📄 Cheat Sheet 1 – Introduction to Genetics & Mendelian Principles 🌱

🔷 Genetics Definition

- Genetics = science of **heredity and variation**.
- **Heredity** = transmission of traits from parents to offspring.
- **Variation** = differences among individuals of the same species.

🔷 Father of Genetics

- **Gregor Johann Mendel (1822–1884)**.
- Conducted experiments on **garden pea (*Pisum sativum*)** between 1856–1863.
- Published in 1866 → work ignored until rediscovery (1900) by Hugo de Vries, Correns & Tschermak.

🔷 Importance of Mendel's Work

- Used **quantitative approach** with statistical analysis.
- Selected pea plant → easily available, short life cycle, distinct contrasting traits, self- and cross-pollination possible.
- Established **laws of inheritance** still valid today.

🔷 Mendelian Principles

1. **Unit factors (genes)** control characters.
2. Genes occur in pairs (alleles).
3. During gamete formation, alleles **segregate** so each gamete receives only one.
4. Genes for different traits **assort independently**.

🔷 Key Terms

- **Gene**: hereditary unit controlling a character.
- **Allele**: alternative forms of a gene.
- **Locus**: specific location of a gene on chromosome.
- **Homozygous**: both alleles identical (AA, aa).
- **Heterozygous**: alleles different (Aa).
- **Genotype**: genetic constitution (e.g., Aa).
- **Phenotype**: observable trait (e.g., tall, dwarf).

🔷 **Mnemonics** 💡

- **Mendel's Principles → "USA"**
  - **U**nit factors (genes)
  - **S**egregation
  - **A**ssortment (independent)

🔷 **Exam Capsule** 🎯

- Genetics = heredity + variation.
- Mendel = Father of Genetics, pea plant experiments (1856–63).
- Rediscovery in 1900 by **Correns, de Vries, Tschermak**.
- Principles: unit factors, segregation, independent assortment.

📄 **Cheat Sheet 2 – Basic Genetic Terminology** 📖

🔷 **Gene**

- A **hereditary unit** located on chromosome.
- Codes for a specific trait or protein.

🔷 **Allele**

- Alternative forms of a gene at the same locus.
- Example: **T** (tall) vs **t** (dwarf).

🔷 **Homozygous vs Heterozygous**

- **Homozygous** → both alleles same (TT, tt).
- **Heterozygous** → alleles different (Tt).

🔷 **Genotype vs Phenotype**

- **Genotype** = genetic makeup (e.g., Tt).
- **Phenotype** = physical expression (e.g., Tall).
- Genotype + Environment = Phenotype.

🔷 **Wild type vs Mutant**

- **Wild type allele** → normal/common in population.
- **Mutant allele** → altered form due to mutation (often rare).

🔷 **Dominant vs Recessive**

- **Dominant** allele → expresses trait even in heterozygous condition (T).
- **Recessive** allele → expressed only in homozygous condition (tt).

🔷 Locus

- Fixed position of a gene on a chromosome.

🔷 Mnemonics 💡

- **Genotype = Gene type | Phenotype = Physical type**.
- **Allele = "Alternative version of a gene"**.

🔷 Exam Capsule 🎯

- Gene = hereditary unit; Allele = alternate gene form.
- Homozygous (TT/tt), Heterozygous (Tt).
- Genotype = genetic constitution; Phenotype = visible trait.
- Wild type = normal allele; Mutant = altered allele.

📄 Cheat Sheet 3 – Mendel's Experiments & Methodology 🌱📊

🔷 Choice of Experimental Plant: *Pisum sativum* (Garden Pea)

- Short life cycle, easy to cultivate.
- Naturally **self-pollinating** but can be cross-pollinated manually.
- Produced large number of seeds.
- Had **7 pairs of contrasting traits** (e.g., tall vs dwarf, round vs wrinkled).

🔷 Mendel's Experimental Method

1. **Selection of true-breeding parents** (homozygous).
2. **Cross-pollination** to produce hybrids.
3. Careful **recording of data** for multiple generations (P, F_1 , F_2).
4. Use of **large sample size** for statistical accuracy.
5. Application of **mathematical ratios** (3:1, 9:3:3:1).

🔷 Traits Studied by Mendel (7 Pairs)

1. Stem height: Tall vs Dwarf.

2. Flower color: Violet vs White.
3. Flower position: Axial vs Terminal.
4. Pod color: Green vs Yellow.
5. Pod shape: Inflated vs Constricted.
6. Seed shape: Round vs Wrinkled.
7. Seed color: Yellow vs Green.

🔶 Rediscovery of Mendel's Work

- Published in **1866** (ignored for ~34 years).
- Rediscovered in **1900** independently by **Hugo de Vries, Carl Correns, Erich von Tschermak**.

🔶 Significance

- Introduced concept of **factors (genes)**.
- First to use **statistical analysis** in biology.
- Foundation of modern genetics.

🔶 Mnemonics 💡

- **7 Traits → "Some Flowers Produce Pretty Seeds"**
  - **S**tem height
  - **F**lower color/position
  - **P**od color/shape
  - **S**eed color/shape

🔶 Exam Capsule 🎯

- Mendel chose pea plant (*Pisum sativum*) for 7 contrasting traits.
- Used large data, true-breeding lines, statistical ratios.
- Published in 1866, rediscovered in 1900 by **de Vries, Correns, Tschermak**.
- Laid foundation of **laws of inheritance**.

📄 Cheat Sheet 4 – Mendel's Laws of Inheritance 🌿⚖️

🔶 1. Law of Dominance

- When two different alleles are present, **one dominates** (expressed), the other is recessive (masked).
- Example: In monohybrid cross of tall (TT) × dwarf (tt):
  - F_1 = all Tall (Tt).
- Ratio: **3:1** (phenotype) in F_2 .

◈ 2. Law of Segregation (Purity of Gametes)

- Allele pairs separate (segregate) during gamete formation.
- Each gamete carries **only one allele** for each trait.
- Example: Monohybrid cross (Tt × Tt) → F_2 = 1 TT : 2 Tt : 1 tt.
- Genotypic ratio = **1:2:1**.

◈ 3. Law of Independent Assortment

- Genes for different traits assort **independently** during gamete formation.
- Example: Dihybrid cross (RrYy × RrYy):
  - Phenotypic ratio in F_2 = **9:3:3:1** (round yellow : round green : wrinkled yellow : wrinkled green).

◈ Experimental Basis

- Mendel deduced laws by analyzing **large populations** of pea hybrids.
- Used **Punnett square logic** (though not formalized until later).

◈ Mnemonics 💡

- **Laws = "DSA"**
  - **D**ominance
  - **S**egregation
  - **A**ssortment (independent)

◈ Exam Capsule 🎯

- **Dominance** → one allele masks another (3:1).
- **Segregation** → alleles separate during gamete formation (1:2:1).
- **Independent Assortment** → different traits assort independently (9:3:3:1).

- Basis of **classical Mendelian genetics**.

📄 **Cheat Sheet 5 – Monohybrid Cross (Law of Segregation)** 🌱➗

◈ **Definition**

- A genetic cross involving **a single pair of contrasting traits**.
- Demonstrates **Law of Segregation (Purity of Gametes)**.

◈ **Example: Stem Height in Pea**

- **Parent (P):** Tall (TT) × Dwarf (tt).
- **F_1 Generation:** All Tall (Tt) → dominance shown.
- **F_2 Generation (Tt × Tt):**

Gametes	**T**	**t**
T	TT	Tt
t	Tt	tt

- Genotypes: **1 TT : 2 Tt : 1 tt**
- Phenotypes: **3 Tall : 1 Dwarf**

◈ **Ratios**

- **Phenotypic ratio:** 3 : 1
- **Genotypic ratio:** 1 : 2 : 1

◈ **Law of Segregation (Purity of Gametes)**

- Two alleles of a gene segregate during gamete formation.
- Each gamete carries **only one allele**.
- Fusion during fertilization restores the diploid condition.

◈ **Significance**

- Explains dominance & recessiveness.
- Demonstrates predictable ratios in inheritance.
- Basis for genetic probability (Punnett square).

💠 Mnemonics 💡

- **Monohybrid = “Mono Trait, Mendel’s 3:1”**

💠 Exam Capsule 🎯

- Monohybrid cross = one trait studied.
- F_1 = uniform (all heterozygous, dominant phenotype).
- F_2 = **3:1 phenotypic, 1:2:1 genotypic** ratio.
- Validates **Law of Segregation**.

📄 Cheat Sheet 6 – Dihybrid Cross (Law of Independent Assortment) 🌿➗

💠 Definition

- A genetic cross involving **two pairs of contrasting traits**.
- Demonstrates **Law of Independent Assortment**.

💠 Example: Seed Shape & Color in Pea

- **Parent (P):** Round Yellow (RRYY) × Wrinkled Green (rryy).
- **F_1 Generation:** All Round Yellow (RrYy).
- **F_2 Generation (RrYy × RrYy):**

Gametes: RY, Ry, rY, ry.

Punnett Square → produces 16 combinations.

💠 F_2 Results (Phenotypic Ratio)

- **9 Round Yellow**
- **3 Round Green**
- **3 Wrinkled Yellow**
- **1 Wrinkled Green**

Ratio = **9 : 3 : 3 : 1**

💠 Explanation of Law

- Alleles of different traits **segregate independently** during gamete formation.
- Thus, inheritance of one trait (seed shape) does not affect another (seed color).

🔹 Significance

- Explains **recombination & variation**.
- Basis of modern **independent assortment** concept.
- Genetic linkage = exception (genes on same chromosome).

🔹 Mnemonics 💡

- **Dihybrid Ratio → "9 + 3 + 3 + 1 = Sweet Sixteen"** (16 combinations in Punnett square).

🔹 Exam Capsule 🎯

- Dihybrid cross = two traits studied simultaneously.
- F_2 ratio = **9:3:3:1**.
- Demonstrates **independent assortment** of alleles.
- Explains recombination & genetic diversity.

📄 Cheat Sheet 7 – Incomplete Dominance 🎨🌱

🔹 Definition

- **Incomplete dominance** = a condition where **neither allele is completely dominant**, and the heterozygote shows an **intermediate phenotype**.

🔹 Key Example: Snapdragon (*Antirrhinum majus*) / Mirabilis jalapa (Four O' Clock Plant)

- **Parent (P):** Red (RR) × White (rr).
- **F_1 Generation:** All Pink (Rr) → intermediate trait.
- **F_2 Generation (Rr × Rr):**
  - 1 Red (RR) : 2 Pink (Rr) : 1 White (rr).

🔹 Ratios

- **Phenotypic ratio:** 1 : 2 : 1
- **Genotypic ratio:** 1 : 2 : 1

- Here, phenotype and genotype ratios are the same (unlike Mendel's 3:1).

💠 Other Examples

- Andalusian fowl → blue feather color (intermediate of black × white).
- Humans → wavy hair (intermediate of curly × straight).

💠 Significance

- Shows **blending of traits** in heterozygotes.
- Demonstrates that dominance is **not universal**.
- Important in plant/animal breeding for new phenotypes.

💠 Mnemonics 💡

- **Incomplete dominance = "Pink Rule"** 🌸 (red + white → pink).

💠 Exam Capsule 🎯

- Incomplete dominance = heterozygote shows **intermediate phenotype**.
- Example: Red × White Snapdragon → Pink F_1 .
- F_2 ratio = **1:2:1** (both phenotype & genotype).
- Significance → introduces variation, breaks strict dominance.

📄 Cheat Sheet 8 – Codominance 🧬

💠 Definition

- **Codominance** = both alleles in a heterozygote are **fully expressed**, and the phenotype shows **both traits simultaneously** (not blended).

💠 Key Example: Human ABO Blood Group

- Gene **I** has three alleles: IA, IB, i.
- **IA and IB are codominant**; both are expressed in heterozygous IAIB.
- Phenotype → **AB blood group** (both A & B antigens on RBC surface).
- Genotypes:
  - IAIA / IAi → Blood group A
  - IBIB / IBi → Blood group B

- IAIB → Blood group AB (codominant expression)
- ii → Blood group O

🔷 Other Examples

- **Erminette fowl** → black (BB) × white (WW) → BW (checkered/erminette feathers, both black & white visible).
- **Roan cattle** → red × white coat → roan (both red & white hairs present).

🔷 Differences: Incomplete Dominance vs Codominance

Feature	**Incomplete Dominance**	**Codominance**
Expression	Blended, intermediate	Both traits expressed equally
Example	Snapdragon (red × white → pink)	ABO blood group, roan cattle
Ratio (F_2)	1:2:1 (same geno/phenotype)	1:2:1 (but phenotype shows both traits, not blended)

🔷 Significance

- Demonstrates that dominance is **not always absolute**.
- Expands understanding of inheritance beyond Mendelian laws.

🔷 Mnemonics 💡

- **Codominance = "Co-Exist"** → both alleles visible together.

🔷 Exam Capsule 🎯

- Codominance = both alleles expressed in heterozygotes.
- Classic example: **AB blood group (IAIB)**.
- Also seen in **roan cattle, erminette fowl**.
- Different from incomplete dominance (which shows blending).

📄 Cheat Sheet 9 – Multiple Alleles 🎨

🔷 Definition

- When a gene has **more than two allelic forms** in a population.

- A single individual still carries only **two alleles** (diploid), but species collectively has **many options**.

🔷 Classic Example: ABO Blood Group in Humans

- Controlled by **I gene** with **three alleles**: IA, IB, i.
- IA → A antigen, IB → B antigen, i → no antigen.
- IA and IB are codominant; i is recessive.
- Genotypes & Phenotypes:
    - IAIA / IAi → Group A
    - IBIB / IBi → Group B
    - IAIB → Group AB (codominance)
    - ii → Group O

🔷 Example 2: Coat Color in Rabbits

- Controlled by a gene with **four alleles**: C > cch > ch > c.
    - C = full color.
    - cch = chinchilla.
    - ch = Himalayan.
    - c = albino.
- Shows **hierarchy of dominance** (C > cch > ch > c).

🔷 Example 3: Eye Color in Drosophila

- Multiple alleles produce variations beyond red & white (e.g., eosin, apricot, etc.).

🔷 Significance

- Explains wide variation in traits within populations.
- Important in **blood transfusion, animal breeding, evolution**.

🔷 Mnemonics 💡

- **Multiple Alleles = "More than Mendel's Two"**.

🔷 Exam Capsule 🎯

- Multiple alleles = more than two forms of a gene in population.
- Individual carries **only two** at a time.
- Examples: ABO blood group (IA, IB, i), rabbit coat color (C, cch, ch, c), Drosophila eye color.

📄 **Cheat Sheet 10 – Polygenic Inheritance 🌈👩👩👦**

🔷 Definition

- A trait controlled by **two or more genes (polygenes)**, each contributing **additively** to the phenotype.
- Produces **continuous variation** (spectrum, not discrete categories).
- Unlike Mendelian traits (tall/dwarf), polygenic traits show gradations.

🔷 Examples

1. **Human Skin Color**
   - Controlled by at least **3 gene pairs**.
   - Each dominant allele contributes pigment → more dominants = darker skin.
   - Phenotypes form a gradient from very light → very dark.
2. **Human Height**
   - Controlled by many genes.
   - Population shows a **bell-shaped distribution**.
3. **Eye Color in Humans**
   - Controlled by multiple loci.
   - Produces a range (blue, green, hazel, brown, black).
4. **Kernel Color in Wheat**
   - Red × White → intermediate shades depending on number of dominant alleles.

🔷 Features

- **Additive effect** of alleles.
- **No dominance/recessive** (each allele contributes partially).
- **Continuous variation** (quantitative traits).
- Environmental factors often influence phenotype.

🔷 Difference: Monogenic vs Polygenic

Feature	**Monogenic**	**Polygenic**
Genes	One	Multiple
Variation	Discontinuous (e.g., tall/dwarf)	Continuous (e.g., height)
Ratios	Simple Mendelian (3:1, 9:3:3:1)	Quantitative distribution
Example	Pea seed shape	Human height

🔷 Mnemonics 💡

- **Polygenic = "Many Genes, Many Shades"**.

🔷 Exam Capsule 🎯

- Polygenic inheritance = traits controlled by **multiple genes** with **additive effects**.
- Results in **continuous variation** (skin color, height, eye color).
- Different from Mendelian (monogenic) traits which show discrete classes.

📄 Cheat Sheet 11 – Significance of Non-Mendelian Inheritance 🌱

🔷 Definition

- **Non-Mendelian inheritance** = patterns of inheritance that do not follow Mendel's simple dominant–recessive ratios.
- Includes: incomplete dominance, codominance, multiple alleles, polygenic traits, cytoplasmic inheritance, epistasis, pleiotropy.

🔷 Types & Importance

1. **Incomplete Dominance**

- Produces intermediate phenotypes (e.g., pink flowers in *Mirabilis*).
- Significance → new variations beyond Mendel's strict ratios.

2. **Codominance**

- Both alleles expressed equally (e.g., AB blood group).

- Important in **medicine** (blood transfusions).

3. **Multiple Alleles**

- Expands diversity (e.g., rabbit coat color, ABO system).
- Key in **genetic counseling & transfusion biology**.

4. **Polygenic Inheritance**

- Explains continuous variation (skin color, height).
- Useful in **plant/animal breeding, evolution studies**.

5. **Cytoplasmic (Extranuclear) Inheritance**

- Traits inherited via **mitochondria/chloroplasts** (e.g., variegated leaves, maternal inheritance).
- Significant in **cytoplasmic male sterility (CMS)** used in hybrid crops.

6. **Pleiotropy & Epistasis**

- One gene → multiple traits (pleiotropy, e.g., sickle cell).
- One gene masks another (epistasis, e.g., coat color in mice).
- Important in **disease genetics** & **biotechnology**.

🔷 Evolutionary & Applied Significance

- Increases **genetic variation** → raw material for natural selection.
- Explains complex human traits & diseases (diabetes, hypertension).
- Basis of **quantitative genetics** → agriculture, breeding programs.
- Medical genetics → understanding inheritance of multifactorial disorders.

🔷 Mnemonics 💡

- **Non-Mendelian = "I Can Make People Curious"**
  - **I**ncomplete dominance
  - **C**odominance
  - **M**ultiple alleles
  - **P**olygenic traits
  - **C**ytoplasmic inheritance

🔷 Exam Capsule 🎯

- Non-Mendelian inheritance = patterns beyond Mendel's laws.

- Includes incomplete dominance, codominance, multiple alleles, polygenes, extranuclear inheritance.
- Explains **continuous variation, complex traits & diseases**.
- Crucial in **medicine, agriculture, evolution & biotechnology**.