GENE EXPRESSION AND MUTATION

GENE EXPRESSION IN PROKARYOTES

- A gene is being "expressed" or "activated" when a protein is being made
- Some are expressed for a time and then turned off

How does a cell know how and when to turn on and off certain genes?

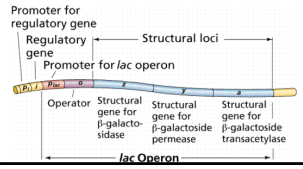
Discovery of Gene Expression

1961: Francois Jacob & Jacques Monod

- studied bacteria e. coli (normal flora in intestines)
- bacteria will break down lactose (into glucose + galactose) from dairy products in intestine to use as energy source (will only do so in presence of lactose)
- three enzymes needed to do this (each has a different gene)
- allows bacteria to conserve energy when gene is off
- **lac operon**: cluster of genes that enables e. coli to build proteins needed for lactose metabolism when lactose is present

The "Players" in Prokaryotic Gene Expression

- **Operon**: promoter, operator, structural (functional) genes
- **Promoter**: control sequence, site where replication starts
- **Operator**: DNA sequence between promoter and enzyme genes, acts as on/off switch for genes
- **Functional genes**: coding sections
- **Inducer**: molecule that initiates gene expression, must be present



- The **default mode** for the operon is the **"off"** position
- Gene expression occurs **only** when the cell needs specific proteins to be made

Steps of Gene Expression in Prokaryotes

I. **Turning on** the lac operon (inducer must be present)

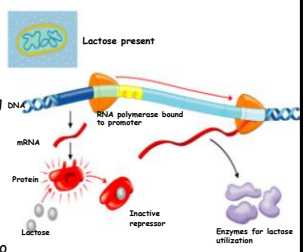
A. RNA polymerase attaches to promoter region near the genes "START HERE"

B. RNA polymerase moves along chromosome to genes

C. Once it hits genes, it produces m RNA (transcription)

D. mRNA instructs ribosomes to make enzymes (translation)

The lac operon in "on" mode



Operon turned on (repressor inactivated by lactose)

II. Turning off the lac operon

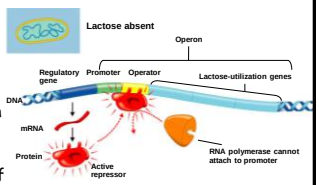
****repressor** – protein that inhibits gene from being expressed

A. repressor attaches to operator and sits between promoter and the genes

B. repressor blocks access of RNA polymerase to genes

C. protein stops being made

The lac operon in **"off"** mode



Operon turned off (default state when no lactose is present)

III. Reactivation of lac operon

if cell needs more enzyme

A. when inducer enters cell it binds to the repressor

B. repressor changes shape

C. repressor falls off operator

D. RNA polymerase binds to promoter and again forms m RNA which will instruct ribosome to again make enzyme

E. when inducer runs out-
- repressor binds to operator again, changes shape & falls off
- operon is turned off

SYSTEM IS AUTOMATIC AND SELF-REGULATING

Lac operon animation

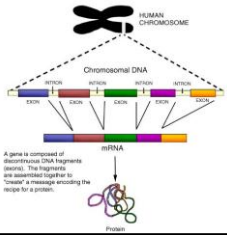
GENE EXPRESSION IN EUKARYOTES

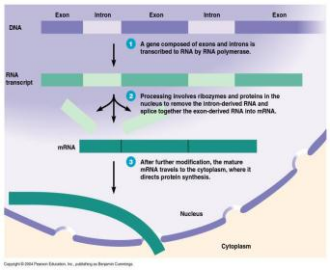
- more complex than prokaryotes
- because nuclear envelope physically separates transcription from translation, more opportunities for regulation of gene expression
- Eukaryotes have DNA on many chromosomes not one circular DNA
- Many different cell types make many different proteins

DNA Proofreading

- remember that before mRNA goes into cytoplasm to start protein synthesis, **RNA polymerase** proofreads strand

Introns: non coding, non functional DNA , "junk DNA"
Exons: – coding functional sections of DNA (1.5%)



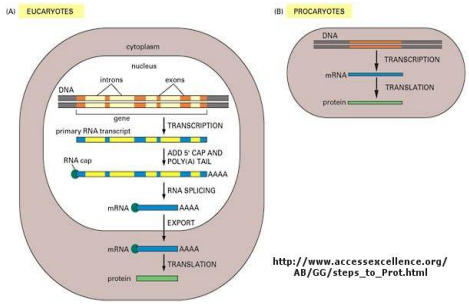


Steps

1. **RNA polymerase** moves along gene and transcribes entire gene
2. **RNA splicing** occurs – introns are removed and exons are spliced back together
3. mRNA leaves and goes to cytoplasm to ribosome to make protein

RNA splicing animation

Differences in Prokaryotic and Eukaryotic Gene Expression



http://www.accessexcellence.org/AB/GG/steps_to_Prot.html

Differences in Prokaryotic and Eukaryotic Gene Expression

Prokaryotes	Eukaryotes
Transcription in cytoplasm	Transcription in nucleus
Uses operons as functional units	No operons
Regulatory gene causes inhibitor to make repressor which binds to operator	Regulatory gene recognizes RNA polymerase and starts transcription
No proofreading- mRNA goes directly to make proteins	Proofreading occurs (prevents mutations) DNA → Pre mRNA → mRNA

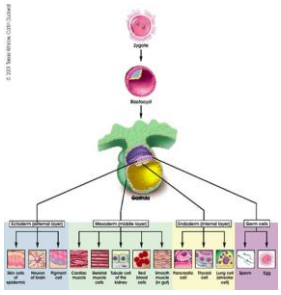
Gene Expression during Development

During zygote development:

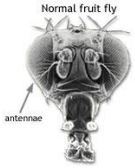
- genes expressed only when specific proteins are needed

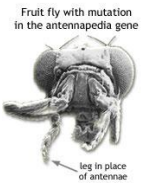
-**cell differentiation**: development of different cells with specialized functions

  - forms tissues and organs



Homeotic Genes





Homeotic genes:

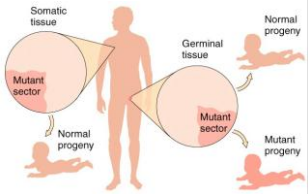
- master genes for development of body organization
- regulate gene expression by turning genes on and off
- increases or decreases cell division rates in areas of developing organism

*** every cell in an organism carries, within its DNA, all of the information necessary to build the entire organism**

MUTATIONS

Mutation: any sudden chemical change in genes or chromosomes (mistake)

- most mutations are recessive
- can occur in any cell
- NOT normal occurrence
  - **germ mutation**: affects reproductive or germ cells (inherited)
  - **somatic mutation**: affects body cells (not inherited)

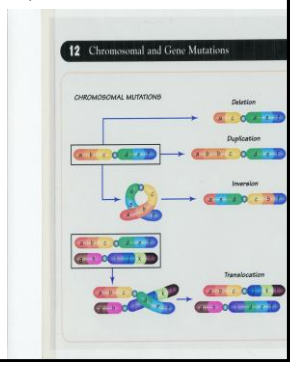


Mutant: organism that has a mutation and shows a completely different trait than its parents

- can also carry 1 recessive gene and not express mutation
- can occur at the level of the chromosome or gene

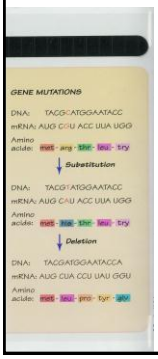
Chromosome mutation: chemical alteration in segments of chrom, whole chrom., or sets of chrom.

1. **deletion** – piece of chrom. is broken off and information is lost
2. **duplication** - segment of chrom. is repeated
3. **inversion** – pieces breaks from chrom and reattaches to same chrom. in reverse order
4. **translocation** – broken piece of one chrom. breaks off and attaches itself to another non- homologous (replicated) chromosome



Gene Mutation: any chemical change in the base code of DNA molecule

- can affect 1 or many nucleotides



1. **point mutation** - single nucleotide is affected

   - **substitution**
     AUG methionine
     AUA isoleucine

2. **frameshift mutation** – **insertion** or **deletion** of a single base

   - shifts groupings of codons following mutation

very serious- will completely change protein made by a single gene

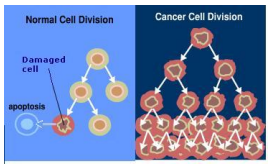
Cancer

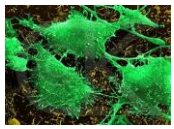
Tumor: abnormal proliferation of cell that results from uncontrolled, abnormal cell division

Benign: non cancerous, cells stay within the mass

Malignant: uncontrolled dividing cells invade and destroy healthy tissues in body

Metastasis: spread of cancer cells beyond original site





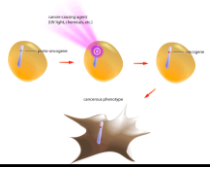
cancer animations

Genetics of Cancer

Oncogenes: genes that cause cancer or other uncontrolled cell proliferation

- **proto-oncogene**: normal form of oncogene that controls cells growth and proliferation

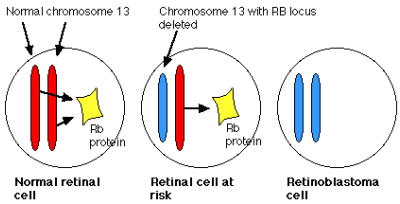
- mutation in proto oncongene causes uncontrolled growth leading to cancer



- **tumor suppressor gene**: codes for proteins that prevent uncontrolled cell division

  - we have two copies (both must be mutated)

  - mutation can cause suppressor expression not to work leading to uncontrolled growth



Causes of Cancer

Exposure to the following:

- Radiation
- Viruses
- Chemicals

Study for the test (lots)!!