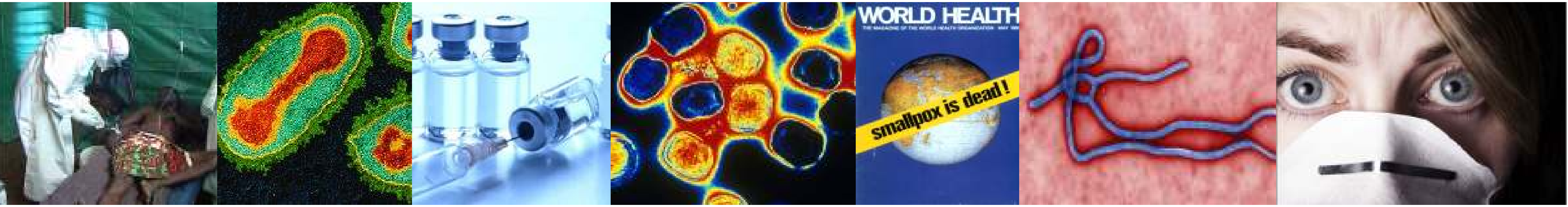
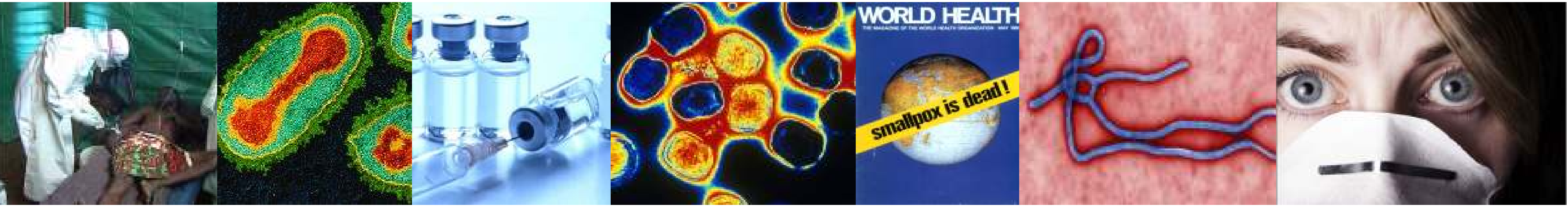


Morfologia, Ultraestrutura e Taxonomia de Vírus

Helena Lage Ferreira

Disciplina ZMV0368 – Microbiologia Fundamental

Engenharia de Alimentos - Diurno



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Cortesia slides: Flávio G. da Fonseca. ICB, CT-Vacinas, UFMG e Ricardo Moro – FZEA, USP

USP

CT Vacinas

Microbiologia SINCE 1969 UFMG

Dogma da biologia molecular e

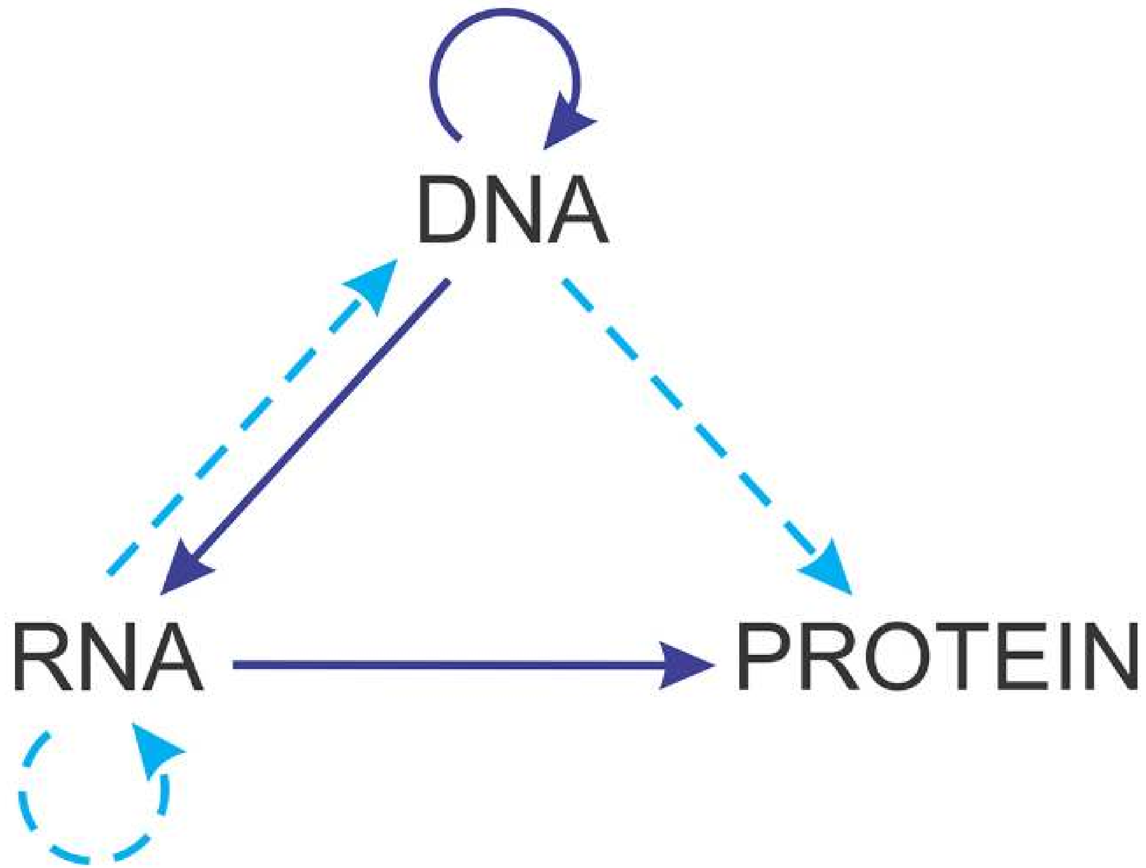
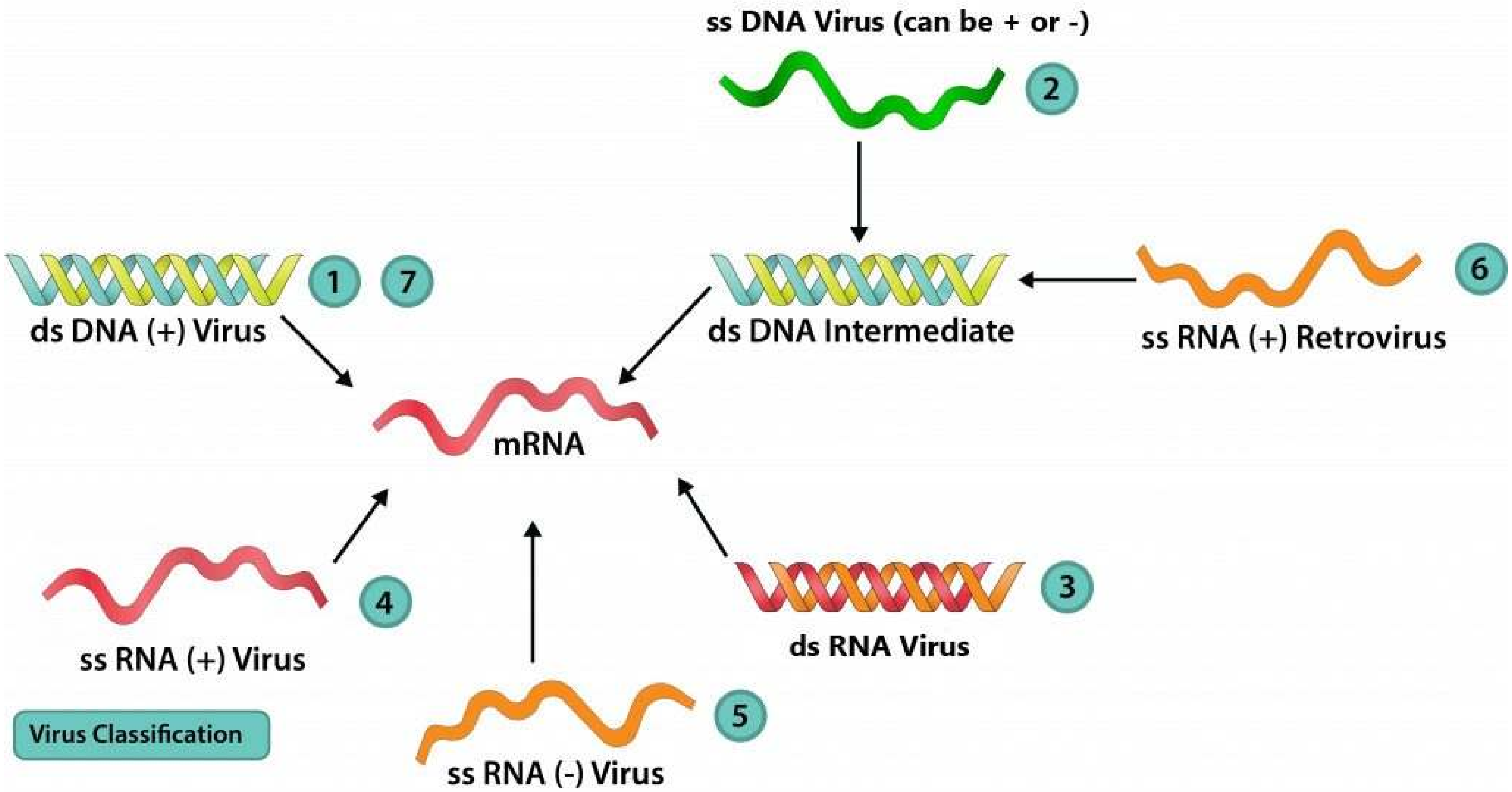


FIG 1 The central dogma of molecular biology. The figure is redrawn from Crick's 1970 article. The solid arrows represent the mainstream routes of information flow, and the dashed arrows show (putative) "special routes" after Crick. Adapted from reference 10 with permission of Springer Nature.

Material genético dos vírus



Histórico

https://www.youtube.com/watch?v=ZMCVgtV2sG4&feature=youtu.be

Eventos mais relevantes na virologia

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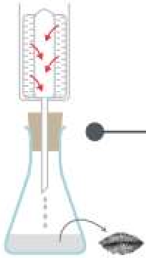
1796

1796 Edward Jenner administers the first smallpox vaccine, which is heralded as the world's first vaccine. The vaccine consists of fluid from a cowpox blister, a virus similar to smallpox, which is scratched onto the skin of an 8-year old boy. When the boy is later inoculated with smallpox matter, no disease develops.

1885

1885 French scientists, Louis Pasteur and Emile Roux, develop the first effective rabies vaccine. The virus is grown in rabbits and a vaccine is made from dried rabbit nervous system tissue, which is successfully administered to a boy that was bitten by a rabid dog.

1892



1892 Dmitri Ivanovsky shows that tobacco mosaic disease, a single-stranded RNA plant virus, can be transmitted by extracts passed through porcelain Pasteur-Chamberland filters, which exclude the smallest known bacteria.

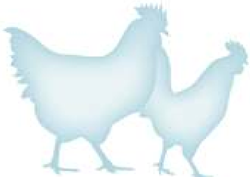
1898

1898 Martinus Beijerinck replicates the filtration experiments performed by Dmitri Ivanovsky and calls the infectious agent that causes tobacco mosaic disease a "virus", which he describes as a "contagium vivum fluidum" or "contagious living fluid". Beijerinck along with Ivanovsky are considered to be the founders of virology.

1898 The first animal virus, known as foot and mouth disease virus, is discovered by German scientists, Friedrich Loeffler and Paul Frosch. They show that cows and sheep can be vaccinated against the virus using a heat-inactivated, filtered vesicle extract.

1901

1901 Walter Reed heads the U.S. Army Yellow Fever Commission, which discovers that yellow fever is transmitted by the bite of an *Aedes aegypti* mosquito rather than by direct contact.



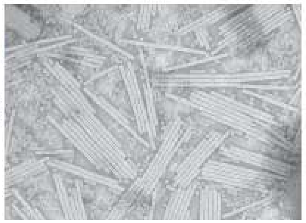
1911 Peyton Rous discovers Rous sarcoma virus (RSV), the first oncogenic retrovirus to be described, which is found to cause sarcoma in chickens. Rous shares the Nobel Prize in Physiology or Medicine in 1966 for his discovery of tumor-inducing viruses.

1911

1933

1933 Cottontail rabbit papillomavirus (CRPV) is discovered and is shown to be the first oncogenic DNA virus in 1935. CRPV causes skin tumors and warts that are typically located on the heads of infected rabbits.

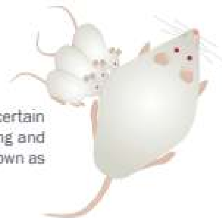
1935



1935 Wendell Stanley produces the first crystals of tobacco mosaic virus and shows that the virus remains active after crystallization. Crystallization of the virus was the first step toward proving that the virus is particulate.

1936

1936 John Bittner reports that an infectious, filterable agent present in the milk of certain cancer-prone mouse strains can be transmitted to newborn, cancer-resistant mice by suckling and it can lead to the development of mammary tumors. This infectious agent later came to be known as mouse mammary tumor virus.



Eventos mais relevantes na virologia

1937

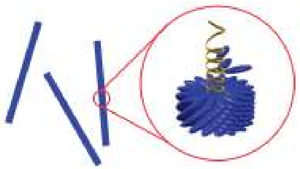
1937 Max Theiler grows the yellow fever virus in chicken eggs and produces a vaccine from an attenuated virus strain. In 1951, he receives the Nobel Prize in Physiology or Medicine for his discovery of an effective yellow fever vaccine, the only Nobel Prize ever awarded for the development of a virus vaccine.

1951

1951 Ludwik Gross identifies the first murine leukemia virus.

1953

1953 Jonas Salk announces on a national radio show and later reports in *The Journal of the American Medical Association* that he has successfully developed and tested an injectable, killed-virus vaccine against poliovirus, the virus responsible for poliomyelitis. Testing of the vaccine starts in 1954 and in 1955, it is announced that the vaccine is safe and effective. In 1962, an oral vaccine developed by Albert Sabin using a weakened form of the live virus becomes available.

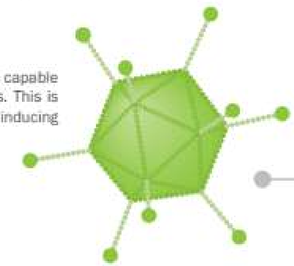


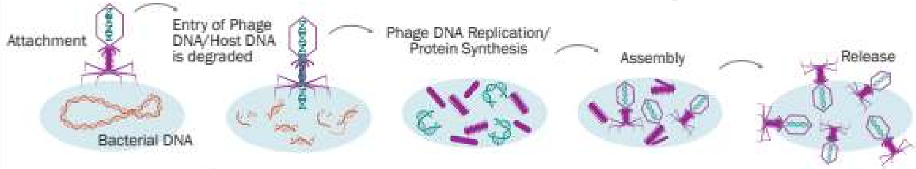
1955

1955 Rosalind Franklin proposes the full structure of tobacco mosaic virus, suggesting that the virus contains a single strand of RNA that spirals in a helical groove inside the center of the viral proteins. Solving the structure of the tobacco mosaic plant virus paved the way for solving the structure of animal viruses, which Franklin's lab subsequently pursued, leading to a publication following her death that described the crystal structure of poliovirus.

1962

1962 John Trentin reports that human adenovirus is capable of causing tumors in experimentally-infected animals. This is the first known human virus reported to be capable of inducing cancer.



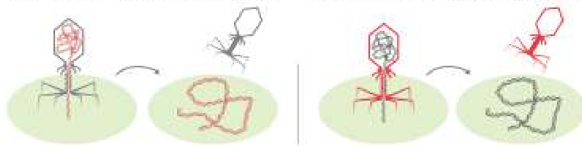


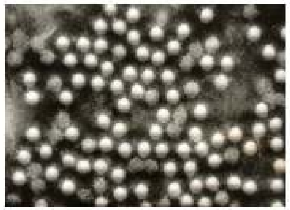
1939

1939 Emory Ellis and Max Delbruck establish the concept of the one-step virus growth cycle, which serves as the basis for understanding viral replication and the virus life cycle. They demonstrate that virus particles do not grow, but rather are assembled from preformed components.

1952

1952 Hershey and Chase demonstrate that DNA alone, not protein, enters a bacterial cell upon infection with enterobacteria phage T2, which is a virus that infects and kills *E. coli*.



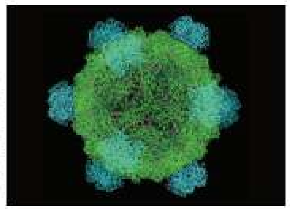


1954

1954 John Franklin Enders, known as "The Father of Modern Vaccines", along with Thomas Huckle Weller and Frederick Chapman Robbins share the Nobel Prize in Physiology or Medicine for their discovery that poliovirus could be grown in cultures using various types of tissues without needing an intact organism. This finding allowed both inactivated and live polio vaccines to be produced for the first time and was critical to being able to create large quantities of different kinds of viruses for research.

1959

1959 The Nobel Prize in Physiology or Medicine is jointly awarded to Severo Ochoa and Arthur Kornberg for their discovery of the mechanisms in the biological synthesis of ribonucleic acid and deoxyribonucleic acid. Ochoa discovered an enzyme that could synthesize RNA, while Kornberg discovered an enzyme that could synthesize DNA. Kornberg later showed that DNA synthesized in a test tube by purified enzymes could produce all of the features of a natural virus using the bacteriophage Phi X 174, a single-stranded DNA virus, as a model.



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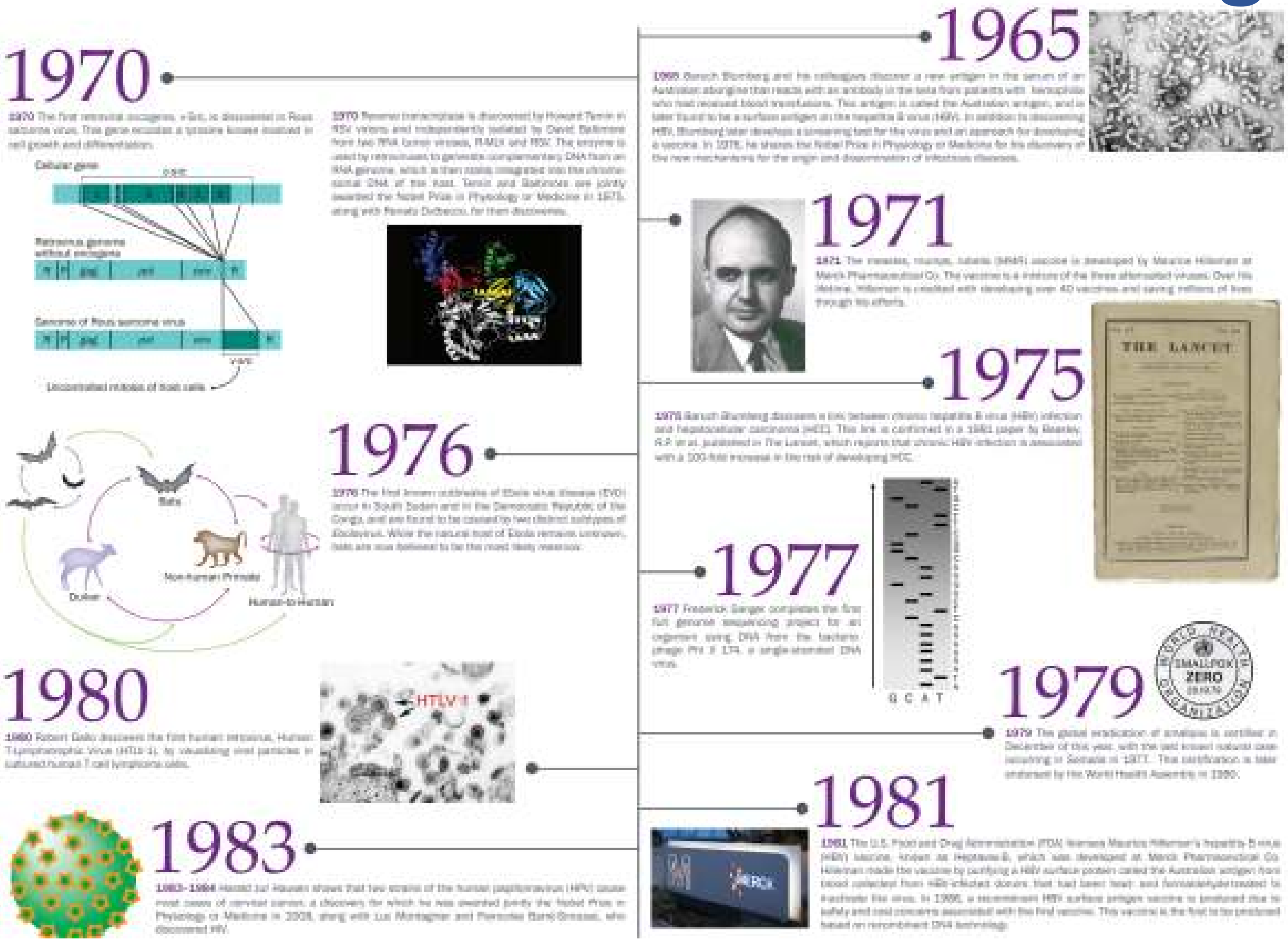
Eventos mais relevantes na virologia



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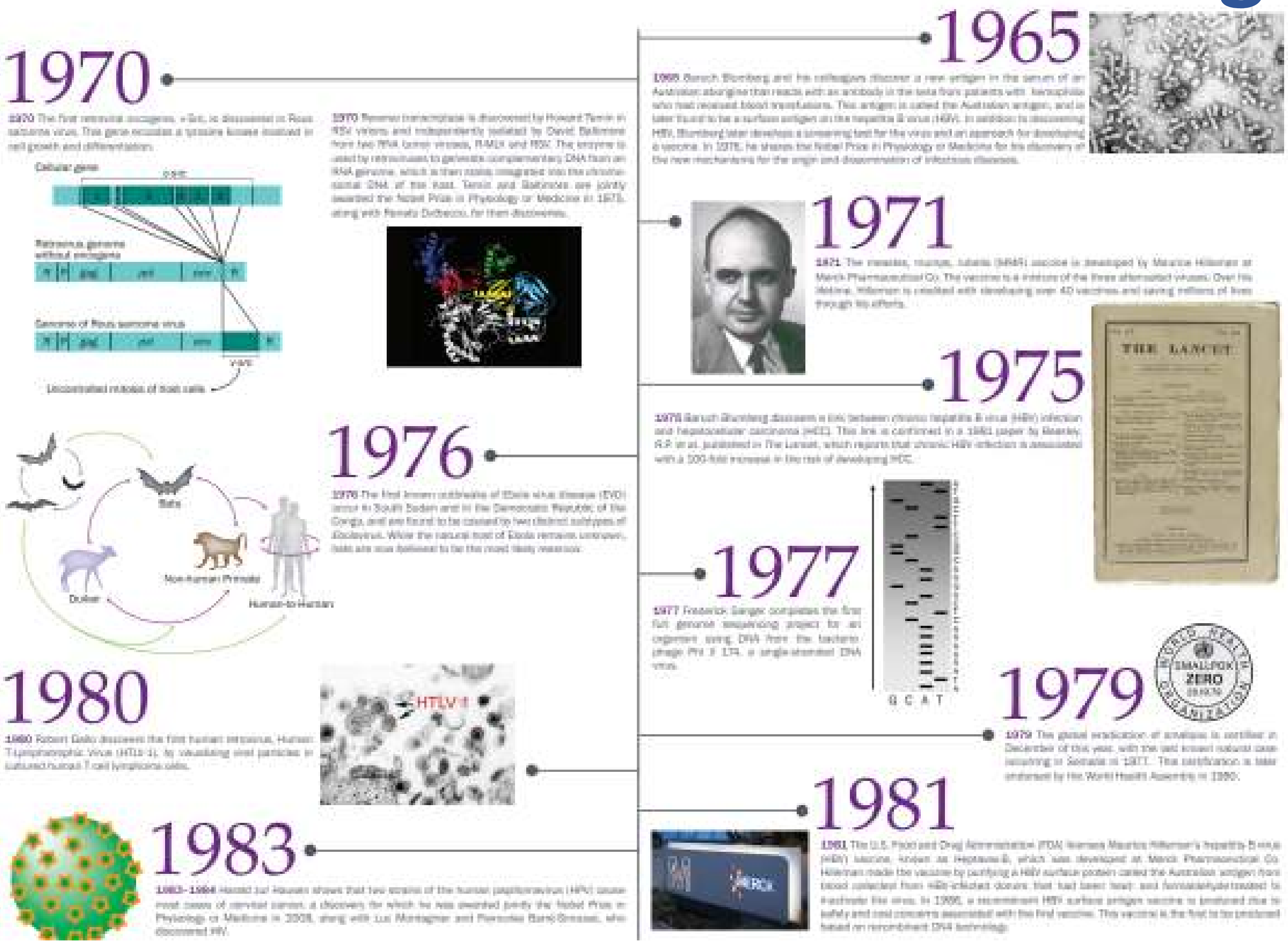
Eventos mais relevantes na virologia



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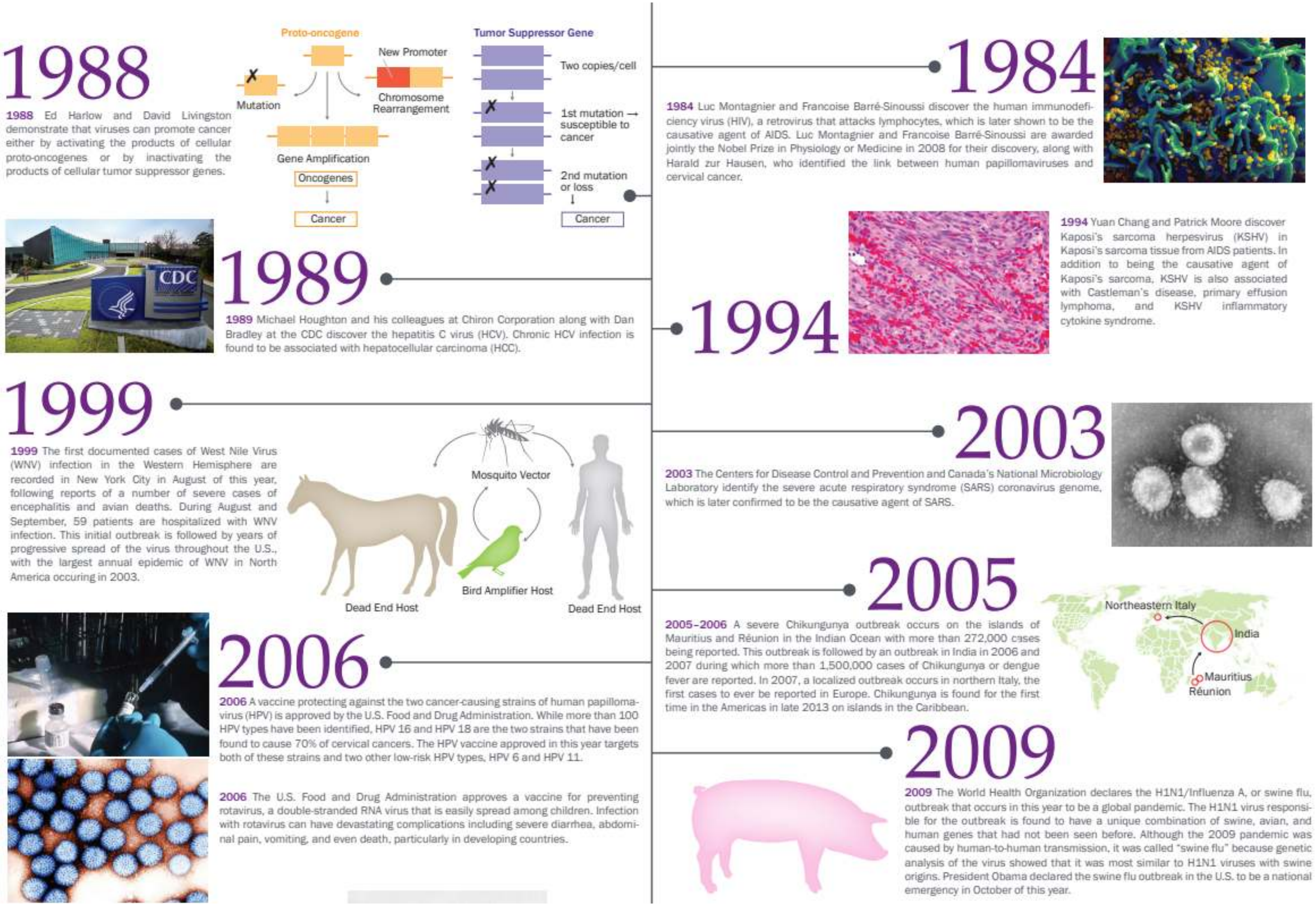
Eventos mais relevantes na virologia



1988

1988 Ed Harlow and David Livingston demonstrate that viruses can promote cancer either by activating the products of cellular proto-oncogenes or by inactivating the products of cellular tumor suppressor genes.

1989

1989 Michael Houghton and his colleagues at Chiron Corporation along with Dan Bradley at the CDC discover the hepatitis C virus (HCV). Chronic HCV infection is found to be associated with hepatocellular carcinoma (HCC).

1999

1999 The first documented cases of West Nile Virus (WNV) infection in the Western Hemisphere are recorded in New York City in August of this year, following reports of a number of severe cases of encephalitis and avian deaths. During August and September, 59 patients are hospitalized with WNV infection. This initial outbreak is followed by years of progressive spread of the virus throughout the U.S., with the largest annual epidemic of WNV in North America occuring in 2003.

2006

2006 A vaccine protecting against the two cancer-causing strains of human papillomavirus (HPV) is approved by the U.S. Food and Drug Administration. While more than 100 HPV types have been identified, HPV 16 and HPV 18 are the two strains that have been found to cause 70% of cervical cancers. The HPV vaccine approved in this year targets both of these strains and two other low-risk HPV types, HPV 6 and HPV 11.

2006 The U.S. Food and Drug Administration approves a vaccine for preventing rotavirus, a double-stranded RNA virus that is easily spread among children. Infection with rotavirus can have devastating complications including severe diarrhea, abdominal pain, vomiting, and even death, particularly in developing countries.

1984

1984 Luc Montagnier and Francoise Barré-Sinoussi discover the human immunodeficiency virus (HIV), a retrovirus that attacks lymphocytes, which is later shown to be the causative agent of AIDS. Luc Montagnier and Francoise Barré-Sinoussi are awarded jointly the Nobel Prize in Physiology or Medicine in 2008 for their discovery, along with Harald zur Hausen, who identified the link between human papillomaviruses and cervical cancer.

1994

1994 Yuan Chang and Patrick Moore discover Kaposi's sarcoma herpesvirus (KSHV) in Kaposi's sarcoma tissue from AIDS patients. In addition to being the causative agent of Kaposi's sarcoma, KSHV is also associated with Castleman's disease, primary effusion lymphoma, and KSHV inflammatory cytokine syndrome.

2003

2003 The Centers for Disease Control and Prevention and Canada's National Microbiology Laboratory identify the severe acute respiratory syndrome (SARS) coronavirus genome, which is later confirmed to be the causative agent of SARS.

2005

2005–2006 A severe Chikungunya outbreak occurs on the islands of Mauritius and Réunion in the Indian Ocean with more than 272,000 cases being reported. This outbreak is followed by an outbreak in India in 2006 and 2007 during which more than 1,500,000 cases of Chikungunya or dengue fever are reported. In 2007, a localized outbreak occurs in northern Italy, the first cases to ever be reported in Europe. Chikungunya is found for the first time in the Americas in late 2013 on islands in the Caribbean.

2009

2009 The World Health Organization declares the H1N1/Influenza A, or swine flu, outbreak that occurs in this year to be a global pandemic. The H1N1 virus responsible for the outbreak is found to have a unique combination of swine, avian, and human genes that had not been seen before. Although the 2009 pandemic was caused by human-to-human transmission, it was called "swine flu" because genetic analysis of the virus showed that it was most similar to H1N1 viruses with swine origins. President Obama declared the swine flu outbreak in the U.S. to be a national emergency in October of this year.

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Eventos mais relevantes na virologia

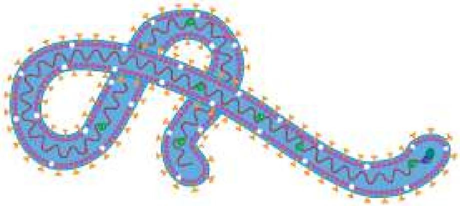
2011

2011 Rinderpest, a contagious viral disease of ruminant mammals, primarily cattle, is declared to be fully eradicated by veterinary epidemiologists, making it only the second disease in history following smallpox to be globally eradicated.

2012

2012 The first case of Middle East Respiratory Syndrome (MERS) is reported in Saudi Arabia. It is found to be caused by Middle East Respiratory Syndrome coronavirus (MERS-CoV), which is thought to have come from an animal source, possibly camels, in the Arabian Peninsula.

2014



2014 The largest Ebola outbreak in history occurs in West Africa, resulting in the death of more than 11,300 people in Guinea, Liberia, and Sierra Leone. In September of this year, the CDC confirms the first laboratory-confirmed case of Ebola to be diagnosed in the U.S., which was found in a man who had traveled from Liberia to Texas.

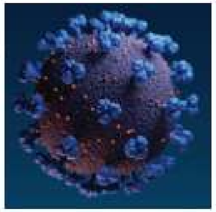
2016

2016 Due to the rapid spread of the Zika virus across Latin America and the Caribbean along with the dramatic increase in the number of reported cases of prenatal microcephaly and adult neurological disorders such as Guillain-Barré syndrome in Brazil and other areas affected by the virus, the World Health Organization declares a public health emergency of international concern.

2018

2018 The world's second largest Ebola outbreak on record begins in August of this year with four cases being confirmed in North Kivu Province in the Democratic Republic of the Congo (DRC). On July 17, 2019, the outbreak is declared a Public Health Emergency of International Concern by the World Health Organization as there are more than 2,500 cases and more than 1,600 deaths reported by the DRC Ministry of Health. By March 16, 2020, more than 3,400 cases of Ebola virus disease are confirmed, and more than 2,260 people have died since the outbreak was first declared.

2019



2019 In late December of this year, a novel coronavirus called severe acute respiratory syndrome (SARS)-CoV-2, is found to be responsible for an outbreak of respiratory illness that was first reported in the city of Wuhan in the Hubei Province of China. The disease caused by SARS-CoV-2 is designated as coronavirus disease 19 (COVID-19), which in severe cases, can lead to potentially life-threatening complications including pneumonia and respiratory failure. On January 30, 2020, the outbreak is declared a global health emergency by the World Health Organization (WHO) as nearly 8,000 cases are reported worldwide and there is evidence that the virus can be transmitted from person-to-person. Six weeks later on March 11, 2020, the WHO declares COVID-19 to be a pandemic as there are over 118,000 cases reported in more than 114 countries and territories around the world, and 4,291 people are reported to have died from the disease.

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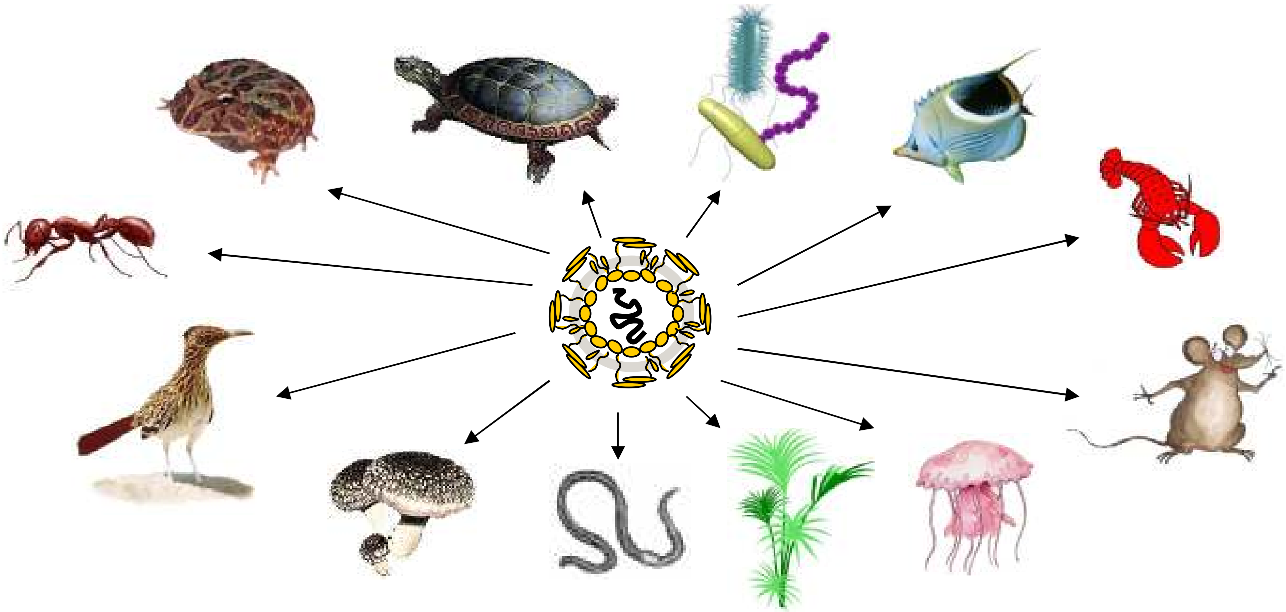
Ubiquidade dos vírus

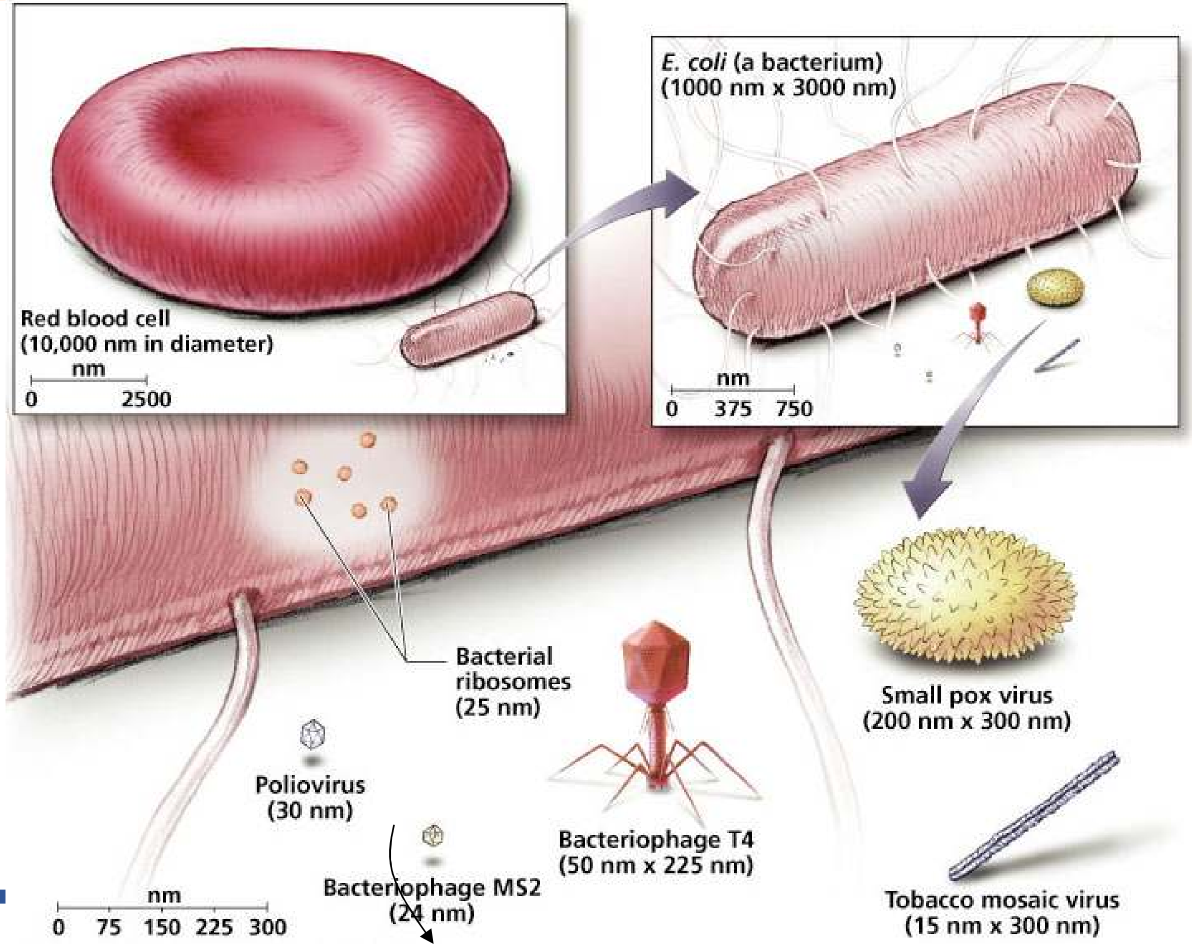
- Todos e qualquer organimo é potencialmente parasitado por algum tipo de vírus



- Consequência evolutiva

Natureza predatória: todo virus é um parasita obrigatório

Tamanho dos Vírus



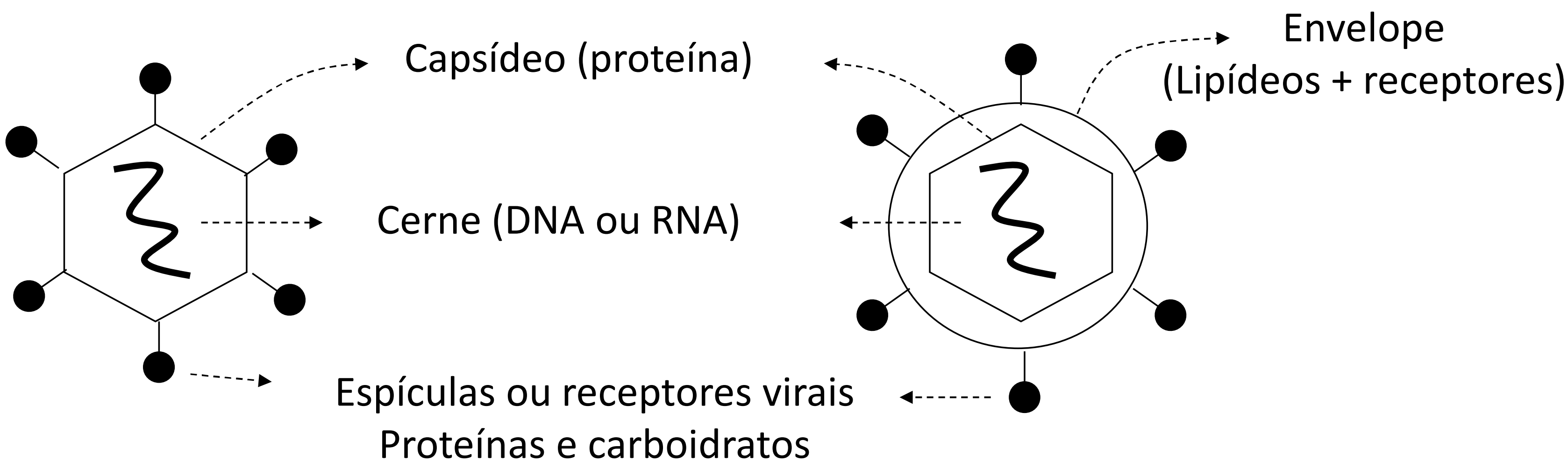
Vírus da Poliomielite (menor vírus humano)

Tamanho da partícula: 15 a 300 nm

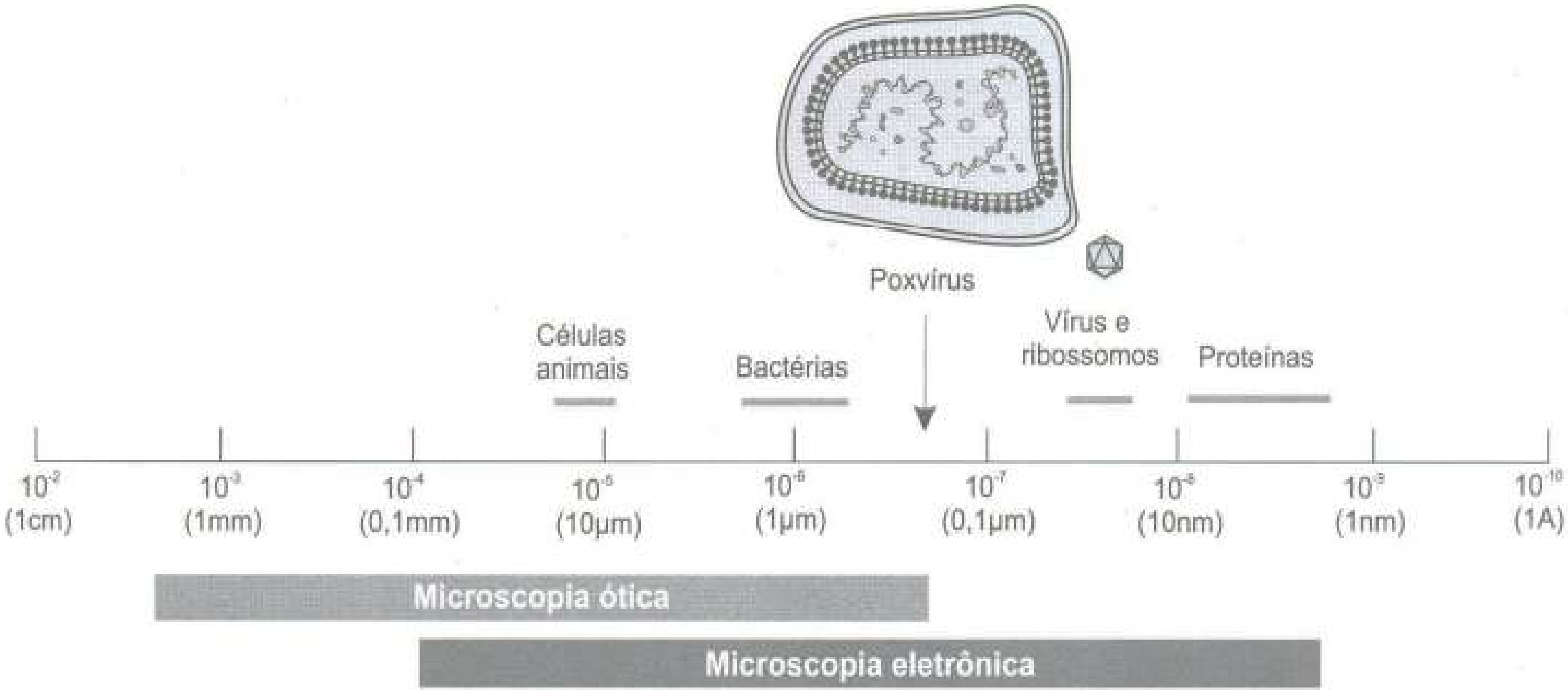
1nm = 1/10.000.000 cm

Vírus Vaccínia / Varíola (maior vírus animal/humano)

Estrutura Viral Básica

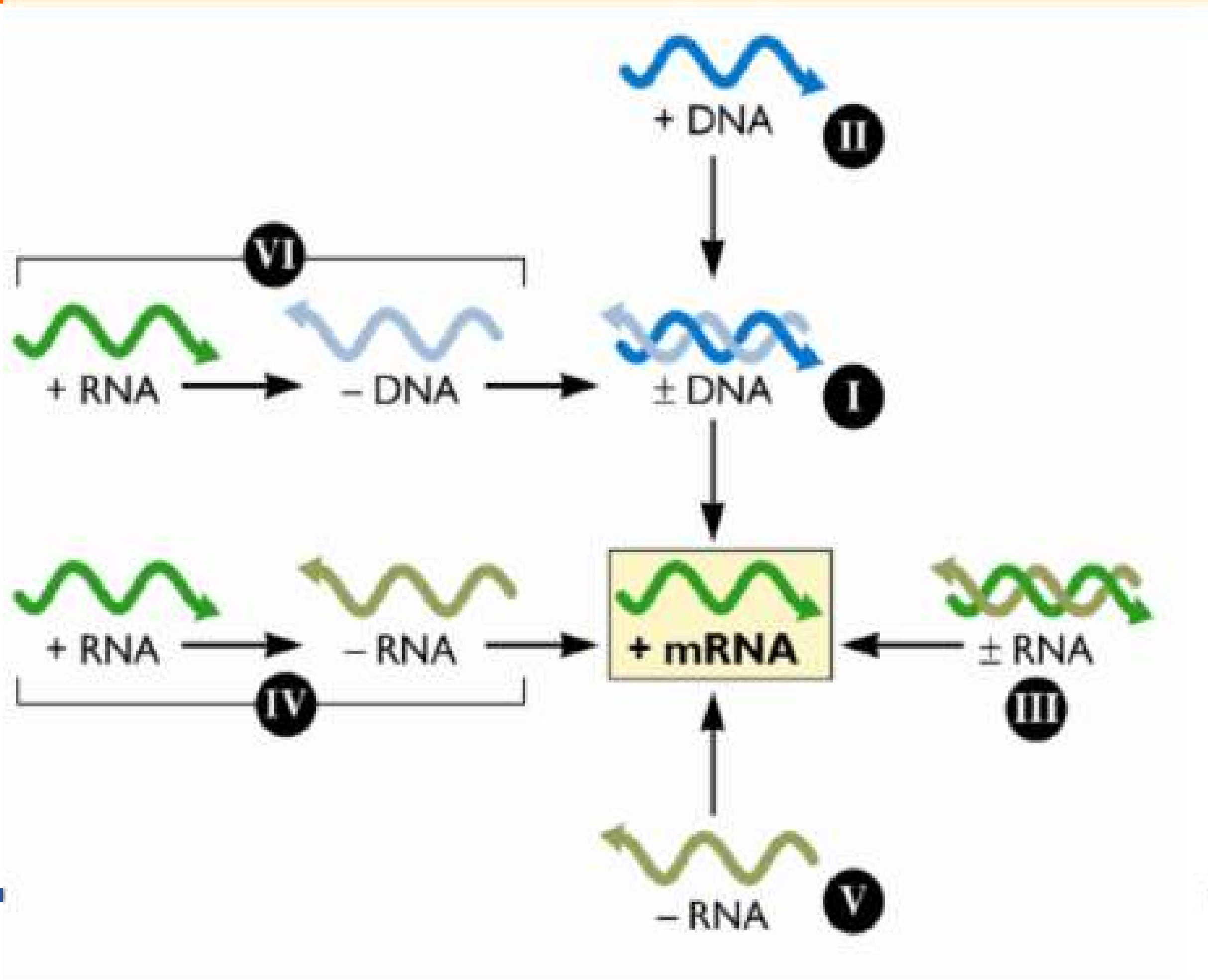


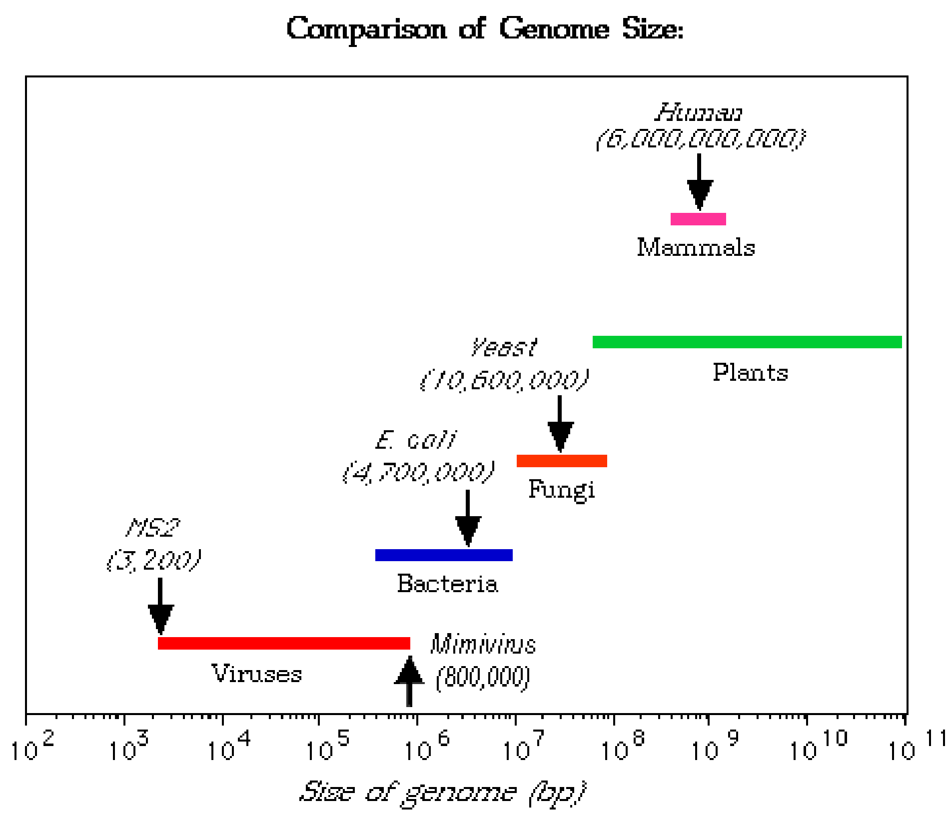
Tamanho



Poxvírus
Células animais
Bactérias
Vírus e ribossomos
Proteínas
10⁻² (1cm)
10⁻³ (1mm)
10⁻⁴ (0,1mm)
10⁻⁵ (10µm)
10⁻⁶ (1µm)
10⁻⁷ (0,1µm)
10⁻⁸ (10nm)
10⁻⁹ (1nm)
10⁻¹⁰ (1A)
Microscopia ótica
Microscopia eletrônica

Genoma Viral

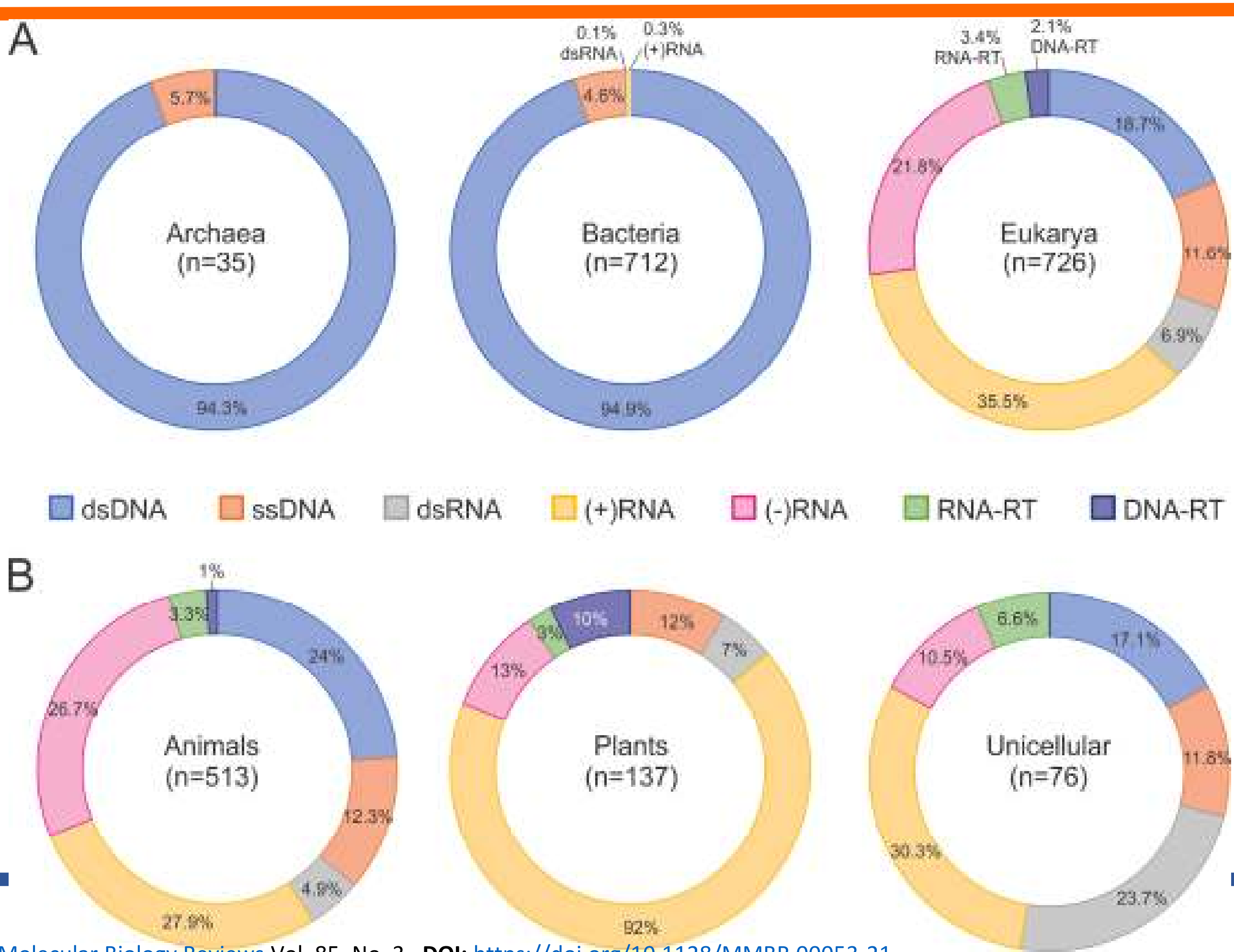




Ácido Nucleico

- simples fita ou dupla fita
- ssDNA, dsDNA, ssRNA e dsRNA
- linear ou circular
- segmentado ou não-segmentado (contínuo)
- ex: 1,2 milhões pares de bases

Ácido nucleico



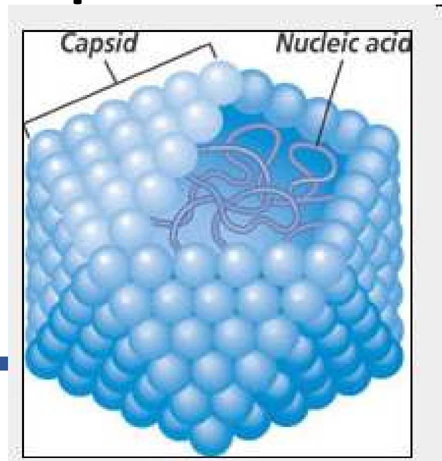
Koonin et al. 2021 Microbiology and Molecular Biology Reviews Vol. 85, No. 3. **DOI:** https://doi.org/10.1128/MMBR.00053-21

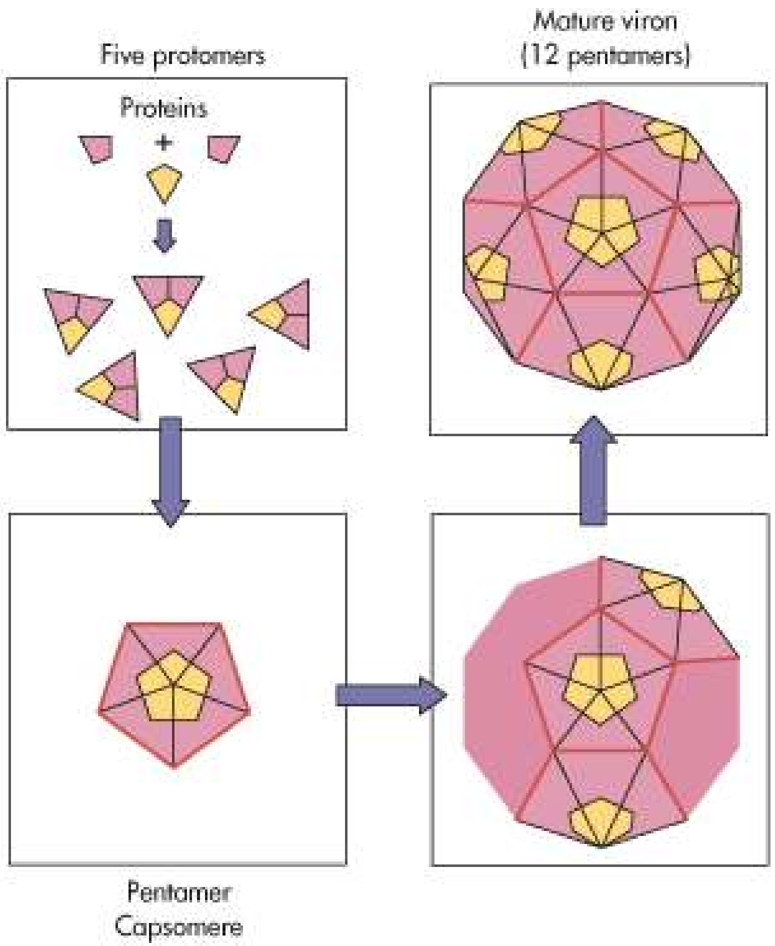
Capsídeo

Capsídeo: função de proteger o material genético

- **subunidades estruturais: capsômeros**

- **1 ou mais tipos de proteínas (protômeros)**

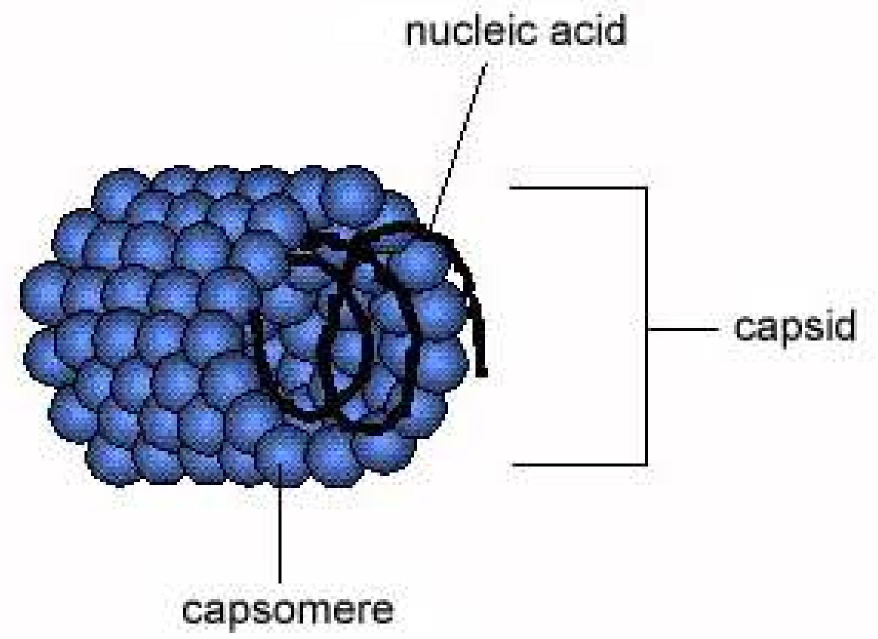




Capsídeo

- **Morfologia viral baseada na estrutura do capsídeo**

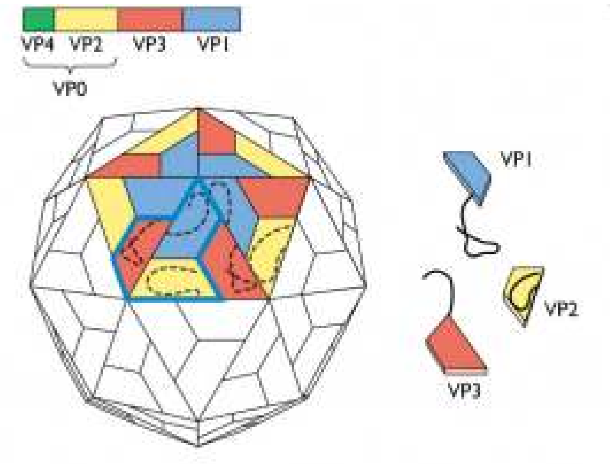
  - **helicoidais: lembram longos bastonetes, genoma no interior de capsídeo cilíndrico oco. Ex.: raiva**

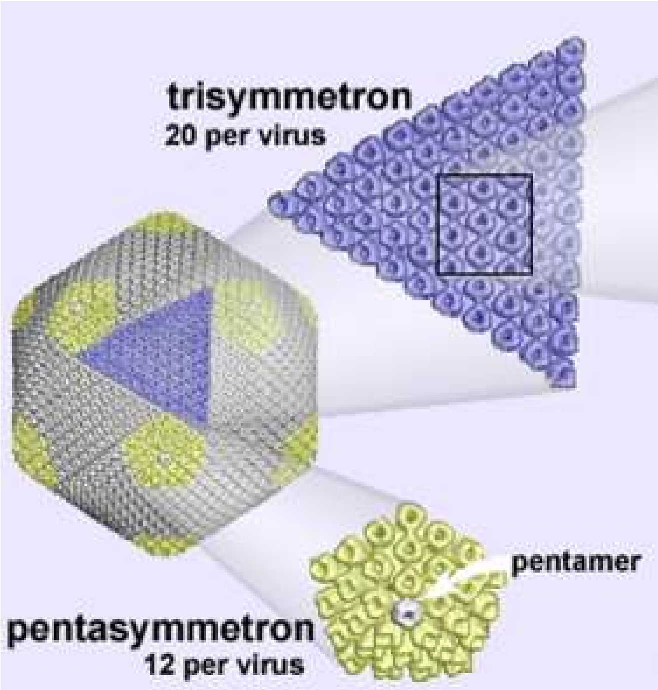


Tortora et al., 2016

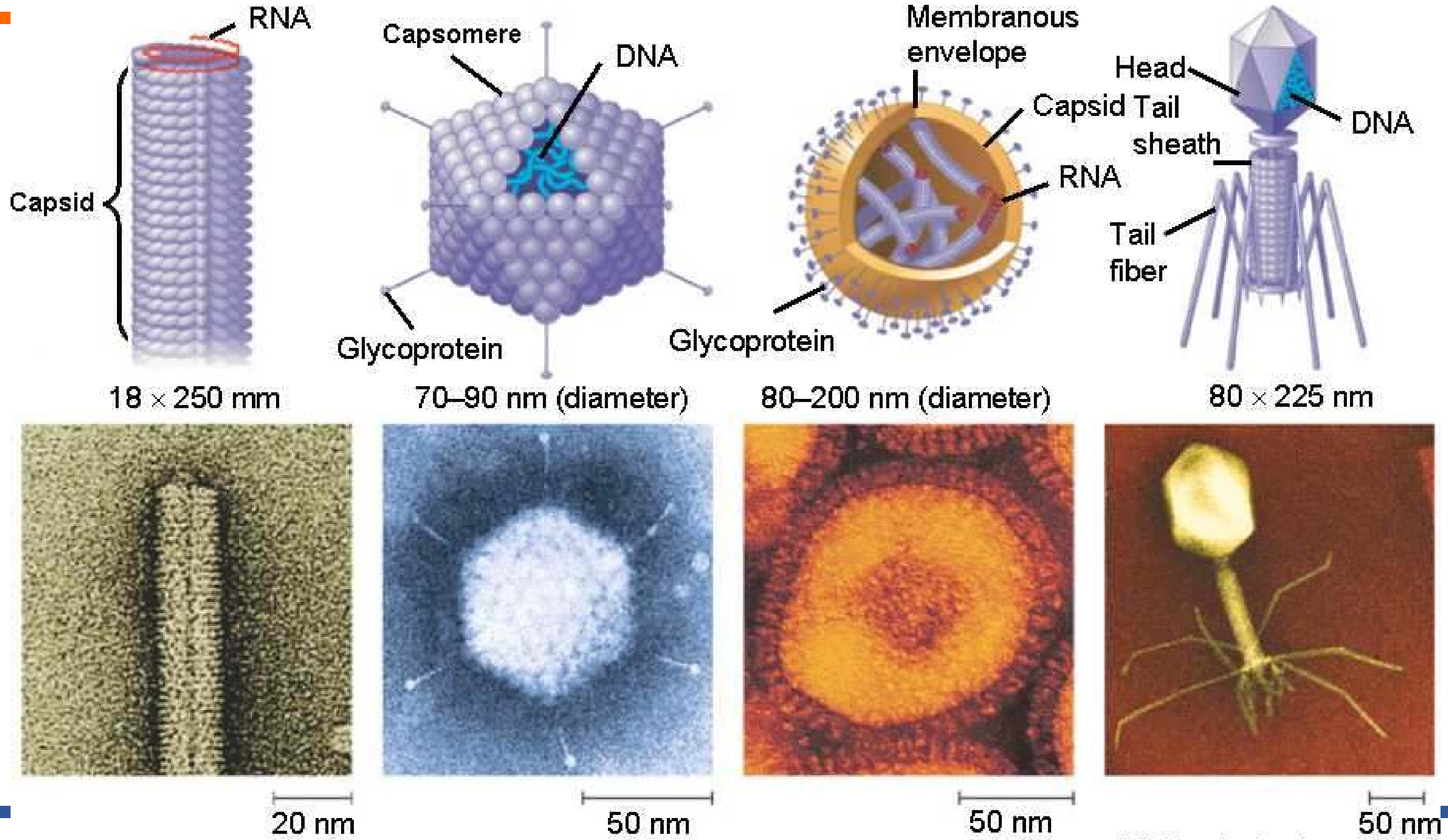
Capsídeo

- poliédricos
- Capsídeo tem forma de icosaédrico.
- Capsômeros de cada face formam um triângulo equilátero.
- Ex.: adenovírus





Morfologia baseada na estrutura do capsídeo



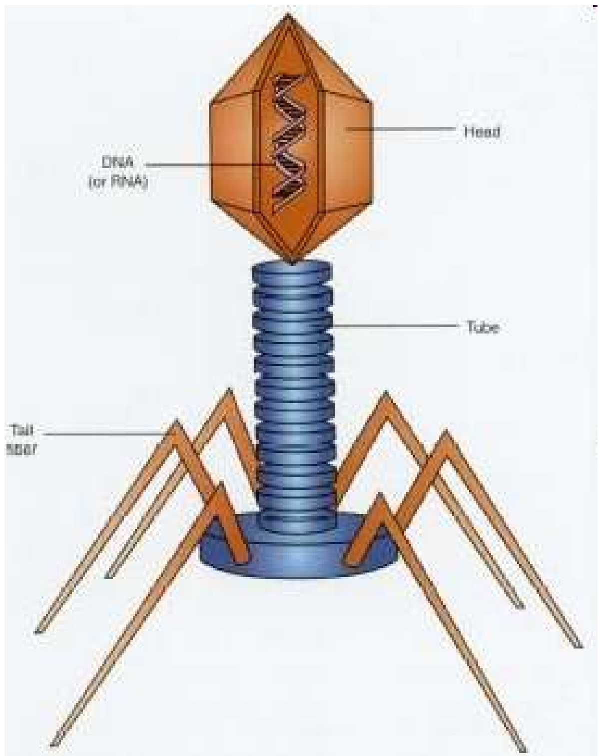
(a) Tobacco mosaic virus (b) Adenoviruses (c) Influenza viruses (d) Bacteriophage T4

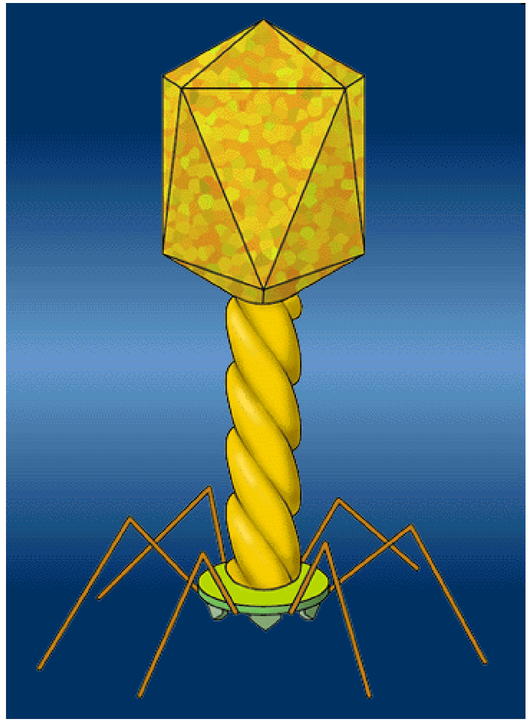
Capsídeo

- Morfologia baseada na estrutura do capsídeo

  - complexos: poliédrico + estruturas adicionais (helicoidal).

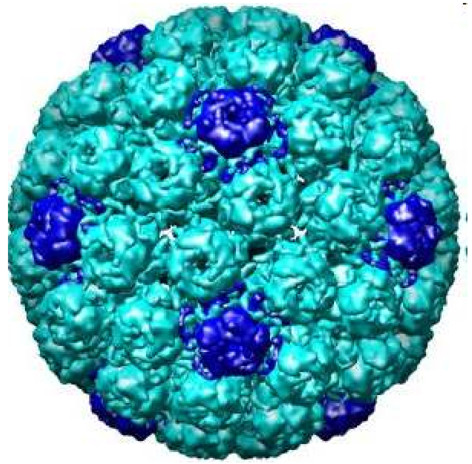
  - Ex.: bacteriófagos





Proteínas virais

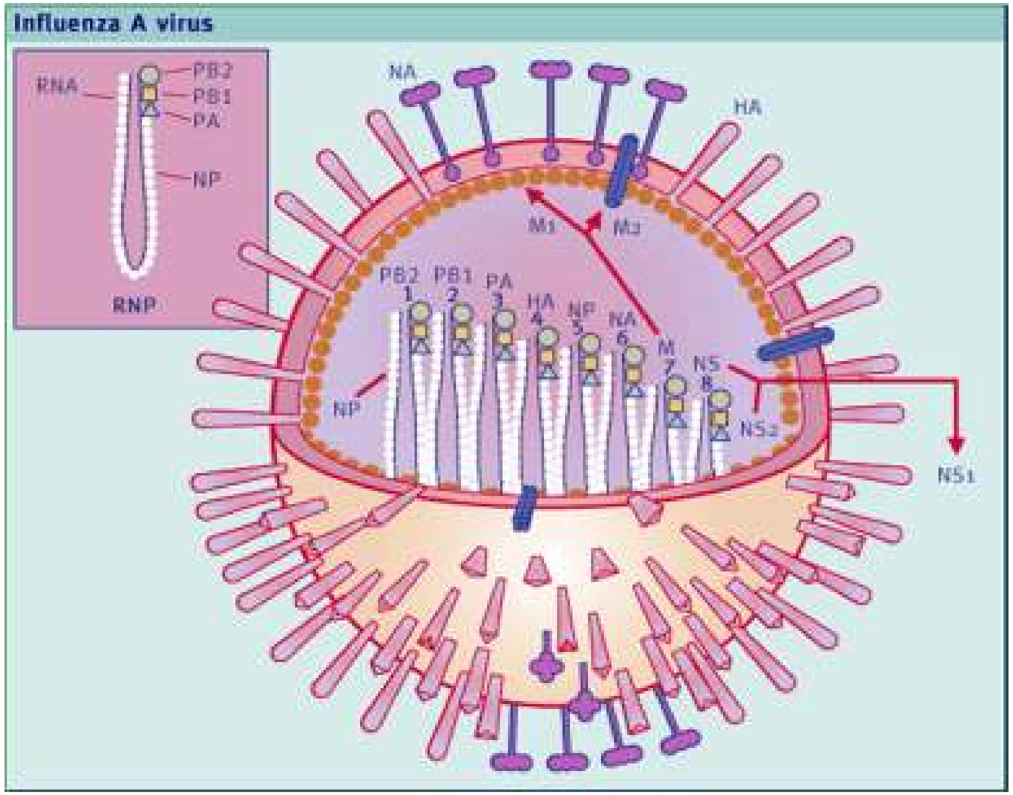
- **Estruturais:**
  - **Participam da construção e "arquitetura"/estrutura do vírus ⇨ presentes no vírion**
- **Não-estruturais:**
  - **Produzidas durante o ciclo replicativo, não participam da "arquitetura" do vírion ⇨ atividades enzimáticas e/ou regulatórias**

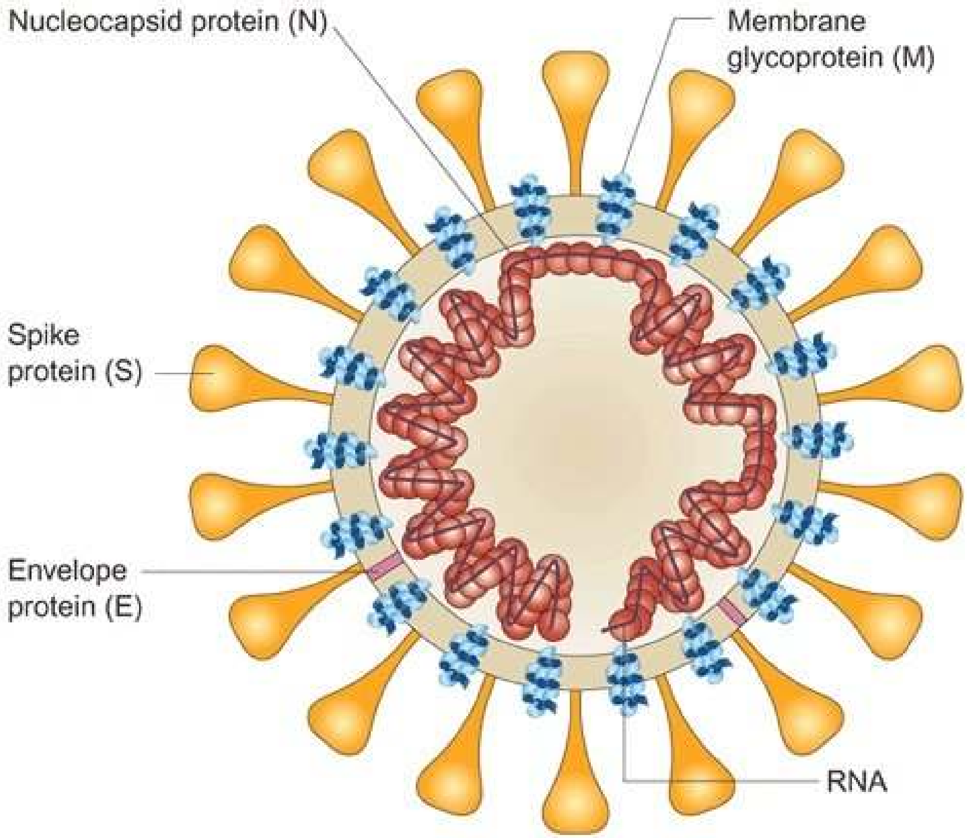


Proteínas virais

- lipídeos (fosfolipídeos e colesterol) + proteínas virais + carboidratos
- derivado de membranas da célula hospedeira (plasmática, retículo endoplasmático, Golgi) através de mecanismo denominado brotamento
- lábil: ácidos, bases, calor, detergente, ressecamento
- espículas ou peplômeros:

Envelope viral



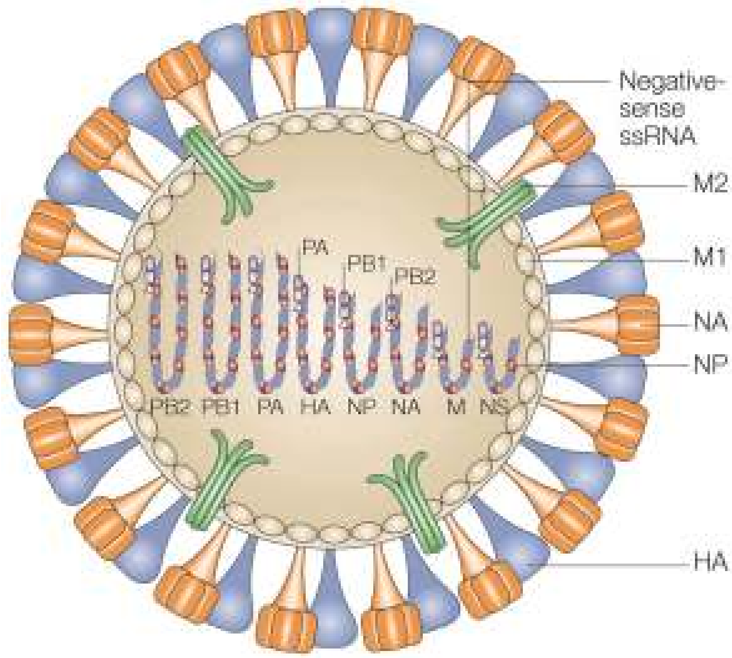


Matriz

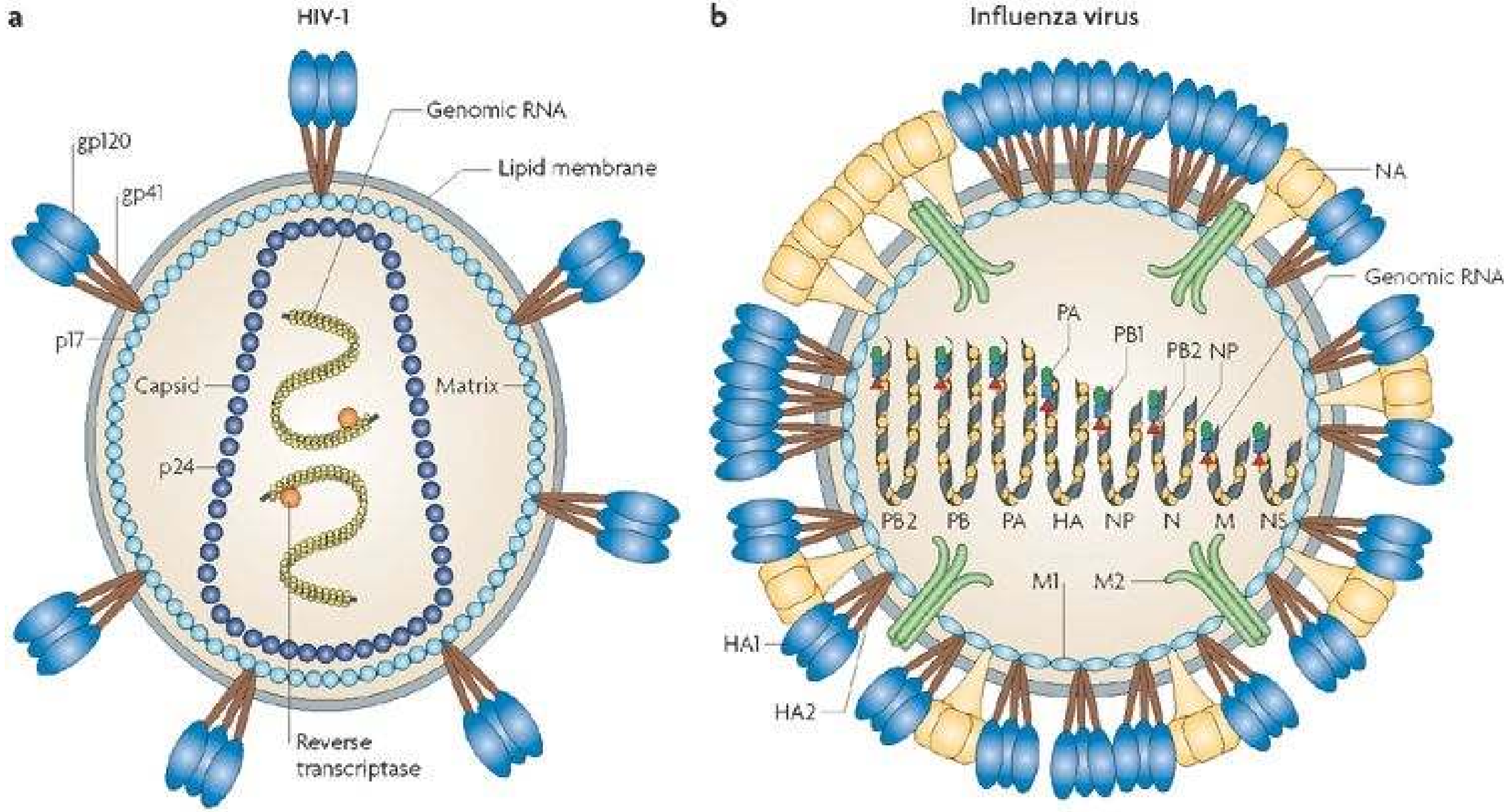
- camada protéica recobrindo externamente o nucleocapsídeo

- faz interação entre nucleocapsídeo e envelope

- glicosilada



Matriz

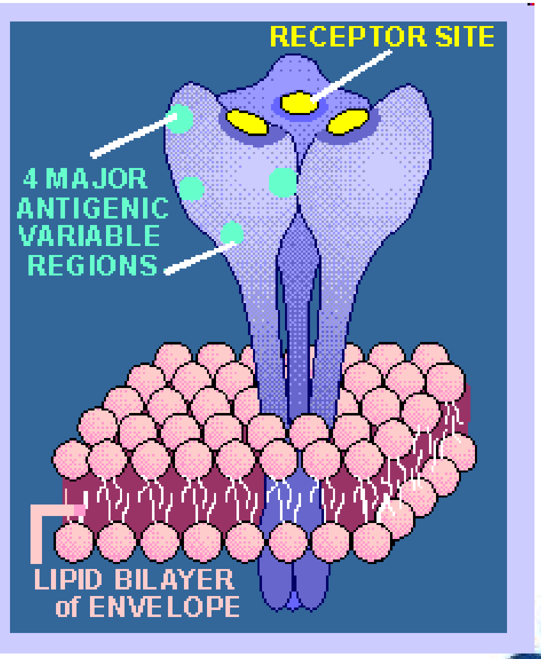


Nature Reviews | Microbiology

Proteínas do envelope

- monômeros, homo ou heterodímeros, trímeros ou tetrâmeros

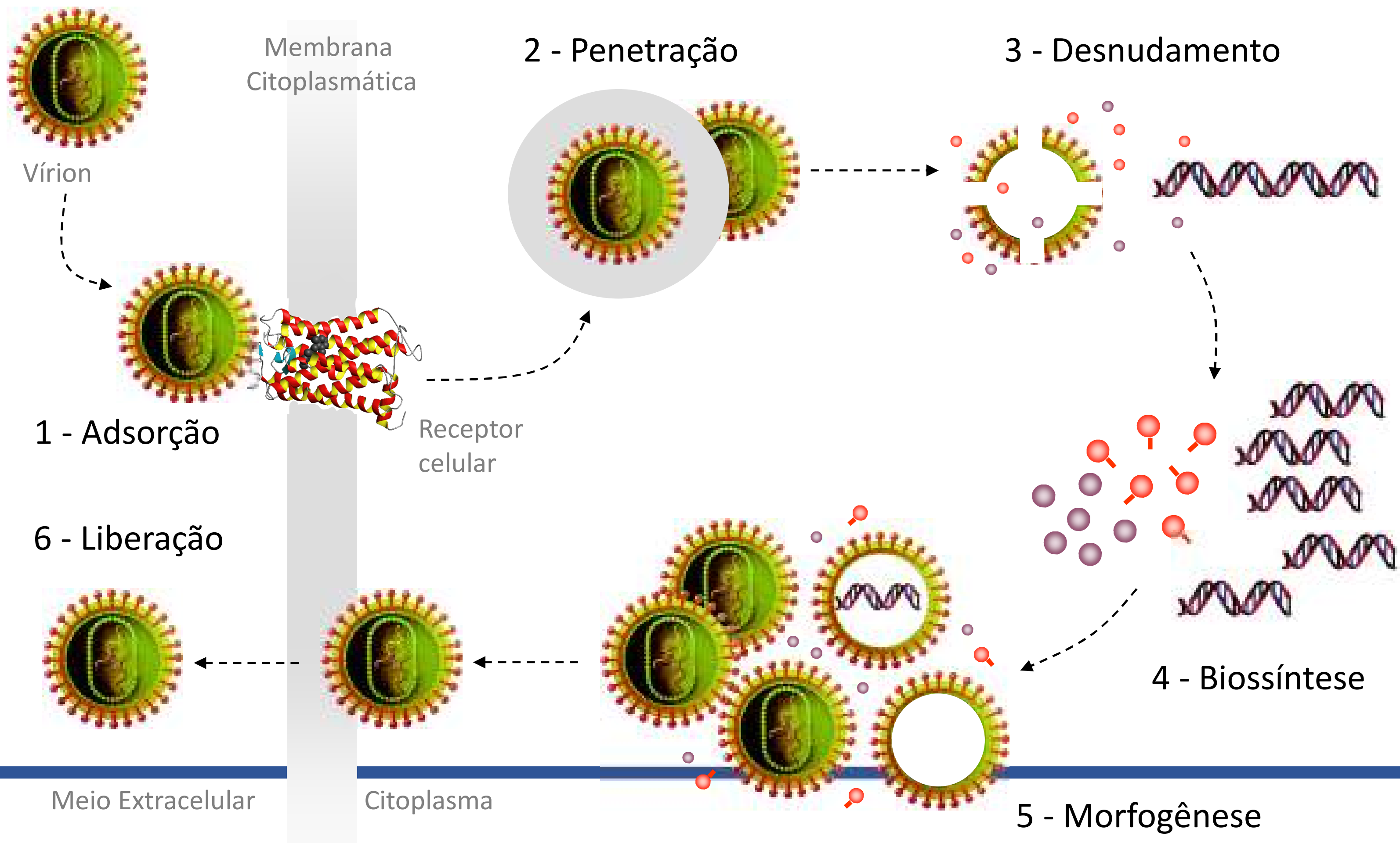
- geralmente: proteínas integrais



Replicação viral – 6 fases

- Adsorção: ligação com os receptores
- Penetração: endocitose ou fusão
- Desnudamento ou Descapsidação
- Biossíntese: ácido nucléico + proteínas virais
- Morfogênese ou montagem das partículas virais
- Liberação (lise ou brotamento)

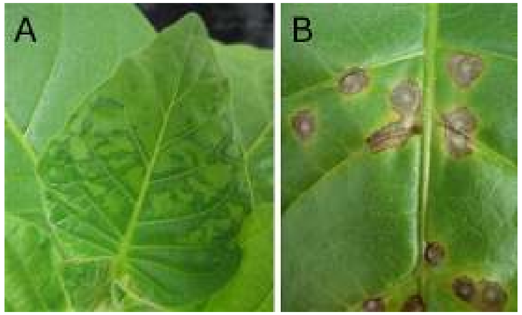
Replicação Viral - 6 fases

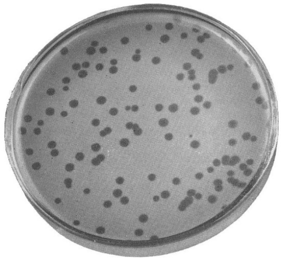


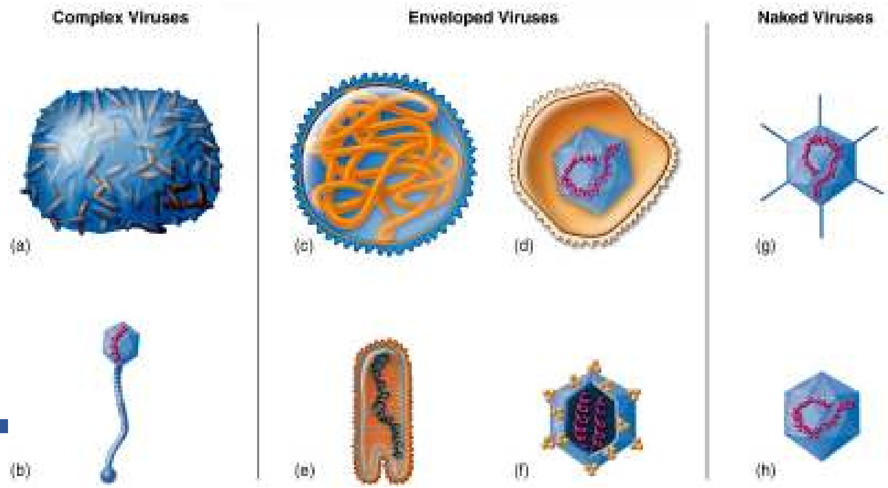
Taxonomia viral

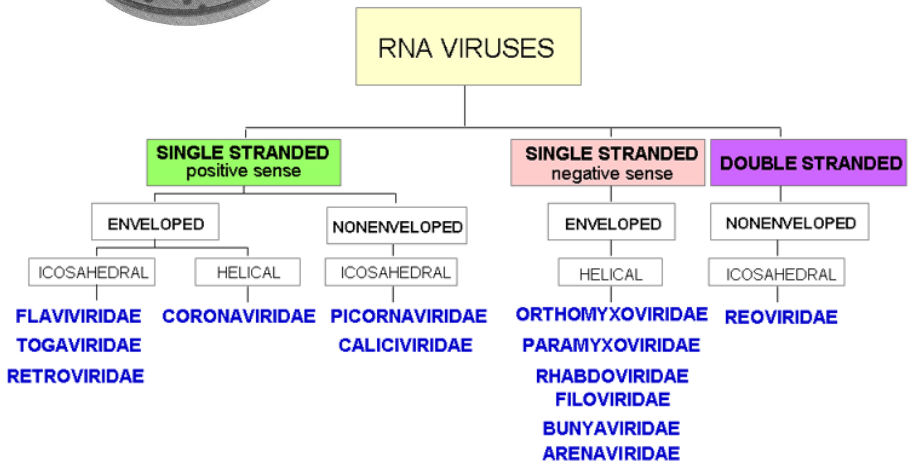
Caracteres discriminatórios entre diferentes espécies virais

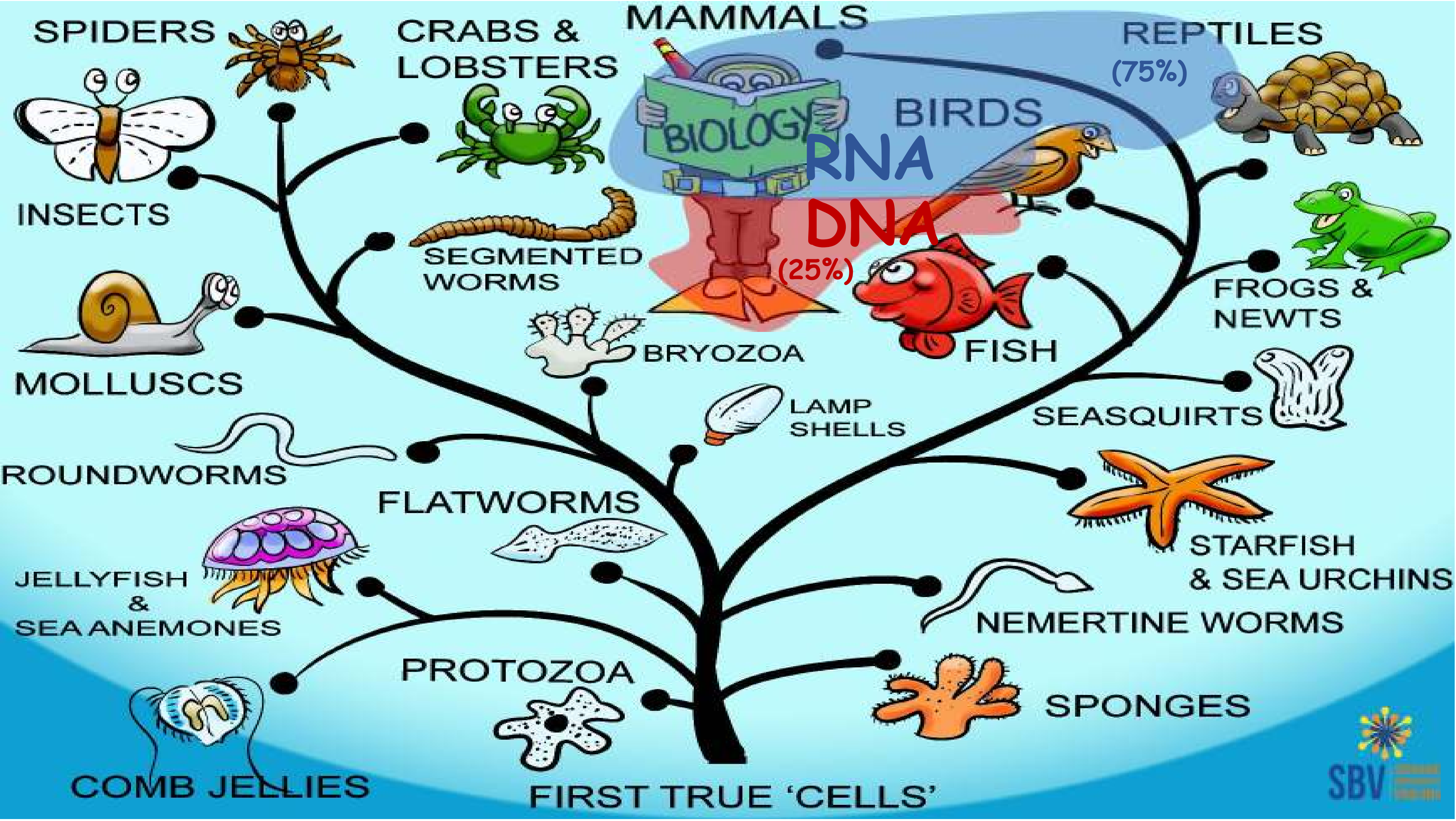
- Similaridade de seqüência genômica
- Hospedeiros naturais (amplitude)
- Tropismo tecidual e celular
- Patogenicidade e citopatogenicidade
- Propriedades físico-químicas dos vírions
- Propriedades antigênicas dos vírions











SPIDERS
CRABS &
LOBSTERS
MAMMALS
REPTILES
(75%)
BIOLOGY
BIRDS
RNA
DNA
(25%)
INSECTS
SEGMENTED
WORMS
FROGS &
NEWTS
MOLLUSCS
BRYOZOA
FISH
LAMP
SHELLS
SEASQUIRTS
ROUNDWORMS
FLATWORMS
STARFISH
& SEA URCHINS
JELLYFISH
&
SEA ANEMONES
NEMERTINE WORMS
PROTOZOA
SPONGES
COMB JELLIES
FIRST TRUE 'CELLS'
SBV

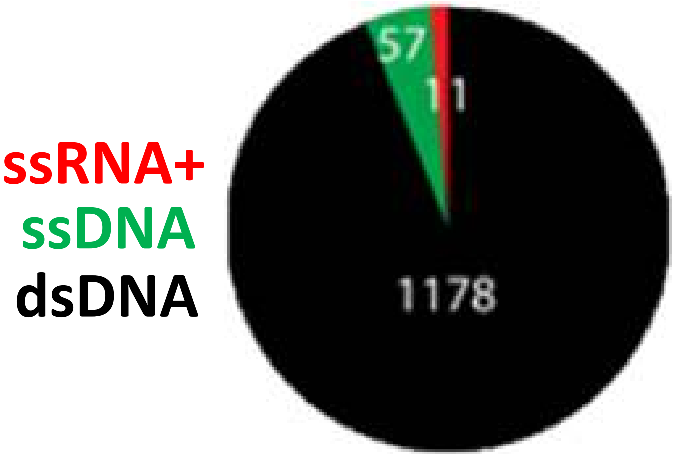
1ª Revolução Metagenômica
DNA-Seq

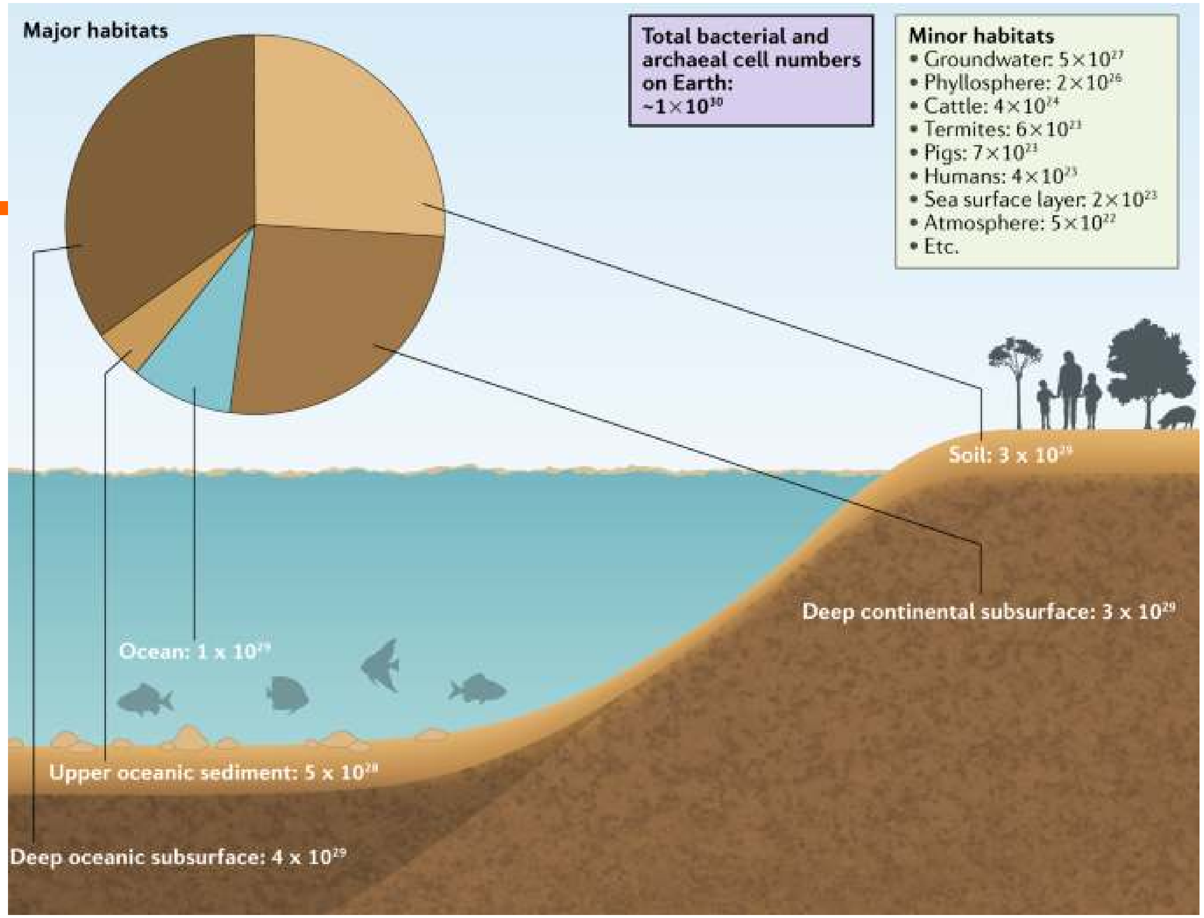
“The number of virus particles on Earth is on the order of 10^{31}”

Hendrix et al., 1999

R. W. Hendrix, M. C. Smith, R. N. Burns, M. E. Ford, and G. F. Hatfull, Proc Natl Acad Sci U S A 96:2192–2197, 1999

Vírus em Bactérias

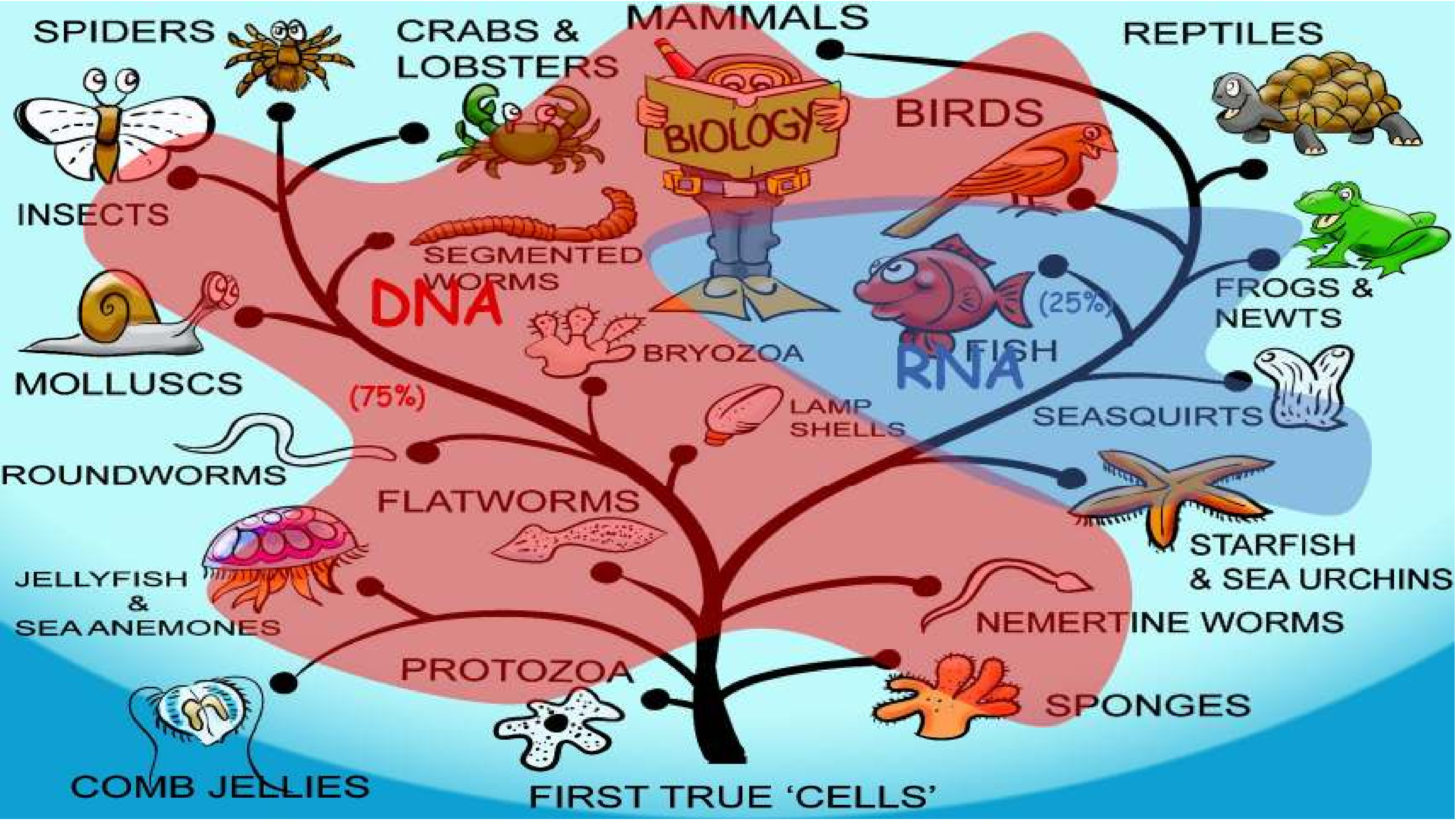




“Because phage particles are typically present in five- to 10-fold excess over bacterial cells, it is plausible that **tailed phages** are not only the most abundant organisms on Earth but, in fact, constitute an absolute majority of organisms.”

Nasir et al. Front Microbiol. 2014; 5:194 / Hendrix at al. Proc Natl Acad Sci U S A 96:2192–2197, 1999.

2ª Revolução Metagenômica
RNA-Seq


SPIDERS
CRABS & LOBSTERS
MAMMALS
REPTILES
BIOLOGY
BIRDS
INSECTS
SEGMENTED WORMS
DNA
FROGS & NEWTS
(25%)
FISH
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STARFISH & SEA URCHINS
JELLYFISH & SEA ANEMONES
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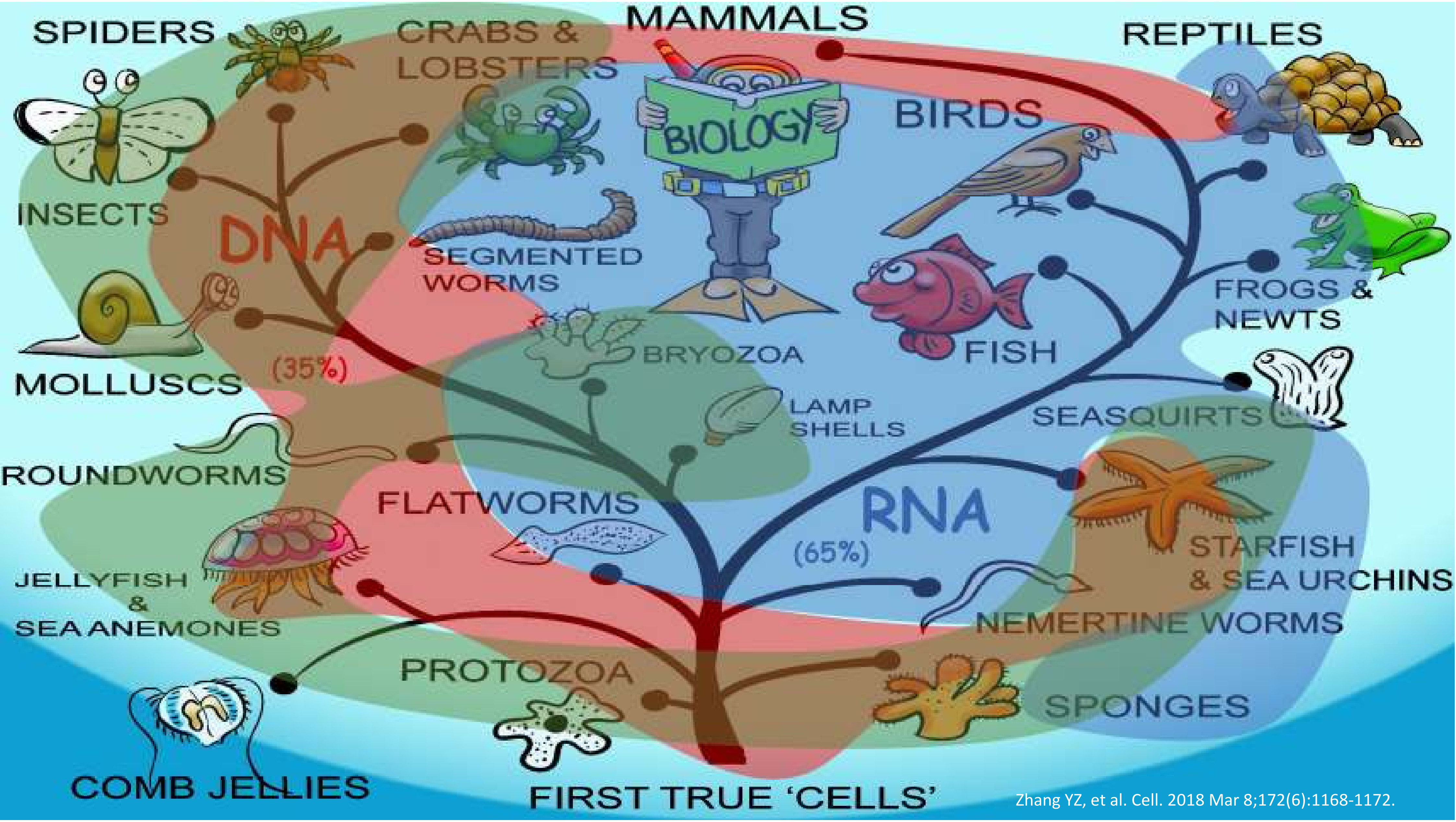
PROTOZOA
SPONGES
COMB JELLIES
FIRST TRUE 'CELLS'



Zhang YZ, et al. Cell. 2018 Mar 8;172(6):1168-1172.


CONSENSUS STATEMENT
https://doi.org/10.1038/s41564-020-0709-x
nature microbiology
Check for updates

OPEN

The new scope of virus taxonomy: partitioning the virosphere into 15 hierarchical ranks

International Committee on Taxonomy of Viruses Executive Committee*

Base de Dados para a Taxonomia Viral

- International Committee on Taxonomy ICTV

É órgão Internacional que governa a nomenclatura e a relação taxonômica de todos os vírus

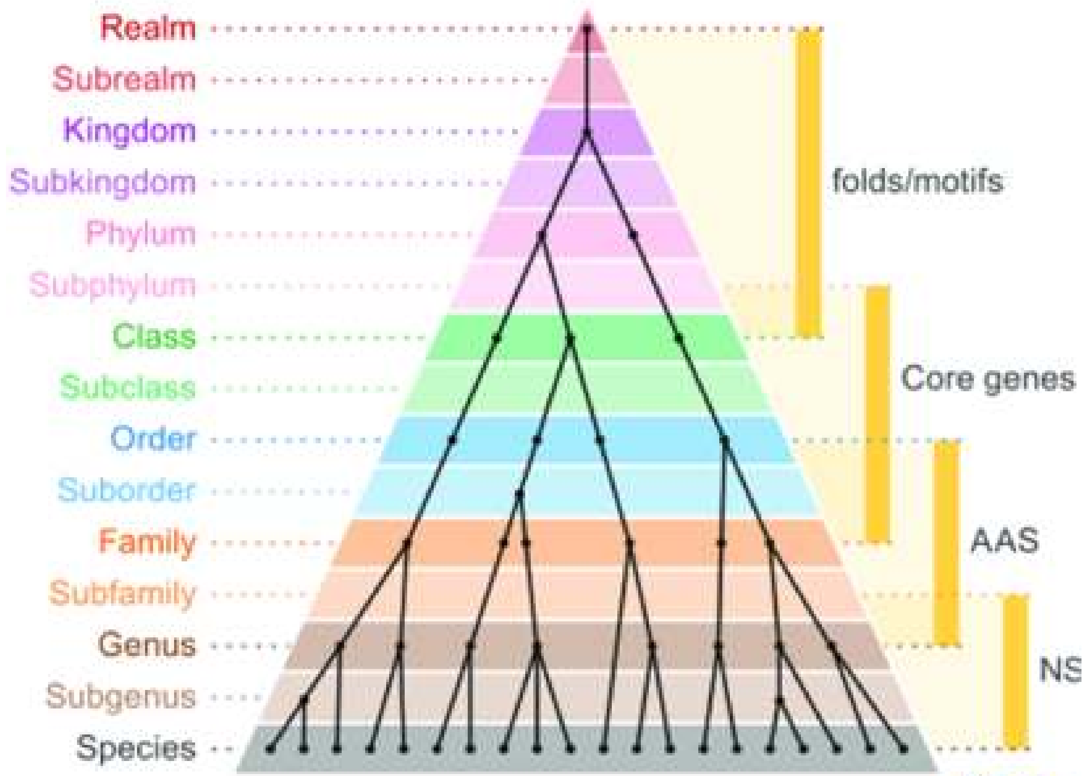
- Archaea
- Bactérias
- Fungos
- Algas
- Plantas
- Animais

Até 2015: Apenas de Ordem a Espécie

Depois de 2015: de Domínio a Espécie

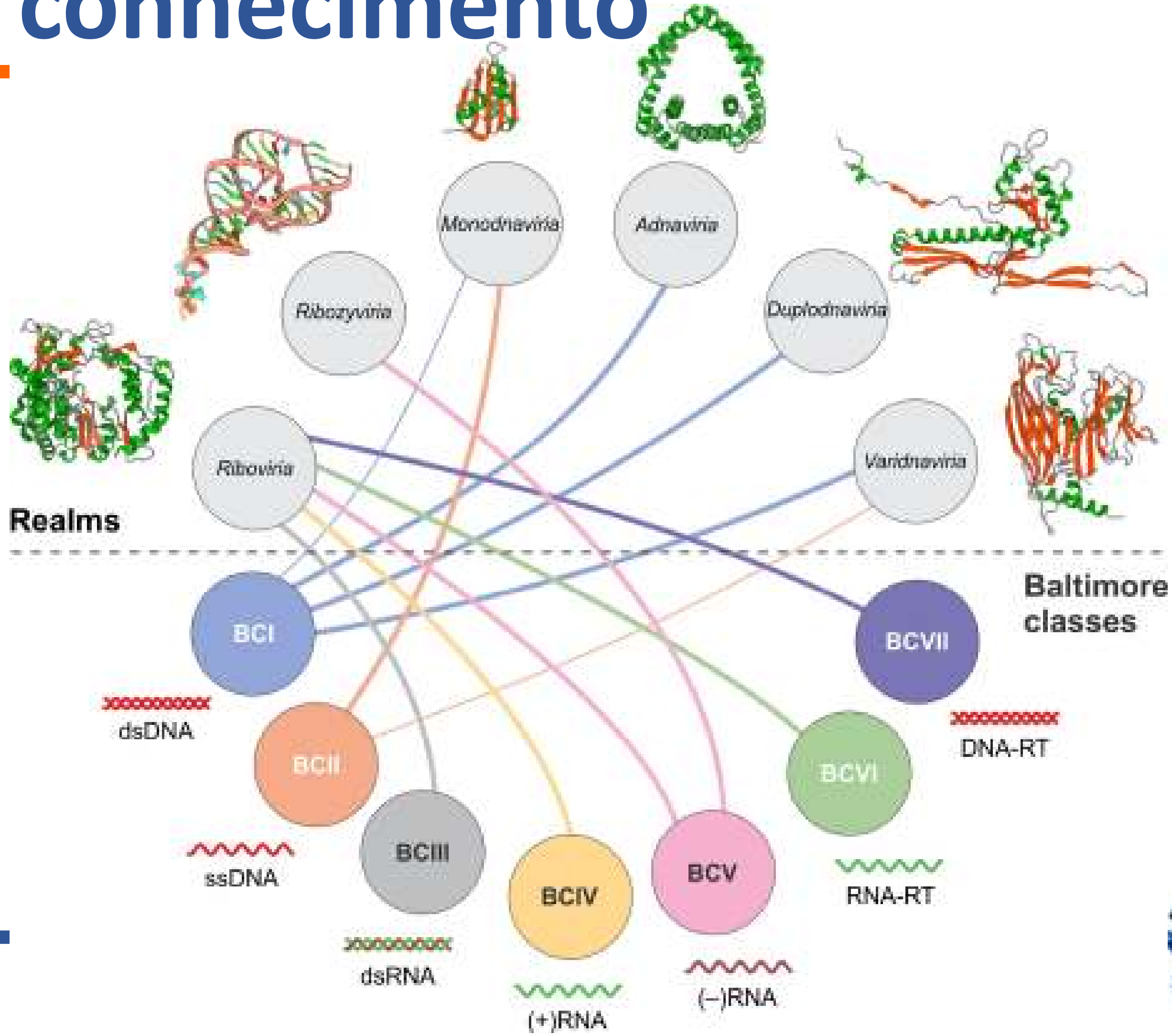
ICTV

- **Princípio 1.** A taxonomia de vírus deve refletir a história evolutiva dos vírus
- **Princípio 2.** As propriedades do vírus podem orientar a atribuição de classificações para maximizar sua utilidade
- **Princípio 3.** Uma taxonomia evolutiva é apenas um dos muitos meios possíveis para classificar vírus
- **Princípio 4.** Atribuições taxonômicas de vírus inferidos a partir de sequências metagenômicas requerem rigoroso controle de qualidade de sequência



https://journals.plos.org/plosbiology/article?id=10.1371/journal.pbio.3001922 https://www.instagram.com/p/CpVooquJPYI/

A evolução do conhecimento



Taxonomia Viral

- **Realm:** *Riboviria*
  - **Kingdom:** *Orthornavirae* Realm: *Riboviria*
    - **Phylum:** *Duplornaviricota* Kingdom: *Orthornavirae*
    - **Phylum:** *Kitrinoviricota* Kingdom: *Orthornavirae*
    - **Phylum:** *Lenarviricota* Kingdom: *Orthornavirae*
    - **Phylum:** *Negarnaviricota* Kingdom: *Orthornavirae*
      - **Subphylum:** *Haploviricotina* Phylum: *Negarnaviricota*
      - **Subphylum:** *Polyploviricotina* Phylum: *Negarnaviricota*
        - **Class:** *Ellioviricetes* Subphylum: *Polyploviricotina*
        - **Class:** *Insthoviricetes* Subphylum: *Polyploviricotina*
          - **Order:** *Articulavirales* Class: *Insthoviricetes*
            - **Family:** *Amnoonviridae* Order: *Articulavirales*
            - **Family:** *Orthomyxoviridae* Order: *Articulavirales*
              - **Genus:** *Alphainfluenzavirus* Family: *Orthomyxoviridae*
                - **Species:** *Alphainfluenzavirus influenzae* Genus: *Alphainfluenzavirus*

Ex: Vírus da Influenza

Como identificar os vírus?

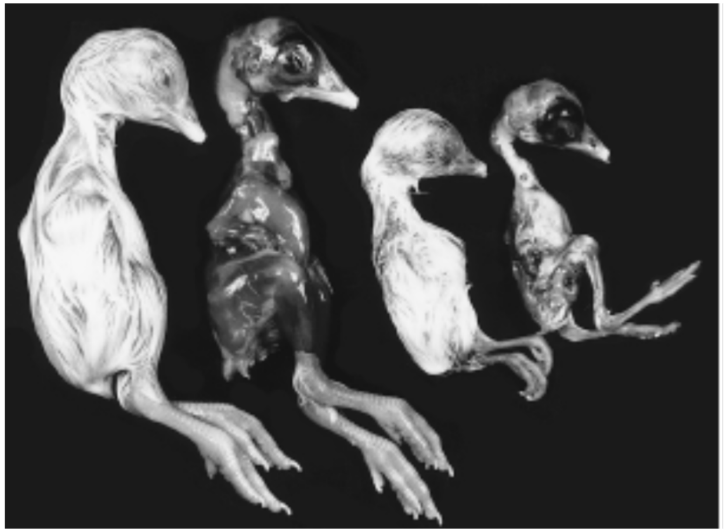
Isolamento viral

1.Cultivo celular	Efeitos citopáticos (CPE) Hemabsorção Imunodetecção
2. Ovos embrionados	Lesões na CAM Hemaglutinação Corpúsculos de inclusão
3. Animais	Doença ou morte

Isolamento viral

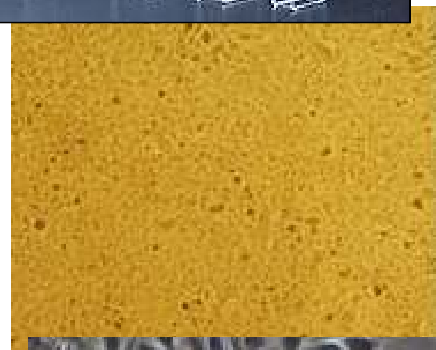
- Inoculação em animais
- Inoculação em ovos embrionados
- Cultivos celulares
  - 3 tipos
  - Métodos imunoquímicos

Isolamento viral em ovos embrionados



Isolamento viral em ovos embrionados

Isolamento viral em cultivo celular



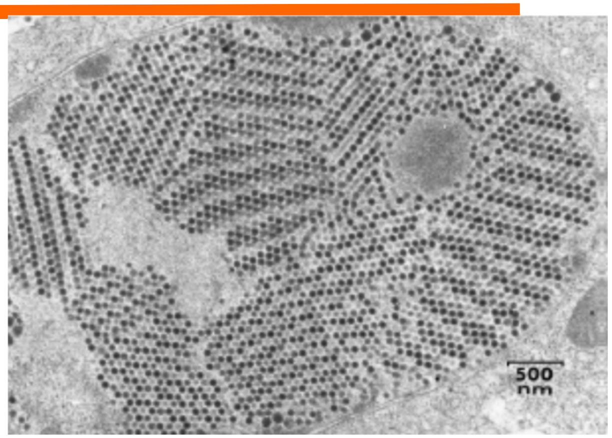
Isolamento viral em cultivo celular

- Cultivos primários (células diplóides)
- Linhas celulares
  - Cultivo semi continuo
    - Diplóide, 40 passagens
  - Cultivo contínuo
    - Número de passagens indefinido

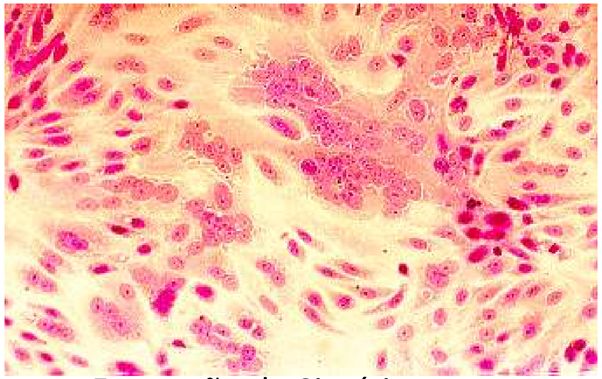
Isolamento viral em cultivo celular

- EFEITO CITOPÁTICO
- É o dano que o vírus causa à célula !
  - Lise
  - Arredondamento
  - Vacuolização
  - Formação de sincícios
  - Inclusões
  - Picnose
  - Apoptose

Isolamento viral em cultivo celular



Adenovirus – Células de Fígado



Formação de Sincícios

Isolamento viral em animais

Detecção do agente (direto)

1. **Microscopia eletrônica**

de transmissão ou varredura morfologia dos agentes

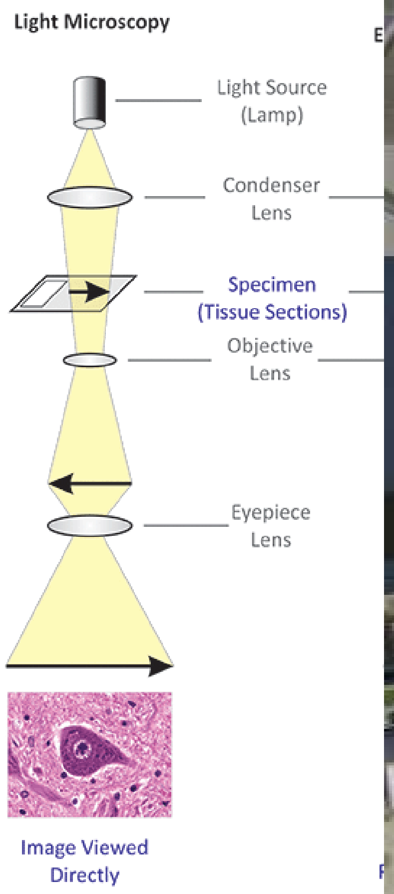
2. Detecção do antígeno immunofluorescência, ELISA, IHC, teste rápido, etc.

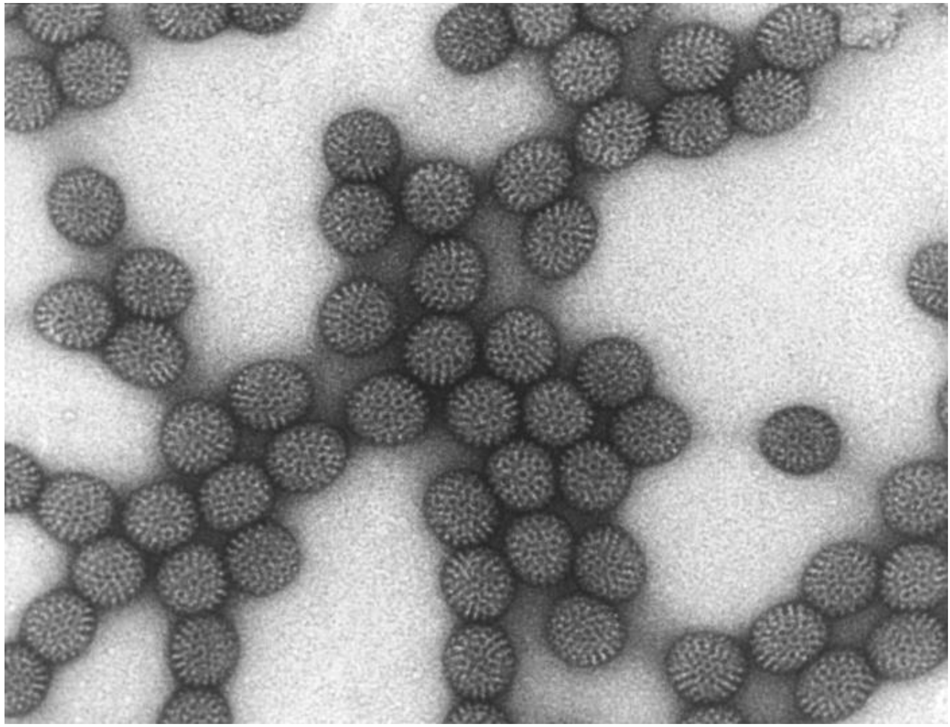
3. Microscopia de luz Histopatologia

Corpúsculo de inclusão

4. Detecção do genoma Técnicas moleculares, hibridização com sondas específicas de ácidos nucléicos PCR, RT-PCR

Microscopia Eletrônica

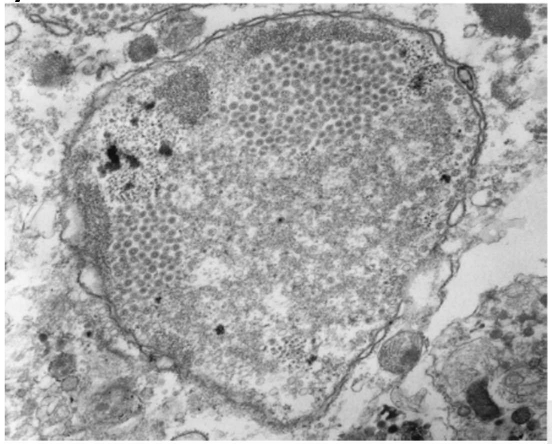


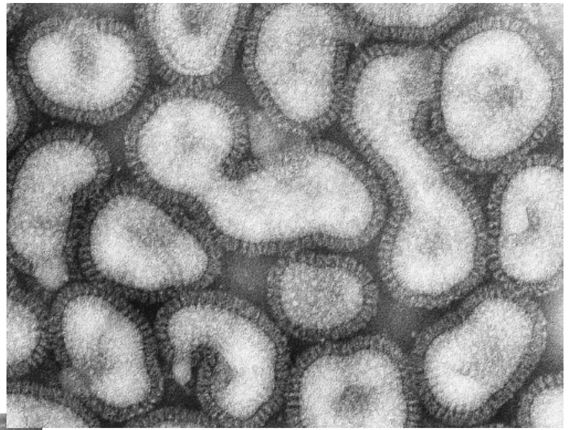


Photos of Rotavirus | CDC

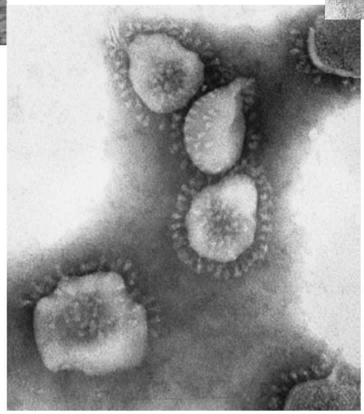
Microscopia eletrônica de transmissão

Herpesvirus 1





Influenzavirus A



Coronavirus

Microscopia eletrônica de transmissão

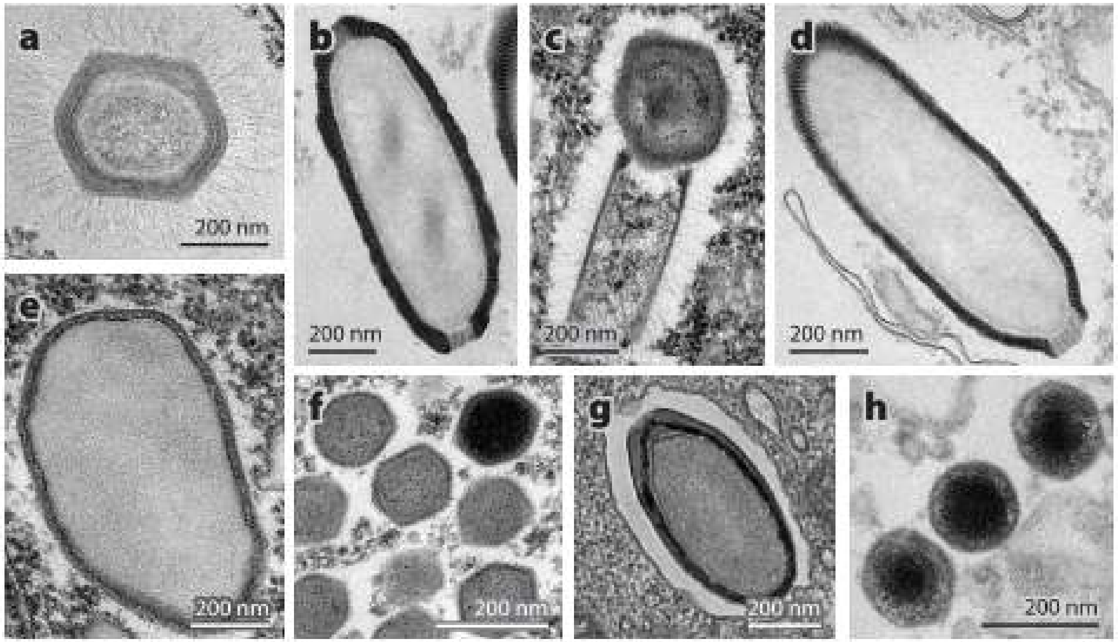
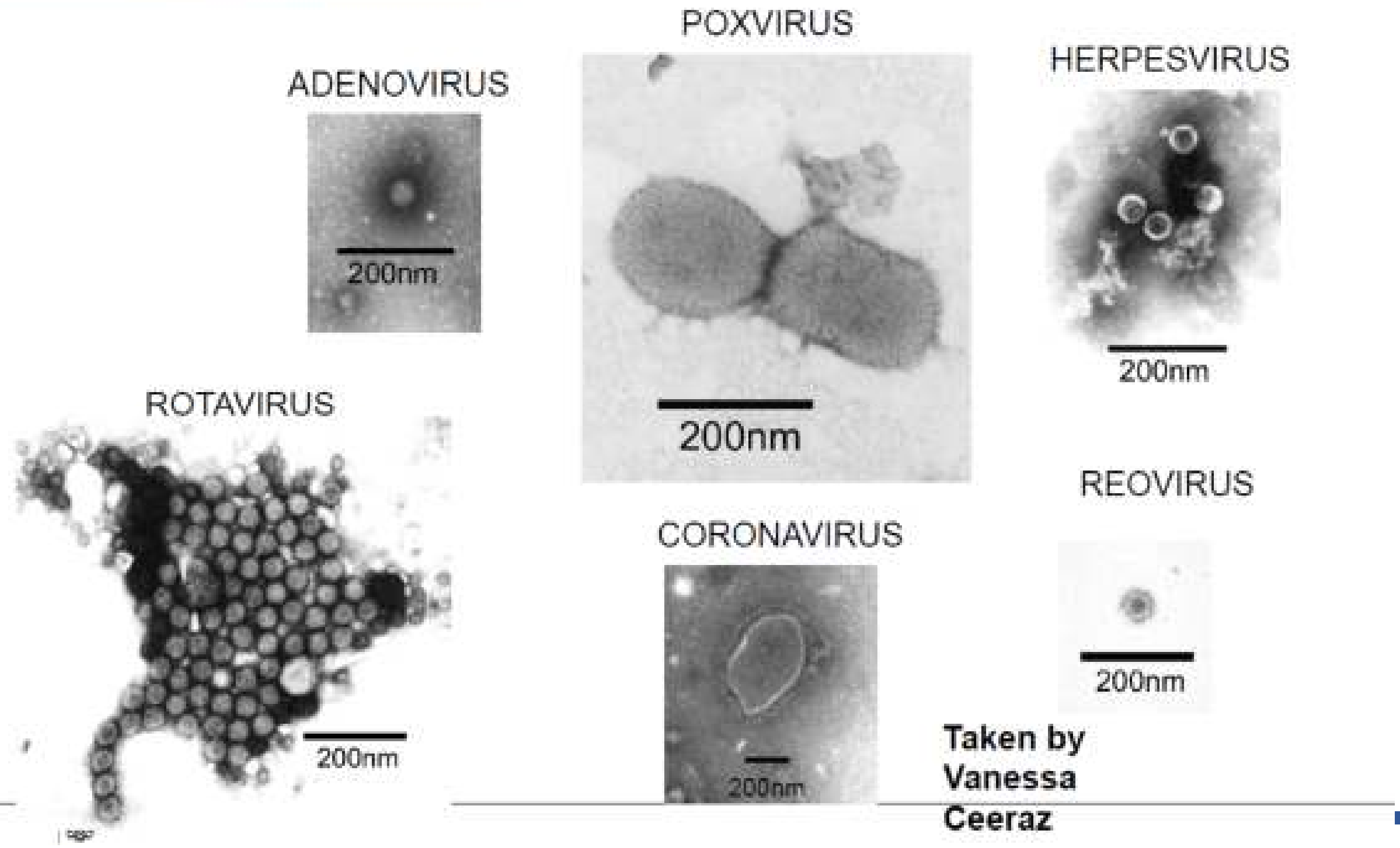


Figure 1

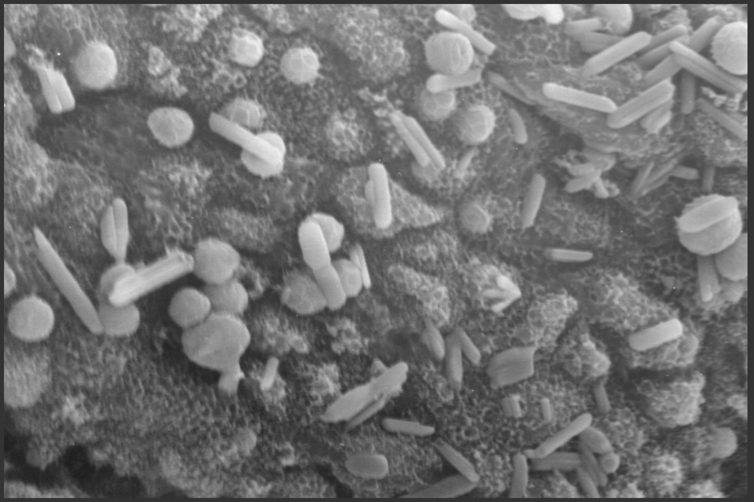
Diversity of amoebae-infecting viruses. Electron microscopy images evidence the structural diversity and complexity of viruses isolated from different amoebae hosts: (*a*) mimivirus, (*b*) cedratvirus, (*c*) tupanvirus, (*d*) pithovirus, (*e*) orpheovirus, (*f*) marseillevirus, (*g*) pandoravirus, and (*h*) kaumoebavirus.

Queiroz et al. Annu. Rev. Virol. 2022. 9:11.1–11.20

Microscopia eletrônica de transmissão



Microscopia eletrônica de varredura

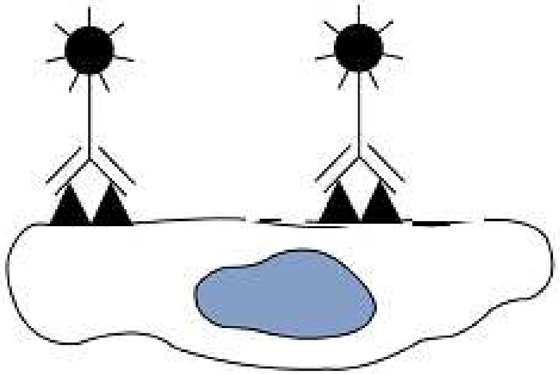


Traquéia mostrando colonização epitelial por *E. coli* e *C. baileyi* com perda severa de cílios. Grupo II, 13 dias de idade, 2000 X.

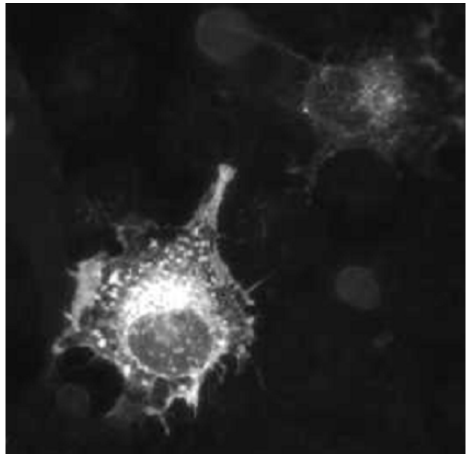
Imunohistoquímica e imunofluorescência

- **Direta**
  - Anticorpo marcado sobre material infectado

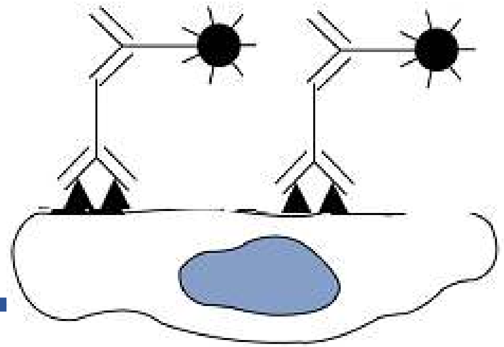
- Material infectado (suspeito)
- Anticorpo específico marcado com FITC ou Peroxidase
- Luz UV ou luz branca



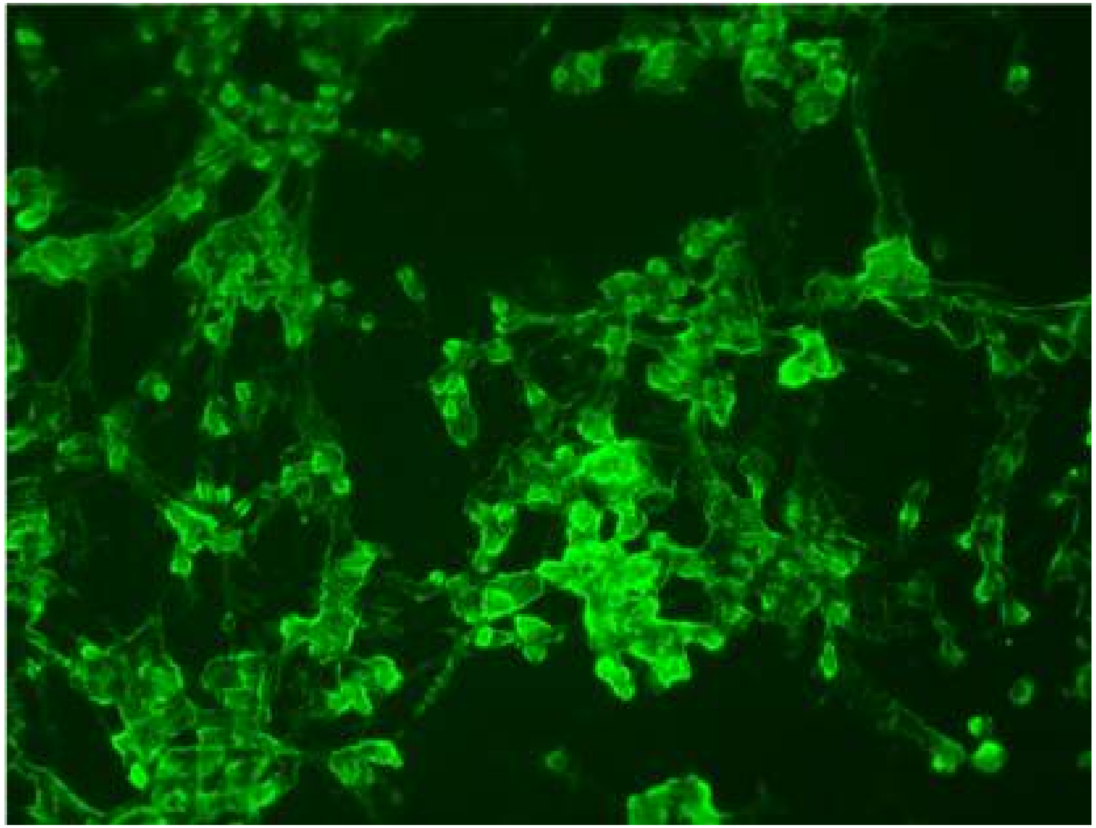
Imunohistoquímica e imunofluorescência



- **Indireta**
  - Utilização de dois anticorpos
- Material infectado (células ou tecidos)
- Soro específico (ex: soro galinha)
- Conjugado anti-IgG específico (ex. anti-IgG galinha/FITC ou Peroxidase)
- Luz UV ou Luz branca



Identificação viral

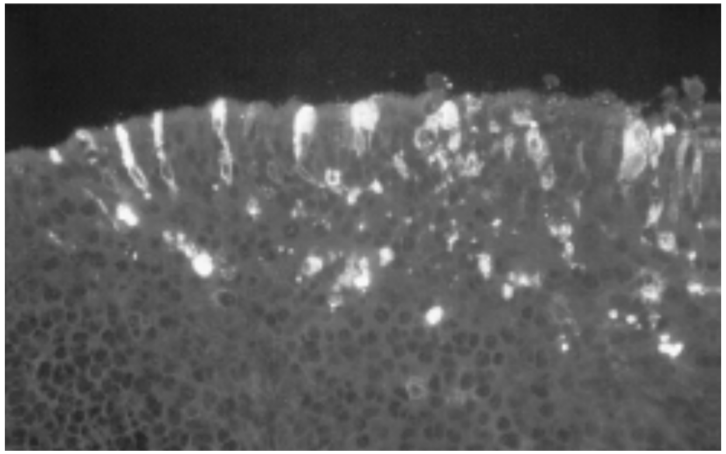


IFA – VERO infectadas com NDV

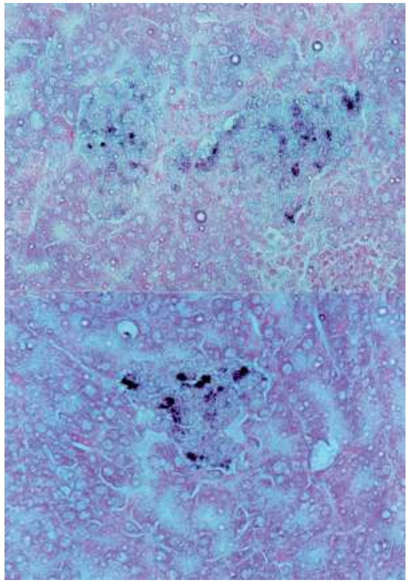
Identificação viral

PFU

Imunohistoquímica e imunofluorescência

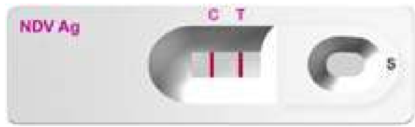


Coronavirus - Intestino

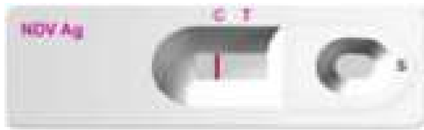


Adenovirus - Pâncreas

Testes rápidos de detecção



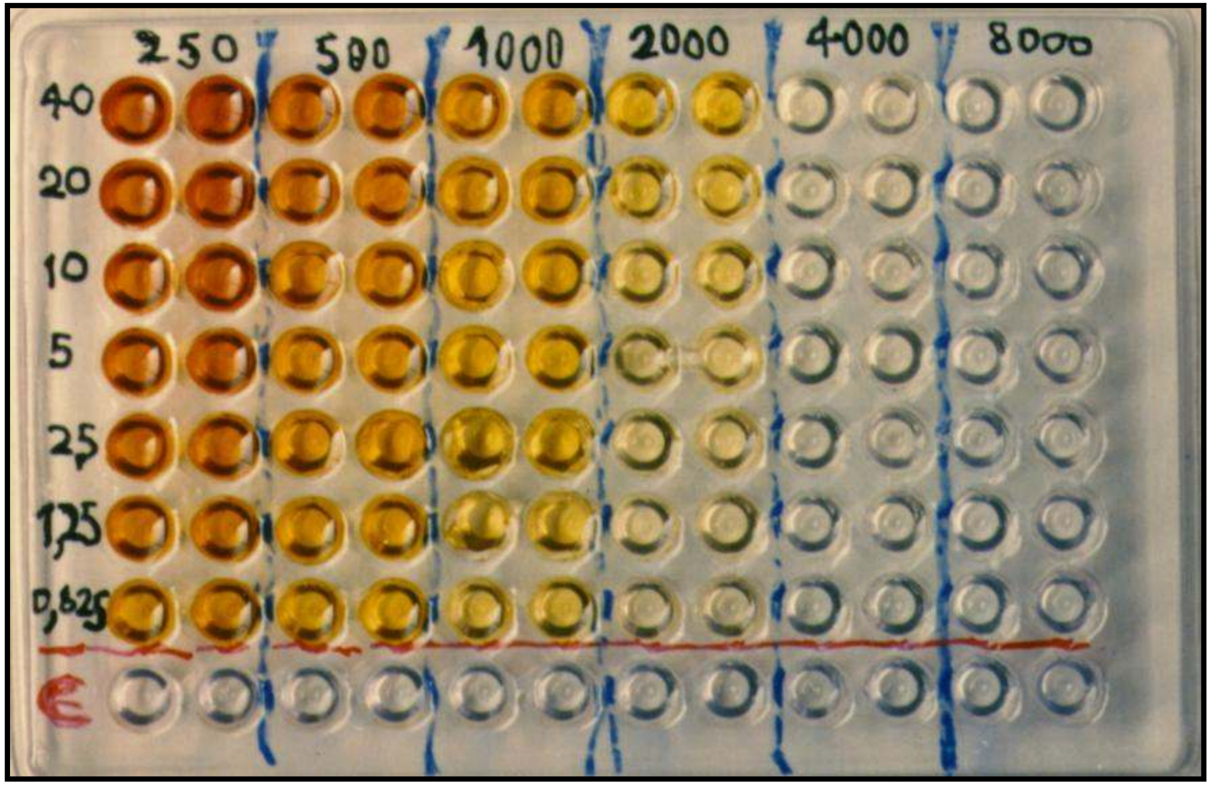
Positivo

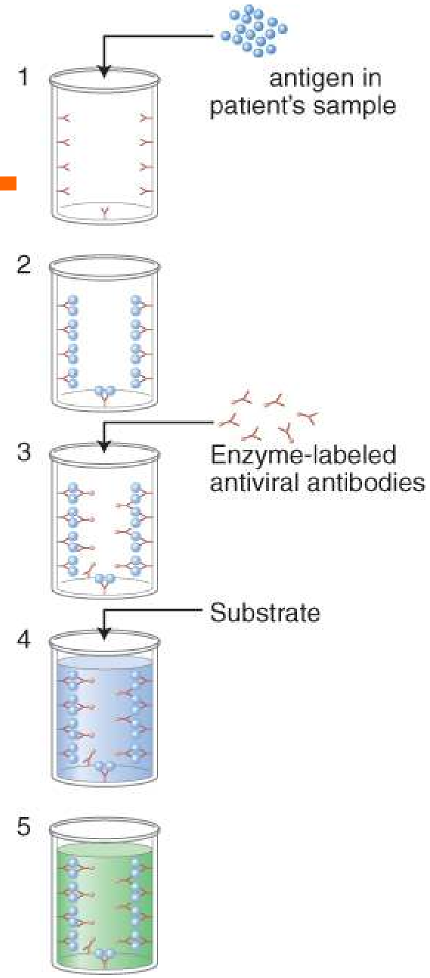


Negativo

http://www.cfsph.iastate.edu/video.php?link=antigen-detection

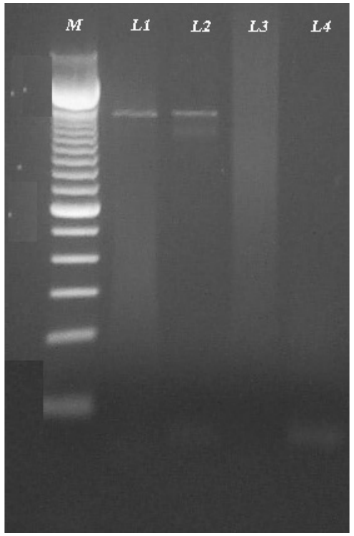
ELISA (DIRETO)



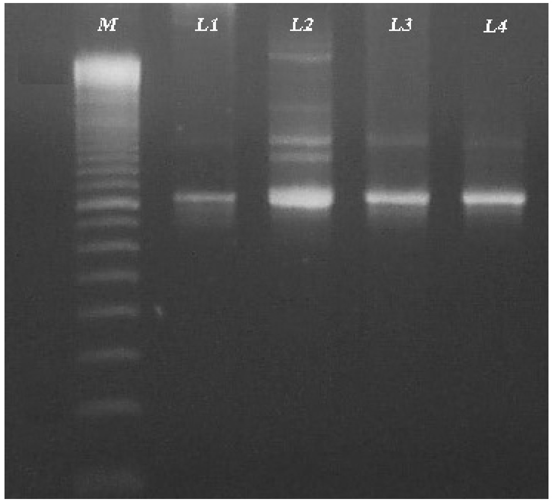


http://www.cfsph.iastate.edu/video.php?link=idexx-elisa

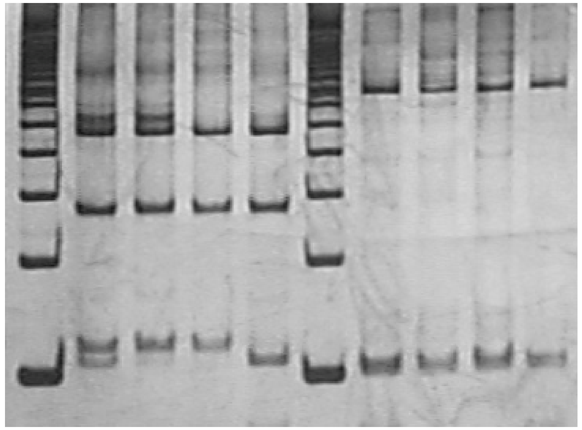
Biologia Molecular



PCR

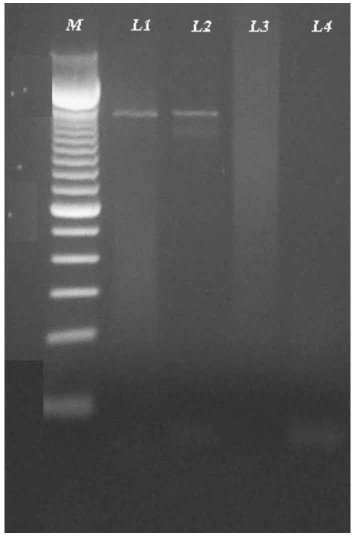


RT-PCR

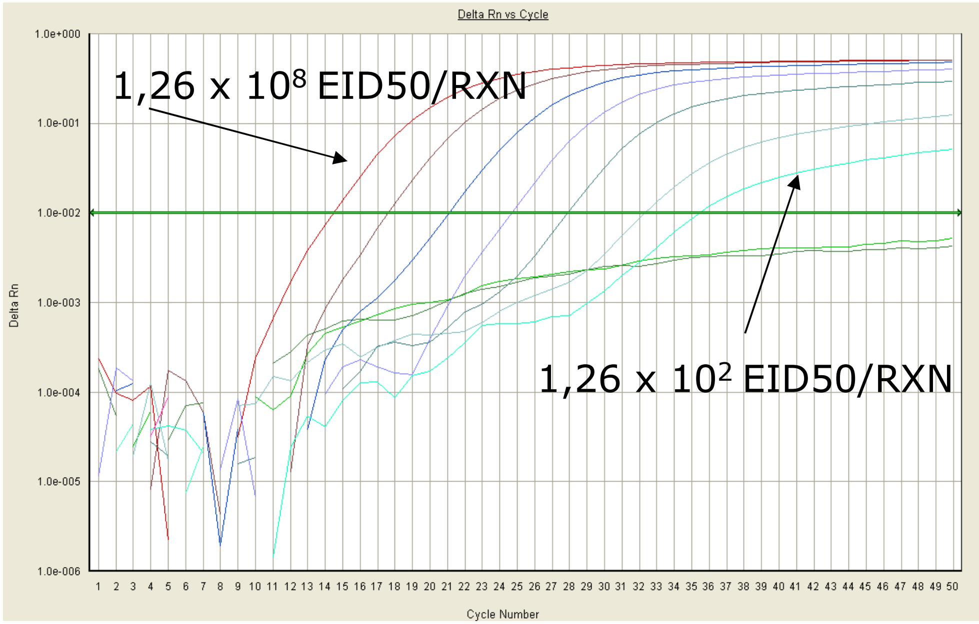


PCR-RFLP

Biologia Molecular

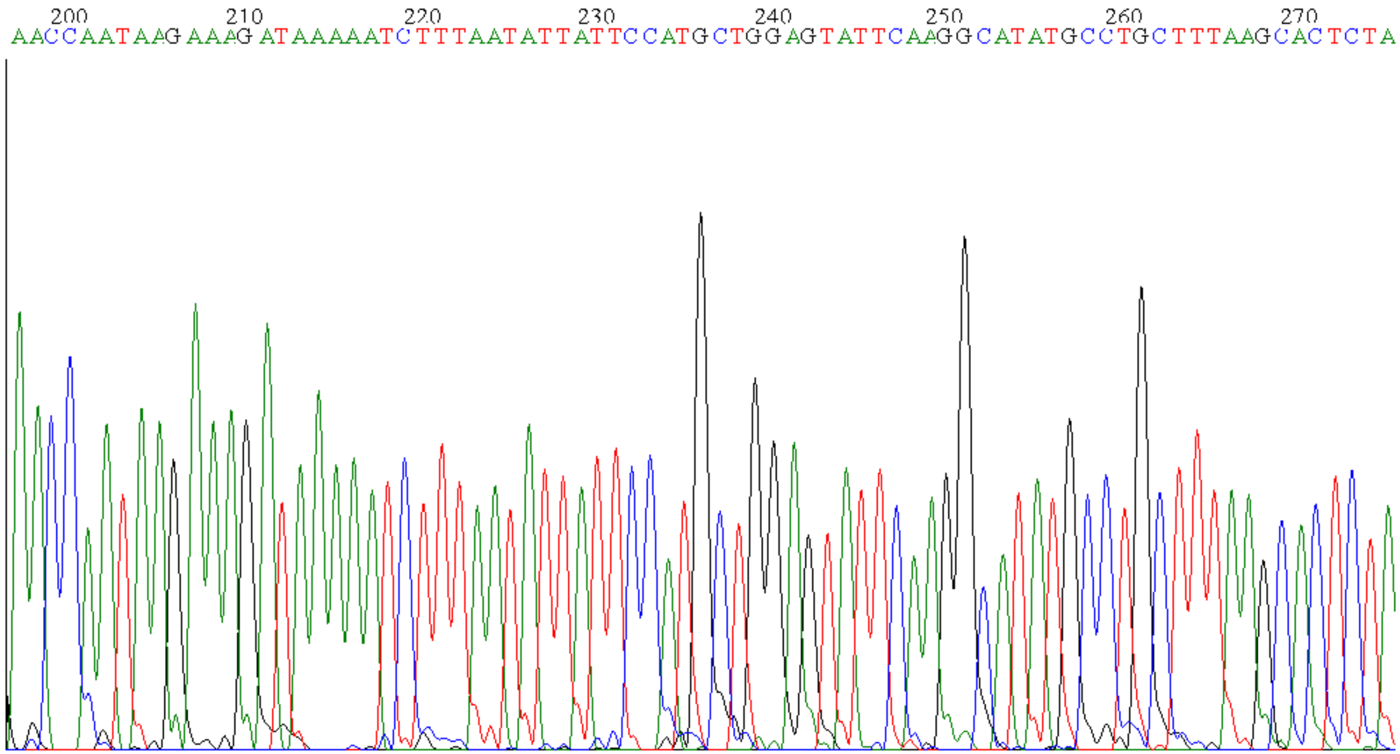


RT- PCR

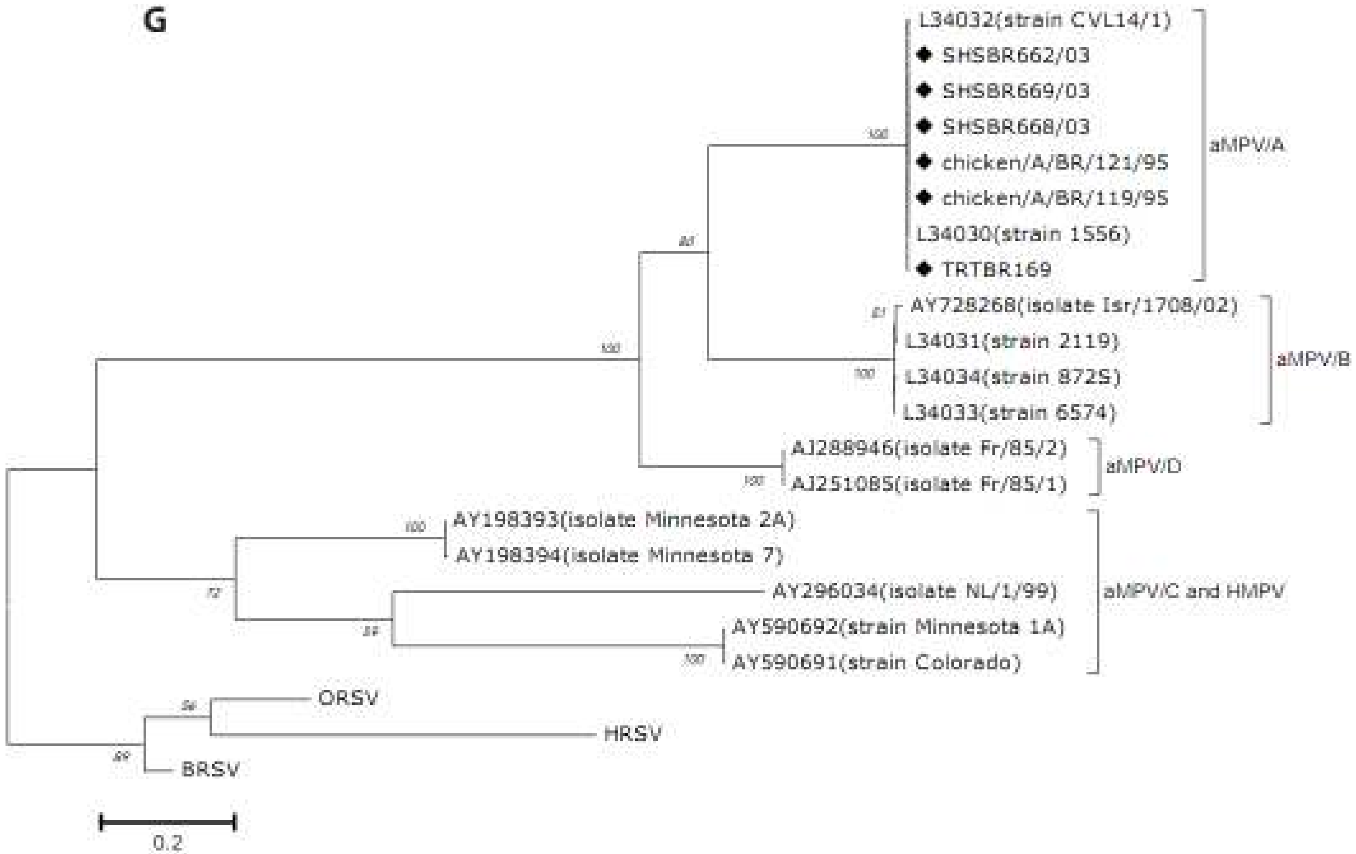


RT-qPCR

Sequenciamento

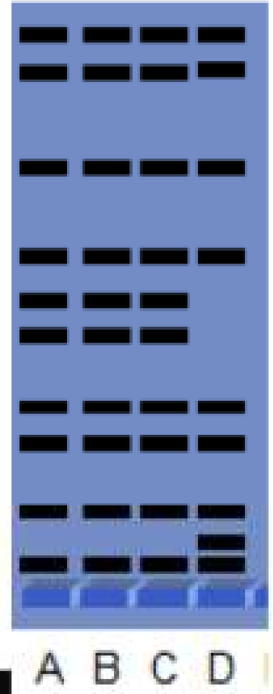


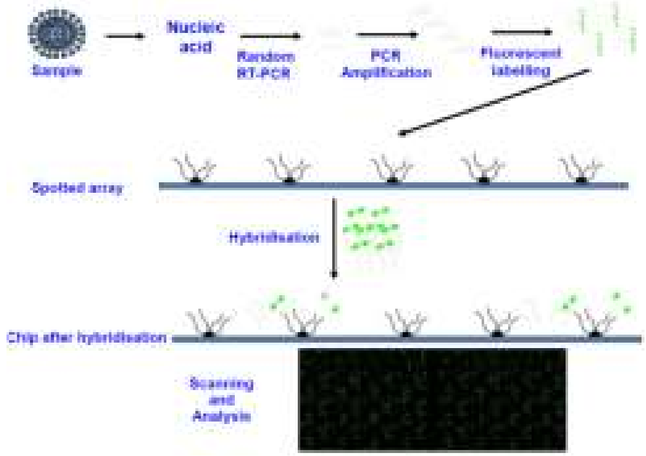
Epidemiologia molecular

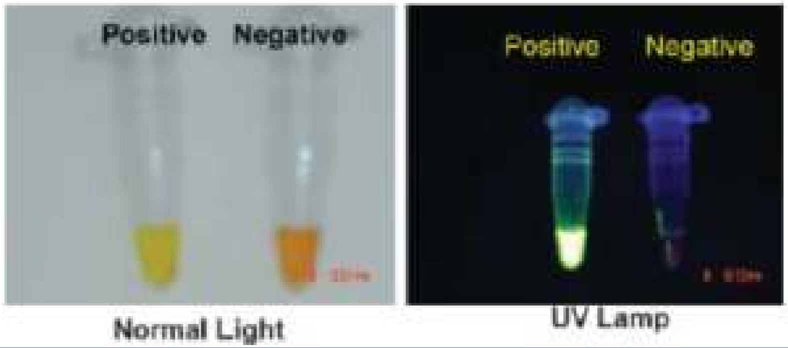


Outras técnicas moleculares

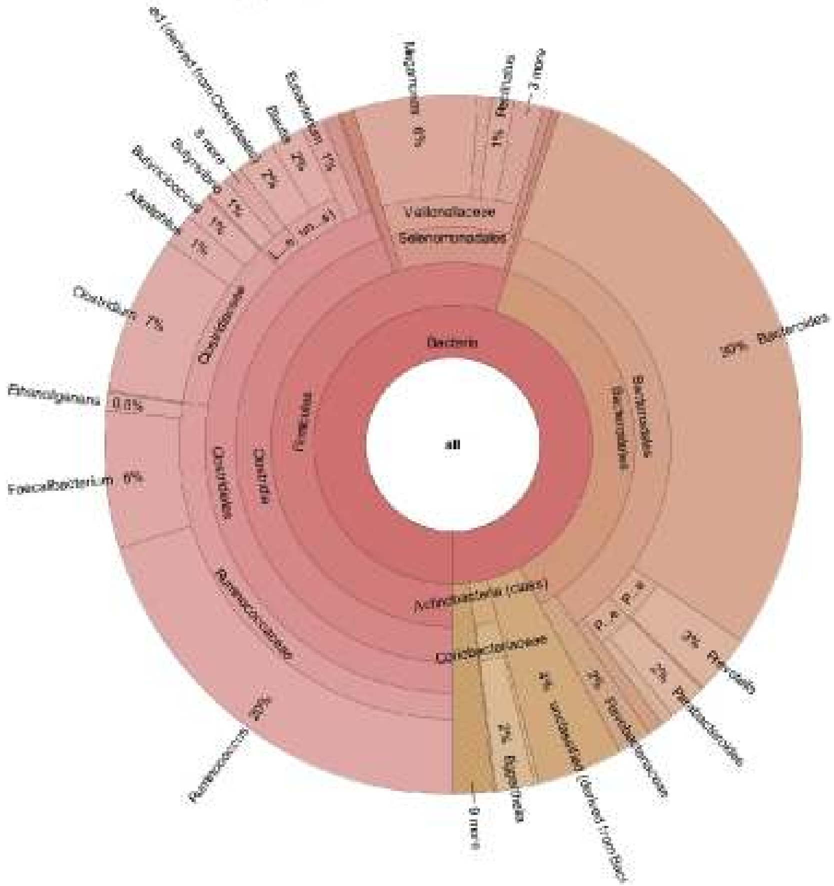
- DNA fingerprint
- LAMP
- Microarray







Metagenômica



Importância dos vírus e os alimentos

Vírus de origem alimentar

- Apenas algumas partículas são necessárias para produzir doenças;
- Um elevado número de partículas virais é derramado nas fezes de pessoas infectadas (até 1011 partículas por grama de fezes relatadas para rotavírus);
- Os vírus precisam de células vivas específicas para se replicar e, portanto, não podem fazê-lo em alimentos ou água;
- Os vírus de origem alimentar normalmente são bastante estáveis fora do hospedeiro e são resistentes ao ácido.

Vírus transmitidos por alimentos ou água

Likelihood of food- or waterborne transmission of enterically transmittable viruses, according to the type of illness associated with infection

Likelihood of food- or waterborne transmission	Illness		
	Gastroenteritis	Hepatitis	Other
Common	Norovirus	Hepatitis A virus	
Occasionally	Enteric adenovirus (types 40/41) Rotavirus (group A–C) Sapovirus Astrovirus Coronavirus Aichivirus	Hepatitis E virus (waterborne)	Enterovirus[a]

[a]Enteroviruses (e.g. poliovirus) are associated with a range of symptoms, including neurological symptoms.

Vírus nos produtos de animais

Table 1. *Summary of data available in the literature on the presence of HPAI viruses in poultry commodities*

Commodity	Species	Strain	Experimental (E) or natural (N) infection	Infecting dose (EID_{50} log_{10})	Titres (log_{10} EID_{50}/g) detected in commodity	Reference (first author)
Meat	Chickens	A/duck/Anyang/AVL-1/01 (H5N1)		6/0.1 ml	5.3 to 5.5	Tumpey, Kishida, Swayne
		A/chicken/Pennsylvania/1370/1983 (H5N2)	E	6/0.1 ml	2.2 to 3.2	
		A/tern/South Africa/61 (H5N3)		7/0.1 ml	>4	
	Turkeys	A/turkey/Italy/4580/99 (H7N1)	E	7/0.1 ml	4.38	Toffan
	Ducks	A/duck/Anyang/AVL-1/01 (H5N1)	E and N	6/0.1 ml	3 to 4	Tumpey, Li
		A/goose/Vietnam/3/2005 (H5N1)	E	6/0.1 ml	3	Pantin-Jackwood
		A/Vietnam/1203/2004, A/ThailandPB/6231/2004, A/crow/Thailand/2004, A/Egret/HK/757.2/2002 (H5N1)	E	5/0.1 ml	4 to 6 (2-week-old birds) 2 to 4 (5-week-old birds)	
		A/egret/HK/757.2/2002 (H5N1)	E	8/0.1 ml	7	
		A/chicken/Yamaguchi/7/2004 (H5N1)	E	7/0.1 ml	1.5	
		A/duck/Vietnam/12/2007 (H5N1)				
Eggs	Turkeys	A/turkey/Ontario/7732/66 (H5N9)	N	Not reported	Not reported	Cappucci, Narayan
		H5N2 (Virginia/1985)	E	Not reported	Not reported	
	Chickens	H5N2 (Virginia/1985)	N	Not reported	Not reported	Cappucci
	Ducks and geese	H5N1 (strain not reported)	N	Not reported	Not reported	Li
	Quail	H5N1 (strain not reported)	N	Not reported	4.6 to 6.2	Promkuntod
Feathers	Chickens, turkeys, quail, guinea fowl	A/chicken/Yamaguchi/7/2004, A/chicken/Miyazaki/K11/2007, A/chicken/Hong Kong/220/1997	E	5.8 to 6.2/0.1 ml	Not investigated	Perkins
	Ducks	A/chicken/Yamaguchi/7/2004, A/chicken/Miyazaki/K11/2007	E	8/0.1 ml	Not investigated	Yamamoto
	Turkeys	H5N1 (strain not reported)	N	Not available	Not investigated	Slomka
Liver	Ducks	A/chicken/Vietnam/12/2005 (H5N1)	E	7/0.1 ml	Not reported	Beato
Blood	Chickens	A/tern/South Africa/61 (H5N3)	E	7/0.1 ml	4	Kishida, Swayne
		A/chicken/Pennsylvania/1370/1983 (H5N2)		6/0.1 ml	Not reported	
	Pigeons, geese	A/turkey/Ontario/7732/66 (H5N9)	E	8/0.5 ml	Not recovered	Narayan
	Turkeys	A/turkey/Italy/4580/99 (H7N1)	E	6/0.1 ml	1 to 5.8	Toffan
		A/turkey/Ontario/7732/66 (H5N9)		8.7/0.5 ml	2.7 to 3.7	
	Ducks	A/chicken/Vietnam/12/2005 (H5N1)	E	7/0.1 ml	Not reported	Beato, Narayan
		A/turkey/Ontario/7732/66 (H5N9)	E	8/0.5 ml	Not recovered	
Skin	Ducks	A/chicken/Yamaguchi/7/2004,	E	8/0.1 ml	2.5 to 4.4	Yamamato
	Geese	A/chicken/Yamaguchi/7/2004	E	8/0.1 ml	3.5	Yamamoto
		A/chicken/Miyazaki/K11/2007	E		4.5	

Beato et al. Avian Pathology, 38:3, 193-200, DOI: 10.1080/03079450902912200

Vírus nos produtos de animais

Table 2. *Summary of data available in literature on the presence of LPAI viruses in poultry commodities*

Commodity	Species	Strain	Natural (N) or experimental (E) infection	Infecting dose (EID_{50} log_{10})	Titres (log_{10} EID_{50}/g	Reference (first author)
Meat	Chickens	A/chicken/aq-Y-55/01 (H9N2);	E	7/0.1 ml	1.6 to 2	Kishida
		A/chicken/aq-Y-135/01(H9N2)	E	7/0.1 ml	1.6 to 2	
	Turkeys	A/turkey/Italy/3675/99 (H7N1)	E	6/0.1 ml		Toffan
		A/turkey/Virginia/159512/2002 (H7N2)	E	6/0.1 ml	No infectious virus detected	
		A/chicken/New York/21586–8/99 (H7N2)	E	6/0.1 ml		
	Ducks	No data available				
Eggs	Turkeys	A/turkey/California/meleagrium/64; A/turkey/California/5142/66	E	2.25/0.2 ml	No infectious virus detected	Shalaby
	Chickens	A/chicken/Alabama/7395/75 (H4N8)	N	Not reported	No infectious virus detected	Shalaby
	Ducks and geese	Not available				
Feathers	Avian species	Not available				
Liver	Avian species	Not available				
Blood	Chickens	A/chicken/aq-Y-55/01 (H9N2)	E (co infection with *S. aureus*)	6/0.1 ml	Not reported	Kishida, Swayne
		A/chicken/Beijing/2/97 (H9N2)		6/0.1 ml		
	Turkeys	A/turkey/Italy/3675/99 (H7N1)	E	6/0.1 ml	<1	Toffan
	Ducks	No data available				

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Vírus nos produtos de animais

Foodborne Germs and Illnesses

Español (Spanish) | Kreyòl (Creole) | Print

CDC estimates that each year 48 million people get sick from a foodborne illness, 128,000 are hospitalized, and 3,000 die.

Causes of Food Poisoning

Top 5 Germs Causing Illness, Hospitalizations, and Deaths From Food Eaten in the United States

Illnesses	Hospitalizations	Deaths
1. Norovirus	1. *Salmonella* (non-typhoidal)	1. *Salmonella* (non-typhoidal)
2. *Salmonella* (non-typhoidal)	2. Norovirus	2. *Toxoplasma gondii*
3. *Clostridium perfringens*	3. *Campylobacter*	3. Listeria monocytogenes
4. *Campylobacter*	4. *Toxoplasma gondii*	4. Norovirus
5. *Staphylococcus aureus*	5. *E. coli* 0157	5. *Campylobacter*

- *Salmonella* can cause salmonellosis and typhoid fever and paratyphoid fever.
- Botulism is most often caused by *Clostridium botulinum*.
- Some other germs that cause foodborne illness include *Cryptosporidium*, *Cyclospora*, hepatitis A virus, *Shigella*, and *Yersinia*.
- See a complete A-Z index of foodborne illnesses.

Norovírus no Brasil

Vírus apontado como causador de surto de diarreia é encontrado em rio de Florianópolis

Agente foi detectado no Rio do Brás, que chega até areia da praia de Canasvieiras, totalmente imprópria para banho. Especialista aponta que falta de saneamento básico pode ajudar na circulação do vírus.

Por Joana Caldas e Juan Todescatt, g1 SC e NSC TV
23/01/2023 06h57 · Atualizado há 2 meses

SEGUNDO JORNAL
Prova do Masterchef Espanha deixa 40 pessoas com intoxicação alimentar

ALEMANHA
Brasileiras que tiveram malas

Norovírus: como prevenir o microrganismo por trás do surto de diarreia em Florianópolis

CNN BRASIL

Medidas de prevenção incluem práticas de higiene e de consumo adequado de alimentos

Medidas de prevenção incluem práticas de higiene e de consumo adequado de alimentos
Fran Jacquier/Unsplash

Rotavírus no Brasil

≡ MENU | g1 PERNAMBUCO

São Lourenço da Mata registra mais de 6 mil casos de rotavírus

Mais de 6,2 mil casos de diversas viroses, incluindo o rotavírus humano, foram registrados entre novembro de 2022 e janeiro deste ano, em São Lourenço da Mata, no Grande Recife **(veja vídeo acima)**.

Errata: *O **g1** errou ao publicar na reportagem que os casos registrados eram só de rotavírus humano. Esse dado foi repassado pela assessoria de comunicação da Unidade de Pronto Atendimento (UPA) do município. Além disso, os casos foram registrados entre novembro de 2022 e janeiro de 2023. As informações foram corrigidas às 7h52 desta quinta (9).*

Segundo a UPA da cidade, essas doenças atingem majoritariamente crianças e causam diarreia, vômito e desidratação, podendo levar à morte (**veja aqui os sintomas**).

- **Compartilhar no WhatsApp**

Muito obrigada

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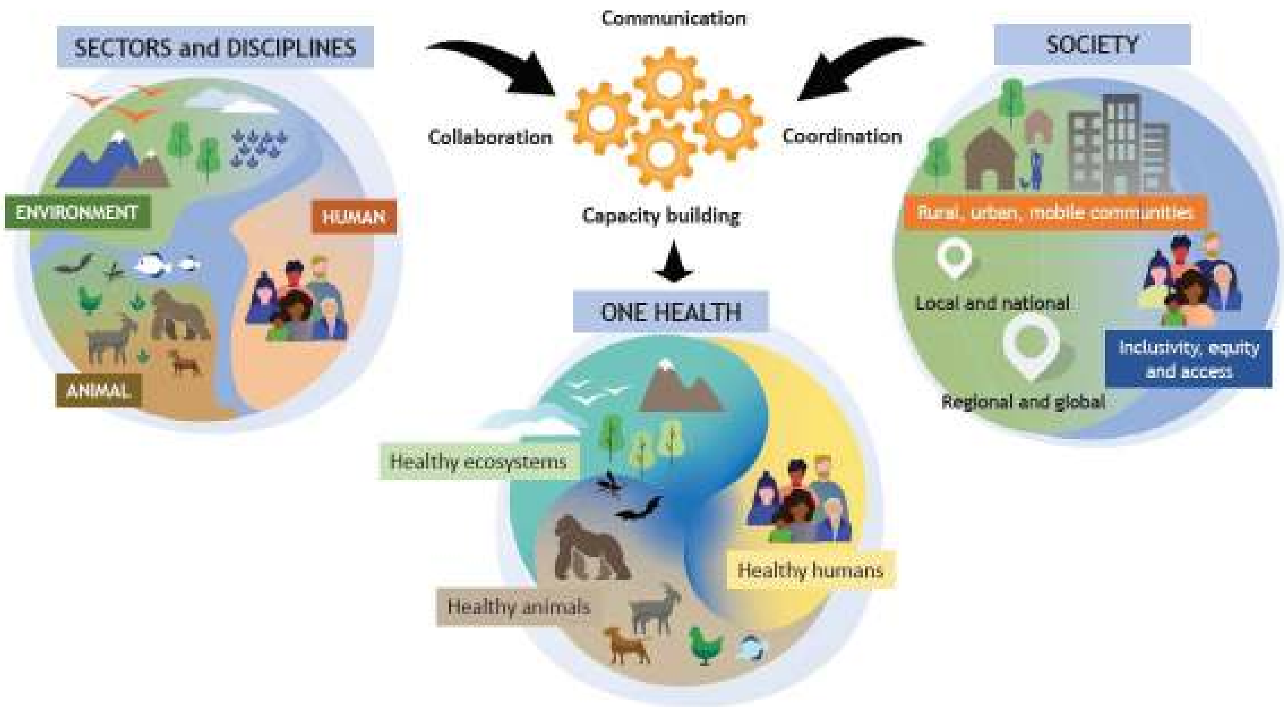
@sbvirologia



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