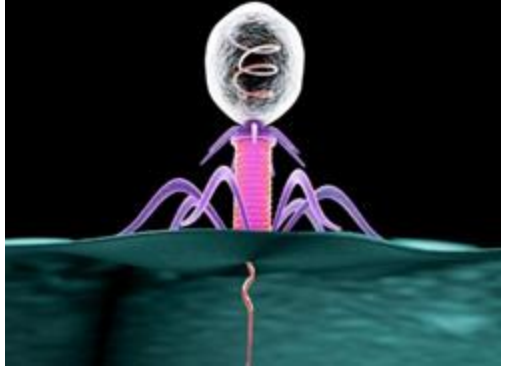


Bacteriophage “Phage”
Attaching to its bacterial host

Clinical Practice: Good viruses for bad bacteria: Phage Therapy Primer for the ICP.

IPAC Canada 2024 National Conference

June 11, 2024

Greg German MD PhD FRCPC DTM&H (UK) et al.

Medical Microbiologist and Clinician-Investigator (LKSKI), Unity Health

Chronic Infection / Phage Therapy Research Clinic St. Joseph’s Health Centre

Professorship in Bacteriophage Therapy Research and Innovation, University of Toronto

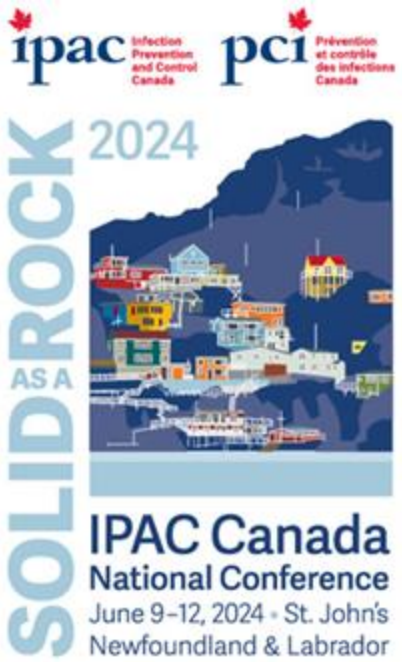
AMMI Canada Phage Therapy Working Group Lead

Phage Canada, Co-Founder

Global Clinical Phage Rounds Chair

Twitter/X: @drgreggerman

Gregory.German@unityhealth.to



PHAGE Canada

UNIVERSITY OF TORONTO

ST. JOSEPH'S UNITY HEALTH TORONTO

St. Michael's
Inspired Care. Inspiring Science.

ipac Infection Prevention and Control Canada

pci Prévention et contrôle des infections Canada

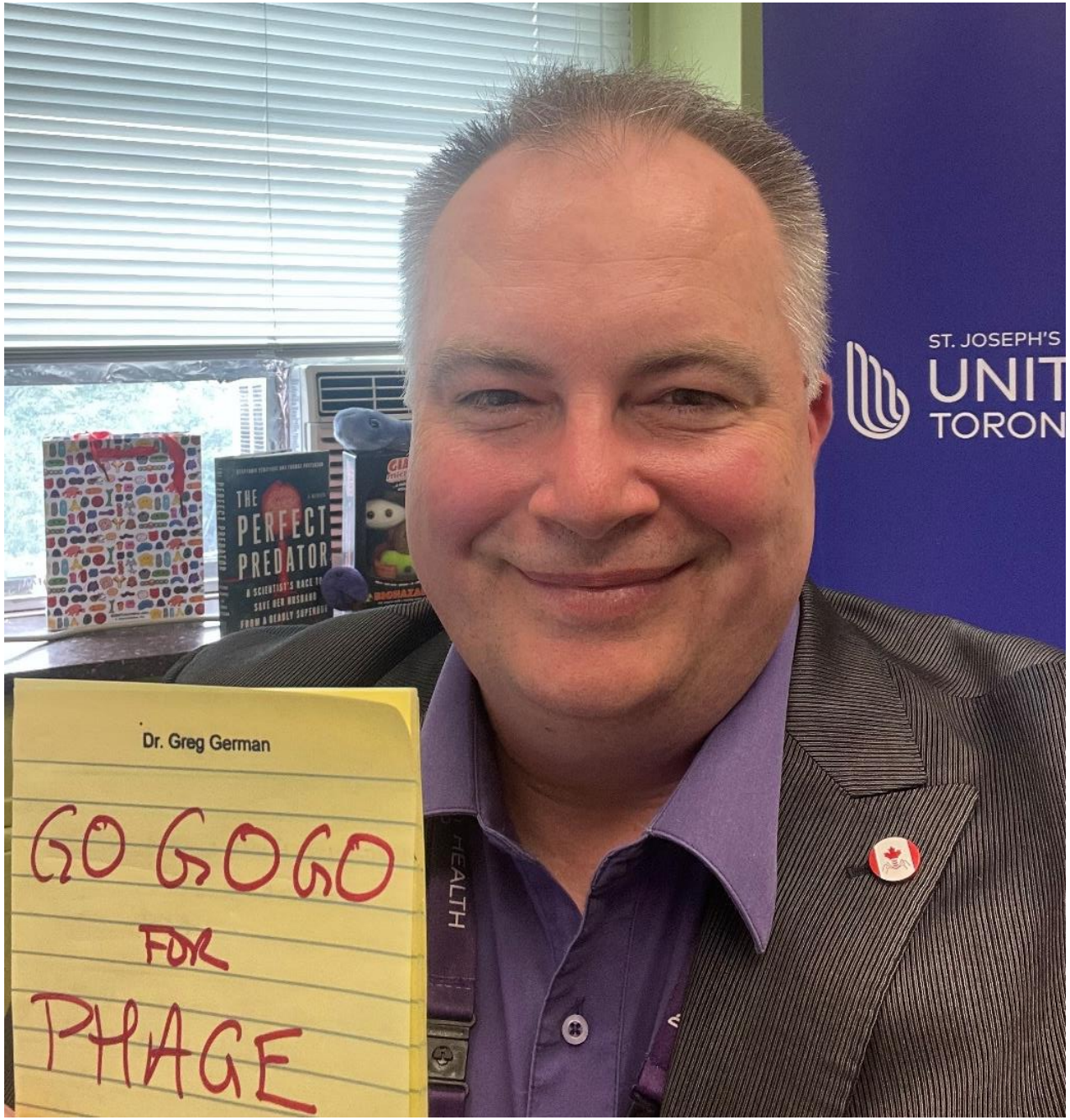
Presenter Disclosure

- **Faculty:** University of Toronto
- **Financial affiliations:**
  - Grants, clinical trials: NCT05537519 (Investigator initiated) Phage Therapy for UTIs
  - Other influential affiliations: Co-founder and Clinical director of Phage Canada, a non-profit organization.
- **Land Acknowledgement:**
  - **We are all treaty people, and we should respect the shared land today and for seven generations to come.**

Does the clicker system work

Pick your Iconic Canadian Food:

1. Beaver Tail
2. Poutine
3. Lobster Roll
4. Maple Taffy
5. Nanaimo Bar
6. Moose



BEAVER TAILS

- sweet AF
- everyone wants to be your friend
- kinda messy though

POUTINE

- great at giving advice
- iconic
- people either love you or hate you

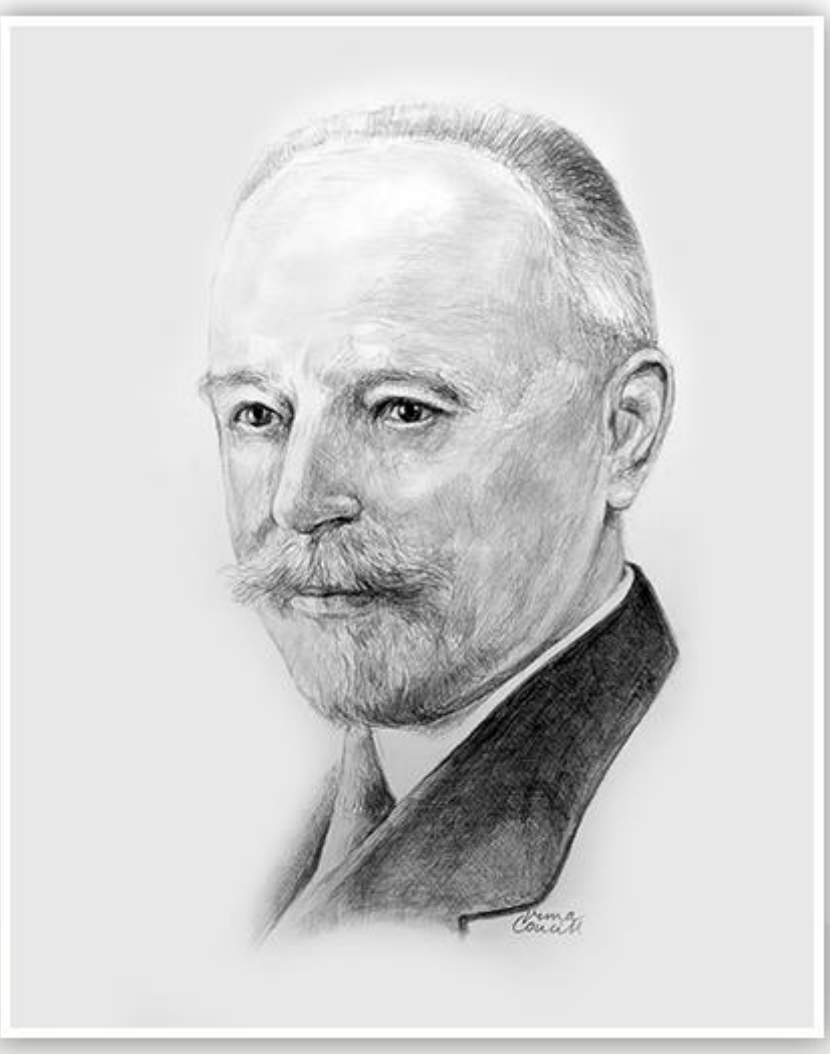
LOBSTER ROLL

- little bit fancy
- the biggest personality in the room
- extremely competitive

MAPLE TAFFY

- loves to relax
- will stick with you forever
- hot one second, cold the next


Crown Royal
MAPLE
FINISHED



A pioneering scientist and a committed global investigator

Félix d'Hérelle applied a single-minded enthusiasm and scientific thoroughness to every new challenge. Records from his first assignment on behalf of the Government of Canada to explore the feasibility of fermenting and distilling maple syrup into "whiskey" were meticulous and reveal the qualities of a great scientist.

More significantly, Dr. d'Hérelle is credited for two brilliant discoveries that together signify a scientific revolution. Considered an "outsider" in science, this vagabond scholar set up a lab in his Montreal home at age 24 and went on to discover a biological control of pests and a cure for bacterial infections using bacteria-eating bacteriophages. Félix D'Hérelle's work led to the founding of the "Phage Group" of scientists.

https://www.cdnmedhall.ca/laureates/felixdherelle

1931

The Canadian
Medical Association Journal

Vol. XXIV TORONTO, MAY, 1931 No. 5

An Address
ON
BACTERIOPHAGY AND RECOVERY FROM INFECTIOUS DISEASES*

BY F. D'HERELLE, M.D.
Yale University
New Haven, Conn.

1935

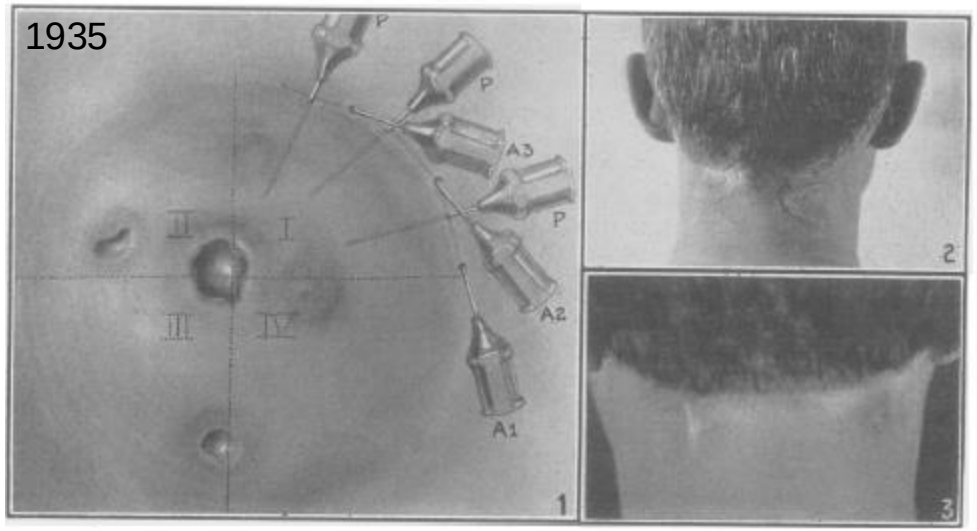


FIG. 1.—Diagram for the injection of carbuncles. The carbuncle is divided into four quadrants. Each quadrant is anæsthetized with a local anæsthetic A_1; A_2; A_3, and injected with bacteriophage P. before carrying on to the successive quadrants. If this procedure is not carried out, but the entire circumference of the carbuncle is injected with the local anæsthetic, the absorption will be so rapid that the anæsthetic effect will disappear before it is possible to inject the circumference of the entire carbuncle with phage.

FIG. 2.—This illustrates the end-result of a carbuncle which extended from the tips of the mastoid processes laterally, and from the external occipital protuberance above, to the 7th cervical spine below. This carbuncle was treated entirely by phage, with a series of seances at an interval of six days. On numerous occasions the cavities were packed with gauze, soaked in bacté-staphy-phage.

FIG. 3.—A patient whose carbuncles had been treated, the one on the left by incision and packing, some four years previously. The carbuncle on the right side was of the same magnitude and was treated entirely by bacteriophage, and, although only about three and one-half weeks old, shows practically no evidence that a disfiguring scar will ensue.

1935

BACTERIOPHAGE IN THE INJECTION TREATMENT OF CARBUNCLES, AND ALLIED SUPERFICIAL INFECTIONS

BY H. GURTH PRETTY, M.D.,
Department of Surgery, Montreal General Hospital,
Montreal

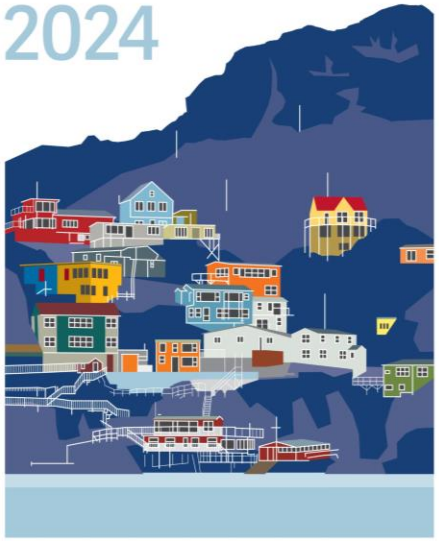
THE discovery of bacteriophage, under the direction of Professor D'Hérelle, has entirely revolutionized the treatment of carbuncles, furuncles and allied superficial infections of the body. Stock bacteriophage is a suspension of ultra-microscopic organisms parasitic to bacteria in a peptone broth. These organisms have been developed with regard to special selective affinity for one specific organism. There are bacteriophage peptone suspensions prepared specifically for the *S. aureus*, *B. coli*, *B. dysenteriæ*, and the cholera bacillus. A pure streptococcus "phage" has not yet been isolated. It is possible, however, to combine and prepare "bacté-pyo-phage", a suspension containing ultra-microscopic organisms, members of which have a specific selectivity. The bacteriophage prepared for staphylococcus infections is known as "bacté-staphy-phage". The mixed phage is known as "bacté-pyo-phage". Bacteriophage may be administered orally or subcutaneously, or by both methods at the same time.

"Bacteriophagy is an infectious disease destructive to bacteria. The agent of this disease is a filterable virus, a protobe, the bacteriophage. [illegible] equilibrium is, indeed, extremely frequent in nature."*

My own personal experience dates from July, 1931, until the present time (November, 1934), both in hospital and private practice. In my opinion the bacteriophage treatment of carbuncles and furuncles has been extremely satisfactory. When considering the treatment of a furuncle, recall the usual operative procedure. The furuncle is incised with a crucial incision, under general or local anæsthesia. The pus is evacuated, and the cavity packed. Eventually the packing is removed and the cavity is re-packed. Gradually the cavity fills up with granulation tissue; then epithelium bridges the gap. Unfortunately, this is a slow and tedious procedure, and in many cases, the infection undermines the skin flaps, necessitating further operative interference. During this period of time the patient is uncomfortable, and may or may not be disabled from work, according to the anatomical position of the furuncle. Further, the person afflicted with a furuncle or carbuncle frequently has a hyperglycæmia which has to be controlled by insulin to promote healing of the wound.

Pre-Test

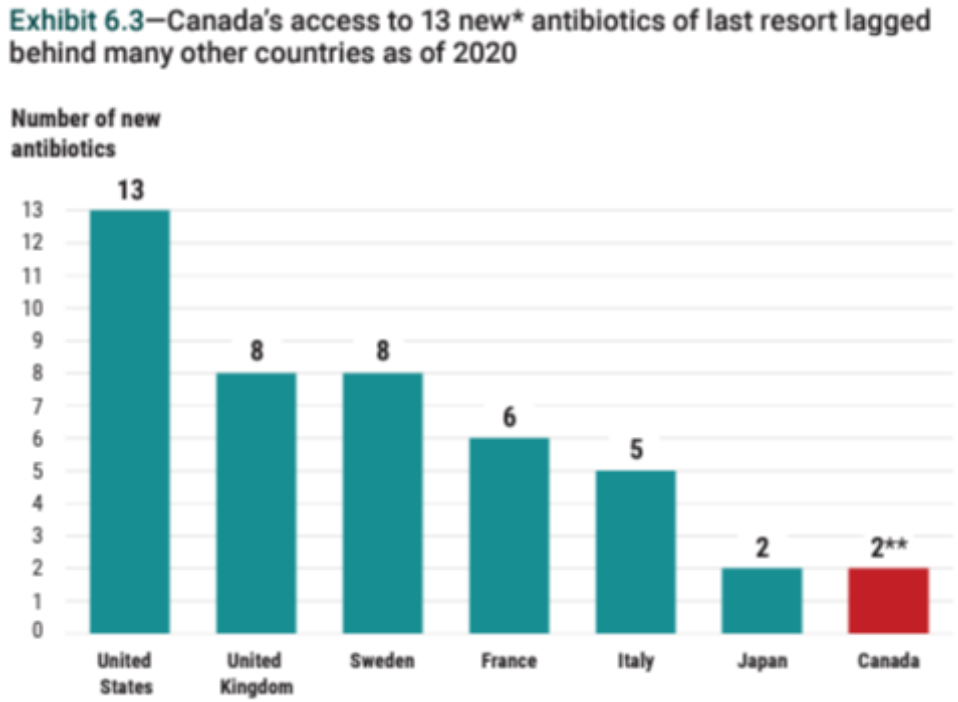
What is your level of comfort with Phage Therapy?

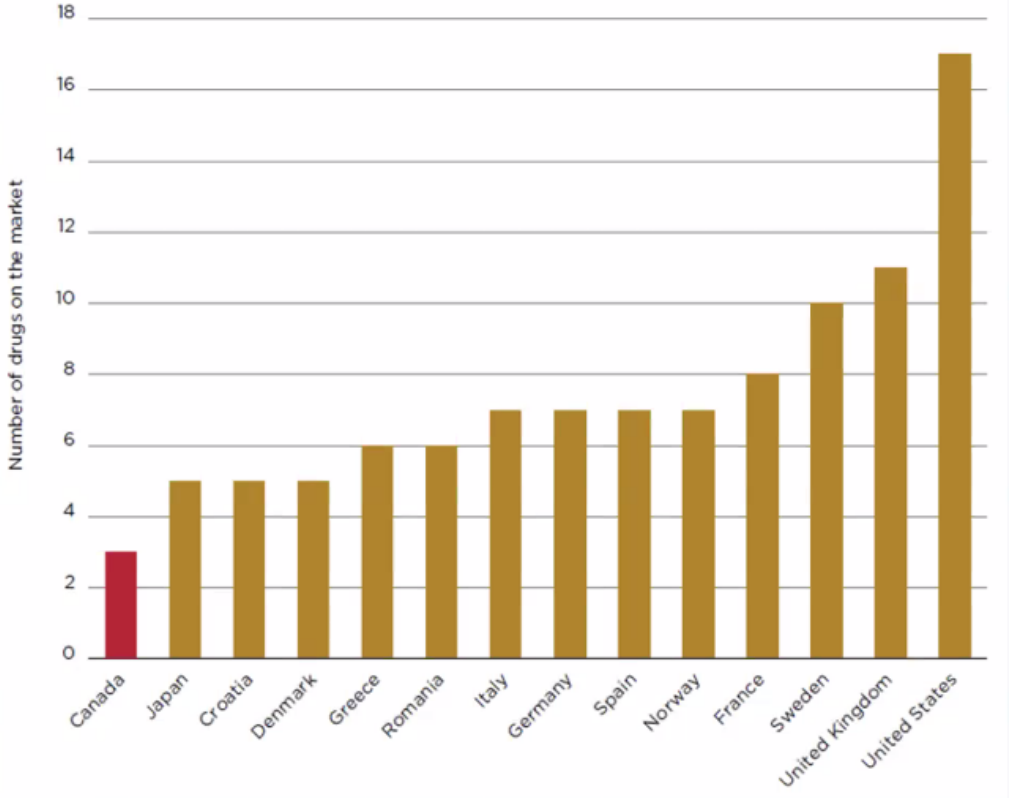


1. Phage Phanatic: I am so my enemy of my enemy is my friend and we have an AMR CRISIS
2. Phage Phriendly: I studied phages, it makes sense, there is hope
3. Phage Phence:… Ask me later
4. Phage Phear: Please show me the successful RCTs, don’t phages carry toxins and resistance genes?
5. Phage Phorgetaboutit

Canadian Government Audit: Federal government did not do enough for a top 10 global public health treat.

- 2023 Plan created but did not cover important elements: concrete deliverables, timelines, and accountability





18 Antimicrobials entered global market in the 2010's
4 of which are on the WHO List of Essential Medicines

CHAN / Turner lab Kelowna BC → Yale

That's why she travelled to the U.S. to become the first Canadian CF patient to try an experimental treatment called phage therapy – using viruses to kill bacteria. She's part of a group of 13 patients receiving care at Yale New Haven Hospital in Connecticut.

"I'm at a point where this is my last resort," said Nicole.

PHAGE THERAPY

She's relying on nature's best killers.

FROM A GROUP OF 13 PATIENTS

- In the article mentions Dr. Jon Dennis University of Alberta for finding phages for CF cases (including B. cepacia complex)

https://www.ctvnews.ca/w5/a-long-forgotten-canadian-discovery-used-to-treat-superbugs-1.4706823

Canadian receiving phage by mail order or Travel to / From Georgia

PHAGE BY MAIL ORDER

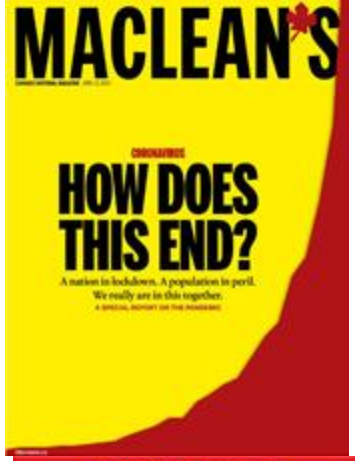
- Past 15 years
- 5 to 10 Canadians a year receive phages from Tbilisi by mail
  - Urine sent directly to lab (not the isolate)
  - Regular commercial phage cocktails provided as nutritional supplement for oral intake only.

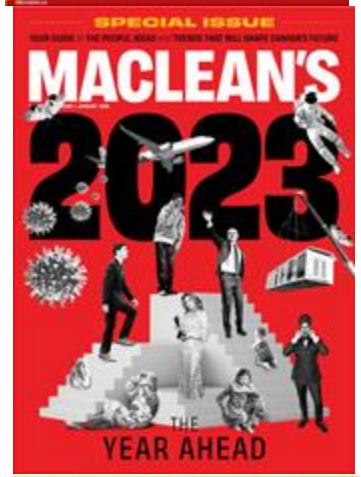
PATIENTS TRAVEL TO EASTERN EUROPE

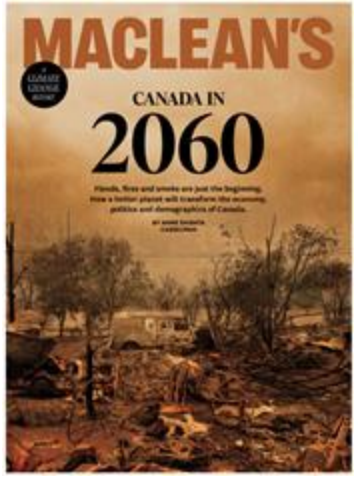
- 10 to 20 Canadians travel to Tbilisi a year for treatment
- 1700 USD per cocktail of 3 or more phages for a single isolate, additional 1000 USD per cocktail for a different genus.
- Titre of cocktails around 10^5 to 10^8.
- Not purified of media or LPS.
  - **1 in 100 patients** Jarisch-Herxheimer reaction (at one center)
  - Some instillation for bladder, some inhalation (but not well tolerated), no IV.

ELIAVA
Phage Therapy Center

Part 1: Phages and ARO







Target superbugs with phage therapy

In 1917, a Franco-Canadian scientist pioneered a treatment that's become a powerful weapon against antibiotic-resistant infections. It should be available here. ***By Greg German***

I HAVE A CLEAR MEMORY of sitting on a Toronto-area park bench in 1985 as my dad—a computer executive and jack-of-all-trades—explained the arms race between our cells and a new virus called HIV. The military metaphor worked for me, an 11-year-old burgeoning physician-scientist with a fascination for jets and *Transformers*. I thought, *Wow, there's a battle going on inside us, and we have to find the right weapon to win it*. That analogy hung on through my adult years and graduate work in microbiology, where I studied phages: tiny, bacteria-destroying viruses alternately known as "nanobot soldiers," "viral smart bombs" and "the perfect predators."

Phages, or bacteriophages, get their name from the Greek word for "devour," and their food of choice is bacteria. In nature, there are more phages than any other entity; these microbes live in soil, seawater and our bodies. (For reference, there are billions of phages in the human gut alone.) Their main objective is to replicate, which they achieve by injecting their DNA into nearby bacteria with the help of external receptors. The bacteria explode and die, expelling up to 300 new phages, which then search for their next target.

More than a century ago, a Franco-Canadian scientist named Félix d'Hérelle—previously known for making whiskey from maple syrup—discovered that these little killing machines could be used to cure infections like shigellosis, which affects the intestines. In its 1930s heyday, phage therapy—which involves phages being applied topically or orally—caught the attention of experts at France's Pasteur Institute, the pharma company Eli Lilly and several American universities. But once that magic drug penicillin came along, Western medicine sent phage therapy to the fringes and leaned into antibiotics, which could be mass-produced and were more widely effective and, therefore, more profitable. In doing so, we inadvertently started another arms race.

Antimicrobial resistance, also called AMR, has led to the rise of drug-resistant superbugs. It's the new pandemic, albeit a silent one. We saw resistance to penicillin as early as 1942, but thanks in part to doctors prescribing antibiotics like candy for decades, the problem is now becoming catastrophic. I am *already* hearing about patients undergoing radical surgery or hospitals paying tens of thousands of dollars to ship end-of-the-line antibiotics over the border from the U.S because we've run out of effective ones up here. And by 2050, more people are expected to die annually from AMR than from cancer. They will also die from complications following very straightforward procedures, like knee replacements. Usually, those surgeries come with a one per cent chance of infection. If that infection is drug-resistant, your seemingly simple joint surgery could become a death sentence. Others may die from simple skin infections. Madonna, a high-profile case, visited the ICU with a serious bacterial infection back in June. Years ago, my own mother died of a drug-resistant urinary tract infection that she contracted in a long-term care facility.

In search of alternative treatments, many Canadian medical professionals are looking, once again, to phages. Health Canada has deemed phages safe enough to spray on food products like meat to knock down bacteria counts, but at the moment, they're not approved in health-care settings, except in clinical trials. Meanwhile, phage therapy is flourishing in other countries. After antibiotics went mainstream, Félix d'Hérelle headed to the Soviet Union to continue his research and later helped to found the Eliava Phage Therapy Center in Tbilisi, Georgia, a country where you can receive phage-filled ampoules over the counter for as little as $2. The centre shares its innovations with other European countries, like the Netherlands and Belgium. Since 2000, Belgium has treated 150 patients with phage therapy; Canada, which has almost four times the population, has treated two.

Earlier this year, my clinic at St. Joseph's Health Centre in Toronto completed the first Canadian trial to successfully use phages to treat a drug-resistant urinary tract infection. For years, our patient's particular strain of *E. coli* thwarted all of the half-dozen antibiotics prescribed to her and cost her a kidney. Because Canada's phage ecosystem is still relatively underdeveloped, we had to send a sample of the patient's bacteria to a lab at the Baylor College of Medicine in Houston, Texas, which matched her strain with three phages and mailed us the winning cocktail. The patient's condition began to improve 48 hours after we gave her an oral dose of phages. But importing phages isn't sustainable. That one shipment cost us roughly the equivalent of a cab ride to Texas.

> "Phages are tiny, bacteria-destroying viruses alternately known as 'nanobot soldiers,' 'viral smart bombs' and 'the perfect predators'"

Even with all the new enthusiasm around personalized medicine—which phage therapy very much is—we're still years away from seeing this treatment in Canadian clinics and hospitals. Right now, there's no way for patients to charge insurance for phage therapy, and randomized control trials are hard to do when infections require a blend of targeted phages tailored to treat each individual case. What Canada *can* do in the meantime is become a major market for phage production, supplying researchers here and abroad. The University of Laval is in the process of expanding its phage depot, and the University of Toronto (where I work) is establishing an accelerator that'll fund grants for phage therapy research for human and animal care.

Phage-centric startups are popping up, too: Qeen BioTechnologies, located just outside Ottawa, supplies phages for international clinical trials and compassionate cases and is aiming to have a full production facility up and running by this coming December. Winnipeg's Cytophage is working on treatments that might one day replace antibiotics used for growth and disease prevention in livestock—such as broiler chickens—as well as new SARS vaccines.

One of the biggest hurdles to making this treatment mainstream, aside from regulation, is a lack of awareness around phage therapy's life-saving potential. My goal is to make phage therapy a topic of discussion everywhere from our dinner tables to the highest levels of government. We should never underestimate the power of a single case—or a single phage—to move the needle: since my team's UTI trial wrapped in the spring, I've received roughly 40 calls from Canadians contending with superbugs who want to give phage therapy a go.

I often think about an analogy from my colleague Jon Iredell, an infectious-disease physician and microbiologist in Australia. He often compares medicine's infection-fighting strategy to a three-legged table. One leg is antibiotics (appropriately used), another leg is vaccines and another is phage therapy. (In my opinion, the fourth, invisible leg is our own immune systems.) For simple skin ulcers or UTIs, I'd say try phages first, while more complicated infections might merit stronger antibiotics. Antimicrobial resistance is a battle that can't be won on one front. It's going to take every weapon we've got. ■

GREG GERMAN *is an assistant professor in the department of laboratory medicine and pathobiology at the University of Toronto and a microbiologist at UnityHealth Toronto. He is also co-founder of the non-profit Phage Canada.*

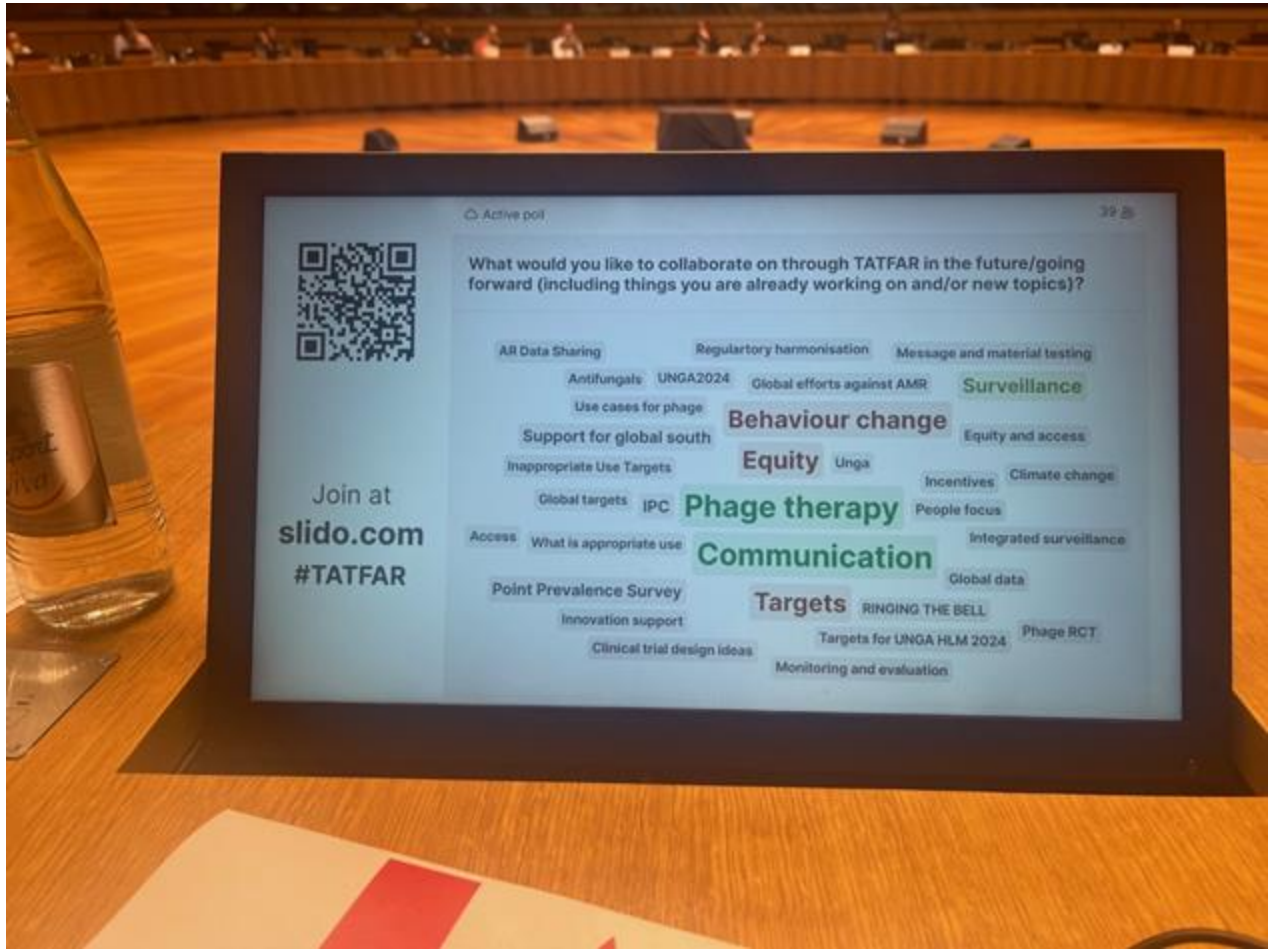
ILLUSTRATION BY **PETE RYAN**

Antimicrobial Resistance is a battle that can't be won on one front. It's going to take every weapon we've got!

Antibiotic Resistance… Everywhere, Everyone, Everything

A top 10 WHO Global Health Priority

US CDC, CANADA, EUROPEAN UNION, NORWAY, UK MEETING NOV 2023

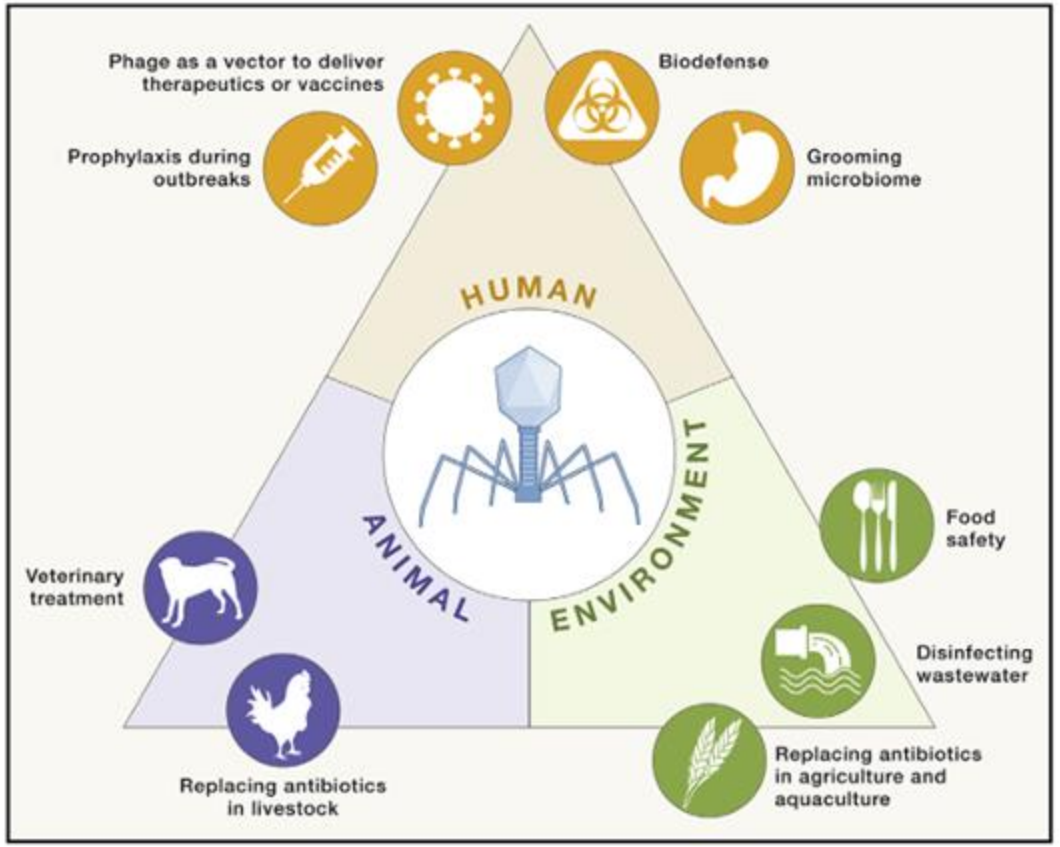


Good Viruses Eating Deadly Bacteria

Bacteriophage therapy

1. Very specific (Less collateral damage)
2. Out evolves and over 3 Billion years
3. Adaptable / trainable / modifiable
4. Predictable code / Safe
5. Ubiquitous / Immune escape
6. Bio-Cures biofilm infections
7. Autodoses / chain reaction
8. Disables bacteria if does not kill
9. Scalable / Shareable / Synergistic
10. Treat infections and non-infections

Cell
Review



2023 PMID: 36608652

Oral Delivery Systems for Encapsulated Bacteriophages Targeted at *Escherichia coli* O157:H7 in Feedlot Cattle

K. STANFORD,[1]* T. A. McALLISTER,[2] Y. D. NIU,[2] T. P. STEPHENS,[1] A. MAZZOCCO,[3] T. E. WADDELL,[4] AND R. P. JOHNSON[3]

[1]*Alberta Agriculture and Rural Development, Agriculture Centre, Lethbridge, Alberta, Canada T1J 4V6;* [2]*Agriculture and Agri-Food Canada, Lethbridge Research Centre, Lethbridge, Alberta, Canada T1J 4B1;* [3]*Public Health Agency of Canada, Guelph, Ontario, Canada N1G 3W4; and* [4]*Pro-Lab Diagnostics, Richmond Hill, Ontario, Canada L4B 1K3*

MS 09-493: Received 20 November 2009/Accepted 11 April 2010

ABSTRACT

Bacteriophages are natural predators of bacteria and may mitigate *Escherichia coli* O157:H7 in cattle and their environment. As bacteriophages targeted to *E. coli* O157:H7 (phages) lose activity at low pH, protection from gastric acidity may enhance efficacy of orally administered phages. Polymer encapsulation of four phages, wV8, rV5, wV7, and wV11, and exposure to pH 3.0 for 20 min resulted in an average 13.6% recovery of phages after release from encapsulation at pH 7.2. In contrast, untreated phages under similar conditions had a complete loss of activity. Steers ($n = 24$) received 10^{11} CFU of naladixic acid–resistant *E. coli* O157:H7 on day 0 and were housed in six pens of four steers. Two pens were control (naladixic acid–resistant *E. coli* O157:H7 only), and the remaining pens received polymer-encapsulated phages (Ephage) on days −1, 1, 3, 6, and 8. Two pens received Ephage orally in gelatin capsules (bolus; 10^{10} PFU per steer per day), and the remaining two pens received Ephage top-dressed on their feed (feed; estimated 10^{11} PFU per steer per day). Shedding of *E. coli* O157:H7 was monitored for 10 weeks by collecting fecal grab and hide swab samples. Acceptable activity of mixed phages at delivery to steers was found for bolus and feed, averaging 1.82 and 1.13 $\times$ 10^9 PFU/g, respectively. However, Ephage did not reduce shedding of naladixic acid–resistant *E. coli* O157:H7, although duration of shedding was reduced by 14 days ($P < 0.1$) in bolus-fed steers as compared with control steers. Two successful systems for delivery of Ephage were developed, but a better understanding of phage–*E. coli* O157:H7 ecology is required to make phage therapy a viable strategy for mitigation of this organism in feedlot cattle.

As of November 2022, in the published literature how many patients have been treated with phage therapy for a urinary tract infections?

1. 5
2. 200
3. 800
4. 1000
5. 1400

Phage Therapy in the Management of Urinary Tract Infections: A Comprehensive Systematic Review

Amany M. Al-Anany, BSc, MSc,[1,*] Payton B. Hooey, BSc Hon,[2,*] Jonathan D. Cook, MD, PhD,[2]
Lori L. Burrows, PhD,[1] Julia Martyniuk, BA, MI,[3] Alexander P. Hynes, PhD,[1,4] and Greg J. German, MD, PhD[2,5]

- Comprehensive and critical assessment of the literature spanning nearly 100 years
- 1450 human cases in the literature (1926 – 2023)
- ~79% reported clinical cure with therapy, and >97% reported improvement in clinical symptoms
- AEs were reported in 8 cases, mostly limited to a single trial

PHAGE Journal

Vancouver 2024

Also see Dr. Jonathan Cook etal.

Poster WP024

WP024

Phage therapy in the management of urinary tract infections: A comprehensive systematic review

Jonathan D Cook[1], Amany M Al-Anany[2], Payton B Hooey[1], Lori L Burrows[2], Julia Martyniuk[3], Alexander P Hynes[2,4], Greg J German[1,5]

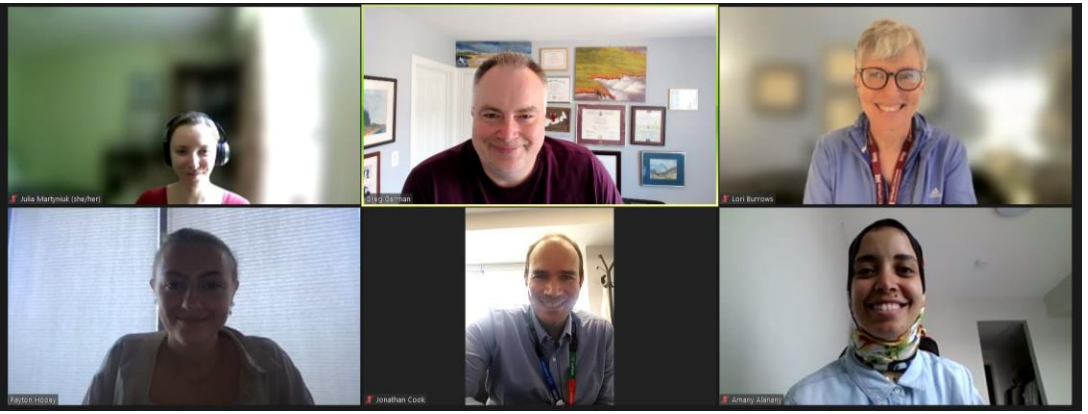
[1]Department of Laboratory Medicine and Pathobiology, University of Toronto, Toronto, ON, Canada. [2]Department of Biochemistry and Biomedical Sciences, McMaster University, Hamilton, ON, Canada. [3]Gerstein Science Information Centre, University of Toronto, Toronto, ON, Canada. [4]Department of Medicine, McMaster University, Hamilton, ON, Canada. [5]Unity Health Toronto, St. Joseph's Health Centre Chronic Infection/Phage Therapy Clinic, Toronto, ON, Canada

UNITY HEALTH TORONTO
Caring hearts. Leading minds.

Laboratory Medicine & Pathobiology
UNIVERSITY OF TORONTO

McMaster University

UNIVERSITY OF TORONTO LIBRARIES



Phage Therapy in the Management of Urinary Tract Infections

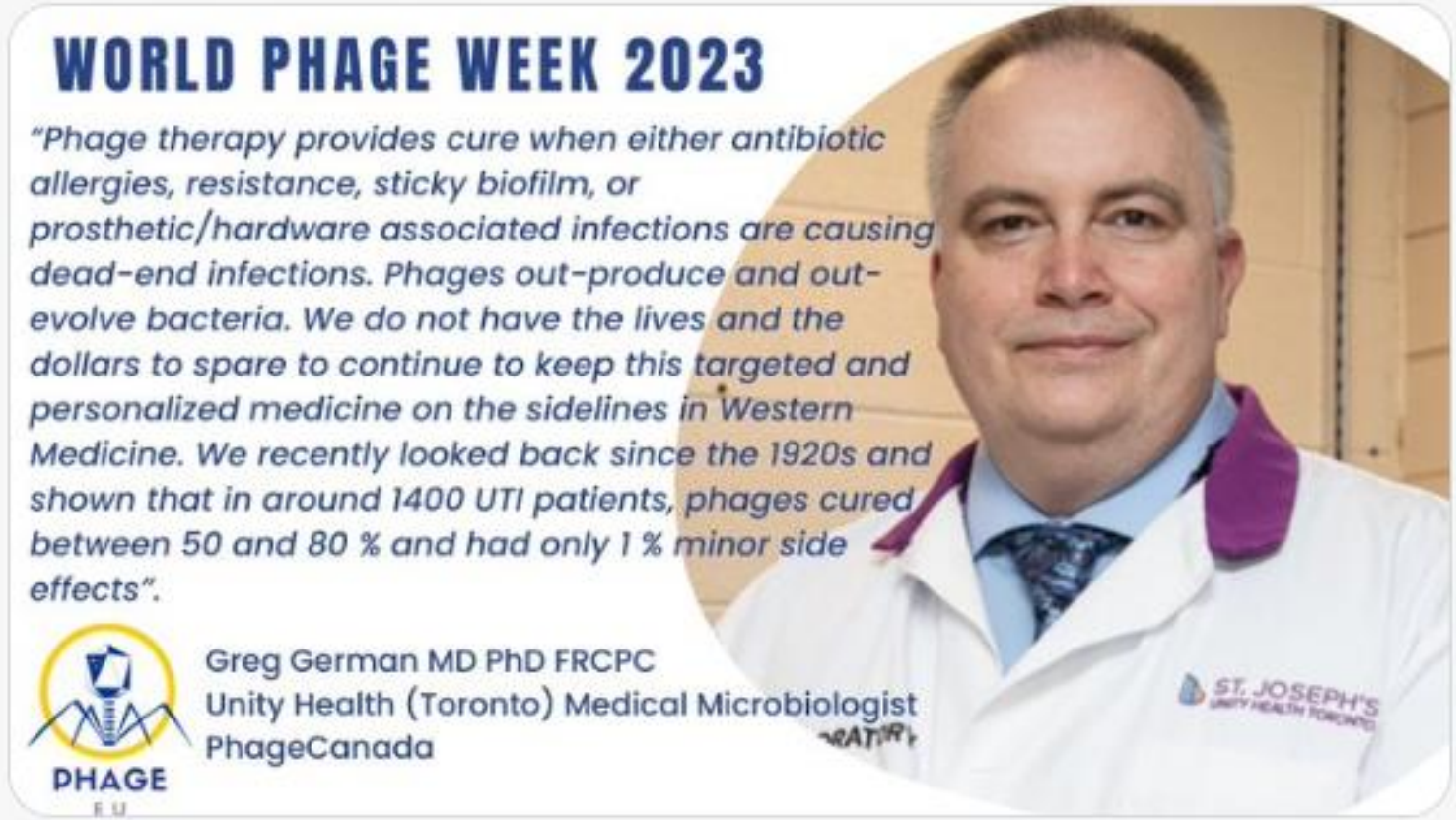
A Comprehensive Systematic Review

Amany M. Al-Anany, Payton B. Hooey, Jonathan D. Cook, Lori L. Burrows, Julia Martyniuk, Alexander P. Hynes, and Greg J. German

Phage Europe @PhageEU · Oct 27

#WorldPhageWeek 2023

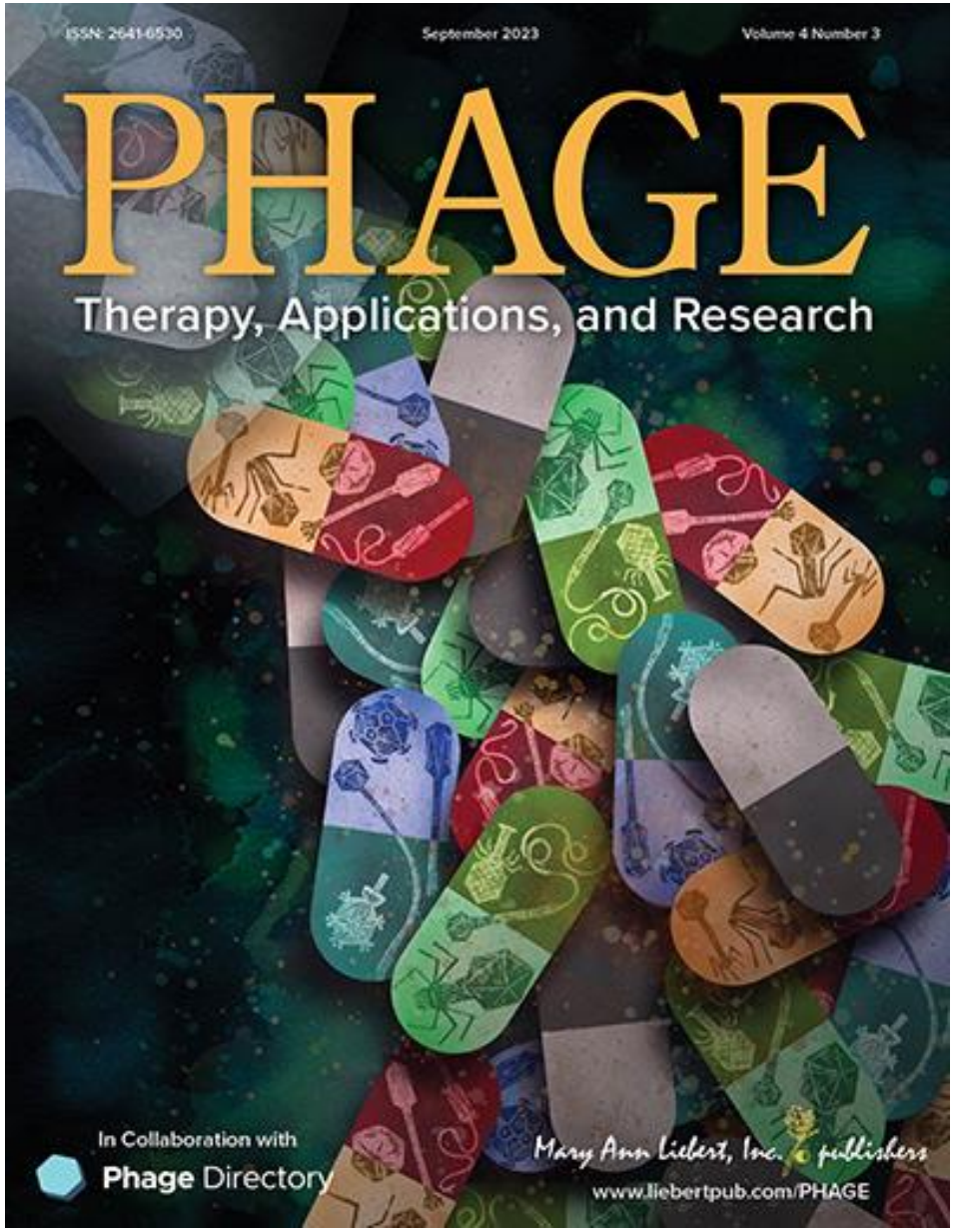
Fighting #AMR is a global challenge and cooperation with partners from all around the world is crucial. @DrGregGerman from @PhageCanada reminds us on the effectiveness of **phage** therapies!



2 9 367

UTI Systematic Review

- Comprehensive and critical assessment of the literature spanning nearly 100 years
- 1450 human cases in the literature (1926 – 2023)
- ~79% reported clinical cure with therapy, and >97% reported improvement in clinical symptoms
- AEs were reported in 8 cases, mostly limited to a single trial



Al-Anany et al. 2023


Dr. Alexander Hynes (he/him)
Greg German
Payton Hooey
Julia Martyniuk
Amany Alanany
Mute
Stop Video
Security
Participants
5
Polls
Share Screen
Reactions
Apps
More
End

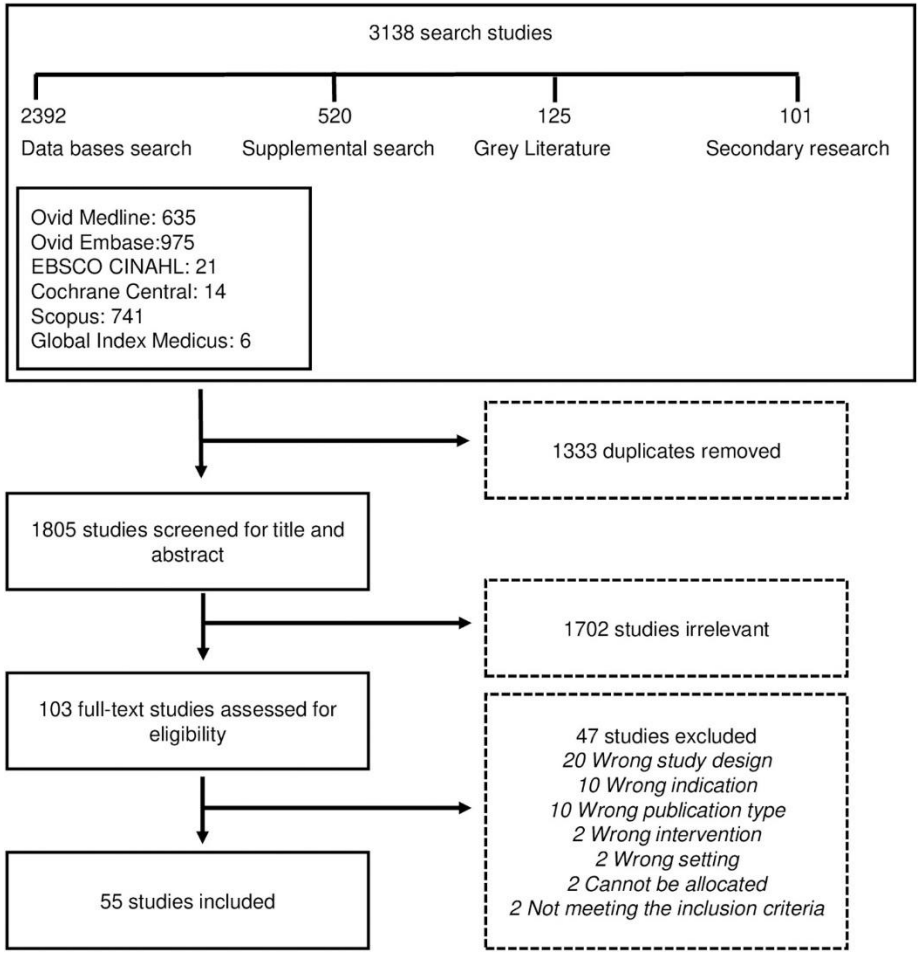
Table 1. Literature Reviews Covering Bacteriophage Therapy for Urinary Tract Infections

Review title	*Type*	*Publication year*	*Limitation*	*References*
Managing urinary tract infections through phage therapy: A novel approach.	A narrative review	2019	Focuses on UPECs and primarily in vitro studies.	15
Prospects of using bacteriophages in urological practice.	A narrative review	2019	Non-English language: Russian, which results in difficulty in data extraction and interpretation.	16
Phage prevalence in the human urinary tract—Current knowledge and therapeutic implications.	A narrative review	2020	Focuses on phage presence within the urobiome and its possible implications for health and disease.	18
Bacteriophages: A panacea in neuro-urology?	A limited narrative review	2020	A short review that focuses on UTIs in patients with neurogenic lower urinary tract dysfunction.	14
Safety and efficacy of phage therapy in difficult-to-treat infections: A systematic review.	A systematic review in 2022 contained a section on UTIs	2022	Limited to articles starting from 2000, English literature only, and studies only in humans.	17

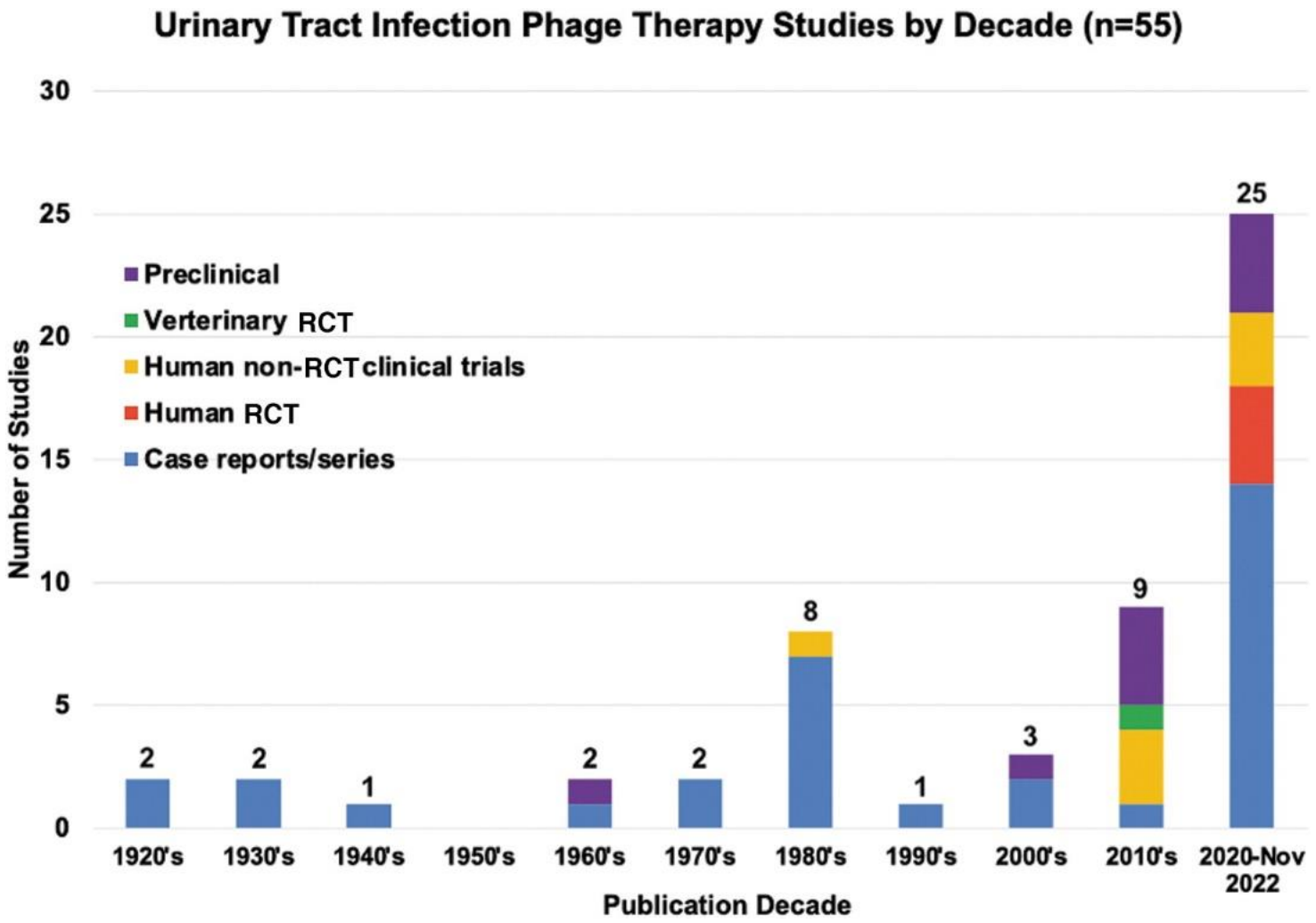
UPEC, uropathogenic *Escherichia coli*; UTI, urinary tract infection.

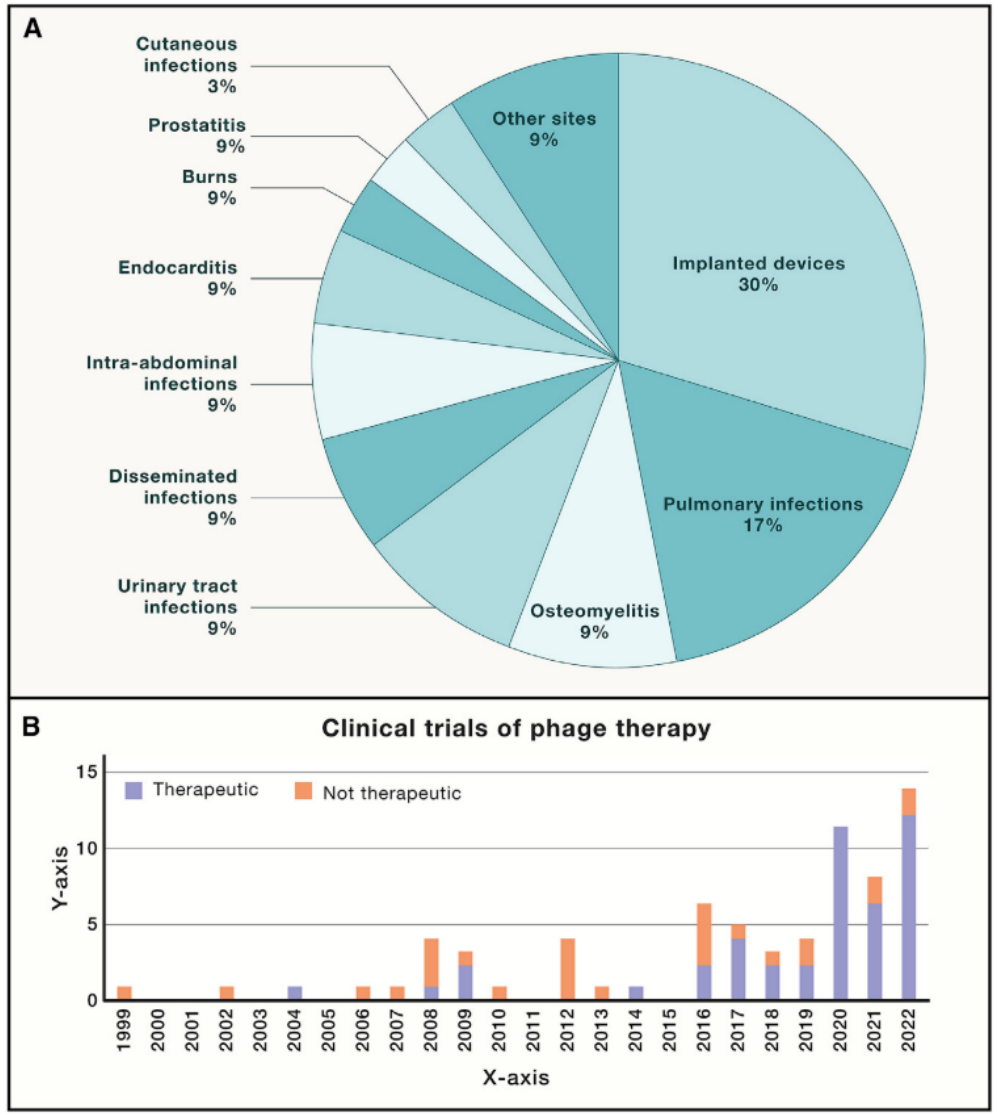
Study Design

- Includes “grey” literature,
- all languages,
- any time period
- Any animal or host
  - All you need is a kidney



- Reflects increasing research efforts





2023 PMID: 36608652

BACTERIOPHAGY IN URINARY INFECTION

PART I. THE INCIDENCE OF BACTERIOPHAGE AND OF BACILLUS COLI SUSCEPTIBLE TO DISSOLUTION BY THE BACTERIOPHAGE IN URINES. PRESENTATION OF CASES OF RENAL INFECTION IN WHICH BACTERIOPHAGE WAS USED THERAPEUTICALLY

NEWTON W. LARKUM
Department of Pathology and Bacteriology, Yale School of Medicine
Received for publication November 24, 1925

BACTERIOPHAGY IN URINARY INFECTIONS FOLLOWING THE ADMINISTRATION OF THE BACTERIOPHAGE THERAPEUTICALLY*

JANET ANDERSON CALDWELL, M.D.
DALLAS, TEXAS

It has been shown that sewage filtrate contains lytic principle of marked activity for most of the gram-negative bacilli found in cases of urinary infections.[1] Of seventy-five consecutive cases of urinary infections which I have studied up to the present time, sewage filtrate has lyzed 90 per cent of the strains of bacilli isolated from the catheterized specimens of urine. The activity of the sewage filtrate is marked, either in the first passage or after only one or two passages. A complete report of this phase of the subject will be made after the series has been extended.

Because of the ease with which the lytic principle could be obtained from sewage filtrate for these organisms, and the fact that in the past the chief obstacle to the use of the bacteriophage in urinary infections has been the lack of potent bacteriophage to many of the causative bacilli, the situation appeared hopeful for the treatment of the patients with sewage filtrate. A small number of patients, twelve in all, have been treated recently, and the processes of bacteriophagy have been followed through frequent cultures of urine and examinations of urine filtrates. Certain observations have been made which have influenced the mode of treatment, and which throw some light on bacteriophagy in the human body. There is a striking paucity of such observations in the literature, and even the few reported are in conflict, so that there is reason for presenting in some detail such a small number of cases at this time. The clinical and therapeutic phases will not be given here, except to say that the cases were chronic, and in most instances the patients had been treated by other methods.

The chief observations that have been reported on the fate of injected bacteriophage have been made in two types of studies: (1) studies of the viscera at various intervals when bacteriophage was injected into normal, uninfected animals, (2) studies of animals after the simultaneous administration of bacteriophage and susceptible organisms.

Experiments of the former sort are summarized in d'Herelle's book, "The Bacteriophage and Its Behavior."[2] There is general agreement

* From the Baylor Hospital Laboratory.

1. Cowie, D. M.: Observations on the Bacteriophage, Ann. Clin. Med. **5**:57 (July) 1926. Caldwell, Janet: Sewage Filtrate as a Source of Bacteriophage, J. Infect. Dis. **4**:575 (May) 1927.

2. D'Herelle, F.: The Bacteriophage and Its Behavior, Baltimore, Williams & Wilkins Company, 1926, p. 381.

BACTERIOPHAGE AS A THERAPEUTIC AGENT IN GENITO-URINARY INFECTIONS*

By E. W. SCHULTZ, M. D.
Stanford University

INTRODUCTION

WILL ROGERS claims that all he knows is what he reads in the newspapers. All I can claim to know regarding the therapeutic merits of bacteriophage in genito-urinary infections is what I have read in the clinical reports sent to my laboratory. Whether the source of my information is any more reliable than that of Will Rogers' is problematic. Despite this uncertain status of my knowledge your program committee has had the courage to invite me to dispense something more or less authoritative on a singularly intricate question—has bacteriophage a place among therapeutic agents of value to the urologist? I must admit at once that I have failed to bring you a categorical answer to this question. To some this may represent the equivalent of a negative reply, but this is not necessarily the case. With any therapeutic procedure which does not yield uniformly successful results—and these are rare—one should not allow himself to be led astray by the failures which may initiate or sprinkle an inquiry. A procedure may have inherent merits, but these may not be fully revealed until the various factors which influence the result have been determined and, if possible, brought under control. Though we recognize that Nature yields up her secrets with great reluctance, we are often apt to draw conclusions long before the evidence is in. Indeed, some of us find the path a little too irksome and are inclined to seek a way out in logic whatever the original premises may perchance happen to be. We cannot escape the fact, however, that, while people may argue indefinitely (as it is said they once did) as to

*From the department of bacteriology and experimental pathology, Stanford University, California.

*Read before the Western Branch of the American Urological Association, November 6, 1931.

TOR001 Case

- 72 year old female non-diabetic previously well,
  - Married, well educated, some international travel
  - Unremarkable past medical history prior to illness
- May 2016, recurrent ***E. coli* infection ESBL**
  - **Recurrent ureteral stents May 2016 to 2017 for hydronephrosis**
  - **Jun 2017 Ureteral ligation and reattachment**
  - **April 2018; 6 weeks of ertapenem**
  - **March 2019; Right Nephrectomy**
  - **Serious reactions to sulfa and fosfomycin, nitrofurantoin diarrhea at treatment dose(6x/d)**
  - **May 2021, Hospitalization and IV ertapenem x 2 weeks.**
  - **May 2022, reaction to macrobid, meropenem x 4 weeks**
  - **No stone / calculi disease**
  - **On Vaginal estradiol tablets 3x a week**

Team

Greg J. German[1,2,3],
Payton B. Hooey[1],
Umesh Jain[1],
Carlos Fernando[1],
Keiko C. Salazar[4,5],
Jonathan D. Cook[2],
Hanjeong Harvey[6],
Udi Blankstein[7],
Andrew M. Kropinski[8],
Anthony W. Maresso[4,5],
Alan R. Davidson[9],
Karen L. Maxwell[3,9],
Austen L. Terwilliger[4,5],
Lori L. Burrows[6]

McMaster University

taiφr

A Health Canada Teleconference you and…

- Dr. Co Pham, Director, Centre for Regulatory Excellence Statistics and Trials (CREST)
- Dr. Michael Rosu-Myles, Centre for Biologics Evaluations (CBE)
- Dr. Alysha Croker, Director, Office of Policy and International Collaboration (OPIC)
- Dr. Emilie Carrier, Associate Director, CBE
- Dr. Nathalie Fortin, Associate Director, CREST
- Dr. Dean Smith, Associate Director and Advisor, CBE
- Dr. Kim Pronovost, Acting Manager, Office of Clinical Trials – Exploratory Division (OCT-E), CREST
- Dr. Tong Wu, Acting Manager, Vaccines Quality Division 3 (VQD3), CBE
- Julie Gervais, Manager Policy Development, OPIC
- Dr. Irene Lisovsky, Senior Reviewer, OCT-E, CREST
- Dr. Sanath Rao, Medical Evaluator, OCT-E, CREST
- Kaitlin Curtis, Regulatory Affairs Supervisor, Office of Regulatory Affairs (ORA), CREST
- Nitika Burman-Watson, Senior Regulatory Affairs Officer (SRAO), CREST

Health Canada / Santé Canada
Health Products and Food Branch / Direction générale des produits de santé et des aliments

Biologic and Radiopharmaceutical
Drugs Directorate
100 Eglantine Driveway
LCDC Building,
Tunney's Pasture, A.L. 0601C
Ottawa, Ontario
K1A 0K9

December 16, 2022

Dr. Gregory German
Medical Microbiologist; Staff Physician ID Clinic
Unity Health Toronto at St. Joseph's Health Centre
30 The Queensway Rm 303G
Toronto ON M6R 1B5
E-mail: Gregory.German@unityhealth.to

Dossier ID: HC6-024-c259297
Control #: 269915

NO OBJECTION LETTER

Dear Dr. Gregory German:

The Clinical Trial Application-Amendment for Phage Therapy cocktail preparation of E. coli phages HP3, HP3.1 and ES19 [UHT1 (HP3,HP3.1,ES19)], Control #269915, concerning Amendment Version 2.2, dated October 9, 2022, to Protocol #TOR001, has been reviewed.

In accordance with Part C, Division 5 of the *Food and Drug Regulations*, there is no objection to implementing this amendment.

You are reminded of the following requirements:

- Reports for all serious and unexpected Adverse Drug Reactions (ADRs) should be:
  - faxed to 613-957-0364 (for biologics and radiopharmaceuticals only); or
  - submitted electronically via the E2B Electronic Gateway. This method is recommended if your company/institution has electronic gateway capability. Please contact the Trading Partner Management Office (TPMO) by email at tpmo-bgpc@hc-sc.gc.ca for more information.

- All Clinical Trial Notifications should be emailed to brdd.ctan-ndec.dmbr@hc-sc.gc.ca and formatted in accordance with Health Canada's *Guidance Document: Preparation of Drug Regulatory Activities in the "Non-eCTD Electronic Only" Format.*

- According to the *Changes to notification requirements for biologic drugs: Notice to Industry,* a completed Clinical Trial Fax-Back Form is only required for clinical trial biological products (other than prophylactic vaccines) and radiopharmaceuticals with a biologic component that:
  - contain Human Derived Active Ingredients (e.g. human serum albumin);
  - contain Human Derived Excipients;
  - are fecal therapies; or
  - are out of specification.

- All Clinical Trial Notifications should be emailed to brdd.ctan-ndec.dmbr@hc-sc.gc.ca and formatted in accordance with Health Canada's *Guidance Document: Preparation of Drug Regulatory Activities in the "Non-eCTD Electronic Only" Format.*

- According to the *Changes to notification requirements for biologic drugs: Notice to Industry,* a completed Clinical Trial Fax-Back Form is only required for clinical trial biological products (other than prophylactic vaccines) and radiopharmaceuticals with a biologic component that:
  - contain Human Derived Active Ingredients (e.g. human serum albumin);
  - contain Human Derived Excipients;
  - are fecal therapies; or
  - are out of specification.

A Fax-Back Form for each lot of drug to be used in the study that is in the scope of the above Notice should be emailed to brdd_faxback_dmbr@hc-sc.gc.ca (this requirement does not apply to Canadian approved drugs obtained directly from the Canadian market).

- A completed Clinical Trial Site Information Form for each Canadian site should be emailed to brdd.ctsi-filec.dmbr@hc-sc.gc.ca prior to initiating the trial at that site.

Consistent with Health Canada's Notice - *Registration and Disclosure of Clinical Trial Information* of November 30, 2007, sponsors are encouraged to register their clinical trials within 21 days of the trial's onset, using a publicly available registry that conforms with international standards for registries such as:

- Clinicaltrials.gov (www.clinicaltrials.gov)
- Current Controlled Trials (www.controlled-trials.com)

Sincerely,

This document has been signed electronically using the Health Canada docuBridge system.

Patricia Basta *on behalf of Nitika Burman Watson*
Senior Regulatory Affairs Officer
Office of Regulatory Affairs
Tel: 613-299-2669
Fax: 613-946-9520

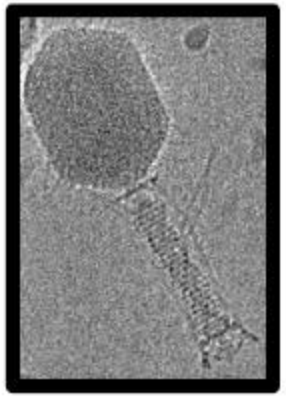
1st Clinical Trial Canada (UTI) NCT05537519

Vom 2023

- Poster

ES19

HP3



100 nm

HP3.1

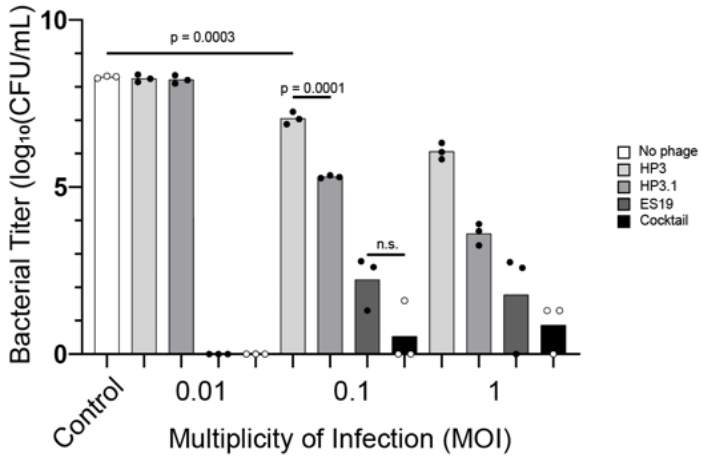


Figure 1. Efficient killing of UHT1 cells by HP3, HP3.1, ES19 and the UHT1 cocktail. A culture of UHT1 (10^6 cells) was mixed with increasing amounts of phage, incubated/shaken at 37°C for 4 hours, and then 0.1 ml was plated for the growth of survivors on a solid medium. Serial dilutions of the cultures and the starting inoculum (control) were then plated using 10µL slants on LB agar plates. The plates were incubated at 37°C overnight and colonies were counted. Results are reported as the average +/- standard deviation of 3 technical replicates. Results indicate good bacterial clearance by the UHT1 cocktail.

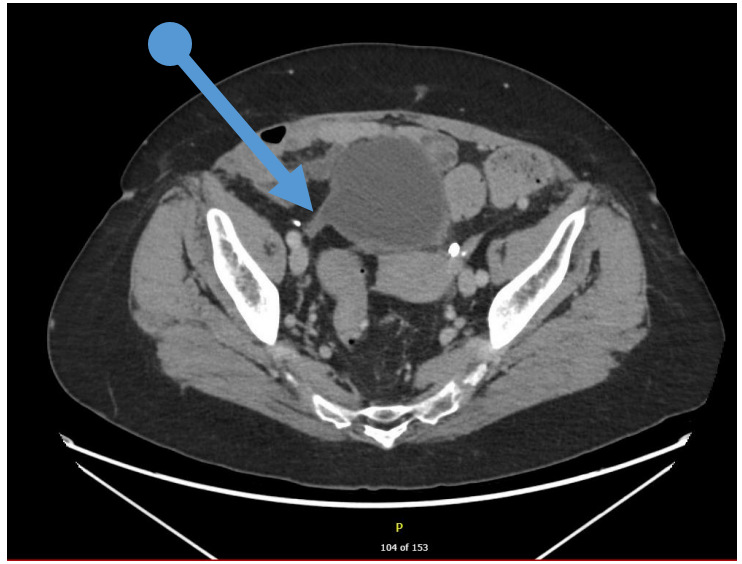
Clinical Trials Process

Step 13b: Contact Health Canada Environmental Assessment unit at least 120 days before for New Substance Program

Step	# of People (ADDIATIVE)	Action to sign a patient for a research participant in a phage therapy in Canada
1	3	Identify patient with a serious condition
2	6	Identify bacterial strain
3	10	No tolerable or reasonable curative solution available
4	15	Funds are identified.
5	18	Bacterial Isolate(s) sent to phage bank
6	21	Phages tested by susceptibility testing of various methods.
7	26	Phages characterized including sequenced and annotated to confirm the absence of deleterious genes.
8	28	Two or three phages are identified that are dissimilar and additive.
9	45	Phages produced in high titre
10	50	Phages are purified to remove bacterial byproducts specifically endotoxins
11	52	Phages are either combined into cocktails or processed further individually.
12	60	Phages are checked for endotoxins and sterility (3 days to 2 weeks, mycobacteria ~ 4 weeks)
13	70	Phage production centre produces an Investigator New Drug filling is created.
14	80	If not already done a research team is created.
15	95	If not already done an optional virtual consultation with Health Canada is provided.
16	115	Form 3011 and supporting documents are submitted to Health Canada which reviews the file within 30 days and if successful provides a no-objection letter (NOL). Time expiring is considered no objection.
17	120	Safety Committee for a future REB proposal is sought.
18	125	Internal Research contracts between clinician, laboratory, clinic / hospital should be completed.
19	135	External Research contracts should be completed between institutions involved at this time. (DELAYED)
20	150	Submission for a REB proposal to a hospital is done after or at the time of the Health Canada submission
21	155	Research manager fills trial on clinicaltrials.gov
22	155	Research Ethics Board does a full review of file.
23a	155	Option 1: REB if successful gives conditional approval pending Health Canada no objection letter.
23b	155	Option 2: REB recommends minor or major modifications.
24b	155	If Option 2 then a Health Canada clinical trial amendment is submitted and a second NOL is required for major changes. Otherwise for minor changes a Clinical trail notification is required.
25	155	REB approves and the study team may approach patient.

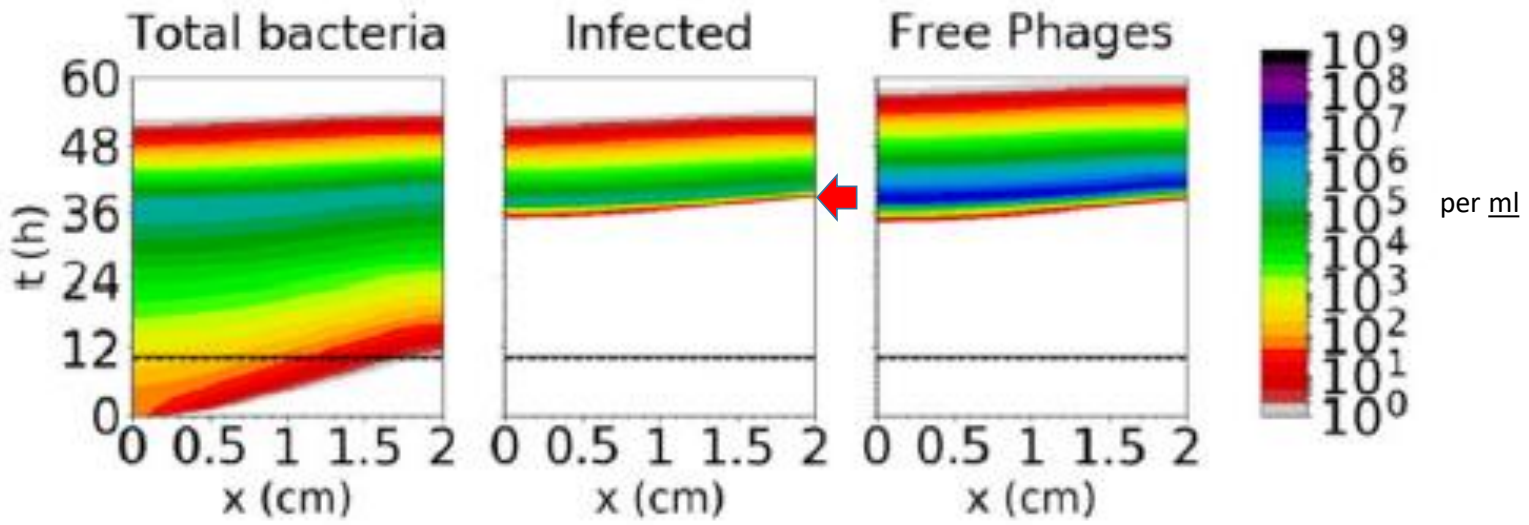
Step	# of People (ADDIATIVE)	Actions Necessary to Treat a Patient with Phage Therapy in Canada
26	156	Consent is signed by the patient to become a research participant
27	160	Phages are imported into the country using a special service
28	163	Phages are stored in pharmacy
29	163	Phage cocktail is prepared in Normal Saline for bladder instillation or 6% bicarbonate for oral therapy
30	164	Phages are taken orally, and then 30 later placed inside the urinary bladder (dwell of 1 hour).
31	165	Phages are prepared and given
32	170	Laboratory specimens are collected prior to phage, and at multiple time points.
33	180	Clinical samples are sent to determine phage levels, bacterial levels, Anti-phage antibodies.

- Safe: No significant adverse events (two minor notes)
  - Slight rash in two instances at days 7 and 14, the later of which was mildly pruritic and both of which was not thought to be significant by the patient or the Safety Committee.
  - Patient developed a brief bout of diverticulitis, with mildly raised biochemical markers (CRP 60) and abdominal pain but no fever. The antibiotics provided (ertapenem x 14 days) likely co-treated this condition. CT Scan with IV contrasted noted an enlarged remnant ureter, but no abscess, and at the time resolving diverticulosis.



- Effective at 90 days after adjunctive antibiotics (Clinical Cure):
  - Initial clinical and microbiological improvement without antibiotics.
  - Provided IV antibiotics after relapse. Treated for only 14 days, and 90 days afterwards no clinical symptoms or microbiology findings.
  - Await testing on Phage – bacterial PCR and possible evolution and anti-phage antibodies (Expected Nov 2023).

Topical Phage Therapy for Cystitis (Practice and Mathematical Modeling)



Mobile bacteria, lower dose with phage wash out, with 12 hour delay,

Phages arrive 24 hours later through diffusion / bacterial motility,

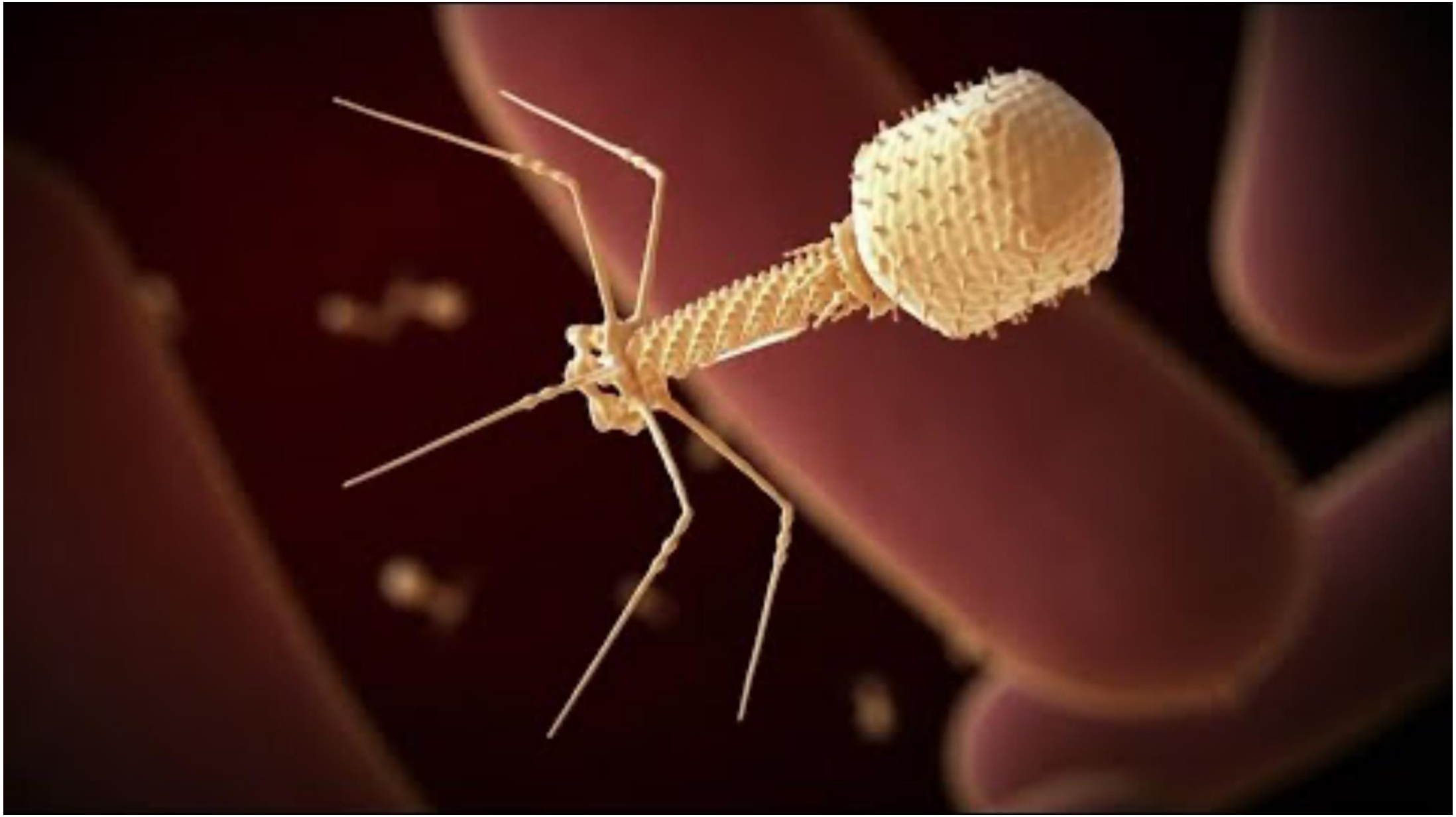
(Blanco and Chen 2019)

Motility offered as D_c = 0.0144 cm^2/h or 0.2 um/s

A Canadian and UHT Breakthrough

CTV News: https://bit.ly/phagevictoria

Greg German and TAILOR LABS, Houston



CTV News: https://bit.ly/phagevictoria

More Work to follow:

- Phage Recovery Analysis
- *E. coli* genomics
- Pre-Clinical mouse models for UTI
- Rapid susceptibility testing and coordination
- IV Phage Therapy case for Male E.coli UTI
- Money: https://bit.ly/CANPHAGEFUND

- P-PEAKS RCT 50 Females

Procedure		Study Day									
		1	2	3	4	5	7	~14	~30	~60	~90
Stool sample	ESBL plating		R[1]			R[1]		R[1]	R[1]	R[1]	R[1]
	Organism recovery		R[2]			R[2]		R[2]	R[2]	R[2]	R[2]
	Phage recovery		R[2]			R[2]		R[2]	R[2]	R[2]	R[2]
Urine sample	Urine culture	X[1]	R[1]	R[1]	R[1]	R[1]	R[1]	R[1]	X[1]	X[1]	X[1]
	Microscopic urinalysis	X[1]	R[1]	R[1]	R[1]	R[1]	R[1]	R[1]	X[1]	X[1]	X[1]
	Urinalysis	X[1]	R[1]	R[1]	R[1]	R[1]	R[1]	R[1]	X[1]	X[1]	X[1]
	Phage recovery	R[2]	R[2]	R[2]	R[2]	R[2]	R[2]	R[2]	R[2]	R[2]	R[2]
	Organism recovery	R[2]	R[2]	R[2]	R[2]	R[2]	R[2]	R[2]	R[2]	R[2]	R[2]
Vaginal swab	Gram stain	X[1]	R[1]	R[1]	R[1]	R[1]	R[1]	R[1]	X[1]	X[1]	X[1]
	Phage recovery	R[2]	R[2]	R[2]	R[2]	R[2]	R[2]	R[2]	R[2]	R[2]	R[2]
	Organism recovery	R[2]	R[2]	R[2]	R[2]	R[2]	R[2]	R[2]	R[2]	R[2]	R[2]
Blood sample	GGT	X[1]	R[1]		R[1]		R[1]	R[1]	X[1]	X[1]	X[1]
	AST	X[1]	R[1]		R[1]		R[1]	R[1]	X[1]	X[1]	X[1]
	Creatinine	X[1]	R[1]		R[1]		R[1]	R[1]	X[1]	X[1]	X[1]
	CRP	X[1]	R[1]		R[1]		R[1]	R[1]	X[1]	X[1]	X[1]
	CBC with differential	X[1]	R[1]		R[1]		R[1]	R[1]	X[1]	X[1]	X[1]
	ESR	R[1]	R[1]		R[1]		R[1]	R[1]	R[1]	R[1]	R[1]
	IgE	R[1]	R[1]		R[1]		R[1]	R[1]	R[1]	R[1]	R[1]
	Anti-phage antibody detection	R[2]	R[2]		R[2]		R[2]	R[2]	R[2]	R[2]	R[2]
	Phage recovery	R[2]	R[2]		R[2]		R[2]	R[2]	R[2]	R[2]	R[2]

~ +/- 1-2 days 14, 30, 60 & 90

X= routine clinical care test
R= research test

[1]= on-site testing
[2]= external testing (to be shipped to TAILOR Labs)

Personalized Phage + Ertapenem and Kinetic Synergy Secondary Prevention phase 2b PICO

P: 50 non-pregnant adult women with *E. coli* UTI treated with ertapenem previously and continues to be colonized.

I: Personalized Phage via mouth, bladder, and vaginal area with a single dose of ertapenem on day 2

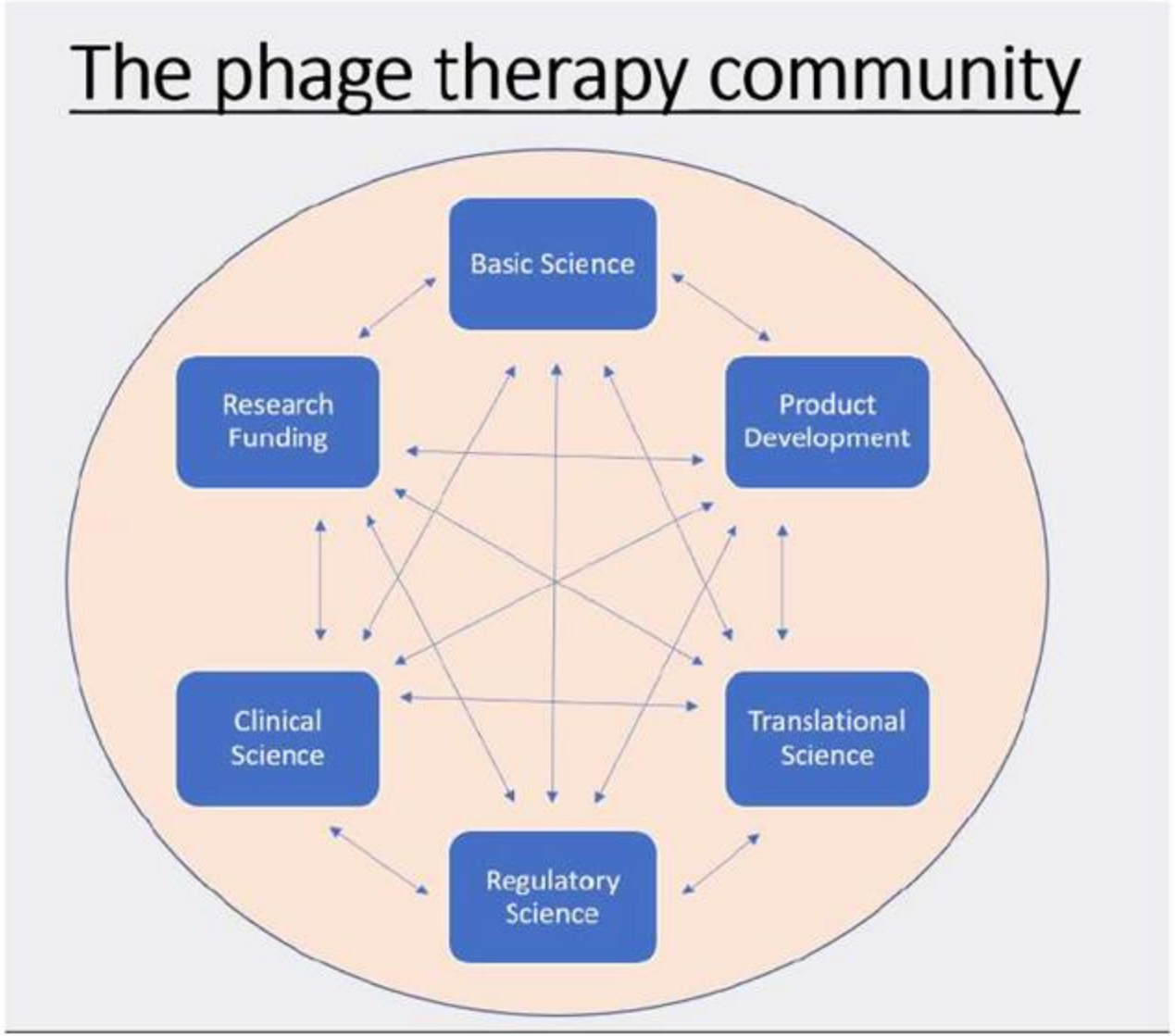
C: Ertapenem 1g plus placebo products

O: Primary: Microbiological resolution at 30 days from date of ertapenem

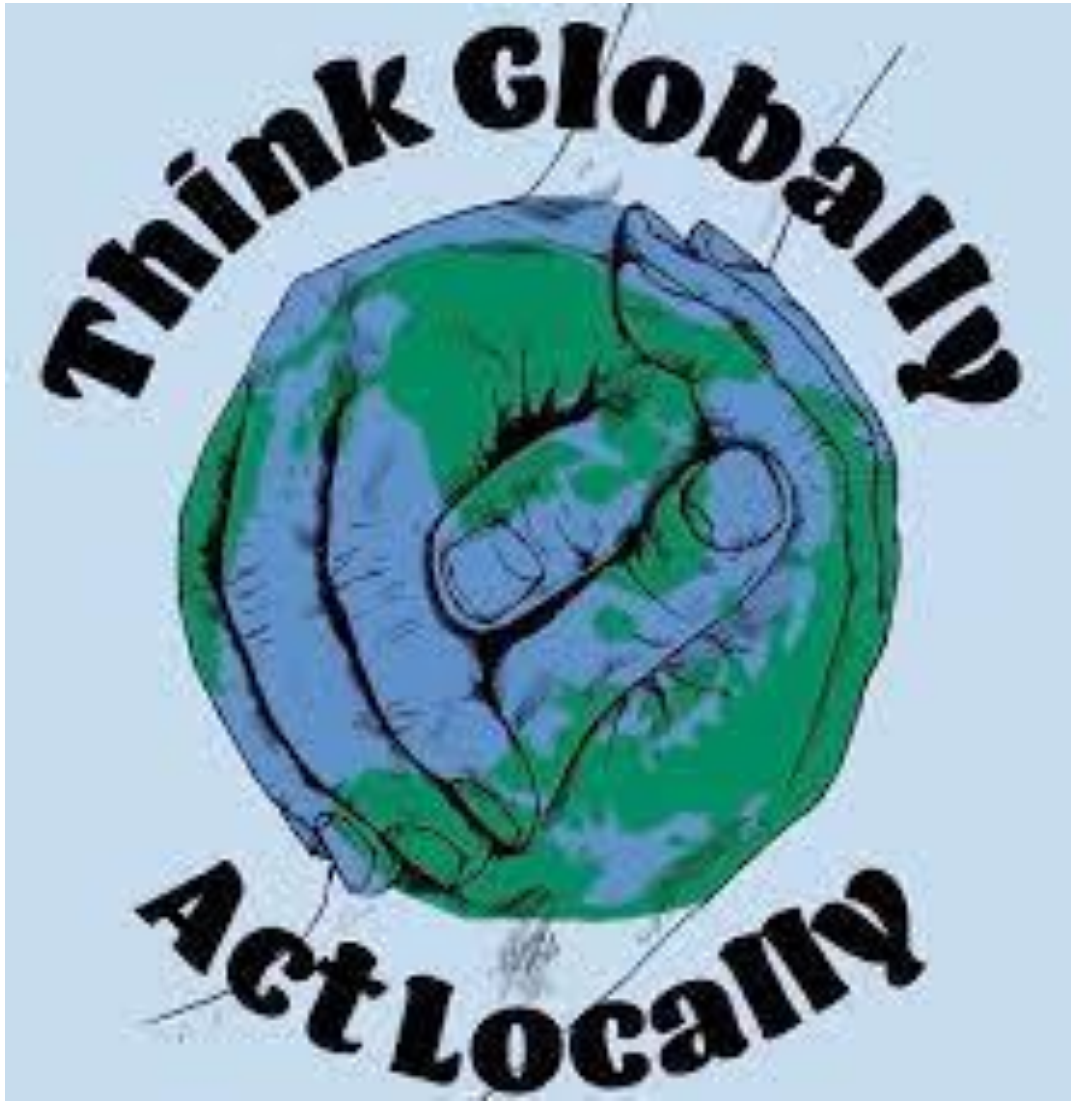
Secondary: Next slide

Personalized-Phage & Ertapenem Advanced Kinetics and Synergy (P-PEAKS) UTI

- Nominated PI: Dr. Greg German,
- PI (Co-PI) Dr. Duminda Wijeysundera, Anesthesiologist and Clinical trial expert.
  - Interim Medical Director at AHRC (hubresearch.ca)
- Co-Applicants:
  1. Dr. Jonathan Cook, Senior Medical Microbiology Resident, University of Toronto
  2. Jenna Wong, Association of Medical Microbiologist and Infectious Diseases Canada Clinical Research Network, Research Coordinator
  3. Dr. Kevin Thorpe, Assistant Professor of Biostatistics, University of Toronto Dalla Lana School of Public Health
  4. Dr. Carlos Fernando, Research Manager, St. Joseph's Health Centre Toronto, part of Unity Health Toronto.
  5. Dr. Gabriel Girouard, Medical Microbiologist and Infectious Diseases physician, Vitalité Health Network, New Brunswick. (Dr. Georges-L.-Dumont University Hospital Centre)
  6. Dr. Sylvain Moineau, Professor and Curator of the University of Laval Bacteriophage reference center.
  7. Dr. Michael Parcey, Director of the National Microbiology Laboratory PhageSTAR (Science, Therapeutics, and Research) Lab
  8. Dr. Kevin Schwartz, Division Head of Infectious Diseases, St. Joseph's Health Centre, Unity Health Toronto.
  9. Dr. Umesh Jain, Urologist, St. Joseph's Health Centre, Unity Health Toronto.
  10. Dr. Jonathan Iredell Clinical Microbiologist and Infectious Disease Physician, Westmead Hospital director of Phage Australia.
  11. Dr. Ameneh Khatami, Paediatric Infectious Diseases physician, Children's Hospital at Westmead, and Deputy Director and Clinical Lead of Phage Australia.
  12. Dr. Ruby Lin, Westmead Institute for Medical Research, Deputy Director Phage Australia
  13. Dr. Holly Sinclair, PhD Trainee, Clinical Microbiology, Infectious Diseases physician.
  14. Dr. Gina Suh, Infectious Disease Physician, Director of the Mayo Clinic Phage Therapy Program.
- Collaborator / Supplier: Dr. Nancy Tawil Qeen Biotheraputics. (Gatineau QC)



The Phage Therapy Globe



Global Clinical Phage Rounds

1

Introducing:

Global Clinical Phage Rounds (G-CPR)

Confidential discussion for phage clinicians on de-identified cases undergoing considerations of phage therapy

Depending on Time Zone*:
December 13 5pm EST
December 13 10pm GMT
December 14 Midnight CEST
December 14 9am AEDT

Dr. Gina Suh, MD
Case discussion:
NTM Mastoiditis

Prof. Ran Nir-Paz, MD
Case discussion:
Bone and joint infection

For Zoom Link and Calendar Invite:
Please sign up with:
https://bit.ly/G-CPR

If having troubles email: Gregory.German@unityhealth.to

Session will not be recorded and capturing screen shots is not allowed
Session is limited to no more than 30 participants

This is a collaborative effort started by Dr. Jon Iredell and Dr. Ameneh Khatami (Australia), Dr. Greg German (Canada), Dr. Ran Nir-Paz (Israel), and Dr. Gina Suh (USA)

*Future sessions will be held at different times on rotating basis

Endorsed by:

Phage Australia · ESGNTA · AMMI Canada

2

Global Clinical Phage Rounds (G-CPR)

A confidential discussion for phage clinicians on de-identified cases undergoing considerations of phage therapy

CASE DISCUSSION

Renal transplant and recurrent UTIs

Dr. Saima Aslam, MBBS
Center for Innovative Phage Applications and Therapeutics (IPATH), UC San Diego
Transplant Infectious Diseases Medical Director

February 28, 15:30 EST
For Zoom Link and Calendar Invite:

CLICK HERE TO REGISTER or scan the QR code

If having troubles email: Gregory.German@unityhealth.to

Session is limited to no more than 50 participants

This is a collaborative effort started by
- *Dr. Jon Iredell and Dr. Ameneh Khatami (Australia)*
- *Dr. Greg German (Canada)*
- *Dr. Ran Nir-Paz (Israel)*
- *Dr. Gina Suh (USA)*

CO-SPONSORED BY:

Phage Australia · ESGNTA · AMMI Canada · IPATH · Pittsburgh Phage Project · taior · MAYO CLINIC

3

Global Clinical Phage Rounds (G-CPR)

A confidential discussion for phage clinicians on de-identified cases undergoing considerations of phage therapy

CASE DISCUSSION

URGENT CASES ON MYCOBACTERIUM

Case 1: Dr. David van Duin, Dr. Anne Friedland and Team
University of North Carolina
Mycobacterium abscessus chest wall infection in a lung transplant patient, query the use of intramuscular (Directly applied phages). (40 MIN)

Case 2: Dr. Candice Bjornson and Team
University of Calgary
Mycobacterium abscessus Paediatric CF infection on daily IV Muddy treatment at the one-year mark. First modern use of phage therapy in a Canadian academic centre. (20 min)

Laboratory Discussant: Dr. Graham Hatfull
Moderators: Dr. Gina Suh and Dr. Greg German

June 1, 2023 - 16:00 EDT
For Zoom Link and Calendar Invite:

CLICK HERE TO REGISTER or scan the QR code

Once you have registered, you will be added to the zoom invite (please allow 1 or 2 days)
If having troubles email: Gregory.German@unityhealth.to

Session is limited to no more than 70 participants

G-CPR is a collaborative effort started by Dr. Jon Iredell and Dr. Ameneh Khatami (Australia), Dr. Greg German (Canada), Dr. Ran Nir-Paz (Israel), and Dr. Gina Suh (USA)

CO-SPONSORED BY:

Phage Australia · ESGNTA · AMMI Canada · IPATH · Pittsburgh Phage Project · taior · MAYO CLINIC

4

Global Clinical Phage Rounds (G-CPR)

A confidential discussion for phage clinicians on de-identified cases undergoing considerations of phage therapy

BELGIAN PUBLISHED CASES

The use of phage cocktail BFC-1 in recurrent complicated invasive infections

Featuring: Professor Dr. Patrick Soentjens and team,
Queen Astrid Military Hospital

Case 1: Jolien Onsea, University Hospital Leuven
Osteomyelitis - *P. aeruginosa* and *S. epidermidis*

Case 2: Brieuc Van Nieuwenhuyse, University Hospital St Luc Brussels
Liver abscesses and liver transplant with *P. aeruginosa*

Case 3: Brieuc Van Nieuwenhuyse, University Hospital St Luc Brussels
Osteomyelitis mixed infection with *S. aureus* and others

June 13, 2023 - 05:00 EDT
For Zoom Link and Calendar Invite:

CLICK HERE TO REGISTER or scan the QR code

Once you have registered, you will be added to the zoom invite (please allow 1 or 2 days)
If having troubles email: sinclair_holly@hotmail.com

Session is limited to no more than 70 participants

G-CPR is a collaborative effort started by Dr. Jon Iredell and Dr. Ameneh Khatami (Australia), Dr. Greg German (Canada), Dr. Ran Nir-Paz (Israel), and Dr. Gina Suh (USA)

CO-SPONSORED BY:

Phage Australia · ESGNTA · AMMI Canada · IPATH · Pittsburgh Phage Project · taior · MAYO CLINIC

5

Global Clinical Phage Rounds (G-CPR)

A confidential discussion for phage clinicians on de-identified cases undergoing considerations of phage therapy

CASE DISCUSSION

How long is long enough: duration of phage therapy for NTM infections in three Australian patients?

Dr Ameneh Khatami
Phage Australia and Sydney Children's Hospital Network, Westmead, Australia

Laboratory Discussant:
Dr. Graham Hatfull
University of Pittsburgh

Clinical Discussant:
Dr. Connie Benson
IPATH-UCSD

July 20, 2023 - 18:30 EDT
For Zoom Link and Calendar Invite:

CLICK HERE TO REGISTER or scan the QR code

Once you have registered, you will be added to the zoom invite (please allow 1 or 2 days)
If having troubles email: Gregory.German@unityhealth.to

Session is limited to no more than 70 participants

G-CPR is a collaborative effort started by Dr. Jon Iredell and Dr. Ameneh Khatami (Australia), Dr. Greg German (Canada), Dr. Ran Nir-Paz (Israel), and Dr. Gina Suh (USA)

CO-SPONSORED BY:

Phage Australia · ESGNTA · AMMI Canada · IPATH · Pittsburgh Phage Project · taior · MAYO CLINIC

6

Global Clinical Phage Rounds (G-CPR)

A confidential discussion for phage clinicians on de-identified cases undergoing considerations of phage therapy

Phage therapy in severe bacterial infections:
THE FRENCH EXPERIENCE

Dr. Tristan Ferry
Infectious and Tropical Diseases Unit, Croix-Rousse Hospital, Hospices Civils de Lyon, Claude Bernard Lyon

PHAGE*in*LYON Clinic

August 29, 10:00 EST
For Zoom Link and Calendar Invite:

CLICK HERE TO REGISTER or scan the QR code

If having troubles email: Gregory.German@unityhealth.to

Session is limited to no more than 50 participants

This is a collaborative effort started by
- *Dr. Jon Iredell and Dr. Ameneh Khatami (Australia)*
- *Dr. Greg German (Canada)*
- *Dr. Ran Nir-Paz (Israel)*
- *Dr. Gina Suh (USA)*

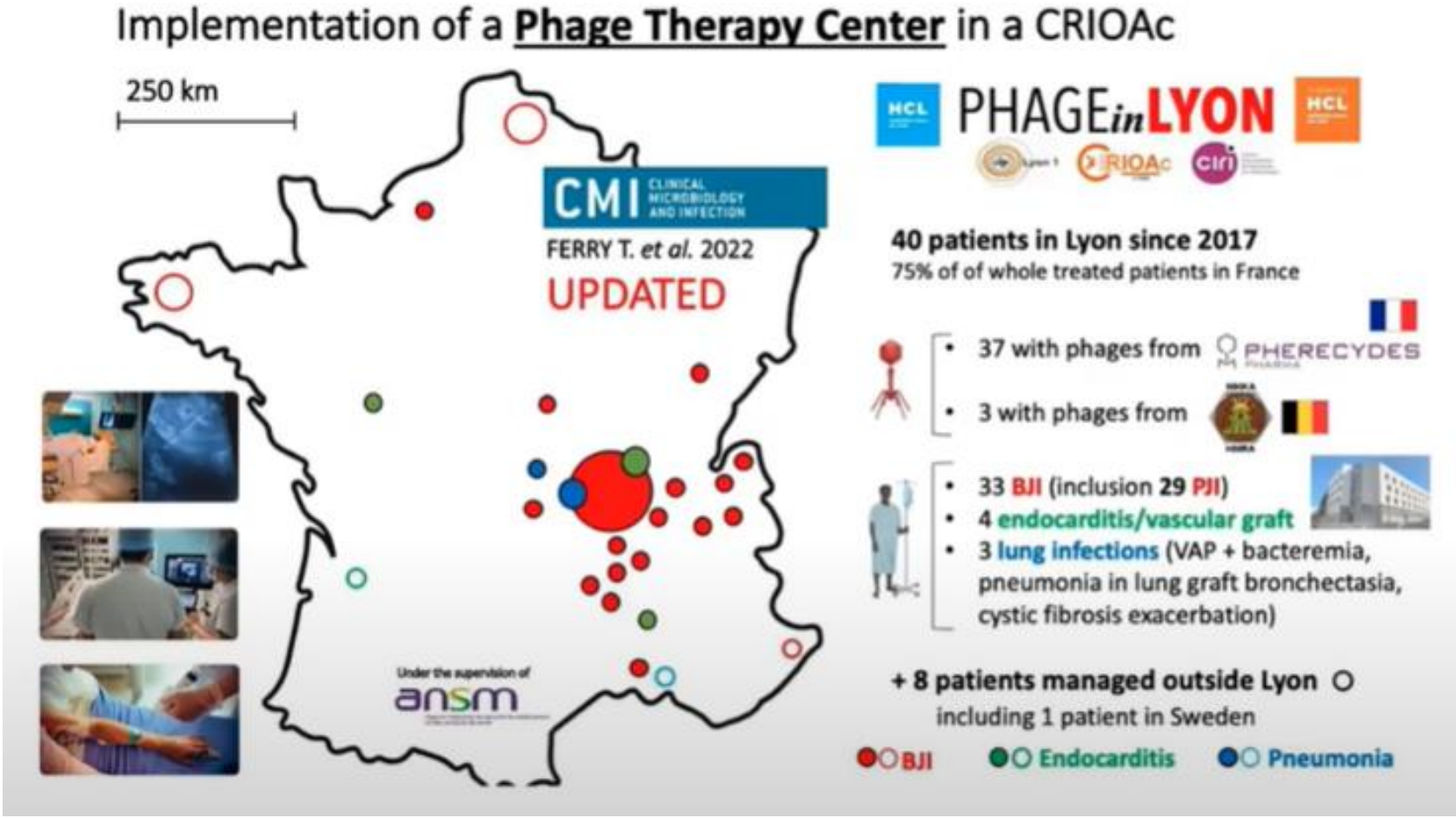
CO-SPONSORED BY:

Phage Australia · ESGNTA · AMMI Canada · IPATH · Pittsburgh Phage Project · taior · MAYO CLINIC

August 29th 2023,

Global Clinical Phage Rounds
Presents:

- Dr. Tristan Ferry
- Phage therapy in severe bacterial infections: The French experience



Global Clinical Phage Rounds (G-CPR)

A confidential discussion for phage clinicians on de-identified cases undergoing considerations of phage therapy

Inhaled Bacteriophage Therapy for Multi-Drug Resistant *Achromobacter spp.*

Dr. Jon Koff

Respirologist and Medical Director, Yale University's Center for Phage Biology and Therapy

Click here for Dr. Koff's Bio

October 18, 2023 – 07:00-08:00 EDT

For Zoom Link and Calendar Invite:

CLICK HERE TO REGISTER or scan the QR code

Once you have registered, you will be added to the zoom invite (please allow 1 or 2 days)
If having troubles email: sinclair_holly@hotmail.com

Session is limited to no more than 100 participants

This is a collaborative effort started by

- *Dr. Jon Iredell and Dr. Ameneh Khatami (Australia)*
- *Dr. Greg German (Canada)*
- *Dr. Ran Nir-Paz (Israel)*
- *Dr. Gina Suh (USA)*

CO-SPONSORED BY:

Phage Australia · ESGNTA · AMMI Canada · IPATH · Pittsburgh Phage Project · taiφr · MAYO CLINIC

YALE JOURNAL OF BIOLOGY AND MEDICINE 95 (2022), pp.413-427.

CASE REPORT

YJBM
CELEBRATING 90 YEARS 1928–2018

Inhaled Bacteriophage Therapy for Multi-Drug Resistant *Achromobacter*

Franziska Winzig[a,b,c], Shiv Gandhi[a,b,d], Alina Lee[a,b], Silvia Würstle[a,b,e], Gail L. Stanley[b,f], Isabella Capuano[f,g], Isabel Neuringer[h], Jonathan L. Koff[b,f,1,*], Paul E. Turner[a,b,i,1,*], and Benjamin K. Chan[a,b,1,*]

[a]Department of Ecology and Evolutionary Biology, Yale University, New Haven, CT, USA; [b]Center for Phage Biology & Therapy, Yale University, New Haven, CT, USA; [c]Technische Universität München, München, Germany; [d]Department of Internal Medicine, Section of Infectious Disease, Yale School of Medicine, New Haven, CT, USA; [e]Department of Internal Medicine II, University Hospital rechts der Isar, School of Medicine, Technische Universität München, München, Germany; [f]Department of Internal Medicine, Section of Pulmonary, Critical Care, & Sleep Medicine, Yale School of Medicine, New Haven, CT, USA; [g]Cornell University, Ithaca, NY, USA; [h]Massachusetts General Hospital, Boston, MA, USA; [i]Program in Microbiology, Yale School of Medicine, New Haven, CT, USA

The rise of antimicrobial resistant (AMR) bacteria is a global public health threat. AMR *Achromobacter* bacteria pose a challenging clinical problem, particularly for those with cystic fibrosis (CF) who are predisposed to chronic bacterial lung infections. Lytic bacteriophages (phages) offer a potential alternative to treat AMR infections, with the possible benefit that phage selection for resistance in target bacteria might coincide with reduced pathogenicity. The result is a genetic "trade-off," such as increased sensitivity to chemical antibiotics, and/or decreased virulence of surviving bacteria that are phage resistant. Here, we show that two newly discovered lytic phages against *Achromobacter* were associated with stabilization of respiratory status when deployed to treat a chronic pulmonary infection in a CF patient using inhaled (nebulized) phage therapy. The two phages demonstrate traits that could be generally useful in their development as therapeutics, especially the possibility that the phages can select for clinically useful trade-offs if bacteria evolve phage resistance following therapy. We discuss the limitations of the current study and suggest further work that should explore whether the phages could be generally useful in targeting pulmonary or other *Achromobacter* infections in CF patients.

Email: Gregory.german@unityhealth.to or Gina Suh Suh.Gina@mayo.edu if you would like to join G-CPR

Global Clinical Phage Rounds (G-CPR)

A confidential discussion for phage clinicians on de-identified cases undergoing considerations of phage therapy

GCPR8: Lessons learned (so far) from treating patients with phage therapy for antibiotic-resistant bacterial infections

Click here fo full bio

Dr. Ghady Haidar, MD
University of Pittsburgh
Assistant Professor of Medicine
Director of Research, Bone Marrow Transplant and Hematological Malignancy Infectious Diseases
Program Director of the Transplant Infectious Diseases Fellowship Program
Chair of the Clinical Phage Therapy Working Group of the Pittsburgh Phage Project

Click here fo full bio

Dr. Daria Van Tyne, PhD
University of Pittsburgh
Assistant Professor of Medicine Infectious Diseases
Infectious Disease Laboratory @VanTyneLab
Early Stage Investigator Award from the Antibacterial Resistance Leadership Group (ARLG)
Chair of the Phage Biology & Discovery Working Group of the Pittsburgh Phage Project

November 15, 2023 – 15:00-16:00 EDT

For Zoom Link and Calendar Invite:

CLICK HERE TO REGISTER or scan the QR code

Once you have registered, you will be added to the zoom invite (please allow 1 or 2 days)
If having troubles email: Gregory.German@unityhealth.to

Session is limited to no more than 100 participants

This is a collaborative effort started by

- *Dr. Jon Iredell and Dr. Ameneh Khatami (Australia), Dr. Greg German (Canada), Dr. Ran Nir-Paz (Israel), and Dr. Gina Suh (USA)*

CO-SPONSORED BY:

Phage Australia · ESGNTA · AMMI Canada · UC San Diego IPATH · Pittsburgh Phage Project · taiφr · MAYO CLINIC

Global Clinical Phage Rounds (G-CPR)

A confidential discussion for phage clinicians on de-identified cases undergoing considerations of phage therapy

GCPR9: *E.coli* Urinary Tract Infections from Single Trials to Planned Personalized RCTs

Click here for full bio

Dr. Greg German,
MD PhD FRCPC
G-CPR, Chair
A Toronto based medical microbiologist, clinician-investigator (LKSKI) and phage clinician
For more background see here: https://macleans.ca/society/health/superbugs-phage-therapy/

Joining him includes:

Dr. Michael Parcey
Public Health Agency of Canada, National Microbiology Laboratories, and the new Phage STAR (Science, Therapeutics, and Research) Lab

Dr. Yasmeen Vincent Marbaniang,
Medical Microbiologist, LifeLabs Ontario, AMMI Canada Phage Therapy Working Group Co-Lead Laboratory Stream. (Discussing the recent Yerrushalmy et al CID paper: https://doi.org/10.1093/cid/ciad514)

December 20, 2023 – 15:00-16:00 EST

For Zoom Link and Calendar Invite:

CLICK HERE TO REGISTER or scan the QR code

Once you have registered, you will be added to the zoom invite (please allow 1 or 2 days)
If having troubles email: Gregory.German@unityhealth.to

Session is limited to no more than 100 participants

This is a collaborative effort started by

- *Dr. Jon Iredell and Dr. Ameneh Khatami (Australia), Dr. Greg German (Canada), Dr. Ran Nir-Paz (Israel), and Dr. Gina Suh (USA)*

CO-SPONSORED BY:

Phage Australia · ESGNTA · AMMI Canada · UC San Diego IPATH · Pittsburgh Phage Project · taiφr · MAYO CLINIC

Global Clinical Phage Rounds (G-CPR)

A confidential discussion for phage clinicians on de-identified cases undergoing considerations of phage therapy

GCPR10: Phage therapy for *P. aeruginosa* infection from compassionate to clinical trial, Paris France

Dr. Alexandre Bleibtreu, MD PhD

Infectious Disease Specialist,
University Hospital Pitié Salpêtrière, Paris, France

ASSISTANCE PUBLIQUE HÔPITAUX DE PARIS www.aphp.fr

CLICK HERE FOR FULL BIO

March 19, 2024 – 09:00-10:00 EST

For Zoom Link and Calendar Invite:

CLICK HERE TO REGISTER or scan the QR code

Once you have registered, you will be added to the zoom invite (please allow 1 or 2 days)
If having troubles email: Gregory.German@unityhealth.to

Session is limited to no more than 100 participants

This is a collaborative effort started by

- *Dr. Jon Iredell and Dr. Ameneh Khatami (Australia), Dr. Greg German (Canada), Dr. Ran Nir-Paz (Israel), and Dr. Gina Suh (USA)*

CO-SPONSORED BY:

Phage Australia · ESGNTA · AMMI Canada Association of Medical Microbiology and Infectious Disease Canada Phage Therapy Working Group · UC San Diego IPATH · Pittsburgh Phage Project · taiΦr · MAYO CLINIC

Global Clinical Phage Rounds (G-CPR)

A confidential discussion for phage clinicians on de-identified cases undergoing considerations of phage therapy

GCPR11: Phage therapy for complex biofilm infections: Clinical and translational lessons learned

Dr. James Doub, MD PhD

Director, Infectious Diseases Ambulatory Practice,
University of Maryland School of Medicine

CLICK HERE FOR FULL BIO

April 4, 2024 – 15:00-16:00 EDT

For Zoom Link and Calendar Invite:

CLICK HERE TO REGISTER or scan the QR code

Once you have registered, you will be added to the zoom invite (please allow 1 or 2 days)
If having troubles email: Gregory.German@unityhealth.to

Session is limited to no more than 100 participants

This is a collaborative effort started by

- *Dr. Jon Iredell and Dr. Ameneh Khatami (Australia), Dr. Greg German (Canada), Dr. Ran Nir-Paz (Israel), and Dr. Gina Suh (USA)*

CO-SPONSORED BY:

Phage Australia · ESGNTA · AMMI Canada Association of Medical Microbiology and Infectious Disease Canada Phage Therapy Working Group · UC San Diego IPATH · Pittsburgh Phage Project · taiΦr · MAYO CLINIC

To Sign up for Global Clinical Phage Rounds:

Bit.ly/GlobalPhageRoundsSignup

Links to session and video
No industry permitted

Two Recent Major Articles:

Pirnay et al Belgian 100 Consecutive case:
PMID: 38834776 Nature Microbiology 2024

- Observational Study
- 2008 to 2022
- 12 Countries
- Different Application Routes
- Clinical Improvement 77%
- Eradication 61.3%
  - 70% less likely to eradicate if antibiotics were not used at the same time.
- 15 adverse events, with 7 non-serious associated with BT.

Aslam et al, P. aeruginosa ventricular assist device 5 ineffective cases
PMID: 38470133; Antimicro Agents Chemotherapy 2024

4 patients, 5 trials of therapy

1 to 4 non-modified phages used in each case

Phages less susceptible in 3 of 5 treatment

Breakthrough bacteremia occurred frequently, even though appears sensitive to phage.

Lack of Clinical Trial Success

THE LANCET
Infectious Diseases

Volume 21, Issue 3, March 2021, Pages 427-436

Articles

Intravesical bacteriophages for treating urinary tract infections in patients undergoing transurethral resection of the prostate: a randomised, placebo-controlled, double-blind clinical trial

Lorenz Leitner MD [a], Aleksandre Ujmajuridze MD [b], Nina Chanishvili PhD [c], Marina Goderdzishvili PhD [c], Irina Chkonia PhD [c], Sophia Rigvava PhD [c], Prof Archil Chkhotua MD [b], Giorgi Changashvili MD [b], Shawna McCallin PhD [a d], Marc P Schneider MD [a], Martina D Liechti PhD [a], Ulrich Mehnert MD [a], Prof Lucas M Bachmann PhD [e], Wilbert Sybesma PhD [a f], Prof Thomas M Kessler MD [a]

- Current NIH Pseudomonas Clinical Trial in CF
  - Not personalized
  - Challenges with recruitment

Part 2: Phages for the ICP

Sinks associated with ICU outbreaks in Mount Sinai, Toronto General

Epidemiology of healthcare-associated *Pseudomonas aeruginosa* in intensive care units: are sink drains to blame?

C. Volling [a], L. Mataseje [b], L. Graña-Miraglia [c], X. Hu [c], S. Anceva-Sami [a], B.L. Coleman [a], M. Downing [d], S. Hota [e], A.J. Jamal [a], J. Johnstone [a], K. Katz [f], J.A. Leis [g], A. Li [a], V. Mahesh [a], R. Melano [h], M. Muller [i], S. Nayani [a], S. Patel [j], A. Paterson [a], M. Pejkovska [a]...M.R. Mulvey [b]

Show more

7% of *P. aeruginosa* HAIs associated with sinks[1]

Both *P. aeruginosa* and *K. oxytoca*[2] form biofilms

HEALTH

Sink design behind Toronto hospital deaths

The design and placement of sinks in Toronto General Hospital rooms with transplant patients caused an outbreak of infections that killed 12 patients between 2004 and 2006, researchers believe.

Dec. 15, 2008 | 4 min read

CDC Centers for Disease Control and Prevention
CDC 24/7: Saving Lives, Protecting People™
Search

EMERGING INFECTIOUS DISEASES®
ISSN: 1080-6059

EID Journal > Volume 18 > Number 8—August 2012 > Main Article

Volume 18, Number 8—August 2012

Research

Outbreak of Extended-Spectrum β-Lactamase–producing *Klebsiella oxytoca* Infections Associated with Contaminated Handwashing Sinks[1]

Christopher Lowe, Barbara Willey, Anna O'Shaughnessy, Wayne Lee, Ming Lum, Karen Pike, Cindy Larocque, Helen Dedier, Lorraine Dales, Christine Moore, Allison McGeer, and the Mount Sinai Hospital Infection Control Team

Author affiliations: University of Toronto, Toronto, Ontario, Canada (C. Lowe, A. McGeer); and Mount Sinai Hospital, Toronto (B. Willey, A. O'Shaughnessy, W. Lee, M. Lum, K. Pike, C. Larocque, H. Dedier, L. Dales, C. Moore, A. McGeer)

Cite This Article

On This Page

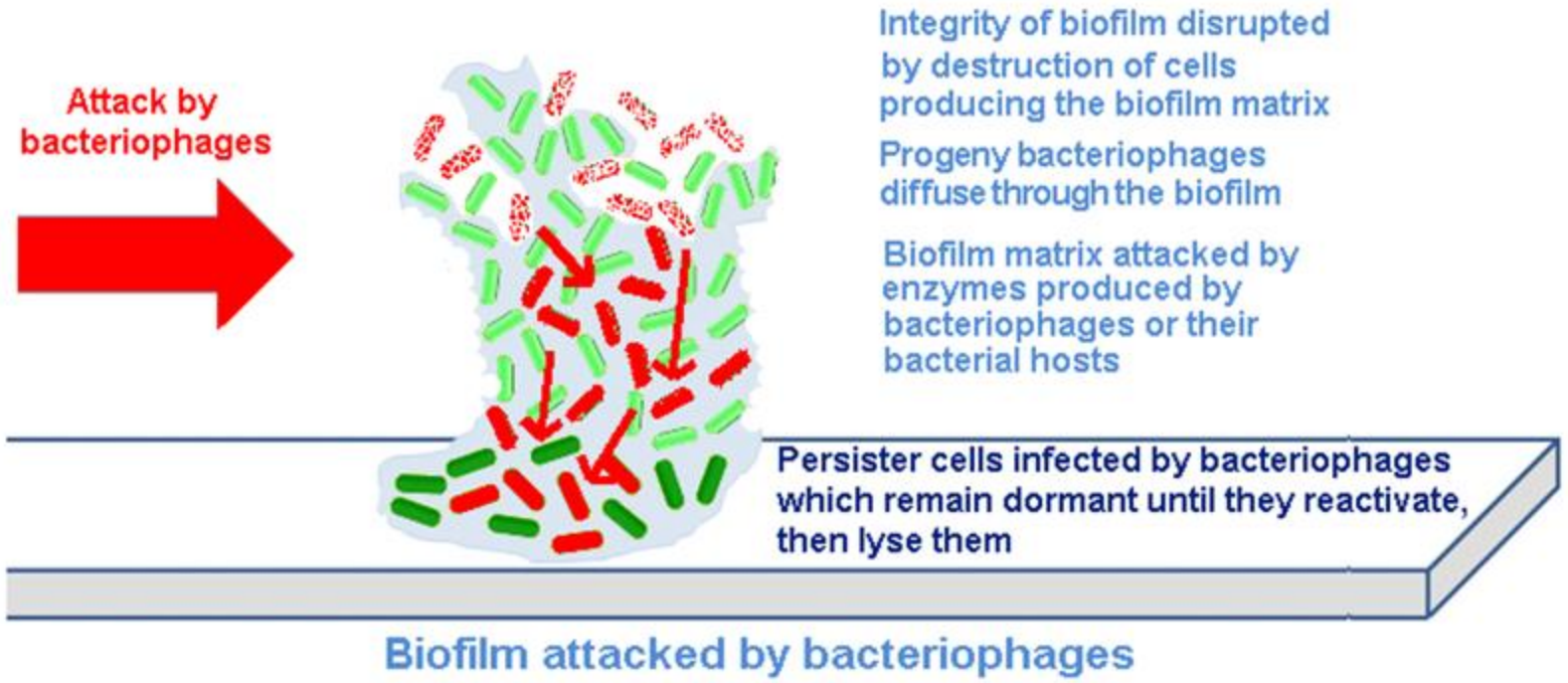
Methods

Results

Discussion

Cite This Article

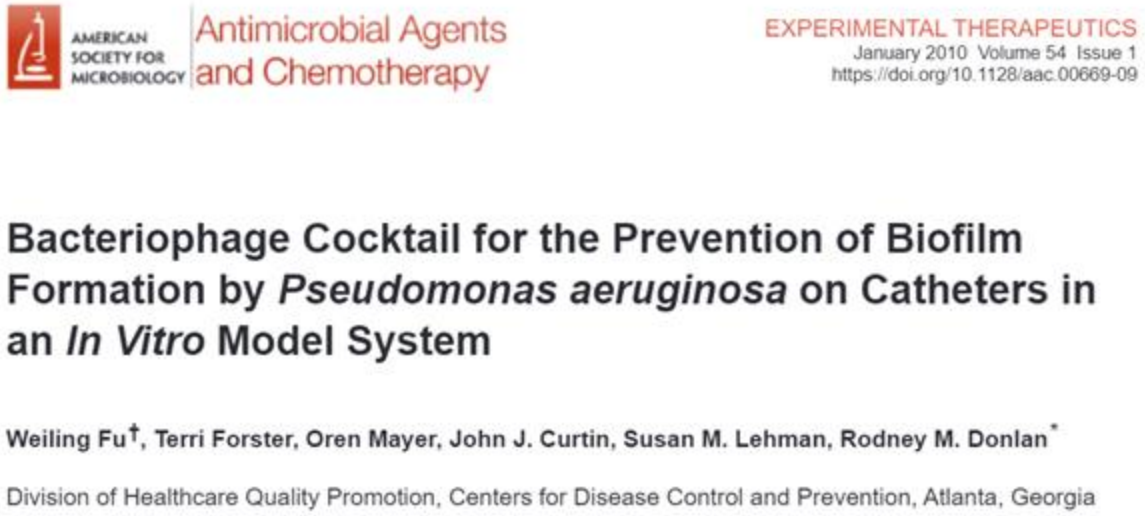
Advantages of phages re biofilms



- Replication
- Express/induce depolymerase enzymes on EPS
- X persister cells too

Harper, D. R., Parracho, H. M. R. T., Walker, J., Sharp, R., Hughes, G., Werthén, M., Lehman, S., & Morales, S. (2014). Bacteriophages and Biofilms. *Antibiotics*, *3*(3), 270–284. https://doi.org/10.3390/antibiotics3030270

Applications



AMERICAN SOCIETY FOR MICROBIOLOGY | Antimicrobial Agents and Chemotherapy

EXPERIMENTAL THERAPEUTICS
January 2010 Volume 54 Issue 1
https://doi.org/10.1128/aac.00669-09

Bacteriophage Cocktail for the Prevention of Biofilm Formation by *Pseudomonas aeruginosa* on Catheters in an *In Vitro* Model System

Weiling Fu†, Terri Forster, Oren Mayer, John J. Curtin, Susan M. Lehman, Rodney M. Donlan*

Division of Healthcare Quality Promotion, Centers for Disease Control and Prevention, Atlanta, Georgia

AIMS Microbiology
2020, Volume 6, Issue 1: 43-63. doi: 10.3934/microbiol.2020003
Research article

Previous Article | Next Article

Bacteriophage treatment of carbapenemase-producing *Klebsiella pneumoniae* in a multispecies biofilm: a potential biocontrol strategy for healthcare facilities

Ariel J. Santiago , Maria L. Burgos-Garay , Leila Kartforosh , Mustafa Mazher , Rodney M. Donlan

Clinical and Environmental Microbiology Branch, Division of Healthcare Quality Promotion, Centers for Disease Control and Prevention, Atlanta, GA, USA

Received: 25 November 2019 | Accepted: 13 February 2020 | Published: 26 February 2020

Mean viable biofilm count was 70% greater in untreated vs treated catheters

Reduction in biofilm-associated bacteria viability initially, but not after 21d
Suggests supplementing phage with non-ionic surfactant

On sinks specifically

Cold Spring Harbor Laboratory

bioRχiv

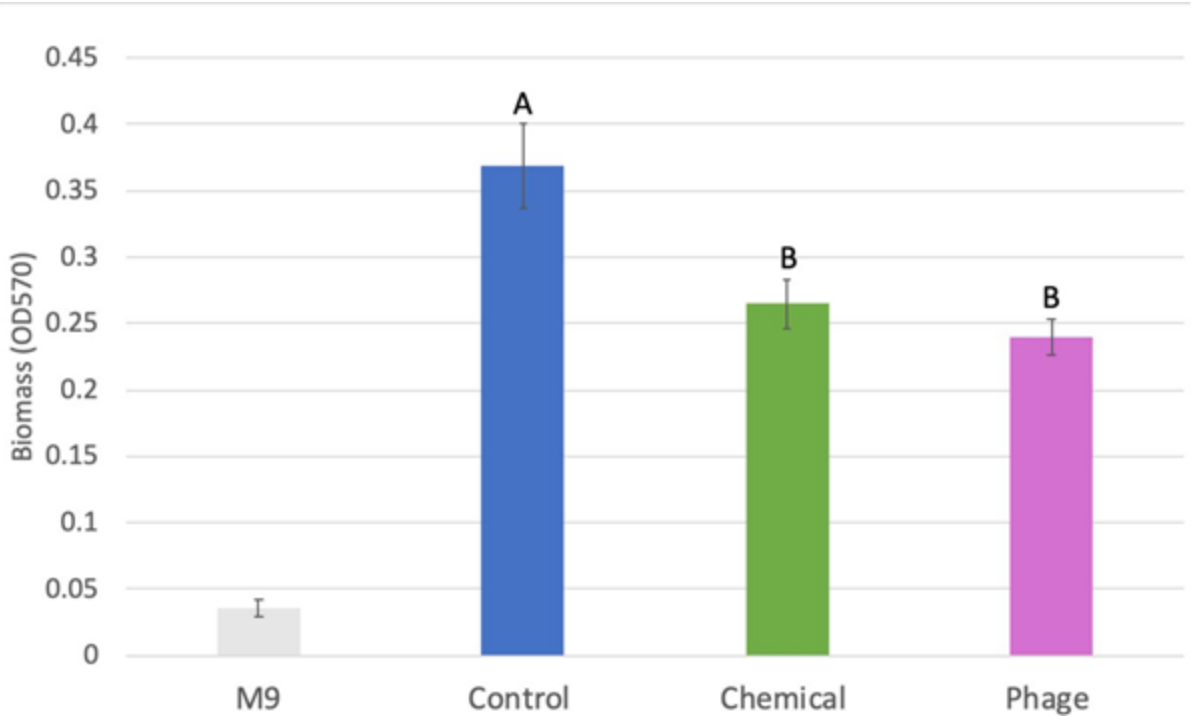
THE PREPRINT SERVER FOR BIOLOGY

New Results

Bacteriophage to Combat Biofilms in Hospital Drains

Jenny Yijian Huang

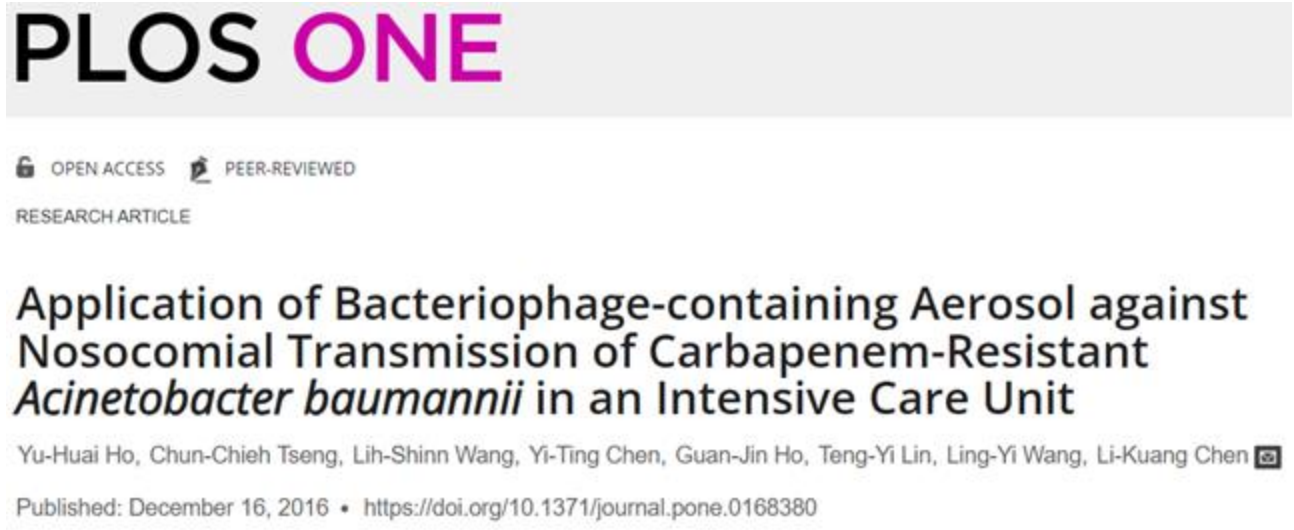
doi: https://doi.org/10.1101/522227



Both chemical (Clorox) and phage effective

Phage showed more uniform effect

Potential for other phage uses in IPAC



PLOS ONE

OPEN ACCESS PEER-REVIEWED

RESEARCH ARTICLE

Application of Bacteriophage-containing Aerosol against Nosocomial Transmission of Carbapenem-Resistant *Acinetobacter baumannii* in an Intensive Care Unit

Yu-Huai Ho, Chun-Chieh Tseng, Lih-Shinn Wang, Yi-Ting Chen, Guan-Jin Ho, Teng-Yi Lin, Ling-Yi Wang, Li-Kuang Chen

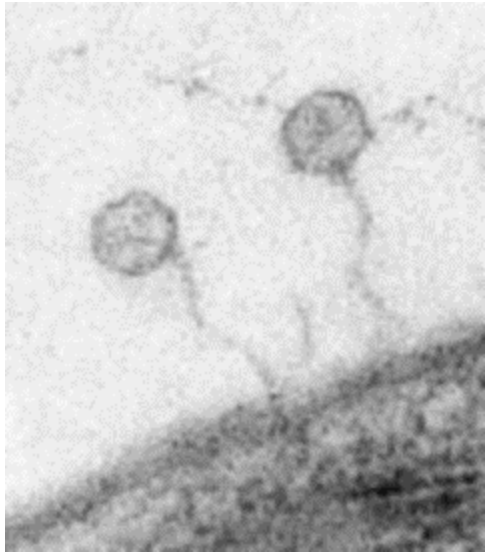
Published: December 16, 2016 • https://doi.org/10.1371/journal.pone.0168380

In ICU

- Rates of new CRAB infections down >40%
- Mean percentage of CRAB isolates went 87.76% to 46.07%

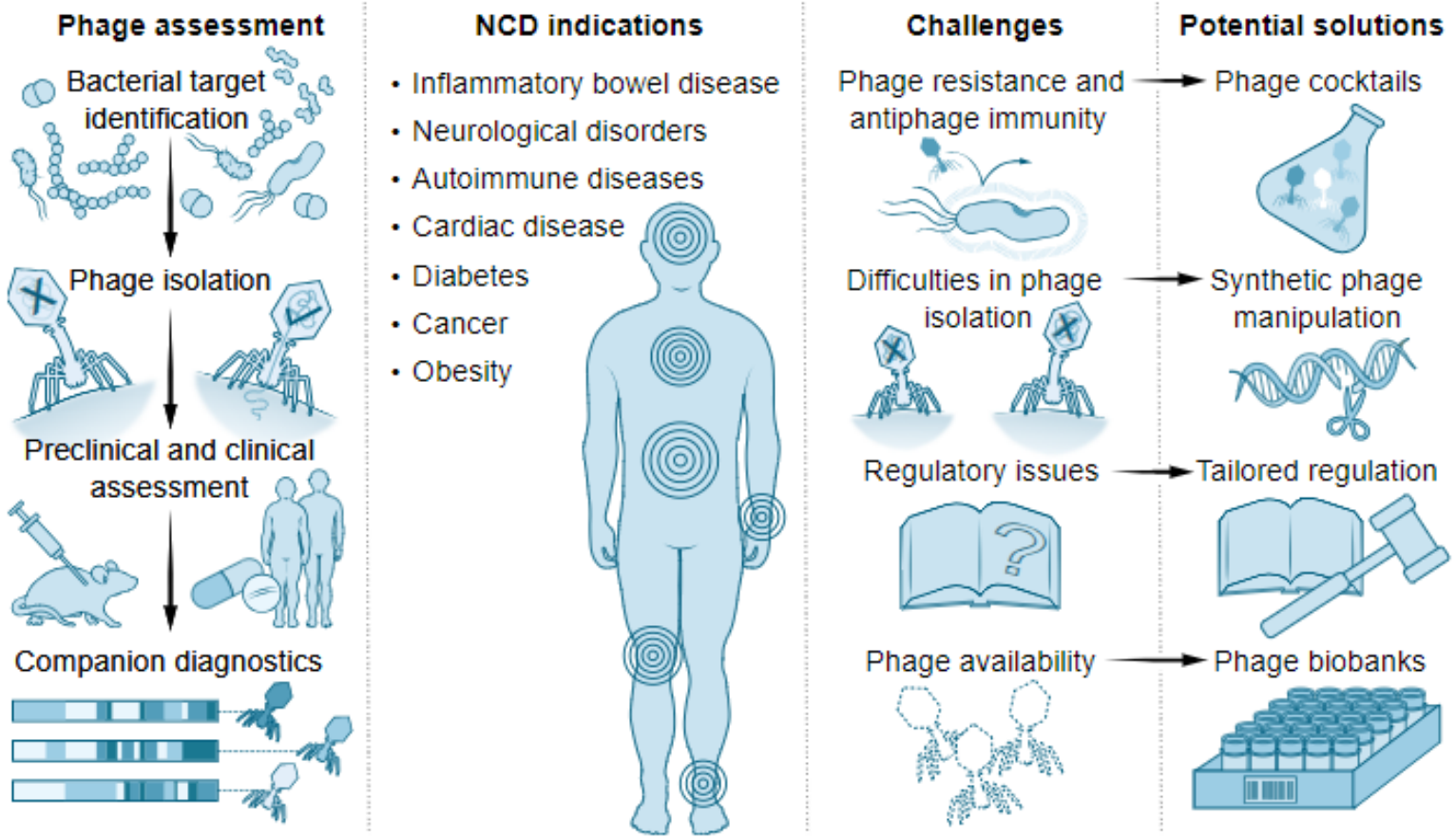
Still need more research in this area…


CANADA



Challenges and prospects of phage therapy

Developing human phage therapy for noncommunicable diseases (NCDs) begins with identifying disease-contributing bacteria and the isolation and testing of potential phages. Complementary phage combinations should prevent the emergence of phage resistance, and these phage cocktails can be tested in preclinical models followed by clinical trials. Companion diagnostics could help identify disease-contributing pathobionts in a patient. However, multiple challenges must be overcome, including difficulties in phage isolation and availability as well as regulatory hurdles.



GRAPHIC: N. BURGESS/*SCIENCE*

Dr. Greg German MD PhD
Univ. of Toronto / UHT
Phages Stopping Killer Infections

Global Clinical Phage Rounds, Chair

310+ Global Group

Association of Medical Microbiology and Infectious Disease (AMMI) Canada
Phage Therapy Working Group Lead / Chair

Engagement: "X" / Clearing House / Events

Regulatory: Dialogue with Health Canada, TATFAR

Laboratory: Phage Banking Screening & Logistics

Clinical: Survey / Registry / Practice Points

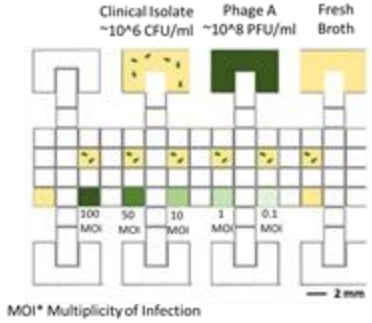
uToronto Phage Accelerator Fund

5,000,000$ over 5 Years
Faculty catalyst

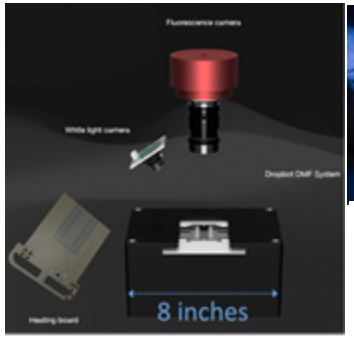
Phage Canada
Co-founder

To support and advance phage research and phage therapeutics in Canada (Patients, Public, Clinicians, Scholars, Industry and Government)

Primary Investigator



MOI* Multiplicity of Infection



UNITY HEALTH TORONTO

Microfluidics-UHT-CRAFT

E. coli, *Pseudomonas*, *Staph. aureus*
6 phages against one bacteria two methods of detection in 3 hours

EUCAST EUROPEAN COMMITTEE ON ANTIMICROBIAL SUSCEPTIBILITY TESTING
European Society of Clinical Microbiology and Infectious Diseases
Expert panel

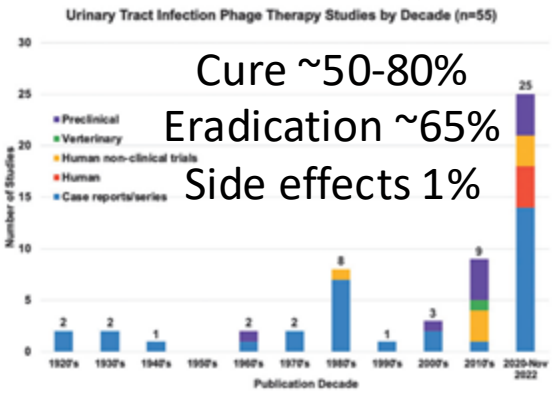
Phage Susceptibility Testing

Co-Moderator

*Phenotypic
*Genomic
*Storage
*Data

BioBanking

UTI Systematic Review N=55
All Years & Languages

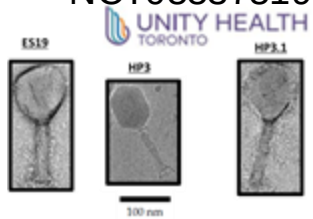


Cure ~50-80%
Eradication ~65%
Side effects 1%

Mouse UTI, non-invasive Tx

Pre-Clinical Work

NCT05537519



Standardize Methods / Registry (STAMP-CAN)
RCT P-PEAKS proposal

Patient Care

PHAGE Canada

Dr. Alex Hynes

Co-Founder

info.phage.canada@gmail.com

Follow: @APHage_

www.phagecanada.ca

PHAGE Canada

Dr. Greg German

Co-Founder
Clinical Director

Gregory.German@Unityhealth.to
+1(416) 799-0861

Follow: @DrGregGerman

www.phagecanada.ca

PHAGE Canada

Dr. Karen Maxwell

Inaugural Board Member

karen.maxwell@utoronto.ca

Follow: @theMaxwellLab

www.phagecanada.ca

bit.ly/PHAGECANADAMEMBER

To support and advance phage research and phage therapeutics in Canada across medical, environmental, and agricultural domains

Follow: @PhageCanada

www.phagecanada.ca

Please See our New FAQ for Patients and Providers on access to Phages in Canada

Let’s Sign up Canada

- General public
- Trainees
- Scientists
- Clinicians

To support and advance phage research and phage therapeutics in Canada across medical, environmental, and agricultural domains

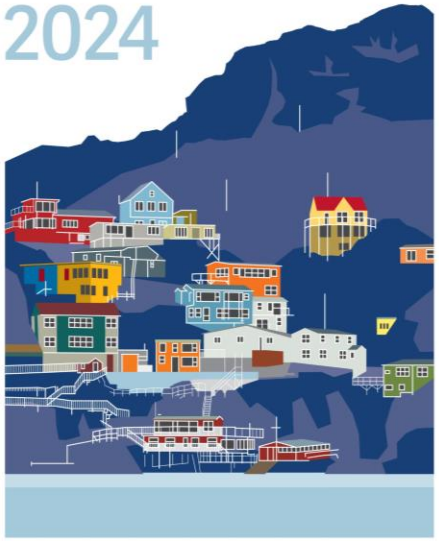
Follow: @PhageCanada

www.phagecanada.ca

bit.ly/PHAGECANADAMEMBER

Post-Test

What is your level of comfort with Phage Therapy?



1. Phage Phanatic: I am so my enemy of my enemy is my friend and we have an AMR CRISIS
2. Phage Phriendly: I studied phages, it makes sense, there is hope
3. Phage Phence:… Ask me later
4. Phage Phear: please show me the successful RCTs, don’t phages carry toxins and resistance genes?
5. Phage Phorgetaboutit

Phage Therapy Takes a Team:

- Payton Hooey, Jonathan Cook, Umesh Jain, Carlos Fernando, Keiko Salazar, Hanjeong Harvey, Udi Blankstein, Andrew Korpinksi, Alan Davidson, Karen Maxwell, Anthony Maresso, Austen Terwilliger, Lori Burrows, Tobi Nagel, Danielle Peters, Aaron Wheeler, Michael Dryden.
- Global Clinical Phage Rounds Executive
- Our latest student contributors:
  - Josephine Davey-Young, Riley Alvarez, Dinuri Punchihewa

Acknowledgements for TOR001:

- Funding provided in part by the Laboratory Physicians Associates of St. Michael's Hospital
- Dr. Mark A. Downing, Dr. Kevin Schwartz, Dr. Melanie Tsang, Dr. Travis Carpenter from St. Joseph's Health Centre and provided early care and/or participate in the safety committee.
- Jenna Wong AMMI Canada Clinical Research Network Research Coordinator
- Cytophage Inc. (Winnipeg) for early assistance with a Phage Search
- The laboratory and research laboratory staff at Unity Health Toronto, in particular Dr. Cathy Streutker, Dr. Larissa Matukas, Matthew Doggart, Catherine Park, Tijan Jallow, Mark Bignell, and Jenny Wu.
- The Pharmacy at Unity Health Toronto, in particular Clarence Chant, Jiten Jain, and Glenda Bennett.
- Gurpreet Lakhanpal Applied Health Research Centre (Unity Health Toronto)
- Dr. Steffanie Strathdee and Dr. Saima Aslam from the Centre for Innovative Phage Applications and Therapeutics, Univ. of California, San Diego.
- Biologic and Radiopharmaceutical Drug Directorate, Health Canada
- The Patient / Research Subject and her Family.

Questions?
QR code for evaluation:

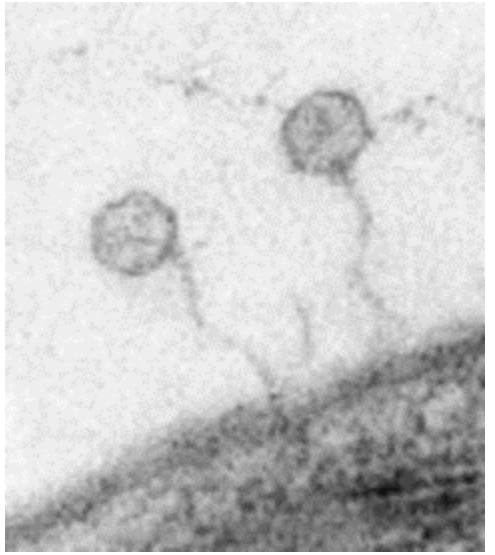
THANK YOU!

Please Contact Dr. Greg German at Gregory.German@unityhealth.to to sign up for GCPR or if you are interested in clinical trials

PHAGE Canada

https://www.phagecanada.ca/


CANADA



TEMERTY FACULTY OF MEDICINE
UNIVERSITY OF TORONTO

TemertyMedicine

and a staff physician in
the Chronic Infection Clinic

Play (k)

4:53 / 45:23

Networks

Canadian

- AMMI Canada
  - Working groups
  - STAMP-CAN
  - P-PEAKS
- Phage Canada
- NRC meetup (2nd year)
- Soon:
  - Univ. of Toronto: Canada wide accelerator fund

Global

- Global Clinical Phage Rounds
- NIH workshops and noon sessions
- ESGNTA (ESCMID-Europe)
- Phage Directory-Phaves series
- Phagistry
- Viruses of Microbes
- Evergreen Phage Meeting
- Phages for Global Health (biobank)
- SEA-Phages
- TATFAR?