Chpt 9: How Genes Work

DNA is your genetic material, it makes up chromosomes

so what are your **genes**?

genes determine what you look like

hair color, eye color, height, nose shape

but genes do much more than that

genes tell cells what to do, **genes contain the instructions for life** and they do that **by coding for proteins**

so again, what is a gene?

genes are regions of DNA on a chromosome

we now know we have 3 billion bases making up DNA

before the **Human Genome Project**, we thought we had 100,000 genes

now we think we have 25,000-30,000 genes and the next big project is the **Proteome project**, trying to catalogue all those proteins and what they do

the old idea was that one gene=one specific region of DNA that contains instruct for making 1 polypeptide chain (one protein)

now we have realized that it is not that simple, we will see that one region of DNA can code for a number of proteins

DNA is considered to be the **blueprint for** making **proteins**

every cell in body has full complement of genetic info, all 46 chromosomes, but cells only use the specific info they need
a skin cell will make different proteins than a muscle cell, so it turns on diff DNA

when a section of **DNA is read** and a **protein is made**, that means **a gene is being expressed**

So, why are **proteins** so important?
-they make up **body structures**
cell membrane: Fluid Mosaic refers to proteins interspersed through phospholipid
protein keratin found in skin, hair, & nails
protein collagen found in skin, tendons, etc
protein actin & myosin found in muscles

-they make up **enzymes** (DNA polymerase)
biological catalysts for all chemical rx

-they are **carrier molecules**: hemoglobin

-they **communicate & regulate**: hormones

-they **defend** the body: antibodies

all instructions for life are stored in DNA, but **DNA does not leave nucleus** and **proteins** are **made in cytoplasm**

so **how do we get the genetic info to the cell**? **RNA**

RNA is half the size of DNA, it is the go-between molecule

there are **3 types of RNA**

1-**messenger RNA: mRNA**

this is a temporary copy of DNA

it contains a copy of gene carried from nucleus------>cytoplasm

2-**ribosomal RNA: rRNA**

along with proteins, this makes up structure of ribosome, which helps in making of proteins

3-**transfer RNA: tRNA**

helps in making of proteins by bringing AA's to the ribosome

three important **terms** to know

1-**DNA synthesis or replication**

the copying of all DNA prior to cell division so all cells have copy

2-**transcription:** copying of DNA into mRNA

this is like copying notes, transcribing

3-**translation:** changing language of genes into the language of proteins

what is the language of genes?

what is the language of proteins?

genetic code made up of 4 bases: A T C G

proteins are made of 20 different AA's

proteins are macromolecules made of 100's of AA's, there are only 20 AA's the building blocks, but there are 100's of 1000's of proteins

We have already learned DNA synthesis, so this chapter begins with RNA synthesis

RNA synthesis or transcription: the making of RNA from DNA

DNA is template: pattern used to make RNA

all 3 types RNA are made in nucleus

3 parts to RNA synthesis or transcription: initiation, elongation, termination

1-**initiation**

RNA polymerase attaches to specific region of DNA called **promoter region**

2-**elongation**

RNA polymerase unwinds, then unzips DNA, this is just like DNA synthesis

then **RNA polymerase reads DNA bases** and brings in complementary RNA nucleotide, there are free-floating RNA nucleotides present in nucleus, RNA polymerase retrieves the correct one, brings it to transcription site, connects nucleotides together, this continues until

3-**termination**

RNA polymerase reaches terminator region or stop code, a combination of bases that says stop, then enzymes are released, RNA is released, and DNA is zipped back up

next, **RNA is then processed**: adjustments are made before leaving nucleus

adjustments are different depending on what kind of RNA was made

-if **mRNA** was made: we **add cap & tail**

the cap: add guanine nucleotides to beginning of mRNA strand

the tail: adds polyA tail (adenine nucleotides)

both of these help protect mRNA as it moves from nucleus to cytoplasm

the tail also helps transport mRNA to cytoplasm and the cap helps to connect to ribosome and begin next process

next, **some parts of RNA may be spliced out**

these are called **introns** and the message that is left is called the **exon**

Why cut out portions of the DNA message?

old hypothesis: one gene is equal to one portion of a DNA molecule,
one gene=one protein

new hypothesis: one portion of DNA can code for a number of different proteins

we can transcribe a portion of DNA, cut out different introns each time, getting different proteins

-if **tRNA** was made: it is processed by folding into clover leaf pattern, **folding into 3D structure**

tRNA is used in next step

-if **rRNA** was made: it is processed by binding to proteins to **form 2 ribosomal units** used in next step

So, we **have copied a gene from DNA**, now we have to move to the cytoplasm to make a protein

Protein Synthesis or Translation

in this step, we change the language of genes into the language of proteins, but how do we do this?

there are only 4 nitrogen bases, so how do we get 20 different AA's from only 4 bases?

-if each DNA base coded for a diff AA, how many different AA's would we get?

-if we used 2 bases to code for an AA, how many AA's would we get?

-if we used 3 bases for a code, how many AA's would we get?

3 bases of DNA or mRNA is code for AA

we transcribed a whole sequence of DNA into mRNA, now we read 3 bases at a time in mRNA: called a **codon**

the mRNA codons are found in Fig.9.10, p.152 of text and in handouts

you need to be able to figure out how to read the chart

Protein Synthesis or Translation

occurs at **ribosomes on ER** in cytoplasm

codon sequence of mRNA will be translated into the AA sequence of proteins

prior to this mRNA was transcribed in nucleus, goes to cytoplasm

tRNA made in nucleus, goes to cytoplasm

tRNA has the anticodon to the codon, it picks up the AA that matches anticodon of and becomes charged

rRNA is assembled, there are 2 parts and the mRNA will attach to the rRNA

Protein Synthesis or Translation

3 parts: initiation, elongation, termination

1-initiation: mRNA attaches to ribosome
ribosome reads start codon, AUG

2-elongation: an enzyme goes to get the charged tRNA w/matching anticodon
this anticodon, UAC, has methionine attached
then the next codon is read by ribosome, an enzyme brings in next charged tRNA w/AA attached
the1st AA is then bonded to 2nd AA by a peptide bond
now, the 1st tRNA is released-now uncharged-it goes to pick up another AA
the process continues, reading codons, bringing in charged tRNA's with matching anticodon, forming bonds between prior AA and next AA, and then releasing the tRNA

3-termination: ribosome reads stop codon
a protein called releasing factor binds to stop codon, translation then stops
tRNA & ribosome release polypeptide chain and mRNA is destroyed, it was temporary copy

once protein is made, it becomes functional when it bends, or spirals, then is folded into 3D shape

Transcription & Translation Errors

mistakes can be made in trying to make a protein

1-frame shift error

there is a shift in reading of bases
this could be due to skipping a base in transcription, known as deletion, or adding a base, known as insertion

correct reading:

DNA: TTA CGC CTG ATT

mRNA: AAU GCG GAC UAA

AA:

frame shift DNA: TAC GCC TGA TT...

mRNA: AUG CGG ACU AA

AA:

what is the effect? we have made a different or defective protein, the cell has to scrap this protein and begin again, the cell may have trouble functioning, but since the mistake was in transcription, we can go back to the DNA and start over

transcription & translation errors

2-premature stop codon

this can happen due to misreading a base in transcription

correct reading:

DNA: GGC AAT TAG ACC

mRNA: CCG UUA AUC UGG

AA:

misreading:

mRNA: CCG UAA AUC UGG

AA:

what is the effect? this makes an incomplete protein that is nonfunctional, so it is defective, again, we must scrap this protein and go back to DNA and begin again

errors

3-some errors have no effect, silent

correct reading:

DNA: ACC GGG TAG

mRNA: UGG CCC AUC

AA:

misreading:

mRNA: UGG CCA AUC

AA:

what is the effect?

What if the error is in the DNA sequence?

4-mutation: change in DNA sequence
if the mutation is in the DNA sequence, it is passed on from cell to cell, from parent to offspring, so every cell has the defect

real life example:

normal hemoglobin (Hb): hemoglobin is a protein made of 4 separate AA strands with over 100 AAs on each strand, these 4 strands achieve a 3D shape and fill up RBCs to carry O2

if there is a mistake in one base in one strand, it makes defective Hb

DNA: GGG CTT CTT TTT

mRNA: CCC GAA GAA AAA

AA: pro-glu-glu-lys

mistake:

DNA: GGG CAT CTT TTT

mRNA: CCC GUA GAA AAA

AA: pro-val-glu-lys

this simple mistake is called a **point mutation**
a point mutation is a change in one base
this makes defective hemoglobin and produces the disease sickle cell anemia

remember mutations

mutations can have 3 effects

1- **harmful or lethal**: can cause malfunctions, death

2- **beneficial:** driving force behind evolution

3- **silent:** no effect

this is where the majority of mutations fit when a base changes but the correct amino acid is still brought in (many codes for each AA), then there is no effect

mutations can occur at the gene level and also at the chromosome level

we will learn about this with genetics

With the knowledge of the structure of DNA & RNA, the science of molecular biology was established

Molecular biology explains how living organisms function at the molecular level

central dogma: information is transferred from DNA to RNA to protein

all info for life is coded for in the DNA, which stays in the nucleus, so it is transferred to RNA, which gets it to the cytoplasm to the cell's machinery, which then makes proteins

remember the mouse eye/fly eye transfer experiments in evolution unit?

we discovered a set of master control genes called homeotic genes

these regulate organ development in specific parts of animal bodies and these genes have been passed down from organism to organism

so they work the same way in different organisms

we have also learned that the environment can have an effect on how genes are expressed

we will touch on this in genetics

We will now return to Viruses

remember **viruses: borderline form of life**

how are they life-like?

- they have genetic info made of either DNA or RNA
- they have proteins
- they can evolve
- they can reproduce **BUT** they need another cell to do so

how are they not life-like?

- they are not cellular
  - what does the cell theory state?
- they have have no cell membrane, no cell organellles, no cytoplasm, no way to make E

virus replication occurs in 2 ways

1-lytic cycle

2-lysogenic cycle

Virus lytic cycle

virus invades host, injects genetic material
viral DNA takes over cell's DNA so the host cell enzymes begin making viral DNA & protein coat, new viral particles are assembled, cell bursts (lysis), kills cell in process, releases viral particles which repeat cycle
influenza virus, bacteriophage virus

Virus lysogenic cycle

in this cycle, the viral DNA is injected into cell, but then it is **spliced** into host cell's DNA so it becomes part of the host cell's DNA
every time the host cell divides, it copies the viral DNA
under stress, viral particles can be released--> giving symptoms of disease

ex. herpes virus, cold sore virus (herpes simplex I)
if you get this, you never get rid of virus

antibiotics kill bacteria but not viruses
your immune system must fight viruses
immunizations are a weakened form of virus given to you so your immune system recognizes virus and you can fight it off without getting sick

Retroviruses: have genetic info in form of RNA instead of DNA

in order to take over a cells genetics, they must transcribe their RNA into DNA, and they have an enzyme called **reverse transcriptase** to do this

copies RNA ---------->DNA

viral DNA then joins host cell's DNA

Scientists can now use viruses for **gene therapy**

can disarm virus by removing genes that cause disease, can inject virus w/good gene (called recombinant DNA)

virus then invades cell, inserts good gene into cell's DNA & every time cell divides, cell gets gene