PROTEIN

Economics of Protein -
a Documentary

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Table of Contents

Key take aways in this documentary

- Protein is a daily essential and irreplaceable nutrient for the human diet. Proteins are among the planet's most complex chemical molecules and are the hallmark of living organisms. Science has not yet discovered enough about how proteins function, to be able to make precise nutritional recommendations.
- Proteins are predominantly found in animal-sourced foods of meat, dairy and eggs. Meaningful amounts of protein are also contained in nuts, pulses, and cereals. Fruits and vegetables supply negligible amounts of proteins. In plant-based sources, the proteins have significantly reduced bioavailability to the human metabolism and are embedded in multiple amounts of carbohydrates or fats, causing high caloric intake.
- Only high-income group countries and mainland China achieve a daily supply of 100 grams of protein or more per person. Lower income countries reach less than half of this amount per person. In the high-income group of countries, around 60% of the proteins are derived from animals.
- On a purchasing-power-parity adjusted basis, poultry meat and eggs provide the consistently least expensive bioavailable protein to all global consumers.
- For humans, it is more efficient to feed low quality cereal proteins to animals and gain high quality proteins from them, than to eat these cereal proteins themselves. From a resource utilization point of view, animals are the most efficient method to produce bioavailable proteins, contrary to the frequent narrative that livestock utilization is inefficient.
- The high metabolic cost for life to produce proteins make it a comparatively expensive part of food. On a purchasing-power-parity adjusted basis, the cost of the basket of actual proteins available, is broadly the same around the world and across all income groups, namely around 0.40 USD per 10 grams of bioavailable proteins.
- On the assumption that an average person needs a daily supply of around 100 grams of proteins, only around 40% of the global population can afford to purchase this much protein in their foods. Even fewer than that actually purchase them. On the same assumption, the world should consume about 80% more proteins than is currently available. By the year 2050, the gap might grow to 140%.
- Government-sponsored nutrition committees recommend a minimum of 0.8 grams of protein per kilogram of bodyweight per day for a healthy adult living a sedentary lifestyle. This is equivalent to about 50 grams per day for the average adult. Epidemiological evidence from real life circumstances, where in addition to healthy, sedentary adults, there are also young, old, ill, pregnant or physically active persons in a society, rather points to an average need of 100 grams of proteins per day, equivalent to 17% of the energy intake per day.

Coming Next: Biological and Evolutionary Perspectives on Protein

In May 2023, GOALSciences will publish a second documentary on proteins, investigating the biological and evolutionary context of protein in human nutrition. The documentary will review the elementary metabolic roles that protein has. It will highlight how the food supply changed between early paleolithic to late paleolithic people, and what appears to have happened during the neolithic and bronze age agricultural revolutions. The documentary reviews the rise of metabolic disease, especially diabetes, and how protein-rich foods may be deployed to combat this crisis. The documentary will also review some current epidemiological evidence on the role of proteins in human nutrition.

The Evolutionary Perspective on Protein

Peer Ederer
May 2023

GOAL Sciences

1. Proteins – an introductory biography for context

This chapter does not cover economics aspect of proteins. It provides background elementary biochemistry to the subject matter for context.

Summary:
Protein is a daily essential and irreplaceable nutrient for the human diet. Proteins are among the planet's most complex chemical molecules and are the hallmark of living organisms. Science has not yet discovered enough about how proteins function, to be able to make precise nutritional recommendations.

Chemically speaking, a protein is a long chain of amino acids which is folded into a bundle of helix and sheet arrangements. Proteins typically consist of between 50 and 2000 amino acids (with an average at around 400), where each kind has its own sequence of them. The sequence makes the protein take different shapes, which then have different functions in the body. Proteins do their work both through the mechanics which a particular shape permits when interacting with other molecules, and the electrochemical bonding characteristics of the surface of these shapes. Proteins are among the most complex chemical molecule known in nature, which makes them a brittle compound that can easily break, and which makes them metabolically expensive to produce.

Amino acids ultimately take their name from the ancient Egyptian god Amun, whose worshippers, the Ammonians, used ammonium chloride in their rites. Both ammonium chloride and amino acids are characterized by containing nitrogen, but are otherwise not related.

Amino acids consist of three groups of molecules: the amino group H_2N, the carboxyl group COOH and the side group R which consists of various combinations of further carbon (C), hydrogen (H), nitrogen (N) and oxygen (O) molecules. The R side group determines the chemical characteristics of the amino acid. A common shortcut to measuring the amount of protein in a substance, is to measure the contained amount of nitrogen, because its presence is what makes it different to the simple carbohydrates and fats which consist only of C, H and O.

Side note:

The word protein is derived from the Greek word for "primary", which was first used by the Dutch chemist and medical doctor Gerardus Johannes Mulder in his 1838 publication on "The composition of some animal substances". All life relies on proteins as its primary tool. Indeed, proteins are what makes life being life. The origin of life is thought to be when "lifeless" amino acids first chained themselves to lipids, enabling stable spherical membranes which separate an inside from an outside. This would have created the opportunity for an "inside" reaction chamber which could maintain chemical and physical reaction sequences that were independent of the "outside".

Notes & Sources

The Shape and Structure of Proteins. Molecular Biology of the Cell. 4th edition. https://www.ncbi.nlm.nih.gov/books/NBK26830/#:~:text=Proteins%20come%20in%20a%20wide,other%2C%20as%20we%20discuss%20below.

Bulletin des Sciences Physiques et Naturelles en Néerlande. https://archive.org/details/bulletindesscien00leyd/page/104/mode/2up

Prebiotic amino acids bind to and stabilize prebiotic fatty acid membranes https://www.pnas.org/doi/full/10.1073/pnas.1900275116

Looking for LUCA, the Last Universal Common Ancestor https://astrobiology.nasa.gov/news/looking-for-luca-the-last-universal-common-ancestor/#:~:text=Around%204%20billion%20years%20ago,the%20Last%20Universal%20Common%20Ancestor.

6 Most Likely Places for Alien Life in the Solar System https://www.space.com/15716-alien-life-search-solar-system.html

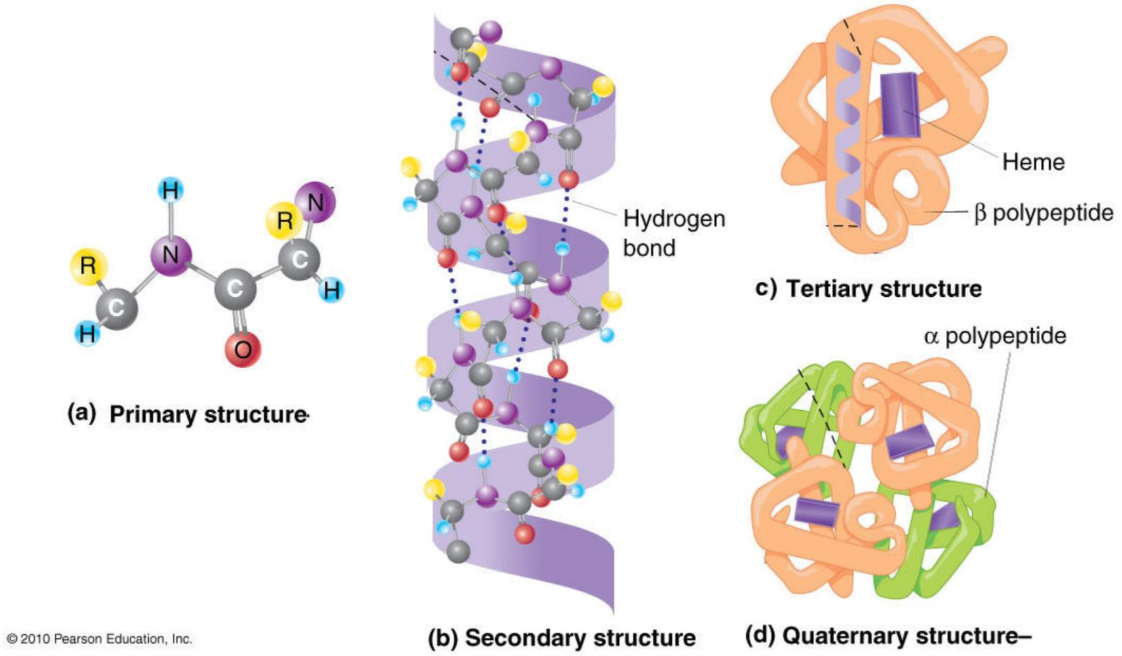
If and when these inside reactions reproduced further identical membranes containing the same inside processes, it would become self-perpetuating, which means it would have started the process of life.

A perpetually self-reproducing chain of amino acids would have been the first protein, the essential enabler of life. It is believed that this happened around 4 billion years ago, near or inside a hyperthermal vent on the ocean floor of the young Earth planet. LUCA, the Last Universal Common Ancestor to all known life traceable by genes, will have emerged soon from these circumstances. There might have been other life branches before LUCA, that since have died out without a trace on the investigable Earth's surface. There might yet be other life branches to be identified deep inside the Earth mantle or on other celestial bodies such as Saturn's moons Enceladus and Titan, or in the upper atmosphere of Venus, but for the time being, LUCA and its ancestors is all there has been in terms of known life.

Notes & Sources

Figure 1:
iGenetics 3rd ed
Figure after © 2010 PJ Russell, all text material © 2014 by Steven M. Carr

Figure 1: Schematic representation of various structures of protein



a) The primary structure is the succession of amino acid residues (C=carbon, N=nitrogen, H=hydrogen, O=Oxygen, R=side group)

(b) The secondary structure is the 3-D arrangement of the right-handed alpha helix (shown here), or alternative structures such as a beta-pleated sheet.

(c) The tertiary structure is the 3-D folding of the alpha helix (show as a purple ribbon), shaped by structures such as proline corners, disulfide bridges between cysteine residues, and electrostic bonds.

(d) Where more than one protein chain contributes to the protein, the quaternary structure is the arrangement of these subunits. In hemoglobin as shown here, the quaternary structure comprises two alpha and two beta polypeptides, held together by elecrostatic bonds.

While there are around 500 different amino acids known in nature, all Earth-life's proteins of today are constructed from just 22 of them (two of which are rarely used - most organisms, including all animals, use only 20). Whether in the beginning of life there were more than those 22 or less, is not known. It is standard practice of organisms not to be able to produce all their required 20 amino acids themselves, but to eat many of them instead. In the case of humans, the body cannot produce nine itself, but must obtain them through food. Therefore, these 9 are called essential. Of the other 11, eight are conditionally essential, meaning if the body is weakened or ill, then they also may need to be supplied via food.

Notes & Sources

An Evolutionary Perspective on Amino Acids
https://www.nature.com/scitable/topicpage/an-evolutionary-perspective-on-amino-acids-14568445/

20 Amino Acids that Make Up Proteins
https://www.ajinomoto.com/amino-acids/20-amino-acids

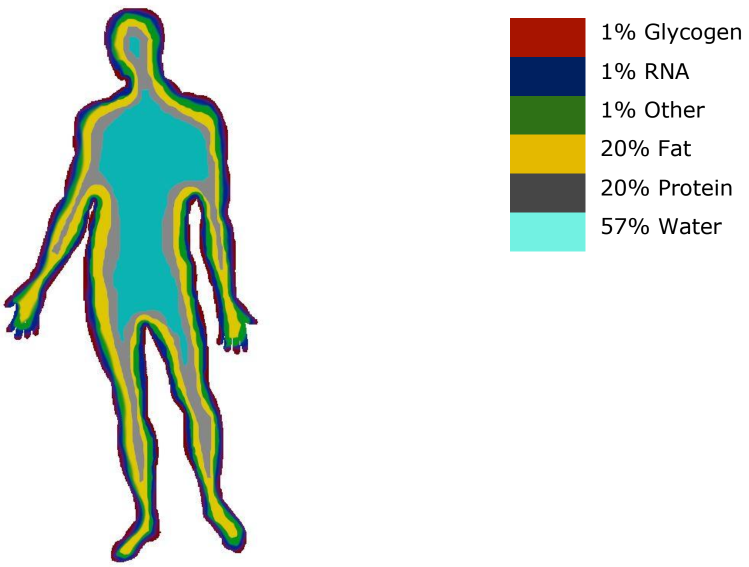
The human body constructs about 100,000 different proteins from these 20 amino acids, and each of them fulfil a variety of different functions in the body. Proteins are the construction material for body cells, organize the transport mechanism for exchanging material between cells, and are the basis for the communication network that instructs the cells what to do. As proteins are brittle, the biological functioning of the body relies on these proteins being constantly dismantled and rebuilt as a matter of preventive maintenance. Thus, the body has a constant need for proteins to be replenished.

Normal weight mammals consist of 20% of proteins, around 10% fats, 1% RNA, 1% glycogen, 1% various, and the remainder water. (Humans are an untypically fat primate, featuring 14% fat for a male well-trained lean athlete. Normal weight humans have around 20% fat content. Other primates such as Chimpanzees have only 9% fat. Insects and bacteria have similar ratios but more variation of protein content, ranging from 15% to 25% protein content. In the plant domain, leaves may contain up to 25% of proteins, while plant stems and trunks usually have only low single digits of protein content.

Comparative Analyses of Chromatin Landscape in White Adipose Tissue Suggest Humans May Have Less Beigeing Potential than Other Primates
https://academic.oup.com/gbe/article/11/7/1997/5522369

Figure 2:
Illustration by GOALSciences

Figure 2: Schematic view of bodily components



After proteins enter the human body as food, the digestive system breaks them down into fragments of amino acid chains (called oligopeptides) or individual amino acids, which will eventually be absorbed by the lining of the intestines and from there are mostly transported to the liver. The liver regulates the supply of amino acids in the blood stream and makes them available for the body to construct itself. Each day, the average human body dismantles (catabolic) and rebuilds (anabolic) about 190 grams of protein from amino acids in its body cells. (The rate is on average 3 grams per kilogram of body weight per day, or about 1.6% of the entire protein mass of an average 62.5-kilogram person.)
This means, for instance, that every morning when looking in a mirror, between 1% and 2% of what one sees was dismantled and rebuilt over the last 24 hours. Put another way, roughly every eight to nine weeks, most of the human body has been completely recycled on average.

Side box

Protein catabolism is different from body cell longevity. The body cells live on average around 10 years, with large variations. Some intestinal cells live only for a few days, while some nerve cells never die. Muscle cells live on average about 15 years, while skeletal cells live for about 10 years until replacement. The much faster replenishment rate of protein dismantling and rebuilding occurs inside the cells without the cell itself dying.

Unlike for other nutrients such as fats, sugars, vitamins or minerals, the body does not store proteins in a reservoir. There is a small circulating pool of free amino acids which is the result of the constant dismantling and rebuilding process. The dismantling produces a non-negligible amount of energy. As much as 50% of the resting energy turnover of muscles and intestinal organs may be supplied by the oxidization ("burning") of amino acids.

While the body is constantly dismantling proteins, the signal for the anabolic rebuilding of protein ("protein synthesis") depends on the availability of amino acids in the blood stream, in particular the prominent but also controversial branched chain amino acids (BCAA). If there is a lack of amino acids in the blood stream, protein rebuilding is delayed and slowed down. Therefore, athletes are advised to take in high-concentrated protein foods immediately after exercise, so that amino acids can be rapidly supplied into the blood stream, as it is known that exercise itself accelerates the dismantling of proteins. If there is a shortage of particular amino acids for necessary protein synthesis, then the body will accelerate catabolic protein dismantling in the muscles in order to obtain the missing amino acids.

If protein shortage persists, the body may deplete the muscular proteins to the point of the muscle cells dying and disintegrating.

Notes & Sources

5.4: Protein Digestion, Absorption and Metabolism
https://med.libretexts.org/Courses/American_Public_University/APUS%3A_An_Introduction_to_Nutrition_(Byerley)/APUS%3A_An_Introduction_to_Nutrition_1st_Edition/05%3A_Proteins/5.04%3A_Protein_Digestion_Absorption_and_Metabolism#:~:text=Once%20passed%20through%20the%20membrane,known%20as%20the%20enterohepatic%20circulation

Life span of human cells defined: most cells are younger than the individual
https://cordis.europa.eu/article/id/24286-life-span-of-human-cells-defined-most-cells-are-younger-than-the-individual

Energy Metabolism in the Liver
https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4050641/

5 Proven Benefits of BCAAs (Branched-Chain Amino Acids)
https://www.healthline.com/nutrition/benefits-of-bcaa

This is a catastrophic event because premature cell death cannot be reversed. The number of muscle cells are largely fixed during early puberty and do not change much thereafter (or else it would be cancer). However, the supply of critical proteins to more survival-critical body tissue such as organs or brains, is more important to the body than the maintenance of proteins in muscle cells, or the muscle cells themselves. This happens in particular during crisis such as a strong immune response where either some amino acids are needed more often than usual, or because some amino acid production pathways do not function anymore.

The body aches experienced while being ill, are the result of the body dismantling muscle cell protein at an accelerated rate in order to mine essential amino acids

The digestive rate of absorption of amino acids may be limited. For a healthy adult it may be optimized at 0.4 grams per kilogram of bodyweight per meal, or for an average 62.5 kilogram person, 25 grams of protein per meal, or around 17% of energy intake. To avoid shortages, it is therefore important to maintain a constant flow of food-provided amino acids into the system. If there are too many amino acids at any given time, then the liver will convert them into either fats or sugars as energy store. This is a non-reversible process, and releases nitrogen in the form of ammonia, which is a highly toxic substance and needs to be quickly excreted in the form of urea towards urine. There are capacity limits to this excretion process. A diet with too much protein exceeding 35% of daily energy leads to liver and kidney inflammation and severe disruptions in the intestines. In this way, both too little and too many proteins in the food supply can be detrimental to health.

The liver regulates not only the amino acid supply for protein construction for the body, but also the distribution of fats and sugars, as well as filters out toxins from the blood stream and much more. The liver runs about 500 different functions and is the busiest part of the body. The liver consumes 18% of the resting energy of the body, compared to 20% for the brain, 8% for the kidneys, 9% for the heart and 22% for the skeletal muscles. After the brain, the liver is considered the most complex organ of the body. It is also the only organ which can regrow itself from as little as 25% of its original size. 80% of the liver consist of hepatocyte cells which do most of the work load of the liver. The regulatory process by which the liver cells "decide" what to do with the amino acid flows at any given time, which levels to maintain in the blood stream, how many to keep as a reserve, and how many to convert into which kinds of fats or sugars, is influenced by numerous messaging systems in the body, which all pass through the liver. These include various hormonal signals, the sympathetic and parasympathetic neuronal signals, and chemical balances of the various material flows in the different body fluids.

Notes & Sources

How much protein can the body use in a single meal for muscle-building? Implications for daily protein distribution
https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5828430/

Protein turnover, amino acid requirements and recommendations for athletes and active populations
https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3854183/#:~:text=Total%20protein%20synthesis%20in%20adult,day%E2%88%921%20(18).

Specific metabolic rates of major organs and tissues across adulthood: evaluation by mechanistic model of resting energy expenditure
https://pubmed.ncbi.nlm.nih.gov/20962155/

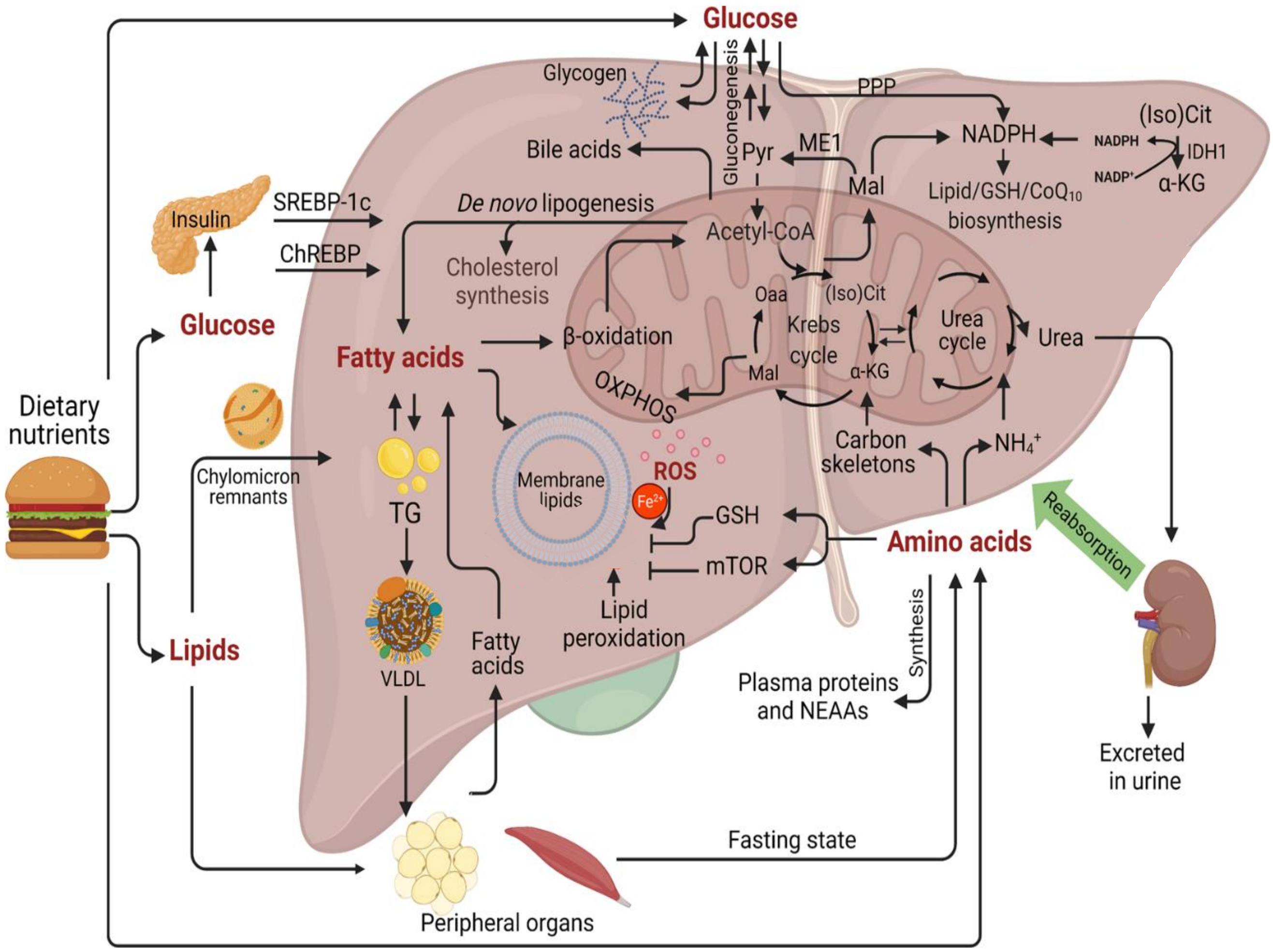
The comprehensive functioning of this messaging system is only poorly understood by science, as it is highly variable by different circumstances and genetic predisposition of each individual.

This lack of sufficient understanding of the regulatory system of amino acid supply is ultimately the source of controversy on how many proteins a human should be consuming each day. Are 50 grams per day sufficient, does it require 100 grams or 200 grams, and of which type and composition? Nutritional science cannot agree on even a narrow band of recommendations, because too little is known about the granular details of the biology of the human body.

Notes & Sources

Figure 3:
The multifaceted role of ferroptosis in liver disease.
https://doi.org/10.1038/s41418-022-00941-0

Figure 3: Nutrient metabolism in the liver



2. Sources of protein in human food

This chapter explains which foods contain how many and which kind of proteins. This is important context to the next chapter of protein availability across the world.

Summary:
Proteins are predominantly found in animal-sourced foods of meat, dairy and eggs. Meaningful amounts of protein are also contained in nuts, pulses, and cereals. Fruits and vegetables supply negligible amounts of proteins. In plant-based sources, the proteins have significantly reduced bioavailability to the human metabolism and are embedded in multiple amounts of carbohydrates or fats, causing high caloric intake.

Notes & Sources

Almost any natural food contains proteins. Only foods that are ultra-processed from fatty or sugary raw materials do not contain any meaningful amounts of proteins, such as margarines, oils or carbonated soft drink beverages. However, there are differences by levels of concentration, bioavailability, and contextual nutrients.

Any kind of muscle meat from an animal consists of just three macro components (besides numerous micronutrients that are not the subject of this documentary, and which are less than 1% by mass): water, protein, and fat. Measured on a dry matter basis, lean meat such as from some fish or modern breeds' chicken breast will be two thirds protein, and one third fats. Fattier meats may have a half/half distribution, or very fatty meats such as bacon correspondingly more fats.

The second major category of protein sources are milks from the different animal species, where cow milk is dominating human nutrition in modern times. Taking away the water (dry matter basis), raw cow milk consists of 27% protein, 29% fat, 38% lactose (which is a type of sugar) and 6% other minerals. How much of each of these components ends up in the various dairy products is much dependent on regional recipes for table milks, cheeses, yogurts or butter and creams, and can therefore not be generalized. It depends on how much water remains in the product and how the components are distributed by the dairy companies, depending on their business model and customer preferences. For instance, cheeses typically have around 20% protein content in the final product (including water), ranging from 8% for a typical cream cheese to 35% for Italian Parmigiano.

The third category of proteins are eggs. It consists 75% of water (90% of the egg white is water), 12.5% of proteins and 10% of fats, with the remainder being minerals and other elements.

The fourth category are nuts and pulses, which each have relatively low water contents of around 10% at most. Various pulses such as beans, peas, or lentils have protein contents ranging from 18% to 25%. In contrast to animal derived proteins which are accompanied by fats, pulses typically contain three times as much carbohydrates (usually mostly starches) as proteins. The prominent exception are the soybeans which contain up to 35% of proteins, 20% fats and 30% carbohydrates.
Therefore, the dominant energy supply from the pulses are carbohydrates and not the proteins.

In nuts, the protein content ratio ranges from 8% to 25%, which are usually accompanied by 3 to 4 times more fat contents, ranging between 43% and 67%. Thus, in nuts, the dominant energy source are the fats. Peanuts have a high content of protein at 26%. However, technically a peanut is not a real nut, but an unusually protein- and fat-rich kind of pulse vegetable.

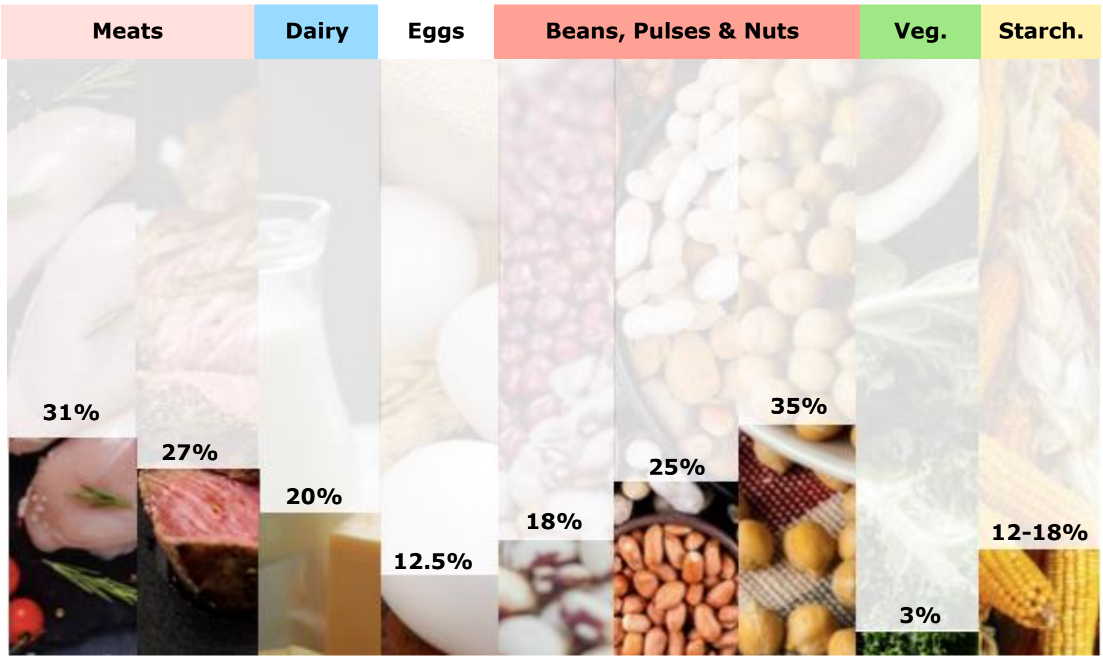
The fifth category are the various vegetables and fruits, most of which contain negligible amounts of proteins. However, some feature comparatively higher amounts, at around 3% in fresh weight, such as spinach, artichokes, asparagus, mushrooms, avocado or broccoli.

The final category are the starchy staples, consisting of cereals and roots. Roots such as potatoes typically have around 2% proteins. Cereals such as rice, maize, and wheat (which are three most common ones), contain respectively 7-8%, 9-12% and 8-18% of proteins. Only four kinds of proteins are contained in cereals which are gliadin and glutenin (together forming gluten), albumins and globulins).

Notes & Sources

Figure 4:
Illustration by GOALSciences
Based on variety of generic sources

Figure 4: Protein content of different foods groups



The bioavailability of proteins from the different sources to the human body is a complex and contested science in itself. It is influenced by two main factors. One factor is how well the intestinal tract can break down the proteins into its component amino acids and absorb them. The other factor is the composition of the amino acid portfolio. Plant-derived sources of protein have a different mix of amino acids from what animals in general and mammals, in particular, require. Therefore, some amino acids would be undersupplied, and some others are oversupplied. Animal-derived sources of protein generally have the same composition of amino acids as humans require because they share the same biology. Animal sources, especially from meats, also have much larger variety of proteins, which makes them more easily digestible and prevents allergies.

To capture the different degrees of bioavailability, the DIAAS score was developed and endorsed by FAO, which is the Digestible Indispensable Amino Acid score. Since protein synthesis relies on a variety of amino acids to be present, the amount of protein synthesized will depend on the amino acid available in the smallest quantity, as more protein cannot be synthesized without the limiting amino acid once it is depleted, regardless of the abundance of other amino acids. The availability of each amino acid is dependent on its digestibility, because that which cannot be digested and utilized by the body cannot be used in protein synthesis. That considered, an ileal digestibility coefficient exists for each amino acid in infants, children and adults, respectively. The DIAAS score uses that ileal digestibility coefficient for each amino acid to determine the true availability of each amino acid in a specific foodstuff. Once that score has been established, the most limiting amino acid is taken into account to determine the actual amino acid score and hence, protein quality of the foodstuff.

According to FAO regulations, if a food item has a DIAAS value greater than 100, it can be considered an “excellent” quality protein source for the specific age group and a “good” quality protein source if the DIAAS value is between 75 and 99. However, a food item with a DIAAS value less than 75 cannot have a claim made for protein.

DIAAS scores for cereals are between 50 and 60, for pulses, nuts, vegetables, and fruit at around 70, for fish and eggs at around 100 and for dairy and meat products between 110 and 120. The interpretation of these values is that 100 means an optimal composition of amino acids, whereas 50 means that any given protein mix from this source is only half as valuable. So, the protein obtained from maize is only half as valuable to the body as the protein from fish. Dairy and meat proteins have values above 100, because they support the utilization of proteins from other sources, and therefore they have a multiplier effect. Food processing can both increase and decrease the DIAAS values. Concentrates of milk or

Notes & Sources

Values for Digestible Indispensable Amino Acid Score (DIAAS) Determined in Pigs Are Greater for Milk Than for Breakfast Cereals, but DIAAS Values for Individual Ingredients Are Additive in Combined Meals
https://academic.oup.com/jn/article/151/3/540/6131862

Grains – a major source of sustainable protein for health
https://academic.oup.com/nutritionreviews/article/80/6/1648/6422500

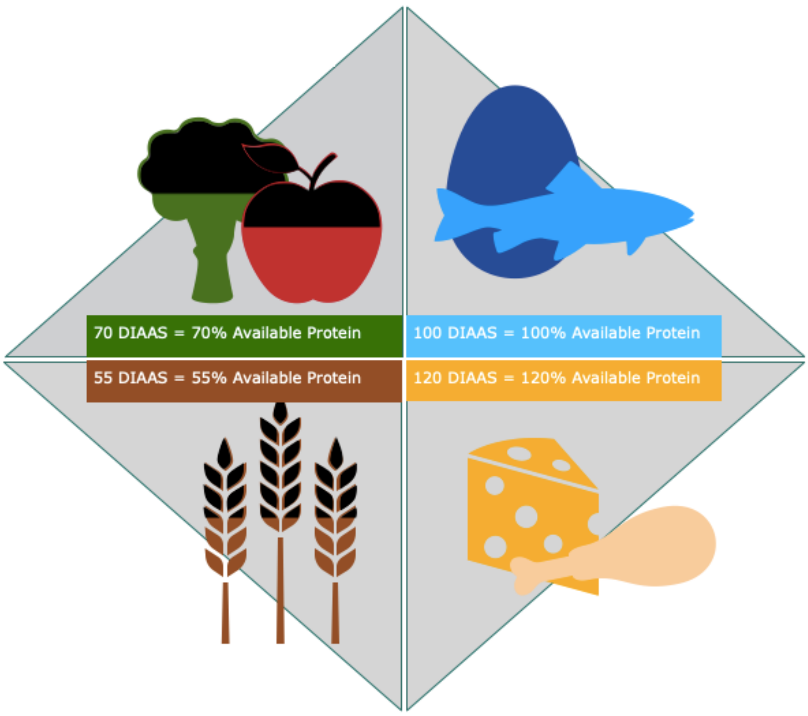
whey have DIAAS values of up to 140 and soybean processing can bring soy-derived protein to 100. Likewise, different cooking procedures can both enhance or reduce the DIAAS value. Generically speaking, traditional food processing methods using fermentation (miso, kimchi, sauerkraut), curing of meat products (with salts or smoking) or tender cooking tend to increase the bioavailability, while modern ultra-processing food methods (strong denaturation, unnatural additives) tend to decrease the bioavailability. For instance, corn flakes has a DIAAS value of 16.

Notes & Sources

Dietary protein quality evaluation in human nutrition
https://www.fao.org/ag/humannutrition/35978-02317b979a686a57aa4593304ffc17f06.pdf

Figure 5:
Illustration by GOALSciences

Figure 5: DIAAS values for different food categories



3. Food protein availability by global regions

This chapter showcases how much protein are available from which source for which global region. Detailed country tables are provided in the Appendix.

Summary:
Only high-income group countries and mainland China achieve a daily supply of 100 grams of protein or more per person on average. Lower income countries reach less than half of this amount per person. In the high-income group of countries, around 60% of the proteins are derived from animals.

Notes & Sources

The FAOStat Food Balance Sheets calculate the availability of all food sources to respective populations in most countries of the world. While the FAO data have weaknesses, it is the only authoritative and consistently measured source for such data worldwide. Therefore, all considerations of global food supply are always based on this data. The FAOStat data include an estimate of the protein supply for each of the food groups. The PLANET Food System Explorer bases all its calculation of global protein supply by country on these FAOStat data. In addition to the standard protein supply data, PLANET multiplied each of the supply numbers with their respective DIAAS value in order to generate bioavailability-adjusted protein supply. The common metric used is to express protein supply in terms of grams of protein per capita (person) per diem (day) (g pc pd).

On the GOALSciences website, it is possible to call up and download each of the below charts for most countries in the world, as well as for country groups such as geographical or development status groups. As of February 2023, the data is available for the years 2018, 2019 and 2020. Additional years and forecasts will be made available with future releases of PLANET. The Appendix to this documentation provides a table listing of bioavailability-adjusted proteins by source in grams per person per day.

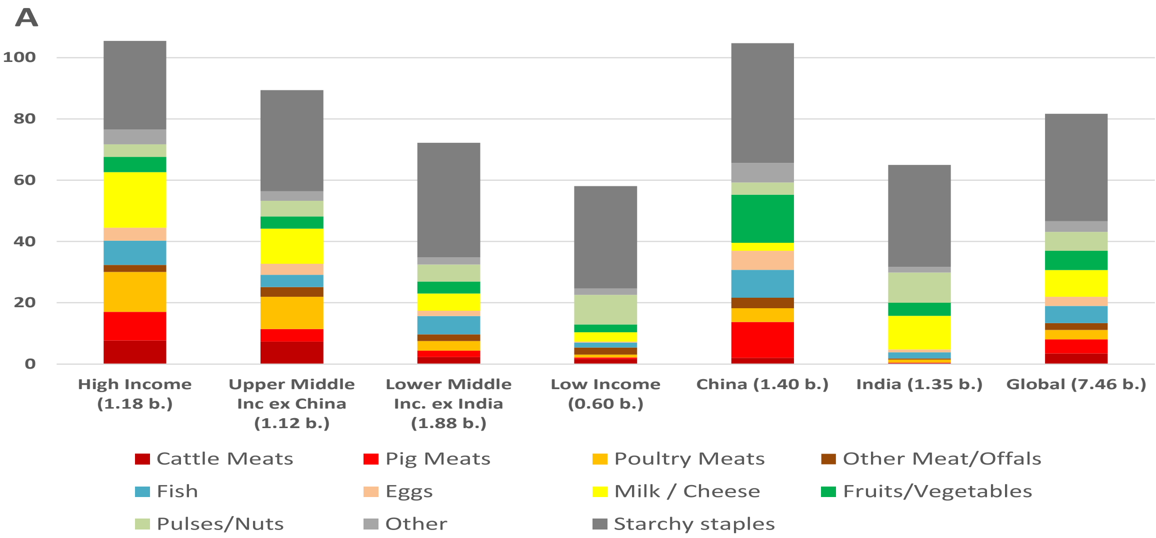
Figure 6 A) and B) show the aggregated standard and bioavailability-adjusted supply of protein for each of the four large country income groups as defined by the World Bank, as well as separately for mainland China and India, (separately because of their large population size). The tables show a large discrepancy of protein availability around the world. The high-income group of countries have almost twice as much protein available per person as low-income group of countries, and almost three times as much on a bioavailability-adjusted basis. The share of animal-sourced foods in the protein supply compounds the scarcity of proteins. High-income countries have a more than three times higher share of animal proteins, and a more than twice higher share of bioavailability-adjusted proteins compared to low-income countries.

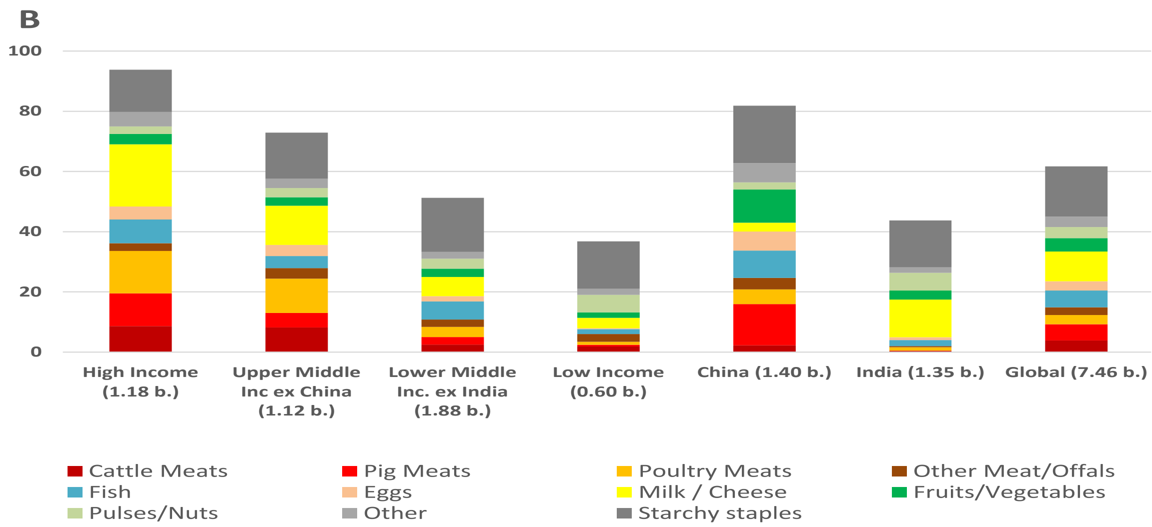
Mainland China achieves a similar performance as high-income countries in the availability of proteins, but with a lower animal-sourced share.

Notes & Sources

Figure 6,7,8:
Computations by GOALSciences

Figure 6: Protein sources of various income groups.





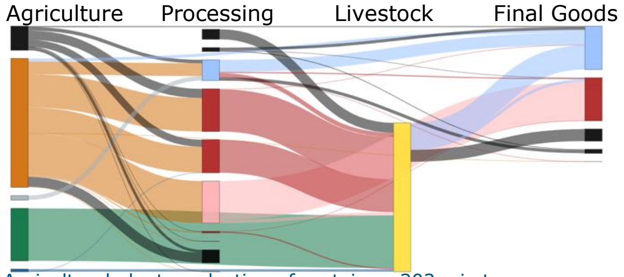
Notes: Sources of protein in gram per capita per day, average per inhabitant of country income group. Income groups are defined as per World Bank classification. Total population in billion per income group in brackets. Data source is GOALSciences calculations based on FAOStat Food Balance Sheets, reference year 2018, retrieved in January 2022.
Figure A) Standard protein content as per FAOStat.
Figure B) Protein content adjusted for bioavailability with DIASS scores (based on Marinangelli 2017).

Figure 7 shows the proportional biomass flows which lead to the respective protein supplies in these six income groups. They show how both high-income countries and mainland China import a significant portion of their proteins, though China exports almost nothing. Low-income countries and India import almost no proteins. China and high-income countries are the least reliant on grasslands for their protein supply. All regions show that animals are essential for converting proteins from inedible sources into edible food for humans, as a small portion of the agriculturally produced proteins are edible to humans.

Potential impact of the digestible indispensable amino acid score as a measure of protein quality on dietary regulations and health
https://academic.oup.com/nutritionreviews/article/75/8/658/4056218

Figure 7: Mass flow balances of protein content in regional food systems.

High Income Countries

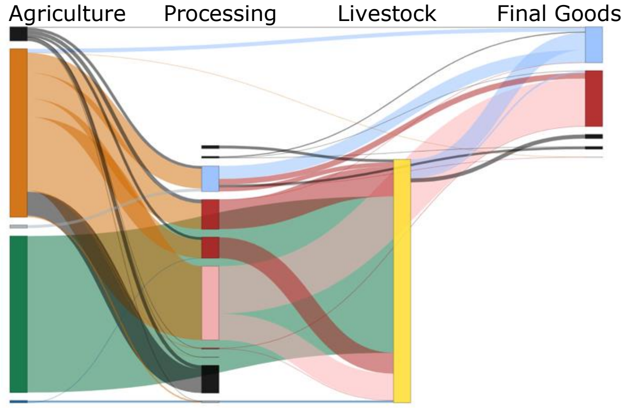


Agricultural plant production of protein	202 mio tons
Of which is edible for humans	17 mio tons (18%)
Total human food proteins	44 mio tons
Of which from animals	27 mio tons (61%)

Low Income

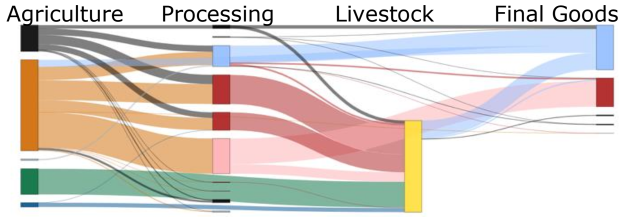
Agricultural plant production of protein	114 mio tons
Of which is edible for humans	10 mio tons (9%)
Total human food proteins	12 mio tons
Of which from animals	2 mio tons (17%)

Upper Middle Income (Ex China)



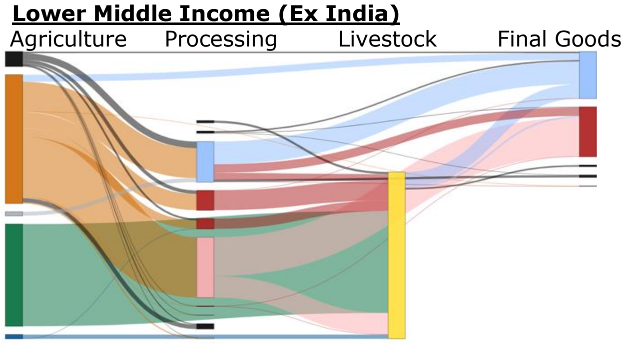
Agricultural plant production of protein	341 mio tons
Of which is edible for humans	18 mio tons (5%)
Total human food proteins	36 mio tons
Of which from animals	18 mio tons (50%)

China Mainland



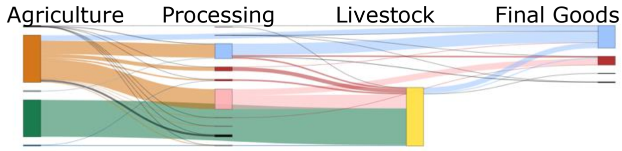
Agricultural plant production of protein	145 mio tons
Of which is edible for humans	30 mio tons (21%)
Total human food proteins	51 mio tons
Of which from animals	21 mio tons (41%)

Lower Middle Income (Ex India)



Agricultural plant production of protein	247 mio tons
Of which is edible for humans	32 mio tons (13%)
Total human food proteins	47 mio tons
Of which from animals	15 mio tons (32%)

India



Agricultural plant production of protein	124 mio tons
Of which is edible for humans	25 mio tons (20%)
Total human food proteins	33 mio tons
Of which from animals	8 mio tons (24%)

Cropland production
Pasture production
Aquatics
Animals
Seeds/losses/data gaps
Exports and imports
Edible foods
Non-edibles
Harvest by-products

Notes: From left to right: from agricultural production stage to processing and animal stages towards food and non-food supply stage. Each flow is shown in proportional size to each other. Flows are measured in actual weight, only pasture is in dry matter weight. Income groups are defined as per World Bank classification. Total population in billion per income group in brackets. Source: Excerpts from PLANET food system explorer of GOALSciences: https://goalsciences.org/planet-food-system-explorer Calculations for the year 2019.

Figure 8.A: Global protein supply by country (gr/cap/day) – 2020

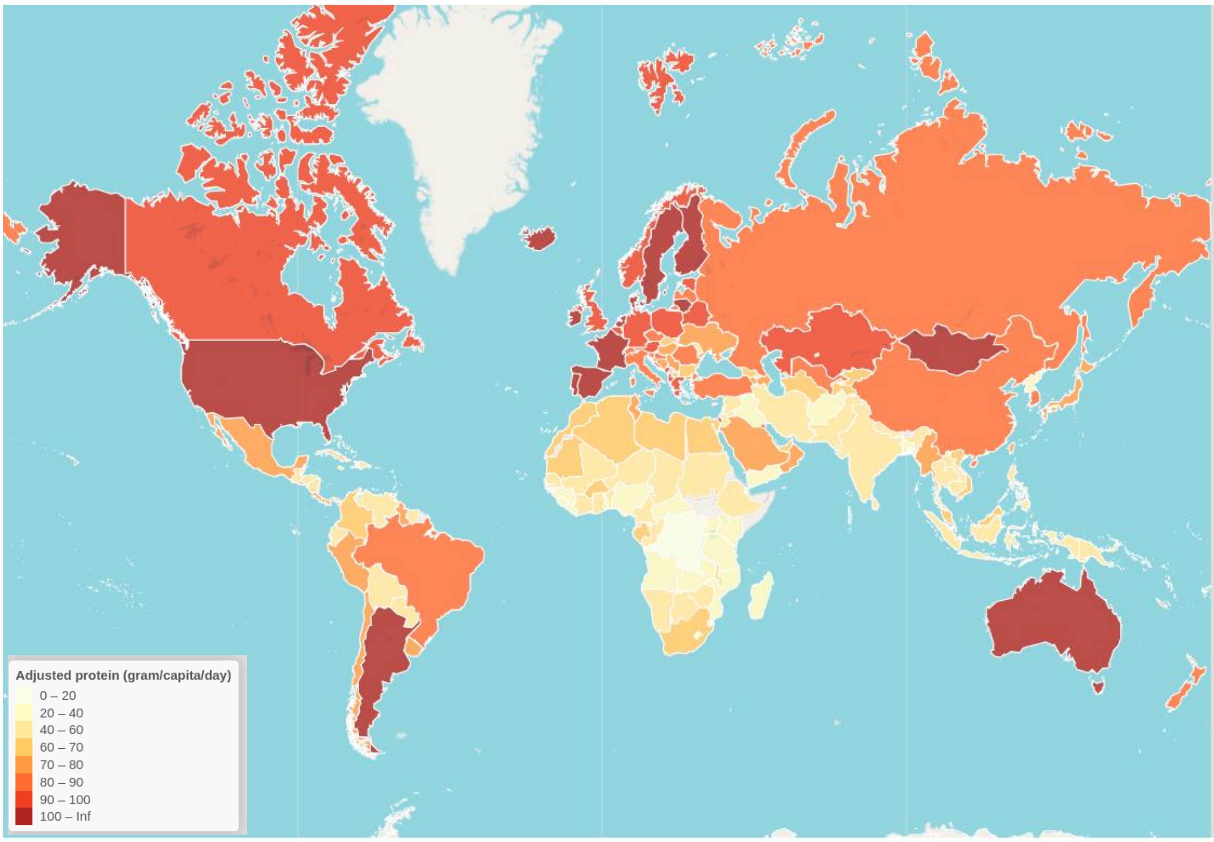
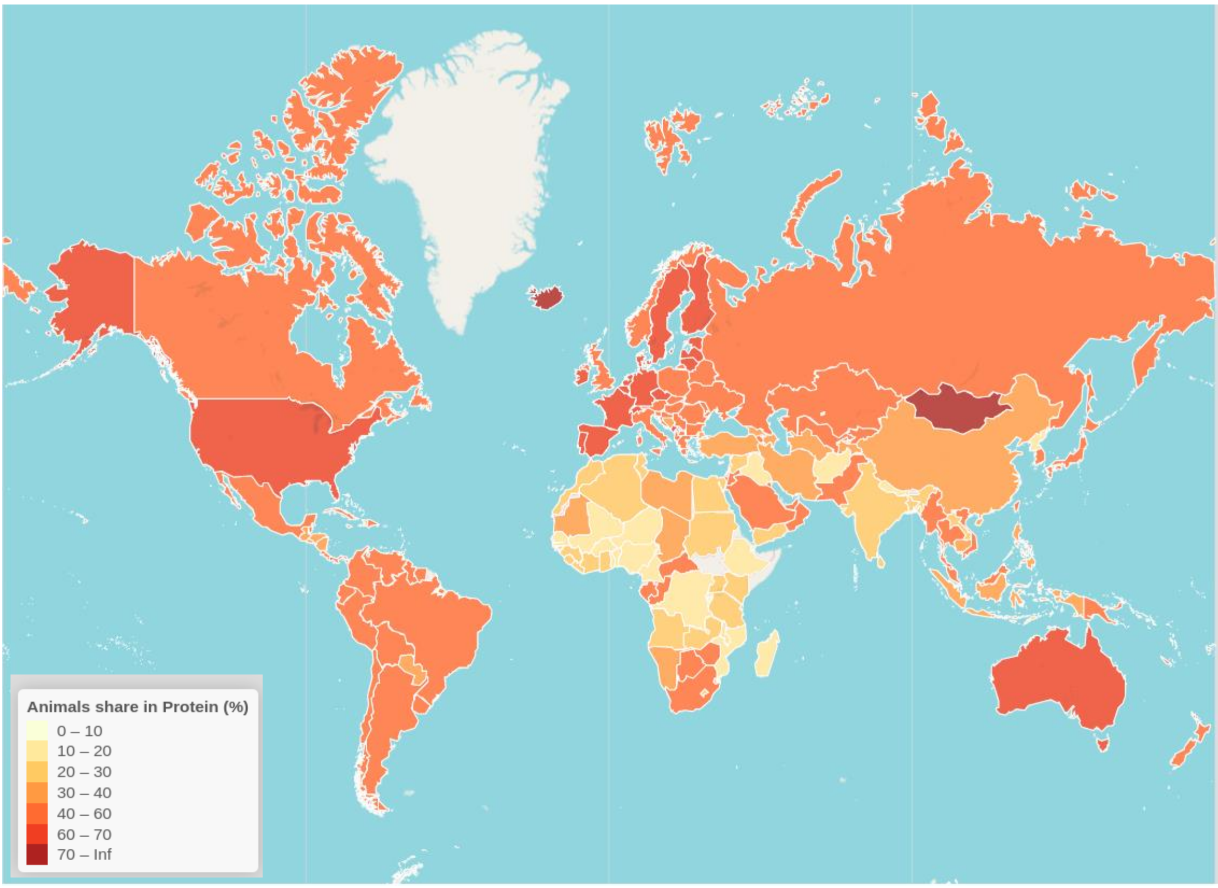


Figure 8.B: Animal share of protein supply (%) by country – 2020



4. Prices of protein by global region and source

This chapter showcases the prices of protein sources by global region, based on a unique World Bank dataset.

Summary:
On a purchasing-power-parity adjusted basis, poultry meat and eggs provide the consistently least expensive bioavailable protein to all global consumers. For humans, it is more efficient to feed low quality cereal proteins to animals and gain high quality proteins from them, than to eat these cereal proteins themselves. From a resource utilization point of view, animals are the most efficient method to produce bioavailable proteins, contrary to the frequent narrative that livestock utilization is inefficient. The high metabolic cost for life to produce proteins make it a comparatively expensive part of food. On a purchasing-power-parity adjusted basis, the cost of the basket of actual proteins available, is broadly the same around the world and across all income groups, namely around 0.40 USD per 10 grams of bioavailable proteins.

Under the auspices of the World Bank, the ICP (international comparison program) created a price catalogue of actual observed prices for consumer goods in most countries of the world for the year 2017 (a new set of prices will be released for year 2022). Among these are also the prices for most food items. The GOALSciences team used this data to calculate price comparisons for protein-rich foods.

The results are summarized in Figure 9. The values refer to the price for a food item, expressed in terms of each 10 gram of contained bioavailability-adjusted protein. The price is converted into USD by the purchasing-power-parity exchange rate for food, as calculated by the World Bank ICP. The values are the population-weighted average of all countries included in the respective income groups. For instance, in order to obtain 10 grams bioavailable protein from cattle meats, a consumer in a high-income country needs to pay 0.67 USD for the corresponding amount of beef. For poultry meats, the consumer would need to pay 0.28 USD. Consumers from low-income countries pay 0.47 USD for both kind of meats.

The graphic shows that eggs have the most uniform cost for proteins across all country income groups, and are overall the second most cost-effective form of protein. The most cost-effective proteins are pulses and nuts, especially in the low-income country group. However, the cost of food preparation is not included in these values. Pulses require long cooking times to eliminate their toxins and make them edible. Fuel cost for cooking is particularly high in the low-income group, but also constitutes a non-negligible cost component of total food consumption across the world.

Notes & Sources

World Bank ICP
https://www.worldbank.org/en/programs/icp

Fish is very expensive in high- and upper-middle-income countries, three and two times respectively than other meats. This is mostly due to the high quality standards required of delivering fish either fresh or freshly refrigerated over long distances to the consumer. In lower income countries, fish will be eaten either directly at source, or will be consumed in dried or salted form, which both have lower processing and logistics costs.

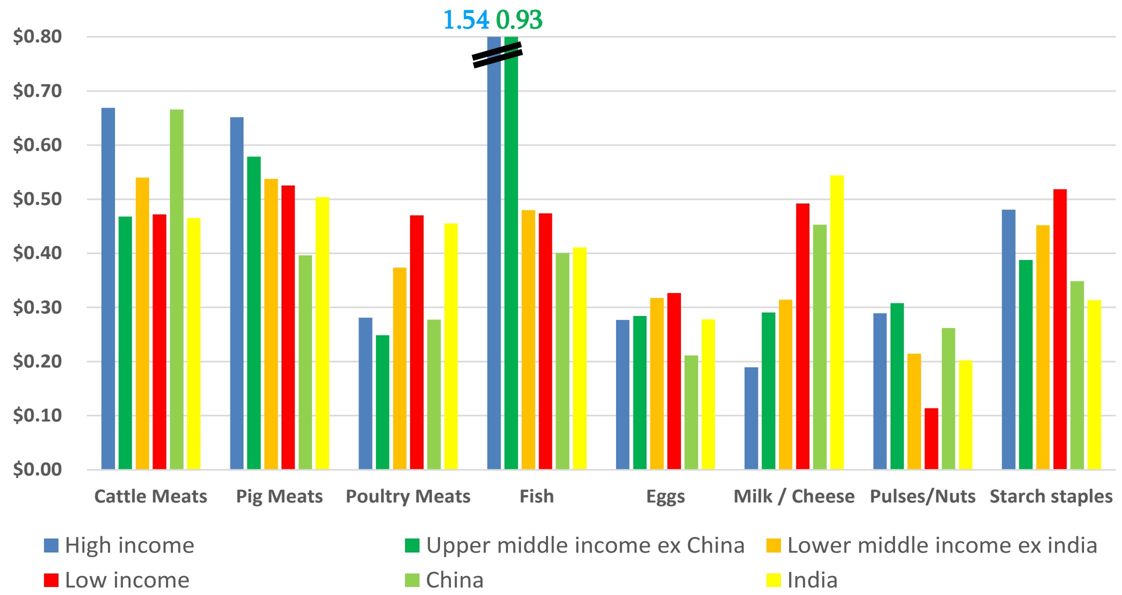
Dairy products have the largest price differential among the income groups. In high-income countries, milk and cheese are the least expensive kinds of protein, not only relative to other high-income country foods, but also across the entire world. In low-income countries, milk and cheese are the most expensive foods, both relative to the other low-income foods and compared to the world. This disparity shows the success and intricacy of higher income country's dairy industry.

In terms of price per protein content, cereals as starchy staples are similarly expensive to the meat sources of cattle, pig and fish, and significantly more expensive than poultry meats or eggs. This belies the often-touted notion that it is inefficient to take harvested crop proteins and feed them to animals in order to obtain proteins. The opposite is true. The low bioavailability of crop proteins are processed by animals into high bioavailability sources of protein for humans in an effective manner.

Notes & Sources

Figures 9,10, 11:
Computations by GOALSciences

Figure 9: Price per food item per 10 gram of bioavailability-adjusted protein content.

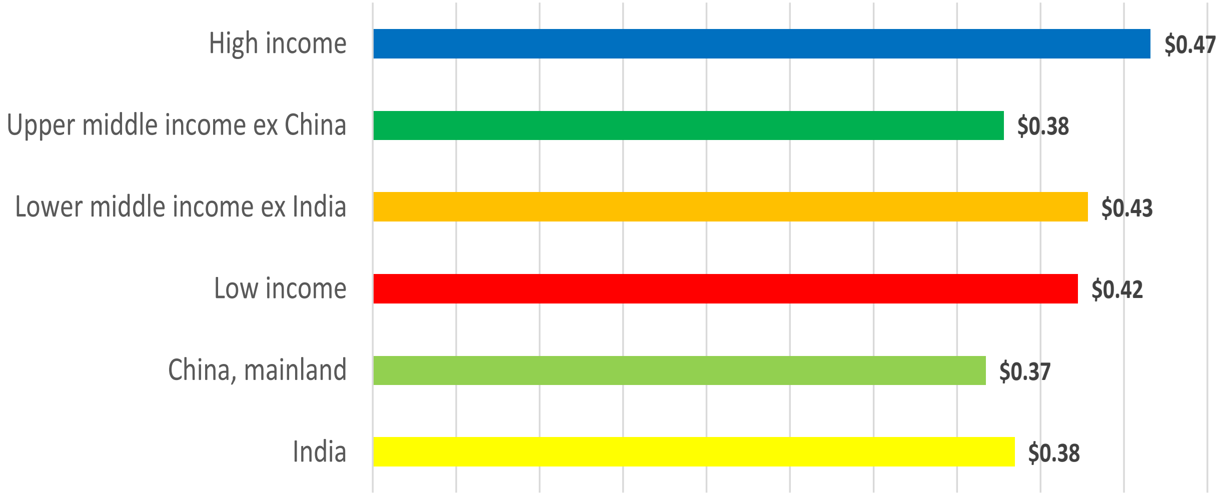


Notes: PPP (food)-adjusted retail price in USD per 10 gram bioavailability-adjusted protein content in a food group item by country income groups. Income groups are defined as per World Bank classification. Protein content is derived from FAOStat Food Balance Sheets, data retrieved in January 2022. Bioavailability is adjusted with DIASS scores (based on Marinangelli 2022, same values as in Figure 1). Retail price data and Purchasing-Power-Parity (PPP) for food are derived from World Bank ICP data (there only available upon application and for scientific purposes only). Calculations performed by GOALsciences.

The previous chapter on protein availability suggested that with decreasing income, both the amount of proteins and the share of animal proteins in those amounts decrease, with China being a significant exception to this trend. Multiplying the figures of availability of foods with the prices of these foods, results in graphic 10 below. It shows how much a consumer of each respective country income group is spending for obtaining 10 grams of bio-available protein. The result is similar across the world, namely at around 0.40 USD per 10 grams.

Notes & Sources

Figure 10: Retail price of bioavailability-adjusted protein food by income group



Note:. PPP (food)-adjusted retail price in USD per 10 gram bioavailability-adjusted protein content of the actually available food by country income groups. Income groups are defined as per World Bank classification. Protein content of food available is derived from FAOStat Food Balance Sheets, data retrieved in January 2022. Bioavailability is adjusted with DIASS scores (based on Marinangelli 2022, same values as in Figure 1). Retail price data and Purchasing-Power-Parity (PPP) for food are derived from World Bank ICP data (there only available upon application and for scientific purposes only). Calculations performed by GOALSciences.

According to the World Bank, final global consumer expenditure was around 60 PPP-USD trillion in the year 2018. Multiplying the consumption amounts of protein products with the ICP data, suggests that around 7 trillion PPP USD was spent on animal sourced foods, or 12%. This does not include the additional value paid for restaurant or food service.

Figure 11.A: Total global consumer expenditure distribution of animal sourced foods by country income group.

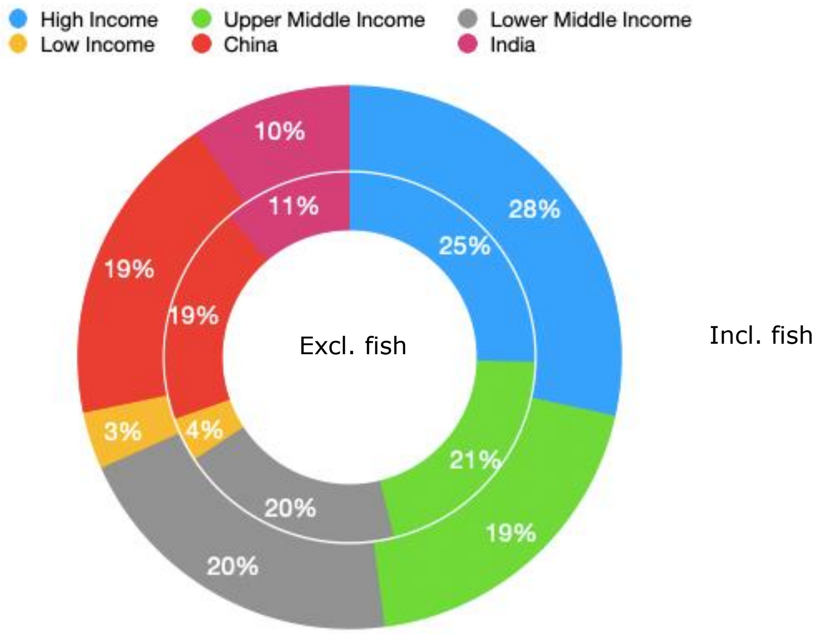
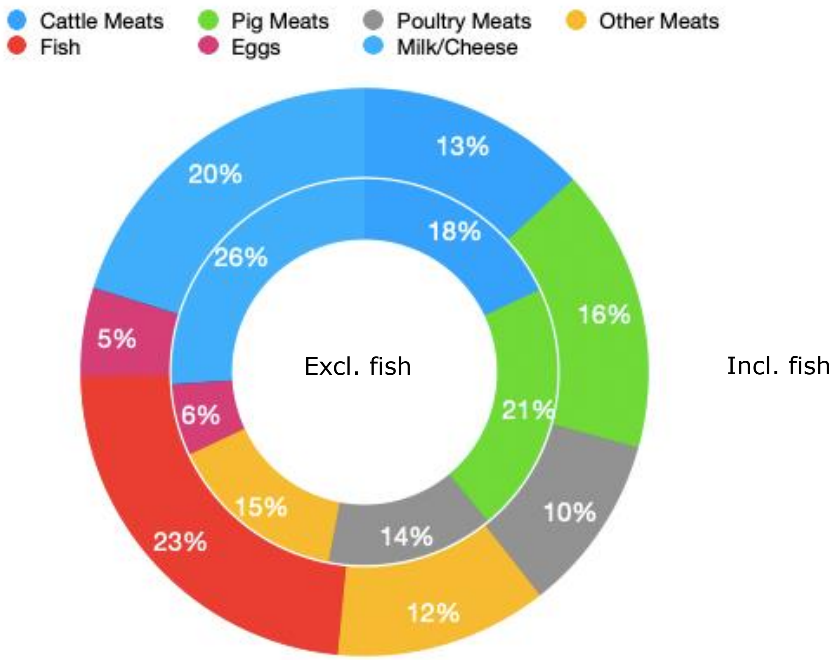


Figure 11.B: Total global consumer expenditure distribution of animal sourced foods by species group.



5. Global supply gap of proteins – now and until 2050.

This chapter discusses whether and how large of a protein supply gap exists for the global population.

Summary:
On the assumption that an average person needs a daily supply of around 100 grams of proteins, only around 40% of the global population can afford to purchase this much protein in their foods. Even fewer than that actually purchase them. On the same assumption, the world should consume about 80% more proteins than is currently available. By the year 2050, the gap might grow to 140%.

Whether there is a shortage of proteins for the global population, depends much on the assumptions about what constitutes a sufficient supply. How many proteins are required per person to constitute a healthy nutrition, is briefly discussed in the next chapter. In this chapter, GOALSciences assumes that a standard average consumption should be 100g of proteins per person per day for the below scenario table (blue colors). An alternative scenario is also calculated for 75g of proteins (green colors). Two other factors determine whether and how large the gap of protein nutrition in the world is. The first is the question of how much food gets lost on the way between being available at retail or in the restaurant, and the food arriving in the stomach. Food may be wasted at the retailer, or rot in the customer's home, may be treated with harsh cooking methods that destroy the proteins, or may not be eaten from the plate. The scenario table provides four values for waste amounts, of 0, 10, 15 or 20% (progressively darker colors).

The other factor is the availability of proteins across all sociodemographic strata of society, and across seasons. For instance, even though China provides more than 100 grams of proteins per person per day on average, 14% of its people cannot afford to purchase even 75g of protein. Accounting for uneven distribution across income and seasons would require a higher supply of proteins on average, in order to ensure that most of the population has enough of them each day. The scenario table provides values for a necessary increase of either 10, 20 or 30% to compensate for uneven distribution. The scenario table shows how, dependent on the assumptions, there is either no protein gap at all, or the world would need to increase supply by 78% in order to supply enough (i.e. from 229,000 kilotons available to 409,000 kt being necessary), with every value in between dependent on the scenario. For the year 2050, the values can be either a manageable necessary 18% increase over today, or a demanding 136% over today (i.e. from 229,000 kilotons available today to necessary 542,000 kilotons in 2050).

Notes & Sources

Figure 12:
Computations by GOALSciences

Figure 12: Global protein gap estimations

Different scenario values: (World total supply 2018: 229,200 kilotons)		2018 need in kilotons	Factor over 2018 supply	2050 need in kilotons	Factor over 2018 supply
RDA protein per capita per day (gram)	75	204 307	0.89	271 013	1.18
+ Logistics / consumer wastes (%)	10	224 737	0.98	298 114	1.30
+ Oversupply for uneven distribution (%)	10	245 168	1.07	325 215	1.42
+ Oversupply for uneven distribution (%)	20	265 599	1.16	352 316	1.54
+ Oversupply for uneven distribution (%)	30	286 029	1.25	379 418	1.65
+ Logistics / consumer wastes (%)	15	234 953	1.02	311 664	1.36
+ Oversupply for uneven distribution (%)	10	255 383	1.11	338 766	1.48
+ Oversupply for uneven distribution (%)	20	275 814	1.20	365 867	1.60
+ Oversupply for uneven distribution (%)	30	296 245	1.29	392 968	1.71
+ Logistics / consumer wastes (%)	20	245 168	1.07	325 215	1.42
+ Oversupply for uneven distribution (%)	10	265 599	1.16	352 316	1.54
+ Oversupply for uneven distribution (%)	20	286 029	1.25	379 418	1.65
+ Oversupply for uneven distribution (%)	30	306 460	1.34	406 519	1.77
RDA protein per capita per day (gram)	100	272 409	1.19	361 350	1.58
+ Logistics / consumer wastes (%)	10	299 650	1.31	397 485	1.73
+ Oversupply for uneven distribution (%)	10	326 891	1.43	433 620	1.89
+ Oversupply for uneven distribution (%)	20	354 132	1.54	469 755	2.05
+ Oversupply for uneven distribution (%)	30	381 373	1.66	505 890	2.21
+ Logistics / consumer wastes (%)	15	313 270	1.37	415 553	1.81
+ Oversupply for uneven distribution (%)	10	340 511	1.49	451 688	1.97
+ Oversupply for uneven distribution (%)	20	367 752	1.60	487 823	2.13
+ Oversupply for uneven distribution (%)	30	394 993	1.72	523 958	2.29
+ Logistics / consumer wastes (%)	20	326 891	1.43	433 620	1.89
+ Oversupply for uneven distribution (%)	10	354 132	1.54	469 755	2.05
+ Oversupply for uneven distribution (%)	20	381 373	1.66	505 890	2.21
+ Oversupply for uneven distribution (%)	30	408 614	1.78	542 025	2.36

Notes Different scenarios for estimating the global protein gap for 2018 (black numbers) and for 2050 (red numbers, then assuming global population of 9.9 billion). The table shows 40 different scenarios. Two scenario clusters are driven by whether the Recommended Daily Allowance (RDA) is either 75 grams per capita per day (green), or whether it is 100 grams pc/pd (blue). The next scenario cluster are assumptions on how much waste needs to be accounted for, whether 0, 10, 15 or 20% (increasing darker shade). The third scenario cluster are assumptions of how much oversupply is necessary to account for uneven sociodemographic or seasonal distribution, whether 10, 20 or 30%. With maximum assumptions, the world would need 1.78 x more protein in 2018, and 2.36 x more in the year 2050 over current supply. With minimum assumptions, the world's population is sufficiently supplied with protein in 2018, and needs only 18% more until 2050. Source: GOALSciences calculations based on FAOStat Food Balance Sheet data.

On the assumption that every person should eat around 100 grams of protein per day, the dilemma for a globally healthy nutrition supply becomes obvious. As shown in the previous chapter, this would indicate a daily expense of 4 USD per day for foods which contain protein, just to cover the basic protein requirements. Likely, the other components of fats and carbohydrates in these foods would cover the daily energy requirements. However, additionally, there would need to be further costs for vegetables and fruits which are not covered by this cost. They do not contain meaningful levels of protein, yet they are also essential and also expensive. On that standard, sufficiently healthy food would cost anywhere between 5 and 6 USD per day per person (all values are always purchasing-power-parity adjusted).

This calculation comes out to about twice the value which a group of poverty researchers have arrived at in their recent analyses for FAO and WHO, where they concluded approximately 3 USD are necessary for a healthy meal. By comparison, to supply a merely energy-sufficient meal, only costs around 1 USD per day, indicating how much more difficult it is for nature to synthesize proteins compared to simple carbohydrates.

However, the difference to the GOALSciences calculation above is smaller than it looks. The poverty researchers made two differing assumptions: first, they required only 75 grams of protein per day per person, and they did not adjust for bioavailability of proteins. In this way the large grain component of their minimum-nutrition diet appears to be providing twice more proteins than they really do. Nonetheless, despite these relaxed assumptions, they still found around 3 billion people in the world are not able to afford this diet, or about 40% of the global population. This calculation assumes that a person cannot spend more than 55% of their income on food. As 3.3 billion people in the world have less than 5.50 USD per day available, this almost equals the number of people who cannot afford a sufficiently nutritious meal each day. Correspondingly, around 1.8 billion people live on less than 3.20 USD per day, and by this measure would have only 1.80 USD available for food. This will translate into 30-40 grams of protein per day, which is far too low to maintain good health by any standard.

Applying the standard of 100 grams of protein per day per person, requiring between 5 and 6 USD spending on food per day means that this person would need to earn at least around 10 USD per day (on a PPP basis). For a concrete family this means that the income-earner may need to also support their children, retired parents and potentially non-working care-giver as well. According to an (incomplete) analysis by the Pew Research Center, only 40% of the global population meet that threshold.

Notes & Sources

Cost of a healthy diet (https://www.foodsystemsdashboard.org/indicators/cost-of-a-healthy-diet-co-hd/map).

By implication, this means that potentially 60% of the global population cannot eat enough of the required proteins each day.

Economists and environmentalists can be justifiably concerned with the environmental shadow cost of food production, when these potentially cause damage to global common goods such as water, biodiversity or climate. That is a reasonable approach, even if burdened with nearly insurmountable methodological barriers. However, in the same way, there should also be calculations of the shadow cost of not providing sufficiently nutritious food to the global population.

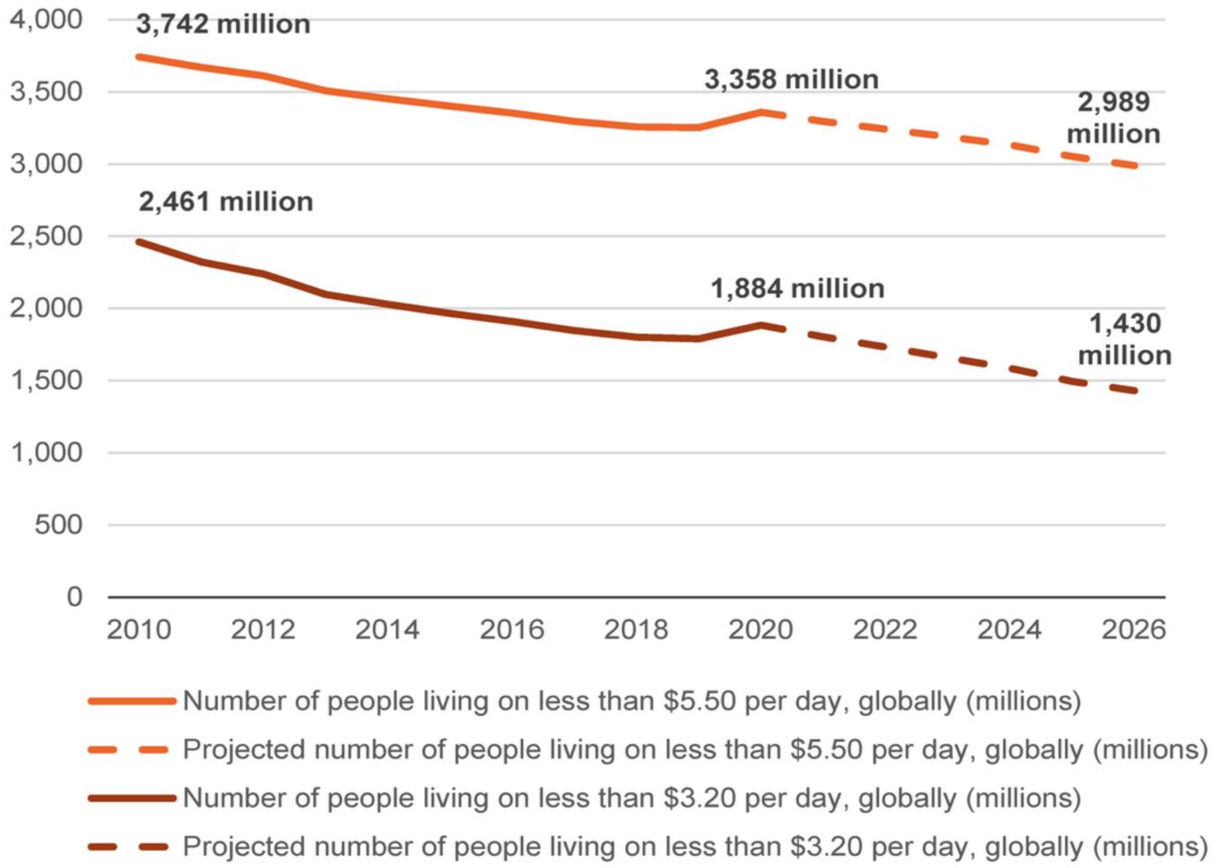
The global food community is called upon to evaluate pathways by which the people of the world can gain more affordable access to proteins in their food.

Notes & Sources

Figure 13: Economic poverty trends: global, regional and national (https://devinit.org/resources/poverty-trends-global-regional-and-national/

Development Initiatives https://devinit.org/resources/poverty-trends-global-regional-and-national/

Figure 13: Number of people living in poverty, globally



6. How many proteins are needed – governmental committee and epidemiological evidence

This chapter closes the documentary with conflicting views on much proteins humans need for a healthy nutritious diet.

Summary:
Government-sponsored nutrition committees recommend a minimum of 0.8 grams of protein per kilogram of bodyweight per day for a healthy adult living a sedentary lifestyle. This is equivalent to about 50 grams per day for the average adult. Epidemiological evidence from real life circumstances, where in addition to healthy, sedentary adults, there are also young, old, ill, pregnant or physically active persons in a society, rather points to an average need of 100 grams of proteins per day, equivalent to 17% of the energy intake per day.

Science does not agree on how many proteins are optimal for human food supply. Partially, this is due to an insufficient understanding of how the complex biology of the human body functions. It is also due to insufficient and inconclusive understanding of the long-term effects of differing nutritional diets. Scientists can somewhat agree on a minimum amount of proteins that are necessary to avoid negative health impacts over the scale of months, which if breached cause atrophy and stunting of critical body systems such as the muscle mass, organs and brain. Likewise, scientists can also somewhat agree on a maximum amount beyond which proteins become harmful, causing inflammation of liver, kidneys and intestines. However, it is less clear what is the optimal amount of protein supply, and for which life circumstances between these two extremes.

Recommended protein amounts are typically described in two different units: either in grams per kilogram bodyweight per day (kg bw/day), or in percentage of energy requirement per day. It is typically noted that the minimum threshold should be 10% of the daily energy intake, and that the maximum intake should not be more than 35%. Assuming a standard 2330 kcal daily diet for the average 62.5 kilograms person, this would translate into a range of 60 grams to 200 grams of protein per person per day.

The US Recommended Dietary Allowances (RDA) propose 0.8 grams of protein per kg bw/day for a healthy sedentary adult person (which could be considered a contradiction in terms). This would translate into only 50 grams of protein per day, which is already lower than the recommended minimum by the same authority when measured by percentage of calories. The EU RDA arrives essentially at the same value with 0.83 grams of protein per kg bw/day. These RDA values are calculated as the average requirement per person, which is considered

Notes & Sources

Dietary Reference Intakes (DRIs): Acceptable Macronutrient Distribution Ranges
(https://www.ncbi.nlm.nih.gov/books/NBK56068/table/summarytables.t5/?report=objectonly

Nutrient Recommendations: Dietary Reference Intakes (DRI)
https://ods.od.nih.gov/HealthInformation/nutrientrecommendations.aspx

EFSA sets population reference intakes for protein
https://www.efsa.europa.eu/en/press/news/120209

to be 0.66 grams of protein, and then take into account variation among persons by including two standard deviations from the mean. Thus 0.8 grams is supposed to cover 98% of all needs of such healthy sedentary persons. Additionally, the RDA figures suggest that infants, children, adolescents, pregnant and lactating women should consume more protein, such as 1.2 grams of protein per kg bw/day.

These values are criticized by many scientists as being too low for several reasons. Firstly, the terminology of RDA is misleading. It is defined as: *"...an estimate of the minimum daily average dietary intake level that meets the nutrient requirements of nearly all (97 to 98 percent) healthy individuals in a particular life stage and gender group*", although no notable differences could be discerned between men and women. The term "Minimum" has a different meaning than "Optimum", which would be implied by the word "Recommended".

Second, these values refer to a "sedentary adult". Physically active or very active persons, should consume substantially more proteins, depending on the level of activity. Athletes with intensive training may need to consume up to 2 grams of protein per kg bw/day (or 125 grams per day for the average 62.5 kilogram person), in a straight-line relationship of the more activity, the more proteins.

Third, a growing body of evidence appears to show that elder adults beyond the age of 50 also require elevated levels of protein, at least on par with children and adolescents. For instance, a study showed that persons in the age group 70-79 years of age consuming only 0.7 grams per kg bw/day, had 40% less lean body mass than those consuming 1.1 grams per kg bw/day.

Fourth, ill, critically ill or chronically ill persons have much elevated needs for protein intake, to as much as 2.5 grams per kg bw/day, in a straight-line relationship of the more ill, the more proteins. Given that the vast majority of adult persons have some kind of illness, this category would be the norm.

Besides these values, scientists also criticize the methods for determining RDA as being outdated. Rather than building on "Nitrogen Balances", the protein requirements should be measured with the "Indicator Amino Acid Oxidation" method. Nitrogen balance is the difference between nitrogen excreted from the body and nitrogen ingested in the diet, whereas the indicator amino acid oxidation (IAAO) method is based on the concept that when one indispensable amino acid (IDAA) is deficient for protein synthesis, then all other IDAA, including the indicator amino acid, will be oxidized.

Notes & Sources

Current Concepts and Unresolved Questions in Dietary Protein Requirements and Supplements in Adults
https://www.frontiersin.org/articles/10.3389/fnut.2017.00013/full

Protein turnover, amino acid requirements and recommendations for athletes and active populations

https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3854183/pdf/0100-879X-bjmbr-45-10-875.pdf

Dietary protein for athletes: from requirements to optimum adaptation

https://pubmed.ncbi.nlm.nih.gov/22150425/

Increased protein intake reduces lean body mass loss during weight loss in athletes
https://pubmed.ncbi.nlm.nih.gov/19927027/

Furthermore, the RDA's do not sufficiently account for the composition of the amino acid portfolio in the proteins from different food sources, which may result in different levels of bioavailability.

The PURE research consortium organizes the largest global epidemiological investigation to study the impact on life circumstances, behaviour and nutrition patterns on health outcomes. It is the only global study that has been tracking 225,000 participants in more than 1000 communities across 27 high, middle and low-income countries. In 2017, PURE researchers published a widely regarded and cited article in which, among other considerations, it was shown that after adjusting for all circumstances, 17% of caloric intake from protein was associated with the lowest mortality rate.

This would translate into 1.6 grams of protein per kg bw/day for the average 62.5 kg person on an average 2330 kcal daily diet or 100 grams of protein per day. At the same time, there does not appear to be any indications that consecutive diets up to 2 grams per kg bw/day cause adverse health outcomes.

It is worth noting that the human body has no storage capacity for extra proteins (as explained in the first introductory chapter), which is in contrast to the overall energy intake or most of the micronutrient requirements, for which the body has many storage buffers that can span weeks or months or even years in the case of fats. Therefore, the supply of proteins must be steady for every day, and even steady in all meals during the day. Excessive protein consumption in one particular meal, or on some days of the week, cannot compensate for protein deficient occasions at other times. The excess protein which the body cannot metabolize in a super-serving will simply be converted into fat or excreted, while the deficient situations have left protein shortages in the system and potentially cause damage. This condition calls for protein supply in the food to rather err on the high side than on the low side, in order to ensure a steady stream of supply at all times.

Notes & Source

PROSPECTIVE URBAN AND RURAL EPIDEMIOLOGICAL STUDY
https://www.phri.ca/research/pure/

Dietary protein intake and human health

https://pubmed.ncbi.nlm.nih.gov/26797090/

Final Thoughts

Every reader needs to draw their own conclusion from the above on what appears to be the right level of protein intake – both for personal circumstances, and for the purpose of analyzing the public health situation of nutritional supply in a country. Government committees and scientists do not agree with each other. GOALSciences prefers to side with the epidemiological evidence of the PURE study, that an average of around 100 grams per person per day needs to be consumed for lowest mortality outcome, corresponding to 1.6 grams per kilogram bodyweight per day. PURE also describes that there is a large uncertainty interval around this value.

On a personal level, completely healthy but largely sedentary adults may go for lower amounts than this average. The very young, the youngish, the older, the very old, the slightly ill, the very ill, the pregnant and lactating or the physically active – in short, the vast majority of people – might consider this value to be a good orientation based on epidemiology and nutritional investigation.

On a public health level, for government committees it is a safe pathway to recommend the amount of proteins which the average of the population in high income countries consumes already anyway, and which the food industry accordingly provides. Few stakeholders will complain. Whether in light of the escalating multiple public health crises of obesity, diabetes and dementia, this is actually the correct interpretation of the scientific evidence, can be questionable.

No doubt, if the world is currently already short of proteins and would need to more than double protein supply in order to optimally feed the world's citizens over the next decades, this would require substantial changes to the way the food is produced today. It would almost certainly require more animals, more efficient methods to feed them, and a radical implementation of circularity principles in agriculture in order to minimize ecological footprint.

Appendix

Bioavailable protein supply per person per country, by food source (DIAAS-adjusted), 2020.

Source: GOALSciences computations based on FAOStat data.

		Total protein by source (gram per capita per day)											
Country	**Animal Share (%)**	**Total**	**Cattle Meats**	**Pig Meats**	**Poultry Meats**	**Other Meats**	**Fish**	**Eggs**	**Milk/ Cheese**	**Fruits/ Veg.**	**Pulse / Nuts**	**Starchy staples**	**Other**
Afghanistan	18.4	56.6	1.3	0.0	0.6	2.3	0.1	0.3	5.7	2.6	1.7	41.4	0.4
Albania	52.4	112.3	4.9	1.5	5.4	5.4	2.6	4.7	34.4	12.7	4.2	34.8	1.8
Algeria	27.5	89.3	1.6	0.0	2.0	3.7	1.2	1.8	14.3	9.0	4.3	50.2	1.2
Angola	25.5	47.8	1.5	2.0	2.9	1.4	3.8	0.0	0.6	2.2	6.2	26.1	1.1
Antigua and Barbuda	66.3	81.9	3.5	5.4	20.3	1.3	14.2	1.6	8.0	3.0	1.4	21.8	1.5
Argentina	59.7	114.2	23.1	4.4	14.8	6.1	1.9	4.6	13.4	3.1	4.2	31.5	7.3
Armenia	46.1	99.1	9.8	2.5	5.2	4.5	1.7	3.6	18.3	8.3	2.3	41.0	1.8
Australia	65.8	114.3	14.1	5.7	16.9	8.5	6.0	2.3	21.7	3.9	8.2	24.2	2.8
Austria	58.2	106.1	6.0	12.9	6.5	2.4	4.0	4.4	25.7	4.9	2.8	28.7	7.9
Azerbaijan	36.3	98.1	5.5	0.2	4.9	5.4	0.6	2.8	16.1	5.7	1.2	54.0	1.6
Bahamas	65.9	76.1	2.9	8.6	18.6	1.6	6.3	2.4	9.7	5.6	1.4	17.6	1.5
Bangladesh	21.2	61.4	0.5	-	0.5	0.9	7.7	1.2	2.2	2.3	4.9	39.1	2.1
Barbados	57.7	85.9	4.4	2.6	16.6	2.2	12.6	2.5	8.7	3.6	5.5	24.7	2.5
Belarus	59.6	103.6	9.2	11.1	10.8	4.4	3.2	4.0	19.1	5.6	1.7	31.3	3.2
Belgium	61.0	104.8	5.1	7.9	4.5	6.8	6.0	4.1	29.5	6.2	4.7	25.6	4.4
Belize	44.2	71.4	1.7	8.5	7.7	0.5	3.1	1.3	8.9	2.8	9.2	24.5	3.4

		Total protein by source (gram per capita per day)											
Country	**Animal Share (%)**	**Total**	**Cattle Meats**	**Pig Meats**	**Poultry Meats**	**Other Meats**	**Fish**	**Eggs**	**Milk/ Cheese**	**Fruits/ Veg.**	**Pulse / Nuts**	**Starchy staples**	**Other**
Benin	17.6	66.2	1.5	0.3	3.1	1.0	4.4	0.3	1.1	2.5	6.9	34.9	10.3
Bolivia	45.7	75.6	7.9	2.6	13.0	4.2	0.8	2.0	4.2	2.7	4.5	31.8	2.0
Bosnia and Herzegovina	36.3	101.8	5.2	3.1	6.8	1.2	2.1	1.8	16.8	10.5	5.3	42.5	6.5
Botswana	40.1	71.8	4.0	0.2	1.3	8.7	0.7	0.4	13.6	2.1	1.8	36.0	3.1
Brazil	59.8	93.0	13.3	3.9	15.8	3.1	2.2	3.5	13.9	2.9	8.2	23.4	2.9
Bulgaria	51.6	78.6	1.3	8.3	8.4	3.0	2.3	1.6	15.7	3.2	2.6	28.9	3.4
Burkina Faso	20.0	93.0	2.1	4.8	3.2	3.0	2.8	0.3	2.3	3.0	24.2	41.0	6.3
Burundi	6.7	41.1	0.4	0.3	0.2	0.5	0.8	0.0	0.6	3.6	17.5	16.1	1.1
Cabo Verde	34.9	69.6	0.8	2.4	7.1	1.3	2.9	1.3	8.7	3.0	8.5	31.8	2.0
Cambodia	30.7	64.1	1.9	1.8	0.9	0.5	13.8	0.3	0.5	1.5	2.8	36.3	3.7
Cameroon	15.9	72.0	1.2	0.4	1.1	2.3	5.1	0.1	1.3	5.7	17.1	33.5	4.2
Canada	55.1	106.2	10.5	5.8	14.2	1.1	5.4	4.4	17.2	4.8	9.0	29.0	5.0
Central African Rep	41.0	49.0	8.3	1.3	0.9	6.2	2.2	0.1	1.2	1.8	9.3	14.3	3.5
Chad	35.2	78.0	11.5	0.1	0.2	10.7	2.9	0.1	2.1	0.4	9.7	36.1	4.3
Chile	52.2	92.2	10.3	6.5	11.9	1.5	3.8	2.7	11.6	3.8	4.7	33.8	1.8
China, Hong Kong	77.5	139.1	11.7	16.1	20.6	27.8	15.7	7.7	8.2	7.7	2.0	17.6	4.0

		Total protein by source (gram per capita per day)											
Country	Animal Share (%)	Total	Cattle Meats	Pig Meats	Poultry Meats	Other Meats	Fish	Eggs	Milk/ Cheese	Fruits/ Veg.	Pulse / Nuts	Starchy staples	Other
China, Macao	66.9	98.0	4.6	16.7	15.7	2.9	16.5	6.1	3.1	5.6	2.3	20.6	3.9
China, mainland	38.0	106.6	2.5	10.7	4.8	3.4	9.4	6.8	2.9	15.6	4.3	39.1	7.0
China, Taiwan	52.9	87.6	3.1	11.5	13.9	1.2	7.4	4.6	4.7	5.5	3.2	23.0	9.5
Colombia	52.1	72.4	5.2	3.2	10.1	1.4	2.7	4.1	11.1	3.7	4.0	24.9	2.1
Comoros	33.2	57.1	1.4	0.0	9.0	1.5	4.6	0.5	1.9	2.1	10.2	24.2	1.7
Congo	49.2	52.2	0.9	2.0	7.9	6.3	7.7	0.1	0.7	3.5	2.9	18.4	1.7
Costa Rica	57.6	84.4	4.6	3.2	10.2	0.9	5.6	3.4	20.6	2.9	7.2	24.4	1.4
Cote d'Ivoire	24.8	63.1	0.6	0.3	1.0	5.2	7.4	0.6	0.6	3.1	3.7	38.1	2.6
Croatia	58.4	94.5	4.7	11.9	6.3	3.1	5.9	2.4	20.9	6.8	2.4	26.0	4.1
Cuba	43.9	84.1	2.9	6.8	11.3	4.6	1.7	2.5	7.2	4.3	10.5	31.3	1.1
Cyprus	55.3	95.9	2.5	9.0	10.7	2.4	7.1	2.0	19.5	3.9	3.4	32.7	2.9
Czechia	62.2	90.2	3.6	11.5	8.1	2.2	2.9	3.0	24.9	3.6	2.8	23.4	4.3
North Korea	18.8	53.8	0.3	1.3	0.5	3.4	2.9	1.4	0.3	5.3	6.5	29.3	2.6
Dem Rep Congo	11.3	29.1	0.1	0.2	0.4	1.2	1.3	0.0	0.1	2.2	3.3	19.4	1.0
Denmark	64.9	110.8	8.9	4.4	10.4	0.9	9.9	5.0	32.4	4.5	3.1	26.1	5.2
Djibouti	18.3	68.3	2.5	0.0	1.3	2.9	1.0	0.4	4.3	3.3	12.8	38.7	1.0

		Total protein by source (gram per capita per day)										
Country	**Animal Share (%)**	**Total**	**Cattle Meats**	**Pig Meats**	**Poultry Meats**	**Other Meats**	**Fish**	**Eggs**	**Milk/ Cheese**	**Fruits/ Veg.**	**Pulse / Nuts**	**Starchy staples**	**Other**
Dominica	55.4	79.7	3.2	4.4	13.0	2.0	8.5	0.8	12.3	7.3	4.2	21.9	2.2
Dominican Republic	48.5	67.8	2.4	2.5	9.6	1.6	2.4	3.8	10.6	8.1	6.6	17.6	2.6
Ecuador	48.1	62.1	5.1	3.5	6.0	2.1	2.3	2.1	8.8	1.6	2.3	27.8	0.5
Egypt	23.9	93.2	3.0	-	5.0	2.6	6.6	0.9	4.2	6.7	3.3	59.4	1.7
El Salvador	35.2	82.9	3.9	1.4	7.9	0.5	2.2	2.4	11.0	3.5	12.6	35.5	2.1
Estonia	66.8	101.2	3.5	9.3	7.2	1.4	3.7	3.6	39.0	3.7	4.1	20.9	5.0
Eswatini	28.9	61.6	6.5	0.7	2.5	2.3	1.2	0.5	4.2	1.9	3.5	36.5	2.0
Ethiopia	10.6	74.1	1.5	0.0	0.2	2.0	0.2	0.1	3.8	0.8	15.6	46.8	3.0
Fiji	39.6	75.8	1.3	1.1	10.2	3.3	7.9	1.9	4.3	3.6	7.2	32.2	2.7
Finland	62.9	117.1	7.5	8.0	8.9	1.5	9.0	3.6	35.3	3.9	3.7	31.1	4.8
France	62.7	119.8	8.2	8.2	9.0	4.4	8.4	4.4	32.4	4.7	2.6	34.2	3.2
French Polynesia	66.3	95.0	10.7	4.9	16.9	3.4	13.6	3.8	9.7	3.0	2.1	23.4	3.6
Gabon	49.0	79.6	2.0	2.8	14.1	9.7	7.8	0.3	2.5	4.1	6.5	28.3	1.7
Gambia	30.1	61.5	1.4	0.1	3.6	0.9	7.4	0.5	4.8	0.9	8.4	32.7	1.1
Georgia	39.5	84.4	2.4	2.3	6.2	2.3	2.9	3.1	14.1	2.5	1.3	45.6	1.7
Germany	62.9	105.9	5.3	12.1	7.5	1.4	4.3	4.8	31.2	4.8	3.1	27.1	4.4
Ghana	25.3	65.2	0.7	0.4	3.6	2.7	8.1	0.3	0.8	4.5	7.1	34.9	2.1

		Total protein by source (gram per capita per day)										
Country	**Animal Share (%)**	**Total**	**Cattle Meats**	**Pig Meats**	**Poultry Meats**	**Other Meats**	**Fish**	**Eggs**	**Milk/ Cheese**	**Fruits/ Veg.**	**Pulse / Nuts**	**Starchy staples**	**Other**
Greece	59.2	102.2	5.2	6.0	10.4	4.9	6.3	2.7	25.0	7.3	3.9	27.1	3.4
Grenada	66.6	75.2	2.3	5.8	13.2	1.7	10.6	5.8	10.7	4.5	3.6	14.3	2.7
Guatemala	35.2	69.6	4.8	1.0	9.4	0.7	1.0	3.5	4.1	3.2	6.7	33.3	1.8
Guinea	20.1	57.5	3.4	0.1	0.9	2.2	2.9	0.6	1.5	6.6	6.6	32.1	0.7
Guinea-Bissau	20.2	44.5	1.5	2.3	1.1	1.2	0.3	0.4	2.2	1.6	3.5	30.0	0.4
Guyana	40.9	90.8	1.7	1.7	13.4	0.9	7.0	0.3	12.1	12.7	5.8	27.0	8.2
Haiti	23.8	45.7	1.6	1.4	3.3	1.5	1.5	0.2	1.4	2.1	6.0	25.9	0.9
Honduras	34.5	60.7	2.6	1.9	7.0	1.4	0.7	1.1	6.3	1.8	7.5	29.9	0.5
Hungary	58.0	87.4	1.5	13.6	11.6	0.5	1.8	4.6	17.0	4.2	1.5	28.3	2.7
Iceland	72.8	140.8	5.7	5.8	12.4	10.5	29.4	3.2	35.5	4.2	1.8	26.4	5.9
India	23.0	67.2	0.4	0.1	0.9	0.3	2.4	1.2	10.3	4.4	10.6	34.8	2.0
Indonesia	38.8	68.8	1.1	0.3	4.6	0.5	13.9	4.9	1.5	3.1	2.3	34.3	2.5
Iran	31.2	84.1	3.2	-	9.3	2.6	3.6	2.6	5.0	6.4	4.9	45.4	1.2
Iraq	16.2	64.1	1.1	0.1	2.0	1.2	1.0	0.8	4.1	4.0	3.6	45.2	1.0
Ireland	63.0	115.0	8.1	8.1	14.3	1.8	6.7	3.0	30.6	5.2	2.6	29.9	5.0
Israel	58.8	125.1	12.0	0.4	28.4	2.3	6.3	3.7	20.6	6.4	5.1	34.9	5.1

		Total protein by source (gram per capita per day)											
Country	Animal Share (%)	Total	Cattle Meats	Pig Meats	Poultry Meats	Other Meats	Fish	Eggs	Milk/ Cheese	Fruits/ Veg.	Pulse / Nuts	Starchy staples	Other
Italy	54.1	105.5	6.5	8.6	8.1	1.9	8.3	3.5	20.2	5.2	6.6	34.4	2.3
Jamaica	49.4	74.3	1.8	0.7	16.4	1.7	7.0	0.8	8.4	4.2	3.0	27.5	2.8
Japan	56.6	88.2	3.8	6.0	8.5	1.2	16.7	6.3	7.5	4.2	1.7	21.7	10.7
Jordan	40.2	62.5	3.0	-	9.4	2.4	1.4	1.5	7.5	4.0	5.4	25.9	2.1
Kazakhstan	56.8	104.9	10.8	2.1	7.3	9.4	0.8	2.3	27.0	6.3	5.2	32.0	1.8
Kenya	22.2	58.6	1.8	0.1	0.4	2.5	0.8	0.5	6.9	3.4	10.8	30.5	0.9
Kiribati	52.0	74.3	1.1	3.4	9.8	0.4	22.8	0.5	0.5	3.0	0.6	25.5	6.6
Kuwait	48.9	103.7	4.4	-	16.0	7.8	4.1	4.5	14.0	8.3	4.3	37.1	3.4
Kyrgyzstan	41.9	86.4	6.0	0.6	1.7	6.5	0.3	1.4	19.7	6.0	3.9	39.3	1.1
Laos	25.5	77.4	3.0	4.1	2.2	2.2	7.2	0.6	0.5	9.8	2.0	39.4	6.5
Latvia	60.2	96.4	2.0	10.1	9.1	2.7	7.7	4.0	22.5	4.7	1.2	27.9	4.5
Lebanon	33.7	68.3	3.9	0.2	6.7	0.9	2.3	1.3	7.9	4.6	7.5	31.1	2.1
Lesotho	28.4	55.7	0.8	1.2	0.8	5.5	1.1	0.2	6.4	1.2	1.9	36.0	0.9
Liberia	26.7	40.8	0.2	1.7	3.9	3.2	1.1	0.5	0.4	1.9	1.3	25.9	0.8
Libya	38.8	82.4	1.4	0.0	11.7	2.9	4.0	2.6	9.3	6.3	3.1	38.9	2.2
Lithuania	65.9	127.0	2.3	17.1	11.4	2.3	10.0	3.6	37.1	3.4	3.1	34.0	2.8

		Total protein by source (gram per capita per day)											
Country	**Animal Share (%)**	**Total**	**Cattle Meats**	**Pig Meats**	**Poultry Meats**	**Other Meats**	**Fish**	**Eggs**	**Milk/ Cheese**	**Fruits/ Veg.**	**Pulse / Nuts**	**Starchy staples**	**Other**
Luxembourg	61.5	109.1	11.2	10.9	7.1	2.0	8.4	5.0	22.5	5.0	1.9	28.4	6.8
Madagascar	13.6	37.3	0.5	0.3	1.1	0.4	1.1	0.2	1.6	1.3	1.2	29.3	0.5
Malawi	18.0	71.0	1.2	3.4	1.9	1.9	3.0	0.3	1.1	5.1	9.5	41.2	2.5
Malaysia	57.0	81.1	2.8	2.2	16.7	0.6	15.8	5.6	2.5	3.3	2.8	25.1	3.7
Maldives	54.4	79.6	2.6	0.1	3.8	0.3	27.1	3.6	5.8	3.4	8.4	22.9	1.6
Mali	14.2	76.6	1.5	0.0	0.8	1.5	2.1	0.2	4.8	5.7	6.6	52.2	1.2
Malta	59.5	108.2	11.1	7.7	11.5	1.3	9.5	3.6	19.7	6.2	2.4	32.9	2.4
Mauritania	35.9	82.9	2.5	-	2.0	8.7	2.4	0.7	13.5	1.9	5.9	43.6	1.7
Mauritius	45.5	86.4	2.2	1.3	13.6	2.2	7.6	1.8	10.4	2.9	7.6	33.9	2.7
Mexico	49.3	91.2	6.0	5.8	10.1	3.2	4.2	5.7	9.9	3.6	6.2	35.1	1.3
Mongolia	71.4	108.9	10.1	0.2	1.1	47.4	0.2	1.7	17.2	2.1	0.5	27.1	1.4
Montenegro	60.2	111.4	6.2	14.3	6.2	2.2	4.3	3.2	30.8	5.0	3.9	32.1	3.3
Morocco	29.3	99.1	3.1	0.0	8.3	3.9	6.1	2.5	5.2	4.1	6.9	57.4	1.7
Mozambique	16.7	44.1	0.2	0.9	1.3	0.2	4.0	0.4	0.4	1.6	6.2	28.4	0.6
Myanmar	46.6	97.0	3.5	6.1	9.7	2.2	15.6	2.7	5.4	4.0	10.5	31.4	5.9
Namibia	34.9	66.8	3.5	1.5	3.7	5.4	3.7	0.3	5.3	1.4	5.6	34.7	1.9

Country	Animal Share (%)	Total protein by source (gram per capita per day)											
		Total	Cattle Meats	Pig Meats	Poultry Meats	Other Meats	Fish	Eggs	Milk/ Cheese	Fruits/ Veg.	Pulse / Nuts	Starchy staples	Other
Nepal	18.5	75.4	2.7	0.3	0.8	2.4	1.0	0.7	6.1	6.2	8.7	43.9	2.6
Netherlands	62.6	112.6	6.6	8.3	4.1	5.9	6.8	6.9	32.1	5.6	4.7	28.6	3.1
New Caledonia	59.2	90.0	7.8	6.0	14.6	2.4	6.3	2.7	13.4	3.7	1.3	28.6	3.1
New Zealand	55.1	93.4	7.2	5.7	9.3	11.3	7.0	3.6	7.4	4.0	5.3	28.7	4.0
Nicaragua	36.4	67.5	0.9	1.5	7.0	1.2	1.6	1.3	11.2	1.7	9.2	31.6	0.4
Niger	12.3	83.7	1.1	0.0	0.3	2.2	0.5	0.1	6.0	4.3	31.3	36.0	1.8
Nigeria	11.6	58.9	0.6	0.5	0.4	1.4	2.6	0.8	0.6	3.2	10.5	35.7	2.8
North Macedonia	42.6	85.9	2.9	4.0	7.1	2.0	1.6	1.5	17.4	9.7	5.2	30.8	3.6
Norway	55.7	115.6	6.4	6.3	8.2	2.9	14.4	3.8	22.3	4.2	11.7	30.6	4.7
Oman	47.7	86.6	3.7	0.1	7.0	6.5	7.1	2.5	14.4	9.2	4.4	29.1	2.6
Pakistan	45.0	68.5	3.4	-	2.1	1.9	0.5	1.1	21.9	1.6	3.2	31.8	1.2
Panama	57.3	86.5	5.6	4.5	16.7	3.3	5.0	1.6	12.8	2.4	3.2	28.3	3.1
Papua New Guinea	54.0	63.0	0.4	3.1	1.4	23.9	4.8	0.2	0.3	6.7	0.5	19.8	2.0
Paraguay	39.0	72.9	8.4	3.1	2.9	2.7	1.2	4.3	5.9	2.6	6.2	29.8	5.9
Peru	48.8	91.6	2.4	1.7	21.3	2.4	7.8	3.0	6.0	4.2	6.2	33.5	3.0
Philippines	38.6	68.8	1.1	4.4	5.3	3.0	8.5	1.6	2.6	4.2	1.5	35.1	1.4

		Total protein by source (gram per capita per day)										
Country	Animal Share (%)	Total	Cattle Meats	Pig Meats	Poultry Meats	Other Meats	Fish	Eggs	Milk/ Cheese	Fruits/ Veg.	Pulse / Nuts	Starchy staples	Other
Poland	57.3	110.1	0.5	18.7	13.6	0.6	6.6	2.7	20.4	4.3	1.3	38.1	3.3
Portugal	63.8	117.6	8.2	10.4	12.6	3.2	18.1	3.2	19.3	5.8	3.4	30.3	3.1
South Korea	51.7	98.1	6.2	10.7	7.7	2.6	15.9	3.9	3.8	9.1	2.3	25.5	10.4
Moldova	40.4	68.5	0.8	5.3	6.0	1.0	3.3	2.4	8.9	3.0	2.3	34.5	1.0
Romania	50.2	106.0	2.2	9.1	10.3	2.9	2.3	4.0	22.5	5.9	2.0	42.2	2.8
Russian Federation	53.7	105.6	5.4	7.7	10.4	4.2	7.2	4.8	17.1	3.8	2.4	40.9	1.9
Rwanda	12.6	56.3	1.1	0.3	0.5	1.8	1.5	0.1	1.9	4.0	20.4	22.1	2.7
Saint Kitts and Nevis	62.8	67.1	1.4	5.2	16.7	1.7	10.5	0.7	6.0	1.9	4.0	17.5	1.6
Saint Lucia	63.2	88.4	1.5	5.0	19.1	13.8	9.3	0.8	6.5	2.2	3.8	25.1	1.4
St. Vinc. and Grenadines	57.8	85.2	2.9	3.9	26.0	1.1	5.8	1.4	8.1	3.9	5.3	23.9	2.8
Samoa	55.4	87.3	2.9	4.0	22.2	2.1	12.7	0.5	4.1	3.8	0.7	30.3	4.2
Sao Tome and Principe	34.2	54.9	1.0	1.5	5.9	0.2	8.5	0.2	1.4	5.4	2.1	28.0	0.7
Saudi Arabia	40.4	92.1	2.0	-	15.4	3.6	3.1	3.0	10.2	5.1	4.2	42.9	2.7
Senegal	19.5	65.0	2.0	0.4	2.5	2.4	3.2	0.7	1.6	3.3	8.8	39.5	0.7
Serbia	49.0	89.9	2.6	11.6	4.9	3.4	2.2	2.8	16.5	4.2	3.0	35.4	3.3
Seychelles	51.5	99.5	5.1	4.6	13.0	1.4	18.1	2.4	6.7	5.4	6.1	31.1	5.7

		Total protein by source (gram per capita per day)										
Country	**Animal Share (%)**	**Total**	**Cattle Meats**	**Pig Meats**	**Poultry Meats**	**Other Meats**	**Fish**	**Eggs**	**Milk/ Cheese**	**Fruits/ Veg.**	**Pulse / Nuts**	**Starchy staples**	**Other**
Sierra Leone	24.2	50.5	0.5	0.3	1.7	1.3	7.1	0.4	0.9	2.7	7.0	28.0	0.5
Slovakia	52.7	72.4	2.0	10.3	5.9	1.7	2.9	2.9	12.5	3.1	2.2	25.8	3.1
Slovenia	53.9	98.7	5.7	7.3	10.6	2.3	3.7	2.9	20.7	5.3	1.9	33.6	4.6
Solomon Islands	30.6	49.6	0.8	1.4	2.4	0.3	9.1	0.2	1.1	1.1	5.5	25.5	2.4
South Africa	45.7	79.1	6.9	1.1	13.8	5.2	1.8	2.4	5.0	1.6	1.3	38.5	1.5
Spain	63.7	111.1	4.8	13.6	13.8	3.6	12.6	4.7	17.7	4.9	5.6	26.7	3.2
Sri Lanka	27.6	70.0	0.5	0.0	3.5	0.1	9.1	1.2	4.8	3.5	7.1	35.3	4.8
Sudan	26.1	74.5	3.2	-	0.6	5.3	0.3	0.4	9.6	3.7	10.7	39.5	1.2
Suriname	46.9	66.4	2.2	2.5	14.8	0.5	4.7	1.7	4.8	4.1	3.4	26.3	1.6
Sweden	63.4	109.5	8.8	9.4	6.5	4.2	8.4	4.3	27.9	4.1	3.2	28.3	4.6
Switzerland	63.0	97.8	6.7	7.5	7.0	3.1	4.2	3.4	29.9	4.8	3.3	25.8	2.4
Syria	25.5	82.2	0.8	0.1	2.3	3.8	0.6	2.5	10.7	5.5	11.1	42.3	2.3
Tajikistan	35.1	81.7	10.4	0.1	1.2	6.8	0.2	1.3	8.7	7.3	3.5	41.1	1.2
Thailand	41.0	64.2	0.8	4.0	3.9	1.1	10.3	3.8	2.5	2.6	2.1	27.9	5.3
Timor-Leste	22.6	50.9	0.6	3.6	3.2	0.6	1.8	0.7	1.0	1.4	5.1	29.1	3.8
Togo	15.4	56.8	0.3	0.7	2.4	1.2	3.2	0.5	0.4	1.1	7.9	37.7	1.2
Trinidad and Tobago	51.6	84.1	2.9	1.9	19.3	2.1	6.8	1.2	9.3	2.9	6.1	29.8	2.0

		Total protein by source (gram per capita per day)										
Country	**Animal Share (%)**	**Total**	**Cattle Meats**	**Pig Meats**	**Poultry Meats**	**Other Meats**	**Fish**	**Eggs**	**Milk/ Cheese**	**Fruits/ Veg.**	**Pulse / Nuts**	**Starchy staples**	**Other**
Tunisia	28.5	100.3	1.5	-	6.6	2.8	3.8	2.2	11.7	10.3	5.8	51.4	4.2
Turkey	35.6	112.7	7.3	-	6.8	0.9	1.5	3.2	20.4	9.6	10.5	49.3	3.1
Turkmenistan	38.9	88.8	9.1	0.0	2.1	10.7	0.8	2.2	9.7	3.7	1.7	48.1	0.8
Uganda	22.0	50.3	1.4	0.8	0.5	0.9	4.3	0.2	2.9	5.3	10.8	19.9	3.1
Ukraine	47.8	88.9	2.9	5.0	8.4	1.6	3.7	5.8	15.1	5.8	1.5	37.7	1.4
United Arab Emirates	43.0	84.0	3.1	-	10.5	4.6	6.6	2.1	9.2	2.9	12.0	30.7	2.2
United Kingdom	56.1	104.5	6.2	7.2	14.2	3.1	5.7	3.5	18.8	4.7	3.6	34.3	3.3
Tanzania	20.3	60.1	3.1	0.1	0.5	1.4	2.1	0.3	4.7	3.1	14.1	29.4	1.3
United St. America / USA	64.1	118.8	12.9	9.2	20.9	0.9	5.5	4.7	22.0	4.8	7.7	26.9	3.2
Uruguay	55.5	89.3	6.7	5.0	6.6	2.2	2.6	3.7	22.6	3.0	2.7	29.9	4.1
Uzbekistan	45.0	104.4	12.7	0.1	0.9	4.5	1.2	2.5	25.0	8.9	1.0	46.8	0.7
Vanuatu	37.5	64.5	3.3	3.9	5.2	0.9	8.8	0.6	1.5	3.2	3.6	28.9	4.5
Venezuela	41.4	55.5	3.8	1.1	5.7	1.1	3.0	1.6	6.8	2.6	6.8	22.2	0.9
Vietnam	41.4	88.0	2.2	11.5	5.1	3.0	11.1	1.3	2.1	7.6	3.5	34.4	6.1
Yemen	21.4	54.7	1.2	-	4.0	2.4	0.9	0.5	2.7	1.3	3.8	37.2	0.7
Zambia	23.1	54.7	3.7	0.5	0.9	2.2	3.9	0.9	0.6	0.9	2.7	36.1	2.4
Zimbabwe	44.1	55.9	16.9	0.2	1.6	2.3	0.9	0.4	2.4	0.9	3.4	26.3	0.7