Could a Parasite Be the Reason for the Crazy Cat Lady?

TOXOPLASMOSIS AND BEHAVIORAL CHANGES

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OBJECTIVES

1. Describe the life cycle and infection of *Toxoplasma gondii*.
2. Consider symptoms and potential complications of toxoplasmosis, including possible links to behavioral changes.
3. Discuss prevention, diagnosis, and treatment of toxoplasmosis.

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TOXOPLASMOSIS

- Infection with *Toxoplasma gondii*, one of the most "successful" protozoan parasites on earth
- >50% prevalence in dogs, rabbits, sea otters, mice, rats, wild birds, cats, bears, and deer
- Also highly prevalent in domestic chickens, geese, cattle, goats, pigs, and sheep
- Up to 50% of the global population is infected
- 40 million+ U.S. men, women, and children carry the carry the parasite, but very few have symptoms.
- Severe consequences in pregnant females and in the immunocompromised
- Considered to be a leading cause of death attributed to foodborne illness in the United States

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TOXOPLASMOSIS, CONT.

- Considered one of the "neglected parasitic infections" (NPIs) of the United States and has been targeted by the CDC for public health action
- Other NPIs include Chagas disease, cyclosporiasis, cyticercosis, toxocariasis, and trichomoniasis
- CDC is working to protect citizens by:
  - Increasing awareness
  - Conducting surveillance
  - Assessing data to help better understand these infections
  - Improving diagnostic testing
  - Advising on treatment

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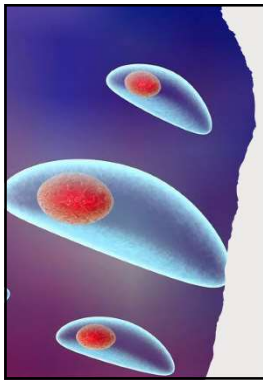

PROTOZOANS

- Single-celled parasitic organisms that can infect all major tissues and organs of the body
- Most common modes of transmission to humans are:
  1. Injection by bites of blood-sucking insects
  2. Accidental ingestion of infective stages
- ***Definitive host*** – organism that parasite must infect in order to mature and sexually reproduce, completing its life cycle
- ***Intermediate host*** – organism that supports immature or non-reproductive forms of the parasite

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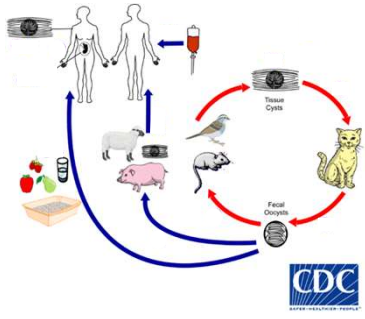
LIFE CYCLE OF *TOXOPLASMA GONDII*



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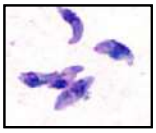

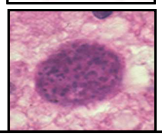

STAGES OF *TOXOPLASMA* DEVELOPMENT

Oocysts – "eggs" shed in feces of domestic cats and their relatives (definitive hosts)

Tachyzoites – form from oocysts in intermediate hosts after shortly after ingestion; rapidly multiply in tissues during acute infections

Bradyzoites – localization of tachyzoites in neural and muscle tissue, slowly multiplying within a cyst-like structure; may transform into active tachyzoites when host immune system is impaired

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EPIDEMIOLOGY AND RISK FACTORS

- Infection often highest in areas of the world that have hot, humid climates and lower altitudes because parasite oocysts survive better after being shed
- Also high in areas where eating raw or undercooked meat is preferred
- Principal routes of transmission
  1. Foodborne
  2. Animal-to-human
  3. Mother-to-child
  4. Rare instances

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FOODBORNE TRANSMISSION

- Eating undercooked, contaminated meat or shellfish
- Accidental ingestion after handling contaminated meat or shellfish and not washing hands, utensils, cutting boards, etc. thoroughly
- Consuming unpasteurized milk or milk products, particularly from goats

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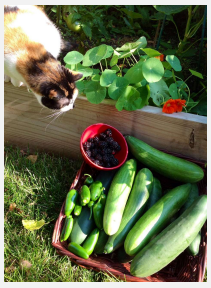
ZOONOTIC TRANSMISSION

- Accidental ingestion of "eggs" (oocysts) after cleaning an infected cat's litterbox or after touching anything that has been in contact with infected cat's feces
- Accidental ingestion of eggs in contaminated soil
- Drinking parasite-contaminated water



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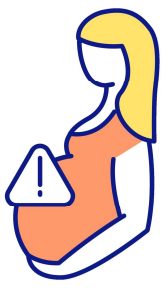

CONGENITAL TRANSMISSION

- A woman recently infected during or just before pregnancy can pass the infection to her unborn child
- Baby is *most* at risk of contracting toxoplasmosis if infection occurs in the third trimester and *least* at risk if infection occurs in the first trimester
- However, the earlier the infection occurs in pregnancy, the more serious the outcomes are for the baby.
- NOTE: If a woman is infected well before pregnancy, it poses no threat to future offspring.

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RARE INSTANCES

- Organ transplant from a *Toxoplasma*-infected donor
- Receipt of infected blood via transfusion
- Accidental inoculation in the laboratory

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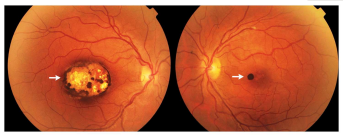
SIGNS AND SYMPTOMS OF DISEASE

- Healthy people: no symptoms or mild flu-like symptoms
- Ocular disease:
  - Eye pain
  - Retinitis
  - Photophobia
  - Tearing of the eyes
  - Blurred vision
  - Decreased vision, usually in one eye
  - Lesions inside the eye



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SIGNS AND SYMPTOMS, CONT.

- Infection during or just before pregnancy:
  - Tachyzoites cross the placenta, can attack fetus's nervous system and eyes
  - Miscarriage or stillbirth
  - Child born with congenital signs (abnormally large or small head)
  - Infected infants may not develop symptoms until later in life (potential vision loss, mental disability, and/or seizures)
- Immunocompromised individuals may have a severe primary infection or a relapse from a previous infection (fever, confusion, headache, encephalitis, seizures, poor coordination).

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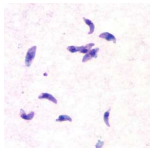

DIAGNOSIS

- Typically made by serologic testing (ELISA or IFA)
  - IgG to determine whether infected
  - IgM to estimate time of infection (pregnant women)
- Direct observation of parasite in stained tissue sections, CSF, or other biopsy material
- Molecular techniques to detect parasite DNA in amniotic fluid
- Ocular disease diagnosed based on symptoms, often combined with serology
- CBC typically shows leukocytosis due to lymphocytosis, with an increase in reactive lymphocytes.

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TORCH SCREENING

- TORCH is an acronym for a group of various infectious diseases that may cause birth defects in a newborn or even fetal loss if the mother contracts them during pregnancy.
  - ***T***oxoplasmosis
  - ***O***ther (Syphilis, Varicella-Zoster Virus (VSV), Parvovirus B19, and HIV)
  - ***R***ubella
  - ***C***ytomegalovirus (CMV)
  - ***H***erpes simplex virus (HSV)
- Ordered on newborns if *in utero* infection is suspected
- May also be ordered for pregnant women
- Detect antibodies to pathogens
- More sensitive methods available for confirmation

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TREATMENT

- Disease is usually self-limiting in immunocompetent adults
- Treatment targets active parasites and not those encysted in tissues
- Pyrimethamine, a folic acid antagonist, is most effective but can cause bone marrow suppression
- Leucovorin/folinic acid also given to decrease bone marrow toxicity from pyrimethamine
- Antibiotic such as sulfadiazine or clindamycin also included
- Therapy lasts 4-6 weeks followed by reevaluation
- Management of maternal and fetal infection varies
- Congenitally infected newborns generally treated for 12 months
- Treatment in immunocompromised patients may last 6 months or longer

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PREVENTION AND CONTROL

- ***Reduce risk from food***
  - Cook food to safe temperatures – use a meat thermometer to measure internal temperature of meat
  - Freeze meat for several days before cooking to greatly reduce chances of infection
  - Peel and/or wash fruits and vegetables thoroughly before eating
  - Wash all surfaces in contact with raw meat, poultry, seafood, or unwashed fruits or vegetables
  - Do not drink unpasteurized goat's milk
  - Do not eat raw or undercooked oysters, mussels, or clams

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PREVENTION AND CONTROL, CONT.

- ***Reduce risk from the environment***
  - Avoid drinking untreated water
  - Wear gloves when gardening
  - Keep outdoor sandboxes covered
  - Feed cats only canned or dried commercial food or well-cooked table food
  - Ensure that the litter box is changed daily (parasite not infectious until 1-5 days after it is shed)

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PREVENTION AND CONTROL, CONT.

- ***If pregnant or immunocompromised***
  - Avoid changing litter box if possible
  - Keep cats indoors to prevent them from hunting
  - Do not adopt or handle stray cats, especially kittens

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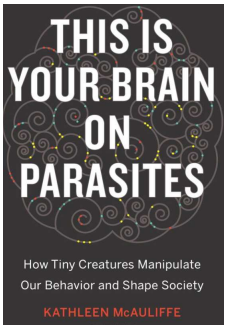
MANY PARASITES IMPACT THE BEHAVIOR OF THEIR HOSTS



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THE PARASITE MANIPULATION HYPOTHESIS

- Proposes that parasites can change the behavior of hosts to increase reproductive success of the parasite
- Well-documented that some parasites have evolved to control the actions of animals to enhance likelihood that parasite can be passed on
- *Plasmodium* species – malarial parasites
- *Ophiocordyceps unilateralis* – "zombie ant" fungus
- *Leucochloridium paradoxum* – "lighthouse snail" parasite
- ***Toxoplasma gondii*** – "fatal attraction" parasite

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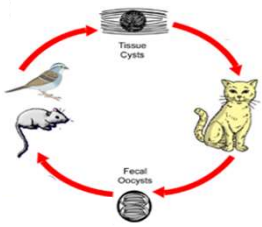
FELINES ARE DEFINITIVE HOSTS FOR TOXO



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FATAL FELINE ATTRACTION

- Infected mice and rats are attracted to cat urine and have decreased reaction times.
- Learning and memory are impaired in infected mice and rats.
- Infected chimpanzees are attracted to tiger and leopard urine.
- Healthy female rats are attracted to infected males.

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IF TOXO CAN DO THAT TO THE BRAINS OF RODENTS, WHAT CAN IT DO TO THE BRAINS OF HUMANS?

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BEHAVIORAL CHANGES IN HUMANS

- Scientific findings in *Toxoplasma* studies in animals complement findings in humans
- Effects of *Toxo* on human personality and behavior are wide-ranged and mostly subtle
- Infected men more suspicious and jealous, with a greater tendency to disregard rules
- Infected women more easy-going and warm-hearted, more likely to follow rules
- Infected males produce more testosterone, and females rated photos of infected men as more masculine.
- Both infected men and women more submissive in conflict, and had blunted reflexes under imminent danger, impaired psychomotor performance, slower reaction times, increased likelihood of being involved in traffic accidents

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BEHAVIORAL CHANGES, CONT.

- Studies linking *Toxoplasma* to schizophrenia, depression, epilepsy, suicide attempts, homicides
- Schizophrenia not described until humans began keeping cats as pets
- Quite rare until the late 1700s, then increased rapidly
- Reports as early as the 1950s that individuals with schizophrenia were more likely to have been infected with *T. gondii*
- *Toxo* and dopamine
  - Increased dopamine in schizophrenia
  - *Toxo*-infected neurons make 3.5x more dopamine than uninfected
  - Anti-psychotic medication suppressed organism's growth *in vitro*
  - Infected rats given anti-psychotic drugs did not develop fatal feline attraction

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CORRELATION ≠ CAUSATION

- For many years, it was thought that coffee consumption raised the risk of cancer
  - In fact, coffee drinkers were much more likely to be smoker than non-coffee drinkers
- *Toxoplasma* ***may*** enhance symptoms in individuals predisposed to disturbances in brain function.
- Only ~1% of people will be diagnosed with schizophrenia—FAR less than the number of people with latent *Toxo* infections
- Current research into the role of *Toxoplasma* in mental health is mostly associative—more solid links are needed to truly understand relationship
- If more definitive evidence can be demonstrated, it may provide an impetus to develop a vaccine for Toxoplasmosis.

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CRAZY CAT LADY?

- No strong evidence that *Toxoplasma* increases human tendency to own many cats
- Numerous studies show that cats confer many psychological benefits on their owners.
- Taking proper precautions to prevent contamination or infection should suffice
- Don't ditch your fur baby!

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