Gut secretion and absorption

**Gut secretion and absorption**

**Fluid and electrolyte transport are important functions of the gastrointestinal tract (even in the absence of food)**

Epithelial cells may...

- **secrete water and electrolytes**
  - i.e. transport from blood to gut lumen

- **absorb water and electrolytes**
  - i.e. transport from gut lumen to blood

**Overall daily gut fluid balance**

- **Ingest** 2 L/day
- **Saliva** 1.5 L/day
- **Gastric secretions** 2 L/day
- **Pancreatic juices** 1.5 L/day
- **Bile** 0.5 L/day
- **Intestinal secretions** 1.5 L/day
- **Small intestine absorbs** 8.5 L/day
- **Colon absorbs** 0.4 L/day

**OUT**
- **9 litres/day**

**IN**
- 0.1 L/day excreted
- **9 litres/day**
Slide 4

**Movement of water and solutes**

- Water moves down osmotic gradients
- Electrolytes move down electrochemical gradients
- To move solutes against their concentration gradients requires energy
- Energy is supplied by sodium gradients (generated by the sodium pump) and by proton gradients

Slide 5

**Membrane domains and transport routes**

- LUMEN
- BLOOD
- Paracellular route
- Transcellular route
- Apical
- Basolateral

Slide 6

**Absorption in the villus: secretion the crypt**

- net absorption
- net secretion
Factors affecting absorption and secretion

- Nutrient intake
- Gastric motility
- Intestinal motility
- Number and state of enterocytes
- Blood & lymph flows
- Luminal factors: Irritants, Bacterial toxins, Bile

Absorption

Secretion

Excretion

Hormonal
Paracrine
Neural

Na⁺-coupled nutrient absorption

......energy-dependent transport

LUMEN pH 6.0

CELL pH 7.2

BLOOD

Intestinal secretion

1. Na⁺/K⁺ ATPase
2. Na⁺/K⁺/2Cl⁻ cotransporter
3. K⁺ channel
4. Cl⁻ channel
5. Physiological control of secretion

Ach, VIP
Diarrhoeal disease

<table>
<thead>
<tr>
<th>TYPE OF DIARRHEA</th>
<th>MECHANISM</th>
<th>CAUSES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hypermotility</td>
<td>Transport too fast for absorption</td>
<td>High fibre diet Diabetes - adrenergic neuropathy</td>
</tr>
<tr>
<td>Osmotic</td>
<td>Non-solute absorption (enzyme deficiency/villous atrophy)</td>
<td>Lactase deficiency Coeliac (sprue) disease</td>
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<tr>
<td>Defective transport</td>
<td>Na⁺ or Cl⁻ transporters absent</td>
<td>Sodium/chloride diarrhoea (rare congenital defects)</td>
</tr>
<tr>
<td>Secretory</td>
<td>Inflammatory Blood hormones Tumours Enterotoxins Viruses/Parasites</td>
<td>Pancreas- VIP secreting Thyroid - calcitonin secreting V. cholerae, E.coli etc Rotavirus/Giardia sp. etc.</td>
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TRAVELLERS DIARRHOEA

<table>
<thead>
<tr>
<th>BACTERIA</th>
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<tbody>
<tr>
<td>Vibrio cholerae (F)</td>
</tr>
<tr>
<td>Campylobacter jejuni (W)</td>
</tr>
<tr>
<td>Clostridium difficile (F)</td>
</tr>
<tr>
<td>Clostridium botulinum (F)</td>
</tr>
<tr>
<td>Shigella sp. (F)</td>
</tr>
<tr>
<td>Salmonella sp. (F)</td>
</tr>
<tr>
<td>E.coli (F)</td>
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<table>
<thead>
<tr>
<th>VIRUSES</th>
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<tbody>
<tr>
<td>Norwalk (F/W)</td>
</tr>
<tr>
<td>Hepatitis A (F)</td>
</tr>
<tr>
<td>Rotavirus (W)</td>
</tr>
</tbody>
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<table>
<thead>
<tr>
<th>PARASITES</th>
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</thead>
<tbody>
<tr>
<td>Entamoeba histolytica (F/W)</td>
</tr>
<tr>
<td>Giardia intestinalis (W)</td>
</tr>
<tr>
<td>Cryptosporidium sp. (W)</td>
</tr>
<tr>
<td>Yersinia sp. (F)</td>
</tr>
</tbody>
</table>

F = food bourne, W = water bourne

Cholera and cholera toxin

DNA sequence of both chromosomes of the cholera pathogen *Vibrio cholerae*

John F. Heidelberg et al., 3 August 2000 Nature 406, 477-482
**Cholera toxin and transport into intestinal cells**


Lencer & Tsai. TIBS: 2003; 28; 639-45

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**Cholera toxin-induced intestinal secretion**

Gut lumen

Cholera toxin

Adenylate cyclase

β-subunit

α-subunit

NAD+

H2O

Cl-

HCO3-

ATP cAMP (↑)

GDP

GTP

X

ADP-ribose

cell surface

Gut lumen

Cholera toxin

α1 subunit hydrolyses Nicotinamide

α1

ADP-ribose

GTPase

GTP

GDP

Adenylate cyclase

---

**Vibrio cholerae colonizing human epithelial cells**

As more bacteria adhere to the host cell surface and secrete cholera toxin, the host cells begin to pump out water and salt due to constitutive activation of adenylate cyclase. In the intestine, the water is pumped into the intestinal lumen, resulting in watery diarrhoea.

Rice water stool
Oral rehydration therapy *

* water, electrolytes and glucose: efficient use of available transporters