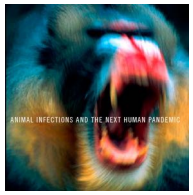
Eco Health - Emerging Disease



ANBI 139 Evolution of Human Disease
Pascal Gagneux

Thursday January 26, 2023

image from the book Spillover by David Quamen 2012: Spillover: Animal Infections and the Next Human Pandemic

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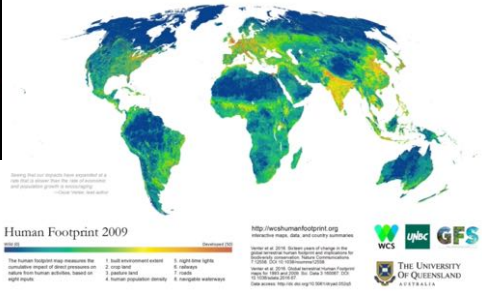
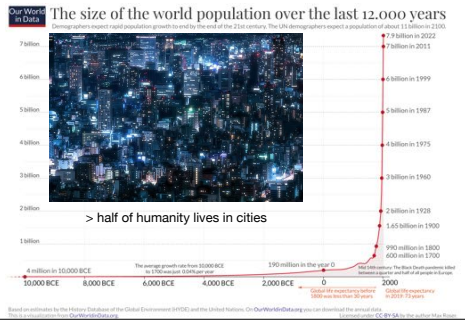
Where we live



Human footprints on the planet depend on numbers of people and the amount of energy used by those people.

Practice question: List for areas where the human footprint is particularly measurable on the planet.
Answer: Est Asia, South Asia, Europe, and Eastern North America.

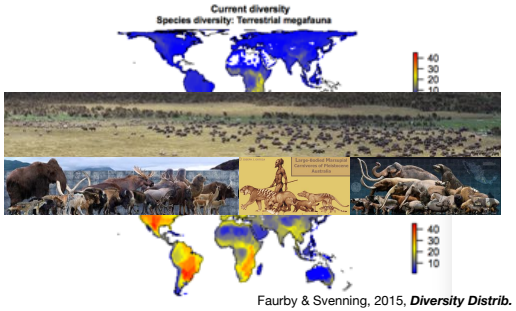
Crowds



> half of humanity lives in cities

Populations growth, one of the many existential threats we face.

Missing Megafauna (>44 kg/97 lbs)?



Faurby & Svenning, 2015, ***Diversity Distrib.***

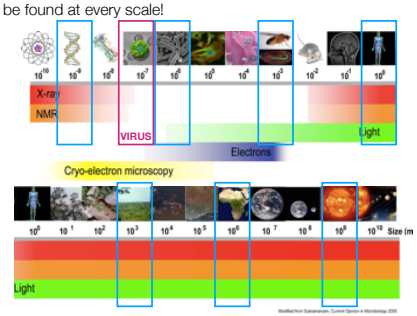
Where ever modern humans have migrated, there seem to be many missing large animals…. except in Africa, where large animals have co-evolved with humans

Practice question: Why is Africa the only continent that still has such large numbers of wild animals?

Answer: African animals evolved with humans, they are people smart. Large animal on all other continents were taken by surprise when these bipedal primates with their efficient hunting tools arrived, many of them died out.

Spatial Scales: from atoms to galaxies

Relevant data to be found at every scale!



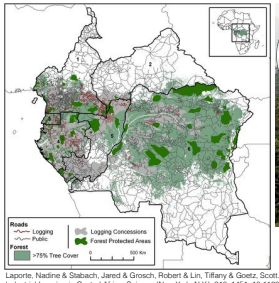
Practice thinking at different spatial scales…jump in scale of 1000 X down all the way to DNA molecules, and up all the way to the sun!

Practice question: What is the size of a virus?

Answer: ~ 100 nanometers or 10^{-7}

Human encroachment

Growing human populations and encroachment of wild areas lead to novel and contact.



New road in the Congo

Laporte, Nadine & Stabach, Jared & Grosch, Robert & Lin, Tiffany & Goetz, Scott. (2007). Expansion of Industrial Logging in Central Africa. Science (New York, N.Y.). 316. 1451. 10.1126/science.1141057.

Demand for natural resources: oil, gas, minerals, timber and pasture leads to ever more encroachment.

Practice question: How do logging roads contribute to increased contact between human and wildlife?

Answer: Once in place, local humans who often are desperate to find new livelihoods follow these new road and establish camps along them and then hunt for animal proteins in areas that had very little human wild life contact.

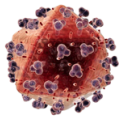
Shipping and recycling, e.g. car tires

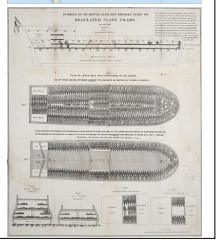
Asian Tiger Mosquito
Aedes albopictus
arrived from Japan in old car tires to Huston, TX 1985!

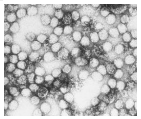
Lounibos, L., O'Meara, G., Escher, R. ***et al.*** Testing Predictions of Displacement of Native ***Aedes*** by the Invasive Asian Tiger Mosquito ***Aedes Albopictus*** in Florida, USA. ***Biological Invasions*** **3**, 151–166 (2001).

Practice question: How could shipments of car tires affect global disease?
Answer: Rain water in old car tires allow mosquitoes to breed and provide unintended transport of novel mosquito species across continents.

Yellow Fever, a flavivirus





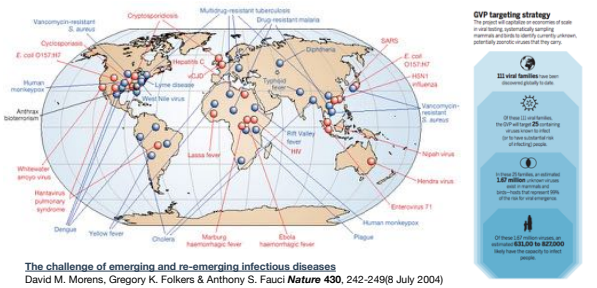


Yellow fever, imported together with its transmitting mosquito by the transatlantic slave trade, is the only flavivirus that can be prevented with a very efficient vaccine.

Practice question: Why was on of the many negative effects of the transatlantic slave trade on global disease?
Answer: African infectious disease and their mosquito vector species arrived in the Americas.

Emerging Diseases

Global Virome Project
Peter Daszak and Nathan Wolfe

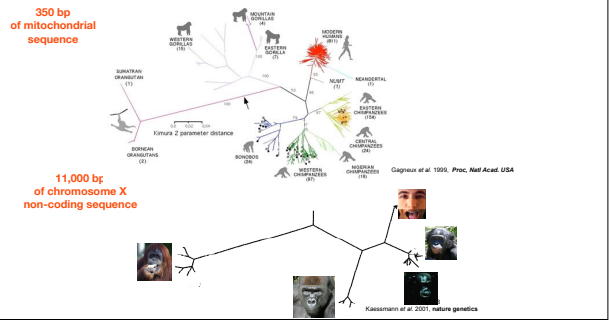


The challenge of emerging and re-emerging infectious diseases
David M. Morens, Gregory K. Folkers & Anthony S. Fauci ***Nature*** **430**, 242-249(8 July 2004)

Despite the misleading impression that humans were winning the fight against infectious disease in the middle of the 20th century, there is a long list of emerging diseases around the world. Many of these are due to novel contact between animals and humans.

Practice question: What technology has made the discovery of new viruses much easier?
Answer: Molecular detection (PCR, next generation sequencing, allowing the detection of viruses in primary samples without prior culture to amplify virus numbers).

Hominid phylogenies, mitochondrial and X-linked DNA



Years ago, I collaborated with a large group of people to compare the DNA sequences of a small stretch of mitochondrial DNA. We reported that each of the great ape species showed much more genetic variation than 800 humans from populations from all around the world.

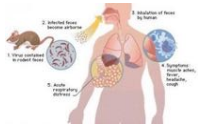
A few years later, Svante Paabö's group sequenced a stretch of DNA 30 times longer on noncoding parts of the X chromosome and found a similar pattern. Now we have whole genomes for all these players including Neanderthals.

Pascal's personal journey:

the late David Woodruff, UCSD Biology

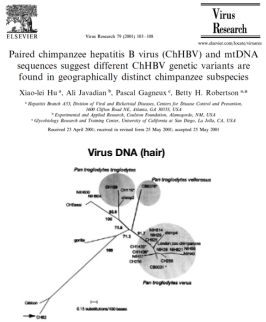
Jeanne Messier
UC San Diego Grad student
victim of Hanta virus

Nicholas Mundy



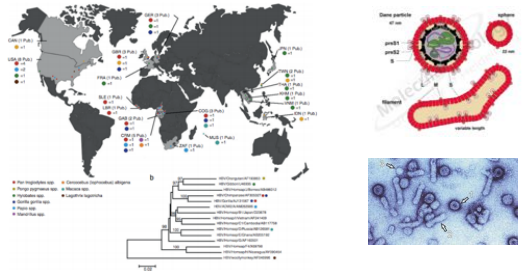
Visiting graduate student in a biology lab at UCSD with the late David Woodruff.
Met Nick Mundy who had just spent three years in Gabon and seen chimpanzees with SIV infections.
Lost a friend to an emerging virus (sin hombre) haunt virus.
Read Laurie Garrett's book the coming plague.

Pascal's personal journey:



Collaborated with people at the CDC on chimpanzee HBV, chimpanzee genetics gives us clues o the evolution of Hepatitis B viruses.

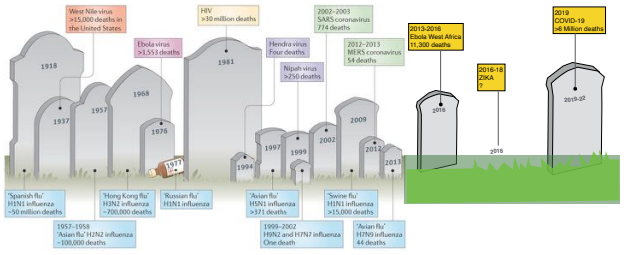
Hepatitis B, an Orthohepadnavirus



Breno et al ***Braz J Infect Dis*** . 2014. 18(5):535–543

Primate origins of HBV: Right: Geographical distribution of publication relating to non-human primates which were detected with some HBV genotype. Sample animals are listed by genera in Table 1. (B) The evolutionary history was inferred by Neighbor–Joining method using differences between DNA sequences. (left graphic): Electron Microscop Presentation of HBV Particles. The round 42 nm particles (1) represent infectious virions (Dane particle). The small empty spheres (3) and the filaments (3) are non infectious. The preparation was enriched in virus particles (EM picture by courtesy of H.-W. Zentgraf, Heidelberg)

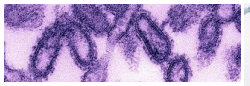
Zoonoses over time



Studying immunity to zoonotic diseases in the natural host — keeping it real. Andrew G. D. Bean, Michelle L. Baker, Cameron R. Stewart, Christopher Cowled, Celine Deffrasnes, Lin-Fa Wang & John W. Lowenthal
Nature Reviews Immunology 13, 851–861 (2013)

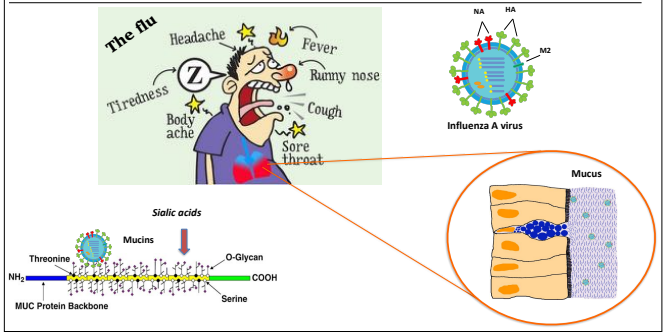
A zoonosis (plural zoonoses) is an infectious disease of humans acquired from non-human animals.
These can get out of hand or resolve relatively quickly.

1918 “Spanish” Flu (H1N1)



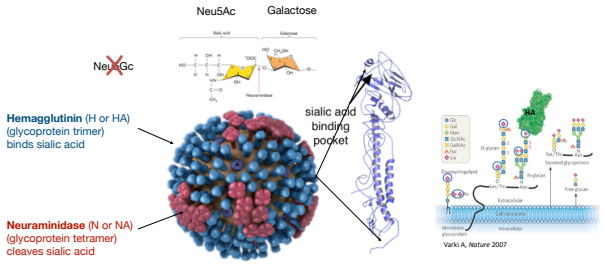
The biggest infectious event of the 20th century killed more people than both world wars combined!

The Flu & The Goo



Our respiratory tracts secrete mucins, glycoproteins very rich in sialic acids that act as protective decoys.
The Influenza virus has evolved to counter such decoys and can clip sialic acids off mucins in order to penetrate towards the cell surface.

Viruses use host glycans as receptors (e.g. Flu Virus)



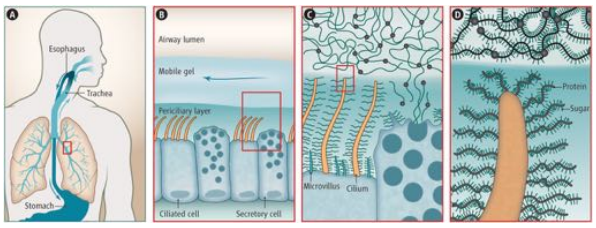
specific for monosaccharides and glycosidic linkage type!

The Influenza A virus cares about the type o sugar and its linkage got the underlying sugar chain.

Practice question: What do the letter H and N in the names of different influenza A viruses stand for?
Answer: Hemagglutinin for binding to cells and Neuraminidase for cutting off sialic acid from cells or muffins.

Defensive host glycans as barriers and decoys

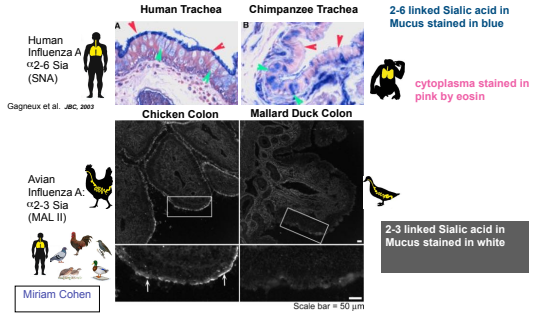
A mobile mucus gel is continually swept out of the lungs and swallowed (blue).



B. F. Dickey *Science* 2012

Airway mucus layers.(A) A mobile mucus gel is continually swept out of the lungs and swallowed (blue). (B) The mucus layer moves over an immobile periciliary layer. Secretory cells synthesize polymeric mucins that form the mobile gel; ciliated cells propel the gel. (C) Secretory cells release mucin polymers that travel upwards to be incorporated into the mobile gel layer. Button et al. now show that glycoconjugates (membrane-tethered mucins and mucopolysaccharides) are present in the periciliary layer at greater density than glycoconjugates (polymeric mucins) in the gel layer. (D) Densely packed sugar side chains cause membrane-tethered mucins to assume a partially extended configuration, whereas mucins in the gel layer are random entangled coils.

Why apes do not get the flu

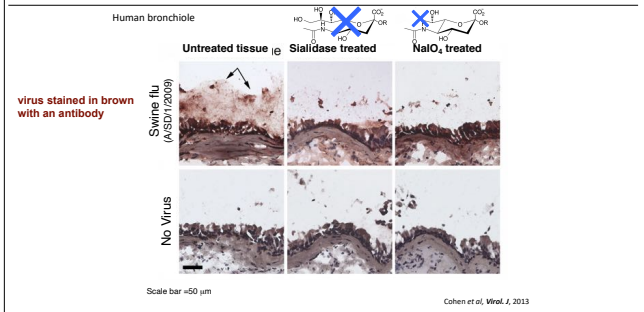


The sialic acid in the lung of chimpanzee are different and differently linked, they do not get the flu! In adapting from bird host to human host, the preference of the virus for the linkage of sialic acid changes (one or two mutations in the protein sequence of the hemagglutinin are enough to cause this switch!)

Practice question: What factor could cause very closely related species such a s humans and chimpanzees to have very different susceptibility to infection by a given virus?

Answer: Changes in nature and/or distribution of cell surface molecules (proteins, glycans or lipids).

Influenza A binds to secreted airways mucus

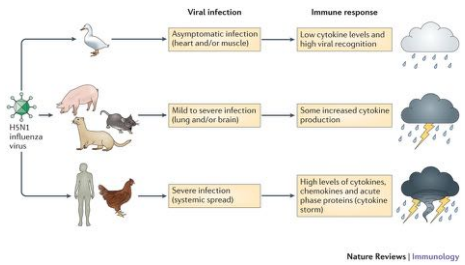


Visualizing Influenza virus trapped in mucus on human bronchial tissue (tissue section from a frozen post-mortem lung sample).

Practice question: How can mucus impact infection risk by a virus?

Answer: The mucus can contain receptor molecules for viruses and act as a decoy/smokescreen.

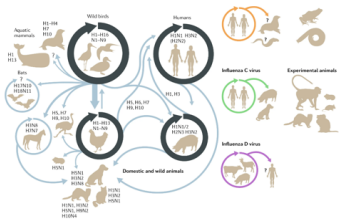
What a wild bird virus can do to us



H5N1 bird flu has dangerous potential! Mutations identified can let the bird virus switch to airborne transmission in humans!

What a wild bird virus can do to us

Very diverse pool of viruses existing in wild aquatic birds



Eradication not possible, only better surveillance prevention, and treatment

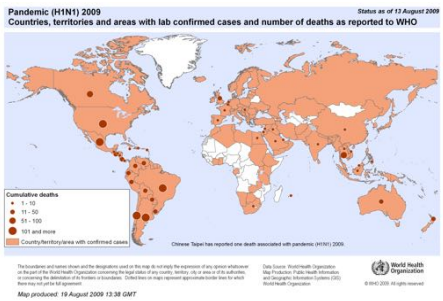
Long, J.S. ***et al.*** Host and viral determinants of influenza A virus species specificity. ***Nat Rev Microbiol*** 17, 67–81 (2019).

Influenza A viruses (haemagglutinin (HA) subtypes 1–16) circulate in the wild bird reservoir. Subtypes from this reservoir are able to cross into many different species, sometimes via intermediate hosts and sometimes requiring adaptive mutations (light blue arrows). Specific subtypes predominate in certain species (dark blue circles). Human-adapted influenza viruses of the H1, H2 and H3 subtypes have circulated in recent history. H1N1 and H3N2 viruses currently circulate whereas H2N2 viruses do not; the same three subtypes have also circulated in pigs. Avian influenza viruses (AIVs) of H5, H6, H7, H9 and H10 subtypes have infected humans following exposure to infected poultry. Viruses of these subtypes currently do not transmit between humans. HA subtypes H17 and H18 circulate only in bats. Influenza B viruses circulate in humans, although infections in seals have been described. Influenza C viruses circulate in humans and swine. The recently discovered influenza D viruses are found to circulate in cattle, goats and pigs1. Despite some serological evidence of infection in humans, the zoonotic threat to humans remains unclear. Detection of influenza virus-like RNA in Wuhan Asiatic toads, Wenling hagfish and spiny eels has recently been described, although their genera remain to be defined. Many species have been experimentally infected by influenza viruses, including ferrets, mice, guinea pigs, macaques and marmosets.

Practice question: Why is it totally unrealistic to eradicate influenza viruses?

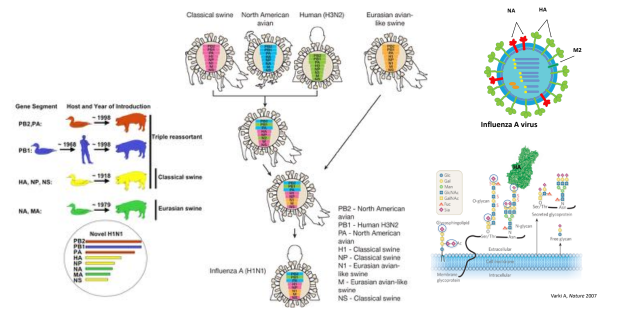
Answer: They have a gigantic reservoir in many species of wild water birds that migrate across the planet.

2009 “Pig Flu” (H1N1)



The 2009 H1N1 swine origin flu was a close call.

2009 “Pig Flu” (H1N1)



It arose through viral sex,,, multiple recombination of viral RNA segments

Discovery of swine H1N1 in 2009 in San Diego!

Dr. Dave Metzgar, who first isolated H1N1 Pig Flu in 2009

JOURNAL OF CLINICAL MICROBIOLOGY, Nov. 2010, p. 4228–4234 Vol. 48, No. 11
0095-1137/10/$12.00 doi:10.1128/JCM.01336-10
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Initial Identification and Characterization of an Emerging Zoonotic Influenza Virus Prior to Pandemic Spread▽

David Metzgar,*‡ Darcie Baynes,†‡ Christopher A. Myers, Peter Kammerer, Michelle Unabia, Dennis J. Faix, and Patrick J. Blair

Department of Respiratory Disease Research, Naval Health Research Center, San Diego, California

Received 30 June 2010/Returned for modification 10 August 2010/Accepted 10 September 2010

Two cases of febrile respiratory illness associated with untypeable influenza A virus were identified in Southern California in March 2009. One was initially detected as influenza virus using an experimental diagnostic device in a clinical trial, while the other was detected at a local reference lab using a diagnostic PCR assay. In both cases, analyses yielded negative results for strain-specific tests targeting circulating strains of influenza A virus (seasonal H1 and H3). These two samples became the first reported cases of the pandemic 2009/H1N1 influenza virus. The first reportable characterization was made from the second collected specimen on 15 April 2009 at the Centers for Disease Control and Prevention central lab using traditional culture and sequencing methods. The novel nature of the strain and its apparent zoonotic origins were initially characterized using the first collected specimen at the Naval Health Research Center in San Diego, CA, on 13 April using an experimental molecular analysis tool, PCR electro-spray ionization-mass spectrometry (PCR/ESI-MS), designed to amplify PCR products from any strain of influenza virus and to generate informative (phylogenetic) strain identifications through mass spectrometry of PCR amplicons. The ability of this high-throughput tool to correctly identify both well-characterized and novel influenza strains offers the possibility to integrate surveillance for emerging strains with on-site rapid diagnosis used for patient management, shortening the times between the emergence of new strains, their detection and identification, and appropriate public health response activities. Here we describe the initial characterization of the pandemic 2009/H1N1 influenza strain and discuss the possible roles of diagnostic tools with discovery potential.

2009 swine H1N1 was first described in San Diego by Nave Health scientist David Metzgar and colleagues.

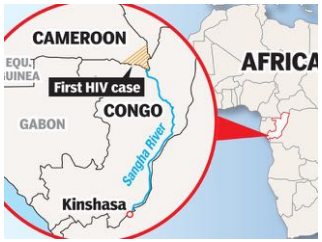
Contrast Legionella to HIV/AIDS

Legionellosis: high priority, AIDS: low priority

1994 Benetton Ad

Legionella, a novel bacterium growing in the air conditioning system of a hotel and sickening members of the American Legion got immediate attention and funding
HIV, and African ape virus infecting gay men, hemophiliacs, heroin users and Haitians, did not for the longest time.

HIV/AIDS: a chimpanzee zoonosis

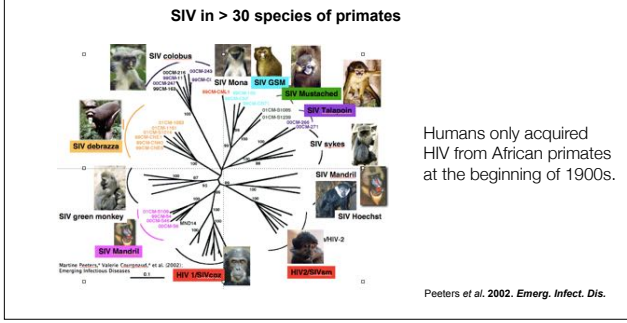


It is now clear that HIV/AIDS emerged as a zoonosis bin Central Africa around the turn of the the 1900s.

HIV infects T-lymphocytes in the blood stream, ultimately causing AIDS. Terese Winslow created this artwork to give scientists new insight into how HIV infects T-lymphocytes. The virion is shown in the first stage of infection, when the virion attaches to the surface of the T-cell. The molecules involved in this docking process are of particular interest to scientists, so she rendered them accurately according to the most up-to-date scientific information. These molecules include gp120 (the blue 'mushrooms' on the surface of the virus), CD4 (the long red molecules on the cell surface), and chemokine receptors (the groups of blue cylinders on the cell surface).

Again, no depiction of the many complex glycan molecules on both, the virus glycoprotein “mushrooms” or the host cell surface.

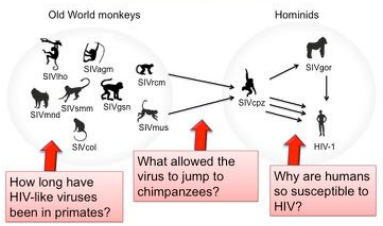
All other African primates have their own SIV



Humans only acquired HIV from African primates at the beginning of 1900s.

Most African non-human primates each have their own versions of HIV, named SIV (simian immunodeficiency virus, a misnomer, as most other African primate species do not get sick).

What caused the virus to jump?



More than a million years in other African primates. Jump likely aided by bush meat hunting/butchering. The bases for human susceptibility are still being studied.

Perfect Storms

Colonial brutality and mass medical campaigns

Large urban centers and mass migrations

Intercontinental Medical Aid

Blood Commerce

(Sex) Tourism and IV Drug use

The convergence of colonial brutality, the first large urban centers (including sex workers), intercontinental medical aid, blood commerce (plasma pheresis businesses in Haiti), and sex tourism and IV drug use formed the perfect storm.

Practice question: Which factors helped spark the HIV/AIDS pandemic?
Answer: Colonialism, mass migration, urban centers including sex workers, intercontinental medical aid, blood commerce, sex tourism, IV drug use.

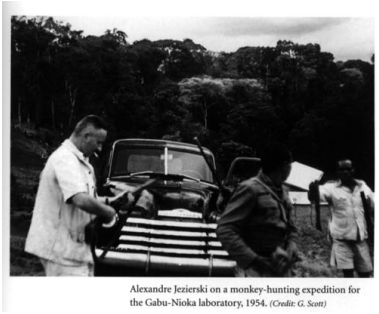
Bush meat trade

Apes are still hunted for their meat throughout tropical Africa, even in the cities, bush meat is valued much more highly than farmed meat.

perfect opportunity for cross-species infections.

Polio vaccine studies in the Belgian Congo used hundreds of wild caught chimpanzees and bonobos for testing the efficacy and safety of vaccine.

These studies could not have caused the HIV1 epidemic which was well underway by the late 1950s.



Alexandre Jezierski on a monkey-hunting expedition for the Gabu-Nioka laboratory, 1954. *(Credit: G. Scott)*

Chimp caught in a liana net by pygmies, at one of Rollais's base camps in the north of Province Oriental, 1958. *(Credit: G. Rollais)*

Two African assistants dismembering a dead chimp in the

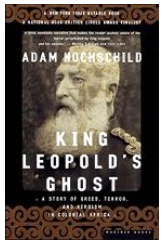
Mass vaccination in Belgian Congo 1959

Agnes Flack vaccinating a "sea of Africans" with CHAT in the Ruzizi Valley, 1958. *(Credit: R. Phillips)*

Oral Polio Vaccine Trials in Belgian Congo in 1959

Mass vaccination in Belgian Congo 1959: suspected by some as possible origin of HIV/ AIDS

BUT
clearly not the case rather HIV was already circulating at the time



The Belgian Congo, a private Colony of the Belgian King Leopold II, was a very dark chapter in human history.

Next to massive colonial brutality involving forced labor at a huge scale, random violence, displacement and brutal oppression, it was also the sigte of massive medical interventions including sleeping sickness surveillance and eradication efforts and vaccine trials.

The Alternative hypotheses about HIV origins:

1.Natural Transfer: infection by killing and butchering of apes for meat, more hunting in modern times, larger cities and more travel.

2. Natural Transfer & syringes (aided by rural clinics with rampant reuse of unsterilized hypodermic needles).

3.Oral Polio Vaccine (OPV), vaccine prepared on chimpanzee tissue cultures? infected with SIV and fed to ~1 million Africans in 1957-1960.

3 has been proven wrong, so likely a combination of 1 and 2.

Logging road in the DRC

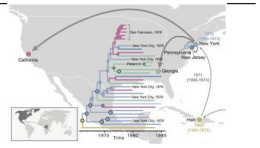
Logging roads are made by international logging companies. Once a road is made, many locals and migrant use it to enter the forests and establish camps along or near the road. These new settlers hunt for their meat and start depopulating all animal populations. They can use bush meat a a cash crop, utilizing the traffic of looking trucks to ship their meat to the cities, where bushmeat fetches much higher prices than that of domestic animals.

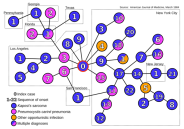
Practice question: How could logging roads affect emerging diseases?

Answer: Local people and immigrants use the road to access new areas where they farm and hunt for bushmeat.

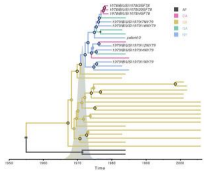
HIV patient ZERO?

Gaëtan Dugas, infamously, and wrongly, labeled Patient Zero.





"Cluster of Cases of the Acquired Immune Deficiency Syndrome: Patients Linked by Sexual Contact," ***Amer. J. Med.*** 76 (1984): 487–92, 488, 61984.



McKay RA. "Patient Zero": the absence of a patient's view of the early North American AIDS epidemic. ***Bull Hist Med.*** 2014; 88(1):161-94.

A 1984 paper linked 40 AIDS patients by sexual contact. Of those patients, Dugas was the first to experience an onset of symptoms of AIDS.
But he was not patient zero!

Eco Health

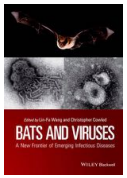
Protecting the environment and preventing diseases

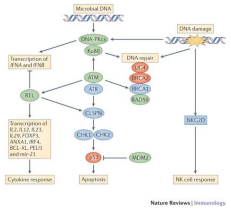
The idea of Eco health is that conservation of ecosystems can contribute to our understanding of emerging diseases and too their prevention.

Bats

Adapted to high viral loads?

Active flight shaped the immune system of bats.





Nature Reviews | Immunology

The figure illustrates key components of the DNA damage response and DNA repair pathways. Whole-genome analysis of two bat species (*Pteropus alecto* and *Myotis davidii*) showed that a high number of genes encoding components of these pathways are positively selected in *P. alecto* and *M. davidii*. Many of these genes are positively selected in both species (these encode proteins that are highlighted in green), whereas others have been positively selected in only one of the species (these encode proteins that are highlighted in red). Professor Linfa Wang studies bats in Singapur for their immunity to viruses and their capacity to avoid cancer.

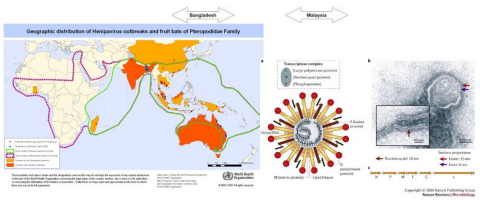
Practice question:

Why are bats so important for monitoring emerging viral diseases?

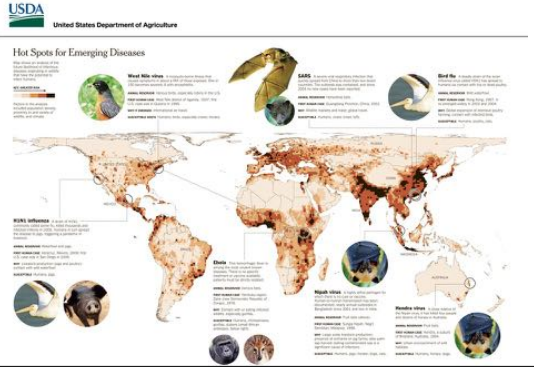
Their high mobility and resistance to viruses make them ideal reservoirs.

Bats and Nipah Virus

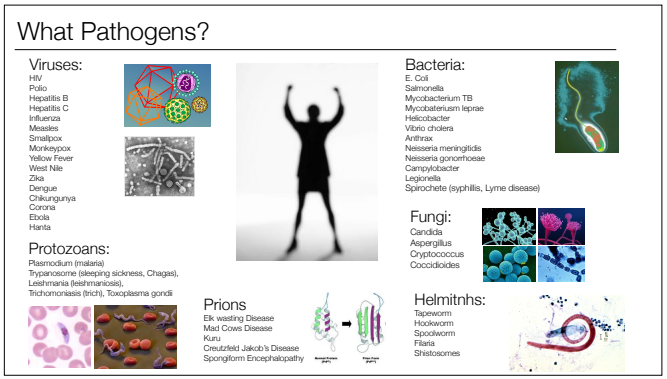
Pteropus megabat



Nipah is a highly virulent virus carried by South East Asian bats and able top infect pigs and people.



What Pathogens?

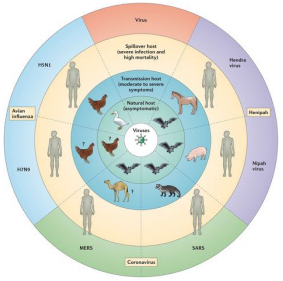


Some major pathogens and parasites causing human disease.

Practice question: List five major classes of human pathogens?

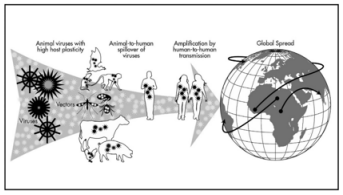
Answer: Viruses, bacteria, protozoans, helminths and fungi & prions.

Many paths for a zoonotic virus to human hosts

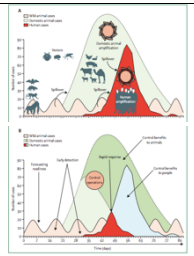


Studying immunity to zoonotic diseases in the natural host — keeping it real. Andrew G. D. Bean, Michelle L. Baker, Cameron R. Stewart, Christopher Cowled, Celine Deffrasnes, Lin-Fa Wang & John W. Lowenthal
Nature Reviews Immunology 13, 851–861 (2013)

Modern Zoonoses and there dynamics



Kreuder Johnson, C., Hitchens, P., Smiley Evans, T. et al. Spillover and pandemic properties of zoonotic viruses with high host plasticity. ***Sci Rep*** 5, 14830 (2015). https://doi.org/10.1038/srep14830

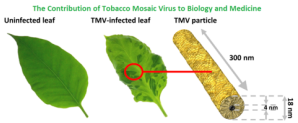


William B Karesh, *et al.* Ecology of zoonoses: natural and unnatural histories
The Lancet V380, 9857, P1936-1945, 2012
https://doi.org/10.1016/S0140-6736(12)61678-X

Figure: Clinical relevance of disease ecology
(A) Transmission of infection and amplification in people (bright red) occurs after a pathogen from wild animals (pink) moves into livestock to cause an outbreak (light green) that amplifies the capacity for pathogen transmission to people.
(B) (B) Early detection and control efforts reduce disease incidence in people (light blue) and animals (dark green). Spillover arrows shows cross-species transmission.

The notion of “viruses” is very recent

Dmitri Iwanowski, discovered viruses in plants in 1892.



“Messieurs Dames, les microbes auront le dernier mot”
Ladies and gentlemen, microbes will have the last word!

However, it was Robert Koch & Louis Pasteur who jointly proposed the ‘germ theory’ of disease in the 1880s .

Plants could be infected with fluid pressed from infected plants that had been filtered through ceramic filters (Pasteur- Chamberland filters that exclude bacteria because the porcelain has pores that measure 0.1 to 1 microns (100 nm to 1 um).

Vaccines: Most Successful Intervention of Medicine

Inactivated: dead whole pathogen
Attenuated: live infectious pathogen manipulated to generate a non-pathogenic state.

Down sides:
not as good an antigen

potential reversal to pathogenic

Subunit vaccines: only part of the pathogen (surface glycoprotein) is used, non-infectious

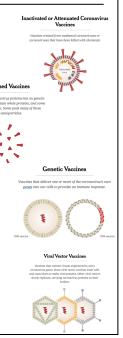
not presenting diverse enough"face" of virus

Genetic vaccines: RNA or DNA encoding viral antigens In viral vector or lipid nanoparticle.

new, limited on longterm risk

Viral vector vaccines: DNA from the virus is Inserted into the capsid of a Harmless virus as delivery vehicle.

little information on longterm risk, limited antigen, risk on innate reaction



There are different ways of manufacturing vaccines.
Vaccines can have risks, but more than half a century of studies have shown that overall the benefits of mass-immunization far outweigh the risks to the individuals.

Practice question: List three types of different anti-viral vaccine with regard to how these are produced and delivered to humans.
Answer: Inactivated, attenuated live, subunit, genetic, viral vector.

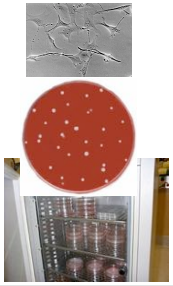
Growing virus to make vaccines:

Primary tissue culture

Primate Kidneys

Hens' eggs

Cell lines

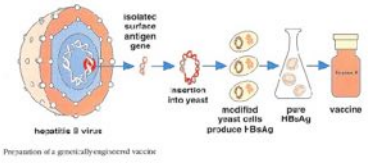


Bioreactor

N-1 at 40 L
Xcellerex XDR-200

The substrate used for making vaccine contributes to certain risks of the vaccine, e.e. Influenza vaccine made in chicken eggs can cause reactions in people who have egg allergies. Animal or human cell lines each carry risks of disease transmission, plant cells are also used, latest technology uses cell-free reactors to synthesize viral RNA (e.g. Pfizer)

Hepatitis B subunit vaccine



First successful anticancer vaccine

Your Hepatitis B vaccine was tested for safety in chimpanzees!

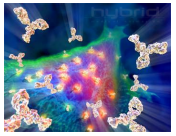
Studies by Alfred Prince and his team at the Vilab in Liberia
have paved the way for a Hepatitis B vaccine.The vaccine is now produced in yeast cells.

Immune defenses

Cellular arm of our immune systems:
- Macrophages
- Natural Killer Cells
- Neutrophiles

Natural killer cells attacking a tumor

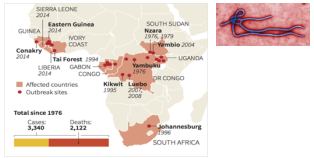
Humoral (soluble molecules)
arm of our immune systems:
- Antibodies (secreted by B-cells)
- Complement



Antibodies homing in
on a tumor cell

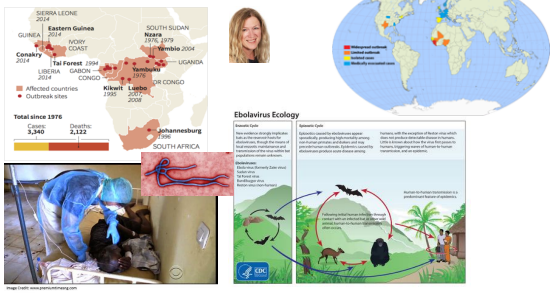
Practice question: List tow components each of the cellular and humoral immune system.
Answer: B-cells and macrophages, antibodies and complement.

Ebola, a filovirus



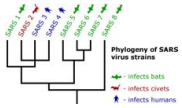
A recently developed vaccine against ebola is a big hope for many.

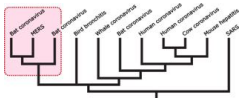
Ebola



My friend and colleague was patient zero for the Ebola Ivory Coast outbreak in 1994.
She infected herself while helping a veterinarian conduct an autopsy of a dead wild chimpanzee.

SARS MERS and other coronaviruses





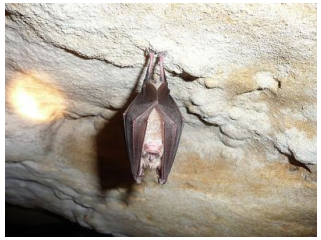
Severe Acute Respiratory Syndrome virus (SARS). News update, July 2013
Since September 2012, a mysterious respiratory infection has been spreading through hospitals in Saudi Arabia and has popped up in nearby countries. MERS (Middle East Respiratory Syndrome) is a coronavirus, like SARS, and has health workers thinking about the devastating effects of that outbreak. So far the new virus, which can cause severe pneumonia and kidney failure, has infected 64 people and killed 38. Some cases are unexplained, but many were contracted from other infected people in the hospital. The ease with which the virus spreads from person to person suggests that it has the potential to trigger an epidemic.

SARS cases 2001 to 2003

The outbreak of SARS corona virus in 2001 to 2003 was controlled in an exemplary way by Chinese Health authorities.

Bats affected by novel diseases themselves

white nose syndrome in little brown bat, USA East Coast



greater horse shoe bat Rhinolophus

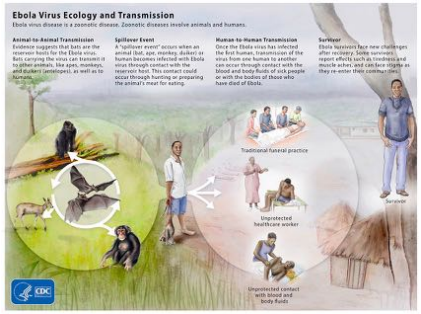
Bats affected by fungal “white nose” disease shed much more corona viruses in their feces!
Davy, C.M.; Donaldson, M.E.; Subudhi, S.; Rapin, N.;Warnecke, L.; Turner, J.M.; Bollinger, T.K.; Kyle, C.J.; Dorville, N.A.S.; Kunkel, E.L.; et al. White-nose syndrome is associated with increased replication of a naturally persisting coronaviruses in bats. Sci. Rep. 2018, 8, 15508.

Ebola (a very scary filovirus)

Virus hides in plain sight and travels widely via fruit bat hosts who do not get sick, but carry plenty of viruses.

Epauletted fruit bat

Hammerhead fruit bat



Epauletted fruit bat (*Epomops franqueti*) and Hammerhead fruit bats (*Hypsignathus monstrosus*) have been found to carry Ebola virus but show no signs of disease!

Monitoring bats and their viruses

A team of researchers from the Wuhan Institute of Virology and the EcoHealth Alliance have trapped bats in caves all over China, like this one in Guangdong, to sample them for coronaviruses.
A research group sent fecal and other bodily samples from bats they trapped in caves to the Wuhan Institute of Virology to search for coronaviruses.
As part of a long-running effort to see what viruses bats harbor, researchers in China examine one temporarily captured in a cave in Guandong. ECOHEALTH ALLIANC

Professor Zhengli Shi from the Wuhan Institute of virology has long studied bat corona viruses. In a paper from 2019. she and her colleagues essentially predicted the current pandemic:
https://www.mdpi.com/1999-4915/11/3/210

Wildlife trade, bush meat (wet) markets


Shenzhen, China


N. Sulawesi, Indonesia


Democratic Republic if Congo

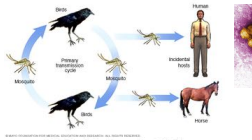

San Diego

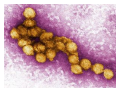

Wuhan, China

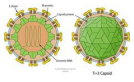
Seattle

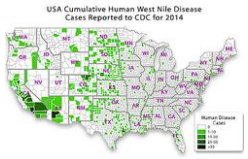
"Wet Markets" where animals caught in the wild are directly sold to customers for food.

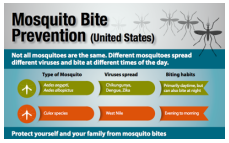
West Nile, a flavivirus





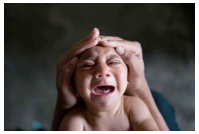


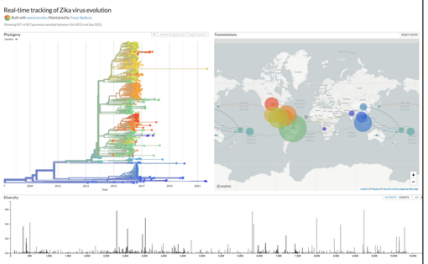




WNV is a bird virus that can cause deadly infections in mammals.

ZIKA, a flavivirus





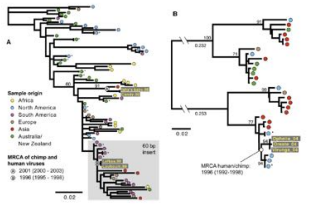
Mosquito borne, causes massive developmental derailments in brains of fetuses…..microcephaly.
Discovered when a sentinel Asian macaque was infected by it in Zika forest Uganda!!!

Anthroponoses, Human to Non-human Animal

Pandemic Human Viruses Cause Decline of Endangered Great Apes

Human respiratory syncytial virus
HRSV

Human metapneumovirus
HMPV



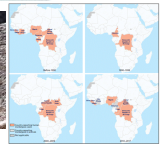
Köngden, S, *et al.* Pandemic human viruses cause decline of endangered great apes. ***Curr Biol.*** 2008 Feb 26;18(4):260-4.

Humans can also pass dangerous viruses to non-human primates, such as these respiratory viruses that caused the death of wild chimpanzees.

Practice question: What do you call a disease in non-human animals caused by a human pathogen?
Answer: An Anthroponosis.

Hunting the last prey…..and its monkeypox….

Congo Rope squirrel (*Funisciurus congicus*)



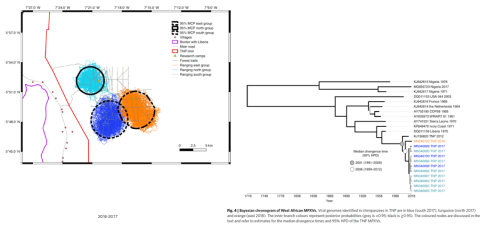
U.S. Monkeypox Cases by State, 2003

State	Confirmed Cases	Probable Cases
Illinois	9	1
Indiana	7	3
Kansas	1	0
Missouri	2	0
Wisconsin	18	6
Total	37	10

African rope squirrels carry monkey pox virus. Kids hunting them have been infected. How was monkeypox virus introduced into the U.S.? Investigators determined that a shipment of animals from Ghana, imported to Texas on April 9, 2003, introduced monkeypox virus from the West African genetic group (clade) into the United States. The shipment contained approximately 800 small mammals representing nine different species, including six genera of African rodents. These rodents included rope squirrels (*Funiscuirus sp.*), tree squirrels (*Heliosciurus sp.*), African giant pouched rats (*Cricetomys sp.*), brush-tailed porcupines (*Atherurus sp.*), dormice (*Graphiurus sp.*), and striped mice (*Lemniscomys sp.*). CDC laboratory testing using PCR and virus isolation demonstrated that two African giant pouched rats, nine dormice, and three rope squirrels were infected with monkeypox virus. After importation into the United States some of the infected animals were housed in close proximity to prairie dogs at the facilities of an Illinois animal vendor. These prairie dogs were sold as pets prior to their developing signs of infection.

Monkey Pox in Wild chimpanzees

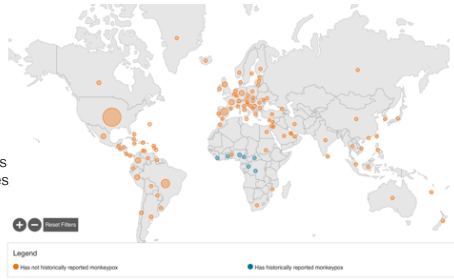
Great ape sentinel system for zoonoses?



Patrono, L.V., Pléh, K., Samuni, L. *et al.* Monkeypox virus emergence in wild chimpanzees reveals distinct clinical outcomes and viral diversity. ***Nat Microbiol*** 5, 955–965 (2020).

Lates news on monkeypox….

82,021 cases
<100 fatalities

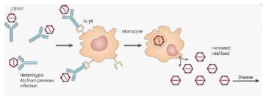


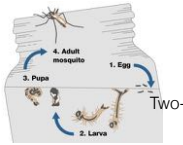
CDC Dec 2022

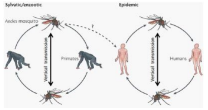
African rope squirrels carry monkey pox virus. Kids hunting them have been infected. How was monkeypox virus introduced into the U.S.? Investigators determined that a shipment of animals from Ghana, imported to Texas on April 9, 2003, introduced monkeypox virus from the West African genetic group (clade) into the United States. The shipment contained approximately 800 small mammals representing nine different species, including six genera of African rodents. These rodents included rope squirrels (*Funiscuirus sp.*), tree squirrels (*Heliosciurus sp.*), African giant pouched rats (*Cricetomys sp.*), brush-tailed porcupines (*Atherurus sp.*), dormice (*Graphiurus sp.*), and striped mice (*Lemniscomys sp.*). CDC laboratory testing using PCR and virus isolation demonstrated that two African giant pouched rats, nine dormice, and three rope squirrels were infected with monkeypox virus. After importation into the United States some of the infected animals were housed in close proximity to prairie dogs at the facilities of an Illinois animal vendor. These prairie dogs were sold as pets prior to their developing signs of infection.

Dengue, another flavivirus

Hemorrhagic Dengue: second round of infection becomes deadly!







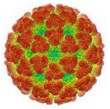
Two-day life cycle!

Whitehead SS, Blaney JE, Durbin AP, Murphy BR2007Prospects for a dengue virus vaccine. Nat Rev Microbiol 5518528

Female *Aedes aegypti* commonly lay eggs on the inner walls of artificial containers. When the containers fill with water, mosquito larvae hatch from the eggs. After developing through four larval stages, the larvae metamorphose into pupas. Like the larval stage, the pupal stage is also aquatic. After two days, a fully developed adult mosquito forms and breaks through the skin of the pupa. The adult mosquito can fly and has a terrestrial habitat.

Chikungunya, a togavirus

Another virus from forest primates of Africa



Which is the better approach to conservation?

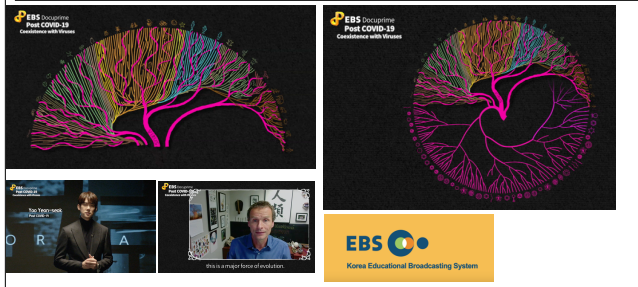
Stop this !
Shock with
the negative?

or

Preserve this !
Elicit
Sympathy and
Concern?

photo Karl Amman

Our Viral Natures:



Educational Broadcasting Service, South Korea, Documentary on Post Covid, December 2021.

Recent documentary by South Korean Educational Broadcasting System.
I was asked to discuss the importance of viruses to the process of evolution.

Summary

Humans have increasingly encroached on wild ecosystems.

This has provided many opportunities for cross-species infections.

Colonial history, mass migration and urbanization, combined with biomedical interventions have provided great opportunities for emerging diseases.

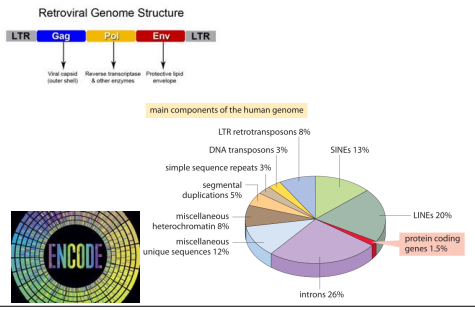
Birds and bats, carry many infectious agents and share these with humans and other species.

Agricultural practices facilitate the evolution of novel pathogens.

Climate change is changing the range of many vector borne diseases.

Conservation and prevention of emerging diseases care many goals (Ecohealth).

Molecular Parasites in your genome: rubbish or opportunity?



More about viruses as active, creative agents in evolution in a later lecture.

Summary

Humans have become a planet-altering force.

Human contact with wildlife is ever more invasive: main facilitator of emerging diseases.

Microbes can become pathogenic after crossing into novel species: emerging disease!

Evolutionary changes in human cell surface molecules, shared by several animal species.

Wild animals can be affected by novel diseases,
increasing the chance of them spreading pathogens to humans.

We have to stop the uncontrolled pillaging of wild animals for human consumption.

We have to rethink how we use animals in the context of emerging diseases: spill over infections and antibiotic resistance in farm animals.

We can only hope that human prosocial tendencies will allow us to take better care of each other and the life-support systems of our planet.

Summary

Humans have become a planet-altering force.

Human contact with wildlife is ever more invasive: it is the main facilitator of emerging diseases.

Microbes inhabit all animals and can become pathogenic after crossing into novel species: emerging disease!

Wild animals can also be affected by novel diseases and this can increase the chance of them spreading pathogens to humans.

We have to stop the uncontrolled pillaging of wild animals for human consumption.

We have to rethink how we use animals in the context of emerging diseases: spill over infections and antibiotic resistance in farm animals.