Plants thru evolution or systemic breeding have acquired in addition to genes which make them susceptible to a pathogen, one or usually more genes for resistance that protect the plants from infection. or from severe disease.

Introduction of a resistant crop variety also leads to the appearence of new population (race) of the pathogen that appears to contain a new gene for virulence that enables the pathogen to attack the crop plants containing the new genes for resistance

New gene arise randomly & suddenly de novo, through mutations or by rearrangement of genetic material of the pathogen. Pathogens with virulence over the new resistance gene were earlier a small population and were ~~excluded~~ undetected before the plants with the new R genes were planted widely.

Variability in organisms - In host plants and pathogens such as most of fungi, parasitic higher plant & nematodes, which can & usually reproduce by segregation & recombination of genes during meiotic div. of zygote. Bacteria & viruses.

exhibit variations; Fungi by hetero ploidy & parasexual processes lead to variation. On the other hand all pathogens produce variants in the absence of any sexual process by means of mutations.

Two general mechanism of variability namely mutations & recombination, occurs both in plant & animals.

## Specialized mechanisms of variability in pathogens:

### Sexual like process in fungi:

a) Heterokaryosis: result of fertilization or anastomosis cells of fungal hyphae contains two or more nuclei which are genetically diff.

In Puccinia graminis tritici the haploid basidiospores infects barberry not wheat whereas dikaryotic aeciospores uredo spore infect wheat not barley. dikaryotic mycelium grows in wheat & in Barley.

b) Parasexualism: genetic recombination in fungal heterokaryons. crossing over occurs during mitotic divisions & results in the appearance of genetic recombinants as the diploid nucleus

progressively and rapidly loses individual chromosomes to revert to its haploid stage

Heteroploidy - existence of cells, tissues or whole Eg. with ~~chr~~ no. of chr./nucleus diff. than 1N or 2N complement
It has been shown for eg. that heteroploids such as diploids of the normally haploid fungus Verticillium albo-atrum which causes wilt of cotton loses the ability to infect cotton plants even when derived from highly virulent haploids.

Sexual ~~like~~ processes like conjugation, transformation & transduction

→ The transfer of genetic information in this manner is not always limited to members of the same species or even genus (vertical inheritance)
transfer b/w kingdom or is called horizontal gene transfer.

Genetic recombination in viruses :- When 2 strains of viruses are ~~infected~~ inoculated in same host. one or more new virus is recovered with properties different from the original strain

Attenuation :- Partial/complete loss of virulence in pathogen when they are cultured for prolonged duration or is passed from one

host to other.

## Stages of variation in pathogens

The entire population of a particular organism has certain morphological and other phenotypic characteristics in common and makes up a species such as Puccinia graminis

↓

some species can attack only wheat, some barley & some oats and these individuals make up groups called varieties or special forms (formae speciales) P. graminis f. sp. tritici
P. graminis f sp. hordei
P graminis avenae.

Even within special forms some individuals attack some of the varieties of host plants but not not other are called race. more than 200 races of P. graminis tritici race 1, race 15, race 59 & so on.

↓

One of the offspring of a race can suddenly attack a new variety or can cause severe symptoms on a variety that it could barely infect before. This ind. is called variant.

↓

The identical individuals produced asexually by a variant make up a biotype.

Each race consists of one or several biotypes