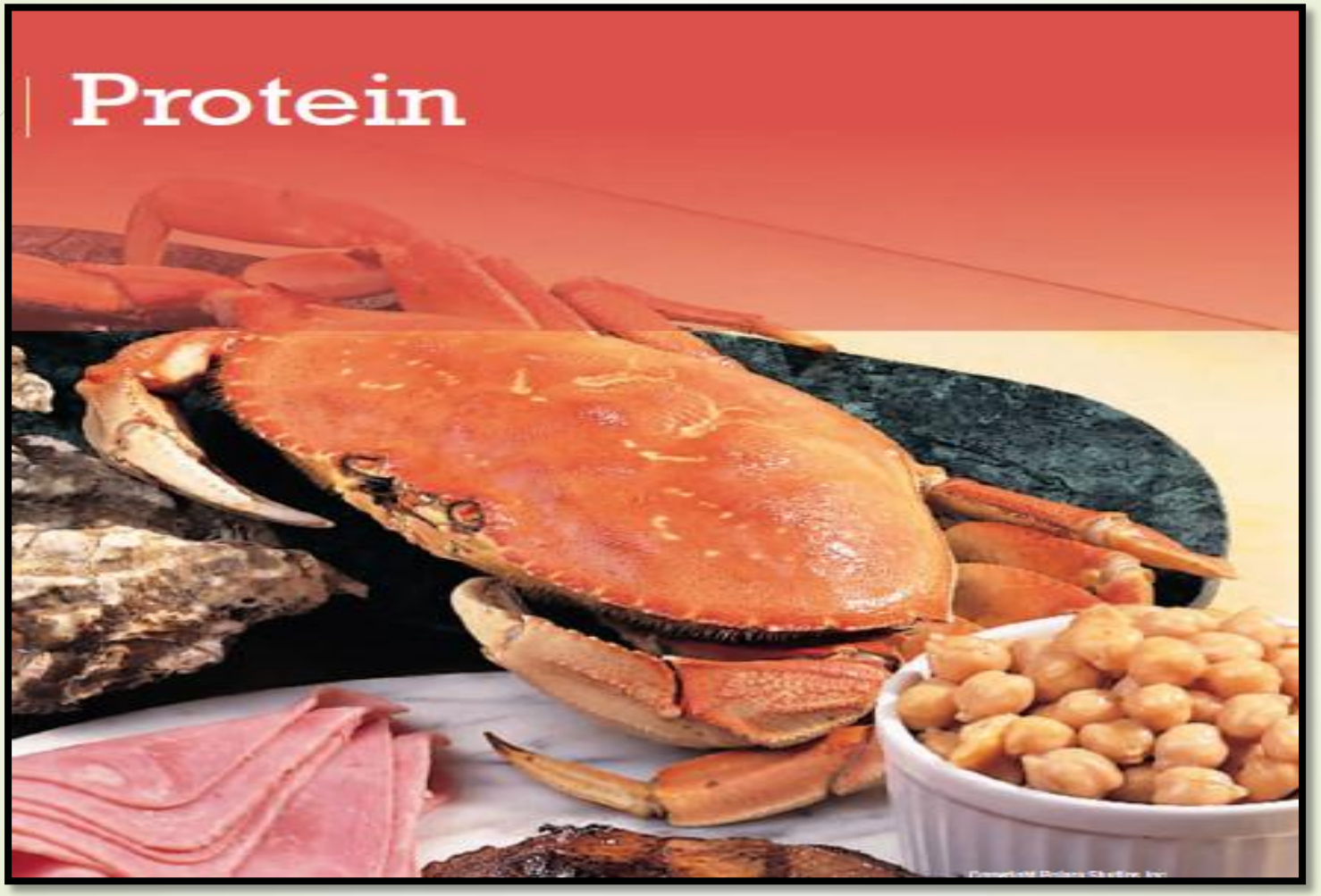

Protein

The Chemist's View of Proteins

Proteins are chemical compounds that contain the same atoms as carbohydrates and lipids—carbon (C), hydrogen (H), and oxygen (O)—but proteins are different in that they also contain nitrogen (N) atoms. These nitrogen atoms give the name amino (nitrogen containing) to the amino acids that form the links in the chains we call proteins.

Roles of Body Proteins

The human body contains an estimated 30,000 or more different kinds of proteins.

The roles of more than 3000 of these proteins are now known, although the number is growing rapidly with the recent surge in knowledge gained from sequencing the human genome.

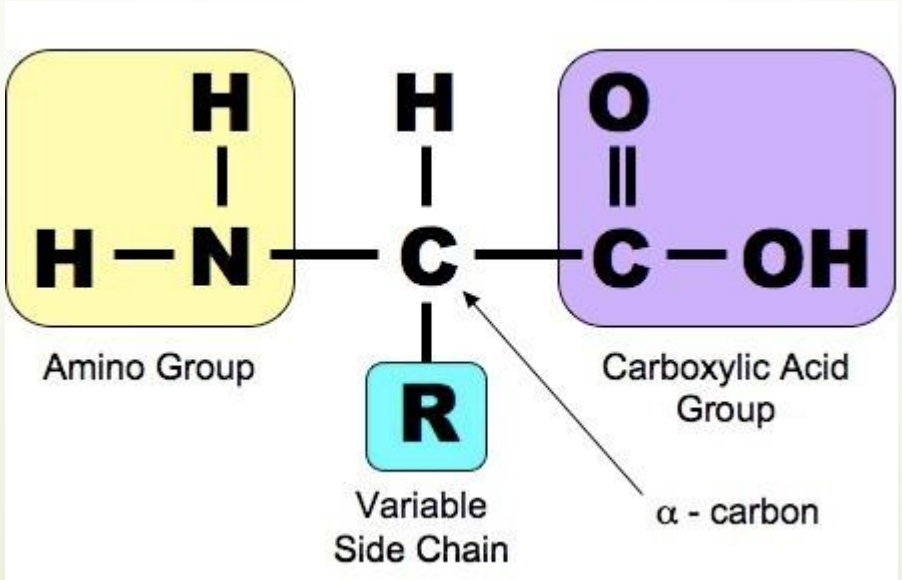
proteins: compounds made from strands of amino acids composed of carbon, hydrogen, oxygen, and nitrogen atoms. Some amino acids also contain sulfur atoms.

amino (a-MEEN-oh) acids: building blocks of protein. Each contains an amino group, an acid group, a hydrogen atom, and a distinctive side group, all attached to a central carbon atom. amino = containing nitrogen

dipeptide: two amino acids bonded together. di = two peptide = amino acid

tripeptide: three amino acids bonded together. tri = three

polypeptide: 10 or more amino acids bonded together. An intermediate strand of between 4 and 10 amino acids is an oligopeptide. poly = many oligo = few



- Chemically speaking, proteins are more complex than carbohydrates or lipids; proteins are made of some 20 different amino acids, 9 of which the body cannot make (they are essential).
- Each amino acid contains a central carbon atom with an amino group, an acid group, a hydrogen atom, and a unique side group attached to it.
- The distinctive sequence of amino acids in each protein determines its shape and function.

	Summary of Functions of Proteins
Structural components	Proteins form integral parts of most body tissues and confer shape and strength on bones, skin, tendons, and other tissues. Structural proteins of muscles allow movement.
Enzymes	Proteins facilitate chemical reactions
Transporters	Proteins transport substance such as lipids, vitamins, minerals, and oxygen around the body
Fluid and electrolyte balance	Proteins help to maintain the distribution and composition of various body fluids
Acid-base balance	Proteins help maintain the acid-base balance of body fluids by acting as buffers
Antibodies	Proteins act against disease agents to fight diseases
Hormones	Proteins regulate body processes. Some, but not all, hormones are made of protein
Energy and glucose	Proteins provide some fuel, and glucose if needed, for the body's energy needs

Protein Turnover and Nitrogen Balance

- Within each cell of the body, proteins are continually being made and broken down, a process known as protein turnover.
- Amino acids must be continuously available to build the proteins of new tissues. The new tissues may be in an embryo, in the muscles of an athlete in training, in a growing child, in the scar tissue that heals wounds, or in new hair and nails.
- Less obvious is the protein that helps replace worn-out cells and internal cell structures. For example, the millions of cells that line the intestinal tract live for three to five days; they are constantly being shed and must be replaced. The cells of the skin die and rub off , and new ones grow from underneath.

PROTEIN TURNOVER

- When proteins break down, their component amino acids are liberated within the cells or released into the bloodstream.
- Some of these amino acids are promptly recycled into other proteins. By reusing amino acids to build proteins, the body conserves and recycles a valuable commodity.
- Other amino acids are stripped of their nitrogen and used for energy.
- Each day, about a quarter of the body's available amino acids are irretrievably broken down and used for energy. For this reason, amino acids from food are needed each day to support the new growth and maintenance of cells.

NITROGEN BALANCE

- Protein requirements may be discussed in terms of nitrogen balance. This occurs when nitrogen intake equals the amount of nitrogen excreted.
- Positive nitrogen balance exists when nitrogen intake exceeds the amount excreted. This indicates that new tissue is being formed, and it occurs during pregnancy, during children's growing years, when athletes develop additional muscle tissue, and when tissues are rebuilt after physical trauma such as illness or injury.
- Negative nitrogen balance indicates that protein is being lost. It may be caused by fevers, injury, surgery, burns, starvation, or immobilization.

protein turnover: the continuous breakdown and synthesis of body proteins involving the recycling of amino acids.

nitrogen balance: the amount of nitrogen consumed (N in) as compared with the amount of nitrogen excreted (N out) in a given period of time. The laboratory scientist can estimate the protein in a sample of food, body tissue, or excreta by measuring the nitrogen in it.

+Nitrogen balance:

- Nitrogen equilibrium (zero nitrogen balance): N in = N out
- Positive nitrogen: N in > N out
- Negative nitrogen: N in < N out

FOOD SOURCES

- Proteins are found in both animal and plant foods .
- The animal food sources provide the highest quality of complete proteins. They include meats, fish, poultry, eggs, milk, and cheese.
- Despite the high biologic value of proteins from animal food sources, they also provide saturated fats and cholesterol. Consequently, complete proteins should be carefully selected from low-fat animal foods such as fish, lean meats, and low-fat dairy products.
- Whole eggs should be limited to two or three a week if hyperlipidemia is a problem.
- Proteins found in plant foods are incomplete proteins and are of a lower biologic quality than those found in animal foods.
- Even so, plant foods are important sources of protein. Examples of plant foods containing protein are corn, grains, nuts, sunflower seeds, sesame seeds, and legumes such as soybeans ,navy beans, pinto beans, split peas, chickpeas, and peanuts.

Table 6-1 *Rich Sources of Proteins*

COMPLETE PROTEINS		INCOMPLETE PROTEINS	
Meats	Eggs	Corn	Grains
Fish	Milk	Peanuts	Nuts
Poultry	Cheese	Peas	Sunflower seeds
		Navy beans	Sesame seeds
		Soybeans	

- Plant proteins can be used to produce textured soy protein and tofu, also called analogues. Meat alternatives (analogues) made from soybeans contain soy protein and other ingredients mixed together to simulate various kinds of meat. Meat alternatives may be canned, dried, or frozen.

- Analogues are excellent sources of protein, iron, and B vitamins.

- Tofu is a soft cheese like food made from soy milk.
- Tofu is rich in high-quality proteins and B vitamins, and it is low in sodium.

- Textured soy protein and tofu are both economical and nutritious meat replacements. Because of their inclusion of either dairy products and eggs or dairy products alone, most individuals who follow lacto-ovo vegetarian or lacto-vegetarian diets will be able to meet their protein requirements through a balanced diet that includes milk and milk products, enriched grains, nuts, and legumes.
- Strict vegetarians who consume no animal products will need to be more careful to include other protein-rich food sources such as soybeans, soy milk, and tofu.

CLASSIFICATION

The classification and quality of a protein depends on the number and types of amino acids it contains. There are 20 amino acids, but only 9 are considered essential to humans .

Most government agencies have adopted the Protein Digestibility-Corrected Amino Acid Score (PDCAAS) as the standard by which to evaluate protein quality.
PDCAAS is based on the profile of essential amino acids and the digestibility of the protein. The highest possible score under these guidelines is 1.00. This amino acid score provides a method to balance intakes of poorer-quality proteins with high-quality dietary proteins.

Source	PDCAAS value
Animal proteins	
Egg	1.00
Milk protein	1.00
Beef/poultry/fish	0.82–0.92
Gelatin	0.08
Plant proteins	
Soybean protein	1.00
Kidney beans	0.68
Whole wheat bread	0.40

Figure 27.19
Relative quality of some common dietary proteins.

Incomplete proteins are those that lack one or more of the essential amino acids. Consequently, incomplete proteins cannot build tissue without the help of other proteins.

The value of each is increased when it is eaten in combination with another incomplete protein, not necessarily at the same meal but during the same day. In this way, one incomplete protein food can provide the essential amino acids the other lacks. The combination may thereby provide all the essential amino acids . When this occurs, the proteins are called **complementary proteins.**

Gelatin is the only protein from an animal source that is an incomplete protein.

Table 6-3 Examples of Complementary Protein Foods

Corn	and	Beans
Rice	and	Beans
Bread	and	Peanut butter
Bread	and	Split pea soup
Bread	and	Cheese
Bread	and	Baked beans
Macaroni	and	Cheese
Cereal	and	Milk

incomplete proteins

proteins that do not contain all of the essential amino acids

complementary proteins

incomplete proteins that when combined provide all ten essential amino acids

FIGURE 5-7 | Complementary Proteins

	Ile	Lys	Met	Trp
Legumes	✓	✓		
Grains			✓	✓
Together	✓	✓	✓	✓

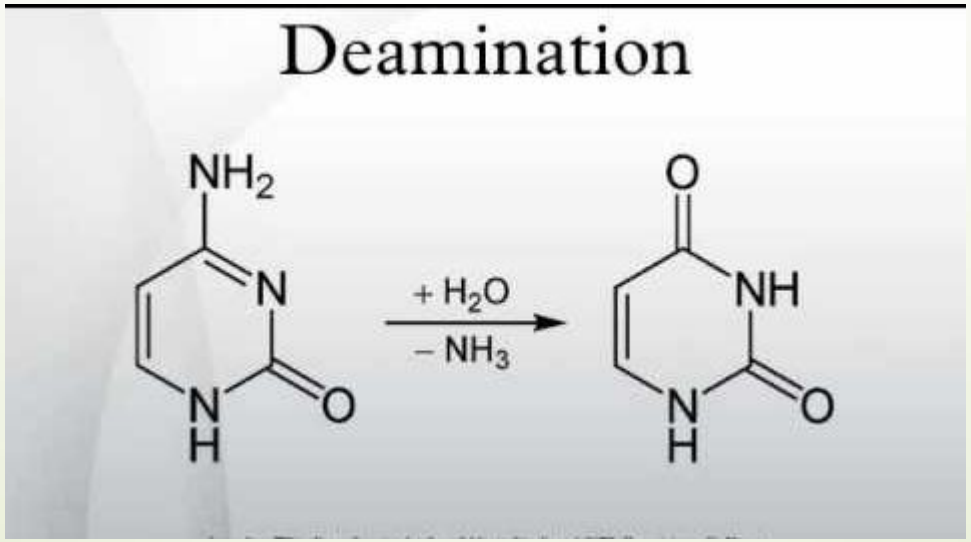
In general, legumes provide plenty of isoleucine (Ile) and lysine (Lys) but fall short in methionine (Met) and tryptophan (Trp). Grains have the opposite strengths and weaknesses, making them a perfect match for legumes.

DIESTION AND ABSORPTION

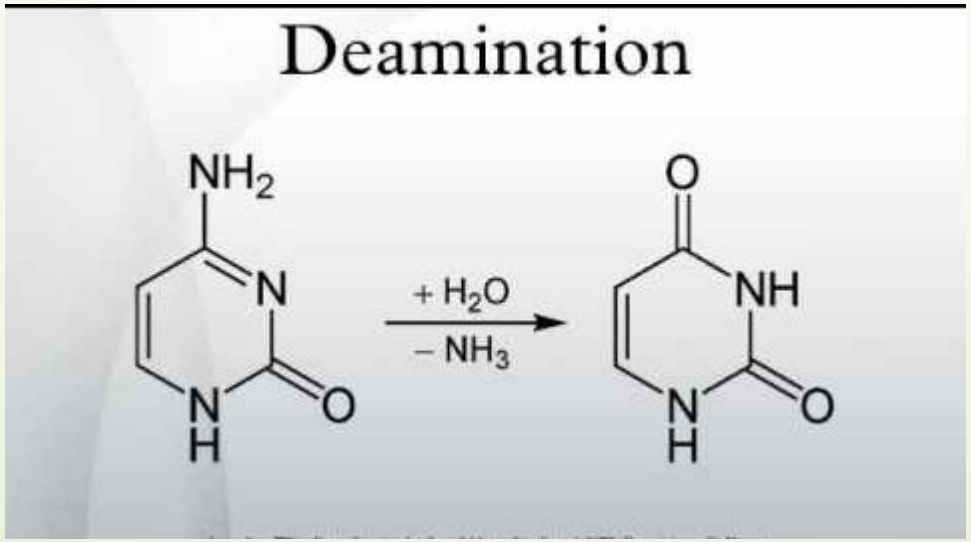
- The mechanical digestion of protein begins in the mouth, where the teeth grind the food into small pieces.
- Chemical digestion begins in the stomach. Hydrochloric acid prepares the stomach so that the enzyme **pepsin** can begin its task of reducing proteins to polypeptides.
- After the polypeptides reach the small intestine, three pancreatic enzymes (**trypsin, chymotrypsin, and carboxypeptidase**) continue chemical digestion.
- Intestinal peptidases finally reduce the proteins to amino acids.
- After digestion, the amino acids in the small intestine are absorbed by the villi and are carried by the blood to all body tissues. There, they are used to form needed proteins.

METABOLISM AND ELIMINATION

- ✓ All essential amino acids must be present to build and repair the cells as needed. When amino acids are broken down, the nitrogen-containing amine group is stripped off.
- ✓ This process is called deamination.



- ✓ Deamination produces ammonia, which is released into the bloodstream by the cells.
- ✓ The liver picks up the ammonia, converts it to urea, and returns it to the bloodstream for the kidneys to filter out and excrete.
- ✓ The remaining parts are used for energy or are converted to carbohydrate or fat and stored as glycogen or adipose tissue.



DIETARY REQUIREMENTS

- One’s protein requirement is determined by size, age, sex, and physical and emotional conditions. A large person has more body cells to maintain than a small person.
- A growing child, a pregnant woman, or a woman who is breastfeeding needs more protein for each pound of body weight than the average adult.
- Extra proteins are usually required after surgery, severe burns, or during infections in order to replace lost tissue and to manufacture antibodies.
- In addition, emotional trauma can cause the body to excrete more nitrogen than it normally does, thus increasing the need for protein foods.

The amount of dietary protein required in the diet varies with its biologic value. The greater the proportion of animal protein included in the diet, the less protein is required.

The *RDA (recommended dietary allowance)* for protein is computed for proteins of mixed biologic value at 0.8 g/kg of body weight for adults, or about 56 g of protein for a 70-kg individual.

People who exercise strenuously on a regular basis may benefit from extra protein to maintain muscle mass; a daily intake of about 1 g/kg has been recommended for athletes.

Women who are pregnant or lactating require up to 30 g/day in addition to their basal requirements. To support growth, infants should consume 2 g/kg/day.

Table 6-4 *Dietary Reference Intakes (DRIs): Protein*

LIFE STAGE GROUP	AGE	PROTEIN (GRAMS/DAY)
Infants		
	0–6 mo	9.1
	7–12 mo	11.0
Children		
	1–3 y	13
	4–8 y	19
Males		
	9–13 y	34
	14–18 y	52
	19–30 y	56
	31–50 y	56
	51–70 y	56
	> 70 y	56
Females		
	9–13 y	34
	14–18 y	46
	19–30 y	46
	31–50 y	46
	51–70 y	46
	> 70 y	46
Pregnancy		
	14–18 y	71
	19–30 y	71
	31–50 y	71
Lactation		
	14–18 y	71
	19–30 y	71
	31–50 y	71

TOO MUCH PROTEIN—HEALTHY?

The American Heart Association does not recommend diets high in protein. Eating too much protein restricts healthful foods that provide essential nutrients. If carbohydrates are lowered with the increased protein, the body will not be able to completely burn fat. Extra protein is stored as fat. Animal protein also contains saturated fat, which can lead to coronary heart disease, stroke, and several kinds of cancer.

(Source: Adapted from American Heart Association, January 2009.)

Protein Excess

- It is easy for people living in the developed parts of the world to ingest more protein than the body requires. There are a number of reasons why this should be avoided.
- The saturated fats and cholesterol common to complete protein foods may contribute to **heart disease** and provide more calories than are desirable.
- Some studies seem to indicate a connection between long-term high-protein diets and **colon cancer** and **high calcium excretion**, which depletes the bones of calcium and may contribute to **osteoporosis**.
- People who eat excessive amounts of protein-rich foods may ignore the also essential fruits and vegetables, and excess protein intake may put more demands on the liver (which converts nitrogen to urea) and the kidneys to excrete excess urea than they are prepared to handle.
- Therefore, the National Research Council recommends that protein intake represent no more than 15% to 20% of one's daily calorie intake and not exceed double the amount given in the table of DRIs (Table 6-4).

Protein and Amino Acid Supplements

- ✓ Protein and amino acid supplements are taken for a number of reasons, such as “bulking up” by athletes, growing fingernails, and sparing body protein in weight loss.
- ✓ It is weight lifting, not protein bars or protein supplements, that builds muscles. Fingernails have never been affected by extra protein, and dieters need a balanced diet using the guidelines of My Pyramid.
- ✓ High-quality protein foods are more biovailable than expensive supplements.
- ✓ Single amino acids can be harmful to the body and never occur naturally in food. The body was designed to handle food, not supplements.
- ✓ If a single amino acid has been recommended, it is very important that a physician be consulted before the amino acid is used.

Protein Deficiency

- When people are unable to obtain an adequate supply of protein for an extended period, muscle wasting will occur, and arms and legs become very thin.
- At the same time, **albumin (protein in blood plasma) deficiency will cause edema,** resulting in an extremely swollen appearance. The water is excreted when sufficient protein is eaten. People may lose appetite, strength, and weight, and wounds may heal very slowly.
- Patients suffering from edema become lethargic and depressed.
- These signs are seen in grossly neglected children or in the elderly , poor, or incapacitated.
- It is essential that people following vegetarian diets, especially vegans, carefully calculate the types and amount of protein in their diets so as to avoid protein deficiency.

Protein Energy Malnutrition (PEM)

- People suffering from **protein energy malnutrition (PEM)** lack both **protein** and **energy-rich foods**.
- Such a condition is not uncommon in developing countries where there are long-term shortages of both protein and energy foods.
- Children who lack sufficient protein do not grow to their potential size. Infants born to mothers eating insufficient protein during pregnancy can have permanently impaired mental capacities.
- Two deficiency diseases that affect children are caused by a grossly inadequate supply of protein or energy or both.

- **Marasmus,** a condition resulting from severe malnutrition, afflicts very young children who lack both energy and protein foods as well as vitamins and minerals. The infant with marasmus appears emaciated but does not have edema. Hair is dull and dry, and the skin is thin and wrinkled.

- The other protein deficiency disease that affects children as well as adults is **kwashiorkor .**
- Kwashiorkor appears when there is a sudden or recent lack of protein-containing food (such as during a famine).
- This disease causes fat to accumulate in the liver, and the lack of protein and hormones results in edema, painful skin lesions, and changes in the pigmentation of skin and hair.
- The mortality rate for kwashiorkor patients is high.
- Those who survive these deficiency diseases may suffer from permanent mental retardation.
- The ultimate cost of food deprivation among young children is high, indeed.

Marasmus or old child syndrome

Kwashiorkor

Comparison of the features of kwashiorkor and marasmus

Feature	Kwashiorkor	Marasmus
Growth failure	Present	Present
Wasting	Present	Present, marked
Edema	Present (sometimes mild)	Absent
Hair changes	Common	Less common
Mental changes	Very common	Uncommon
Dermatosis, flaky-paint	Common	Does not occur
Appetite	Poor	Good
Anemia	Severe (sometimes)	Present, less severe
Subcutaneous fat	Reduced but present	Absent
Face	May be edematous	Drawn in, monkey-like
Fatty infiltration of liver	Present	Absent

FAO/WHO

THANK YOU