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NET LIFE SCIENCE

**DIVERSITY IN
LIFE FORMS**
FOR CSIR NET LIFESCIENCE

MODULE 9

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A. PRINCIPLES AND METHODS IN TAXONOMY

Taxonomy is the science of naming and classification of organisms based on their genetic (evolutionary) relationships. Taxonomy is very much a field of systematics in that it is based on phylogeny and comparisons between organisms and groups of organisms. It is the science of arranging living things into groups reflecting their relationships.

- Classification is the actual practice of placing animals into these groups.
- Nomenclature is the collection of rules and procedures of assigning names to the groups.

Higher taxa

A taxon (pl. taxa) is a unit of classification of organisms. Higher taxonomic categories (taxa) group species together, ideally according to what evolutionary relationships exist between species (just as human individuals group themselves into families, etc.)

Taxonomic categories, going from larger (most inclusive) to smaller include

Kingdom
Phylum
Subphylum
Superclass
Class
Subclass
Infraclass
Cohort
Superorder
Order
Suborder
Infraorder
Superfamily (-oidea)
Family (-idae)
Subfamily (-inae)
Tribe (ini)
Subtribe (-ina)
Genus
Subgenus
Species
Subspecies

Artificial classification is based on one or a few easily observed characteristics, and is usually designed for a practical purpose with an emphasis on convenience and simplicity.

Linnaeus included all worm-like organisms in a single group, the Vermes. This included a wide range of animals, from simple nematode worms and earthworms to snakes. This was an artificial classification because it did not take account of important natural relationships, such as the fact that snakes have backbones and earthworms do not. Snakes have more in common with other vertebrates than with worms.

An example of an artificial classification of fish could be to group them as freshwater fish, brackish-water fish and marine fish on the basis of their environment. This would be convenient for the purpose of investigating their mechanisms of osmoregulation. Similarly, all microscopic organisms are known as microorganisms a convenient group for the purposes of study but not a natural group.

Natural classification tries to use natural relationship between organisms. It considers more evidence than artificial classifications, including internal as well as external features.

It takes help from similarities of embryology, morphology, anatomy, physiology, biochemistry, cell structure and behavior are all relevant.

Most classifications in use today **natural and phylogenetic**.

Phylogenies: A typical goal of systematic (and paleontology) is the construction of phylogenies

A phylogeny of a description of the genealogical (i.e., blood, i.e., evolutionary) relationships between groups of organisms

A phylogeny thus can be a description of the macroevolutionary history of a species or of more than one species

A Phylogenetic classification is one based on evolutionary relationship. In such a systems organisms belonging to the same groups are believed to have a common ancestors. The phylogeny (evolutionary history) of a group can be shown by means of a 'family tree',

Phenetic Classification: Another way to classify organisms is to use a phenetic classification. This is an attempt to avoid the problem of establishing evolutionary relationships, which can be very difficult and very controversial, especially if there is little or no fossil evidence. The word 'phenetic' comes from the Greek phainomenon, 'that which is seen'. This classification is based solely on observable characteristics (phenetic similarity) and all characters used are considered of equal importance.

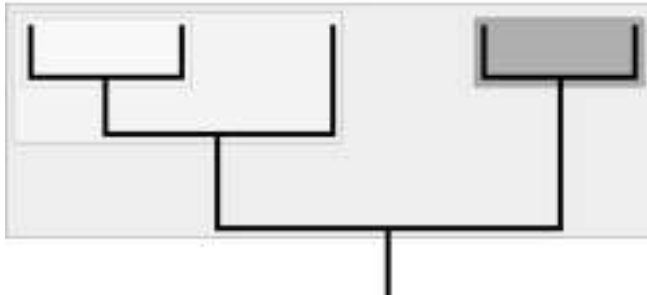
All features of an organism can be considered, the more the better, and they do not necessarily have to be of evolutionary significance. Masses of data are collected and the degrees of similarities between different organisms are calculated, usually by computer because the calculations are extremely complex.

The use of computers in taxonomy is known as **numerical taxonomy**. Phenetic classifications often resemble phylogenetic classifications, but they are not constructed with this in view.

Evolutionary trees depict clades:

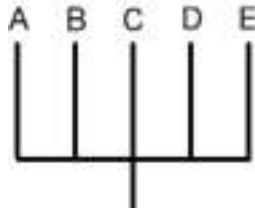
A clade is a group of organisms that includes an ancestor and all descendants of that ancestor. You can think of a clade as a branch on the tree of life. Some examples of clades are shown on the tree below.

Each colored rectangle below represents a clade:

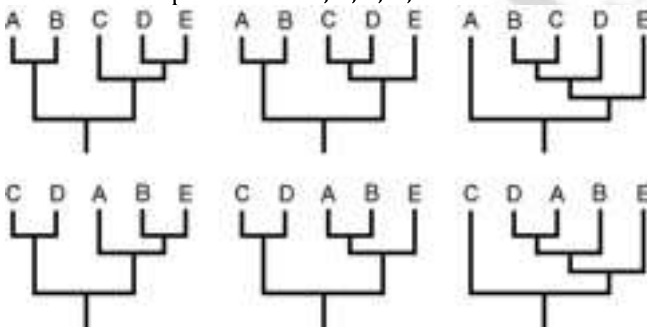


Often, one sees phylogenies that include polytomies, nodes with more than two descendent lineages, creating a "pitchfork." This can mean one of two things:

1. Lack of knowledge: Usually, a polytomy means that we don't have enough data to figure out how those lineages are related. By not resolving that node, the scientists who produced the phylogeny are telling you not to draw any conclusions — and also to stay tuned: often gathering more data can resolve a polytomy.

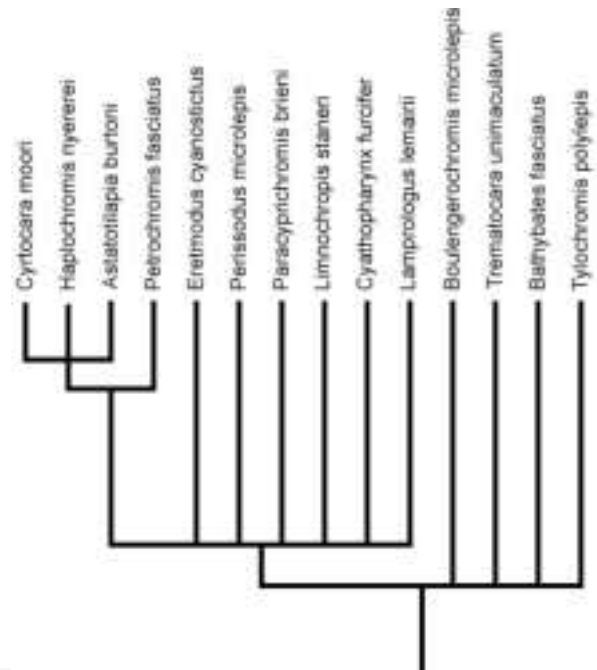


There are many ways that the polytomy above could be resolved. Six are shown below. Only more data can help us decide which is the most accurate representation of the relationships between A, B, C, D, and E.



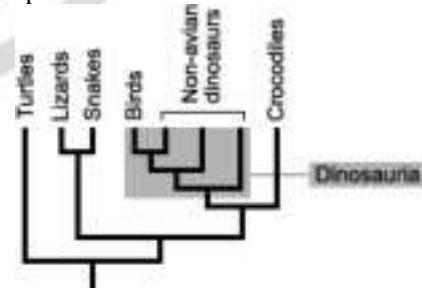
2. Rapid speciation: Sometimes a polytomy means that multiple speciation events happened at the same time. In this case, all the daughter lineages are equally closely related to one another. The researchers who have reconstructed the tree you are examining should tell you if they feel that the evidence indicates that this is the case.

The phylogeny below shows the relationships among the members of a group of fish called cichlids. Cichlid fish speciated quickly after their home lakes formed in Africa, resulting in several phylogenetic polytomies.



Using trees for classification

Clearly, evolutionary trees convey a lot of information about a group's evolutionary history. Biologists are taking advantage of this by using a system of phylogenetic classification, which conveys the same sort of information that is conveyed by trees. In contrast to the traditional Linnaean system of classification, phylogenetic classification names only clades. For example, a strictly Linnaean system of classification might place the birds and the non-Avian dinosaurs into two separate groups. However, the phylogeny of these organisms reveals that the bird lineage actually branches off of the dinosaur lineage, and so, in phylogenetic classification, the birds should be considered a part of the group Dinosauria.



Advantages of phylogenetic classification

Phylogenetic classification has two main advantages over the Linnaean system. First, phylogenetic classification tells you something important about the organism: its evolutionary history. Second, phylogenetic classification does not attempt to "rank" organisms. Linnaean classification "ranks" groups of organisms artificially into kingdoms, phyla, orders, etc. This can be misleading as it seems to suggest that different groupings with the same rank are equivalent. For example, the cats (Felidae) and the orchids (Orchidaceae) are both family level groups in Linnaean classification. However, the two groups are not comparable:

- Some Interesting forms of Algae
 - Rolling algae - *Volvox*
 - Water net - *Hydrodictyon*
 - Stone wort - *Chara*
 - Irish moss - *Chondrus crispus*
 - Sea lettuce - *Ulva*
 - Heterotrichous algae- *Draparnaldiopsis*
 - Frog spawn algae - *Batrachospermum*
 - Smallest algae - *Microcystis*
 - Largest algae - *Macrocystis*
 - Parasitic algae - *Cephaleuros*

Algae Classification:

Algae possess diverse characters in their pigments, nature of reserve food, nature of cilia etc. According to these morphological and physiological differences they are classified by many people. Fritsch (1935) classified the whole of the algae into eleven classes on the basis of type of pigments, nature of reserve food material, mode of reproduction etc.

Smith classified algae into seven divisions. These divisions include one or more classes. The divisions and classes are the following.

1. Chlorophyta: Chlorophyceae and Charophyceae
2. Chrysophyta: Chrysophyceae, Xanthophyceae and Bacillariophyceae
3. Pyrophyta: Dinophyceae and Desmophyceae
4. Euglenophyta
5. Phaeophyta
6. Rhodophyta
7. Cyanophyta

Smith included certain algae of uncertain position into Chloromonadales and Cryptophyceae

Algae possess diverse characters in their pigments, nature of reserve food, nature of cilia etc. According to these morphological and physiological differences they are classified by many people. Fritsch (1935) classified the whole of the algae into eleven classes on the basis of type of pigments, nature of reserve food material, mode of reproduction etc. They are Chlorophyceae, Xanthophyceae, Chrysophyceae, Bacillariophyceae, Cryptophyceae, Dinophyceae, Chloromonodineae, Euglinineae, Phaeophyceae, Rhodophyceae and Myxophyceae (Cyanophyceae). The classification is published in his book titled "The Structure and Reproduction of Algae".

1. Class: Chlorophyceae (Green Algae)

- Occurrence: Most forms are fresh water and a few are marine.
- Pigments: Chief pigments are chlorophyll a and b and carotenoids (yellow pigments)
- Reserve food: Starch
- Structure: Unicellular motile to heterotrichous filaments. Cell wall consists of Cellulose.

Pyrenoids are commonly surrounded by starch sheath. Motile cells have equal flagella (2-4).

- Reproduction: Sexual reproduction ranges from isogamous to advanced oogamous type.
- Example: *Chlamydomonas*, *Volvox*, *Chloralla*, *Scenedesmus*, *Pediastrum*.

2. Class: Xanthophyceae (Yellow green algae)

- Occurrence: Most forms are fresh water but a few are marine.
- Pigments: Yellow xanthophyll is found abundantly.
- Reserve food: oil
- Structure: Unicellular motile to simple filamentous. Cell wall rich in pectic compounds and composed of two equal pieces overlapping at their edges. Motile cells have two very unequal flagella. Pyrenoids absent.
- Reproduction: Sexual reproduction is rare and always isogamous. Example: *Vaucheria*

3. Class: Chrysophyceae

- Occurrence: Most forms occur in cold fresh water but a few are marine.
- Pigments: Chromatophores are brown or orange colored. Phycochrysin serves as chief accessory pigments.
- Reserve food: Fat and leucosin.
- Structure: Plants are unicellular motile to branched filamentous. Flagella are unequal attached at front end. Cells commonly contain one or two parietal chromatophores.
- Reproduction: Sexual reproduction seldom occurs but is of isogamous type.

4. Class: Bacillariophyceae (Diatoms)

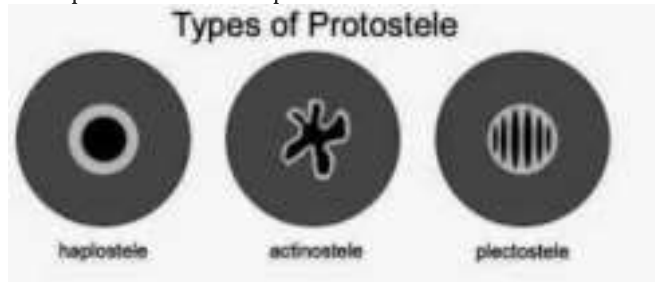
- Occurrence: In all kind of fresh water, sea, soil and terrestrial habitats.
- Pigments: Chromatophores are yellow or golden brown.
- Nature of accessory pigments is not very definite.
- Reserve food: Fat and volutin
- Structure: All the members are unicellular or colonial
- Cell wall is partly composed of silica and partly of pectic substances. It consists of two halves and each has two or more pieces. Cell wall is richly ornamental
- Reproduction: Forms are diploid. Sexual reproduction is special type, occurs by fusion of protoplasts of the ordinary individuals.
- Example: *Pinnularia*

Stelar system in Pteridophytes

Basically, there are four types of steles:



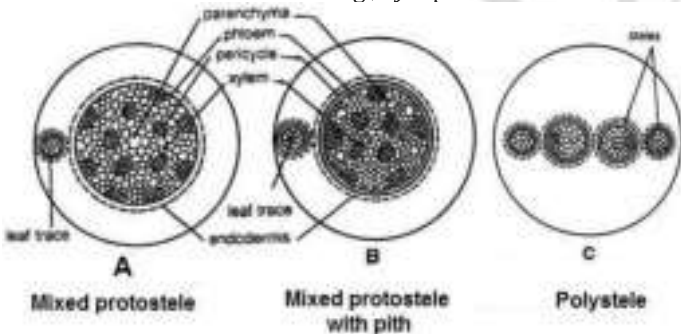
I. Protostele: The vasculature consists of central core of xylem completely surrounded by phloem. This is the most primitive and simplest of steles.



1. Haplostele: This is the most primitive type of protostele. Here the central solid core of xylem is surrounded by a layer of phloem, e.g., *Selaginella* sp.

2. Actinostele: Central xylem core with radiating ribs or a star shaped appearance surrounded by phloem. More advanced than haplostele, e.g., *Psilotum* stem lower regions

3. Plectostele: Xylem is plate like arranged parallel to each other and each plate is surrounded by phloem. More advanced than actinostele, e.g., *Lycopodium clavatum*



4. Mixed Protostele: In this case xylem and phloem are uniformly distributed. Xylem elements break up into small groups and all get surrounded by phloem. Most advanced among protostele and considered as a transitional type between true protosteles and siphonosteles e.g., *Lycopodium cerennum*, *Gleichenia* sp., *Osmunda* sp.

5. Polystele: Generally in a protostele, the stem has a single stele in the centre. But in *Selaginella*, the stem axis has several steles in parallel arrangement (di-stelic or polystelic). Each stele is a protostele with xylem core surrounded by phloem with peri cycle and endodermis. Eg: *Selaginella* stem

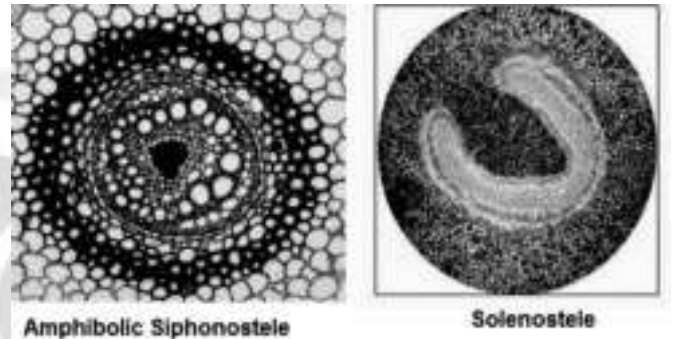
II. Siphonostele: It is a modified protostele with a central pith region or medullated proto stele.

- Pith region is often parenchymatous rarely sclerenchymatous
- Pith formed may be intra stelar in origin or by invasion of cortical tissue.

1. Simple Siphonostele: This type of stele has centre pith which may be parenchymatous or sclerenchymatous. That is tube like or siphonous. Otherwise this is a protostele with a pith at the centre or medullated protostele. E.g: *Psilotum*

a. Ectophloic Siphonostele: This type of stele has centre pith which is surrounded by concentric rings of xylem followed by phloem.

b. Amphiphloic Siphonostele: In this type of stele the centre is occupied by pith. Xylem is surrounded of both external and inner sides by rings of phloem. e.g. *Marsilea* rhizome



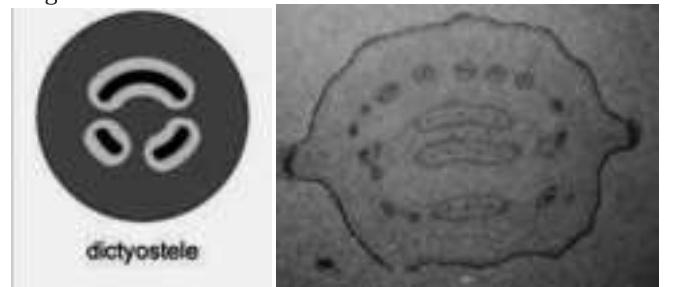
2. Solenostele: A siphonostele possesses a leaf gap on one point. It may be ectophloic or amphiphloic Solenostele

a. Amphiphloic solenostele: In this type of stele, the centre is occupied by pith. Xylem is surrounded on both sides by rings of phloem. In *Adiantum* and *Marselia* rhizome at leaf arising regions.

b. Ectophloic solenostele: Xylem is surrounded only on the outer side by phloem. Eg. *Osmunda*

III. Dictyostele: Siphonosteles with overlapping leaf gaps form dictyostele. The portion of vascular tissue which lies in between two gaps is termed as Meristele. Each meristele is protostelic in nature e.g. *Fem*

a. Simple dictyostele: Dictyosteles arranged in single ring.



b. Polycyclic dictyostele: Dictyosteles arranged in two or more rings.

S) Bluethroat: The Bluethroat is a small passerine bird that was formerly classed as a member of the thrush family Turdidae, but is now more generally considered to be an Old World flycatcher, Muscicapidae. It, and similar small European species, are often called chats. It is a migratory insectivorous species breeding in wet birch wood or bushy swamp in Europe and Asia with a foothold in western Alaska. It nests in tussocks or low in dense bushes. It winters in north Africa and the Indian Subcontinent.

T) Long billed Pipit: The Long-billed Pipit or Brown Rock Pipit is a passerine bird which has a wide distribution. A number of subspecies have been created for the populations in Africa, through the Arabian peninsula and South Asia. The systematics of this complex is yet to be clarified. Most birds are residents or short distance migrants.

D4. COMMON HUMAN PARASITES AND PATHOGENS

A parasitic disease is an infectious disease caused or transmitted by a parasite. Many parasites do not cause disease per se. Parasitic diseases can affect practically all living organisms, from plants to mammals. The study of parasitic diseases is called by parasitology.

Some parasites like *Toxoplasma gondii* can cause disease directly, but other protozoan cause disease by the toxins that they produce. Not all pathogens are bad. In entomology, pathogens are one of the "Three P's" (Predators, Pathogens, and Parasitoids) that serve as natural or introduced biological controls to suppress arthropod pest populations.

Diseases caused by bacteria:

	Disease	Causal organism	Mode of infection
1	Tuberculosis	<i>Mycobacterium tuberculosis</i>	Droplet infections
2	Diphtheria	<i>Corynebacterium diphtheria</i>	Droplet infections
3	Whooping Cough (pertussis)	<i>Bacillus pertussis</i>	Droplet infections
4	Cholera	<i>Vibrio cholera</i>	Water/Food
5	Typhoid	<i>Salmonella typhi</i>	Water
6	Syphilis	<i>Treponema pallidum</i>	Blood borne
7	Gonorrhoea	<i>Gonococcus</i> , <i>Neisseria gonorrhoeae</i>	Sexual Contact
8	Tetanus	<i>Clostridium tetani</i>	Wound infections
9	Leprosy	<i>Mycobacterium leprae</i>	Prolonged contact
10	Anthrax	<i>Bacillus anthracis</i>	Spores
11.	Food Poisoning	<i>Clostridium botulinum</i>	Food Borne

12.	Food Poisoning	<i>Campylobacter</i> , <i>Salmonella</i> , <i>Listeria</i> , <i>E.coli</i> O157, <i>Clostridium perfringens</i> .	Food Borne
13.	Bulbionic plague	<i>Yersinia pestis</i>	<i>Xenopsylla cheopis</i> (Rat flea)
14.	Lyme disease	<i>Borrelia burgdorferi</i>	<i>Ixodes</i> (Tick)

Diseases caused by Protozoa, Virus and Helminthes:

S. No	Diseases	Causal Organism	Vector
Protozoa			
1	Sleeping Sickness	<i>Trypanosoma brucei</i>	<i>Glossina</i> (tse tse fly)
2.	Chagas disease	<i>Trypanosoma cruzi</i>	<i>Triatomine</i>
3.	Malaria	<i>Plasmodium</i> sps	<i>Anopheles</i> Mosquito
4.	Leishmaniasis	<i>Leishmania</i>	<i>Phlebotomus</i> (sand fly)
5.	Amoebic Dysentery	<i>Entamoeba histolytica</i>	Water/Food borne
6.	Giardiasis	<i>Giardia intestinalis</i>	Water/Food borne
7.	Toxoplasmosis	<i>Toxoplasma gondii</i>	Water/Food borne
Virus			
1.	Japanese encephalitis (JE)	<i>Flavivirus</i>	<i>Culex</i> Mosquito
2.	West Nile disease	<i>Flavivirus: West Nile virus</i>	<i>Culex</i> Mosquito
3.	Yellow fever	<i>Flavivirus: Yellow fever virus</i>	<i>Aedes</i> Mosquito
4.	Dengue Fever	<i>Flavivirus: Dengue virus</i>	<i>Aedes</i> Mosquito
5.	Chikungunya	<i>Alpha Virus: chikungunya virus</i>	<i>Aedes</i> Mosquito
6.	Chronic gastritis	<i>Helicobacter pylori</i>	Food/water/contact
7.	Scarlet fever	<i>Streptococcus pyrogenes</i>	Sneezing , coughing
8.	Typhus	<i>Rickettsia prowazekii</i>	Louse (<i>Pediculus humanus corporis</i>)
9.	Chicken pox	<i>Varicella-zoster</i>	Contact (tiny droplets from infected people)
10.	Measles (Rubeola)	<i>Myxovirus</i>	Sneezing , coughing
11.	Poliomyelitis	<i>Enterovirus</i>	Fecal-oral route
Helminthes			
1.	Elephantiasis/ Filaria	<i>Wuchereria bancrofti</i>	Mosquito and Tick species
2.	Taeniasis	<i>Taenia solium</i>	Raw or undercooked beef or pork
3.	Ascariasis	<i>Ascaris lumbricoides</i>	Fecal-oral route

D5. COMMON PATHOGENS OF CROP PLANTS

Plant Pathology is the study of (1) the living entities and the environmental conditions that cause disease in plants; (2) the mechanisms by which these factors produce disease in plants; (3) the interactions between the disease causing agents and the diseased plant; and (4) the methods of preventing or controlling disease and alleviating the damage it causes. While plant diseases may be caused by environmental factors, viruses, mycoplasma, bacteria, nematodes, a few protozoa, and parasitic higher plants, by far the majority (more than 3/4) of plant diseases are caused by fungi.

1. Fungus:

Disease causing fungi are found in class Phycomycetes, Ascomycetes, Basidiomycetes and Fungi Imperfecti. No species of Myxomycetes are known to cause disease in plants, except mushrooms. Some of the important diseases are listed in the given table.

Table 1: Diseases caused by Fungi

S.No	Disease	Causal fungus
1	Ergot of bajra	<i>Claviceps microcephala</i>
2	Green Ear disease of Bajra	<i>Sclerospora graminicola</i>
3	Smut of bajra	<i>Tolyposporium penicillare</i>
4	Loose smut of barley	<i>Ustilago nuda hordei</i>
5	Coffee rust	<i>Hamileia vastatrix</i>
6	Wilt of cotton	<i>Fusarium vasinfectum</i>
7	Club root disease of crucifers	<i>Plasmodiophora brassicae</i>
8	White rust of crucifers	<i>Albugo candida</i>
9	Stem gall of dhanian	<i>Portomyces macrosporous</i>
10	Tikka disease of groundnut	<i>Cercospora personata</i> or <i>C. archidicola</i>
11	Downy mildew of jowar (sorghum)	<i>Sclerospora sorghii</i>
12	Covered smut of oat	<i>Ustilago kollerii</i>
13	Early blight of potato	<i>Alternaria solani</i>
14	Late blight of potato	<i>Phytophthora infestans</i>
15	Blast of rice	<i>Pyricularia oryzae</i>
16	Brown leaf spot of rice	<i>Helminthosporium oryzae</i>
17	Red rot of sugarcane	<i>Colletotrichum falcatum</i>
18.	Blister blight of tea	<i>Exobasidium vexans</i>
19.	Black or stem rust of wheat	<i>Puccinia graminis tritici</i>
20.	Loost smut of wheat	<i>Ustilago nuda tritici</i>
21.	Powdery mildew of wheat	<i>Erysiphe graminis tritici</i>

2. BACTERIA

Crown gall disease caused by *Agrobacterium* Most bacteria that are associated with plants are actually saprotrophic, and do no harm to the plant itself. However, a small number, around 100 species, are able

to cause disease. Bacterial diseases are much more prevalent in sub-tropical and tropical regions of the world.

Most plant pathogenic bacteria are rod shaped (bacilli). In order to be able to colonise the plant they have specific pathogenicity factors. There are 4 main bacterial pathogenicity factors:

1. Cell wall degrading enzymes - used to break down the plant cell wall in order to release the nutrients inside. Used by pathogens such as *Erwinia* to cause soft rot.
2. Toxins These can be non-host specific, and damage all plants, or host specific and only cause damage on a host plant.
3. Phytohormones - for example *Agrobacterium* changes the level of Auxin to cause tumours.
4. Exopolysaccharides - these are produced by bacteria and block xylem vessels, often leading to the death of the plant.

Bacteria control the production of pathogenicity factors via quorum sensing.

Significant bacterial plant pathogens

- Citrus Canker: *Xanthomonas axonopodis* pv. *citri* and *Xanthomonas axonopodis* pv. *aurantiofolii*.
- Potato Scab: *Streptomyces scabies*.
- Crown gall: *Agrobacterium tumefaciens*
- Hairy root disease (root tumor): *Agrobacterium rhizogenes*

3. PHYTOPLASMAS ('Mycoplasma-like organisms') and spiroplasmas

Vitis vinifera with "Ca. *Phytoplasma vitis*" infection

Phytoplasma and Spiroplasma are a genre of bacteria that lack cell walls, and are related to the mycoplasmas which are human pathogens. Together they are referred to as the mollicutes. They also tend to have smaller genomes than true bacteria. They are normally transmitted by sap-sucking insects, being transferred into the plants phloem where it reproduces.

4. VIRUSES, VIROIDS AND VIRUS-LIKE ORGANISMS

There are many types of plant virus, and some are even asymptomatic. Normally plant viruses only cause a loss of yield. Therefore it is not economically viable to try to control them, the exception being when they infect perennial species, such as fruit trees.

Most plant viruses have small, single stranded RNA genomes. These genomes may only encode 3 or 4 proteins: a replicase, a coat protein, a movement protein to allow cell to cell movement and sometimes a protein that allows transmission by a vector.