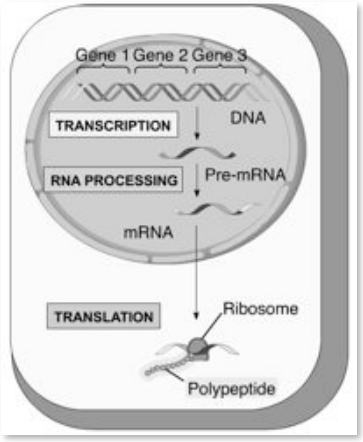
Topics

- Gene expression
  - Translation
  - Post-translational modifications
- Viruses
- Evolution

Gene Expression in Eukaryotes



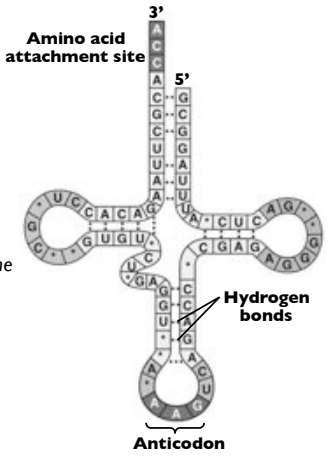
The mRNA sequence of nucleotides is **translated** into a sequence of amino acids in the cytoplasm with the help of **ribosomes**

Translation

Necessary Materials

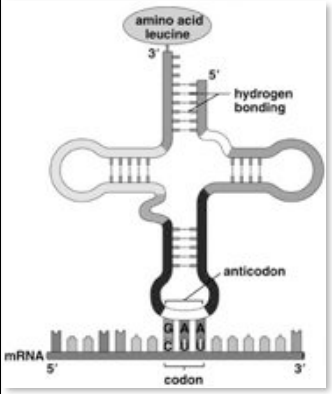
1. mRNA
2. Amino acids
3. Transfer RNA (**tRNA**)

   tRNAs bring amino acids to the ribosome
4. Ribosome



Two-dimensional structure

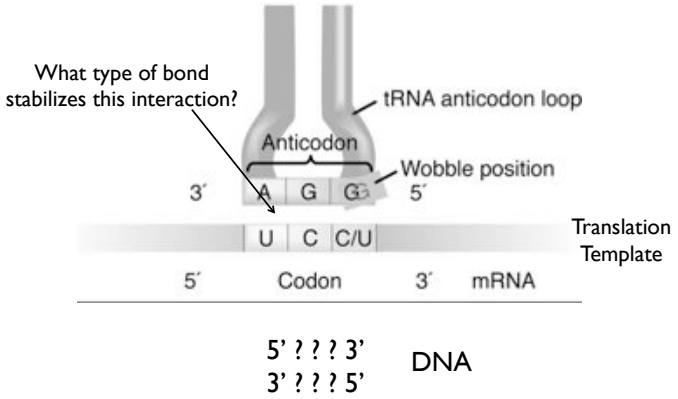
Translation

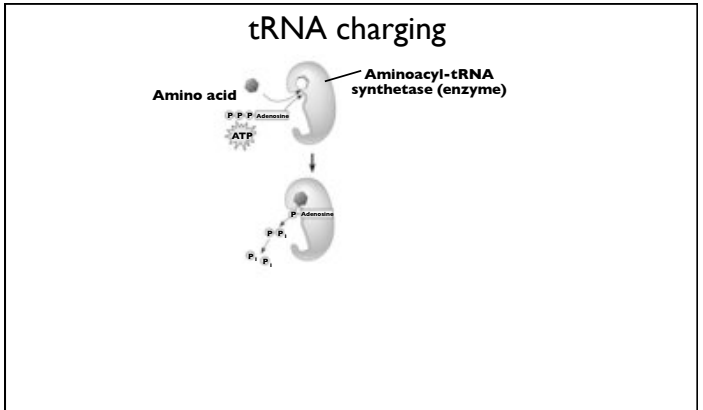


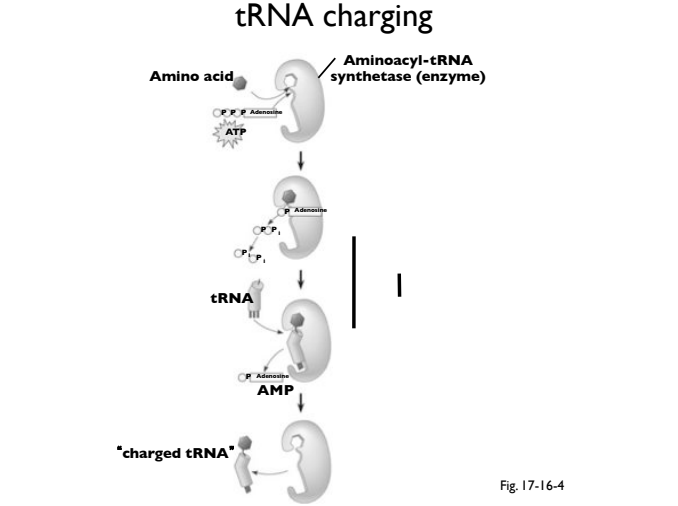
tRNA binds amino acid covalently at 3' end

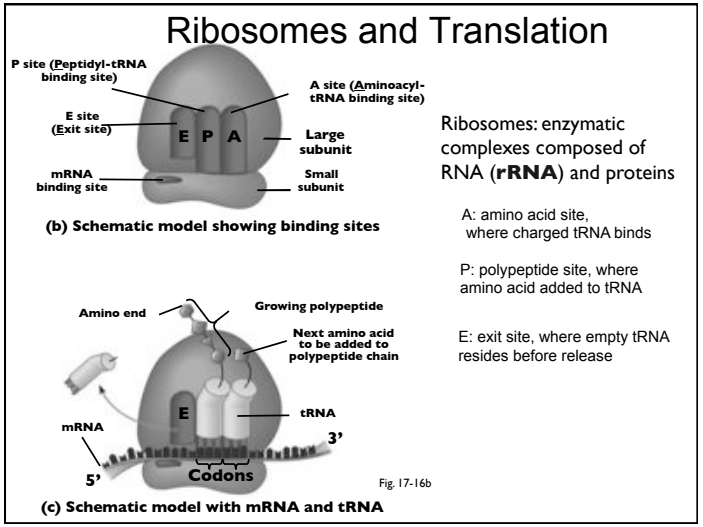
Cloverleaf "arms" and codon/anticodon interactions are held together by H+ bonds.

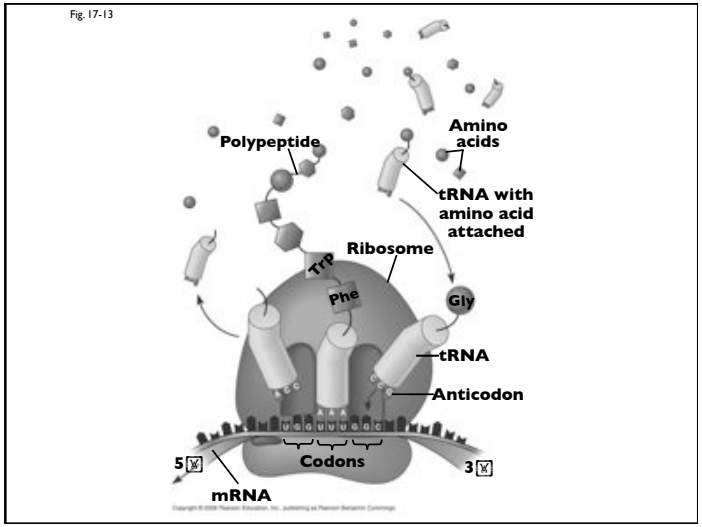
The **ribosome** knows which amino acid to add to the growing **polypeptide** chain by the **codon/anticodon** interaction.


What type of bond stabilizes this interaction?
tRNA anticodon loop
Anticodon
Wobble position
3′
A G G
5′
U C C/U
Translation Template
5′ Codon 3′ mRNA
5’ ? ? ? 3’
3’ ? ? ? 5’
DNA


tRNA charging
Amino acid
Aminoacyl-tRNA synthetase (enzyme)
ATP
Adenosine


tRNA charging
Amino acid
Aminoacyl-tRNA synthetase (enzyme)
ATP
tRNA
AMP
"charged tRNA"
Fig. 17-16-4


Ribosomes and Translation
P site (Peptidyl-tRNA binding site)
A site (Aminoacyl-tRNA binding site)
E site (Exit site)
E P A
Large subunit
mRNA binding site
Small subunit
(b) Schematic model showing binding sites
Amino end
Growing polypeptide
Next amino acid to be added to polypeptide chain
E
tRNA
mRNA
3’
5’
Codons
Fig. 17-16b
(c) Schematic model with mRNA and tRNA
Ribosomes: enzymatic complexes composed of RNA (rRNA) and proteins
A: amino acid site, where charged tRNA binds
P: polypeptide site, where amino acid added to tRNA
E: exit site, where empty tRNA resides before release



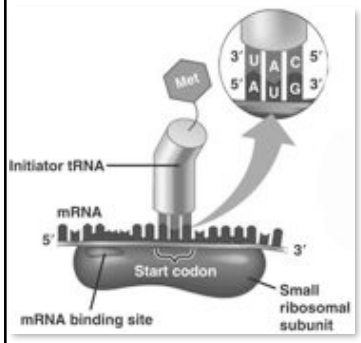
Accurate translation requires two steps:

First: a correct match between a tRNA and an amino acid, done by the enzyme **aminoacyl-tRNA synthetase**
Second: a correct match between the tRNA anticodon and an mRNA codon

The three stages of translation:
Initiation
Elongation
Termination

3 Steps of Translation

1. Initiation



Components:

1) Charged tRNA
2) Small ribosomal subunit
3) Both bound to mRNA

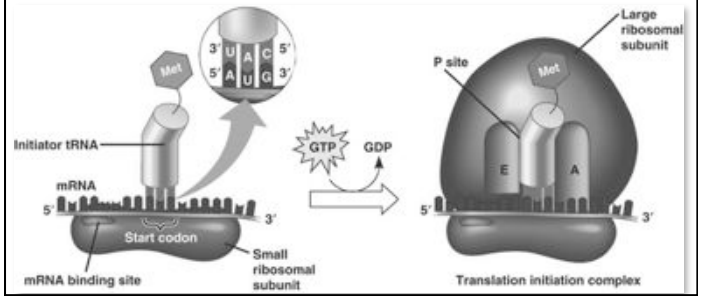
There are **two** ribosomal subunits. The **small** ribosomal subunit binds to the mRNA first and scans along until it finds the start codon, AUG

3 Steps of Translation

1. Initiation

Once the **initiator tRNA** and small subunit bind the AUG, the **large** ribosomal subunit attaches to begin translation.

This process **requires a GTP**



2. Elongation

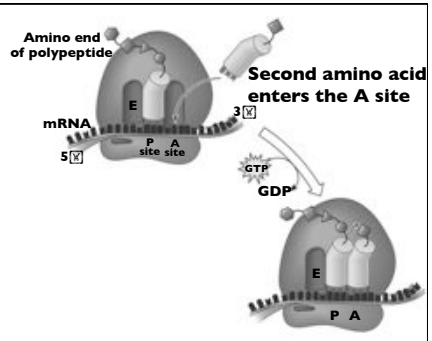


Fig. 17-18-2

2. Elongation

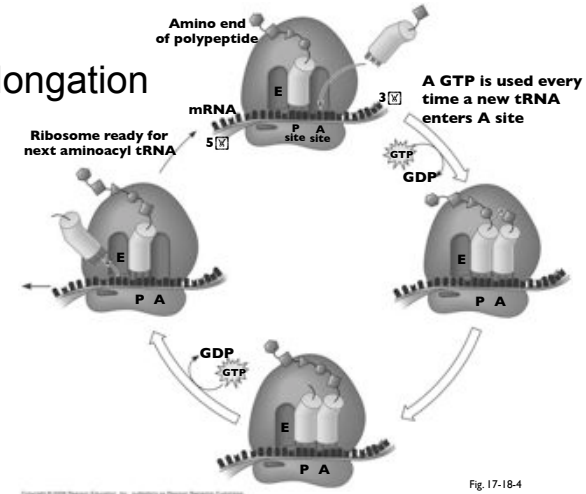
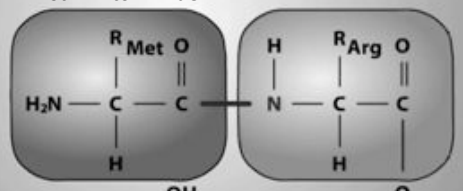


Fig. 17-18-4

2. Elongation

Met = N-terminus

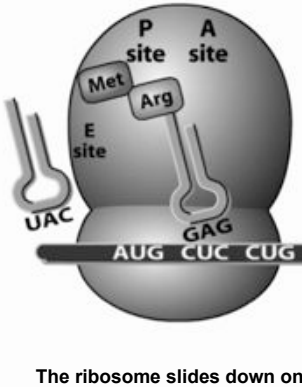


The peptide bond transfers the growing chain to the tRNA in the A-site

P site tRNA

A site tRNA

2. Elongation



Large subunit catalyzes 2 reactions:

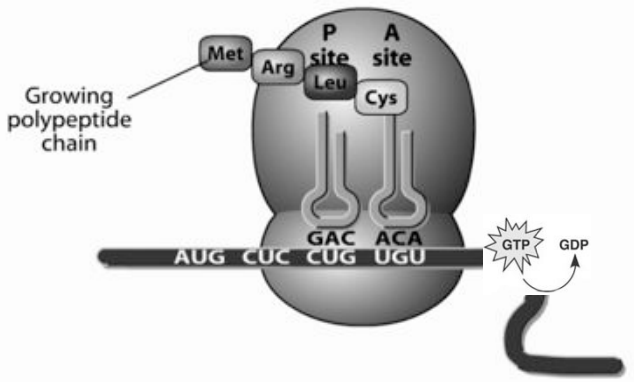
1) Breaks the bond between the Met and its tRNA at the P site

2) Catalyzes formation of a **peptide bond** between the Met and second aa

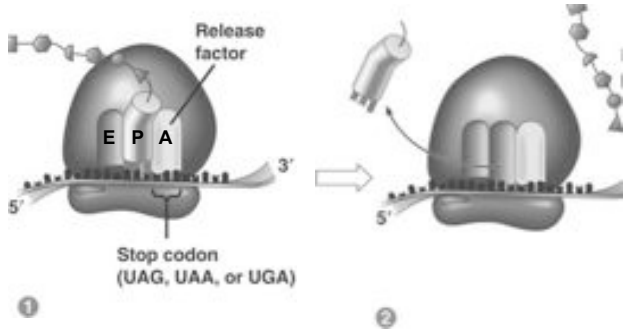
The ribosome slides down one codon and shifts the tRNA from the A site to the P site.

The empty tRNA exits the ribosome via the "E" (exit) site.

2. Elongation



3. Termination



Stop codon is bound by a protein **release factor**:
Hydrolyzes the bond between the polypeptide chain and tRNA at the P site

Post-translational modifications

Newly synthesized protein may contain a **signal sequence-**
Short amino acid stretch that indicates where it belongs in the cell

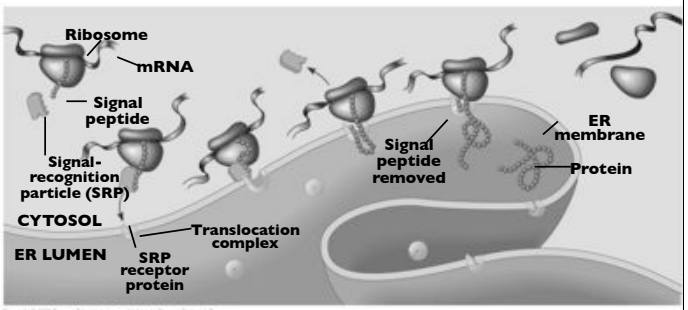
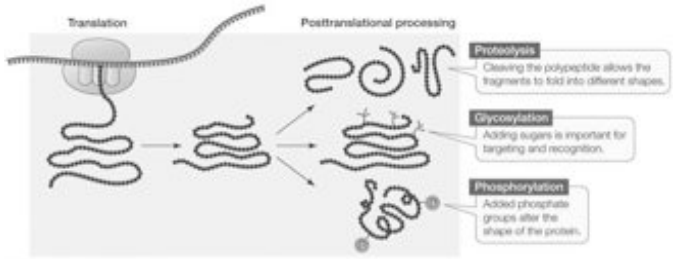


Fig. 17-22

Post-translational modifications

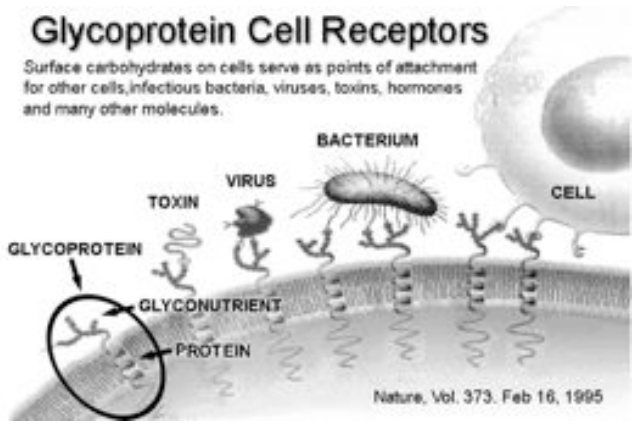
Mature polypeptide usually contains multiple post-translational modifications.



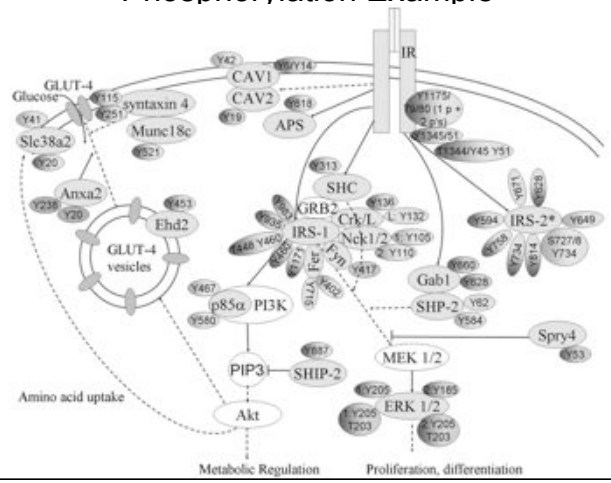
Proteolysis occurs through **proteases**

Phosphorylation occurs through **protein kinases**

Glycosylation example

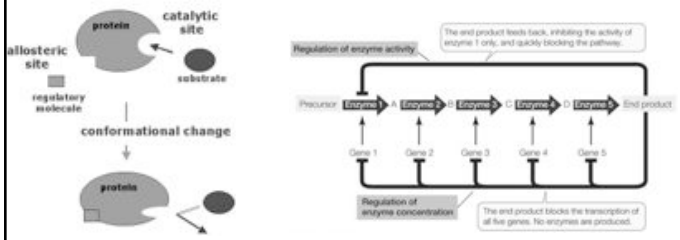


Phosphorylation Example

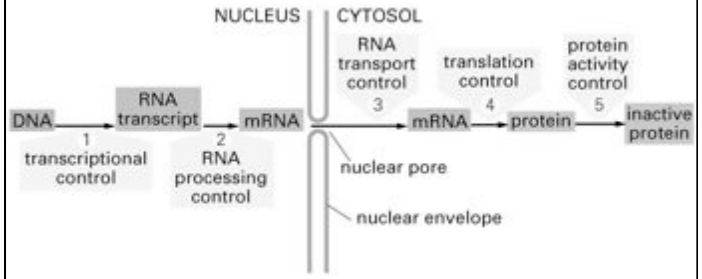


Reminder: allosteric regulation

Regulation of a protein (enzyme) by a molecule (end-product) binding an enzyme at a site other than the active site and changing the enzyme's activity.



Regulation of Gene Expression



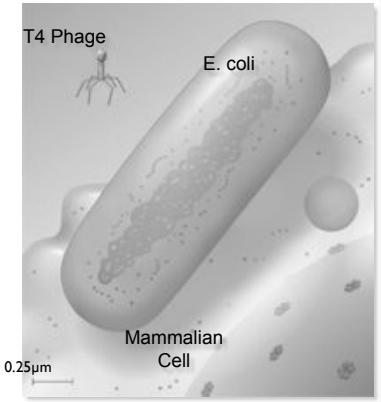
All stages have been explored.

Viruses and Phages

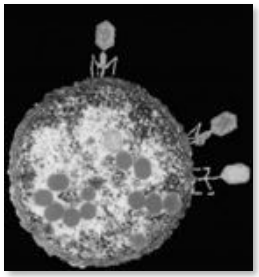
Very small

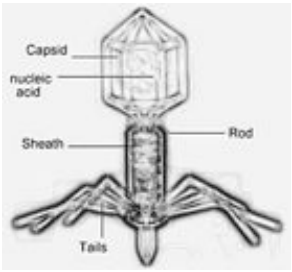
Some as small as 20 nm (smaller than a ribosome)

Most understood of all viruses are **bacteriophages**



Virus Components



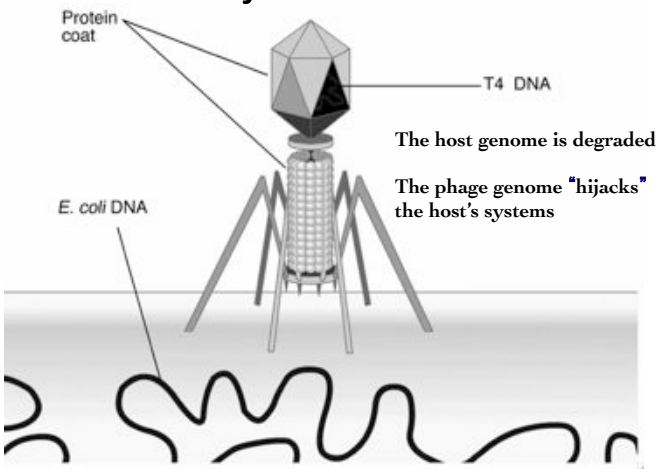


Bacteriophages on *E. coli* (double stranded DNA)

Viruses are composed of a **genome (DNA or RNA)** surrounded by a protein **capsid.**

Viruses are **acellular.**

T4 Injects its DNA



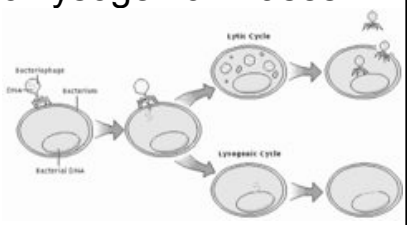
The host genome is degraded

The phage genome "hijacks" the host's systems

The Lytic/Lysogenic Phases

Lytic: host cell breaks open (lysis) to release viral particles

Viruses that participate in lytic phases are termed **virulent.**

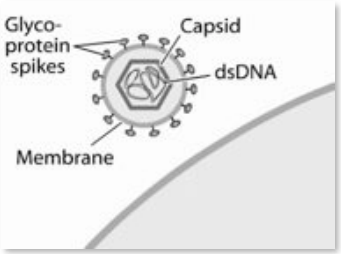


Lysogenic : dormant phase, viral genome is incorporated into host genome, but may not be replicated until later in host cell's life cycle

An efficient phage can wipe out a whole population of bacteria.

...but no more bacteria means no more phages as well..

Enveloped Viruses

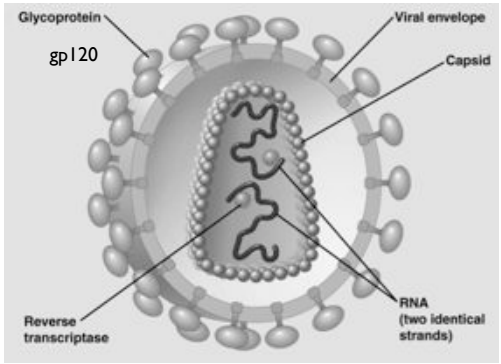


Most animal viruses also have an outer membrane, separate from the capsid, called an **envelope.**

The **envelope** and the proteins embedded within it come from the *host cell membrane*

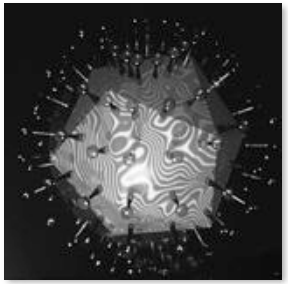
Most viruses that infect humans are enveloped viruses.

RNA Virus (HIV)



Retrovirus: ssRNA genome is converted to DNA by **reverse transcriptase**. The DNA copy is then integrated into the host genome.

Herpes and Humans



Herpes viruses cause many disorders

- Oral and genital cold sores
- Chickenpox
- Shingles
- Mononucleosis
- Burkitt's Lymphoma

Recurrences are the result of neural ganglia infection.

Are Viruses Alive?

Depends on how you define "*alive*".

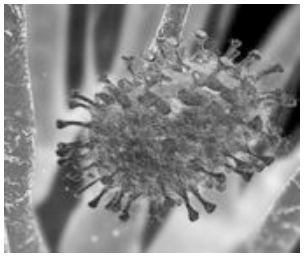
"Viruses lead a borrowed life..."

- Marc H.V. van Regenmortel and Brian W.J. Mahy

For	Against
Viruses contain genetic material	They lack all organelles, metabolic enzymes, ribosomes and cannot make proteins.
Viruses infection results in **reproduction** of their genetic material	Viruses cannot reproduce without using a living cell's machinery. Viruses lack **"autonomy"**

The number of viruses expected to exist on Earth.

Vaccines



H1N1 virus

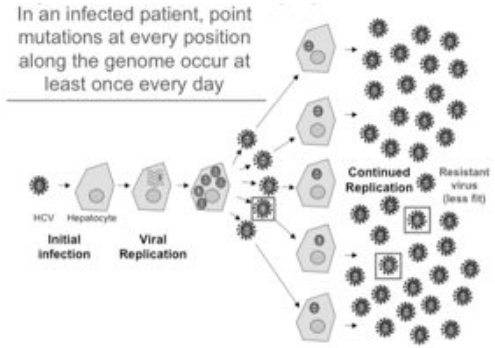
Antibiotics DO NOT kill viruses

Vaccines stimulate your immune system to be able to fight the disease-causing organism

The best treatments attack viral mechanisms distinct from host mechanisms

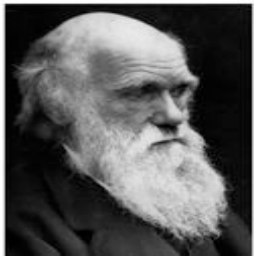
Viral evolution

Why do we need new flu vaccines every year?



Evolution

Charles Darwin



Darwin trained to be a Clergyman, while studying natural sciences.

The Galapagos Islands

Animals found in the Galapagos

- Land Tortoises
- Marine Iguanas
- Blue-Footed Booby
- Darwin Finches

Darwin was fascinated by the land tortoises and marine iguanas.

Darwin's Theory of Evolution

- **Evolution**, or change over time, is the process by which modern organisms have descended from ancient organisms.
- A scientific **theory** is a well-supported testable explanation of phenomena that have occurred in the natural world.

Darwin Witnessed Adaptation Everywhere

Adapted for wet climate

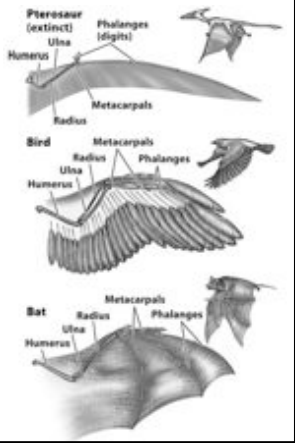
Adapted for dry climate

Giant tortoises varied in predictable ways from one island to another.
The shape of a tortoise's shell could be used to identify which island a particular tortoise inhabited.

Convergent Evolution

The acquisition of the same biological trait in unrelated species.

Wings arose as modifications of existing structures in different species.
Species may share a common ancestor.

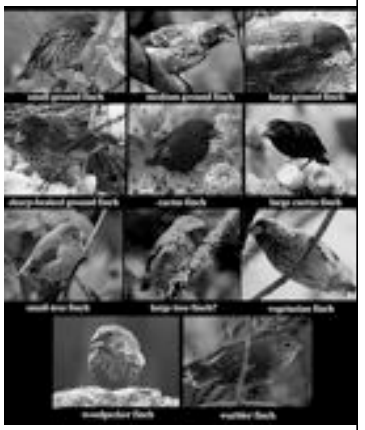


Divergent Evolution

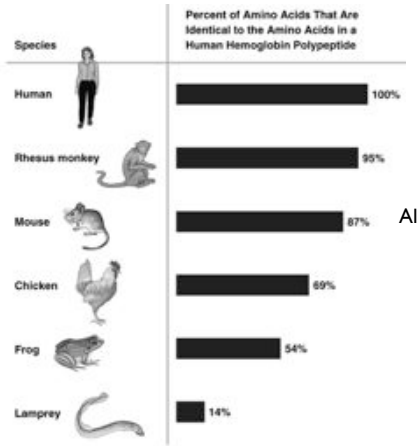
The accumulation of differences between organisms which can lead to the formation of new species.

Usually due to the same species moving to different, isolated environments.

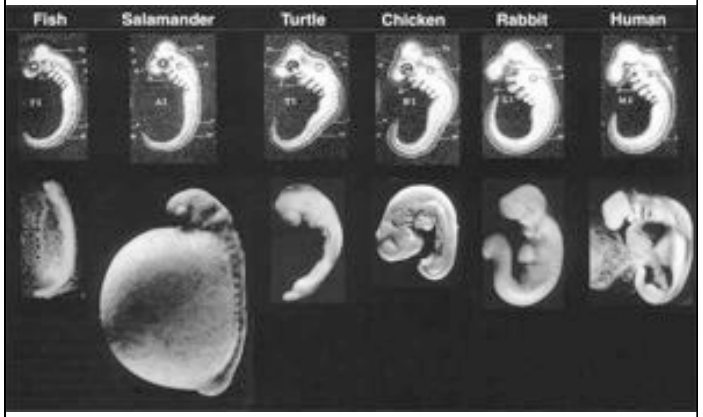
The two groups develop into distinct species due to differences in the demands driven by the environment.



The Commonality of Species

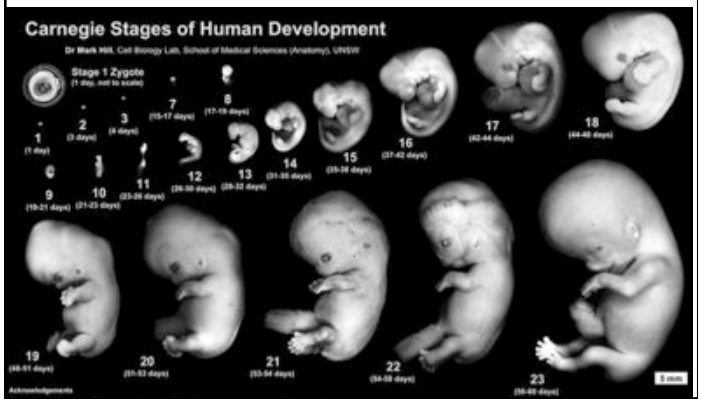


All vertebrates (almost) have the gene for hemoglobin.



Development

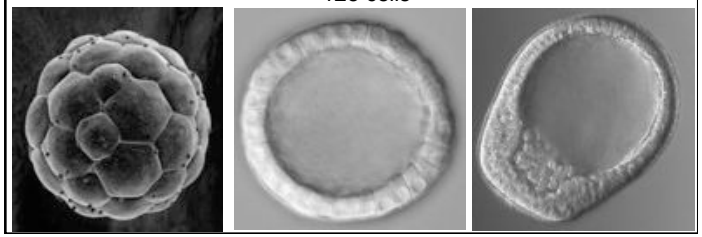
The process through which a single cell changes into a multicellular organism



What happens after fertilization?

The zygote undergoes a series of mitotic cell divisions called ***cleavage***.
The stages of development are: Fertilized ovum (zygote) →

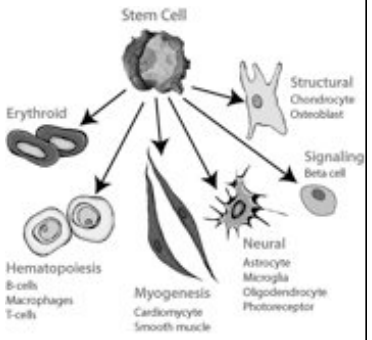
Morula → Blastula → Gastrula
~128 cells



4 key processes of development

1) **Determination-** sets the developmental fate of a cell, even before the phenotype is visible.

Indicates a cell's "irreversible" commitment to becoming a particular cell type.



2) Once cell fate is determined, Differential gene expression leads to…..

Differentiation- the process by which different cell types arise from less specialized cells

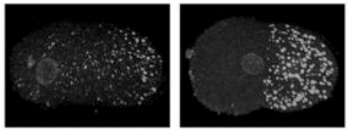
Cell fate

Differential gene expression- Each adult cell contains the same genes, it's how they express those genes that differentiates an organism.

2 ways to induce cells to transcribe different genes:

1) **differential distribution** of a cytoplasmic factor so that its 2 daughter cells receive unequal amounts

2) **differential exposure** of the 2 daughter cells to an external inducer


One-celled embryo Two-celled embryo

4 key processes of development

3) **Growth**- increase in size of the body and its organs

4) **Morphogenesis-** process that gives a tissue, organ, or organisms its shape and position.