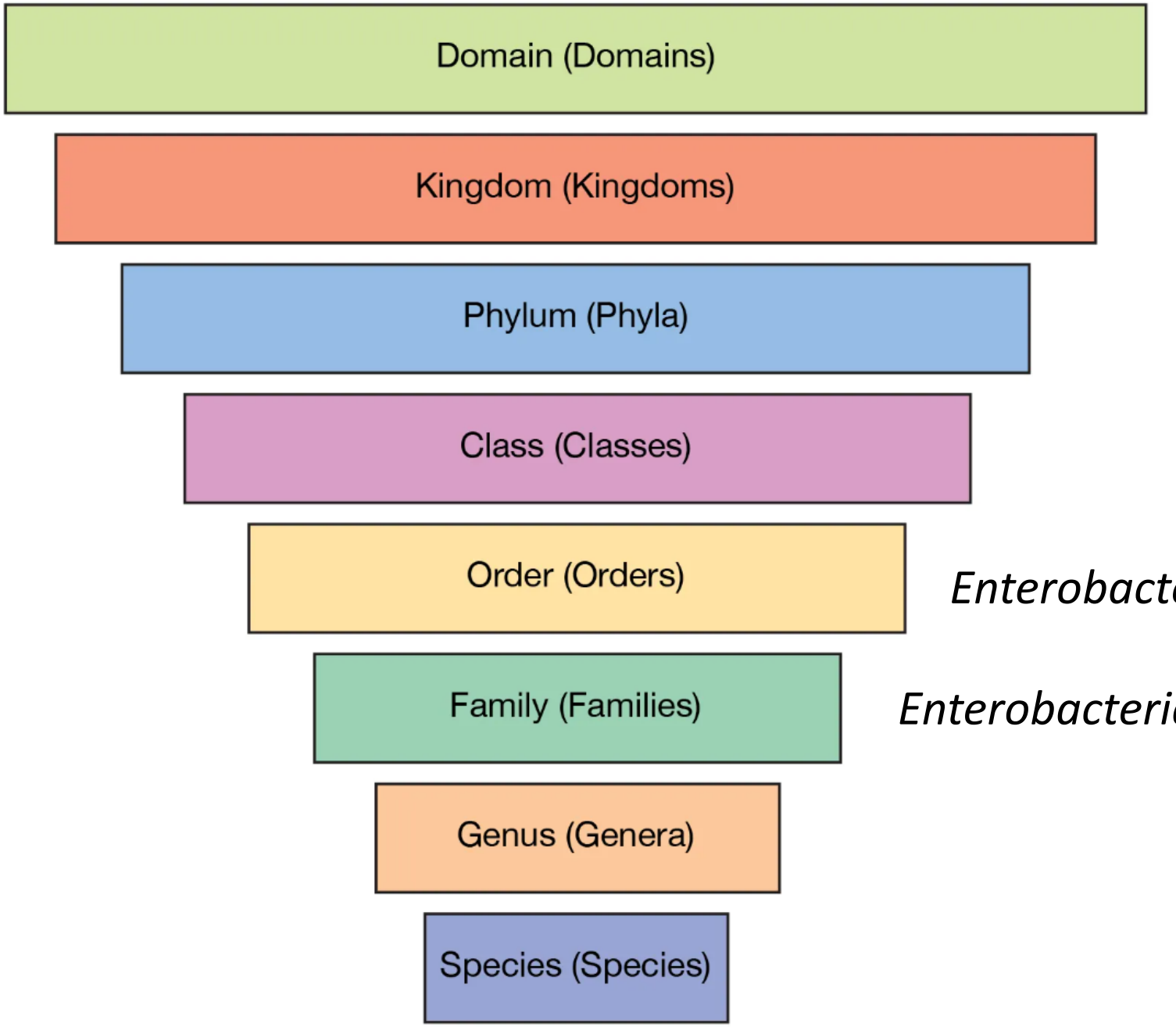
G- bacteria I

Enterobacterales
G+ and G- anaerobes

Anežka Gryndlerová

anezka.gryndlerova@lfmotol.cuni.cz

Enterobacterales



Enterobacterales (order)

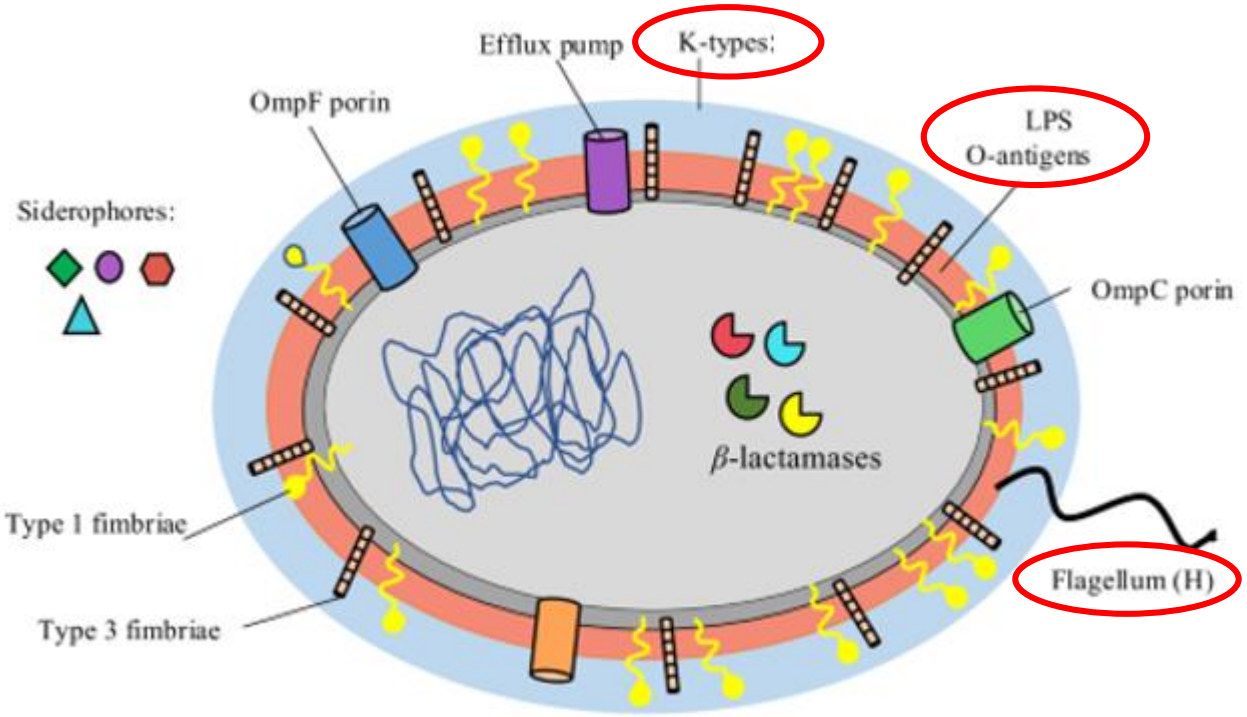
Enterobacteriaceae (family)

Enterobacterales

- G- rods
- >250 species
- Mostly motile (except *Shigella, Klebsiella, Yersinia pestis*)
- Glucose fermenting
- Gut microbiota (various infections) X gut infections
- Good growth on blood agar and MacConkey agar; relatively resistant to harsh environmental conditions
- Often capable of conjugation – spread of a resistance genes (plasmids) → different resistance patterns

https://www.flickr.com/

Cell wall structure

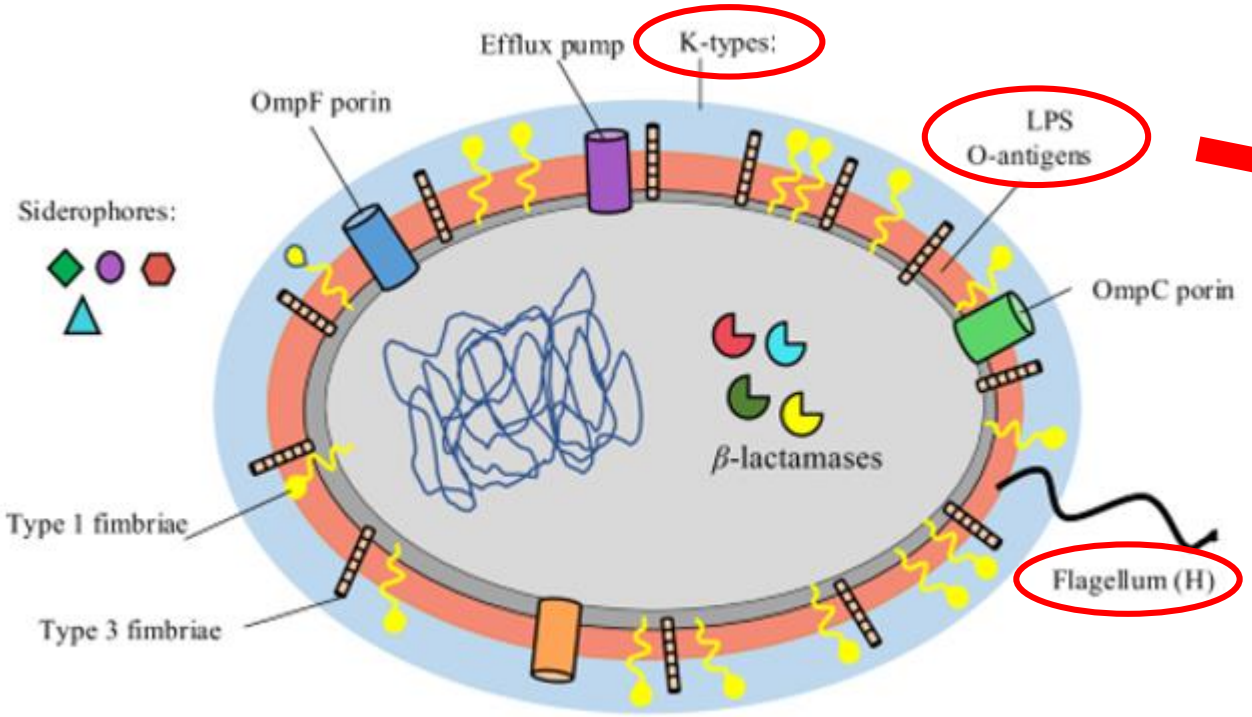


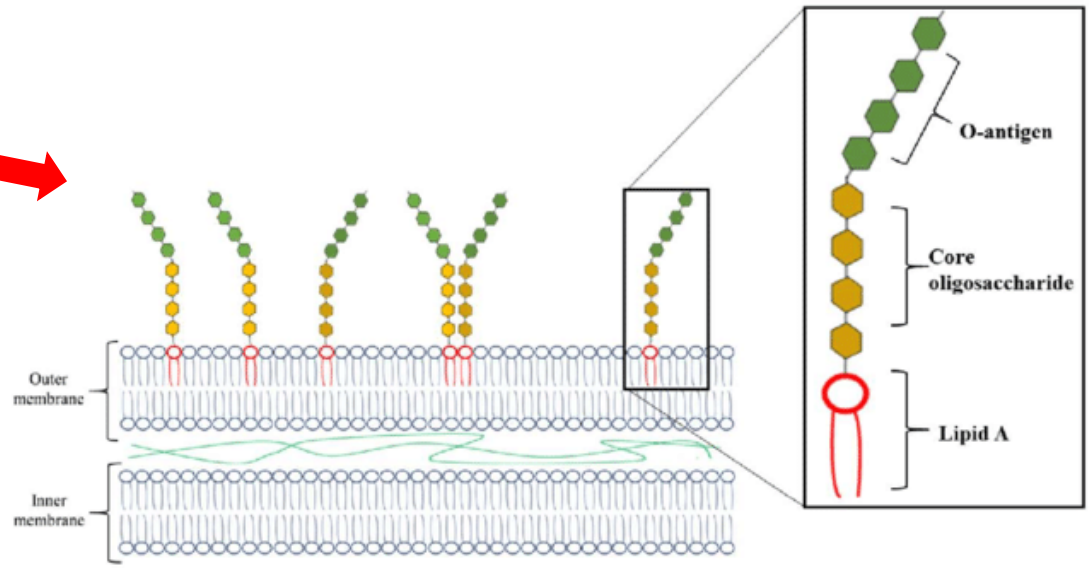
- Crucial microbiological diagnosis in specific cases

Cabrera et al., modified

Cell wall structure

- Lipopolysaccharide (LPS) – endotoxin
  - Lipid A moiety – toxicity
  - Inflammatory response (macrophage activation, proinflammatory cytokines, complement activation)
  - Blood stream – fever, shock, multiorgan failure

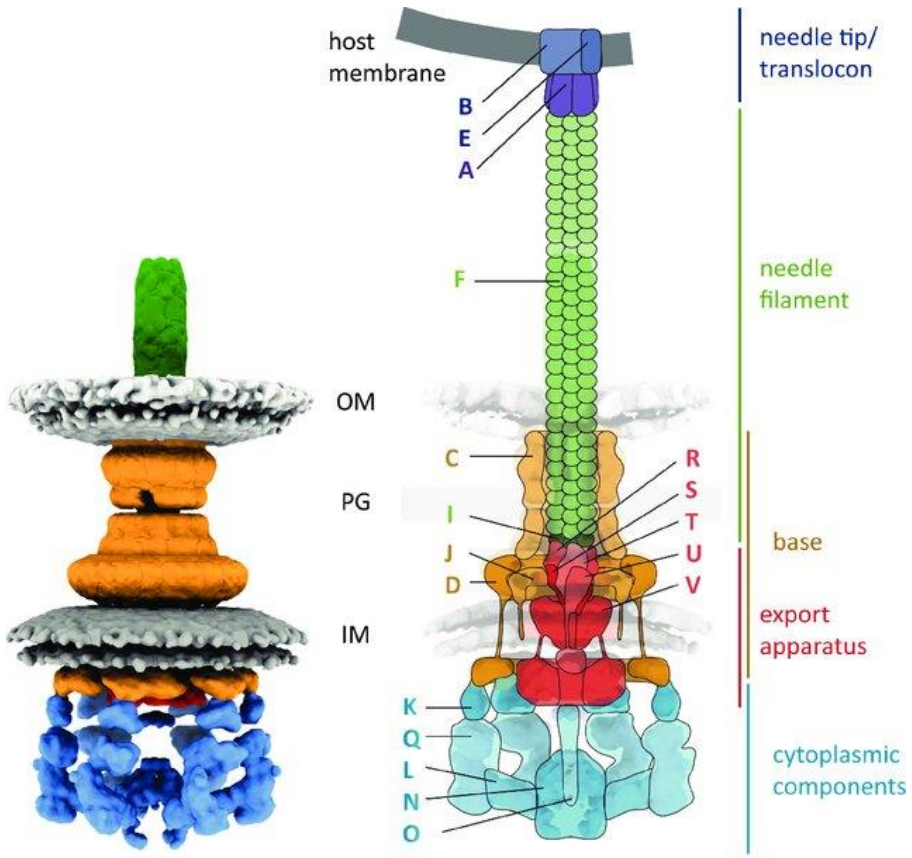




- Crucial microbiological diagnosis in specific cases

Cabrera et al., modified

Type 3 secretion system (T3SS)

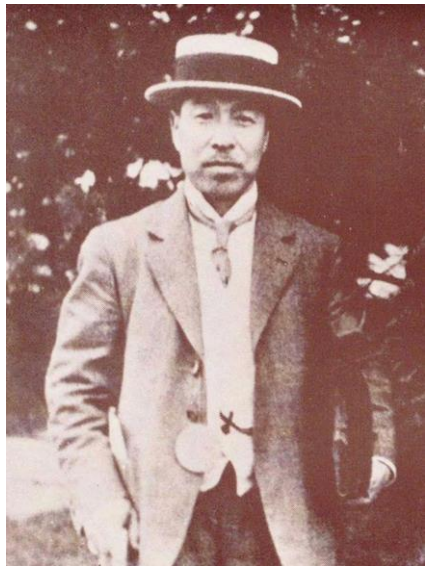


vT3SS	SctJ	SctQ	SctL	SctN	SctO	SctR	SctS	SctT	SctU	SctV	SctP
fT3SS	FliF	FliMN	FliH	FliI	FliJ	FliP	FliQ	FliR	FlhB	FlhA	FliK

Complex structures of G- bacteria
– injection of bacterial effector proteins into a cytoplasm of another cell

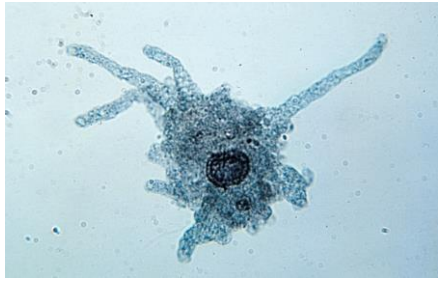
Pais, Sara & Kim, Eunjin & Wagner, Samuel. (2023). Virulence-associated type III secretion systems in Gram-negative bacteria: This article is part of the Bacterial Cell Envelopes collection.. Microbiology. 169. 10.1099/mic.0.001328.

- Kiyoshi Shiga
- 1897 dysentery epidemic in Japan, >91 000 cases



https://www.ndl.go.jp/portrait/e/datas/6049/

Dysentery:
- Bloody diarrhea with mucus, fever, abdominal pain, tenesmus
- Bacterial, amoeboic

()

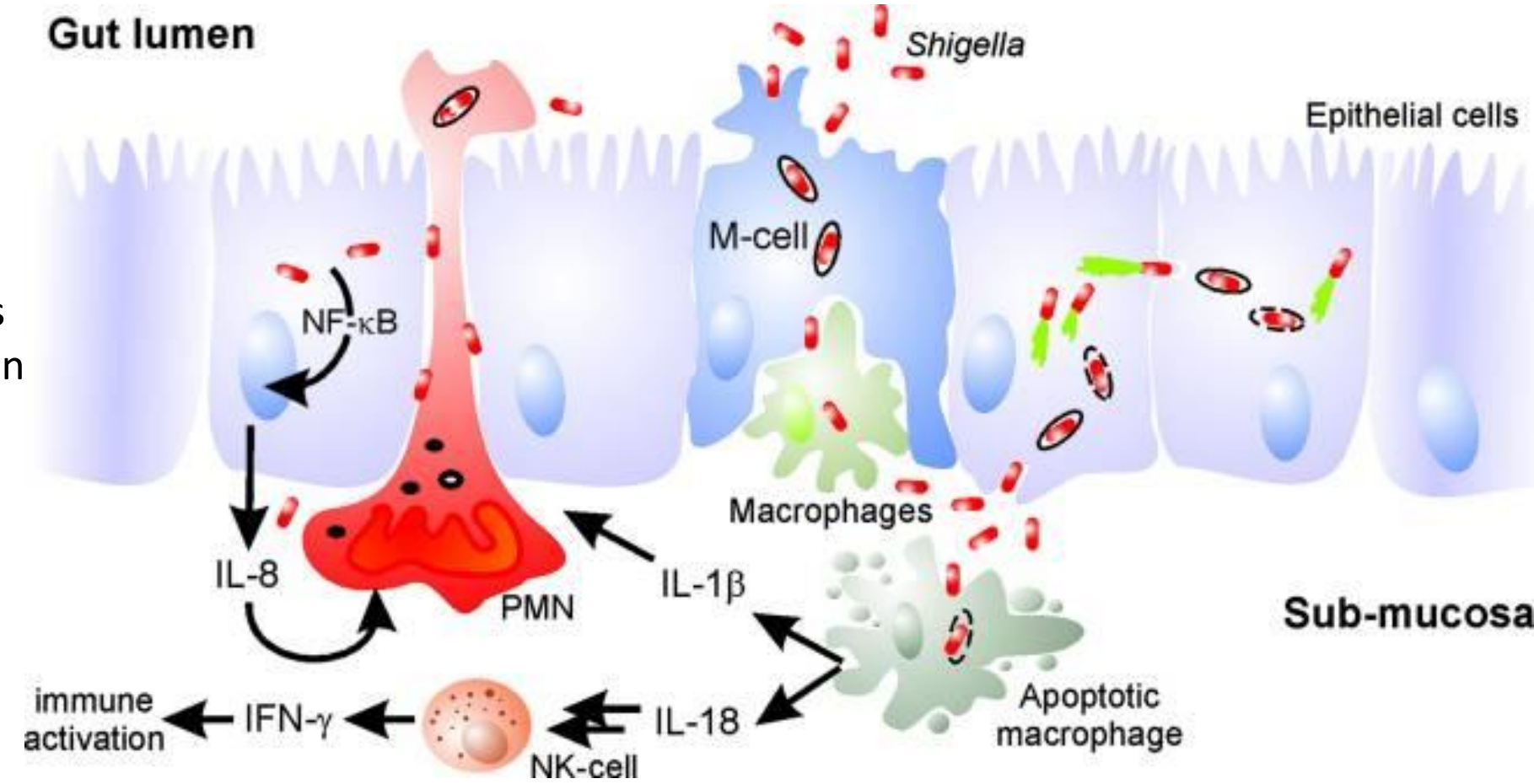
https://www.britannica.com/

Shigella

- *S. dysenteriae, S. boydii, S. flexneri, S. sonnei*
- Nonmotile; inf. limited to humans
- Rel. resistant to acidic environment → infectious dose 10-100 cells
- Fecal-oral transmission, contaminated food and water, sexual transmission (MSM)
- Poor hygiene
- Infection of the large intestine
  - Watery diarrhea, dysentery

Shigella – pathogenesis

- <u>Invasive</u>:
- Transcytosis
- Macrophage – apoptosis – proinflammatory cytokines
- Epithelial invasion and spread
- Polymorphonuclear leukocytes
- Massive intestinal inflammation and epitelial layer destruction



Shigella

- Shiga toxin (some *S. dysenteriae* types)
- Hemolytic-uremic syndrome (HUS)
  - A week or more after onset of diarrhea
  - *Shigella* – not the most common cause of HUS

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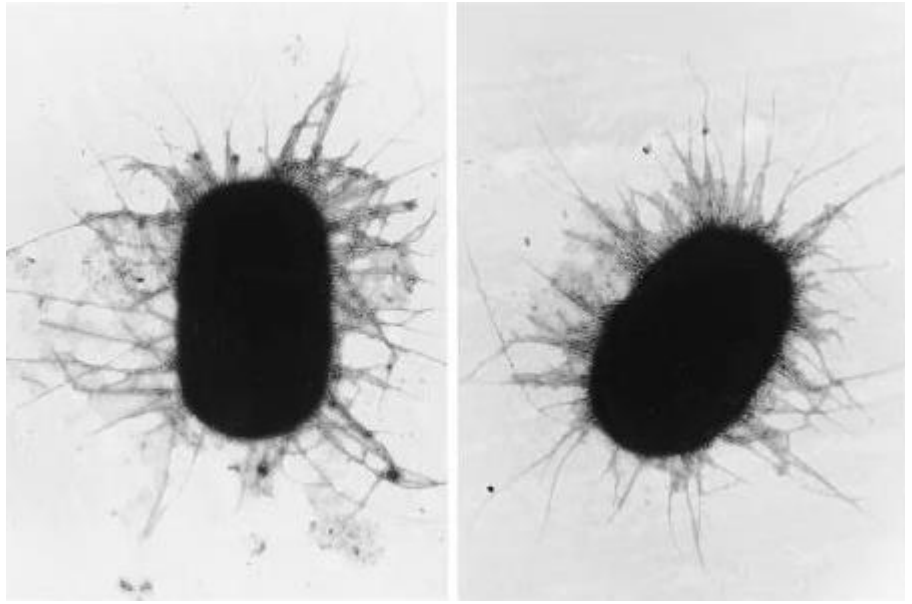
Escherichia coli

Sokurenko, Evgeni & Tchesnokova, Veronika & Doyle, Ron & Hasty, David. (1997). The Journal of biological chemistry. 272. 17880-6.



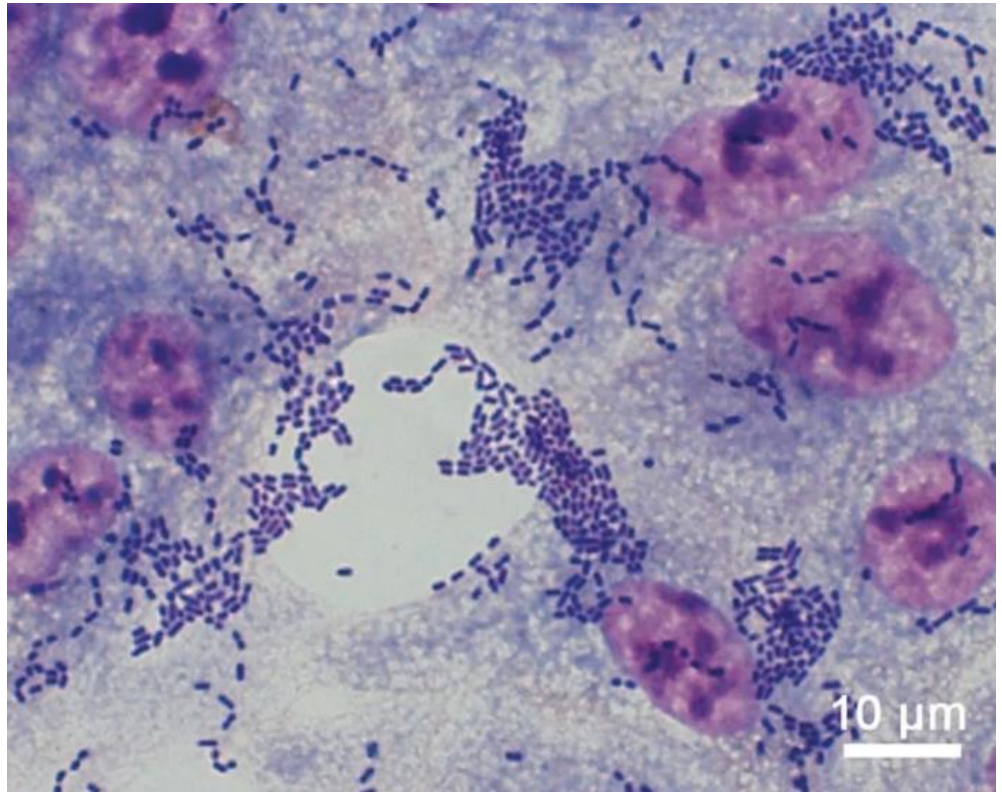
- Gut microbiota, motile
- Extraintestinal pathogens
  - Meningitis (neonates)
  - Uropathogenic *E. coli* (UPEC)
    - Periurethral colonization → cystitis (women – urethral length, proximity to anus; risk factors: outflow obstruction, neurological disorders)
    - → pyelonephritis → sepsis
    - Fimbriae, adhesins, toxins – local damage
- Intestinal pathogens
  - Different virulence factors and clinical presentations → pathotypes
  - Diarrhea, abdominal pain, may be vomiting, fever
  - Faecal-oral route of transmission, contaminated food and water

Enterotoxigenic *E. coli* (ETEC)

- Leading cause of traveller´s diarrhea (developing countries)
- Production of toxins after epitelial adhesion (small intestine)
- Heat-labile (LT), heat-stabile (ST) toxin
  - Increasing cAMP or cGMP → chloride secretion, inhibition of NaCl absorption → free water secretion
- Watery diarrhea

Enteroaggregative *E. coli* (EAEC)

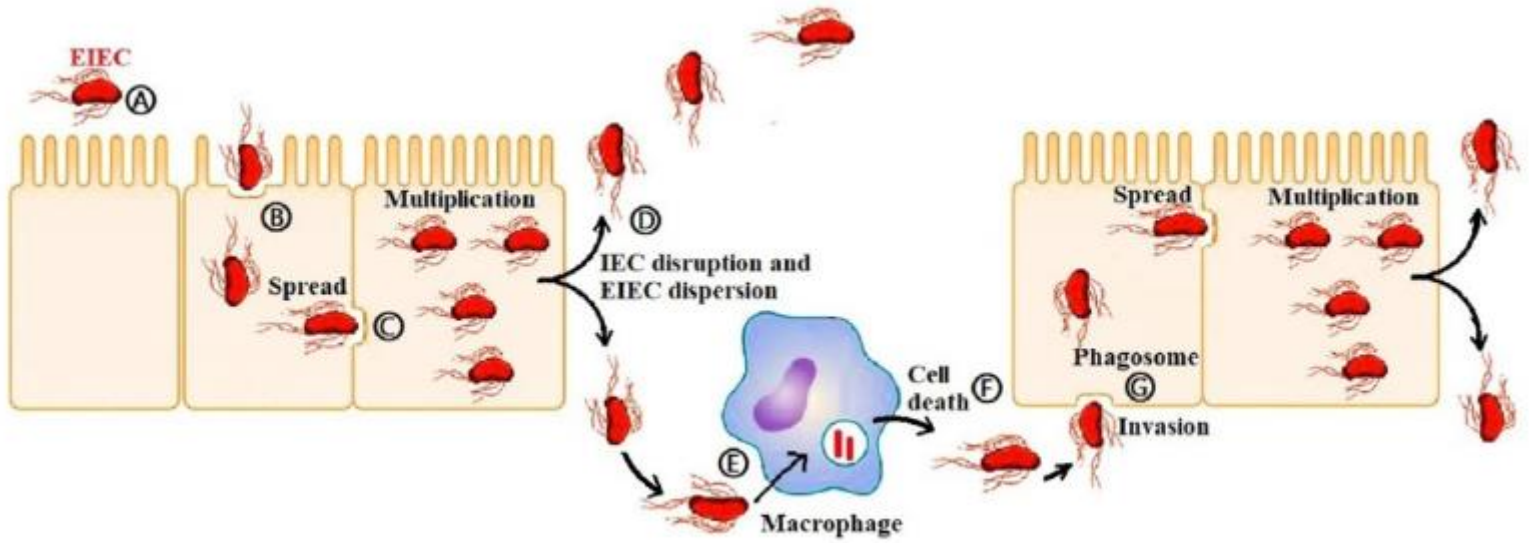
- Children, traveller´s diarrhea, HIV+ patients
- Adhesion to small intestine via AAF (aggregative adherence factors – fimbriae)
  - „stacked-brick“ adherence pattern
- Biofilm production
- Cytotoxins – local effect
- Watery diarrhea
- Can lead to chronic illness



Karch, Helge & Denamur, Erick & Dobrindt, Ulrich & Finlay, B. & Hengge, Regine & Johannes, Ludger & Ron, Eliora & Sansonetti, Philippe & Vicente, Miguel. (2012). EMBO Molecular Medicine. 4. 841-848.

Enteroinvasive *E. coli* (EIEC)

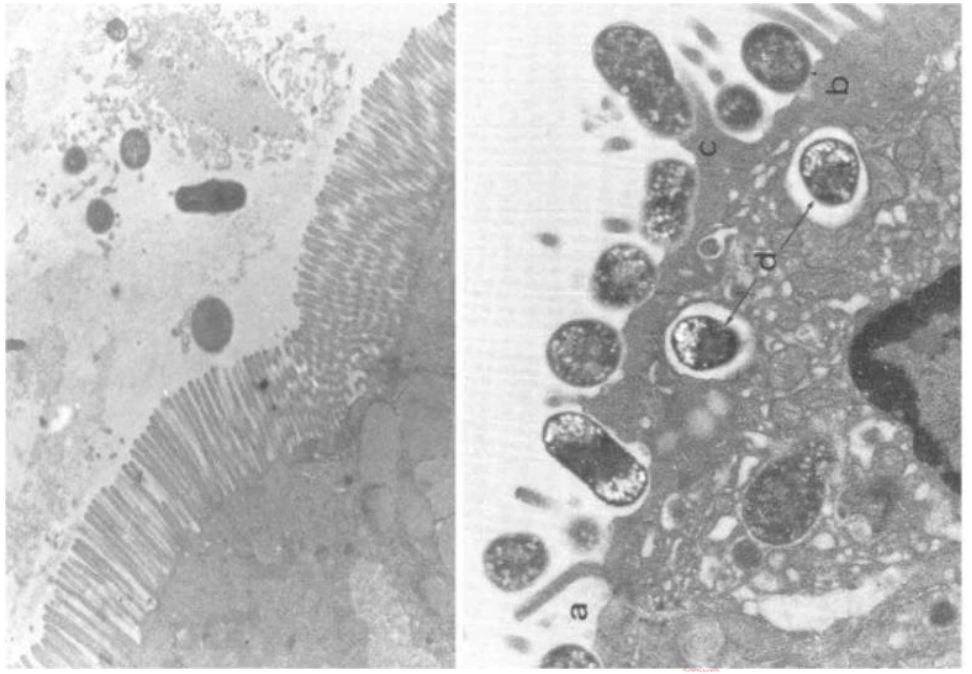
- Closely related to *Shigella;* invasivity
- Watery diarrhea → dysentery



https://www.creative-diagnostics.com/

Enteropathogenic *E. coli* (EPEC)

- Attaching and effacing lesions (A/E) in small intestine
  - Destruction of microvilli and polymerization of actin
  - Pedestal-like structures
- Watery diarrhea in <u>children</u> (<2 years)



Piérard, Denis & De Greve, Henri & Haesebrouck, Freddy & Mainil, Jacques. (2012). Veterinary Research. 43. 13.

Enterohemorrhagic *E. coli* (EHEC)

- Reservoir: cattle (asymptomatic)
- Contaminated food and water
- Mostly children <5 years
- A/E lesions (similar to EPEC)
- Hemorrhagic colitis
- Shiga-like toxins (STEC – shiga-like toxin producing *E. coli*)
  - Hemolytic-uremic syndrome (HUS)

Hemolytic-uremic syndrome (HUS)

- D+ HUS (typical)
  - Shiga-toxin (EHEC, *S. dysenteriae)*
  - Toxicity – microvascular endothelial cells
- Destruction and apoptosis of endotelium cells
  – activation of platelets:
  platelet aggregation, coagulation and **thrombus formation**

X D- HUS (atypical)

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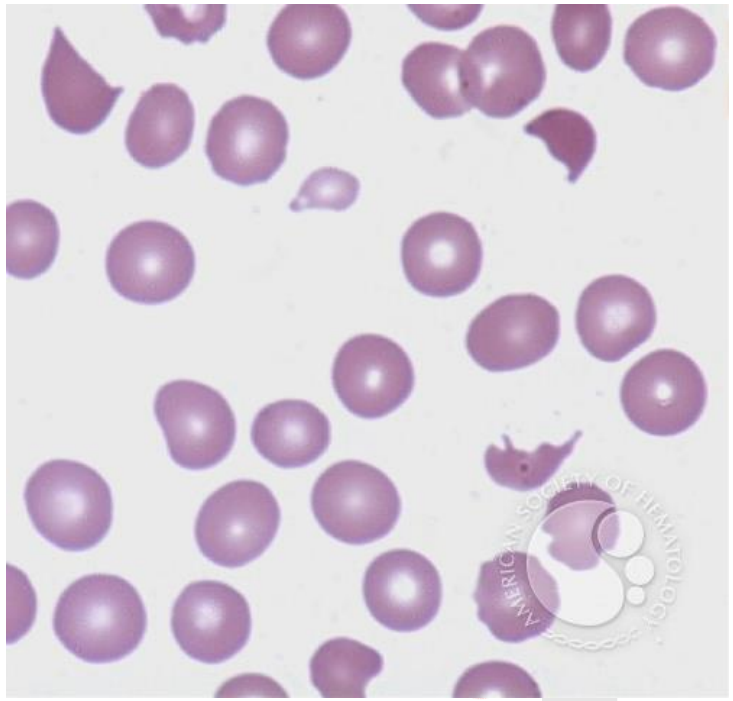
Hemolytic-uremic syndrome (HUS)

- Triad
  - Hemolytic anemia: schistocytes (RBC fragments)
  - Thrombocytopenia
  - Renal insufficiency
- Common cause of acute kindney injury in children
- Possible CNS involvement
  - Seizures, altered mental status
- ATB therapy NOT recommended
  - Other management strategies in pediatrics
- 3-4% acute mortality
- 30-50% irreversible kidney injury



https://imagebank.hematology.org/image/3718/schistocytes--1

LIDOVÉ NOVINY
LIDOVKY.CZ

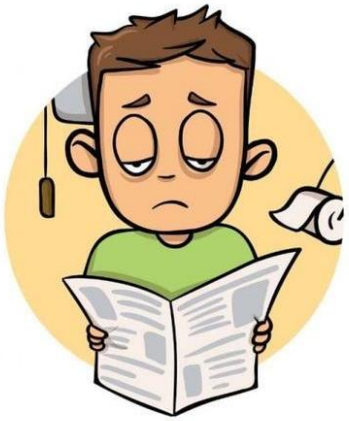
Němci opět potvrdili: Zdrojem nákazy jsou klíčky

Autor: ČTK, Lidovky.cz
10. června 2011 16:49, aktualizováno 18:01

BERLÍN - Právě po měsíci pátrání po zdroji epidemie střevní nákazy přenášené bakterií EHEC německé úřady tentokrát zřejmě už definitivně rozpoznali její zdroj v luštěninových klících a výhoncích z biofarmy v dolnosaském Bienenbüttelu.

Infekce si zatím vyžádala 32 obětí, z toho 31 v Německu, kde se dalších více než 2800 lidí nakazilo. Klíčky byly v podezření už o minulém víkendu a počátkem tohoto týdne. Panika kolem nákazy však mezitím způsobila

E. coli diagnosis – intestinal pathotypes



Culture identification by MALDI-TOF: *E. coli* → which pathotype?

- Serotyping
  - Agglutination
  - O- and H-type
  - EHEC: O157:H7

Treatment – symptomatic

https://www.carolinadigestive.com/blog-post/why-do-i-have-stomach-pain-and-diarrhea
https://www.wikihow.com/Take-a-Stool-Sample

E. coli diagnosis – intestinal pathotypes

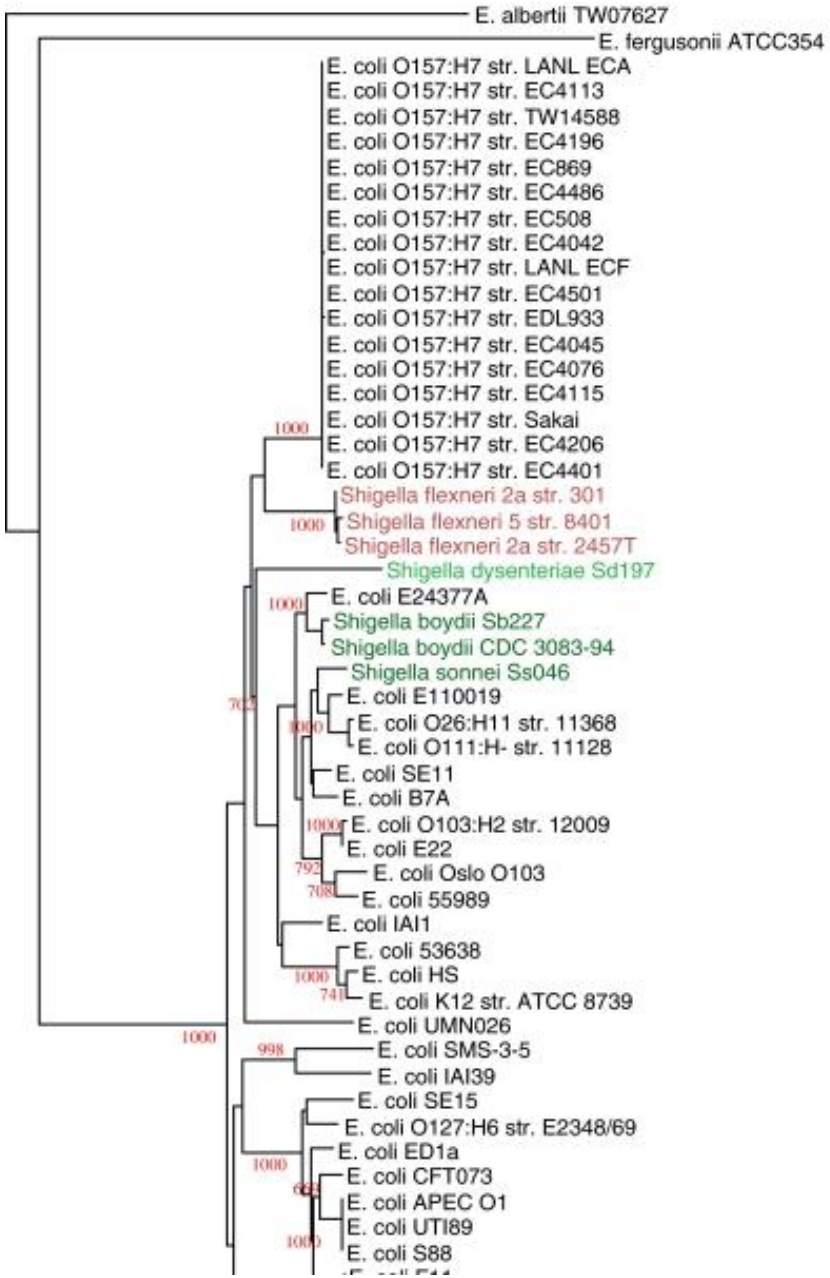
Protokol: VIR-2603-2255 --- Konečný výsledek ---
Vzorek: Stolice
Vyšetření: Střevní infekce vyjma CD - PCR, Shigella/EIEC - kultivace

Střevní infekce - PCR

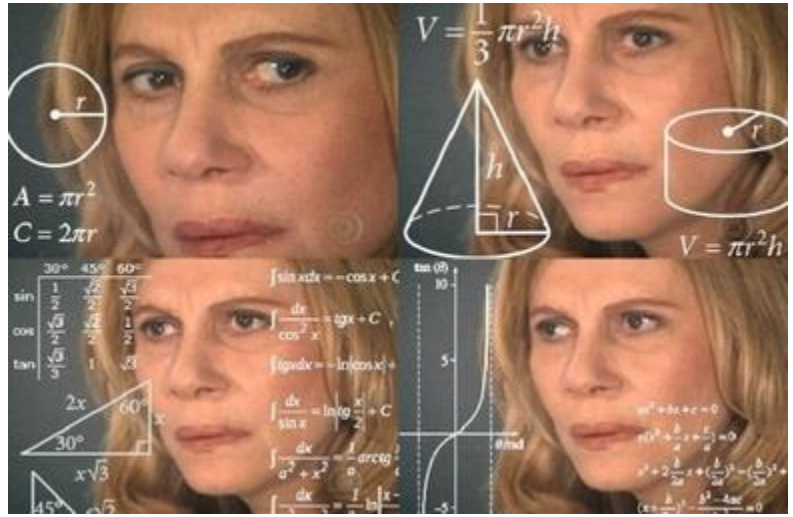
Shigella/Enteroinvazivní E.coli (EIEC): POZITIVNÍ (****)
Shiga toxin: negativní
Salmonella spp.: negativní
Campylobacter spp.: negativní
Aeromonas spp.: negativní
Yersinia spp.: negativní
Sapovirus: negativní
Rotavirus (skup. A): negativní
Norovirus: negativní
Adenovirus (skup. F, G): negativní
Astrovirus: negativní
Giardia intestinalis: negativní
Cryptosporidium spp.: negativní
Entamoeba histolytica: negativní

E. coli and *Shigella* similarities

- Invasivity
  - *Shigella* and enteroinvasive *E. coli* (EIEC)
- Shiga and shiga-like toxin production
  - Hemolytic-uremic syndrome
  - Some *S. dysenteriae* strains and enterohemorrhagic *E. coli* (EHEC)



- MLST (comparision of 7 houskeeping genes)
- *Shigella* species are in fact another pathotypes of *E. coli*
- Terminology is maintained due to historical reasons



Lukjancenko O, Wassenaar TM, Ussery DW. Comparison of 61 sequenced Escherichia coli genomes. *Microb Ecol*. 2010;60(4):708-720. doi:10.1007/s00248-010-9717-3

Salmonella enterica

- *Salmonella enterica* subspecies *enterica*

Nontyphoidal	Typhoidal
• Serotype Enteritidis, Typhimurium	• Serotype Typhi, Paratyphi A, B, C
• Gastroenteritis, …	• Enteric fever
• Source: animals	• Source: human

Nontyphoidal *Salmonella*

- *Salmonella enterica* subspecies *enterica* serotype Enteritidis
  - = *Salmonella* Enteritidis
- *Salmonella enterica* subspecies *enterica* serotype Typhimurium
  - = *Salmonella* Typhimurium

- Small intestine: cell invasion, intracellular replication

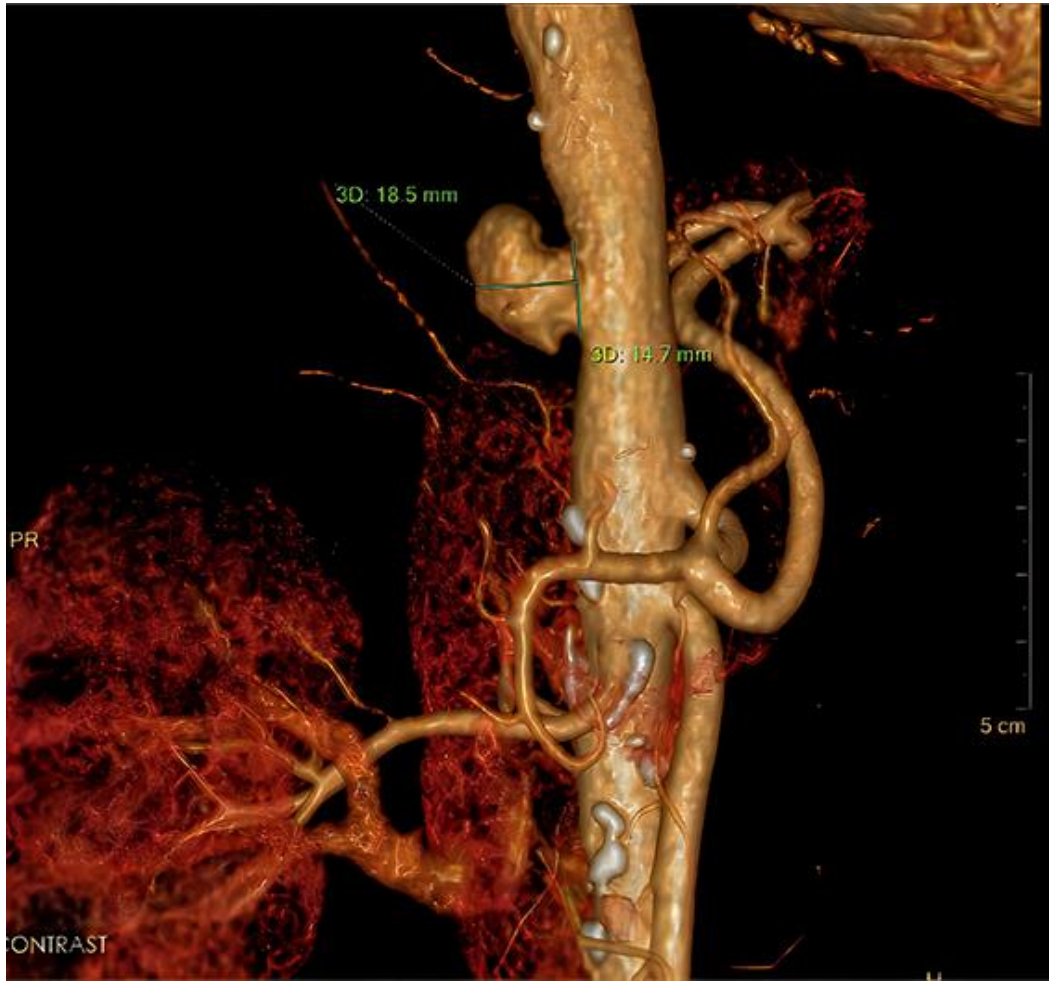
- Foodborne gastroenteritis (eggs, milk, poultry)
  - Diarrhea, vomiting, nausea, fever, abdominal pain
- Bacteremia → osteomyelitis, arthritis, arteritis, endocarditis, meningitis (<1 year)

https://gardening.co.za/

Nontyphoidal *Salmonella*

Mycotic aneurysm in aortitis

- Usually bacterial



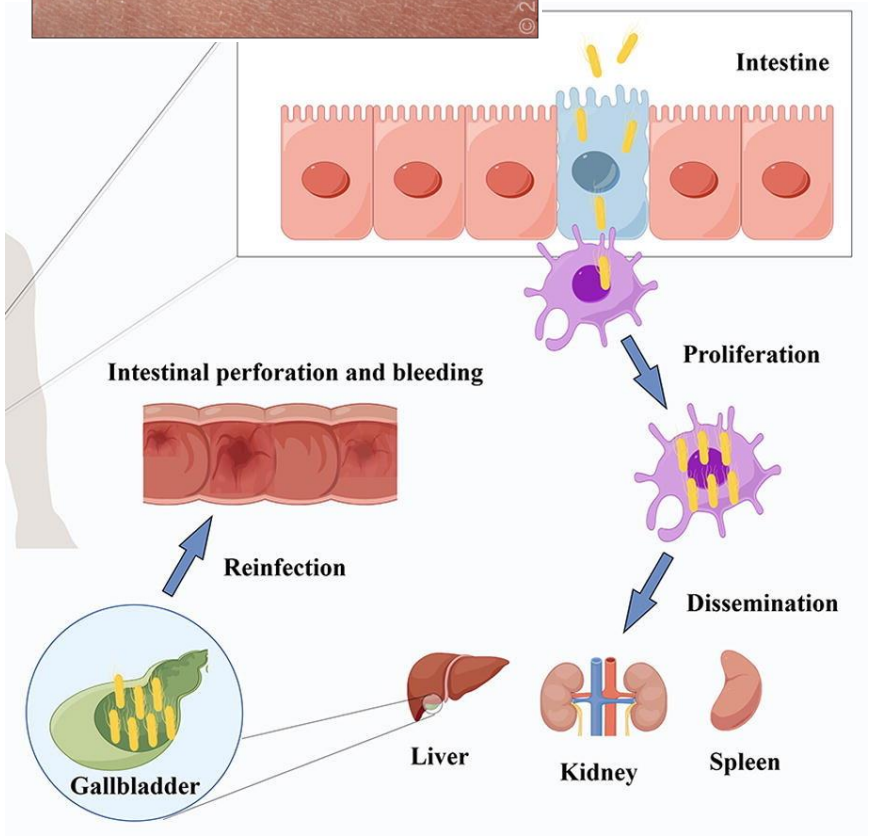
Han Y, Zhang Y, Gong G, Ou C, Li F. Mycotic Pseudoaneurysm of Thoracic Aortic Caused by Salmonella Paratyphi A: A Case Report. *Infect Drug Resist*. 2023;16:4171-4176 https://doi.org/10.2147/IDR.S416783

Typhoidal *Salmonella*

- *Salmonella* Typhi, *S*. Paratyphi A, B, C
- Human hosts – fecal-oral transmission, contaminated food and water
- Capsular Vi (virulence) antigen – *S.* Typhi
  - Inhibition of fagocytosis and complement
- *S*. typhi: O (somatic) 9,12 (capsular) Vi H (flagellar) d

Typhoidal *Salmonella*

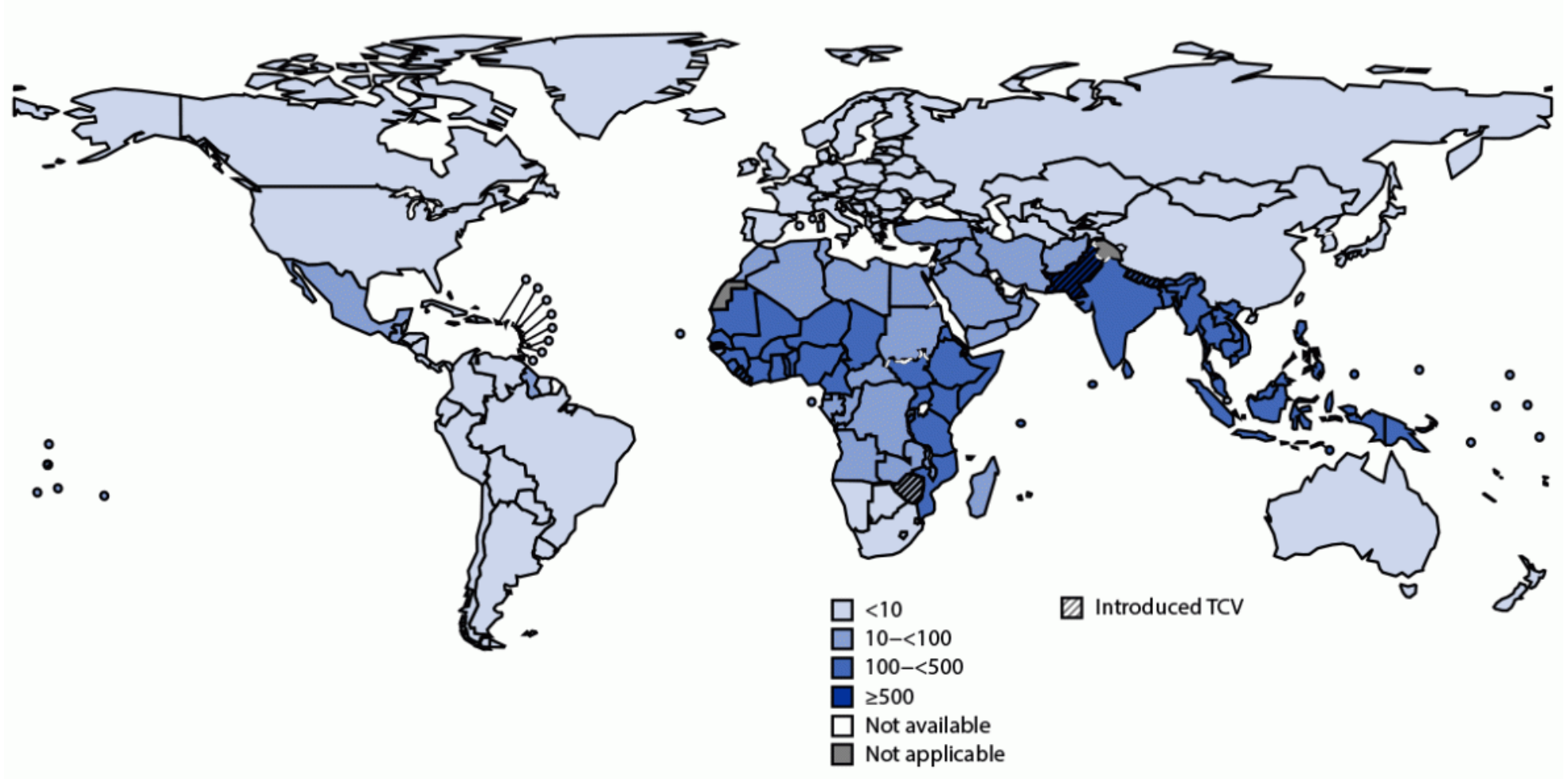
- Enteric fever (typhoid and paratyphoid fever)
  - Small bowell infection → necrosis → perforation
  - Replication in mesenterial lymphatic nodes → repl. in bone marrow, spleen, liver
  - Sepsis
  - Rose spots
  - Headache common; altered mental status, …
- Typhoid vaccine
  - Vi antigen



Ying Chen, Lingwei Chen, Yanzhen Lin, Yanguang Cong, Journal of Advanced Research, Volume 81, 2026, 583-592, https://doi.org/10.1016/j.jare.2025.05.054.
Uptodate.com

Carriage in gallbladder

2021: 9,3 mil. cases globally, > 100 000 deaths



Hancuh M, Walldorf J, Minta AA, et al. **Typhoid Fever** Surveillance, Incidence Estimates, and Progress Toward Typhoid Conjugate Vaccine Introduction — Worldwide, **2018–2022**. MMWR Morb Mortal Wkly Rep 2023;72:171–176. DOI: http://dx.doi.org/10.15585/mmwr.mm7207a2

Salmonella enterica – diagnosis and treatment

- Diagnosis
  - Stool – culture, PCR
  - Invasive disease: blood culture, bone tissue, synovial fluid
  - Serotype differentiation – agglutination
  - *S.* typhi – serology (Widal)

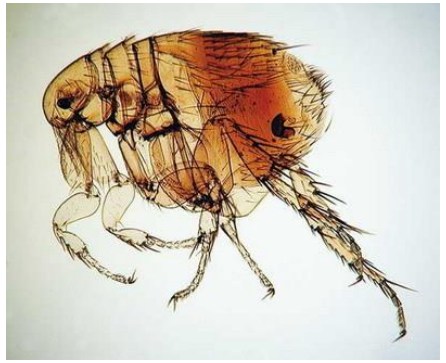
- Treatment
  - Gastroenteritis: symptomatic
  - Invasive disease: fluoroquinolones, 3rd generation cephalosporins

Yersinia spp.

- *Yersinia pestis*
  - Non-motile
  - Plague

- *Y. enterocolitica, Y. pseudotuberculosis*
  - Motile at 22-30°C
  - Gastroenteritis, mesenterial lymphadenitis

Yersinia pestis

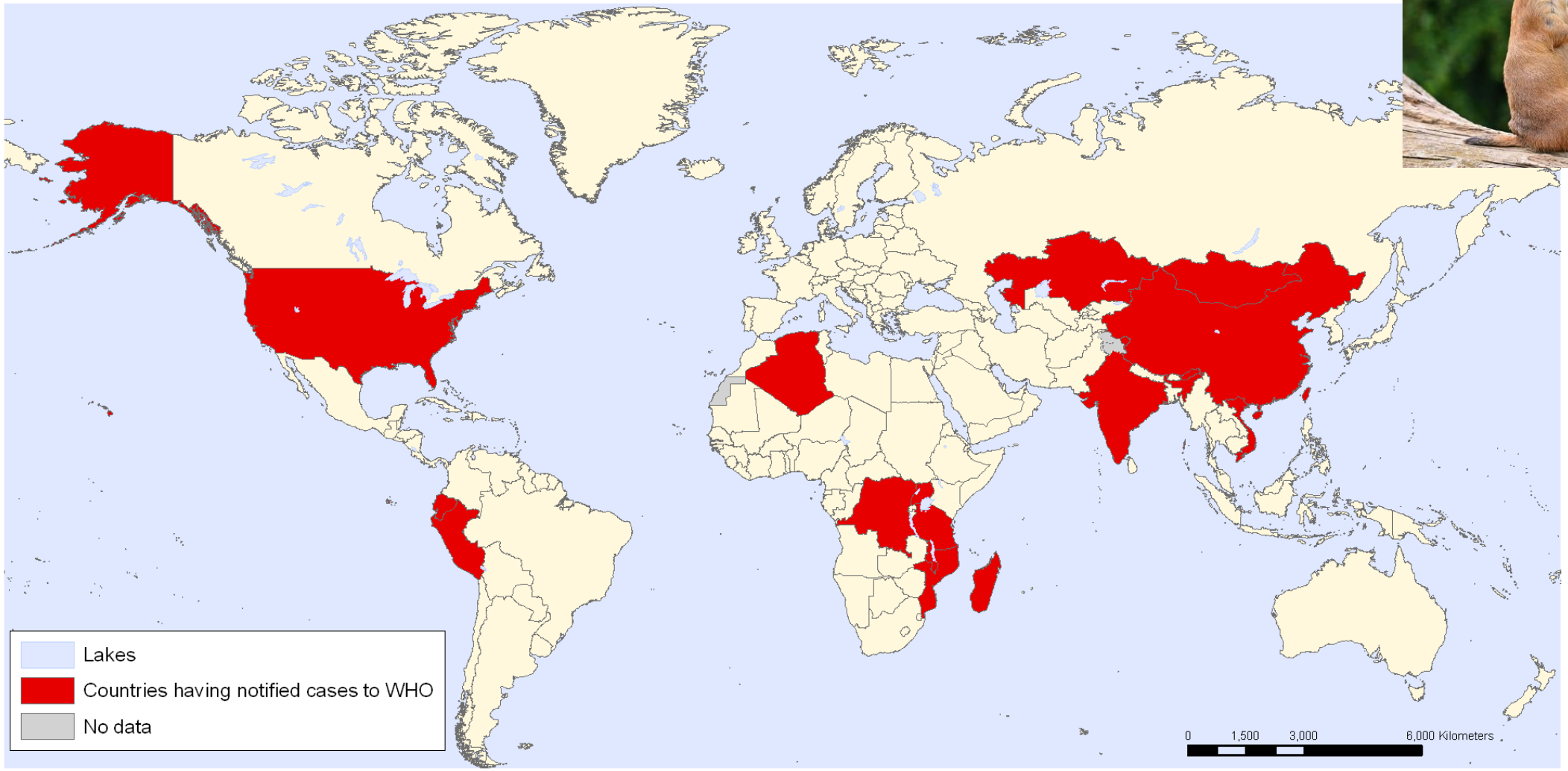


- Plague
- *Xenopsylla cheopis* (reservoir: rodents)
- Transmission: flea bites, contact with infected animals, inhalation (animal secretions, droplets from infected human)
- Pandemics in history
  - Europe, 14th century – 17-28 mil. deaths

https://www.herbalus.cz/
Vesmir.cz

Countries having notified human cases of plague to WHO, 2002-2005

fotoaparat.cz



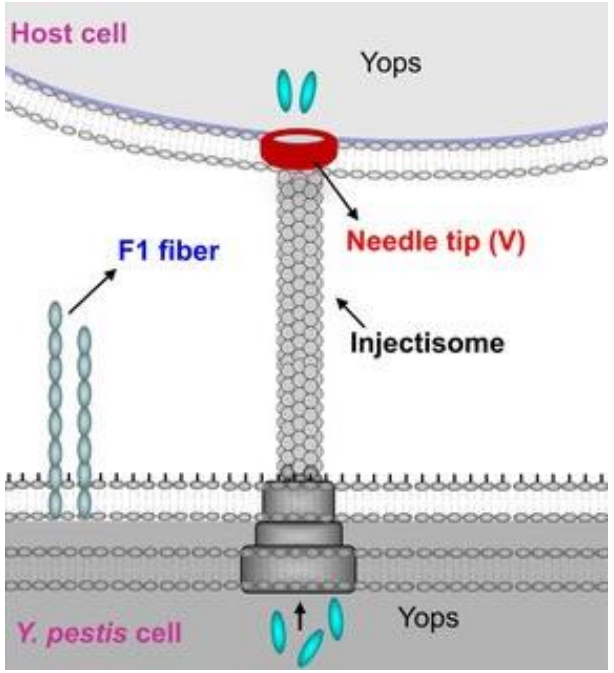
The boundaries and names shown and the designations used on this map do not imply the expression of any opinion whatsoever on the part of the World Health Organization concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries. Dotted lines on maps represent approximate border lines for which there may not yet be full agreement.

Data Source: World Health Organization
Map Production: Public Health Mapping and GIS
Communicable Diseases (CDS)
World Health Organization

World Health Organization

Pathogenesis and symptoms

- Flu-like symptoms
- Bubonic plague (cutaneous or mucous membrane exposure)
  - Bubo – regional lyphadenopathy, painful
  - 40-70% mortality (untreated)
- Pneumonic plague
  - Pneumonia, bloody sputum
  - 100% mortality (without early treatment)
- Septicaemic plague
  - Bacteriaemia
  - Multiorgan failure
  - Disseminated intravascular coagulopathy (endotoxin) – acral necrosis



Tao, Pan & Mahalingam, Marthandan & Zhu, Jingen & Moayeri, Mahtab & Kirtley, Michelle & Fitts, Eric & Andersson, Jourdan & Lawrence, William & Leppla, Stephen & Chopra, Ashok & Rao, Venigalla. (2017). Frontiers in Immunology. 8.

The Guardian

This article is more than **13 years old**

Oregon man recovering from rare case of the plague

Paul Gaylord no longer in critical condition but fears for fingers and toes after contracting plague from cat

Paul Gaylord recovering from the plague in hospital in Oregon. 'We didn't even know the plague was around anymore,' said his sister. Photograph: AP

https://mapsius.com/state/oregon/

Y. enterocolitica, Y. pseudotuberculosis

- Growth in low temperature (4°C)
- Reservoir: variety of animals (pig)
- Transmission – fecal-oral route, contaminated food and water

- Gastroenteritis, mesenterial lymphadenitis
- Fever, abnominal pain (pseudoapendicitis), vomiting, watery or bloody diarrhea (can be absent)

- Risk patients (immunosupression, <1 year, …)
  - Sepsis

https://www.farmarsky-obchod.cz/jitrnice-2

Y. enterocolitica, Y. pseudotuberculosis

- Post-infectious sequelae
  - Immunopathology
  - Erythema nodosum
  - Reactive arthritis
    - Large joints
  - Conjunctivitis
  - Often self-limited

Yersinia – diagnosis and treatment

- *Y. pestis*
  - Blood culture, sputum, lymphatic nodes (tissue, pus) – culture
  - Serology
  - Fluoroquinolones

- *Y. enterocolitica, Y. pseudotuberculosis*
  - Stool – culture, PCR
  - Mesenteric lymph nodes, appendix tissue (in case of surgery) – culture
  - Serology
  - Symptomatic therapy
  - High risk patients, severe infection (sepsis, highly bloody stool with high fever)
    - Fluoroquinolones, 3rd generation cephalosporins

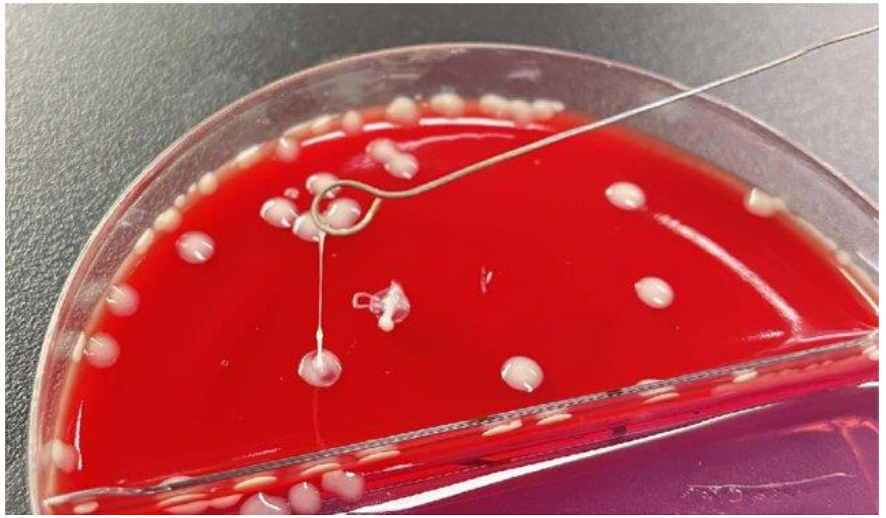
Extraintestinal pathogens

- Gut microbiota

- Extraintestinal *E. coli* pathotypes
- *Klebsiella spp*.
- *Enterobacter cloacae* complex
- *Citrobacter spp.*
- *Serratia spp.*
- *Proteus spp.*
- *Providencia spp*.
- …

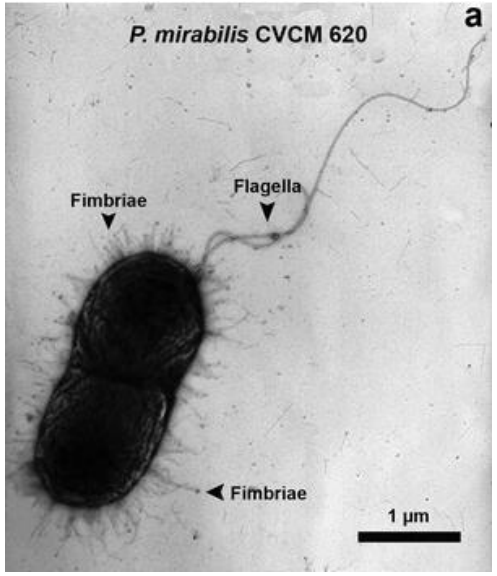
Klebsiella spp.

- *K. pneumoniae*, *K. variicola*, *K. oxytoca*, …
- Hospital-acquired infections, immunity alteration
  - Pneumonia, urinary tract infections, wound infections, sepsis
- Hypervirulent *K. pneumoniae*
  - Community acquired infections in healthy adults
  - Brain or liver abscess, meningitis, endophtalmitis, necrotizing fasciitis
- Resistance genes
  - Primary resistant to aminopenicillins
  - ESBL, carbapenemases, non-β-lactam resistance



Zhang, Zongwei & Wen, Hainan & Wang, Hui & Zhang, Pan & Li, Jing & Liang, Yueyi & Liu, Yanchao & Sun, Lihong & Xie, Shoujun. (2022). Infection and Drug Resistance. Volume 15. 4927-4933

Proteus mirabilis



- Swarming motility
- Fimbriae
- Urinary tract infections
- Urease production ammonia (cell toxicity, urine alkalization)
  →ion precipitation, struvite stone formation → impaired urine flow
- Colonization of chronic skin lesions

Struvite
- magnesium ammonium phosphate

- Primary resistant to nitrofurantoin!

Fernández-Delgado, M., Duque, Z., Rojas, H. *et al. Ann Microbiol* **65**, 1401–1409 (2015).
https://microbeonline.com/proteus-species-properties-diseases-identification
https://www.baus.org.uk/patients/conditions/6/kidney_stones/

Other *Enterobacterales*

- *Enterobacter cloacae*
- *Citrobacter freundii*
- *Morganella morganii*
- *Serratia marcescens*
- *Providencia stuartii*

Organisms	Ampicillin/Amoxicillin	Amoxicilin-clavulanic acid	Ampicillin-sulbactam	Ticarcillin	Cefazolin, Cephalothin Cefalexin, Cefadroxil	Cefoxitin[2]	Cefuroxime	Tetracyclines	Tigecycline	Polymyxin B, Colistin	Fosfomycin	Nitrofurantoin
Providencia stuartii	R	R	R		R			R		R		R
Raoultella spp.	R			R								
Serratia marcescens	R	R	R		R	R	R			R		R

Colonization of patients with prolonged ATB administration

- Opportunistic nosocomial pathogens
- Urinary tract infections, CLABSI (Central Line-Associated Bloodstream Infections), pneumonia, intraabdominal infections
- AmpC β-lactamases (naturally inducible production → constitutive)

Diagnosis – *Enterobacterales* – extraintestinal infections

- Cystitis, pyelonephritis – midstream urine, (blood culture in the latter)
- Meningitis – cerebrospinal fluid, blood culture
- Pneumonia – low respiratory tract samples (sputum), blood culture
- Skin, soft tissue and wound infection, abscess – tissue, pus, (swab)

- Treatment
  - β-lactam antibiotics: aminopenicillins (icl. inhibitors), piperacillin/tazobactam, (2^{nd}), 3^{rd}, 4^{th} gen. cephalosporins, carbapenems
  - Cystitis also:
    - nitrofurantoin (nitroimidazole)
    - (piv)mecillinam (penicilin – *Enterobacterales*)
    - fosfomycin (inh. of peptidoglycan synthesis)

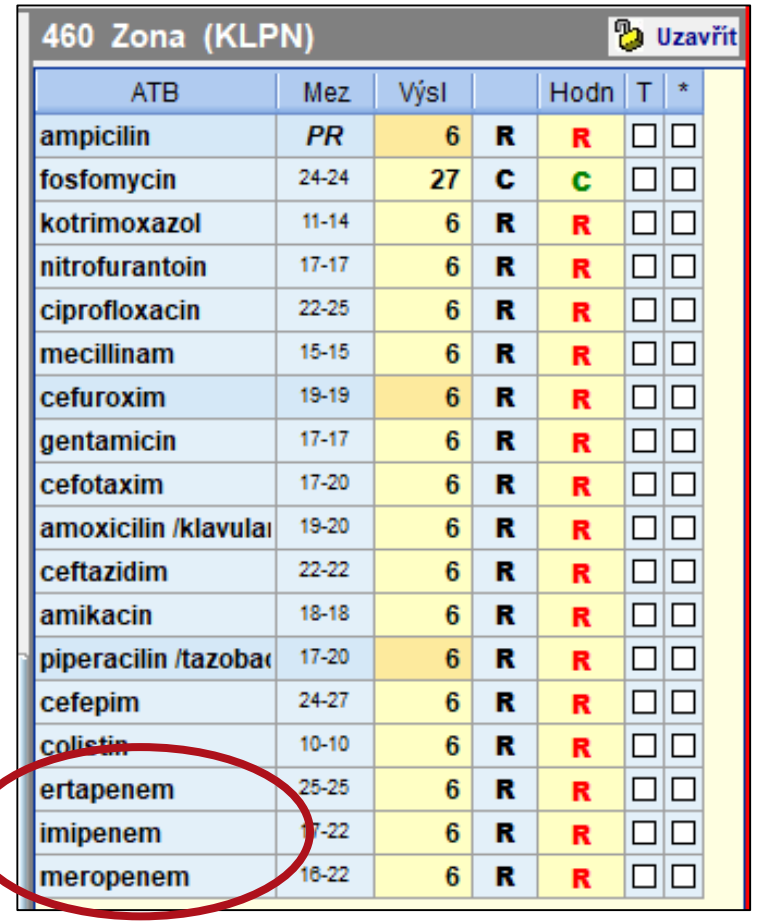
Enterobacterales – antibiotic resistance (aminoglycosides)

Gene	Accession no.	Target(s)	Enzyme encoded	Reference
aac(3)-Ia	DQ370505	Gentamicin	3-*N*-Acetyltransferase	29
aac(3)-Ib	L06157	Gentamicin	3-*N*-Acetyltransferase	13
aac(3)-Id	AY458224	Gentamicin	3-*N*-Acetyltransferase	13
aac(3)-III	X13542	Gentamicin	3-*N*-Acetyltransferase	1
aac(3)-IVa	X01385	Gentamicin	3-*N*-Acetyltransferase	8
aac(3)-Vb	M97172	Gentamicin	3-*N*-Acetyltransferase	24
aac(6′)-I30	AY289608	Amikacin	6′-*N*-Acetyltransferase	22
aac(6′)-Ib	AY103455	Amikacin, kanamycin	6′-*N*-Acetyltransferase	13
aac(6′)-IIa	AY123251	Gentamicin	6′-*N*-Acetyltransferase	22
aac(6′)-Ia	M18967	Amikacin, kanamycin	6′-*N*-Acetyltransferase	28
aacC1	U04610	Gentamicin	3-*N*-Acetyltransferase	13
aacC2	S68058	Gentamicin	3-*N*-Acetyltransferase	32
aacCA5	AY463797	Gentamicin, kanamycin, amikacin	3-*N*-Acetyltransferase	22
aadA1	EF422367	Streptomycin	3″-Adenylyltransferase	32
aadA2	AF071555	Streptomycin	3″-Adenylyltransferase	5
aadA21	AY171244	Streptomycin	3″-Adenylyltransferase	22
aadA5	AB126604	Streptomycin	3″-Adenylyltransferase	22
aadA7	AY458224	Streptomycin	3″-Adenylyltransferase	12
aadB	AY204504	Gentamicin, kanamycin	2″-Adenylyltransferase	13
aadE	AF516335	Streptomycin	6-Adenylyltransferase	13
aph(3)-Ia	V00359	Kanamycin	3′-Phosphotransferase	6
aph(3)-IIa	V00618	Kanamycin	3′-Phosphotransferase	6
aph4	V01499	Hygromycin B	Aminocyclitol phosphotransferase	20
aphA-3	AF516335	Kanamycin	3′-Phosphotransferase	13
aphA7	AY509004	Kanamycin		
aphD	Y00459	Streptomycin		
aphE	X53527	Streptomycin		
aphIII	V01547	Kanamycin		
strA	AY055428	Streptomycin		
strB	NC_005014	Streptomycin		

Baker, Katherine & Orfe, Lisa & Shah, Devendra & Besser, Thomas & Call, Douglas. (2010). Discovery of a Gene Conferring Multiple-Aminoglycoside Resistance in Escherichia coli. Antimicrobial agents and chemotherapy. 54. 2666-9. 10.1128/AAC.01743-09.

Enterobacterales – resistance to β–lactam ATB (examples)

Beta-lactamase	Treatment
AmpC	Cefepim
ESBL (extended spectrum beta-lactamases)	Carbapenems
Carbapenemases	Ceftazidime/avibactam
	Imipenem/relebactam
	Aztreonam/avibactam
	Cefiderocol



460 Zona (KLPN) — Uzavřít

ATB	Mez	Výsl		Hodn	T	*
ampicilin	*PR*	6	R	R	☐	☐
fosfomycin	24-24	27	C	C	☐	☐
kotrimoxazol	11-14	6	R	R	☐	☐
nitrofurantoin	17-17	6	R	R	☐	☐
ciprofloxacin	22-25	6	R	R	☐	☐
mecillinam	15-15	6	R	R	☐	☐
cefuroxim	19-19	6	R	R	☐	☐
gentamicin	17-17	6	R	R	☐	☐
cefotaxim	17-20	6	R	R	☐	☐
amoxicilin /klavula	19-20	6	R	R	☐	☐
ceftazidim	22-22	6	R	R	☐	☐
amikacin	18-18	6	R	R	☐	☐
piperacilin /tazoba	17-20	6	R	R	☐	☐
cefepim	24-27	6	R	R	☐	☐
colistin	10-10	6	R	R	☐	☐
ertapenem	25-25	6	R	R	☐	☐
imipenem	17-22	6	R	R	☐	☐
meropenem	16-22	6	R	R	☐	☐

G+ and G- anaerobes

Anaerobic bacteria – definition

- Do not survive in presence of oxygen
- But: aerotolerant anaerobes

- Treatment by metronizadole
- But: *Actinomyces, Cutibacterium*

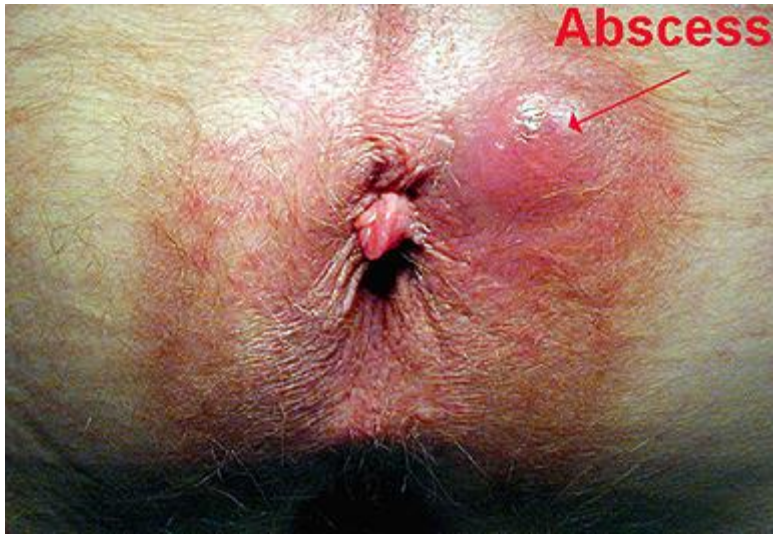
Anaerobic bacteria – characteristics

- Low level of catalase and superoxide dismutase – oxygen radicals
- Colonization of mucosa: gut, gingival sulcus, tonsillar crypts, hair follicles, vagina
- Major part of gut microbiota
- Multiplication of aerobic organisms – consumption of O_2
  - Polymicrobial etiology
- Infection sites
  - Limited oxygen: abscess, devitalized tissue (haemorrhage, trauma)
  - Penetration of foreign material

Anaerobic bacteria – infections

- Intraabdominal infections (abscess, peritonitis, surgical-site infections)
- Lung abscess, pleural empyema
- Brain abscess
- Skin and soft tissue infections
  - Putrid odor, gas formation
- Oral abscess

Absesses!

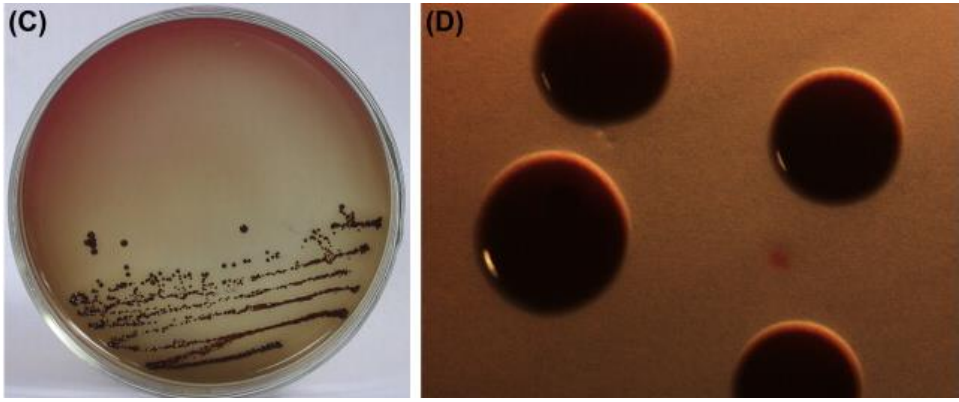


- Often polymicrobial etiology

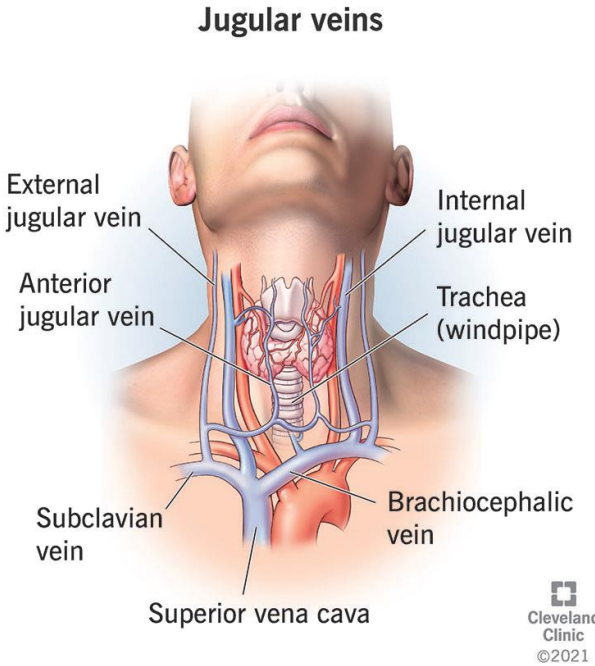
David A Schwartz, MD and Maurits J Wiersema, MD.

G- anaerobic bacilli

- *Bacteroides fragilis*, *B. thetaiotaomicron*, …
- *Prevotella melaninogenica, P. nigrescens*
  - Melanin
- *Fusobacterium necrophorum*
  - Vincent´s tonsilitis – gangrene, malodorous breath
  - Peritonsilar abscess and cellulitis
  - Lemierre syndrome
    - = septic thrombophlebitis of internal jugular vein
    - Oropharyngeal infection → vein wall infection → thrombus → septic emboli (lugs)

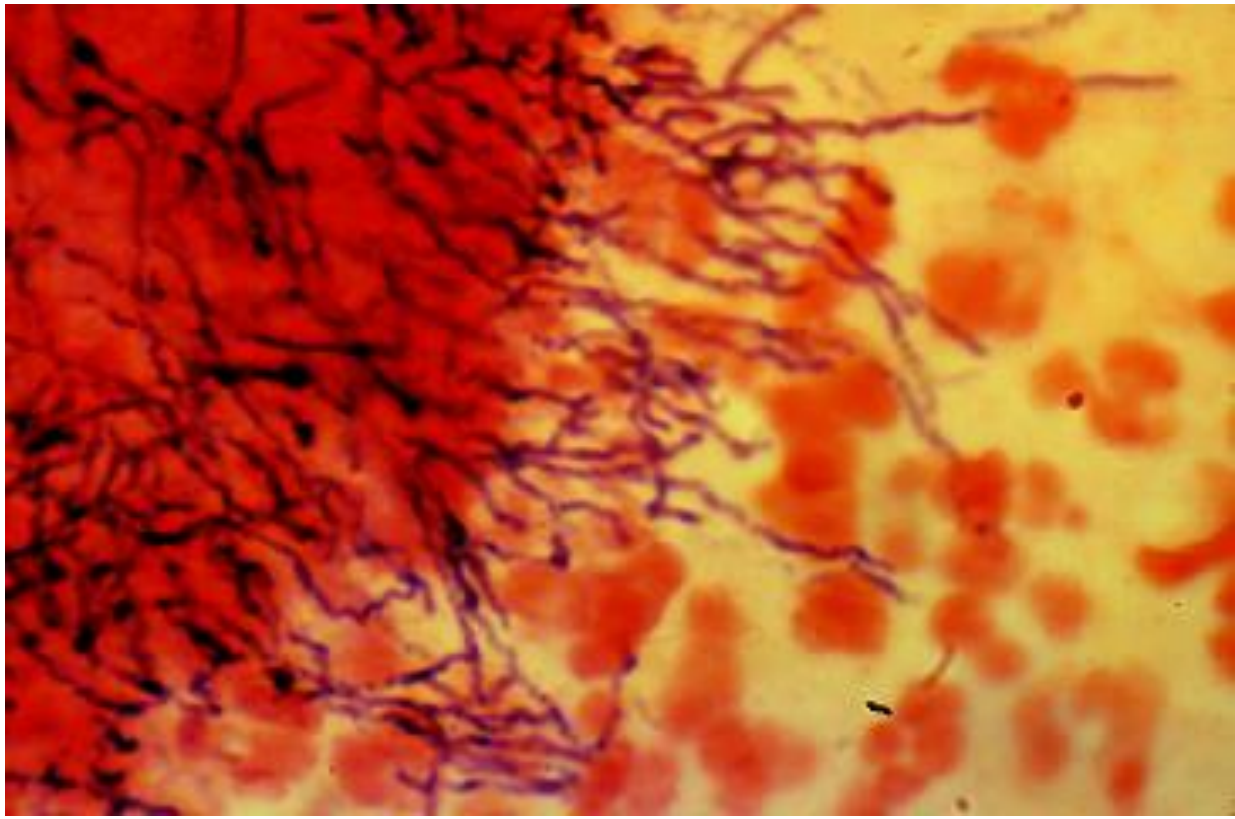


https://www.sciencedirect.com



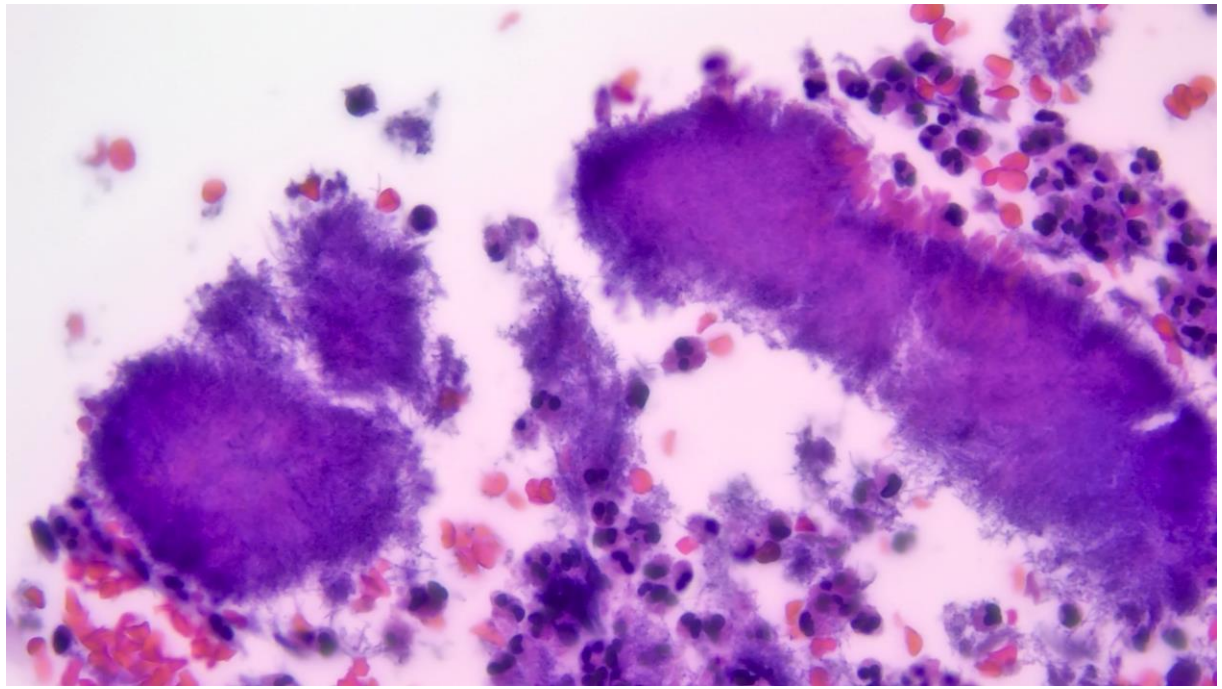
G+ anaerobic bacilli

- *Clostridium* spp.
  - Sporeforming; Lecture „G+ rods“
- *Cutibacterium acnes*
  - Skin microbiota
  - Device-related infections (arthritis, CNS shunt infections)
- *Actinomyces* spp.
  - G+ rods – branching filaments
  - Long growth
  - Actinomycosis
- *Lactobacillus* spp., *Bifidobacterium* spp.



UptoDate, Harriet Provine.

Actinomycosis



Violet Quann, D.O. and Lucy Ma, M.D.

- *Actinomyces israelii*
- Oral, gut, vaginal microbiota
- Cervicofacial, thoracopulmonary, abdominal, pelvic form (IUD)
- Mucosal barrier impairment
  → invasion
  → abscesses, necrosis, fistulae, tissue fibrosis
  spread through anatomical barriers
- „sulfur granules“ – aggregates of bacteria (no sulphur)
- Can mimic malignancy
- Treatment – natural penicillins (2-12 months)

Actinomycosis

Hartung M, Actinomycosis related to longstanding IUD. Case study, Radiopaedia.org (Accessed on 11 Apr 2026) https://doi.org/10.53347/rID-77303

Anaerobic cocci

- Low virulence, microbiota

- G+ anaerobic cocci
  - *Finegoldia magna* – wound infections, prosthetic joint infections
  - *Parvimonas micra*, *Peptostreptococcus* spp., *Peptoniphilus* spp.
  - Low virulence – infections of polymicrobial etiology

- G- anaerobic cocci
  - *Veilonella parvula* (oral microbiota)

Anaerobes – treatment

- Penicillins
- Carbapenems
- Clindamycin
- Metronidazole
  - Broad spectrum (anaerobes); antiprotozoic activity
  - Primary resistance: *Actinomyces*, *Cutibacterium*
  - Bactericidal
  - Nitroimidazole ATB, prodrug – activation → free nitroso radicals → DNA damage

Thank you for your attention!