

## UNIT IV BIOCHEMISTRY OF DIGESTION 2

### OBJECTIVE:

1. Explain the chemical reactions involved in the process of digestion.
2. Analyze certain basic biochemical processes to explain commonly occurring health-related problems in digestion
3. Discuss the digestion of complex biomolecules in the body;

### TOPICS

<p>Unit 4: BIOCHEMISTRY OF DIGESTION</p> <ol style="list-style-type: none"> <li>1. Definition and factors affecting Digestion</li> <li>2. Phases of Digestion               <ol style="list-style-type: none"> <li>a. Salivary Digestion</li> <li>b. Gastric Digestion</li> <li>c. Intestinal Digestion</li> <li>d. Pancreatic Juice</li> <li>e. Intestinal Juice</li> <li>f. Bile</li> </ol> </li> </ol>	<ol style="list-style-type: none"> <li>3. Chemical changes in the large intestines and feces               <ol style="list-style-type: none"> <li>a. Fermentation</li> <li>b. Putrefaction</li> <li>c. Deamination</li> <li>d. Decarboxylation</li> <li>e. Detoxification</li> </ol> </li> <li>4. Feces and its Chemical Composition</li> </ol>
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### CHEMICAL CHANGES IN THE LARGE INTESTINE AND FECES, CHEMICAL COMPOSITION OF FECES

The **large intestine**, also known as colon or the **large bowel**, is the last part of the gastrointestinal tract and of the digestive system in vertebrates. The digestive tract includes the mouth, esophagus, stomach, small intestine, large intestine and the rectum.

There are 4 major functions of the large intestine:

1. recovery of water and electrolytes (Na, Cl etc)
2. formation and temporary storage of feces
3. maintaining a resident population of over 500 species of bacteria
3. fermentation of some of the indigestible food matter by bacteria.

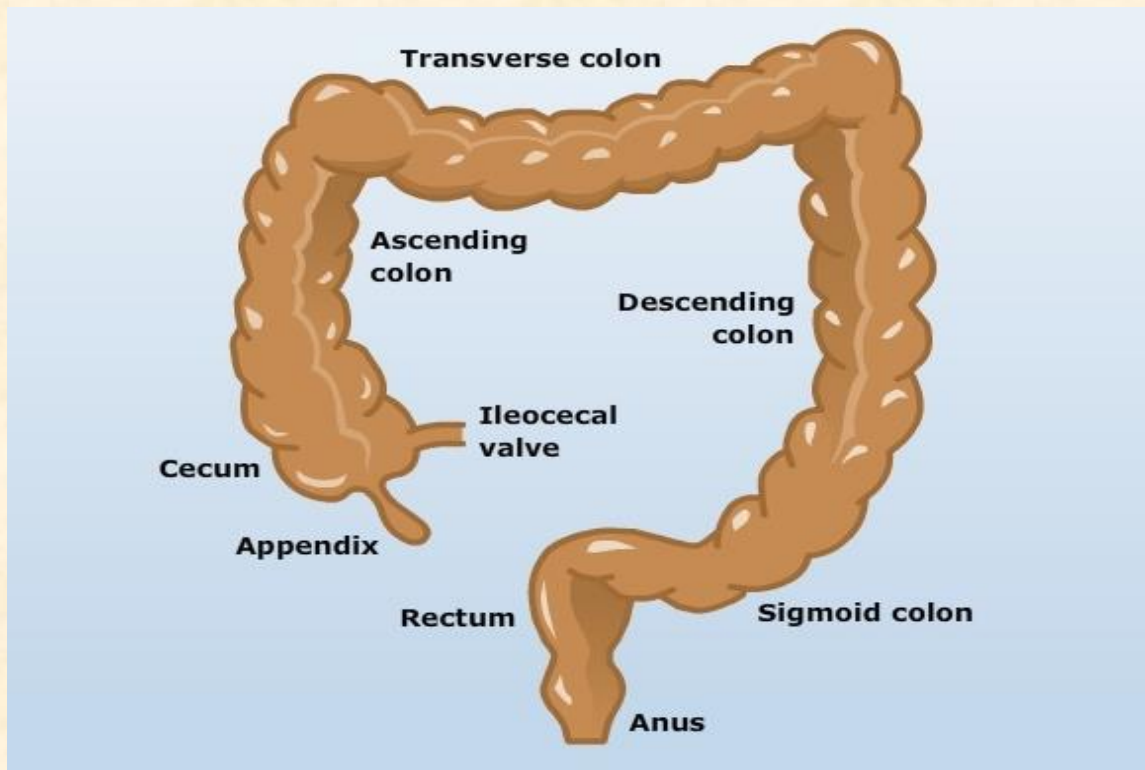
By the time partially digested foodstuffs reach the end of the small intestine (ileum), about 80% of the water content will be absorbed by the large intestine. The colon absorbs most of the remaining water.

As the remnant food material moves through the colon, it is mixed with bacteria and mucus, and formed into feces for temporary storage before being eliminated by defecation

In humans, the large intestine begins in the right iliac region of the pelvis, just at or below the waist, where it is joined to the end of the small intestine at the cecum, via the ileocecal valve. It then continues as the

colon ascending the abdomen, across the width of the abdominal cavity as the transverse colon, and then descending to the rectum and its endpoint at the anal canal. Overall, in humans, the large intestine is about 1.5m(5 feet) long, which is about one-fifth of the whole length of the gastrointestinal tract

The large intestine consists of 4 main parts: caecum, colon, rectum and anal canal.



#### CHEMICAL CHANGES IN THE LARGE INTESTINES AND FECES

**FERMENTATION** Is a metabolic process that produces chemical changes in organic substrates through the action of enzymes. In biochemistry, it is narrowly defined as the extraction of energy from carbohydrates in the absence of oxygen.

#### PUTREFACTION

Is the decomposition of organic matter, especially protein, by microorganisms, resulting in production of foul-smelling matter.

#### DEAMINATION

It is the removal of an amine (amino) group from a molecule. Deamination is the process by which amino acids are broken down if there is an excess of protein intake. The amino group is removed from the amino acid and converted to ammonia.

Typically, in humans, deamination occurs when an excess in protein is consumed, resulting in the removal of an amine group, which is then converted into ammonia and expelled via urination, followed by the **release of energy** from the remainder of the amino acid. This deamination process allows the body to convert excess amino acid into usable by-products. Although deamination occurs throughout the human body, it is most common in the liver and to a lesser extent in the kidneys.

#### DECARBOXYLATION

It is a chemical reaction that removes a carboxyl group and releases carbon dioxide. Usually, decarboxylation refers to a reaction of carboxylic acids, removing a carbon atom from a carbon chain. The removal or loss of a carboxyl group from an organic compound, as amino acid, usually resulting in the formation of carbon dioxide.

#### DETOXIFICATION

Detoxification or detoxication is the physiological or medicinal removal of toxic substances from a living organism, including the human body, which is mainly carried out by the liver. The metabolic process by which toxins are changed into less toxic or more readily excretable substances or the act of detoxifying. Detoxification means cleansing the blood. This is done by removing impurities from the blood in the liver, where toxins are processed for elimination. The body also eliminates toxins through the kidneys, intestines, lungs, lymphatic system and skin.

#### PHYSICAL AND CHEMICAL CHANGES THAT OCCURS THROUGHOUT THE DIGESTIVE SYSTEM

While mastication occurs, it's a physical change. The food is then moistened with saliva creating a soft mass called a bolus right after it is passed down the esophagus. This is a chemical change.

When the substance is passed down to the esophagus, it's still a physical change because the only changes that's happening is that the food is going down by the process of contractions that is caused by gravity.

When the substance lands on the stomach, many changes happen, First the substance is crushed and while this happens, hydrochloric and pancreatic acids jump on the food to dissolve it, it turns into a soapy liquid called chyme (pulpy acidic fluid that pass from the stomach onto the small intestine) and this is a chemical change

Pancreas-sends pancreatic juices into the small intestine.

Then the chyme goes to the small intestine through a sphincter that connects the small intestine and stomach. Then the carbohydrates, protein, fats, minerals, and vitamins are extracted, which is a chemical change. The nutrients are carried all over the circulatory system where they are dropped for cells that need them. This is a physical change because the nutrients remain the same. Waste is then collected from the cells and brought down to the small intestine where it is



passed down to the large intestine. Fat that has not been dissolved in the small intestine is then dissolved by bile (helps to absorb the fat that is left and then it is stored and concentrated in the gallbladder). This is a chemical change. The small intestine is joined with the large intestine throughout the lower part of the abdomen where the substance that couldn't be digested, turns into feces. This process is chemical change. Feces is achieved by absorbing the water, nutrients and salt of the remaining part of the chyme. Getting rid of residue (a small part of something huge), this is chemical change. Once the water is all absorbed, what's left is known as feces. Feces consists of none digested food. This is chemical change. Feces is then stored in the rectum after passing all over through the large intestine where it can be passed out through the buttocks completing the digestive system. This is physical change.

#### THE RECTUM AND THE ANUS

Once food has passed through the bowel the waste moves to the rectum which stretches, triggering a message to the brain to say that the rectum is full and needs to be emptied. The pelvic floor muscles ensure that the anus remains closed until the person is ready to open their bowels

The nerves can usually tell the brain whether it's wind or stool that is filling the rectum.

*In some neurological and spinal conditions, the brain cannot tell whether the bowel is full of waste (feces) or just wind. This can lead to accidental leakage.*

#### FOR THE BOWEL TO FUNCTION PROPERLY IT NEEDS:

- the nerves of the rectum and anus to be sending the correct messages to the brain so that it can sense when stool or wind arrives in the rectum and can transmit messages to the muscles to hold it in
- the internal and external anal sphincters to be working
- stools which are not too soft or too hard

#### NORMAL BOWEL FUNCTION

The frequency and consistency of bowel movements will vary from person to person. It averages between three times a day to three times a week, with the stool being soft and easy to pass. Stool consistency is usually measured using the Bristol Stool Chart and ideally should be between 3 and 4 to be regarded as normal

A good position on the toilet is when knees are higher than hips (unless recent hip surgery), leaning slightly forward and with the elbows on knees, relax and breath easily and do not strain.



### THE HUMAN FECES: CHEMICAL COMPOSITION Human feces/Stool

are the solid or semisolid remains of the food that could not be digested or absorbed in the small intestine of humans, but has been rotted down by bacteria in the large intestine. It also contains bacteria and a relatively small amount of metabolic waste products such as bacterially altered bilirubin, and the dead epithelial cells from the lining of the gut. It is discharged through the anus during a process called defecation

#### CHEMICAL COMPOSITION OF FECES

- $\frac{3}{4}$  Water,  $\frac{3}{4}$  solid
- Undigested and unabsorbed food
- Intestinal secretion, mucous
- Bile pigment and salts
- Bacteria and inorganic material
- Epithelial cells, leukocytes

Human feces have similarities to feces of other animals and vary significantly in appearance (i.e. size, color, texture), according to the state of the diet, digestive system and general health. Normally human feces are semisolid, with a mucus coating. Small pieces of harder, less moist feces can sometimes be seen impacted in the distal (final or lower) end. This is a normal occurrence when a prior bowel movement is incomplete, and feces are returned from the rectum to the large intestine, where water is absorbed.

In the medical literature, the term "**stool**" is more commonly used than "feces".








Human feces together with human urine are collectively referred to as human waste or human excreta. Containing human feces, and preventing spreading of pathogens from human feces via the fecal-oral route, are the main goals of sanitation.

The Bristol stool scale is a medical aid designed to classify the form of human feces into seven categories. Sometimes referred to in the UK as the Meyers Scale, it was developed by K.W. Heaton at the University of Bristol and was first published in the *Scandinavian Journal of Gastroenterology* in 1997. The form of

the stool depends on the time it spends in the colon. The seven types of stool are:

1. Separate hard lumps, like nuts (hard to pass)
2. Sausage-shaped but lumpy
3. Like a sausage but with cracks on the surface
4. Like a sausage or snake, smooth and soft
5. Soft blobs with clear-cut edges
6. Fluffy pieces with ragged edges, a mushy stool
7. Watery, no solid pieces. Entirely liquid

Types 1 and 2 indicate constipation. Types 3 and 4 are optimal, especially the latter, as these are the easiest to pass. Types 5–7 are associated with increasing tendency to diarrhea or urgency. Meconium is a newborn baby's first feces

<b>Bristol Stool Chart</b>	
Type 1	 Separate hard lumps, like nuts (hard to pass)
Type 2	 Sausage-shaped but lumpy
Type 3	 Like a sausage but with cracks on its surface
Type 4	 Like a sausage or snake, smooth and soft
Type 5	 Soft blobs with clear-cut edges (passed easily)
Type 6	 Fluffy pieces with ragged edges, a mushy stool
Type 7	 Watery, no solid pieces. <b>Entirely Liquid</b>



**COLOR**

Human fecal matter varies significantly in appearance, depending on diet and health

**1. Brown**

Human feces ordinarily has a light to dark brown coloration, which results from a combination of bile, and bilirubin derivatives of stercobilin and urobilin, from dead red blood cells. Normally it is semisolid, with a mucus coating.

**2. Yellow**

Yellowing of feces can be caused by an infection known as giardiasis, which derives its name from *Giardia*, an anaerobic flagellated protozoan parasite that can cause severe and communicable yellow diarrhea. Another cause of yellowing is a condition known as Gilbert's Syndrome. Yellow stool can also indicate that food is passing through the digestive tract relatively quickly. Yellow stool can be found in people with gastroesophageal reflux disease (GERD)

**3. Pale or Gray**

Stool that is pale or grey may be caused by insufficient bile output due to conditions such as cholecystitis, gallstones, giardia parasitic infection, hepatitis, chronic pancreatitis, or cirrhosis. Bile pigments from the liver give stool its brownish color. If there is decreased bile output, stool is much lighter in color.

**4. Black or Red**

Feces can be black due to the presence of red blood cells that have been in the intestines long enough to be broken down by digestive enzymes. This is known as melena, and is typically due to bleeding in the upper digestive tract, such as from a bleeding peptic ulcer.

Conditions that can also cause blood in the stool include hemorrhoids, anal fissures, diverticulitis, colon cancer, and ulcerative colitis. The same color change can be observed after consuming foods that contain a substantial proportion of animal blood, such as black pudding or *tiết canh*. Black feces can also be caused by a number of medications, such as bismuth subsalicylate (the active ingredient in Pepto-Bismol), and dietary iron supplements, or foods such as beetroot, black liquor ice, or blueberries

Hematochezia is similarly the passage of feces that are bright red due to the presence of undigested blood, either from lower in the digestive tract, or from a more active source in the upper digestive tract. Alcoholism can also provoke abnormalities in the path of blood throughout the body, including the passing of red-black stool. Hemorrhoids can also cause surface staining of red on stools, because as they leave the body the process can compress and burst hemorrhoids near the anus

**5. Blue**

Prussian blue, or blue, a coloring used in the treatment of radiation, cesium, and thallium poisoning, can turn the feces blue. Substantial consumption of products containing blue food dye, such as blue curaçao or grape soda, can have the same effect

**6. Silver**

A tarnished-silver or aluminum paint-like feces color characteristically results when biliary obstruction of any type (white stool) combines with gastrointestinal bleeding from any source (black stool). It can also suggest a carcinoma of

the ampulla of Vater, which will result in gastrointestinal bleeding and biliary obstruction, resulting in silver stool

#### 7. Green

Feces can be green due to having large amounts of unprocessed bile in the digestive tract and strong-smelling diarrhea. This can occasionally be the result from eating liquor ice candy, as it is typically made with anise oil rather than liquor ice herb and is predominantly sugar. Excessive sugar consumption or a sensitivity to anise oil may cause loose, green stools. It can also result from consuming excessive amounts of blue or green dye, such as were found in Burger King's Halloween Whopper

#### 8. Violet Purple

Violet or purple feces is a symptom of porphyria or more likely the consumption of beetroot

### **ODOR**

Feces possess physiological odor, which can vary according to diet and health status. For example, meat protein is rich in the amino acid methionine, which is a precursor of the sulfur-containing odorous compounds listed below. The odor of human feces is suggested to be made up from the following odorant volatiles

### **AVERAGE CHEMICAL CHARACTERISTICS**

On average humans eliminate 128 g of fresh feces per person per day with a Ph value of around 6.6. Fresh feces contain around 75% water and the remaining solid fraction is 84–93% organic solids

These organic solids consist of: 25–54% bacterial biomass, 2–25% protein or nitrogenous matter, 25% carbohydrate or undigested plant matter and 2–15% fat. Protein and fat come from the colon due to secretion, epithelial shedding and gut bacterial action. These proportions vary considerably depending on many factors such as mainly diet and body weight

The remaining solids are composed of calcium and iron phosphates, intestinal secretions, small amounts of dried epithelial cells, and mucus

The Fecal pH test for healthy humans is a pH of 6.6

### **UNDIGESTED FOOD REMNANTS**

Sometimes food may make an appearance in the feces. Common undigested foods found in human feces are seeds, nuts, corn, and beans, mainly because of their high dietary fiber content. Beets may turn feces different hues of red. Artificial food coloring in some processed foods, such as highly colorful packaged breakfast cereals, can cause unusual coloring of feces if eaten in sufficient quantities.

Undigested objects such as seeds can pass through the human digestive system, and later germinate. One result of this is tomato plants growing where treated sewage sludge has been used as fertilizer

### **DISEASES & CONDITIONS**

There are many diseases and conditions that are associated with the colon. Colorectal cancer is cancer that occurs in the colon or in the lower colon near the rectum. It is one of the most common causes of cancer-associated death.



The American Cancer Society estimates there will be 93,090 new cases of colon cancer in the United States in 2015 and one in 20 will get colorectal cancer in their lifetime

Polyps are an abnormal growth of tissue on the inner lining of the colon or rectum that are benign, non-cancerous tumors. These polyps can sometimes turn into cancer, but many times do not. There are several types of polyps. Adenomatous polyps can change into cancer and are considered pre-cancerous. Hyperplastic polyps and inflammatory polyps are not typically pre-cancerous, though some in the medical community think they may be signs of future colon cancer, according to the American Cancer Society. Doctors usually remove all polyps, just in case.

Colon dysplasia is when a spot of cells on the lining of the colon look abnormal under a microscope. These cells are not cancerous, but can change into cancer over time. People who have had diseases such as ulcerative colitis or Crohn's disease for many years can develop colon dysplasia

Spastic colon, also called irritable bowel syndrome, is more than just a colon problem. It is the spontaneous contractions or loss of movement of the muscles in the small and large intestines

#### COLON CANCER: CAUSES, SYMPTOMS AND TREATMENTS

Colon cancer, also known as colorectal cancer, is the second-leading cause of cancer deaths in both men and women. According to the Centers for Disease Control (CDC), 51,783 Americans died from colon cancer in 2011 (the most recent year for available data). The disease affects slightly more men than women, and risk increases with age

"Colon cancer is a growth in the colon that usually arises from a polyp. Sometimes the polyps look like stalks of cauliflower, sometimes they're flat. "When they spread that's when [people] have life-threatening issues.

#### CAUSES

Excluding very rare types, colon cancer develops in the cells lining the inside of the colon and/or rectum. The colon, or large intestine, is a curving structure that continues the digestion of food from the small intestine, absorbs liquid out of the stool and carries it down to the rectum for elimination.

While there is no specific cause of colon cancer, certain factors can increase risk of developing the disease. These factors include genetics, diet and health. Individuals with a family history of colon cancer, especially if more than one relative has had the disease, are at increased risk. Also, two genetic syndromes, familial adenomatous polyposis and Lynch syndrome, have been associated with colon cancer

#### SYMPTOMS & SCREENS

Symptoms that may indicate the presence of cancer cells in the colon or rectum include:

1. blood in bowel movements,
2. weight loss,
3. stomach pains and

#### 4. constipation or diarrhea

Often, individuals will not experience any symptoms of colon cancer until it has become advanced. For this reason, the U.S. Preventive Services Task Force recommends that all individuals ages 50 to 75 undergo routine screening. African Americans, who have an increased risk, are advised to begin screening at age 45, according to the American College of Gastroenterology

#### TREATMENT

If a diagnosis of colon cancer is made, treatment is determined by the stage of the disease. In other words, earlier stages in which the cancer is small and localized may require less intervention. Typically, surgery can effectively remove small tumors and chemotherapy is prescribed to kill any remaining cells. Chemotherapy drugs commonly used for colon cancer include irinotecan, oxaliplatin, capecitabine and 5-fluorouracil. More advanced cancers in which the disease has metastasized, or spread, throughout larger areas of the colon or to other parts of the body may require removal of whole sections of the large intestine.

#### PROMOTING GOOD COLON HEALTH

There are many ways to improve large intestine health. Eat a healthy, balanced diet that is full of fruits and vegetables, consume fiber-rich diet, drink adequate amounts of water, exercise regularly and follow recommended guidelines for colon cancer screening and colonoscopies

For colonoscopy procedures often, the remaining colon can be reconnected to the rectum, but if the cancer has also reached the rectum, a colostomy may be needed. In this procedure, a surgeon creates an opening in the abdomen and attaches a colostomy "bag." Waste collects in the bag instead of passing through the rectum. Chemotherapy and radiation are then prescribed to kill remaining cancer cells, and control as much as possible the spread of the disease.