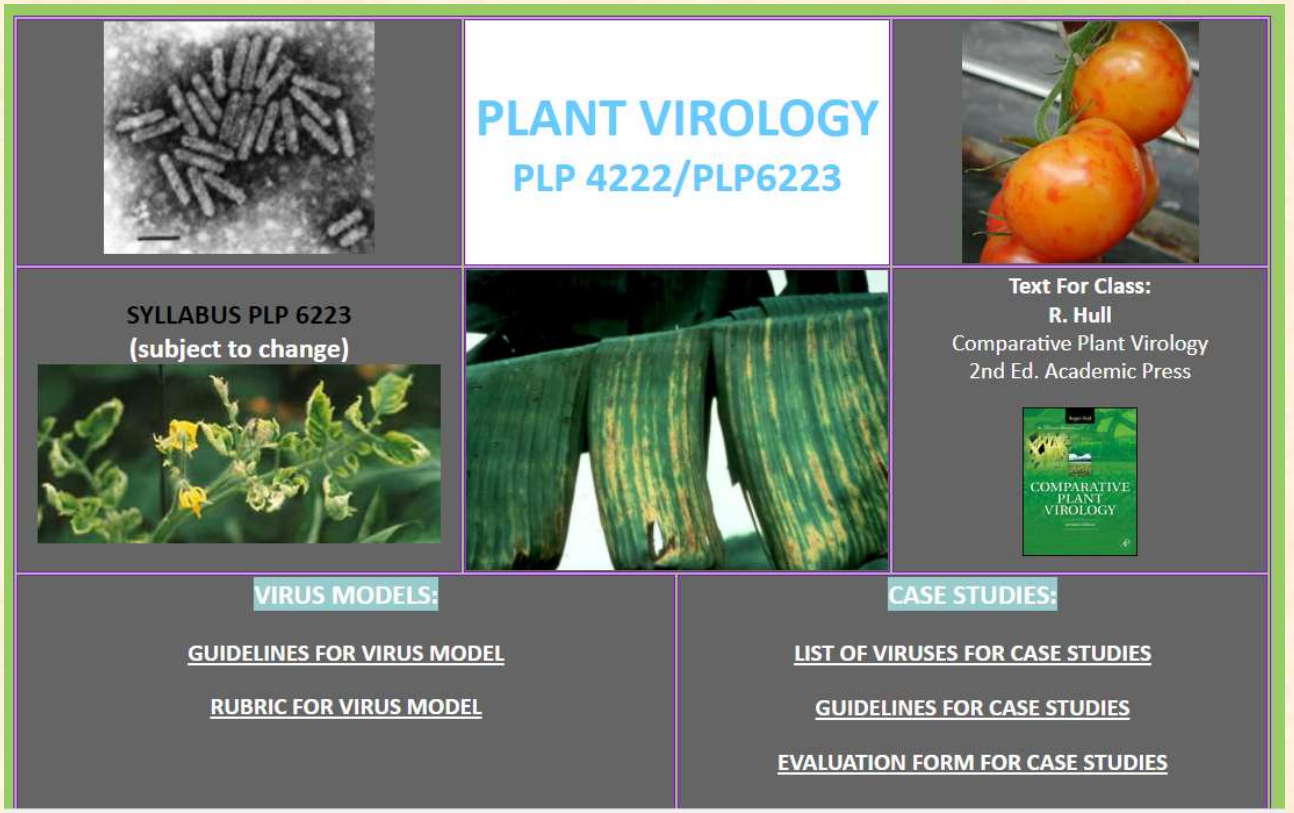
Plant Virology

PLP 6223

Course Materials:

Website:
plantpath.ifas.ufl.edu/classes/plp4222-plp6223/index.html

Lectures will be uploaded by 5 pm the day before class



Use your syllabus!

- Makes your instructor happy
- Its your game plan/strategy for success in the class
- Prevents stress due to lack of preparation

PLP6223C Viral Pathogens of Plants

Instructor: Jane E. Polston, Ph.D.
Rm. 1439 Fifield Hall
jep@ufl.edu; 352-273-4627

Course Time/ Location:
10 weeks, May 17 – July 29, 2019
Lectures: 2564 Fifield Hall, Monday, Wednesday and Friday, period 4 (12:30 pm – 1:45 pm),
Labs: 2306 Fifield Hall, Monday and Wednesday, periods 5 and 6 (2:00 pm – 4:45 pm)

Prerequisites: Graduate or upper undergraduate course in Plant Pathology; and Graduate or upper undergraduate course in Biochemistry or Molecular Biology.

Class Website: http://plantpath.ifas.ufl.edu/classes/PLP4222-PLP6223/index.html
This website presents all the lectures, papers, protocols, instructions needed for each lecture, laboratory and discussion session by week and day.

Office Hours: Office hours by appointment

Course Description:

The course is designed as a survey of contemporary concepts and principles of viruses that infect plants: their taxonomy and nomenclature, their structure and genetics, how they interact with their plant hosts, vectors, and other viruses, and their epidemiology, ecology and management. While the taxonomic relationship of plant viruses to other viruses is discussed the focus of the course is on plant viruses. Discussion sessions, which are formal discussions of pre-assigned papers, will take place during laboratory periods. Discussion periods are designed to supplement information presented in lecture, as well as to help students develop the confidence to read and correctly interpret papers in plant virology so that they can acquire new knowledge as needed in their careers. Class Exercises are designed to give students an opportunity to learn through creating and give students an opportunity to use the information they are learning. Wet laboratories are designed to give students hands-on experience to enhance comprehension of course content.

Course Objectives:

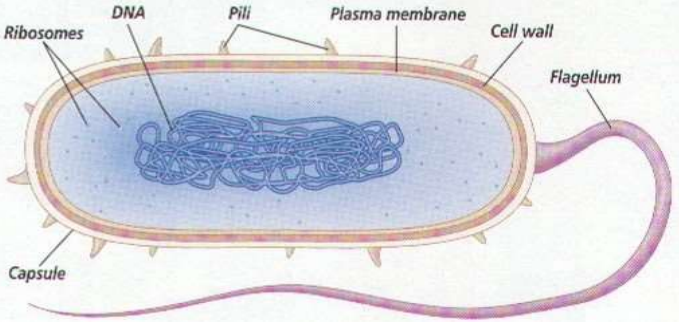
Plant viruses are one of the largest groups of plant pathogens, second only to fungi in their diversity and species number. Due to their inability to be cultured or easily visualized, they

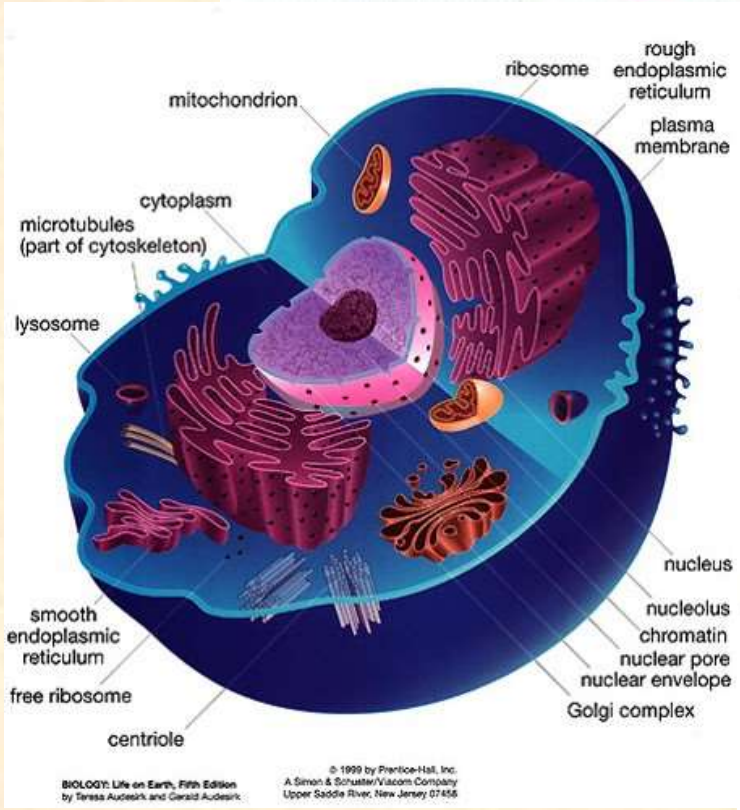
You are now entering…..

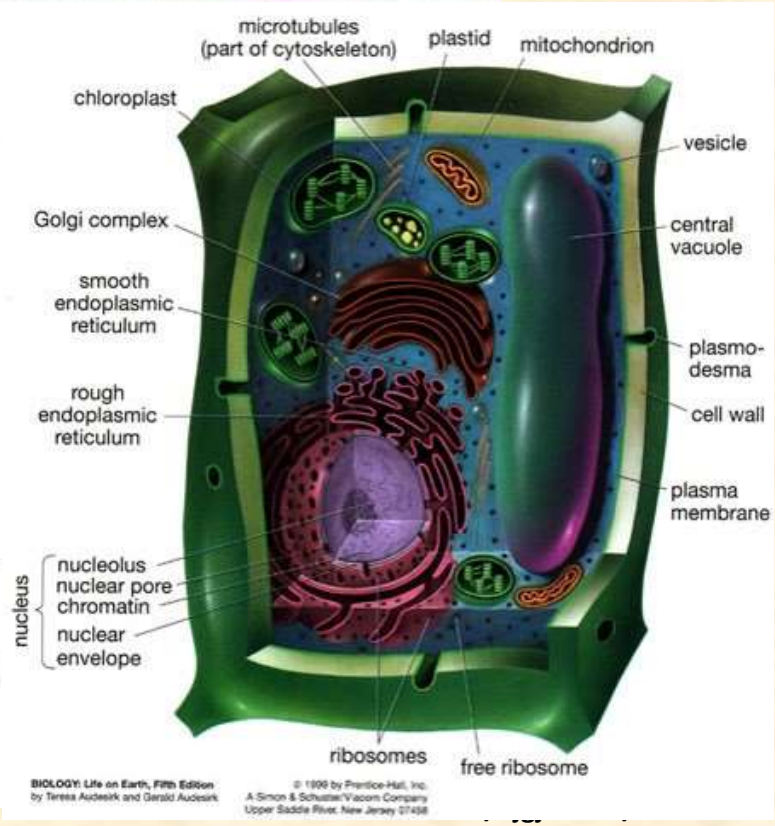
The Molecular World

Bacteria and archaebacteria are prokaryotes. All other organisms are eukaryotes.

A **Prokaryotic cell** does not have internal organelles surrounded by a membrane. Most of a prokaryote's metabolic functions take place in the cytoplasm.

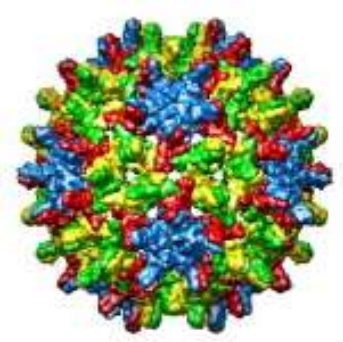




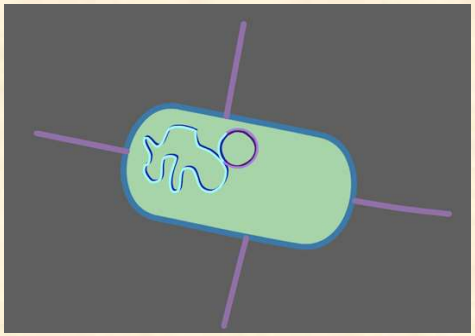


Rich diversity of parasites at the molecular level:

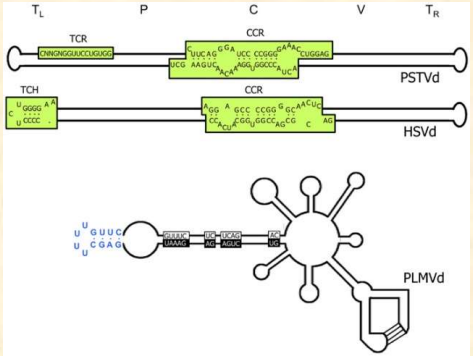
Known collectively as Mobile Genetic Elements



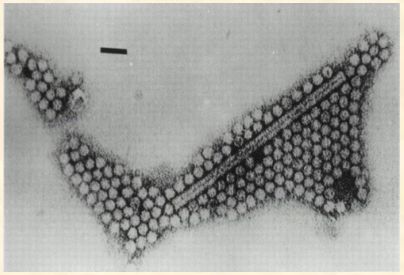
Viruses



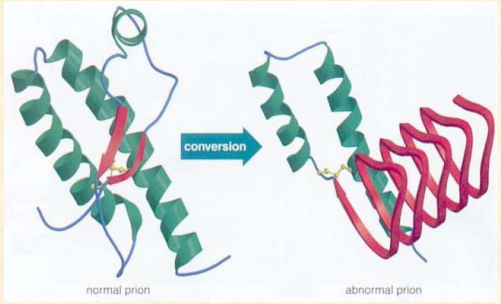
Plasmids



Viroids



Satellites

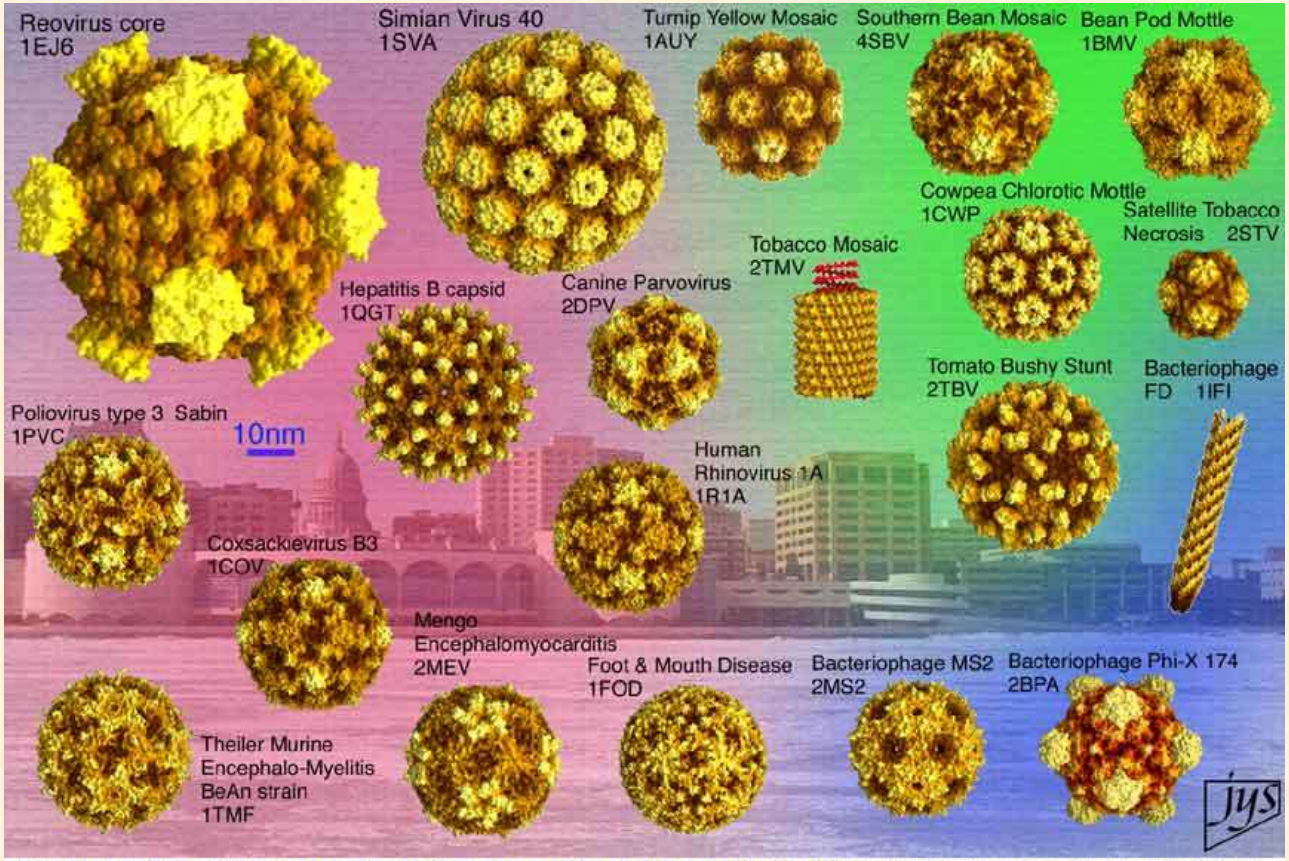


Prions

Transposons

Types of Mobile Elements:

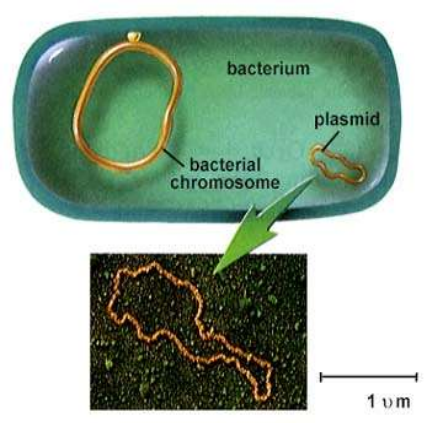
1. Viruses nucleic acid enclosed in a protein coat that it encodes, contains genes



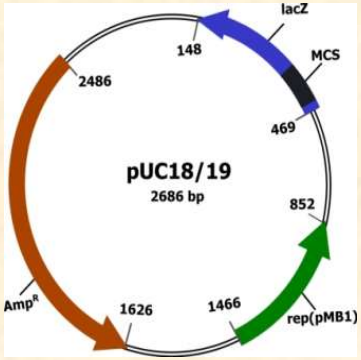
Animal (red area), plant (green area) and bacteriophages (blue area) are depicted to scale (see 10nm bar) as GRASP surfaces from published X-cray crystallography coordinates. Virus names are followed by their PDB entry code (see www.rcsb.org or mmtsb.scripps.edu/viper).
For downloadable images see also www.bocklabs.wisc.edu. Background: Madison landscape seen from Monona lake.
All images by Dr. Jean-Yves Sgro, Institute for Molecular Virology, UW-Madison.

Types of Mobile Genetic Elements:

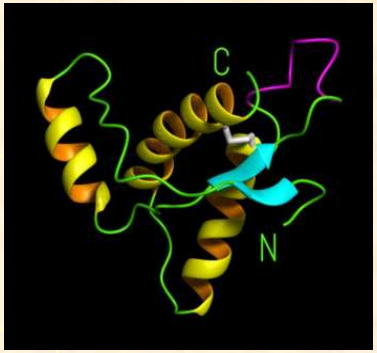
2. Plasmids



Double-stranded circular DNA found in bacteria, (contain genes)

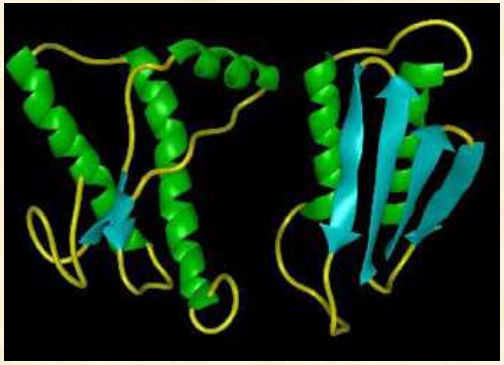


3. Prions



an infectious particle composed of protein; does not replicate, causes normal PrP proteins to become misfolded and aggregate into tightly packed beta sheets which are extremely dense and stable.

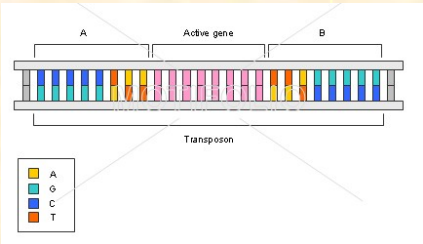
Only known from long-lived animals



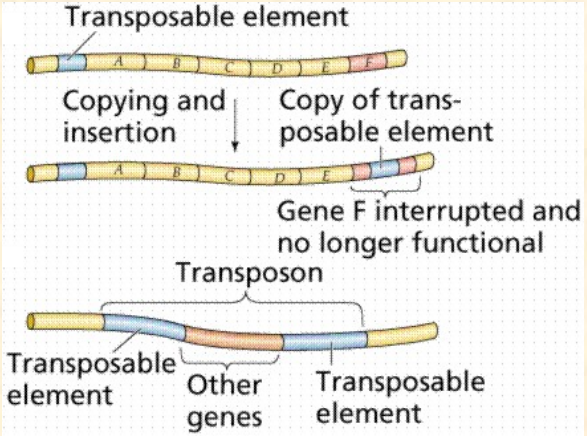
Normal Prp **Prion**

Types of Mobile Elements:

4. Transposons (Transposable Element)

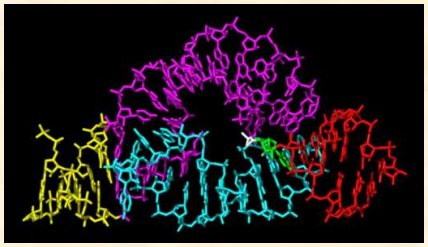


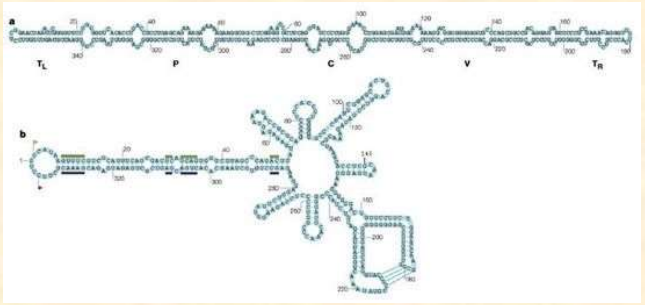
a short discrete DNA sequence that can move from one location in a gene and reinsert at another site in that organism or another. The ends are usually inverted repeats. May contain genes. Found in both prokaryotes and eukaryotes

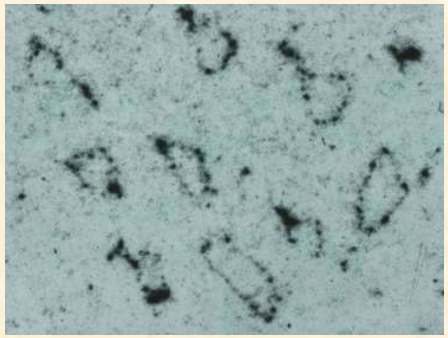


5. Viroids

small single stranded RNA circular molecules, contain no genes, only found in plants



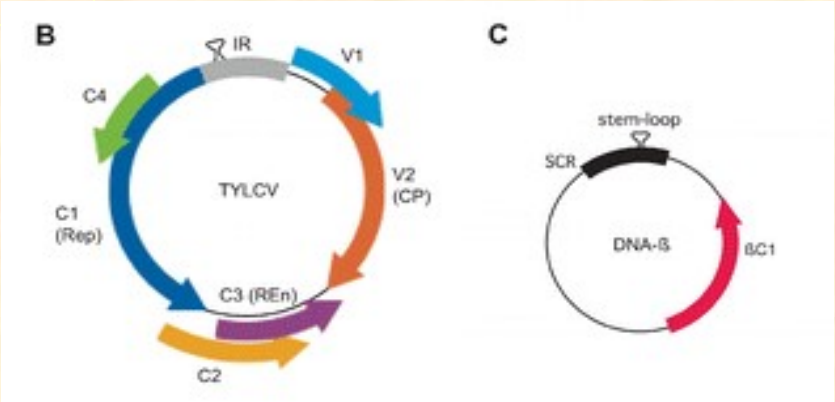




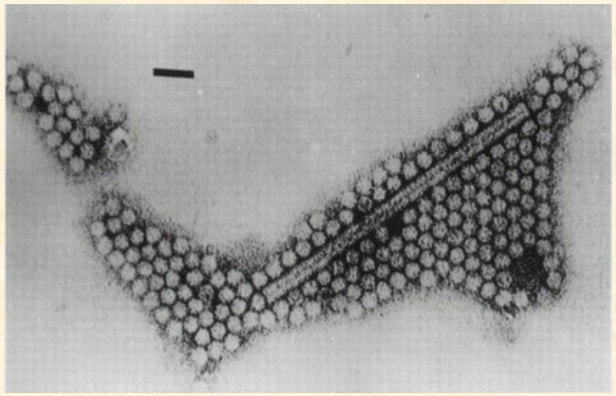
Types of Mobile Elements:

6. Satellites

nucleic acids that need a host virus to survive, may or may not have genes, may or may not be enclosed in a protein coat



Begomovirus and Beta satellite



Tobacco mosaic virus **and satellite**

Are mobile genetic elements alive?

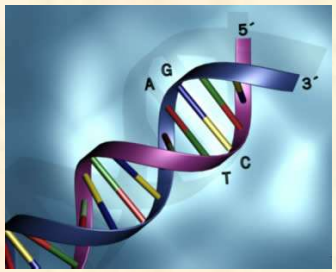
Do mobile genetic elements have intelligence?

Martin Hanczyc:
The line between life and not-life
TEDSalon London Spring
2011 · 14:37 · **Filmed** May 2011

http://www.ted.com/talks/martin_hanczyc_the_line_between_life_and_not_life.html

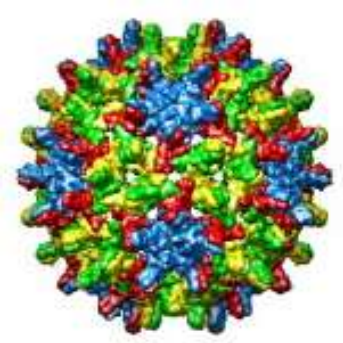
Mobile Genetic Elements:

- All act as parasites
- All these elements replicate independently of the host genome
- All (but one) exploit host cell's metabolism to replicate
- All types can (and many members do) affect the phenotype of the host
- All are used as powerful tools to study normal cell machinery

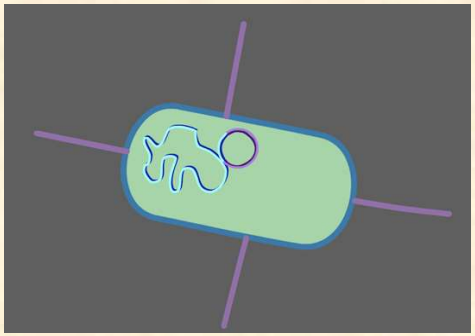


Rich diversity of parasites at the molecular level:

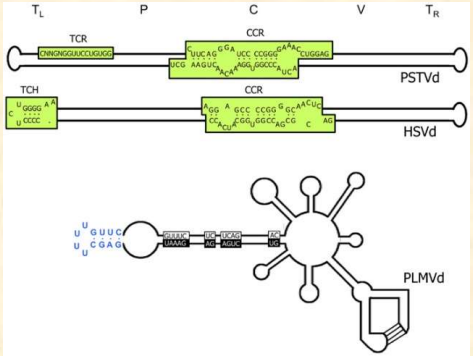
Known collectively as Mobile Genetic Elements



Viruses



Plasmids



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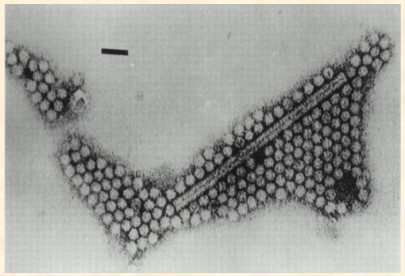
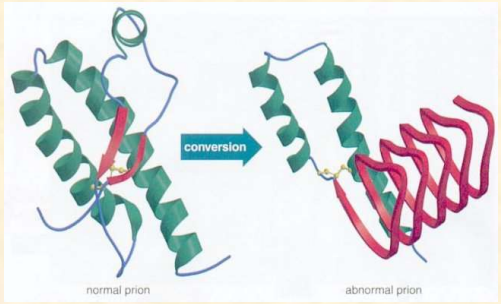


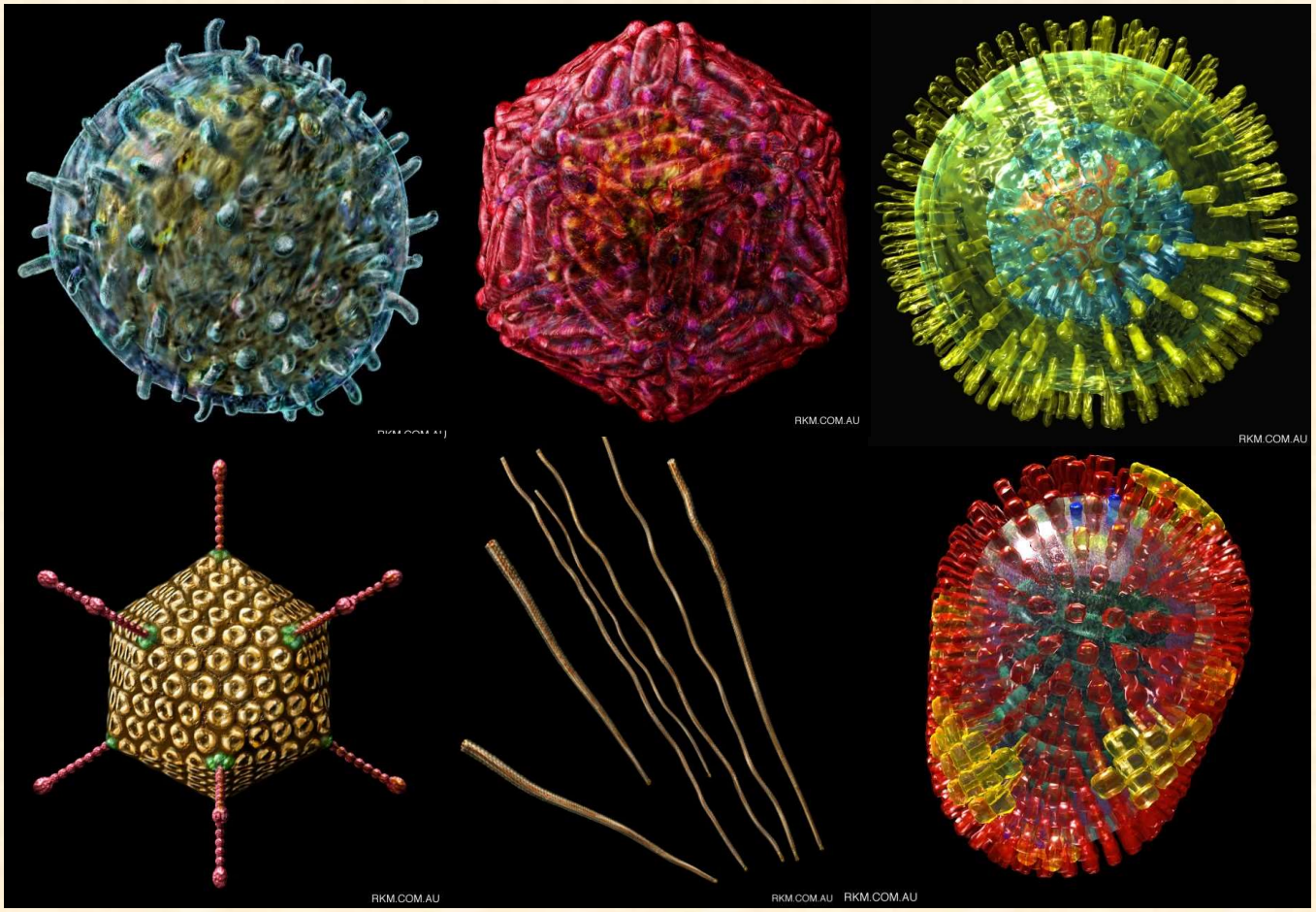
Satellites



Prions

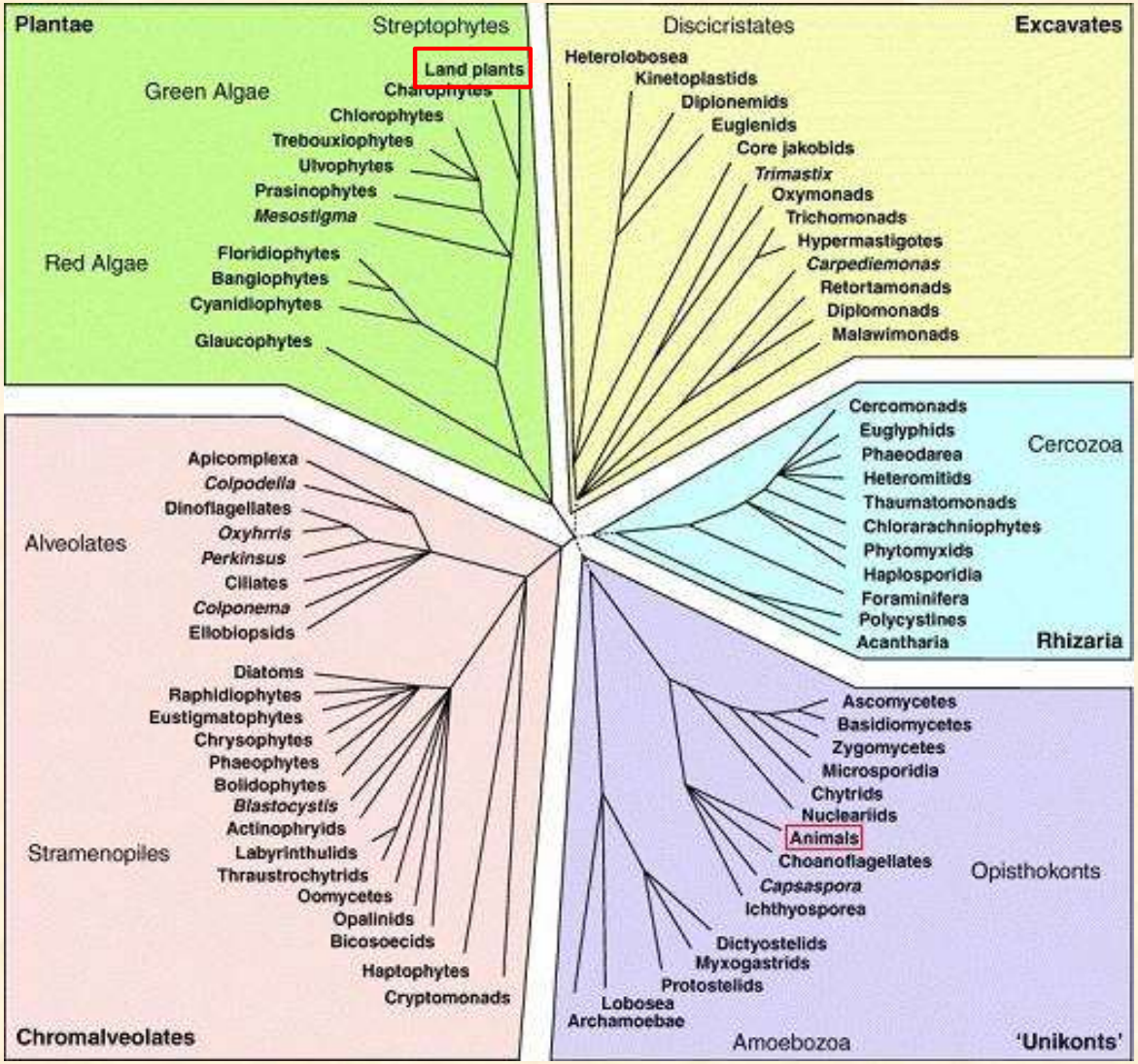
Transposons

VIRUSES



Tree of Eukaryotic Life

Viruses can be found in all types of organisms



Keeling, PJ, G Burger, DG Durnford, BF Lang, RW Lee, RE Pearlman, AJ Roger, MW Gray. 2005. The tree of eukaryotes. *Trends Ecol Evol* 20: 670-676. doi: 10.1016/j.tree.2005.09.005

What are viruses?
How do viruses differ from other mobile genetic agents?

Selected Good Definitions of Viruses:

1. Viruses are acellular organisms whose genomes consist of nucleic acid, and which obligately replicate inside host cells using host metabolic machinery and ribosomes to form a pool of components which assemble into particles called VIRIONS.

2. Viruses are submicroscopic, obligate intracellular parasites, and consist primarily of nucleic acid and protein.

Terminology

THE WORD…… “VIRUS”:

Latin *virus* refers to poisons and other noxious things, first loaned into English in 1392

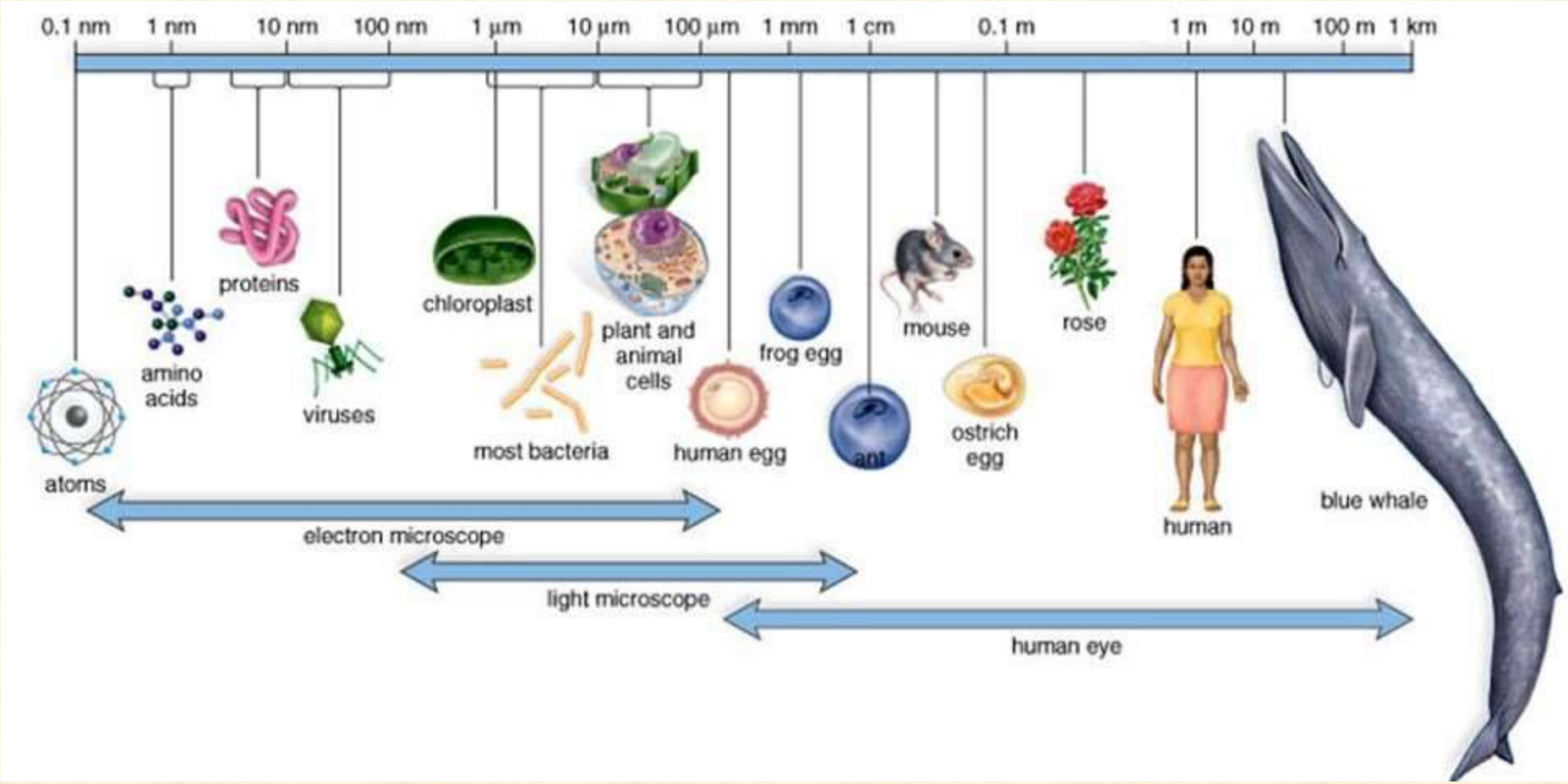
Virus - meaning an "agent that causes infectious disease" is first recorded in 1728, long before the discovery of viruses

The term *virus* usually refers to those particles that infect eukaryotes.

The term *bacteriophage* or *phage* describes viruses that infect prokaryotes (bacteria and bacteria-like organisms lacking a nucleus)

How do viruses differ from other plant pathogens?

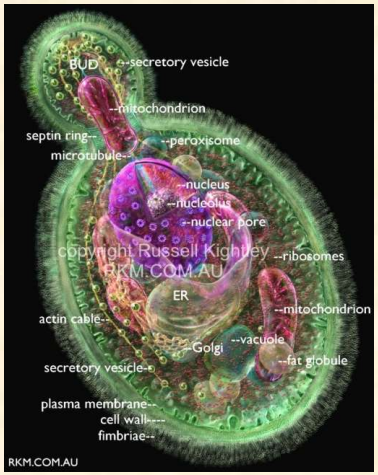
Size



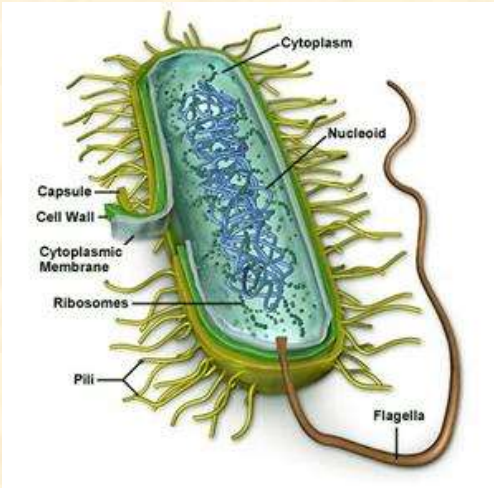
Interactive website:
https://www.cellsalive.com/howbig.htm

Complexity

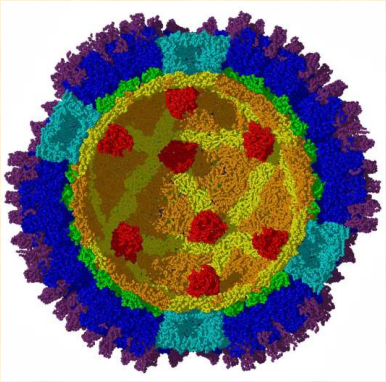
Single/Multiple Cells



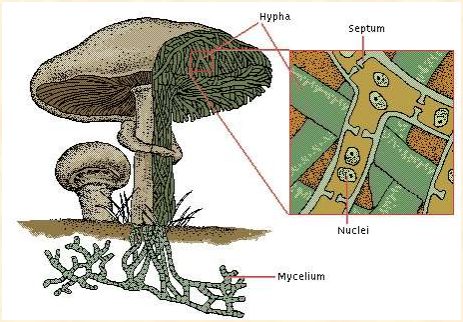
Single Cell



No Cell

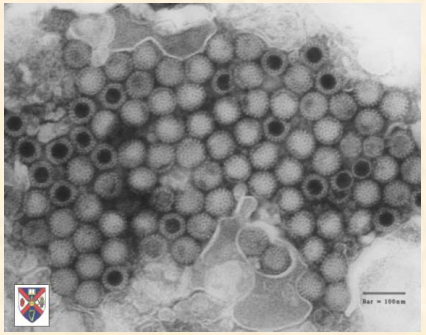


Fungi



Bacteria

Virus



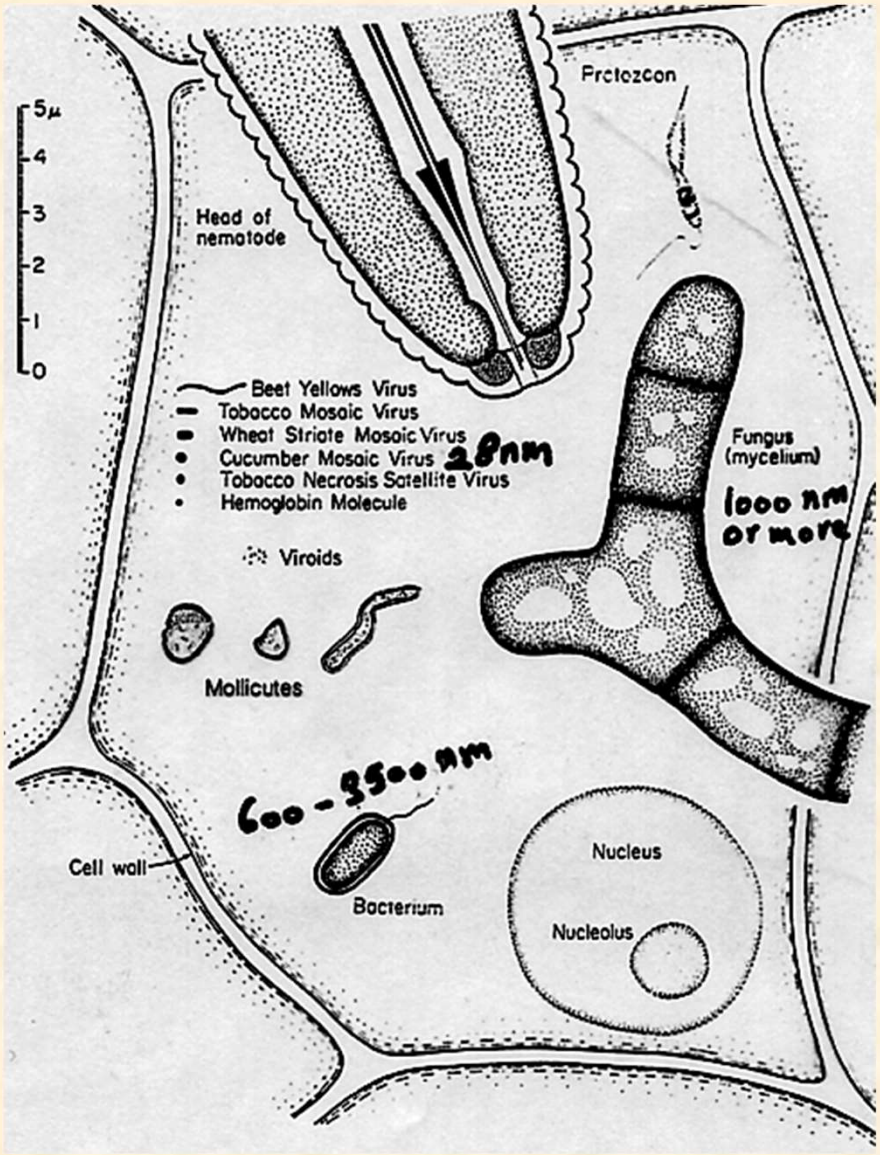
Volume:

Small virus…2 x 10^4 nm^3

Big virus ….. 6 x 10^5 nm^3

Cell …… 2 x 10^{13} nm^3

Therefore:
10^7 particles (10 million) of a small virus would occupy only 1% volume of a typical cell



Genome Coding Potential:

Animals & plants……. 50,000 –100,000 genes

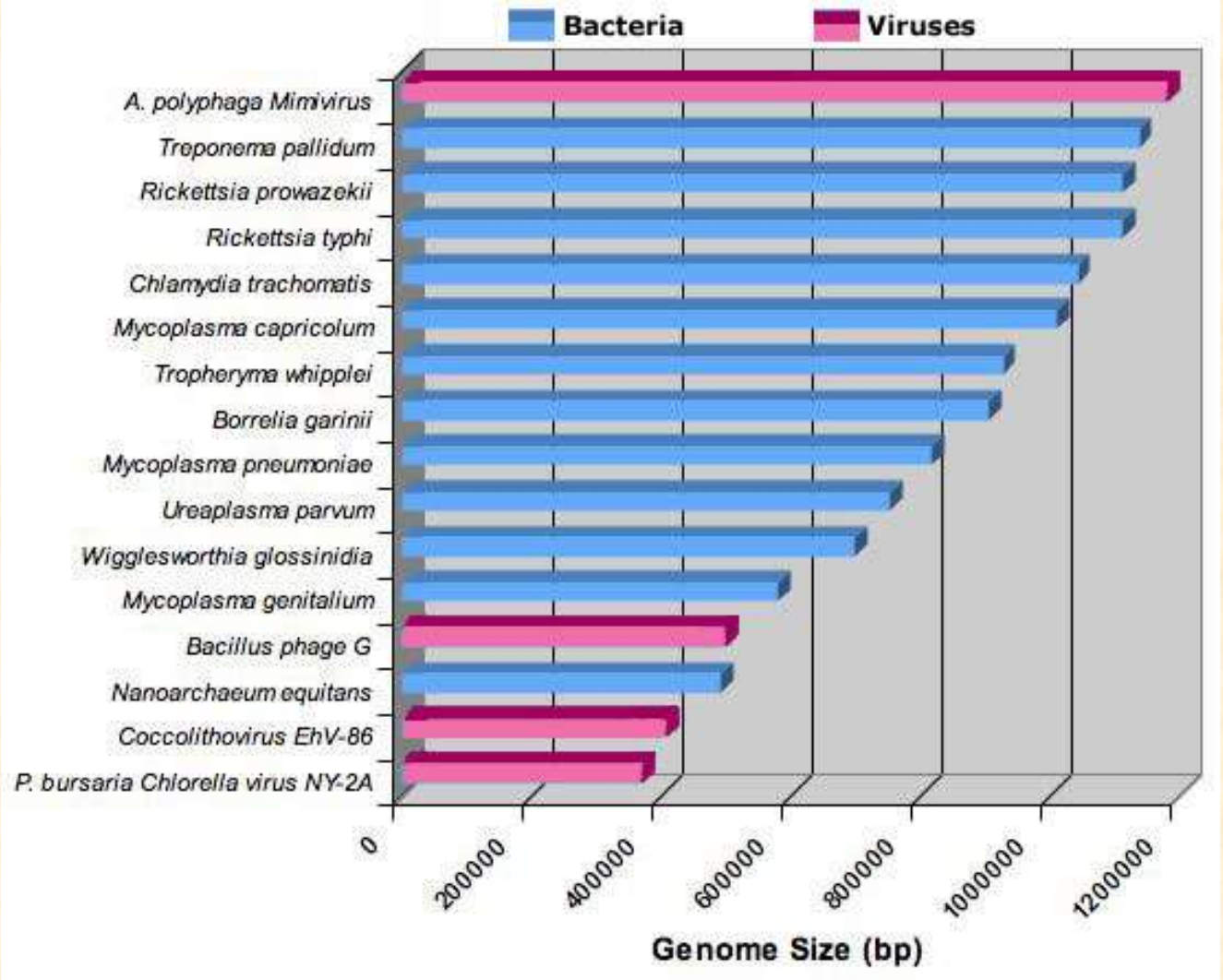
Bacteria…….. up to 4,500 genes

Viruses ……up to 911 genes

Plant Viruses ……..up to 12 genes

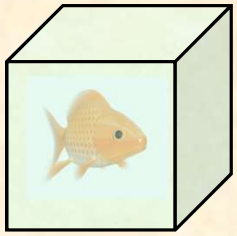
Comparison of Genome Sizes:

Viruses vs Bacteria



Koonin EV. (2005) Virology: Gulliver among the Lilliputians. Curr Biol. 15: 167-169; I am what I eat and I eat what I am: acquisition of bacterial genes by giant viruses. Filee J. et al. Trends Genet. 2007 23: 10-15

Viruses are the major players in the genetic universe



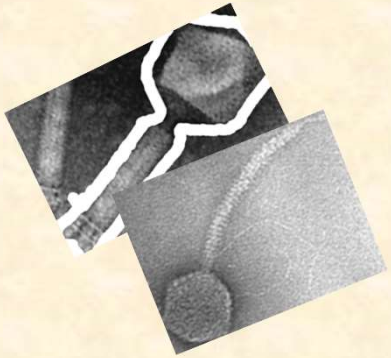
1 cm^3 of seawater contains 10^6-10^9 virus particles

Suttle, C.A. (2005) *Nature* **437**:356

Viruses dominate the biosphere:
there are 10-100 viruses for every living cell!

Number and Diversity of Plant Viruses

Estimated No. of Virus Species in the World	No. Virus Species Characterized 2018	No. Species Known to Infect Land Plants 2018
1×10^{31}	5,562	Approx. 1,800



There are millions of diverse viral species in the world (65% of partial viral sequences found have no homologues in GenBank)

Edwards and Rohwer (2005) *Nat. Rev. Microbiol.* 3:504

Just published May 2019:

a single coordinated study found 200,000 virus species in earth's oceans!!

Ann C.Gregory et al. 2019. Marine DNA Viral Macro- and Microdiversity from Pole to Pole. Cell, ttps://doi.org/10.1016/j.cell.2019.03.040.

Plant Viruses

WHY STUDY PLANT VIRUSES?

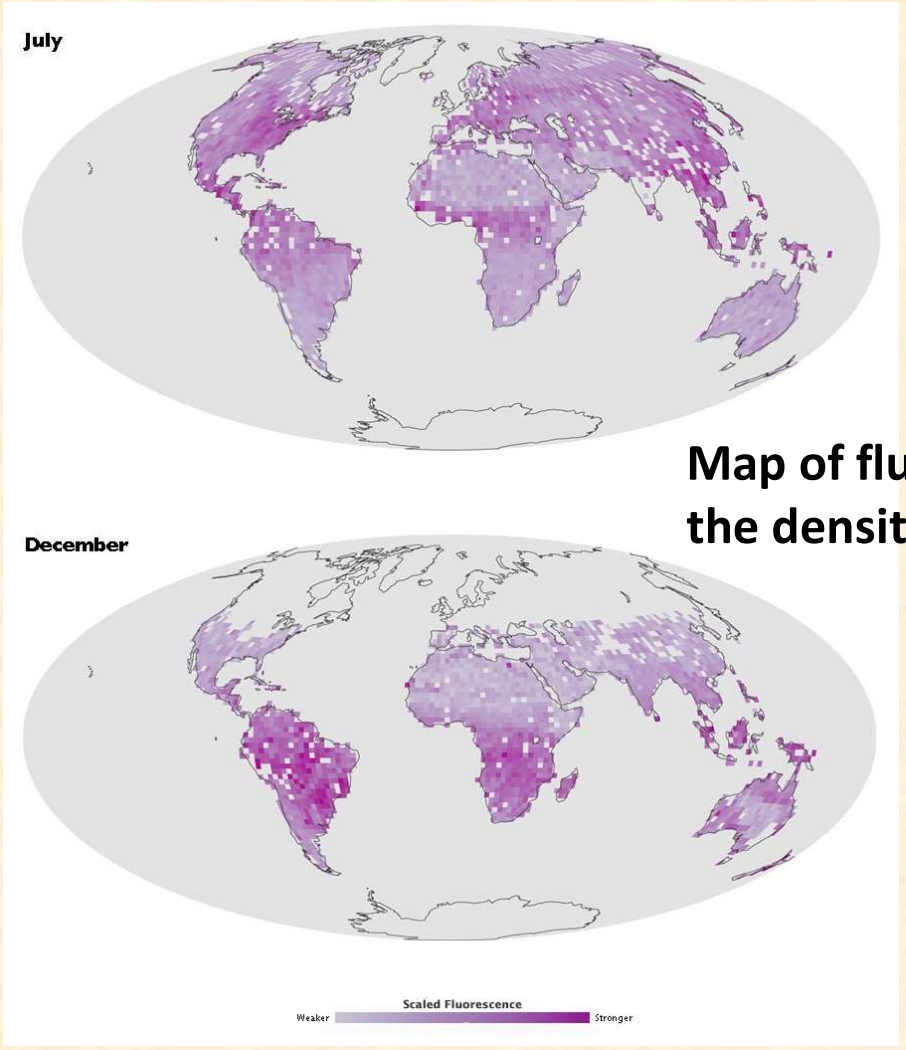
1. Viruses are Important Pathogens

Second most diverse group of plant pathogens

They are widely distributed pathogens that are not easy to work with.

They cause economic losses in food and fiber production.

Not always readily recognized, identified, distinguished or managed.



Viruses of plants are found across the earth – wherever plants grow

+ Some plant viruses found in water (water plants, stable viruses)

Map of fluorescence indicating the density of growing plants

http://www.nasa.gov/topics/earth/features/fluorescence-map.html

Comparison of Species Diversity of Plant Pathogens (2018)

Type of Organism	Estimated No. of Species in the World	No. Species Known to Cause Plant Disease
Fungi	$1.5 – 5.0 \times 10^{6}$	8,000
Bacteria	$1 \times 10^{11\text{-}12}$	100
Viruses	1.0×10^{31}	1,600+

WHY STUDY PLANT VIRUSES?

2. Viruses are TOOLS for Exploring Basic Cellular Processes

Provide simple systems to manipulate and investigate the functions of cells.

- **Viruses have provided valuable information about many aspects of cell biology:**
  Ex. Source of promoters, delivery mechanism for gene expression, have simplified the study of genetics

- **Viruses have increased our understanding of the basic mechanisms of molecular genetics (DNA replication, transcription, RNA processing), translation (genetics), protein transport, and immunology.**

WHY STUDY PLANT VIRUSES?

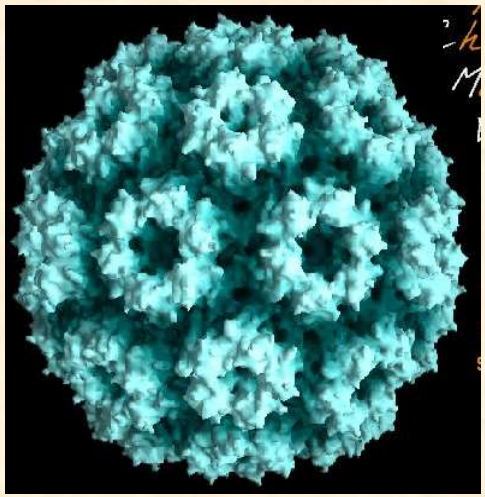
3. Viruses are being used as Expression Vectors in Plants

Viruses are used to synthesize large amounts of proteins and peptides of commercial interest in plants

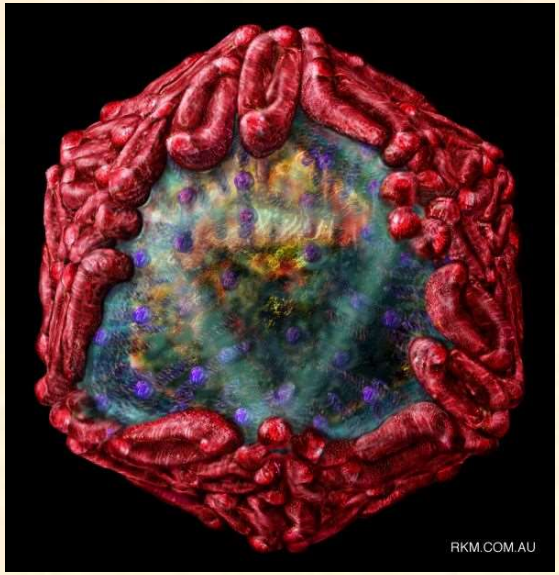
4. Viruses ARE Nanobots

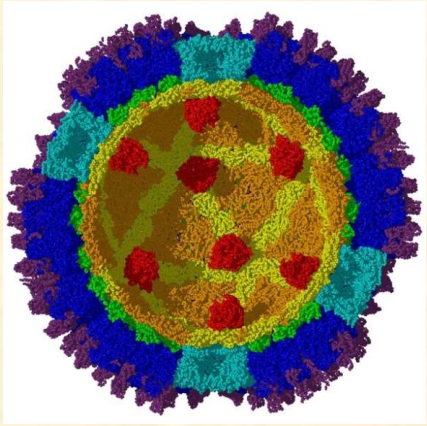
Viruses are model systems for Materials Science and Nanotechnology

Viruses will one day be created which can act as agents on behalf of bio-mechanical healing devices giving humans or other animals extended life.



5. PLANT VIRUSES ARE *COOL*



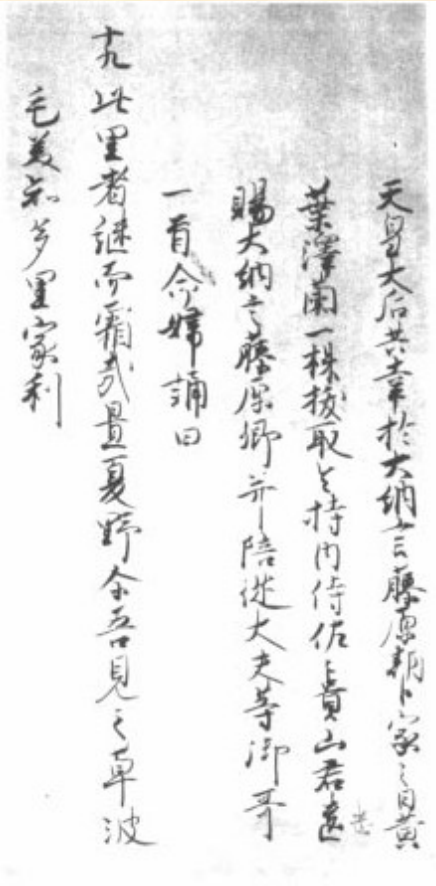


How did we first learn about plant viruses?

Explanation for diseases caused by viruses:

Ancient times → angry gods, evil spirits

Many centuries → poisonous vapors



Poem by Empress Kokan, Japan

First written documentation of symptoms of a plant virus - 752 CE

Viruses as Pathogenic Agents

1861 → **DeBary (fungi)**

1876 → **Pasteur & Koch (bacteria)**

1886-1898 → **Mayer, Ivanovsky, Beijerinck** **?**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First Clues:

- 1886 Adolf Mayer (Holland)

  -described symptoms associated with mosaic disease of
  -demonstrated that the juice of the diseased tobacco plants was infectious
  - proposed that the causal agent was an infectious “ferment” (like an enzyme)
  - using filters (2 layers of filter paper) the agent was smaller than a fungi so he concluded it was a bacteria

First Clues:

- 1892 Dmitry Ivanovsky (Russia)

  - confirmed Mayer's work on transmission
  - demonstrated that the agent was transmitted across a graft
  - demonstrated that bacteria could pass through Mayer's double filters
  - so he disagreed with Mayer's conclusions and concluded that the symptoms were caused by a toxin or a bacteria

First Clues:

- 1898 Martinus Beijerinck (Holland)

  - passed the pathogenic agent through agar (no microbe could get through)
  - concluded that he had a “contagium vivum fluidum”
  - demonstrated through serial dilutions that the agent was reproducing in the plant
  - first to use the term virus for the infectious agent

1904-1935:

Many diseases caused by viruses were described based on their hosts, symptoms and means of transmission

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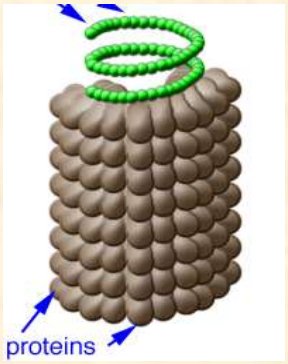
But these researchers still had no idea what a virus was

- 1935: Wendall M. Stanley (USA) crystallized TMV - demonstrating that virus particles (TMV) contained protein



- 1936: F. C. Bawden (England) and N. W. Pirie discovered that virus particles (TMV) were made up of protein and nucleic acid


F. C. Bawden

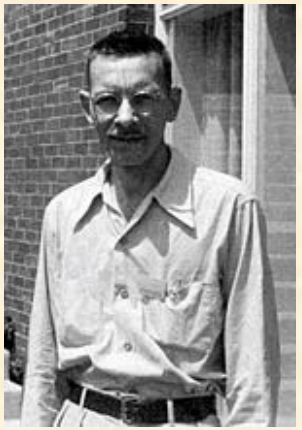
Still did not know whether genetic information was due to the protein or the RNA

Later:

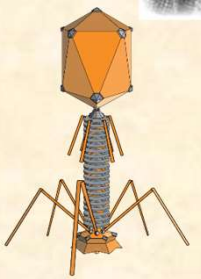
- 1939: Kaushe, Pfankuch, Ruska brothers (Germany) using the newly invented EM, were the first to see a virus
- They proved that a virus (TMV) was composed of very small rod shaped particles

1931 - the Ruska brothers

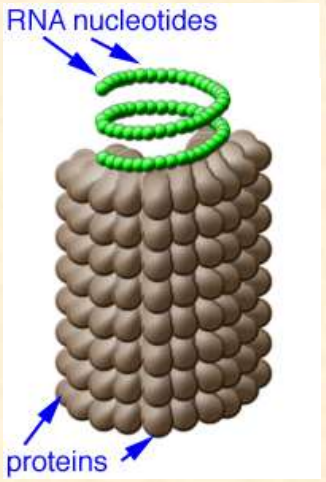
Much later:



- 1952, Hershey and Chase (USA) demonstrated that DNA and not the protein of a phage contained the genetic information



- 1956, Fraenkel-Conrat and colleagues (USA) demonstrated that the RNA was the infectious part of the virus, and that RNA and not protein contained the genetic information



So what does this history tell us about pathogen discovery?

- **Working with something you can't see, makes you dependent on technology**

- **If you can't culture the pathogen - identification is more challenging**

Top Ten Virologists:

http://www.virology.ws/2011/11/01/ten-seminal-virologists/