Contents

CONTENTS

CONTENTS

CONTENTS

12 Factorization

Factorization

To express a given polynomial as product of polynomials, each of degree less than that of the given polynomial such that no such a factor has a factor of lower degree, is called factorization. There are following methods for factorization.

(a) Factorization by taking out the common factor.
(b) Factorization by grouping.
(c) Factorization by making a perfect square.
(d) Factorization the difference of two squares.
(e) Factorization of quadratic polynomial by splitting the middle term.
(f) Factorization of an algebraic expression as the sum or differences of two cubes.
(g) Factorization of an algebraic expression of the form $a^3 + b^3 + c^3 - 3abc$.

Factorization using Identities

Binomial Theorem Identities

(i) $(x + y)^2 = x^2 + 2xy + y^2$
(ii) $(x - y)^2 = x^2 - 2xy + y^2$
(iii) $(x + y)^3 = x^3 + y^3 + 3xy\,(x + y) = x^3 + y^3 + 3x^2y + 3xy^2$
(iv) $(x - y)^3 = x^3 - y^3 - 3xy\,(x - y) = x^3 - y^3 - 3x^2y + 3xy^2$
(v) $(x + y)^4 = x^4 + 4x^3y + 6x^2y^2 + 4xy^3 + y^4$
(vi) $(x - y)^4 = x^4 - 4x^3y + 6x^2y^2 - 4xy^3 + y^4$

Factor Identities

(i) $x^2 - y^2 = (x + y)\,(x - y)$
(ii) $x^3 + y^3 = (x + y)\,(x^2 + y^2 - xy)$
(iii) $x^3 - y^3 = (x - y)\,(x^2 + y^2 + xy)$
(iv) $(x^4 - y^4) = (x^2 - y^2)\,(x^2 + y^2) = (x - y)(x + y)(x^2 + y^2)$
(v) $x^2 + (a + b)x + ab = (x + a)\,(x + b)$

Three Variables Identities :

(i) $(x + y + z)^2 = x^2 + y^2 + z^2 + 2(xy + yz + zx)$
(ii) $x^3 + y^3 + z^3 - 3xyz = (x + y + z)\,(x^2 + y^2 + z^2 - xy - yz - zx)$

$$= \frac{(x + y + z)}{2}\left[(x - y)^2 + (y - z)^2 + (z - x)^2\right]$$

Special Case : If x + y + z = 0 or x = y = z then $x^3 + y^3 + z^3 = 3xyz$

Factorization of Type (*x* + a) (x + b) [Spliting the middle term method] :

Let us study the following pattern:

$x^2 + ax + bx + ab$: **Four terms**

$= x(x+a) + b(x+a)$: **Two terms** [Here, we have taken *x* common from 1st and 2nd terms and *b* common from 3rd and 4th terms and hence two terms are formed which have $(x + a)$ common]

$= (x+a)(x+b)$: **One term** [Here, we have taken $(x + a)$ common]

Hence, $x^2 + ax + bx + ab = (x+a)(x+b)$.

IMPORTANT TIPS FOR COMPETITIVE EXAMS

- When an expression is the product of two or more expressions then each of these expressions is called a factor of the given expression.
- The process of writing a given expression as the product of two or more factors is called factorisation.
- The greatest common factor of two or more monomials is the product of the greatest common factors of the numerical coefficients and the common letters with smallest powers.
- When a common monomial factor occurs in each term of an algebraic then it can be expressed as a product of the greatest common letters with smallest powers.
- If the given expression is the difference of two squares, then to factorise it, we use the formula : $(a^2 - b^2) = (a + b)(a - b)$.
- If the given expression is a complete square, we use one of the following formulae to factorise it :
  (i) $a^2 + 2ab + b^2 = (a + b)^2 = (a + b)(a + b)$
  (ii) $a^2 - 2ab + b^2 = (a - b)^2 = (a - b)(a - b)$
- If the given expression is in the form $x^2 + x(a + b) + ab$, then we factorise, it in the form (x + a)(x + b).

SOLVED PROBLEMS

Example 1: Factorise $12x^3y^4 - 4x^5y^2$

Solution: $12x^3y^4 - 4x^5y^2 = 4x^3y^2(3y^2 - x^2)$

Example 2: Factorise: $8(p-8q)^2 - 6(p-8q)$

Solution: $8(p-8q)^2 - 6(p-8q) = 2(p-8q)[4(p-8q)-3]$

$= 2(p-8q)(4p-32q-3)$

Example 3: Factorise: $(a^2+9b^2-6ab)-4c^2$

Solution: We can write $a^2+9b^2-6ab=(a-3b)^2$

$\therefore$ The given expression $=(a-3b)^2-(2c)^2$

$=(a-3b+2c)(a-3b-2c)$

Example 4: Factorise: x^4-81

Solution: $x^4-81=(x^2)^2-(9)^2=(x^2+9)(x^2-9)$

$=(x-3)(x+3)(x^2+9)$

Example 5: Factorise: $9x^2+16+24x-a^2+2ab+b^2$

Solution: $9x^2+16+24x-a^2+2ab-b^2=9x^2+16+24x-(a^2-2ab+b^2)$

$=(3x+4)^2-(a-b)^2$

$=(3x+4-a+b)(3x+4-a+b)$

Example 6: Factorise: (a) $4x^2-11x+6$

Solution: $4x^2-11x+6=4x^2-8x-3x+6$

$=4x(x-2)-3(x-2)$

$=(x-2)(4x-3)$

Example 7: Factorise: $\frac{3}{2}x^2-x-\frac{4}{3}$

Solution: $\frac{3}{2}x^2-x-\frac{4}{3}=\frac{3}{2}x^2-2x+x-\frac{4}{3}$

$=\frac{3}{2}x\left(x-\frac{4}{3}\right)+1\left(x-\frac{4}{3}\right)$

$=\left(\frac{3}{2}x+1\right)\left(x-\frac{4}{3}\right)$

Example 8: Evaluate : (i) $(107)^2$, (ii) $(94)^2$, (iii) $(0.99)^2$

Solution : (i) $(107)^2=(100+7)^2$

$=(100)^2+(7)+2\times100\times7$

$=10000+49+1400$

$=11449$

(ii) $(94)^2=(100-6)^2$

$=(100)^2+(6)^2-2\times100\times6$

$=10000+36-1200$

$=8836$

(iii) $(0.99)^2=(1-0.01)^2$

$=(1)^2+(0.01)^2-2\times1\times0.01$

$=0.9801$

Example 9: If $x^2 + \frac{1}{x^2} = 23$, find the values of $\left(x + \frac{1}{x}\right), \left(x - \frac{1}{x}\right)$ and $\left(x^4 + \frac{1}{x^4}\right)$.

Solution: $x^2 + \frac{1}{x^2} = 23$ ...(i)

$\Rightarrow \quad x^2 + \frac{1}{x^2} + 2 = 25$ [Adding 2 on both sides of (i)]

$\Rightarrow \quad (x)^2 + \left(\frac{1}{x^2}\right) + 2.x.\frac{1}{x} = 25$

$\Rightarrow \quad \left(x + \frac{1}{x}\right)^2 = (5)^2$

$\Rightarrow \quad x + \frac{1}{x} = \pm 5$

$\left(x - \frac{1}{x}\right)^2 = x^2 + \frac{1}{x^2} - 2$

$\Rightarrow \quad \left(x - \frac{1}{x}\right)^2 = 23 - 2 = 21$

$\left(x - \frac{1}{x}\right) = \pm\sqrt{21}$

$\left(x^2 + \frac{1}{x^2}\right)^2 = \left(x^4 + \frac{1}{x^4}\right) + 2$

$\Rightarrow \quad \left(x^4 + \frac{1}{x^4}\right) = \left(x^2 + \frac{1}{x^2}\right)^2 - 2$

$\Rightarrow \quad \left(x^4 + \frac{1}{x^4}\right) = (23)^2 - 2 = 529 - 2$

$\Rightarrow \quad \left(x^4 + \frac{1}{x^4}\right) = 527$

Example 10: Prove that : $a^2 + b^2 + c^2 - ab - bc - ca = \frac{1}{2}\left[(a-b)^2 + (b-c) + (c-a)^2\right]$

Solution: Here, L.H.S. $a^2 + b^2 + c^2 - ab - bc - ca$

$= \frac{1}{2}\left[2a^2 + 2b^2 + 2c^2 - 2ab - 2bc - 2ca\right]$

$= \frac{1}{2}\left[(a^2 - 2ab + b^2) + (b^2 - 2bc + c^2) + (c^2 - 2ca + a^2)\right]$

$= \frac{1}{2}\left[(a-b)^2 + (b-c)^2 + (c-a)^2\right]$

R.H.S.

Example 11: If $a + b + c = 9$ and $ab + bc + ca = 23$, then find the value of $a^2 + b^2 + c^2$.

Solution: $(a + b + c)^2 = a^2 + b^2 + c^2 + 2(ab + bc + ca)$

$(9)^2 = a^2 + b^2 + c^2 + 2(23)$

$a^2 + b^2 + c^2 = 81 - 46$

$a^2 + b^2 + c^2 = 35$

Example 12: If $x - \frac{1}{x} = 5$, find the value of $x^3 - \frac{1}{x^3}$.

Solution: We have, $x - \frac{1}{x} = 5$ ....(i)

$\Rightarrow \left(x - \frac{1}{x}\right)^3 = (5)^3$ [Cutting both sides of (i)]

$\Rightarrow x^3 - \frac{1}{x^3} - 3x.\frac{1}{x}.\left(x - \frac{1}{x}\right) = 125$

$\Rightarrow x^3 - \frac{1}{x^3} - 3\left(x - \frac{1}{x}\right) = 125$

$\Rightarrow x^3 - \frac{1}{x^3} - 3 \times 5 = 125$ [Substituting $\left(x - \frac{1}{x}\right) = 5$]

$\Rightarrow x^3 - \frac{1}{x^3} - 15 = 125$

$\Rightarrow x^3 - \frac{1}{x^3} = (125 + 15) = 140$

Example 13: Find the product of following expression :

(i) $(3x - 4y + 5z)(9x^2 + 16y^2 + 25z^2 + 12xy - 15zx + 20yz)$

(ii) $(2a - 3b - 2c)(4a^2 + 9b^2 + 6ab - 6bc + 4ca)$

Solution (i) $(3x - 4y + 5z)(9x^2 + 16y^2 + 25z^2 + 12xy - 15zx + 20yz)$

Let, $a = 3x$, $b = -4y$, $c = 5z$

$= (a + b + c)(a^2 + b^2 + c^2 - ab - bc - ca)$

$= (a^3 + b^3 + c^3 - 3abc)$

$= (3x)^3 + (-4y)^3 + (5z)^3 - 3(3x)(-4y)(5z)$

$= 27x^3 - 64y^3 + 125z^3 + 180xyz$

(ii) $(2a - 3b - 2c)(4a^2 + 9b^2 + 6ab - 6bc + 4ca)$

Let $x = 2a$, $y = -3b$, $z = -2c$

$= (x + y + z)(x^2 + y^2 + z^2 - xy - yz - zx)$

$= (x^3 + y^3 + z^3 - 3xyz)$

$= (2a)^3 + (-3b)^3 + (-2c)^3 - 3(2a)(-3b)(-2c)$

$= 8a^3 - 27b^3 - 36abc$

REVISION EXERCISE

LEVEL - I

1. The factors of $a^2 + b - ab - a$ are

(A) $(a-1)(a-b)$ (B) $(a+b)(a-1)$ (C) $(a+1)(a-b)$ (D) none

2. One of the factors of $x^2 + \frac{1}{x^2} + 2 - 2x - \frac{2}{x}$ is

(A) $x - \frac{1}{x}$ (B) $x + \frac{1}{x} - 1$ (C) $x + \frac{1}{x}$ (D) $x^2 + \frac{1}{x^2}$

3. One of the factors of $x^7 + xy^6$ is

(A) $x^2 + y^2$ (B) x (C) (A) and (B) (D) neither (A) nor (B)

4. The factors of $x^2 + xy - 2xz - 2yz$ are

(A) $(x-y)(x+2z)$ (B) $(x+y)(x-2z)$ (C) $(x-y)(x-2z)$ (D) $(x+y)(x+2z)$

5. How many factors $x^9 - x$ will have (except 1 and itself)

(A) 5 factors (B) 4 factors

(C) 2 factors (D) cannot be determined

6. The factors of $\frac{x^2}{4} - \frac{y^2}{9}$ are

(A) $\left(\frac{x}{4} + \frac{y}{9}\right)\left(\frac{x}{4} - \frac{y}{9}\right)$ (B) $\left(\frac{x}{2} + \frac{y}{9}\right)\left(\frac{x}{2} - \frac{y}{9}\right)$ (C) $\left(\frac{x}{2} + \frac{y}{3}\right)\left(\frac{x}{2} - \frac{y}{3}\right)$ (D) none of these

7. The factors of $1 - p^3$ are

(A) $(1-p)(1+p+p^2)$ (B) $(1+p)(1-p-p^2)$ (C) $(1+p)(1+p^2)$ (D) $(1+p)(1-p^2)$

8. The factors of $x^4 + y^4 + x^2y^2$ are

(A) $(x^2+y^2)(x^2+y^2-xy)$ (B) $(x^2+y^2)(x^2-y^2)$

(C) $(x^2+y^2+xy)(x^2+y^2-xy)$ (D) factorization is not possible

9. Write one of the factor of $a^3 + 8b^3 - 64c^3 + 24abc$ is

(A) $a + 2b - 4c$ (B) $a - 2b + 4c$ (C) $a + 2b + 4c$ (D) $a - 2b - 4c$

10. Factorization of $xy - pq + qy - px$ is

(A) $(y-p)(x+q)$ (B) $(y-p)(x-q)$ (C) $(y+p)(x+q)$ (D) $(y\ p)(x-q)$

11. One factor of $-x^2 + x\sqrt{3} + 6$ is

(A) $2\sqrt{3} + x$ (B) $-2\sqrt{3} + \sqrt{3x}$ (C) $x - \sqrt{3}$ (D) $2\sqrt{3} - x$

12. Factorize: $a^4b - ab^4$
(A) $ab(a^3 + b^3)$ (B) $ab(a - b)(a^2 + ab + b^2)$
(C) $ab(a + b)(a^2 - ab + b^2)$ (D) $ab(a^2 - b^2)$

13. The factors of $x^4 + 4$ are
(A) $(x^2 + 2)^2$ (B) $(x^2 + 2)(x^2 - 2)^2$
(C) $(x^2 + 2x + 2)(x^2 - 2x + 2)$ (D) $(x + 1)(x - 1)$

14. One factor of $x^4 - (x - z)^4$ is
(A) $2x + z$ (B) $x + 2z$ (C) $2x - z$ (D) $x - 2z$

LEVEL - II

1. $\dfrac{0.86\times0.86\times0.86+0.14\times0.14\times0.14}{0.86\times0.86-0.86\times0.14+0.14\times0.14}$ is equal to :

2. $10\left(3x-\dfrac{4}{x}\right)^2-3\left(3x-\dfrac{4}{x}\right)-7$ is equal to :

3. Factorise $y^{16} - 63y^8 - 64$.

4. Factorise : $a^2+\dfrac{1}{a^2}+3-2a-\dfrac{2}{a}$:

5. If $\left(x^{3/2}-xy^{1/2}+x^{1/2}y-y^{3/2}\right)$ is divided by $\left(x^{1/2}-y^{1/2}\right)$, then find the quotient.

6. Factorise : $2\sqrt{2}x^3+3\sqrt{3}y^3+\sqrt{5}(5-3\sqrt{6}xy)$.

MULTIPLE CHOICE QUESTIONS

1. One of the factors of $a^3(b - c)^3 + b^3(c - a)^3 + c^3(a - b)^3$ is
(A) $a - b$ (B) $b - c$ (C) $c - a$ (D) all the above

2. The value of $\dfrac{0.76\times0.76\times0.76+0.24\times0.24\times0.24}{0.76\times0.76-0.76\times0.24+0.24\times0.24}$ is
(A) 0.52 (B) 1 (C) 0.01 (D) 0.1

3. If the factors of $a^2 + b^2 + 2(ab + bc + ca)$ are $(a + b + m)$ and $(a + b + nc)$, then the value of $m + n$ is
(A) 0 (B) 2 (C) 4 (D) 6

4. If $(x^2 + 3x + 5)(x^2 - 3x + 5) = m^2 - n^2$, then m =
(A) $x^2 - 3x$ (B) $3x$ (C) $x^2 + 5$ (D) none

5. One of the factor of $(a^2 - b^2)(c^2 - d^2) - 4abcd$ is
(A) $(ac - bd + bc + ad)$ (B) $ac - bd + bc - ad$
(C) cannot be determined (D) none of these

6. The factors of $\sqrt{3}x^2+11x+6\sqrt{3}$ are
(A) $(x-3\sqrt{3})(\sqrt{3}x+2)$ (B) $(x-3\sqrt{3})(\sqrt{3}x-2)$
(C) $(x+3\sqrt{3})(\sqrt{3}x-2)$ (D) $(x+3\sqrt{3})(\sqrt{3}x+2)$

7. The factors of $x^4 + 2x^2 + 9$ is

(A) $(x^2 - 2x + 3)(x^2 + 2x + 3)$ (B) $(x^2 + 3)(x^2 - 3)$

(C) factorization is not possible (D) none of these

8. The factors of $15x^2 - 26x + 8$ are

(A) $(2x - 4)(5x + 2)$ (B) $(3x - 4)(5x - 2)$ (C) $(3x + 4)(5x - 2)$ (D) $(3x + 4)(5x + 2)$

9. If $3x + 3y = 24$ and $3x - 3y = 12$ then the value of xy is

(A) 10 (B) 12 (C) 18 (D) 14

10. If $\left(x + \frac{1}{x}\right) = 3$, then $\left(x^2 + \frac{1}{x^2}\right)$ equals

(A) $\frac{10}{3}$ (B) $\frac{82}{9}$ (C) 7 (D) 11

11. One factor of $a^2 - 2ab - c^2 + b^2$ is

(A) $(a - b + c)$ (B) $(a + b + c)$ (C) $(a + b - c)$ (D) None of these

12. Expansion of $(2a + 3b + 4c)^2$ is

(A) $4a^2 + 9b^2 + 16c^2 + 12ab + 24bc + 16ca$ (B) $a^2 + b^2 + 2ca$

(C) $a^2 - b^2 - 2ca$ (D) $a^2 - b^2 + 2ca$

13. The value of $45^3 - 65^3 + 20^3$ is

(A) 175500 (B) –175500 (C) 170000 (D) –170000

14. $\frac{(856+167)^2 + (856-167)^2}{856 \times 856 + 167 \times 167}$ is equal to

(A) 1 (B) 2 (C) 689 (D) 3

15. The value of $(997)^2$ is

(A) 994000 (B) 994009 (C) 990000 (D) 994900

CHAPTER

3 Sound

Wave Motion

Wave motion is a vibratory disturbance travelling through a medium in which energy is transferred from one point to another without there being a direct contact between the two points.

Any motion which repeats itself after a fixed period (*or* interval) of time is known as **periodic motion**. The motion of earth around the sun, the motion of the hands of a clock, etc are examples of periodic motion. The periodic motion in which a body moves back and forth continuously is called vibratory **(*or* oscillatory) motion**. The most familiar types of oscillatory motion are the motion of a swing and the motion of a simple pendulum. All the vibratory motions have a common feature that they are repetitive and periodic about a mean position. We will now discuss some important definitions connected with wave motion.

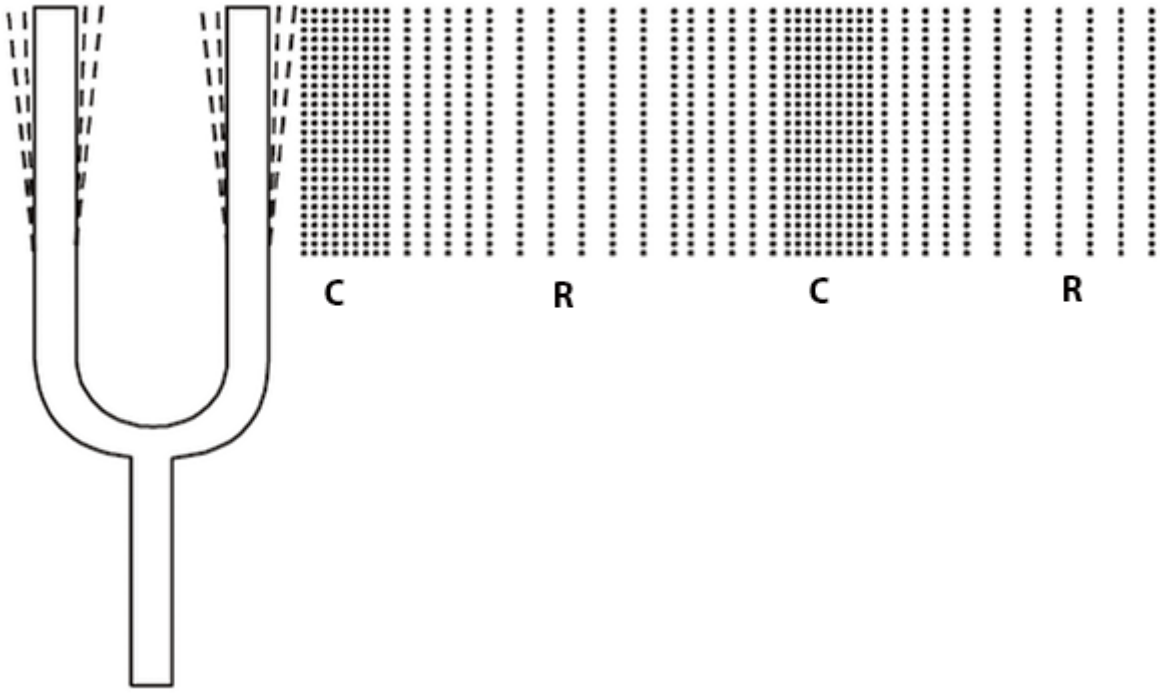
Sound

Sound is a form of energy which produces the sensation of hearing. Hearing is one of the primary sensations. The physical cause that produces the sensation of hearing is the vibration of the source.

Production of Sound: Sound is produced when an object vibrates (moves back and forth rapidly). In other words, ***sound is produced by vibrating objects***. Thus, whenever we hear a sound, some material must be vibrating to produce that sound. When an object vibrates to produce sound, there is a certain amount of energy which travels in the form of sound waves. For examples, the buzzing sound of bees and mosquitoes is produced by the vibration of their wings, the sound in a sitar, veena or guitar is produced by the vibrations of stretched strings. The sound of our voice is produced due to vibrations in the vocal cords. The sound of school bell is produced by the vibrations of an iron or brass plate when it is hit by a hammer. In most of these cases, *i.e.,* sound producing objects vibrate so rapidly that we cannot see its vibrations with our naked eyes.

Propagation of Sound: When an object vibrates, the layers of air around it also start vibrating exactly in the same way and carry sound waves from the sound producing object to our ears. The matter or substance through which sound is transmitted is called a medium. This medium can be solid, liquid or gas.

Compressions is a region where particles of medium are close to each other than normal position. Refraction is a region where particles of medium are away from each other than normal position.



A vibrating object creating a series of compressions (C) and rarefactions (R) in the medium.

Air is the most common medium through which sound travels. When a vibrating object moves forward, It pushes and compresses the air in front of it, creating a region of high pressure called compression (C). When the vibrating object moves backwards it creates a low-pressure region called rarefaction (R). As the object moves back and forth rapidly, a series of compressions and rarefactions is created in the air. These makes the sound wave to propagate through the medium.

Note: Sound needs a material medium like solid, liquid or gas to travel but it cannot travel through vacuum (or empty space), because sound needs material medium for its propagation.

Amplitude: The amplitude of a wave is the maximum displacement of the particle in a medium on either side of the mean position. It is usually represented by the letter A.

Wavelength: Wavelength of a wave is the length which is equal to the distance travelled by the wave during the time, any one particle of the medium completes one vibration about its mean position. It is usually represented by λ(lambda). Its SI unit is metre (*m*).

Note: The distance between two consecutive crests or two consecutive troughs of a transverse wave is called the wavelength.

OR

The distance between two consecutive compressions or two consecutive rarefactions of a longitudinal wave is called the wavelength.

Frequency: Frequency gives us an idea about how frequently an event occurs. Thus, the number of complete oscillations per unit time is called the frequency of the wave. It is usually represented by the letter *v* (nu). Its SI unit is hertz (Hz).

For example, if 10 complete waves (*or* vibrations) are produced in one second, then the frequency of the wave is 10 Hz. Similarly in tuning forks, it is often marked with numbers like 256, 512, etc. These numbers signify the frequency of vibrations of tuning forks. A tuning fork of frequency 256 means that its prongs make 256 vibrations in one second when hit on a hard surface.

Time Period: The time taken to complete one vibration is called time period. It is represented by the letter T. Its SI unit is second(s).

OR

The time required to produce one complete wave (*or* cycle) is called time period of the wave.

Relation between Time Period and frequency: Let the time period of a wave be T second.

Now, In T second, number of vibrations produced = 1

∴ In 1 second, number of vibrations produced = 1/T

Since the no of vibration produced in 1 second is called its frequency, therefore

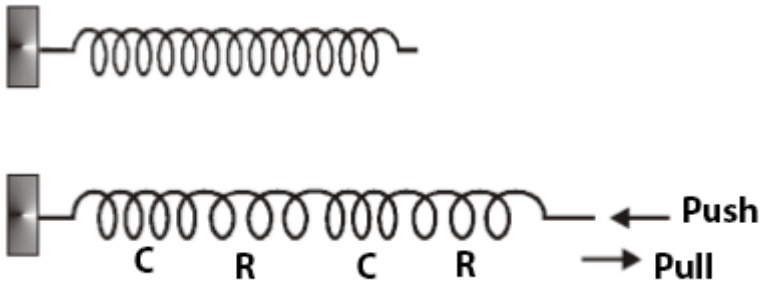
$$Frequency = \frac{1}{Time\ period}$$

or $v = \frac{1}{T} \Longrightarrow \quad T = \frac{1}{v}$

∴ time period and frequency are reciprocal of each other.

Longitudinal waves: A wave in which the particles of the medium vibrate back and forth along the same direction along which the wave is propagated is called longitudinal wave. For example,

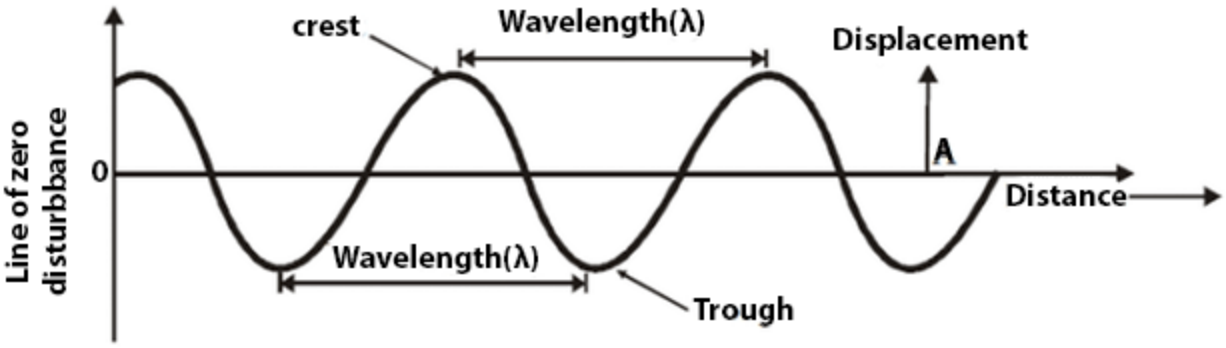
The waves which travel along a spring when it is pushed or pulled are longitudinal waves.



In a spring, a compression is that part in which the coils are closer together than normal position and rarefaction is that part in which the coils are further apart than normal position. As it is ready discussed that sound propagates in a medium as series of compressions and are factions. Thus, comparing propagation of disturbance in a spring with the sound propagation in the medium we conclude that these waves are longitudinal in nature.

Transverse Waves

For transverse waves the displacement of the medium is perpendicular to the direction of propagation of the wave.



Representation of Transverse Waves

Transverse waves	Longitudinal waves

(i)	In transverse waves, the particles of the medium vibrate at right angles to the direction of wave propagation.	(i)	In longitudinal waves, the particles of the medium vibrate parallel to the direction of wave propagation.
(ii)	Transverse wave travels through a medium in the form of crests and troughs.	(ii)	Longitudinal waves travel in the form of compressions and rarefactions.
(iii)	Light waves are transverse in nature. These are also called non-mechanical or electromagnetic waves, (light waves do not require any material medium for their propagation).	(iii)	Sound waves are longitudinal and these are also called mechanical waves, (sound waves requires material medium for their propagation).

Speed of Sound: The speed of sound is defined as the distance which a point on a wave such as compression or rarefaction travels per unit time.

We know that Speed = $\frac{\text{Distance travelled}}{\text{Time taken}}$ or $v = \frac{\lambda}{T}$

where, λ = wave length of the sound wave which is the distance travelled by the sound wave in one time period T.

$$\therefore v = \lambda v \quad [\because v = \tfrac{1}{T}]$$

$$Speed = Wavelength \times Frequency$$

Its standard unit is meter per second.

The speed of sound depends on: (a) the nature of material (*or* medium) through which it travels. The speed of sound remains almost the same for all frequencies in a given medium under the same physical conditions.

Speed of sound in solids > Speed of sound in liquids > Speed of sound in gases.

b) The speed of sound also depends on temperature. For example, the speed of sound in air is 332 ms^{-1} at 0°C and 344 ms^{-1} at 22°C.

Speed of sound in different medium

Medium	**Speed in m./s**

Dry air	331 m/s
Water	1500 m/s
Glass	5000 m/s
Steel	5000 - 7000 m/s

Fact: People living near railway tracks often press their ears against the track to find whether a train is approaching or not. Why?

The reason is that sound produced by the wheels travels faster through the tracks than through the air.

The Race between Sound and Light: The speed of sound in air is about 344 ms^{-1} and speed of light in air is 3×10^8 ms^{-1}. So it is clear that speed of light is greater as compared to speed of sound. For this reason, the sound of a thunder is heard a little later than the flash of lightning seen. We can also observe that in the game of cricket, the ball is seen to hit the bat first the sound of hitting is heard a little later.

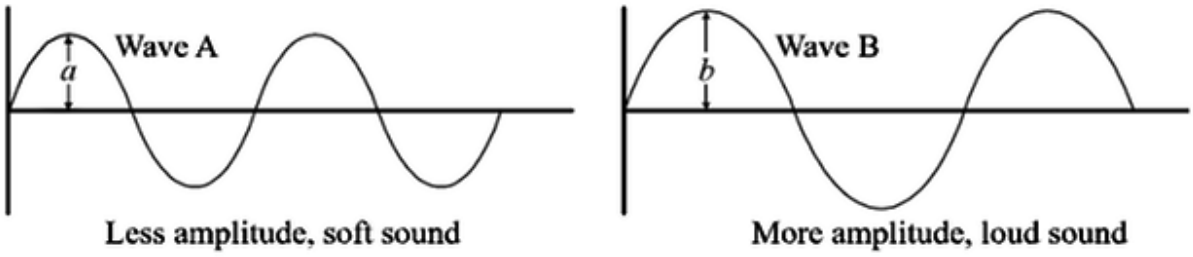
Characteristics of Sound Waves

Intensity or Loudness: Intensity of sound is defined as the amount of sound energy passing per unit time per unit area around a point. Intensity is a purely physical quantity and can be measured easily. Its SI unit is watt m^{-2}. The standard intensity (I_0) is taken arbitrarily as the lowest intensity of sound of frequency 1000 Hz for which a normal human ear can respond. It corresponds to a value of $10^{—12}$ Wm^{-2}. It is also called the threshold of hearing or threshold of audibility.

Loudness is a measure of the response of the ear to the sound. Thus, the sensation produced in the ear which enables us to distinguish between a loud and a faint sound is called **loudness**. It is measured in terms of decibels, (dB) a unit named after Graham Bell. Loudness depends upon

(i) Intensity of sound

(ii) Sensitiveness of the ear.



Loudness of sound is proportional to the square of the amplitude of the vibration producing the sound.

If the amplitude becomes twice, the sound becomes four times louder.

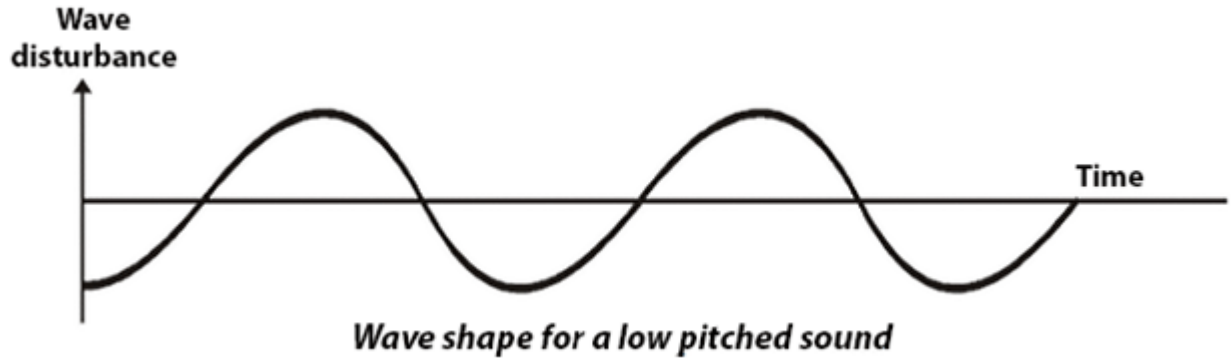
Intensity of sound $\propto$(amplitude)^2

The loudness of sound is commonly measured in decibels (dB)

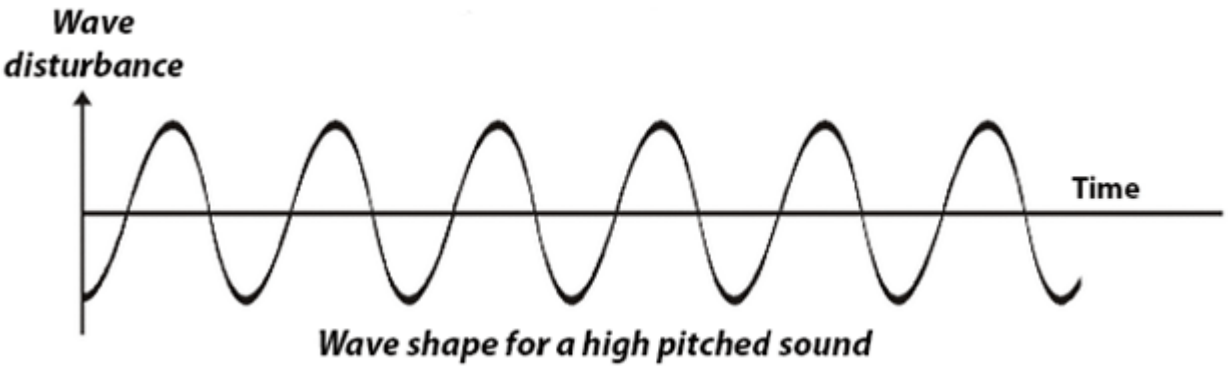
Sound	**Decibel level**
Whispering	20
Normal conversation	60
Loud (cheering)	70 – 80
Loud, stereo lightning	100 – 110
Painful sound	More than 120

Pitch or frequency: Pitch is that characteristics of sound which distinguishes a sharp sound from a dull sound. Pitch depends on the frequency of the source. The faster the vibration of the source, the higher the frequency and hence the higher is the pitch.

For example, frequency of ladies 'voice is usually higher than that of gents. Therefore, ladies' voice is sharper or shriller than gent's voice.

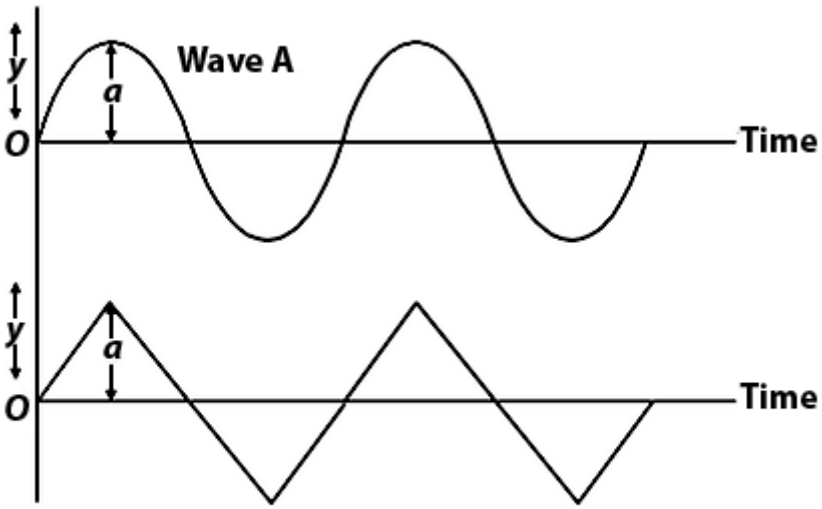


Wave shape for a low pitched sound



Wave shape for a high pitched sound

Quality or Timbre: The quality or timbre is that characteristic of sound which enables us to distinguish one sound from the other having same pitch and intensity. It depends upon the waveform of the second.

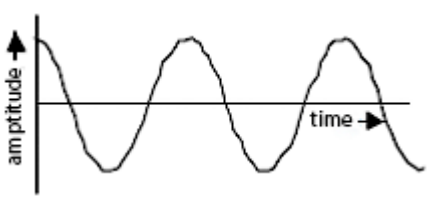
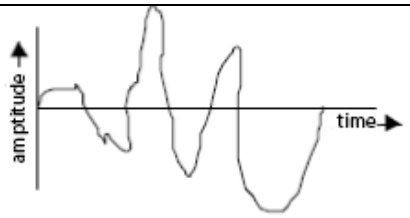


Waves of some amplitude and same frequency but of different quality

For example, we can recognize our friends from their voices on the basis of the quality of their sound.

Note: The sound which is more pleasant is said to be of a rich quality. A sound of single frequency is called a tone. The sound which is produced due to a mixture of several frequencies is called a note. Noise is unpleasant to the ear.

Musical Sound and Noise

Parameter	Musical Sound	Noise
Effect on ear	It produces pleasing effect to our ears and mind.	It produces unpleasing effect to our ears and mind
Frequency	The frequency of musical sound is high	The frequency of noise is low.
Waveform	It products a regular waveform	It produces an irregular waveform
Type of vibration	There are no sudden changes in the amplitude or wavelength representing a musical sound (regular periodic vibration)	There are sudden changes in the amplitude or wavelength representing a noise (irregular, non-periodic vibration)
Example	Sound produced by musical instruments	Sound produced by machines in a factory, motion of train, etc.
Waveform		

Reflection of Sound

Sound gets reflected from the surface of a solid or liquid in the same way as light and follows the same laws of reflection. Reflection of sound, however, does not require a

smooth and shining surface like that of a mirror. Sound can be reflected from any hard surface, whether smooth or rough.

Echo: If we stand on one side of a big empty hall and shout or clap, we will hear the same sound again a little while later. This sound which we hear is called an **echo**. This happens because the sound that we shout or clap is reflected from the walls of the hall and this reflected sound forms the echo. **An echo is simply a reflected sound**.

To hear a distinct echo, the time interval between the original sound and the reflected sound must be at least 0.1 s. Now, knowing the minimum time interval required for an echo to be heard, and the speed of sound in air, we can calculate the minimum distance from a sound reflecting surface to hear an echo. We know that,

Speed of sound in air at $22°C = 344 m/s$

Time taken = 0.1 s

$$\therefore \text{Speed} = \frac{\text{Distance travelled}}{\text{Time taken}}$$

or Distance travelled = Speed × Time

= 344 × 0.1

= 34.4 m

Thus, for hearing distinct echoes, the minimum distance of the obstacle from the source of sound must be half of 34.4 m which is $\frac{34.4}{2} = 17.2\ m$

Please note that 17.2 m from a sound reflecting surface is the minimum distance to hear an echo. We will also hear an echo when our distance is more than 17.2 m from a reflecting source. But no echo can be heard when our distance is less than 17.2 m from a sound reflecting source.

Reverberation: A sound created in an auditorium or big hall will persist by repeated reflection from the walls. **The successive or repeated reflection that results in this persistence of sound is called reverberation.** Sometimes excessive reverberation is highly undesirable. To reduce reverberation, the roof and walls of the auditorium are generally covered with sound absorbent materials like compressed fiberboard, rough plaster, etc. The seat materials are also selected on the basis of their sound absorbing properties.

Uses of Multiple Reflection of Sound

i) Megaphones, horns, musical instruments like trumpets, shehanais, etc, are all designed to send sound in a particular direction without spreading it in all directions.

ii) A medical instrument named as Stethoscope is used by the doctors for listening to sounds produced within the body, chiefly in the heart or lungs of the patient.

iii) The ceiling of concert hall, auditorium, conference hall, cinema hall are curved so that sound after reflection reaches all the corners of the hall.

Audible and Inaudible Sounds

Infrasonic Sounds: The sound of frequencies lower than 20 Hz are known as infrasonic sound or simply infrasonic. Infrasonic cannot be heard by human beings. The earthquakes, volcanic eruptions, simple pendulum and some animals like Whales, Elephants, Rhinoceroes produce infrasound.

Ultrasonic Sounds: The sounds of frequencies higher than 20 kHz are known as ultrasonic sound or simply ultrasound. Ultrasound also cannot be heard by human beings. But some animals like dogs, cats, rat, deer, bats, tortoises, leopard etc, can hear ultrasound. The ultrasound produced by bats are reflected back by other objects in their path and the echoes thus formed are detected by bats. It is due to this reason that bats can fly at night without colliding with other objects or can locate the prey.

Applications of Ultrasound

Ultrasounds are high frequency waves which can penetrate deep inside (because of their very high frequency and very short wavelength) and even in the presence of obstacles. Ultrasounds are used extensively in industries, medicine and technology.

Uses of Ultrasound in Industries

1. Effective Cleaning Agent: When some engines and machines are used in industries the particles of dust, grease and dirt reach in places like odd shaped parts of machines, electronic components, etc. Cleaning of such particles is very difficult. Ultrasound can be used to clean such particles present in hard-to-reach places. It is done in the following manner:

Objects to be cleaned are placed in a cleaning solution and ultrasonic waves are passed into the solution. Due to their high frequency, the ultrasound waves stir up the cleaning solution. Due to stirring, the particles of dust, grease and dirt sticking to the dirty object vibrate at a very high speed. Very fast vibrations make the particles of dust, grease and dirt loose, as a result, these particles get detached from the dirty object and fall into the solution. Then these particles are removed and the object gets cleaned thoroughly.

2. Detection of cracks in metal blocks: Metallic components are generally used in construction of big structures like buildings, bridges, machines and also scientific equipments. The cracks or holes inside the metal blocks (which are invisible from outside the metal blocks) reduce the strength of the structure from one end, ultrasonic waves are allowed to pass through the metal block (which is to be checked for detection to cracks, if any) detectors are placed on the other end which detects the transmitted waves. On passing the ultrasound through the metal block, if it passes unreflected as per the report of the ultrasound detectors, then the metal block does not have any internal cracks or holes (figure). The metal block is flawless and defect less, but if there is a small defect, crack or a hole, the ultrasound gets reflected back from that flaw or defect (figure). The ultrasound detectors indicate the presence of crack or hole in the metal block.

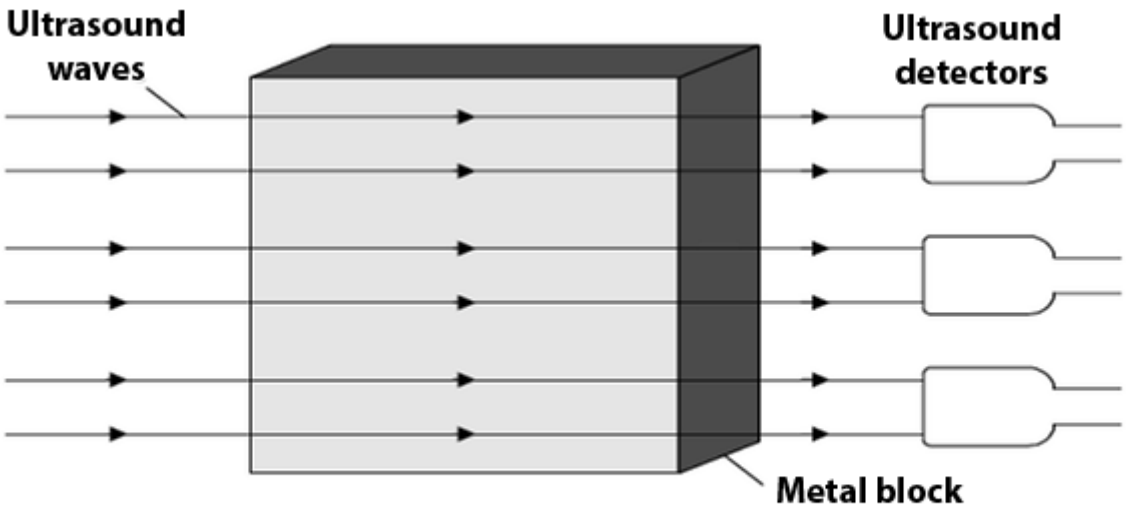


Fig.Since no ultrasonic waves are reflected, so this metal block in falwless

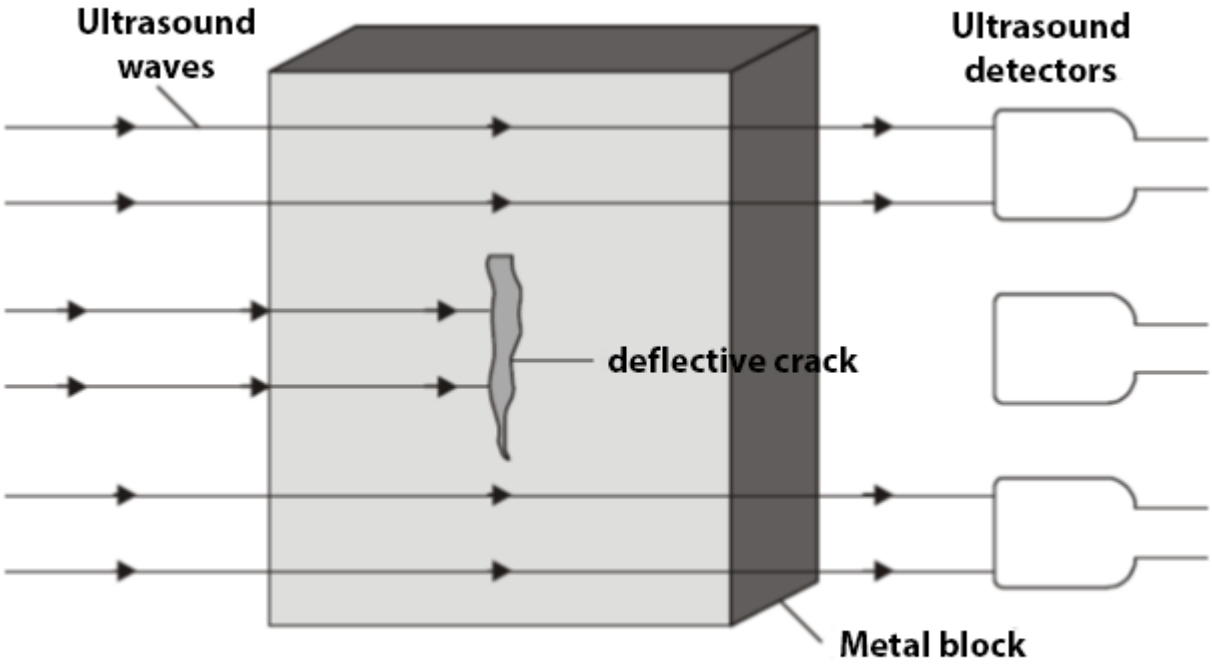


Fig.Ultrasonic waves are reflected from a part of a blocks so this metal block is defective

Use of Ultrasound for Medical Purpose

1. **Ultrasonography: The technique of obtaining images of the internal organs of the body by using ultrasonic waves is called ultrasonography:** an ultrasound scanner is a medical instrument which is used by the doctors to detect abnormalities such as stones in the gall bladder and kidney or tumours in different organs. In this technique, the ultrasound scanner produces ultrasound which travels through the tissues of the body and if there are stones in the gall bladder or kidney or there is tumour in any internal organ, then ultrasound gets reflected from these organs. These reflected ultrasonic waves are fed into the computer. These reflected ultrasound waves are converted into electrical signals, generating a three-dimensional image of the organ on the monitor of the computer or can be pointed on a film.

2. **Echocardiography: The technique of obtaining images (pictures) of the heart of the body by using ultrasonic waves is called echocardiography.** In this technique ultrasonic waves are sent to the various parts of the heart. The ultrasonic waves travel through the tissues of the heart and get reflected. The reflected ultrasonic waves when fed in the computer get converted into electrical signals which form the image of the heart. This technique is used to study congenital heart diseases, tumour of the heart and other heart disorders.
3. **Detection of fetal abnormalities:** Ultrasonography is also used for examination of the foetus during pregnancy. This technique is used to monitor the growth, development and well-being of the foetus. It is also used to detect some fetal abnormalities. This diagnosis allows appropriate treatment to be given during pregnancy and child birth.

4. **Breaking of kidney stones:** Kidney stones are hard deposits which can grow inside a person's kidneys. They can be painful and dangerous to life. Ultrasonic waves are directed towards kidneys. These waves break the stones into tiny pieces so they can pass out of the kidney.

Uses of Ultrasound in Technology

1. **SONAR (Sound Navigation and Ranging): Sonar is a device which is used to find the depth of a sea, or to locate underwater objects like enemy's submarine, sunken ships, shoal of fish, etc.**

A sonar apparatus consists of two parts:

a) transmitter (for emitting ultrasonic waves) and
b) receiver cum recorder (for receiving reflected ultrasonic waves) (figure.)

Now, suppose a sonar device is attached to the underside of a ship and we want to find the depth of the sea (below the ship). To do this, the transmitter of sonar is made to emit ultrasonic waves. The ultrasonic waves travelling down the seawater, strike the bottom of the sea and the reflected back to the ship in the form of echo. The receiver cum recorder receives the echo and measures the time taken (*t*) by the ultrasonic waves to travel from the ship to the bottom of the sea and back to the ship.

We can calculate the depth of the sea by using the formula.

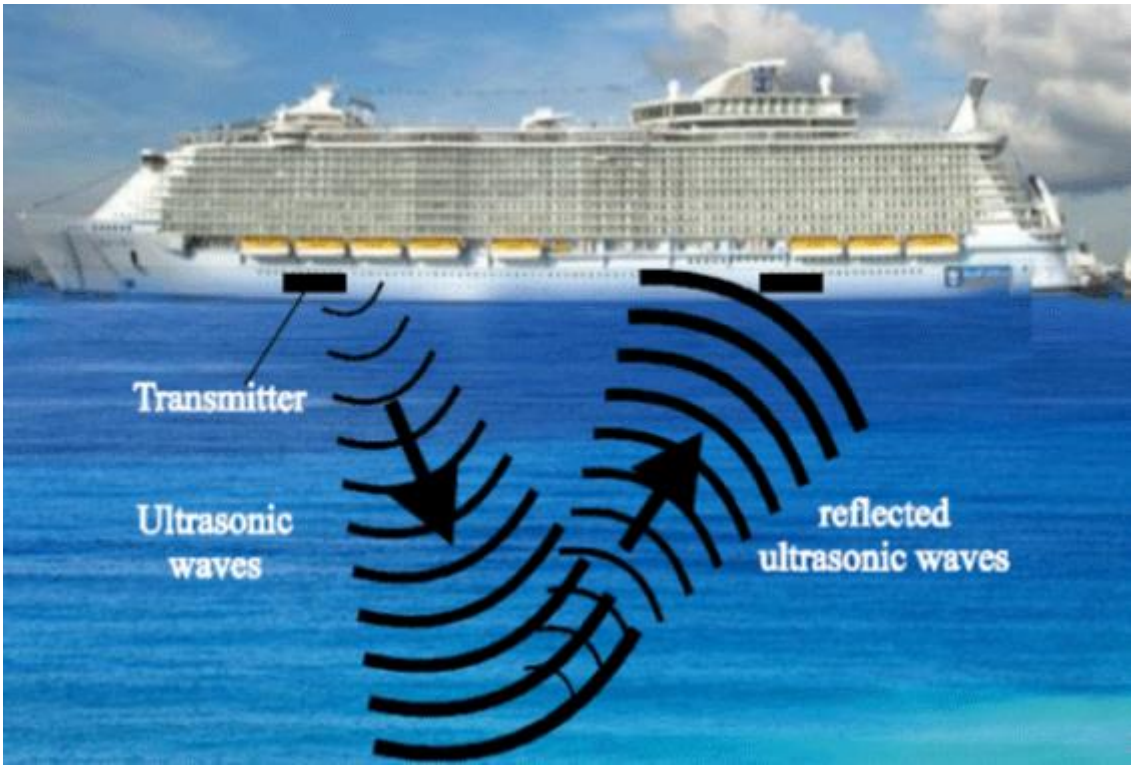


Fig. Ships use sonar to measure the depth of the sea

Velocity of sound (in water).

$$V_w = \frac{2\ (\text{Distance (d)})}{\text{Time taken (t)}} \text{ or d} = d = \frac{V_w \times t}{2}$$

Nowadays, all these calculations are done by the computers attached to the sonar. The machine is also equipped to construct the shape of the obstacle (like enemy submarine, iceberg, etc). on the screen of the cathode tube.

Ultrasonic waves (sound having frequency greater than 20000 Hz) are used in sonar because: a) Ultrasonic waves (can penetrate water to long distance (because of their very high frequency and very short wavelength), but ordinary sound waves cannot penetrate water to such long distance.

b) Ultrasonic waves cannot be confused with engine noises or other sound made by the ship (because they cannot be heard by human brings

2. RADAR (Radio Detection and Ranging). In air, radar is used to detect the presence of obstacle and finding is distance (or range) by using the echo method. Air traffic control systems use radar. The tower emits radio waves which travel at 300000000 m/s. They are reflected from the aircraft and picked up by the receivers in the tower. The time taken for the signal to return can be used to calculate the distance of the aircraft. The signals are led to the screen that picks the aircrafts position, Harbours also use radar to help ships to continue sailing even when the visibility is bad (i.e. during night and in fog).

Miscellaneous Uses

Detect oil deposits: Echoes are also used by geologists to detect underground ores or oil deposits.

Trawlers: The fishermen use trawlers (based in the principle of echo method) to find the direction and the distance of the shoal of fish.

Ultrasonic spectacles for blind people: Such a spectacle is fitted with a transmitter and a receiver. The transmitter sends pulses of sound which after striking the object are reflected back and are received by the receiver. The receiver produces a high sound (if the object is near) or a low sound (if the object is far) in the blind person’s ear.

Echolocation

Do you know bats have no power of vision? Inspite of being without vision, the bats can fly at full speed freely at night without striking any object. How is it possible? Bats use ultrasonic waves to perceive its surroundings. Let us see how a bat catches its prey.

During flight, the bat emits a series of high frequency ultrasonic waves. If any prey (insect) is flying in its path, these high-pitched ultrasonic waves strike the prey and get reflected (figure). The reflected ultrasonic waves are received as echoes by the bat's ear. The nature of reflections (echoes) tells the bat about the prey in the following manner.

The time elapsed between the emission of ultrasonic waves by the bat and in its returning as an echo gives bat an estimate of the distance of the prey from it, i.e., if the echoes take longer time to return from the prey then it indicates that the prey is far away from the bat but if the echo takes shorter time to return from the prey then it indicates that the prey is very near that bat.

Shock Waves: If the speed of a body (say, an aircraft) in air is greater than the speed of sound, then it is called the supersonic speed. Such a body leaves behind it a conical region of disturbance which spreads continuously. Such a disturbance is called a ***Shock Wave***. This wave carries huge energy. If it happens to strike a building, then the building may be damaged. These waves may even make cracks in window panes and cause landslide.

Fig. The bat emits ultrasonic waves that strike the insect and are reflected back to the bat. The bat uses the echolocation method to detect the insect's position.

Shock Waves

If the speed of a body (say, an aircraft) in air is greater than the speed of sound, then it is called the supersonic speed. Such a body leaves behind it a conical region of disturbance which spreads continuously. Such a disturbance is called a ***Shock Wave***. This wave carries huge energy. If it happens to strike a building, then the building may be damaged. These waves may even make cracks in window panes and cause landslide.

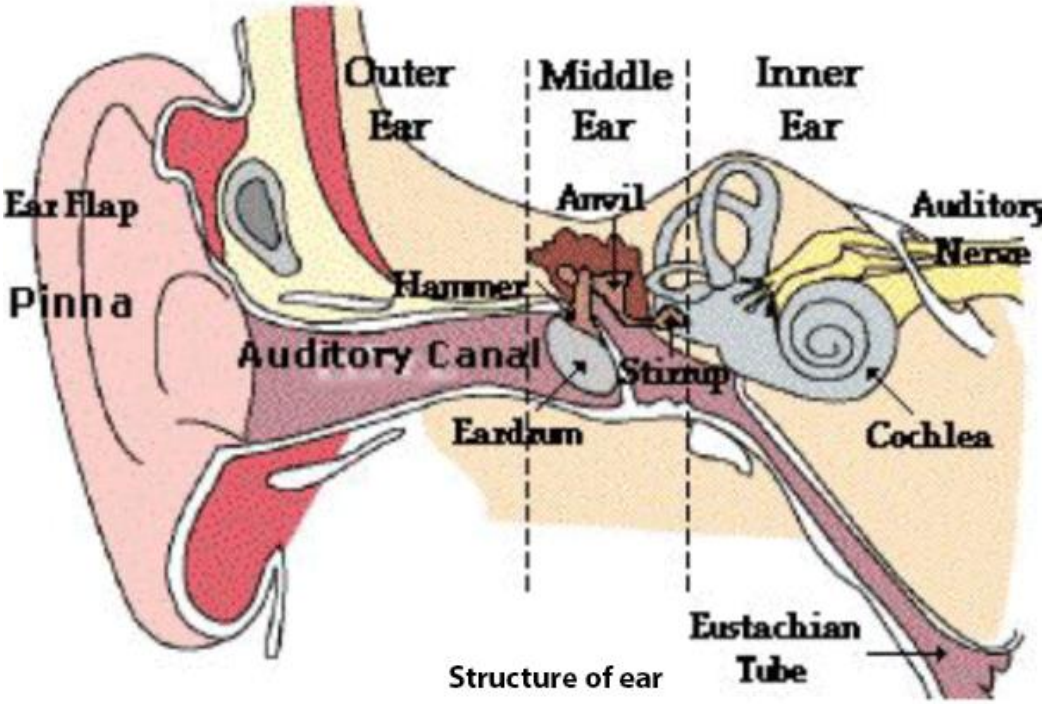
Structure and Working of Human Ear : We are able to hear sound from our surroundings through sensory organ called **ear**. We have learnt that sound is produced by a vibrating body and it needs a medium for its propagation. When the sound propagating through air, reaches our ear, we are able to hear it Ear is divided into three parts

1. External Ear
2. Middle Ear
3. Internal Ear

External ear: The external ear is the fleshy part with side on our face. It is called the **pinna**. Its main function is to collect the sound waves and direct to the ear. The sound waves travel along the auditory **canal**. At the end of the auditory canal there is a thin membrane called **tymphonic membrane or eardrum.**

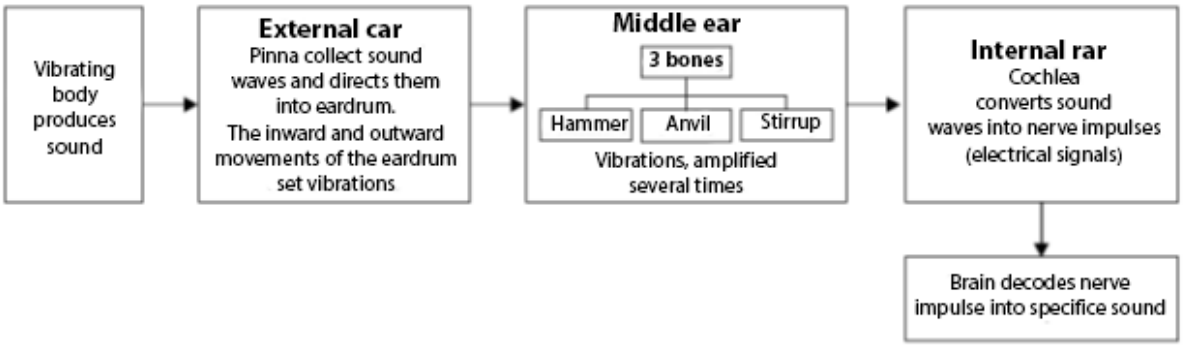
We know sound travels in air as longitudinal wave and also we have learnt that longitudinal waves consist of compressions and rarefactions. When a compression of the medium reaches the eardrum (or tympanic membrane), the pressure on the outside of the membrane increases and forces the eardrum inward. Similarly, when a rarefaction of the medium reaches the eardrum, the pressure on the outside of the membrane decreases and forces the eardrum to relax outward. This continuous inward and outward movement of the eardrum sets itself into vibrations The vibrating eardrum passes the vibrations to the middle ear.

Middle ear: The middle ear begins with the inner side of the eardrum. The eardrum is attached to the three bones — the hammer, the anvil and the stirrup. These bones are named according to their shapes. The vibrating eardrum causes the three bones (hammer, anvil and stirrup) to vibrate. These three bones in the middle ear increase the strength of vibrations coming from the eardrum before passing them to the inner ear. So, the function of these three bones is to amplify the vibrations several times to the middle ear. The middle ear transmits the amplified sound waves into the inner ear. The Eustachian tube maintains pressure inside the middle ear and outside.



Structure of ear

Internal ear: The internal ear contains cochlea. Cochlea is filled with a fluid and has many hair cells inside it. The vibrating eardrum causes the three bones to vibrate., The vibrating bones pass their vibration to the cochlea. The sensitive hair cells present in the cochlea respond to the sound vibrations received and change them into nerve impulses (electrical signals). These impulses are then carried by the auditory nerves to the brain. The brain on receiving the nerve impulses decodes them into specific sounds and then only we react to the sound.



Working of human ear

SOLVED PROBLEMS

Problem 1: The frequency of a source of sound is 200 Hz. How many times does it vibrate in a minute?

Solution: v = 200 Hz

1 minute = 60 seconds

∴ No. of vibrations = 200 × 60 = 12000 Hz

Problem 2: A sound wave has a frequency of 3000 Hz and a wavelength of 38 cm. How long will it take to travel 2 km?

Solution: We have, v = 3000 Hz and $\lambda = 38cm = \frac{38}{100}m$

The wave speed is $v = v\lambda = 300 \times \frac{38}{100} = 1140\ m/s$

The time taken by the wave to travel 2 km is

$$t = \frac{x}{v} = \frac{2\ km}{1140m/s} = \frac{2000m}{1140m/s} = 1.75\ sec$$

Problem 3: A girl clapped her hands near a cliff and heard the echo after 10 sec. What is the distance of the cliff from the girl if the speed of sound, v is taken as 346 ms^{-1}?

Solution: Given, speed of sound, v = 346 ms^{-1}

time taken for hearing echo, t = 10 sec

distance travelled by sound = $v \times t$ = 346 × 10 = 3460 m

In 10 sec sound has to travel twice the distance between cliff and girl. Hence distance between cliff and person

$$= \frac{3460}{2} = 1730\ m$$

Problem 4: A sound wave has a frequency 2KHz and wavelength of 40 cm. How long will it take to travel 1.6 km?

Solution: Given frequency, $v = 2\text{KHz} = 2 \times 10^3 Hz$,

wavelength, $\lambda = 40\text{ cm} = 0.40\text{ m}$

That is $v = v\lambda = (2 \times 10^3) \times (0.40)$

$$= 0.80 \times 10^3 = 800\ \text{ms}^{-1}$$

$$\text{Time} = \frac{\text{distance}}{\text{speed}} \text{ i.e., t} = \frac{\text{s}}{\text{v}}$$

Given, distance $= s = 1.6\,\text{km} = 1.6 \times 10^3\,\text{m}$

$$\therefore \text{time}, t = \frac{1.6 \times 10^3}{800} = \frac{1600}{800} = 2\ sec$$

Problem 5: The wavelength of waves produced on the surface of water is 20 cm. If the wave velocity is 24 ms^{-1}. Calculate

(a) the no. of waves produced in one second

(b) time period to produce one waves.

Solution: Given wavelength λ =20 cm = 0.20 m and wave velocity = 24 ms^{-1}

(a) We know $v = v\lambda$

Frequency, $v = \frac{v}{\lambda}$

No. of waves produced in one second is simply frequency i.e.,

$$v = \frac{24}{0.20} = 120$$

(b) Time period, $T = \frac{1}{v} = \frac{1}{120}$ second $= 8.33 \times 10^{-3}$ seconds.

Problem 6: A boy hears the echo of his own voice from a distance hill after 0.8 second. If the speed of sound in air is 340 m/s, calculate the distance of hill from boy.

Solution: Let *S* be the distance of the hill from the boy and *t* be time of to and pro journey of sound waver, then from relation

distance = velocity × time

$$2S = v \times t$$

$$S = \frac{v \times t}{2}$$

$$here\ v = 340\ m/s, t = 0.8\ sec$$

$$S = \frac{340 \times 0.8}{2} = 340 \times 0.4\,136\,\text{m}$$

Problem 7: A person hears the thunder 3 seconds after a flash of lightning is seen. At what distance has the lightning strike? (velocity of sound in air = 340 m/s)

Solution: Time = 3 sec, velocity of sound = 340 m/s

To find distance

$$\text{Velocity} = \frac{\text{distance}}{\text{time}}$$

$$\therefore \text{distance} = \text{velocity} \times \text{time}$$

$$\text{distance} = 340 \times 3$$

$$\therefore \text{distance} = 1020 \text{ m}$$

The lightning struck at a distance of 1020 m.

Problem 8: A source produces 15 waves in 3 seconds. The distance between a crest and a trough is 14 cm. Find the (a) frequency (b) wavelength and (c) velocity of wave.

Solution: (a) Number of waves produced in 3 seconds = 15

Number of waves produced in 1 second $= \frac{15}{3} = 5$

So, the frequency of wave (*v*) is 5 Hz

(b) Distance between crest and tough = 15 cm = half of waves

$$\frac{\lambda}{2} = 15\ m$$

$$\lambda = 30 \text{ cm} = \frac{30}{100} = 0.3\ m$$

Thus, wavelength of wave is 30 cm or 0.3 m.

(c) We know

$$v = v \times \lambda$$

$$= 5\text{Hz} \times 0.3 = 1.5 \text{ m/s}$$

Thus, velocity of wave is 1.5 m/s

IMPORTANT DEFINITIONS

1. ***Sound:*** Sound is a form of energy which produces a sensation of hearing in our ears.
2. ***Medium:*** The substance or matter through which sound is transmitted is called a medium. Sound cannot travel through vacuum.
3. ***Wave:*** It is a disturbance that moves through a medium when the particles of the medium set neighboring particles into motion.

4. ***Wave motion:*** It is a vibratory disturbance produced in one part of the medium that travels to another part involving the transfer of energy but not the transfer of any matter with it.
5. **Longitudinal wave:** A wave in which the particles of the medium oscillate (vibrate) to-and fro (back and forth) in the same direction in which the wave is moving is called a longitudinal wave. Sound is a longitudinal wave. Sound is a longitudinal wave It travels as successive compressions and rarefactions in the medium.
6. ***Amplitude:*** The maximum displacement of the particles of a medium from their mean positions during the propagation of a wave is called the amplitude of the wave.
7. ***Time period:*** The time required to produce one complete vibration is called the time period. Its SI unit is second.
8. ***Frequency:*** The frequency of a wave is defined as the number of waves produced per second. Its SI unit is hertz.
9. ***Wave velocity:*** The distance travelled by a wave in one second is called the velocity of the wave. Velocity = Frequency × Wavelength.
10. ***Pitch:*** It is a characteristic of a musical sound by which we can distinguish a shrill sound from a grave sound even though the two sounds have the same loudness. Pitch of a sound depends upon the frequency of vibration.
11. ***Loudness:*** It is a sensation as perceived by the listener. It is a measure of the response of the ear to the sound. It depends upon the intensity of sound near the ear.
12. ***Quality of sound (timbre):*** It is the characteristic of a musical sound that enables us to distinguish between two sounds of the same pitch and loudness produced by two different sources. It depends upon the waveform of the sound.
13. ***Tone:*** A sound of single frequency is called a tone.
14. ***Note:*** A sound which is produced due to mixture of several frequencies is called a note.
15. ***Speed of sound:*** It is defined as the distance which a point on a wave, such as compression or a rarefaction travels per unit time.
16. ***Factors affecting speed of sound:*** Nature of medium, density, temperature, wind movement, humidity.

17. ***Sonic boom:*** Objects moving at supersonic speed produce a shock wave in air, creating a sudden change in air pressure and producing a very sharp and loud sound on the ground, called sonic boom.
18. ***Reflection of sound:*** The changing of the direction of sound when it strikes a hard surface is called reflection of sound.
19. ***Echo:*** It is the repetition of the original sound heard after it is reflected from a distant, dense and rigid object.
20. ***Persistence of hearing:*** The sensation of sound persists in our ear to one tenth of a second after the original sound dies off. This time is called persistence of hearing.
21. ***Audible sounds:*** We are able hear sounds whose frequency lies between 20 Hz and 20,000 Hz. This is called audible sound.
22. ***Infrasonic sounds:*** Inaudible sounds having frequency less than 20 Hz are known as infrasonic sounds.
23. ***Ultrasonography:*** The technique of obtaining images of the internal organs of the body by using ultrasonic waves is called ultrasonography.
24. ***Echocardiography:*** It is the technique of obtaining images (pictures) of the heart by using ultrasonic waves.
25. ***Sonar:*** It is a device which is used to find the depth of a sea or to locate underwater objects like enemy's submarine, sunken ships, shoal of fish.
26. ***Echo location:*** A method in which animals like bats, dolphins, etc. emit ultrasonic waves and listen to their echoes to find their prey, avoid obstacles and move around without vision.

IMPORTANT FORMULAE

1. Frequency, $\nu = \frac{1}{T}$
2. Wave velocity = Distance travelled by a wave/Time taken
3. Velocity of the wave $V = v \times \lambda$

SI Units

4. Wavelength, metre (m)
5. Amplitude metre (m)
6. Time period, T second (s)

7. Frequency, *v* herz (Hz)
8. Wave velocity, *v* metre/second (m/s)

REVISION EXERCISE - LEVEL – I

1. In order to reduce the loudness of a sound we have to
   (a) decrease its frequency of vibration of sound
   (b) increase its frequency of vibration of sound
   (c) decrease its amplitude of vibration of sound
   (d) increase its amplitude of vibration of sound
2. Which of the following statements are correct?
   (i) Sound is produced by vibrations.
   (ii) Sound requires a medium for propagation.
   (iii) Light and sound both require a medium for propagation
   (a) (i) and (ii) only (b) (i), (ii) and (iii) only
   (c) (ii), (iii) only (d) None of the above
3. How is sound produced in a bamboo jute?
   (a) By the vibration of air inside the bamboo
   (b) By vibration of bamboo
   (c) By hitting the bamboo
   (d) By a change in direction of air
4. Sonic vibrations were sent down from a ship return after 2 seconds. What is depth of the sea, if speed of sound in water is 1.5 km/s.
   (a) 150 m (b) 3 km (c) 1.5 km (d) 3.5 km
5. Which of the following does not produce a sound wave?
   (a) A silencer fixed gun fixed (b) A bell ringing under water
   (c) A hammer hitting a block of rubber (d) An explosion on the moon
6. Why is sound heard when a ball strikes the floor?
   (a) The air particles from the floor flow into our ears.
   (b) The air particles from the floor vibrate and pass signal to our ears.
   (c) The air particles from the floor vibrate and produce transverse waves which flow through air into our ears.
   (d) The wavelength of sound wave is large enough to produce sound.
7. An ultrasound equipment used for investigating and tracking many medical problems, work at the frequencies.

(a) greater than 20,000 Hz

(b) less than 20,000 Hz

(c) greater than 20 Hz but less than 20,000 Hz

(d) equal to 20 Hz

8. The number of vibrations produced in one second is called _____ of the oscillation.

(a) time period (b) frequency (c) wavelength (d) amplitude

9. A female voice is generally shriller than a male voice, because the female voice has

(a) higher frequency (b) lower frequency

(c) lower amplitude (d) higher amplitude

10. Waves produced on the surface of water are:

(a) longitudinal only (b) transverse wave only

(c) electromagnetic waves (d) both longitudinal and transversal

11. In longitudinal waves, the particles vibrate in a _____ of direction of propagation

(a) parallel (b) perpendicular

(c) curved (d) both parallel and perpendicular

12. The quantity 1 /λ is known as

(a) wave velocity (b) wavelength (c) frequency (d) wave number

13. In which of the following speed of sound is maximum

(a) air (b) steel (c) water (d) kerosene

14. When echo is heard?

(a) if the time interval between original sound and reflected sound is more than 1/10 sec

(b) If the time interval between original sound and reflected sound is less than 1/10 sec.

(c) If the time interval between original sound and reflected sound is less than 1/120 sec.

(d) If the time interval between original sound and reflected sound is 1/120 sec.

15. Bats detect the obstacles in their path by receiving reflected____.

(a) infrasonic waves (b) radio waves

(c) electromagnetic waves (d) ultrasonic waves

16. The relation between wave velocity *v* and frequency *f* and wavelength 'λ' is _____

(a) $v = \frac{f}{\lambda}$ (b) $v = f\,\lambda$ (c) $v = \frac{\lambda}{f}$ (d) $v = \frac{1}{f\lambda}$

17. The amplitude of a wave is:
    (a) the distance the wave moves in one second.
    (b) the distance the wave moves in one time period of wave.
    (c) the maximum distance moved by medium particles on either side of mean position.
    (d) the distance equal to one wavelength.
18. The physical quantity, which oscillates in most waves, is:
    (a) mass (b) energy (c) amplitude (d) wavelength
19. The speed of sound in medium depends upon
    (a) amplitude (b) frequency
    (c) wavelength (d) properties of medium
20. Sound and light waves both
    (a) have similar wavelength (b) obey law of reflection
    (c) travels as longitudinal waves (d) travel through vaccum

LEVEL – II

1. An ultrasonic wave is sent from a ship towards the bottom of the sea. It is found that the time interval between the sending and receiving of the wave is 1.6s. What is depth of sea, if velocity of sound in seawater is 1400 m/s?
   (a) 1120 m (b) 120 m (c) 4120 m (d) 112 m
2. If a vibrator strikes the water 10 times in one second, then the frequency of water is:
   (a) 10 Hz (b) 0.5 Hz (c) 5 Hz (d) 0.1 Hz
3. The distance between a compression and next refaction of a longitudinal wave is:
   (a) $\frac{\lambda}{4}$ (b) 2λ (c) $\frac{\lambda}{2}$ (d) $\frac{\lambda}{8}$
4. A source of frequency of 500 Hz emits waves of wavelength 0.4m, how long does the waves take to travel 600 m?
   (a) 3s (b) 6s (c) 9s (d) 12s
5. The time period of a vibrating body is 0.05s. The frequency of wave it emit is:
   (a) 5 Hz (b) 20 Hz (c) 200 Hz (d) 2 Hz

6. A sound source sends waves of 400 Hz. It produces waves of wavelength 2.5 m. The velocity of sound wave is:
   (a) 100 m/s (b) 1000 m/s (c) 10000 m/s (d) 3000 km/s
7. The frequency of a wave travelling at a speed of 500 ms^{-1} 25 Hz. Its time period will be:
   (a) 20s (b) 0.05s (c) 25s (d) 0.04s
8. The minimum distance between source and reflector, so that an echo is heard is approximately equal to:
   (a) 10 m (b) 17 m (c) 34 m (d) 50 m
9. Sound waves travel with a speed of 330 m/s. What will be the wavelength of sound, whose frequency is 5504 Hz?
   (a) 0.9 m (b) 0.6 m (c) 0.5 m (d) 0.8 m
10. A longitudinal wave of wavelength 1 cm travels in air with a speed of 330 ms–1. Then the frequency of wave is:
    (a) 30,000 Hz (b) 33,000 Hz (c) 33,500 Hz (d) 30 KHz
11. Radio waves of speed 3×10^8 ms^{-1} are reflected of the moon and received back on earth. The time lapsed between the sending of the signal and receiving it back on the earth station is 2.5 sec. Then what will be the distance of the moon from earth?
    (a) 2.75×10^8 m (b) 1.75×10^8 m (c) 3.75×10^8 m (d) 4.75×10^8 m
12. A sound of wavelength 0.332 m has a time period of 10^{-3}s. If the time period is decreased to 10^{-4} sec. Then what will be the wavelength and frequency of new wave.
13. Calculate
    (a) the wavelength
    (b) the time period of a tuning fork of frequency 512 Hz which is set to vibrate. Velocity of sound in air is 320 m/s.
14. If the ratio of intensities of two sound waves is 1:2. Then what will be the ratio of their amplitudes.
15. A source of sound produces 15 waves in 3 sec. Then what will be the frequency of wave.
16. The wavelength of a sound wave is 2 m. If its time period of oscillation is 2 sec, then calculate the wave velocity.

17. A sound wave has a frequency of 1000 Hz and a wavelength of 34 cm. How long it will take to travel 1 km?
18. A man standing 25 m away from a wall produces a sound and receives the reflected sound. (a) calculate the time after which he receives the reflected sound if the speed of sound in air is 350 ms^{-1}. (b) will the man be able to hear a distinct echo?
19. A ship on the surface of water sends a signal and received back from a submarine inside water after 4 sec. Calculate the distance of submarine from ship. (The speed of sound in water is 1450 ms^{-1})
20. A person standing between the two vertical cliffs produces a sound. Two successive echoes are heard at 4s and 6s. Calculate the distance between cliffs.

HIGHER ORDER THINKING SKILLS (HOTS)

1. Ravi pressed his ears to the railways tracks for a while and confidently said that a train was approaching them. However, his friend could not see any approaching train even far away. Also, he could not hear the train. After some time, Ravi was proved right and train whizzled by Ravi was able to hear the approaching train because
   (a) Ravi had extraordinary hearing abilities
   (b) Vibration of air
   (c) Vibration of railway tracks
   (d) Sound travels fasters in solid than in air
2. In a family, the voice of father, mother and children are different. What is reason?
   (a) shape of lungs are different
   (b) size of vocal chords are different
   (c) size of larynx is different
   (d) radius of wind pipe is different
3. The legendary singer, Lata Mangeshkar also called as the nightingale of India. The quality of her voice is considered to be supreme. The characteristic of sound
   (a) amplitude (b) loundness
   (c) frequency (d) all of the above
4. Galileo discovered the laws of simple pendulum. A freely

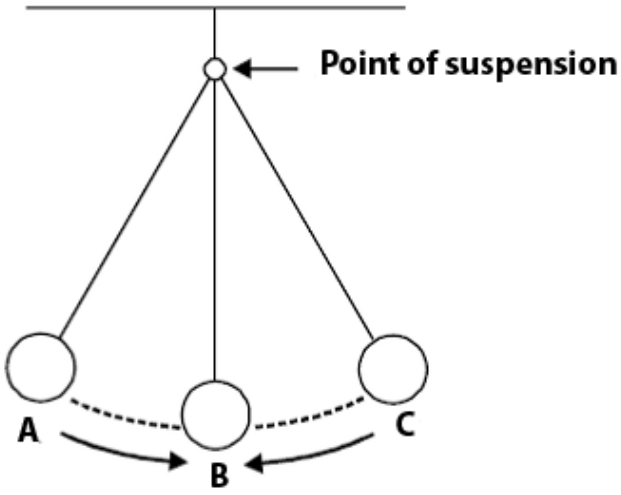
oscillating simple pendulum of a given lengths always possesses a constant time period. Thus, it can be used as a

(a) weight measuring device

(b) musical instrument

(c) time measuring device

(d) none of the above



5. At very high altitude, the gravitational force reduces slightly, what effect does it have on time period of pendulum.

(a) Time period becomes longer

(b) Time period becomes shorter

(c) It doesn't have any effect on the period

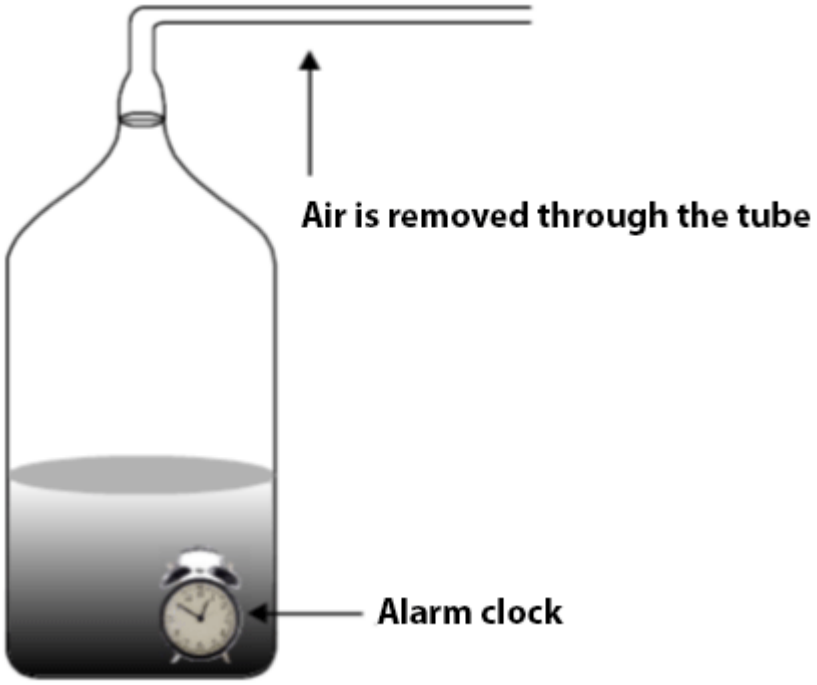
(d) Can't say

6. When a sound wave passes from air into water, what happens to its frequency?

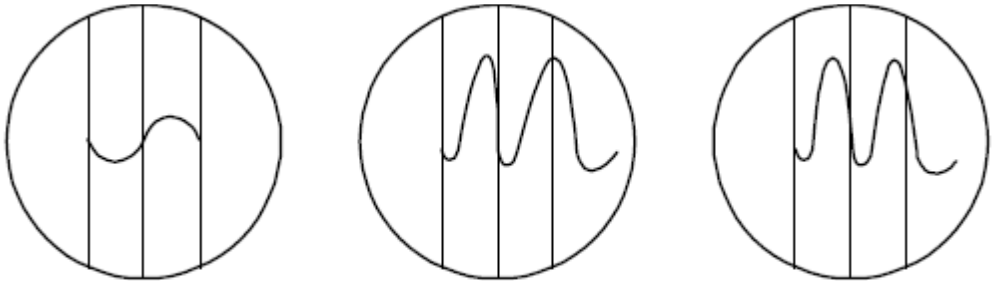
(a) Its increases (b) It decreases

(c) It does not change (d) None of these

7. An alarm bell is kept inside a vessel as shown below figure. A person standing close to it can distinctly hear the sound of alarm. Now if the air inside the vessel is removed completely how will the loudness of alarm get affected for the same person.



8. A microphone is connected to the Y-input of a C.R.O. Three different sounds are made in turn in front of microphone. The traces (a), (b) and (c) produced on screen as shown in below figure.



(a) (b) (c)

(I) Which trace represents loudest sound?

(II) Which trace represents the sound with the lowest pitch?

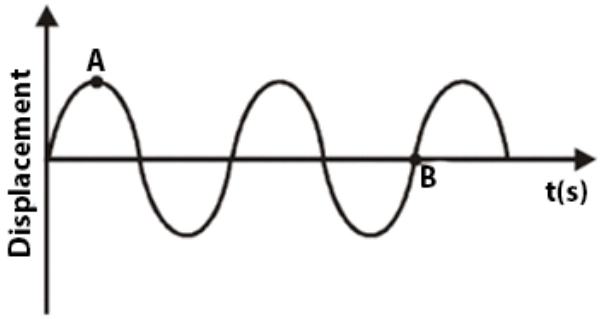
9. A man standing in front of a vertical cliff fires a gun. He hears the echo after 3 seconds. On moving closer to the cliff by 82.5 m, he fires again. This time, he hears the echo after 2.5 seconds. Calculate:
(i) the distance of cliff from initial position of man
(ii) the velocity of sound

10. A man standing in front of a large wall, claps two objects against each other at an interval of 1.2s regularly. The echo of the first clap coincides with the fifth

clap. If the speed of sound in air is 340 m/s, the distance between the man and the wall is _____.

(a) 400 m (b) 1632 m (c) 816 m (d) 204 m

11. A violin string emits sound wave with a frequency of 850 Hz as shown in the figure. If the speed of sound in air is 340 m/s, the distance between points A and B is



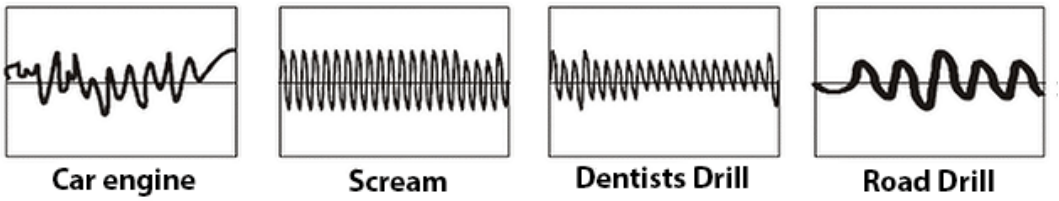
(a) 6 m

(b) 70 cm

(c) 60 cm

(d) 80 cm

12. The oscilloscope traces for sound waves with different frequencies are shown below. The noises shown in the diagram in the increasing order of frequency are



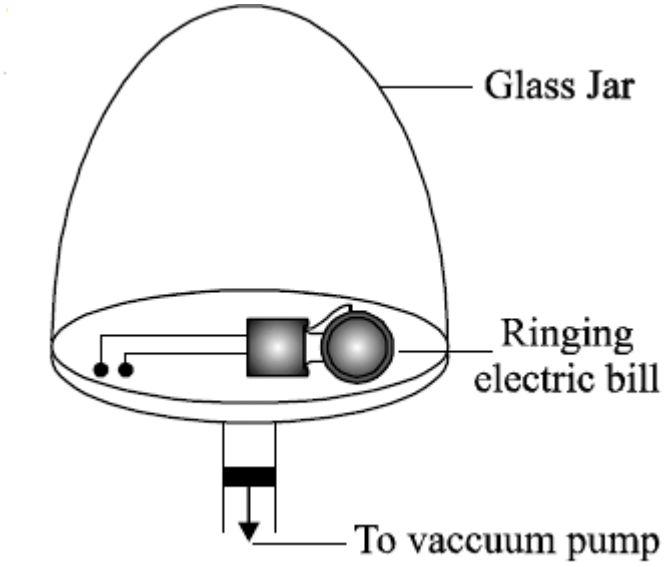
(a) Car engine, Scream, Dentists's drill, Road drill

(b) Road drill, Car engine, Dentists drill, Scream

(c) Scream, Car engine, Dentists drill, Road drill

(d) Dentists drill, Road drill, Scream, Car engine

13. A scientist performed an experiment as shown in the figure. What happened when air was pumped out of the jar completely and herang the bells



(a) The sound became louder

(b) The sound became fainter first and then louder once all the air was pumped out,

(c) The sound could not be heard any more

(d) the sound was the same as before

14. Why is sound heard when a ball strikes the floor?

(a) The air particles from the floor flow into our ears

(b) The air particles from the floor vibrate and pass the signal to our ears

(c) The air particles from the floor vibrate and produce transverse waves which flow through the air into our ears

(d) The wavelength of the sound wave is large enough to produce the sound

15. The loudness of a note on a guitar can be increased by increasing the

(a) tension on the guitar string

(b) amplitude of vibration of guitar string

(c) thickness of the guitar string

(d) length of the guitar string

ADDITIONAL EXERCISE

1. Eardrum is a part of:

(A) Sound producing organ (B) Skeletal system

(C) Hearing organ (D) Reproductive organ.

2. The hearing range of human ear is:

(A) 20 Hz to 20,000 Hz (B) Less than 20Hz

(C) More than 20,000 Hz (D) 20 Hz to 25,000 Hz

3. The voice box is also called:
   (A) Stomach (B) Heart (C) Larynx (D) Mouth
4. Large amplitude of sound vibrations will produce:
   (A) Loud sound (B) Weak sound (C) Slow sound (D) Shreak
5. The pitch of sound depends on:
   (A) Frequency (B) Amplitude
   (C) Both of these (D) None of these.
6. Sound is a kind of
   (A) work (B) energy (C) force (D) none.
7. To and fro motion of an object is called
   (A) waves (B) amplitude (C) vibration (D) all of above
8. Sound propagates fastest in
   (A) gas (B) liquid (C) solid (D) all
9. The transfer of energy in a material medium due to the periodic motion of its particles is called
   (A) wave motion (B) stream
   (C) pulse (D) none of the above
10. A body which produces sound is in the state of
    (A) translatory motion (B) rotatory motion
    (C) vibratory motion (D) rest
11. A pulse is a wave:
    (A) of long duration (B) of short duration
    (C) both (A) and (B) (D) none of these
12. Sound waves cannot pass through:
    (A) a solid liquid mixture (B) a liquid gas mixture
    (C) an ideal gas (D) a perfect vacuum
13. In a sound wave, the direction of propagation is:
    (A) in the direction of the vibrations of the vibrating body
    (B) opposite to the direction of vibrations of vibrating body
    (C) perpendicular to the direction of vibrations of the vibrating body
    (D) at an angle of 60° to the direction of vibrations of the vibrating body
14. The frequency of ultrasonic waves lies in the same range as that of radio frequency waves. However

(A) the ultrasonic waves are mechanical and longitudinal in nature

(B) the ultrasonic waves are transverse and electromagnetic

(C) the ultrasonic waves are longitudinal and electromagnetic in nature

(D) nature of both is similar

15. When longitudinal wave propagates through a medium then the physical quantities propagating in the direction of wave are:

(A) Energy (B) Energy, Momentum and mass

(C) Energy and mass (D) Energy and momentum

16. Which of the following statement is correct?

(A) In air the waves of light and sound are longitudinal.

(B) In air the waves of light and sound are transverse.

(C) In air the sound waves are transverse and the light waves are longitudinal.

(D) In air the sound waves are longitudinal and the light waves are transverse.

17. The characteristic of sound which distinguishes a feeble sound from a louder sound of the same frequency is:

(A) pitch (B) Loudness (C) music (D) timbre

18. One hertz is equivalent to:

(A) one cycle per second (B) one second

(C) one metre per second (D) one second per metre

19. The product of time period and frequency is:

(A) 0 (B) 1 (C) infinite (D) 0 or 1

20. Infrasonic frequency range is:

(A) below 20Hz (B) 20 Hz to 20 kHz

(C) above 20 kHz (D) no limit

21. 1 kHz is equivalent to

(A) 10Hz (B) 100Hz (C) 1000 Hz (D) 10000Hz

22. Time period of a sound wave having the wavelength 0.2m and frequency 10Hz will be:

(A) 2 s (B) 0.2 s (C) 0.1 s (D) 0.02 s

23. Speed of sound at constant temperature depends on:

(A) pressure (B) density of gas

(C) above both (D) none of the above

24. Echo is a type of:

(A) reflected sound (B) refracted sound

(C) polarized sound (D) none of these

25. To hear a distinct echo, the minimum distance of a reflecting surface should be:

(A) 17 metres (B) 28 metres (C) 68 metres (D) 340 metres

26. The speed of sound in air at 0°C is approximately:

(A) $332ms^{-1}$ (B) $350ms^{-1}$ (C) $530\ ms^{-1}$ (D) $332\ kms^{-1}$

27. The shrillness of a musical note depends upon:

(A) amplitude (B) loudness (C) frequency (D) quality

28 Mark the correct options according to terms in column I and column II

Column I	**Column II**
(1) high pitch	(p) Faint sound
(2) low pitch	(q) Loud sound
(3) small amplitude	(r) High frequency
(4) large amplitude	(s) Low frequency

(A) (1) → r, (2) → s, (3) → p, (4) → q (B) (1) →r, (2) → p, (3) → r, (4) → q

(C) (1) →s, (2) → q, (3) → r, (4) → P (D) (1) →p, (2) →s, (3) →r, (4) →q

Directions (29 to 31): Each questions contains Statement-1 (Assertion) and Statement-2 (Reason). Each question has 4 choices (I), (II), (III) and (IV) out of which only one is correct.

(I) Statement-1 is true, Statement-2 is true, Statement-2 is a correct explanation for Statement-1.

(II) Statement-1 is true, Statement-2 is true, Statement-2 is not a correct explanation for Statement-1.

(III) Statement-1 is true, Statement-2 is false.

(IV) Statement-1 is false, Statement-2 is true.

29. **Statement-1:** On a rainy-day sound travel slower than on a dry day.

Statement-2: When moisture is present in air the density of air increases.

(A) I (B) II (C) III (D) IV

30. Statement-1: Two persons on the surface of moon cannot talk to each other.

Statement-2: There is no atmosphere.

(A) I (B) II (C) III (D) IV

31. Statement-1: Waves produced in a cylinder containing a liquid by moving its piston back and forth are longitudinal waves.

Statement-2: Longitudinal waves are also called pressure waves.

(A) I (B) II (C) III (D) IV

CHAPTER

5

Chemical Effects of Current

Conductors and Insulators

- Most of the materials under certain conditions conduct electricity and therefore they can be classified as good conductors of electricity or poor conductors of electricity instead of conductors and insulators.
- Testing of substance as conductor or insulator can be done by connecting the substance to the two ends of a two wires which are connected to terminals of battery. If the bulb connected in the circuit glows, the substance is conductor and if does not do so the substance is insulator. The circuit is shown in the figure.

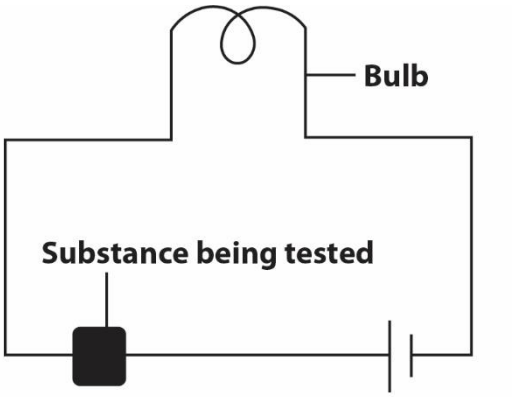


Figure shows Testing of a substance as conductor or insulator

- Generally metals like copper and aluminium are good conductors of electricity, whereas rubber, wood, plastics are insulators or poor conductors of electricity and do not allow electric current to pass through them. Hence they are used in appliances to provide protection from electric shock.
  - In some atoms, the electrical force is not strong enough to hold the electrons to the nucleus. Consequently, the electrons are able to move freely in the material.
  - Materials in which electrons can move easily are called good conductors.
  - Materials in which electrons cannot flow freely are called poor conductors.

Differences between Conductor and Insulators

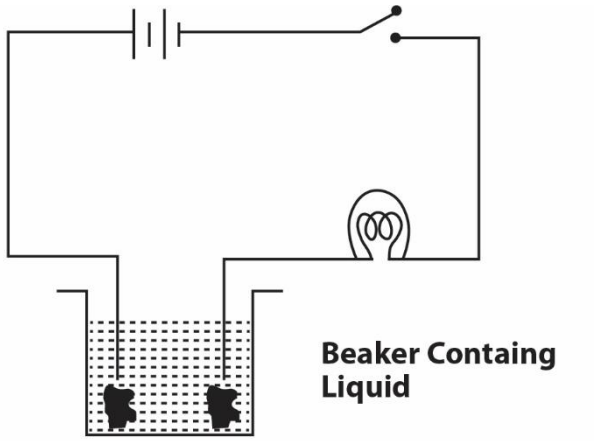
Some key conductor and insulator differences are given in the table below.

Conductor	Insulator
Materials that permit electricity or heat to pass through it	Materials that do not permit heat and electricity to pass through it

A few examples of a conductor are silver, aluminium, and iron	A few examples of an insulator are paper, wood, and rubber
Electrons move freely within the conductor	Electrons do not move freely within the insulator
The electric field exists on the surface but remains zero on the inside	The electric field doesn't exist

Liquids Conduct Electricity

- Liquids are poor conductors of electricity.
- Kerosene, petrol, alcohol & vegetable oil are poor conductors of electricity.
- Pure water is a non-conductor of electricity.
- Impure water is a good conductor of electricity.



Testing the conductivity of liquids

- Pure water which is a poor conductor of electricity, becomes a good conductor of electricity on adding acids, bases and salts to it. Kerosene, petrol, alcohol & vegetable oil are poor conductors of electricity. Pure water is a non-conductor of electricity. Impure water is a good conductor of electricity. Pure water which is a poor conductor of electricity, becomes a good conductor of electricity on adding acids, bases and salts to it.

For example:

(a) A solution of acids like sulphuric acid (H_2SO_4) and hydrochloric acid (HCl) conducts electricity.

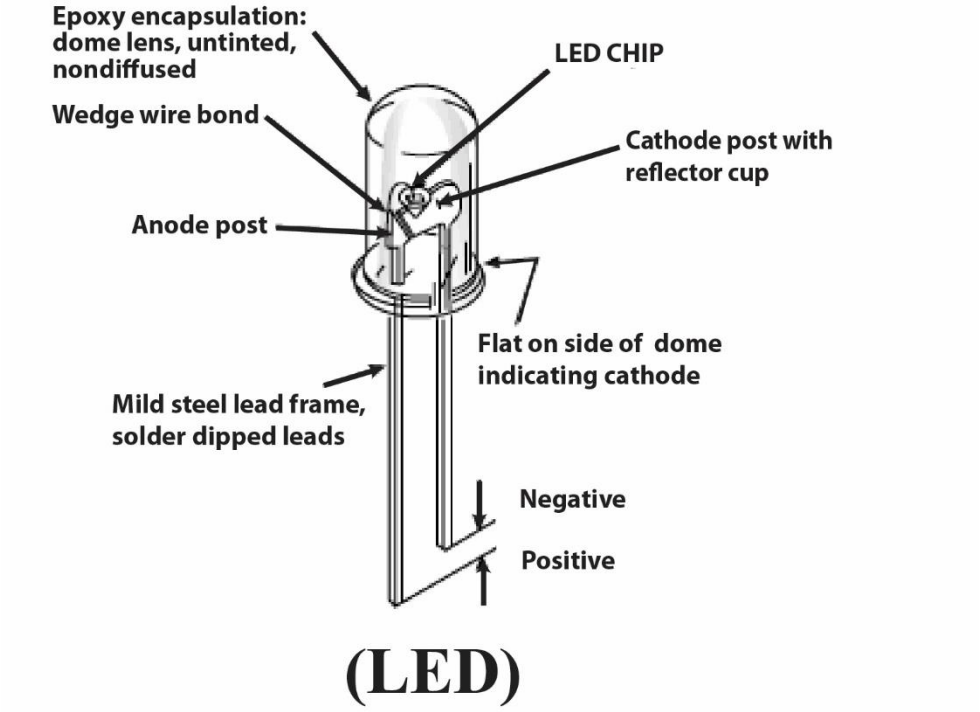
(b) A solution of sodium hydroxide (NaOH) or any other base soluble in water conducts electricity.

(c) Common salt (sodium chloride) or any other salt when added to pure water it conducts electricity.

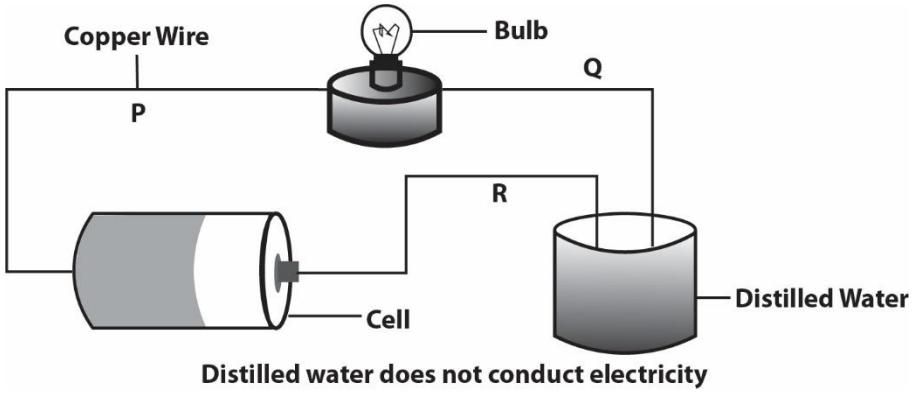
The current through liquids is generally weak, therefore, testing becomes difficult. Hence we use a battery and the tester (or bulb) is replaced by a LED (Light Emitting Diode).

Light Emitting Diode (LED)

LED can be used in place of electric bulb in case of weak electric current. The LED glows even when a weak electric current flows through it. A LED has two wires attached to it. These wires are called as leads and one of the lead is slightly longer which is always connected to positive terminal of battery and shorter terminal is connected to negative terminal of battery. LEDs are available in many colours e.g. red, green, yellow, blue etc. LEDS are increasingly used for lighting.



(LED)



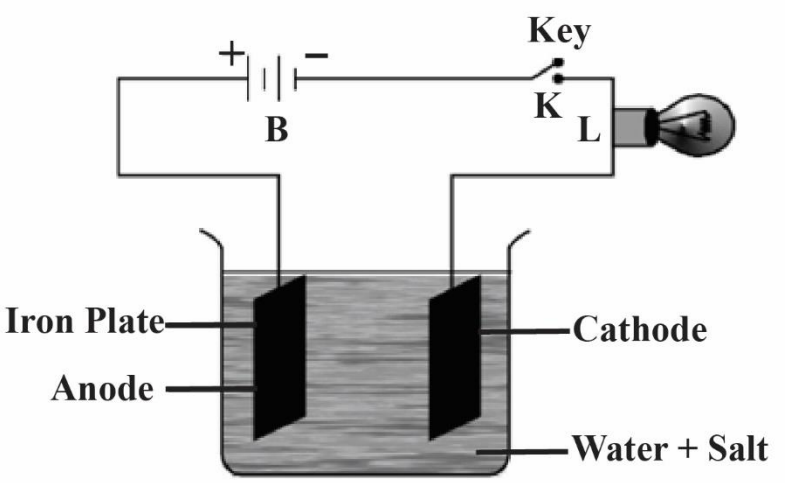
Distilled water does not conduct electricity

Electrolysis

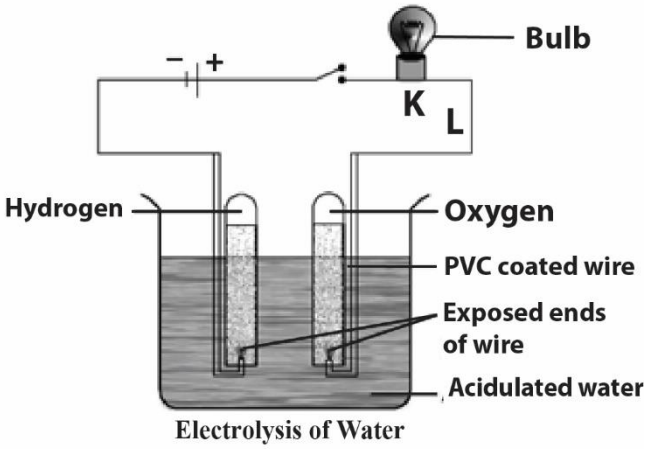
When electric current passes through a conducting solution, it decomposes the solution. The solution that conducts electricity is called an electrolyte and the process by which an

electrolyte is decomposed with the help of electricity is called electrolysis. The electrolysis process is shown in the figure, where two iron plates are taken and heads of the plates are connected with copper wires and joined to a battery.

The two iron plates which facillates in conduction are electrodes. The electrode connected to positive terminal of battery becomes positive charged and called as anode. The electrode connected to negative terminal gets negatively charged and is known as **cathode.**



Some amount of water is taken in beaker and salt which is an electrolyte is added to the water in beaker. The electrodes are dipped in solution. When the battery is switched on, the bulb glows showing that the current passes through the solution when circuit is complete.



Electrolysis of Water

Chemical Effects of Electric Current

The electric current can bring about a chemical change. When electric current passes through solution containing water and copper sulphate, the copper and oxygen are obtained at the two electrodes which shows a chemical change which can be termed as chemical effect of current.

i) On the electrodes during electrolysis of water there is a possibility of gas bubbles being formed.

The gas bubbles are formed at the exposed end of wire. These are hydrogen and oxygen gases. Hydrogen is evolved at cathode (negative terminals) and oxygen at the anode (positive terminals)

ii) Deposition of metals at electrode. e.g. in case of a solution of water containing siliver nitrate (acting as electrolyte). Copper spoon is taken as cathode attached to negative terminal of battery and silver plate acts as anode connected to positive terminal of battery. On passage of current the silver gets deposited on copper spoon.

iii) The colour of solution also changes with the passage of current in solution e.g. in case of electrolysis using $CuSO_4$ as electrolyte, Zinc as anode and Copper as cathode it can be seen that after passage of current for some time the blue colour of $CuSO_4$ solution changes to colourless.

Applications of Chemical Effects of Current

Electroplating is one of the most common applications of chemical effects of electric current. **Electrorefining** is based on chemical effects of current. The method is used to purify or refine metals like gold, silver, copper, tin, etc. The extraction of metals like aluminium and sodium makes use of chemical effects of current.

Electroplating

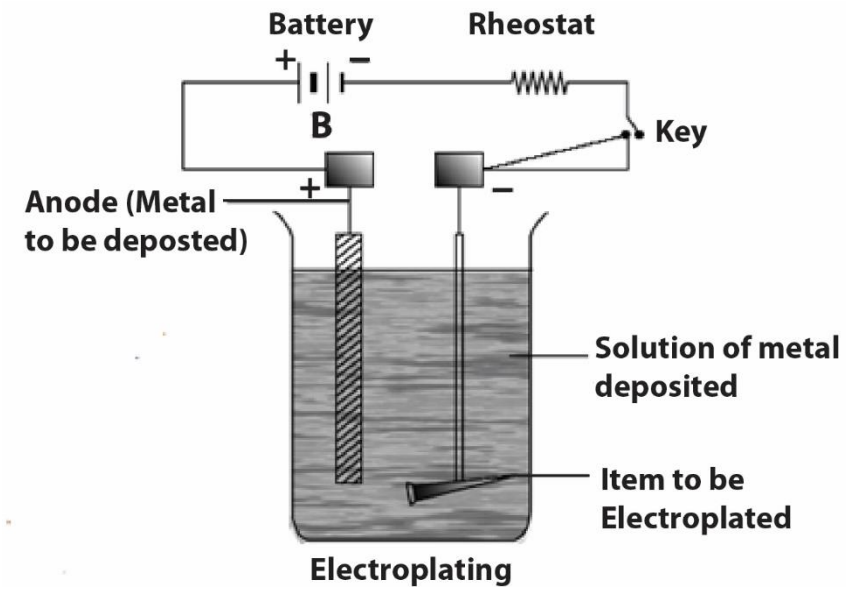
The process of depositing a thin layer of a metal on any conducting substance by the process of electrolysis is known as electroplating.

Conditions required for electroplating

(a) The surface of the metal to be electroplated should be thoroughly cleaned with an alkali and then made free of grease and oil.

(b) A direct current should be passed as A.C. current causes discharge and ionisation thus giving no effective coating.

(c) The metallic article to be electroplated is always placed at the cathode because during electrolytic reaction, the metal is always deposited at the cathode by gain of electrons.



(d) The metal to be plated on a metallic article is always made the anode & needs to be periodically replaced because the metal at the anode continuously dissolves as ions in solution.

(e) A small current should be applied for a long period of time to get the proper thickness & consistent coating.

(f) Suitable temperature is necessary around the electroplating equipment. Conduction of electricity through electrolyte increases with the rise in temperature.

The cleaned and washed object is made cathode and is suspended into the salt solution of the metal to be deposited. The anode is a thick rod of the same metal and is dipped in the other part of the solution. The outer circuit is completed using a battery, rheostat and a key. The current is passed through the solution and after some time, the required amount of electroplating is done on the item. Gold, silver, chromium, nickel etc. are deposited by electrolysis on articles of cheaper metals in order to improve their appearance, or to increase their strength or to prevent surface corrosion.

Uses of Electroplating

i) Used for decoration purposes like silver plating is done in case of cutlery, jewellery. Even gold plating is done in case of silver jewellery to give a rich look and finish.

ii) Protection against corrosion: More reactive metals gets rusted. The objects made up of very reactive metals are electroplated with less reactive metals. For example, iron can be protected against rusting by electroplating with zinc, the

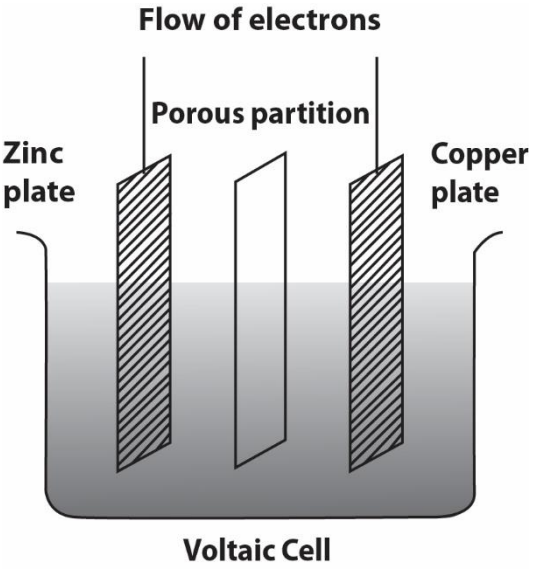
process is also known as galvanization. Brass objects are protected against corrosion by chromium electroplating also known as chrome plating.

iii) Repairing finer machine parts: Finer parts of certain machines can be repaired by depositing desired metal at proper location electrolytic ally.

Voltaic and Dry Cells

These are electrochemical cells. The device used to generate electricity through chemical reactions is called an electrochemical cell. These cells are used in cars and other automobiles to give a start. Also, the cells are used in torches, transistors, watches etc.

Voltaic Cell: The first electrochemical cell was constructed by Volta in 1796. It is called Voltaic Cell.



In this cell, a strip of zinc is placed in zinc sulphate solution and a copper strip is placed in copper sulphate solution. Both the solutions are separated by a porous partition which allows the ions to pass through it, but does not allow the mixing of the two solutions. The zinc plate acts as an anode (negative electrode), while copper plate acts as cathode (positive electrode).

It is to be kept in mind that the signs of the electrodes in an electrochemical cell are opposite to that of an electrolytic cell.

Working of a Voltaic Cell: When both the electrode terminals are connected by a wire then there is a flow of electrons (electric current) from zinc to copper terminal (Figure.) occurs. Zinc metal is more reactive than copper, so it has a greater tendency to lose electron.

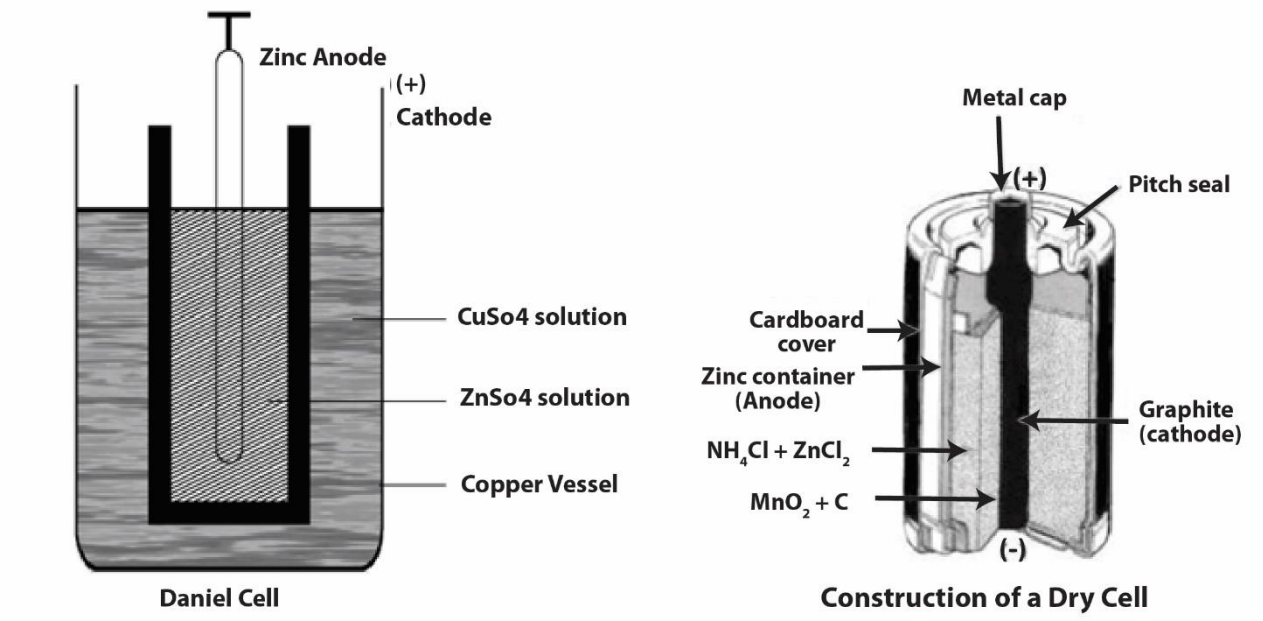
$$Zn \longrightarrow Zn^{2+} + 2e^{-} \text{ (Oxidation)}$$

These electrons flow through the wire to the copper cathode. The reaction that occurs at the copper cathode is

$$Cu^{2+} + 2e^{-} \longrightarrow Cu \text{ (Reduction)}$$

Daniel Cell: An improvement over the voltaic cell was Daniel Cell. Here, the zinc sulphate solution is kept in a porous pot that is suspended in a solution of copper sulphate in a copper vessel. This cell gives a more steady current. The voltage of cell is 1 volt.

Dry Cell: The cell used in torch and transistor etc., is called dry cell. The most common dry cell, that is, the Leclanche cell, is used in flashlight and transistor radios. The anode of the dry cell consists of zinc container which is in contact with manganese dioxide (MnO_2) and an electrolyte. The electrolyte consists of ammonium chloride and zinc chloride in water to which starch is added to thicken the solution to a paste like consistency so that it is less likely to leak (Figure). A carbon rod serves as cathode, which is immersed in the electrolyte in the centre of cell. The voltage produced by dry cell is 1.5V.



The cell reactions are:

Anode $Zn_{(s)} \longrightarrow Zn^{2+}_{(aq)} + 2e^-$

Cathode $2NH^+_{4(aq)} + 2Mn_2O_2 + 2e^- \longrightarrow 2Mn_2O_3 + 2NH_{3(aq)} + H_2O_{(l)}$

Overal $Zn_{(s)} + 2NH^+_{4(aq)} + 2MnO_2 \longrightarrow Zn^{2+}_{(aq)} + 2NH_{3(aq)} + H_2O_{(l)}$

REVISION AT A GLANCE

Electrical conductivity: The measure of the ability of a substance to carry electric current.

Electrolysis: The production of a chemical reaction by passing an electric current through an electrolyte.

Electrolyte: A substance which conducts electricity when dissolved in water or when melted. An electrolyte undergoes partial or complete dissociation into ions and the electricity is conducted in the solution by the flow of these ions.

Electroplating: The method of coating one metal over the other by using electric current.

Ions: Atoms or group of atoms that carry positive or negative charges.

Electrochemical cells: The device used to generate electricity through chemical reactions.

REVISION EXERCISE LEVEL – I

1. The decomposition of an electrolyte when electricity is passed through it, is called
   (a) Conduction (b) Coating
   (c) Electrolysis (d) Electro refining
2. Which out of the following do not conduct electricity?
   (a) Copper (b) Alcohol
   (c) Dilute sulphuric acid (d) Vinegar
3. The electrode, connected to the positive terminal of a battery is called
   (a) Anode (b) Pole (c) Cathode (d) Photodiode
4. A metal is released in the electrolysis of a salt. It gets deposited on
   (a) Anode (c) Both (A) and (B)
   (b) Cathode (d) Sides of container
5. An electrochemical cell is an example of conversion of
   (a) Magnetic energy into chemical energy
   (b) Electrical energy into chemical energy
   (c) Chemical energy into electrical energy
   (d) Chemical energy into magnetic energy

6. Which one of the following is a weak electrolyte?
   (a) Sodium chloride (b) Acetic acid
   (c) Nitric Acid (d) Potassium chloride
7. Which of the following metal is not extracted by electrolysis?
   (a) Aluminium (b) Iron (c) Sodium (d) Potassium
8. The process in which zinc metal is deposited on iron material to prevent rusting is known as
   (a) Chromeplating (b) Galvanization (c) Leaching (d) Vulcanization
9. Which of the following is a strong electrolyte?
   (a) Carbonic acid (b) Citric acid
   (c) Sodium chloride (d) Oxalic acid
10. Distilled water is a
    (a) Conductor (b) Insulator
    (c) Semi-conductor (d) Semi-insulator
11. Signs of electrodes in a electrochemical cell is
    (a) Same as that of electrolytic cell (b) Can be interchanged
    (c) Opposite to that of electrolytic cell (d) None of the above
12. In Leclanche cell_____ is used as electrolyte
    (a) $CuSO_4$ solution (b) $ZnSO_4$ solution
    (c) NH_4Cl solution (d) NaOH solution
13. In Daniel cell_____ acts as positive electrodes
    (a) Copper vessel (b) $CuSO_4$ (c) Zinc rod (d) $ZnSO_4$
14. The common dry cell produces a voltage of
    (a) 1.5V (b) 30V (c) 60 V (d) 3 V
15. In a dry cell, the formation of hydrogen layer over carbon rod is prevented by
    (a) Evaporation of hydrogen ions
    (b) The reaction of MnO_2 with the hydrogen
    (c) The reaction of powdered carbon with hydrogen
    (d) The reaction of NH_4Cl and the hydrogen
16. In dry cell, the positive terminal is
    (a) Carbon rod (b) MnO_2
    (c) MnO_2 and Carbon (d) Metal cap on the carbon rod

17. Ammonium chloride in dry cell is a
    (a) Paste (b) Liquid state (c) Solid state (d) Gaseous state
18. The long terminal of LED is connected to
    (a) Positive terminal of battery (b) Negative terminal of battery
    (c) Does not matter (d) Not connected
19. The change in composition of substances using current shows
    (a) Magnetic effect of current (b) Heating effect of current
    (c) Chemical effect of current (d) None
20. Cells of lithium battery produces a voltage of
    (a) 1.5V (b) 3V (c) 4.2V (d) 6V

LEVEL - II

1. Which one of the following is bad conductor of electricity?
   (a) Distilled water (b) Alcohol
   (c) Salt water (d) Tap water
2. When electric current is passed through copper sulphate solution, the copper deposites on the electrode connected to
   (a) positive terminal of battery (b) negative terminal of battery
   (b) negative terminal of battery (d) none of these
3. When electric current is passed through a bulb, the bulb gives light because of
   (a) electric effect of current (b) heating effect of current
   (c) glowing effect of current (d) lighting effect of current
4. The process of producing chemical decomposition of a compound by passing electricity through the compound is called
   (a) electrolysis (b) electroplating
   (c) electrolyte (d) none of above
5. Mica sheets used in an iron instruments because
   (a) mica is good conductor of electricity
   (b) mica is bad conductor of electricity and heat
   (c) mica is bad conductor of electricity but good conductor of heat
   (d) mica is very light and bad conductor of electricity
6. Tin cans are the tin electroplated on iron. These tin cans are used to preserve food items. Why not iron cans used without tin coating?

(a) Tin is less reactive than iron (b) Tin is more reactive than iron

(b) Tin is more reactive than iron (d) Tin is lighter than iron

7. Which property of the electricity is responsible for use of fuse wire in household wiring?

(a) Chemical effect (b) Heating effect

(c)Magnetic effect (d) All of these

8. Shiny objects are often made by electroplating steel with

(a) Nickel (b) Titanium (c) Chromium (d) Zinc

9. The scientist who showed electrolysis of water

(a) Nicholson (b) Felmming

(c) Faraday (d) None of these

10. Fill in the blanks:

(a) The object to be electroplated is taken as _____ electrode

(b) One of the most common applications of chemical effect of electric current is

(c) Small amount of a mineral salt present naturally in water makes it a _____ of electricity.

(d) Electroplating of _____ is done on objects like water taps and cycle bell to give them a shiny appearance.

ASSERTION AND REASON TYPE QUESTIONS

In the following questions, a statement of assertion (A) is followed by a statement of reason (R)

(A) If both Assertion and Reason are true and the reason is the correct explanation of the assertion.

(B) If both Assertion and Reason are true but the reason is not the correct explanation of the assertion.

(C) If Assertion is true statement but Reason is false

(D) If both Assertion and Reason are false statements.

1. **Assertion:** It is unsafe for electricians to carry out outdoor electrical repairs during heavy rainfall.

   Reason: Rain water is good conductor of electricity.

2. **Assertion:** Addition of common salt in distilled water makes it conducting.

Reason: Common salt is an example of electrolyte.

3. **Assertion:** Chromium plating is done on many objects such as car parts, bath taps, wheel rims etc.

   Reason: Chromium has a shiny appearance. It does not corrode.

4. **Assertion:** When electric current passes through a conducting solution. The colour of solution may change.

   Reason: The phenomenon of change of colour of a conducting solution is called electroplating.

5. **Assertion:** All material do not conduct electric current.

   Reason: Most of the metals have large number of free electrons, so they conduct electric current.

MATRIX MATCH TYPE QUESTIONS

1. Match the following:

Column - I	**Column- II**
(A) Kerosene	(i) Artificial jewellery
(B) Positive electrode	(ii) Non-electrolyte
(C) Negative electrode	(iii) Anode
(D) Electroplating	(iv) Cathode

(a) (A) – (iv), (B) – (iii), (C) – (ii), (D) – (i)

(b) (A) – (ii), (B) – (iii), (C) – (iv), (D) – (i)

(c) (A) – (i), (B) – (ii), (C) – (iii), (D) – (iv)

(d) (A) – (iii), (B) – (iv), (C) – (i), (D) – (iii)

2. Match the following:

	Column - I	**Column- II**
(A)	The appearance in which electroplating is carried out	(i) Galvanisation
(B)	Deposition of zinc oniron	(ii) Electrolysis
(C)	The process of depositing thin layer of metal with the help of electricity	(iii) Electroplating bath
(D)	The decomposition of a liquid on passing electric current	(iv) Electroplating

(a) (A) – (i), (B) – (ii), (C) – (iii), (D) – (iv)

(b) (A) – (ii), (B) – (iii), (C) – (i), (D) – (iv)

(c) (A) – (iii), (B) – (i), (C) – (iv), (D) – (ii)

(d) (A) – (iv), (B) – (iii), (C) – (ii), (D) – (i)

3. Match the following:

	Column - I	**Column- II**
(A)	Distilled water	(i) Free electrons
(B)	Soap solution	(ii) Poor conductor
(C)	Wood	(iii) Good conductor
(D)	Metals	(iv) Electrolyte

(a) (A) – (iii), (B) – (iv), (C) – (iii), (D) – (i)

(b) (A) – (ii), (B) – (iii), (iv), (C) – (ii), (D) – (i), (iii)

(c) (A) – (i), (B) – (iii), (C) – (ii), (D) – (i), (iii)

(d) (A) – (iii), (B) – (ii), (iv), (C) – (i), (D) – (ii)

ADDITIONAL EXERCISE

1. When a glass rod is rubbed with silk, it acquires a positive charge because :
   (A) Electrons are added to it (B) Protons are added to it
   (C) Protons are removed from it (D) Electrons are removed from it
2. When two bodies are charged together by rubbing each other then both of them acquire:
   (A) Unequal charges (B) Equal and opposite charges
   (C) Unequal and opposite charges (D) None of these
3. Silicon is a :
   (A) Conductor (B) Insulator
   (C) Semi-conductor (D) Super-conductor
4. Materials which allow larger current to flow through the mare called
   (A) Insulators (B) Semi-conductors
   (C) Alloys (D) Conductors
5. Good conductors have many loosely bound :
   (A) Molecules (B) Atoms (C) Protons (D) Electrons
6. Bakelite is a/an:

(A) semi-conductor (B) Conductor

(C) insulator (D) None of the above

7. When the path of current, starting from one terminal of cell, ends at the other terminal of the cell is broken at some point, then such a circuit is called :

(A) closed or complete circuit (B) open or incomplete circuit

(C) either (A) or (B) (D) None of these

8. The S.I. unit of current is :

(A) Coulomb (B) Ampere (C) Volt (D) Ohm

9. Electric current is :

(A) flow of charge per unit time (B) work done per unit time

(C) resistance per unit time (D) all of the above

10 If I is the current through a wire and e is the charge of electron, then the number of electrons in t second will be given by:

(A) $\frac{Ie}{t}$ (B) *Ite* (C) $\frac{e}{It}$ (D) $\frac{It}{e}$

11. Conventionally the direction of the current is taken as :

(A) the direction of flow of negative charge

(B) the direction of flow of atoms

(C) the direction of flow of molecules

(D) the direction of flow of positive charge

12. In an electrolytic cell, the electrode that is connected to the positive terminal of the battery is called:

(A) cation (B) cathode (C) anion (D) anode

13. The process by which a chemical change takes place in a substance when electric current is passed through it is called :

(A) electrolysis (B) electroplating

(C) electrodes (D) thermionic conduction

14. Electroplating is a method of :

(A) making plates using electricity

(B) plating a metal with another metal

(C) coating any object with an electrically conducting plate

(D) coating a metal with another metal bypassing an electric current

15. Cathode is :

(A) positively charged electrode

(B) negatively charged electrode

(C) a positively charged ion formed in the electrolyte

(D) a negatively charged ion formed in the electrolyte

16. Electric bell works on the principle of :

(A) chemical effect of current (B) magnetic effect of current

(C) heating effect of current (D) all of the above

17. Which of the following is an example of non-electrolyte?

(A) NaOH (B) HCl (C) $CuSO_4$ (D) CCl_4

18. The anode during copper plating is :

(A) Copper metal (B) article to be copper plated

(C) iron metal (D) none of these

19. The process of depositing a thin layer of a superior metal over an inferior metal with the help of electric current is called :

(A) electroplating (B) electro refining

(C) electrotyping (D) None of these

20. The process of electrolysis is used in :

(A) extraction of metals (B) electroplating

(C) refining of metals (D) all of these

21. A weak current can be detected by replacing an electric bulb in an electric tester with

(A) LED (B) Magnetic compass

(C) both (A) and (B) (D) none of these

22. A solution of a chemical compound which conducts electric current and at the same time undergoes a chemical change is known as :

(A) Conductor (B) Insulator (C) Electrolyte (D) None of these

23. The process due to which a solution of a chemical compound conducts electric current and at the same time undergoes chemical change is called :

(A) Electrolyte (B) Electrolysis (C) Electrode (D) None of these

24. The negatively charged ion formed when a chemical compound dissolves in water, is known as :

(A) Cation (B) Anion (C) Cathode (D) Anode

25. The positively charged ion formed when chemical compound is dissolved in water is called :
    (A) Anion (B) Cation (C) Cathode (D) Anode
26. A vessel consisting of electrodes and the electrolysis is called :
    (A) Electrolyte (B) Voltmeter (C) Voltameter (D) None of these
27. The magnetic field around a current carrying coil lasts
    (A) for three hours (B) as longer current flows through it
    (C) till its half life period (D) field is permanent
28. Insulators have
    (A) low resistance (B) high resistance
    (C) high conductance (D) all of the above
29. Splitting a compound using electricity is called
    (A) electrolysis (B) electrolyte (C) electrokinesis (D) none of these
30. Which of the following combination of electrodes and electrolyte belong to a secondary cell?
    (A) zinc, carbon and ammonium chloride
    (B) zinc, silver oxide and potassium hydroxide
    (C) lead, lead oxide and sulphuric acid
    (D) copper, zinc and copper sulphate
31. Charge flows between two ends of a conductor when
    (A) same electric potential is present at the two ends
    (B) equal and same type of charges are present at the two ends
    (C) different electric potentials exists at the two ends of a conductor
    (D) the potential difference between the ends is zero
32. The soft-iron ore of an electromagnet loses its magnetism once the current passing through the electromagnetic coil stops because
    (A) domains lose their alignment when the current is stopped
    (B) iron cannot hold alignment for longer time even when the current is passing through the coil
    (C) magnetic properties of iron are weak
    (D) domains inside the iron get aligned in north to south direction
33. In how many parts (equal) a wire of 100Ω be cut so that a resistance of 1Ω is

obtained by connecting them in parallel?

(A) 10 (B) 5 (C) 100 (D) 50

34. Fuse is made up of a wire whose

(A) melting point is greater than those of the metals used in the circuit

(B) melting point is less than those of two metals used in the circuit

(C) resistance is less than the effective resistance of the circuit

(D) none of these

35. The protons inside the nucleus are held together by

(A) Electrostatic force (B) Nuclear force

(C) Gravitational force (D) None of these

36. A body acquires a positive charge by

(A) Gaining protons (B) Gaining electrons

(C) Loosing electrons (D) Loosing protons

37. A body acquires negative charge by

(A) Gaining proton (B) Gaining electrons

(C) Loosing electrons (D) Loosing protons

38. A body acquires negative charge by

(A) Gaining proton (B) Gaining electrons

(C) Loosing electrons (D) Loosing protons

39. A charged body can be used to give opposite charge to an uncharged metallic body by

(A) Induction (B) Conduction (C) Radiation (D) None of these

40. There is no loss of charge in the charging body in case of

(A) Conduction (B) Induction

(C) Both (A) and (B) (D) None of these

41. The charge density (charge per unit area) is

(A) More at sharp edges (B) Same everywhere

(C) Nothing can be said (D) None of these

42. Which is for quantisation of charge?

(A) q = ± n(2e) (B) $q = \pm\left(\frac{n}{2}\right)(e)$

(C) $q = \pm\left(\frac{n}{2}\right)(2e)$ (D) $q = \pm\left(\frac{n}{2}\right)(4e)$

43. 1 μA is equal to

(A) 10^{-3} mA (B) 10^{3} mA (C) 10^{-5} A (D) 10^{-4} A

44. If 5A of current flows for 10 min then the amount of charge that flow in the circuit?

(A) 50 C (B) 3000 C (C) 2000 C (D) 300 C

45. An electric fuse is connected with

(A) neutral wire (B) livewire

(C) earth wire (D) any of the three

46. Alloys are used in heating devices rather than pure metal because alloys have

(A) low melting point and high resistivity

(B) high melting point and low resistivity

(C) low melting point and low resistivity

(D) high melting point and high resistivity

47. The frequency of DC is

(A) 50Hz (B) 60Hz (C) zero (D) None of these

48. Surest test of magnetism is

(A) Attraction (B) Repulsion

(C) Either (A) or (B) (D) None of these

49. Conventional direction of electric current is from

(A) Positive terminal to negative terminal

(B) Negative terminal to positive terminal

(C) Depends on circuit

(D) None of these

CHAPTER

3

Reproduction in Animals

Why Reproduction is Necessary?

All the living organisms grow old with time and ultimately die. In fact, every living organism remains alive on this earth for a limited period of time and then dies. So, new organisms have to be produced in place of those who die. **The production of new organisms from the existing organisms of the same species is known as reproduction**. In most simple words we can say that *reproduction is the creation of new living things* (*from the existing living things*). **Reproduction is essential for the survival of a species on this earth**. So, living organisms produce more organisms of their kind to maintain the life of their species on this earth.

The process of reproduction ensures continuity of life on earth. For example, human beings reproduce by giving birth to babies (sons and daughters). These babies grow and ultimately become adults. So, when the old parents die, their sons and daughters keep living on this earth. These sons and daughters also reproduce by giving birth to more babies, and this process goes on and on. Thus, reproduction by human beings ensures that the human species will continue to exist on this earth for all the time to come.

Types of Reproduction

Each species of organisms reproduces in a different way. Thus, there are two main methods of reproduction in living organisms:

(i) Asexual reproduction and (ii) sexual reproduction

Asexual Reproduction

In asexual reproduction, the offspring arises from a single parent. **The production of a new organisms from a single parent without the involvement of sex cells (or gametes) is called asexual reproduction. Examples of asexual reproduction are: binary fission in *Amoeba;* budding in *Hydra, etc.***

Sexual Reproduction

The male parent contains male sex cells (or male gametes) and the female parent contains female sex cells (or female gametes). **The production of a new organism from two parents by making use of their sex cells (or gametes) is called sexual reproduction.** In sexual reproduction, the sex cell of one parent fuses with the sex cell of the other parent to form a new cell called **'zygote'**. This zygote then grows and develops into new organism. Thus, in sexual reproduction, two parents are needed to produce a new organism. The male and female parents have special organs in them which produce male sex cells and female sex cells respectively (which are required in sexual reproduction). The humans, fish, frogs, etc.**,** all reproduce by sexual reproduction.

ASEXUAL REPRODUCTION

Asexual reproduction takes place by five different methods. These are:

1. Fission
2. Budding
3. Spore formation
4. Regeneration and fragmentation
5. Vegetative propagation.

1. Fission

In the process of fission, the parent organism splits (or divides) to form two (or more) new organisms. Fission is of two types: binary fission and multiple fission, depending on whether the parent organism splits to form two new organisms or more than two organisms. The two types of fission are discussed below:

(i) **Binary Fission:** Binary fission is an asexual method of reproduction of organisms. **In binary fission, the parent organism splits (or divides) to form two new organisms.** When this happens, the parent organism ceases to exist and two new organisms come into existence. Unicellular organisms like *Amoeba, Paramoecium***,** bacteria, etc., reproduce by binary fission. This is described below.

Amoeba reproduces by binary fission by dividing itself into two parts. This happens as follows:

When the *Amoeba* cell has reached its maximum size of growth, then first the nucleus of *Amoeba* lengthens and divides into two parts. After that the cytoplasm of *Amoeba* divides into two parts, surrounding each nucleus. In this way, one

parent *Amoeba* divides to form two smaller Amoebae (called daughter Amoebae). The reproduction in *Amoeba* by binary fission is show in Figure 1.

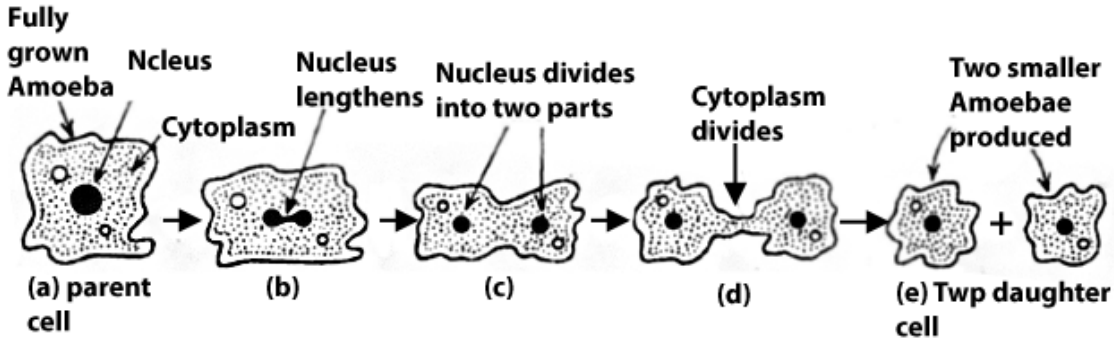


Figure 1. Amoeba reproducing by binary fission

The two daughter Amoebae produced here grow to their full size by eating food and then divide again to produce four Amoebae, and so on. Let us consider the case of *Paramecium* now.

Paramoecium also reproduces by the method of binary fission. A fully grown *Paramoecium* divides its body into two parts to form two smaller Paramecia. This happens by the division of nucleus followed by the division of cytoplasm. The reproduction in *Paramecium* by binary fission is shown in figure. Two small Paramecia produced by binary fission grow to their full size and split again to produce four *Paramoecia.* And this process of reproduction is repeated again and again (fig 2).

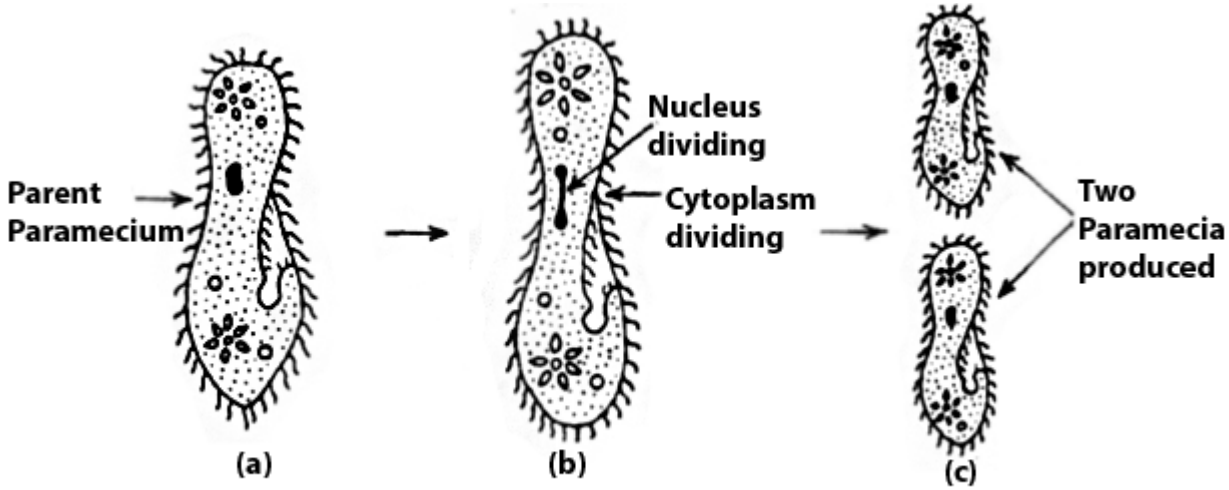


Figure 2. Paramecium reproducing by binary fission

From the above discussion we conclude that the simple animals like *Amoeba* and *Paramecium* reproduce by binary fission. The simple plants like *Spirogyra* and bacteria also reproduce by the method of binary fission.

(ii) **Multiple Fission:** Multiple fission is also an asexual method of reproduction in organisms. **In multiple fission, the parent organism splits (or divides) to form**

many new organisms at the same time. This happens as follows: Sometimes (particularly during unfavourable conditions), a cyst or protective wall is formed around the cell of a single-celled organism (like that of *Plasmodium*). [fig. 3(a)].

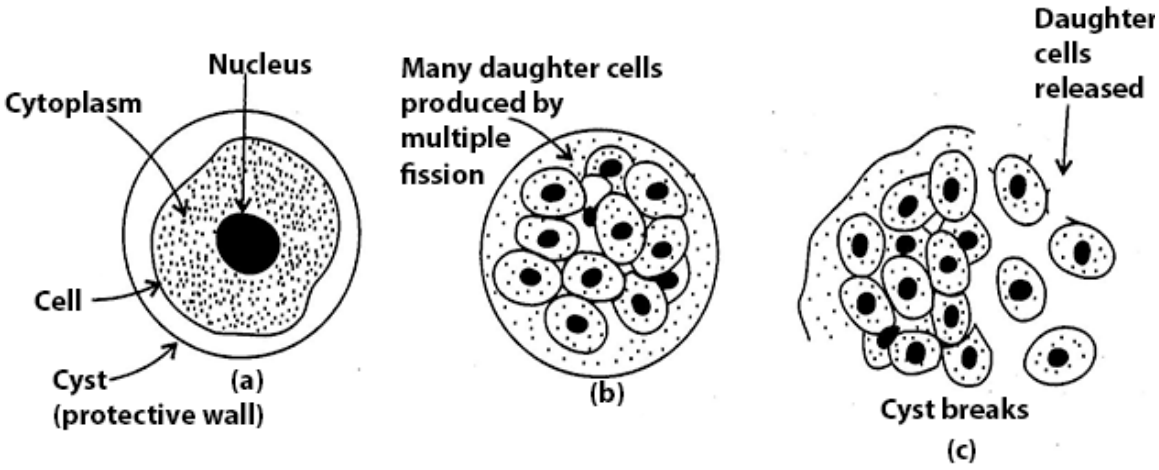


Figure 3. Reproduction by multiple fiision

Inside the cyst, the nucleus of cell splits (or divides) several times to form many smaller nuclei called daughter nuclei. Little bits of cytoplasm collect around each daughter nuclei and thin membranes are formed around them. In this way, many new daughter cells are formed from a single parent cell within the cyst [fig. 3(b)]. When the favourable conditions arrive, the cyst breaks and the new daughter cells present in it are released, each forming a new organism [fig. (c)]. In this way, a single celled parent undergoes multiple fission to reproduce many daughter cells at the same time. About 1000 daughter cells are produced by the multiple fission of one. *Plasmodium* is the malarial parasite which produces malaria disease in human beings.

2. Budding

Budding is an asexual method of reproduction. In budding, a small part of the body of the parent organism grows out as a ‘bud’ which then detaches and becomes a new organism. The asexual reproduction by budding is observed in *Hydra* and yeast. This is described below:

Hydra is a simple multicellular animal [fig. 4 (a)]. *Hydra* reproduces by the process of budding. This happens as follows: In *Hydra*, first a small outgrowth called ‘bud’ is formed on the side of its body by the repeated mitotic divisions of its cells [fig. 4(b)]. This bud then grows gradually to form a small *Hydra* by developing a mouth and tentacles [fig. 4(c)]. And finally the tiny new *Hydra* detaches itself from the body of parent *Hydra* and lives as a separate organism [fig. 4(d)]. In this way, the parent *Hydra* has produced (or created) a new *Hydra*. Thus, *Hydra* reproduces asexually by growing buds from its body. This is called budding. Please note that the bud formed in a *Hydra* is not a single cell. It is a group of cells. We will now describe the

reproduction in yeast plant by the process of budding. Please note that each single cell of yeast is a complete plant in itself.

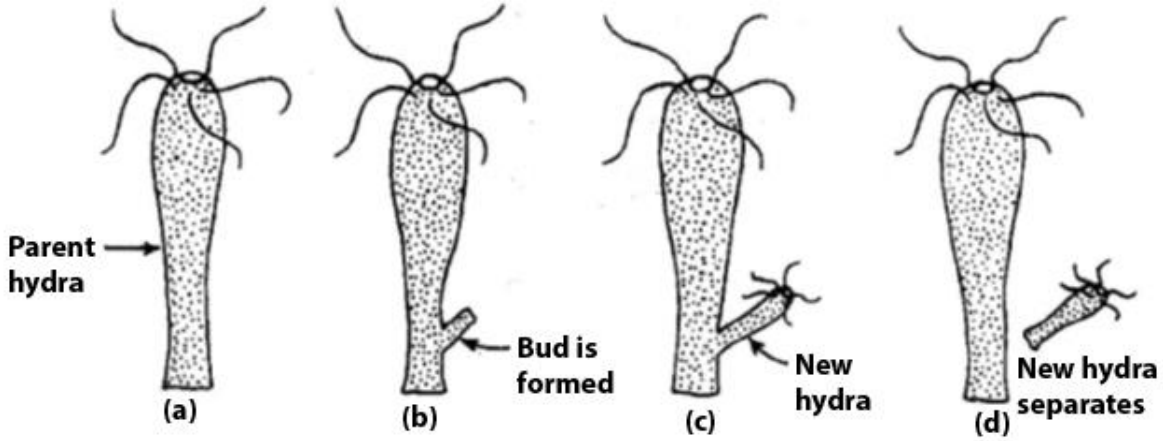


Figure 4. Hydra reproducing by the method of budding

Yeast is tiny, unicellular, non-green plant (which is a fungus). Yeast reproduces by budding [fig. 4(a)] shows a parent yeast cell (which is a complete plant). In yeast, first a bud appears on the outside of the cell wall [fig. 5(b)]. The nucleus of parent yeast cell then divides into two parts and one part of the nucleus moves into the bud [fig. 5(b)]. Ultimately, the bud separates off from the parent yeast cell and forms a new yeast cell (or new yeast plant) [fig. 5(c)].

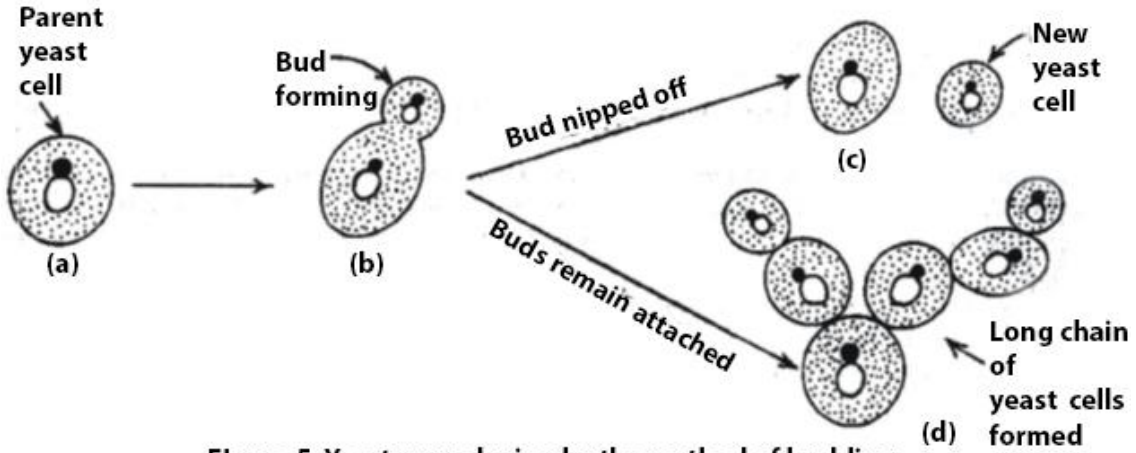


FIgure 5. Yeast reproducing by the method of budding

The budding in yeast, however, often takes place so fast that the first buds start forming their own buds and all of them remain attached to the parent yeast cell forming a chain of yeast cells. [fig. 5(d)]. After sometime, all the yeast cells of the chain separate from one another and form individual yeast plants. In some organisms like sponges and corals, the buds remain attached to the parent organism permanently. These buds then grow and produce buds of their own. In this way, **a colony of sponges or corals is formed.**

3. Spore Formation

Spore formation is method of asexual reproduction in this method of reproduction new organisms developed from reproductive structures called spores. Most of the fungi and bacteria reproduce by spore formation. e.g., *Rhizopus*, *Mucor,* etc.

Definitions

- **Hypha:** The fine thread like structures which make up the body of fungi and many non-green plants are called hyphae (singular: hypha).
- **Sporangiophore:** From the horizontal hyphae some stand erect, such erect hyphae (or vertical hyphae) are called sporangiophores.
- **Sporangia:** These are knob like structures present at the tip of sporangiophores.

Spores: Spores are the microscopic asexual or sexually produced reproductive bodies which are covered by a hard protective coat.

Characteristic features of spores:

(i) Spores are covered with a thick coat that enables them to survive under unfavourable conditions like lack of food, lack of water and extreme temperatures. When the conditions are favourable (food and water is available, and temperature is suitable), then the spores grow to produce new fungi or plants. Thus, spores play the same role as seeds do for higher plants.

(ii) These spores are very light and keep floating in air all around us. They are so small that we cannot see them with naked eyes. Spores are produced in sporangia of *Rhizopus* (common bread mould), *Mucor* (pin mould) and *Penicillium* (blue-green mould).

Spore formation: During the growth of a fungus (like *Rhizopus*), tiny round, bulb-like structures called sporangia develop at the top of the erect hyphae called sporangiophore. The nucleus divides several times within the sporangium and around each newly formed nucleus small amount of cytoplasm accumulates which eventually develops into a spore. When the sporangium of the fungus bursts, then the spores spread into air. When these air-borne spores land on suitable substratum under favourable conditions (like damp and warm conditions), they germinate and produce new fungus or plant. Hundreds of tiny

spores are produced by fungi or lower plants like ferns which can then produce new fungi or plants.

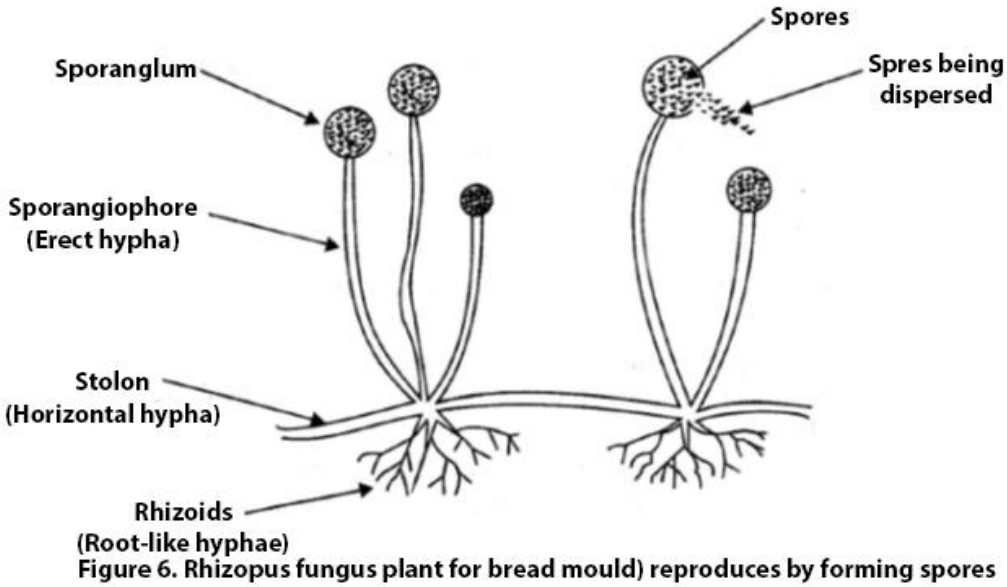


Figure 6. Rhizopus fungus plant for bread mould) reproduces by forming spores

4. Regeneration and Fragmentation

Regeneration is an asexual method of reproduction in animals. In this method new organisms can be obtained from the cut pieces of the body of the parent organism as each part regenerates the lost parts and develops into adult. The organisms like *Hydra,* Star fish*, Spirogyra* and sponges show regeneration.

If the body of *Hydra* gets cut into two or more pieces, each piece of the body of *Hydra* can regenerate into a complete *Hydra* by growing all the missing parts. This is shown clearly in Figure 7.

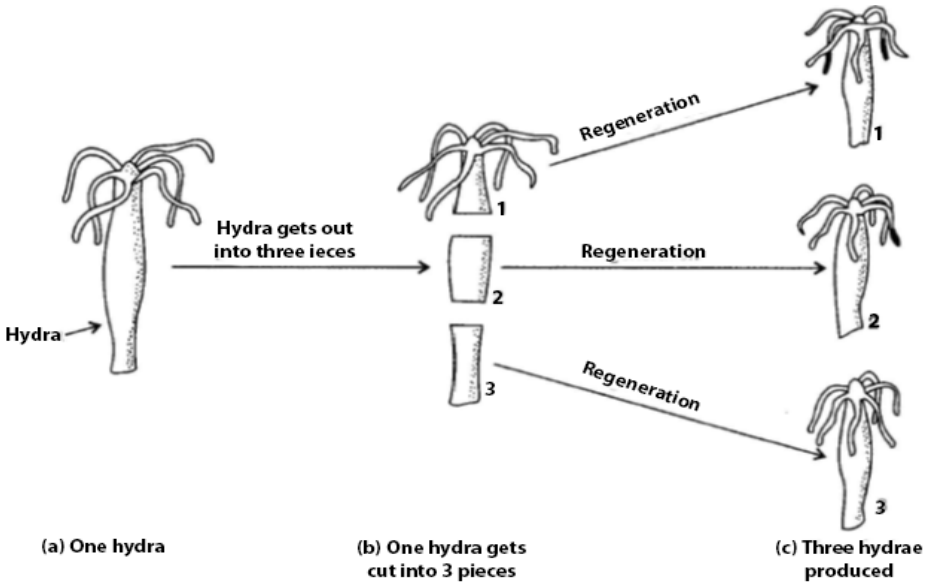


Figure 7. Regeneraiton in hydra

The bodies of some of the multicellular organisms break up easily into small pieces (or fragments), each one of which develops into complete new organism. **The breaking of a multicellular organism into two or more parts (on its own), each of which grows to form a new organism, is called fragmentation.** Fragmentation is special case of regeneration in which a parent multicellular organisms on maturing breaks up naturally to produce two or more fragments that developed into mature fully grown individual. **So, fragmentation is a method of asexual** reproduction. The organisms *Planaria* (flatworm) and *Spirogyra* (algae) can reproduce by the method of regeneration (or rather fragmentation). This point will become clearer from the following example.

Figure 8(a) shows a *Planaria* worm. This *Planaria* grows and matures [fig. 8(b)]. On maturity, the body of *Planaria* breaks up into three parts on its own, each of which develops to form a new *Planaria* worm [fig. 8(c)].

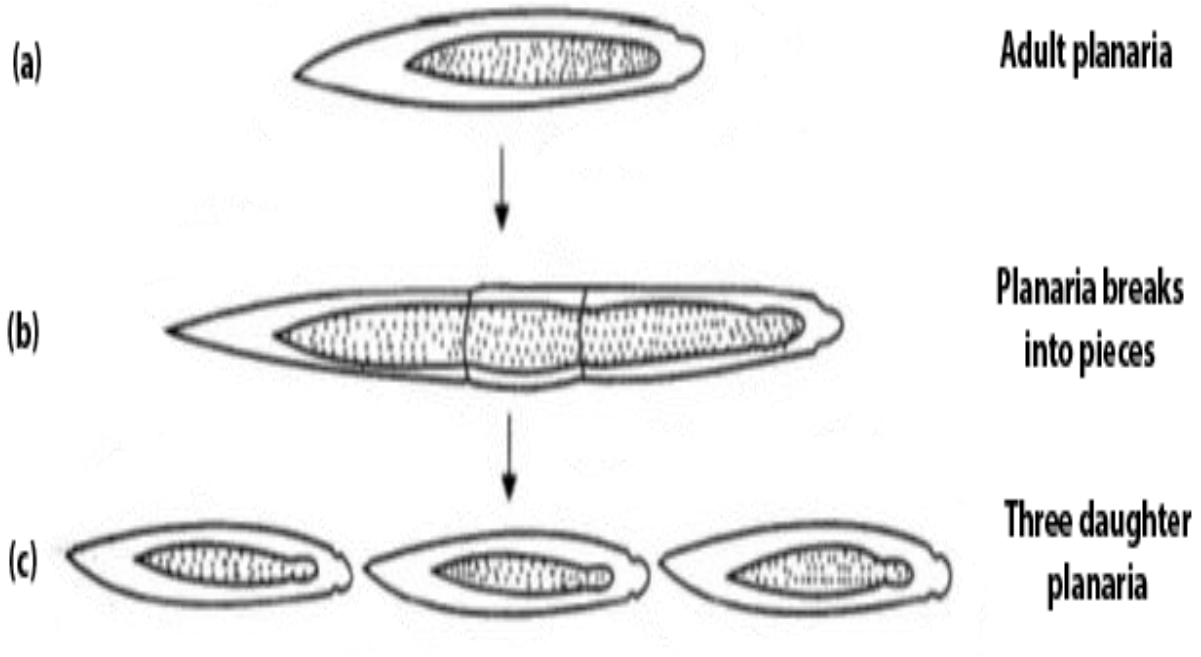


Figure 8. Asexual reporoduction in planaria worm by regenaration (or fragmentation)

Spirogyra (which is an alga) breaks up into two or more fragments on maturity, and each fragment grows into a new *Spirogyra*. This is called fragmentation. Thus, *Spirogyra* also reproduces by the asexual method of fragmentation (which is a kind of regeneration).

The main difference between fission and fragmentation is that in fission, a unicellular organism breaks up to form two (or more) daughter organisms, whereas in fragmentation, a multicellular organism breaks up to form two (or more) daughter organisms.

5. Vegetative Propagation

Vegetative propagation is an asexual method of propagation in some higher plants. In this method of reproduction, a new plant develops from the vegetative part of a plant such as a stem, root or leaf. **In vegetative propagation, new plants are obtained from the parts of old plants (like stems, roots and leaves), without the help of any reproductive organs.** Vegetative propagation usually involves the growth and development of one (or more) buds present on the old part of the plant to form a new plant. These buds are in the dormant state (inactive state) in the old part of the plant. When provided suitable conditions (like moisture, warmth, etc.), these buds grow to form new plants. It is a common observation that green grass plants spring up in dry fields after the rains. This happens due to vegetative propagation. The fields have dry stems of the old grass plants all over them. These dry stems have buds which are in the inactive state. By getting rain water, the buds present on dry grass stems get activated and grow to produce new grass plants. Thus, the green grass grows in the fields after rains from the dry, old stems of grass plants present in the fields, by the method of vegetative propagation.

Buds are present on the stems and can be present on roots or leaves of some plants like in *Bryophyllum*. In this plant buds are present on leaves along the margin in the notches. *Bryophyllum* plants can reproduce by vegetative propagation by using either a piece of its stem or its leaves. For example, if we plant a cut piece of the stem of a *Bryophyllum* plant in the ground, we will get a new *Bryophyllum* plant growing from it in a week's time. Even the leaves of a *Bryophyllum* plant can produce new plants. This is because the leaves of a *Bryophyllum* plant have special type of buds which get detached from the leaves, fall to the ground and then produce new *Bryophyllum* plants.

The roots of a guava plant have buds which can develop into new guava plants. In fact, a large number of plants can be reproduced by the method of vegetative propagation. Some of the examples of the plants which can reproduce by vegetative propagation are *Bryophyllum,* Guava, Potato, Onion, Banana, Garlic, Water Hyacinth, Tulip, Mint, Strawberry and Lily. Vegetative propagation is practiced by man in number of plants. Such methods of artificial propagation of plants are used in agriculture, for raising crops and horticulture (cultivation of vegetables, fruits and flowers). The three common methods for the artificial vegetative propagation are:
(i) Cuttings (ii) Layering and (iii) Grafting

Cuttings

A part of the plant which is removed by cutting it, is called a 'cutting'. A cutting may be a piece of stem, root or leaf (or even a bulb scale). In this method, a cutting of the plant (say, of stem) is buried partly in the moist soil. After some time, the cutting develops

roots and grows into a new plant (which is exactly similar to the parent plant). For example, *Chrysanthemum* plants are propagated (or reproduced) by means of cuttings from stems (or shoots) as follows: A piece of stem is cut from an existing *Chrysanthemum* plant and its lower part is buried in moist soil. After some time, this cutting develops roots and grows to become a new *Chrysanthemum* plant. Many horticultural plants like rose plants, *Chrysanthemum*, grapes, *phalsa* and *Geranium* are often propagated (or reproduced) by means of cuttings.

Layering

In this method, a branch of the plant is pulled towards the ground and a part of it is covered with moist soil leaving the tip of the branch exposed above the ground. After some time, new roots develops from the part of the branch buried in the soil. The branch is then cut off from the parent plant. The part of the branch which has developed roots grows to become a new plant (just like the parent plant). Jasmine plant (*chameli*) is propagated or produced by the layering method is shown in figure.

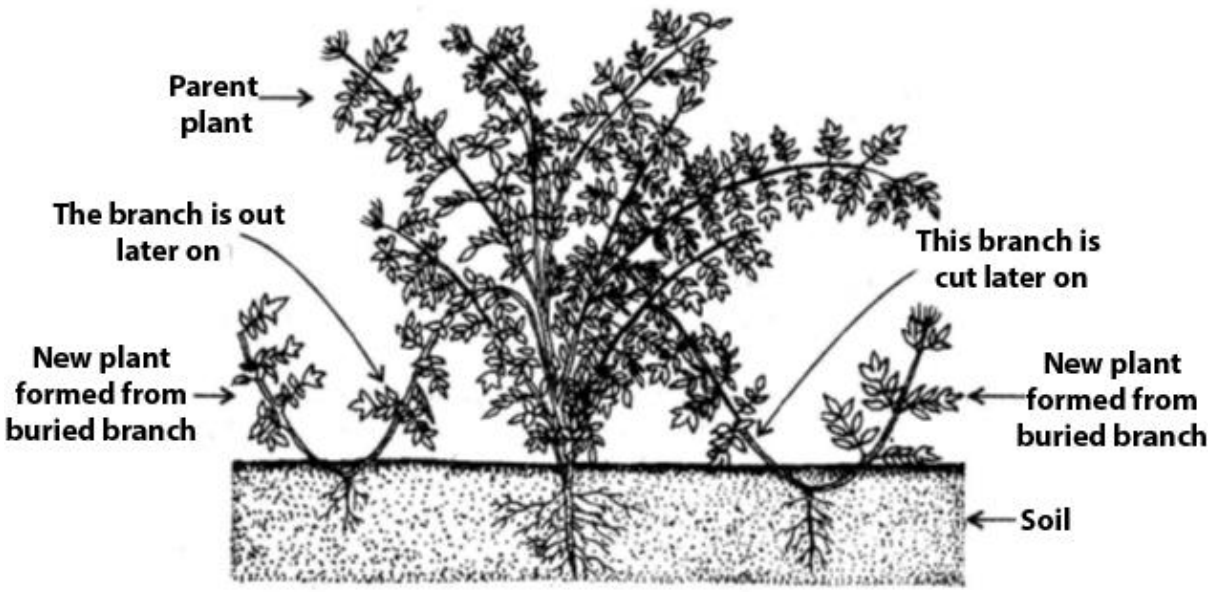


Figure 9. The propagation of jasmine plants (chameli) by the layering method

The layering method is used for the propagation (or reproduction) of plants like: Jasmine, Strawberry, Lemon, Guava, *Hibiscus* (China rose), *Bougainvillea*, *Mogra* and many slender ornamental plants.

Grafting

Grafting is a method in which the cut stems of two different plants (one with roots and the other without roots) are joined together in such a way that the two plant stems join and grow as a single plant (which will have the characteristics of both the original plants). The cut stem of a plant having roots (which is fixed in the soil) is called **stock.** Stock is the lower part of a plant having the root system. The cut stem of another plant (without

roots) is called **scion**. Scion is the upper part of a plant which may have leaves on it (but no roots).

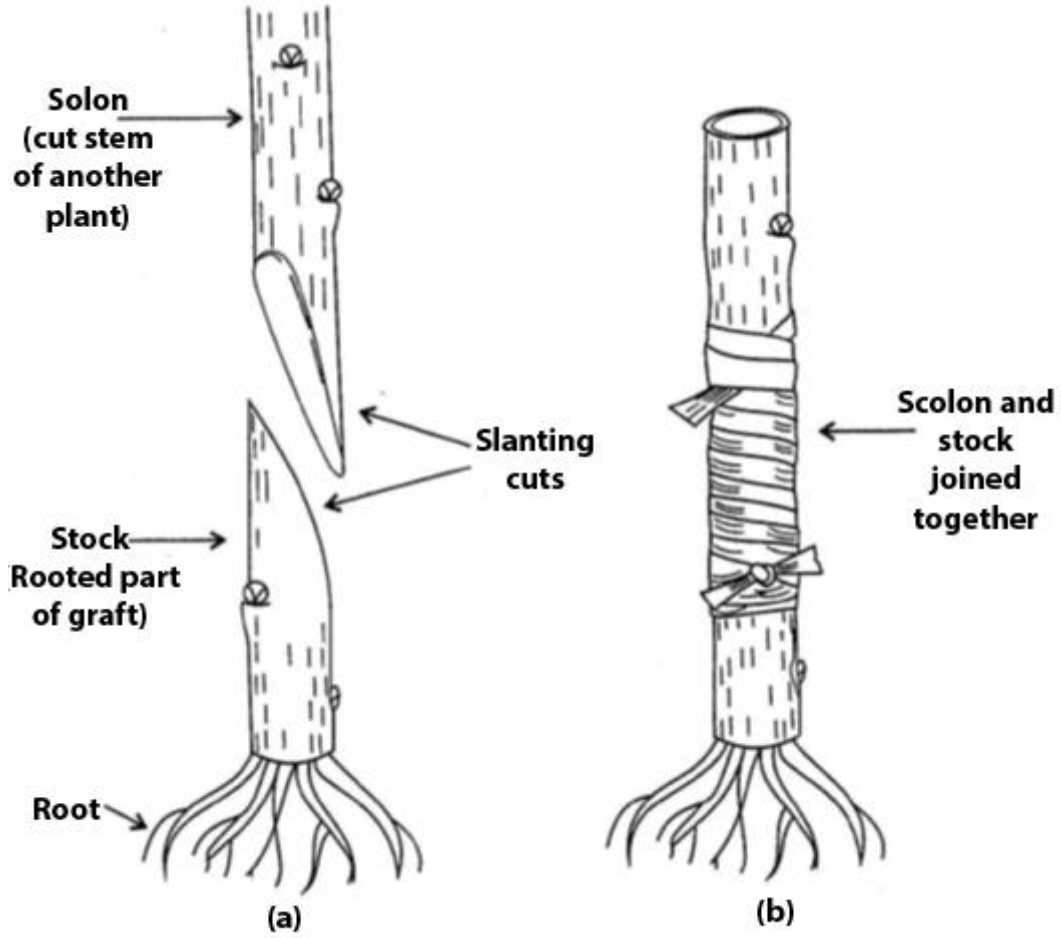


Figure 10: The grafting method for the artificial propagation of plants

In the grafting method, the stock and scion chosen for grafting should be equal in diameter. Slanting cuts are made in the stock and scion as shown in figure 10(a). The two cut surfaces of the scion and stock are fitted together and bound tightly with a piece of cloth and covered with polythene sheet (so as to prevent harmful infection by bacteria and the loss of water and plant sap from the cut and joined ends of stock and scion) [fig. 10(b)]. While joining the scion to the stock, care should be taken to make sure that the cambium of scion is in contact with the cambium of stock (because cambium layer in the stem is responsible for growth). By grafting method, a very young scion (shoot part of a plant) can be made to flower and produce fruits quite fast when it is grafted to the stock (stem having roots) of a mature tree.

Sometimes, scions from different varieties of plants are grafted on the same stock to obtain flowers and fruits having different desired characteristics. For example, we can graft the scions of varieties like sweet orange, lemon, lime and grape fruit on the same citrus root stock to obtain more varieties of these fruits. In fact, by using the grafting

techniques, desired variety and quality of fruits can be obtained. Many varieties of mango have been produced by grafting.

Advantages of Artificial Vegetative Propagation

The artificial propagation of farm and garden plants has several advantages. Some of the important advantages of the artificial vegetative propagation of plants are given below:

1. The new plants produced by artificial vegetative propagation will be exactly like the parent plants. Any desirable features of the parent plant will be replicated in the new plants.
2. The fruit trees grown from seeds may take many years before they start to bear fruit. But the fruit trees grown from cuttings or by grafting start to bear fruits much earlier (only after a few growing seasons).
3. The plants grown by vegetative propagation usually need less attention in their early years than the plants grown from seeds.

SEXUAL REPRODUCTION IN ANIMALS

In order to understand the sexual reproduction, we should know the meanings of some important terms like gametes, sperms, ova (or eggs), fertilisation, zygote and embryo, which are involved in sexual reproduction. These are discussed below:

Gametes

Sexual reproduction takes place by the combination of special reproductive cells called ‘sex cells’. These sex cells are known as ‘gametes’. We can now say that: **The cells involved in sexual reproduction are called gametes.** Gametes are of two types: male gametes, and female gametes. The male gamete in animals is called ‘sperm’ and the female gamete in animals is called ‘ovum’ or ‘egg’. Sperms and ova (or eggs) are extremely small cells which can be seen only with the help of a high power microscope. Please note that a female gamete (or female sex cell) is known by two names: ovum and egg.

The cell which is formed by the fusion of a male gamete and a female gamete is called zygote. In most simple words, *zygote is a ‘fertilised ovum’ or ‘fertilised egg’*. All the multicellular animals start their life from a zygote through sexual reproduction. The process of fusion of gametes is called *fertilization*.

Fertilisation

The fusion of a male gamete with a female gamete to form a zygote during the sexual reproduction, is called **fertilisation**. The zygote (or fertilised egg) grows and develops to form a new baby. The stage of development between the zygote (fertilised egg) and the newly formed baby is called **embryo**.

Internal and External Fertilisation

The fertilisation which occurs inside the female body is called internal fertilisation. In internal fertilisation, the female animal's eggs are fertilised by sperms inside her body. In mammals (including human beings), birds and reptiles, the fertilisation occurs inside the female body. In internal fertilisation, the male animal puts his sperms into the female animal's body at the time of copulation (or mating). During copulation, very large number of sperms are discharged into the female body. These sperms fertilise the eggs inside her body.

The fertilisation which occurs outside the female body is called external fertilisation. In external fertilisation, the female animal's eggs are fertilised by sperms outside its body. In amphibians (like frogs and toads) and fishes, the fertilisation of eggs occurs outside the female animal's body. In external fertilisation, the male and female animals release their sperms and eggs in water where fertilisation takes place by collisions between sperms and eggs.

Unisexual Organisms

For sexual reproduction, involvement of two sexes, male and female is essential. In most of the higher animals, sexes are separate. That is, some animals are males whereas other animals are females. **An organism which possesses only one kind of reproductive organs (male or female) in its body, is called a unisexual organism.** For example, humans are unisexual organisms. Some of the humans are male whereas other humans are females. The male humans (called men) have only male reproductive organs called 'testes' in their body. And the female humans (called women) have only female reproductive organs called 'ovaries' in their body. No human can have both types of sex organs (male and female) in its body. In fact, most of the higher animals are unisexual (having one sex only). In addition to **humans, frogs, birds, fishes and reptiles (like lizard), etc., are all unisexual organisms**. Unisexual animals can produce only one kind of gametes in them. These can be either male gametes or female

gametes. Gonads are the primary sex organs. The gonads produce gametes (or sex cells) by meiotic division (or reduction division). Testis is the male gonad which produces male gametes called *sperms*. Ovary is the female gonad which produces female gametes called *ova* or *eggs*.

Bisexual Organisms (Hermaphrodites)

There are some animals which possess both, male and female reproductive organs in the same body. **An organism which possesses both male and female reproductive organs in its body is called a hermaphrodite.** Thus, hermaphrodites are bisexual organisms (having two sexes in the same body). **The animals like earthworms, tapeworms, starfish and leeches; and most of the flowering plants are bisexual organisms or hermaphrodites** (because they have both male as well as female organs in the same body). So, the same earthworm behaves as a male and as a female. Similarly, the same leech will behave as a male as well as a female for the purpose of reproduction. Hermaphrodite produce both kinds of gametes (male gametes as well as female gametes) in the same body. The flowers in most of the plants are bisexual.

The Advantages of Sexual Reproduction

1. Since the fusing gametes come from two different and sexually distinct individuals, the offsprings exhibit **diversity of characters**.
2. Meiosis during gamete formation provides opportunities for new combination of genes. It plays a prominent role in the origin of species.
3. Gamete formation, inside the gonads of diploid organisms, involves meiosis or reduction division. The gamete mother cell is **diploid** (2n), i.e., it has two sets of chromosomes. This single dipolid cell divides by meiosis to form 4 **haploid** (n) daughter cells. Each daughter cell becomes a gamete, either male or female. Fusion of these gametes results in the formation of slightly different individuals which show **variations**.

How Sexual Reproduction in Animals Takes Place

Sexual reproduction is the most common method of reproduction in animals (including human beings). The sexual reproduction in animals takes place in the following steps:

1. The male parent produces male gametes (male sex cells) called sperms. The sperm is a small cell with a long tail (flagellum) for movement [figure 11(a)].

2. The female parent produces female gametes (female sex cells) called ova (or eggs). The ovum (or egg) is a much bigger cell than the sperm, having a lot of cytoplasm [Figure 11(a)].
3. The sperm enters into the ovum (or egg) and fuses with it to form a new cell called 'zygote' [Figure 11(b) and (c)]. This process is called fertilisation. So, the zygote is a fertilised ovum (or fertilised egg).
4. The zygote then divides again and again to form a large number of cells. And ultimately zygote grows and develops to become a new baby.

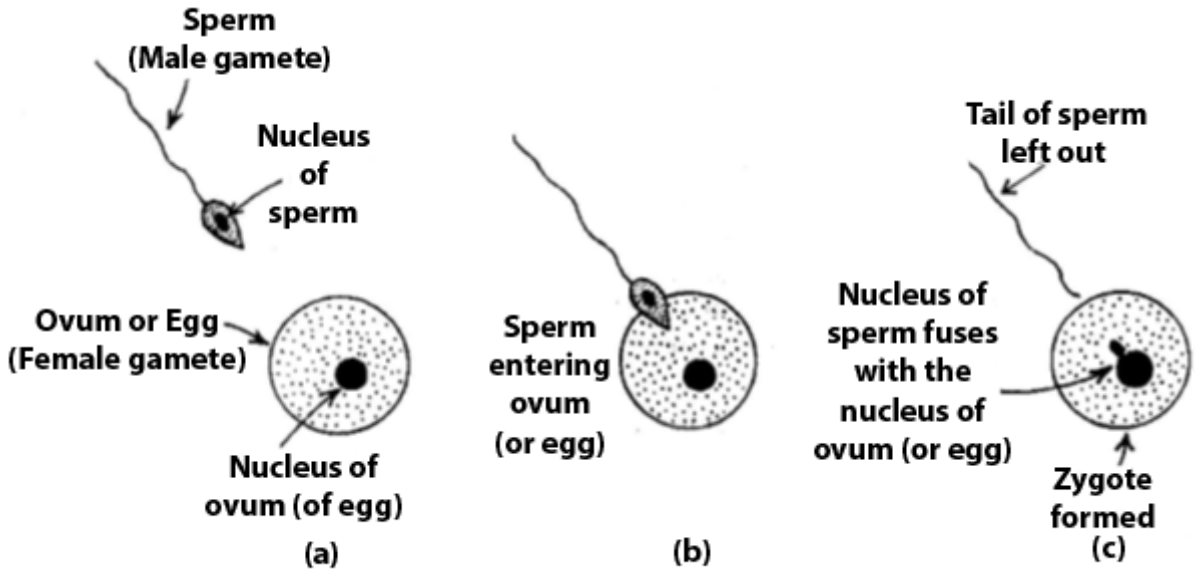


Figure 11. Fertilisation of an ovum (or egg) by a sperm to form a zygote

Human Reproductive System

The organs associated with the process of reproduction in human males and human females are different. The reproductive systems in human beings becomes functional (or start functioning) at a definite age called *puberty*. **The age at which the sex hormones (or gametes) begin to be produced and the boy and girl become sexually mature (able to reproduce) is called puberty.** Puberty tends to start earlier in females (girls) than in males (boys) On attaining puberty, the male gonads called testes start producing male gametes called sperms and the female gonads called ovaries start producing female gametes called ova (or eggs). In addition to producing sex cells (or gametes) male and female gonads (testes and ovaries) also secrete sex hormones with the onset of puberty. The testes produce the male sex hormone called *testosterone*, and the ovaries produce two female sex hormones, *estrogen* and *progesterone*. The sex hormones play an important role in the process of reproduction.

THE MALE REPRODUCTIVE SYSTEM

The human male reproductive system consists of the following organs: Testes, Scrotum, Epididymis, Vas deferens (or Sperm ducts), Seminal vesicles and Penis. The human male reproductive system is shown in fig. 12. Testes are the oval shaped organs which lie outside the abdominal cavity of a man (fig. 12). A man has two testes (singular of testes is testis). **Testes are the primary reproductive organs in man.** The function of testes is to make the male sex cells (or male gametes) called sperms and also to make the male sex hormone called testosterone. Note that the testes of a man make the sex gametes (or sperms) from puberty onwards, throughout his life. The testes of a man lie in small muscular pouch called *scrotum*, outside the abdominal cavity (fig. 12). The testes are outside the abdominal cavity of the body (and not deep inside the body), because the sperm formation is very sensitive to temperature. The temperature of scrotum is 1 to 3°C lower than the temperature inside the body. In this way, the testes provide an optimal temperature (most suitable temperature) for the formation of sperms.

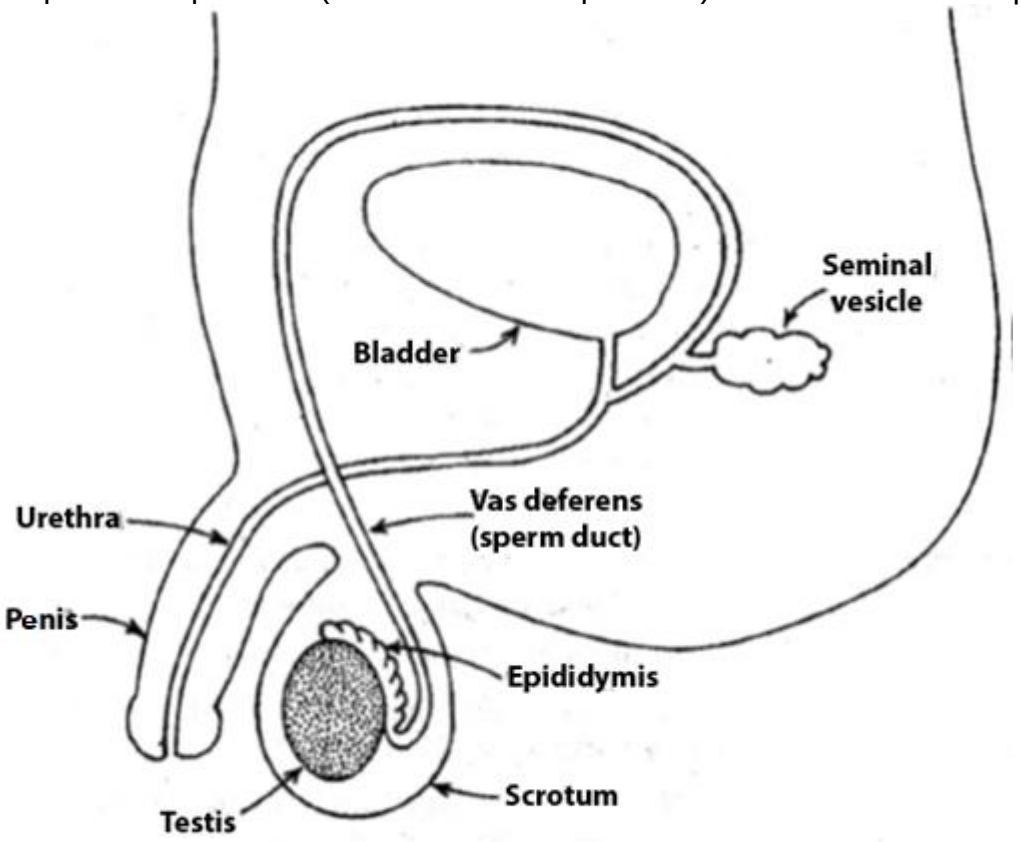


Figure 12. The male reproductive system is human (side view)

The sperms formed in testes come out and go into a coiled tube called *epididymis*. The sperms get stored temporarily in epididymis. From epididymis, the sperms are carried by a long tube called *vas deferens* (or *sperm duct*) into glands called *seminal vesicles*. The sperms get stored in seminal vesicles. The seminal vesicles join to another tube called urethra coming from the bladder. Urethra carries the sperms to an organ called *penis* which opens outside the body. (These sperms are carried in a liquid called *semen*). The

penis passes the sperms from the man's body into vagina in the woman's body for the purpose of reproduction.

Please note that in man (or human male) there is only one opening for the urine and sperms to pass out of the body.

THE FEMALE REPRODUCTIVE SYSTEM

The human female reproductive system consists of the following organs: Ovaries, Fallopian tubes (which are also called oviducts). Uterus, Cervix and Vagina. Ovaries are the primary reproductive organs in a woman (or female). The function of ovaries is to make the female sex cells (or female gametes) called 'ova' or 'eggs', and also to make the female sex hormones (called estrogen and progesterone). Just above the ovaries are the tubes called fallopian tubes (oviducts). The ovum (or egg cell) released by an ovary goes into the fallopian tube through its funnel-shaped opening.

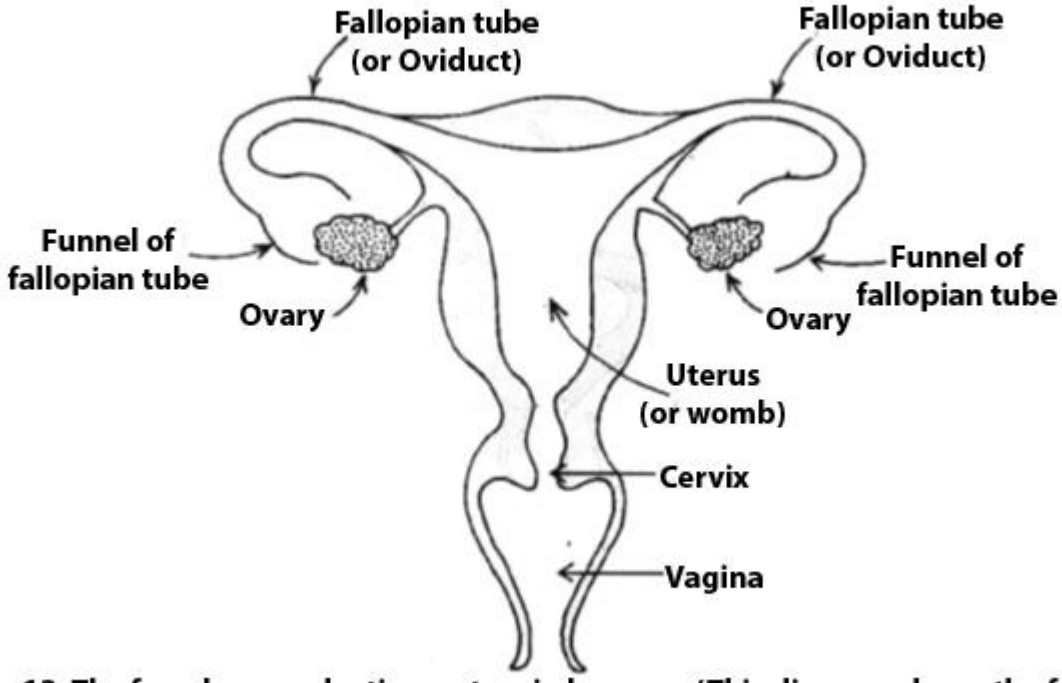


Figure 13. The female reproductive system in humans. (This diagram shows the front view of the female reproductive system)

The fertilisation of egg (or ovum) by a sperm takes place in the fallopian tube (or oviduct). The two fallopian tubes connect to a bag like organ called *uterus* (or womb). The uterus is connected through a narrow opening called cervix to another tube called vagina which opens to the outside of the body (fig. 13). Vagina receives the penis for putting sperms into the woman's body. Vagina is a tubular structure. Vagina is also called '*birth canal*', because it is through this passage that the baby is born after the

completion of development inside the uterus of the mother. Please note that in woman (or human female) the opening for passing out urine (called urethra) and the vaginal opening are separate.

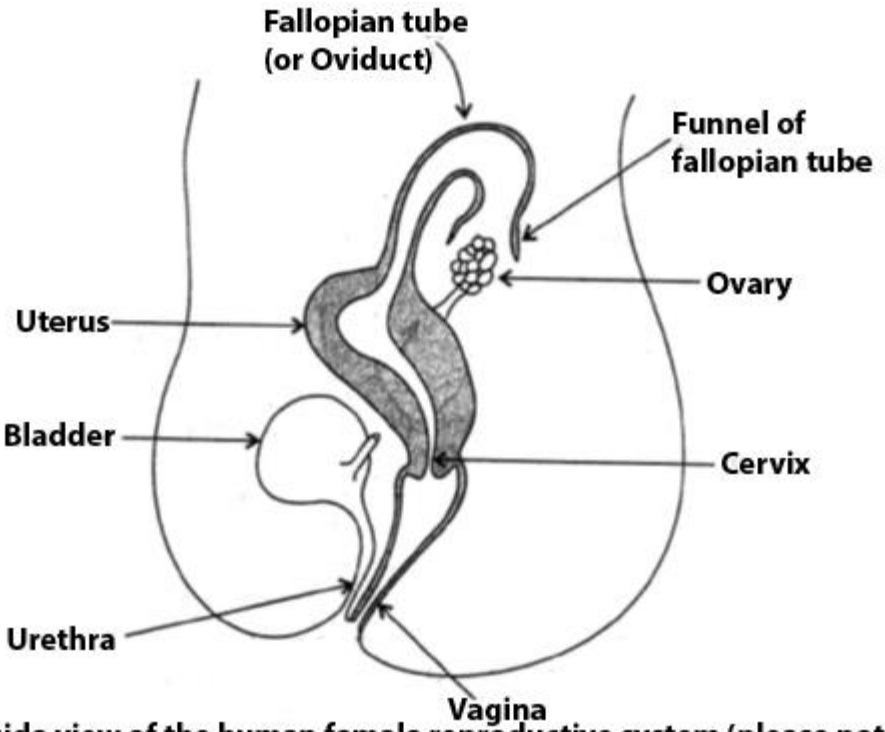


Figure 14. The side view of the human female reproductive system (please note that only one falopian tube can be shown in this side view. Also note the the separate opening for urine (urethral) and vagina

When a girl reaches the age of puberty, then each ovarian follicle develops at a time to form a mature ovum (or egg). On maturing, the follicle bursts and the ovum (or egg) shoots out of the ovary. This is called ovulation. Thus, **the release of an ovum (or egg) from an ovary is called ovulation.** In a normal, healthy girl (or woman), ovulation takes place on the 14th day of the menstrual cycle of 28 days. This means that ovulation takes place in the middle of the menstrual cycle (because 14th day is the middle of 28 days). In human females (or girls), the ovaries start releasing ovum or egg (female gamete) once every 28 days from the age of puberty. Please note that ovulation does not take place every day after puberty. It takes place after a period of every 28 days (which is almost once a month).

Sexual Cycle in Females: Menstruation

The sexual cycle in females (or women) is called menstruation or menstrual cycle. This is described below:

1. When a girl reaches puberty at the age of about 12 years, the sex hormones released into her blood cause some of the ova (or egg cells) in her ovaries to become mature (or ripe).
2. Usually one mature ovum (or egg) is released from the ovary into the fallopian tube (or oviduct) once every 28 days. This is called **ovulation**.
3. Before ovulation (or release of ovum), the inner lining of uterus becomes thick and spongy and full of tiny blood vessels (or blood capillaries), and prepares itself to receive the fertilised ovum or egg (in case it gets fertilised by sperm).
4. If the ovum (or egg) does not get fertilised (due to non-availability of sperm in the female body) then the thick and soft inner lining of uterus is no longer needed and hence it breaks. So, the thick and soft inner lining of uterus along with the blood vessels and the dead ovum (or egg) comes out of the vagina in the form of a bleeding called **menstruation**.
5. Menstruation usually occurs 14 days after ovulation and usually lasts for about 3 to 5 days.
6. After menstruation is over, the inner lining of the uterus starts building up again so that it may become ready to receive the next ovum (or egg) in case it gets fertilised.
7. If the ovum (or egg) does not get fertilised even now, then menstruation takes place again. This cycle of menstruation is repeated again and again in women after every 28 days (till the time ovum gets fertilised). **The menstrual cycle is controlled by hormones.**

Menstruation stops when the ovum (or egg) gets fertilised and the woman gets pregnant. This is because in this case the thick and soft lining of the uterus containing lot of blood vessels is needed for the growth and development of fertilised ovum (or fertilised egg cell) to form a baby. Menstruation restarts after the birth of the baby. Menstruation stops permanently when a woman reaches the age of around 50 years.

The beginning of menstruation at puberty is called menarche. The start of menstruation marks the beginning of the reproductive life of a woman (when she is biologically prepared to bear children). Menstruation stops temporarily when the woman is pregnant. In fact, both ovulation and menstruation stop till the birth of the baby and restart after that.

The age at which the menstruation stops and a woman loses her ability to bear children is called menopause. Menopause occurs in women around the age of 50

years. The period between menarche and menopause (which is usually from 12 years to about 50 years) is the normal reproductive life in women (or human females). She can bear children only during this period.

Fertilisation

In human beings, internal fertilisation takes place. The sperms (or male gametes) made in the testes of man are introduced into the vagina of the woman through penis during copulation (or mating). In this way, millions of sperms are released into the vagina at one time. The sperms are highly active and mobile (moving). The sperms move up through cervix into the uterus. From uterus, the sperms pass into the fallopian tubes.

One of the fallopian tubes contains an ovum (or egg cell) released by the ovary during ovulation. Only one sperm fuses with the ovum (or egg) in the fallopian tube to form a zygote. This is called fertilisation. Thus, the fertilisation of the ovum (or egg) takes place in the fallopian tube. Please note that fertilisation can occur only if copulation (to release sperms) takes place during the ovulatory period (middle of the menstrual cycle) of a woman. Once the ovum (or egg) gets fertilised by sperm, the woman in said to be pregnant. As soon as fertilisation takes place (or pregnancy begins), the menstruation stops.

The time period from the fertilisation up to the birth of the baby is called gestation.

The average gestation period in humans (or the average duration of human pregnancy) is about 40 weeks or 280 days. It is calculated from the first day of the last menstrual cycle). During the gestation period, the foetus grows to become a baby. Birth begins when the strong muscles in the walls of the uterus start to contract. The contraction of uterus muscles gradually pushes the baby out of the mother's body through vagina (or birth canal). This process of birth is called **parturition** (which is commonly called labour).

Differences between sexual reproduction and asexual reproduction

	Sexual Reproduction		**Asexual Reproduction**
1.	It involves two parents.	1.	It involves single parent.
2.	Special sexual organs are present in male and female individuals called male and female reproduction organs.	2.	No special organ is needed.
3.	Involves sperm and ova, gametes produced by male and female respectively.	3.	No involvement of sperm and ova.
4.	It is mostly found in higher animals and plants	4.	It is mostly in unicellular and lower animals and plants.
5.	Eg. In humans or multicellular	5.	Eg. Budding in case of ***Hydra*** etc.

	organisms		
6.	Asexually produced offsprings are genetically similar to the parent while sexually produced offsprings show genetic variations with their parents.		

Population Control

The population of our country is increasing rapidly day by day. Though our country has sufficient food resources but still many people do not get sufficient food for their large families (having many children) due to poverty. So, every year it is becoming very difficult for our Government to provide sufficient food, adequate clothing, good housing and proper education to every citizen of the country. It is, therefore, very important for the couples (husbands and wives) who are in the reproductive stage of their lives to control the size of their families by having fewer children by practicing family planning.

Family planning can be done by practicing birth control which can be done by preventing pregnancy in females (or women). And pregnancy can be prevented by adopting a method or procedure by which sperms produce during copulation between man and his wife can be prevented from meeting the ovum (or egg) and fertilising it. It is possible to prevent fertilisation (and hence prevent pregnancy) because the ovum is available for fertilisation only for a short period. Since frequent pregnancies have a very bad effect on the mother's health, and also add to our already exploding population, so a number of techniques or methods have been developed to prevent pregnancies in women.

The prevention of pregnancy in women (by preventing fertilisation) is called *contraception*. And any device or chemical (drug) which prevents pregnancy in woman is called *contraceptive*. All the birth control methods can be broadly divided into three categories:

1. Barrier methods 2. Chemical methods, and 3. Surgical methods

Barrier Methods: In the barrier methods of preventing pregnancy, the physical devices such as condoms and diaphragm (or cap) are used. Condoms are used by males and diaphragm is used by females. These devices prevent the sperms from meeting the ovum (or egg) by acting as a barrier between them.

Chemical Methods: In the chemical methods of preventing pregnancy, the females use two types of pills: oral pills and vaginal pills, which are made of specific drugs.

The oral pills contain hormones which stop the ovaries from releasing ovum (or eggs) into the fallopian tube. Oral pills are also called *Oral Contraceptives* (written in short as OC). The vaginal pills contain the chemicals called *spermicides* which kill the sperms.

Surgical Methods: Surgical method of birth control are available for males as well as females. In males, a small portion of the sperm duct (or vas deferens) is removed by surgical operation and both the cut ends are ligated (or tied) properly. This prevents the sperms from coming out. The surgical procedure carried out in males is called '*vasectomy*'. In females, a small portion of the fallopian tubes (or oviducts) is removed by surgical operation and the cut ends are ligated (or tied). This prevents the ovum (or egg) from entering into the fallopian tubes. The surgical procedure carried out in females is called '*tubectomy*'.

Intra-Uterine Contraceptive Device (IUCD): The use of *intrauterine contraceptive device* called Copper-T is also very effective in preventing pregnancy. A Copper-T is placed inside the uterus by a doctor or a trained nurse. The IUCD or Copper-T prevents the implantation of fertilised egg in the uterus.

Sexually Transmitted Diseases (STD)

The diseases which are spread by sexual contact with an infected person are called sexually transmitted diseases (or STD). Thus, a healthy person can get a STD by making sexual contact with an infected person. Some of the common sexually transmitted diseases are:

(i) Gonorrhoea (ii) Syphilis, and (iii) Trichomoniasis

Gonorrhoea and syphilis are caused by bacteria and trichomoniasis is caused by protozoa. The bacteria and protozoa which cause these diseases spread through sexual contact with an infected person. The most common symptoms of these sexually transmitted diseases are burning sensation at urination, passing of urethral discharge (containing pus) and sores in the genitals.

Another sexually transmitted disease is AIDS (Acquired Immuno Deficiency Syndrome): AIDS disease is caused by a virus called HIV (Human Immunodeficiency Virus). AIDS damages the body's immune system so that the body becomes weak and cannot protect itself against infection. So, AIDS is a very dangerous disease which leads to death. No definite cure has been found for the AIDS disease so far.

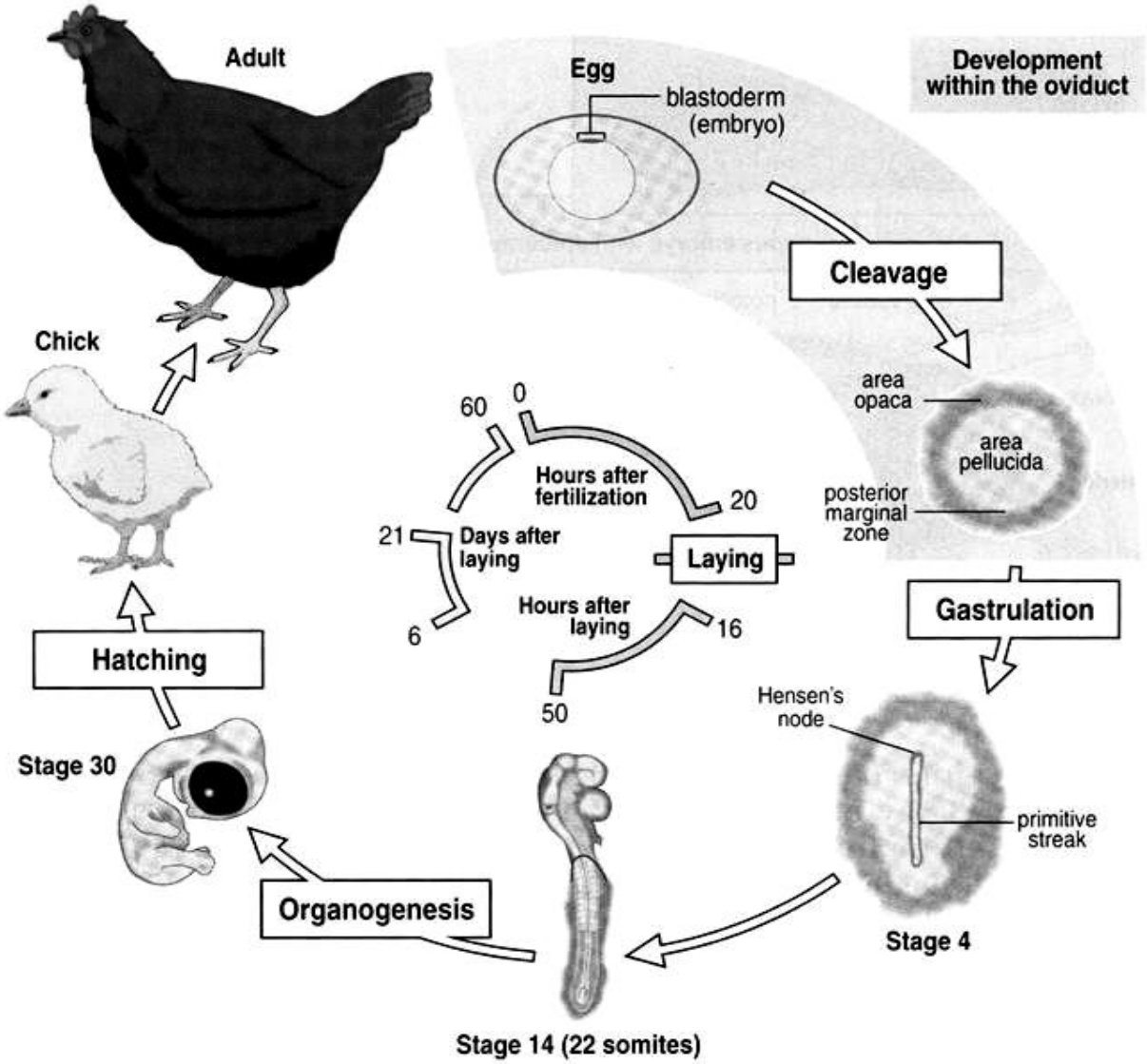
Oviparous and viviparous animals

Oviparous animals are animals that lay eggs, with little or no other embryonic development within the mother. This is the reproductive method of most fish, amphibians,

reptiles, all birds. **Viviparity** is a form of reproduction found in most **mammals** and in several other **species**. Viviparous animals give **birth** to living young that have been nourished in close contact with their mother's body. Humans, dogs, and **cats** are viviparous animals. Viviparous animals differ from egg-laying animals, such as **birds** and most **reptiles**. Egg-laying, or **oviparous**, animals obtain all nourishment as they develop from the yolk and the protein-rich albumen, or "white," in the egg itself, not from direct contact with the mother, as is the case with viviparous young.

Fertilisation of egg in hen

The case of Hen



The hen is a bird. Internal fertilisation takes place in hen also but a hen does not give birth to chicks (like human being give birth to babies). We will now describe how chicks are born.

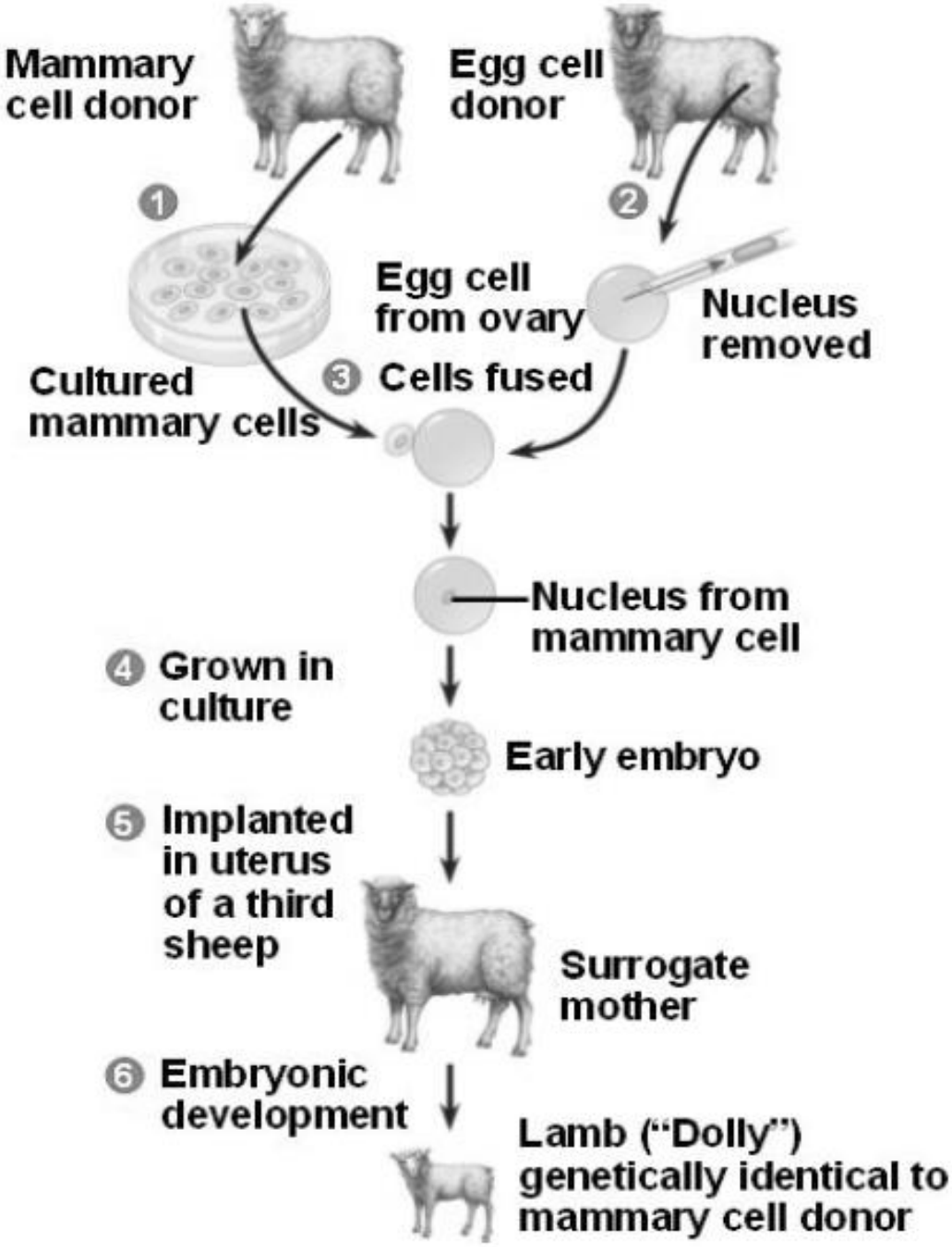
- After fertilisation takes place inside the body of the hen, the fertilised egg. (or zygote) divides repeatedly to form embryo which travels down the oviduct.
- As it travels down the oviduct, many protective layers are formed around the embryo.
- After the hard egg shell is formed around the developing embryo, the hen finally lays the egg.
- The hen then sits on the eggs to provide sufficient warmth to the eggs for the development of the embryo into the chicks. The embryo takes about three weeks to develop into a complete chick.
- After the chick is completely developed, the egg shell breaks open automatically and the chicks comes out of it.

During its development into chick, the embryo gets all its food from the egg yolk. The albumen present in egg helps to protect the embryo from damage. The embryo obtains oxygen by the diffusion of air through the egg shell and other membranes. The embryos of all the birds and reptiles, etc., develop in the same way (like that of hen) inside their shelled eggs.

Cloning of Dolly

A population of identical molecules or cells or organisms all of which are derived from the same parent, by an asexual process, is called a clone. The process of producing genetically similar molecules, cells or organisms from a common precursor ‘in vitro’ or ‘in vivo’ is known as cloning.

Cloning Sheep



In 1997, Scottish scientists led by Ian Wilmut at the Roslin Institute near Edinburgh, announced that they had produced a cloned sheep which they named Dolly. This is the first ever successful attempt to clone a mammal.

Steps in Cloning Experiment

- Donor cells from udder of a Finn Dorset ewe were collected.

- Collected cells were transferred to culture medium containing growth factors enough to keep cells alive.
- Unfertilized eggs were collected from Scottish blackface ewe. The nucleus from the egg cell was removed.
- The enucleated egg cell and the donor cells are fused subjecting them to gentle pulses of electricity.
- The fused cell is transferred to a culture which allows division and growth.
- The egg was then implanted into the uterus of blackface ewe which will act as surrogate mother.
- After gestation period, the pregnant black faced ewe gave birth to a baby Finn Dorset lamb, which was named Dolly.

IMPORTANT DEFINITIONS

1. ***Asexual reproduction:*** The process of reproduction in which a new organism is produced by a single parent is called asexual reproduction. Gametes (sperm and ovum) are not produced in these organisms
2. ***Binary fission:*** It is a method of asexual reproduction in which one parental animal divides in two similar daughter organisms.
3. ***Budding:*** It is a process of asexual reproduction where some part of the parental body separates to form new individuals.
4. ***Sexual reproduction:*** Method of reproduction in which a new individual develops from zygote formed by the fusion of sex cells / gametes is called sexual reproduction. Generally, two parents (male and female) are involved.
5. ***Sperms:*** Male gametes.
6. ***Eggs:*** Ovum with egg membrane; produced as female gamete.
7. ***Fertilization:*** Event of fusion of sperm and ovum to form zygote is called fertilization.
8. ***External fertilization:*** Fusion of sperm and ovum takes place outside the female body.
9. ***Internal fertilization:*** Fusion of sperm and ovum occurs inside the mother's body (in genital tract).
10. ***Zygote:*** Resultant cell produced by fusion of sperm and ovum forms a zygote.
11. ***Embryo:*** Early developing structure is called embryo. It includes all the stages

involved after fertilization and before foetus formation.

12. ***Foetus:*** Developing structure in which all the body parts can be identified is called a foetus.
13. ***Metamorphosis:*** The transformation of an insect or amphibian from an immature form or larva to an adult form is called metamorphosis.
14. ***Oviparous animals:*** The group of animals in which development of egg into embryo takes place outside the mother's body or the animals which lay eggs are called oviparous animals.
15. ***Viviparous animals:*** Group of animals which give birth directly to young ones are called viviparous animals.

IMPORTANT POINTS TO REMEMBERS

- Reproduction is the process by which living organisms produce young ones of their own species.
- There are two modes of reproduction in animals. These are: (i) Asexual reproduction and (ii) Sexual reproduction.
- In Asexual reproduction, only a single parent is involved and no sex cells / gametes are involved. Budding in yeast and Binary fission in Amoeba are examples of asexual reproduction.
- Sexual reproduction involves the fusion of male and female gametes.
- Male reproductive organs include testes, vas deferens and penis.
- Female reproductive organs include ovaries, fallopian tubes and uterus.
- The ovary produces female gametes called ova and the testes produce male gametes called sperms.
- Fusion of male gamete (sperm) and female gamete (ovum) is referred to as fertilization and the fertilised egg is called a zygote.
- Fertilization that takes place inside the female body is called internal fertilization. This is observed in human begins and other animals such as hens, cows and dogs.
- Fertilization that takes place outside the female body is called external fertilization. This is observed in frogs, fish, starfish etc.
- The zygote undergoes repeated divisions to form an embryo, which gets

implanted in the wall of the uterus for further development.

- The stage of the embryo in which all the body parts are identifiable is called foetus.
- The transformation of the larva into adult through drastic changes is called metamorphosis.

VALUE BASED QUESTIONS

1. All the animals finally die, yet the species survive. Give reasons for this.
2. Why does the child look like the parents?

REVISION EXERCISE - LEVEL – I

I. **Fill in the blanks:**

1. The hormone produced by the testes is_____.
2. Four tiny glands attached to the thyroid gland are called _____.
3. _____ is the main link between the endocrine system and the nervous system.
4. Syphilis is caused by _____.
5. Every sperm has _____ sex chromosome.

II. **State True or False:**

1. Thyroxine is produced by the pituitary gland.
2. Gonorrhoea is a bacterial disease.
3. Hormons are called chemical messengers.
4. AIDS weakens the body's immune system.
5. Hormones act wherever they are released by the glands.

III. **Match the following:**

Column A		**Column B**	
(a)	Head	(i)	Enzymes
(b)	Middle piece	(ii)	Sperm motility
(c)	Acrosome	(iii)	Energy
(d)	Tail	(iv)	Genetic material

IV. Multiple Choice Questions

1. In humans beings, fertilization takes place in which of the following parts?

(a) Ovary (b) Fallopian tube

(c) Uterus (d) Mammary gland

2. The process of sperm formation is called :
   (a) Spermatogenesis (b) Oogenesis
   (c) Parturition (d) Implantation
3. Which of the following is/are the part(s) of mammalian sperm?
   (a) Head (b) Middle piece
   (c) Tail (d) All of these
4. The site of development of human embryo is :
   (a) Fallopian tube (b) Uterus
   (c) Ovary (d) Vagina
5. Which one of the following is the larva of frog?
   (a) Caterpillar larva (b) Tadpole larva
   (c) Torneria larva (d) Axolicial larva
6. Which of the following is not an oviparous animal?
   (a) Hen (b) Woman (c) Moth (d) Snake
7. Sexual maturity in boys occurs between the age of :
   (a) 10 to 15 years (b) 11 to 16 years
   (c) 17 years (d) 21 years
8. Which of the following glands is not present in human male?
   (a) Cowper's gland (b) Seminal vesicle
   (c) Bartholin's gland (d) Prostate gland
9. Dolly was born on _____
   (a) 5th July 1996 (b) 10th July 1996
   (c) 5th June 1996 (d) 2nd October 2001
10. Which of the following statements is incorrect?
   (a) External fertilization takes place in starfish
   (b) Frog's egg is covered by a jelly like covering
   (c) IVF technology is carried for normally reproducing females
   (d) The embryo takes about 3 weeks to develop into a chick

LEVEL - II

1. Spawning is related to which animal?
   (a) Human (b) Hen (c) Frog (d) Snake

2. Select the correct sequence of development in silk moth :
   (a) Adult → egg → pupa → larva
   (b) Adult → egg → caterpillar → pupa
   (c) Egg → pupa → caterpillar → adult
   (d) Catterpillar → pupa → egg → adult
3. The number of nuclei present in a zygote is :
   (a) None (b) One (c) Two (d) Four
4. Direct development occurs in :
   (a) Man (b) Frog (c) Silk worm (d) None of these
5. Sets of reproductive terms are given below. Choose the set that has an incorrect combination :
   (a) sperm, testis, sperm duct, penis
   (b) menstruation, egg, oviduct, uterus
   (c) sperm, oviduct, egg, uterus
   (d) ovulation, egg, oviduct, uterus
6. Which of the following statements about reproduction in humans is correct?
   (a) Fertilisation takes place externally
   (b) Fertilisation takes place in the testes
   (c) During fertilisation egg moves towards the sperm
   (d) Fertilisation takes place in the human female
7. In human beings, after fertilisation, the structure which gets embedded in the wall of uterus is :
   (a) ovum (b) foetus (c) embryo (d) zygote
8. Aquatic animals in which fertilisation occurs in water are said to be :
   (a) viviparous without fertilisation
   (b) oviparous with external fertilisation
   (c) viviparous with internal fertilisation
   (d) oviparous with internal fertilisation
9. After fertilisation, the resulting cell which gives rise to a new individual is the :
   (a) embryo (b) foetus (c) ovum (d) zygote
10. In human beings, the correct sequence of events during reproduction is :
   (a) gamete formation, fertilisation, zygote, embryo
   (b) embryo, zygote, fertilisation, gamete formation

(c) fertilisation, gamete formation, embryo, zygote

(d) gamete formation, fertilisation, embryo, zygote

ADDITIONAL EXERCISE

1. Primary sex organ secretes
   (A) Growth hormone (B) Gamete
   (C) Only maintains reproductive health (D) All of these
2. Life cycle of frog doesn't include
   (A) Tadpole (B) Metamorphosis
   (C) Internal fertilization (D) Dual life
3. In asexual reproduction
   (A) Fusion of gamete of the two opposite sexes occurs
   (B) Fusion of gamete of same sexes occurs
   (C) Fusion of gamete may or may not occur
   (D)No fusion of gametes occurs
4. Metamorphosis is a process of transformation of
   (A) larva into adult (B) stem cell into egg cell
   (C) egg cell in to zygote (D) tadpole into adult
5. Hydra reproduces by
   (A) Binary fission (B) Cloning
   (C) Budding (D) Metamorphosis
6. Eggs are formed in the
   (A) Testes (B) Penis (C) Ovary (D) None of these
7. There are modes reproduction in animals
   (A) Only one type (B) Two types (C) Three types (D) Four types
8. A sperm consists of
   (A) two parts (B) true parts (C) three parts (D) four parts
9. Foetus is the
   (A) Well developed embryo (B) Developing embryo
   (C) A zygote (D) Male gamete
10. Viviparous organisms are those which
    (A) Produce eggs
    (B) Produce young ones

(C) Produce sometimes eggs or sometimes young ones

(D) None of these

11. Multiple fission is observed in

(A) *Amoeba* (B) Bacteria (C) *Hydra* (D) *Plasmodium*

12. Yeast reproduces by

(A) sexual reproduction (B) asexual reproduction

(C) parthenogenesis (D) none of these

13. External fertilisation and external development takes place in

(A) Hen (B) frog (C) elephant (D) human beings

14. Testes are found in

(A) males only (B) females only

(C) both males and females (D) none of these

15. When the embryo can be identified with body parts, it is known as

(A) zygote (B) foetus (C) infant (D) egg

16. Metamorphosis can be observed in

(A) tadpole (B) earthworm (C) hen (D)*Hydra*

17. Breaking of the egg shell and the chick coming out is known as

(A) Bear (B) Tiger (C) Leech (D) Wolf

18. Which of the following is hermaphrodite animal?

(A) Oestrogen (B) Progesterone (C) Testosterone (D) Pituitary

19. Which hormone is secreted by males?

(A) Oestrogen (B) Progesterone (C) Testosterone (D) Pituitary

20. A sperm is a

(A) Multi celled (B) Single celled (C) Multi layered (D) Single layered

21. Which organ releases sperm?

(A) Vas deferens (B) Testes (C) Scrotum (D) Urethra

22. Parthenogenesis occurs in which of the following animals?

(A) Sheep (B) Sponges (C) Ant (D) Hydra

23. Which is not a part of female reproductive system?

(A) Uterus (B) Vagina

(C) Urethra (D) A pair of ovaries

24. Which part of sperm gives or provides energy for movement of sperm?

(A) Head (B) Middle piece (C) Tail (D) All the above

25. The genetic information is carried by which part of the sperm?
(A) Tail (B) Middle piece (C) Head (D) None of these
26. An ovary is large due to presence of
(A) Yolk (B) Water (C) Air (D) Minerals
27. Which hormone is responsible for secondary sexual character in females?
(A) Testosterone (B) Oestrogen (C) Thyroxine (D) Pituitary
28. Another name for oviduct is
(A) Cervix (B) Seminal vesicles
(C) Prostate gland (D) Fallopian tube
29. Which of the following connects foetus with placenta?
(A) Umbilical cord (B)Amniotic fluid (C)Wall of uterus (D) Fallopian tube
30. Which of the following is an unisexual animal?
(A) Tiger (B) Earthworm (C) Leech (D) Tape worm
31. The function of copper T is to prevent
(A) Fertilization (B) Egg maturation
(C) Ovulation (D) Implantation of blastocyst
32. Where does fertilization occur in mammals?
(A) Uterus (B) Fallopian tube (C) Vagina (D) Cervix
33. Which type of fertilization is found in frogs?
(A) External in water (B) Internal in abdomen
(C) External in uterus (D) Internal in epididymis
34. If an organism is a diploid (or 2n) with 16 chromosomes, then how many chromosomes its sperm cells or egg cells will contain?
(A) 8 (B) 16 (C) 32 (D) 64
35. The vas deferens connects the epididymis to the
(A) Seminal vesicles (B) Urethra
(C) Testes (D) Prostate gland
36. After sperm move through the vas deferens, they enter the
(A) Seminal vesicles (B) Urethra
(C) Urinary bladder (D) All the above
37. A sperm tail consists of
(A) A nucleus (B) Mitochondria (C) Flagellum (D) Golgi body
38. A zygote is a/an
(A) Implanted fertilized egg (B) Fertilized egg
(C) Ovulated egg (D) Blastocyst
39. How many chromosomes does a mature human sperm cell contain?
(A) 1 (B) 2 (C) 23 (D) 46
40. Which structure is cut and tied off in a vasectomy?
(A) Penis (B) Epididymis (C) Urethra (D) Vas deferens