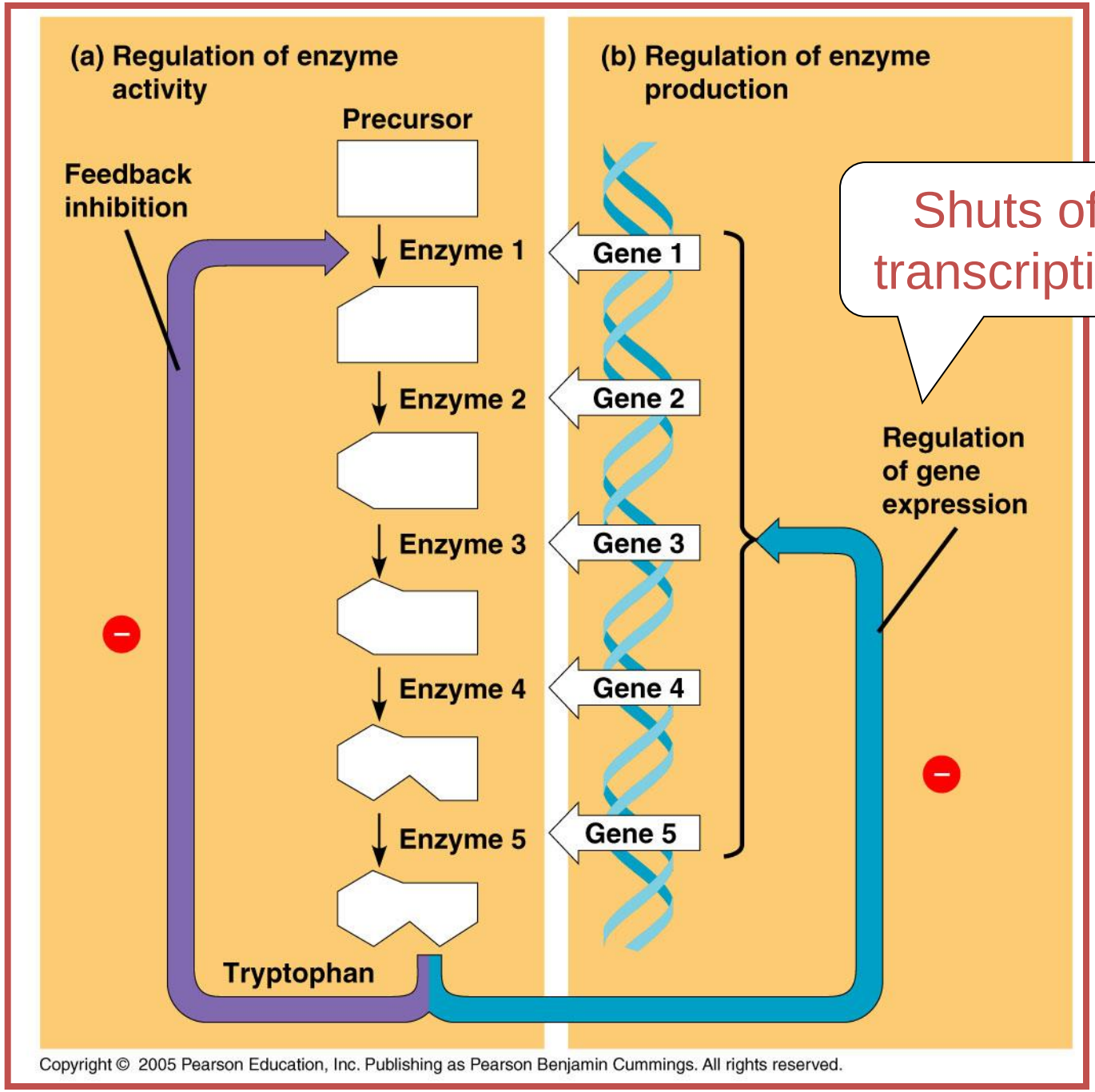
Chapter 18: Regulation of Gene Expression

Regulation of Metabolism



Types of Feedback

- Negative feedback = body's response is to reduce the stimulus
  - Ex: regulation of body temp, blood glucose levels, trp and lac operon

- Positive feedback = body's response is to increase the stimulus
  - Ex: child birth, blood clotting, CAP regulation

Control of Gene Expression

- **Operons** – sequence of DNA that directs particular biosynthetic pathways

- **Four Major Components of an Operon**

- **Regulatory Gene** – produces a repressor protein that prevents gene expression by blocking RNA Polymerase
- **Promoter region** – sequence of DNA where RNA Polymerase attaches for transcription
- **Operator region** – can block action of RNA Polymerase if region is occupied by repressor protein
- **Structural gene** – contain DNA sequences that code for several related enzymes that direct production of an end product

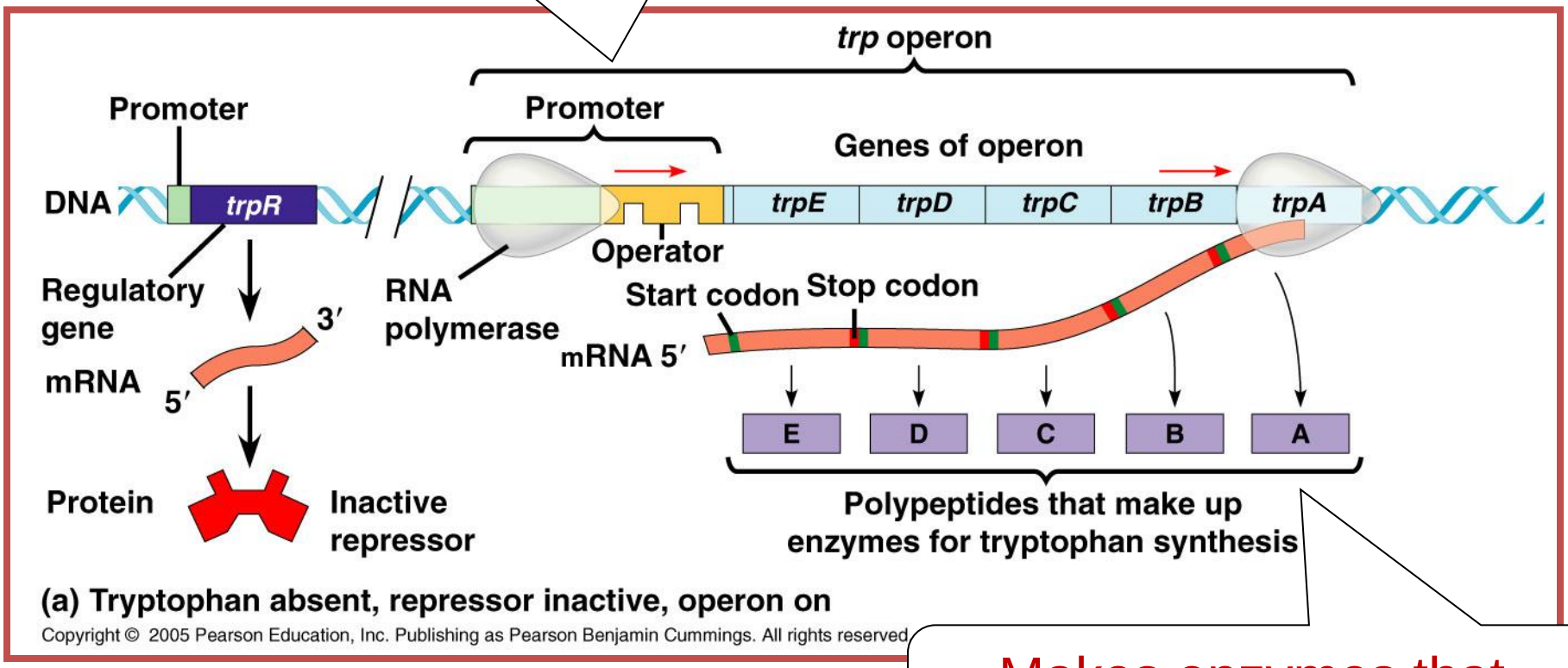
Control of Gene Expression

- To conserve energy, cells make or use proteins responsible for certain metabolic processes only when those processes are needed

- **Trp operon** – enzymes make needed tryptophan
  - Repressor inactivaed in response to presence of tryptophan
  - Tryptophan acts as Corepressor
  - "Repressible enzymes" – *Usually turned on and has to be turned off*
- **Lac operon** – enzymes used to break down lactose
  - Controls breakdown of lactose
  - Lactose presence needed to turn on Operon
  - Allolactose inactivates the repressor at the operator site
  - "Inducible enzymes" – *Usually turned off and needs to be turned on*

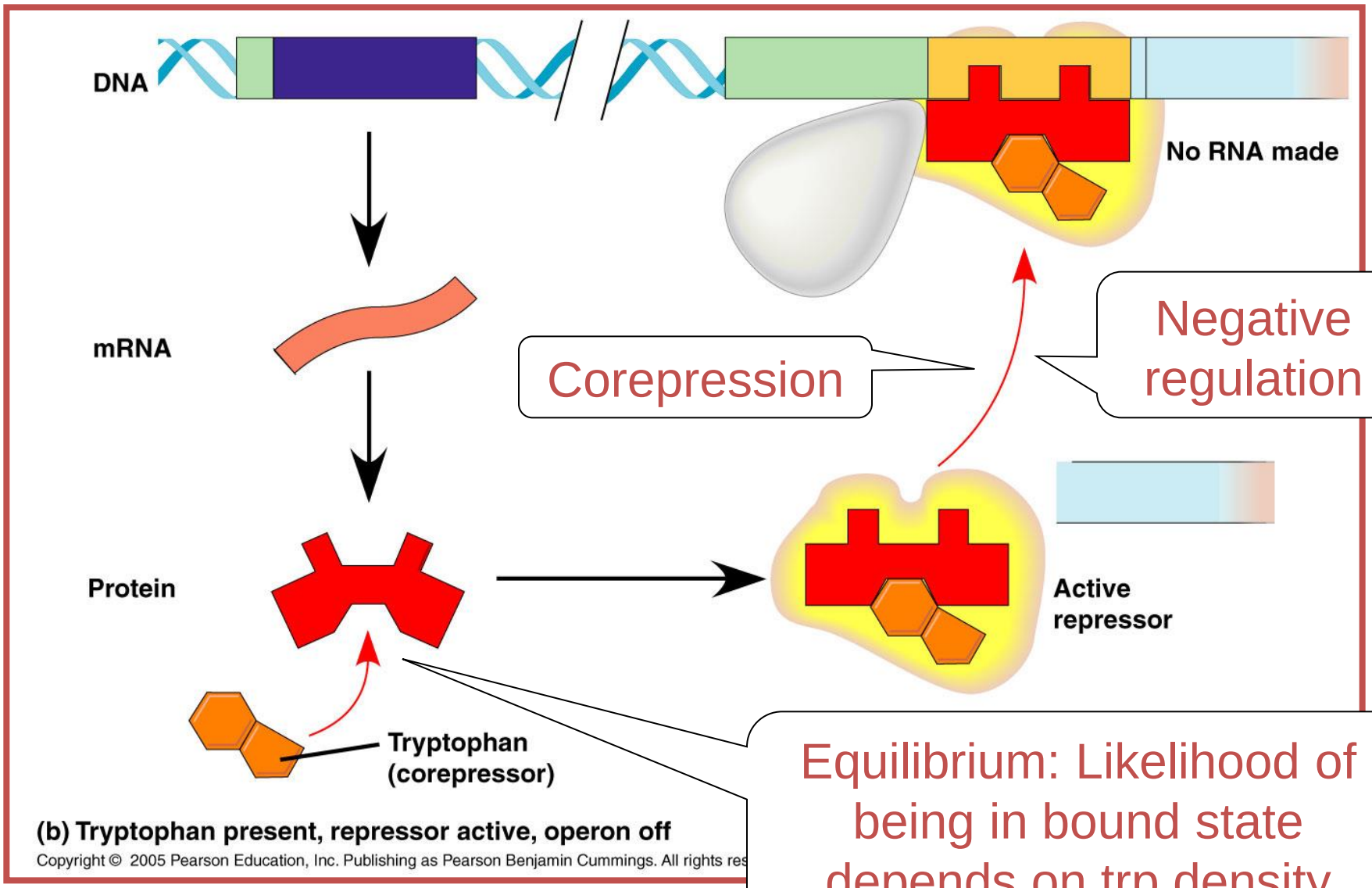
Trp Operon (low trp densities)

Promoter is the site of RNA polymerase binding



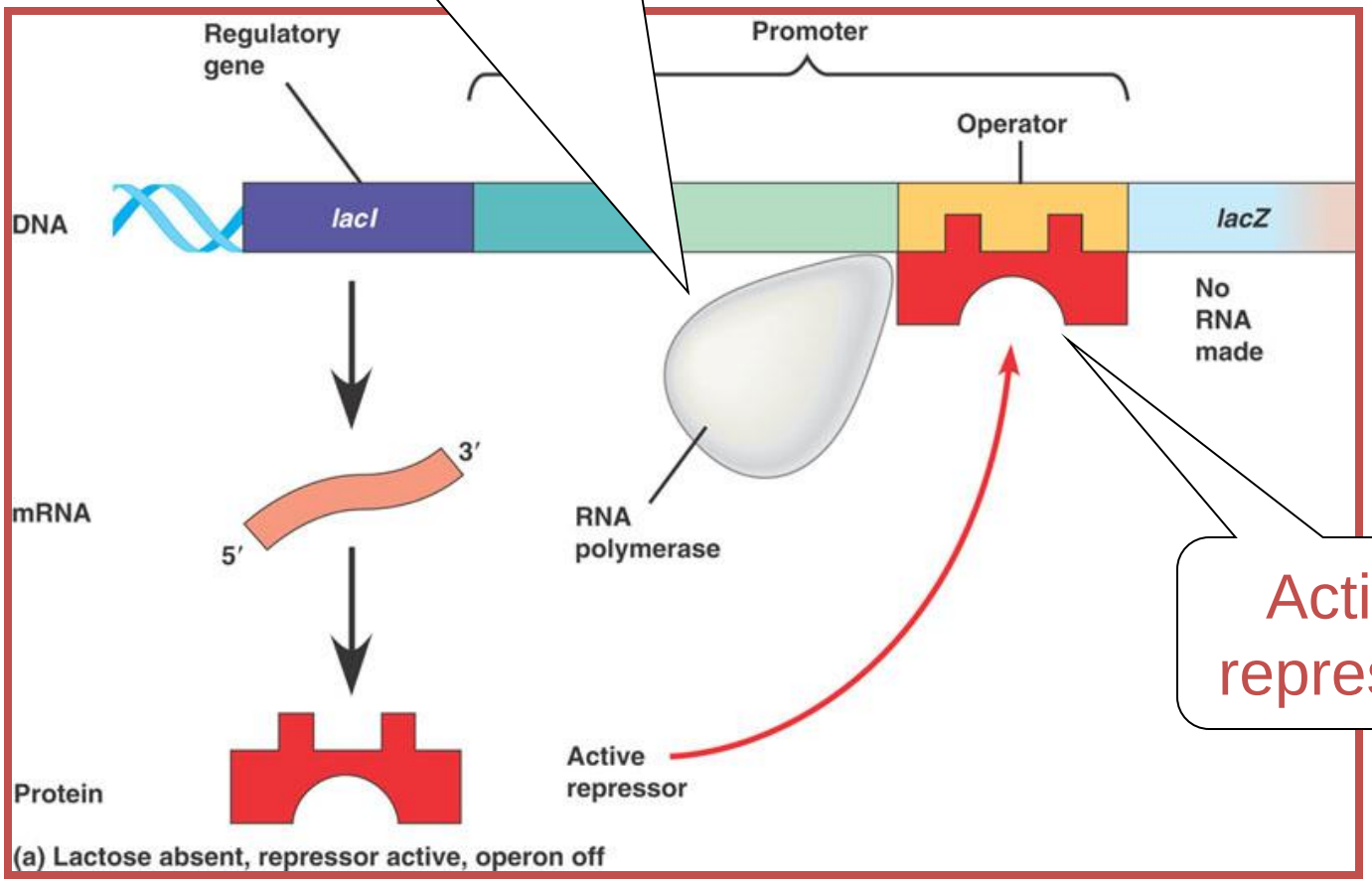
Makes enzymes that produce tryptophan

Trp Operon (higher trp densities)



Lac Operon (lower lactose densities)

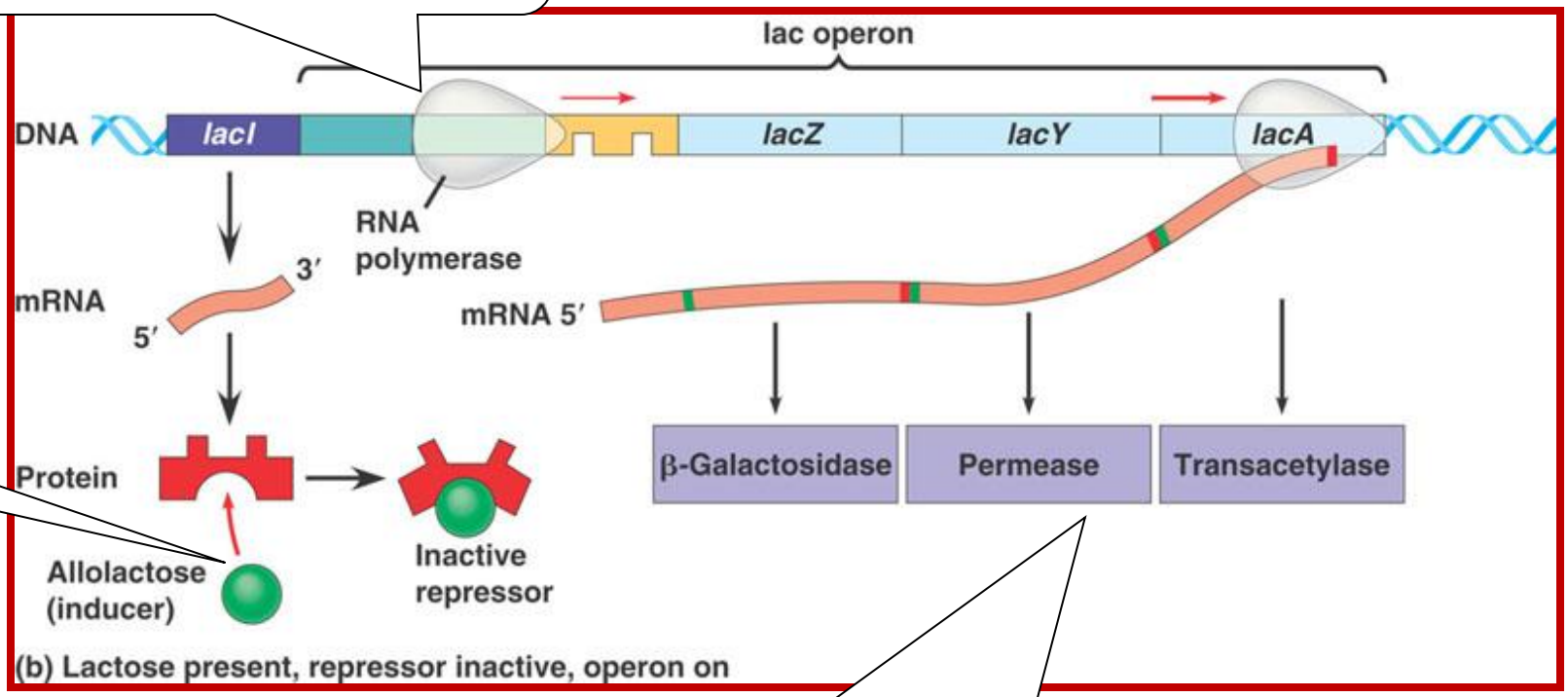
RNA polymerase is unable to bind to the DNA



Active repressor

Lac Operon (higher lactose densities)

RNA polymerase can do transcription



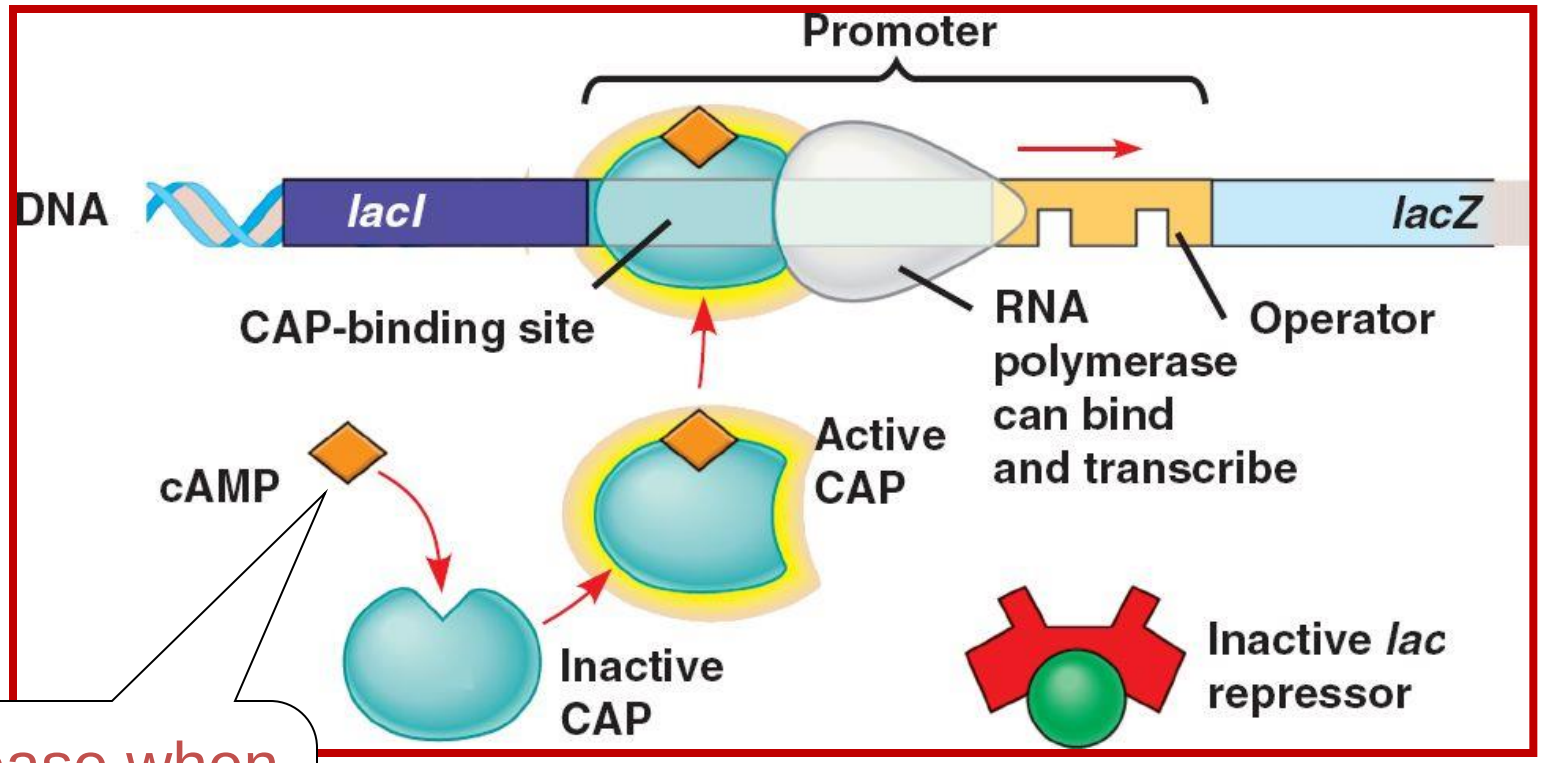
Inducer

Makes enzymes that break down lactose

Positive Gene Regulation

- When glucose levels are high and lactose is high, bacteria will break down glucose first
- When glucose levels drop, then the lac operon is activated
  - cAMP levels increase when glucose decreases
  - Active CAP protein binds to promoter and increases the RATE of transcription
  - Allolactose and moving the repressor protein are still needed and work on negative feedback

Positive Gene Regulation



Increase when glucose levels decline

Still need to inactivate for transcription to occur

Eukaryotic Regulation at Any Stage of Protein Synthesis

- Chromatin structure
  - Histone acetylation – addition of acetyl groups decreases the binding and allows transcription to occur easier
  - DNA methylation – adding methyl groups to cause DNA to wind more tightly and decreases the expression of genes
    - Genomic imprinting – methylation of DNA causes maternal or paternal genes to not be expressed
  - Epigenetic inheritance – inheriting traits by mechanisms not directly involving nucleotide sequence

- http://highered.mcgraw-hill.com/olcweb/cgi/pluginpop.cgi?it=swf::535::535::/sites/dl/free/0072437316/120080/bio27.swf::Combination+of+Switches+-+the+Lac+Operon

- https://www.youtube.com/watch?v=oBwtxdI1zvk

Cell differentiation

- Observable cell differentiation results from the expression of genes for tissue-specific proteins

- Induction of transcription factors during development results in sequential gene expression

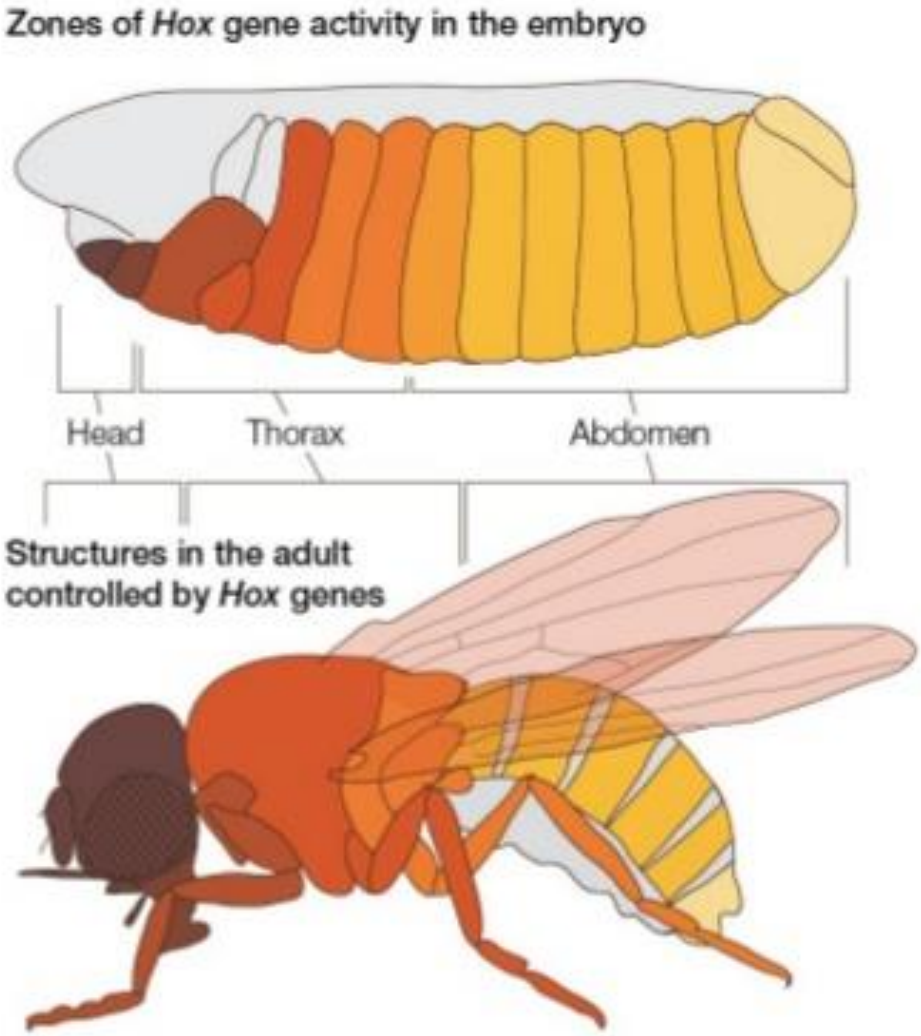
- Homeotic (HOX) genes – regulate developmental patterns and sequences such as location of each body part

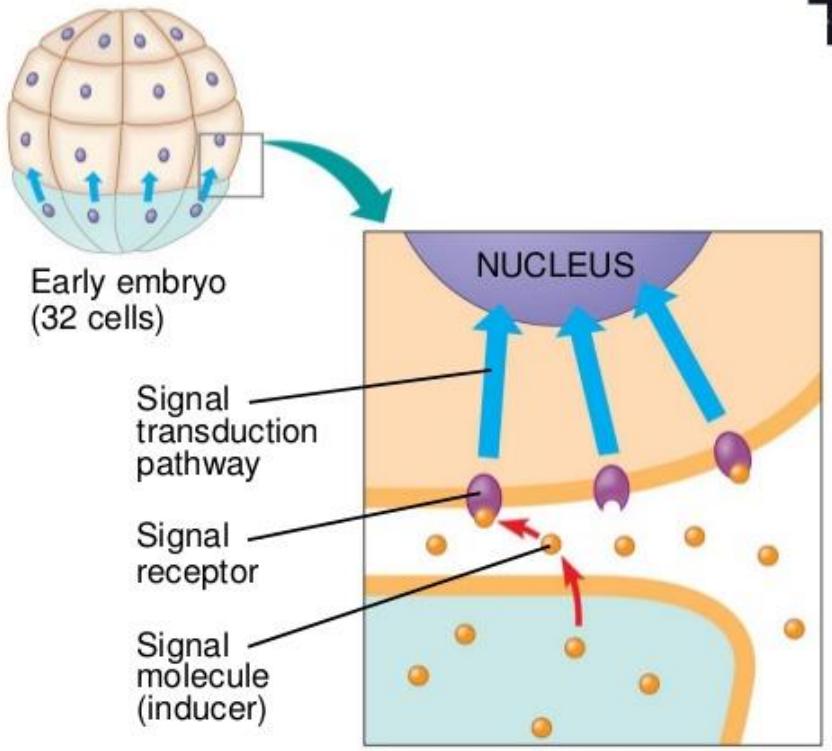
- Embryonic induction – when one group of developing tissues directs the development of another group

- Cytoplasmic determinants – regulatory molecules that allows for the expression of different genes in different cells as they divide

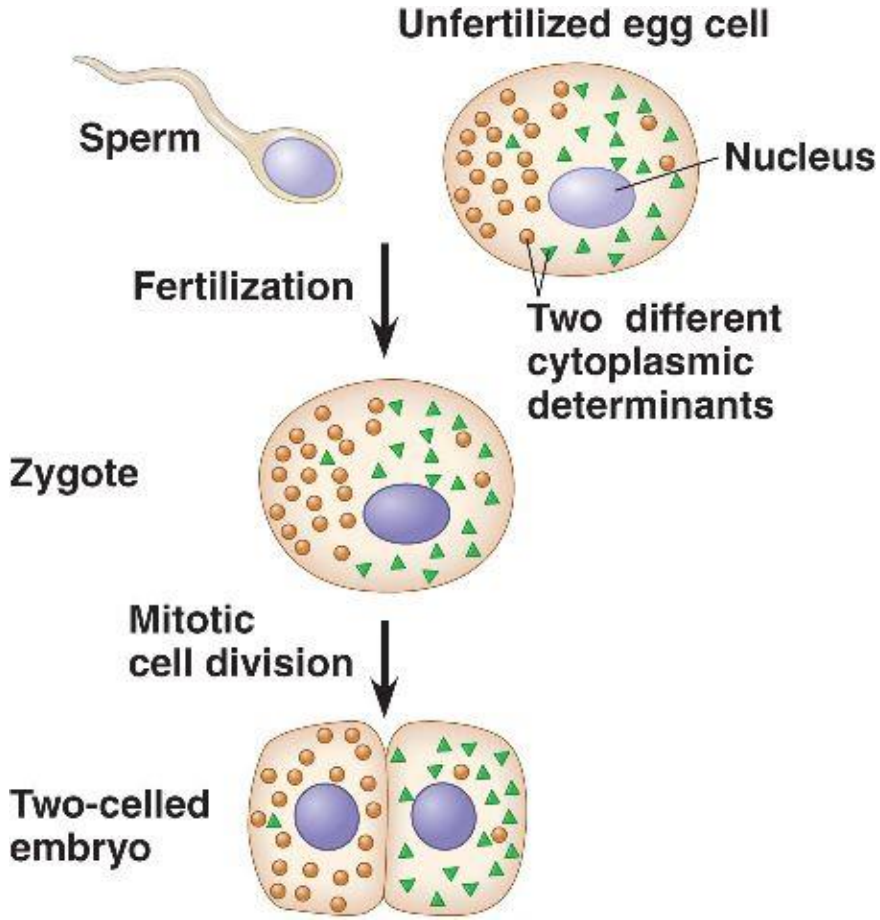
homeotic gene

gene that specifies the types of appendages and other structures that each segment will form

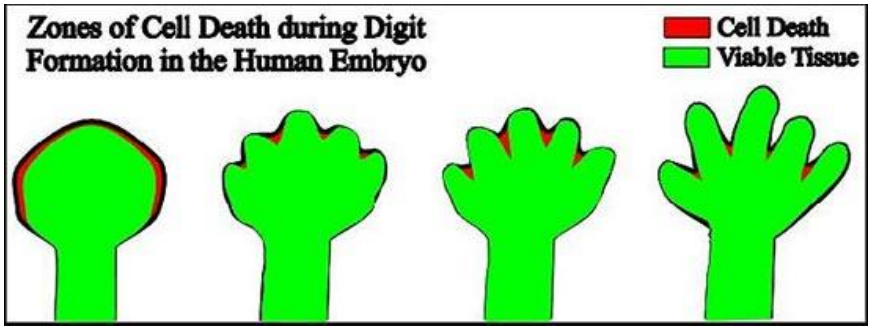




(b) Induction by nearby cells

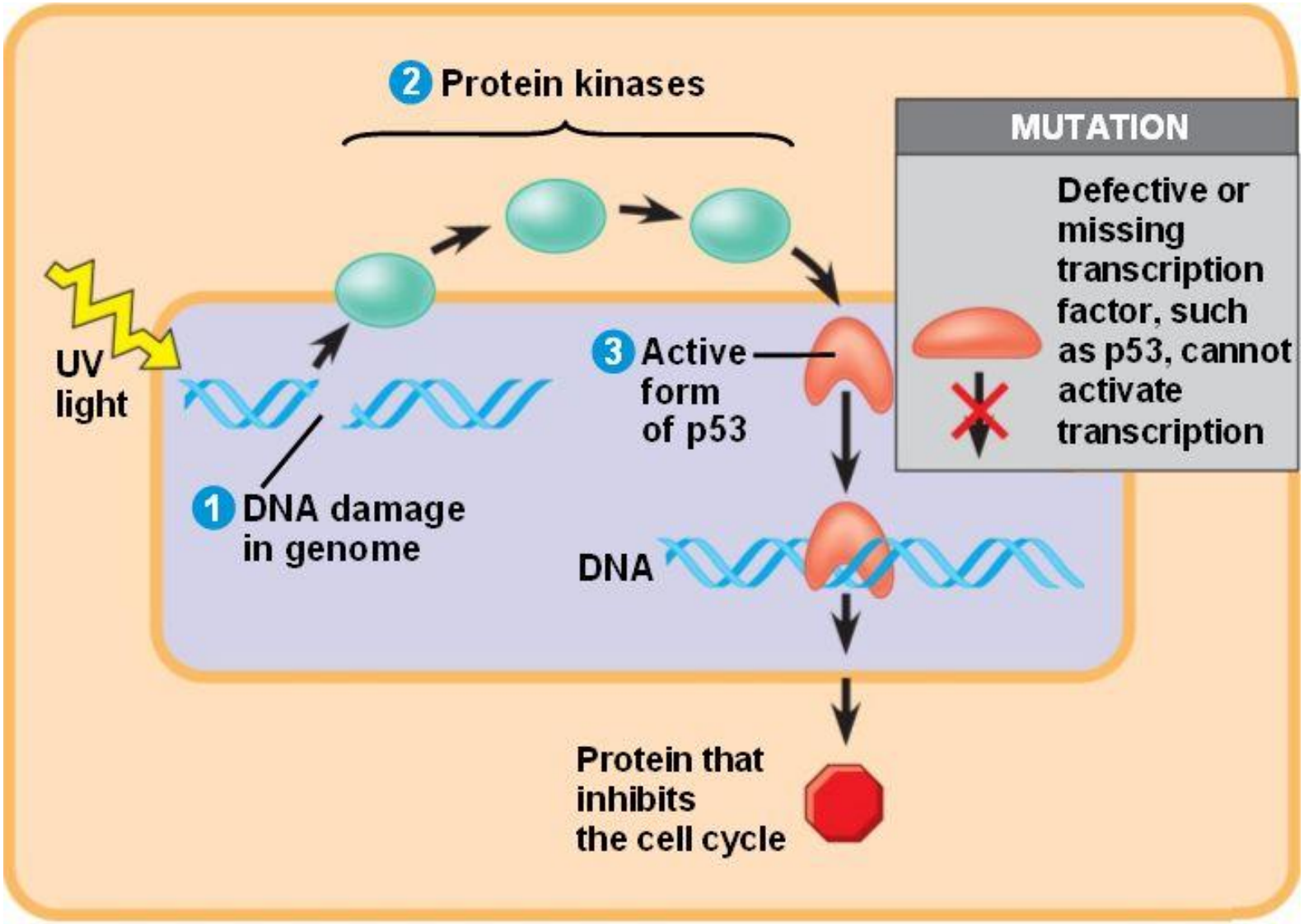


- Apoptosis – programmed cell death
  - Controlled by several genes – BCL-2 family of genes is shown to cause cancers when mutated
  - Morphogenesis of fingers and toes
  - C. Elegans development - Video



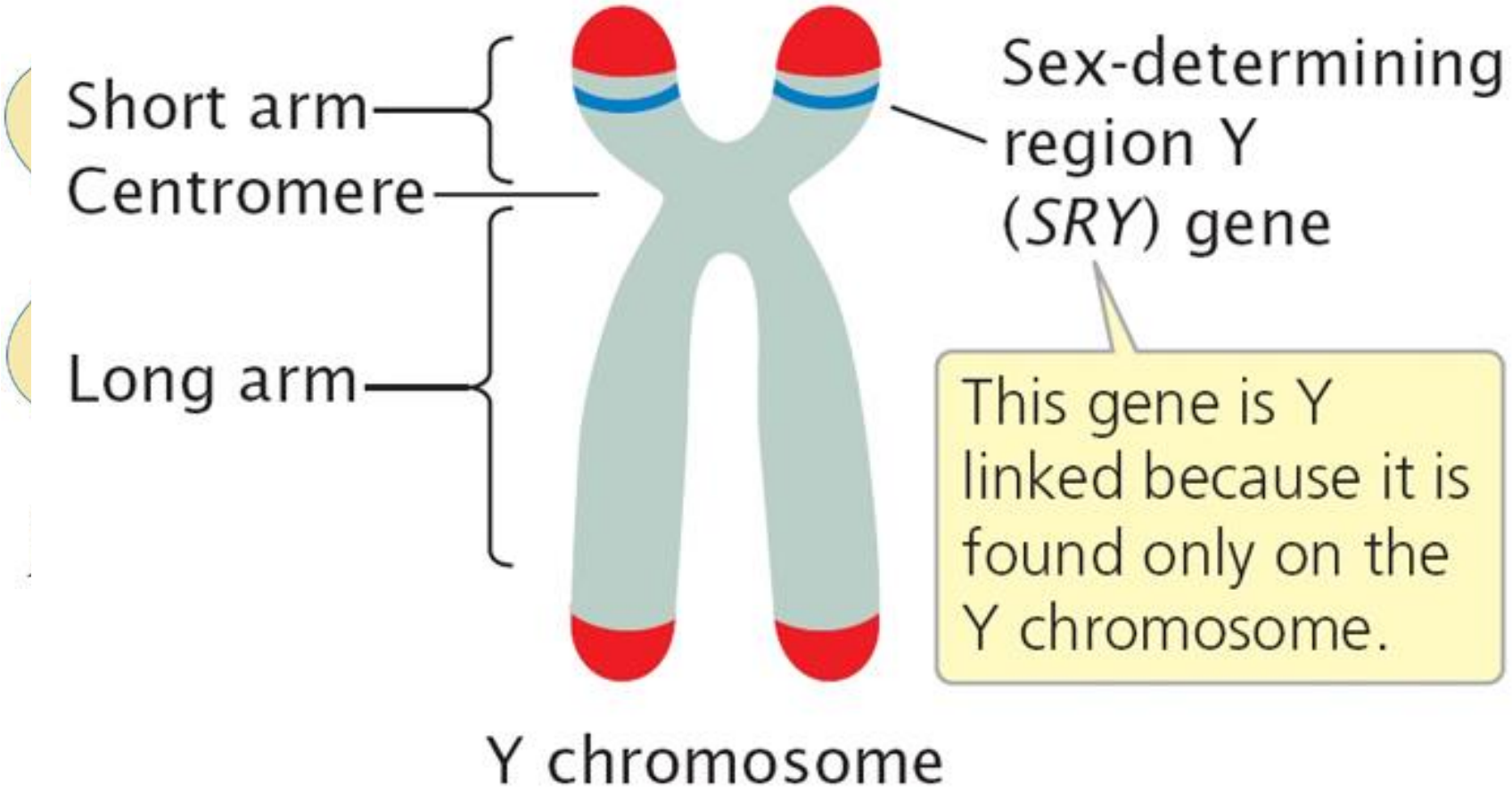
- p53 gene – protein acts as a transcription factor and when mutated it cannot activate transcription an d will not produce a protein needed to inhibit mitosis

- SRY gene – sex-determining region Y protein starts processes that cause a fetus to develop male gonads and prevents the formation of female gonads


2 Protein kinases
MUTATION
Defective or missing transcription factor, such as p53, cannot activate transcription
UV light
3 Active form of p53
1 DNA damage in genome
DNA
Protein that inhibits the cell cycle

Sex Determination in Mammals

Male development



- Antifreeze gene – glycoprotein that prevents the formation or expansion of ice crystals in organism's blood during periods of extreme cold
  - The gene was discovered in 1969 in an Antarctic fish
  - Organisms such as bacteria, fungi, plants, insects, and vertebrates
  - Genetic engineering has been used to transfer the antifreeze gene from one organism to another to impart cold resistance