This document contains a few interesting viruses and genes to search for. This document excludes many obvious clinical and disease-causing viruses, these are not off-limits to your search. Remember – you can search for a gene and a virus in the same search.

**Toxin encoding genes and their hosts (**[**source**](http://www.cell.com/trends/microbiology/fulltext/S0966-842X(02)02459-9?_returnURL=https%3A%2F%2Flinkinghub.elsevier.com%2Fretrieve%2Fpii%2FS0966842X02024599%3Fshowall%3Dtrue)**):**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Protein** | **Gene** | **Bacteriophage** | **Bacterial host** | **Refs** |
| **Extracellular toxins** | | | | |
| Diphtheria toxin | tox | β-phage | Corynebacterium diphtheriae | [[6](javascript:void(0);) |
| Neurotoxin | C1 | Phage C1 | Clostridium botulinum | [[7](javascript:void(0);) |
| Shiga toxins | stx1, -2 | H-19B | Escherichia coli | [[8.](javascript:void(0);), [9.](javascript:void(0);)] |
| Enterohemolysin | hly2 | ΦFC3208 | E. coli | [[38](javascript:void(0);) |
| Cytotoxin | ctx | ΦCTX | Pseudomonas aeruginosa | [[10](javascript:void(0);) |
| Enterotoxin | see, sel | NA | Staphylococcus aureus | [[11](javascript:void(0);) |
| Enterotoxin P | sep | ΦN315 | S. aureus | [[25](javascript:void(0);) |
| Enterotoxin A | entA | Φ13 | S. aureus | [[24](javascript:void(0);) |
| Enterotoxin A | sea | ΦMu50A | S. aureus | [[25](javascript:void(0);) |
| Exfoliative toxin A | eta | ΦETA | S. aureus | [[27](javascript:void(0);) |
| Leukocidin | lukS, -F, -M | PVL, PV83 | S. aureus | [[26](javascript:void(0);) |
| Toxin A | speA | T12 | Streptococcus pyogenes | [[12](javascript:void(0);) |
| Toxin C | speC | CS112 | S. pyogenes | [[13](javascript:void(0);) |
| Toxin A1, A3, C, I, H, M, L, K | speA1, -A3, -C, -I, -H, -M -L, -K | 8232.1, 315.5, 370.1, 370.2, 8232.3, 315.4 | S. pyogenes | [[18](javascript:void(0);) |
| Superantigens | ssa | 315.2 | S. pyogenes | [[18](javascript:void(0);) |
| Cholera toxin | ctxAB | CTXΦ | Vibrio cholerae | [[44](javascript:void(0);) |
|  |  |  |  |  |
| **Proteins that alter antigenicity** | | | | |
| Membrane proteins | Mu-like |  | Neisseria meningitidis | [[79](javascript:void(0);) |
| Glucosylation | rfb | ε34 | Salmonella enterica | [[46](javascript:void(0);) |
| Glucosylation | gtr | P22 | S. enterica | [[51](javascript:void(0);) |
| O-antigen acetylase | oac | Sf6 | Shigella flexneri | [[48.](javascript:void(0);), [49.](javascript:void(0);)] |
| Glucosyl transferase | gtrii | SfII, SfV, SfX | S. flexneri | [[50](javascript:void(0);) |
|  |  |  |  |  |
| **Effector proteins involved in invasion** | | | | |
| Type III effector | sope | SopEΦ | S. enterica | [[80](javascript:void(0);) |
| Type III effector | gogb | Gifsy-1 | S. enterica | [[56](javascript:void(0);) |
| Type III effector | sseI (gtgB) | Gifsy-2 | S. enterica | [[54](javascript:void(0);) |
| Type III effector | sspH1 | Gifsy-3 | S. enterica | [[55](javascript:void(0);) |
|  |  |  |  |  |
| **Enzymes required for intracellular survival** | | | | |
| Superoxide dismutase | sodc | Sp4, -10 | E. coli O157 | [[35](javascript:void(0);) |
| Superoxide dismutase | sodC-I | Gifsy-2 | S. enterica | [[54](javascript:void(0);) |
| Superoxide dismutase | sodC-III | Fels-1 | S. enterica | [[55](javascript:void(0);) |
| Neuraminidase | nanh | Fels-1 | S. enterica | [[55](javascript:void(0);) |
| Staphylokinase | sak | Φ13 | S. aureus | [[24](javascript:void(0);) |
| Hyaluronidase | hylp | H4489A | S. pyogenes | [[15](javascript:void(0);) |
|  |  |  |  |  |
| **Serum resistance** | | | | |
| OMP | lom | λ | E. coli | [[39](javascript:void(0);) |
| OMP | bor | λ | E. coli | [[39](javascript:void(0);) |
| OMP | eib | λ-like | E. col | [[42](javascript:void(0);) |
|  |  |  |  |  |
| **Adhesions for bacterial host attachment** | | | | |
| Vir | Vir | MAV1 | Mycoplasma arthritidis | [[81](javascript:void(0);) |
| Coat proteins | pblA, pblB | SM1 | Streptococus mitis | [[70](javascript:void(0);) |
| TCP pilus | tcp | VPIΦ | V. cholerae | [[68](javascript:void(0);) |
|  |  |  |  |  |
| **Others** | | | | |
| IS-like | gipa | Gifsy-1 | S. enterica | [[62](javascript:void(0);) |
| Antivirulence gene | grva | Gifsy-2, Fels-1 | S. enterica | [[63](javascript:void(0);) |
| G-protein-like | glo | K139 | V. cholerae | [[82](javascript:void(0);) |
| Mitogenic factors | mf2, -3, -4 | 370.1, 370.3, 315.3 | S. pyogenes | [[18](javascript:void(0);) |
| Streptodornases | sdn, sda | 315.6, 8232.5 | S. pyogenes | [[18](javascript:void(0);) |
| Phospholipase | sla | 315.4 | S. pyogenes | [[18](javascript:void(0);) |

**Phi x 174 (**[**link**](https://en.wikipedia.org/wiki/Phi_X_174)**) – common contaminant of metagenomes introduced during sequencing**

**Phage therapy studies (**[**link**](https://www.ncbi.nlm.nih.gov/pmc/articles/PMC90351/table/T1/?report=objectonly)**) – phage therapies are banned in the US, so all of these studies are foreign**

| **Reference(s)** | **Infection(s)** | **Etiologic agent(s)** | **Comments** |
| --- | --- | --- | --- |
| Babalova et al. (7) | Bacterial dysentery | *Shigella* | *Shigella* phages were successfully used for prophylaxis of bacterial dysentery. |
| Bogovazova et al. (11) | Infections of skin and nasal mucosa | *K. ozaenae, K. rhinoscleromatis*, and *K. pneumoniae* | Adapted phages were reported to be effective in treating *Klebsiella* infections in all of the 109 patients. |
| Cislo et al. (17) | Suppurative skin infections | *Pseudomonas, Staphylococcus, Klebsiella, Proteus*, and *E. coli* | Thirty-one patients having chronically infected skin ulcers were treated orally and locally with phages. The success rate was 74%. |
| Ioseliani et al. (22) | Lung and pleural infections | *Staphylococcus, Streptococcus, E. coli*, and *Proteus* | Phages were successfully used together with antibiotics to treat lung and pleural infections in 45 patients. |
| Kochetkova et al. (25) | Postoperative wound infections in cancer patients | *Staphylococcus* and *Pseudomonas* | A total of 131 cancer patients having postsurgical wound infections participated in the study. Of these, 65 patients received phages and the rest received antibiotics. Phage treatment was successful in 82% of the cases, and antibiotic treatment was successful in 61% of the cases. |
| Kucharewicz-Krukowska and Slopek (27) | Various infections | *Staphylococcus, Klebsiella, E. coli, Pseudomonas*, and *Proteus* | Immunogenicity of therapeutic phages was analyzed in 57 patients. The authors concluded that the phages' immunogenicity did not impede therapy. |
| Kwarcinski et al. (29) | Recurrent subphrenic abscess | *E. coli* | Recurrent subphrenic abscess (after stomach resection) caused by an antibiotic-resistant strain of *E. coli* was successfully treated with phages. |
| Litvinova et al. (32) | Intestinal dysbacteriosis | *E. coli* and *Proteus* | Phages were successfully used together with bifidobacteria to treat antibiotic-associated dysbacteriosis in 500 low-birth-weight infants. |
| Meladze et al. (33) | Lung and pleural infections | *Staphylococcus* | Phages were used to treat 223 patients having lung and pleural infections, and the results were compared to 117 cases where antibiotics were used. Full recovery was observed in 82% of the patients in the phage-treated group, as opposed to 64% of the patients in the antibiotic-treated group. |
| Miliutina and Vorotyntseva (35) | Bacterial dysentery and salmonellosis | *Shigella* and *Salmonella* | The effectiveness of treating salmonellosis using phages and a combination of phages and antibiotics was examined. The combination of phages and antibiotics was reported to be effective in treating cases where antibiotics alone were ineffective. |
| Perepanova et al. (40) | Inflammatory urologic diseases | *Staphylococcus, E. coli*, and *Proteus* | Adapted phages were used to treat acute and chronic urogenital inflammation in 46 patients. The efficacy of phage treatment was 92% (marked clinical improvements) and 84% (bacteriological clearance). |
| Sakandelidze and Meipariani (45) | Peritonitis, osteomyelitis, lung abscesses, and postsurgical wound infections | *Staphylococcus, Streptococcus*, and *Proteus* | Phages administered subcutaneously or through surgical drains in 236 patients having antibiotic-resistant infections eliminated the infections in 92% of the patients. |
| Sakandelidze (46) | Infectious allergoses (rhinitis, pharyngitis, dermatitis, and conjunctivitis) | *Staphylococcus, Streptococcus, E. coli, Proteus*, enterococci, and *P. aeruginosa* | A total of 1,380 patients having infectious allergoses were treated with phages (360 patients), antibiotics (404 patients), or a combination of phages and antibiotics (576 patients). Clinical improvement was observed in 86, 48 and 83% of the cases, respectively. |
| Slopek et al. (52–58) | Gastrointestinal tract, skin, head, and neck infections | *Staphylococcus, Pseudomonas, E. coli, Klebsiella*, and *Salmonella* | A total of 550 patients were treated with phages. The overall success rate of phage treatment was 92%. |
| Stroj et al. (67) | Cerebrospinal meningitis | *K. pneumoniae* | Orally administered phages were used successfully to treat meningitis in a newborn (after antibiotic therapy failed). |
| Tolkacheva et al. (69) | Bacterial dysentery | *E. coli* and *Proteus* | Phages were used together with bifidobacteria to treat bacterial dysentery in 59 immunosuppressed leukemia patients. The superiority of treatment with phage-bifidobacteria over antibiotics was reported. |
| Weber-Dabrowska et al. (74) | Suppurative infections | *Staphylococcus* and various gram-negative bacteria | Orally administered phages were used to successfully treat 56 patients, and the phages were found to reach the patients' blood and urine. |
| Zhukov-Verezhnikov et al. (77) | Suppurative surgical infections | *Staphylococcus, Streptococcus, E. coli*, and *Proteus* | The superiority of adapted phages (phages selected against bacterial strains isolated from individual patients) over commercial phage preparations was reported in treating 60 patients having suppurative infections. |

**More former Soviet studies on Phage Therapy (**[**link**](https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3278644/table/T1/?report=objectonly)**)**

Some human phage therapy studies performed in the former Soviet Union

| Authors | Year | Ref | Target organisms | Disease | n[\*](https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3278644/table/T1/?report=objectonly#TF1) | Route | Success | Details |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Markoishvili et al. | 2002 | [83](https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3278644/#R83) | E. coli Proteus Pseudomonas Staphylococcus | Ulcers and wounds | 96 | Phage BioDerm | 70% | Healing associated with reduction or elimination of target organisms in 22 patients with ulcers |
| Lazareva et al. | 2001 | [84](https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3278644/#R84) | Proteus Staphylococcus Streptococcus | Burn wounds | 54 | Tablets |  | Pyophage; Reduced septic complications, better temperature normalization, two-fold reduction of staphylococci and streptococci, and a 1.5-fold Proteus with phage use |
| Perepanova et al. | 1995 | [85](https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3278644/#R85) | E. coli Proteus Staphylococcus | Acute and chronic urogenital inflammation | 46 |  | 92%, 84% | 92% for marked clinical improvement; 84% for bacteriological clearance |
| Miliutina and Vorotyntseva | 1993 | [86](https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3278644/#R86) | Salmonella Shigella | Salmonellosis |  |  |  | Phages versus combined phages and antibiotics was examined with combination effective but not antibiotics alone |
| Bogovazova et al. | 1992 | [87](https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3278644/#R87) | K. ozaenae K. pneumoniae K. rhinoscleromatis |  | 109 |  |  | Adapted phages used; treatment reportedly effective; see also references [88](https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3278644/#R88) and [89](https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3278644/#R89) |
| Sakandelidze et al. | 1991 | [90](https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3278644/#R90) | Enterococcus E. coli P. aeruginosa Proteus Staphylococcus Streptococcus | Infectious allergoses | 936 |  | 86% | Phages only, n = 360, 86% success; antibiotics only, n = 404, 48% success; antibiotics plus phages, n = 576, 83% success |
| Kochetkova et al. | 1989 | [91](https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3278644/#R91) | Pseudomonas Staphylococcus | Post-surgical wounds | 65 |  | 82% | Cancer patients; treatment was successful in 61% of antibioticonly treatment |
| Anpilov and Prokudin | 1984 | [92](https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3278644/#R92) | Shigella | Dysentery (prophylaxis) |  |  |  | Double-blinded; ca. 10-fold lower incidence of dysentery in phage-treated group |
| Martynova et al. | 1984 | [93](https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3278644/#R93) | P. aeruginosa S. aureus | Prophylactic | 27 (10) | Mouth rinse |  | 2 times/day for 3–5 days in 27 patients; normalization of microflora in infected sites with IgA production stimulated |
| Meladze et al. | 1982 | [94](https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3278644/#R94) | Staphylococcus | Infections of the lung parenchyma and pleura | 223 |  | 82% | Full recovery seen with phages versus 64% with antibiotics only (n = 117) |
| Tolkacheva et al. | 1981 | 95 | E. coli Proteus Dysentery |  | 59 |  |  | Immunosuppressed leukemia patients treated with improved results in combination with bifidobacteria |
| Ioseliani et al. | 1980 | [95](https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3278644/#R95) | E. coli Proteus Staphylococcus Streptococcus | Lung and pleural infections | 45 |  |  | Successful phage use in combination with antibiotics |
| Litvinova et al. | 1978 | [97](https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3278644/#R97) | E. coli Proteus | Antibiotic-associated dysbacteriosis | 500 |  | successful | Premature/low-birth-rate infants; phages used in combination with bifidobacteria |
| Zhukov-Verezhnikov et al. | 1978 | [98](https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3278644/#R98) | E. coli Proteus Staphylococcus Streptococcus | S.I. | 60 |  |  | Improved efficacy using phages selected against bacterial strains isolated from individual patients versus commercial phage preparations |
| Pipiia et al. | 1976 | [99](https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3278644/#R99) |  | Abscessing pneumonia |  | Parenteral |  | Multiple treatment approaches including use of phages |
| Sakandeldze et al. | 1974 | [100](https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3278644/#R100) | Proteus Staphylococcus Streptococcus |  | 236 | Subcutaneous or through surgical drainage | 92% | Success = elimination of infections |