

## Concept Checks

- The NTM are a diverse group of organisms commonly found in the environment, and the group includes both saprophytes and human pathogens.
- The NTM can be further classified into the rapid growers (grow in < 7 days) and slow growers. Each group can be subdivided on the basis of pigment production.
- Members of MAC are among the most frequently isolated NTM. They are responsible for significant disease in patients with AIDS and others with chronic lung disease.
- *M kansasii* causes pulmonary infections that mimic tuberculosis. It responds to therapy with INH, RIF, and EMB.
- The rapid growers are diverse. *M fortuitum* complex, *M chelonae*, and *M abscessus* are the most prevalent. *M abscessus* causes the most severe disease and is often multidrug resistant.
- *M leprae* causes the disease leprosy. The organism is not cultivatable, so diagnosis is difficult. Treatment with dapson, RMP, and clofazimine is often prolonged for many years.

## REVIEW QUESTIONS

1. A 60-year-old man has a 5-month history of progressive weakness and a weight loss of 13 kg along with intermittent fever, chills, and a chronic cough productive of yellow sputum, occasionally streaked with blood. A sputum specimen is obtained, and numerous acid-fast bacteria are seen on the smear. Culture of the sputum is positive for *M tuberculosis*. Which treatment regimen is most appropriate for initial therapy?
  - (A) Isoniazid and rifampin
  - (B) Sulfamethoxazole-trimethoprim and streptomycin
  - (C) Isoniazid, rifampin, pyrazinamide, and ethambutol
  - (D) Isoniazid, cycloserine, and ciprofloxacin
  - (E) Rifampin and streptomycin
2. If the patient's *M tuberculosis* isolate (question 1) proves to be resistant to isoniazid, the likely mechanism for resistance is
  - (A)  $\beta$ -Lactamase
  - (B) Mutations in the catalase-peroxidase gene
  - (C) Alterations in the  $\beta$  subunit of RNA polymerase
  - (D) Mutations in the DNA gyrase gene
  - (E) Mutations in the genes encoding the S12 protein and 16S rRNA
3. A 47-year-old woman presents with a 3-month history of progressive cough, weight loss, and fever. Chest radiography shows bilateral cavitory disease suggestive of tuberculosis. Sputum culture grows an acid-fast bacillus that is a photochromogen (makes an orange pigment when exposed to light). The organism most likely is
  - (A) *Mycobacterium tuberculosis*
  - (B) *Mycobacterium kansasii*
  - (C) *Mycobacterium gordonae*
  - (D) *Mycobacterium avium* complex
  - (E) *Mycobacterium fortuitum*
4. A 31-year-old Asian woman is admitted to the hospital with a 7-week history of increasing malaise, myalgia, nonproductive cough, and shortness of breath. She has daily fevers of 38–39°C and a recent 5-kg weight loss. She had a negative chest radiograph when she entered the United States 7 years ago. The patient's grandmother died of tuberculosis when the patient was an infant. A current chest radiograph is normal; results of other tests show a decreased hematocrit and liver function test abnormalities. Liver and bone marrow biopsies show granulomas with giant cells and acid-fast bacilli. She is probably infected with
  - (A) *Mycobacterium leprae*
  - (B) *Mycobacterium fortuitum*
  - (C) *Mycobacterium ulcerans*
  - (D) *Mycobacterium gordonae*
  - (E) *Mycobacterium tuberculosis*
5. It is very important that the patient in question 4 also be evaluated for
  - (A) HIV/AIDS
  - (B) Typhoid fever
  - (C) Liver abscess
  - (D) Lymphoma
  - (E) Malaria
6. Of concern regarding the patient in question 4 is that she could be infected with a *Mycobacterium* that is
  - (A) Susceptible only to isoniazid
  - (B) Resistant to streptomycin
  - (C) Resistant to clarithromycin
  - (D) Susceptible only to ciprofloxacin
  - (E) Resistant to isoniazid and rifampin
7. You observe a 40-year-old man begging on a street in a town in India. He has clawing of the fourth and fifth digits with loss of distal parts of the digits of both hands, strongly suggesting leprosy. The causative agent of this disease
  - (A) Is susceptible to isoniazid and rifampin
  - (B) Grows in parts of the body that are cooler than 37°C
  - (C) Can be cultured in the laboratory using Middlebrook 7H11 medium
  - (D) Is seen in high numbers in biopsies of tuberculoid leprosy lesions
  - (E) Commonly infects people in Texas because armadillos are hosts of *M leprae*
8. Which of the following statements about the purified protein derivative (PPD) and the tuberculin skin test is most correct?
  - (A) It is strongly recommended that medical and other health science students have PPD skin tests every 5 years.
  - (B) Persons immunized with BCG rarely, if ever, convert to positive PPD skin test results.
  - (C) The intradermal skin test is usually read 4 hours after being applied.
  - (D) A positive tuberculin test result indicates that an individual has been infected with *M tuberculosis* in the past and may continue to carry viable mycobacteria.
  - (E) A positive PPD skin test result implies that a person is immune to active tuberculosis.
9. A 72-year-old woman has an artificial hip joint placed because of degenerative joint disease. One week after the procedure, she has fever and joint pain. The hip is aspirated, and the fluid is submitted for routine culture and for culture for acid-fast

organisms. After 2 days of incubation, there is no growth on any of the media. After 4 days, however, bacilli are seen growing on the sheep blood agar plate, and similar-appearing acid-fast bacilli are growing on the culture for acid-fast bacteria. The patient is most likely infected with

- (A) *Mycobacterium tuberculosis*  
 (B) *Mycobacterium chelonae*  
 (C) *Mycobacterium leprae*  
 (D) *Mycobacterium kansasii*  
 (E) *Mycobacterium avium* complex
10. A 10-year-old child has a primary pulmonary *M tuberculosis* infection. Which of the following features of tuberculosis is most correct?
- (A) In primary tuberculosis, an active exudative lesion develops and rapidly spreads to lymphatics and regional lymph nodes.  
 (B) The exudative lesion of primary tuberculosis often heals slowly.  
 (C) If tuberculosis develops years later, it is a result of another exposure to *M tuberculosis*.  
 (D) In primary tuberculosis, all of the infecting *M tuberculosis* organisms are killed by the patient's immune response.  
 (E) In primary tuberculosis, the immune system is primed, but the PPD skin test result remains negative until there is a second exposure to *M tuberculosis*.
11. Which of the following statements regarding interferon- $\gamma$  release assays (IGRAs) is correct?
- (A) They are useful for evaluating immunocompromised patients for active tuberculosis.  
 (B) They detect antigens present in all *Mycobacterium* species.  
 (C) They are not available yet for testing in the United States.  
 (D) They are performed using molecular probes that detect organism DNA.  
 (E) They are used as alternatives to the tuberculin skin test to evaluate for latent tuberculosis.
12. *M abscessus* most often causes pulmonary disease among which group of individuals?
- (A) Young children exposed to dirt  
 (B) African American smokers  
 (C) Elderly, nonsmoking white females  
 (D) Hispanic men who work outdoors  
 (E) Persons living in the Northwestern United States
13. A newly characterized rapidly growing *Mycobacterium* that has emerged as an important cause of central venous catheter associated infections is
- (A) *Mycobacterium phlei*  
 (B) *Mycobacterium mucogenicum*  
 (C) *Mycobacterium xenopi*  
 (D) *Mycobacterium smegmatis*  
 (E) *Mycobacterium terrae*
14. The definition of extensively drug-resistant (XDR) tuberculosis includes
- (A) Resistance to isoniazid  
 (B) Resistance to a fluoroquinolone  
 (C) Resistance to capreomycin, amikacin or kanamycin  
 (D) Resistance to rifampin  
 (E) All of the above

15. All of the following organisms are rapidly growing mycobacteria *except*

- (A) *Mycobacterium fortuitum*  
 (B) *Mycobacterium abscessus*  
 (C) *Mycobacterium mucogenicum*  
 (D) *Mycobacterium nonchromogenicum*  
 (E) *Mycobacterium chelonae*

### Answers

- |      |       |       |
|------|-------|-------|
| 1. C | 6. E  | 11. E |
| 2. B | 7. B  | 12. C |
| 3. B | 8. D  | 13. B |
| 4. E | 9. B  | 14. E |
| 5. A | 10. A | 15. D |

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peptidoglycan synthesis such as penicillins, cephalosporins, and vancomycin are not effective against fungi.

- The fungal cell membrane contains **ergosterol**, whereas the bacterial cell membrane does not contain ergosterol. Therefore, antibiotics that inhibit ergosterol synthesis (e.g., the azole drugs) are not effective against bacteria. Similarly, amphotericin B that binds to fungal cell membranes at the site of ergosterol is not effective against bacteria.

### Pathogenesis

- Infection with certain systemic fungi, such as *Histoplasma* and *Coccidioides*, elicits a **granulomatous host defense response** (composed of macrophages and helper T cells). Infection with other fungi, notably *Aspergillus*, *Mucor*, and *Sporothrix*, elicits a **pyogenic response** (composed of neutrophils).
- Infection with the systemic fungi, such as *Histoplasma* and *Coccidioides*, can be detected by using **skin tests**. An antigen extracted from the organism injected intradermally elicits a **delayed hypersensitivity reaction**, manifested as **induration** (thickening) of the skin. Note that a positive skin test only indicates that infection has occurred, but it is not known whether that infection occurred in the past or at the present time. Therefore, a positive skin test does not indicate that the disease the patient has now is caused by that organism. Note also that a false-negative skin test can occur in patients with reduced cell-mediated immunity, such as those with a low CD4 count. To determine whether the patient can mount a delayed hypersensitivity response, a control skin test with a common antigen, such as *C. albicans*, can be used.
- Reduced cell-mediated immunity predisposes to disseminated disease caused by the systemic fungi, such as *Histoplasma* and *Coccidioides*, whereas a reduced number of neutrophils predisposes to disseminated disease caused by fungi such as *Aspergillus* and *Mucor*.

### Fungal Toxins & Allergies

- Ingestion of *Amanita* mushrooms causes **liver necrosis** due to the presence of two fungal toxins, amanitin and phalloidin.

**Amanitin** inhibits the RNA polymerase that synthesizes cellular mRNA.

- Ingestion of peanuts and grains contaminated with *A. flavus* causes **liver cancer** due to the presence of **aflatoxin**. Aflatoxin epoxide induces a mutation in the *p53* gene that results in a loss of the p53 tumor suppressor protein.
- Inhalation of the spores of *Aspergillus fumigatus* can cause **allergic bronchopulmonary aspergillosis**. This is an IgE-mediated immediate hypersensitivity response.

### Laboratory Diagnosis

- Microscopic examination of a **KOH preparation** can reveal the presence of fungal structures. The purpose of the KOH is to dissolve the human cells, allowing visualization of the fungi.
- **Sabouraud's agar** is often used to grow fungi because its low pH inhibits the growth of bacteria, allowing the slower-growing fungi to emerge.
- DNA probes can be used to identify fungi growing in culture at a much earlier stage (i.e., when the colony size is much smaller).
- Tests for the presence of fungal antigens and for the presence of antibodies to fungal antigens are often used. Two commonly used tests are those for cryptococcal antigen in spinal fluid and for *Coccidioides* antibodies in the patient's serum.

### Antifungal Therapy

- The selective toxicity of amphotericin B and the azole group of drugs is based on the presence of **ergosterol** in fungal cell membranes, in contrast to the cholesterol found in human cell membranes and the absence of sterols in bacterial cell membranes.
- Amphotericin B binds to fungal cell membranes at the site of ergosterol and disrupts the integrity of the membranes.
- Azole drugs, such as itraconazole, fluconazole, and ketoconazole, inhibit the synthesis of ergosterol.
- The selective toxicity of echinocandins, such as caspofungin, is based on the presence of a cell wall in fungi, whereas human cells do not have a cell wall. Echinocandins inhibit the synthesis of **D-glucan**, which is a component of the fungal cell wall.

## SELF-ASSESSMENT QUESTIONS

1. Regarding the structure and reproduction of fungi, which one of the following is most accurate?
  - (A) Peptidoglycan is an important component of the cell wall of fungi.
  - (B) Molds are fungi that grow as single cells and reproduce by budding.
  - (C) Some fungi are dimorphic (i.e., they are yeasts at room temperature and molds at body temperature).
  - (D) The fungal cell membrane contains ergosterol, whereas the human cell membrane contains cholesterol.
  - (E) As most fungi are anaerobic, they should be cultured under anaerobic conditions in the clinical laboratory.
2. Regarding fungal pathogenesis, which one of the following is most accurate?
  - (A) Ingestion of *Amanita* mushrooms typically causes kidney failure.
  - (B) The host response to infection by the systemic fungi, such as *Histoplasma* and *Coccidioides*, consists of granulomas formation.
  - (C) The fever seen in systemic fungal infections is caused by endotoxin-induced release of interleukin-1.
  - (D) Ingestion of aflatoxin produced by *Aspergillus flavus* can cause adenocarcinoma of the colon.
  - (E) A positive result in the skin test to fungal antigens, such as coccidioidin, is caused by an immediate hypersensitivity reaction.

3. Regarding the mode of action of antifungal drugs, which one of the following is most accurate?
- (A) Azole drugs, such as fluconazole, act by inhibiting ergosterol synthesis.
  - (B) Amphotericin B acts by inhibiting fungal protein syntheses at the 40S ribosomal subunit.
  - (C) Terbinafine acts by inhibiting fungal DNA synthesis but has no effect on DNA synthesis in human cells.
  - (D) Echinocandins, such as caspofungin, act by inhibiting messenger RNA synthesis in yeasts but not in molds.

## ANSWERS

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- 1. (D)
- 2. (B)
- 3. (A)

## PRACTICE QUESTIONS: USMLE & COURSE EXAMINATIONS

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## Tinea Versicolor

Tinea versicolor (pityriasis versicolor), a superficial skin infection of cosmetic importance only, is caused by *Malassezia* species. The lesions are usually noticed as hypopigmented areas, especially on tanned skin in the summer. There may be slight scaling or itching, but usually the infection is asymptomatic. It occurs more frequently in hot, humid weather. The lesions contain both budding yeast cells and hyphae. Diagnosis is usually made by observing this mixture in KOH preparations of skin scrapings. Culture is not usually done. The treatment of choice is topical miconazole, but the lesions have a tendency to recur. Oral antifungal drugs, such as fluconazole or itraconazole, can be used to treat recurrences.

## Tinea Nigra

Tinea nigra is an infection of the keratinized layers of the skin. It appears as a brownish spot caused by the melanin-like pigment in the hyphae. The causative organism, *Cladosporium werneckii*, is found in the soil and transmitted during injury. In the United States, the disease is seen in the southern states. Diagnosis is made by microscopic examination and culture of skin scrapings. The infection is treated with a topical keratolytic agent (e.g., salicylic acid).

## SUBCUTANEOUS MYCOSES

These are caused by fungi that grow in soil and on vegetation and are introduced into subcutaneous tissue through trauma.

## Sporotrichosis

*Sporothrix schenckii* is a **dimorphic** fungus. The mold form lives on plants, and the yeast form occurs in human tissue. When spores of the mold are introduced into the skin, typically by a thorn, it causes a local pustule or ulcer with nodules along the draining lymphatics (Figure 48–2). The lesions are typically painless, and there is little systemic illness. Untreated lesions may wax and wane for years.



**FIGURE 48–2** Sporotrichosis. Note papular lesions on left hand and forearm. Caused by *Sporothrix schenckii*. (Reproduced with permission from Wolff K, Johnson R. *Fitzpatrick's Color Atlas & Synopsis of Clinical Dermatology*. 6th ed. New York: McGraw-Hill, 2009. Copyright © 2009 by The McGraw-Hill Companies, Inc.)

In human immunodeficiency virus (HIV)–infected patients with low CD4 counts, disseminated sporotrichosis can occur. Sporotrichosis occurs most often in **gardeners, especially those who prune roses**, because they may be stuck by a rose thorn.

In the clinical laboratory, round or cigar-shaped budding yeasts are seen in tissue specimens. In culture at room temperature, hyphae occur bearing oval conidia in clusters at the tip of slender conidiophores (resembling a daisy). The drug of choice for skin lesions is itraconazole (Sporanox). It can be prevented by protecting skin when touching plants, moss, and wood.

## Chromomycosis

This is a slowly progressive granulomatous infection that is caused by several soil fungi (*Fonsecaea*, *Phialophora*, *Cladosporium*, etc.) when introduced into the skin through trauma. These fungi are collectively called **dematiaceous** fungi, so named because their conidia or hyphae are dark-colored, either gray or black. Wartlike lesions with crusting abscesses extend along the lymphatics. The disease occurs mainly in the tropics and is found on bare feet and legs. In the clinical laboratory, dark brown, round fungal cells are seen in leukocytes or giant cells. The disease is treated with oral flucytosine or thiabendazole, plus local surgery.

## Mycetoma

Soil fungi (*Petriellidium*, *Madurella*) enter through wounds on the feet, hands, or back and cause abscesses, with pus discharged through sinuses. The pus contains compact colored granules. Actinomycetes such as *Nocardia* can cause similar lesions (actinomycotic mycetoma). Sulfonamides may help the actinomycotic form. There is no effective drug against the fungal form; surgical excision is recommended.

## SELF-ASSESSMENT QUESTIONS

- Regarding ringworm and the dermatophytes, which one of the following is most accurate?
  - The dermatophytes are molds and are not thermally dimorphic.
  - The drug of choice for the treatment of ringworm lesions is amphotericin B.
  - The purpose of the KOH prep is to observe fungal antigens within infected cells.
  - The dermatophytid reaction refers to the necrotic area typically seen in the center of ringworm lesions.
  - The principal reservoir of dermatophytes in the genus *Trichophyton* is domestic animals such as dogs and cats.
- Regarding sporotrichosis and *Sporothrix schenckii*, which one of the following is most accurate?
  - The main reservoir of *Sporothrix* is dog feces.
  - Laboratory diagnosis involves seeing a nonseptate mold in an aspirate of the lesion.

- (C) *Sporothrix* is often acquired by penetrating wounds sustained while gardening.
- (D) The treatment of choice for sporotrichosis is surgical removal of the lesion because there is no effective drug.
- (E) Disease occurs primarily in patients who are deficient in the late-acting complement components.
3. Your patient is a 65-year-old woman with a 2-cm ulcerated lesion on the palm of her hand that has been gradually getting bigger during the past month. The lesion is only slightly tender and is not red, hot, or painful. A careful history reveals that she was making holly wreaths for use at Christmas. (Holly leaves have sharp points.) She is afebrile and otherwise well. An aspirate of the lesion was obtained. Which one of the following would best support a diagnosis of sporotrichosis?
- (A) A culture on blood agar at 25°C revealed white, beta-hemolytic colonies.
- (B) A methenamine silver stain examined in the light microscope revealed budding yeasts.
- (C) A KOH preparation examined in the light microscope revealed septate hyphae.
- (D) A culture on Sabouraud's agar at 37°C revealed a brownish mycelium with green spores.
- (E) An unstained sample examined in the dark field microscope revealed non-septate hyphae.
4. Your patient is a 10-year-old boy with tinea pedis (athlete's feet). Which one of the following is the best choice of drug to treat his infection?
- (A) Amphotericin B
- (B) Caspofungin
- (C) Flucytosine
- (D) Terbinafine

## ANSWERS

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1. (A)
2. (C)
3. (B)
4. (D)

## SUMMARIES OF ORGANISMS

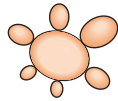
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Brief summaries of the organisms described in this chapter begin on page 679. Please consult these summaries for a rapid review of the essential material.

## PRACTICE QUESTIONS: USMLE & COURSE EXAMINATIONS

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**FIGURE 49–9** *Paracoccidioides brasiliensis*. Note the multiple buds of the yeast form of *Paracoccidioides*, in contrast to the single bud of *Blastomyces*.

## PARACOCCIDIOIDES

### Disease

*Paracoccidioides brasiliensis* causes paracoccidioidomycosis, also known as South American blastomycosis.

### Properties

*Paracoccidioides brasiliensis* is a **dimorphic** fungus that exists as a mold in soil and as a yeast in tissue. The yeast is thick-walled with **multiple buds**, in contrast to *B. dermatitidis*, which has a single bud (Figures 49–9 and 49–10).

### Transmission & Epidemiology

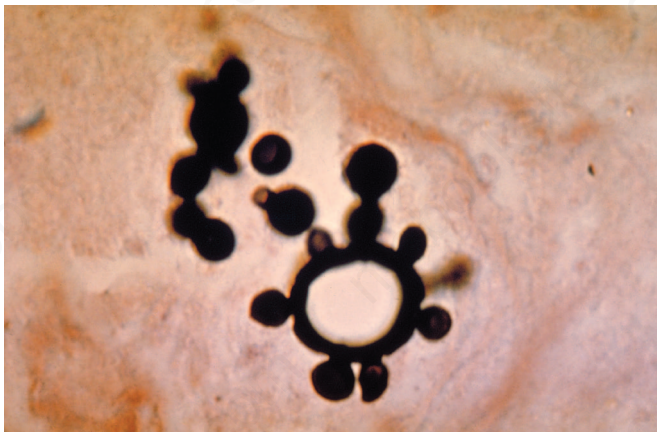
This fungus grows in the soil and is endemic in rural Latin America. Disease occurs only in that region.

### Pathogenesis & Clinical Findings

The spores are **inhaled**, and early lesions occur in the lungs. Asymptomatic infection is common. Alternatively, oral mucous membrane lesions, lymph node enlargement, and sometimes dissemination to many organs develop.

### Laboratory Diagnosis

In pus or tissues, yeast cells with multiple buds resembling a “ship captain’s wheel” are seen microscopically. A specimen cultured for 2 to 4 weeks may grow typical organisms.



**FIGURE 49–10** *Paracoccidioides*—yeasts with multiple buds resembling a “ship captain’s wheel.” Methenamine silver stain. (Source: Dr. Lucille Georg, Public Health Image Library, Centers for Disease Control and Prevention.)

Skin tests are rarely helpful. Serologic testing shows that when significant antibody titers (by ID or CF) are found, active disease is present.

### Treatment & Prevention

The drug of choice is itraconazole taken orally for several months. There are no means of prevention.

## SELF-ASSESSMENT QUESTIONS

- Regarding coccidioidomycosis and *C. immitis*, which one of the following is most accurate?
  - C. immitis* is a mold in the soil and a yeast in the body.
  - The diagnosis of acute coccidioidomycosis can be made by detecting IgM antibodies in the patient’s serum.
  - Travelers to the Philippines are at high risk of acquiring the disease.
  - The nodules of erythema nodosum are a typical finding in disseminated coccidioidomycosis.
  - Infection typically occurs when arthrospores enter the skin (e.g., through a wound caused by a rose thorn).
- Regarding histoplasmosis and *H. capsulatum*, which one of the following is most accurate?
  - In tissue biopsies, *H. capsulatum* is found as a yeast within macrophages.
  - The laboratory diagnosis is made by seeing germ tubes when incubated at 37°C.
  - Histoplasmosis occurs primarily in the tropical areas of Central and South America.
  - To prevent disease, people who live in endemic areas should receive the vaccine containing histoplasmin.
  - Most infections are acquired by ingesting food accidentally contaminated with fungal spores from the soil.
- Regarding *B. dermatitidis*, which one of the following is most accurate?
  - It forms a mycelium in culture at 37°C in the clinical lab.
  - Humoral immunity is the main host defense against this organism.
  - It causes a dermatophytid (“id”) reaction when it disseminates to the skin.
  - The most important virulence factor of this organism is endotoxin in its cell wall.
  - It is a dimorphic fungus that exists as a mold in the soil and a yeast in the body.
- Your patient is a 30-year-old woman who is in her third trimester of pregnancy, is of Filipino origin, and lives in the Central Valley of California. She complains of severe low back pain of several weeks in duration. An X-ray reveals a lesion in the fourth lumbar vertebra. Material from a needle biopsy of the lesion is examined by a pathologist who calls to tell you the patient has coccidioidomycosis. Of the following, which one did the pathologist see in the biopsy?
  - Nonseptate hyphae
  - Septate hyphae
  - Spherules containing endospores
  - Yeasts with a single bud
  - Yeasts with multiple buds

5. Your patient is a 30-year-old man who is human immunodeficiency virus (HIV) antibody positive with a CD4 count of 100. He has an ulcerated lesion on his tongue, and biopsy of the lesion reveals yeasts within macrophages. A diagnosis of disseminated histoplasmosis is made. Which one of the following is the best choice of drug to treat his disseminated histoplasmosis?
- (A) Amphotericin B
  - (B) Caspofungin
  - (C) Clotrimazole
  - (D) Flucytosine
  - (E) Terbinafine

## ANSWERS

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- 1. (B)
- 2. (A)
- 3. (E)
- 4. (C)
- 5. (A)

## SUMMARIES OF ORGANISMS

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## PRACTICE QUESTIONS: USMLE & COURSE EXAMINATIONS

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## SELF-ASSESSMENT QUESTIONS

- Regarding *C. albicans*, which one of the following is most accurate?
  - The diagnosis of disseminated candidiasis is typically made by detecting IgM antibodies.
  - It exists as a yeast on mucosal surfaces but forms pseudohyphae when it invades tissue.
  - Antibody-mediated immunity is a more important host defense than cell-mediated immunity.
  - A positive skin test can be used to confirm the diagnosis of skin infection caused by *C. albicans*.
  - In the clinical laboratory, it is diagnosed by isolating a mold with nonseptate hyphae when cultures are grown at room-temperature.
- Regarding *Cryptococcus neoformans*, which one of the following is most accurate?
  - It is a dimorphic fungus, growing as a mold in the soil and a yeast in the body.
  - It is acquired primarily by ingestion of food contaminated with pigeon guano.
  - Dark field microscopy is typically used to visualize the organism in spinal fluid.
  - Pathogenesis involves an exotoxin that acts as a superantigen recruiting lymphocytes into the spinal fluid.
  - Laboratory diagnosis of cryptococcal meningitis can be achieved by detecting the capsular polysaccharide of the organism in the spinal fluid.
- Regarding *Aspergillus fumigatus* and aspergillosis, which one of the following is most accurate?
  - The natural habitat of *A. fumigatus* is the hair follicles of the human skin.
  - In the clinical laboratory, cultures of *A. fumigatus* incubated at 37°C form yeast colonies.
  - The India ink stain is typically used to visualize *A. fumigatus* in the clinical laboratory.
  - A. fumigatus* causes “fungus balls” in patients with lung cavities caused by tuberculosis.
  - The main predisposing factor to allergic bronchopulmonary aspergillosis is neutropenia.
- Regarding *Mucor* species, which one of the following is most accurate?
  - Infection is acquired by the ingestion of food contaminated by spores of the organism.
  - Diabetic ketoacidosis is a major predisposing factor for invasive mucormycosis.
  - Mucor* species have septate hyphae in contrast to *Aspergillus* species, which have nonseptate hyphae.
  - In biopsy specimens obtained from patients with invasive disease, *Mucor* species appear as pseudohyphae.
  - Skin tests using mucoroidin as the immunogen are used to determine whether the patient has been infected with *Mucor* species.
- Your patient is a 20-year-old woman who is human immunodeficiency virus (HIV) antibody positive with a CD4 count of 50. She has recovered from cryptococcal meningitis. Which one of

the following is the best choice of drug to use as long-term prophylaxis to prevent another episode of cryptococcal meningitis?

- Amphotericin B
  - Caspofungin
  - Fluconazole
  - Flucytosine
  - Terbinafine
- Your patient is a 1-month-old infant with whitish lesions in the mouth that are diagnosed as oropharyngeal candidiasis (thrush). Which one of the following is the best choice of drug to treat this infection?
    - Amphotericin B
    - Caspofungin
    - Fluconazole
    - Flucytosine
    - Terbinafine
  - Your patient is a 50-year-old woman with leukemia who is neutropenic from her cancer chemotherapy. She now has disseminated aspergillosis that does not respond to amphotericin B. Which one of the following is the best choice of drug to treat this infection?
    - Amphotericin B
    - Caspofungin
    - Fluconazole
    - Flucytosine
    - Terbinafine

## ANSWERS

- (B)
- (E)
- (D)
- (B)
- (C)
- (C)
- (B)

## SUMMARIES OF ORGANISMS

Brief summaries of the organisms described in this chapter begin on page 680. Please consult these summaries for a rapid review of the essential material.

## PRACTICE QUESTIONS: USMLE & COURSE EXAMINATIONS

Questions on the topics discussed in this chapter can be found in the Mycology section of Part XIII: USMLE (National Board) Practice Questions starting on page 728. Also see Part XIV: USMLE (National Board) Practice Examination starting on page 751.

**SELF-ASSESSMENT QUESTIONS**

- Regarding *Entamoeba histolytica*, which one of the following is most accurate?
  - Entamoeba histolytica* causes “flask-shaped” ulcerations in the colon mucosa.
  - Domestic animals such as dogs and cats are the main reservoir of *E. histolytica*.
  - In the microscope, *E. histolytica* is recognized by having two sets of paired flagella.
  - Entamoeba histolytica* infections are limited to the intestinal mucosa and do not spread to other organs.
  - The infection is typically acquired by the ingestion of the trophozoite in contaminated food and water.
- Regarding *Giardia lamblia*, which one of the following is most accurate?
  - The drug of choice for giardiasis is chloroquine.
  - In giardiasis, ova and parasite (O&P) analysis of the stool reveals sporozoites in the feces.
  - Giardia lamblia* produces an enterotoxin that increases cyclic AMP within the enterocyte, resulting in diarrhea.
  - Giardia lamblia* infection is acquired by ingestion of food or water contaminated with human feces only (i.e., there is no animal reservoir for this organism).
  - Infection by *G. lamblia* occurs principally in the small intestine, frequently resulting in the malabsorption of fat and foul-smelling, frothy, fat-containing stools.
- Regarding *Cryptosporidium hominis*, which one of the following is most accurate?
  - Humans are the only reservoir for *C. hominis*.
  - Microscopic examination of the diarrheal stool reveals both red cells and white cells.
  - Laboratory diagnosis involves seeing cysts of the organism in an acid-fast stain of the stool.
  - Cryptosporidium hominis* is typically acquired by the ingestion of trophozoites in contaminated food or water.
  - In immunocompromised patients, such as AIDS patients with a very low CD4 count, disseminated disease occurs that typically involves the brain and meninges.
- Regarding *Trichomonas vaginalis*, which one of the following is most accurate?
  - The drug of choice for trichomoniasis is metronidazole.
  - Domestic animals, such as dogs and cats, are the principal reservoir of the organism.
  - Trichomonas vaginalis* is typically acquired by contact with the cysts of the organism during sexual intercourse.
  - Laboratory diagnosis typically involves the detection of a greater than fourfold rise in the titer of IgA antibody.
  - The asymptomatic male sex partner of a woman with *T. vaginalis* infection should not be treated because asymptomatic men are rarely the source of the organism.
- Your patient is a 30-year-old woman who returned from traveling in Eastern Europe 1 week ago. While on the trip, she experienced anorexia, nausea but no vomiting, and abdominal bloating. For the last 2 days, she has had explosive watery diarrhea. An examination of her stool revealed pear-shaped, flagellated, motile organisms. Of the following, which one is the most likely cause of this infection?
  - Cryptosporidium hominis*
  - Entamoeba histolytica*
  - Giardia lamblia*
  - Trichomonas vaginalis*
- Regarding the patient in Question 5, which one of the following is the best antibiotic to treat the infection?
  - Chloroquine
  - Metronidazole
  - Nifurtimox
  - Praziquantel
  - Stibogluconate
- Your patient is a 30-year-old Peace Corps volunteer who has recently returned from Central America. She now has fever and right-upper-quadrant pain. She reports that she had bloody diarrhea 2 months ago. A CT scan reveals a radiolucent area in the liver that is interpreted to be an abscess. Aspiration of material from the abscess was performed. Microscopic examination revealed motile, nonflagellated trophozoites with ameboid movement. Of the following, which one is the most likely cause of this infection?
  - Cryptosporidium hominis*
  - Entamoeba histolytica*
  - Giardia lamblia*
  - Trichomonas vaginalis*
- Your patient is a 30-year-old man with persistent watery diarrhea for 2 weeks. He is HIV antibody positive with a CD4 count of 10. Routine stool culture revealed no bacterial pathogen. Ova and parasite analysis revealed cysts that stained red in an acid-fast stain. Of the following, which one is the most likely cause of this infection?
  - Cryptosporidium hominis*
  - Entamoeba histolytica*
  - Giardia lamblia*
  - Trichomonas vaginalis*

**ANSWERS**

- (A)
- (E)
- (C)
- (A)
- (C)
- (B)
- (B)
- (A)

**SUMMARIES OF ORGANISMS**

Brief summaries of the organisms described in this chapter begin on page 682. Please consult these summaries for a rapid review of the essential material.

**PRACTICE QUESTIONS: USMLE & COURSE EXAMINATIONS**

Questions on the topics discussed in this chapter can be found in the Parasitology section of Part XIII: USMLE (National Board) Practice Questions starting on page 731. Also see Part XIV: USMLE (National Board) Practice Examination starting on page 751.

## SELF-ASSESSMENT QUESTIONS

- Regarding *Plasmodium* species, which one of the following is most accurate?
  - These organisms are transmitted by the bite of female *Anopheles* mosquitoes.
  - The bite of the vector injects merozoites into the bloodstream that then infect red blood cells.
  - Both male and female gametocytes are formed in the vector and are injected into the person at the time of the bite.
  - Hypnozoites are produced by *P. falciparum* and can cause relapses of malaria after the acute phase is over.
  - Malaria caused by *P. vivax* is characterized by a cerebral malaria and blackwater fever more often than malaria caused by the other three species.
- Regarding drugs used to treat or prevent malaria, which one of the following is most accurate?
  - The combination of atovaquone and proguanil is useful for the treatment of acute malaria but not for prevention.
  - Chloroquine is the drug of choice in malaria caused by *P. falciparum* because resistance to the drug is rare.
  - Mefloquine is useful for the prevention of chloroquine-sensitive *P. falciparum* but not for chloroquine-resistant strains.
  - Artemisinin derivatives, such as artesunate and artemether, are effective in the treatment of multiple-drug resistant *P. falciparum*.
  - Primaquine is useful in the treatment of infections caused by *P. falciparum* because it kills the hypnozoites residing in the liver.
- Regarding *T. gondii*, which one of the following is most accurate?
  - One way to prevent this infection is to advise pregnant women not to drink unpasteurized milk.
  - The form of *Toxoplasma* found in the tissue cysts in humans is the rapidly dividing tachyzoite.
  - The most important definitive host (the host in which the sexual cycle occurs) for *Toxoplasma* is the domestic cat.
  - Infection in people with reduced cell-mediated immunity, such as AIDS patients, is characterized by persistent watery (nonbloody) diarrhea.
  - If your patient is a pregnant woman who has IgM antibody to *Toxoplasma* in her blood, then you can tell her that it is unlikely that her fetus is at risk for infection.
- Regarding *P. jiroveci*, which one of the following is most accurate?
  - The treatment of choice is a combination of penicillin G and an aminoglycoside.
  - Finding oval cysts in bronchial lavage fluid supports a diagnosis of *Pneumocystis* pneumonia.
  - Large domestic animals such as cows and sheep are an important reservoir of human infection with this organism.
  - Patients with a CD4 count below 200 should receive the vaccine containing the surface glycoprotein as the immunogen.
  - Transmission occurs by the ingestion of food contaminated with the organism, after which it enters the bloodstream and is transported to the lung.
- Regarding *Trypanosoma cruzi*, which one of the following is most accurate?
  - Humans are the main reservoir of *T. cruzi*.
  - The drug of choice for the acute phase of Chagas' disease is chloroquine.
  - The vector for *T. cruzi*, the cause of Chagas' disease, is the reduviid (cone-nosed) bug.
  - Seeing trypomastigotes in a muscle biopsy supports the diagnosis of Chagas' disease.
  - The main site of disease caused by *T. cruzi* is skeletal muscle, resulting in severe muscle pain.
- Regarding leishmaniasis, which one of the following is most accurate?
  - Mefloquine is effective in preventing disease caused by *L. donovani*.
  - Large domestic animals such as cattle are the principal reservoir of *L. donovani*.
  - Both visceral leishmaniasis and cutaneous leishmaniasis are transmitted by the bite of sandflies.
  - Marked enlargement of the heart on chest X-ray is a typical finding of visceral leishmaniasis.
  - Pathologists examining a specimen for the presence of *L. donovani* should look primarily at eosinophils in the peripheral blood.
- Your patient is a 20-year-old man who, while playing soccer, experienced palpitations and dizziness and then fainted. An electrocardiogram showed right bundle branch block. Holter monitoring showed multiple runs of ventricular tachycardia. A ventricular myocardial biopsy was performed. Microscopic examination revealed a lymphocytic inflammatory process surrounding areas containing amastigotes. The patient was born and raised in rural El Salvador and came to this country 2 years ago. Of the following, which one is the most likely cause?
  - Leishmania donovani*
  - Plasmodium falciparum*
  - Toxoplasma gondii*
  - Trypanosoma brucei*
  - Trypanosoma cruzi*
- Your patient is a 25-year-old man with fever and weight loss for the past 3 weeks. He is a soldier in the U.S. Army who recently returned from a tour of duty in the Middle East. Physical exam was noncontributory. Laboratory tests revealed anemia and leukopenia. Multiple blood cultures for bacteria and fungi were negative, as was a test for the p24 antigen of HIV. CT scan of the abdomen revealed splenomegaly. A bone marrow biopsy was performed, and a stained sample revealed amastigotes within mononuclear cells. Of the following, which one is the most likely cause?
  - Leishmania donovani*
  - Plasmodium falciparum*
  - Toxoplasma gondii*
  - Trypanosoma brucei*
  - Trypanosoma cruzi*
- Your patient is a 55-year-old man with fever and increasing fatigue during the past week. Today, he was so weak he "could barely stand up". He had been working in Cameroon and Chad for 2 months and returned 2 weeks ago. On examination, he was febrile to 40°C, hypotensive, and tachycardic. Pertinent lab work revealed anemia and thrombocytopenia. Blood smear revealed ring-shaped trophozoites within red blood cells. Of the following, which one is the most likely cause?
  - Leishmania donovani*
  - Plasmodium falciparum*
  - Toxoplasma gondii*
  - Trypanosoma brucei*
  - Trypanosoma cruzi*
- Your patient is a 35-year-old woman who has just had a seizure. A CT scan shows a ring-enhancing lesion in her brain. History

reveals that she is an intravenous drug user and is HIV antibody positive with a CD4 count of 30. Serologic tests confirm that the patient is infected with *Toxoplasma gondii*. Which one of the following is the best choice of drug to treat her cerebral toxoplasmosis?

- (A) Artemether
  - (B) Atovaquone
  - (C) Mefloquine
  - (D) Metronidazole
  - (E) Pyrimethamine and sulfadiazine
11. Regarding the patient in Question 10, she was treated and recovered without sequelae. Antiretroviral therapy was instituted. As long as her CD4 count remains below 100, she should receive chemoprophylaxis to prevent recurrent disease caused by *T. gondii*. Which one of the following is the best chemoprophylactic drug?
- (A) Artesunate
  - (B) Metronidazole
  - (C) Pentamidine
  - (D) Primaquine
  - (E) Trimethoprim-sulfamethoxazole

## ANSWERS

1. (A)
2. (D)
3. (C)
4. (B)
5. (C)
6. (C)
7. (E)
8. (A)
9. (B)
10. (E)
11. (E)

## SUMMARIES OF ORGANISMS

Brief summaries of the organisms described in this chapter begin on page 682. Please consult these summaries for a rapid review of the essential material.

## PRACTICE QUESTIONS: USMLE & COURSE EXAMINATIONS

Questions on the topics discussed in this chapter can be found in the Parasitology section of Part XIII: USMLE (National Board) Practice Questions starting on page 731. Also see Part XIV: USMLE (National Board) Practice Examination starting on page 751.



## SELF-ASSESSMENT QUESTIONS

- Regarding *Taenia solium*, which one of the following is most accurate?
  - The scolex of *T. solium* has four suckers and a circle of hooklets.
  - The drug of choice for the adult worm in humans is metronidazole.
  - The cysticercus of *T. solium* contains the mature eggs of the organism.
  - In the laboratory, identification of adult worms is based on finding the typical scolex in the stool.
  - Ingestion of the terminal proglottids of *T. solium* by pigs results in mature tapeworms in the pig's intestine.
- Cysticercosis is most likely to be acquired by:
  - drinking water contaminated with feces of an infected pig.
  - drinking water contaminated with feces of an infected cow.
  - drinking water contaminated with feces of an infected human.
  - ingestion of undercooked pork from an infected pig.
  - ingestion of undercooked beef from an infected cow.
- Regarding *D. latum*, which one of the following is most accurate?
  - Cattle are the most important intermediate hosts.
  - Megaloblastic anemia may occur as a result of vitamin B<sub>12</sub> deficiency.
  - The laboratory diagnosis depends on finding a scolex with hooklets in the stool.
  - Infection is acquired by the ingestion of eggs in food or water contaminated with human feces.
  - Larvae migrate from the gastrointestinal tract via the portal circulation to the liver, where abscesses can occur.
- Regarding *E. granulosus*, which one of the following is most accurate?
  - The drug of choice for *E. granulosus* infection is metronidazole.
  - Dogs are a required part of the life cycle of the causative organism.
  - Echinococcus granulosus* is one of the longest tapeworms, sometimes measuring 10 ft in length.
  - Echinococcus granulosus* larvae typically migrate to skeletal muscle, where they cause an abscess.
  - The main mode of transmission to humans is ingestion of eggs in food or water contaminated with human feces.

- Your patient is a 15-year-old girl with a 2-week history of headache and vomiting and a 3-day history of confusion and incoherent speech. She was born in Ecuador but moved to this country 5 years ago. MRI of the brain reveals multiple lesions bilaterally. The following day, she has a seizure and dies. On autopsy, the brain lesions consist of a cyst-like sac containing a larva. Of the following, which one is the most likely cause?
  - Dipylidium latum*
  - Echinococcus granulosus*
  - Taenia saginata*
  - Taenia solium*
- Your patient is a 40-year-old man with occasional mild right upper abdominal discomfort but is otherwise well. On examination, his liver is enlarged. An MRI reveals a cystic mass in the liver. On questioning, he says that he was born and raised in rural Argentina on a sheep ranch and came to this country 10 years ago. Of the following, which one is the most likely cause?
  - Dipylidium latum*
  - Echinococcus granulosus*
  - Taenia saginata*
  - Taenia solium*
- Your patient is a 20-year-old woman who is a recent immigrant from Central America. On routine exam, a stool ova and parasite test reveal eggs resembling those of *T. solium*. Which one of the following is the best choice of drug to treat this patient?
  - Ivermectin
  - Pentamidine
  - Praziquantel
  - Pyrimethamine and sulfadiazine
  - Stibogluconate

## ANSWERS

- (A)
- (C)
- (B)
- (B)
- (D)
- (B)
- (C)

## SUMMARIES OF ORGANISMS

Brief summaries of the organisms described in this chapter begin on page 685. Please consult these summaries for a rapid review of the essential material.

## PRACTICE QUESTIONS: USMLE & COURSE EXAMINATIONS

Questions on the topics discussed in this chapter can be found in the Parasitology section of Part XIII: USMLE (National Board) Practice Questions starting on page 731. Also see Part XIV: USMLE (National Board) Practice Examination starting on page 751.



## SELF-ASSESSMENT QUESTIONS

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1. Regarding schistosomes, which one of the following statements is the most accurate?
  - (A) The visual appearance of male and female schistosomes is the same.
  - (B) Humans are infected by schistosomes when cercariae penetrate the skin.
  - (C) Infection of freshwater fish is a required part of the life cycle of schistosomes.
  - (D) The pathology of schistosomiasis is principally caused by the cercariae entering hepatocytes and killing them.
  - (E) Infection by nonhuman schistosomes can cause meningitis in people who swim in certain lakes in the United States.
2. Regarding *Schistosoma mansoni*, which one of the following statements is the most accurate?
  - (A) The main site of *S. mansoni* in the human body is the mesenteric venules.
  - (B) Schistosomiasis caused by *S. mansoni* has been eradicated from the Western hemisphere.
  - (C) The laboratory diagnosis of *S. mansoni* depends on seeing eggs with a terminal spine in the stool.

- (D) Adult schistosomes are passed in the stool, and it is obligatory that they be ingested by freshwater snails to continue the life cycle.
- (E) Swimmer's itch occurs when *S. mansoni* eggs spread from the liver to the skin, where they induce a histamine-mediated immediate (type 1) hypersensitivity reaction.
3. Which one of the following is the drug of choice for infections with *S. mansoni* and *S. haematobium*?
- (A) Albendazole  
 (B) Metronidazole  
 (C) Nifurtimox  
 (D) Praziquantel  
 (E) Stibogluconate
4. Your patient is a 30-year-old man with low-grade perineal pain for several weeks who had an episode of painful ejaculation and postcoital hematuria yesterday. He is in a long-standing monogamous relationship. He has traveled extensively throughout the world during the past 10 years. Urinalysis and urine culture were negative. Cytologic examination of cells in the urine revealed no tumor cells. Cystoscopy revealed several polypoid lesions, and a biopsy of a lesion was taken. The tissue was examined in the light microscope, and eggs with a terminal spine were seen. Of the following, which one is the **MOST** likely cause?
- (A) *Clonorchis sinensis*  
 (B) *Paragonimus westermani*  
 (C) *Schistosoma haematobium*  
 (D) *Schistosoma japonicum*  
 (E) *Schistosoma mansoni*

## ANSWERS

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1. (B)
2. (A)
3. (D)
4. (C)

## SUMMARIES OF ORGANISMS

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Brief summaries of the organisms described in this chapter begin on page 686. Please consult these summaries for a rapid review of the essential material.

## PRACTICE QUESTIONS: USMLE & COURSE EXAMINATIONS

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Questions on the topics discussed in this chapter can be found in the Parasitology section of Part XIII: USMLE (National Board) Practice Questions starting on page 731. Also see Part XIV: USMLE (National Board) Practice Examination starting on page 751.

- (C) *Enterobius vermicularis*  
 (D) *Trichinella spiralis*  
 (E) *Wuchereria bancrofti*
2. In the same villages as described in Question 1, you observe that some people are eating unwashed raw vegetables. Which one of the following organisms is most likely to cause infection in these people?  
 (A) *Ancylostoma duodenale*  
 (B) *Ascaris lumbricoides*  
 (C) *Enterobius vermicularis*  
 (D) *Trichinella spiralis*  
 (E) *Wuchereria bancrofti*
3. Which one of the following nematodes is transmitted by a filariform larva penetrating the skin?  
 (A) *Anisakis simplex*  
 (B) *Onchocerca volvulus*  
 (C) *Strongyloides stercoralis*  
 (D) *Toxocara canis*  
 (E) *Trichuris trichiura*
4. One of the most important public health measures in the United States in the twentieth century was recommending that children in rural areas wear shoes. This effort was designed to prevent infection through the feet with which one of the following organisms?  
 (A) *Ascaris lumbricoides*  
 (B) *Enterobius vermicularis*  
 (C) *Necator americanus*  
 (D) *Onchocerca volvulus*  
 (E) *Trichuris trichiura*
5. The larvae of certain nematodes migrate through the lung and cause pneumonitis characterized by cough or wheezing. Infection by which one of the following nematodes is most likely to cause this clinical picture?  
 (A) *Anisakis simplex*  
 (B) *Ascaris lumbricoides*  
 (C) *Enterobius vermicularis*  
 (D) *Trichinella spiralis*  
 (E) *Trichuris trichiura*
6. Of the following drugs, which one is the **MOST** effective in nematode infections?  
 (A) Albendazole  
 (B) Chloroquine  
 (C) Praziquantel  
 (D) Primaquine  
 (E) Stibogluconate
7. Your patient is a 60-year-old man with abdominal pain, vomiting, and weight loss for the past 2 months. He has a history of asthma that requires 20 mg of prednisone daily to control. He lived most of his life in Cuba, moved to Spain 10 years ago, and has lived in this country for 1 year. Abdominal exam is normal, and radiographic studies are unrevealing. His white blood cell count is 10,900 with 16% eosinophils. Examination of the stool reveals rhabditiform larvae. Of the following, which organism is the **MOST** likely cause?  
 (A) *Ascaris lumbricoides*  
 (B) *Onchocerca volvulus*  
 (C) *Strongyloides stercoralis*  
 (D) *Toxocara canis*  
 (E) *Trichinella spiralis*

## SELF-ASSESSMENT QUESTIONS

1. You are a volunteer with Doctors Without Borders in sub-Saharan Africa. In certain villages, you detect anemia in a significant number of children. This is most likely due to infection with which one of the following?  
 (A) *Ancylostoma duodenale*  
 (B) *Ascaris lumbricoides*

8. Regarding the patient in Question 7, which one of the following is the best drug to treat the infection?
- Ivermectin
  - Metronidazole
  - Nifurtimox
  - Pentamidine
  - Praziquantel
9. Your patient is a 40-year-old man with fever, myalgia, and facial swelling. White blood cell count was 14,400 with 24% eosinophils. Additional history reveals that he shot a bear in Canada and ate some of it about 6 weeks ago. He emphasized that he likes his meat rare. A muscle biopsy was performed, and a H&E stain of the tissue showed coiled larvae within skeletal muscle. Of the following, which one is the most likely cause?
- Ancylostoma caninum*
  - Anisakis simplex*
  - Necator americanus*
  - Trichinella spiralis*
  - Wuchereria bancrofti*
10. Your patient is a 35-year-old woman with severe upper abdominal pain for the past hour. There is no nausea, vomiting, or diarrhea. You suspect she may have cholecystitis, pancreatitis, or a perforated viscus but first ask her if she has ingested raw fish recently. She says yes, and tells you that she had sashimi the night before last. Endoscopy reveals a larva in the gastric mucosa. Of the following, which one is the most likely cause?
- Ancylostoma caninum*
  - Ancylostoma duodenale*
  - Anisakis simplex*
  - Toxocara canis*
  - Trichuris trichiura*
11. Your patient is a 5-year-old boy who complains of perianal itching, especially at night. A “Scotch tape” preparation reveals the eggs of *Enterobius* in the microscope. Which one of the following is the best drug to treat his pinworm infection?
- Ivermectin
  - Mebendazole
  - Pentamidine
  - Praziquantel
  - Pyrimethamine and sulfadiazine

## ANSWERS

- (A)
- (B)
- (C)
- (C)
- (B)
- (A)
- (C)
- (A)
- (D)
- (C)
- (B)

## SUMMARIES OF ORGANISMS

Brief summaries of the organisms described in this chapter begin on page 687. Please consult these summaries for a rapid review of the essential material.

## PRACTICE QUESTIONS: USMLE & COURSE EXAMINATIONS

Questions on the topics discussed in this chapter can be found in the Parasitology section of Part XIII: USMLE (National Board) Practice Questions starting on page 731. Also see Part XIV: USMLE (National Board) Practice Examination starting on page 751.