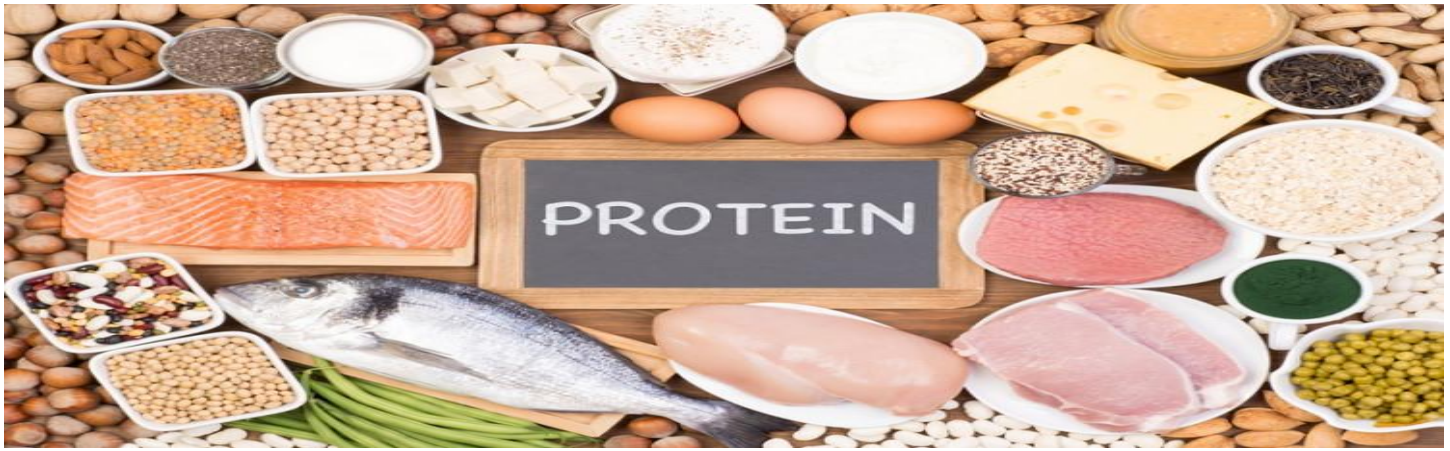


Digestion and Absorption of Proteins

Dr Trushna Shah
Associate Professor
SBKSMI&RC

The learner will be able to:

- Describe the digestion of proteins
- Explain the absorption of amino acids
- Outline Meister cycle

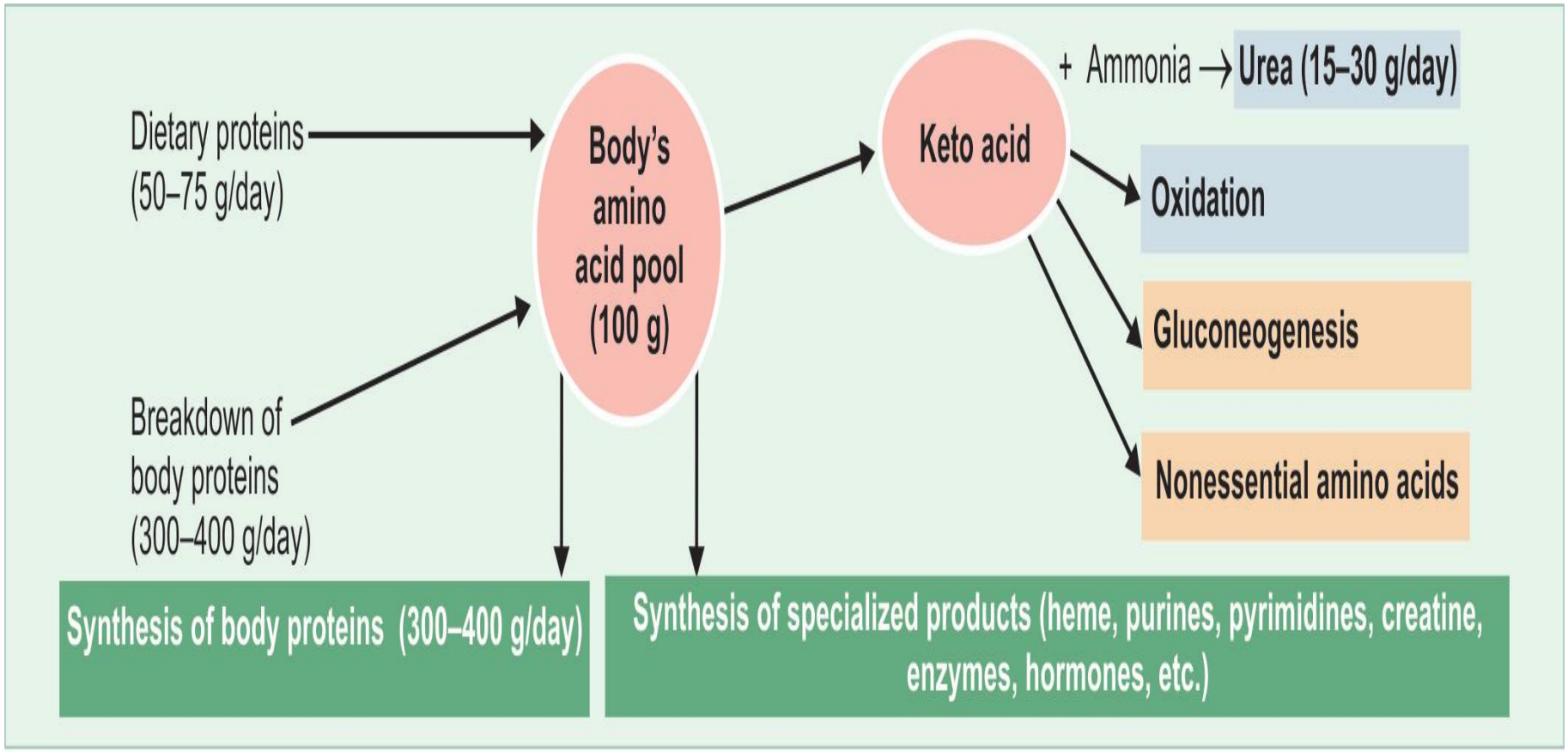
- For more explanation you need to Read Biochemistry Book and Make notes.
- Question mostly ask in 5 Marks
- Write down in point wise manner
- Remember Carbohydrate digestion starts with mouth while protein digestion starts in Stomach.
- No digestion in Carbohydrates
- Always compare both the digestion and absorption than read the entire topic

- The main role of amino acids is in the **synthesis of structural and functional proteins**. A 70 kg man has an average protein turnover rate of 400 g per day (same amount synthesized and same amount broken down).

- The nonessential amino acids are either derived from the diet or synthesized in the body.

- The **essential amino acids are obtained from the diet**. Even if one amino acid is deficient, protein synthesis cannot take place.

- The body amino acid pool is always in a dynamic steady state.
- In an adult, the rate of synthesis of proteins balances the rate of degradation, so that nitrogen balance is maintained proteins are generally not used for providing energy



Overview of metabolism of amino acids

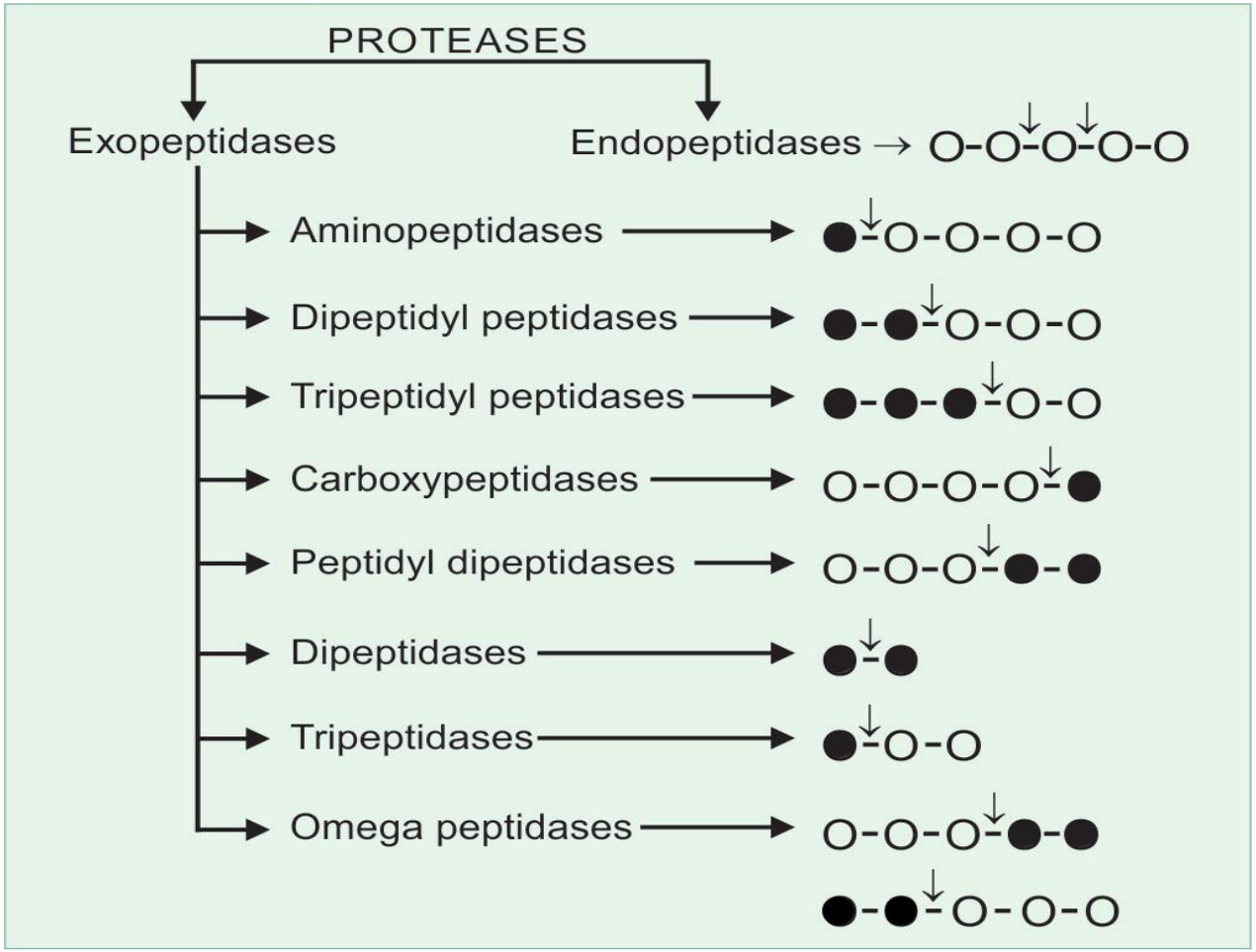
Digestion of Proteins

- **Proteolytic enzymes are secreted as inactive zymogens.**
- **These are then converted to their active form in the intestinal lumen. This would prevent auto-digestion of the secretory acini.**
- **Premature activation of trypsinogen results in acute pancreatitis.**
- **It is a life-threatening condition.**

- The proteolytic enzymes include:
  1. **Endopeptidases:** They act on peptide bonds inside the
     protein molecule, so that the protein becomes successively smaller and smaller units.
- This group includes Pepsin, Trypsin, Chymotrypsin and Elastase.
  2. **Exopeptidases:** Which act only on the peptide bond located at the ends of the polypeptide chain.

     This group includes:

  a. **Carboxypeptidase,** which acts only on the peptide bond at the carboxy terminal end of the chain.
  b. **Aminopeptidase,** which acts only on the peptide bond at the amino terminal end of the chain.



Action of proteases. The enzyme hydrolyses the peptide bond at the site of arrow

- Main site of Protein Digestion occurs:

Stomach :	**HCl and Pepsin**
Pancreas :	**Trypsin**
	Chymotrypsin
	Elastase
Intestine:	**Carboxypeptidase**
	Amino peptidase
	Dipeptidase

1. Stomach Digestion

HCL

- In the stomach, hydrochloric acid is secreted.
- It makes the pH optimum for the action of pepsin and also activates pepsin.
- The acid also denatures the proteins.

Rennin

- Rennin otherwise called **Chymosin**, is active in infants and is involved in the curdling of milk.
- It is absent in adults.
- Milk protein, casein is converted to paracasein by the action of rennin.
- This denatured protein is easily digested further by pepsin.

Pepsin

- It is secreted by the chief cells of stomach as inactive **pepsinogen**.
- The optimum pH for activity of pepsin is **around 2**.
- Pepsin is an endopeptidase.
- By the action of pepsin, proteins are broken into proteoses and peptones.

Rennin is active in infants and is involved in the curdling of milk. It is absent in adults. Milk protein, casein is converted to paracasein by the action of rennin.

Rennin and Renin are different

Rennin is the proteolytic enzyme present in gastric juice.
Renin is proteolytic enzyme, secreted by kidneys. It is involved in the activation of angiotensinogen to angiotensin, a hypertensive agent.

Pancreatic Digestion

Pancreatic Digestion of Proteins

- The optimum pH for the activity of pancreatic enzymes (pH 8) is provided by the alkaline bile and pancreatic juice.
- The secretion of pancreatic juice is stimulated by the peptide hormones, **Cholecystokinin** and **Pancreozymin.**
- Pancreatic juice contains the important endopeptidases, namely **Trypsin, Chymotrypsin, Elastase** and **Carboxypeptidase.**
- These enzymes are also secreted as zymogens (trypsinogen, chymotrypsinogen and proelastase), so that the pancreatic acinar cells are not autolyzed.

Trypsin

- Trypsinogen is activated by enterokinase (enteropeptidase) present on the intestinal microvillus membranes.
- Acute pancreatitis: Premature activation of trypsinogen inside the pancreas itself, will result in the autodigestion of pancreatic cells.
- The result is acute pancreatitis.
- It is a life-threatening condition.

- Trypsin and chymotrypsin degrade the proteins into small peptides; these are further hydrolyzed into dipeptides and tripeptides by **carboxypeptidases** present in the pancreatic juice.

- The procarboxypeptidase is activated by trypsin.

- They are metalloenzymes requiring zinc.

3. Intestinal Digestion of Proteins

- Complete digestion of the small peptides to the level of amino acids is brought about by enzymes present in intestinal juice (**succus entericus**).

- The luminal surface of intestinal epithelial cells contains the following enzymes:

- Aminopeptidases release the N-terminal amino acids.

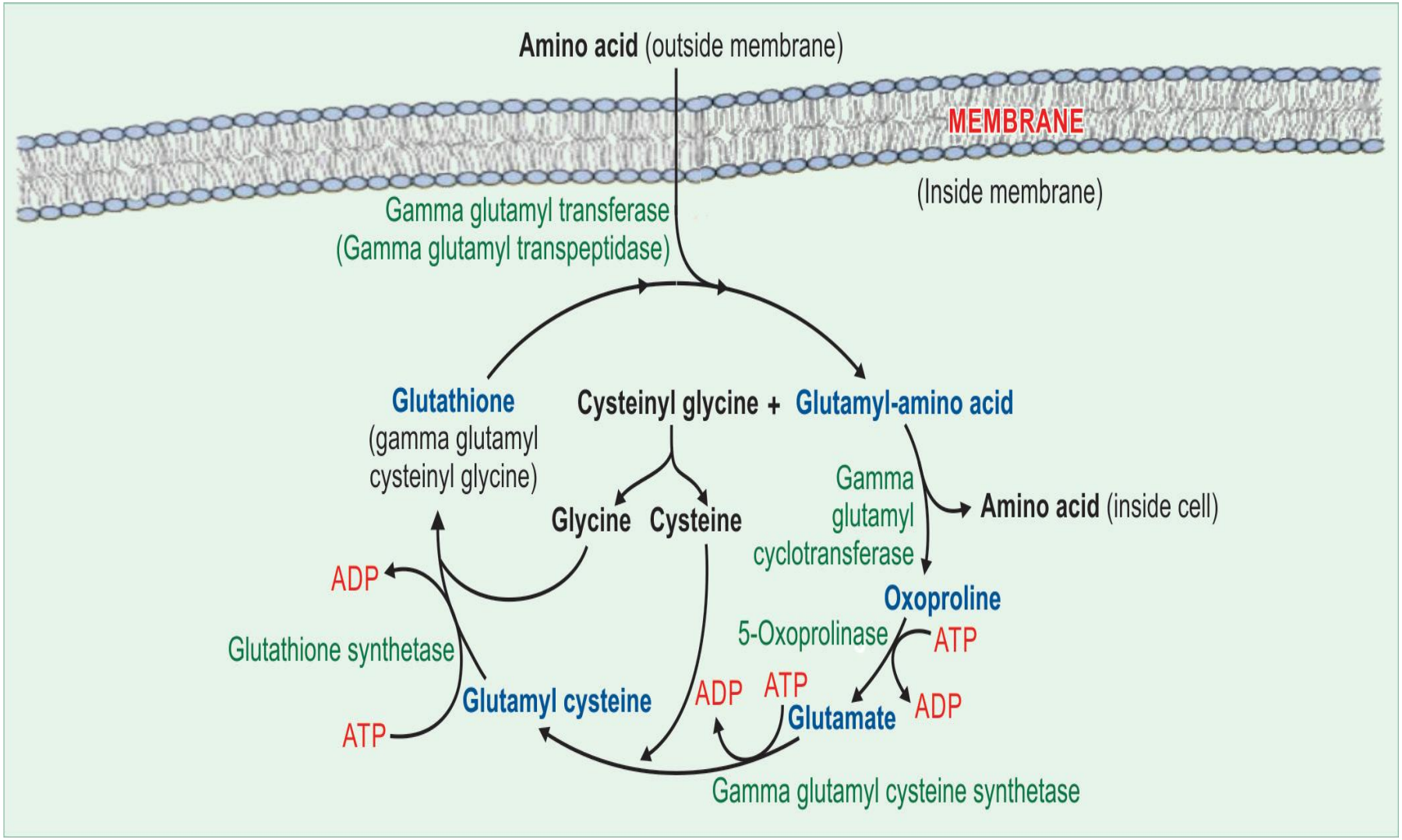
- Dipeptidases and tripeptidases will complete the digestion of proteins.

From intestine
Energy requiring process
Five transport systems

Gamma glutamyl cycle

- The absorption of amino acids occurs mainly in the small intestine.
- It is an energy requiring process.
- These transport systems are carrier mediated and/or ATP sodium dependent symport systems.
- There are **5 different carriers** for amino acids:
  1. Neutral amino acids (Ala, Val, Leu, Met, Phe, Tyr, Ile)
  2. Basic amino acids (Lys, Arg) and Cysteine
  3. Imino acids and Glycine
  4. Acidic amino acids (Asp, Glu)
  5. Beta amino acids (beta alanine).

- In intestines, kidney tubules and brain, the absorption of neutral amino acids is effected by the gamma-glutamyl cycle.
- The tripeptide **glutathione** (GSH) (gammaglutamyl-cysteinyl glycine) reacts with the amino acid to form gamma-glutamyl amino acid.
- That is then cleaved to give the free amino acid.
- The net result is the transfer of an amino acid across the membrane.



Gamma-glutamyl cycle (Meister cycle).

- Dipeptides and tripeptides can enter the brush border of mucosal cells; they are immediately hydrolyzed into single amino acids.
- They are then transported into portal vein.
- These are immunogenic, causing antibody reaction, leading to food allergy.

Clinical Applications

1. The deficiency of the enzyme 5-oxoprolinase leads to **oxoprolinuria** (pyroglutamic aciduria).
2. The allergy to certain food proteins (milk, fish) is believed to result from absorption of partially digested proteins.
3. Defects in the intestinal amino acid transport systems are seen in inborn errors of metabolism such as:
   a. **Hartnup disease**
   b. Imino glycinuria
   c. Cystinuria
4. Partial gastrectomy, pancreatitis, carcinoma of pancreas and cystic fibrosis may affect the digestion and absorption of proteins.
5. **Protein-losing enteropathy:** There is an excessive loss of proteins through the gastrointestinal tract.

- For more explanation you need to Read Biochemistry Book and Make notes.
- Question mostly ask in 5 Marks
- Write down in point wise manner
- Remember Carbohydrate digestion starts with mouth while protein digestion starts in Stomach.
- No digestion in Carbohydrates
- Always compare both the digestion and absorption than read the entire topic