GMB QUIZ-2 RUBRICS (Total 50 Marks)
(ATTEMPT ANY 5)

Q1: In pigeons, a dominant allele C causes a checkered pattern in the feathers; its recessive allele c produces a plain pattern. Feather coloration is controlled by an independently assorting gene; the dominant allele B produces red feathers, and the recessive allele b produces brown feathers. Birds from a true-breeding checkered (CC BB), red variety are crossed with birds from a true-breeding plain, brown variety (cc bb).

(a) Predict the phenotype of their progeny.
(b) If these progeny are intercrossed, what phenotypes will appear in the F2, and in what proportions?

Answer :

In pigeons, we have two genes:

1. **Pattern gene (C/c)**:
   - C (dominant): checkered pattern
   - c (recessive): plain pattern
2. **Color gene (B/b)**:
   - B (dominant): red feathers
   - b (recessive): brown feathers

The cross involves:

- True-breeding checkered, red birds (CCBB)
- True-breeding plain, brown birds (ccbb)

(a) Phenotype of the F1 Progeny

- The **F1 generation** results from a cross between CCBB and ccbb.

The resulting genotypes of the F1 progeny will be: CcBb

- **Pattern**: Cc (heterozygous for checkered pattern, so checkered will be dominant)
- **Color**: Bb (heterozygous for red feathers, so red will be dominant)

Predicted F1 phenotype:

- **Checkered, red** (since both checkered pattern and red feathers are dominant traits).

(b) Phenotypes and Proportions in the F2 Generation

The F1 progeny are CcBb and when they are intercrossed (CcBb×CcBb), we need to perform a **dihybrid cross** to determine the F2 phenotypic ratios.

♂\♀	CB	Cb	cB	cb
CB	CCBB	CCbB	cCBB	cCbB
Cb	CCbB	CCbb	cCbB	cCbb
cB	cCBB	cCbB	ccBB	ccbB
cb	cCbB	cCbb	ccbB	ccbb

Dihybrid Cross

We now combine the probabilities of each genotype from the pattern and color genes using a **4x4 Punnett square**. The resulting phenotypes are:

- **Checkered, red** (C_ B_): 9/16
- **Checkered, brown** (C_ bb): 3/16
- **Plain, red** (cc B_): 3/16
- **Plain, brown** (cc bb): 1/16

Predicted F2 Phenotypic Ratio:

- **9/16 checkered, red**
- **3/16 checkered, brown**
- **3/16 plain, red**
- **1/16 plain, brown**

This is the typical **9:3:3:1 ratio** expected from a dihybrid cross with independently assorting genes.

Q2**:** In humans, the ABO blood group system is controlled by a single gene with three alleles: I^A, I^B, and i. A woman with blood type AB marries a man with blood type B whose mother had blood type O.

(a) What are the possible blood types and their ratios of the children?
(b) Explain the type of dominance displayed in each possible offspring's blood type.

(a) **Possible Blood Types and Ratios of the Children**

- The woman has blood type **AB** (genotype: I^AI^B).
- The man has blood type **B**, but his mother had blood type **O**, meaning he must be heterozygous for allele I^B (I^Bi).

The possible combinations for their children's genotypes are:

- I^AI^B (AB)
- I^Ai (A)
- I^BI^B(B)
- I^B i (B)

Thus, the possible blood types and their ratios are:

- **Blood type AB**: 1/4
- **Blood type A**: 1/4
- **Blood type B**: 1/2

The ratio of blood types is **1 AB : 1 A : 2 B**.

(b) **Type of Dominance Displayed**

- **AB blood type**: This displays **codominance**, where both allelesI^A and I^B are expressed equally.
- **A and B blood types**: These display **complete dominance**, as the dominant alleles I^A and I^B are dominant over allele i.

Q3**:** In mice, coat color is determined by two independently assorting genes. The first gene, located on chromosome 5, controls pigment production, with the dominant allele A resulting in the production of black pigment and the recessive allele a resulting in no pigment (albino). The second gene, located on chromosome 8, controls pigment deposition, with the dominant allele B allowing the pigment (if produced) to be deposited in the fur, resulting in black fur, and the recessive allele b resulting in a failure to deposit pigment, leading to brown fur. A homozygous black mouse (AABB) is crossed with an albino mouse (aabb), and their offspring are intercrossed to produce an F2 generation.

(a) Identify the type of epistasis and explain how epistasis is involved in determining the coat color of the F2 generation.
(b) Calculate the expected phenotypic ratios for coat color in the F2 generation (black, brown, and albino).

(a) **Type of Epistasis**

In this case, the gene controlling pigment production (A/a) is epistatic to the gene controlling pigment deposition (B/b). This is an example of **recessive epistasis** because when the genotype is homozygous recessive at the first gene (aa), it prevents the deposition of pigment, regardless of the B/b gene's alleles.

(b) **Phenotypic Ratios in the F2 Generation**

To determine the phenotypic ratios, we perform a dihybrid cross between the F1 offspring, which are heterozygous for both genes (AaBb x AaBb). The F2 generation can be calculated using a Punnett square for two genes:

♂\♀	AB	Ab	aB	ab
AB	AABB	AAbB	aABB	aAbB
Ab	AAbB	AAbb	aAbB	aAbb
aB	aABB	aAbB	aaBB	aabB
ab	aAbB	aAbb	aabB	aabb

- **Black** (A_B_): 9/16

  Mice with at least one dominant **A** allele (i.e., **A A** or **A a**) can produce pigment. Mice with at least one dominant **B** allele (i.e., **B B** or **B b**) can deposit the pigment in the fur, making them black. Hence, 9 out of 16 mice have **black fur**.

- **Brown** (A_bb): 3/16

  Mice with at least one dominant **A** allele can produce pigment (black pigment). However, if they are **bb** (homozygous recessive for the **B** gene), the pigment is not deposited properly, leading to **brown fur**.

- **Albino** (aaB_ or aabb): 4/16

  If a mouse is **aa** (homozygous recessive for the **A** gene), it **cannot produce any pigment**, regardless of the alleles at the **B/b** gene.

Thus, the expected phenotypic ratio is **9 black : 3 brown: 4 albino**.

Q4: In a rare genetic disorder affecting muscle development, a single dominant allele M causes muscle weakness. However, not all individuals with the M allele show symptoms, and the severity of the weakness varies among those who do. What genetic phenomenon can explain this variation, and how might they affect the expression of the disorder?

Answer: The variation in muscle weakness despite the presence of the dominant allele **M** can be explained by:

- **Incomplete Penetrance**: Penetrance refers to the proportion of individuals with a specific genotype who actually display the associated phenotype (observable traits). In incomplete penetrance, not all individuals with a genotype that predisposes them to a particular trait or condition actually express it. Not all individuals with the M allele express muscle weakness.
- **Variable Expressivity**: Expressivity refers to the degree or extent to which a genetic trait is expressed in an individual. In variable expressivity, individuals with the same genetic mutation can show a wide range of symptoms, from mild to severe. Like incomplete penetrance, variable expressivity can be influenced by environmental factors, the presence of other genetic variants, lifestyle, or stochastic events during development. It describes the range of possible phenotypic outcomes for a particular genotype.

These phenomena indicate that the presence of the M allele does not guarantee the disorder's expression, and even when it is expressed, the symptoms can range in intensity due to other genetic or environmental factors.

Q5: In the study of bacterial genetics, understanding how bacteria exchange genetic material is crucial for grasping their adaptability and evolution. Write about the types of gene transfer in bacteria and differentiate between them with the help of a diagram.

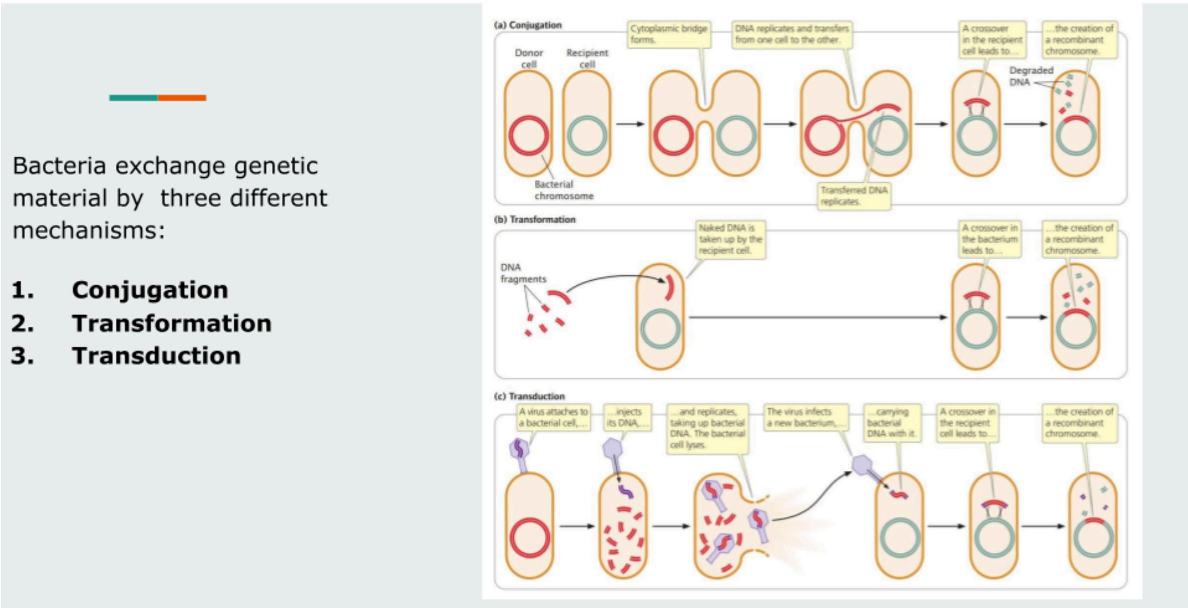
Answer: There are three main types of gene transfer in bacteria:

1. **Transformation**: Transformation is a form of genetic recombination in which a DNA fragment from a dead, degraded bacterium enters a competent recipient bacterium and is exchanged for a piece of DNA of the recipient. Transformation usually involves only homologous recombination, a recombination of homologous DNA regions having nearly the same

nucleotide sequences. Typically this involves similar bacterial strains or strains of the same bacterial species.
2. **Conjugation**: The transfer of genetic material through direct contact between bacterial cells, usually via a pilus.
3. **Transduction**: The transfer of bacterial genes by a virus (bacteriophage). During transduction bacteriophage, called a transducing particle, infects another bacterium, it injects the fragment of donor bacterial DNA it is carrying into the recipient where it can subsequently be exchanged for a piece of the recipient's DNA by homologous recombination.

Diagram: A well-labeled diagram should illustrate these three processes, highlighting how genetic material is transferred in each case.

Bacterial Gene Transfer



Q6: In a population of mice, fur color is controlled by a gene with two alleles: B (black) and b (brown), where B is dominant and b is recessive. Another gene controls tail length, with two alleles: L (long tail) and l (short tail), where L is dominant and l is recessive. 50% of the mice are heterozygous for fur color (Bb), 30% are homozygous dominant (BB), and 20% are homozygous recessive (bb). 60% of the mice are heterozygous for tail length (Ll), 25% are homozygous dominant (LL), and 15% are homozygous recessive (ll).

What is the probability that a randomly selected mouse:
(a) Has black fur and a long tail?
(b) Is either homozygous dominant or heterozygous for both fur color and tail length?
(c) Suppose that a disease breaks out in the population, and it is discovered that only mice with brown fur and short tails (genotype bb and ll) are immune to the disease. What is the probability that a randomly selected mouse is immune to the disease?

Answer: Given the genetic distribution:

- For fur color: 50% Bb, 30% BB, 20% bb
- For tail length: 60% Ll, 25% LL, 15% ll

(a) **Probability of Black Fur and Long Tail**

To have black fur, the mouse must have at least one B allele (BB or Bb). The probability for this case is:

P(BB or Bb)=30%+50%=80%

For a long tail, the mouse must have at least one L allele (LL or Ll). The probability for this case is:

P(LL or Ll)=25%+60%=85%

Thus, the probability of having both black fur and a long tail is:

P(black fur and long tail)=0.80×0.85= 0.68 = 68%

(b) **Probability of Homozygous Dominant or Heterozygous for Both Traits**

For fur color, the probability of being homozygous dominant (BB) or heterozygous (Bb) is:

P(BB or Bb) = 80%

For tail length, the probability of being homozygous dominant (LL) or heterozygous (Ll) is:

P(LL or Ll) = 85%

Thus, the probability of being homozygous dominant or heterozygous for both traits is:

P(BB or Bb and LL or Ll)= 0.80×0.85 = 0.68 = 68%

(c) **Probability of Immunity to Disease**

For a mouse to be immune, it must have the genotype **bb ll** (brown fur and short tail). The probability of being **bb** is 20%, and the probability of being **ll** is 15%.

Thus, the probability of a randomly selected mouse being immune is: P(bb and ll) = 0.20 × 0.15= 0.03 = 3%