

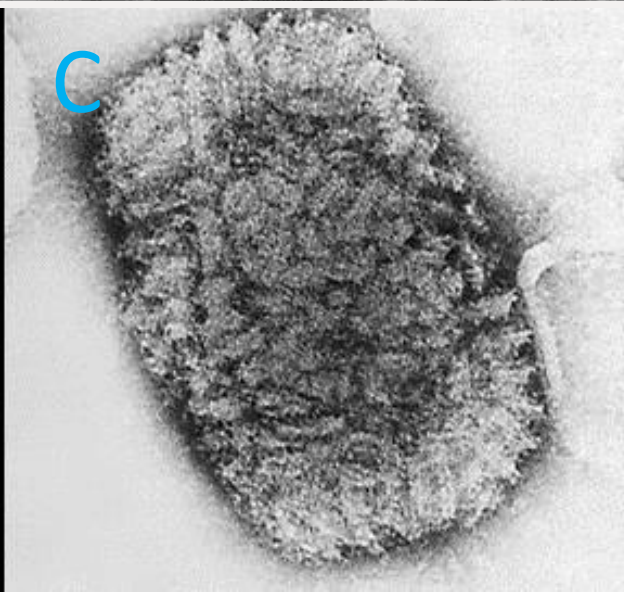
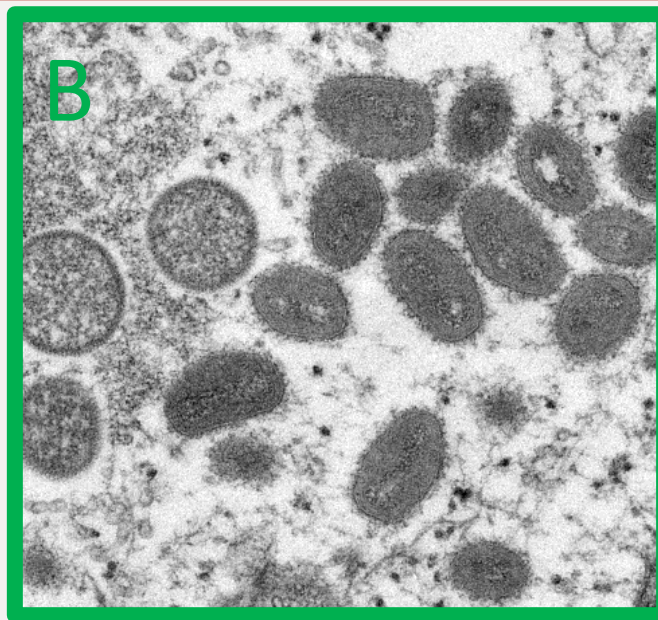
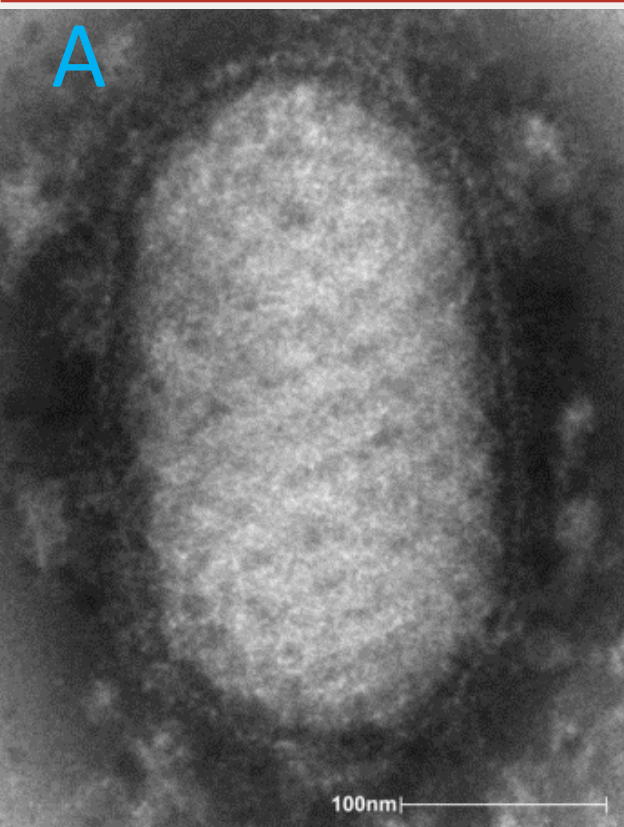
MONKEYPOX

Mpox

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Family *Poxviridae*

- **What is a poxvirus?**
 - Large, brick or ovoid shape
 - Complex dsDNA viruses
 - Replicate in cytoplasm
 - 135-240 kbp genomes
 - Up to 200+ proteins

A: Orf virus (sore mouth)

B: Monkeypox virus (monkeypox)

C: Vaccinia virus (smallpox vaccine)

D: Variola virus (smallpox)

Monkeypox virus

(Classic)

- Zoonotic orthopoxvirus disease that closely resembles smallpox
- Patients are ill for 2-4+ weeks
- 1-11% mortality in patients without prior smallpox vaccination
- First described in wild-caught laboratory monkeys; first confirmed as a human disease in 1970
- Two clades of virus, Clade II (West African) and Clade I (Congo Basin), with differences in pathogenicity



A Phylogeographic Investigation of African Monkeypox

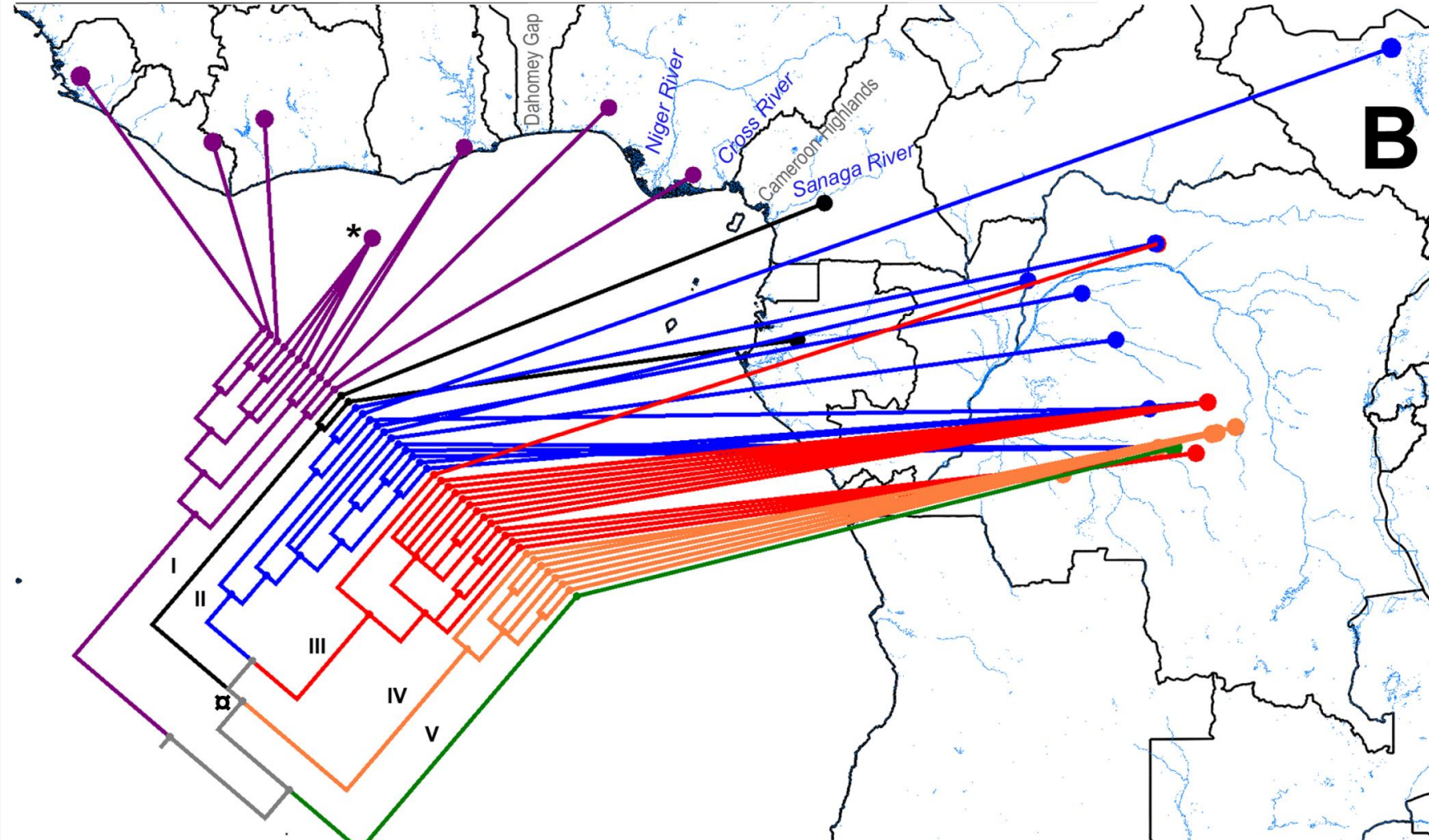
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Transmission

- Animal-to-human
- Human-to-human
 - Known to occur for Clade I (Central African) monkeypox
 - More recently recognized for Clade II (West African) monkeypox
- Routes:
 - Respiratory droplets
 - Contact with lesions
 - Contact with urine, feces (noted in animal models)
 - Contact with contaminated or infected tissues
 - Fomites (orthopoxviruses are hearty)
 - Transplacental
- Patients are infectious until the crusts fall off and a fresh layer of skin has formed.

Increased incidence

- Several countries are detecting and confirming cases for the first time in 30 to 40 years – Sierra Leone, Liberia, Nigeria, Cameroon
 - In-country expertise to identify and respond to monkeypox is lacking
- Documented increase in incidence of disease in areas of Democratic Republic of the Congo (DRC)
- Absence of vaccine-derived immunity (smallpox vaccine) in endemic areas since eradication of smallpox in 1980
- Improvements in disease detection and response post-Ebola (2014)
- Movement of people due to unrest, migration?
- Environmental and ecological changes
- Animal dynamics may play a role

Historical description of clinical features

- Febrile prodrome, 2-5 days before the rash
 - Fatigue
 - Headache
 - Respiratory symptoms
 - Lymphadenopathy
- Characteristic rash
 - Similar to ordinary type smallpox with centrifugal distribution
 - Macule – papule – vesicle – pustule – crust – desquamation
 - Deep-seated, firm, well-circumscribed with central umbilication
 - Single stage of development on a given site of the body
 - Rash is often present on the palms and soles

Characteristic lesions



Adler, et al. Lancet ID 2022



Reed, et al. NEJM 2004



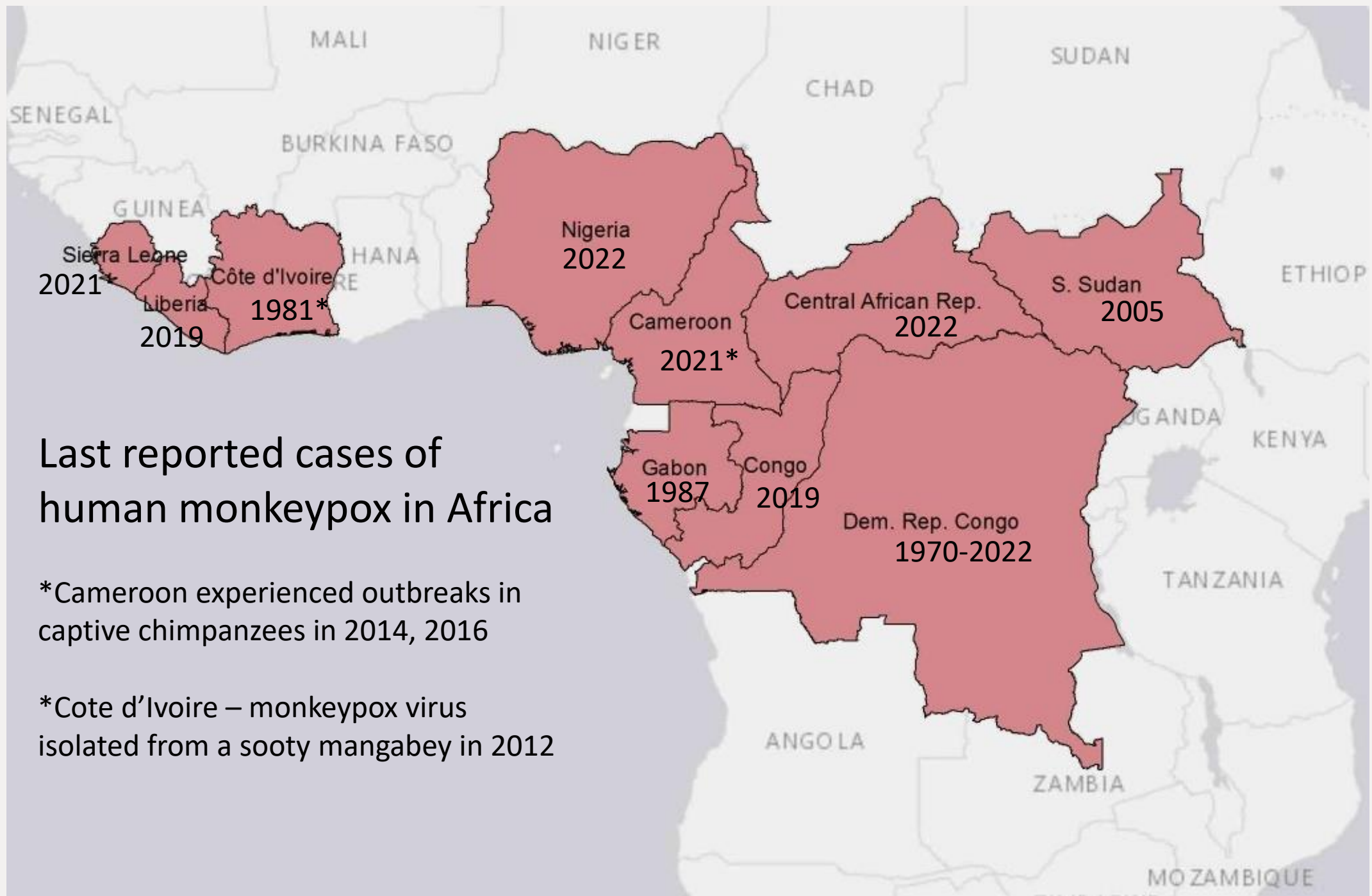
Reed, et al. NEJM 2004



Additional complications and sequelae

- Bronchopneumonia
- Dehydration
- Gastrointestinal disruption
- Secondary infections
- Sepsis
- Encephalitis
- Ocular infection & corneal scarring
- Skin scarring
- Death (11% unvaccinated)



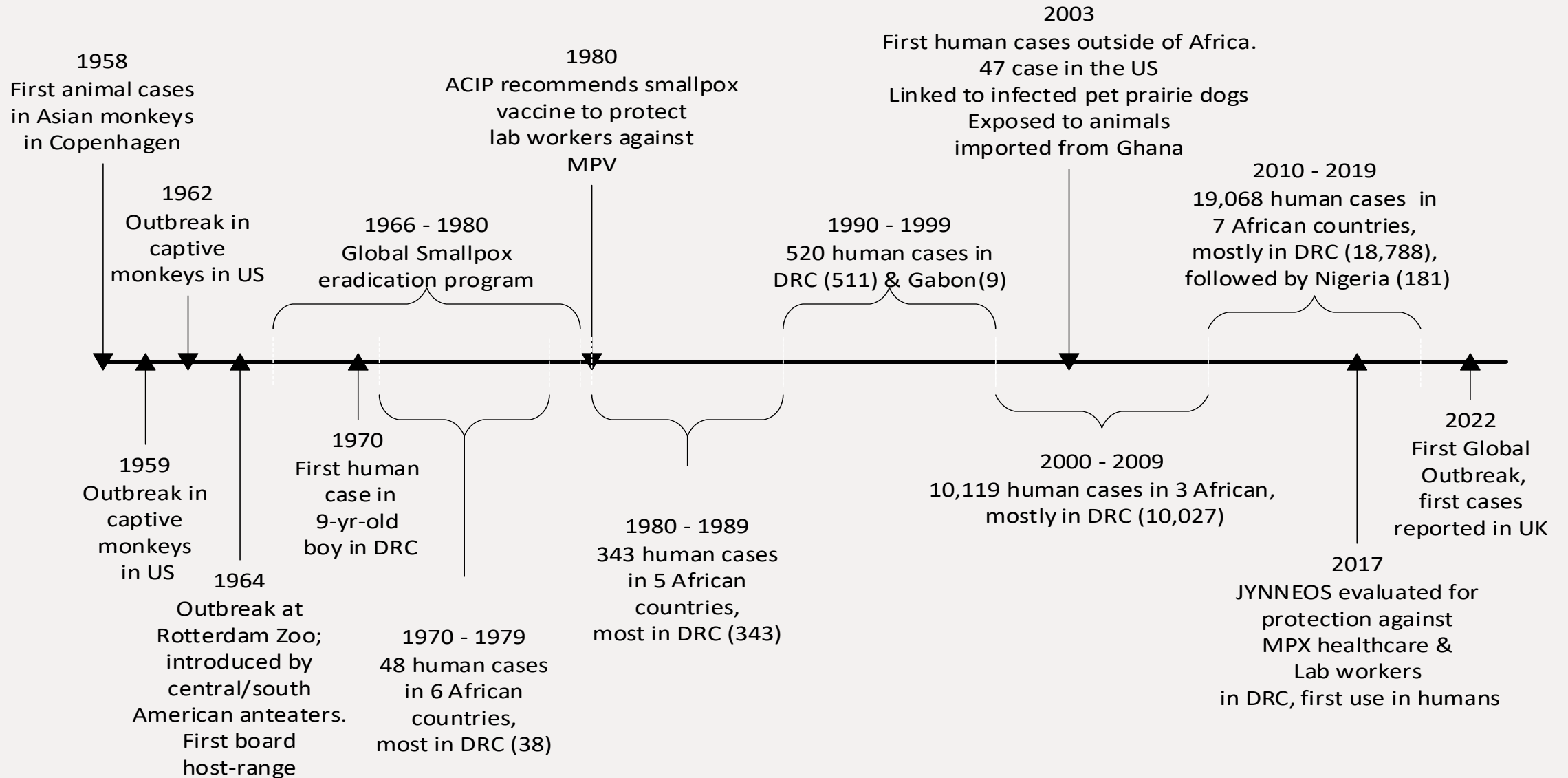


Last reported cases of human monkeypox in Africa

*Cameroon experienced outbreaks in captive chimpanzees in 2014, 2016

*Cote d'Ivoire – monkeypox virus isolated from a sooty mangabey in 2012

Monkeypox timeline



Orthopoxvirus Host Systems

Orthopoxvirus	(Potential) Host
Cowpox	<i>Apodemus sylvaticus</i> <i>Myodes glareolus</i>
Volepox	<i>Peromyscus californicus</i> <i>Peromyscus trueii</i>
Taterapox	<i>Tatera kempii</i>
Akhmeta virus	<i>Apodemus spp.</i>
Alaskapox	<i>Myodes rutilus</i>

Animal reservoir

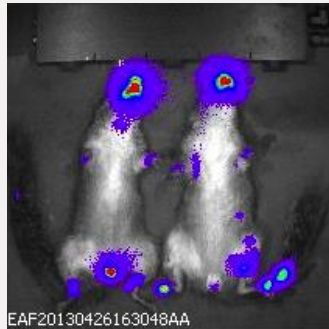
Animal reservoir remains unknown.

MPXV has only been isolated from wild animals in two occasions:

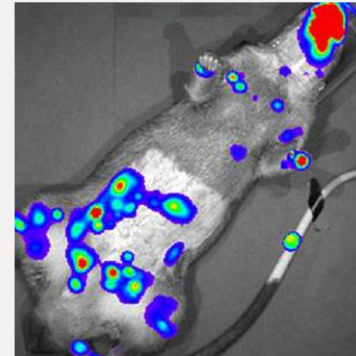
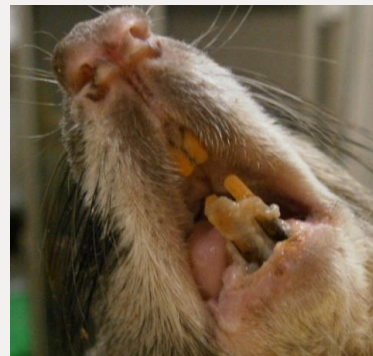
- Rope squirrel, DRC - 1985
- Sooty mangabey, Cote d'Ivoire - 2012

Animals associated with the importation of monkeypox into the US in 2003 include:

- African dormice
- Giant Pouched rats
- Rope squirrels



MPXV in Rope Squirrels
(*Funisciurus anerythrus*)



MPXV in Gambian Pouched Rats
(*Cricetomys gambianus*)

African dormouse
Graphiurus sp.



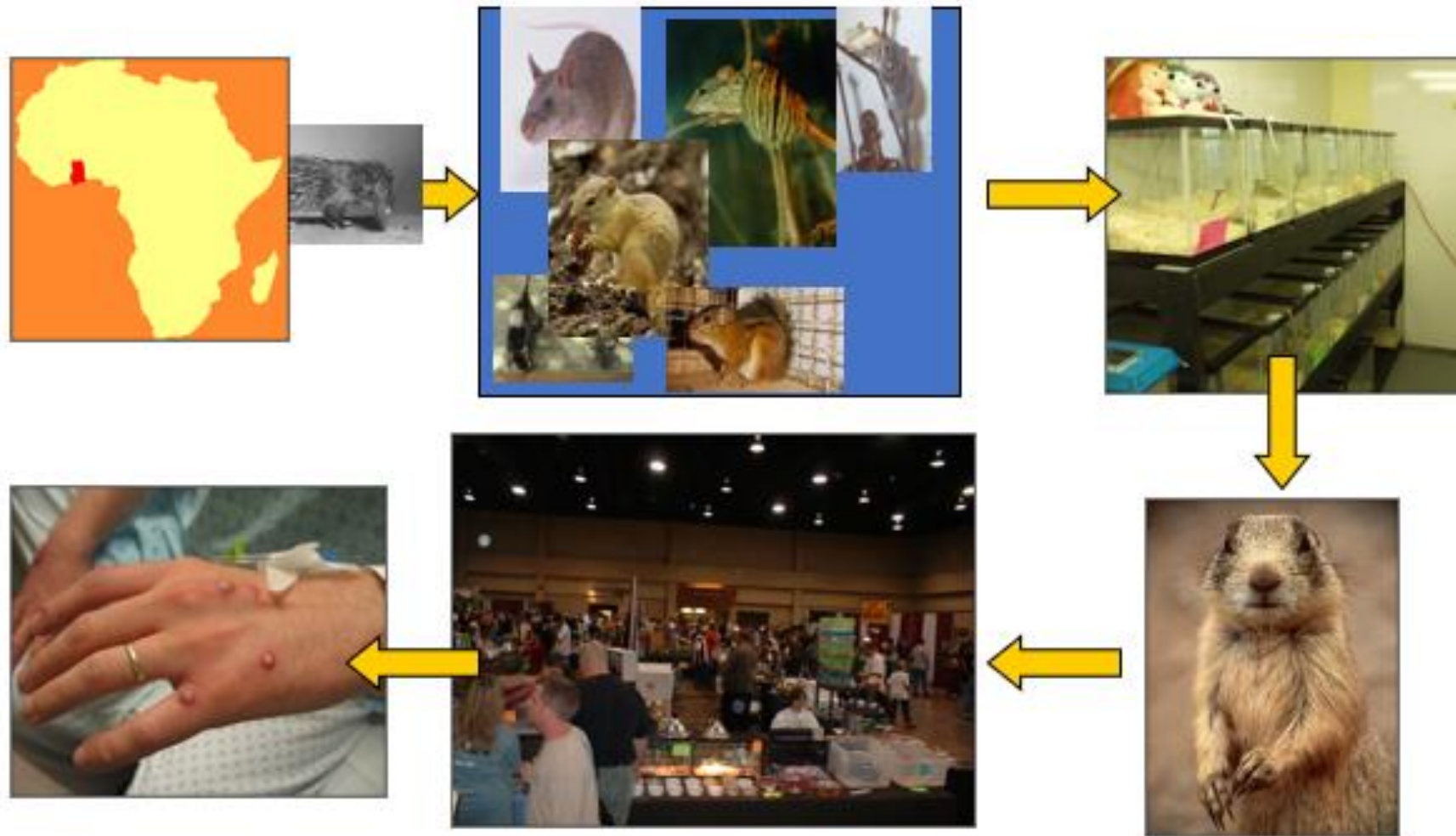
Gambian giant pouched rat
Cricetomys gambianus



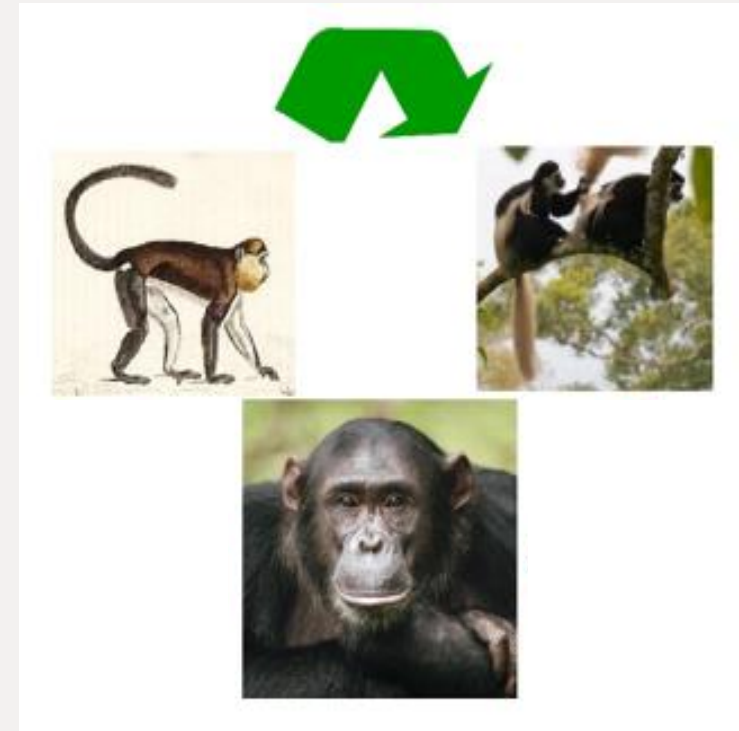
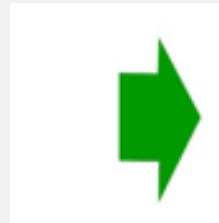
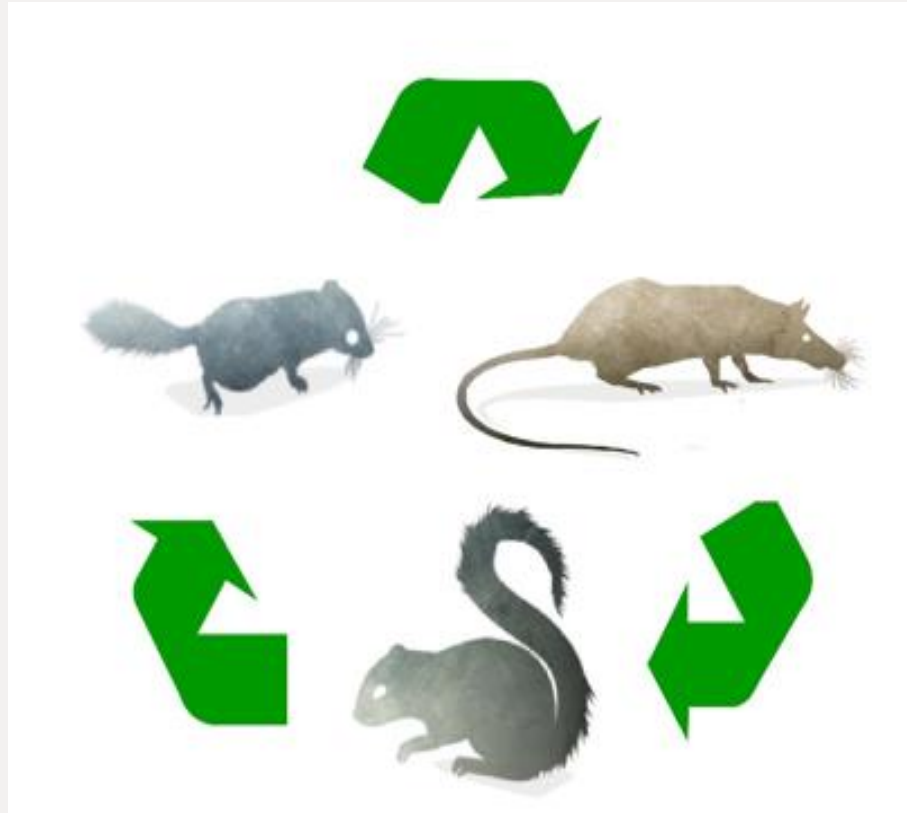
Rope squirrels
Funisciurus sp.



Monkeypox Importation to the United States, 2003

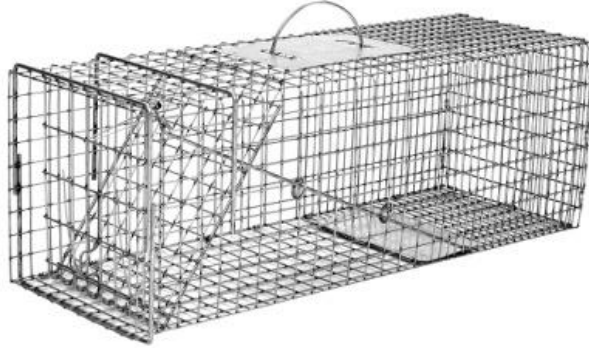


Hypothetical Natural Cycle





Traps



Processing

- Captured animals are transported to a central processing site
- Anesthesia
- Standard measurements and data collection
- Euthanasia: exsanguination followed by cervical dislocation
- Blood, lesion swabs, skin, heart, kidney, liver, lung, spleen,
- ABSL3 PPE
 - Gowns
 - 2x gloves
 - PAPRs
 - N-95 & faceshield
- Sample storage
 - Liquid nitrogen
 - Proper labeling





MONKEYPOX DISEASE DYNAMICS

CLINICAL MARKERS



PCR



SEROLOGY



IgM

IgM may appear as early as two days after rash onset, rises for ~2 weeks before declining and typically disappearing within the year (collect between days 4-56 post rash onset)

IgG

IgG may appear as early as one day after rash onset, rises for ~6 weeks and can last for decades (collect at day ≥ 14 post rash onset)

ENANTHEM

Lesions on the oral mucosa typically appear as the febrile prodrome is ending and the rash is beginning

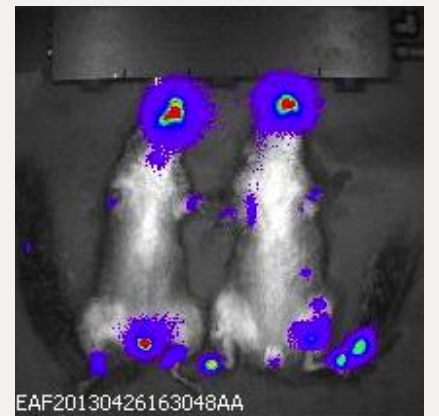
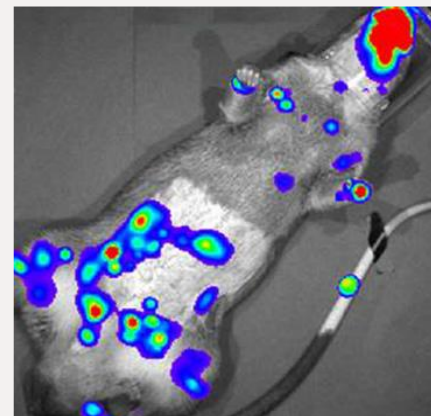
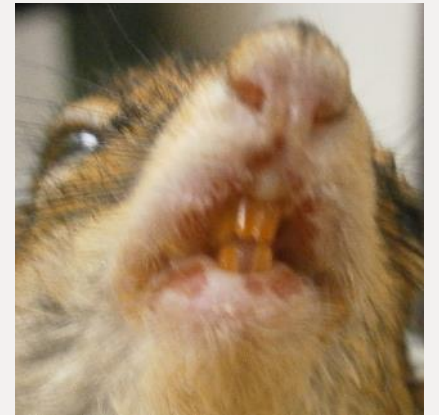
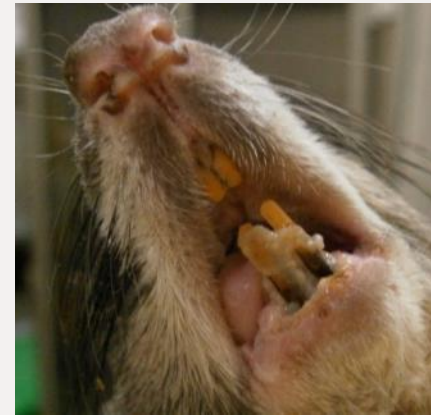
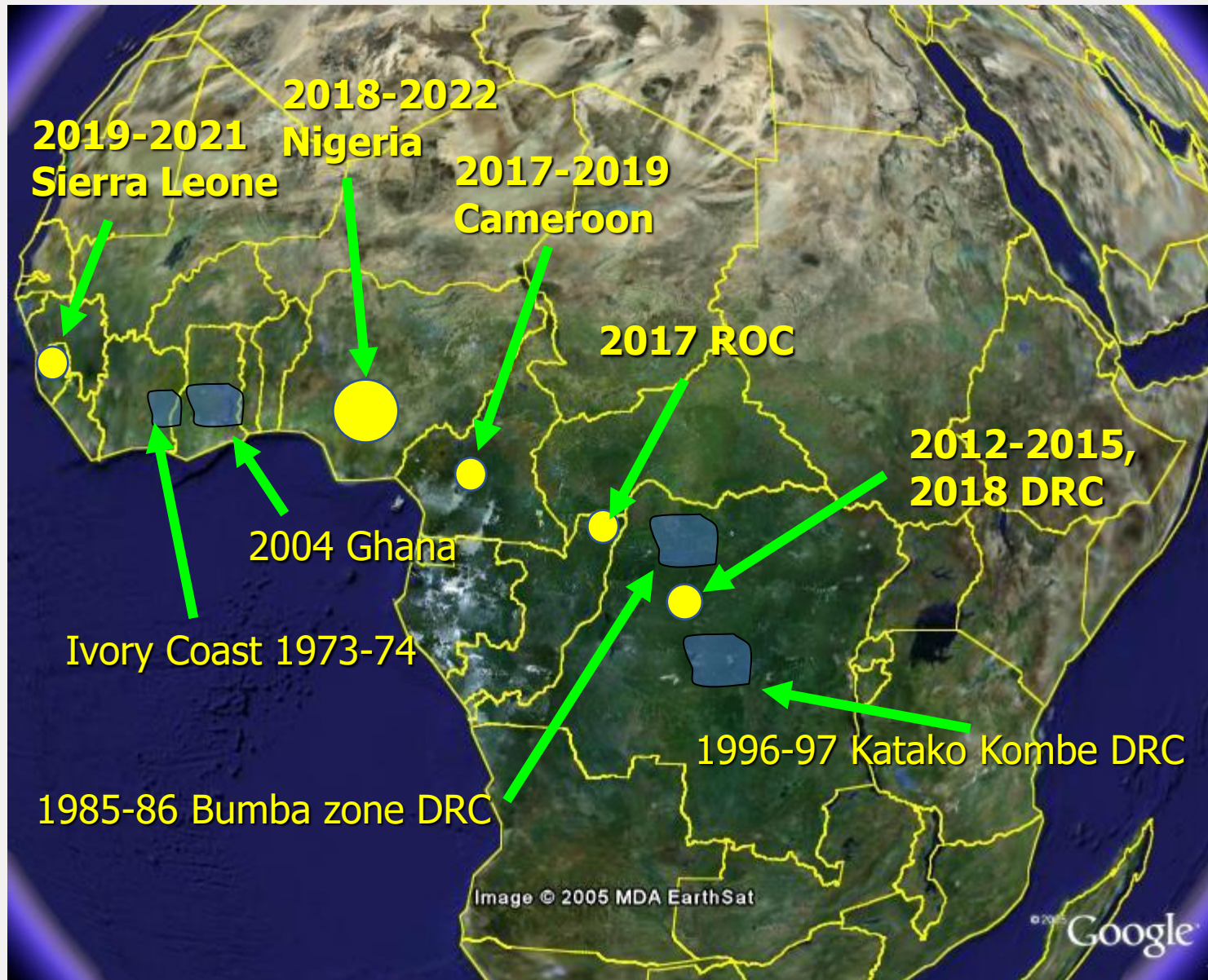
BLOOD VIREMIA

Viremia begins part way through the incubation period and its duration varies from days to weeks making it an unsuitable specimen alone for diagnosis

RASH LESION

Monkeypox virus DNA is present in lesion material throughout the rash stage

Major Ecological Surveys



Zoonotic aspects of current epidemic

Messaging

- People with monkeypox should avoid contact with animals.
- If someone with monkeypox must provide care for their animals, there are precautions to take to prevent infection in the animals.

One Health Special Study

- Collecting samples from animals in homes of people with monkeypox
- Performing PCR, ELISA, viral culture on samples
- Completing questionnaire to assess risk factors for animal infections

Preventing spillover to wildlife

- Domestic animals may be able to serve as a bridge to transmit monkeypox virus to wildlife and potentially establish new reservoirs

Evidence of human-to-dog transmission of monkeypox virus?

- Report from Paris, France in The Lancet
 - Two men who live together presented at a hospital in Paris, France, on June 10, 2022. Both were confirmed to have monkeypox
 - 4yo Italian greyhound developed symptoms 12 days after men's symptom onset (mucocutaneous lesions, including abdomen pustules and a thin anal ulceration).
 - Lesion, oral, anal swabs + by PCR, High ct values, but have 19.5kbp of seq data
 - No serologic response as of day 26 post PCR test; seroneutralization assay
- Report from Brazil – 5-month-old dog
 - Dog developed pustules (8/13) on back and neck 10 days after owner's symptom onset, lesion samples positive by PCR: [Detection of Monkeypox in animals in Minas Gerais | State Department of Health of Minas Gerais \(saude.mg.gov.br\)](#)



The Lancet:
[https://doi.org/10.1016/S0140-6736\(22\)01487-8](https://doi.org/10.1016/S0140-6736(22)01487-8)



For more information, contact CDC

1-800-CDC-INFO (232-4636)

TTY: 1-888-232-6348 www.cdc.gov

The findings and conclusions in this report are those of the authors and do not necessarily represent the official position of the Centers for Disease Control and Prevention.