

# Tiny Terrors: The Science and Surveillance of Tick-Borne Diseases


Stephanie Blackburn, EdD, MLS(ASCP)CM  
LSU Health Shreveport  
School of Health Professions & Sciences



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# OBJECTIVES

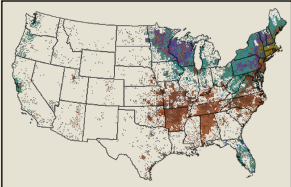
- Identify the most common tick species responsible for transmission of human diseases in the United States.
- Differentiate major tick-borne illnesses based on causative agents, symptoms, and geographic distribution.
- Examine the surveillance of tick exposure and incidence of disease.



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# Tick-borne diseases: a growing threat

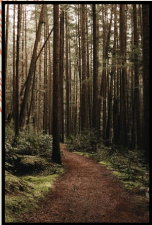
- Fastest growing vector-borne threat in North America
- Annual cases more than doubled since 2004
  - >50,000 cases reported annually to CDC



Climate change and habitat expansion continue to drive geographic spread of tick populations into previously unaffected regions.

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# Diseases transmitted by ticks





- Anaplasmosis
- Babesiosis
- Bourbon virus
- Colorado tick fever
- Ehrlichiosis
- Hard tick relapsing fever
- Heartland virus
- Lyme disease
- Powassan virus
- Rickettsi parkeri rickettsiosis
- Rocky Mountain spotted fever
- Soft tick relapsing fever
- STARI
- Tularemia
- 364D rickettsiosis

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# Disease Incidence

Annual cases reported:

- 89,000 Lyme disease
- 1200 Rocky Mountain Spotted Fever (RMSF)
- 1500 Ehrlichiosis
- 5500 Anaplasmosis
- 2000 Babesiosis
- 200 Tularemia

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# General Symptoms

Many tick-borne diseases have similar signs and symptoms

- Fever/chills
- Aches & pains: headache, fatigue, muscle aches
- Distinctive rash
  - Lyme disease
  - STARI
  - RMSF
  - Ehrlichiosis
  - Tularemia



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## Tick paralysis

- Thought to be caused by toxin in the tick's saliva
- Weakness due to loss of muscle function or paralysis that gradually moves up the body
- Resembles other neurological conditions
- Usually regain movement within 24 hours of removing tick

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Tick-borne diseases in the U.S. are caused by diverse pathogens transmitted through specific tick species



Critical to recognize the causative agent, signs & symptoms, and mode of transmission to make an accurate diagnosis for effective clinical management

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## Common Tick Species in U.S.

 <p><b>Blacklegged Tick (<i>Ixodes scapularis</i>)</b></p> <ul style="list-style-type: none"> <li>• aka deer tick</li> <li>• Lyme disease</li> <li>• Anaplasmosis</li> <li>• Babesiosis</li> <li>• Endemic throughout Northeast and upper Midwest U.S.</li> </ul>	 <p><b>Western Blacklegged Tick (<i>Ixodes pacificus</i>)</b></p> <ul style="list-style-type: none"> <li>• Lyme disease</li> <li>• Anaplasmosis</li> <li>• West Coast</li> </ul>	 <p><b>American Dog Tick (<i>Dermacentor variabilis</i>)</b></p> <ul style="list-style-type: none"> <li>• Rocky Mountain Spotted Fever</li> <li>• Tularemia</li> <li>• Widely distributed across eastern U.S.</li> </ul>	 <p><b>Lone Star Tick (<i>Amblyomma americanum</i>)</b></p> <ul style="list-style-type: none"> <li>• Ehrlichiosis</li> <li>• Tularemia</li> <li>• Widespread in SE and Midwest U.S.</li> </ul>
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## How ticks find their host



- Detect breath or body odor
- Senses body heat, moisture, and vibrations
- Climbs onto host
- Some attach quickly; others wander until it finds thin area of skin

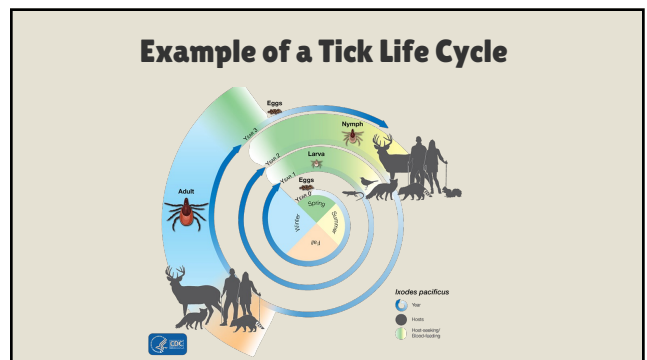
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## How ticks spread disease



- Preparing to feed may take 10 minutes to 2 hours
- Once it grasps to skin's surface, it inserts its feeding tube ~ secretes cement-like substance to keep it attached
- Secretes saliva with anesthetic properties so that the host can't feel it
- Tick feeds may last minutes to days
- Pathogen transmitted by the tick's saliva while it is feeding
- After feeding, tick drops off

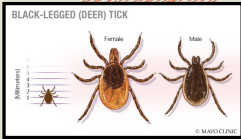
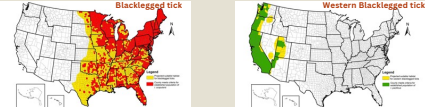
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## Lyme Disease

- Most prevalent tick-borne illness in U.S.
- Blacklegged tick (aka deer tick)
- Western blacklegged tick
- Causative agent: *Borrelia burgdorferi* (spirochete)

**Blacklegged tick**

**Western Blacklegged tick**

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## Lyme Disease



- Early symptoms:
  - Fever
  - Headache
  - Fatigue
  - Myalgias
  - Characteristic erythema migrans "bull's-eye" rash
- Usually, successfully treated with antibiotics
  - Doxycycline, amoxicillin, or cefuroxime




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## Lyme Disease

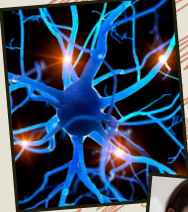

- If untreated the infection progresses
- Later stages:
  - Infection spreads to joints, heart, and nervous system
  - Arthritis
  - Neurological complications

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## Neurological Lyme disease

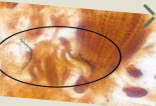

- Cranial nerve involvement
- Peripheral nerve involvement
- Central nervous system involvement
- Treat with doxycycline or ceftriaxone

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## Lyme Carditis

- Organism enters tissue of heart
- Interferes with electrical signals for heart's upper to lower chambers, which coordinates heartbeat

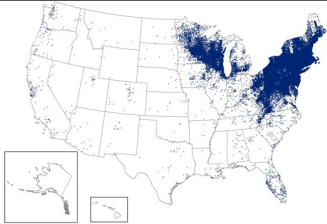



## Lyme Arthritis

- Organism enters joint tissue
- Inflammation of joints
- Obvious swelling
- If untreated, results in permanent joint damage

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## Lyme disease – Geographic distribution



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## Lyme Disease

Highest risk of exposure:

- Wooded areas
- Overgrown brush
- Residential areas adjacent to any wooded areas



Most cases of Lyme disease occur when tick is attached for over 24 hours

**Important to promptly remove ticks!**

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## Lyme Disease Diagnosis

- EM rash - diagnosed clinically
- Serological testing
  - IgM usually peaks at 3-6 weeks
  - IgG starts increasing several weeks following exposure and may persist for years, even after successful treatment
- Best to perform EIA or IFA followed by Western Blot for confirmation



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## Lyme Disease or STARI?

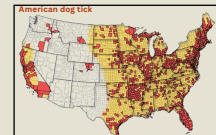
- Both conditions cause erythema-like rash
- STARI: Southern Tick-Associated rash illness
  - Transmitted by lone star tick
    - Central Texas and Oklahoma
    - Throughout southern US and Atlantic Coast
  - Disseminated disease has not been reported
  - No lab testing available
  - Unknown if treatment is necessary
- Both conditions cause erythema-like rash



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## Rocky Mountain Spotted Fever

- American dog tick
- Rocky mountain wood tick
- Causative agent: *Rickettsia rickettsii*



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## Rocky Mountain Spotted Fever

Signs & Symptoms

- Fever
- Headache
- Rash
- Nausea or vomiting
- Stomach pain
- Muscle pain
- Lack of appetite



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## RMSF Rash

- Develops 2-4 days after fever begins
- Varies widely over course of illness
  - Red and splotchy
  - Pinpoint dots
- Challenging to diagnose RMSF since the rash appears later in illness



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## Rocky Mountain Spotted Fever

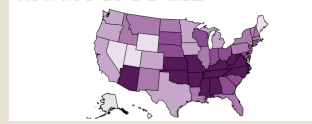
- Complications:
  - Amputation of arms, legs, fingers, or toes ~ Due to blood vessel damage
  - Hearing loss
  - Mental disability
- Fatal if not treated promptly
  - Treat with doxycycline



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## RMSF – Geographic distribution

Annual incidence (per million population) of reported spotted fever rickettsiosis-United States for 2021



- 2019-2023: 5 states accounted for 50% RMSF cases
- Alabama
  - Arkansas
  - Missouri
  - North Carolina
  - Tennessee

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## Lab testing for RMSF

- Serological testing
  - IFA for IgG performed on acute and convalescent serum samples collected 2-10 weeks apart
    - Look for 4-fold seroconversion
  - IgM IFA assays available, but not recommended
  - Ab remain elevated for many months after RMSF resolves
- PCR on serum or plasma
  - May not circulate in large numbers until disease has progressed to severe infection



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## Anaplasmosis

- Blacklegged tick (deer tick)
- Western blacklegged tick
- Causative agent: *Anaplasma phagocytophilum*
- Not uncommon to see co-infection with Lyme disease



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## Anaplasmosis

- Signs & symptoms usually start within 1-2 weeks after tick bite
- Early symptoms:
  - Fever
  - Chills
  - Headache
  - Myalgias
  - Nausea, vomiting, diarrhea
  - Loss of appetite
- Leukopenia
- Thrombocytopenia
- Elevated liver enzymes



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## Anaplasmosis

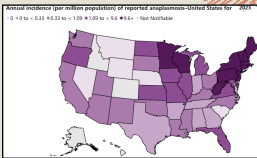
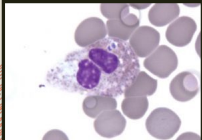
- Treat with doxycycline
- If untreated the infection progresses
  - Late illness
    - Respiratory failure
    - Bleeding problems
    - Organ failure
    - Death
- Risk factors for severe illness
  - Delayed treatment
  - Over 65-years old
  - Immunocompromised



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## Anaplasmosis



- Most frequently reported in upper midwest and northeast
- Difficult to diagnose
- Start treatment as soon as its suspected
- Lab testing:
  - PCR on whole blood is best method for identification
  - Immunohistochemical staining of organism from biopsy

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## Ehrlichiosis



- General name to describe diseases caused by:
  - *Ehrlichia chaffeensis*
  - *Ehrlichia ewingii*
  - *Ehrlichia muris euclairensis*
- Lone star tick

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## Ehrlichiosis



- Signs & symptoms usually start within 1-2 weeks after tick bite
- Early symptoms:
  - Fever
  - Chills
  - Headache
  - Myalgias
  - Nausea
- Up to 1 in 3 people report a rash
  - Red splotches or pinpoint dots

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## Ehrlichiosis


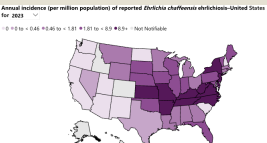
- Treat with doxycycline
- If untreated the infection progresses
- Late-stage illness
  - Damage to brain or nervous system
  - Respiratory failure
  - Uncontrolled bleeding
  - Organ failure
  - Death
- Risk factors for severe illness
  - Delayed treatment
  - Under 5-years old or over 65-years old
  - Immunocompromised

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## Ehrlichiosis

- Most people infected by tick bite
- May be spread through blood transfusion or organ transplant (this is rare)
- Most frequently reported in southeastern and south-central United States

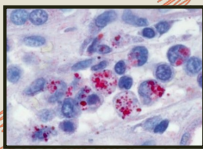
2019-2023: 5 states accounted for 50% ehrlichiosis cases

- Arkansas
- Missouri
- North Carolina
- New York
- New Jersey

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## Ehrlichiosis Diagnosis

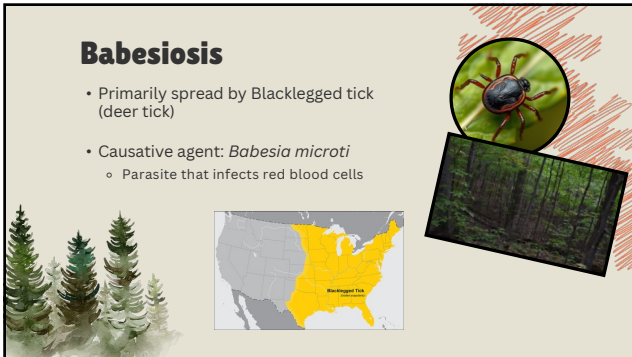
- Difficult to diagnose, especially in early stages
- Start treatment as soon as its suspected
- PCR on whole blood is most sensitive within first week of illness
- Serological testing:
  - IgG IFA on acute and convalescent serum
- During first week of illness perform peripheral blood smear:
  - *E. chaffeensis* infects monocytes
  - *E. ewingii* infects granulocytes



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## Babesiosis

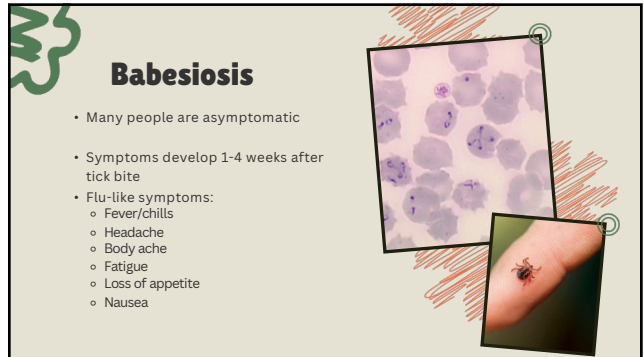
- Primarily spread by Blacklegged tick (deer tick)
- Causative agent: *Babesia microti*
  - Parasite that infects red blood cells



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## Babesiosis

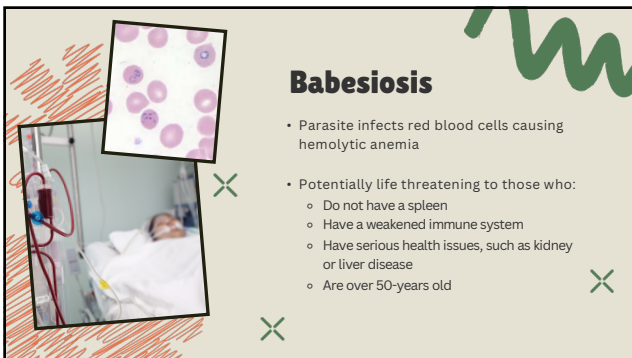
- Many people are asymptomatic
- Symptoms develop 1-4 weeks after tick bite
- Flu-like symptoms:
  - Fever/chills
  - Headache
  - Body ache
  - Fatigue
  - Loss of appetite
  - Nausea



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## Babesiosis

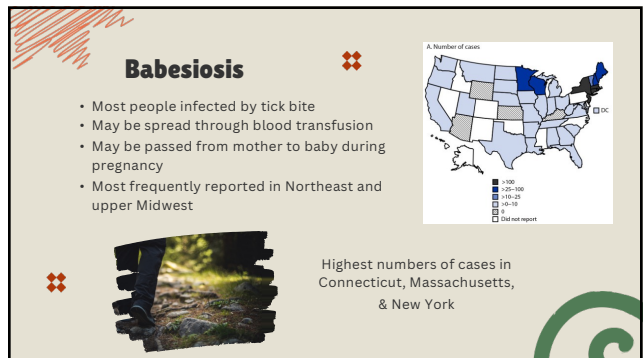
- Parasite infects red blood cells causing hemolytic anemia
- Potentially life threatening to those who:
  - Do not have a spleen
  - Have a weakened immune system
  - Have serious health issues, such as kidney or liver disease
  - Are over 50-years old



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## Babesiosis

- Most people infected by tick bite
- May be spread through blood transfusion
- May be passed from mother to baby during pregnancy
- Most frequently reported in Northeast and upper Midwest

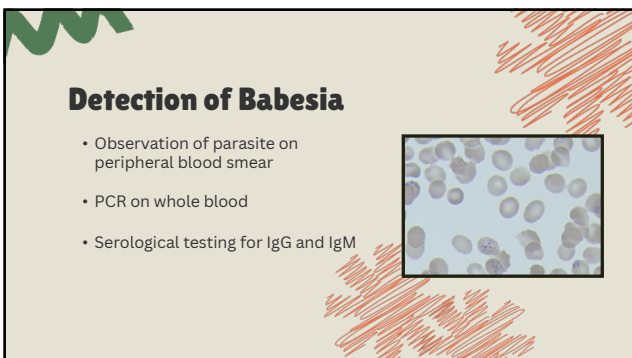


Highest numbers of cases in Connecticut, Massachusetts, & New York

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## Detection of Babesia

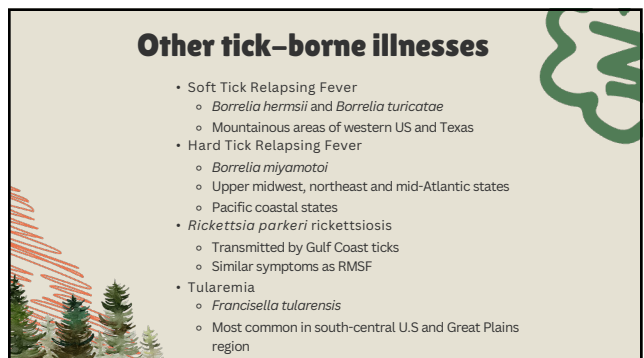
- Observation of parasite on peripheral blood smear
- PCR on whole blood
- Serological testing for IgG and IgM



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## Other tick-borne illnesses

- Soft Tick Relapsing Fever
  - Borrelia hermsii* and *Borrelia turicatae*
  - Mountainous areas of western US and Texas
- Hard Tick Relapsing Fever
  - Borrelia miyamotoi*
  - Upper midwest, northeast and mid-Atlantic states
  - Pacific coastal states
- Rickettsia parkeri* rickettsiosis
  - Transmitted by Gulf Coast ticks
  - Similar symptoms as RMSF
- Tularemia
  - Francisella tularensis*
  - Most common in south-central U.S and Great Plains region



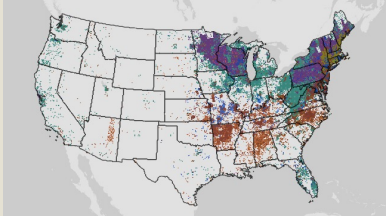
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## Common ticks in Louisiana

- **Lone Star tick**
  - Transmits Ehrlichiosis and Tularemia
  - Associated with Southern Tick-Associated Rash Illness (STARI)
- **American dog tick**
  - Transmits RMSF
  - Often feeds on small mammals
- **Gulf Coast tick**
  - Found throughout SE US
- **Brown dog tick**
  - Prefers to feed on dogs
- **Blacklegged tick (deer tick)**
  - Transmits Lyme disease

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## Incidence Trends in the U.S.




[CDC Tickborne Disease Surveillance](https://www.cdc.gov/ticks/tickborne-disease-surveillance/)

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## Surveillance Systems & Reporting

- **National Notifiable Disease Surveillance System (NNDSS)**
  - Most tickborne diseases are nationally notifiable
  - Standardized case definitions ensure consistent reporting
- **Laboratory-Based Surveillance**
  - Local labs report cases to public health laboratories
- **Enhanced surveillance activities**
  - Tick testing programs
  - Seroprevalence studies
  - Vector surveillance



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## Preventive Measures

### Personal Protection

- Use EPA-approved insect repellents
- Wear long sleeves and pants
- Thorough tick checks

### Public Health Surveillance


- Monitor tick populations
- Monitor disease incidence
- Identify high risk areas

### Environmental Management

- Maintain yards
- Create barriers between lawns and wooded areas

### Community Education


- Tick habitats
- Symptoms of tick-borne disease
- Prevention strategies
- Educational material



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## In conclusion...

- Clinical diagnosis is essential for timely treatment
- Lab plays a crucial role in diagnosing these diseases accurately
- Diversity of tick species and pathogens complicates lab identification
- Accurate surveillance data from diagnostic labs help public health department
  - Monitor disease trends
  - Guide prevention strategies
  - Effective allocation of resources
- Increased awareness in tick-borne disease



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## References

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