<table>
<thead>
<tr>
<th>Virus Family</th>
<th>Hosts</th>
<th>Other Vertebrates</th>
<th>Size of Genome</th>
<th>Family</th>
</tr>
</thead>
<tbody>
<tr>
<td>Human Coronavirus viruses</td>
<td>Mare's, breeds, swine, cats</td>
<td></td>
<td>20,000-30,000</td>
<td>Coronaviridae</td>
</tr>
<tr>
<td>Hepatitis C</td>
<td>Swine, cattle, primates, birds</td>
<td></td>
<td>9500-12,500</td>
<td>Coronaviridae</td>
</tr>
<tr>
<td>Dengue, yellow fever, TBE</td>
<td>human forest viruses, horse</td>
<td></td>
<td>-11,600</td>
<td>Togaviridae</td>
</tr>
<tr>
<td>WEE, VEE, HFR, Measles, Rubella</td>
<td>cattle, chicken, sheep, swine</td>
<td></td>
<td>6800-7900</td>
<td>Arenaviridae</td>
</tr>
<tr>
<td>Human astroviruses</td>
<td></td>
<td></td>
<td></td>
<td>Astroviridae</td>
</tr>
<tr>
<td>Norwalk viruses</td>
<td></td>
<td></td>
<td></td>
<td>Caliciviridae</td>
</tr>
<tr>
<td>Hepatitis A viruses</td>
<td>Rabbits, swine, cattle</td>
<td></td>
<td>7500</td>
<td>Caliciviridae</td>
</tr>
<tr>
<td>Human rhinoviruses</td>
<td>cattle, monkeys, mice</td>
<td></td>
<td>7500</td>
<td>Caliciviridae</td>
</tr>
</tbody>
</table>

Palamo et al. 2002
<table>
<thead>
<tr>
<th>Viral Genus</th>
<th>Virus Name</th>
<th>Abbreviation*</th>
<th>Usual Host(s)</th>
<th>Transmission</th>
<th>Disease</th>
<th>World Distribution</th>
</tr>
</thead>
<tbody>
<tr>
<td>ERBOVIRUS</td>
<td>Equine rhinopharyngitis</td>
<td>EVF</td>
<td>Swine</td>
<td>Oral/rectal</td>
<td>Encephalitis, Paralytic</td>
<td>Eastern Europe (central and endemic worldwide)</td>
</tr>
<tr>
<td>TESCHOVIRUS</td>
<td>Porcine teschovirus</td>
<td>PTV</td>
<td>Swine</td>
<td>Oral/rectal</td>
<td>Paralytic, Encephalitis, Meningitis</td>
<td>Britain, central and endemic worldwide (isolate in Japan, oysters)</td>
</tr>
<tr>
<td>HEPAVIRUS</td>
<td>Hepatitis A</td>
<td>HAV</td>
<td>Humans</td>
<td>Oral/rectal</td>
<td>Hepatitis</td>
<td>Endemic worldwide</td>
</tr>
<tr>
<td>KOBUVIRUS</td>
<td>Human parechovirus (formerly echovirus 22)</td>
<td>HPeV</td>
<td>Humans, cattle</td>
<td>Oral/rectal</td>
<td>Gastroenteritis</td>
<td>Worldwide</td>
</tr>
<tr>
<td>CARBOVIRUS</td>
<td>Human rhinoviruses (&gt;100 serotypes)</td>
<td>HRV-A, HRV-B</td>
<td>Humans</td>
<td>Aerial, contact</td>
<td>Common cold</td>
<td>Worldwide</td>
</tr>
<tr>
<td>APHTHOVIRUS</td>
<td>Encephalomyocarditis virus</td>
<td>EMCV</td>
<td>Mice</td>
<td>Oral/rectal</td>
<td>Encephalitis, Cardiomyopathy</td>
<td>Worldwide (except US)</td>
</tr>
<tr>
<td>RHILOVIRUS</td>
<td>Encephalomyocarditis</td>
<td>EMCO</td>
<td>Mice</td>
<td>Oral/rectal</td>
<td>Encephalitis, Cardiomyopathy</td>
<td>Worldwide (except US)</td>
</tr>
<tr>
<td>TESCHOVIRUS</td>
<td>Equine rhinotracheitis B</td>
<td>ERBV</td>
<td>Horses</td>
<td>?</td>
<td>?</td>
<td>?</td>
</tr>
<tr>
<td>ENTEROVIRUS</td>
<td>Poliovirus (3)</td>
<td>PV</td>
<td>Humans</td>
<td>Oral/rectal</td>
<td>Paralysis, Encephalitis, Paralytic</td>
<td>Worldwide</td>
</tr>
<tr>
<td></td>
<td>Coxsackie (23A and 6B)</td>
<td></td>
<td>Humans</td>
<td>Oral/rectal</td>
<td>Aseptic Meningitis, Common cold</td>
<td>Worldwide</td>
</tr>
<tr>
<td></td>
<td>Echovirus (29)</td>
<td></td>
<td>Humans</td>
<td>Oral/rectal</td>
<td>Aseptic Meningitis, Common cold</td>
<td>Worldwide</td>
</tr>
<tr>
<td></td>
<td>Enterovirus (4 human, 30 other)</td>
<td></td>
<td>Humans</td>
<td>Oral/rectal</td>
<td>Aseptic Meningitis, Common cold</td>
<td>Worldwide</td>
</tr>
</tbody>
</table>

* Standard abbreviations are given for either the virus listed (such as poliovirus) or for the type member of the genus.
Phylogenetic Tree of the Picornaviridae

**Hepatitis viruses**
- Hepatitis A
- Simian hepatitis A
- Echovirus 22
- Parechovirus 22

**Rhinoviruses**
- Human rhinovirus 2
- Human rhinovirus 14
- Human rhinovirus 89
- Coxsackie A16
- Poliovirus type 1
- Enterovirus 70
- Swine vesicular disease
- Coxsackie B3

**Aphthoviruses**
- FMDV-A
- FMDV-O
- EMC

**Kobuviruses**
- Aichi
- TMEV (Theilers)

**Cardioviruses**
- Aphthoviruses
- Rhinoviruses

**Parechoviruses**
- FMDV-A
- FMDV-O
- EMC

**Hepatoviruses**
- FMDV-A
- FMDV-O
- EMC

**Evolutionary distance**

- 0
- 0.5
Poliovirus: 1) usually infects gastrointestinal tract with little or no illness, in rare cases (<1%) enters CNS to give paralytic poliomyelitis; 2) single stranded, plus-sense RNA genome; 3) isosahedral shell of 60 copies of 4 VPs; 4) RNA is ~ 7500 nts; 5) usually infects gastrointestinal tract with little or no illness; 6) in rare cases (>1%) enters CNS to give paralytic poliomyelitis.

(c) Vaccine era

Vaccinated in persons < 15 years

Incidence of paralytic poliomyelitis was ~ 21,000 cases; 1/3 of the cases and 2/3 of the deaths in epidemic - in 1916-80% of the cases were in children > 5 years; in the early 1950s, the annual epidemic - in each major epidemiological phases:

- high level of subclinical infection (1% infections produce clinical illness)
- dorsal root ganglia
- anterior horn cells of the spinal cord (major involvement)
- intermediate grey ganglia, posterior horn and
- primary viremia in blood can allow CNS to be infected
- the virus first replicates in the tonsils, lymph nodes of the neck, Peyers patches and small intestine.

Polioviruses - 3 serotypes

Poliovirus: 3) isosahedral shell of 60 copies of 4 VPs; 4) RNA is ~ 7500 nts; 5) single stranded, plus-sense RNA genome

(c) Vaccine era

Vaccinated in persons < 15 years
Polio - The Disease

Cured? Eliminated?

Type 3 (Ienon)

Type 2 (P2/712)

Type 1 (mahaney)

Neurovirulent

Attenuated

3 Serotypes:

Live (Sabin) vs Killed (Salk) Vaccine

Sabin 3 (11 substitutions)

Sabin 2 (23 substitutions)

Sabin 1 (55 substitutions)

Polio - The Disease
### Attenuated Poliovirus

#### A. Determinants of Sabin type 3 attenuation

- **Mutation**
  - VP3 (3091) 5'-UTR (472)
  - VP1 (1443) 5'-UTR (481)
  - VP4 (4965) 5'-UTR (480)

- **Location/mutated position**
  - VP3/5'-UTR
  - P2/Sabin
  - VP1 (1106) P1/Sabin

**Passages**
- P3/Leon 124 ILK3/56 Sabin vaccine strain
- 6 passages in vitro (preparative monkey kidney cultures)
- 3 passages in vitro (monkey kidney cultures)
- 39 passages in vitro (monkey testicular cultures)
- 8 passages in vivo (intracerebrally in monkeys)
- 21 passages in vivo (intracutaneously in monkeys)

#### B. Determinants of Sabin type 2 attenuation
Reversion to Virulence
Salk Vaccine

Killed Salk Vaccine: advantages and disadvantages

Advantages:
- May prove especially useful in certain tropical areas where live vaccine has failed
- Absence of living virus excludes potential for mutation and reversion to virulence
- Absence of living virus permits its use in immunodeficient or immunosuppressed individuals and their households
- Has greatly reduced the spread of polioviruses in three small northern European countries where it has been properly used (wide and frequent coverage)
- May prove especially useful in certain tropical areas where live vaccine has failed to "take" in some young infants

Disadvantages:
- Confers humoral immunity in vaccinees if sufficient numbers of doses of potent vaccine are given. Can be incorporated into regular pediatric immunization, with other vaccines (DPT)
Salk Vaccine (cont'd)

Disadvantages:

- Early studies indicated a disappointing record in percentage of vaccinees developing antibodies after three doses, but more immunopotent antigens are now developed antibodies after three doses. However, repeated boosters have been required to maintain detectable antibody levels.
- Does not induce local intestinal immunity in the vaccinee; hence vaccinees do not serve as a block to transmission of wild polioviruses by the fecal-oral route.
- More expensive than live vaccine.
- Growing scarcity of monkeys for kidney tissue substrate was a potential problem.
- Since monkey neurol influencnce tests are no longer required before release of vaccine, it has been overcome by use of continuous-passage Vero monkey cells for vaccine production.
- More expensive than live vaccine.

Vaccine production.

Immunopotent antigens are now produced.

Salk Vaccine (cont'd)
Sabin Vaccine

Live polio vaccine: advantages and disadvantages

Advantages:

- Confers both humoral and intestinal immunity, like the natural infection.
- Immunity induced may be lifelong.
- Induces antibody very quickly in a large proportion of vaccinees.
- Can be prepared in pretested human or monkey cells, thus is dependent on continuous booster doses.
- Is relatively inexpensive, both to produce and to administer, and does not require refrigeration and no freezers.
- When stabilized, it can remain potency under difficult field conditions with less administration does not require use of highly trained personnel.
- Oral administration is more acceptable to vaccinees than injection and is easier to accomplish.
- Induces antibody very quickly in a large proportion of vaccinees.
- Immunity induced may be lifelong.
- Confers both humoral and intestinal immunity, like the natural infection.

Disadvantages:

- Theoretical risk of including monkey virus contaminants in the vaccine.
- Use of continuous cell lines eliminates the need for neurovirulence testing.
- Use of continuous cell lines eliminates the need for monkey cells, thus is dependent on continuous booster doses.
- Is relatively inexpensive, both to produce and to administer, and does not require refrigeration and no freezers.
- When stabilized, it can remain potency under difficult field conditions with less administration does not require use of highly trained personnel.
- Oral administration is more acceptable to vaccinees than injection and is easier to accomplish.
- Induces antibody very quickly in a large proportion of vaccinees.
- Immunity induced may be lifelong.
- Confers both humoral and intestinal immunity, like the natural infection.
Disadvantages:

- Vaccine viruses may mutate and, in very rare instances, have reverted toward neurovirulence sufficient to cause paralytic polio in recipients or their contacts.
- Vaccine progeny virus spreads to household contacts and to other persons in the community. Some people consider this spread to be an advantage, but the progeny virus is not a safety-tested vaccine, licensed for use in the general population.
- Vaccine viruses may mutate and, in very rare instances, have reverted toward neurovirulence sufficient to cause paralytic polio in recipients or their contacts.
- Requires monkeys for safety testing.
- Contraindicated in those with immunodeficiency diseases, and in their household associates, as well as in persons undergoing immunosuppressive therapy and their household. In certain tropical countries, induction of antibodies in a satisfactorily high proportion of vaccinees has been difficult to accomplish with the dose of OPV as currently constituted.
U.S. Cases of Polio
Worldwide Incidence of Polio