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Illustrated
Reviews

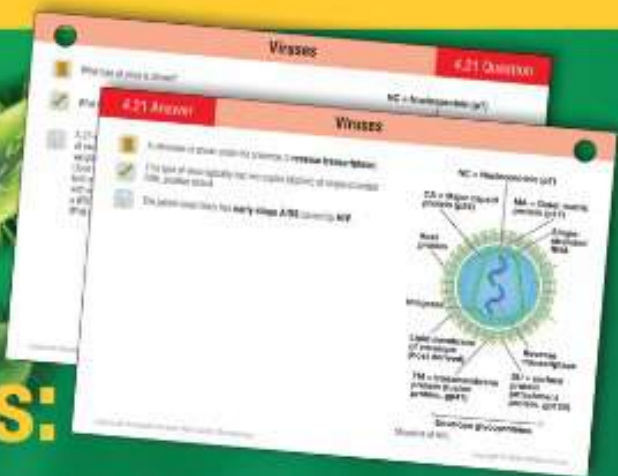
Flash Cards:

Microbiology

Cynthia Nau Cornelissen



Wolters Kluwer





Lippincott Illustrated Reviews Flash Cards

MICROBIOLOGY

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Some drugs and medical devices presented in this publication have Food and Drug Administration (FDA) clearance for limited use in restricted research settings. It is the responsibility of the health care provider to ascertain the FDA status of each drug or device planned for use in his or her clinical practice.

Features: Three-Step Review



SPOT FLASH

Test your grasp of key concepts on a unit-by-unit basis!



COURSE REVIEW

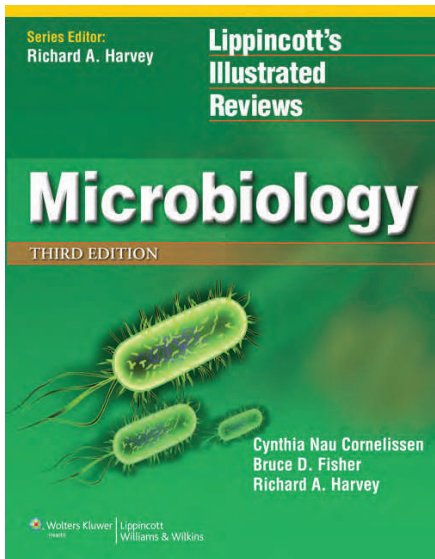
In-depth questions to ensure a thorough understanding of course material. High-yield facts for Course- and Board-exam review!



CLINICAL CORRELATIONS

Explain how the basic science helps predict outcomes in a clinical setting!

Featuring the same visionary artwork found in
Lippincott Illustrated Reviews: Microbiology
With Lippincott Illustrated Reviews, Seeing is Understanding.



Preface

Lippincott Illustrated Reviews Flash Cards: Microbiology is a portable study tool designed for self-assessment and review of medical microbiology. The flash cards were developed primarily for use by medical students while taking a microbiology course and in preparation for course and U.S. medical licensing exams, but information is presented with a clarity and level of detail that suits them as supplements for any of the allied health sciences.

Q CARDS

The entire deck is composed of Q cards, which prompt the reader with questions to assess level of understanding and depth of knowledge.

Q cards contain three-tiered questions or sets of questions on a common topic: The first tests recognition of basic microbial morphology and processes, whereas the next questions build on the basics to test understanding of concepts and clinical presentations. The three question types are denoted by icons.



SPOT FLASH: Illustration-based questions test your recognition of basic microbial morphologies, mechanisms of action, or microbial processes and are intended for use on a unit-by-unit assessment and review basis.



COURSE REVIEW: More in-depth questions test the student's retention of key concepts related to specific microbial pathogens or mechanisms of action. The answers focus on high-yield facts to help consolidate memory during course- and licensing-exam review.



CLINICAL CORRELATIONS: The clinical cases underscore how microbial morphologies, results of biochemical tests, and epidemiological clues can be synthesized to correctly identify the etiological agents of infectious disease.

Continued, over

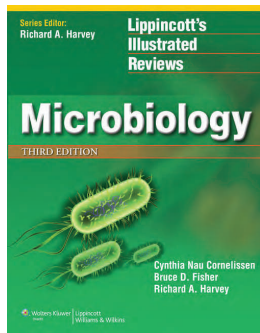


Q cards include several features to aid learning and memorization:

- **Illustrations:** Richly detailed illustrations from the popular companion text, *Lippincott Illustrated Reviews: Microbiology*, appear on both sides of the cards. Many of the illustrations include narrative boxes to help guide readers through complex concepts and processes.
- **Emphasis:** Key terms and diseases are bolded for rapid review and assimilation.

The card deck is designed to be comprehensive, covering all significant medical microbiology concepts.

Note: Our knowledge and understanding of microbiology evolves constantly in the light of new research discoveries. Future editions of *Lippincott Illustrated Reviews Flash Cards: Microbiology* will be updated to take into account such findings and to respond to user feedback.



Acknowledgments

The author wishes to thank her family, friends, and students for support and encouragement throughout this project. In addition, she is indebted to the outstanding faculty at Virginia Commonwealth University who provided many concepts for cases and questions.

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Figure Credits

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Cards 1.7–1.8 Question and Answer: From Forbes BA, Sahn DIF, Weissfeld AS. *Baily & Scott's Diagnostic Microbiology*. St. Louis, MO: Mosby; 1988, Fig 15-6, p. 212.

Cards 1.24, 1.25, 1.29–1.33, 1.36–1.40, 3.20, and 3.21 Question and Answer: Adapted from Clarke MA, Finkel R, Rey JA, et al. *Lippincott's Illustrated Reviews: Pharmacology*. 5th ed. Philadelphia, PA: Lippincott Williams & Wilkins; 2012.

Cards 1.27, 1.34, 1.35, and 2.25 Question and Answer: Adapted from Engleberg NC, DiRita V, Dermody TS. *Schaecter's Mechanisms of Microbial Disease*, 5th ed. Philadelphia,

PA: Lippincott Williams & Wilkins; 2013.

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Card 2.15 Question and Answer: From Bottone EJ, Girolami R, Stamm JM. *Schneier's Atlas of Diagnostic Microbiology*. 9th ed. Abbott Park, IL: Abbott Laboratories; 1984: 5.

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Sherris JC, ed. *Medical Microbiology*. 2nd ed. Norwalk, CT: Appleton & Lange; 1990, Fig. 19.3, p. 349.

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Card 2.34 Question and Answer: From Wistreich G. *Microbiology Perspectives: A Photographic Survey of the Microbial World*. Prentice-Hall, Inc.; 1999, Fig. 72, p. 39.

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Kassierer JP. *Images in Clinical Medicine*. Massachusetts Medical Society; 1997: 38. (bottom) From Farrar WE, Wood MJ, Innes JA, et al. *Infectious Diseases*. 2nd ed. Gower Medical Publishing; 1992, Fig. 2.25, p. 2.8.

Card 2.36 Question and Answer: (A) From Cutlip RC, National Animal Disease Center. United States Department of Agriculture. Agricultural Research Service. (B) From Wistreich G. *Microbiology Perspectives: A Photographic Survey of the Microbial World*. Prentice-Hall, Inc.; 1999, Fig. 158-B, p. 71.

Card 2.37 Question and Answer: (left) From Wistreich G. *Microbiology Perspectives: A Photographic Survey of the Microbial World*. Prentice-Hall, Inc.; 1999, Fig. 193, p. 86. (right) From Center for Disease Control, Atlanta, GA.

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Sellers, Emory University, Public Health Image Library, Centers for Disease Control and Prevention.

Card 2.47 Answer: (left) From Koneman EW, Allen SD, Janda WM, et al. *Color Atlas and Textbook of Diagnostic Microbiology*. 5th ed. Philadelphia, PA: J. B. Lippincott Company; 1997, Plate 8-3H. (right) From Koneman EW, Allen SD, Janda WM, et al. *Color Atlas and Textbook of Diagnostic Microbiology*. 4th ed. Philadelphia, PA: J. B. Lippincott Company; 1992, Plate 7-2J.

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Card 2.64 Question and Answer: (A) From 2000 Red Book: Report of the Committee on Infectious Diseases, American Academy of

Pediatrics. (B left) From Alexander SK, Strete D. *Microbiology: A Photographic Atlas for the Laboratory.* Benjamin Cummings; 2001, Fig. 2.7, p. 13. (B right) Courtesy of Harriet C. W. Thompson, MS, Department of Microbiology, Immunology and Parasitology, Louisiana State University Health Science Center, New Orleans. (B bottom) From Farrar WE, Wood MJ, Innes JA, et al. *Infectious Diseases.* 2nd ed. Gower Medical Publishing; 1992, Fig 1.35, p. 1.11.

Card 2.66 Question and Answer: (A) From Schaechter M, Engleberg NC, Eisenstein BI, et al. *Mechanism of Microbial Disease.* 3rd ed. Williams and Wilkins; 1998, Fig. 14.6, p. 166. (B) From Hoeprich PD, Jordan MC, Ronald AR. *Infectious Diseases: A Treatise of Infectious Processes.* 5th ed. Philadelphia, PA: J. B. Lippincott Company; 1994, Fig. 70-6, p. 681.

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Card 2.70 Question and Answer: (top row, left and right) Courtesy of Dr. Donna Duckworth. (bottom row, left) From Bisno AL, Stevens, DL. Current concepts: Streptococcal infections of skin and soft tissues. *N Engl J Med.* 1996;334(4):241. (bottom row, middle) From Peterson PK, Dahl MV. *Dermatologic Manifestations of Infectious Diseases.* The Upjohn Company; 1982, Fig. 48-1, p. 105. (bottom row, right): From Mir MA, *Atlas of Clinical*

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Diagnosis. W. J. B. Saunders Company Ltd.; 1995, Fig. 2.103, p. 86.

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Card 2.80 Question and Answer: From Iseman, Michael D, S/M Infectious Diseases Division. National Jewish Medical Research Center.

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Card 3.2 Question and Answer: (A) From Rubin E, Farber JL. *Pathology*, 2nd ed. J. B. Lippincott Company; 1994, Fig. 9-5. (B) From Goldman M, Johnson PC, Sarosi GA. Fungal pneumonias. The endemic mycoses. *Clinics in Chest Medicine*. 1999;20(3); Fig. 3.

Card 3.3 Question and Answer: From Dr. Libero Ajello, Public Health Image Library, Centers for Disease Control and Prevention.

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Card 3.9 Question and Answer: (A) From McGee J, Isaacson PG, Wright NA. *Oxford Textbook of Pathology*. Oxford Press; 1992, Fig. 6.30.

Card 3.10 Question and Answer: From Gillies RR, Dodds, TC. *Bacteriology Illustrated*. 3rd ed. Williams and Wilkins Company; 1973: 194.

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Appleton & Lange; 1990. Fig. 19.3, p. 349.

Card 4.9 Question and Answer:
(B) From Ginsberg HS. *The Adenoviruses*. Plenum Publishers; 1984.
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Card 4.10 Question and Answer:
(A) From Volk WA, Gebhardt BM, Hammarskjold M, et al. *Essentials of Microbiology*. 5th ed. Philadelphia, PA: Lippincott-Raven; 1996, Fig. 38-4A, p. 522. (B) From Public Health Image Library, Centers for Disease Control and Prevention.

Card 4.11 Question and Answer:
(A) From Volk WA, Gebhardt BM, Hammarskjold M, et al. *Essentials of Microbiology*. 5th ed. Philadelphia,

PA: Lippincott-Raven; 1996, Fig. 38-4A, p. 522. (B) From Habif TP. *Clinical Dermatology: A Color Guide to Diagnosis and Therapy*. St Louis, MO: Mosby, 1996. Fig. 12-34, p. 345.

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Card 4.13 Question and Answer:
(A) Courtesy of Joan Barenfanger, Laboratory Medicine, Memorial Medical Center, Springfield, IL.
(B) From Ball AP, Gray JA. *Colour Guide Infectious Diseases*. Edinburgh, Scotland: Churchill Livingstone; 1992, Fig. 56, p. 40.

Card 4.14 Question and Answer:
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Card 4.16 Question and Answer:
(B and C) From Ordoukhanian E, Lane AT. Warts and molluscum contagiosum: beware of treatments worse than the disease. *Postgrad Med*. 1997;223-232,

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Card 4.22 Question and Answer:
(A) From Fields BN, Knipe DM, Howley PM. *Virology*. 3rd ed.

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(B) From Center for Disease Control, Atlanta.

Card 4.25 Question and Answer:
(B) Courtesy Dr. Heinz F. Eichenwald, Public Health Image Library, Centers for Disease Control and Prevention.

Card 4.26 Question and Answer:
(A) From Fields BN, Knipe DM, Howley PM. *Virology*. 3rd ed. Philadelphia, PA: Lippincott Williams and Wilkins; 1996, Fig. 2, p. 1401.

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Card 4.30 Question and Answer: From Cotran RS. *Robbins Pathologic Basis of Disease*. 6th ed. W. B. Saunders Company; 1996. Fig. 7-38.

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From Fields BN, Knipe DM, P.M. *Virology*. 3rd edition. Philadelphia, PA: Lippincott Williams and Wilkins; 1996, Fig. 2, p. 1357. Photo courtesy of George Leser, Northwestern University, Evanston, IL.

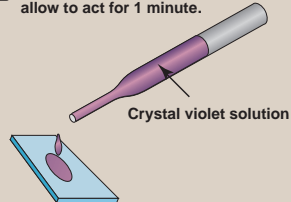
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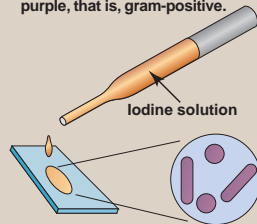


What is the next step in this procedure and what does it accomplish?

- 1** Heat-fix specimen to slide. Flood slide with crystal violet solution; allow to act for 1 minute.

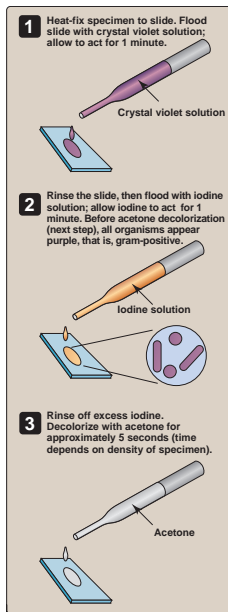


- 2** Rinse the slide, then flood with iodine solution; allow iodine to act for 1 minute. Before acetone decolorization (next step), all organisms appear purple, that is, gram-positive.





The next step in this procedure is destaining with acetone to differentiate between Gram positives, which retain the initial purple stain, and Gram negatives, which lose the purple stain during decolorization.

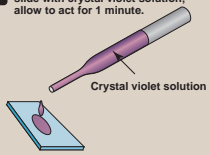


Steps in Gram stain method.
Gram positive = violet;
Gram negative = red.

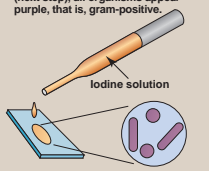


What is the next step in this procedure and what does it accomplish?

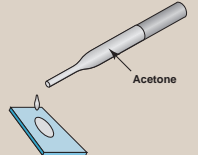
1 Heat-fix specimen to slide. Flood slide with crystal violet solution; allow to act for 1 minute.



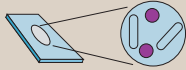
2 Rinse the slide, then flood with iodine solution; allow iodine to act for 1 minute. Before acetone decolorization (next step), all organisms appear purple, that is, gram-positive.



3 Rinse off excess iodine. Decolorize with acetone for approximately 5 seconds (time depends on density of specimen).

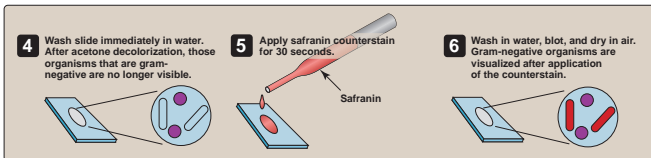


4 Wash slide immediately in water. After acetone decolorization, those organisms that are gram-negative are no longer visible.



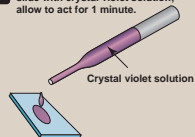


The next step in this procedure is to counterstain with safranin to stain those Gram-negative cells red that have become colorless due to the previous destaining step.

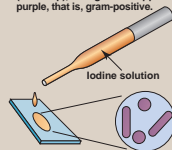


Steps in Gram stain method. Gram positive = violet; Gram negative = red.

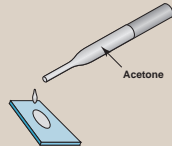
- 1** Heat-fix specimen to slide. Flood slide with crystal violet solution; allow to act for 1 minute.



- 2** Rinse the slide, then flood with iodine solution; allow iodine to act for 1 minute. Before acetone decolorization (next step), all organisms appear purple, that is, gram-positive.



- 3** Rinse off excess iodine. Decolorize with acetone for approximately 5 seconds (time depends on density of specimen).

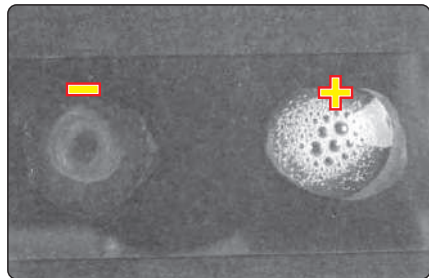




Adding H_2O_2 to bacteria containing what enzyme will produce O_2 bubbles?



This test differentiates between which groups of Gram-positive bacteria?

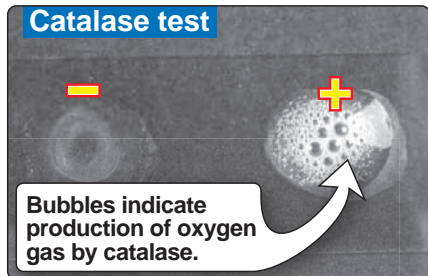




Adding H_2O_2 to bacteria containing **catalase** produces O_2 bubbles.



This test differentiates between catalase-positive staphylococci and catalase-negative streptococci. Also, *Bacillus* species are positive, whereas *Clostridium* species are negative.

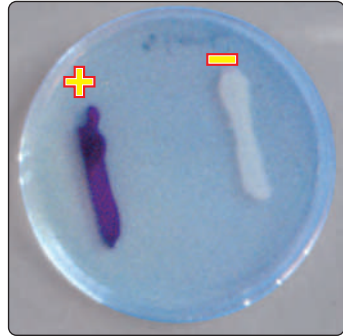




When a phenylenediamine derivative donates electrons to a particular bacterial electron transport chain enzyme, the bacteria turn purple. What enzyme is responsible for this reaction and resulting purple color?



This test differentiates between which groups of Gram-negative bacteria?

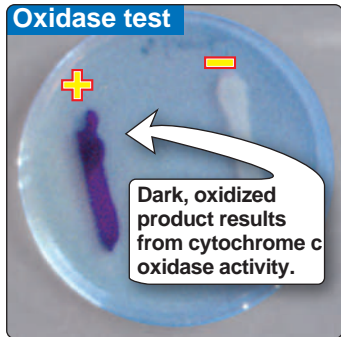




Bacteria positive for cytochrome C **oxidase** turn purple when the reagent for the oxidase test is added, as shown.



This test differentiates between oxidase-positive *Pseudomonas* species and the oxidase-negative family *Enterobacteriaceae*. Also, *Neisseria* species are positive, whereas *Acinetobacter* species are negative.





When bacteria are grown on this urea-containing medium, those that are positive for what enzyme will turn red?



What is the end product of this reaction?



What species of bacteria are noted for producing the enzyme detected by this test?





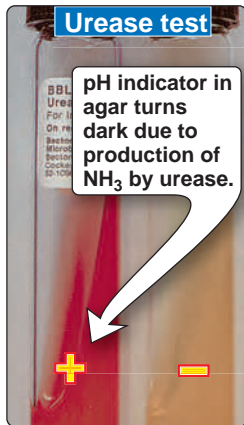
Bacteria positive for **urease** turn red when grown on this urea-containing medium.



Ammonia is the end product of this reaction.



Helicobacter pylori and *Proteus mirabilis* produce urease.

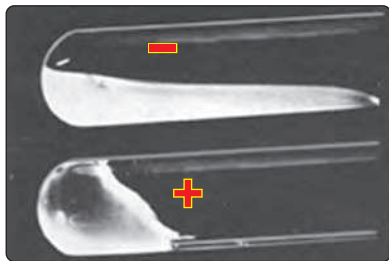




When bacteria are added to serum, those that are positive for what enzyme will cause a clot to form?



This test differentiates between which groups of Gram-positive bacteria?

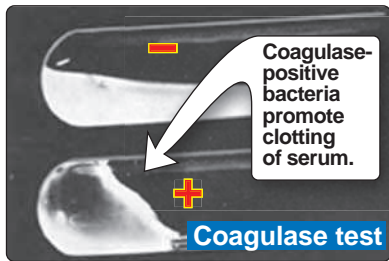




Bacteria positive for **coagulase** cause a clot to form when added to serum.



This test differentiates between coagulase-positive *Staphylococcus aureus* and the other less invasive staphylococci, including *Staphylococcus epidermidis* and *Staphylococcus saprophyticus*, which are coagulase negative.

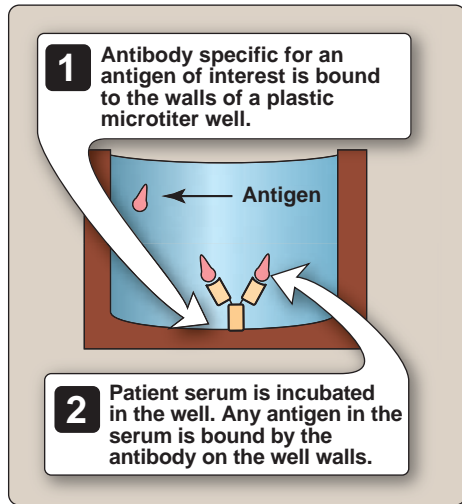




What is the next step in the molecular test shown?



What is an important characteristic of the reagent added in the next step?

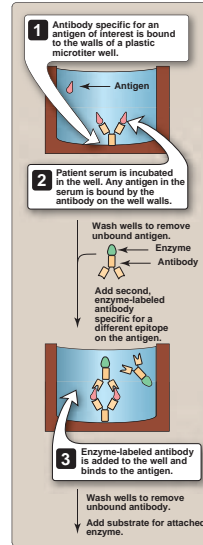




After washing away unbound antigen, antibody specific for the antigen is added as the next step. The antibody is labeled with an enzyme that is detectable by its conversion of substrate to product.



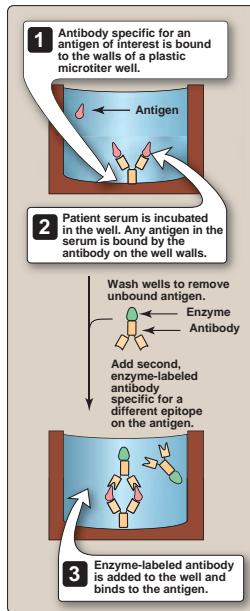
The enzyme-labeled antibody must recognize a different epitope than the antibody that was used to coat the enzyme-linked immunosorbent assay (ELISA) plate.



Enzyme-linked immunosorbent assay (ELISA)

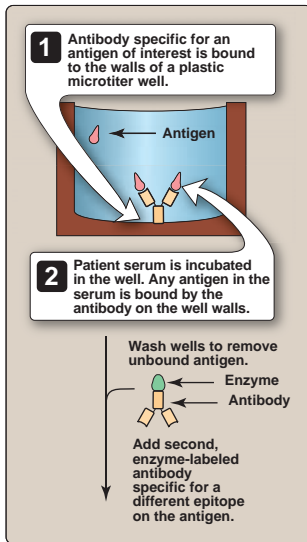


What is the next step in this molecular test?

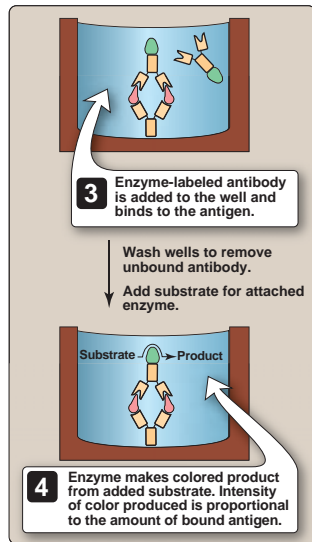




After washing away unbound antibody, the substrate for the enzyme attached to the antibody is added as the next step. The enzyme quantitatively converts substrate to product, the amount of which is proportional to the amount of antigen present in the patient's sample.



Enzyme-linked immunosorbent assay (ELISA)

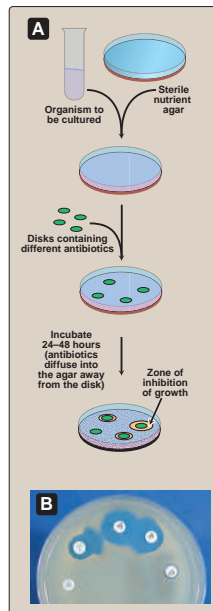




Indicate whether the test organism is sensitive or resistant to the antibiotics in each of the disks (from left to right in **panel B**).



What two factors impact the growth inhibition zone in these disk assays?

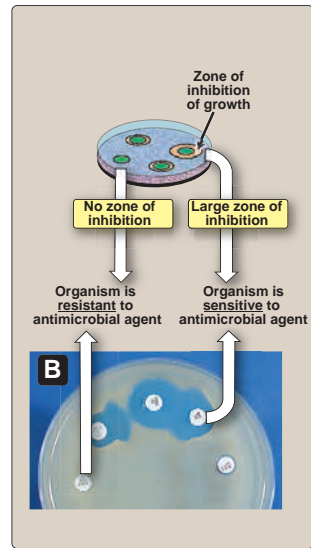
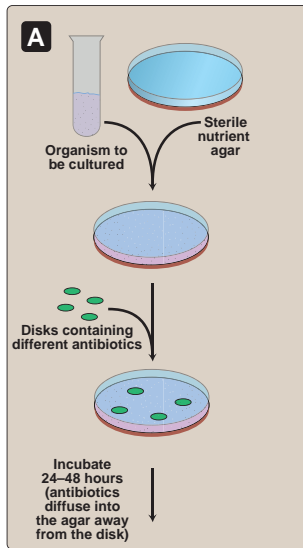




From left to right, the test organism is antibiotic resistant, sensitive, sensitive, and resistant.



The degree of sensitivity of the tested bacterium and the degree to which the antibiotic diffuses through the medium away from the disk on the plate surface impact the size of the growth inhibition zone.



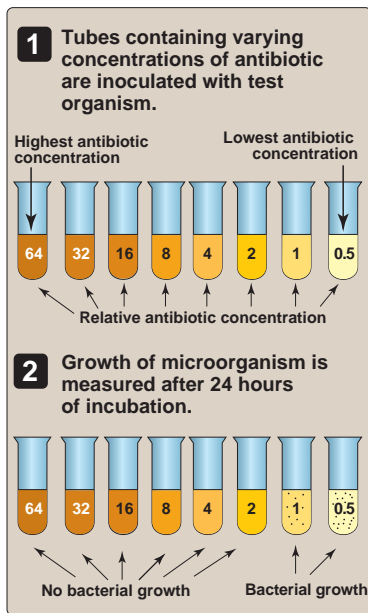
A. Outline of disk-diffusion method for determining the sensitivity of bacteria to antimicrobial agents. **B.** Photograph of culture plate with antibiotic-impregnated disks.



What is the **minimum inhibitory concentration (MIC)** for the bacterium and antibiotic shown?



Removing bacteria from each tube shown and plating the culture on medium without antibiotic allows for **minimum lethal concentration (MLC)** determination. If colonies appeared on plates removed from tubes 64, 32, 16, and 8 but no other tubes, what is the MLC for this bacterium and antibiotic?

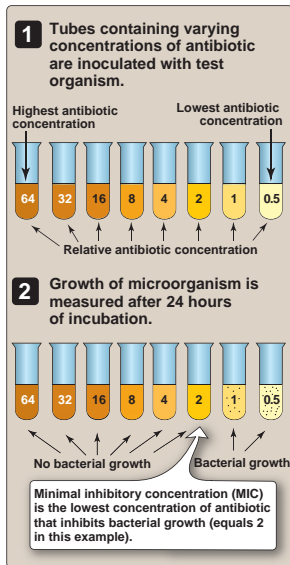




The MIC for this bacterium and antibiotic is 2 units.



The MLC for this bacterium and antibiotic is 4 units.



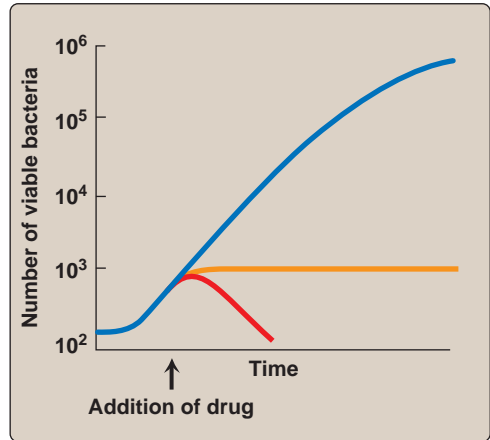
Determination of minimal inhibitory concentration (MIC) of an antibiotic.



If bacterial growth is plotted over time, without the addition of a drug, the number of viable bacteria increases logarithmically (blue line). What type of antibiotic added to the culture could prevent an increase in viable bacteria over time (yellow line)?



What type of antibiotic added to the culture could result in a decrease in viable bacteria over time (red line)?

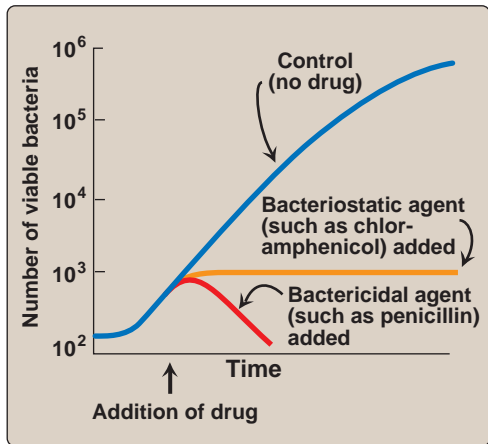




Bacteriostatic antimicrobial agent would prevent viable bacteria increase over time.



Bactericidal antimicrobial agent would decrease viable bacteria over time.



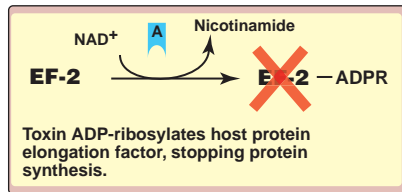
Effects of bactericidal and bacteriostatic drugs on the growth of bacteria *in vitro*.



What toxin has the mechanism of action shown?



What bacterium produces the exotoxin with this activity?

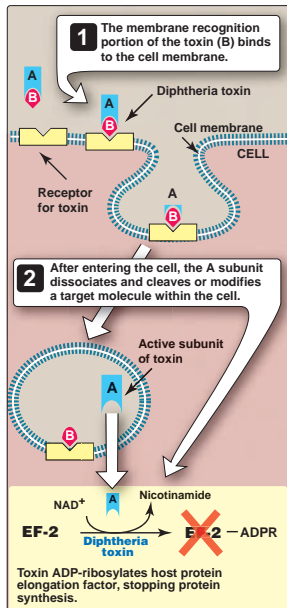




Diphtheria toxin acts via the mechanism shown (exotoxin A produced by *Pseudomonas aeruginosa* uses the same mechanism).



Corynebacterium diphtheriae produces the exotoxin with this activity.

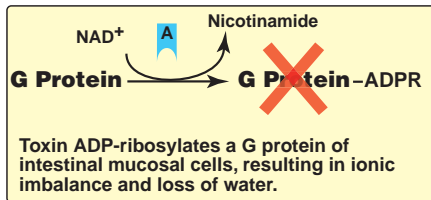




What toxin has the mechanism of action shown?



What bacterium produces the exotoxin with this activity?

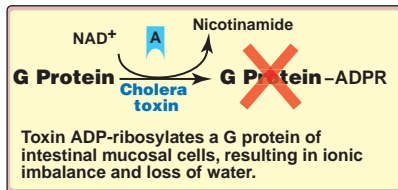




Cholera toxin acts via the mechanism shown (heat-labile toxin produced by ETEC acts by the same mechanism).



Vibrio cholerae produces the exotoxin with this activity.

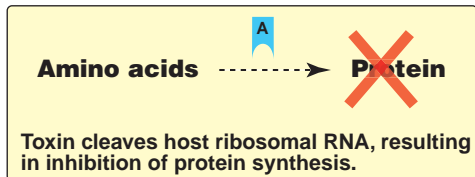




What toxin has the mechanism of action shown?



What bacterium produces the exotoxin with this activity?

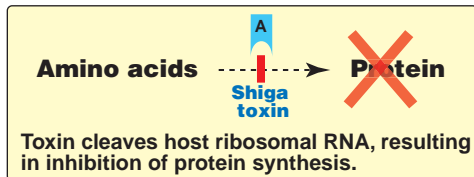




Shiga toxin acts via the mechanism shown.



Shigella dysenteriae produces the exotoxin with this activity.

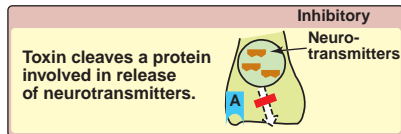




What toxin has the mechanism of action shown?



What bacterium produces the exotoxin with this activity?

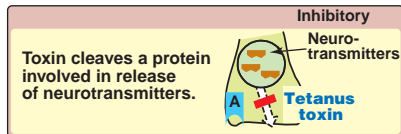




Tetanus toxin (tetanospasmin) acts via the mechanism shown.



Clostridium tetani produces the exotoxin with this activity.

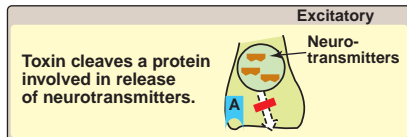




What toxin has the mechanism of action shown?



What bacterium produces the exotoxin with this activity?

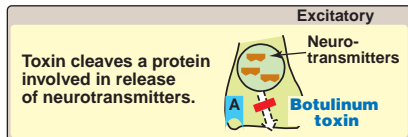




Botulinum toxin acts via the mechanism shown.



Clostridium botulinum produces the exotoxin with this activity.

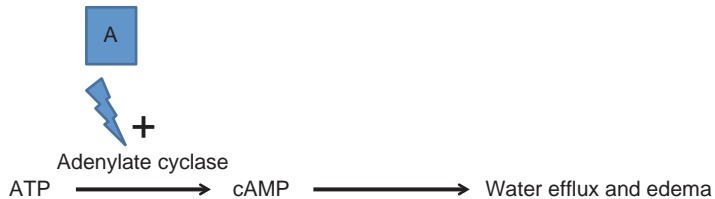




What toxin has the mechanism of action shown?



What bacterium produces the exotoxin with this activity?

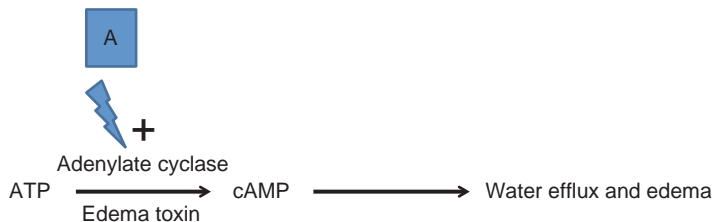




Edema toxin acts via the mechanism shown.



Bacillus anthracis produces the exotoxin with this activity.



Edema toxin activates adenylate cyclase resulting in increased cAMP concentrations, water efflux, and edema.



What toxin has the mechanism of action shown?



What bacterium produces the exotoxin with this activity?

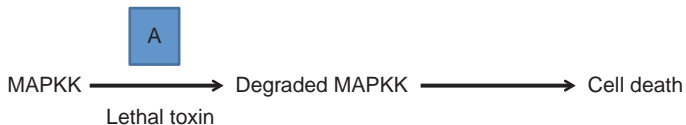




Lethal toxin acts via the mechanism shown.



Bacillus anthracis produces the exotoxin with this activity.



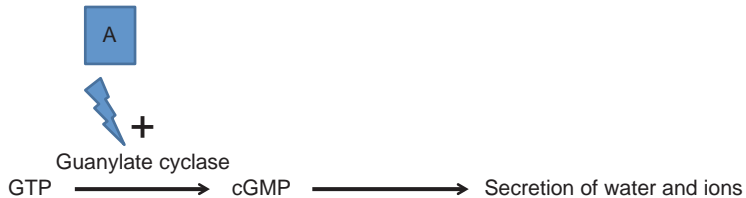
Toxin is a protease that cleaves MAPKK (a host kinase) leading to cell death.



What toxin has the mechanism of action shown?



What bacterium produces the exotoxin with this activity?

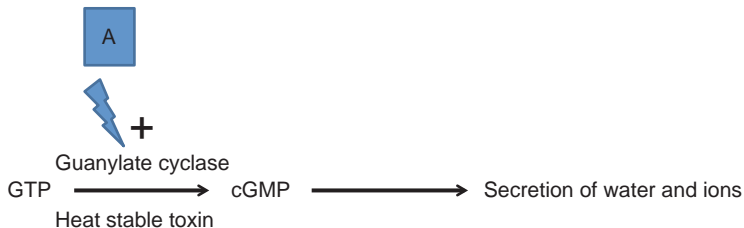




Heat-stable toxin acts via the mechanism shown.



Enterotoxigenic *Escherichia coli* (ETEC) produces the exotoxin with this activity.



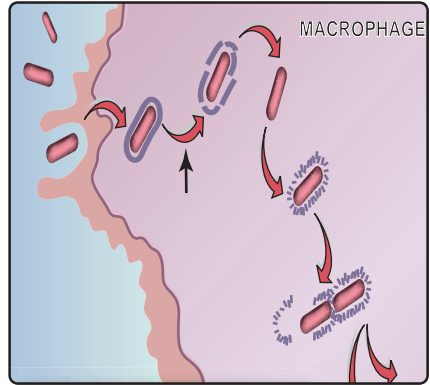
Heat stable toxin produced by ETEC activates guanylate cyclase resulting in an increase in cGMP concentrations and increased secretion of water and ions and to diarrhea.



What toxin exerts its activity when the intracellular bacterium producing it is within a phagocytic vesicle, as indicated by the black arrow?



What bacterium produces the exotoxin with this activity?

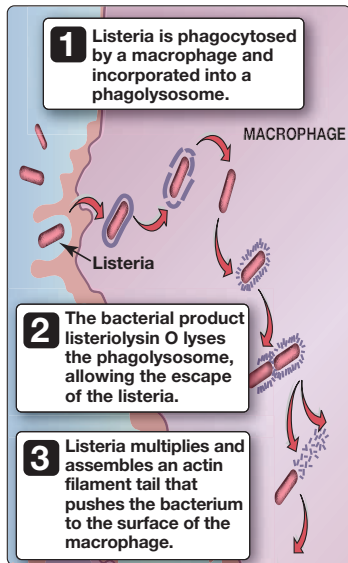




Listeriolysin O acts via the mechanism shown.



Listeria monocytogenes produces the exotoxin with this activity.



Lifecycle of *Listeria monocytogenes* in host macrophages.



What toxins produced by the same bacterial species have the mechanism of action shown?



What bacterium produces the exotoxins with this activity?

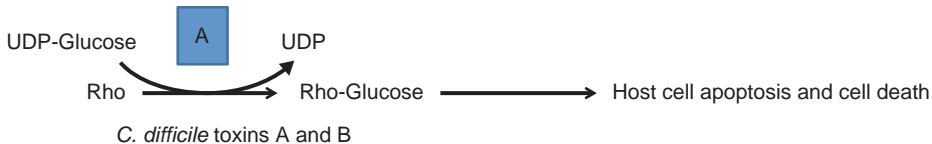




Toxins A and B act via the mechanism shown.



Clostridium difficile produces the exotoxins with this activity.



Toxins A and B are transglycosylases that glucosylate and inactivate Rho family proteins.



Koch's postulates are still used today to demonstrate a linkage between disease and microbial pathogen. The first two criteria of Koch's postulates are shown. What is the next step?



What is the final criterion of Koch's postulates?



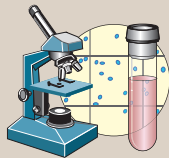
What are two serious limitations to employing Koch's postulates to identify disease etiology?



Sick

1

The microorganism must always be found in similarly diseased animals but not in healthy ones.



2

The microorganism must be isolated from a diseased animal and grown in pure culture.



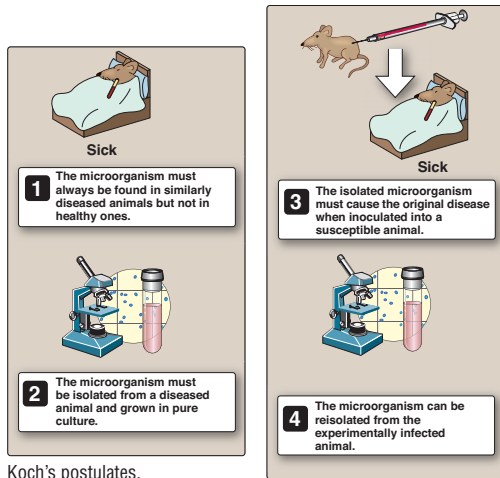
The next step in Koch's postulates is that the isolated microorganism must cause the original disease when inoculated into a susceptible animal.



The final criterion of Koch's postulates is that the microorganism can be reisolated from the experimentally infected animal.



Two serious limitations to employing Koch's postulates to identify disease etiology are (1) the organism must be culturable in the laboratory and (2) the organism must cause disease in an animal other than humans.





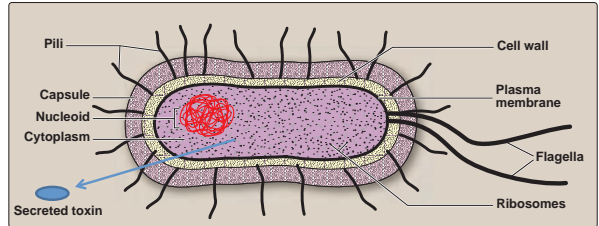
Infections by which bacterial pathogens are prevented by vaccines composed of capsular material?



Infections by which bacterial pathogens are prevented by vaccines composed of inactivated toxins?



Infections by which bacterial pathogens are prevented by vaccines composed of whole, heat-inactivated bacterial cells?





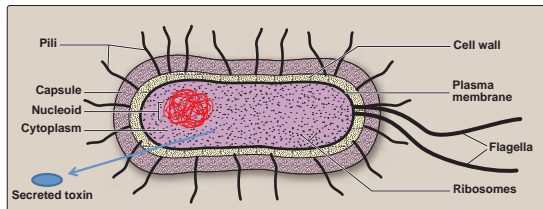
Infections by *Neisseria meningitidis*, *Haemophilus influenzae*, and *Streptococcus pneumoniae* are prevented by vaccines composed of capsular material.



Infections by *Bacillus anthracis*, *Corynebacterium diphtheriae*, *Clostridium tetani*, and *Bordetella pertussis* are prevented by vaccines composed of inactivated toxins.



Infections by *Salmonella enteritidis* serovar Typhi are prevented by vaccines composed of whole, heat-inactivated bacterial cells.



Generalized structure of a bacterial cell. Blue oval represents a secreted toxin.



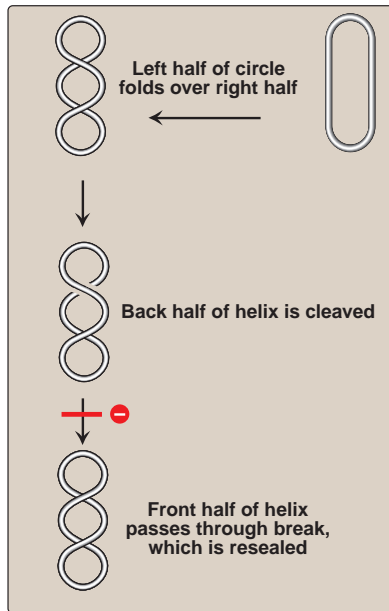
Which class of antibacterial drugs targets the pathway shown?



What is their mechanism of action?



Why is the drug selective for bacteria without affecting host functions?





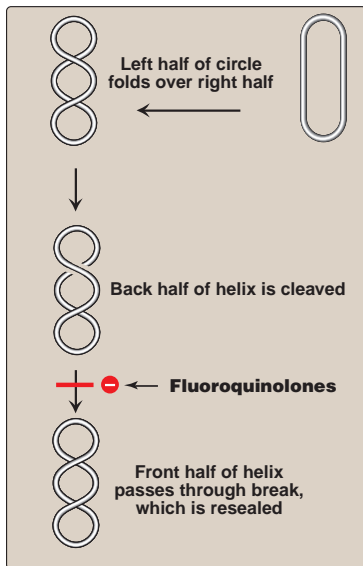
Fluoroquinolones such as ciprofloxacin target the pathway shown.



Fluoroquinolones bind to a complex of DNA gyrase and DNA, inhibiting the rejoining step. The resulting cleavage of DNA results in bacterial cell death.



Fluoroquinolones are selective for bacteria without affecting host functions because DNA gyrase is an enzyme uniquely found in bacteria.



Action of DNA gyrase. Adapted from *LIR Pharmacology, Fifth Edition*.



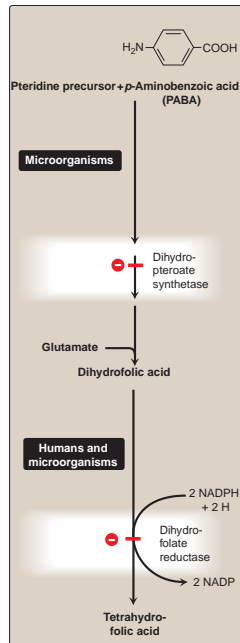
What class of antibacterial agent inhibits the first enzymatic step in the pathway shown?



What antibacterial agent inhibits the enzyme dihydrofolate reductase in the pathway?



What antimicrobial agent combines the effects of these two inhibitors?





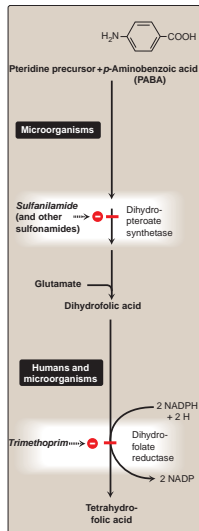
Sulfonamides inhibit the first enzymatic step in the pathway shown.



Trimethoprim inhibits the enzyme dihydrofolate reductase in the pathway shown.



Trimethoprim-sulfamethoxazole (Bactrim) combines the effects of these two inhibitors.



Inhibition of tetrahydrofolate synthesis by sulfonamides and trimethoprim. Adapted from *LIR Pharmacology, Fifth Edition*.



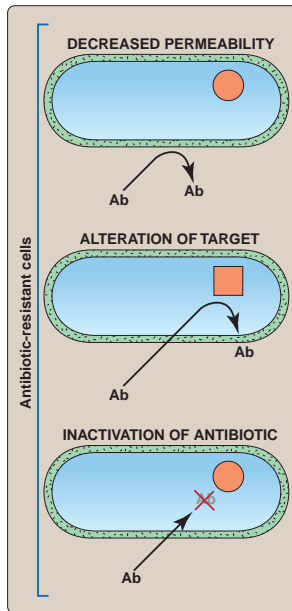
Some bacteria produce β -lactamases, thereby becoming resistant to the bactericidal effects of β -lactam-type antimicrobials. Which mechanism of resistance is represented by expression of β -lactamases?



Some bacteria become resistant to penicillin by expressing new penicillin-binding proteins (PBPs) in their cell wall. Which mechanism of resistance is represented by expression of unique PBPs?



Some Gram-negative bacteria become resistant to antibacterial drugs and other unrelated substances such as antimicrobial peptides and detergents by expression of an efflux system in the cell envelope. Which mechanism of resistance is represented by expression of efflux pumps?





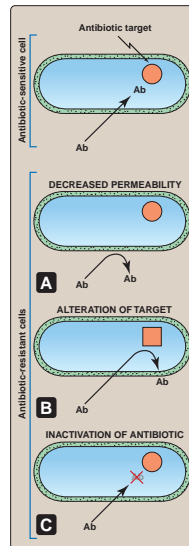
The mechanism of resistance represented by expression of β -lactamases is **C. Antibiotic inactivation**. The β -lactamase cleaves the β -lactam ring of this class of antimicrobials, thereby inactivating it.



The mechanism of resistance represented by expression of unique PBPs is **B. Target alteration**. The new PBPs no longer bind to penicillin with the same affinity, producing drug resistance.



The mechanism of resistance represented by expression efflux pumps is **A. Decreased permeability**. The efflux systems pump out the drugs or noxious substances faster than accumulation can occur in resistant bacteria.



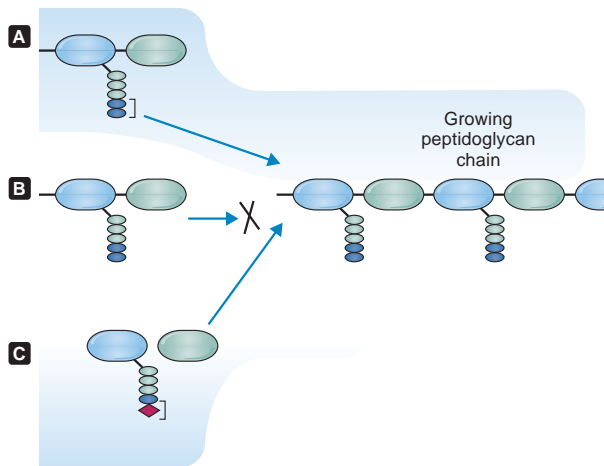
The common mechanisms of antibiotic resistance. Adapted from *LIR Pharmacology, Fifth Edition*.



Where does vancomycin bind to the structure shown?



What is the result of incorporating D-lac into the peptide instead of D-ala, as shown in **panel C**?

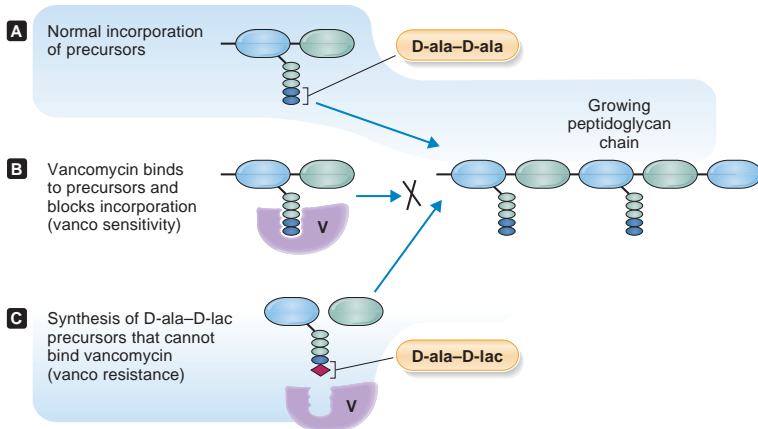




Vancomycin binds to the terminal D-ala–D-alanine residues shown in dark blue.



Incorporating D-lac into the peptide instead of D-alanine means that vancomycin no longer binds to the terminal residues of the stem peptide. Therefore, bacteria (including *Enterococcus* species) that produce this modified peptidoglycan subunit are resistant to vancomycin's action.



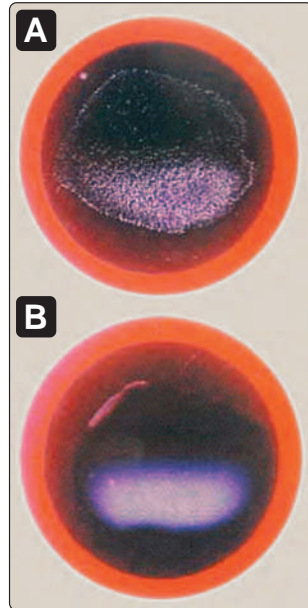
Target of vancomycin action and mechanism of resistance. Adapted from *Schaecter's Mechanisms of Microbial Disease*, Fifth Edition.



Which result (**panel A** or **B**) represents a positive outcome for the latex agglutination test?



What is the immunological basis for this test?

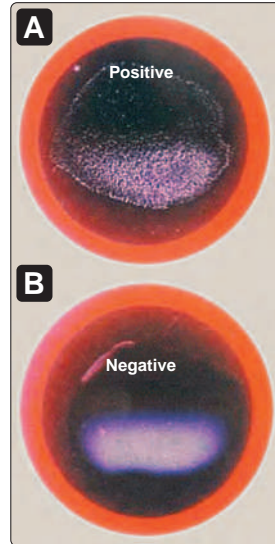




Panel A. The spread out, particulate appearance of the latex beads represents a positive result.



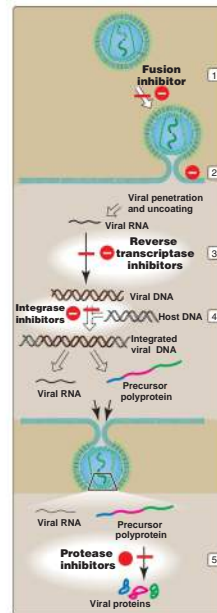
The immunological basis for the latex agglutination test is that antibodies bound to the latex bead are specific for a bacterial antigen (e.g., *Streptococcus pyogenes* Lancefield group A antigen), and will agglutinate when the antigen is present in patient specimens.



Latex agglutination for identification of group A streptococci.

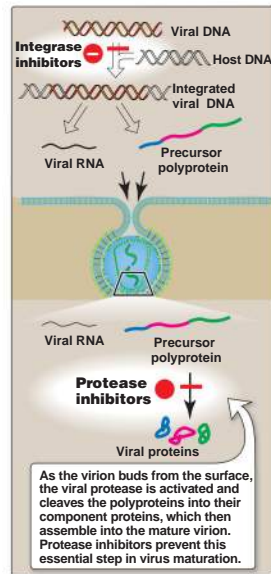
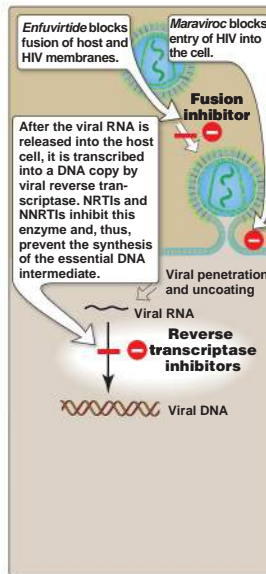


What antiviral agent blocks the replication step labeled 1?





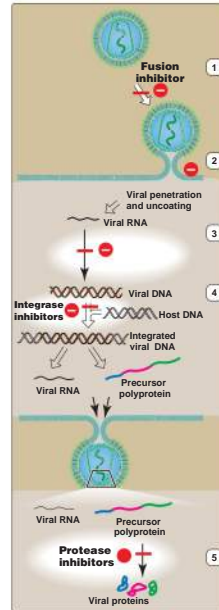
The antiviral **enfuvirtide** blocks this replication step.



Drugs used to prevent HIV from replicating. Adapted from *LIR Pharmacology, Fifth Edition*.

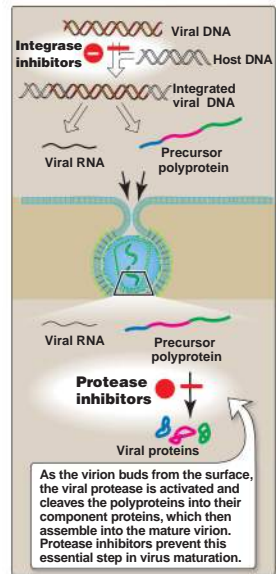
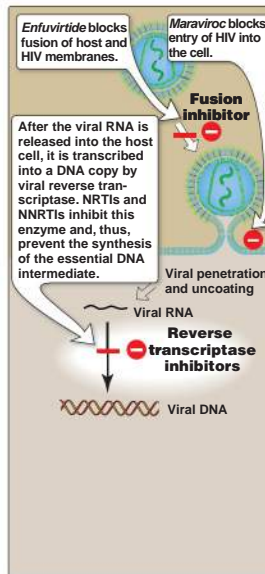


What antiviral agent blocks the replication step labeled 2?





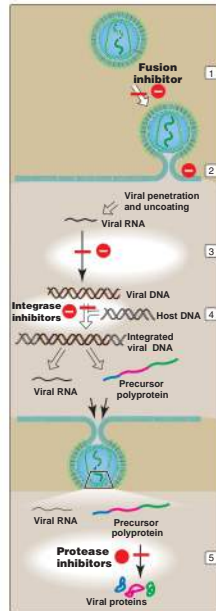
The antiviral **maraviroc** blocks this replication step.



Drugs used to prevent HIV from replicating. Adapted from *LIR Pharmacology, Fifth Edition*.

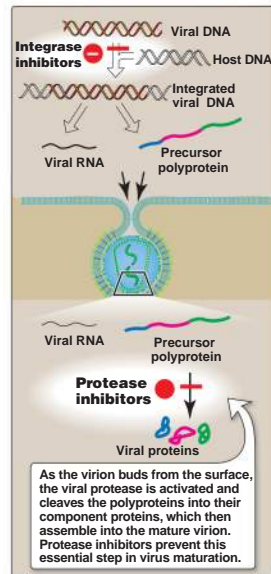
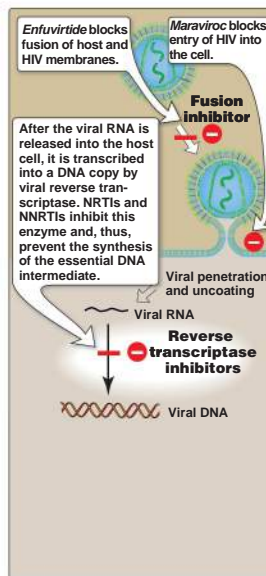


What class of antiviral agents blocks the replication step labeled 3?





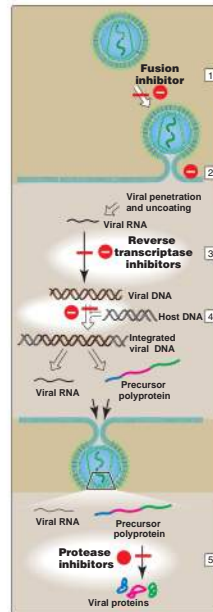
The **reverse transcriptase inhibitors** block this replication step.



Drugs used to prevent HIV from replicating. Adapted from *LIR Pharmacology, Fifth Edition*.

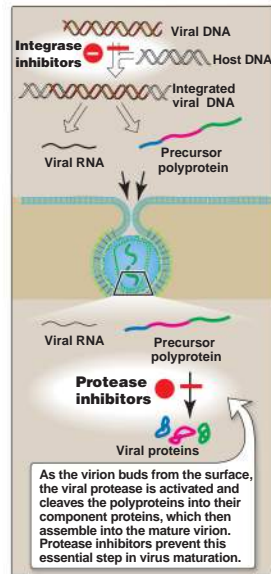
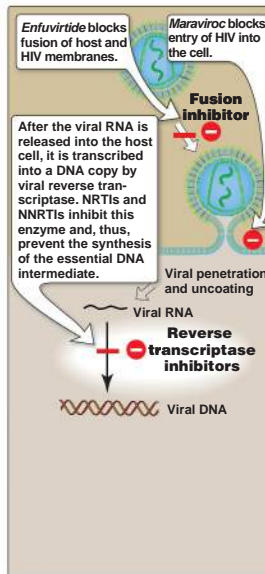


What antiviral agent blocks the replication step labeled 4?





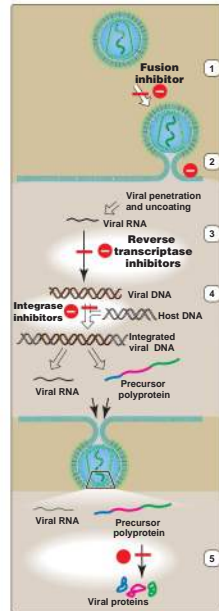
Integrase inhibitors such as **Raltegravir** block this replication step.



Drugs used to prevent HIV from replicating. Adapted from *LIR Pharmacology, Fifth Edition*.

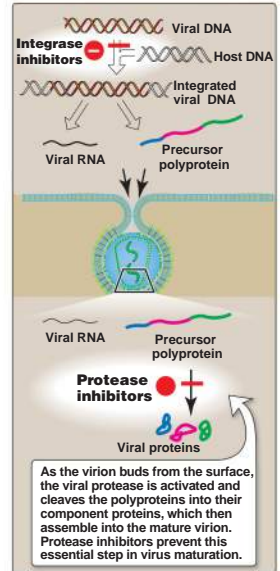
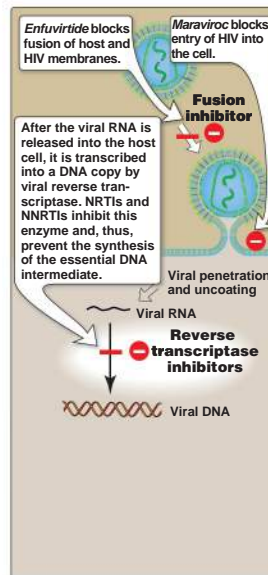


What class of antiviral agents blocks the replication step labeled 5?





The **protease inhibitors** block this replication step.



Drugs used to prevent HIV from replicating. Adapted from *LIR Pharmacology, Fifth Edition*.



What bacterial toxin blocks the step shown by the asterisk?



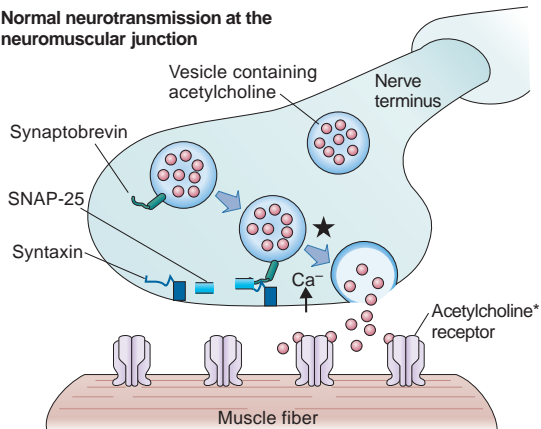
What are the physiological consequences of this toxin's activity?



A 3-month-old infant is brought to the emergency department by her mother. The child has not been eating well, seems lethargic, and has lax muscle tone. The mother notes that she seemed "floppy" when lifted from her crib earlier in the morning. The infant does not have a fever. Her mother indicates that she had recently started the child on solid foods including cereal sweetened with honey. What is the most likely etiology and infection?

A

Normal neurotransmission at the neuromuscular junction





Botulinum toxin blocks this step.



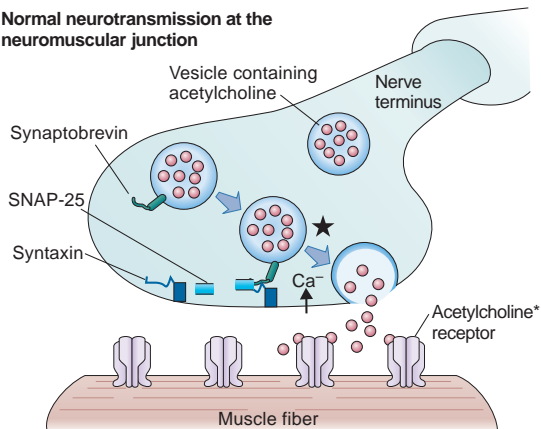
This toxin causes **flaccid paralysis** due to an inability to release acetylcholine into the neuromuscular junction.



The patient most likely has **infant botulism** caused by *Clostridium botulinum*.

A

Normal neurotransmission at the neuromuscular junction



Mechanism of action of botulinum toxins. Adapted from *Schaecter's Mechanisms of Microbial Disease, Fifth Edition*.



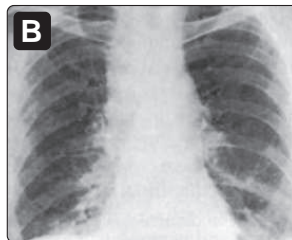
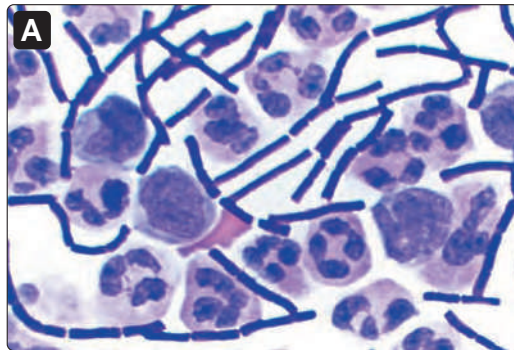
What is the Gram reaction and morphology of the bacterium shown (**panel A**)?



The bacterium shown produces two potent toxins, both of which have the same binding (or B) subunit. What is the name and function of the toxins' B subunit?



A farmer in Iowa presents at the emergency department with fever and confusion. Chest x-ray shows mediastinitis and mediastinum widening, as shown (**panel B**). The physician collects a CSF sample for analysis, and Gram stain of the CSF material is similar to that shown. The physician urgently treats the patient with IV antibiotics and notifies the public health department. What is the most likely etiology and infection?





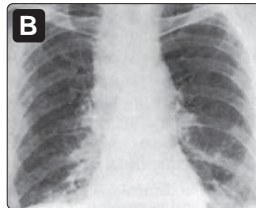
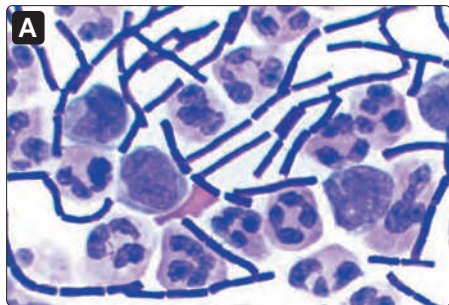
These bacteria are Gram-positive rods with square ends.



The B unit is called the **protective antigen**, which allows the activity domains to bind to susceptible host cells, and is also the protective component of the acellular vaccine to prevent this infection.



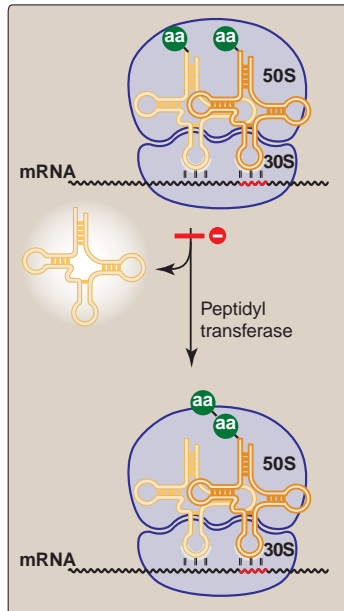
The patient most likely has pulmonary (or inhalational) **anthrax** and **meningitis** caused by ***Bacillus anthracis***.



A. Gram stain of *Bacillus anthracis*. **B.** Chest radiograph of a patient with pulmonary anthrax. Adapted from *Schaecter's Mechanisms of Microbial Disease, Fifth Edition*.

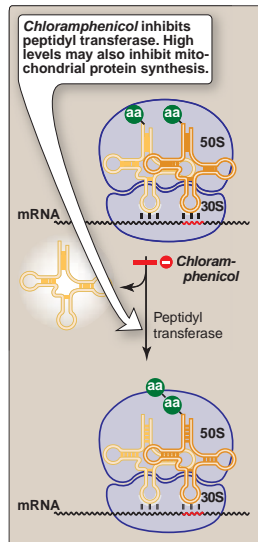


What antibacterial drug acts via the mechanism shown?





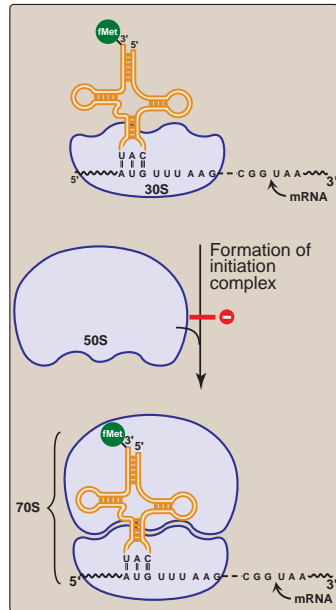
Chloramphenicol acts via this mechanism.



Mechanism of action of chloramphenicol. Adapted from *LIR Pharmacology, Fifth Edition*.

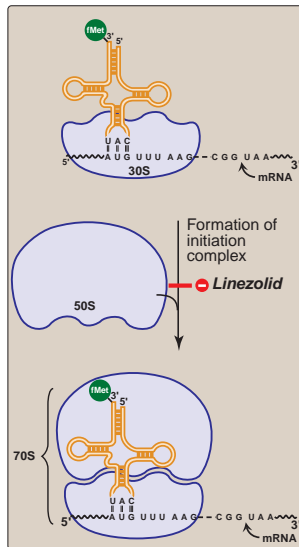


What antibacterial drug acts via the mechanism shown?





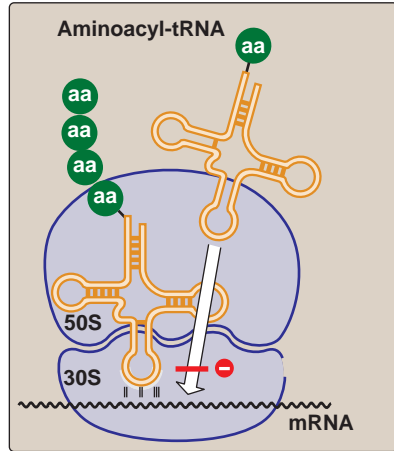
Linezolid acts via this mechanism.



Mechanism of action of linezolid.
Adapted from *LIR Pharmacology*,
Fifth Edition.

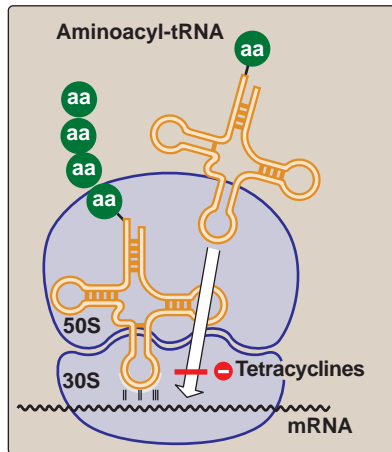


What class of antibacterial drugs acts via the mechanism shown?





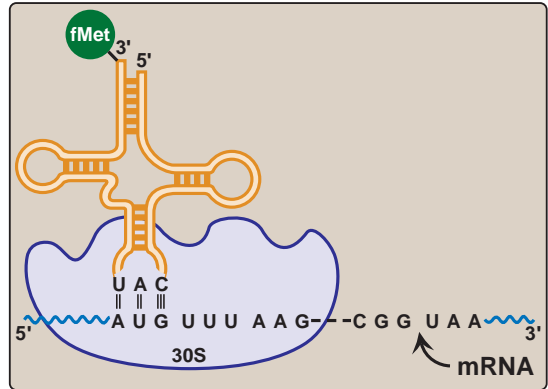
Tetracyclines act via this mechanism.



Mechanism of action of tetracyclines. Adapted from *LIR Pharmacology, Fifth Edition*.

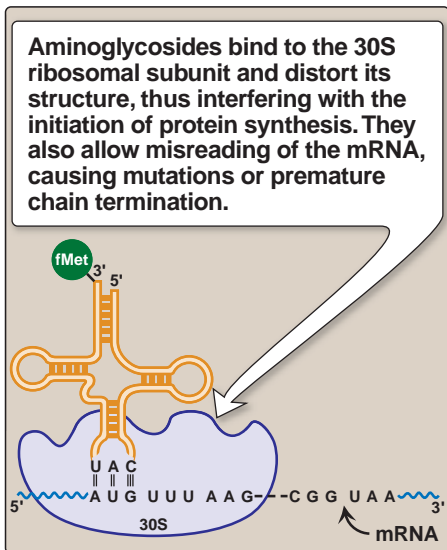


What class of antimicrobial drugs binds to the 30S ribosomal subunit and distorts its structure thus interfering with translation initiation?





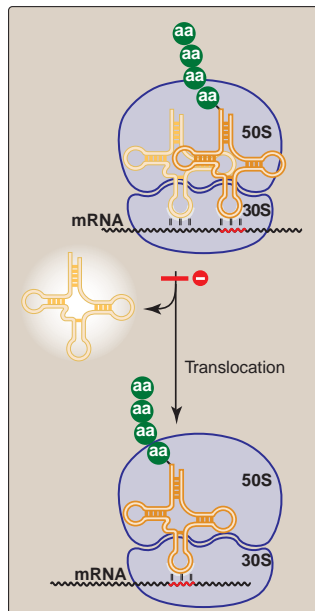
Aminoglycosides bind to the 30S ribosomal subunit and distort its structure.



Mechanism of action of aminoglycosides. Adapted from *LIR Pharmacology, Fifth Edition*.



What antibacterial drugs act via the mechanism shown?

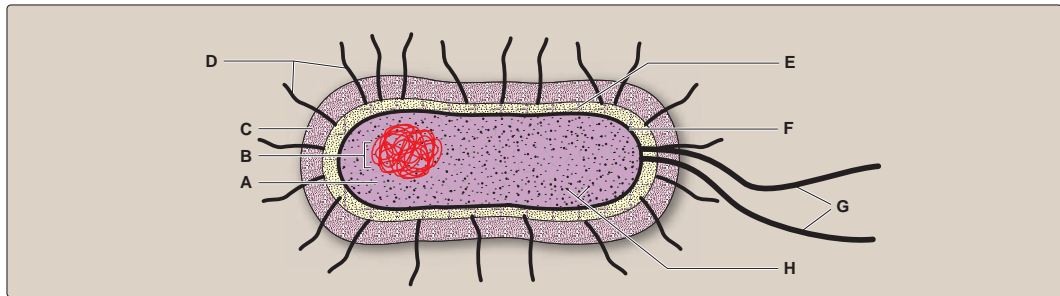




Label the structures on a typical bacterial cell.



Which of the structures shown is important for evading phagocytosis and preventing desiccation?



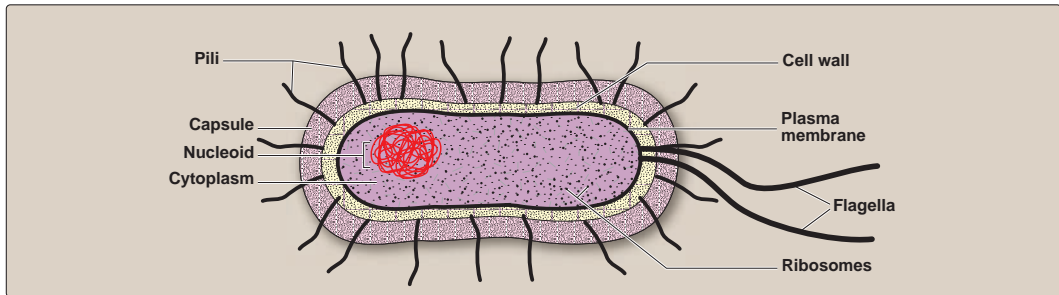


The structures on a typical bacterial cell are:

- A. **Cytoplasm**
- B. **Nucleoid**
- C. **Capsule**
- D. **Pili**
- E. **Cell wall**
- F. **Plasma membrane**
- G. **Flagella**
- H. **Ribosomes**



The capsule is important for evading phagocytosis and preventing desiccation.



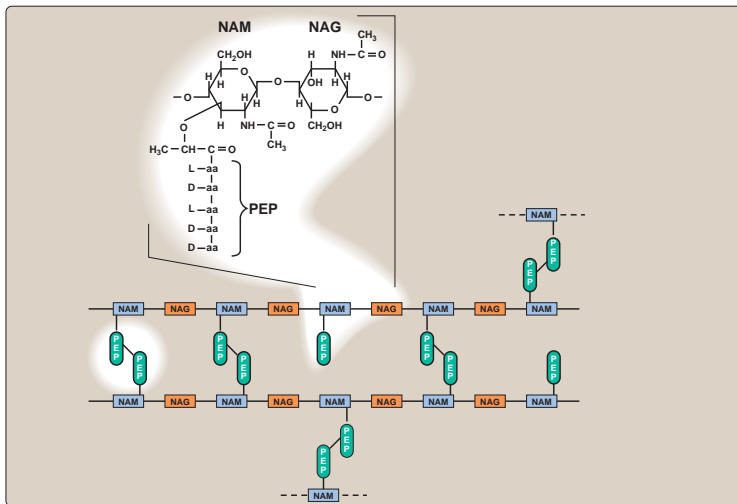
Generalized structure of a bacterial cell.



What is the chemical structure shown?



What class of antibacterials target the synthesis of this structure as their mechanism of action?

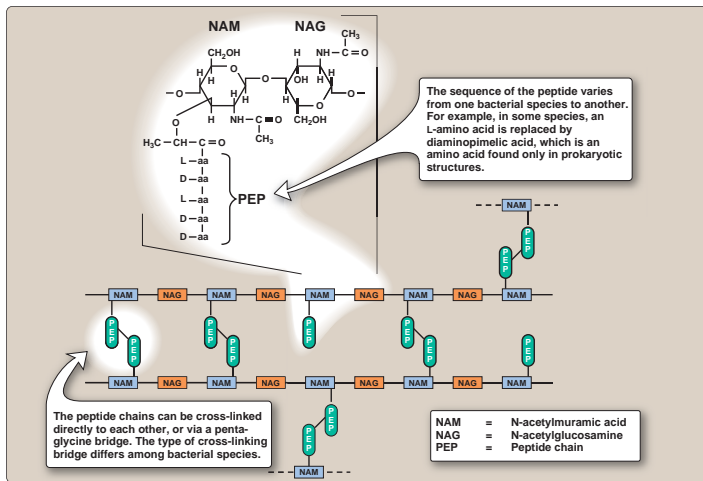




Peptidoglycan is shown.



β -Lactam antibacterials (and **vancomycin**) target the peptidoglycan synthesis as their mechanism of action.



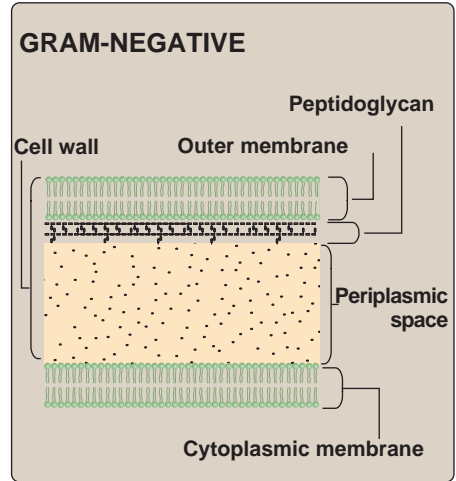
Structure of peptidoglycan.



What unique component in this type of cell is found in the outer membrane's outer leaflet?



What portion of this unique outer membrane component has profound effects on human physiology?

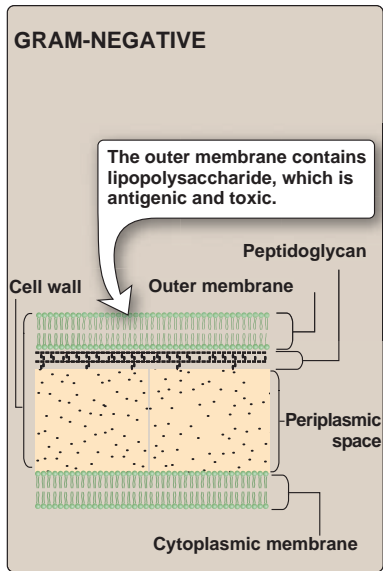




Lipopolysaccharide (endotoxin) is found in the outer membrane's outer leaflet.



Lipid A has profound effects on human physiology.



Composition of Gram-negative cell walls.



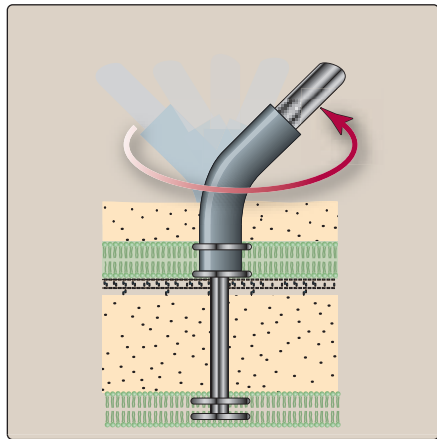
What structure, found in both Gram-positive and Gram-negative bacteria, is shown?



What is the purpose of this bacterial structure?



To avoid the host's immune response, this structure is often subject to what process?





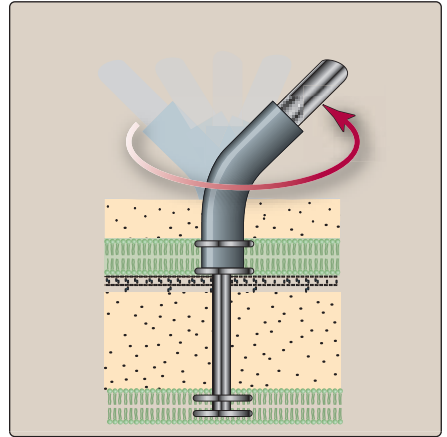
The flagellum, found in both Gram-positive and Gram-negative bacteria, is shown.



This bacterial structure allows for movement and **chemotaxis** in chemical gradients.



To avoid the host's immune response, this structure is often subject to **antigenic variation**.



The flagellum.



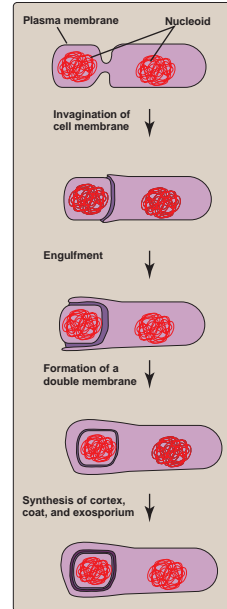
What process is shown?



What is the advantage of this process for bacteria that can accomplish it?



What pathogenic bacterial genera are capable of accomplishing this process?





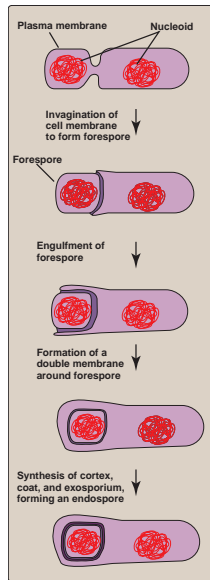
Sporulation is shown.



Sporulation allows survival of the genetic material under harsh environmental conditions such as radiation, heat, desiccation, and nutrient deprivation.



Bacillus and *Clostridium* are capable of sporulation.



Formation of an endospore.



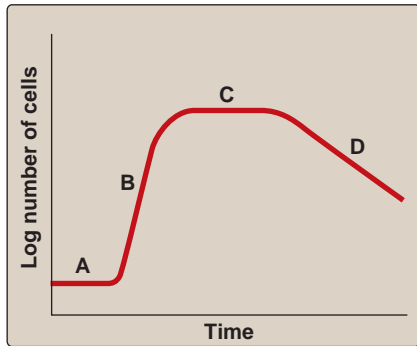
Label the phases of bacterial growth.



Which phase represents the stage at which bacteria are transitioning to new growth conditions?



Which phase represents the stage at which bacteria grow synchronously with sufficient nutrients?





The phases of bacterial growth are:

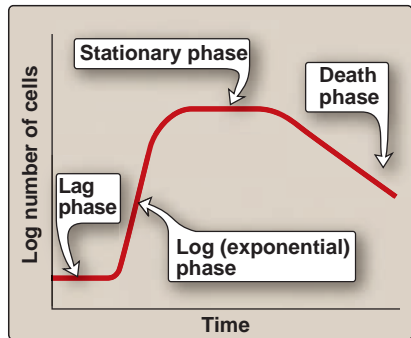
- A. **Lag phase**
- B. **Log phase**
- C. **Stationary phase**
- D. **Death phase**



During the **lag phase**, bacteria are transitioning to new growth conditions.



During the **log (exponential) phase**, bacteria grow synchronously with sufficient nutrients.



Kinetics of bacterial growth in liquid medium.



Which step shown is blocked by the antimicrobial drug cycloserine?



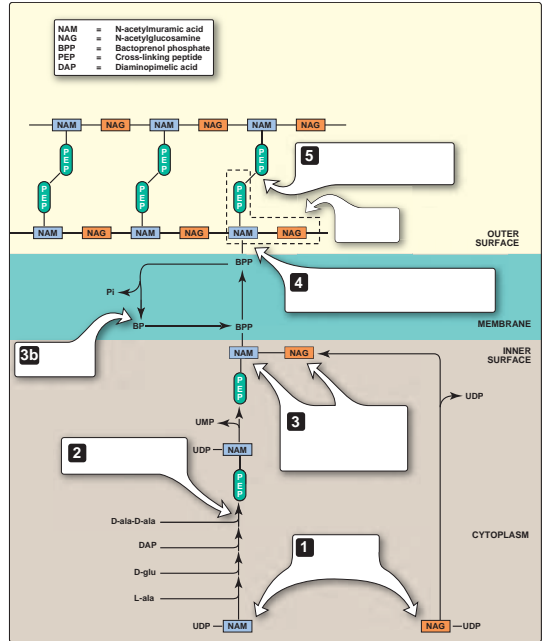
Which is blocked by bacitracin?



Which is blocked by vancomycin?



Which is blocked by penicillin?





Step 2 is blocked by cycloserine.



Step 3b is blocked by bacitracin.

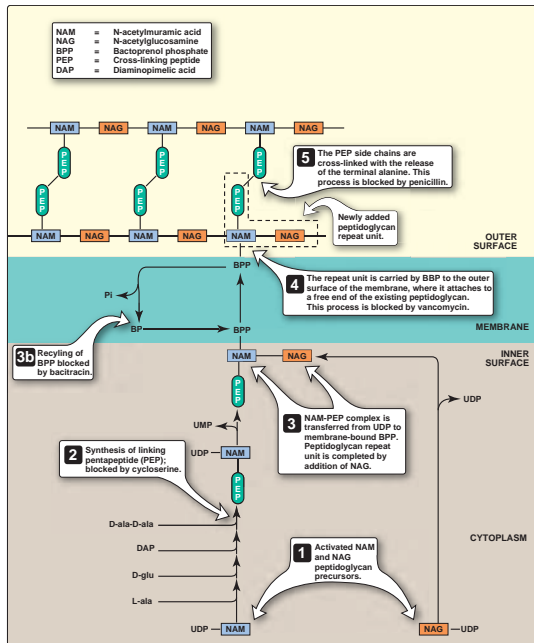


Step 4 is blocked by vancomycin.



Step 5 is blocked by penicillin.

Synthesis of the bacterial cell wall.





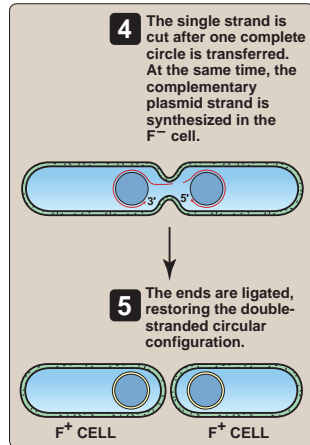
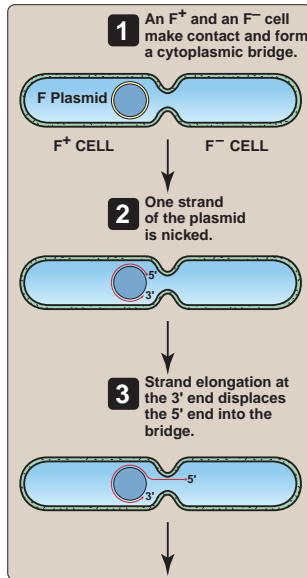
What is the name of the process shown?



What surface structure is required for the process shown to occur?



What are the distinguishing characteristics of this horizontal gene exchange mechanism compared to the two other common mechanisms?





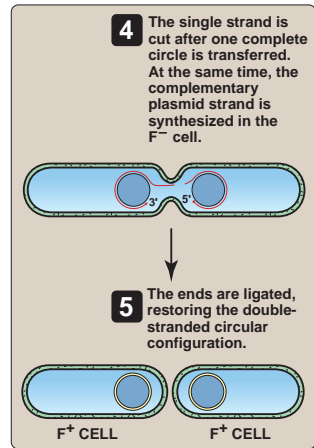
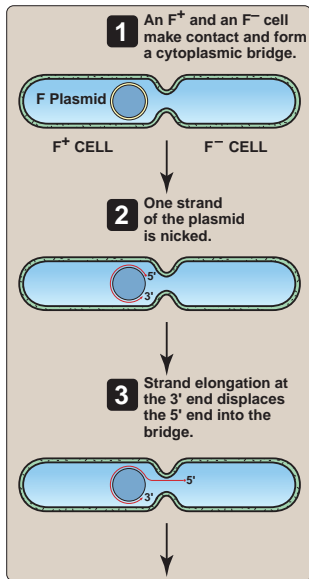
Conjugation is shown.



The **F** or **sex pilus** is required for conjugation to occur.



In contrast to the two other common exchange mechanisms, conjugation requires **cell-to-cell contact** and would be inhibited if the donor and recipient cells were separated by a membrane. Conjugation is resistant to DNase treatment.



Cell-to-cell transfer of a plasmid by conjugation.



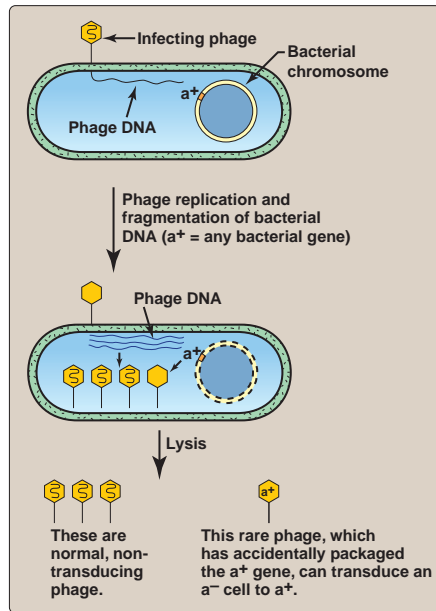
What process is shown?



What is absent from transducing phages in this process?



What are the distinguishing characteristics of this horizontal gene exchange mechanism compared to the two other most common mechanisms?





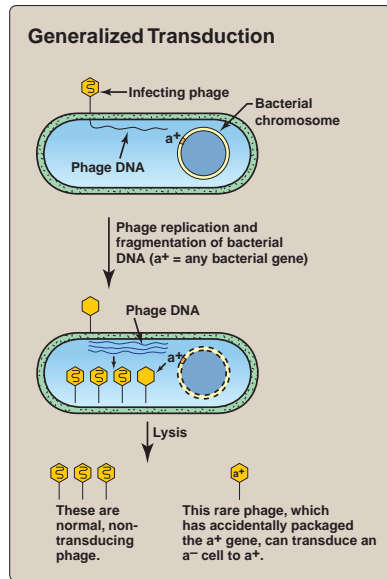
Generalized transduction is shown.



The **bacteriophage genome** is absent from transducing phages in this process.



In contrast to the two other common exchange mechanisms, transduction can occur with supernatant only, if the donor cells are removed by filtration. Transduction is not sensitive to the presence of DNase.



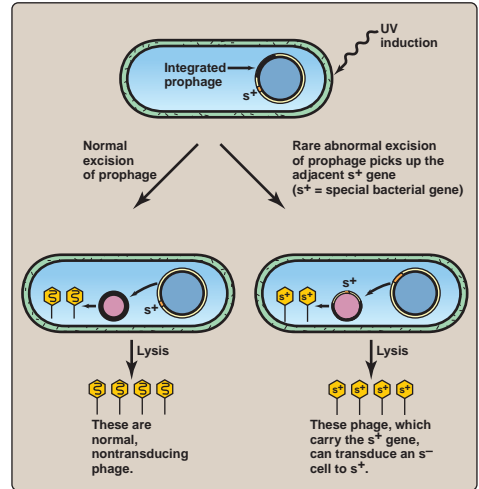
Generalized transduction.



What process is shown?



What bacterial genes can be horizontally transferred by this mechanism?

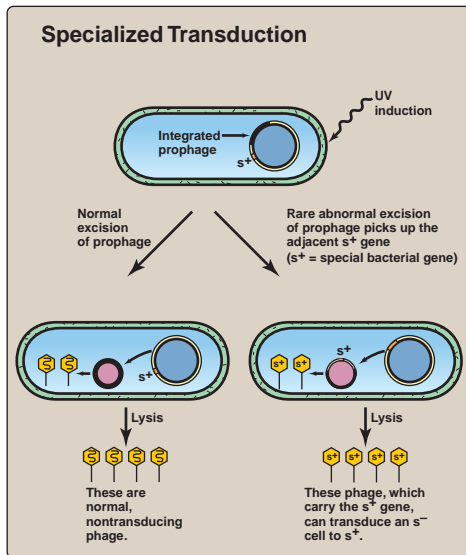




Specialized transduction is shown.



Only genes adjacent to the location of integration by the F plasmid can be horizontally transferred by this mechanism.



Specialized transduction.



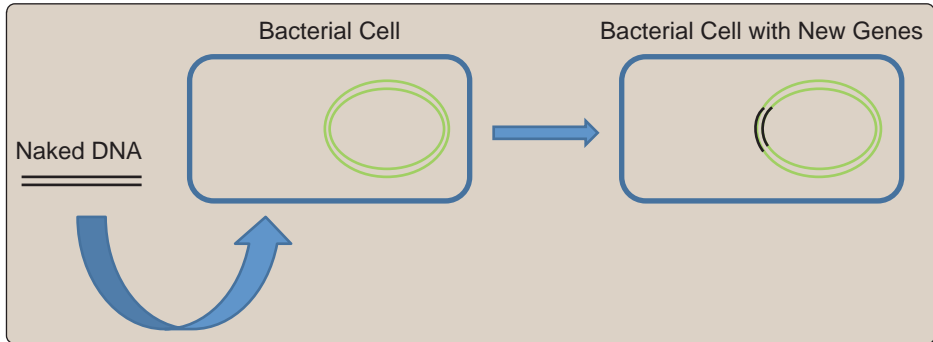
What process is shown?



What characteristic must the recipient bacterial cell express for this process to occur?



What are the characteristics that distinguish this horizontal gene exchange mechanism from the two other most common mechanisms?





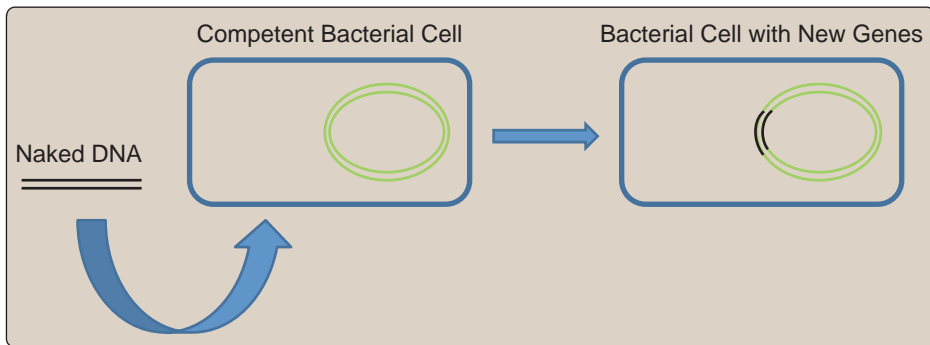
Transformation is shown.



The recipient bacterial cell must express competence for transformation to occur.



In contrast to the two other most common gene exchange mechanisms, transformation is sensitive to the presence of DNase and does not require cell-to-cell contact. Transformation can occur with supernatant only, if the donor cells are removed by filtration.



Bacterial transformation.



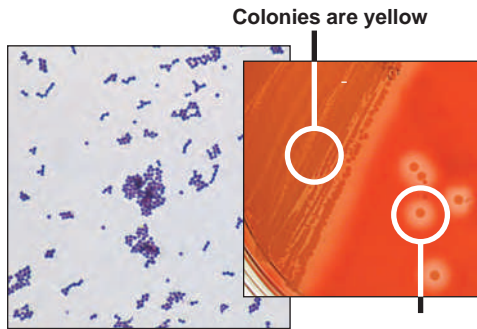
What is the cell and colony morphology of the bacterium shown?



If the bacterial pathogen with this morphology is coagulase positive, what surface protein binds the Fc portion of IgG, thereby preventing effective opsonization?



A 20-year-old woman with a history of IV drug use presents at the emergency department with rapid onset lethargy, fever, and a heart murmur. Blood cultures were collected for analysis, and golden colonies grew from blood specimens. The Gram stain of the cells from the colonies resembled that shown. What is the most likely etiology and infection?



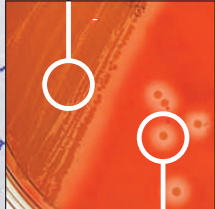
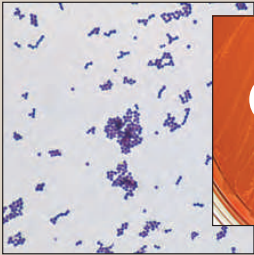


 Gram-positive cocci in clusters are shown. Yellow colonies produce β -hemolysis on blood agar plates.

 **Protein A** is the surface protein that binds the Fc portion of IgG, preventing effective opsonization.

 The patient most likely has **acute endocarditis** caused by *Staphylococcus aureus*.

Colonies are yellow



Staphylococcus aureus cultured from a wound infection

Staphylococcus aureus on blood agar surrounded by zone of β hemolysis.

- Catalase (+)
- Nonmotile
- Do not form spores
- Round cocci tending to occur in bunches like grapes
- Facultative anaerobic organisms
- Cultured on enriched media containing broth and/or blood



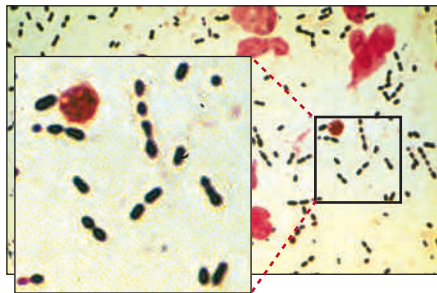
What is the morphology of the Gram-stained bacterium shown?



What key virulence factor produced by this bacterium is responsible for evading immunity and is part of a protective vaccine?



A 65-year-old man presents at his physician's office with fever, cough, and evidence of pneumonia. Sputum and blood cultures are collected for analysis. α -Hemolytic colonies grew on blood agar, and bacterial cells demonstrated the morphology shown. What is the most likely etiology and infection?





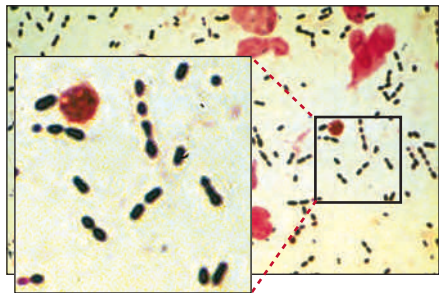
Gram-positive, lancet-shaped cocci in pairs and short chains are shown.



The **polysaccharide capsule** is the virulence factor responsible for evading immunity and is part of a protective vaccine.



The patient most likely has **pneumonia** caused by ***Streptococcus pneumoniae***.



Streptococcus pneumoniae.



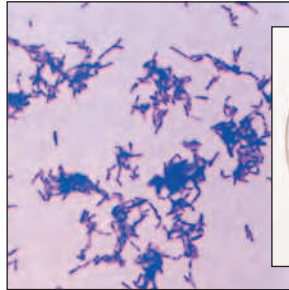
What is the cell and colony morphology of the bacterium shown?



What is the key virulence factor produced by the bacterium?



A 4-year-old Russian immigrant was taken to a U.S. hospital due to marked swelling of the throat and lymph nodes and the presence of a thick, gray membrane over the throat and tonsils. Material recovered from the throat was plated on tellurite agar, and black colonies appeared after incubation, as shown. Gram stain of the colony material resembled that shown. What is the most likely etiology and infection?





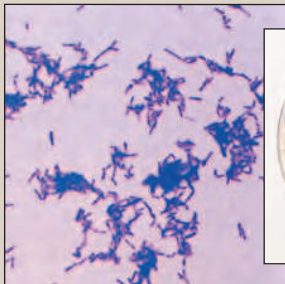
Gram-positive, short bacilli are shown in a palisade or Chinese letter arrangement. Black colonies are produced in the presence of tellurite.



Diphtheria toxin is the key virulence factor produced by the bacterium.



The patient most likely has **diphtheria** caused by *Corynebacterium diphtheriae*.



Corynebacterium diphtheriae
Gram stain



Corynebacterium diphtheriae
grown on tellurite blood
medium

- Small, slender, pleomorphic rods form characteristic clumps that look like Chinese characters or a picket fence.
- They are nonmotile and unencapsulated.
- Most species are facultative anaerobes.
- Culture aerobically on selective medium, such as Tinsdale agar containing tellurite (an inhibitor of the other respiratory flora).



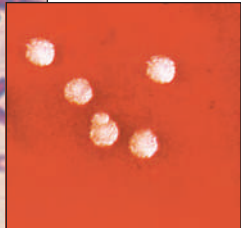
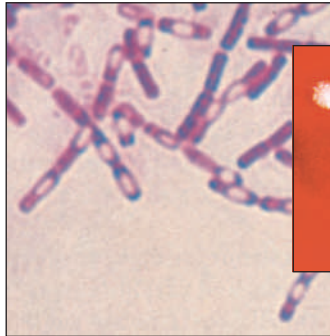
What is the cell and colony morphology of the bacterium shown?



What are the activities of its toxins?



A farm worker presents in the emergency department with a black, necrotic wound on his forearm. He does not recall any injury to the area, but the lesion is now swollen and nearly painless. Samples collected from the lesion were plated on blood agar. Resulting colonies were rough edged and nonhemolytic. Gram stain of the colony material resembled that shown. What is the most likely etiology and infection?





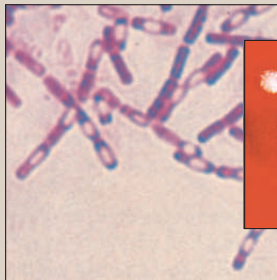
Square-ended, Gram-positive rods (boxcars) are shown with centrally located endospores. Wrinkled, nonhemolytic colonies grow on blood agar.



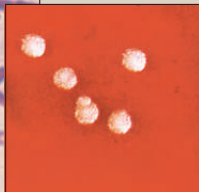
The microorganism produces **edema factor**, which is a calmodulin-dependent AC that results in elevated cAMP levels and concomitant edema, and **lethal factor**, which is a protease that cleaves MAPKK, resulting in aberrant host cell signaling and cell death.



The patient most likely has **cutaneous anthrax** caused by *Bacillus anthracis*.



Gram stain of *Bacillus anthracis* culture smear showing typical bacilli with highly refractile unstained spores



Usual nonhemolytic culture on blood agar

- Blunt-ended bacilli that occur singly; in pairs; or, frequently, in long chains.
- Form endospores—oval and centrally located.
- Nonmotile with a capsule that is antiphagocytic.
- Facultative or strictly aerobic organisms.
- Culture on blood agar.



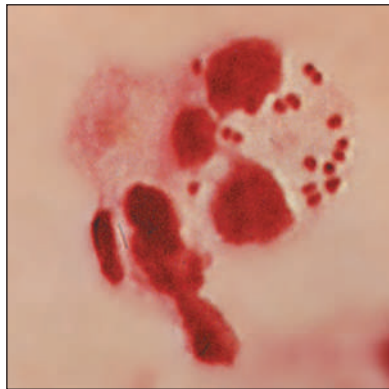
What is the morphology of the Gram-stained bacterium shown?



What surface structure is required for twitching motility, natural transformation, and initial adherence to mucosal membranes?



A 19-year-old male presents at his doctor's office with a urethral discharge and pain upon urination. The patient is sexually active and admits to having unprotected sex with several different partners over the last 6 months. The urethral discharge was examined directly by Gram stain and microscopy. The Gram-stained sample appeared as shown. What is the most likely etiology and infection?





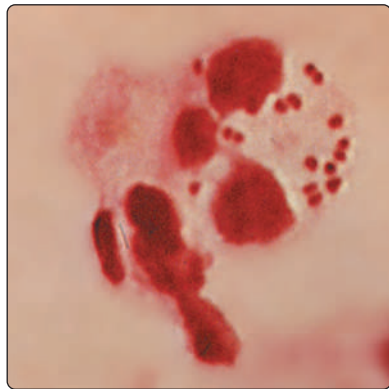
Gram-negative diplococci inside of PMNs



The **type IV pilus** is the surface structure required for twitching motility, natural transformation, and initial adherence to mucosal membranes. It is composed of subunit proteins called **pilin**.



The patient most likely has **gonorrhea** caused by *Neisseria gonorrhoeae*.



Neisseria gonorrhoeae within polymorphonuclear leukocytes in urethral discharge.



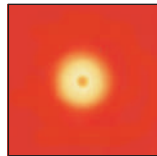
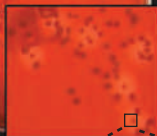
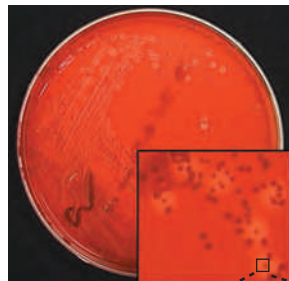
What is the cell and colony morphology of the bacterium shown?



What key virulence factor emanates from its cell surface, is antigenically variable between strains, and is antiphagocytic?



A 4-year-old girl is taken to her pediatrician's office by her mother. The child has a temperature of 102.4°F, is nauseous, and has a sore throat. Upon examination, the doctor notes swollen lymph nodes and a purulent exudate on the nasopharynx. A rapid antigen test is negative, but a second throat swab was plated on blood agar for confirmation. The colony and cell morphologies of the bacteria recovered from the throat swab were similar to that shown. The colonies were catalase negative. What is the most likely etiology and infection?





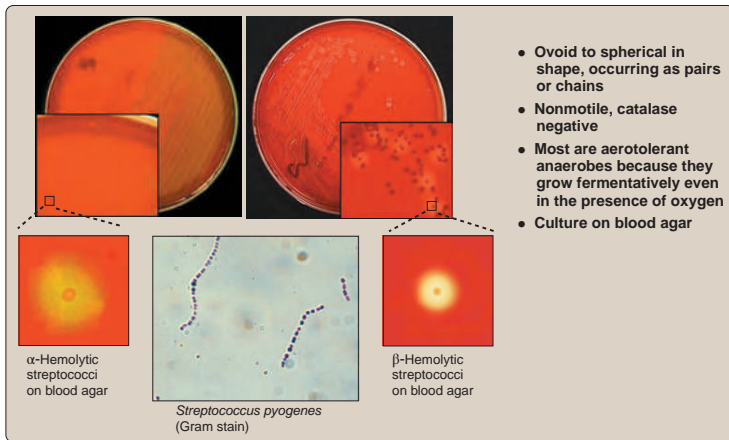
Gram-positive cocci in chains are shown. Growth on blood agar shows **β -hemolysis**.



M protein is the virulence factor that emanates from the cell surface, is antigenically variable between strains, and is antiphagocytic.



The patient most likely has **streptococcal pharyngitis** caused by *Streptococcus pyogenes*.





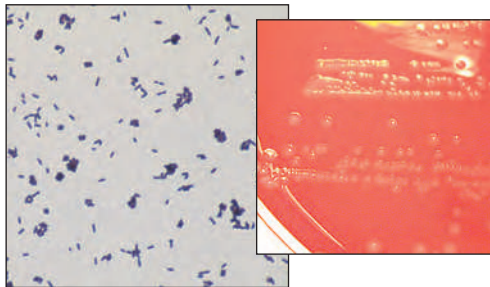
What is the cell and colony morphology of the bacterium shown?



What virulence factor allows the microorganism to escape the phagocytic vacuole inside the host cell?



A 65-year-old man was seen in the emergency department, presenting with fever, photophobia, and stiff neck but no obvious rash. The physician collected CSF and blood specimens for analysis. The colony and cell morphologies of the bacteria recovered from the CSF sample were similar to that shown. The colonies were catalase positive. What is the most likely etiology and infection?





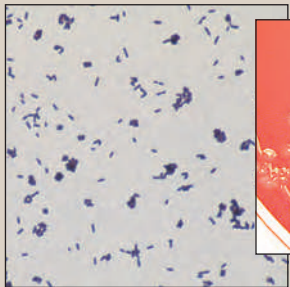
Gram-positive short rods are shown. Growth on blood agar shows the narrow zone of β -hemolysis.



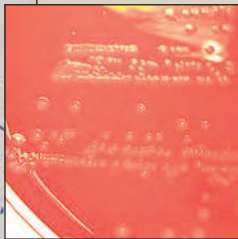
Listeriolysin O is the virulence factor that allows the microorganism to escape the phagocytic vacuole inside the host cell.



The patient most likely has **meningitis** caused by *Listeria monocytogenes*.



Listeria monocytogenes
in cerebrospinal fluid
(Gram stain)



Listeria monocytogenes
on blood agar

- Slender, short rods, sometimes occurring as diplobacilli or in short chains
- Intracellular parasites
- Catalase positive
- Distinctive tumbling motility in liquid medium
- Grow facultatively on various enriched media



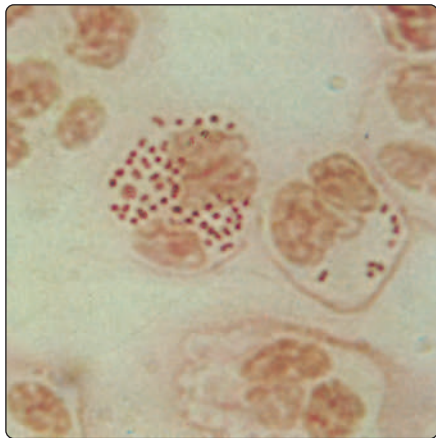
What is the cell morphology of the bacterium shown?



What virulence factor is variable between strains and allows the microorganism to evade phagocytosis and survive desiccation?



A 3-year-old child is brought to the emergency department by his parents. He has been irritable and not eating well for the past 12 hours. He now has a temperature of 103°F and has a petechial rash on his trunk. The physician collects blood and CSF samples for analysis. When Gram stained, the CSF sample appears as shown. Both CSF and blood samples were plated on chocolate agar, resulting in white, mucoid colonies. Cells from the colony growth were Gram negative and oxidase positive. What is the most likely etiology and infection?





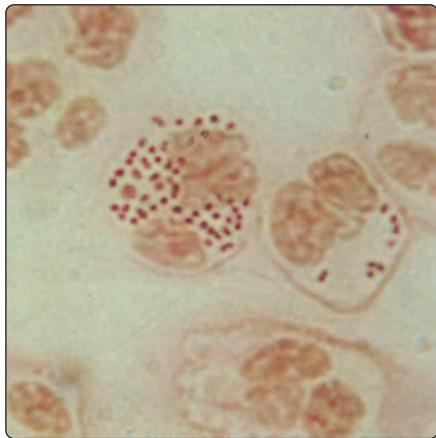
Gram-negative intracellular diplococci are shown within PMNs.



The **polysaccharide capsule** is the virulence factor that is variable between strains and allows the microorganism to both evade phagocytosis and survive desiccation.



The patient most likely has **meningitis** caused by *Neisseria meningitidis*.



Smear of purulent cerebrospinal fluid showing intracellular *Neisseria meningitidis*.



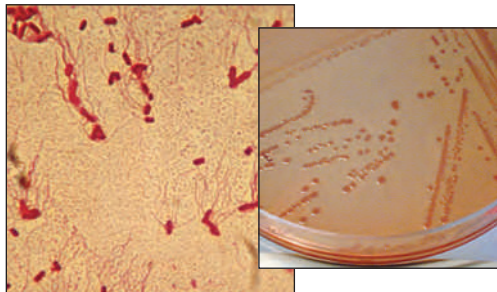
What is the cell and colony morphology of the bacterium shown?



Two vaccines are available to prevent infection by the organism shown. The oral vaccine contains live attenuated bacteria. What is the composition of the second licensed vaccine?



A 28-year-old male presents in the emergency department with fever, chills, myalgia, and diarrhea. He has a faint maculopapular rash on his trunk. The patient recently returned from a trip to Central America. The physician collects blood samples for analysis. The resulting colonies on MacConkey agar resemble those shown and are catalase positive but oxidase negative. What is the most likely etiology and infection?





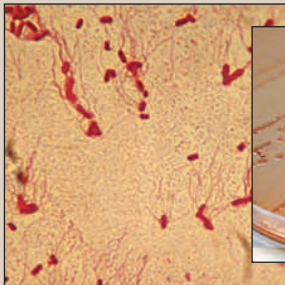
Short, flagellated rods and lactose-negative colonies are shown on MacConkey agar. Growth on MacConkey indicates that the bacterium is nonfastidious and Gram negative.



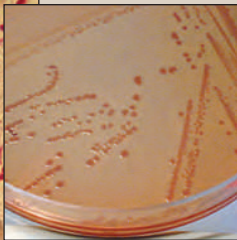
Vi capsular polysaccharide is in the second licensed vaccine.



The patient most likely has **typhoid fever** caused by *Salmonella enteritidis* serovar Typhi.



Salmonella typhi



Salmonella species
on MacConkey agar

- Short, flagellated rods
- Facultative anaerobes
- Ferment glucose
- Do not ferment lactose
- Catalase positive
- Oxidase negative
- Culture on MacConkey agar



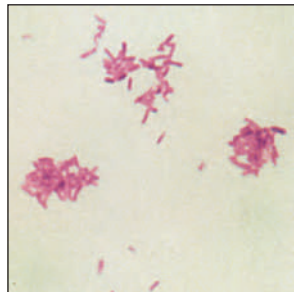
What is the cell morphology of the bacterium shown?



If the bacterium shown does not produce hydrogen sulfide when grown on Hektoen agar and is an enteric pathogen, by what mechanism does it spread from cell to cell in the colonic epithelium?



A 3-year-old child, who attends day care, is seen at the emergency department presenting with bloody diarrhea (“currant jelly” stools), accompanied by painful abdominal cramping. Stool specimens were plated on MacConkey and Hektoen agars. Gram stain of the resulting bacteria resembled that shown. Colorless colonies grew on both MacConkey and Hektoen agars, and the organisms were nonmotile. What is the most likely etiology and infection?





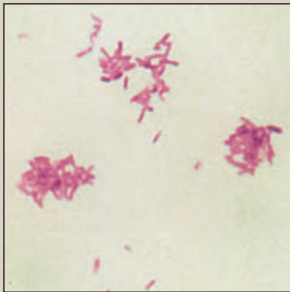
Gram-negative rods are shown.



The organism spreads from cell to cell in the colonic epithelium via **actin-based motility**.



The patient most likely has **bacillary dysentery** caused by *Shigella sonnei*.



Gram stain

- Nonmotile and nonencapsulated
- Cannot ferment lactose
- Most strains do not produce gas in a mixed-acid fermentation of glucose
- Culture on selective medium such as Hektoen agar



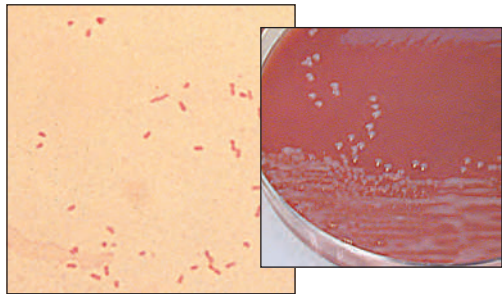
What is the cell and colony morphology of the bacterium shown?



What is the composition of the protective vaccine that prevents invasive disease caused by some serotypes of this organism?



A 70-year-old man with a long history of smoking now has a fever and a cough productive of greenish sputum. His physician suspects pneumonia, which is confirmed by chest x-ray. A sputum sample was plated on chocolate, blood, and MacConkey agars. Colonies only grew on chocolate agar. Gram stain of the resulting bacteria resembled that shown. The bacteria were oxidase positive and required supplementation with hemin and NAD^+ . What is the most likely etiology and infection?





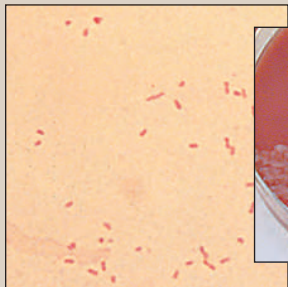
Gram-negative pleomorphic rods are shown. Growth on enriched medium (chocolate agar) indicates a fastidious organism.



The protective vaccine that prevents invasive disease caused by some serotypes of the organism is **type B capsular material, polyribose phosphate**.



The patient most likely has **bronchopneumonia** caused by *Haemophilus influenzae*.



Gram stain of
Haemophilus influenzae



Haemophilus influenzae
on chocolate agar

- Pleomorphic in shape, ranging from small coccobacilli to long slender filaments
- Obligate parasites, requiring hemin and NAD⁺ for growth
- Culture on chocolate agar containing hemin and NAD⁺



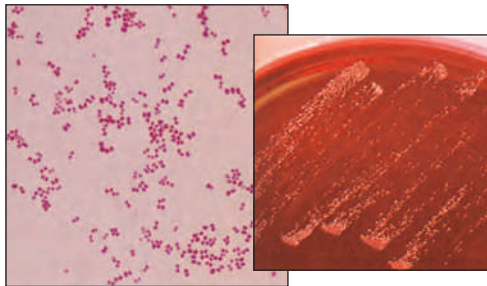
What is the cell and colony morphology of the bacterium shown?



The characteristic sound made by patients suffering from infection with this bacterium occurs during what phase of the infection?



A 3-year-old male child is brought to the emergency department presenting with violent coughing, followed by a whoop-like sound and then vomiting. The parents indicate that their son had had a mild cold for the past few days, but the new severe symptoms caused them to seek medical attention. The family is homeless, and the child has not had routine vaccinations. The physician collects a nasopharyngeal swab specimen, which results in growth on Regan-Lowe medium. The colonies showed morphology similar to that shown. What is the most likely etiology and infection?





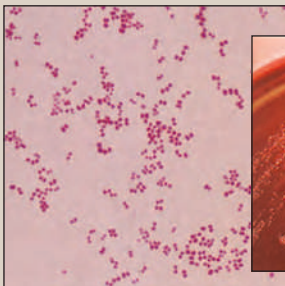
Gram-negative, short rods are shown. The bacteria form tiny colonies on specialized medium (Regan-Lowe).



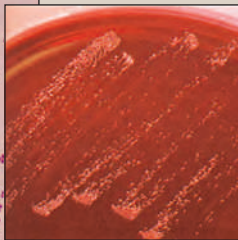
The characteristic sound made by patients suffering from infection with this bacterium occurs during the **noninfectious paroxysmal phase**.



The patient most likely has **whooping cough (pertussis)** caused by *Bordetella pertussis*.



Bordetella pertussis (Gram stain)



Bordetella pertussis on
Regan-Lowe medium

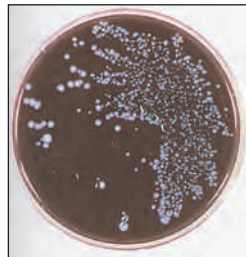
- Small coccobacilli that grow singly or in pairs
- Encapsulated
- Aerobic
- Culture on Regan-Lowe agar



If the bacterium shown is a Gram negative short bacillus that grows in the macrophage cytoplasm and on enriched medium containing buffered charcoal, what is the organism's natural reservoir?



A 68-year-old male is brought to the emergency department by his wife. He presents with a nonproductive cough and a fever but has complained of malaise, myalgia, and headache for the last week. He is not eating well and also has diarrhea. The man is a heavy smoker and diabetic. Lung x-rays were conducted and respiratory secretions collected. Stains of respiratory secretions demonstrated Gram negative short bacilli. Growth was achieved from respiratory secretions on specialized buffered charcoal medium. What is the most likely etiology and infection?

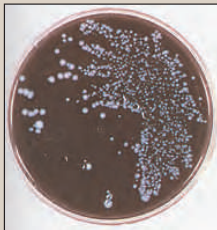




Environmental amoebae growing in water supply systems provide a natural reservoir for this organism.



The patient most likely has **Legionnaires' disease** caused by *Legionella pneumophila*.



Legionella pneumophila
grown on buffered
charcoal yeast extract
agar

- Slender rod in nature; coccobacillary in clinical material
- Facultative, intracellular parasites
- Organisms are unencapsulated; monotrichous flagella
- Culture on specialized medium



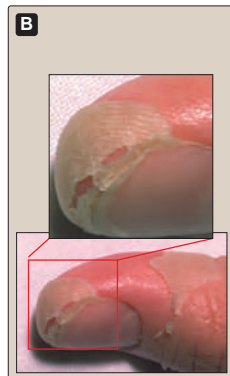
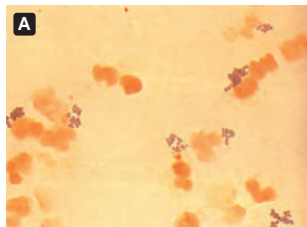
What is the cell morphology of the bacterium shown (**panel A**)?



What is the mechanism of action of the toxin produced by some strains of the bacterium shown that results in skin desquamation (especially of the digits, **panel B**) during convalescence?



A 20-year-old woman is seen in the emergency department suffering from fever, nausea, vomiting, diarrhea, hypotension, and a diffuse rash. She is currently menstruating and has been using tampons for the last several days. A bacterium with the morphology shown was cultured from the genital tract. The organism was catalase and coagulase positive. What is the most likely etiology and infection?





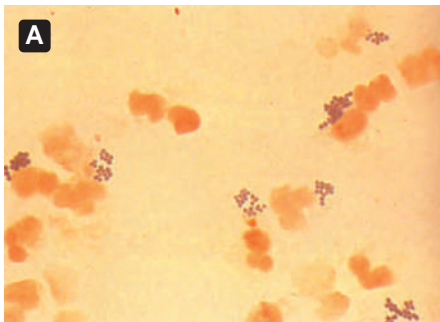
Gram-positive cocci in clusters are shown.



TSST is a superantigen that activates massive numbers of T cells resulting in release of cytokines (including IFN- γ and TNF- α), which causes skin desquamation during convalescence.



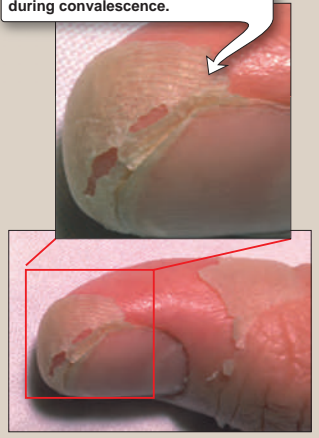
The patient most likely has **TSS** caused by circulation of the toxin (TSST) produced by *Staphylococcus aureus*.



A. Gram stain of *Staphylococcus aureus*. Adapted from *Schaechter Mechanisms of Microbial Disease, 5th Edition*.
B. Characteristic presentation of toxic shock syndrome.

B

Toxic shock syndrome is characterized by fever, hypotension, multisystem organ dysfunction, and an erythematous rash with desquamation occurring during convalescence.





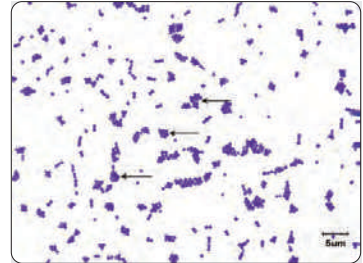
What is the cell and colony morphology of the bacterium shown?



Given that the bacterium is catalase positive and coagulase negative, what is the most important virulence factor it produces?



One month after undergoing hip replacement surgery, a 65-year-old man develops fever and malaise. The area of the replaced joint and incision is tender and erythematous. Blood cultures are positive for the bacteria shown. The responsible pathogen is catalase positive, coagulase negative, and novobiocin sensitive. What is the most likely etiology and infection?





Gram-positive cocci are shown in clusters and white, nonhemolytic colonies on blood agar plates.

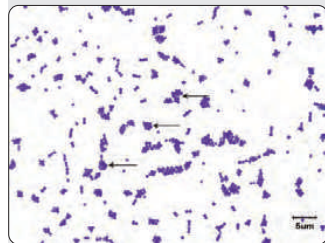


Extracellular polysaccharide material (slime), which enables the bacterium to produce biofilms on prosthetic surfaces, is its most important virulence factor.



The patient most likely has **bacteremia** and **artificial joint infection** caused by ***Staphylococcus epidermidis***.

Gram Stain of *Staphylococcus epidermidis*



Staphylococcus epidermidis Growing on Blood Agar





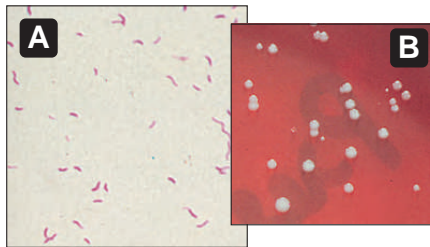
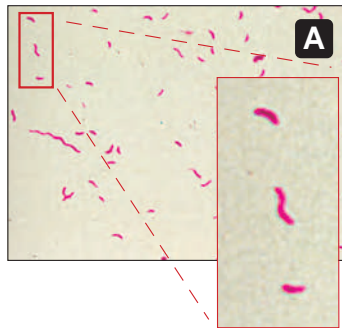
What is the cell and colony morphology of the bacterium shown?



What are the most common transmission routes for the disease it causes?



Three days after consuming chicken and potato salad at a picnic, a 35-year-old man suffered from abdominal cramps, diarrhea, and fever. He was seen by his primary care physician, who ordered tests including culture and visual examination of stool specimens. Stool specimens were plated on Preston selective medium. Gram stain of the resulting bacteria resembled that shown. Direct wet mount of fecal material revealed curved organisms demonstrating darting motility. What is the most likely etiology and infection?





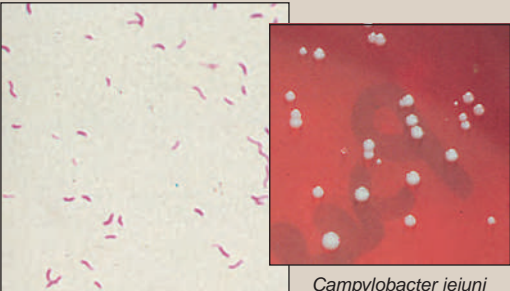
Curved, Gram-negative rods are shown and nonhemolytic, white colonies on selective medium.



The fecal–oral route, by ingestion of contaminated meat (especially poultry), and unpasteurized milk are the disease's most common transmission routes.



The patient most likely has **enteritis** caused by *Campylobacter jejuni*.



Campylobacter jejuni

Campylobacter jejuni
(Preston selective medium)

- Curved, spiral, or S-shaped rods
- Single, polar flagellum, resulting in characteristic darting motion
- Microaerophilic
- Do not ferment carbohydrates
- Culture on selective medium (blood agar containing antibiotics to inhibit growth of other fecal flora)



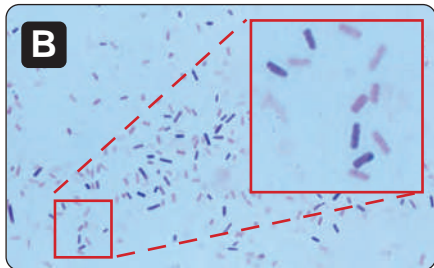
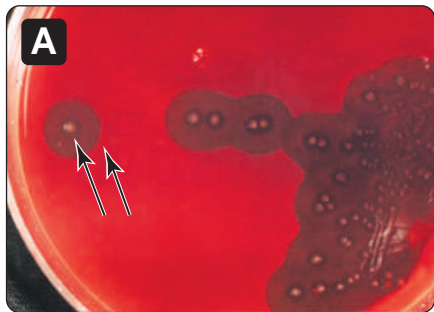
What is the cell and colony morphology of the bacterium shown?



List the two toxins (important virulence factors) responsible for the appearance of colonies on blood agar (**panel A**).



Following a car accident, which resulted in a compound fracture of the right arm, a 20-year-old, hospitalized male is taken for immediate debridement surgery due to the presentation of erythematous, painful swelling near the fracture. An open wound near the fracture is weeping, and the nearby tissue produces a crinkling sensation upon palpation. The exudate from the wound smells foul. Culture produces the colony morphology shown. What is the most likely etiology and infection?





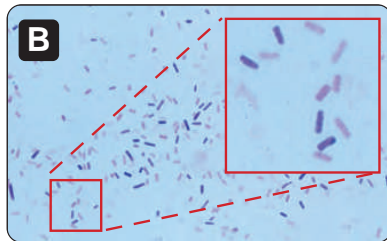
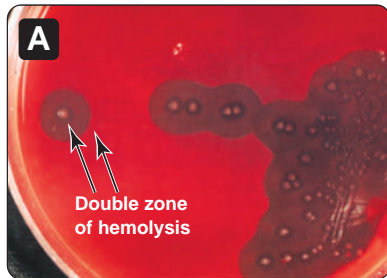
Gram-positive rods (with some poorly staining cells, which are typical of old cultures) are shown. Colonies produce a double zone of hemolysis on blood agar.



The toxins responsible for colonization on blood agar are **alpha toxin**, a lecithinase that degrades membranes and causes partial clearing on blood agar plates, and **theta toxin (perfringolysin O)**, a hemolysin that completely lyses RBCs, resulting in complete clearing on agar plates.



The patient most likely has **gas gangrene (myonecrosis)** caused by ***Clostridium perfringens***.



Clostridium perfringens. **A.** colonies on blood agar showing double zone of hemolysis. **B.** Gram stain of *C. perfringens*.



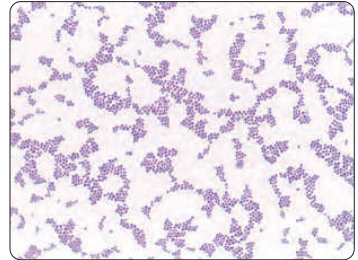
What is the cell and colony morphology of the bacterium shown?



If this organism was cultured from a urine specimen, what is the expected result when it is exposed to novobiocin?



A 25-year-old woman, who is sexually active with a single partner, is seen by her primary care physician. Her complaints are dysuria, pelvic pain, and low-grade fever. Bacteria resembling those shown were cultured from the urine specimen. The cultured bacteria were catalase positive and coagulase negative. What is the most likely etiology and infection?





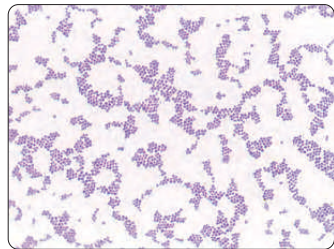
Gram-positive cocci are shown in clusters and white, nonhemolytic colonies on blood agar plates.



If cultured from a urine specimen and exposed to novobiocin, the bacterium would prove novobiocin resistant.



The patient most likely has **cystitis** caused by *Staphylococcus saprophyticus*.



Staphylococcus saprophyticus Growing on Blood Agar





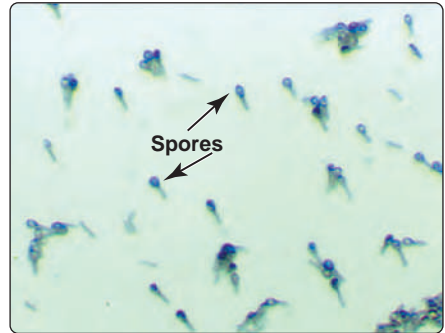
What is the cell morphology of the bacterium shown?



What is the mechanism of action of the toxin it produces?



A 65-year-old man, who is an avid gardener, suffers a puncture wound on his right hand while clearing brush and debris from his yard. Within a few days of the injury, he suffers from myalgias and spasms in the area of the wound but no fever. He makes an appointment with a new primary care physician, not having seen a doctor in nearly 15 years. The physician orders a wound culture, and bacteria resembling those shown were detected with swarming growth on anaerobic blood agar plates. The physician prescribes antibiotics, antitoxin, and vaccination. What is the most likely etiology and infection?





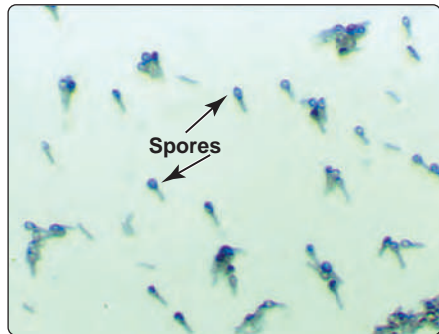
Sporulating, rod-shaped bacteria are shown. The spore location is terminal.



The bacterium produces **tetanus toxin (tetanospasmin)**, which binds to neurons. The activity domain is internalized, where it cleaves a small synaptic vesicle protein called **synaptobrevin**. By its proteolytic activity, tetanospasmin prevents the release of inhibitory neurotransmitters (glycine and GABA), resulting in unrestrained excitation of motor neurons, or **hyperreflexia**.



The patient most likely has **tetanus** caused by *Clostridium tetani*.



Clostridium tetani showing terminal spores.



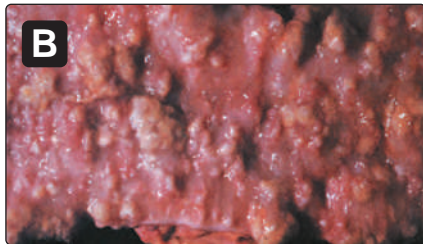
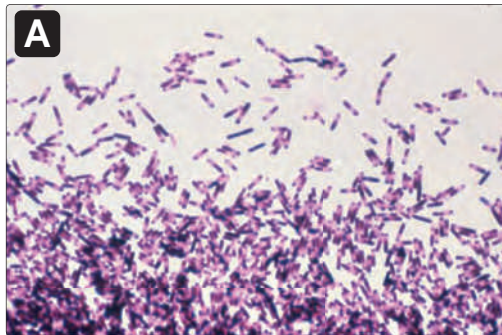
What is the cell morphology of the bacterium shown in **panel A**?



What predisposes patients to the disease manifestation shown in **panel B**, which is caused by the bacterium in **panel A**?



Following open heart surgery and IV antibiotic administration, a 65-year-old man suffers from debilitating diarrhea while still hospitalized. Endoscopy demonstrated an ulcerated epithelium, as shown in **panel B**. Anaerobic culture of stools resulted in bacteria growth resembling that shown in **panel A**. The resulting bacteria produced potent toxins detectable by ELISA. What is the most likely etiology and infection?





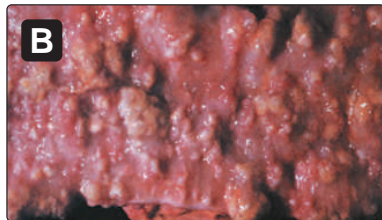
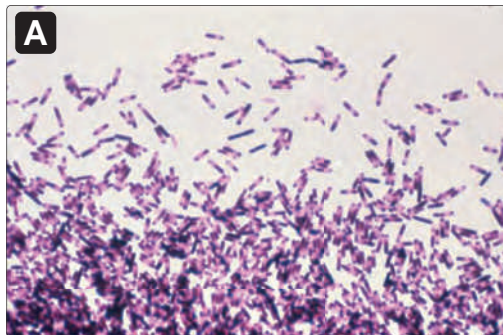
Sporulating rod-shaped bacterium are shown. The spore location is subterminal.



Administration of antimicrobial drugs predisposes patients to pseudomembranous colitis. Drugs most frequently associated with this infection include β -lactam drugs such as ampicillin, amoxicillin or cephalosporins, and clindamycin.



The patient most likely has **antibiotic-associated pseudomembranous colitis** caused by *Clostridium difficile*.



A. Gram stain of *Clostridium difficile*. From *Public Health Image Library*. **B.** Pseudomembranous colitis.



What is the cell morphology of the bacterium shown?



What characteristic feature allows for motility through viscous solutions and mucus?



A 20-year-old male was seen in the emergency department for fever, swollen lymph nodes, and a red maculopapular rash, which involves the trunk and extends to the palms of the hands. The patient is sexually active and admitted to unprotected sex over the last few months with a new partner. Dark field microscopy of material from the lesions showed organisms with the morphology shown. Serological tests were positive for presence of the bacterium shown. What is the most likely etiology and infection?





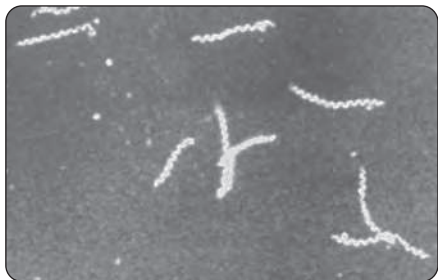
Spirochetes are shown.



The **endoflagellum**, which is attached at both ends of the bacterial cell and is located between the outer and inner membranes of the bacterium, elicits a corkscrew-type of motility through viscous solutions and mucus.



The patient most likely has **secondary syphilis** caused by ***Treponema pallidum***.



Dark-field microscopy of *Treponema pallidum*.



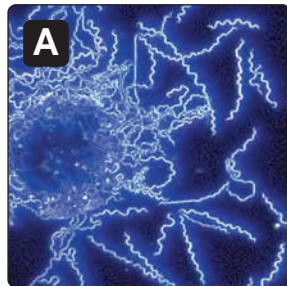
What is the cell morphology of the bacterium shown (**panel A**)?



What is the transmission route for the disease and bacterium?



One week after a 25-year-old woman returned from a camping trip, she noticed a red, circular rash with a clear center on her chest. The lesion resembled that shown (**panel B**) and was accompanied by constitutional symptoms including fever and malaise. Confirmatory ELISA and Western blot testing was conducted and resulted in positive reactions. What is the most likely etiology and infection?





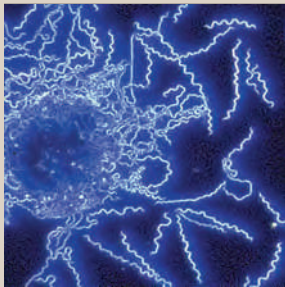
Spirochetes are shown.



The infection is transmitted to humans by the bite of a tick in the genus *Ixodes*.



The patient most likely has **Lyme disease** caused by *Borrelia burgdorferi*.



Dark-field microscopic image of spirochetes taken from a culture of the organism in the laboratory.

- Gram-negative, but some stain poorly and need to be visualized by other means
- Long, slender, flexible, spiral- or corkscrew-shaped rods
- Highly motile
- Difficult and time-consuming to culture



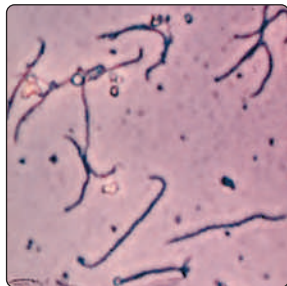
What is the cell morphology of the bacterium shown?



What is the transmission route for the disease and bacterium?



One week after returning from Ecuador, a 24-year-old male suffered from fever, chills, myalgia, and jaundice. His physician ordered blood and urine tests. Bacteria resembling those shown were detectable in the urine. Serological testing resulted in positive reactions. What is the most likely etiology and infection?





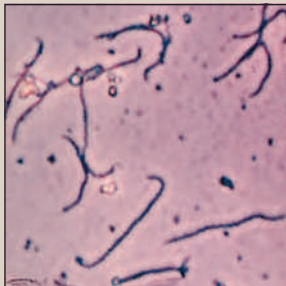
Spirochetes with hooked ends are shown.



The infection is transmitted to humans by exposure to food or water contaminated with animal urine. The organisms enter the skin through small abrasions or through the conjunctiva.



The patient most likely has **leptospirosis** caused by *Leptospira interrogans*.



Leptospira interrogans

- Gram-negative, but stains poorly, and needs to be visualized by other means, such as dark-field examination of wet-mount preparations
- Long, slender, flexible, spiral- or corkscrew-shaped rods
- Highly motile



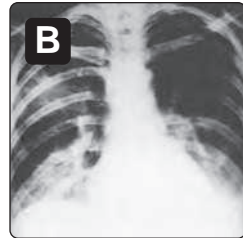
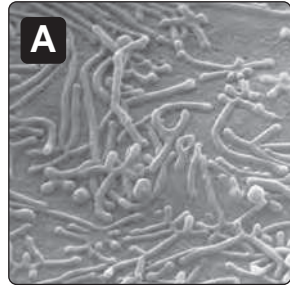
What is the cell morphology of the bacterium shown (**panel A**)?



Bacteria with this morphology are naturally resistant to which class of antibiotics?



A 23-year-old woman was seen by her primary care physician. She complains of a low-grade fever, chills, and malaise that has slowly developed over 3 weeks. She has a nonproductive cough, and chest radiograph (**panel B**) shows patchy, diffuse bronchopneumonia involving both lobes. Cold agglutinins were detected when a specimen of the patient's serum was chilled to 4°C. What is the most likely etiology and infection?





The bacteria are pleomorphic, lacking a cell wall.



β -Lactams target cell wall biosynthesis, a structure which is absent in the *Mycoplasma* species.



The patient most likely has “walking” pneumonia caused by *Mycoplasma pneumoniae*.



Scanning electron micrograph
of *Mycoplasma pneumoniae*

- Not seen with Gram stain because it lacks peptidoglycan cell walls
- Plastic, pleomorphic shape (neither rods nor cocci)
- Cell membrane is a sterol-containing lipid bilayer
- Rarely cultured for diagnostic purposes



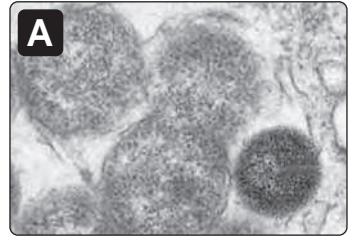
Two morphological forms are characteristic of the bacterium shown (**panel A**). One form is infectious, the other replicative. What are these forms called?



What characteristic virulence trait allows the organism to produce inclusion bodies in the infected cell's cytoplasm?



A 17-year-old woman is seen by a physician at an STD clinic due to a vaginal discharge, dysuria and pelvic pain. The patient admits to unprotected sex with a new partner within the last month. The vaginal discharge and a urine specimen were subjected to molecular testing, the results of which were positive. Direct staining of a vaginal epithelial cell smear showed cytoplasmic inclusions similar to those shown (**panel B**). What is the most likely etiology and infection?





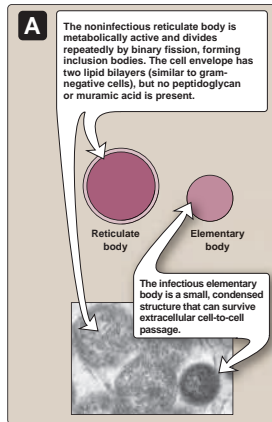
The infectious form (smaller form) is called the **elementary body**. The replicative form (larger, less dense form) is called the **reticulate body**.



Inhibition of phagolysosomal fusion allows the bacterium to create an inclusion body in which the reticulate body successfully replicates.



The patient most likely has **nongonococcal urethritis** and **cervicitis** caused by ***Chlamydia trachomatis***.





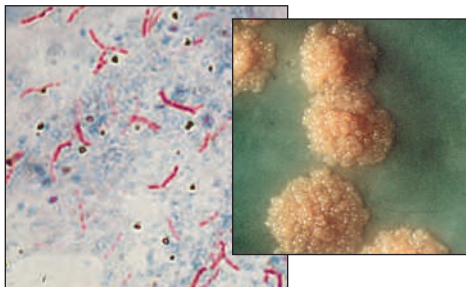
What is the cell and colony morphology of the bacterium shown?



What type of immunity is critical to controlling infections it causes?



A 50-year-old smoker with diabetes presents to the emergency department with fever, shaking chills, and weight loss over the last few weeks. He has a productive cough, and chest radiograph shows the presence of air-filled cavities. Using special protective measures, hospital staff collect sputum samples for staining, results of which were similar to those shown. After a long incubation period, colonies appeared on selective medium. What is the most likely etiology and infection?



Acid fast stain.



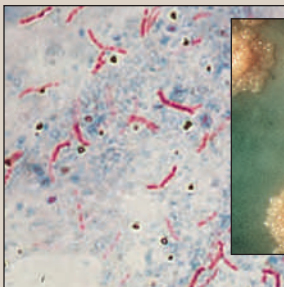
Acid-fast, long, slender rods and wrinkled colonies on specialized medium are shown.



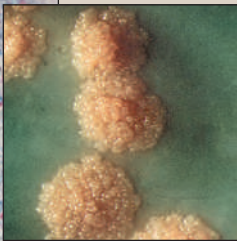
Cell-mediated immunity contributes to both disease pathology and immunity. **Humoral immunity** plays no role in protection.



The patient most likely has **secondary (reactivational) tuberculosis** caused by *Mycobacterium tuberculosis*.



Mycobacterium tuberculosis
(acid-fast stain)



Mycobacterium tuberculosis
(colonies on Lowenstein-Jensen media)

- Acid-fast rods
- Not colored by Gram stain due to lipid-rich cell walls
- Long, slender, nonmotile rods
- Aerobic
- Resistant to drying
- Culture *Mycobacterium tuberculosis* on specialized medium such as Lowenstein-Jensen agar
- *Mycobacterium leprae* does not grow in culture



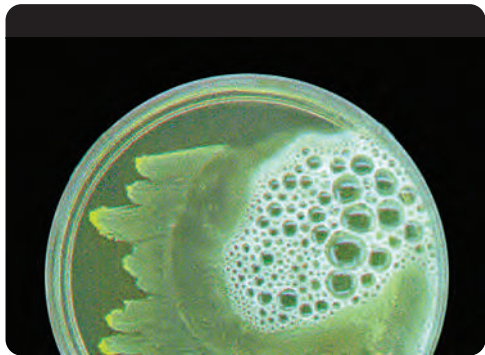
When H_2O_2 is added to a bacterial culture, gas bubbles are released, as shown. This test result indicates that the bacterium produces what enzyme?



Production of the enzyme responsible for conversion of H_2O_2 to O_2 is typical of what physiological groupings of bacteria?



A high school football player presents at his primary care physician's office with a lower extremity abrasion. Outward from the abrasion, the skin is swollen, erythematous, and painful. The lesion is cultured, which yields Gram-positive cocci in clusters. The resulting bacteria are catalase positive, coagulase positive, and methicillin resistant. What is the most likely etiology and infection?





Release of oxygen bubbles indicates that this bacterium produces **catalase**.

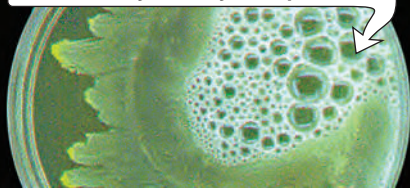


Bacteria that grow in the presence of O_2 , including aerobes, facultative anaerobes, and microaerophiles, use aerobic respiration for energy generation, which generates toxic O_2 byproducts (such as H_2O_2) that can be detoxified with catalase.



The patient most likely has **community-acquired MRSA** caused by ***Staphylococcus aureus***.

The test for catalase is performed by removing a colony to a slide with a drop of 3% hydrogen peroxide. Catalase-positive cultures produce O_2 bubbles. Here it is demonstrated more dramatically directly on a plate.



Catalase positive culture of *Staphylococcus aureus*.



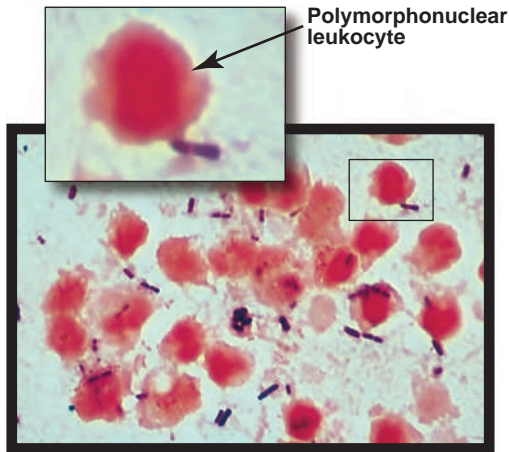
What is the cell morphology of the bacterium shown?



If the specimen collected for this staining analysis was collected from a deep necrotic lesion with crepitus in a patient with diabetes, is the causative agent likely to be an obligate aerobe or an obligate anaerobe?



A 63-year-old man with diabetes was rushed to a second surgery after suffering rapid clinical deterioration following abdominal surgery. The original surgical lesion was necrotic with crepitus (gas displacement with palpation). Culture of the necrotic lesion yielded the bacteria shown. The causative agent was hemolytic on blood agar plates. What is the most likely etiology and infection?





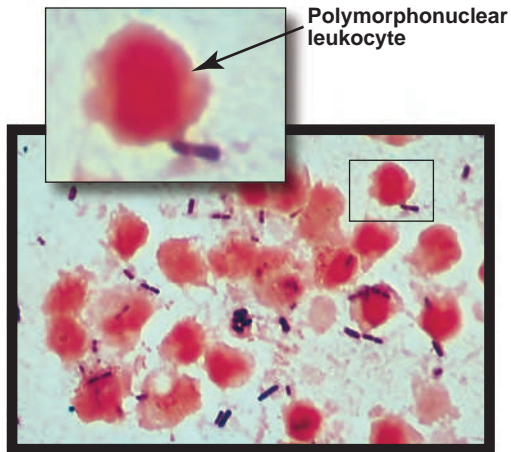
Gram-positive rods are shown.



A deep necrotic lesion with crepitus from a patient with diabetes would likely be caused by an **obligate anaerobe**.



The patient most likely has **myonecrosis** caused by ***Clostridium perfringens***.



Gram stain of *Clostridium perfringens* from crepitant area.



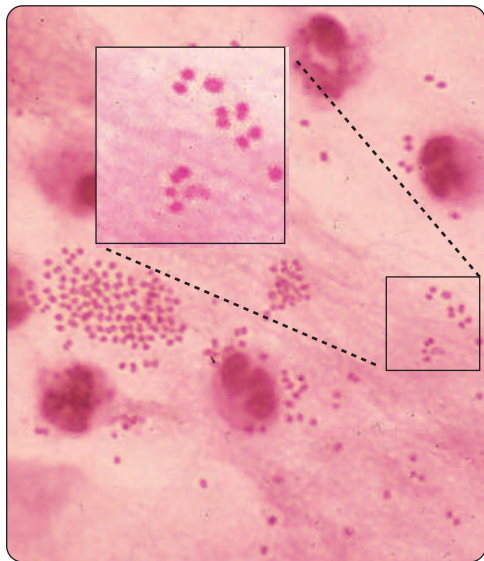
What is the cell morphology of the bacterium shown?



What toxic molecule produced by the bacterium shown causes the majority of damage to the host?



A 17-year-old male was seen at his primary care physician's office suffering from conjunctivitis. The patient also notes that he has had difficulty urinating and a white urethral discharge for 2–3 days. Conjunctival and urethral swab specimens were examined by Gram stain, revealing bacteria with a cell morphology similar to that shown. The urethral swab specimen contained numerous PMNs, some with intracellular bacteria. What is the most likely etiology and infection?





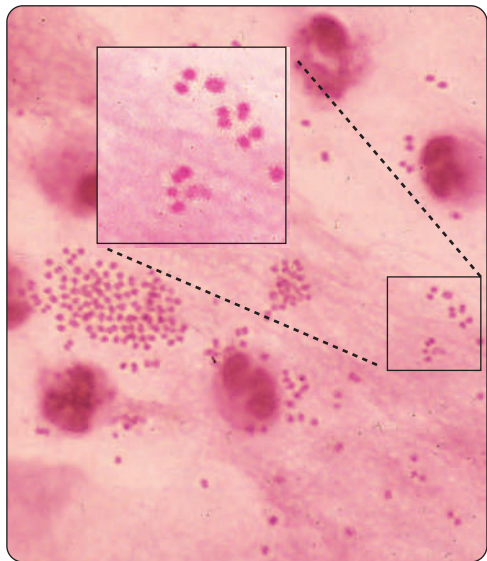
Gram-negative diplococci are shown.



The **LOS** (endotoxin) is responsible for the majority of damage to the host.



The patient most likely has **gonococcal conjunctivitis** and **urethritis** caused by ***Neisseria gonorrhoeae***.



Gram stain of *Neisseria gonorrhoeae*.



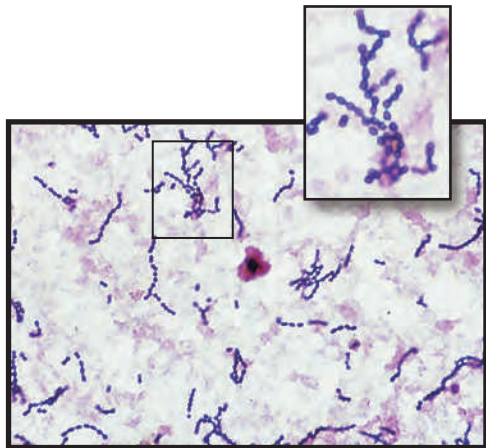
What is the cell morphology of the bacterium shown?



If this isolate was collected from a pregnant female's lower genital tract, to which Lancefield group does it most likely belong?



A pregnant 28-year-old woman was screened at 38 weeks' gestation for a bacterial pathogen that could be passed to her newborn during vaginal birth. The screen identified the bacterium shown, which is catalase negative and β -hemolytic. The pregnant woman was treated prophylactically with penicillin G. What is the most likely etiology and syndrome?





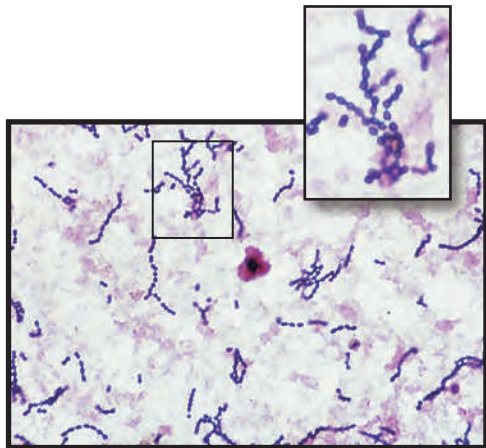
Gram-positive cocci are shown in chains.



If collected from a pregnant woman's lower genital tract, the isolate would most likely belong to Lancefield group B.



The patient is most likely vaginally colonized with ***Streptococcus agalactiae***.



Gram stain of *Streptococcus agalactiae*.



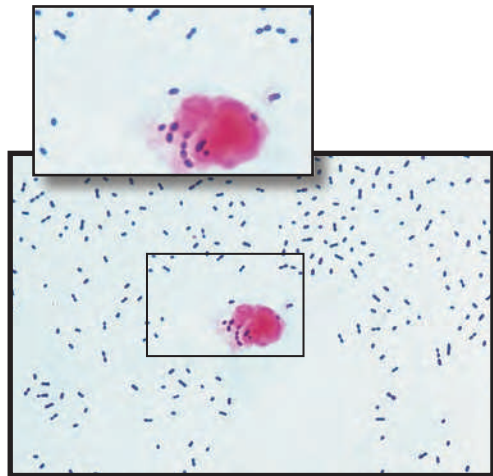
What is the cell morphology of the bacterium shown?



Infections it causes can be prevented by vaccination with what antigen?



A 78-year-old man, who resides in an assisted-living facility, is taken to the emergency department by ambulance. He is in a coma and has a temperature of 104.5°F. Chest x-ray indicates pneumonia. Lumbar puncture showed cloudy CSF, which showed bacteria similar to those shown when stained. They were α -hemolytic and sensitive to optochin in culture. What is the most likely etiology and infection?





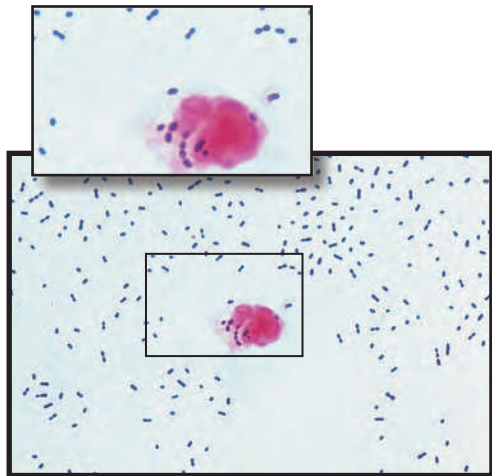
Gram-positive cocci in pairs are shown.



Vaccination with polysaccharide capsule can prevent the infections they cause.



The patient most likely has **pneumonia** and **meningitis** caused by ***Streptococcus pneumoniae***.



Gram stain of *Streptococcus pneumoniae*.



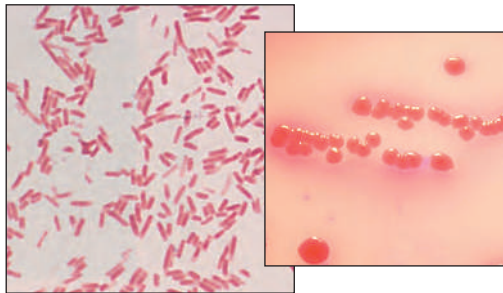
What is the cell and colony morphology of the bacterium shown?



If it does not produce a capsule, what is the outermost, variable polysaccharide on the cell surface?



A 19-year-old woman returns to the United States from spring break in Mexico. For several days, she has experienced crampy, watery diarrhea but no fever. Bacteria cultured from the stool resembled that shown and produced toxins as assessed by molecular methods. What is the most likely etiology and infection?





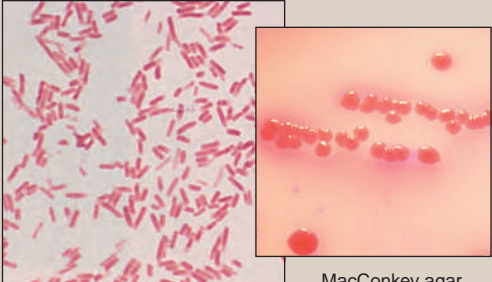
Gram-negative rods are shown. Red to pink colonies developed on MacConkey agar, indicating lactose fermentation.



The outermost, variable polysaccharide on the cell surface is the **O antigen of LPS (lipopolysaccharide)**.



The patient most likely has **traveler's diarrhea** caused by **enterotoxigenic *Escherichia coli***.



E. coli
(Gram stain)

MacConkey agar

- Short rods
- Facultative anaerobe
- Ferments glucose
- Most strains ferment lactose
- Catalase positive
- Oxidase negative
- Culture on MacConkey agar



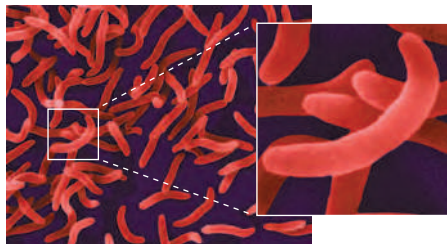
What is the cell morphology of the bacterium shown?



Given that this pathogen is polarly flagellated, a lactose nonfermenter, and oxidase positive, what is the mechanism of action of the key bacterial exotoxin it produces?



A middle-aged man returns from a trip to India and immediately begins passing voluminous, watery diarrhea. When he is seen in the emergency department, he is suffering from dehydration and has tachycardia but no fever. While in the emergency department, he is given fluids and electrolytes. What is the most likely etiology and infection?





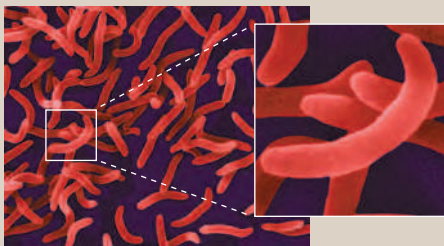
Curved rods (bacilli) are shown.



Cholera toxin is an ADP ribosyl transferase that targets host Gs (stimulatory) proteins. Gs protein modification results in overactivation of AC, leading to increased levels of cAMP.



The patient most likely has **cholera** caused by *Vibrio cholerae*.



Vibrio cholerae (colorized scanning electron micrograph)

- Short, curved, rod shaped
- Rapidly motile as a result of single polar flagellum
- Facultative anaerobes
- Growth of many *Vibrio* strains requires or is stimulated by NaCl
- Culture on blood or MacConkey agar



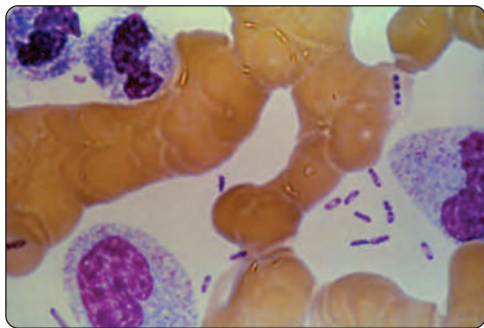
What is the cell morphology of the bacterium shown?



Given that it is Gram negative and a lactose nonfermenter, how is this organism transmitted to humans to cause disease?



A 27-year-old avid hiker returns from a trip to the Southwest to his home in Maine. He presents to the emergency department 3 days after his return with fever, chills, skin purpura, and an enlarged inguinal lymph node. Bacteria recovered from the lymph node resembled those shown. What is the most likely etiology and infection?



Wright's stain.



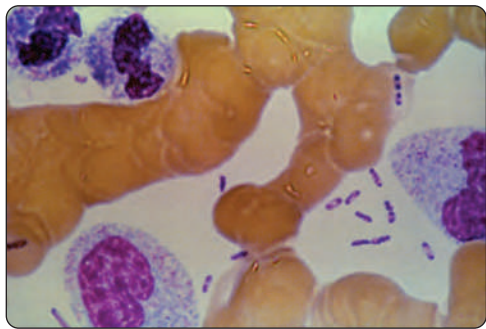
Rod-shaped bacteria are shown with bipolar staining.



This organism is transmitted to humans via flea bite or by inhalation.



The patient most likely has **bubonic plague** (from a flea bite) caused by ***Yersinia pestis***.



Yersinia pestis with bipolar staining. From *Public Health Image Library*.



What is the cell morphology of the bacterium shown?



Given that it is Gram negative, what virulence factor allows it to survive in the hostile environment of the human stomach?



A middle-aged man visits his physician, complaining of long-term stomach pain. Discomfort is at its peak after meals. A radioactive diagnostic test confirms the presence of and metabolism by the suspected bacterial pathogen (shown). What is the most likely etiology and infection?





Curved rods (spirals) are shown with multiple, polar flagella (**lophotrichous**).



The organism produces **urease**, an enzyme that converts urea to ammonia (which neutralizes stomach acid), thereby creating a suitable environment.



The patient most likely has a **stomach ulcer** caused by ***Helicobacter pylori***.



Helicobacter pylori.



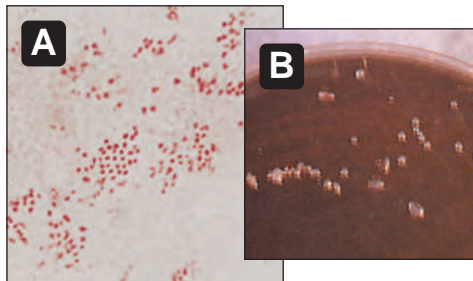
What is the cell and colony morphology of the bacterium shown (**panel A and B**)?



The mucoid colony morphology is consistent with the expression of what surface-exposed virulence factor?



A 35-year-old man visits his primary care physician because he has an erythematous, painful ulcer on his left thumb (**panel C**). Upon examination, the doctor notices that the patient's left axillary lymph nodes are also enlarged. The patient is an avid hunter and spent the previous weekend hunting and skinning rabbits. What is the most likely etiology and infection?





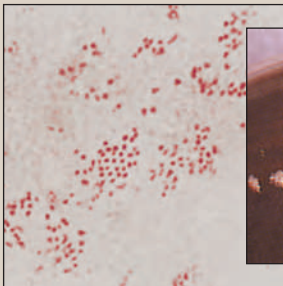
Gram-negative (pleomorphic) coccobacilli are shown with mucoid growth on selective medium (buffered charcoal yeast agar).



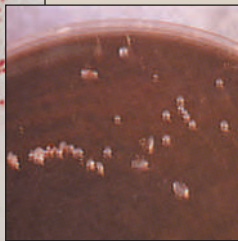
The mucoid colony morphology is consistent with polysaccharide capsule expression.



The patient most likely has **ulceroglandular tularemia** caused by *Francisella tularensis*.



Gram stain of
Francisella tularensis.



Francisella tularensis
on buffered charcoal
yeast agar

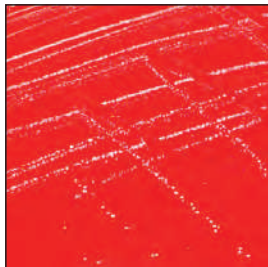
- Small, pleomorphic coccobacillus with a lipid-rich capsule
- Facultative intracellular parasite
- Primarily pathogen of animals
- Rarely cultured



If the bacterium shown is a Gram negative, pleomorphic coccobacillus, an aerobe and an intracellular parasite of macrophages, how is it transmitted to humans?




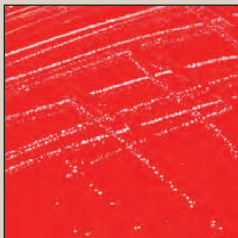
A 28-year-old woman visits her physician complaining of a flu-like illness of slow, insidious onset. Her symptoms include fever, malaise, anorexia, headache, and lower back pain. Within the last week, the fever had risen during the day, only to break at night, bringing on shaking chills. The patient denies sexual activity or travel. Upon further questioning, the doctor learns that the woman only consumes organic foods, mostly from a local farmer's market. She concedes that she only consumes unpasteurized dairy products because she believes they are safer and more natural than pasteurized products. Gram negative coccobacilli were cultured from the patient's blood. What is the most likely etiology and infection?





 The organism is transmitted to humans via consumption of contaminated, unpasteurized milk or by contact with livestock.

 The patient most likely has **brucellosis (undulant fever)** caused by *Brucella melitensis*.



Brucella species on
sheep blood agar

- Small coccobacilli, arranged singly or in pairs
- Unencapsulated
- Aerobic
- Intracellular parasites
- Culture on blood agar



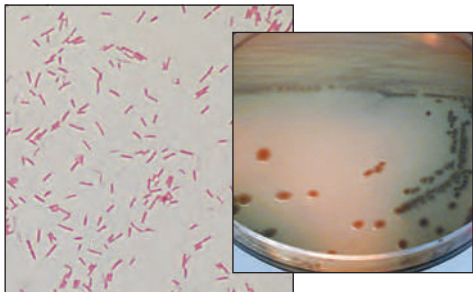
What is the cell and colony morphology of the bacterium shown?



Given that the bacterium is oxidase positive, what blue-green pigment does it produce and release into the environment?



An elderly patient with diabetes in the ICU has been on a ventilator for 4 days following open heart surgery. Lung function has deteriorated, and lung specimens were collected and analyzed by culture, revealing bacteria resembling those shown. The organisms were resistant to many antimicrobial drugs. What is the most likely etiology and infection?





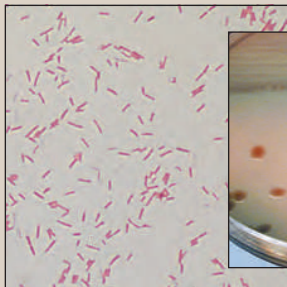
Gram-negative rods are shown. Colorless colonies on MacConkey agar indicate that the bacterium cannot ferment lactose.



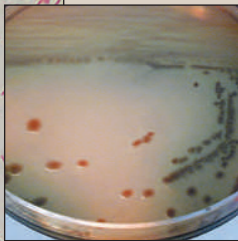
The bacterium produces the blue-green siderophore **pyocyanin**.



The patient most likely has **ventilator-associated pneumonia** caused by *Pseudomonas aeruginosa*.



Pseudomonas aeruginosa
grown from sputum
(Gram stain)



Pseudomonas aeruginosa
on MacConkey
agar

- Encapsulated, motile rods (polar flagella)
- Aerobic or facultative anaerobe
- Produces diffusible green and blue pigments
- Oxidase positive
- Oxidizes but does not ferment carbohydrates, such as lactose
- Culture on MacConkey agar



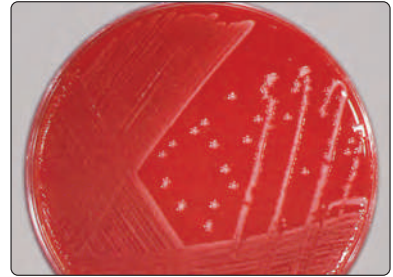
What is the cell and colony morphology of the bacterium shown?



Given that it is Gram negative and both catalase and oxidase positive, what is this bacterium's most common mode of transmission to humans?



A 60-year-old woman was bitten by her cat in the morning. By afternoon, the area around the bite was swollen, inflamed, and painful. She visited her doctor late in the day, at which point she was running a fever. The bite was cultured, resulting in bacteria resembling those shown. What is the most likely etiology and infection?





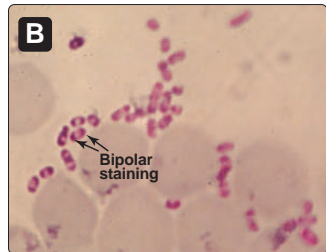
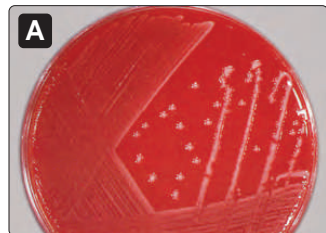
Bipolar staining of short rods (coccobacilli) is shown with nonhemolytic, white colonies on blood agar.



The most common transmission mode to humans is via animal (usually a cat) bite or scratch.



The patient most likely has **cellulitis** caused by *Pasteurella multocida*.



Pasteurella multocida. **A.** Culture on blood agar showing small, translucent nonhemolytic colonies. **B.** Blood smear stained with Wright stain.



What enzyme catalyzes the reaction shown in **A**?



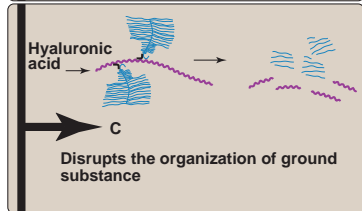
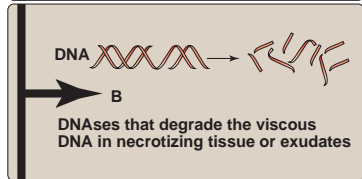
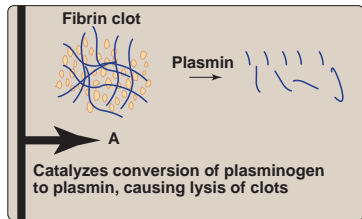
What enzyme catalyzes the reaction shown in **B**?



What enzyme catalyzes the reaction shown in **C**?



What bacterium produces these enzymes, and how do they contribute to infection?





Streptokinase catalyzes the reaction shown in **A**.



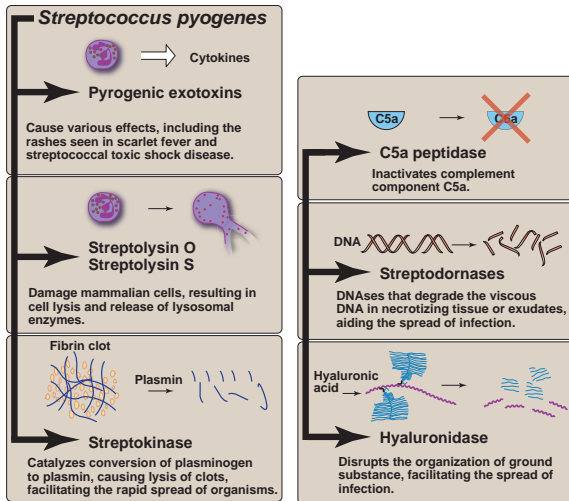
Streptodornase catalyzes the reaction shown in **B**.



Hyaluronidase catalyzes the reaction shown in **C**.



Streptococcus pyogenes produces these enzymes, which aid in invasiveness by facilitating host tissue destruction and spread.



Toxins and exoenzymes produced by *Streptococcus pyogenes*.



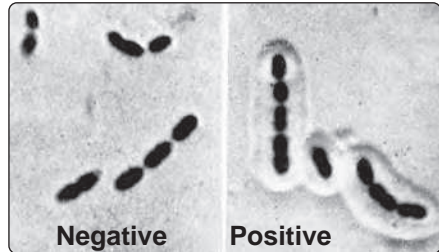
What test is shown?



What is added to produce the positive reaction shown?



The reaction shown is characteristic of what bacterium?





The **Quellung reaction** is shown.



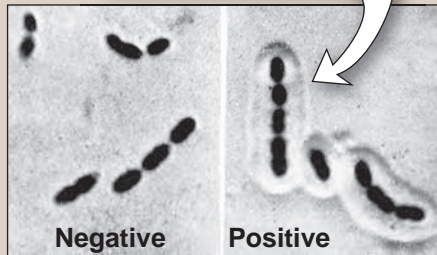
Antibody specific to the capsular material is added to produce this positive reaction.



This reaction is characteristic of ***Streptococcus pneumoniae***.

Quellung reaction

Capsules of ***Streptococcus pneumoniae*** swell in the presence of specific pneumococcal antiserum.





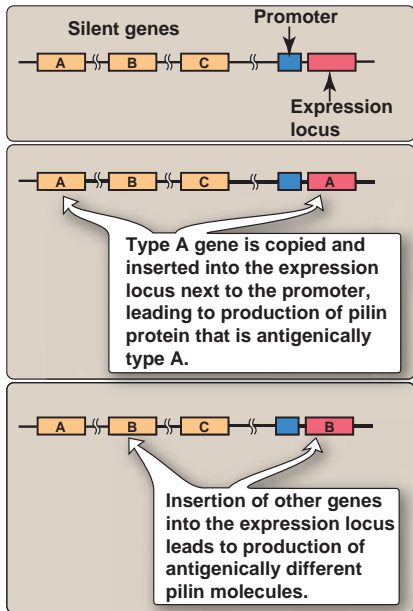
What process is shown?



What does it accomplish for the bacterium?



What is the function of the surface structure subjected to this process?





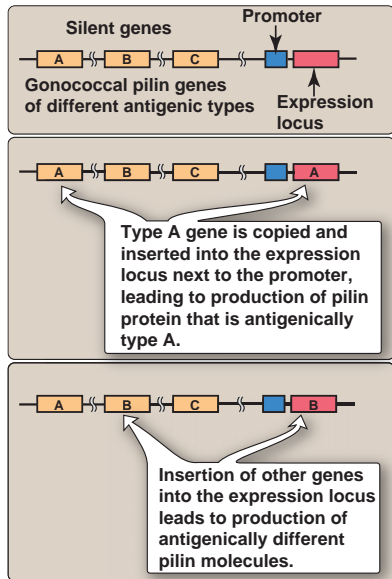
Antigenic variation by gene conversion is shown.



Numerous, antigenically different pilin proteins can be produced by the bacterium (the gonococcus in this example) by this process, allowing the organism to evade an immune response elicited against any one antigenic type of pilin protein.



The surface structure subjected to this process provides initial adherence to mucosal epithelial cells.



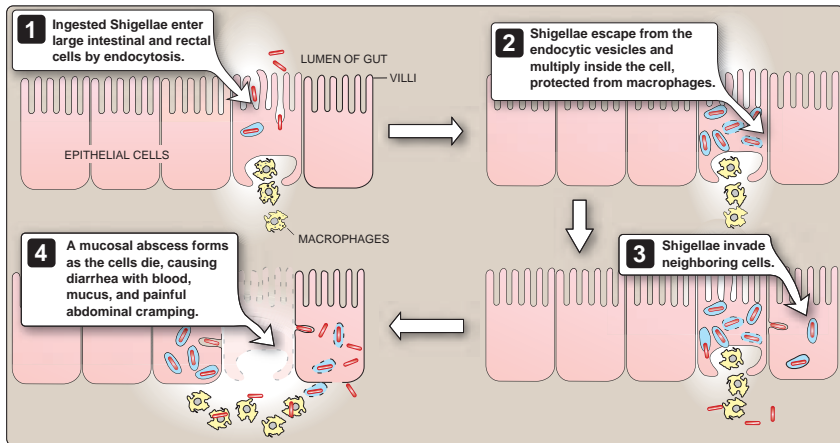
Antigenic variation in *Neisseria gonorrhoeae*.



What virulence factor expressed by *Shigella* species allows the process shown in **panel 1**?

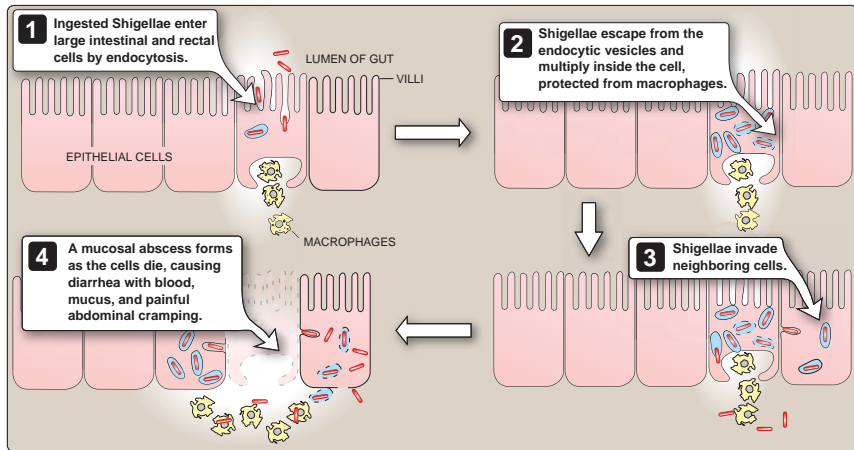


What virulence factor expressed by *Shigella* species allows the cell-to-cell spread shown in **panel 3**?





- ✔ Ingestion of effector proteins by a type III secretion system induces the host cell to phagocytose the *Shigella* species, as shown.
- ✔ IcsA is expressed from a virulence plasmid. This protein polymerizes actin on one pole of the bacterium and allows the bacterium to be propelled through the cytoplasm and into adjacent cells, as shown.



Shigella infection.



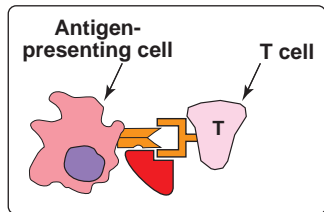
What is the general class of toxic molecule shown in red?



What are the consequences of the molecular interactions shown?



What is the difference between the molecular interactions shown and the normal situation?





Superantigen is shown in red.



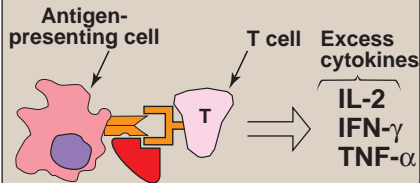
T cells induce huge amounts of cytokines, including IL-2, INF- γ , and TNF- α . These mediators can lead to damaging effects on the host, including fever, rashes, and shock.



Normally, antigens are presented in the peptide-binding groove of the MHC receptor. When presented in this pocket, peptides only activate a small percentage of T cells to induce cytokine expression. Superantigens bind outside of the peptide-binding region and directly link the antigen-presenting cell to the T cell, resulting in massive overstimulation of T cells to produce toxic amounts of cytokines.

SUPERANTIGEN EXOTOXINS

- Toxins have an affinity for the T cell receptor–MHC Class II antigen complex.
- Toxins stimulate an enhanced T-lymphocyte response.
- T-cell activation can cause toxic shock by release of large amounts of T-cell cytokines.





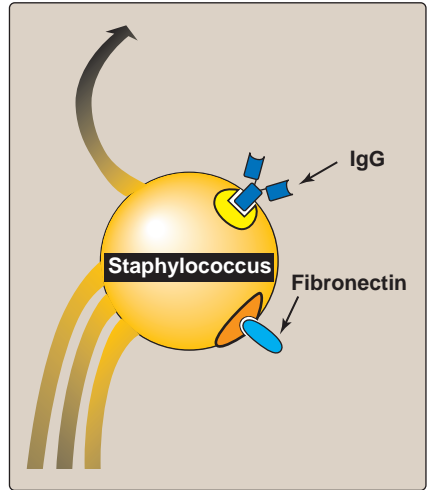
What is the protein labeled in yellow on the staphylococcal cell wall?



How does this protein contribute to infection?



What is the name and function of the protein labeled in orange?





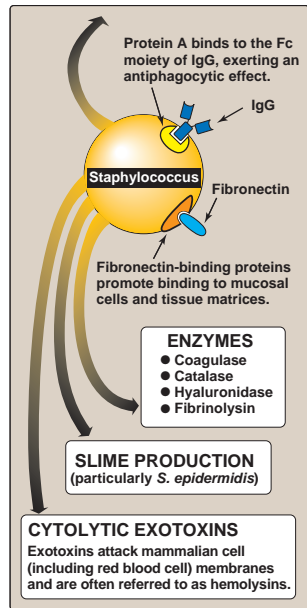
Protein A is labeled in yellow on the staphylococcal cell wall.



Protein A contributes to infection by binding IgG by the Fc region, which prevents the Fc region from being recognized by phagocytes and complement factors. Thus, expression of protein A enables staphylococci to evade phagocytosis and innate immunity.



Fibronectin-binding protein binds to fibronectin, which is an extracellular matrix protein. Binding to this host protein facilitates adherence and invasion by the bacterium.





What disease is shown?



What microorganism causes it?



What type of immunity is critical to its clinical presentation?





The patient has **lepromatous leprosy**.



Mycobacterium leprae causes leprosy.



Cell-mediated immunity is critical to its clinical presentation.



Leprosy in a 13-year-old boy. Progression of the disease after 2 years.



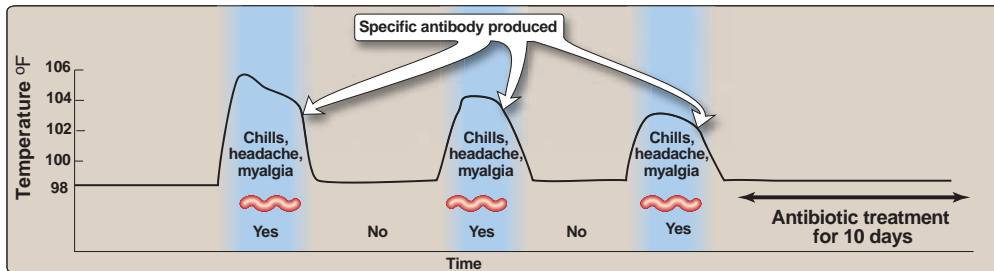
What disease is represented by the graph?



What microorganism causes the epidemic form of it?



What molecular event accounts for the clinical stages, as graphed?





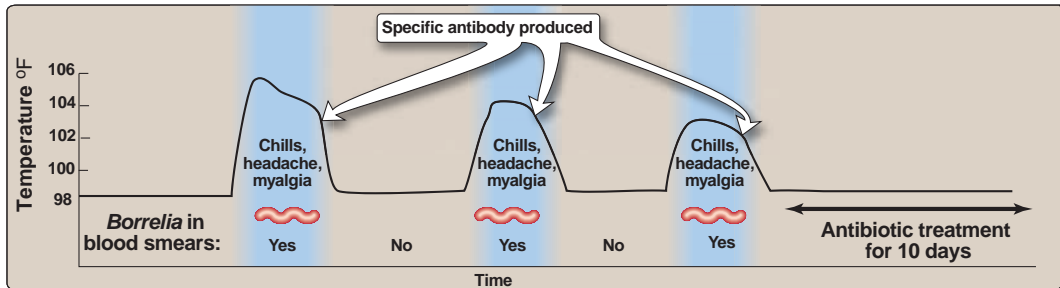
Relapsing fever is shown.



Borrelia recurrentis causes the epidemic form of the disease.



A new antigenic variant of a surface protein (Vmp) arises with each relapse. Spirochetes are present in the blood during periods of fever. Once this variant is cleared by the host, another Vmp protein variant is expressed, allowing the spirochete to cause the next recurrence of fever.



Clinical stages of relapsing fever.



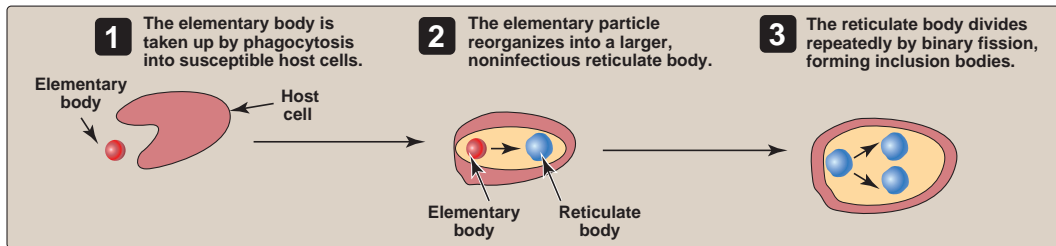
In the life cycle of the microorganism shown, what is the next obligatory step?



Why is replication obligatorily intracellular?



A college student seeks treatment at student health for a nonproductive cough, low-grade fever, and fatigue. Chest x-ray indicates the patient has pneumonia. Sputum specimens showed many PMNs but no bacteria detectable by Gram stain. Giemsa stain of expectorated epithelial cells demonstrated intracellular inclusions. What is the most likely etiology and infection?





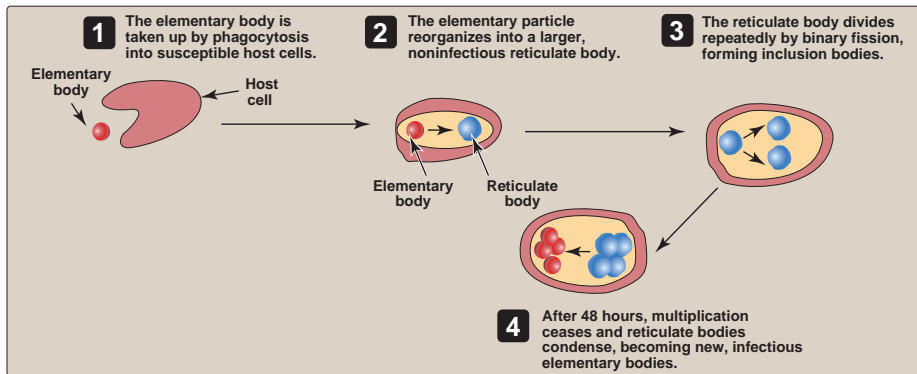
The next obligatory step in the life cycle shown is that multiplication of reticulate bodies cease and the accumulated reticulate bodies convert to elementary bodies.



Replication is obligatorily intracellular because the pathogen must acquire ATP and NAD⁺ from the host cell.



The patient most likely has **atypical pneumonia** caused by *Chlamydia pneumoniae*.



Reproductive cycle of *Chlamydiaceae*.



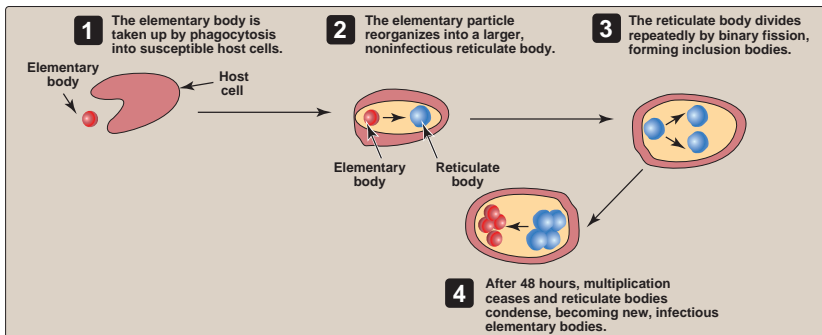
In the life cycle of the microorganism shown, what is the next obligatory step?



What are the unique characteristics of the cell form that exists in the next obligatory step?



A 30-year-old male who works in a zoo aviary visits his physician complaining of a dry cough, fever, and body aches. Lung examination revealed crackles and rales, and physical examination showed the patient had mild splenomegaly. Chest x-ray demonstrated pneumonia. Sputum specimens showed many PMNs but no bacteria detectable by Gram stain. Giemsa stain of expectorated epithelial cells demonstrated intracellular inclusions. What is the most likely etiology and infection?





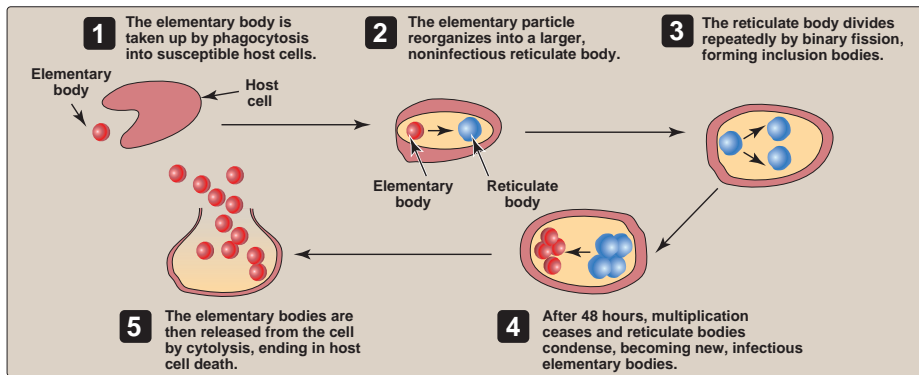
The next obligatory step in the life cycle shown is that elementary bodies accumulate until the host cell lyses. The elementary bodies are then able to infect epithelial cells in the same or another host.



Elementary bodies are uniquely condensed, metabolically inactive, able to survive extracellularly, and infectious.



The patient most likely has **psittacosis** caused by *Chlamydia psittaci*.



Reproductive cycle of *Chlamydiaceae*.



Describe the lesion shown.



If the patient lives in the U.S. mid-Atlantic area and plays outdoors and this rash is accompanied by fever and headache, what is the most likely diagnosis?



How is the pathogen in this case transmitted to humans?





A spotted rash with raised purpura on the hand and wrist is shown.



This patient likely has **Rocky Mountain spotted fever** caused by *Rickettsia rickettsii*.



This pathogen is transmitted to humans via infected wood or dog tick bite.



Child's right hand and wrist displaying the characteristic spotted rash with raised or palpable purpura, which is pathognomonic for Rocky Mountain spotted fever.



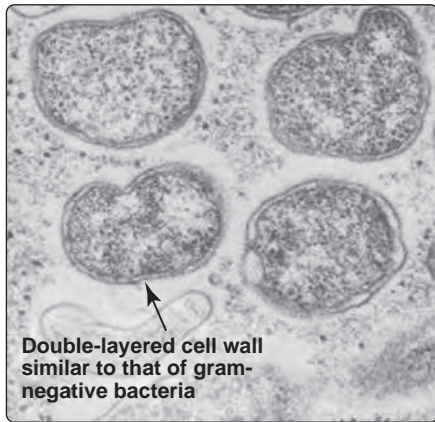
What is the genus of the pathogen shown, based upon its obligate intracellular residence in the cytoplasm of a host cell?



What is the reservoir for this pathogen, which is responsible for sporadic disease outbreaks?



If the patient lives in the U.S. southeast area; has a rash that spreads from trunk to extremities; and has other symptoms including high fever, chills, and severe headache, what is the most likely diagnosis?





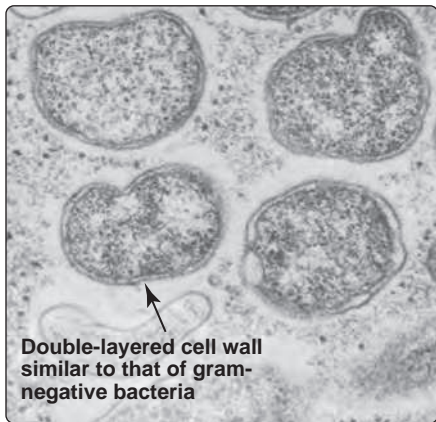
Based upon its obligate intracellular residence in the cytoplasm of a host cell, this pathogen must be ***Rickettsia***.



Flying squirrels are the reservoir for this pathogen.



This patient most likely has **epidemic typhus** caused by ***Rickettsia prowazekii***.



Electron micrograph of *Rickettsia prowazekii* in experimentally infected tick tissue.



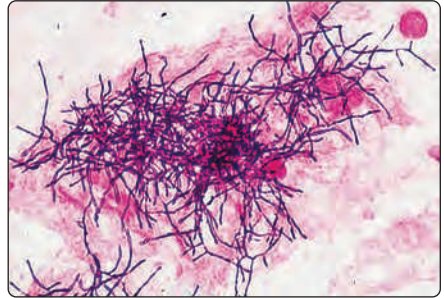
Describe the morphology of the Gram stain shown.



If the organism is weakly acid-fast, what is its most likely genus?



Describe the epidemiology of the disease caused by this organism, in terms of susceptible populations and transmission.





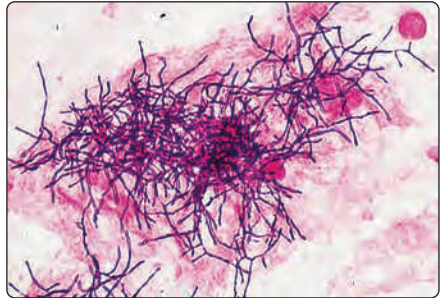
Gram-positive, branched, filamentous rods are shown.



The most likely genus of this weakly acid-fast bacterium is ***Nocardia***.



The most common *Nocardia* species in the United States is *Nocardia asteroides*, which is found ubiquitously in soil. The organism is transmitted to humans via inhalation of contaminated soils. Important conditions predisposing to infection are immunosuppression associated with cancer or immunosuppressive drug administration.



Nocardia.



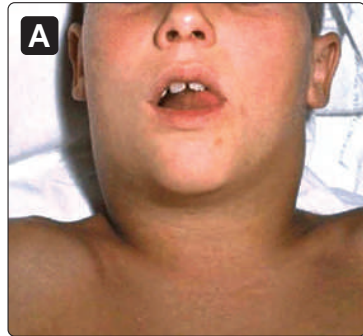
The patient shown presents with marked swelling of the lymph nodes (**panel A**) and the presence of a white pseudomembrane covering the oropharynx (**panel B**). Club-shaped bacteria are recovered from the throat. What is the most likely etiology and diagnosis?



What is the mechanism of action of its primary virulence factor?



What could have prevented this infection?





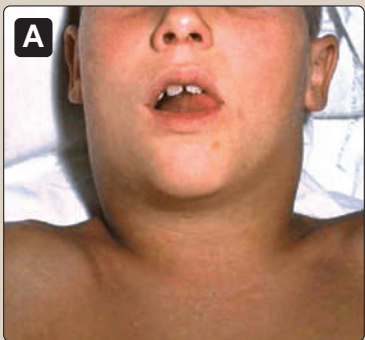
This patient has **diphtheria** caused by *Corynebacterium diphtheriae*.



The mechanism of action of its primary virulence factor is ADP-ribosylation of EF-2, resulting in inhibition of protein synthesis and host cell death.



Vaccination with diphtheria toxoid (in DPT, TDaP, or DT vaccines) could have prevented this infection.



Corynebacterium diphtheriae infection of the throat. Gross swelling and congestion of the whole pharyngeal and tonsillar area, with a gray exudate covering the tonsil.



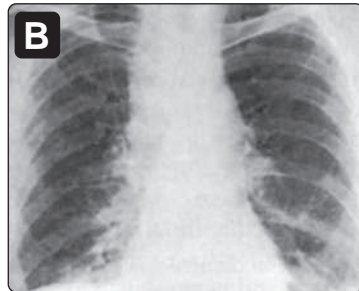
What Gram-positive bacillus is capable of causing both cutaneous (**panel A**) and pulmonary (**panel B**) manifestations, as shown?



What is the composition of the capsular material produced by the pathogen responsible for these manifestations?



How is the pathogen transmitted to humans?





Bacillus anthracis is capable of causing both the cutaneous and pulmonary manifestations shown.



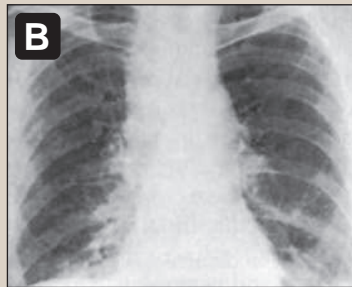
Poly-D-glutamic acid is the capsular material produced by the pathogen responsible for these manifestations.



This pathogen is transmitted to humans via spores found in the soil. Spores can be introduced into wounds to produce cutaneous anthrax or can be inhaled to produce pulmonary anthrax.



Cutaneous anthrax



Chest radiograph of a patient with pulmonary anthrax, showing widening of the mediastinum.



What Gram-negative diplococcus is capable of causing the urogenital (**panel A**) and ocular (**panel B**) manifestations shown?



How is the pathogen transmitted to humans?



Where is the pathogen often detected in clinical specimens?





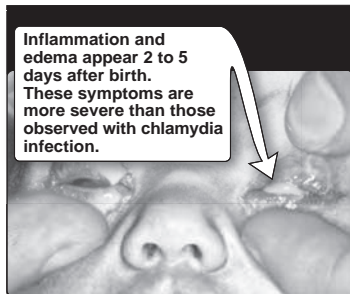
Neisseria gonorrhoeae can cause both the urogenital and ocular manifestations shown.



This pathogen is an exclusive human pathogen and is transmitted person to person via sexual contact or by vertical transmission from infected mother to neonate.



It is often detected in clinical specimens within PMNs.



Urethral discharge of gonorrhea and gonococcal ophthalmia neonatorum.



Describe this patient's condition.



If the patient's CSF contained numerous PMNs with Gram-negative diplococci, what is the most likely etiology and infection?



If the child had been vaccinated with the capsule-containing conjugate vaccine to prevent this infection, what is the most likely serogroup of the organism causing this infection?





The child suffers from a petechial and purpuric rash. The child's neck is also extended.



If the CSF contained numerous PMNs with Gram-negative diplococci, the patient has **meningitis and meningococemia** caused by ***Neisseria meningitidis***.



The current vaccines containing capsular material from *N. meningitidis* do not contain capsule from serogroup B because it is not immunogenic.



Petechial and/or purpuric rash and neck extension characteristic of meningococcal meningitis.



If the organism responsible for the presentation shown in the image is a Gram-positive coccus that forms clusters and is coagulase positive, what is the most likely etiology and infection?



What is the catalase reaction of the responsible organism?



What virulence factor is responsible for the manifestation shown?





If the responsible organism is a Gram-positive coccus that forms clusters and is coagulase positive, the patient most likely has **staphylococcal scalded skin syndrome** caused by *Staphylococcus aureus*.



The responsible organism is catalase positive.



The exotoxin **exfoliatin** is the responsible virulence factor. This toxin cleaves desmosomes, which play a critical role in cell-to-cell adhesion in the superficial epidermis.



Staphylococcal scalded skin syndrome



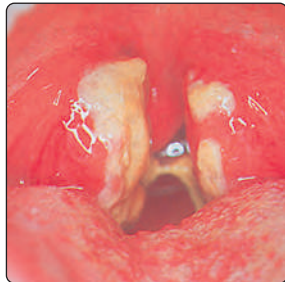
If the organism responsible for the presentation shown in the image is a Gram-positive coccus that forms chains and is catalase negative, what is the most likely etiology and infection?



If this infection is not treated, what is the primary concern in terms of downstream sequelae?



What virulence factor is critical for infectivity and also contributes to the downstream sequelae?





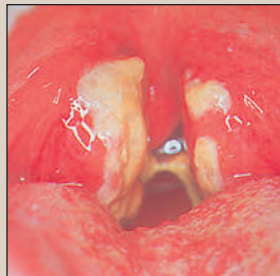
If the responsible organism is a Gram-positive coccus that forms chains and is catalase negative, the patient most likely has **pharyngitis** caused by ***Streptococcus pyogenes***.



Rheumatic fever could result if this infection is not treated.



M protein is critical for infectivity and also contributes to the downstream sequelae.



Streptococcal pharyngitis



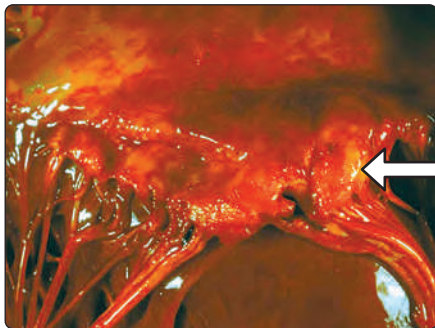
If the heart valve vegetations shown contain Gram-positive cocci in chains that form β -hemolytic colonies on plates, what is the most likely etiology and infection?



What is the normal habitat of this infectious organism?



What is the most common member of this group of microorganisms that causes dental caries?





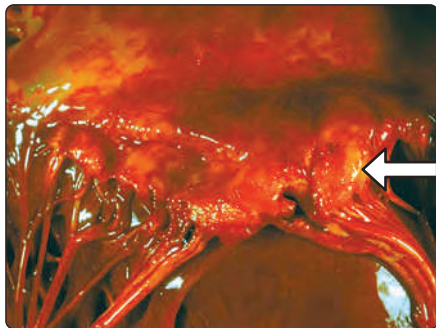
If the heart valve vegetations shown contain Gram-positive cocci in β -hemolytic chains, this patient most likely has **endocarditis** caused by **viridans Streptococci**.



The human oral cavity is the normal habitat of this infectious organism.



Streptococcus mutans is the most common member of this group of microorganisms that causes dental caries.



Streptococcal endocarditis showing vegetation of the mitral valve.



The patient shown in the image presents 5 days after surgery with a red and swollen incision and crepitus in the surrounding tissue. Gram-positive, endospore-forming rods are cultured from the wound. What is the most likely etiology and infection?



What type of metabolism does this infectious agent use for growth?



If the infectious agent is plated on blood agar, what would be the expected outcome?





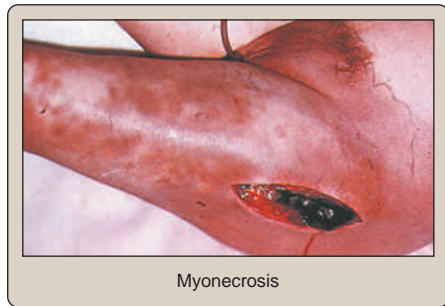
The patient most likely has **myonecrosis** caused by ***Clostridium perfringens***.



This infectious agent is strictly anaerobic.



If the infectious agent is plated on blood agar, a double zone of hemolysis due to the elaboration of α -toxin and perfringolysin O would be expected.





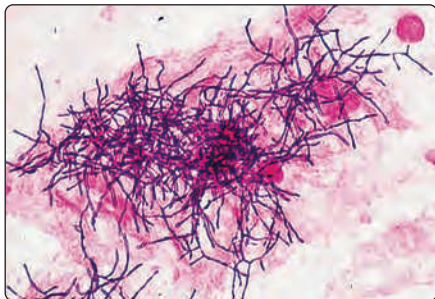
What is the morphology of the Gram-stained bacterium shown?



What is the mechanism of transmission of this organism to humans?



A kidney transplant patient in Kentucky, who has been treated with immunosuppressive drugs, presents at the emergency department with pneumonia. The patient reports that the symptoms, including chest pain, coughing, and fever, developed gradually. Sputum samples were stained, resulting in the organisms shown. What is the most likely etiology and infection?





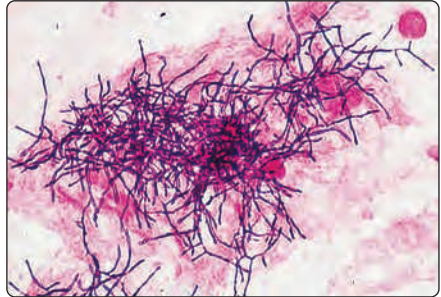
The morphology of the bacterium shown is Gram positive with branched filaments.



The organism is transmitted to humans via inhalation or skin wound contamination.



This patient most likely has **nocardiosis** caused by ***Nocardia asteroides*** (most common species in the United States to cause this infection).



Nocardia.



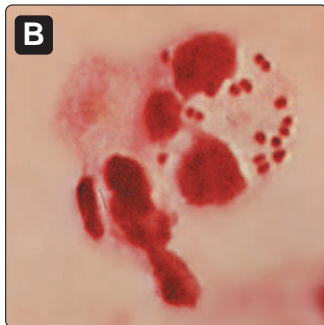
What is the morphology and Gram reaction of the bacterium shown (**panel B**)?



What clinical manifestation caused by this bacterial pathogen is shown (**panel A**)?



A 3-day-old infant is brought to the physician with the ophthalmic discharge and swelling shown (**panel A**). The infant was delivered at home and was not treated prophylactically with antibiotic eye drops. The discharge was collected and Gram stained, yielding results similar to that shown (**panel B**). What is the most likely etiology and infection?





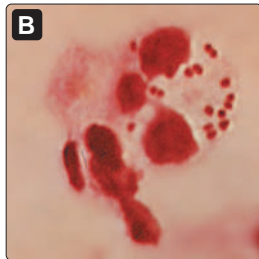
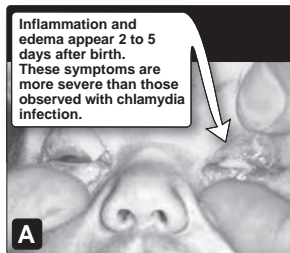
The bacteria are Gram-negative intracellular diplococci.



This bacterium causes **conjunctivitis (ophthalmia neonatorum)**.



The patient most likely has **conjunctivitis** caused by ***Neisseria gonorrhoeae***.



Gonococcal ophthalmia neonatorum and *Neisseria gonorrhoeae* in polymorphonuclear leukocytes.



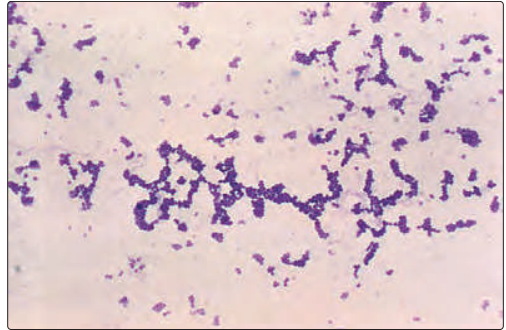
What is the morphology of the Gram-stained bacterium shown?



If the organism shown forms golden colonies on agar plates and ferments mannitol, what is the expected outcome of the coagulase test?



A 12-year-old girl presents at her pediatrician's office with pain in her femur and fever of 4 days' duration. The upper thigh is tender, and x-ray shows swelling of the femur lining and bone erosion. Blood cultures were positive for the organism shown. What is the most likely etiology and infection?





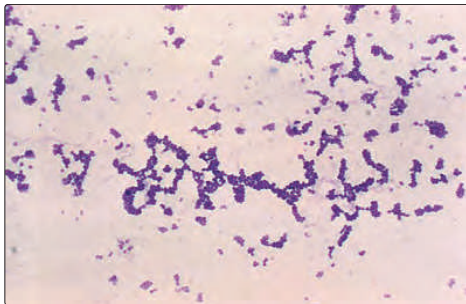
The bacteria are gram-positive cocci in clusters.



If the bacterium forms golden colonies on agar plates and ferments mannitol, it would be coagulase positive.



The patient most likely has **osteomyelitis** caused by ***Staphylococcus aureus***.



Gram stain of *Staphylococcus aureus*. From *Public Health Image Library*.



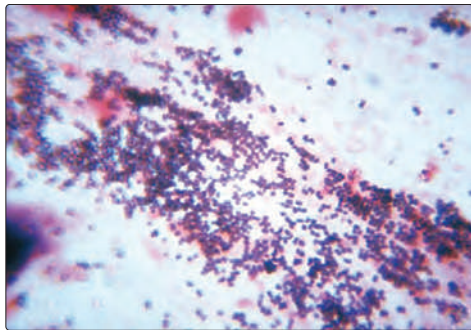
What is the morphology of the Gram-stained bacterium shown?



If the pathogen is coagulase positive, what virulence factor expressed by clinical isolates allows it to resist phagocytosis and desiccation?



A 75-year-old woman who has been hospitalized for a month following hip replacement surgery develops pneumonia. Gram stain of sputum samples resembles that shown. The pathogen produces a small cleared zone on blood agar and is coagulase positive. What is the most likely etiology and infection?





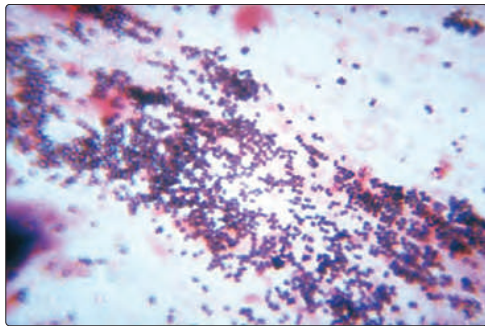
The bacteria are gram-positive cocci in clusters.



A **polysaccharide “microcapsule”** allows this pathogen to resist phagocytosis and desiccation.



The patient most likely has **nosocomial (hospital-associated) pneumonia** caused by ***Staphylococcus aureus***.



Gram stain of *Staphylococcus aureus*. From *Public Health Image Library*.



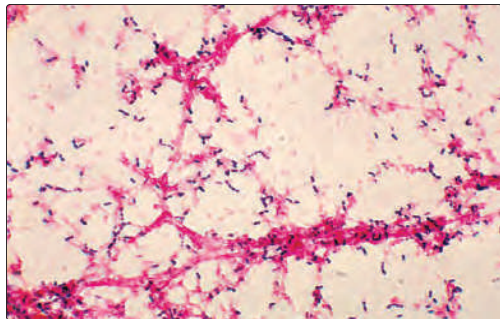
What is the morphology of the Gram-stained bacterium shown?



What virulence factor produced by the pathogen shown binds to cholesterol in host cells, stimulates production of proinflammatory cytokines, and activates complement?



A 30-year-old woman presents at the emergency department with fever, confusion, chills, and increased respiratory rate. Medical history indicates that she is asplenic due to a previous automobile accident. Gram stain of blood cultures resembles that shown. The bacterium is catalase negative and optochin sensitive. What is the most likely etiology and infection?





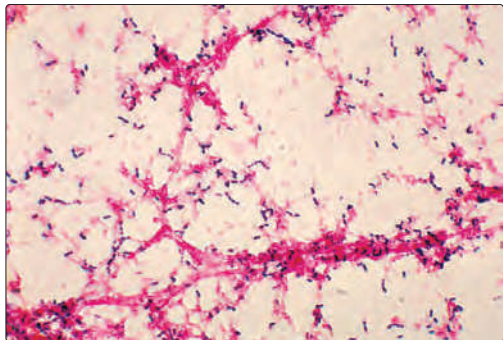
The bacteria are Gram-positive cocci in pairs and short chains.



The toxin **pneumolysin** binds to cholesterol in host cells, stimulates production of proinflammatory cytokines, and activates complement.



The patient most likely has **sepsis (bacteremia)** caused by ***Streptococcus pneumoniae***.



Gram stain of *Streptococcus pneumoniae*. From *Public Health Image Library*.



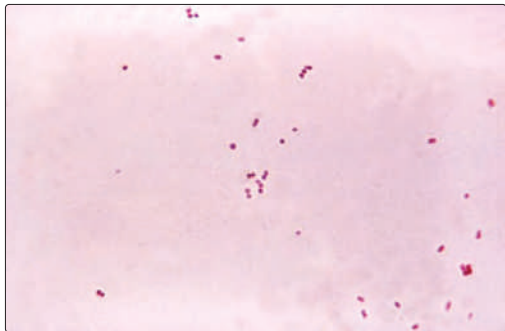
What is the morphology of the Gram-stained bacterium shown?



If this pathogen has a polysaccharide capsule, what result would you expect from a maltose utilization test?



A 19-year-old college student who lives in a dormitory is taken to the emergency department. He has a fever, photophobia, neck stiffness, and myalgias. The physician notices a rash on his trunk that does not blanch when pressed. Medical records indicate that he has not received any recent vaccinations. CSF samples were collected and stained, and Gram-negative diplococci were noted within PMNs. The CSF samples were cultured on chocolate agar, and the resulting colonies demonstrate the morphology shown. What is the most likely etiology and infection?





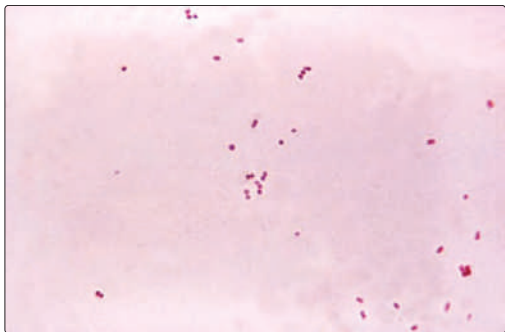
The bacteria are Gram-negative diplococci.



With a polysaccharide capsule, this pathogen is capable of utilizing glucose and maltose, but not lactose or sucrose.



The patient most likely has **meningitis** caused by ***Neisseria meningitidis***.



Gram stain of *Neisseria meningitidis*. From *Public Health Image Library*.



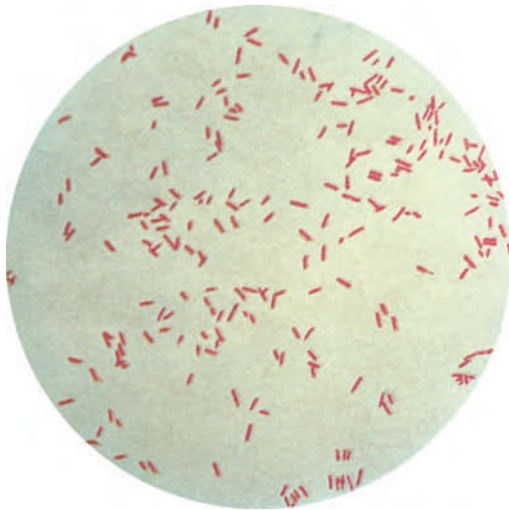
What is the morphology of the Gram-stained bacterium shown?



If this pathogen is flagellated, oxidase positive, and nonfermentative, what virulence factor confers resistance to phagocytosis and lung clearance?



An 18-year-old child with cystic fibrosis suffers from sudden, decreased lung function, which prompts a trip to the emergency department. Sputum samples were collected and plated on MacConkey agar. The resulting colorless colonies yielded Gram-negative, rod-shaped bacteria similar to those shown. What is the most likely etiology and infection?





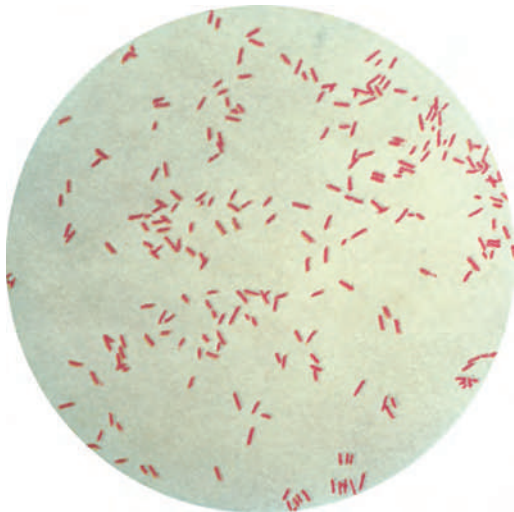
The bacterium is a Gram-negative rod (or bacillus).



The capsular material **alginate**, composed of a repeating polymer of mannuronic and glucuronic acids, confers resistance to phagocytosis and lung clearance.



The patient most likely has a lung infection with ***Pseudomonas aeruginosa***.



Gram stain of *Pseudomonas aeruginosa*. From *Public Health Image Library*.



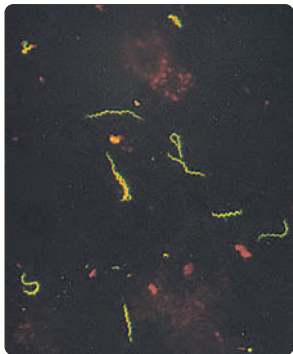
What is the cell morphology of the bacterium shown?



Although spirochetes have a Gram-negative cell structure, most spirochetes (except *Leptospira*) lack what cell envelope structure?



A 19-year-old male presents to an STD clinic with a hard, painless chancre on his penis. The physician collects material from the chancre for analysis by direct immunofluorescence staining, as shown. What is the most likely etiology and infection?





The bacterium is a **spirochete**.



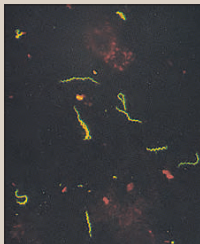
Most spirochetes lack **LPS** (or **endotoxin**).



The patient most likely has **primary syphilis** caused by *Treponema pallidum*.

Spirochetes

Treponema species



Treponema pallidum by
direct immunofluorescence

- Gram-negative, but most stain poorly and need to be visualized by other means
- Long, slender, flexible, spiral- or corkscrew-shaped rods
- Organisms are highly motile
- Does not grow in culture



Primary syphilis presenting as
painless chancres of the penis



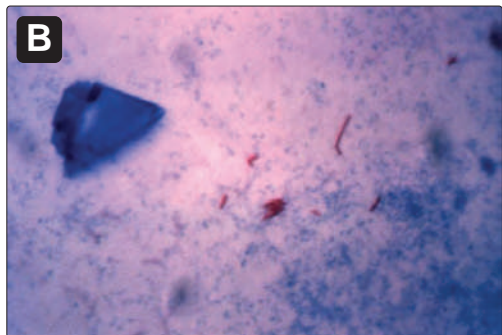
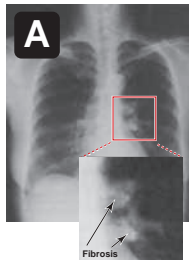
What is the cell morphology of the bacterium shown (**panel B**)?



What are the fibrotic lesions seen on the chest x-ray (**panel A**) called?



A 60-year-old male with depressed cell-mediated immunity presents with fever, chills, and weight loss. Acid-fast staining of sputum samples resembled that shown (**panel B**). What is the most likely etiology and infection?





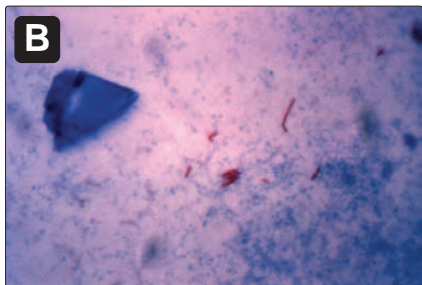
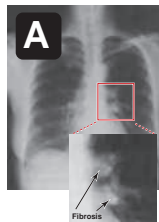
The bacteria are acid-fast, long, slender rods.



The fibrotic lesions are **Ghon complexes**.



The patient most likely has **tuberculosis** caused by ***Mycobacterium tuberculosis***.



A. Chest radiograph showing some fibrosis—the classic Ghon complex. **B.** *Mycobacterium tuberculosis* in a sputum smear stained with Ziehl-Neelsen staining technique. From *Public Health Image Library*.



The test and reaction shown is intended to monitor and document exposure to what pathogen?

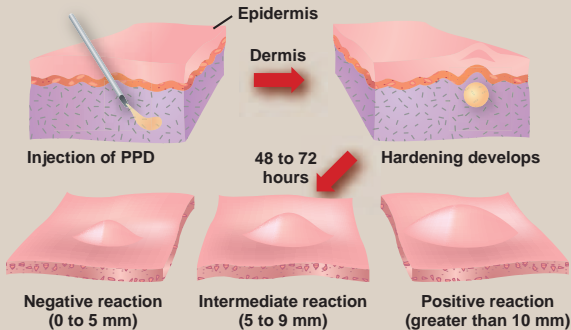


What is the basis for the reaction shown?

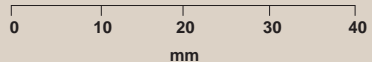


What is the recommended treatment for a person who suffers from the disease caused by this pathogen?




A Schematic summary of test

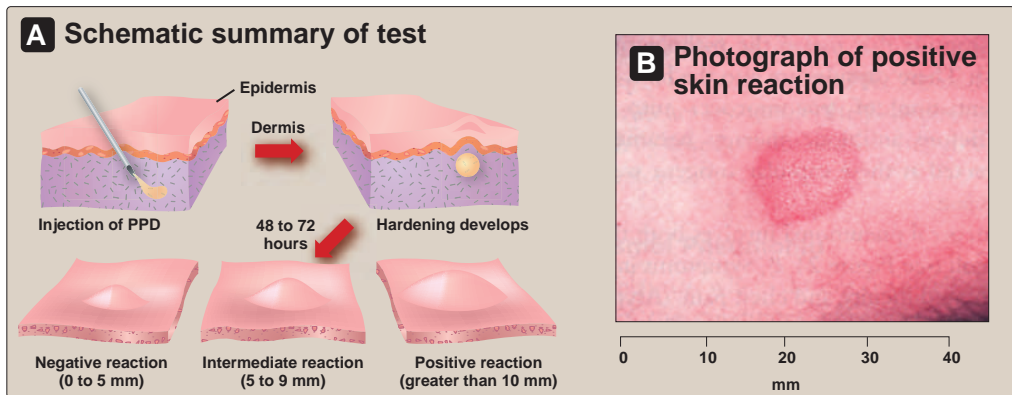


B Photograph of positive skin reaction





-  This test is for *Mycobacterium tuberculosis*.
-  Hypersensitivity to the protein antigen administered (**purified protein derivative [PPD]**) results.
-  The patient would get concomitant treatment with four antimicrobials: isoniazid, rifampin, pyrazinamide, and ethambutol or streptomycin.



Mantoux skin test for tuberculosis.



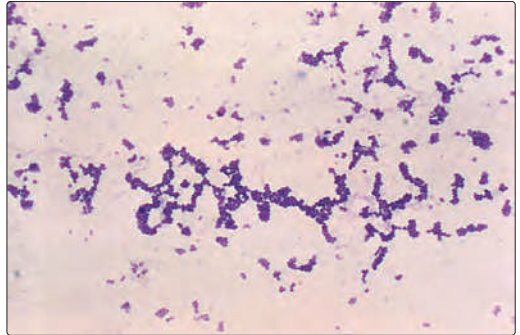
What is the cell morphology of the bacterium shown?



The pathogen shown is coagulase positive. What toxin is produced by some strains of this bacterium that results in lysis of lymphocytes?



The health care–associated strains of this pathogen are particularly difficult to treat. What is the drug of first choice to treat these infections empirically?





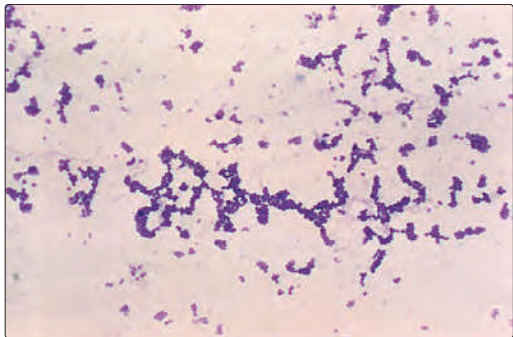
The bacteria are Gram-positive cocci in clusters.



This bacterium produces **Panton Valentine leucocidin (PVL)**.



Vancomycin is the drug of first choice to treat these infections.



Gram stain of *Staphylococcus aureus*. From *Public Health Image Library*.



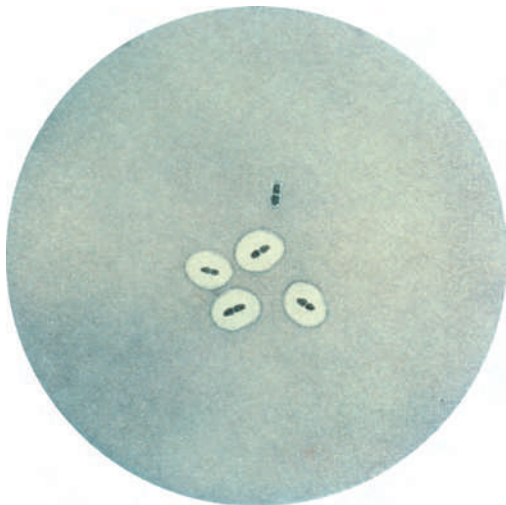
What is the cell morphology of the bacterium shown?



What test can be used to identify the structure surrounding the bacterial cells shown?



Since penicillin resistance has emerged within this species of bacteria, what are currently the drugs of first choice for empiric treatment of invasive infections with this pathogen?





The bacteria are encapsulated, lancet-shaped cocci arranged in pairs.



The **Quellung test** detects the polysaccharide capsule with specific antibodies.



The drugs of first choice for empiric treatment of invasive infections are third-generation **cephalosporins** (e.g., ceftriaxone) and vancomycin.



Streptococcus pneumoniae detected by the Quellung test.
From *Public Health Image Library*.



What is the cell morphology of the bacterium shown?



When the pathogen shown is acquired by inhalation of contaminated respiratory droplets, what is the characteristic symptom of the disease?



Besides antibiotic therapy, what must be administered to a patient suffering from this very contagious disease?





The bacteria are Gram-positive, club-shaped bacilli in a palisade arrangement.



When this pathogen (*Corynebacterium diphtheriae*) is inhaled, it produces a gray, pseudomembrane covering the oropharynx.



Patients suffering from this very contagious disease must also be given **anti-diphtheria toxin antibodies**, which neutralize the diphtheria toxin.



Gram stain of *Corynebacterium diphtheriae*. From *Public Health Image Library*.



What is the cell and colony morphology of the bacterium shown?



The pathogen shown is capable of causing disease with what three distinctive manifestations (one of which is very rare in humans but common in herbivores)?



What is the drug of first choice to treat infections (or ideally to prevent infections) with the pathogen shown?





The bacteria are Gram-positive, square-ended bacilli forming long chains and nonhemolytic, nonpigmented colonies with irregular edges.



This pathogen causes **GI** (rare in humans), **cutaneous**, and **pulmonary anthrax**.



Ciprofloxacin is the drug of first choice to treat/prevent these infections. [Note: Pulmonary anthrax requires multidrug treatment with ciprofloxacin, rifampin, and either clindamycin or vancomycin.]



A. Gram stain of *Bacillus anthracis*. **B.** *B. anthracis* colonies grown on blood agar. From *Public Health Image Library*.



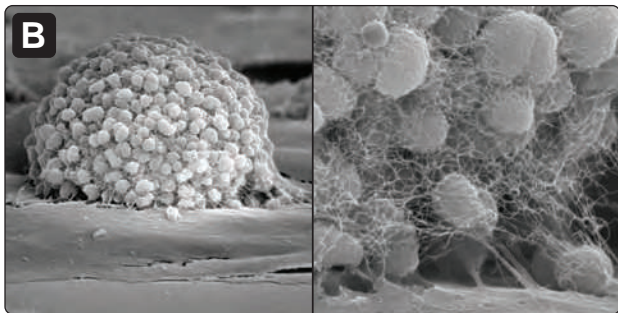
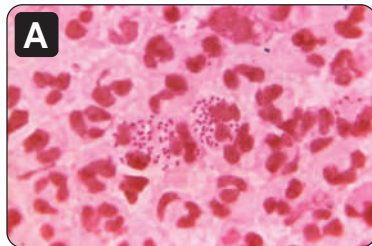
What is the cell morphology of the bacterium shown (**panel A**)?



What surface appendage (shown in **panel B**) is responsible for microcolony formation and adherence to host cells?



Antibiotic resistance has emerged in the pathogen shown, which produces acid from glucose but not maltose. What is the recommended treatment for infections caused by the pathogen shown?





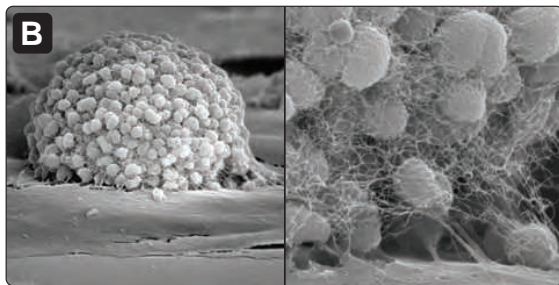
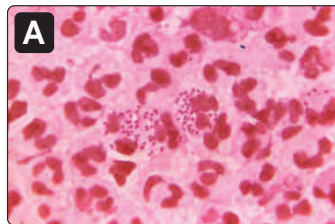
The bacteria are Gram-negative intracellular diplococci.



The **pilus** forms microcolonies and adheres to host cells.



Ceftriaxone and azithromycin or doxycycline (to treat the commonly coinfecting pathogen *Chlamydia trachomatis*) are used to treat infections with *Neisseria gonorrhoeae*.



A. *Neisseria gonorrhoeae* in polymorphonuclear leukocytes. From *Public Health Image Library*. **B.** Two different magnifications of a microcolony of *Neisseria gonorrhoeae* attached to human epithelial cells. Cobweb-like structures are Type IV pili.



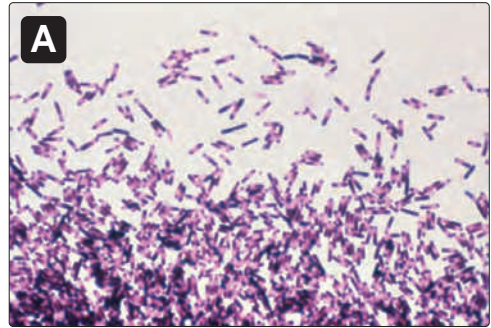
What is the cell and colony morphology of the bacterium shown?



What is the significance of sporulation by this species with respect to disease transmission?



If the organism shown is an obligate anaerobe that causes antibiotic-associated colitis, what is the recommended treatment for infections caused by the pathogen shown?





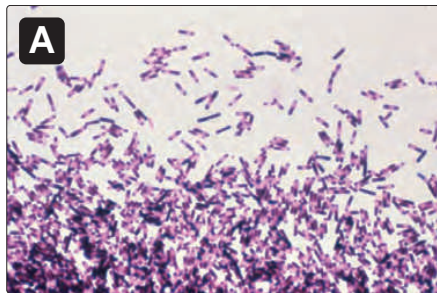
The bacteria are Gram-positive rods with endospores, not forming chains. Colonies are yellow and irregular on plates.



The spores are hardy, resistant to desiccation, and difficult to render noninfectious, meaning that contamination of surfaces and fomites (particularly within a hospital setting) is frequent and a ready source of contagion.



The drug of first choice to treat infections caused by *Clostridium difficile* is **metronidazole**, followed by **vancomycin**.



A. Gram stain of *Clostridium difficile*. **B.** Colony morphology of *C. difficile*. From *Public Health Image Library*.



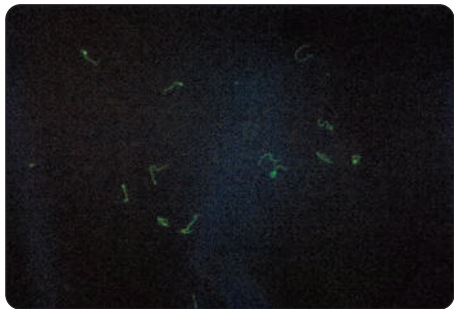
What is the morphology of the bacterium shown?



If the organism shown is a human-specific pathogen that does not infect other animals, what are the three states of disease that can be manifested after infection?



What is the recommended therapy for the early stages of disease caused by this pathogen?





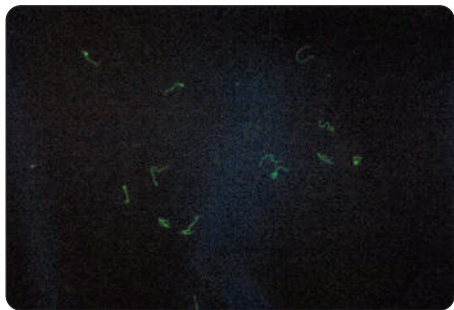
The bacterium is a spirochete.



Following infection with *Treponema pallidum*, a chancre forms, representing **primary syphilis**, which is followed by an asymptomatic period of variable length. **Secondary syphilis** is characterized by a generalized rash and systemic signs and is followed by a latent phase without obvious symptoms. The final stage is **tertiary syphilis**, which can be very difficult to treat.



Penicillin is the recommended therapy for early-stage disease.



Immunofluorescent microscopy image of *Treponema pallidum*. From *Public Health Image Library*.



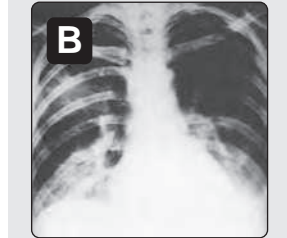
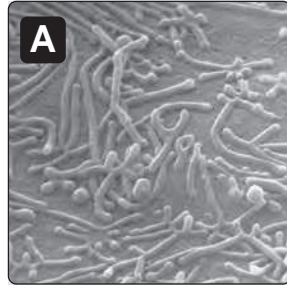
What is the morphology of the bacterium shown?



What unique component is found in the cell wall of bacteria with the morphology shown?



What class of antibiotics cannot be used to treat infections caused by the genus of bacterium shown?





The bacteria are pleomorphic, showing both elongated rods and cocci.



Mycoplasma species have **sterols** in their membranes, which must be provided by the host.



Cell-wall active antibiotics (e.g., the β -lactams) cannot be used to treat mycoplasma infections because these bacteria do not have peptidoglycan, rendering the antibiotics inactive.



Scanning electron micrograph
of *Mycoplasma pneumoniae*

- Not seen with Gram stain because it lacks peptidoglycan cell walls
- Plastic, pleomorphic shape (neither rods nor cocci)
- Cell membrane is a sterol-containing lipid bilayer
- Rarely cultured for diagnostic purposes



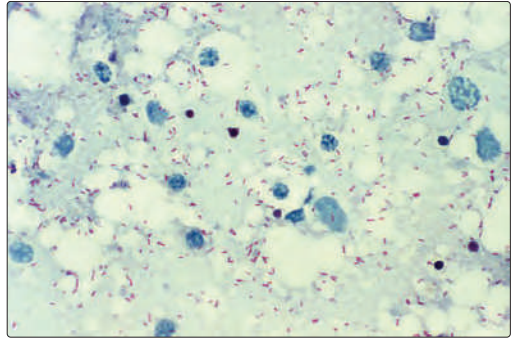
What is the morphology of the bacterium shown?



If the organism shown is an obligate intracellular pathogen, grows in the nucleus and cytoplasm, and is transmitted to humans by ticks, what type of rash is a typical symptom of disease?



What is the recommended therapy for the disease caused by this pathogen?





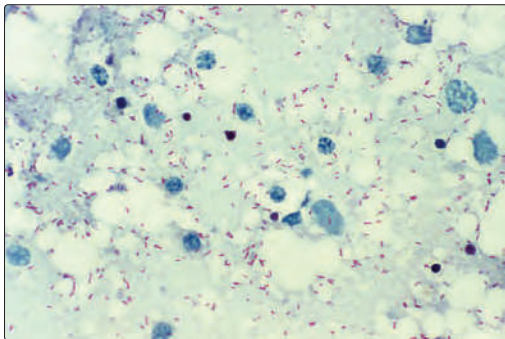
The bacteria are Gram-negative, short rods.



Rocky Mountain spotted fever is caused by *Rickettsia rickettsii*. The rash caused by this bacterium spreads centripetally from the palms of the hands and soles of the feet to the trunk.



Doxycycline is recommended to treat this disease.



Gimenez-stained *Rickettsia rickettsii*. From *Public Health Image Library*.



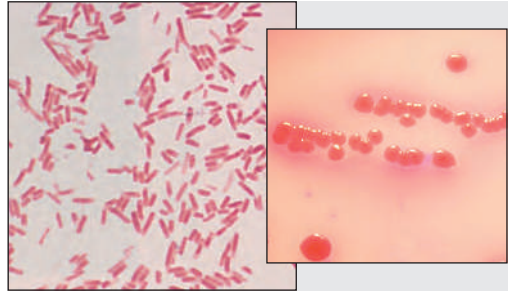
What is the cell and colony morphology of the bacterium shown?



What toxins are responsible for the development of hemorrhagic colitis caused by the organism shown?



Why does treatment of disease caused by this bacterium NOT include antibacterial agents?





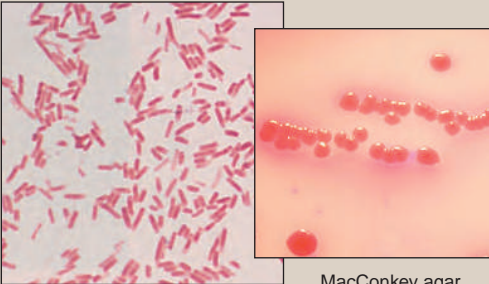
The bacteria are Gram-negative rods, forming red to pink colonies on MacConkey agar.



Shiga-like toxins 1 or 2 cause hemorrhagic colitis.



Antibacterial agents cause death and lysis of the **Enterohemorrhagic *Escherichia coli***, but the toxins are still active. Their effects on the host may be exacerbated by antibacterial therapy due to increased release and circulation.



- Short rods
- Facultative anaerobe
- Ferments glucose
- Most strains ferment lactose
- Catalase positive
- Oxidase negative
- Culture on MacConkey agar

E. coli
(Gram stain)

MacConkey agar



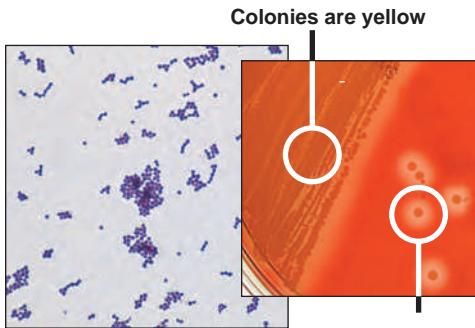
What is the colony and cell morphology of the bacterium shown?



What is the common feature of toxic shock syndrome, gastroenteritis, and scalded skin syndrome, caused by the pathogen shown?



A 20-year-old male attends a family picnic and 3 hours later feels nauseous, starts vomiting, and has mild diarrhea. The symptoms resolve on their own within 24 hours. Upon reflection, the young man recalls eating egg salad and ham sandwiches at the picnic. What is the most likely cause of the symptoms in this case?





The bacteria are Gram-positive cocci in clusters forming β -hemolytic colonies on blood agar.

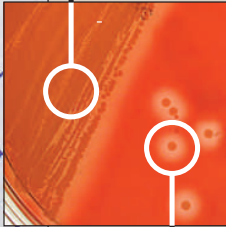
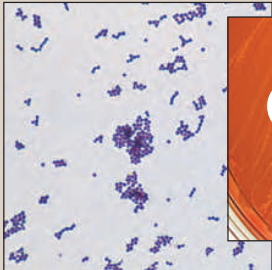


These diseases are all **toxinoses**, which are caused by exotoxin circulation.



His symptoms were most likely caused by ingestion of **preformed staphylococcal enterotoxin** produced by *Staphylococcus aureus*.

Colonies are yellow



- Catalase (+)
- Nonmotile
- Do not form spores
- Round cocci tending to occur in bunches like grapes
- Facultative anaerobic organisms
- Cultured on enriched media containing broth and/or blood

Staphylococcus aureus cultured from a wound infection

Staphylococcus aureus on blood agar surrounded by zone of β hemolysis.



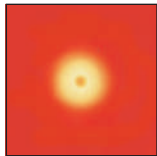
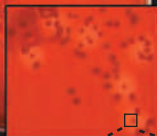
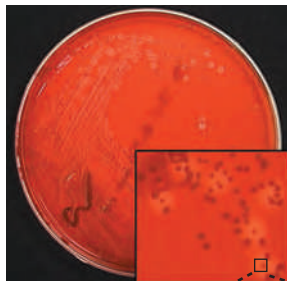
What is the cell and colony morphology of the bacterium shown?



What common feature is shared by toxic shock syndrome and scarlet fever, caused by the pathogen shown?



A 12-year-old child is brought to the pediatrician's office suffering from sore throat; fever; swollen lymph nodes; and a sunburn-like rash on the trunk, neck, and extremities. A quick antigen test is positive, and culture of the nasopharyngeal specimen demonstrates the bacterium with the cell and colony morphology shown. What is the most likely etiology and infection?





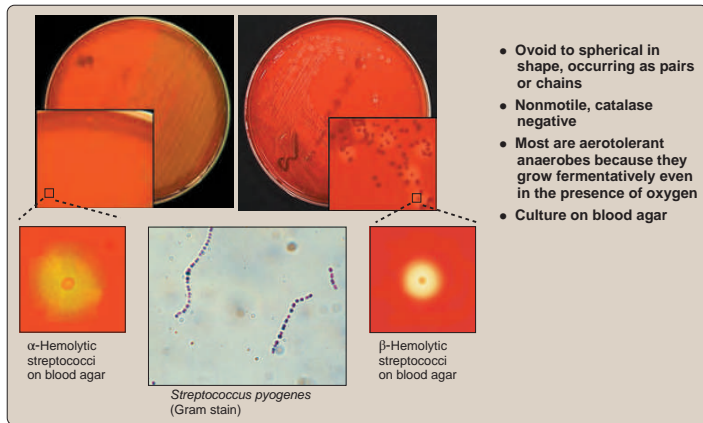
The bacteria are Gram-positive cocci in chains. Growth on blood agar shows β -hemolysis.



Both diseases are **toxinoses**, caused by **circulating pyrogenic toxins**.



The patient most likely has **scarlet fever** caused by ***Streptococcus pyogenes***. [Note: Only some strains carry the bacteriophage that produces scarlet fever toxin.]





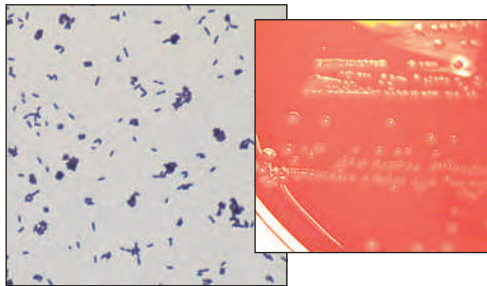
What is the cell and colony morphology of the bacterium shown?



The organism shown demonstrates what unique characteristic in liquid medium that can be used in diagnosis?



A cluster of cases of meningitis occurred among elderly people (age >65 years) over a large geographic region. The causative agent, isolated from the CSF of infected patients, had the cell and colony morphology shown. The only common feature among the patients was that they all consumed fresh cantaloupe within a week of onset of symptoms. What is the most likely etiology and infection?





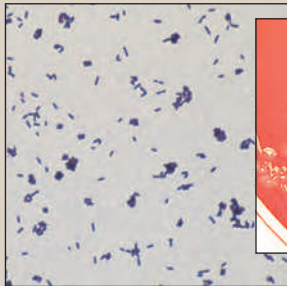
The bacteria are Gram-positive short rods. Growth on blood agar shows the narrow zone of β -hemolysis.



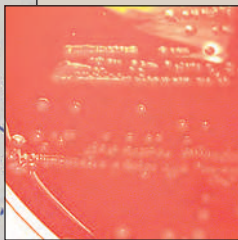
This organism uniquely demonstrates **tumbling, end-over-end motility**.



The patients most likely have **meningitis** caused by *Listeria monocytogenes*.



Listeria monocytogenes
in cerebrospinal fluid
(Gram stain)



Listeria monocytogenes
on blood agar

- Slender, short rods, sometimes occurring as diplobacilli or in short chains
- Intracellular parasites
- Catalase positive
- Distinctive tumbling motility in liquid medium
- Grow facultatively on various enriched media



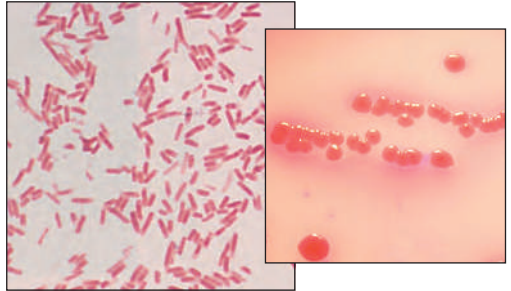
What is the cell and colony morphology of the bacterium shown?



One virotype of the pathogen shown is invasive for mucosal epithelial cells, causing a dysentery-like syndrome with fever and bloody stools. What virulence factors are responsible for the invasion of and spread among host cells by this pathogen?



A 1-month-old infant was brought to the emergency department by his parents. The child presented with lethargy, fever, and vomiting. The physician noted a bulging fontanelle and ordered a spinal tap to recover CSF specimens. Culture of blood and CSF samples resulted in bacteria with the morphology shown. In addition, the pathogen had a polysaccharide capsule detectable with specific antibodies. What is the most likely etiology and infection?





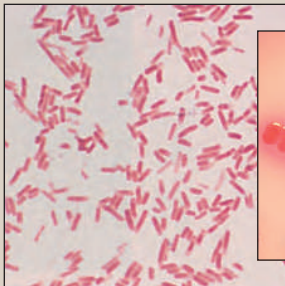
The bacteria are Gram-negative rods, forming red to pink colonies on MacConkey agar, which indicates lactose fermentation.



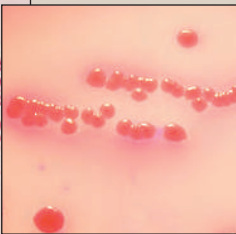
A plasmid-encoded set of proteins, which is nearly identical to those produced by *Shigella* species, allows enteroinvasive *Escherichia coli* (EIEC) to invade host cells and spread from cell to cell by actin-based motility.



The patient most likely has **meningitis** caused by *E. coli* serotype K1.



E. coli
(Gram stain)



MacConkey agar

- Short rods
- Facultative anaerobe
- Ferments glucose
- Most strains ferment lactose
- Catalase positive
- Oxidase negative
- Culture on MacConkey agar



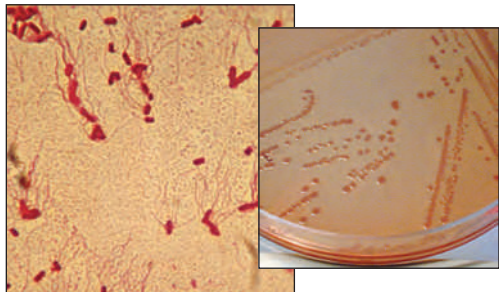
What is the cell and colony morphology of the bacterium shown?



What cell type does this pathogen preferentially invade and survive within in the human host?



A 35-year-old woman presents at her primary care physician's office complaining of nausea, vomiting, and nonbloody diarrhea. The patient has also had fever and abdominal cramps. Forty-eight hours prior to the onset of symptoms, the patient had consumed chicken and salad at home. Stool specimens were cultured and yielded bacteria with the morphology shown. What is the most likely etiology and infection?





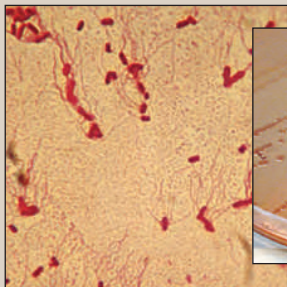
The bacteria are short flagellated rods, forming lactose-negative colonies on MacConkey agar, which indicates that the bacterium is a nonfastidious Gram negative.



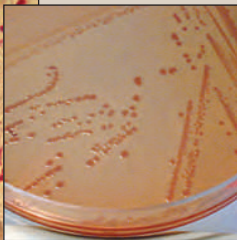
This pathogen preferentially invades and survives within macrophages.



The patient most likely has **gastroenteritis** caused by *Salmonella* serovars **Enteritidis** or **Typhimurium**.



Salmonella



Salmonella species
on MacConkey agar

- Short, flagellated rods
- Facultative anaerobes
- Ferment glucose
- Do not ferment lactose
- Catalase positive
- Oxidase negative
- Culture on MacConkey agar



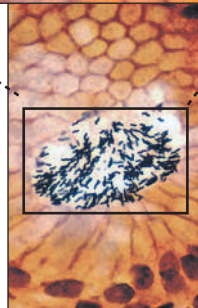
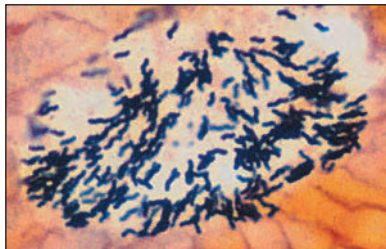
The stained bacteria shown are associated with a gastric pit. This does not represent a Gram stain. What is the cell morphology of the bacterium shown?



The pathogen shown is unique in its ability to colonize the stomach for extended periods of time. What virulence factor allows the bacterium shown to survive in the presence of stomach acid?



A 50-year-old male visits his primary care physician complaining of upper gastric pain of extended duration. His physician administers a breath test in which radiolabeled urea is administered. Radioactive carbon dioxide was released, indicating a positive test for the pathogen shown. What is the most likely etiology and infection?





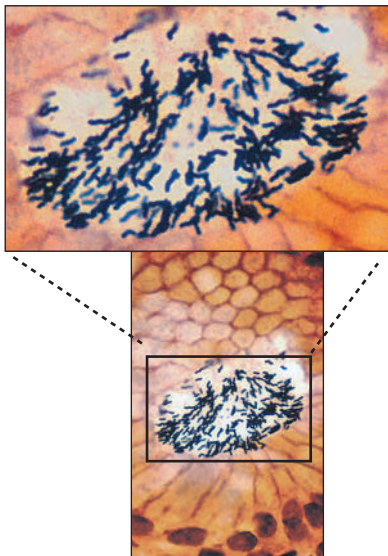
The bacteria are spiral shaped.



The **virulence factor urease** cleaves urea to ammonia and carbon dioxide. The ammonia neutralizes the acid in the stomach, making conditions favorable for the bacterium.



The patient most likely has a **gastric ulcer** caused by ***Helicobacter pylori***.



Helicobacter pylori in a gastric pit.



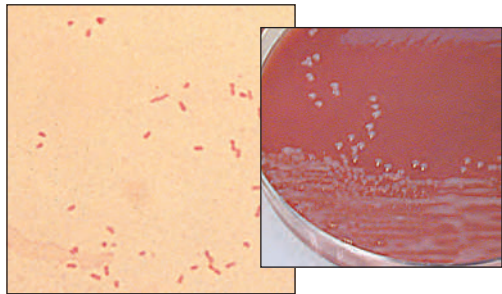
What is the cell and colony morphology of the bacterium shown?



The organism shown is fastidious and requires supplementation with various growth factors. What two organic compounds must be provided to this obligate human pathogen to survive during in vitro growth?



A 3-year-old child was brought to the emergency department with fever, vomiting, light sensitivity, and neck stiffness. The CSF specimen was positive for Gram-negative rods, similar to that shown and was positive for growth on chocolate agar. When asked, the parents indicated that they were resistant to vaccination, and the patient was not current on recommended vaccinations. What is the most likely etiology and infection?





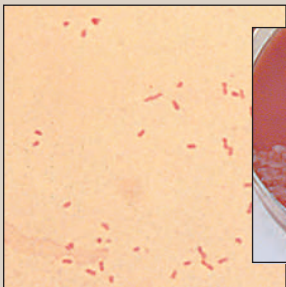
The bacteria are Gram-negative pleomorphic rods that grow on enriched medium (chocolate agar).



This obligate human pathogen would require nicotinamide adenine dinucleotide NAD^+ and hemin to survive during in vitro growth.



The patient most likely has **meningitis** caused by *Haemophilus influenzae* type B.



Gram stain of
Haemophilus influenzae



Haemophilus influenzae
on chocolate agar

- Pleomorphic in shape, ranging from small coccobacilli to long slender filaments
- Obligate parasites, requiring hemin and NAD^+ for growth
- Culture on chocolate agar containing hemin and NAD^+



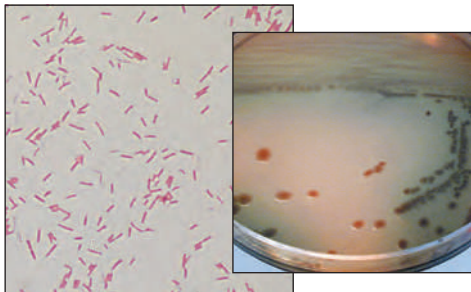
What is the cell and colony morphology of the bacterium shown?



If the bacterium shown is oxidase positive and produces a blue-green pigment, is the pathogen considered fastidious? Why or why not?



An 8-year-old boy is seen by his pediatrician suffering from ear pain and fever. His left external ear canal has an obvious discharge, which is mucoid. The discharge is cultured and demonstrates bacteria with the colony and cell morphology shown. The bacterial pathogen is oxidase positive, produces a blue-green pigment, and has a “fruity” odor. What is the most likely etiology and infection?





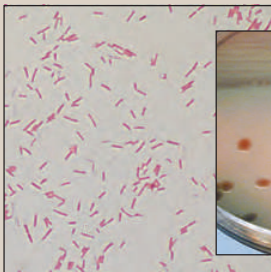
The bacteria are Gram-negative rods, forming colorless colonies on MacConkey agar, which indicates that the bacterium cannot ferment lactose.



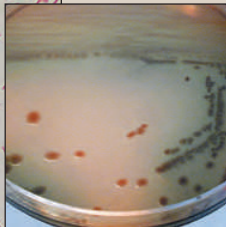
This oxidase-positive pathogen (*Pseudomonas aeruginosa*) is not fastidious. It can live in a variety of nutrient poor environments (e.g., IV tubing and hot tubs). Growth on MacConkey agar also indicates the pathogen is not fastidious.



The patient most likely has **otitis externa (swimmer's ear)** caused by *Pseudomonas aeruginosa*.



Pseudomonas aeruginosa
grown from sputum
(Gram stain)



Pseudomonas aeruginosa
on MacConkey
agar

- Encapsulated, motile rods (polar flagella)
- Aerobic or facultative anaerobe
- Produces diffusible green and blue pigments
- Oxidase positive
- Oxidizes but does not ferment carbohydrates, such as lactose
- Culture on MacConkey agar



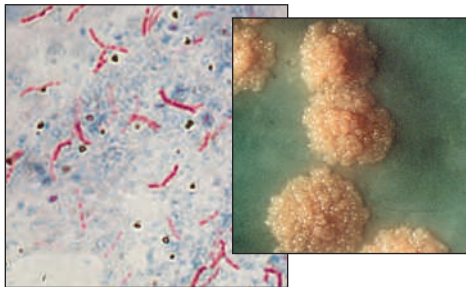
What is the cell and colony morphology of the bacterium shown?



What chemical compound in the bacterial envelope makes the bacterium shown acid-fast and resistant to desiccation?



A 30-year-old gay male with AIDS presents to the emergency department with fever, chills, night sweats, and weight loss. Because he is homeless and an IV drug user, his HIV has not been well controlled. The patient is isolated and specimens are collected for analysis. His CD4+ T-cell count is 400 cells per μl , and his sputum specimen is positive for acid-fast bacilli. Slow growth appears on plates resembling that shown. What is the most likely etiology and infection?



Acid fast stain.



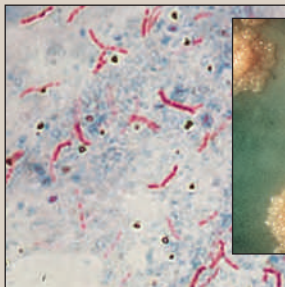
The bacteria are acid-fast, long, slender rods, forming wrinkled colonies on specialized medium.



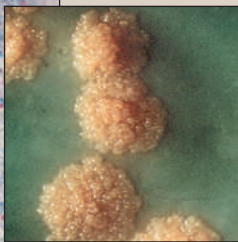
Mycolic acid confers resistance to desiccation.



The patient most likely has **reactivation tuberculosis** caused by *Mycobacterium tuberculosis*.



Mycobacterium tuberculosis
(acid-fast stain)



Mycobacterium tuberculosis (colonies
on Lowenstein-Jensen media)

- Acid-fast rods
- Not colored by Gram stain due to lipid-rich cell walls
- Long, slender, nonmotile rods
- Aerobic
- Resistant to drying
- Culture *Mycobacterium tuberculosis* on specialized medium such as Lowenstein-Jensen agar
- *Mycobacterium leprae* does not grow in culture



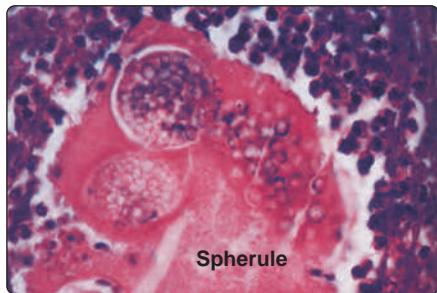
What is found within the spherule shown?



What is the mechanism of transmission of this organism to humans?



A 30-year-old male, who is HIV-positive and lives in Fresno, California, presents at the emergency department with fever, arthralgias, and chest pain. Pleural lung biopsy demonstrated spherules, as shown. What is the most likely etiology and infection?





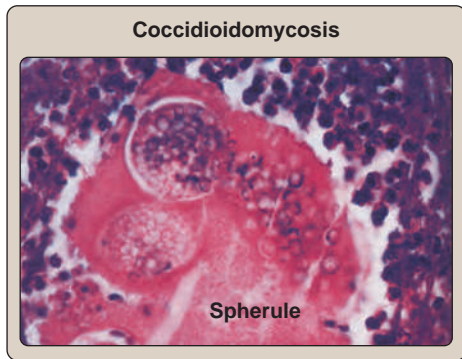
The spherule contains **endospores** that can be released to disseminate the organism.



The organism is transmitted to humans via inhalation.



This patient most likely has **coccidioidomycosis** caused by ***Coccidioides immitis*** (most common species in the southwestern United States to cause this infection).





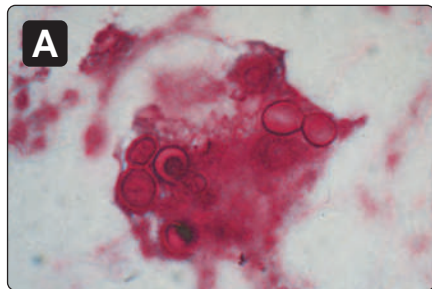
What form of the pathogen is detected in pathological specimens, as shown (**panel A**)?



If this organism often appears with unipolar, broad-based buds, what are the most likely body sites of dissemination?



A 30-year-old male, who works as a landscaper in Mississippi, presents at his doctor's office with pneumonia. Chest radiograph showed diffuse reticulonodular infiltrate of the lungs (**panel B**). Bronchoalveolar lavage was conducted and cultured on appropriate medium. Exoantigen test was positive. What is the most likely etiology and infection?





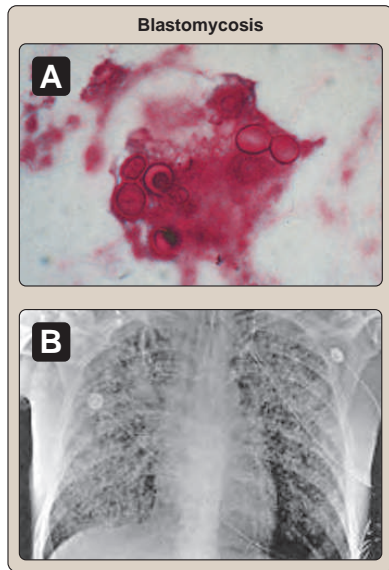
The yeast form is detected in pathological specimens.



Skin, bone, and the GU tract are the most likely dissemination sites.



This patient most likely has **blastomycosis** caused by ***Blastomyces dermatitidis*** (most common species in the United States to cause this infection).



A. Blastomycosis. **B.** Chest radiograph.



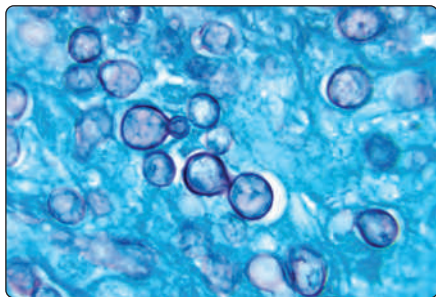
What form of the pathogen is detected in pathological specimens, as shown?



If this pathogen is endemic to the Mississippi and Ohio River valleys in the United States and is particularly associated with bat dropping inhalation, what characteristic distinguishes this organism from other fungi?



A 27-year-old male, who is HIV-positive and lives in Cincinnati, Ohio, presented at an emergency department with fever, chest pain, nonproductive cough, and joint pain. His history was remarkable for a spelunking trip 2 weeks prior to the onset of symptoms. Bronchoalveolar lavage fluid was examined by stain and was cultured on appropriate medium. A urine antigen test was positive. What is the most likely etiology and infection?





The yeast form is detected in pathological specimens.

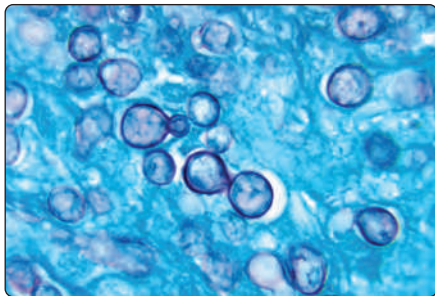


This fungus is uniquely capable of intracellular residence and parasitism inside reticuloendothelial system cells.



The patient most likely has **histoplasmosis** caused by *Histoplasma capsulatum*.

Histoplasmosis





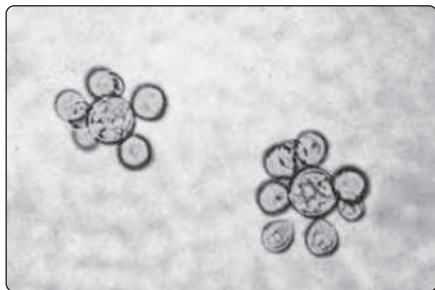
What is the term for a fungus that appears as a yeast in the host (as shown) and in the mycelial form in the environment?



In the host, if the central yeast cell is surrounded by a series of buds (as shown), what is the most likely body site to which the pathogen can disseminate?



After an extended trip to Brazil, a 30-year-old male visits his primary care physician complaining of dry cough, dyspnea, fever, and weight loss. Oral, pharyngeal, and cutaneous lesions were also noted. Sputum and skin scrapings contained organisms similar to those shown. After culture of the pathogen, the exoantigen test was positive. What is the most likely etiology and infection?





Dimorphic fungi appear as yeasts in the host and in mycelial form in the environment.

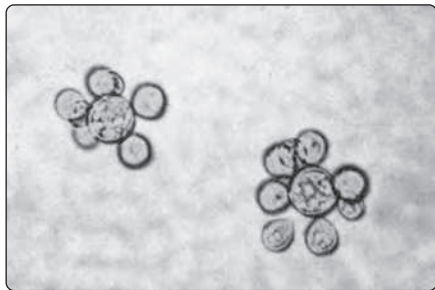


If the central cell is surrounded by a series of buds, the pathogen will most likely disseminate to mouth and nose mucosae.



The patient most likely has **paracoccidioidomycosis** caused by ***Paracoccidioides brasiliensis***.

Paracoccidioidomycosis





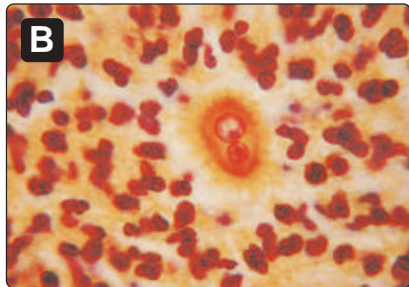
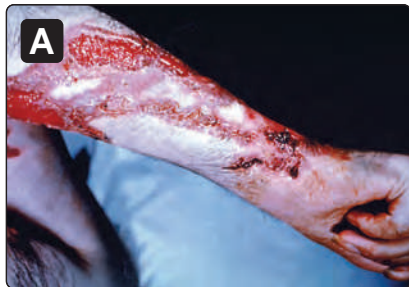
What form of the pathogen is detected in pathological specimens, as shown (**panel B**)?



How is the infection transmitted to humans?



A 34-year-old gardener visits his primary care physician complaining of ulcers on his right arm (**panel A**). The infection started with a series of small granulomatous lesions, which appeared after the patient cleared an overgrown area of vegetation. Secondary lesions formed along draining lymphatics. The ulcers drained clear fluid. What is the most likely etiology and infection?





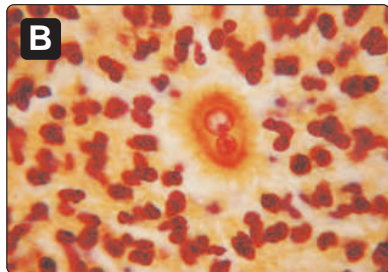
The yeast form is detected in pathological specimens.



Subcutaneous mycoses (**panel A**) are transmitted through traumatic lacerations or puncture wounds. This infection is often transmitted via the prick of a thorn.



The patient most likely has **sporotrichosis** caused by *Sporothrix schenckii*.



A. Sporotrichosis. **B.** Tissue section showing the budding yeast *Sporothrix schenckii*.



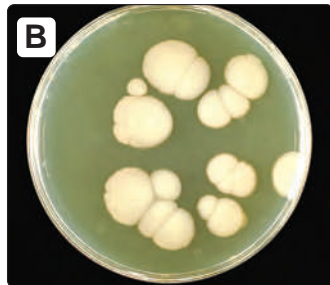
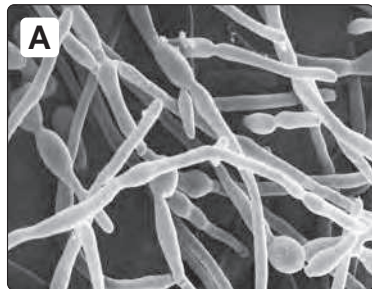
What form of the pathogen is detected in pathological specimens after growth at 37°C?



This pathogen causes disease after normal body flora are disrupted (e.g., by antibiotic treatment). Diseases caused by this pathogen fall into what classification category?



A 20-year-old female presents at her gynecologist's office with itching and burning pain of the vulva and vagina. A white discharge is also apparent. When cultured on Sabouraud dextrose agar, colonies appear, as shown (**panel B**). The patient reports having recently finished a course of antibiotics to treat a sinus infection. What is the most likely etiology and infection?





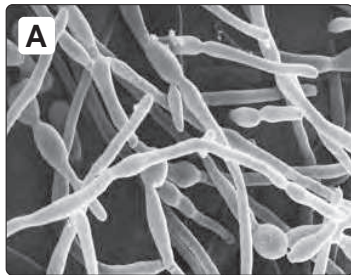
The yeast form would be detected at 37°C. A true mycelium (**panel A**) is produced at room temperature.



Opportunistic mycoses cause disease after normal body flora are disrupted.



The patient most likely has **vaginal candidiasis** caused by *Candida albicans*.



A. *Candida albicans*. **B.** Colonies of *Candida albicans*.



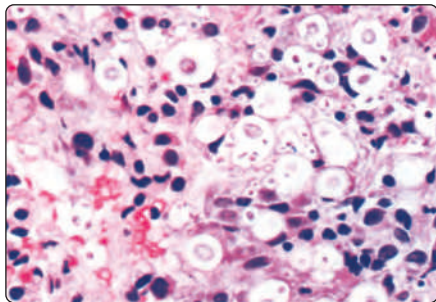
What causes the clear zones around the stained fungal cells as shown?



What is the mechanism of transmission to humans for the pathogen shown?



A 43-year-old homeless male, who is HIV-positive, is brought to an emergency department after he was discovered stumbling and appearing confused in a park. He had a temperature of 101°F, was photophobic, and exhibited nuchal rigidity. Emergency department staff suspected meningitis and conducted a lumbar puncture. Many polymorphonuclear cells were observed in the CSF. Staining of the specimen resembled that shown. What is the most likely etiology and infection?





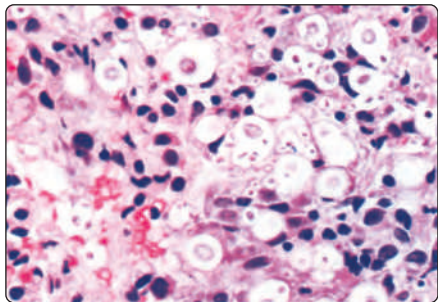
The clear zones around the fungal cells appear because the polysaccharide capsule produced by the pathogen does not take up the stain.



Inhalation of contaminated soil, especially soils containing bird (pigeon) droppings, is the mechanism of transmission.



The patient most likely has **meningitis** caused by *Cryptococcus neoformans*.



Cryptococcus neoformans.



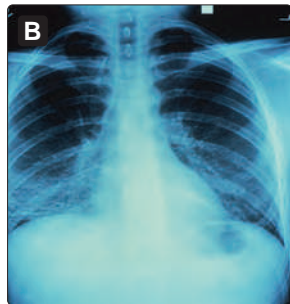
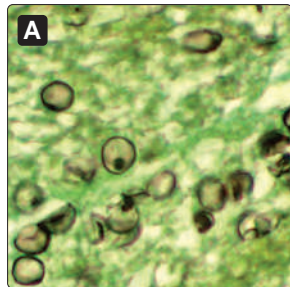
Under what conditions do the cysts (**panel A**) become activated and lead to pneumonia (**panel B**)?



The disease caused by this organism is still referred to as PCP, despite the organism's reclassification. Although it is most closely related to fungi, the pathogen is unusual in that it lacks what component of the fungal membrane?



A 40-year-old male, who is HIV-positive, comes to the clinic complaining of cough and fever. Because he is an IV drug user and homeless, his AIDS has been poorly controlled for some time. The organisms shown were detected by silver stain of lung biopsy tissue. The pneumonia caused by the pathogen (**panel B**) is characterized as a bilateral interstitial infiltrate. The infection could have been prevented by prophylactic treatment with sulfamethoxazole and trimethoprim. What is the most likely etiology and infection?





In a state of immunocompromise, particularly in the case of late-stage AIDS, the cysts activate and cause infection.

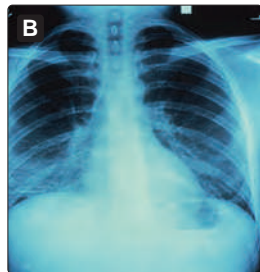
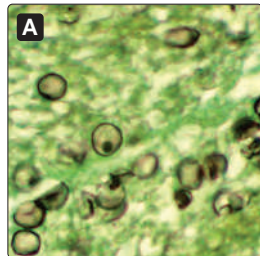


The pathogen lacks **ergosterol**.



The patient most likely has **pneumonia** caused by ***Pneumocystis jiroveci***.

[*Note: The currently accepted name for this organism is *P. jiroveci*, not *Pneumocystis carinii* (hence the name **PCP**, for *P. carinii* pneumonia).]*



A. Silver stain of *Pneumocystis jiroveci* cysts. **B.** *Pneumocystis pneumonia*.



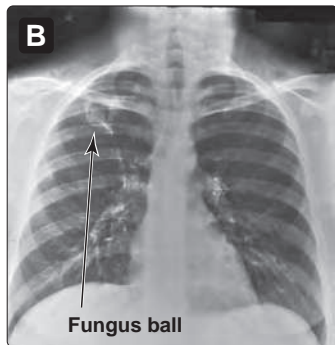
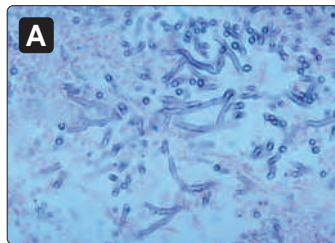
Describe the morphology of the fungus shown (**panel A**).



What is the morphology of this fungus when grown in vivo?



A 35-year-old male with asthma presents to his primary care physician with cough, fever, and low blood oxygen saturation. Chest x-ray resembles that shown (**panel B**) and is remarkable for the presence of small, well-demarcated spheres. Bronchoalveolar lavage was cultured on Sabouraud agar and examined by microscopy, revealing distinctive fungal hyphae. What is the most likely etiology and infection?





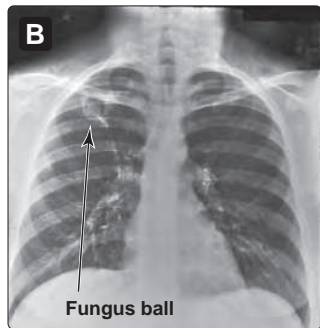
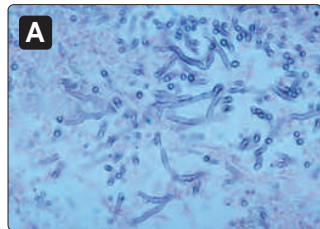
This fungus is characterized by septate hyphae that branch at 45° angles.



When grown in vivo, this fungus grows exclusively as a filamentous mold, producing prodigious numbers of **conidiospores**.



The patient most likely has **aspergillosis** caused by *Aspergillus fumigatus*.



A. *Aspergillus* species. **B.** Fungus ball.



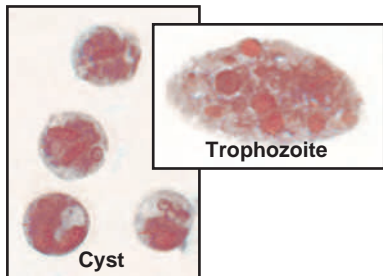
Which form of the pathogen shown is the infectious form?



What type of motility is accomplished by this pathogen?



Following a trip to Mexico, a 35-year-old man visits his primary care physician with complaints of loose stools and painful abdominal cramping but no fever. A stool specimen was collected for examination, which revealed blood and cysts (as shown). What is the most likely etiology and infection?





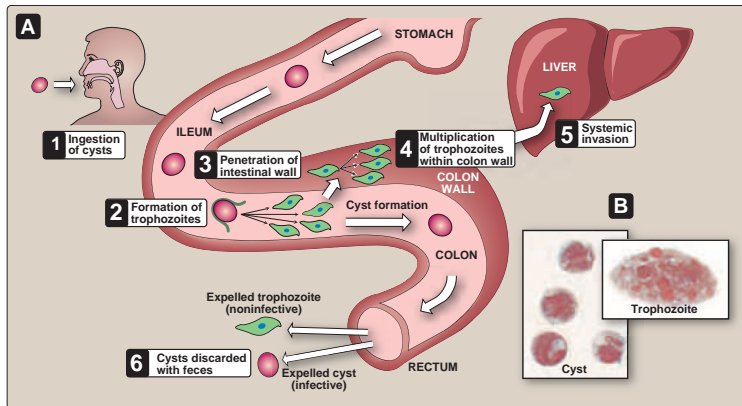
The **cyst** form is infectious.



The pathogen is an ameba, as can be seen in the **trophozoite** form. Amebas move by extending cytoplasmic projections.



The patient most likely has **amebic dysentery** caused by *Entamoeba histolytica*.



A. Life cycle of *Entamoeba histolytica*. **B.** Photomicrographs of trophozoite and cyst forms.



If the pathogen shown has two nuclei (resembling eyes) and four flagella, what category of protozoan is it?



What type of motility is accomplished by this pathogen?



Following a backpacking trip, a 25-year-old female visits her primary care physician complaining of loose stools that “float,” flatulence, and abdominal cramps. The woman concedes that she drank untreated lake water approximately 1 week previous to the onset of symptoms. An ELISA test was positive for a protozoal pathogen. Trophozoites similar to that shown were detected in a stool specimen. What is the most likely etiology and infection?





With two nuclei and four flagella, the pathogen would be a **flagellate protozoan**.



Flagellates move by rotating whiplike flagella.



The patient most likely has **giardiasis** caused by *Giardia lamblia*.



Giardia lamblia trophozoite in stool sample.



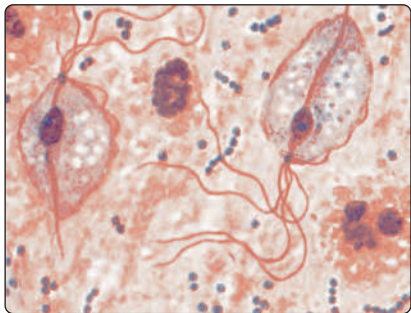
Based on the morphology shown, what category of protozoan is this pathogen?



How is this protozoal pathogen transmitted to humans?



A 19-year-old, sexually active female visits an STD clinic complaining of vaginal itching and a heavy, foul-smelling discharge. A vaginal discharge specimen was collected and examined microscopically, revealing motile organisms resembling those shown, with one nucleus and five flagella. What is the most likely etiology and infection?





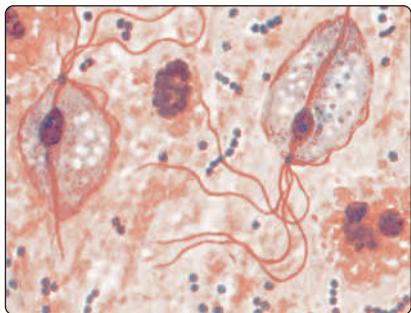
This pathogen is a **flagellate protozoan**.



This pathogen is transmitted to humans via sexual contact. It lacks a cyst form and an environmental reservoir.



The patient most likely has **trichomoniasis** caused by ***Trichomonas vaginalis***.



Trichomonas vaginalis.



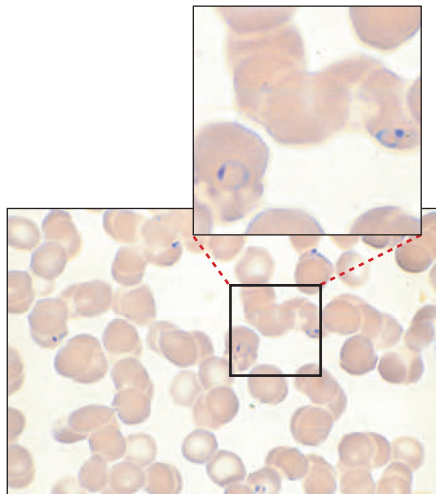
How is the infectious agent shown, which replicates inside of red blood cells, transmitted to humans?



What organ does the pathogen preferentially infect in humans?



A 20-year-old student returned from a trip to Haiti feeling as though she had the flu. However, the symptoms rapidly progressed over the next few days, finally resulting in periodic high fever, chills, and fatigue. Upon examination, the patient is jaundiced and suffering from hepatosplenomegaly. A blood specimen is collected and stained, revealing ring structures within RBCs, as shown. What is the most likely etiology and infection?





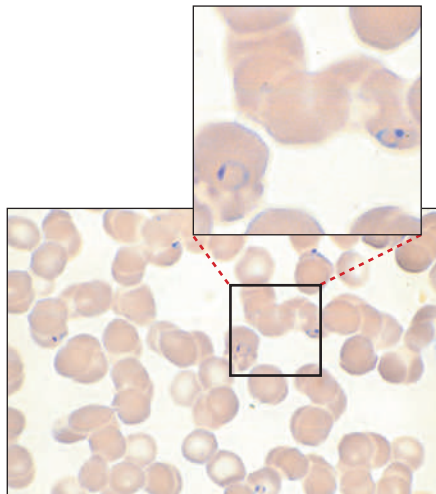
The agent is transmitted to humans by the bite of an *Anopheles* mosquito or by injection of contaminated blood products.



It infects the liver preferentially.



The patient most likely has **malaria** caused by *Plasmodium* species (*Plasmodium falciparum* is shown).



Ring form of *Plasmodium falciparum* in red blood cell.



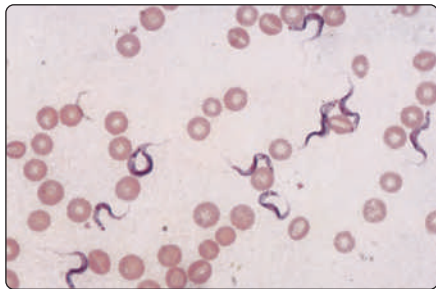
If the parasite shown was acquired in Africa, what is the most likely means by which the pathogen was transmitted?



What organ system is preferentially invaded subsequent to extracellular reproduction of this protozoan pathogen in the bloodstream?



A 29-year-old male living in Maryland visits his primary care physician complaining of fatigue and somnolence (inability to stay awake). The man reports that prior to the fatigue, he suffered from fever, headache, and swollen lymph nodes. Upon further questioning, the patient indicates that he had recently returned from a safari in East Africa. The physician collects blood and CSF samples for staining. The CSF sample was positive, and the stained blood sample resembles that shown. What is the most likely etiology and infection?





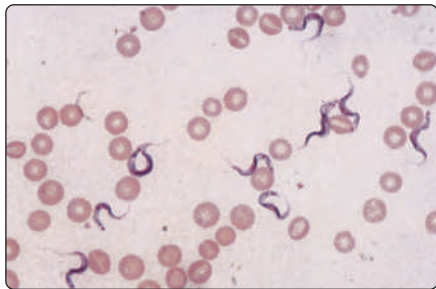
The parasite was most likely transmitted by the bite of a **tsetse fly**.



The pathogen preferentially invades the CNS, leading to the characteristic symptoms of African "**sleeping sickness**."



The patient most likely has **African trypanosomiasis** caused by ***Trypanosoma brucei*** (likely subspecies *rhodesiense*, which is the predominant trypanosome in East Africa).



Trypanosoma brucei.



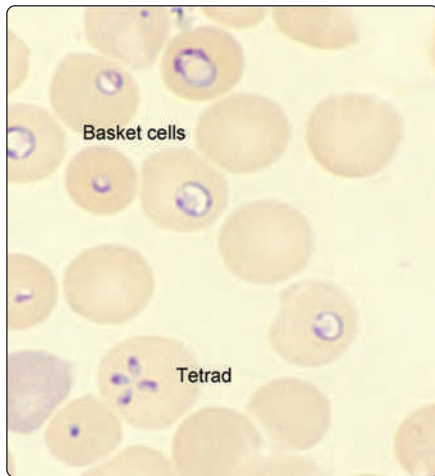
What are the two most likely protozoal pathogens to cause the ringlike structures shown?



How are these two protozoal pathogens transmitted to humans?



An avid outdoorsman who lives in Connecticut reports to his physician that he thinks he has the flu. He has fever, chills, sweats, headache, and nausea. Upon questioning, the patient indicates that he had recently returned from a camping trip during which time he noticed and removed a tick from his abdomen. The tick bite showed no signs of infection or inflammation. The doctor collected blood specimens for staining, revealing the ring structures within RBCs, as shown. What is the most likely etiology and infection?





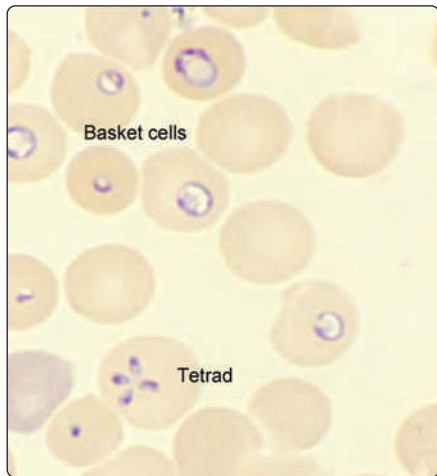
Plasmodium and ***Babesia*** would most likely cause the ringlike structures.



The agents are transmitted to humans by the bite of an *Anopheles* mosquito and an *Ixodes* tick, respectively.



The patient most likely has **babesiosis** caused by ***Babesia microti***.



Wright-stained peripheral blood smear from child with *Babesia microti* infection.



If the lesion shown is caused by a protozoan pathogen that was acquired in Central America, what is its most likely mode of transmission to humans?



What cell type does this protozoan pathogen preferentially infect and replicate within?



A man from Guatemala goes to a local clinic complaining of an ulcer on his left hand (as shown). The edges of the ulcer are raised but not particularly painful. The ulcer started as a small papule but then spread into the large ulcerated region shown. Material from the ulcer was collected for staining. Nonflagellated amastigotes were detected in the tissue specimen. What is the most likely etiology and infection?





The bite of an infected **sand fly** is its most likely mode of transmission to humans.



This protozoan pathogen preferentially infects and replicates within macrophages.



The patient most likely has **cutaneous leishmaniasis** caused by ***Leishmania mexicana*** (based upon the residence of the patient).



Skin ulcer due to leishmaniasis.



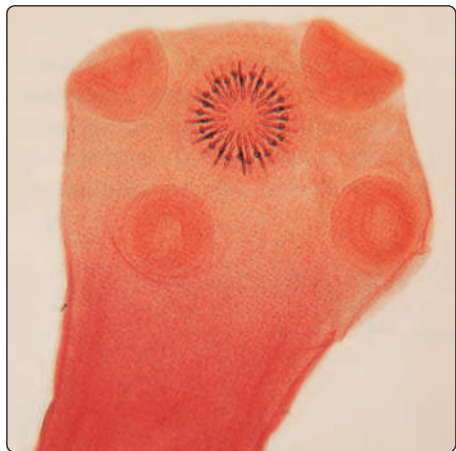
What is the purpose of the structure on the helminth shown?



If this pathogen was acquired from a pig, what is the most likely mechanism of transmission to humans?



A middle-aged man visits his primary care physician with complaints of abdominal pain, loss of appetite, and weight loss. The patient has no house pets but is a pig farmer. The physician collects a fecal specimen and identifies small, white, rectangular segments. In addition, eggs were detected by microscopy. What is the most likely etiology and infection?





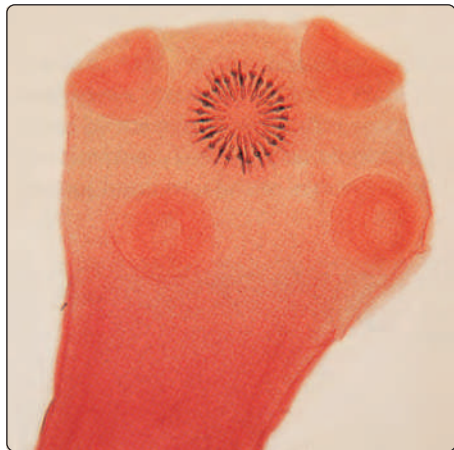
This structure, the scolex, allows the helminth to attach to the host's small intestine.



The most likely mechanism of transmission to humans is via ingestion of larvae by consuming undercooked pork or ingestion of eggs from pig feces.



The patient most likely has **taeniasis** caused by *Taenia solium*.



The scolex of *Taenia solium* has four suckers and a rostellum with hooks for attachment.



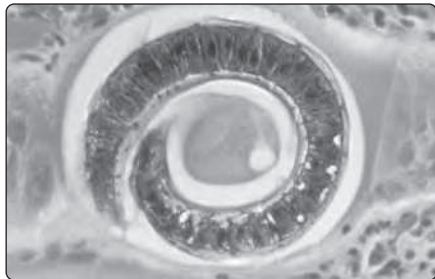
What type of helminth is shown?



If the image represents a coiled larval form of the pathogen in human muscle tissue, what is the most likely mode of transmission to humans?



A middle-aged pig farmer visits his primary care physician with complaints of abdominal pain and diarrhea. These initial symptoms were followed by muscle aches. The physician conducts a muscle biopsy in the painful area, which reveals coiled larvae similar to that shown. What is the most likely etiology and infection?





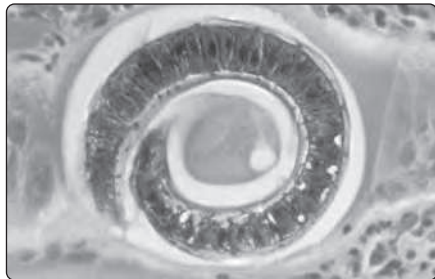
A roundworm or nematode is shown.



The most likely mode of transmission to humans is via ingestion of **larvae** in undercooked pork muscle.



The patient most likely has **trichinosis** caused by ***Trichinella spiralis***.



Coiled larva of *Trichinella spiralis* in skeletal muscle.



Based on the clinical presentation shown, what diagnostic tool should be used?



Based on the clinical presentation shown, what is the most likely mechanism of transmission?



A mother brings her 5-year-old child to the pediatrician because he is irritable and fidgety. The child complains of itching around his anus, particularly at night. The doctor examines the child and finds the helminths shown in the perianal region. He confirms his diagnosis by identifying the pathogen's eggs, also in the perianal region. What is the most likely etiology and infection?





The “scotch tape” technique to detect eggs in the perianal region should be used for diagnosis.



Fecal–oral transmission of the eggs is the most likely mechanism of transmission. Humans are the only host.



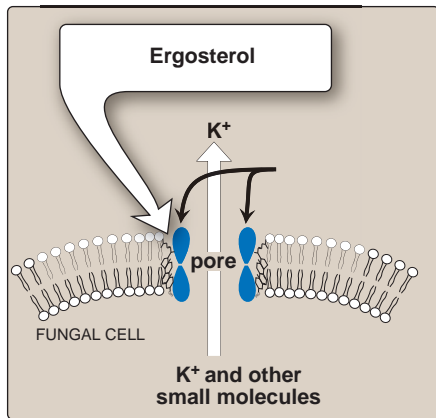
The patient most likely has **enterobiasis (pinworm disease)** caused by ***Enterobius vermicularis***.



Pinworms leaving the anus of a 5-year-old child.

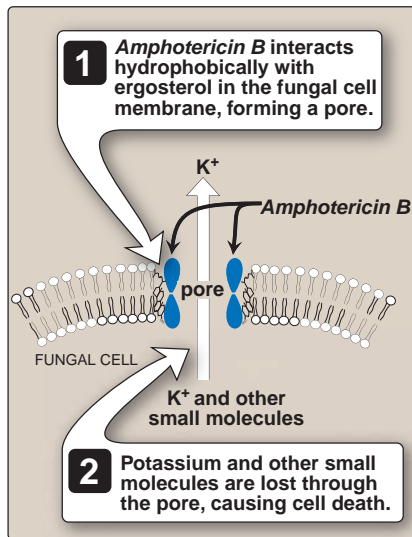


What antifungal agents act via the mechanism shown (*black arrows*)?





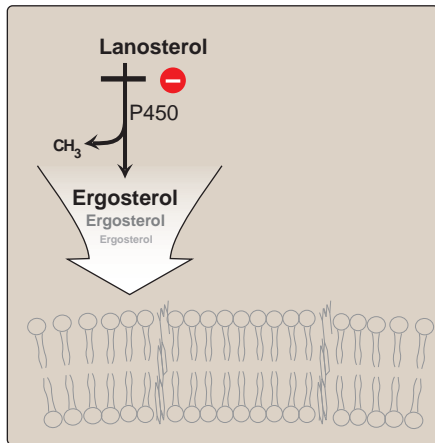
Antifungals **amphotericin B** and **nystatin** act as shown.



Pore formed by amphotericin B in the lipid bilayer membrane. Adapted from *LIR Pharmacology, Fifth Edition*.

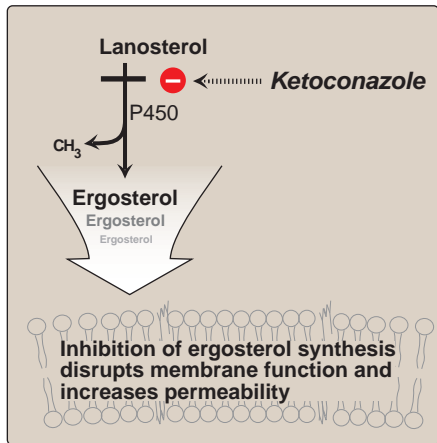


What antifungal agents act via the mechanism shown?





The **imidazole** and **triazole** antifungal agents including ketoconazole and fluconazole act as shown.



Mode of action of ketoconazole. Adapted from *LIR Pharmacology, Fifth Edition*.



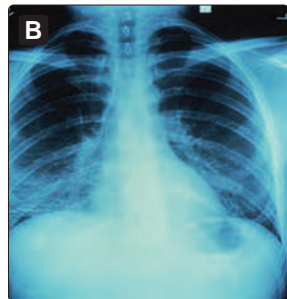
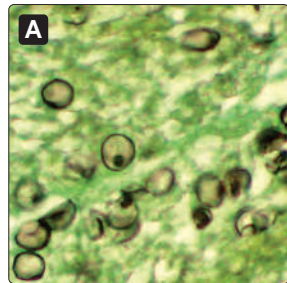
What type of microorganism displays the morphology shown (**panel A**) and causes pneumonia (**panel B**) especially in patients who are immunocompromised (e.g., those with AIDS)?



What membrane component, typical of this type of microorganism, is absent in the pathogen shown?



What is the recommended therapy for the disease caused by this pathogen?





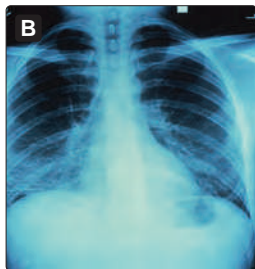
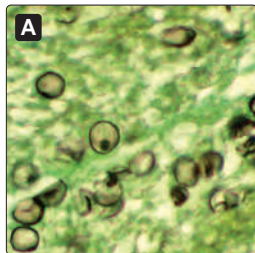
A yeastlike fungus (*Pneumocystis jiroveci*) is shown and causes pneumonia, especially in patients who are immunocompromised.






Ergosterol, which is typically found in fungal membranes, is absent from this pathogen.



Trimethoprim-sulfamethoxazole (Bactrim) is recommended to treat and prevent this disease.






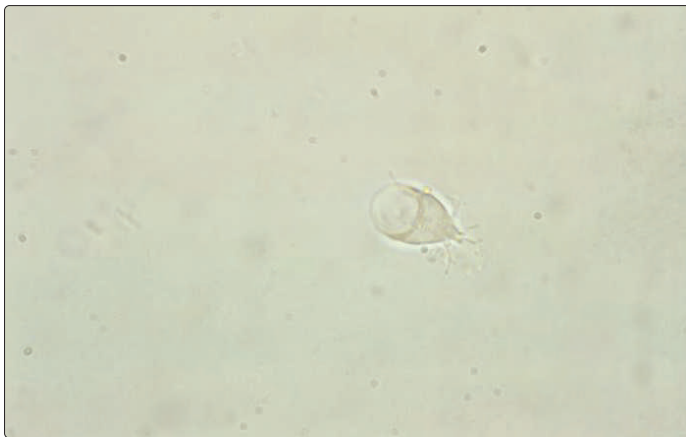
A. Silver stain of *Pneumocystis jiroveci* cysts in tissue from an AIDS patient. **B.** *Pneumocystis* pneumonia.

-  If the protozoan pathogen shown has two nuclei and four flagella, what is the means of transmission to humans?
-  What part of the body is preferentially inhabited by the parasite shown?
-  What is the recommended therapy for the disease caused by this pathogen?





-  Human infection with *Giardia lamblia* starts by ingestion of cysts from contaminated water sources.
-  The duodenum is preferred by this parasite, which means that the trophozoites may not be obvious in stool specimens.
-  **Metronidazole** is recommended to treat this disease.



Giardia lamblia trophozoite. From *Public Health Image Library*.



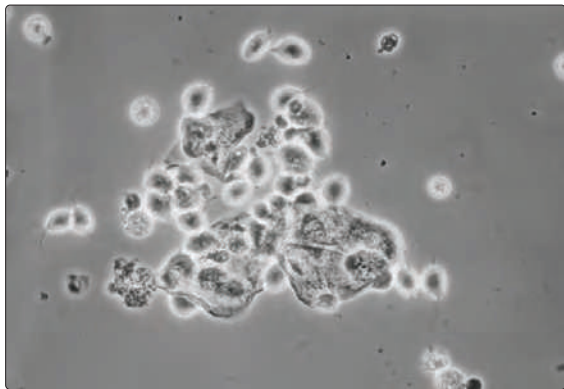
If the specimen shown represents a wet mount of a vaginal discharge specimen, what type of motile, protozoan pathogen is responsible for the infection?



What conditions in the female genital tract favor disease caused by this protozoan pathogen?



What is the recommended therapy for the disease caused by this pathogen?





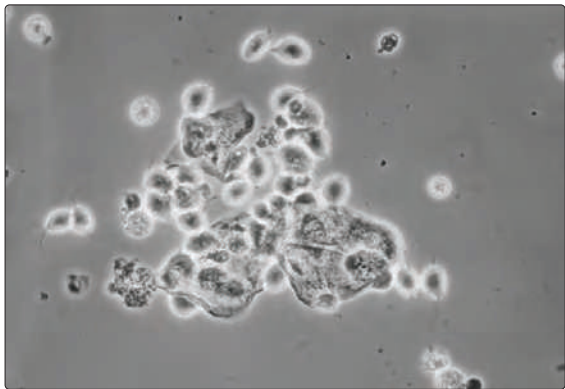
A flagellate (*Trichomonas vaginalis*) is responsible for the infection.



A higher-than-normal pH favors disease onset because *T. vaginalis* preferentially grows at pH 6.0.



Metronidazole is recommended to treat this disease.



Trichomonas vaginalis. From Public Health Image Library.



The ring-form trophozoites shown are detected by Giemsa staining of peripheral blood smears. How is infection by the protozoan shown transmitted to humans?

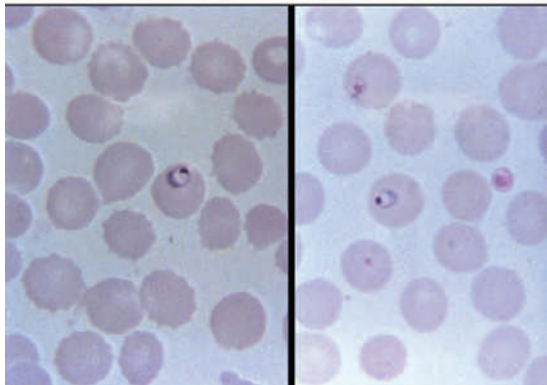


Where are the trophozoite forms of the pathogen located within the human host?



Some species of the pathogen shown must be treated with two different antiparasitic drugs: chloroquine and primaquine. Patients treated with primaquine must be tested for deficiency in what enzyme to avoid development of hemolytic anemia?

Ring-form Trophozoites





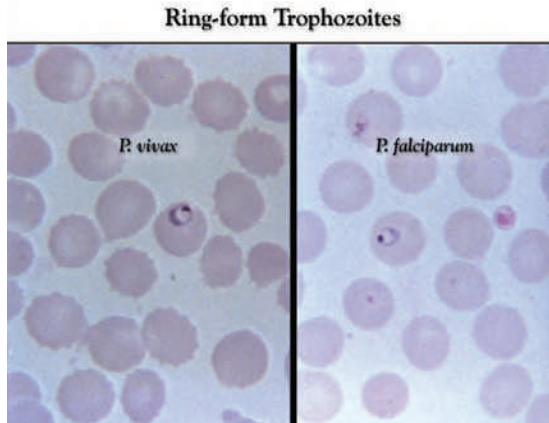
Plasmodium species are transmitted to humans by mosquito bite.



Trophozoites replicate inside RBCs and produce more merozoites.



Patients treated with primaquine must also be tested for glucose 6-phosphate dehydrogenase deficiency to prevent hemolytic anemia.



Plasmodium species. From *Public Health Image Library*.



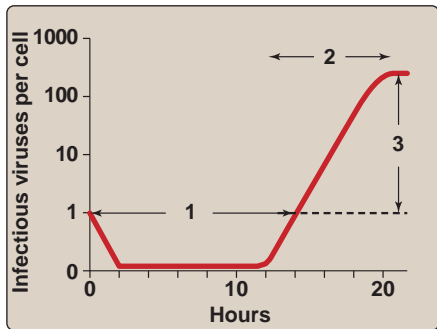
What does 1 represent in the one-step viral growth curve shown?
What occurs during this time?



What does 2 represent in the one-step viral growth curve shown?
What occurs during this time?



What does 3 represent in the image?





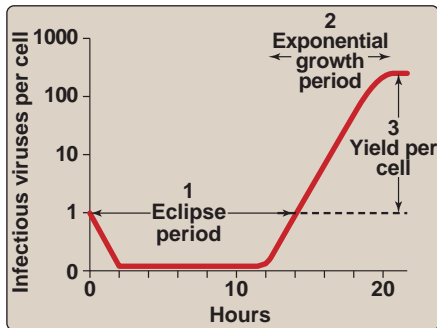
The **eclipse period** is represented (1), which is when viral component synthesis occurs.



The **exponential growth period** is represented (2), which is when virus progeny is produced.



The number of virus progeny per cell is represented (3).



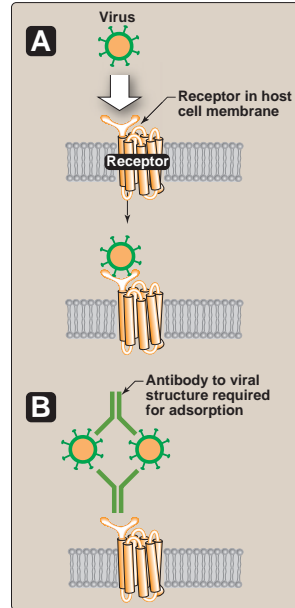
One step growth curve of a single cell infected with a single virus particle.



What process is represented in **panel A** in the image?



What process is represented in **panel B** in the image?

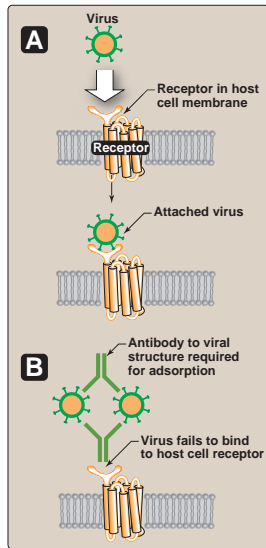




Viral **adsorption** (or attachment) is shown.



Viral **neutralization** is shown.



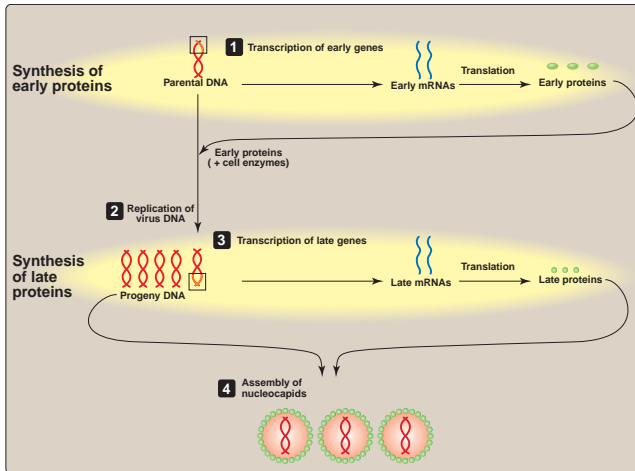
A. Attachment of virus to receptor on host cell membrane. **B.** Antibody prevents adsorption of virus resulting in neutralization.



What temporally distinguishes late mRNAs from early mRNAs in DNA virus replication cycles?



Where does DNA virus replication generally occur? What DNA virus is an exception to this rule?

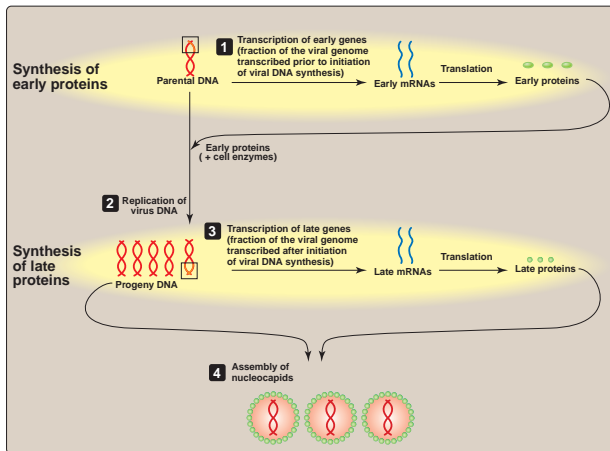




Late mRNAs are synthesized after genome replication and generally encode structural proteins, whereas early mRNAs are synthesized before genome replication and generally encode enzymes necessary for genome synthesis.



Most DNA viruses replicate and assemble in the nucleus, with the exception of **poxviruses**, which replicate entirely in the cytoplasm.



Replication of DNA viruses.



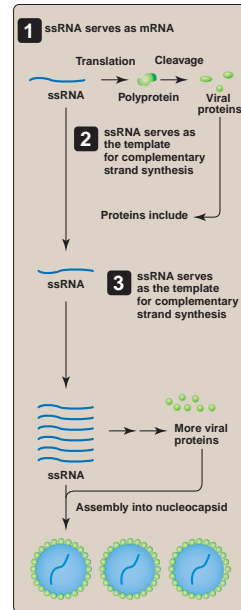
The replication cycle shown is from an RNA virus. What is the polarity of the RNA that is replicated in this fashion?



What virally encoded enzyme is needed to accomplish this replication cycle?



Why do RNA viruses of the polarity shown typically translate **polyproteins**, which are subsequently cleaved into individual proteins?





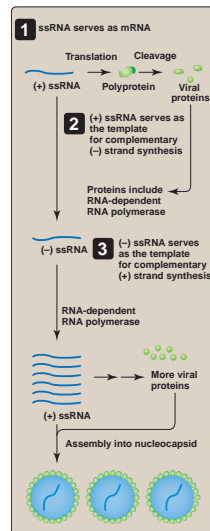
The replication cycle shown is for a positive (+) polarity, single-stranded RNA virus.



An **RNA-dependent RNA polymerase** is needed to accomplish this replication cycle.



The positive-polarity mRNA must encode several proteins, but eukaryotic mRNAs strictly encode a single protein. Generating polyproteins that are subsequently cleaved into smaller products overcomes this restriction.



ssRNA genome of (+) polarity replicates via a complementary (-) strand intermediate.



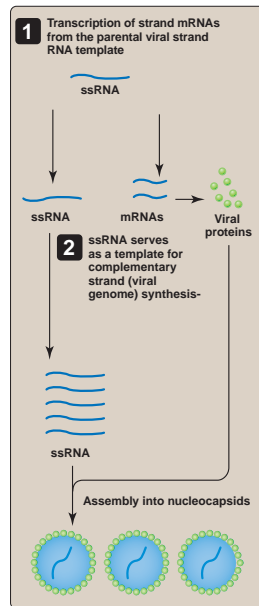
The replication cycle shown is from an RNA virus. What is the polarity of the RNA that is replicated in this fashion?



What virus-specific polymerase is necessary to accomplish this replication cycle, and what is unique about this enzyme's required localization?



Where within the host cell does this replication cycle take place?





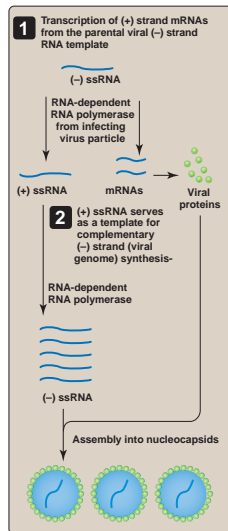
The replication cycle shown is for a negative (–) polarity, single-stranded RNA virus.



An **RNA-dependent RNA polymerase** is necessary to create a positive-stranded mRNA from the negative-strand genome. This enzyme is also required to generate new progeny genomes from positive-polarity mRNA. Because the host cell does not have an enzyme capable of generating positive-polarity mRNA from a negative-polarity template, this type of RNA virus must package and bring this viral enzyme into the host cell along with the genome.



The replication cycle takes place within the host cell cytoplasm.



ssRNA genome of (–) polarity replicates via a complementary (+) strand intermediate.



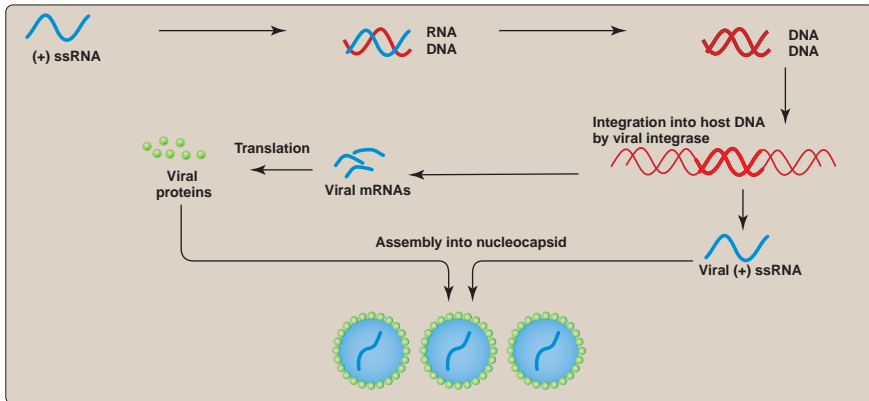
What type of virus replicates as shown?



What type of polymerases are required to complete this replication cycle?



Where within the host cell does this replication cycle take place?





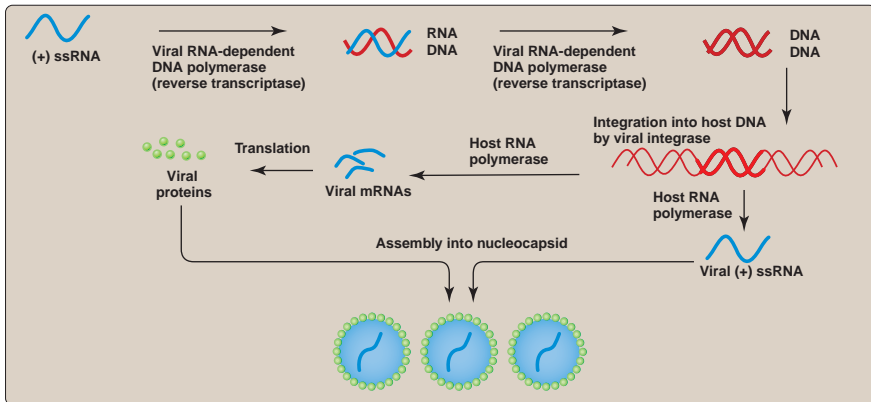
Retroviruses replicate as shown.



A virus-carried **RNA-dependent DNA polymerase (reverse transcriptase)** and the host's DNA-dependent RNA polymerase are required to complete this replication cycle.



Replication occurs in both the host cell cytoplasm and nucleus.



ssRNA genome of (+) polarity replicates via a DNA intermediate.



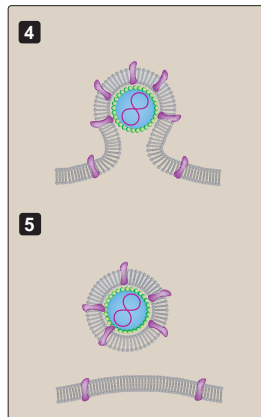
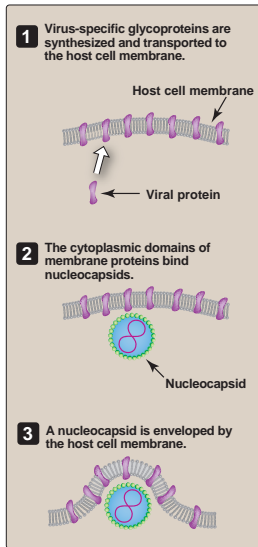
What process is shown?



Does release of progeny virus by this mechanism require host cell lysis? Why or why not?



Are viruses produced by the process shown sensitive or resistant to detergents, organic solvents, and harsh environmental conditions?





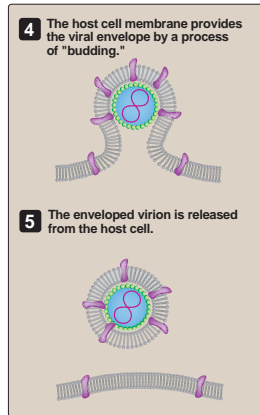
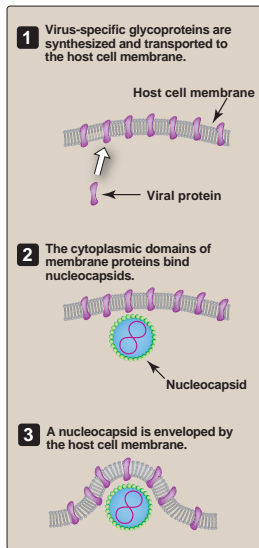
Budding of an enveloped virus is shown.



This process does not require host cell lysis because progeny virus is continuously released as long as the host cell membrane is intact.



Enveloped viruses produced by the process shown are more sensitive to environmental conditions and are generally transmitted by respiratory, parenteral, or sexual routes. [Note: Nonenveloped viruses are more stable to environmental conditions and are often transmitted via the fecal–oral route.]



Release of enveloped virus from a host cell by the process of "budding."



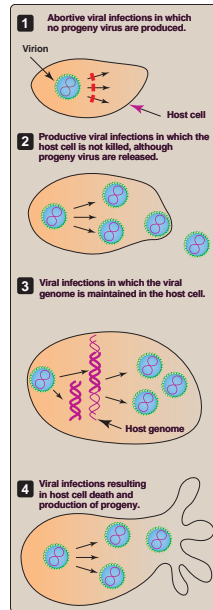
What type of infection is caused by the viral replication process shown in part 2?



What type of infection is caused by the viral replication process shown in part 3?



What type of infection is caused by the viral replication process shown in part 4?





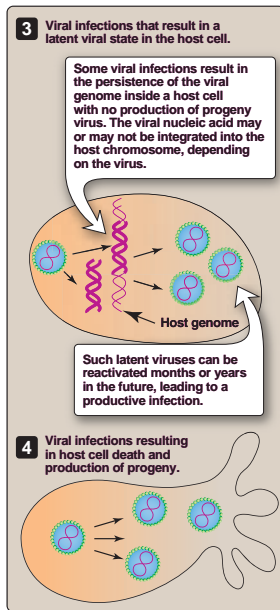
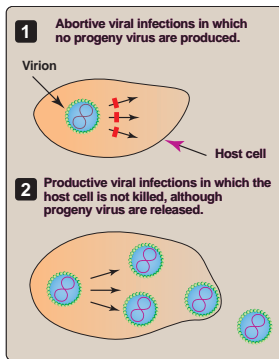
A **persistent infection** occurs when viral replication does not interfere with host cell viability or functions.



A **latent infection** occurs when the viral genome is maintained by the infected cell but most of the viral proteins are not produced. [Note: The latent viral genome can be reactivated later, leading to a productive infection.]



A **lytic infection** is caused by viral replication that results in host cell lysis or death (e.g., when the virus shuts down host cell macromolecular machinery).



Effects of viral infection of a host cell.



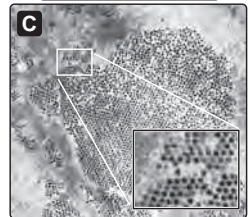
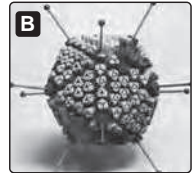
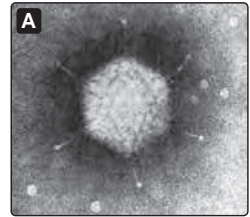
What type of capsid is shown?



The family of virus that demonstrates this morphology has what type of genetic material?



A 7-year-old boy is seen by his pediatrician for an upper respiratory tract infection. The child presents with fever, cough, sore throat, and nasal congestion. In addition, he has conjunctivitis of his right eye. The pediatrician has seen several children from the same grade school class with similar symptoms. The doctor suspects infection by the virus shown, so she informs the child's mother that there is no treatment for this illness. She recommends rest and keeping the child out of school until symptoms resolve. What is the most likely etiology and infection?





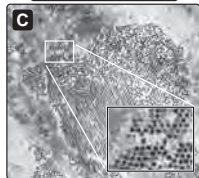
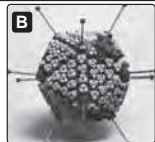
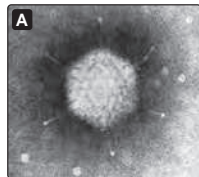
An icosahedral capsid is shown.



This virus family has double-stranded DNA.



The patient most likely has **pharyngoconjunctival fever** caused by an **adenovirus**.



A. Electron micrograph of an adenovirus virion with fibers. **B.** Model of adenovirus. **C.** Crystalline aggregates of adenovirus in the nucleus of a cell.



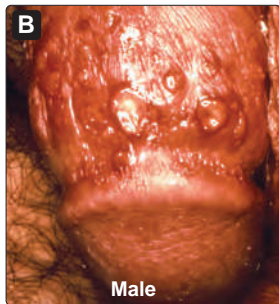
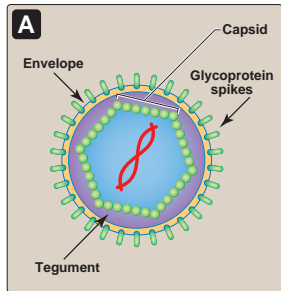
What type of virus has the morphology shown (**panel A**)?



The family of virus that demonstrates this morphology has what type of genetic material?



A 20-year-old male presents at an STD clinic with lesions similar to those shown (**panel B**). He is also suffering from fever, malaise, and myalgias. The doctor suspects the patient is infected with a virus with the morphology shown and prescribes acyclovir. What is the most likely etiology and infection?





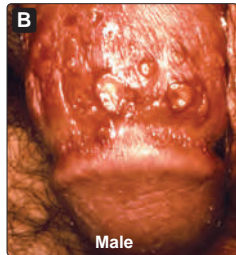
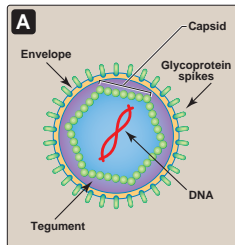
Herpesvirus has the morphology shown.



This virus family has double-stranded DNA.



The patient most likely has **genital herpes** caused by **herpes simplex virus type 2 (HSV-2)**.



Herpesvirus. **A.** Schematic drawing of the structure. **B.** Genital herpes simplex infections.



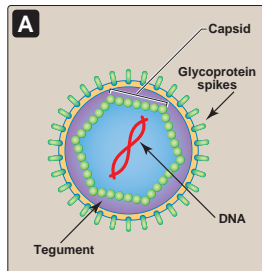
What type of capsid is characteristic of the virus shown (**panel A**)?



Is this type of virus likely to be sensitive to detergents and organic solvents? Why or why not?



A child is brought to the pediatrician by her mother due to a rash similar to that shown (**panel B**). Prior to the onset of the rash, the child suffered from fever, malaise, and headache. The doctor suspects the patient is infected with the virus shown. What is the most likely etiology and infection?





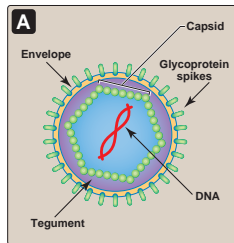
An icosahedral capsid would be characteristic of this virus.



Because the virus is enveloped, it is sensitive to agents that dissolve or disrupt this outer layer.



The patient most likely has **chickenpox (varicella)** caused by **varicella-zoster virus**.



Herpesvirus. **A.** Schematic drawing of the structure.
B. Chickenpox.



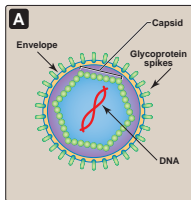
What material exists between the envelope and the capsid proteins (**panel A**)?
Of what is it composed?



Where does viral replication and assembly occur inside of host cells for this class of viruses?



A 68-year-old woman presents at her primary care physician's office with the rash shown (**panel B**). The rash represents a cluster of vesicular lesions along a single dermatome (affecting the skin supplied by cutaneous branches from a single spinal nerve). The patient indicates that she is experiencing a burning pain in the area of the rash. The physician suspects that the woman is experiencing a reactivation of a latent form of the virus shown. What is the most likely etiology and infection?



B Vesicles erupt on an erythematous base and eventually dry and scab. The vesicles appear in regions supplied by the peripheral sensory nerves arising in latently infected root ganglia.



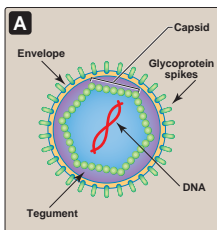
The **tegument** exists between the envelope and the capsid proteins and consists of virus-encoded enzymes and transcription factors essential for initiation of the infectious cycle.



Viral replication and assembly occurs inside the host cell nucleus. mRNAs must be exported into the cytoplasm for transcription, but viral proteins are imported back into the nucleus for assembly into progeny virus.



The patient most likely has **herpes zoster (shingles)** caused by reactivated **varicella-zoster virus (VZV)**.



Herpesvirus. **A.** Schematic drawing of the structure.
B. Cutaneous manifestations of acute herpes zoster.

B

Vesicles erupt on an erythematous base and eventually dry and scab. The vesicles appear in regions supplied by the peripheral sensory nerves arising in latently infected root ganglia.





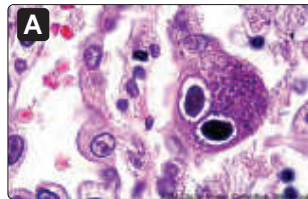
The cells shown demonstrate an “owl eye” appearance (**panel A**) due to what process?



By what mechanism was the disease transmitted to the neonate shown?



Immediately after birth, the delivering obstetrician noted the distinctive rash and extended abdomen of the neonate, as shown (**panel B**). The physician recognizes that the hepatosplenomegaly and rash resulted from replication of the virus shown and notifies the parents that, if confirmed, the child will be severely impaired, probably including mental retardation, blindness, and deafness. What is the most likely etiology and infection?





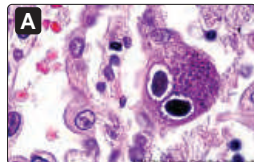
The owl-eye appearance is due to viral replication in the nucleus, resulting in nuclear inclusions.



The virus can be passed from pregnant woman to child in utero. The mother was probably newly infected with the virus during pregnancy.



The patient most likely has **congenital cytomegalovirus disease** caused by **human cytomegalovirus (HCMV)**.



A. Cytomegalovirus infection in a lung section showing typical owl-eye inclusions. **B.** Newborn with congenital cytomegalovirus disease showing hepatosplenomegaly and rash.



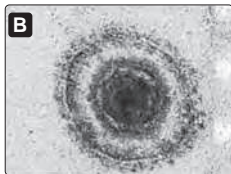
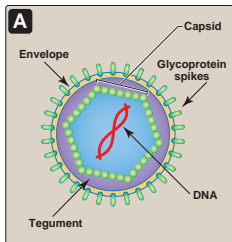
When a peripheral blood smear shows atypical, pleomorphic lymphocytes with prominent nucleoli, the patient is expected to be infected with the type of virus shown (**panels A and B**). What is the site of latency for this virus?



Why do patients suffering from this disease produce heterophile antibodies, which are detected by a diagnostic test that demonstrates RBC agglutination?



A 17-year-old girl visits her primary care physician complaining of fever, sore throat, and extreme exhaustion. Anterior and posterior cervical lymph nodes are enlarged. The physician notes modest splenomegaly and orders a heterophile test and an examination of a peripheral blood smear. The heterophile (monospot) test is positive, and the peripheral blood smear demonstrates many abnormal mononuclear cells. What is the most likely etiology and infection?





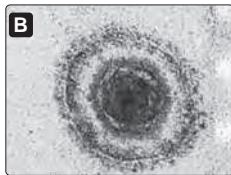
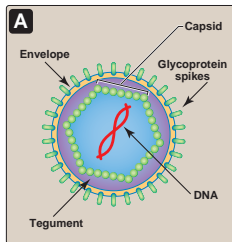
The site of latency for this virus is B lymphocytes. When a patient is infected with this virus, a peripheral blood smear usually shows atypical, pleomorphic mononuclear cells, which are actually **cytotoxic T cells**, and an indicator of infection with a type of herpesvirus that is latent in **B lymphocytes**.



This virus infects B lymphocytes, causing them to proliferate. The overproduced B cells secrete nonspecific immunoglobulin molecules (IgG, IgM, and IgA). These antibodies (called **heterophile**) agglutinate sheep and horse RBCs, resulting in a positive test.



The patient most likely has **infectious mononucleosis** caused by **Epstein-Barr virus (EBV)**.



Structure of herpesvirus.

A. Schematic drawing.

B. Transmission electron micrograph.



The image is of an infection that no longer circulates in the human population but is a concern as the pathogen that causes it could be used as a potential biological weapon. What is the mechanism by which this viral infection could be spread to humans in the event of a bioterrorism attack?



What unique aspect of viral replication allows diagnosis by identification of cytoplasmic inclusions inside of cells scraped from skin lesions?



In a small town in Somalia, many of the residents are stricken with a rash, which was preceded by fever and muscle aches. The rash, which resembles that shown, progressed from vesicles to papules to pustules and eventually scabbed over. Many of the infected residents died. Lesions from the rash were highly infectious and were characterized by the presence of intracytoplasmic inclusion bodies. What is the most likely etiology and infection?



From *Public Health Image Library*.



The virus could be aerosolized, and human infection would result from inhalation. The virus would first infect the upper respiratory tract, with subsequent spread to the regional lymph nodes, skin and blood vessels.



Although the genome is double-stranded DNA, this type of virus replicates exclusively in the cytoplasm, forming inclusion bodies. This virus is capable of cytoplasmic replication because it carries all of the necessary enzymes for replication and gene expression, including a **DNA-dependent RNA polymerase**.



The residents most likely had **smallpox** caused by the **variola virus**. This disease has been eradicated from the human population, but the scenario described is consistent with a bioterrorism event.



Smallpox infection. From *Public Health Image Library*.



The type of virus responsible for the infection shown has what type of genomic material?



Is this type of virus likely to be sensitive to detergents and organic solvents? Why or why not?



A 19-year-old sexually active woman visits her gynecologist for her yearly exam and Pap smear. The doctor notices anogenital warts, similar to those shown (**panel C**), during the exam. The patient was counseled on safe sex practices and the warts removed by laser vaporization. What is the most likely etiology and infection? What is a possible sequela of this infection?





This type of virus has double-stranded DNA.



Because the virus is not enveloped, it is resistant to agents that dissolve or disrupt this outer layer.



The patient most likely has **genital warts** caused by **human papillomavirus (HPV)**. Some strains of HPV can cause cervical cancer.



Warts caused by papillomavirus.



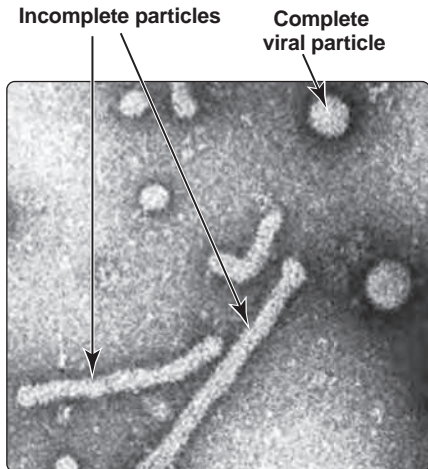
What protein coats the complete viral or Dane particle (shown) and is also the sole component of the incomplete particles (shown)?



What is the route of transmission of this virus to humans?



A 25-year-old man presents to his physician with nausea, weight loss, malaise, jaundice, and right upper quadrant pain. He fell ill a few months following a return from Thailand, where he spent several months. During this time, he received several extensive tattoos. The physician orders a battery of blood tests including liver enzyme levels and viral antigen tests. Liver enzymes are elevated, and IgM antibodies against viral antigens were detected. What is the most likely etiology and infection?





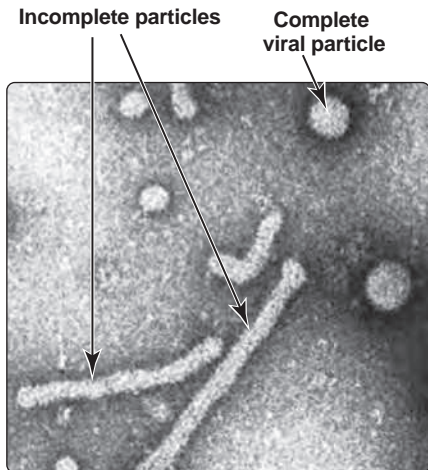
The **surface antigen, or HBsAg**, coats the complete viral particle and is also the sole component of the incomplete particles.



This virus can be transmitted to humans via contact with blood products or sexual contact. Getting tatoos outside of the US is also a risk factor.



The patient most likely has **acute hepatitis** caused by **hepatitis B virus**.



Electron micrograph of hepatitis B virus.



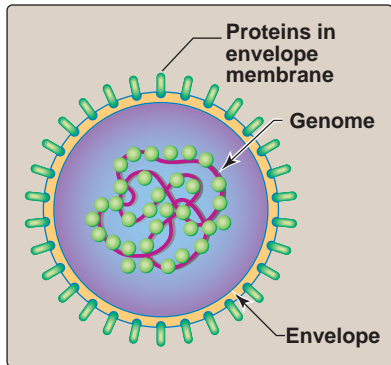
If the virus shown has delta antigen complexed with its genome, what type of surface antigen is found in the envelope?



What type of genome is typical of the type virus shown?



A 25-year-old IV drug user presents at the emergency department with nausea, vomiting, fever, and jaundice. The patient's liver is enlarged and tender. Blood tests demonstrate elevated liver enzymes, antibodies against viral antigens, and the presence of two types of viral antigens. What is the most likely etiology and infection?





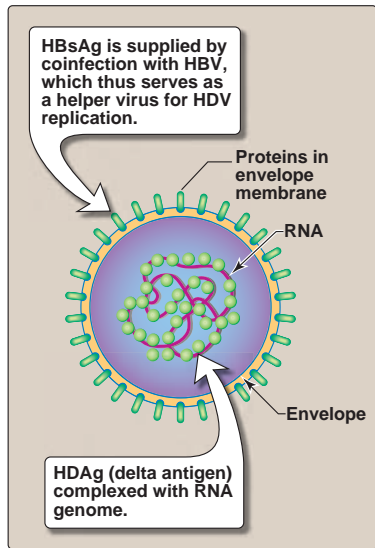
HBsAg is supplied by a coinfecting virus. The virus that produces delta antigen is incapable of productive infection alone.



The virus has single-stranded RNA with negative polarity.



The patient most likely has **acute hepatitis** caused by coinfection with both **hepatitis B** and **D viruses**.



Structure of hepatitis D virus.
HBsAg = hepatitis B surface antigen.



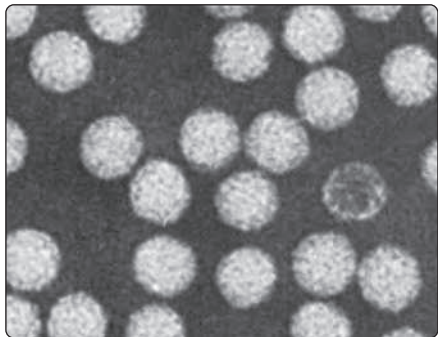
If the virus shown is a picornavirus, what type of genome does it have?



The virus is an example of an enterovirus, which is spread to humans via GI tract infection. What other body system can be infected by this group of viruses?



A young girl in Afghanistan complains of fever, fatigue, nausea, headache, and flulike symptoms. In addition, her back and neck are stiff, and she has pain and asymptomatic weakness in her limbs. The physician suspects she is infected with the virus shown, which is preventable by vaccination. What is the most likely etiology and infection?





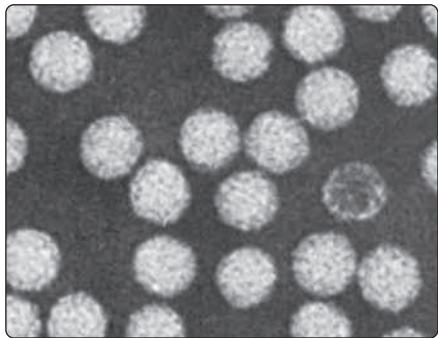
If the virus is a picornavirus, it has single-stranded RNA, positive strand, and nonsegmented.



The CNS can also be infected by enteroviruses.



The patient most likely has **poliomyelitis** caused by **poliovirus**.



Poliovirus.



If the virus shown is a picornavirus, what type of capsid does it have?



Is this type of virus likely to be sensitive to detergents and organic solvents? Why or why not?



A 30-year-old male presents at his primary care physician's office with jaundice and upper quadrant pain. Preceding onset of these symptoms, the patient had suffered from fever, nausea, myalgia, and headache. The patient had recently returned from an extensive trip throughout Southeast Asia, and he had not been vaccinated against endemic infections prior to travel. The physician confirms her suspicions by conducting liver enzyme and serum IgM tests. AST and ALT levels were elevated; IgM specific for the virus shown was detectable. The physician informs the patient that vaccination would have prevented this food-borne infection, but that the prognosis for his recovery was good. What is the most likely etiology and infection?





Picornaviruses have icosahedral capsids.



This virus is not sensitive to detergents and organic solvents because it is nonenveloped.



The patient most likely has **hepatitis** caused by **hepatitis A virus**.



Electron micrograph of hepatitis A virus. From *Public Health Image Library*.



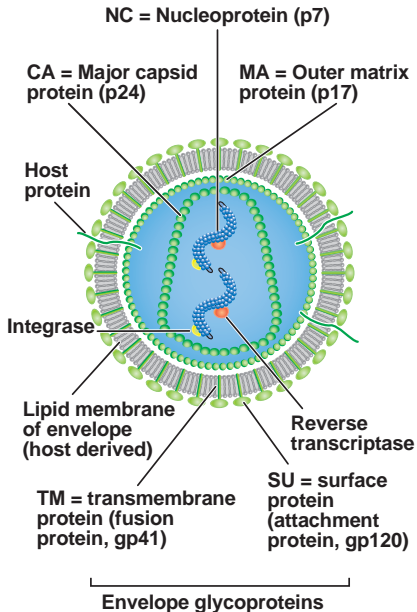
What type of virus is shown?



What type of genome is characteristic of this type of virus?



A 27-year-old male presents to his physician's office complaining of swollen lymph nodes, diarrhea, chronic fevers, night sweats, and weight loss. He has oral ulcers and a white coating on his tongue. Upon questioning, the patient confides that he is sexually active with both male and female partners. The physician diagnoses the patient with oral herpes and candidiasis but suggests further tests including a WBC count. The patient's CD4+ T-cell count was 500 cells/ μ l. What is the most likely etiology and underlying infection?





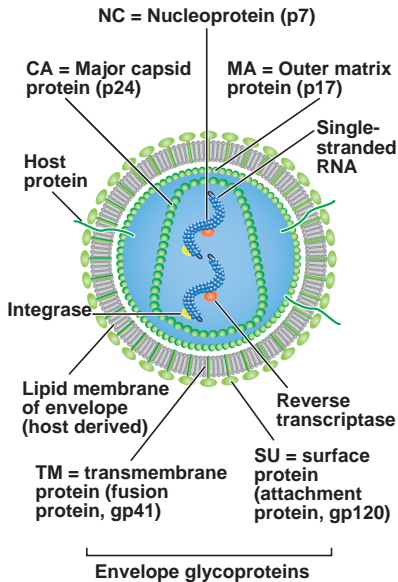
A retrovirus is shown (note the presence of **reverse transcriptase**).



This type of virus typically has two copies (diploid) of single-stranded RNA, positive strand.



The patient most likely has **early-stage AIDS** caused by **HIV**.



Structure of HIV.



The virus shown is a rhabdovirus that infects humans. What type of genome does this virus contain?



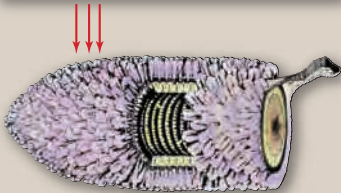
What type of capsid does the virus shown have?



A veterinarian was bitten by a feral dog. The dog subsequently died, but the veterinarian was protected from contracting the disease by a vaccine given prophylactically to people at risk. What is the composition of the protective vaccine?

A

Surface glycoproteins (G proteins) extending from the lipid envelope. The G protein is antigenic, resulting in host production of neutralizing antibodies.

**B**



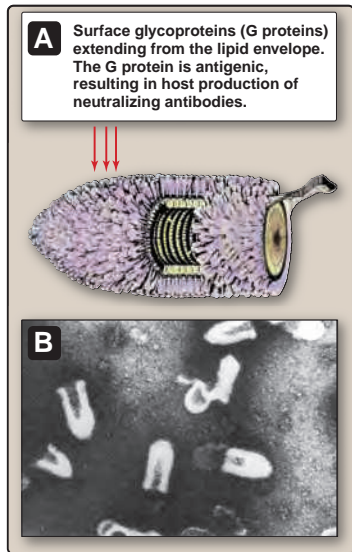
The virus has a nonsegmented, single-stranded RNA, negative strand.



The virus has a **helical nucleocapsid**.



The vaccine is composed of inactivated **rabies virus** grown in cell culture.



Rabies virus. **A.** Schematic drawing.
B. Electron micrograph.



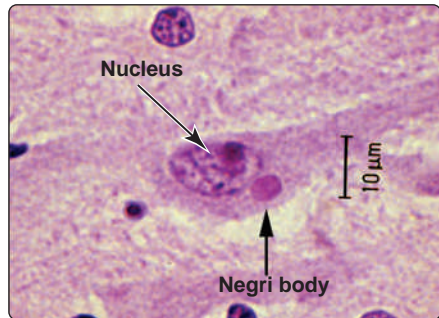
This brain section shows an eosinophilic cytoplasmic inclusion known as a **Negri body**. What occurs in this inclusion?



How is the virus that produces Negri bodies transmitted to humans?



A farm worker was bitten by a bat while working in a barn. He cleaned the wound, but being uninsured, he did not seek medical treatment. The wound healed, but 2 months later, he suffered muscle weakness and started hallucinating. When his wife found him unconscious, he was taken to the hospital by ambulance. His wife relayed the details of the case to the physician and noted that he had been unable to drink fluids because he suffered pain on swallowing. The patient subsequently fell into a coma and died. At autopsy, Negri bodies (as shown) were detected in brain tissue. What is the most likely etiology and infection?





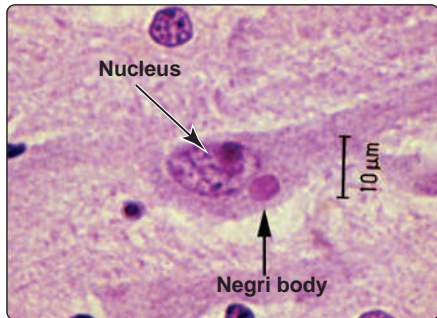
Virus replication occurs in the Negri bodies.



The virus is transmitted to humans by the bite of an infected animal, frequently a small mammal, such as a raccoon or a bat.



The patient most likely had **rabies** caused by **Lyssavirus (rabies virus)**.



An oval Negri body in the brain cell from a human rabies case.



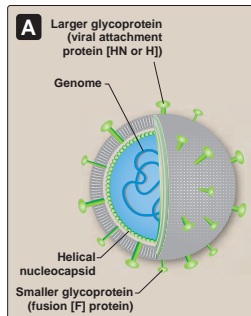
If the virus shown (**panel A**) is a member of the family *Paramyxoviridae*, what type of genome does it have?



What function does the F glycoprotein perform?



A 4-year-old child is taken to the emergency department with flulike symptoms and swollen parotid glands (**panel B**). The child's family is homeless, and he is not current on his childhood vaccinations. The physician suspects that the child is infected with the virus shown. What is the most likely etiology and infection?





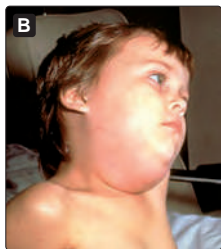
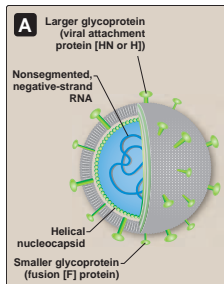
This virus would have single-stranded RNA, negative strand, nonsegmented.



The F glycoprotein, a surface protein, fuses the viral and cellular membranes, thereby facilitating virus entry into the cytoplasm, where replication occurs.



The patient most likely has **mumps** caused by the paramyxovirus **Rubulavirus**.



A. Model of paramyxovirus.

B. Child with mumps showing swollen parotid gland.



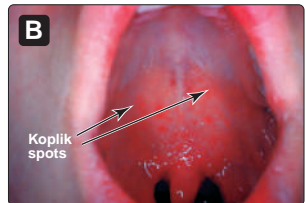
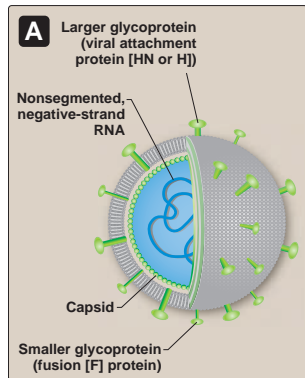
If the virus shown (**panel A**) is a member of the family *Paramyxoviridae*, what type of capsid does it have?



What is the function of the H protein on the viral envelope?



A 15-month-old child is brought to an emergency care center by his mother. The child is suffering from fever, cough, runny nose, and conjunctivitis. Currently, the child has a macular rash. The lacy pattern covers most of the child's body and blanches when pressed. White spots with bright red edges are obvious in the child's mouth, as shown (**panel B**). The mother concedes that she has not allowed her child to be vaccinated out of fear of complications. What is the most likely etiology and infection?





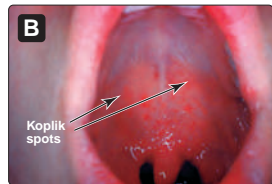
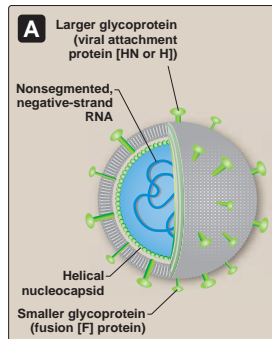
This virus would have a helical capsid.



The H protein allows the virus to attach to the receptor, the CD46 protein on human cells.



The patient most likely has **measles (rubeola)** caused by the **measles virus**.



A. Model of paramyxovirus.

B. Koplik spots in the mouth caused by measles virus.



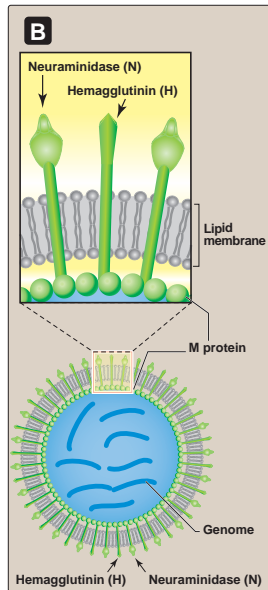
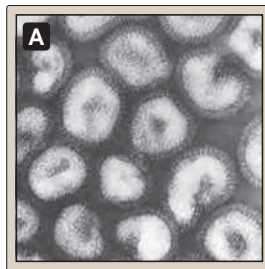
If the virus shown is an orthomyxovirus, what type of genome does it have?



What are the biological consequences of the genome type possessed by the virus shown and that the virus can infect animals and humans?



In November, a 28-year-old kindergarten teacher presents at her primary care physician's office with abrupt onset fever, chills, myalgia, and nonproductive cough. A nasopharyngeal swab specimen tested positive for the viral antigens shown. What is the most likely etiology and infection?





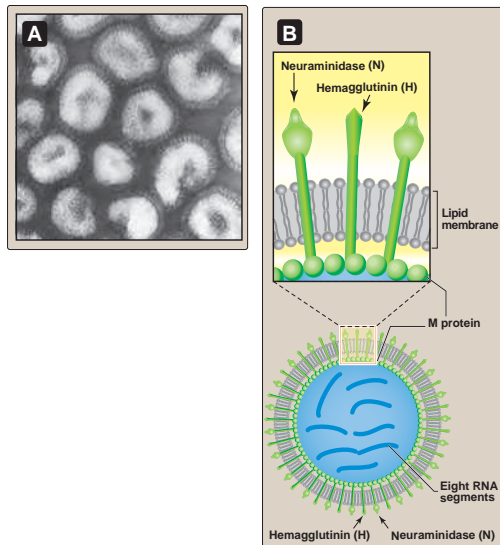
The virus would have a segmented, single-stranded RNA genome, negative strand.



The biological consequence of this genome type is antigenic variation arising from antigenic shift. When an animal reservoir is infected with at least two different types of virus, the RNA segments reassort in the virus progeny produced. The resulting virus has a different combination of H and N antigens, resulting in antigenic shift. This phenomenon explains why the vaccine to prevent this infection must be reformulated yearly.



The patient most likely has **influenza** caused by **influenza virus**.



Influenza virus. **A.** Electron micrograph. **B.** Schematic drawing showing envelope proteins (H and N spikes). M protein = matrix protein.



If the virus shown is a filovirus, what type of genome does it have?



Besides humans, what other animals are susceptible to this type of virus?



A man in Zaire is found critically ill in his home with fever, hypotension, and bleeding onto his skin and mucous membranes. He was brought to a local hospital by his family, where he later died. The virus shown was isolated from the patient at autopsy. The hospital and the patient's family were quarantined. What is the most likely etiology and infection?



From *Public Health Image Library*.



The virus would have single-stranded RNA, negative strand, nonsegmented.



Nonhuman primates (e.g., monkeys, gorillas, chimpanzees) are also susceptible to filoviruses.



The patient most likely had **viral hemorrhagic fever** caused by **Ebola virus**.



From *Public Health Image Library*.



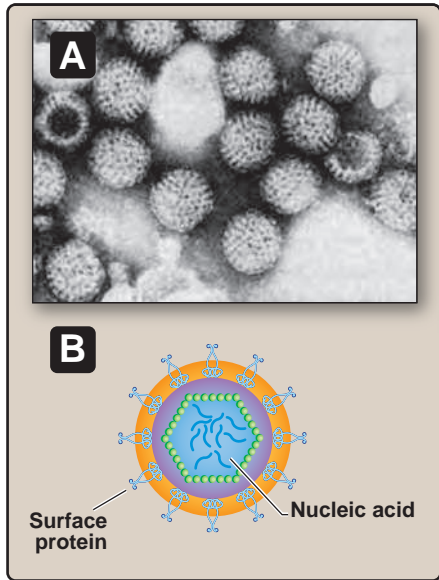
If the virus shown is a reovirus, what type of genome does it have?



What type of enzyme is required for transcription of viral genes?



A 4-year-old child is brought to his pediatrician's office by his mother. The child has suffered from vomiting and watery, nonbloody diarrhea for several days. At presentation, the child's mucous membranes are dry, and his eyes appear sunken. An ELISA test conducted on stool was positive for capsid antigens from the virus shown. What is the most likely etiology and infection?





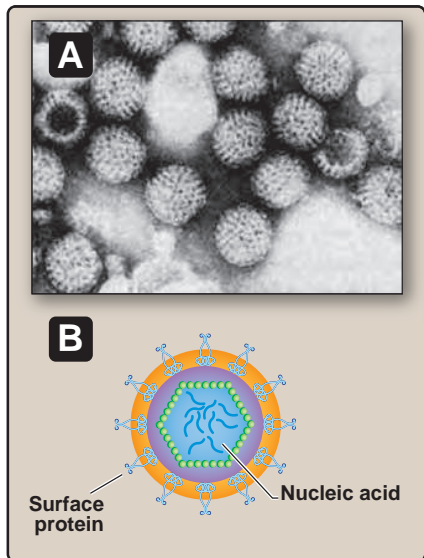
The reovirus has a double-stranded, segmented RNA genome.



A virus-encoded **RNA-dependent RNA polymerase** is required for transcription.



The patient most likely has **gastroenteritis** caused by **rotavirus**.



Structure of rotavirus. **A.** Electron micrograph.
B. Schematic drawing.



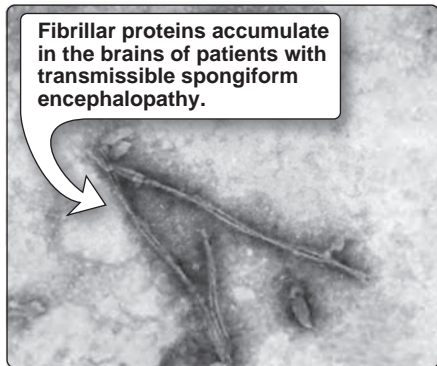
If this infectious agent has no genetic material, of what is the fibril material shown composed?



How does this infectious agent without genetic material “reproduce”?



A 25-year-old man with hemophilia suffers from a rapid-onset, progressive dementia over a period of a few weeks, culminating with institutionalization in a home for the mentally ill. Within 2 months, the man died. The autopsy results demonstrated gross pathology in the brain including plaques and spongiform lesions, without inflammatory signs. What is the most likely etiology and infection? [Note: The disease in this case is not caused by a virus.]





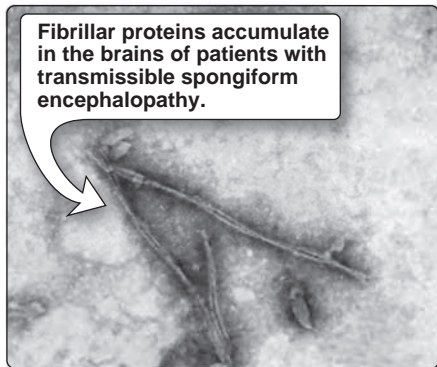
The fibril material is composed of **misfolded PrP protein** in the β -sheet conformation, rather than in the α -helical secondary conformation typical of the cellular or native PrP protein.



Reproduction occurs via the infectious (β -sheet) PrP molecule interacting with the normal PrP (α -helix), causing the normal form to fold into the infectious form.



The patient most likely had **Creutzfeldt-Jakob disease** caused by prion transmission via blood transfusion.



Electron micrograph of fibrillar prion proteins.



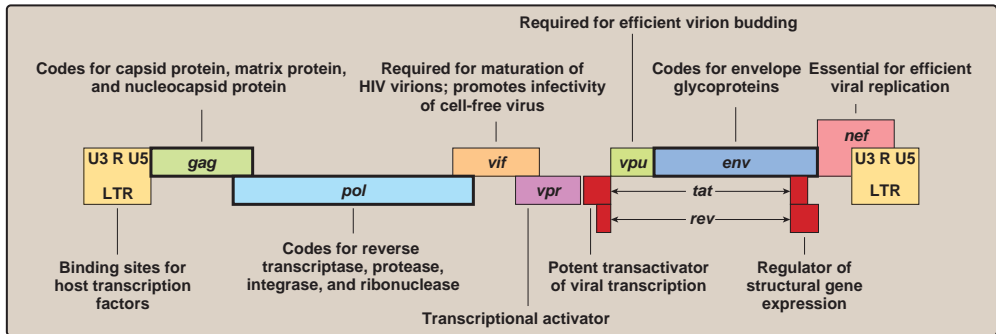
What virus has the genomic composition and arrangement shown?



How are the individual gene products produced by this virus, given that the genome is transcribed by the host's RNA polymerase?



A 35-year-old gay male presents with pneumonia, which is eventually diagnosed as being caused by *Pneumocystis jiroveci*. With this diagnosis, his physician is concerned and orders a T-cell count. The result of 200 cells/ μl confirms the physician's suspicion. What is the most likely etiology and underlying infection?





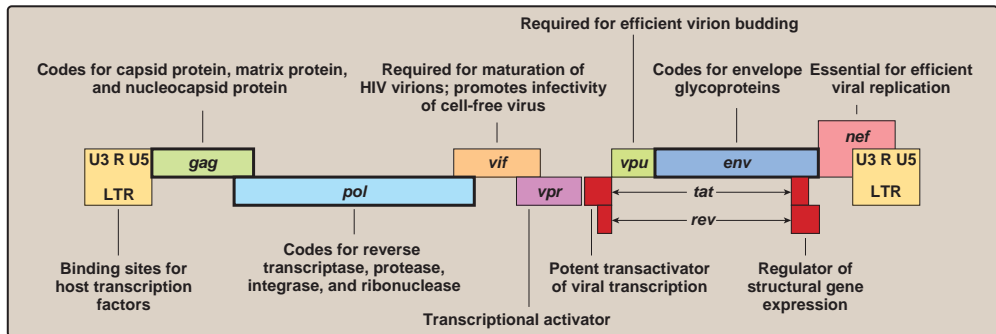
HIV has this genomic composition and arrangement.



The host's RNA polymerase generates a single transcript and a spliced RNA. The Gag, Pol, and Env proteins are produced as a polyprotein that is proteolytically processed. The Rev and Tat proteins are produced via alternative RNA splicing.



The patient most likely has **AIDS** caused by **HIV infection**.



HIV proviral genome.



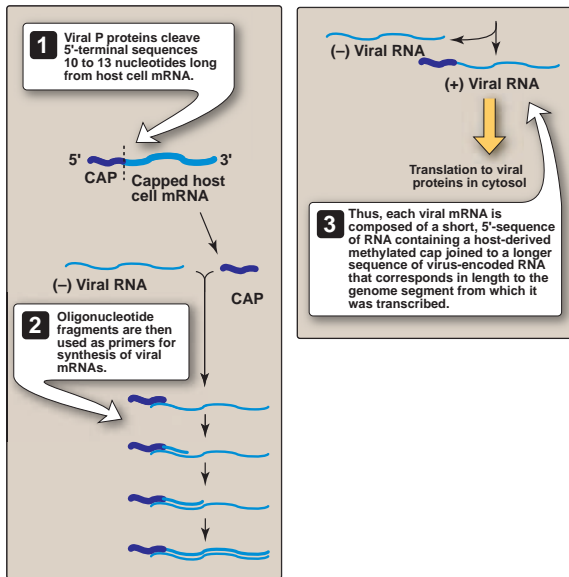
What process is shown?



Why is this process necessary for production of viral proteins and mature virions?



In October, a 14-year-old girl is brought to her pediatrician by her mother. The patient suffers from rapid-onset fever, chills, and malaise. Her temperature is 101.5°F at presentation. A rapid antigen test is positive, so the pediatrician prescribes oseltamivir. What is the most likely etiology and infection?





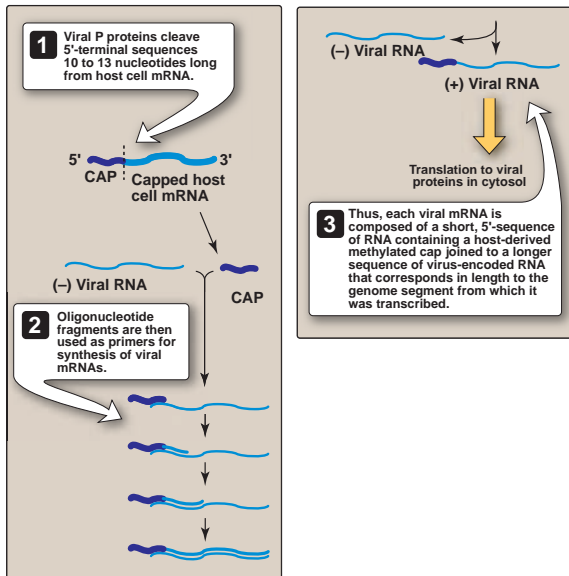
“Cap snatching” is shown.



“Cap snatching” is necessary for production of viral proteins and mature virions because the virus lacks the ability to make an RNA polymerase enzyme with capping and methylation functions. Therefore, virus-specific mRNAs would not be translated in the cytoplasm without it.



The patient most likely has **influenza** caused by the **influenza virus**.



“Cap snatching” by influenza virus prior to viral mRNA translation.



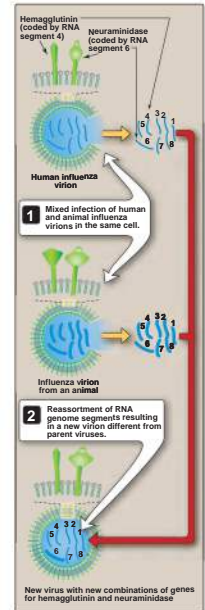
What is the consequence of the process shown?



How is the vaccine against this pathogen impacted by the process shown?



A 45-year-old school teacher presents at her primary care physician's office with fever, chills, and body aches of 2 days' duration. She has asthma for which she takes corticosteroids. The patient is diagnosed as having the flu and treated with oseltamivir. What is the most likely complication if this illness is not treated?





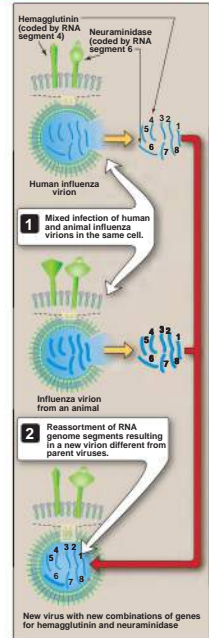
Viral antigens reassort, resulting in dramatic antigenic variation in the progeny virus, a process known as **antigenic shift**.



Because a virus with new antigens can emerge at any time due to antigenic shift, circulating strains worldwide are monitored each season, and the vaccine produced the following year includes the principle strains recovered during the previous year.



If the flu goes untreated, a **super-infection** with a respiratory tract pathogen (e.g., *Streptococcus pneumoniae*) is the most likely complication, leading to pneumonia.



Mechanism of antigenic shift in influenza virus.



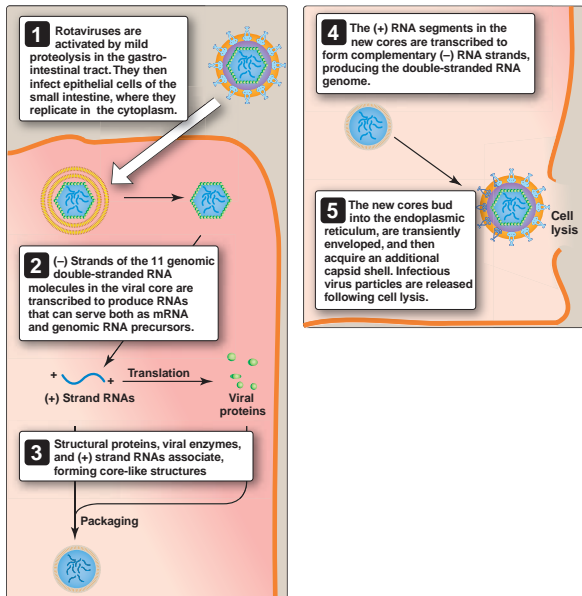
What are the two consequences of the genome structure of the virus shown?



What virus-encoded protein must be packaged into progeny virions for this virus to be infectious?



A 2-year-old child is brought to the emergency department suffering from severe diarrhea, dehydration, and electrolyte imbalance. The child is treated with IV fluids and electrolytes. The virus infecting the child resembles that shown. What is the most likely etiology and infection?





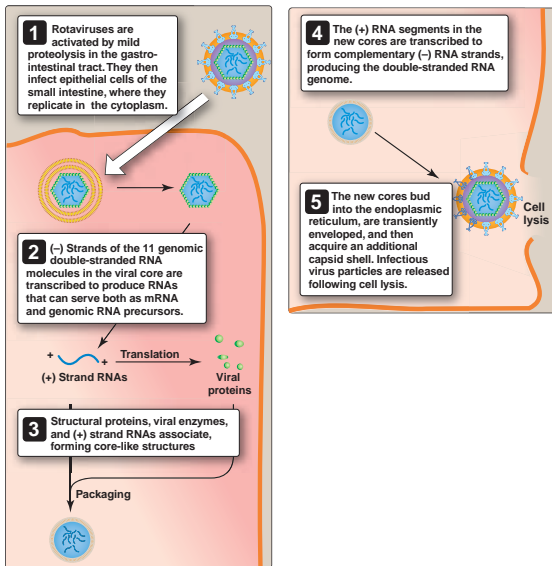
The 11 genomic segments are capable of reassembling into viral progeny with distinct antigens if a patient is simultaneously infected with multiple strains, leading to **antigenic shift**. Secondly, the 11 segments are translated separately into independent gene products eliminating the need for proteolytic processing of polyproteins by this virus.



For this virus to be infectious, **RNA-dependent RNA polymerase** must be packaged into progeny virions, which the host does not provide.



The patient most likely has **gastroenteritis** caused by **rotavirus**.



Replication of rotavirus.



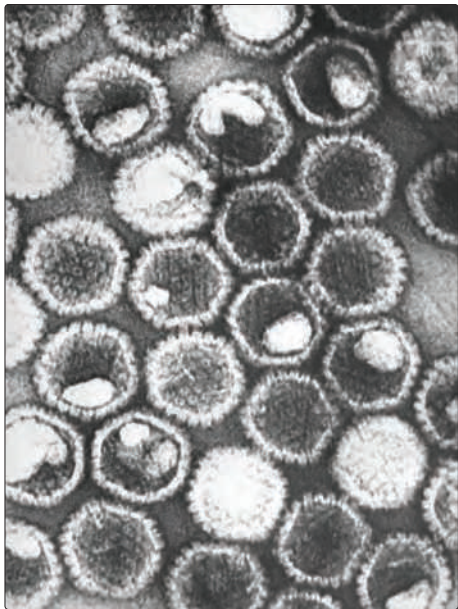
The virus particles shown demonstrate what type of capsid symmetry?



If this is an enveloped virus with a DNA genome that causes infections in both the oral and genital tracts, what two types of infection are manifested?



What is the recommended therapy for the disease caused by this virus?





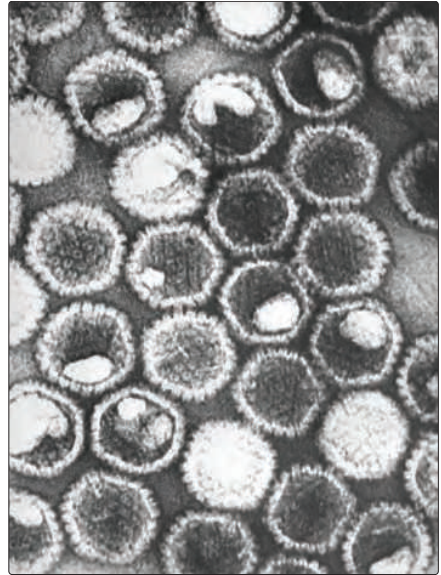
These particles show icosahedral capsid symmetry.



Herpes simplex virus (HSV) causes cytotoxic (causing ulcers) and latent (no outward signs of infection and no virus replication) infections.



Acycloguanosine or **acyclovir** is recommended to treat this disease.



Herpes simplex virions. From *Public Health Image Library*.



If the virus shown is spherical and enveloped with a segmented genome, is the genome “infectious”? Why or why not?



Reassortment of genomic segments during mixed infections with the virus shown leads to antigenic shift. What surface antigens are subject to this form of antigenic variation?



What antiviral drugs are effective against both types (type A and type B) of virus in this family?





No, the genome is not infectious because it is of negative polarity and must be converted to positive polarity before translation by host ribosomes.



The **H (hemagglutinin)** and **N (neuraminidase) antigens** are subject to antigenic shift.



Zanamivir and **oseltamivir**, which inhibit neuraminidase activity, can be used to treat both influenza virus types (A and B).



Influenza virus budding from the surface of an infected cell.

| ABBREVIATION | EXPANSION | ABBREVIATION | EXPANSION |
|--------------------|--|--------------------------------|--|
| AC | adenyl cyclase | GTP | guanosine-5'-triphosphate |
| ADP | adenosine diphosphate | GU | genitourinary |
| ADPR | adenosine diphosphate ribose | HBsAg | hepatitis B surface antigen |
| AIDS | acquired immune deficiency syndrome | HBV | hepatitis B virus |
| ALT | alanine transaminase | HCMV | human cytomegalovirus |
| AST | aspartate transaminase | HDAg | hepatitis D antigen (delta antigen) |
| ATP | adenosine triphosphate | HIV | human immunodeficiency virus |
| BPP | Bactoprenol phosphate | HPV | human papillomavirus |
| cAMP | cyclic 3'5' - adenosine monophosphate | HSV | herpes simplex virus |
| cGMP | cyclic guanosine monophosphate | ICU | intensive care unit |
| CNS | central nervous system | IFN-γ | interferon γ |
| CSF | cerebrospinal fluid | Ig | immunoglobulin |
| DAP | Diaminopimelic acid | IL-2 | interleukin 2 |
| DPT/TDaP/DT | Vaccines to prevent diphtheria, pertussis, and tetanus | IV | intravenous |
| EBV | Epstein-Barr virus | LOS | lipooligosaccharide |
| EF-2 | elongation factor 2 | LPS | lipopolysaccharide |
| EIEC | enteroinvasive <i>Escherichia coli</i> | MAPKK | mitogen-activated protein kinase kinase |
| ELISA | enzyme-linked immunosorbent assay | MHC | major histocompatibility complex |
| ETEC | enterotoxigenic <i>Escherichia coli</i> | MIC | minimum inhibitory concentration |
| fMET | N-formyl-methionine | MLC | minimum lethal concentration |
| GABA | γ -aminobutyric acid | mRNA | messenger RNA |
| GI | gastrointestinal | MRSA | methicillin-resistant <i>Staphylococcus aureus</i> |
| | | NAD | nicotinamide adenine dinucleotide |



| ABBREVIATION | EXPANSION | ABBREVIATION | EXPANSION |
|--------------|--|--------------------------------|------------------------------------|
| NAG | N-acetylglucosamine | RBC | red blood cell |
| NAM | N-acetylmuramic acid | SNAP-25 | synaptosomal-associated protein 25 |
| NNRTI | nonnucleoside reverse transcription inhibitors | STD | sexually transmitted disease |
| NRTI | nucleoside reverse transcriptase inhibitors | TNF-α | tumor necrosis factor α |
| PABA | p-Aminobenzoic acid | TSS | toxic shock syndrome |
| PBPs | penicillin-binding proteins | TSST | toxic shock syndrome toxin |
| PMN | polymorphonuclear leukocyte | UDP | uridine diphosphate |
| PPD | purified protein derivative | Vmp | variable major protein |
| PrP | prion protein | VZV | varicella-zoster virus |
| PVL | Panton Valentine leucocidin | WBC | white blood cell |

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