Mosquitoes and other vectors you should know about.

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Public Health Pests

- Harm humans
  - Biting or stinging
- Annoy or cause discomfort
- Parasites
- Transmit disease agents
  - Pathogens affecting people

Direct effect on People

- Pests that bite, sting, parasitize or annoy a person, can affect their health

- Arthropods serve as vectors, meaning they give a pathogen to a susceptible host

- The pathogens can then result in disease

Direct effect on People

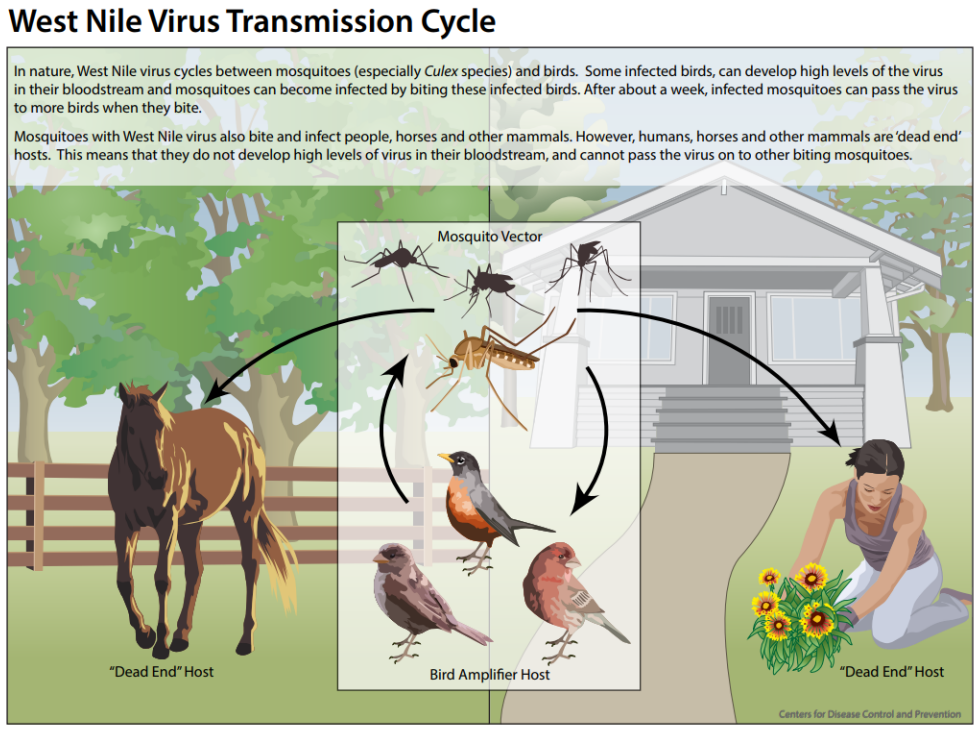
Defensive behaviors of some arthropods can impact humans

- Stinging by bees, wasps, ants and scorpions
- Biting by spiders and centipedes
- Blistering by beetles, caterpillars and millipedes

Synanthropic behavior

- Makes other animals become public health pests
- They live in close association to people
- Animal is dependent on this association with humans
  - Ex. House flies, cockroaches, rodents

Indirect effect on People



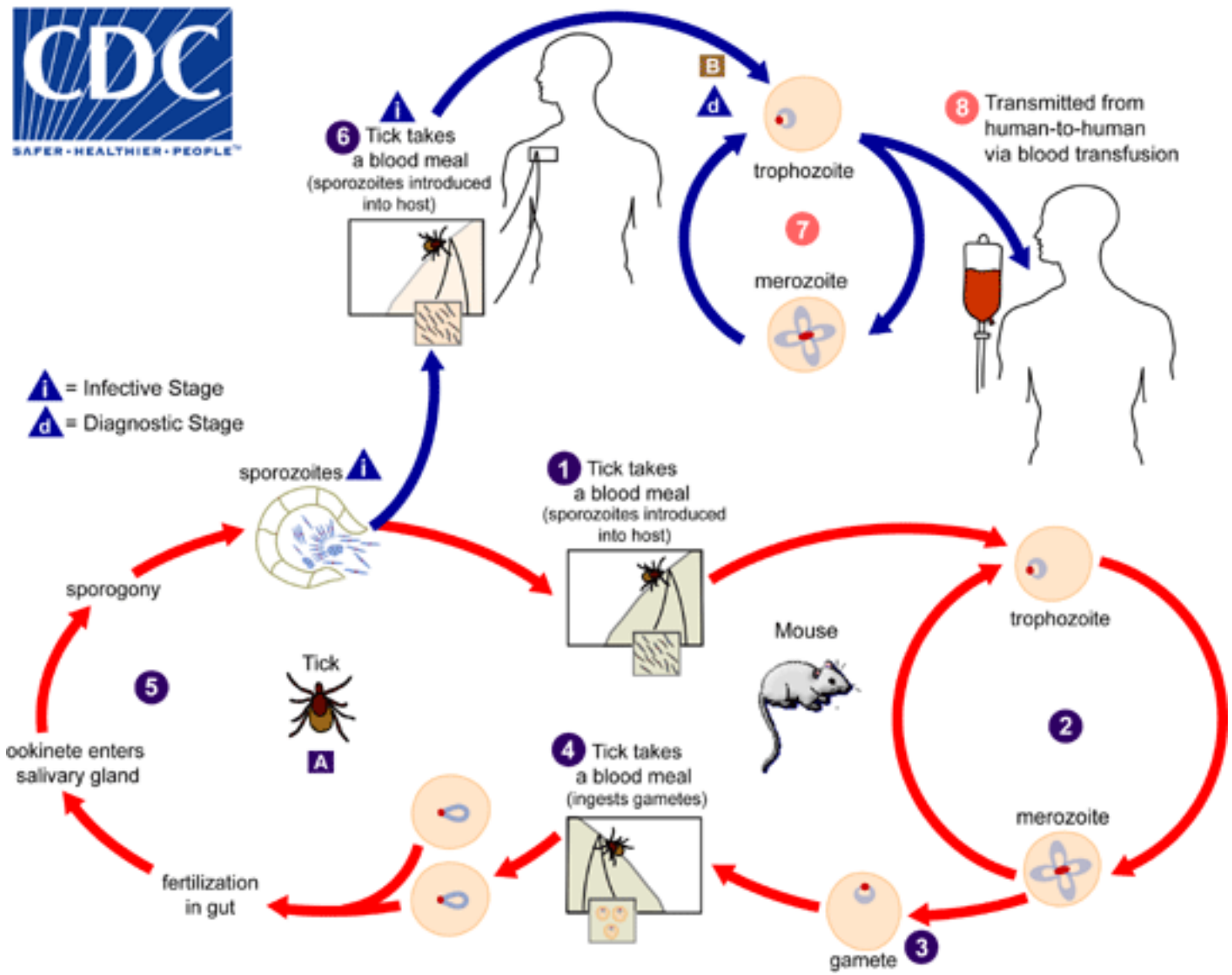
- Pests indirectly effects humans by serving as reservoirs and/or vector of parasites or pathogens

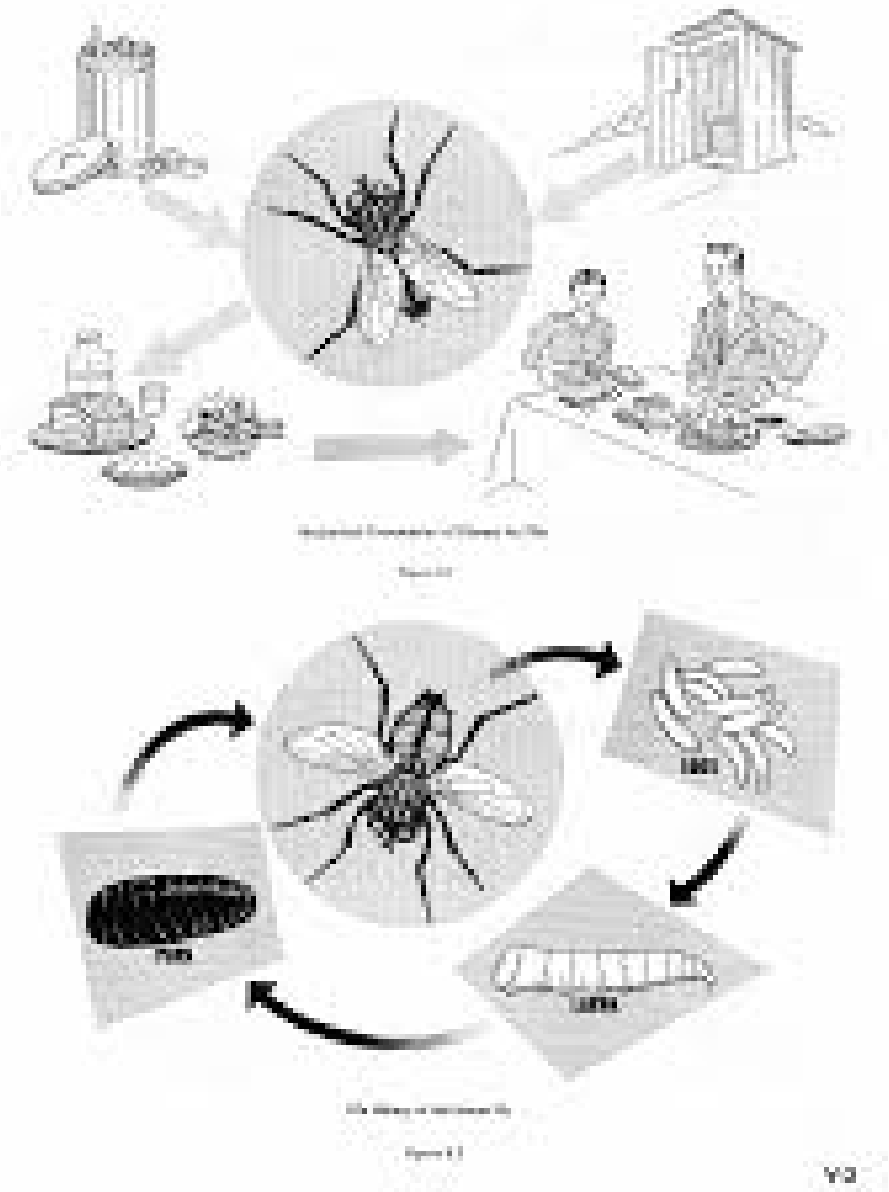
- A reservoir is an infected vertebrate and/or arthropod (such as lice or fleas) that maintains a pathogen or parasite responsible for a disease that is thereby transmitted to another animal and causes disease

- A vector is a living transporter and transmitter of a causative agent of disease

Indirect effect on People

- Disease agents can be transmitted by a vector <u>biologically</u> or <u>mechanically</u>
- ***Biological*** transmission occurs when the vector uptakes the agent, usually through a blood meal, replicates and/or develops it, and then regurgitates the pathogen onto or into a susceptible host



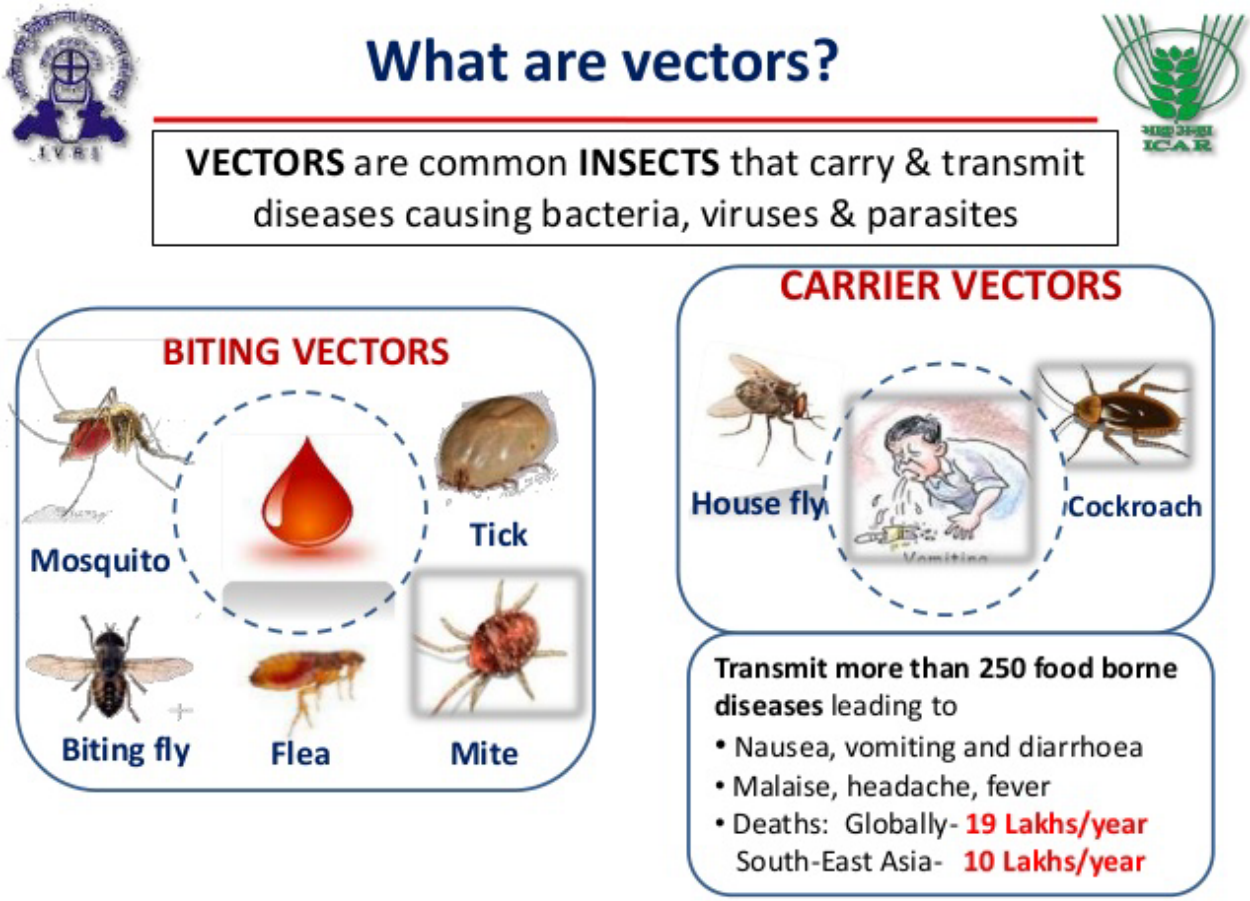


Indirect effect on People

- ***Mechanical*** transmission occurs when the pest is simply just a vehicle to transport the disease-causing agent from the reservoir to the susceptible host.

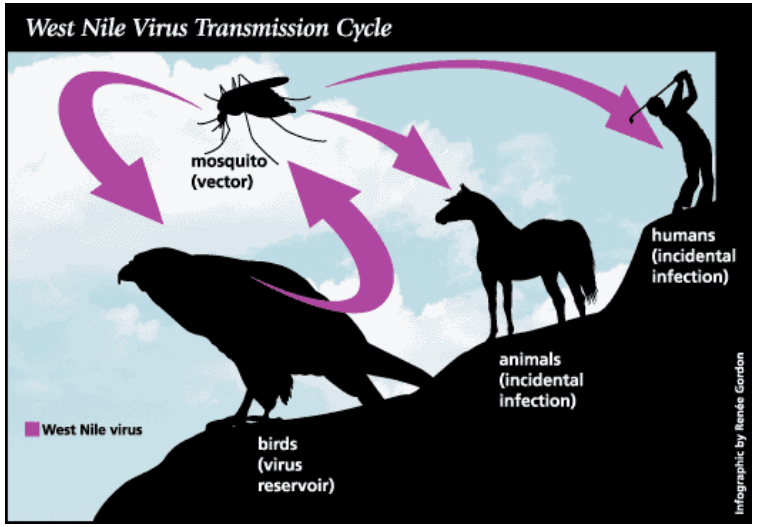
Indirect effect on People

- Vector-borne diseases are causal agents (viruses, bacteria, protozoans or parasites) carried by living organisms.
  - Humans, rats and other animals can serve as vectors in addition to arthropods
- The term arthropod-borne disease is used to signify transmission by an insect or other arthropod.



Disease Transmission: All 4 MUST be Present for Disease to Occur

- Host
  - The affected organism
- Disease Agent
  - Pathogen
    - Causal agent of disease
    - Can be transmitted by vector
- Vector
  - Arthropod that can carry or transmit the pathogen
  - Biological or Mechanical
- Reservoirs
  - Animal hosting the pathogen and serving as the source for a vector
- Susceptible hosts
  - Human or animal lacking resistance to pathogen



Reservoirs

People

Parasites that cause dengue, malaria, Zika, chikungunya

Other Vertebrates: Mammals, birds

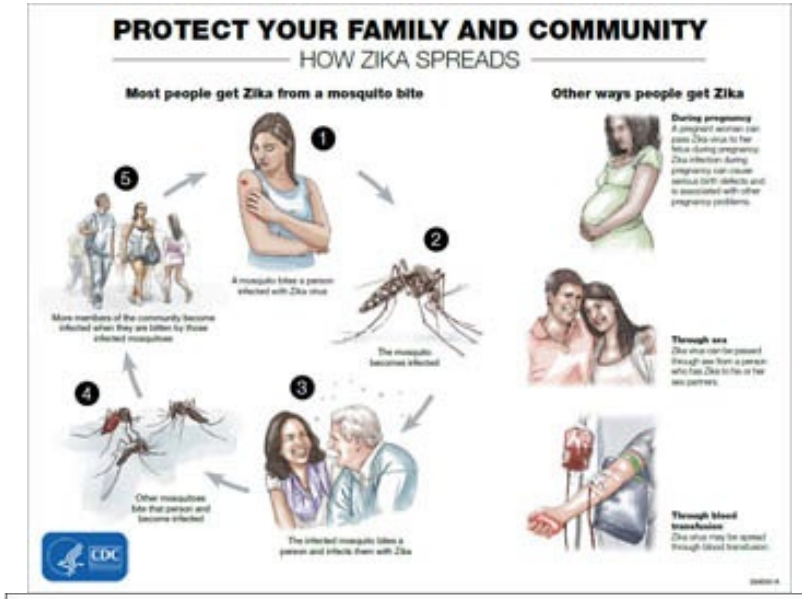
Plague, tularemia, murine typhus, WNV, SLE, WEE, EEE, La Crosse

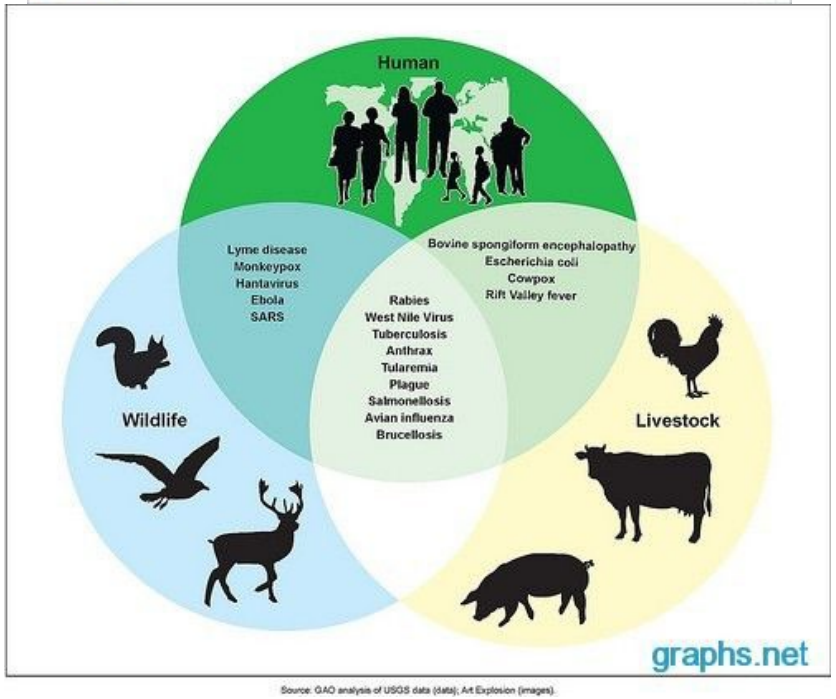
Arthropods

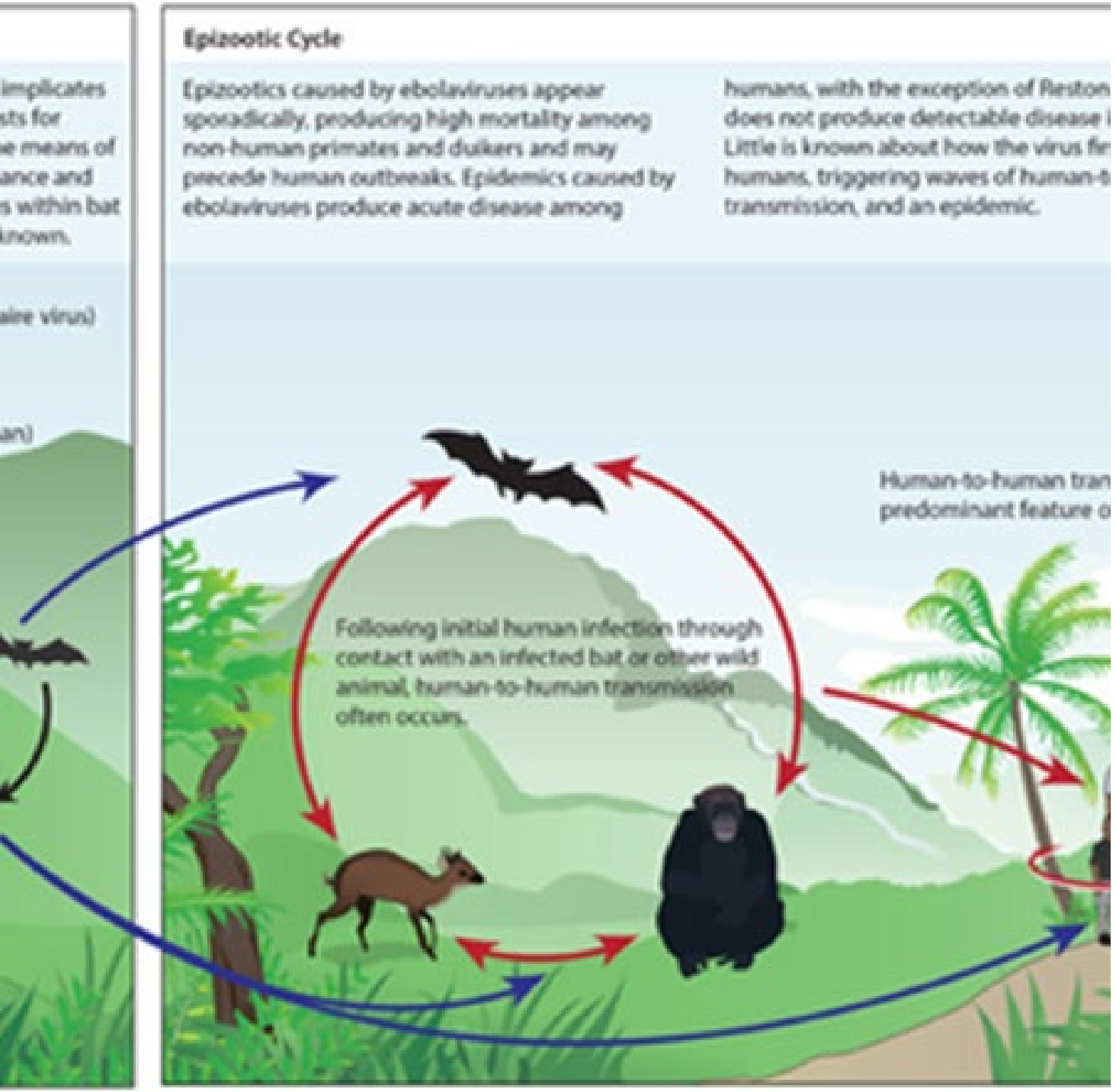
Plague, Spotted fever, tickborne relapsing fever, scrub typhus

Disease Transmission

- Arthropod-borne diseases are classified as either
  - Anthroponsis
    - Primary reservoir and susceptible hosts are humans
      - Malaria, dengue, Zika
  - Zoonosis
    - Diseases of animals that can be transmitted to humans – occasionally
      - Other animals are reservoirs and susceptible hosts of the pathogen
        - WNV, rabies, plague, tularemia, chagas







Disease Transmission

- Arthropod-borne diseases tend to occur and cycle at low levels between disease outbreaks
- Diseases that continuously cycles in epicenters are said to be endemic (in the case of anthroponoses) or enzootic (in the case of zoonoses)
- Epidemiology is the study and control of human-affecting diseases
- Epidemic is an outbreak of a disease in a human population
- Epizootiology is the study of diseases affecting other animals
- Epizootic is an outbreak of a disease in animals – typically preceding epidemics when arthropod-borne

Prevent and Control Arthropod-borne disease outbreaks

- Must know the location of the epicenters for a given disease
- Must know the animals, people or other vertebrates that serve as reservoirs and susceptible hosts
- Must know the arthropod vectors for the pathogen
- Must know other animals and/or arthropods that might become involved if disease spreads to humans or other animals
- Must know the conditions favoring the spread of a disease

Managing Public Health Pests

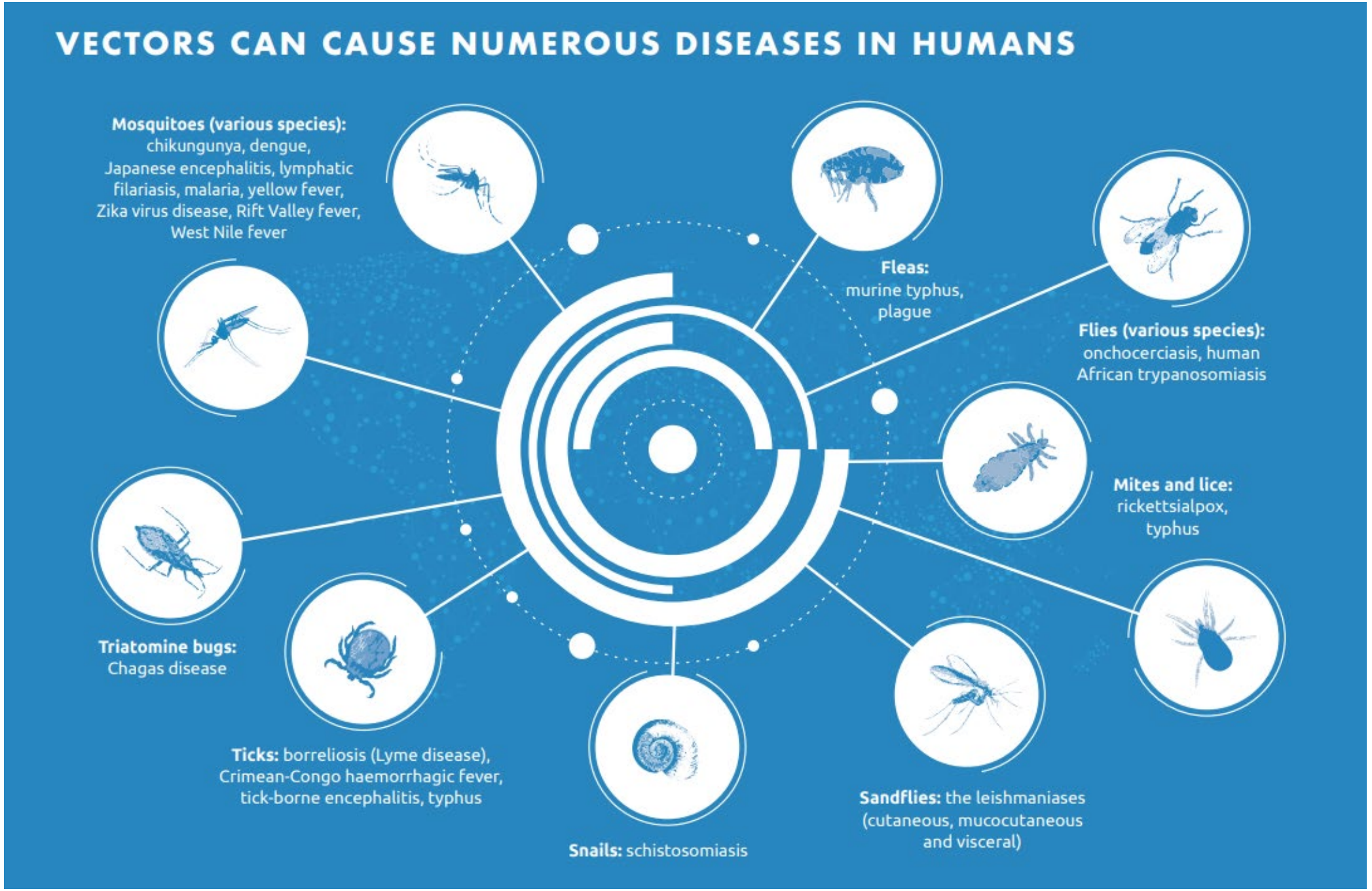
Principles of IPM SHOULD be followed to prevent and control pest problems

5 principal ingredients:

1. Knowledge
   - Know the pest's biology & epidemiology of the disease
2. Survey and Monitor
   - To detect and assess the status of a pest or disease
3. Multi-tactic prevention & control
   - Include compatible tactics proven to be effective against the pest or disease
4. Program evaluation
   - To ensure the best methods are being used
5. Public education
   - Create awareness, understanding and support

IPM & Public Health Tactics

- Using 2 or more will effectively control a pest
- Sanitation
  - Removing a pest's source of food, water and shelter; dispose of trash
- Culture control
  - Changing some physical factors in the environment; draining standing water
- Biological control
  - Using a pest's natural enemies; mosquito fish
- Mechanical control
  - Using special equipment to remove or exclude a pests; traps
- Personal protection
  - Clothing and/or repellents, change activity patters to avoid contact
- Chemical suppression
  - Use pesticides
  - Follow the label



Risk:
80% of the world's population is at risk for one or more vector-borne disease

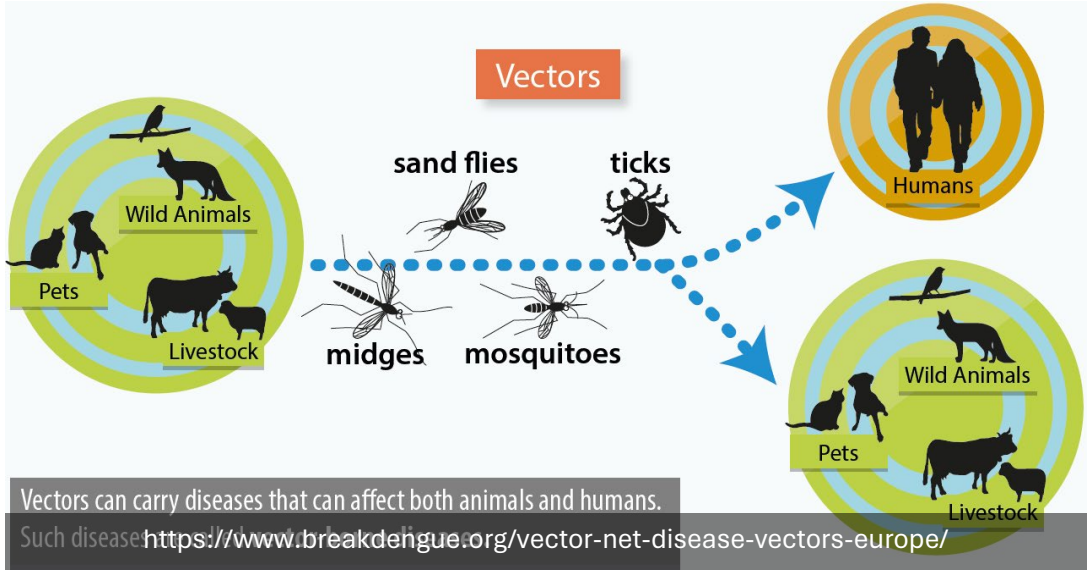
Burden:
17% of the global burden of communicable diseases is due to vector-borne diseases

Mortality:
Over 700,000 deaths are caused by vector-borne diseases annually

http://www.who.int/vector-control/publications/WHO_HTM_GVCR_2017.01/en/

Vector-borne diseases

Diseases caused by parasites, viruses and bacteria that are transmitted to humans by mosquitoes, sandflies, triatomine bugs, blackflies, ticks, tsetse flies, mites, snails and lice.

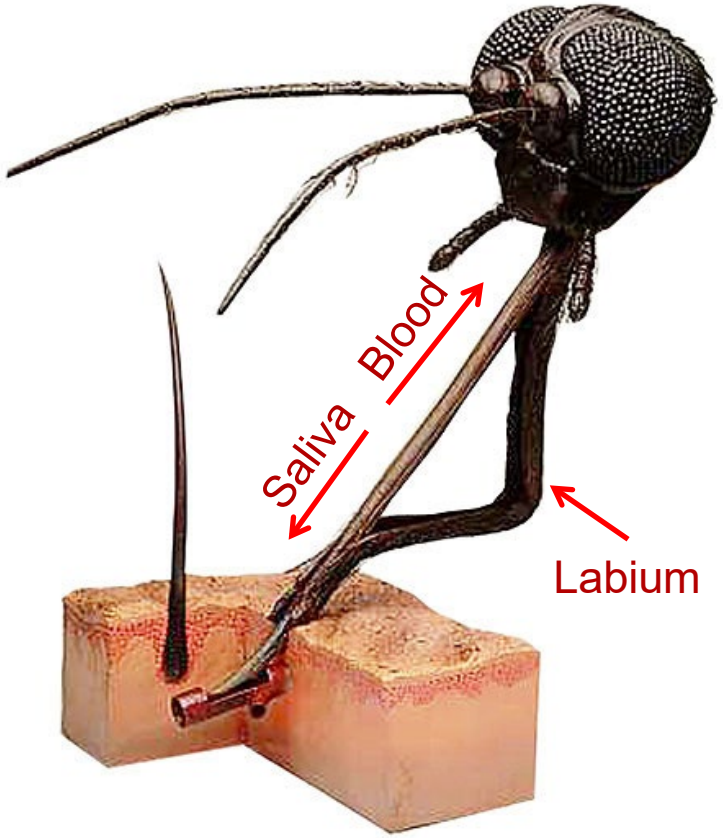


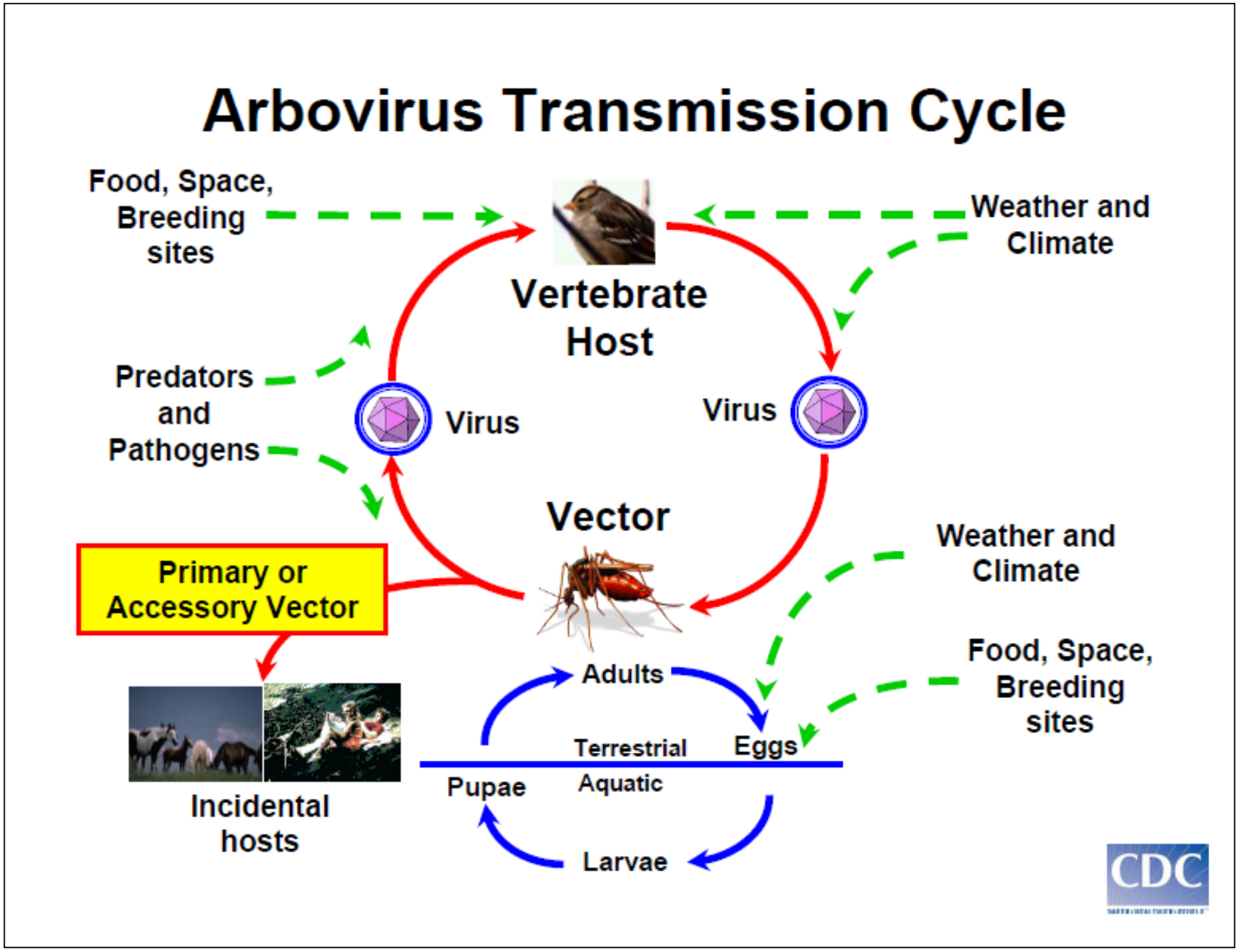
Mosquitoes as Disease Vectors

Mosquitoes use blood for egg production

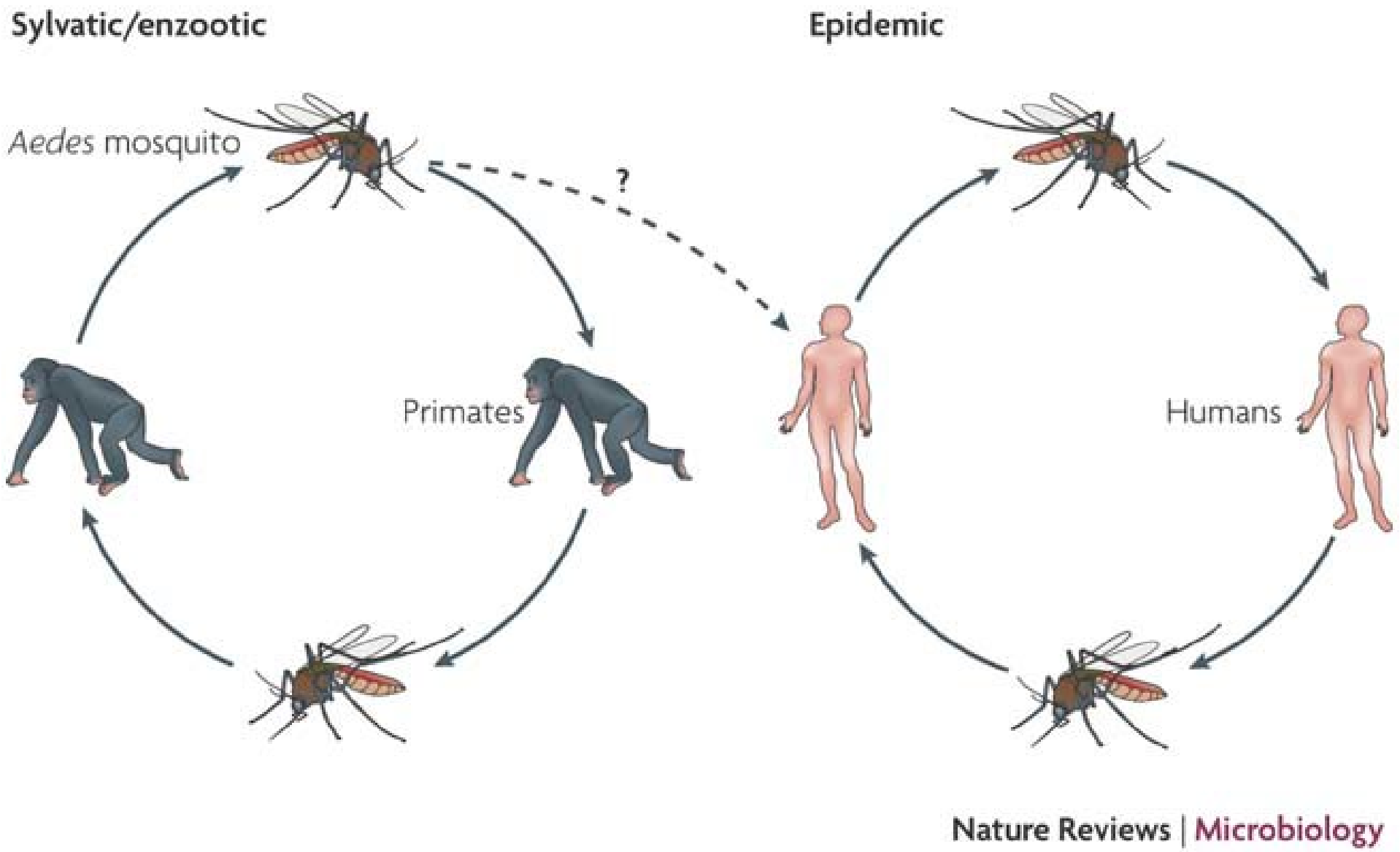
Mosquito saliva injected during blood feeding contains:

- Anticoagulants
- Anesthetic
- Vasodilators
- Immunomodulators
- Pathogens



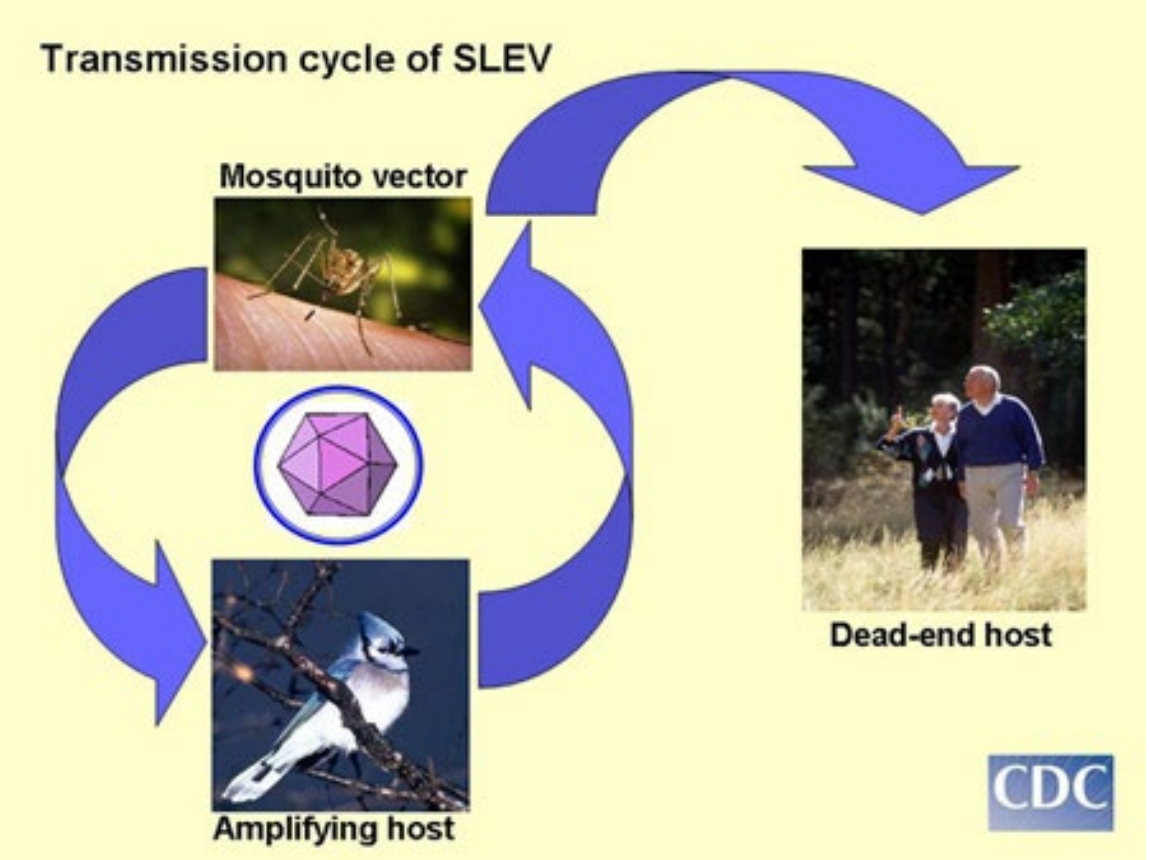


Examples:
WNV
SLEV
EEEV
WEEV



Examples:
ZIKV
CHIKV
DENV
YFV

St. Louis Encephalitis

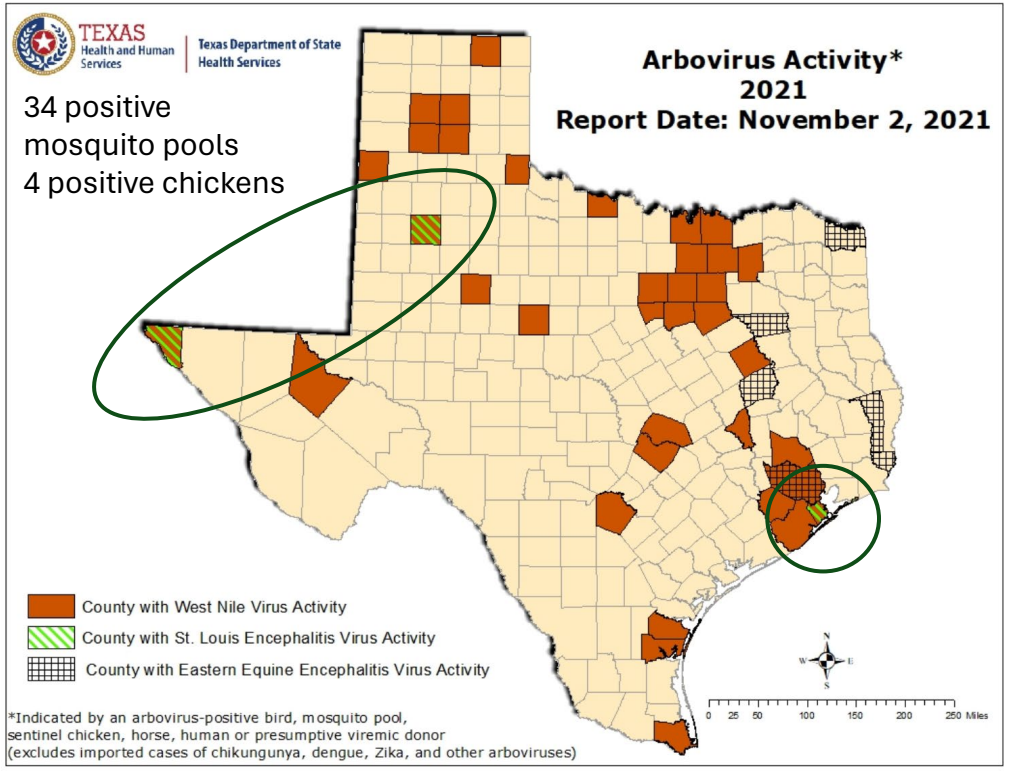


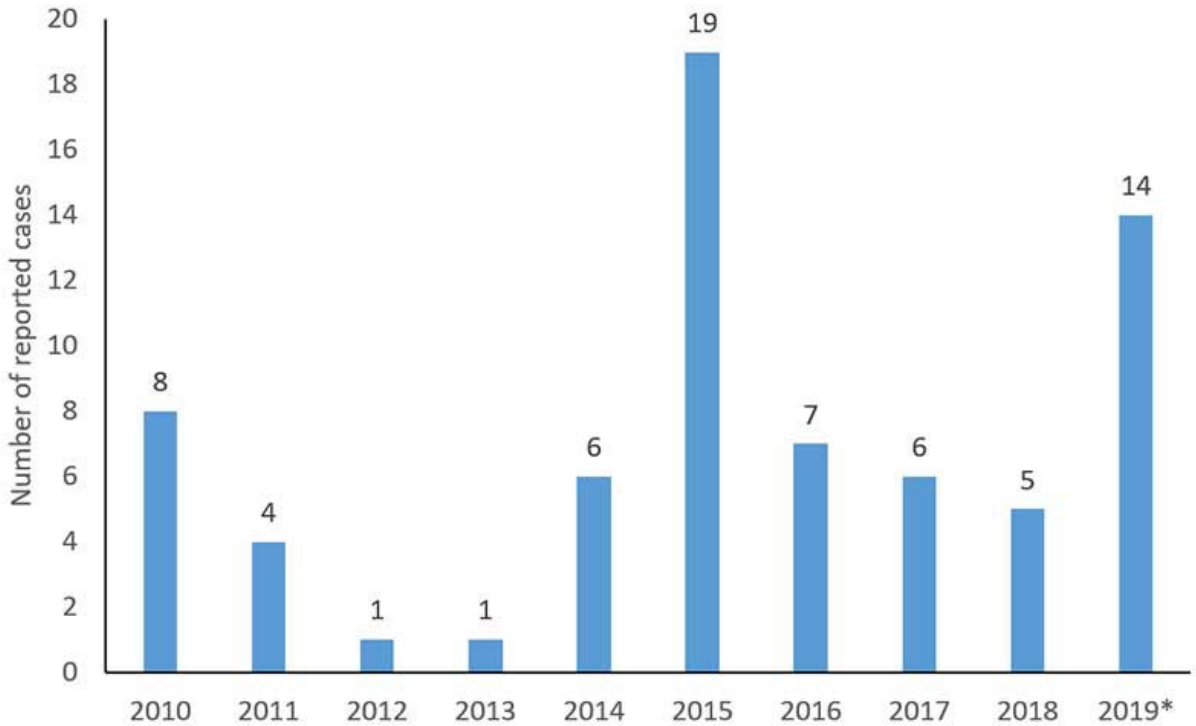
- Most infections are silent
- Range from mild to meningitis or encephalitis
  - Severity risk increases with age
    - Serious symptoms are rare - Some cases develop signs of central nervous system infections, including stiff neck, confusion, disorientation, dizziness, tremors and unsteadiness. Coma can develop in severe cases.
- Cases occur primarily in late summer or early fall
- In southern states, can be year round
- The principal vectors:
  - *C. pipiens* and *C. quinquefasciatus* in the east
  - *C. nigripalpus* in Florida
  - *C. tarsalis* and members of the *C. pipiens* complex in western states

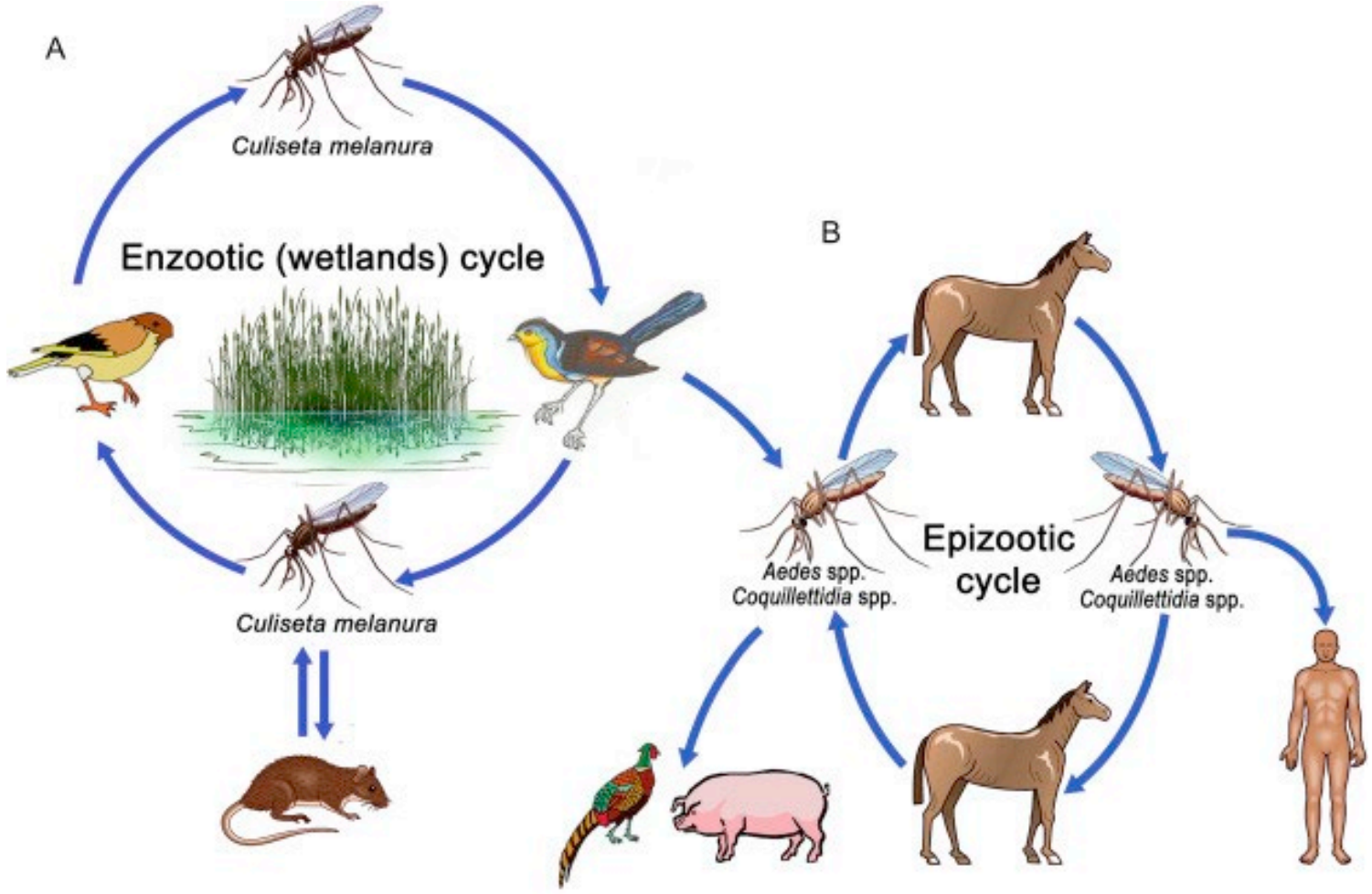
Saint Louis Encephalitis Virus Neuroinvasive Cases Reported to CDC 2010-2019

SLE	2021	2020	2019	2018	2017	2016	2015	2014	2013	2012	2011	2010
Human	0	3	0	0	0	0	0	4	1	3	0	3
+ Mosquito Pools	34	16	9	2	0	1	4	7				
Chicken	4	1	0	0	1	2	1	0				

Figure 1. Texas Counties Reporting Arbovirus Activity, Week 43







- Eastern equine encephalitis virus (EEEV) is maintained in a cycle between *Culiseta melanura* mosquitoes and avian hosts in freshwater hardwood swamps.

- *Cs. melanura* is not considered to be an important vector of EEEV to humans because it feeds almost exclusively on birds.
- Transmission to humans requires mosquito species capable of creating a “bridge” between infected birds and uninfected mammals such as some *Aedes*, *Coquillettidia*, species.

Eastern Equine Encephalitis Virus Symptoms

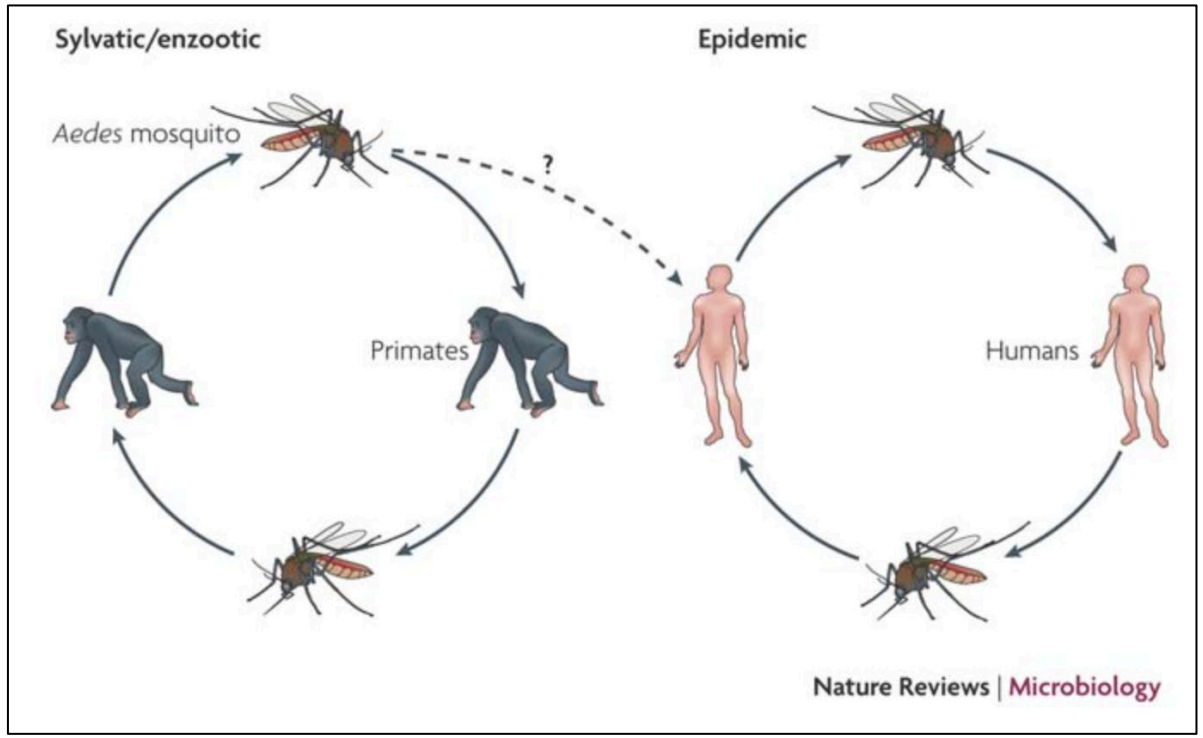
Symptoms in most people – Approximately 90% of people who get infected will develop symptoms. EEEV infection can result in one of two types of illness, systemic or encephalitic, depending on the age of the person and other host factors.

High mortality rate – Approximately 33% of people who get infected will die from the disease. Of those who recover, many are left with disabling and progressive mental and physical sequelae, which can range from minimal brain dysfunction to severe intellectual impairment, personality disorders, seizures, paralysis, and cranial nerve dysfunction. Many patients with severe sequelae die within a few years.

No symptoms in some people – It is possible that some people who become infected with EEEV will not develop any symptoms.

Dengue

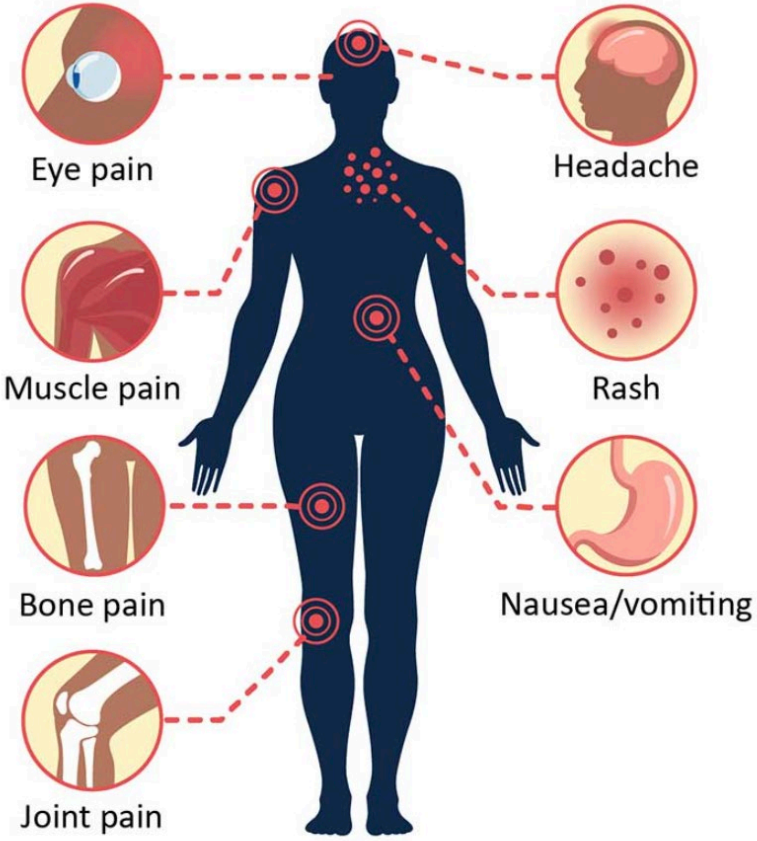
- Vector: *Aedes aegypti* and *Ae.albopictus*
- Pathogen: Dengue virus (DENV)
  - Flavivirus
- Sylvatic cycle originates in primates
- Urban Cycle: Mosquito-Human
- EIP in mosquito: 8-12 days
- IIP in humans: 3-14 days



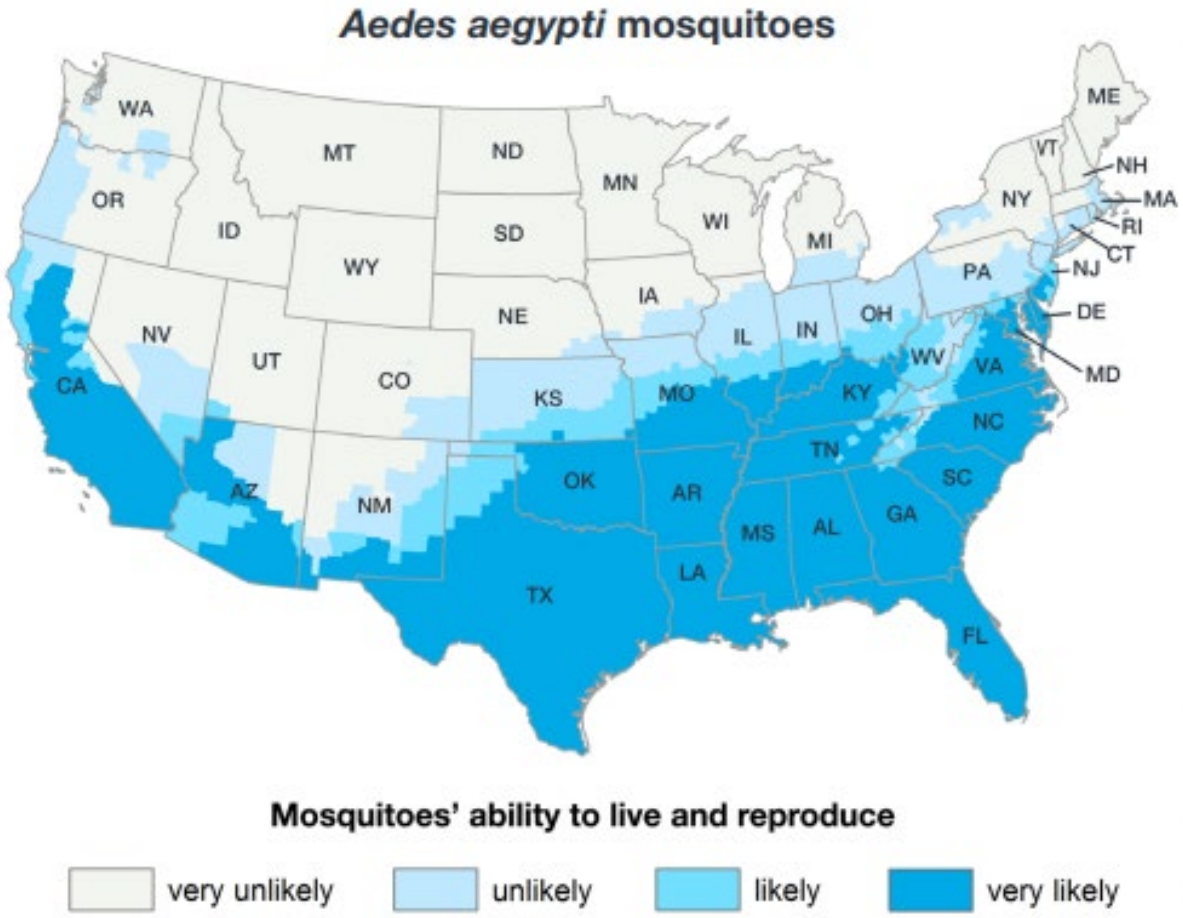
Chan, M., & Johansson, M. A. (2012). The incubation periods of Dengue viruses. *PloS one*, *7*(11), e50972. https://doi.org/10.1371/journal.pone.0050972
https://www.cdc.gov/dengue/index.html

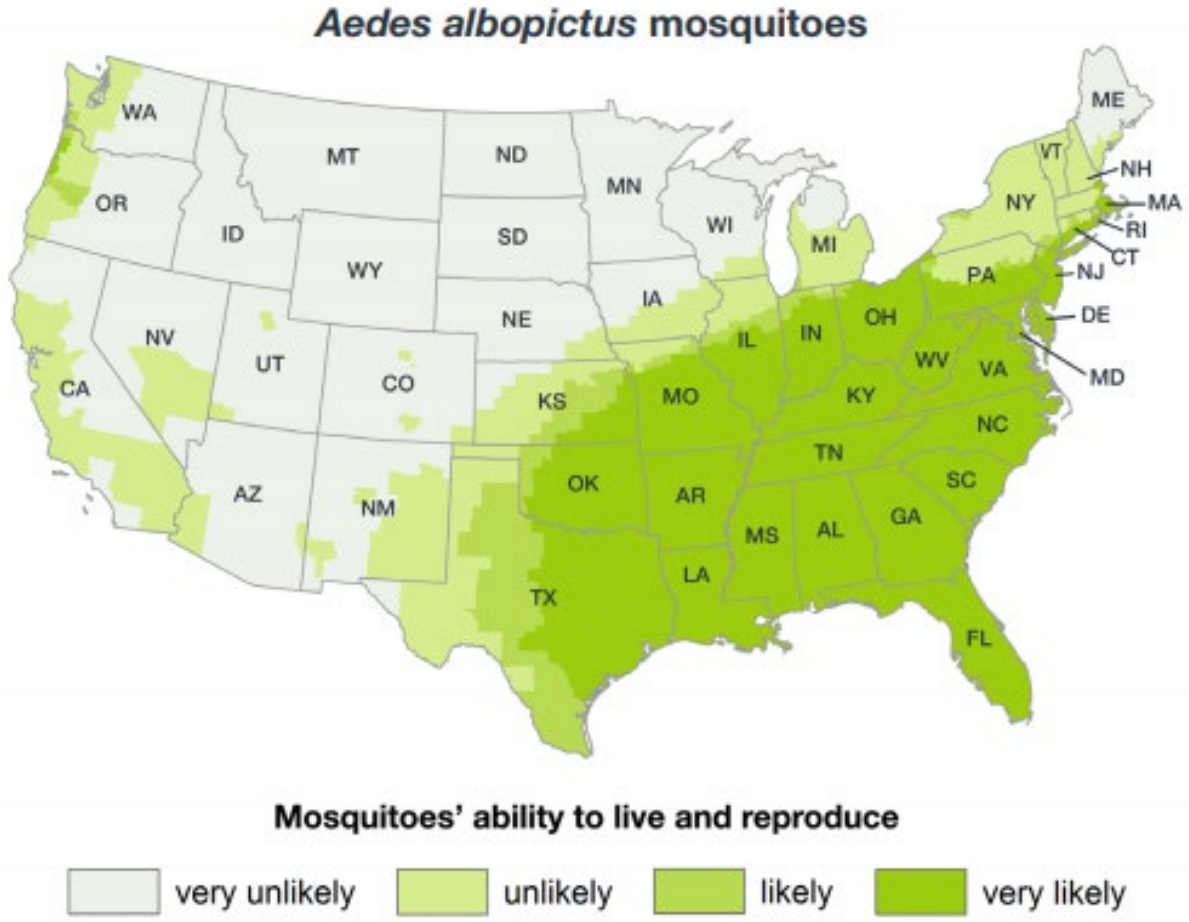
Dengue Epidemiology

- Most common: 400 millions infected annually; 22,000 deaths
- Causes flu-like illness, and occasionally develops into dengue hemorrhagic fever (DHF), a potentially lethal complication
- Four (4) serotypes
  - Infection with one gives lifetime immunity
  - Co-infection or re-infection with other types increases risk for severe complications
  - DHF and DSS, multi-organ failure
- Vaccination efforts are ongoing, but early detection and proper care of severe cases lowers mortality to below 1%
  - DHF = 2-5% treated, 50% untreated



Approximate Distribution of Aedes Species



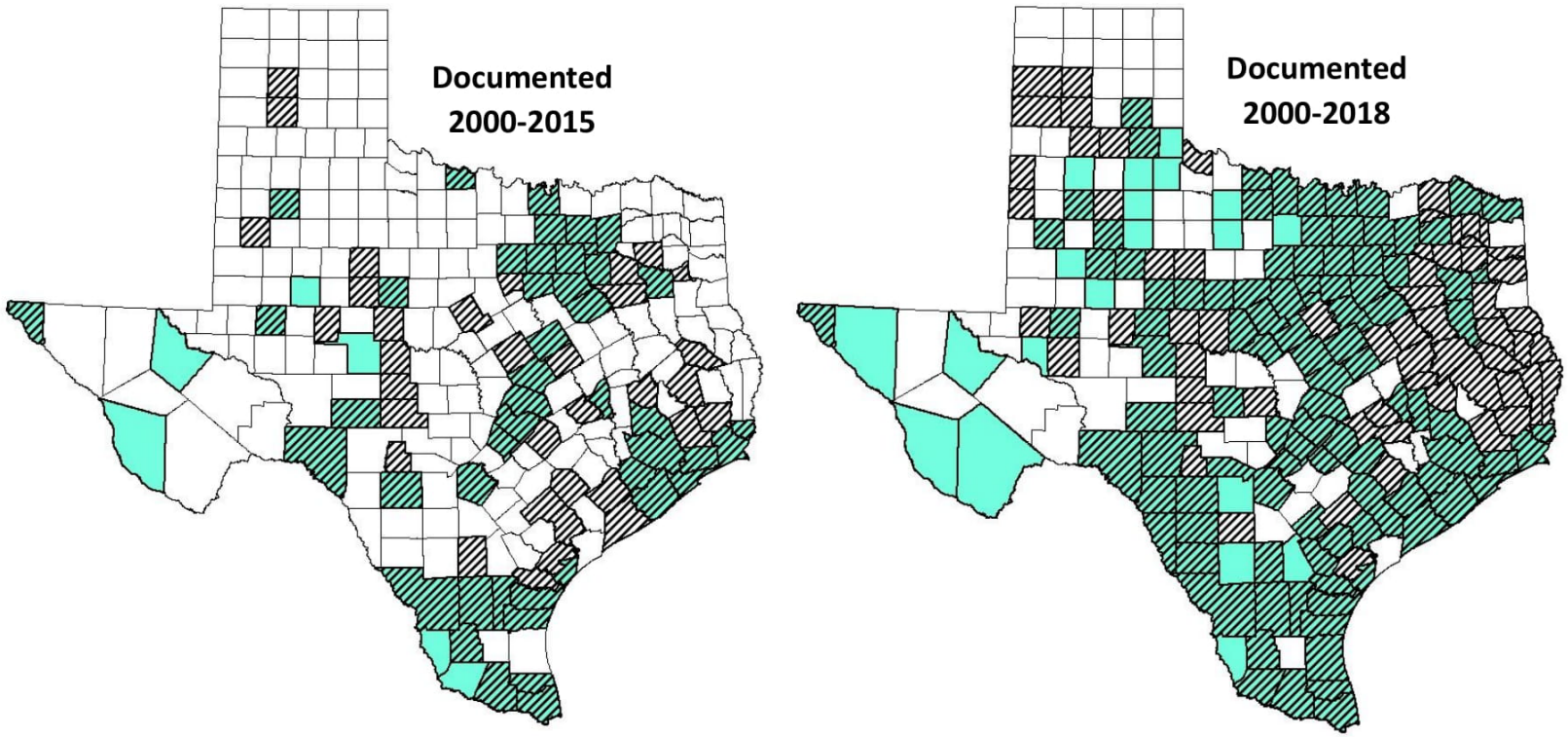


https://www.cdc.gov/zika/vector/range.html

TEXAS
Health and Human Services

Texas Department of State Health Services

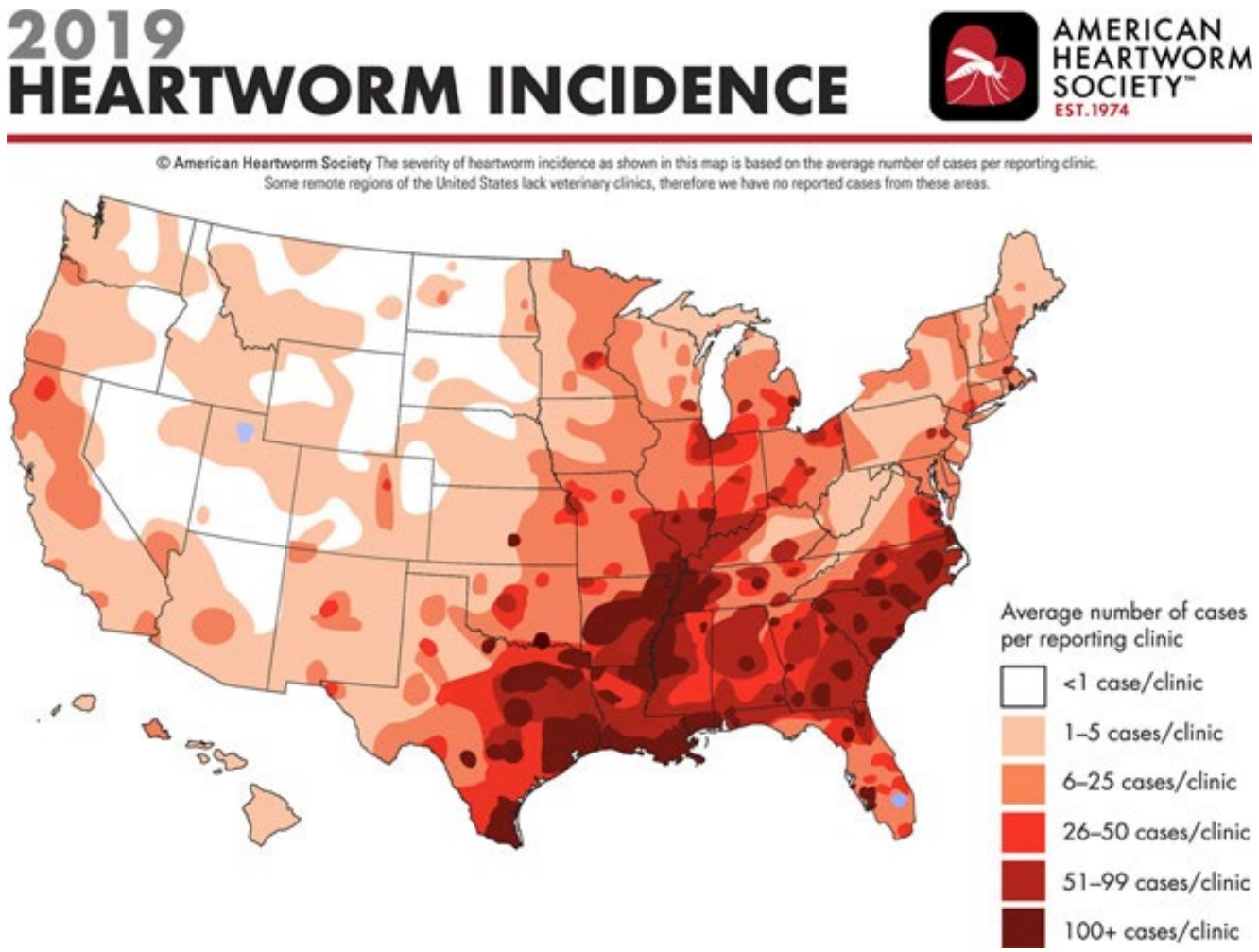
Documented presence of *Stegomyia* species in Texas*



*Based on mosquito collections submitted to the Texas DSHS Arbovirus Laboratory from local jurisdictions, data records obtained from the Centers for Disease Control and Prevention, and documentation provided by Texas entomologists. Counties with newly documented presence of *Aedes aegypti* and/or *Ae. albopictus* during 2016-2018 were added based on collaborative projects between DSHS, Texas AgriLife Extension, and University partners. Updated 2.4.19.

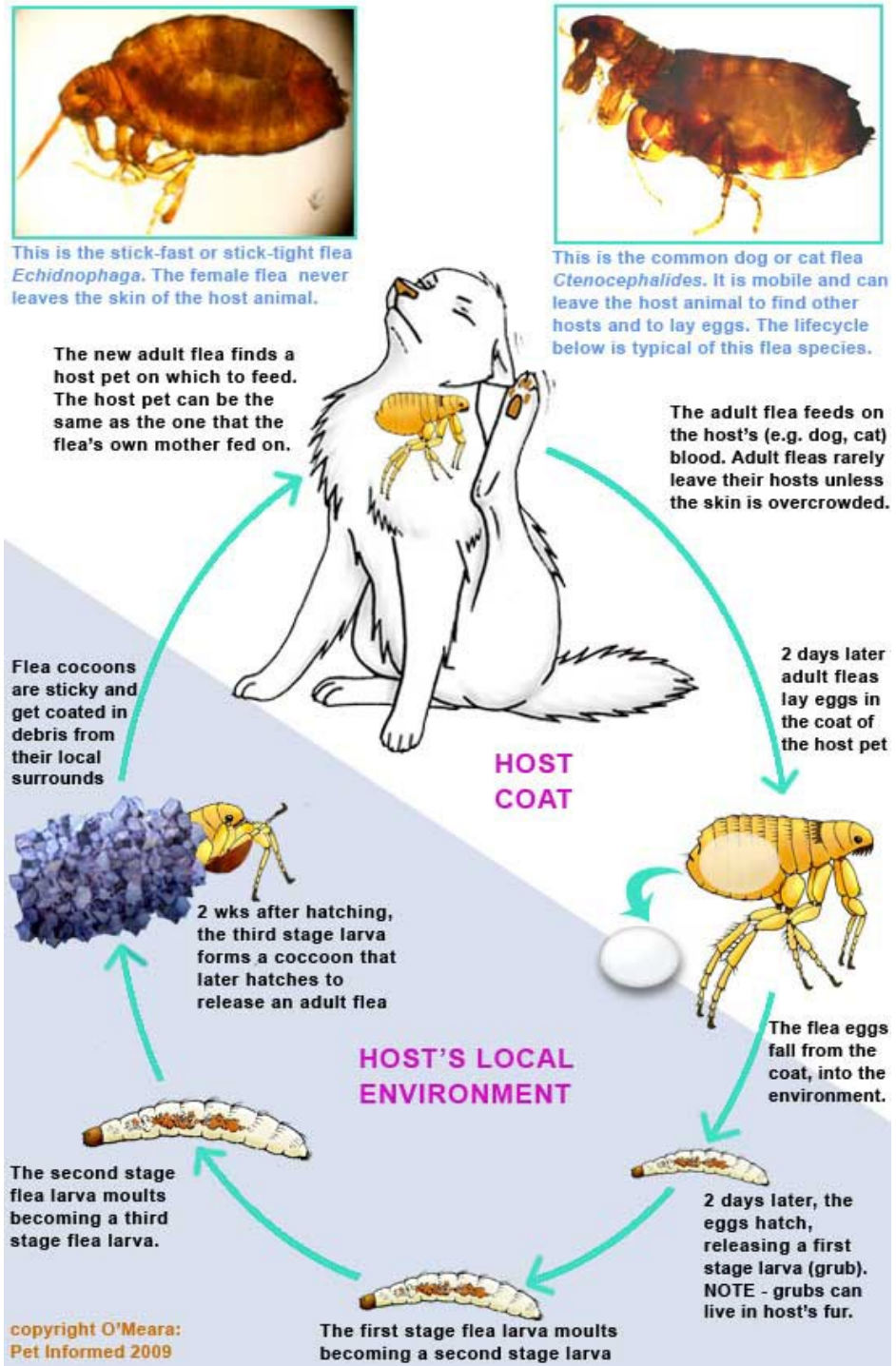
Dog Heartworm

- Vector: *Culex quinquefasciatus* (also *Aedes, Anopheles, Psorophora,* and other *Culex* species)
- Pathogen: *Dirofilaria immitis*
- A parasitic **round worm**
- Most prevalent in Gulf Coast States
- Prophylactic medication available for pets



Order Siphonaptera - Fleas

- Named for their mouthparts
  - Lack of wings
  - Dorsally flattened
  - Small, parasitic
- More than 2,200 species worldwide
  - Live on mammals and birds
- 33 species in Texas
  - Cat flea – *Ctenocephalides felis*
  - Human flea – *Pulex irritans*
  - Oriental rat flea – *Xenopsylla cheopis*
- Impact
  - Abundance
  - Irritating bites
  - Ability to transmit diseases
- Vectors of
  - Plaque
  - Murine typhus
  - Tapeworms – ingested



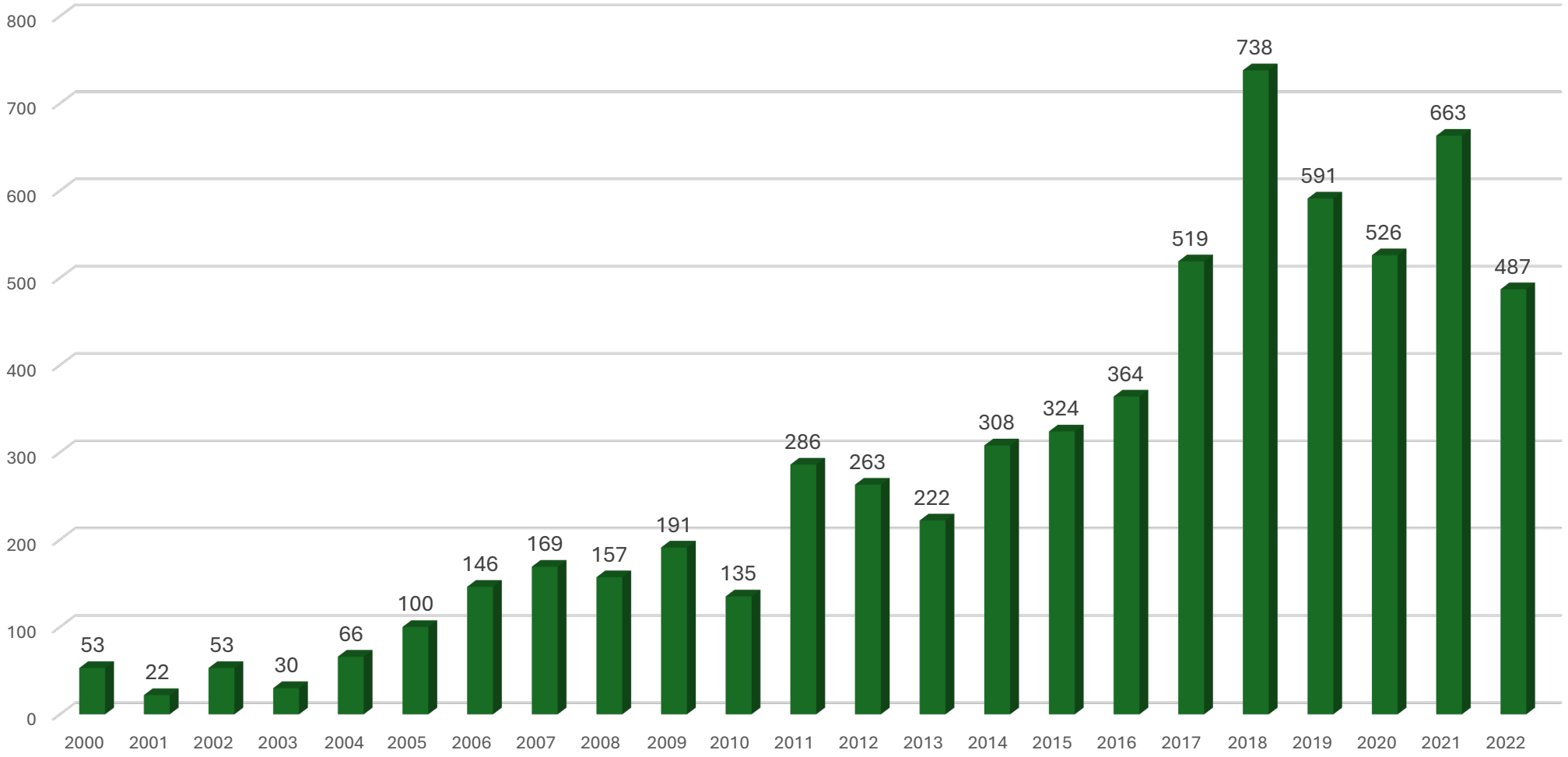
Flea Life Cycle

- Adults live on the animal;
- Larvae & eggs live in the bedding
- Entire life cycle of cat fleas completed in 20 to 35 days
- Cycle influenced by temperature and moisture conditions
- Under unfavorable conditions, complete development may require months or even a year
- Indoors – year round

Flea-Borne Typhus / Murine Typhus

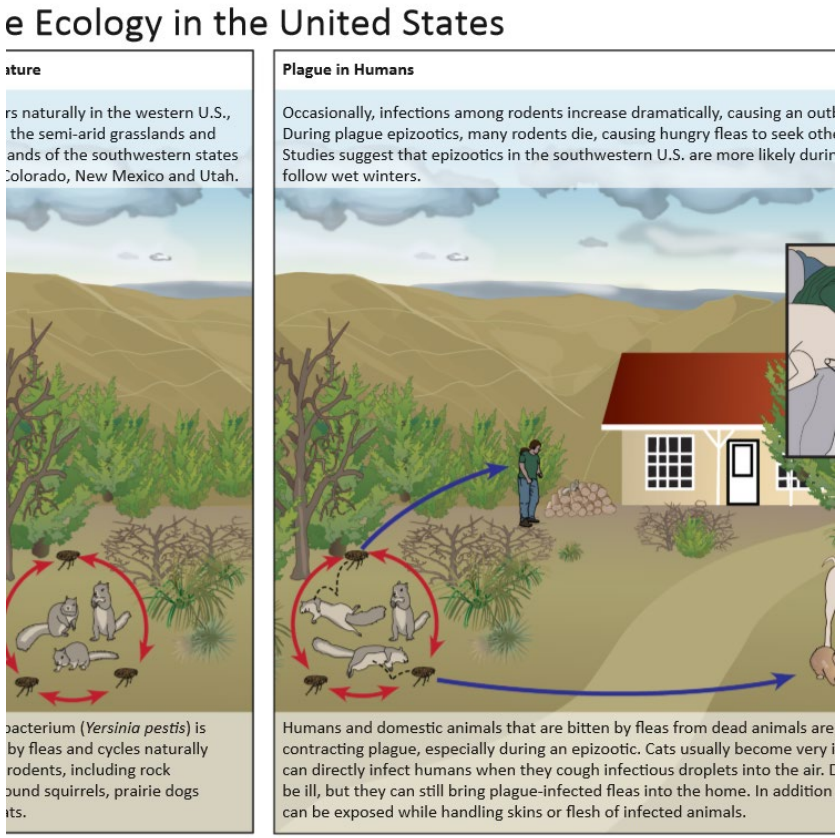
- Pathogen organisms found naturally infecting
  - *Xenopsylla cheopis* – oriental rat flea
  - *Nosophyllus fasciatus* – northern rat flea
  - *Leptopsylla segnis* – European mouse flea
  - *Ctenocephalides felis* – cat flea

Typhus Cases in Texas – total 6,413



Plague

- Caused by *Yersinia pestis*, a bacterium, introduced in 1900
- Is an acute disease characterized by high fever and high mortality
- Before antibiotics and an effective vaccine, it was one of the most dangerous diseases known
- Spreads rapidly from one person to another
- Occurs in rural and semi-rural areas of western US
- Scientists think that plague bacteria circulate at low rates within populations of certain rodents without causing excessive rodent die-off. These infected animals and their fleas serve as long-term reservoirs for the bacteria. This is called the enzootic cycle.



Control

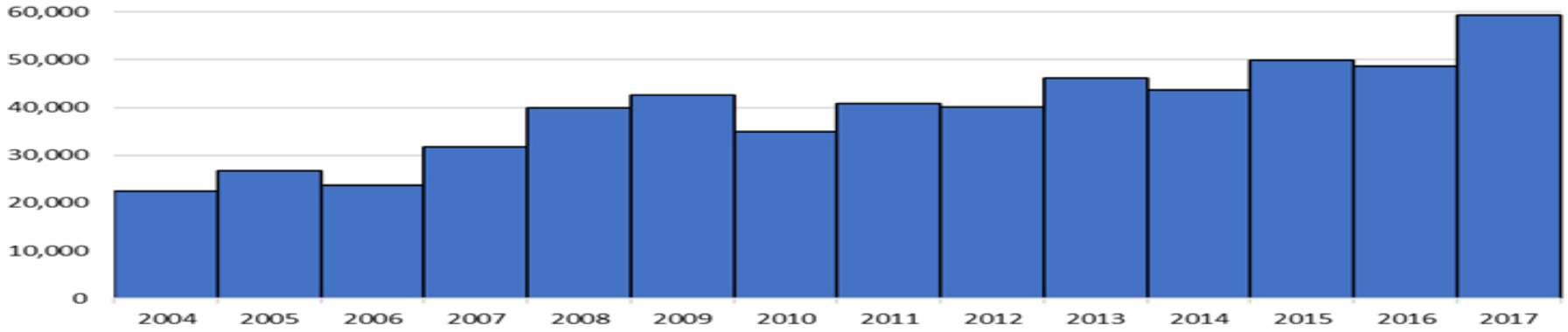
- Sanitation
  - Change bedding often
  - Vacuum thoroughly
    - Under furniture, cushions, chairs, beds
    - Along walls
    - Discard bag
- Habitat alteration
  - Implement exclusion procedures for prevent pets and pests (rodents)

- Treating Pets
  - Flea comb and bathe
  - IGR spot ons, pills, feed additives
  - Chemical spot ons
- Treating homes
  - Treat when treating animal and bedding
  - Boric acid, citrus sprays
  - IGR sprays
- Treating Outdoors
  - Dispose of strays or wild animals
  - Around breeding areas
  - Maintain lawns
  - Treat burrows with dusts
  - Spray grounds
    - Bifenthrin, cyfluthrin

What are ticks?

- Ticks are arachnids, not insects
  - Like spiders, adults have 8 legs
  - Larvae have 6 legs

- Transmit protozoan, viral and bacterial pathogens



Ticks generally divided into 2 main groups

- Hard ticks and Soft ticks

- Soft (Argasid) ticks
  - Found in caves, animal burrows, under houses, etc.
  - Some carry Relapsing Fever Borrelia
    - *B. hermsii, B. turicatae, B. parkeri*
    - Transmission by bite; can happen w/in 30 seconds of initiating a blood meal!

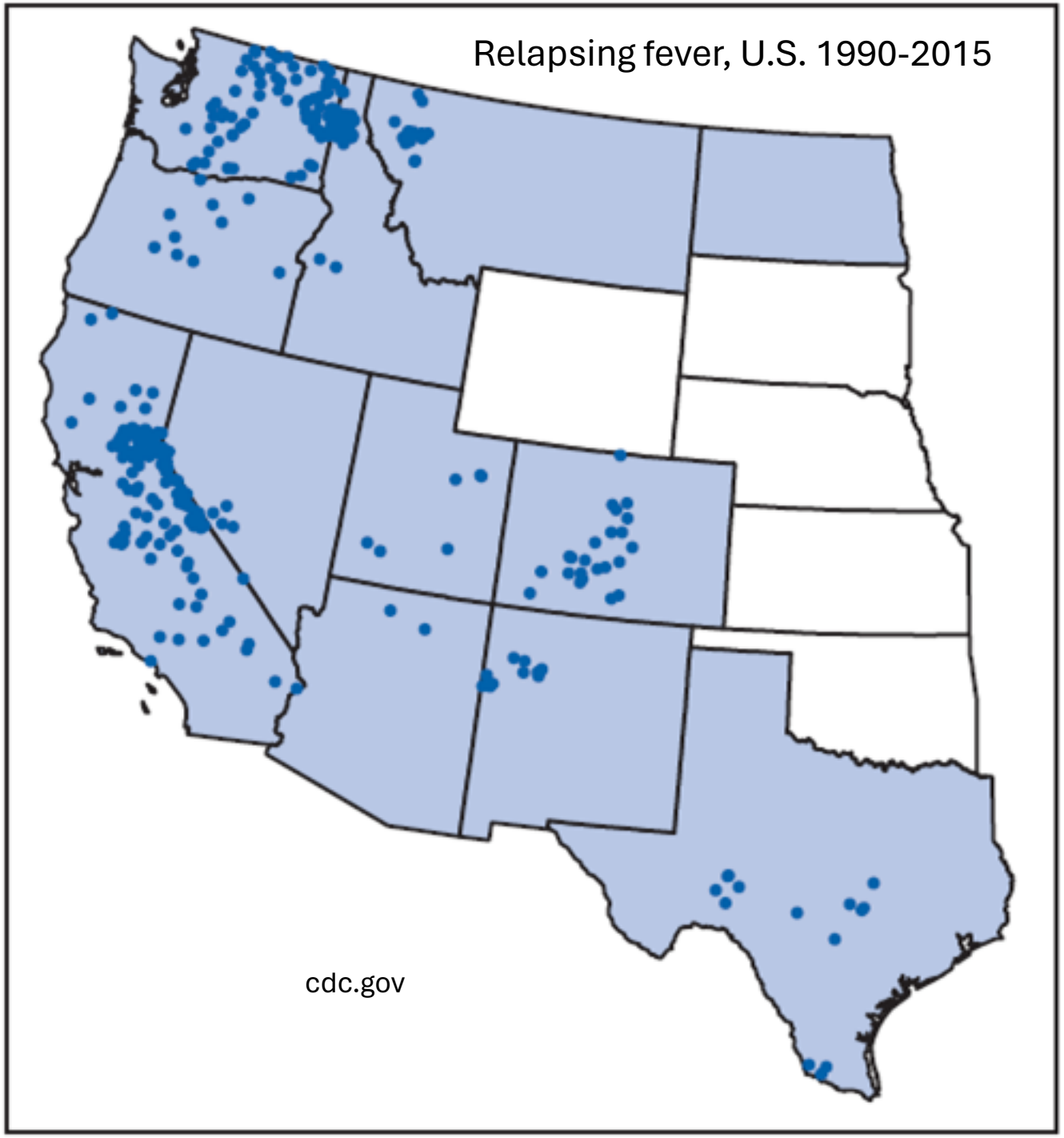
Tick Borne Relapsing Fever

- Bacterial infection linked to cave exposure in Texas
- ~ 7-day incubation period

- Periodic (i.e., relapsing) fever
  - Duration about 3-5 days
  - Febrile intervals 3-7 days
  - w/o treatment, see 3-7 episodes of fever

- Fever accompanied by myalgia, sweating/chills, headache, vomiting

- Treated with antibiotics—very effective



Ixodid (Hard) ticks

- Hard (Ixodid) ticks
  - Includes most of the ticks of concern to humans and pets
  - Represent the vast majority of ticks submitted
    - 13 genera and 650 species
  - Characterized by a dorsal sclerotised scutum or shield

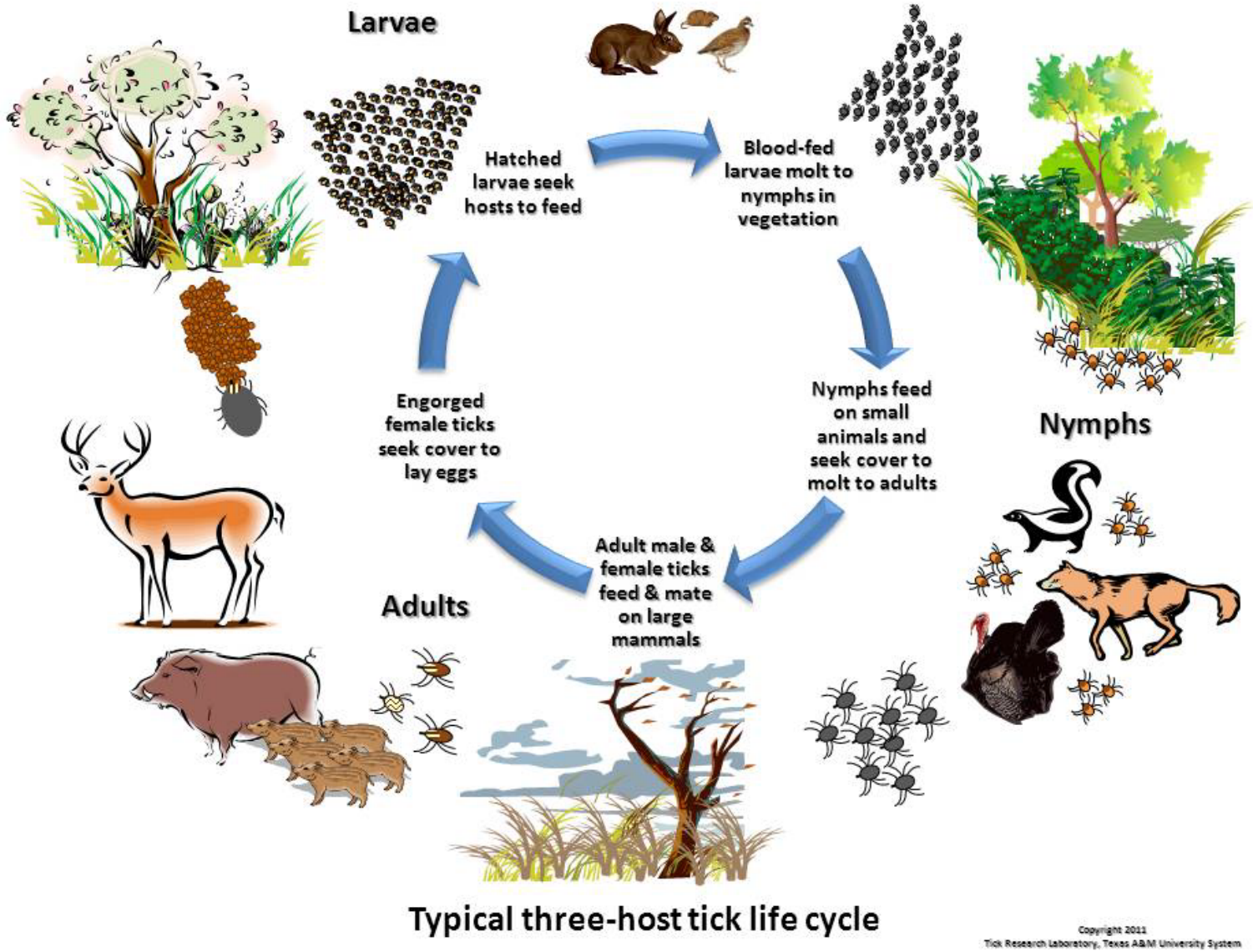
Ticks have multiple life stages

- Ticks typically feed before transition to next life stage.

Ticks are Obligate Blood Feeding Parasites

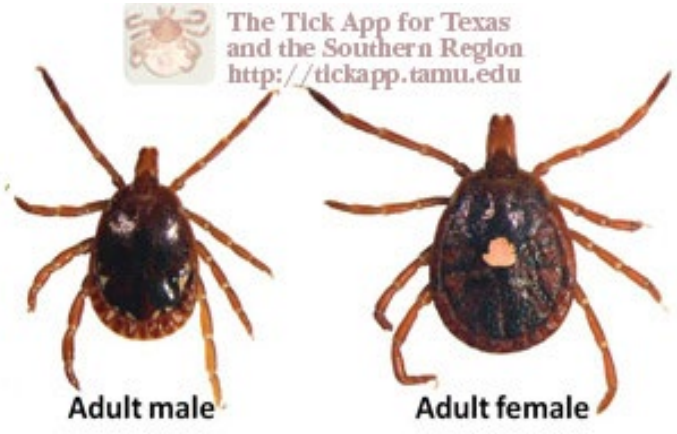
Ticks can have multiple hosts

- Categorized by feeding preference
- 1-host ticks
  - Complete life cycle on a single host (i.e., one animal)
- 2-host ticks
  - Larvae and nymphs feed on one host, adults on a second
- 3-host ticks
  - Each life stage feeds on a different host
  - Most hard ticks are 3-host ticks

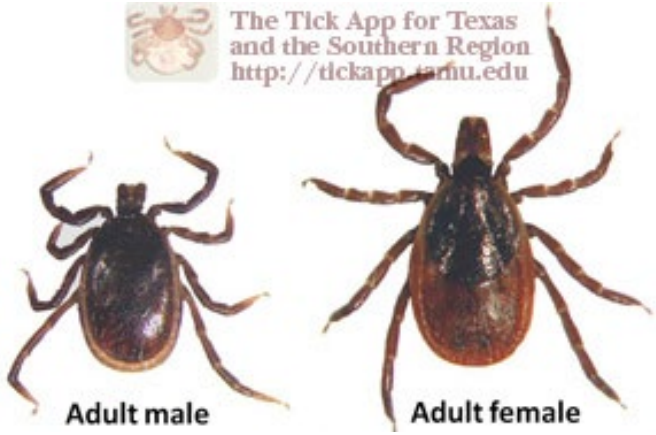


http://tickapp.tamu.edu/tickbiology.php

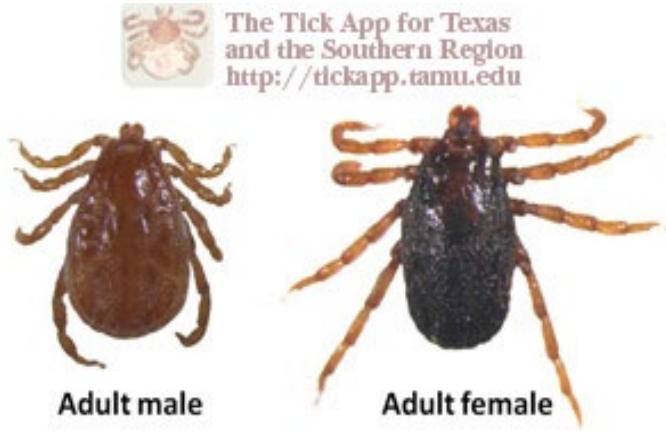
Non-regulatory Ticks Commonly found



Lone Star Tick
Amblyomma americanum



Black-legged Tick
Ixodes scapularis



Winter Tick
Dermacentor albipictus

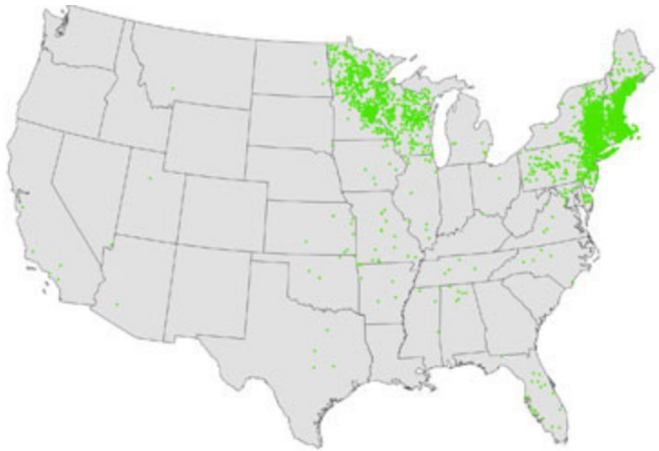
Gulf Coast Tick
Amblyomma maculatum

Brown Dog Tick
Rhipicephalus sanguineus

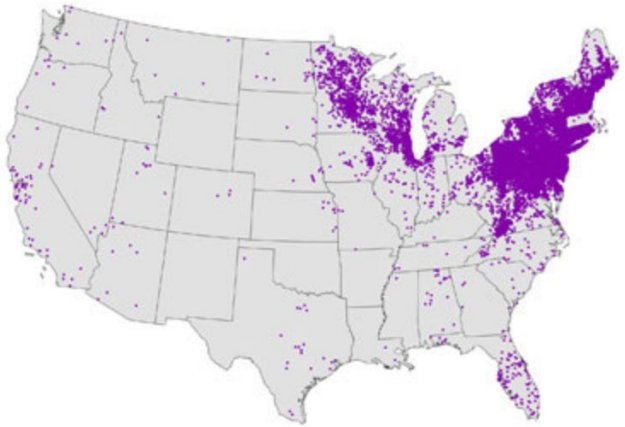
American Dog Tick
Dermacentor variabilis

Vector	Disease	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Tick	Lyme Disease	142	74	75	82	40	54	71	66	47	36	11	32	22
	Spotted Fever Group Rickettsiosis	34	52	77	83	94	61	87	106	76	20	12	10	18
	Tick-borne Relapsing Fever	0	0	0	0	0	1	0	7	2	0	1	1	0
	Tularemia	1	0	0	1	0	1	3	1	0	0	0	1	1

Tick-borne disease cases in the USA (2019)



ANAPLASMOSIS



LYME DISEASE

TULAREMIA

EHRLICHIOSIS

Each dot represents one case. Cases are reported from the infected person's county of residence, not necessarily the place where they were infected.

BABESIOSIS

SPOTTED FEVER RICKETTSIOSIS
(INCLUDING ROCKY MOUNTAIN SPOTTED FEVER)

AR, OK, MO is the middle of the bullseye for several TBD

Tick management on pets

- Inspected periodically, and after each outing to suspected tick-infested areas
- Special attention should be paid to pet resting areas and bedding materials.
  - Remove and clean bedding
  - Bag materials in black plastic (solar treatment)
  - Destroy bedding materials from kennels, doghouses or other places of pet residence.
- Heavy or persistent infestations of pets may require the advice of your local veterinarian.

Personal Protection

Repellents

Clothing repellents (permethrin) ex. Permanone – apply to shoes, socks, pants, shirts and gear (pretreated clothing can be purchased).

- Used by the U.S. military for over 25 years
- Pre-treated clothing – military and consumer

Skin repellents (DEET) – for exposed skin.

Skin Repellents

Clothing Only

U.S. Army Public Health Command (Provisional) USAPHC

DoD Insect Repellent System

What about non-DEET and non-permethrin repellents?

- BioUD marketed as skin and clothing repellent
  - BioUD - 2-undecanone (a keytone) – wild tomato plants
  - NCSU study – repellency did not differ from DEET, IR 3535 or oil of lemon eucalyptus with *A. americanum* and *D. variabilis*.
  - ~ 90% repellency on cheese cloth after 5 weeks
- Other effective non-DEET repellents:
  - Picaridin
  - IR3535
  - Oil of lemon eucalyptus

Clothing and Self-Checking

- Wear light–colored clothing, tuck in shirt tail and pants into socks (light-colored clothing does not repel ticks; allows you to see them)
- Inspect yourself for ticks frequently, examine clothing and body at least twice daily when in infested areas
- Prompt removal of ticks - the longer a tick is attached, the greater the chance of it transmitting a pathogen (2-48 hrs., many > 24 hr., viruses may require less time)
- If bitten, record the date of the tick bite

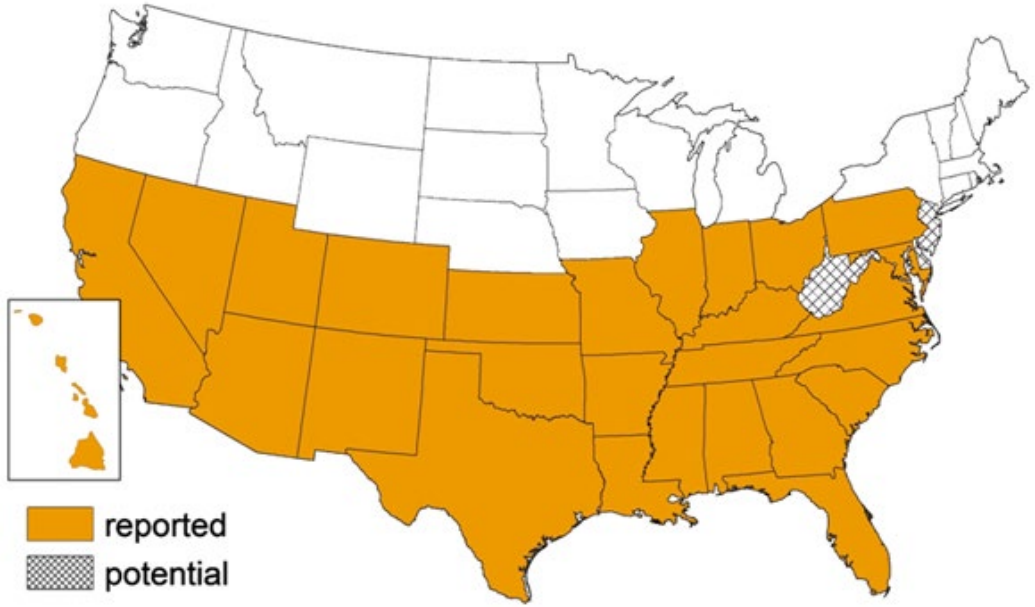
Tick Removal

- Grasp the tick with tweezers.
- Pull upward with steady pressure, do not jerk or twist the tick.
- If mouthparts remain in the skin, remove them with a sterilized needle (similar to removing a splinter).
- Write down the date of the tick bite. Removed ticks can be preserved in a vial with alcohol.
- Wash hands and bite area thoroughly with soapy water then apply an antiseptic.

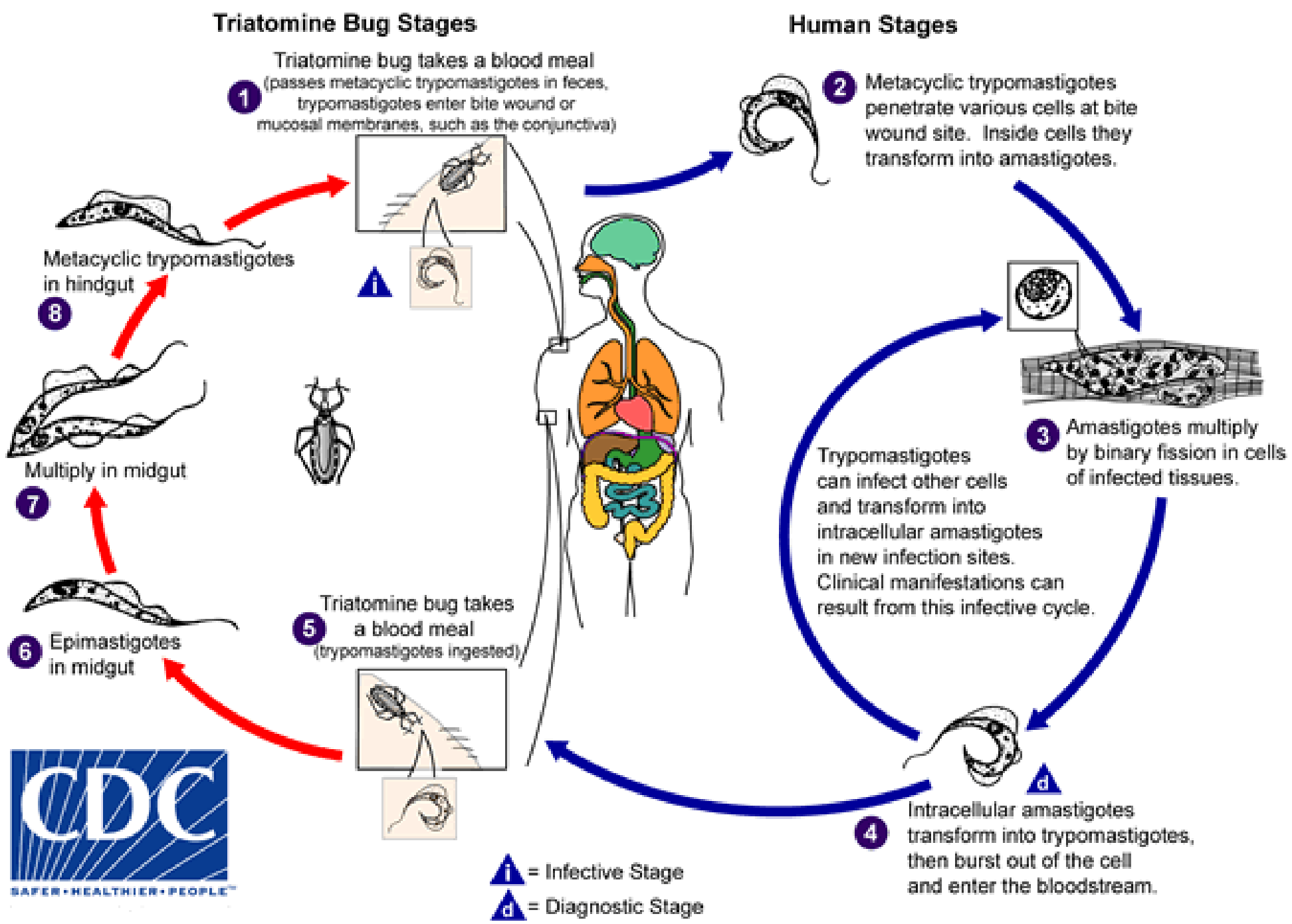
Triatomine Bugs as Disease Vectors

- Called kissing bugs, reduviid bugs, cone-nosed bugs, and blood suckers.
- Can transmit the protozoan parasite *Trypanosoma cruzi*, which is the causative agent for Chagas disease.
- Chagas disease has an acute and a chronic phase.
  - If untreated, infection is lifelong.
  - Infection may be mild or asymptomatic.
  - There may be fever or swelling around the site of inoculation.
- Many people may remain asymptomatic for life and never develop Chagas-related symptoms.
- However, an estimated 20 – 30% of infected people will develop debilitating and sometimes life-threatening medical problems over the course of their lives.

Triatomine Bug Occurrence by State



https://kissingbug.tamu.edu/


Triatomine Bug Stages
Human Stages
Triatomine bug takes a blood meal
(passes metacyclic trypomastigotes in feces, trypomastigotes enter bite wound or mucosal membranes, such as the conjunctiva)
1
i
Metacyclic trypomastigotes in hindgut
8
Multiply in midgut
7
Epimastigotes in midgut
6
Triatomine bug takes a blood meal
(trypomastigotes ingested)
5
2
Metacyclic trypomastigotes penetrate various cells at bite wound site. Inside cells they transform into amastigotes.
3
Amastigotes multiply by binary fission in cells of infected tissues.
Trypomastigotes can infect other cells and transform into intracellular amastigotes in new infection sites. Clinical manifestations can result from this infective cycle.
d
4
Intracellular amastigotes transform into trypomastigotes, then burst out of the cell and enter the bloodstream.
i = Infective Stage
d = Diagnostic Stage
CDC
SAFER·HEALTHIER·PEOPLE™

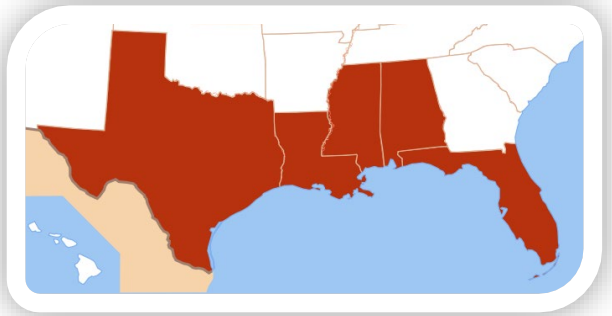
Management of *Trypanosoma cruzi*

- To reduce the chance of Triatomine bugs entering the home, work on excluding them. Some of the following may help to manage the bugs.
- Prune trees and shrubs so they do not touch or overhang the house
- Do not stack firewood or other items against the house
- Seal openings into the home with sealant, weather stripping, screens, copper mesh, etc.
- Turn off outside lights at night. If that is not possible, use “bug bulbs” that have a wavelength less attractive to insects
- Pesticides can be used to target areas of kissing bug activity such as dog houses/ kennels, indoor cracks and crevices where the insects hide or outside possible entry areas
- Control and remove rodent nests from the area

GULF SOUTH VECTOR

Vector Educational Center for Training, Outreach & Resources

Strengthening Training, Evaluation, and Partnerships in the Prevention and Control of Vector-Borne Diseases



Purpose:

Create a strong comprehensive, multi-sectorial Gulf South regional network that leverages existing infrastructure to train professionals and students in vector-borne disease (VBD)control.

To receive information about the Gulf South VECTOR Collaborative, register using the QR code

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Thank you

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