Animal Genetics and Breeding

Section: Genetics (Unit II)

Overview of the Section

L1: The Cell Cycle – Mitosis, Meiosis, and Gametogenesis
  MCQs 1: The Cell Cycle

L2: Basic Genetics: Mendelian, Non-Mendelian, Advanced Genetics Concepts
MCQs 1: Basic Genetics

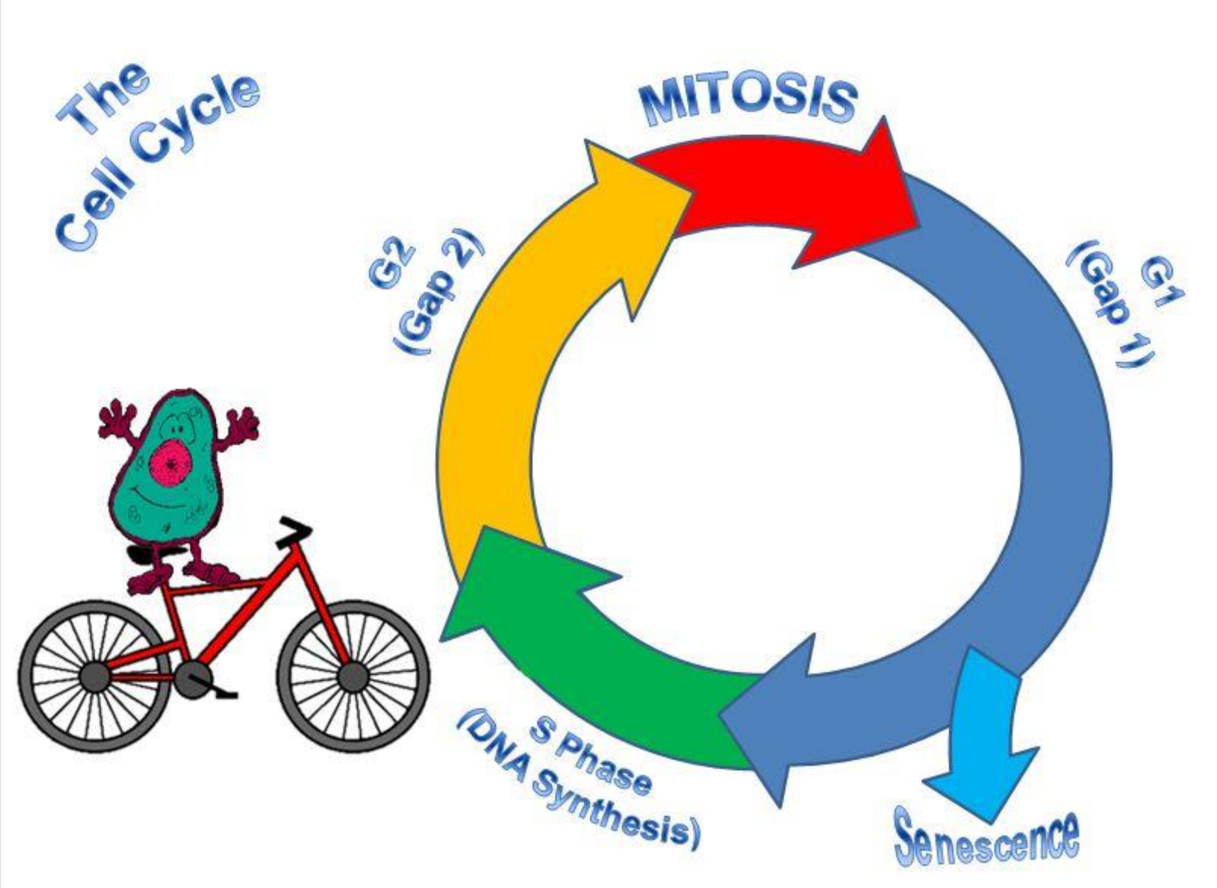
L3: Population Genetics: Gene frequencies & Hardy Weinberg Equilibrium
  MCQs 2: Population Genetics

L4: Quantitative Genetics: Heritability, Repeatability, Correlation
  MCQs 3: Quantitative Genetics

Section: Genetics (Unit II)

Overview of the Section

THE CELL CYCLE



The sequence of events a cell undergoes as it grows and divides.

Two main phases:

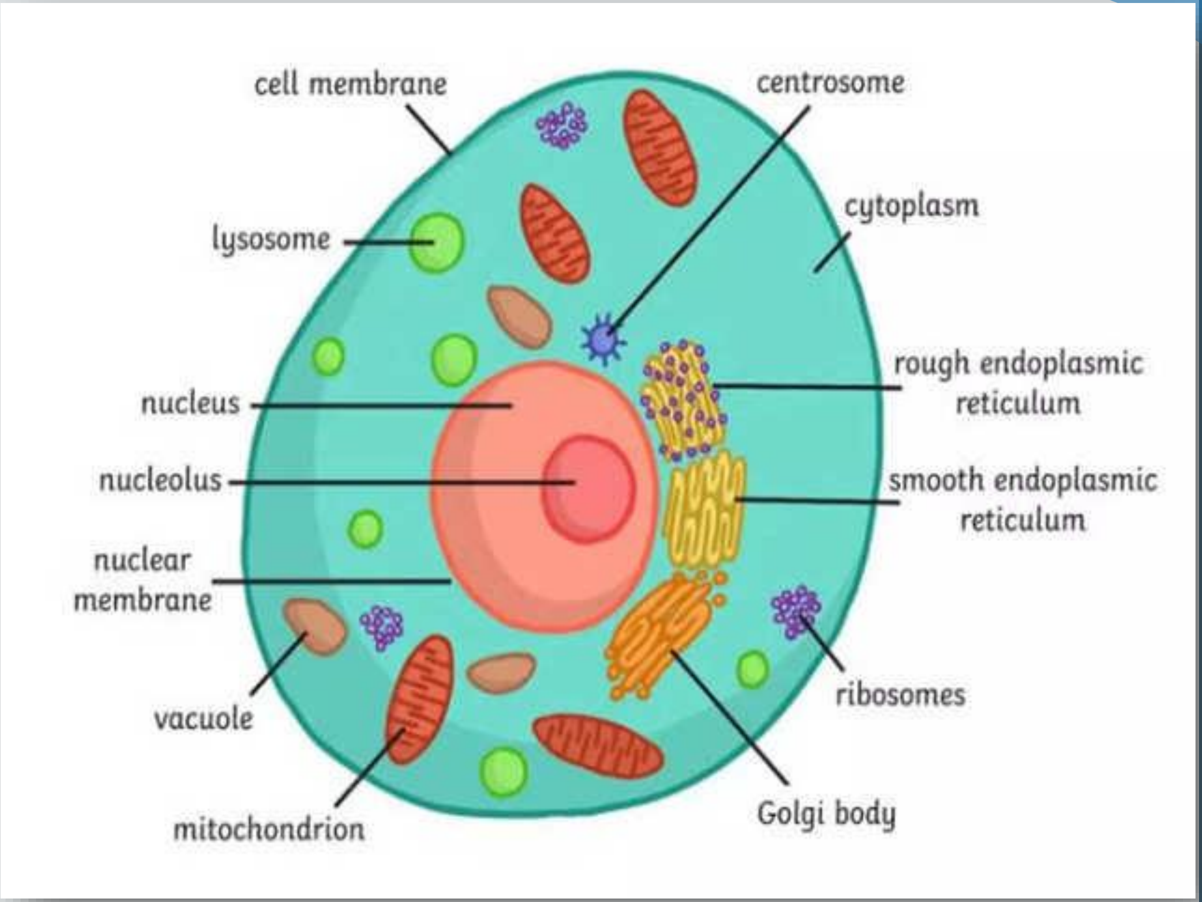
1. Interphase
2. Mitosis

THE CELL CYCLE

CELL

Cell – Basic structural and functional unit of life

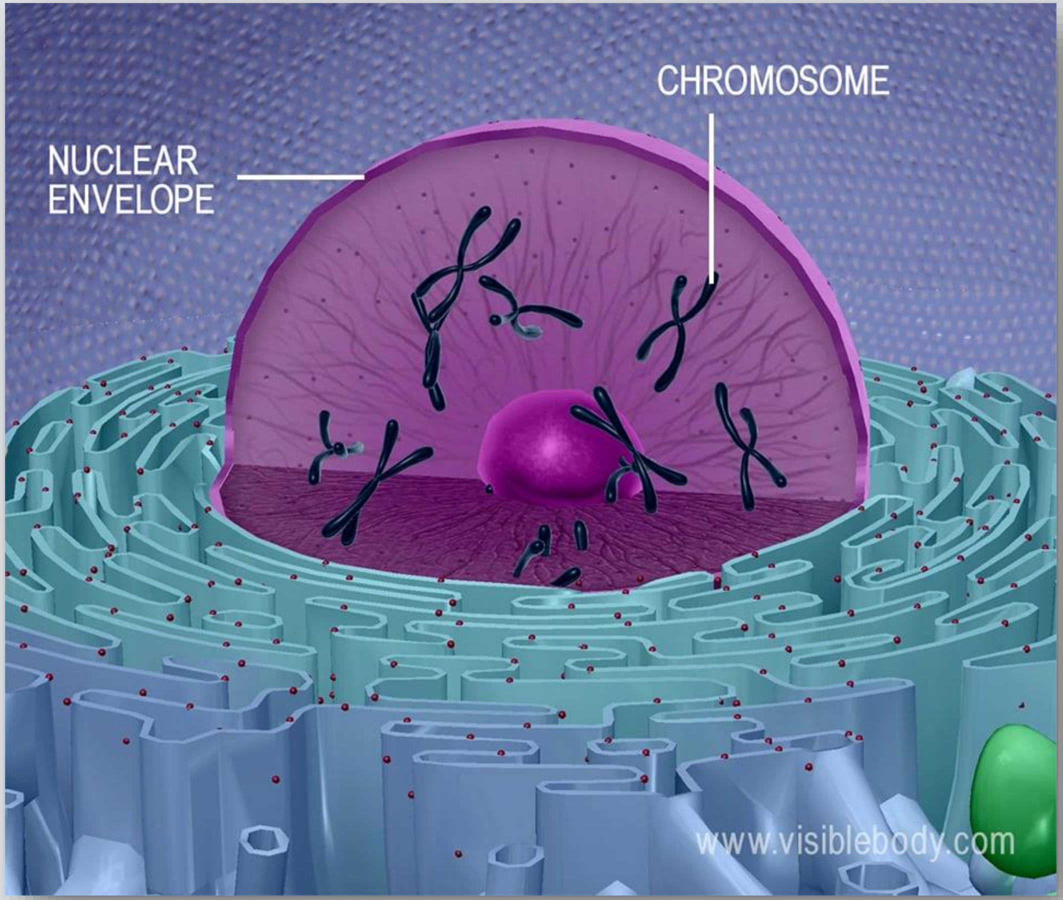
- Cell contents – called protoplasm
- Contains organelles – req. for functioning
- Cytoplasm = cytosol + suspended organelles
- Centriole – Barrel shaped self-replicating organelles – Involved in organization of mitotic spindle and completion of cytokinesis during cell division



THE CELL CYCLE

NUCLEUS

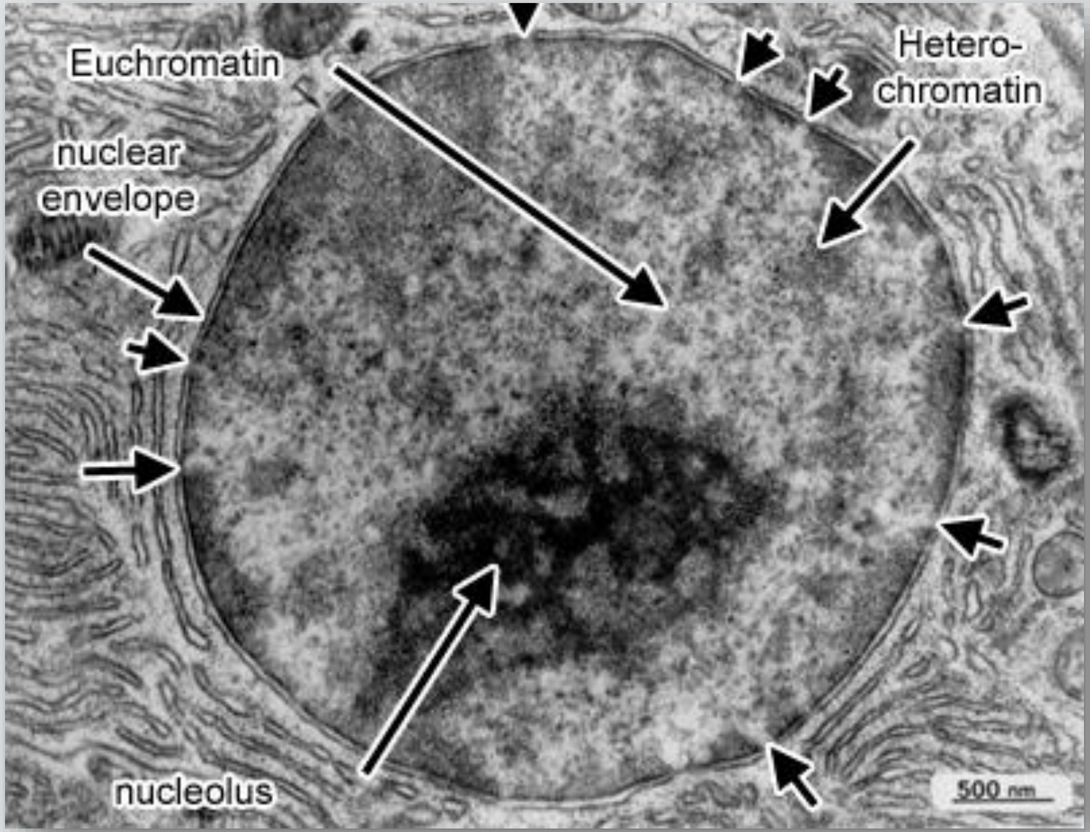
- Enclosed by nuclear envelope
- Contains nucleolus & nucleoplasm
- Contains the cell's genetic material (DNA) in a complex with histones – in the form of chromosomes
- Similar DNA present in all body cells – but depending on cell type, certain genes are turned 'on' or 'off' – creating differences within two different types of cells



THE CELL CYCLE

NUCLEUS

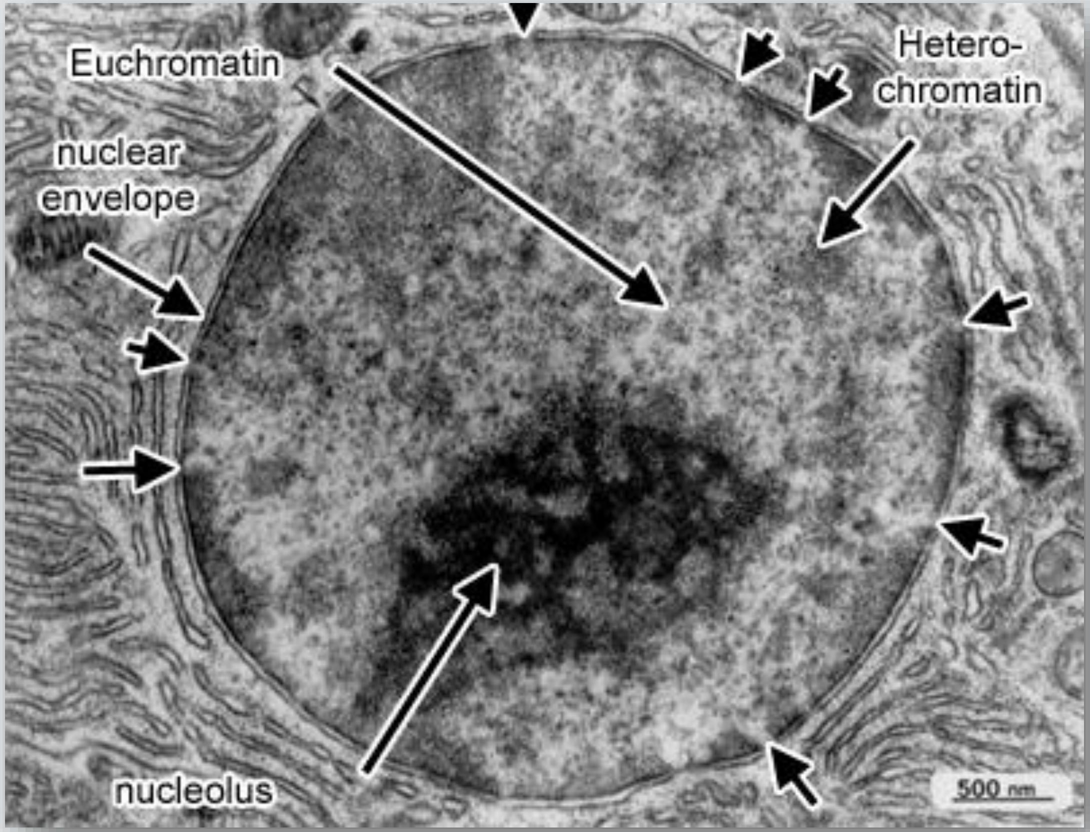
- Nuclear envelope –
  - Perinuclear envelope/ nucleolemma / karyotheca
  - Double membrane
  - Separates DNA from cytosol
  - Outer membrane continuous with RER
  - Space between two nuclear membranes – perinuclear space / cisterna
- Nucleolus – no membrane – involved in ribosome biogenesis and assembly



THE CELL CYCLE

CHROMOSOMES

- Thread-like self-replicating genetic structure in the nucleus
- One chromosome = One DNA molecule
- Two types –
  - autosomes
  - sex chromosomes (gynosomes)
- Chromosome number – remains constant for each species



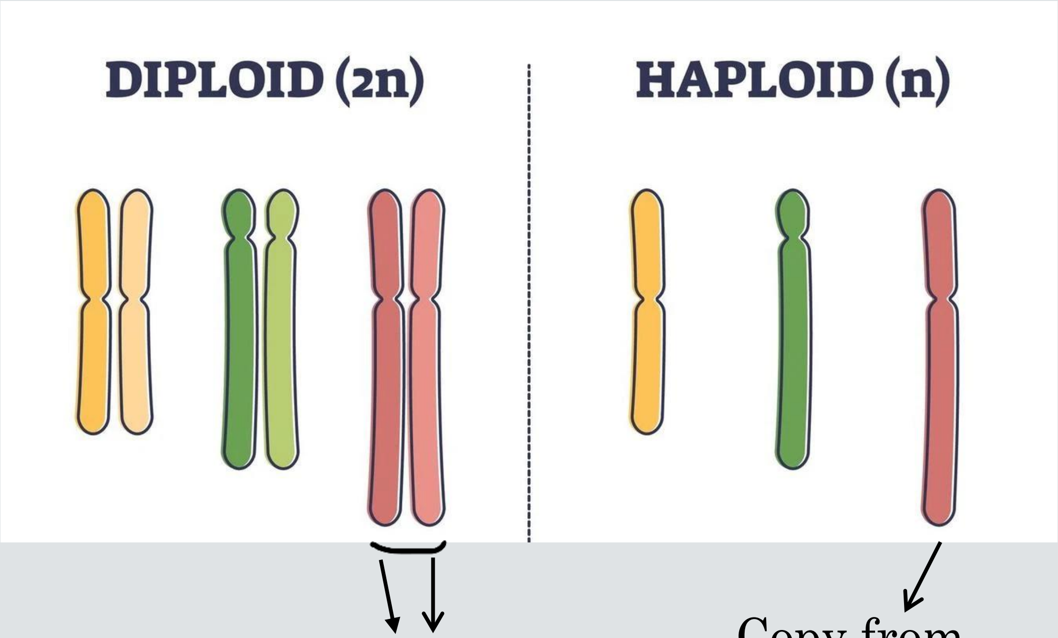
THE CELL CYCLE

CHROMOSOMES

Chromosome numbers

Haploid vs Diploid

Normal cell state	Diploid chromosome number (2n)
Gametes	Haploid chromosomes (n)



Homologous chromosomes

Copy from one parent

THE CELL CYCLE

CHROMOSOMES

Chromatid

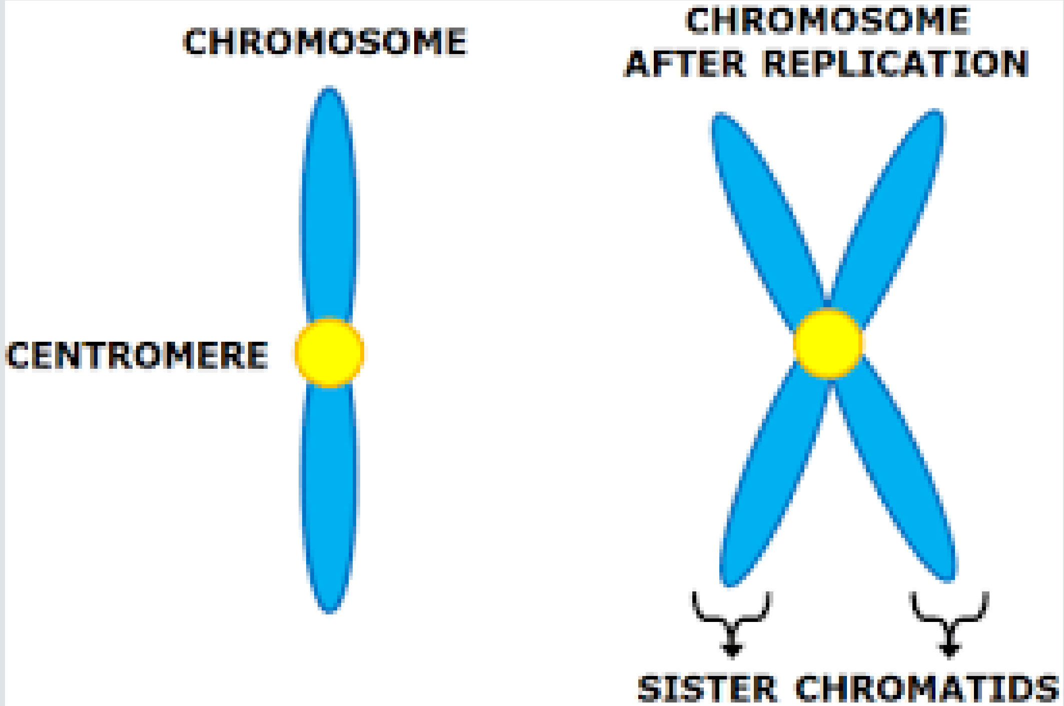
During replication –

One chromosome – duplicates into two

These two are identical copies

Remain connected at the centromere

- These are called sister chromatids (single copy – chromatid)

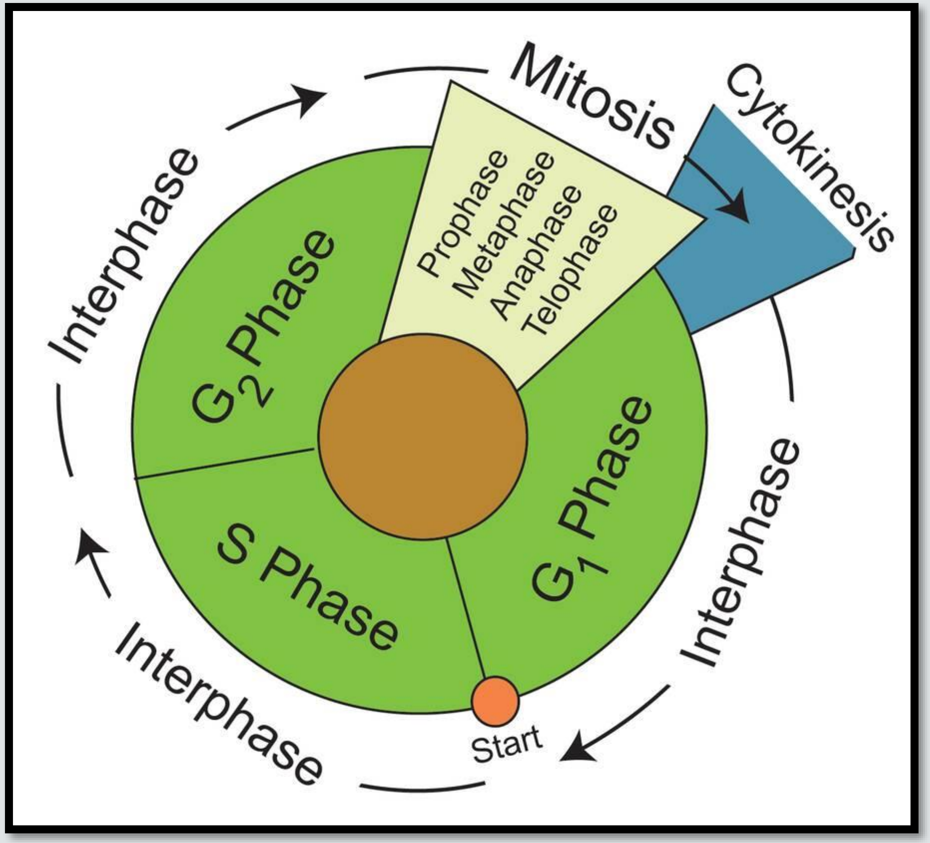


THE CELL CYCLE

PHASES OF THE CELL CYCLE

Phase I - Interphase

1. G1 Phase –
    1. Increase cell size
    2. Produce RNA & proteins needed for DNA synthesis
    3. Prepare to replicate DNA
    4. Longest phase

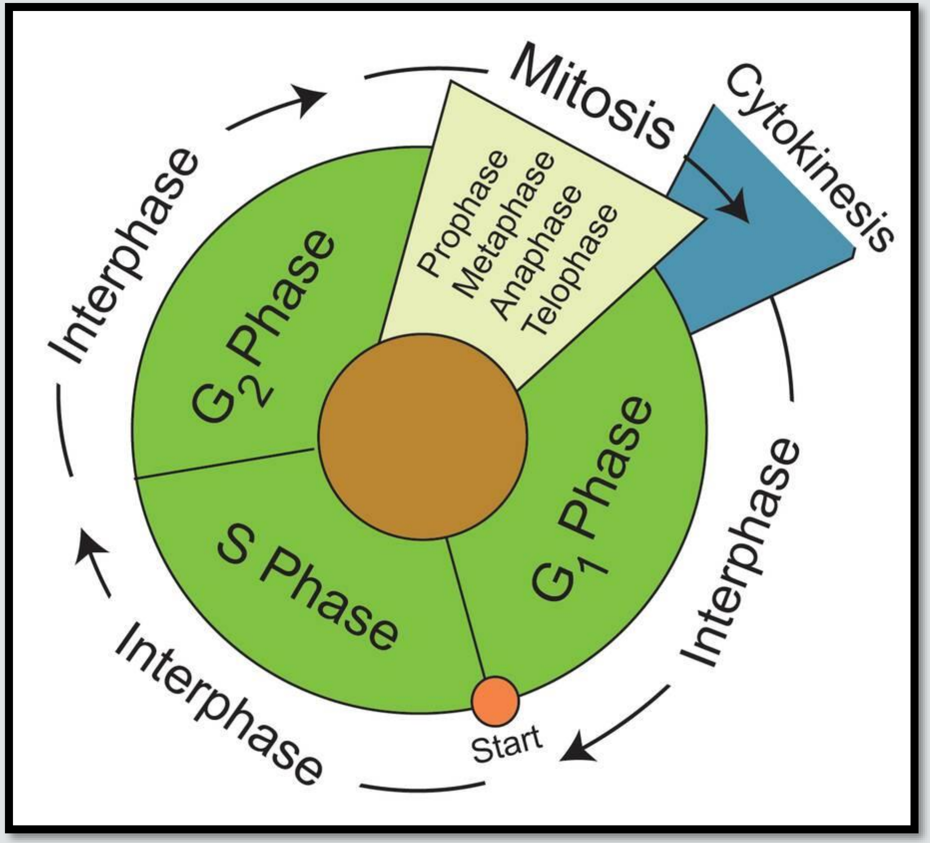


THE CELL CYCLE

PHASES OF THE CELL CYCLE

Phase I - Interphase

2. S Phase –
   1. Duplication of chromosomes
   2. One chromosome – two sister chromatids
   3. Sister chromatids remain connected at centromere
   4. Duplication of centrosome

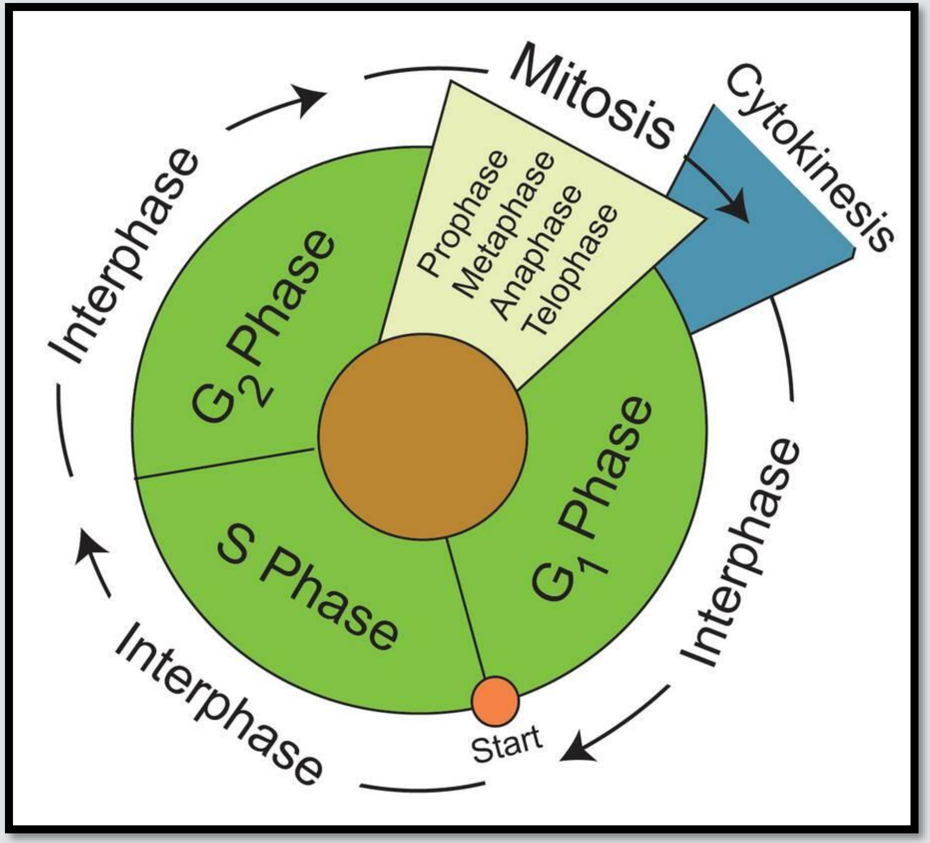


THE CELL CYCLE

PHASES OF THE CELL CYCLE

Phase I - Interphase

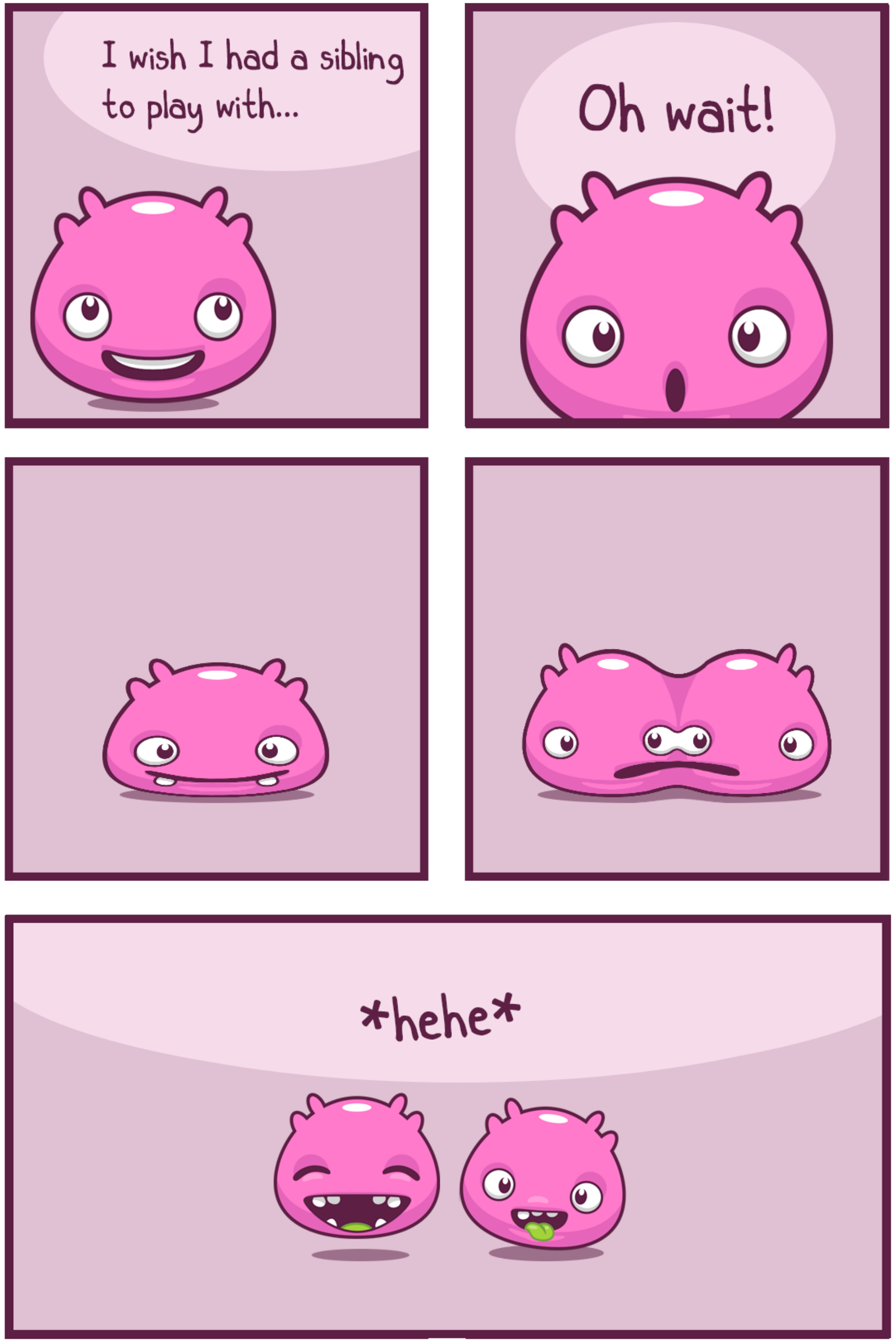
3. G2 Phase–
    1. Rapid cell growth
    2. Microtubule production
    3. Damaged, replicated DNA is repaired
    4. G2 check point – cell is ready for division



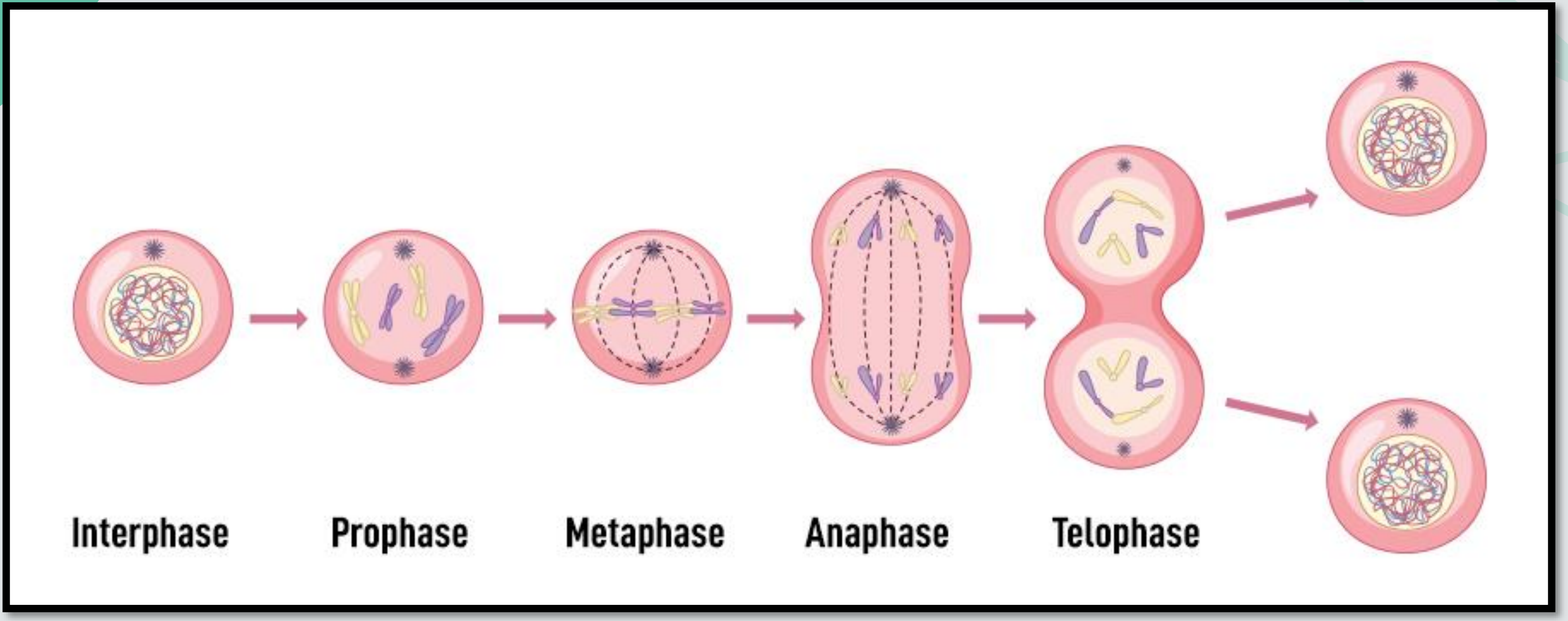
Phase II: Mitosis

Equational Division

Happens in All Cells



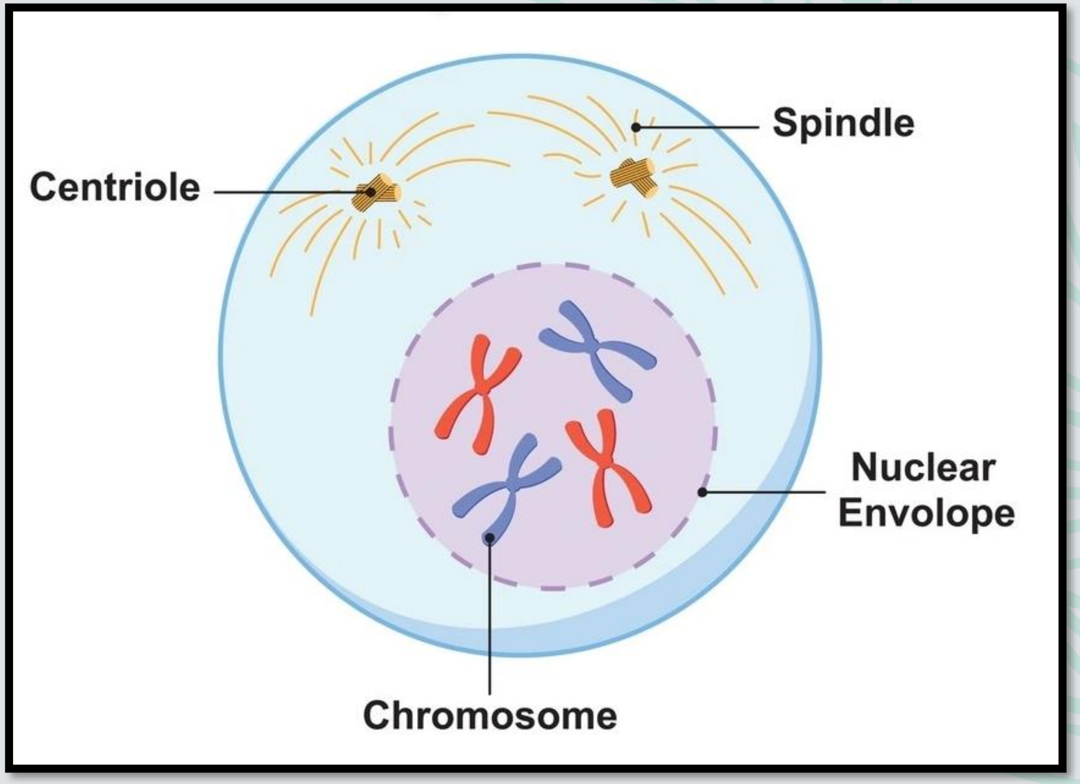
Stages of Mitosis



Stages of Mitosis:

1. Prophase

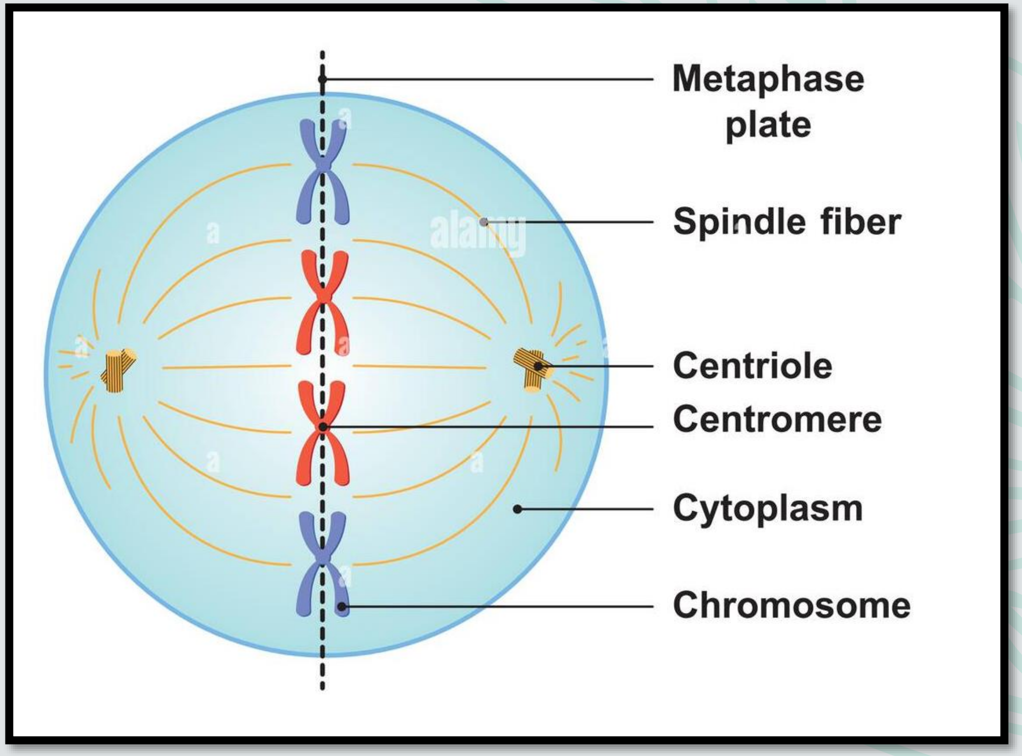
- Chromosome Condensation
- Nucleolus disappears
- Nuclear envelope breaks down
- Centrosomes start moving



Stages of Mitosis:

2. Metaphase

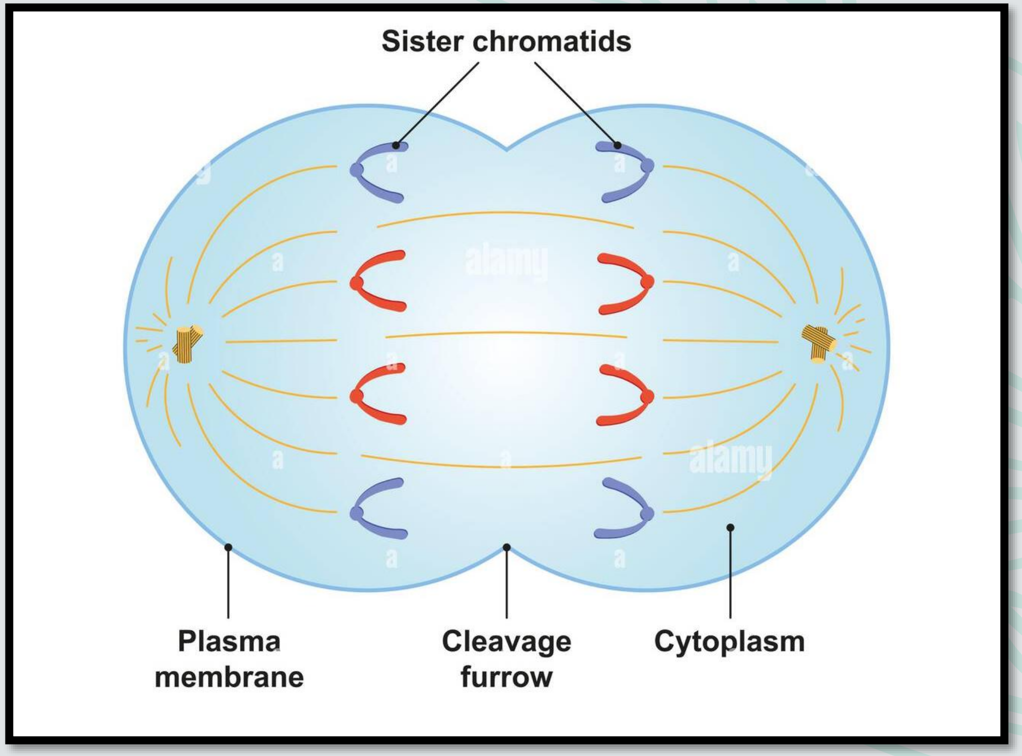
- Chromosomes alignment
- Spindle fibre attachment
- Metaphase check-point



Stages of Mitosis:

3. Anaphase

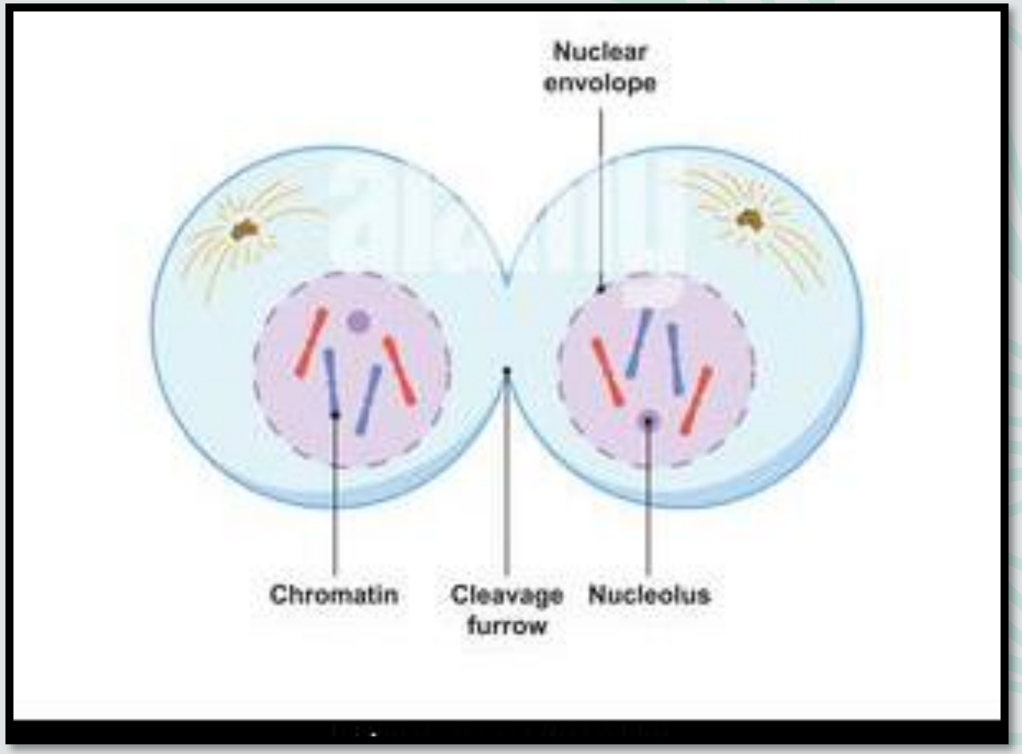
- Chromatid separation
- Chromosome movement
- Pole formation



Stages of Mitosis:

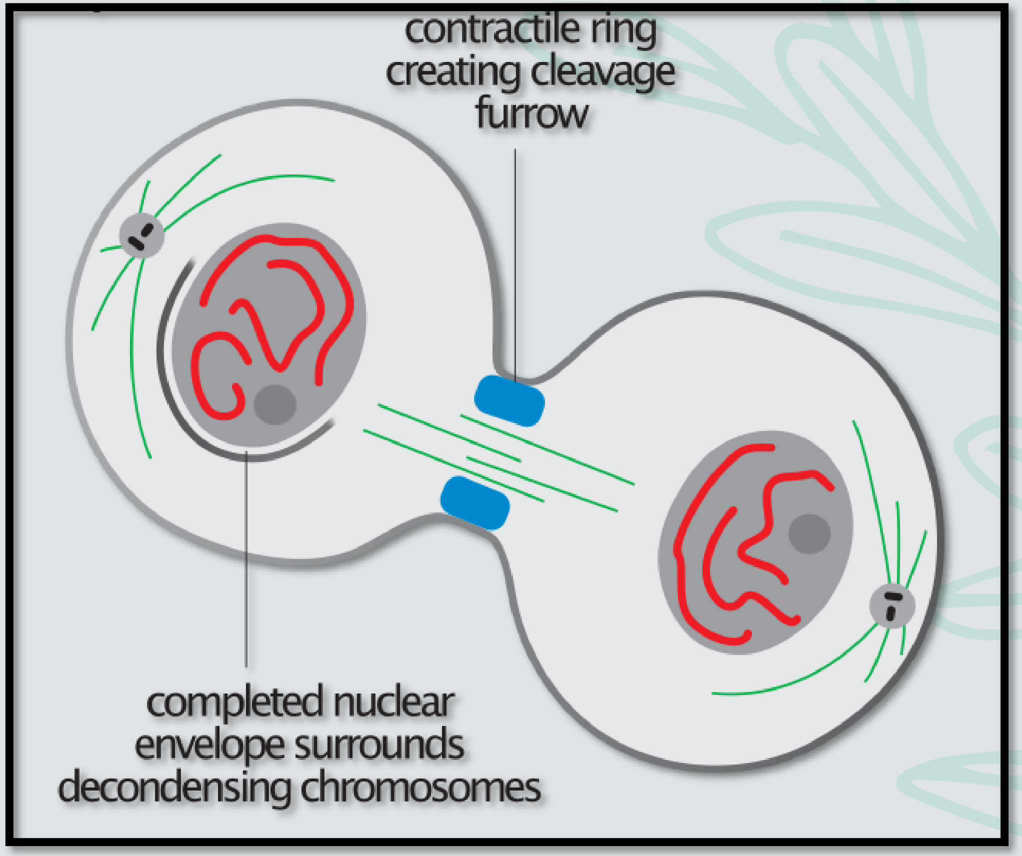
4. Telophase

- Chromosome decondensation
- Nuclear envelope reforms
- Nucleolus reappears
- Spindle dis-assembles



Cytokinesis

- Final step in cell division
- One cell – Two daughter cells



Key terms before starting Meiosis

1. Tetrad/Bivalent

   A pair of homologous chromosomes (containing four sister chromatids in total)

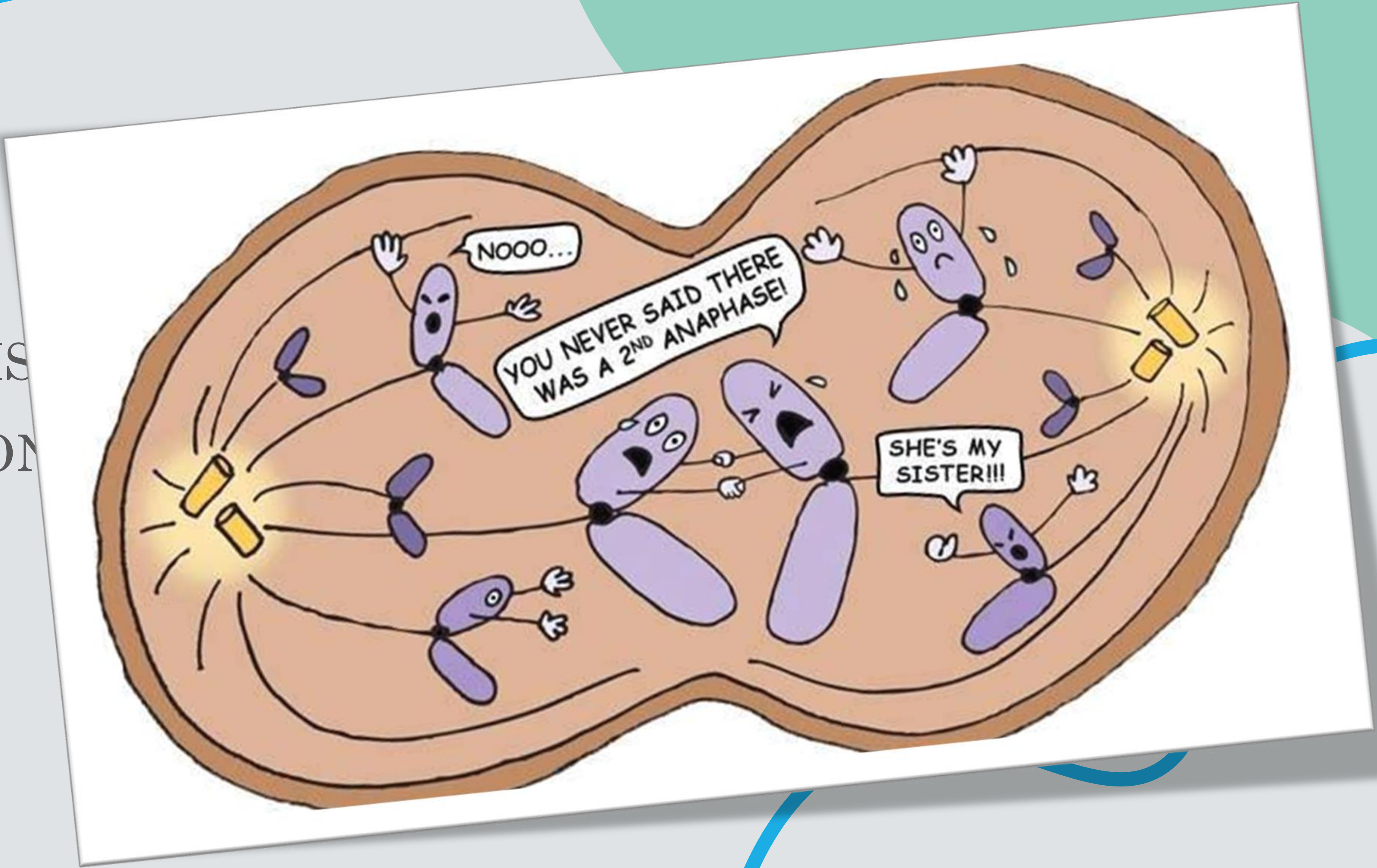
2. Crossing Over –

   Exchange of genetic material between homologous chromosomes

MEIOSIS

REDUCTIONAL DIVIS

TAKES PLACE IN GON



MEIOSIS

Has two stages –

Meiosis I

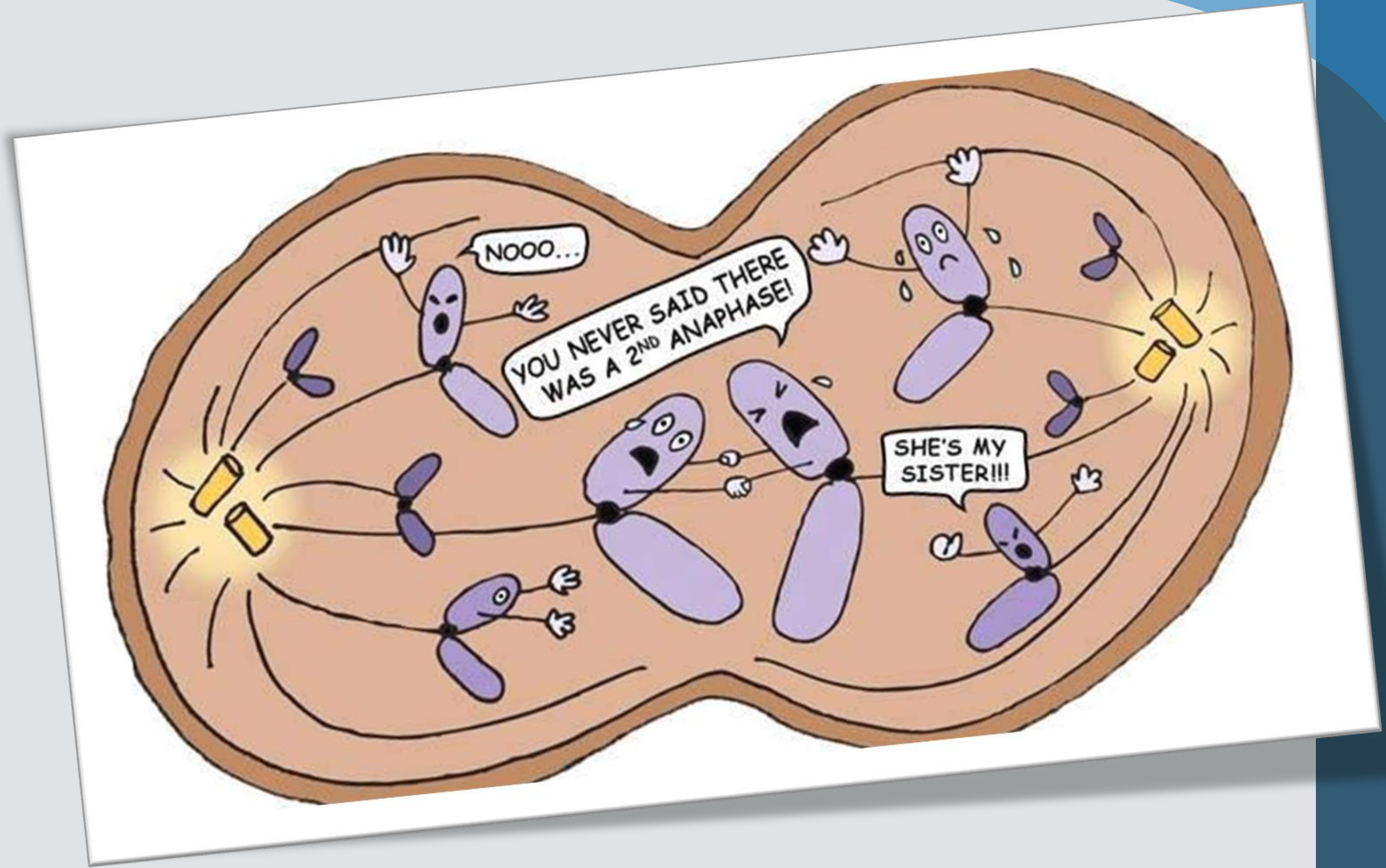
- Reductional division

Meiosis II

- Equational division like mitosis

Both divisions have all four phases –

Prophase, Metaphase, Anaphase and Telophase



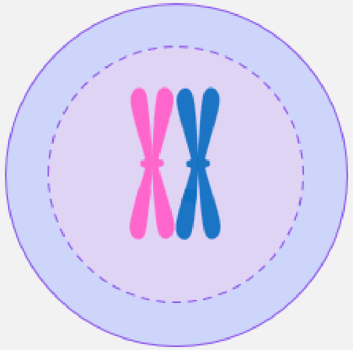
Meiosis I

<u>Four Phases:</u>

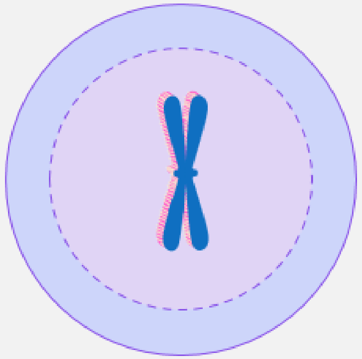
1. Prophase I
    1. Leptotene
    2. Zygotene
    3. Pachytene
    4. Diplotene
    5. Diakinesis
2. Metaphase I
3. Anaphase I
4. Telophase I

Meiosis I

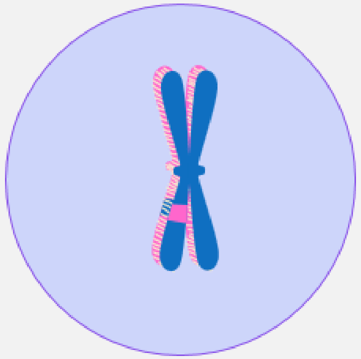
Prophase I



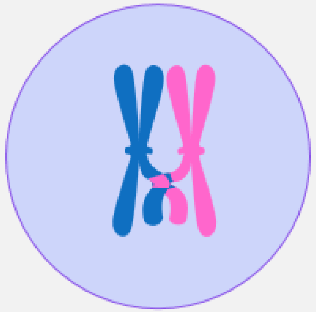
Leptotene
- Chromatin condense to form chromosomes



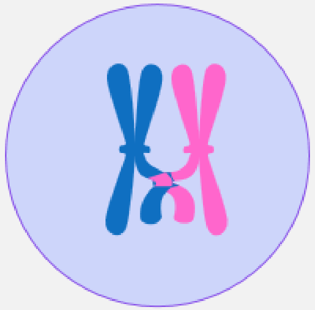
Zygotene
- *Homologous chromosomes come close*
- ***Synaptonemal** complex begins to form*



Pachytene
- **Crossing over** occurs

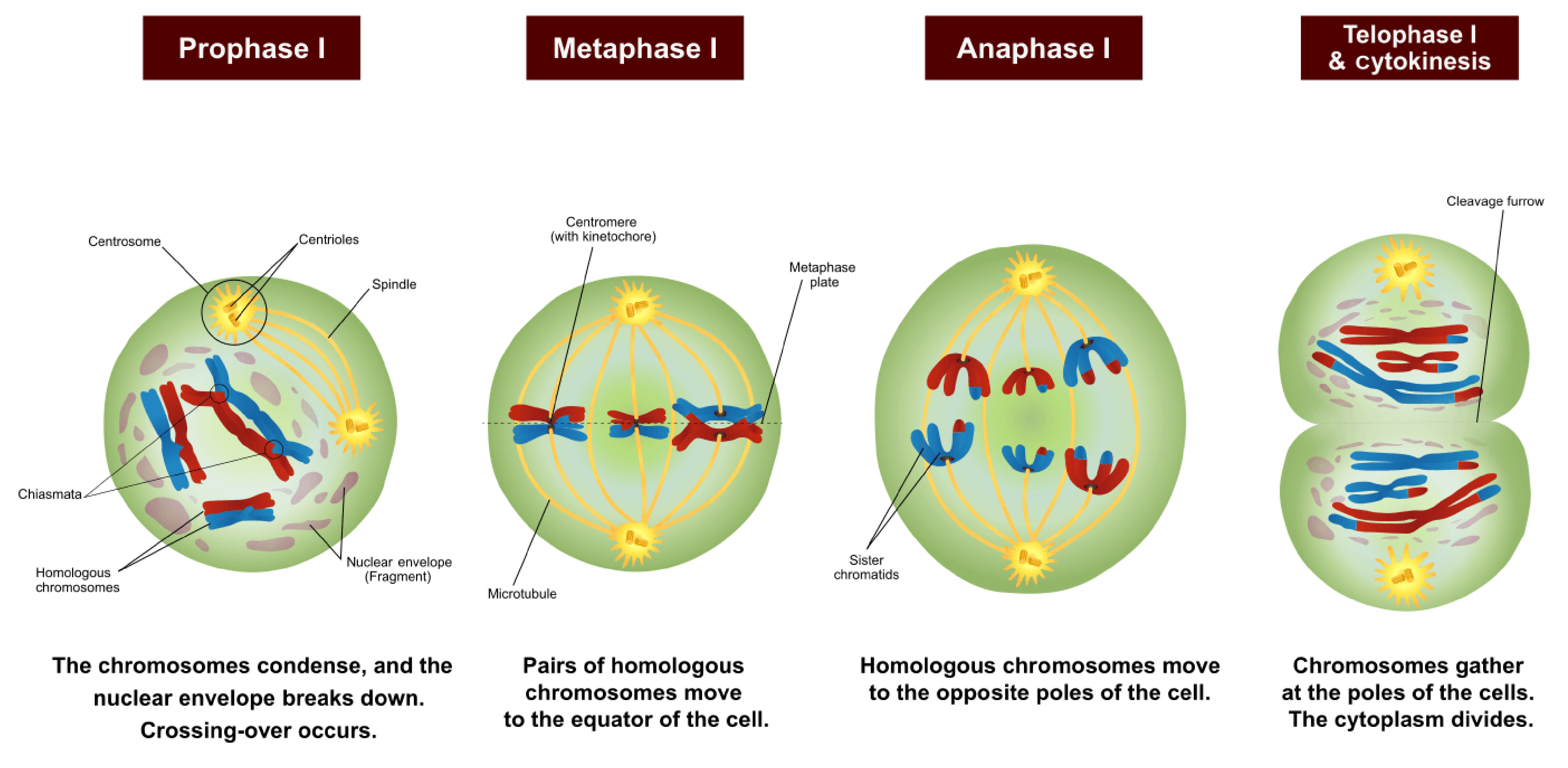


Diplotene
- **Synaptonemal complex** disintegrates
- Chiasma appears



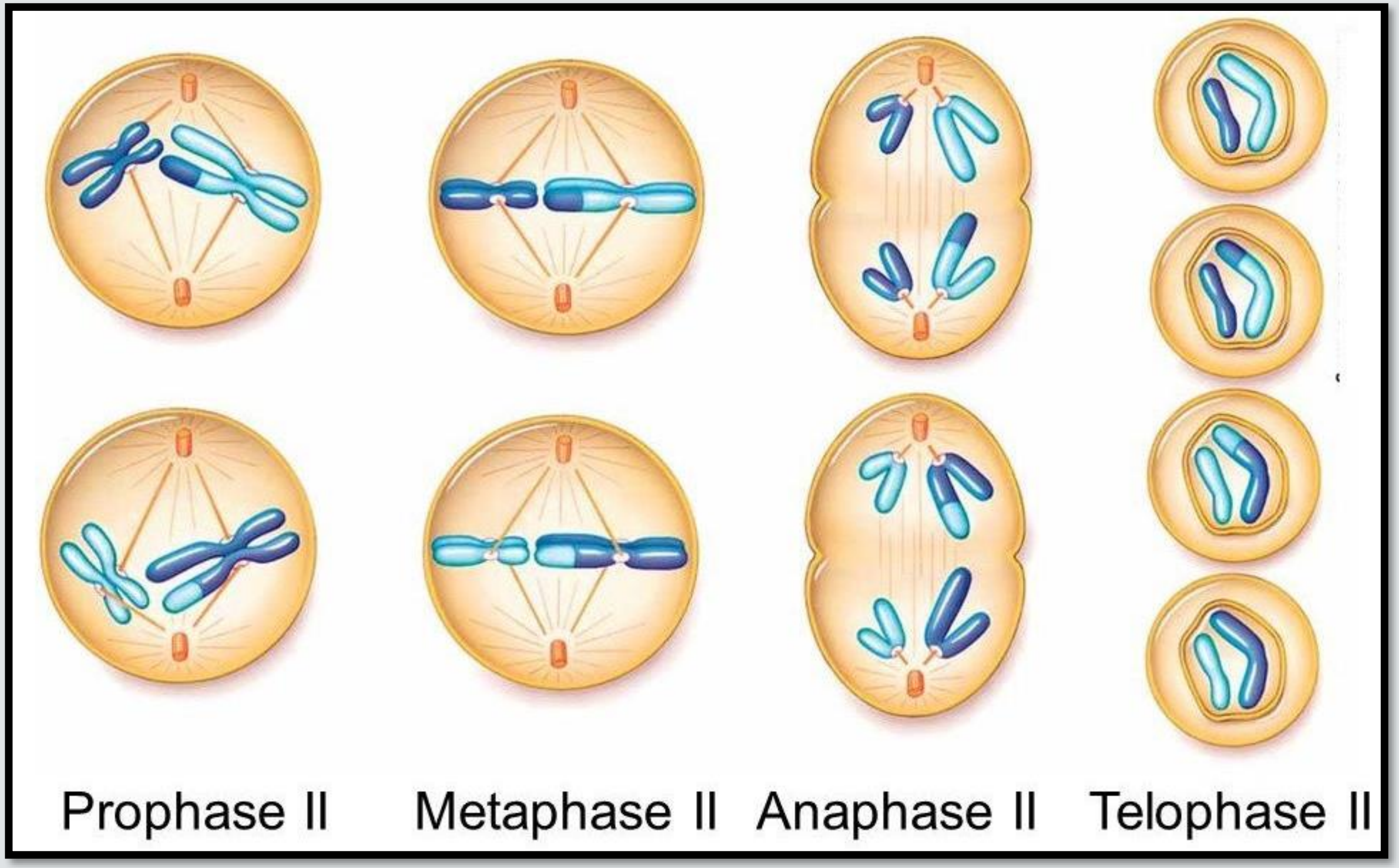
Diakinesis
- Homologous chromosomes **move farther**
- Chiasma becomes more prominent
- Nuclear membrane disappears

Meiosis I



Prophase I
Metaphase I
Anaphase I
Telophase I & cytokinesis
Centrosome
Centrioles
Spindle
Chiasmata
Homologous chromosomes
Nuclear envelope (Fragment)
Centromere (with kinetochore)
Metaphase plate
Microtubule
Sister chromatids
Cleavage furrow
The chromosomes condense, and the nuclear envelope breaks down. Crossing-over occurs.
Pairs of homologous chromosomes move to the equator of the cell.
Homologous chromosomes move to the opposite poles of the cell.
Chromosomes gather at the poles of the cells. The cytoplasm divides.

Meiosis II



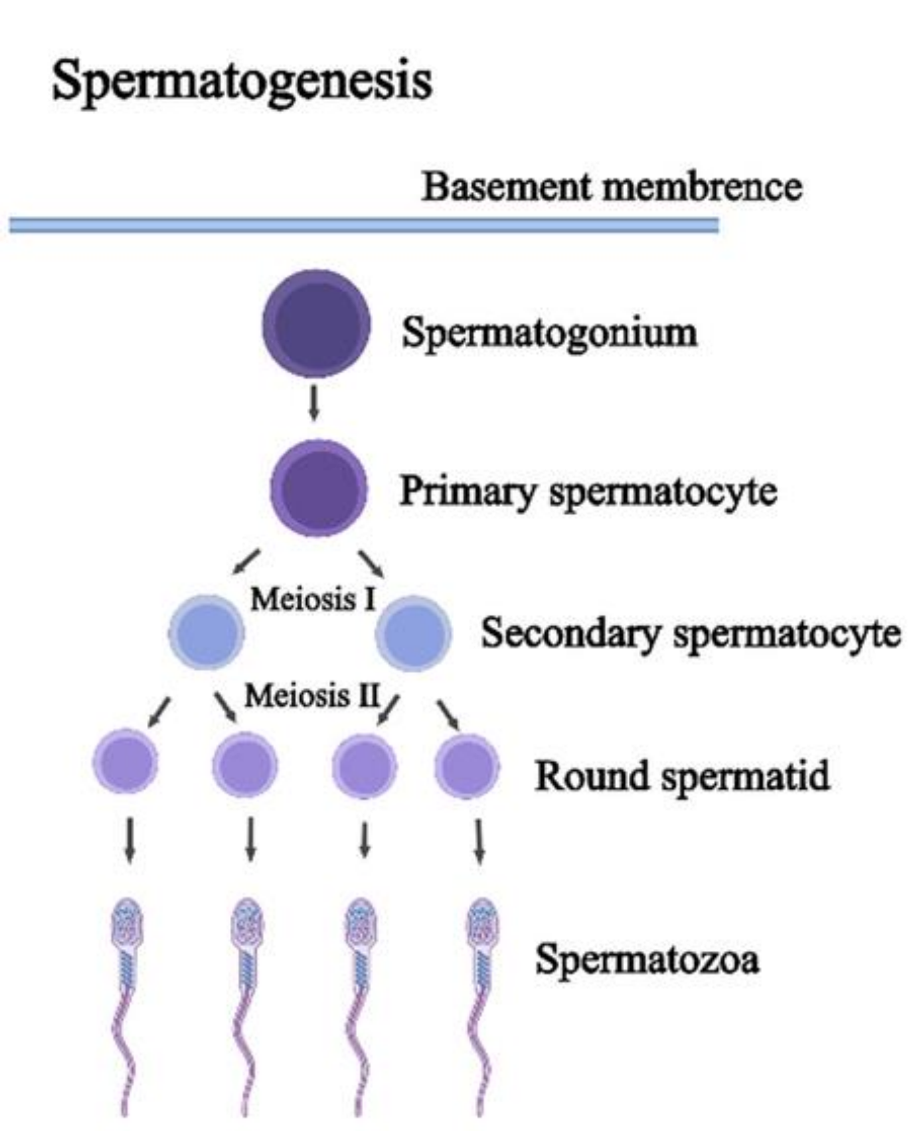
GAMETOGENESIS

- SPERMATOGENESIS
- OOGENESIS

Spermatogenesis

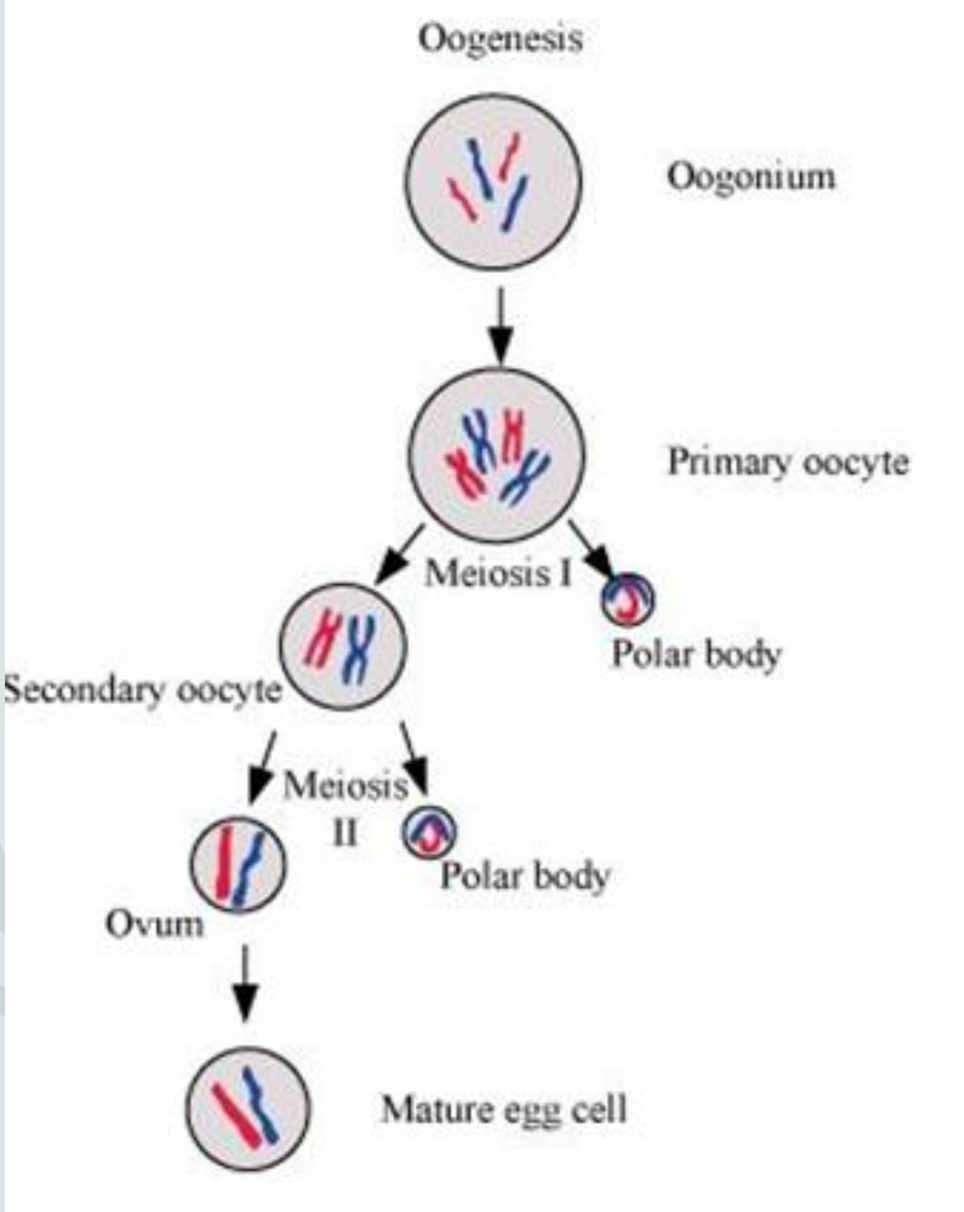
- Spermatogenesis begins at puberty
- Haploid sperms produced from spermatogonia
- Spermiogenesis –

Spermatid heads embedded in Sertoli cells – become matured to spermatozoa



Oogenesis

- Oogonia – formed in the developing foetus
- Primary oocytes –
  - ✓ Oogonia enter meiosis I before birth
  - ✓ Become arrested at prophase I
- Restart of oogenesis at puberty
  - ✓ Meiosis I is completed
  - ✓ Meiosis II begins
  - ✓ Secondary oocyte – arrested at Meiosis II
- Meiosis II is completed after fertilisation



Process of oogenesis

MCQs – The Cell Cycle

1. The science that deals with chromosomes are: UK VO - 2024

a) Molecular genetics

b) Cytogenetics

c) Biochemical genetics

d) Developmental genetics

MCQs – The Cell Cycle

1. What is the number of chromosomes in riverine buffaloes? UK VO 2024

a) 54

b) 52

c) 50

d) 48

MCQs – The Cell Cycle

- Which of the following statements are true: JKPSC 2019
- 1) Maximum diameter of chromosome was observed in anaphase
- 2) The chromosome pairing occurs between homologous chromosomes
- 3) The centromere divide chromosome into five equal halves
- 4) Each chromosome has definite place in interphase
- Choose the correct answer:
- (A) 1 and 2 only
- (B) 2 and 3 only
- (C) 2 and 4
- (D) 2,3 and4 only

MCQs – The Cell Cycle

- Match the following Species of animals with their Chromosomes (2n) JKPSC 2019
- **Species** **Chromosomes (2n)**
- (a) Domestic cattle (1) 60
- (b) Domestic river buffalo (2) 54
- (c) Domestic sheep (3) 38
- (d) Domestic swine (4) 50
- Select the correct answer using the code below:
- (A) a-1; b-3; c-1; d-4
- (B) a-2; b-4; c-3; d-1
- (C) a-1; b-4; c-2; d-3
- (D) a- 1; b-3; c-2; d-4

MCQs – The Cell Cycle

- During which phase of mitotic cell division, the nuclear membrane and nucleolus disappear?
- [A] Prophase
- [B] Metaphase
- [C] Anaphase
- [D] Telophase

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MCQs – The Cell Cycle

- . Crossing over takes place between:
- (A) Sister cromatid
- (B) Non-sister cromatid
- (C) Chromosome
- (D) Chromonema

MPPSC 2022

MCQs – The Cell Cycle

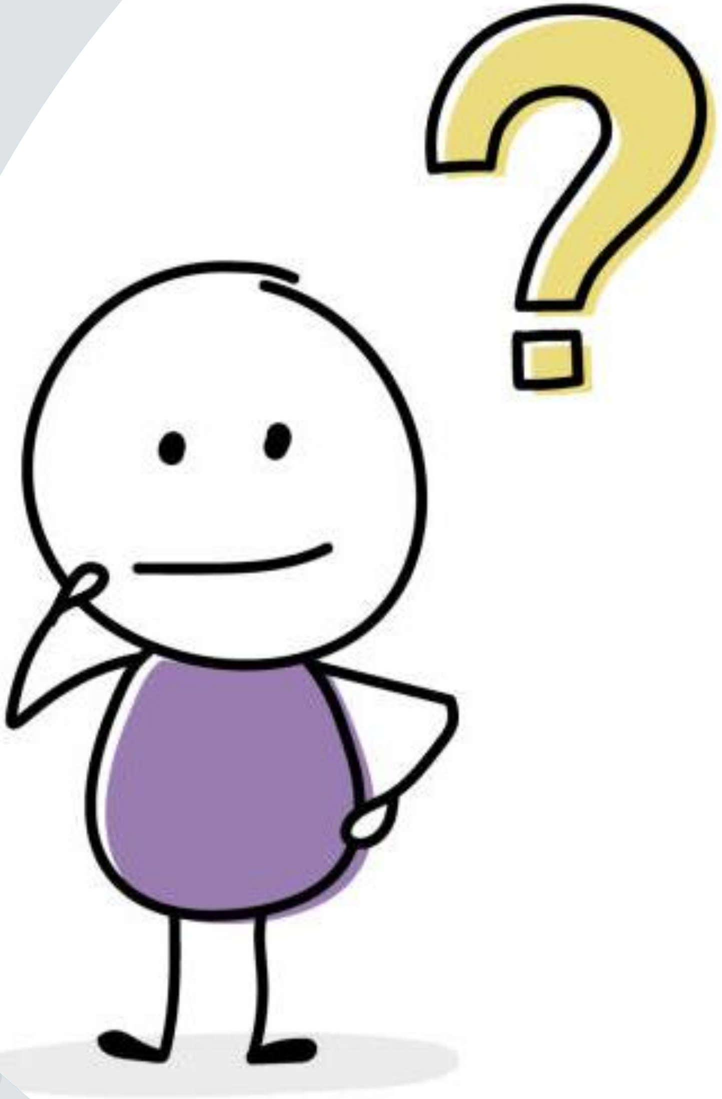
- During karyokinesis the chromosome exhibit minimum coiling at which phase?
- (A) Prophase
- (B) Metaphase
- (C) Anaphase
- (D) Interphase

MPPSC 2022

MCQs – The Cell Cycle

- The stage of cell division in which the chromosomes are most discrete and arranged in an equatorial plate?
- (A) Prophase
- (B) Anaphase
- (C) Metaphase
- (D) Telophase OPSC

ANY QUESTIONS?



Lecture 2
Topic - 1

Mendelian Genetics

Some Basic Concepts

Who was Mendel?

Monohybrid Cross

Dihybrid Cross

Mendel's Laws of Inheritance

MCQs

Some Basic Concepts

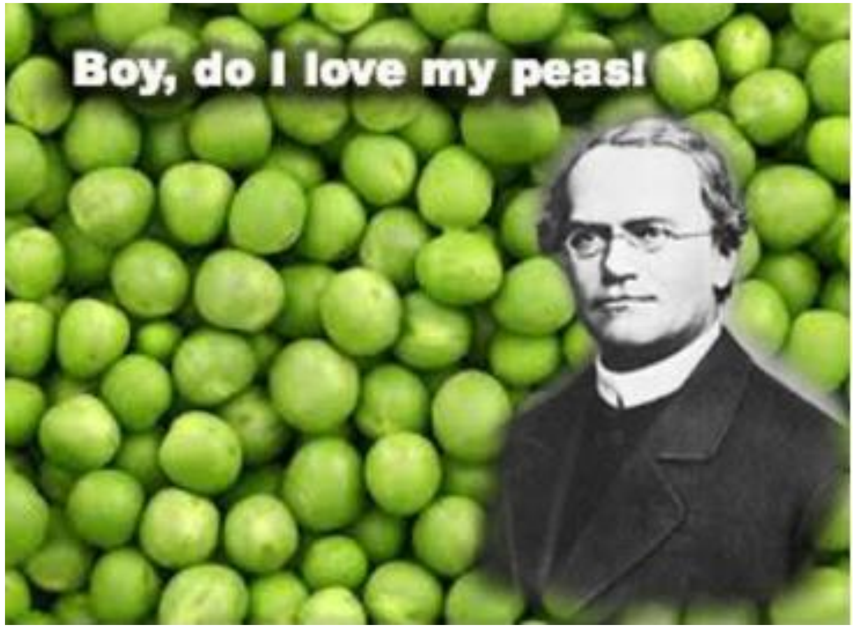
Some Basic Concepts

S. No.	Term	Definition/Explanation
1.	DNA	chain of nucleotides (comprising of a specific nucleotide sequence – i.e. the genetic information)
2.	Gene	The functional unit of heredity, gene is the segment of DNA which codes for a polypeptide.
3.	Genome	The entire set of genes in an organism is called its genome
4.	Chromosome	Composed of DNA in a supercoiled state (1 chromosome = 1 DNA molecule)
5.	Allele	The alternative forms of a gene (coding for the alternative forms of a trait) are called alleles
6.	Locus	The physical position of a gene on a chromosome is called its locus
7.	Homozygous	When an individual has the same allele for a gene in both its homologous chromosomes, it is said to be homozygous for that trait.

Some Basic Concepts

S. No.	Term	Definition/Explanation
8.	Heterozygous	When an individual has different alleles for a gene in both its homologous chromosomes, it is said to be heterozygous for that trait.
9.	Dominant allele	When one allele, in a heterozygous condition, does not allow the expression of the other allele, it is said to be dominant.
10.	Recessive allele	The allele unable to express itself is the recessive allele
11.	Genotype	the genetic constitution of an individual with respect to a particular set of gene(s) (or the whole genome) is said to be its genotype
12.	Phenotype	The observable characteristics of individuals which are produced as a result of its genotype is called its phenotype.

Who was Mendel?



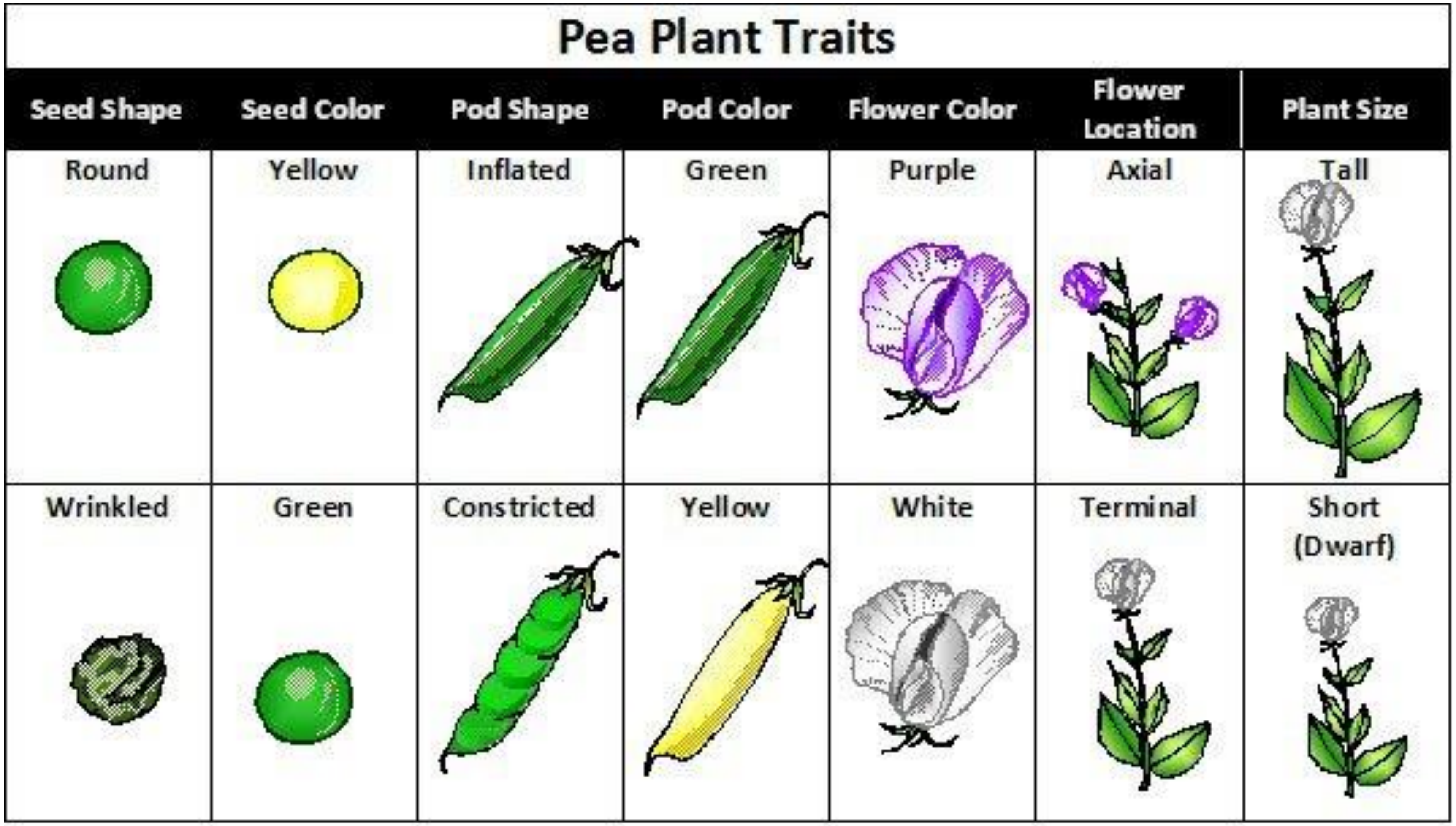
- Austrian Monk
- Father of Genetics
- Experimented with Peas
- Mendel first presented his findings at the Brunn Society for Natural Science - 1865
- Published findings in a paper – "Experiments on Plant Hybridisation" – 1866
- His work was lost – later rediscovered by Hugo de Vries, Carl Correns, and Erich von Tschermak. (1900)
- Laid groundwork for the field of genetics

Why so famous Mendel?

Reasons for his success:

- Focused on one or two traits at a time.
- Used true-breeding plant varieties.
- Maintained meticulous records of his experiments.
- Selected traits that did not show linkage or incomplete dominance.
- Benefited from the fact that the genes for the traits he studied were mostly on separate homologous chromosomes.

Traits Studied

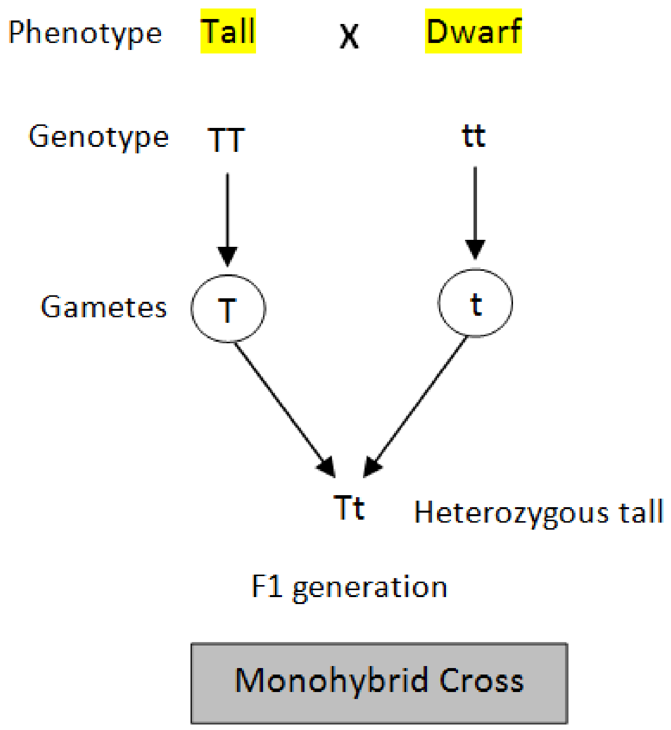


Pea Plant Traits						
Seed Shape	Seed Color	Pod Shape	Pod Color	Flower Color	Flower Location	Plant Size
Round	Yellow	Inflated	Green	Purple	Axial	Tall
Wrinkled	Green	Constricted	Yellow	White	Terminal	Short (Dwarf)

Monohybrid Cross

Monohybrid cross

- Involves one trait at a time



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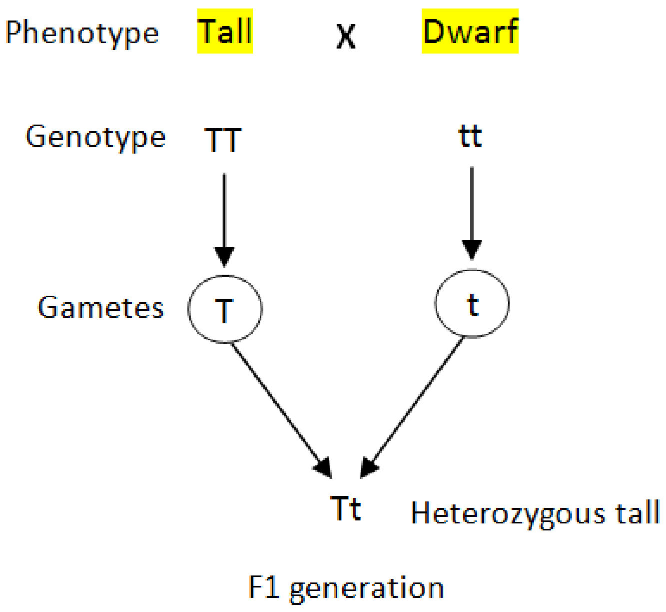
Monohybrid cross

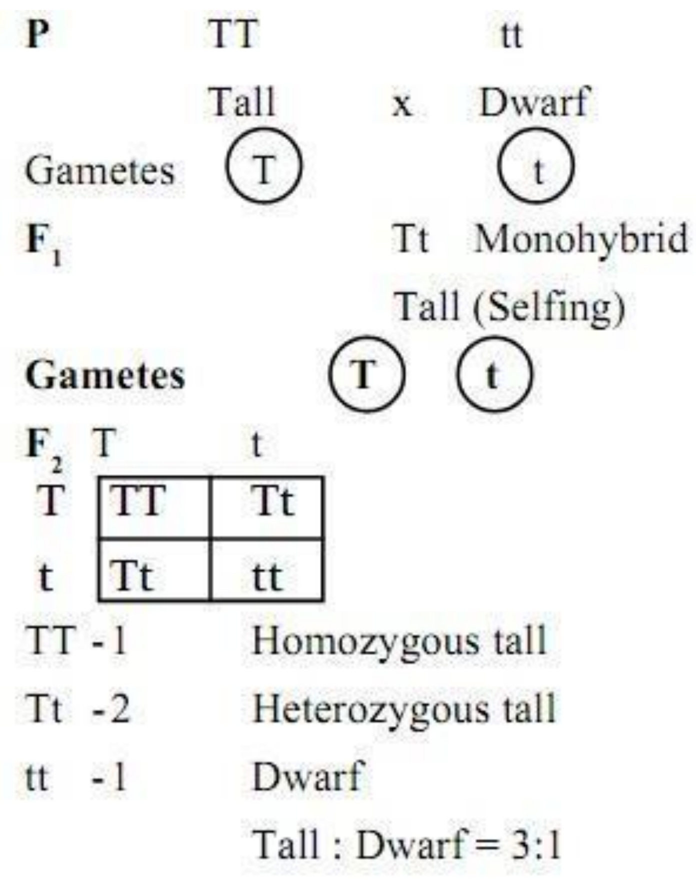
- Involves one trait at a time



Monohybrid Cross

$\underline{F_2 :}$ $Tt \times Tt$

Monohybrid cross



- Genotypic ratio:
  - TT : Tt : tt = 1:2:1
- Phenotypic ratio
  - Tall : Dwarf = 2:1

Monohybrid cross

- Homework:

Draw up monohybrid crosses for all Mendel's traits

Dihybrid cross

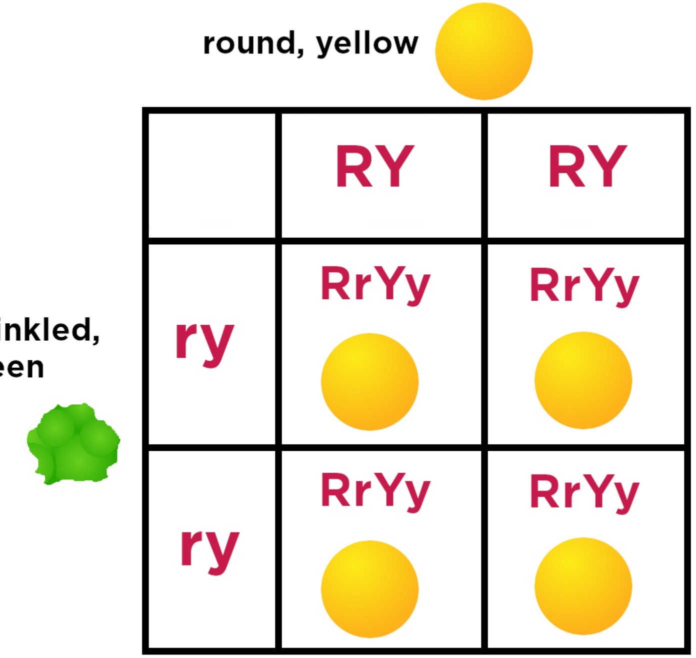
- Two traits considered at a time
- E.g. seed is:

Round Yellow (RRYY) × Wrinkled green (rryy)

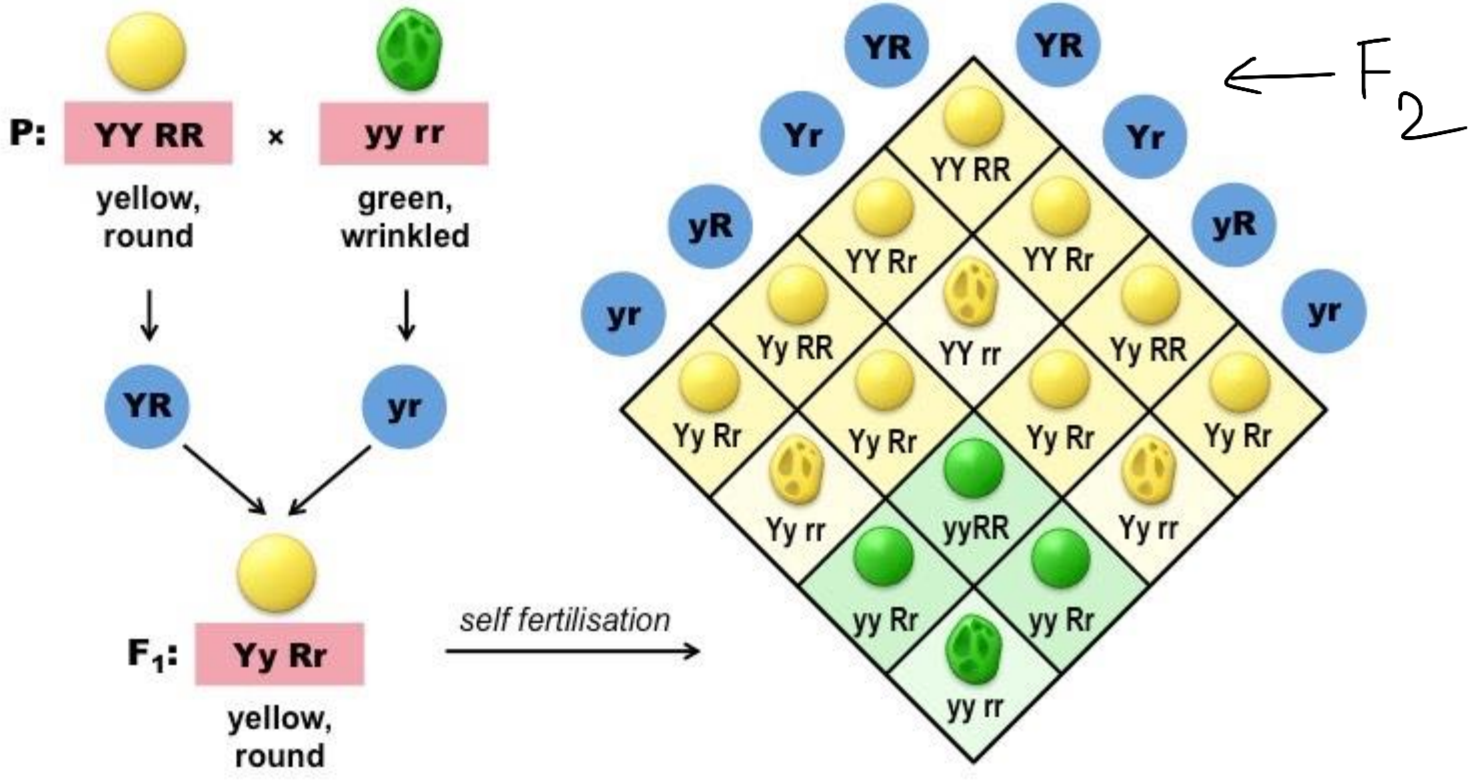
Dihybrid cross

F_1 Gen :

Cross of Parent Generation



Dihybrid cross



Ratios

Genotypic:

1:2:1:2:4:2:1:2:1

Phenotypic:

9:3:3:1

Mendel's laws of Inheritance

Law of Dominance:	• In a pair of alleles, one allele can mask the expression of the other. The dominant allele is expressed in the phenotype, while the recessive allele is not, unless in a homozygous state.
Law of Segregation:	• During gamete formation, the two alleles for a gene segregate, so each gamete carries only one allele. This law was demonstrated through monohybrid crosses, showing a 3:1 phenotypic ratio in the F2 generation.
Law of Independent Assortment:	• Alleles for different traits segregate independently of each other during gamete formation, leading to genetic variation. This law was derived from dihybrid crosses, resulting in a 9:3:3:1 phenotypic ratio.

MCQs on Mendelian Inheritance

- Mendel's law of segregation states that:
  a) Alleles segregate during gamete formation
  b) Genes are located on chromosomes
  c) Traits are inherited independently
  d) Dominant alleles mask recessive alleles

- A test cross involves crossing an individual with:
  a) Homozygous dominant genotype
  b) Heterozygous genotype
  c) Homozygous recessive genotype
  d) Another individual with unknown genotype

MCQs on Mendelian Inheritance

- The genotypic ratio of a monohybrid cross is:
  a) 1:2:1
  b) 9:3:3:1
  c) 3:1
  d) 1:1:1:1

- Independent assortment of genes occurs during:
  a) Mitosis
  b) Meiosis
  c) Fertilization
  d) Mutation

MCQs on Mendelian Inheritance

- Alleles are:
  a) Different forms of a gene
  b) Genes located on different chromosomes
  c) Mutations in genes
  d) Proteins coded by genes

- Mendel's law of independent assortment holds true for genes located on:
  a) The same chromosome
  b) Different chromosomes
  c) Sex chromosomes
  d) Mitochondrial DNA

MCQs on Mendelian Inheritance

- A backcross involves crossing the F1 generation with:
  a) One of the parents
  b) F2 generation
  c) An unrelated individual
  d) Itself (self-pollination)

- Mendel's law of dominance states that:
  a) Recessive alleles are always expressed
  b) Dominant alleles mask the effect of recessive alleles
  c) Alleles blend in the offspring
  d) Genes assort independently

MCQs on Mendelian Inheritance

- Mendel's principles of inheritance were rediscovered in the early 20th century by:
  a) Watson and Crick
  b) Darwin and Wallace
  c) deVries, Correns, and Tschermak
  d) Lamarck and Lysenko

- In guinea pigs, black coat color (B) is dominant over white (b), and short hair (S) is dominant over long hair (s). If two guinea pigs with genotypes BbSs are crossed, what proportion of their offspring will have a white coat and long hair?
  a) 1/16
  b) 1/8
  c) 3/16
  d) 1/4

Lecture 2 – Topic 2

Modified Mendelian Inheritance

Modified mendelian ratios

Sex-linked, sex-limited, sex-influenced traits

Sex-determination

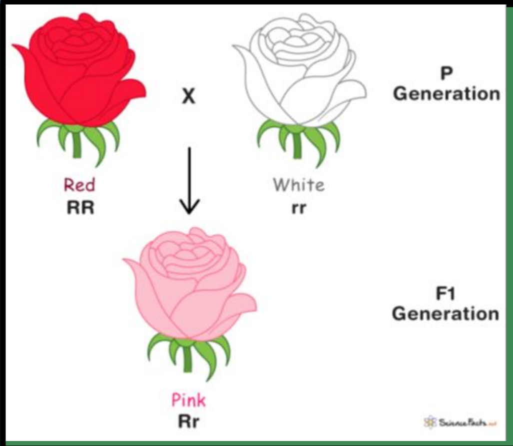
Modified Mendelian Inheritance

- a.k.a. Modified Mendelian Ratios/Deviation from Mendelian Inheritance
- Deviates from Mendel's laws
- Can be divided based on Monohybrid and Dihybrid crosses

Modified Mendelian Inheritance

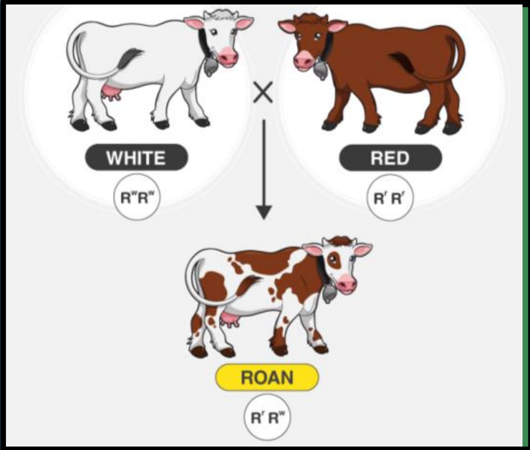
Pattern	Phenotypic F2 ratio
Incomplete dominance	3:1
Co-dominance/Mosaic Inheritance	1:2:1
Multiple allelism	1:2:1
Complementary genes	9:7
Dominant Epistasis	12:3:1
Recessive Epistasis	9:3:4
Duplicate dominant	15:1
Duplicate recessive	9:7

Based on Monohybrid Cross



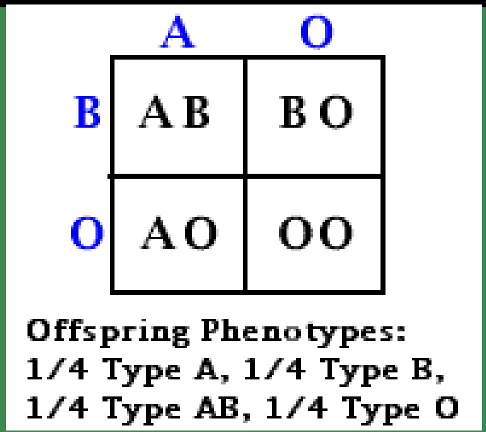
Incomplete Dominance

Antirrhinum majus



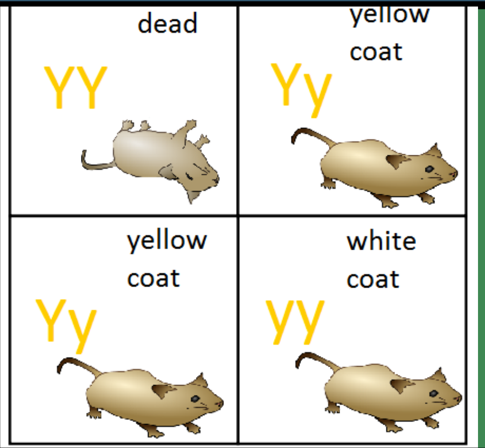
Co-dominance

Shorthorn Cattle coat colour
ABO Blood group



Multiple allelism

ABO Blood group

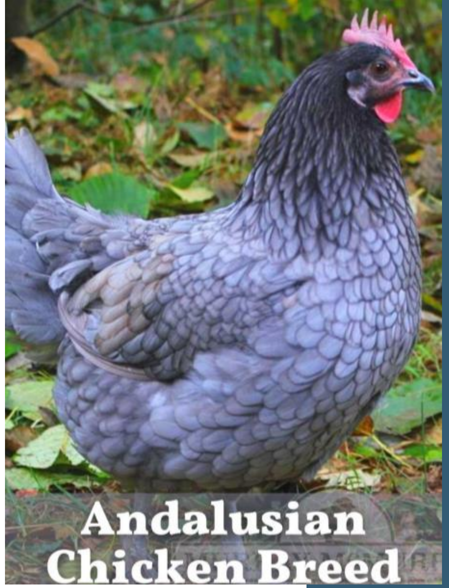


Lethal Genes

Yellow coat colour in mice

1. Incomplete Dominance

- Alleles do not show complete dominance
- Examples:
  - 4 o'clock plant (*Mirabilis jalapa*) – flower colour – red and white flowered plants produce progeny with pink coloured flowers
  - Feather colour of Andalusian chickens
- Phenotypic ratio in F2 generation – 1:2:1

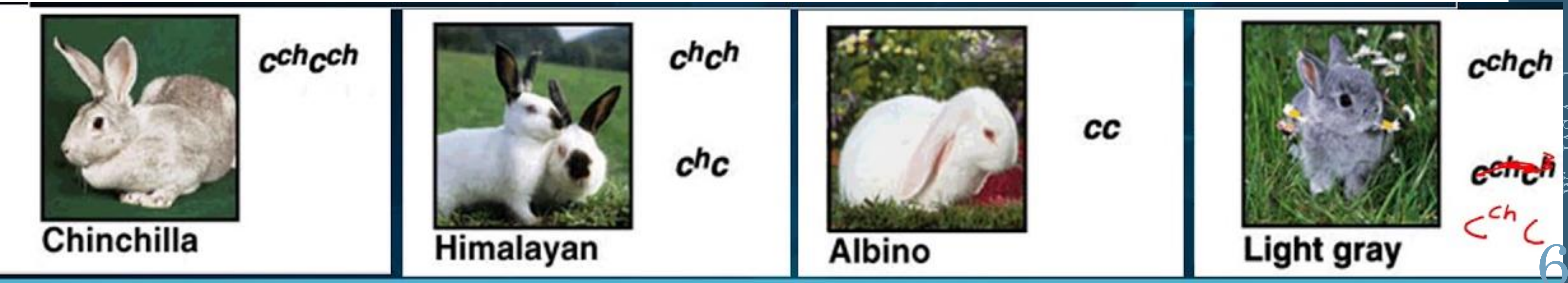


2. Codominance

- There is no dominant allele
- Both alleles are expressed equally
- Examples:
  - AB Blood group in humans
  - Shorthorn cattle – coat colour

3. Multiple Allelism

- More than two alleles exist for a trait
- Can occur due to mutations
- Examples:
    - ABO blood groups in humans
    - Coat colour in rabbits
- Phenotypic Ratio (F2) – 1:2:1



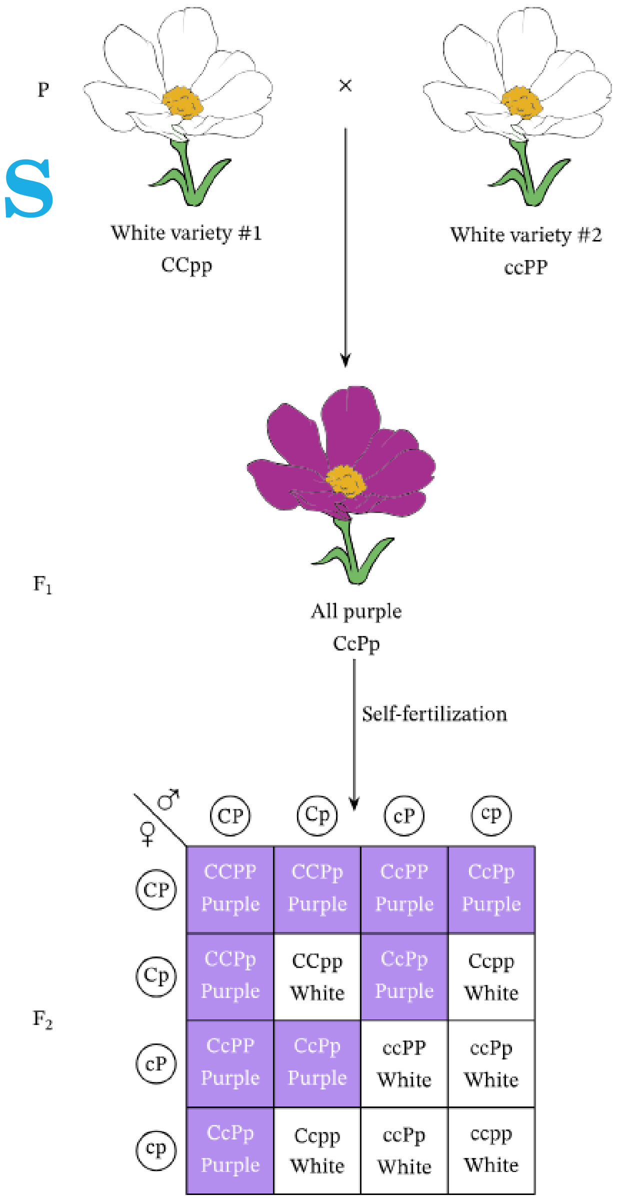
Lethal Genes

Cause death – either during the prenatal period or after birth

- Types:
  - Recessive Lethal – lethal in homozygous recessive condition
    - E.g. cystic fibrosis, sickle cell anaemia
  - Dominant Lethal – LL/Ll = Death
    - E.g. Huntington's disease
  - Conditional Lethal Genes
    - Cause death only under certain condition
    - E.g. favism

4. Complementary Genes

- A pair of genes work together (complement each other) to produce a particular phenotype
- Instead of having 4 phenotypes (like in Mendelian dihybrid cross), only 2 phenotypes are observed here
- Both dominant alleles needed for dominant phenotype expression
- F2 Phenotypic Ratio –
  Dominant : Recessive phenotype = 9:7
- Example:
  - Flower colour in sweet pea
  - C_P_ - purple flowers
  - ccP_ / C_pp / ccpp – white flowers



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5. Epistasis

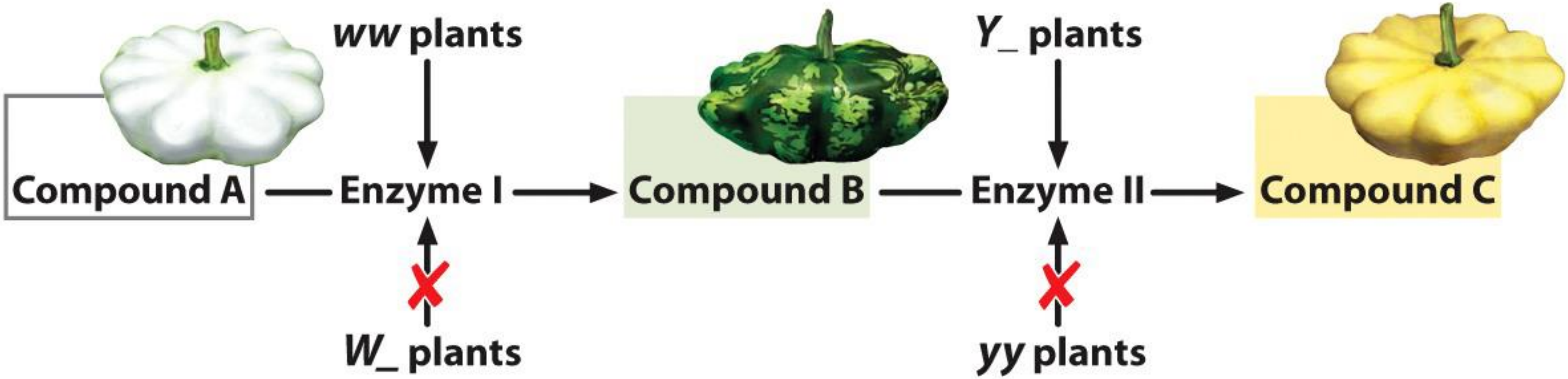
One gene (at one locus) affects the expression of another gene (at a different locus)

Types of Epistasis:

- Dominant
  - 12:3:1
- Recessive
  - 9:3:4
- Duplicate dominant
  - 15:1
- Duplicate Recessive
  - 9:7

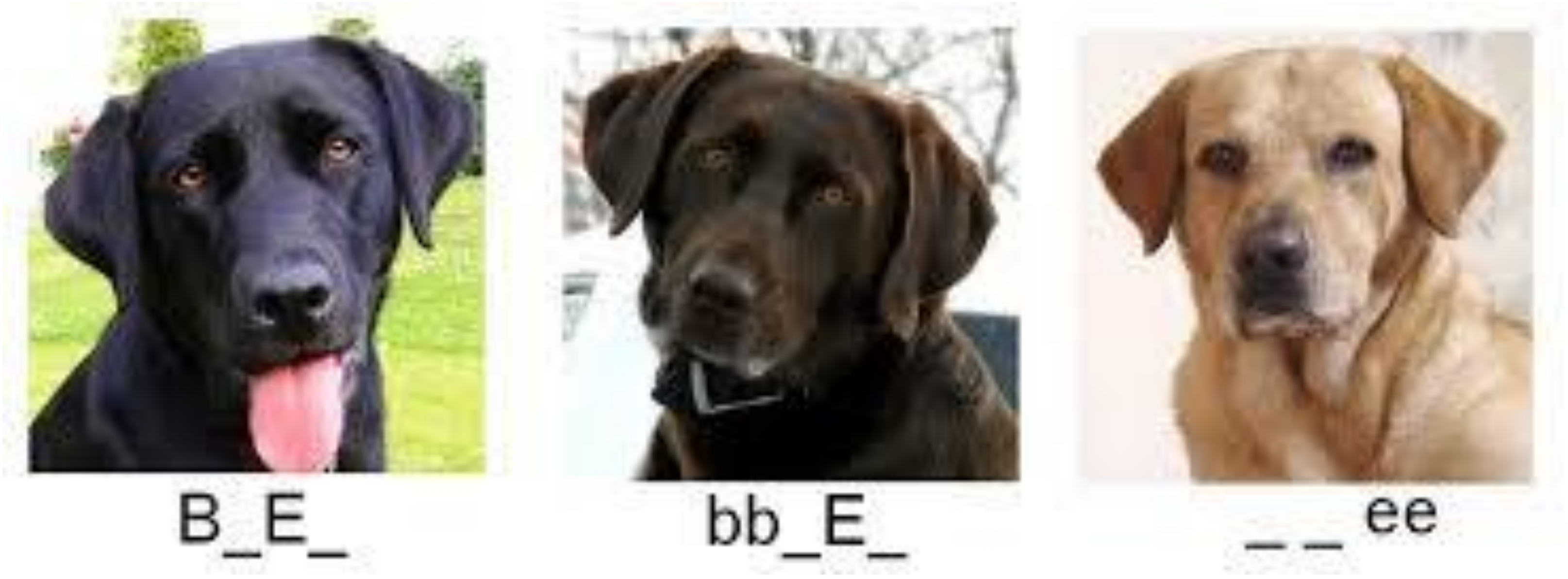
5. Epistasis

- Dominant Epistasis
  - Example: Summer squash – colour
  - F2 Ratio – 12:3:1



5. Epistasis

- Recessive Epistasis
  - Example: Labrador retrievers – coat colour
  - B – determines coat colour
  - E – affects pigment deposition (E allows deposition, e prevents it)
  - F2 Ratio – 9:3:4



5. Epistasis

- Duplicate Dominant Epistasis
  - Example: awn development (bristle like extension) in rice
  - Presence of one dominant allele masks the expression of the other recessive allele
  - Dominant allele A or B – awn present
  - Recessive state – aabb – awnless condition
  - F2 ratio – 15:1

5. Epistasis

- Duplicate Recessive Epistasis
  - Example: flower colour in some plants
  - Two genes – A and B
  - Presence of recessive allele at either of the two genes can mask the dominant phenotype

- Purple Flowers: A_B (A or B is dominant)

- White Flowers: aa__ or __bb (both recessive)

- Either gene has two recessive alleles – dominant phenotype is masked

Reasons for the deviation

1. Linkage
2. Crossing over
3. Inter-genic interactions
4. Environment

Sex Linked, Sex Limited, Sex Influenced Inheritance

Sex-Linked Inheritance

(Genes transmitted through sex chromosomes)

- Two types:
  - X-Linked
    - Criss-cross inheritance pattern
    - Red-green colour blindess, hemophilia
  - Y-Linked
    - Holandric genes
    - Father-to-son
    - Hypertrichosis, webbed toes

Sex-Influenced Inheritance

- Autosomal traits
- Genes present in both sexes
- Expression influenced by sex hormone
- Dominant in one sex and recessive in another

E.g. Male pattern baldness, Index finger length,

- Horn development in sheep – Dorset & Suffolk
- Mahogany & Red colour in Ayreshire cattle
  - Aa genotype
  - mahogany in males
  - red in females)

Sex-Limited Traits

- Genes present on autosomes
- Expressed in one trait and not in another due to
  - Hormonal influence
  - Anatomical differences
- E.g.
  - Milk production in females
  - Egg production in poultry
  - Plumage in peacocks
  - Breast-development in women

Sex-Determination

Sex-Determination

- Chromosomal Theory of Inheritance
  - XX-XY system (Mammals)
  - XO system (grasshoppers)
    - Females – XX
    - Males – XO
  - Haplodiploidy (ants)
    - Unfertilised eggs – males
    - Fertilised eggs - females
  - ZZ-ZW system (birds)

Sex-Determination

- **Genic Balance Theory**
  - Given by C.B. Bridges
  - Applicable to XX-XY system for *Drosophila*
  - Based on the ratio between sex chromosomes to autosomes

Ratio (X:A)	Ratio	Sex
XX:AA	1.0	Normal female
XY:AA	0.5	Normal female
XXX:AA	1.5	Triple-X female
XO:AA	0.5	Meta-female

Pleiotropy

- Single gene influences multiple, seemingly unrelated traits
- Gene's product (protein) is involved in many processes
- E.g.
  - Cystic fibrosis gene (CFTR gene) – mutation
    - Production of thick mucous
    - Affects multiple organs – respiratory dysfunction, pancreatic insufficiency and reproductive complications

Penetrance

- Proportion of individuals with a specific genotype who exhibit the associated phenotype
- It is a measure of how consistently a gene expresses its traits. (qualitative)
- The likelihood that a genetic variant will result in the expected trait or disease

Two types

Complete Penetrance:

e.g., neurofibromatosis type 1 (NF1) shows complete penetrance.

Reduced Penetrance:

e.g., BRCA1 gene mutation has a breast cancer penetrance of about 65% by age 70.

Expressivity

- Expressivity refers to the degree or intensity with which a particular genotype is expressed in the phenotype
- It is a quantitative measure

Variable Expressivity

- Variable expressivity occurs when individuals with the same genotype exhibit different phenotypes.
- This can result in a spectrum of traits that vary in severity, size, color, etc.
- E.g. Polydactyly in Hemmingway Cats – number of extra toes varies due to difference in expressivity
- Or – three patients, same disease – different array of symptoms

Penetrance *vs* Expressivity

Penetrance	Expressivity
Whether the trait is expressed or not	How much or to what degree is it expressed
A percentage of the population (containing a genotype) showing the trait	Described as a range of phenotypic variation
Useful in predicting the likelihood of a trait appearing	Understanding the potential severity of the trait

MCQs – Modified Mendelian Genetics

- In incomplete dominance, the phenotype of the heterozygous individual is:
  a) Same as the dominant parent
  b) Same as the recessive parent
  c) Intermediate between the two parents
  d) Not expressed at all

- Which of the following is an example of co-dominance?
  a) ABO blood grouping in humans
  b) Flower color in snapdragons
  c) Coat color in Labrador retrievers
  d) Feather color in Andalusian chickens

MCQs – Modified Mendelian Genetics

- In complementary gene action, the phenotypic ratio of the F2 generation in a dihybrid cross is:
  a) 3:1
  b) 1:2:1
  c) 9:7
  d) 15:1

- Which type of epistasis results in a phenotypic ratio of 12:3:1 in the F2 generation?
  a) Dominant epistasis
  b) Recessive epistasis
  c) Duplicate dominant epistasis
  d) Duplicate recessive epistasis

MCQs – Modified Mendelian Genetics

- In Labrador retrievers, the presence of two recessive alleles (ee) at one locus masks the expression of black or brown coat color, resulting in yellow coat. This is an example of:
  a) Dominant epistasis
  b) Recessive epistasis
  c) Duplicate dominant epistasis
  d) Duplicate recessive epistasis

- Which of the following is an example of Y-linked inheritance?
  a) Red-green color blindness
  b) Hemophilia
  c) Hypertrichosis (hairy ears)
  d) Duchenne muscular dystrophy

MCQs – Modified Mendelian Genetics

- In X-linked recessive traits, the condition is more common in:
  a) Males
  b) Females
  c) Both males and females equally
  d) Neither males nor females

- Which of the following is an example of a sex-limited trait?
  a) Milk production in cattle
  b) Baldness in humans
  c) Horn development in sheep
  d) Sickle cell anemia

MCQs – Modified Mendelian Genetics

- In sex-influenced inheritance, the expression of traits is influenced by:
  a) The presence of sex chromosomes
  b) The hormonal environment
  c) The age of the individual
  d) The diet of the individual

- The ZW system of chromosomal sex determination is found in:
  a) Birds
  b) Mammals
  c) Bees
  d) Grasshoppers

MCQs – Modified Mendelian Genetics

- In a cross between a red-flowered snapdragon (RR) and a white-flowered snapdragon (rr), the F1 generation will have:
  a) All red flowers
  b) All white flowers
  c) All pink flowers
  d) A 3:1 ratio of red to white flowers

- Which of the following coat colors in shorthorn cattle is an example of co-dominance?
  a) Red
  b) White
  c) Roan
  d) Black

MCQs – Modified Mendelian Genetics

- In a dihybrid cross involving two complementary genes, if both parents are heterozygous for both genes, the proportion of offspring with the recessive phenotype will be:
  a) 1/16
  b) 3/16
  c) 9/16
  d) 7/16

- Which type of epistasis results in a phenotypic ratio of 9:3:4 in the F2 generation?
  a) Dominant epistasis
  b) Recessive epistasis
  c) Duplicate dominant epistasis
  d) Duplicate recessive epistasis

MCQs – Modified Mendelian Genetics

- Epistasis is:
  a) Inter allelic interaction
  b) Intra allelic interaction
  c) Inter and intra allelic interaction
  d) Genotype – Environment interaction

- Which type of epistasis results in a phenotypic ratio of 9:3:4 in the F2 generation?
  a) Dominant epistasis
  b) Recessive epistasis
  c) Duplicate dominant epistasis
  d) Duplicate recessive epistasis

- Parents of one generation passes on the sex-linked characters to the opposite sex in the next generation. This process is known as
  a) Conjugation
  b) Crossing over
  c) Cross-over unit
  d) Criss-cross inheritance


THANK YOU!

L2:

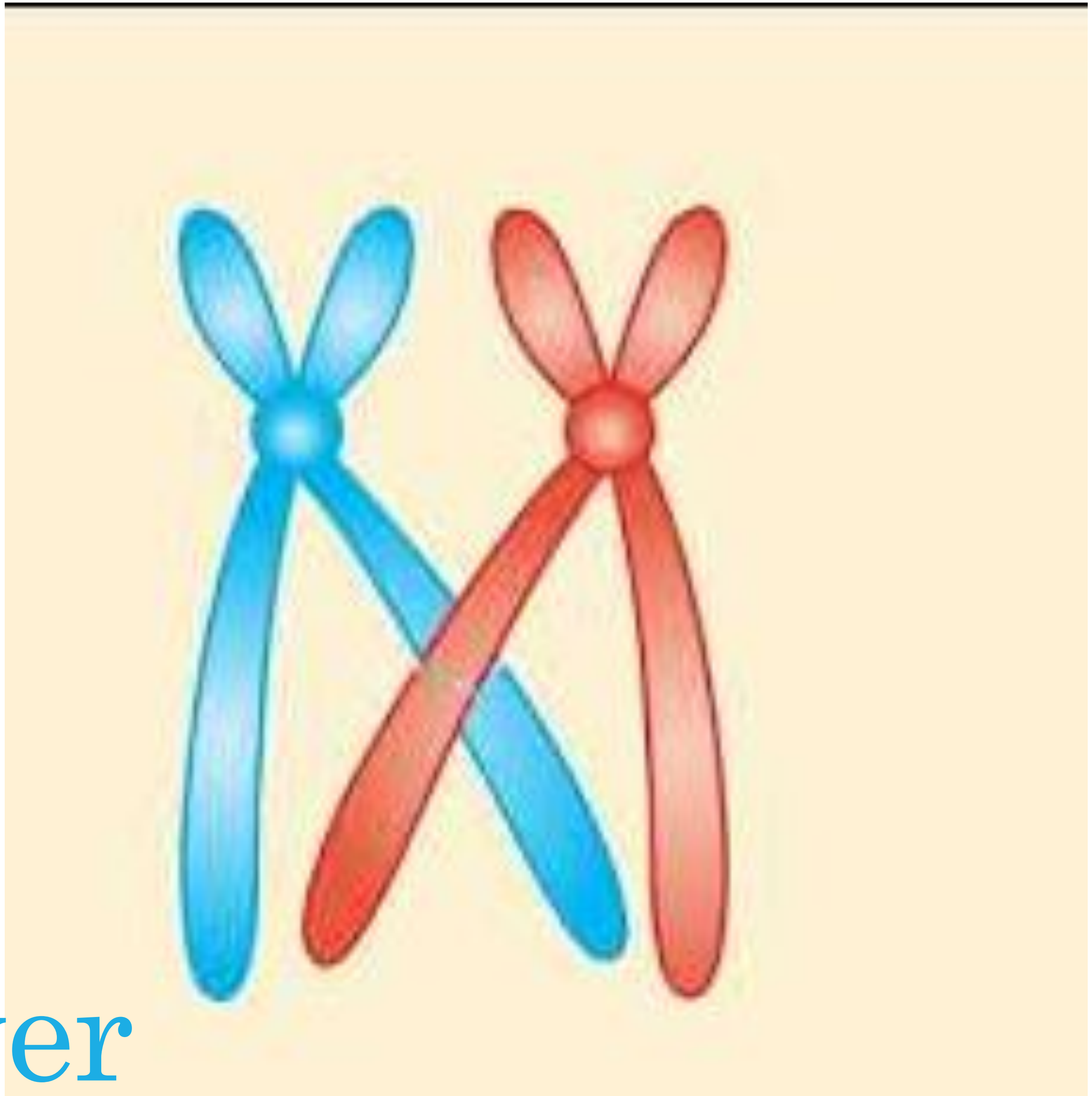
Topic 1: Advanced Genetics Concepts

Linkage

Crossing Over

Mutations

Linkage & Crossing Over



Linkage

- Genes located close to each other on chromosome are inherited together
- No independent assortment
- Higher recombination frequency
- Linkage Map – relative position/distance between genes on a chromosome
  - Expressed in unit cM (centiMorgan)

Linkage

- Linkage Groups:
  - All genes located on a given pair of chromosomes form a linkage group
  - So,

> Number of Linkage groups for a species = Haploid number of chromosomes

Example:
No. of Linkage groups for cattle = 60/2 = 30

No. of Linkage groups for dog =

No. of Linkage groups for cat =

No. of Linkage groups for river buffalo =

Linkage

<u>Important Facts about Linkage</u>

- Reduces Genetic Variability
- Strength of linkage depends on the distance between genes
- Linkage can be determined by test cross
- T.H. Morgan studied linkage in *Drosophila melanogaster* – concluded that it has two phases (coupling and uncoupling)

Linkage

- Classification of Linkage
  - On the basis of crossing over
    - Complete linkage
    - Incomplete linkage
  - On the basis of genes involved
    - Coupling phase
    - Repulsion phase
  - On the basis of chromosomes
    - Autosomal linkage
    - Sex linkage

Crossing over

- Exchange of genetic segments between non-sister chromatids of homologous chromosomes
- Occurs in Prophase I (pachytene) of meiosis I
- Leads to more genetic diversity in sexual reproduction

Crossing Over

Key Concepts

- Recombination
- Chiasmata
- Synapsis/Synaptonemal Complex
- Interference
- Parental/Non-crossover/Non-recombinant Types
- Non-parental/Crossover/Recombinant types

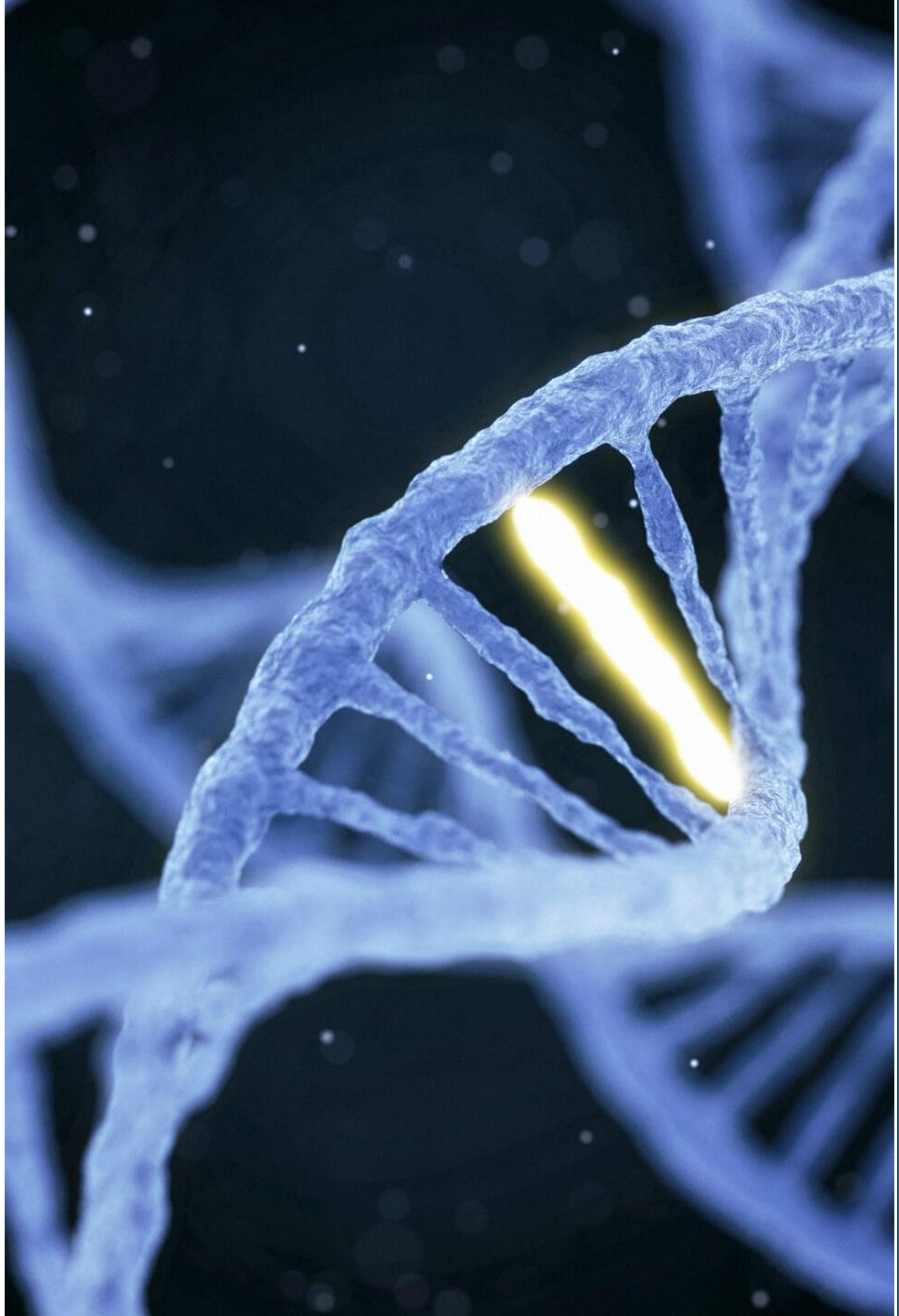
Crossing Over

- Types of Crossing Over
  - Single Cross Over
  - Double Cross Over
  - Multiple Cross Over

Linkage *vs* Crossing Over

Linkage	Crossing Over
Keeps genes together	Separates genes from each other
Produces parental combinations	Produces recombinant combinations
Happens between genes placed close together	Happens between genes located away from each other

Mutation



Mutation

- Sudden heritable change in DNA is known as mutation
- Types:
  - Gene Mutations
  - Chromosomal Mutations
  - Numerical Aberrations

Mutation

- Gene Mutations:

Point Mutation

- Substitution – One base substituted by another
  - Transition – Purine substituted by purine, pyrimidine by pyrimidine
  - Transversion – Purine substituted by pyrimidine
- Insertion – Addition of one or more bp
- Deletion – Removal of one or more bp

Frame Shift Mutation

Mutation

- **Point Mutations:**
  - **Non-Sense Mutations** – Premature stop codon appearance & termination of peptide chain – protein is often non-functional.
    - E.g. cystic fibrosis – CFTR gene (Glycine>X) due to GGA>TGA (premature stop codon)
  - **Mis-sense Mutations** – Sickle cell anaemia – change in one nucleotide (A>T) causes change in amino acid coded – (glutamic acid to valine)
  - **Silent Mutations** – Change in base doesn't cause amino acid to be changed (e.g. CCA>CCG – both code for proline – no change in a.a.)

Mutation

Chromosomal Mutations	Deletion	
	Duplication	
	Inversion	
	Translocation	Robertsonian Translocation – fusion of two acrocentric chromosomes to form one single metacentric chromosome

Mutation

Numerical Aberrations of Chromosomes

- Numerical Aberrations of Chromosomes
  - Euploidy
    - Haploidy
    - Polyploidy
  - Aneuploidy
    - Monosomy (2n-1)
    - Nullisomy (2n-2)
    - Trisomy (2n+1)
    - Tetrasomy (2n+2)

Mutation

Numerical Aberrations of Chromosomes - Disorders

Turner Syndrome	Klinefelter's Syndrome	Down's Syndrome	Edward's Syndrome	Patau Syndrome
Monosomy of Sex Chromosome (XO)	Trisomy of Sex Chromsome (XXY)	Trisomy of Chromosome 21	Trisomy of Chromosome 18	Trisomy of Chromosome 13
2n-1=45	2n+1=47			

MCQs – Advanced Genetics Concepts

- What is the maximum number of linkage groups in a species?
  a) Equal to the diploid number of chromosomes
  b) Equal to the haploid number of chromosomes
  c) Double the haploid number of chromosomes
  d) Independent of the chromosome number

- Which of the following is true about the frequency of recombination?
  a) It is inversely proportional to the distance between two genes
  b) It is directly proportional to the distance between two genes
  c) It always exceeds 50%
  d) It is independent of the distance between two genes

- In the linked genes, recombinant gametes are:
  a) More than 50%
  b) 50%
  c) Less than 50%
  d) none of the above

MCQs – Advanced Genetics Concepts

- Which of the following is NOT a type of gene mutation?
  a) Transition
  b) Transversion
  c) Frame shift mutation
  d) Inversion

- Germline mutations are present in:
  a) Somatic cells only
  b) Egg or sperm cells
  c) All body cells
  d) None of the above

- Which of the following term is used for replacement of a purine base by a pyrimidine base and vice versa?
  a) Reversion
  b) Transversion
  c) Transition
  d) Alteration

MCQs – Advanced Genetics Concepts

- Which of the following is an example of a chromosomal aberration?
  a) Point mutation
  b) Transition
  c) Deletion
  d) Frame shift mutation

- Monosomy is characterized by:
  a) One extra chromosome
  b) One missing chromosome
  c) Two extra chromosomes
  d) Two missing chromosomes

MCQs – Advanced Genetics Concepts

- Klinefelter's syndrome is an example of:
  a) Monosomy
  b) Trisomy
  c) Tetrasomy
  d) Nullisomy

- Robertsonian translocations involve:
  a) Metacentric chromosomes
  b) Acrocentric chromosomes
  c) Telocentric chromosomes
  d) Submetacentric chromosomes

MCQs – Advanced Genetics Concepts

- Which of the following is an example of aneuploidy?
  a) Haploidy
  b) Autotriploid in maize
  c) Turner's syndrome
  d) Wheat allopolyploidy
- The maximum frequency of recombination between two genes is:
  a) 25%
  b) 50%
  c) 75%
  d) 100%
- Sudden heritable change is :
  a) Epistasis
  b) Mutation
  c) Chromosomal aberration
  d) None of the above

L3

Topic 1:
Hardy Weinberg Equilibrium and Gene Frequencies

Population Genetics

- Population:
  - Group of individuals
  - In a given geographical area at a particular time
  - Free interbreeding & produce fertile offspring

- Gene pool
  - total of all genes (at all loci) of all individuals in a populations

Population Genetics

- Allele (Gene) frequency
  - Proportion of one allele in a gene pool compared to other alleles at the same locus
  - p – frequency of dominant allele (A)
  - q- frequency of recessive allele (a)

- Genotype frequency
  - The proportion of individuals of a particular genotype (for a trait) in a population
  - Obtained by dividing the number of individuals with that genotype by the total number of individuals in the population

Population Genetics

Sample Problem:

In a population of 100 individuals with 40 homozygous dominant (AA), 40 heterozygous (Aa), and 20 homozygous recessive (aa) individuals, then allele frequencies (using the allele counting method) will be as follows:

Hardy Weinberg Equilibrium

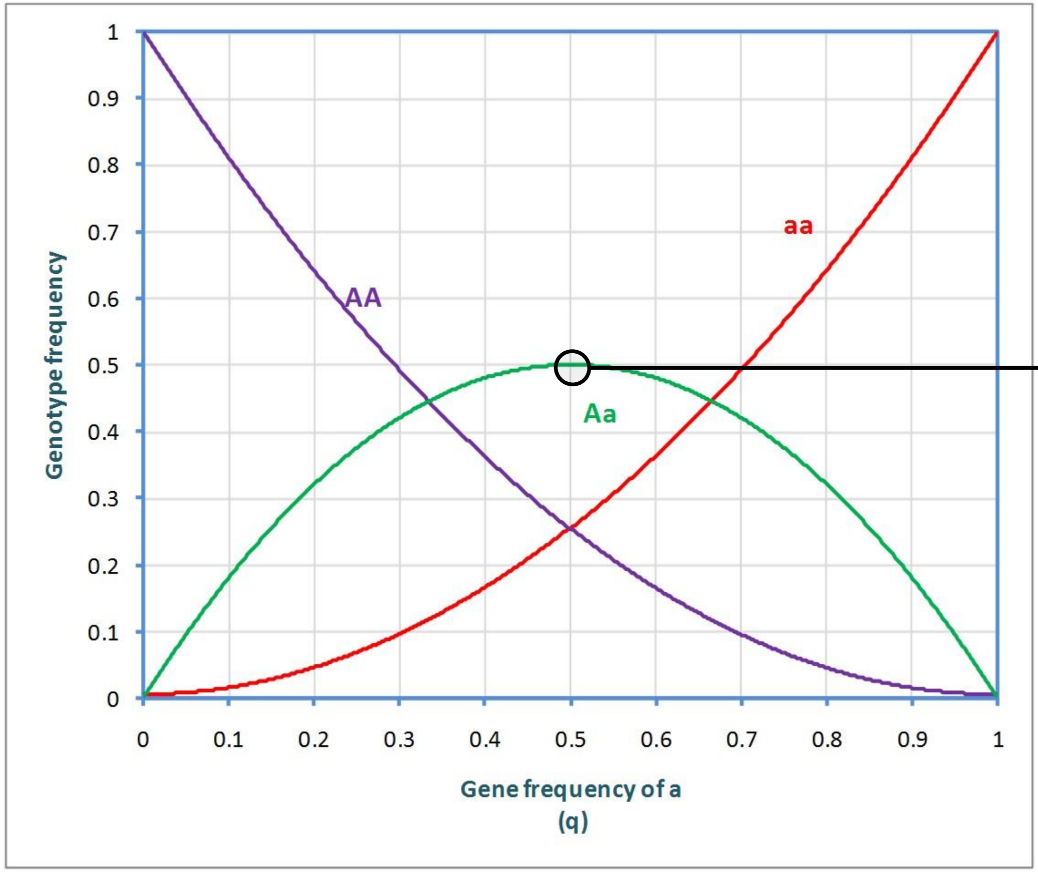
- Independently formulated by G. H. Hardy and Wilhelm Weinberg (1908)
- Describes a situation where a population is undergoing no evolutionary change
- States that:
  - The allele and genotype frequencies remain constant over generations in a large, randomly mating population when evolutionary forces (migration, mutation, selection) are absent.

Hardy Weinberg Equilibrium

- Assumptions:
  - No mutation, selection, migration
  - Large population size
  - Random mating
  - Equal gamete production and random combination

- Gene and Genotype frequencies:
  - $p+q = 1$
  - $P^2 + 2pq + q^2 = 1$

Relationship between gene & genotype frequencies



Relationship between genotype frequencies and gene frequency for two alleles in a population in Hardy-Weinberg equilibrium

p=q=0.5

Max. gene frequency of any allele

Applications of HW

- Calculation of frequencies of dominant and recessive genes in a population
- Introgression of new genes in a population – testing the frequency of new genes (used as a base by breeders)
- Calculation of frequency of carriers (heterozygotes) in a population
- To test for agreement of a population with HW equilibrium

Attaining HW Equilibrium

- Assuming other conditions are met, HW equilibrium in population is attained for:
  - Autosomal traits – 1 generation of random mating
  - Sex-linked traits – 8-10 generations of random mating

- Key feature of HW Eq^{m} – rapid attainment of equilibrium in one generation of random mating
  - Serves as a null model for population genetics

Sample Questions

- In a population of 1000 cats, coat color is determined by a single gene with two alleles. The dominant allele B produces black coat color, while the recessive allele b produces white coat color. After surveying the population, researchers found 490 black cats and 510 white cats.
- *Find the following:*
    - 1. Calculate the frequencies of the B and b alleles in this population.
    - 2. Using the calculated allele frequencies, predict the expected genotype frequencies (BB, Bb, bb) in the next generation, assuming Hardy-Weinberg equilibrium.

Sample Questions

Solution:

- **Calculating allele frequencies:**
- Frequency of b allele (q): $\sqrt{(510/1000)} = \sqrt{0.51} = 0.714$
- Frequency of B allele (p): 1 - 0.714 = 0.286

- **Predicting genotype frequencies:**
- BB: p^2 = 0.286^2 = 0.082 or 8.2%
- Bb: 2pq = 2(0.286)(0.714) = 0.408 or 40.8%
- bb: q^2 = 0.714^2 = 0.51 or 51%

Sample Questions

In a population of 500 cats, a recessive allele causes a genetic disorder. After testing, 36 cats were found to have the disorder.

Calculate:
a) The frequency of the recessive allele (q)
b) The frequency of the dominant allele (p)
c) The expected number of heterozygous carriers in the population

Sample Questions

- *Solution*:
  a) Calculating the frequency of the recessive allele (q):

- Number of affected cats (homozygous recessive) = 36
- Total population = 500
- Frequency of affected individuals = 36/500 = 0.072
- Since q^2 = 0.072 (frequency of homozygous recessive)
- q = √0.072 = 0.268 (rounded to three decimal places)

Sample Questions

b) Calculating the frequency of the dominant allele (p):

- Since $p + q = 1$
- $p = 1 - q = 1 - 0.268 = 0.73$

c) Calculating the expected number of heterozygous carriers:

- Frequency of heterozygotes = $2pq$
- $2pq = 2 \times 0.732 \times 0.268 = 0.392$
- Expected number of heterozygotes = $0.392 \times 500 = 196$ cats

Sample Questions

- A population has an allele frequency of 0.6 for allele A. Migrants with an allele frequency of 0.8 for A enter the population at a rate of 0.1 per generation. Calculate the new allele frequency after one generation of migration.

Sample Questions

Solution:

$\Delta p = m(pm - p)$

- $= 0.1(0.8 - 0.6)$
- $= 0.1(0.2)$
- $= 0.02$
- New allele frequency = $p + \Delta p = 0.6 + 0.02 = 0.62$

Sample Questions

- . In a population, allele A mutates to allele a at a rate of 1×10^{-5} per generation. The back mutation rate from a to A is 2×10^{-5} per generation. If the initial frequency of A is 0.8, calculate the change in allele frequency due to mutation in one generation.

$$\Delta p = \nu q - \mu p$$

Sample Questions

Solution:

$\Delta p = \nu(1\text{-}p) - \mu p$

$= (2 \times 10^{-5})(1-0.8) - (1 \times 10^{-5})(0.8)$

$= (2 \times 10^{-5})(0.2) - (8 \times 10^{-6})$

$= 4 \times 10^{-6} - 8 \times 10^{-6}$

$= -4 \times 10^{-6}$

- The frequency of allele A will decrease by 0.000004 in one generation due to mutation.

Sample Questions

- A population has an initial frequency of 0.7 for allele B. It experiences migration from a population with a B frequency of 0.9 at a rate of 0.05 per generation. Additionally, B mutates to b at a rate of 2×10^{-6} per generation, with no back mutation. Calculate the new allele frequency after one generation.

Sample Questions

Solution:

Change due to migration: $\Delta p_m = m(p_m - p) = 0.05(0.9 - 0.7) = 0.01$
Change due to mutation: $\Delta p\mu = -\mu p = -(2 \times 10$^-6)(0.7) = -1.4 $\times$ 10^-6

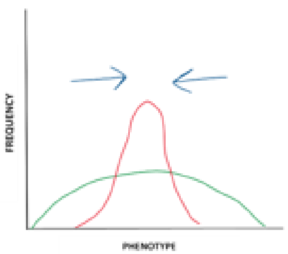
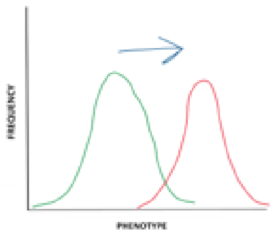
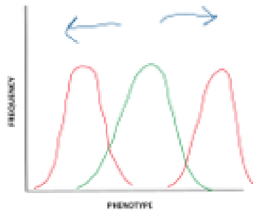
- Total change: Δp = Δpm + Δpμ = 0.01 - 0.0000014 = 0.0099986

- New allele frequency = 0.7 + 0.0099986 = 0.7099986

Factors Affecting Gene Frequency

- Mutations
- Migration (Gene Flow)
- Non-random mating
  - Assortative mating
- Natural Selection
  - Directional Selection – favours one extreme
  - Stabilising selection – favours the intermediate phenotype
  - Disruptive Selection – favours both extremes

Factors Affecting Gene Frequency

SELECTION TYPE	CHANGE IN MEAN	CHANGE IN VARIANCE	DIRECTION OF SELECTION	GRAPH
STABILIZING	No change in mean value	Mean frequency increases, changing overall variance	→ | ←	
DIRECTIONAL	Mean value changes	Change in mean decreases variance, allele frequency changes	→ OR ←	
DISRUPTIVE	Mean value changes	Mean favors extreme phenotypes, increasing variability	← | →	

Factors Affecting Gene Frequency

- Genetic Drift –
  - Bottleneck effect –
    - Population size is drastically reduced for atleast 1 generation
    - Environmental effects/Human activities
    - E.g. Overhunting of northern elephant seals (1800s) – population came down to 20
    - E.g. Cheetahs – 12000 years ago – low genetic diversity
  - Founder effect –
    - New population established by a small section of a larger population
    - Non-random sample of genes
    - low genetic variation
    - E.g. Afrikaner population (South Africa) (came from Dutch) – higher prevalence of Huntington's
    - E.g. Amish community – higher prevalence of Ellis van Creveld syndrome

MCQs

- What is a population in the context of population genetics?
  a) A group of different species occupying a given area
  b) A group of individuals of the same species that cannot interbreed
  c) A group of individuals of the same species occupying a given area that can freely interbreed and produce fertile offspring
  d) A group of individuals with different genotypes

- The sum total of genes of all individuals in a population is called:
  a) Genotype frequency
  b) Allele frequency
  c) Gene pool
  d) Phenotype frequency

MCQs

- Which of the following is NOT an assumption of the Hardy-Weinberg equilibrium?
  a) No mutation
  b) Large population size
  c) Random mating
  d) Presence of selection

- The maximum gene frequency for heterozygotes in a one-locus-two-allele situation is achieved when:
  a) p = 0.25 and q = 0.75
  b) p = 0.75 and q = 0.25
  c) p = q = 0.5
  d) p = 1 and q = 0

MCQs

- In a population of 1000 individuals, 160 are found to have a recessive genetic disorder. What is the frequency of the recessive allele (q)?
  a) 0.16
  b) 0.32
  c) 0.4
  d) 0.8

- In a population of cats, the dominant allele B produces black coat color, while the recessive allele b produces white coat color. If the frequency of the B allele is 0.6, what is the expected frequency of heterozygous (Bb) cats?
  a) 0.24
  b) 0.36
  c) 0.48
  d) 0.64

MCQs

- In a population of 800 individuals, 128 are found to have a recessive genetic disorder. Assuming the population is in Hardy-Weinberg equilibrium, what is the frequency of the dominant allele (p)?
  a) 0.2
  b) 0.4
  c) 0.6
  d) 0.8

- The change in allele frequency due to mutation is represented by the equation:
  a) $\Delta p = \nu(1-p) + \mu p$
  b) $\Delta p = \nu(1-p) - \mu p$
  c) $\Delta p = \mu(1-p) - \nu p$
  d) $\Delta p = \mu(1-p) + \nu p$

MCQs

- Hardy-Weinberg equilibrium is not attained in a single generation of random mating in case of (OPSC 2022)
  a) Sex-linked genes
  b) Multiple alleles
  c) Two autosomal alleles
  d) Polyploids

- The direction of change in the allelic frequencies cannot be predicted in: (OPSC 2022)
  (A) Mutation
  (B) Migration
  (C) Selection
  (D) Genetic drift

MCQs

- When two or more alleles of a gene are present in a gene pool the population is: (UK VO 2024)
  a) Polymorphic
  b) Evolving
  c) Drifting
  d) Somatic

- The change in allele frequency due to mutation is represented by the equation:
  a) $\Delta p = \nu(1-p) + \mu p$
  b) $\Delta p = \nu(1-p) - \mu p$
  c) $\Delta p = \mu(1-p) - \nu p$
  d) $\Delta p = \mu(1-p) + \nu p$

MCQs

- . Frequency of two alleles in parents is 'p' and 'q'; then proportion of heterozygotes in progeny will be:
  a) 2pq
  b) p2
  c) q2
  d) p+q


THANK YOU!

L3:
Quantitative Genetics Concepts

Heritability

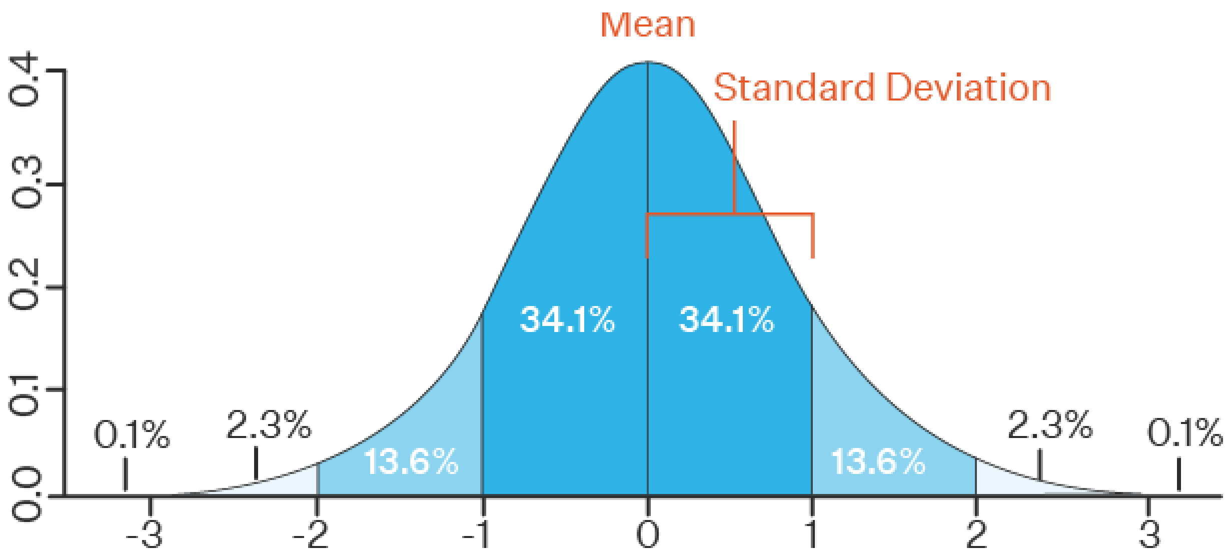
Repeatability

Correlation

Some Basic Concepts

Standard Deviation (S.D./σ)

- It measures how far data points tend to deviate from the mean on average
- Low σ - values tend to be close to the mean
- High σ – values spread out over wide range from the mean



$$\sigma = \sqrt{\frac{\sum (x_i - \mu)^2}{N}}$$

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Some Basic Concepts

- Imagine you're a teacher, and you've just given a math test to a class of five students. Here are their scores out of 100:
  75, 80, 85, 90, 95

Some Basic Concepts

- Variance (σ^2)
- Square of standard deviation
- Used to calculate heritability, repeatability, covariance, correlation.

Economic Traits

- Selection of traits – market demand and parameters
- Trait = character
- Phenotype = alternate forms of a trait/specific measurements made on a trait

Different Phenotypes of coat colour in labrador retrievers

Economic Traits

- These are traits of economic importance –
  - Related to economic value/productivity/profitability

Related to

Production	Reproduction	Growth
Milk, meat, wool, skin, manure	AFI, ICI, prolificacy, conception rate, service period	Birth wt., yearling wt., FCR

Quantitative Genetics

- Quantity --→ measurement
- *Quantitative Trait* –

  polygenic, measurable, continuous, and environmentally affected/controlled
- Then, the phenotype 'P' can be written as,

$$P = G + E$$

$$P = (A+D+I) + (E_P + E_T)$$

Quantitative Genetics

- Then, the phenotype 'P' can be written as,

$$P = G + E$$

$$P = (A+D+I) + (E_P + E_T)$$

Also, the variability in the measured phenotype can be written as,

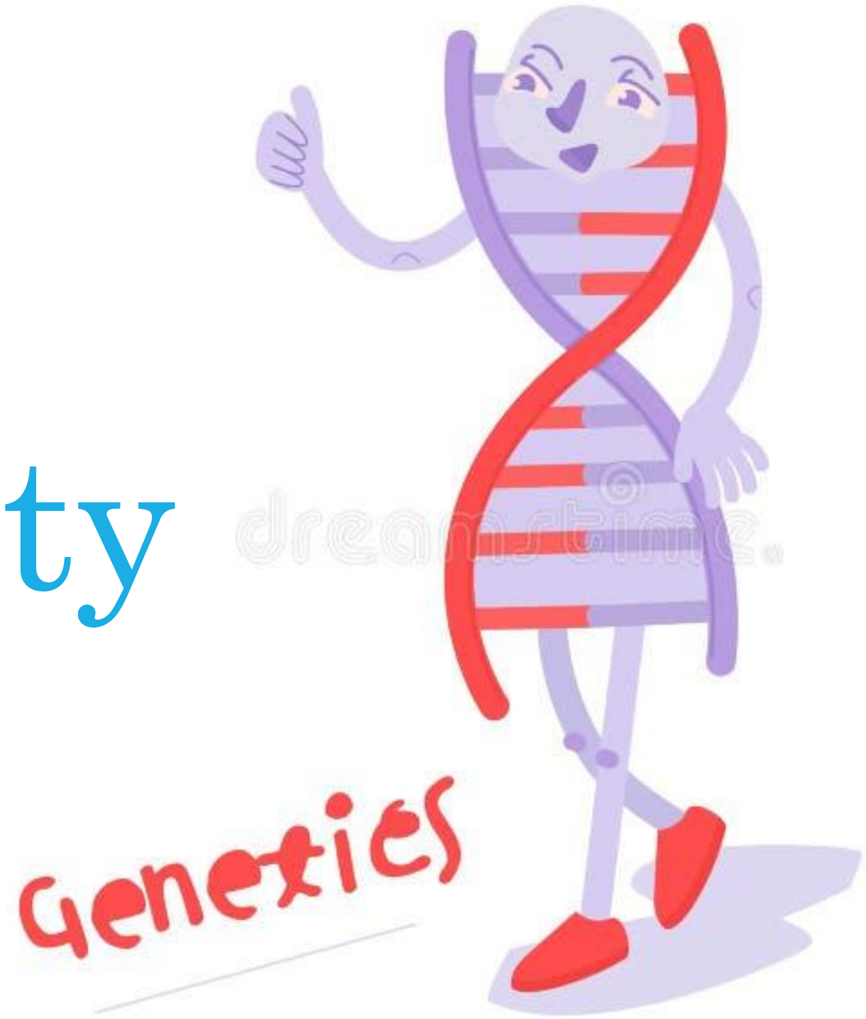
$$V_P = V_G + V_E$$

$$V_P = (V_A+V_D+ V_I)+ (V_{Ep} + V_{Et})$$

Quantitative Genetics

- Selection for improvement of economic traits is necessary
- Phenotype is affected by genotype
- Measure genetic parameters for selecting the best animals (parents)
- Genetic parameters include – heritability, repeatability and genetic correlation

Heritability



Heritability

- Heritability measures the degree to which offspring resemble their parents in trait performance.
- It represents the strength of the relationship (consistency) between phenotypic values and breeding values for a trait in a population.
- Denoted by the symbol h^2.
- Heritability is dimensionless, estimable, and a population parameter.
- Heritability is necessary to predict breeding values

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Heritability - Types

H^2

Broad sense:

- $H^2 = V_G / V_P$
- Represents the influence of the entire genotype on the phenotype.

h^2

Narrow Sense:

- $h^2 = V_A / V_P$
- Represents the additive genetic portion of phenotypic variance.
- More useful for breeding purposes.

Characteristics of heritability

- Ranges from 0 to 1 or 0% to 100%.
- Always a positive value mathematically.
- Population measure.
- A pure ratio

Heritability

- When we say,
  - h^2 is high & production is high – so, a large proportion of the V_P comes from V_A
  - h^2 is low & production is high – that means, V_A is less

In which of the above cases will the phenotype of an individual give a higher indication of its breeding value?

Example

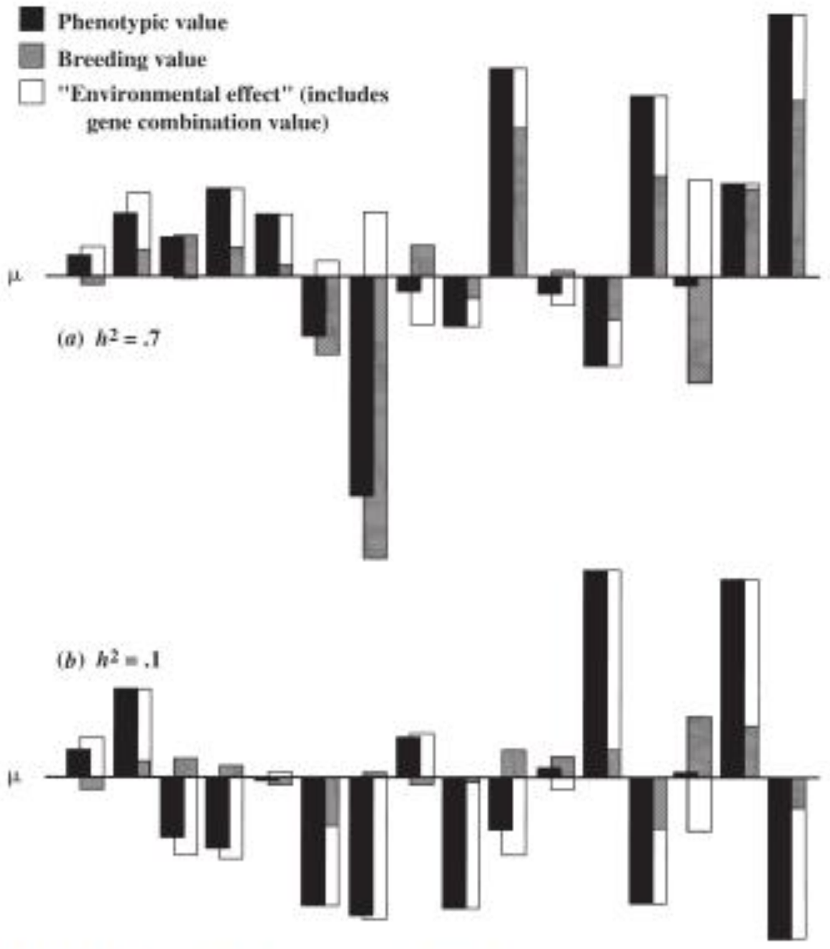

FIGURE 9.1 Schematic representation of animal performance for two traits that differ in heritability. Records for a sample of 16 animals are shown for each trait. Contributions of breeding values and "environmental effects" (environmental effects and gene combination values combined) are shown in the background. Heritabilities (h^2) for the traits depicted in the upper (a) and lower (b) diagrams are .7 and .1, respectively.

- Fig. (a) –
  - Positive BV – above avg performance
  - Negative BV – below avg performance
  - Larger the BV, higher the deviation from mean
  - ∴ strong consistent relationship b/w BV and P
- Fig (b):
  - Cases with negative BV – higher P
  - Cases with less BV – higher P
  - Cases with high BV – lower P
  - Phenotype influenced by environment
  - Animal's own performance not a good indicator of BV

Questions

- **What is the heritability for the number of legs in a dog?**
- **What is the heritability for the length of legs in a dog?**

Fun Fact

Temperament is a heritable trait. Make sure that donor cows are docile and easy to handle to ensure the calf crop is too!

Estimation of heritability

In terms of correlation/regression, an alternative form for heritability is given as,

$$h^2 = b/r \quad \text{or} \quad h^2 = t/r$$

Where 'b' $\longrightarrow$ regression of parent on offspring

't' $\longrightarrow$ correlation between full sibs/half sibs

'r' $\longrightarrow$ coefficient of additive variance in covariance (theoretical correlation)

Heritability Range

- **Low heritability**: $h^2 < 0.2$ (e.g., reproduction & fitness traits – fertility)
- **Moderate heritability**: $h^2 = 0.2\text{-}0.4$ (e.g., production traits like milk production, growth rate)
- **High heritability:** $h^2 > 0.4$ (e.g., growth traits, carcass traits, structural size, mature body weight)

Estimation of heritability

When the contributions of epistatic interactions and environment are ignored, heritability can be estimated as given below,

Relatives	Heritability (in terms of b or t)
Offspring and one parent	$h^2 = 2b$
Offspring and mid-parent	$h^2 = b$
Full sibs	$h^2 \leq 2t$
Half sibs	$h^2 = 4t$

KEY TAKEAWAYS SO FAR

Population parameter – depends on population size too

KEY TAKEAWAYS SO FAR

Population parameter – depends on population size too

Estimated for a trait in a population

KEY TAKEAWAYS SO FAR

Population parameter – depends on population size too

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Narrow sense h^2 (V_A/V_P) used in breeding

KEY TAKEAWAYS SO FAR

Population parameter – depends on population size too

Estimated for a trait in a population

Narrow sense h^2 (V_A/V_P) used in breeding

When h^2 is high, P is a good indicator of animal's BV

KEY TAKEAWAYS SO FAR

Population parameter – depends on population size too

Estimated for a trait in a population

Narrow sense h^2 (V_A/V_P) used in breeding

When h^2 is high, P is a good indicator of animal's BV

∴ Heritability - particular population; specific environment; particular time

Practical Implications of h^2

Selection

- Only phenotypic value available, but selection is for breeding value therefore, use h^2
- High h^2 – individual selection
- Low h^2 – Individual performance not a good indicator of genotype – other types of selection

Prediction

- High h^2 – Highly likely that progeny is similar to parent in production

Management

- High h^2 – Phenotype influenced by genetics – environment has low impact
- Low h^2 – Phenotype mostly influenced by enviroment

Breeding Strategies

- High V_A/V_P – Selection will be fruitful in a few generations
- Low V_A/V_P , but high V_G/V_P – Non additive gene action is dominant – heterosis breeding is beneficial

Factors affecting heritability estimates

- Sample Size
- Data Collection
- Sampling Methods
- Environment
- Experimental Design – decides all these factors

Repeatability

Repeatability

- Strength of relationship (correlation) between repeated records (measurements) for a trait in a population
- Can be determined for traits which have more than one measurement
- $r = V_G/V_P$
- Population parameter
- Ranges from -1 to +1 (it is a correlation), but repeatabilities are rarely negative
- r=0 – trait is hardly repeatable, r close to 1 – trait is extremely repeatable
- Examples – Lactation yield, litter size, wool production etc.

Repeatability

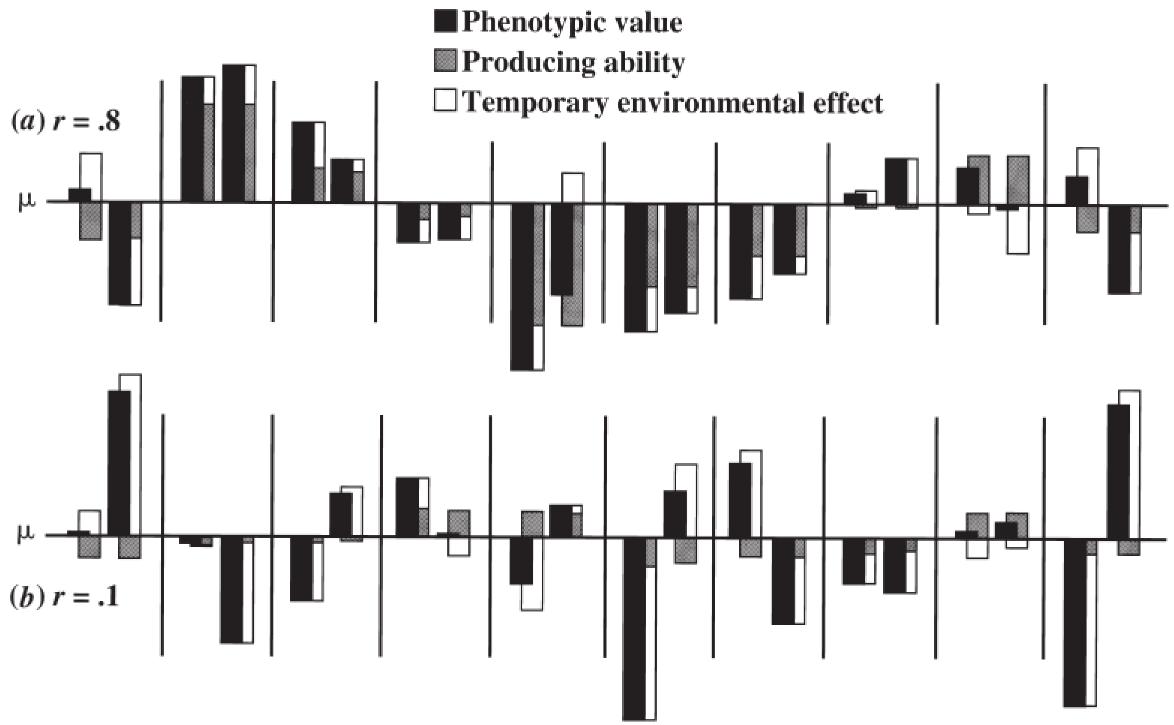

Figure 9.4 Schematic representation of animal performance for two traits that differ in repeatability. For each trait, pairs of repeated records from a sample of 10 animals are illustrated. (For clarity, vertical lines separate each pair.) Contributions of producing abilities and temporary environmental effects are shown in the background. Repeatabilities (*r*) for the traits depicted in the upper (*a*) and lower (*b*) diagrams are .8 and .1, respectively.

- Trait (a) – high ‘r’ value
- Trait (b) – low ‘r’ value

Repeatability

<u>Practical implications:</u>

- When repeatability is high, first record is a good indicator of its second record

OR

- Repeatability is the strength of relationship between single performance records and producing abilities.

- *When repeatability is high – differences in animal performances are largely attributable to differences in producing ability, not among environmental effects and vice versa.*

Some repeatability estimates

Repeatability range:

- R < 0.2 – lowly repeatable
- 0.2 < r < 0.4 – moderately repeatable
- R > 0.4 – highly repeatable

Species	Trait	*r*
Cattle (beef)	Calving date (trait of the dam)	.35
	Birth weight (trait of the dam)	.20
	Weaning weight (trait of the dam)	.40
	Body measurements	.80
Cattle (dairy)	Services per conception	.15
	Calving interval	.15
	Milk yield	.50
	% fat	.60
	Udder support	.50
	Teat placement	.55
	Rear leg set	.30
	Stature	.75
Poultry	Egg weight	.90
	Egg shape	.95
	Shell thickness	.65
	Shell weight	.70

Characteristics of Repeatability

- Repeatability is a population measure – not determined for an individual
- It is not fixed – varies between populations and environments
- Upper Limit of h^2
- Determines gain from repeated measurements
- Allows prediction of future performance

Importance of Repeatability

- Repeatability and Culling

  Two cows:
  Ruby – Decent milker, but slow to breed back
  Emerald – Poor milker, but quick to breed back
  Whom would you cull?

  When repeatability is high –
  When repeatability is low –

- Repeatability and Prediction

Importance of Repeatability

- Repeatability and Prediction

Calculation of MPPA – Most Probable Producing Ability

Repeatability is necessary to predict producing abilities

Some concepts

- Higher the h^2 for a trait – one record is a good indicator of animal's BV
- Higher the r for a trait – one record is a good indicator of its producing ability
- Both h^2 and r are not constant – they can be increased for a population
  - Use common environments while determining
  - Accurate measurement

Correlation

Correlation

- **Correlation coefficient** – measure of strength of relationship between two variables
  - Variables can be two traits or two values for the same trait

- **Types:**
  - ***Genetic correlation*** **–**
    strength of relationship between breeding values of two traits
  - ***Environmental correlation*** **–**
    Relationship b/w environmental effects of one trait and another
  - ***Phenotypic correlation*** **–**
    Strength of relationship between performance in one trait and performance in another

Correlation

It's a population measure, denoted by the letter 'r'
Correlation range: -1 to +1

Range : -1 to +1

r = 0
no relationship between traits

r>1
Selection for one trait leads to improvement in another

E.g. Milk yield and mastitis incidence
(0.15-0.68)

r<1
Selection for one trait leads to decline in another

E.g. – milk yield and milk fat percentage

Correlated Response to Selection

- Selection for one trait leads to selection of another
- Causes of correlated response:
  - Pleiotropy – major cause – one gene influences more than one trait

    e.g. halothane gene in swine – increased lean yield, feed efficiency, decreased litter size, survival rate and meat quality

    HYPP gene – horses – increased muscling and decreasing survival
  - Linkage – Selection for one trait increases frequency of the other

Correlated Response to Selection

- Genetic correlations –
- Positive –
  - Keel length and body weight in turkeys (r=0.5)
- Negative correlation:
  - Milk yield and milk fat in dairy cows (-0.3)

MCQs - h^2, r, and correlation (r_{xy})

1. Measures of the correlation between the repeated measurements of the same individual is known as (MPSC, 2019)
   (1) Repeatability
   (2) Phenotypic correlation
   (3) Genetic correlation
   (4) Heritability

2. The major cause of genetic correlation is (UK VO – 2024)
   a) Pleiotropy
   b) Segregation
   c) Heterozygosity
   d) Homozygosity

MCQs - h^2, r, and correlation (r_{xy})

- The reproductive traits of livestock indicate heritability as: (UK VO 2024)
  a) Low
  b) Zero
  c) Medium
  d) High

- Heritability estimate of a trait is higher when there is (UK VO 2024)
  a) Uniform environment
  b) Genetically uniform population
  c) Small population
  d) Dominance effect

MCQs - h^2, r, and correlation (r_{xy})

- The sum of average effect of all the alleles, is known as: (UK VO 2024)
  a) Dominance effect
  b) Transmitting ability
  c) Breeding value
  d) Genetic load

- Proportion of phenotypic variance caused due to additive gene variance is (JKPSC 2019)
  a) Heritability
  b) Correlation
  c) Regression
  d) Response

MCQs - h^2, r, and correlation (r_{xy})

- Correlation among different measurements on a character in the life of an animal is called (JKPSC 2019)

  a) Repeatability
  b) Heritability
  c) Regression
  d) Variance

- Selection on the basis of individuality is most important, when h^2 of the trait is: (PPSC 2016)
  a) Low
  b) Medium
  c) High
  d) None of the above

MCQs - h^2, r, and correlation (r_{xy})

- Which of the following is used to predict future performance of individual ?

  (RPSC 2019)

  a) Genetic Correlation
  b) Heritability
  c) Repeatability
  d) Phenotypic correlation

- Which of the following is a heritable and fixable component of phenotypic variance? (MPPSC 2021)
  a) Environmental variation
  b) Additive variation.
  c) Both of the above
  d) None of the above

MCQs - h^2, r, and correlation (r_{xy})

- Which of the following statements indicates about narrow-sense heritability? (MPPSC 2023)

  a) It is the ratio of genetic variance to total phenotypic variance
  b) It is the ratio of environmental variance to total phenotypic variance
  c) It is the ratio of additive genetic variance to total phenotypic variance
  d) It is the ratio of phenotypic variance to total environmental variance

- What will be the heritability range for wool quality traits like fiber diameter, staple length, crimp frequency etc.? (MPPSC 2023)
  a) Less than 0-3
  b) More than 0.5
  c) Between 0-1 and 0-2
  d) None of the above

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MCQs - h^2, r, and correlation (r_{xy})

- The causes which are responsible for the genetic correlation between two characters are (MPPSC 2022)

  a) Pleiotropy and linkage between genes
  b) Dominance and lethal genes
  c) Heterosis and pleotrophy
  d) Linkage and multiple alleles

- Family selection of the method of choice for traits with: (MPPSC 2022)
  a) High heritability
  b) Low heritability
  c) Expression in one sex only
  d) Large families

MCQs - h^2, r, and correlation (r_{xy})

- Intra-class correlation between repeated measurements of the same individual is a measure of (OPSC 2022)

  a) Genetic correlation
  b) Heritability
  c) Phenotypic correlation
  d) Repeatability

- Which of the following variances is fully transmitted to the next generation? (OPSC 2022)
  a) Dominance variance
  b) Epistatic variance
  c)) Additive genetic variance
  d) Phenotypic variance


THANK YOU!

L5:
Quantitative Genetics Concepts: Selection

Selection Differential

Response to Selection

Intensity of Selection

Bases of Selection

Methods of Selection

Selection & Mating Systems

- Selection –
  - Which individuals will become parents?
  - How many progenies will they produce?
  - How long will these individuals remain in the breeding population?

- Mating –
  - Which of the selected male will mate with which female?
  - Controls how the parents are mated to produce the next generation

- Breeding Plan = Selection + Mating System

Selection

- Giving preference to certain individuals to reproduce
- Differential reproduction
- No creation of new genes
- Genetic structure of the population changes
- Two types of selection:
  - Natural Selection – “survival of the fittest”
  - Artificial Selection – intentional selection done by the breeder

Artificial Selection

- Concerned with increasing the frequency of desirable genes in the herd or flock
- Sorts the genes - keep the desired genes, cull the undesired

Selection Differential / Reach

- Phenotypic superiority of parents over population (before selection)
- For a particular phenotype:
- P_b – Population mean
- P_s – Mean of the selected parents
- Then selection differential (S):

$$S = P_s - P_b$$

Question:

Will the entire 'S' be transmitted to the next generation as it is?

Will a portion be transmitted to the next generation?

Selection Differential / Reach

Depends on:

- Size of the selected population
- Large litter bearing animals – S.D. is large (Swine > Cattle)
- Herd size
- Use of AI, ETT and superovulation
- Standard deviation of base population

Response to Selection/Genetic Gain

- Change in performance of progeny generation due to artificial selection is known as response to selection/genetic gain
- Symbol: R
- How much change has been seen in the population after selection?

$$R = P_o - P_b$$

Annual Genetic Gain (ΔG):

$$\Delta G = \frac{R}{Generation\ Interval}$$

Response to Selection/Genetic Gain

R is also estimated from 'S' – ***Expected Genetic Gain***

- We know that only h^2 portion of 'S' is transmitted to next generation, so,

$$R = h^2 S$$

Then, $h^2 = R/S$,

This is called *realised heritability* (what is actually passed on to the next generation

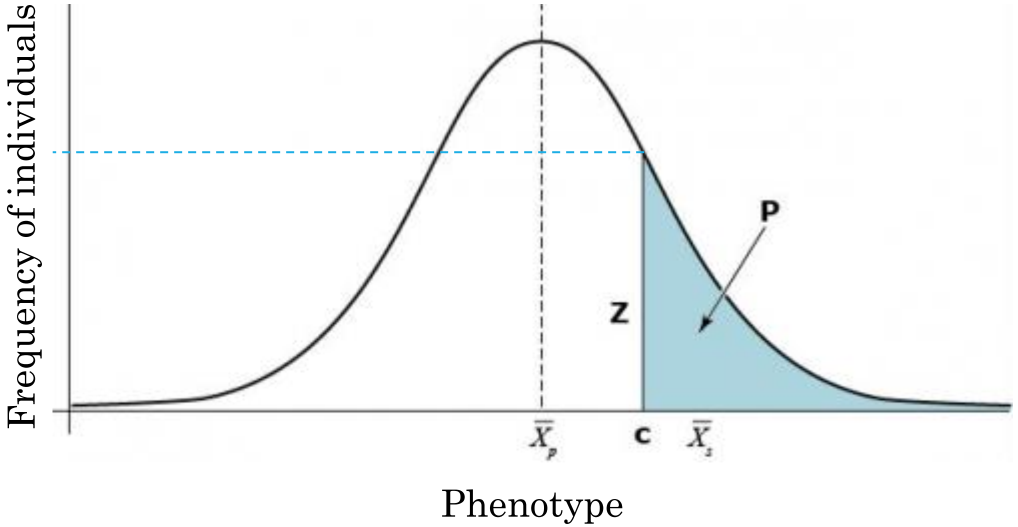
- Easily estimated
- Not as valid an estimate as the other formula

Selection Plateau / Selection Limit

Selection Intensity (i)

$$i = \frac{S}{\sigma_P}$$

- Pure ratio
- If '*i*' is high – selection process is good
- In truncation selection:
- $i = z/p$



Example question

- (population) Post weaning average dairy weight gain = 1.8 lb/day
- Selected females – 2.3 lb/day
- Calculate S, R, h^2, and i

Response to Selection/Genetic Gain

Factors Affecting R

- h^2 (V_A) $\propto$ R
- S $\propto$ R
- i $\propto$ R
- Generation Interval – average age of parent when offspring is born
  - GI $\propto$ 1/R
- Genetic correlation
- Proportion of selected parents
- Accuracy of selection – sources of information
  (closer the relationship, more accurate the info, more accuracy of selection)

Combined Selection

- Selection of individuals based on 2 or more sources of information
- Index selection – combining information from various relatives
- Osborne index (used in poultry) – gives weightage to each trait according to its importance, and helps in selection of multiple traits at a time

Bases of Selection

Bases of Selection

Choosing the source of information based on which we will select the animal

- Individual Selection
  - Not for – sex limited traits, slaughter traits, traits with low h^2
- Progeny Selection
- Pedigree Performance
  - 4-6 generations of ancestral records
- Relatives' Performance

Bases of Selection

1. **Individual Selection:**

- Easiest, quickest, most common
- Best way when h^2 is high
- Generation interval is very low
- Minimum environmental effect – individuals will be in same environment
- If systematic records absent – best way

Multitrait selection – Considering whole individual instead of one trait

Bases of Selection

1. **Individual Selection:**

Methods of individual selection:

1. Tandem Selection
2. Independent Culling Level
3. Selection Index

$$I = \sum b_i x_i$$

b is the weightage (depends on h^2, economic value & genetic correlation)

Bases of Selection

2. **Pedigree Selection:**

- Ancestral records – increase accuracy
- Useful for lowly heritable traits
- Performance of close relatives – better indicator than its own performance

Advantage:

- Less costly
- Selection at younger age
- Sex limited traits
- 2 individual – same performance, whom would you select?

Bases of Selection

2. Pedigree Selection:

Factors affecting pedigree selection:

- Generation Interval
- Environmental variance
- Selection intensity

Bases of Selection

3. **Family Selection**

- Traits : sex limited, slaughter traits, low h^2, disease resistance
- E.g. full sibs, half sibs, cousins, aunts
- Collateral relatives receive common genes
- Individuals which exceed the family means are selected (not the entire family)

Bases of Selection

4. **Progeny Selection**

- Evaluating individuals based on their progeny performance
- Progenies compared to their contemporaries (born in same herd, same season, calved in the same time)
- Accuracy $\propto$ No. of progenies tested
- Mostly done for sires than females – why?
- Result of progeny testing is expressed as '*sire index*'.

Bases of Selection

4. Progeny Selection

- *Advantages:*
  - Sex-limited, Slaughter traits can be selected
  - High selection intensity (S>>>)
  - Correct method to evaluate genotype
  - Prove that sire is free from recessive genes

Bases of Selection

4. **Progeny Selection**

- *Disadvantages:*
  - High generation interval (in cattle)
  - Cost
  - $\Delta G/year$ –
  - Need to compare many sires
  - Only few males are progeny tested

Correlated Response to Selection

Indirect Selection:

- When selection for one trait affects the phenotype of another trait, it is called correlated response to selection
- Can go two ways:
  - *Positive genetic correlation –*
    - halothane sensitivity gene in pigs is correlated with poor quality of meat
    - Egg weight and egg dimensions
  - *Negative genetic correlation –*
    - Milk yield and milk fat

MCQs – Selection

1. Response to selection is the difference between mean phenotypic value of : (MPSC 2017)
   a) Offsprings and selected parents
   b) Offsprings of selected parents and parental population before selection
   c) Sire and dam
   d) Selected parents and base population before selection

2. Method is used for selection when several traits are considered simultaneously : (MPSC 2017)
   a) Individual selection
   b) Independent Culling Level
   c) Selection Index
   d) Tandom Selection

MCQs – Selection

1. The difference of mean phenotypic value between the offspring of the selected parents and the whole of the parental generation before (MPSC 2019)
   a) Selection differential
   b) Response to selection
   c) Phenotypic average
   d) Genetic gain

2. The index selection is efficient over other methods of selection because it takes account of : (MPSC 2019)
   a) Heritability of traits
   b) Relative economic weights of traits
   c) Genetic and phenotypic variances and covariance of all traits
   d) All of the above

MCQs – Selection

1. Selection is effective for those traits which are governed by: (UK VO 2024)
   a) Additive genes
   b) Dominant genes
   c) Epistatic genes
   d) Recessive genes

2. Among the following species in which the high intensity of selection is not possible? (UK VO 2024)
   a) Pig
   b) Cattle
   c) Poultry
   d) Rabbit

MCQs – Selection

1. Osborne index (Kerala PSC 2023)
   a) High phenotypic variance
   b) High environmental variance
   c) Progeny evaluation
   d) Parity evaluation

2. Maximum Production from livestock can be obtained from (Kerala PSC 2023)
   a) Superior herd with poor environment
   b) Poor genotype with best environment
   c) Superior genotype with best environment
   d) Poor genotype with poor environment

MCQs – Selection

1. Traits having low h^2 can be improved through (JKPSC 2019)
   a) Family selection
   b) Individual selection
   c) Combined selection
   d) Tandem selection

2. Response to selection depends on (JKPSC 2019)
   a) Intensity of selection
   b) Correlation
   c) Regression
   d) Inbreeding

MCQs – Selection

1. The method of selection used when inadequate information is available about the individual is (JKPSC 2019)

   a) Performance testing
   b) Progeny testing
   c) Pedigree selection
   d) Show ring testing

2. Selection differential depends on all except:

   a) Sex of the animal
   b) Proportion selected
   c) Heritability
   d) Phenotypic standard deviation

MCQs – Selection

Q.6) Read the following statements

1) Progeny testing is useful for sex limited traits

2) Polled condition in cattle, is an example for lack of dominance

3) Mutation produces new genes in the population

4) In tandem selection, more number of traits selected at one time

Which of the following statements is / are correct?

A) 1 and3

B) 3and2

C) 1 and4

D) 2and4 (JKPSC 2020)


THANK YOU!

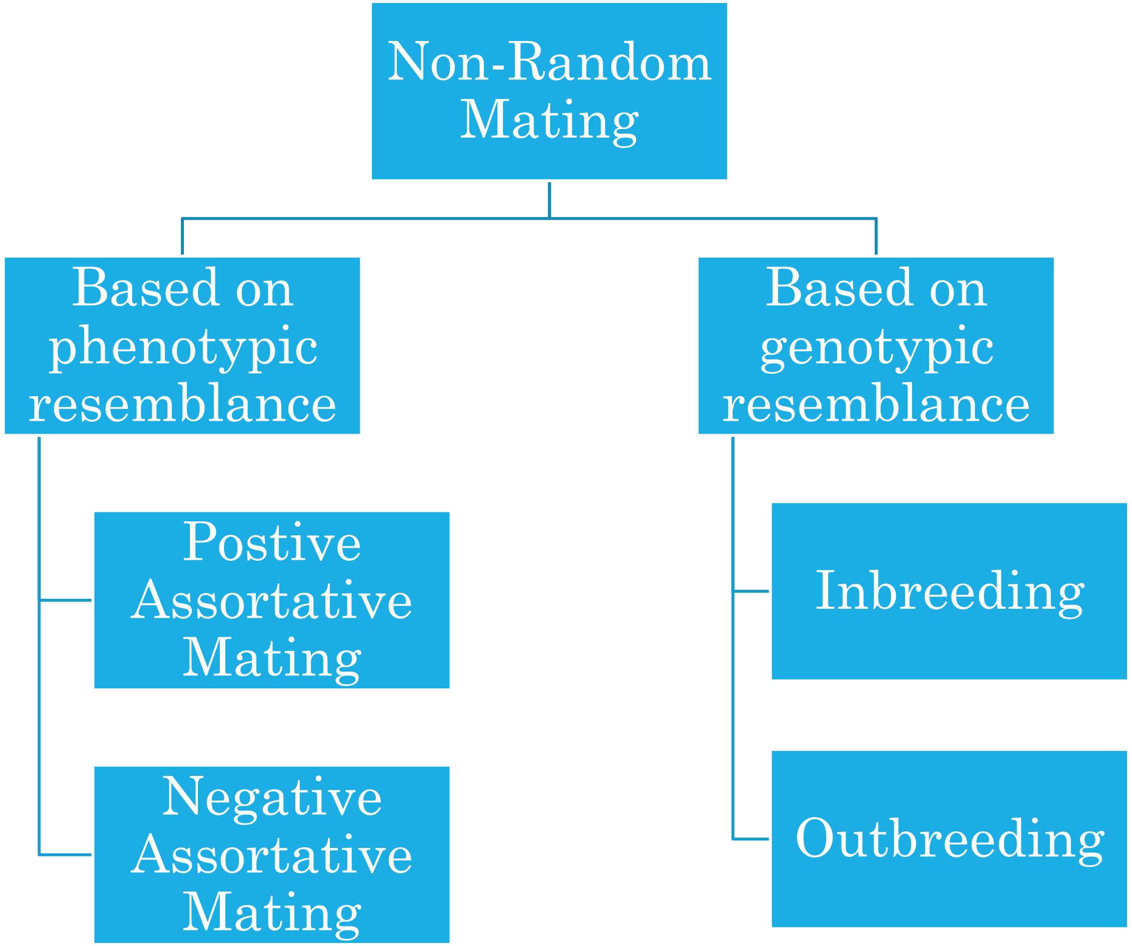
L6:
Quantitative Genetics Concepts: Mating Systems

Inbreeding

Outbreeding

Mating Systems:

- Random Mating (Panmixia)
- Non-Random/Artificial Mating



Inbreeding

- Mating of related individuals, having common ancestors in the pedigree upto 4-6 generations
- Classification:
  - Close inbreeding
  - Line breeding
  - Strain breeding

Inbreeding

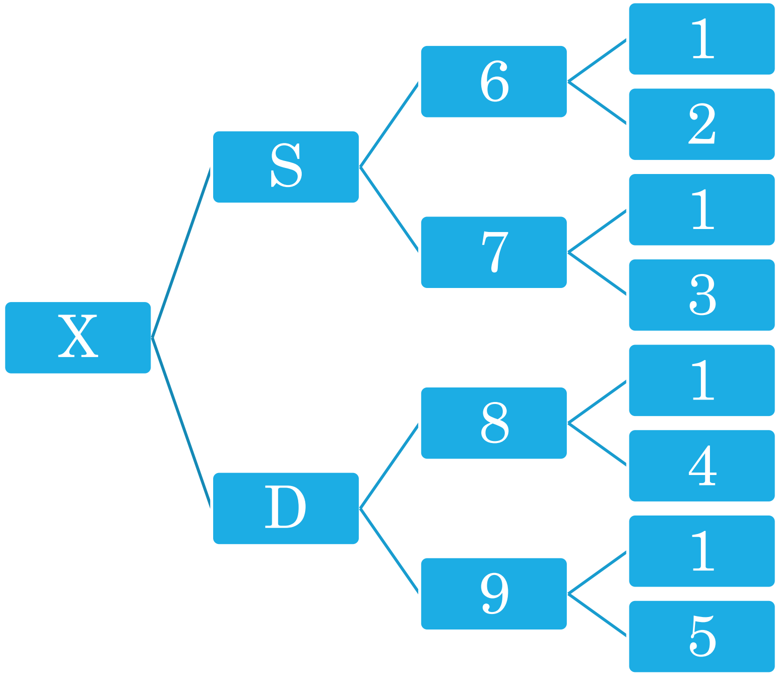
- ***Close inbreeding***
  - Mating between very close relatives – Full-sibs/parents-progeny
  - High homozygosity
  - Commonly used method ‘full-sib mating’
  - Purpose:
    - Highly inbred lines
    - Discover undesirable genes
    - Get more uniform progeny

- ***Strain breeding***
  - Breeding within a population
  - No entry of new individuals for atleast 3-5 generations

Inbreeding

- ***Line Breeding***
  - Milder form
  - Individuals within the line are related to one outstanding ancestor
  - Either mate with the ancestor, or with individuals who are related to the ancestor

Pedigree



Arrow Diagram

Inbreeding

Inbreeding Depression

- Reduction in the performance of the progeny below the average of their parents
- Unfavourable gene combination influencing polygenic traits
- Opposite to hybrid vigour
- Noticeable for fitness traits especially

Question:

Is inbreeding depression heritable?

Outbreeding

- Mating of unrelated individuals
- Increase in heterozygosity
- Increase in variability of the population

Outbreeding

Hybrid Vigour/Heterosis

- Increased phenotypic value of progeny over the average of its parents is called heterosis
- Favourable gene combination value (non-additive dominance & interaction)
- Genetic basis: Dominance, Overdominance, Epistatic theory

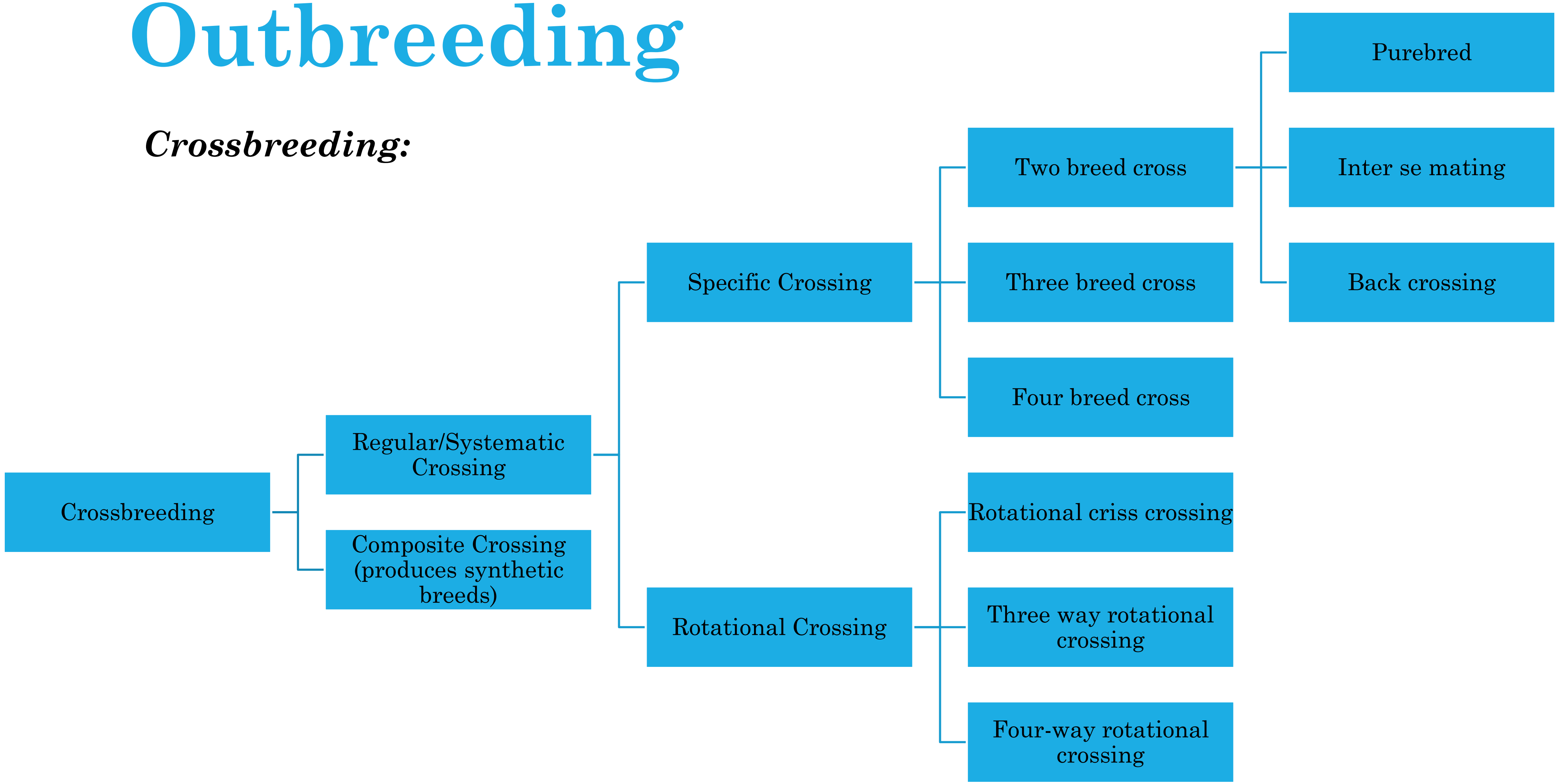
Outbreeding

Types of Outbreeding:

1. Outcrossing
2. Crossbreeding
3. Top crossing
4. Line crossing
5. Grading up
6. Species hybridisation

Outbreeding

Crossbreeding:



Outbreeding

Crossbreeding – Systematic Crossing:

1**. Specific Crossing:**

1. Two breed cross
   - Pure breds:
     $A \times B \rightarrow AB$; progenies are heterozygous, show 100% heterosis
   - *Inter se* mating:
     $F_1 \times F_1$ - creation of new genetic groups
   - Back crossing – $F_1 \times Parent$ $(P1$ or P2)
     Utilisation of maternal or paternal heterosis
2. Three breed cross
3. Four breed cross

Outbreeding

Crossbreeding – Systematic Crossing:

Specific Crossing:

1. Two breed cross
2. Three breed cross:
   - $A \times B \rightarrow AB \times C \rightarrow ABC$
   - F1 female crossed with another breed
   - Full utilisation of maternal and individual heterosis in F2
3. Four breed cross

Outbreeding

Crossbreeding – Systematic Crossing:

Specific Crossing:

1. Two breed cross
2. Three breed cross
3. Four breed cross/Double two breed cross
    1. Crossbred females from two breeds × Crossbred males from two other breeds
    2. $AB \times \mathrm{CD} \rightarrow ABCD$
    3. Full exploitation of both maternal and paternal heterosis

Demerit of specific crossing:

Separate pure bred population of animals needs to be maintained to generate heterosis in progeny

Outbreeding

Crossbreeding – Systematic Crossing:

Specific Crossing:

1. Two breed cross
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    1. Crossbred females from two breeds × Crossbred males from two other breeds
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Demerit of specific crossing:

Separate pure bred population of animals needs to be maintained to generate heterosis in progeny

Outbreeding

Crossbreeding – Systematic Crossing:

Rotational Crossing:

Males of two or three breeds used in regular sequence in successive generations on crossbred females of previous generations

Advantage : All female crossbreds obtained from the programme itself

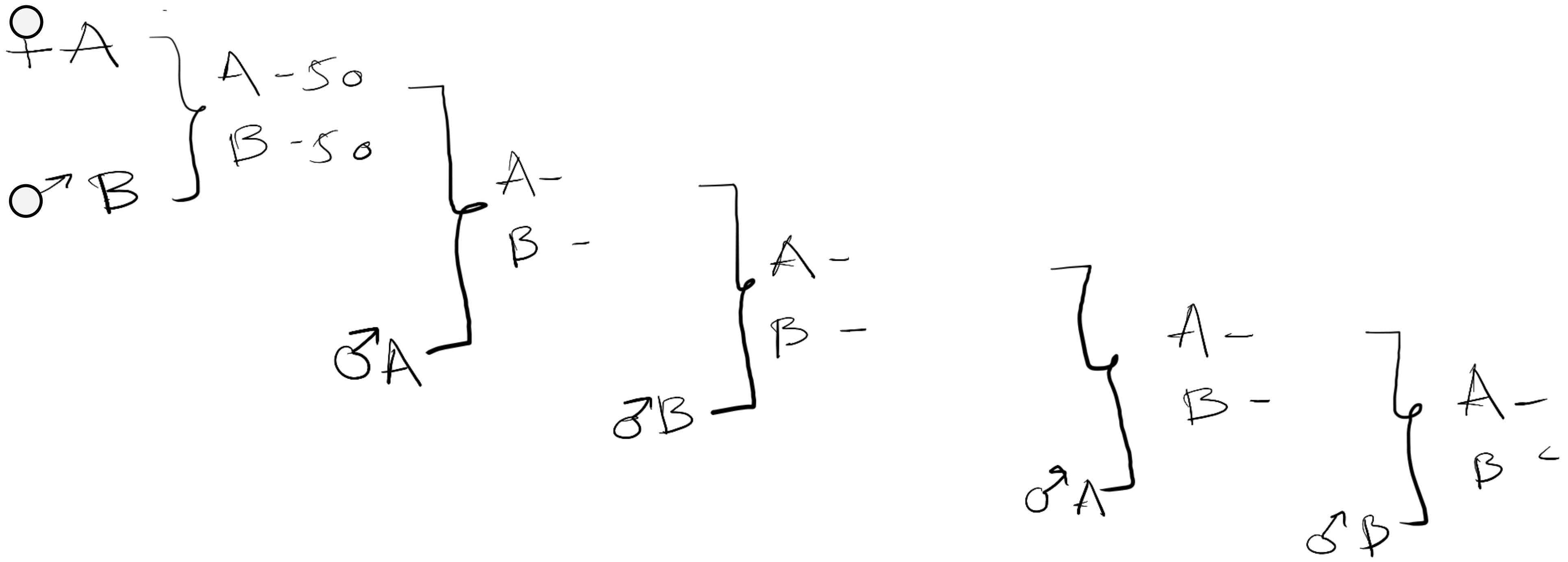
- Used in pig breeding for producing hybrids for sale
- No exploitation of complementarity
- Used for populations: less complementarity but high heterosis

Outbreeding

Crossbreeding – Systematic Crossing:

<u>Rotational Crossing:</u>

1. Rotational criss-crossing –
2. At equilibrium – 2/3rd inheritance from immediate sire's breed, 1/3rd from the other breed



Outbreeding

Crossbreeding – Systematic Crossing:

Three way rotational Crossing:

- Rotational criss-crossing with three breeds
- First generation of female crossbreds with male of third breed

Outbreeding

Crossbreeding – Systematic Crossing:

Three way rotational Crossing:

- Rotational criss-crossing with three breeds
- First generation of female crossbreds with male of third breed
- At equilibrium –
  - 4/7 inheritance from breed of immediate sire
  - 2/7 inheritance from breed of maternal grandsire
  - 1/7 inheritance from the third breed

Outbreeding

Composite breeds

S.No.	Synthetic Breed	Breeds Used		Remarks
1	Karan Swiss	Brown Swiss	Red Sindhi, Sahiwal	Developed at NDRI, Karnal
2	Karan Fries	HF	Tharparkar	Developed at NDRI, Karnal
3	Frieswal	HF	Sahiwal	Developed at Military Dairy Farms
4	Jerthar	Jersey bulls	Tharparkar cows	Developed at Bangalore
5	Jersind	Jersry	Red Sindhi	Developed at Allahabad Agriculture institute
6	Santa Gertrudis	Shorthorn	Brahman	

Outbreeding

Species hybridisation:

S. No.	Hybrid	Species Involved	
1.	Mule		
2.	Hinny		
3.	Zebroid		
4.	Cattalo		
5.	Pien niu		
6.	Liger		
7.	Geep		

Outbreeding

Species hybridisation:

S. No.	Hybrid	Species Involved	
1.	Mule	Male donkey (Jack)	Female horse (Mare)
2.	Hinny	Female ass (Jennet)	Male horse (Stallion)
3.	Zebroid	Male zebra	Female horse
4.	Cattalo	Male American bison	*Bos taurus* cow
5.	Pien niu	Male cattle	Female yak
6.	Liger	Male lion	Female tiger
7.	Geep	Male sheep	Female goat

Combining ability

- Animals with same genotype can produce different phenotypes in the same environment
- Reason: Type of gene action – Additive / Non-additive
- We know that,

$$V_P = V_A + V_D + V_I + V_E$$

Combining ability

- Animals with same genotype can produce different phenotypes in the same environment
- Reason: Type of gene action – Additive / Non-additive
- We know that,

$$V_P = V_A + V_D + V_I + V_E$$

Continuous selection – V_A gets exhausted – selection response declines

Some traits – V_D and V_I induce variation

Combining Ability

General Combining Ability (GCA)

- The average performance of a parent in hybrid combinations
- Indicative of the ability of the parent to transmit desirable genes to its offspring
- Used to identify superior parents in breeding programmes
- GCA effects – due to additive gene action
- High GCA – Parents' ability to produce superior progeny when crossed with another variety

Combining Ability

Specific Combining Ability (SCA)

- The performance of a particular cross, as deviating from the average GCA of the two lines
- SCA effects due to non-additive gene action
- Used to identify superior cross/hybrid combinations
- Important for traits which show heterosis

Combining Ability

Diallel Mating

- All possible mating combinations between several genotypes
- Greek. *Diallelos* – crossing each other
- Calculation of GCA and SCA effects

RS and RRS

<u>Recurrent Selection (RS)</u>

- Highly inbred line × Tester Line
- Evaluate the test cross progeny and select parents from the tester line
- Used for improving single lines
- Effective for traits with high h^2
- Focuses on either GCA or SCA

RS and RRS

RS and RRS

Reciprocal Recurrent Selection (RRS)

- Two highly inbred lines crossed
- Progeny evaluated to select parents from both lines
- Improves GCA of each population and SCA between two populations

People who coined terms

Term	Scientist
GCA	Sprague and Tatum (1942)
SCA	Sprague and Tatum (1942)
Heterosis	G.H.Shull (1914)
Recurrent Selection	Hull (1945)
Reciprocal Recurrent Selection	Comstock *et al.* (1949)

MCQ – Mating Systems

- General combining ability calculated in a diallel mating is indicative of (JKPSC 2019)

(A) Overdominance

(B) Epistasis

(C) Non-additive genetic effect

(D) Additive genetic effect

MCQ – Mating Systems

- General combining ability calculated in a diallel mating is indicative of (JKPSC 2019)

(A) Overdominance

(B) Epistasis

(C) Non-additive genetic effect

(D) Additive genetic effect

MCQ – Mating Systems

- Continuous use of purebred sire on non- descript female is JKPSC 2019

(A) Cross breeding

(B) Top crossing

(C) lnter se mating

(D) Grading up

MCQ – Mating Systems

- The Father of animal breeding is JKPSC 2019

(A) Gregor John Mendel

(B) T.H. Morgon

(C) Robert Bakewell

(D) Watson Crick

MCQ – Mating Systems

1. A new breed can be evolved by: JKPSC (2012)

(A) Grading up

(B) Out crossing

(C) Cross-breeding

(D) Inbreeding

MCQ – Mating Systems

1. As inbreeding progresses, proportion of heterozygote will: JKPSC (2012)

(A) Increase

(B) Decrease

(C) Both

(D) None

MCQ – Mating Systems

1. Which type of mating should be preferred for the improvement of non-descript animals? JKPSC 2012

- (A) Inbreeding
- (B) Line breeding
- (C) Upgrading
- (D) All of the above

MCQ – Mating Systems

1. Inbreeding coefficient measures: (2012)

- (A) Heterozygosity
- (B) Homozygosity
- (C) Cross-breeding
- (D) None of the above

MCQ – Mating Systems

- The mean performance of line when expressed as the deviation from the mean of all crosses is:

A) General combining ability of line

B) Average effect of the line

C) General and Specific combing ability of line

D) Specific combing ability of line

(JKPSC 2010)

MCQ – Mating Systems

- Which of the following species was first domesticated by human beings?

A) Cattle

B) Sheep

C) Dog

D) Goat

JKPSC 2010

MCQ – Mating Systems

- Which of the following about heterosis is not true? (Punjab PSC 2016)

a) Term coined by G H Shull

b) Depends on difference of gene frequency

c) Might be caused by Overdominance

d) Independent of degree of dominance

MCQ – Mating Systems

- . Maximum heterosis is observed in (RPSC 2019)

(1) base population

(2) F1 generation

(3) F2 generation

(4) F3 generation

MCQ – Mating Systems

- Diallele crossing is usually practiced in RPSC 2019

(1) Cattle

(2) Sheep

(3) Camel

(4) Poultry

MCQ – Mating Systems

- Full sib and half sib mating in poultry and parent offspring or uncle- cousin mating in swine is most commonly used in RPSC 2013
- (1) Outcrossing
- (2) Inbreeding
- (3) Pure breeding
- (4) Strain crossing

MCQ – Mating Systems

- Which of the following system of breeding enlightens the less desirable recessive genes?

(A) Cross breeding

(B) Grading up

(C) Inbreeding

(D) Species hybridization

MPPSC 2021


THANK YOU!

AGB
Lecture – 7
Breeds of Livestock Species

Cattle

Buffalo

Sheep

Goat

Pigs

Poultry

NBAGR Registered Breeds

Species	Number of Registered Breeds
Cattle	53
Buffaloes	20
Goat	39
Sheep	45
Chicken	20
Pig	14
Yak	1
Horse and pony	8
Camel	9
Donkey	3
Duck	3
Geese	1
Dog	3

Total - 220

Including 1 synthetic dairy cattle

Newly Registered Breeds

Cattle Breeds	State
Poda Thurpu	Telangana
Dagri	Gujarat
Thutho	Nagaland
Shweta Kapila	Goa
Himachali Pahari	Himachal Pradesh
Purnea	Bihar
Nari	RJ & GJ
Kathani	Maharashtra
Sanchori	Rajasthan
Masilum	Meghalaya
Frieswal (synthetic)	UP & Uttarakhand

Buffalo Breeds	State
Gojri	Punjab and HP
Dharwadi	Karnataka
Manda	Odisha
Purnathadi	Maharashtra
Goat Breeds	**State**
Sojat	Rajasthan
Karauli	Rajasthan
Gujari	Rajasthan
Anjori	Chattisgarh
Andamani	Andaman & Nicobar

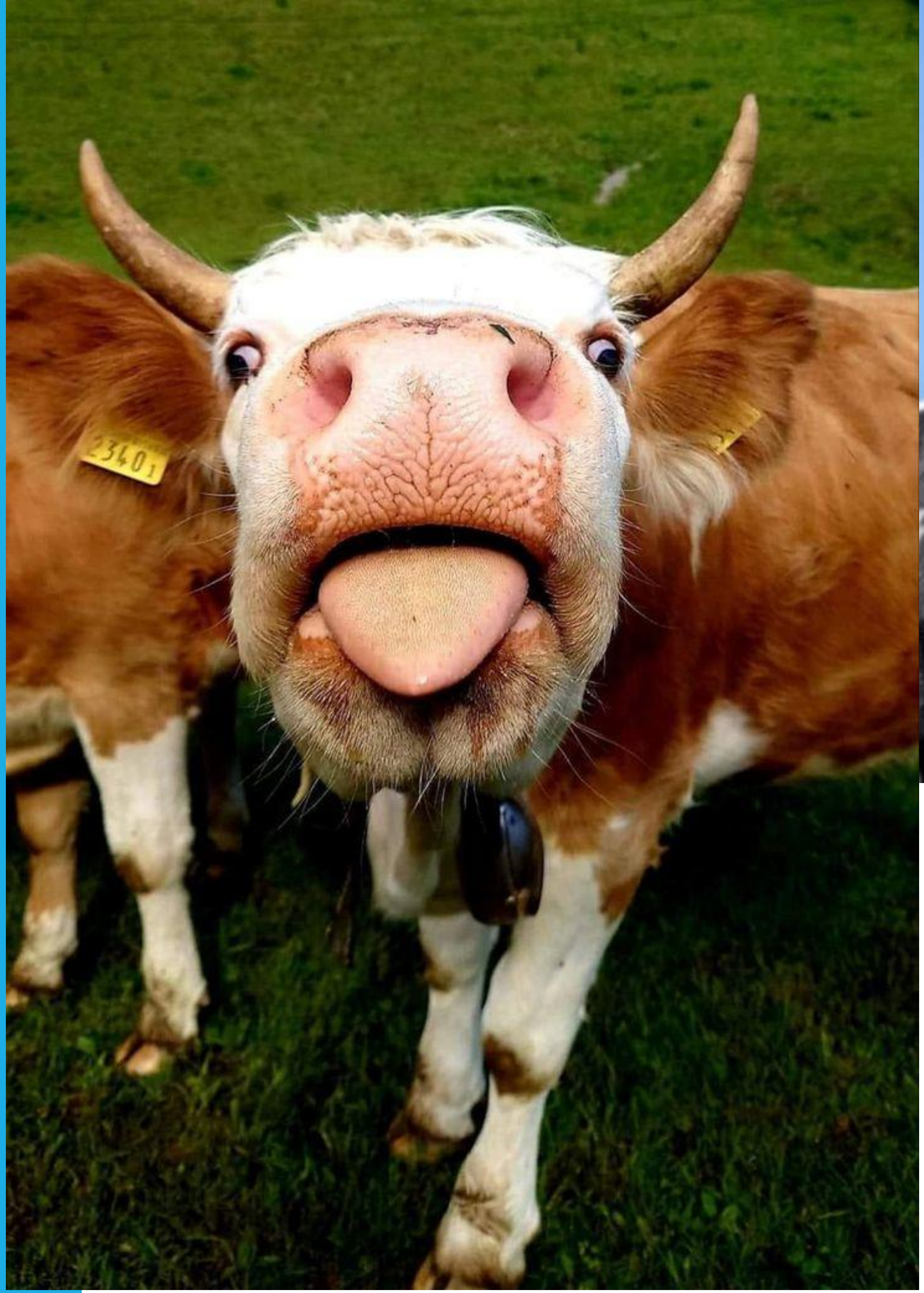
Newly Registered Breeds

Sheep	State
Kajali	Punjab
Macherla	Andhra Pradesh
Pigs	**State**
Mali	Tripura
Purnea	Bihar, Jharkhand
Banda	Jharkhand
Manipuri Black	Manipur
Wak chambil	Meghalaya
Andamani	Andaman & Nicobar

Chicken	State
Aravali	Gujarat
Donkey	**State**
Kacchhi	Gujarat
Horse	**State**
Bhimthadi	Maharashtra

Species Special Names

Species	Names
Buffalo	Black gold/Triple purpose breeds
Sheep	Poor man's mobile bank
Goat	Poor man's cow, shy breeder
Pig	Most intelligent animal
Yak	Ship of high hills
Mithun	Mountain cattle



Cattle Breeds

Indigenous Cattle – Classification

Group	Characteristics	Breeds
Group I	Broad face, lyre horns Flat dished forehead Western India	Kankrej, Kherigarh, Malvi, Tharparkar, Kenkatha, Ponwar, Dagri
Group II	Convex face, white/ light grey, short horn Coffin shaped skull	Hariana, Ongole, Bachaur, Gaolao, Krishna valley, Mewati, Nagori, Rathi
Group III	Heavy bull, even curled horn Pendulous sheath , Spotted red/white	Gir, Sahiwal, Red sindhi, Deoni, Dangi, Nimari
Group IV	Medium sized, Long horn up to back Mysore type cattle	Amritmahal, Deoni, Dangi, Nimari, Hallikar, Bargur
Group V	Heterogeneous mixture- north India	Siri , Ponwar
Group VI	Draft – tight naval sheath and dewlap	Dhani

Indigenous Cattle – Classification

Milch (1500-2000 L)	• Gir, Sahiwal, Red Sindhi, Rathi, Tharparkar
Dual Purpose (1200-1500 L)	• Hariana, Kankrej, Ongole, Deoni, Nimari, Dangi, Mewati, Rathi, Red Kandhari, Kathani
Draught (<500 L)	• Hallikar, Kenkatha, Amritmahal, Bargur, Nagori, Bachur, Malvi, Kherigarh, Kangayam, Ponwar, Siri, Gaolao, Krishna Valley, Umblacherry, Pulikulam

Indigenous Cattle – Specifics

Breed	Specification
Sahiwal, Red Sindhi, Gir, Rathi	Milch type, heat and drought tolerant
Hariana, Ongole	Dual purpose, Milch type, heat and drought tolerant
Nagori	Excellent draught animal for hot climate
Vechur	Miniature cattle
Punganur	Dwarf cattle
Umblacherry	Excellent for wet ploughing
Siri	Dual purpose, high altitude breed

Exotic Cattle Breeds – Milch Breeds

Breed	Origin	Characters
Jersey	Isle of Jersey, British Channel Islands	High fat percentage (5.5%) Double dished forehead Long Lactation Period (365 days)
HF	Holland/Netherlands	High milk producer (6150 L/lactation) Low milk far percentage (3.5%)
Ayreshire	Scotland	Deep cherry red, Mahogany
Brown Swiss/Braunveih	Switzerland	Oldest High Milk Lactose (5%) Most heat tolerant exotic animal
Guernsey	Isle of Guernsey, British Channel Islands	Yellow milk

Exotic Cattle Breeds – Beef Breeds

Breed	Origin	Characters
Angus	Scotland	Black, polled, high dressing percentage
Brahman	India	Brought from India, tick resistant,
Hereford	Hereford, England	Red colour, white face, compact body
Charolais	France	White/cream coloured, good marbling
Devon	Southwest England	Red, hardiness, thrive on various types of forage
Beef Master	Texas, Colorado	Brahman X Shorthorn
Braford	Brazil	Brahman X Hereford
Brangus	United States	Angus X Brahman, Black/Red

Synthetic Cattle Breeds

Breed	Composition	Origin
Taylor (1856)	Shorthorn & Jersey/Guernsey * Local cow	Patna
Jersind	Jersey * Red Sindhi	Allahabad, NIANI
Sunandini	Brown Swiss * ND	Munnar, Kerala (Indo Swiss Project)
Frieswal	HF * Sahiwal	Military Dairy Farms, ICAR
Karan Fries	HF * Tharparkar	NDRI, Karnal
Karan Swiss	Brown Swiss * Sahiwal/Red Sindhi	NDRI, Karnal
Jerthar	Jersey bull * Tharparkar cow	Bangalore
Vrindavani	HF/Jersey/Brown Swiss * Hariana	IVRI - AICRP
Brown Sind	Brown Swiss * Red Sindhi	

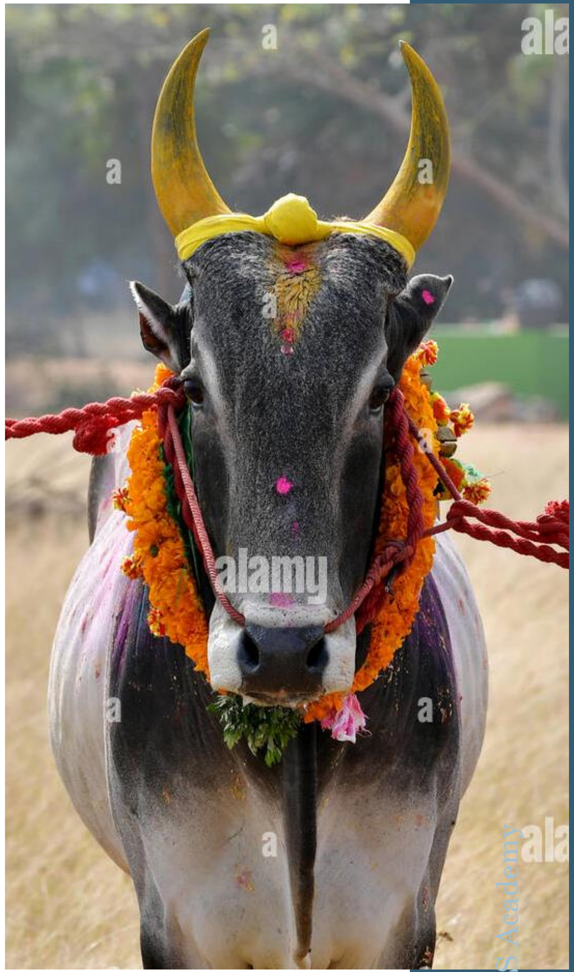
Best breeds, Peculiarities and Special horns

Traits	Breed
Economic Milk Producer	Red Sindhi
Best dairy breed	Sahiwal
Heaviest dairy breed/Spotted milch breed	Gir
Beef breed of India	Gir, Dangi
Disease Resistance breed	Tharparkar, Kosali, Malanad gidda
High Altitude Cattle	Siri
"Sawai Chal" Gait	Kankrej
Heaviest cattle	Kankrej
Lightest cattle	Punganur
Jalikattu breed	Pulikulam

Peculiarities	Breed
High milk producing exotic cattle	HF
High fat producing exotic cattle	Jersey
Golden Milk	Guernsey

Special ho

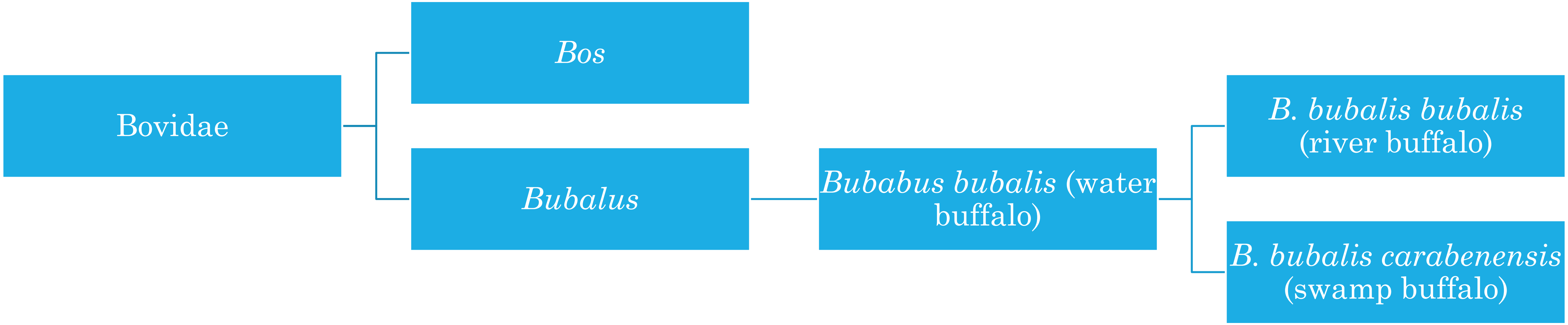
Horns	Breed
Half Moon Shaped	Gir
Bow Shaped	Khillari
Lyre Shaped	Kankrej, Malvi, Ponwar
Crescent shaped	Punganur, Kangayam
Spiral horn	Nari (backward curl – females Forward curl – males)



Long drooping ear – Red Kandhari
Leaf like ear – Gir

Buffalo Breeds

Buffalo Breeds



Buffalo Breeds

20 registered breeds with NBAGR

1. Banni (Gujarat)
2. Bargur (Tamil Nadu)
3. Bhadawari (Uttar Pradesh and Madhya Pradesh)
4. Chhattisgarhi (Chhattisgarh)
5. Chilika (Odisha)
6. Dharwadi (Karnataka)
7. Gojri (Punjab and Himachal Pradesh)
8. Jaffarabadi (Gujarat)
9. Kalahandi (Odisha)
10. Luit (Swamp) (Assam)
11. Manda (Odisha)
12. Marathwadi (Maharashtra)
13. Mehsana (Gujarat)
14. Murrah (Haryana and Delhi)
15. Nagpuri (Maharashtra)
16. Nili Ravi (Punjab)
17. Pandharpuri (Maharashtra)
18. Purnathadi (Maharashtra)
19. Surti (Gujarat)
20. Toda (Tamil Nadu)

Classification

Group	Breed
Murrah Group	Murrah, Nili Ravi, Godavari
Gujarat Group	Surti, Jaffrabadi, Mehsana, Banni
Uttar Pradesh Group	Bhadawari, Tarai
Central India Group	Nagpuri, Pandharpuri, Mandi, Jerangi, Kalahandi, Sambalpuri
South India Group	Toda, South Kanara

Classification

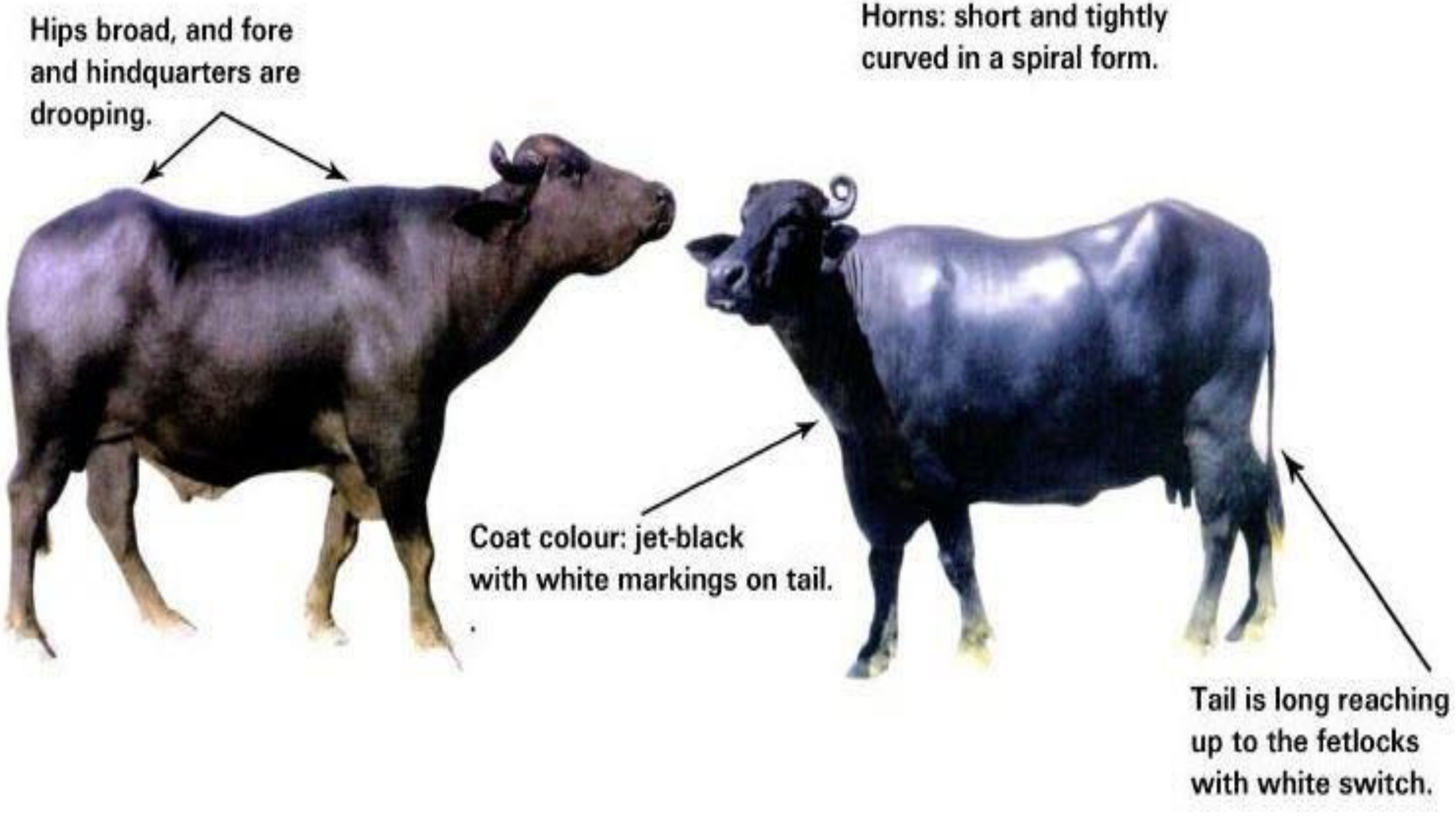
Group	Breed
Murrah Group	Murrah, Nili Ravi
Gujarat Group	Surti, Jaffrabadi, Mehsana, Banni
Uttar Pradesh Group	Bhadawari, Tarai
Central India Group	Nagpuri, Pandharpuri, Manda, Jerangi, Kalahandi, Chattisgarhi
South India Group	Toda, South Kanara

State	Breed
Odisha	Chilika Kalahandi Manda
Gujarat	Banni
Assam, Mizoram, Manipur (Brahmaputra valley)	Luit Buffalo (Swamp)
Punjab, Himachal Pradesh (Gujjar community)	Gojri
Karnataka	Dharwadi

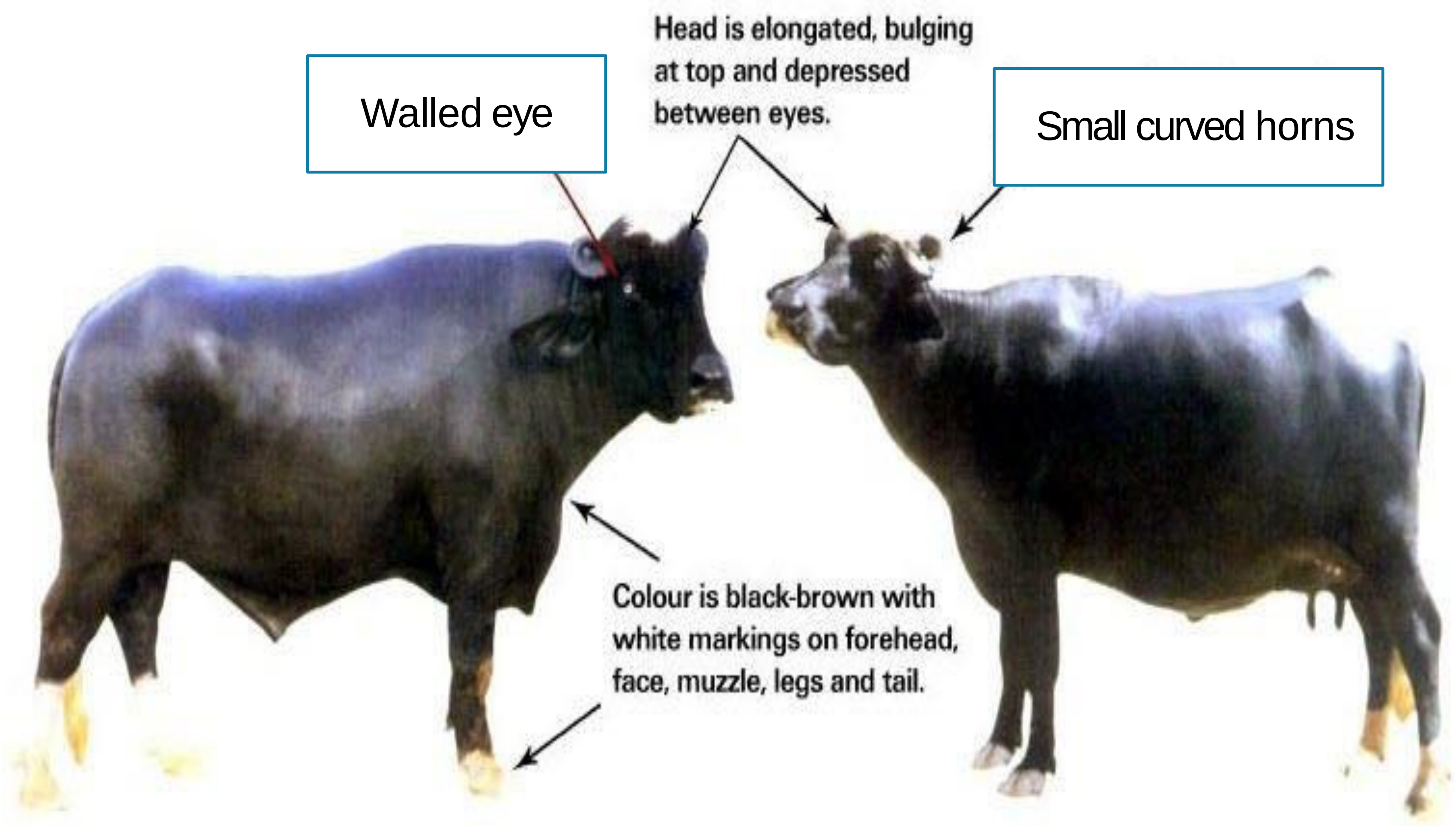
Breed Characteristics

Breed	Origin	Characteristics	Specifics/Peculiarities	Remarks
Murrah (Kundi/Kali)	Rohtak, Hisar	Jet black, tail reaches fetlock	Most efficient milker, Tightly curled horns	1500-2000 kg milk with 7% fat
Nili Ravi (Panch Kalyani/ Panch Bhadra)	Punjab, Pakistan	Small horns, tightly coiled, White markings on body	Wall eyes Lowest fat (4%)	Milk yield: 1500-1850 kg/lactation
Jaffarabadi	Gir forest, Gujarat	Black in colour, Prominent forehead	Heaviest buffalo breed Long drooping 'J' shaped horns	Avg milk – 1000-1200 kg
Bhadawari	Uttar Pradesh & Gwalior	'Chevron' – two white lines on lower side of neck	Light copper coloured body Highest fat percentage	MY : 800-1000 kg Fat content: 6-12.5%

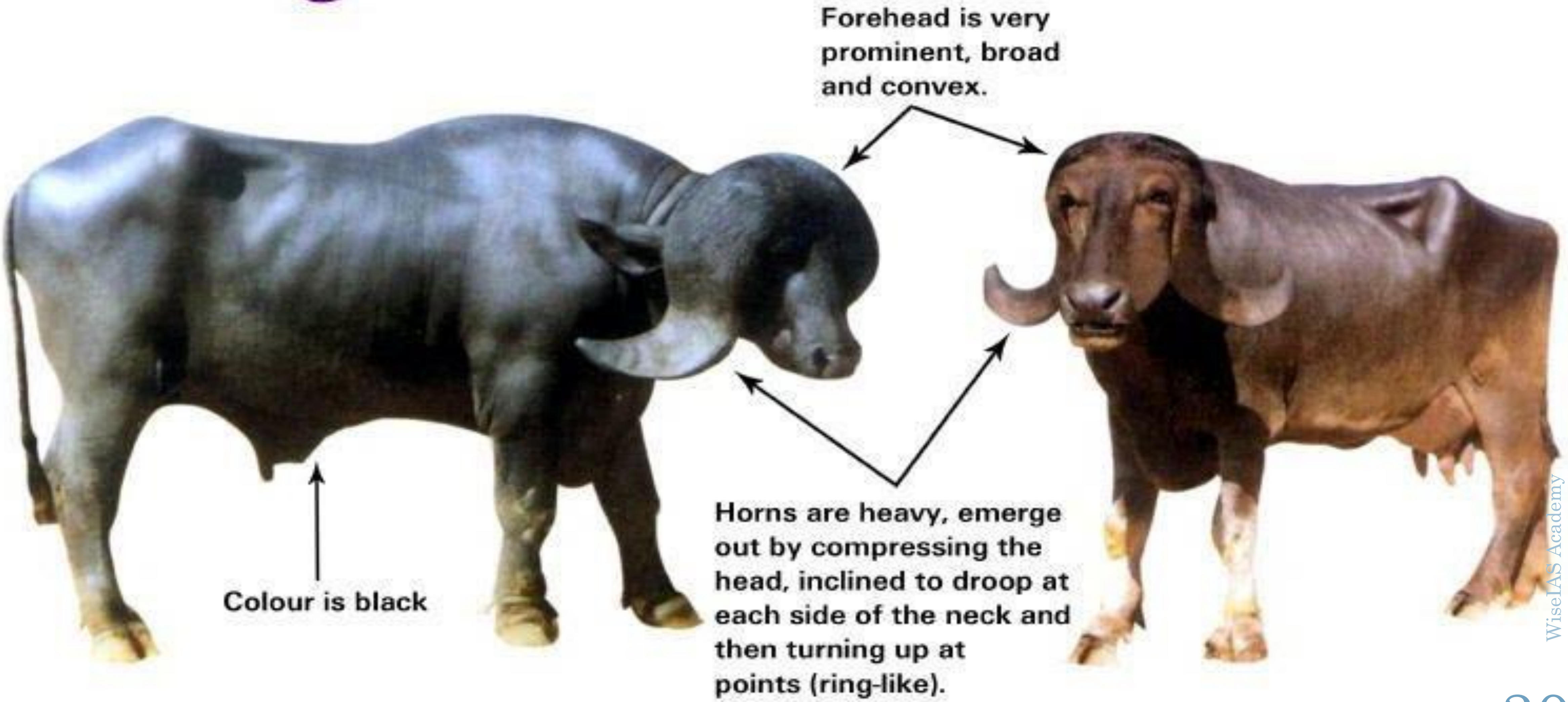
MURRAH


Hips broad, and fore
and hindquarters are
drooping.
Horns: short and tightly
curved in a spiral form.
Coat colour: jet-black
with white markings on tail.
Tail is long reaching
up to the fetlocks
with white switch.

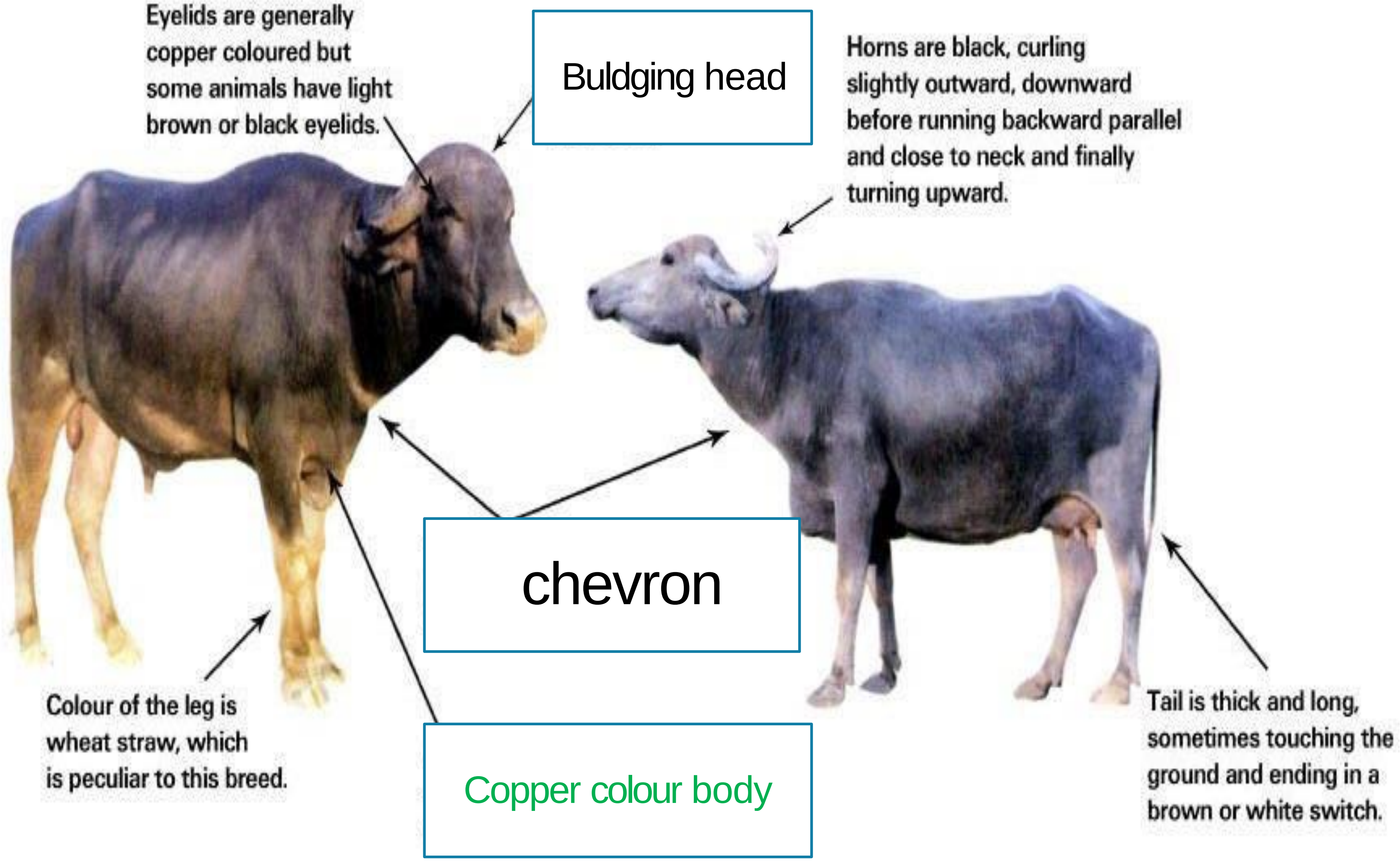
NILI-RAVI


Walled eye
Head is elongated, bulging at top and depressed between eyes.
Small curved horns
Colour is black-brown with white markings on forehead, face, muzzle, legs and tail.

JAFFARABADI



BHADAWARI

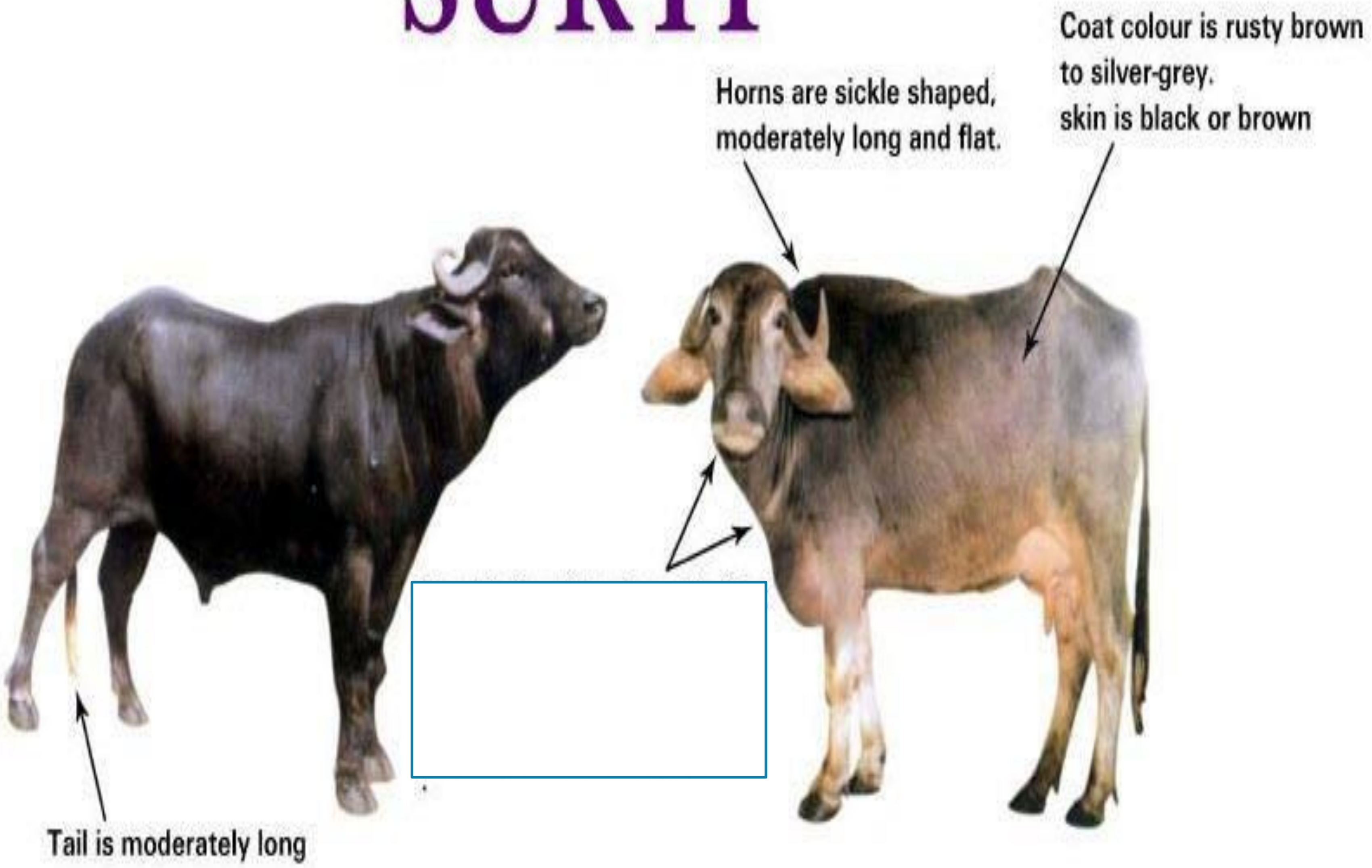


Eyelids are generally copper coloured but some animals have light brown or black eyelids.
Buldging head
Horns are black, curling slightly outward, downward before running backward parallel and close to neck and finally turning upward.
chevron
Colour of the leg is wheat straw, which is peculiar to this breed.
Copper colour body
Tail is thick and long, sometimes touching the ground and ending in a brown or white switch.

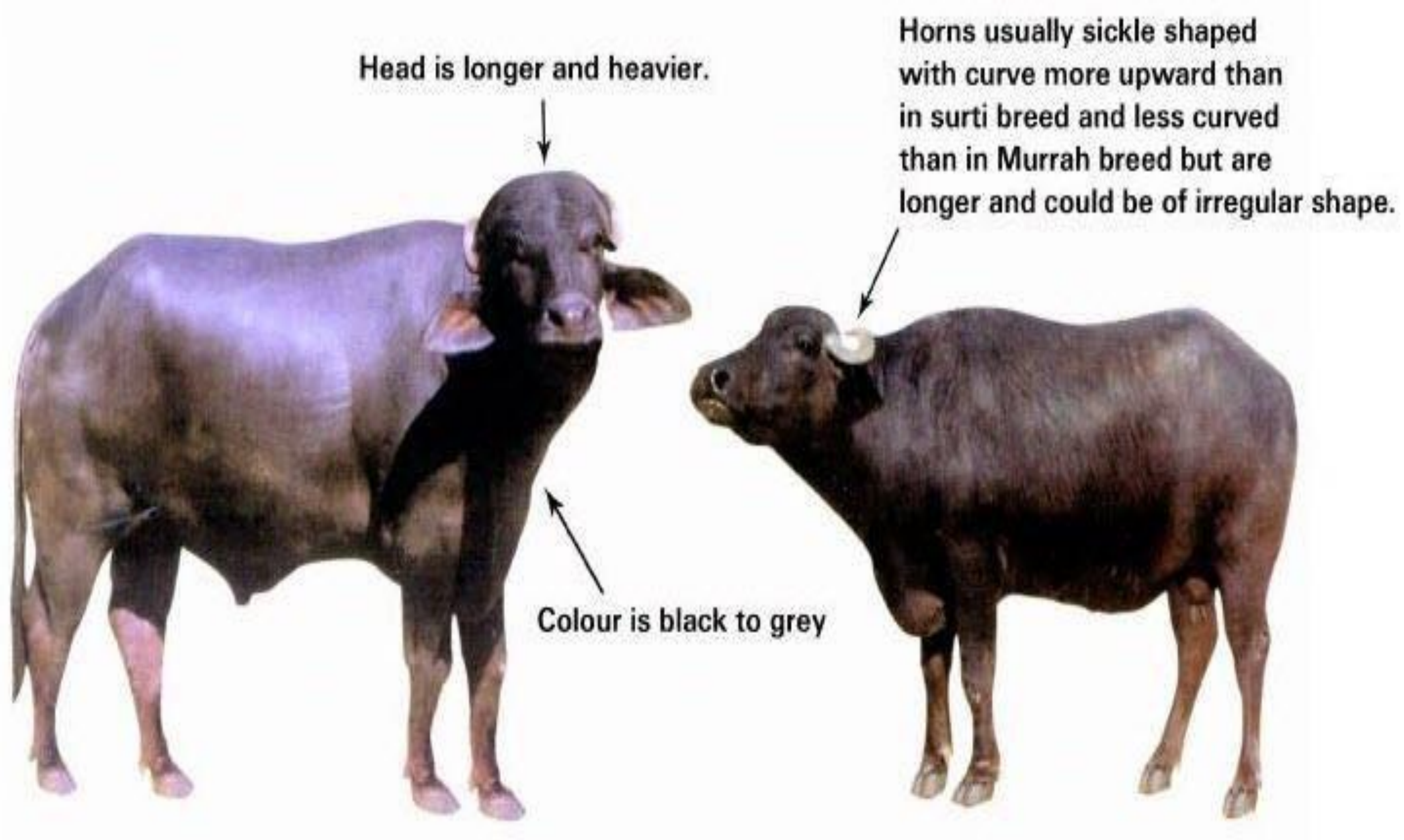
Breed Characteristics

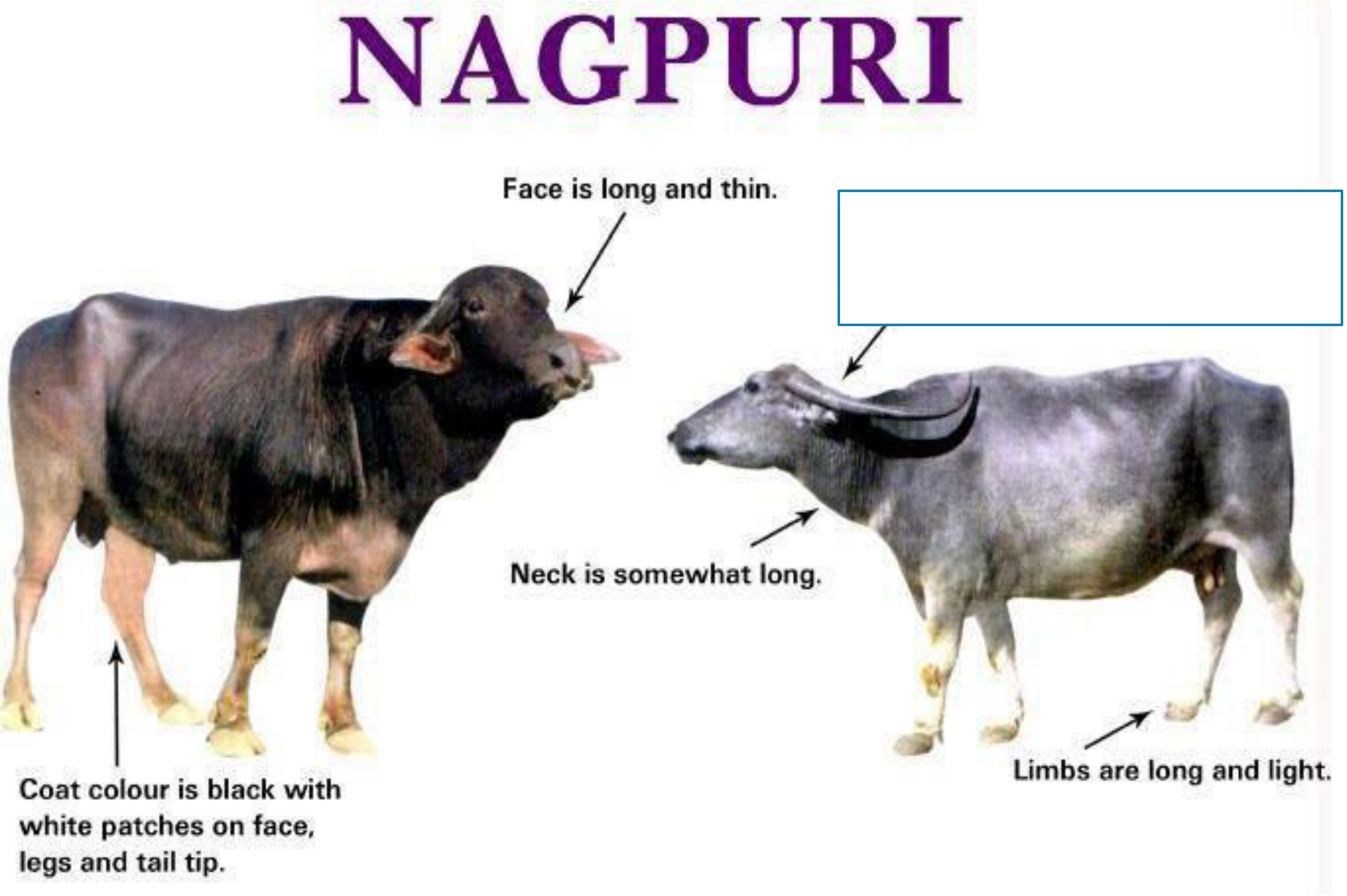
Breed	Origin	Characteristics	Specifics/Peculiarities	Remarks
Surti	Baroda, Gujarat	Colour: rusty brown to silver grey, Two white collars (jaw & brisket)	Sickle shaped horns	900-1300 kg MY 8-12% far (high fat percent)
Mehsana (Surti X Murrah)	Mehsana, Gujarat	Black/brown colour	Longest Lactation	MY: 1200-1500 kg Good lactation persistency 'Amul Milk'
Nagpuri	Maharashtra	Black with white patches (face, legs, tail) Long thin face, long neck	Sword shaped horns	MY: 700-1200 kg
Pandharpuri	Maharashtra		Sword Shaped horns	Longer letting down period

SURTI


Horns are sickle shaped, moderately long and flat.
Coat colour is rusty brown to silver-grey. skin is black or brown
Tail is moderately long

MEHSANA

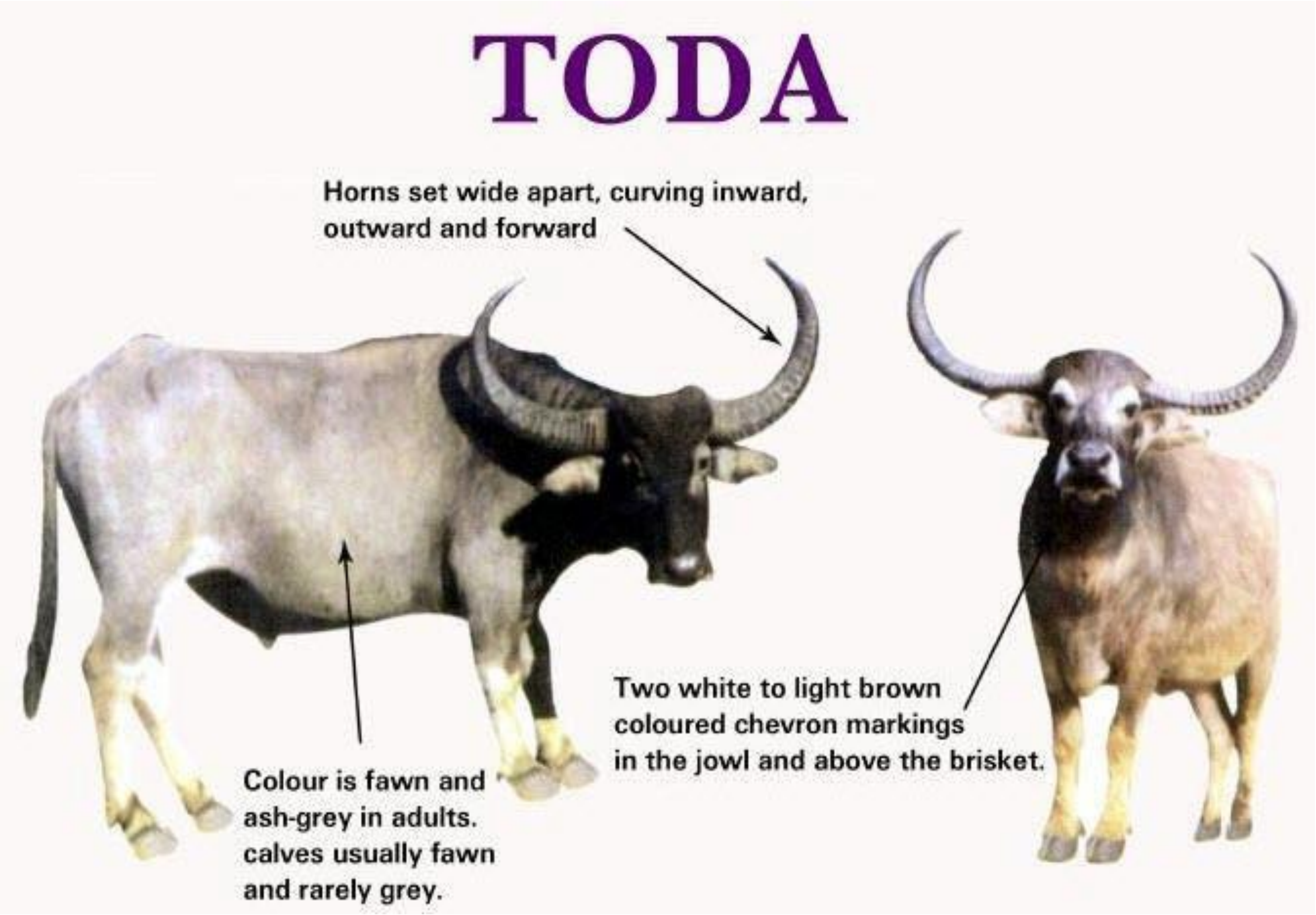

Head is longer and heavier.
Horns usually sickle shaped with curve more upward than in surti breed and less curved than in Murrah breed but are longer and could be of irregular shape.
Colour is black to grey


NAGPURI
Face is long and thin.
Neck is somewhat long.
Coat colour is black with white patches on face, legs and tail tip.
Limbs are long and light.

Sword shape horn

Breed Characteristics

Breed	Origin	Characteristics	Specifics/Peculiarities	Remarks
Toda	Nilgiri, Tamil Nadu	Fawn, ash grey colour, Long body, deep broad chest, strong legs	Most violent buffalo breed	Maintained by tribes
Bunni/Kutchi/Kundi	Gujarat	Black coloured, tightly coiled horns with single/double coiling		Night grazing on grasslands


TODA
Horns set wide apart, curving inward, outward and forward
Two white to light brown coloured chevron markings in the jowl and above the brisket.
Colour is fawn and ash-grey in adults. calves usually fawn and rarely grey.

Banni Buf

Buffalo Special

Feature	Breed
Buffalo used for crossbreeding	Murrah, Surti
Sword Shaped Horns	Nagpuri, Pandharpuri
Inverted coiling/Double coiling	Banni
Long horn upto pinbone	Pandharpuri
Half circle horn	Kalahandi
J-shaped horn	Jaffarabadi
Lightest breed	Nagpuri
Heaviest breed	Jaffarabadi
Long tail touching ground	Murrah, Nili ravi
Highest fat content	Bhadawari (6.5-12%)
Small size (deer buffalo)	Jerangi
Copper coloured buffalo	Bhadawari

Pig Breeds

Species	Native	Character
Large white Yorkshire	England	• 1st grade bacon, Highly prolific • Black spot 'Freckles'. Good mother, good milker
Middle white Yorkshire	North England	• Large white X Small white • Excellent pork pig (high % lean meat to bone) • Dished face. Good walker- fast
Berkshire	England	• Descent of old English hog. Erect ears • Good quality pork – typical pork breed • South India for upgrading. Colour – 6 white points
Landrace	Denmark	• Excellent for cross breeding (India) - Loop ears • Highest quality bacon in world • Body has Freckles and Susceptible to sunburn
Hampshire	USA	• Black with white belt around chest
Tamworth	Central England	• Fine quality bacon. Excellent foragers • Colour: Golden red. Used for CB in south east Asia • Careful mother
Duroc	USA	• Jersey red X Duroc of New york • Excellent rate of gain and feed efficiency
Chester white	USA	• Very prolific sow • Foundation stock- English Yorkshire, Lincolnshire, Cheshire breed
Hereford	USA	• Small breed and 2/3rd red colour, white face
Saddle back	England	• Black colour with white forelegs. Very high FCR
Large black	Great Britain	• One of oldest in this area. Very good milker

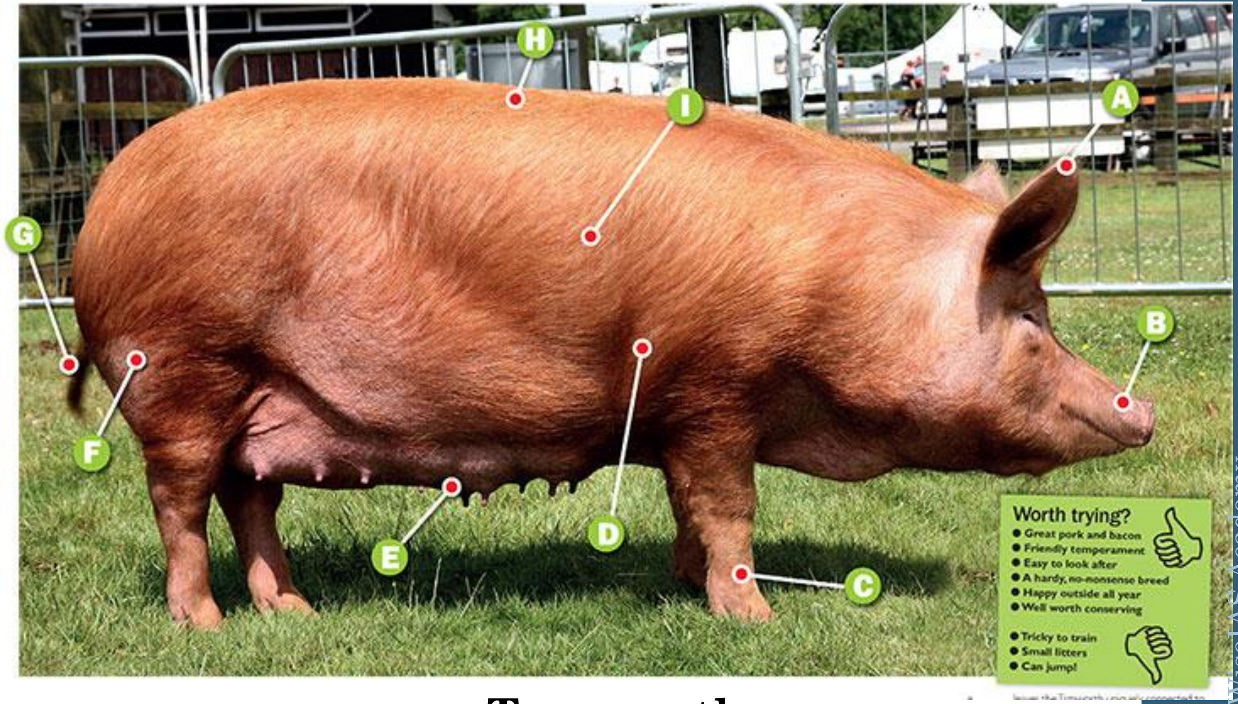

Large white
Yorkshire


Middle white Yorkshire


Hampshire Pig


Berkshire

Duroc



Tamworth

Indigenous Pig Breeds

Breed	Origin	Characteristics
Ghungroo	North Bengal, Assam	Black colour, pendulous ear, Highly prolific – 6-10 piglets
Niang Megha	Meghalaya	Black, star shaped white patches on forehead 50-60 kg adult body weight
Andamani	Andaman & Nicobar	Adult body weight 68-70 kg, Black/rusty gray
Banda	Jharkhand	Pork, manure type; Adult body weight 27-28 kg, Litter size 4-7 piglets
Manipuri	Manipur	Adult body weight 96 kg (males), Litter size – 6-11 piglets Meat taste preferred by local people
Wak Chambil	Garo hills, Meghalaya	Round & pendulous belly Pork – unique flavour & taste Used for religious & ceremonial occasions

Indigenous Pig Breeds

Breed	Origin	Characteristics
Angoda Goan	Goa	Adapted to coastal environment, few animals, white patches on leg and face
Tenyivo	Nagaland	Pot bellied (pendulous belly touching ground), sagging back, white switch markings, tail touches hock, white stockings
Nicobari	Andaman & Nicobar	Fast runners, No curling of tail
Doom	Assam	Black, large, flat belly type
Zovawk	Mizoram	

Pigs - Specifics

Aspect	Pig Breed
Pigs used for crossbreeding	Landrace
Pigs used for upgrading	Large White Yorkshire
Heart-shaped ear pig	Ghungroo
Best pig for show	Duroc
Smallest breed of pig	Kune-Kune pig
Best meat producers	Duroc, American Yorkshire
Bacon Pigs	Large White Yorkshire, Landrace, Tamworth
1st grade bacon	Large White Yorkshire
Pork Pigs	Middle white Yorkshire, Berkshire, Hampshire

MCQs - Breeds

- Which of the following is a dual breed of cattle
  JKPSC 2019

(A) Red sindhi

(B) Haryana

(C) Sahiwal

(D) Amritmahal

MCQs - Breeds

- Match the following livestock & poultry breeds with their recognized number as per National Bureau of Animal Genetic Resources (NBAGR), Karnal: JKPSC (2019)

Species	No of recognized breeds
(a) Cattle	(1) 34
(b) Buffalo	(2) 43
(c) Goat	(3) 19
(d) Chicken	(4) 16

Select the correct answer using the code below:

(A) a-1, b-2, c-3, d-4

(B) a-2, b-3, c-4, d-1

(C) a-2, b-4, c-1, d-3

(D) a-1, b-2, c-4, d-3

MCQs - Breeds

Match the following Species of animals with their Chromosomes (2n) JKPSC 2019

Species	**Chromosomes (2n)**
(a) Domestic cattle	(1) 60
(b) Domestic river buffalo	(2) 54
(c) Domestic sheep	(3) 38
(d) Domestic swine	(4) 50

- Select the correct answer using the code below:
- (A) a-1; b-3; c-1; d-4
- (B) a-2; b-4; c-3; d-1
- (C) a-1; b-4; c-2; d-3
- (D) a- 1; b-3; c-2; d-4

MCQs - Breeds

- Which breed of cattle is known as milch breed? JKPSC (2012)

(A) Kankrej

(B) Haryana

(C) Gir

(D) Amrit Mahal

- Best dairy breed of cattle in India is: JKPSC (2012)

(A) Haryana

(B) Red Sindhi

(C) Sahiwal

(D) Tharparkar

MCQs - Breeds

- The heaviest Indian cattle breed is: JKPSC (2012)

(A) Rathi

(B) Ongole

(C) Sahiwal

(D) Kankrej

- Buffalo species having 48 chromosomes is known as: JKPSC (2012)

(A) River buffalo

(B) Water buffalo

(C) African buffalo

(D) Swamp buffalo

MCQs - Breeds

- Match the livestock and poultry breed as per the recognition by the National Bureau of Animal Genetic resources (Jan, 2020)

Species	No.of recognized breeds
i) Cattle	1) 7
ii) Sheep	2) 3
iii) Horses & Ponies	3) 53
iv) Ducks & Geese	4) 45

- Select the correct answer using the code below

A) 1-2, ii- 3, iii-1, iv -4

B) I-3, ii-4,iii-1.iv-2

C) i-l, ii-3, iii-2, iv -4

D) i-2,ii-4,iii-1,iv-3

MCQs - Breeds

- Konkan Kapila cattle breed is native of ___________________
  a) Maharashtra and Goa
  b) Karnataka and Andhra Pradesh
  c) Kerala and Karnataka
  d) Maharashtra and Karnataka

- The swamp buffaloes distributed mostly in upper Brahmaputra valley of Assam is _________
  a) Luit
  b) Ghurrah
  c) Toda
  d) Chattisgarh

MCQs - Breeds

- All Tamil Nadu cattle breeds are__________

    a) a. Milch breeds

    b) b. Draught breeds

    c) c. Dual purpose

    d) d. None of the above

- The wall-eyed buffalo breed

a. Bhadawari

b. Nili-Ravi

c. Murrah

d. Toda

MCQs - Breeds

- Cross of Tharparkar and Holstein Friesian
  a) Karan Swiss
  b) Karan Fries
  c) Avikalin
  d) Avivastra

- Which of the following is not a Mysore type of cattle
  a) Amrihmahal
  b) Hallikar
  c) Bargur
  d) Krishna Valley

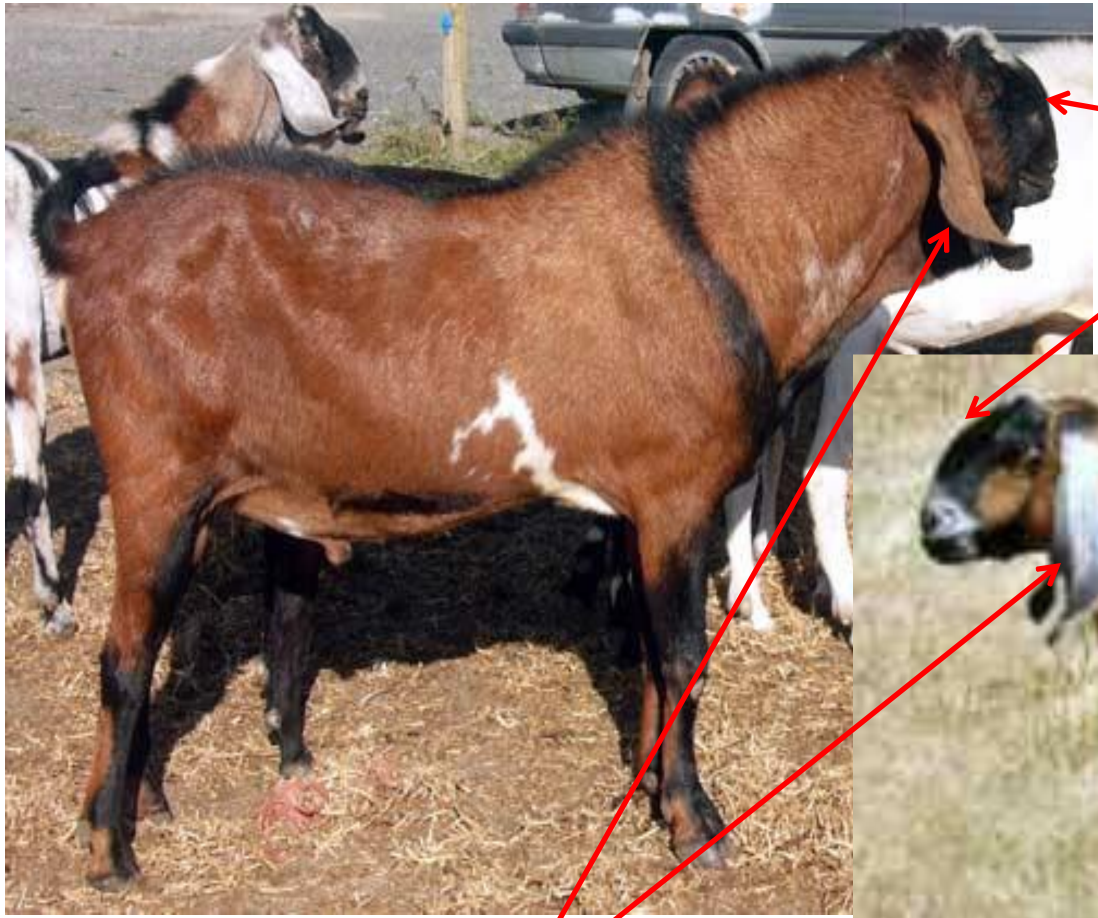
Goat Breeds

Exotic Goat Breeds

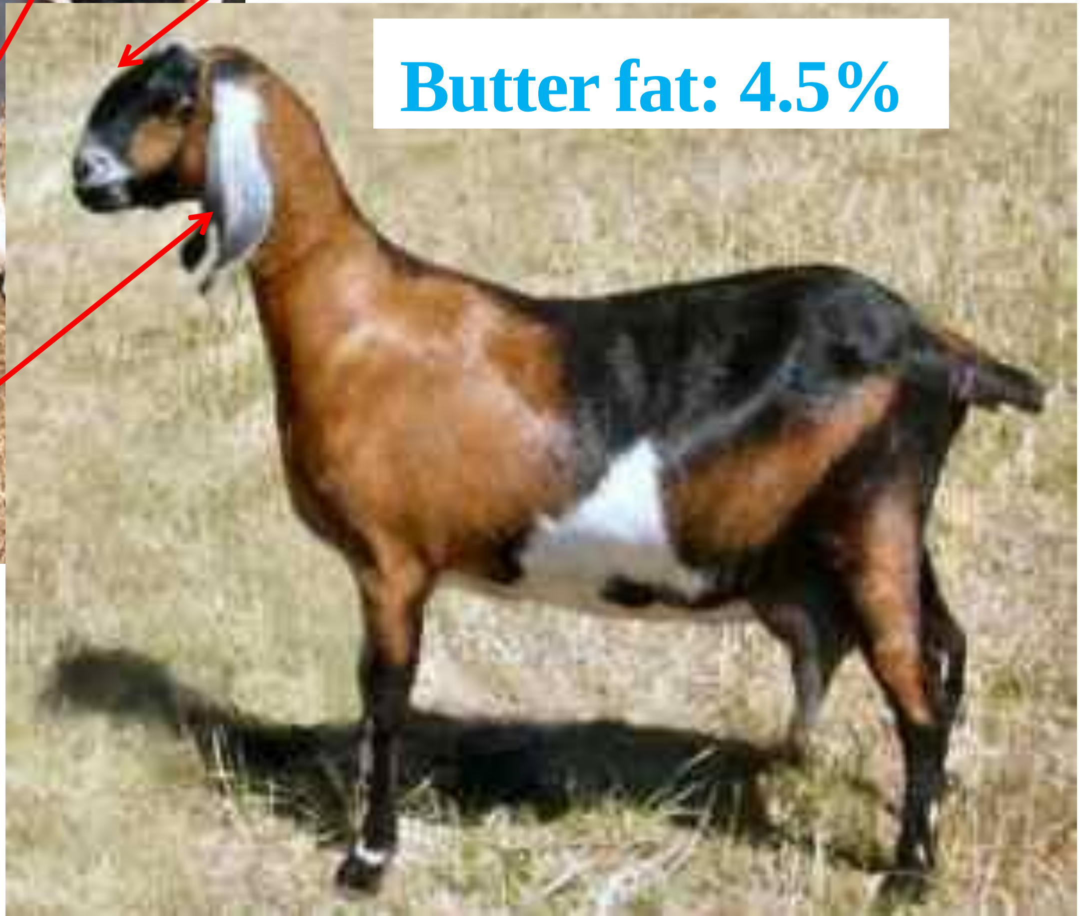
Goat Breed	Origin	Characteristics	Specials
Saanen	Switzerland	Sabre shaped horns Sensitive to sunlight 4-4.5 L milk/day 3-4% fat	"Milk Queen" of goat world
Toggenberg	Switzerland	Chocolate coloured body Hardy breed – milk producing	
Anglo-Nubian	Jamnapari/Malabari X English breed	Most outstanding dual purpose breed	"Jersey cow of goat world"
Alpine	Africa, France, Switzerland	Not suited to areas of high humidity	Scimitar shaped horns

“Milk Queen” - Saanen

ANGLO-NUBIAN GOAT : Jersey of goat(Dual Purpose)



Roman nose



Long, pendulous
and floppy ears

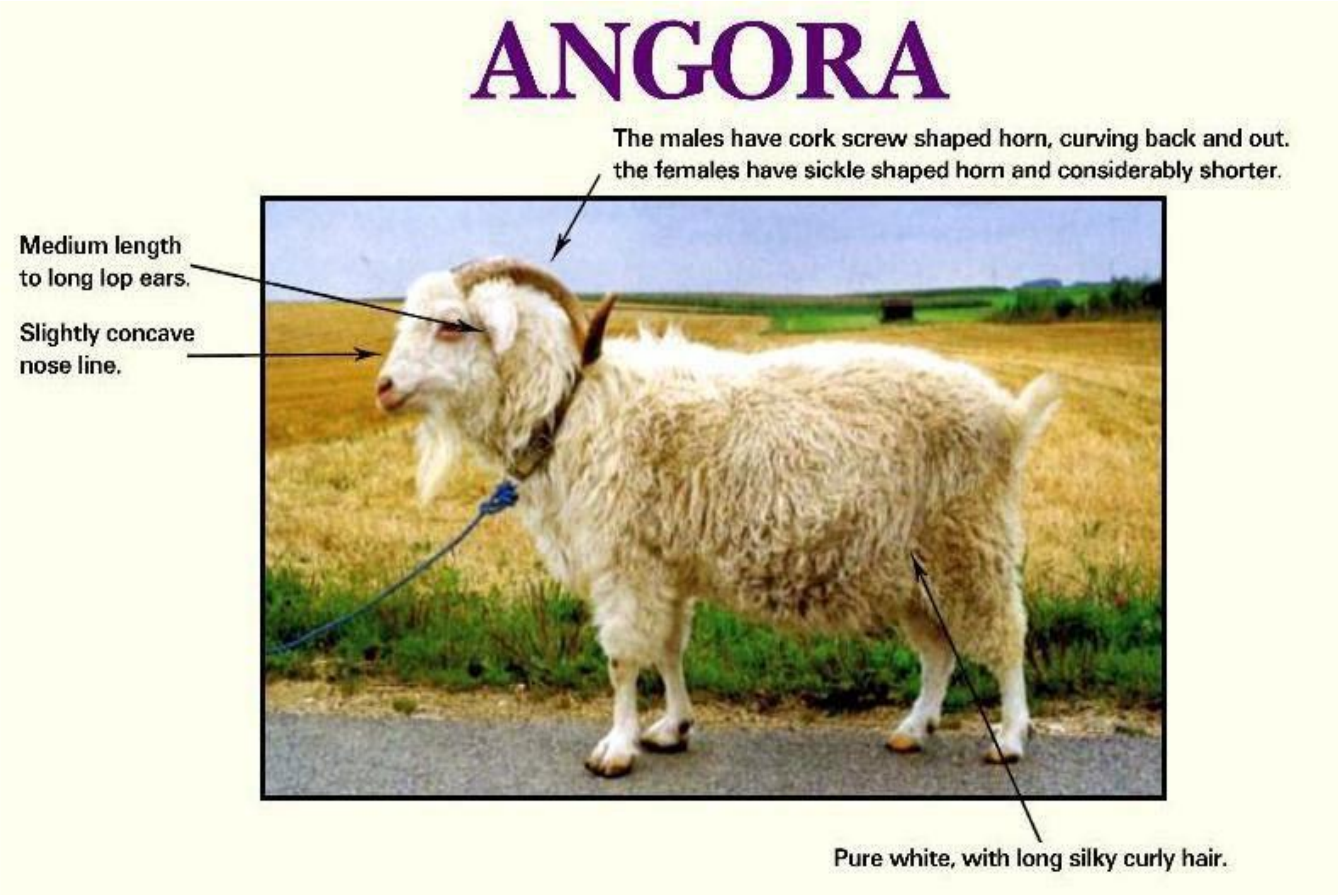
ALPINE GOAT

Erect ears described as "alertly graceful“;

No distinct color

Alpine × Beetal crossbred developed at NDRI for milk purpose

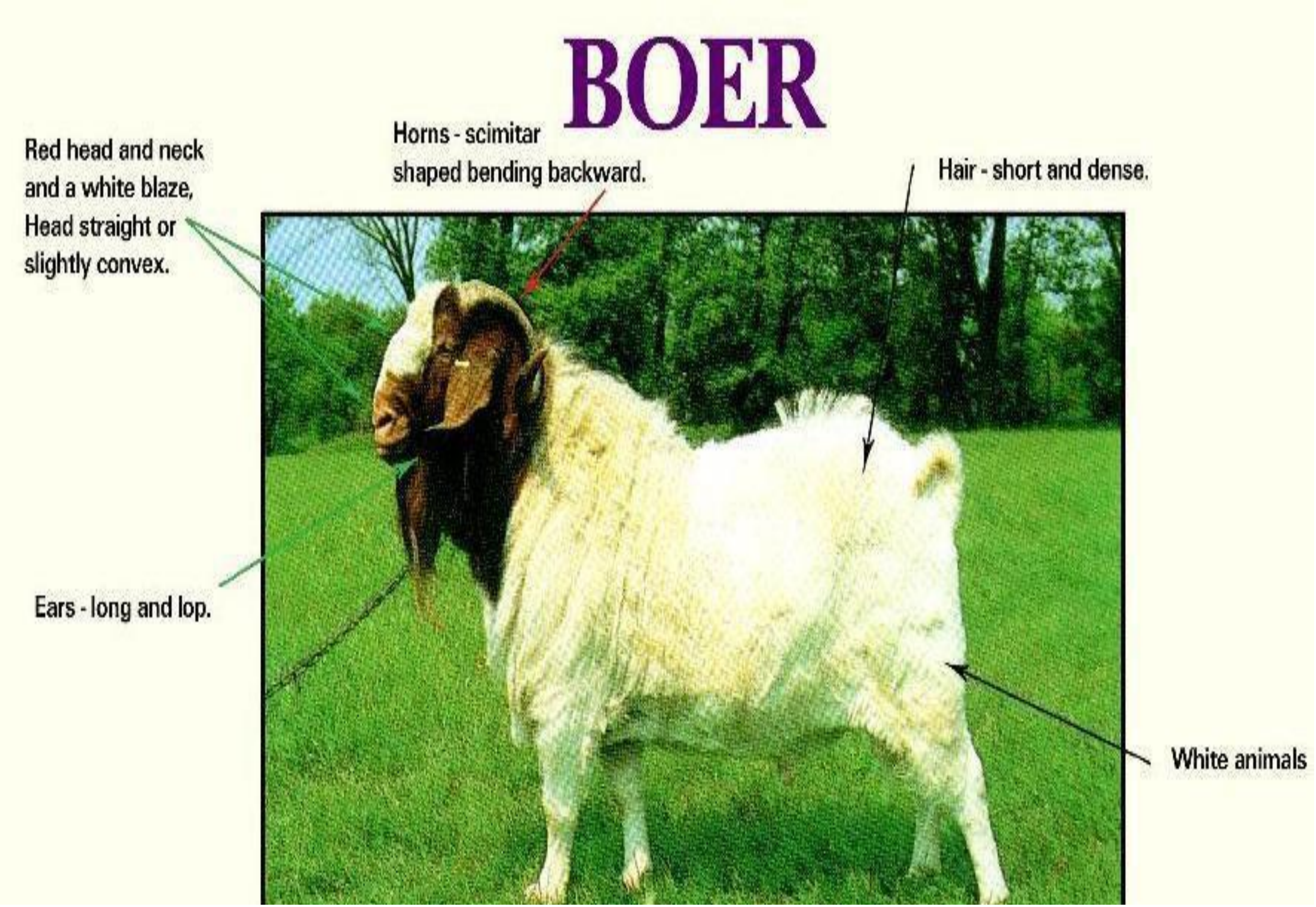
WiseIAS Academy



Angora goat : Mohair production;
Goat having sheep like texture;

WiseIAS Academy

ANGORA GOAT

Boer goat : high prolificacy and famous for meat production (broiler goat)

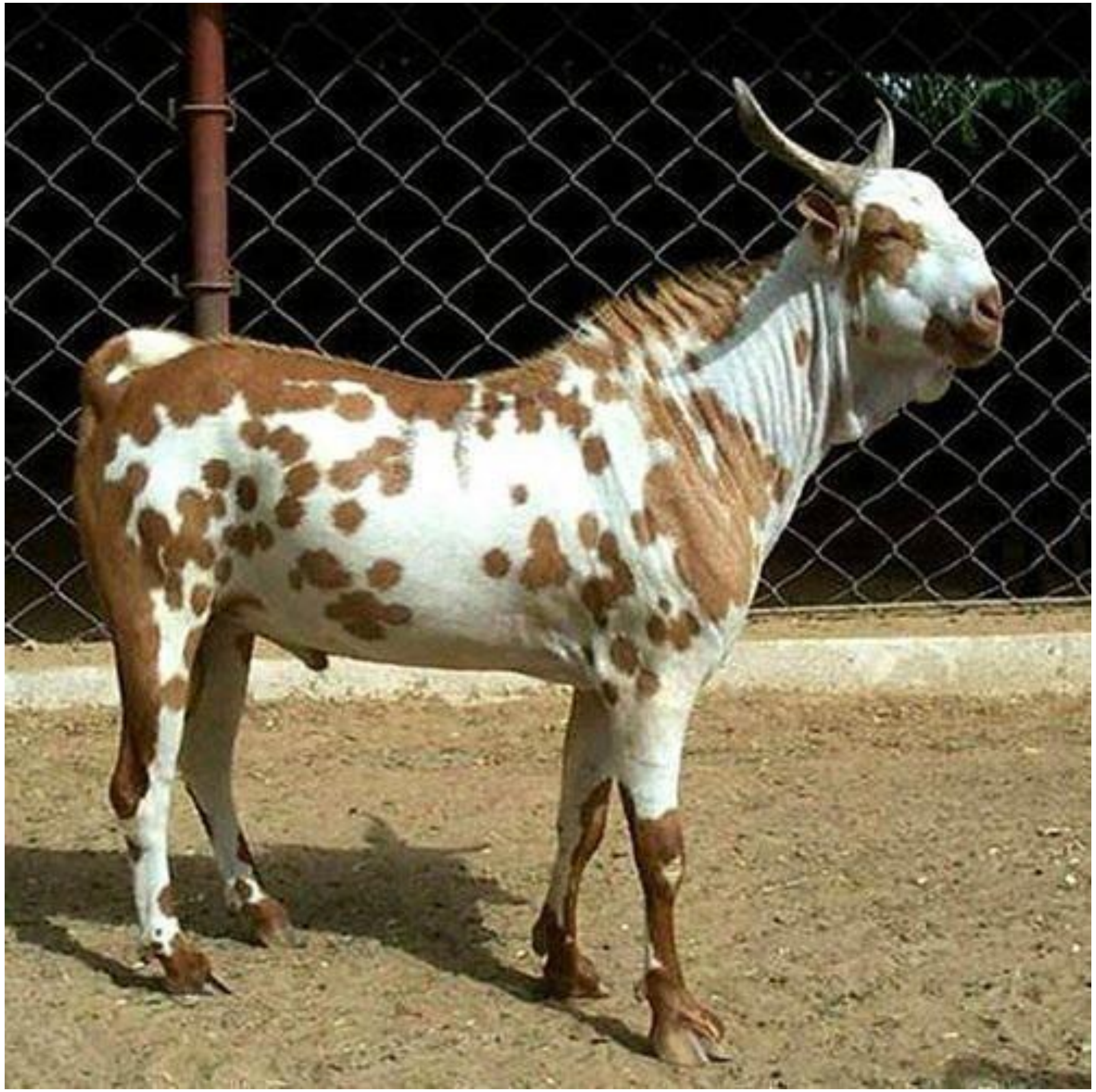
Indigenous Goat Breeds

- Milch Purpose
  - Beetal, Surti, Mehsana
- Meat purpose
  - Sirohi, Zalawadi, Black Bengal, Ganjam, Attapady Black, Berari, KanniAdu, Konkan kanyal,
- Meat + Milk
  - Jamnapari, Barbari, Marwari, Osmanabadi, Malabari, Gohilwadi
- Pashmina
  - Changthangi, Chegu

Indigenous Goat Breeds

Breed	Purpose	State	Characteristics	Specific
Beetal	Milch	Punjab	Males possess beard Convex face, black lips Long pendulous ears	Males possess beard
Jamnapari	Dual (Milk/Meat)	Uttar Pradesh	White colour Both sexes horned Thick hair on buttocks (feathers)	"Most majestic breed" Parrot mouth Milk – 3.89 kg/day avg Butterfat (4.84%) - high
Barbari	Dual (Milk/meat)	Uttar Pradesh/ Rajasthan	Suitable for stall feeding Wedge shaped body City breed	Maximum milk fat (5%)
Jharkhana	Milk	Rajasthan	White spots on ear & muzzle Twisted horns in both sexes	Skin popular for "tanning" purpose
Sirohi	Dual purpose	Rajasthan	Coarse, short hair Brown/white/patched	

Barbari



Indigenous Goat Breeds

Breed	Purpose	State	Characteristics	Specific
Kutchi	Milk, Meat, Hair	Gujarat		"Corkscrew horns" pointed upwards
Black Bengal	Meat, Hide	West Bengal	Black coloured Both sexes – small-med horns Beard in both sexes Hair coat- short & lustrous	"Best chevon breed" of India Skin – shoe making Highly prolific
Changthan gi	Wool, Meat	J&K (Ladakh)	White + Brown Twisted horns in both sexes Small size	Pashmina breed – high quality Kashmiri rug/shawl (70-500 g/goat annually)
Chegu	Wool, Meat	Himachal Pradesh, Uttarakhan d	Twisted horn in both sexes Long hair, fine downy undercoat White + greyish red mix	Pashmina producing breed

Kutchi

Black Bengal

Changthangi

Chegu

What you should remember…

Aspect	Breed
Lightest goat breed	Changthangi
Tallest goat	Jamunapari
Shortest goat	Barbari
Sheep like goat	Angora
Goat like sheep	Nellore
Fine wool breed of India (goat)	Changthangi
High yielder	Jamunapari
Tender low fat meat and delicate skin	Black Bengal, Surti
Best chevon breed	Black Bengal
Short estrous cycle, high yielder	Barbari
Highly prolific	Black Bengal, Malabari

What you should remember…

Aspect	Breed
Long drooping ear	Jamnapari
High FCR	Jamnapari, Barbari
Minimum DM intake	Barbari, Black Bengal
Screw like horn	Zalawadi
Corkscrew horn	Kutchi, Changthangi, Marwari, Zalawadi
Scimitar Shaped horn	Boer, Alpine
Sabre shaped horn	Saanen
Cork shaped horn	Chegu
Goat used for upgrading	Anglo-Nubian

Scimitar

Sheep Breeds

Exotic Sheep Breeds

Breed	Origin	Characteristics	Specifics
Merino	Spain	Horned rams, polled ewes Head-leg – covered with wool	Most popular fine wool breed – Pashmina producing
Rambouillet	France	Horned rams, polled ewes Excellent fine wool fleece Heavy compact fleece	
Dorset	England	Hardy breed	Superior quality mutton
Southdown	England	Oldest English Breeds Mousey grey face Excellent mutton breed	Contributed to development of many sheep

Exotic Sheep Breeds

Merino

Rambouillet

Exotic Sheep Breeds

Dorset

Southdown

Exotic Sheep Breeds

Trait	Breed
Largest and heaviest sheep breed	Lincoln
Best pelt breed (good quality fur)	Karakul
Best mutton breed	Suffolk
Pashmina producing breed/most popular fine wool breed in the world	Merino
Largest fine wool breed/French Merino	Rambouillet

Lincoln

Karakul

Indigenous Sheep Breeds

Trait	Breed
Indian Merino	Chokla
Yellow wool, Canary coloured wool	Nali
Highly disease & worm resistant	Marwari
Tallest sheep / Goat like sheep / Best mutton breed (India)	Nellore
Shortest, smallest sheep / Best mutton conformation	Mandya
Most prolific sheep	Garole
High quality skin	Mecheri
Best carpet wool	Chokla, Patanwadi
High quality palatable meat	Mandya
Lustrous carpet wool	Magra
Fine quality wool	Gaddi sheep

Nali – Yellow wool sheep

Nellore

Indigenous Sheep Breeds

Trait	Breed
High quality skin	Mecheri
Best carpet wool	Chokla, Patanwadi
High quality palatable meat	Mandya
Lustrous carpet wool	Magra
Fine quality wool	Gaddi sheep

Synthetic Breeds of Sheep

Breed	Exotic Inheritance	Crosses	Character	Place of development
Bharat merino	75%	Chokla and Nali X Rambouillet Merino	Apparel wool	CSWRI, Avikanagar
Avivastra	50%	Chokla and Nali X Rambouillet Merino	Apparel wool	CSWRI, Avikanagar
Avikalin	50%	Malpura X Rambouillet	Meat & Carpet wool	CSWRI, Avikanagar
Avimans	50%	Malpura and Sonadi X Dorset and Sufflok	Mutton breed	CSWRI, Avikanagar
Indian Karakul	75%	Marwari, Malpura and Sonadi X Karakul	Pelt, Meat, Wool	CSWRI, Bikaner

Synthetic Breeds of Sheep

Breed	Exotic Inheritance	Crosses	Character	Place of development
Kashmir Merino	50-75%	Gaddi, Bhakarwal and Poonchi X Merino and Rambouillet	Apparel wool	J&K
Nilgiri synthetic	62.5-75%	Nilgiri X Merino and Rambouillet	Apparel wool	Sheep Breeding Research Station, Sandynallah
Patanwadi synthetic	50%	Patanwadi X Rambouillet and Merino	Wool	DAU, Dantiwada
Hissardale	75%	Bikaneri ewes X Merino rams	Fine wool	GLF, Hisar
Sandyno		Interse mated (Merino X Nilgiri)	Fine wool	

Who Produces Which Fibre???

Wool Fibre Type	Who Produces It?
Angora	Angora Rabbit
Mohair	Angora Goat
Pashmina (finest grade Cashmere)	Changthangi goat
Cashmere	Cashmere goats (group) – double coat (fine, soft undercoat) Chinese, Iranian, Mongolian, Australian, American
Qiviut	Muskox (not domesticated)

Poultry breeds

Exotic Breeds of Poultry – Classes

American	Asiatic	English	Mediterranean
• Clean shanks • Single/pea combs • Dual	• Feathered shanks • Pea combs • Excellent meat • Ornamental • Moderate eggs no.	• Clean shank • Various types of combs • Good meat • Variable egg • (Dual)	• Clean shank • Yellow shank • Single combs • Egg type

Exotic Breeds of Poultry

PNRJ
W

BC
L

English
C-
DOSA

Medica
l
LAMA

American	Asiatic	English	Mediterranean
• Plymouth rock • New Hampshire • Rhode Island Red • Jersey Black Giant • Wyandotte	• Bramha • Cochin/Shanghai • Langshan	• Australorp • Cornish • Orpington • Sussex • Dorking	• Minorca • Leghorn • Ancona • Andalusian

Indigenous Poultry Breeds

Breed	Origin	Characteristics
Kadaknath/Kalamasi	Madhya Pradesh	Black pigmentation – external and internal surface Light brown eggs Purple comb, wattles and tongue
Aseel	Chattisgarh, Odisha, Andhra Pradesh	Fighting abilities – Game bird Majestic gait, high stamina Broody bird Close relationship with breed 'Ghagus'
Punjab brown	Punjab, Haryana	Meat quality
Chittagong/Malay	Northeast India	Game bird

Naked neck – no feathers around neck – helps with heat dissipation in hot, humid areas
*Naked neck is a genetic trait, not a breed.
- Major gene line developed for broiler production

Strains Developed at CARI

Desi/Backyard	• CARI Nirbheek (Aseel cross) • CARI Shyama (Kadaknath cross) • Hitcari (Naked Neck cross) • Upcari (Frizzle cross)
Layers	• CARI Priya • CARI sonali – White leghorn X RIR • CARI-Debendra – Synthetic broiler X RIR • CARI Gold – Selective breeding in RIR
Broilers	• CARI Vishal (Caribro-91) • CARI-rainbro (B-77) • CARIbro – Dhanraja • Caribro – mritunjai (CARI Naked neck)

Strains Developed at PDP, Hyderabad

Strain	Cross	Purpose
Vanaraja	Cornish male X Synthetic population	Dual
Gramapriya	Synthetic male X White leghorn female	Dual
Krishibro		Coloured Broiler

Other Strains

Strain	Place
Giriraja, Swanadhara	Bangalore (KVAFSU)
Kalinga brown	CPDO, Bhubaneshwar, Odisha
Nandanam chicken (I and II)	TANUVAS
Lohmann	Suguna Poultry Farm Ltd., TN
Gramalakshmi	KAU, Kerala
Krishna J	JNKVV, Jabalpur

Other Poultry Birds from CARI

Quails
CARI Uttam
CARI Pearl
CARI Ujjwal, CARI Sweta
CARI Brown, CARI sunheri

Guinea Fowl
Guncari – Egg
Kadambari – Meat
Chitambari – Egg
Swetambari - Meat

Duck
Moti – Egg
Moti – Meat
Turkey
CARI Virat

Ducks

Three registered breeds with NBAGR:

1. Pati Duck – Assam
2. Maithili – Bihar
3. Andamani – Andaman & Nicobar

*Khaki Campbell = Indian Runner + Mallard + Rouen

Egg type

- Khaki Campbell* (300 eggs/year)
- Indian Runner (200-300 eggs/year)

Meat type

- Muscovy – Quiet breed
- Aylesbury – White skin
- White Pekin, Rouen

Turkeys

- **Broad breasted bronze**
  - Black plumage
- **Broad breasted white**
  - Broad breasted bronze X White Holland
- **Beltsville small white**

CARI Virat from CARI

All things Chicken

Trait	Breed
Disease resistant breed	Kadaknath – free range
Most susceptible to Marek's disease	Kadaknath – Intensive system
Best egg producer (Indian)	Nicobari
World No. 1 egg Producer	Leghorn
Excellent fleshing quality	Sussex
Best broiler breed	Cornish
Best brooder (India)	Brahma
Graceful bird	Langham
Poor mothering ability	Chittagong

All things Chicken

Trait	Breed
Large egg producer	Hampshire
Blue eggs producing chicken	Araucana, Amerucana
Meat of medicinal value	Kadaknath, Telicherry
Convection ability	Naked Neck, Frizzle fowl
Improved adult fitness	Naked neck

MCQs - Breeds

- Malabari breed of goat originates in the state of JKPSC 2019

(A) Orissa

(B) Jharkhand

(C) Kerala

(D) Andhra Pradesh

- The strain developed at CSWRI by crossing Rambouillet on Chokla and Nali sheep is JKPSC 2019

(A) Avivastra

(B) Abhimanas

(C) Abhikalin

(D) Kheri

MCQs - Breeds

- The original home tract of Sannen breed is JKPSC 2019
  - (A) USA
  - (B) Switzerland
  - (C) Turkey
  - (D) England
- Which of the following is a milch breed of goat JKPSC 2019
  - (A) Beetal
  - (B) Chegu
  - (C) Ganjam
  - (D) Assam Hill

MCQs - Breeds

- The goat breeds that produce longer and fine pashmina on sides and shoulders are JKPSC 2019

1) Gaddi

2) Chegu

3) Changthangi

4) Barbari

Choose the Correct Answers:

(A) 1 and2

(B) 2 and3

(C) 3 and4

(D) 2 and 4

MCQs - Breeds

- Newly recognized chicken breed UTTARA hails from the state of JKPSC 2019

(A) Jharkhand

(B) Chhattisgarh

(C) Uttarakhand

(D) Telangana

- The first successful cloning of livestock was done in 1996 with JKPSC 2019

(A) cattle

(B) sheep

(C) swine

(D) goats

MCQs - Breeds

- __________is the fibre obtained from Angora goats.

a) Pashmina

b) Cashmere

c) Qiviut

d) Mohair

- Name the smallest sheep breed with typical reversed ―U‖ shaped body conformation from rear side.

a) Nellore

b) Magra

c) Mandya

d) Hassan

MCQs - Breeds

- Hitkari is the breed of chicken developed at_______________
  a) Hyderabad
  b) CARI
  c) IARI
  d) Kerala

- Magra breed of sheep is famous for the production of
  a) Coarse wool
  b) Superior carpet wool
  c) Milk production
  d) Mutton

MCQs - Breeds

1. Which is the shortest breed
    a) Nilgiri
    b) Mandya
    c) Nellore
    d) Both b and c

2. Minorca breed of poultry belongs to which class
    a) Asiatic
    b) English
    c) Mediterranean
    d) American

J&K Specific

(J&K + Ladakh)

J&K Specific

(J&K + Ladakh)

Species	Number of Registered Breeds	Name of the Breeds
Cattle	2	Ladakhi, Kashmir Valley
Buffalo	0	-
Sheep	5	Changthangi, Poonchi, Gurez, Karnah, Kashmir Merino
Goats	2	Changthangi, Bakarwal
Camel	1	Bactrian Camel
Poultry	1	Kashmir Favorella
Yak	1	
Horse	1	Zanskari
Geese	1	Kashmir Anz

Species	Breed	Region	Special Characteristics
Cattle (2)	Ladakhi	Leh-Ladakh	Adapted to high altitude and hypoxic conditions; resistant to diseases; produces 2-5 kg milk/day with high fat content (4.6%)
	Kashmir Valley	Kashmir	Not officially recognized; adapted to temperate climate
Buffalo (0)	-	-	No registered indigenous buffalo breeds
Sheep (5) **Kashmir Merino is not registered with NBAGR*	Kashmir Merino	Kashmir Valley	Fine wool quality; adapted to temperate climate
	Bhakarwal	Jammu	Coarse carpet wool; White with black head
	Poonchi	Poonch, J&K	Carpet wool type; adapted to subtropical climate
	Gurez	Gurez Valley, J&K	Superior Carpet wool; adapted to high altitude
	Karnah	Kupwara, J&K	Superior Carpet wool; adapted to temperate climate
	Changthangi	Changthang, Ladakh	Good fleece, long staple length of wool, fine wool

Species	Breed	Region	Special Characteristics
Goat	Changthangi	Ladakh	Produces pashmina fiber; adapted to extreme cold
	Bhakarwal	J&K	Dairy type; adapted to migratory life
Camel	Double Humped Camel	Nubra Valley, Ladakh	Critically endangered; adapted to cold desert
Poultry	Kashmir Favorolla	Kashmir	Disease resistant; adapted to hostile climate; multiple plumage colors
Yak *(not registered with NBAGR)*	-	Ladakh	Adapted to high altitude; multi-purpose (milk, meat, fiber)
Horse	Zanskari	Ladakh	Adapted to high altitude; used for transportation
Geese	Kashmir Anz	Kashmir	Hardy; disease resistant; good foragers

AGB
Lecture 9

Livestock Breeding Policy of India

Livestock Breeding Policy of Jammu & Kashmir

Conservation of Livestock Breeds

National Breeding Policy

(DAHD, 2013)

Breeding Policy for Cattle and Buffaloes

Cattle

- Selective Breeding of indigenous high yielding cattle in their home tracts
- Upgradation of ND cattle:
  - Exotic cattle – Jersey and Holstein Friesian
  - Indigenous cattle – Sahiwal, Red Sindhi, Gir and Tharparkar (Resource deficient areas)

Buffalo

- Selective breeding of major buffalo breeds
- Graing up of ND breeds – Murrah and Surti

General

- Production of high genetic potential males
- Formation of breed associations for indigenous breeds
- Produce high genetic merit bulls (disease resistant) for natural mating
- Use of semen of PT bulls for crossbreeding

Breeding Policy for Sheep and Goats

Aims: Improve growth, body weight, reproductive efficiency, meat and wool quality/quantity, reduce mortality

Approach: Area-specific for coarse and fine wool improvement

Focus: Produce and distribute quality rams/bucks of indigenous breeds

Methods:

- Artificial insemination encouraged
- Cross-breeding with high-yielding exotic and native goat breeds considered

SHEEP BREEDS:

- Upgrading – Chokla, Nali, Patanwadi, Malpura
- Crossbreeding - Suffolk, Dorset, Rambouillet, Soviet Merino

GOAT BREEDS:

- Upgrading – Beetal, Jamnapari

Breeding Policy for Pigs

Objectives:	• Improve growth, prolificacy, meat quality/quantity, survivability, and feed utilization
Conservation:	• Preserve meritorious indigenous breeds in local tracts
Cross-breeding:	• Encouraged with high-yielding, disease-resistant exotic breeds
Exotic germplasm limit:	• Maximum 50% in crossbreeding
Upgrading:	• Ghungroo, Dome (indigenous), Large white Yorkshire, Landrace (exotic)
Crossbreeding:	• Large white Yorkshire, Landrace, Hampshire, Duroc

Key Points

1. Each species has specific breeding objectives
2. Indigenous breed conservation is emphasized
3. Cross-breeding is species and area-specific
4. Artificial insemination is promoted where applicable
5. Exotic germplasm use is limited and controlled

Poultry Breeding

- **Low input technology chicken varieties:**
  - Improve heat tolerance through feather modification genes (Na, F, Sc)
  - Reduce body size genes
  - Cross Aseel males with CARI red hens to produce CARI Nirbheek
- **Maintain high-yielding varieties:**
  - Focus on parent and grandparent stock
- **Advanced breeding technologies:**
  - Use QTLs, CRISPR, transgenesis, RNAi
  - Identify and propagate robust, high-producing stocks

Poultry Breeding

Immune competence:
- Develop strains adaptable to changing farm conditions

Small-holder systems:
- Implement creep-upgrading
- Establish nucleus crossbreeding programs
- Develop community-based breeding programs
- Create strategies for replacement stock generation

Key points to remember:

- Emphasis on both indigenous and exotic breeds
- Focus on heat tolerance and disease resistance
- Use of advanced genetic technologies
- Tailored approaches for commercial and small-scale farming

AGB
Lecture – 9

Livestock Breeding Policy of India

Livestock Breeding Policy of Certain Indian States

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(DAHD, 2013)

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- Focus on heat tolerance and disease resistance
- Use of advanced genetic technologies
- Tailored approaches for commercial and small-scale farming

State Breeding Policies

Madhya Pradesh – Breeding Policy

Cattle and Buffaloes

- Malvi, Nimari, Kenkatha and Gaolao – Selective breeding in home tract
- Crossbreeding – Jersey/HF – 50% inheritance fixed
- Crossbreeding for development of ND cattle
- Upgrading with Sahiwal, Gir or Red Sindhi in areas unsuitable for crossbreeding
- Encourage breeders' societies for breed improvements

Sheep

- Indigenous breeds –
  - **Bharat Merino** – selective breeding for meat and wool
  - **Shahabadi** – selective breeding for mutton production
- Crossbreeding –
  - Exotic inheritance (**75%)** – Corriedale or Rambouillet breeds
- **Grading up of ND with Shahabadi breed**

Madhya Pradesh – Breeding Policy

Goats

- Indigenous breeds (selective breeding)
  - **Jamunapari**: Chambal ravine area
  - **Barbari**: Gwalior and Bhind districts
  - **Black Bengal**: Rewa, Satna, and Sidhi districts
- Grading up of non-descript goats with Jamunapari or Barbari breeds
- Encourage formation of breeders' societies

Poultry

- Indigenous breeds:
  - Kadaknath: Conservation and improvement in its home tract (Jhabua district)

Rajasthan – Breeding Policy

Cattle and Buffaloes

- Upgrading of ND animals with high yielding animals
- Selective breeding and conservation of Gir, Hariana, Malvi, Rathi, Kankrej, Nagauri, Sahiwal and Tharparkar cattle
- Crossbreeding – exotic inheritance fixed to 50-62.5% - Exceeding the level only after ensuring enough resources for management
- Castration of bulls and calves not used for breeding
- Breed of choice for buffalo breeding
  - Murrah - Jaipur, Jodhpur, Kota, Ajmer, Bharatpur
  - Surti – Udaipur division

Goats –

- Selective breeding in their native tracts
  - Marwari - Osian block (Jodhpur dist.),
  - Sirohi - Sirohi, Udaipur and Chittorgarh dist
  - Jharkhana - Alwar dist.
- Marwari and Sirohi bucks for upgrading (Buck to doe ratio 1:15 to 1:20)
- ONBS for cluster areas to promote development

Rajasthan – Breeding Policy

Sheep

- Indigenous breeds - Chokla, Nali, Marwari, Jaisalmeri, Sonadi, Malpuri, Pugal and Magra
- Improvement by provision of superior rams to farmers
- Genetic improvement:
  - **Malpura** – for mutton production (selective breeding)
  - **Chokla** – wool quality and quantity (selective breeding)
  - **Rambouillet and Merino** used for crossbreeding
- Level of exotic inheritance – 75%
- Specific Breeding Programmes:
  - Sheep breeding farm (Fatehpur, Sikar) – production and distribuition of superior breeding rams (Chokla, Nali, Marwari breeds) at subsidised rates
  - Central Sheep and Wool Research Institute (CSWRI)

Rajasthan – Breeding Policy

Camels

- *In situ* conservation in their breeding tracts
- Rajasthan Camel Act 2015 – bans evacuation or temporary migration of camels out of state
- Four recognised camel breeds – Marwari, Bikaneri, Jaisalmeri, Kutchi
- Emphasis on improving milk production in camels
- Incentives for camel breeding to combat the declining population
- Breeding programmes:
  - Ushtra Vikas Yojana (Camel Development Scheme) – 2016 – connservation and development

Punjab – Breeding Policy

Cattle

- Indigenous Breeds
  - Sahiwal: Selective breeding in home tract (Ferozepur, Amritsar, Tarn Taran)
  - Conservation of Red Sindhi and Tharparkar breeds
- Crossbreeding
  - Holstein Friesian (HF) preferred for crossbreeding
  - Maintain 62.5% HF inheritance (5/8 HF : 3/8 Indigenous)
  - Jersey crosses to be upgraded to HF crosses

Buffaloes

- Breed of choice: Nili Ravi – Selective breeding
- Murrah

AI Coverage to be increased from 20% to 50% in 5 years

Embryo transfer technology to be used for faster genetic improvement

Punjab – Breeding Policy

Sheep	Goat
• Breeds: Nali, Lohi, Desi, and their crosses • Crossbreeding with exotic breeds not recommended • Focus on selective breeding within indigenous breeds • Emphasis on mutton production • Ram exchange program to avoid inbreeding	• Breeds: Beetal and Black Bengal • Selective breeding within Beetal breed • Black Bengal to be used for crossbreeding with Beetal for meat production • Emphasis on both milk and meat production • Buck exchange program to avoid inbreeding

Punjab – Breeding Policy

Pigs

- Breeds: Large White Yorkshire, Landrace, and their crosses
- Crossbreeding with Large White Yorkshire and Landrace
- Maintain 50% inheritance of each breed in crossbreds
- Focus on increasing litter size and growth rate

Uttar Pradesh – Breeding Policy

Cattle Breeding Policy:

- Indigenous Breeds – Improvement of indigenous cattle breeds like Sahiwal, Gir, Kankrej, Tharparkar, Hariana

Buffalo Breeding Policy:

- Conservation and improvement of indigenous breeds like Murrah, Bhadawari and Jaffarabadi
- Grading up for ND buffaloes
- AI preferred for genetic improvement

Uttar Pradesh – Breeding Policy

Sheep Breeding Policy

- Improvement of sheep breeds like Muzzaffarnagari, Jalauni, Malpura
- Crossbreeding with Corriedale and Rambouillet
- Crossbreeding limit – 50% exotic inheritance

Goat Breeding Policy

- Indigenous Breeds – conservation and improvement of Jamunapari, Barbari and Sirohi
- Natural service is the primary breeding method for goats

Pig Breeding Policy

- Indigenous breeds improvement –
- Crossbreeding – Large White Yorkshire, Landrace (75% exotic inheritance limit)

Conservation of breeds

Conservation

Preservation + Improvement to better use in future

World level – FAO – Nodal Agency for conservation of livestock genetic resources

Reasons to conserve

- Maintain genetic variation (within and between breeds)
- Exploiting heterosis
- Linked to history
- Aesthetic reasons
- Research
- Meeting future needs

Methods of Conservation

- In situ
  - Active - conservation + improvement through breeding programmes
    - Best method
  - Passive
  - Limitation:
    - Large number of animals – expensive
    - Not feasible for breeds that are not economically viable
    - Large number of animals maintained – avoid _______ and _________
- Ex situ
  - Good for economically unviable breeds
  - *In vivo* or *In vitro*
  - *In vivo* - conservation away from breeding tract (live animals)
  - *In vitro* - storage of live cells

MCQs – Breeding Policy

- Which of the following exotic cattle breeds is NOT mentioned for crossbreeding with non-descript cattle in supportive climates?
  a) Jersey
  b) Holstein Friesian
  c) Sahiwal
  d) Brown Swiss

MCQs – Breeding Policy

- In the National Livestock Policy 2013, what is the maximum limit of exotic germplasm recommended for pig crossbreeding?
  a) 25%
  b) 50%
  c) 75%
  d) 100%
- Which of the following is NOT a method mentioned for improving poultry breeding in the National Action Plan for Egg & Poultry-2022?
  a) QTLs
  b) CRISPR
  c) RNAi
  d) Embryo transfer

MCQs – Breeding Policy - RJ

1. What is the recommended exotic inheritance percentage range for cattle crossbreeding in Rajasthan?
   a) 25-37.5%
   b) 37.5-50%
   c) *50-62.5%*
   d) 62.5-75%

2. Which buffalo breed is recommended for the Udaipur division in Rajasthan?
   a) Murrah
   b) *Surti*
   c) Mehsana
   d) Jaffarabadi

3. What is the recommended buck to doe ratio for goat breeding in Rajasthan?
   a) 1:5 to 1:10
   b) *1:15 to 1:20*
   c) 1:25 to 1:30
   d) 1:35 to 1:40

4. What is the maximum recommended level of exotic inheritance for sheep crossbreeding in Rajasthan?
   a) 50%
   b) 62.5%
   c) *75%*
   d) 87.5%

MCQs – Breeding Policy - MP

1. What is the fixed exotic inheritance percentage for cattle crossbreeding in Madhya Pradesh?
   a) 25%
   b) *50%*
   c) 75%
   d) 100%
2. Which of the following is NOT mentioned as an indigenous sheep breed for improvement in Madhya Pradesh?
   a) Bharat Merino
   b) Shahabadi
   c) *Malpura*
   d) None of the above
3. In which districts is the Black Bengal goat breed recommended for selective breeding in Madhya Pradesh?
   a) Gwalior and Bhind
   b) Jhabua and Dhar
   c) *Rewa, Satna, and Sidhi*
   d) Bhopal and Indore
4. Which indigenous poultry breed is specifically mentioned for conservation in its home tract in Madhya Pradesh?
   a) Aseel
   b) *Kadaknath*
   c) Chittagong
   d) Naked Neck

MCQs – Breeding Policy - Punjab

1. What is the preferred exotic breed for cattle crossbreeding in Punjab?
   a) Jersey
   b) *Holstein Friesian*
   c) Brown Swiss
   d) Ayrshire
2. Which buffalo breed is recommended as the breed of choice in Punjab?
   a) Murrah
   b) *Nili-Ravi*
   c) Mehsana
   d) Jaffarabadi
3. What is the breeding recommendation for sheep in Punjab?
   a) *Selective breeding within indigenous breeds*
   b) Crossbreeding with exotic breeds
   c) Grading up with Merino
   d) Importing exotic breeds
4. What is the recommended crossbreeding strategy for pigs in Punjab?
   a) 75% Large White Yorkshire, 25% Landrace
   b) 75% Landrace, 25% Large White Yorkshire
   c) *50% Large White Yorkshire, 50% Landrace*
   d) 100% Large White Yorkshire

MCQs – Breeding Policy – UP

1. Which of the following is NOT mentioned as an indigenous cattle breed for improvement in Uttar Pradesh's breeding policy?
   a) Sahiwal
   b) Gir
   c) Kankrej
   d) *Red Sindhi*
2. What is the recommended crossbreeding limit for sheep in Uttar Pradesh?
   a) 25% exotic inheritance
   b) *50% exotic inheritance*
   c) 75% exotic inheritance
   d) 100% exotic inheritance
3. Which breeding method is primarily recommended for goats in Uttar Pradesh?
   a) Artificial Insemination
   b) Embryo Transfer
   c) *Natural Service*
   d) In-vitro Fertilization
4. What is the maximum recommended exotic inheritance for pig crossbreeding in Uttar Pradesh?
   a) 50%
   b) *75%*
   c) 62.5%
   d) 87.5%

Thank you

Conservation of breeds

Conservation

Preservation + Improvement to better use in future

World level – FAO – Nodal Agency for conservation of livestock genetic resources

Reasons to conserve

- Maintain genetic variation (within and between breeds)
- Exploiting heterosis
- Linked to history
- Aesthetic reasons
- Research
- Meeting future needs

Methods of Conservation

- In situ
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  - *In vivo* or *In vitro*
  - *In vivo* - conservation away from breeding tract (live animals)
  - *In vitro* - storage of live cells

MCQs – Breeding Policy

- Which of the following exotic cattle breeds is NOT mentioned for crossbreeding with non-descript cattle in supportive climates?
  a) Jersey
  b) Holstein Friesian
  c) Sahiwal
  d) Brown Swiss
- What is the maximum recommended exotic inheritance limit for cattle in the temperate region of Jammu and Kashmir?
  a) 50%
  b) 62.5%
  c) 75%
  d) 100%

MCQs – Breeding Policy

- In the National Livestock Policy 2013, what is the maximum limit of exotic germplasm recommended for pig crossbreeding?
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  d) Embryo transfer

MCQs – Breeding Policy

- What is the recommended exotic inheritance limit for sheep in Jammu and Kashmir?
  a) 50%
  b) 62.5%
  c) 75%
  d) 87.5%
- Which goat breed is recommended for the improvement of non-descript flocks in the Kashmir Division?
  a) Beetal
  b) Jamnapari
  c) Bakerwali
  d) Gaddi

MCQs – Breeding Policy

- In the Jammu and Kashmir Livestock Breeding Policy (2019), which equine breed is mentioned for upgrading local horses?
  a) Thoroughbred
  b) Arabian
  c) Kathiawari
  d) Zanskari

- What is the primary breeding strategy recommended for yaks in Ladakh?
  a) Crossbreeding with exotic breeds
  b) Selective breeding for production traits
  c) Artificial insemination
  d) Embryo transfer

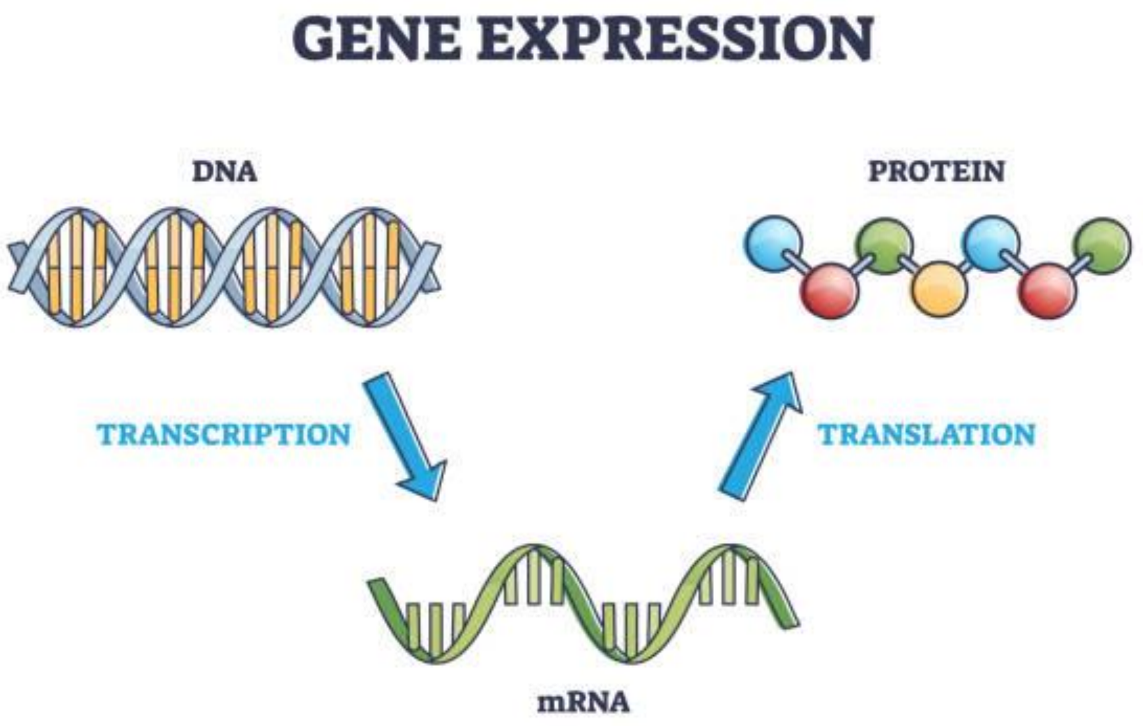
MCQs – Breeding Policy

- Which buffalo breed is recommended for upgrading the local buffalo population in R.S. Pura, Kathua, and Samba regions?
  a) Murrah
  b) Surti
  c) Nili Ravi
  d) Jaffarabadi

- According to the Jammu and Kashmir Livestock Breeding Policy (2019), what is the recommended approach for double-humped camel breeding?
  a) Crossbreeding with exotic breeds
  b) In situ conservation
  c) Ex situ conservation
  d) Artificial insemination

Veterinary Officer Exam
WISEIAS ACADEMY

Gene Expression



Gene Expression

- The process by which information from a gene is used to synthesize functional gene products

Regulation of Gene Expression

- Multiple Levels – DNA, RNA, Protein
- Control over – timing, location, amount of product
- Vital for – differentiation, morphogenesis, adaptability
- Based on this, types of genes:

- Constitutive
  - rRNA genes
- Facultative
  - Human β-globin gene
- Housekeeping
  - GAPDH
- Inducible
  - HSP genes

DNA Replication

(Semi-Conservative Replication)

Initiation
Elongation
Termination

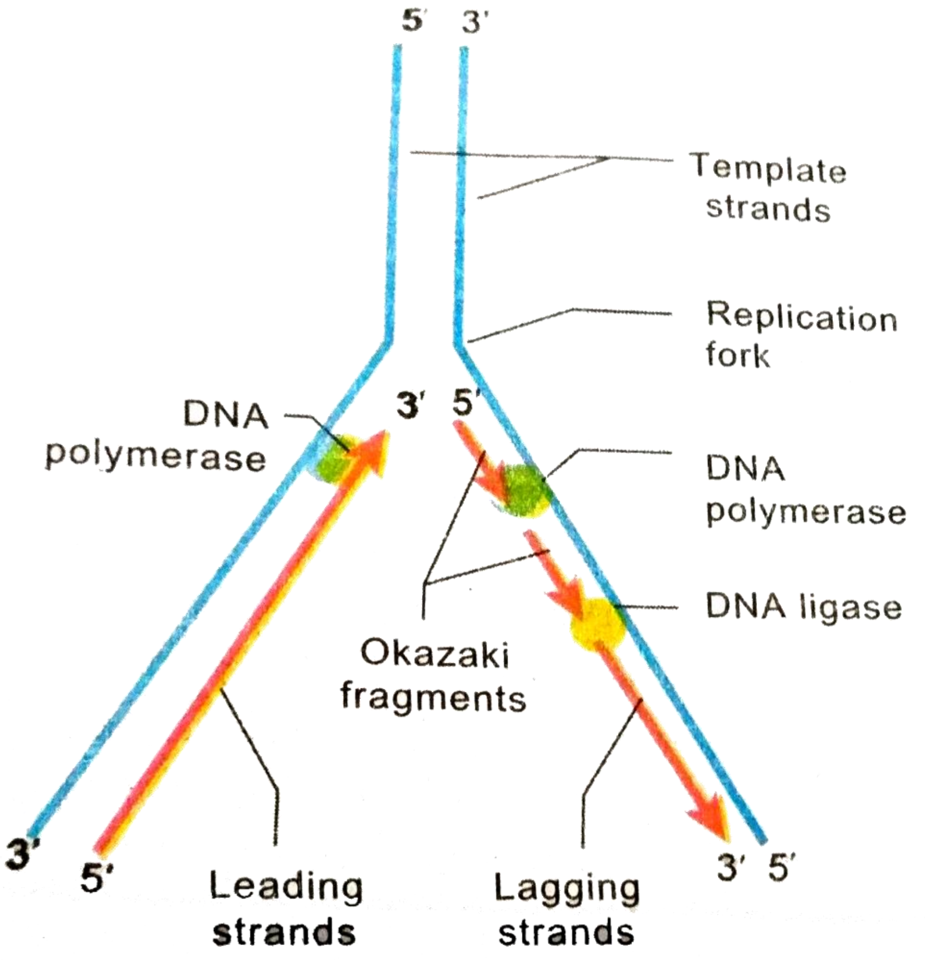
DNA Replication – Enzymes Involved

- Helicase
- Primase
- DNA Polymerase III
- DNA Polymerase I
- Ligase
- Topoisomerase
- SSBP

DNA Replication - Steps

1. Initiation

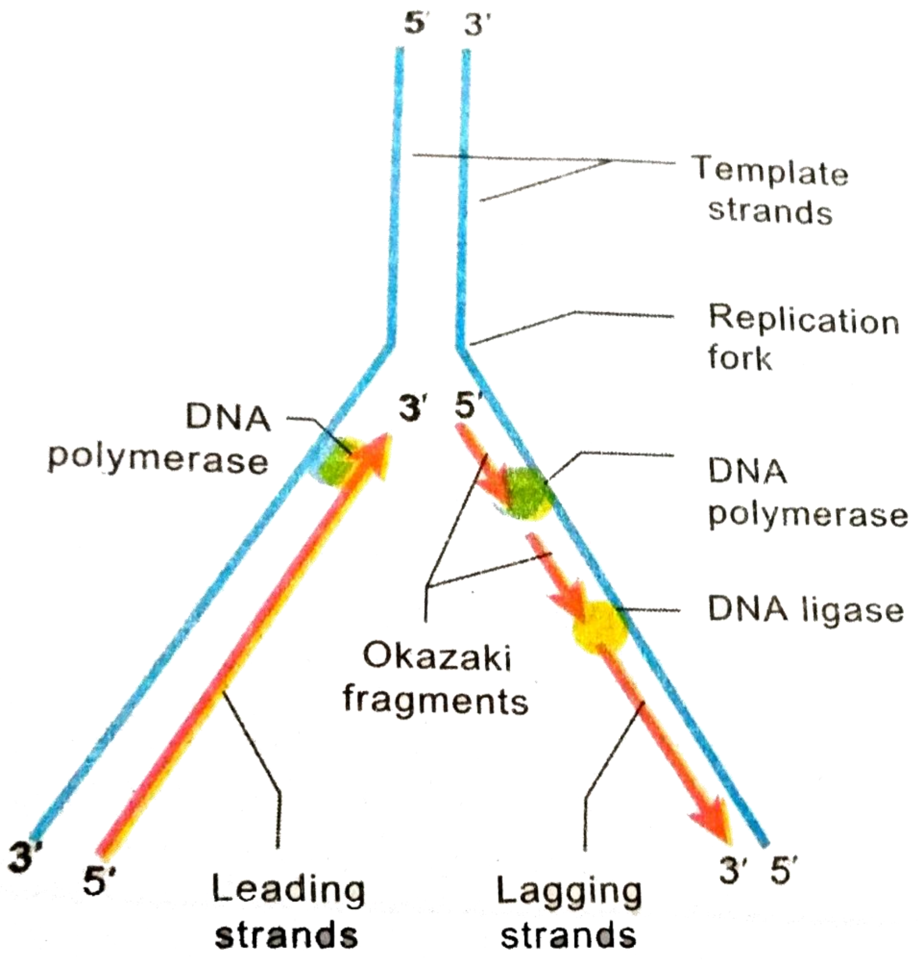
   - Begins at specific location – origin of replication
   - Initiator proteins – separate 2 strands
   - Helicase for unwinding
   - SSBP for stabilisation – prevent reannealing



DNA Replication - Steps

2. Elongation

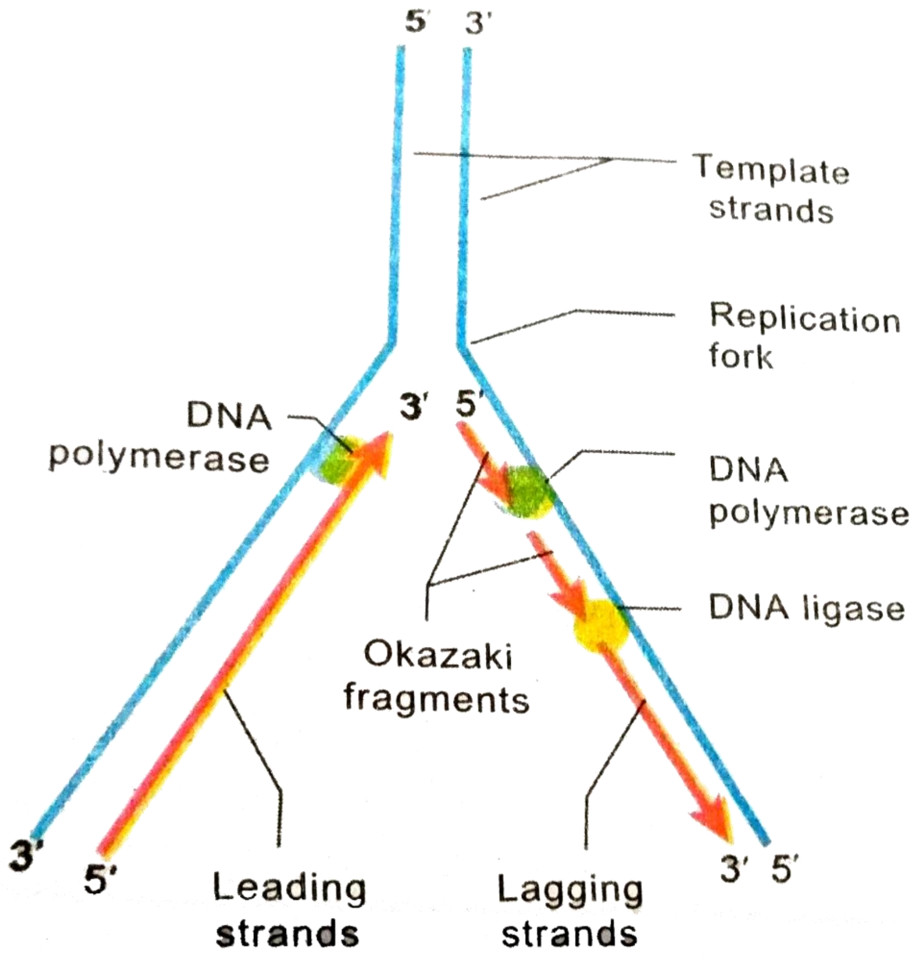
- Two strands – Leading and Lagging
- Leading strand – continuous replication
- Lagging strand – Okazaki fragments
- DNA Pol III – Adds nucleotides
- DNA Pol I – Replaces RNA primer with DNA
- DNA Ligase – Joins Okazaki fragments



DNA Replication - Steps

3. Termination

- Continues until full molecule is replicated
- Linear DNA –
  - Enzyme telomerase replicates the telomeres
  - Adds TTAGGG to ends of replicated DNA



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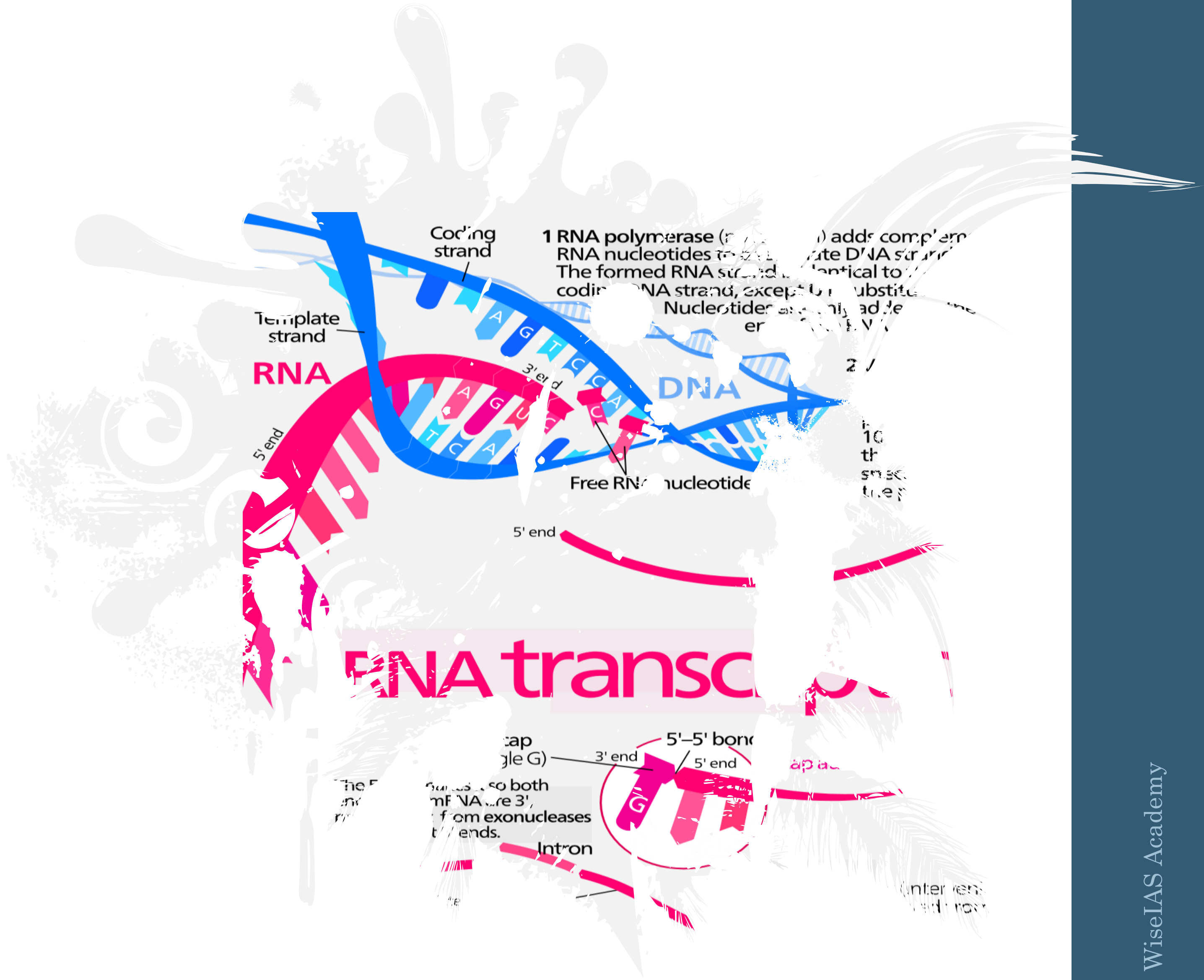
Transcription

DNA ⟶ RNA

Information in DNA copied to a complementary RNA Strand



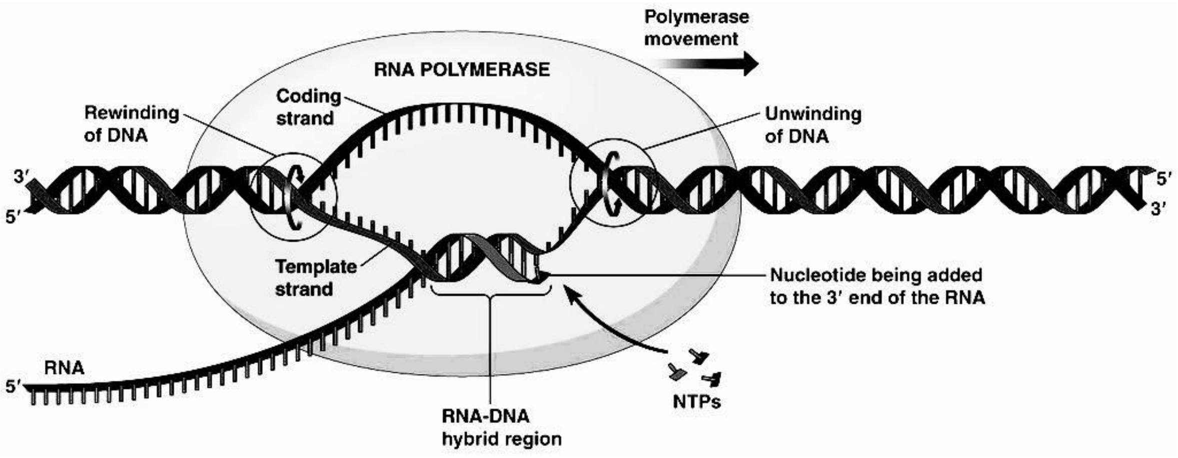
Transcription – Key Enzymes & Components

- RNA Polymerase
  - RNA Pol I (Prokaryotes)
  - RNA Pol I, II, III (Eukaryotes)
- Promotor
  - TATA Box (Eukaryotic genes)
- Transcription Factors
- Terminator

Steps in Transcription

1. **Initiation**

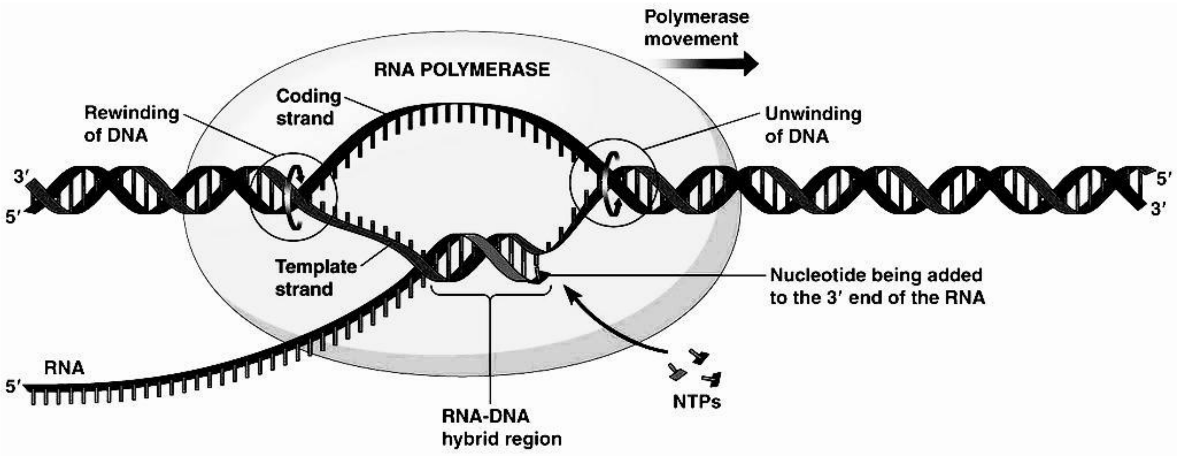
- RNA Pol binds to promotor
- TATA Box (Eukaryotes) – 25-30 bp upstream of transcription start site
- DNA double helix – separated
- Two strands:
  - Coding strand/Sense Strand
  - Template strand/Anti-sense strand



Steps in Transcription

2. **Elongation**

- RNA Pol moves along template strand
- Strand read in 3'-5' dir
- RNA molecule produced in 5'-3' direction



3. **Termination**

- At the terminator sequence
- New RNA & RNA Pol released from DNA
- DNA double helix is reformed

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Processing of Eukaryotic Nascent mRNA

- Capping – 5’ cap addition (7-methyl guanine residues)
  - Protection from exonucleases
  - Facilitates translation
  - RNA export
- Tailing – Poly-A residues at 3’ end
- Splicing – removal of introns

Transcription – Prokaryotes vs Eukaryotes

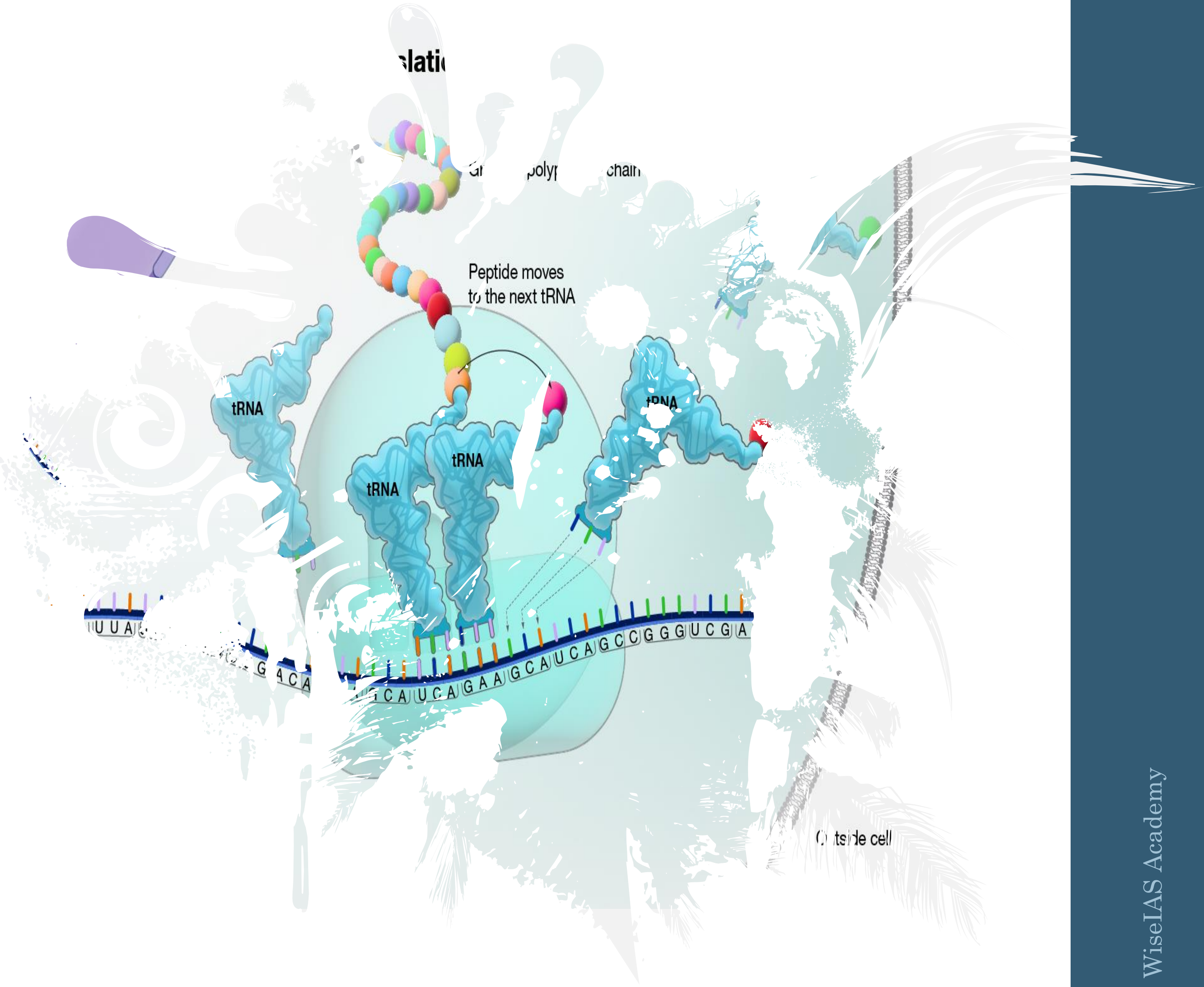
Prokaryotic Transcription

- Occurs in cytoplasm
- No post-transcriptional modifications of RNA
- Translation begins immediately

Eukaryotic Transcription

- Occurs in nucleus
- Post-transcriptional modifications are seen in nascent RNA
- Mature mRNA transported to cytoplasm for transcription

Translation
mRNA⟶Protein



Occurs in cytoplasm

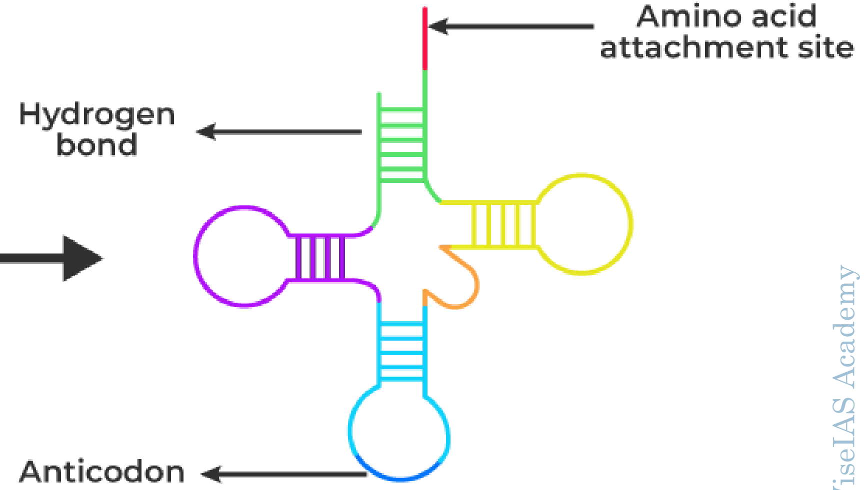
Translation – Key Components

mRNA

Ribosomes
- Two subunits – large and small
- Prokaryotes – 70S (30S + 50S)
- Eukaryotes – 80S (40S + 60S)

tRNA
- Adapter molecules
- Clover leaf shaped
- Site for mRNA at one arm, site for amino acid on the other

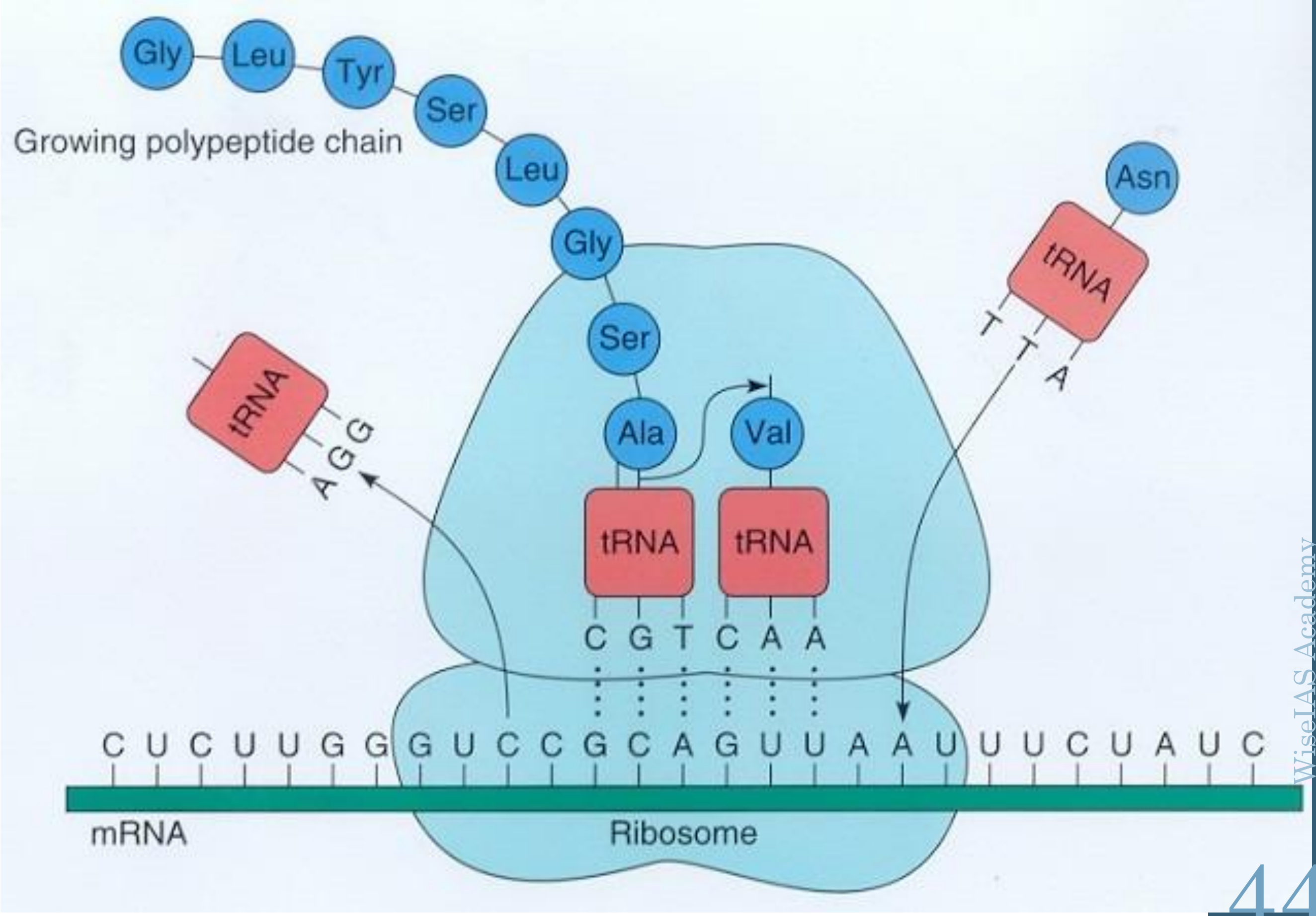
Amino Acids



Translation - Steps

1. **Initiation**

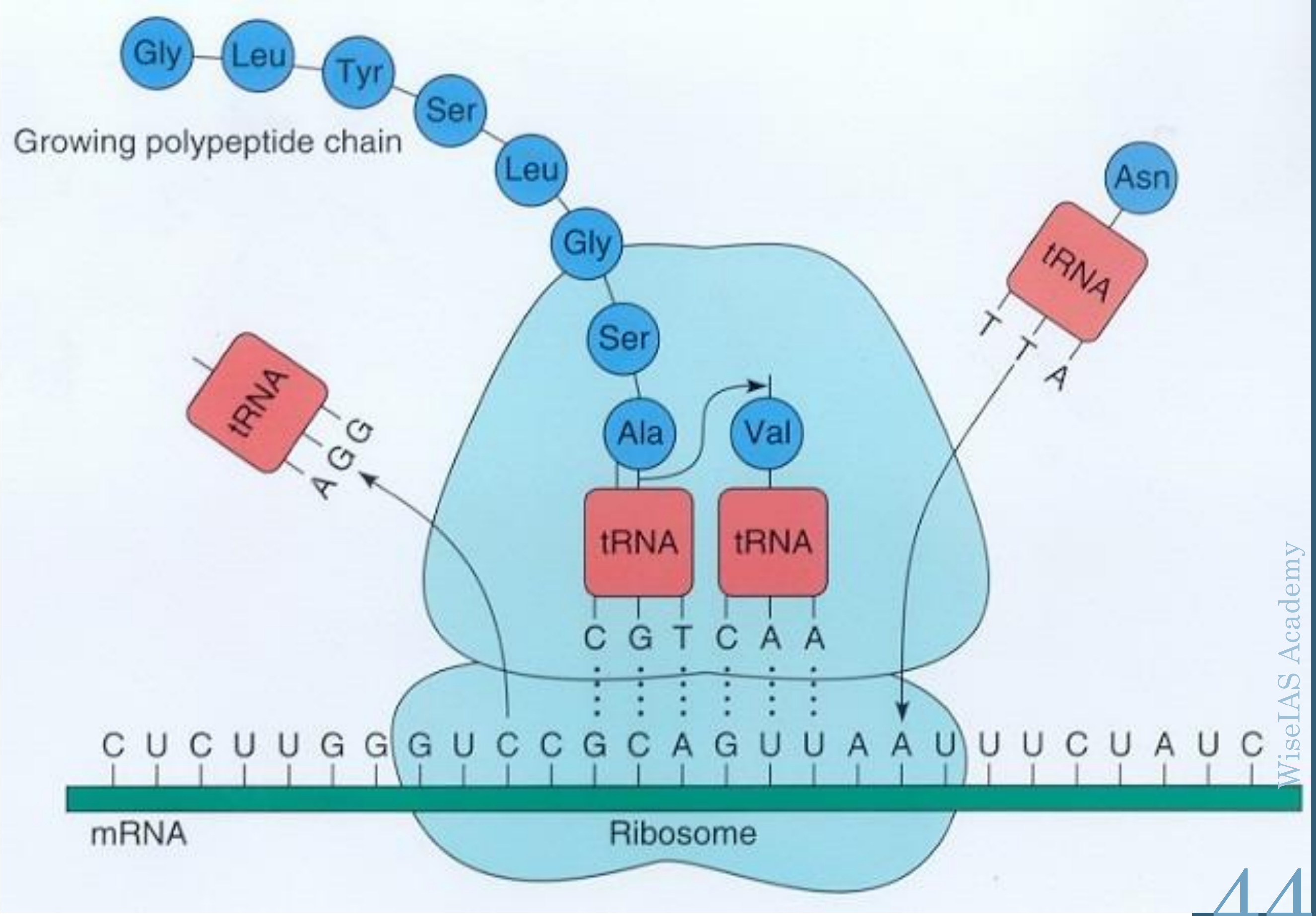
- Assembly of all required molecules
- Prokartoyes – initiation sequence
    - Shine Dalgarno sequence
- Eukaryotes –
    - Multiple initiation factors
    - 5' cap
- Begins with the codon – AUG (Met)



Translation - Steps

2. **Elongation**

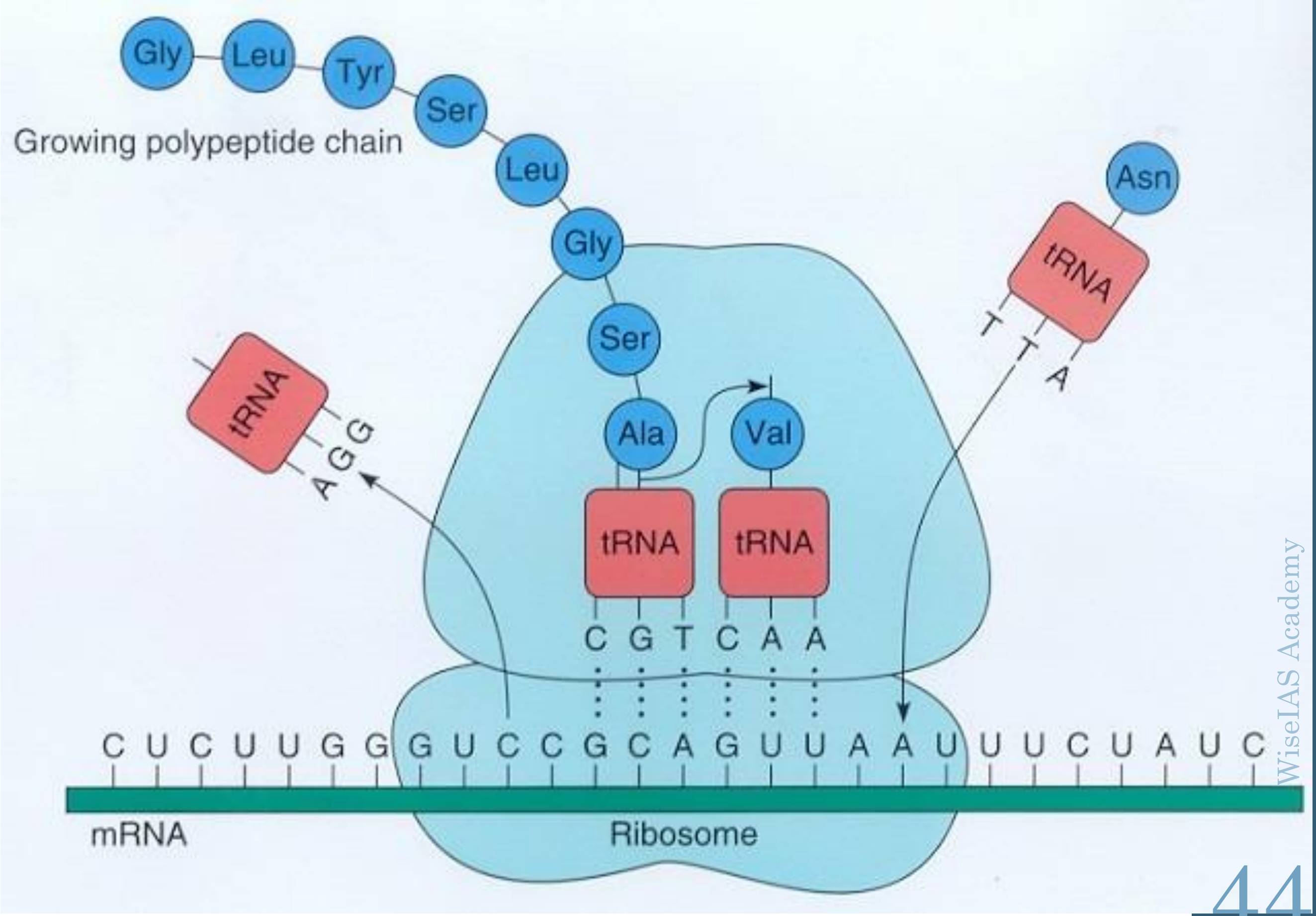
- Ribosome moves along mRNA
- Reads codons, adds amino acids
- Elongation factors –
  - EF-Tu (Prokaryotes)
  - eEF1 (Eukaryotes)
- Translocation –
  - Movement of ribosome to next codon
  - Aided by EF-G (prokaryotes) & eEF-2 (Eukaryotes)



Translation - Steps

3. **Termination**

- mRNA reaches stop codons
  - UAA – ochre
  - UAG – amber
  - UGA – opal
- Triggers peptide release
- Ribosome dissociates from mRNA



Translation – Prokaryotes vs Eukaryotes

Prokaryotes

- Transcription & Translation are coupled

Eukaryotes

- Transcription in nucleus & Translation in cytoplasm

MCQs – Gene Expression

- Which enzyme catalyzes the synthesis of RNA from a DNA template during transcription?
  a) DNA polymerase
  b) Helicase
  c) **RNA polymerase**
  d) Ligase

- In eukaryotes, which type of RNA polymerase transcribes mRNA?
  a) RNA polymerase I
  b) **RNA polymerase II**
  c) RNA polymerase III
  d) All of the above

- Which enzyme unwinds the double helix during DNA replication?
  a) DNA polymerase
  b) **Helicase**
  c) Primase
  d) Topoisomerase

- In prokaryotes, translation occurs in the:
  a) Nucleus
  b) Endoplasmic reticulum
  c) **Cytoplasm**
  d) Mitochondria

MCQs – Gene Expression

- Which enzyme catalyzes the formation of peptide bonds during translation?
  a) Aminoacyl-tRNA synthetase
  b) **Peptidyl transferase**
  c) Elongation factor
  d) Release factor

- Which of the following is a stop codon?
  a) AUG
  b) GGG
  c) **UAG**
  d) CCC

- Which enzyme unwinds the double helix during DNA replication?
  a) DNA polymerase
  b) **Helicase**
  c) Primase
  d) Topoisomerase

- In prokaryotes, translation occurs in the:
  a) Nucleus
  b) Endoplasmic reticulum
  c) **Cytoplasm**
  d) Mitochondria

MCQs – Gene Expression

- Which enzyme joins Okazaki fragments together during DNA replication?
  a) DNA polymerase I
  b) DNA polymerase III
  c) **DNA ligase**
  d) Primase

- Which of the following is NOT a global regulator of translation?
  a) Initiation factors
  b) Ribosome availability
  c) **Elongation factors**
  d) Phosphorylation of initiation factors

Thank-you