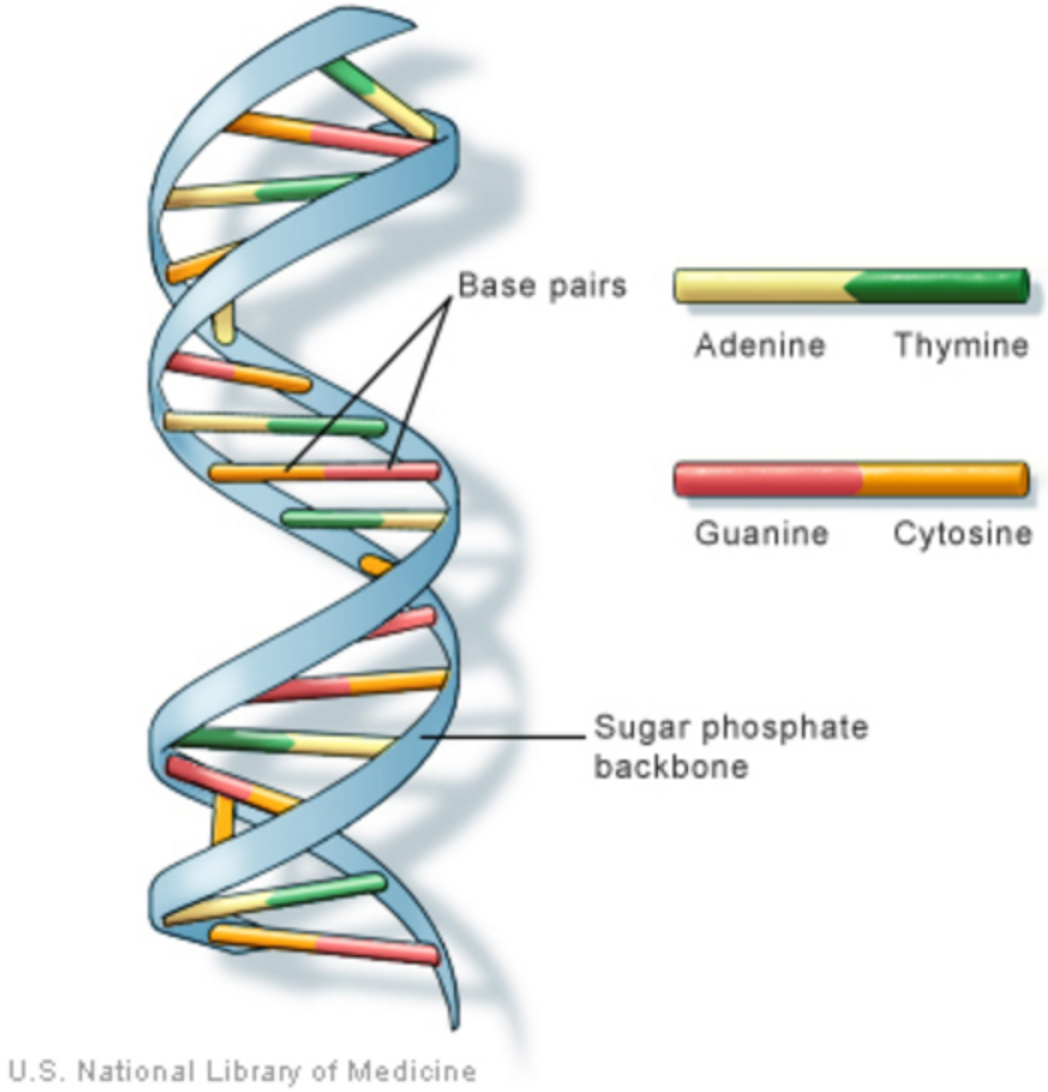
Unit 6 - Heredity and Genetics

Hereditary:

Hereditary refers to traits or characteristics that are passed down from one generation to the next through genetic inheritance. These traits can include physical characteristics like eye color or height, as well as certain health conditions or predispositions to certain diseases. Hereditary traits are encoded in the DNA and are transferred from parents to offspring during reproduction.

DNA, or deoxyribonucleic acid, is a molecule that carries the genetic instructions for the development, functioning, growth, and reproduction of all known living organisms and many viruses.



It consists of two long chains made up of nucleotides, which are composed of a sugar (deoxyribose), a phosphate group, and one of four nitrogenous bases: adenine (A), cytosine (C), guanine (G), and thymine (T).

The four base pairs of DNA are:

1. Adenine (A)
2. Thymine (T)
3. Cytosine (C)
4. Guanine (G)

These bases pair with each other in a specific manner: Adenine (A) pairs with Thymine (T), and Cytosine (C) pairs with Guanine (G). This complementary base pairing is a fundamental aspect of DNA structure and is crucial for its stability and replication.

These nucleotide sequences encode the genetic information necessary for the synthesis of proteins and the regulation of cellular activities. DNA is organized into structures called chromosomes, which are located in the cell nucleus in eukaryotic organisms.

In prokaryotes, DNA is found in the cell's cytoplasm. DNA replication and the transmission of genetic information through processes such as transcription and translation are fundamental to the continuity of life and the inheritance of traits from one generation to the next.

The Structure of DNA:

The discovery of the structure of DNA is primarily attributed to the work of James Watson, Francis Crick, Rosalind Franklin, and Maurice Wilkins. Here's an overview:

1. **Initial Insights**: In the early 1950s, the race to unravel the structure of DNA was intense. Rosalind Franklin, a biophysicist, used X-ray crystallography to study DNA's structure at King's College London. Her colleague, Maurice Wilkins, worked alongside her.
2. **X-ray Diffraction**: Franklin's X-ray diffraction images of DNA provided crucial insights into its structure. One famous photograph, known as Photo 51, showed a pattern indicating a helical structure.
3. **Model Building**: Meanwhile, James Watson, an American biologist, and Francis Crick, a British physicist, were working at the Cavendish Laboratory in Cambridge. They were inspired by Franklin's work and aimed to build a model that fit the X-ray data.
4. **Discovery of the Double Helix**: In 1953, Watson and Crick proposed the double helix model of DNA. Their breakthrough came from combining Franklin's X-ray data, which suggested a helical structure, with Chargaff's rules, which dictated the pairing of nitrogenous bases (A with T, and C with G).

5. **Publication**: Watson and Crick's model of DNA was published in the journal Nature on April 25, 1953, in a paper titled "Molecular Structure of Nucleic Acids: A Structure for Deoxyribose Nucleic Acid."

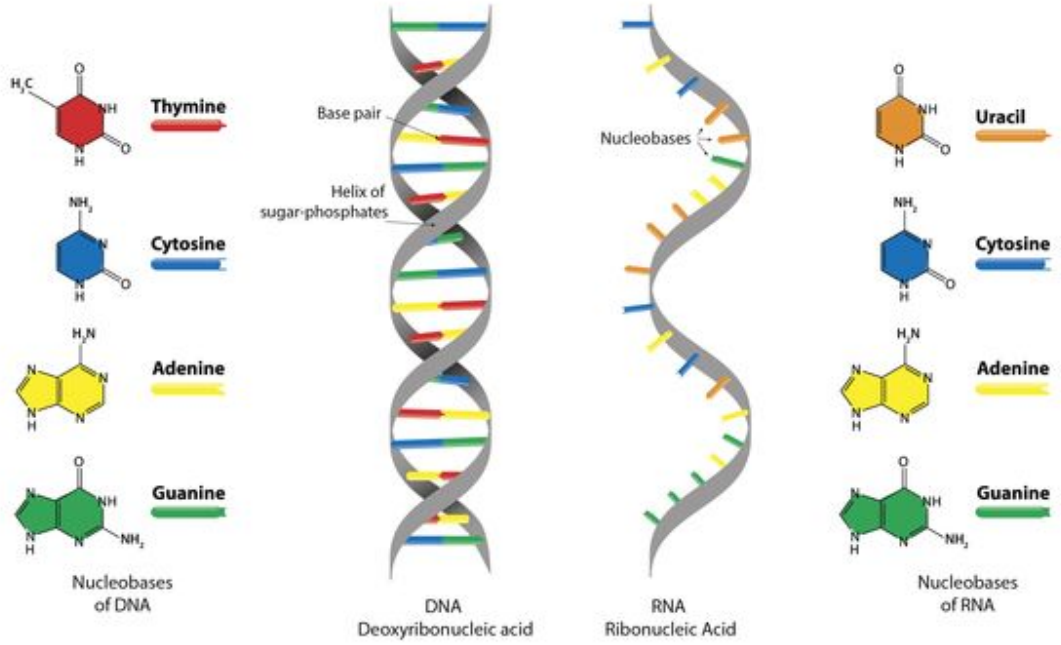
Recognition: Watson, Crick, and Wilkins were awarded the Nobel Prize in Physiology or Medicine in 1962 for their discoveries concerning the molecular structure of nucleic acids and its significance for information transfer in living material. However, due to her untimely death, Franklin was not eligible for the Nobel Prize.

The discovery of DNA's structure is credited to James Watson, Francis Crick, Rosalind Franklin, and Maurice Wilkins. Rosalind Franklin and Maurice Wilkins' X-ray diffraction images provided essential insights into DNA's structure, while Watson and Crick built the first accurate model of the DNA double helix based on this data. Therefore, all four individuals played crucial roles in unraveling the structure of DNA.

The Contributions of Women in Science:

- **Marie Curie**: As a physicist and chemist, Marie Curie conducted pioneering research on radioactivity, discovering the elements polonium and radium. Her work laid the foundation for the development of radiology and nuclear physics. She was also the first woman to win a Nobel Prize, receiving the Nobel Prize in Physics in 1903 alongside her husband Pierre Curie and Henri Becquerel, and later the Nobel Prize in Chemistry in 1911 for her discovery of radium and polonium.
- **Rosalind Franklin**: Franklin's X-ray diffraction images of DNA provided critical evidence for its double helix structure. Her work, although initially undervalued, was instrumental in James Watson and Francis Crick's proposal of the DNA model. Her contributions were recognized posthumously for their significance in the understanding of DNA's structure.
- **Barbara McClintock**: McClintock, a geneticist, made groundbreaking discoveries in genetics, particularly in maize. She discovered transposable elements or "jumping genes," which are genetic elements that can change their position within a genome. This work revolutionized our understanding of genetic regulation and earned her the Nobel Prize in Physiology or Medicine in 1983.
- **Ada Lovelace**: Ada Lovelace, an English mathematician and writer, is often regarded as the world's first computer programmer. She collaborated with Charles Babbage on his proposed mechanical general-purpose computer, the Analytical Engine, and wrote the first algorithm intended to be processed by a machine. Her work laid the groundwork for modern computer programming.

DNA Structure:



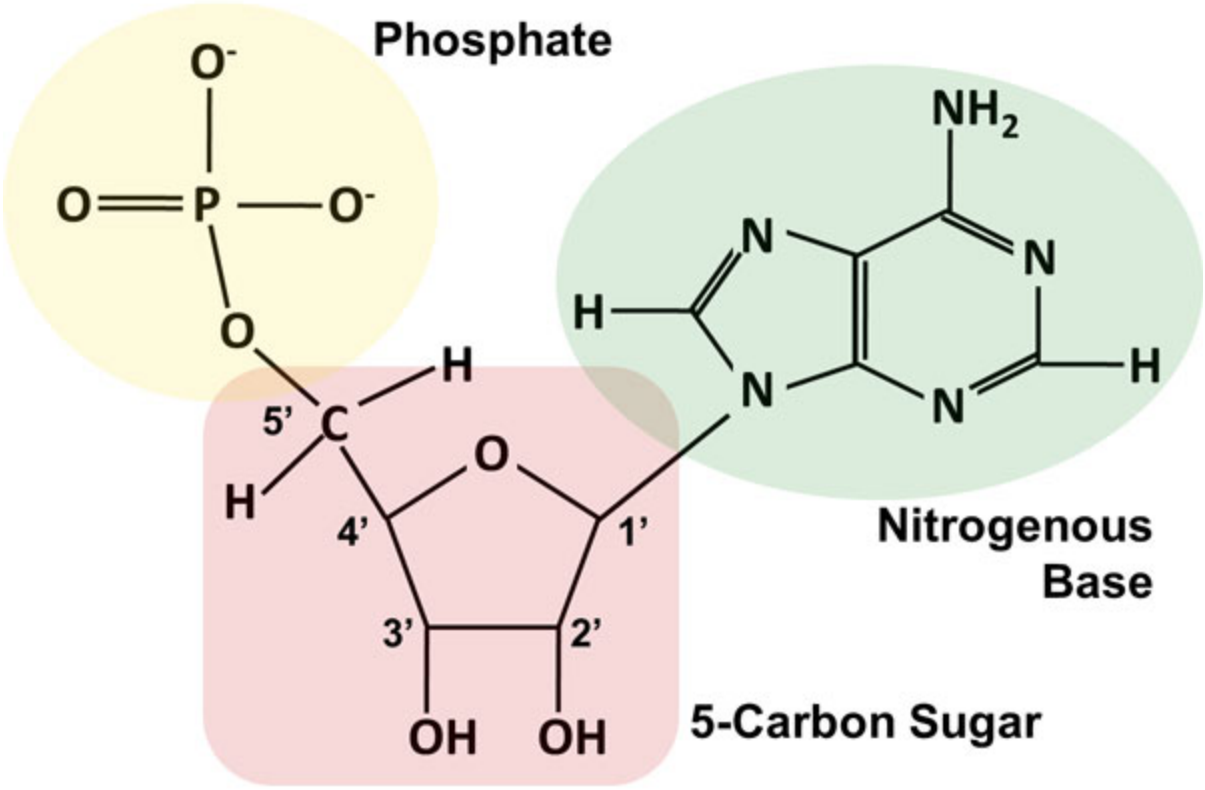
Key terms:

1. **Replication**: Replication is the process by which DNA molecules make exact copies of themselves. It is a fundamental process in biology, occurring during cell division, and ensures that genetic information is passed accurately from one generation to the next.
2. **Heredity**: Heredity is the passing on of traits from parents to offspring through genetic information encoded in DNA. These traits can include physical characteristics, such as eye color or height, as well as predispositions to certain diseases. Heredity is responsible for the similarities between parents and their offspring.
3. **DNA Helix**: The DNA helix refers to the double-stranded structure of DNA, which resembles a twisted ladder. Each strand of the helix consists of a sequence of nucleotides made up of a sugar-phosphate backbone and nitrogenous bases (adenine, thymine, cytosine, and guanine). The two strands are held together by hydrogen bonds between complementary base pairs (A-T and C-G).
4. **Semi-conservative**: Semi-conservative replication is a type of DNA replication where each newly synthesized DNA molecule contains one original

(parental) strand and one newly synthesized (daughter) strand. This process ensures that genetic information is faithfully copied and passed on to daughter cells during cell division.

Nucleotide:

A nucleotide is a molecule that serves as the basic building block of nucleic acids like DNA and RNA. It consists of three main parts:



1. **Phosphate Group**: This is a group of atoms containing phosphorus and oxygen, bonded together in a specific arrangement. In a nucleotide, the phosphate group is attached to the sugar molecule.
2. **Sugar Molecule**: In DNA, the sugar molecule is deoxyribose, while in RNA, it is ribose. This sugar molecule has a five-carbon structure and forms the backbone of the nucleic acid chain. The nitrogenous base is attached to one of the carbon atoms in the sugar molecule.

3. **Nitrogenous Base**: This is a nitrogen-containing molecule that forms the "code" or sequence in nucleic acids. There are four types of nitrogenous bases found in DNA: adenine (A), thymine (T), cytosine (C), and guanine (G). In RNA, uracil (U) replaces thymine. The nitrogenous base is attached to the sugar molecule at one of its carbon atoms.

The role of DNA:

DNA (deoxyribonucleic acid) plays a critical role in our bodies as the molecule that carries the genetic instructions necessary for the growth, development, functioning, and reproduction of all known living organisms. Here are some key roles of DNA in our bodies:

1. **Genetic Information**: DNA contains the genetic information that determines an organism's traits. This information is encoded in the sequence of nitrogenous bases (adenine, thymine, cytosine, and guanine) along the DNA molecule. The specific sequence of bases in a gene determines the sequence of amino acids in a protein, which ultimately determines an organism's characteristics.
2. **Protein Synthesis**: DNA serves as the template for protein synthesis. Genes, which are specific sequences of DNA, are transcribed into messenger RNA (mRNA) through a process called transcription. The mRNA carries the genetic information from the DNA to the ribosomes, where it is translated into a specific sequence of amino acids to form proteins. Proteins are essential for the structure, function, and regulation of the body's cells and tissues.
3. **Cellular Replication**: During cell division, DNA is replicated to ensure that each new cell receives an identical copy of the genetic information. This process, known as DNA replication, is crucial for the growth and repair of tissues and organs in the body.
4. **Inheritance**: DNA is passed from parents to offspring during reproduction, ensuring that genetic information is transmitted from one generation to the next. Offspring inherit a combination of DNA from both parents, resulting in genetic variation.
5. **Regulation of Gene Expression**: DNA plays a role in regulating gene expression, determining when and to what extent genes are turned on or off in response to internal and external cues. This regulation is essential for

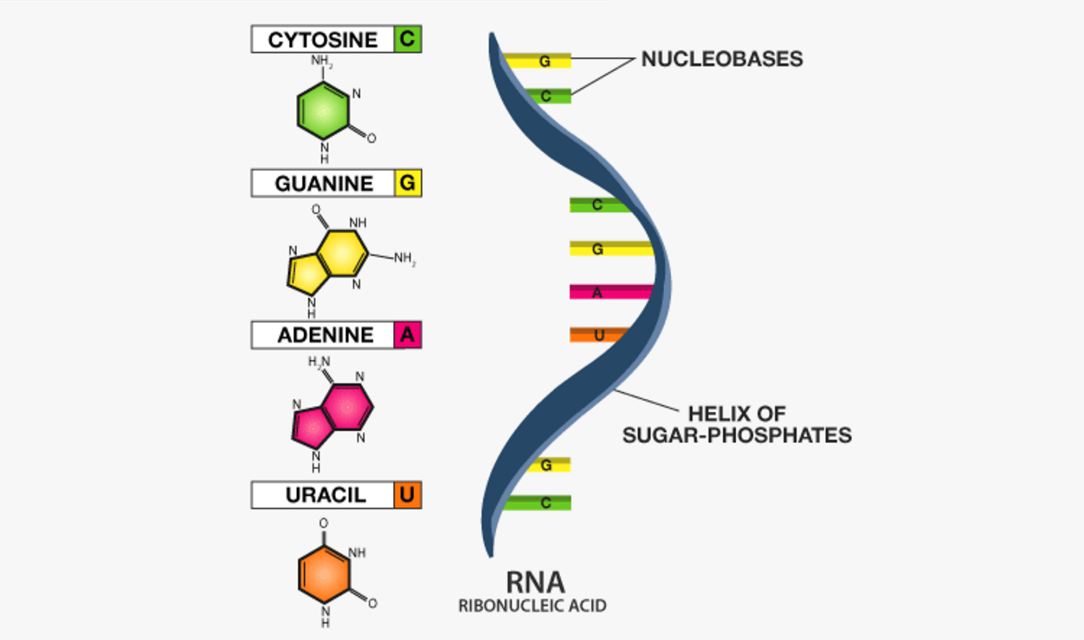
controlling the development, differentiation, and functioning of cells in the body.

DNA Replication:

DNA replication is the process by which a cell makes an identical copy of its DNA. It is a fundamental process in biology, essential for cell division, growth, and repair.

1. **Initiation**: Replication begins at specific sites called origins of replication, where the DNA double helix is unwound.
2. **Unwinding**: Enzymes called helicases unwind and separate the DNA double helix into two separate strands, creating replication forks.
3. **Primer Binding**: RNA primers are synthesized by an enzyme called primase. These primers provide a starting point for DNA polymerase to begin synthesizing new DNA strands.
4. **Elongation**: DNA polymerase adds complementary nucleotides to the template strands, following the rules of base pairing (A with T, and C with G). The leading strand is synthesized continuously in the 5' to 3' direction, while the lagging strand is synthesized discontinuously in short fragments called Okazaki fragments.
5. **Proofreading**: DNA polymerase has proofreading capabilities and can detect and correct errors that occur during replication. Incorrect nucleotides are removed, and the correct ones are added to maintain accuracy.
6. **Ligase Action**: DNA ligase joins the Okazaki fragments on the lagging strand by catalyzing the formation of phosphodiester bonds, creating a continuous strand.
7. **Termination**: Replication proceeds bidirectionally from each origin of replication until the entire DNA molecule is copied. The process continues until replication forks from adjacent origins meet and terminate.

RNA:

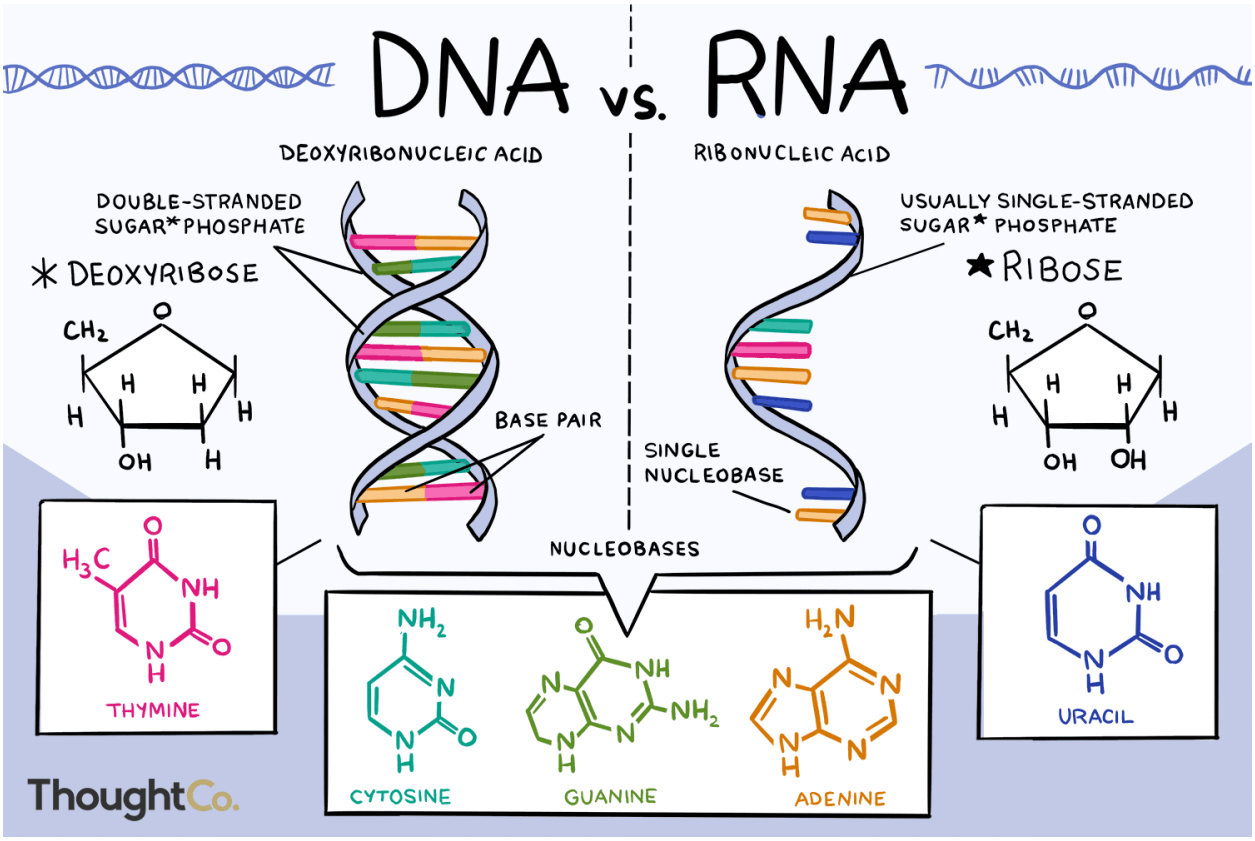


RNA, or ribonucleic acid, is a molecule that plays a crucial role in various cellular processes, including protein synthesis, gene regulation, and the transmission of genetic information. Like DNA, RNA is composed of nucleotides, which consist of a sugar molecule (ribose), a phosphate group, and one of four nitrogenous bases: adenine (A), cytosine (C), guanine (G), and uracil (U).

Role of RNA:

1. **Messenger RNA (mRNA)**: mRNA carries genetic information from the DNA in the cell nucleus to the ribosomes in the cytoplasm, where proteins are synthesized. It serves as a template for protein synthesis by specifying the sequence of amino acids that make up a protein.
2. **Transfer RNA (tRNA)**: tRNA functions as an adapter molecule that brings amino acids to the ribosomes during protein synthesis. Each tRNA molecule carries a specific amino acid and recognizes the corresponding codon on the mRNA, ensuring that the correct amino acids are added to the growing polypeptide chain.
3. **Ribosomal RNA (rRNA)**: rRNA is a structural component of ribosomes, the cellular organelles responsible for protein synthesis. It helps catalyze the formation of peptide bonds between amino acids during translation, the process of protein synthesis.

RNA vs. DNA:



DNA (Deoxyribonucleic acid)	RNA (Ribonucleic acid)
Definition	
It is a long polymer. It has a deoxyribose and phosphate backbone having four distinct bases: thymine, adenine, cytosine, and guanine.	Is a polymer with a ribose and phosphate backbone with four varying bases: uracil, cytosine, adenine, and guanine.
Location	
It is located in the nucleus of a cell and the mitochondria.	It is found in the cytoplasm, nucleus and the ribosome.
Sugar portion	
It has 2-deoxyribose.	It has Ribose.
Function	
The function of DNA is the transmission of genetic information. It acts as a medium for	RNA is critical for the transmission of the genetic code that is necessary for protein

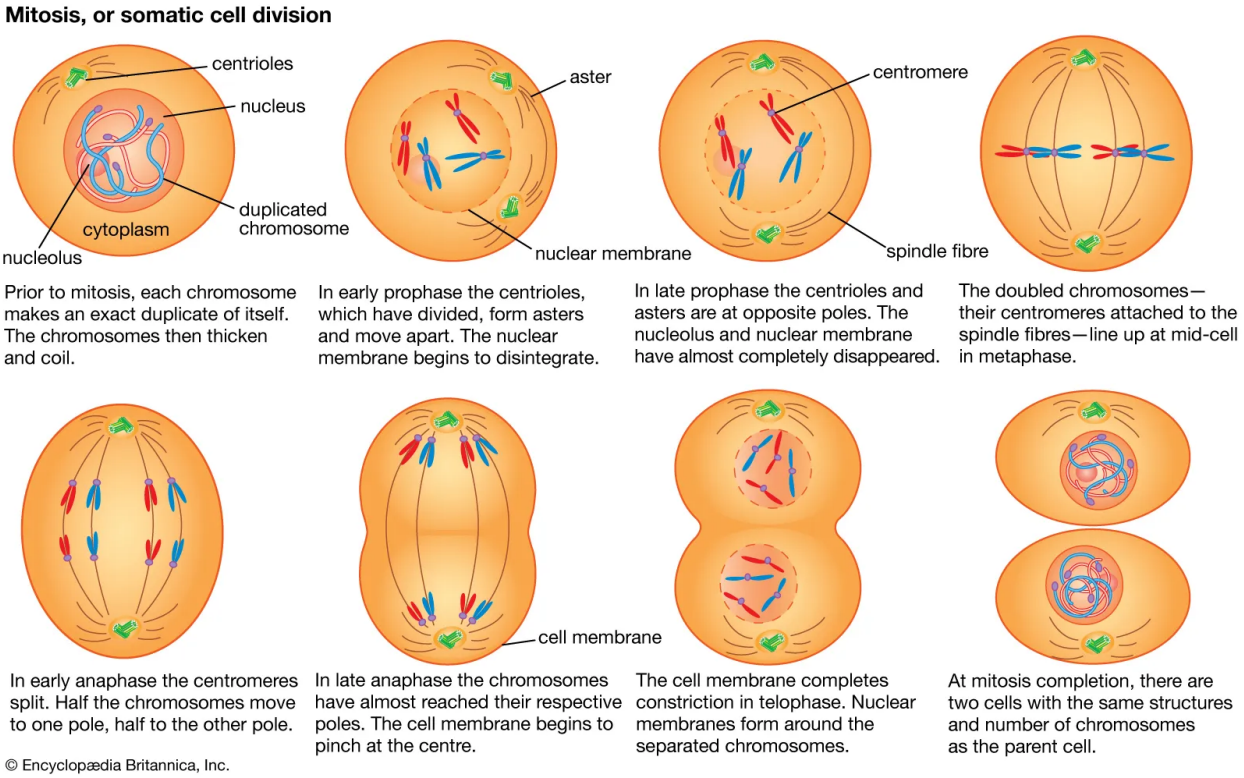
long-term storage.	creation from the nucleus to the ribosome.
Predominant Structure	
DNA is a double-stranded molecule that has a long chain of nucleotides.	RNA is a single-stranded molecule which has a shorter chain of nucleotides.
Propagation	
DNA replicates on its own, it is self-replicating.	RNA does not replicate on its own. It is synthesized from DNA when required.
Nitrogenous Bases and Pairing	
The base pairing is as follows: GC (Guanine pairs with Cytosine) A-T (Adenine pairs with Thymine).	The base pairing is as follows: GC (Guanine pairs with Cytosine) A-U (Adenine pairs with Uracil).

Cell Division:

Mitosis:

Video: https://www.youtube.com/watch?v=f-ldPgEfAHI

Mitosis is a process of cell division in which a single cell divides into two identical daughter cells, each containing the same number of chromosomes as the parent cell. It is a fundamental process for growth, development, and tissue repair in multicellular organisms. Mitosis consists of several stages: prophase, metaphase, anaphase, and telophase.



1. **Prophase**:
    - Chromatin condenses into visible chromosomes.
    - The nuclear envelope breaks down, allowing the spindle fibers to access the chromosomes.
    - Spindle fibers, composed of microtubules, begin to form and extend from opposite ends of the cell, called centrosomes or spindle poles.
    - The centrosomes move towards opposite ends of the cell, and the spindle fibers attach to the centromeres of the chromosomes.
2. **Metaphase**:
    - The chromosomes align along the metaphase plate, which is an imaginary plane equidistant between the two spindle poles.
    - Each chromosome is attached to spindle fibers from opposite poles at its centromere.
3. **Anaphase**:

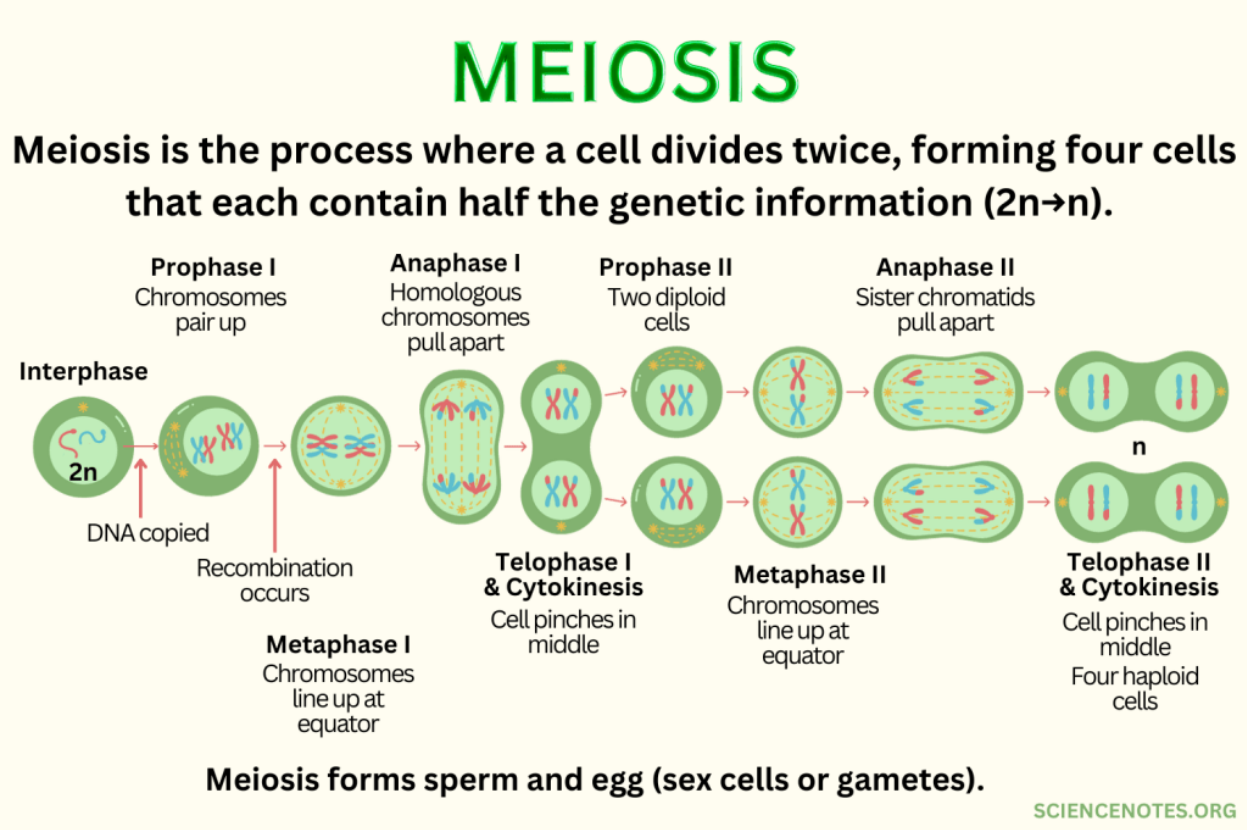
- Sister chromatids, which are held together at the centromere, are pulled apart towards opposite poles of the cell by the shortening spindle fibers.
- As the sister chromatids separate, they are now considered individual chromosomes.
- The cell elongates as the spindle fibers continue to push the poles apart.

4. **Telophase**:
    - The separated chromosomes arrive at opposite poles of the cell.
    - Nuclear envelopes form around each set of chromosomes, creating two distinct nuclei.
    - The chromosomes begin to decondense, returning to their less tightly coiled chromatin form.
    - The spindle fibers disassemble, and the cell prepares for cytokinesis.

After telophase, cytokinesis typically follows, which is the division of the cytoplasm and the formation of two separate daughter cells. This process completes the cell division, resulting in two genetically identical daughter cells, each with a complete set of chromosomes.

Meiosis:

Video: https://www.youtube.com/watch?v=kQu6Yfrr6j0



Meiosis is a specialized type of cell division that occurs in sexually reproducing organisms to produce gametes (sperm and egg cells) with half the number of chromosomes found in somatic (non-reproductive) cells. It consists of two sequential divisions, known as meiosis I and meiosis II, resulting in the formation of four haploid daughter cells.

Meiosis plays a crucial role in sexual reproduction by introducing genetic variation through processes such as crossing over and independent assortment. The genetic diversity generated during meiosis contributes to the variability observed in offspring and is essential for the survival and evolution of sexually reproducing organisms.

1. **Meiosis I**:
    - **Prophase I**:
        - Chromatin condenses into visible chromosomes, and homologous chromosomes pair up to form bivalents or tetrads.

    - Crossing over occurs, where genetic material is exchanged between non-sister chromatids of homologous chromosomes, leading to genetic recombination.
    - The nuclear envelope breaks down, and spindle fibers begin to form.
- **Metaphase I**:
    - Homologous chromosome pairs line up along the metaphase plate, with one chromosome from each pair facing opposite poles of the cell.
    - Spindle fibers attach to the centromeres of each chromosome.
- **Anaphase I**:
    - Homologous chromosomes separate and move towards opposite poles of the cell, pulled by spindle fibers.
    - Sister chromatids remain attached at their centromeres.
- **Telophase I**:
    - Chromosomes arrive at opposite poles of the cell, and nuclear envelopes may begin to reform.
    - Cytokinesis often follows, dividing the cell into two daughter cells, each with a haploid set of chromosomes (half the number of chromosomes as the parent cell).

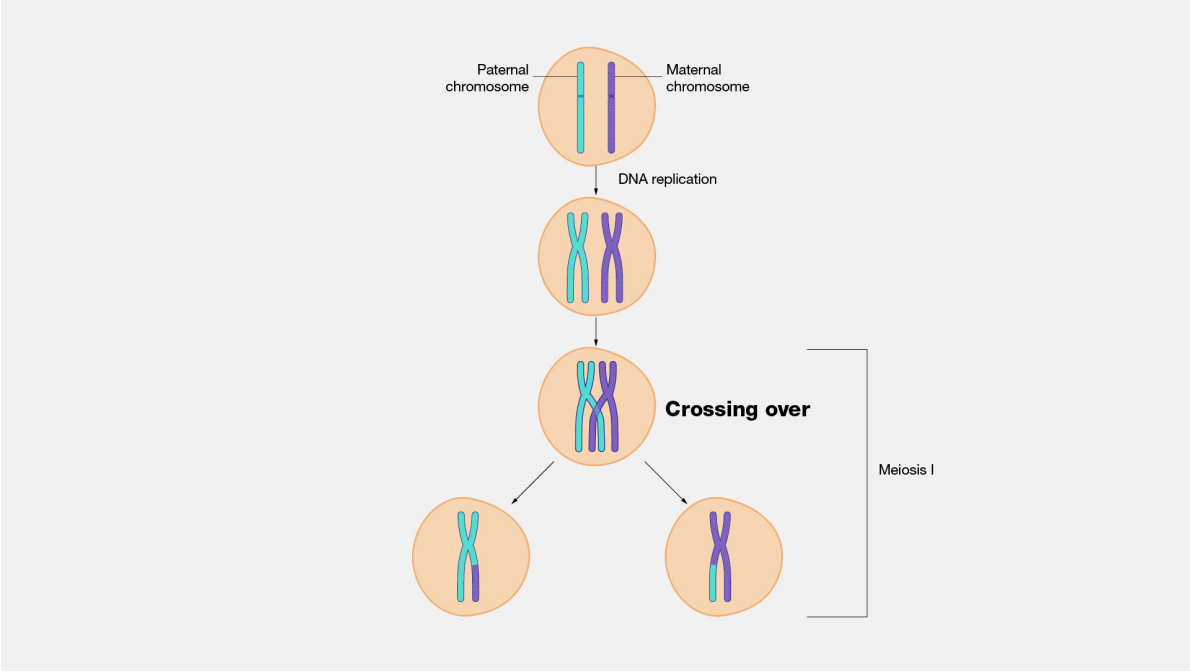
2. **Meiosis II**:
    - **Prophase II**:
        - If nuclear envelopes formed during telophase I, they break down again.
        - Spindle fibers reappear and begin to organize the chromosomes.
    - **Metaphase II**:
        - Chromosomes align along the metaphase plate in each daughter cell.
        - Spindle fibers attach to the centromeres of the sister chromatids.
    - **Anaphase II**:

- Sister chromatids separate and move towards opposite poles of the cell, pulled by spindle fibers.

- **Telophase II**:
  - Chromosomes arrive at opposite poles of the cell, and nuclear envelopes begin to reform around the separated chromosomes.
  - Cytokinesis follows, resulting in the formation of four haploid daughter cells, each with a unique combination of genetic material due to crossing over and independent assortment during meiosis I.

Importance of Crossing Over:

Crossing over is a process that occurs during prophase I of meiosis, where genetic material is exchanged between non-sister chromatids of homologous chromosomes. It promotes genetic diversity by creating new combinations of alleles on chromosomes. During crossing over, homologous chromosomes pair up to form bivalents or tetrads.



Protein complexes called synaptonemal complexes hold the homologous chromosomes together. At specific points along the chromosomes called chiasmata, segments of chromatids break and exchange places with corresponding segments of chromatids on the adjacent chromosome.

This exchange results in the recombination of genetic material between homologous chromosomes. Crossing over increases genetic diversity among offspring by generating new combinations of alleles on chromosomes, contributing to the variability observed in sexually reproducing organisms.

Mitosis vs. Meiosis:

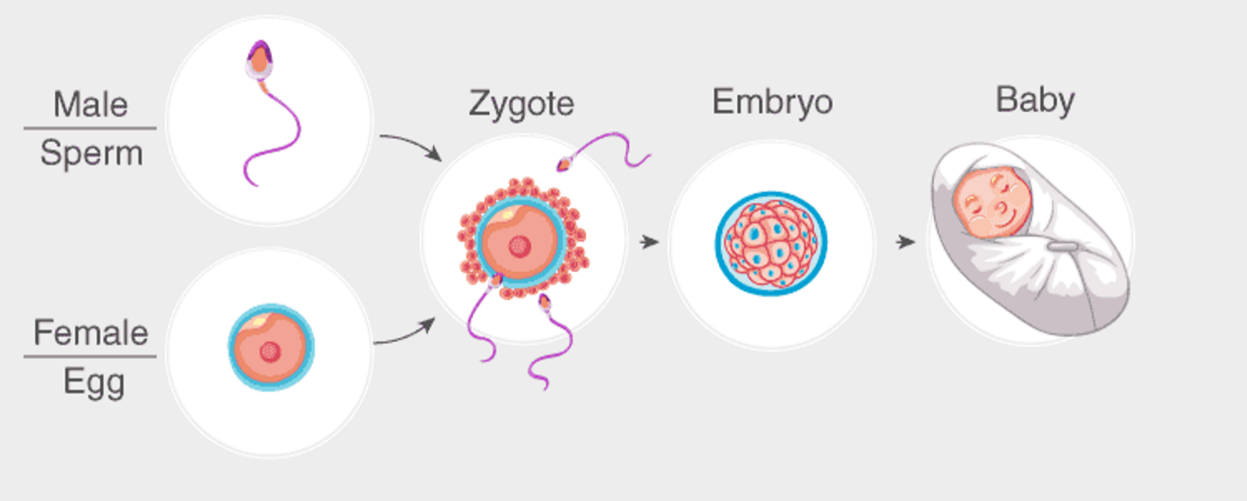
Difference between Mitosis and Meiosis	
Mitosis	**Meiosis**
Interphase	
Each chromosome replicates during the S phase of the interphase. The result is two genetically identical sister chromatids (However, do note that interphase is technically not a part of mitosis because it takes place between one mitotic phase and the next).	Chromosomes not yet visible but DNA has been duplicated or replicated.
Prophase	
Prophase –Each of the duplicated chromosomes appears as two identical or equal sister chromatids. The mitotic spindle begins to form. Chromosomes condense and thicken.	Prophase I – crossing-over and recombination – Homologous chromosomes (each consists of two sister chromatids) appear together as pairs. Tetrad or bivalent is the structure that is formed. Segments of chromosomes are exchanged between non-sister chromatids at crossover points known as chiasmata (crossing-over).
Metaphase	
Metaphase -The chromosomes assemble at the equator at the metaphase plate.	Metaphase I – Chromosomes adjust on the metaphase plate. Chromosomes are still intact and arranged as pairs of homologues (bivalent).
Anaphase	
Anaphase – The spindle fibres begin to contract. This starts to pull the sister chromatids apart. At the end of anaphase,	Anaphase I – Sister chromatids stay intact. However, homologous chromosomes drift to the opposite or reverse poles.

a complete set of daughter chromosomes is found on each pole.	
Mode of Reproduction	
Asexual Reproduction	Sexual Reproduction
Occurrence	
All the cells	Reproductive cells
Function	
General growth and repair, Cell reproduction	Genetic diversity through sexual reproduction
Cytokinesis	
Occurs in Telophase	Occurs in Telophase I and in Telophase II
Discovered by	
Walther Flemming	Oscar Hertwig

Reproduction:

1. **Reproduction**: It's the biological process by which organisms generate offspring, ensuring the continuation of their species. It can occur through sexual or asexual means.
2. **Human Reproduction**:
    - **Sexual Reproduction**: Involves the union of sperm (produced in testes) and egg (produced in ovaries) to form a zygote.

Begins with the formation of haploid gametes through meiosis.
Fertilization typically occurs in the fallopian tubes.



The zygote develops into an embryo, which implants in the uterine wall and grows into a fetus.

- Childbirth or delivery results in the birth of the offspring.

Asexual Reproduction: Rare in humans; may occur through medical interventions like cloning.

3.

Importance: Reproduction ensures species survival, contributes to genetic diversity, and influences social and cultural structures.

IVF:

Video: https://www.youtube.com/watch?v=fnYBLYfFx2Y

1. **Definition**:
   - IVF (In Vitro Fertilization) is a fertility treatment where eggs are retrieved from the ovaries and fertilized with sperm in a laboratory dish.
2. **Procedure**:
   - Ovarian stimulation: Hormonal medications are administered to stimulate the ovaries to produce multiple eggs.
   - Egg retrieval: Mature eggs are collected from the ovaries using a needle guided by ultrasound.

- Fertilization: The collected eggs are fertilized with sperm in a laboratory dish.
- Embryo culture: Fertilized eggs develop into embryos in the laboratory for a few days.
- Embryo transfer: One or more embryos are transferred into the woman's uterus using a thin catheter.

3. **Indications**:
    - IVF is used for infertility issues such as blocked fallopian tubes, male infertility, ovulation disorders, and unexplained infertility.
4. **Success Rates**:
    - Success rates vary based on factors like the woman's age, cause of infertility, and number of embryos transferred.
5. **Ethical Considerations**:
    - Ethical concerns include the creation, selection, and disposition of embryos, as well as the emotional and psychological impact on individuals and families.
6. **Cost and Accessibility**:
    - IVF can be expensive and may not be covered by insurance. Access may also be limited by legal and regulatory restrictions, as well as financial constraints.

How do Different Organisms reproduce:

Asexual Reproduction:

- **Binary Fission**: Single-celled organisms like bacteria and protists divide into two identical daughter cells.
- **Budding**: Small outgrowths (buds) develop on the parent organism and detach to form new individuals.
- **Fragmentation**: The parent organism breaks into fragments, each capable of developing into a new individual.

- **Parthenogenesis**: Unfertilized eggs develop into offspring without sperm in some insects, reptiles, and fish.

Sexual Reproduction:

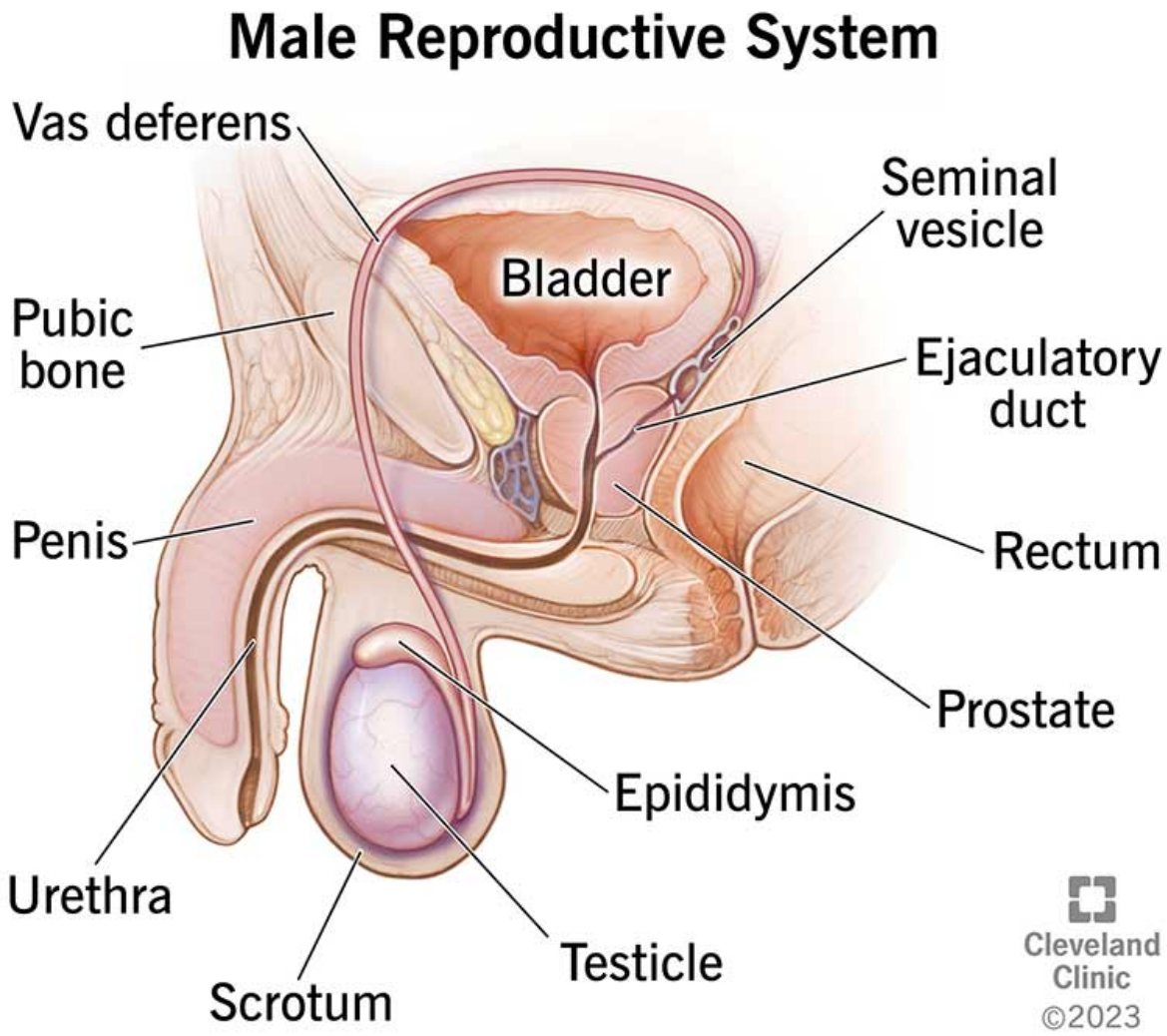
- **External Fertilization**: Eggs and sperm are released into the water for fertilization, common in fish, amphibians, and many invertebrates.
- **Internal Fertilization**: Fertilization occurs inside the female's body, common in mammals, birds, and some reptiles, and insects.
- **Hermaphroditism**: Individuals possess both male and female reproductive organs, allowing for self-fertilization or cross-fertilization.
- **Pollination**: Transfer of pollen containing male gametes from anthers to the stigma of flowers in flowering plants, leading to fertilization and seed production.

Sexual vs. Asexual Reproduction:

Asexual Reproduction	Sexual Reproduction
Occurs in prokaryotic microorganisms and some eukaryotic unicellular and multicellular organisms, lower invertebrates, and plants	Occurs almost in all types of multicellular organisms including humans, animals, and higher plants.
It is uniparental.	It is usually bi-parental.
Gametes are not formed.	Gametes are formed.
Somatic cells of parents are involved.	Germ cells of parents are involved.
No fertilization occurs.	Fertilization takes place.
No involvement of reproductive organs.	Presence of fully developed reproductive organs.
Only mitosis type of cell division occurs.	Both meiosis and mitosis type of cell division occur.
The progeny and the parent are genetically identical.	The progenies will be genetically different from the parents.
Characteristics of only one parent are inherited.	Characteristics of both parents are inherited.

Male and Female Reproductive System:

Male Reproductive System:

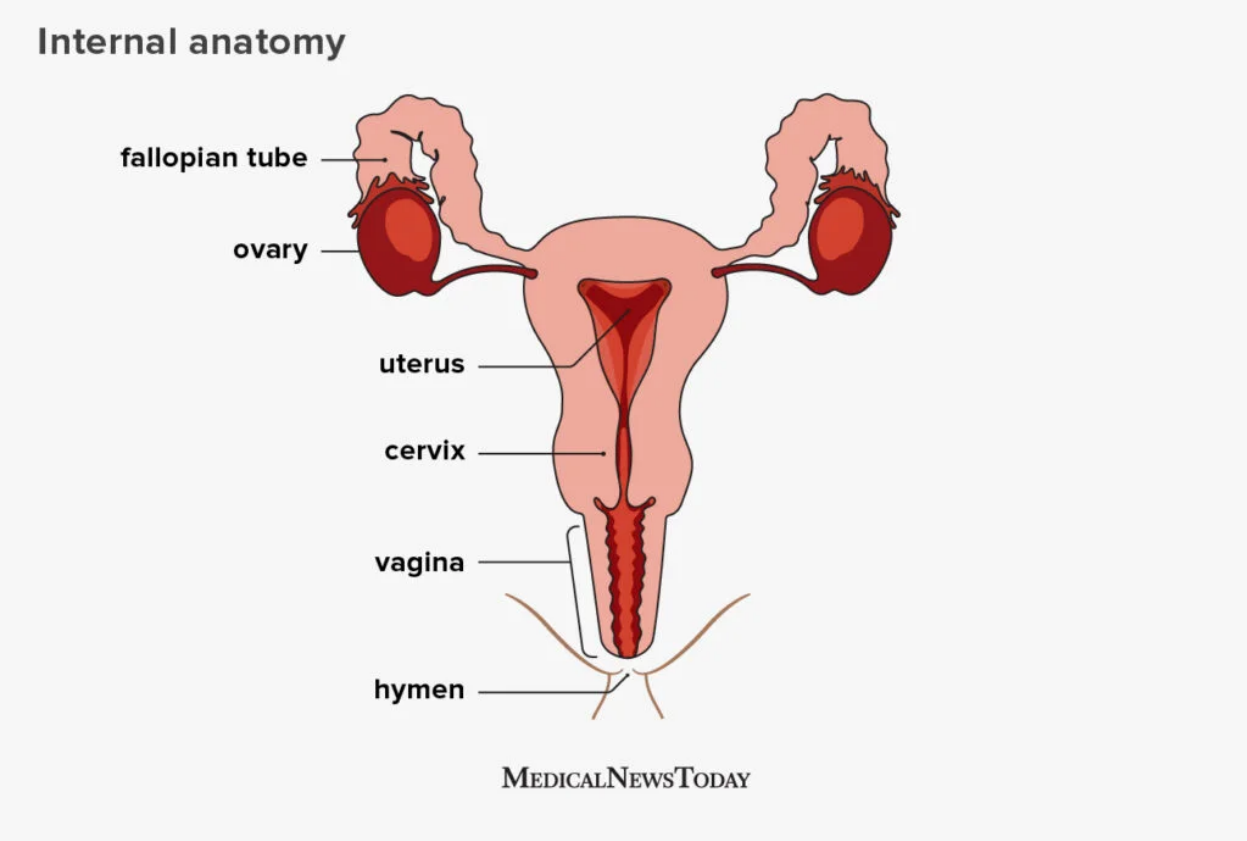


1. **Testes**:
    - Paired organs are located in the scrotum outside the body cavity.
    - Site of sperm production (spermatogenesis) and testosterone secretion.
2. **Scrotum**:
    - The external sac that houses the testes.

- Helps regulate the temperature of the testes for optimal sperm production.

3. **Epididymis**:
    - A coiled tube is attached to the testes where sperm mature and are stored.
4. **Vas Deferens**:
    - Muscular tube that transports mature sperm from the epididymis to the ejaculatory duct during ejaculation.
5. **Seminal Vesicles, Prostate Gland, and Bulbourethral Glands**:
    - Accessory glands produce seminal fluid, which nourishes and transports sperm during ejaculation.
6. **Urethra**:
    - The tube that carries semen and urine out of the body through the penis.
7. **Penis**:
    - External male reproductive organ.
    - Contains the urethra and is responsible for delivering semen into the female reproductive tract during intercourse.

Female Reproductive System:



1. **Ovaries**:
    - Paired organs are located in the pelvic cavity.
    - Site of egg (ovum) production and hormone secretion (estrogen and progesterone).
2. **Fallopian Tubes (Oviducts)**:
    - Pair of tubes that transport eggs from the ovaries to the uterus.
    - Site of fertilization, where sperm meet and fertilize the egg.
3. **Uterus (Womb)**:
    - The hollow, muscular organ where a fertilized egg implants and develops into a fetus during pregnancy.
    - Composed of the fundus, body, and cervix.
4. **Cervix**:
    - The lower part of the uterus that connects to the vagina.

- Secretes mucus to facilitate sperm transport and serves as a barrier to pathogens.

5. **Vagina**:
    - Muscular tube that connects the cervix to the external genitalia.
    - Receives the penis during sexual intercourse and serves as the birth canal during childbirth.
6. **Labia Majora and Labia Minora**:
    - Outer and inner folds of skin surrounding the vaginal opening.
    - Help protect the vaginal and urethral openings.
7. **Clitoris**:
    - A small, sensitive organ is located at the top of the vulva.
    - Contains erectile tissue and plays a role in sexual arousal.

Reproduction as a Process:

Video: https://www.youtube.com/watch?v=J1Sgkpc-iLM

1. **Gamete Production**:
    - The male reproductive system produces sperm in the testes, while the female reproductive system produces eggs (ova) in the ovaries.
    - Sperm and eggs are specialized sex cells, or gametes, that carry genetic material necessary for fertilization.
2. **Fertilization**:
    - During sexual intercourse, sperm are ejaculated into the female reproductive tract and travel through the cervix and uterus to reach the fallopian tubes.
    - In the fallopian tubes, sperm encounter and fertilize an egg if one is present. Fertilization typically occurs in the ampullary region of the fallopian tube.
    - Fertilization results in the formation of a zygote, which is the initial stage of embryo development.

3. **Embryo Development**:
    - After fertilization, the zygote undergoes cell division and development as it travels down the fallopian tube towards the uterus.
    - Once the embryo reaches the uterus, it implants into the uterine lining and continues to develop into a fetus.
4. **Pregnancy**:
    - The female reproductive system supports the developing fetus throughout pregnancy by providing nutrients and a protective environment.
    - Hormonal changes in both the male and female reproductive systems play crucial roles in maintaining pregnancy and preparing for childbirth.
5. **Childbirth**:
    - During childbirth, contractions of the uterine muscles help push the fetus through the birth canal (vagina) and out of the body.
    - The male reproductive system does not directly participate in childbirth but may provide emotional and physical support to the female partner during labor and delivery.