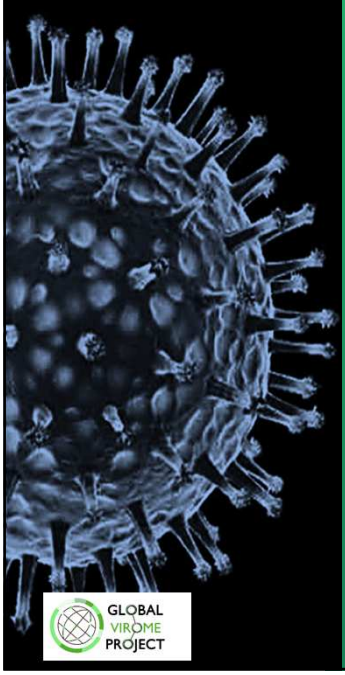
The Global Virome Project

The Transformative Power of Big Data

Dr. Dennis Carroll
GVP Core Team

GLOBAL VIROME PROJECT

0



GLOBAL VIROME PROJECT

The Global Virome Project

The Challenge:
We are losing the fight against emerging infectious diseases – despite having spent billions, our understanding of EIDs is inadequate

The Concept:
Equip countries to monitor and characterize the majority of unknown zoonotic viruses in wildlife, and use the data to develop a global knowledge network

The Impact:
Transform virology into a big data science and lay the foundation for the global health community to prevent, detect and respond to threats more efficiently, effectively and proactively

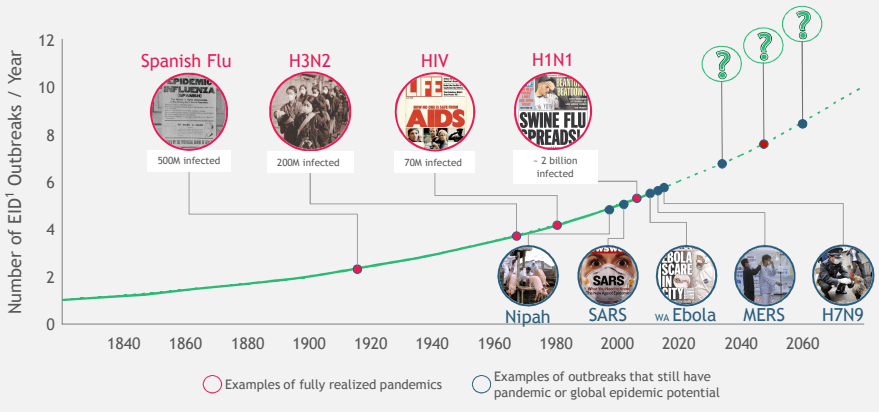
The Path Forward:
A 10-year, coordinated effort across 50 countries, with the first wave of National Virome Projects joining an incubation phase in 2019

1

The challenge

The threat of viral outbreaks is growing rapidly…

Largely driven by population growth, wildlife encroachment, and globalization



1. EID: emerging infectious disease; only diseases with zoonotic emergence are included; Reference for graph: Allen et al. (2017) Nature Communications

Challenge

…and there are many high-risk pathogens in wildlife we have not yet discovered

To date, **111 viral families** have been discovered around the world

25 of these families are likely to be capable of infecting humans

Across these 25 high-risk families, there are estimated to be **1.7M unknown viruses**

About **700k of which** likely have the potential to infect humans

We currently know <0.1% of the viruses with zoonotic potential; GVP will get us to 70%

For example, for every known coronavirus, there are currently **thousands of unknown coronaviruses** circulating in wildlife

The same is likely true for other viral families

GLOBAL VIROME PROJECT

Carroll et al. (2018) *Science*

Challenge

We urgently need to improve our understanding of these threats, and reinvent "what to do about it"

Our **knowledge** of viral threats barely scratches the surface

Our **understanding** of the relative risk of these threats is limited

Our **capacities** to address such threats are inadequate

Despite having spent billions on prevention, detection and response, we have not made much progress

GLOBAL VIROME PROJECT

5

The concept

The Global Virome Project is a necessary first step

A 10-year effort to collect and characterize the majority of unknown viruses in ~50 countries

Virus identification and genome sequence

Metadata on "viral ecology" – host range, geographic distribution, epidemiology

Documenting >70% of the world's unknown zoonotic threats

GVP is a ***transformative "down payment"*** to lay the foundation for:

- Long-term country capacity
- Sustained, longitudinal surveillance of viral evolution
- Development of an innovative "tool box" for diagnostics, treatments, and prevention

Concept

From 2009-2016, USAID invested ~$140M to strengthen global capacity for viral discovery in 30 countries by:

- Sampling wild animals
- Discovering novel viruses
- Training field and lab staff

Using learnings from the PREDICT "proof of concept," we can answer several key questions about GVP:

1. How many samples do we need to collect?
2. Which geographies and wild life species do we target?
3. What data do we need to collect to be able to gauge spillover risk?

GLOBAL VIROME PROJECT

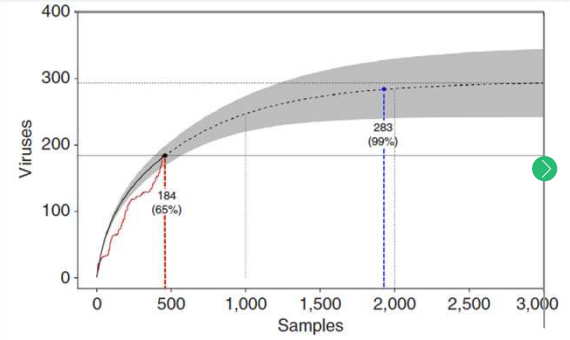
8

Concept

How many samples to we need to collect?

Goal of collecting ~1-2000 samples per species

Collecting **~2000 samples** per species yields **~99%** of a species' **viral diversity**



- GVP will collect **~1-2000 samples per species**, to be revised based on practicality (e.g., threatened or difficult-to-capture species)
- Some species' curves will saturate even more quickly; curves will be assessed and "early stopping" levels **defined to increase efficiency**

Anthony et al. (2015) *Nature Communications*

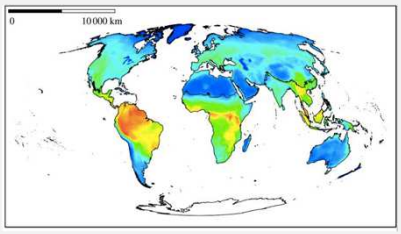
GLOBAL VIROME PROJECT

9

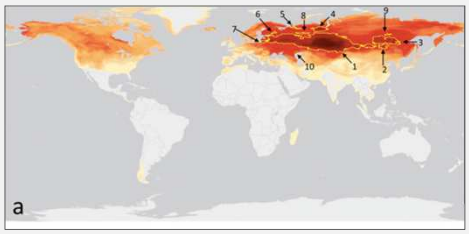
Concept

Which geographies and species do we target?

Mammals and water birds are the principle viral reservoirs



Mammalian Habitat ranges



Waterfowl breeding hotspots

GLOBAL VIROME PROJECT

10

Concept

How Many Sites are Needed?

Sites selected to maximize biodiversity, minimize cost; ~70% of mammalian virome found within ~130 sites

- GVP targets hotspots for mammalian diversity and waterbird breeding; prioritizes sites harboring spillover hosts and distinct species assemblages
- Site selection further refined based on accessibility, availability of laboratory facilities
- Sampling at the regional level minimizes duplication of sites in adjacent countries, allows logistical efficiencies to drive site selection
- Exact site selection to be refined, including with input from field countries

GLOBAL VIROME PROJECT

IUCN 2016; Weiss et al. (2018) Nature

11

Concept

What data do we need to collect to be able to gauge spillover risk?

40+ data points to be collected

Ecological traits

- Geographic hotspots for emergence
- Host species traits, geographic range, relatedness
- Host abundance
- Epidemiological / contact interface

Viral traits

- Host breadth / plasticity
- Proportion of known zoonoses in viral family
- Phylogenetic relatedness to known zoonoses
- Viral prevalence in host
- Other virus-specific traits

Key questions that can be answered from the data

- How abundant is the virus's host species?
- Where are the hosts distributed geographically?
- Where does the host come into contact with livestock or humans?
- How many hosts species can the virus infect?
- Are other viruses in this viral family known to be zoonotic?
- How close phylogenetically is the virus to other zoonoses?

GLOBAL VIROME PROJECT

12

The impact

GLOBAL VIROME PROJECT

13

Impact

Three direct "deliverables"

1. **In-country capacity** — Trained personnel, protocols and equipment in place for GVP sampling and analysis
2. **Viral database** — Large-scale, ecological and genetic knowledge network of the world's unknown viruses
3. **Risk characterization** — Understanding of which viruses are most likely to "spill over" to livestock and humans

Transforming the basic science of virology into a ***field driven by big data*** and enabling ***sustained longitudinal surveillance*** of viral evolution

GLOBAL VIROME PROJECT

14

Impact

These deliverables will equip the global health community with the inputs it needs in order to…

…continue to strengthen ***key surveillance and lab capacities*** even after the GVP concludes

…***identify natural & lab-enhanced pathogens*** more rapidly in the event of an outbreak

…improve understanding of individual viruses and viral families for the ***development of diagnostics, vaccines & treatments***

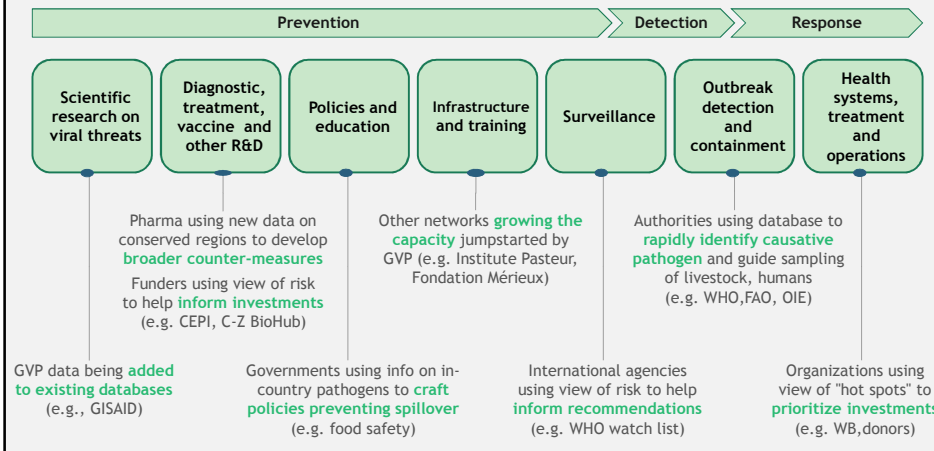
…minimize spillover by ***targeting surveillance and policies*** toward the highest-risk pathogens and geographies

GLOBAL VIROME PROJECT

15

Impact

GVP will be an integrating and complementary force



GLOBAL VIROME PROJECT

16

The Path Forward

GLOBAL VIROME PROJECT

17

Path Forward

The go-forward vision: 3 Phases

1. Incubation Period
2019 - 2021

- Underway in ~2 countries (Thailand and China)
- Science & ops validated, refined as needed
- End users beginning to analyze and act on the data
- Funding secured for first several years, key roles hired

2. Steady State
2022 - 2031

- GVP scales up and launches National Virome Projects across ~50[1] countries
- Local buy-in to continue collecting data and end users investing in its use
- Funding secured for duration

3. Pan-GVP

- Tracking Risk: Longitudinal multisectoral monitoring of viral evolution of "prioritized" viruses (starts during Steady State)
- Expanding the Tool Box End users leveraging new technologies and insights enabled by GVP

GLOBAL VIROME PROJECT

Path Forward

Incubation Period:

Main Objectives	Key Points
1 *Validate the "science" behind GVP*	• *Key scientific elements to validate*: scientific protocols and assumptions; sampling operations and ability to scale efficiently; data platform & analytics • *Means of validation*: "proof of concept" NVPs in 2 countries; independent SAG of internationally recognized scientists; Working Groups to ensure quality, efficiency, and incorporation of key learnings
2 *Mobilize funding and other resources*	• Articulate GVP's value and feasibility to a global network of influential advocates who can introduce GVP into the *political "mainstream"* • Engage governments and other potential donors to *secure 2-3 years of funding* • Explain GVP's value to in-country decision makers to *secure next wave of NVPs*
3 *Build out the GVP organization*	• *Establish formal entity with interim BoD & SAG* to guide GVP strategy, provide financial & scientific oversight, ensure global representation, & seek funding • *Scale up organization* through phased hiring, starting with an ExD • Build towards *int'l NFP; finalize data sharing*, licensing protocols and intellectual property rights issues

GLOBAL VIROME PROJECT

Path forward

Trajectory for the GVP 2018-20

Hub

~$1M p.a.

- Central staff to support GVP operations
- Capital investments (database platform)

Field

~$3M p.a.

- Sampling operations piloted in 2 countries (China and Thailand)

Over time, GVP will onboard an increasing number of countries and expand the budget

Total: $1.2B through 2030

GLOBAL VIROME PROJECT

20

Path Forward

GVP Operating Model

An international, central hub will set sampling protocols, ensure sufficient funding, and provide operational support to countries

Country-led National Virome Projects (NVP) will select sites, complete sampling and sequencing, and share data with the central hub

The central hub will aggregate and analyze the inputs, and then make available the database and risk characterization

GLOBAL VIROME PROJECT

21

The current GVP governing body - "The Steering Committee*" - approved in June, 2018 the GVP "Operating Model", the "Incubation Period Governance Ecosystem"…

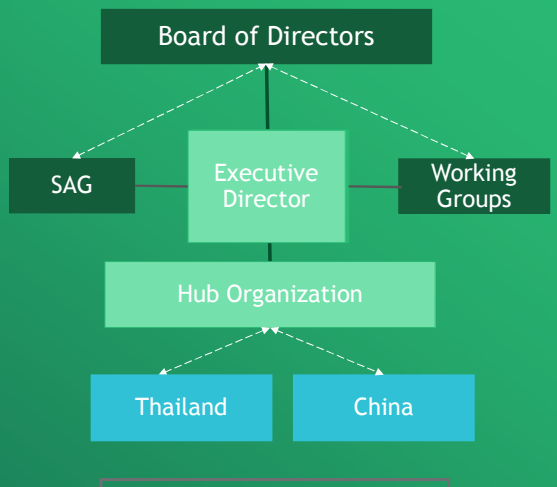
… and a Calendar of steps towards realizing a legally constituted Global Virome Project

*16 representatives from Brazil, China, France, Germany, HK, Italy, Nigeria, Switzerland, Thailand, UK, US

GLOBAL VIROME PROJECT

Path forward

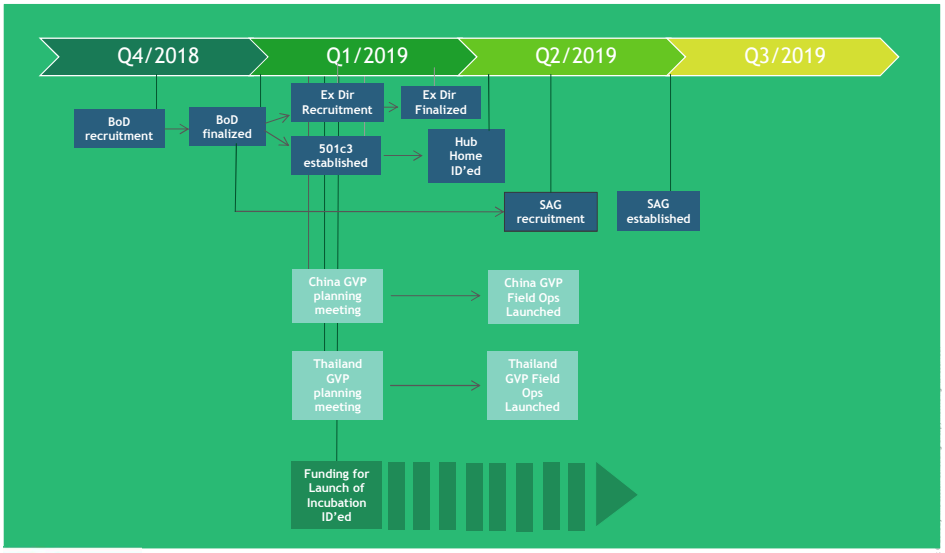
Incubation Period Governance Ecosystem



22

Path Forward

Major Milestones: Next 12 Months



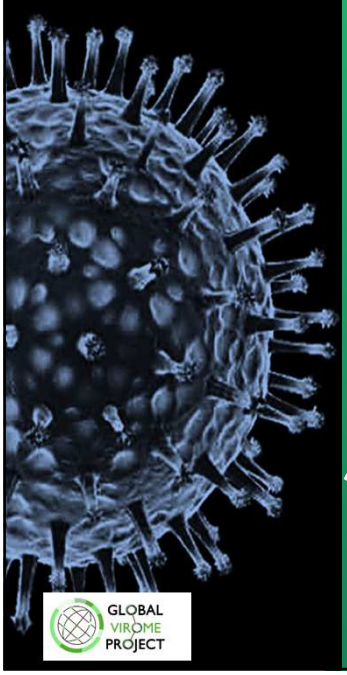
GLOBAL VIROME PROJECT

Key: GVP Organization | GVP Country Ops | GVP funding

What GVP IS and What it is NOT

GLOBAL VIROME PROJECT

24



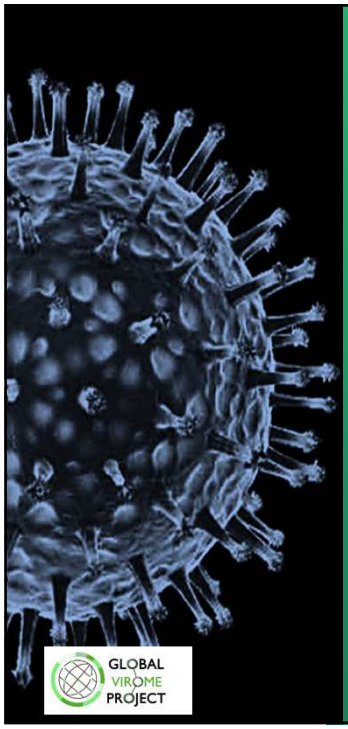
GLOBAL VIROME PROJECT

GVP NOT ≠

What GVP is NOT!

- Simply a sequence database
- A tool to predict the next pandemic
- An academic exercise
- At the expense of ongoing viral research
- A US-based project

25



GVP IS =

What GVP Is

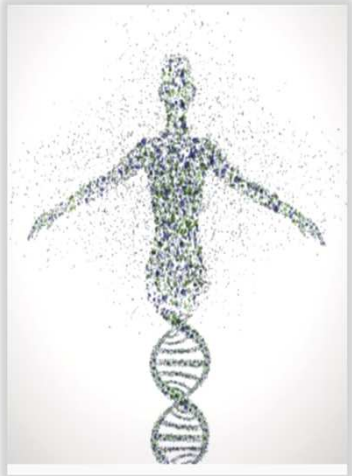
- Global partnership led by partners
- Promotes equitable access to data and benefits
- Invests in the systems and capacities for sustainable surveillance
- Addresses the risks posed by viruses to both animals and humans
- Transforms the global health culture from being "reactive" to "proactive"

26

GVP IS

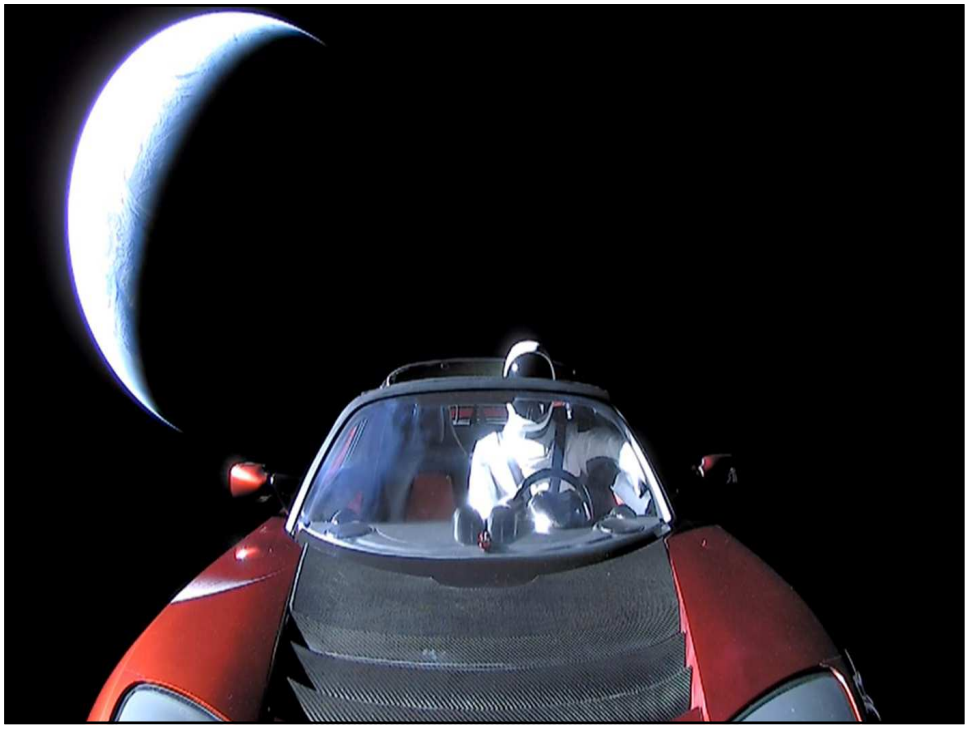
GVP ALSO…..

Shares many attributes with the Human Genome Project



- An audacious, but doable, multi-year initiative with clearly defined goals and metrics
- Completed in distinct phases - each generating discrete, useful information
- Provides a foundation to transform the way we engage in global health
- Potential for a multitude of applications above and beyond the immediate outputs
- Harnesses the transformational power of Big Data

27




DON'T
PANIC!

GVP: A Growing Network .....

Ministry of Health
FIOCRUZ
Oswaldo Cruz Foundation
Smithsonian Institution
IDRC | CRDI
International Development Research Centre
Centre de recherches pour le développement international
CHAN ZUCKERBERG BIOHUB
CHINESE ACADEMY OF SCIENCES
SCHOOL OF PUBLIC HEALTH
THE UNIVERSITY OF HONG KONG
香港大學公共衛生學院
World Health Organization
MERCK
THE GRADUATE INSTITUTE GENEVA
FAO
FIAT PANIS
NIH
National Institute of Allergy and Infectious Diseases
Oie
WORLD ORGANISATION FOR ANIMAL HEALTH
Institut Pasteur
WCS
FONDATION MERIEUX
GenomeCanada
COLUMBIA UNIVERSITY
USAID
FROM THE AMERICAN PEOPLE
CDC
CHINESE CENTER FOR DISEASE CONTROL AND PREVENTION
METABIOTA
O'NEILL INSTITUTE
FOR NATIONAL & GLOBAL HEALTH LAW
GEORGETOWN LAW
华大基因
BGI
UCDAVIS
VETERINARY MEDICINE
One Health Institute
Mahidol University
EcoHealth Alliance
GISAID
2008 - 2018
CEPI
THE NIGERIAN ACADEMY OF SCIENCE

GLOBAL VIROME PROJECT

31