Introduction: A protein is any one of a large number of organic compounds that make up living organisms and are essential to their functioning. First discovered in 1838, proteins are now recognized as predominant ingredients of cells, making up more than 50 percent of the dry weight of animals. The word protein is coined from the Greek proteios, or “primary.”

Protein molecules range from the long, insoluble fibers that make up connective tissue and hair to the compact, soluble globules that can pass through cell membranes and set off metabolic reactions. Humans are made up of an estimated 30,000 different proteins, of which only about 2 percent have been adequately described. Proteins in the diet serve primarily to build and maintain cells, but their chemical breakdown also provides energy, yielding close to the same 4 calories per gram as do carbohydrates.

Besides their function in growth and cell maintenance, proteins are also responsible for muscle contraction. Digestive enzymes are proteins, as are insulin and most other hormones. The antibodies of the immune system are proteins, and proteins such as hemoglobin carry vital substances throughout the body.

Not all proteins are equal, just as all carbohydrates are not the same. While glycogen is formed by chains of glucose subunits, proteins are composed of chains of amino acids. The chains of amino acids in proteins are linked by peptide bonds and each protein is a unique combination of amino acids.

Protein is composed of about 20 different amino acids which in turn, are composed of carbon, hydrogen, oxygen, nitrogen, and sometimes sulfur. In a protein molecule these acids form peptide bonds—bonds between amino and carboxyl (COOH) groups—in long strands (polypeptide chains). The almost numerous combinations in which the acids line up, and the helical and globular shapes into which the strands coil, help to explain the great diversity of tasks that proteins perform in living matter. In the body, there are two types of amino acids: essential and non-essential. There are eight essential amino acids that cannot be synthesized by the body. Because of this, you must consume these essential amino acids regularly in your diet. The remaining 12 non-essential amino acids are very important, but can be synthesized in the body at a rate that equals demand. Eight essential amino acids are needed to maintain health in humans: leucine, isoleucine, lysine,
methionine, phenylalanine, theonine, tryptophan, and valine. All of these are available in proteins produced in the seeds of plants, but because plant sources are often weak in lysine and tryptophan, nutrition experts advise supplementing the diet with animal protein from meat, eggs, and milk, which contain all the essential acids.

Complete proteins include all of the essential amino acids, and are therefore better quality proteins. Incomplete proteins are missing one or more of the essential amino acids, and are therefore of lower quality.

**Protein measurement tools:** More important than looking at the amino acid profile of certain proteins are the analytical tools developed to measure protein’s effectiveness. Various tools are used to measure digestibility, amino acid profile, muscular growth and absorption. Though no single tool gives a complete picture of a protein’s effectiveness, a chart outlining all the measures allows for a more complete assessment.

The **Protein Digestibility Corrected Amino Acid Score (PDCAAS)** is the USDA’s officially approved method of scoring protein quality.

**Amino Acid Score** is a count of total amino acids in a protein and adjusted for their make-up.

Another method used to measure protein quality is the **Protein Efficiency Ratio (PER)**. The PER rating is based upon the evaluation of the growth of animals consuming a fixed amount of dietary protein from a single source. As the PER increases, so does the quality of the protein.

**Biological Value (BV)**, another measure of protein quality, measures the amount of protein that is retained from the absorbed protein for maintenance and growth. It measures the fraction of the nitrogen in the diet that remains after the nitrogen losses in the waste products have been subtracted.

### Protein Quality Comparison Chart

<table>
<thead>
<tr>
<th>Protein Type</th>
<th>Protein Digestibility Corrected Amino Acid Score (PDCAAS)</th>
<th>Amino Acid Score</th>
<th>Protein Efficiency Ratio (PER)</th>
<th>Biological Value (BV)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Whey Protein</td>
<td>1.00*</td>
<td>1.14</td>
<td>3.2</td>
<td>100</td>
</tr>
<tr>
<td>Whole Egg</td>
<td>1.00</td>
<td>1.21</td>
<td>3.8</td>
<td>88-100</td>
</tr>
<tr>
<td>Casein</td>
<td>1.00</td>
<td>1.00</td>
<td>2.5</td>
<td>80</td>
</tr>
<tr>
<td>Soy Protein</td>
<td>0.99</td>
<td>0.99</td>
<td>2.2</td>
<td>74</td>
</tr>
<tr>
<td>Beef Protein</td>
<td>0.92</td>
<td>0.94</td>
<td>2.9</td>
<td>80</td>
</tr>
<tr>
<td>Canned Kidney Beans</td>
<td>0.68</td>
<td>NA</td>
<td>NA</td>
<td>49</td>
</tr>
<tr>
<td>Wheat Gluten</td>
<td>0.25</td>
<td>0.47</td>
<td>NA</td>
<td>54</td>
</tr>
</tbody>
</table>

*Whey protein has a PDCAAS of 1.14. The reported score is 1.0, which is the maximum value allowed by the USDA for reporting purposes.*
**Isolate, Hydrolysate, Concentrate:**
Isolates are the purest form of protein and contain 90 - 95% protein. Isolates are formed using either ion exchange or cross filtration, with either method resulting in a protein with little (if any) fat or lactose (in milk proteins). Concentrates are available in a number of different types from 25% protein content to 89% protein content, containing some fat, lactose and minerals. As a rule, when the protein level increases the amount of lactose decreases. Whey protein concentrate at 80% protein content is the form most readily available as a protein powder supplement. The process of hydrolysis breaks the protein chains down into smaller segments called peptides. Hydrolyzed protein is more easily digested (BV=100) and has a reduced potential for allergic reactions versus non-hydrolyzed proteins while remaining very high quality. Sports nutrition products and infant formulas often use hydrolyzed proteins for these reasons.

**Casein:** Casein is the major protein found in cow’s milk (80-82%). In fact, Casein is what is used to make cheese. Most meal replacement products, and some protein powders, today use Casein as one of their main ingredients. Casein contains a high quantity of alpha Casein—a protein found only in animal milk, which is not easily digestible by humans. In fact, science shows that Casein in high amounts may actually delay gastric emptying. This is why Casein is considered a “slow” protein. What does this mean to you? Essential amino acids and nitrogen are released more slowly, and you need both to build and repair muscle. An interesting fact: human breast milk contains 10-50% Casein and 50-90% whey, whereas milk from a cow contains 80% Casein and 20% Whey.

**Whey Protein:** Whey protein is a high quality, complete protein and a rich source of branched chain amino acids and essential amino acids which are critically important for individuals who are involved in sports, exercise, or do resistance training. Whey protein is a dairy protein and comes from cow's milk, not animal flesh. In the United States whey protein is a by-product of the cheese making process and in most cases a microbial type of rennet is used in the manufacturing process. Whey protein is acceptable for any vegetarian diet that allows dairy products including lacto-ovo, lacto, and ovo types of vegetarian diets.

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**notes from the Endurance Research Board**
Soy protein is an abundant and inexpensive protein source. Even though soy protein is vegetable based, it contains a wide range of essential amino acids. The amino acids in soy protein parallel those of animal based protein, however soy protein is lower in methionine. Although methionine is considered a rate limiting amino acid, the FDA suggests the typical American diet generally makes up for its lower availability in soy products. Soy protein has very high concentrations of the amino acids lysine and leucine, which are necessary for maintenance of nitrogen levels. Long and short-term studies have supported the use of soy protein concentrates as the sole source of protein to maintain healthy nitrogen balance in healthy adults. Research supports the digestibility of soy being comparable to that of other high quality protein sources such as dairy and animal based products. While soy flour can cause flatulence (due to our lack of the enzyme alpha galactosidase), the process of conversion to soy isolates, those generally found in supplements, reduces this side effect. Soy protein supports health in many ways: as a source of dietary fiber it has been linked with controlling blood cholesterol, cancer prevention, and improving glucose tolerance. Beyond these effects, the isoflavones from soy protein have been associated with prevention of bone loss and the symptoms of menopause. While the lower cost and health benefits of soy make it an attractive option when considering protein supplementation the gastric side effects may be inhibitory to some athletes.

By Sally Warner MA, Ph.D.

**Egg Protein:** Egg protein is considered by many to be the gold standard in food
proteins. Egg is a complete protein, easily digestible and assimilated. The only downside to egg protein is found in the high cholesterol content of the yolk. As a food there is no better source of protein available, however when you turn to supplements egg proteins are more difficult to work with. The mixability and palatability of concentrated egg proteins is not as good as soy, whey or milk which is why you rarely see egg as the primary protein in supplemental shakes.

**Recommendation:**
It is a commonly held belief that athletes, particularly bodybuilders, have greater requirements for dietary protein than sedentary individuals. The evidence in support of this contention is controversial, although a growing number of researchers advocate protein supplementation for endurance athletes between 1.2 – 1.6g/kg. For a 70kg (155lb person) this means 84g – 112g of protein daily, preferably consumed in five or more meals per day. Though the case for athletes favors whey hydrolysate as the protein of choice, there is a strong argument for soy isolate due to its health benefits. Soy’s heart health, cholesterol and cancer prevention benefits may sometimes outweigh the benefits of whey. A handful of supplements combine the two proteins, assuring that you benefit from each protein’s attributes.

There are three primary components to complete recovery: 1) glycogen replenishment, 2) water and electrolyte replenishment, and 3) muscle repair. As a recovery tool, protein’s main role is to repair damaged muscle tissue. Without a positive nitrogen balance through the consumption of protein, your body will not have the tools necessary to repair exhausted muscles and in time you will slowly but surely lose muscle. And consuming a high protein shake or food following exhaustive exercise without paying attention to the other two components is a common mistake to be avoided.

There is some evidence, although limited, that protein consumption during exercise can help shuttle glycogen to your working muscles. This, in effect, will spare glycogen and allow you to workout or race longer. More research is needed in this area to further solidify this theory.

Post-exercise, it is critical that you consume a high quality protein with a high glycemic carbohydrate. High glycemic carbohydrates help shuttle glycogen and protein to the cell. This is the foundation of proper recovery and should be done religiously. The best ratio of carbohydrates to protein is somewhere between 3:1 and 5:1. Also keep in mind that there is a short window of opportunity immediately following exercise when your insulin sensitivity is at its highest. Recovery is maximized if you consume your carbohydrate/protein drink immediately following exhaustive exercise.

(See added recommendations by Neal Henderson MS CSCS on the following page)
notes from the Endurance Research Board

Protein recommendation:
Most athletes have dialed in their nutrition needs pretty well on the day before and the day of competition, but the day to day nutritional practices are what allow you to train effectively, recover, and ultimately improve.

As athletes, our protein needs are higher than the average person, but consuming excessive protein will not increase strength, or speed recovery. There is a maximum quantity of protein that the body can digest and use and any excess gets converted to fat or carbohydrates. The highest rates of protein turnover that have been observed in athletes are at 2 grams of protein per kilogram of body weight. Though, the US RDA for protein is less than 1/2 of that value at .8 grams/kilogram. The recommendations for endurance athletes who are involved in moderate training is 1 to 1.2 grams/kilogram of body weight. During very heavy training, shooting for 1.5 to 2 grams/kilogram would be well advised. Again, the quality of the protein should not be overlooked.

For athletes in training with busy schedules (e.g. work, family, social events, etc.), getting in quality protein at the right time is important. Research indicates that post-exercise meals that include a combination of both carbohydrate and protein improves the rate of glycogen re-synthesis in the muscle through a more efficient insulin response, increased growth hormone and decreased cortisol levels leading to improved recovery. For this reason, it is recommended that all endurance athletes incorporate a high quality protein and carbohydrate recovery meal within the first 30 minutes following exercise. Post exercise drink supplements can help meet your needs in a simple pre-mixed or "just add water" formula. Whey protein supplements are many times preferred due to its high concentration of glutamine. Glutamine deficiency has been observed in over-trained athletes, and in athletes with depressed immune function.

By Neal Henderson MS CSCS

References:
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"Protein," Microsoft® Encarta® Online Encyclopedia 2003


