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PART THREE. SPECIFIC EXCRETED PATHOGENS: ENVIRONMENTAL AND EPIDEMIOLOGY ASPECTS

CRYPTOSPORIDIUM SPP.

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Summary

Cryptosporidium [illegible] *Cryptosporidium* [illegible] *Cryptosporidium* [illegible]

[illegible]

Cryptosporidium [illegible] *C. hominis*, *C. parvum* [illegible] *C. meleagridis* [illegible] *Cryptosporidium* [illegible]

[illegible]

[illegible] *Cryptosporidium* [illegible] *Cryptosporidium* [illegible]

[illegible] *Cryptosporidium* [illegible] *Cryptosporidium* [illegible]

[illegible] *Cryptosporidium* [illegible]

[illegible] *Cryptosporidium* [illegible]

[illegible] *Cryptosporidium* [illegible] *Cryptosporidium* [illegible]

[illegible] *Cryptosporidium* [illegible]

1.0 Epidemiology of the Disease and Pathogen(s)

1.1 Global Burden of Disease

[illegible] *Cryptosporidium* [illegible]

1.2 Taxonomic Classification of the Agent(s)

[illegible] *C. hominis* [illegible] *C. parvum* [illegible] *C. parvum* [illegible]

[illegible]

Table 1. Formally described *Cryptosporidium s*pecies, their oocyst sizes, major hosts and reported human infections

***Cryptosporidium* species**	**Mean Oocyst Dimensions (μm)[a]**	**Major Host(s)**	**Reported Human Infection**
C. andersoni	[illegible]	[illegible]	[illegible]
C. avium [illegible]	[illegible]	[illegible]	[illegible]
C. apodemi	[illegible]	[illegible]	[illegible]
C. baileyi	[illegible]	[illegible]	[illegible]
C. bovis [illegible]	[illegible]	[illegible]	[illegible]
C. canis [illegible]	[illegible]	[illegible]	[illegible]
C. cuniculus [illegible]	[illegible]	[illegible]	[illegible]
C. ditrichi	[illegible]	[illegible]	[illegible]
C. ducismarci	[illegible]	[illegible]	[illegible]
C. erinacei	[illegible]	[illegible]	[illegible]
C. fayeri [illegible]	[illegible]	[illegible]	[illegible]
C. felis	[illegible]	[illegible]	[illegible]
C. fragile	[illegible]	[illegible]	[illegible]
C. galli	[illegible]	[illegible]	[illegible]
C. homai	[illegible]	[illegible]	[illegible]
C. hominis [illegible] *C. parvum* [illegible]	[illegible]	[illegible]	[illegible]
C. huwi [illegible] *piscine* [illegible]	[illegible]	[illegible]	[illegible]
C. macropodum [illegible]	[illegible]	[illegible]	[illegible]
C. meleagridis	[illegible]	[illegible]	[illegible]
C. molnari	[illegible]	[illegible]	[illegible]
C. muris	[illegible]	[illegible]	[illegible]
C. occultus	[illegible]	[illegible]	[illegible]
C. parvum [illegible]	[illegible]	[illegible]	[illegible]
C. proliferans	[illegible]	[illegible]	[illegible]
C. ryanae [illegible]	[illegible]	[illegible]	[illegible]
C. rubeyi	[illegible]	[illegible]	[illegible]
C. scrofarum [illegible]	[illegible]	[illegible]	[illegible]
C. serpentis	[illegible]	[illegible]	[illegible]

***Cryptosporidium* species**	**Mean Oocyst Dimensions (µm)[a]**	**Major Host(s)**	**Reported Human Infection**
C. suis [illegible]	[illegible]	[illegible]	[illegible]
C. tyzzeri [illegible]	[illegible]	[illegible]	[illegible]
C. ubiquitum [illegible]	[illegible]	[illegible]	[illegible]
C. viatorum	[illegible]	[illegible]	[illegible]
C. varanii [illegible] *C. saurophilum* [illegible]	[illegible]	[illegible]	[illegible]
C. wrairi	[illegible]	[illegible]	[illegible]
C. xiaoi [illegible] *C. bovis* [illegible] *C. agni)*	[illegible]	[illegible]	[illegible]

[illegible]

[illegible] *Cryptosporidium* [illegible] *C. parvum* [illegible] *C. hominis* [illegible] *Cryptosporidium* [illegible] *C. hominis* [illegible] *C. parvum* [illegible]

1.3 Transmission

[illegible] *Cryptosporidium* [illegible]

[illegible] *C. parvum* [illegible] *C. hominis* [illegible]

[illegible] *C. hominis* [illegible] *C. parvum* [illegible] *C. meleagridis* [illegible] *C. meleagridis* [illegible] *C. parvum* [illegible] *C. hominis* [illegible]

[illegible] *Cryptosporidium* [illegible] *C. hominis* [illegible] *C. parvum* [illegible]

[illegible]

Cryptosporidium [illegible]

[illegible]

[illegible] *Cryptosporidium* [illegible]

[illegible] *Cryptosporidium* [illegible] *C. hominis* [illegible] *C. parvum* [illegible] *C. parvum* [illegible] *Cryptosporidium* [illegible] *C. felis* [illegible] *C. canis* [illegible] *Cryptosporidium* [illegible] *C. cuniculus* [illegible]

[illegible] *Cryptosporidium* [illegible] *C. parvum* [illegible] *C. hominis* [illegible] *Cryptosporidium* [illegible] *C. cuniculus* [illegible]

[illegible] *Cryptosporidium* [illegible]

[illegible] *Cryptosporidium* [illegible] *Cryptosporidium* [illegible]

[illegible] *Cryptosporidium* [illegible] *Cryptosporidium* [illegible] *Cryptosporidium* [illegible]

[illegible]

Cryptosporidium [illegible] *Cryptosporidium* [illegible] *C. hominis* [illegible] *C. parvum* [illegible] *C. parvum* [illegible] *C. parvum* [illegible] *C. parvum* [illegible] *C. parvum* [illegible] *Cryptosporidium* [illegible] *C. canis* [illegible] *C. felis* [illegible] *C. meleagridis* [illegible] *C. hominis* [illegible]

[illegible] *Cryptosporidium* [illegible]

Cryptosporidium [illegible] *Cryptosporidium* [illegible] *C. parvum* [illegible] *C. bovis* [illegible] *C. ryanae* [illegible] *C. andersoni* [illegible]

[illegible]

Cryptosporidium [illegible]

[illegible] *C. hominis* [illegible] *C. parvum* [illegible]

[illegible] *Cryptosporidium* [illegible]

Cryptosporidium [illegible] *Cryptosporidium* [illegible] *Cryptosporidium* [illegible] *Cryptosporidium* [illegible] *Cryptosporidium* [illegible]

1.4 Population and Individual Control Measures

[illegible]

Cryptosporidium [illegible]

Cryptosporidium

Cryptosporidium

Cryptosporidium

staff

C. parvum *C. hominis*

2.0 Environmental Occurrence and Persistence

Cryptosporidium

[illegible]

2.1 Detection Methods

[illegible]

2.2 Data on Occurrence

[illegible]

[illegible]

[illegible]

[illegible] *Cryptosporidium* [illegible] *Cryptosporidium* [illegible] *Cryptosporidium* [illegible]

Table 2. Frequency of detection and concentration of *Cryptosporidium* in untreated sewage

Country	Sample Type	Percent Positive Samples	Concentration Average (Range) Oocysts/L	Reference
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

[illegible]

[illegible] *Cryptosporidium* [illegible]

Cryptosporidium [illegible]

[illegible] *Cryptosporidium* [illegible]

[illegible] *C. parvum* [illegible] *C. hominis* [illegible]

[illegible] *C. parvum* [illegible] *C. hominis* [illegible] *Cryptosporidium* [illegible] *Cryptosporidium* [illegible] *Cryptosporidium* [illegible]

[illegible]

[illegible] *Cryptosporidium* [illegible] *Cryptosporidium* [illegible] *Cryptosporidium* [illegible] *Cryptosporidium* [illegible] *Cryptosporidium* [illegible] *Cryptosporidium* [illegible]

Table 3. Occurrence of *Cryptosporidium* spp. in surface water and recreational waters

Country	Sample Type	Percent Positive Samples	Concentration Average (Range) Oocyst/L	Reference
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Country	Sample Type	Percent Positive Samples	Concentration Average (Range) Oocyst/L	Reference
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible] [illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible] [illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Country	Sample Type	Percent Positive Samples	Concentration Average (Range) Oocyst/L	Reference
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible] *Cryptosporidium* [illegible] *Cryptosporidium* [illegible] *C. parvum* [illegible]

[illegible] *Cryptosporidium* [illegible] *Cryptosporidium* [illegible] *Cryptosporidium* [illegible]

Table 4. Occurrence of *Cryptosporidium o*ocysts in groundwater systems

Country	Sample Type	Percent Positive Samples	Concentration Average (Range) Oocysts/L	Reference
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

[illegible]

[illegible] *Cryptosporidium* [illegible]

[illegible] *Cryptosporidium* [illegible] *Cryptosporidium* [illegible] *Cryptosporidium* [illegible]

[illegible]

[illegible] *Cryptosporidium* [illegible]

Table 5. Occurrence of *Cryptosporidium o*ocysts in treated drinking waters

Country	Sample Type	Percent Positive Samples	Concentration Average (Range) Oocysts/L	Reference
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Country	Sample Type	Percent Positive Samples	Concentration Average (Range) Oocysts/L	Reference
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

[illegible] *Cryptosporidium* [illegible]

[illegible] *Cryptosporidium* [illegible] *Cryptosporidium* [illegible]

[illegible] *Cryptosporidium* [illegible] *Cryptosporidium* [illegible] *Cryptosporidium* [illegible] *Cryptosporidium* [illegible] *Cryptosporidium* [illegible]

[illegible]

[illegible] *C. andersoni* [illegible] *C. parvum* [illegible] *C. baileyi* [illegible] *C. bovis* [illegible] *C. andersoni* [illegible] *C. parvum* [illegible] *C. ubiquitum* [illegible] *Cryptosporidium* [illegible]

[illegible] *Cryptosporidium* [illegible]

[illegible]

[illegible] *Cryptosporidium* [illegible] *Giardia* [illegible] *Toxoplasma* [illegible] *Cryptosporidium* [illegible] *C. parvum* [illegible] *C. hominis* [illegible] *C. baileyi*, *C. meleagridis*, *C. andersoni* [illegible] *C. felis* [illegible] *Cryptosporidium* [illegible] *C. parvum*, *C. hominis* [illegible] *C. meleagridis* [illegible] *C. parvum* [illegible] *C. hominis* [illegible] *C. parvum* [illegible]

[illegible] *Cryptosporidium* [illegible] *C. parvum* [illegible]

[illegible] *Cryptosporidium* [illegible] *Giardia* [illegible] *Cryptosporidium* [illegible] *Giardia* [illegible] *Cryptosporidium* [illegible] *Giardia* [illegible] *Cryptosporidium* [illegible]

C. parvum [illegible] *Giardia lamblia*, *Encephalitozoon intestinalis*, *E. hellem* [illegible] *Enterocytozoon bieneusi* [illegible]

[illegible] *Cryptosporidium* [illegible] *Cryptosporidium* [illegible]

[illegible] *Cryptosporidium* [illegible] *Cryptosporidium* [illegible] *Cryptosporidium* [illegible] *Cryptosporidium* [illegible] *Cryptosporidium* [illegible] *C. parvum* [illegible] *C. parvum* [illegible] *C. hominis* [illegible] *C. meleagridis* [illegible] *Cryptosporidium* [illegible]

[illegible] *C. parvum* [illegible] *Mytilus* [illegible] *Cryptosporidium* [illegible] *Toxoplasma gondii* [illegible]

2.3 Persistence

[illegible] *Cryptosporidium* [illegible] *Cryptosporidium* [illegible]

Cryptosporidium [illegible]

[illegible]

[illegible] *Cryptosporidium* [illegible]

Cryptosporidium [illegible]

[illegible] *C. parvum* [illegible]

Table 6. Environmental factors influencing the viability and infectivity of *C. parvum* oocysts (Carey et al., 2004)

Environmental Media	Temperature (°C)	Time Days (Unless Otherwise Noted)	Reduction in Oocyst Viability/Infectivity	Assessment Method	References
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Environmental Media	Temperature (°C)	Time Days (Unless Otherwise Noted)	Reduction in Oocyst Viability/Infectivity	Assessment Method	References
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

[illegible]

[illegible]

[illegible] *Cryptosporidium* [illegible]

[illegible] *Cryptosporidium* [illegible]

[illegible]

[illegible] *Cryptosporidium* [illegible] *C. parvum* [illegible]

[illegible] *C. parvum* [illegible] *Cryptosporidium* [illegible]

[illegible] *C. parvum* [illegible] *C. parvum* [illegible]

3.0 Reduction by Sanitation Management

[illegible] *Cryptosporidium* [illegible]

Table 7. A Summary of studies on the removal efficiency of *Cryptosporidium o*ocysts by different wastewater treatment processes

Country	Plant	Population Served	Primary Treatment	Secondary Treatment	Tertiary Treatment	Disinfection	Oocyst/L Influent Average	Oocyst/L Effluent Average	Log_{10} Removal	Reference
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
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Country	Plant	Population Served	Primary Treatment	Secondary Treatment	Tertiary Treatment	Disinfection	Oocyst/L Influent Average	Oocyst/L Effluent Average	Log_{10} Removal	Reference
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
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3.1 Excreta and Wastewater Treatment

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[illegible] *Cryptosporidium* [illegible] *Cryptosporidium* [illegible]

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[illegible] *Cryptosporidium* [illegible]

[illegible] *C. parvum* [illegible]

Cryptosporidium *C. parvum* *Salmonella*

Cryptosporidium *Cryptosporidium*

Cryptosporidium

Cryptosporidium *Cryptosporidium* *C. parvum*

C. parvum

Cryptosporidium *Cryptosporidium* *Cryptosporidium*

3.2 Disinfection

References

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[illegible] *Cryptosporidium* [illegible] *Giardia* [illegible]

[illegible]

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[illegible] *et al* [illegible] *Cryptosporidium* [illegible] *Giardia* [illegible]

[illegible]

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[illegible] *et al* [illegible] *Giardia duodenalis* [illegible] *Cryptosporidium* [illegible]

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[illegible]

[illegible] *et al* [illegible] *Cryptosporidium parvum* [illegible]

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[illegible]

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Cryptosporidium parvum

Cryptosporidium parvum *Cryptosporidium hominis* *Giardia duodenalis*

Cryptosporidium parvum *Cryptosporidium hominis* *Giardia duodenalis*

Cryptosporidium *Giardia*

Cryptosporidium

et al *Cryptosporidium* *Cryptosporidium* *Apicomplexa*

Cryptosporidium

Cryptosporidium *Giardia* *Enterocytozoon bieneusi*

Cryptosporidium parvum

Cryptosporidium *Giardia*

Cryptosporidium parvum

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[illegible] *Cryptosporidium* [illegible] *Giardia* [illegible]

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[illegible] *et al* [illegible]

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[illegible] *et al* [illegible]

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