3 MEDICAL BACKGROUND

3.1 Introduction

Our fascinating journey of the human body begins with an overview of the disciplines of anatomy and physiology which is essential for the point of view of this research.

Anatomy is the branch of science which deals with body structures and relationship between them. Earlier it was accomplished by dissection in vitro, but the advances of medical imaging made it possible to do it on vivo. On the other hand Physiology is the science which deals with body functions, how an organ functions?. Earlier it was too difficult to access functioning but now a day’s medical advances made it possible to describe functioning even at in vivo level. Through detailed research done in the past on anatomy, it is found that the basic structure of a body at the Chemical Level contains atoms and molecules. Atoms like Carbon (C), Hydrogen (H) and Oxygen (O) etc which are essential for maintaining life. All join together to form molecules and two main molecules are D.N.A (Deoxyribonucleic acid) and blood sugar (glucose). The further advancement in body structure occurs when molecules combine and create Cells. The cell is known as basic functional and structural unit. Example of these cells are muscle cell, nerve cells etc. The next level which have foundation stone as cell is Tissue, a group of cells and the material surroundings them that work together to perform a particular function ex. Epithelial tissue, connective tissue, muscular tissue etc. The Organ Level is the combination of the different tissues, joined to perform a specific function and have a recognizable shape and size ex. Skin, heart, brain etc. The different organs make a system, known as System-Organ Level as in digestive systems made to perform digestion and absorption organs like pharynx, esophagus mouth, stomach, small intestine, large intestine, in border view. Now comes Organisational Level or Organism, best creation has been body of a living being. (Borley, Glass, Ind, & Mundy, 2005)

According to the G. J. Tortora et.al, system-organ level of a human body is divided in eleven system and defined as

- Integumentary System
3.2 Digestion System

The area of interest for the research is Digestive System of the body, a system which prepare food for providing the energy to different other system. In this preparation of food, making it able to reach basic life source i.e. cell, various organs are involve and are defined here after.

3.2.1 Mouth:

Mouths, as shown in Figure 3.1, directly involved for digestion, consisting cheeks, soft and hard palates, lips, vestibule, uvula, and arches (Palatoglossal and palate pharyngeal arches), with Others organ known as accessory digestive organs like Salivary Gland, Teeth and Tongue. Checks forms the lateral walls of oral cavity covered externally by skin and internally by a mucous membrane. (Borley, Glass, Ind, & Mundy, 2005) Lips or Labia are the folds adjacent the opening of mouth. They have orbicularis oris muscle and enclosed externally by skin and internally by a mucous membrane. The inner surface of every lip attached to its matching gum by a midline of mucous membrane called labial Frenulum. During chewing, lips assist in controlling food between lower and upper teeth. The vestibule (doorway to a canal) of the oral cavity is a gap enclosed externally through the cheeks and lips and internally by the gums and teeth. The proper oral cavity is space that pull out from the gums and teeth to the fauces, the space between the oral cavity and the pharynx (throat).
The hard palate the frontal segment of the top of the mouth is formed by maxilla and palatine bone and is roofed by mucous membrane and it produces a body partition between oral and nasal cavities. The soft palate, which form subsequent segment of mouth roof of the mouth, is an arch-shaped muscular separation between oropharynx and nasopharynx that is lined with mucous membrane. Lynching from the free boundary of the soft palate is a conical muscular projection called uvula (little grape). On the side, the nasal cavity, bottom of the uvula have two muscular folds that run down the lateral sides of the soft palate. Interiorly the Palatoglossal arch, and spread to the bottom of the tongue; posterior, the Palatopharyngeal arch extends closely the pharynx. The Pataline tonsils are located between the arches and lingual tonsils and situated at foundation of the tongue. At the posterior boundary of soft palate, the mouth opens into oropharynx from end to end of fauces. (Borley, Glass, Ind, & Mundy, 2005)

(Borley, Glass, Ind, & Mundy, 2005)

**Figure 3.1: Bucco-Pharyngeal Cavity**
3.2.2 **Pharynx:**

It is alienated into three parts Nasopharynx, Oropharynx, and Laryngopharynx. The Nasopharynx plays significant role in respiration, while Oropharynx and Laryngopharynx are channel common to both respiratory and the digestive systems see Figure 3.2. The Pharynx afterward has two projections to the esophagus. The wall layers of Pharynxes consist stratified Squamous Epithelium layer all over, in core this is fibrous tissue be full of blood and lymph vessels and nerves, and at outer coating consist of involuntary muscles as subsequent to entering in pharynx, from here swallowing is no longer continue as voluntary. The Vagus and Glossopharyngeal nerves manage parasympathetic signals and cervical Ganglia control sympathetic signals. (Borley, Glass, Ind, & Mundy, 2005)

![Diagram of Pharynx](image)

(Borley, Glass, Ind, & Mundy, 2005)

**Figure 3.2: Structure of Pharynx**

3.2.3 **Esophagus:**

It is unremitting with the pharynx at upper end and at lower end it attaches to stomach immediately underneath the diaphragm. It is about 25cm long and about 2cm in diameter, lying
in median plane in the thorax in facade of vertebral column, at the back of the trachea and heart. Immediately when it traverses the Diaphragm it curves aloft, before aperture to the stomach, to avoid the regurgitation (backflow) of gastric substance. The higher and inferior ends, are clogged by sphincters, the upper sphincter known as Cricopharyngeal or upper esophageal. Sphincter checks air to go by for the duration of inspiration and prevent aspiration of esophageal content shown by Figure 3.3. The cardiac or lower esophageal sphincter is make available at stomach end to avert back flow of acid gastric content into the esophagus. The thickening of circular muscles at this sphincter is not there, so these sphincters are without any anatomical structure. When intra abdominal pressure is elevated, the tone of the lower esophageal sphincter increases. Four layers assemble its walls, outer layer of elastic fibrous tissue recognized as adventitia, attach esophagus with surrounding structure.

Layers of longitudinal and circular muscles are underneath adventitia, and offer motion to the food bolus. Subsequent to this sub mucosa of loose connective tissues with plexus are there. Inner most lining is separated in three parts with diverse tissues. Stratified Squamous Epithelium lining at Proximal third, and Columnar epithelium at distal third. The middle third is layered by blend of two (Borley, Glass, Ind, & Mundy, 2005).

3.2.4 Stomach:

It is J-shaped widen portion shown in Figure 3.4, to be found in the epigastria, umbilical and left hypochondria section of the abdominal cavity. The stomach have cardiac sphincter at upper end and at distal end pyloric sphincter is there. It has two curvatures; the lesser curvature is small, at the posterior surface of the stomach and is the downward extension of the esophagus wall. Just before the pyloric sphincter it curves to complete the J shape.
(Borley, Glass, Ind, & Mundy, 2005)

**Figure 3.3:** Structure of Esophagus

(Borley, Glass, Ind, & Mundy, 2005)

**Figure 3.4:** Structure of Stomach
Frontal surface where esophagus connects the stomach it makes an acute angle, then curve goes downward to form the greater curvature. Then this surface goes a little upwards on the way to the pyloric sphincter which stays closed at what time food is inside the stomach. The stomach is divided into three regions. Posterior area is Fundus, middle area is the Body and the distal region is Antrum. Walls of stomach are same as they are at other locations but with moderations in the muscle layer see Figure 3.5. The muscle layers have in it three layers. Outer layer have longitudinal fibers and circular fibers at middle layer. The inner most layers are of oblique orientation of muscles fibers. These layers help in churning and peristaltic actions. The circular muscles are stronger at pyloric Antrum and pyloric sphincter. Mucosa has longitudinal wrinkles known as rogue which have gastric glands and cells.

(Borley, Glass, Ind, & Mundy, 2005)

Figure 3.5: - Muscle Architecture of Stomach

3.2.5 **Small Intestine:**

This is incessant with the stomach at the pyloric sphincter and last part at large intestine with Ileocaecal valve. It is in the order of 5m length and enclosed by larger intestine.
The small Intestine encompasses three main sections. Duodenum is about 25 cm long and curves in the region of pancreas head, secretions from the gall bladder and pancreas are released into the duodenum through a common arrangement, the Hepatopancreatic Ampulla as shown by Figure 3.6. This opening is controlled by means of Hepatopancreatic Sphincter (Sphincter of Oddi). The Jejunum is the middle segment and about 2 meter long. At the last, the Ileum is about 3m long and concluded at the Ileocaecal valve, which bond Ileum to large intestine and check regurgitation. The walls of small intestine have four layers, two layers Sub mucosa and muscularis are similar as other organs of G.I tract, but outer layer is Peritoneum known as mesentery. Mucosa layer of small intestine have circular folds, villi and microvilli, which amplify its float up area.

(Borley, Glass, Ind, & Mundy, 2005)

Figure 3.6:- Structure and Parts of Small Intestine
These villi are tiny finger like projections of the mucosal layer, about 0.5 mm to 1mm long. At surface of villi, columnar epithelial cells known as Enterocytes is present with microvilli (1mm long) see Figure 4.1.

Goblet cells are interspersed with Enterocytes and secrete mucus. Every villus has lacteal, a set of connections consisting blood and lymph capillaries. Whole Epithelium refreshed within 3-5 day.

3.2.6 **Large Intestine:**

It is about 1.5m long & 6.5 mm. commencement at Caecum and terminates at the rectum see Figure 3.7. It forms an arch in the region of Small Intestine.

**Caecum:** This is first part of the colon, has a blind end inferiorly and widen region is connected to the ascending colon. Just underneath the junction of the Caecum and ascending colon, Ileocaecal valves open. It has a vermiform appendix, begins from the caecum and is about 8 to 9cm long and share similar wall structure as of the colon, which have lymphoid tissues see Figure 3.8.

(Borley, Glass, Ind, & Mundy, 2005)

Figure 3.7: Structure of Large Intestine
**Ascending Colon:** It is elevating colon and makes acute curve immediately under the liver, towards left to turn out to be transverse colon see Figure 3.8. Transverse Colon is expansion of this colon that extends across the abdominal cavity. It begins from the face of duodenum end up to the spleen, where it forms Splenic flexure and curves acutely downwards to develop into the Descending Colon.

**Descending Colon:** It runs along the left surface of abdominal cavity in downward direction and curves in the direction of the pelvis here it is known as Sigmoid Colon see Figure 3.8. This takes form of S-Shaped curve in the pelvis that carries on downward becoming rectum.

**Rectum:** It is wider section of colon about 13 cm long, and goes up to anal canal see Figure 3.8 and Figure 3.9. Two sphincter muscles be in command of the anus, internal sphincter is of smooth muscle and the voluntary exterior Sphincter of Skeletal muscle. It is also made of four layers of tissue with little variations. By the side of Colon longitudinal muscle fibers are composed into bands at regular intervals known as Taeniae coli. The sub-mucosa layers have rich quantity of lymphoid tissue than other divisions of tract to guard tract from microbes.

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*(Borley, Glass, Ind, & Mundy, 2005)*

**Figure 3.8: Parts of Large Intestine**
3.2.7 **Accessory Organ:**

The different organs which assist and speed up the digestion process by secreting fluids and indirectly take action on food at various stages, are known as Accessory organ.

- **Tongue** a voluntary muscular structure that resides in the floor of mouth. It is connected by its bottom to the hyoid base by a mucus membrane fold called Fenulum. The upper surface is of stratified Squamous Epithelium; with several papillae (little projections), which have sensory receptors for the sense of taste at taste buds as shown by the Figure 3.10. Functions of tongue are mastication, degulation, speech, and taste.

(Borley, Glass, Ind, & Mundy, 2005)

*Figure 3.9: Parts of Rectum*
- **Teeth** are entrenched in the alveoli or opening of alveolar ridges made up of the mandible and maxilla. The incisor and canine teeth are the cutting teeth, whereas the premolar and molar teeth are for grinding and chewing the food.

- **Salivary Gland** discharge secretion into duct of mouth. Three main pairs of Salivary glands are Parotid, Sub-mandibular, and Sublingual glands. Parotid gland’s duct is above the second upper molar tooth on each side and land is situated immediately below external acoustic Meatus. Sub-mandibular gland lies on each side of the Frenulum and sublingual glands have plentiful minute duct opening at the floor of mouth. Sublingual glands are positioned beneath mucus membrane at floor of the mouth in front of the sub-mandibular glands see Figure 3.10. Functions of these glands are chemical digestion, polysaccharides, lubrication of food, cleaning and lubrication, defense from microbes and taste.

(Borley, Glass, Ind, & Mundy, 2005)

Figure 3.10: Accessory Organs (Teeth, Tongue, and Salavary Gland)
- **Pancreas** is pale grey gland weigh around 60 gm, having length 12 to 15 cm and is placed at Epigastric and left Hypochondriac region of the abdominal cavity as shown in Figure 3.12. It has broad head, and narrow tail. The head is in the curve of duodenum and tail is at frontage of the Kidney and just reaches the spleen. The glands produce both endocrine and exocrine.

- **Liver** weighing about 1 to 2.3 kg. It is positioned at the upper part of the abdominal cavity reside in the right hypochondriac region, and part of the epigastria region. It extends up to the left hypochondriac region as shown in Figure 3.11. Its upper and anterior surface are curved to fit the below the diaphragm, its posterior surface is irregular surface. It have four lobes as under:
  - Right Lobe
  - Left lobe
  - Quadrate Lobe
  - Caudate Lobe

- **Gall Bladder**: The gall bladder is attached to posterior surface of the liver by connective tissue. It have expanded end, a body or main part, and a neck. see Figure 3.13.

(Borley, Glass, Ind, & Mundy, 2005)

Figure 3.11: Structure Of Liver
Figure 3.12: Structure of Pancreas

(Borley, Glass, Ind, & Mundy, 2005)

Figure 3.13: Structure of Gall Bladder

(Borley, Glass, Ind, & Mundy, 2005)
3.3 **Functions of a Digestive System:**

It is understandable that the functions of an organ are not leaning to a single mechanism or processes i.e. organs perform many functions, so it is very intricate to comprehend the functioning of an organ. In this research the work is restricted to digestion so discussing Physiology of the other organs will be exhausting. For the purpose of study, work is restricted to processes of stomach accordingly the physiology of the stomach is defined. The selection of stomach is on the basis that stomach as an organ has maximum number of functions and motility actions. The processes of digestive system are divided in six basic processes. (Borley, Glass, Ind, & Mundy, 2005)

1. **Ingestion:** taking in the food by the mouth.
2. **Secretion:** it is releasing of water, buffers, acid and enzymes into lumen of tract.
3. **Mixing and Propulsion:** alternate contraction and relaxation of muscles of organs of G. tract, mix food and propel them towards the anus.
4. **Digestion:** the breakdown of food into small molecules,
5. **Absorption:** the passage of the digested food through the wall of the tract with the blood and the lymph.
6. **Defecation:** removal of wastes through the anus (M)

Looking to the objective of the research work, processes directly involving mechanical action are defined here before concluding to functions of stomach.

3.4 **Anatomy of Mastication:**

Earlier than entering the stomach the food undergoes number of intraoral, pharyngeal and transport processes and mechanism. Mastication establishes when the ingested food is not appropriate for transportation via intraoral organs. In this course, cutting and crushing of the food is done along with mixing saliva and creating the bolus, which is suitable for swallowing. The function of tongue is to shift the food within intraoral organs for appropriate mixing and transport it. Whereas the functions of teeth, jaw, and jaw closing muscle is to fracture food in minute pieces. Preliminary puncturing forces on food are applied by premolar and molar teeth with movement of jaw in vertical plane, with this shearing force mediate the process by the moving the jaw in an inclined plane. The tongue, after the breaking of food in minute portions
transported it to point of swallowing. Here the movement of jaw is obtained by the Masseter, Temporalis, and medial Pterygoid muscles. In each cycle; the closing of jaw occur due to gravity till tooth-food-tooth contact is obtained after that muscle start working. The gap of jaw is obtained through the relaxation of the jaw closing muscles together with lateral Pterygoid muscle, Condyles, Sub-mandibular muscles, and Digastrics muscles. The cycle of jaw movement is reliant upon the kind of food and consistency of the food. Movement envelop of jaw is limited by the anatomical borders of the jaw and obtained in phases. In first stage it is pivot like movement due to Condyles and Mandible Fossae. Whereas second stage starts when teeth gap of 25 mm with anterior movement or protrusion of the Condyles occur, leading further rotation of food. Most of the jaw movements are cognizant and proscribed by the CNS. (M2)

3.5 **Anatomy of swallowing:**

Swallowing is reflex when food or fluid stimulates sensory nerves in Oropharynx. Food swallowing has been separated into three phase, typically described as oral, pharyngeal and esophageal phase.

- **Oral Phase** is the phase where a voluntary event transports the food bolus from the oral cavity to Fauces. This transportation is on the whole completed by the tongue where mouth creates shallow midline gutter using tongue to put up the bolus and then tongue elevates toward the back, with bottom of midline gutter through contraction of Styloglossi and Genioglossi muscles. The emptying of gutter is attain by contraction of Hyoglossus and Intrinsic Lingual muscles with combination to Mylohyoid, Geniohyoid and Stylohyoid muscles from the anterior and mid tongue, hyoid bone, and the mouth floor also move at the same time. This elevation is accompanied by the relaxation of Palatoglossi muscle due to movement of posterior oral seal and onward movement of posterior tongue providing a cam-like act to tongue meant for sweeping and squeezing of the bolus in the direction of the fauses to pharyngeal aperture which is closing and opening in a cycle.

- **Pharyngeal Phase** a reflex phase during which pharynx modify from air channel (connection between nares and laryngeal inlet) to food channel (connection between fauses to upper end of esophagus). This is accomplishing by shutting of glottis to seal the airway. Double protection is given by lifting and tipping the laryngeal inlet under the
posterior part of the tongue, by this bending of epiglottis over the laryngeal inlet occur, and make clear passage for the bolus to go by. Chronological contraction of three pharyngeal constriction muscles is the driving force to accomplish transportation.

- **Esophageal Phase** in this Crico-pharyngeus (upper esophageal sphincter) offer aperture by relaxing to permit bolus to go into esophagus and to arrive up to lower esophageal sphincter. Propulsion is accomplished by the in order waves of the contraction of esophageal muscles. The lower esophageal sphincter open for a moment and allow the bolus to enter stomach.

### 3.6 Propulsion, Mixing, and Segmentation:

Peristalsis wave mechanism is behind each shift of the Gastrointestinal tract’s walls. The first confirmation of propulsion are establish at esophagus where the bolus is stirred to lower esophageal sphincter by the synchronized contraction and relaxation of the circular and longitudinal layers of Muscularis. Here the piece of esophagus wall immediately behind the bolus contracts by the circular smooth muscles layers and then longitudinal smooth muscles contract layers, and thrust the bolus onward in the direction of the stomach. These contractions are recurring in an intermittent manner and directed to end of the esophagus and lower esophageal sphincter relaxes to allow bolus to go in the stomach.

The food enters the stomach, and then peristalsis movement described as mixing waves. It starts after every 15 to 25 seconds. These waves crush the food, mix it with secretion of the gastric glands, and alter it to a soupy fluid called chyme. Following the starting the digestion, more dynamic mixing wave commence and its pace strengthen previous to reaching to the pylorus. The pyloric sphincter stay closed till chyme reaches to it except allowing only 3 ml of chyme to go into duodenum this phenomenon is recognized as gastric emptying. Residual chyme is propelled reverse to stomach for additional mixing with gastric juices and to remain in procession to wait till the permission from the duodenum is agreed.

There are two types of peristalsis movement at small intestine primary being segmentation and subsequent type is migrating motility complexes. These movements ruled by the Myenteric plexus. Segmentations are localized, mixing contraction happening at swollen portion of intestine. Segmentation does not thrust the intestinal content along the tract but starts with the
contraction of circular muscles fibers, via which constriction of the intestine into segments occur. Muscle fiber that surrounds the middle of every segment also contracts and each segment divides all over again. Finally, the fibers relax and each small segment fuses to create large segments again. As this series of events duplicate, the chymes splatter back and forth. After absorption of food, which lessens distention of the wall of the small intestine, segmentation brings to an end and peristalsis begins. This peristalsis happening at the small intestine, termed as migrating motility complex (MMC).

The passageway of chyme on or after the ileum to ceacum is synchronized by ileocecal sphincter. Normally, this valve leftover partly closed so that the passage of chyme into the ceacum occurs slowly. But straight away after a meal, a Gastroileal reflexes make stronger peristalsis at the ileum and forces chyme into ceacum. The hormone gastrin as well relaxes the sphincter. Movements in the colon commence when stuff passes the ileocecal sphincter, because chyme moves through the small intestine at a steady rate, the time requisite for a meal to go by into the colon is determined by gastric emptying. As food passes through the ileocecal sphincter, it packs the ceacum and mounts up in the ascending colon. One of the characteristics of the large intestine movement is Haustral churning. Here peristalses occur, at a slower rate (3 – 12 contraction per minute). A final type of movement is mass peristalsis, a physically powerful peristaltic wave begin at middle of the transverse colon and rapidly drives the content of the colon into the rectum. Food in the stomach initiates gastro colic reflex in the colon, so mass peristalsis typically takes place three or four times a day, immediately after a meal. (Borley, Glass, Ind, & Mundy, 2005)

### 3.7 Sphincters and Valve mechanisms

It is well recognized information from the radiological data, that food by way of lumen of G. I tract is regulated previous to entering into one organ. This regulation of food is accomplished with the help of sphincters and valves. In this series of sphincters first dictatorial body is upper esophageal sphincter at the connection of pharynx and esophagus. There are various constrictors in the pharynx to control the food and air for digestion and respiration respectively. The one which control the stream of food is named as circopharyngeus or upper sphincter situated at the intersection of the laryngopharynx and oesopharynx. After passing esophagus, when food is about to enter the stomach the lower esophagus sphincter or cardiac sphincter control the flow,
which is a dedicated zone of circular smooth muscle neighboring the esophagus at its journey through the diaphragm and abdominal. The walls of esophagus are under tonic contraction, except during swallowing, and ingress of ingest to the stomach. This is controlled by the intramural plexuses of the enteric nervous system. One additional mechanism operates, known as Functional External Sphincter provided by the crural diaphragm, which enclose the esophagus as it passes into the abdomen. The muscular fibers situated around the esophagus of this sphincter contract during inspiration or when intra-abdominal pressure is greater than before. Passing from the stomach to the small intestine the chyme has to go by pyloric orifice. Pyloric sphincter is muscular circle formed by the Circular gastric muscles intertwine by longitudinal fibers. The digested food from the small intestine enters to large intestine with under regulation Ileocaceal valve. This orifice has a regulator consisting of two flaps which are projected into the lumen of the large intestine. The upper horizontal flap is attached to the intersection of the ileum and cacecum. At their end the flaps combine, hold a narrow membranous crest, the frenula of the valve. The muscles of ileocecal valve are similar to the intestinal mucosa. This valve prevents reflux of chyme to the ileum from caceum. The surface of this valve is covered with villi at the ileal side. Surfaces at cecum have numerous orifices of tubular glands of the colonic mucosa. At the last, before the defecation the digested food has to pass two more sphincters, positioned at junction of large intestine and anal canal and outer environment namely internal and external anal sphincter respectively. The Internal anal sphincter is a well distinct ring of obliquely oriented smooth muscles fibers continuous by means of circular muscle of the rectum. The inferior portion of the sphincter is intervene by fibers from the conjoint longitudinal coat which passes into the sub mucosa of the lower canal. Here the contraction and relaxation is completed through the hypo-gastric plexus. External anal sphincter is an oval tube fashioned complex striated muscle, composed largely of type I (slow twitch) skeletal muscle fibers, which are well matched to prolonged contraction. The greater parts of middle fibers of external anal sphincter enclose the lower part of the internal sphincter. (Gregersen, 1962).

From the above description, it is clear all the mechanical action have been backed by the forces applied by the muscles on the microstructure of the organs. Which makes changes in their structure to complete the action or say prepare food for further processing to be conducted at the in-series organs of the G. I tract, so study of the biomechanics of microstructure of the organs and muscles is very important to understand the mechanical digestion point of view. Further the
cause of changes at lumen structure while mechanical digestion, compels to study the physiology of muscles.