Tutorial 2

Covers Lectures 2 and 3

On 21st March 2023 for D4 and 23rd March 2023 for D3

1.   Paradigm shifts – prokaryotes and eukaryotes

The distinction between prokaryotes and eukaryotes seems to be blurring. Do you expect the discovery of organisms that straddle (= here, it means being on both sides) the two domains? Why or why not?

You may refer to two tables given at the end of this tutorial.

Yes, we may expect to discover organisms that straddle prokaryotes and eukaryotes. More precisely, we may expect organisms that straddle all three domains of life viz., eubacteria, archaea, and eukaryota.

Reasons:

(i)   Discovery of bacteria (a) that have membrane-enclosed nucleus and (b) that are visible to naked eye
(ii)   Discovery of giant viruses
(iii)   The knowledge that the set of bacteria that we have studied (to any level of detail) may possibly constitute just 1-2% of all bacteria that exist...
(iv)   Unlike larger organisms e.g., dinosaurs, bacteria are perhaps more resilient to environmental changes and hence, may have survived
(v)   Bacteria are found in a wide variety of ecological niches affirming their adaptability
(vi)   [may be there are a few other reasons...]

A paradigm is a set of concepts and ideas. Any observation or experimental result that leads to a change in these set of concepts and ideas is said to bring about a paradigm change or a paradigm shift.

Example:

Old paradigm: Both bacteria and archaea are prokaryotes

New paradigm (or Paradigm shift): Archaea shares similarities with both the domains (prokaryote and eukaryote).

Similarities with eukaryotes:

i.   Similar DNA replication, transcription and translation.
ii.   Archaea has histones proteins that binds with DNA.

2.   *Traditionally, viruses are considered non-living. However, in recent years, there have been arguments that viruses also are living.*

(a) Give at least one reason why viruses cannot be considered as living

Viruses do not have a metabolism of their own. Discovery of giant viruses is invalidating some of the other reasons that were used to categorize viruses as non-living

i.   No nucleus, cytosol or membrane bound organelles
ii.   Virus do not grow

(b) Give at least one reason why viruses ought to be considered as living

Viruses are able to reproduce. The level of dependency of 'external' hosts is much higher than that of other organisms but yet, they are able to reproduce.

i. Virus can reproduce and multiply themselves.

ii. Adaptation towards environment (-Lytic or lysogenic)

iii. Genes for synthesis of their own building blocks

3.   *Phage therapy*

(a) It has been reported that, "*bacteriophages are very species-specific with regard to their hosts and usually only infect a single bacterial species or even specific strains within a species*." Base on this, do you think it is safe to use phage therapy?

The given information is inadequate to conclude that phage therapy is safe.

The conclusion that bacteriophages are very species-specific is based on studies that

(i) tested only a subset of all phages and

(ii) against only a subset of bacterial hosts for any given phage.

Incomplete information leads you to multiple interpretations [take the example mentioned in (b)].

We do not know whether the host-specificity could be considered for phage therapy. Phages sometimes carry toxin coding genes (e.g., shiga toxin), which can show toxicity to human. Also, the lysogenic or lytic life cycle preference of the phage is not mentioned. Although the phage can kill specific pathogenic bacteria, we don't know whether it can harm the human host or not. Also, Inactivation of virus (here bacteriophage) are difficult.

(b) A set of statements about "eating banana" are given below. Are the interpretations of these statements appropriate?

Statement	Interpretation
Only I ate banana	No one else ate bananas It does not tell whether or not I ate anything else
I only ate Banana	Tells that I ate banana and didn't do anything else with Banana. This statement does not tell if I drank anything (milk, water, ...). Nor does it tell what others ate or drank
I ate only Banana	Tells what I ate.

	This statement does not tell if I drank anything (milk, water, ...). Nor does it tell what others ate or drank

(c) Revisit the possible interpretations of the observation about host specificity reported in (a) above.

Note that concerns have been expressed about the use of phage therapy citing inadequate experimental data. If interested, read this and this.

(d) Antibiotics have proven to be very beneficial as long as one avoids overuse and adheres to the dosage regimen.

Are there concerns about the use of phage therapy that are not applicable in the case of antibiotics?

Concerns of phage therapy:

i.   Viruses are difficult to inactivate inside host.

ii.   Phages may carry toxin-coding genes (e.g. shiga toxin).

iii.   A lysogenic phage will be inherited in new generations as a part of host genome.

iv.   Phage can mediate Horizontal Gene Transfer between pathogens and non-pathogens

(e) Additional reading:

https://edition.cnn.com/2022/07/08/health/phage-superbug-killer-life-itself-wellness/index.html

4.   Determining the genotype of a pea plant

Suppose that we have a pea plant that bears purple flowers. What is the minimum number of crosses that one has to unambiguously determine the genotype of this plant with respect to flower color?

You may refer to the following from Slide 51 (Lecture 3).
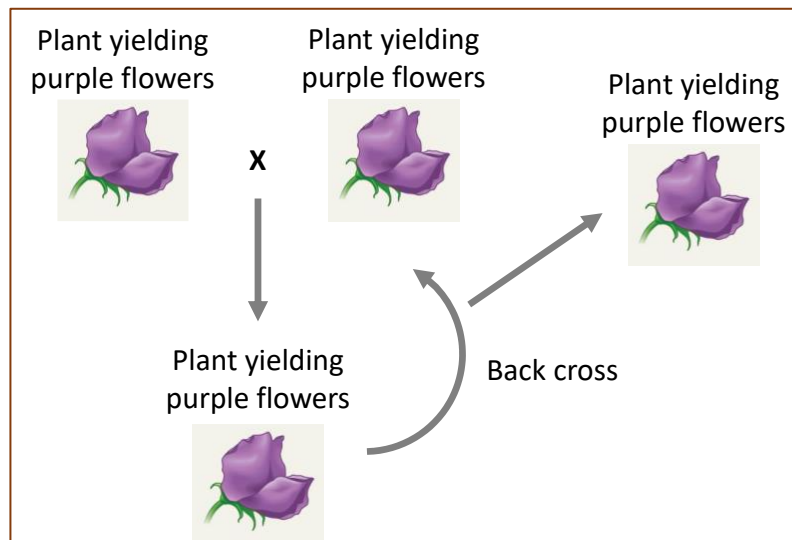
Here the flower color is a single gene trait. Suppose the alleles for the gene (responsible for purple color) are 'P' and 'p'.

We know that purple color is a dominant trait and white is recessive, the genotype would be either 'PP' or 'Pp' for purple, and 'pp' for white (recessive).

To determine the parent genotype (PP or Pp) the F1 generation (PP or Pp) is crossed with recessive plant (white; pp)

Case 1 (if the parent genotype is PP): PP X pp -> F1 generation: All Pp (purple)

Case 2 (if the parent genotype is Pp): Pp X pp -> F1 generation: 50% Pp (purple), 50% pp (white)

So, we need to do only one back cross to determine the genotype of the plant.

5.   *An outcome that depends upon a single factor / multiple factors*

| Sugar dissolved in otherwise pure water | Hyderabadi biryani |

(a) Shown above are a solution of sugar (in pure water) and a rice dish prepared by using a variety of spices. Using these, differentiate a single gene trait from a multi-gene trait.

Single Gene Trait: A trait controlled by only one gene. Suppose, here only sugar in water decides whether the water is sweet or not. Gene=Sugar, Phenotype= Sweet or not sweet

Polygenic or Multi-gene trait: A trait controlled by two or more genes. Here, multiple components (salt, ginger, mint leaves, spices, etc.) together decide the taste of the biryani. Consider each component is a gene and final product (biryani) taste as phenotype.

(b) Give an example each for a single gene trait and a multi-gene trait in humans.

Single Gene Trait: Widow's peak (a V-shaped growth of hair towards the centre of the forehead)

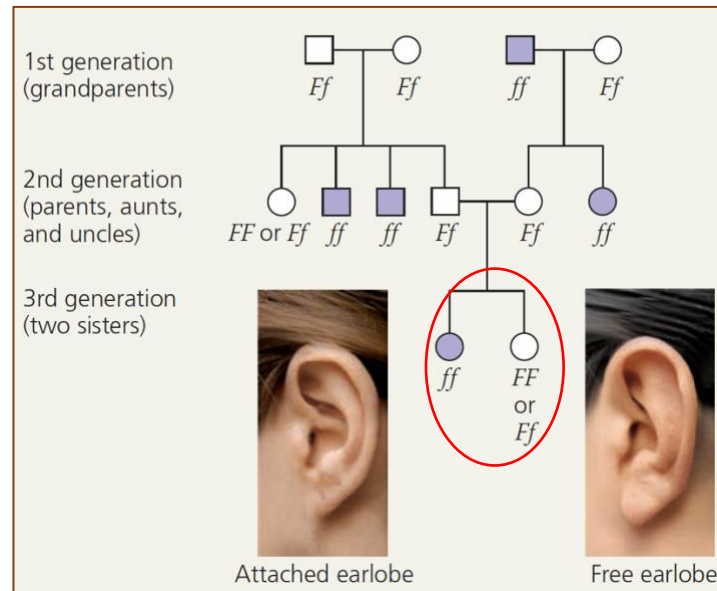Polygenic or Multi-gene trait: Height of a person. Difference in height across the population is caused by polygenic inheritance.
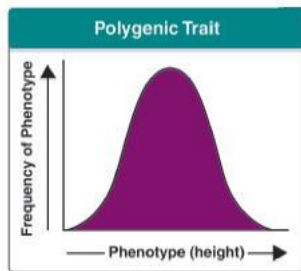
6.   Dominant and recessive traits

Analyse the schematic given below (Figure 1.14 from Campbell's Biology, 10th edition) to find out if attached earlobe is a dominant or a recessive trait.

This table is NOT meant for memorization

The attached earlobe is a recessive trait. In a heterozygous state, the dominant allele determines the phenotype. Here, 'FF' and 'Ff' both show free earlobe and 'ff' show attached earlobe phenotype. Considering the Ff heterozygous state, if 'f' allele is dominant then 'Ff' heterozygous state should show attached earlobe instead of free earlobe. So Attached earlobe is a recessive trait.

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