Varastegan
Institute for Medical Sciences

Digestion, Absorption, Transport, and Excretion of Nutrients

(Session 5)

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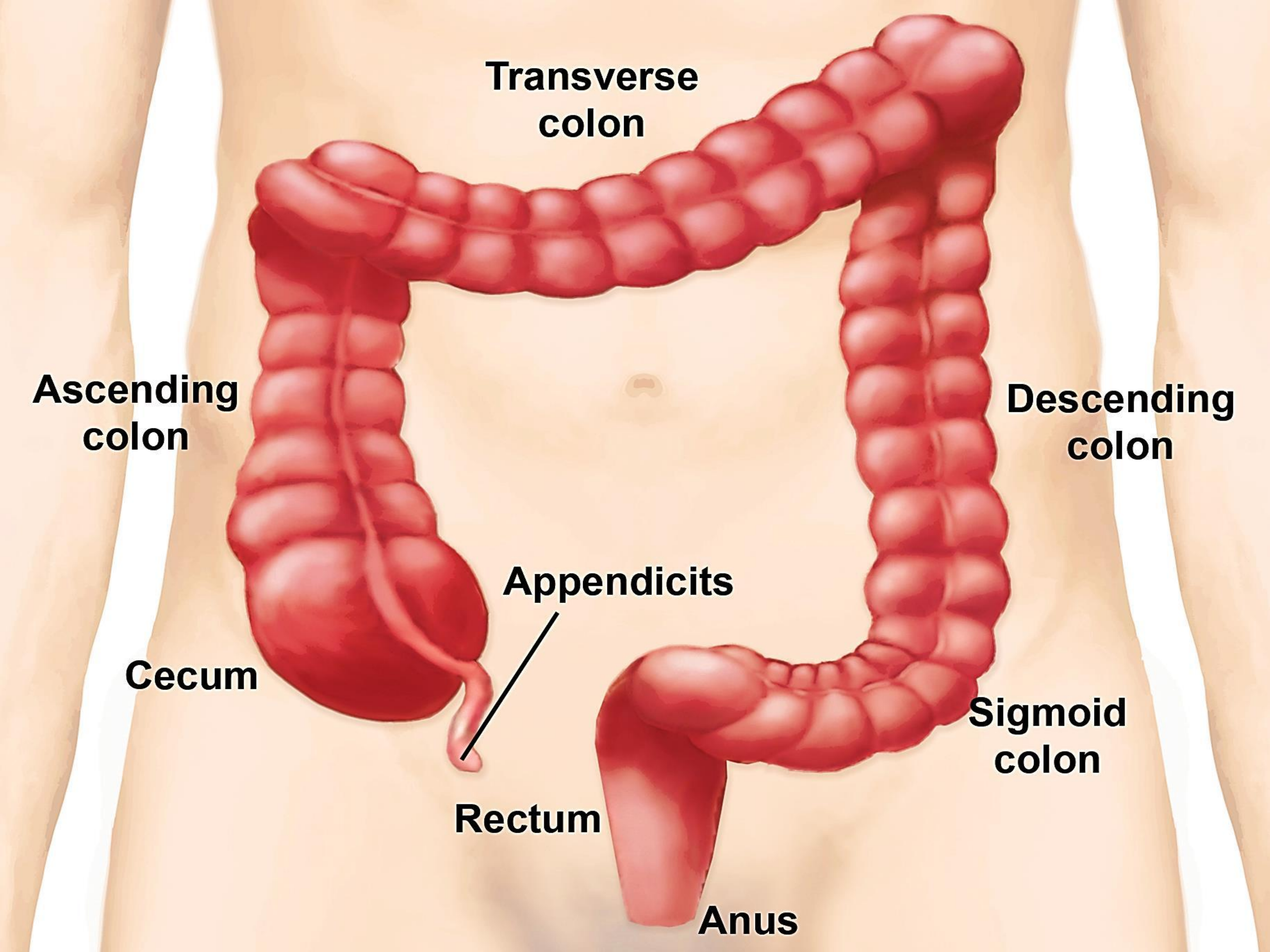
The Large Intestine

The large intestine is approximately 1.5 m long and consists of the cecum, colon, and rectum.

Mucus secreted by its mucosa protects the intestinal wall and provides the medium for binding the feces together.

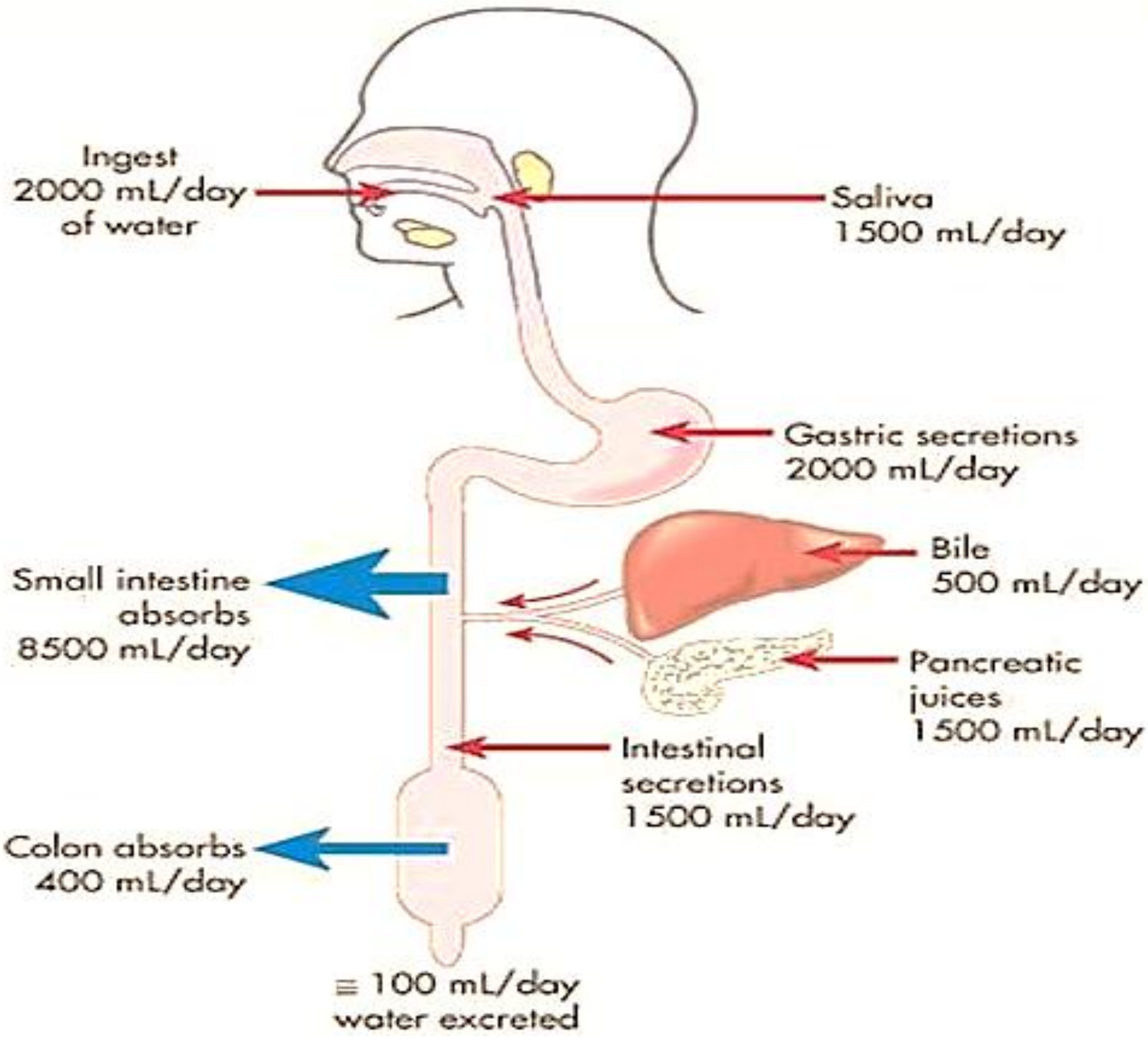
Bicarbonate ions secreted in exchange for absorbed chloride ions help to neutralize the acidic end products produced from bacterial action.


Transverse
colon
Ascending
colon
Descending
colon
Appendicits
Cecum
Sigmoid
colon
Rectum
Anus

Approximately 2 L of fluids are taken in food and beverages during the day, and 7 to 9 L of fluid is secreted along the GIT.

Under normal circumstances, most of that fluid is absorbed in the small intestine and **approximately 1 to 1.5 L of fluid enters the large intestine**.

Only approximately 100 mL remain to be excreted in the feces.


Ingest
2000 mL/day
of water
Saliva
1500 mL/day
Gastric secretions
2000 mL/day
Bile
500 mL/day
Small intestine
absorbs
8500 mL/day
Pancreatic
juices
1500 mL/day
Intestinal
secretions
1500 mL/day
Colon absorbs
400 mL/day
≡ 100 mL/day
water excreted

The large intestine is also the site of bacterial fermentation of remaining carbohydrates and amino acids, synthesis of a small amount of vitamins, and storage and excretion of fecal residues.

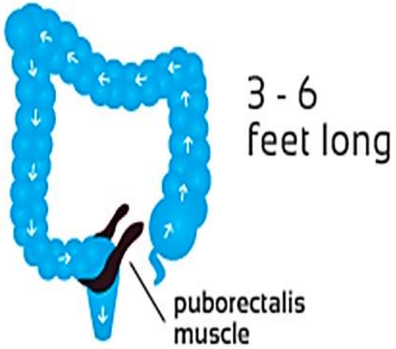
Colonic contents move forward slowly at a rate of 5 cm/h.

Defecation, occurs with varying frequency, ranging from three times daily to once every 3 or more days.

we are designed to squat to eliminate

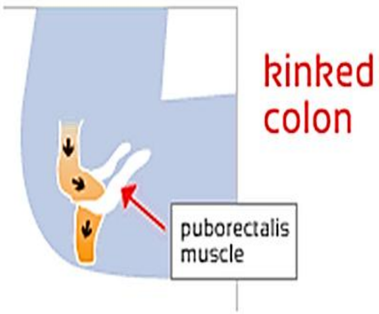
Humans have squatted for millennia – until the advent of the modern toilet.

this is your colon



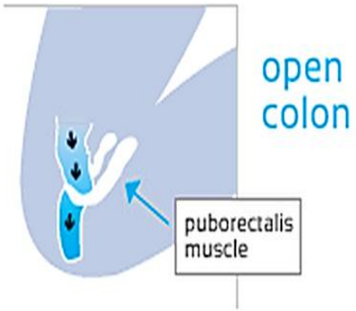
The colon moves waste to the rectum for elimination. It has a natural kink that maintains continence.

sitting stops the flow



The puborectalis muscle partially relaxes, keeping the colon kinked and blocking the flow of waste.

squatty potty opens the colon



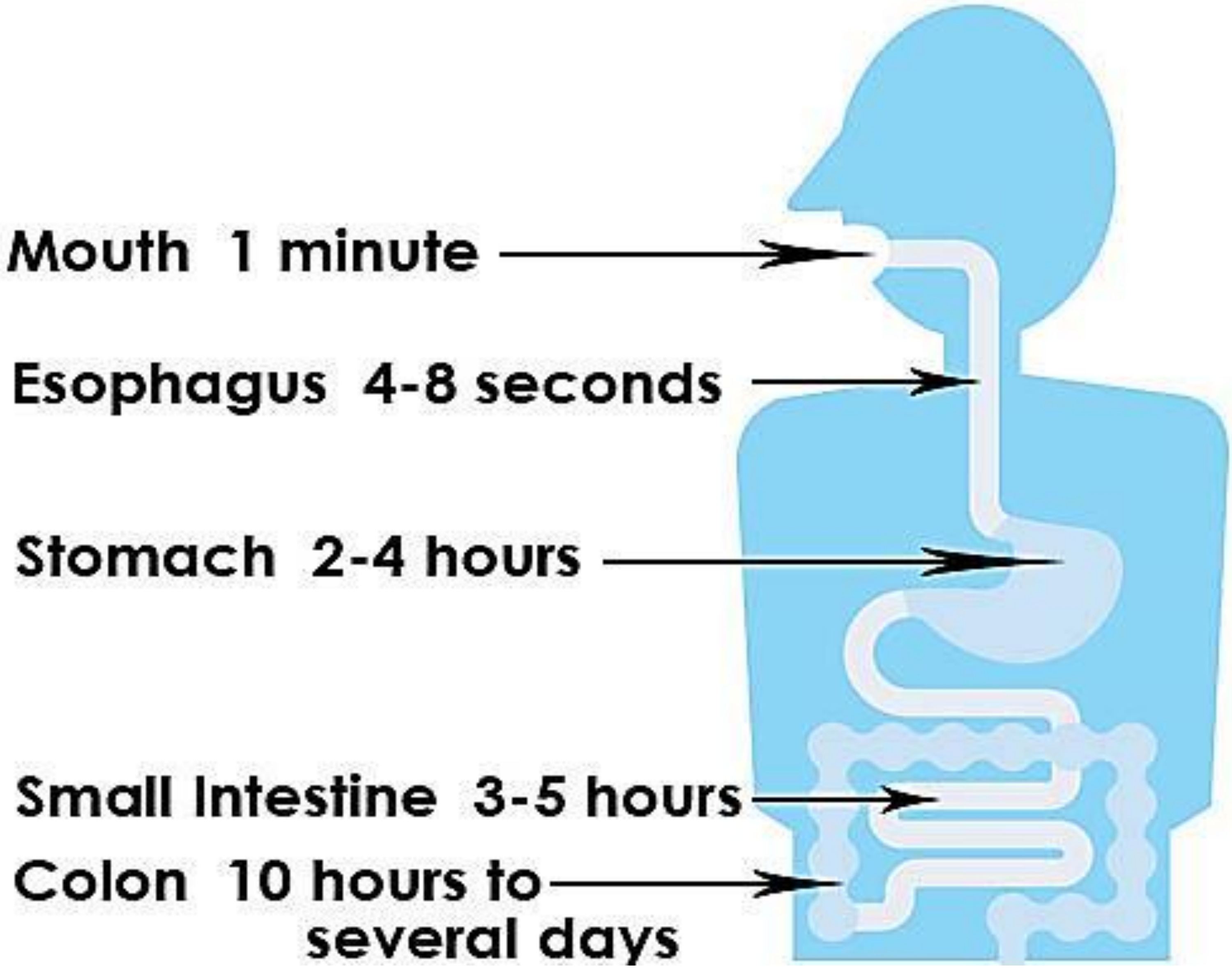
The puborectalis muscle fully relaxes allowing the colon to empty quickly and completely.

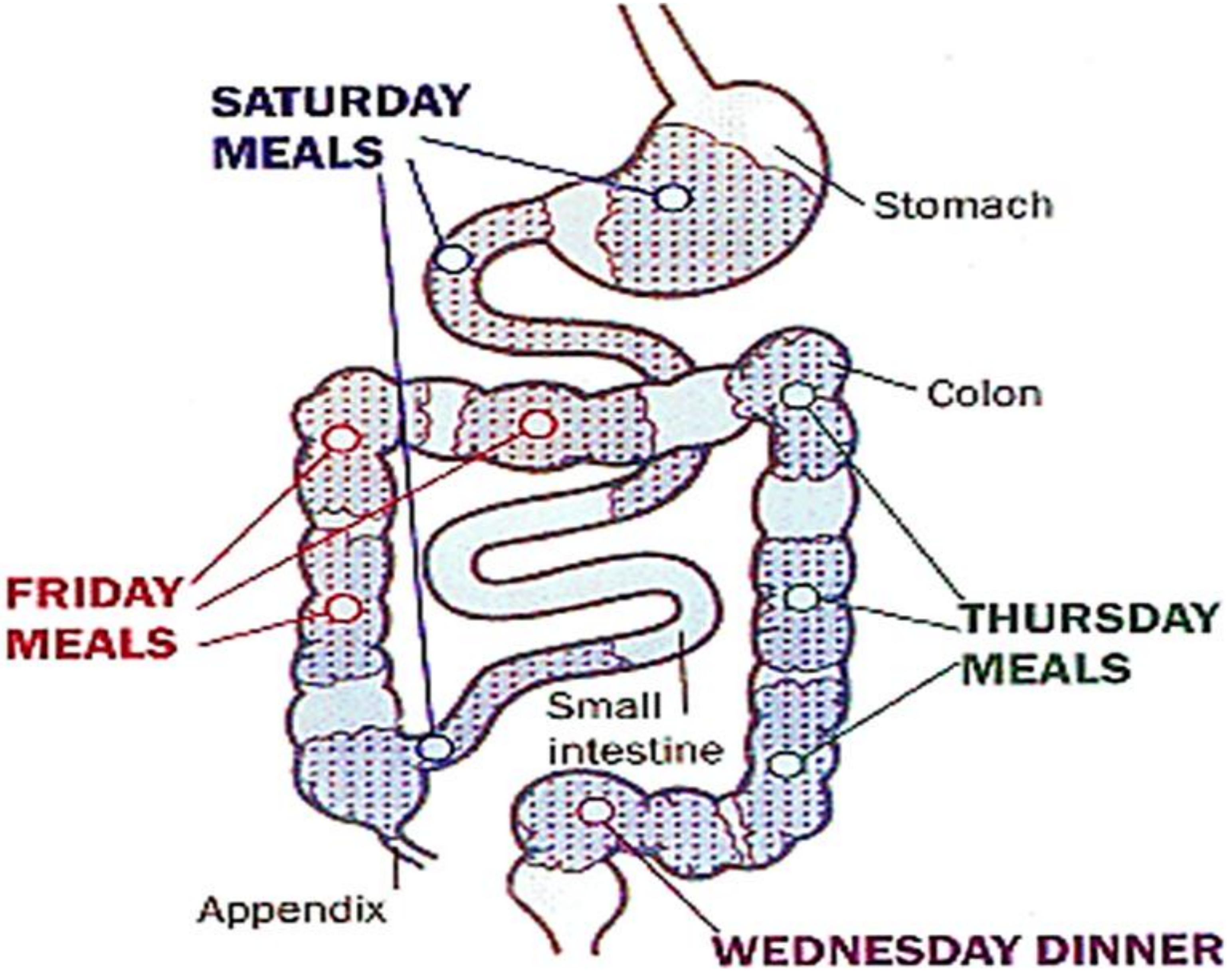
Average stool weight is in the range of 100 to 200 g, and **mouth-to-anus transit time may vary from 18 to 72 hours**.

The feces generally consist of 75% water and 25% solids.

Approximately two thirds of the contents of the wet weight of the stool is bacteria, with the remainder coming from GI secretions, mucus, sloughed cells, and undigested foods.

A diet abundant in fruits, vegetables, legumes, and whole grains results in a shorter overall GI transit time, more frequent defecation, and larger and softer stools.


Mouth 1 minute
Esophagus 4-8 seconds
Stomach 2-4 hours
Small Intestine 3-5 hours
Colon 10 hours to
several days


SATURDAY MEALS
Stomach
Colon
FRIDAY MEALS
THURSDAY MEALS
Small intestine
Appendix
WEDNESDAY DINNER

Bacterial Action

At birth, the GIT is sterile, but Lactobacillus organisms soon become the chief component of the GIT flora until an infant begins to eat solid foods, which in turn leads to the predominance of Escherichia coli in the distal ileum.

The primary colonic flora are anaerobic, with species of the genus Bacteroides occurring most frequently.

Lactobacilli are also present in the stools of most people who consume an ordinary mixed diet; but differences in the host's genome, dietary intake, hygiene, and medical and surgical history affect the kind of flora in the GIT.

TABLE 1-4

Most Common Microbes Colonizing the Gastrointestinal Tract

Bacteria	Lactobacilli	Fungi
Acinetobacter	*Peptostreptococcus*	*Candida*
Bacteroides	*Porphyromonas*	
Bifidobacterium	*Prevotella*	*Parasites*
Clostridium	*Propionibacterium*	*Blastocystis*
Corynebacterium	*Pseudomonas*	*Endolimax*
Eubacterium	*Staphylococcus*	*Entamoeba coli*
Enterobacteriaceae	*Streptococcus* A, B, C, F, G	*E. hartmanni*
Enterococcus	*Streptococcus bovis*	*E. polecki*
Fusobacterium	*Streptococcus*	*Iodamoeba*
Helicobacter	*Veillonella*	*Trichomonas hominis*

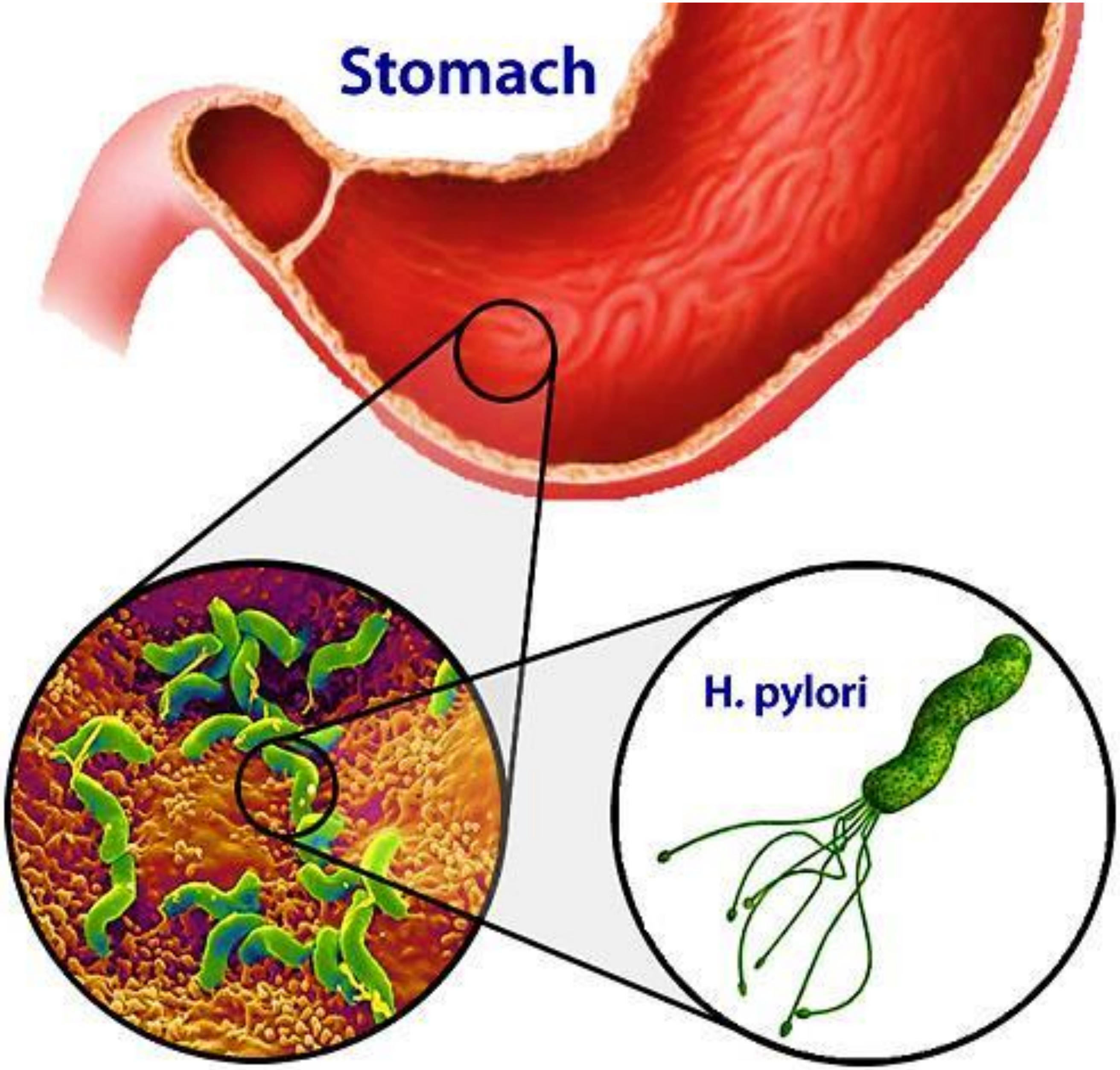
INTESTINAL MICROFLORA

10^{14} micro-organisms, >500 differentes species

Normally, few bacteria remain in the stomach or small intestine after meals because bile, hydrochloric acid (HCl), and pepsin work as germicides.

However, decreased gastric secretions can increase the risk of inflammation of the gastric mucosa (gastritis), increase the risk of bacterial overgrowth in the small intestine, or increase the numbers of microbes reaching the colon.

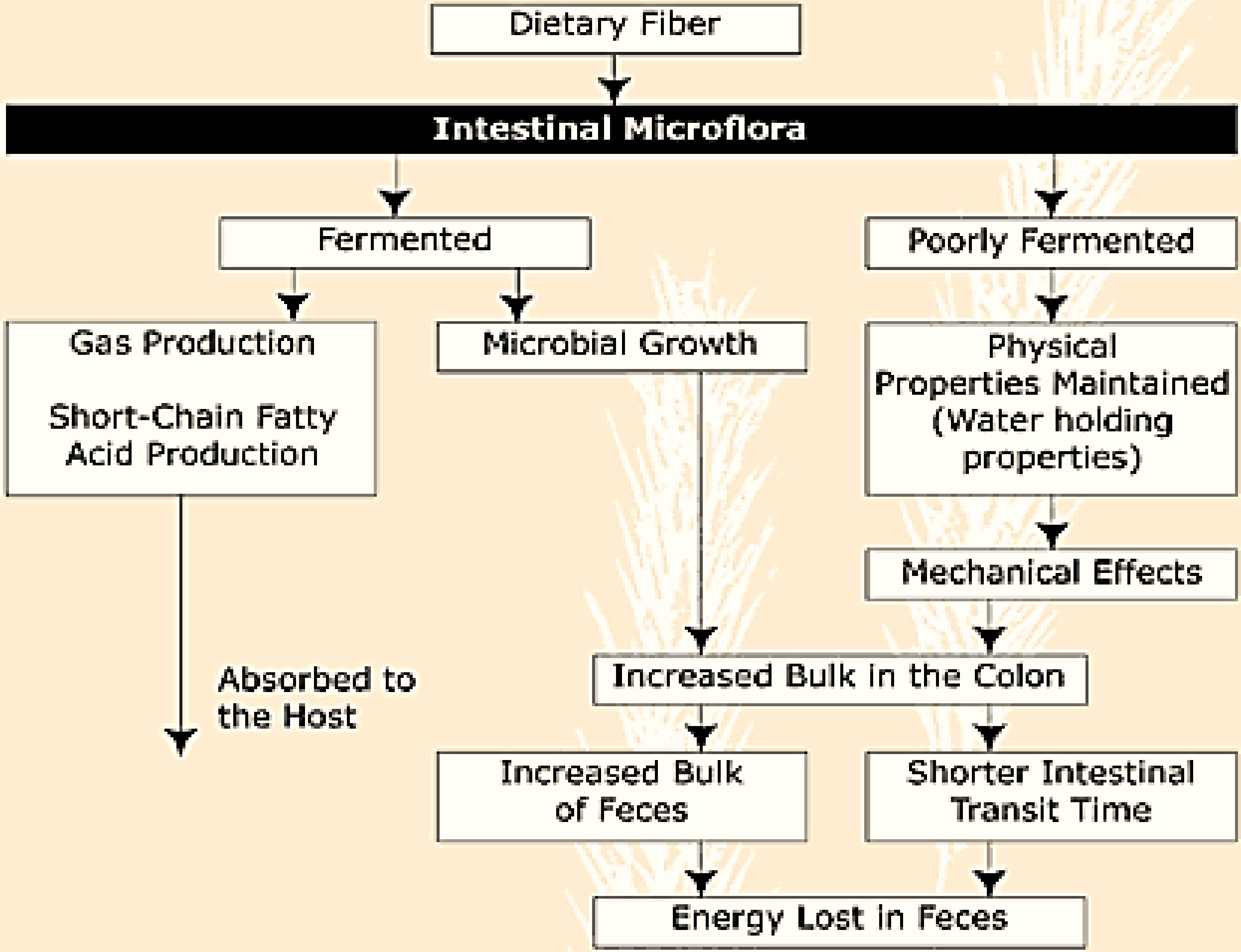
Intrestingly, an acid-tolerant bacterium is known to infect the stomach (Helicobacter pylori) and may cause gastritis and ulceration in the host.


Stomach
H. pylori

Bacterial action is most intense in the large intestine.

Following a meal, dietary fiber, resistant starches, remaining bits of amino acids, and mucus sloughed from the intestine are fermented in the colon.

Colonic bacteria contribute to the formation of gases (e.g. hydrogen, carbon dioxide, nitrogen, and in some individuals methane) **and SCFAs** (e.g. acetic, propionic, butyric, and some lactic acids).


Dietary Fiber
Intestinal Microflora
Fermented
Poorly Fermented
Gas Production
Short-Chain Fatty Acid Production
Microbial Growth
Physical Properties Maintained (Water holding properties)
Mechanical Effects
Absorbed to the Host
Increased Bulk in the Colon
Increased Bulk of Feces
Shorter Intestinal Transit Time
Energy Lost in Feces

Colonic bacteria continue the digestion of some materials that have resisted digestion, and during this process several nutrients (e.g. vitamin K, vitamin B_{12}, thiamin, and riboflavin) are formed by bacterial synthesis.

These nutrients usually contribute little to meeting the nutrient requirements of the human host.

Increased consumption of prebiotic material leads to an increase in SCFAs and in the microbial mass of beneficial indigenous bacterial species such as Bifidobacteria and Lactobacilli.

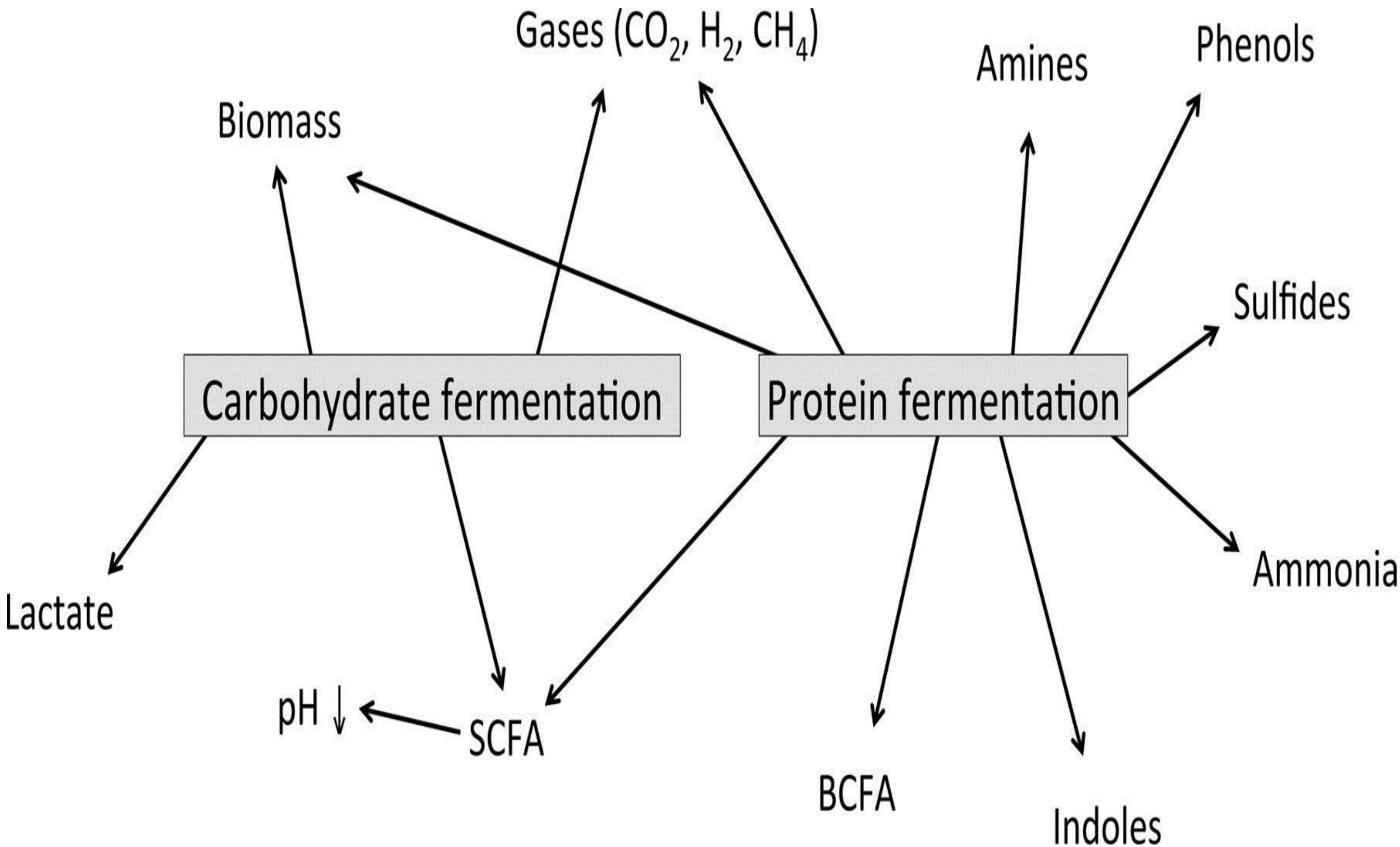
Prebiotic carbohydrates typically refer to oligosaccharides from vegetables, grains, and legumes.

Chicory, Jerusalem artichokes, soybeans, and wheat bran are the best dietary sources of prebiotics.


tomatoes
artichokes
onions
garlic
chicory
dandelion greens
asparagus
leeks
Foods Naturally High in Prebiotics
berries
bananas
flax seed
legumes

Bacterial action also may result in the formation of potentially toxic substances such as ammonia, indoles, amines, and phenolic compounds such as indolacetate, tyramine, histamine, and cresol.

Some of the gases and organic acids produced by bacterial action contribute to the odor of feces.


Gases (CO_2, H_2, CH_4)
Amines
Phenols
Biomass
Sulfides
Carbohydrate fermentation
Protein fermentation
Ammonia
Lactate
pH ↓
SCFA
BCFA
Indoles

Interactions among the host immune system, host genome, diet, and GI microflora may be linked with several infectious and inflammatory bowel diseases, allergies, immune disorders, metabolic disorders, and neoplasms.

This fact has led to the increasing attention being given to the therapeutic potential of probiotic, prebiotic, and synbiotic products as antibiotics and antiinflammatory or immunosuppressive agents.

Probiotics are foods or concentrates of live organisms that contribute to a healthy microbial environment and suppress potential harmful microbes.

Prebiotics are oligosaccharide components of the diet (e.g. fructo-oligosaccharides, inulin) that are the preferred energy substrates of "friendly" microbes in the GIT.

Synbiotics are a combination of probiotics and prebiotics.

TABLE 38.1	DESIRED CHARACTERISTICS OF PROBIOTICS AND PREBIOTICS
Probiotics	Beneficial effect when consumed Lack of pathogenicity and toxicity Large numbers of viable cells Ability to survive and metabolize in the gut Retained viability during storage and use If incorporated into a food, good sensory qualities
Prebiotics	Resistance to gastric acidity and hydrolysis by mammalian enzymes and gastrointestinal absorption Ability to be fermented by intestinal microflora Selective stimulation of growth and/or activity of intestinal bacteria associated with health and well-being

- Synbiotics are made of long-chain, inulin-type fructans as compared with short-chain derivatives.

- These fructans, extracted from chicory roots, are prebiotic food ingredients that are fermented to lactic acid and SCFAs in the gut lumen.

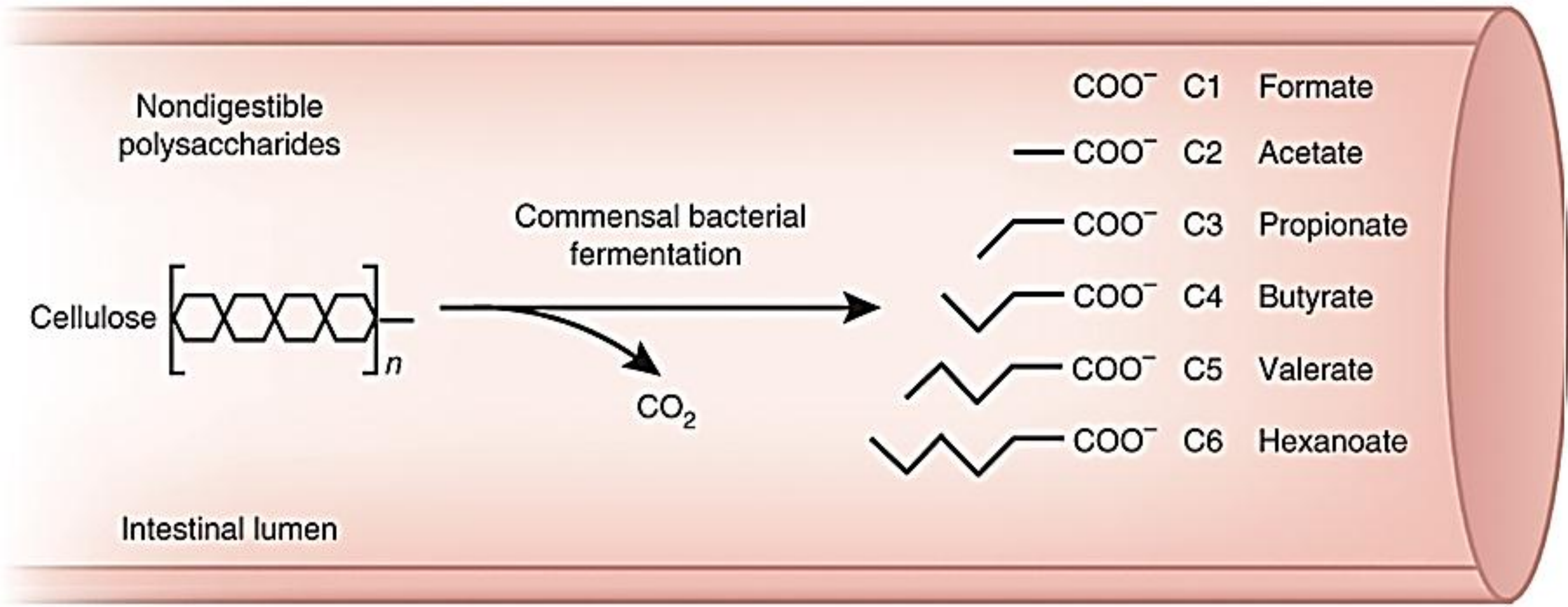
- Synbiotics may be useful for early prevention or treatment of allergic disease.

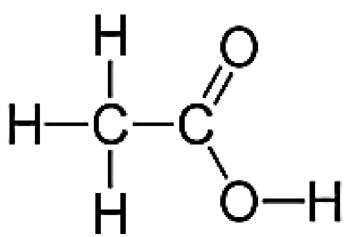
Colonic Salvage of Malabsorbed Energy Sources and Short-Chain Fatty Acids

Normally, varying amounts of small-molecular-weight carbohydrates and amino acids reach the colon.

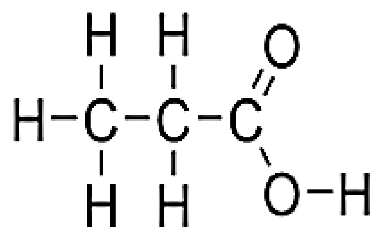
Accumulation of these molecules could become osmotically important if it was not for the action of colonic bacteria.

The disposal of residual substrates through production of SCFAs is called colonic salvage.

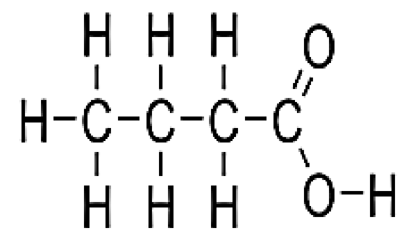




Acetic acid (acetate)



Propionic acid (propionate)



Butyric acid (butyrate)

Colonic production of short-chain fatty acids (i.e. colonic salvage)

SCFAs produced in fermentation are rapidly absorbed and serve as fuel for the colonocytes and gut microbes, stimulate colonocyte proliferation and differentiation, enhance the absorption of electrolytes and water, and reduce the osmotic load of malabsorbed sugars.

SCFAs also help slow the movement of GI contents and participate in several other regulatory functions.

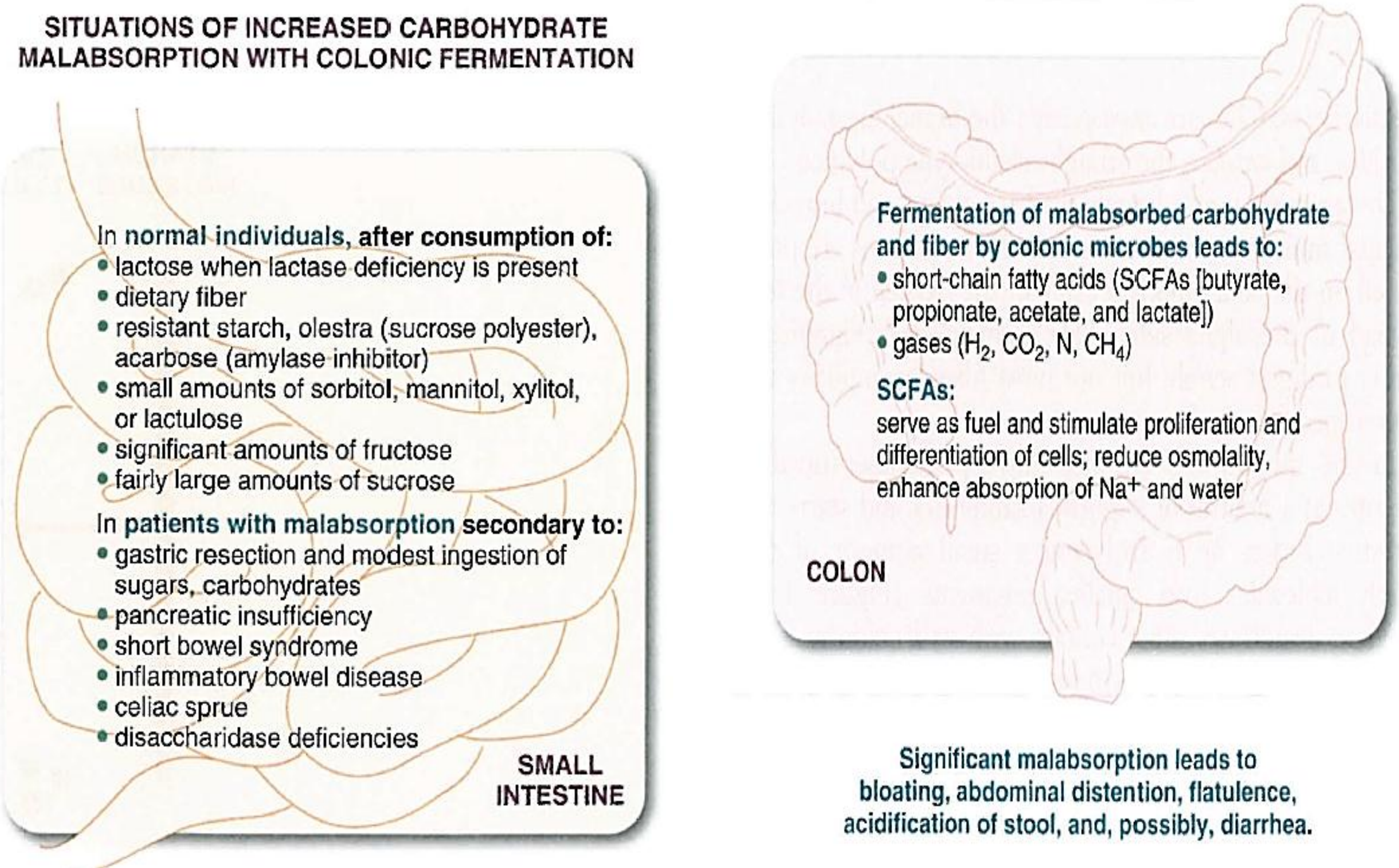


FIGURE 1-6 Colonic fermentation of malabsorbed carbohydrates and fiber.

In humans, colonic fermentation only disposes of 20 to 25 g of carbohydrate over 24 hours.

Excess amounts of carbohydrate and fermentable fiber in the colon can cause increased gas production, abdominal distention, bloating, pain, increased flatulence, decreased colonic pH, or even diarrhea.

However, over time, adaptation occurs in individuals consuming diets high in fiber.

Thus, consumption of 24-38 g/d of dietary fiber from fruits, vegetables, legumes, and whole grains is recommended for:

(1) Maintaining the health of the cells lining the colon

(2) Preventing excessive intracolonic pressure

(3) Preventing constipation

(4) Maintaining a stable and healthful microbial population

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2- Murray RK, Bender DA, Botham KM, Kennelly PJ, Rodwell VW, Weil PA, editors. Harper's Illustrated Biochemistry. 28th ed. USA: McGraw-Hill; 2009.

3- Ross AC, Caballero B, Cousins RJ, Tucker KL, Ziegler TR, editors. Modern Nutrition in Health and Disease. 11th ed. USA: Lippincott Williams & Wilkins; 2014.

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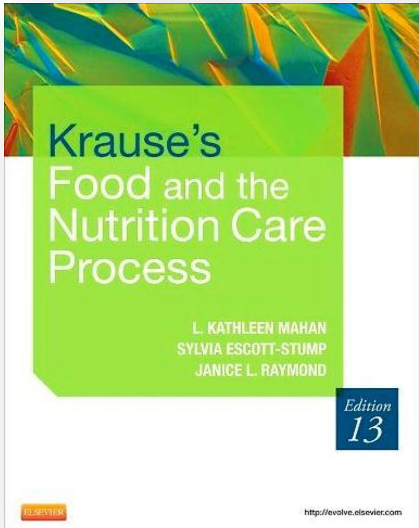

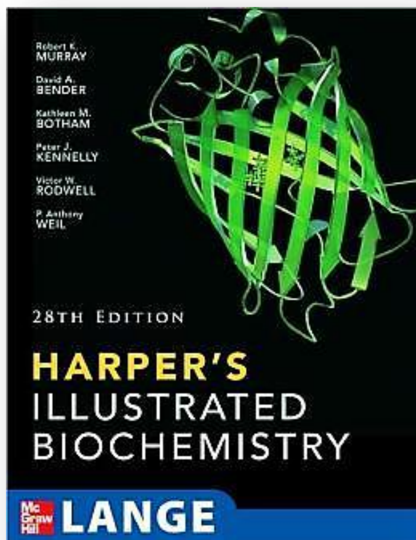

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