Lecture 9 (FW)
February 23, 2009
Regulating Gene Expression; Review
Reading: pp. 143-154

C. There is the general question: how do males with only 1 X chromosome apparently live and express phenotype as well as females, who have 2 X chromosomes? Usually loss of one autosomal chromosome is lethal.

The answer is that the difference in gene dosage is compensated. In mammals this is done by imposing a random inactivation of one of the two X chromosomes in females, so that adult female mammals have a mosaic of cells, some of which express one X chromosome, others of which express the other X chromosome. This can be observed in the coat color patterns of calico cats.

Lecture 9: Regulating Gene Expression
Primary Goal: How genes get turned on and off

I. The regulation of gene expression

A. There are genes that encode proteins which are part of the chromatin/chromosome. They may be part of the chromatin on a permanent, or a temporary basis.

1. Some of these proteins are necessary for the normal cell cycle and mitosis/meiosis.

2. Still other proteins interact with the DNA to prevent RNA polymerase from carrying out transcription. This is not a permanent genetic change, but a temporary and reversible one. In other words, these kinds of mechanisms affect the read-out of the DNA instruction booklet, but do not interfere with the inheritance of genes.

B. There are also many genes that make proteins whose function is to regulate transcription of other genes. In other words, some genes regulate other genes. These "regulatory proteins" work because they interact with **RNA polymerase**, and with certain DNA sequences near the gene of interest, to either **enhance** or **suppress transcription**. These actions of regulatory proteins are at the basis of embryonic development and cell specialization.

1. For example, even though there are hemoglobin genes in all cells of the body, only the developing red blood cell transcribes those genes. That is because there are regulatory proteins, present only in developing red cells, necessary for Hb gene transcription.

2. The question then becomes: why are these special regulatory proteins necessary for Hb gene transcription only present in developing red cell, and not in all cells. That complicated question is one of the leading research fields in biology, and answers are starting to come in. The general answer is that factors in the environment, mainly signals being sent to and from other cells in the embryo, stimulate expression of many of the "**regulatory" genes**.

3, All cells in an organism have the same genes, but different genes are expressed in different cells. This is the paradox of differential gene expression.

4. Signals from other cells or from the environment can influence the transcription and/or translation and/or activation of transcription factor proteins.

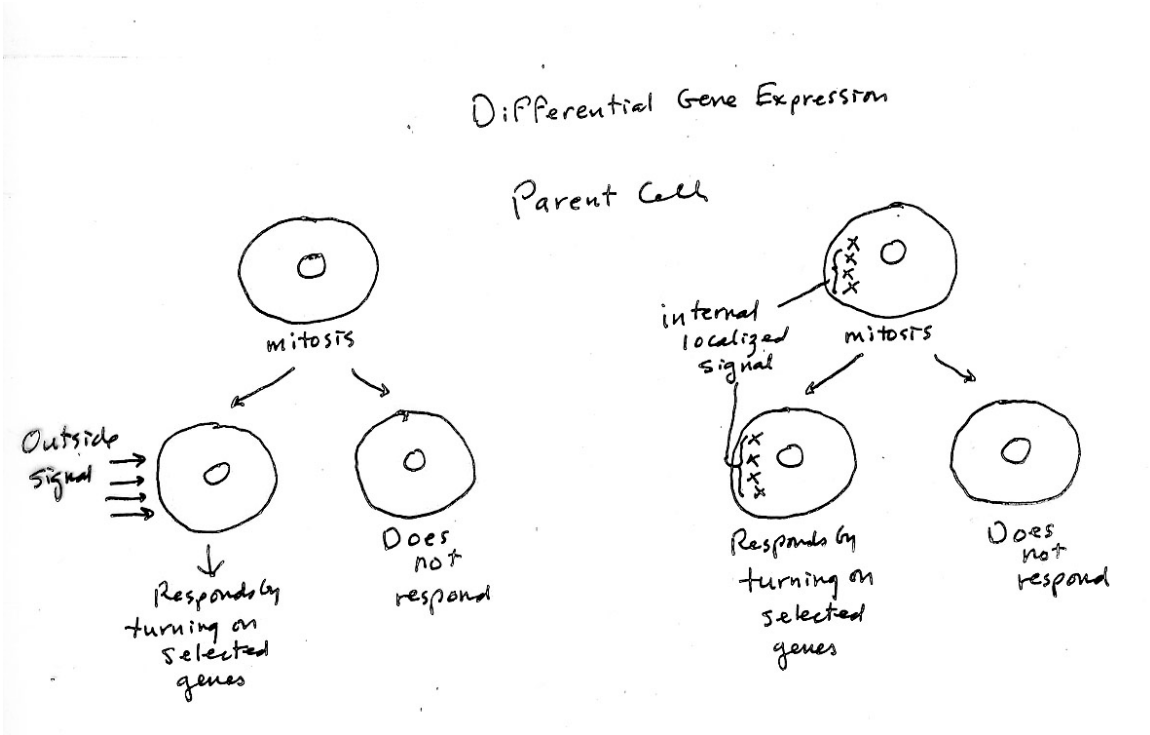
5. If two daughter cells that are genetically identical are exposed to different environmental signals that influence transcription factor activity, then the way is paved for differential gene expression.

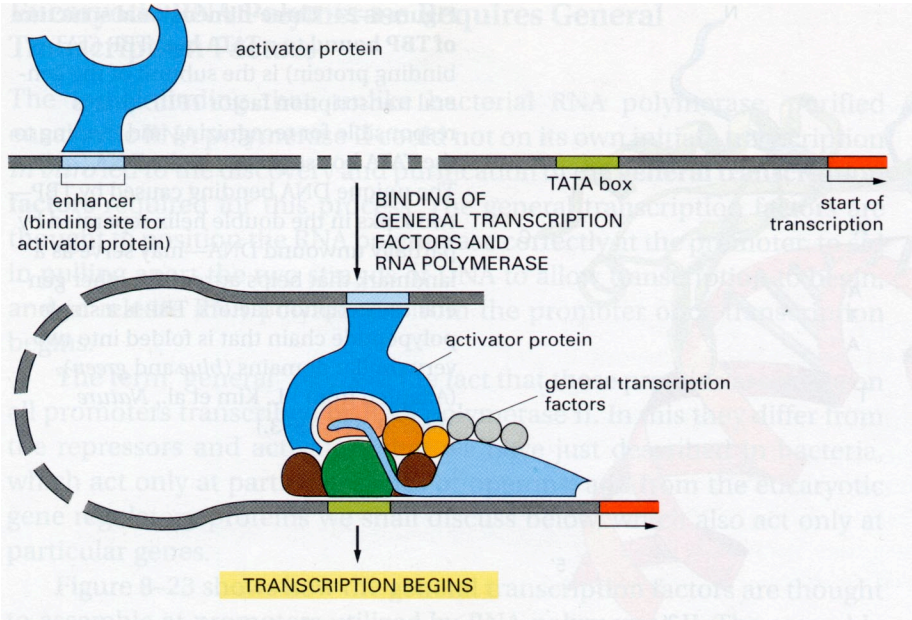
6. How can two sister cells be exposed to different signaling environments?

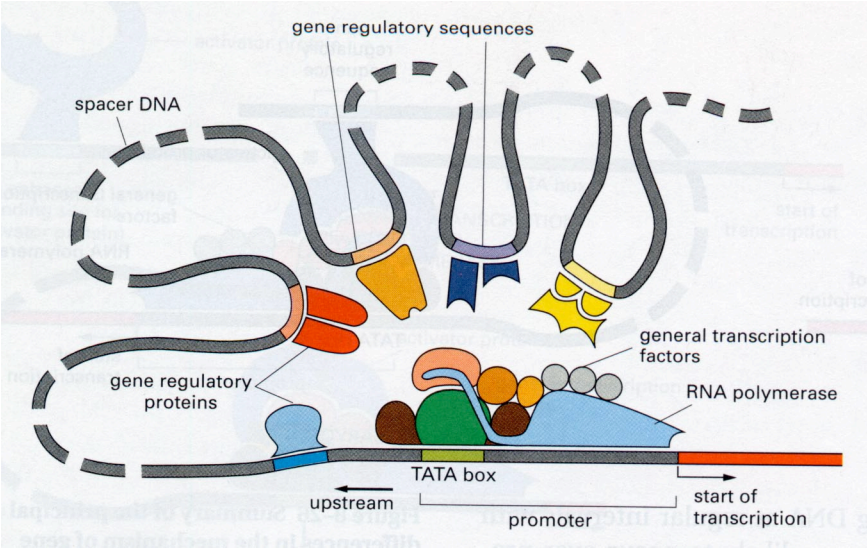
a. Maybe when the sisters originate they are exposed to different external environments. For instance, maybe one sister is on the outside of an organ, exposed to body fluids, while the other remains buried in the interior of the organ and is exposed to signals from neighboring cells. This can and does occur.

b. Or possibly the different environments in the two daughter cells originated from some unequal partitioning during mitosis of some critical signaling molecules.

c. These two possibilities are diagrammed below.







III. Review of Lectures 1-9

A. DNA is the genetic material

B. DNA is a double helix, and can be replicated by base-pairing. of new strands.
Mitosis distributes the replicated DNA to daughter cells

C. DNA can also be replicated by recombinant DNA technology, using vectors and host cells. The PCR reaction using primers allows DNA replication of selected sequences, in vitro.

D. There are two functions of a gene, replication for heredity and transcription/translation for instructions on making and maintaining a cell (or organism).
DNA transcribes mRNA translates into protein.

E. Instructions in DNA are encoded in triplet codes that are universal, redundant and punctuated.

tRNA is the adaptor for assembling amino acids on the mRNA-ribosome factory.

F. Sexual reproduction involves having two (homologs) of each kind of chromosome.

Genes (genotypes) segregate and distribute independently, unless they are linked

Diploid chromosome sets are reduced to haploid by meiosis.

Meiosis involves one DNA replication, a pairing of homologs, and two distributive divisions. Crossing over (genetic recombination) can occur during the tetrad stage of paired homologs.

Genes on the same chromosome are linked and will consequently not show Mendelian independent assortment.

G. There are different kinds of chromosomes (autosomes and sex chromosomes) and different variants of the same gene (alleles). Some alleles are dominant, co-dominant, or recessive. Some genes are sex-chromosome linked.

H. There are variations in the penetrance and expressivity of alleles. The environment may affect the expression of genes.

I. Some genes encode proteins that regulate the transcription of other genes. The expression of these genes can be modified by non-genetic influences in the environment.

IV. Some terms to know:

transcription factor, post-transcriptional processing, RNA polymerase, enhancer, suppressor, regulatory gene.

V. Link to powerpoint slides

VI. There will be a review session : Tuesday, 2/24/ 5-6:30 PM, 159 Mulford

Mid term I: Wednesday, 2/25, 1-2 PM. sections 102 & 103, in 101 Morgan

sections 101,104, 105, 106, in 100 GPB