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Medical and pharmaceutical information useful to everyone Rosheta provides you with important medical and pharmaceutical information for all family members through specialized doctors and pharmacists. Page 2 Page 3 Page 4 Page 5 Page 6 Page 7 Page 8 Page 9 Page 10 Page 11 Page 12 Page 13 Page 14 Page 15 Page 16 Page 17 Page 18 Page 19 Page 20 Page 21 Page 22 Page 23 Page 24 Page 25 Page 26 Amino acids serve as the fundamental building blocks of proteins, the workhorses of biological systems. These remarkable molecules join together through peptide bonds to form peptides and ultimately proteins that perform countless essential functions in the human body. From maintaining tissue structure to catalyzing biochemical reactions, the journey from simple amino acids to complex proteins is central to understanding human physiology and biochemistry. Table of Contents All amino acids share a common structural framework while maintaining unique properties that contribute to protein diversity. This balance between uniformity and variation makes amino acids particularly fascinating molecules to study. General structure of amino acids At their core, amino acids consist of a central carbon atom (the alpha carbon) bonded to four key groups: Amino group (-$NH_2$): A basic functional group that can accept protons Carboxyl group (-COOH): An acidic functional group that can donate protons Hydrogen atom (H): The simplest element, attached directly to the alpha carbon R group (side chain): The variable component that gives each amino acid its unique properties This tetrahedral arrangement creates a chiral center at the alpha carbon (except in glycine, where the R group is simply another hydrogen). The resulting stereoisomers are designated as L-amino acids (left-handed) or D-amino acids (right-handed). Remarkably, almost all proteins in living organisms are composed exclusively of L-amino acids. The diverse side chains of amino acids determine their chemical behavior and biological functions. Based on these R groups, amino acids can be classified into several categories: Nonpolar (hydrophobic) amino acids These amino acids have side chains that repel water and typically cluster in the interior of proteins, away from the aqueous environment. Examples include: Alanine (Ala): Contains a simple methyl group Valine (Val): Has a branched-chain structure Leucine (Leu): Features a longer branched-chain Isoleucine (Ile): Contains an isomeric form of the leucine side chain Phenylalanine (Phe): Includes an aromatic ring structure Polar (hydrophilic) amino acids These amino acids have side chains that interact favorably with water and often appear on protein surfaces. Examples include: Serine (Ser): Contains a hydroxyl group Threonine (Thr): Features a hydroxyl group on a secondary carbon Asparagine (Asn): Contains an amide group Glutamine (Gln): Features a longer side chain with an amide group Acidic amino acids These contain carboxyl groups in their side chains and can donate protons: Aspartic acid (Asp): Contains a short side chain ending in a carboxyl group Glutamic acid (Glu): Features a longer side chain ending in a carboxyl group Basic amino acids These contain nitrogen-rich groups that can accept protons: Lysine (Lys): Contains a side chain ending in an amino group Arginine (Arg): Features a guanidino group Histidine (His): Contains an imidazole ring that can be protonated Special amino acids Some amino acids have unique properties that don't fit neatly into the categories above: Glycine (Gly): The simplest amino acid, with just a hydrogen atom as its side chain Proline (Pro): Contains a cyclic structure where the side chain connects back to the amino group Cysteine (Cys): Contains a sulfhydryl group capable of forming disulfide bonds Methionine (Met): Contains a sulfur atom in its side chain Tryptophan (Trp): Features an indole ring structure Tyrosine (Tyr): Contains a phenolic group Essential versus non-essential amino acids From a nutritional perspective, amino acids are categorized based on whether the human body can synthesize them: Essential amino acids cannot be synthesized by the human body and must be obtained through diet. For adults, these include: Valine Leucine Isoleucine Phenylalanine Tryptophan Methionine Threonine Lysine Histidine (especially important for infants) Non-essential amino acids can be synthesized by the body and include: Alanine Asparagine Aspartic acid Glutamic acid Serine Cysteine Glycine Proline Tyrosine Glutamine Arginine In nursing practice, understanding essential amino acids is crucial when managing patients with dietary restrictions or malnutrition, as deficiencies can lead to serious health issues. Peptide Bonds: The Chemical Foundation of Protein Structure When amino acids join together, they form peptide bonds—the chemical linkages that serve as the backbone of protein structure. Formation of peptide bonds A peptide bond forms through a condensation reaction (also called a dehydration synthesis) between two amino acids: The carboxyl group (-COOH) of one amino acid reacts with the amino group (-$NH_2$) of another A water molecule ($H_2O$) is released during this process The resulting covalent bond, designated as C-N, is the peptide bond The reaction can be represented as: $R_1$-CH($NH_2$)-COOH + $R_2$-CH($NH_2$)-COOH → $R_1$-CH($NH_2$)-CO-NH-CH($R_2$)-COOH + $H_2O$ In biological systems, this process is catalyzed by the ribosome during protein synthesis, using the coded information from messenger RNA (mRNA). Properties of peptide bonds Peptide bonds possess several important characteristics: Partial double bond character: The peptide bond has approximately 40% double bond character due to resonance structures, making it relatively rigid Planar structure: The atoms involved in the peptide bond (C, O, N, H) lie in the same plane Trans configuration: Most peptide bonds adopt a trans configuration where the alpha carbons are on opposite sides of the bond Stability: Peptide bonds are quite stable under physiological conditions but can be hydrolyzed by specific enzymes (proteases) These properties create important constraints on protein folding while providing stability to the resulting structures. Directionality in peptide chains Peptide chains have inherent directionality, with: N-terminus: The end with a free amino group, conventionally written on the left C-terminus: The end with a free carboxyl group, conventionally written on the right This directionality is crucial in protein biochemistry and is always specified when referring to peptide sequences. In the body, protein synthesis always proceeds from the N-terminus to the C-terminus. From Peptides to Proteins: Understanding the Hierarchy As amino acids link together through peptide bonds, they form chains of increasing complexity that eventually fold into functional proteins. Oligopeptides versus polypeptides Based on their length, peptide chains are classified as: Dipeptides: Two amino acids joined by a single peptide bond Tripeptides: Three amino acids linked by two peptide bonds Oligopeptides: Generally containing between 2-20 amino acids Polypeptides: Longer chains containing more than 20-50 amino acids The distinction between oligopeptides and polypeptides is somewhat arbitrary, but generally relates to molecular weight and complexity. Many shorter peptides serve crucial biological functions: Glutathione: A tripeptide (Glu-Cys-Gly) that functions as an important antioxidant Oxytocin: A nonapeptide hormone involved in childbirth and social bonding Vasopressin: A nonapeptide hormone regulating water retention and blood pressure Enkephalins: Pentapeptides functioning as natural painkillers Insulin: A hormone composed of two polypeptide chains (A and B) linked by disulfide bonds, regulating blood glucose In nursing practice, understanding these peptides is essential when administering medications like oxytocin for labor induction or insulin for diabetes management. Protein structure: The four levels of organization Proteins exhibit a hierarchical organization: Primary structure The linear sequence of amino acids in a polypeptide chain, joined by peptide bonds. This sequence is determined by the genetic code and forms the foundation for all higher levels of structure. Secondary structure Regular, recurring patterns stabilized by hydrogen bonds between the backbone atoms, not involving the side chains. The main types are: Alpha-helix: A right-handed spiral structure where each backbone N-H group forms a hydrogen bond with the C=O group of another amino acid four residues earlier Beta-sheet: Extended strands lying side by side, with hydrogen bonds forming between adjacent strands Beta-turns and loops: Structures that connect other secondary structure elements Tertiary structure The overall three-dimensional arrangement of all atoms in a single polypeptide chain, stabilized by various interactions including: Hydrophobic interactions: Nonpolar side chains clustering in the protein core Hydrogen bonds: Between side chains Ionic bonds: Between oppositely charged side chains Disulfide bridges: Covalent bonds between cysteine residues Quaternary structure The arrangement of multiple polypeptide chains (subunits) in a single functional protein complex. Examples include: Hemoglobin: Four polypeptide chains (two alpha and two beta) Collagen: Three polypeptide chains arranged in a triple helix Clinical Significance in Nursing Practice Understanding amino acids, peptides, and protein structure has numerous applications in nursing care: Nurses must assess protein requirements and dietary sources, particularly for: Critically ill patients: Who may need increased protein for tissue repair Patients with kidney disease: Who may require protein restriction Vegetarian/vegan patients: Who need guidance on plant-based protein complementation to obtain all essential amino acids Elderly patients: Who often have increased protein needs but decreased intake Many pathological conditions involve protein abnormalities: Phenylketonuria (PKU): Inability to metabolize phenylalanine Maple Syrup Urine Disease: Defect in metabolism of branched-chain amino acids Albinism: Defective tyrosine metabolism affecting melanin production Sickle Cell Anemia: Single amino acid substitution in hemoglobin Cystic Fibrosis: Mutation affecting chloride channel protein Protein-based therapeutics Nurses frequently administer protein and peptide medications: Insulin: For diabetes management Monoclonal antibodies: For cancer and autoimmune conditions Erythropoietin: For anemia Human Growth Hormone: For growth disorders Various peptide hormones: Including oxytocin, vasopressin, and calcitonin Modern Research and Future Directions The field of protein biochemistry continues to evolve: Proteomics: The large-scale study of proteins and their functions Protein engineering: Designing proteins with novel functions Therapeutic peptides: Development of peptide-based drugs with enhanced specificity Protein folding prediction: Using computational methods to predict 3D structure from primary sequence Protein misfolding diseases: Understanding conditions like Alzheimer's and Parkinson's that involve protein aggregation These advancements continue to shape our understanding of protein structure and function, with significant implications for healthcare. Conclusion Amino acids, peptide bonds, and peptides form the foundation of protein structure and function. From the simplest dipeptide to complex multi-subunit proteins, the principles of amino acid chemistry and peptide bond formation guide how these biomolecules assume their functional forms. For nursing students, this knowledge provides essential context for understanding nutrition, metabolism, pharmacology, and pathophysiology—all critical aspects of patient care. What do you think? How might your understanding of protein structure influence how you explain dietary protein requirements to patients with different health conditions? How could knowledge of peptide hormones help you better understand the mechanisms of certain medications you might administer? Amino acids, peptides, and proteins are all fundamental components of cells that play a crucial role in biological functions. Amino acids are organic compounds composed of an amino and a carboxylic group with a unique side chain. They are the building blocks of peptides and proteins. Peptides are short chains of amino acids, typically between two and 50 amino acids in length, while proteins are larger molecules composed of 50 or more amino acids. The basic distinguishing factors between peptides and proteins are size and structure. Peptides tend to have a less complex structure than proteins, which can adopt complex conformations. Additionally, peptides and proteins differ in their functions, with proteins serving as structural and functional components of tissues and organs, while peptides act as signaling molecules. Understanding the differences between these molecules is essential for various applications, including drug development and the diagnosis and treatment of diseases.Differences between Amino Acids, Peptides and Proteins Characteristics Amino Acids Peptides Proteins Definition Amino acids are organic compounds composed of an amino and a carboxylic group with a side chain (designated as R) unique to all amino acids. Peptides are short chains of amino acids, typically between two and 50 amino acids in length. Proteins are large peptide molecules, composed of 50 or more amino acids. Structure Amino acids are the building blocks of proteins. Peptides have a less complex structure compared to proteins. Proteins have four levels of structure: primary, secondary, tertiary, and quaternary. They can adopt complex conformations and have the ability to form stable, three-dimensional structures. Function Amino acids play diverse roles in energy provision and the formation of other biomolecules, including hormones, neurotransmitters, and signaling molecules. Peptides act as signaling molecules, including neuropeptides, peptide hormones, and polypeptide growth factors. They are indispensable for biological functions but have less diverse functions than proteins. Proteins serve as structural and functional components of tissues and organs. They are required for a vast array of cellular functions, including DNA replication, metabolic reactions, transportation of molecules, and responding to stimuli. Therapeutic Use N/A Peptides are attractive for therapeutic use due to their length, which allows for chemical synthesis, and their potential to be more selective, potent, and safer. Proteins have served as both targets and therapeutics in medicine. They can act as antibodies and have been used to treat a range of diseases, including cancer and autoimmune diseases. Amino acids are the building blocks of proteins Amino acids are organic compounds composed of an amino and a carboxylic group with a side chain (designated as R) unique to all amino acids. They are the building blocks of proteins and play a crucial role in the provision of energy and the formation of other biomolecules, including hormones, neurotransmitters, and signalling molecules. Amino acids can exist as both acidic and basic ions, known as zwitterions, and they are amphoteric, meaning they can act as both acids and bases.Amino acids form chains, which can be relatively short (peptides) or long (proteins). These chains are held together by peptide bonds, also called amide bonds. Peptides are typically defined as molecules consisting of between 2 and 50 amino acids, while proteins are made up of 50 or more amino acids. This distinction, however, is not always clear-cut, and the terminology used by scientists can be somewhat flexible.The structure of peptides and proteins is an important factor in their function. Peptides have a less complex structure compared to proteins, which can adopt more complex conformations known as secondary, tertiary, and quaternary structures. Proteins can fold into stable, three-dimensional shapes, which contribute to their functionality. For example, haemoglobin, a protein found in red blood cells and essential for carrying oxygen, is made up of four different amino acid chains.The diversity of peptide and protein structures allows them to play a wide range of roles in biological processes. Peptides act as signalling molecules, including neuropeptides, peptide hormones, and polypeptide growth factors. Proteins, on the other hand, are required for almost all cellular functions, including DNA replication, metabolic reactions, transportation of molecules, providing structure to cells, and responding to stimuli.Peptides are short chains of amino acids Peptides are generally defined as molecules that consist of between 2 and 50 amino acids. However, the definition is somewhat loose, and peptides can be further subdivided into oligopeptides and polypeptides. Oligopeptides have a few amino acids, typically between 2 and 20, while polypeptides have many amino acids, usually more than 20.The length of a peptide chain is important in the manufacture of therapeutic peptide-based drugs. For example, peptides with a fatty acid or lipid attached, called cyclic lipopeptides, have been used to develop antibiotics that target Gram-negative bacteria. One well-known peptide-based drug is exenatide, which is used to control blood sugar levels in type 2 diabetes patients.Peptides are indispensable for biological functions. They act as signalling molecules, including neuropeptides, peptide hormones, and polypeptide growth factors. For example, oxytocin is a neuropeptide that is involved in a variety of neurological functions and provides protection from cardiovascular disease.Proteins are made up of polypeptides Amino acids are organic compounds composed of an amino and a carboxylic group with a side chain. They are the building blocks of proteins. Peptides and proteins are also made up of strings of amino acids, but the key difference between peptides and proteins is that peptides are made up of shorter chains of amino acids than proteins.Peptides are typically defined as molecules consisting of between 2 and 50 amino acids, while proteins are made up of 50 or more amino acids. Peptides can be further subdivided into oligopeptides, which have a few amino acids (2 to 20), and polypeptides, which have many amino acids.Polypeptides are linear chains of amino acids, and proteins are made up of one or more of these polypeptide chains. The human genome contains the information to dictate the formation of approximately 20,000 polypeptides. However, the average size of a protein is between 40 and 100 amino acids, and they can be as short as 40 or as long as several hundred amino acids.While the terms "peptide" and "polypeptide" are sometimes used interchangeably, the term "polypeptide" is often used to refer to a chain of 10 or more amino acids, with "protein" being used for larger peptide molecules. As such, proteins are essentially very large peptides, and the distinction between the two is not always apparent. However, the fundamental differences between them go beyond an arbitrary length threshold, including differences in structure, function, and therapeutic use. Peptides and proteins have different structures and functions Peptides and proteins are composed of amino acids, which are organic compounds made up of an amino and a carboxylic group with a side chain. However, they differ in their structure and function.StructurePeptides are short chains of amino acids, typically between two and 50 amino acids in length. They are less complex and have a less well-defined structure than proteins. Peptides may be subdivided into oligopeptides, which have few amino acids (up to 20), and polypeptides, which have many amino acids.On the other hand, proteins are larger molecules composed of multiple peptide subunits. They are made up of at least 50 and usually more than 100 amino acids. Proteins have four levels of structure: primary (sequence of amino acids), secondary (structures such as alpha helices and beta sheets), tertiary (3-dimensional structure), and quaternary (complexes of multiple protein subunits). The structure of a protein contributes to its function, and modifications to this structure can affect its activity.FunctionPeptides act as signalling molecules, including neuropeptides, peptide hormones, and polypeptide growth factors. They are indispensable for biological functions but have a less diverse range of functions compared to proteins. Peptides can be used as drugs due to their length, which allows them to be chemically synthesized, and their ability to mimic the behaviour of natural ligands.Proteins, on the other hand, are required for almost all cellular functions and serve as structural and functional components of tissues and organs. They give cells their shape and perform a variety of tasks such as DNA replication, catalyzing metabolic reactions, transporting molecules, and responding to stimuli. Proteins can also serve as therapeutics, such as antibodies, which are particularly useful in anti-cancer treatments.Peptides and proteins are used as pharmaceuticals Peptides and proteins are fundamental components of cells that carry out important biological functions. They are composed of amino acids held together by peptide bonds. However, they differ in size and structure, with peptides being smaller and less well-defined in structure than proteins. These differences impact their respective therapeutic uses.Peptides are short chains of amino acids, typically consisting of between two and 50 amino acids. They are defined by their amino acid sequence, which refers to the order of the different building blocks in the peptide. Oligopeptides have fewer than 20 amino acids, while polypeptides have many amino acids, typically over 50. The synthesis of peptides can be controlled by gene clusters, leading to structurally and functionally diverse peptides.Peptides have emerged as a significant class of drugs with diverse applications, including antimicrobial, anti-tumour, and anti-diabetic properties. They can act as hormones, growth factors, neurotransmitters, ion channel ligands, or anti-infective agents. Peptide hormones, such as insulin, transmit signals between cells by binding to membrane-bound receptors. Peptides can also be used in hormone replacement therapies. For example, insulin is used to treat type 1 diabetes, and oxytocin is a neuropeptide involved in various neurological functions and providing protection from cardiovascular disease.Proteins, on the other hand, are larger and can adopt complex conformations known as secondary, tertiary, and quaternary structures. They are formed from one or more polypeptides joined together and typically consist of 50 or more amino acids. The structure of a protein contributes to its function, and modifications to its structure can toggle it between active and inactive forms.Proteins serve as structural and functional components of tissues and organs and are required for various cellular functions. For example, enzymes are a type of protein that catalyzes and speeds up reactions necessary to sustain life. G-protein coupled receptors (GPCRs) are a commonly targeted protein for therapeutics due to their involvement in numerous physiological functions. Monoclonal antibodies, a type of protein therapeutic, have revolutionized medicine and are used to treat a range of diseases, including cancer.In summary, peptides and proteins have distinct characteristics that make them valuable in pharmaceutical applications. Peptides have advantages such as heightened target specificity and potency, while proteins provide structural support and perform essential cellular functions. The development and use of peptide and protein-based therapeutics continue to advance and play an increasingly significant role in the pharmaceutical industry.Frequently asked questions Amino acids are organic compounds composed of an amino and a carboxylic group with a side chain. They are the building blocks of proteins. Peptides are short chains of amino acids, typically between two and 50 amino acids in length. Proteins are large peptide molecules, composed of multiple peptide subunits, with at least 50 amino acids. Amino acids are the building blocks of peptides and proteins. Peptides are relatively short chains of amino acids, while proteins are longer chains with a more complex structure. Peptides have a less complex structure and are more flexible than proteins. Proteins can adopt complex conformations known as secondary, tertiary, and quaternary structures. Amino acids play diverse roles in energy provision and the formation of other biomolecules, including hormones, neurotransmitters, and signalling molecules. Peptides act as signalling molecules, including neuropeptides, peptide hormones, and polypeptide growth factors. They are indispensable for biological functions. Proteins are required for almost all cellular functions and serve as structural and functional components of tissues and organs. They give cells their shape and perform a variety of functions such as DNA replication, metabolic reactions, transportation of molecules, and responding to stimuli. Peptides have potential as therapeutic drugs due to their selective and potent nature, and their ability to mimic the behaviour of natural ligands. They can be used to create peptide-based drugs, such as exenatide, which helps control blood sugar levels in type 2 diabetes patients. Proteins, on the other hand, can serve as therapeutic targets, with G-protein coupled receptors being a common target. Proteins can also be used as therapeutics, such as monoclonal antibodies for treating diseases like cancer and rheumatoid arthritis. Organic compounds containing amine and carboxylic groups This article is about the class of chemicals. For the structures and properties of the standard proteinogenic amino acids, see Proteinogenic amino acid. Structure of a typical L-alpha-amino acid in the "neutral" form Amino acids are organic compounds that contain both amino and carboxylic acid functional groups.[1] Although over 500 amino acids exist in nature, by far the most important are the 22 α-amino acids incorporated into proteins.[2] Only these 22 appear in the genetic code of life.[3][4] Amino acids can be classified according to the locations of the core structural functional groups (alpha- (α-), beta- (β-), gamma- (γ-) amino acids, etc.); other categories relate to polarity, ionization, and side-chain group type (aliphatic, acyclic, aromatic, polar, etc.). In the form of proteins, amino-acid residues form the second-largest component (water being the largest) of human muscles and other tissues.[5] Beyond their role as residues in proteins, amino acids participate in a number of processes such as neurotransmitter transport and biosynthesis. It is thought that they played a key role in enabling life on Earth and its emergence.[6] Amino acids are formally named by the IUPAC-IUBMB Joint Commission on Biochemical Nomenclature in terms of the fictitious "neutral" structure shown in the illustration. For example, the systematic name of alanine is 2-aminopropanoic acid, based on the formula CH3−CH(NH2)−COOH. The Commission justified this approach as follows:[7] The systematic names and formulas given refer to hypothetical forms in which amino groups are unprotonated and carboxyl groups are undissociated. This convention is useful to avoid various nomenclatural problems but should not be taken to imply that these structures represent an appreciable fraction of the amino-acid molecules. The first few amino acids were discovered in the early 1800s.[8][9] In 1806, French chemists Louis-Nicolas Vauquelin and Pierre Jean Robiquet isolated a compound from asparagus that was subsequently named asparagine, the first amino acid to be discovered.[10][11] Cystine was discovered in 1810,[12] although its monomer, cysteine, remained undiscovered until 1884.[13][11][a] Glycine and leucine were discovered in 1820.[14] The last of the 20 common amino acids to be discovered was threonine in 1935 by William Cumming Rose, who also determined the essential amino acids and established the minimum daily requirements of all amino acids for optimal growth.[15][16] The unity of the chemical category was recognized by Wurtz in 1865, but he gave no particular name to it.[17] The first use of the term "amino acid" in the English language dates from 1898,[18] while the German term, Aminosäure, was used earlier.[19] Proteins were found to yield amino acids after enzymatic digestion or acid hydrolysis. In 1902, Emil Fischer and Franz Hofmeister independently proposed that proteins are formed from many amino acids, whereby bonds are formed between the amino group of one amino acid with the carboxyl group of another, resulting in a linear structure that Fischer termed "peptide".[20] The 21 proteinogenic α-amino acids found in eukaryotes, grouped according to their side chains' pKa values and charges carried at physiological pH (7.4) 2-, alpha-, or α-amino acids[21] have the generic formula H2NCHRCOOH in most cases,[b] where R is an organic substituent known as a "side chain".[22] Of the many hundreds of described amino acids, 22 are proteinogenic ("protein-building").[23][24][25] It is these 22 compounds that combine to give a vast array of peptides and proteins assembled by ribosomes.[26] Non-proteinogenic or modified amino acids may arise from post-translational modification or during nonribosomal peptide synthesis. The carbon atom next to the carboxyl group is called the α-carbon. In proteinogenic amino acids, it bears the amine and the R group or side chain specific to each amino acid, as well as a hydrogen atom. With the exception of glycine, for which the side chain is also a hydrogen atom, the α−carbon is stereogenic. All chiral proteogenic amino acids have the L configuration. They are "left-handed" enantiomers, which refers to the stereoisomers of the alpha carbon. A few D-amino acids ("right-handed") have been found in nature, e.g., in bacterial envelopes, as a neuromodulator (D-serine), and in some antibiotics.[27][28] Rarely, D-amino acid residues are found in proteins, and are converted from the L-amino acid as a post-translational modification.[29][c] Five amino acids possess a charge at neutral pH. Often these side chains appear at the surfaces on proteins to enable their solubility in water, and side chains with opposite charges form important electrostatic contacts called salt bridges that maintain structures within a single protein or between interfacing proteins.[32] Many proteins bind metal into their structures specifically, and these interactions are commonly mediated by charged side chains such as aspartate, glutamate and histidine. Under certain conditions, each ion-forming group can be charged, forming double salts.[33] The two negatively charged amino acids at neutral pH are aspartate (Asp, D) and glutamate (Glu, E). The anionic carboxylate groups behave as Brønsted bases in most circumstances.[32] Enzymes in very low pH environments, like the aspartic protease pepsin in mammalian stomachs, may have catalytic aspartate or glutamate residues that act as Brønsted acids. Functional groups found in histidine (left), lysine (middle) and arginine (right) There are three amino acids with side chains that are cations at neutral pH: arginine (Arg, R), lysine (Lys, K) and histidine (His, H). Arginine has a charged guanidino group and lysine a charged alkyl amino group, and are fully protonated at pH 7. Histidine's imidazole group has a pKa of 6.0, and is only around 10% protonated at neutral pH. Because histidine is easily found in its basic and conjugate acid forms it often participates in catalytic proton transfers in enzyme reactions.[32] The polar, uncharged amino acids serine (Ser, S), threonine (Thr, T), asparagine (Asn, N) and glutamine (Gln, Q) readily form hydrogen bonds with water and other amino acids.[32] They do not ionize in normal conditions, a prominent exception being the catalytic serine in serine proteases. This is an example of severe perturbation, and is not characteristic of serine residues in general. Threonine has two chiral centers, not only the L (2S) chiral center at the α-carbon shared by all amino acids apart from achiral glycine, but also (3R) at the β-carbon. The full stereochemical specification is (2S,3R)-L-threonine. Nonpolar amino acid interactions are the primary driving force behind the processes that fold proteins into their functional three dimensional structures.[32] None of these amino acids' side chains ionize easily, and therefore do not have pKas, with the exception of tyrosine (Tyr, Y). The hydroxyl of tyrosine can deprotonate at high pH forming the negatively charged phenolate. Because of this one could place tyrosine into the polar, uncharged amino acid category, but its very low solubility in water matches the characteristics of hydrophobic amino acids well. Several side chains are not described well by the charged, polar and hydrophobic categories. Glycine (Gly, G) could be considered a polar amino acid since its small size means that its solubility is largely determined by the amino and carboxylate groups. However, the lack of any side chain provides glycine with a unique flexibility among amino acids with large ramifications to protein folding.[32] Cysteine (Cys, C) can also form hydrogen bonds readily, which would place it in the polar amino acid category, though it can often be found in protein structures forming covalent bonds, called disulphide bonds, with other cysteines. These bonds influence the folding and stability of proteins, and are essential in the formation of antibodies. Proline (Pro, P) has an alkyl side chain and could be considered hydrophobic, but because the side chain joins back onto the alpha amino group it becomes particularly inflexible when incorporated into proteins. Similar to glycine this influences protein structure in a way unique among amino acids. Selenocysteine (Sec, U) is a rare amino acid not directly encoded by DNA, but is incorporated into proteins via the ribosome. Selenocysteine has a lower redox potential compared to the similar cysteine, and participates in several unique enzymatic reactions.[34] Pyrrolysine (Pyl, O) is another amino acid not encoded in DNA, but synthesized into protein by ribosomes.[35] It is found in archaeal species where it participates in the catalytic activity of several methyltransferases. Amino acids with the structure NH+3−CXY−CXY−CO−2, such as β-alanine, a component of carnosine and a few other peptides, are β-amino acids. Ones with the structure NH+3−CXY−CXY−CXY−CO−2 are γ-amino acids, and so on, where X and Y are two substituents (one of which is normally H).[7] Main article: Zwitterion Ionization and Brønsted character of N-terminal amino, C-terminal carboxylate, and side chains of amino acid residues The common natural forms of amino acids have a zwitterionic structure, with −NH+3 (−NH+2− in the case of proline) and −CO−2 functional groups attached to the same C atom, and are thus α-amino acids, and are the only ones found in proteins during translation in the ribosome. In aqueous solution at pH close to neutrality, amino acids exist as zwitterions, i.e. as dipolar ions with both NH+3 and CO−2 in charged states, so the overall structure is NH+3−CHR−CO−2. At physiological pH the so-called "neutral forms" −NH2−CHR−CO2H are not present to any measurable degree.[36] Although the two charges in the zwitterion structure add up to zero it is misleading to call a species with a net charge of zero "uncharged". In strongly acidic conditions (pH below 3), the carboxylate group becomes protonated and the structure becomes an ammonio carboxylic acid, NH+3−CHR−CO2H. This is relevant for enzymes like pepsin that are active in acidic environments such as the mammalian stomach and lysosomes, but does not significantly apply to intracellular enzymes. In highly basic conditions (pH greater than 10, not normally seen in physiological conditions), the ammonio group is deprotonated to give NH2−CHR−CO−2. Although various definitions of acids and bases are used in chemistry, the only one that is useful for chemistry in aqueous solution is that of Brønsted:[37][38] an acid is a species that can donate a proton to another species, and a base is one that can accept a proton. This criterion is used to label the groups in the above illustration. The carboxylate side chains of aspartate and glutamate residues are the principal Brønsted bases in proteins. Likewise, lysine, tyrosine and cysteine will typically act as a Brønsted acid. Histidine under these conditions can act both as a Brønsted acid and a base. Composite of titration curves of twenty proteinogenic amino acids grouped by side chain category For amino acids with uncharged side-chains the zwitterion predominates at pH values between the two pKa values, but coexists in equilibrium with small amounts of net negative and net positive ions. At the midpoint between the two pKa values, the trace amount of net negative and trace of net positive ions balance, so that average net charge of all forms present is zero.[39] This pH is known as the isoelectric point pI, so pI = 1/2(pKa1 + pKa2). For amino acids with charged side chains, the pKa of the side chain is involved. Thus for aspartate or glutamate with negative side chains, the terminal amino group is essentially entirely in the charged form −NH+3, but this positive charge needs to be balanced by the state with just one C-terminal carboxylate group is negatively charged. This occurs halfway between the two carboxylate pKa values: pI = 1/2(pKa1 + pKa(R)), where pKa(R) is the side chain pKa.[38] Similar considerations apply to other amino acids with ionizable side-chains, including not only glutamate (similar to aspartate), but also cysteine, histidine, lysine, tyrosine and arginine with positive side chains. Amino acids have zero mobility in electrophoresis at their isoelectric point, although this behaviour is more usually exploited for peptides and proteins than single amino acids. Zwitterions have minimum solubility at their isoelectric point, and some amino acids (in particular, with nonpolar side chains) can be isolated by precipitation from water by adjusting the pH to the required isoelectric point. The 20 canonical amino acids can be classified according to their properties. Important factors are charge, hydrophilicity or hydrophobicity, size, and functional groups.[28] These properties influence protein structure and protein–protein interactions. The water-soluble proteins tend to have their hydrophobic residues (Leu, Ile, Val, Phe, and Trp) buried in the middle of the protein, whereas hydrophilic side chains are exposed to the aqueous solvent. (In biochemistry, a residue refers to a specific monomer within the polymeric chain of a polysaccharide, protein or nucleic acid.) The integral membrane proteins tend to have outer rings of exposed hydrophobic amino acids that anchor them in the lipid bilayer. Some peripheral membrane proteins have a patch of hydrophobic amino acids on their surface that sticks to the membrane. In a similar fashion, proteins that have to bind to positively charged molecules have surfaces rich in negatively charged amino acids such as glutamate and aspartate, while proteins binding to negatively charged molecules have surfaces rich in positively charged amino acids like lysine and arginine. For example, lysine and arginine are present in large amounts in the low-complexity regions of nucleic-acid binding proteins.[40] There are various hydrophobicity scales of amino acid residues.[41] Some amino acids have special properties. Cysteine can form covalent disulfide bonds to other cysteine residues. Proline forms a cycle to the polypeptide backbone, and glycine is more flexible than other amino acids. Glycine and proline are strongly present within low complexity regions of both eukaryotic and prokaryotic proteins, whereas the opposite is the case with cysteine, phenylalanine, tryptophan, methionine, valine, leucine, isoleucine, which are highly reactive, or complex, or hydrophobic.[40][42][43] Many proteins undergo a range of posttranslational modifications, whereby additional chemical groups are attached to the amino acid residue side chains sometimes producing lipoproteins (that are hydrophobic),[44] or glycoproteins (that are hydrophilic)[45] allowing the protein to attach temporarily to a membrane. For example, a signaling protein can attach and then detach from a cell membrane, because it contains cysteine residues that can have the fatty acid palmitic acid added to them and subsequently removed.[46] "Amino acid code" redirects here. For base-pair encoding of amino acids, see Genetic code § Codons. Main article: Proteinogenic amino acid Although one-letter symbols are included in the table, IUPAC–IUBMB recommend[7] that "Use of the one-letter symbols should be restricted to the comparison of long sequences". The one-letter notation was chosen by IUPAC-IUB based on the following rules:[47] Initial letters are used where there is no ambiguity: C cysteine, H histidine, I isoleucine, M methionine, S serine, V valine,[47] Where arbitrary assignment is needed, the structurally simpler amino acids are given precedence: A Alanine, G glycine, L leucine, P proline, T threonine,[47] F PHenylalanine and R aRginine are assigned by being phonetically suggestive,[47] W tryptophan is assigned based on the double ring being visually suggestive to the bulky letter W,[47] K lysine and Y tyrosine are assigned as alphabetically nearest to their initials L and T (note that U was avoided for its similarity with V, while X was reserved for undetermined or atypical amino acids); for tyrosine the mnemonic tYrosine was also proposed,[48] D aspartate was assigned arbitrarily, with the proposed mnemonic asparDic acid;[49] E glutamate was assigned in alphabetical sequence being larger by merely one methylene –CH2– group,[48] N asparagine was assigned arbitrarily, with the proposed mnemonic asparagiNe;[49] Q glutamine was assigned in alphabetical sequence of those still available (note again that O was avoided due to similarity with D), with the proposed mnemonic Qlutamine.[49] Amino acid 3- and 1-letter symbols Side chain Hydropathy index[50] Molar absorptivity[51] Molecular mass Abundance in proteins (%)[52] Standard genetic coding,IUPAC notation 3 1 Class Chemical polarity[53] Net chargeat pH 7.4[53] Wavelength,λmax (nm) Coefficient ε(mM−1·cm−1) Alanine Ala A Aliphatic Nonpolar Neutral 1.8 89.094 8.76 GCN Arginine Arg R Fixed cation Basic polar Positive −4.5 174.203 5.78 MGR, CGY[d] Asparagine Asn N Amide Polar Neutral −3.5 132.119 3.93 AAY Aspartate Asp D Anion Brønsted base Negative −3.5 133.104 5.49 GAY Cysteine Cys C Thiol Brønsted acid Neutral 2.5 250 0.3 121.154 1.38 UGY Glutamine Gln Q Amide Polar Neutral −3.5 146.146 3.9 CAR Glutamate Glu E Anion Brønsted base Negative −3.5 147.131 6.32 GAR Glycine Gly G Aliphatic Nonpolar Neutral −0.4 75.067 7.03 GGN Histidine His H Cationic Brønsted acid and base Positive, 10%Neutral, 90% −3.2 211 5.9 155.156 2.26 CAY Isoleucine Ile I Aliphatic Nonpolar Neutral 4.5 131.175 5.49 AUH Leucine Leu L Aliphatic Nonpolar Neutral 3.8 131.175 9.68 YUR, CUY[e] Lysine Lys K Cation Brønsted acid Positive −3.9 146.189 5.19 AAR Methionine Met M Thioether Nonpolar Neutral 1.9 149.208 2.32 AUG Phenylalanine Phe F Aromatic Nonpolar Neutral 2.8 257, 206, 188 0.2, 9.3, 60.0 165.192 3.87 UUY Proline Pro P Cyclic Nonpolar Neutral −1.6 115.132 5.02 CCN Serine Ser S Hydroxylic Polar Neutral −0.8 105.093 7.14 UCN, AGY Threonine Thr T Hydroxylic Polar Neutral −0.7 119.119 5.53 ACN Tryptophan Trp W Aromatic Nonpolar Neutral −0.9 280, 219 5.6, 47.0 204.228 1.25 UGG Tyrosine Tyr Y Aromatic Brønsted acid Neutral −1.3 274, 222, 193 1.4, 8.0, 48.0 181.191 2.91 UAY Valine Val V Aliphatic Nonpolar Neutral 4.2 117.148 6.73 GUN Two additional amino acids are in some species coded for by codons that are usually interpreted as stop codons: 21st and 22nd amino acids 3-letter 1-letter Molecular mass Selenocysteine Sec U 168.064 Pyrrolysine Pyl O 255.313 In addition to the specific amino acid codes, placeholders are used in cases where chemical or crystallographic analysis of a peptide or protein cannot conclusively determine the identity of a residue. They are also used to summarize conserved protein sequence motifs. The use of single letters to indicate sets of similar residues is similar to the use of abbreviation codes for degenerate bases.[54][55] Ambiguous amino acids 3-letter 1-letter Amino acids included Codons included Any / unknown Xaa X All NNN Asparagine or aspartate Asx B D, N RAY Glutamine or glutamate Glx Z E, Q SAR Leucine or isoleucine Xle J I, L YTR, ATH, CTY[f] Hydrophobic Φ V, I, L, F, W, Y, M NTN, TAY, TGG Aromatic Ω F, W, Y, H YWY, TTY, TGG[g] Aliphatic (non-aromatic) Ψ V, I, L, M VTN, TTR[h] Small π P, G, A, S BCN, RGY, GGR Hydrophilic ζ S, T, H, N, Q, E, D, K, R VAN, WCN, CGN, AGY[i] Positively-charged + K, R, H ARR, CRY, CGR Negatively-charged − D, E GAN Unk is sometimes used instead of Xaa, but is less standard. Ter or * (from termination) is used in notation for mutations in proteins when a stop codon occurs. It corresponds to no amino acid at all.[56] In addition, many nonstandard amino acids have a specific code. For example, several peptide drugs, such as Bortezomib and MG132, are artificially synthesized and retain their protecting groups, which have specific codes. Bortezomib is Pyz–Phe–boroLeu, and MG132 is Z–Leu–Leu–Leu–al. To aid in the analysis of protein structure, photo-reactive amino acid analogs are available. These include photoleucine (pLeu) and photomethionine (pMet).[57] A polypeptide is an unbranched chain of amino acids.β-Alanine and its α-alanine isomerThe amino acid selenocysteine Main article: Pro

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Media related to Amino acids at Wikimedia Commons Retrieved from " 2 2-Aminoisobutyric acid Names Preferred IUPAC name 2-Amino-2-methylpropanoic acid Other names α-Aminoisobutyric acid2-Methylalanine Identifiers CAS Number 62-57-7 Y 3D model (JSmol) Interactive image ChEBI CHEBI:27971 Y ChemSpider 5891 Y DrugBank DB02952 Y ECHA InfoCard 100.000.495 EC Number 200-544-0 KEGG C03665 Y PubChem CID 6119 UNII 1E7ZW41IQU Y CompTox Dashboard (EPA) DTXSID0058772 InChI InChI=1S/C4H9NO2/c1-4(2,5)3(6)7/h5H2,1-2H3,(H,6,7) YKey: FUOOLUPWFVMBKG-UHFFFAOYSA-N YInChI=1/C4H9NO2/c1-4(2,5)3(6)7/h5H2,1-2H3,(H,6,7)Key: FUOOLUPWFVMBKG-UHFFFAOYAD SMILES O=C(O)C(N)(C)C Properties Chemical formula C4H9NO2 Molar mass 103.12 g/mol Appearance white crystalline powder Density 1.09 g/mL Boiling point 204.4 °C (399.9 °F; 477.5 K) Solubility in water soluble Acidity (pKa) 2.36 (carboxyl; H2O)10.21 (amino; H2O)[1] Except where otherwise noted, data are given for materials in their standard state (at 25 °C [77 °F], 100 kPa). Y verify (what is YN ?) Infobox references Chemical compound 2-Aminoisobutyric acid (also known as α-aminoisobutyric acid, AIB, α-methylalanine, or 2-methylalanine) is the non-proteinogenic amino acid with the structural formula H2N-C(CH3)2-COOH. It is rare in nature, having been only found in meteorites,[2] and some antibiotics of fungal origin, such as alamethicin and some lantibiotics. In the laboratory, 2-aminoisobutyric acid may be prepared from acetone cyanohydrin, by reaction with ammonia followed by hydrolysis.[3] Industrial scale synthesis can be achieved by the selective hydroamination of methacrylic acid. 2-Aminoisobutyric acid is not one of the proteinogenic amino acids and is rather rare in nature (cf. non-proteinogenic amino acids). It is a strong helix inducer in peptides due to Thorpe–Ingold effect of its gem-dimethyl group.[4] Oligomers of AIB form 310 helices. See also: Cell-free system and Cell-free protein synthesis 2-Aminoisobutyric acid is compatible with ribosomal elongation of peptide synthesis. Katoh et al. used flexizymes[5] and an engineered a tRNA body to enhance the affinity of aminoacylated AIB-tRNA species to elongation factor P.[6] The result was an increased incorporation of AIB into peptides in a cell free translation system. Iqbal et al.. used an alternative approach of creating an editing deficient valine—tRNA ligase to synthesize aminoacylated AIB-tRNAVal. The aminoacylated tRNA was subsequently used in a cell-free translation system to yield AIB-containing peptides.[7] ^ Haynes, William M., ed. (2016). CRC Handbook of Chemistry and Physics (97th ed.). CRC Press. p. 5–88. ISBN 978-1498754286. ^ "Immune System of Humans, Other Mammals Could Struggle to Fight Extraterrestrial Microorganisms". Science News. 23 July 2020. Retrieved 24 July 2020. ^ Clarke, H. T.; Bean, H. J. (1931). "α-Aminoisobutyric acid". 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