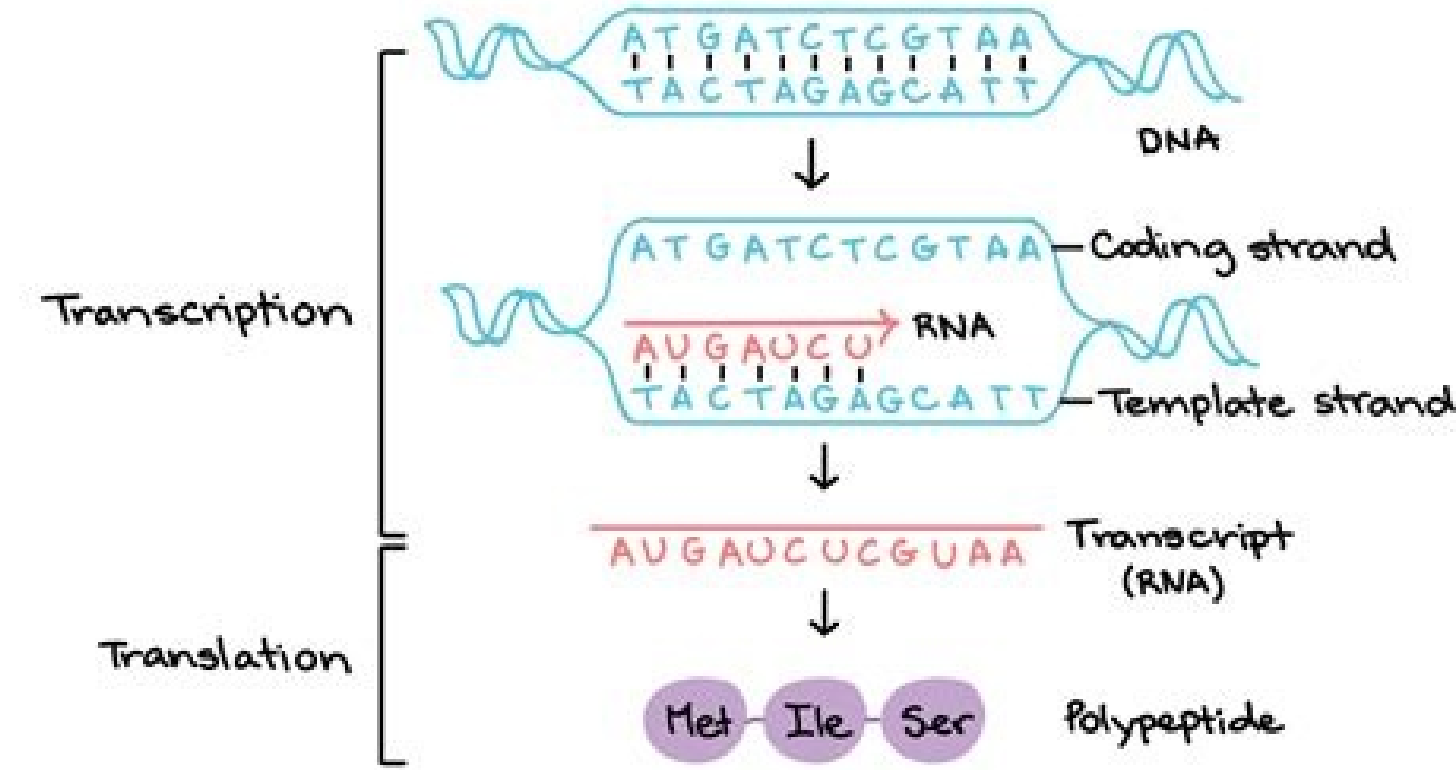
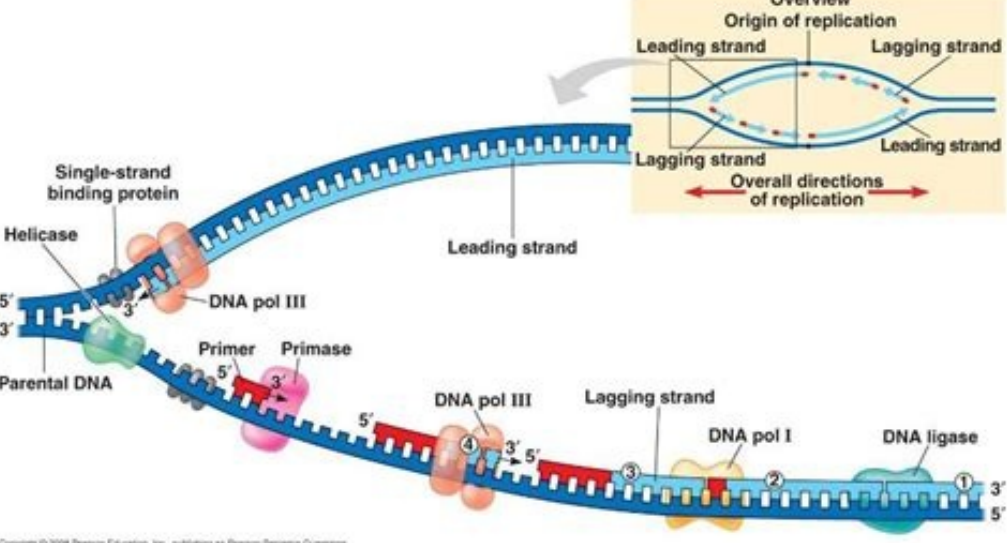


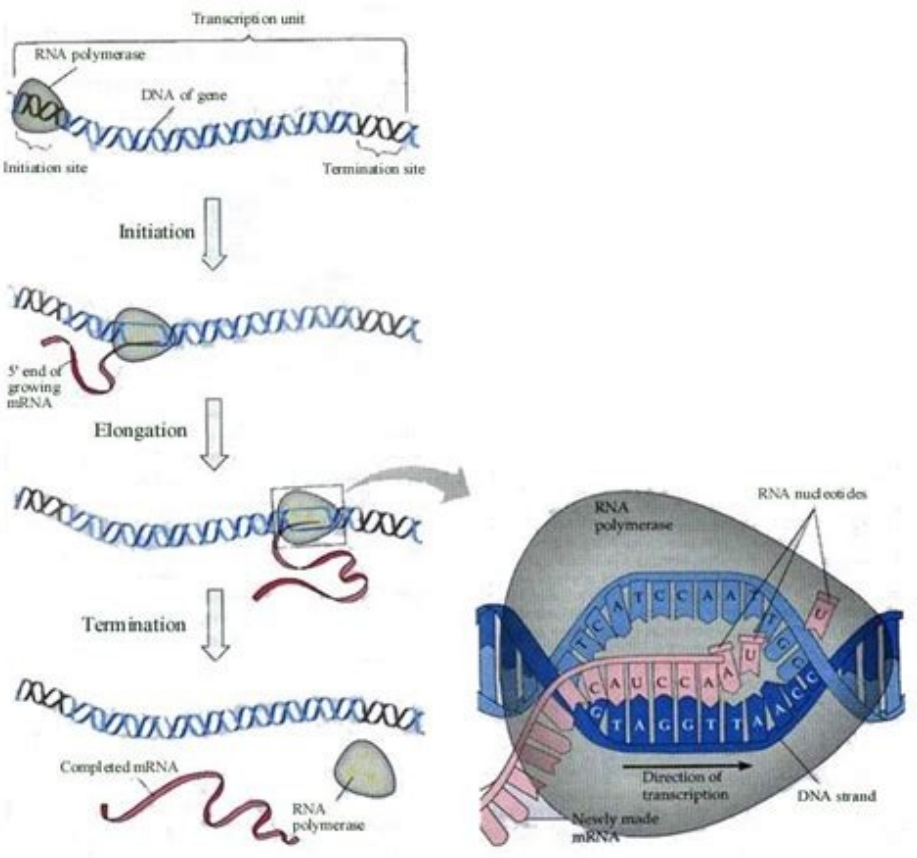
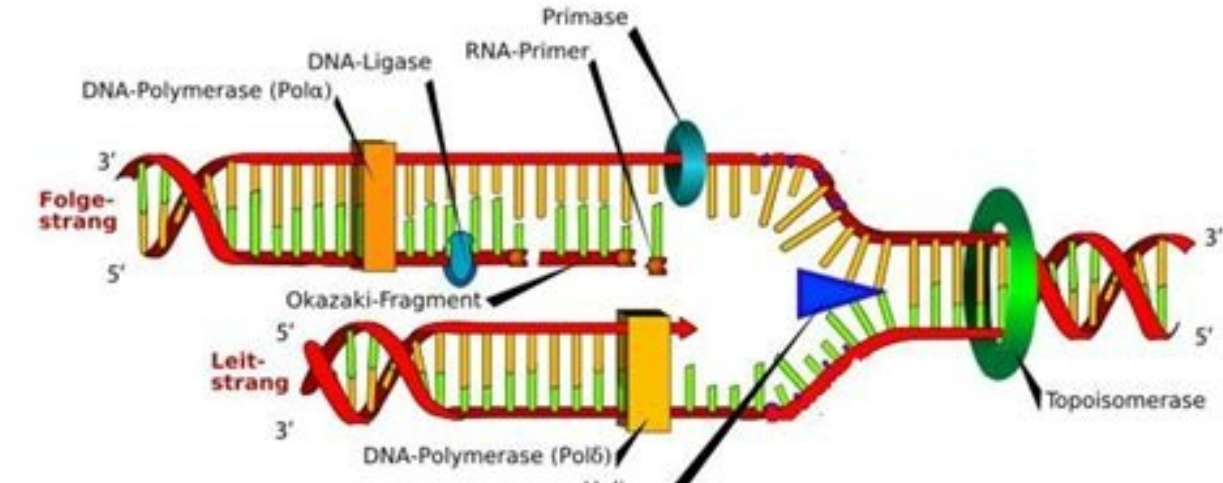
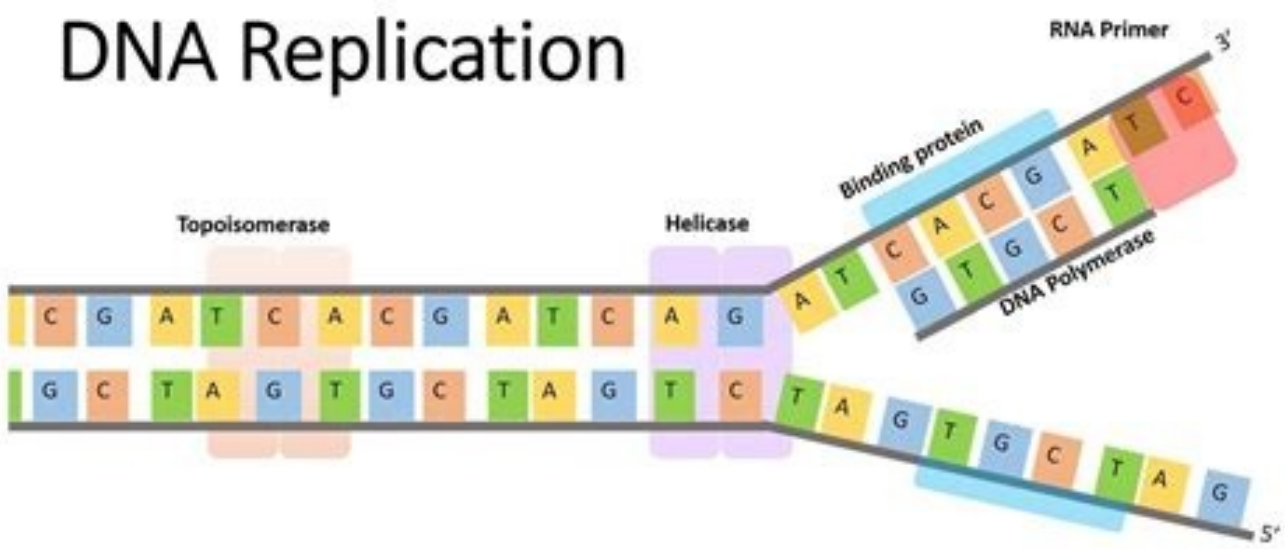
Synthesis of dna from rna template

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DNA Replication



Synthesis of dna from rna template occurs in. The synthesis of an rna molecule from a dna template strand is called quietlet. Synthesis of rna from dna template. The synthesis of rna molecules from a dna template is known as. Synthesis of an rna molecule from a dna template. The synthesis of an rna molecule from a dna template strand is. Reverse transcriptase catalyzes the synthesis of dna from an rna template. The synthesis of a complementary strand of rna from a dna template is.

Ribonucleic acid (RNA) is a molecule that is present in the majority of living organisms and viruses. It is made up of nucleotides, which are ribose sugars attached to nitrogenous bases and phosphate groups. The nitrogenous bases include adenine, guanine, uracil, and cytosine. RNA mostly exists in the single-stranded form, but there are special RNA viruses that are double-stranded. The RNA molecule can have a variety of lengths and structures. An RNA virus uses RNA instead of DNA as its genetic material and can cause many human diseases. Transcription is the process of RNA formation from DNA, and translation is the process of protein synthesis from RNA. The means of RNA synthesis and the way that it functions differs between eukaryotes and prokaryotes. Specific RNA molecules also regulate gene expression and have the potential to serve as therapeutic agents in human diseases. Three main types of RNA are involved in protein synthesis. They are messenger RNA (mRNA), transfer RNA (tRNA), and ribosomal RNA (rRNA). mRNA is transcribed from DNA and contains the genetic blueprint to make proteins. Prokaryotic mRNA does not need to be processed and can proceed to synthesize proteins immediately. In eukaryotes, a freshly transcribed RNA transcript is considered a pre-mRNA and needs to undergo maturation to form mRNA. A pre-mRNA contains non-coding and coding regions known as introns and exons, respectively. During pre-mRNA processing, the introns are spliced, and the exons are joined together. A 5' cap known as 7-methylguanosine is added to the 5' end of the RNA transcript and the 3' end is polyadenylated. Polyadenylation refers to the process where a poly(A) tail, which is a sequence of adenine nucleotides, is added to the transcript. The 5' cap protects the mRNA from degradation, and the 3' poly(A) tail contributes to the stability of mRNA and aids in its transport. Researchers are also studying mRNA as an anti-cancer treatment due to its ability to modify cells.[1] tRNA tRNAs are RNA molecules that translate mRNA into proteins. They have a cloverleaf structure that consists of a 3' acceptor site, 5' terminal phosphate, D arm, T arm, and anticodon arm. The primary function of a tRNA is to carry amino acids on its 3' acceptor site to a ribosome complex with the help of aminoacyl-tRNA synthetase. Aminoacyl-tRNA synthetases are enzymes that load the appropriate amino acid onto a free tRNA to synthesize proteins. Once an amino acid is bound to tRNA, the tRNA is considered an aminoacyl-tRNA. The type of amino acid on a tRNA is dependent on the mRNA codon, which is a sequence of three nucleotides that codes for an amino acid. The anticodon arm of the tRNA is the site of the anticodon, which is complementary to an mRNA codon and dictates which amino acid to carry. tRNAs also regulate apoptosis through acting as a cytochrome c scavenger.[2] rRNA rRNA forms ribosomes, which are essential in protein synthesis. A ribosome contains a large and small ribosomal subunit. In prokaryotes, a small 30S and large 50S ribosomal subunit make up a 70S ribosome. In eukaryotes, the 40S and 60S subunit form an 80S ribosome. The ribosomes contain an exit (E), peptidyl (P), and acceptor (A) site to bind aminoacyl-tRNAs and link amino acids together to create polypeptides. A major concern is RNA mutations, which can disrupt the normal functioning of RNA and cause potentially life-threatening diseases. RNA errors can be the result of defects in the ribonucleoprotein complex, RNA itself, RNA binding proteins, or any RNA assembly factors. Myotonic dystrophy is a neuromuscular disease that is caused by a CTG nucleotide repeat on the DMPK gene resulting in a pathogenic RNA gain-of-function.[3] A mutation in splicing can result in a mutated SMN2 gene and lead to spinal muscular atrophy.[4] Other concerning illnesses caused by RNA mutations include Prader Willi syndrome, prostate cancer, fragile X syndrome, and amyotrophic lateral sclerosis (ALS). The mutation rates of RNA viruses that cause various illnesses in humans are very high. It can be up to 1 million times higher than the mutation rate of their hosts [5]. This increase accounts for their fast evolution and ability to produce newer variants with higher infectivity or increased resistance to antibiotics. Since such mutations are heritable, they provide a bottleneck for the development of drugs or vaccines to combat viral infections. HIV infections are an example of the emergence of many drug-resistant strains, where the viruses replicate and cause severe disease even in the presence of drugs.[6]Additionally, RNA viruses can also recombine and reassort with DNA and RNA from the host or other viral strains, potentially generating a newer strain. Influenza viruses have a very high ability to reassort; for example, the H1N1 influenza strain recombined with the RNA segments from birds, humans, and pig viruses to generate the H1N1 strain that caused a pandemic in 2009.[7]RNA makes proteins using amino acids. There are 20 different types of amino acids that make up a protein's primary structure. Once a ribosome binds to an mRNA transcript, it starts decoding the mRNA codons and recruits tRNAs with the encoded amino acid. Codons are deciphered using the genetic code. In the genetic code, each codon represents a specific amino acid—for example, CUU codes for leucine and GGU codes for glycine. The genetic code is redundant in the fact that different codons can code for the same amino acid. For example, both UAU and UAC code for tryptophan. Once a ribosome finishes reading the mRNA, the amino acid sequence will fold and form a protein.Besides the most important function of RNA to make proteins, other critical cellular functions include modifying and restructuring of other RNAs and regulation of gene expressions during growth and development, and changing cellular environments. Some RNAs also function as catalytic RNA to drive biochemical reactions; hence they are termed as ribozymes. The ribozymes also sometimes pair with auxiliary proteins to carry out their catalytic functions. The biochemical reactions catalyzed by ribozymes include protein synthesis, RNA splicing, and RNA cleavage. Ribozymes fold into a complex tertiary structure to form an active site that allows nucleophilic substitution reactions for phosphoryl transfer. These reactions are facilitated through acid-base catalysis with the involvement of ribonucleosides and metal ions.[8] Ribozymes classify into two types: small ribozymes (example - hairpin, hammerhead, and Hepatitis delta virus), and large ribozymes (group I and II introns, RNase P, spliceosome and the ribosomes). What is the composition of RNA? The primary structure of RNA is composed of nucleotides attached by 5'-3' phosphodiester bonds between ribose sugars. Ribose has the molecular formula, C5H10O5, and has a naturally occurring D-ribose form and a less common L-ribose. The D and L designations refer to the hydroxyl group positions. The nucleotide bases consist of adenine, guanine, cytosine, and uracil. Two hydrogen bonds form between adenine and uracil, while three bonds form between cytosine and guanine. The base pairing via hydrogen bonds is the basis of the RNA secondary structure. The RNA tertiary structure is the result of RNA folding, which creates a three-dimensional shape consisting of helices and grooves. RNA differs from DNA in that it contains a uracil nucleotide instead of thymine and carries a 2' hydroxyl group rather than a 2' hydrogen. Due to its interaction with the solvent environment, the 2' hydroxyl group contributes to RNA conformation.[9] How is it made? RNA polymerases synthesize RNA from DNA through a process called transcription. In prokaryotes, a single RNA polymerase catalyzes transcription for all types of RNA. In eukaryotes, there are different types of RNA polymerases, each responsible for synthesizing a specific RNA. RNA polymerase I synthesizes rRNA, RNA polymerase II creates mRNA, and RNA polymerase III makes tRNA. To initiate transcription, an RNA polymerase enzyme binds to a promoter region on DNA, and the DNA double helix unwinds into a template strand and non-coding strand. During transcription, an RNA polymerase uses the 3'-5' DNA template strand to synthesize a 5'-3' RNA strand with complementary nucleotides. The newly synthesized RNA strand is nearly identical to the non-coding strand of DNA except for uracil substituting thymine. In eukaryotes, each RNA polymerase has a unique mechanism to terminate transcription. For example, RNA polymerase II transcribed RNA has an AAUAAA poly(A) site that recruits a group of factors to cleave the transcript.[10]Prokaryotic RNA undergoes Rho-dependent or Rho-independent termination. In Rho-dependent termination, a Rho factor helicase binds to C-rich sites on the RNA, and ATP hydrolysis powers Rho to unwind the DNA-RNA complex and release the RNA transcript. [11] On the other hand, Rho-independent termination utilizes a hairpin loop that causes the RNA polymerase to stall and allows the RNA transcript to be released. The primary function of RNA is to create proteins via translation. RNA carries genetic information that is translated by ribosomes into various proteins necessary for cellular processes. mRNA, rRNA, and tRNA are the three main types of RNA involved in protein synthesis. RNA also serves as the primary genetic material for viruses. Other functions include RNA editing, gene regulation, and RNA interference. These processes are carried out by a group of small regulatory RNAs, which include small nuclear RNA, microRNA, and small interfering RNA. Small Nuclear RNA Small nuclear RNAs (snRNA) are non-coding RNAs that are responsible for splicing introns. The snRNAs join with proteins to form small nuclear ribonucleoproteins (snRNP), which most commonly contain U1, U2, U4, U5, and U6 snRNA molecules.[12] Spliceosome assembly and activity begins once U1 of the snRNP binds a complementary sequence on the 5' splice site of a pre-mRNA transcript. Introns are then removed from the pre-mRNA transcript by the spliceosome complex and mature mRNA forms. MicroRNA MicroRNAs (miRNA) are non-coding RNAs mainly involved in gene regulation. They are mostly processed from introns and are transcribed into primary miRNA from the host gene by RNA polymerase II. They are then modified by endonucleases, such as Drosha and Dicer into a mature miRNA. Studies have shown that miRNAs that bind to an untranslated region (3'UTR) on mRNAs suppress translation, while miRNA binding to promoter regions can upregulate transcription.[13] miRNAs can also function similarly to hormones. They are released into the extracellular fluid and taken up by target cells for regulation of cellular activity. Additionally, researchers are studying these extracellular miRNAs as ideal biomarkers for various diseases. Research has already shown circulating miRNAs to be involved in cancer through its role in controlling oncogenes and tumor suppressors.[14] Small Interfering RNA Small Interfering RNAs (siRNA) are double-stranded, non-coding RNAs that inhibit gene expression through RNA interference. They interfere with gene expression by degrading mRNA and preventing the translation of proteins. siRNAs form from long double-stranded RNAs with the assistance of Dicer. Once fully formed, siRNA binds to an RNA induced silencing complex (RISC) and cleaves mRNA through a catalytic RISC protein, Argonaute.[15] Small interfering RNAs have the potential to be therapeutic agents for diseases due to their potency and ability to knock down genes. Unlike miRNAs, siRNAs can specifically target a gene of choice, and a single siRNA guide strand can function multiple times.[16]The mechanism of RNA translation into protein is carried out in three steps: initiation, elongation, and termination. During initiation, a tRNA and ribosome join an mRNA. The start codon, AUG, codes for methionine and will always be the first amino acid in the sequence. After initiation, the ribosome moves along the mRNA in the 5'-3' direction reading the codons and binding tRNAs carrying the respective amino acids for which the codons are coding. The sequence of amino acids progressively becomes longer and terminates upon reaching a stop codon. The stop codons are UAG, UAA, and UGA. The polypeptide is then released from the ribosomal complex and modified into an active protein. In eukaryotic cells, translation occurs after transcription, while in prokaryotic cells, transcription and translation occur simultaneously. Nucleic acid testing originally came into being as a method to screen donor blood to reduce blood transfusion infections. Later, it developed into an indicator of diseases, such as HIV and cancer. RNA genetic testing has proven to be an effective supplement to DNA genetic testing by clarifying inclusive results and improving outcomes for genetic testing of hereditary cancers.[17] RNA sequencing has the potential to be an efficient clinical diagnostic tool because of its ability to measure gene expression outside the physiological range, allele-specific expression, and defects in alternative splicing.[18] Sequencing RNA involves isolating the RNA, preparation of an RNA library, and utilization of next-generation sequencing technology. The transcriptome can then undergo analysis for any aberrant genes.RNA viruses can survive and disrupt physiological processes by replicating their genome inside a host cell. There are different kinds of RNA viruses that each have a unique mechanism of replication. Double-stranded RNA viruses, such as retroviruses fuse with host cell membranes and inject their viral contents inside to replicate their genome via reverse transcription. Reverse transcription requires a ribonuclease H and a DNA polymerase with the ability to copy an RNA or a DNA template to synthesis a linear double-stranded DNA from an RNA.[19] Positive-stranded RNA viruses have a positive virion RNA that already acts as an mRNA and therefore, can be translated immediately by RNA polymerase. Negative-stranded RNA viruses have a negative virion RNA that is complementary to mRNA and must be copied into a positive-sense mRNA before translation. Viral proteins are then released from the host cell to infect other cells, consequently interfering with normal biological processes.Many neurological diseases such as spinocerebellar ataxia (SCA), amyotrophic lateral sclerosis (ALS), myotonic dystrophy, frontotemporal dementia (FTD), fragile X tremor/ataxia syndrome (FXTAS) and Huntington's disease-like 2 (HDL-2), etc., are attributed to the expansion of non-coding RNA repeats. The repeat expansion generates abnormal hairpin folds to develop in an RNA strand, thus disrupting the normal RNA function. Accumulation of RNA within the nucleus is termed as RNA toxicity, which can induce splicing defects, nucleolar functional abnormality, cytoplasmic and mRNA transport, and autophagy.[20]There are a wide variety of RNA viruses, such as coronavirus, rhinovirus, and retrovirus that can cause human diseases. These viruses can be classified as positive or negative sense depending on the polarity and have a naked or enveloped membrane. Coronavirus is most notable for causing severe acute respiratory syndrome. Its transmission is via droplets, and studies have found a higher viral load in the nasal mucosa compared to in the throat.[21] It also has associations with an increase in inflammatory cytokines, such as IL2, IL7, IL10, and TNFα, and has symptoms of fever, cough, sore throat, and pneumonia.[22] Another well-known RNA family that can cause a fatal human disease is a retrovirus, a positive sense, enveloped RNA virus consisting of HIV and HTLV. HIV destroys naïve and memory CD4+ T cells and is often symptomatic until the last stage when it causes acquired immunodeficiency syndrome.[23] With an impaired immune system, there is an increased risk of developing opportunistic infections and viral-induced cancers. Lastly, rhinovirus is the key viral agent in the common cold. They enter by endocytosis with the help of LDLR and ICAM-1 and produce symptoms of coughing, sore throat, and nasal congestion.[24] Other notable human diseases caused by RNA viruses include hepatitis, West Nile fever, rabies, polio, and measles. Review Questions1.Van Lint S, Heirman C, Thielemans K, Breckpot K. mRNA: From a chemical blueprint for protein production to an off-the-shelf therapeutic. Hum Vaccin Immunother. 2013 Feb;9(2):265-74. [PMC free article: PMC3859745] [PubMed: 23291946]2.Raina M, Ibbm M. tRNAs as regulators of biological processes. Front Genet. 2014;5:171. [PMC free article: PMC4052509] [PubMed: 24966867]3.Yum K, Wang ET, Kalsotra A. Myotonic dystrophy: disease repeat range, penetrance, age of onset, and relationship between repeat size and phenotypes. Curr Opin Genet Dev. 2017 Jun;44:30-37. [PMC free article: PMC5447468] [PubMed: 28213156]4.Cooper TA, Wan L, Dreyfuss G. RNA and disease. Cell. 2009 Feb 20;136(4):777-93. 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