

Mutations

Section 13.3



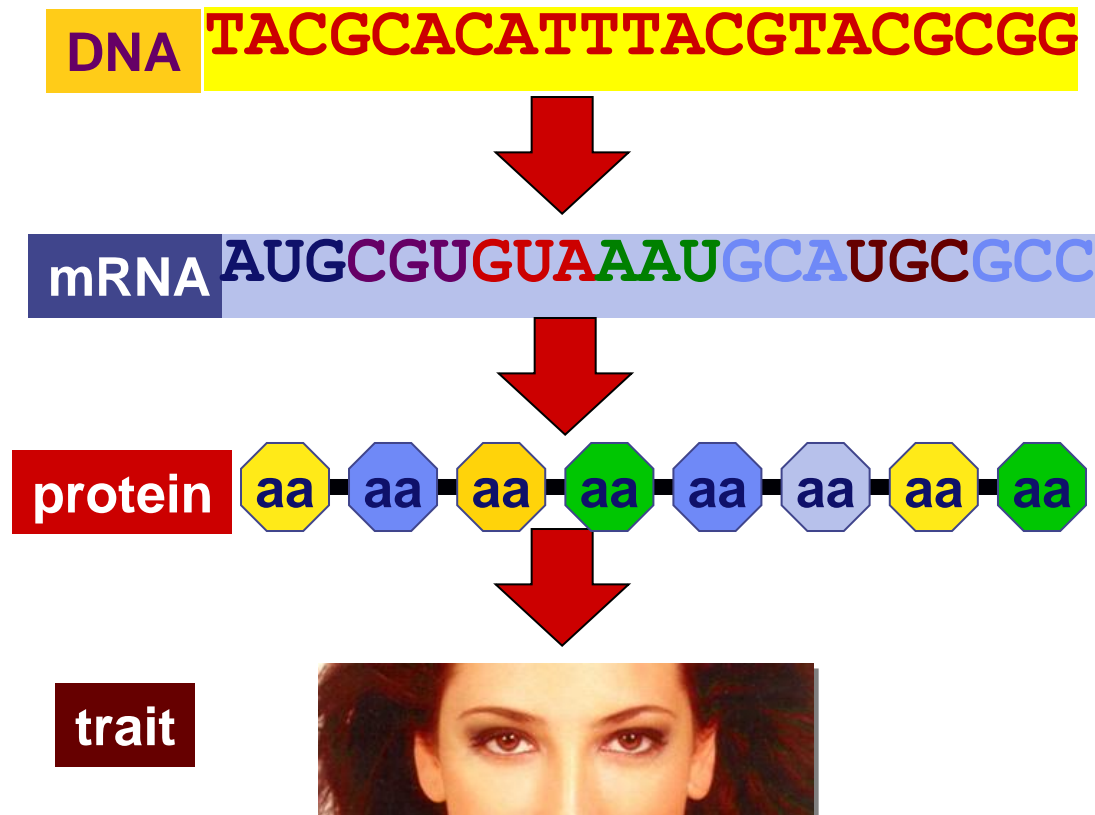
10 μ m

Val	His	Leu	Thr	Pro	Val	Glu	...
1	2	3	4	5	6	7	

(b) Sickled red blood cells and the primary structure of sickle-cell hemoglobin

Genes

- Genes code for proteins
 - ◆ the order of A, T, C & G
- Proteins create traits

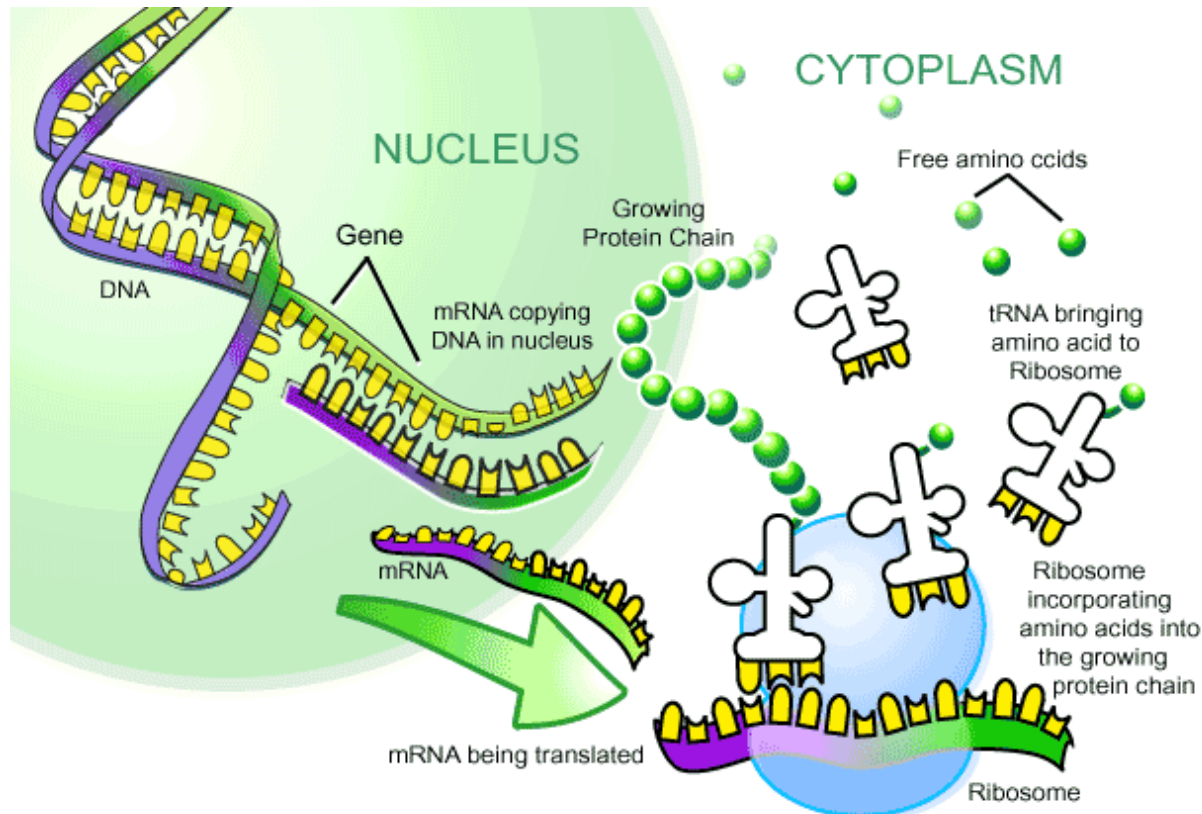


Transcription & Translation

■ Genes code for proteins through...

- ◆ transcription
- ◆ translation

trait



Mutations

- **Mutations are changes in DNA sequences**
 - ◆ changes to the order of A, T, C & G
 - ◆ different order = different amino acid in protein
 - ◆ different protein structure = different protein function



BB



Bb



bb

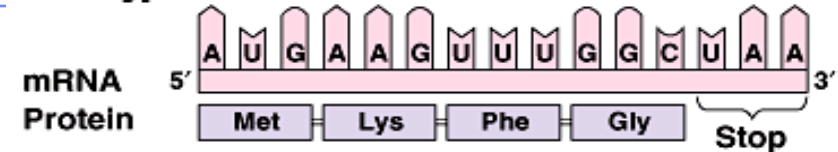
Mutations

■ Point mutations

◆ single base change

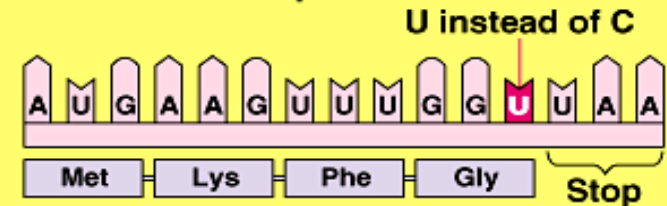
- silent mutation
 - ◆ no amino acid change
 - ◆ redundancy in code
- missense
 - ◆ change amino acid
- nonsense
 - ◆ change to stop codon

Wild type



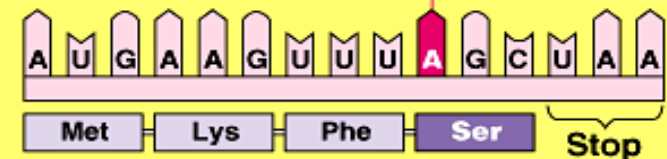
Base-pair substitution

No effect on amino acid sequence



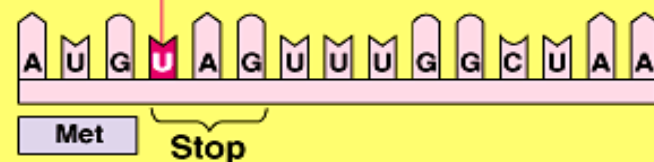
Missense

A instead of G



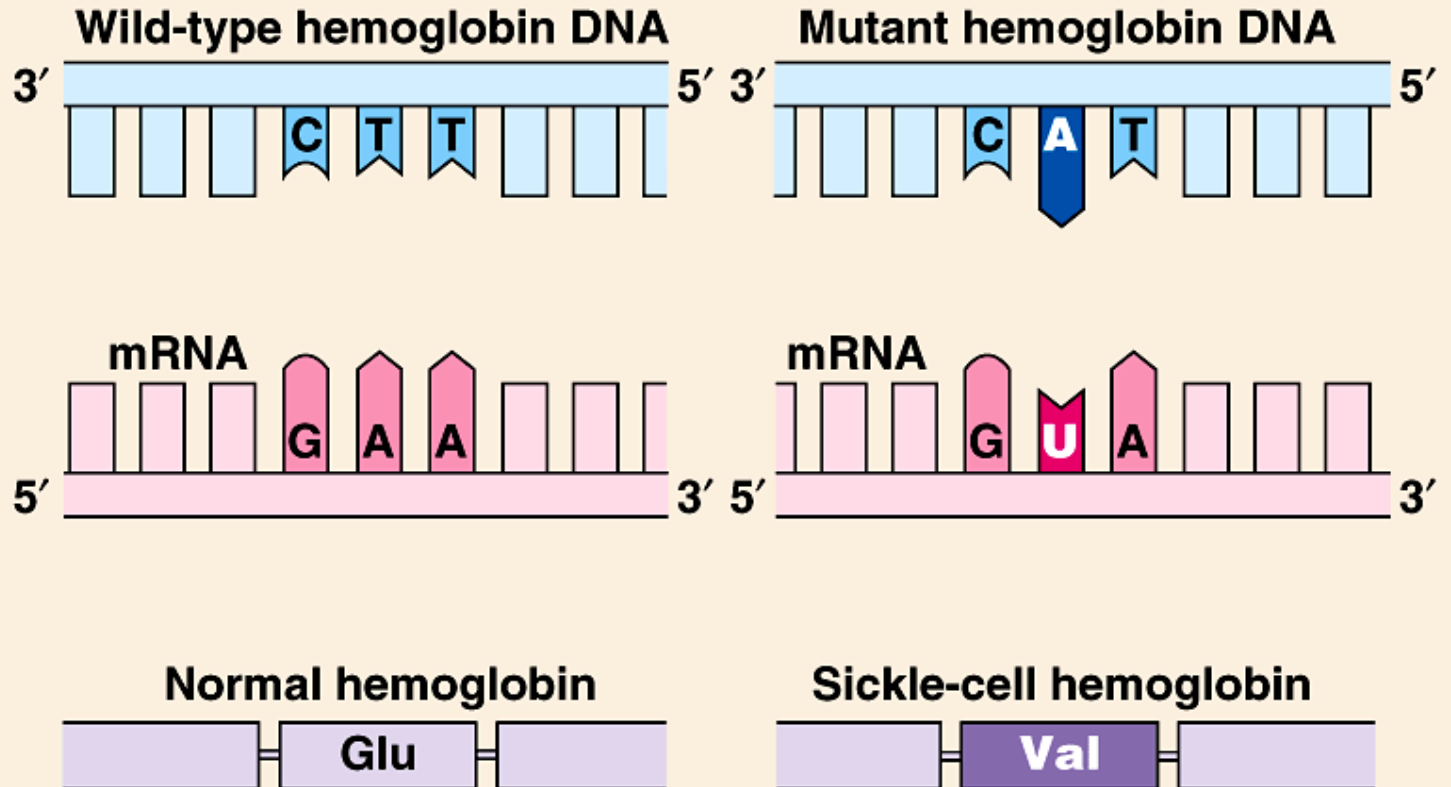
Nonsense

U instead of A

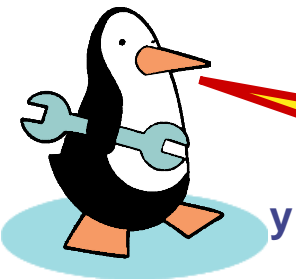


Point mutation leads to Sickle cell anemia

What kind of mutation?



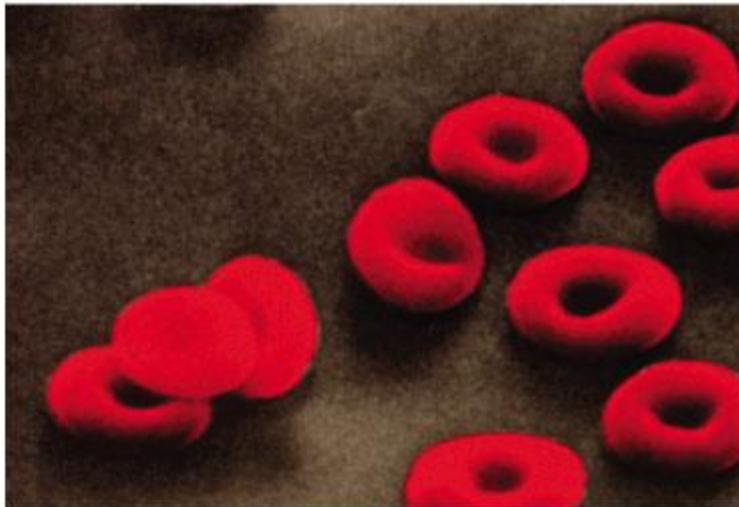
Missense!



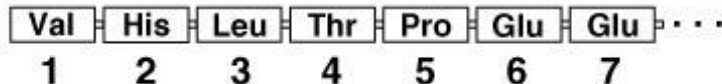
Sickle cell anemia

■ Primarily Africans

- ◆ recessive inheritance pattern
- ◆ strikes 1 out of 400 African Americans



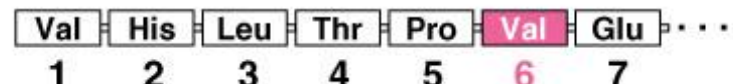
10 μm



(a) Normal red blood cells and the primary structure of normal hemoglobin



10 μm



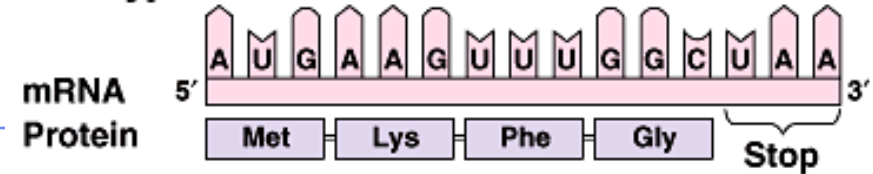
(b) Sickled red blood cells and the primary structure of sickle-cell hemoglobin

Mutations

■ Frameshift

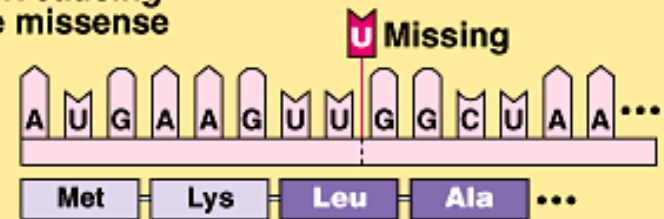
- ◆ shift in the reading frame
 - changes everything “downstream”
- ◆ insertions
 - adding base(s)
- ◆ deletions
 - losing base(s)

Wild type

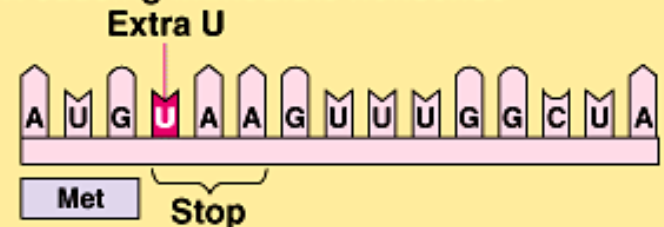


Base-pair insertion or deletion

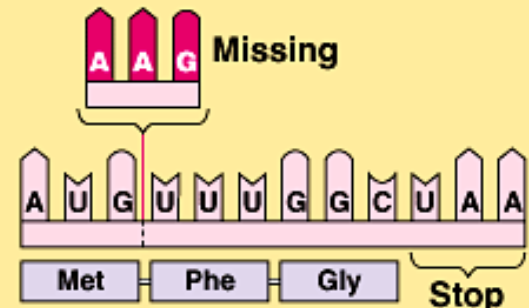
Frameshift causing extensive missense



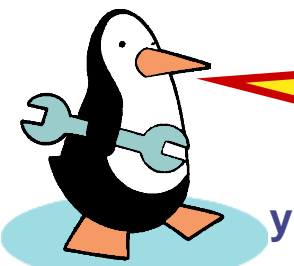
Frameshift causing immediate nonsense



Insertion or deletion of 3 nucleotides: no frameshift; extra or missing amino acid



Where would this mutation cause the most change: beginning or end of gene?



Frameshift mutations

THE RAT AND THE CAT AT THE RED BAT

Deletion

THE RT AND THE CAT AT THE RED BAT

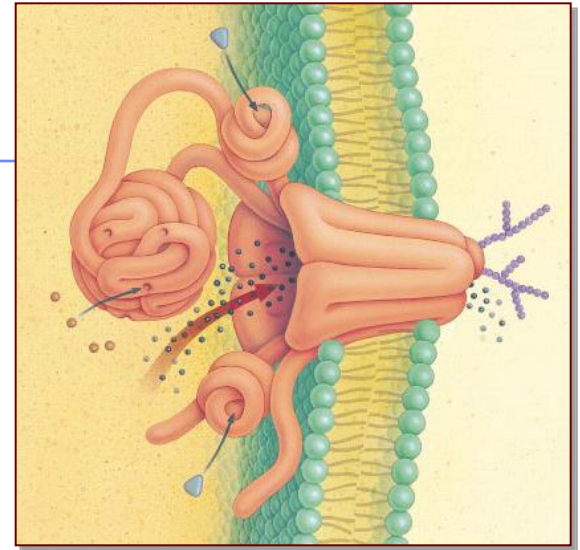
Insertion

THE RA AT AND THE CAT AT THE RED BAT

Cystic fibrosis

■ Primarily whites of European descent

- ◆ strikes 1 in 2500 births
 - 1 in 25 whites is a carrier (Aa)
- ◆ normal allele codes for a membrane protein that moves Cl^- across cell membrane
 - mutant channel limit movement of Cl^- (& H_2O) across cell membrane
 - thicker & stickier mucus coats cells
 - mucus build-up in the pancreas, lungs, digestive tract & causes bacterial infections
- ◆ without treatment children die before 5; with treatment can live past their late 20s

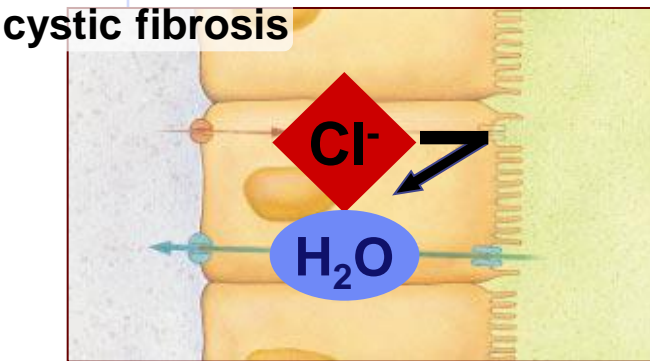
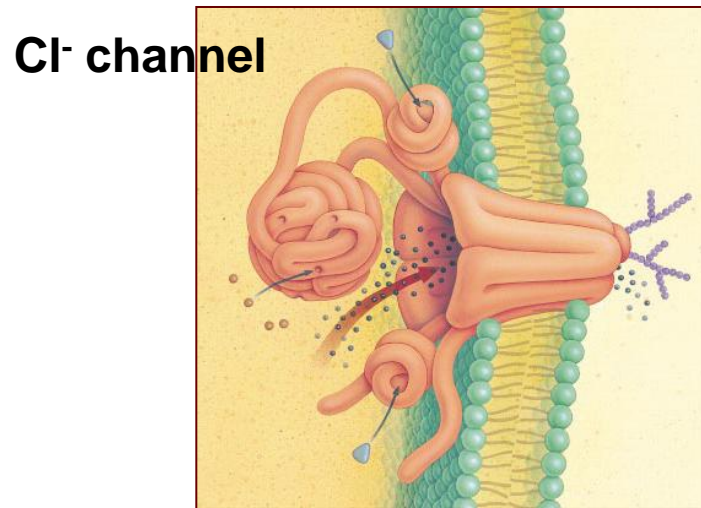
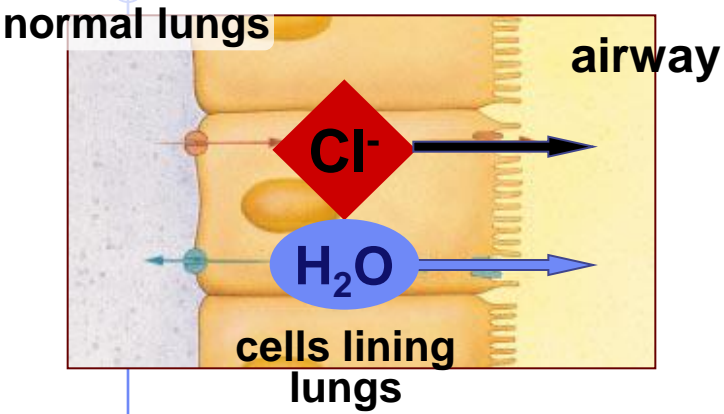


Effect on Lungs

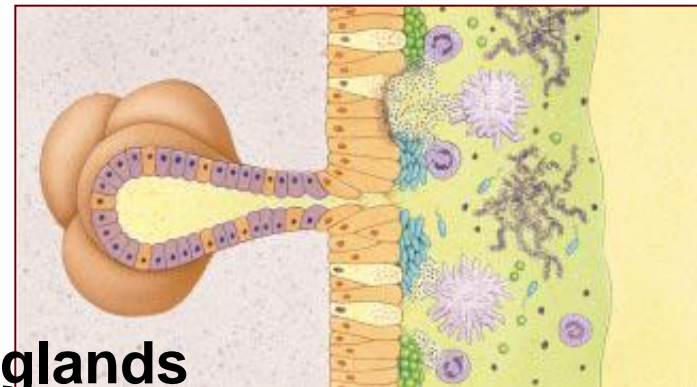
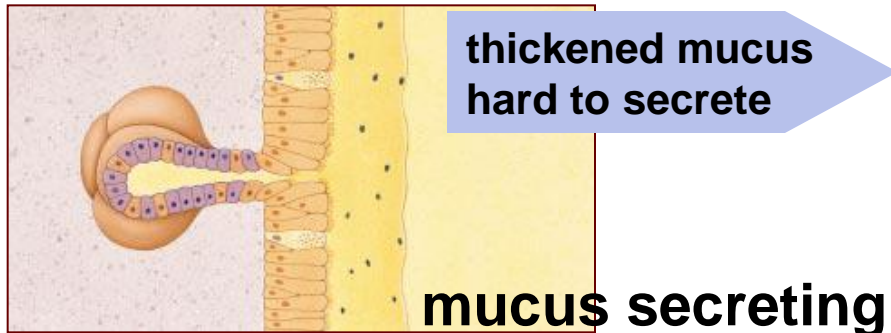
Chloride channel

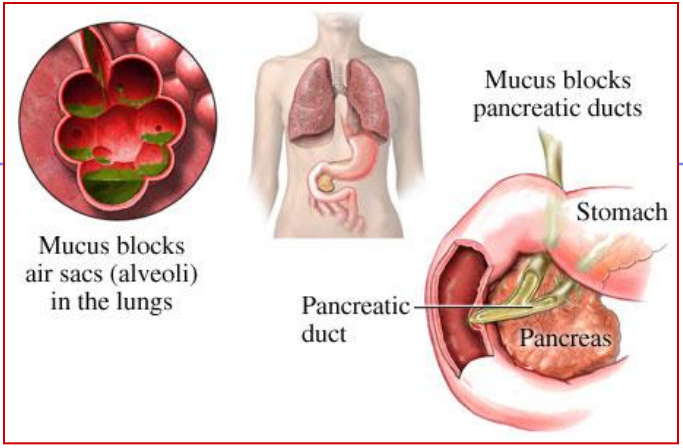
transports chloride through protein channel out of cell

Osmotic effects: **H₂O follows Cl⁻**



bacteria & mucus build up

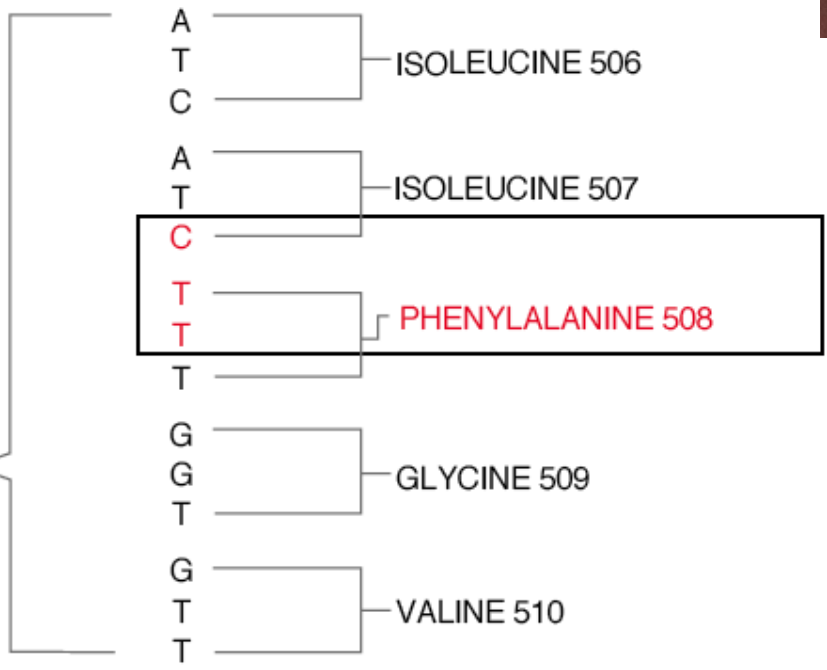
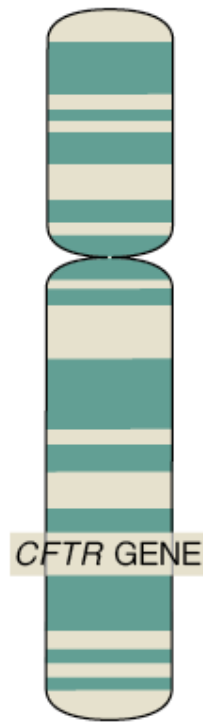




Chromosome 7

Sequence of nucleotides in *CFTR* gene

Amino acid sequence of *CFTR* protein



DELETED IN MANY PATIENTS WITH CYSTIC FIBROSIS

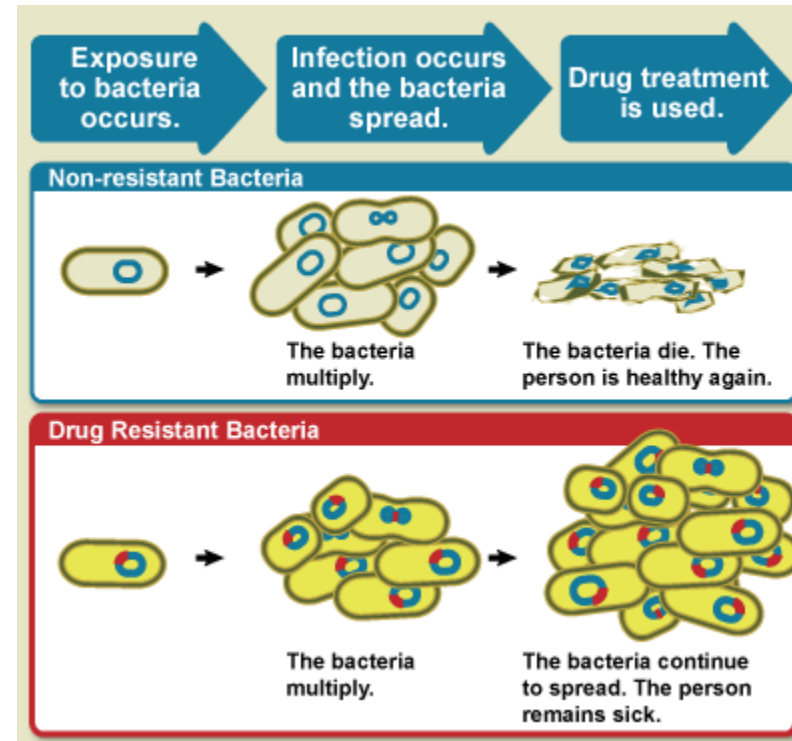


Effects of Mutations

- **Many mutations caused by an error during replication.**
 - ◆ **One incorrect base every 10 million bases.**
- **Small changes accumulate over time.**
- **E.g. Bacteria**
 - ◆ **Can give new traits – ability to consume new food or resist poison.**

Mutagens

- **Chemical or physical agents in the environment.**
 - ◆ **Chemical:** Pesticides, tobacco smoke, environmental pollutants
 - ◆ **Physical:** Electromagnetic radiation (x-rays and UV light)



Harmful and Helpful Mutations

- **Effects vary widely – little or greatly**
 - ◆ **Depends on how its DNA changes relative to the organism's situation.**
- **Often thought negative because they disrupt the normal function of genes.**
- **Without mutations, organisms cannot evolve**
 - ◆ **Source of genetic variability in a species.**



What's the value of mutations?