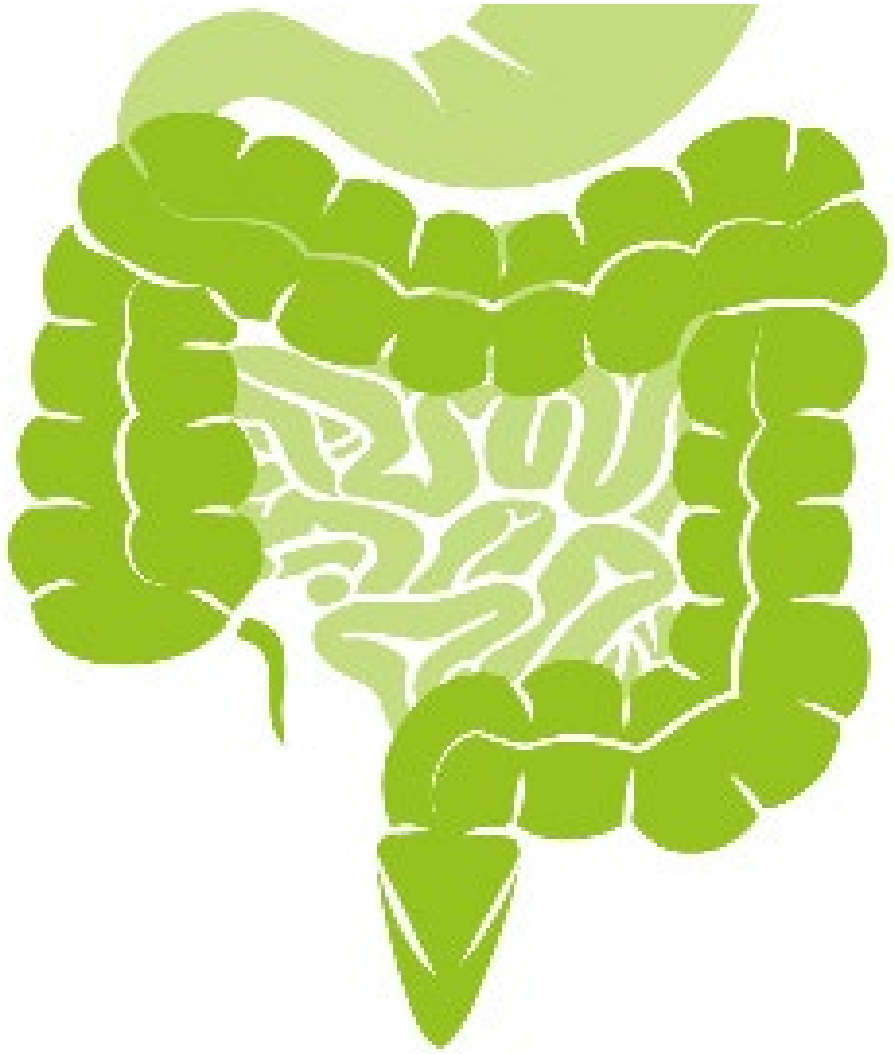


Coccidia Part 1 (intestinal apicomplexans)

Cryptosporidium parvum

Parasitic Protozoa we cover

Grouped by Infection Site and Motility

Apicomplexa
(sg =Alveolates)

Flagellates
(sg = Excavates)

Blood

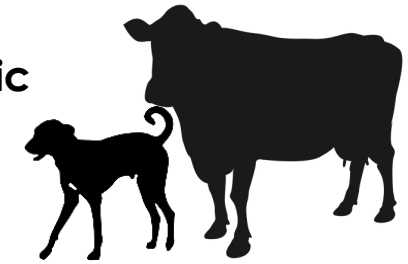
Blood apicomplexa (piroplasms)

Babesia spp.
Cytauxzoon felis
Theileria spp.

Hemoflagellates

Trypanosoma cruzi
Leishmania infantum

Systemic



Systemic apicomplexa

Toxoplasma gondii
Neospora caninum
Sarcocystis spp.
Hepatozoon americanum

Intestines/ urogenital

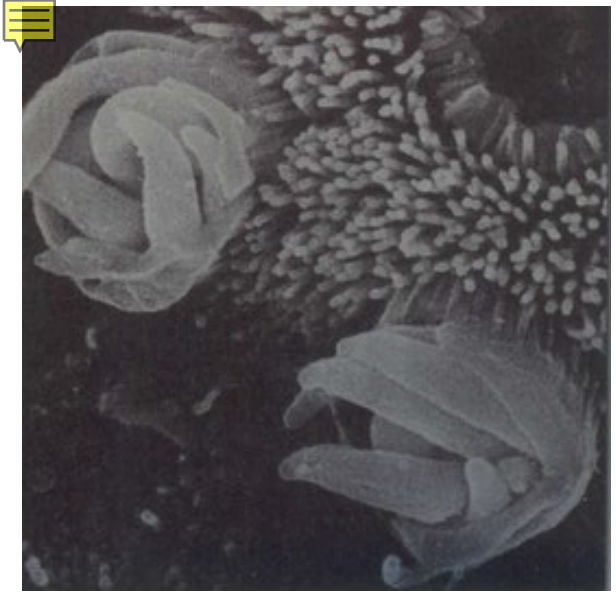
Intestinal apicomplexan (coccidia)

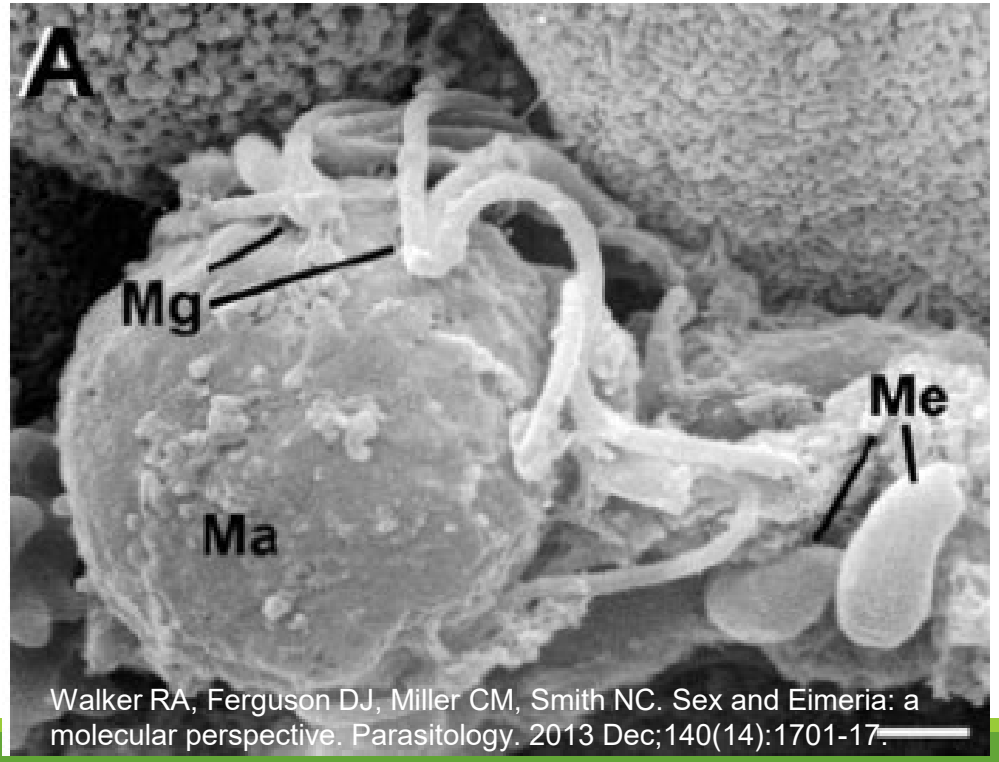
Cryptosporidium parvum
Eimeria spp.
Cystoisospora spp.

Mucoflagellates

Tritrichomonas foetus (bovine venereal)

Tritrichomonas blagburni
Giardia spp.





Walker RA, Ferguson DJ, Miller CM, Smith NC. Sex and Eimeria: a molecular perspective. Parasitology. 2013 Dec;140(14):1701-17.

Apicomplexan: Select Characteristics

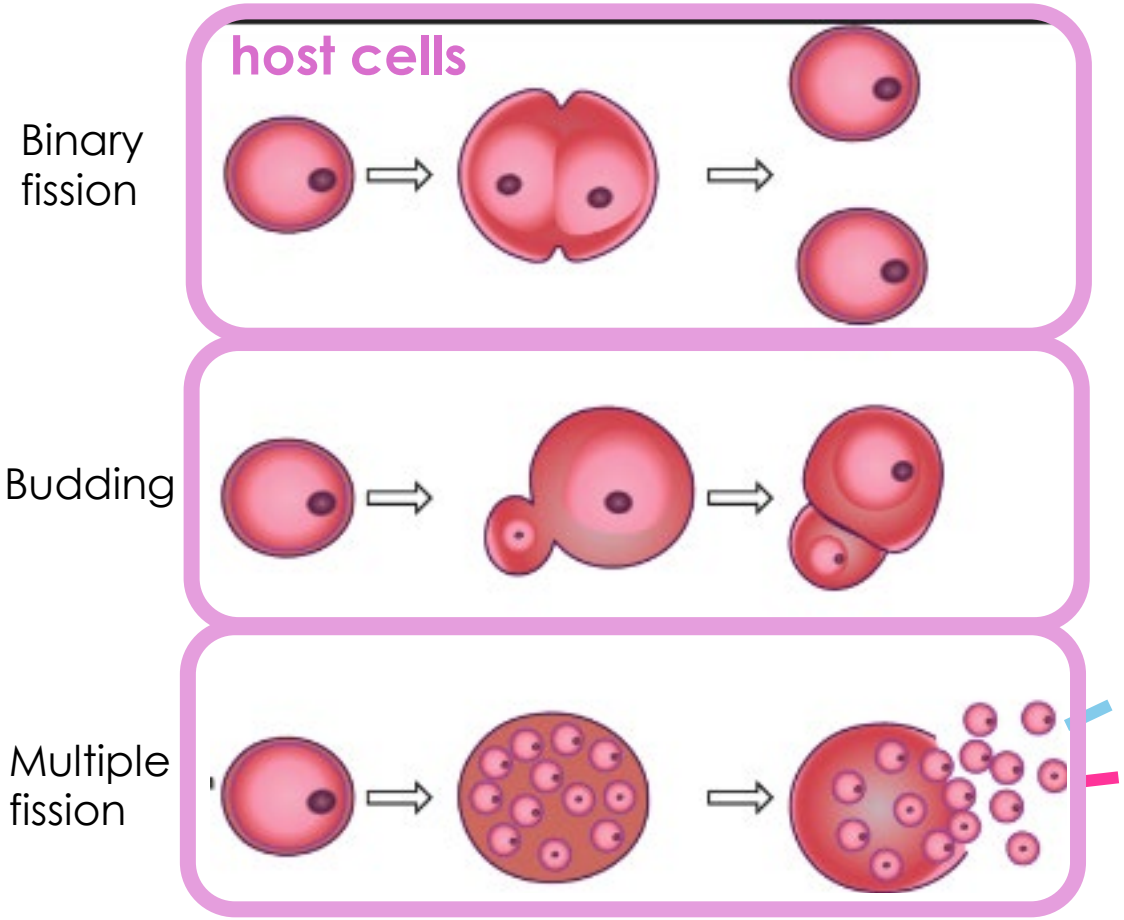
- Intracellular with apical complex
- Gliding motility
- Life cycle alternates b/w **sexual and asexual reproduction**
- Many morphological stages = "zoites" and "-onts"

Protozoa Reproduction

Asexual

-binary or multiple fission, budding

-create many organisms quickly = damage to host cells

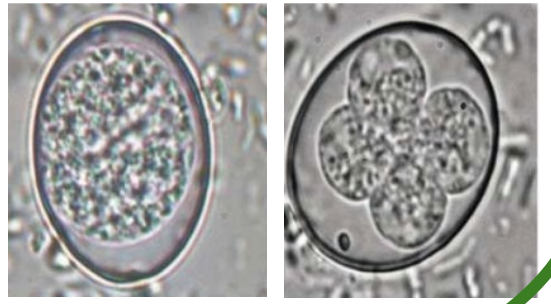


coccidia

Sexual

(Apicomplexa protozoa)

Infective cells



Microgamete (male)

Macrogamete (female)

Apicomplexan: Terms

- **Sporozoite =** infective stage; spore-like cells
- **Merozoite =** sporozoite that is inside host cell, will start asexual replication

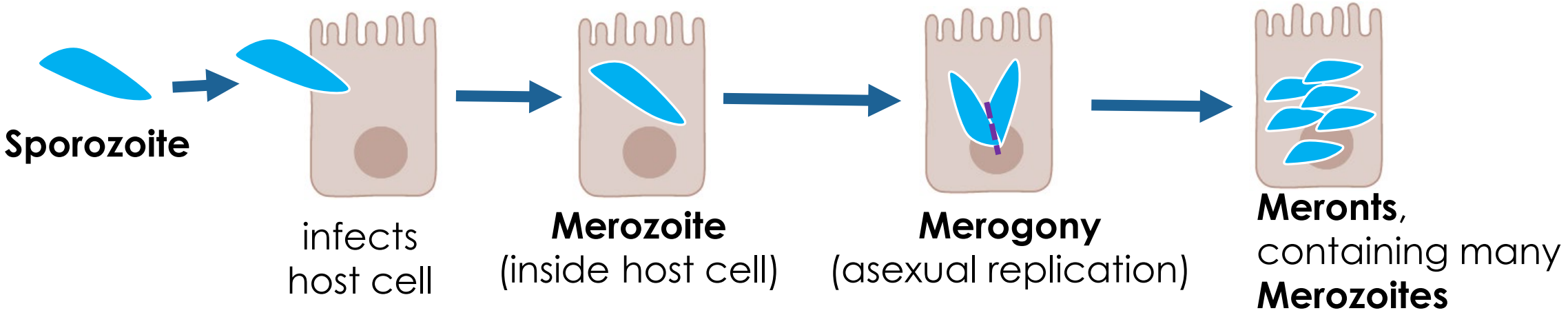
- **Merogony** = merozoite going through asexual replication in host cells

  merogony ≈ schizogony
  (the slight difference is in exact type of asexual replication)

- **Meronts** = a bag of merozoites

  meront ≈ schizont

Meront



Apicomplexan: Replication

Asexual replication (this is how the tissue damage in the host occurs)

Merogony (schizogony) → asexual replication of merozoites within the host cell

Sporogony (sporulation) → asexual replication within the oocyst resulting in sporozoites

Sexual replication (this is how oocysts are made)

Gametogony→ merozoite develops into a gamete

microgamete = male

macrogamete = female

Fertilization→ microgamete fertilizes a macrogamete, which develops into a zygote then an oocyst

GI Apicomplexan: General Life Cycle

male (microgametes)
female (macrogametes)

Sporulated oocyst (infective)

Sporogony (sporulation)

oocyst

zygote

Sexual Fertilization

Gametogony (merozoite develops into gametes)

Merozoites

sporocysts

sporozoites

Sporozoite

host cell

Merozoite (inside host cell)

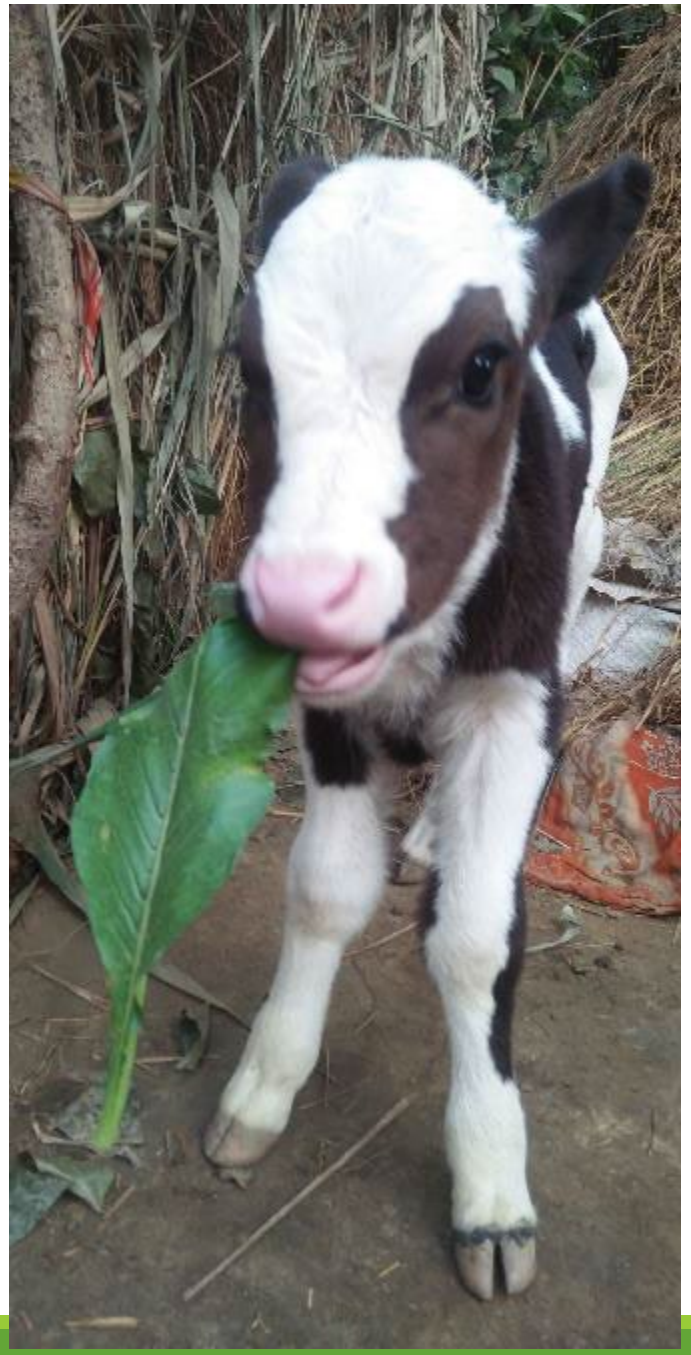
Merogony (asexual replication)

Meronts, containing **Merozoites**

Merogony repeats

Cryptosporidium parvum

- **Intestinal pathogen of calves**
- *C. parvum* has very low host specificity!
- There are many *Cryptosporidium* spp. that are more host specific (*C. ryanae*, *C. bovis*, *C. canis*, *C. felis* etc)



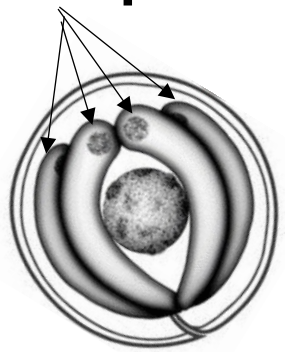
Learning Objectives: *Cryptosporidium parvum*

1. Morphology: understand identifiable (diagnostic) characteristics
2. Life cycle: know that this is a direct life cycle, where sporulation occurs and why that is important
3. Transmission: understand how it becomes infectious and the implications of oocysts having a thin vs thick wall.
4. Pathogenesis: understand the primary method of pathogenesis and where it occurs.
5. Clinical signs: recognize the clinical signs.
6. Diagnosis: understand how to diagnose *C. parvum*.
7. Treatment: understand the most effective and important way to treat diarrhea in calves
8. Control: understand how to prevent *C. parvum* infections and how oocysts viability will affect your efforts.
9. Epidemiology: recognize the common risk factors for calves
10. Zoonosis: understand *C. parvum* is highly zoonotic and how most people are infected.

FYI will not be tested

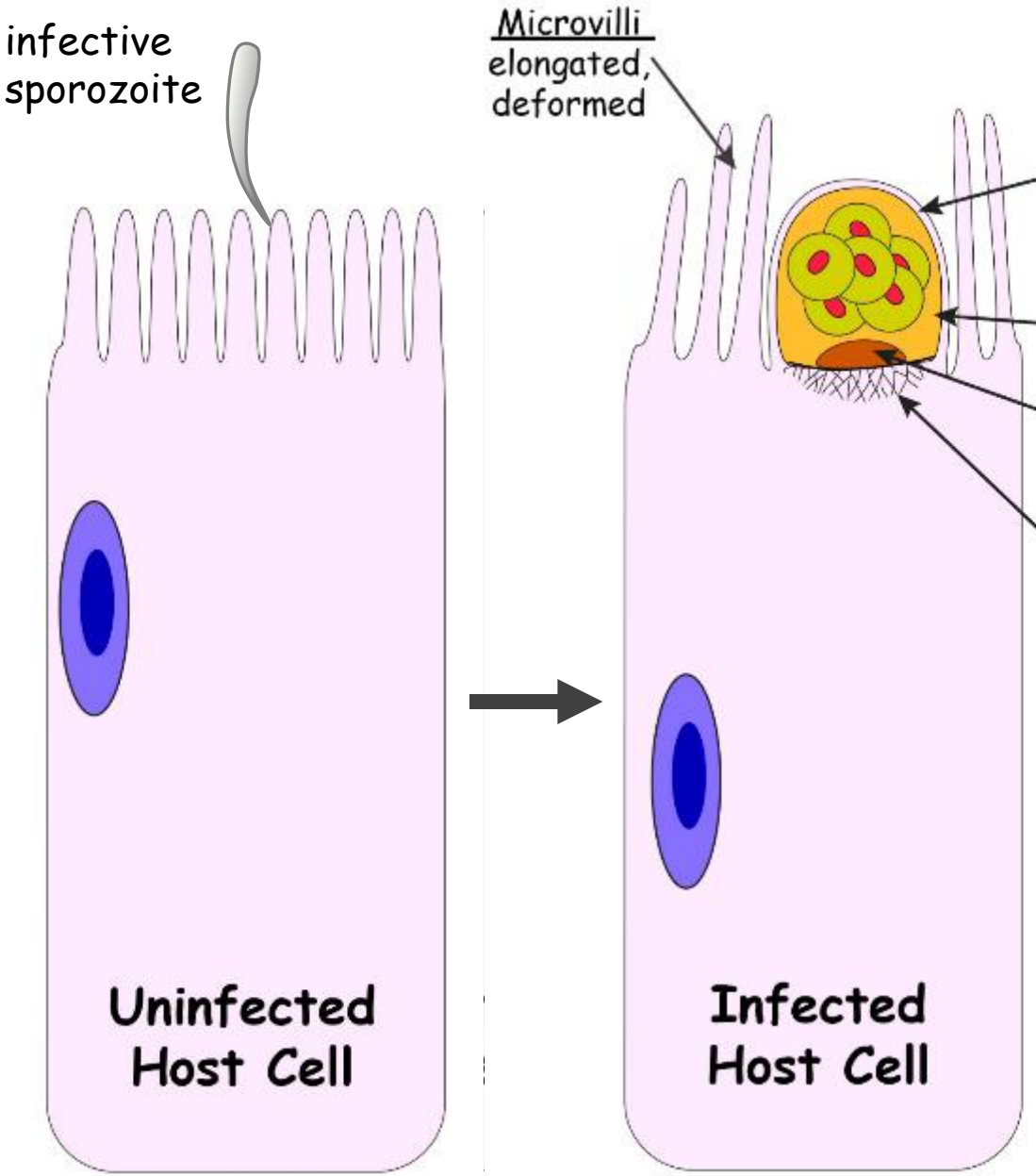
Morphology: *C. parvum*

Oocyte
w/ 4 sporozoites



5-8 um (**very small**)

thick or thin walls



FYI

Parasitophorous Vacuole
made of host and parasite components

Meront
with developing merozoites

Residual Body
germinative body from which merozoites bud

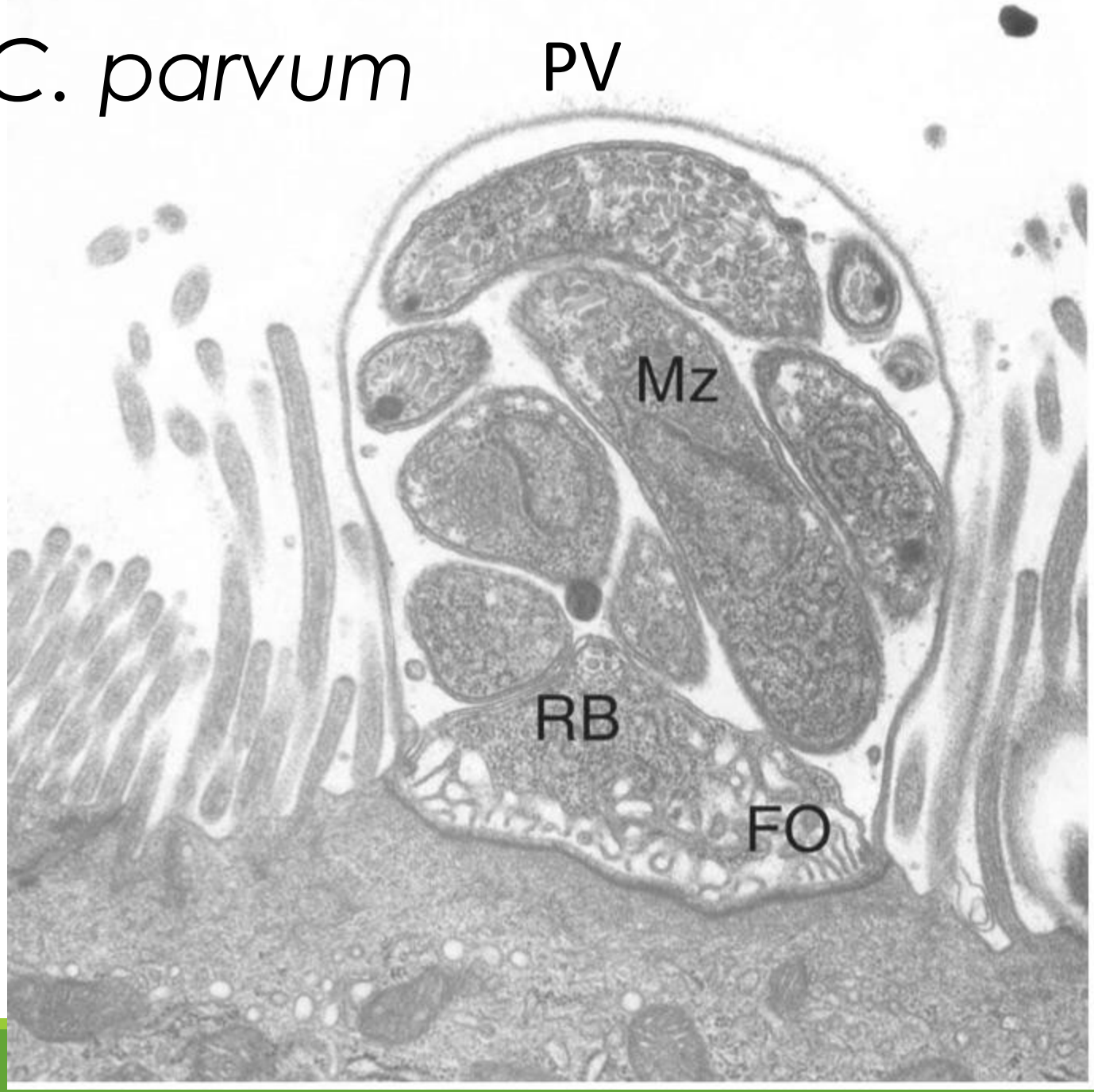
Feeder Organelle
obtains nutrients from host cell

FYI

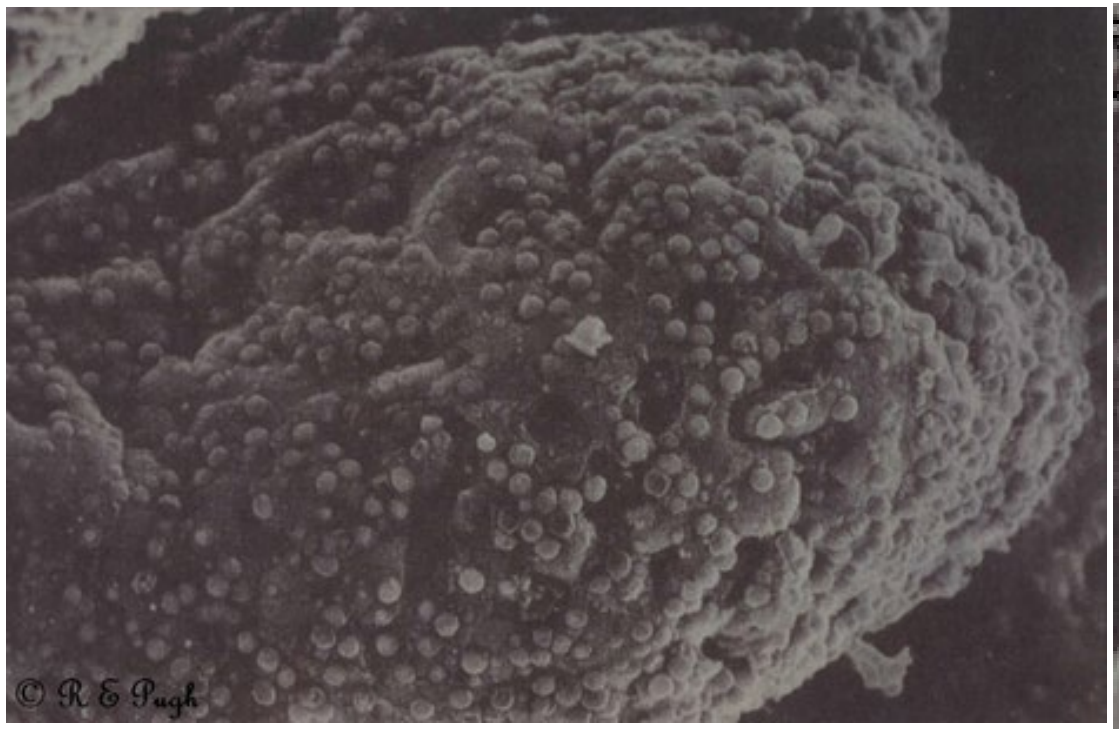
Morphology: *C. parvum*

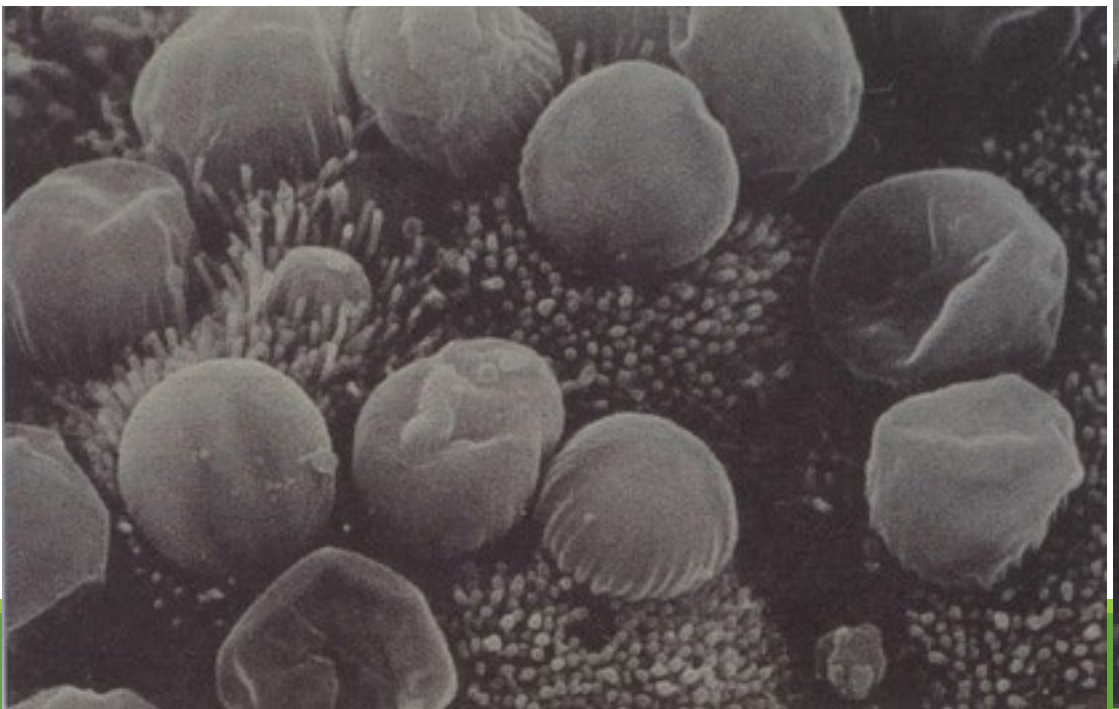
parasitophorous vacuole (PV)
feeder organelle (FO)
residual body (RB)
merozoites (Mz)

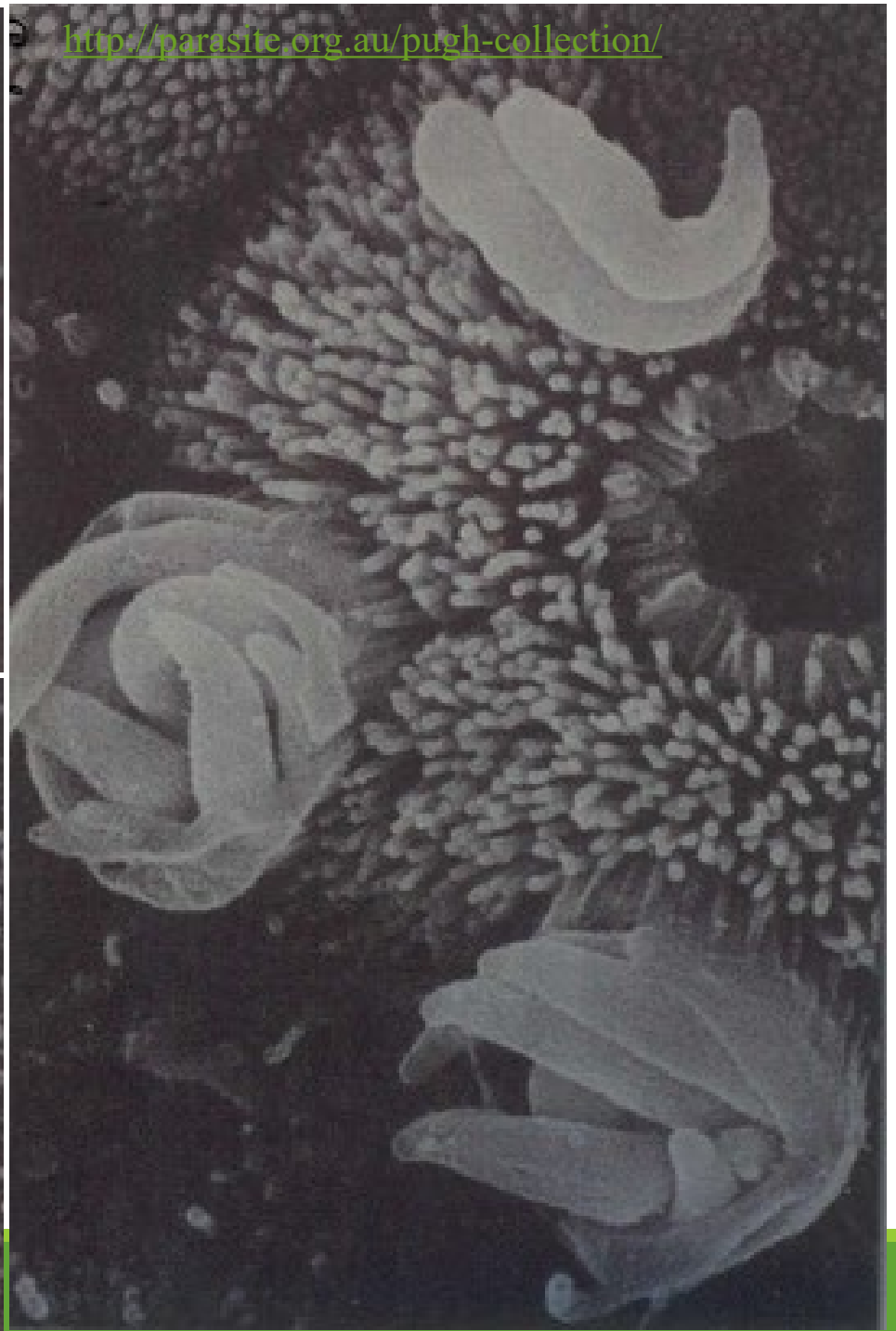
The enterocyte microvilli immediately adjacent to the parasite are typically elongated.



https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3368497/







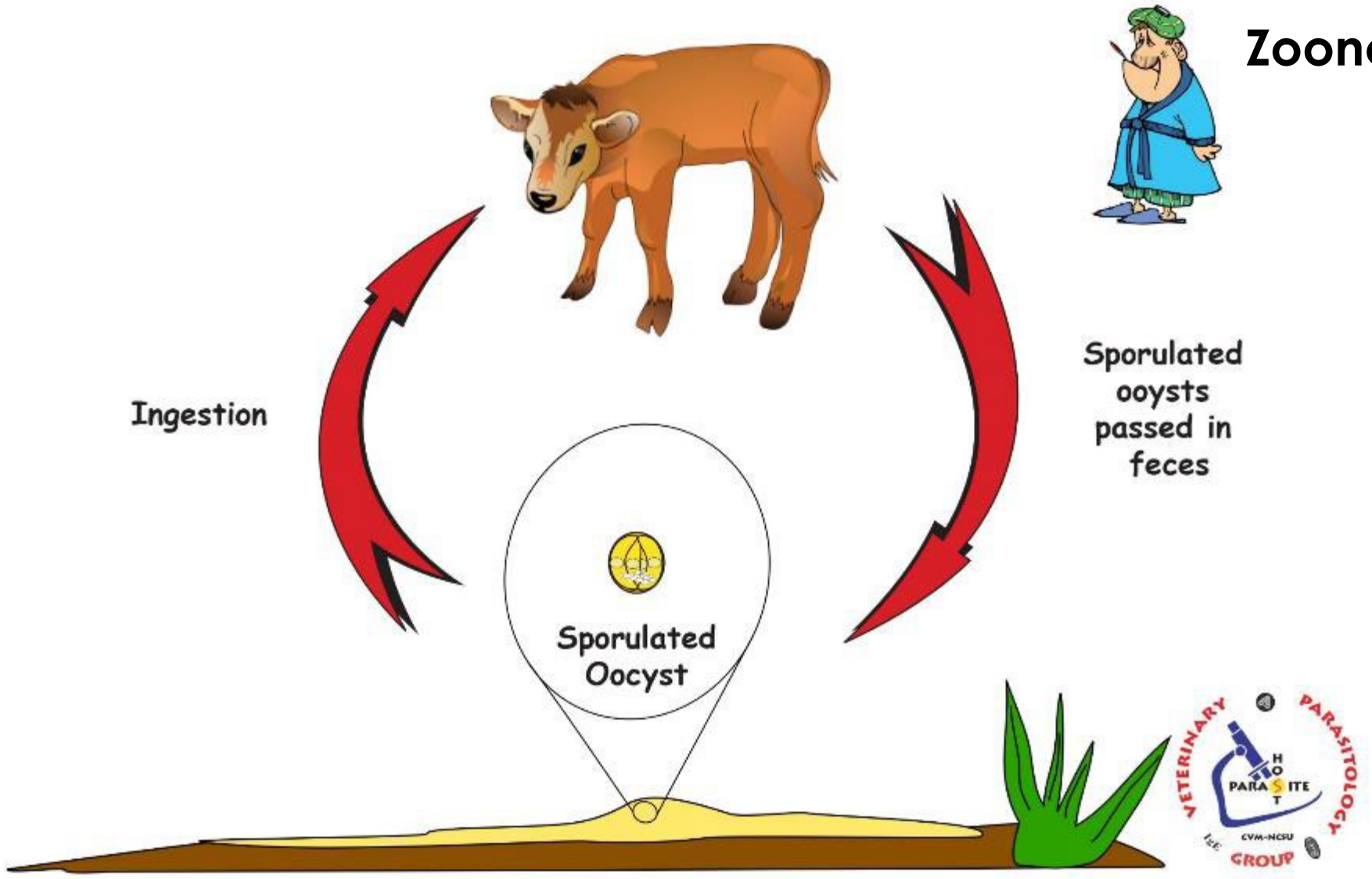
SEM's of Crypto

FYI

NC STATE UNIVERSITY

Direct life cycle

Cryptosporidium parvum

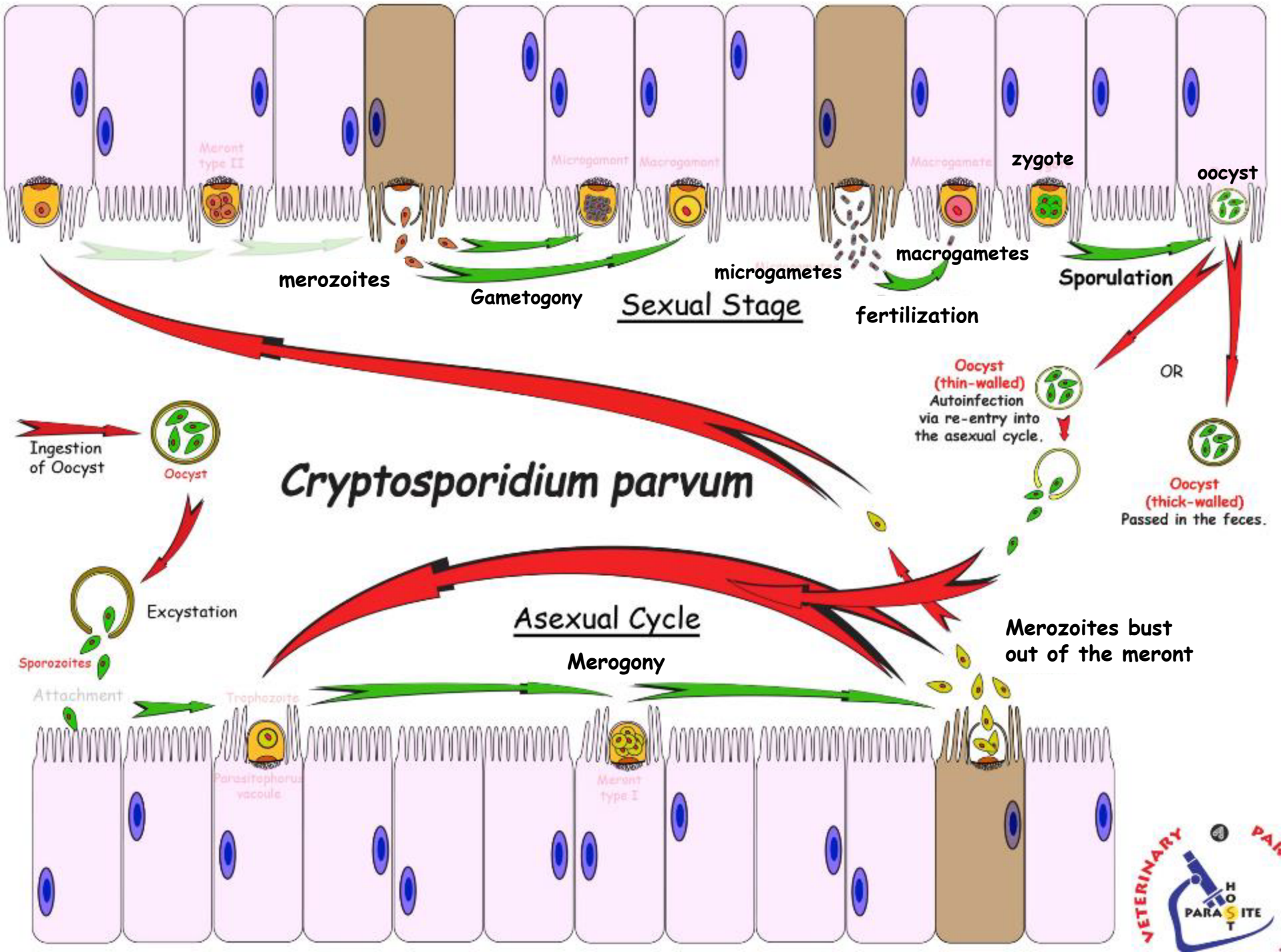


Zoonotic!

Life Cycle: *C. parvum*

start here

small intestines



Life Cycle: *C. parvum*

Transmission

- **Direct life cycle – fecal-oral, ingestion of sporulated oocyst**

Invasion

- Sporocysts excyst from oocyst and **invade microvillus border of enterocyte**

Asexual reproduction (small intestines: Ileum, less in cecum & colon)

- Merogony

Sexual reproduction

- Final generation of merozoites infect other enterocytes and undergo gametogony (production of gametes)

- Fertilization – a microgamete fuses with a macrogamete eventually forming an oocyte

Life Cycle: *C. parvum*

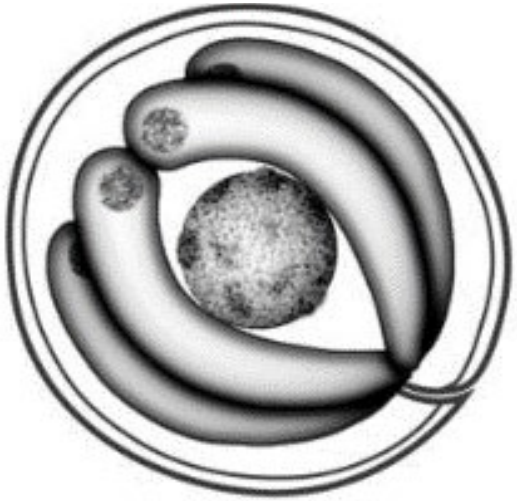
Sporogony (= Sporulation) – oocyst forms 4 sporozoites

- **Sporulation occurs within the host gut = oocyst immediately infectious.**

Dissemination

- **Thin-walled Oocysts**
  - **Autoinfection:** oocysts have thin walls and **excyst within the same host**
    - Normal immune system → low grade chronic pathology (diarrhea)
    - Immunocompromised → hyperinfection / severe pathology / mortality.

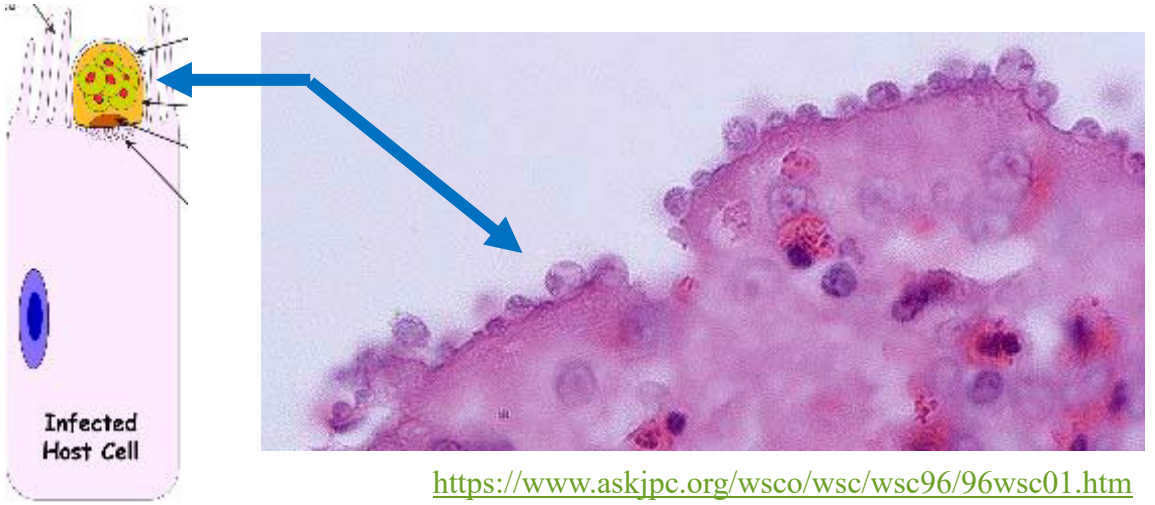
- **Thick-walled Oocysts**
  - **Exit the host in the feces**
    - Contaminate the environment and **transmission to the next host**.
    - **Infectious when passed**



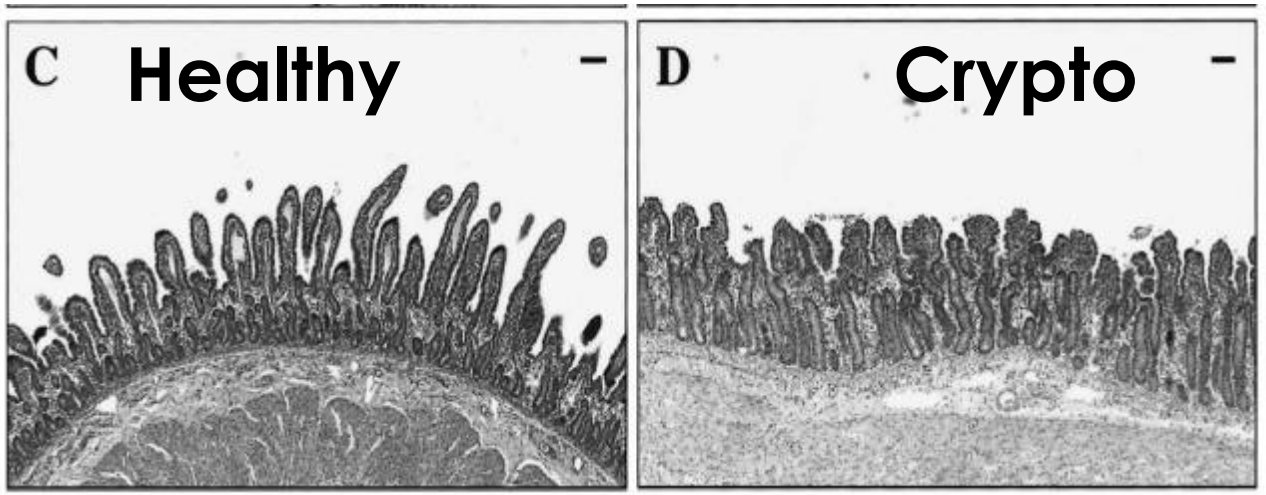
C. parvum Pathogenesis → Watery Diarrhea

Direct damage (inside microvilli)

- **Small Intestine villus atrophy and dysfunction**
  - ↓ surface area
  - ↓ absorption
- Crypt hyperplasia causes ↑ secretory activity



https://www.askjpc.org/wsco/wsc/wsc96/96wsc01.htm



Indirect damage

- Inflammation

↑ permeability, with loss of fluids into the gut lumen.

Image: Gookin, Jody L., Shila K. Nordone, and Robert A. Argenzio. "Host responses to Cryptosporidium infection." *Journal of veterinary internal medicine* 16.1 (2002): 12-21.

Clinical Disease: *C. parvum*

http://www.vetserviceswairarapa.co.nz/news/article/16/calf-scours-feeder-calf-rearing/

Mild to severe watery diarrhea

- **usually in neonatal calves** (1-2 weeks)
- "**Calf Scours**"
- Most cases are self-limiting (2-3 days)
- **dehydration, weight loss, and emaciation**.
- **Severe / lethal in immunodeficient hosts**
- Also see clinical disease in small ruminants

Clinical Disease:

C. parvum

"*Calf Scours*"

http://calfcare.ca/calf-care-corner/feeding-to-fight-disease/

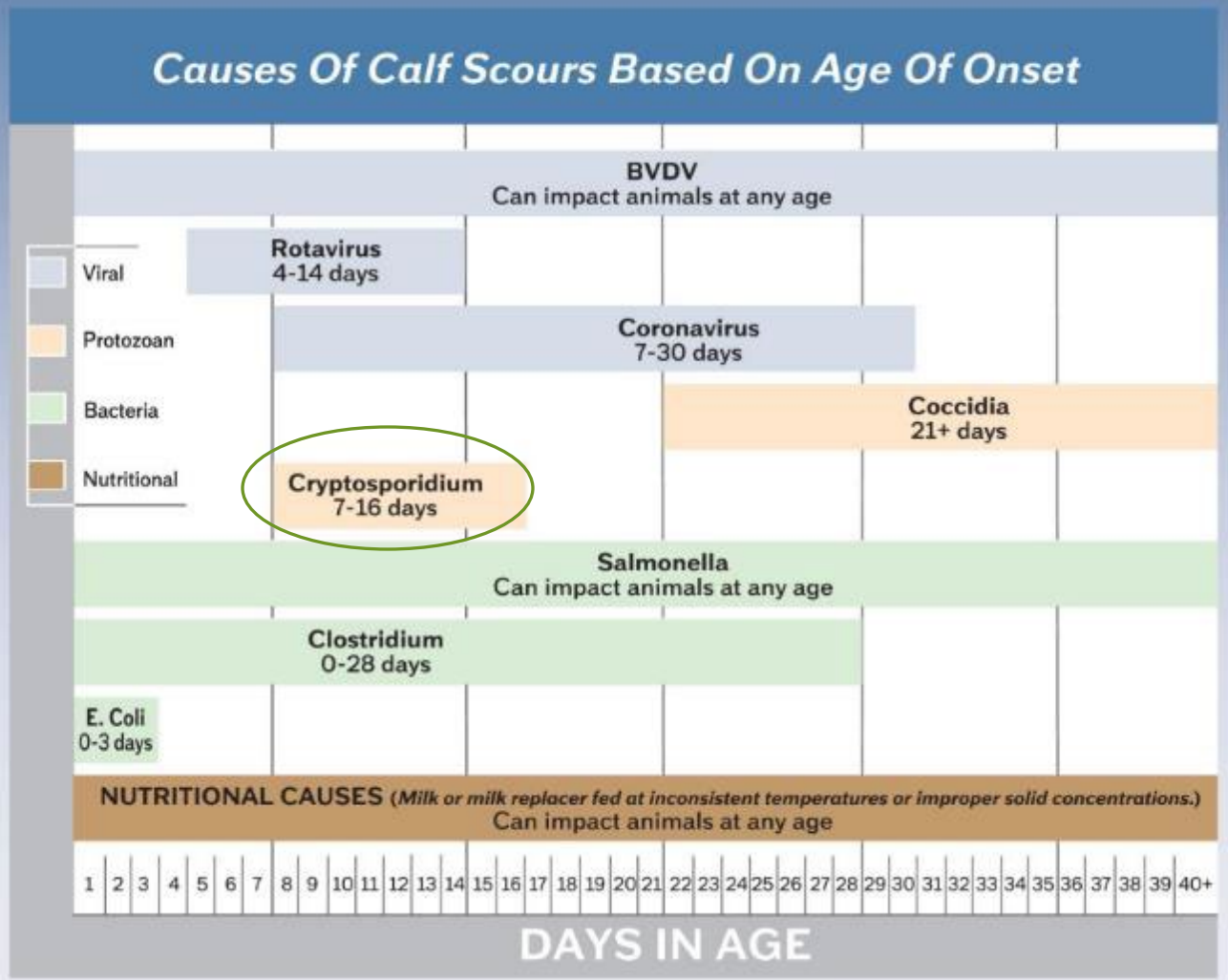
http://coloradodisasterhelp.colostate.edu/prefair/disease/dz/Cryptosporidiosis.html

Differential Diagnoses "Calf Scours" <21 days old

1. ***Cryptosporidium* 7-16 days**
2. *Enterotoxigenic E.coli*
3. Rotavirus
4. Coronavirus
5. *Salmonella*

<u>*Others*</u>
Bovine viral diarrhea virus (BVDV)
Clostridium
Nutritional causes

Know the age difference between *Crypto* and *Eimeria* infections (other differentials are **FYI**)



GOALS WHEN TREATING SCOURS

1. Maintain caloric intake. Keep the calf on its normal feeding schedule.
2. Restore hydration status.
3. Stabilize the intestinal tract.

http://crystalcreeknatural.com/causes-of-calf-scours-based-on-age-of-onset/

FYI: this chart

Diagnosis: *C. parvum*

Fecal Float Centrifugation
- very small oocysts
- don't confuse with yeast

Thin fecal smear with special staining
- acid fast stains

Molecular diagnostics
- Fluorescent antibodies bind oocysts, ELISA, PCR

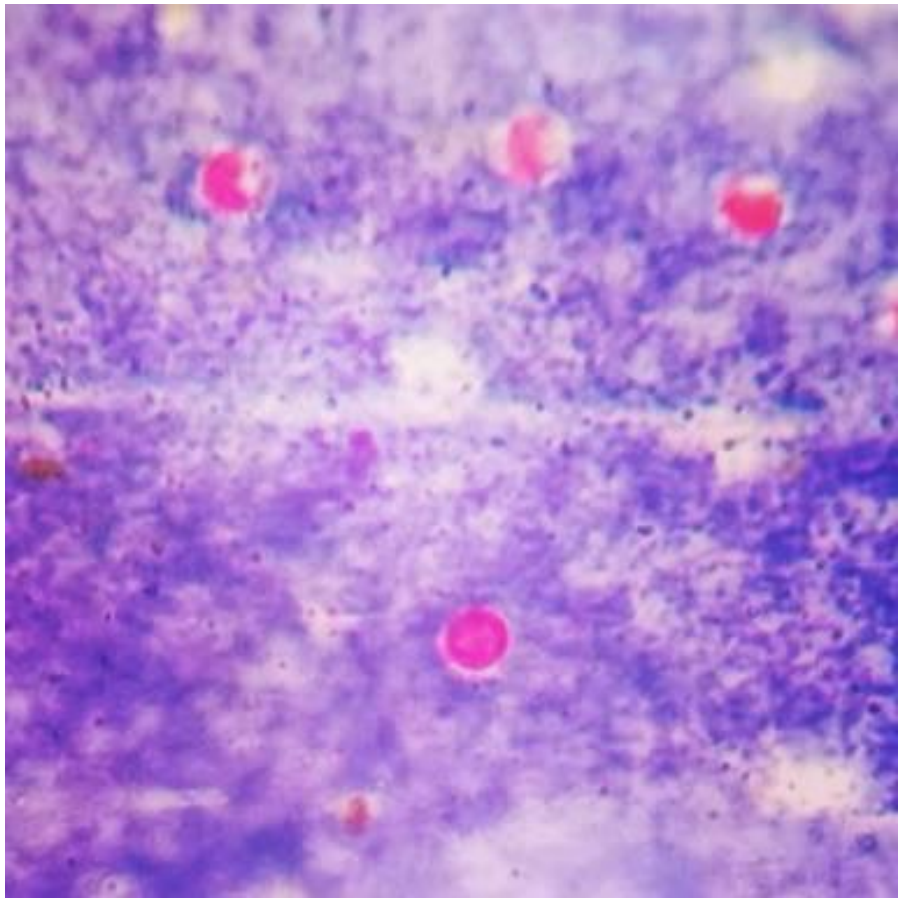
C. parvum

Use concentrated sucrose for fecal float

https://mcdinternational.org

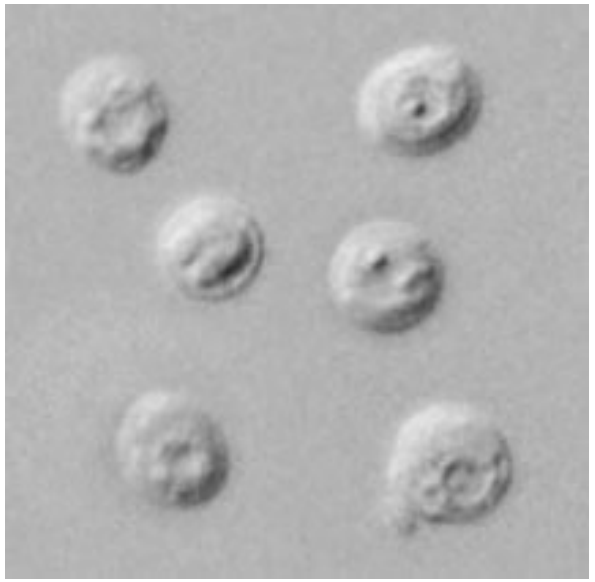
Diagnosis: *C. parvum*

Acid-fast Stain



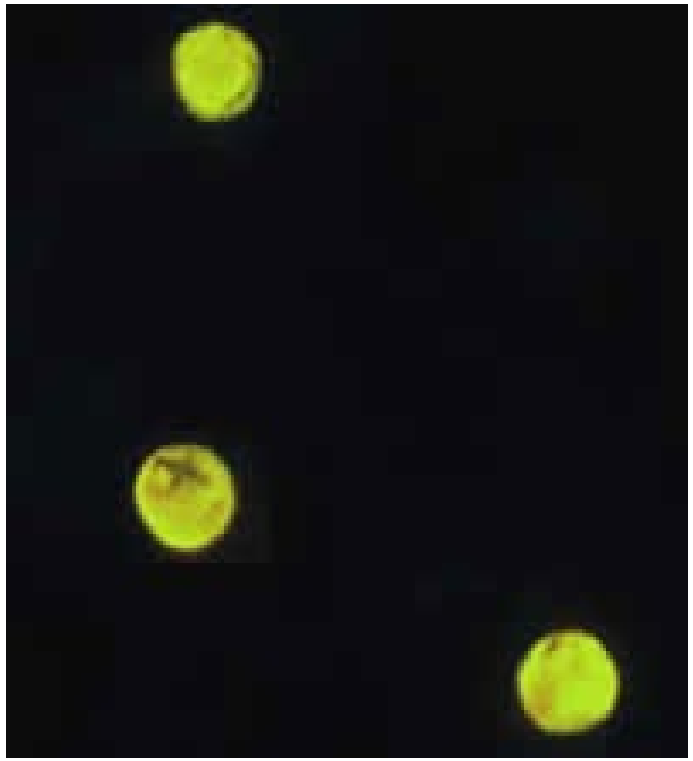
http://www.imgrum.org/media/1000074980669288494_423165795

Wet Mounts



https://mcdinternational.org

Fluorescent stain



https://www.cdc.gov/dpdx/cryptosporidiosis/

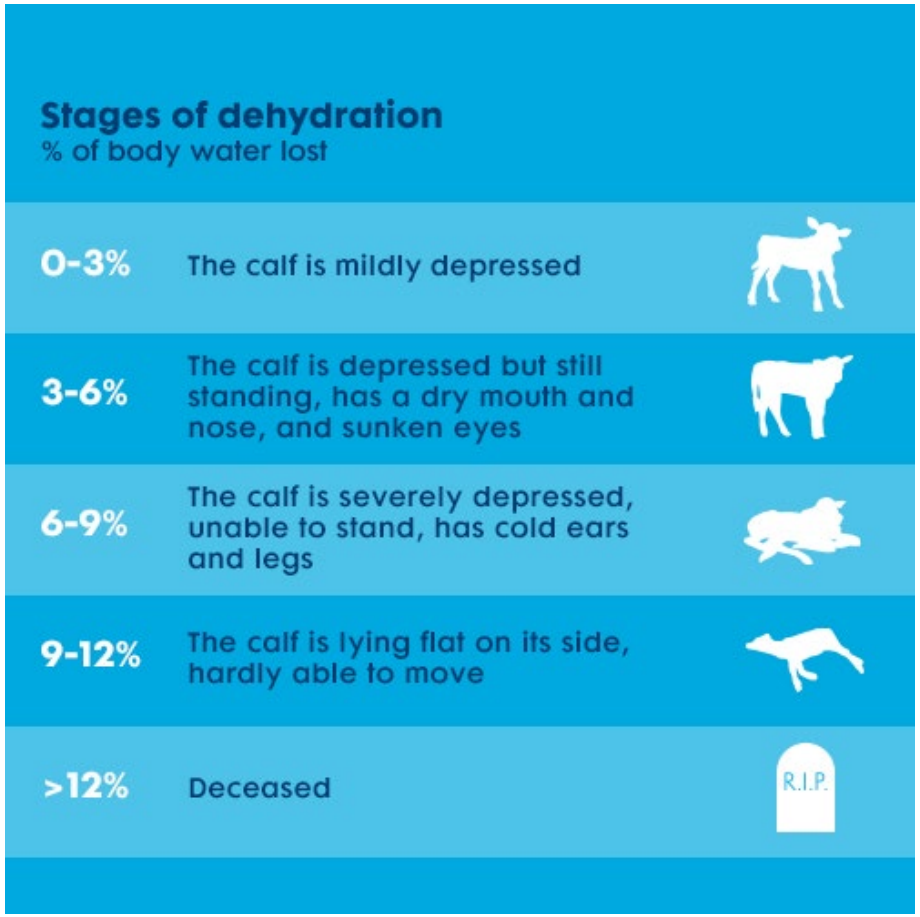
Treatment: *C. parvum*

- Some drugs are only suppressive (Paromomycin, Azithromycin, etc.)
- **Coccidiostats don't work**
- Infection is usually self-limiting in immunocompetent hosts (only need supportive care)
- **Fluid-replacement therapy** for dehydration caused by diarrhea is the main way to treat *C. parvum*.

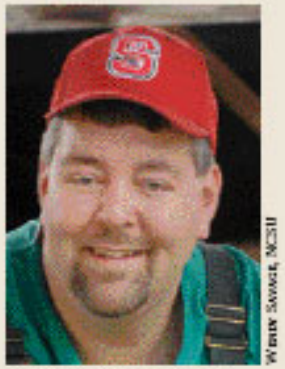
  Electrolyte solution

  Allow calf to feed on milk

FYI: Dehydration Decisions



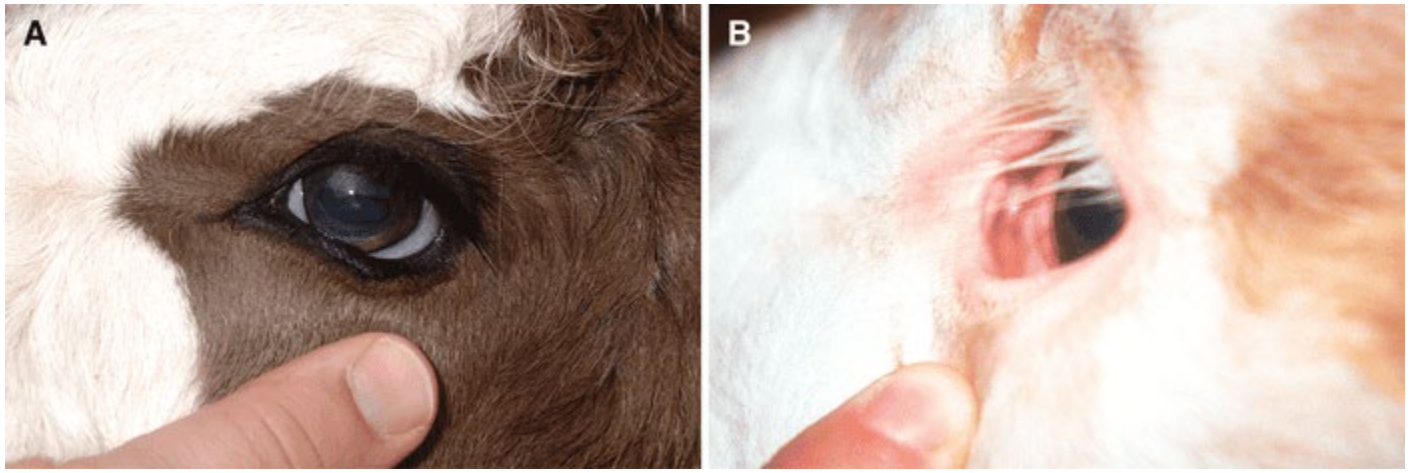
https://www.farmosan.com/en/ruminants/beef-farming/calf-rearing/scours/



Geof Smith, DVM, PhD, Dipl. ACVIM

CALF DEHYDRATION ASSESSMENT CHART

% of dehydration	Demeanor	Sunken eye	Skin tenting
< 6%	Normal	none	none
6-8%	Depressed	2-4 mm	1-3 seconds
8-10%	Depressed	4-6 mm	2-5 seconds
10-12%	Comatose	6-8 mm	5-10 seconds
> 12%	Dead	8-12 mm	> 10 seconds



Oral and IV fluid replacement decisions made based on severity of dehydration.

Control: *C. parvum*

- **Sanitation and hygiene**
- **Isolation/separation (sick/young)**
  - Hutch system for dairy calves
- **Colostrum**
- **Oocysts are viable for months** unless exposed to:
  - extreme temps (0°C or >65 °C), drying
  - disinfectants (5% ammonia, 3-6% H2O2 or 10% formaldehyde)
- No Vaccines Available

Calf hutches

Epidemiology

Disease is primarily in **neonatal calves** (and small ruminants)

Concurrent infections with rotavirus & coronavirus tends to make disease worse, than with *Crypto* alone.

Risk factors for calf scours:

1. Dirty or contaminated environments
2. Stress factors
3. Housing sick calves with healthy calves
4. Not enough, or low-quality, colostrum

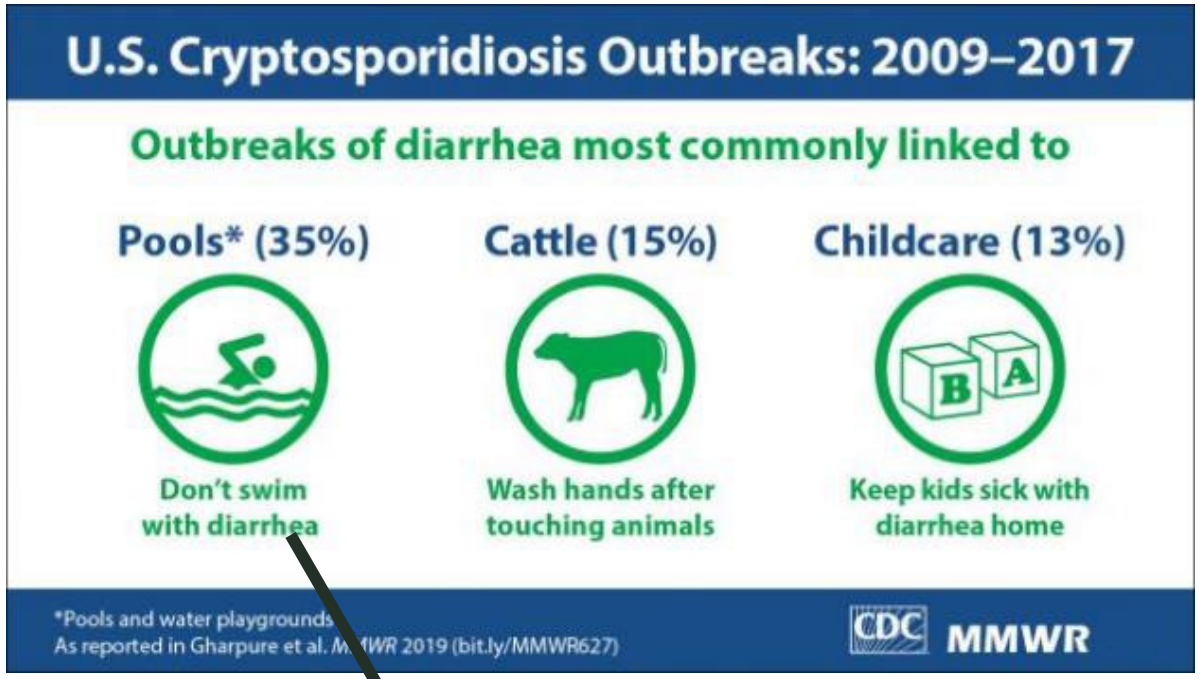
Zoonosis: *C. parvum* (*C. hominis* in humans, too)

Highly zoonotic

Transmission:

- **Predominantly human-to-human**
- **Direct contact with animals**
- **Contamination of drinking water**
- Food-borne outbreaks
- **Veterinarians and farmers at high risk**

Very dangerous in the immunocompromised.



Resistant to chlorine

Zoonosis: *C. parvum*

Levine, Levy, Walker, Crittenden. 1988.

Cryptosporidiosis in veterinary students.

JAVMA. 193: 1413-1414.

Abstract: Cryptosporidiosis was diagnosed in **10 veterinary students**. Exposure to the pathogen was associated with **direct contact with infected calves and contact with contaminated materials**. Affected students had fever (50%), headache (50%), nausea (70%), diarrhea (80%), and vomiting (40%). Clinical signs persisted for 30 hours to 16 days after the onset of clinical signs of disease. Although one student required hospitalization, the remaining students recovered without treatment.

FYI

FYI: *Cryptosporidium spp.* in Dogs and Cats

C. canis and *C. felis*

Most canine / feline *Cryptosporidium* infections are subclinical and self-limiting.

IF clinical signs occur = diarrhea (usu. small bowel)and dehydration, depend on host immune status and co-infections

More frequently detected with GI pathogen co-infections (i.e diarrhea not resolving with treatment for a GI pathogen, think Crypto)

Diagnosis: oocysts in fecal floats (difficult to detect), GI PCR panel (Antech KeyScreen), Fecal ELISA (cornell)

Treatment for persistent diarrhea (anecdotal) = Paromomycin, Tylosin or Azithromycin

Cryptosporidium parvum Take Home Points

1. Direct Life Cycle, fecal-oral transmission
2. Direct destruction of the enterocytes causes diarrhea
3. Primarily disease of calves (7-16 days old)"calf scours"
4. Infectious immediately after passed
5. Hyper infection from thin-walled walled oocysts
6. On a fecal, oocysts very small
7. Treat the dehydration
8. Prevention is key!
9. NOT host specific (zoonotic)
10. Veterinarians and farmers at risk

In-Class Discussion

A 12-day old calf is showing severe scours.

Treatment plan?

Zoonotic concerns?

What if this calf was 1 month old??

Have Questions?

baquroll@ncsu.edu

Illustration by Allie Brosh, http://hyperboleandahalf.blogspot.com/