Vaccines: evidence-based medicine and societal perceptions

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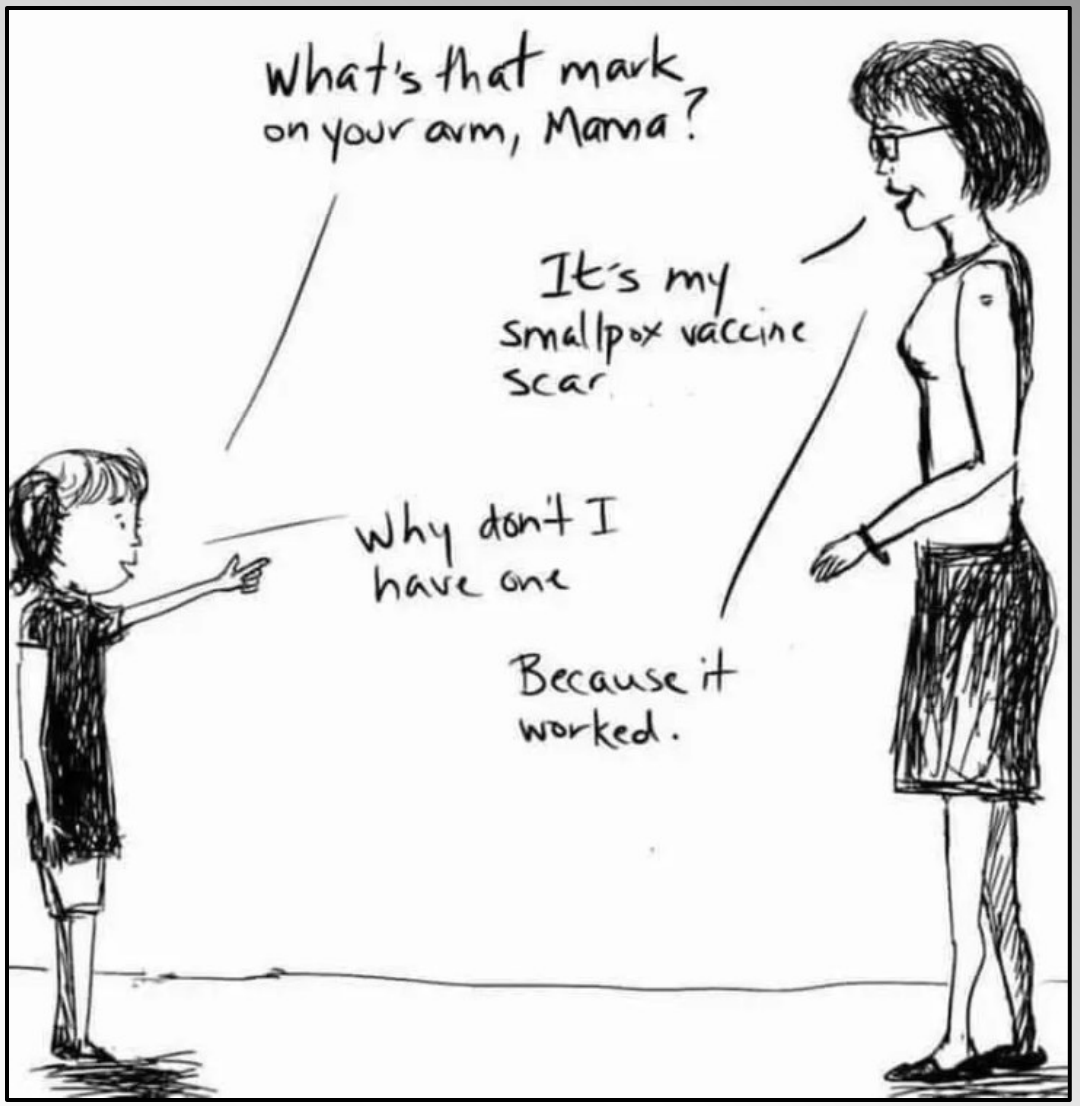
Learning objectives

1. Identify and Recognize Vaccine History and Fallacies
2. Identify and summarize childhood and adult vaccine schedules and the scientific basis of these vaccines
3. Identify and review current and future vaccine technology

When a vaccine or some other health care measure prevents a disease, it leads people to forget the disease that it prevents.



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Vaccine definition

- A substance used to stimulate immunity to a particular infectious disease or pathogen, typically prepared from an inactivated or weakened form of the causative agent or from its constituents or products

Benefits of Vaccines

- Vaccines have saved millions of lives by reducing the incidence or severity of many infectious diseases.

- In developed countries, the incidence of many diseases has dropped to virtually zero (e.g. smallpox, diphtheria, tetanus).

- Vaccine-mediated prevention of childhood mortality is considered the greatest public health success in history.

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History of vaccines

- 1400's – 1700's
  - People in many parts of the world have tried to prevent illness by intentionally exposing healthy people to smallpox lesions
  - Inoculation – implanting pathogen into a person to induce immunity against an infectious disease; also called "variolation" (variolation from "la variole" – Latin for smallpox)

First “western” example of vaccines

- 1721: Lady Mary Wortley Montagu brought smallpox inoculation to Europe. Requested that her daughters be inoculated against smallpox as she had seen in Turkey
- Anecdotal evidence - milkmaids that had gotten cowpox did not get smallpox
- 1774: Farmer Benjamin Jesty –tests his hypothesis that infection with cowpox could protect a person (his family) from smallpox
- 1796: English physician Edward Jenner expands on this discovery and inoculates 8-year-old James Phipps with matter collected from a cowpox sore. He had a local reaction and felt unwell for a few days
- 1796 – 2 months later – Jenner inoculates Phipps with matter form a smallpox sore. He remained in perfect health.
- Vaccine” is derived from the Latin “vacca” for cow.

Smallpox and cowpox lesions

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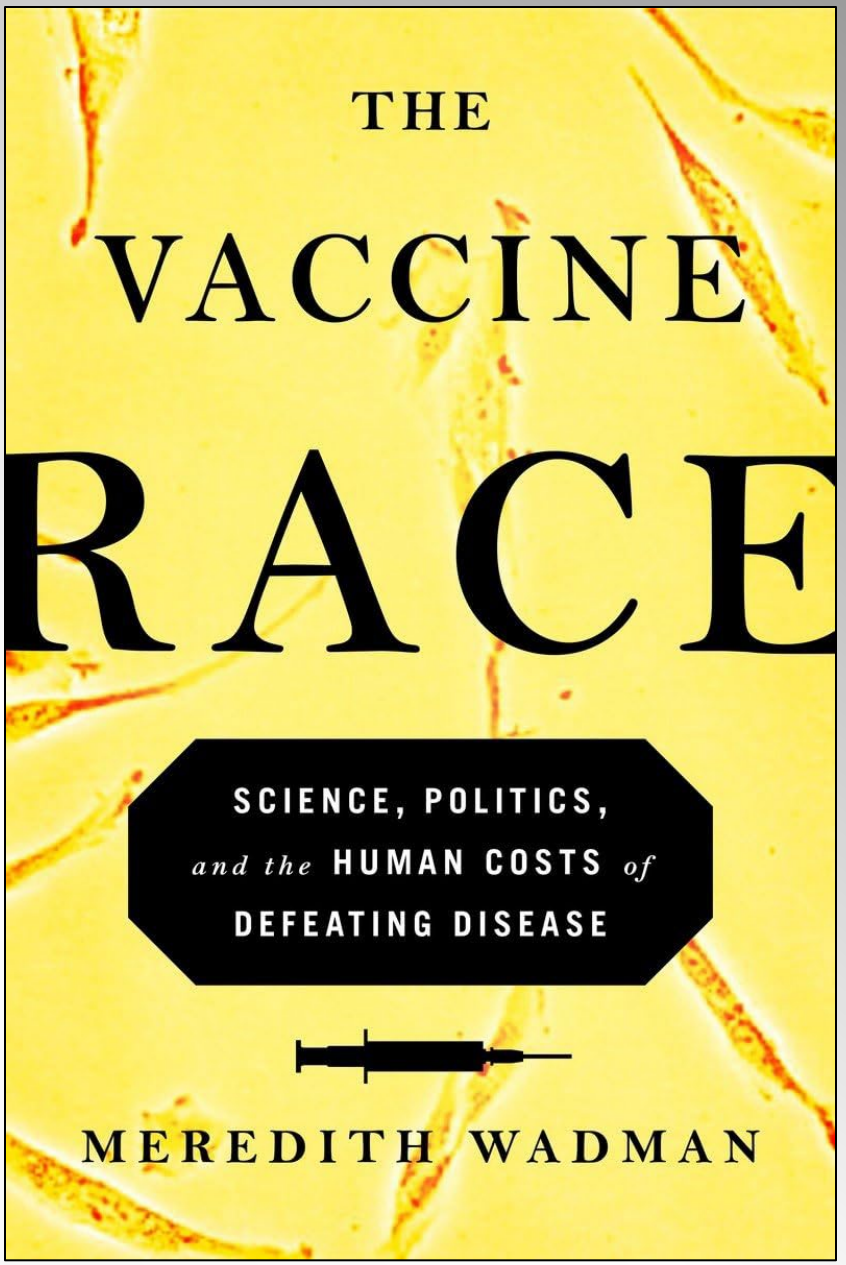
More history of vaccines

- 1806 – Napoleon and Thomas Jefferson acknowledge Jenner's work & endorse his smallpox vaccine
- 1885 Pasteur successfully prevents rabies through post exposure inoculations
- 1894 – Diphtheria bacteria isolated by Dr. Anna Wessels Williams
- 1918-19 Spanish Flu epidemic kills 20-50 million worldwide. US Military works to develop a vaccine

More history of vaccines

- 1937 Vaccine against yellow fever developed
- 1939 Bacteriologists Pearl Kendrick and Grace Eldering develop vaccine for pertussis-whooping cough (leading to DPT vaccine in 1948 with Loney Clinton Gordon)
- 1950's – Race for Polio vaccine
- 1960's – Race for Rubella vaccine
- 1970's -1990's – more vaccines for childhood diseases



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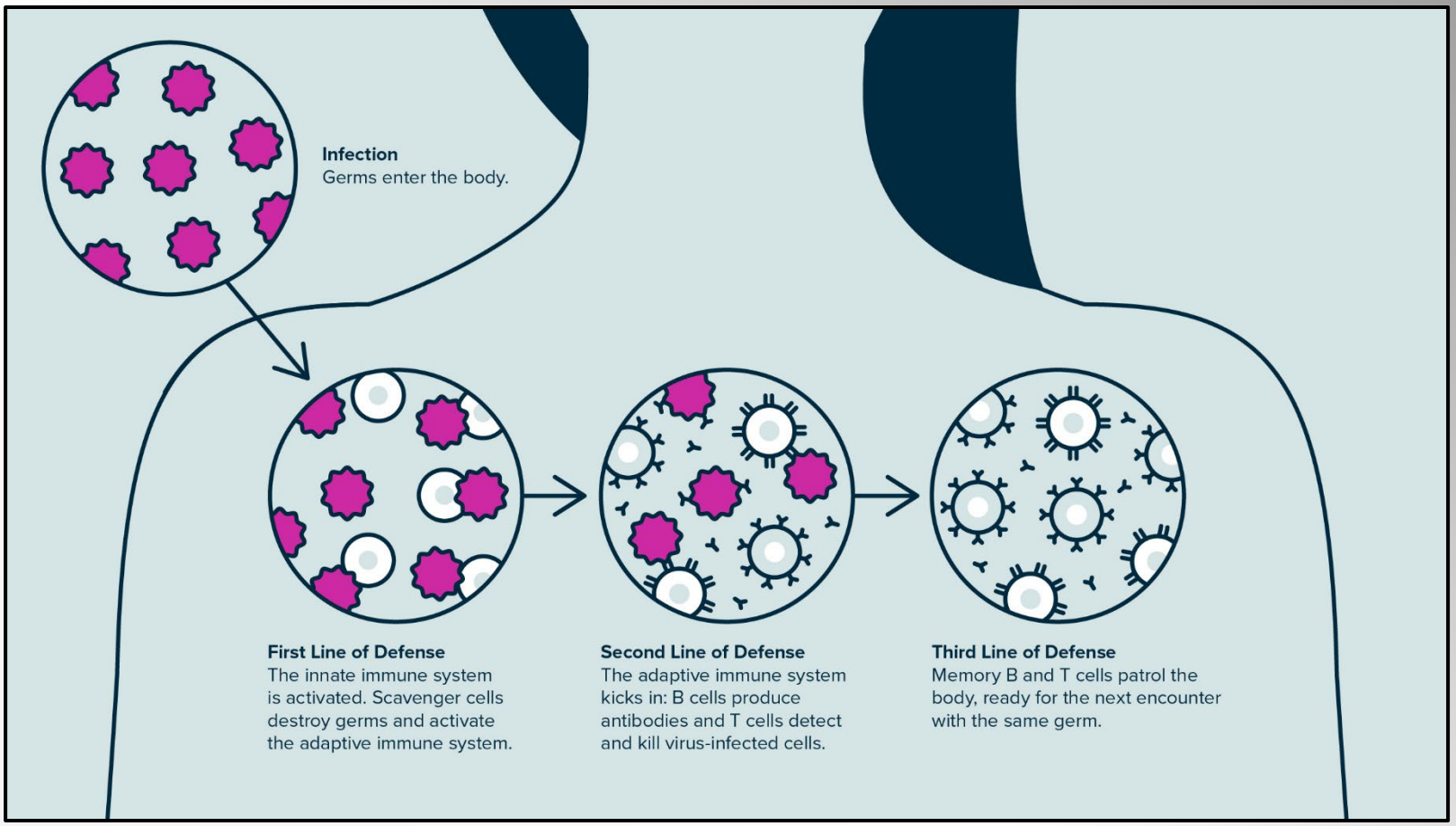
Goal of vaccination

- Generate an immune response that will eliminate the pathogen before any symptoms of illness develop
- The best vaccines are those that:
  - Prevent the pathogen from entering
  - Immediately clear pathogens that do gain entry
- Booster immunizations are often necessary to achieve and maintain immunity

Vaccines mimic the immune response to infection



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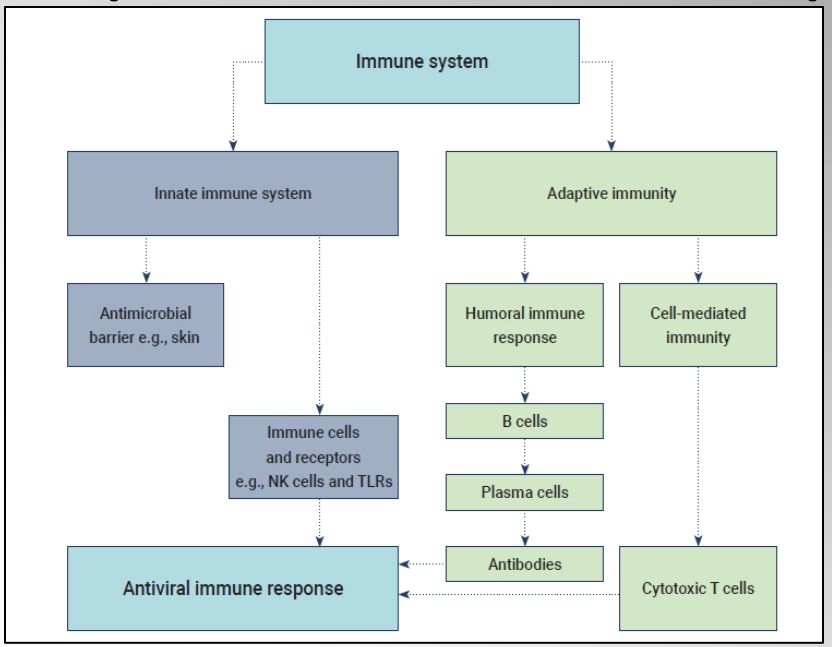
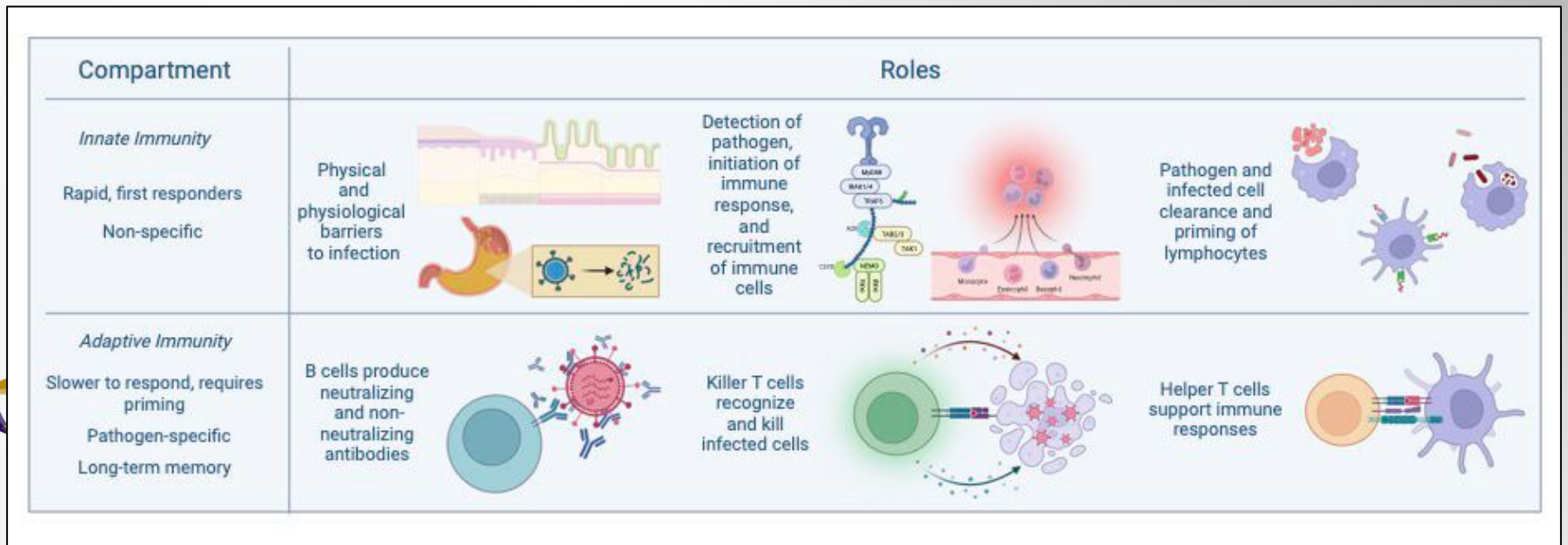
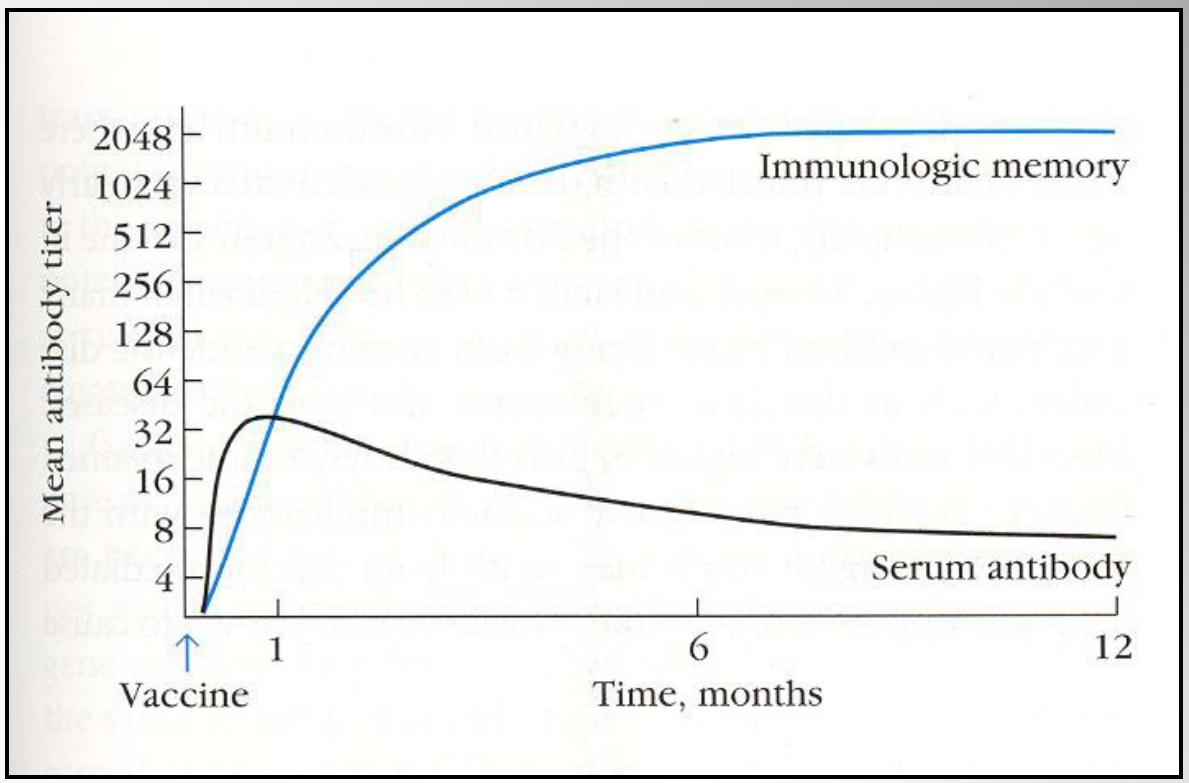
Innate & Adaptive Immune Response





Immunological Memory vs. Serum Antibody Levels



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Criteria for a successful vaccine program

When delivered well, vaccination programs can prevent infection on a large scale.

Factors that affect how successful a vaccine program will be:

- **Availability** - Suitable vaccines must be affordable and available in large amounts for mass immunization.
- **Minimal side effects** - The fewer the side effects from the vaccine, the better the public acceptance.
- **Infrastructure** - Necessary resources for producing, storing, and transporting the vaccine are essential, including advanced technology and refrigeration.
- **Administration** - Proper and timely vaccine administration is important, requiring trained healthcare workers
- **Herd immunity** - The goal is to vaccinate the majority of the population to achieve herd immunity.

Factors that may prevent the elimination of a disease:

- **Individual immunity failures** - People with weak immune systems (babies, elderly people, and patients with compromised immune systems) may not be able to withstand vaccines, or may not develop an immune response.
- **Pre-immunity infection** - Some individuals might contract the disease post-vaccination but before immunity develops, becoming potential disease reservoirs.
- **Pathogen mutation and antigenic variability** - Rapid antigenic changes due to frequent mutations can make vaccines ineffective, as the immune system can no longer recognize the pathogen's new antigens (e.g. with diseases like influenza).
- **Pathogen variety** - With diseases like the common cold, the sheer number of pathogen variants can make developing a universally effective vaccine nearly impossible.
- **Pathogen hiding** - Certain pathogens can evade the immune system by 'hiding' inside cells or inhabiting hard-to-reach body regions like the intestines (e.g. with cholera).
- **Psychosocial -Vaccine objections/hesitancy** - Personal, religious, ethical, or medical objections to vaccination can hinder disease eradication. Misinformation can lead to reduced vaccination rates.

Types of Vaccines

- Inactivated – used the killed version of the pathogen that causes the disease
- Live attenuated –weakened, generally by repeated culture passages (years)
- Toxoid vaccines (inactivated toxins)
- Subunit, recombinant, polysaccharide, & conjugate vaccines
- Viral vector vaccines
- mRNA vaccines

Types of Vaccines

- Inactivated – Hepatis A, Flu, Polio, Rabies
- Live attenuated – Measles, Mumps, Rubella Chickenpox, Rotavirus, Yellow fever, Smallpox, Cholera
- Toxoid vaccines –Diphtheria, Tetanus
- Subunit, recombinant, polysaccharide, & conjugate vaccines – Hepatitis B, HPV, Hib, Whooping cough, pneumococcal & meningococcal disease
- Viral vector vaccines (Adenovirus, vaccinia, VSV – Ebola and some Covid 19 vaccines
- mRNA vaccines – Covid 19 vaccines

Antigenic variability

- Vaccination relies on introducing a pathogen's antigens into the body to stimulate an immune response. However, some pathogens can change their antigens in a process known as antigenic variability.
- Antigenic variability makes it difficult to develop vaccines against some pathogens because if the antigens change enough they will no longer be recognized by the immune system. This means that memory cells produced from vaccination against one strain will not recognize the antigens from another strain.
- As a result, vaccines need to be changed frequently to provide protection against the most recent pathogenic strains. (Flu)

Effectiveness of Vaccinations

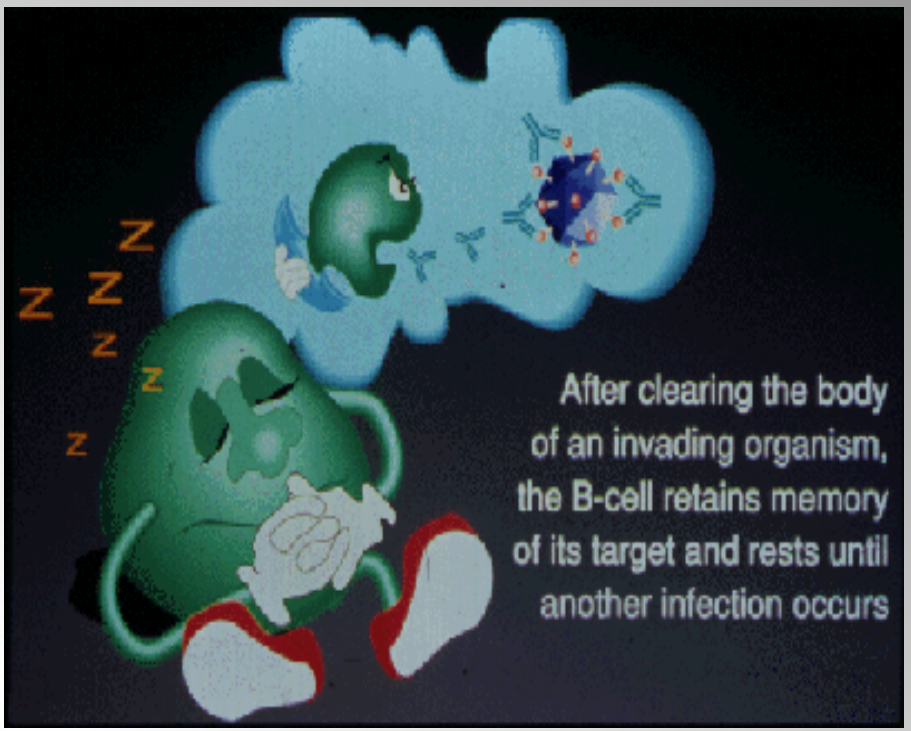
- Small percentage of recipients will respond poorly
  - Role of genetic determinants ?
- Herd Immunity
  - Majority of population is immune, so chance of susceptible individual contacting infected individual is low

Herd Immunity

- Factors affecting herd immunity
  - Environmental Factors: crowded conditions, seasonal variations
  - Strength of Individual's Immune System
  - Infectiousness of Disease: greater the risk of infection, the higher percentage of people need vaccines to attain herd immunity (R0)
- When enough people are vaccinated, chance of germ infecting the non-immunized population is small
- Can lead to disappearance of diseases (smallpox)
  - Vaccination no longer necessary

Active Immunization

- Natural Infection with microorganism or artificial acquisition (vaccine)
- Both stimulate the proliferation of T and B cells, resulting in the formation of effector and **memory** cells
- The formation of memory cells is the basis for the relatively permanent effects of vaccinations



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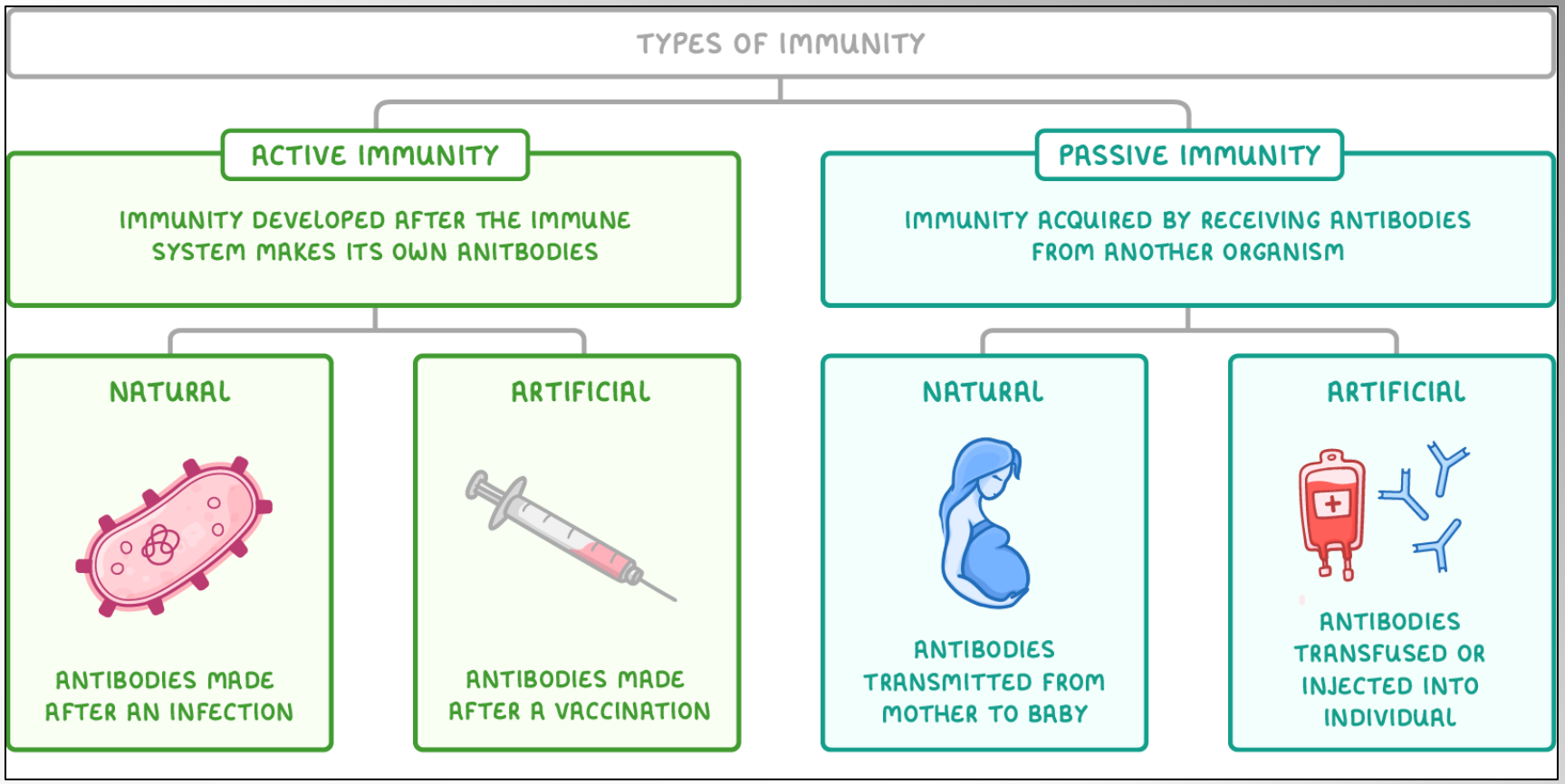
Active vs. Passive Immunization



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Common agents used for Passive Immunization

Disease	Agent
Black widow spider bite	Horse antivenom
Snake bite	Horse antivenom
Botulism	Horse anti-toxin
Diphtheria	Horse anti-toxin
Hepatitis A or B	Pooled human immunoglobulin
Measles	Pooled human immunoglobulin
Rabies	Pooled human immunoglobulin
Tetanus	Pooled human immunoglobulin or Horse anti-toxin

Studying vaccine safety

1. Randomized, double-blind placebo-controlled study
    - Participants receive either experimental vaccine or placebo. The person receiving the injection and the care provider do not know to which group the participant belongs. The sample size needs to be large enough to sufficiently answer the research question.
    - The researchers then look at how many people contracted the disease, unseal the groups, determine if there is a sufficient enough effect to recommend. -whether the results are generalizable to others.

2. Subsequent iterations of a vaccine will compare a newer version of a vaccine to the "Standard of Care" vaccine – not a placebo. It would be UNETHICAL to deprive persons of a known preventative vaccine.

3. Systemic Review and Meta-Analysis

    A.) Systematically locate as many papers as possible on a given subject, use criteria to evaluate the quality of each study. Papers will be eliminated because do not meet the criteria such as
        - They are not directly related to the topic at hand
        - They are not original research studies, but other types of papers such as case reports (which describe a finding without performing a controlled study, or an editorial)
        - They are not peer-reviewed

    B.) Use statistical analyses to evaluate & summarize what all the studies indicate on this subject

Vaccine ingredients

- Antigens - to stimulate the immune system
- Excipients –inactive substances
  - Preservatives –help prevent contamination (thimerosal)
  - Adjuvants – enhance the immune response (aluminum salts)
  - Stabilizers –maintain vaccine effectiveness during storage & transport: amino acids, proteins, sugars
  - Other trace materials –residual ingredients from the manufacturing process
- Other common ingredients
  - Formaldehyde –used to kill/inactivate viruses, bacteria, & toxins
  - Antibiotics – to prevent bacterial growth
  - Water

COMMON COMPONENTS OF VACCINES

As well as the active components, vaccines contain a number of other substances. This graphic examines these and the reasons for their inclusion.

ACTIVE COMPONENTS

A form of the virus, bacteria or toxin that causes the disease is used as the antigen. This antigen is modified from the original form so it no longer causes disease, but still illicits an immune response from the body. To modify the disease-causing agent, it can be treated with specific chemicals, so it cannot replicate. It can also be treated so it does not cause serious disease, or only parts of the disease-causing agent that do not cause serious symptoms can be used.

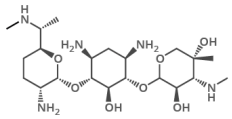
ADJUVANTS

$Al(OH)_3$
ALUMINIUM HYDROXIDE

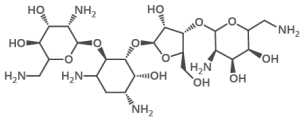
$AlPO_4$
ALUMINIUM PHOSPHATE

Added to enhance the body's immune response to the vaccine. How they work isn't entirely understood, but it's thought they help keep antigens near the site of injection. This means they can be easily accessed by the immune system cells. There is no evidence of any serious adverse effects from adjuvants, though they can cause some minor reaction near the injection site.

ANTIBIOTICS

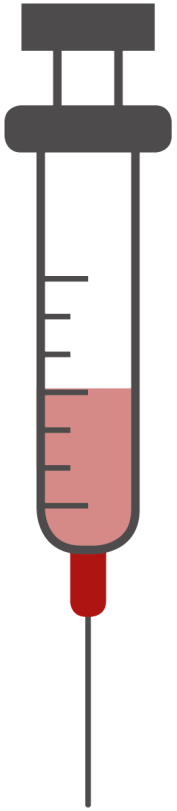


GENTAMICIN

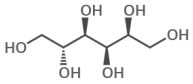


NEOMYCIN

Antibiotics are used in the manufacturing process of the vaccine to prevent bacterial contamination. They are later removed, and only residual quantities remain in the vaccine after the production process.



STABILISERS

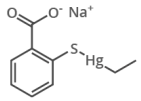


SORBITOL

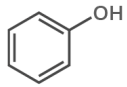
$MgSO_4$
MAGNESIUM SULFATE

Vaccines need to be storable, so stabilisers are added to ensure the various components remain stable and effective. A variety of different stabilisers are used; either inorganic magnesium salts such as magnesium sulfate or magnesium chloride, or mixtures of lactose, sorbitol and gelatin. Monosodium glutamate and glycine are also used in some cases.

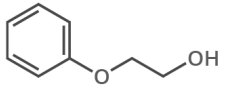
PRESERVATIVES



THIOMERSAL



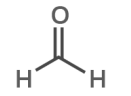
PHENOL



PHENOXYETHANOL

Preservatives help prevent contamination of vaccines. They are used particularly in multi-dose vaccines. Thiomersal is a common preservative, though its use declined in the late 1990s when vaccines were falsely linked to child autism. This link was later shown to be an elaborate medical hoax, and there is no link between thiomersal and autism.

TRACE COMPONENTS



FORMALDEHYDE

These are left-over from the vaccine production process. Though they are purposefully removed, residual amounts remain. Formaldehyde is one such agent, used to deactivate viruses and detoxify bacteria, but amount remaining is several hundred times lower than the smallest amount known to cause harm in humans.

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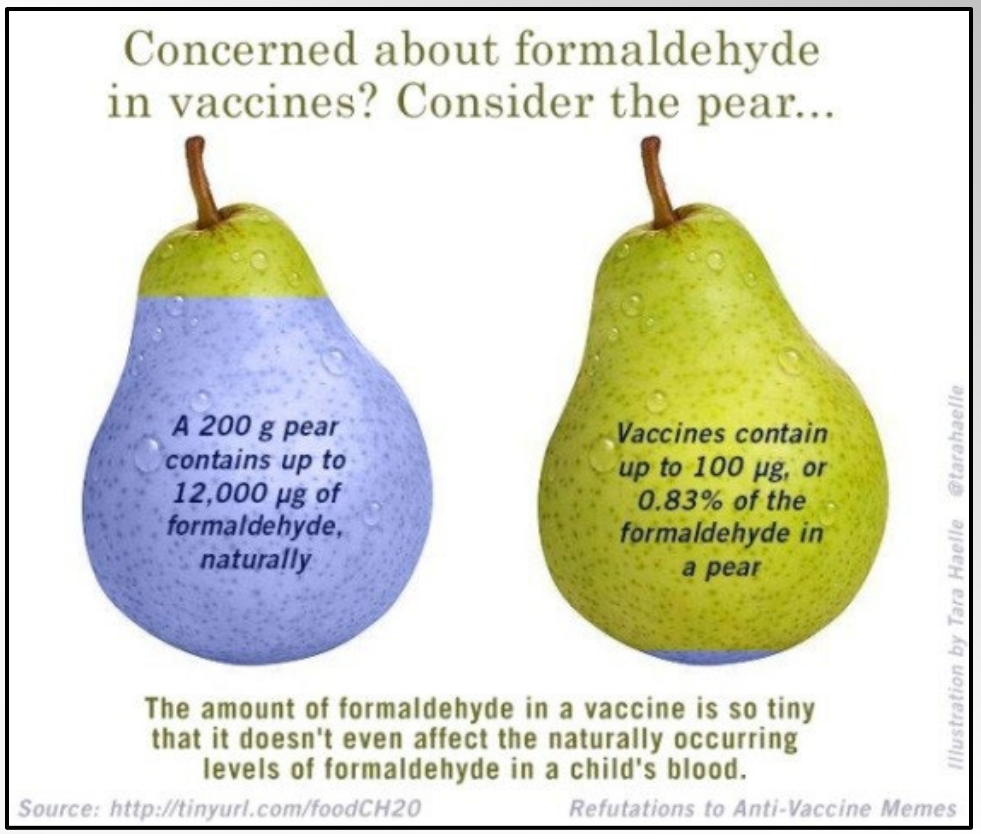
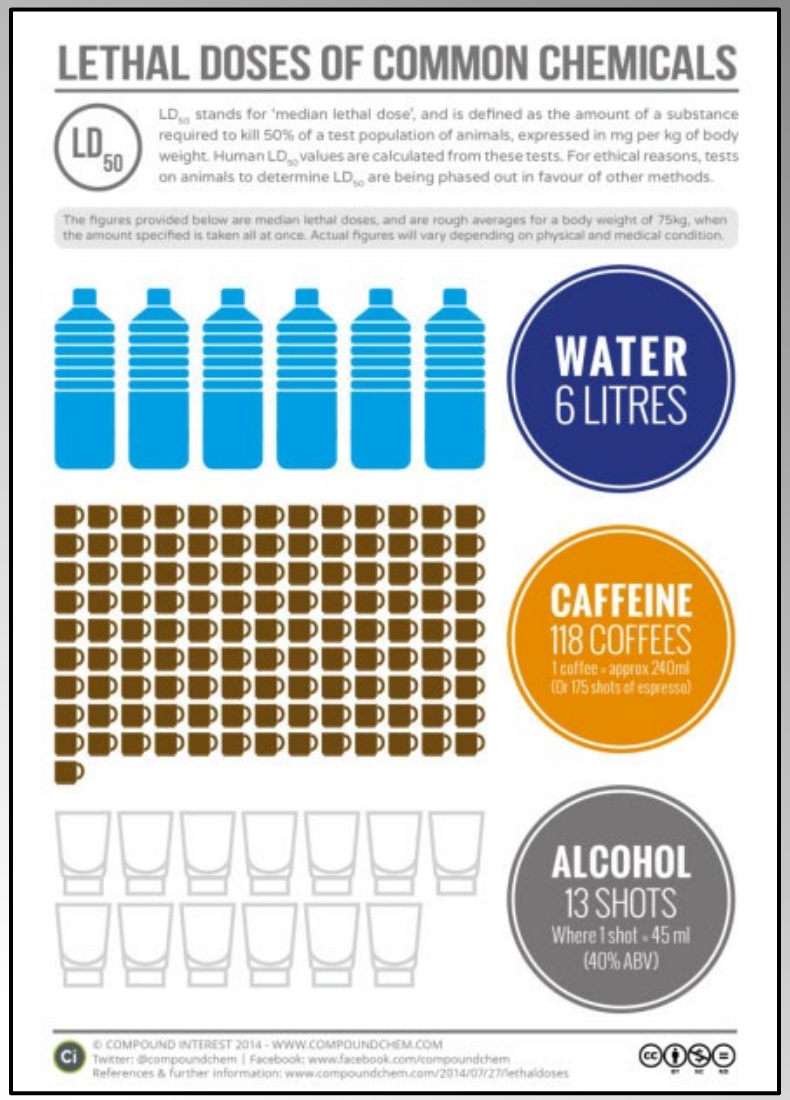
Paracelsus

"The dose makes the poison"





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Robert F. Kennedy, Jr., HHS Secretary

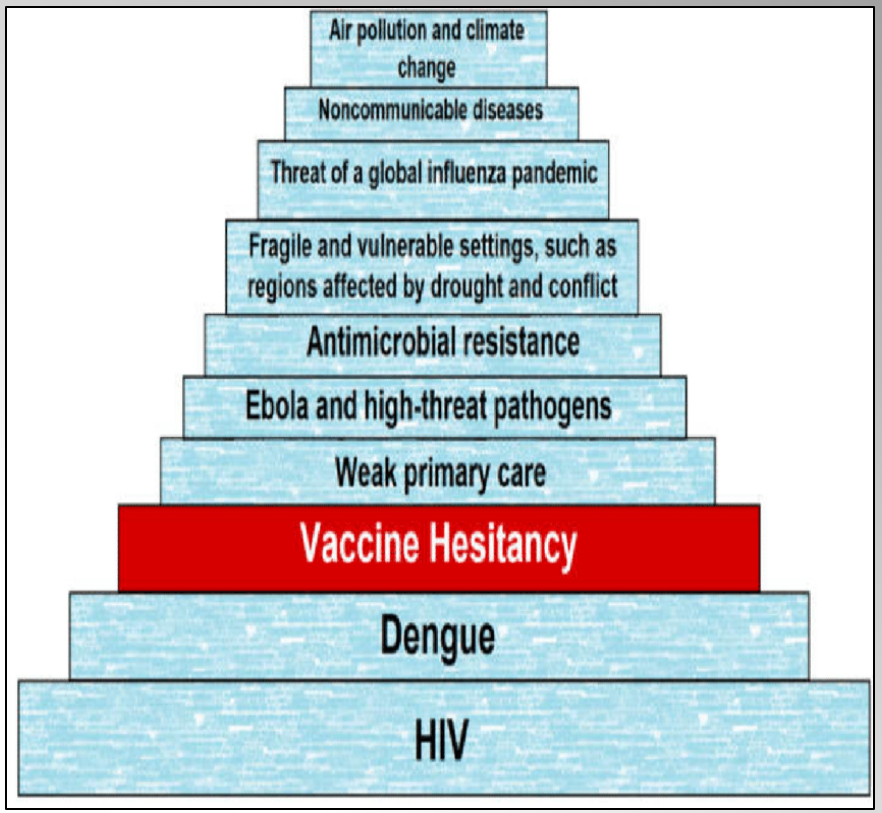
- On an episode of Joe Rogan's podcast. RFK Jr. informed Rogan's listeners that pharmaceutical companies "never do placebo-controlled trials."
- **NOT TRUE**
- Increase in Autism cases – diagnostic criteria for autism (Autism Spectrum Disorder) has
- Increased awareness, expanded definition

Thimerosal (Ethylmercury)

- Mercury –naturally occurring element that is found in the earth crust, air, soil, & water. Released by volcanic eruptions, weathering of rocks, burning of coal.
- Bacteria in the environment can change mercury to Methylmercury which makes its way through the food chain to fish, animals, & humans. At high levels, it is TOXIC to humans.
- Thimerosal contains Ethylmercury which is broken down & excreted much faster than Methylmercury, so it does not accumulate in the body & cause harm.
- Since these two types of mercury differ by only a single letter, people are confused thinking they must be the same thing or very similar buy they are not.
- Think of ethanol and methanol
- Thimerosal was REMOVED from childhood vaccines (Nov ‘97) with exception of the flu vaccine

Vaccine misinformation –significant threat to global health (2019) World Health Organization (WHO)

1. Vaccine preventable diseases are harmless
2. Question trustworthiness of healthcare authorities who administer vaccines
3. Alternative methods to replace vaccination
4. Effectiveness – vaccines don't work
5. Safety –vaccines have more risks that benefits



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List of popular misinformation about vaccines

- Vaccines cause Autism
- Vaccines cause the same disease that one is vaccinated against.
- Vaccine preventable diseases are harmless
- Vaccines can cause harmful side effects
- Vaccines cause infertility
- Alternative remedies to vaccination
  - Eating yogurt cures HPV
  - Homeopathy can protect against measles
  - Nutritional supplements/vitamins can protect from measles, covid

More misinformation

- Vaccines could depopulate the earth – mRNA Vaccines can alter DNA in the nucleus. (no, they stay in cytosol)
- Vaccines contain forbidden additives (Thiomersal, Aluminum)
- Vaccines are part of a government/pharmaceutical conspiracy
- Personal anecdotes amplified on social media
- Polio is not a real disease & is caused by environmental poisoning (DDT)
- Covid 19 vaccines contain microchips to identify & track people

Feb 1998 Gastroenterologist Andrew Wakefield reports that his team has found a “genuinely new syndrome”—a link between the measles, mumps and rubella (MMR) vaccine and an increased risk of autism, Autistic colitis (*Lancet* **351**, 637–641, 1998). “Science by press conference”

- 1998 paper

EARLY REPORT

Early report

Ileal-lymphoid-nodular hyperplasia, non-specific colitis, and pervasive developmental disorder in children

A J Wakefield, S H Murch, A Anthony, J Linnell, D M Casson, M Malik, M Berelowitz, A P Dhillon, M A Thomson, P Harvey, A Valentine, S E Davies, J A Walker-Smith

Summary

Background We investigated a consecutive series of children with chronic enterocolitis and regressive developmental disorder.

Methods 12 children (mean age 6 years [range 3–10], 11 boys) were referred to a paediatric gastroenterology unit with a history of normal development followed by loss of acquired skills, including language, together with diarrhoea and abdominal pain. Children underwent gastroenterological, neurological, and developmental assessment and review of developmental records. Ileocolonoscopy and biopsy sampling, magnetic-resonance imaging (MRI), electroencephalography (EEG), and lumbar puncture were done under sedation. Barium follow-through radiography was done where possible. Biochemical, haematological, and immunological profiles were examined.

Findings Onset of behavioural symptoms was associ by the parents, with measles, mumps, and rub vaccination in eight of the 12 children, with measl infection in one child, and otitis media in a... All 1 children had intestinal abnormalities ...ang... from lymphoid nodular hyperplasia to a...noid u...ration. Histology showed patchy chronic infla...tion i... in 11 children and reactive ileal lympho...perplasia in seven, but no granulomas. Be...viour...l diso...s included autism (nine), disintegrati...sis (one), a... possible postviral or vaccinal encephalitis (one). There were no focal neurological ab...malities and MRI and EEG tests were normal. Abno...l laboratory results ...re significantly raised urinary ...thylma... acid compared with age-matched control... (p=...03), low haemoglobin in four children, a... low s...n IgA in ...r children.

Interpretation We ide... associated gastrointestinal di...se and ...evelopmental regression in a group of previ...ly ...rmal chi...n, which was generally associated in time ... possible environmental triggers.

Lancet 199...**351:** 637–41
See Commentary page

Inflammatory Bowel Disease Study Group, University Departments of Medicine and Histopathology (A J Wakefield FRCS, A Anthony MB, J Linnell PhD, A P Dhillon MRCPath, S E Davies MRCPath) **and the University Departments of Paediatric Gastroenterology** (S H Murch MB, D M Casson MRCP, M Malik MRCP, M A Thomson FRCP, J A Walker-Smith FRCP.), **Child and Adolescent Psychiatry** (M Berelowitz FRCPsych), **Neurology** (P Harvey FRCP), **and Radiology** (A Valentine FRCR), **Royal Free Hospital and School of Medicine, London NW3 2QG, UK**

Correspondence to: Dr A J Wakefield

Introduction

We saw several children who, after a p...d of apparent normality, lost acquired skills, includ... com...nication. They all had gastrointestinal ...mptoms, ...luding abdominal pain, diarrhoea, and ...iting and, ...some cases, food intolerance. We ...cribe... clinical f...ings, and gastrointestinal feature... of these chi...n.

Patients and meth...s

12 children, con...ecutively ...ferred to th... department of paediatric gastr...erology ... a hi...y of a pervasive developmental ...der with loss ...quired skills and intestinal symptoms ...rrh... abdominal ...n, bloating and food intolerance), were inv...tigated. All children were admitted to the ward for ... week, accomp...ed by their parents.

Clinical investigations

...y took histor... including details of immunisations and e...posure to infect...s diseases, and assessed the children. In 11 ca...the history ...as obtained by the senior clinician (JW-S). Neur...ical and psychiatric assessments were done by consultant staff (PH, MB) with HMS-4 criteria.[1] Developmental ... included a review of prospective developmental records from parents, health visitors, and general practitioners. Four children did not undergo psychiatric assessment in hospital; all had been assessed professionally elsewhere, so these assessments were used as the basis for their behavioural diagnosis.

After bowel preparation, ileocolonoscopy was performed by SHM or MAT under sedation with midazolam and pethidine. Paired frozen and formalin-fixed mucosal biopsy samples were taken from the terminal ileum; ascending, transverse, descending, and sigmoid colons, and from the rectum. The procedure was recorded by video or still images, and were compared with images of the previous seven consecutive paediatric colonoscopies (four normal colonoscopies and three on children with ulcerative colitis), in which the physician reported normal appearances in the terminal ileum. Barium follow-through radiography was possible in some cases.

Also under sedation, cerebral magnetic-resonance imaging (MRI), electroencephalography (EEG) including visual, brain stem auditory, and sensory evoked potentials (where compliance made these possible), and lumbar puncture were done.

Laboratory investigations

Thyroid function, serum long-chain fatty acids, and cerebrospinal-fluid lactate were measured to exclude known causes of childhood neurodegenerative disease. Urinary methylmalonic acid was measured in random urine samples from eight of the 12 children and 14 age-matched and sex-matched normal controls, by a modification of a technique described previously.[2] Chromatograms were scanned digitally on computer, to analyse the methylmalonic-acid zones from cases and controls. Urinary methylmalonic-acid concentrations in patients and controls were compared by a two-sample *t* test. Urinary creatinine was estimated by routine spectrophotometric assay.

Children were screened for antiendomyseal antibodies and boys were screened for fragile-X if this had not been done

RETRACTED

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Timeline (The Guardian)

February 1998 The Lancet publishes Andrew Wakefield's study linking autism to MMR, sparking a drop in uptake and a rise in measles

March 1998 Medical Research Council panel, ordered by government, finds no evidence to support Wakefield's claim

December 2001 Wakefield leaves his post at the Royal Free hospital

February 2004 Brian Deer, Sunday Times reports parents of some children in the study were pursuing a legal case against MMR makers and Wakefield was being funded to investigate a link

March 2004 Ten of the 12 co-authors of the 1998 paper withdraw support for Wakefield's autism-MMR link claim

2005 MMR uptake falls to 81%

June 2006 General Medical Council investigation begins into alleged misconduct

July 2007 AW Appears at the GMC disciplinary hearings, denying misconduct

January 2010 GMC panel finds Wakefield guilty of serious professional misconduct during research for his paper

February 2010 Lancet retracts Wakefield's paper

May 24, 2010 AW Struck off by the GMC (revokes his license)

Timeline continued

- Small sample size (N=12); No controls
- Fraud –data selection, data manipulation
  - Wakefield reportedly stood to earn $$$$$ selling diagnostic kits for a non-existent syndrome he claimed to have discovered.
  - He also held a patent to a rival vaccine at the same time
  - He had been employed by a lawyer representing parents in lawsuits against vaccine producers
- Papers in medical journals - Lancet, JAMA refuted Wakefield's findings in early 2000's
- BMJ –several papers outlining the fraud & ethical problems in the aughts
- BMJ 2011 editorial: "it has taken the diligent skepticism of one man, standing outside medicine and science, to show that the paper was in fact an elaborate fraud"

“Perhaps the most damaging medical hoax of the 20th Century”

- Flaherty, Dennis K. (13 September 2011). "The vaccine-autism connection: a public health crisis caused by unethical medical practices and fraudulent science". *The Annals of Pharmacotherapy 45 (10)1302*–1304. doi:10.1345/aph.1Q318. ISSN 1542-6270. PMID 21917556. S2CID 39479569.

“A Lie Can Travel Halfway Around the World Before the Truth Puts On its Shoes”

Once the lies are believed, the damage has been done.

And continues to this day.

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Cochrane Database of Systematic reviews 11/22/21

Vaccines for measles, mumps, rubella, and varicella in children

- 138 studies, 23 million children up to 15 yrs
  - 51 studies (10 million children) assessed efficacy; 87 studies (13 million) assessed unwanted effects
  - One dose of vaccine 95% in preventing measles
  - One dose of vaccine 72% effective in preventing mumps –rises to 86% after second dose
  - One dose of vaccine 89% effective in preventing rubella; 95% effective in preventing chickenpox
- The vaccine did not cause autism (2 studies 1,194,764 children), encephalitis (2 studies 1,071,088 children) or any other suspected unwanted effect.

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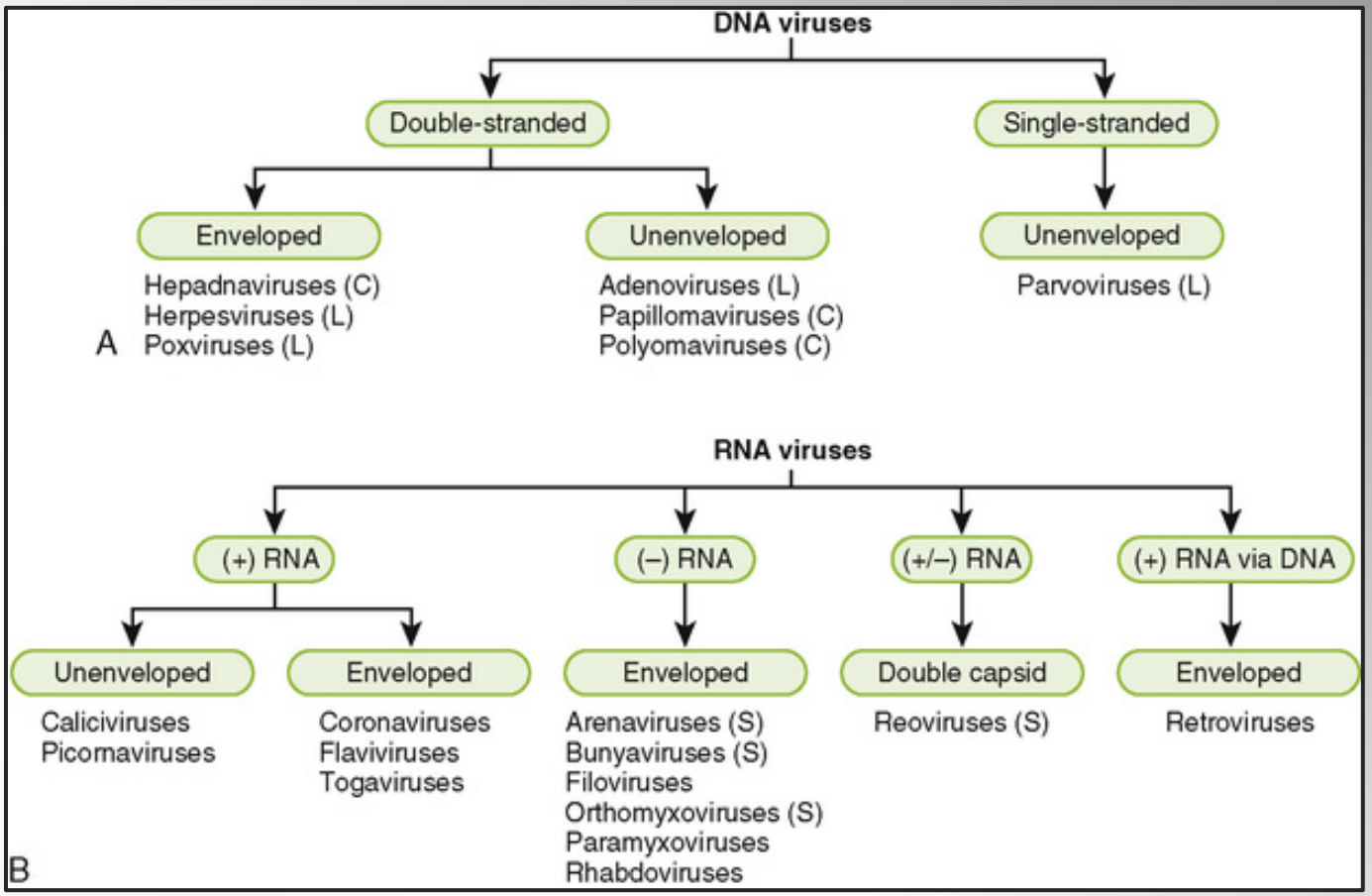
Vaccines for

- Viruses
- Bacteria
- Parasites

Viral genomes



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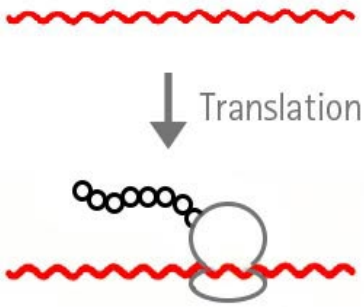
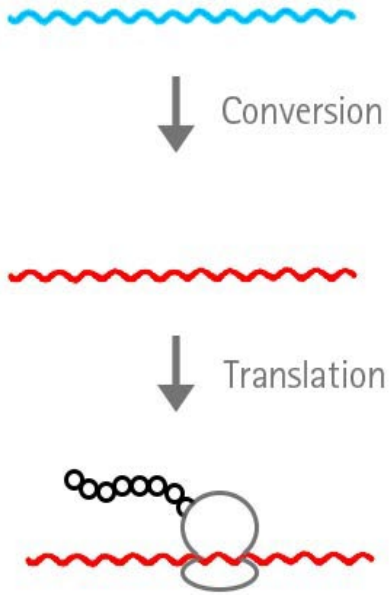
Positive-sense single-stranded RNA virus

- In the host cell, the positive-sense RNA of the virus is directly translated into viral proteins.
- It is 5'-to-3' as the host mRNA.
- Since the host ribosome moves from 5' to 3' for translation, the positive-sense single-stranded RNA is directly used for protein synthesis.

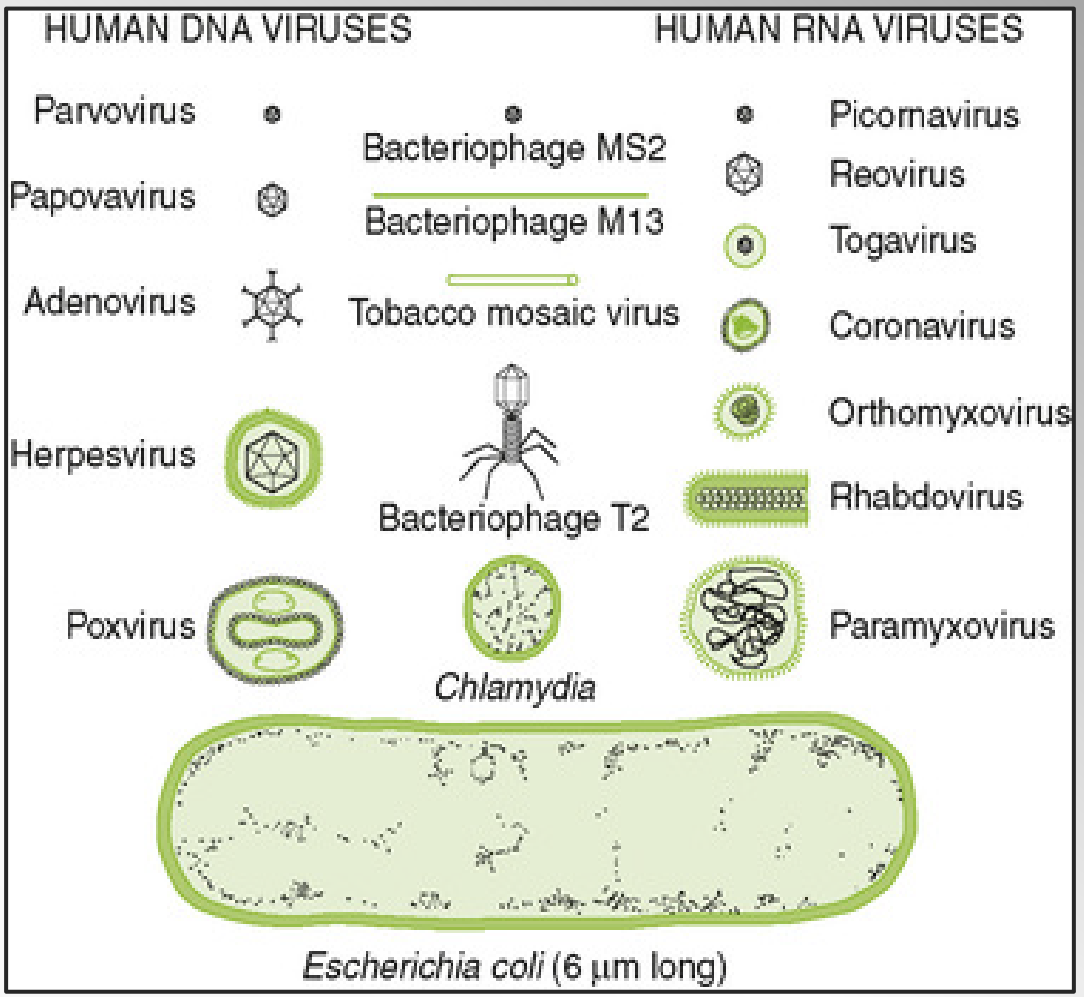


Negative-sense single-stranded RNA virus

- These viruses contain negative-sense RNA as genetic material
- It is not readable by the host ribosome.
- First, the negative-sense RNA (3'-to-5') is converted into positive-sense RNA (5'-to-3') by viruses RNA-dependent RNA polymerase.
- The positive-sense RNA then functions as mRNA and is translated into protein by the ribosome.



Relative sizes



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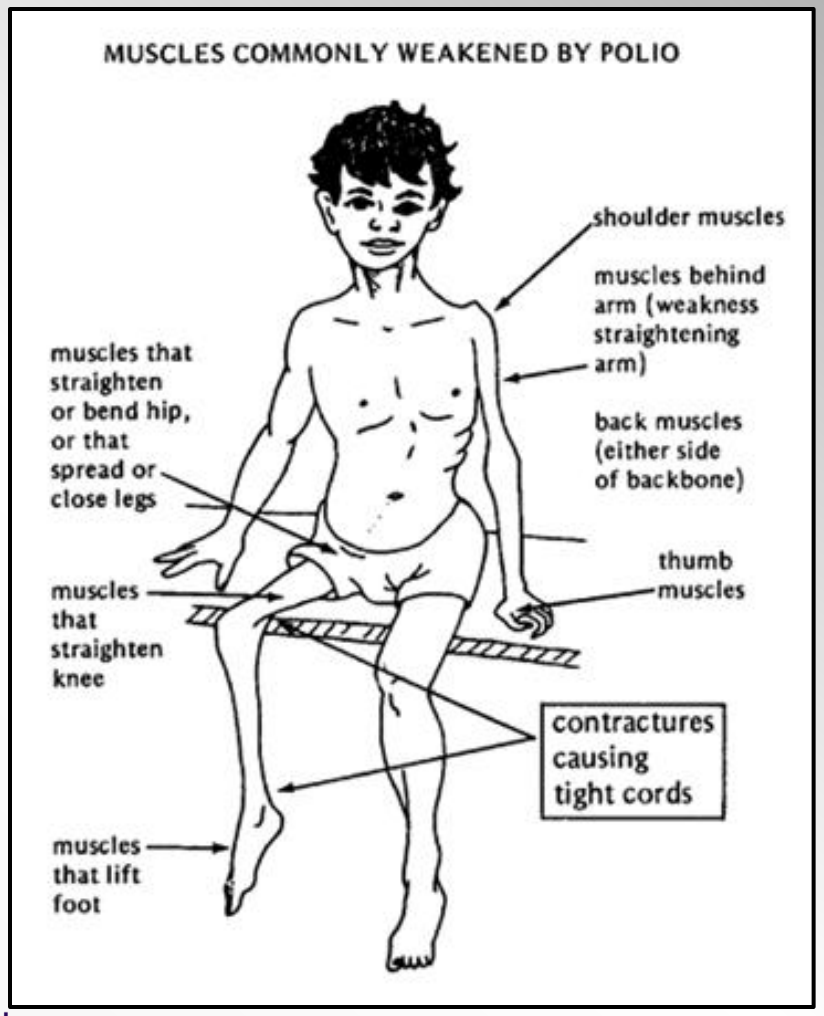
Polio

- First isolated in 1909 (Landsteiner) and structure elucidated by Rosalind Franklin
- + stranded RNA genome –directly translated into protein
- Infection occurs by fecal-oral route; virus is ingested and replication occurs in GI tract
- Survives the acidic conditions in stomach & spreads through lymphatics
- Binds to CD 155 on the cell surface present on most human cells
- Targets motor neurons in the anterior horn of the spinal cord and brain stem (mechanisms by which poliovirus enters the CNS are poorly understood)
- Mainly affects children under 5
- One in 200 get irreversible paralysis. Of those 5-10% die
- There is no cure for polio, it can only be prevented
- 2 vaccines – inactivated/killed (injection) & live attenuated (oral)

Post Polio Syndrome



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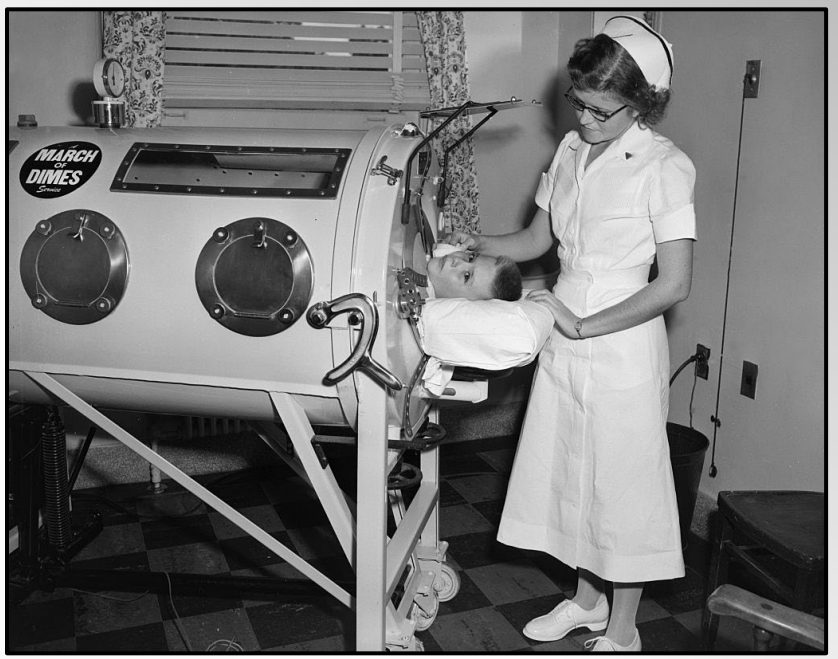
Lab Studies

- CSF
    - ↑ protein
    - normal glucose
    - ↑ white blood cells
    - Presence of viral RNA
- viral isolation
    - stool
    - Throat

- **Making the diagnosis**
    - **based on clinical presentation and laboratory studies**

Polio Management approach

- Mainstay of treatment is supportive care
- Management is focused on vaccine and prevention
- **Physical therapy and occupational therapy**
- **Respiratory support** -disease progression to respiratory system



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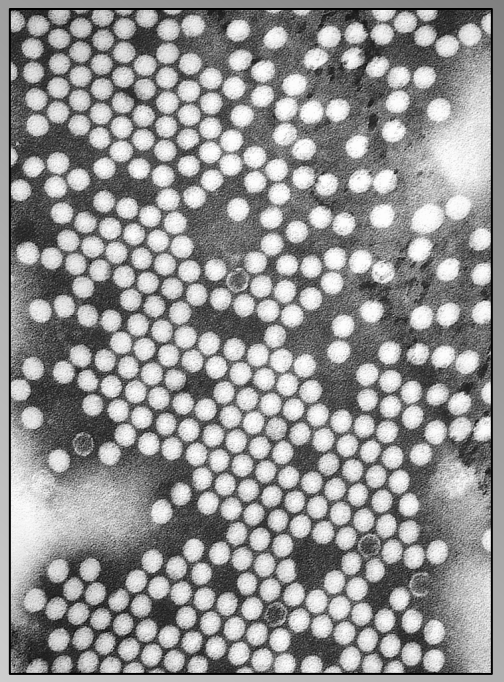
Polio



- Mainly affects children under 5
- One in 200 get irreversible paralysis. Of those 5-10% die
- There is no cure for polio, it can only be prevented
- 2 vaccines – inactivated injection, IPV & live attenuated oral, OPV
- Global Polio Eradication Initiative started in 1980's– WHO, UNICEF, CDC, Gates Foundation
- As of 2024, Afghanistan and Pakistan are the only 2 countries where polio is endemic

Recommended childhood vaccines

- Hepatitis A/Hepatitis B
- Rotavirus
- Diphtheria
- Tetanus
- Pertussis
- Haemophilus influenzae type b (Hib)
- Polio
- Pneumococcal disease
- Measles
- Mumps
- Rubella
- Chicken pox
- Influenza
- Covid 19
- Influenza (flu)
- Meningococcal
- HPV

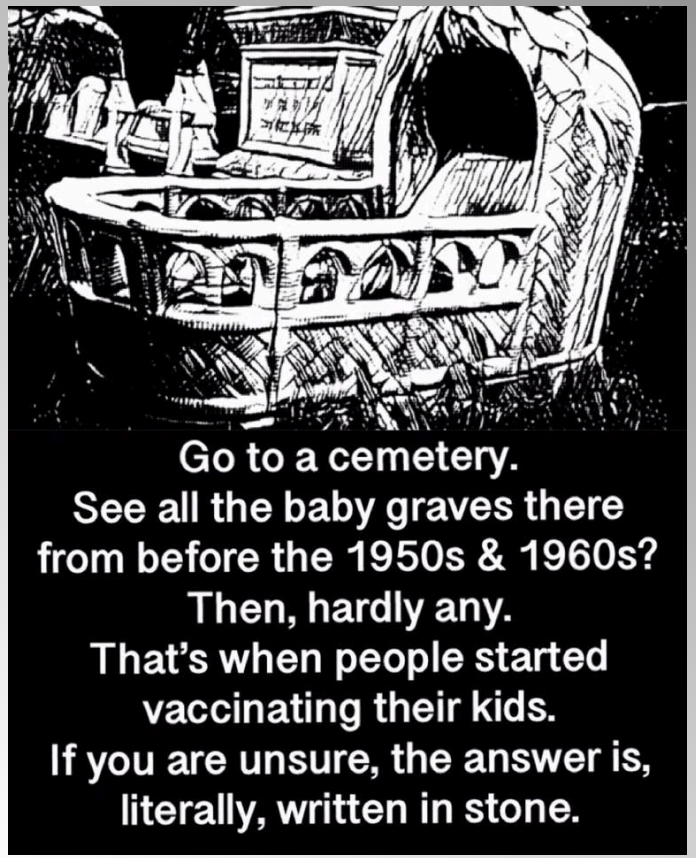


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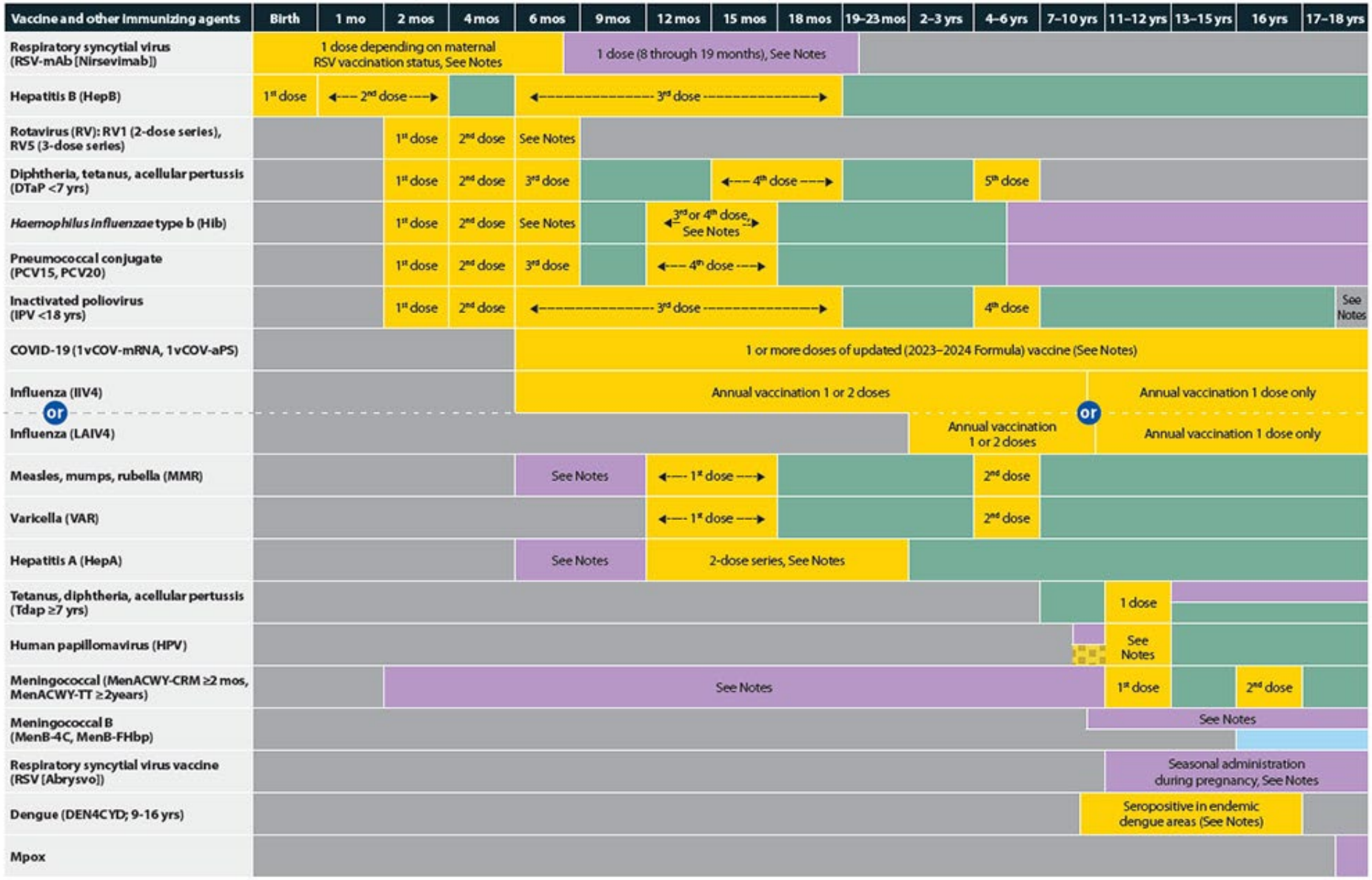
Table 1 Recommended Child and Adolescent Immunization Schedule for Ages 18 Years or Younger, United States, 2024

These recommendations must be read with the notes that follow. For those who fall behind or start late, provide catch-up vaccination at the earliest opportunity as indicated by the green bars. To determine minimum intervals between doses, see the catch-up schedule (Table 2).



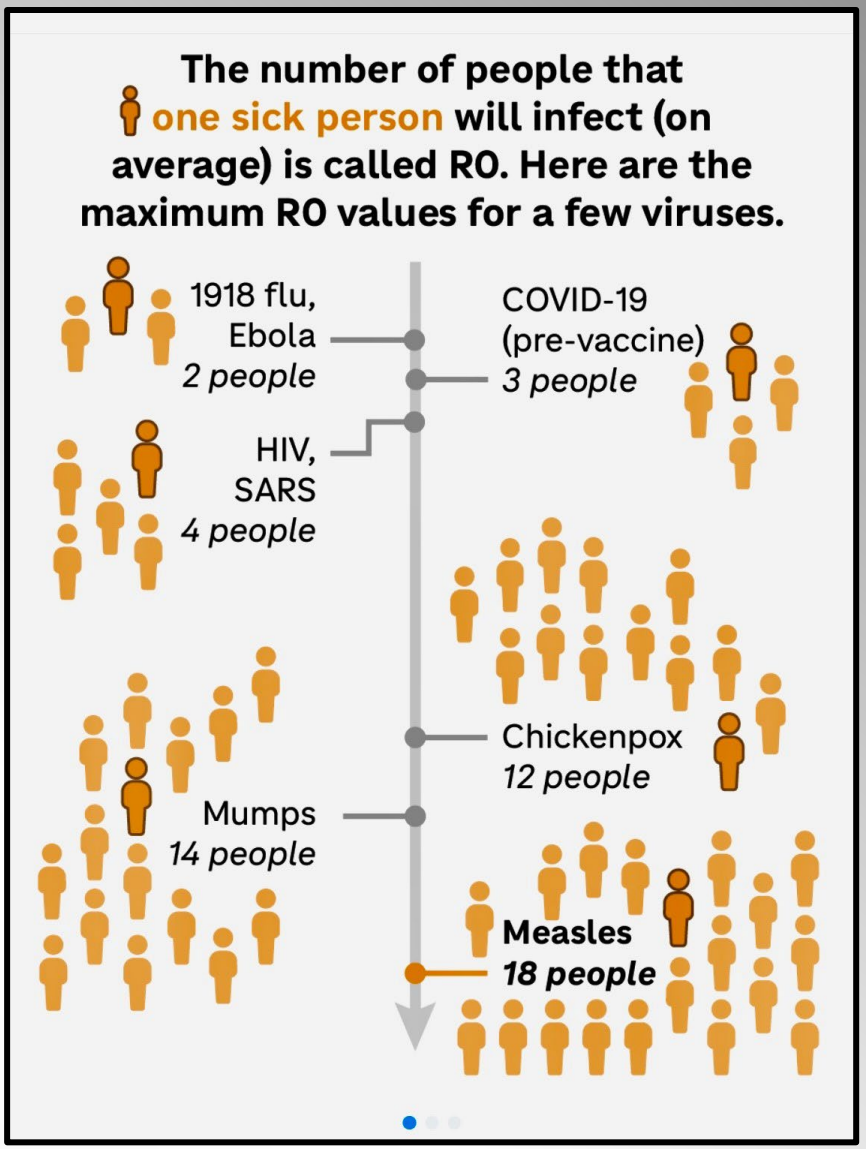
1. MMR (measles, mumps, rubella)
MMRV (measles, mumps, rubella, chickenpox)

1. Measles virus (Rubeola)

- Enveloped helical capsid, linear SS negative sense RNA
- Highly contagious
- 1st vaccine 1963

R0: R zero or R naught

- Has to do with “infectivity”
- Particularly high for Measles
- Measles can live on surfaces for up to 2 hours



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Measles Pathogenesis

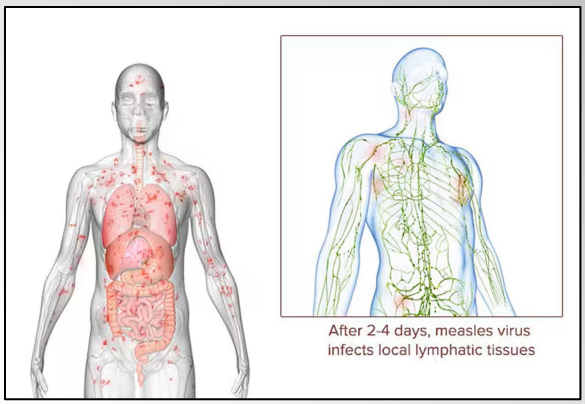
- Virus contains the F (fusion) protein
- Can induce cell-to-cell fusion, creating multi-nucleated giant cells
- Helps mediate virus and cell membrane fusion, ultimately resulting in infection of the host cell
- Hemagglutinin (HA) protein helps the virus attach to the host cell
- Virus replicates in epithelial cells in the respiratory tract and lymph nodes

Measles History

- 1954 Measles virus isolated from 13 yr old boy
- Was used to make vaccine (live, attenuated)
- Estimates for U.S. before vaccine became available (1963):
  - 3-4 million infected each year
  - 400-500 people died
  - 48,000 were hospitalized
  - 1000 suffered encephalitis

Symptoms

- Prodrome – “3 C’s” 10-12 days post exposure, lasts 2 -4 days
  - High-grade fever
  - **C**ough
  - **C**onjunctivitis
  - **C**oryza - inflammation of the mucous membrane in the nose –runny nose
  - **PEAK INFECTIOUS TIME**
- Physical exam
  - Koplik spots (buccal mucosa with bluish white macules with background of bright red –may occur before rash
  - pathognomonic for measles
- Confluent maculopapular rash 3-7 days after onset of Prodromal symptoms
  - starts in the head and neck and spreads downward to trunk
  - initially blanching with pressure in the first few days
  - excludes palms and soles
- Lymphadenopathy



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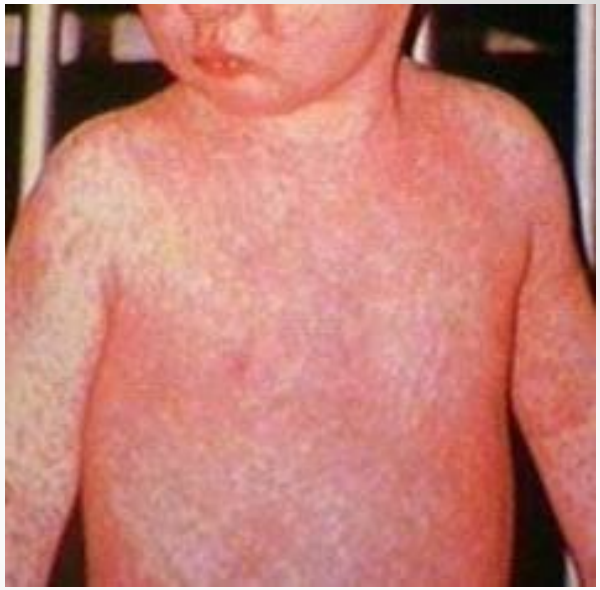
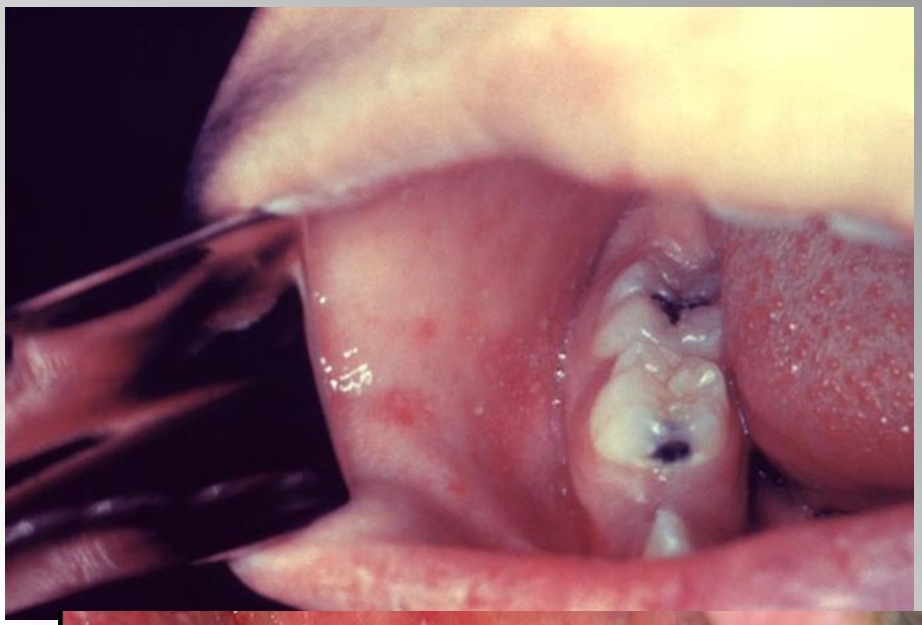
Complications

- Encephalitis
- Giant Cell Pneumonia
- Subacute Sclerosing Panencephalitis
  - Can present years later
  - Neurodegenerative – initially memory loss, irritability, behavior changes. Progresses to motor dysfunction – ataxias, seizures, monoclinic jerks
  - MRI – Multiple white matter hyperintensities, scarring, & cerebral atrophy
  - Poor prognosis – fatal 1-3 years

Measles





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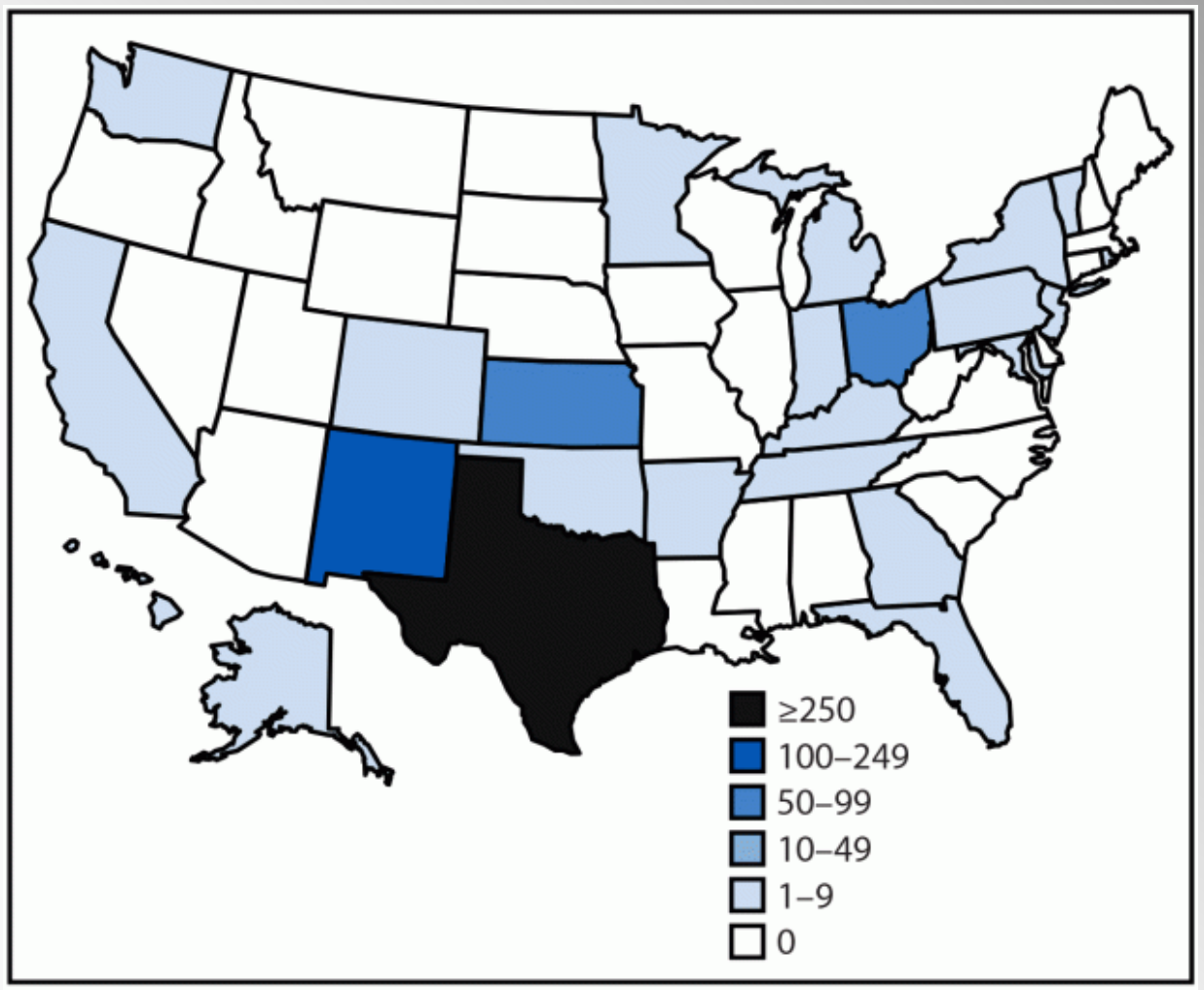
Confirmed US Measles cases 1/1/25 -4/17/25



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Mathis AD, Raines K, Filardo TD, et al. Measles Update — United States, January 1–April 17, 2025. MMWR Morb Mortal Wkly Rep 2025;74:232–238. DOI: http://dx.doi.org/10.15585/mmwr.mm7413a1.

TABLE. Selected characteristics of patients with reported measles — United States, January 1–April 17, 2025*

Characteristic	No. of measles cases (%)		
	Total	International importations	U.S.-acquired
Total measles cases	800 (100)	48 (6)	752 (94)
Age group, yrs			
<5	249 (31)	17 (35)	232 (31)
5–19	304 (38)	6 (13)	298 (40)
≥20	231 (29)	22 (46)	209 (28)
Unknown	16 (2)	3 (6)	13 (2)
Measles vaccination status			
Unvaccinated or unknown	771 (96)	43 (90)	728 (97)
Vaccinated, 2 doses	19 (2)	4 (8)	15 (2)
Vaccinated, 1 dose	10 (1)	1 (2)	9 (1)
Measles vaccination status (excluding Texas residents)			
Unvaccinated	162 (77)	30 (68)	132 (80)
Unknown	30 (14)	9 (20)	21 (13)
Vaccinated, 2 doses	12 (6)	4 (9)	8 (5)
Vaccinated, 1 dose	6 (3)	1 (2)	5 (3)
Residency			
U.S. resident	790 (99)	44 (92)	746 (99)
Outcome			
Hospitalized	85 (11)	15 (31)	70 (9)
Died†	3 (3.8)	0 (—)	3 (4.0)
Vaccination status of hospitalized patients§			
Unvaccinated	56 (66)	11 (73)	45 (64)
Unknown	28 (33)	3 (20)	25 (36)
Vaccinated, 1 dose	1 (1)	1 (7)	0 (—)

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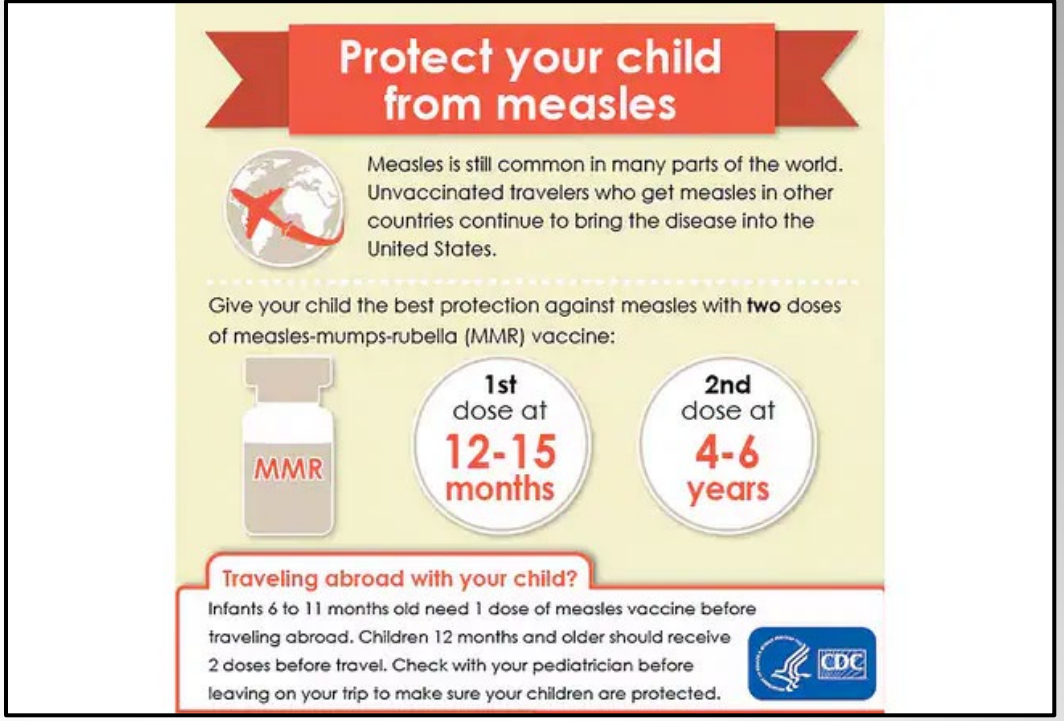

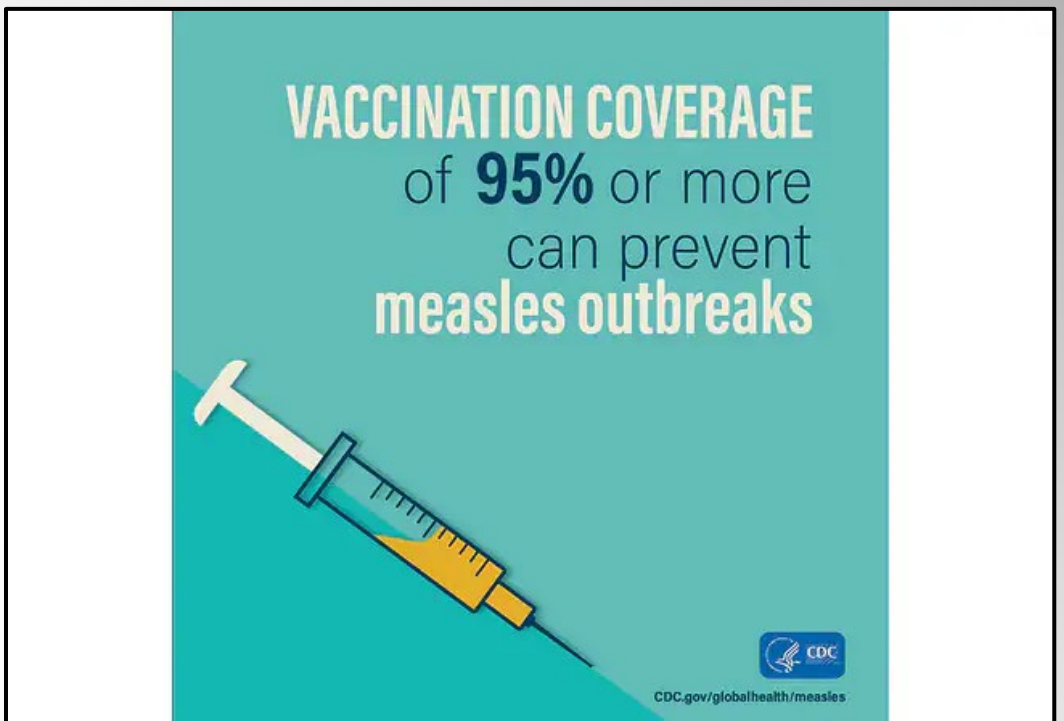

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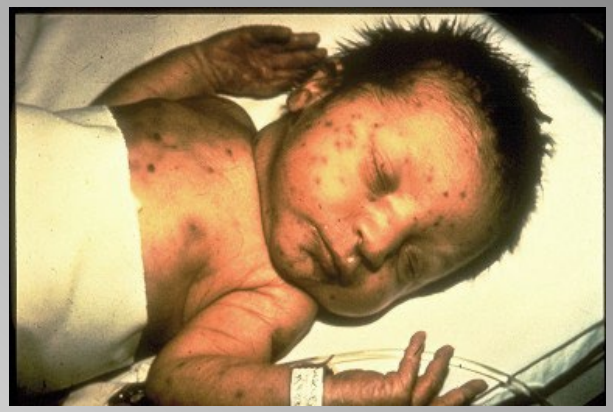
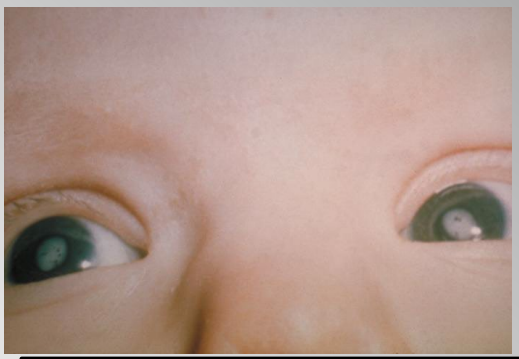
2. Rubella virus

- Enveloped, single-stranded, positive-sense RNA virus; Icosahedral capsid
- Causes rubella (German measles)
- Transmission via respiratory secretions or placentally
- Incidence –decreased due to vaccine, still found in parts of the world
- Vaccine race in mid 60's. First licensed in 1969

Rubella (German Measles)

- Infection during pregnancy, can cause congenital rubella syndrome in infants
- Triad of symptoms
  - Sensorineural deafness (58%)
  - Eye abnormalities –glaucoma, cataracts, retinopathy, microphthalmia (small eyes with anatomic malformations) (43%)
  - Congenital heart disease – pulmonary artery stenosis and patent ductus arteriosus (50%)
- Other – intellectual disability, microcephaly, low birth rate, extramedullary hematopoiesis hepatomegaly, Thrombocytopenic Purpura





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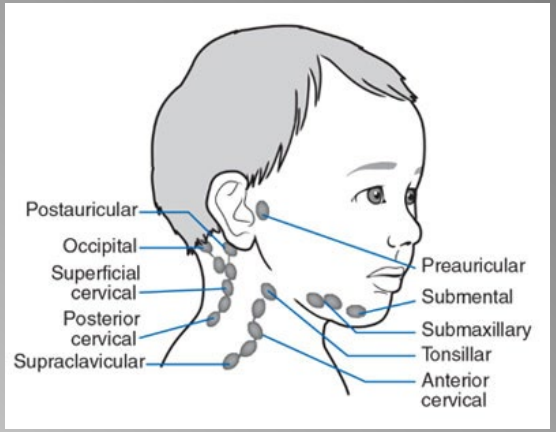
Clinical Presentation

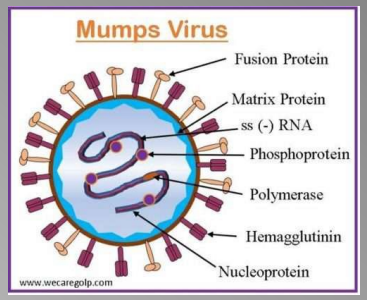


- Symptoms
  - Low-grade fever
  - Polyarthritis and polyarthralgia -more common in adult females - fingers, wrists, and knees are most commonly involved
- Physical exam
  - Lymphadenopathy before the rash
- Fine pink non-confluent maculopapular rash
  - Starts on face and spreads to trunk & extremities
  - Itchy, desquamates resolves in 3 days
  - Petechial rash on soft palate
  - Orchitis

Labs, Diagnosis & Management

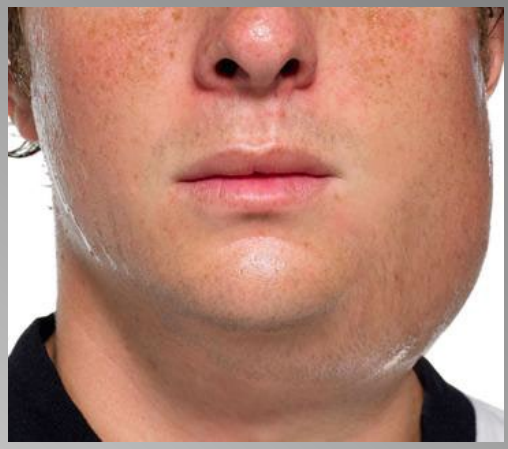
- Detection of rubella-specific immunoglobulin M or G
- Detection of virus on reverse transcriptase-polymerase chain reaction
- Making the diagnosis - based on clinical presentation and confirmed with laboratory studies
- Supportive care –fluids, antipyretics, analgesics
- Prevention with vaccines

3. Mumps virus (paramyxovirus)

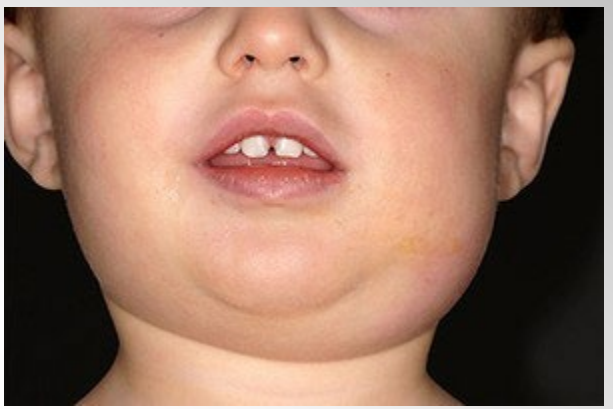


- Helical capsid, linear single stranded negative sense RNA genome
- Transmission via respiratory secretions – coughing, sneezing, sharing drinks
- Most common cause of acquired deafness until vaccine (1968) - live attenuated vaccine
- Two randomized placebo -controlled trials showed that it worked.
- Mumps cases fell from more than 150,000 in 1968 to 357 in 2024, according to CDC data.
- In late April, HHS Secretary Robert F. Kennedy Jr. made the bold claim that "the mumps part" of the measles, mumps, and rubella (MMR) vaccine "has never worked."

Mumps virus



- Prodrome – headache, fever, fatigue, malaise, decreased appetite
- Classic hallmark painful swelling of the jaw (parotid salivary gland)
- Mostly children 2-12
- Adolescents & adults have more severe symptoms
- Highest incidence in winter and spring, crowded conditions
- Usually mild, but can have serious complications – deafness, meningitis, encephalitis, thyroiditis, inflammation of ovaries, testes
- Can cause aseptic meningitis and pancreatitis
- Treatment –supportive care
- Prevention with vaccine
- Mumps outbreaks in recent years –not getting vaccine



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How is mumps treated?

Use ice or heat to ease swelling and discomfort.

Drink plenty of fluids.

Non-aspirin medications such acetaminophen and ibuprofen can be used to bring a fever under control and help with pain from swollen glands.

Mumps is a highly preventable disease because of the effectiveness of the MMR vaccine.

Cleveland Clinic

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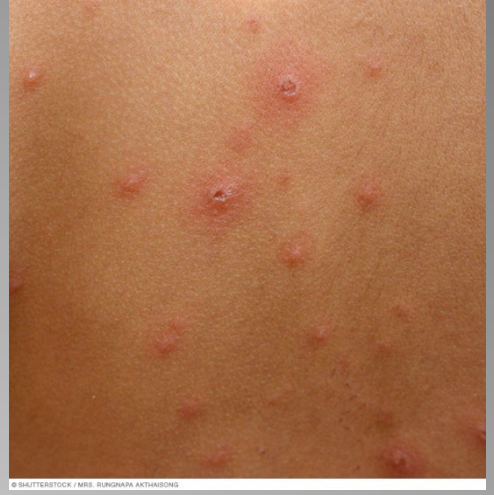
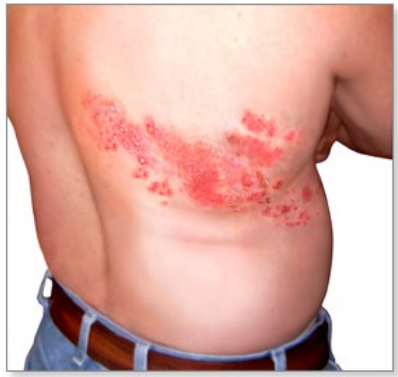
4. Chickenpox (Varicella-Zoster virus)



- Itchy rash with small fluid filled blisters, occurs 10-21 days after exposure
- Three phases of rash:
  - Raised bumps called papules, which break out over a few days.
  - Small fluid-filled blisters called vesicles, which form in about one day and then break and leak.
  - Crusts and scabs, which cover the broken blisters and take a few more days to heal.
- Lasts ~ 7 days

Chickenpox

- Other symptoms –fever, loss of appetite, headache, tiredness
- Spread through air droplets (sneeze) or direct contact
- Contagious 1-2 day before the rash appears & until all the blisters are crusted over
- Complication – contains gelatin
- Complication: Shingles. Virus stays in your nerve cells, can come back in older adults with weakened immune system
- Live Vaccine for chickenpox -1995
- Before vaccine ~ 10,000 hospitalizations, 100 deaths/year
- Inactivated Vaccine (Shingrix)recommended for those 50 and over


Shingles

A.D.A.M.

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Respiratory Syncytial Virus (RSV)

- Single stranded negative sense RNA virus of family Paromyxoiridae
- RSV enters though eyes, mouth, or nose and causes infection of lungs & respiratory tract, ranges from mild to severe
- Infants and older adults, immunocompromised persons are at risk; kills up to 10,000 per year
- Virus can live for hours on countertops, crib rails, toys

RSV vaccines (2023)

- Elderly (75+) – protein based (grown in cell culture) vaccine
- Adults 60 -74 with underlying disease
- Infants
  - Vaccination of the mother while pregnant
  - Monoclonal antibody to F protein (prevents virus from binding & entering cells)
  - (Both are passive immunizations) Antibodies last long enough ~ 1 year to protect when baby is most vulnerable

Preliminary 2024-2025 U.S. RSV Burden Estimates

CDC estimates* that, from October 1, 2024 through December 7, 2024, there have been:

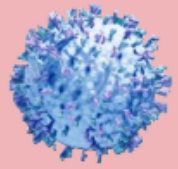
470,000–950,000

RSV Outpatient Visits

22,000–45,000

RSV Hospitalizations

980–2,300



RSV Deaths

*Based on data from September 29, 2024 through December 7, 2024.

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Fall and Winter Immunization Guide

	2024-2025 COVID-19[1]	2024-2025 Influenza[2]	RSV[3]
Infants & Children	**6 months - 17 years** Some children 6 months through 4 years may need multiple doses	**6 months - 17 years** Some children 6 months through 8 years may need two doses ≥ 4 weeks apart	**All infants <8 months* and children 8 through 19 months with risk factors should get nirsevimab** Typically, October through March, *if mother not vaccinated with maternal RSV vaccine
Pregnant Women	**All**	**All**	**32–36 weeks gestation should get RSV vaccine (Pfizer, Abrysvo only)** Typically, September–January
Adults 18-59 yrs	**All**	**All**	See pregnant women
Adults ≥60+ yrs	**All** Two doses recommended for adults ≥65 yrs, 6 months apart	**All** High-dose, recombinant, or adjuvanted preferred for ≥65 yrs, if available	**All adults ≥75 and adults 60 through 74 years with risk factors should get a single dose of RSV vaccine at this time.**

[1] People ages 6 months and older with moderate or severe immunocompromise should get 2 doses of 2024-2025 COVID-19 vaccine 6 months (minimum interval 2 months) apart and may also get additional doses of COVID-19 vaccine under shared clinical decision-making. If previously unvaccinated or receiving initial vaccination series, more doses may be needed.

[2] Solid organ transplant recipients ages 18 through 64 yrs on immunosuppressive medications may get high-dose or adjuvanted flu vaccine, if available, without a preference over other age-appropriate inactivated or recombinant influenza vaccines.

[3] All infants should be protected by either maternal RSV vaccine or nirsevimab. Both are not needed for most infants. For infants born during October through March, nirsevimab should be administered in the first week of life—ideally during the birth hospitalization.

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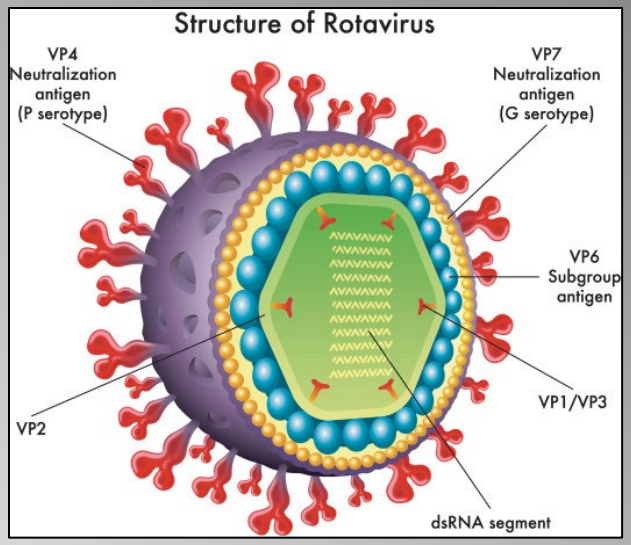
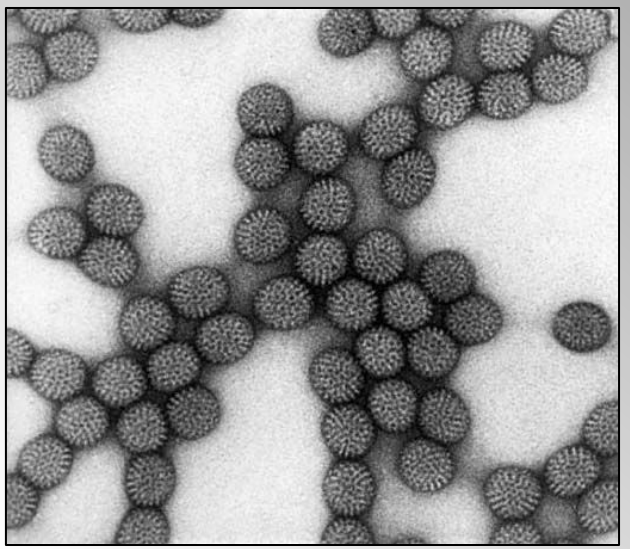
Rotavirus

- DS RNA virus, double icosahedral (2 layer) capsid, non-enveloped
- Decreases activity of digestive enzymes (lactase & maltase) so don't absorb nutrients
- Produces NSP 4 (nonstructural protein 4) damages villi and causes apoptosis in enterocytes)
- Activates enteric nervous system –secretes electrolytes into intestinal lumen
- ~ 8 strains, group A strain most common
- Reovirus family (Respiratory, Enteric, Orphan)
- Occurs in human & animal neonates, occasionally in adults
- Fecal oral transmission
- Viral gastroenteritis –can shed virus in stool up to 10 days after recovery
- Very contagious





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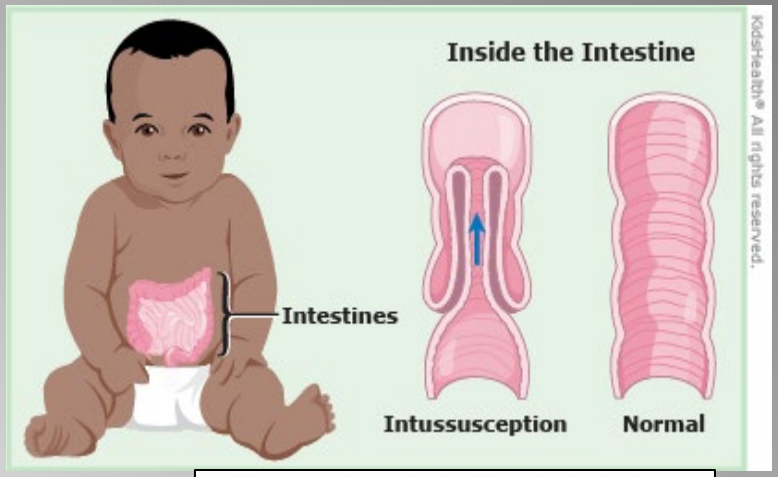
Rotavirus

- Infects the lining of the small intestine in children under 2 yrs old causing high fever, persistent severe vomiting, & diarrhea, & intestinal blockage (Intussusception 1 in 20,000 – 1 in 100,000) –pain, lethargy swollen belly, blood & mucus in stools “Currant Jelly) Can also go to CSF –seizures
- In one year, causes illness in 2.7 million (usually between 6-24 months)500 K Dr visits, 55-70K hospitalizations, 20-60 deaths
- Vaccine approved 2006 (2 currently, one recombinant, 1 attenuated)
- An earlier vaccine was pulled off the market in 1999 because 1 in 100,000 had intestinal blockage. Current studies show NO increases in rates of intussusception



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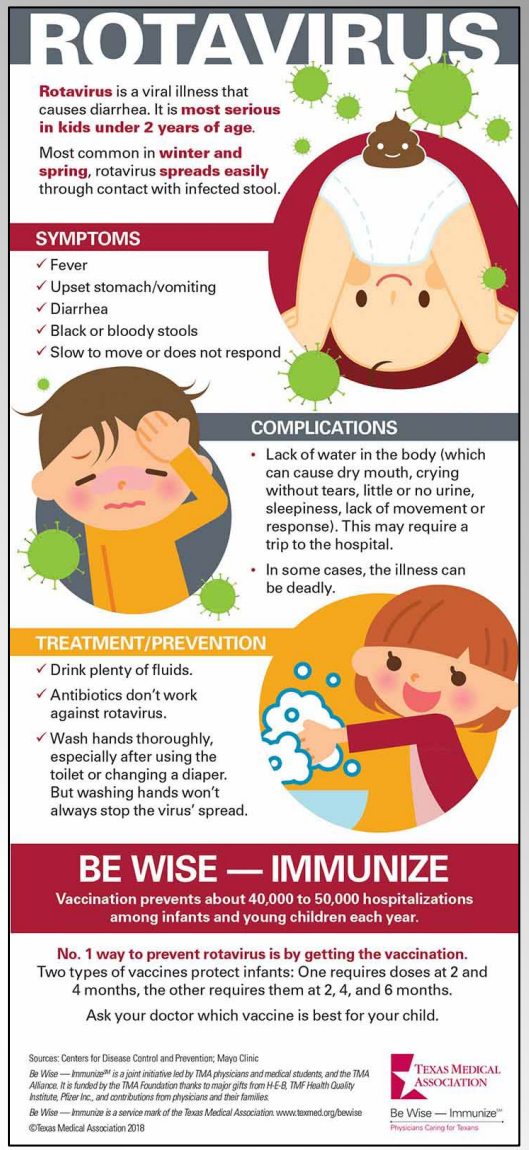
Treatment

- Supportive (fluids)
- Prevention – vaccine, block fecal oral transmission (water supply); washing hands and surfaces



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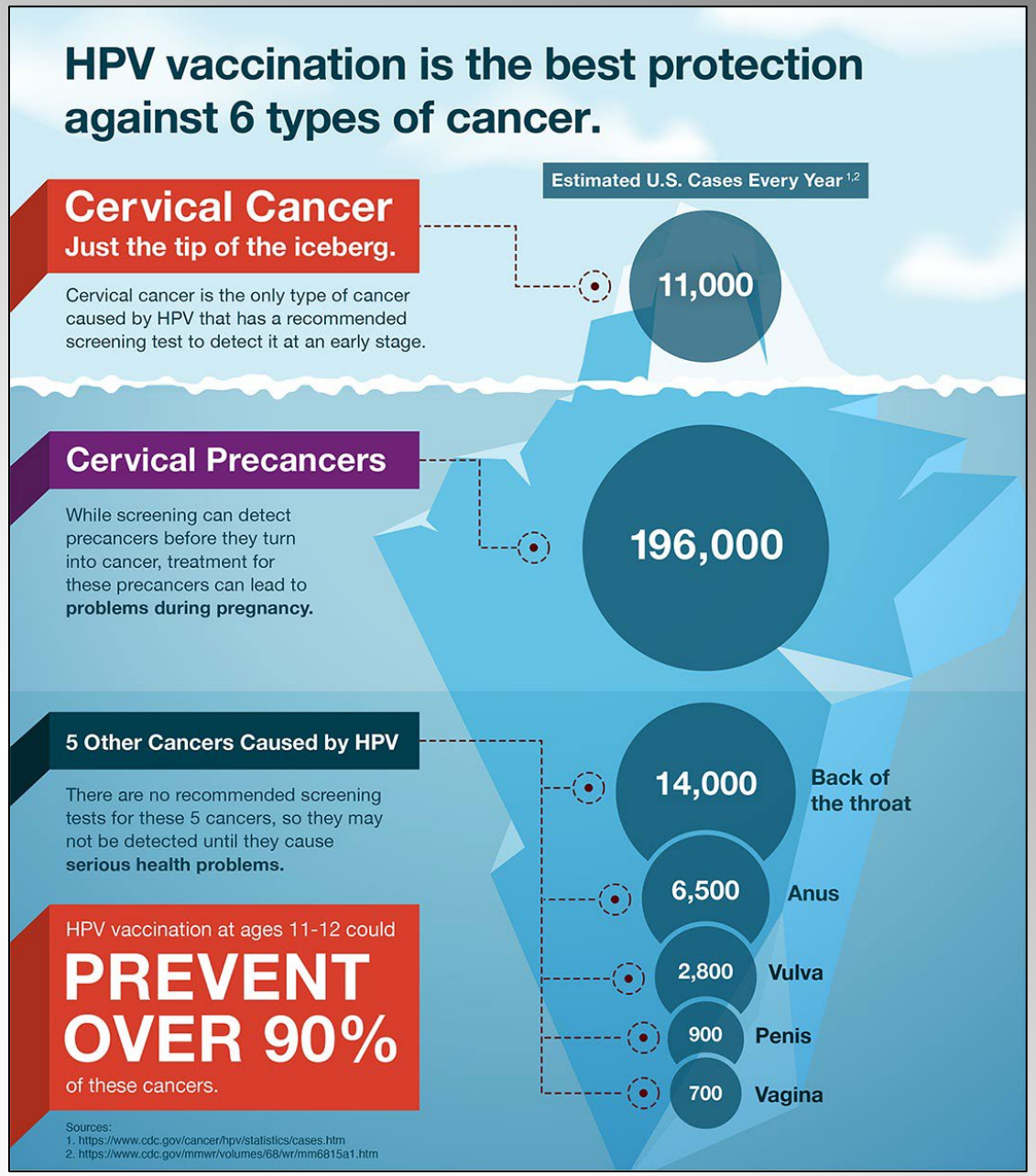
Human Papilloma Virus (HPV)

- DS DNA virus; Many genotypes
- Types 16 & 18 cause 70% of cervical cancer
- Recombinant vaccine – (Gardisil) first available in 2006

Cancer Types	% Caused by HPV
Cervical cancer	91%
Anal cancer	91%
Vaginal cancer	75%
Oropharyngeal cancer	72%
Vulvar cancer	69%
Penile cancer	63%

HPV vaccines

- Second generation, Gardisil 9, approved in 2014



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Vaccines for Bacteria

- Tetanus
- Diphtheria
- Pertussis

DTaP: Infants @ 2, 4, 6 months (primary) & 2 boosters @ 15, 18 months
Tdap: Age 7 and older, In pregnancy ok;
Td: Adults –booster every 10 years or as needed for tetanus booster

- Pneumococcal disease (*Pneumococcus - Strep Pneumoniae*)
- Meningococcal disease (*Meningococcus Neisseria meningitides*)
- Haemophilus Influenza type b (Hib)- leading cause of bacterial meningitis in children under 5 years old
- Tuberculosis

Diphtheria, Tetanus, & Pertussis

- Diphtheria – toxin from *Corynebacterium diphtheriae*. Toxin causes membrane to form on throat –difficult to breathe & swallow. Common cause of death in children before first vaccine in 1940s.
- Tetanus –toxin from Clostridium tetani. Does NOT spread from person to person. Organism lives in soil –enters body thru cuts, punctures from nails/glass in soil. Toxin causes muscle spasms which progress throughout body – heart, jaw, throat, diaphragm. Mortality 10% with vaccine. Globally tetanus deaths have decreased due to vaccine
- Pertussis - *Bordetella pertussis*. Pertussis makes people cough uncontrollably. In children creates a "whooping" sound. Adults may have it without knowing it & spread to children. "100 day cough" The cough can be so violent that people with pertussis can crack ribs, break blood vessels, or develop hernias. Before vaccine (1940's) 200,000 got sick NS 9000 died as a result. Since 1996 –"acellular pertussis vaccine (2-5 proteins, genetically engineered, rather than whole cell inactivated)

DO VACCINES OVERWHELM THE IMMUNE SYSTEM?

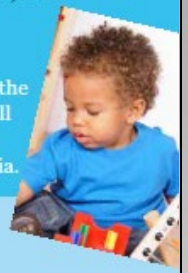
The short answer is no! Check out why.

Our immune systems fight potential pathogens all day, every day!

The average adult carries more bacteria than the number of cells they are made of. For example:

A 25-year-old, 5'7" male who weighs 154 lbs. has about:

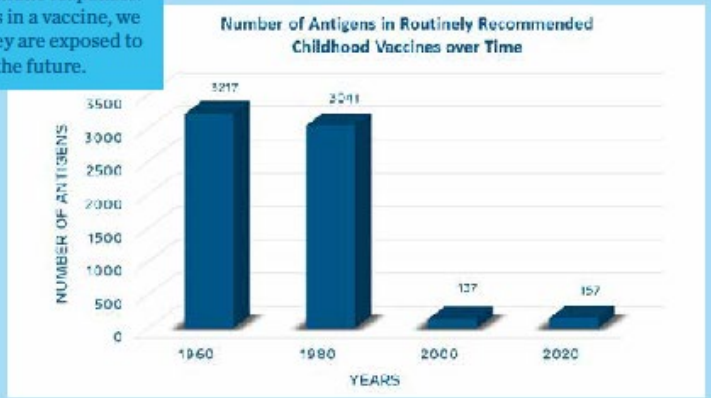
- 30,000,000,000,000 Cells
- 39,000,000,000,000 Bacteria



Even if a baby is 1/10th the size of an adult, they still have trillions of cells & carry trillions of bacteria.

The number of antigens in vaccines has decreased over time.

What is an antigen?
Antigens are the parts of viruses & bacteria that induce immune responses. By introducing antigens in a vaccine, we can protect people if they are exposed to the virus or bacteria in the future.



Find more info:

vaccine.chop.edu

Children's Hospital of Philadelphia
Vaccine Education Center

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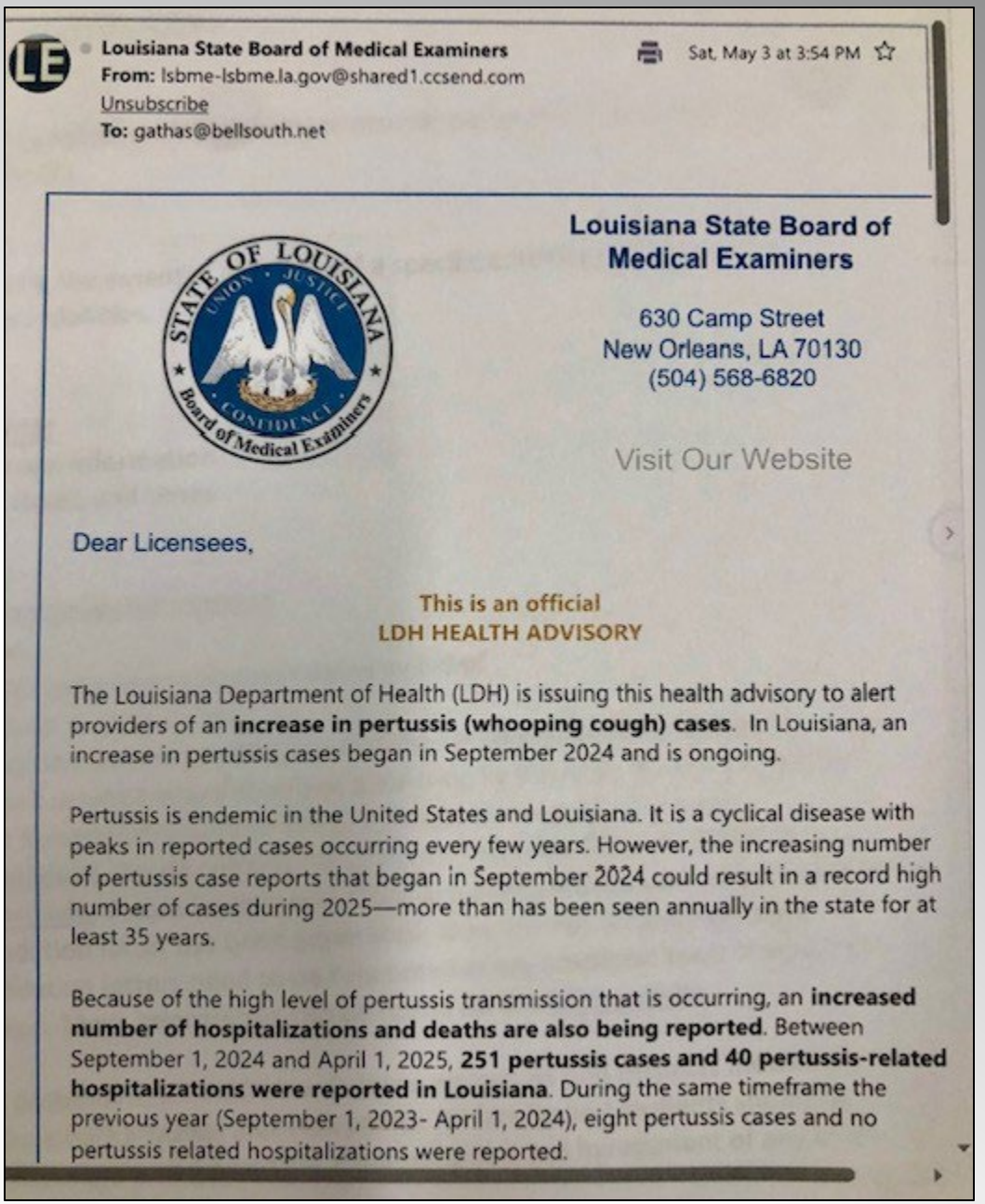

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Louisiana State Board of Medical Examiners

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Visit Our Website

Dear Licensees,

This is an official
LDH HEALTH ADVISORY

The Louisiana Department of Health (LDH) is issuing this health advisory to alert providers of an **increase in pertussis (whooping cough) cases**. In Louisiana, an increase in pertussis cases began in September 2024 and is ongoing.

Pertussis is endemic in the United States and Louisiana. It is a cyclical disease with peaks in reported cases occurring every few years. However, the increasing number of pertussis case reports that began in September 2024 could result in a record high number of cases during 2025—more than has been seen annually in the state for at least 35 years.

Because of the high level of pertussis transmission that is occurring, an **increased number of hospitalizations and deaths are also being reported**. Between September 1, 2024 and April 1, 2025, **251 pertussis cases and 40 pertussis-related hospitalizations were reported in Louisiana**. During the same timeframe the previous year (September 1, 2023- April 1, 2024), eight pertussis cases and no pertussis related hospitalizations were reported.

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Whooping cough

EFFECTS OF DISEASE

1 in 125 babies under the age of 6 months with whooping cough will die.

Other effects of this disease can include:

- Coughing until vomiting
- Seizures
- Pneumonia
- Brain Damage
- Sleep disturbances
- Urinary incontinence
- Fainting
- Rib fractures

SIDE EFFECTS OF VACCINE

About 1 in 10 has local swelling, redness or pain at the injection site, or fever (DTPa/dTpa vaccine).

Booster doses of DTPa may occasionally be associated with extensive swelling of the limb, but this resolves completely within a few days.

Serious adverse events are very rare.

Immunisation Foundation of Australia

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Vaccines available for other bacterial infections

- Neisseria meningitidis, which causes meningococcal disease - meningitis
- *Salmonella typhi*, which causes typhoid
- *Mycobacterium tuberculosis*, which causes tuberculosis (Bacille Calmette-Guérin (BCG) – not used in U.S.)
- *Yersinia pestis*, which causes bubonic plague
- *Bacillus anthracis*, which causes anthrax
- *Vibrio cholerae*, which causes cholera

Distinguishing a BCG scar from a Smallpox scar

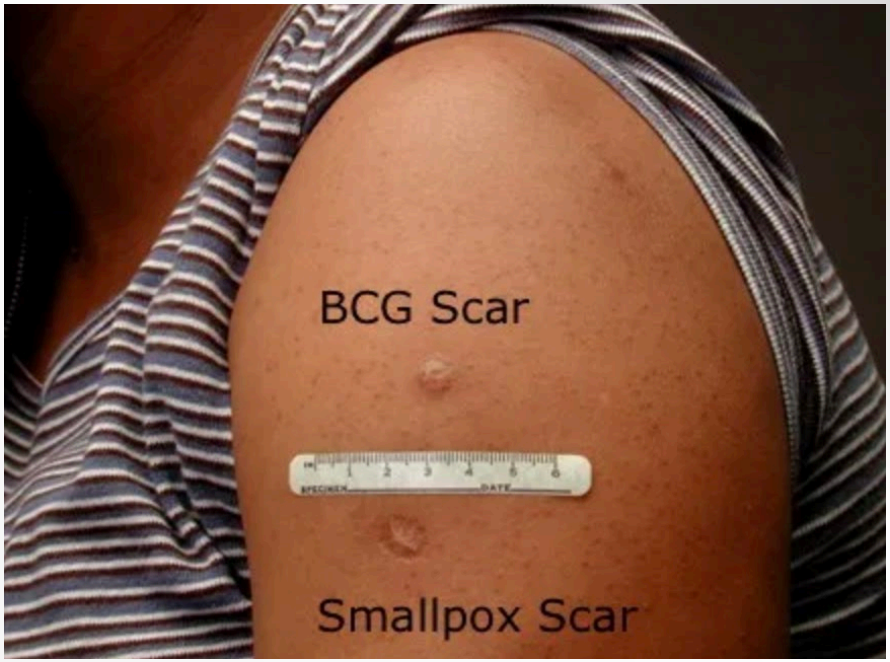
BCG Scar
Classic Features

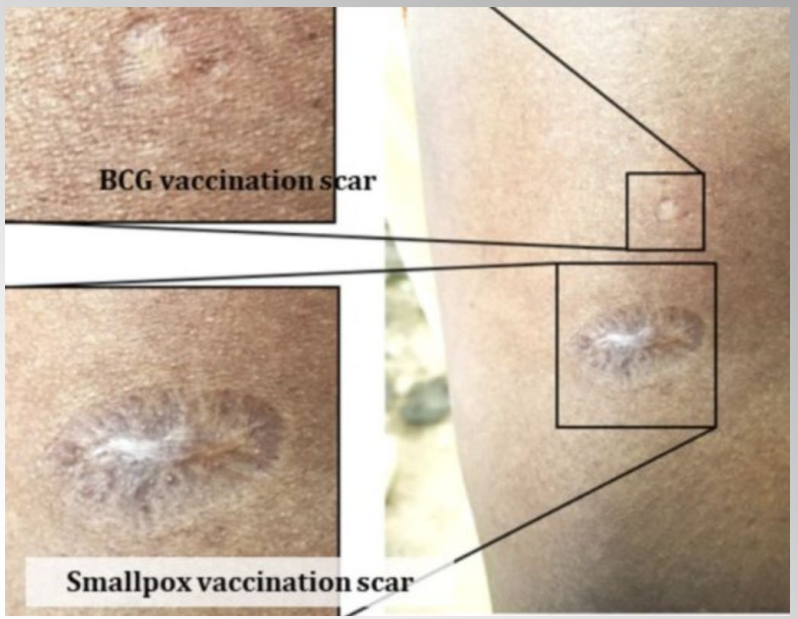
- Raised centre
- Left upper arm or, much less commonly, on thigh or forearm

Smallpox Scar
Classic Features

- Depressed with radiating lines to edges
- Routine use stopped in the late 1970's

Distinguishing smallpox from BCG scars





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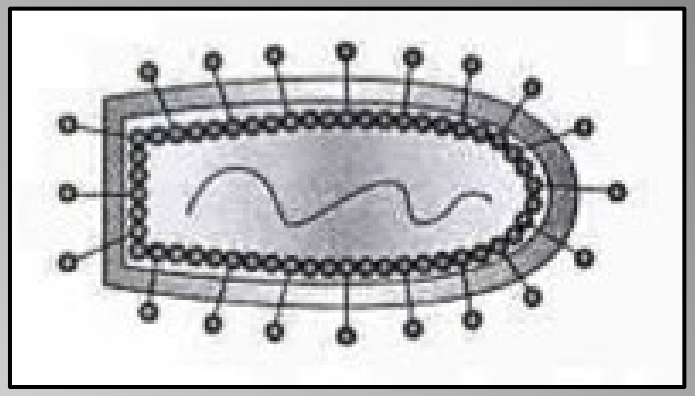
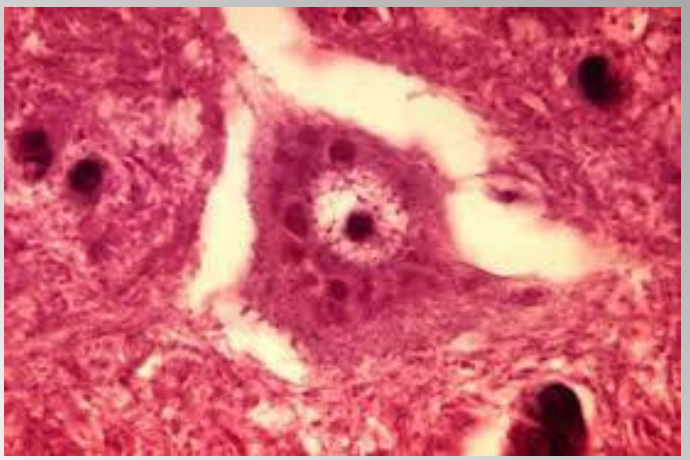
Some other vaccines of interest

Rabies virus



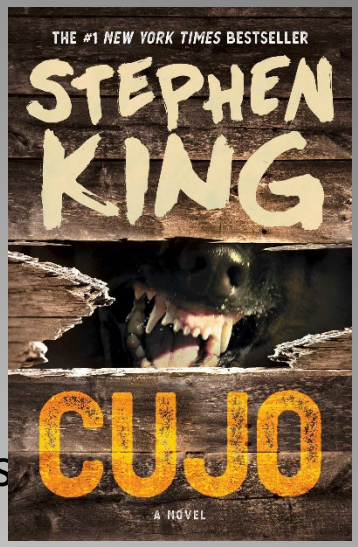
- Linear negative single stranded RNA
- Helical capsid & bullet shaped
- More common in children
- Majority of cases in Asia and Africa
- Pathogenesis
  - Replicates in muscle, binds to nicotinic acetylcholine receptor
  - Retrograde migration to CNS via dynein motors
  - Long incubation period
  - Affects the brain area controlling swallowing, speaking, breathing. Have painful throat spasms; also increases saliva production (foaming at the mouth)



Rabies virus

- Zoonotic - spreads through saliva through bites, scratches, contact with mucosa
- Incubation time generally 2-3 months (viral load, location of entry)
- Progressive inflammation of central nervous system; once symptoms appear, 100% fatal
- First “vaccine” 1885 (Pasteur & Roux) –ground up neural tissue of rabbit, heated & desiccated - injected into a child that was bit by rabid dog –he survived
- Further advancements –modern cell culture vaccines produced in the 20th century –human, chicken, monkey cells but $$$
- Most often given post-exposure; Given to vets, lab workers, animal handlers, spelunkers
- Ground up neural tissue vaccines used in 3rd world

Rabies



- 99% of human rabies caused by dogs, mostly in underdeveloped nations
- In US, Blood-feeding bats, raccoons, skunks, foxes, coyotes
- CDC collects info from state health depts; Surveillance program also works with wildlife professional to vaccinate with oral vaccine “baits”
- < 10 deaths per year in US
- Vaccination for pets in US
- Post-exposure prophylaxis
  - Wound washing with soap & water 15 min or more
  - A course of rabies vaccine
  - Administration of rabies immunoglobulin or monoclonal into wound

Influenza “Flu” Vaccine

- WHO Global Influenza Surveillance and Response System- (152 national influenza centers testing thousands of samples from patients year-round) GISRS
- Each year, WHO recommends virus strains for inclusion in flu vaccines for each hemisphere
- Vaccine usually changes each year as scientists determine how the virus has mutated & spread
- Trivalent –protect against 3 main groups of flu viruses A(HN1), A(H3N2) and B/Victoria lineage
- There are egg-based vaccines and cell/recombinant-based vaccines
- FluMist –nasal spray flu vaccine (live attenuated) –approved 2024 by FDA; available 2025 season

1918-1919 Flu Pandemic

- H1N1 strain of influenza A virus
- Affected 500 million worldwide
- Killed 20-50 million
- Influenza virus isolated and identified in 1933
- Inactivated vaccine tested for safety & efficacy on US military, before being licensed for wider use in 1945.
- 1948 WHO –worldwide influenza centre; 1952 GISRS
- Other flu pandemics – 1957-58, 1968-69, & 2009-10.

Preliminary 2024–2025 U.S. Flu In-Season Disease Burden Estimates

Since October 1, 2024, CDC estimates there have been between:

Flu Illnesses	Flu Medical Visits	Flu Hospitalizations	Flu Deaths
1.2 Million-2.1 Million	530,000-930,000	15,000-33,000	630-3,200




Based on data from October 1, 2024, through December 7th, 2024

Because influenza surveillance does not capture all cases of flu, CDC provides these estimated ranges to better reflect the full burden of flu in the United States. These estimates are calculated using a mathematical model based on CDC's weekly influenza surveillance data and are preliminary and are updated weekly throughout the season.

FluVIEW CDC

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Debunking FLU MYTHS

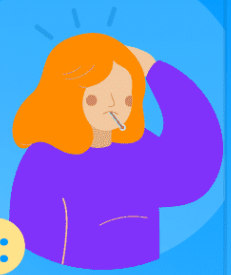
Flu Myth:
Getting the flu is not a big deal.

Flu Fact:
The flu can result in serious illness and even death. Some high-risk groups include seniors and infants.

Flu Myth:
The flu vaccine will give you the flu.

Flu Fact:
Flu vaccines cannot give you the flu. Instead, they use an "inactive virus" that helps your immune system fight potential infections.

Flu Myth:
The flu is the same thing as a cold.



Flu Fact:
The flu and the cold can have similar symptoms. Contact your family doctor if you have any flu symptoms for further testing and treatment.

Flu Myth:
You don't need a flu vaccine if you're healthy.

Flu Fact:
The CDC recommends that all eligible individuals six months and older get a flu vaccine every year.

MAKING FLU VACCINES

How eggs, ferrets, and sheep are used to make seasonal flu vaccines

START

Around 150 organisations across the globe gather data on emerging flu strains and send their data to the World Health Organisation (WHO)

To understand each new flu strain, ferrets are infected and their blood antiserum is analysed. Ferrets are used because they have an identical immune response to humans

Using data from the ferret tests, the WHO chooses up to four strains of flu which warrant a new vaccine

Next, sheep are used to test the potency of the potential vaccine. Potency tests check that the amount of virus within a vaccine is effective

Chosen flu strains are injected into fertilised chicken eggs

Flu strains multiply inside the chicken eggs
1 egg = 1 vaccine

Liquid containing millions of copies of flu virus is harvested from the chicken eggs

The pure form of the flu virus is extracted from the egg liquid

The remaining virus particles go through a sterilisation process to make it safe for use in vaccines

FINISH

Now that the main ingredient for the vaccine is complete, manufacturing begins!

UNDERSTANDING ANIMAL RESEARCH

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Recommended Adult Immunization Schedule
for ages 19 years or older

UNITED STATES
2024

Vaccines in the Adult Immunization Schedule*

Vaccine	Abbreviation(s)	Trade name(s)
COVID-19 vaccine	1vCOV-mRNA	Comirnaty®/Pfizer-BioNTech COVID-19 Vaccine Spikevax®/Moderna COVID-19 Vaccine
	1vCOV-aPS	Novavax COVID-19 Vaccine
Haemophilus influenzae type b vaccine	Hib	ActHIB® Hiberix® PedvaxHIB®
Hepatitis A vaccine	HepA	Havrix® Vaqta®
Hepatitis A and hepatitis B vaccine	HepA-HepB	Twinrix®
Hepatitis B vaccine	HepB	Engerix-B® Heplisav-B® PreHevbrio® Recombivax HB®
Human papillomavirus vaccine	HPV	Gardasil 9®
Influenza vaccine (inactivated)	IIV4	Many brands
Influenza vaccine (live, attenuated)	LAIV4	FluMist® Quadrivalent
Influenza vaccine (recombinant)	RIV4	Flublok® Quadrivalent
Measles, mumps, and rubella vaccine	MMR	M-M-R II® Priorix®
Meningococcal serogroups A, C, W, Y vaccine	MenACWY-CRM MenACWY-TT	Menveo® MenQuadfi®
Meningococcal serogroup B vaccine	MenB-4C MenB-FHbp	Bexsero® Trumenba®
Meningococcal serogroup A, B, C, W, Y vaccine	MenACWY-TT/ MenB-FHbp	Penbraya™
Mpox vaccine	Mpox	Jynneos®
Pneumococcal conjugate vaccine	PCV15 PCV20	Vaxneuvance™ Prevnar 20™
Pneumococcal polysaccharide vaccine	PPSV23	Pneumovax 23®
Poliovirus vaccine	IPV	Ipol®
Respiratory syncytial virus vaccine	RSV	Arexvy® Abrysvo™
Tetanus and diphtheria toxoids	Td	Tenivac® Tdvax™
Tetanus and diphtheria toxoids and acellular pertussis vaccine	Tdap	Adacel® Boostrix®
Varicella vaccine	VAR	Varivax®
Zoster vaccine, recombinant	RZV	Shingrix

*Administer recommended vaccines if vaccination history is incomplete or unknown. Do not restart or add doses to vaccine series if there are extended intervals between doses. The use of trade names is for identification purposes only and does not imply endorsement by the ACIP or CDC.

12/28/2023

How to use the adult immunization schedule

1. Determine recommended vaccinations by age **(Table 1)**
2. Assess need for additional recommended vaccinations by medical condition or other indication **(Table 2)**
3. Review vaccine types, dosing frequencies and intervals, and considerations for special situations **(Notes)**
4. Review contraindications and precautions for vaccine types **(Appendix)**
5. Review new or updated ACIP guidance **(Addendum)**

Recommended by the Advisory Committee on Immunization Practices (www.cdc.gov/vaccines/acip) and approved by the Centers for Disease Control and Prevention (www.cdc.gov), American College of Physicians (www.acponline.org), American Academy of Family Physicians (www.aafp.org), American College of Obstetricians and Gynecologists (www.acog.org), American College of Nurse-Midwives (www.midwife.org), American Academy of Physician Associates (www.aapa.org), American Pharmacists Association (www.pharmacist.com), and Society for Healthcare Epidemiology of America (www.shea-online.org).

Report

- Suspected cases of reportable vaccine-preventable diseases or outbreaks to the local or state health department
- Clinically significant adverse events to the Vaccine Adverse Event Reporting System at www.vaers.hhs.gov or 800-822-7967

Questions or comments

Contact www.cdc.gov/cdc-info or 800-CDC-INFO (800-232-4636), in English or Spanish, 8 a.m.–8 p.m. ET, Monday through Friday, excluding holidays.

Download the CDC Vaccine Schedules app for providers at www.cdc.gov/vaccines/schedules/hcp/schedule-app.html.

Helpful information

- Complete Advisory Committee on Immunization Practices (ACIP) recommendations: www.cdc.gov/vaccines/hcp/acip-recs/index.html
- ACIP Shared Clinical Decision-Making Recommendations: www.cdc.gov/vaccines/acip/acip-scdm-faqs.html
- *General Best Practice Guidelines for Immunization* www.cdc.gov/vaccines/hcp/acip-recs/general-recs/index.html
- Vaccine information statements: www.cdc.gov/vaccines/hcp/vis/index.html
- Manual for the Surveillance of Vaccine-Preventable Diseases (including case identification and outbreak response): www.cdc.gov/vaccines/pubs/surv-manual

Scan QR code for access to online schedule

U.S. Department of Health and Human Services
Centers for Disease Control and Prevention

CDC guidance - Travel vaccines

- Be up to date on your routine vaccines
- Make an appt with your health care provider or travel health specialist 4-6 weeks before your trip
- May be prudent to have bacterial, viral, fungal (coccidioidomycosis) & parasitic vaccines
- CDC Travelers' Health page https://wwwnc.cdc.gov/travel/destinations/list
  - Thailand – Routine vaccines, Chikungunya, Hepatitis A, B, Japanese encephalitis, Malaria, Typhoid

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CDC Travel health notices

- Level 4 – Avoid All Travel
- Level 3 – Reconsider Nonessential Travel
- Level 2 – Practice Enhanced Precautions
- Level 1 – Practice Usual Precautions

On the horizon…….

- More cancer vaccines:
  - Melanoma – Several mRNA vaccines in clinical trials
- Pancreatic Cancer -
- *Nature* **volume 639**, pages1042–1051 (2025)**RNA neoantigen vaccines prime long-lived CD8$^+$ T cells in pancreatic cancer**
  - https://www.nbcnews.com/health/cancer/pancreatic-cancer-vaccine-mrna-treatment-trial-rcna192702

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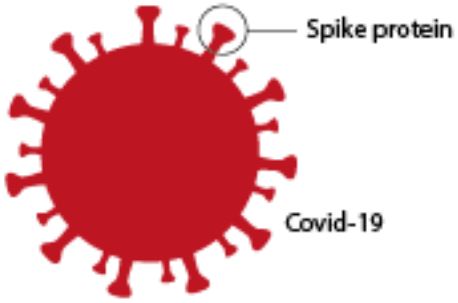
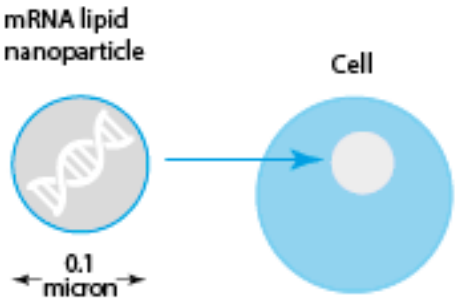
How mRNA vaccines work

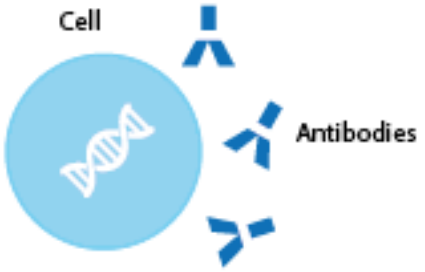
Contain instructions to the cell to make one protein that is encoded by the mRNA
This protein appears on the surface and stimulates an immune response.



Messenger RNA (mRNA) is a synthetic genetic sequence. It contains instructions that cells can use to make the Covid-19 spike protein without causing the disease.



The mRNA is packaged in fatty lipid nanoparticles. These protect the fragile genetic instructions while they are manufactured, transported and finally administered.



Once inside the cell, the mRNA instructs the cell to produce the viral protein. This appears on the surface of the cells and stimulates an immune system response.

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The end

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- Children's Hospital of Philadelphia Vaccine Education Center website
- Cleveland Clinic, Mayo Clinic, St. Jude research websites

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