SCIENTISTS

Frederick Griffith: wanted to learn how certain types of bacteria produce pneumonia
isolated 2 similar, but different types of bacteria from mice.
only one caused pneumonia → called s strain. non dangerous ⇒ r strain
S strain = smooth r strain = rough
He injected mice with different mixes of s and r strain:

S strain mice	r strain mice	heat killed S	heat killed S + r
↓	↓	↓	↓
pneumonia/died	alive	alive	pneumonia/died

concluded that when he mixed the 2 types of bacteria together, some chemical factor transfered from heat killed s strain to r strain.

he thought this chemical compound contains info that could change harmless bacteria into disease-causing ones. This process is transformation. (permanantely changing something into another)

he concluded the transforming factor = gene

Oswald Avery: wanted to determine which molecule in heat-killed S strain caused transformation
destroyed different molecules and saw if transformation still occured (proteins, lipids, etc)
When destroyed DNA, transformation did not occur
DNA was transforming factor
concluded that the nucleic acid DNA stores and transmits genetic info from one generation to next.

bacteriophage: virus that infects bacteria
attaches to surface of bacteria cell and injects genetic info to make more bacteriophages and destroy bacteria.

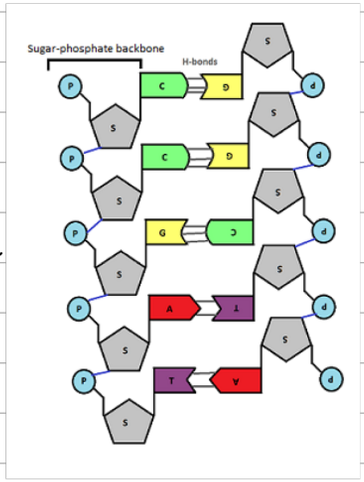
Hershey and Chase: found bacteriophage has DNA core and protein coat
wanted to see which part has genetic info.
put phosphorus in DNA and sulfer in protein of bacteria phage
after putting bacteriophage into bacteria, found all radioactivity came from phosphorus.
confirmed Averys results and DNA has genetic info.

DNA is capable of storing, copying, and transmitting genetic info in a cell
↳ the genetic material stores info needed by every living cell
before a cell divides, its genetic info must be copied
when a cell divides each daughter cell must receive a complete copy of genetic info
↳ and to transmit genes from one generation to another

DNA STRUCTURE AND BASE PAIRING

DNA is a nucleic acid made up of nucleotides joined into long strands or chains by covalent bonds

nucleotides are the building blocks of nucleic acids
nucleotides are made up of a 5 carbon sugar called deoxyribose, a phosphate group, and a nitrogenous base



Nitrogenous base: adenine, guanine, cytosine, and thymine

nucleotides in DNA are joined by covalent bonds formed between the sugar of one nucleotide and the phosphate group of the next

Chargaff's Rule: amount of adenine = amount of thymine
amount of guanine = amount of cytosine

Franklin's x-rays: used x-ray diffraction to get info. about DNA structure
found the strands of DNA were twisted around in shape of helix
found that bases were in center of DNA molecule

Watson and Crick: build 3D models of DNA
The clues in Franklin's x-ray pattern enabled Watson and Crick to build a model that explained the specific structure and properties of DNA called model a double helix, in which 2 strands of nucleotide sequences were wound around each other

The 2 strands of DNA run in opposite directions. The strands are antiparallel
This enables the bases on both strands to come into contact at the center of molecule
Also allows each strand of double helix to carry a sequence of nucleotides

The bases attach one another by weak hydrogen bonds
This is important because if the 2 strands of helix were held together by strong bonds, it would be impossible to separate them (for mRNA)

5' CARBON TO 3' CARBON

If one DNA strand goes from 5 to 3 the other end goes from 3 to 5

the 5' and 3' origins from the sugargroup by positions of the 5 carbons
The position of the carbons have a number which is used for 5' and 3' indication

DNA REPLICATION

During replication, the DNA molecule seperates into 2 strands and produces 2 new complementary strands following the rules of base pairing

The 2 strands of the double helix are unzipped, allowing 2 replication forks to form.
As each new strand forms new bases are added following the rules of base pairing
The result is 2 DNA molecules identical to each other and to the original molecule.
Each DNA molecule resulting from replication has one original strand and one new strand (semi-conservative)

1) The DNA molecule seperates into 2 strands by enzyme helicase
2) Hydrogen bonds between base pairs are broken and 2 strands of DNA uncoil
3) Produces 2 new complementary strands following rules of base pairing
4) Each strand of the double helix of DNA serves as a template for new strand
5) The 2 strands of DNA are joined by enzyme ligase
6) DNA polymerase joins individual nucleotides to produce a DNA molecule and then proofreads each new DNA strand

The main enzyme involved in DNA replication is called DNA polymerase

The tip of eukaryotic chromosomes are known as telomeres
Because the ends of a DNA molecule are difficult to replicate, a special enzyme called telomerase does it. This enzyme adds short, repeated DNA sequences to telomeres as chromosomes replicate
Telomerase helps prevent genes from being damaged or lost during replication

The cells of most prokaryotes have a single, circular DNA molecule in the cytoplasm, containing nearly all of the cell's genetic info.

Eukaryotic cells can have up to 1000x more DNA than prokaryotes
Nearly all of the DNA of eukaryote cells is found in the nucleus, tightly packed together with proteins called histones to form a substance called chromatin
Together, DNA and histone molecules form beaded structures called nucleosomes

Prokaryotic DNA replication: Replication does not start until regulatory proteins bind to a single starting point on the chromosome. These proteins then trigger S phase, and replication starts. Replication starts from one single point and proceeds in 2 directions until the entire chromosome is copied

Eukaryotic DNA replication: Replication may begin at dozens or even hundreds of places on the DNA molecule, proceeding in both directions until each chromosome is completely copied. The 2 copies of DNA produced by replication in each chromosome condense and the chromatids become clearly visible in mitosis. After replication, 2 cells will be produced, each with a complete set of genes coded in DNA

RNA

RNA is another nucleic acid that consists of a long chain of nucleotides
sugar: ribose Bases = adenine, uracil, guanine, and cytosine. A → U G → C

The first step in decoding genetic information is to copy part of the base sequence from DNA into RNA
RNA then uses these instructions to direct the production of proteins which help determine an organism's characteristics

RNA has many functions, but mainly, they do protein synthesis
RNA controls the assembly of amino acids into proteins
3 main types of RNA

messenger RNA (mRNA): carry copies of instructions for assembling amino acids into proteins from DNA to other parts of the cell

ribosomal RNA (rRNA): Proteins are assembled on ribosomes (small organelles composed of 2 subunits) made up of several ribosomal RNA

Transfer RNA (tRNA): Transfers each amino acid to the ribosome as it is specified by the coded messages in mRNA when a protein is built.

Transcription

In transcription, segments of DNA serve as templates to produce complementary RNA molecules
The base sequences of the transcribed RNA complement base sequences of DNA template

In prokaryotes, RNA synthesis and protein synthesis take place in cytoplasm
In eukaryotes, RNA is produced in the cell's nucleus and then moves to the cytoplasm to play a role in the production of protein

Transcription requires an enzyme known as RNA polymerase
RNA polymerase binds to DNA during transcription and seperates DNA strands
It uses one strand of DNA as a template from which to assemble nucleotides into a complementary strand of RNA

The enzyme binds only to promoters which are regions of DNA that have specific base sequences
Promoters are signals in the DNA molecule that show RNA polymerase exactly where to begin making RNA
Similar signals in DNA cause transcription to stop when a new RNA molecule is completed

Pre mRNA molecules have bits and pieces cut out of them before they can go into action
The portions that are cut out and discarded are called introns
In eukaryotes, introns are taken out of the pre-mRNA while they are still in the nucleus.
The remaining pieces, known as exons, are then spliced back together to form the final mRNA

PROTEIN SYNTHESIS

proteins are made by joining amino acids together into long chains called polypeptides
The order in which amino acids are joined influences the shape and function of the protein

Genes are coded DNA instructions that control the production of proteins
Genetic messages can be decoded by copying part of the nucleotide seqence from DNA to RNA
RNA contains coded info for making proteins

The language of the bases is called genetic code
The genetic code is read 3 letters at a time so that each triplet is 3 bases long and corresponds to a single amino acid
Each 3 letter triplet in mRNA is called a codon

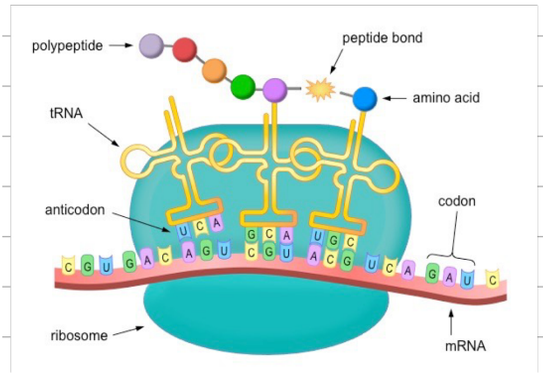
The methionine codon AUG also serves as the initiation, or start codon for protein synthesis
following the start codon, mRNA is read 3 bases at a time, until it reaches a stop codon

Translation

Once the polypeptide is complete, it then folds into its final shape or joins with other polypeptides to become a functional protein

Ribosomes use the sequence of codons in mRNA to assemble amino acids into polypeptide chains
The decoding of an mRNA message into a protein is a process known as translation

Translation begins when a ribosome attaches to an mRNA molecule in the cytoplasm.
As each codon passes through the ribosome, tRNAs bring the proper amino acids into the ribosome, then the ribosome attaches these amino acids to the growing chain



Each tRNA molecule carries just one kind of amino acid
each tRNA molecule has 3 unpaired bases, called anticodon
each tRNA anticodon is complementary to one mRNA codon

The ribosome helps form a peptide bond between the first and second amino acids

At the same time, the bond holding the first tRNA molecule to its amino acid is broken
That tRNA then moves into a 3rd binding sit, from which it exits the ribosome
the ribosome then moves to the 3rd codon, where tRNA brings it the amino acid specified by 3rd codon

The poplypeptide continues to grow until the ribosome reaches a stop codon on mRNA molecule
When the ribosome reaches a stop codon, it releases both the newly formed polypeptide and the mRNA molecule, completing the process of translation

Ribosomes themselves are composed of roughly 80 proteins and 3-4 different rRNA
rRNA molecules help hold ribosomal proteins in place and help locate the beginning of mRNA message and may even carry out the chemical reaction that join amino acids together

Proteins determine organism traits
Proteins are enzymes, which catalyze and regulate chemical reactions

GENE REGULATION

TO conserve energy and resources, prokaryotes regulate their activities, using only the genes necessary for the cell to function
By regulating gene expression, bacteria can respond to changes in their environment
DNA binding proteins in prokaryotes regulate genes by controlling transcription
Some regulatory proteins help switch genes on, while others turn gene off

Operon = group of genes that are regulated together
The genes in an operon usually have related functions

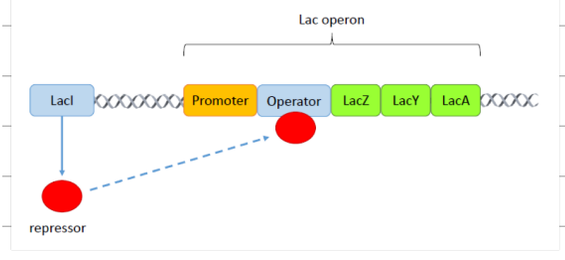
Ex. There are genes that must be turned on together before the bacterium can use sugar lactose as food. These 3 lactose genes in E. coli are called the lac operon

Lactose is a compound made up of 2 simple sugars, and to use lactose for food, the bacterium must transport lactose across its cell membrane and then break the bond between sugars

These tasks are performed by proteins coded for by genes of the lac operon

One one side of the operon's 3 genes are 2 regulatory regions.
The first is a promoter, which is a site where RNA polymerase can bind to do transcription
The other region is called the Operator where DNA-binding protein (lac repressor) can bind to DNA

When lactose is not present, the repressor protein binds to the operating region.
This blocks from RNA polymerase from transcribing the Lac gene.



When lactose is present it binds to the repressor
This causes the repressor to change shape and then moves away from the operating region
Now, the RNA polymerase can bind to the promoter and transcribe the genes of the operon

TATA box of eukaryotes is a short region of DNA, about 25-30 base pairs before start of gene
The TATA box binds a protein that helps position RNA polymerase by making a point just before the beginning of a gene

By binding DNA sequences in the regulatory regions of eukaryotic genes, transcription factors control the expression of those genes

Some transcription factors enhance transcription by opening up tightly packed chromatin
Others help attract RNA polymerase
In most cases, multiple transcription factors must bind before RNA polymerase is able to attach the the promoter region and start transcription

Promoters have multiple binding sites for transcription factors each of which can influence transcription

Some factors activate scores of genes at once, while some form only in response of chemical signals

Eukaryotic gene expression can be regulated by factors such as the exit of mRNA, stability of mRNA, and breakdown of gene's protein products

Cell specialization requires genetic specialization, yet all of the cells in the multicellular organism carry the same genetic code in their nucleus

Cells contain lots of small RNA molecules that don't belong to the 3 main RNA groups
These molecules are useful in gene regulation by interfering with mRNA

The small RNA molecules fold into double-stranded loops.
An enzyme called Dicer cuts these doublestranded loops into micro RNA (miRNA)
The 2 strands of the loops seperate
One of the miRNA pieces attaches to a cluster of proteins to form a silencing complex
The silencing complex binds to and destroys any mRNA containing a sequence that is complementary to the miRNA.
In effect, miRNA sticks to certain mRNA molecules and stops them from passing on their protein-making instructions

The silencing complex effectively shuts down the expression of the gene whose mRNA it destroys
Blocking gene expression by means of an miRNA silencing complex is known as RNA interface

Each of the specialized cell types found in the adult originates from the same fertilized eggcell
As the embryo develops, different sets of genes are regulated by transcription factors and repressors
Gene regulation helps cells undergo differentiation, becoming specialized in structure/function

A set of master genes, known as homeotic genes, regulates organs that develop in specific parts of the body
homeotic genes share a very similar 180 base DNA sequence so they are called homeobox genes
homeobox genes code for transcription factors that activate other genes important for development

A group of homeobox genes are known as Hox genes and are located side by side in a single cluster
These genes tell the cells of the body how to differentiate as the body grows

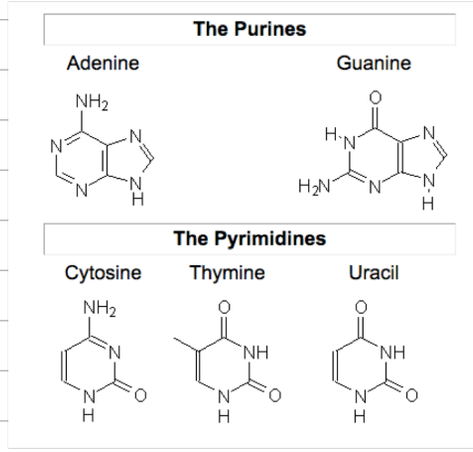
Common patterns of genetic control exist because all these genes descended from the genes of common ancestors

Master control genes are like switches that trigger particular patterns of development and differentiation in cells and tissues

In prokaryotes and eukaryotes, environmental factors like temperature, salinity, and nutrient availability can influence gene expression

PURINES AND PYRIMIDINES

purines in DNA = adenine and guanine } same
purines in RNA = adenine and guanine
pyrimidines in DNA = cytosine and thymine
pyrimidines in RNA = cytosine and uracil



QUESTIONS ON TEST:

How many nucleotides are required to code for 1 amino acid? 3
Types of RNA involved in protein synthesis? mRNA, rRNA, tRNA
A group of genes that operates together? Operator
Why is it possible for an amino acid to be specified by more than one kind of codon?
multiple codons are there to code for one amino acid
Which statement is false? organism's inherited traits depend on proteins
A codon contains sufficient info to a specific a single amino acid
Which of the following are copied from DNA? mRNA, tRNA, and rRNA
What is produced during transcription? RNA molecules
What is the role of the anticodon in the process of translation? the anticodon binds to codon on mRNA