion of "fiber" (undigestible carbohydrates)

Product of fermentation = VFA (passively absorbed to circulation)

-Importance of coprophagy (dietary matter that came out of cecal fermentation)

G. Large Intestine / Colon.

- Some alloenzymatic digestion (VFA, Microbe (from dead bug body), Prot. / lipid)

(variable importance depending on species and diet)

- H_2O reabsorption

- lots of immune surveillance * fire alarm

- Vitamin production by microbes - Vit K. Some B-vit.

III. Gut derived hormones of digestion

Hormone	Source	Stimulus	Target(s)	Result
Gastrin	G-cells	Physical (distension, peptides)	Parietal cells →	HCl
			Chief cells →	Pepsinogen, Gastric Lipase
			ileocecal sphincter ⇝	relax (to allow passage)
Somatostatin (stop)	D-cells	low PH	Parietal cells →	Stop secreting HCl/enzymes
			Chief cells →	
Cholecystokinin (CCK)	I-cells of duodenum	a.a. peptides f.a.	Pancreatic Acinar cells →	digestive enz. of pancreas
			sphincter of Oddi ⇝	relax
			gall bladder (storing bile) ⇝	contract
				(dump to SI)
Secretin	S-cells	low PH	duct cells of panc.	$NaHCO_3$ secretion to neutralize stuff entering S.I.

Carbohydrates

- Types + funct.
- dig. absorp. trafficking
- fates in body - met. pathways

I. Intro: hydrates of C. formula = $(CH_2O)_n$

- Sugars, starches, celluloses - all are "saccharides"
- most common saccharides = $(CH_2O)_6 = C_6H_{12}O_6$ = glucose (glc) Fructose (Frc), galactose (gal)

II. types / functions

A. Monosaccharides - Single "sugar" units

- usually 3-6 C

- riboses - 5C - DNA, RNA, ATP, NAD^+, etc.
(Pentoses)

- hexoses - most common = glc ← most abundant in uni.

IIA. Glucose - Widely used to generate ATP ($\mathcal{E}$)

(ADP + P_i → ATP)

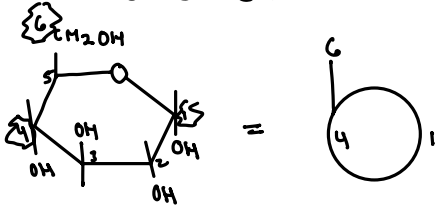
All animals need glucose

- Critical to metabolism in animals - many safeguards to ensure a supply of glucose in animals.

- Store excess glc as glycogen

- Sometimes convert excess glc to fatty acids (but cannot reverse)

- Other stuff



IIB. Disaccharides - 2 monosaccharides linked by a covalent glycosidic bond
↓
α or β configuration

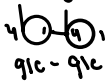
Examples: sucrose = fructose - glucose (α)
maltose = glc - glc (α)
lactose = gal - glc (β)
cellobiose = glc - glc (β)

- generally - β bonds are not broken by animal digestive enzymes

(exception = lactose - broken by animal lactase)

(mostly neonatal mammals)

II_B. Glycosidic link:

α: Maltose 

β: cellobiose 

II. C. Complex CHO (carbohydrate) - anything w/ more than 2 saccharide units

1. Oligo saccharides - 3-10 sugar units

-digestion intermediates

-"glycans" - linked to proteins / lipids as a signal / identifier

-or as a protective layer (mucins) (mucus) (highly glycosylated)

2. Polysaccharides — >10 sugar units.

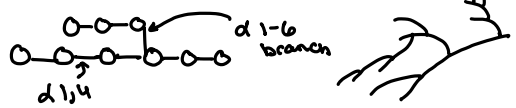
a. in plants -amylose -glc polymer

linked by α 1-4 glycosidic bonds

(2 ends)

II c.2.a

-amylopectin - glc polymer α1-4 linked and α 1-6 "branches" every ~25 units



(multiple ends)

amylose+ amylopectin = "starch"

-cellulose -glc polymer — β 1-4 links

structural molecule

II C.2.b. In animals - glycogen

glc polymer α1-4 links and α1-6 branches every 8-10 units

-highly branched

-liberate more glc per unit of time

-lotsa ends - for rapid need

II c.2.b. glycogen synthesized when glc supply is high and broken down (back to glc) when glc supply is low.

III. Digestion, Absorption, Trafficking

A. Digestion- break all dietary CHO into monosaccharides (cross cell membrane)

2. Phases

↳ luminal phase... by amylases

α amylase - Saliva - minor role

pancreatic amylase - small intestine - major role

Net result: amylose + amylopectin $\xrightarrow{\text{amylases}}$ Oligosaccharides

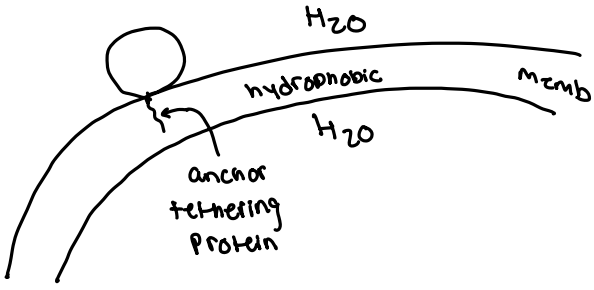
glycogen is digested the same way

III.A.2 Brush-border Phase

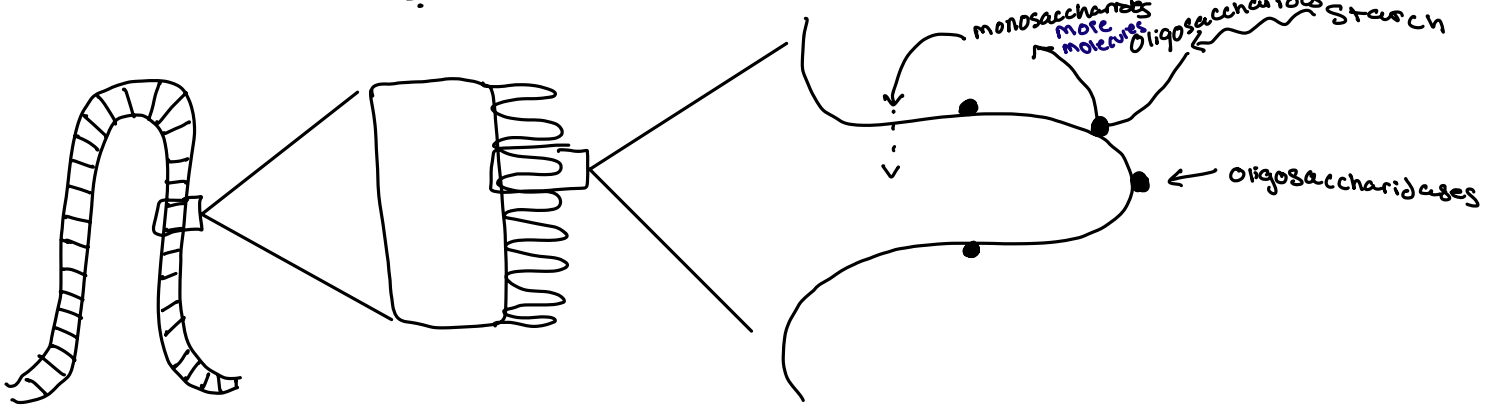
- Oligosaccharides tethered to brush border membrane.

(Peripheral membrane proteins)

- Oligosaccharides ⟶ monosaccharides

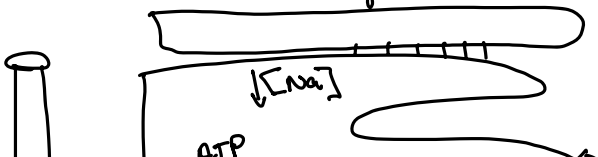


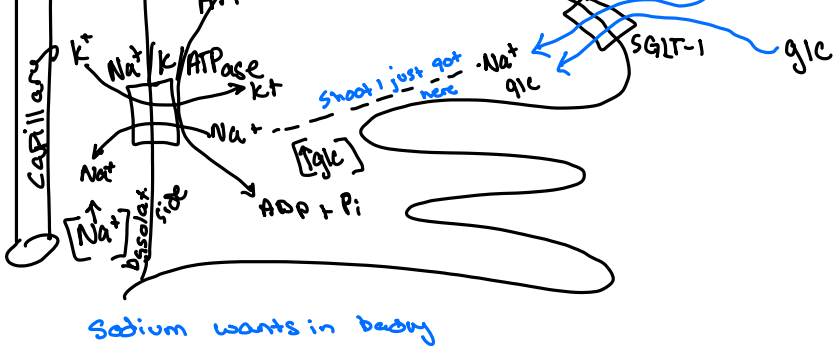
A.2



III B. Absorption — crossing the apical membrane of the enterocyte

- Pumping glc UP its conc. gradient
- 2° active transport
- SGLT-1: (Sodium-glucose transporter-1)
- uses a [Sodium] gradient to drive glucose uptake by Symport
- [Na^+] gradient created by Na^+/K^+ ATPase





Sodium wants in badly

III.C. Trafficking → all movement of glucose in the body is down a glucose concentration gradient

Sidebar! Polar Covalent bond
↑ partial charge

Strongest polarity of a covalent bond

Polar - hydrophilic
Polar dissolves in water

H and O, N, F

Glucose is polar doesn't go comfortably into the membrane

↳ down the gradient by Facilitated diffusion

III.C. Diffusion facilitators = GLUT Proteins

(glucose transporters) lets things through but only downhill

Many GLUTs - Each has different kinetics and regulation

III.C. each tissue matches its GLUT expression to meet its glc demand

III.C.1 GLUT1 — wide tissue distribution (most tissues in the body)

(RBC, Skeletal muscle, Brain/neural tissue, liver, gut etc...)

- relatively low K_m ← affinity constant (low km = high affinity)
- responsible for baseline glc demand for cells
(just enough to stay alive)

- Tissue baseline demand is proportional to GLUT1 expression

III C.2. GLUT2 - Liver, Pancreas, basolateral membrane of enterocyte.

- High K_m, high capacity (V_{max})

- moves lots of glucose, but only when lots of glucose is around

- Enterocyte GLUT2 allows glucose to dump (spill) into the blood

Then blood goes

- Liver - GLUT 2 allows glc into hepatocytes (glucose stored as glycogen...)

- Pancreas - GLUT2 allows glucose into endocrine cells

α - inhibits release of glucagon — glucose is gone/low

β - Stimulates release of insulin

lots of energy around lets store it