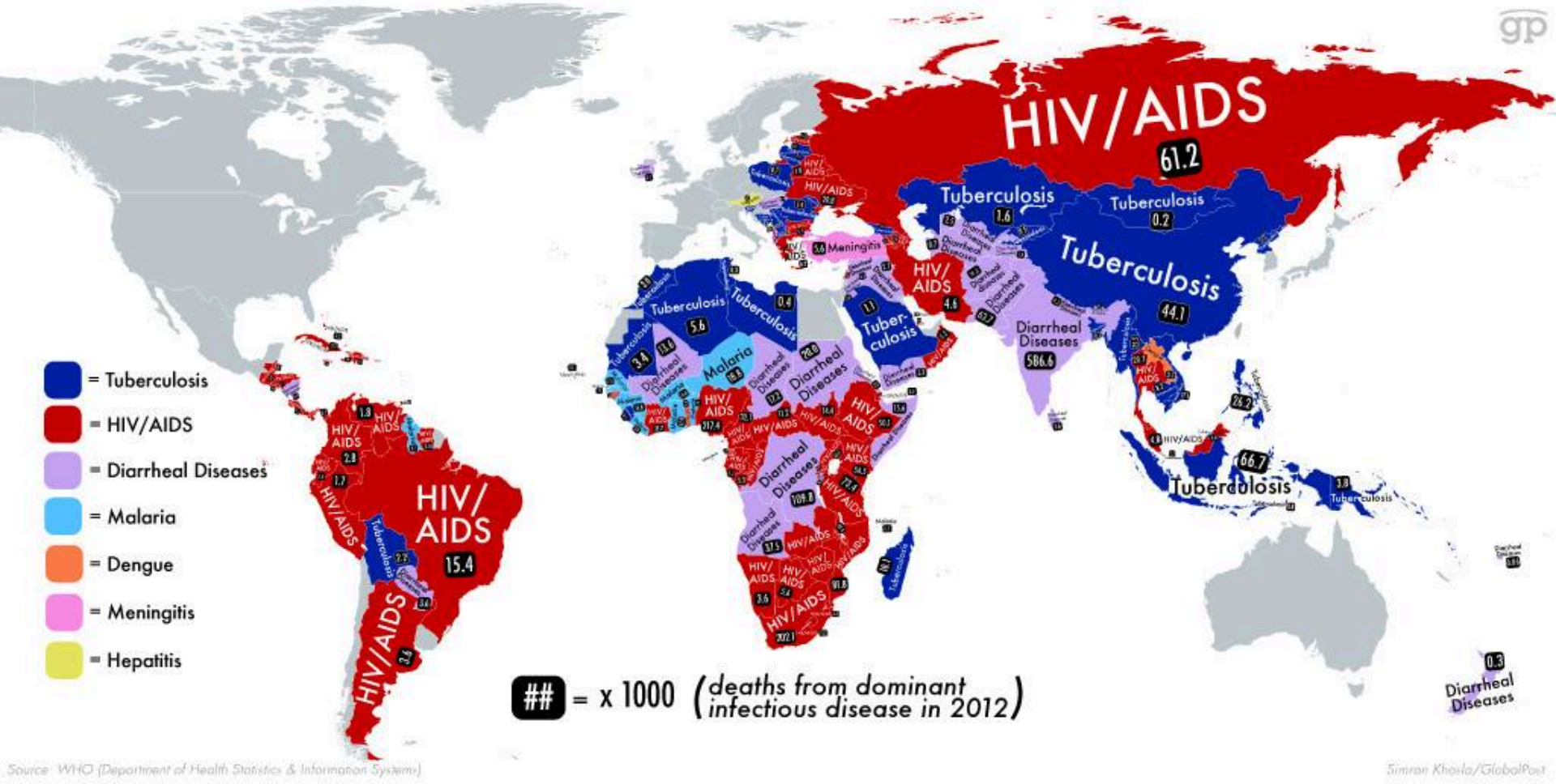
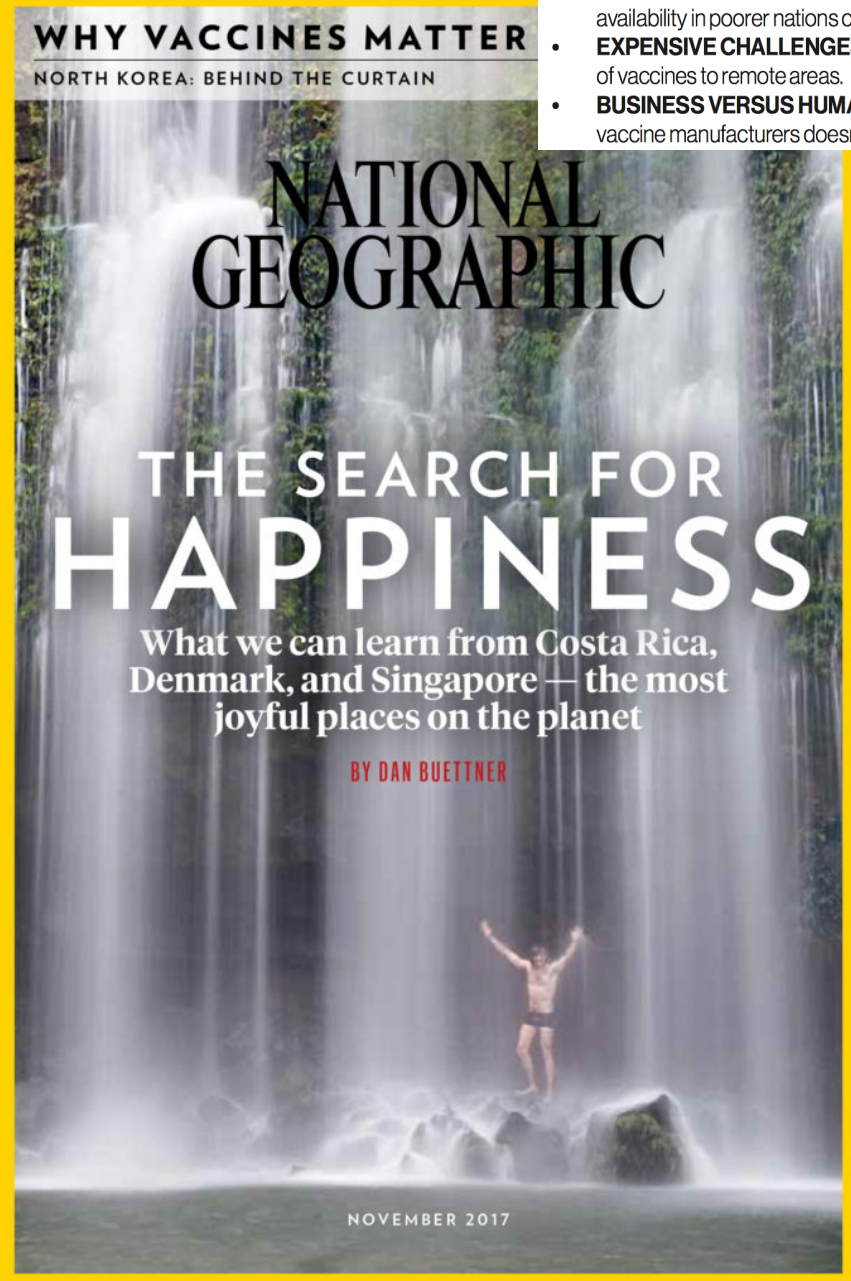
VIROLOGIA

Viral vaccines


= Tuberculosis
= HIV/AIDS
= Diarrheal Diseases
= Malaria
= Dengue
= Meningitis
= Hepatitis
= x 1000 (deaths from dominant infectious disease in 2012)
HIV/AIDS
61.2
Tuberculosis
1.6
Tuberculosis
0.2
Tuberculosis
44.1
Diarrheal Diseases
586.6
HIV/AIDS
4.6
Tuberculosis
66.7
Tuberculosis
3.8
Diarrheal Diseases
0.3
HIV/AIDS
15.4
Malaria
Meningitis
Source: WHO (Department of Health Statistics & Information Systems)
Simran Khosla/GlobalPost

Why Vaccines Matter

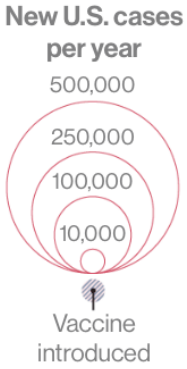
- **A LIFE OR DEATH SITUATION:** While ar[illegible] availability in poorer nations can be a death sentence.
- **EXPENSIVE CHALLENGES:** Bangladesh and other countries face challenges like multiple strains of diseases, manufacturing and delivery of vaccines to remote areas.
- **BUSINESS VERSUS HUMANITARIAN INTERESTS:** While poorer countries are in greater need of vaccines, the surest economic return to vaccine manufacturers doesn't come from meeting the most critical need.



CASE STUDY: U.S.

VACCINE VICTORIES

Since the 1940s, as new vaccines have been released (striped circles), the incidence of infectious diseases that once afflicted hundreds of thousands of Americans—mostly children—has plummeted. Polio and rubella are gone from the U.S.; diphtheria is rare. It used to kill up to 15,000 a year.



VACCINATION:
OUR PROVEN BEST DEFENSE AGAINST VIRUSES

the vaccine concept

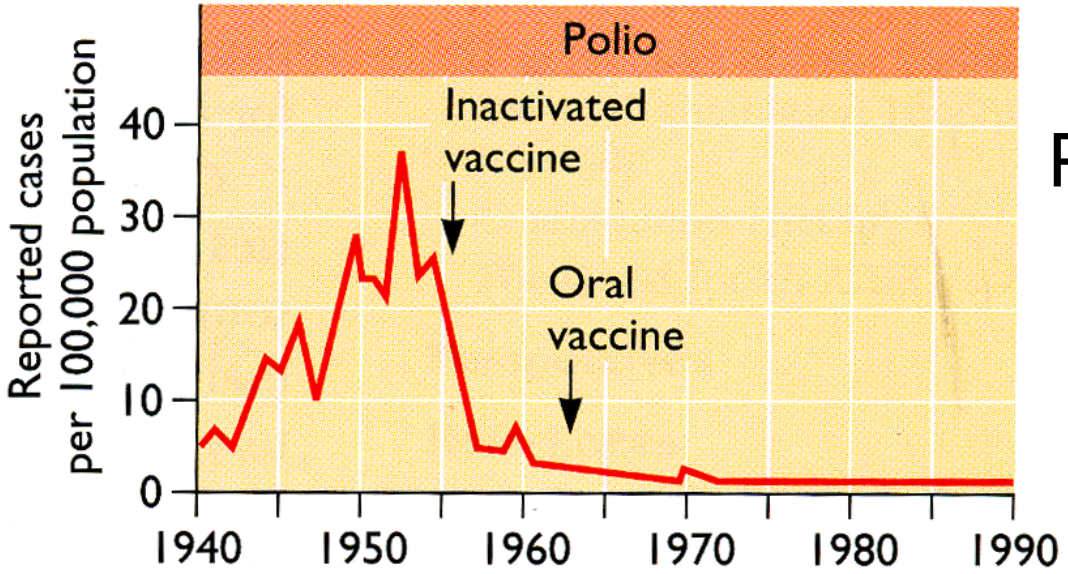
- Protects a recipient from a pathogenic agent
- Establishes an immunological resistance to an infection (immune memory)
- Breaks the chain of transmission

VACCINES:

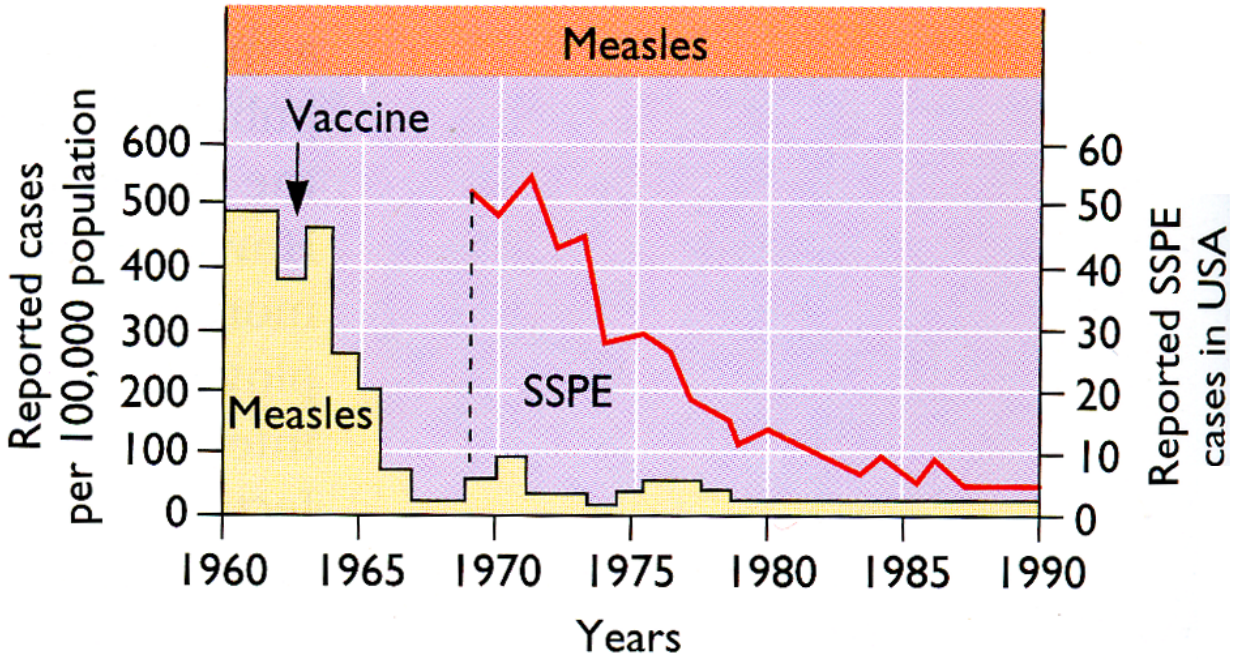
the proven best defense against viruses

Impact of antiviral vaccines on diseases frequency: pre-vaccination era vs. 1998 (USA)

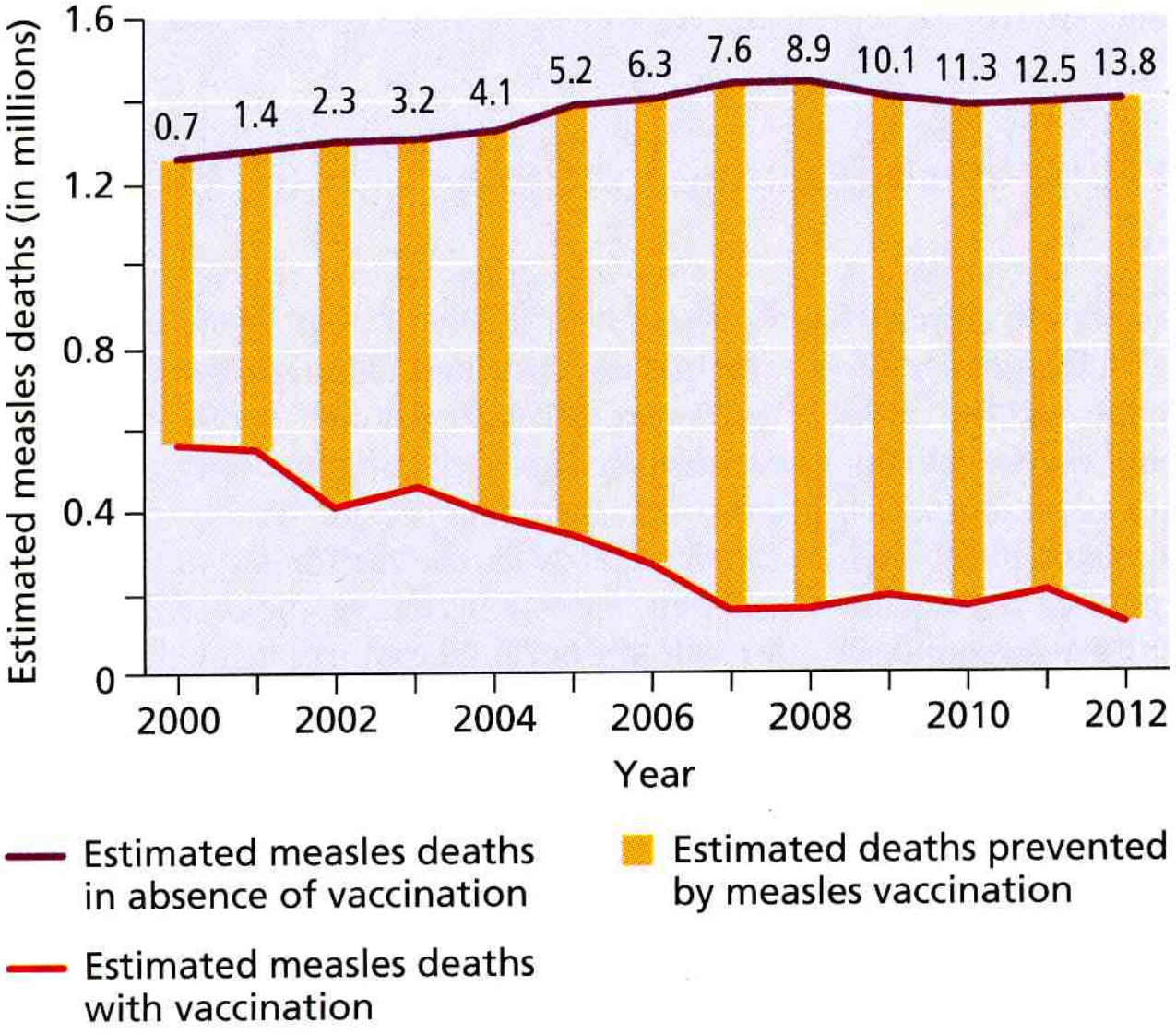
Disease	Dates	Annual reported cases: Pre-vaccination	Post-vaccination (1998)	Decrease (%)
Smallpox	1900–04	48,164	0	100
Poliomyelitis (paralysis)	1951–54	1,314	1*	100
Measles	1958–62	503,282	89	100
Mumps	1968	152,209	606	99.6
Rubella	1966–68	47,745	345	99.3
Congenital rubella syndrome	1958–62	823	5	99.4



Profiles of successful vaccination campaigns



Decline in worldwide measles deaths due to vaccination



Milestones in antiviral vaccine development

Pre-1700s	Chinese doctors use powdered smallpox scabs to "immunize" intranasally. Mediterranean-area doctors use directed leishmania-infected sandfly bites to induce long-term protection from reinfection.
1721	Lady Montagu brings concept of variolation (inoculation with pus from recovering smallpox victim) from Turkey to England.
1798	Jenner publishes *Variolae Vaccinae*, the use of cowpox inoculation to protect against smallpox.
1885	Pasteur and collaborators introduce air-dried rabbit spinal cord as rabies vaccine.
1900	Walter Reed demonstrates that yellow fever is caused by a filterable virus.
1930–45	Introduction of vaccines for Japanese B encephalitis (1930), yellow fever (1935), and influenza (1936).
1946–75	Introduction of vaccines for polioviruses types 1–3 (Sabin attenuated strains and Salk inactivated virus); measles, mumps, and rubella viruses; tick-borne encephalitis virus; mouse brain, duck embryo, and tissue culture vaccines for rabies virus; inactivated influenza A and B viruses; and adenoviruses.
1975–present	Introduction of vaccines for hepatitis B virus, hepatitis A virus, varicella zoster virus (chickenpox), live, cold-adapted influenza virus, rotavirus, and human papillomavirus.

VACCINES:
the proven best defense against viruses

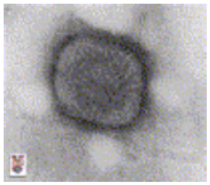
- Development of vaccines
- Eradicating a viral disease: is it possible?
- The eradication of smallpox (1978)
- The eradication of rinderpest virus (2011)
- What make eradication conceivable?
- The poliovirus case: should be vaccine eradication be next?

Viral vaccines

Smallpox: a Historical Perspective

Smallpox: an historical perspective

Figure 2



A. Smallpox virus

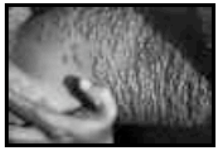
Figure 3

A. Edward Jenner

B. The mummified head of Ramses V (died 1157 BCE) with rash that is probably the result of smallpox

B. Dr Jenner about to vaccinate a child

C. Infant with smallpox



D. Smallpox lesions on skin of trunk. Photo taken in Bangladesh.
CDC/James Hicks

C. Blossom the cow

E. Powdered smallpox scabs were inhaled to protect against smallpox in Chinese medicine

F. The last known person in the world to have a natural case of smallpox. Variola minor in 23-year-old Ali Maow Maalin, Merka, Somalia
CDC

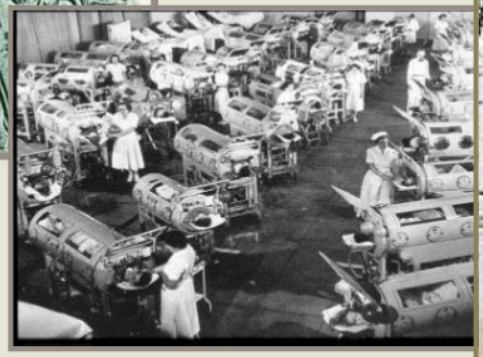
Table 19.1 Features of smallpox that enabled its eradication

Virology and disease aspects
No secondary hosts; it is a human-only virus
Long incubation period
Infectious only after incubation period
Low communicability
No persistent infection
Subclinical infections are not a source of spread
Easily diagnosed
Immunology
Infection confers long-term immunity
One stable serotype
Effective vaccine available
Vaccine is stable and cheap
Social political aspects
Severe disease with high morbidity and mortality
Considerable savings to developed, nonendemic countries
Eradication from developed countries demonstrated its feasibility
Few cultural or social barriers to case tracing and control

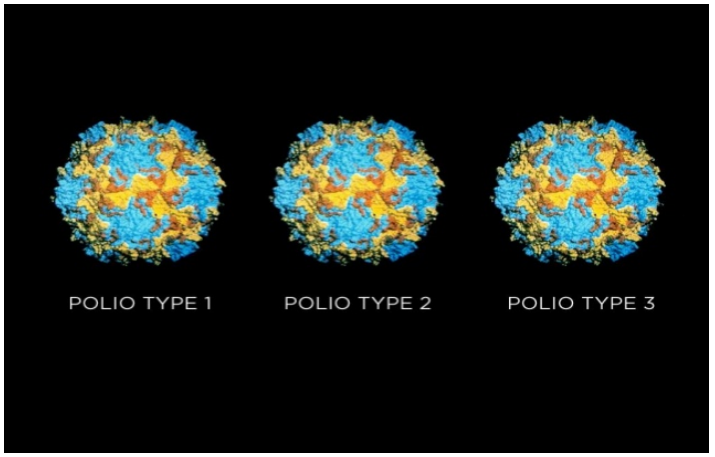
Viral vaccines

The poliomyelitis eradication:should vaccine eradication be next?

Polio Across the Centuries



Rotary



THE ROLE OF INACTIVATED POLIO VIRUS (IPV)

"The next step towards a sustainable polio-free world"

Rotary END POLIO NOW

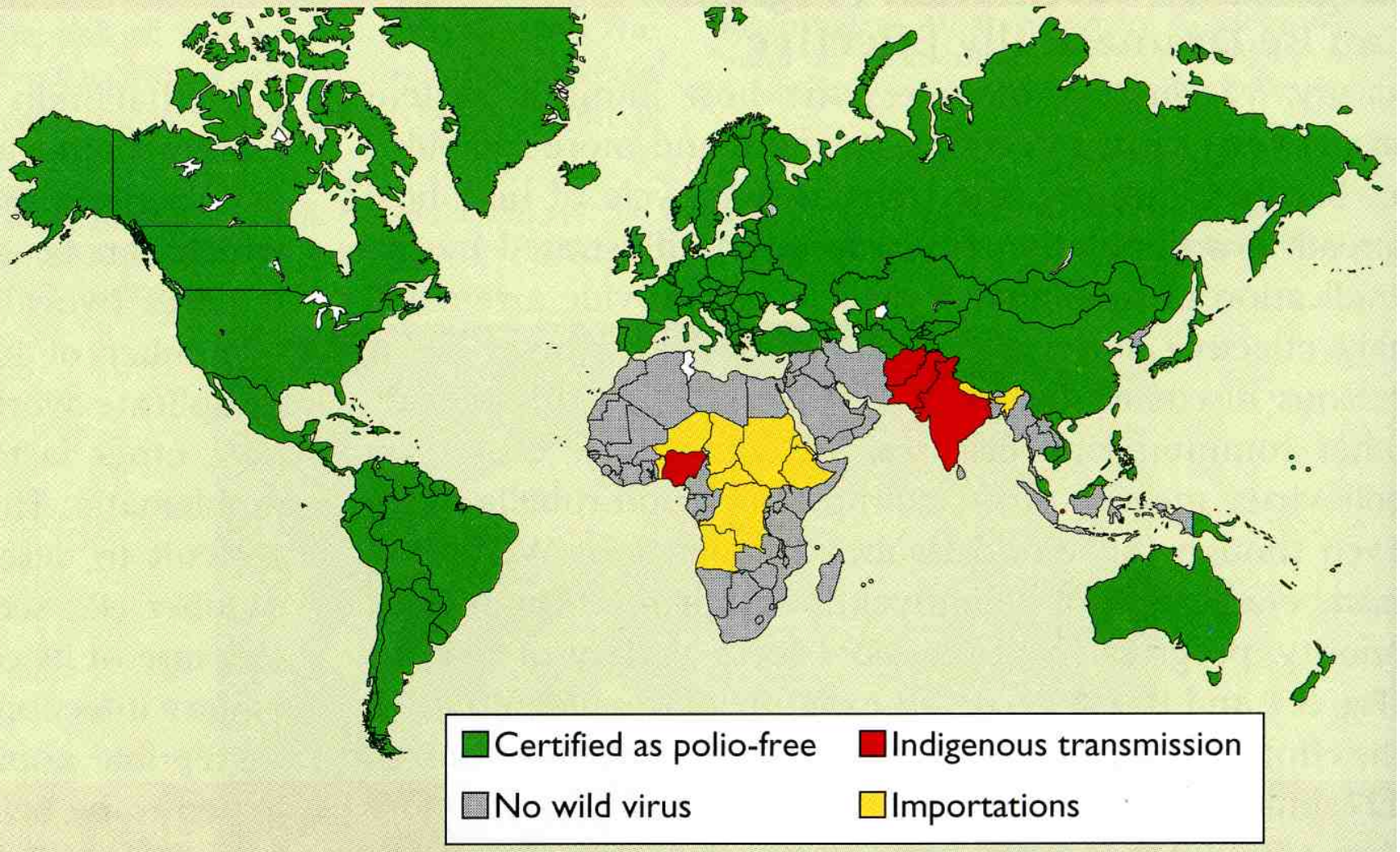
Global Polio Eradication Initiative - 2006

* as of 8 July 2006

Since the momentous launch of the Global Polio Eradication Initiative in 1988 during the World Health Assembly in Geneva, nearly five million children, who otherwise would have been paralyzed and incapacitated by polio, are walking, able and symptoms-free. More than 1.5 million deaths have been prevented.

The number of polio cases reported annually has decreased by 99% from 350,000 in 1988 to 2,000 cases in 2006.

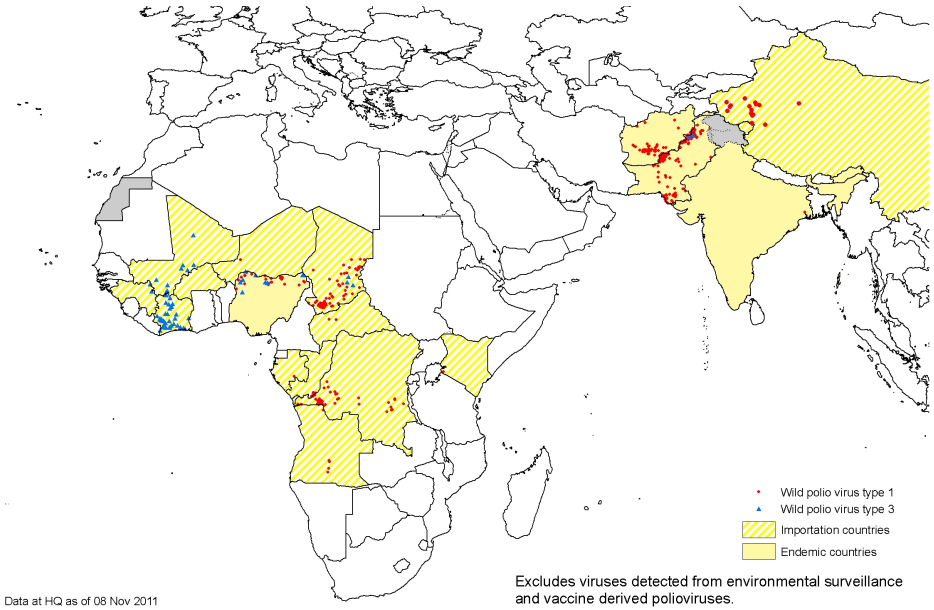
Globally reported incidence of poliomyelitis in 2008. The Americas, Western Pacific, and European regions have been declared poliomyelitis free by the WHO. The number of cases has declined from an estimated 350,000 in 1988 to ca. 1,300 in 2008. At the same time, the number of countries in which poliovirus is endemic has decreased from >125 to 4.



POLIO GLOBAL ERADICATION INITIATIVE

every last child

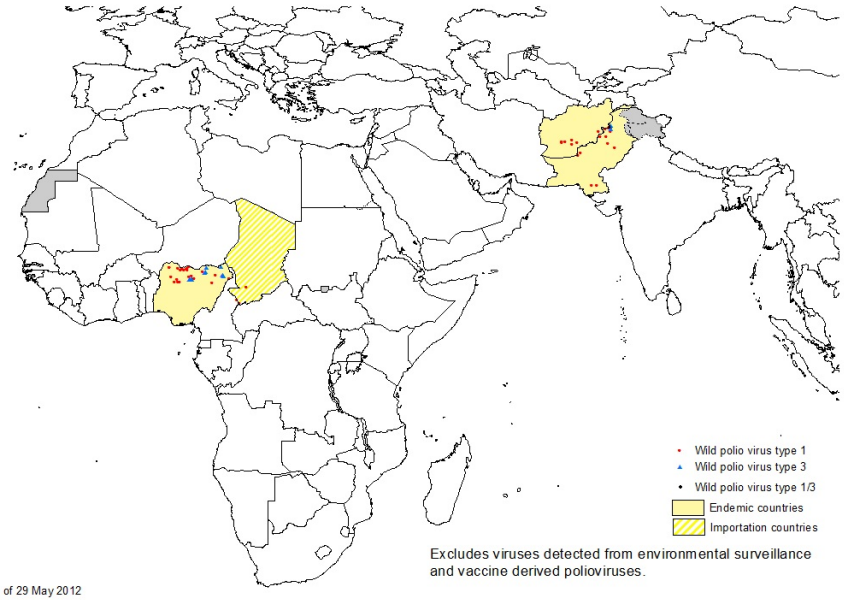
Wild Poliovirus - 2011



Excludes viruses detected from environmental surveillance and vaccine derived polioviruses.

Data at HQ as of 08 Nov 2011

Wild Poliovirus - 2012



Excludes viruses detected from environmental surveillance and vaccine derived polioviruses.

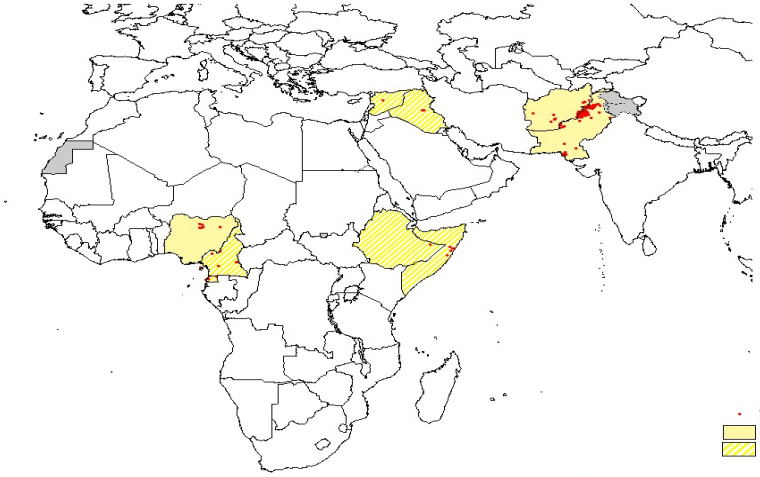
Data at HQ as of 29 May 2012

As 2012, Polio remained endemic in four countries – **Afghanistan, India, Nigeria and Pakistan** – with a further four countries known to have (**Angola, Chad and Democratic Republic of the Congo**) or suspected of having (**Sudan**) re-established transmission of poliovirus. Several more countries had outbreaks in 2010 due to importations of poliovirus.

GLOBAL POLIO ERADICATION INITIATIVE

every last child

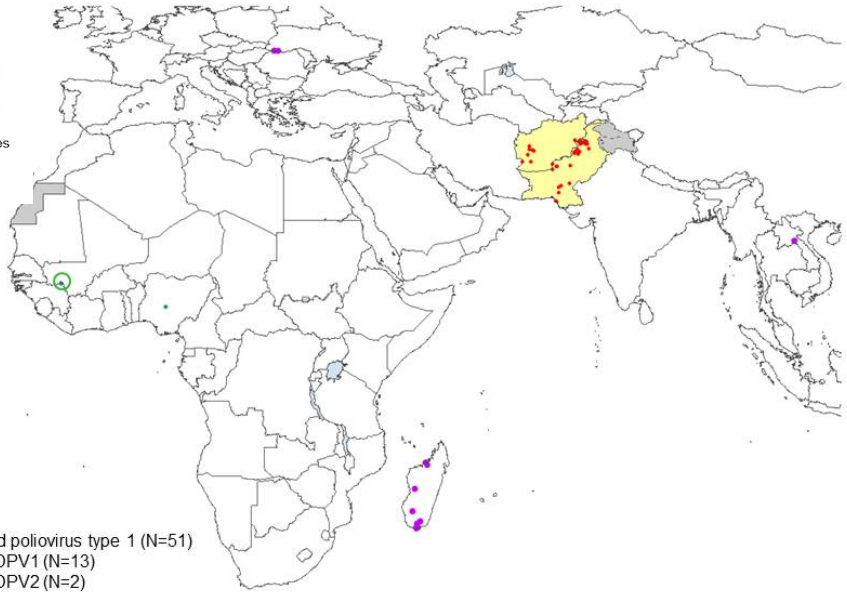
Wild Poliovirus - 2014
01 January - 28 October



Excludes vaccine derived polioviruses and viruses detected from environmental surveillance.

Data in HQ as of 28 October 2014

Wild Poliovirus & cVDPV Cases[1], 2015
01 January – 27 October



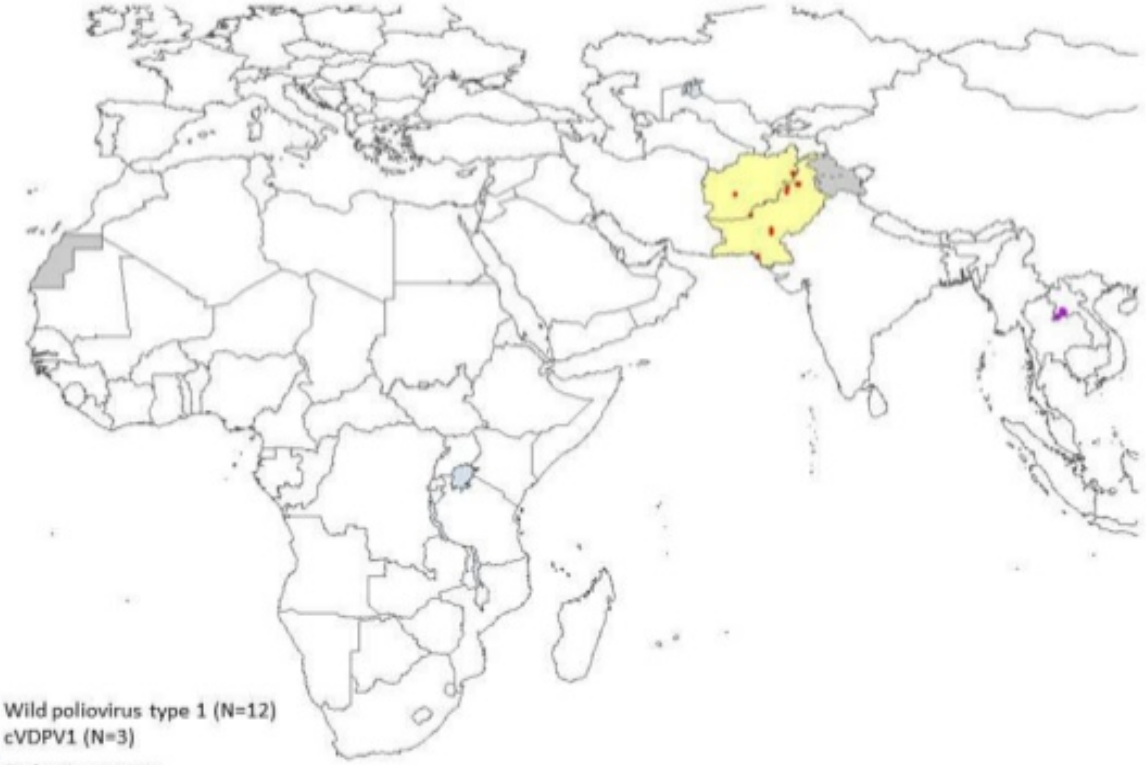
[1]Excludes viruses detected from environmental surveillance.

Data in WHO HQ as of 27 October 2015

POLIO GLOBAL ERADICATION INITIATIVE

every last child

Wild Poliovirus & cVDPV Cases[1], 2016
01 January – 26 April



- Wild poliovirus type 1 (N=12)
- cVDPV1 (N=3)
- Endemic country

[1]Excludes viruses detected from environmental surveillance.

Data in WHO HQ as of 26 April 2016

Viral vaccines

Vaccination in Italy

Ministero della Salute

MENU

Vaccinazioni

D.L. n.73, 7 giugno 2017

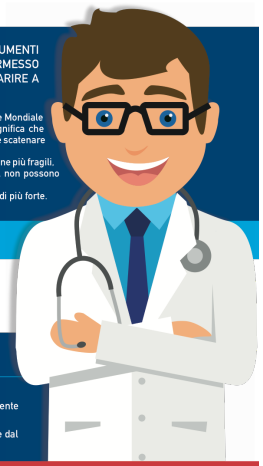
I VACCINI, LA MIGLIOR DIFESA PER IL NOSTRO FUTURO

È IN VIGORE IL **NUOVO DECRETO VACCINI**

PERCHÈ I VACCINI SONO IMPORTANTI?

TUTTA LA COMUNITÀ SCIENTIFICA INTERNAZIONALE RICONOSCE CHE I VACCINI SONO UNO DEGLI STRUMENTI DI SALUTE PUBBLICA PIÙ SICURI ED EFFICACI DI TUTTI I TEMPI. NEL PASSATO HANNO, INFATTI, PERMESSO DI ELIMINARE, QUASI OVUNQUE, UNA TERRIBILE MALATTIA COME LA POLIOMIELITE E DI FAR SCOMPARIRE A LIVELLO GLOBALE IL VAIOLO.

Il 95% è la soglia di copertura vaccinale raccomandata dall'Organizzazione Mondiale della Sanità (OMS) per raggiungere la c.d. immunità di gregge. Ciò significa che un alta percentuale di vaccinati impedisce agli agenti infettivi di circolare e scatenare epidemie.
Il raggiungimento di tale soglia consente, quindi, di tutelare anche le persone più fragili, ad esempio quegli individui che, a causa delle loro condizioni di salute, non possono essere vaccinati.
Un bambino vaccinato sarà un bambino più tutelato dalle malattie e quindi più forte.



LE VACCINAZIONI OBBLIGATORIE E GRATUITE PASSANO DA 4 A 10

VACCINI OBBLIGATORI	VACCINI FORTEMENTE RACCOMANDATI	AMMISSIONE A SCUOLA	PRENOTAZIONI IN FARMACIA
ANTI-POLIOMIELITICO ANTI-DIFTERICO ANTI-TETANICO ANTI-EPATITE B ANTI-PERTOSSE ANTI-MORBILLO ANTI-ROSOLIA ANTI-PAROTITE ANTI-VARICELLA ANTI-HAEMOPHILUS TIPO B	ANTI-MENINGOCOCCICO B ANTI-MENINGOCOCCICO C ANTI-PNEUMOCOCCICO ANTI-ROTAVIRUS	Le dieci vaccinazioni obbligatorie costituiscono un requisito per l'ammissione all'asilo nido e alle scuole dell'infanzia (per i bambini da 0 a 6 anni).	Le famiglie possono prenotare gratuitamente in farmacia le vaccinazioni previste dal decreto-legge.

È VERO CHE:

L'attuale riduzione delle coperture vaccinali ha provocato la recrudescenza di alcune malattie come il morbillo e potrebbe portare al ritorno di altre patologie ormai assenti dal nostro paese ma non ancora debellate dal resto del mondo, come la poliomielite o la difterite.

Il morbillo può causare gravi complicazioni e danneggiare temporaneamente le difese immunitarie. Tutto ciò può essere prevenuto dal vaccino.

La sicurezza dei vaccini è documentata da milioni di dosi somministrate, dalla costante attività di sorveglianza sui possibili eventi avversi e dagli studi di sicurezza che vengono effettuati sia prima dell'autorizzazione che dopo l'immissione in commercio.

L'Italia è uno dei 14 Paesi dove il morbillo è ancora endemico ed è nella "top ten" dei paesi che hanno segnalato più casi a livello mondiale da novembre 2016 ad aprile 2017. Dall'inizio del 2017 sono stati notificati oltre 4.000 casi, molte complicanze gravi inclusi casi di polmonite e di encefalite e alcuni decessi. Il 40% circa dei casi è stato ricoverato in ospedale e il 35% circa ha riportato almeno una complicanza.

La malattia impegna il sistema immunitario molto di più della corrispondente vaccinazione. Inoltre nella composizione dei vaccini attuali gli antigeni presenti sono molti meno rispetto a quelli che venivano somministrati trenta anni fa.

È FALSO CHE:

I VACCINI POSSONO INDEBOLIRE IL SISTEMA IMMUNITARIO E PORTARE ALLA COMPARSA DI MALATTIE AUTOIMMUNI.
PERCHÉ È FALSO: la nostra capacità di rispondere agli antigeni si sviluppa prima ancora della nascita e il sistema immunitario di un neonato è perfettamente capace di rispondere ogni giorno a migliaia di antigeni, molti di più di quelli contenuti nei vaccini.

I VACCINI CONTENGONO SOSTANZE TOSSICHE E PERICOLOSE COME AD ESEMPIO IL MERCURIO.
PERCHÉ È FALSO: nessuno dei vaccini commercializzati in Europa contiene derivati del mercurio.

I VACCINI, IN PARTICOLARE QUELLO CONTRO MORBILLO, PAROTITE E ROSOLIA (MPR), CAUSANO L'AUTISMO.
PERCHÉ È FALSO: dai numerosi studi scientifici effettuati non emerge alcuna correlazione tra il vaccino MPR e l'autismo. Lo studio che riportava il legame è stato dimostrato fraudolento e l'autore è stato radiato dall'albo dei medici del Regno Unito.

A CAUSA DEL DECRETO SULL'OBBLIGO AUMENTANO I VACCINI SOMMINISTRATI AI BIMBI NEL PRIMO ANNO DI VITA.
PERCHÉ È FALSO: il decreto non modifica il calendario vaccinale. Infatti, il numero di vaccini e la tempistica restano identici a quelli degli anni precedenti, con la sola differenza che vaccini che prima erano raccomandati ora sono obbligatori.

ESISTONO DEGLI ESAMI CHE POSSONO PREDIRE EVENTUALI EFFETTI COLLATERALI DEI VACCINI.
PERCHÉ È FALSO: non esiste alcun test di questo tipo.

È IN VIGORE IL NUOVO DECRETO VACCINI

PER L'ANNO SCOLASTICO **2017/2018**. FACCIAMO **CHIAREZZA**

DOCUMENTI NECESSARI

SE MIO FIGLIO **HA EFFETTUATO TUTTE LE VACCINAZIONI**, QUALI DOCUMENTI DEVO PRESENTARE ALLA SCUOLA?

Devi presentare **copia del libretto delle vaccinazioni** timbrato dalla ASL o il **certificato vaccinale** o **un'attestazione dello stato vaccinale** rilasciato dalla ASL.

MALATTIE GIÀ CONTRATTE

SE MIO FIGLIO **HA GIÀ AVUTO** UNA DELLE MALATTIE PER CUI È PREVISTA LA VACCINAZIONE, COSA DEVO FARE?

È sufficiente che il medico di medicina generale o il pediatra di libera scelta **attesti** che tuo figlio **ha già avuto** la malattia.

In ogni caso, effettuare una vaccinazione non comporta **alcun rischio** per un soggetto immunizzato, ma **rafforza** comunque le difese immunitarie.

LIBRETTO VACCINALE

SE **NON TROVO** IL LIBRETTO VACCINALE, COSA DEVO FARE PER **COMPROVARE** ALLA SCUOLA LE AVVENUTE VACCINAZIONI?

Puoi presentare un'**autocertificazione** per dichiarare le vaccinazioni effettuate entro il **31 ottobre 2017** per la scuola dell'obbligo o entro il **10 settembre 2017** per i nidi e la scuola dell'infanzia.

Entro il **10 marzo 2018** dovrai presentare copia del libretto delle vaccinazioni timbrato dalla ASL o il certificato vaccinale o un'attestazione dello stato vaccinale rilasciato dalla ASL.

SE ALCUNE VACCINAZIONI EFFETTUATE **NON DOVESSERO RISULTARE SUL LIBRETTO VACCINALE** PERCHÉ FATTE, AD ESEMPIO, DAL MEDICO DI MEDICINA GENERALE, DAL PEDIATRA DI LIBERA SCELTA O PRIVATAMENTE, COSA DEVO FARE?

Devi recarti alla **ASL** per ottenere la **registrazione** sul libretto.

IMPOSSIBILITÀ A VACCINARSI

SE MIO FIGLIO **NON PUÒ VACCINARSI** PERCHÉ È MALATO, COSA DEVO FARE?

Se tuo figlio si trova in condizioni di salute che non gli consentono di vaccinarsi in **maniera definitiva,** devi richiedere al pediatra di libera scelta o al medico di medicina generale di tuo figlio un'attestazione per giustificare la mancata somministrazione. Se invece tuo figlio è malato in **modo temporaneo,** puoi posticipare la data della vaccinazione fino alla sua guarigione, presentando un'attestazione del pediatra di libera scelta o del medico di medicina generale di tuo figlio.

SE MIO FIGLIO *(DA 0 A 6 ANNI)* **NON HA EFFETTUATO UNA VACCINAZIONE OBBLIGATORIA** ENTRO IL **10 SETTEMBRE** 2017, PUÒ FREQUENTARE L'ASILO NIDO O LA SCUOLA DELL'INFANZIA?

Sì, tuo figlio **può frequentare regolarmente,** purché tu dimostri di aver prenotato la vaccinazione alla ASL, che provvederà ad eseguire la vaccinazione *(o ad iniziarne il ciclo, nel caso preveda più dosi)* **entro la fine dell'anno scolastico.**

SE MIO FIGLIO È, INVECE, NELLA **FASCIA DI ETÀ TRA 6 E 16 ANNI** E NON HA EFFETTUATO UNA DELLE VACCINAZIONI OBBLIGATORIE, POTRÀ FREQUENTARE LA SCUOLA?

Sì, potrà frequentare, ma, sarai **contattato dalla ASL** per un **colloquio informativo.** Ove tu non provveda, comunque, a far vaccinare tuo figlio, ti verrà applicata una **sanzione pecuniaria.**

CALENDARIO VACCINALE

Ministero della Salute — Istituto Superiore di Sanità — Agenzia Italiana del Farmaco AIFA

PER MAGGIORI INFO E PER CONSULTARE IL CALENDARIO VACCINALE VISITA IL SITO **WWW.SALUTE.GOV.IT/VACCINI** O TELEFONA AL **NUMERO VERDE 1500**

Numero Verde 1500

Vaccinazioni

Vaccinazioni obbligatorie da zero a 16 anni

Il decreto vaccini ha aumentato il numero di vaccinazioni obbligatorie per i minori da zero a 16 anni, estendendole da 4 a 10 in base all'anno di nascita. La vaccinazione per la varicella è obbligatoria soltanto per i nati a partire dal 2017. Di seguito una tabella riepilogativa:

Vaccinazione \ Anno	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
anti-poliomielitica	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
anti-difterica	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
anti-tetanica	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
anti-epatite B	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
anti-pertosse	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
anti-Haemophilus tipo b	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
anti-morbillo	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
anti-rosolia	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
anti-parotite	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
anti-varicella																	X

Vaccinazioni

Il calendario vaccinale del Piano Nazionale di Prevenzione Vaccinale 2017-2019

Vaccino	0gg-30gg	3° mese	4° mese	5° mese	6° mese	7° mese	11° mese	13° mese	15° mese	6° anno	12°-18° anno	19-49 anni	50-64 anni	> 64 anni	Soggetti ad aumentato rischio
DTPa**		DTPa		DTPa			DTPa			DTPa***	dTpaIPV	1 dose dTpa**** ogni 10 anni			(1)
IPV		IPV		IPV			IPV			IPV					
Epatite B	EpB-EpB*	Ep B		Ep B			Ep B								(2)
Hib		Hib		Hib			Hib								(3)
Pneumococco		PCV		PCV			PCV							PCV+PPSV	(4) ^^
MPRV								MPRV		MPRV					(6) ^
MPR								*oppure* MPR + V		*oppure* MPR + V					(5) *****
Varicella															(6)^
Meningococco C								Men C§			Men ACWY coniugato				(7)
Meningococco B*^		Men B	Men B		Men B			Men B							
HPV											HPV°: 2-3 dosi (in funzione di età e vaccino)				(8)
Influenza														1 dose all'anno	(9) °°
Herpes Zoster														1 dose#	(10)
Rotavirus		Rotavirus## (due o tre dosi a seconda del tipo di vaccino)													
Epatite A															(11)

Co-somministrare nella stessa seduta

Somministrare in seduta separata

Vaccini per categorie a rischio

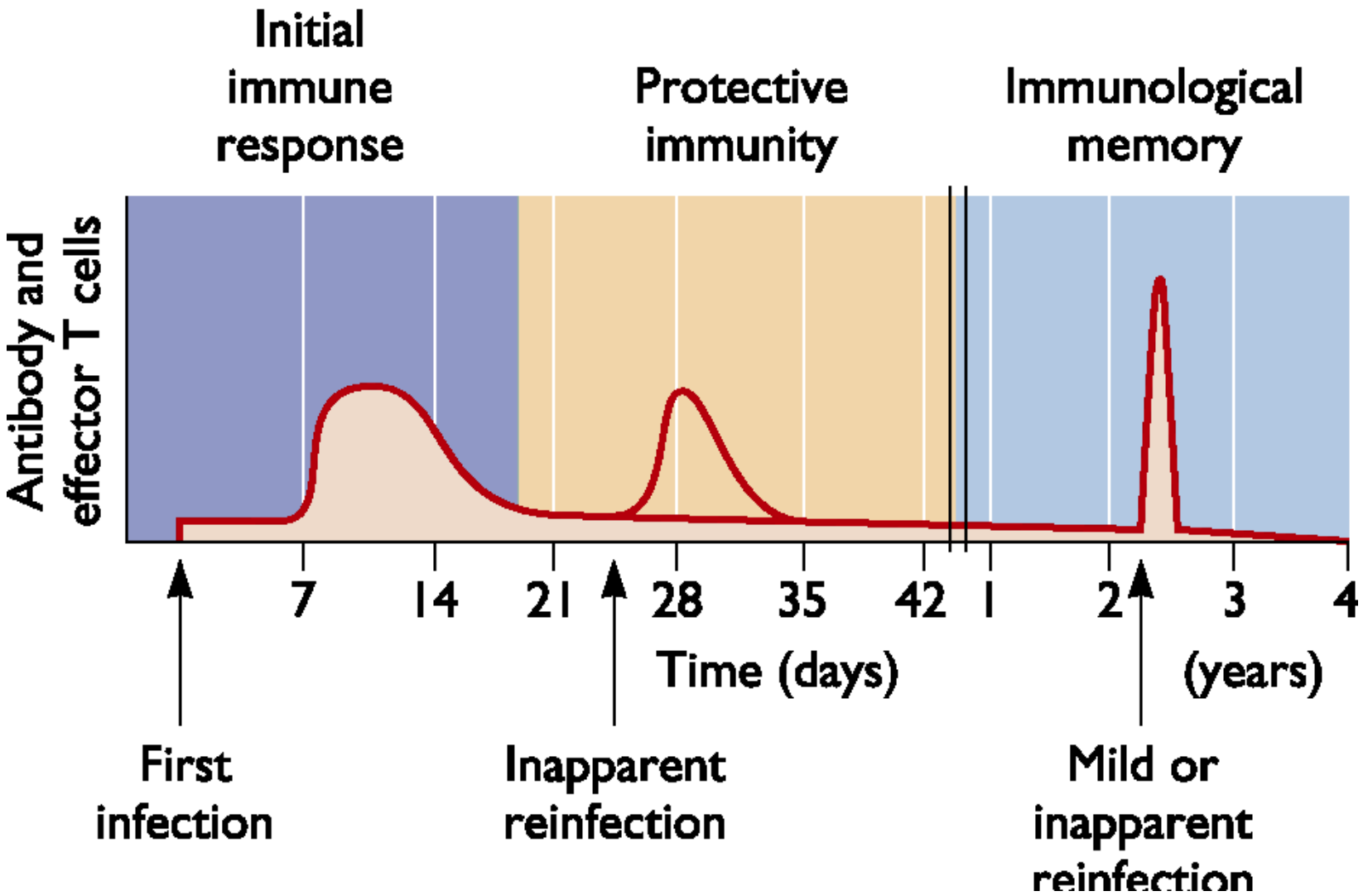
IPV	=	vaccino antipolio inattivato
Ep B	=	vaccino contro il virus dell'epatite B
Hib	=	vaccino contro le infezioni invasive da *Haemophilus influenzae* tipo b
DTPa	=	vaccino antidifterite-tetano-pertosse acellulare
dTpa	=	vaccino antidifterite-tetano-pertosse acellulare, formulazione per adulti
dTpa-IPV	=	vaccino antidifterite-tetano-pertosse acellulare e polio inattivato, formulazione per adulti
MPRV	=	vaccino tetravalente per morbillo, parotite, rosolia e varicella
MPR	=	vaccino trivalente per morbillo, parotite, rosolia
V	=	vaccino contro la varicella
PCV	=	vaccino pneumococcico coniugato
PPSV	=	vaccino pneumococcico polisaccaridico
MenC	=	vaccino contro il meningococco C coniugato
MenB	=	vaccino contro il meningococco B
HPV	=	vaccino contro i papillomavirus
Influenza	=	vaccino contro l'influenza stagionale
Rotavirus	=	vaccino contro i rotavirus

Viral vaccines

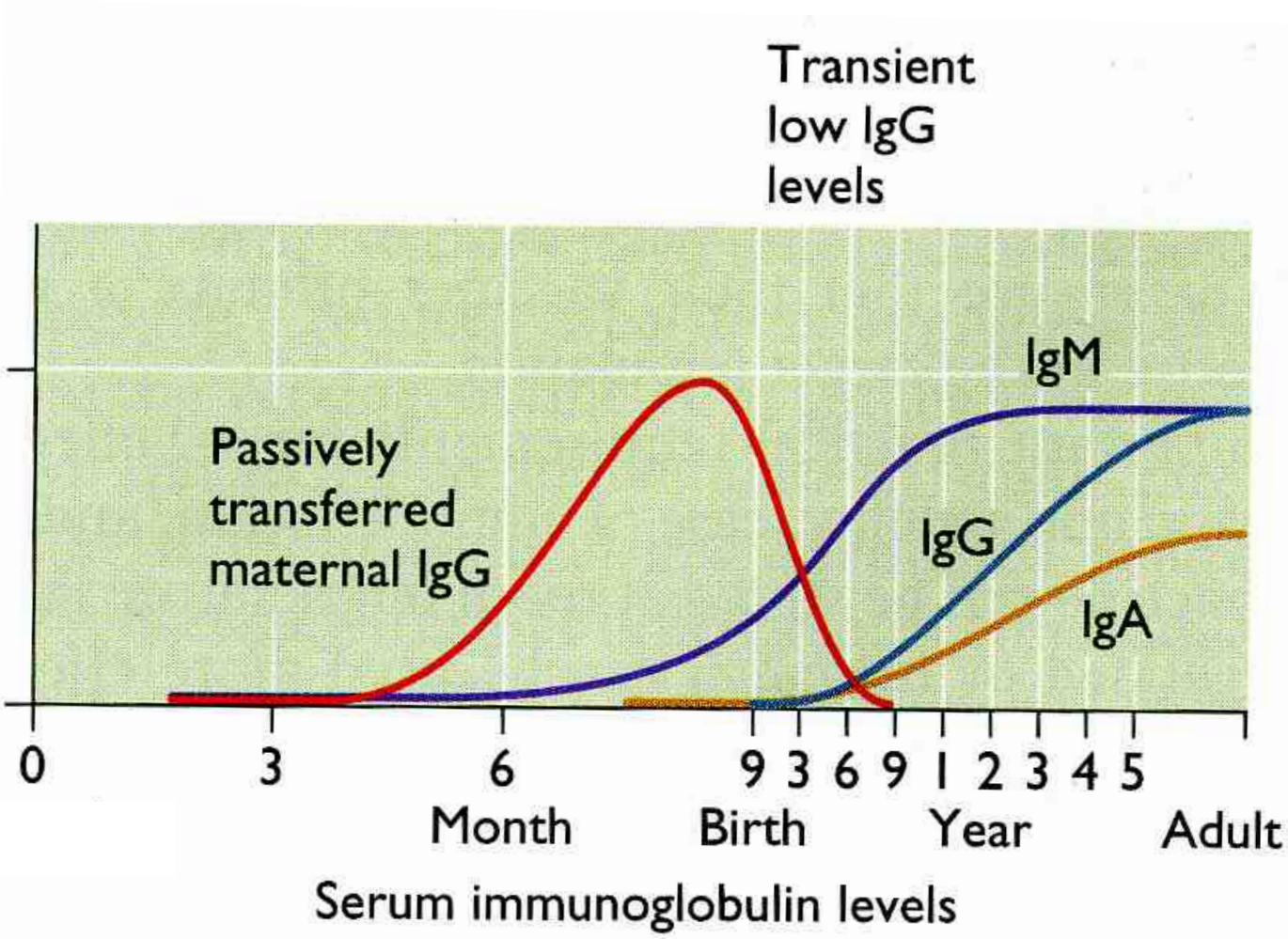
Vaccine Basics

VACCINATION:

basis for protective immunity



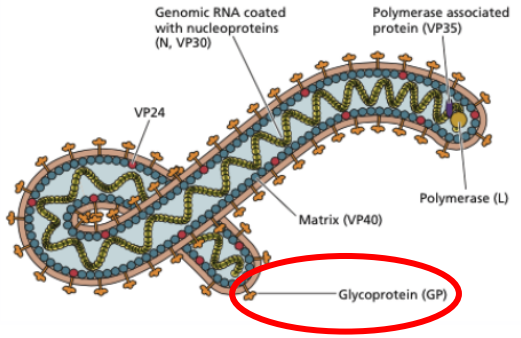
NATURAL PASSIVE IMMUNIZATION:
transfer of antibody from mother to infant

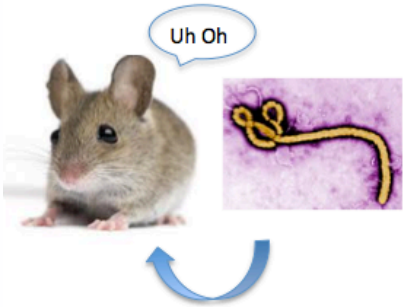


VACCINATION:
vaccines can be *active* or *passive*

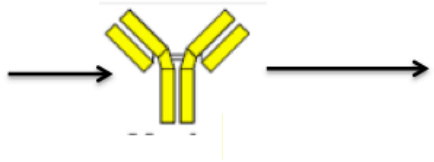
- **Active** – instilling into the recipient a modified form of the pathogen or material derived from it that induces immunity to disease (long term protection).
- **Passive** – instilling the products of the immune response (antibodies or immune cells) into the recipient (short term protection)

Zmapp, the best known passive vaccine





Mice are infected with Ebola



This forms mouse antibodies

The antibodies are humanized so they are not attacked by the immune system

Then a gene is removed from the new antibody...

And is inserted into The tobacco genome

The **genetically modified** leaves make large quantities of the drug

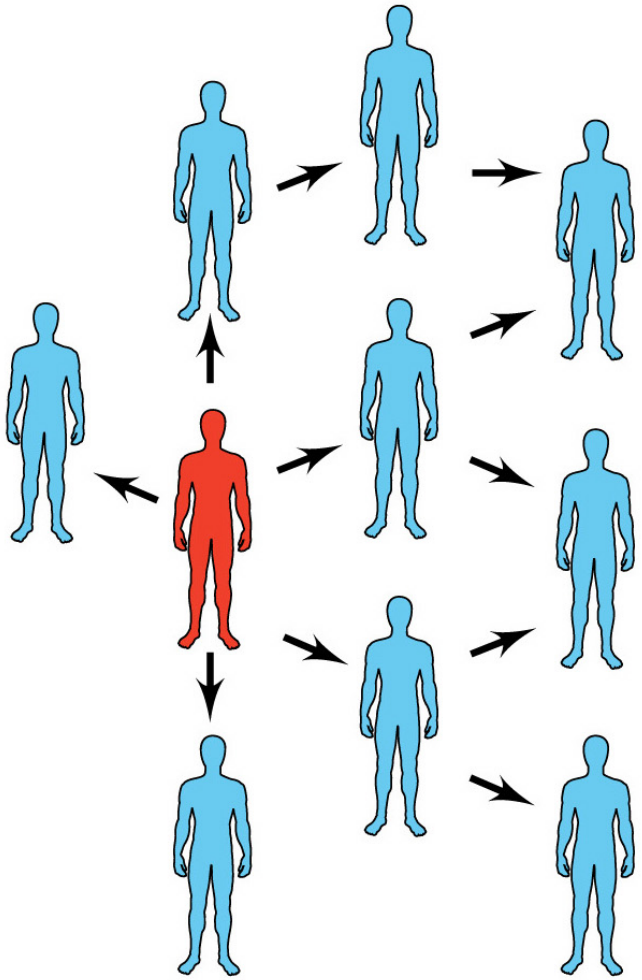
ZMAPP

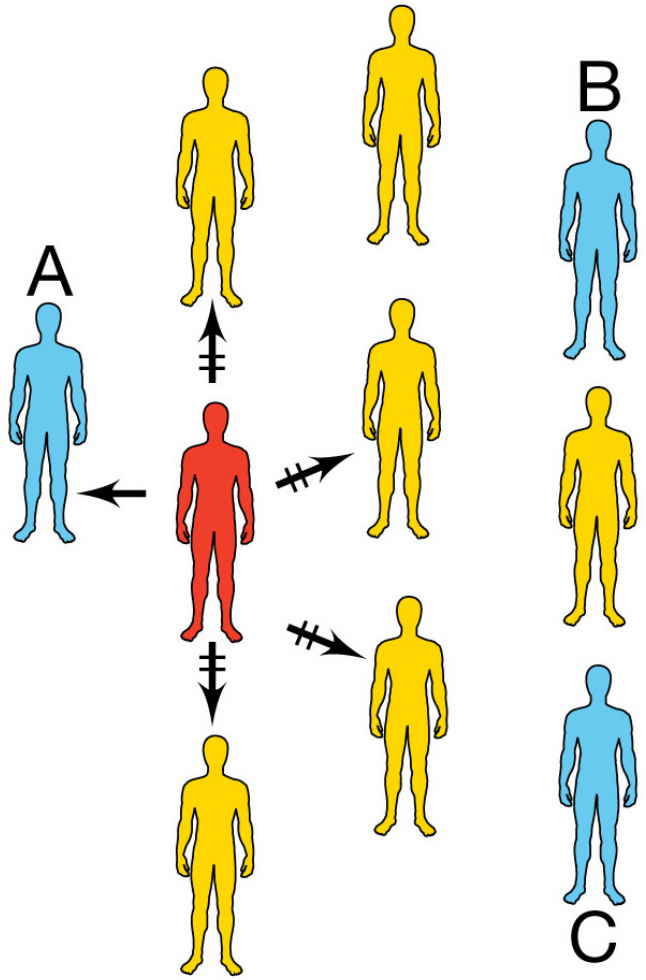
- Raised in mice immunized with virus-like particles
- Chimerized into human IgG1 scaffold
- Produced in tobacco plants

VACCINATION:
requirements for an effective vaccine

Safety	The vaccine must not cause disease
Side effects must be minimal	
Induction of protective immune response	Vaccinated individuals must be protected from illness due to pathogen
	Proper innate, cellular, and humoral responses must be evoked by vaccine
Practical issues	Cost per dose must not be prohibitive
	The vaccine should be biologically stable (no genetic reversion to virulence; able to survive use and storage in different surroundings)
	The vaccine should be easy to administer (oral delivery preferred to needles)
	The public must see more benefit than risk

THE HERD IMMUNITY CONCEPT





Herd immunity threshold (HT): $1-1/R_0$

R_0 reproduction number

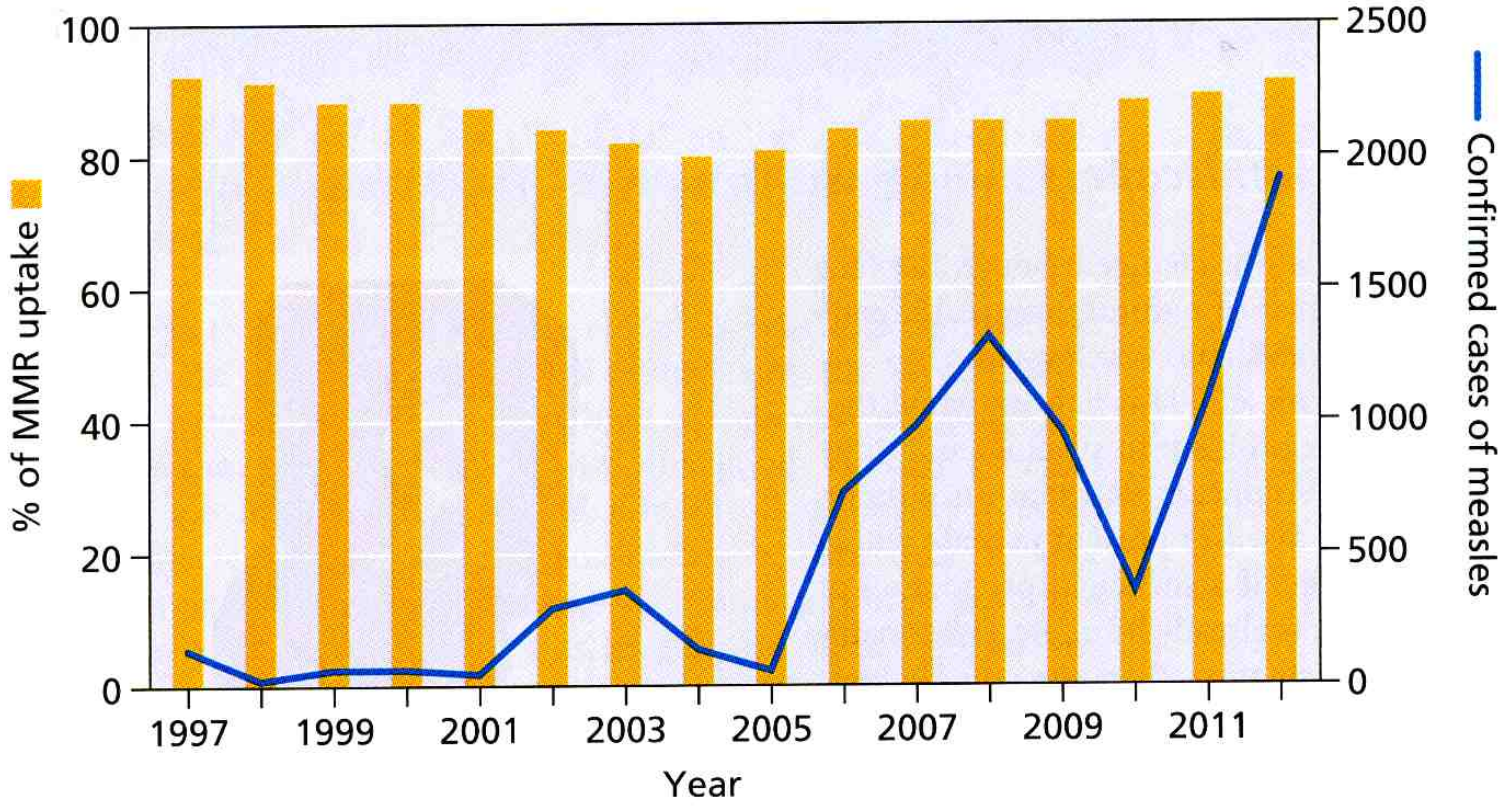
R_0 smallpox: 5-7 HT: 80-85%

R_0 measle: 12-18 HT: 93-95%

THE HERD IMMUNITY CONCEPT

The correlation between herd immunity and the potential for outbreaks.

As the % of vaccinated individuals dip below 90%, a corresponding rise in the number of acute cases is observed

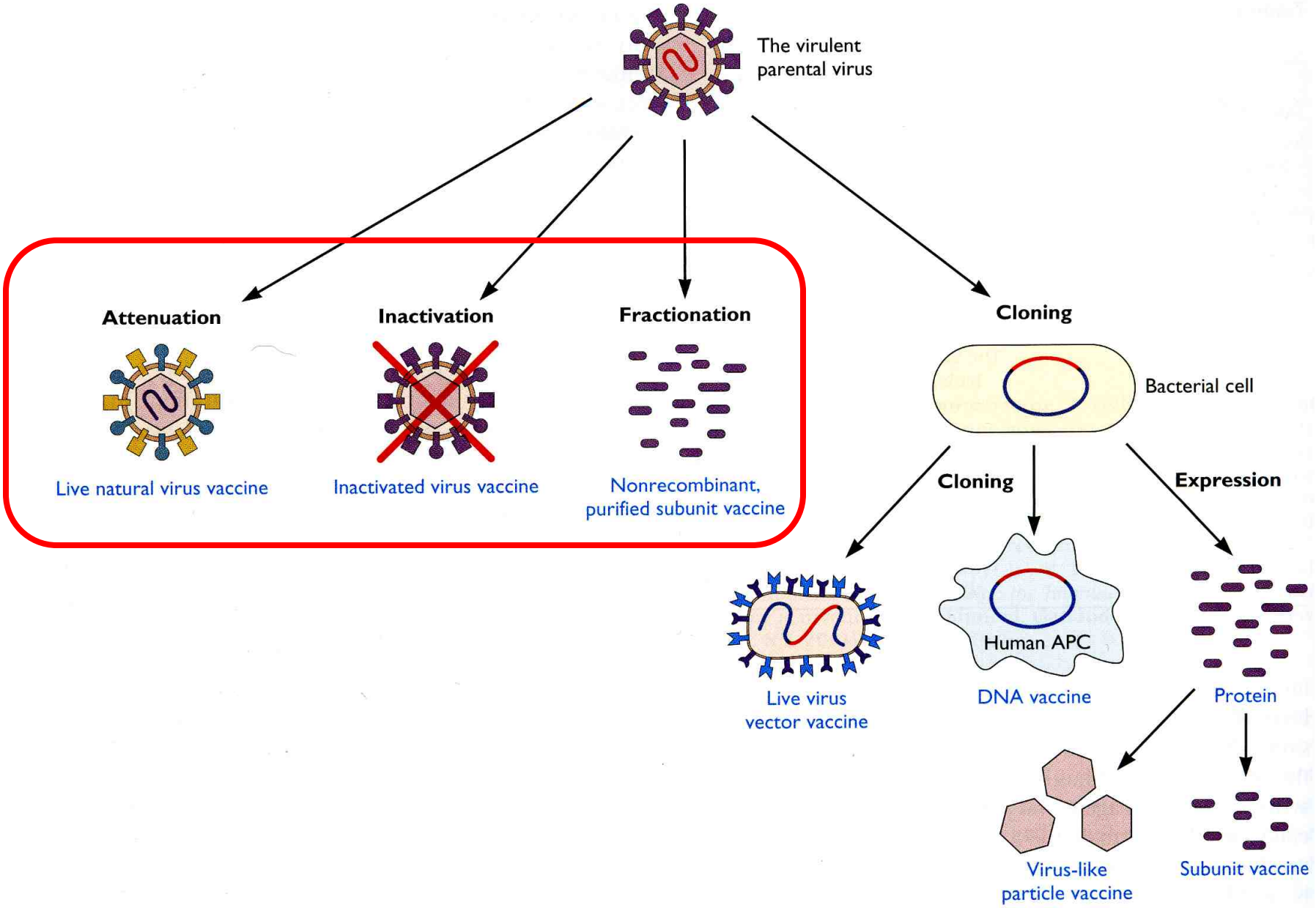


When 80% of population is immunized with measles, 76% of population is immune

VACCINATION:
viral vaccines in the USA

Disease or virus	Type of vaccine	Indications for use	Schedule
Adenovirus	Live attenuated, oral	Military recruits	One dose
Hepatitis A	Inactivated whole virus	Travellers, other high-risk groups	0, 1, and 6 mo
Hepatitis B	Yeast-produced recombinant surface protein	Universal in children, exposure to blood, sexual promiscuity	0, 1, 6, and 12 mo
Influenza	Inactivated viral subunits	Elderly and other high-risk groups	One dose seasonally
Influenza	Live attenuated	Children 2–8 yr old, not previously vaccinated with influenza vaccine	Two doses at least 1 mo apart
		Children 2–8 yr old, previously vaccinated with influenza vaccine	One dose
		Children, adolescents, and adults 9–49 yr old	One dose
Japanese encephalitis	Inactivated whole virus	Travelers to or inhabitants of high-risk areas in Asia	0, 7, and 30 days
Measles	Live attenuated	Universal vaccination of infants	12 mo of age; 2nd dose, 6 to 12 yr of age
Mumps	Live attenuated	Universal vaccination of infants	Same as measles, given as MMR
Papilloma (human)	Yeast- or SF9-produced virus-like particles	Females 9–26 yr old	Three doses
Rotavirus	Live reassortant	Healthy infants	2, 3, and 6 mo or 2 and 4 mo of age depending on vaccine
Rubella	Live attenuated	Universal vaccination of infants	Same as measles, given as MMR
Polio (inactivated)	Inactivated whole viruses of types 1, 2, and 3	Changing: commonly used for immunosuppressed where live vaccine cannot be used	2, 4, and 12–18 mo of age, then 4 to 6 yr of age
Polio (live)	Live, attenuated, oral mixture of types 1, 2, and 3	Universal vaccination; no longer used in United States	2, 4, and 6–18 mo of age
Rabies	Inactivated whole virus	Exposure to rabies, actual or prospective	0, 3, 7, 14, and 28 days postexposure
Smallpox	Live vaccinia virus	Certain laboratory workers	One dose
Varicella	Live attenuated	Universal vaccination of infants	12 to 18 mo of age
Varicella-zoster	Live attenuated	Adults 60 yr old and older	One dose
Yellow fever	Live attenuated	Travel to areas where infection is common	One dose every 10 yr

VACCINATION: how to make a vaccine?



VACCINATION:
traditional vaccines

Traditional vaccines are of two types:

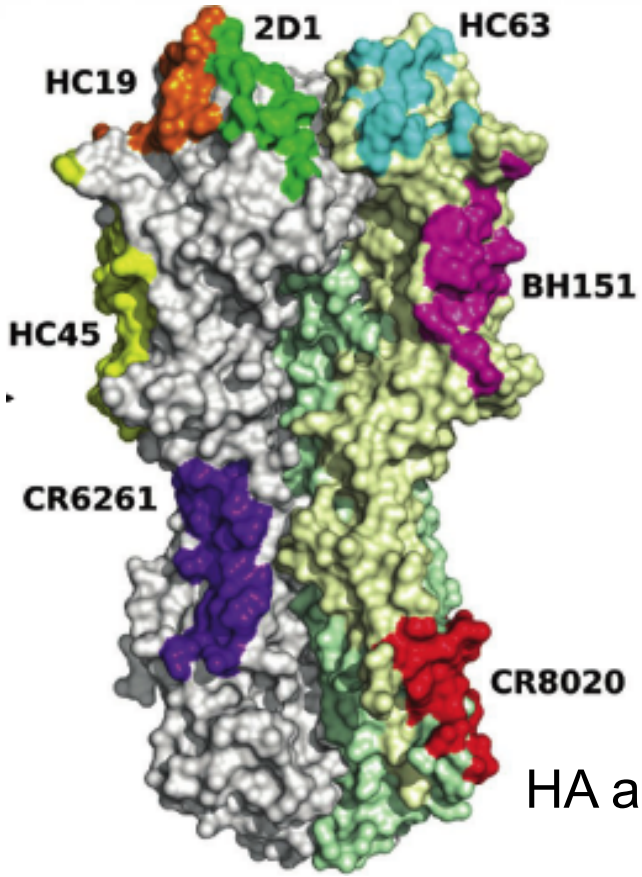
- **Inactivated** (killed) - (whole cells, viruses, inactivated toxin proteins (toxoids)
- **Attenuated** (live) –viral or bacterial strain

VACCINATION:
commonly used traditional antiviral vaccines

- **Attenuated (replication competent) vaccines**
  - **Poliomyelitis**
  - **Mumps**
  - **Measles**
  - **Rubella**
  - **Yellow fever**
  - **Varicella**
- **Inactivated vaccines**
  - **Influenza**
  - **Poliomyelitis**
  - **Rabies**

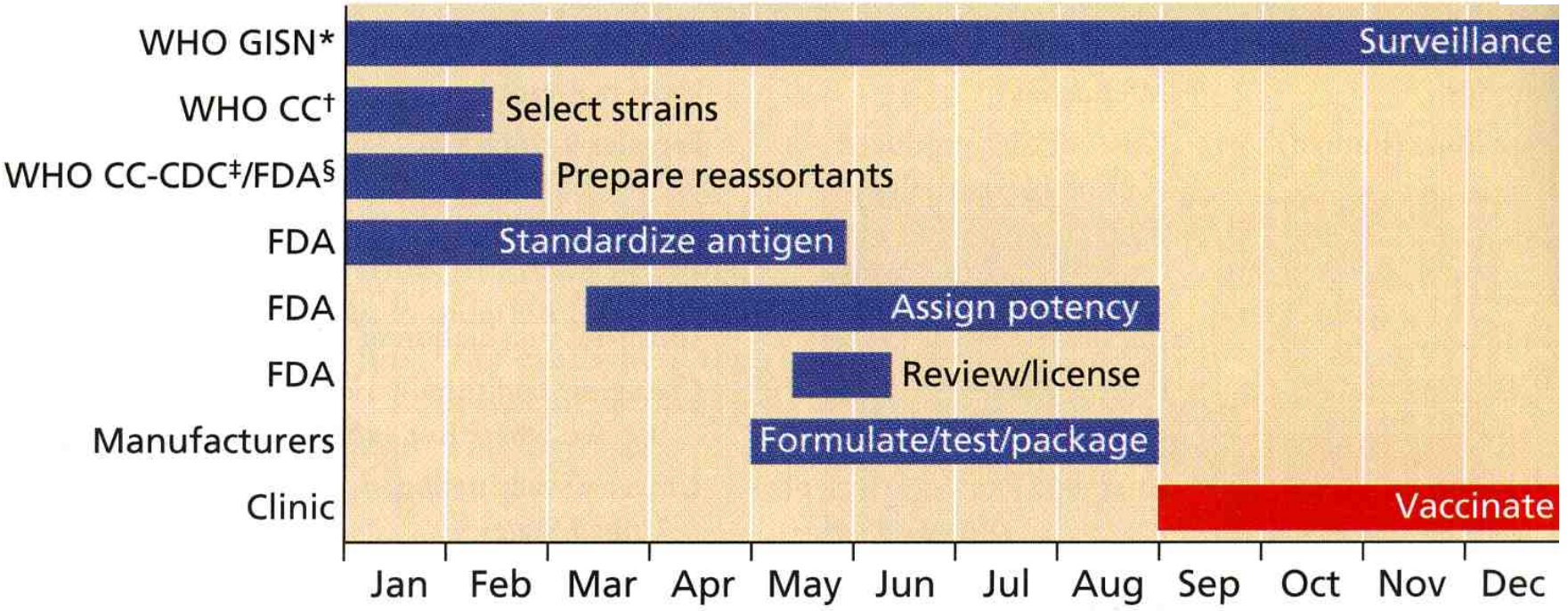
Inactivated influenza vaccine

- >7000 deaths/yr in Italy due to influenza virus
- Vaccine: virus grown in embryonated chicken eggs, formalin-inactivated or detergent or chemically disrupted virions.
- Hundreds million of doses manufactered each year.
- 60% effective in healthy children and adults <65 yr.
- Protection correlates with antibodies to HA and NA.
- Envelope proteins change each year; new strains must be selected in the first months for manifacture.
- Use reasssortants with most RNA segments from high-yielding strain, HA, NA from selected strain.



HA antigenic drift: influenza virus

Annual timeline for creating an influenza virus vaccine



*World Health Organization Global Influenza Surveillance Network
†WHO Collaborating Centres
‡US Centers for Disease Control and Prevention
§US Food and Drug Administration

SORVEGLIANZA VIROLOGICA dell'INFLUENZA

NIC - MIPI
Istituto Superiore di Sanità

InfluNet
Rete Italiana Sorveglianza Influenza

26 febbraio 2016

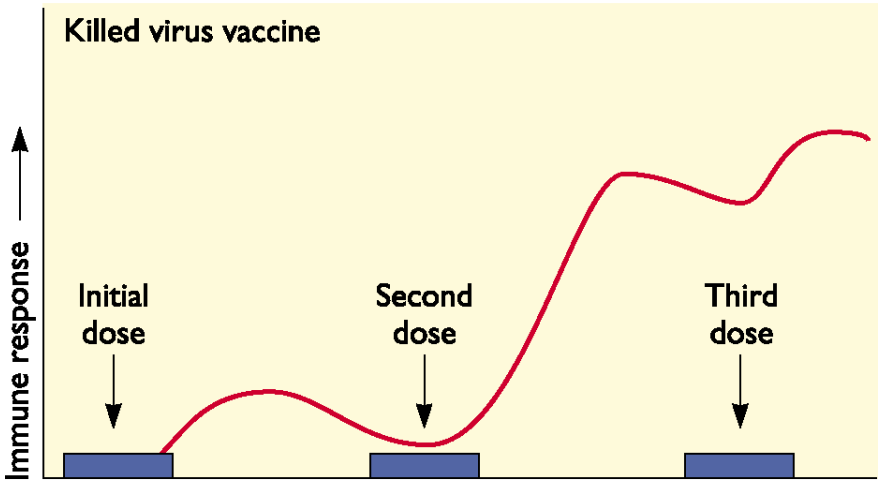
Raccomandazioni dell'OMS per la composizione del vaccino antinfluenzale per la stagione 2016-2017 (Emisfero Nord)

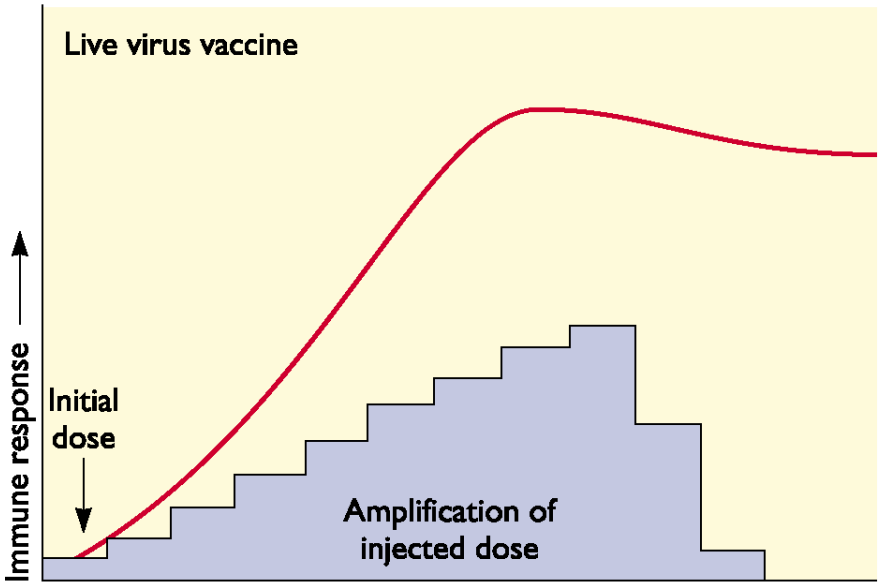
Dal 22 al 24 febbraio 2016 si è svolto a Ginevra il *meeting* annuale dell'OMS per l'aggiornamento della composizione del vaccino antinfluenzale per la stagione 2016/2017.
Le raccomandazioni emanate sono il risultato dei dati di sorveglianza virologica forniti da tutti i Centri Nazionali di riferimento (NIC), afferenti alla rete internazionale dell'OMS, attualmente composta da oltre 140 laboratori.

Qui di seguito viene riportata la nuova composizione vaccinale 2016/2017:

A/California/7/2009 (H1N1)	Presente anche nel vaccino 2015/2016
A/Hong Kong/4801/2014 (H3N2)	**Nuova variante**
B/Brisbane/60/2008 (lineaggio B/Victoria)	**Nuova variante**

VACCINATION: comparison of the predicted immune response to live and killed viruses used as vaccines





Comparison of immune responses to live and killed viruses

VACCINATION:
problems with traditional vaccines

- Disadvantages of inactivated vaccines:

  - they themselselves can cause severe reactions.

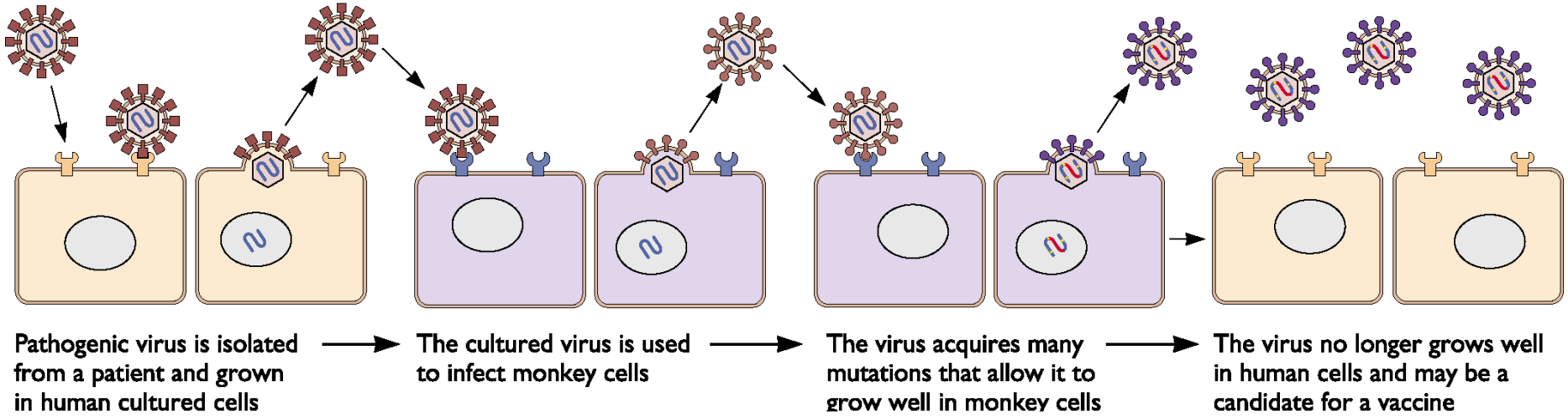
  - the organism or the toxin may not be completlely killed or inactivated.

  - in some cases producing a sufficient quantity of infectious agent is extremerly costly or even impossible (HBV, HPV)

Severe adverse events associated with antiviral vaccine administration

Vaccine implicated	Event
Smallpox ("lymph" vaccines)	Sepsis due to bacterial contamination
Yellow fever (1942)	Vaccine lot contaminated with hepatitis B virus, leading to 28,000 cases of hepatitis B
Inactivated polio (1955)	Incomplete inactivation of virus, leading to 204 cases of paralytic disease (Cutter incident)
Inactivated measles (1960s)	Atypical (severe) disease upon exposure to natural measles infection
Attenuated polio (Sabin)	Vaccine-associated paralysis (~1 per 2.4 million persons vaccinated) due to reversion to more pathogenic strain
Live vaccines (vaccinia, polio, measles)	Dissemination and death in immunocompromised individuals
Attenuated live measles	Unexplained mortality in girls who received high titer formulations (relative risk of death doubled to age 5); more than 20 million doses of vaccine distributed
Inactivated influenza A	Apparent risk of Guillain Barré Syndrome (~1 per 1 million persons vaccinated), only in some years
Rotavirus (1999)	Intussusception—bowel folding and obstruction (vaccine withdrawn)

VACCINATION:
producing attenuated human viruses



Passage history of the Oka-strain VZV vaccine

Isolated by Takahashi et al. in 1974 from three-year-old Japanese boy (family name Oka)

Initial growth in human lung fibroblast cells

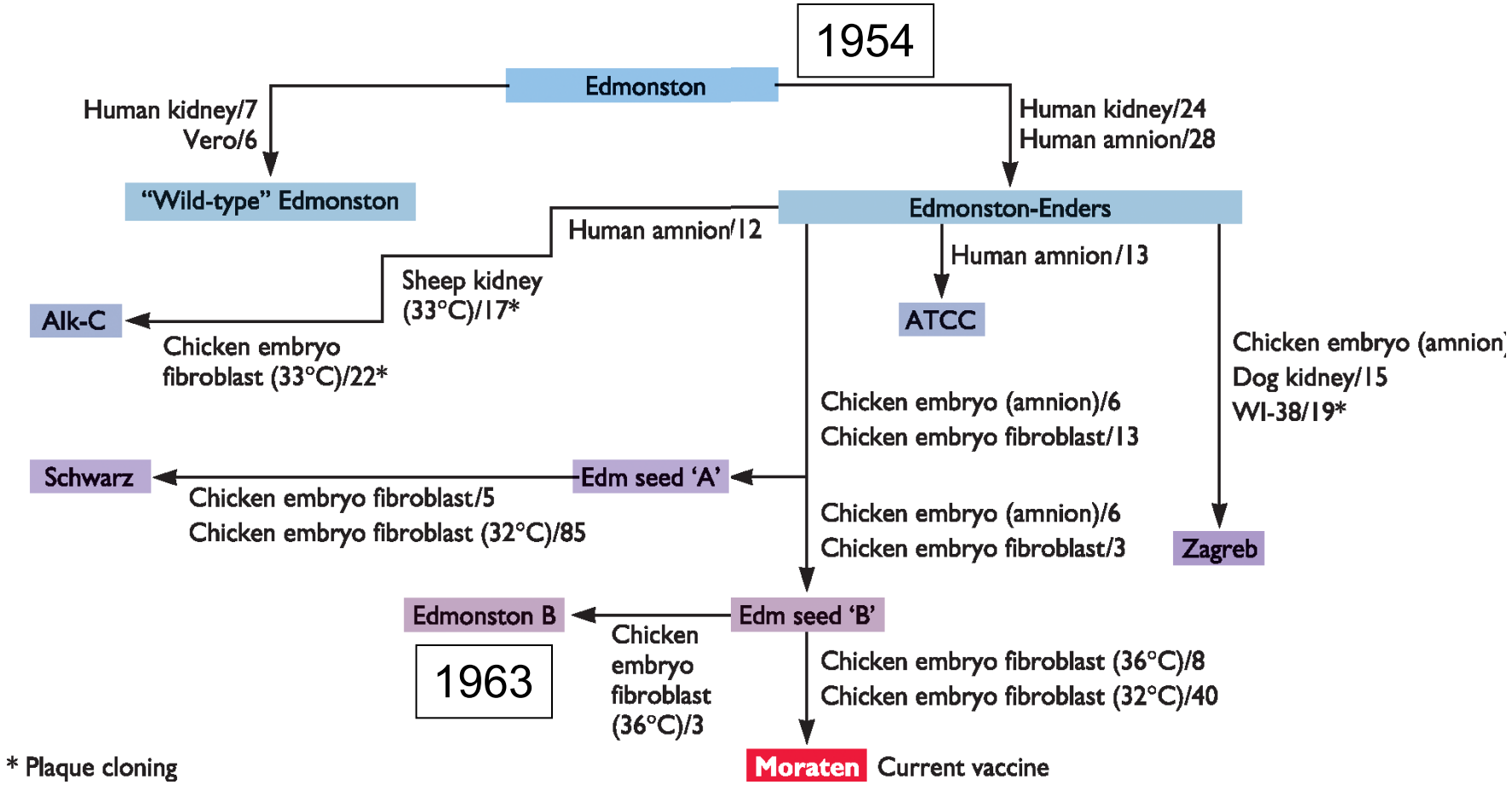
Twelve passages in primary guinea pig fibroblasts

Two passages in WI-38 cells (human diploid fibroblasts)

Three to six passages in MRC-5 cells (human diploid lung cells)

Licensed for use in Japan and Korea in late 1980s, and in USA in 1995

Live attenuated vaccines: passage histories of live attenuated measles virus vaccines derived from original isolate of Edmonston



VACCINATION:
live attenuated oral poliovirus vaccines

A **Derivation of Sabin type 3 attenuated poliovirus**

Type 3
P3/Leon/37
(isolate from fatal paralytic case)

Passages

21 passages in vivo (intracerebrally in monkeys)
8 passages in vitro (monkey testicle cultures)
39 passages in vitro (monkey kidney cultures)
3 plaque purifications (monkey kidney cultures)
3 passages in vitro (preparative, monkey kidney cultures)

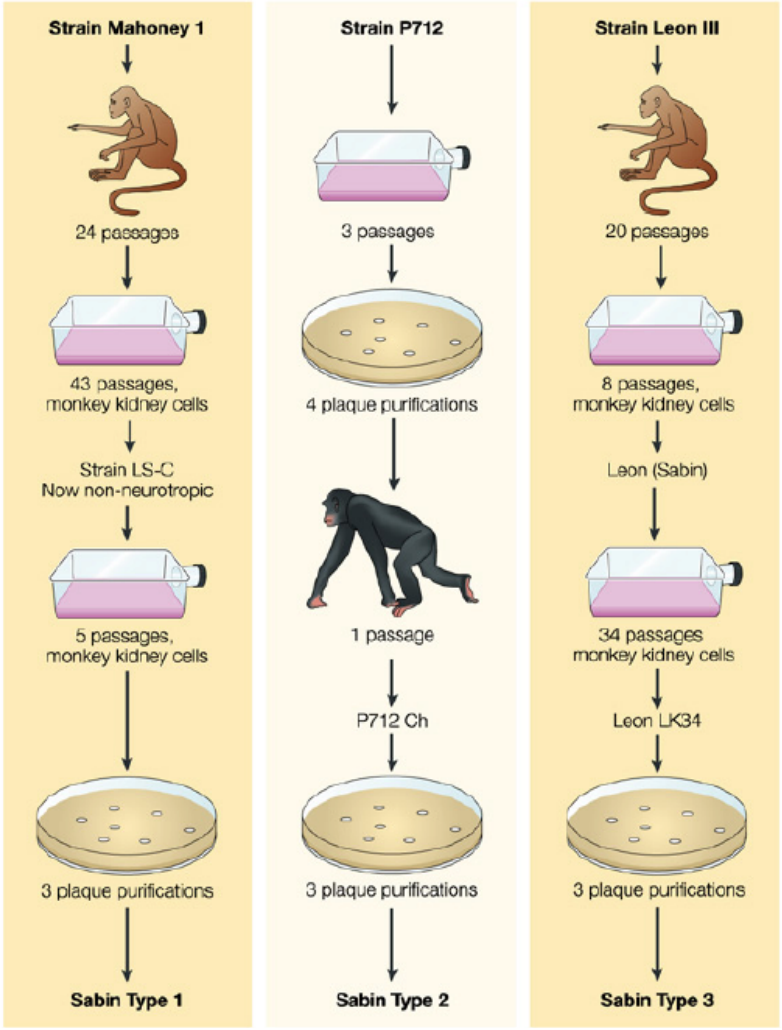
P3/Leon 12a1b KP3/56 Sabin vaccine strain

B **Determinants of attenuation in the Sabin vaccine strains**

Virus	Mutation (location/nucleotide position)
P1/Sabin	5'-UTR (480) VP1 (1106) VP1 (1134) VP3 (3225) VP4 (4065)
P2/Sabin	5'-UTR (481) VP1 (1143)
P3/Sabin	5'-UTR (472) VP3 (3091)

VACCINATION:

live attenuated oral poliovirus vaccines



Attenuation of poliovirus neurovirulence: the Sabins9 OPV licensed in 1961

VACCINATION:
problems with traditional vaccines

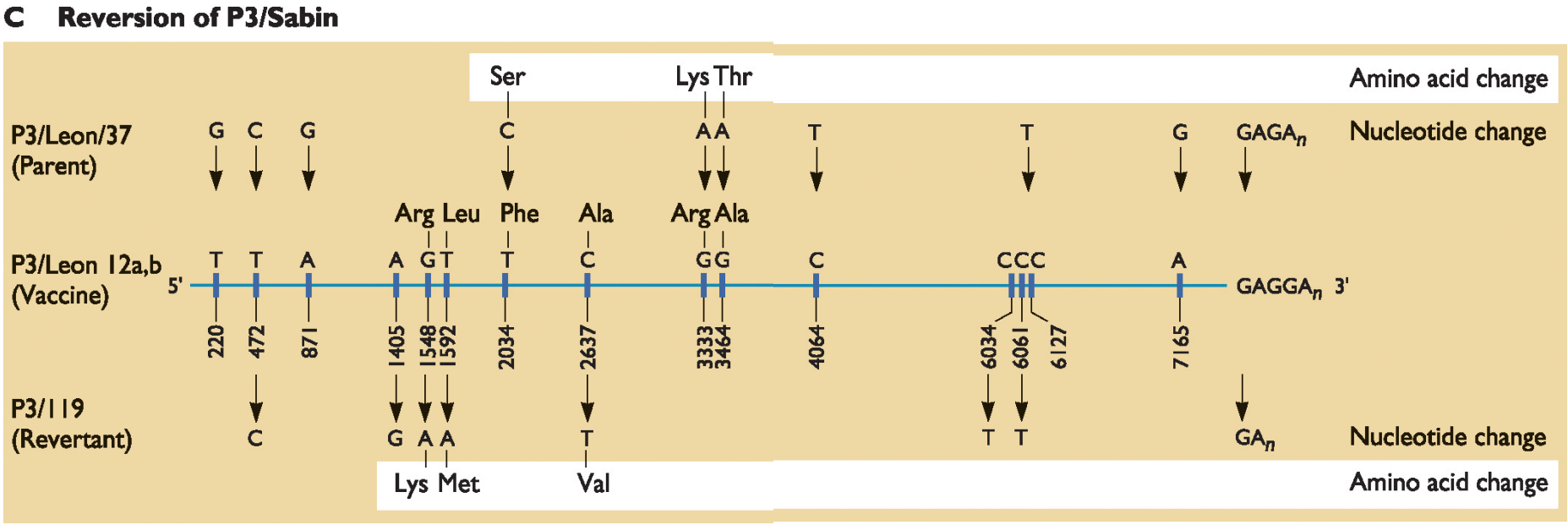
- Disadvantages of attenuated vaccines:

  - reversion to the virulent state (polio).

  - growth in tissue culture cells or in animals poses the risk of introducing hidden viruses from host cells (early lots of polio vaccines- SV40).

  - even attenuated pathogens can produce severe disease in people with immune system deficiences.

VACCINATION:
reversion of P3/sabin (1/790.000)



Virus strain	Number of mutations	Number of amino acid changes	Number of mutations required for return to neurovirulence
Sabin strain 1	57	23	>10
Sabin strain 2	23	5	5–6
Sabin strain 3	~6	3	1–2

Limitations to Current Vaccine Production Methods

- Not all pathogens can be grown in culture
- Cell culture is expensive
- Yield and rate of production may be low
- Extensive safety precautions needed
- Inactivation/attenuation must be 100%
- Attenuated strains might revert
- Limited shelf-life and refrigeration requirements
- Not all diseases preventable by vaccines

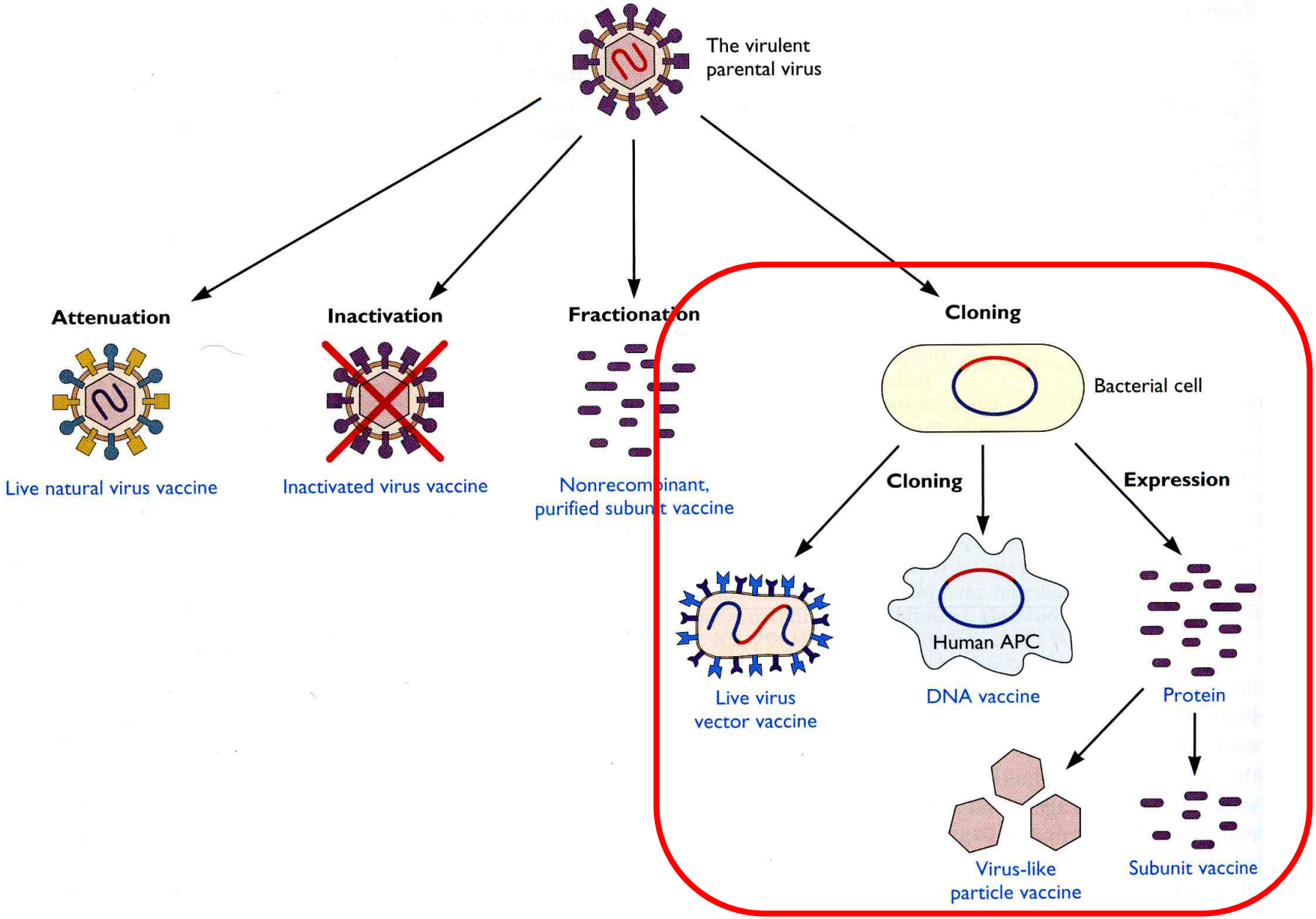
NEW VACCINE TECHNOLOGY:
Impact of rDNA technology approach to vaccine production

1. Attenuate organism by specific deletion of virulence gene (bacmid technology)

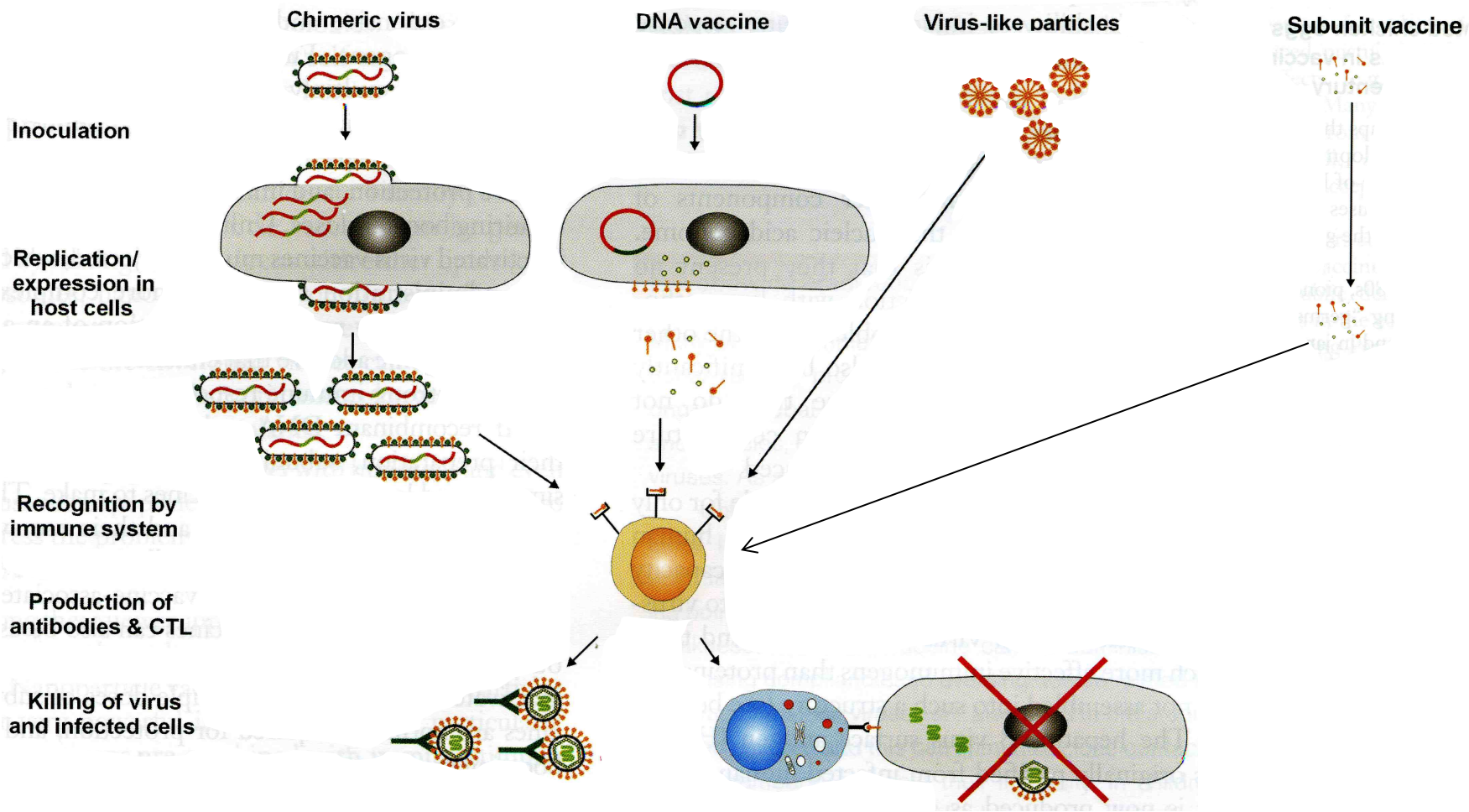
1. Engineer live, non pathogenic carrier (vector)to contain antigenic determinant for disease organism (viral vector technology)

1. If non-culturable, clone pathogen's genes, and overexpress a subset of viral proteins to use as vaccines (subunit vaccines, VLPs)

VACCINATION: how to make a vaccine?



VACCINATION: how to make a vaccine?



Recombinant antiviral vaccines

MODERNS VACCINES

- Subunit Vaccines
- Peptide Vaccines
- Genetic Immunization
- Attenuated Vaccines
- Vector Vaccines

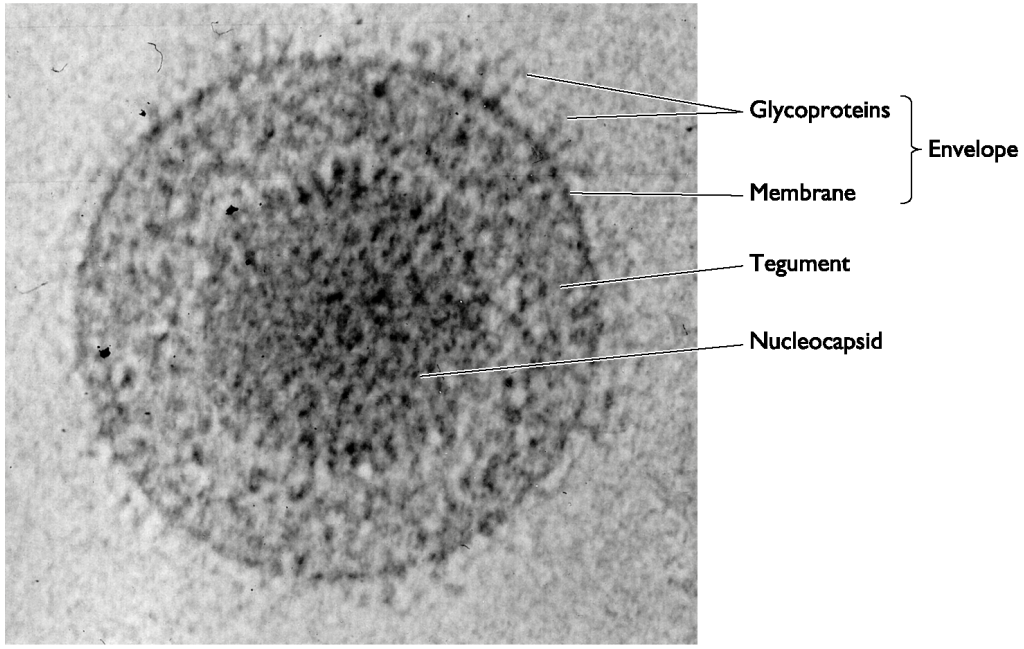
MODERNS VACCINES

- **Subunit Vaccines**
- Peptide Vaccines
- Genetic Immunization
- Attenuated Vaccines
- Vector Vaccines

Subunit Vaccines

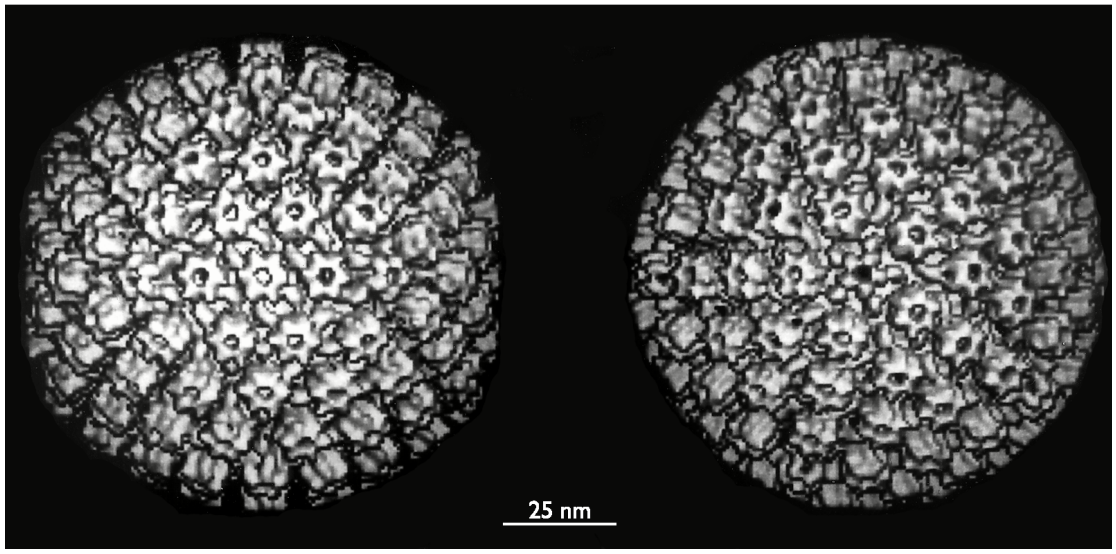
- Generally whole pathogenic agent used to construct attenuated or inactivated vaccine
- Immune response generally elicited by interaction with proteins on outer surface of pathogen

A



Subunit vaccines for viruses

B



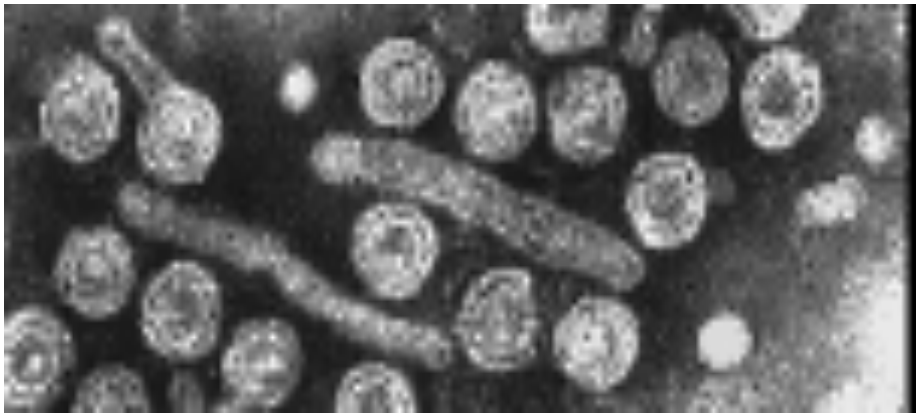
Subunit Vaccine

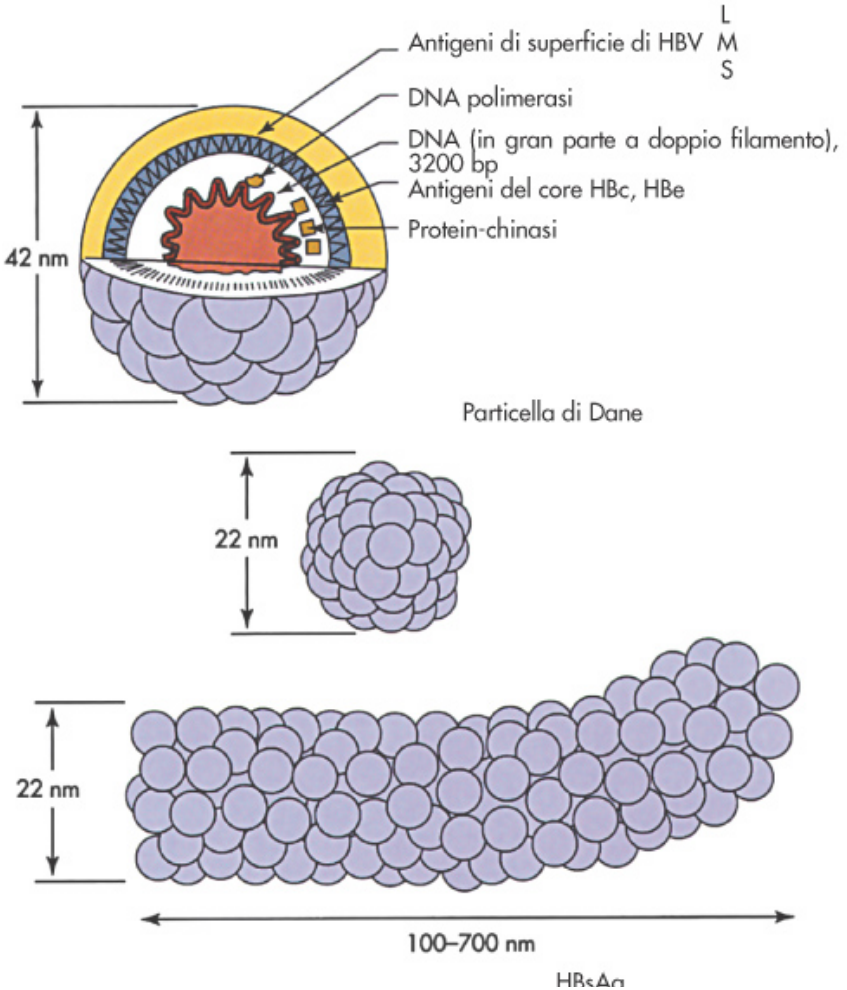
- So, is the entire pathogen required?

- No, only outer surface proteins are needed to elicit an immune response
- Vaccines that use components of a pathogen rather than the whole organism are “subunit” vaccines

Subunit Vaccine

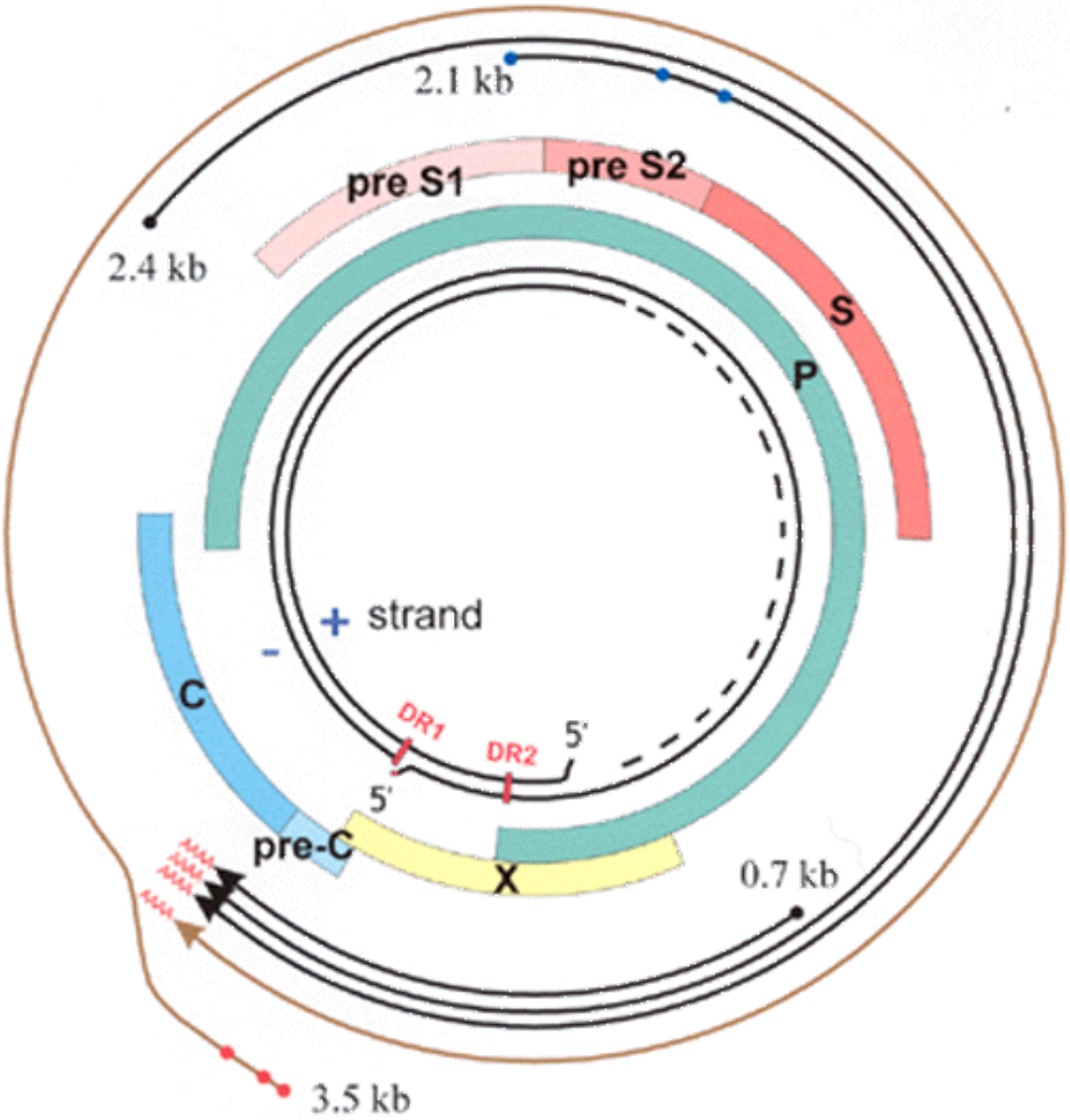
- Advantages
  - Easily to produce
  - Using a purified protein ensures that the vaccine is safe and stable
  - Inexpensively
- Disadvantages
  - Isolated protein may not have the same conformation as in the pathogen, so may not have the same antigenicity (weakness and short duration of immunity)
  - It may also be necessary to administer the antigen in a specific manner (in a concentrated form, with adjuvants





Virus-like particles (VLPs)vaccines: HBV

Subunit Vaccine - Example: HBV



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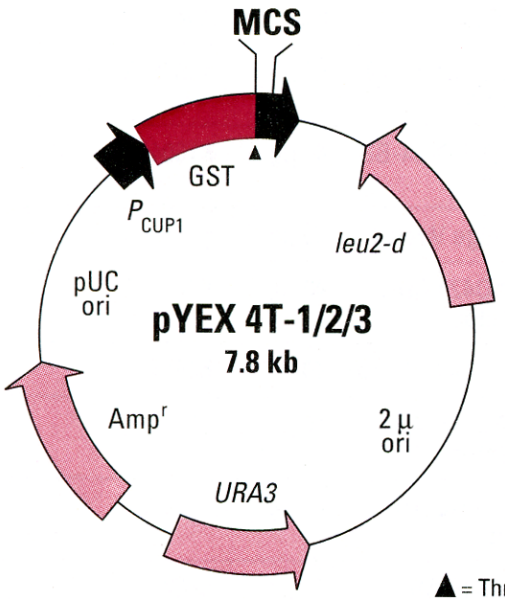

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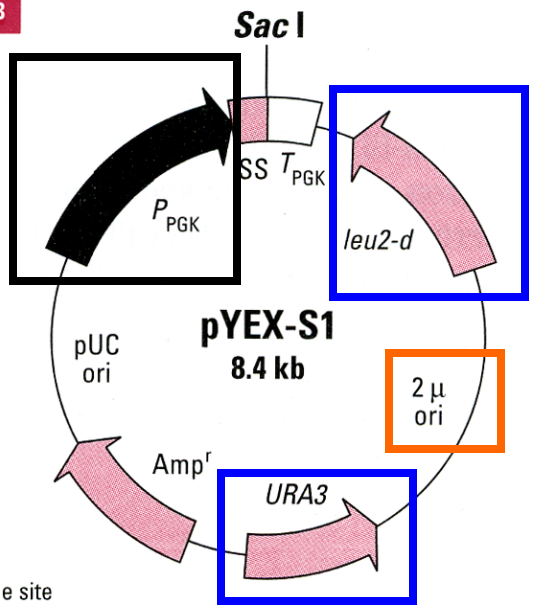


▲ = Thrombin cleavage site

C

pYex 4T-1 MCS

Thrombin recognition site ↓ — STOPs

CTG GTT CCG CGT GGA TCC CCG GAA TTC CCG GGT CGA CTC GAG CGG CCG CAT CGT GAC TGA CTG A

BamH I *EcoR I* *Sma I* *Sal I* *Xho I* *Not I*

pYex 4T-2 MCS

Thrombin recognition site ↓ — STOPs

CTG GTT CCG CGT GGA TCC CCA GGA ATT CCC GGG TCG ACT CGA GCG GCC GCA TCG TGA CTG ACT GA

BamH I *EcoR I* *Sma I* *Sal I* *Xho I* *Not I*

pYex 4T-3 MCS

Thrombin recognition site ↓ — STOPs

CTG GTT CCG CGT GGA TCC CCG AAT TCC CGG GTC GAC TCG AGC GGC CGC ATC GTG ACT GAC TGA

BamH I *EcoR I* *Sma I* *Sal I* *Xho I* *Not I*

pYex-Bx MCS

GGA TCC GCA GCT GTC GAC TGC AGA ATT C

BamH I *Pvu* II *Sal I* *Pst I* *EcoR I*

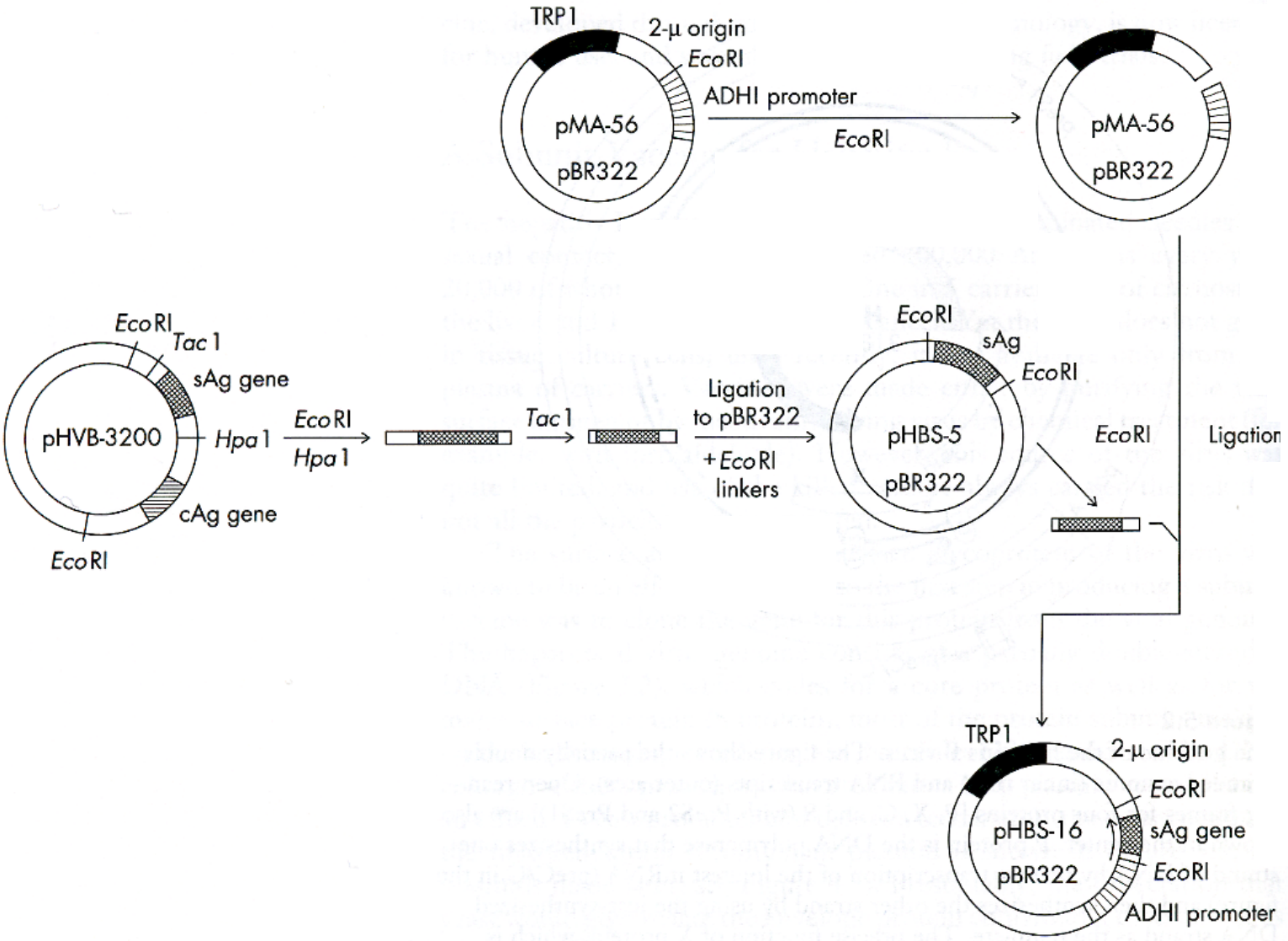
pYex-S1 MCS

KEX2 ↓

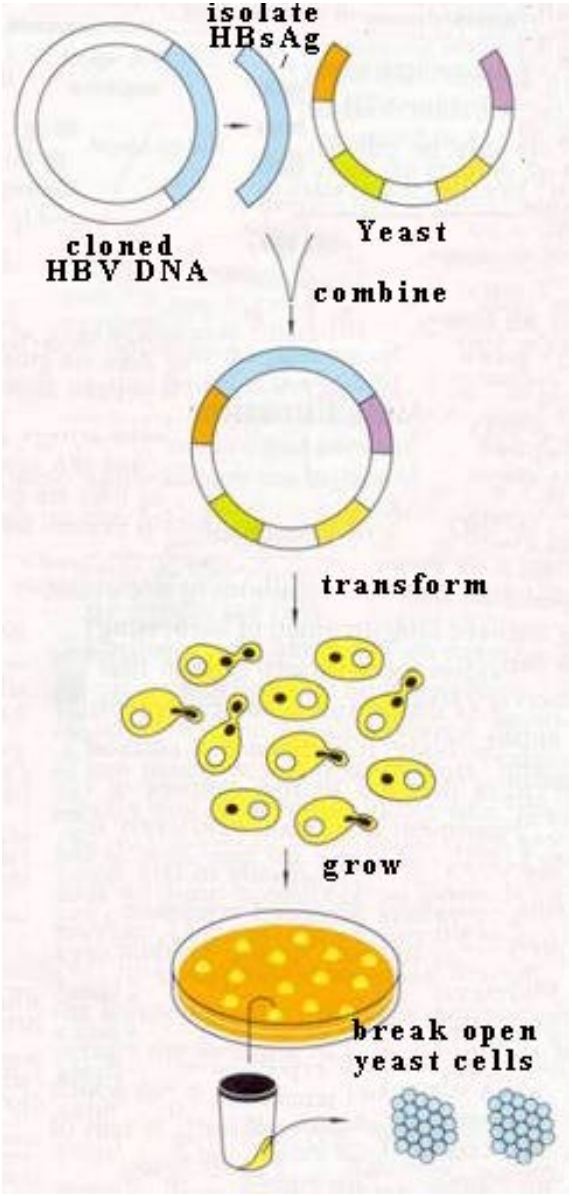
AAA AGG AGC TCG AAT TC

Sac I *Eco*R I

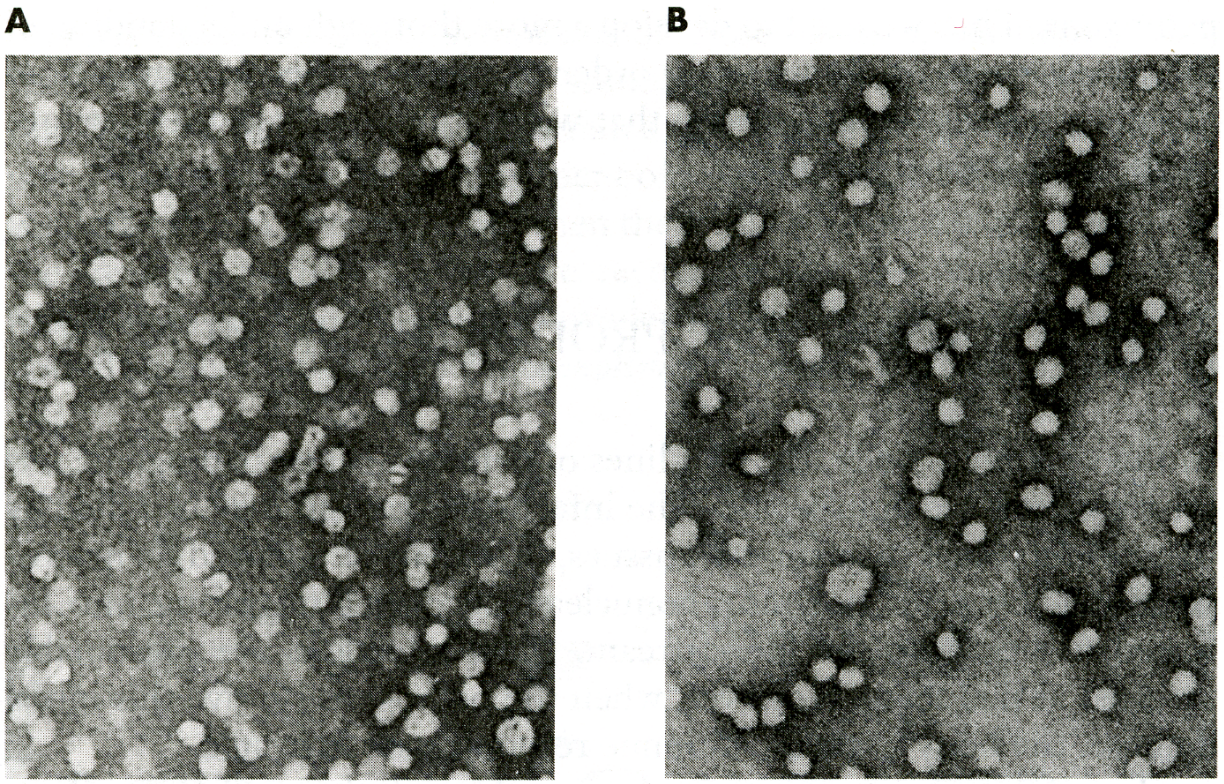
Subunit Vaccine - Example: HBV



Subunit Vaccine - Example: HBV



Subunit Vaccine - Example: HBV



Negative stained electron micrographs of (A) plasma-derived and (B) yeast-derived hepatitis B surface antigen vaccines

MERCK & CO., INC.
Whitehouse Station, NJ 08889, USA

7994332

RECOMBIVAX HB®
HEPATITIS B VACCINE (RECOMBINANT)

DESCRIPTION

RECOMBIVAX HB® Hepatitis B Vaccine (Recombinant) is a non-infectious subunit viral vaccine derived from hepatitis B surface antigen (HBsAg) produced in yeast cells. A portion of the hepatitis B virus gene, coding for HBsAg, is cloned into yeast, and the vaccine for hepatitis B is produced from cultures of this recombinant yeast strain according to methods developed in the Merck Research Laboratories.

The antigen is harvested and purified from fermentation cultures of a recombinant strain of the yeast *Saccharomyces cerevisiae* containing the gene for the *adw* subtype of HBsAg. The fermentation process involves growth of *Saccharomyces cerevisiae* on a complex fermentation medium which consists of an extract of yeast, soy peptone, dextrose, amino acids and mineral salts. The HBsAg protein is released from the yeast cells by cell disruption and purified by a series of physical and chemical methods. The purified protein is treated in phosphate buffer with formaldehyde and then coprecipitated with alum (potassium aluminum sulfate) to form bulk vaccine adjuvanted with amorphous aluminum hydroxyphosphate sulfate. The vaccine contains no detectable yeast DNA but may contain not more than 1% yeast protein. The vaccine produced by the Merck method has been shown to be comparable to the plasma-derived vaccine in terms of animal potency (mouse, monkey, and chimpanzee) and protective efficacy (chimpanzee and human).

The vaccine against hepatitis B, prepared from recombinant yeast cultures, is free of association with human blood or blood products.

PRESCRIBING INFORMATION

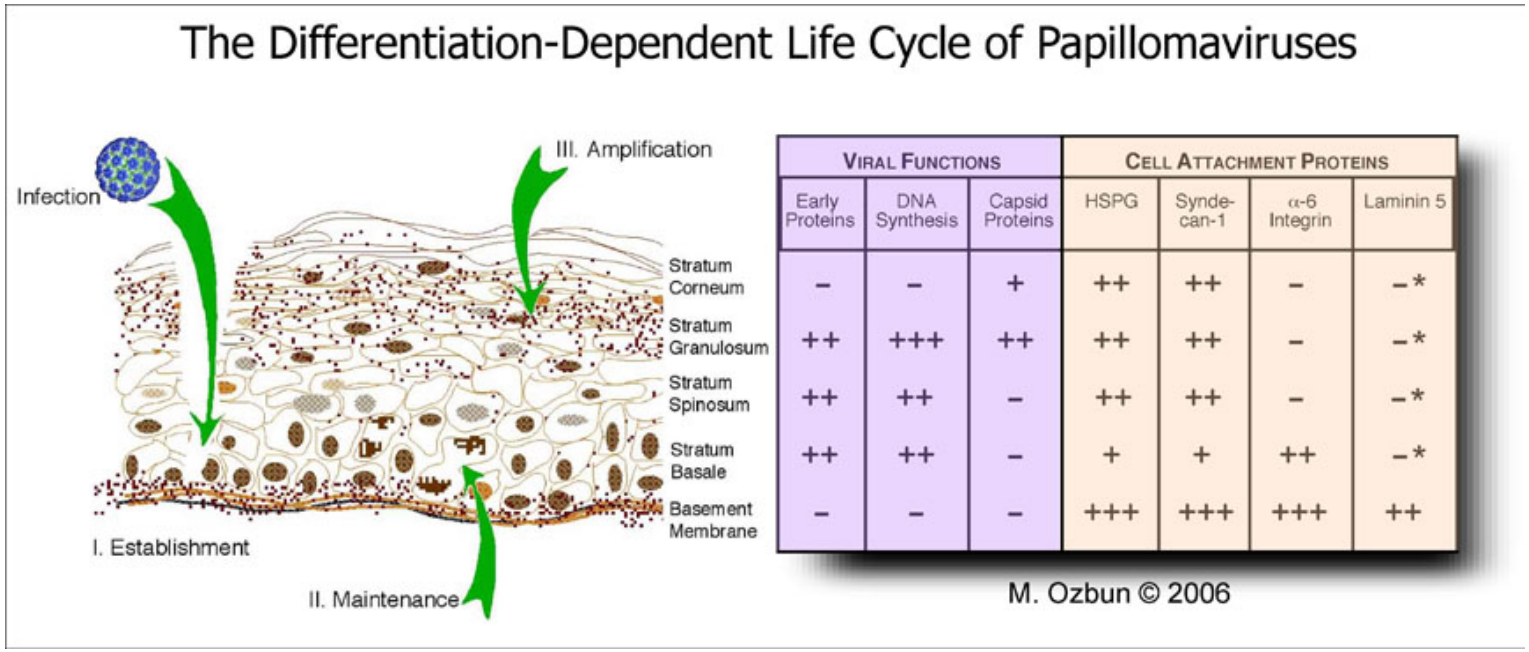
ENGERIX-B®
[Hepatitis B Vaccine (Recombinant)]

DESCRIPTION

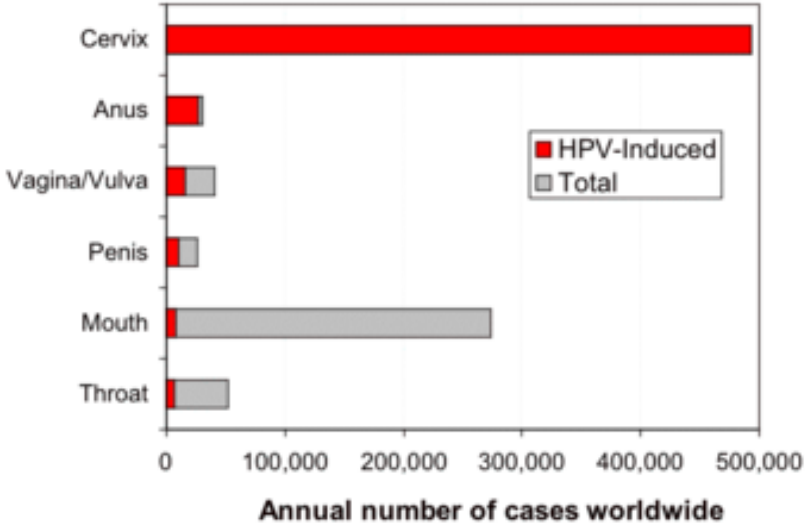
ENGERIX-B [Hepatitis B Vaccine (Recombinant)] is a noninfectious recombinant DNA hepatitis B vaccine developed and manufactured by GlaxoSmithKline Biologicals. It contains purified surface antigen of the virus obtained by culturing genetically engineered *Saccharomyces cerevisiae* cells, which carry the surface antigen gene of the hepatitis B virus. The surface antigen expressed in *Saccharomyces cerevisiae* cells is purified by several physicochemical steps and formulated as a suspension of the antigen adsorbed on aluminum hydroxide. The procedures used to manufacture ENGERIX-B result in a product that contains no more than 5% yeast protein. No substances of human origin are used in its manufacture.

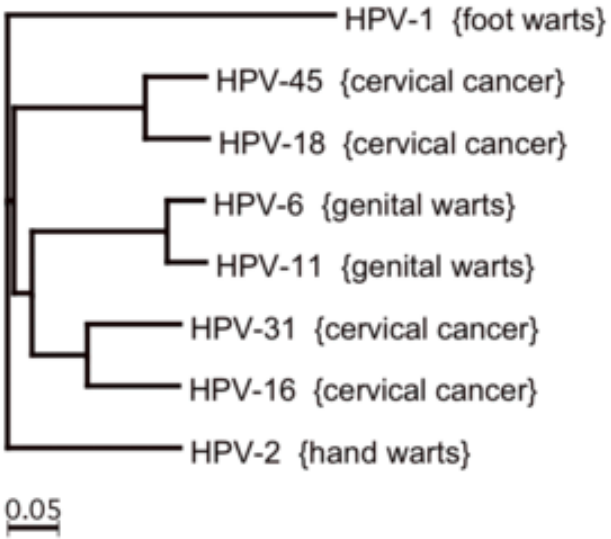
ENGERIX-B is supplied as a sterile suspension for intramuscular administration. The vaccine is ready for use without reconstitution; it must be shaken before administration since a fine white deposit with a clear colorless supernatant may form on storage.

Virus-like particles (VLPs) vaccines: HPV

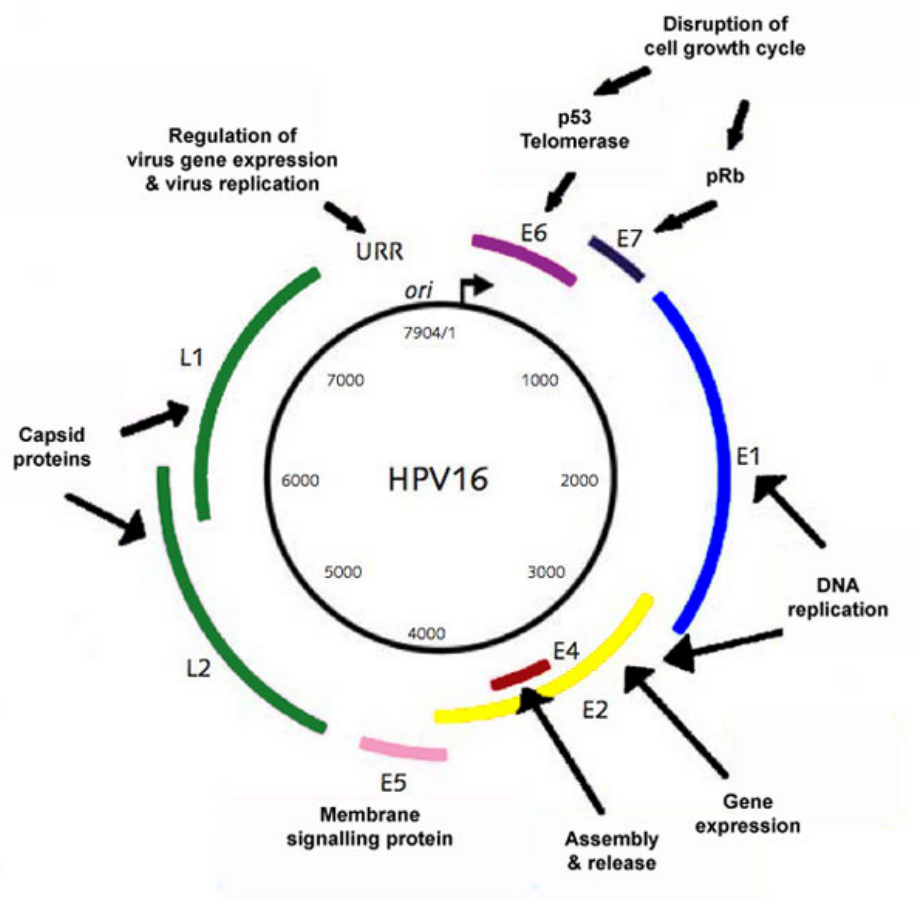


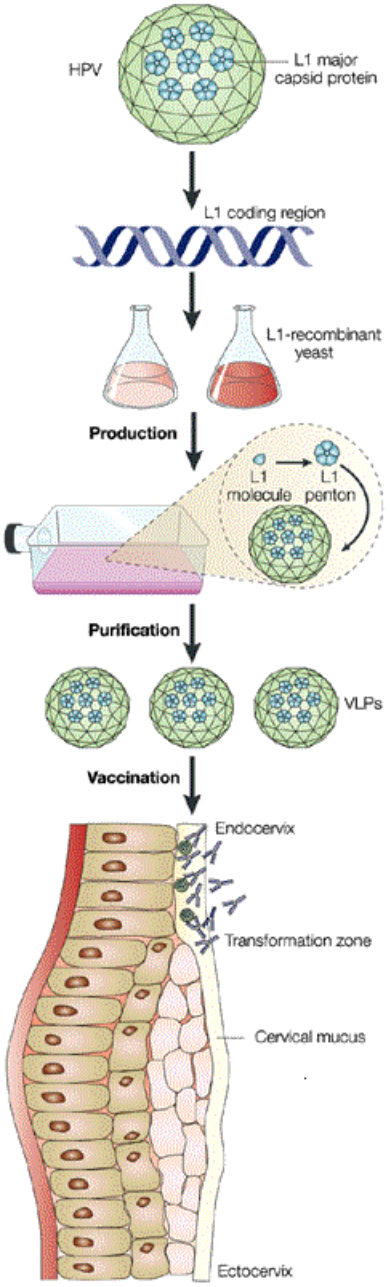
Viral Functions			Cell Attachment Proteins			
Early Proteins	DNA Synthesis	Capsid Proteins	HSPG	Syndecan-1	α-6 Integrin	Laminin 5
–	–	+	++	++	–	–*
++	+++	++	++	++	–	–*
++	++	–	++	++	–	–*
++	++	–	+	+	++	–*
–	–	–	+++	+++	+++	++





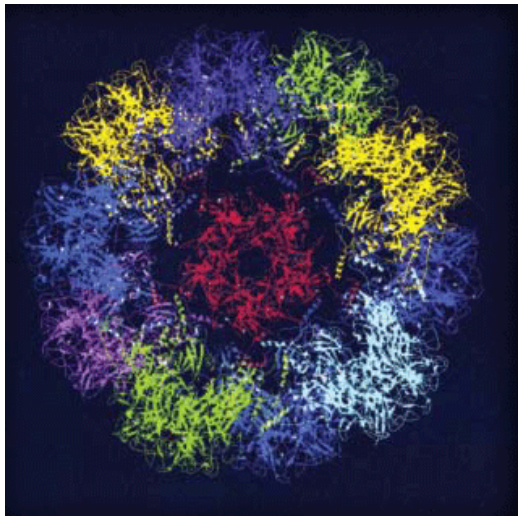
Virus-like particles (VLPs) vaccines: HPV

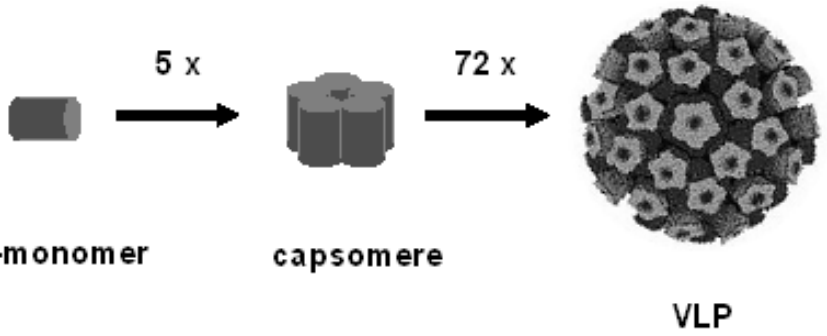


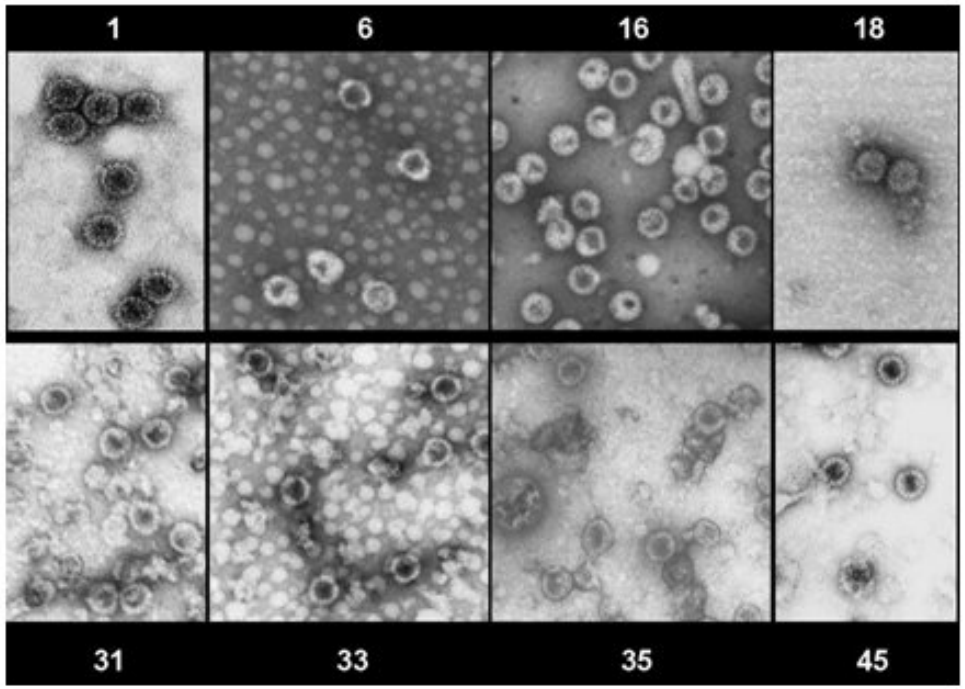


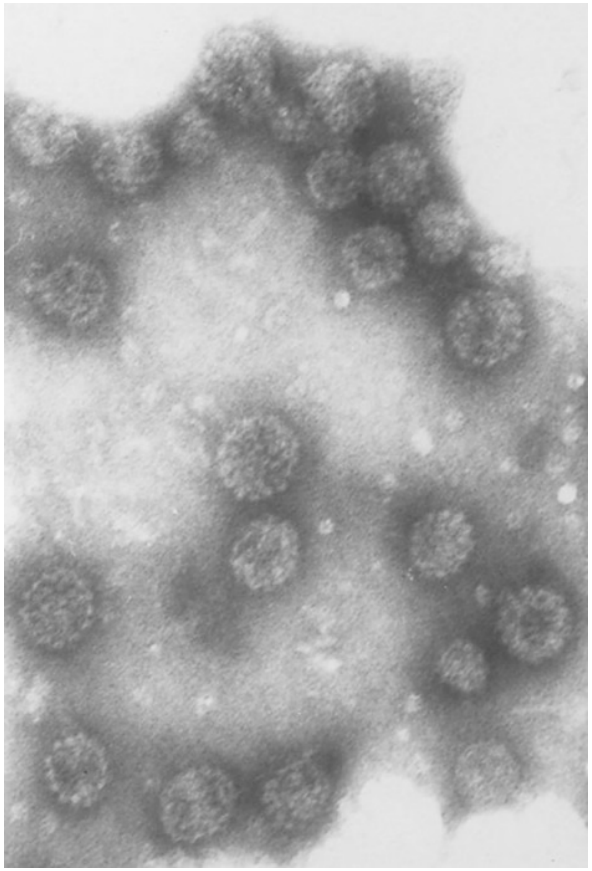
Nature Reviews | Microbiology

Virus-like particles (VLPs)vaccines: HPV



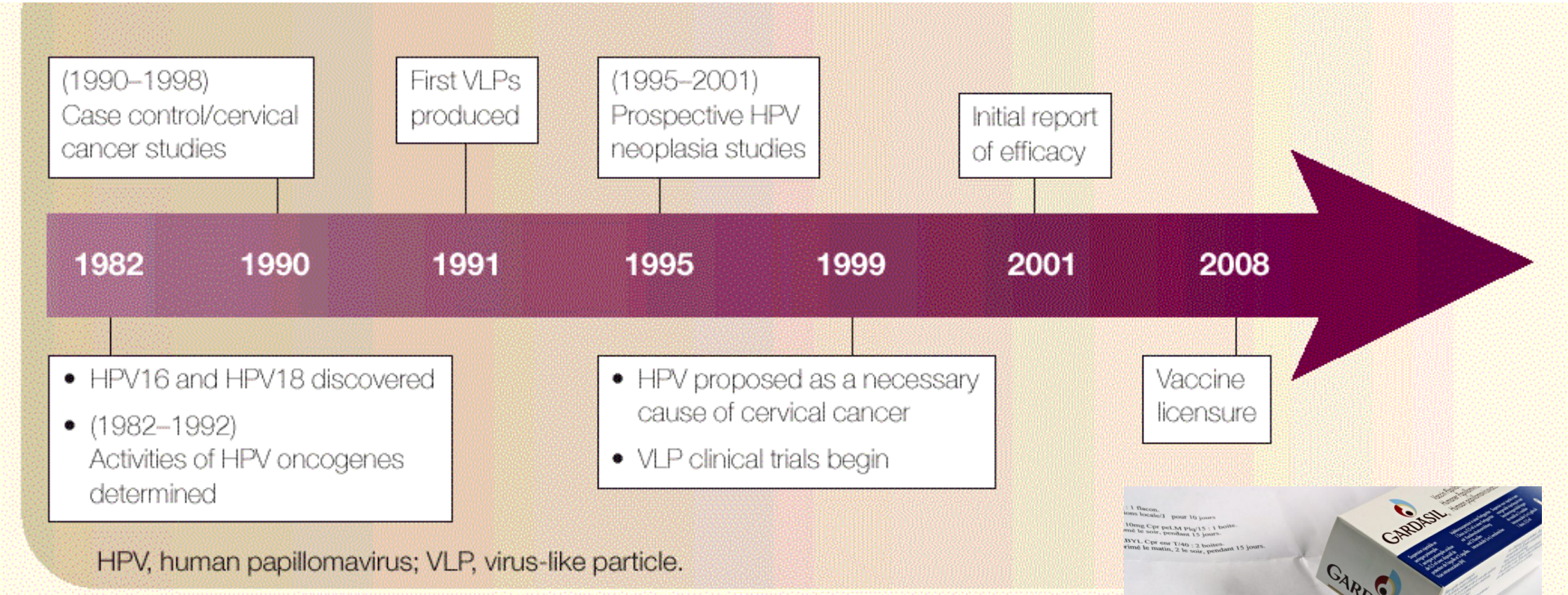






Virus-like particles (VLPs)vaccines: HPV

HPV VLPs vaccine development: ***timeline***



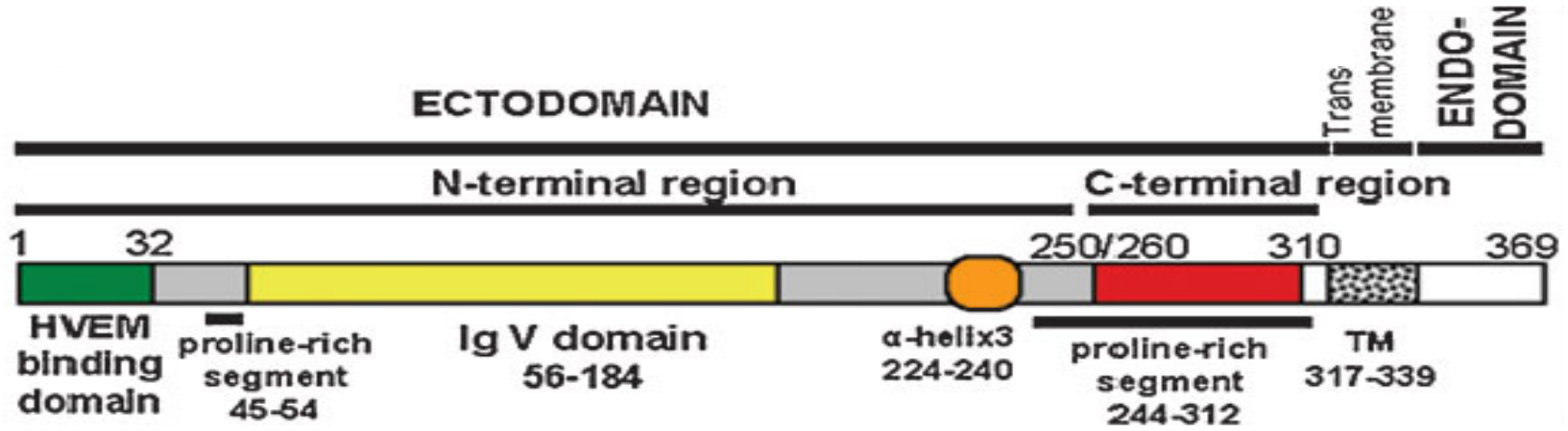
The failure of a subunit Vaccine - HSV

- Herpes Simplex Viruses (HSV-1,2)
  - sexually transmitted disease (HSV-2)
  - cancer associated agent (HSV-2)
  - encephalitis and severe eye infections
- Subunit vaccine would be best
  - inactivated or attenuated virus would have to be 100% or risk infecting patient

Subunit Vaccine - Example: HSV Target Antigenic Protein

- Herpes Simplex Virus
  - What is the antigenic target?
  - HSV viral envelope glycoprotein D
  - gD interacts with entry receptors (HVEM, nectin-1, 3-O-sulphated HS)

Structure and function of HSV **gD** glycoprotein

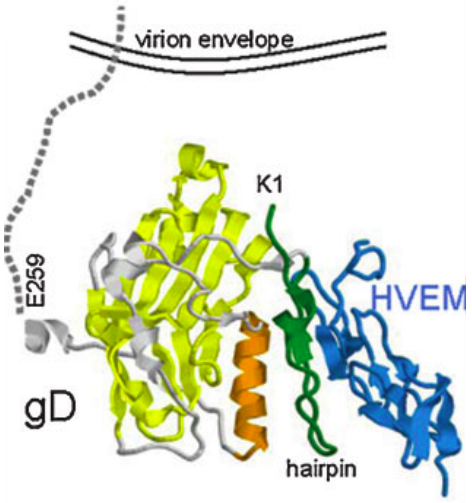


Campadelli *et al*., 2007

- **369 aa**
- **organized in three domains:**

1) ecto-domain: aa 1-317

N-terminal: aa 1-260
core: aa 56-184;
α-helix, aa 224-240
C-terminal: aa 261-310



2) trans-membrane domain: aa 318-339
3) endo-domain: aa 340-369

gD functions:

1) **receptor recognition**
2) **triggering of fusion**

Functions of HSV **gD**: receptor recognition

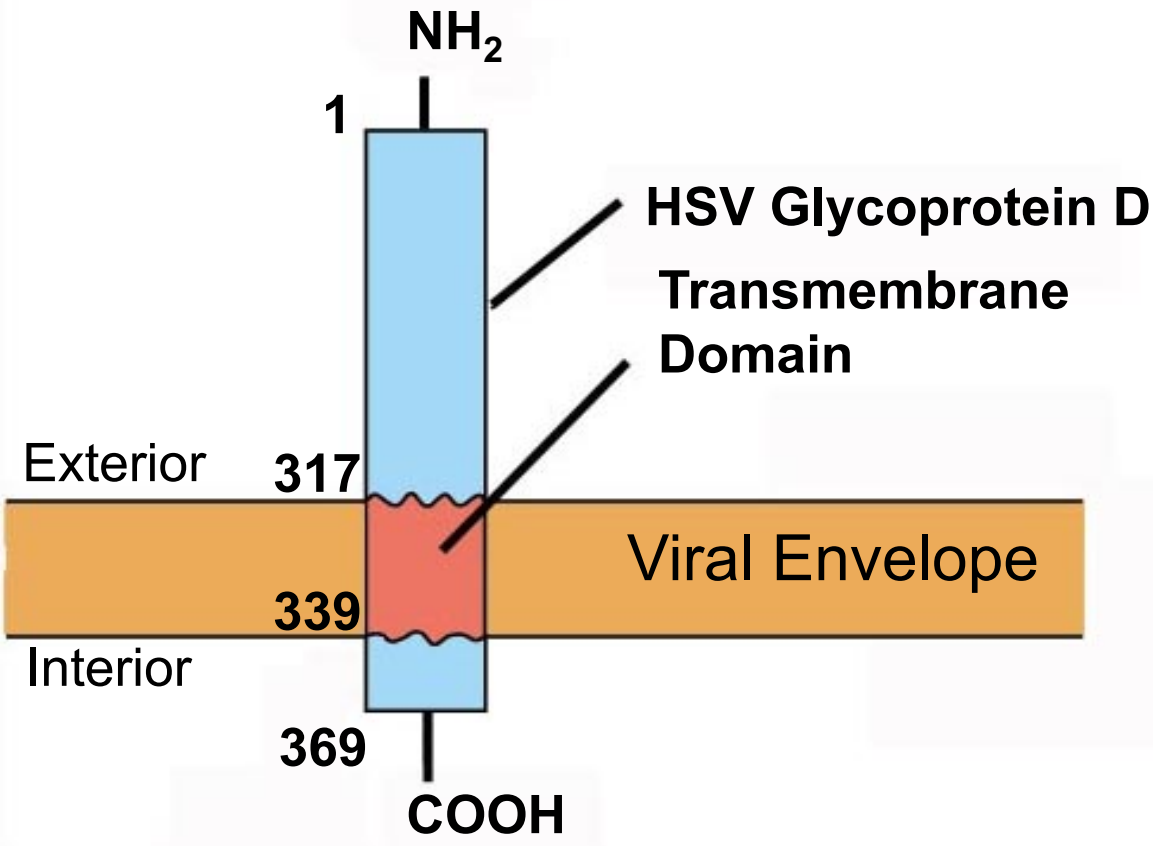
The three natural gD receptors:

1. **herpesvirus entry mediator (HVME):**
   tumor necrosis factor receptor family;
   in T-lymphocytes or lymphoyd organ.
   HVEM binding-site: aa 1-32 (contact residues between aa 7-15 and 24-32).

2. **nectin 1:**
   intercellular adhesion molecules family;
   in sensory neurons, muco-epithelia or epithelia cells.
   nectin-1 binding-site: critical aa residues (aa 34, 38, 215 and aa 222-223).

3. **O-sulphated HS (heparan sulfate):**
   modified heparan sulfate by enzymes in neuronal and endothelial cells, corneal fibroblasts.

HSV Glycoprotein D



HSV glycoprotein D vaccine

- Isolate gene
- Clone into mammalian exp. system
- Purify expressed protein

- Membrane proteins typically difficult to purify - aggregate
  - Mutate so not membrane bound

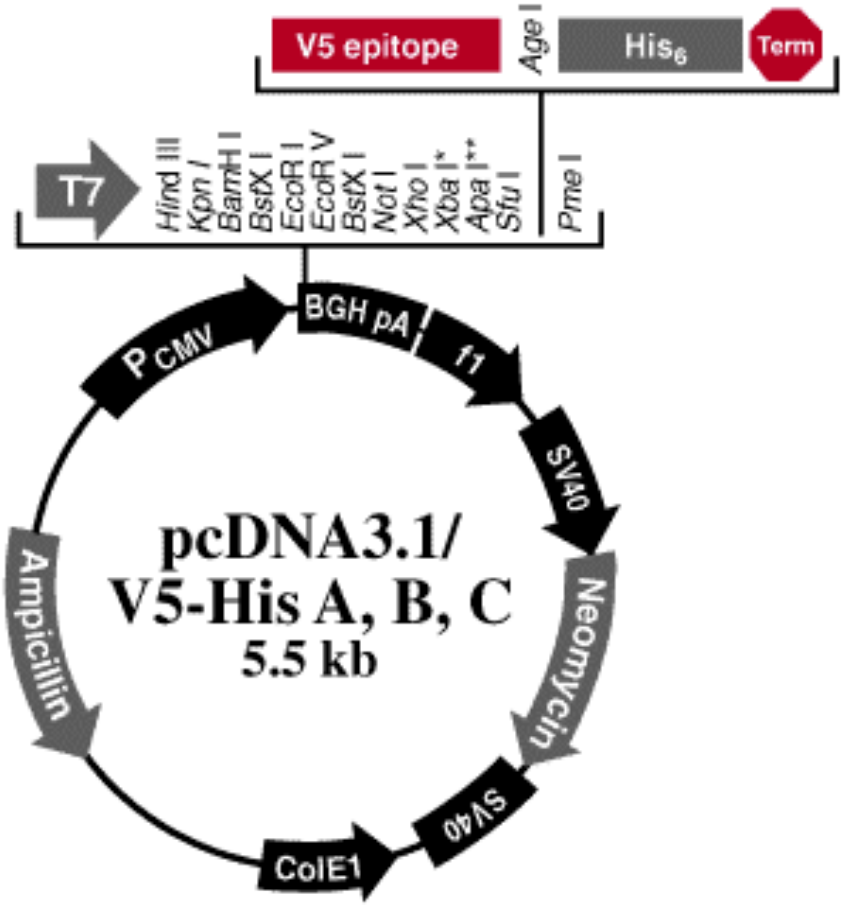
A Mammalian expression vector

Comments for pcDNA3.1/V5-His A
5503 nucleotides

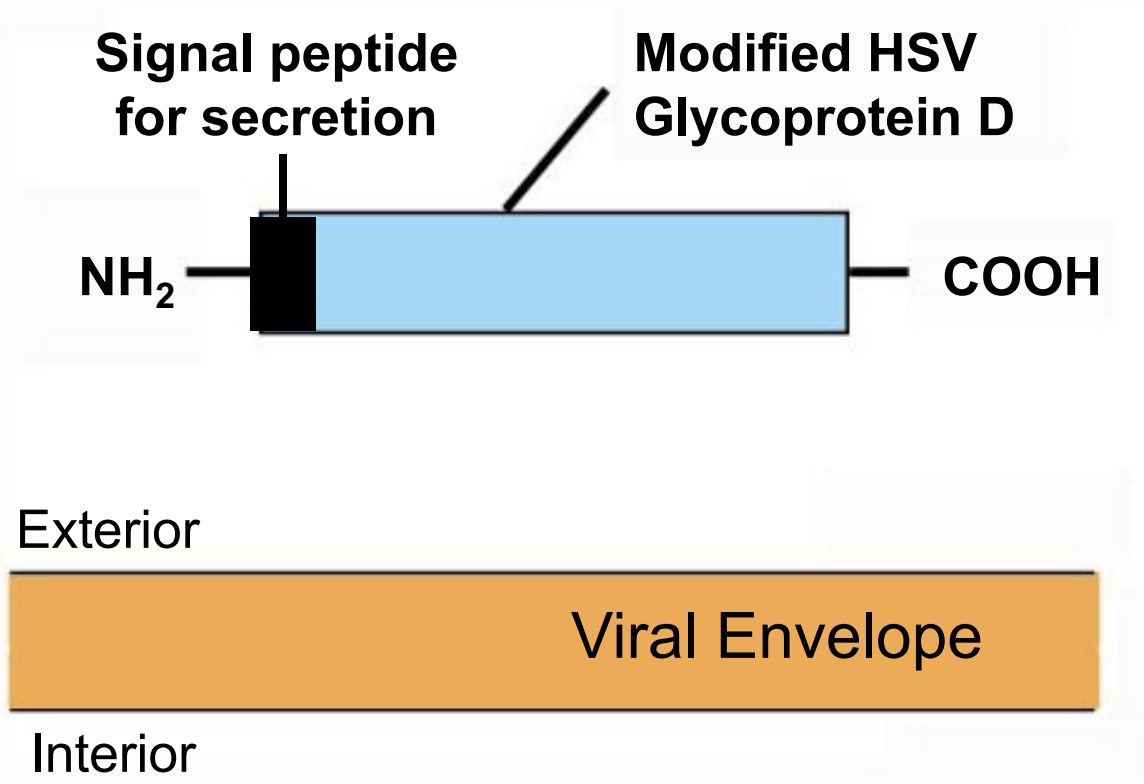
CMV promoter: bases 209-863
T7 promoter/priming site: bases 863-882
Multiple cloning site: bases 902-999
V5 epitope: bases 1000-1041
Polyhistidine tag: bases 1051-1068
pcDNA3.1/BGH reverse priming site: bases 1091-1108
BGH polyadenylation signal: bases 1090-1304
f1 origin of replication: bases 1357-1780
SV40 promoter and origin: bases 1845-2170
Neomycin resistance gene: bases 2206-3000
SV40 polyadenylation signal: bases 3019-3257
ColE1 origin: bases 3689-4362
Ampicillin resistance gene: bases 4507-5367

* After the *Xho* I site, there is a unique *BstE* II site, but no *Xba* I or *Apa* I sites in version C.

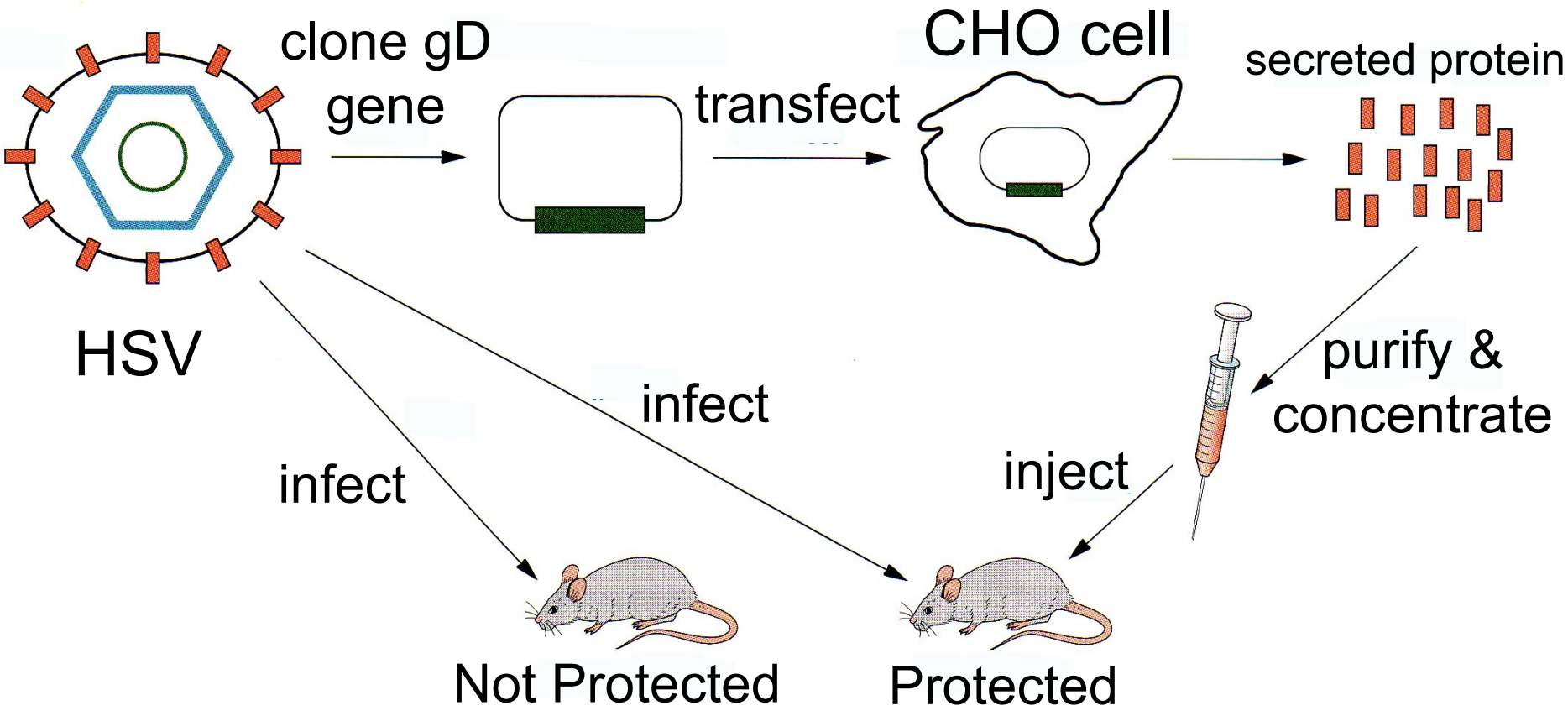
** There is a unique *Sac* II site between the *Apa* I site and the *Sfu* I site in version B only.



Modified HSV glycoprotein D



Development of Subunit Vaccine against HSV



HSV glycoprotein D vaccine

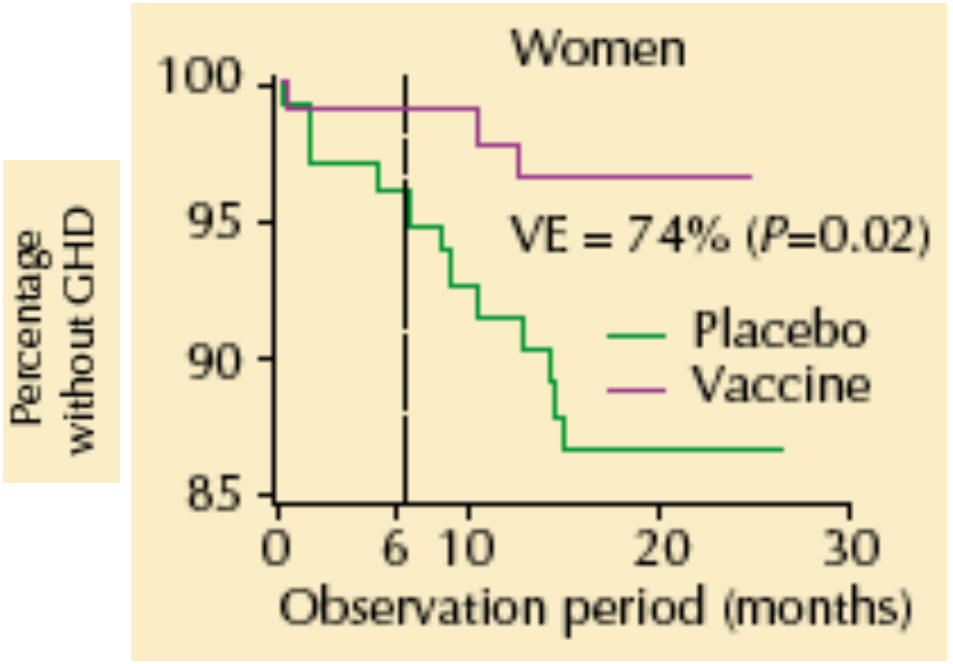
- HSV Subunit vaccine production
  - Transfect modified glycoprotein gene into mammalian cells
  - Overexpress
  - Purify
- Modified HSV glycoprotein D was effective against both HSV-1 and HSV-2 in animal lab tests

HSV glycoprotein D vaccine

Table 4: Summary of human trials of prophylactic herpes simplex virus (HSV) vaccines

Vaccine	Manufacturer
Live-attenuated/replication disabled	
R7020	Pasteur Merieux[2]*
ICP10DPK	AuRx Inc.[32]
Killed/viral component	
Skinner[7–9]	
Cappel *et al.*[14]	
HSV-2 GS	Merck, Sharpe & Dohme[16]
Biocine	Chiron[60]*
gD2/gB2/ MF59	Chiron[35]
Simplirix (gD2/MPL-alum)	GlaxoSmithKline[3]

*Trial referred to within this reference.



ORIGINAL ARTICLE

Efficacy Results of a Trial of a Herpes Simplex Vaccine

Robert B. Belshe, M.D., Peter A. Leone, M.D., David I. Bernstein, M.D., Anna Wald, M.D., Myron J. Levin, M.D., Jack T. Stapleton, M.D., Iris Gorfinkel, M.D., Rhoda L. Ashley Morrow, Ph.D., Marian G. Ewell, Sc.D., Abbie Stokes-Riner, Ph.D., Gary Dubin, M.D., Thomas C. Heineman, M.D., Ph.D., Joann M. Schulte, D.O., and Carolyn D. Deal, Ph.D., for the Herpevac Trial for Women

ABSTRACT

BACKGROUND

Two previous studies of a herpes simplex virus type 2 (HSV-2) subunit vaccine containing glycoprotein D in HSV-discordant couples revealed 73% and 74% efficacy against genital disease in women who were negative for both HSV type 1 (HSV-1) and HSV-2 antibodies. Efficacy was not observed in men or HSV-1 seropositive women.

METHODS

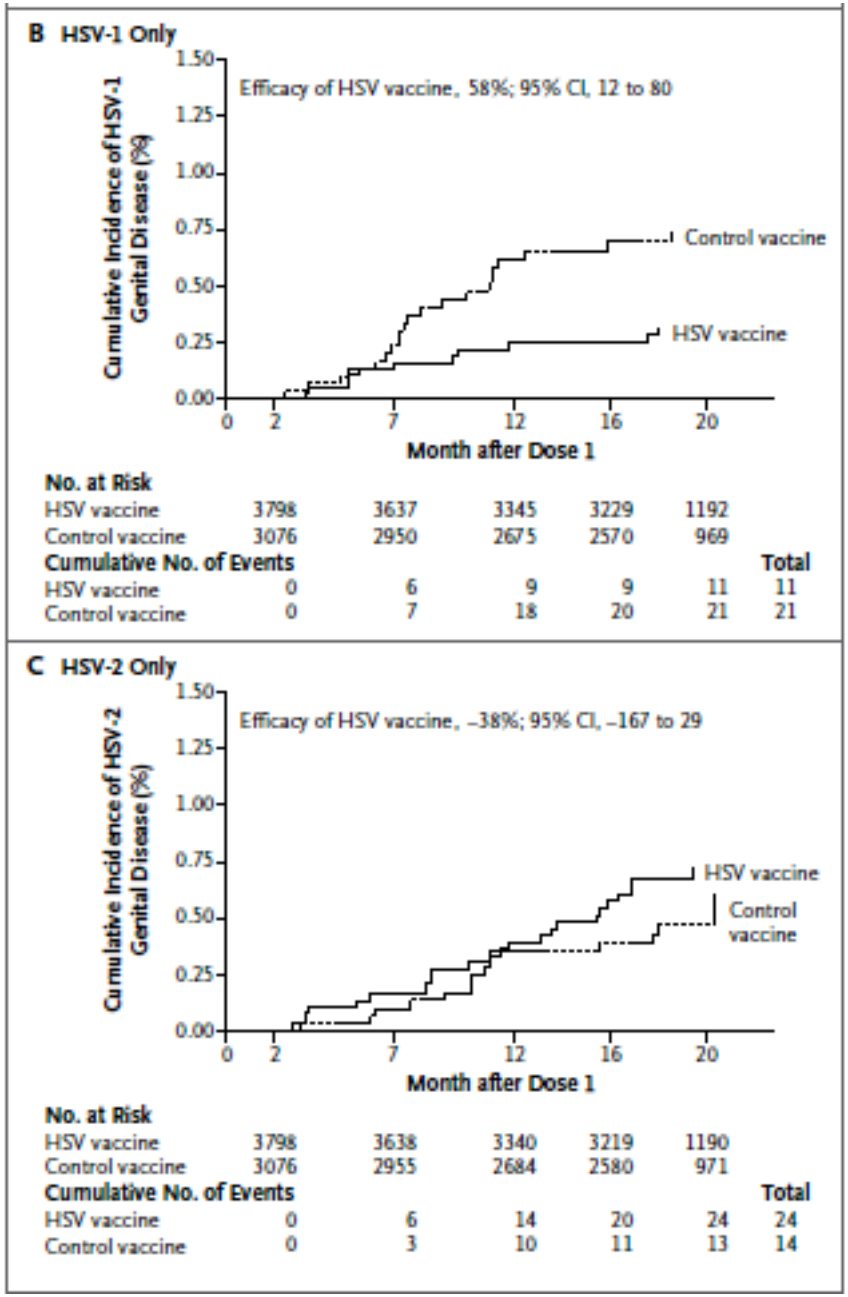
We conducted a randomized, double-blind efficacy field trial involving 8323 women 18 to 30 years of age who were negative for antibodies to HSV-1 and HSV-2. At months 0, 1, and 6, some subjects received the investigational vaccine, consisting of 20 μg of glycoprotein D from HSV-2 with alum and 3-*O*-deacylated monophosphoryl lipid A as an adjuvant; control subjects received the hepatitis A vaccine, at a dose of 720 enzyme-linked immunosorbent assay (ELISA) units. The primary end point was occurrence of genital herpes disease due to either HSV-1 or HSV-2 from month 2 (1 month after dose 2) through month 20.

RESULTS

The HSV vaccine was associated with an increased risk of local reactions as compared with the control vaccine, and it elicited ELISA and neutralizing antibodies to HSV-2. Overall, the vaccine was not efficacious; vaccine efficacy was 20% (95% confidence interval [CI], −29 to 50) against genital herpes disease. However, efficacy against HSV-1 genital disease was 58% (95% CI, 12 to 80). Vaccine efficacy against HSV-1 infection (with or without disease) was 35% (95% CI, 13 to 52), but efficacy against HSV-2 infection was not observed (−8%; 95% CI, −59 to 26).

CONCLUSIONS

In a study population that was representative of the general population of HSV-1– and HSV-2–seronegative women, the investigational vaccine was effective in preventing HSV-1 genital disease and infection but not in preventing HSV-2 disease or infection. (Funded by the National Institute of Allergy and Infectious Diseases and GlaxoSmithKline; ClinicalTrials.gov number, NCT00057330.)



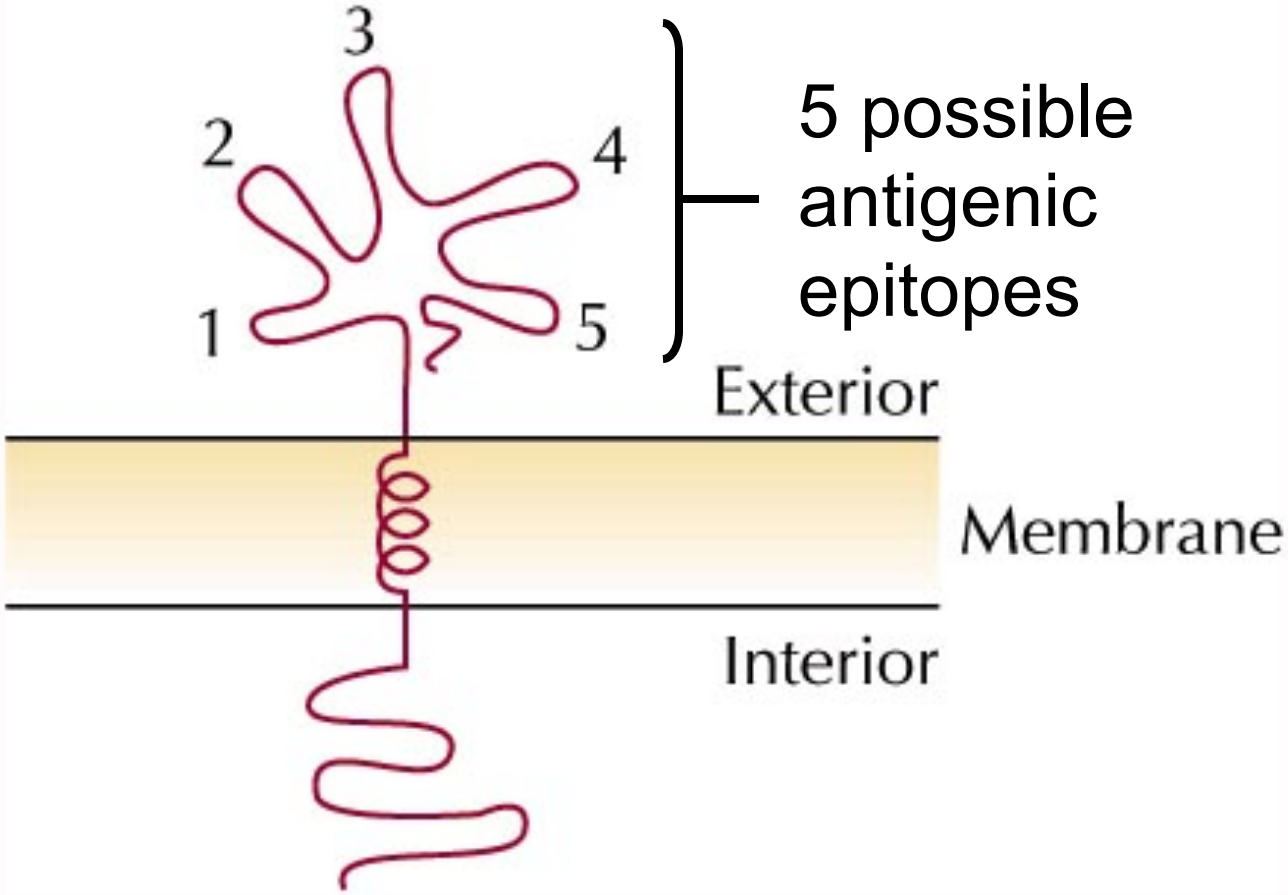
MODERNS VACCINES

- Subunit Vaccines
- **Peptide Vaccines**
- Genetic Immunization
- Attenuated Vaccines
- Vector Vaccines

Peptide Vaccines

- Subunit vaccine uses entire protein
  - Contains several antigenic determinants (B and T cells epitopes)
- Peptide Vaccine
  - vaccine from a specific domain of an antigenic protein
  - single epitope or antigenic determinant (immunogenic epitope)

Generalized membrane-bound protein with external epitopes



Peptide Vaccines

- Advantages of peptide vaccines:

  - can be made by chemical synthesis and eliminate the need of expensive process of protein purification (remove host DNA,LPS).

  - they are less expensive, purer and more stable than protein-containing subunit vaccines.

  -in addition, using only a part of the antigenic protein there will be no unwanted immunological reactions.

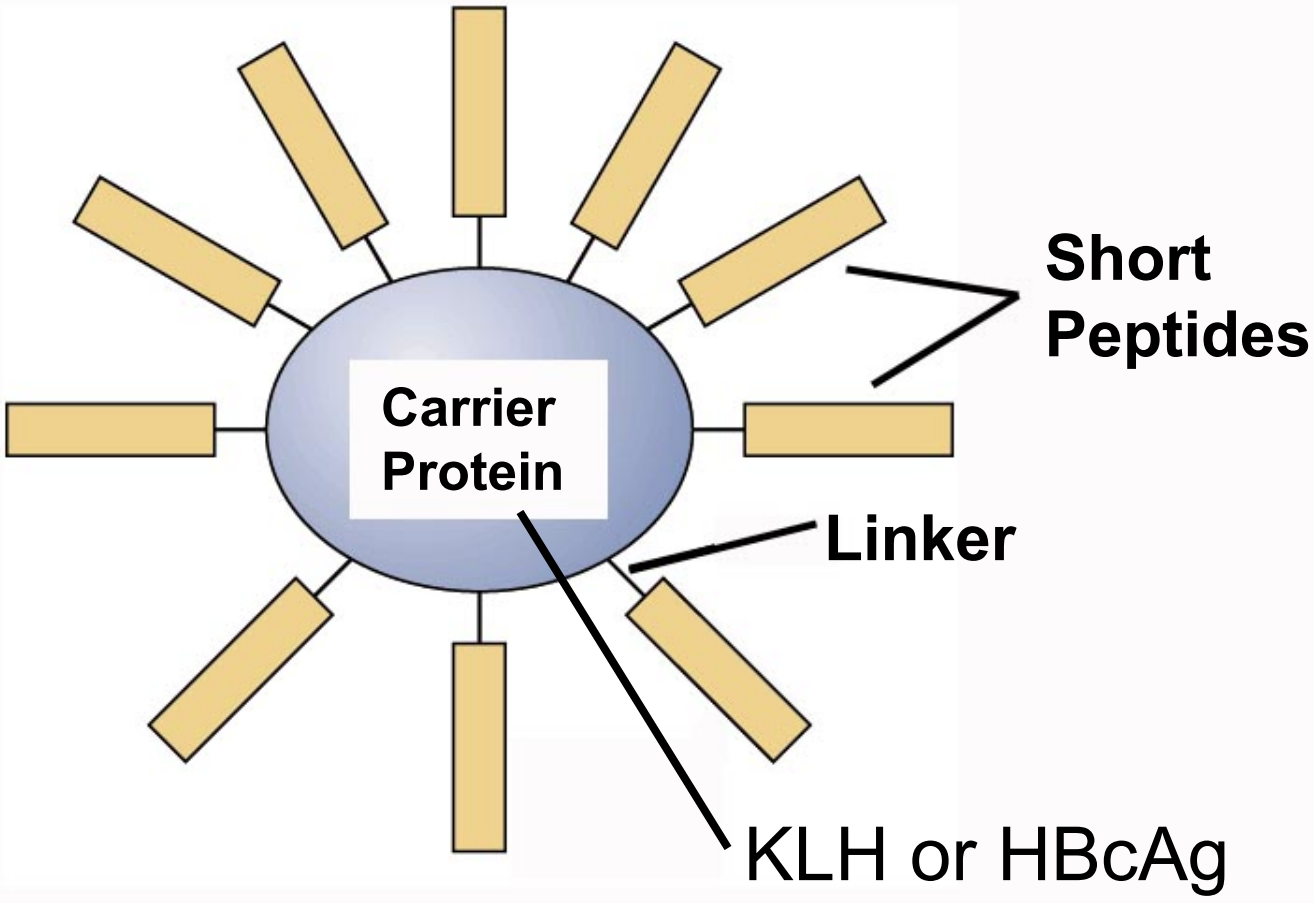
Peptide Vaccines

Peptides need to be linked to another molecule to prevent rapid degradation

- Keyhole limpet hemocyanin
  - an inert carrier protein
  - from a marine gastropos mollusk
- Hepatitis B core protein (HBcAg)
  - highly immunogenic carrier protein
  - self assembles into small particles

Keyhole Limpet (Diodora aspera)

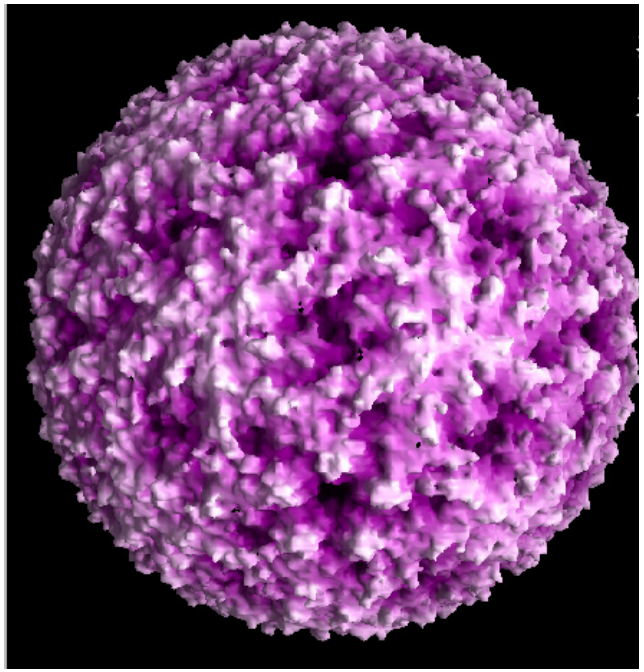
Structure of a peptide vaccine

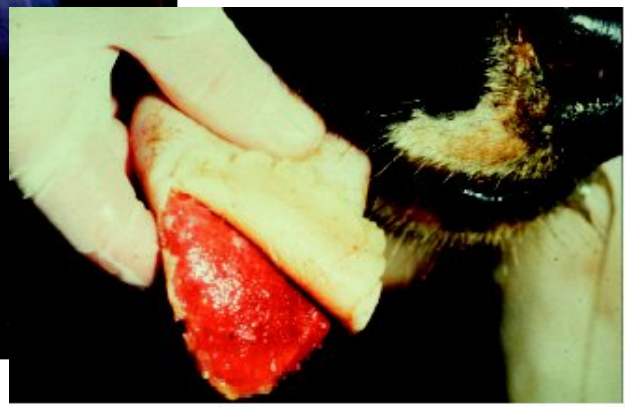


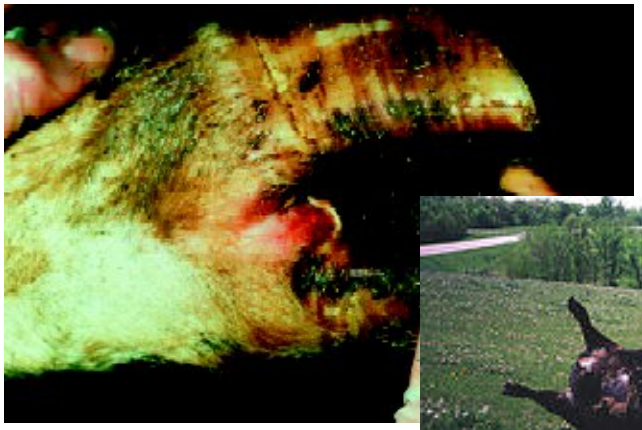
Limitations of Peptide Vaccines

- Epitope must consist of a contiguous stretch of amino acids
- Not all peptides are effective in eliciting an immune response (may need 2 or more)
- Peptide must have the same conformation as in pathogen
- Selection of immune escape mutants is highly probable (may need 2 or more)
- Amount of peptide required to elicit an immune response may be 1000X more than for inactivated pathogen

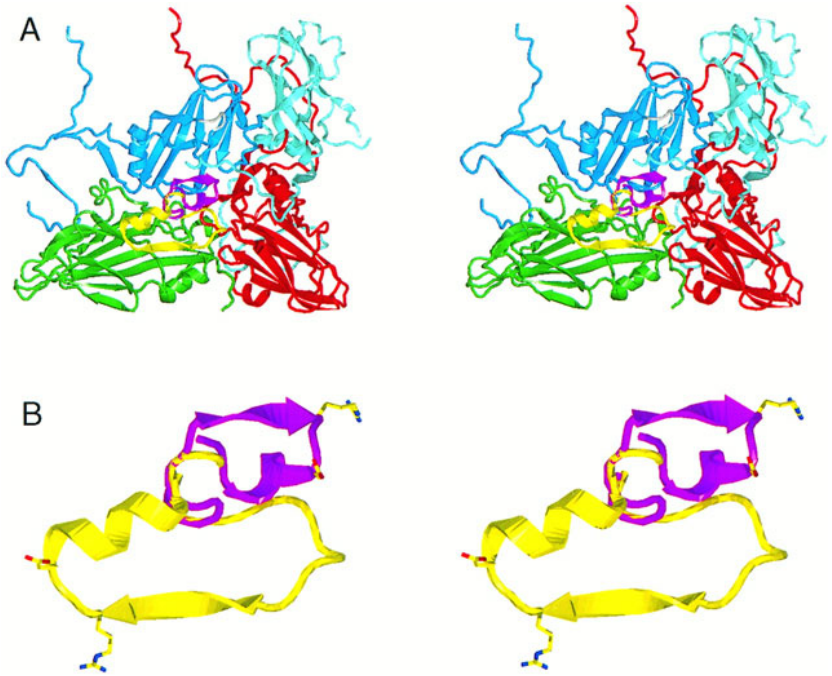
Peptide Vaccine Effectiveness
Foot and Mouth Disease Virus (FMDV)

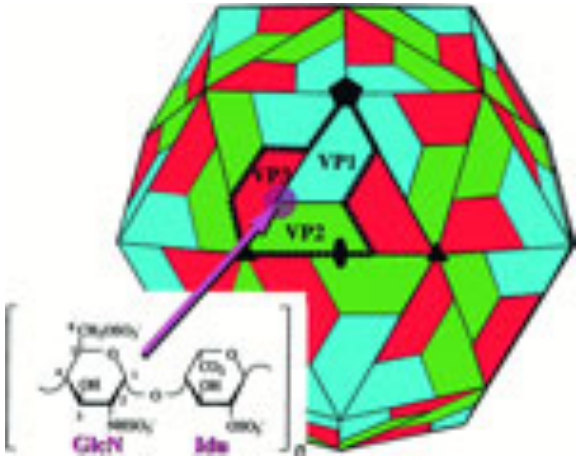


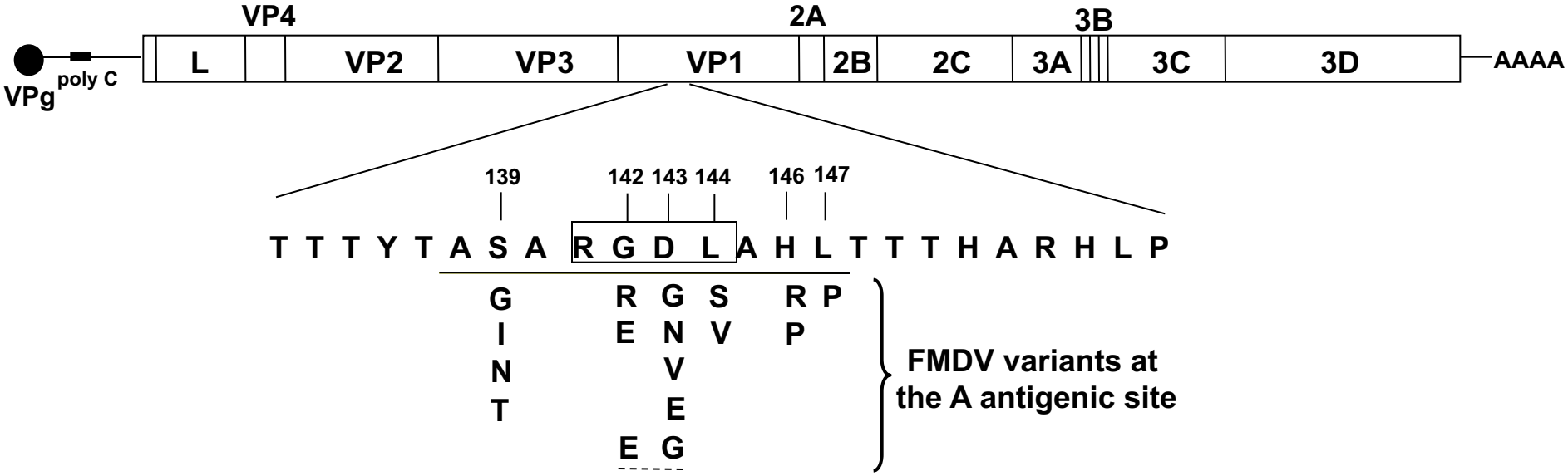




FMDV peptide vaccines







Peptide Vaccine Effectiveness - Example FMVD

Foot and Mouth Disease peptide vaccines

FMDV particles	1
VP1-HBcAg particles VP1=142-160 aa	1/10
VP1-β-gal fusion VP1=137-162 aa	1/350
VP1 142-160 aa	1/5000

MODERNS VACCINES

- Subunit Vaccines
- Peptide Vaccines
- **Genetic Immunization**
- Attenuated Vaccines
- Vector Vaccines

GENETIC IMMUNIZATION

- Novel variation of recombinant vaccine strategy
  - First reported in 1992
  - Instead of injecting protein antigen to elicit immune response, inject gene encoding antigen
- Also called **“DNA Vaccine”**

Genetic Immunization / DNA Vaccine

- Gene directs production of encoded protein antigen directly into tissues of the vaccinee
- A relative low dose of immunizing protein (ng range) seems to be sufficient to produce long-lasting immune response
- Antigen activates an immune response
  - Antibody production
  - Cell mediated response

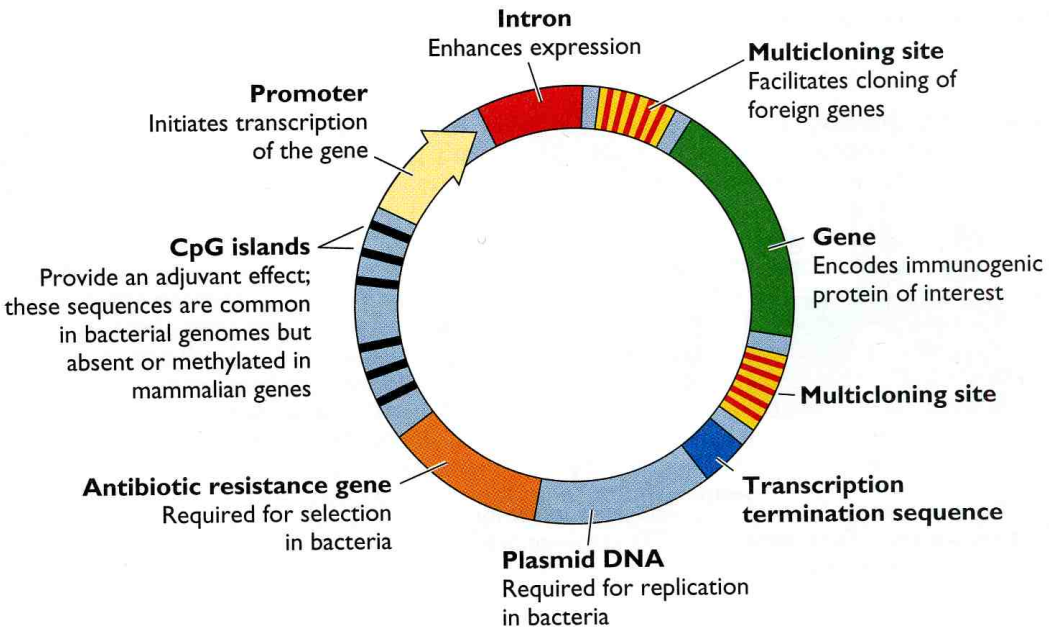
Genetic Immunization / DNA Vaccine

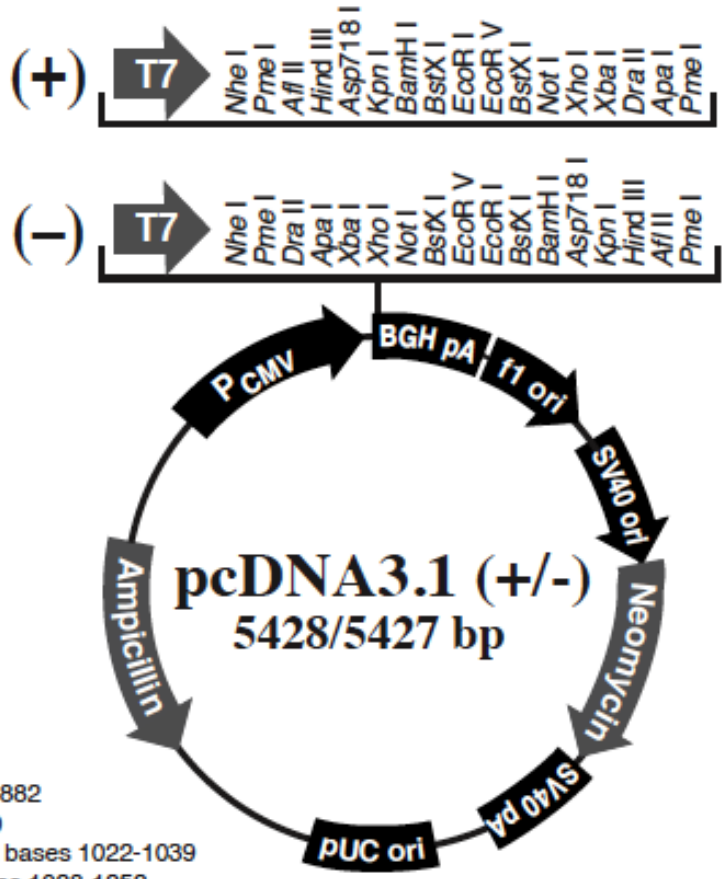
- The method of inoculation appears to dictate the type of immune response:
  - Direct Injection into muscle of an aqueous DNA solution (DNA travels to spleen - Th1 response)
  - Biolistic method - DNA coated metal beads (keratinocytes express ag, Langerhans cells move to the draining lymph node – Th2 response)

Genetic Immunization / DNA Vaccine

- Advantages of genetic immunization
  - Cultivation of pathogen not required
  - No chance of reversion
  - No adjuvants are necessary to stimulate an immune response
  - Inexpensive - no need to purify protein
  - Inexpensive – purified DNA is stable
  - One plasmid could encode several antigens

Genetic Immunization / DNA Vaccine





Comments for pcDNA3.1 (+)
5428 nucleotides

CMV promoter: bases 232-819
T7 promoter/priming site: bases 863-882
Multiple cloning site: bases 895-1010
pcDNA3.1/BGH reverse priming site: bases 1022-1039
BGH polyadenylation sequence: bases 1028-1252
f1 origin: bases 1298-1726
SV40 early promoter and origin: bases 1731-2074
Neomycin resistance gene (ORF): bases 2136-2930
SV40 early polyadenylation signal: bases 3104-3234
pUC origin: bases 3617-4287 (complementary strand)
Ampicillin resistance gene (*bla*): bases 4432-5428 (complementary strand)
ORF: bases 4432-5292 (complementary strand)
Ribosome binding site: bases 5300-5304 (complementary strand)
bla promoter (P3): bases 5327-5333 (complementary strand)

Genetic Immunization / DNA Vaccine

- Disadvantage
  - Don't know fate of DNA
    - Transient - will repeated treatments be needed?
    - Integration into genome - mutations?

Genetic Immunization / DNA Vaccine

Representative results of DNA vaccine trials

Virus	Proteins	Induction of antibody	Induction of CTL response	Protection against challenge
Bovine herpesvirus	gD	+	ND	+ (cattle)
Hepatitis B virus	Surface and core antigens	+ (chimpanzees); ND (humans)	+ (chimpanzees)	+ (chimpanzees)
Hepatitis C virus	Nucleocapsid	+	+	+ (mice)
Herpes simplex virus type 1	gD, gB	+	+	+ (mice)
HIV type 1	Env, Gag, Rev	+	+	+ (rhesus macaques)
Influenza virus	HA, M1, Np	+	+	+ (chickens, mice)
Lymphocytic choriomeningitis virus	NP	+	+	+ (mice)
Rabies virus	Glycoprotein, NP	+	+	+ (cynomolgus monkeys)
Respiratory syncytial virus	Glycoprotein	+	+	+ (mice)

[a]Data from A. Reyes-Sandoval and H. C. Ertl, *Curr. Mol. Med.* **1**:217–243, 2001, with permission. ND, not detected.

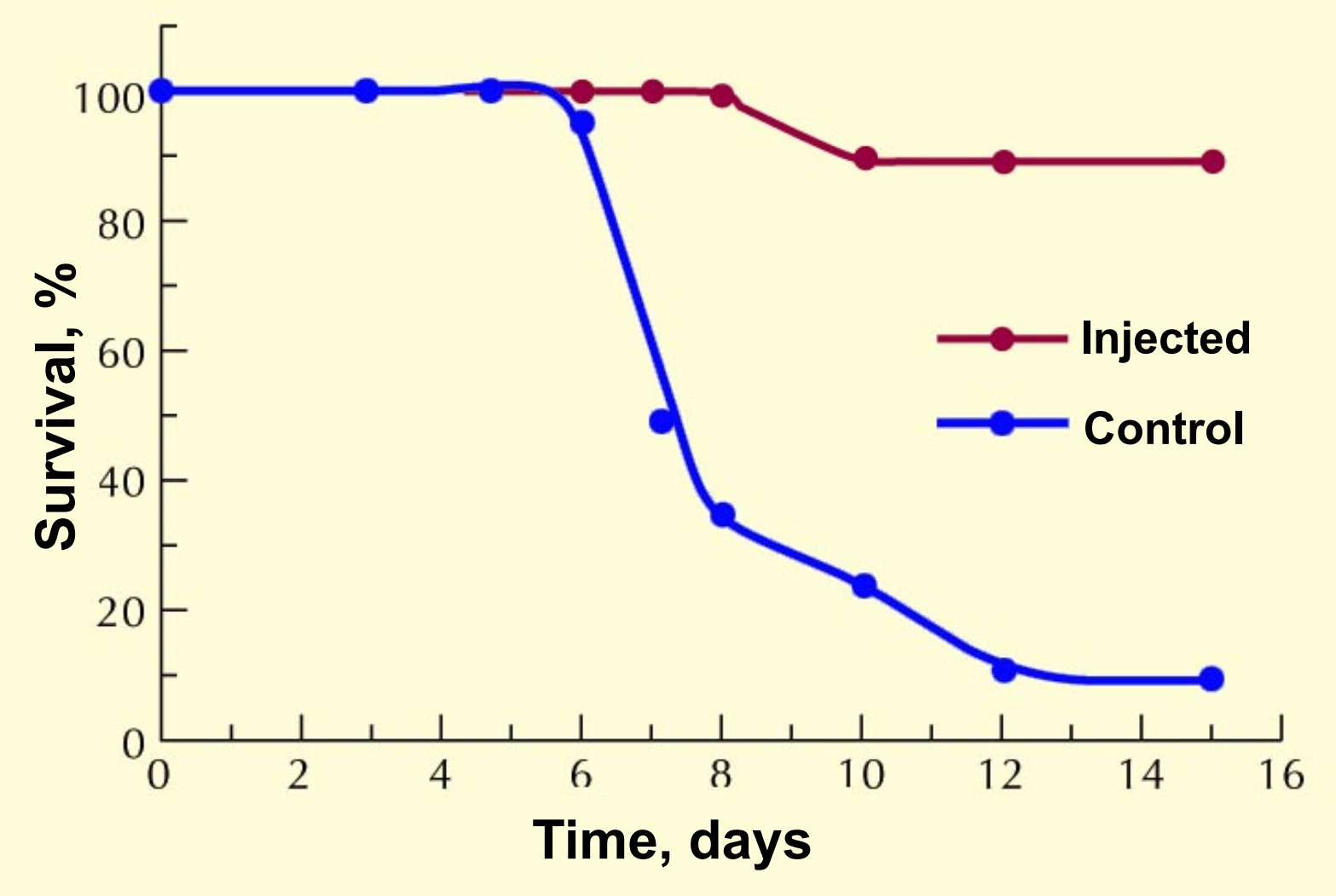
Genetic Immunization/ DNA Vaccine
Example Influenza Virus

- Inject mice with plasmid
  - Gene
    - influenza virus nucleocapsid NP coding sequences
  - Promoter
    - Cytomegalovirus (CMV) promoter
  - Injection site
    - quadriceps muscles of both rear legs

Genetic Immunization of Mice Against Influenza Virus

- Couldn’t detect expression of protein
- Could detect Abs to flu virus nucleoprotein
- Injected mice were protected from Influenza virus (Iv)

Survival of DNA-immunized Mice



Genetic Immunization / DNA Vaccine

The immunostimulatory sequences of plasmid vector DNA have adjuvant effects:

- Bacterial DNA has intrinsic immunostimulatory activity in mammalian cells through TLR9 stimulation.
- DNA motifis containing unmethylated CpG dinucleotides flanked by two 5' purines and by two 3' pyrimidines (5'-GACGTC-3')induce synthesis of IL6, IFN-γ, IL12, TNF.
- CpG DNA as a PAMP such as LPS, PGN, LTA dsRNA

MODERNS VACCINES

- Subunit Vaccines
- Peptide Vaccines
- Genetic Immunization
- **Attenuated Vaccines**
- Vector Vaccines

ATTENUATED VACCINES: a modern approach

- Attenuated vaccines
  - generally more effective vaccines
  - BUT - must not have virulent forms present
- rDNA techniques permit genetic manipulation for generating attenuated vaccines

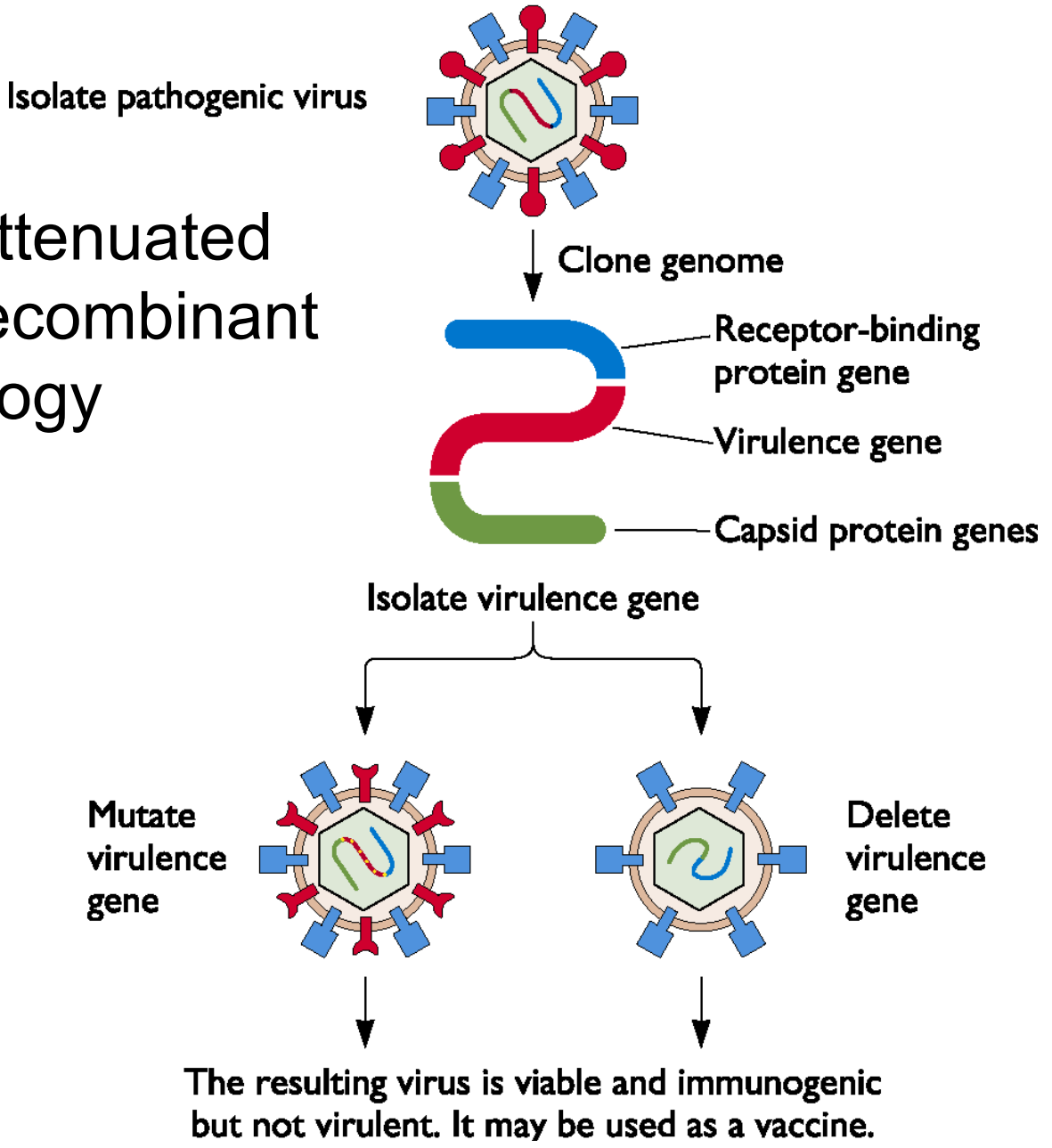
rDNA Technology Based Approach for Modifying Organisms to Generate Attenuated Vaccines

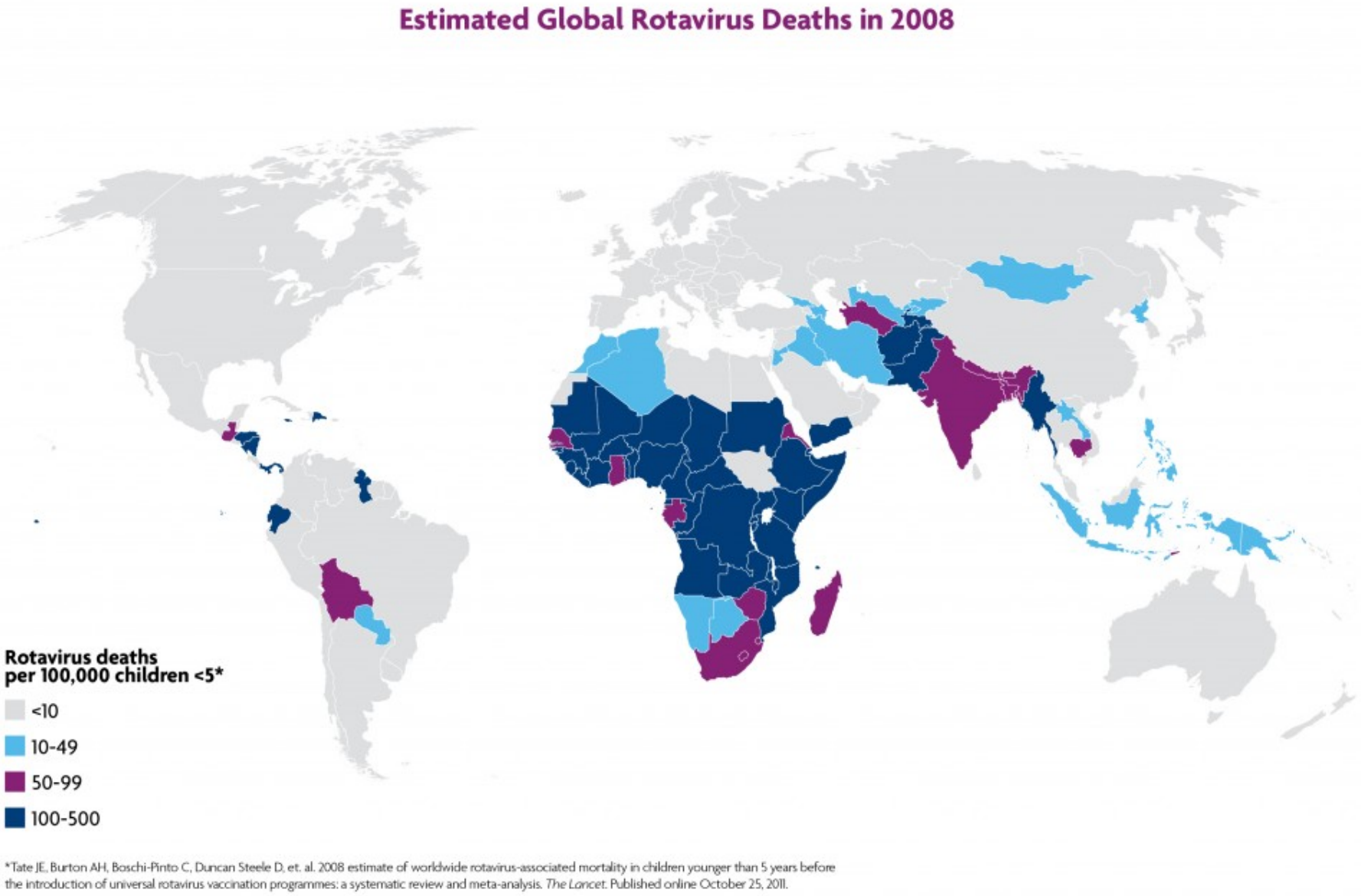
- A non-pathogenic organism engineered to carry and express antigenic determinants from a target pathogenic agent (vector vaccines)
- A pathogenic organism engineered such that the virulence genes have been modified or deleted (Bacmid technology)

Benefits of Attenuated Vaccines generated by rDNA technology

- Only a selected antigenic determinant from the pathogen is put into the non-pathogen, so there is no chance of vaccine causing disease
- Deletion of virulence genes greatly decreases the likelihood of reversion back to the virulent form
- Whole pathogen much more immunogenic than subunit or peptide vaccines (concentrated forms, in the presence of PAMPs)

Construction of attenuated Viruses by using recombinant DNA tecnology





Rotaviruses are the leading cause of severe diarrhea among infants and young children. Each year an estimated 453,000 children die from diarrhoeal disease caused by Rotavirus, most of whom live in developing countries, and another two million are hospitalised.

Rotavirus pathogenesis

Reoviruses

Rotavirus

Virus	Disease
Orthoreovirus	Mild upper respiratory tract disease, gastroenteritis, biliary atresia
Orbivirus/coltivirus	Colorado tick fever: febrile disease, headache, myalgia (zoonosis)
Rotavirus	Gastroenteritis

Epidemiology

Transmission
- Fecal-oral route

Distribution of virus
- Ubiquitous (type A)
- Less common in summer

At risk
- Rotavirus type A
  - Infants <24 months of age (gastroenteritis, dehydration)
  - Older children (mild diarrhea)
  - Undernourished persons in underdeveloped countries (diarrhea, dehydration, death)
- Rotavirus type B
  - Infants, older children, adults in China (severe gastroenteritis)

Vaccines or antiviral drugs
- None

Disease mechanisms

Transmitted by fecal-oral route

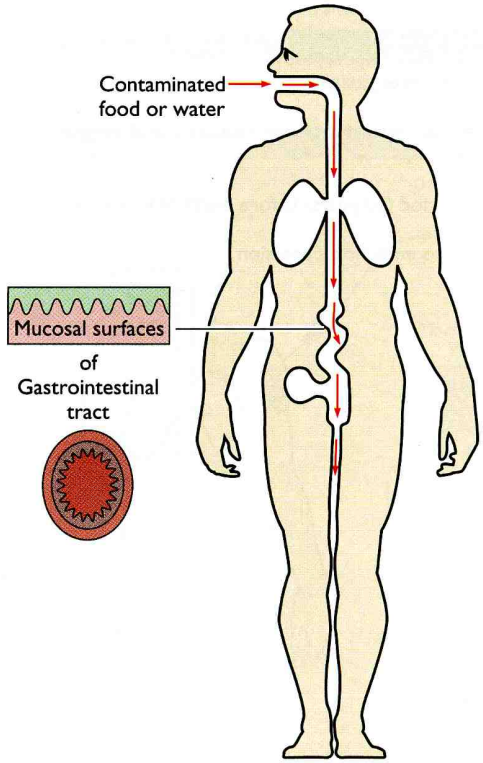
nsP4 is a viral enterotoxin that causes diarrhea

Disease is serious in infants <24 months old, asymptomatic in adults

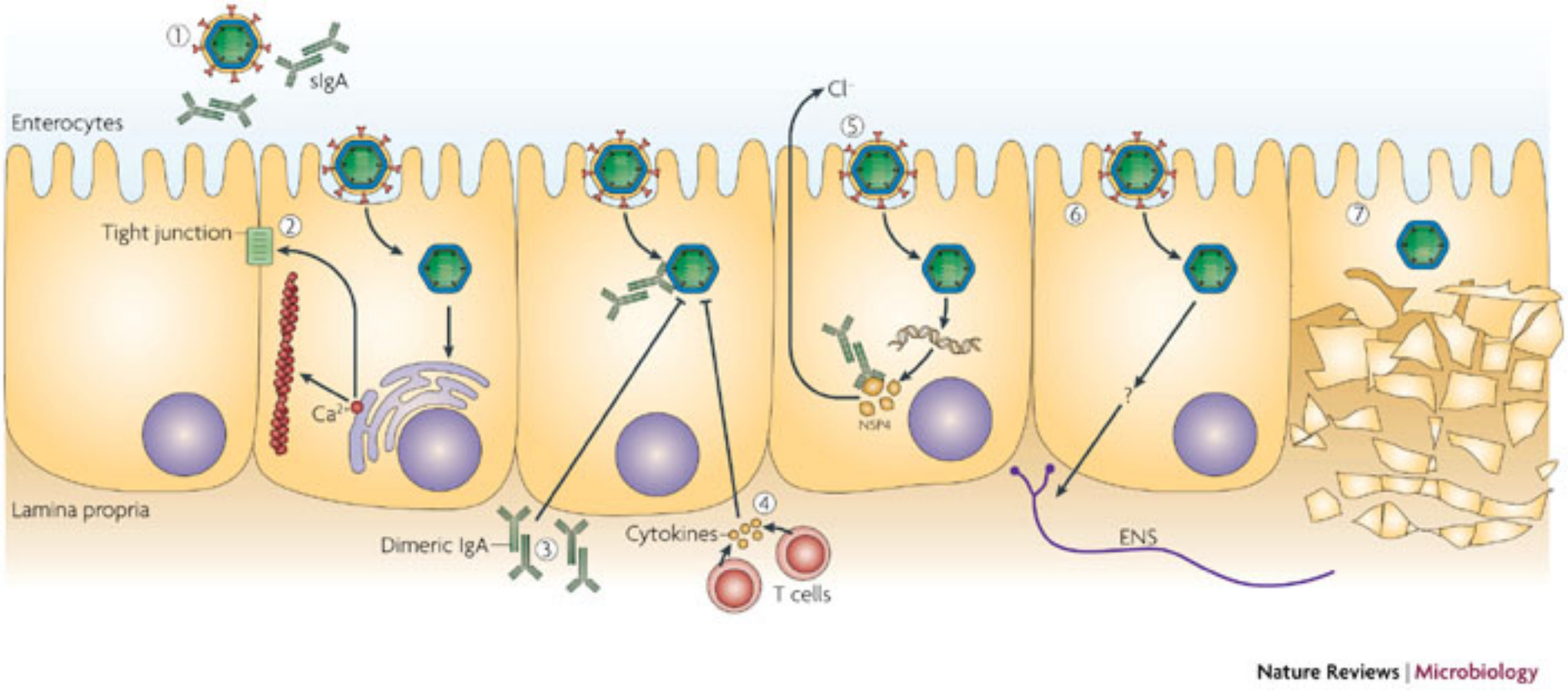
Large quantities of virions released in diarrhea

Immunity to infection depends on IgA in gut lumen

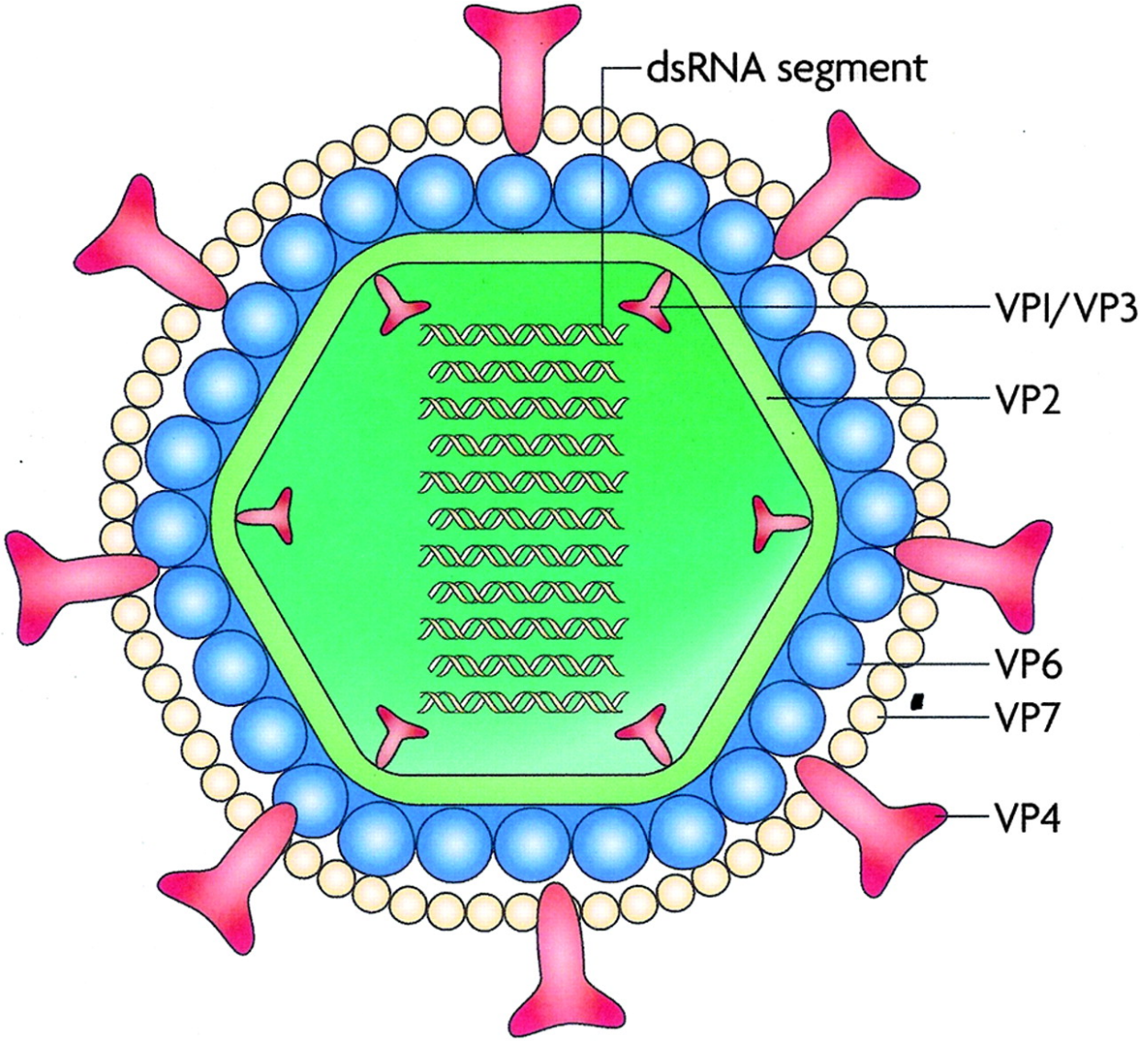
Rotavirus is highly contagious and resistant and, regardless of water quality and available sanitation nearly every child in the world is at risk of infection.



The mechanisms of Rotavirus pathogenesis and immunity



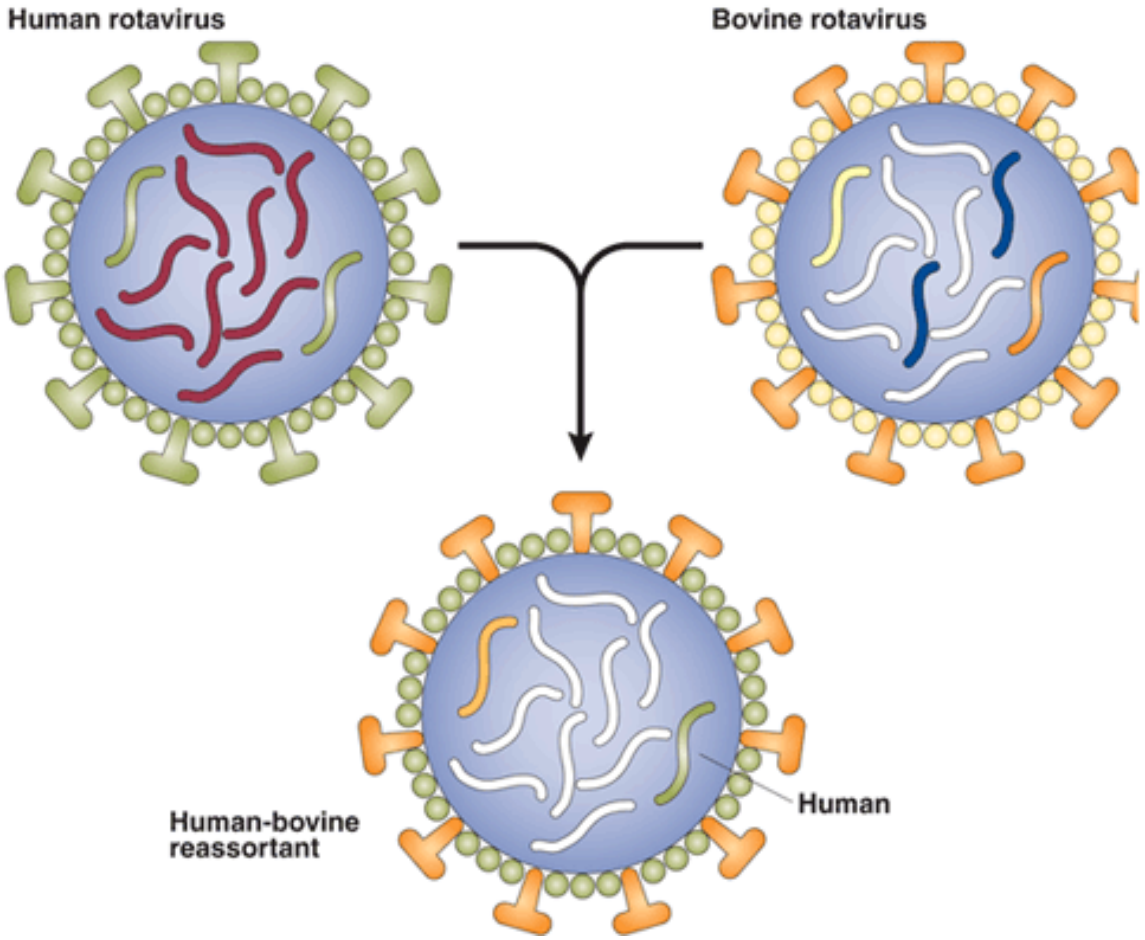
Schematic representation of a rotavirus virion.

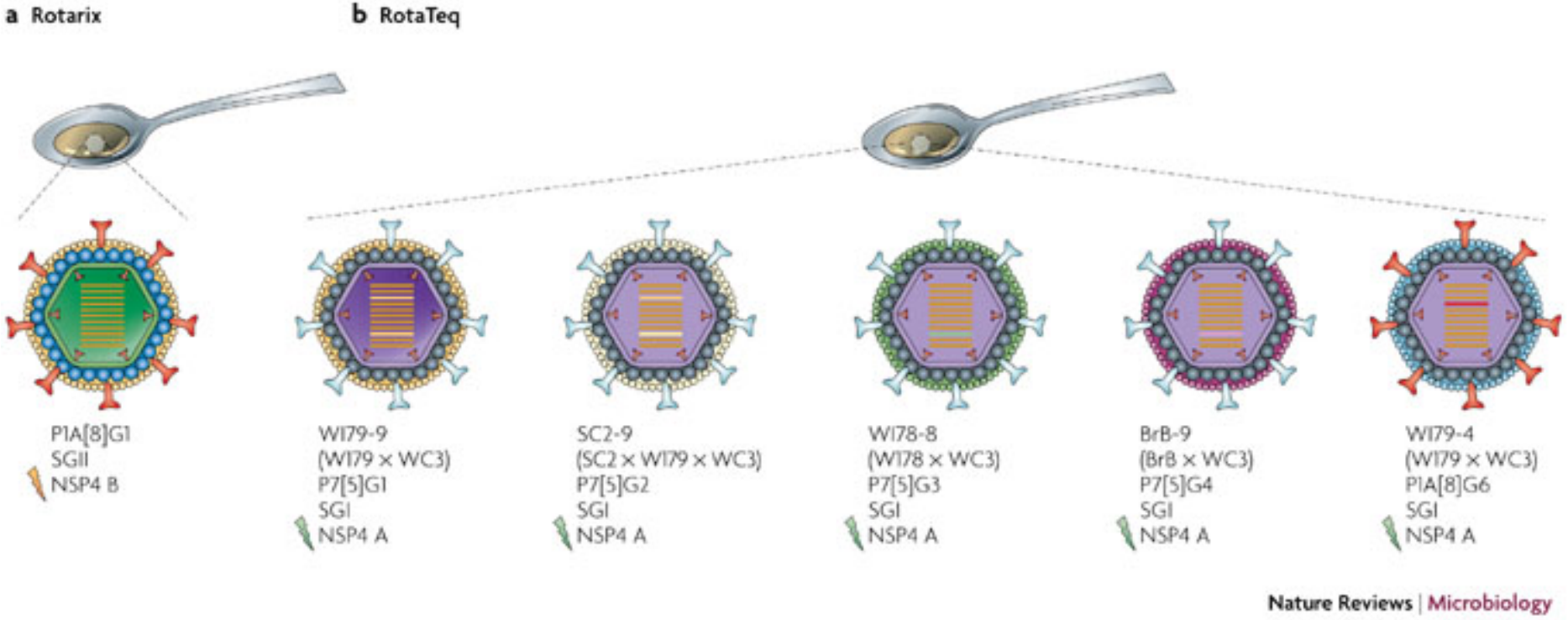


Rotavirus vaccine

- Rotaviruses contain 11 segments of double-stranded RNA.
- Rotaviruses are classified into seven groups (A to G) on the basis of their distinct antigenic and genetic properties. Human infection has been reported with group A, B, and C rotaviruses. Of these, group A rotavirus is the most important, being a significant cause of severe gastroenteritis in children worldwide.
- The two outer capsid proteins, **VP4** and **VP7**, allow classification of rotavirus into **P** and **G** genotypes, respectively. In rotavirus, at least **15 G** genotypes have been recognized by neutralization assay and **27 P** genotypes have been identified by hybridization or sequence analysis. Of these, four rotavirus **G-P** combinations, i.e., **G1P[8]**, **G2P[4]**, **G3P[8]**, **G4P[8]**, and **G9P[8]**, are the most common globally and are therefore the targets for current vaccine development strategies.
- Since effective antirotavirus drugs have not been developed, a rotavirus vaccine would be very useful.

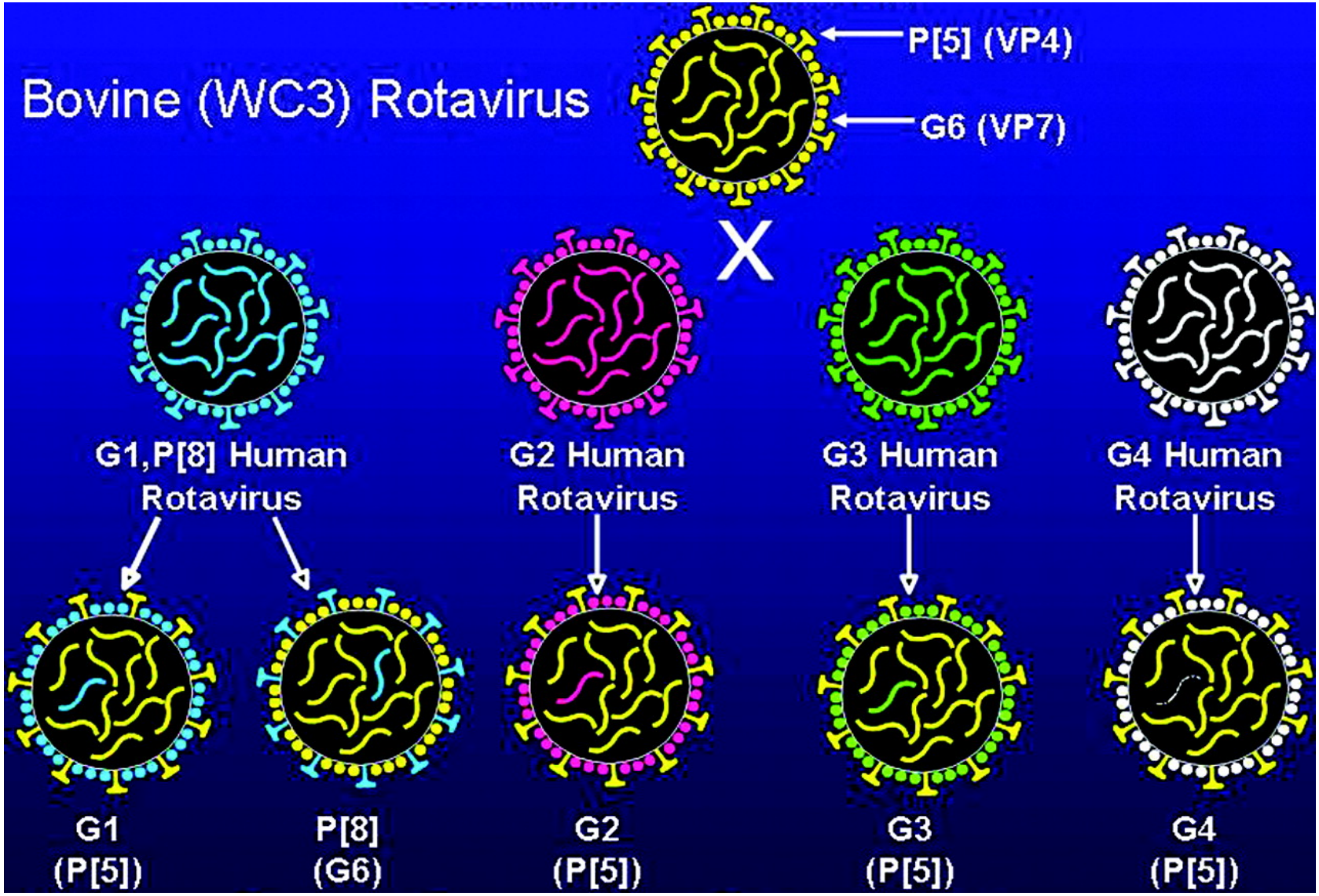
Rotavirus reassortant to generate oral live virus vaccine





a) **Rotarix** is an attenuated human rotavirus vaccine made of a tissue-culture-adapted human P1A[8]G1, VP6 subgroup II and NSP4 geno-group B strain.

b) **RotaTeq** is a bovine (WC3)–human reassortant vaccin. RotaTeq is a live, oral pentavalent vaccine that contains five rotaviruses produced by reassortment. The rotavirus A parent strains of the reassortants were isolated from human and bovine hosts. Four reassortant rotaviruses express one of the outer capsid, VP7, proteins (serotypes G1, G2, G3, or G4) from the human rotavirus parent strain and the attachment protein VP4 (type P7[5]) from the bovine rotavirus parent strain. The fifth reassortant virus expresses the attachment protein VP4, (type P1[8]), from the human rotavirus parent strain and the outer capsid protein VP7 (serotype G6) from the bovine rotavirus parent strain.



RotaTeq is a bovine (WC3)–human reassortant vaccin. RotaTeq is a live, oral pentavalent vaccine that contains five rotaviruses produced by reassortment.. Four reassortant rotaviruses express one of the outer capsid, VP7, proteins (serotypes G1, G2, G3, or G4) from the human rotavirus parent strain and the attachment protein VP4 (type P7[5]) from the bovine rotavirus parent strain. The fifth reassortant virus expresses the attachment protein VP4, (type P1[8]), from the human rotavirus parent strain and the outer capsid protein VP7 (serotype G6) from the bovine rotavirus parent strain.

RotaTeq®

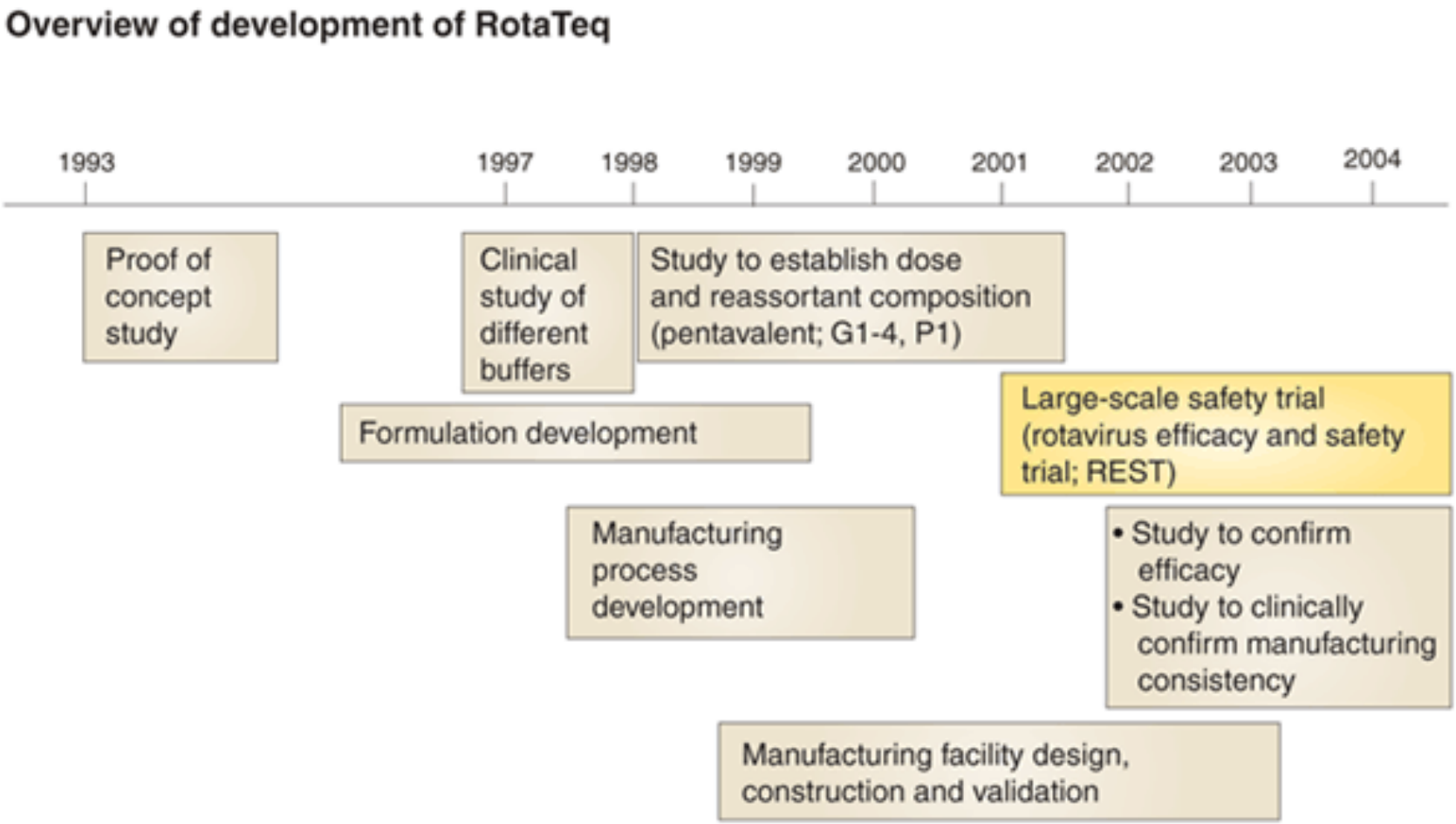
[Rotavirus Vaccine, Live, Oral, Pentavalent]

Name of Reassortant	Human Rotavirus Parent Strains and Outer Surface Protein Compositions	Bovine Rotavirus Parent Strain and Outer Surface Protein Composition	Reassortant Outer Surface Protein Composition (Human Rotavirus Component in Bold)	Minimum Dose Levels (10^6 infectious units)
G1	WI79 – G1, P1[8]	WC3 - G6, P7[5]	**G1**, P7[5]	2.2
G2	SC2 – G2, P2[6]		**G2**, P7[5]	2.8
G3	WI78 – G3, P1[8]		**G3**, P7[5]	2.2
G4	BrB – G4, P2[6]		**G4**, P7[5]	2.0
P1[8]	WI79 – G1, P1[8]		G6, **P1[8]**	2.3

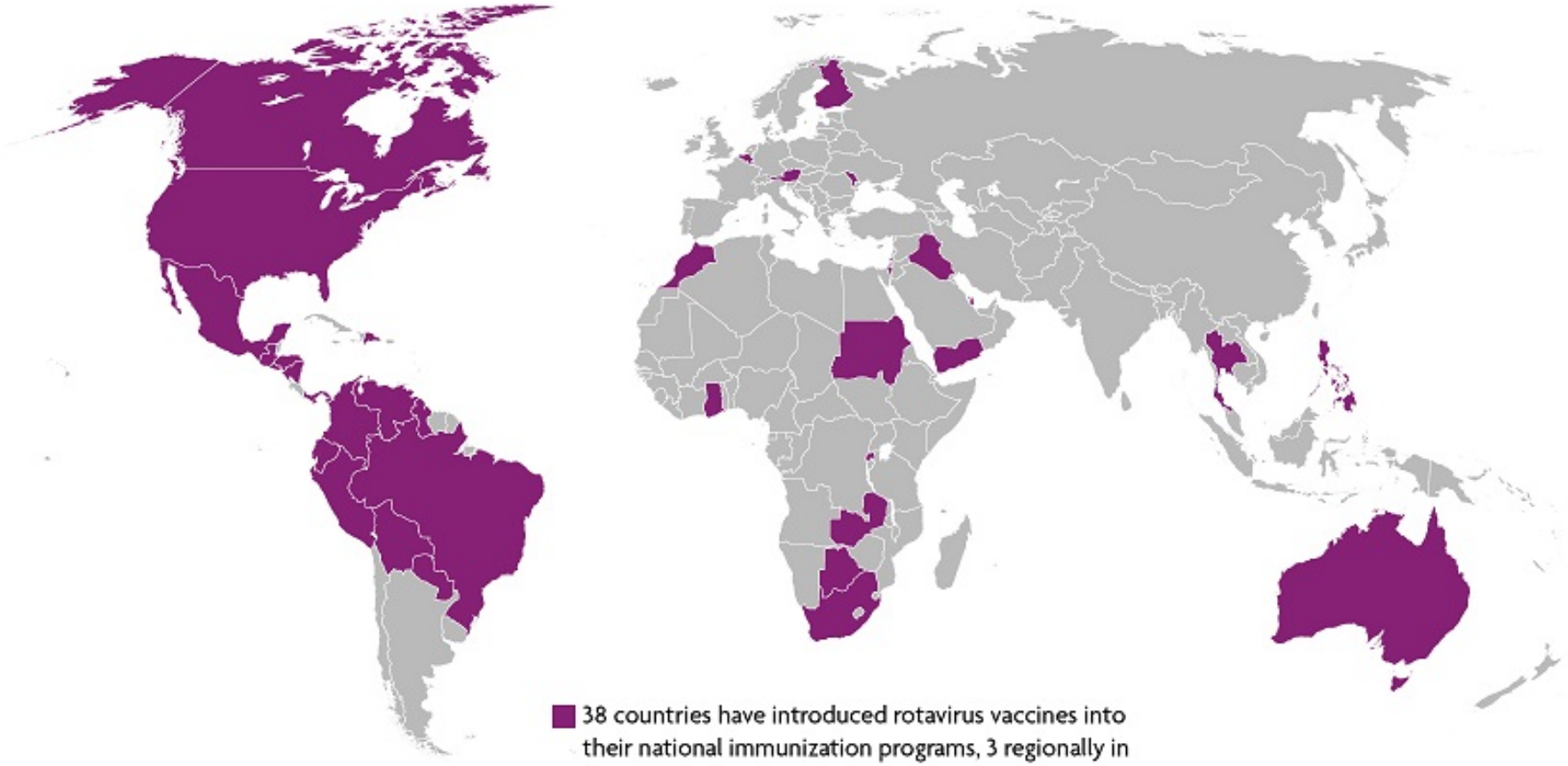
DESCRIPTION

RotaTeq* is a live, oral pentavalent vaccine that contains 5 live reassortant rotaviruses. The rotavirus parent strains of the reassortants were isolated from human and bovine hosts. Four reassortant rotaviruses express one of the outer capsid proteins (G1, G2, G3, or G4) from the human rotavirus parent strain and the attachment protein (P7) from the bovine rotavirus parent strain. The fifth reassortant virus expresses the attachment protein, P1A (genotype P[8]), hereafter referred to as P1[8], from the human rotavirus parent strain and the outer capsid protein G6 from the bovine rotavirus parent strain (see Table 1).

Overview of the development of a vaccine against Rotavirus (Rotateq)



As of September 2012, 41 Countries Have Introduced Rotavirus Vaccines



38 countries have introduced rotavirus vaccines into their national immunization programs, 3 regionally in Canada, Thailand and Zambia

World Health Organization, 2012
PATH, 2012

MODERNS VACCINES

- Subunit Vaccines
- Peptide Vaccines
- Genetic Immunization
- Attenuated Vaccines
- **Vector Vaccines, see. Viral vectors**

Some antiviral vaccines currently under development

Virus family	Virus species	Most promising strategies
Arenavirus	Junin	Live attenuated
	Lassa fever	Recombinant vaccinia virus
Calicivirus	Norwalk	Recombinant capsid "ghosts"
Filovirus	Ebola/Marburg	DNA
		Recombinant vesicular stomatitis virus
Flavivirus	Hepatitis C	Recombinant envelope glycoprotein, peptide, polypeptide
	Dengue	Tetravalent attenuated, DNA
Hepadnavirus	Hepatitis B	DNA, recombinant surface antigen including pre-S1/S2 regions; curative hepatitis B vaccine: DNA with CpG motifs
Herpesvirus	Epstein–Barr	Whole inactivated, subunit (gp350)
	Herpes simplex 1, 2	Recombinant polypeptide, vectored
Orthomyxovirus	Influenza A	Vectored, DNA, peptide
Paramyxovirus	Measles	Vectored, DNA
	Parainfluenza	Live attenuated
	Respiratory syncytial	Subunit G and fusion protein, DNA, vectored, peptide
Parvovirus	Parvovirus B19	Empty capsid with VP1 protein
Picornavirus	Enterovirus 71	Whole inactivated
Reovirus	Rotavirus	Live reassortants of simian or human origin
Retrovirus	HIV-1, 2	Recombinant polypetide, DNA, vectored, chimeric
Unclassified	Hepatitis E	Recombinant protein ORF2