Study Questions

Choose the ONE best answer.

1.1 An 18-year-old female patient is brought to the emergency department due to drug overdose. Which of the following routes of administration is the most desirable for administering the antidote for the drug overdose?

A. Intramuscular.
B. Subcutaneous.
C. Transdermal.
D. Oral.
E. Intravenous.

Correct answer = E. The intravenous route of administration is the most desirable because it results in achievement of therapeutic plasma levels of the antidote rapidly.

1.2 Chlorothiazide is a weakly acidic drug with a pK_a of 6.5. If administered orally, at which of the following sites of absorption will the drug be able to readily pass through the membrane?

A. Mouth (pH approximately 7.0).
B. Stomach (pH of 2.5).
C. Duodenum (pH approximately 6.1).
D. Jejunum (pH approximately 8.0).
E. Ileum (pH approximately 7.0).

Correct answer = B. Because chlorothiazide is a weakly acidic drug (pKa = 6.5), it will be predominantly in non-ionized form in the stomach (pH of 2.5). For weak acids, the nonionized form will permeate through cell membrane readily.

1.3 Which of the following types of drugs will have maximum oral bioavailability?

A. Drugs with high first-pass metabolism.
B. Highly hydrophilic drugs.
C. Largely hydrophobic, yet soluble in aqueous solutions.
D. Chemically unstable drugs.
E. Drugs that are P-glycoprotein substrates.

Correct answer = C. Highly hydrophilic drugs have poor oral bioavailability, because they are poorly absorbed due to their inability to cross the lipid-rich cell membranes. Highly lipophilic (hydrophobic) drugs also have poor oral bioavailability, because they are poorly absorbed due their insolubility in aqueous stomach fluids and therefore cannot gain access to the surface of cells. Therefore, drugs that are largely hydrophobic, yet have aqueous solubility have greater oral bioavailability because they are readily absorbed.

1.4 Which of the following is *true* about the blood–brain barrier?

A. Endothelial cells of the blood–brain barrier have slit junctions.
B. Ionized or polar drugs can cross the blood–brain barrier easily.
C. Drugs cannot cross the blood–brain barrier through specific transporters.
D. Lipid-soluble drugs readily cross the blood–brain barrier.
E. The capillary structure of the blood–brain barrier is similar to that of the liver and spleen.

Correct answer = D. Lipid-soluble drugs readily cross the blood–brain barrier because they can dissolve easily in the membrane of endothelial cells. Ionized or polar drugs generally fail to cross the blood–brain barrier because they are unable to pass through the endothelial cells, which do not have slit junctions.

1.5 A 40-year-old male patient (70 kg) was recently diagnosed with infection involving methicillin-resistant *S. aureus*. He received 2000 mg of vancomycin as an IV loading dose. The peak plasma concentration of vancomycin was reported to be 28.5 mg/L. The apparent volume of distribution is:

A. 1 L/kg.
B. 10 L/kg.
C. 7 L/kg.
D. 70 L/kg.
E. 14 L/kg.

Correct answer = A. V_d = dose/C = 2000 mg/28.5 mg/L = 70.1 L. Because the patient is 70 kg, the apparent volume of distribution in L/kg will be approximately 1 L/kg (70.1 L/70 kg).

1.6 A 65-year-old female patient (60 kg) with a history of ischemic stroke was prescribed clopidogrel for stroke prevention. She was hospitalized again after 6 months due to recurrent ischemic stroke. Which of the following is a likely reason she did not respond to clopidogrel therapy? She is a:

A. Poor CYP2D6 metabolizer.
B. Fast CYP1A2 metabolizer.
C. Poor CYP2E1 metabolizer.
D. Fast CYP3A4 metabolizer.
E. Poor CYP2C19 metabolizer.

Correct answer = E. Clopidogrel is a prodrug, and it is activated by CYP2C19, which is a cytochrome P450 (CYP450) enzyme. Thus, patients who are poor CYP2C19 metabolizers have a higher incidence of cardiovascular events (for example, stroke or myocardial infarction) when taking clopidogrel.

1.7 Which of the following phase II metabolic reactions makes phase I metabolites readily excretable in urine?

A. Oxidation.
B. Reduction.
C. Glucuronidation.
D. Hydrolysis.
E. Alcohol dehydrogenation.

Correct answer = C. Many phase I metabolites are too lipophilic to be retained in the kidney tubules. A subsequent phase II conjugation reaction with an endogenous substrate, such as glucuronic acid, results in more water-soluble conjugates that excrete readily in urine.

1.8 Alkalization of urine by giving bicarbonate is used to treat patients presenting with phenobarbital (weak acid) overdose. Which of the following best describes the rationale for alkalization of urine in this setting?

A. To reduce tubular reabsorption of phenobarbital.
B. To decrease ionization of phenobarbital.
C. To increase glomerular filtration of phenobarbital.
D. To decrease proximal tubular secretion.
E. To increase tubular reabsorption of phenobarbital.

Correct answer = A. As a general rule, weak acid drugs such as phenobarbital can be eliminated faster by alkalization of the urine. Bicarbonate alkalizes urine and keeps phenobarbital ionized, thus decreasing its reabsorption.

1.9 A drug with a half-life of 10 hours is administered by continuous intravenous infusion. Which of the following best approximates the time for the drug to reach steady state?

A. 10 hours.
B. 20 hours.
C. 33 hours.
D. 40 hours.
E. 60 hours.

Correct answer = D. A drug will reach steady state in about four to five half-lives. Thus, for this drug with a half-life of 10 hours, the approximate time to reach steady state will be 40 hours.

1.10 A 55-year-old male patient (70 kg) is going to be treated with an experimental drug, Drug X, for an irregular heart rhythm. If the V_d is 1 L/kg and the desired steady-state plasma concentration is 2.5 mg/L, which of the following is the most appropriate intravenous loading dose for Drug X?

A. 175 mg.
B. 70 mg.
C. 28 mg.
D. 10 mg.
E. 1 mg.

Correct answer = A. For IV infusion, Loading dose = (V_d) × (desired steady-state plasma concentration). The V_d in this case corrected to the patient's weight is 70 L. Thus, Loading dose = 70 L × 2.5 mg/L = 175 mg.

Study Questions

Choose the ONE best answer.

2.1 Isoproterenol produces maximal contraction of cardiac muscle in a manner similar to epinephrine. Which of the following best describes isoproterenol?

A. Full agonist.
B. Partial agonist.
C. Competitive antagonist.
D. Irreversible antagonist.
E. Inverse agonist.

Correct answer = A. A full agonist has an E_{max} similar to the endogenous ligand. A partial agonist would only produce a partial effect. An antagonist would block the effects of an endogenous agonist. An inverse agonist would reverse the constitutive activity of receptors and exert the opposite pharmacological effect.

2.2 If 10 mg of naproxen produces the same analgesic response as 100 mg of ibuprofen, which of the following statements is correct?

A. Naproxen is more efficacious than is ibuprofen.
B. Naproxen is more potent than ibuprofen.
C. Naproxen is a full agonist, and ibuprofen is a partial agonist.
D. Naproxen is a competitive antagonist.
E. Naproxen is a better drug to take for pain relief than is ibuprofen.

Correct answer = B. Without information about the maximal effect of these drugs, no conclusions can be made about efficacy or intrinsic activity. E is false because the maximal response obtained is often more important than the amount of drug needed to achieve it.

2.3 If 10 mg of morphine produces a greater analgesic response than can be achieved by ibuprofen at any dose, which of the following statements is correct?

A. Morphine is less efficacious than is ibuprofen.
B. Morphine is less potent than is ibuprofen.
C. Morphine is a full agonist, and ibuprofen is a partial agonist.
D. Ibuprofen is a competitive antagonist.
E. Morphine is a better drug to take for pain relief than is ibuprofen.

Correct answer = E. Based on the information presented here, since morphine is more efficacious than is ibuprofen, it is going to provide more pain relief. As long as the situation warrants the necessity of such efficacious pain relief and without any information about differences in side effects caused by the two drugs, morphine is the better choice. Choice C would only be true if both drugs bound to the same receptor population, and that is not the case. The other choices are incorrect statements.

2.4 In the presence of naloxone, a higher concentration of morphine is required to elicit full pain relief. Naloxone by itself has no effect. Which of the following is correct regarding these medications?

A. Naloxone is a competitive antagonist.
B. Morphine is a full agonist, and naloxone is a partial agonist.
C. Morphine is less efficacious than is naloxone.
D. Morphine is less potent than is naloxone.
E. Naloxone is a noncompetitive antagonist.

Correct answer = A. Since naloxone has no effect by itself, B and C are incorrect. Since it decreases the effect of an agonist but this inhibition can be overcome by giving a higher dose of morphine, naloxone must be a competitive antagonist. No information is given about potency of either drug.

2.5 In the presence of pentazocine, a higher concentration of morphine is required to elicit full pain relief. Pentazocine by itself has a smaller analgesic effect than does morphine, even at the highest dose. Which of the following is correct regarding these medications?

A. Pentazocine is a competitive antagonist.
B. Morphine is a full agonist, and pentazocine is a partial agonist.
C. Morphine is less efficacious than is pentazocine.
D. Morphine is less potent than is pentazocine.
E. Pentazocine is a noncompetitive antagonist.

Correct answer = B. Pentazocine has a lower E_{max} value than does morphine but still has some efficacy. Thus, pentazocine is a partial agonist. Even though pentazocine blocks some of the actions of morphine, since it has some efficacy, it cannot be an antagonist. No information is given about the potency of either drug.

2.6 In the presence of picrotoxin, diazepam is less efficacious at causing sedation, regardless of the dose. Picrotoxin by itself has no sedative effect even at the highest dose. Which of the following is correct?

A. Picrotoxin is a competitive antagonist.
B. Diazepam is a full agonist, and picrotoxin is a partial agonist.
C. Diazepam is less efficacious than is picrotoxin.
D. Diazepam is less potent than is picrotoxin.
E. Picrotoxin is a noncompetitive antagonist.

Correct answer = E. Picrotoxin has no efficacy alone, so B and C are false. Since it decreases the maximal effect of diazepam, it is a noncompetitive antagonist. No information is given about potency of either drug.

2.7 Which of the following statements most accurately describes a system having spare receptors?

A. The number of spare receptors determines the maximum effect.
B. Spare receptors are sequestered in the cytosol.
C. A single drug–receptor interaction results in many cellular response elements being activated.
D. Spare receptors are active even in the absence of an agonist.
E. Agonist affinity for spare receptors is less than their affinity for "non-spare" receptors.

Correct answer = C. One explanation for the existence of spare receptors is that any one agonist–receptor binding event can lead to the activation of many more cellular response elements. Thus, only a small fraction of the total receptors need to be bound to elicit a maximum cellular response. The other choices do not accurately describe spare receptor systems.

2.8 Which of the following would up-regulate postsynaptic β_1 adrenergic receptors?

A. Daily use of amphetamine that causes norepinephrine to be released.
B. A disease that causes an increase in the activity of norepinephrine neurons.
C. Daily use of isoproterenol, a β_1 receptor agonist.
D. Daily use of formoterol, a β_2 receptor agonist.
E. Daily use of propranolol, a β_1 receptor antagonist.

Correct answer = E. Up-regulation of receptors occurs when receptor activation is lower than normal, such as when the receptor is continuously exposed to an antagonist for that receptor. Down-regulation of receptor number occurs when receptor activation is greater than normal because of continuous exposure to an agonist.

Study Questions

Choose the ONE best answer.

3.1 Which of the following is correct regarding the autonomic nervous system (ANS)?

A. Afferent neurons carry signals from the CNS to the effector organs.
B. The neurotransmitter at the parasympathetic ganglion is norepinephrine (NE).
C. The neurotransmitter at the sympathetic ganglion is acetylcholine (ACh).
D. Sympathetic neurons release ACh in the effector organs.
E. Parasympathetic neurons release NE in the effector organs.

Correct answer = C. The neurotransmitter at the sympathetic and parasympathetic ganglia is acetylcholine. Sympathetic neurons release NE and parasympathetic neurons release ACh in the effector cells. Afferent neurons carry signals from the periphery to the CNS.

3.2 Which of the following is correct regarding somatic motor neurons?

A. The neurotransmitter at the somatic motor neuron ganglion is acetylcholine.
B. The neurotransmitter at the somatic motor neuron ganglion is norepinephrine.
C. Somatic motor neurons innervate smooth muscles.
D. Somatic motor neurons do not have ganglia.
E. Responses in the somatic motor neurons are generally slower than in the autonomic nervous system.

Correct answer = D. Somatic motor neurons innervate skeletal muscles (not smooth muscle) and have no ganglia. Answers A and B are incorrect, since there are no ganglia. Also, the responses in the somatic motor nervous system are faster compared to the responses in the autonomic nervous system due to the lack of ganglia in the former.

3.3 Which of the following physiological changes could happen when a person is attacked by a grizzly bear?

A. Increase in heart rate.
B. Increase in lacrimation (tears).
C. Constriction of the pupil (miosis).
D. Increase in gastric motility.

Correct answer = A. When a person is in the "fight-or-flight" mode, as in the case of a bear attack, the sympathetic system will be activated. Activation of the sympathetic system causes an increase in heart rate and blood pressure and a decrease (not increase) in gastric motility. It also causes dilation (not constriction) of the pupil and inhibition of lacrimation.

3.4 Which of the following changes could theoretically happen in a person when the parasympathetic system is inhibited using a pharmacological agent?

A. Reduction in heart rate.
B. Constriction of the pupil (miosis).
C. Increase in gastric motility.
D. Dry mouth (xerostomia).
E. Contraction of detrusor muscle in the bladder.

Correct answer = D. Activation of the parasympathetic system causes a reduction in heart rate, constriction of the pupil, an increase in gastric motility and salivation, and contraction of the bladder muscle. Therefore, inhibition of the parasympathetic system causes an increase in heart rate, dilation of the pupil, a decrease in gastric motility, dry mouth, and relaxation of detrusor muscles.

3.5 Which of the following statements is correct regarding the sympathetic and parasympathetic systems?

A. Acetylcholine activates muscarinic receptors.
B. Acetylcholine activates adrenergic receptors.
C. Norepinephrine activates muscarinic receptors.
D. Activation of the sympathetic system causes a drop in blood pressure.

Correct answer = A. Acetylcholine is the neurotransmitter in the cholinergic system, and it activates both muscarinic and nicotinic cholinergic receptors, not adrenergic receptors. Norepinephrine activates adrenergic receptors, not muscarinic receptors. Activation of the sympathetic system causes an increase in blood pressure (not a drop in blood pressure) due to vasoconstriction and stimulation of the heart.

3.6 Which of the following statements concerning the parasympathetic nervous system is correct?

A. The parasympathetic system uses norepinephrine as a neurotransmitter.
B. The parasympathetic system often discharges as a single, functional system.
C. The parasympathetic division is involved in accommodation of near vision, movement of food, and urination.
D. The postganglionic fibers of the parasympathetic division are long compared to those of the sympathetic nervous system.
E. The parasympathetic system controls the secretion of the adrenal medulla.

Correct answer = C. The parasympathetic nervous system maintains essential bodily functions, such as vision, movement of food, and urination. It uses acetylcholine, not norepinephrine, as a neurotransmitter, and it discharges as discrete fibers that are activated separately. The postganglionic fibers of the parasympathetic system are short compared to those of the sympathetic division. The adrenal medulla is under the control of the sympathetic system.

3.7 Which of the following is correct regarding neurotransmitters and neurotransmission?

A. Neurotransmitters are released from the presynaptic nerve terminals.
B. Neurotransmitter release is triggered by the arrival of action potentials in the postsynaptic cell.
C. Intracellular calcium levels drop in the neuron before the neurotransmitter is released.
D. Serotonin and dopamine are the primary neurotransmitters in the ANS.

Correct answer = A. Neurotransmitters are released from presynaptic neurons, triggered by the arrival of an action potential in the presynaptic neuron (not in the postsynaptic cell). When an action potential arrives in the presynaptic neuron, calcium enters the presynaptic neuron and the calcium levels increase in the neuron before the neurotransmitter is released. The main neurotransmitters in the ANS are norepinephrine and acetylcholine.

3.8 An elderly man was brought to the emergency room after he ingested a large quantity of carvedilol tablets, a drug that blocks α_1, β_1, and β_2 adrenergic receptors, which mainly mediate the cardiovascular effects of epinephrine and norepinephrine in the body. Which of the following symptoms would you expect in this patient?

A. Increased heart rate (tachycardia).
B. Reduced heart rate (bradycardia).
C. Dilation of the pupil (mydriasis).
D. Increased blood pressure.

Correct answer = B. Activation of α_1 receptors causes mydriasis, vasoconstriction, and an increase in blood pressure. Activation of β_1 receptors increases heart rate, contractility of the heart, and blood pressure. Activation of β_2 receptors causes dilation of bronchioles and relaxation of skeletal muscle vessels. Thus, inhibition of these receptors will cause vasorelaxation (α_1 blockade), reduction in heart rate (β_1 blockade), reduction in contractility of the heart (β_1 blockade), reduction in blood pressure, bronchoconstriction (β_2 blockade), and constriction of blood vessels supplying skeletal muscles (β_2 blockade).

3.9 All of the following statements regarding central control of autonomic functions are correct *except*:

A. Baroreceptors are pressure sensors located at various cardiovascular sites.
B. The parasympathetic system is activated by the CNS in response to a sudden drop in blood pressure.
C. The parasympathetic system is activated by the CNS in response to a sudden increase in blood pressure.
D. The sympathetic system is activated by the CNS in response to a sudden drop in blood pressure.

Correct answer = B. When there is a sudden drop in blood pressure, the baroreceptors send signals to the brain, and the brain activates the sympathetic system (not the parasympathetic system) to restore blood pressure to normal values.

3.10 Which of the following is correct regarding membrane receptors and signal transduction?

A. ANS neurotransmitters bind to membrane receptors on the effector cells, which leads to intracellular events.
B. Cholinergic muscarinic receptors are examples of ionotropic receptors.
C. Cholinergic nicotinic receptors are examples of metabotropic receptors.
D. Metabotropic receptors activate ion channels directly.

Correct answer = A. Neurotransmitters generally bind to the membrane receptors on the postsynaptic effector cells and cause cellular effects. Acetylcholine (ACh) binds to cholinergic muscarinic receptors in the effector cells and activates the second messenger pathway in the effector cells, which in turn causes cellular events. These types of receptors that are coupled to second messenger systems are known as metabotropic receptors. Thus, metabotropic receptors do not directly activate ion channels. ACh also binds to cholinergic nicotinic receptors and activates ion channels on the effector cells directly. These types of receptors that activate ion channels directly are known as ionotropic receptors.

Study Questions

Choose the ONE best answer.

4.1 Botulinum toxin blocks the release of acetylcholine from cholinergic nerve terminals. Which of the following is a possible effect of botulinum toxin?

A. Skeletal muscle paralysis.
B. Improvement of myasthenia gravis symptoms.
C. Increased salivation.
D. Reduced heart rate.

Correct answer = A. Acetylcholine released by cholinergic neurons acts on nicotinic receptors in the skeletal muscle cells to cause contraction. Therefore, blockade of ACh release causes skeletal muscle paralysis. Myasthenia gravis is an autoimmune disease where antibodies are produced against nicotinic receptors and inactivate nicotinic receptors. A reduction in ACh release therefore worsens (not improves) the symptoms of this condition. Reduction in ACh release by botulinum toxin causes reduction in secretions including saliva (not increase in salivation) causing dry mouth and an increase (not reduction) in heart rate due to reduced vagal activity.

4.2 A dentist would like to reduce salivation in a patient in preparation for an oral surgical procedure. Which of the following strategies will be useful in reducing salivation?

A. Activate nicotinic receptors in the salivary glands.
B. Block nicotinic receptors in the salivary glands.
C. Activate muscarinic receptors in the salivary glands.
D. Block muscarinic receptors in the salivary glands.

Correct answer = D. Salivary glands contain muscarinic receptors, not nicotinic receptors. Activation of muscarinic receptors in the salivary glands causes secretion of saliva. Blocking muscarinic receptors, using drugs such as atropine, reduces salivary secretions and makes the mouth dry.

4.3 Which of the following is a systemic effect of a muscarinic agonist?

A. Reduced heart rate (bradycardia).
B. Increased blood pressure.
C. Mydriasis (dilation of the pupil).
D. Reduced urinary frequency.
E. Constipation.

Correct answer = A. A muscarinic agonist binds to and activates muscarinic receptors in the heart, endothelial cells (blood vessels), the gut, and iris sphincter (eye) and urinary bladder wall muscles, in addition to several other tissues. Activation of muscarinic receptors by an agonist causes a reduction in heart rate, constriction of circular muscles in the iris sphincter leading to constriction of the pupil (miosis), increased GI motility (hence, diarrhea, not constipation), and contraction of bladder muscles leading to an increase (not decrease) in urination frequency. In the endothelial cells of blood vessels, muscarinic activation produces release of nitric oxide that causes vasorelaxation and a reduction (not increase) in blood pressure.

4.4 If an ophthalmologist wants to dilate the pupils for an eye examination, which of the following drugs/classes of drugs could be theoretically useful?

A. Muscarinic receptor activator (agonist).
B. Muscarinic receptor inhibitor (antagonist).
C. Acetylcholine.
D. Pilocarpine.
E. Neostigmine.

Correct answer = B. Muscarinic agonists (for example, ACh, pilocarpine) contract the circular smooth muscles in the iris sphincter and constrict the pupil (miosis). Anticholinesterases (for example, neostigmine, physostigmine) also cause miosis by increasing the level of ACh. Muscarinic antagonists, on the other hand, relax the circular smooth muscles in the iris sphincter and cause dilation of the pupil (mydriasis).

4.5 In Alzheimer's disease, there is a deficiency of cholinergic neuronal function in the brain. Theoretically, which of the following strategies will be useful in treating the symptoms of Alzheimer's disease?

A. Inhibiting cholinergic receptors in the brain.
B. Inhibiting the release of acetylcholine in the brain.
C. Inhibiting the acetylcholinesterase enzyme in the brain.
D. Activating the acetylcholinesterase enzyme in the brain.

Correct answer = C. Since there is already a deficiency in brain cholinergic function in Alzheimer's disease, inhibiting cholinergic receptors or inhibiting the release of ACh will worsen the condition. Activating the acetylcholinesterase enzyme will increase the degradation of ACh, which will again worsen the condition. However, inhibiting the acetylcholinesterase enzyme will help to increase the levels of ACh in the brain and thereby help to relieve the symptoms of Alzheimer's disease.

4.6 An elderly female who lives in a farm house was brought to the emergency room in serious condition after ingesting a liquid from an unlabeled bottle found near her bed, apparently in a suicide attempt. She presented with diarrhea, frequent urination, convulsions, breathing difficulties, constricted pupils (miosis), and excessive salivation. Which of the following is correct regarding this patient?

A. She most likely consumed an organophosphate pesticide.
B. The symptoms are consistent with sympathetic activation.
C. Her symptoms can be treated using an anticholinesterase agent.
D. Her symptoms can be treated using a cholinergic agonist.

Correct answer = A. The symptoms are consistent with that of cholinergic crisis. Since the elderly female lives on a farm and since the symptoms are consistent with that of cholinergic crisis (usually caused by cholinesterase inhibitors), it may be assumed that she has consumed an organophosphate pesticide (irreversible cholinesterase inhibitor). Assuming that the symptoms are caused by organophosphate poisoning, administering an anticholinesterase agent or a cholinergic agonist will worsen the condition. The symptoms are not consistent with that of sympathetic activation, as sympathetic activation will cause symptoms opposite to that of cholinergic crisis seen in this patient.

4.7 Sarin is a volatile nerve agent that inhibits cholinesterase enzymes. Which of the following symptoms would you expect to see in a patient exposed to sarin?

A. Urinary retention.
B. Tachycardia.
C. Constriction of pupils (miosis).
D. Dilation of the pupils (mydriasis).
E. Dry mouth.

Correct answer = C. Sarin is an organophosphate nerve gas that inhibits cholinesterase enzymes and increases ACh levels. Therefore, symptoms of cholinergic crisis (increased urination, bradycardia, excessive secretions, constriction of pupils, etc.) should be expected in patients exposed to sarin. Urinary retention, tachycardia, mydriasis, and dry mouth are usually seen with muscarinic antagonists.

4.8 Head and neck irradiation in cancer patients can decrease salivary secretion and cause dry mouth. All of the following drugs or classes of drugs are theoretically useful in improving secretion of saliva in these patients *except*:

A. Muscarinic antagonists.
B. Muscarinic agonists.
C. Anticholinesterase agents.
D. Pilocarpine.
E. Neostigmine.

Correct answer = A. Activation of muscarinic receptors in the salivary glands causes secretion of saliva. This can be achieved in theory by using a muscarinic agonist such as pilocarpine or an anticholinesterase agent such as neostigmine (increases levels of ACh). Muscarinic antagonists (anticholinergic drugs) will reduce salivary secretion and worsen dry mouth.

4.9 Which of the following drugs or classes of drugs will be useful in treating the symptoms of myasthenia gravis?

A. Nicotinic antagonists.
B. Muscarinic agonists.
C. Muscarinic antagonists.
D. Anticholinesterase agents.

Correct answer = D. The function of nicotinic receptors in skeletal muscles is diminished in myasthenia gravis due to the development of antibodies to nicotinic receptors in the patient's body (autoimmune disease). Any drug that can increase the levels of ACh in the neuromuscular junction can improve symptoms in myasthenia gravis. Thus, cholinesterase inhibitors help to improve the symptoms of myasthenia gravis. Muscarinic drugs have no role in myasthenia gravis, and nicotinic antagonists will worsen the symptoms.

4.10 *Atropa belladonna* is a plant that contains atropine (a muscarinic antagonist). Which of the following drugs or classes of drugs will be useful in treating poisoning with belladonna?

A. Malathion.
B. Physostigmine.
C. Muscarinic antagonists.
D. Nicotinic antagonists.

Correct answer = B. Atropine is a competitive muscarinic receptor antagonist that causes anticholinergic effects. Muscarinic agonists or any other drugs that can increase the levels of ACh will be able to counteract the effects of atropine. Thus, anticholinesterases such as malathion and physostigmine can counteract the effects of atropine in theory. However, malathion being an irreversible inhibitor of acetylcholinesterase is not used for systemic treatment in patients. Muscarinic antagonists will worsen the toxicity of atropine. Nicotinic antagonists could worsen the toxicity by acting on parasympathetic ganglionic receptors and thus reducing the release of ACh.