Chapter 17 - From Gene to Protein

Main Questions:

* The information content in DNA is the specific sequence of \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ along the DNA strands.
* How does this information determine the organism’s \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_?
* How is the information in the DNA sequence \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ by a cell into a specific trait?

Before Transcription and Translation

* Before these had been discovered, there was many questions as to what caused many metabolic \_\_\_\_\_\_\_\_\_\_\_.
* In 1909, Archibald Garrod was the first man to suggest that \_\_\_\_\_\_\_\_\_ code for \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ that dictate phenotypes of organisms.
* He called these “\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_.”
* He used \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ as a example.

George Beadle and Boris Ephrussi

* Proposed a similar \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_regarding eye pigment production in fruit flies.
* As time went on, biochemists performed numerous experiments that \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ the hypotheses of Garrod, Beadle and Ephrussi.

Experiments Demonstrating the Relationship Between Genes and Enzymes

* George Beadle and Edward Tatum experimented with \_\_\_\_\_\_\_\_\_\_\_\_ mold (*N. crassa*)
* Bread mold is \_\_\_\_\_\_\_\_\_\_\_\_\_. It can grow on minimal medium because it can use various pathways to synthesize everything it needs to survive.
* \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ is culture medium that contains everything necessary for growth of the wild type: usually inorganic salts, a carbon source including vitamins and water.

Beadle and Tatum

* Exposed the bread mold to X-rays to create a variety of \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_.
* Most mutants could survive on complete growth medium--medium supplied with \_\_\_\_\_\_\_\_\_\_\_\_\_\_ and \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_.
* Looked to see how they responded to various growth medium--those \_\_\_\_\_\_\_\_\_\_\_\_\_ various nutrients required for growth.
* Looked closely at the pathway that synthesized \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_.
* Found that each mutant was \_\_\_\_\_\_\_\_\_\_\_\_\_ to carry out one step in the pathway for synthesizing arginine because it \_\_\_\_\_\_\_\_\_\_\_ the necessary \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_.
* They also noticed that the mutants would \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ if they were grown on a medium supplied with a compound made after the defective step.

Beadle and Tatum’s Famous Experiment

* They hypothesized the arginine synthesis \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_.
* Examined 4 strains of *\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_*.
* Found mutants could \_\_\_\_\_\_ grow when the compound is supplied after the defect.
* Results confirmed their \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ enzyme hypothesis.

Beadle and Tatum

* Somehow the gene that converts one product to the next in the pathway must have been affected by the \_\_\_\_\_\_\_\_\_\_.
* One gene must be \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ for one enzyme--their original hypothesis.

One-Gene One-Enzyme Hypothesis

* As more was learned about proteins, it was determined that \_\_\_\_\_ all proteins are enzymes--(they are \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_, though)
* The hypothesis was revised: It is now the \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ hypothesis.
* Many enzymes are comprised of \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ proteins.
* Even this is wrong because some genes code for \_\_\_\_\_\_\_\_\_ (that may not become protein).

The Bridge Between DNA and Protein

* RNA is the \_\_\_\_\_\_\_\_\_\_\_ stranded compound that carries the message from the DNA to the ribosome for \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ into protein.
* Recall, \_\_\_\_\_\_ = A,T,C,G; \_\_\_\_\_\_= A,U,C,G
* The \_\_\_\_\_\_\_\_\_\_\_ of these bases carries the code for the protein which is constructed from any or all of the 20 amino acids.

Transcription and Translation

* Going from \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_.
* \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ is the synthesis of mRNA using DNA as the template. Similar to DNA synthesis.
* mRNA is the \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ (hence the “m”) from the gene.
* \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ is the process that occurs when the mRNA reaches the ribosome and protein synthesis occurs.

RNA

* RNA is used because it is a way to \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ the DNA from possible damage.
* Many copies of RNA can be made from \_\_\_\_\_\_\_\_\_ gene, thus, it allows many copies of a protein to be made \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_.
* Additionally, each RNA transcript can be translated repeatedly--via \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_.

Polyribosome

* Here you can see an mRNA transcript being translated into many copies of protein by multiple \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ in a eukaryote.
* This is a way in which the cell can efficiently make \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ copies of protein.
* Here it is again in a prokaryote.
* The process essentially the \_\_\_\_\_\_\_ between prokaryotes and eukaryotes.

One Main Difference

* Between prokaryotes and eukaryotes, there is \_\_\_\_\_\_ main difference between transcription and translation. The two processes can occur simultaneously in \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ because they \_\_\_\_\_\_\_\_\_ a nucleus.
* In eukaryotes, the two processes occur at \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ times. Transcription occurs in the \_\_\_\_\_\_\_\_\_\_\_\_, translation occurs in the \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_.

The Genetic Code

* Scientists began wondering how the genetic information contained within DNA instructed the formation of \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_.
* How could \_\_\_\_ different base pairs code for \_\_\_\_\_ different amino acids?
* 1:1 obviously didn’t work; a 2 letter code didn’t work either; but a 3 letter code would give you more than enough needed.
* \_\_\_\_\_ of the 64 codons code for amino acids.
* 3 of the codons code for \_\_\_\_\_\_ codons and signal an end to \_\_\_\_\_\_\_\_\_\_\_.
* AUG--\_\_\_\_\_\_\_\_ codon
* The genetic code is said to be \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_.
* More than one \_\_\_\_\_\_\_\_\_\_\_\_\_ codes for the same amino acid.
* One triplet only codes for one amino acid.
* The \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ frame is important because any error in the reading frame codes for gibberish.

Transcription

* The gene determines the \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ of bases along the length of the mRNA molecule.
* One of the two regions of the DNA serves as the template.
* The \_\_\_\_\_\_\_\_\_ is read 3’-->5’ so the \_\_\_\_\_\_\_\_\_\_\_ can be synthesized 5’-->3’

Translation

* mRNA triplets are called \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_.
* Codons are written \_\_\_\_\_\_\_\_\_\_\_\_\_\_
* Codons are read 5’-->3’ along the mRNA and the appropriate \_\_\_\_\_ is incorporated into the protein according to the codon on the mRNA molecule.
* As this is done, the \_\_\_\_\_\_\_\_\_\_\_\_ begins to take shape.

mRNA and RNA Polymerase

* mRNA is the “\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_” or vehicle that carries the genetic information from the DNA to the protein synthesizing machinery.
* RNA \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ pries apart the DNA and joins RNA nucleotides together in the 5’-->3’ direction (adding, again, to the free 3’ end).
* RNA polymerase is just like DNA polymerase, but it doesn’t need a \_\_\_\_\_\_\_\_\_\_\_\_\_.

The Synthesis of mRNA

* RNA \_\_\_\_\_\_\_\_\_\_\_ encounters a promoter on the DNA near a transcriptional unit and starts synthesizing RNA.
* When the RNA pol II encounters a terminator sequence, transcription \_\_\_\_\_\_.

Different Types of RNA Polymerase

* \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ have one type of RNA polymerase that synthesizes mRNA and the other types of RNA as well.
* \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ have 3 different types in their nuclei (I, II, III). mRNA synthesis uses RNA pol II.

Promoters

* Promoters are found on the \_\_\_\_\_\_\_ molecule and initiates the transcription of the gene.
* This is the site where transcription factors and RNA polymerase \_\_\_\_\_\_\_\_\_\_\_\_\_.
* Transcription is finished when the RNA polymerase reaches the \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_.
* The stretch of DNA that is transcribed is known as the \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ unit.
* Usually extend a few \_\_\_\_\_\_\_\_\_\_\_\_ nucleotides upstream from the transcription start point.
* Include a \_\_\_\_\_\_\_\_\_\_ box in eukaryotes.
* \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ are important for the binding of the RNA polymerase.

The Initiation of Transcription

* Transcription factors \_\_\_\_\_\_\_\_ to the promoter region enabling RNA pol II to do so.
* The RNA pol II binds with additional transcriptional factors creating a \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ initiation complex.
* DNA \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ and transcription \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_.

RNA pol II

Promoter Differences Between Prokaryotes and Eukaryotes

* In \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_, RNA polymerase recognizes and binds to the promoter on the DNA and immediately begins synthesizing mRNA.
* In \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_, a group of proteins called transcription factors are needed for the binding of the RNA polymerase and the initiation of transcription.

Promoter Differences Between Prokaryotes and Eukaryotes

* Once the transcription factors bind to the \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_, RNA pol II binds and \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ can then proceed.
* The entire group of \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ in the eukaryote are called the transcription initiation complex.

Transcription

* As the RNA pol II moves along the DNA, it \_\_\_\_\_\_\_\_\_\_\_\_\_ it, synthesizes the mRNA transcript and peels away from the DNA allowing it to \_\_\_\_\_\_\_\_\_\_\_.
* Numerous RNA polymerases can \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ the same DNA segment (protein) at the same time.
* This enables the cell to make large amounts of \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ in a short period of time.
* An electron \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ showing the transcription of 2 genes.

Transcription Termination

* In prokaryotes transcription proceeds through a DNA sequence that functions as a termination signal causing the polymerase to \_\_\_\_\_\_\_\_\_\_\_ from the DNA.
* This release of the transcript makes it immediately available for use as \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_.
* In \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_, when the RNA pol II reads a certain signal sequence, it cleaves off the RNA from the growing chain as RNA pol II continues transcribing DNA.
* The RNA pol II continues to read and transcribe DNA and eventually falls off the DNA template strand, (not fully understood).
* The RNA produced now is still \_\_\_\_\_\_ ready for use.

Transcription

* [Movie](http://www.travismulthaupt.com/page1/page5/files/17_07TranscriptionIntro_A.swf)

RNA Modification

* The eukaryotic RNA transcript now gets \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ before it enters the cytoplasm.
* The \_\_\_\_ end of the transcript gets modified before leaving the nucleus--a 5’ cap of nucleotides.
* The \_\_\_\_ end is also modified--numerous adenine nucleotides--called a poly-A tail.

Important Functions of the 5’ Cap and Poly-A Tail

* They facilitate \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ of the mature mRNA from the nucleus.
* They \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ mRNA from degradation by hydrolytic enzymes.
* They assist in the \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ of the ribosome to the 5’ end of the mRNA.

mRNA Modification

* The mRNA is further processed after the ends have been modified--\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_.
* The initial transcript (~8000 bp) is \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ (to ~1200 on average).
* The large, non-encoding regions of the DNA that get transcribed are \_\_\_\_\_\_\_\_\_\_\_\_\_ out.
* \_\_\_\_\_\_\_\_\_\_\_--intervening regions are removed.
* \_\_\_\_\_\_\_\_\_\_\_--expressed regions are kept.
* Some untranslated regions of the exons are saved because they have important functions such as \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_.
* RNA splicing occurs via \_\_\_\_\_\_\_\_\_\_\_\_’s.
* snRPs consist of RNA and protein and join together to form a \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_which interacts with the intron to clip it out and join the exons together.

So, Why is RNA Splicing Significant?

* In many genes, different \_\_\_\_\_\_\_\_\_\_\_ encode separate domains of the protein product.

RNA Splicing

* The way the RNA is spliced determines which proteins will be \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_.
* The different sexes of some organisms \_\_\_\_\_\_\_\_\_RNA differently and thus \_\_\_\_\_\_\_\_\_\_\_\_\_\_the genes into proteins differently--contributing to differences seen among sexes.
* The \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ is one possible reason humans can get by with relatively few genes.