

### In this article...

- How age affects the normal functioning of the digestive system
- Age-related changes to the mouth, oesophagus, stomach, intestines, liver and pancreas
- Conditions experienced by older people as a result of declining digestive function

# Anatomy and physiology of ageing 3: the digestive system

## Key points

**1** In older people, reduced appetite and food intake may lead to weight loss and malnutrition

**2** Dry mouth is common in older people and may be a side-effect of a range of drugs

**3** Significant changes in gut microbe populations that occur with age increase the risk of bacterial infection

**4** With age, peristalsis slows in the oesophagus and the colon, leading to issues such as dysphagia, reflux and constipation

**5** Incidence of several gut pathologies, including cancer of the colon, rises with age

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**Abstract** Ageing can have drastic effects on the functions of the digestive system. One of these is reduced appetite due to changes in hormone production and an alteration in smell and taste. Physiological changes in pharyngeal skills and oesophageal motility may lead to dysphagia and reflux. In the intestines, several factors contribute to changes in the regular gut microbial fauna, making older people more prone to bloating, pain and bacterial infection. There is also a drastic age-associated rise in the incidence of several gut pathologies including cancer of the colon. This third article in our series on the anatomy and physiology of ageing explores the digestive system.

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The main role of the digestive system is to mechanically and chemically break down food into simple components that can be absorbed and assimilated by the body. The gut and accessory organs also play an important role in the elimination of indigestible food components, bile pigments, toxins and excess salts. The system performs a range of anatomically and physiologically distinct functions, each of which is affected differently by ageing (Fig 1).

### The 'anorexia of ageing'

Food intake diminishes with age due to a range of complex reasons that lead to reduced appetite. These include physiological changes and changes in psychosocial and pharmacological circumstances.

Appetite is controlled mainly by sensors in the gastrointestinal tract, which detect the physical presence of food and prompt the GI tract to produce a range of hormones. These are released before, during and after eating, and control eating behaviours, including the amount consumed. They include:

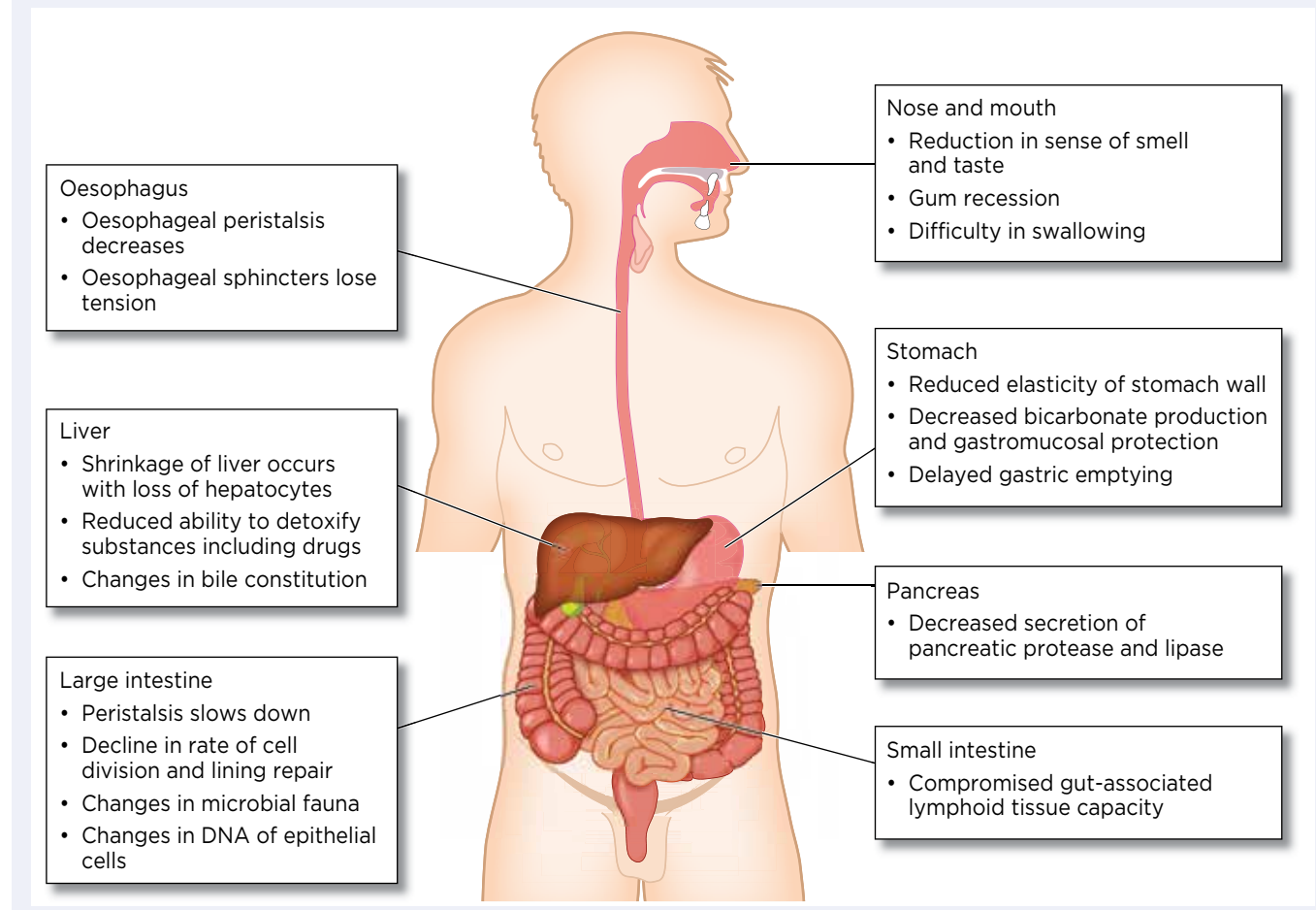
- Ghrelin;
- Peptide tyrosine tyrosine (PYY);
- Cholecystokinin (CCK);
- Insulin;
- Leptin (Pilgrim et al, 2015).

Table 1 highlights the changes that occur in the production of these hormones with advancing age; the overall result is reduced appetite.

We choose what we eat based on the smell and taste of food; however, the number of olfactory receptors decreases with age and the sense of smell diminishes. US research suggests that about half of people aged 65-80 and around three-quarters of those aged over 80 years have a demonstrable loss of smell (Doty and Kamath, 2014).

This decreased sense of smell can have significant safety implications; for example, a disproportionately high number of older people die from accidental gas poisoning. It can also be an early sign of neurodegenerative disorders such as Parkinson's or Alzheimer's disease (Hüttenbrink et al, 2013). Olfactory loss – including loss of the ability to discriminate between

Fig 1. Age-related changes to the gastrointestinal tract



smells – may also be a consequence of age-related skull bone growth that results in a pinching of sensory nerve fibres.

Most older people experience regional taste deficits in the mouth. However, what is perceived as a taste defect (gustatory dysfunction) is often a primary defect in olfaction – although some studies suggest that age-related changes in the taste cell membranes diminish the sense of taste (Seiberling and Conley, 2004).

The gradual reduction in smell and taste, and therefore in appetite, leads to diminished food intake, possibly resulting in weight loss and malnutrition, while the inability to taste and enjoy food can lead to anxiety. The ability to taste salt also diminishes (Mauk, 2010) and may lead to increased consumption of salt-rich meals, which can aggravate health conditions such as hypertension. Older people should be encouraged to use herbs or mild spices in their dishes, rather than salt, if they need to add flavour.

### The mouth

The lips, tongue, salivary glands and teeth all play a role in chewing, breaking down

and swallowing food. Age-related shrinkage of the maxillary and mandibular bones and reduction in bone calcium content cause a slow erosion of the tooth sockets, leading to gum recession and an increased risk of root decay (Pradeep et al, 2012). People without teeth (edentulous) or who have poorly fitting dentures may find chewing difficult and, therefore, eat less and become malnourished. Alternatively they may choose highly refined, easy-to-chew foods, thereby consuming less dietary fibre; this will affect their bowel function, and may cause problems such as constipation.

A dry mouth (xerostomia) is common among older people; Smith et al (2013) showed that healthy subjects aged 70 years and over produced less saliva than younger people. However, while the number of tongue acinar (saliva-producing) cells decreases with age, there is conflicting evidence as to whether the volume of saliva produced also decreases. Xerostomia can be an adverse effect of medication or can result from diseases such as diabetes. Although it is common among older

people generally, it is more likely to occur in those who are taking more than four prescription drugs per day (Yellowitz and Schneiderman, 2014). Drug categories that may cause xerostomia include:

- Diuretics;
- Antihypertensives;
- Antibiotics;
- Bronchodilators;
- Certain antidepressants.

### Swallowing

Having formed a bolus of food, the mouth prepares to swallow. The bolus reaches the posterior pharyngeal wall and the musculature contracts around it; swallowing occurs and food travels through the upper oesophageal sphincter into the oesophagus. With age, the muscular contractions that initiate swallowing slow down, increasing pharyngeal transit time (Nikhil et al, 2014). This may lead to swallowing difficulties (dysphagia), which can increase the risk of choking and the feeling that food is stuck in the throat. Up to 26.7% of people aged 76 years and over experience dysphagia (Baijens et al, 2016).

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### The oesophagus

In general, the motor function of the GI tract is relatively well preserved in healthy older people, but there are significant changes in oropharyngeal and oesophageal motility. In the very old, impaired oesophageal motility is common; oesophageal peristalsis weakens with age (Gutschow et al, 2011) and peristalsis may no longer be triggered by each swallow. Both upper and lower oesophageal sphincters lose tension; the lower one in particular undergoes a reduction in pressure, resulting in problems such as dysphagia, reflux and heartburn (Grassi et al, 2011). In addition, the gag reflex is absent in 43% of older people (Davies et al, 1995).

### The stomach

The stomach acts as a reservoir for food, allowing us to eat at regular intervals. With age, it cannot accommodate as much food, primarily because its wall loses elasticity.

As a normal part of digestion, the stomach secretes gastric juice containing hydrochloric acid and pepsin. Although, in general, older and younger people produce gastric acid at a similar rate (Merchant et al, 2016), acid hyposecretion occurs in 10-20% of older people versus <1% of younger subjects (Gidal, 2007). This can compromise the bioavailability of certain drugs, including vitamin B<sub>12</sub>, and lead to disorders such as chronic atrophic gastritis.

There is also an age-related reduction in mucus-producing goblet cells, which results in reduced secretion of protective mucus and therefore a weakened mucosal barrier. Consequently the stomach's lining becomes more prone to damage (Saber and Bayumi, 2016).

Gastric bicarbonate (HCO<sub>3</sub><sup>-</sup>) and mucus normally provide an alkaline layer to defend the stomach lining against gastric juices; however, research suggests that advancing age is associated with a decline in HCO<sub>3</sub><sup>-</sup> secretion (Saber and Bayumi, 2016). The protective prostaglandin content of mucus also decreases with age, making older people more prone to gastromucosal injury such as lesions and ulcers, especially after ingesting non-steroidal anti-inflammatory drugs, which are commonly taken by older people. However, proton pump inhibitors (PPIs), which suppress acid production, are often prescribed alongside NSAIDs (Fujimori, 2015).

Finally, gastric emptying slows down with age; this means food remains in the stomach for longer, prolonging satiation and reducing appetite (Nieuwenhuizen et al, 2010).

**Table 1. Age-related changes in appetite hormones**

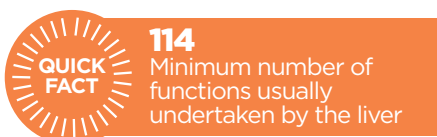
| Hormone                         | Produced by  | Function            | Change with age   |
|---------------------------------|--|---------------------|---|
| Ghrelin                         | Stomach in response to fasting                             | Increases appetite  | Secretion decreases (Di Francesco et al, 2008)                                |
| Peptide tyrosine tyrosine (PYY) | Ileum and colon in response to food intake                 | Suppresses appetite | Levels increase (Hickson et al, 2016)   |
| Cholecystokinin (CCK)           | Small intestine in response to presence of fat and protein | Suppresses appetite | Secretion increases (de Boer et al, 2013) and responsiveness to it increases  |
| Insulin                         | Pancreas in response to high blood glucose                 | Suppresses appetite | Production decreases, effect declines (Gong and Muzumdar, 2012)               |
| Leptin                          | Adipose tissue (secretion linked to body mass index)       | Inhibits hunger     | Levels are believed to rise (de Boer et al, 2012) but evidence is conflicting |

Source: Adapted from Pilgrim et al (2015)

### The small intestine

The main function of the small intestine is to digest and absorb food. It produces a range of digestive enzymes, supported by the pancreas and liver.

Absorption of nutrients occurs in the jejunum and ileum, the second and third regions of the small intestine. The lining of the small intestine is shaped into microscopic folds (villi), which increase the surface area available for absorption. Although an age-related reduction in villus height has been shown, the impact on nutrient uptake does not seem to be clinically significant (Drozdowski and Thomson, 2006).



There is evidence that the production of the enzyme lactase decreases with age, making older people more prone to lactose intolerance (Di Stefano et al, 2001); lactase is created following instruction from the LCT gene, which becomes less active over time.

Populations of certain bacteria that reside in the small intestine have been shown to increase as we age, leading to bloating, pain and decreased absorption of nutrients such as calcium, folic acid and iron. This can have a negative effect on health. In addition, PPIs have been shown to provoke bacterial overgrowth in the small intestine, which may exacerbate NSAID-induced small intestinal injury and

foster the development of systemic conditions, including inflammatory bowel disease, diabetes and autoimmune diseases (Fujimori, 2015).

Peyer's patches – small nodules of lymphatic tissue that form part of the gut's immune defence system – monitor populations of intestinal bacteria to prevent the growth of pathogens. However, there is a gradual reduction in the number of Peyer's patches in the small intestine, accompanied by a gradual loss of lymphoid follicles (Merchant et al, 2016); this can result in an uncontrolled growth of resident micro-flora.

### The large intestine

As already mentioned, oesophageal peristalsis slows with age, but research has recently shown that small intestinal transit time does not seem to be affected (Fischer and Fadda, 2016). In contrast, there is an age-related slowing down of colonic transit caused by a decline in propulsive activity of the colon, which is associated with a reduction in neurotransmitters and neuroreceptors (Britton and McLaughlin, 2013). This causes a delay in colonic transit of waste, leading to constipation (Wiskur and Greenwood-Van Meerveld, 2010).

Peristalsis is also affected by the age-related atrophy of the mucosa and muscle layers of the colon. The walls of the colon sag, prompting the formation of pouches (diverticuli). Straining to eliminate faeces may put additional pressure on weakened blood vessel walls, giving rise to haemorrhoids.



The rate of cell division declines in the digestive epithelium, which cannot repair and replace itself as well as it needs to. There is also a drastic age-associated rise in the incidence of several gut pathologies including cancer of the colon – in fact, age is the key risk factor for colorectal cancer. Recent studies indicate that ageing induces changes in the DNA of epithelial intestinal cells, particularly in the colon; this process – known as DNA methylation – is believed to play a significant part in the development of colorectal cancers (Masoro and Austad, 2010).

### Gut microbes

Changes in the populations of gut microbes lead to an increase in facultative anaerobes – including streptococcus, staphylococcus, enterococcus and enterobacteriaceae – which are able to thrive in inflamed conditions (Pédron and Sansonetti, 2008). The ageing process mimics the intestinal microbe profile that accompanies inflammatory bowel diseases and obesity (Neish, 2009).

The commensal micro-organisms inhabiting the lumen of the colon are prevented from entering surrounding tissues by a single layer of epithelial cells that form an impermeable mucosal barrier. This barrier becomes 'leaky' with age (Mabbott, 2015). As the barrier function of the mucosal immune system is impaired, the incidence of GI pathogen infections is higher – and is a major cause of morbidity and mortality in older people (Mabbott et al, 2015). This group is also at increased risk of infection with *Clostridium difficile*, which causes a potentially fatal dehydrating diarrhoea for which the two major risk factors are age of ≥65 years and exposure to antimicrobials (Jump, 2013).

### The accessory organs

With age, the pancreas – which generates four major digestive enzymes – decreases in weight and some of its tissue undergoes fibrosis. Its exocrine function is impaired and the secretion of chymotrypsin and pancreatic lipase reduced (Laugier et al, 1991), adversely affecting the ability of the small intestine to digest food.

The liver undertakes more than 114 functions for the body; as it shrinks with age and blood flow to it decreases, its functional capacity also decreases (Drozdowski and Thomson, 2006). There is a decrease in the rate of protein synthesis and of metabolism, the liver's ability to detoxify many substances, as well as the production and flow of bile (involved in fat emulsification). In addition, bile becomes

thicker and its salt content diminishes, resulting in higher plasma concentrations of cholesterol, particularly in women (Frommherz et al, 2016). Drugs are no longer inactivated quickly by the liver and are therefore more likely to cause dose-related side-effects: dosages therefore need to be carefully checked when prescribing for older people. **NT**

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## Anatomy and physiology of ageing – updated series

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