I’ve got that gut feeling - motility in the GI tract

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Learning Outcomes:

- **LO1 - Explain the integration and control mechanisms of swallowing (oral, pharyngeal and oesophageal phases) and control of lower oesophageal sphincter function.**

- **LO2 - Define the motility patterns in fasted and fed states of the stomach and intestinal tract**

- **LO3 - Define motility in the small and large intestine (peristalsis, haustrations, mass movements)**

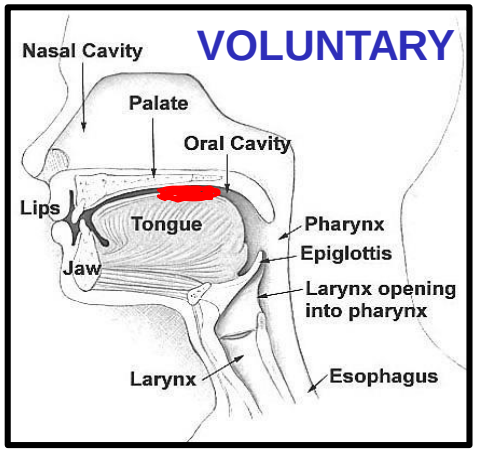
- **LO4 - Define how we remove indigestible matter (anatomy of the ano-rectum, defecation and external anal sphincter control)**

LO2

Swallowing (deglutition)

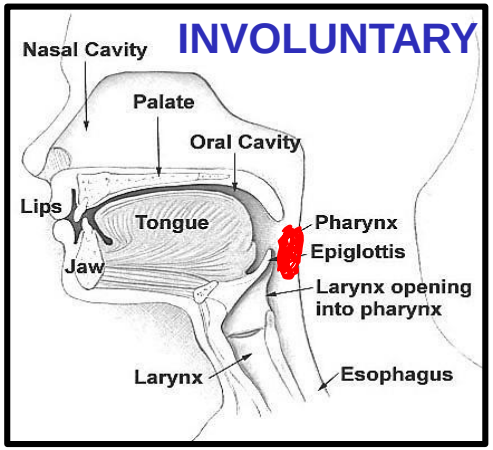
Three phases to swallowing – one voluntary (conscious), two involuntary (unconscious) control

Phase I - ORAL



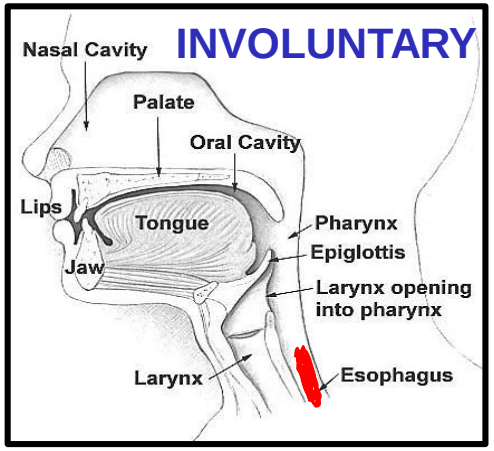
- *Food bolus formed by mastication*
- *Tongue moves up and backwards*

Phase II - PHARYNGEAL



- *Soft palate rises*
- *Epiglottis closes*
- *Pharynx contracts*
- *UOS relaxes,*

Phase III - OESOPHAGEAL

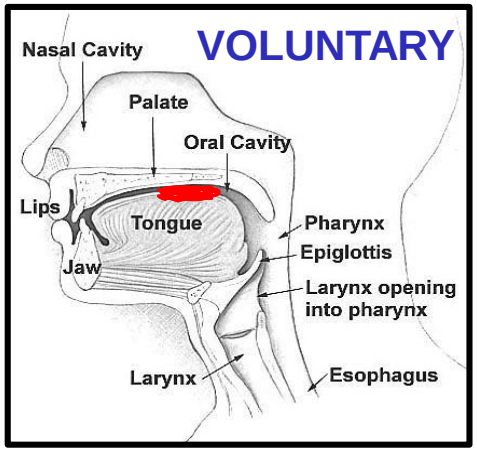


- UOS contracts
- Bolus moved by peristalsis
- LOS relaxes, then contracts

LO2

Swallowing (deglutition)

Phase I - ORAL



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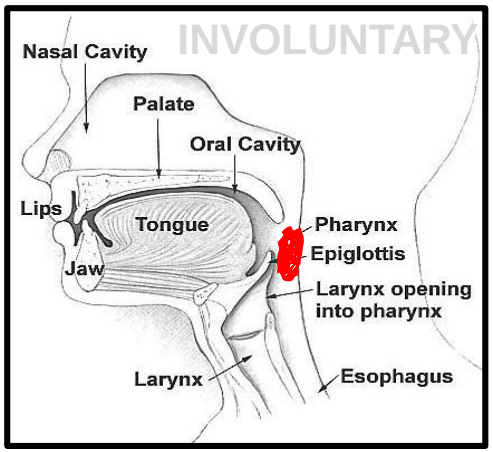

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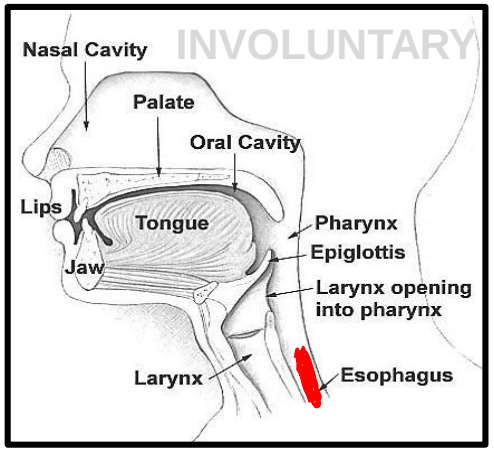


- UOS contracts
- Bolus moved by peristalsis
- LOS relaxes, then contracts

Phase I - the oral phase of swallowing (voluntary)

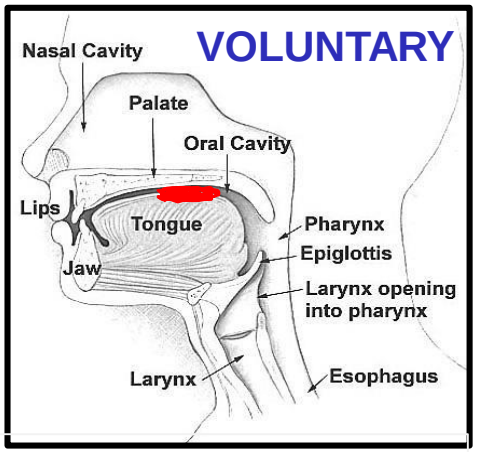
Hypoglossal (XII cranial) nerve plays a key role

- **provides motor innervation to tongue and many of the suprahyoid muscles stabilising the lower jaw bone.**
- **supports preparation, formation, positioning and transport of the food bolus ready to swallow.**

LO2

Swallowing (deglutition)

Phase I - ORAL



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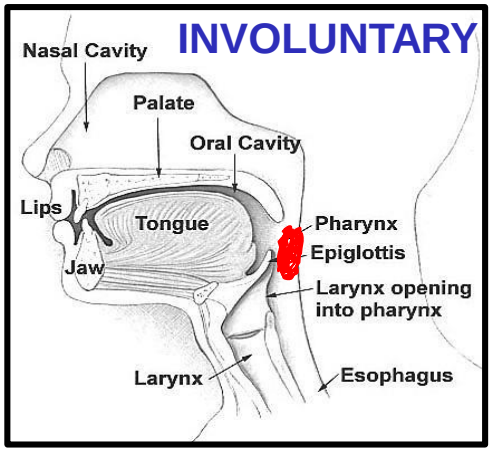
Phase II - PHARYNGEAL



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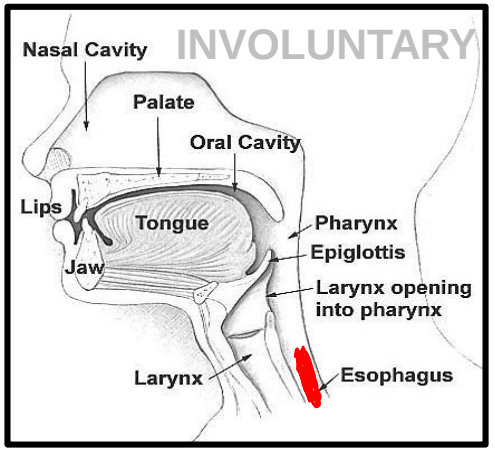

- UOS contracts
- Bolus moved by peristalsis
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Phase II – Pharyngeal phase - tactile/distension receptors activate afferent nerves signalling to the brain stem

Glossopharyngeal nerve (IX cranial) nerve
Pharyngeal branches of the Vagus (X cranial) nerve

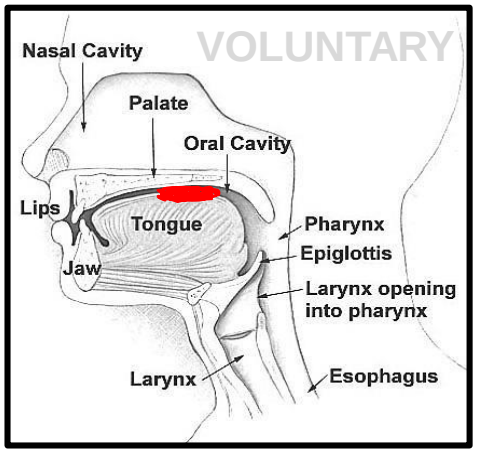
Efferent fibre signals from brain stem effect actions to initiate a safe swallow

LO2

Swallowing (deglutition)

Phase I - ORAL

VOLUNTARY



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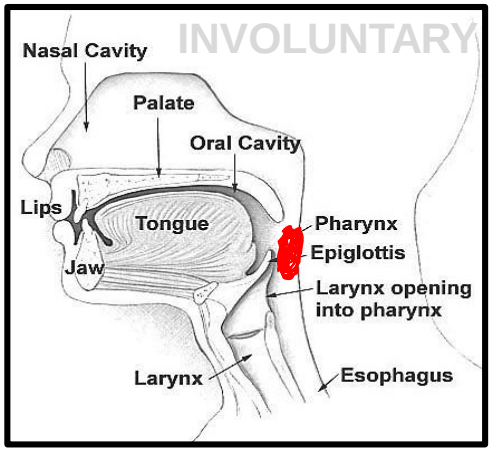
Phase II - PHARYNGEAL

INVOLUNTARY



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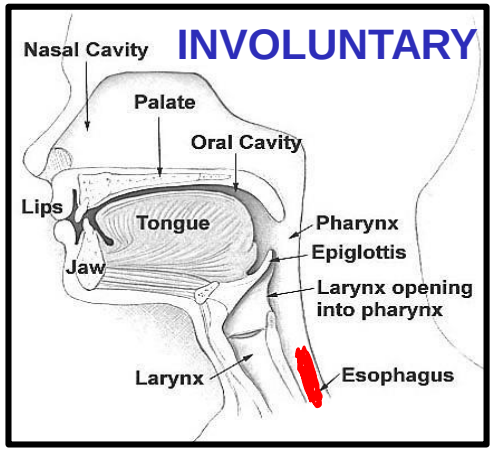


- **UOS contracts**
- **Bolus moved by peristalsis**
- **LOS relaxes, then contracts**

Phase III - Oesophageal phase

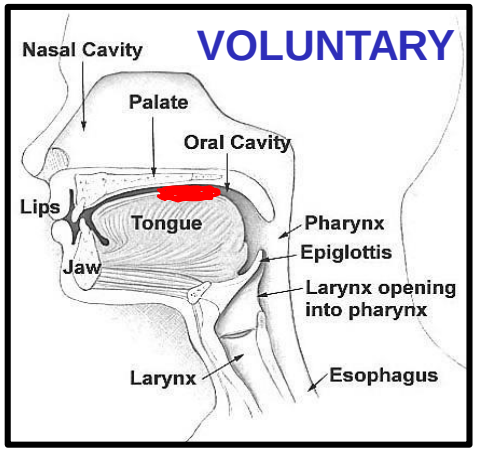
Glossopharyngeal nerve (IX cranial) nerve & Vagus (X cranial) nerve

- Primary peristalsis UOS to LOS wave of contraction (gradient striated to smooth muscle) **Transit time 6-9 sec**
- Secondary peristalsis if blockage (also a conscious swallow possible)
- Reflex opening of the LOS for food to enter the stomach and closure to prevent gastric content refluxing

LO2

Swallowing (deglutition)

Phase I - ORAL



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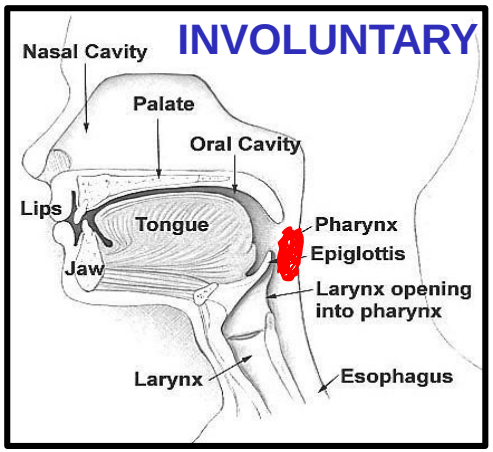

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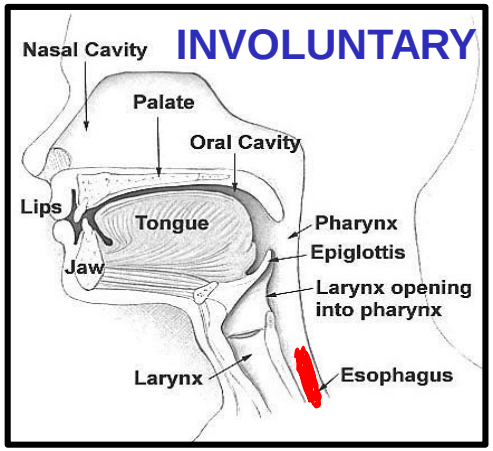

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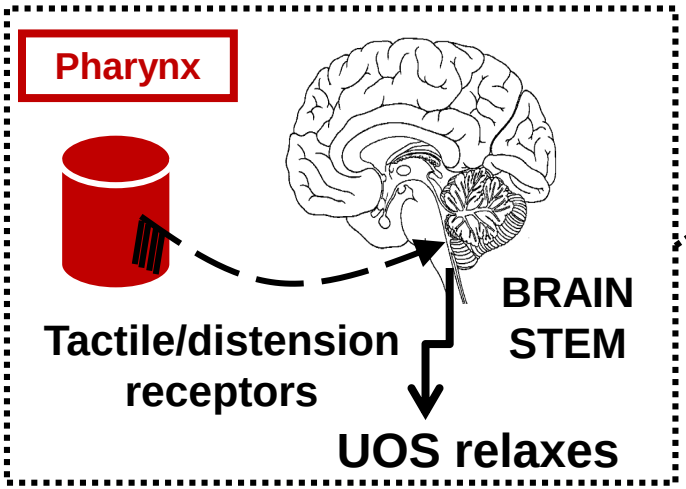
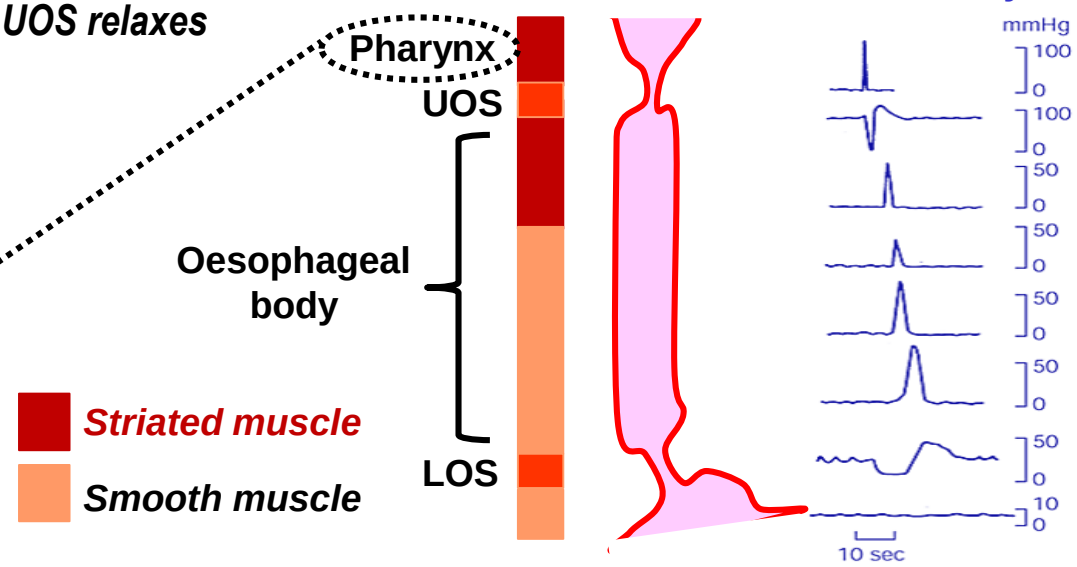


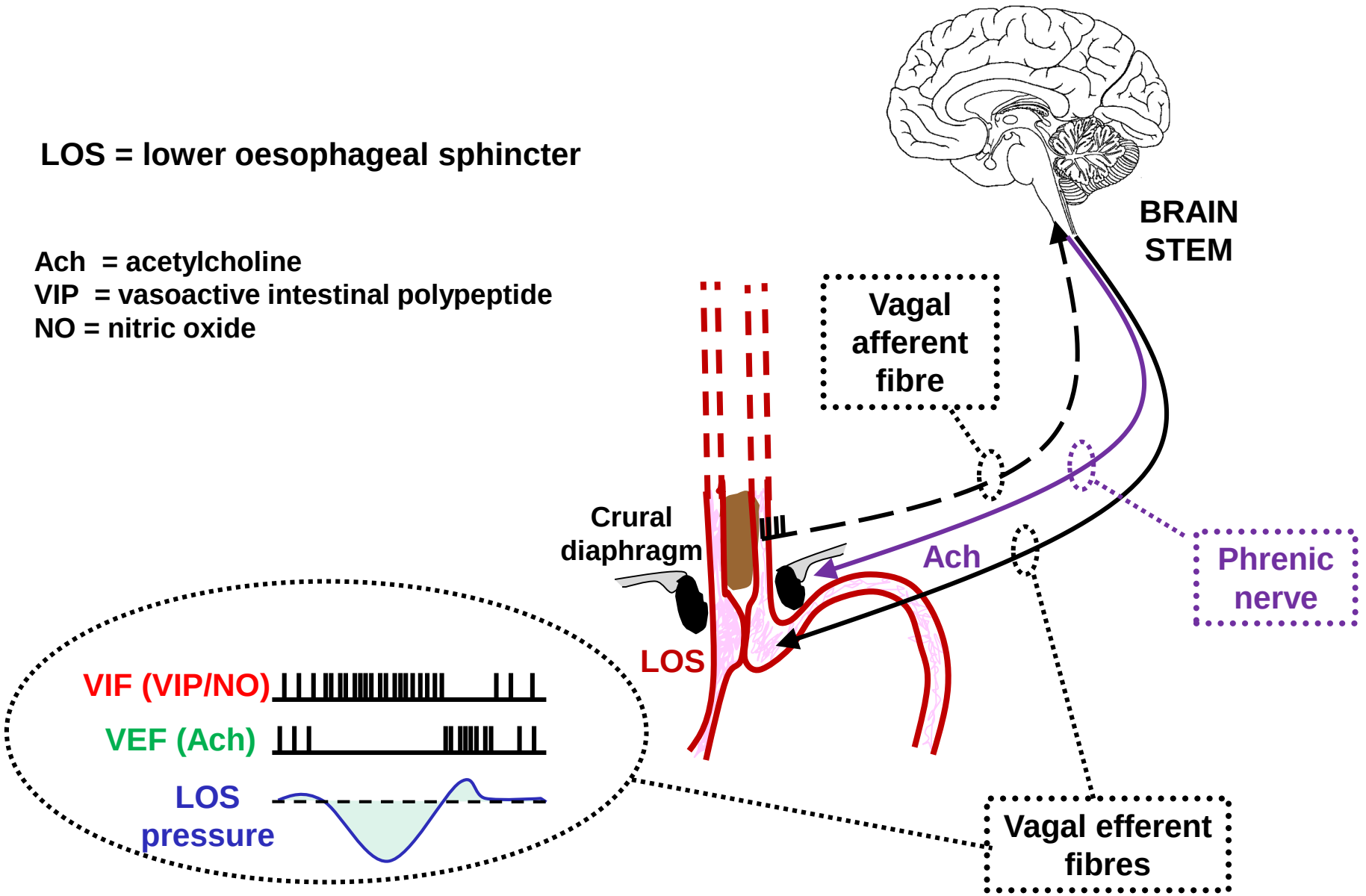


LO2

Entry of food into the stomach

LOS = lower oesophageal sphincter

Ach = acetylcholine
VIP = vasoactive intestinal polypeptide
NO = nitric oxide



LO2

Gastric motility

Controls entry to intestines

Lower oesophageal sphincter (LOS)

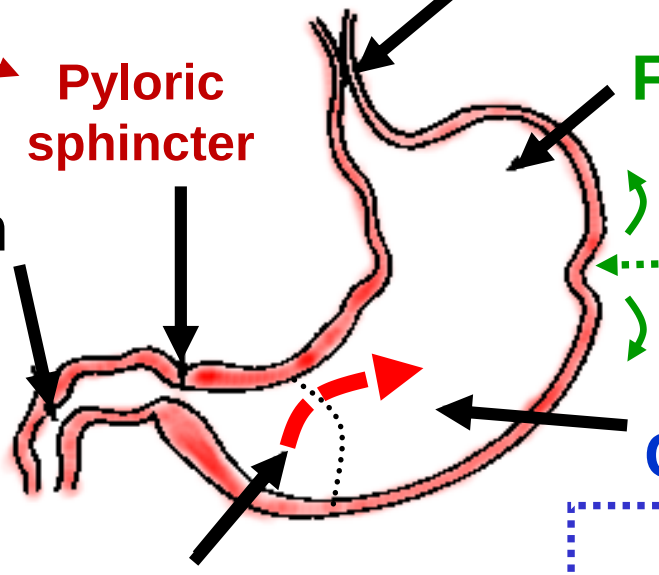
Controls entry to stomach Cardia

Pyloric sphincter

Fundus

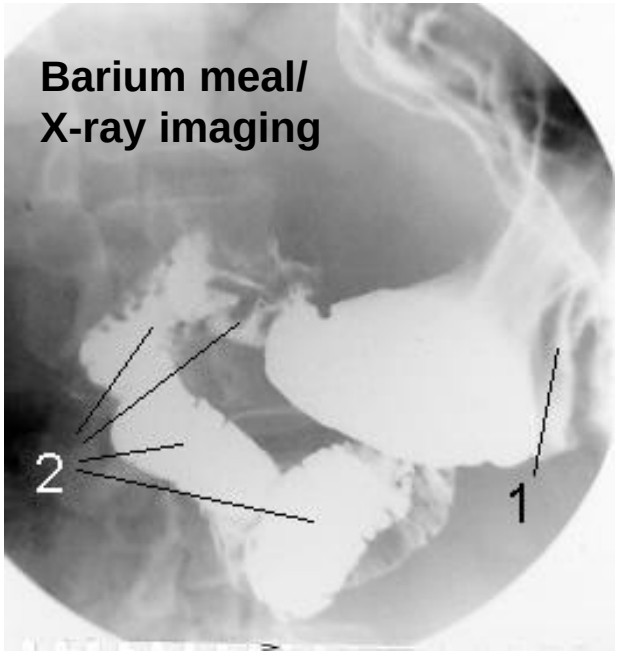
Duodenum

"Pacemaker zone" - initiates peristaltic contractions



Corpus

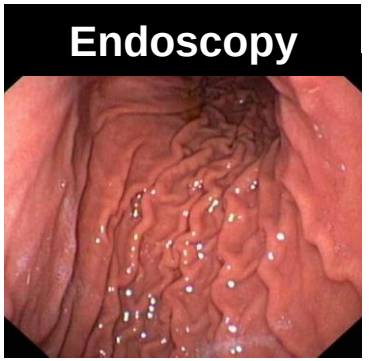
Relaxes to accommodate a meal



Antrum

Powerful muscular pump of the stomach

= retropulsion



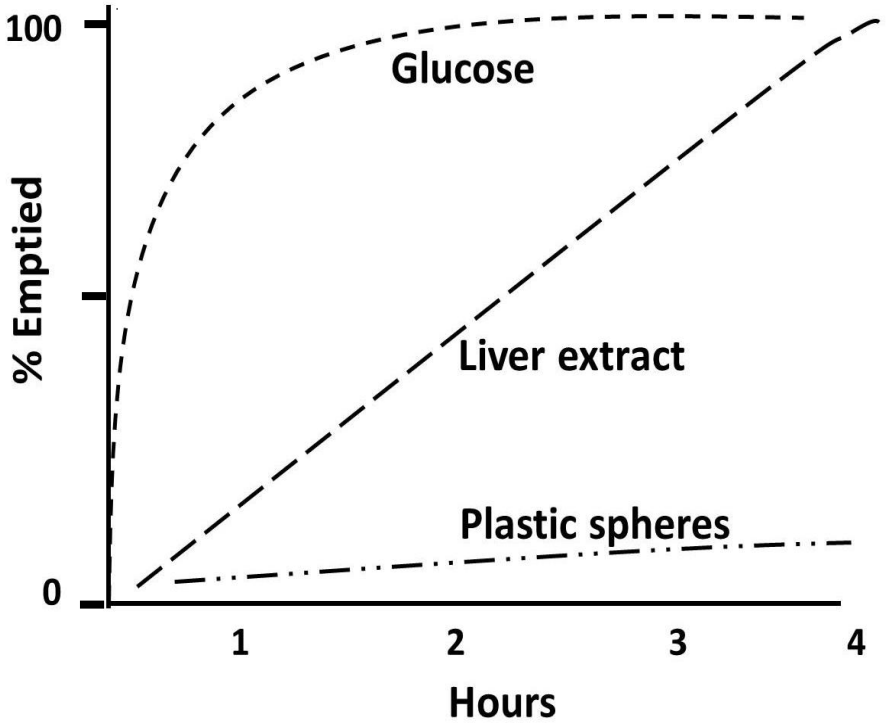
Internal rugae to channel liquids fast

LO2

Gastric emptying of chyme

Gastric emptying is the process by which the contents of the stomach ('chyme') are moved into the duodenum

Accomplished by 4 mechanisms: (1) Peristaltic waves, (2) systolic contractions of the antrum, (3) reduction in size of the stomach, and (4) reflex relaxation of the pyloric sphincter



- **Liquids empty more rapidly than solids**
- **Fat-rich, carb-rich, hypertonic and acidic meals, and meals with high viscosity all delay gastric emptying**
- **Rate of emptying is controlled by duodenum**
- **Indigestible solids empty very slowly**

LO2

Basal underlying smooth muscle tension – Interstitial cells of Cajal are pacemakers of the gut

ICC cell network

Slow wave mechanism

Slow wave conducted to smooth muscle

- primitive myofibroblast-like cells that are electrically rhythmic.
- Found within both circular and longitudinal muscle layers, and submucosa, closely associated with myenteric and submucosal nerve plexi
- ICC form synapse-like junctions with enteric nerves and gap junctions with smooth muscle cells to conduct slow waves and transmit signal
- Frequency of waves – Stomach 3/min; duo 11-13/min, ileum 9-10/min, colon 3-4/min
- They are sensitive to stretch in addition to a number of enteric neurotransmitters including acetylcholine, ATP and NO

LO2

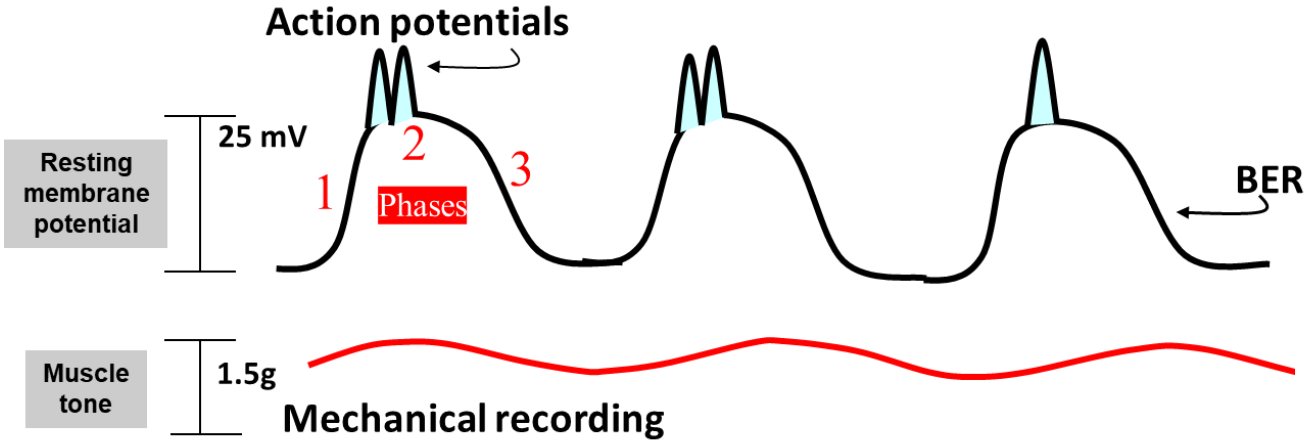
The ICC sets the basic electric rhythm (or slow wave activity) that can lead to smooth muscle contraction

ICC cell network

Slow wave mechanism

Slow wave conducted to smooth muscle

L type Ca^{2+} current & action potential mechanism



Basal electrical rhythm (BER) originates in ICC, but itself does not cause contraction; when spike potentials occur at maximum depolarisation of BER due to Ca^{2+} entry, the result is contraction

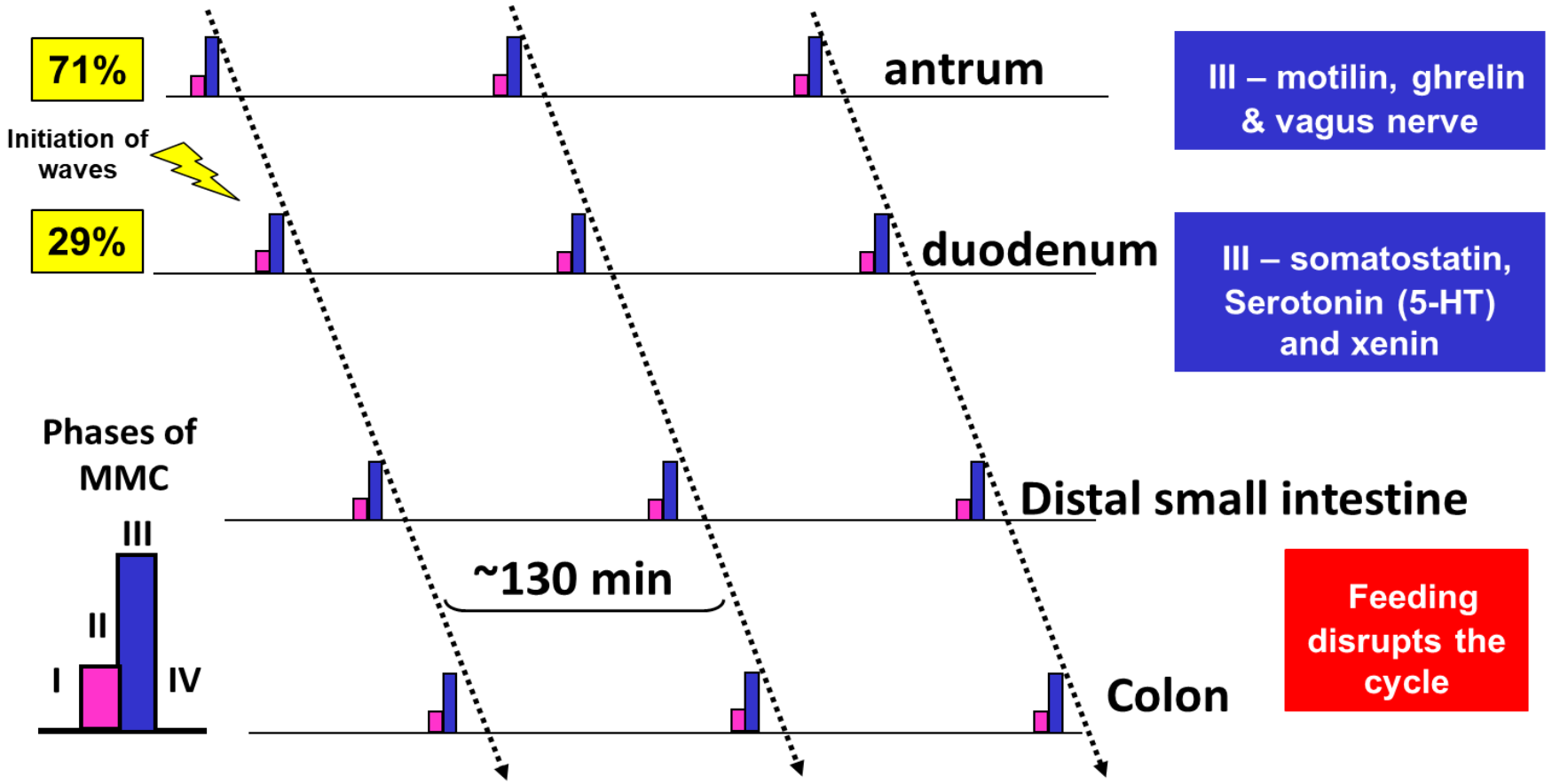
1. **Depolarisation -** **(Ca^{2+} ion influx) and formation of action potentials**
2. **Plateau is maintained and action potential complex propagates to smooth muscle via gap junctions, initiating voltage sensitive L-type Ca^{2+} channels in the smooth muscle to initiate excitation-contraction.**
3. **Repolarisation – outward K+ flux, slow wave activity**

LO2

Fasting motility patterns

The Migrating Myoelectric Complex (MMC)

From the stomach to the ileum - to clear residual contents



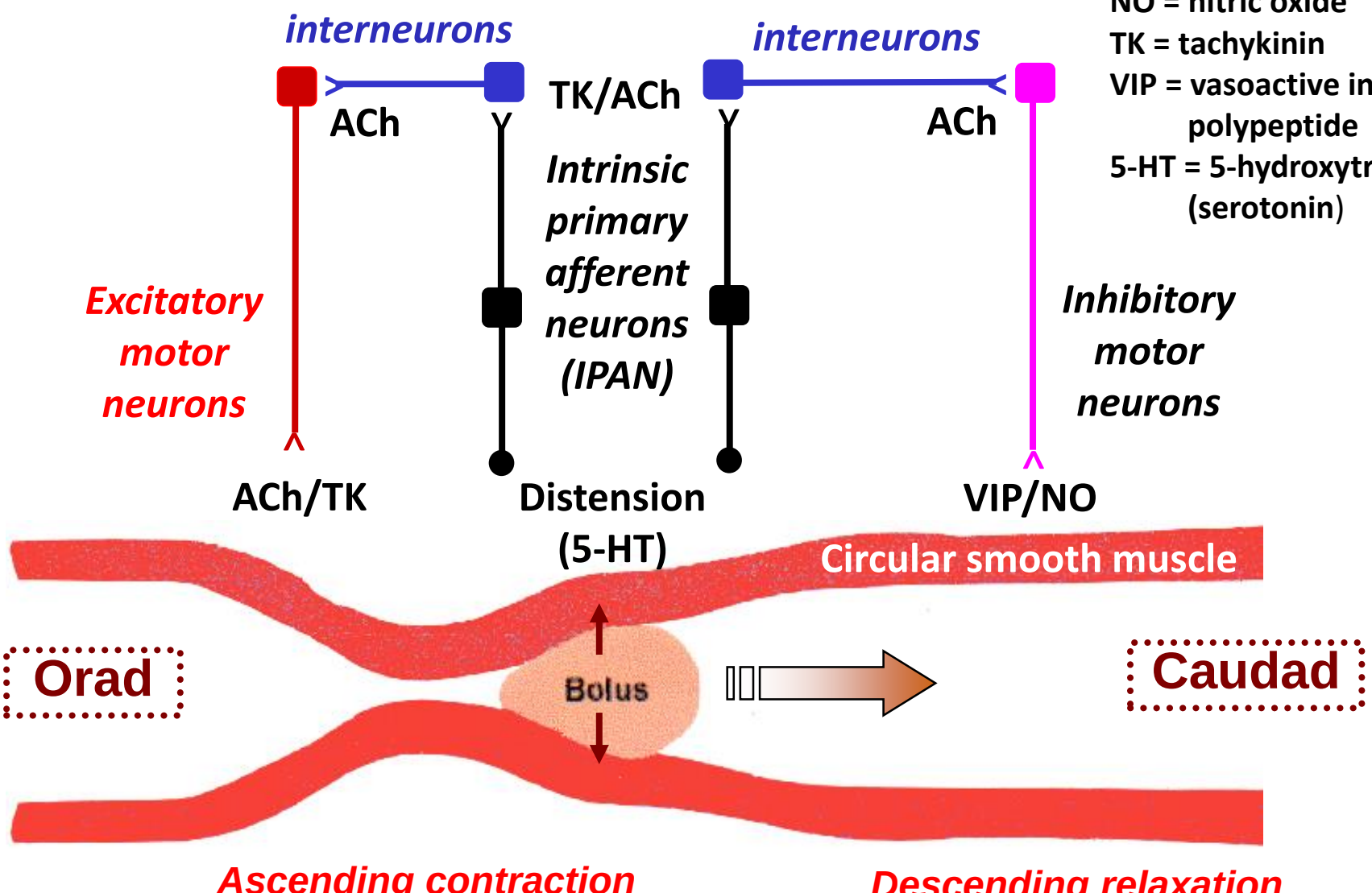
I - quiescence; II - random contractions; III - burst of contractions (max. amplitude & duration); IV - rapid decrease of contractions.

LO2
LO3

Intestinal movement - peristaltic reflex

Animation at www.westga.edu/~lkral/peristalsis/

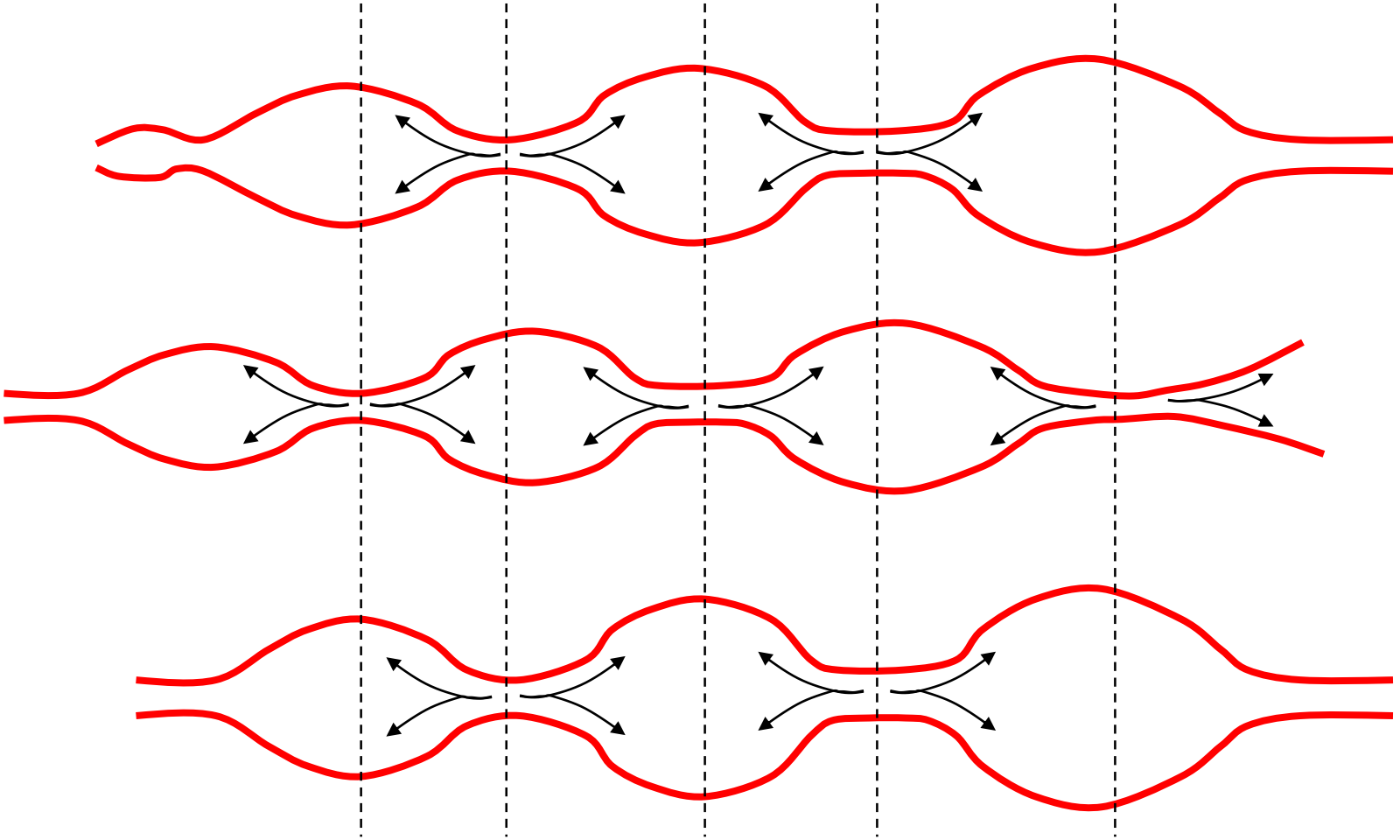
Ach = acetylcholine
NO = nitric oxide
TK = tachykinin
VIP = vasoactive intestinal polypeptide
5-HT = 5-hydroxytryptamine (serotonin)



LO2
LO3

Intestinal movement - segmentation

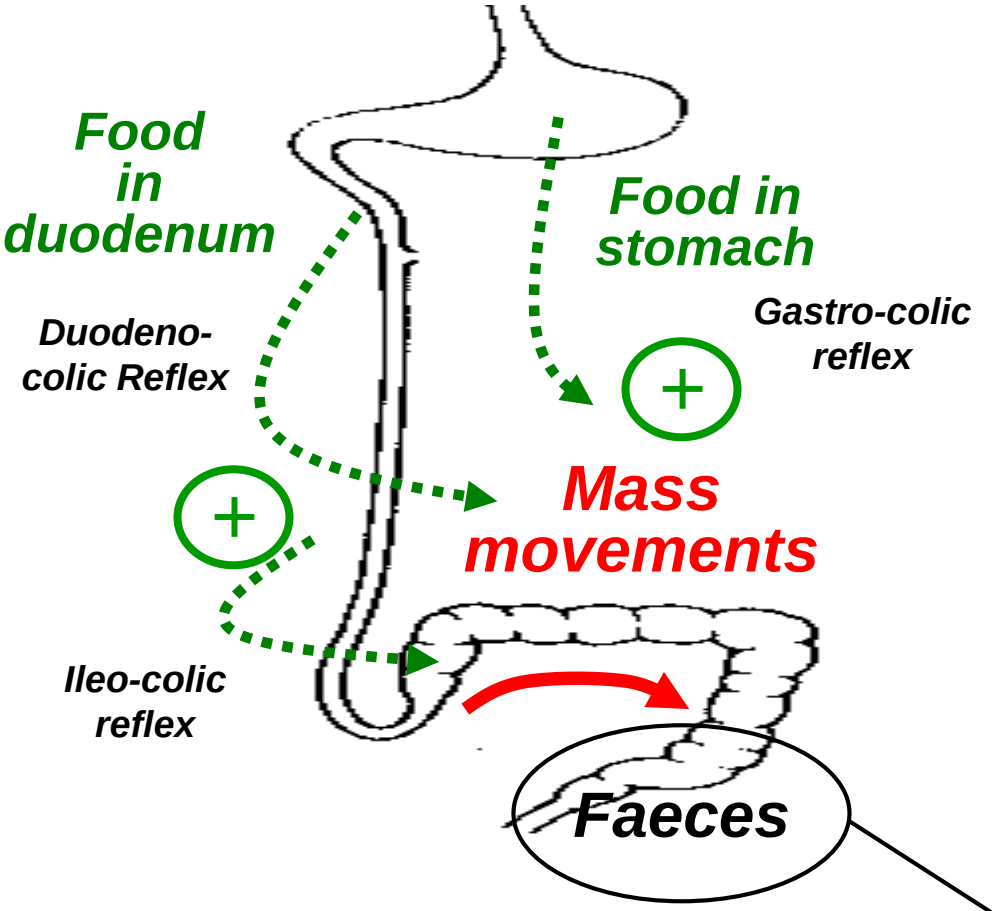
Alternate contraction and relaxation of adjacent segments causes thorough mixing of food contents



LO2
LO3

Removing indigestible material

Movement in the colon and rectum



Mass movements

- strong peristaltic waves resulting from new food entering the GI tract
- 1-3 x/day to push contents distally
- Mediated by parasympathetic system - **Ach (Vagus nerve)**
- Sympathetic stimulation blocks motility **(Noradrenaline)**

Segmentation (haustration)

- mixes indigestible matter
- helps microbial fermentation of dietary fibre
- facilitates fat and water absorption
- formation of stools

Defaecation reflex

LO2
LO3

Removing indigestible material

Defaecation reflex

DISTENSION (FAECES/FLATUS)

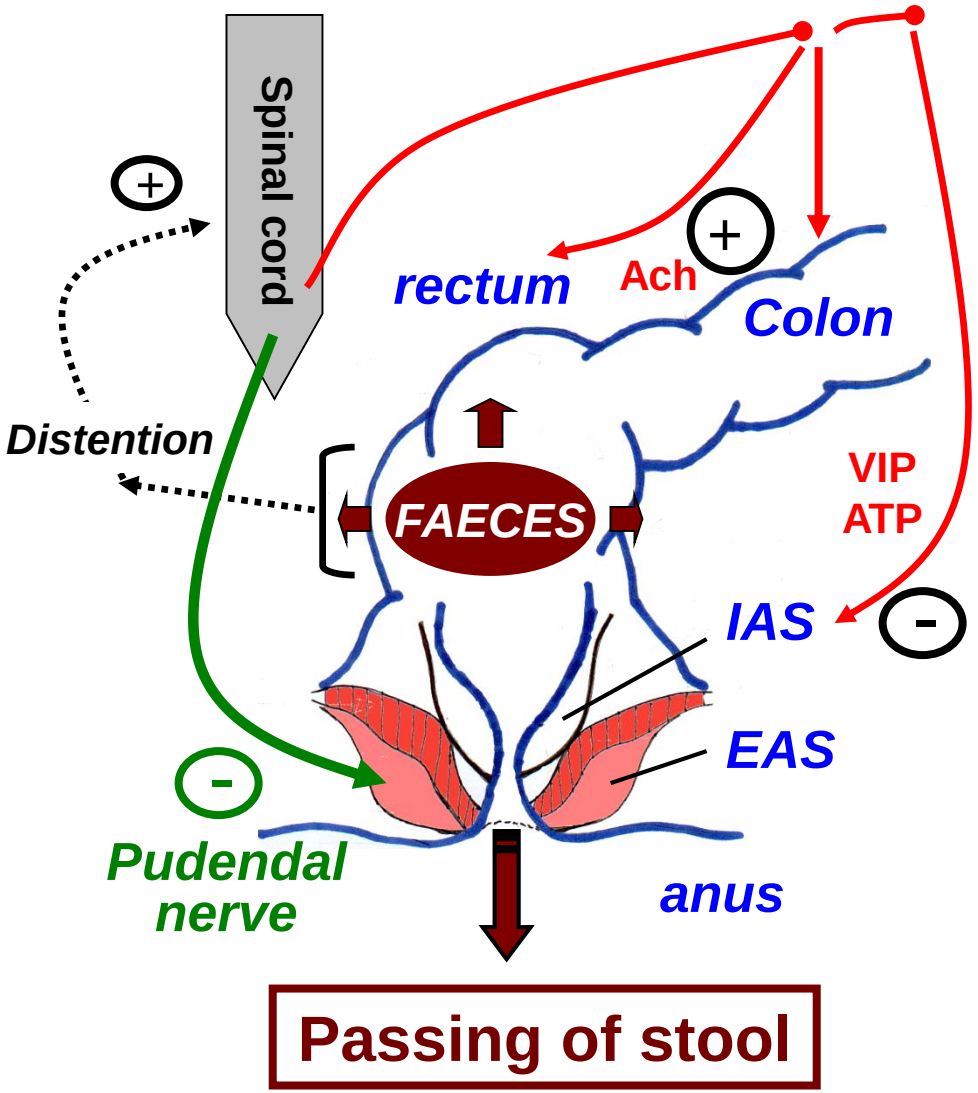
Modulated by the sacral region (S2-S3) parasympathetic pelvic nerves

- Contraction - sigmoid colon and rectum **(Ach)**
- Relaxation IAS (circular smooth muscle) & pelvic floor muscles (to straighten and prevent anal prolapse) **VIP/ATP**
- **The EAS remains contracted (striated muscle - somatic innervation)**

This gives the urge to defaecate!

Defaecation

- Correct ano-rectal angle (45° squat) is most efficient
- **voluntary control via the Pudendal nerve (cerebral cortex – somatic nerves – relax striated muscle)**



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Thank you for your attention.

- bjcampbl@liv.ac.uk
- http://pcwww.liv.ac.uk/~bjcampbl/gimotility.htm