

GENETIC ENGINEERING



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Rearranging the Molecules of Life
Mini-STEM February 25th, 2014

Steven P. Bennett, PhD.

OVERVIEW OF TOPICS

- What is Genetic Engineering (GE)?
 - How is GE performed?
 - What are the common uses for GE?
 - Concerns with GE
-

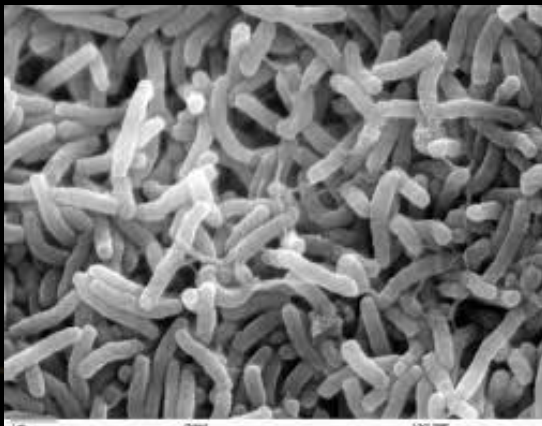
DEFINITION OF GENETIC ENGINEERING

- IUPAC definition:

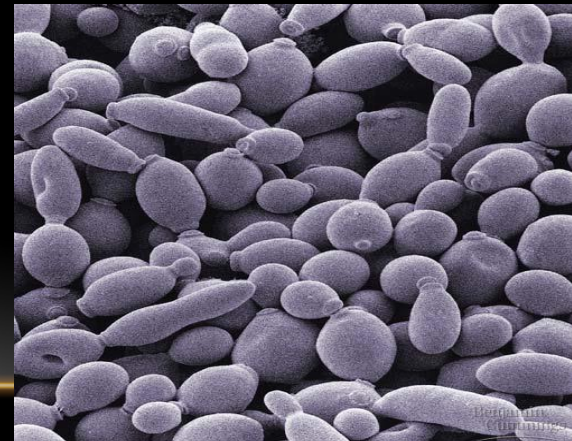
Process of inserting **new genetic information** into existing cells in order to modify a specific organism for the purpose of changing its characteristics

Also Known as Recombinant DNA technology, gene modification, and gene therapy

Microorganisms



Bacteria



Yeast

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Plants



Arabidopsis thaliana



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Animals



Glofish

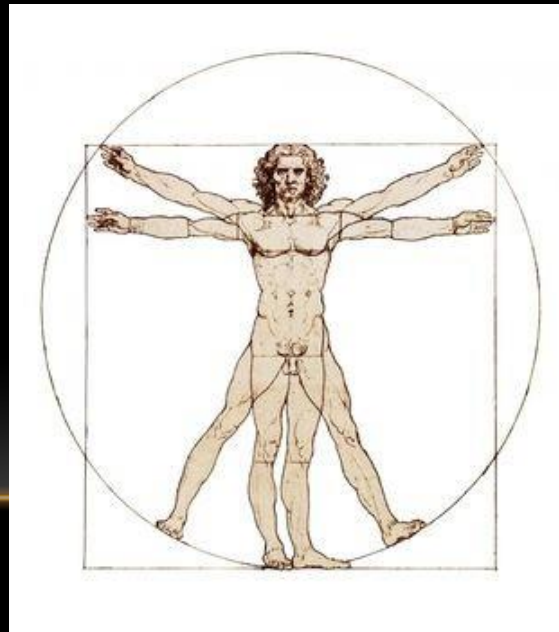


DEFINITION OF GENETIC ENGINEERING

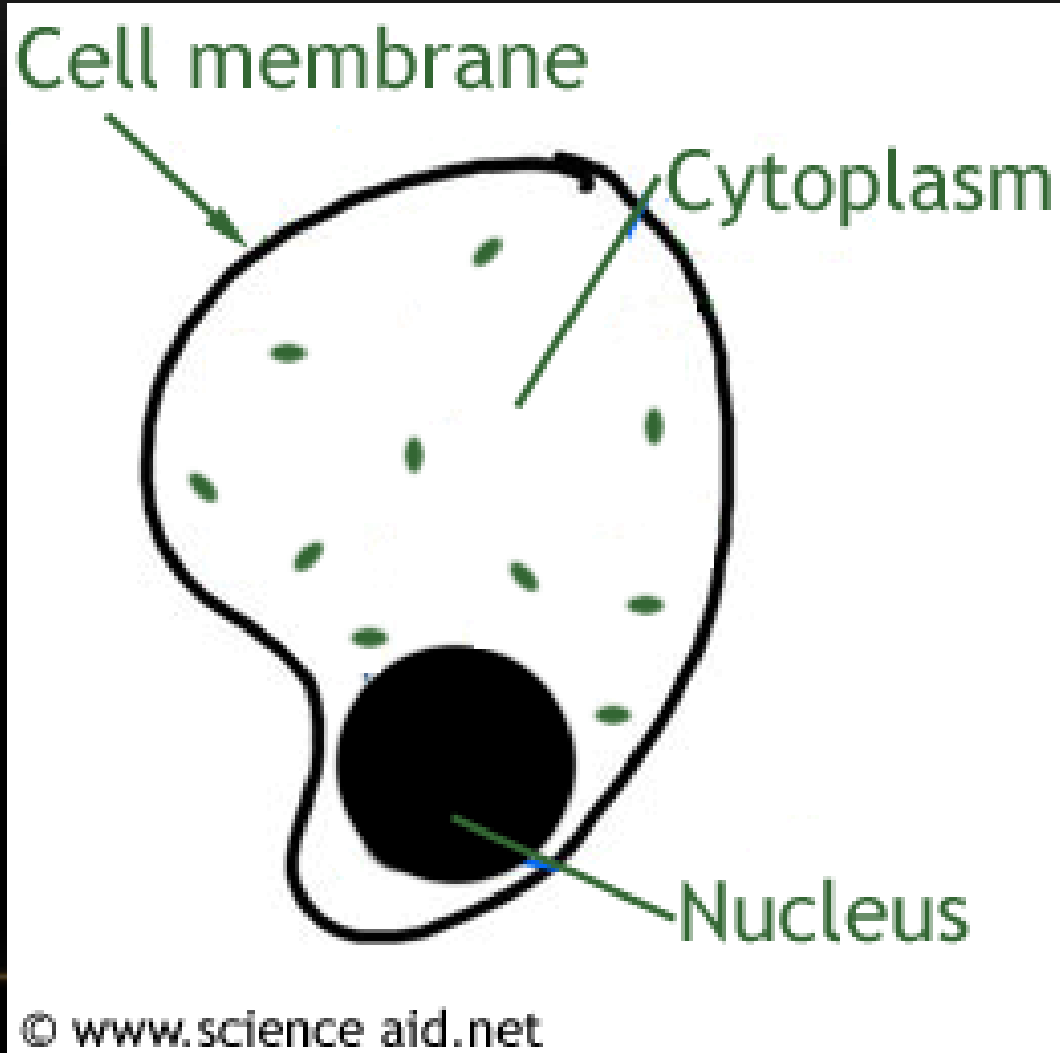
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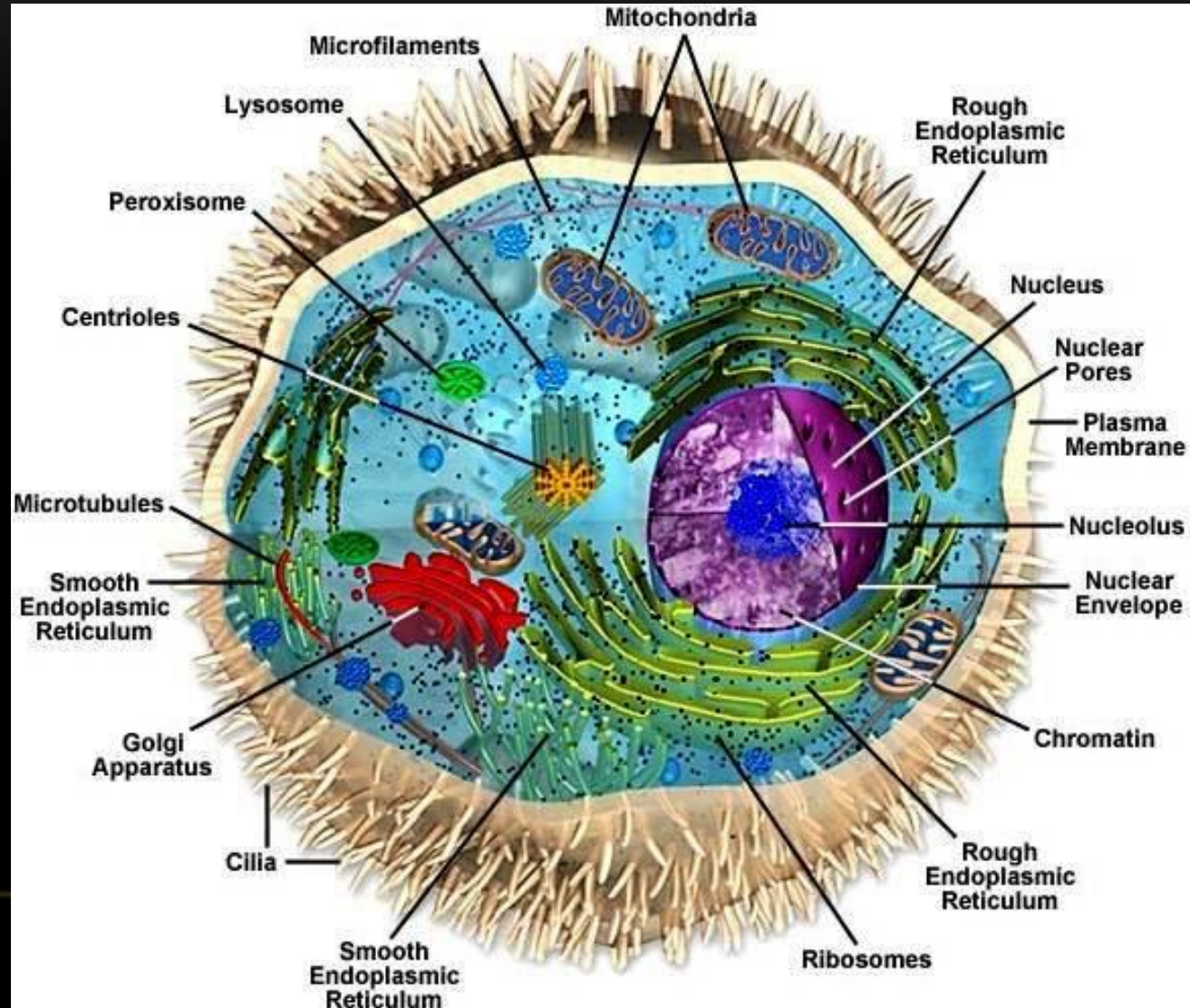
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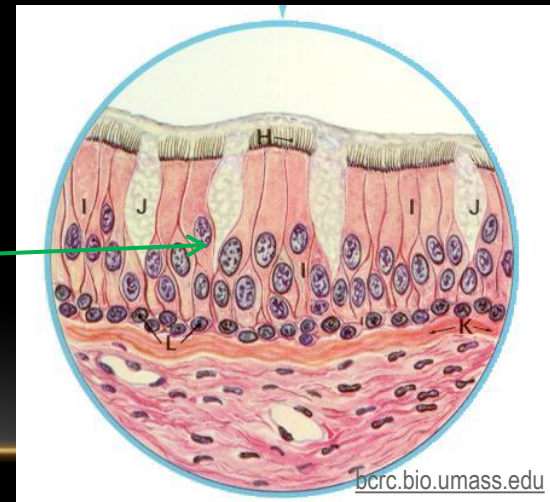
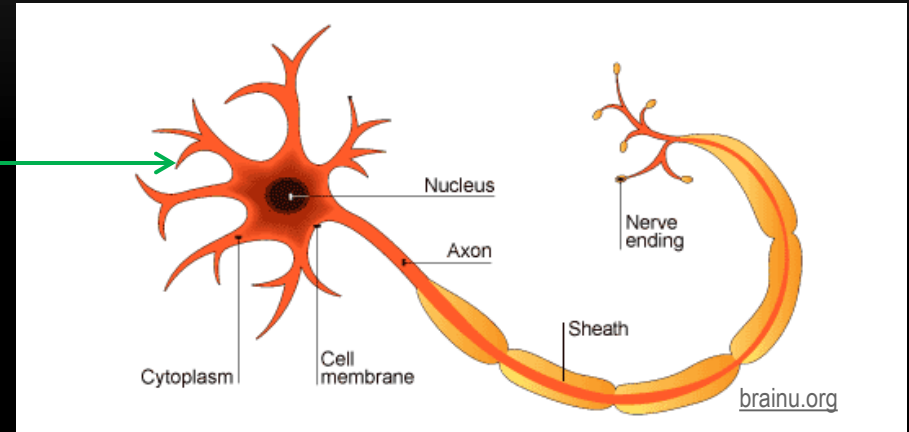
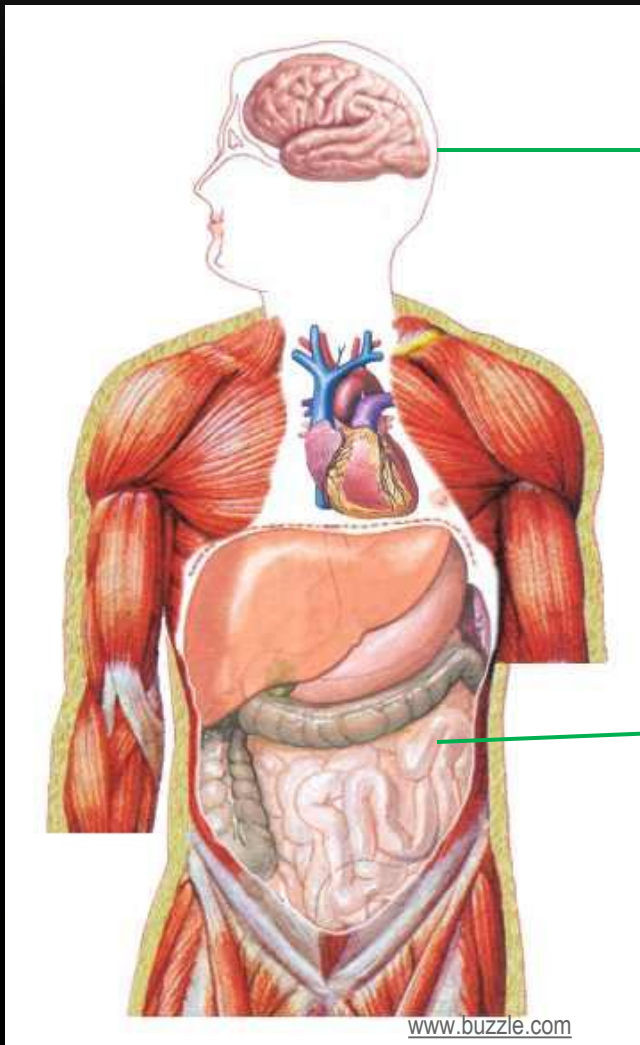
A TYPICAL ANIMAL CELL



A TYPICAL ANIMAL CELL

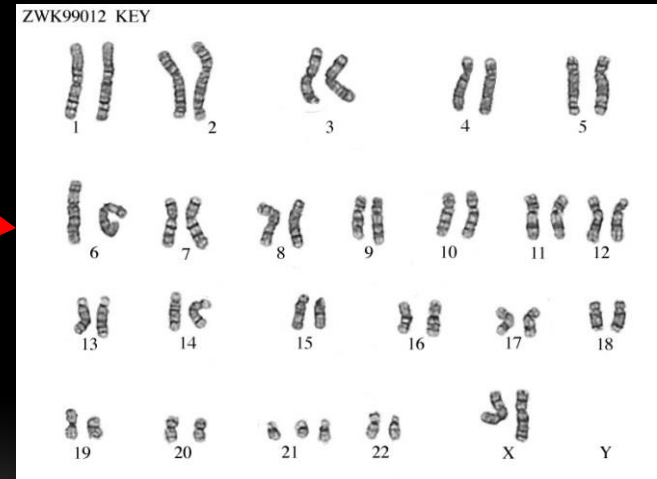
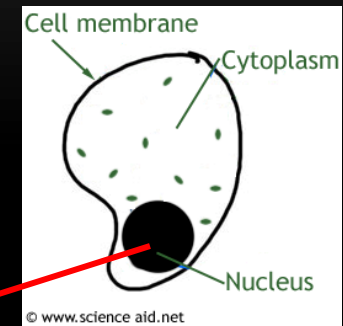
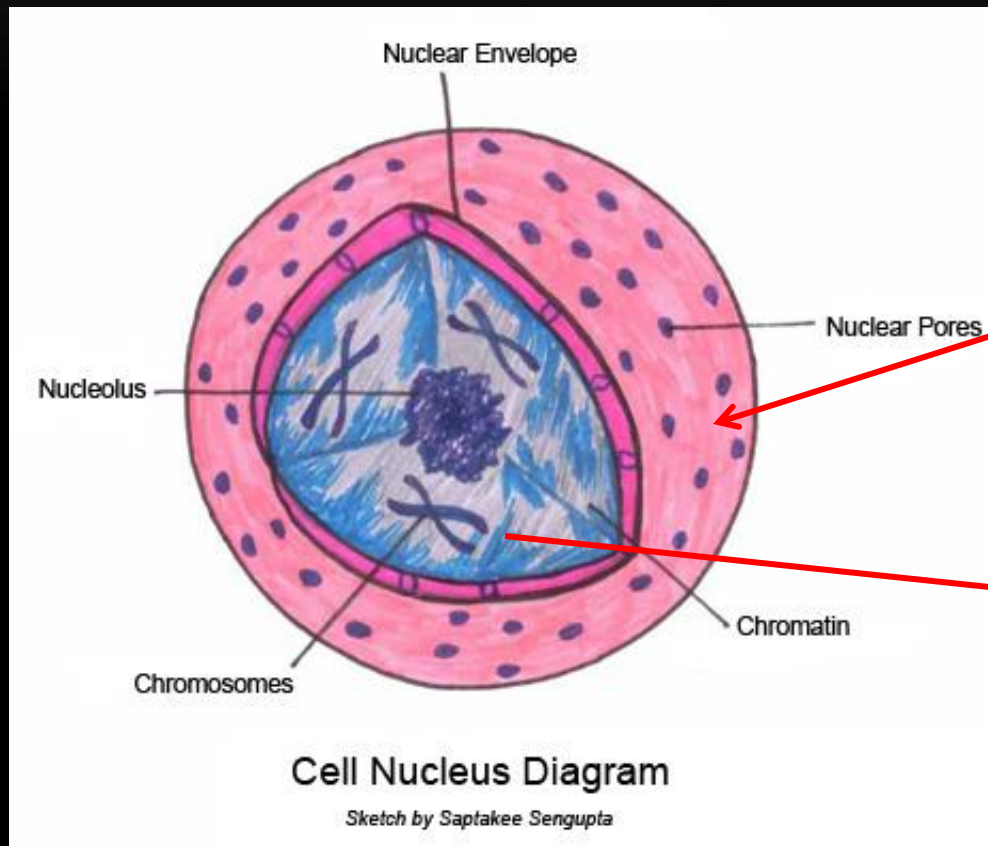


CELL DIVERSITY IN HUMANS

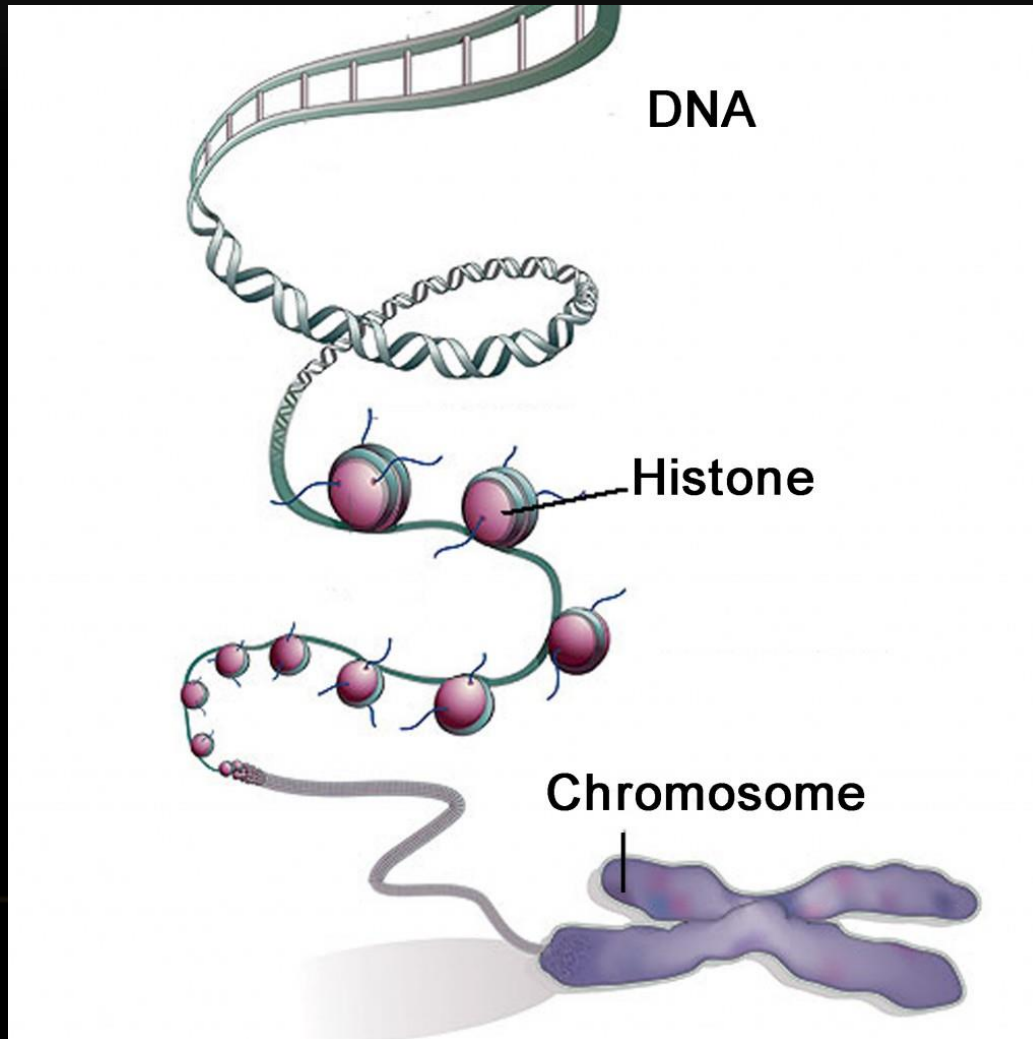


All genes are in each cell nucleus, but only those specific to that tissue are turned “on”

CHROMOSOMES AND GENETIC MATERIAL

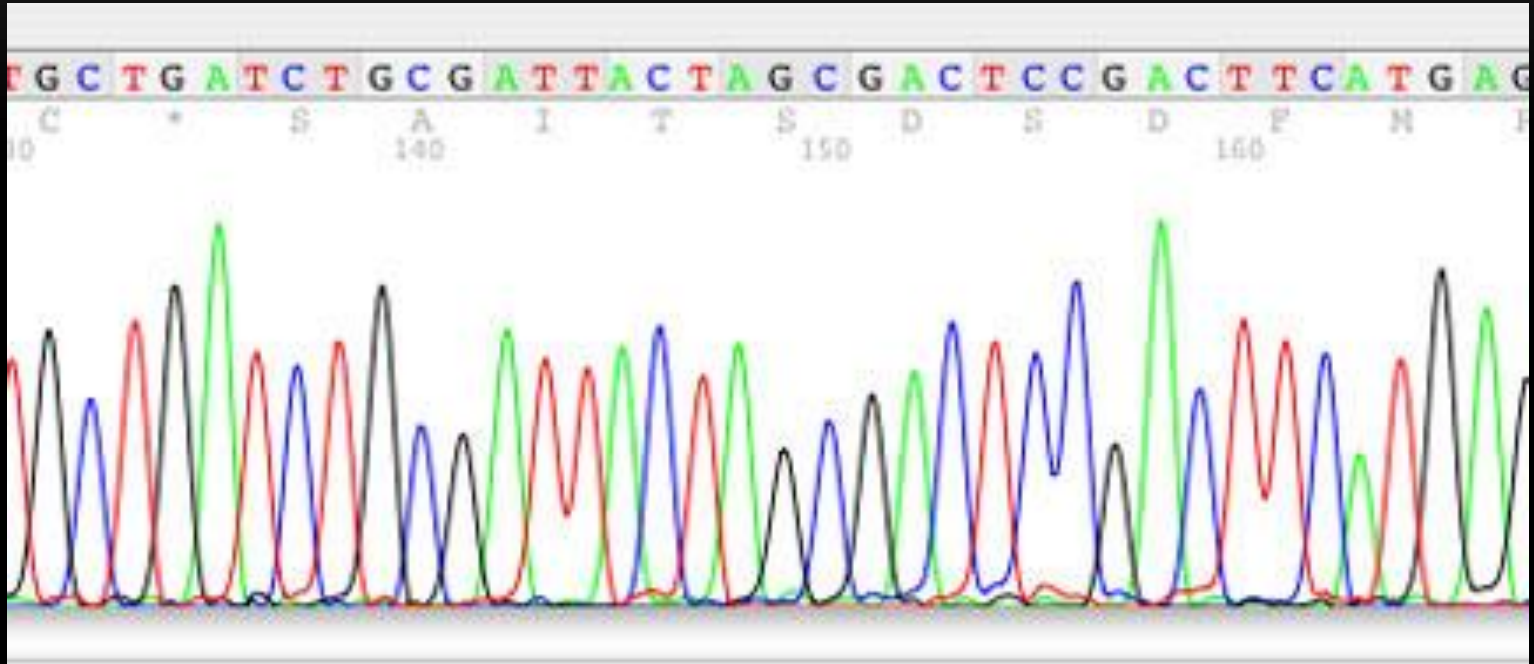


PACKAGING GENETIC INFORMATION



THE **UNIVERSAL** GENETIC CODE

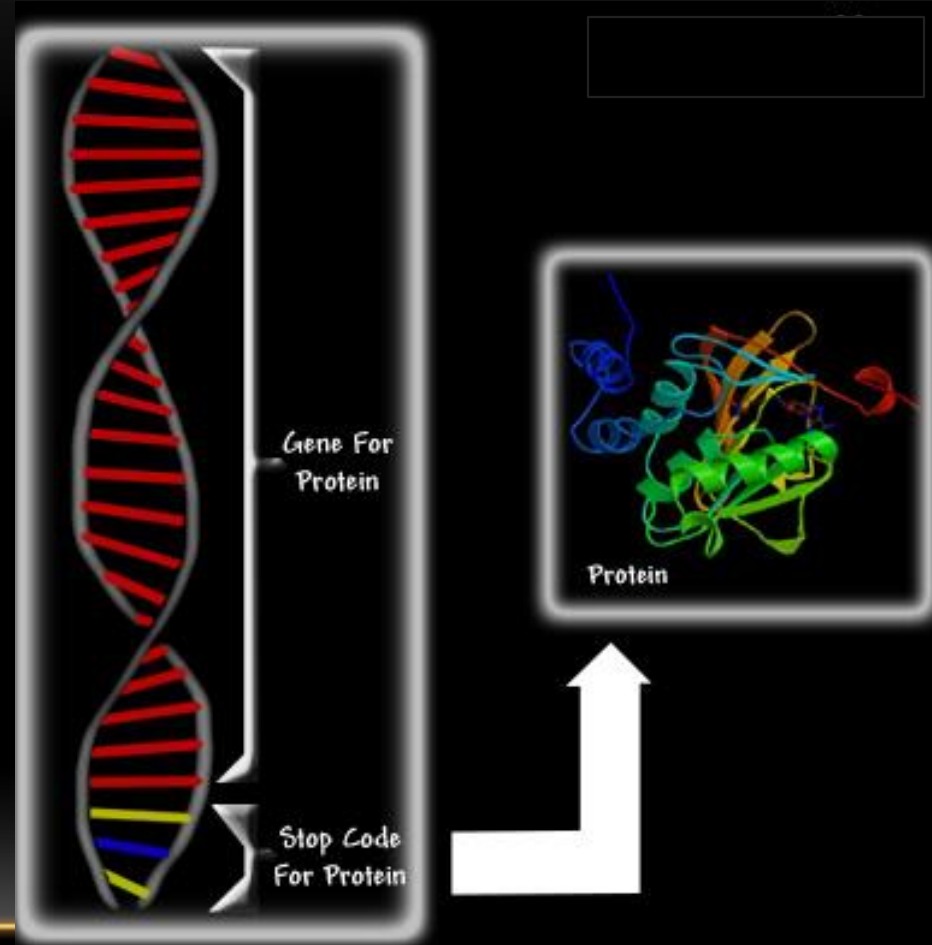
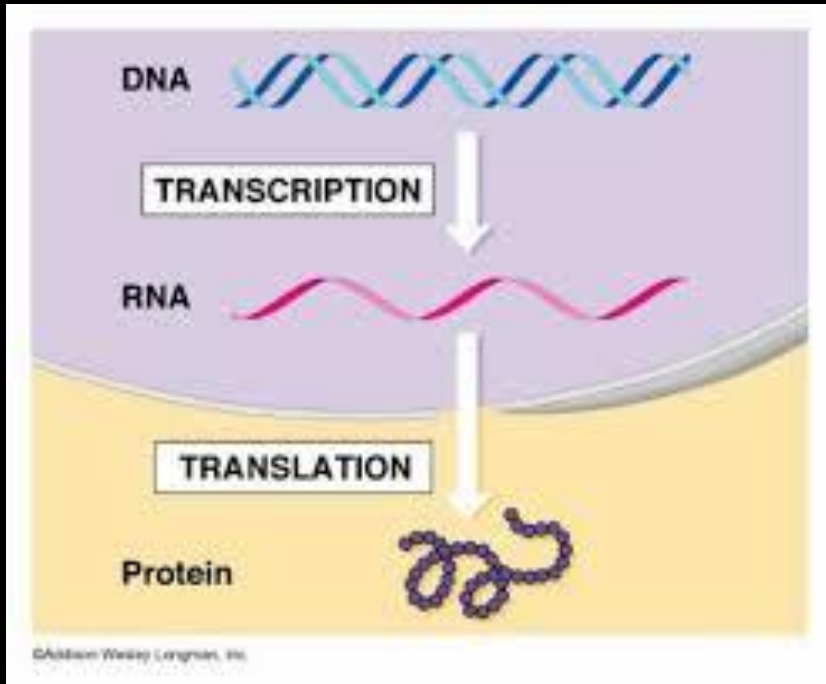
A-Adenine
C-Cytosine
G-Guanine
T-Thymine



bjpsbiotech.edublogs.org

Understanding the human body based on genetic code is like learning English with only a dictionary

GENE TRANSCRIPTION & TRANSLATION- CENTRAL PRINCIPLE OF MOLECULAR BIOLOGY



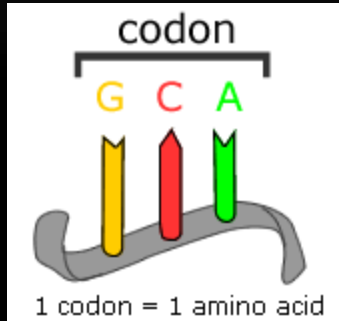
PROTEINS



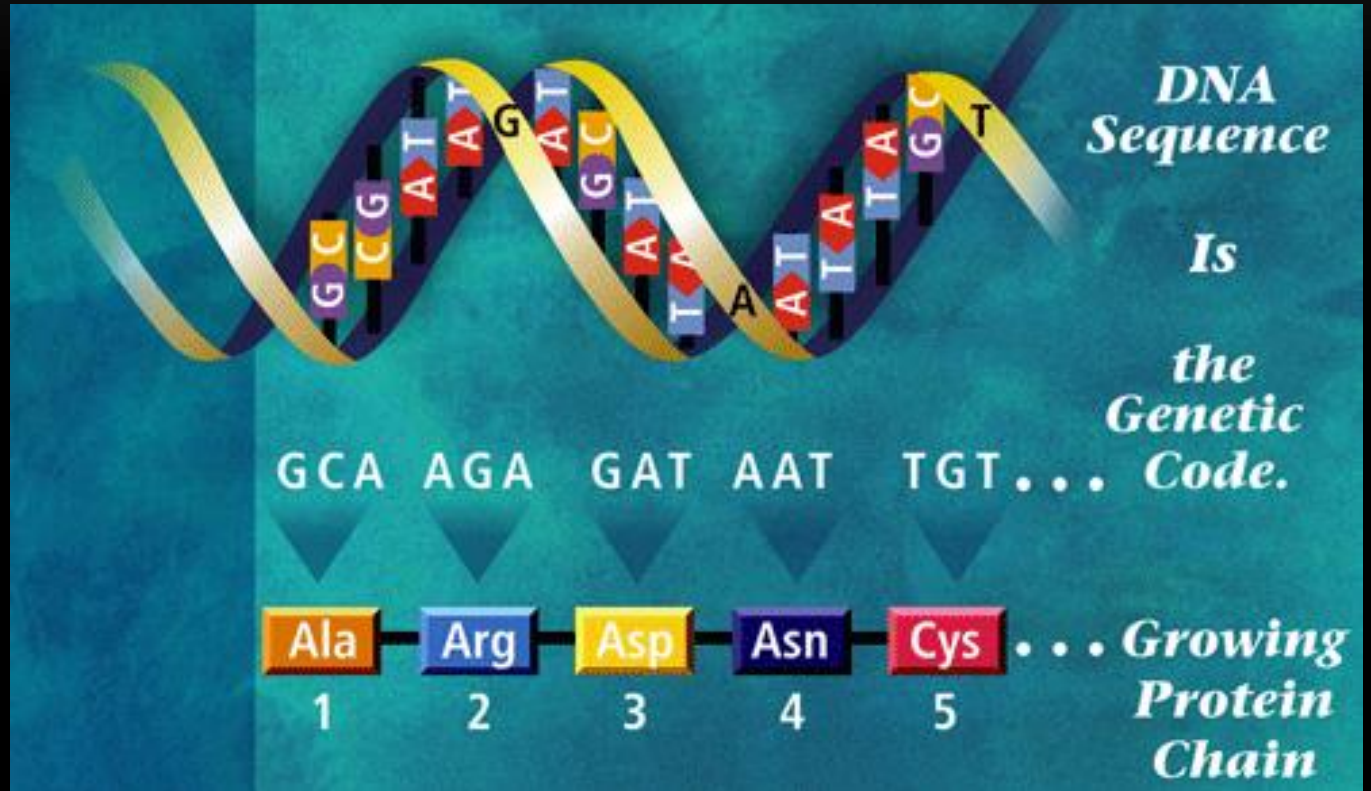
“Functional molecules”

- Structural (collagen)
- Enzymes (Trypsin)
- Transporters (hemoglobin)
- Antibodies (immune response)
- Cell receptors (Insulin)

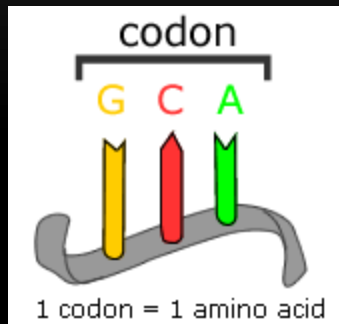
TRANSLATION: PROTEIN MANUFACTURING



evolution.berkeley.edu



TRANSLATION: PROTEIN MANUFACTURING



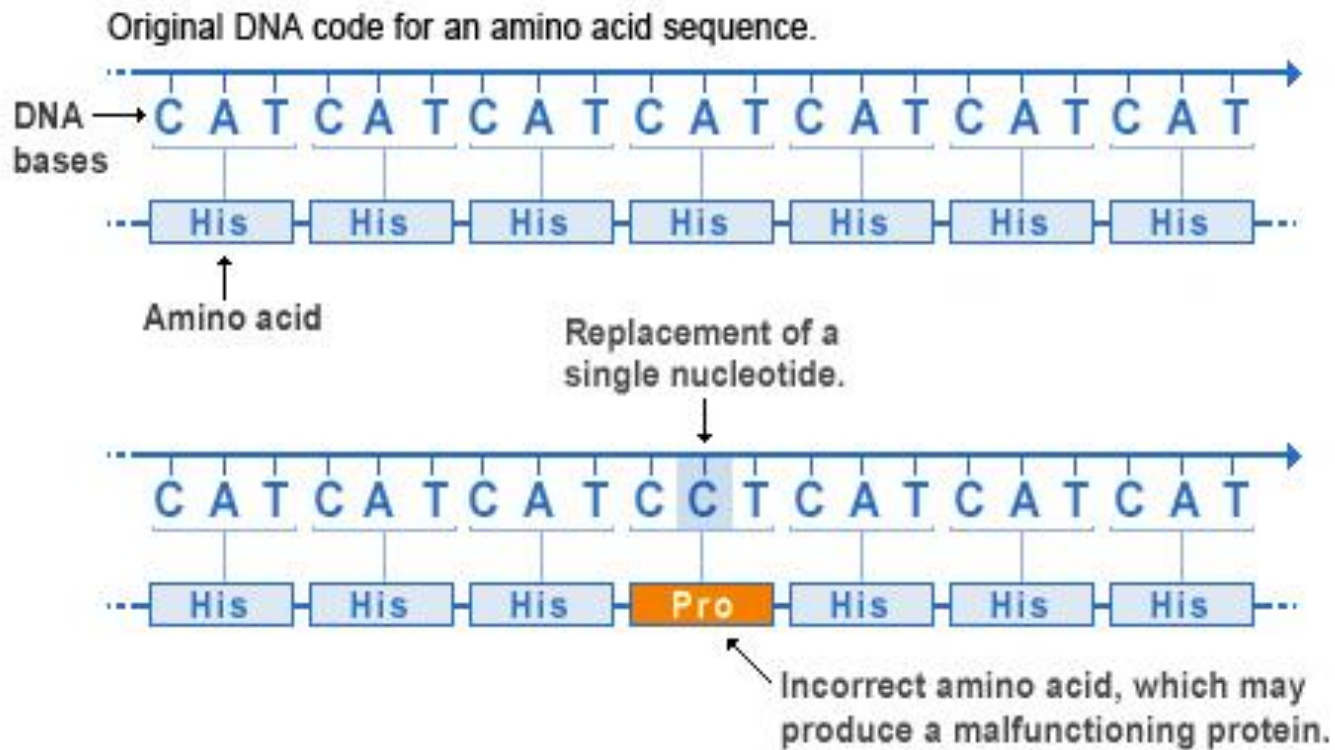
evolution.berkeley.edu

TTT } - F TTC } TTA } - L TTG }	CTT } CTC } - L CTA } CTG }	ATT } - I ATC } ATA } ATG - M start	GTT } GTC } - Y GTA } GTG }
TCT } TCC } - S TCA } TCG }	CCT } CCC } - P CCA } CCG }	ACT } ACC } - T ACA } ACG }	GCT } GCC } - A GCA } GCG }
TAT } - Y TAC } TAA } - stop TAG }	CAT } - H CAC } CAA } - Q CAG }	AAT } - N AAC } AAA } - K AAG }	GAT } - D GAC } GAA } - E GAG }
TGT } - C TGC } TGA - stop TGG - W	CGT } CGC } - R CGA } CGG }	AGT } - S AGC } AGA } - R AGG }	GGT } GGC } - G GGA } GGG }

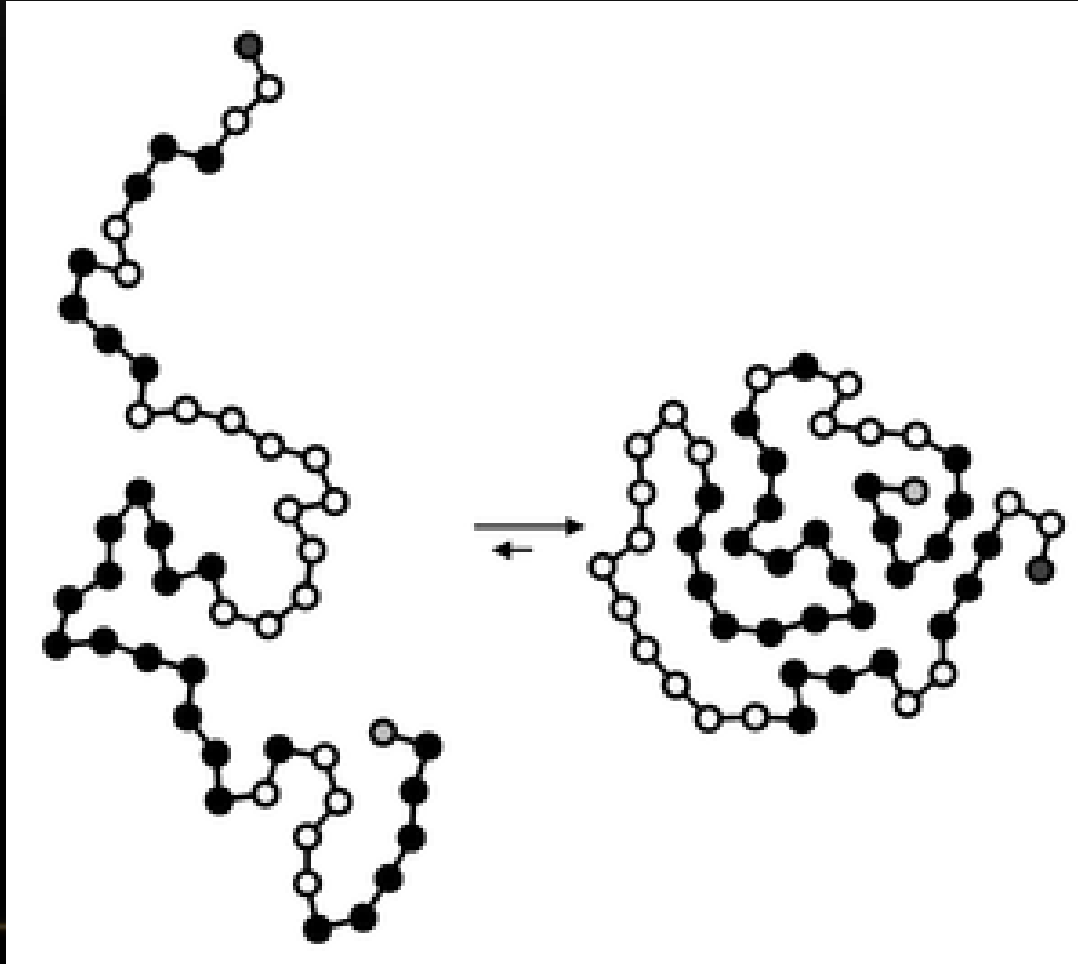
Why is this so important?

The code is **Universal**

GENETIC MUTATION

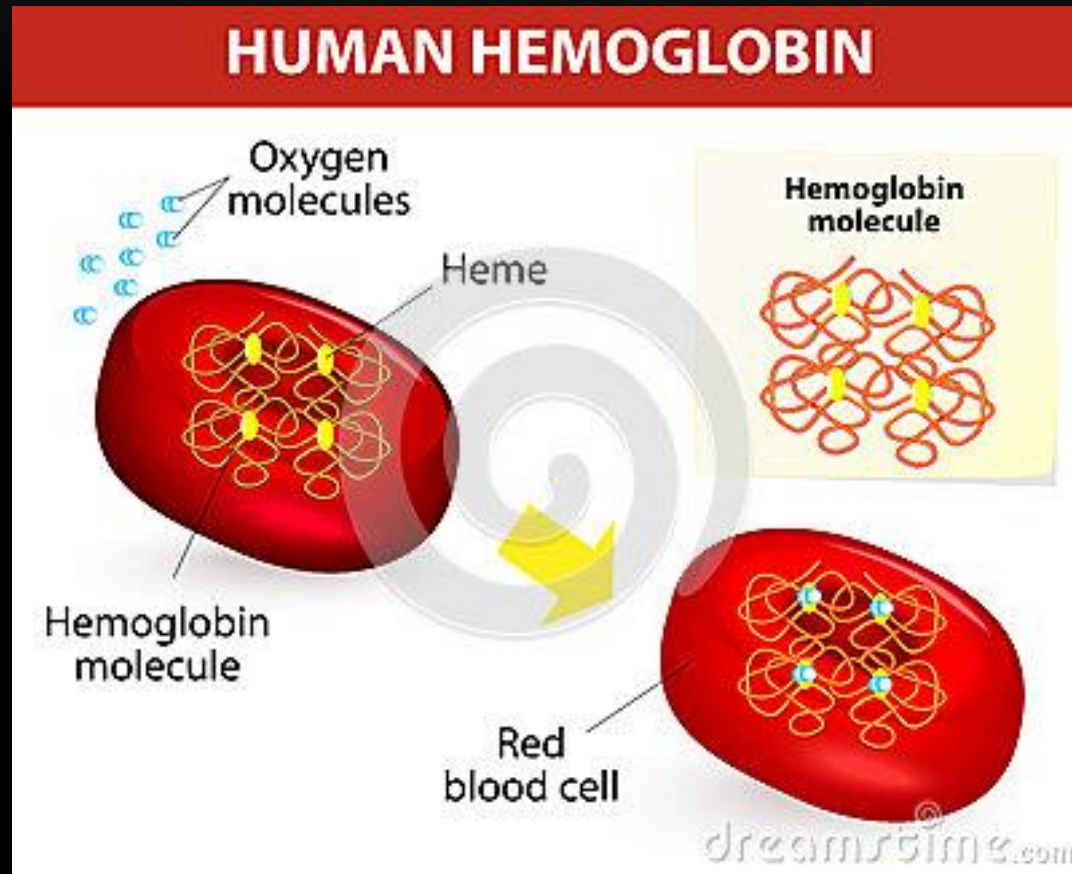


PROTEIN FOLDING AND STRUCTURE



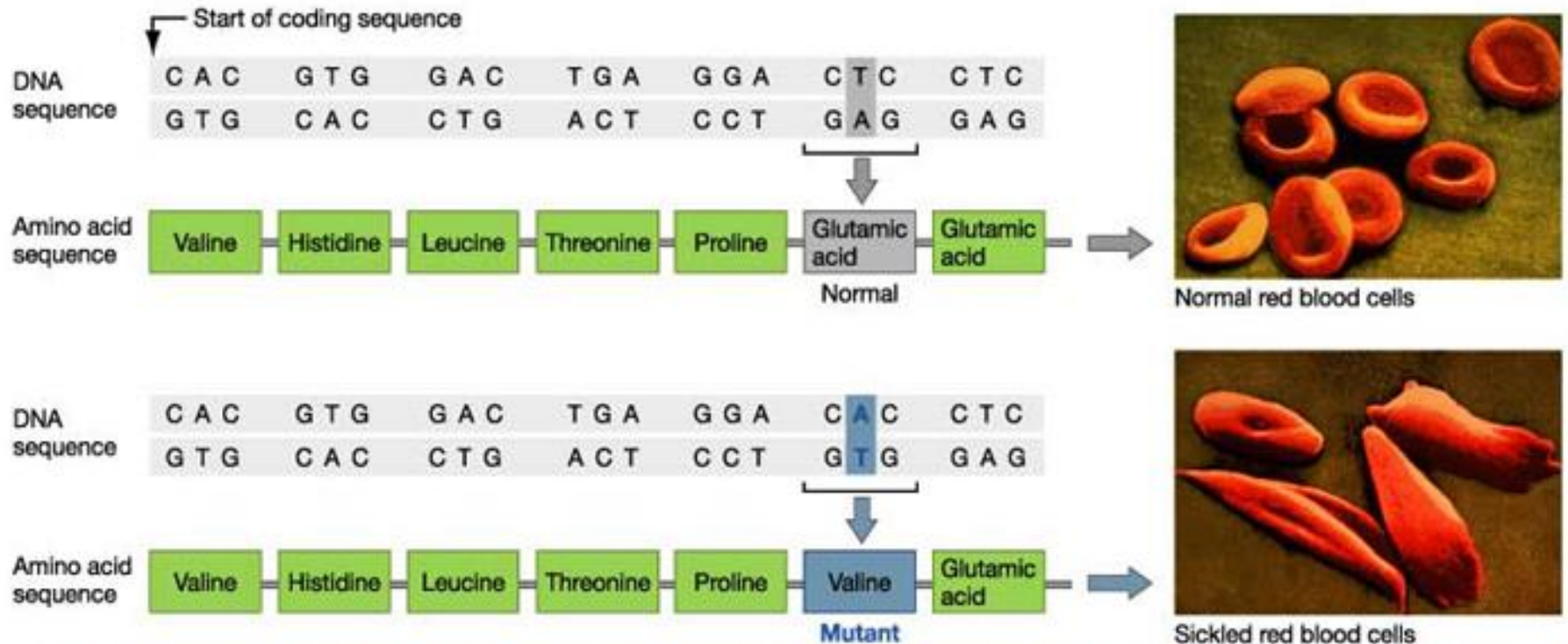
ESSENTIAL PROTEINS IN THE BODY-

HEMOGLOBIN



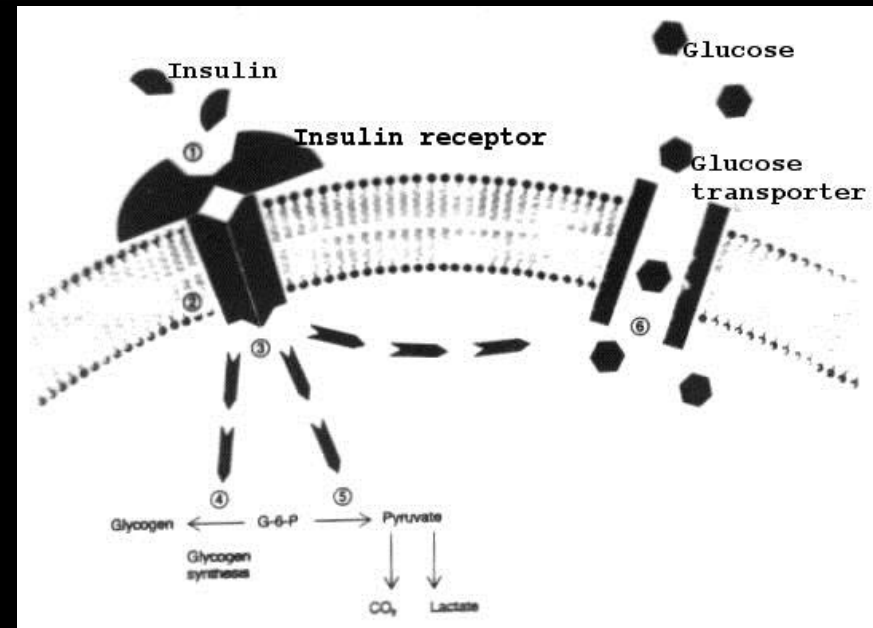
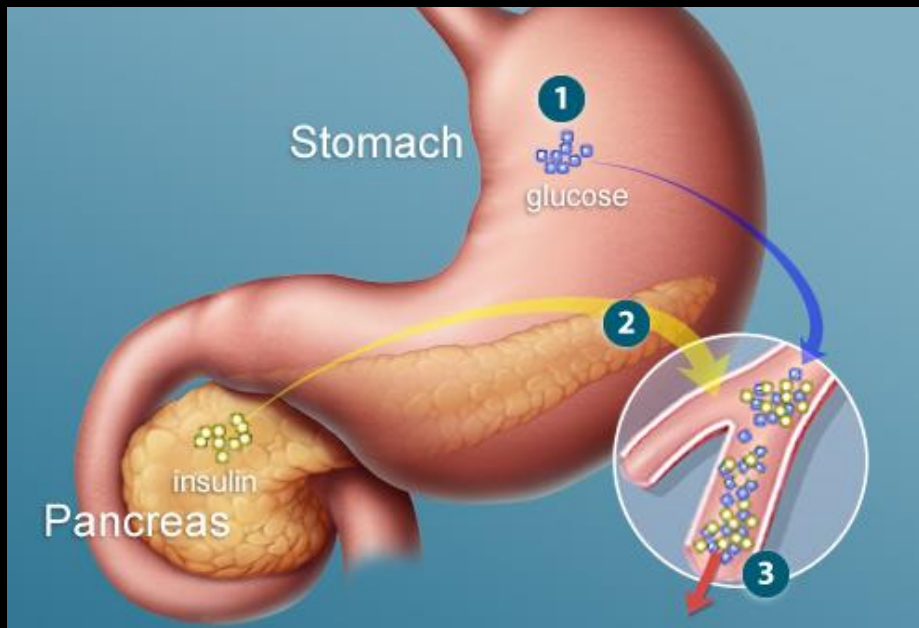
ESSENTIAL PROTEINS IN THE BODY-

HEMOGLOBIN

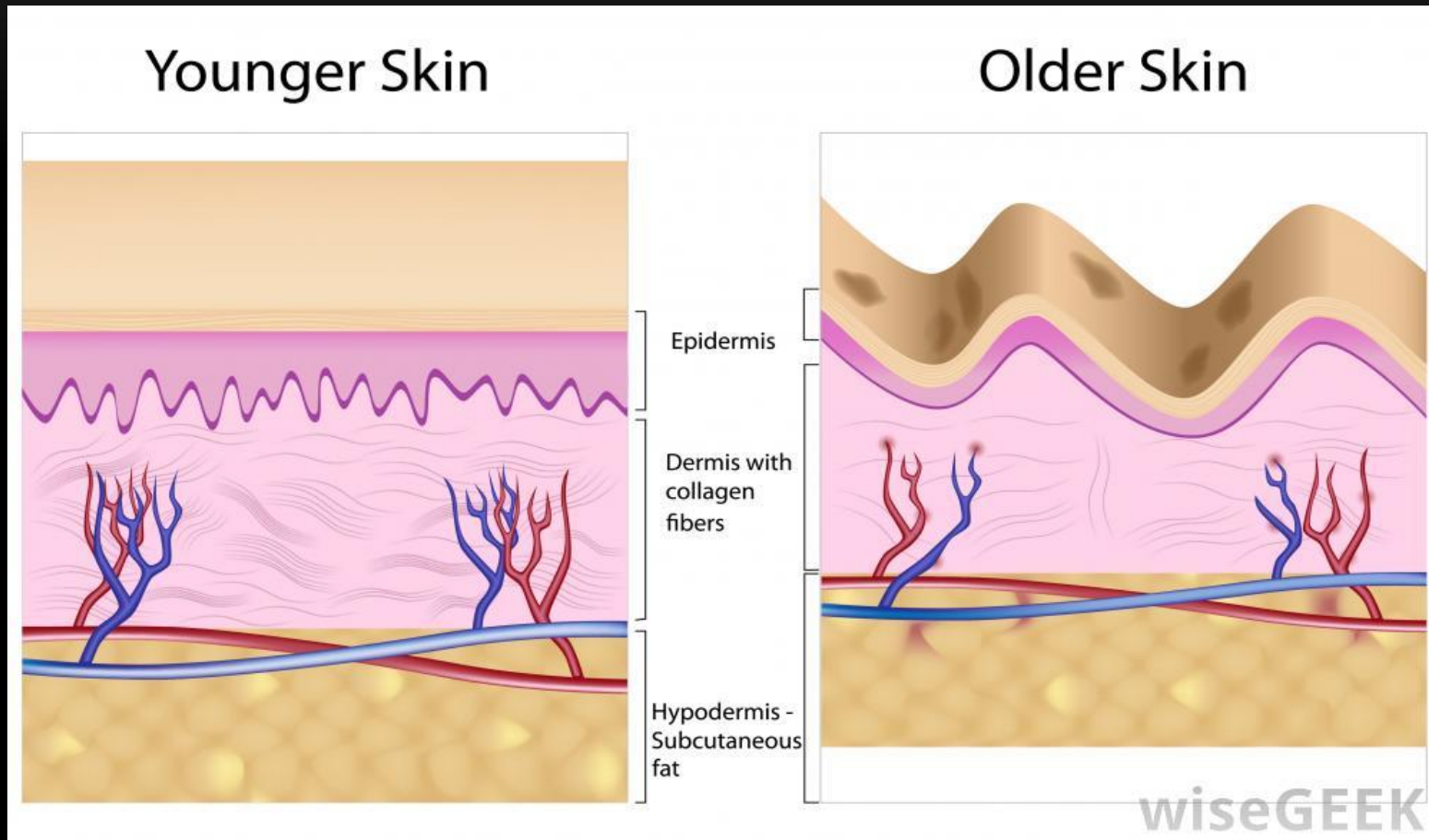


The change in amino acid sequence causes hemoglobin molecules to crystallize when oxygen levels in the blood are low. As a result, red blood cells sickle and get stuck in small blood vessels.

ESSENTIAL PROTEINS IN THE BODY- INSULIN



ESSENTIAL PROTEINS IN THE BODY- COLLAGEN



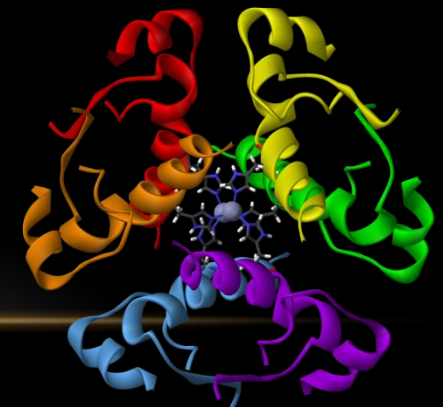
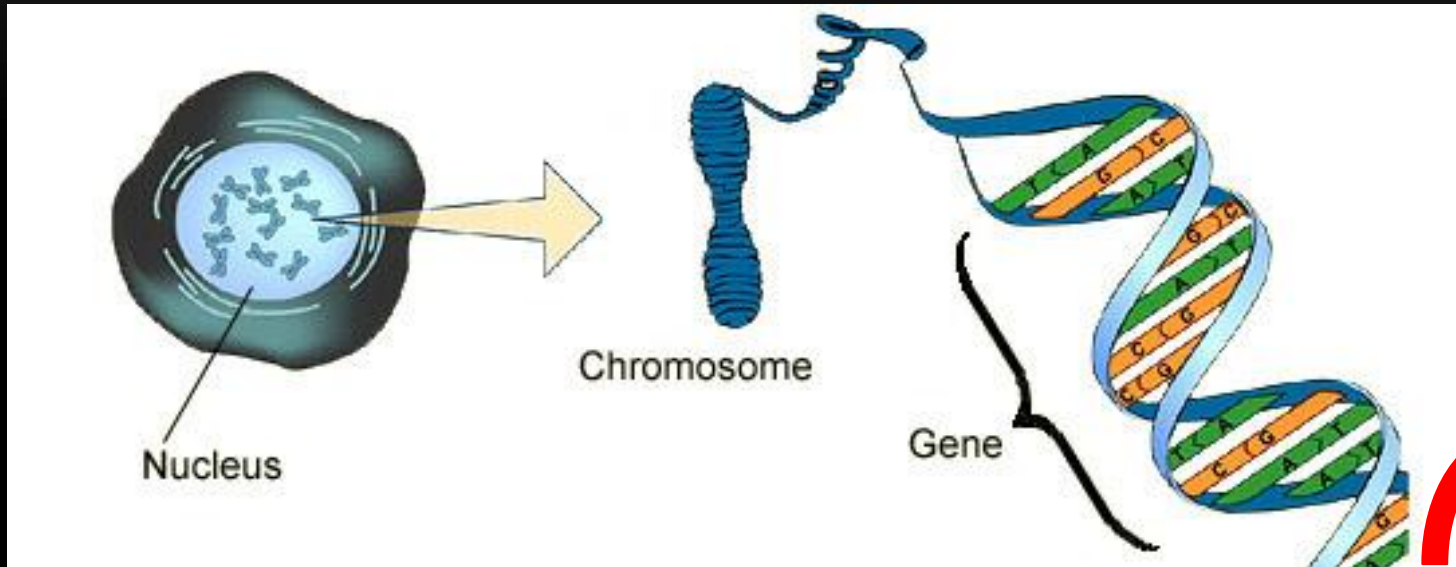
Several diseases linked to mutations in the COL1A1 gene

ESSENTIAL PROTEINS IN THE BODY- COLLAGEN



Common diseases linked to mutations in the COL1A1 gene

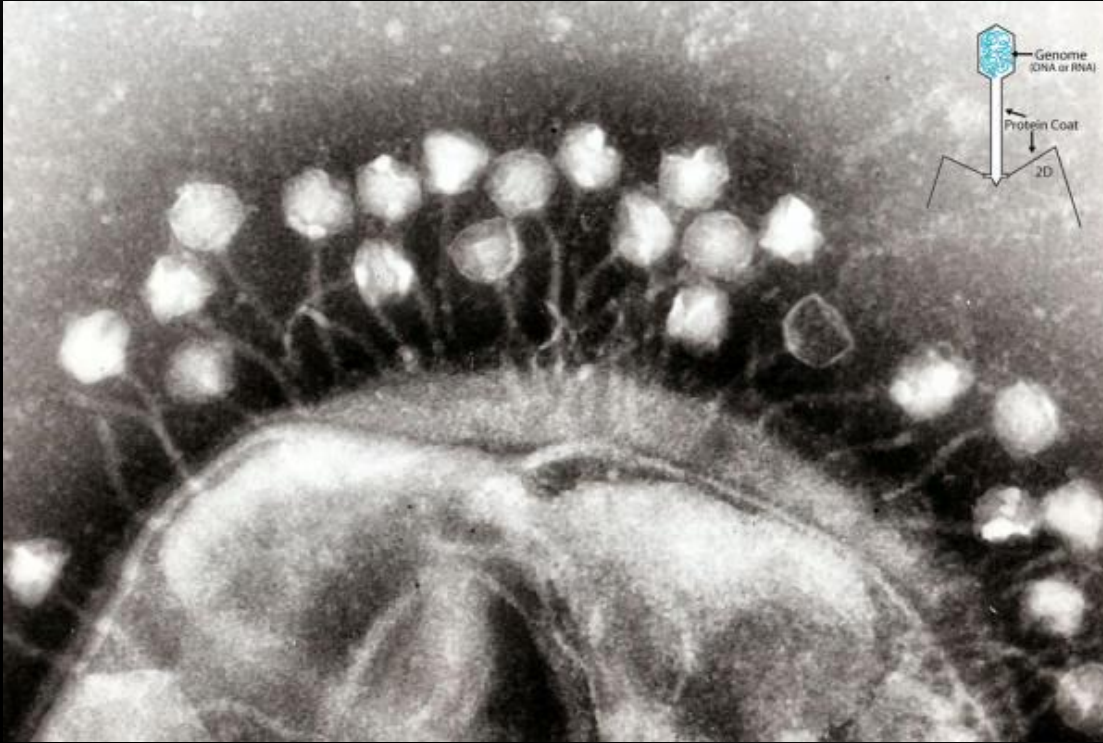
MOLECULAR BIOLOGY SUMMARY



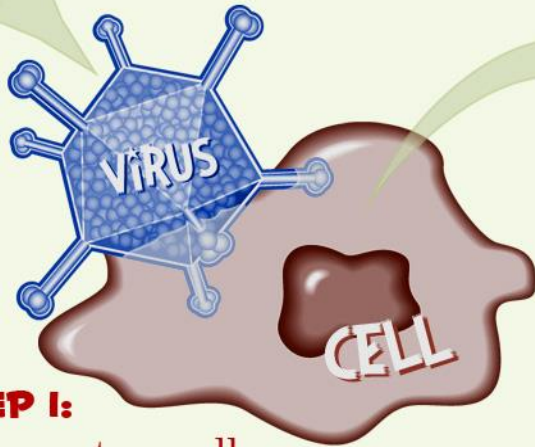
Insulin

HOW CAN THIS INFORMATION BE ALTERED?

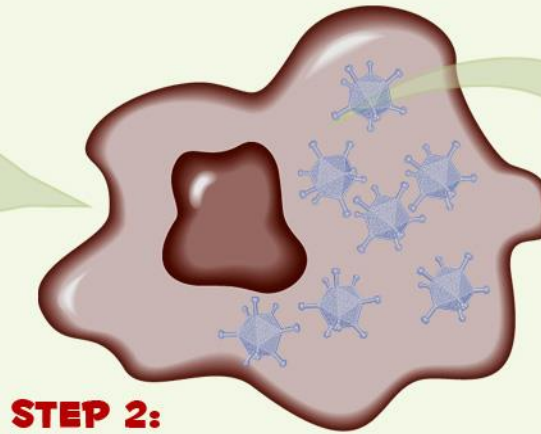
BACTERIOPHAGE



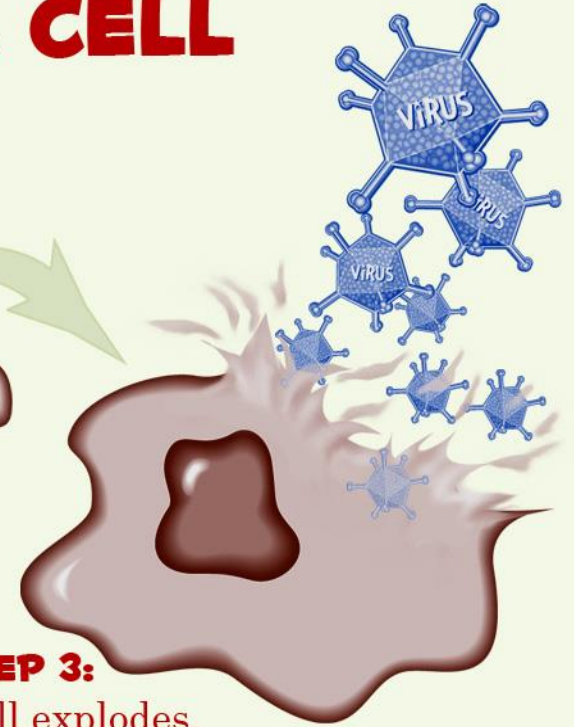
HOW A VIRUS KILLS A CELL



STEP 1:
Virus enters cell

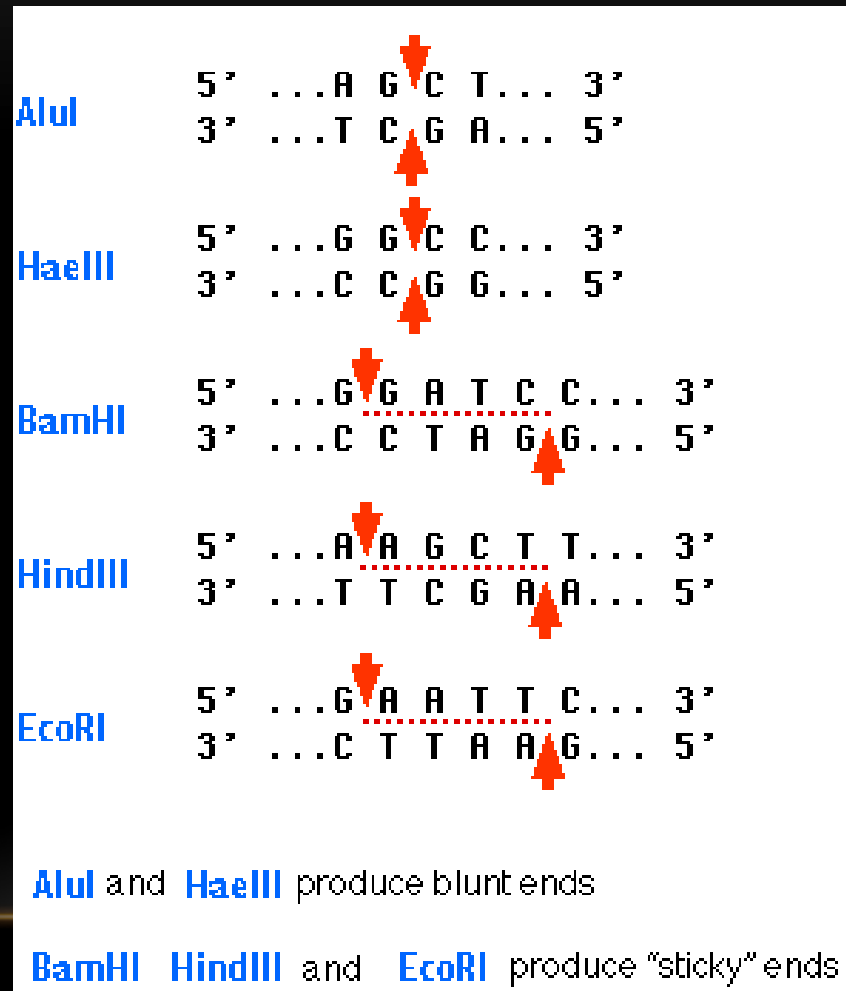


STEP 2:
Virus duplicates itself

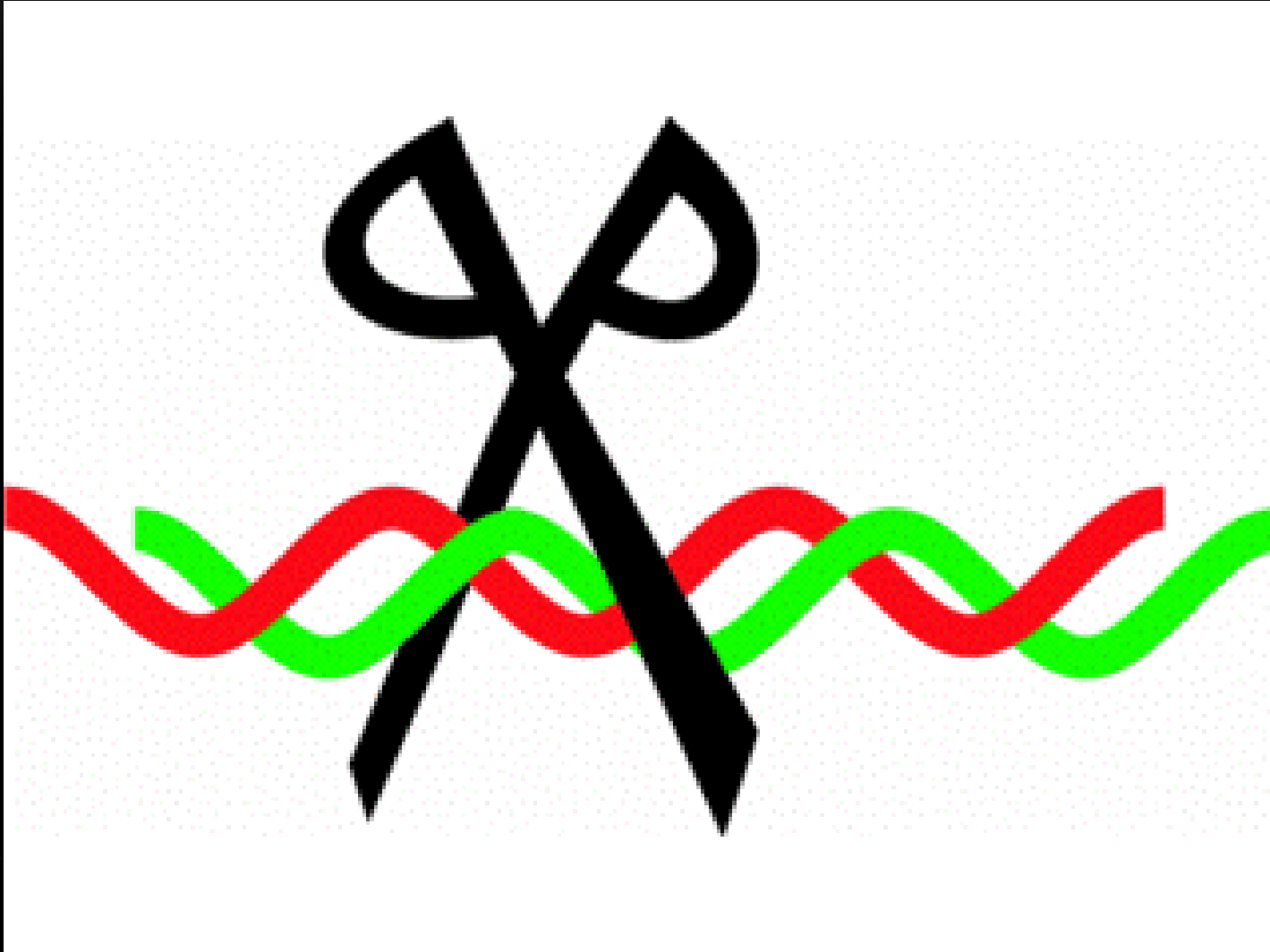


STEP 3:
Cell explodes,
releasing thousands
of brand-new virus particles

BACTERIAL DEFENSE

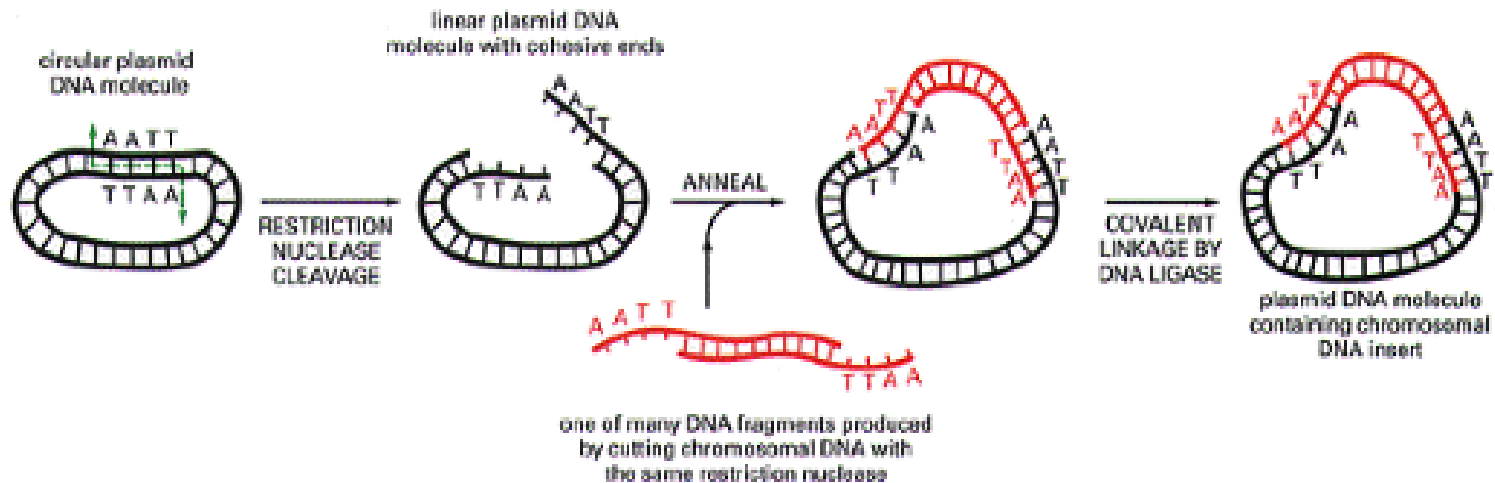


BACTERIAL DEFENSE



MOLECULAR CLONING

The Formation of a Recombinant DNA Molecule



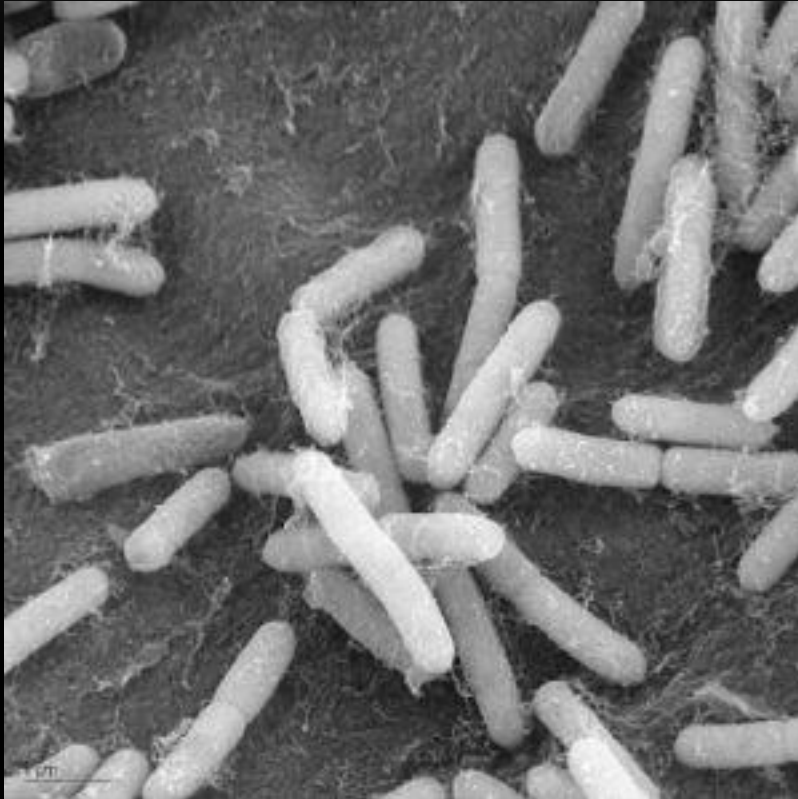
USES OF GENETIC ENGINEERING

- Industrial- mass production of hormones and biofuels
 - Agricultural- herbicide, insect resistant plants
 - Animals- Disease mechanisms and food sources
 - Medical- Gene Therapy
-

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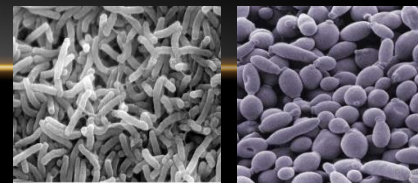
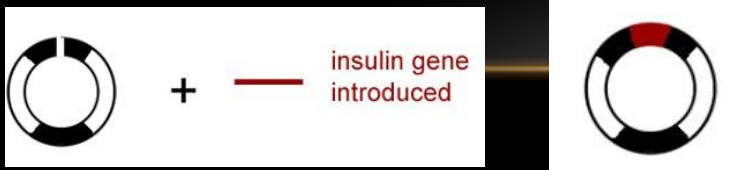
OIL CLEAN UP AND *PSEUDOMONAS PUTIDA*



INDUSTRIAL INSULIN PRODUCTION



microorganisms



BIOFUEL *ARABIDOPSIS THALIANA*



Decreased Lignin production

USES OF GENETIC ENGINEERING

- Industrial- mass production of hormones and biofuels
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-

GENETICALLY MODIFIED FOOD (GMO)



Antiviral



Increased Nutrition



Herbicide Resistance



Insect Resistance

GOT PAPAYA??



Papaya ring virus
Resistance gene



ROUNDUP RESISTANT SOYBEANS



Glyphosate
Resistance gene



INSECT RESISTANT CORN



Corn borer worm “billion dollar bug”



Bt Corn- *Bacillus thuringiensis*
Bacterial toxins
(Cry proteins)



GOLDEN RICE

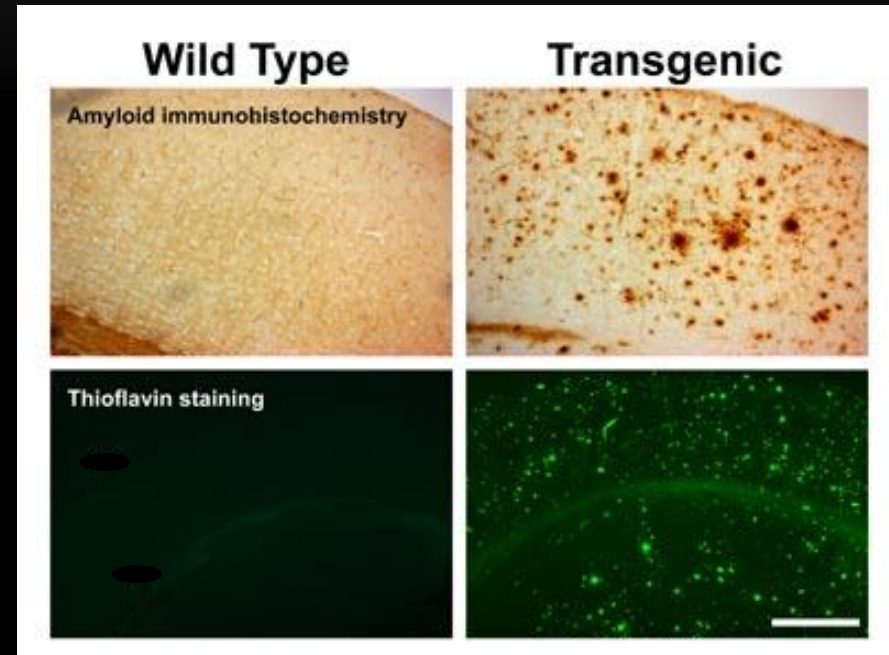
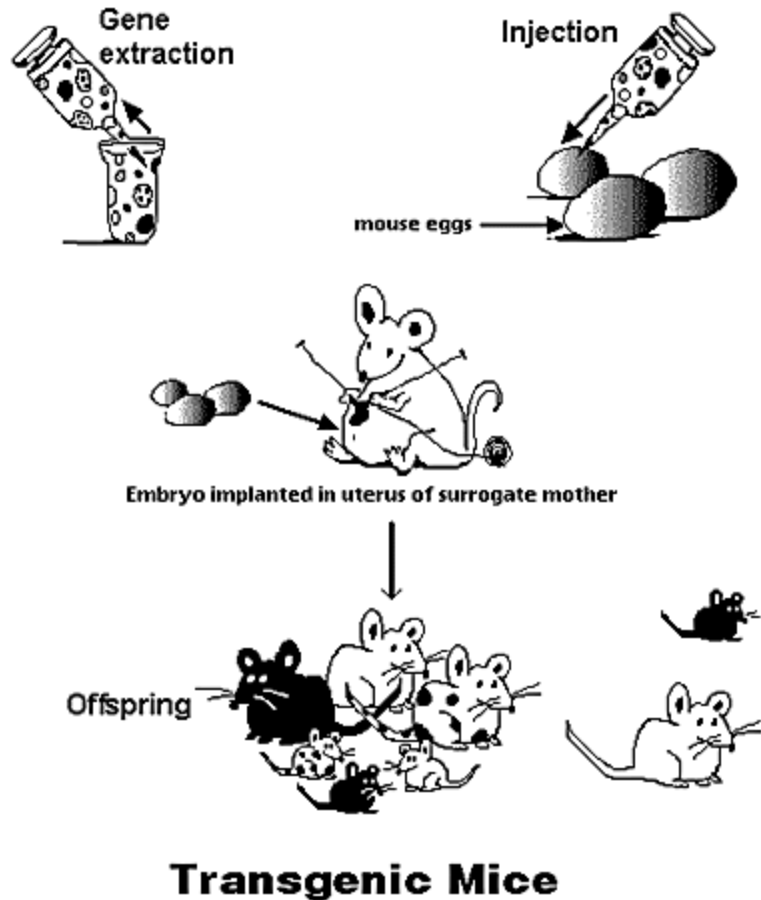


Biosynthesis of beta carotene-
a vitamin A precursor via GMO

USES OF GE

- Industrial- mass production of hormones and biofuels
 - Agricultural- herbicide, insect resistant plants
 - **Animals- Disease mechanisms and food sources**
 - Medical- Gene Therapy
-

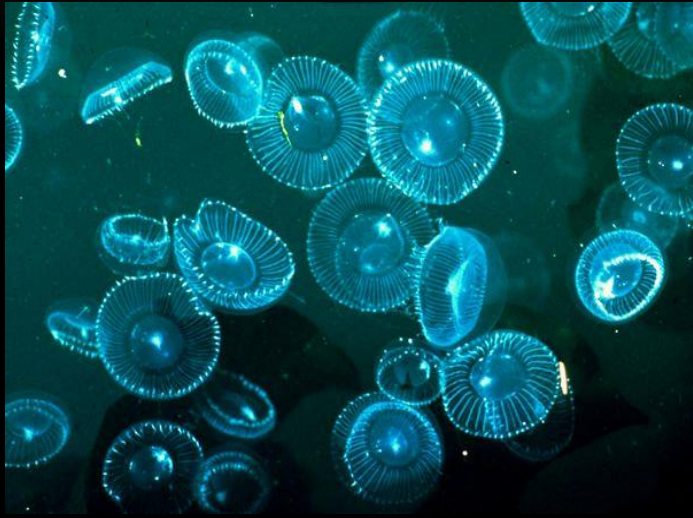
TRANSGENIC MICE- ALZHEIMER'S DISEASE



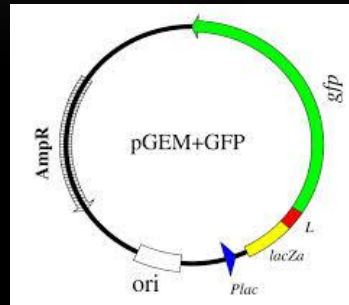
www.nbrc.ac.in

Amyloid Plaques

TRANSGENIC MICE- GREEN FLUORESCENT PROTEIN



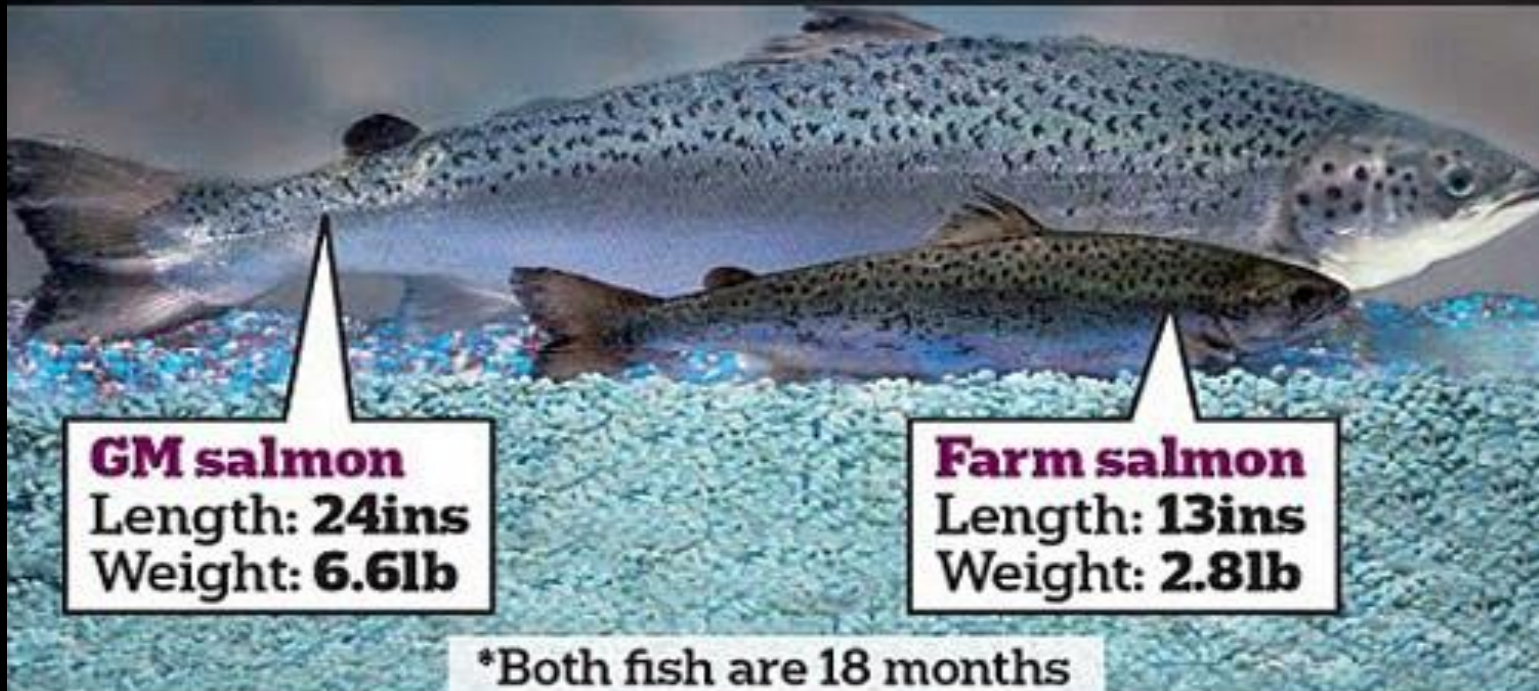
Aequorea victoria



- 1) Visualize animal development
- 2) Transplants
- 3) "Tag" other proteins

GMO ANIMALS AS A FOOD SOURCE

HOW THEY COMPARE

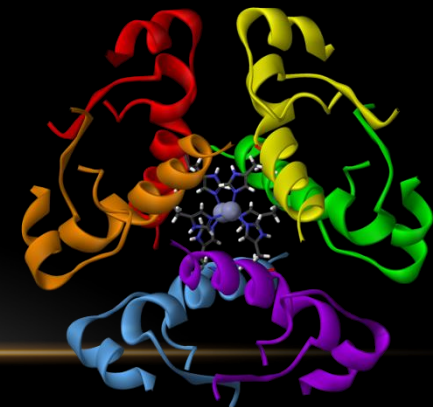
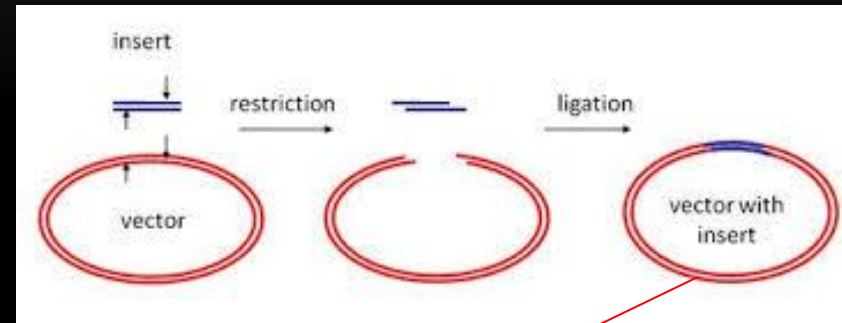
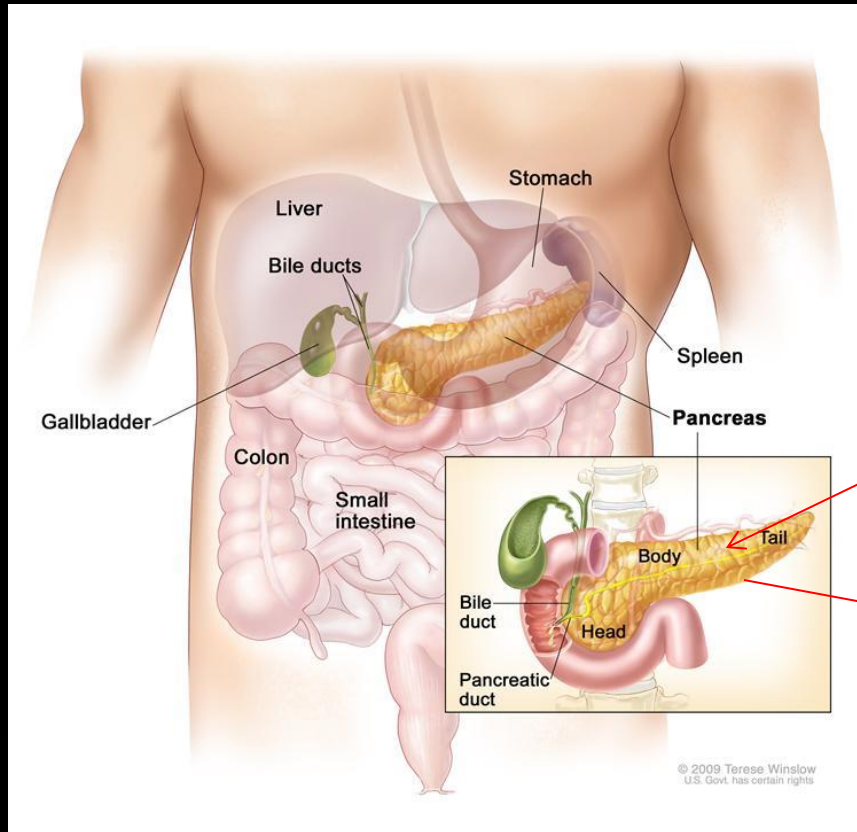


USES OF GENETIC ENGINEERING

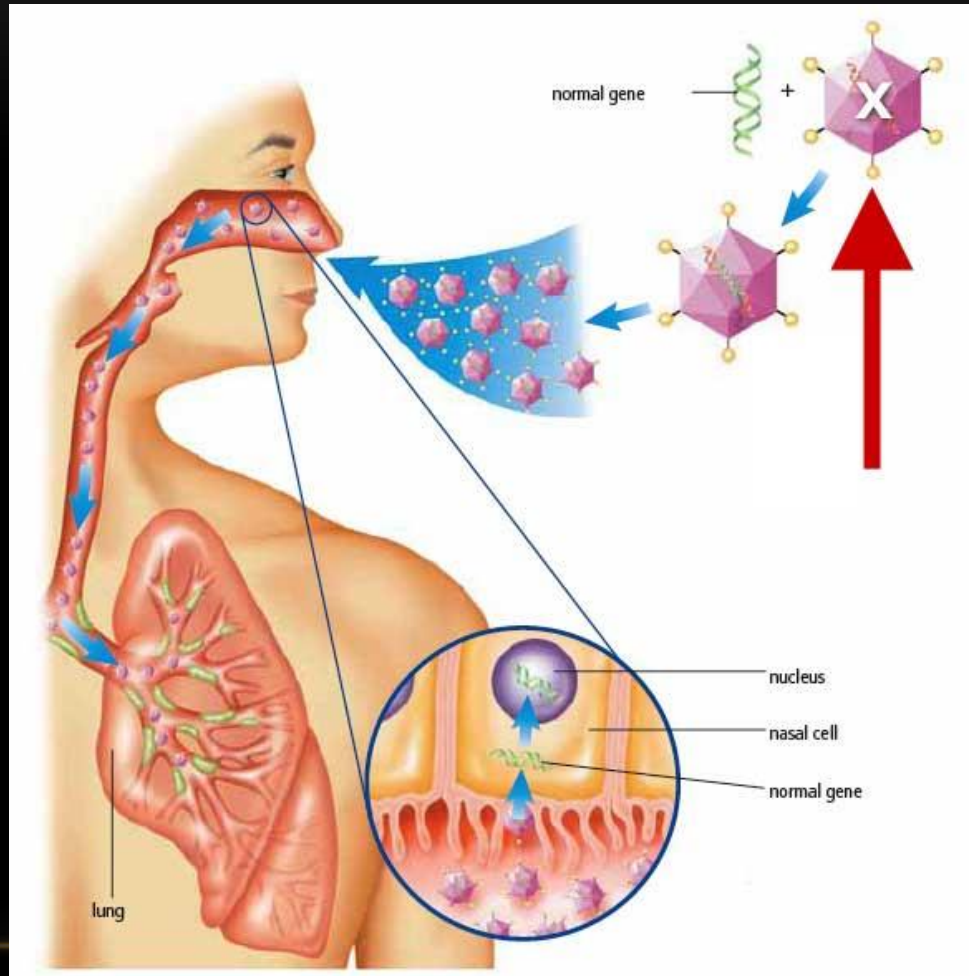
- Industrial- mass production of hormones and biofuels
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 - **Medical- Gene Therapy**
-

IN VIVO GENE THERAPY (DIABETES)

- Insulin that is produced is mutated/defective

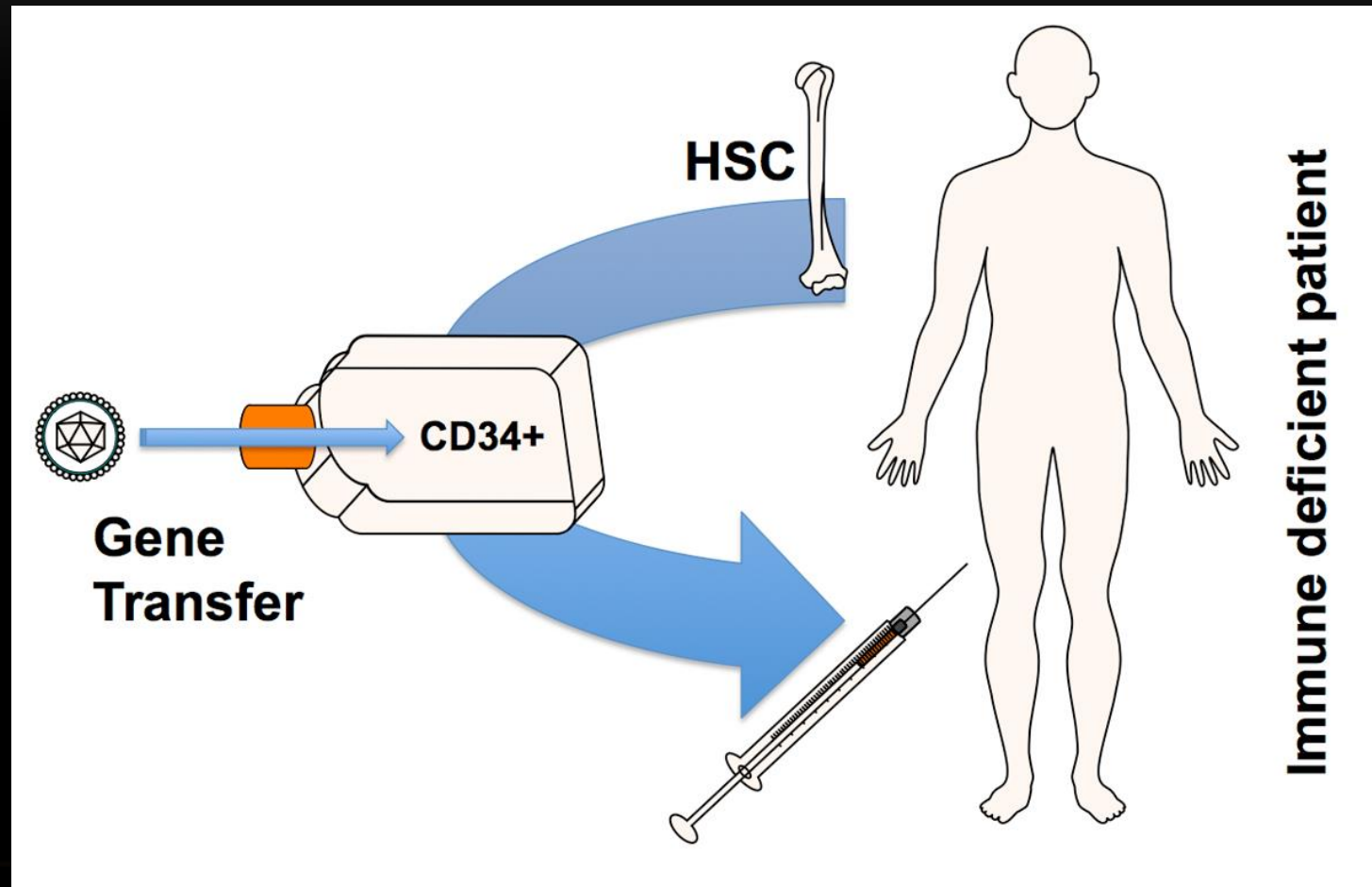


IN VIVO GENE THERAPY (CYSTIC FIBROSIS)



CFTR
Cystic fibrosis
transmembrane
conductance
regulator gene
mutations

EX VIVO GENE THERAPY (HIV)

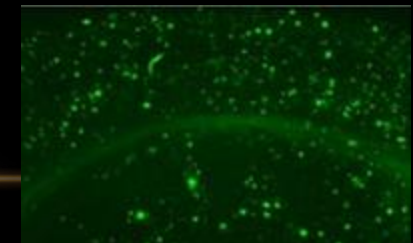
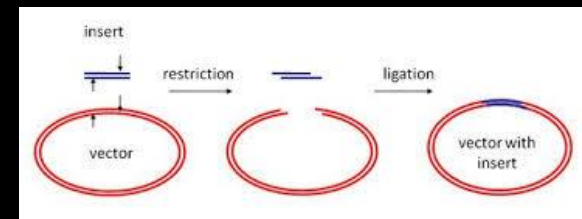
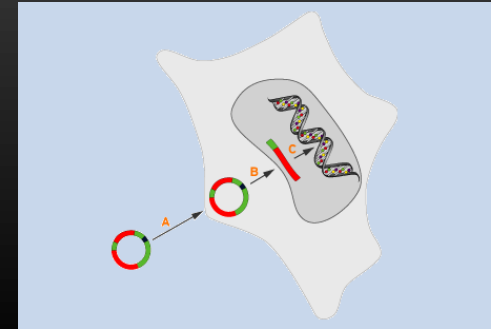


ETHICAL CONCERNS

- Health concerns
 - Eating GMOs
 - Livestock consuming GMOs
- Environmental concerns
 - Pollution
 - Gene Flow
 - Genetic contamination
 - Cross breeding
- Moral concerns
 - Are we improving life or going too far?
 - Do we have a medical obligation to humans with gene therapy?
 - Do we have a moral obligation to produce food in quantity and quality?

SUMMARY OF TOPICS

- What is Genetic Engineering (GE)?
- How is GE performed?
- What are the common uses for GE?
 - Industrial, Agricultural, Animals, Gene Therapy
- Ethical Aspects of GE



GENETIC ENGINEERING

Sometimes you can go too far

QUESTIONS?



CODONS AND PROTEIN ABBREVIATIONS

	U	C	A	G
U	UUU } Phe UUC } UUA } Leu UUG }	UCU } Ser UCC } UCA } UCG }	UAU } Tyr UAC } UAA } Stop UAG }	UGU } Cys UGC } UGA } Stop UGG } Trp
C	CUU } Leu CUC } CUA } CUG }	CCU } Pro CCC } CCA } CCG }	CAU } His CAC } CAA } Gln CAG }	CGU } Arg CGC } CGA } CGG }
A	AUU } Ile AUC } AUA } AUG } Met	ACU } Thr ACC } ACA } ACG }	AAU } Asn AAC } AAA } Lys AAG }	AGU } Ser AGC } AGA } Arg AGG }
G	GUU } Val GUC } GUA } GUG }	GCU } Ala GCC } GCA } GCG }	GAU } Asp GAC } GAA } Glu GAG }	GGU } Gly GGC } GGA } GGG }

Abbreviations for amino acids

<i>Amino acid</i>	<i>Three-letter abbreviation</i>	<i>One-letter symbol</i>
Alanine	Ala	A
Arginine	Arg	R
Asparagine	Asn	N
Aspartic acid	Asp	D
Asparagine or aspartic acid	Asx	B
Cysteine	Cys	C
Glutamine	Gln	Q
Glutamic acid	Glu	E
Glutamine or glutamic acid	Glx	Z
Glycine	Gly	G
Histidine	His	H
Isoleucine	Ile	I
Leucine	Leu	L
Lysine	Lys	K
Methionine	Met	M
Phenylalanine	Phe	F
Proline	Pro	P
Serine	Ser	S
Threonine	Thr	T
Tryptophan	Trp	W
Tyrosine	Tyr	Y
Valine	Val	V

GFP ANIMALS

