Test Bank for Biochemistry A Short Course 3rd Edition by Tymoczko Test Bank ISBN 1464126135 9781464126130 Full download

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Chapter 1 Biochemistry and the Unity of Life

Matching Questions

Use the following to answer questions 1–10:

Choose the correct answer from the list below. Not all of the answers will be used.

uracil
cytoplasm
protein
thymine
carbohydrate
sugar–phosphate units
cell wall
transcription
glycogen
lipid
central dogma
phagocytosis
endoplasmic reticulum
translation
prokaryotes
eukaryotes
lysosome

DNA is made from the building blocks adenine, guanine, cytosine, and _____________.

_____________: Unbranched polymer that, when folded into its three-dimensional shape, performs much of the work of the cell.

_____________: Scheme that describes the flow of information from one strand of DNA to a new strand of DNA.

_____________: Process where large amounts of material are taken into the cell.

The transfer of information from DNA to RNA is called _____________.

_____________ are cells that are composed of multiple specialized compartments.

_____________: Class of biological macromolecules with many functions, such as forming barriers between cell organelles, serving as a metabolic fuel, and cell-to-cell signaling.

_____________: Highly organized region of the cell where glycolytic metabolism occurs.

_____________: Responsible for protein processing and xenobiotic metabolism.

10.. _____________: Filled with proteases and other digestive enzymes.

Fill-in-the-Blank Questions

11. Organisms are known to be highly uniform at the ___ level.
Ans: molecular Section: Introduction

12. After hydrogen and oxygen, the next most common element in living systems is ___.

13. A chemical that can dissolve in water is said to be ___ .

14. A nucleotide consists of one or more ___groups, a 5-carbon ribose sugar, and a nitrogen-containing aromatic ring group.

15. The most common carbohydrate fuel is ___ .

16. Heritable information is packaged into discrete units called ___.

17. A group of enzymes called ___catalyze replication.

18. Although all cells in an organism have the same DNA, tissues differ due to selective ___.

19. The basic unit of life is considered the ___.

20. Secretory vesicles fuse with the plasma membrane to release material outside of the cell via ___.

Multiple-Choice Questions

21. The structure of DNA described by Watson and Crick
22.included:Inhigher organisms, which of the following is composed of a polymer
a withdoubledoubhe**l**eix-stranded. phosphodiester-linked
monomers? B)A)theRNAsugar–phosphate backbone
aligned in the center of theB) DNAhelix.
C)) theproteinbase pairs that are stacked on the
inside of the doubleD)carbohydratehelix.
D)E) ANoa**n**de ofB. the above.
A and C.

What gives proteins such a dominant role in biochemistry?
the variation in protein sizes
the ability to act as a blueprint
their ability to self-replicate
their ability to spontaneously fold into complex three-dimensional structures
All of the above.

□ Ā □ Ā □ Ā □
roteins are chiefly composed of which of the following? A)
carbohydrate and amino acids
B) long unbranched amino acid polymers
C) peptide bonds formed between lipid moieties
D) aggregated amino acids
E) A and B Section
1.3

How a protein folds is determined by:
whether the environment is hydrophobic or hydrophilic.
the location in the cell in which the protein is located.
the pH of the cytoplasm.
the order of the amino acids found in the sequence.
All of the above.

The half-life of which of the following is likely to be shortest?
protein
lipid
carbohydrate
DNA
RNA

The central dogma describes:
the formation of cells from individual components.
the selective expression of genes.
the flow of information between DNA, RNA, and protein.
the work of polymerases on RNA and DNA.
All of the above.

Translation takes place on/in the:
ribosomes.
smooth endoplasmic reticulum.
nucleus.
DNA polymerases.
DNA parent strand.

Which of the following organelles has a double membrane?
nucleus
endoplasmic reticulum
mitochondria
plasma membrane
A and C
All of the above.

The main function of the plasma membrane is to:

provide the interior of the cell an enclosed environment that no molecules may cross.
provide a selectively permeable barrier with the aid of transport proteins.
give eukaryote and prokaryote cells structural strength.
allow only the free passage of water in and out of the cell.
None of the above.

Filaments and microtubules are components of a network called the:

chloroplast.
cytoplasm.
cytoskeleton.
cell wall.
B and D.

Poisons that kill an organism as a result of a loss of high-energy ATP molecules are most likely to target which organelle?

mitochondria
cytoskeleton
cytoplasm
endoplasmic reticulum
nucleus

A secreted protein would be processed through organelles in the following order:

nucleus; secretory vesicle; Golgi complex.
cytoplasm; Golgi complex; cytosol; secretory vesicle.
endoplasmic reticulum; cytoplasmic reticulum; Golgi complex.
nucleus; cytoplasm; endoplasmic reticulum; Golgi complex; secretory vesicle.
None of the above.

Extracellular material is taken into the cell via which process?

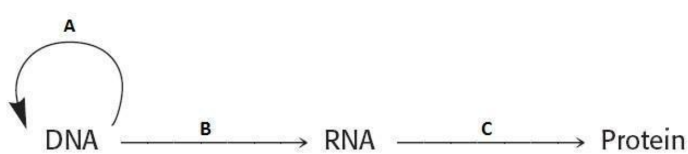
exocytosis
phagocytosis

lysosome-mediated endocytosis
reverse secretory mechanism
phago-cytosolic internalization

The rigid material that provides structural support to a plant cell is/are called the:
plant cytoskeleton.
plasma membrane.
cell wall.
chloroplast anchor proteins.
microfilaments and microtubules.

In studying secreted proteins, you find that Substance X inhibits the secretion of a labeled protein. However, you do find a fully synthesized, folded, and glycosylated proteins in the cell. Where is the most likely site in the synthesis and secretion of proteins for Substance X to act?
A) nucleus during translation
B) budding of the secretory granule
C) translation on the ribosome
D) enzyme modification in the
Golgi E) All of the above.

Below is the scheme known as the central dogma. Each of the arrows (A, B, C) represents a particular process in gene expression. A, B, and C, respectively, are:



replication, transcription, translation.
reverse transcription, transcription, translation.
transcription, translation, replication.
replication translation, expression.
None of the above.

Match the loss of a particular organelle with the associated disease. A) Hypercholesterolemia – smooth endoplasmic reticulum
B) Diabetes – endosome
C) Tay-Sachs disease - lysosome
D) Muscle degeneration – mitochondria
E) Stroke – Golgi body

In a biochemistry lab course, you are asked to design an experiment to identify a strain of bacteria. Your lab partner claims that she thinks the bacterium contains a rough endoplasmic reticulum. To verify her claim, which of the following experiments would you preform?
A) determine whether the bacterium can synthesize ATP in the presence of fuel molecules and O_2
B) determine whether the bacterium can synthesize proteins
C) determine whether the bacterium generates CO_2 in the presence of fuel molecules
D) determine whether the bacterium has an internal membrane-enclosed compartment
E) All of these experiments will work.

Short-Answer Questions

What are the four key classes of biomolecules?

How do eukaryotic cells differ from prokaryotic cells?

Describe the central dogma and why it is important for cell life.

43. Define an organelle.

What is the role of the endoplasmic reticulum (ER)?

Of the biochemical macromolecules, which class is chiefly responsible for catalysis of cellular processes?

DNA and RNA are composed of what basic biochemical compounds?

What are the important functions of carbohydrates?

What is significant about the DNA process of replication?

Which property of lipids drives the formation of membranes?

What data might Monod cite to justify the phrase “Anything found to be true of *E. coli* must also be true of elephants”?

Chapter 2 Water, Weak Bonds, and the Generation of Order Out of Chaos

Matching Questions

Use the following to answer questions 1–10:

Choose the correct answer from the list below. Not all of the answers will be used.

ionic bonds or salt bridges
Brownian motion
hydrophobic
hydrogen
polar
nonpolar
van der Waals
entropy
ion product of water
amphipathic
positive
dielectric constant
negative

1 ____________: The type of bond found between an oxygen on one water molecule and hydrogen on a different water molecule.

Movement of particles due to the random fluctuations of energy content of the environment is known as ____________.

Electrostatic interactions between atoms with opposite electrical charges are also called ____________.

Water weakens the electrostatic interaction of ions due to its high ____________.

The distance when two atoms no longer repulse each other yet have the strongest attraction is known as the____________ contact distance.

____________: Thermodynamic force that drives hydrophobic interactions.

____________: A molecule with two distinctive chemical properties or characteristics.

Which type of amino acid is responsible for increasing entropy as a protein folds?

____________: The charge on acetic acid when the pH is more than one pH unit above the pK_a.

____________: The charge of an amino group when the pH is one pH unit below the pK_a.

Fill-in-the-Blank Questions

11 Molecules that are readily soluble in water are considered ___ .

12 The force that is quantified by Coulomb's law is called _ _ .

13 A solvent with a low dielectric constant would be a ___ solvent for salts.

The transient force, which while weak, still has a large impact on how macromolecules interact is the ___ .

15 Hydrophobic molecules are driven together by ___, not because they have an affinity for each other.

Lipids that interact with both the water and the hydrophobic regions of the membrane are considered .

17 An acid ionizes to form a proton and its ___ .

18 When the pH is more than two pH units above the pK_a of a carboxyl group, the acid is ____

19 Buffers are critical in maintaining proper ____ levels in biological systems.

20 The source of the key buffering component of blood is ____ .

Multiple-Choice Questions

What is the H^+ concentration in a urine sample that has a pH of 6?
10^{-6} M
10^{-8} M
10^{6} M
10^{-14} M
8 M

Which of the following is considered a noncovalent bond?
electrostatic interactions
hydrogen bonds
van der Waals interactions
All of the above.
None of the above.

What charged group(s) is/are present in glycine at a pH of 7?
$-NH_3^+$
$-COO^-$
$-NH_2^+$
A and B
A, B, and C

Water can form hydrogen bonds with the ___________ of another molecule.
carbonyl groups
amine groups
aromatic rings
alcohol groups
A, B, and D

What pairs of atoms in nucleotide bases are involved in hydrogen bonds?
N–H and C═O
N–H and S–H
O–H and P–O All
of the above. None
of the above.

Typical van der Waals energies are about:
4–20 kJ/mol.
2–4 kJ/mol.
200 kJ/mol.
All of the above.
None of the above.

What two properties of water are important for biological interactions?
the polarity of water
the density of water
the cohesive properties of water
A and C
B and C

List atoms commonly found in biological molecules that are often hydrogen-bond acceptors.
carbon
oxygen
nitrogen
B and C
All of the above.

What happens to nonpolar molecules in water?
They dissolve independently.
They aggregate together.
They precipitate.
All of the above.
None of the above.

What is the $[A^-]/[HA]$ ratio when the weak acid is in a solution one pH unit above its pK_a?
1:1
1:10
10:1
2:1

None of the above.

What are the primary chemical components present in a phosphate buffer at pH 7.4?
H_3PO_4 and PO_4^{-3}
$H_2PO_4^-$ and PO_4^{-3}
HPO_4^{-2} and PO_4^{-3}
$H_2PO_4^-$ and HPO_4^{-2}
H_3PO_4 and HPO_4^{-2}

What is the concentration of acetic acid in 250 ml of a 100 mM acetate buffer at pH 4.76?
250 mM
100 mM
50 mM
75 mM
There is not enough information to tell.

Climate scientists are concerned with the ongoing decrease in the pH of the Earth's oceans. Based on what you know about weak acid/base equilibria, which of the following would contribute to ocean acidification?
An increase in phosphate containing fertilizers from river runoff causes a shift in phosphoric acid equilibrium.
An increase in atmospheric CO_2 causes a shift in carbonic acid equilibrium.
An increase in atmospheric SO_2 emissions causes a shift in sulfuric acid equilibrium.
All of the above.
None of the above.

Citric acid is an important intermediate in glucose metabolism and is synthesized in mitochondrial matrix. The three pK_a values for each of the carboxylic acids are 3.1, 4.8, and 6.4. What would the charge be on a citrate molecule formed in the mitochondrial matrix where the pH is 7.8?
+3
+2
-3
-2
None of the above.

A student observes that when an unknown molecule is added to water, it forms micelles. What can this student infer about this phenomenon?
The unknown molecule is amphipathic.
The micelle formation is driven by the resulting decrease in entropy of water.
The unknown molecule forms many van der Waals interactions with water.
Micelle formation is driven by the hydrophilic effect.
All of the above.

Short-Answer Questions

36. Using Coulomb's law, describe how water is an ideal solvent for the ions found in cells?

What is the significance of hydrogen bonding in biochemical structures such as DNA?

What is an electrostatic interaction? Give an example.

How is water able to be a solvent for so many biological molecules?

What is the net effect of many van der Waals interactions?

How is protein folding driven?

If noncovalent bonds are so much weaker than covalent bonds, how do they stabilize large biochemical structures?

What thermodynamic and free-energy changes participate in protein folding?

How do hydrophobic interactions aid in membrane formation?

Give examples of key functional groups found in biochemistry.

Draw a titration curve for the ionization of acetic acid.

Why are conjugate acid–base pairs so important in biological systems?

Tris buffers are commonly used in biochemistry labs because they buffer within the physiological range of 7.1 to 9.1 due to a pK_a of 8.1. To demonstrate the buffering capacity of Tris buffer, your biochemistry lab teaching assistant has given you one liter of a 0.1 M Tris buffer at pH 7.4. Add 2 mL of 1M HCl to this buffer and calculate what the new pH will be.

Chapter 3 Amino Acids

Matching Questions

Use the following to answer questions 1–10:

Choose the correct answer from the list below. Not all of the answers will be used. Answers may be used more than once.

L amino acids
water
protons
zwitterions
arginine
serine
tyrosine
cysteine
glutamate
histidine
proline
asparagine
D amino acids

_____________: Chiral type of amino acids found in proteins.

_____________: Another name for dipolar molecules.

_____________: Disulfide bonds are formed by pairs of this amino acid.

_____________: The amino acid with a side-chain pK_a just below neutral pH.

_____________: The amino acid with a side group that has a terminal carboxamide.

_____________: The amino acid with an imidazole side chain.

____________: An amino acid that must be supplied by the diet.

____________: The amino acid with a negatively charged side chain at neutral pH.

____________: The amino acid with a sulfhydryl side chain.

____________: The amino acid with the abbreviation Ser.

Fill-in-the-Blank Questions

35 The amino acid that contains a weakly acidic “phenolic” group is ___.

___ are amino acids with neutral R groups containing an electronegative atom.

37 The amino acid with the smallest-size side chain allowing greatest flexibility in a protein is ___.

38 The charge of glycine when the pH is < 2.0 is ___ .

39 Between the amino and the carboxyl functional group, the ___ has the lowest affinity for a proton.

40 The amino acid with an indol ring is ___ .

___ is an amino acid with a hydrophobic side chain containing a thioether.

42 The ___ group is the functional group that makes an amino acid more reactive than nonpolar amino acids such as valine, alanine, and phenylalanine.

The group of amino acids that can be supplied by an organism under a defined condition are the amino acids.

___ is often seen in a child with a protein-deficient diet.

Multiple-Choice Questions

What charged group(s) is/are present in glycine at a pH of 7?

–NH_3^+
–COO^-
–NH_2^+
A and B
A, B, and C

At a pH of 12, what charged group(s) is/are present in glycine?

–NH_3+
–COO^-
–NH_2+
A and B
A, B, and C

In what pH range is zwitterionic alanine the predominate structure?

0–2

9–14
8–10
2–4
2–9

Which amino acids contain reactive aliphatic hydroxyl groups?

serine and methionine
serine and threonine
methionine and threonine
cysteine and methionine
cysteine and threonine

Name three amino acids that are positively charged at a neutral pH.

lysine and arginine
histidine and arginine
cysteine and arginine
lysine and proline
glutamine and histidine

What would interactions between side chains of aspartate and arginine at neutral pH be?
hydrophobic
ionic
hydrogen bonding
steric
covalent

Which amino acid has a side chain with a hydroxyl group?
serine
alanine
tryptophan
histidine
glutamine

Which amino acid has a carboxyl group in its side chain?
glutamine
galanine
cysteine
glutamate
None of the above.

What would the overall charge of a peptide of the following peptide sequence at pH 1 be (Asp-Gly-Arg-His)?
−1
0
1
2
3

Which of the following amino acids would most likely be soluble in a nonpolar solvent such as benzene?
valine
histidine
glutamine
glycine
All of the above.

Below is a list of five tripeptides identified by their single letter codes. They are listed as A, B, C, D, and E. Which tripeptide contains an amino acid capable of forming covalent disulfide bonds?

FNC
RGK
VIL
MDE
SYT

Below is a list of five tripeptides identified by their single letter codes. They are listed as A, B, C, D, and E. Which tripeptide is negatively charged at physiological pH?

FNC
RGK
VIL
MDE
SYT

Below is a list of five tripeptides identified by their single letter codes. They are listed as A, B, C, D, and E. Which tripeptide has the most polar side chains?

FNC
RGK
VIL
MDE
SYT

Where are Trp and Phe found in a globular protein and why?

exterior due to the hydrophilic effect
interior due to the hydrophobic effect
exterior forming polar H-bonds with water
interior forming ionic bonds with other amino acids
exterior forming ionic-polar bonds with water

Amino acids contain all of the following functional groups except:

indole.
thioester.
phenyl.
sulfhydryl.
amine.

Short-Answer Questions

What is the advantage of having multiple functional groups in proteins?

What is the advantage of protein interaction and assembly with other proteins?

Draw the general structure of an amino acid at pH 7.0 with the side group shown as an “R.”

Why is the central carbon on an amino acid so important?

Draw the structure of alanine, aspartic acid, and histidine when the pH is 1.0, 7.0, and 12.0.

What is the net charge of each the following amino acid: alanine, aspartic acid, and histidine when the pH is 1.0, 7.0, and 12.0?

A gene is mutated so the amino acids glycine and glutamate are now alanine and leucine, respectively. What are the potential results of each of these mutations? Assume that the mutations are not near each other in the primary sequence and have no impact on the other.

What are the four ways amino acids can be classified?

What are the three aromatic amino acids?

Which amino acid side chains are capable of ionization?

Which are the branched amino acids, and what impact do they have on protein shape?

Draw a titration curve for glycine.

What do serine, threonine, and tyrosine have in common?

Which amino acid is responsible for stabilizing the structure of a protein by forming pairs of sulfhydryl groups?

What functions make histadine an important amino acid?

Which amino acids have a side chain that includes a modified carboxyl group, carboxaminde?

Which ionizable group has the lowest affinity for protons: the terminal α-carboxyl group, the aspartic acid side group, or the terminal α-amino group?

Malnourished children with Kwashiorkor display a distended stomach, giving the illusion of being full. Why does this happen?

What is the difference between nonessential and essential amino acids?

List the essential amino acids.

Chapter 4 Protein Three-Dimensional Structure

Matching Questions

Use the following to answer questions 1–10:

Choose the correct answer from the list below. Not all of the answers will be used.

amino
water
protons
DNA
secondary structure
tertiary structure
Ramachandran
RNA
domain
cystine
proline
Sanger
D amino acids
cysteine

When a peptide bond is formed between two amino acids, a(n) ____________molecule is lost.

____________: Codes for the sequence of amino acids.

According to convention, ____________ is the terminus drawn on the left side of a peptide.

Two amino acids undergo oxidation to form a dimer called ____________.

Changes in ____________ create amyloid fibers, which are insoluble and are the source of mad cow disease, Alzheimer disease, and Parkinson disease.

____________: Compact regions that may be connected by a flexible segment of polypeptide chain.

____________: This amino acid residue disrupts the α helix because its side chain contains a unique ring structure that restricts bond rotations.

The plot that allows one to investigate the likely orientation of certain amino acid pairs is called the _____________.

_____________: The type of structure to which α helices, β sheets, and turns are referred.

The overall 3D-structure of a single polypeptide chain is referred to as _____________.

Fill-in-the-Blank Questions

90 The ___ of a disulfide bridge results in a separation of two protein chains.

91 The peptide bond is also known as a(n) ___ .

92 Peptides differ from proteins in ___ .

93 Due to the side chain steric clash, almost all peptide bonds are ___in their configuration.

The secondary structure that is stabilized by CO and NH hydrogen bonding within the peptide chain is the ___.

95 The ___ indicates the left- or right-handedness of an α helix.

___ is a fibrous protein and is the primary component of wool and hair.

97 Every third residue in the protein collagen is ___ .

98 Disulfide bonds in proteins can be reduced to free sulfhydryl groups by reagents such as ___.

99 The β-sheet structure occurs when the two strands are oriented in opposite directions (N → C). ___

A protein whose peptide backbone is mostly extended and hydrogen bonded to different strands of the protein is composed mostly of the ___secondary structure.

101 A protein is considered to be _ when it is converted into a randomly coiled structure without its normal activity.

is the major fibrous protein present in skin, bone, tendon, cartilage, and teeth.

103 Collagen contains ___, a modified amino acid.

104 Compact, globular proteins are typically water ___and consist mostly of ___ secondary structure.

refers to the spatial arrangement of subunits and the nature of their interactions.

Multiple-Choice Questions

What determines a protein's function?
its structure
its gene sequence
N-terminal amino acids
None of the above.
All of the above.

What is the approximate mass of a protein containing 200 amino acids? (Assume there are no other protein modifications.)
20,000
11,000
22,000
222,000
None of the above.

Key properties of proteins include:
a wide range of functional groups.
an ability to possess either rigid or flexible structures as dictated by functional requirements.
the ability to interact with other proteins.
A and B.
All of the above.

Why is the peptide bond planar?
Bulky side chains prevent free rotation around the bond.
It exhibits partial double-bond character, preventing rotation.
Hydrogen bonding between the NH and C=O groups limits movement.
None of the above.
All of the above.

The configuration of most α-carbon atoms of amino acids linked in a peptide bond is:
cis.
circular.
parallel.
trans.
perpendicular.

What structure(s) did Pauling and Corey predict in 1951?
α helix
β sheet
β turn
A, B, and C
A and B

Which of the following protein(s) contain examples of α-helical character?
keratin
ferritin
myosin
tropomyosin
All of the above.

Which of the following amino acid residues would most likely be buried in the interior of a water-soluble, globular protein?
aspartate
serine
phenylalanine
lysine
glutamine

Where are β turns and loops often found?
in a hydrophobic pocket
on the interior cleft
at the protein interface with ligand
on the surface of proteins
None of the above.

The folding of a protein into its native shape can best be described as:
a random event.
a random event catalyzed by ribosome proteins to maintain a low energy structure.
a series of controlled folds with a few random-shaped structures.
a series of repeatable random events where the lowest energy structure is maintained.
an event where the highest possible energy state is stabilized with discrete folding intermediates.

Your study group is trying to identify differences in the four levels of protein structure. Which of the following would you say is true of important stabilizing forces in secondary structure but not tertiary structure?
The structure is stabilized by ionic attractions between oppositely charged side chains.
The structure is stabilized by H-bonding between polar side chains.
The structure is stabilized by hydrophobic interactions between nonpolar side chains.
The structure is stabilized by H-bonding between the oxygen of the backbone carbonyl and the hydrogen of the backbone amine.
None of these differentiate between secondary and tertiary structure.

117 A clinician friend comes to you and tells you she has a patient that she thinks has some sort of defect in the collagen structure. She wants to know what kinds of structural differences there might be. Which of the following is NOT true for defects leading to scurvy or brittle bone disease?
Proline residues are not hydroxylated.
Glycine is replaced by other amino acids.
Proyloyl hydroxylase activity is deficient.
Accumulation of defective collagen causes cell death.
All of the above are true.

All of the following would disrupt quaternary structure except:
increase the temperature.
decrease the pH.
add 8 m Urea.
treat with ascorbic acid (vitamin C).
treat with β-mercaptoethanol.

Which of the following secondary structures would you expect to find on the surface of a globular protein?
α helix
β sheet
loops between two α-helices
none of the above because water would disrupt the hydrogen bonding that stabilizes these structures
A, B, and C as long as the polar and charged amino acid side chains face the surface of the protein

The metamorphic protein lymphotactin undergoes changes in ____what_______ structure in order to carry out its full biochemical activity?

primary and therefore also tertiary
primary, secondary, and tertiary
quaternary (subunits separate and carry out individual activities)
secondary and tertiary
primary, secondary, tertiary, and quaternary

Short-Answer Questions

How does a protein's amino acid sequence influence the tertiary structure?

What is the advantage of protein interaction and assembly with other proteins?

How does the protein backbone add to structural stability?

Why are all the theoretical combinations of phi and psi not possible?

Describe some of the features of an α helix.

What is the "hydrophobic effect" as it relates to protein structure?

What are the key characteristics that make the peptide bond important to protein folding/structure?

What are prions?

In the ribonuclease experiments performed by Anfinsen, what was the significance of the presence of the reducing agent β-mercaptoethanol?

What is the advantage of having certain regions of partially correct folded regions?

A primary sequence of a protein contains a run of reasonably small amino acids, containing few branched amino acids or serines. This sequence ends in a proline. What can you deduce from this information?

What is the sequence of amino acids found in collagen? What is the significance of the sequence and what is the complication of scurvy?

Prion diseases are often latent; that is, those with prion diseases are asymptomatic for many years after their initial infection. What causes this latency?

Chapter 5 Techniques in Protein Biochemistry

Matching Questions

Use the following to answer questions 1-10:

Choose the correct answer from the list below. Not all of the answers will be used.

HPLC
specific activity
MALDI-TOF mass spectrum
gradient centrifugation
proteome
SDS
two-dimensional electrophoresis
Svedberg
immunoglobulin
differential centrifugation
overlap peptides
affinity chromatography

The ratio of enzyme activity relative to total protein is called ____________.

The first step in protein purification from a homogenate is usually ____________.

_____________ A type of purification that is based on the attraction of the protein for a particular chemical group.

_____________ can be added prior to gel electrophoresis to denature the proteins.

Sedimentation coefficients are expressed in _____________ units.

Proteins with different sedimentation coefficients can be separated by _____________.

In order to sequence a whole protein, _____________ are used.

_____________ The subset of gene products actually expressed by the cell.

_____________ A protein purification technique characterized by high resolution and rapid separation.

_____________ The separation of proteins based on charge then size.

Fill-in-the Blank Questions

Proteins can be separated from small molecules and ions through a semi-permeable membrane by .

145 Molecular exclusion gel or gel-filtration chromatography separates molecules on the basis of __.

In amino acid composition analysis, amino acids are visualized after separation using the chemical reagent __.

In the Edman procedure for peptide sequence, phenyl isothiocyanate is used to selectively remove the ___ residue as a PTH-derivative.

Antibodies used as reagents to quantify proteins or other antigens is the basis for the technique called .__

allows the detection of small amounts and the size of target proteins.

Polypeptides can be fragmented into smaller peptides by cleavage with chymotrypsin, which hydrolyzes the peptide bond at the C-terminal side of __residues.

___ gels are often used as the media for electrophoretic techniques such as SDS-PAGE and isoelectric focusing.

152 The __of a protein is the pH at which its net charge is zero.

Multiple-Choice Questions

When enzymes are purified, the assay is often based on:

A) light absorbance.
B) catalytic activity.
pH.
D) temperature changes.
E) mRNA levels.

Receptor proteins are often assayed using:

binding assays.
enzymatic activity.
amino acid analysis.
None of the above.
All of the above.

What is the advantage of adding SDS to gel electrophoresis?
SDS colors the proteins for visualization.
SDS reduces disulfide bonds.
SDS allows proteins to be separated on the basis of approximate mass.
None of the above.
All of the above.

Two-dimensional electrophoresis is a combination of what two techniques?
isoelectric focusing and affinity chromatography
ion-exchange chromatography and SDS-PAGE
affinity chromatography and SDS-PAGE
isoelectric focusing and SDS-PAGE
isoelectric focusing and ion-exchange chromatography

Which of the following affects the sedimentation of a particle?
A) mass
B) shape
the density of the solution
D) All of the above.
E) A and B

Cyanogen bromide cleaves the peptide bond at:
the carboxyl side of Arg and Lys residues.
the carboxyl side of Met residues.
the amino terminus.
None of the above.
All of the above.

Trypsin cleaves the peptide bond at:
the carboxyl side of Arg and Lys residues.
the carboxyl side of Met residues.
the amino terminus.
None of the above.
All of the above.

Which of the following techniques can be used to determine the size of a target protein?
A) Edman degradation
B) affinity chromatography
western blot
D) ELISA
E) isoelectric focusing gel

What types of molecules can serve as antigens?
A) proteins
B) polysaccharides
metal ions
D) All of the above.
E) A and B

Affinity chromatographs:
allow high resolution and rapid separation.
separate proteins based on size.
separate proteins based on charge.
separate proteins based on attraction to another molecule.
separate proteins based on charge and size.

What conditions could cause changes in the proteome of a cell?
developmental stage
environmental condition
enzymatic modification
All of the above.
None of the above.

Which technique cannot be used for quantitative analysis?
A) gradient centrifugation
B) ELISA
enzyme assay
D) All of the above.
E) None of the above.

Which of the following is true regarding gel filtration chromatography and PAGE?
A) In both, small proteins move most rapidly.
B) In both, large proteins move most rapidly.
In PAGE, large proteins move most rapidly but in gel filtration, small proteins move most rapidly.
D) In gel filtration, large proteins move most rapidly, but in PAGE, small proteins move most rapidly.
E) None of the above.

Two proteins are similar in size but differ significantly in the number of acidic and basic amino acids. Which of the following techniques would be best suited to separating these two proteins?
SDS-PAGE and gel-filtration chromatography
isoelectric focusing and dialysis immunoprecipitation
and affinity chromatography isoelectric focusing and
ion-exchange chromatography None of the above.

Two proteins are similar in the number of acidic and basic amino acids but are different significantly in size. Which of the following techniques would be best suited to separating these two proteins?
SDS-PAGE and gel-filtration chromatography
isoelectric focusing and dialysis
immunoprecipitation and affinity chromatography
isoelectric focusing and ion-exchange chromatography
None of the above.

Calmodulin is a calcium-binding protein expressed in eukaryotic cells. What two techniques would greatly reduce the number of steps to purify calmodulin?
SDS-PAGE and gel-filtration chromatography
isoelectric focusing and dialysis
immunoprecipitation and affinity chromatography
isoelectric focusing and ion-exchange chromatography
None of the above.

You have isolated a protein, but by the time you have gotten it pure, you have only enough sample to do one type of analysis. Which of the following would you choose and why?
MALDI-TOF mass spectrometry to determine as much sequence data as you can.
ELIZA to identify any antigenic determinants.
Amino Acid Composition Analysis because it can be done for the whole protein.
2D gel electrophoresis to determine charge and size data of the protein.
Salting out to concentrate the protein for further study.

You are interested in studying a powerful enzyme that is expressed in low amounts. Which of the following would you choose to determine how much is found in the tissue of interest?
MALDI-TOF mass spectrometry to determine as much sequence data as you can.
ELIZA to identify any antigenic determinants.
Amino Acid Composition Analysis because it can be done for the whole protein.
2D gel electrophoresis to determine charge and size data of the protein.
Salting out to concentrate the protein for further study.

Short-Answer Questions

Why is an assay necessary for protein purification studies?

How is lactic acid dehydrogenase assayed?

How do gel-filtration and ion-exchange chromatography differ?

How can a protein’s isoelectric point be used in protein purification?

What is the purpose of determining the specific activity, yield, and purification level of a protein purification protocol?

What type of information can be obtained from gradient centrifugation?

Describe the Edman degradation method for protein-sequence analysis.

How can the amino acid sequences be used to design a DNA probe?

Explain the process of immunoprecipitation.

Explain the trend of specific activity as a protein is purified.

List five possible steps in protein purification. Start with a technique used on a complex mixture of proteins such as a cell lysate through a series of steps to a pure protein.

Why is there a need for different digestion tools when fingerprinting a protein?

A protein that on a SDS PAGE runs as a single 25,000 dalton band runs as a 75,000 dalton band on a native gel. Why?

Chapter 6 Basic Concepts of Enzyme Action

Matching Questions

Use the following to answer questions 1-10:

Choose the correct answer from the list below. Not all of the answers will be used.

apoenzymes
hydrolyases
active site
transition state
spontaneous
induced fit
energy
prosthetic group
lock and key
substrate(s)
oxidoreductases
equilibria

____________ The site on the enzyme where the reaction occurs.

____________ The substance that the enzyme binds and converts to product.

Enzymes that do not have the required cofactor bound are called ____________.

A tightly bound cofactor might be called a(n) ____________.

Enzymes will decrease the energy of activation but do not change the ____________ of a chemical reaction.

A reaction that is exergonic will be ____________.

An endergonic reaction requires an input of ____________ to proceed.

Enzymes that transfer electrons are called ___________.

Enzymes that cleave molecules by addition of water are called ____________.

Which model is more appropriate to explain an enzyme binding to its substrate?

Fill-in-the-Blank Questions

194 Enzymes accelerate the rate of a chemical reaction by _ the free energy of activation of the reaction.

The difference between the standard-state free energy, ΔG^{o}, and the biochemical standard-state free energy is that ΔG^{o} refers to the standard free-energy change at __.

196 An enzyme that loosely binds substrate will have a __ level of specificity.

197 Organic cofactors are referred to as __ .

198 A reaction can occur spontaneously only if ΔG is _ .

199 When ΔG for a system is zero, the system is at __.

200 An enzyme that has been stripped of small molecules needed for activity is called __.

201 The total change of free energy in a reaction depends on ___and ___ .

202 The difference in values for ΔG and $\Delta G_o'$ is in the ___.

Competitive inhibitors that mimic the substrate while in the transition state are called ___ inhibitors.

Multiple-Choice Questions

What is the common strategy by which catalysis occurs?
increasing the probability of product formation
shifting the reaction equilibrium
stabilization the transition state
All of the above.
None of the above.

An enzyme will specifically bind its substrate because of____________
a tight lock and key binding mechanism.
a high number of hydrophobic amino acids in the center of the protein.
a large number of weak interactions at the active site.
additional nonprotein cofactors.
None of the above.

Examples of cofactors include:
Zn^{+2}, Mg^{+2}, and Ni^{+2}.
biotin and thiamine pyrophosphate.
pyridoxal phosphate and coenzyme A.
B and C.
All of the above.

A cofactor is best defined as ______________.
another protein
a covalently bound inorganic molecule
a small molecule that holds the substrate in the active site
a molecule responsible for most of the catalytic activity of the enzyme
None of the above.

Which of the following is true?
Enzymes force reactions to proceed in only one direction.
Enzymes alter the equilibrium of the reaction.
Enzymes alter the standard free energy of the reaction.
All of the above.
None of the above.

The Gibbs free energy of activation is:
the difference between the substrate and the transition state.
the difference between the substrate and the product.
the difference between the product and the transition state.
All of the above.
None of the above.

At equilibrium, the Gibb's free energy is ___________.
a positive value
neutral
a negative value
zero
one

The rate of a reaction, or how fast a reaction will proceed, is best determined by __________.
ΔR
$\Delta G^{\ddagger}$
$\Delta G^{o\prime}$
ΔH
None of the above.

The relationship between $\Delta G^{o\prime}$ and ΔG is best described as _______________.
determined by the temperature
described by changes in K_{eq}
differ from standard state to physiological or actual concentrations of reactants and products
dependent on the reaction mechanism of the reaction
differ only in terms of the types of reactions used for each value

For the two reactions a) $A \rightarrow B$ $\Delta G^{o\prime} = 2$ kJmol^{-1} and b) $X \rightarrow Y$ $\Delta G^{o\prime} = -3.5$ kJmol^{-1}, which of the following statements is correct?
Reaction a is not spontaneous at cellular concentrations.
Reaction b will react very quickly.
Reaction a is a more thermodynamically favorable reaction than b.
Neither reaction is reversible.
None of the above.

A graph of product versus time (as in Fig. 6.2 in your textbook) for an enzyme is determined to be hyperbolic. Why does the amount of product level off as time increases?
The reaction has reached equilibrium, that is, the forward and reverse reactions are occurring at a fixed rate.
There is a product inhibition of the enzyme.
The reaction runs out of reaction materials.
The enzyme has finished accelerating the reaction.
None of the above.

The free energy of activation is _______________.
the amount of chemical energy available in the transition state
the difference in free energy between the substrate and product
the free energy gained by adding a catalyst
the difference in free energy between the transition state and the substrate
All of the above.

The molecular structure that is short-lived and neither substrate nor product is known as_______.
substrate analog
transition state
free energy stabilization state
catalysis state
equilibrium intermediate

Riboflavin is a water-soluble organic substance that is not synthesized by humans. Metabolically, it is chemically converted into a substance called flavin adenine dinucleotide, which is required by succinate dehydrogenase. Which of the following statements is **most** correct?
Riboflavin is a coenzyme.
Flavin adenine dinucleotide is a vitamin.
Succiniate dehydrogenase is a coenzyme.
Flavin adenine dinucleotide is a coenzyme.

The active site of an enzyme_____________.
is a series of amino acids that bind the enzyme
is a linear sequence of amino acids that react with each other
binds covalently to the substrate
allows water to enter into the solvate the substrate
None of the above.

The conversion of glucose-6-phosphate to fructose-6-phosphate is catalyzed by an isomerase enzyme. Glucose-6-phosphate was mixed with the enzyme under standard conditions and the reaction was allowed to come to equilibrium. If the K_{eq}' is 0.50 and the equilibrium [glucose-6-phosphate] is 1.43 M, what is the equilibrium [fructose-6-phosphate]?

1.00 M
1.33 M
0.667 M
0.250 M
0.150 M

The conversion of glucose-6-phosphate to fructose-6-phosphate is catalyzed by an isomerase enzyme. Glucose-6-phosphate was mixed with the enzyme under standard conditions and the reaction was allowed to come to equilibrium. If the K_{eq}' is 0.50, what is the $\Delta G^{\circ\prime}$ in kJ/mol?

+0.99
+1.71
0, as defined by equilibrium conditions
–0.99
–2.27

The conversion of glucose-6-phosphate to fructose-6-phosphate is catalyzed by an isomerase enzyme. Under cellular conditions (37$_{o}$C), the glucose-6-phosphate is 6.6 μM and the fructose-6-phosphate is 1.3 μM. If the K_{eq}' is 0.50, what is the ΔG in kJ/mol? (Hint: Use the $\Delta G^{\circ\prime}$ from the previous question.)

+4.19
–1.81
–4.03
–2.50
–1.75

That many transition-state analogs bind more tightly than the native substrate reinforces the concept that:

transition-state analogs are planar structures.
transition-state analogs are highly charged at physiological pH.
binding to the transition state is through a lock-and-key-mechanism.
transition-state analogs are hydrophobic.
binding to the transition state is through an induced-fit mechanism.

Short-Answer Questions

What is the relation between an enzyme-catalyzed reaction and the transition state of a reaction?

What is the difference between prosthetic groups and coenzymes?

How do enzymes facilitate the formation of the transition state?

How is the substrate bound to the active site?

You believe a substrate fits into a cleft like a key into a lock, but your roommate does not. Who is right?

In an enzymatic reaction in a test tube, the reaction will eventually reach equilibrium. Why does this not happen in living organisms?

How is free energy useful for understanding enzyme function?

While some enzymes have very specific substrates, others are more promiscuous. What would you suspect is the reason for this?

Multiple dilution and dialysis of a purified protein results in a loss of enzymatic activity. What might be the cause for this? Assume the structure of the protein is retained.

If $K_{eq} = 1$, what is the $\Delta G°'$? If $K_{eq} > 1$, what is the $\Delta G°'$? If $K_{eq} < 1$, what is the $\Delta G°'$?

The free energy change ($\Delta G'$) for the oxidation of the sugar molecules in a sheet of paper into CO_2 and H_2O is large and negative (the = $\Delta G°'$ – 2833 kJ/mol). Explain why paper is stable at room temperature in the presence of oxygen (O_2).

The $\Delta G^{\circ\prime}$ for the hydrolysis of ATP to ADP + P_i is approximately –31kJ/mole. Calculate the equilibrium constant for this reaction (R = 8.314J/°mole) at the cellular temperature of 37°C. If the cellular concentrations of ATP, ADP, and Pi are 8, 1, and 8mM, respectively, is the above reaction at equilibrium in the cell?

How does a rigid, lock and key model for substrate binding not fit with the formation of the transition state?

A mutation of a proteolytic enzyme described in Section 6.1 results in a stable covalent bond between one of the catalytic amino acids of the protease with its protein substrate. What would be the most likely outcome of enzyme function?

What are transition state analogs?

Chapter 7 Kinetics and Regulation

Matching Questions

Use the following to answer questions 1-10:

Choose the correct answer from the list below. Not all of the answers will be used.

first-order reaction
second-order reaction
metabolism
ensemble
biomolecular
turnover number
Michaelis
equilibrium
sequential
kinetics
initial reaction velocity
allosteric
ping-pong

____________is a complex array of enzyme catalyzed reactions organized in multiple pathways.

_______________ is the study of rates of chemical reactions.

A reaction that is directly proportional to the concentration of reactant is a ____________.

A reaction with two substrates is considered a ____________ reaction.

At ____________ there will be no net change in the concentration of substrate or product.

The value Vo is called the ____________.

The k_{cat} is often referred to as the ____________.

The property that describes the enzyme-substrate interaction is measured by what constant?

____________ Enzymes that do not obey Michaelis–Menten kinetics.

____________ Experiments that determine the kinetics of a population of enzyme molecules.

Fill-in-the-Blank Questions

248 One way to measure the rate of an enzymatic reaction is to measure the loss of ___ over time.

249 Reactions that have more than two reactants or substrates are considered ___ reactions.

250 The ___ rule states that all subunits in an allosteric enzyme must be in either the R or the R state; no hybrids.

251 The Michaelis–Menten model assumes that ___ is the rate constant ignored because P has not accumulated.

is directly dependent on enzyme concentration.

An enzyme will be most sensitive to changes in cellular substrate concentration when the concentration is___.

The type of inhibition where the product of one enzyme inhibits another enzyme that acts earlier in a metabolic pathway is considered a(an)___ inhibitor.

Allosteric enzymes can be identified because the plot of initial velocity, V_0, versus substrate concentration, S, is not hyperbolic but ___-shaped.

256 Negative allosteric ___stabilize the T-state of the enzyme.

257 The straight-line kinetic plot of 1/ V_0 versus 1/S is called a ___.

Multiple-Choice Questions

A critical feature of the Michaelis–Menten model of enzyme catalysis is
increasing the probability of product formation.
shifting the reaction equilibrium.
formation of an ES complex.
All of the above.
None of the above.

What value of [S], as a fraction of K_M is required to obtain 20% V_{max}? [S] =
0.2 K_M
0.25 K_M
0.5 K_M
0.75 K_M
0.8 K_M

Allosteric proteins:
contain distinct regulatory sites and have multiple functional sites.
display cooperativity.
always consist of several identical subunits.
A and B.
A, B, and C.

Allosteric effectors alter the equilibria between:
the ES state.
the R and T forms of a protein.
the forward and reverse reaction rate.
the formation of product and it's reverse reaction.
All of the above.

262 The formula $V_0 = V_{max} \dfrac{[S]}{[S] + K_M}$, indicates the relationship between

A) the enzyme activity and the equilibrium constant.
B) the rate of a catalyzed reaction and the equilibrium constant.
C) enzyme activity as a function of substrate concentration.
D) All of the above.
E) None of the above.

The model describing allosteric regulation that requires all subunits to be in the same state is called the ________.
concerted model
syncopated model
cooperative model
equilibrium model
None of the above.

Loss of allosteric regulation in the production of purine nucleotides results in ___________.
excess nucleotides for DNA
loss of RNA due to ribose phosphate synthetase
decreased urate degradation
loss in urate concentration
None of the above.

The K_M is:
equal to the product concentration at initial reaction conditions.
equal to the substrate concentration when the reaction rate is half its maximal value.
proportional to the standard free energy.
All of the above.
None of the above.

Given are five K_M values for the binding of substrates to a particular enzyme. Which has the strongest affinity when k_{-1} is greater than k_2?
A) 150 mM B) 0.15 mM C) 150 μM D) 1.5 nM E) 15,000 pM

When substrate concentration is much greater than K_M, the rate of catalysis is almost equal to A) K_d. B) $k_{cat.}$ C) V_{max}. D) All of the above. E) None of the above.

Which of the following is true under the following conditions: The enzyme concentration is 5 nM, the substrate concentration is 5 mM, and the K_M is 5 μM.
The enzyme is saturated with substrate.
Most of the enzyme does not have substrate bound.
There is more enzyme than substrate.
All of the above.
None of the above.

Homotrophic effects of allosteric enzymes:
A) are due to the effects of substrates.
B) are due to the effects of allosteric activators.
shift the kinetics curve to the left.
D) shift the kinetics curve to the right.
E) None of the above.

Multiple substrate enzyme reactions are divided into two classes:
sequential reactions and double displacement reactions.
double displacement reactions and concerted reactions.
sequential reactions and concerted reactions.
A and C.
None of the above.

When [S] << K_M, the enzymatic velocity depends on__________.
the values of k_{cat}/K_M, [S], and [E]t
the V_{max} of the reaction
the affinity of the substrate for the catalytic site
k_{cat}
the formation of the ES complex

Allosteric effectors:
can cause large changes in enzymatic activity.
can lead to a decrease in the availability of a protein.
do not alter the sensitivity of a metabolic pathway.
decrease the sensitivity of the enzyme at nearly all concentrations of substrate.
alter enzyme activity by binding to the active site of an enzyme.

For decades, enzymes have been studied using ensemble methods, but technology now allows them to be studied in singulo. Which of the statements below states one of the significant outcomes of this new technology?
New methods better demonstrate cooperativity of allosteric enzymes.
New methods allow for better determination of k_{cat}.
New methods reveal a distribution of enzyme characteristics.
New methods validate the steady-state assumption of Michaelis–Menten kinetics.
New methods provide understanding of average enzyme kinetic data.

When reaction conditions are such that the amount of substrate is far greater than the amount of enzyme present, then the following conditions are also met.
The [substrate] is much less than K_M.
The V_0 is half V_{max}.
The enzyme is displaying second-order kinetics.
The enzyme is displaying first-order kinetics.
The enzyme is displaying zero-order kinetics.

During the early stages of an enzyme purification protocol, when cells have been lysed but cytosolic components have not been separated, the reaction velocity versus substrate concentration is sigmoidal. As you continue to purify the enzyme, the curve shifts to the right. Explain your results.

This is an enzyme that displays Michaelis–Menten kinetics, and you purify away a homotrophic inhibitor.

This is an enzyme that displays Michaelis–Menten kinetics, but you must use a Lineweaver–Burk plot to determine K_M and V_{max} correctly.

This is an allosteric enzyme, but you must use a Lineweaver–Burk plot to determine K_M and V_{max} correctly.

This is an allosteric enzyme, and during purification you purify away a heterotrophic activator.

This is an allosteric enzyme displaying a double-displacement mechanism, and during purification you purify away one of the substrates.

After purifying the enzyme in the previous question, you determine the Mr to be 75,000. By assaying 5 μg of the enzyme under saturating [S] concentrations, you determine the V_{max} to be 1.68 μmol/sec. Calculate the turnover number for this enzyme.

2.25×10^6 sec^{-1}

1.50×10^5 sec^{-1}

2.50×10^4 sec^{-1}

1.79×10^5 sec^{-1}

You need to also know the K_M for this enzyme to calculate turnover number.

Short-Answer Questions

In many enzyme assays, the natural substrate and product are not used. Why?

A protease hydrolyzes the peptide backbone. What is the substrate(s) and product for this reaction? Assuming that the concentration of water is so high (~55M) that it does not appreciably change, to what kind of reaction order would one assign this reaction?

The rate of a reaction is dependent on [ES]. Using an enzyme catalyzed reaction scheme, (6), describe the kinetic model for [ES].

Figure 7.8 is a simplified version of a common set of converging metabolic pathways. Describe the type of regulation necessary if each of the reactions was reversed and a product, A or G, were preferred.

Draw a Cleland notation for a sequential reaction and for a double-displacement reaction.

What is the Michaelis–Menten equation? Define all parameters.

What does V_{max} indicate?

What is the upper limit of k_{cat} / K_M?

How do the intermediate steps in multi-substrate enzyme mechanisms differ?

Describe the difference between the concerted and the sequential model of allosteric regulation.

Would you expect the order of substrate binding to be critical for enzyme catalysis?

What is the turnover number for an enzyme and what does this value tell us about the enzyme?

When designing a drug to inhibit the formation of a product, which requires several enzymes in a metabolic pathway, what should be the first piece of information a biochemist needs in order to develop the drug?

How does the sequential model differ from the concerted model for allosteric enzymes?

Draw a sketch of a Michaelis–Menten plot and a Lineweaver–Burk plot. Identify how you would determine K_M and V_{max} from each of these plots. Explain why the Michaelis–Menten is used more widely than the Lineweaver–Burk plot even though, in general, straight-line plots are easier to interpret.

Chapter 8 Mechanisms and Inhibitors

Matching Questions

Use the following to answer questions 1-10:

Choose the correct answer from the list below. Not all of the answers will be used.

hydrolysis
affinity label
tyrosinase
chymotrypsin
pepsin
noncompetitive
uncompetitive
metal ion
approximation and orientation
acid–base
competitive

____________ An enzyme that temporarily undergoes covalent catalysis as part of its mechanism.

____________ The type of reaction catalyzed by proteases.

____________ A protease enzyme with a low pH optimum.

____________ The type of catalysis where two substrates are brought into close proximity.

 ____________ A molecule also known as a substrate analog.

_____________ The inhibitor that binds only to the ES complex and lowers the V_{max} and K_M.

_____________ The enzyme inhibition that can be overcome by increasing concentration of substrate.

_____________ A type of catalysis where the proton donor is not water.

_____________ A type of enzyme inhibitor where K_M is unaltered.

_____________ An enzyme that is part of a pigment formation pathway and has a low-temperature optimum.

Fill-in-the-Blank Questions

An enzyme catalyst mechanism that uses a metal cation to stabilize a negative charge in the active site is a __.

is a catalytic mechanism that forces two substrates into an appropriate 3-dimensional arrangement for the reaction to occur.

304 The antibiotic, penicillin, is an example of what kind of inhibitor? __.

In conducting an experiment with a new drug, you find that regardless of the concentration of substrate, the drug is able to inhibit the enzyme activity. You are likely to not have what kind of inhibitor? .

306 An uncompetitive inhibitor will have two __lines on a double-reciprocal plot.

A inhibitor binds irreversibly to the active site of an enzyme.

308 The ___stabilizes the tetrahedral intermediate of the hydrolysis of a peptide bond by chymotrypsin.

A inhibitor has a structure similar to the substrate and reversibly binds to the active site of the enzyme.

310 The straight-line kinetic plot of 1/ V_0 versus 1/S is called a ___.

Which amino acids in chymotrypsin are found in the active site and are participants in substrate cleavage? .

A) his, ser, asp B) his, ser, asn C) asp, lys, ser D) lys, arg, asn E) his, ser, arg

312 The mechanism of chymotrypsin involves the formation of an unstable ___-shaped intermediate that is stabilized by the oxyanion hole.

Multiple-Choice Questions

What conclusion can be drawn concerning an inhibitor if the K_M is the same in the presence and absence of the inhibitor?
The inhibitor binds to the substrate.
The inhibitor has a structure that is not very similar to the substrate.
The inhibitor forms a reversible covalent bond with the enzyme.
The inhibitor binds to the same active site as the substrate.
The V_{max} is larger in the presence of inhibitor.

What type(s) of inhibition can be reversed?
A) competitive
B) noncompetitive
uncompetitive
D) All of the above.
E) None of the above.

In what type of inhibition can the inhibitor only bind to the ES complex to form an ESI complex?
A) competitive
B) noncompetitive
irreversible
D) uncompetitive
E) None of the above.

How is specificity determined by chymotrypsin?
interaction of the active site amino acids with the substrate
binding of the N-terminus amino acid at the active site
covalent binding of a his residue to the substrate
conformational change upon binding of substrate
binding of the proper amino acid into a deep pocket on the enzyme

Where does cleavage of the scissile bond by chymotrypsin occur?
between a his and ser amino acid
on the N-terminal side of a phe or trp residue
on the C-terminal side of a phe or trp residue
at the N-terminal amino acid
on the C-terminal side of an arg or lys amino acid

An enzyme is optimally active at neutral pH, but activity drops off sharply if the pH is changed, This enzyme is likely to have what in the active site?
the side chains of aspartate and glutamate
two histidine amino acid side chains
a glycine amino acid
polar side chains
nonpolar side chains

In this catalytic strategy, a cofactor serves as an electrophile to stabilize a negative charge on a reaction intermediate.
covalent catalysis
general acid–base catalysis
metal ion catalysis
catalysis by approximation and orientation
irreversible catalysis

In Chapter 7, it stated that double-reciprocal plots were not used to determine K_M and V_{max}; however, they are shown again in Chapter 8, Section 2. What explanation could there be for their use in this chapter?
The slope of the line, + inhibitor, relative to the slope of the line, – inhibitor, gives information about whether or not the enzyme is regulated allosterically.
The x-axis more accurately determines k_{cat} for the reaction + inhibitor.
The slope of the line provides information about the transition state intermediate.
The slope of the line, + inhibitor, relative to the slope of the line, – inhibitor, gives information about the mechanism of inhibition.
The y-axis can be used to determine binding constants for substrate versus inhibitor.

In designing a drug to inhibit an enzyme specific to a new strain of *E. coli*, would you choose a group-specific inhibitor or a mechanism-based inhibitor? Why?
Mechanism-based because it mimics the transition-state intermediate.
Mechanism-based because it modifies a catalytically active group on the enzyme.
Group-specific because it will react to specific R-groups in the enzyme.
Group-specific because its activity can be enhanced with an allosteric inhibitor.
Group-specific because they are structurally similar to the enzyme's substrate.

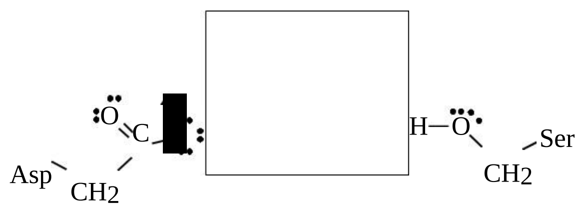
What two biochemical principles explain the enzyme activity versus temperature curve?
The rising portion of the curve is due to increase in Brownian motion of the molecules, and the decrease is due to activation of inhibitor molecules.
An increase in temperature increases the interactions with allosteric activators, and a decrease in temperature increases the interactions with allosteric inhibitors.
The rising portion of the curve is due to increase in Brownian motion of the molecules, and the decrease is due to enzyme denaturation.
The rising portion of the curve is due to increase in enzyme synthesis, and the decrease is due to reduction in Brownian motion of the molecules.
The rising portion of the curve is due to increase in enzyme synthesis, and the decrease is due to activation of inhibitor molecules.

When chymotrypsin activity is monitored with a chromogenic substrate, the kinetics shows a burst phase and a steady-state phase. What does this tell us about chymotrypsin's mechanism of catalysis?
The chromogenic stubtrate is an uncompetitive inhibitor.
The burst phase is due to release of the chromophore and formation of an enzyme-acyl intermediate.
The steady-state phase occurs more rapidly causing a deacylation and release of more chromophore.
All of the above.
None of the above.

Short-Answer Questions

How are the types of inhibition kinetically distinguishable?

Complete the structure of the catalytic triad of chymotrypsin by drawing the proper structure of the missing residue side chain in the box provided. Show the proper hydrogen bonding involved in this triad.



What is the challenge for a protease to facilitate hydrolysis of a peptide bond?

How can covalent modification be used to determine the mechanism of action of an enzyme?

What is an affinity label?

Why are substrate analogs used to monitor enzyme activity?

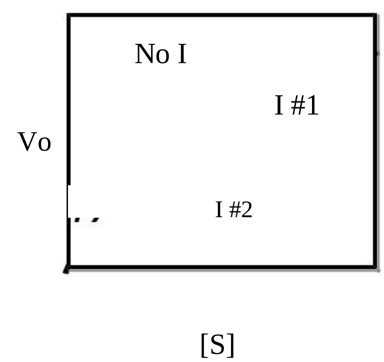
What caused a "burst" of activity followed by a steady-state reaction when chymotrypsin was studied by stop-flow techniques?

Designing drugs to inhibit enzymes is a large part of pharmaceutical research. What are some of the enzymatic features that are important?

What factors should an enzymologist consider when designing an enzyme assay?

There is a key difference between an enzyme that uses a covalent catalysis mechanism and the other catalytic strategies. What is the key difference?

333 Which of the following curves (no inhibitor, inhibitor #1, and inhibitor #2) represents the rate of reaction versus substrate concentration for a competitive and uncompetitive inhibitor. Draw the double-reciprocal plot for each case.



What is the difference between K_M and K_M app?

Draw and describe the reaction pathway for a noncompetitive inhibitor.

What are group specific reagents?

Bacteria that become penicillin resistant express an enzyme called β-lactamase and this enzyme hydrolyses the lactam ring on penicillin. Suggest a reason why this protein allows cells to grow in the presence of penicillin?

The initial reaction kinetics of some enzymes result in a quick burst of product in a short period of time followed by a slower but sustained increase in product formation over time. What does this type of kinetic response tell an enzymologist about the mechanism of the catalysis?

A site directed mutagenesis converting histidine 57 of chymotrypsin to a lysine results in an inactive enzyme even though lysine has an amino group in its side chain. Describe why the scientist may have thought this result surprising and why it wasn't.

How does the enzyme chymotrypsin bind, and specifically, hydrolyze its substrate? How does this differ from other proteases?

Describe the mechanism for the proteolysis catalyzed by chymotrypsin.

You measure the initial velocity of an enzyme in the absence and presence of an inhibitor. In each case the inhibitor is at 10 µM. Show the primary data for all three cases and the Lineweaver–Burk plot. Calculate the K_M and V_{max} for each case both graphically and mathematically. Determine the mechanism for each inhibitor and where they will interact on the enzyme.

	Initial Velocity (µmole/ml min)		
[S] mM	Enzyme alone	Enzyme + inhibitor 1	Enzyme + inhibitor 2
0.33	1.65	1.05	0.79
0.50	2.13	1.43	1.02
1.00	2.99	2.22	1.43
2.00	3.72	3.08	1.79
5.00	4.00	3.80	2.00

Chapter 9 Hemoglobin: An Allosteric Protein

Matching Questions

Use the following to answer questions 1-10:

Choose the correct answer from the list below. Not all of the answers will be used.

cooperative
oxygen
fMRI
carbamate
histidine
hyperbolic
myoglobin
bicarbonate ion
sickle-cell anemia
protoporphyrin
fetal
carbonic acid

_____________ The shape of the myoglobin binding curve that shows that it is not regulated allosterically.

_____________ This is the organic portion of the heme group in hemoglobin.

_____________ This method of studying hemoglobin monitors changes in magnetic fields during the binding of oxygen.

_____________ This is the chemical form in which most of the carbon dioxide is transported in the blood.

____________ This substance is produced when carbon dioxide reacts with water.

_____________ This type of hemoglobin is composed of two α chains and two γ chains.

_____________ This is the molecule whose function is to facilitate diffusion of oxygen in muscle cells.

_____________ The iron atom in heme is bound to the fifth coordination site of this molecule.

_____________ This type of binding is indicated by a sigmoidal-shaped binding curve.

_____________ This condition is a result of a single-point mutation in the β chain of hemoglobin.

Fill-in-the Blank Questions

353 Under normal conditions, the heme iron in myoglobin and hemoglobin is in the _ oxidation state.

The ability of myoglobin to bind oxygen depends on the presence of a bound prosthetic group called .__

355 The form of hemoglobin found in the R state is called __.

356 The binding of 2,3-bisphosphogycerate to hemoglobin __ (increases; decreases) its affinity of oxygen binding.

357 The effect of pH on oxygen binding of hemoglobin is referred to as the __ .

Carbon dioxide reacts with the amino terminal groups of hemoglobin to form carbamate groups, which carry a ___charge.

The T state of hemoglobin is stabilized by a salt bridge between β_1 Asp 94 and the C-terminal of ___the β_1 chain.

In normal adult hemoglobin, HbA, the β6 position is a glutamate residue, whereas in sickle-cell hemoglobin, HbS, it is a ___residue.

As the partial pressure of carbon dioxide increases, the affinity of oxygen binding to hemoglobin .___

362 2,3-Bisphosphoglycerate binds only to the ___form of hemoglobin.

Multiple-Choice Questions

What factor(s) influence(s) the binding of oxygen to myoglobin?
the concentration of bicarbonate ion, HCO_3^-
the partial pressure of oxygen, pO_2
the concentration of hemoglobin present
the concentration of 2,3-BPG
B and D.

Which of the following is correct concerning the differences between hemoglobin and myoglobin?
Both hemoglobin and myoglobin are tetrameric proteins.
Hemoglobin exhibits a hyperbolic O_2 saturation curve while myoglobin exhibits a sigmoid-shaped curve.
Hemoglobin exhibits cooperative binding of O_2 while myoglobin does not.
Hemoglobin exhibits a higher degree of O_2 saturation at all physiologically relevant partial pressures of O_2 than does myoglobin.
All of the above.

Which of the following is NOT correct concerning myoglobin?
The globin chain contains an extensive α-helix structure.
The heme group is bound to the globin chain by two disulfide bonds to cysteine residues.
The iron of the heme group is in the Fe^{2+} oxidation state.
The diameter of the iron ion decreases upon binding to oxygen.
The function of myoglobin is oxygen storage in muscle.

The structure of normal adult hemoglobin can be described as
a tetramer composed of four myoglobin molecules.
a tetramer composed of two αβ dimers.
a tetramer composed of two α_2 and two β_2 dimers.
a tetramer composed of two α_2 and two γ_2 dimers.
None of these accurately describe hemoglobin.

Which of the following is correct concerning fetal hemoglobin?
Fetal hemoglobin is composed of two α and two γ subunits.
Fetal hemoglobin binds 2,3-BPG more tightly than normal adult hemoglobin.
Fetal hemoglobin binds oxygen less than HbA at all pO_2.
Fetal hemoglobin does not exist in the T-form.
None of the above.

Hemoglobin binding of oxygen is best described as a:
concerted model.
Michaelis–Menten model.
sequential model.
combination of sequential and concerted models.
None of the above.

2,3-Bisphosphoglycerate
binds in the central cavity in the T-form of hemoglobin.
preferentially binds to deoxyhemoglobin and stabilizes it.
is present in the red blood cells.
All of the above.
None of the above.

What is the Bohr effect?
the ability of hemoglobin to retain oxygen when in competition with myoglobin
the regulation of hemoglobin binding by hydrogen ions and carbon dioxide
the alteration of hemoglobin conformation during low oxygen stress
All of the above.
None of the above.

Which of the following statements is correct for hemoglobin and oxygen transport?
The oxygen binds to the proximal histidine residue of the globin chain.
Bonding of carbon dioxide to hemoglobin molecules increases the binding of oxygen.
Hemoglobin binds more oxygen as the pH is lowered.
Hemoglobin binds more oxygen at higher [BPG] concentrations.
The binding of each O_2 molecule to hemoglobin increases its affinity for the next O_2.

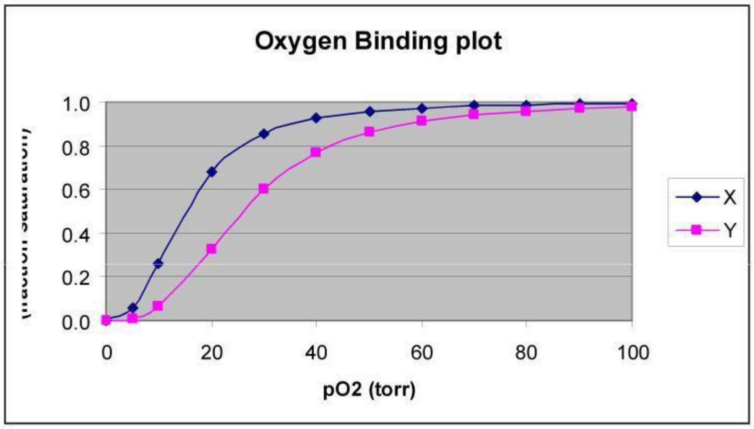
Which of the following describes the Bohr effect?
Lowering the pH results in the release of O_2 from oxyhemoglobin.
Increasing the pressure of CO_2 results in the release of O_2 from oxyhemoglobin.
Increasing the pH increases the T-form of hemoglobin.
All of the above.
A and B.

Which of the following is correct concerning the following equilibria?
$CO_2 + H_2O \rightleftharpoons H_2CO_3$
An increase in the pressure of CO_2 will result in a decrease of pH.
This reaction is catalyzed by carbonic anhydrase.
The H_2CO_3 dissociates to H^+ and bicarbonate ion, HCO_3^-.
The majority of CO_2 is transported to the lungs in the form of HCO_3^-.
All of the above.

Carbon dioxide forms carbamate groups in proteins by reaction with:
aspartate residues.
cysteine residues.
N-terminal amino groups.
tyrosine residues.
heme groups.

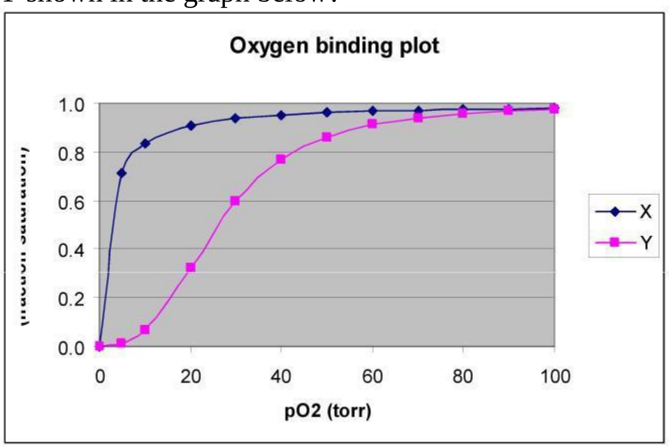
Sickle-cell anemia is caused by:
a decreased production of α chains of hemoglobin.
a substitution of a Glu residue for a Phe residue at the β6 position.
the loss of the heme group because the proximal His is oxidized.
a substitution of a Val residue for a Glu residue at the β6 position.
a substitution of Glu residue for His at the C-terminal of the α chain.

Which of the following is correct concerning the oxygenation plot of proteins X and Y shown in the graph below?



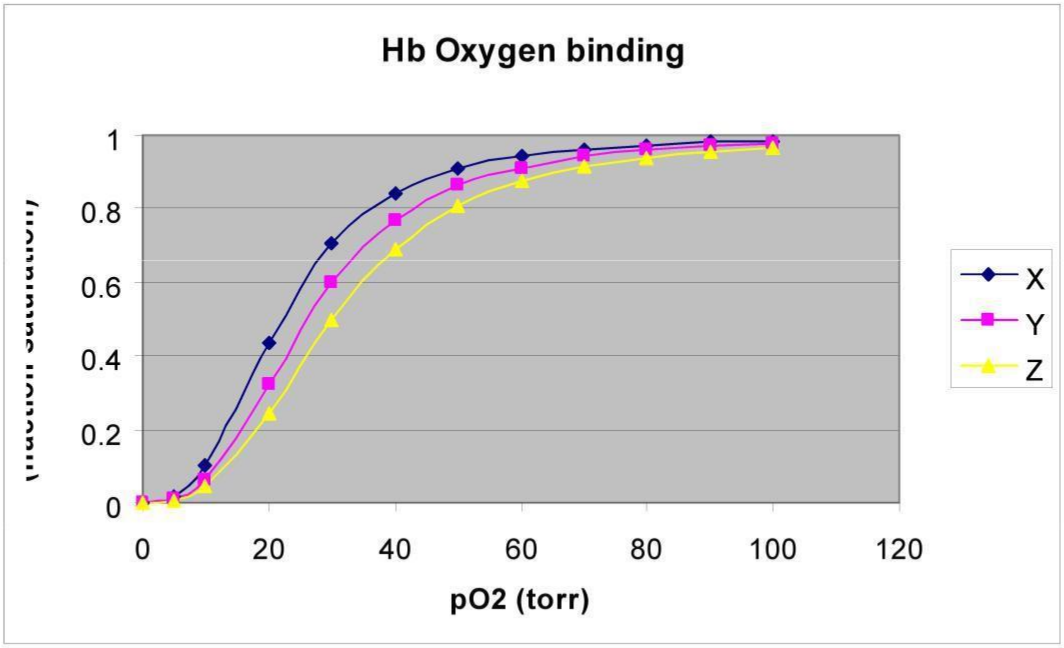
Protein Y exhibits tighter oxygen binding than protein X.
Protein Y corresponds to fetal hemoglobin, and protein X corresponds to normal adult hemoglobin.
Protein X corresponds to fetal hemoglobin, and protein Y corresponds to normal adult hemoglobin.
Protein X corresponds to myoglobin, and protein Y corresponds to hemoglobin.
None of the above.

Which of the following is NOT correct concerning the oxygenation plot of proteins X and Y shown in the graph below?



Protein X exhibits tighter oxygen binding than protein Y.
Protein Y would function as a better transport protein than protein X.
Protein X exhibits cooperative binding, whereas Y does not.
Protein X corresponds to myoglobin, and protein Y corresponds to hemoglobin.
Protein Y contains multiple-binding sites.

Consider the oxygen-binding profile at three different pH values of 7.6, 7.4, and 7.2. Which statement is most correct?



Curve X most likely corresponds to pH 7.2.
Curve Z most likely corresponds to pH 7.6.
Hb has a higher affinity for oxygen at the pH of curve Z.
Curve Y most likely corresponds to pH 7.4.
pH has no effect on the oxygenation of hemoglobin.

What would be the expected result of a Lys residue being substituted with a Ser residue in the BPG binding site of hemoglobin?
BPG would bind tighter because of the loss of a positive charge.
BPG would bind tighter because of the gain of a positive charge.
BPG would bind less tightly because of the loss of a positive charge
BPG would bind less tightly because of the gain of a positive charge.
This substitution would have no effect on the binding of BPG.

Why are blood transfusions a successful treatment for thalassemia but not sickle-cell anemia?
Thallasemia results from a reduced solubility of the deoxygenated form of hemoglobin.
Thallasemia results in high concentrations of deoxygenated hemoglobin.
Thallasemia results in low levels of functional hemoglobin leading to decreased production of RBCs.
Sickle-cell anemia has a single amino acid substitution of valine for glutamate.
Sickle-cell anemia results in tetramers that contain only the β chain leading to decreased production of RBCs.

What does fMRI measure on the molecular level and what does this mean at the tissue level?

fMRI measures the changes in the fifth coordination site in binding iron revealing the amount of carbon monoxide bound in carbon monoxide poisoning.

fMRI measures the changes in the fifth coordination site in binding iron revealing sensory brain activity.

fMRI measures the changes in magnetic properties of γ-chain hemoglobin and is a noninvasive way of measuring fetal hemoglobin levels during pregnancy.

fMRI measures the changes in magnetic properties of hemoglobin revealing the relative amounts of deoxy- and oxyhemoglobin in the circulation of a specific organ

fMRI measures pO_2 levels in the circulatory system in any organ.

Short-Answer Questions

Why is it advantageous for hemoglobin to have allosteric properties?

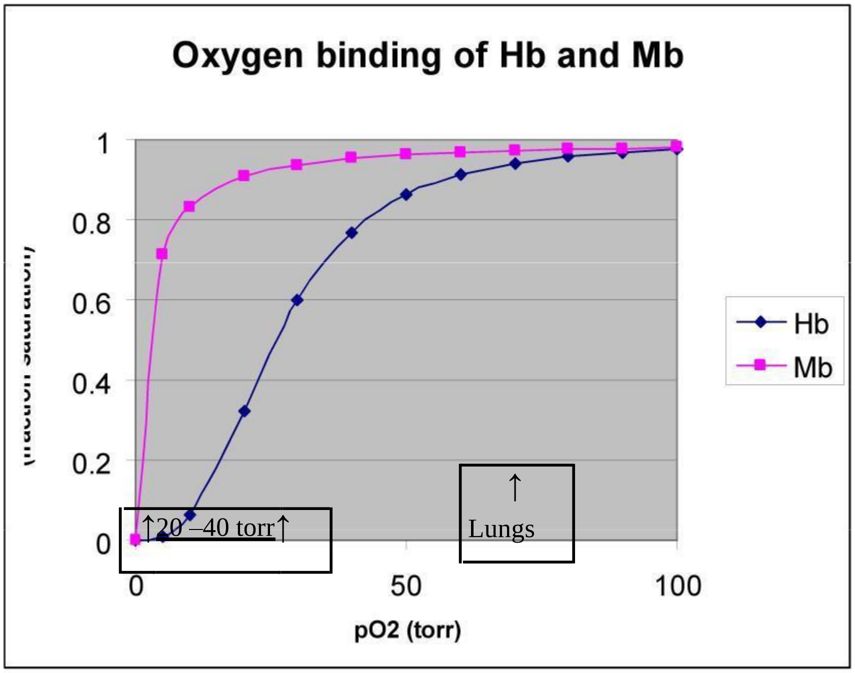
What is fetal hemoglobin? How does it differ from adult hemoglobin?

Describe the octahedral coordination sphere of the iron ion in hemoglobin and myoglobin.

What functional role does the “distal histidine” play in the function of myoglobin and hemoglobin?

Draw the oxygen-binding curve of myoglobin and that of hemoglobin. Indicate the partial pressure of oxygen in the lungs and the range of pressure in tissue.

Ans:



Section: 9.1

Describe the structure of normal adult hemoglobin.

Briefly describe cooperative binding.

Describe the concerted model to explain allosteric cooperative binding.

Describe the role of 2,3-bisphosphoglycerate in the function of hemoglobin.

Describe the chemical basis of the Bohr effect.

Describe how carbon dioxide affects the oxygenation of hemoglobin.

51. Briefly describe the cause of sickle-cell anemia.

How does the binding of oxygen to hemoglobin result in the T-to-R-state transition?

Describe the molecular and physiological adaptations for the high-altitude flying bar-headed goose.

What is the driving force for moving CO_2 out of body tissues and into red blood cells?

Chapter 10 Carbohydrates

Matching Questions

Use the following to answer questions 1-10:

Choose the correct answer from the list below. Not all of the answers will be used.

Fehling's
enantiomers
UDP
glycogen
monosaccharides
cellulose
lectins
heparin
axial
glycoproteins
epimers
glycosyltransferases

_____________ This class of compounds has the molecular formula CH_2O_n.

_____________ These are stereoisomers that are mirror images of one other.

_____________ These monosaccharides differ at a single asymmetric carbon.

_____________ This is one of the most abundant organic molecule in the biosphere.

_____________ This is a test solution used to identify reducing and nonreducing sugars.

_____________ This is the storage form of glucose in animals.

_____________ This is an example of a glycosaminoglycan.

_____________ These are the enzymes that synthesize oligosaccharides.

_____________ These are molecules to which most sugars are attached prior to transfer.

_____________ These proteins bind to specific carbohydrate structures.

Fill-in-the Blank Questions

A ___is a stereoisomer that is not a mirror image.

A ___is a five-membered ring formed from a monosaccharide.

A ___is formed when two monosaccharides are linked together via a glycosidic bond.

Plant starch is composed of amylose, a linear polymer of glucose, and a branched polymer of glucose referred to as ___ .

1 Maltose is composed of two molecules of glucose linked together by a ___ glycosidic bond.

___ is a galactose joined to a glucose by a β-1,4 glycosidic bond.

1 In *N*-linked glycoproteins, the carbohydrate portion is attached to a(n) ___ residue in the protein.

When the carbohydrate portion is attached to a serine or threonine residue in a glycoprotein, it is referred to as a(n) ___ glycoprotein.

1 The influenza virus recognizes ___ residues of glycoproteins present on cell surfaces.

1 Repeating units in ___ have a least one negatively charged carboxylate or sulfate group.

Multiple-Choice Questions

Carbohydrates are:

aldehydes with two or more hydroxyl groups.
ketones with two or more hydroxyl groups.
acids with two or more hydroxyl groups.
alcohols with two or more hydroxyl groups.
A and B.

The simplest carbohydrates are:

D- and L-glyceraldehyde.
dihydroxyacetone and D- and L-glyceraldehyde.
dihydroxyacetone and glycerate.
All of the above.
None of the above.

An aldehyde and alcohol can react to form a:

A) hemialkyl.
B) hemiketal.
hemiacetal.
D) All of the above.
E) None of the above.

Fructose can cyclize to (a):

pyranose ring.

furanose ring.
both pyranose and furanose ring forms.
All of the above.
None of the above.

The nutritional storage form(s) of glucose in plants.
A) glycogen B) amylose C) amylopectin D) B and C. E) All of the above.

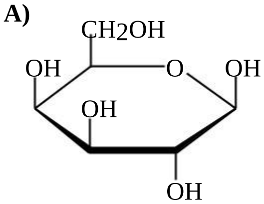
Which enzyme digests amylopectin?
A) α-amylase
B) amylose
C) cellulose
D) All of the above.
E) None of the above.

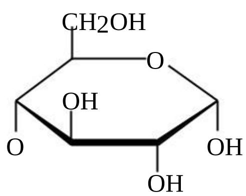
1 To which amino acid residues in glycoproteins are the sugars commonly linked?
A) tyrosine and asparagine
B) serine, threonine, and asparagine
C) serine, tyrosine, and asparagine
D) serine and threonine
E) A and D.

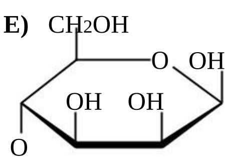
1 Glycoproteins are normally:
A) found on membranes.
B) secreted as extracellular proteins.
C) found inside organelles.
D) A and B.
E) All of the above.

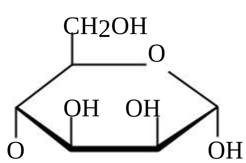
1 All of the following are repeating units of glycosaminoglycans except:
A) chondroitin 6-sulfate.
B) keratin sulfate.
C) hyaluronate.
D) heparin.
E) All of these form glycosaminoglycans.

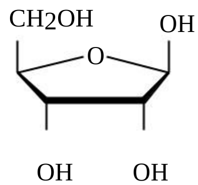
1 Which of the following is the anomer of β-D-glucopyranose?

A)


C)


E)


B)


D)


All of the following are thought to play a role in cancer prevention except:
glucosinolates that are formed by the condensation of glucose with an organic isothiocyanate.
plants of the order Brassicales hydrolyze glucosinolates and that store organic isothiocyanates as a defense against herbivory.
organic isothiocyanates that have a mustard-oil flavor.
Brassicales, which include mustard, relish, kale, and broccoli.
in humans, glucosinolates that stimulate the production of detoxifying enzymes.

Selectins are proteins that:
selectively bind proteins destined for lysozomes.
aid in selection of proteins bound for the Golgi complex.
bind immune-system cells as part of the inflammatory response.
All of the above.
None of the above.

What are lectins?
proteins that bind the carbohydrates on glycoproteins and other macromolecules
proteins that promote cell-cell interaction
proteins found in animals, plants, and microorganisms
All of the above.
None of the above.

How do some viruses gain entry into specific cells?
by attaching to ion channels
by cleaving the glycosidic bonds and altering protein shapes
by binding to glycoproteins on the cell surface that are unique to specific cells
All of the above.
None of the above.

Inhibitors against which viral enzyme have potential as anti-influenza agents?
A) calnexin
B) neuramidase
selectin
D) All of the above.
E) None of the above.

1 How do some viruses gain entry into specific cells?
by attaching to ion channels
by cleaving the glycosidic bonds and altering protein shapes
by binding to glycoproteins on the cell surface that are unique to specific cells
All of the above.
None of the above.

Biochemists organize proteins with carbohydrates attached into three classes. Below is a list of structural differences in these three classes, one of which is assigned to the wrong class. Identify the incorrect structural correlation.

Unlike glycoproteins and proteoglycans, in mucopolysaccharides carbohydrates are attached via ester bonds to Asp and Glu.

The glycosaminoglycan component of proteoglycans determines their properties.

The defining feature of the mucopolysaccharide is a region of the protein backbone called the variable number of tandem repeats region.

The carbohydrate portion of glycoproteins such as erythropoietin are thought to make it more soluble in blood.

Glycosaminoglycans often have repeating units of disaccharides containing a negatively charged carboxylate or sulfate group.

Short-Answer Questions

List some of the reasons carbohydrates are considered important molecules.

Draw the Fischer projection structures of all of the trioses.

What is the difference between an enantiomer and a diastereoisomer?

How is the D or L configuration determined in carbohydrates?

Draw the Haworth projections of the two pyranose forms of D-glucose.

Draw the structure of lactose. Identify the monosaccharides involved and identify the type of linkage in lactose?

Compare the structures of amylopectin and amylose.

What are the chemical, structural, and functional differences between cellulose and glycogen?

Describe some of the functions of glycosaminoglycans and proteoglycans.

How does a genetic mutation account for some of the different human blood types?

What is the advantage of having different blood types within a species?

What are some of the defining characteristics of mucins?

What are the two primary functions of the Golgi complex?

What are selectins and how do they facilitate development?

Which tissues synthesize mucins and why?

Your grandfather tells you that his doctor is now measuring A1c (a form of hemoglobin) levels to check his diabetes. Your grandfather is confused as to why his doctor would check levels of a protein (hemoglobin) to monitor blood carbohydrate (glucose) levels. What do you tell him?

Chapter 11 Lipids

Matching Questions

Use the following to answer questions 1-10:

Choose the correct answer from the list below. Not all of the answers will be used.

ether-linked lipid
triacylglycerol
sterol
amphipathic
16 or 18
organic solvent
cholesterol
cysteine
phospholipid
prokaryotes
glycolipid
20 or 24
sphingosine
serine

____________ The storage form of fatty acids.

____________ This is the number of carbons in most common fatty acids.

____________ In addition to phospholipids and glycolipids, this is a major type of membrane lipid.

____________ This is a term applied to molecules that have both hydrophilic and hydrophobic moieties.

6 ____________ A lipid is defined as a compound soluble in ________________.

_____________ Lipids that are bound to carbohydrates.

_____________Type of lipid with two acyl chains, a glycerol backbone, and a polar head group.

_____________ Flat polycylic molecule absent in prokaryotic membranes.

_____________ These lipids are less resistant to hydrolysis, potentially due to the way the acyl chain is linked to the glycerol backbone.

_____________ A complex amino alcohol backbone for membrane lipids.

Fill-in-the-Blank Questions

___is a membrane lipid composed of sphingosine, fatty acid, and a simple sugar.

13 The common name of hexadecanoic acid is ___ .

14 In phosphoglycerides, the fatty acids are linked to the glycerol backbone by the ___ linkages.

15 The configuration of most fatty acids in biological systems is ___ .

16 Fatty acids are ionized at physiological pH and so are referred to in their ___form.

___The short-hand notation indicating that there are two *cis* double bonds between carbons 9 and 10 and again between 12 and 13.

The presence of double bonds in fatty acids limits tight packaging and the number ___ of interactions.

___ is the type of glycolipid that contains a branched chain of as many as seven sugar residues.

20 The reduction in tight packing due to cis double bonds ___ the melting temperature of a fatty acid.

21 One important ___ is EPA (eicosapentoenoate) and is found in fatty fish and shellfish.

Multiple-Choice Questions

Membrane lipids are primarily comprised of:
phospholipids. B) glycolipids. C) cholesterol. D) A and B. E) A, B, and C.

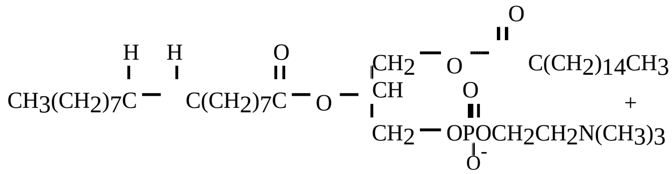
Which of the following is NOT a main function of lipids?
cell signaling
fuel source
structural rigidity of the cytoskeleton
membrane component
All of the above.

Octadecatrienoic acid has how many double bonds?
0
1
2
3
4

An ω-3 fatty acid ____________.
has a methyl group at the carboxyl end of the fatty acid
has a methyl group on the third carbon of the chain
has a double bond the third carbon in from the carboxyl group
has a triple bond on the third carbon from the methyl end of the fatty acid
None of the above.

The notation 12:2 indicates which of the following about a fatty acid?
There are 12 carbons in the chain with two double bonds.
There are two 12-carbon chains for this fatty acid.
The second carbon has a fatty acid double bond.
The 12^{th} carbon has a double bond.
There are two trans-double bonds on this 12-carbon fatty acid.

Which of the following is NOT correct concerning the structure given?



It is a component of biological membranes.
It is amphipathic.
It is a sphingolipid.
It is a phosphoglyceride.
It is phosphatidyl choline.

The longer the fatty acid the ________ the fatty acid.
more oxidized
lower the melting point of
higher the melting point of
more reduced
more double-bond containing

Palmitate has how many carbons in its chain?
12
14
16
20
24

Unsaturations ________ melting points of fatty acids and their derivatives.
maintain
decrease
increase
are unrelated to
None of the above.

Eating ____________ increases the ω-3 fatty acids decreasing ___________.
arachidonic acid, cardiovascular disease
a low fat diet, cardiovascular disease
fatty fish, cardiovascular disease
shellfish, lung cancer
vegetable oils, blood pressure

The backbone of a phospholipid is which of the following?
glucose
cholesterol
fatty acid chain
triacylglycerol
glycerol

The polar head group of phospholipids is found at which carbon of glycerol?
C1
C2
C3
C1-OH
C2-OH

Polar-head groups of phospholipids are esterified to what functional group?
methyl
phosphate
ketone
thiol
aldehyde

A phosphatidate lipid (phosphatidic acid) has which of the following components?
phosphate
glycerol
ester linkage
acyl chain
All of the above.

Which phospholipid is enriched in neural sheath membranes?
phosphatidic acid
phosphatidylcholine
sphingomyelin
diphophatidylglycerol (cardiolipin)
phosphatidylinositol

Identify the differences in archaea membrane lipids compared to those of eukaryotes or bacteria and how these differences help them withstand extreme environmental conditions.

The ether linkages are more, readily hydrolyzed by enzymes allowing the membrane to serve as an energy reserve.
The glycerol moiety is esterified to multiple complex carbohydrate chains making them more soluble in low pH environments.
The fatty acid chains are branched, allowing them to pack more tightly, thereby protecting membrane integrity.
There are two phosphate esters instead of only one giving the archaea better solubility in high salt environments.
Omega ω-3 fatty acids are common in membranes and may act as important precursors as they do in eukaryotes.

You are studying a protein known to be localized to the membrane surface. What protein modifications might you look for to determine how the protein is attached to the membrane?

Determine whether a farnesyl group is attached to a carboxy terminal cysteine residue.
Determine whether a fatty alcohol is attached to a serine residue on the surface of the protein.
Determine whether a glycosylphosphatidylinositol anchor is attached to the carbosy terminus.
A and C only.
All of the above.

Cholesterol and other steroids are not soluble in blood, and therefore must be transported. Predict what chemical modifications must occur for cholesterol to move through the circulatory system.

Cholesterol forms micells in blood, the surface of which is hydrophilic and the interior is hydrophobic.
Cholesterol cannot be transported in blood and so it broken down and resynthesized in all cells.
Cholesterol moves through cell membranes from tissue to tissue.
Cholesterol forms glycolipids with large carbohydrate complexes in order to increase solubility.
Cholesterol is esterified to a fatty acid for transport by lipoprotein particles, the surface of which is hydrophilic and the interior is hydrophobic.

Short-Answer Questions

What does the notation 18:2 for fatty acids imply?

What are the two systems for naming the positions of the double bonds? Provide examples.

What are some molecules that form the polar-head group of phospholipids? Provide several examples.

Explain the biochemical nature of why *trans* bonds do not have the same effect as *cis* bonds on the melting point of fatty acids.

Explain why fats are an efficient way to store biochemical energy.

Draw and label a typical phospholipid.

How are birds that migrate across the Gulf of Mexico able to sustain flight over long distances?
Ans: The energy source for these migrations are fatty acids, stored as triacylglycerols (TAGs). TAGs are stored in a nearly anhydrous form, and as a result, a gram of fat stores more than six times as much energy as a gram of hydrated glycogen.
Section: 11.2

What is the difference between a sphingolipid and a glycerolipid?

Steroid hormones come from what lipid?

Define the different chemical characteristics for the phospholipids, phosphatidylserine, phosphatidylcholine, and phosphadidylinositol.

How does the structure of cholesterol give it a unique structural quality among the lipids?

Based on your knowledge of lipids, guess why some fats from plants are oils (liquid at room temperature) and animal fats are solid at room temperature.

Phosphoglycerides have common but varying structural features. Describe which structural features are common to all phosphoglycerides and which ones vary. Draw correlations between structural variability and membrane function.

Draw the structure of sphingomyelin and label the linkages in this structure.

Chapter 11 Lipids

Matching Questions

Use the following to answer questions 1-10:

Choose the correct answer from the list below. Not all of the answers will be used.

ether-linked lipid
triacylglycerol
sterol
amphipathic
16 or 18
organic solvent
cholesterol
cysteine
phospholipid
prokaryotes
glycolipid
20 or 24
sphingosine
serine

_____________ The storage form of fatty acids.

_____________ This is the number of carbons in most common fatty acids.

_____________ In addition to phospholipids and glycolipids, this is a major type of membrane lipid.

_____________ This is a term applied to molecules that have both hydrophilic and hydrophobic moieties.

_____________ A lipid is defined as a compound soluble in ________________.

_____________ Lipids that are bound to carbohydrates.

_____________Type of lipid with two acyl chains, a glycerol backbone, and a polar head group.

_____________ Flat polycylic molecule absent in prokaryotic membranes.

_____________ These lipids are less resistant to hydrolysis, potentially due to the way the acyl chain is linked to the glycerol backbone.

_____________ A complex amino alcohol backbone for membrane lipids.

Fill-in-the-Blank Questions

___is a membrane lipid composed of sphingosine, fatty acid, and a simple sugar.

65 The common name of hexadecanoic acid is ___ .

66 In phosphoglycerides, the fatty acids are linked to the glycerol backbone by the ___ linkages.

67 The configuration of most fatty acids in biological systems is ___ .

68 Fatty acids are ionized at physiological pH and so are referred to in their ___ form.

___The short-hand notation indicating that there are two *cis* double bonds between carbons 9 and 10 and again between 12 and 13.

The presence of double bonds in fatty acids limits tight packaging and the number ___ of interactions.

___ is the type of glycolipid that contains a branched chain of as many as seven sugar residues.

72 The reduction in tight packing due to cis double bonds ___ the melting temperature of a fatty acid.

73 One important ___ is EPA (eicosapentoenoate) and is found in fatty fish and shellfish.

Multiple-Choice Questions

Membrane lipids are primarily comprised of:
phospholipids. B) glycolipids. C) cholesterol. D) A and B. E) A, B, and C.

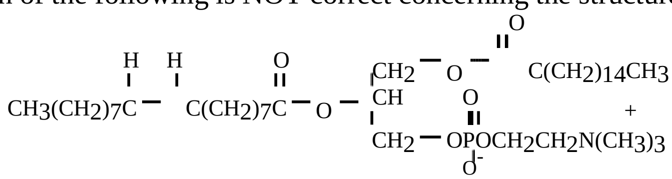
Which of the following is NOT a main function of lipids?
cell signaling
fuel source
structural rigidity of the cytoskeleton
membrane component
All of the above.

Octadecatrienoic acid has how many double bonds?
0
1
2
3
4

An ω-3 fatty acid ____________.
has a methyl group at the carboxyl end of the fatty acid
has a methyl group on the third carbon of the chain
has a double bond the third carbon in from the carboxyl group
has a triple bond on the third carbon from the methyl end of the fatty acid
None of the above.

The notation 12:2 indicates which of the following about a fatty acid?
There are 12 carbons in the chain with two double bonds.
There are two 12-carbon chains for this fatty acid.
The second carbon has a fatty acid double bond.
The 12th carbon has a double bond.
There are two trans-double bonds on this 12-carbon fatty acid.

Which of the following is NOT correct concerning the structure given?



It is a component of biological membranes.
It is amphipathic.
It is a sphingolipid.
It is a phosphoglyceride.
It is phosphatidyl choline.

The longer the fatty acid the ________ the fatty acid.
more oxidized
lower the melting point of
higher the melting point of
more reduced
more double-bond containing

Palmitate has how many carbons in its chain?
12
14
16
20
24

Unsaturations ________ melting points of fatty acids and their derivatives.
maintain
decrease
increase
are unrelated to
None of the above.

Eating ____________ increases the ω-3 fatty acids decreasing ___________.
arachidonic acid, cardiovascular disease
a low fat diet, cardiovascular disease
fatty fish, cardiovascular disease
shellfish, lung cancer
vegetable oils, blood pressure

The backbone of a phospholipid is which of the following?
glucose
cholesterol
fatty acid chain
triacylglycerol
glycerol

The polar head group of phospholipids is found at which carbon of glycerol?
C1
C2
C3
C1-OH
C2-OH

Polar-head groups of phospholipids are esterified to what functional group?
methyl
phosphate
ketone
thiol
aldehyde

A phosphatidate lipid (phosphatidic acid) has which of the following components?
phosphate
glycerol
ester linkage
acyl chain
All of the above.

Which phospholipid is enriched in neural sheath membranes?
phosphatidic acid
phosphatidylcholine
sphingomyelin
diphophatidylglycerol (cardiolipin)
phosphatidylinositol

Identify the differences in archaea membrane lipids compared to those of eukaryotes or bacteria and how these differences help them withstand extreme environmental conditions.
The ether linkages are more, readily hydrolyzed by enzymes allowing the membrane to serve as an energy reserve.
The glycerol moiety is esterified to multiple complex carbohydrate chains making them more soluble in low pH environments.
The fatty acid chains are branched, allowing them to pack more tightly, thereby protecting membrane integrity.
There are two phosphate esters instead of only one giving the archaea better solubility in high salt environments.
Omega ω-3 fatty acids are common in membranes and may act as important precursors as they do in eukaryotes.

You are studying a protein known to be localized to the membrane surface. What protein modifications might you look for to determine how the protein is attached to the membrane?
Determine whether a farnesyl group is attached to a carboxy terminal cysteine residue.
Determine whether a fatty alcohol is attached to a serine residue on the surface of the protein.
Determine whether a glycosylphosphatidylinositol anchor is attached to the carbosy terminus.
A and C only.
All of the above.

Cholesterol and other steroids are not soluble in blood, and therefore must be transported. Predict what chemical modifications must occur for cholesterol to move through the circulatory system.
Cholesterol forms micells in blood, the surface of which is hydrophilic and the interior is hydrophobic.
Cholesterol cannot be transported in blood and so it broken down and resynthesized in all cells.
Cholesterol moves through cell membranes from tissue to tissue.
Cholesterol forms glycolipids with large carbohydrate complexes in order to increase solubility.
Cholesterol is esterified to a fatty acid for transport by lipoprotein particles, the surface of which is hydrophilic and the interior is hydrophobic.

Short-Answer Questions

What does the notation 18:2 for fatty acids imply?

What are the two systems for naming the positions of the double bonds? Provide examples.

What are some molecules that form the polar-head group of phospholipids? Provide several examples.

Explain the biochemical nature of why *trans* bonds do not have the same effect as *cis* bonds on the melting point of fatty acids.

Explain why fats are an efficient way to store biochemical energy.

Draw and label a typical phospholipid.

How are birds that migrate across the Gulf of Mexico able to sustain flight over long distances?

Ans: The energy source for these migrations are fatty acids, stored as triacylglycerols (TAGs). TAGs are stored in a nearly anhydrous form, and as a result, a gram of fat stores more than six times as much energy as a gram of hydrated glycogen.

Section: 11.2

What is the difference between a sphingolipid and a glycerolipid?

Steroid hormones come from what lipid?

Define the different chemical characteristics for the phospholipids, phosphatidylserine, phosphatidylcholine, and phosphadidylinositol.

How does the structure of cholesterol give it a unique structural quality among the lipids?

Based on your knowledge of lipids, guess why some fats from plants are oils (liquid at room temperature) and animal fats are solid at room temperature.

Phosphoglycerides have common but varying structural features. Describe which structural features are common to all phosphoglycerides and which ones vary. Draw correlations between structural variability and membrane function.

Draw the structure of sphingomyelin and label the linkages in this structure.

Chapter 12 Membrane Structure and Function

Matching Questions

Use the following to answer questions 1-10:

Choose the correct answer from the list below. Not all of the answers will be used.

glycolipids
biomolecular sheets
lateral diffusion
integral
hydrophobic effect
acetylsalicylic acid (aspirin)
water lipid
raft
hydrophobic
ions
high
peripheral
low

106 Lipid biolayers spontaneously form ____________.

107 The driving force for the formation of membrane bilayers.

________ has a higher permeability through lipid bilayers than ions and most polar molecules.

____________membrane proteins are embedded in the hydrocarbon chains of membrane lipids.

____________ This substance inhibits prostaglandin H_2 synthase-1 by blocking the channel through which the substrate, arachidonate, travels.

Cells maintain a __________ concentration of intracellular potassium as compared to the extracellular concentration.

____________ The type of amino acid found in the transmembrane helix of an integral protein.

____________ This is the process by which lipids and proteins move in the membrane bilayer.

____________ These membrane components contain carbohydrates.

____________ This is a complex between cholesterol and membrane phospholipids.

Fill-in-the-Blank Questions

is the noncovalent force that favors close packing of the tails of the lipids in a membrane.

are bilayer lipid vesicles with an aqueous compartment.

118 The __of small molecules is correlated with their relative solubilities in water and non-polar solvents.

119 Membranes are said to be ___ because their two faces always differ from each other.

inserts into lipid bilayers, disrupting interactions between fatty acids, thereby helping to maintain membrane fluidity.

membrane proteins are bound primarily by electrostatic and hydrogen bond interactions with the head groups of lipids.

122 Most cell membranes are electrically polarized, the inside being ___relative to the outside.

The rate of lateral diffusion is such that a phospholipid molecule can travel from one end of a bacterium to the other in ___of time.

The temperature at which a phospholipid membrane transitions from a rigid to a fluid state is referred to as ___.

125 An increase in the ratio of saturated to unsaturated fatty acid chains in a membrane the fluidity of the membrane. ___

Multiple-Choice Questions

The energy for __________ transport comes from the gradient itself.
active
facilitated
passive
pumped
ATP-mediated

Which of the following is true?
Membranes are lipid bilayers.
Membrane lipids have both hydrophobic and hydrophilic properties.
Many membranes are electrically polarized.
All of the above.
None of the above.

How many molecules thick are membranes?
two
one
infinite
varying thickness, depending on structure
None of the above.

Which of the following membranes would be the most fluid?
a bilayer made of lipids with polyunsaturated 18 carbon-fatty acids
a bilayer made of lipids with saturated 18 carbon-fatty acids
a bilayer made of lipids with saturated 16 carbon-fatty acids
a bilayer made of lipids with polyunsaturated 16 carbon-fatty acids
All of the above are equivalent in fluidity.

Which of the following statements is consistent with the structure of biological membranes?
All membrane proteins are integral and associate with the hydrophobic region of the membrane.
Both proteins and lipids readily undergo transverse (“flip-flop”) diffusion from the inside to the outside of the membrane.
Membranes are symmetric.
The membrane lipids self-assemble to form the lipid bilayer.
A biological membrane consists of proteins sandwiched between two layers of lipids, which is referred to as a lipid bilayer.

Digitalis is a cardiotoinic steroid that does not act like a steroid. Instead its function is to inhibit____________.
the Na+-K+ pump
fatty acid intake
calcium channels
potassium and sodium pores
dropsy channel

An anti-porter and a symporter are examples of ______________.
passive diffusion
primary active transporters
entropy driven pores
an ABC transporter
secondary transporter

Carbohydrate residues attached to the membrane lipids are
always positioned on the intracellular side of the membrane.
always positioned on the inside center of the bilayer.
always positioned on the extracellular side of the membrane.
always positioned equally on both sides of the membrane.
also covalently attached to membrane proteins.

What force(s) stabilize(s) the lipid bilayers?
van der Waals interactions
electrostatic and hydrogen bonding between the polar heads and surrounding water
covalent bonds between the lipid tails
covalent bonds between the lipids and membrane proteins
A and B

The degree of membrane fluidity depends on
the percentage of lipids that contain choline.
the percentage of glycolipids.
the percentage of free fatty acids.
the percentage of unsaturated fatty acids.
None of the above.

Which is the proper order of permeability of molecules across a membrane, from the most permeable to the least?
A) water, glucose, urea, sodium ion
B) water, indole, glucose, sodium ion
water, indole, sodium ion, glucose
D) indole, glucose, urea, sodium ion
E) indole, water, glucose, sodium ion

The most common motif found in membrane spanning proteins is:
α helices of nonpolar amino acids that pass through the membrane.
α helices of charged amino acids that form channels via extensive hydrogen bonding.
triple helix of α helices.
a helix-turn-helix arrangement of the peptide strands.
None of the above.

The fluorescence recovery after photobleaching (FRAP) technique has been used to study:
membrane composition.
lateral diffusion in membranes.
protein structural motifs in membranes.
All of the above.
None of the above.

The low incidence of protein or lipid flip-flop in a membrane preserves:
A) membrane fluidity.
B) membrane melting temperatures.
membrane asymmetry.
D) All of the above.
E) None of the above.

Which of the following helps regulate membrane fluidity in animals?
A) protein
B) cholesterol
ATP
D) magnesium ion
E) None of the above.

Which of the following describes the role of a protein in the selective permeability of a membrane?
The polar heads of phospholipids in allowing polar molecule to cross membranes.
The binding of steroids to an extracellular peripheral membrane protein.
The insertion of a porin with polar amino acids forming the β strands.
Na^+, K^+-ATPase activity that sets up an electrical potential across the membrane.
All of the above.

Would you agree that a peripheral membrane protein can act as a Na^+, K^+-ATPase and why?
Yes, because the Na^+ and K^+ is available intracellularly and extracellularly.
Yes, because the hydrophobic amino side chains of the α helices firmly anchor the protein to the membrane.
No, because a peripheral protein does not form a transporter across the entire membrane.
No, because only secondary active transport proteins can act as a Na^+,K^+-ATPase.
No, because a P-glycoprotein must also be present for Na^+, K^+-ATPase activity.

What evidence exists to show that membrane asymmetry can be preserved for long periods?
Lateral diffusion from fluorescence recovery after photo-bleaching experiments.
Transverse diffusion of proteins has not been observed.
Facilitated diffusion can take place in either direction depending on the concentration gradient.
Tumor cells often become resistant to drugs.
The α helices in membrane-spanning proteins are hydrophobic and tightly packed.

If you wanted to study how membranes regulate their curvature and budding processes, which of the following membrane structures would you study?
presence of lipid rafts
degree of fatty acid unsaturation
presence of active transport proteins
presence of prostaglandin H_2 synthase-1
None of the above.

Short-Answer Questions

Why are membranes impermeable to most substances?

How do proteins function to make membranes selectively permeable?

What are the key biochemical elements for transmembrane spanning proteins?

Flip flopping of lipids takes place once in several hours. This is evidence for what?

Draw a cross-section of a membrane bilayer and a liposome.

Describe a lipid raft and their potential role in a cell.

How are lipid bilayers formed? What is the driving force?

Why do most phospholipids preferentially form sheets instead of micelles?

What are liposomes? What are some of the current commercial applications?

Describe the effect of introducing a sodium ion pore into a membrane containing the Na^+-glucose symporter.

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What is the function of prostaglandin H_2 synthase-1? How does its position in the membrane facilitate its activity?

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Ans: There are critical amino acids on helical domains in the pore of the channel that face the center. These residues point a carboxyl group inward, which binds potassium ions, creating a selective filter for the K^+ ions
Section: 12.5

How do secondary transporters drive the transport of a substance up its concentration gradient? Ans: The thermodynamically uphill flow of one molecule is coupled to the downhill flow of another.
Section: 12.5

Why do defects in ABC transporters cause such serious health problems?
Ans: ABC transporters are transport proteins that include ATP- binding domains called ATP-binding cassettes (ABCs). ABC transporters are one of the largest protein superfamilies and are found in all forms of life. Examples include multi-drug resistance protein (MRDR) and cystic fibrosis transmembrane regulator (CFTR) . Defects in ABC transporters usually involve a defect in an active transport system within an organ or cell type.
Section: 12.5

Chapter 12 Membrane Structure and Function

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Section: 12.5

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Section: 12.5

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Section: 12.5

Chapter 13Signal-Transduction Pathways

Matching Questions

Use the following to answer questions 1–10:

Choose the correct answer from the list below. Not all of the answers will be used.

protein kinase A (PKA)
calmodulin
fatty acids
proto-oncogene
R_2C_2
R_1C_2
cAMP
phospholipase C
protein kinase C (PKC)
epinephrine
oncogene
small G proteins

1 ____________ The primary messenger responsible for the "fight or flight" response.

The enzyme that becomes active when bound to cAMP is ____________.

____________ The α and γ subunits of heterotrimeric G proteins are anchored to the cell membrane by being covalently linked to these types of molecules.

The ____________ enzyme becomes active when bound to Ca^{2+} and diacylglycerol.

The inactive form of protein kinase A is ____________.

Ras is a member of the ____________ family of proteins.

____________ A gene that leads to the transformation of susceptible cell types into cell types with cancer-like characteristics.

The _____________ protein binds to calcium ions and serves as a Ca^{2+} sensor in eukaryotic cells.

The _____________ molecule functions as a secondary messenger.

_____________ The enzyme that catalyzes the cleavage of PIP_2.

Fill-in-the-Blank Questions

11. Protein kinase A phosphorylates serine and ___residues.

___ is the membrane protein that catalyzes the conversion of ATP to cAMP.

13. The cytosolic side, or β subunit, of the insulin receptor is a ___kinase.

14. The___receptor undergoes dimerization and cross-phosphorylation when activated.

___ is a secondary messenger and is abbreviated IP_3.

16. 7TM is an abbreviation for ___receptors.

___ binds to β-andrenergic receptors.

18. The binding of IP_3 to the IP_3 receptor results in the release of ___from the endoplasmic reticulum.

19. When activated, the insulin receptor results in the mobilization of ___transporters to the cell surface.

20. The ___is a calcium-binding unit in many proteins and is characterized by a helix-loop-helix structure.

Multiple-Choice Questions

Most signal molecules:
easily diffuse through the membrane and bind to a receptor in the cytoplasm.
bind to membrane receptors and transmit information across a membrane without traversing the membrane.
carry out functions in the nucleus after binding to a receptor in the cell membrane.
A and C.
A, B, and C.

Examples of second messengers include:
cAMP.
calcium ion.
diacylglycerol.
A and B.
A, B, and C.

Advantages of second messengers include:
the signal can be amplified by making many second messengers.
can freely diffuse to other sites within the cell.
a few common second messengers can be used in multiple signaling pathways.
All of the above.
None of the above.

Which of the following amino acids can be phosphorylated?
tyrosine, serine, threonine
tyrosine, serine, tryptophan
serine, threonine, asparagine
histidine, serine, phenylalanine
tyrosine, methionine, tryptophan

Which form of the guanyl nucleotide is bound in the unactivated state?
GTP
GDP
GMP
dGTP
None of the above.

The mechanism by which insulin-signaling processes might be terminated includes:
change in temperature.
the aggregation of all protein subunits.
protein dephosphorylation by phosphatases.
All of the above.
None of the above.

How does the binding of a hormone to a receptor activate a G-protein?

It causes an exchange of GTP for bound GDP.
It causes the γ subunit to be released from binding to the β subunit.
It causes an exchange of GDP for bound GTP.
A and B.
None of the above.

Why is bound GTP considered a “clock”?

It behaves in specific time intervals.
GTP is exchanged for GDP after binding to adenylate cyclase.
The G_α receptors have intrinsic GTPase activity, hydrolyzing GTP to GDP and P_i.
All of the above.
None of the above.

The enzyme responsible for induction of the phosphoinositide cascade is:

phospholipase C.
phospholipase A.
C-dependent protein (CDP).
All of the above.
None of the above.

What are the two messenger products formed by cleavage of PIP_2?

diacylglyercol and inositol 1,4,5-triphosphate
diacylglyercol and inositol 1,3,5-triphosphate
diacylglyercol and inositol 1,3-diphosphate
diacylglyercol phosphate and inositol 1,4,5-trisphosphate
None of the above.

How is calmodulin activated?

by binding of both calcium and potassium
by binding Ca^{2+} when the cytosolic concentration is raised
by binding to a positively charged helix on another protein
All of the above.
None of the above.

Cross-phosphorylation is possible when two receptor proteins with kinase domains

are cleaved.
form dimers.
are internalized into organelles.
All of the above.
None of the above.

Example(s) of disease(s) caused by altered G-protein activity include
whooping cough.
cholera.
diabetes.
A and B.
B and C.

_______________ may be effective anti-cancer drugs.
Monoclonal antibodies against offending receptors
EGF mimics
Protein kinase inhibitors
All of the above.
Both A and C.

When insulin binds to its receptor, which of the following occurs?
A PIP_2-dependent kinase is activated.
Calmodulin binds to Ca^{2+}.
Sos stimulates the exchange of GTP for GDP.
All of the above.
None of the above.

Which of the five steps in the generalized scheme of transduction pathways is defective in Cushing Syndrome?
termination
release of primary messenger
relay of information by second messenger
reception of primary messenger
activation of effectors

That Gα subunits have intrinsic GTPase activity is important in which of the five steps in the generalized scheme of transduction pathways?
termination
release of primary messenger
relay of information by second messenger
reception of primary messenger
activation of effectors

The cleavage of PIP_2 is important in which of the five steps in the generalized scheme of transduction pathways?
termination
release of primary messenger
relay of information by second messenger
reception of primary messenger

activation of effectors

7TM proteins action is important in which of the five steps in the generalized scheme of transduction pathways?
termination
release of primary messenger
relay of information by second messenger
reception of primary messenger
activation of effectors

Short-Answer Questions

What are some of the common structural features of the receptors to which signal molecules bind?

What is a disadvantage of using common molecules for signaling paths?

What happens when signaling paths are not terminated properly?

How many 7TM membranes are there? What are some of their functions?

What is the general mechanism for signal transmission by 7TM receptors?

How does binding of epinephrine initiate the cAMP production? Discuss briefly in terms of receptor structure and function.

How is the hormone-bound activated receptor reset after activation?
Ans: The hormone dissociates, and the receptor returns to its initial, unactivated state. It may bind the hormone, depending on the concentration in the environment.
Section: 13.2

47. What are receptor tyrosine kinases? Provide an example.

Describe how phosphatidylinositol-4,5-diphosphate is converted into two secondary messengers.

What is the difference between a proto-oncogene and an oncogene?

What is meant by an EF hand? Draw or describe the structure.

Give the reaction catalyzed by tyrosine kinase.

What steps lead from the activation of a cross-phosphorylated receptor tyrosine kinase to an activated small G protein such as Ras?

What is the difference between heterotrimeric G proteins and small G proteins?

Describe the role of phosphoinositol 4,5-bisphosphate (PIP_2) in insulin signal transduction.

Why are mutated or overexpressed receptor tyrosine kinases frequently observed in tumors?

Chapter 13Signal-Transduction Pathways

Matching Questions

Use the following to answer questions 1–10:

Choose the correct answer from the list below. Not all of the answers will be used.

protein kinase A (PKA)
calmodulin
fatty acids
proto-oncogene
R_2C_2
R_1C_2
cAMP
phospholipase C
protein kinase C (PKC)
epinephrine
oncogene
small G proteins

1 ____________ The primary messenger responsible for the "fight or flight" response.

The enzyme that becomes active when bound to cAMP is ____________.

____________ The α and γ subunits of heterotrimeric G proteins are anchored to the cell membrane by being covalently linked to these types of molecules.

The ____________ enzyme becomes active when bound to Ca^{2+} and diacylglycerol.

The inactive form of protein kinase A is ____________.

Ras is a member of the ____________ family of proteins.

____________ A gene that leads to the transformation of susceptible cell types into cell types with cancer-like characteristics.

The _____________ protein binds to calcium ions and serves as a Ca^{2+} sensor in eukaryotic cells.

The _____________ molecule functions as a secondary messenger.

_____________ The enzyme that catalyzes the cleavage of PIP_2.

Fill-in-the-Blank Questions

11. Protein kinase A phosphorylates serine and ___residues.

___ is the membrane protein that catalyzes the conversion of ATP to cAMP.

13. The cytosolic side, or β subunit, of the insulin receptor is a ___kinase.

14. The___receptor undergoes dimerization and cross-phosphorylation when activated.

___ is a secondary messenger and is abbreviated IP_3.

16. 7TM is an abbreviation for ___receptors.

___ binds to β-andrenergic receptors.

18. The binding of IP_3 to the IP_3 receptor results in the release of ___from the endoplasmic reticulum.

19. When activated, the insulin receptor results in the mobilization of ___transporters to the cell surface.

20. The ___is a calcium-binding unit in many proteins and is characterized by a helix-loop-helix structure.

Multiple-Choice Questions

Most signal molecules:

easily diffuse through the membrane and bind to a receptor in the cytoplasm.
bind to membrane receptors and transmit information across a membrane without traversing the membrane.
carry out functions in the nucleus after binding to a receptor in the cell membrane.
A and C.
A, B, and C.

Examples of second messengers include:

cAMP.
calcium ion.
diacylglycerol.
A and B.
A, B, and C.

Advantages of second messengers include:

the signal can be amplified by making many second messengers.
can freely diffuse to other sites within the cell.
a few common second messengers can be used in multiple signaling pathways.
All of the above.
None of the above.

Which of the following amino acids can be phosphorylated?

tyrosine, serine, threonine
tyrosine, serine, tryptophan
serine, threonine, asparagine
histidine, serine, phenylalanine
tyrosine, methionine, tryptophan

Which form of the guanyl nucleotide is bound in the unactivated state?

GTP
GDP
GMP
dGTP
None of the above.

The mechanism by which insulin-signaling processes might be terminated includes:

change in temperature.
the aggregation of all protein subunits.
protein dephosphorylation by phosphatases.
All of the above.
None of the above.

How does the binding of a hormone to a receptor activate a G-protein?
It causes an exchange of GTP for bound GDP.
It causes the γ subunit to be released from binding to the β subunit.
It causes an exchange of GDP for bound GTP.
A and B.
None of the above.

Why is bound GTP considered a “clock”?
It behaves in specific time intervals.
GTP is exchanged for GDP after binding to adenylate cyclase.
The G_α receptors have intrinsic GTPase activity, hydrolyzing GTP to GDP and P_i.
All of the above.
None of the above.

The enzyme responsible for induction of the phosphoinositide cascade is:
phospholipase C.
phospholipase A.
C-dependent protein (CDP).
All of the above.
None of the above.

What are the two messenger products formed by cleavage of PIP_2?
diacylglyercol and inositol 1,4,5-triphosphate
diacylglyercol and inositol 1,3,5-triphosphate
diacylglyercol and inositol 1,3-diphosphate
diacylglyercol phosphate and inositol 1,4,5-trisphosphate
None of the above.

How is calmodulin activated?
by binding of both calcium and potassium
by binding Ca^{2+} when the cytosolic concentration is raised
by binding to a positively charged helix on another protein
All of the above.
None of the above.

Cross-phosphorylation is possible when two receptor proteins with kinase domains
are cleaved.
form dimers.
are internalized into organelles.
All of the above.
None of the above.

Example(s) of disease(s) caused by altered G-protein activity include
whooping cough.
cholera.
diabetes.
A and B.
B and C.

_______________ may be effective anti-cancer drugs.
Monoclonal antibodies against offending receptors
EGF mimics
Protein kinase inhibitors
All of the above.
Both A and C.

When insulin binds to its receptor, which of the following occurs?
A PIP_2-dependent kinase is activated.
Calmodulin binds to Ca^{2+}.
Sos stimulates the exchange of GTP for GDP.
All of the above.
None of the above.

Which of the five steps in the generalized scheme of transduction pathways is defective in Cushing Syndrome?
termination
release of primary messenger
relay of information by second messenger
reception of primary messenger
activation of effectors

That Gα subunits have intrinsic GTPase activity is important in which of the five steps in the generalized scheme of transduction pathways?
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release of primary messenger
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Chapter 14 Digestion: Turning a Meal into Cellular Biochemicals

Matching Questions

Use the following to answer questions 1-10:

Choose the correct answer from the list below. Not all of the answers will be used.

ATP-dependent proton pump
catabolism
hydrolyzed
pepsin
digestion
zymogen
lipases
anabolism
carbohydrates
lipids
micelle
enteropeptidase

____________ is the first stage in the conversion of foods to energy.

In digestion, proteins are ____________ into their individual 20 amino acids.

____________ is the mechanism by which the stomach maintains a pH of around 1–2 pH units.

____________is a protease released by the stomach for digestion of protein.

____________ activation is a mechanism of permanently activating a protease by covalent modification.

α Amylase begins the digestion of ____________ in the gut.

______________ These enzymes start the hydrolysis of proteins in the small intestine.

____________ are lipid vesicles that act to carry fats to the intestinal epithelium for absorption.

Snake venom contains ____________, which cause hydrolysis of red blood cells.

___________ is a set of reactions that use energy and small molecules to synthesize new biomolecules.

Fill-in-the-Blank Questions

12 The set of reactions that extract biologically useful energy from environmental sources is ___.

13 One common motif in metabolism is that pathways are ___in common ways.

14 The ___pH of the stomach is important for the denaturation of proteins.

15 The pancreas releases ___to neutralize the acid produced in the stomach.

A __is an inactive enzyme that must be partially digested to attain full enzymatic activity.

17 Inactive chymotrypsinogen will be hydrolyzed to become an active enzyme called ___.
18 Amylase digests carbohydrates by cleaving the ___ bonds of starch.

19 The limit dextrin is material not digested by amylase due to the ___ .

Emulsification of lipids requires what amphipathic molecule released from the gall bladder?___

Micelles are important for lipid absorption across the plasma membrane, but secretion into the lumen of the intestine and into the lymph system takes the formation of ___.

22 Dietary fat is primarily transported from the gut to the ___ .

23 Snake venom has a high concentration of ___, which digests the cell membrane.

___causes the release of digestive enzymes from the pancreas.

25 Bile salts are produced from the precursor ___ .

26 Protein digestion leads to release of ___ by intestinal mucosal cells into the blood for use by other tissues.

Multiple-Choice Questions

Digestion is___________

the process of breaking down large molecules in food.
the salvage of metabolic intermediates.
creating energy from foodstuff.
the set of reactions that degrade small molecules into a few simple units.
a pathway activated by steroid hormones.

You are studying a metabolic pathway and are trying to decide if it is an anabolic pathway or a catabolic pathway. Which of the following would help diagnose this problem?

Look for ATP requiring steps.
Look for common intermediates.
Look for enzymes under allosteric regulation
Look for phagocytic activity.
None of the above.

Digestion of which of the following involves hydrolases?
carbohydrates
triacylglycerols
proteins
All of the above.
A and C only.

What is the significance of having transporters move amino acids from the lumen of the small intestine into intestinal cells but anti-porters move them then into blood?
The transporters are driven by a K^{+}/H^{+} *ATPase*, which provides energy to completely deplete the intestine of all amino acids.
The secondary active transport of the anti-porter moves amino acids into blood, regardless of the blood concentrations of amino acids, keeping the intestinal cell concentrations low.
Peptidases in the intestinal cell membrane also act as amino acid transport channels driving amino acids into intestinal cells.
The transporters on the lumen side of the intestinal cell will let oligopeptides into the cell, and the anti-porter ensures that these oligopeptides can be utilized by serum proteins.
None of the above.

A digestible proton pump inhibitor would likely have the following effect:
undigested protein.
nucleic acid hydrolysis.
loss of ATP production.
pepsin activation.
decreasing levels of bile salts.

The pancreas releases _________ to buffer the pH of the stomach juices.
a strong base to counter the strong acid
HCl
$NaHCO_3$
pepsin
ATPase activating protein

Pepsin requires _________ to achieve activity.
low pH
partial denaturation of protein
zymogen activation
All of the above.
None of the above.

Which of the following enzymes activates trypsin?
zymogenase
pepsin
trypsinase
enteropeptidase
carboxypeptidase

All of the following are pancreatic proteases except:
pepsin.
chymotrypsin.
trypsin.
carboxypeptidase.
elastase.

Complex carbohydrates are absorbed:
as acetyl CoA.
as starch or glycogen.
as glucose and simple sugars.
as short 4-glucose residues.
after the digestion of α 1,6 bonds by α amylase.

Glucose transport into intestinal epithelial cells takes place by:
active transport using sodium gradient.
active transport using ATP as the energy source.
passive transport using the glucose gradient.
secondary active transport using potassium gradient.
secondary active transport using the sodium glucose cotransporter.

The result of lipase activity in digestion is:
phopholipid head group hydrolysis.
monoacylgycerol and two free fatty acids.
bile salt formation.
hydrolysis of membrane proteins.
emulsion formation.

The transport of lipids in the lymph is carried out by:
lipases.
micelles.
cholesterol bile salt binding.
chylomicrons.
None of the above.

Snake venom's poison is actually:
a collection of digestive enzymes.
repertory toxins.
paralysis toxins and red blood cell poisons.
All of the above.
None of the above.

Which of the following is released by the upper intestine and increases zymogen secretion?
secritin pepsin
cholecystekinin
bile salts
enteropeptidiase

What is the advantage in synthesizing enzymes as zymogens?
It allows them to be packaged in chyomicrons more easily.
Zymogens can be stored for rapid release when needed.
Depending on the zymogen, it can be activated by the low pH in the stomach or the high pH in the intestine.
Zymogens are resistant to inactivation by kinases.
Diet pills can be designed to inhibit zymogen hydrolysis.

Short-Answer Questions

How are dietary proteins, carbohydrates, and lipids digested?

How is the release of pancreatic enzymes coordinated with digestion in the stomach?

Why is the acidification of the stomach juices important for digestion of proteins?

What would happen if an enzyme mutation occurred that seriously inhibited the activity of amylase?

What is the role of cholesterol in digestion?

What is a limit dextrin?

Non-fat substitutes often come with a warning of runny or watery stool. What metabolic condition is similar?

Explain the mechanism of snake bite poisons.

Why does the drug Omeprazole impact protein digestion more than lipid digestion?

What is a chylomicron?

Chapter 14 Digestion: Turning a Meal into Cellular Biochemicals

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Explain the mechanism of snake bite poisons.

Why does the drug Omeprazole impact protein digestion more than lipid digestion?

What is a chylomicron?

Chapter 15 Metabolism: Basic Concepts and Design

Matching Questions

Use the following to answer questions 1-10:

Choose the correct answer from the list below. Not all of the answers will be used.

O_2
niacin
phototrophs
ATP
CO_2
coenzyme A
vitamins
amphibolic
ADP
NADPH
chemotrophs
FAD

_____________ These organisms use energy from sunlight and convert it to chemical energy.

_____________ These organisms obtain chemical energy from oxidation of foodstuffs.

_____________ Pathways that can be either anabolic or catabolic depending on the energy conditions of the cell.

_____________ In aerobic organisms, this is the ultimate acceptor of electrons.

_____________ In aerobic metabolism, this is the product of oxidation of carbon containing fuels.

_____________ The electron carrier, NADH, is derived from this vitamin.

_____________ This substance is the electron donor in most reductive biosyntheses.

_____________ This compound serves as an acyl carrier in metabolism.

_____________ This is the “chemical currency” of metabolism.

_____________ These small organic compounds are required in the diet of higher organisms and are components of coenzymes.

Fill-in-the-Blank Questions

is the type of metabolism where useful energy is harvested.

___

A thermodynamically unfavorable reaction can be driven by a thermodynamically favorable reaction to which it is ___.

116 ATP is considered an “energy rich” compound because it contains two ___ bonds.

In the cell, the hydrolysis of an ATP molecule in a coupled reaction changes the equilibrium ratio of products to reactants by a factor of ___ .

118 In vertebrate muscle, ___ serves as a reservoir of high-potential phosphoryl groups that can be readily transferred to ADP to regenerate ATP.

is the process of building larger molecules from smaller ones.

120 FAD is an electron carrier that is derived from the vitamin ___ .

121 The acetyl group is attached to coenzyme A by a ___bond.

122 ATP-generating (catabolic) pathways are inhibited by a ___ (high, low) energy charge.

123 One way that metabolism is regulated is through control of the accessibility of ___ .

Multiple-Choice Questions

The major purpose(s) for which organisms require energy is/are:
A) performance of mechanical work.
B) active transport.
synthesis of biomolecules.
D) A and C.
E) A, B, and C.

Reaction pathways that transform fuels into cellular energy are:
A) anabolic.
B) catabolic.
allobolic.
D) All of the above.
E) None of the above.

Metabolic pathways that require energy and are often biosynthetic processes are:
A) anabolic.
B) catabolic.
allobolic.
D) All of the above.
E) None of the above.

Electron carrier(s) that include ATP are:
A) NAD^+ B) FAD C) FMN D) A and B. E) A, B, and C.

What is the standard-state free energy ($\Delta G°'$) for the hydrolysis of ATP to ADP?
A) +45.6 kJ/mol
B) −45.6 kJ/mol
−5 kJ/mol
D) −14.6 kJ/mol
E) +5 kJ/mol

Which of the following molecule(s) have a higher phosphoryl-transfer potential than ATP?
A) phosphoenolpyruvate
B) creatine phosphate
1,3-bisphosphoglycerate
D) A and B.
E) C, B, and C.

This energy source is used to regenerate ATP from ADP and P_i.
oxidation of carbon to CO_2
electrochemical potential of stored glycogen
reduction of pyruvate to lactate
All of the above.
None of the above.

The reduced form of flavin adenine dinucleotide is:
A) FADH. B) FAD. C) $FADH^{++}$. D) $FADH_2$. E) None of the above.

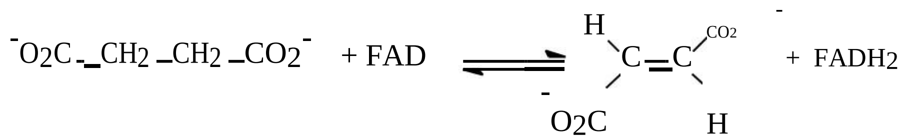
Which of the following is the electron donor used for reductive biosynthesis?
A) NADH
B) NADPH
$FADH_2$
D) CoASH
E) ATP

Pantothenate kinase associated degeneration:
A) is a predominantly neurological disorder.
B) can cause anemia.
affects tissues that are dependent on aerobic metabolism.
D) A and C.
E) A, B, and C.

Which is the correct coenzyme: carrier pair?
NADH: acyl
tetrahydrofolate: electrons
coenzyme A: acyl
lipoamide: aldehyde.
thiamine pyrophosphate: glucose

Which activated carriers contain adenosine phosphate units?
A) NADH B) $FADH_2$ C) coenzyme A D) A and B. E) A, B, and C.

Which of the following is an example of an oxidation reaction?

A)


B) $CH_3COCO_2^- + CO_2 + ATP \longrightarrow {}^-O_2CCH_2COCO_2^- + ADP + P_i$

C)


$\text{Ala-Ser} + H_2O \rightarrow \text{Ala} + \text{Ser}$

None of the above.

Metabolic processes are regulated by:

transcriptional regulation of the amount of enzyme.

allosteric control of enzyme activity.

accessibility of substrates by compartmentalization.

A and B.

A, B, and C.

Some of the mechanisms by which enzyme catalytic activity is controlled are:

A) allosteric control.

B) feedback inhibition.

covalent modification .

D) A and C.

E) A, B, and C.

The phosphorylation of fructose-6-phosphate is an endergonic reaction with a $\Delta G_o'$ of 16.3 kJ/mol. How do cells overcome this thermodynamic barrier for this reaction under standard conditions?

The enzyme that catalyzes this reaction couples it with the condensation of ADP and inorganic phosphate, resulting in an overall $\Delta G_o'$ of –46.8 kJ/mol.

The enzyme that catalyzes this reaction couples it with the hydrolysis of ATP to ADP and inorganic phosphate, resulting in an overall $\Delta G_o'$ of –14.2 kJ/mol.

This reaction will proceed to the right because the K_{eq} is small.

This reaction will proceed to the right because the K_{eq} is negative.

By uncoupling the reaction to the hydrolysis of ATP, the reaction can be driven forward.

You are interested in studying bacteria found in peat swamps and you identify a new bacterium that you believe is a chemotroph. Which of the following would you use to verify your belief?
screen for ATP synthesis
screen for enzymes that oxidize carbon
screen for light gathering structures
screen for digestive enzymes
screen for linked reactions

The formation of ATP by creatine kinase is shown in the reaction below:
creatine phosphate + ADP ↔ ATP + creatine
Using the Table of Standard Free Energies (Table 15.1 in text), determine if this reaction is thermodynamically favored under standard conditions.
No, it is not thermodynamically favored because the K'_{eq} is 12.6.
No, it is not thermodynamically favored because the $\Delta G_o'$is 12.6 kJ/mol.
No, it is not thermodynamically favored because the $\Delta G_o'$is is -73.6 kJ/mol.
Yes, it is thermodynamically favored because the K'_{eq} is 73.6.
Yes, it is thermodynamically favored because the $\Delta G_o'$is is -12.6 kJ/mol.

The hydrolysis of a phosphate group from ATP releases 30.5 kj/mol, whereas the hydrolysis of a phosphate from glucose 6-phosphate releases only 13.82 kJ/mol. In that the product is the same, what accounts for the difference?
ATP has greater resonance stabilization than the product orthophosphate.
There is a greater increase in entropy when ATP is hydrolyzed.
Water hydrates ATP greater than glucose 6-phosphate.
ATP has a larger phosphoryl-transfer potential.
The phosphate ester in ATP is more thermodynamically stable than in glucose 6-phosphate.

Short-Answer Questions

Explain how a metabolic pathway can contain an energetically unfavorable reaction yet still occur.

What are the two criteria that must be satisfied by a biochemical pathway?

Draw the structure of ATP and identify the phosphoanhydride bond(s).

What general factors contribute to the high phosphoryl-group transfer of ATP?

Draw the resonance structures of orthophosphate and explain why these structures are not significant in ATP.

How much ATP is used daily by a typical human? How is it regenerated?

What is oxidative phosphorylation?

Why are fats a more efficient fuel source than carbohydrates?

What is an activated carrier? Provide two examples.

Compare ATP to acetyl CoA.

How are metabolic processes unified? How can you use this to help learn and understand biochemistry?

List five activated carriers in metabolism and give the vitamins that are the precursors of these carriers.

What is the relationship between the energy charge of a cell and control of the ATP-generating pathway?

How is metabolism controlled?

If many compounds are common to both anabolic and catabolic paths, how can metabolism be controlled?

Why do we call ATP a carrier of phosphoryl groups and not a storage molecule for phosphoryl groups?

Chapter 16 Glycolysis

Matching Questions

Use the following to answer questions 1-10:

Choose the correct answer from the list below. Not all of the answers will be used.

obligate anaerobes
AMP
pyruvate
NAD^+
glucose
UDP-glucose
GLUT5
facultative anaerobes
ATP
magnesium
galactokinase
GLUT2
galactose isomerase

159 ____________ is the principle carbohydrate in living systems.

160 ____________ This is the product of aerobic glycolysis.

____________ These organisms cannot survive in the presence of oxygen.

_____________ This substance must be regenerated for glycolysis to proceed.

_____________ This intermediate is necessary for the conversion of galactose to glucose.

_____________ This molecule is an allosteric inhibitor of phosphofructokinase.

_____________ This transporter is responsible for fructose uptake in the intestine.

_____________ The enzyme responsible for converting galactose to be used in the glycolytic pathway.

_____________ is the transporter found in the pancreas and liver.

_____________ This is an allosteric activator of glycolysis.

Fill-in-the-Blank Questions

169 Glycolysis produces a net of ___ moles of ATP per one mole of glucose.

170 Glucose is the most stable hexose because the hydroxyl groups are all in the ___position.

171 The key regulatory enzyme for glycolysis is ___ .

are enzymes that catalyze the transfer of a phosphoryl group from ATP to an acceptor.

173 The regeneration of ___in the reduction of pyruvate to lactate sustains glycolysis under anaerobic conditions.

In alcoholic fermentation, the decarboxylation of pyruvate requires a coenzyme that contains the vitamin ___

175 A potent allosteric activator of liver phosphofructokinase is ___, which is produced from fructose-6-phosphate by PFK2.

176 In the absence of oxygen, ___increases the expression of most glycolytic enzymes and the glucose transporters GLUT1 and GLUT3.

177 The first irreversible enzymatic reaction unique to a metabolic pathway is called the ___step.

mediate the thermodynamically downhill movement of glucose across plasma membranes.

Multiple-Choice Questions

Which of the following are reasons that glucose is a common metabolic fuel used by living organisms?
It has a stable ring structure and is unlikely to glycosylate proteins.
It has been found as one of the monosaccharides formed under prebiotic conditions.
It is the only sugar used by the brain.
A and B.
A, B, and C.

What is the purpose of phosphorylating glucose in cytosol?
to trap glucose in the cell
to destabilize glucose and facilitate the next series of metabolic steps
to convert it to a more soluble form
All of the above.
A and B.

What two 3-carbon molecules are generated by the cleavage of fructose-1,6-bisphosphate?
glyceraldehyde-3-phosphate and 3-phosphoglycerate
glyceraldehyde-3-phosphate and dihydroxyacetone phosphate
pyruvate and phosphoenolpyruvate
enolase and 2-phosphoglycerate
glyceraldehyde-3-phosphate and pyruvate

What is a common mechanistic feature of kinases?
Phosphoryl groups are transferred from AMP to an acceptor.
Binding of substrate induces cleft closing.
It converts aldoses to ketoses.
All of the above.
None of the above.

What reaction is catalyzed by aldolase?
isomerization of DHAP to GAP
ligation of GAP and DHAP
reversible cleavage of F-1,6-BP to DHAP and GAP
cleavage of DHAP to GAP
irreversible aldol condensation of DHAP and GAP

What is the function of glyceraldehyde 3-phosphate dehydrogenase?
oxidation by NAD^+ and formation of acyl-phosphate
oxidation of the alcohol to an aldehyde
dehydration and dephosphorylation of GAP
hydrolysis of GAP
None of the above.

What is the function of a thioester intermediate such as the one formed from GAP?
It speeds up the actual reaction so that more product can be made.
The thioester shifts the equilibrium of the first stage of the reaction.
The thioester allows the two-step reaction to be coupled so the second reaction, the energetically unfavorable phosphorylation, can proceed.
The thioester intermediate induces a conformational change that alters the enzyme specificity.
The thioester prevents the formation of metabolically unfavorable side products.

What is substrate-level phosphorylation?
phosphorylation of AMP by ATP
ATP synthesis when the phosphate donor is a substrate with high phosphoryl transfer potential
phosphorylation of glycolytic intermediates
phosphorylation of ATP coupled to an ion gradient
ATP and AMP synthesis from two molecules of ADP

What type of enzyme catalyzes the intramolecular shift of a chemical group?
A) hydrolase
B) kinase
dehydrogenase
D) mutase
E) None of the above.

What are the primary metabolic fates of pyruvate?

A) ethanol
B) lactate
acetyl CoA
D) All of the above.
E) None of the above.

Fructose can enter glycolysis at two distinct points, depending on the tissue. How is fructose metabolized in adipose tissue?

Fructose is cleaved to two molecules of GAP.
Fructose is converted to fructose-1-phosphate.
Fructose is converted to fructose-6-phosphate.
Fructose is cleaved to GAP and DHAP.
Fructose is converted to glucose, which enters the pathway.

Lactose intolerance is caused by a deficiency of:

A) lactase. B) elastase. C) lactose D) sucrase E) None of the above.

How are the glycolytic enzymes regulated?

A) transcriptional control
B) reversible phosphorylation
allosteric control
D) All of the above.
E) None of the above.

Cancer driven hypoxia brings about the induction of which genes involved in glycolysis?

GLUT3
hexokinase
aldolase
All of the above.
None of the above.

During exercise, glycolysis is stimulated by a:

high-energy charge of the cell.
feed-forward stimulation of pyruvate kinase.
negative feedback inhibition on hexokinase.
A and C.
All of the above.

The release of insulin from β cells in the pancreas in response to increase of blood glucose levels follows a multistep process. You want to design a drug to overcome what you think might be the step that is impaired in diabetes. What might this drug do?

activate K^+ channels
block Ca^{2+} channels
decrease ATP/ADP ratios
inhibit GLUT5 synthesis
stimulate GLUT2 synthesis

What is significant about the fact that glucokinase is found in liver and β cells of the pancreas and that hexokinase is found in most cells?
At low glucose levels, very little is taken up by the liver, so glucose is pared for other tissues.
Hexokinase is not inhibited by glucose 6-phosphate, allowing accumulation in muscle for storage as glycogen.
Glucokinase phosphorylates glucose when blood glucose levels are low.
Hexokinase has a high K_M, so it does not become saturated until blood glucose levels are extremely high.
The role of hexokinase is to provide glucose 6-phosphate for the synthesis of fatty acids.

How and why are pyruvate kinase isozymes regulated differently?
In muscle, phosphorylation of pyruvate kinase diminishes its activity in response to low blood-glucose levels.
In muscle, dephosphorylation of pyruvate kinase is activated in response to high levels of fructose 1,6-bisphosphate.
In the liver, phosphorylation of pyruvate kinase diminishes its activity in response to low blood-glucose levels.
In the liver, dephosphorylation of pyruvate kinase is activated in response to high levels of fructose 1,6-bisphosphate.
In the liver, activation of the GLUT2 receptors increases ATP synthesis leading to a decrease in pyruvate kinase activity.

Fermentation occurs in the absence of oxygen, but O_2 is not found in any of the reactions of glycolysis or fermentation. So, what drives these reactions at the level of glycolysis and fermentation?
NADH synthesized in glycolysis is used to oxidize pyruvate to acetyl CoA during fermentation reactions.
ATP is synthesized in glycolysis, only if NAD^+ is regenerated during fermentation.
Pyruvate donates electrons to NADH in lactic acid fermentation.
In the formation of ethanol, pyruvate is decarboxylated in a reversible reaction, once oxygen is present again.
In the formation of ethanol, acetaldehyde accepts electrons from NADH, regenerating NAD^+.

Short-Answer Questions

Why is it important that the glycolytic and gluconeogenic pathways are reciprocally regulated?

Why is glucose the most stable hexose?

Both hexokinase and glucokinase phosphorylate glucose. The function of glucokinase is to phosphorylate glucose in liver cells as a means to regulate blood-sugar levels. Would you expect its Km to be higher or lower than hexokinase?

What two isomerization reactions occur in glycolysis? Why are these steps necessary?

At equilibrium, there is far more DHAP than GAP. Yet the conversion of DHAP by triose phosphate isomerase proceeds readily. Why?

How is the conversion of phosphoenolpyruvate to pyruvate accompanied by ATP formation?

Describe the biochemical explanation for galactosemia.

What are fermentations?

How is glycolysis maintained under anaerobic conditions?

How does citrate influence glycolysis?

Why is it more sensible for phosphofructokinase to be an important control step, rather than hexokinase?

What are glucose transporters and how do the different types of transporters differ?

Describe how pyruvate kinase regulation occurs and how this is important in the regulation of glycolysis.

There are several key regulatory steps where glycolysis in muscle is left “on” and in liver the same pathway is “off” or inhibited. What are these steps and why is this important?

Describe the two isoforms of pyruvate kinase.

How might a defect in a pancreatic β-cell calcium channel affect insulin release when blood glucose levels rise?

Chapter 17 Gluconeogenesis

Matching Questions

Use the following to answer questions 1-10:

Choose the correct answer from the list below. Not all of the answers will be used.

liver
muscle
one day
endoplasmic reticulum
gluconeogenesis
phosphoenolpyruvate carboxykinase
PFK-2
Cori
fructose 2,6-bisphosphate
magnesium
oxaloacetate
biotin
2 hours
ATP

____________ This is the process by which noncarbohydrate precursor molecules are converted into glucose.

The stores of glucose are enough to support metabolism of a person for how long? ____________

The major tissue in which gluconeogenesis takes place is ____________.

The conversion of glucose 6-phosphate to glucose takes place where in the cell? __________

The reaction that uses GTP and not ATP as its high phosphoryl-transfer potential donor is ____________.

Which compound will activate glycolysis and inhibit gluconeogenesis via conversion of fructose 1,6-bisphosphate? ___________

____________ controls the synthesis and degradation of fructose 2,6-bisphosphate.

____________ This intermediate is decarboxylated and phosphorylated to produce phosphoenolpyruvate.

____________ This essential nutrient is required for the carboxylation of pyruvate in humans.

The ____________ cycle is responsible for converting muscle lactate into glucose in the liver.

Fill-in-the-Blank Questions

224 The daily glucose requirement for a typical adult brain is ___ .

225 The amount of glucose in the bloodstream and other body fluids is ___.

226 The process of forming glucose from amino acids is called ___ .

Glycerol from fats is modified first by glycerol kinase and then by a second enzyme to enter gluconeogenesis at ___intermediate.

228 The gluconeogenesis step responsible for reversing pyruvate kinase is ___ .

229 Gluconeogenesis is the reversal of steps in glycolysis ___ (true or false).

230 Some amino acids are converted to glucose via conversion to pyruvate and ___ .

231 The enzyme that carboxylates pyruvate is ___ .

232 The first step of gluconeogenesis takes place in ___ cellular compartment.

233 ATP in the reaction catalyzed by PEPCK is use to fix ___ to biotin.

234 Transport of oxaloacetate produced by PEPCK utilizes ___mitochondrial and cytosolic enzyme.

235 AMP will have a(an) ___on PFK and a(an) ___ effect on F-1,6-BPase.

236 Allosteric activators of gluconeogenesis are going to ___ the flux of carbon to glucose.

237 The ___ cycle refers to the metabolic reactions by which glucose is converted into lactate in skeletal muscle, and then lactate converted back into glucose in the liver.

238 The first step in gluconeogenesis is the ___ of pyruvate to form oxaloacetate.

Multiple-Choice Questions

Biotin provides __________ for the pyruvate carboxylase reaction.
a long flexible arm for active site location of substrate
carboxylation of pyruvate
group transfer from one site of the enzyme to another
All of the above.
None of the above.

The phosphoryl donor in the formation of phophoenolpyruvate is:
pyruvate.
PEP.
ATP.
GTP.
inorganic phosphate.

The enzymes involved in shuttling carbons in gluconeogenesis from the mitochondria to the cytosol are called:
malate dehydrogenase.
citrate synthase.
oxaloacetate transferase.
oxaloacetate reductase.
None of the above.

Glucose 6-phosphatase takes place in which cellular location?
cytoplasm
endoplasmic reticulum
mitochondria
nucleus
plasma membrane

High levels of ATP and citrate ___________.
indicate a high energy–well fed state
indicate remote gluconeogenesis
inhibit glycolysis
All of the above.
None of the above.

Phosphofructokinase (PFK) is a highly regulated enzyme. Which of the following statements about PFK are correct?
AMP and ADP both bind to and stabilize the inactive conformation of F6P.
ATP can overcome the inhibition by citrate.
Citrate is an inhibitor of PFK.
Acidic conditions from anaerobic metabolism activate PFK.
None of the above.

The bifunctional enzyme is also known as __________.
phosphofructokinase I
phosphofructokinase II
fructose 1-6 phosphatase
protein kinase 2
phosphoenolpyruvate carboxy kinase

Hormonal activation of cyclic AMP levels will:
activate protein kinase A phosphorylation of FBPase2.
phosphorylate PFK2 on a tyrosine residue.
lead to the activation of PFK.
activate the PKC phosphorylation of PFK2.
increase the activation of gluconeogenesis.

The major site for gluconeogenesis is in which of the following tissues?
brain
liver
striated muscle
adipose
red blood cells

High blood sugar after a meal _______ the level of insulin released by the pancreas
increases
decreases
has no effect on
chronically activates
chronically inhibits

In general the liver_______________.
will not utilize glucose under starvation/low energy conditions.
acts as a glucose buffer for the rest of the body.
is a producer of glucose for the body under low energy conditions.
All of the above.
None of the above.

Insulin resistance is a hallmark of__________.
PEPCK activation
pancreatic disorder
type 1 diabetes
type 2 diabetes
long-term starvation

Lactate produced in muscle tissue is converted to _________ by __________ .
glucose; gluconeogenesis
lactate; the Cori cycle
glucose; the Cori cycle
pyruvate; glycolysis
ATP; the Krebs cycle

The primary raw materials for gluconeogenesis are:
A) galactose and sucrose.
B) pyruvate and oxaloacetate.
lactate and amino acids.
D) fructose and glycerol.
E) lactose and lactate.

How many high-energy phosphate bonds are consumed in gluconeogenesis?
A) three B) six C) two D) four E) one

What are the thermodynamic constraints on the formation of phosphoenolpyruvate from pyruvate and how are they overcome in gluconeogenesis?
The $\Delta G°'$ for the reverse of the glycolytic reaction for pyruvate kinase is +31 kJ/mol, which is overcome in gluconeogenesis by the carboxylation/decarboxylation reactions.
The $\Delta G°'$ for reverse of the glycolytic reactions for pyruvate kinase is –31 kJ/mol, which is overcome in gluconeogenesis by the futile cycle enzymes.
The $\Delta G°'$ for the reverse of the glycolytic reaction for pyruvate kinase is +0.8 kJ/mol, which is overcome in gluconeogenesis by the actions of pK_a.
The $\Delta G°'$ for the reverse of the glycolytic reaction for pyruvate kinase is –0.8 kJ/mol, which is overcome in gluconeogenesis by the futile cycle reactions.
The $\Delta G°'$ for the reverse of the glycolytic reaction for pyruvate kinase is –38 kJ/mol, which is overcome in gluconeogenesis by the carboxylation/decarboxylation reactions.

Glycerol, lactate, and amino acids contribute carbon precursors in the formation of glucose; however, the path that glycerol takes is striking different from the other precursors. Explain how it differs.
Glycerol is decarboxylated to acetyl CoA and enters gluconeogenesis as pyruvate.
Glycerol enters gluconeogenesis as a breakdown product of triacylglycerols in the form of dihydroxyacetone phosphate.
Glycerol undergoes a reversible reduction/oxidation reaction to form phosphoenolpyruvate.
Glycerol is first oxidized in a reaction requiring NAD^+ and then phosphorylated in reversible reaction of glycolysis.
Glycerol is oxidized and enters gluconeogenesis as glyceraldehyde phosphate.

What strategy does the liver use to maintain adequate levels of glucose in the blood for use by other tissues?
Glucose 6-phosphatase has a low K_M for glucose 6-phosphate so that glycogen is formed only when glucose is plentiful.
Transporters named T1, T2, and T3 are responsible for transporting glucose 6-phosphate in and glucose and inorganic phosphate out of the mitochondrion for gluconeogenesis.
Pyruvate is transported out of the mitochondrion via the oxaloacetate shuttle when glucose levels in the blood are low.
Glucose 6-phosphatase is bound to the lumen side of the ER where the products of this enzyme reaction are then transported back to the cytoplasm.
None of the above.

What can account for the 1000-fold increase in ATP production when a lot of ATP is needed such as in intense exercise?
substrate cycles
fructose bisphosphatase 2 activity
phosphorylation of a single serine residue in phosphofructokinase 2
activation of PEPCK
activation of glycedrol kinase

Short-Answer Questions

Explain how fructose 2,6 bisphosphate is created and degraded in the cell, how the metabolism of fructose 2,6-bisphosphate is regulated and the effect fructose 2,6 bisphosphate has on glycolysis and gluconeogenesis

Eating raw eggs will lead to the ingestion of avidin, a compound that tightly binds to the head group of biotin. What would be the result of this on a person’s blood sugar level?

What are the key glycolytic enzymes and why are they considered key? How are these steps overcome in gluconeogenesis?

What is the role biotin takes in pyruvate carboxylase catalytic mechanism?

Bumble bees are active when cold while other insects are dormant. This is due to a high rate of ATP hydrolysis. What might help bring this about?

How does liver restore the level of glucose for active muscles?

How are gluconeogenesis and glycolysis coordinated by nucleotides?

The mitochondrial inner membrane is very tight. This means that only a few compounds may permeate the membrane without a transporter. Oxaloacetate and NADH are two such compounds. In this light, how can gluconeogenesis continue?

Which metabolic steps differ from glycolysis in gluconeogenesis?

How are gluconeogenesis and glycolysis regulated reciprocally?

What role do citric acid cycle intermediates play in the regulation of gluconeogenesis and glycolysis?

Chapter 18 Preparation for the Cycle

Matching Questions

Use the following to answer questions 1-10:

Choose the correct answer from the list below. Not all of the answers will be used.

lactic acidosis
phosphorylation
beriberi
mitochondria
acetyl CoA
E_3
thiamine pyrophosphate
lipoamide
pyruvate dehydrogenase
coenzyme A
E_1
glyoxylate cycle

_____________ Where does the citric acid cycle take place in the cell?

_____________ The activated carrier of acyl groups.

_____________ In the presence of oxygen pyruvate is converted to this.

_____________ This is a large multi-subunit enzyme complex that links glycolysis and the citric acid cycle under aerobic conditions.

_____________ This provides a flexible linker between active sites on the PDH complex.

_____________ Pyruvate is decarboxylated at this active site in PDH.

_____________ This coenzyme is the prosthetic group in the decarboxylation of pyruvate.

_____________ Arsenite inhibits the function of this component of the PDH.

_____________ This type of enzyme regulation process inhibits the pyruvate dehydrogenase complex.

_____________ is caused by a deficiency in vitamin B_1.

Fill-in-the-Blank Questions

is the PDH subunit responsible for the regeneration of the oxidized form of lipoamide.

280 Decarboxylation, oxidation, and __are the three steps critical to preserve the free energy derived from decarboxylation of the PDH complex.

281 E_1 of the pyruvate dehydrogenase complex requires the coenzyme __for proper activity.

E_2 of the pyruvate dehydrogenase complex contains a lipoyl group that is covalently attached to a re~~sid~~ue of the enzyme.

is the~~ cr~~itical functional group of lipoamide responsible for carrying acetyl groups and maintaining the free energy of CoA.

provides a flexible linkage for substrate to move between active sites on the PDH.

inserts the lipoamide arm of the SH domain deep into the channel in E1.

286 PDH is inactive when it the enzyme is ___ .

287 High-energy charge, which results in increasing concentration of NADH, ___ the activity of PDH.

288 Beriberi is caused by a deficiency of ___ .

Multiple-Choice Questions

The citric acid cycle is also known as the:

A) Krebs cycle.
B) Cori cycle.
tricarboxylic acid cycle.
D) A and C.
E) A, B, and C.

Pyruvate is decarboxylated by which subunit of the PDH?

A) E_1
B) E_2
E_3
D) E_4
E) E_5

What enzyme(s) is (are) responsible for the following reaction?

$$\text{Pyruvate} + \text{CoA} + \text{NAD}^+ \rightarrow \text{acetyl CoA} + \text{NADH} + \text{H}^+ + \text{CO}_2$$

A) acetyl CoA synthetase B)
pyruvate decarboxylase
pyruvate dehydrogenase complex
D) A and B.
E) A, B, and C.

What are the steps involved (in order) in the conversion of pyruvate to acetyl CoA?
decarboxylation, oxidation, transfer to CoA
decarboxylation, transfer to CoA, oxidation
oxidation, decarboxylation, transfer to CoA
oxidation, transfer to CoA, decarboxylation
None of the above.

Which of the following vitamins are precursors to coenzymes that are necessary for the formation of acetyl CoA from pyruvate?
thiamine, riboflavin, niacin, lipoic acid, and pantothenic acid
thiamine, riboflavin, niacin, lipoic acid, pantothenic acid, and biotin
thiamine, riboflavin, niacin, and biotin
thiamine, riboflavin, and lipoic acid
None of the above.

Which of the following functions as a "flexible swinging arm" when it transfers the reaction intermediate from one active site to the next?
FAD
NAD^+
lipoamide
thiamine pyrophosphate
coenzyme A

Pyruvate dehydrogenase is _____________ when ATP/ADP ratios are high.
A) activated
B) inhibited
phosphorylated
D) B and C.
E) A and C.

PDH phosphatase deficiency results in which condition?
A) overstimulated PDH
B) low blood glucose
chronic elevated plasma lactate
D) high levels of acetyl CoA
E) None of the above.

Milling and polishing rice results in ______________.
A) loss of the husk of rice
B) white rice
potential for beriberi
D) loss of thiamine pyrophosphase
E) All of the above.

Beriberi symptoms are similar to those of which disease?
A) arsenite poisoning
B) lactic acidosis
type II diabetes
D) scurvy
E) cancer

Which of the following conditions will activate pyruvate dehydrogenase kinase, which catalyzes the phorphorylation and inactivation of E_1 in the pyruvate dehydrogenase complex?
elevated concentrations of NADH and ATP
elevated concentrations of NAD^+ and ADP
Ca^{2+}
insulin
elevated concentrations of acetyl CoA

In addition to pyruvate dehydrogenase, what other enzyme(s) in the citric acid cycle has a key thiamine pyrophosphate coenzyme?
A) isocitrate dehydrogenase
B) α-ketoglutarate dehydrogenase
citrate synthase (in bacteria)
D) A and B.
E) A, B, and C.

The $\Delta G^{\circ\prime}$ for the sum of the reactions in the pyruvate dehydrogenase complex is –33.4 kJ/mol. What is the primary contribution to this large and negative free energy change?
In E_3, two electrons are transferred from $FADH_2$ to NAD^+, a thermodynamically favored transfer.
The product of the reaction, acetyl CoA, is shuttled into the mitochondria, keeping the cytosolic concentration low.
Free energy from the decarboxylation step drives the formation of NADH.
A and B.
A, B, and C.

Why is it important that the eight catalytic trimers of the transacetylase enzyme, E_2, are assembled to form the hollow cube of the enzyme complex?
Binding of the final coenzyme, NAD^+, occurs on the inner surface of the hollow core structure.
This hollow core separates the intermediates of the three enzyme reactions.
The hollow core is connected to the 20-Å-long hydrophobic channel in the E_1 enzyme.
Substrates move from active site to active site across the hollow core.
The E_2 enzyme contains the long flexible lipoamide arm needed for the structural integration of the complex.

Which of the following illustrates the role of Ca^{2+} in PDH complex regulation?
Ca^{2+} activates phosphatase activity, deactivating PDHase activity.
Ca^{2+} is elevated intracellularly with the increase of muscle contractions, activating PDHase activity.
Insulin causes a decrease in Ca^{2+}, activating pyruvate kinase activity.
In liver, Ca^{2+} stimulates pyruvate kinase, increasing conversion of pyruvate to acetyl CoA.
None of the above.

Why does acetyl CoA, a product of fatty acid catabolism, influence the pyruvate dehydrogenase complex (PDH), a control point in carbohydrate catabolism?
When fatty acid breakdown is inhibited, ADP is low, causing a decrease in activity.
When fatty acid breakdown is inhibited, PDH is inhibited by acetyl CoA due to phosphatase activity.
When fatty acid breakdown is high, ADP is low and PDH is inhibited by phosphatase activity.
When fatty acid breakdown is high, PDH is inhibited by acetyl CoA due to pyruvate kinase activity.
When fatty acid breakdown is high, NADH levels drop, causing an increase in E_2 activity.

Short-Answer Questions

Review the fates of pyruvate and the cellular conditions that dictate these fates.

What reaction serves to link glycolysis and the citric acid cycle?

How does the term “mad as a hatter” realistically reflect the condition?

What are the three enzyme subunits in the PDH complex and the reactions they catalyze?

What coenzyme is required for the decarboxylation reaction in PDH and what is the vitamin precursor?

Identify the coenzyme, and its vitamin precursor, that is responsible for the transfer of a two-carbon group to form a high-energy thioester bond in coenzyme A.

Identify the coenzyme, and its vitamin precursor, that accepts electrons to reoxidize lipoamide in PDH.

How are the three active sites of PDH linked?

What are the two advantages that are derived from the coordinated actions of the three enzymes in the PDH complex?

If NADH levels are high, what is the fate of acetyl CoA?

Why do beriberi and mercury poisoning present with similar symptoms even though they have different molecular causes?

Chapter 19 Harvesting Electrons from the Cycle

Matching Questions

Use the following to answer questions 1-10:

Choose the correct answer from the list below. Not all of the answers will be used.

cytosol
isocitrate dehydrogenase
anaplerotic
harvesting
cis-aconitate
malonate
metabolic hub
oxaloacetate
inner membrane
citrate
carbon dioxide
glyoxylate cycle
malate dehydrogenase

316 The function of the citric acid cycle is ____________ high-energy electrons.

317 ____________ The product found by the condensation of oxaloacetate and acetyl CoA.

318 ____________ This is the intermediate between citrate and isocitrate.

319 ____________ This is the location of succinate dehydrogenase.

_____________ This citric acid cycle intermediate is both at the beginning and at the end of the citric acid cycle.

_____________ This is the product of the complete oxidation of carbon in the citric acid cycle.

_____________ This is a name suggested for the citric acid cycle's role in the cell.

_____________ This substance is a competitive inhibitor of succinate dehydrogenase.

___________ is the primary control point of the citric acid cycle.

_____________ This is the name applied to metabolic reactions that replenish citric acid cycle intermediates that are depleted because they were used for biosynthesis.

Fill-in-the-Blank Questions

326 Carbons from carbohydrate enter the citric acid cycle in the form of ___ .

327 In the citric acid cycle, the ___ is produced by a substrate-level phosphorylation.

328 The free energy at standard state for malate DHase in the direction of the citric acid cycle is ___.

reactions refer to the process of filling up a cycle with outside carbon compounds.

is a citric acid cycle enzyme that is also an example of an iron-sulfur protein.

331 The ___ is an organelle in plants and some bacteria where two-carbon acetyl units are converted into four-carbon units (succinate) for glucose synthesis, energy production, and biosynthesis.

During the oxidation of isocitrate, the intermediate that is decarboxylated to form α-ketoglutarate is ___ .

333 In general, the citric acid cycle is inhibited under___(high, low) energy conditions.

is the first citric acid cycle intermediate to be oxidized.

335 Organisms that can convert fat into sugar use the ___cycle.

Multiple-Choice Questions

A mutation in the active site of succinyl CoA synthetase where His is converted to Lys would result in which of the following?

A) increased stable folding
B) loss of a succinyl phosphate intermediate
loss of a positively charged amino acid necessary for catalysis
D) All of the above.
E) None of the above.

What molecule initiates the citric acid cycle by reacting with oxaloacetate?

A) pyruvate
B) acetyl CoA
oxaloacetate
D) All of the above.
E) None of the above.

In muscle, the enzyme that catalyzes a substrate level phosphorylation is:

A) nucloside triphosphate transferase
B) protein kinase C
GTP kinase
D) succinyl CoA synthetase
E) ATP-GTP transferase

339 The direct movement of substrates from one enzyme to the next is called _________.

A) protein complex
B) substrate channeling
linker coenzyme
D) cell with sufficient available water
E) electron acceptor

Which of the following vitamins are precursors to coenzymes that are necessary for the formation of succinyl CoA from α-ketoglutarate?
thiamine, riboflavin, niacin, lipoic acid, and pantothenic acid
thiamine, riboflavin, niacin, lipoic acid, pantothenic acid, and biotin
thiamine, riboflavin, niacin, and biotin
thiamine, riboflavin, and lipoic acid
None of the above.

Isomerization of citrate is catalyzed by ___________.
A) citrate synthase
B) aldolase
α-ketogutarate dehydroenase
D) aconitase
E) citrate isomerase

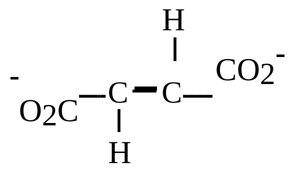
Formation of citrate from acetyl CoA and oxaloacetate is a(n) _________ reaction.
A) oxidation
B) reduction
condensation
D) ligation
E) None of the above.

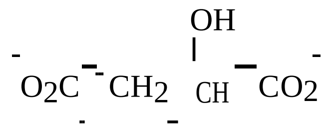
What is(are) the chemical change(s) involved in the conversion of citrate into isocitrate?
A) hydration followed by dehydration
B) oxidation
oxidation followed by reduction
D) dehydration followed by hydration
E) A and B.

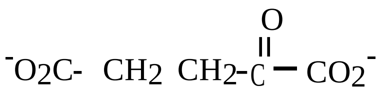
In which reaction is GTP (or ATP) directly formed in the citric acid cycle?
conversion of succinyl CoA to succinate
decarboxylation of α-ketoglutarate
conversion of isocitrate to α-ketoglutarate
All of the above.
None of the above.

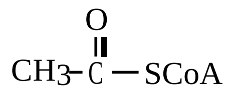
In which step of the citric acid cycle is $FADH_2$ formed?
the conversion of succinate to malate
the conversion of succinate to oxaloacetate
the conversion of succinate to fumarate
the conversion of malate to oxaloacetate
None of the above.

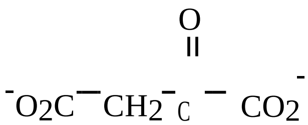
Which of these compounds is oxidized by a multi-enzyme complex that requires five different coenzymes?

A) 

D) 

B) 

E) 

C) 

Succinate dehydrogenase deficiency or genetic mutation results in ___________.

A) cancer through HIF-1
B) decreased rate of glycolysis
depletion of succinate in mitochondria
D) A and B.
E) A, B, and C.

Approximately how many ATP or GTP equivalents are produced during one turn of the citric acid cycle?

A) 10 B) 6 C) 9 D) 12 E) None of the above.

In addition to pyruvate dehydrogenase, what other enzymes are key regulatory sites in the citric acid cycle?

A) isocitrate dehydrogenase
B) α-ketoglutarate dehydrogenase
citrate synthase (in bacteria)
D) A and B.
E) A, B, and C.

The glyoxylate cycle enables plants to survive using only:

A) pyruvate.
B) acetate.
oxaloacetate.
D) All of the above.
E) None of the above.

The citric acid cycle (CAC) is activated in the presence of oxygen, but what is the link between the CAC and oxygen?

Oxygen is an allosteric activator for citrate synthase.
The presence of O_2 in the mitochondrial matrix releases CO_2 into the cytosol.
The one substrate-level phosphorylation in the CAC can occur in the absence of oxygen.
A primary product of the CAC is NADH, the principle electron donor to the O_2, the last electron acceptor in the electron-transport system.
The iron-sulfur center requires oxygen to be in the appropriate oxidation state.

What role does isocitrate lyase play in allowing plants to grow on acetate?
Isocitrate lyase hydrolyzes isocitrate to form malate and acetate; acetate is used to synthesize fatty acids.
Isocitrate lyase hydrolyzes isocitrate to form malate and acetate; acetate is used to synthesize glucose.
One product of isocitrate lyase is succinate, an intermediate in glucose synthesis via the glyoxylate cycle.
One product of isocitrate lyase is succinate, a potent inhibitor of pyruvate kinase.
One product of isocitrate lyase is succinate, an intermediate in steroid synthesis.

Although we study the citric acid cycle as the final stage oxidation of carbon from glucose, an in-depth look at the cycle shows intermediates entering and leaving the cycle from a number of metabolic pathways. With all of these demands on the cycle, how does it maintain a minimal level of oxaloacetate (OAA) to allow the cycle to function?
OAA can be formed by the condensation of two moles of acetyl CoA and occurs when the energy charge of the cell is high.
The rate of the cycle is increased when the cell has high levels of NADH.
Isocitrate dehydrogenase is allosterically inhibited by ADP, which signifies the need for more energy.
OAA is formed directly via the deamination of glutamate.
OAA is synthesized via pyruvate carboxylase in an anapleurotic reaction that occurs when acetyl CoA is present.

Chemically, why is it necessary for citrate to undergo an isomerization to isocitrate prior to decarboxylation?
This conversion forms an unstable α-ketoacid, which drives the cycle forward.
The aconitase reaction is a thermodynamically unfavored hydration reaction followed by a highly favored dehydration.
The tertiary alcohol in citrate does not favor the oxidative carboxylation that occurs next; however, the secondary alcohol of isocitrate does.
Citrate induces a major structural rearrangement in aconitase leading to the creation of the binding site for the water molecule in the hydration step.
Only when the alcohol is attached to C-2 can it block prolyl hydroxylase 2 activity, ensuring synthesis of glycolytic proteins.

Short-Answer Questions

Draw each reaction and the name of the enzyme for the production of CO_2 from pyruvate.

Why is the isomerization of citrate to isocitrate a necessary step of the citric acid cycle?

List the five coenzymes that are required for the oxidative decarboxylation of α–ketoglutarate and give the essential nutrient (vitamin) that is required for each.

Explain when GDP vs. ADP is used as a substrate with succinyl CoA synthetase.

Give the reaction in the citric acid cycle by which the energy is conserved in the formation of a phosphoanhydride bond by substrate level phosphorylation. Give the name of the enzyme that catalyzes this reaction and give the structures of the reactants and products of this reaction.

What reaction serves to link glycolysis and the citric acid cycle?

In the α-ketoglutarate dehydrogenase enzyme complex, why is the observed electron transfer from $FADH_2$ to NAD^+ unusual?

What is the energy source that drives the condensation of oxaloacetate and acetyl CoA to produce citrate?

How does the decarboxylation of α-ketoglutatarate resemble that of pyruvate decarboxylation?

How many ATP equivalents are produced from the total oxidation of one pyruvate to 3 CO_2.

$\Delta G^{\circ\prime} = -21$ kJ/mol for the reaction catalyzed by isocitrate dehydrogenase yet $\Delta G^{\circ\prime} = +29.7$ kJ/mol for the reaction catalyzed by malate dehydrogenase. Both of these reactions involve the oxidation of a secondary alcohol. Give an explanation as to why the oxidation of isocitrate is so exergonic.

How is succinate dehydrogenase unique when compared to the other enzymes in the citric acid cycle?

Are the acetyl carbons that enter the citric acid cycle the exact same carbons that leave as CO_2? Briefly explain.

Explain the difference in how carbon from fat can be converted to sugar.

Give a sequence of metabolic reactions by which all six carbons in citrate could be obtained from two pyruvate molecules.

If ^{14}C-labeled acetyl CoA is added to isolated mitochondria, is ^{14}C-labeled CO_2 released in the first full cycle of the citric acid cycle? Explain your answer.

Chapter 20 The Electron-Transport Chain

Matching Questions

Use the following to answer questions 1-10:

Choose the correct answer from the list below. Not all of the answers will be used.

mitochondria
cytochrome c
coenzyme Q
FMN
iron-sulfur clusters
respiration
transporters
porins
succinate dehydrogenase
cytochrome c oxidase
Complex II
Complex III

____________ This is where oxidative phosphorylation occurs in eukaryotes.

_____________ An ATP-generating process in which an inorganic substance such as oxygen serves as the ultimate electron acceptor.

_____________ The permeability of the outer mitochondrial membrane is primarily due to the presence of these substances.

_____________ This electron carrier is a derivative of quinone and has an isoprenoid tail.

_____________ This enzyme catalyzes the reduction of O_2.

_____________ This prosthetic group is present in Complexes I, II, and III of electron transport.

_____________ This citric acid cycle enzyme is also part of an electron-transport complex.

_____________ Prosthetic group in Complex I that accepts electrons from NADH.

_____________ The complex with three Fe-sulfhydryl electron acceptors.

_____________ This is a process by which cytoplasmic NADH can be oxidized by O_2 using the electron-transport system.

Fill-in-the-Blank Questions

381 A strong oxidizing agent has a tendency to ___ (accept, donate) electron(s).

382 Another name for coenzyme Q is ___ .

383 Cytochrome ___is the only water-soluble cytochrome of the electron-transport chain.

384 Cytochrome c oxidase contains two heme A groups and three___ions.

carries electrons from Complex III to Complex IV.

386 The transfer of a single electron to O_2 forms the reactive ___ion.

donates electrons to cytochrome C.

is an enzyme that scavenges H_2O_2 and converts it to molecular oxygen and water.

389 Complex IV is also known as ___.

are the result of uncontrolled electron transfer to oxygen

Multiple-Choice Questions

Choose the correct path taken by a pair of electrons as they travel down the electron-transport chain.

NADH → Complex I → CoQ → Complex III → Cyt c → Complex IV → O_2

$FADH_2$ → Complex I → CoQ → Complex III → Cyt c → Complex IV → O_2

NADH → Complex I → Complex II→ Complex III → Cyt c → Complex IV → O_2

$FADH_2$ → Complex II → CoQ → Complex III → Cyt c → Complex IV → O_2

A and D.

Which of the following does **not** participate in, nor is a component of, the electron-transport chain?
coenzyme A
non-heme, iron-sulfur proteins
coenzyme Q
cytochrome c_1
NADH

Electron flow down the electron-transport chain leads to the:
transport of protons across the inner mitochondrial membrane from inside the matrix to the intermembrane space.
transport of protons across the inner mitochondrial membrane from the intermembrane space into the matrix.
coupled synthesis of GTP.
a dangerous imbalance of K^+ ions across the mitochondiral membrane.
None of the above.

Coenzyme Q is also called:
A) NADH.
B) oxidoreductase.
ubiquinone.
D) All of the above.
E) None of the above.

Which of the following does not pump protons?
A) Complex I
B) Complex II
Complex III
D) Complex IV
E) All of the above.

In proteins these amino acid residues usually complex to the iron-sulfur clusters.
A) Gly B) Arg C) Cys D) All of the above. E) None of the above.

What is a cytochrome?
a protein that transfers electrons, and that also contains a heme prosthetic group
a chloroplast protein that transfers electrons, and that also contains an iron sulfur prosthetic group
a protein that pumps ATP, and that also contains iron
All of the above.
None of the above.

In the Rieske center, the iron-sulfur center is coordinated to the amino acid(s) _______.
A) His B) Cys C) His and Cys D) Cys and Met E) None of the above.

The Q cycle:
transfers electrons from a two-electron carrier to a one-electron carrier.
recycles protons.
acts as an NADH exchange with the cytosol.
A and B.
A, B, and C.

What pathologic condition(s) results from free-radical injury?
A) emphysema B) Parkinson’s disease C) diabetes D) atherogenesis E) All of the above.

What evidence is there that modern mitochondria are the result of a single ancient event? What is the event called?
Modern mitochondria have specific transcription and translation machinery similar to viruses: viral endosymbiosis event.
Modern mitochondria have circular DNA similar to bacteria: endosymbiotic event.
Modern mitochondria are the only organelles in the cell with a double membrane: electron-transfer event.
Modern mitochondria have DNA polymerase sequences similar to a single bacteria: replication event.
None of the above.

Carbon monoxide is considered toxic because it acts on Complex IV. How would the addition of carbon monoxide to actively respiring mitochondria affect the relative oxidation-reduction states of all components of the electron-transport chain?
All four complexes would remain oxidized because they function as a multisystem complex.
Complexes I and III would be reduced, but complexes II and IV would be oxidized because the electrons come from $FADH_2$ oxidation, not NADH.
Complexes I, II, and III would be oxidized but Complex IV would remain reduced.
Complexes I, II, and III would be reduced and Complex IV would be oxidized.
All four complexes would remain reduced because they function as a multisystem complex.

Electrons are not very soluble in hydrophobic environments such as a bilipid membrane. What evidence is there that electrons move from complex to complex through the lipid membrane?
Cytochrome C is the electron carrier in the membrane and undergoes a head-over-heel flip to set up the proton gradient.
Cytochrome C is the electron carrier in the membrane and contains a cydrophoric porphyrin center.
CoQ is the electron carrier within the membrane and seems to be confined to the respirasome.
CoQ is the electron carrier within the membrane and it contains a hydrophobic porphyrin center.
FeS clusters are the carriers within the membrane and the electrons move from one cluster to the next in a chain-like fashion.

What is the rationale for saying that “electrons flow ***down*** the electron-transport chain”?
Electrons flow from oxidized carriers to reduced carriers in discrete steps like a staircase.
Electrons flow from half-reactions with more positive redox potentials to more negative.
Electrons flow from reactions that continuously generate negative free energy values.
Electrons flow from the outer surface to the inner surface, a top down perception.
Because we think of electrons flowing like a liquid, the only direction electrons can flow is down.

Short-Answer Questions

Draw the structure of a mitochondrion and indicate the sites of oxidative phosphorylation and the citric acid cycle.

Describe the path by which electrons from $FADH_2$ enter the electron-transport chain.

Explain why less ATP is made from the reoxidation of $FADH_2$ as compared to NADH.

Give the balanced equation for the net reaction catalyzed by Q-cytochrome c oxido-reducatase.

What is a major defense strategy against oxidative damage caused by reactive oxygen species (ROS)?

The reduction potential of iron from Fe^{3+} to Fe^{2+} is +0.77V. How can it participate in multiple exergonic redox reaction I electron transport?

Calculate the $\Delta G°'$ for the reaction where lactate + NAD^+ is converted to pyruvate + NADH.

What are the mechanisms that a cell uses to protect against production of oxygen radicals?

Describe the role that Q takes as the NADH-Q oxidoreductase transfers electrons from NADH to coenzyme Q.

What is the “dead zone” in the Gulf of Mexico and how did it come into being?

In a table of reduction potentials, values for E'° are given as plus (+) or minus (-). What is this in reference to?

In what direction do electrons flow in the electron-transport chain?

For the reaction:

$$4\ \text{Cyt}\ c_{\text{red}} + 8\ H^+_{\text{matrix}} + O_2 \rightarrow 4\ \text{Cyt}\ c_{\text{ox}} + 2\ H_2O + 4\ H^+_{\text{intermembrane space}}$$

the reduction of molecular oxygen to form water releases far more free energy than the 87.2 kJ/mol required to consume the protons from the matrix. What evidence is there that the excess free energy is not lost simply as heat?

Chapter 21 The Proton-Motive Force

Matching Questions

Use the following to answer questions 1-10:

Choose the correct answer from the list below. Not all of the answers will be used.

Peter Mitchell
chemiosmotic theory
binding-change
loose
ATP
entropy
α subunit
tight
glycerol 3-phosphate shuttle
c ring
ATP-ADP translocase
malate-aspartate shuttle
Sir Hans Krebs

418 ____________ The thermodynamic driving force of ATP synthesis due to pumping of protons.

419 ____________ first described the chemiosmotic hypothesis.

420 ____________ is the mechanism for the proton-driven ATP synthesis.

421 ____________ Which form of the ATPase subunits is responsible for phosphorylation of ADP?

422 ____________ Rotation of this, driven by proton gradient, powers ATP synthesis.

____________ ADP transport into the mitochondria is coupled to the export of __________.

____________ Dihydroxyacetone phosphate is part of the ______________ shuttle.

____________ This is the name given to the hypothesis proposed by Peter Mitchell to explain how ATP synthesis is coupled to electron transport.

____________ Atractyloside inhibits this mitochondrial protein.

____________ This is a process by which cytoplasmic NADH can be reoxidized by O_2 using the electron-transport system.

Fill-in-the-Blank Questions

428 Transfer of electrons from NADH leads to how many ATP? __.

429__ membrane protein couples the entry of ADP into the mitochondrial matrix with the exit of ATP.

430The protein involved with thermogenesis by uncoupling electron transport from oxidative phosphorylation is __ .

431__is a molecular assembly in the inner mitochondrial membrane that carries out the synthesis of ATP.

432In the glycerol phosphate shuttle, cytoplasmic glycerol phosphate dehydrogenase uses cytoplasmic NADH to reduce __to glycerol-3-phosphate.

433Acceptor control of oxidative phosphorylation means that the rate of respiration depends on the level of __.

434 __ is a poison because it blocks the flow of electrons from cytochrome c to oxygen.

435 In the presence of ___ respiration continues but no ATP is formed.

436 The antibiotic ___ inhibits the flow of protons through ATP synthase.

437 ATP is transported out of the mitochondria by the antiporter___ .

Multiple-Choice Questions

What type of gradient is critical to ATP formation by oxidative phosphorylation?

A) sodium ion
B) chloride ion
proton
D) potassium ion
E) None of the above.

When glucose is totally oxidized to CO_2 and H_2O, how many ATP molecules are made by oxidative phosphorylation relative to the maximum yield?

12 out of 30
26 out of 30
26 out of 32
12 out of 38
None of the above.

What is the chemical effect of rotenone on aerobic metabolism?

The flow of electrons from NADH to CoQ is blocked.
The flow of electrons from Cyt a-a_3 to oxygen is blocked.
Oligomycin blocks the proton transfer through F_0 of ATP synthase and therefore blocks the phosphorylation of ADP to form ATP.
The transport of ATP out of and ADP into the mitochondria are blocked.
Oxidative phosphorylation is uncoupled from electron transport and all the energy is lost as heat.

The subunit of the ATPase embedded in the inner mitochondrial membrane is the __________.

anchor subunit
membrane-c ring subunit
F_0 subunit
F_1 subunit
F_m subunit

The F_1 component of ATP synthase is composed of _________.
three α subunits
three β subunits
a subunit
All of the above.
None of the above.

The proton motive force consists of _____________.
A) a chemical gradient
B) a proton gradient.
an electron gradient
D) A and B.
E) A, B, and C.

Electron flow down the electron-transport chain leads to the
transport of protons across the inner mitochondrial membrane from inside the matrix to the intermembrane space.
transport of protons across the inner mitochondrial membrane from the intermembrane space into the matrix.
coupled synthesis of GTP.
a dangerous imbalance of K^+ ions across the mitochondiral membrane.
None of the above.

How does the rotation of the c ring lead to ATP synthesis?
The c ring is linked tightly to the gamma and epsilon subunits in the stalk of F_1.
The c ring interacts with the beta subunit.
The gamma subunit rotates with proton gradient formation inducing the binding-change mechanism.
All of the above.
None of the above.

What are the driving force (energetic) costs for the ATP-ADP translocase?
entropy – concentration gradient of ATP
membrane potential from electron transport
active transport by Na-K ATPase
All of the above.
None of the above.

A diet pill that acts to increase oxygen consumption and a high amount of electron transport without ATP production is likely what kind of compound?
uncoupler
ATP synthase activator
site I inhibitor
site II activator
cyanide

What is the reaction of ATP synthase?

$AMP^{3-} + 2\ HPO_4^{2-} + H^+ \Leftrightarrow ATP^{4-} + H_2O$

2– + 4–

$ADP^{3-} + HPO_4 + H \Leftrightarrow ATP + H_2O$

2– + 4–

$ADP^{3-} + HPO_4 + 2H \Leftrightarrow ATP + H_2O$

2– + 4–

$AMP^{3-} + 2\ HPO_4 + 2H \Leftrightarrow ATP + H_2O$

None of the above.

What is the net ATP obtained from one cytoplasmic NADH when it is oxidized by the electron-transport chain using the glycerol 3-phosphate shuttle?

2.5. B) 1.5. C) 2.0. D) 1.0. E) None of the above.

In the malate-aspartate shuttle, electrons from NADH are transferred to ________, forming malate.

A) oxaloacetate
B) aspartate
acetate
D) glutamate
E) None of the above.

Suppose there is a mutation in the **c** subunit of ATP synthase, such that the glutamate found in the middle of one of the membrane spanning helices is converted to a valine. What is likely to be the effect on ATP synthesis and why?

No effect. The middle of the helix is in contact with the hydrophobic center of the lipid bilayer and the valine is readily soluble in lipid.

No effect. The valine side chain is shorter than the glutamate side chain, so it causes no change in the secondary structure of the helix.

Inhibit ATP synthesis. Valine cannot bind a proton, so there will be no proton flow through the inner membrane.

Inhibit ATP synthesis. Because valine is hydrophobic, the α subunit will move in the reverse direction, causing the hydrolysis of ATP, not synthesis.

Increase ATP synthesis. Because the valine side chain is hydrophobic, the α subunit can move easily without regard to oxidative processes.

Why is it not surprising that substances such as intermediates for the citric acid cycle, protons, inorganic phosphate, nucleotide phosphates, and many others have their transport across the inner membrane regulated?

Regulated transport allows for more effective substrate cycling.

Ultimately all electrons flow into the electron-transport chain, which regulates electron flow from the matrix to the inner membrane space.

The experiment where bacteriorhodopsin and ATP synthase were inserted into reconstituted vesicles showed that biochemically, membranes control the movement of electrons in the respiratory chain.

Many of the reactions in the citric acid cycle and ATP synthesis are driven by accessibility of substrates and differential gradients across the inner membrane.

It is necessary to segregate the enzymes capable of substrate level phosphorylation during anaerobic respiration.

Short-Answer Questions

Provide a brief description of oxidative phosphorylation.

What additional free energy driven processes are powered by a proton gradient? Explain why less ATP is made from the reoxidation of $FADH_2$ as compared to NADH. What is the actual function of the protons in the synthesis of ATP by F_0F_1 ATP synthase? What was the proof that the ATP synthase was rotating?

How does the glycerol 3-phosphate shuttle function?

In the malate-aspartate shuttle, how is oxaloacetate regenerated even though there is no transporter for oxaloacetate across the inner membrane?

How is oxidative phosphorylation regulated?

What are uncouplers? Provide an example of when this might be useful.

Explain why carbon monoxide is toxic.

What is the mechanism for nonshivering thermogenesis?

What is the relationship between obesity and UCP-1?

What is the IF1 protein and what is its protective role in tissues?

Would you expect polar bears to have a rich store of brown adipose? Why or why not?

What is the difference between a respiratory inhibitor and a decoupling agent? Describe an experiment that could determine the difference.

Chapter 22 The Light Reactions

Matching Questions

Use the following to answer questions 1-10:

Choose the correct answer from the list below. Not all of the answers will be used.

960 nm
magnesium
ATP synthase
chloroplasts
thylakoids
copper
β-carotene
680 nm FAD
chlorophyll *a*
ferredoxin *b*
resonance energy transfer

_____________ This is where photosynthesis takes place.

_____________ These membranous structures in a chloroplast are stacked, flattened disks.

_____________ This is the principal photoreceptor in chloroplasts of green plants.

_____________ Chlorophyll *a* contains this ion in the center of the tetrapyrole.

_____________ Plastocyanin requires this cofactor for activity.

_____________ This is the prosthetic group of ferredoxin-$NADP^+$ reductase.

_____________ This is another name for the CF_1-CF_0 complex.

_____________ This is one of the accessory pigments in plants.

_____________ This electron carrier of photosystem I is an iron-sulfur protein.

_____________ Photosystem II responds to wavelengths shorter than this value.

Fill-in-the-Blank Questions

478 The inner membrane of a chloroplast surrounds a space called the ___.

The process in which a positive charge forms on one molecule by the loss of a photoexcited electron, and a negative charge forms on another by the gain of an electron is referred to as ___.

___ is the receptor of excited electrons from P680.

481 P700 is the pigment reaction center for ___ .

482 The manganese center of photosystem II converts ___ to ___ .

483 Electrons flow from photosystem I to photosystem II through the ___ complex.

In the light reactions of photosynthesis, the cooperation between photosystem I and photosystem II creates a flow of electrons from H_2O to ___ .

485 The light-induced electron transfer in photosynthesis results in the transfer of ___ into the thylakoid lumen.

486 In ___ ATP is generated without the concomitant formation of NADPH.

The transfer of excitation energy from one molecule to one nearby through electromagnetic interactions is called ___.

Multiple-Choice Questions

How is light used in photosynthesis?
Light is necessary to make the chlorophyll green, so the pigment can transmit electrons.
Light is used to generate high-energy electrons with great reducing potential.
Light provides heat energy for the chloroplasts.
Light is absorbed by oxygen, which is converted into water.
None of the above.

Stacked and unstacked regions of the thylakoid are arranged such that
photosystem I is located in the unstacked regions.
photosystem II is located in the stacked region.
ATP synthase occurs mainly in unstacked regions.
A and C.
A, B, and C.

How many chloroplasts does a typical plant cell have?
A) 1–100 B) 200–500 C) >1000 D) 500–800 E) None of the above.

Light absorbed by a chlorophyll *a* causes
an electron to move from the photon to the chlorophyll.
an electron to move from ground state to an excited state.
an electron to move to a neighboring water molecule.
an electron to move from chlorophyll to ADP.
None of the above.

In the overall stoichiometry of light reactions, eight photos of light generate
A) 4 NADPH.
B) 4 NADH.
3 ATP.
D) B and C.
E) A, B, and C.

The D1 and D2 subunits of photosystem II
span the thylakoid membrane.
are similar to each other.
are homologous to the L and M chains of the bacterial center.
A and C.
A, B, and C.

Light absorption induces electron transfer from P680 to
A) pheophytin.
B) QH_2.
cytochrome c.
D) chlorophyll PP.
E) None of the above.

What is the original source of electrons used to neutralize the special pair in photosystem II?
reduced cytochrome bf
NADH
H_2O
membrane lipids
ferredoxin

Complete the following reaction for photosystem I:

$Pc(Cu^{+}) + Fd_{ox} + light \rightarrow$

$Pc(Cu^{+}) + Fd_{ox} + light \rightarrow Pc\ (Cu^{+}) + (Cu^{+})\ Fd_{red}$

$Pc(Cu^{+}) + Fd_{ox} + light \rightarrow Pc\ (Cu^{2+}) + Fd_{red}$

$Pc(Cu^{+}) + Fd_{ox} + light \rightarrow Pc + Fd_{red}(Cu^{2+})$

$Pc(Cu^{+}) + Fd_{ox} + light \rightarrow Pc^{-}\ (Cu^{3+}) + Fd_{red}$

None of the above.

The pathway of electron flow from H_2O to $NADP^{+}$ in photosynthesis is referred to as

A) cooperative special pairs.
B) photorespiration.
the Z scheme of photosynthesis.
D) photophosphorylation.
E) None of the above.

How many protons are transferred into the thylakoid lumen after absorption of four photons?

A)2 B)12 C)18 D)4 E)8

Which of the following is/are light harvesting molecules?

vitamin D
carotenoids
chlorophyll *b*
plastocyanin
B and C.

Use the information in table 20.1 to answer the following question. Let us consider the overall light reaction in photosynthesis.

$NADP^{+} + H_2O \rightarrow NADPH + ½O_2 + H^{+}$

Determine E'_0 for this reaction

-0.50 V
+0.50 V
-1.14 V
+1.14 V
-0.26 V

Determine the $\Delta G^{o\prime}$ for this reaction: $NADP^{+} + H_2O \rightarrow NADPH + ½O_2 + H^{+}$

96.5 kJ/mol
–96.5 kJ/mol
50.18 kJ/mol
–220..02 kJ/mol
220.02 kJ/mol

What evidence exists to support an endosymbiotic event for the formation of a chloroplast? The DNA of the chloroplast and the cyanobacterium
is arranged in operons.
is linear.
has multiple start sites for DNA replication.
encodes all chloroplast proteins.
contains both chlorophyll and mitochondrial genes.

What is the implication of the difference in permeability of the mitochondrial membrane vs. the thylakoid membrane to Mg^{2+} and Cl^-?
The thylakoid membrane is less permeable to Mg^+, Cl^-, and H^+ and therefore more energy is needed to pump protons across the membrane.
The mitochondrial membrane, being permeable to Mg^{2+} and Cl^- means that electron flow only occurs with transport of 1 Mg^{2+} and one Cl^-.
The thylakoid membrane, being permeable to Mg^{2+} and Cl^- means that electron flow only occurs with transport of 1 Mg^{2+} and one Cl^-.
The mitochondrial membrane, being permeable to Mg^{2+} and Cl^- means that although protons are pumped across the membrane, no membrane potential is generated.
The thylakoid membrane, being permeable to Mg^{2+} and Cl^- means that although protons are pumped across the membrane, no membrane potential is generated.

Short-Answer Questions

Write out the reaction for photosynthetic production of carbohydrates and oxygen.

Humans do not produce energy by photosynthesis. Why, then, is this process critical to our survival?

How is a chloroplast similar to a mitochondrion?

Why are chlorophylls good candidates for photoreceptors?

How is energy transferred from a photoreceptor molecule to photosystem II?

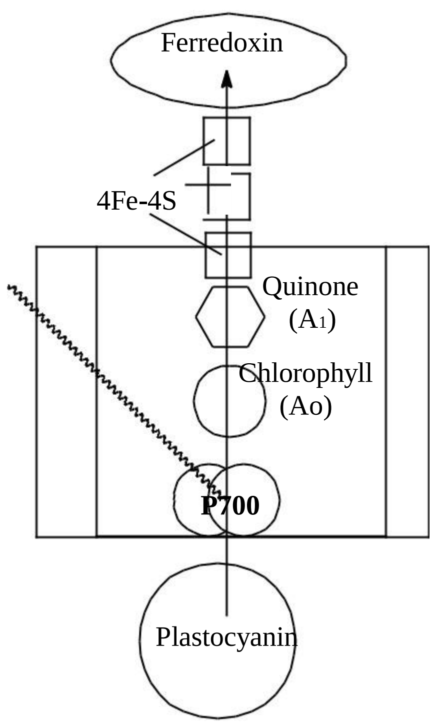
Write the overall reaction of photosystem II.

What are the likely reasons that manganese evolved as the ion used in photosystem II?

Describe the process of cyclic photophosphorylation.

Give the overall net equation as catalyzed by the "Z scheme" of photosynthesis.

Describe the path of electrons in photosystem I.



Treatment of chloroplasts with KCN inhibits photophosphorylation, presumably at the level of plastocyanin. Predict the effect of KCN on a plant's ability to perform cyclic photophosphorylation.

How is it possible to make ATP without generating NADPH?

How do herbicides such as diuron or atrazine work?

What is the role of accessory pigments in photosynthesis?

Chapter 23 The Calvin Cycle

Matching Questions

Use the following to answer questions 1-10:

Choose the correct answer from the list below. Not all of the answers will be used.

rubisco
transketolase
Crassulacean acid metabolism
autotrophs
C_6
pyruvate-P*i* dikinase
hexose monophosphate pool
heterotrophs
glycolysis
C_4
sucrose
3-phosphoglycerate

____________ These organisms can synthesize glucose from carbon dioxide and water.

____________ This is the product of CO_2 fixation with ribulose-1,6-bisphosphate.

____________ This is another name for ribulose 1,5-bisphosphate carboxylase/oxygenase.

____________ This is the pathway that ensures that sufficient amounts of CO_2 are available to minimize wasteful photorespiration.

Glucose 1-phosphate, glucose 6-phosphate, and fructose 1-phosphate belong to the ____________.

_____________ This enzyme is involved in both the Calvin cycle and the pentose phosphate pathway.

_____________ This metabolic adaptation is employed by plants living in hot, dry climates.

_____________ This sugar found in plants is readily transported and easily mobilized.

_____________ These organisms obtain energy from chemical fuels.

_____________ is the final enzyme in the C_4 pathway.

Fill-in-the-Blank Questions

The biochemist who first described the pathway for fixing CO_2 is ______.

The enzymes that catalyze the dark reactions of photosynthesis are located in the _____of the chloroplasts.

The first step of the Calvin cycle involves the addition of CO_2 to _____ to produce two molecules of 3-phosphoglycerate.

The binding site of Mg^{2+} to rubisco involves the formation of a _____ group between lysine 221 and CO_2.

In photorespiration oxygen is consumed and _____ is released.

The three stages of the Calvin cycle are _____.

In C_4 plants, carbon dioxide is added to _____ to form oxaloacetate, which is reduced to malate, which carries CO_2 to the bundle-sheath cells.

Volcanoes, which spew millions of tons of gasses and particles into the atmosphere, cause a(an) (decrease/increase) _____ in photosynthesis specifically during the daytime.

_____is an example of a mechanism of accelerating photosynthesis by increasing carbon dioxide concentration.

Plants adapt to arid ecosystems using _____.

Multiple-Choice Questions

ATP is called the energy currency. The currency of biosynthetic reducing power is A) NADPH. B) CoA. C) AMP. D) ADP. E) None of the above.

What is the source of carbons for the Calvin cycle?

A) glucose
B) carbon dioxide
glycogen
D) glyoxylate
E) None of the above.

Plants store glucose as ____________ and _____________.
starch; sucrose
fructose; sucrose
starch; fructose All
of the above. None
of the above.

The most abundant protein on Earth is:
ribulose 1.5-bisphosphate.
aldolase.
rubisco.
phosphopentose epimerase.
transketolase.

In the Calvin cycle, 3-phosphoglycerate is converted into which hexose phosphate?
A) glucose 1-phosphate
B) glucose 6-phosphate
fructose 6-phosphate
D) All of the above.
E) None of the above.

Which form of thioredoxin activates certain Calvin cycle enzymes?
A) reduced B) oxidized C) dimeric D) A and C E) B and C

Which coenzyme is required by glyceraldehyde 3-phosphate dehydrogenase in chloroplasts to convert 3-phosphoglycerate into glyceraldehyde-3-phosphate?
A) NADH
B) NADPH
NAD^+
D) $NADP^+$
E) thiamine pyrophosphate

The C_4 pathway is necessary in tropical plants because:
at high temperatures, the plants cannot maintain sufficient water levels within the cells.
tropical plants do not have proper day/light cycles to maintain the balance of CO_2 necessary for carbohydrate storage.
at high temperatures, the oxygenase activity of rubisco is high.
All of the above.
None of the above.

What is the energy cost of the C_4 pathway?
Thirty molecules of ATP are used per hexose molecule made.
Eighteen molecules of ATP are used per hexose molecule made.
Thirty molecules of NADPH are used per hexose molecule made.
Eighteen molecules of ATP and 12 of NADPH are used per hexose molecule made.
None of the above.

Rubisco is found:
in the meso sheath bundles.
in the stroma of the chloroplasts.
embedded in the plant cell wall.
in the lumen of the thylakoid disc.
None of the above.

The enzyme that catalyzes the rate-limiting step in hexose synthesis is:
aldolase.
transketolase.
rubisco.
phosphosepentose isomerase.
None of the above.

________ rounds of the Calvin cycled are required for the production of hexose.
One
Three
Six
Twelve
Nine

The immediate unwanted side reaction of rubisco is:
phosphoglycolate .
ribulose 1,5-bisphosphate.
glycerol.
amylose.
phosphofuctose.

The energetic equivalent of ______ ATP molecules is(are) consumed in transporting CO_2 to the chloroplasts of the bundle-sheath cells.
1
2
3
4
6

The protein that regulates the Calvin cycle is:
protein kinase C.
rubisco .
thioredoxin.
ferredoxin-thioredoxin reductase.
None of the above.

On a molecular level, how might global warming affect carbon dioxide fixation?
Carbon dioxide, being a denser gas than oxygen, will cause more plants to sequester CO_2 in mesophyll cells.
Increase in temperatures leads to increase in water loss in leafy plants compared to succulents, thus, the light reactions are inhibited.
Rubisco's oxygenase activity decreases with an increase in temperature, requiring more plants to use the C_3 cycle.
Ribusco's oxygenase activity increases with an increase in temperature, requiring more plants to use the C_4 pathway.
Ribusco's carboxylase activity increases with an increase in temperature, requiring more plants to use the C_3 pathway.

Desert plants prevent loss of water vapor by closing stomata during the heat of the day and opening them at night. How does this affect the movement of CO_2 and what are the implications for CO_2 fixation?

Stomata, like cellular transporters can be selective and bent water molecules enter through different stomata than linear CO_2 and $O_{2;}$ thus, desert plant CO_2 fixation is not affected.

CO_2, being a non-polar molecule moves easily thought cell membranes, thus, the opening and closing of stomata does not affect CO_2 fixation.

Under normal conditions, the light reactions don't work at maximum saturation, therefore, a diurnal pattern of H_2O decreases CO_{2+} fixation only minimally.

CO_2 entry into the plant is also inhibited by the closing of the stomata; however, the impact on CO_2 fixation is minimal.

CO_2 entry into the plant is also inhibited by the closing of the stomata; however, CO_2 is sequestered in vacuoles in the form of malate.

Knowing what you do about the distribution of the light reaction enzymes, where would you expect to find Calvin cycle enzymes and why?

lumen of the thylakoid membrane, as this is the location of the splitting of water

lumen of the thylakoid membrane, as this is the location of NADPH and ATP synthesis

thylakoid integral membrane proteins that derive energy from proton pumping

stromal side of thylakoid membrane, as this is the location of NADPH and ATP formation

stromal side of the thylakoid membrane, as this is the location of the splitting of water

The mechanics of CO_2 binding involves Mg^{2+} and Lys 201. What would you expect to be the pH optimum and [Mg^{2+}] for this to occur?

high pH, high [Mg^{2+}]

high pH, low [Mg^{2+}]

low pH, high [Mg^{2+}]

low pH, low [Mg^{2+}]

neutral pH, low [Mg^{2+}]

Short-Answer Questions

Why are reactions of the Calvin cycle called the "dark reactions"?

Describe the stages of the Calvin cycle.

1.

Which enzyme is cited as the most abundant enzyme in the biosphere? Why is this so?

What is photorespiration? Why is it wasteful?

Give the sequence of reactions involved in the synthesis of sucrose from two glucose 6-phosphate.

Why is the chemistry of the "dark reactions" referred to as a cycle and not a pathway?

Explain/describe the stoichiometry of the Calvin cycle to convert three molecules of CO_2 into one molecule of dihydroxyacetone phosphate.

What is the energy requirement for the formation of hexose from CO_2 in terms of ATP equivalents and NADPH?

How is rubisco activity controlled?

Describe the role of thioredoxin in regulating the Calvin cycle.

Write the balanced reaction for the Calvin cycle.

Describe, in biochemical terms, how bread becomes stale.

Explain how the relationship of the mesophyll cell and the bundle-sheath cell help to regulate the Calvin cycle.

How does light alter the fixation of CO_2?

What is the basic difference between C_4 and C_3 plants?

Rubisco's Km for CO_2 is 50 times higher than for O_2 but k_{cat} values are similar. This suggests that at the level of oxygenase activity would be negligible. Why then is it not? [O_2] vs. [CO_2].

Chapter 24 Glycogen Degradation

Matching Questions

Use the following to answer questions 1-10:

Choose the correct answer from the list below. Not all of the answers will be used.

reducing
α-1,6-glycosidic
phosphorylase kinase
α-1,4-glycoside non-reducing
phosphorylase a
glucose 6-phosphatase
UTP-glucose
calmodulin
phosphorolysis
epinephrine
glucagon

____________ Most of the glucose residues in glycogen are linked by this type of bond.

____________is the end of glycogen where the anomeric carbon is free to change to the open or closed conformation.

____________ This is the process by which a bond is cleaved by the addition of orthophosphate.

_____________ This type of bond is located at the branch points in glycogen.

_____________ This is the liver enzyme that cleaves the phosphate from glucose-6-phosphate.

_____________ This enzyme catalyzes the phosphorylation of glycogen phosphorylase.

____________ This protein is the δ subunit of phosphorylase kinase.

_____________ This hormone signifies the starved state.

_____________ Takes place instead of hydrolysis in glycogen breakdown.

_____________ This enzyme serves as the glucose "sensor" enzyme in liver cells.

Fill-in-the-Blank Questions

In order to degrade branches in glycogen, two enzymes are required; a transferase and _____.

Phosphoglucomutase requires the intermediate _____ for the interconversion of glucose-1-phosphate and glucose-6-phosphate.

In skeletal muscle, the binding of _____ stabilizes phosphorylation b into the active form.

Phosphorylase kinase becomes fully active by being phosphorylated and binding _____.

_____markdedly stimulates glycogen breakdown in muscle by initiating a cAMP signal-transduction cascade.

The transferase enzyme shifts a block of _____ glycosyl units.

The hydrolysis catalyzed by α-1,6-glucosidase releases a _____ molecule.

In the liver, glycogen synthesis and degradation are regulated to maintain levels of _____ in blood.

Which GTP binding protein is activated by epinephrine binding to the adrenergic 7TM receptor? _____.

One mechanism for turning off glycogen degradation involves the removal of a phosphate group from glycogen phorphorylase by the enzyme _____.

Multiple-Choice Questions

The major site(s) of glycogen storage is (are):

A) adipose tissue.
B) liver.
skeletal muscle.
D) B and C
E) A, B, and C

The key enzyme in glycogen degradation is:

A) glycogen phosphatase.
B) glycogen phosphorylase.
glucose 1-phosphate synthase.
D) All of the above.
E) None of the above.

Calcium binds and leads to the activation of what enzyme in glycogen degradation?

A) phosphorylase
B) phosphoglucomutase
protein kinase C
D) phosphorylase kinase
E) glycogen phosphorylase

Conversion of glucose 1-phosphate to glucose 6-phosphate is carried out by the enzyme:

A) phosphoglucomutase.
B) kinase 1-P.
phosphoglycerate mutase.
D) All of the above.
E) None of the above.

What molecule must be excluded from the active site of glycogen phosphorylase?
A) glucose
B) glucose 1-phosphate
water
D) All of the above.
E) None of the above.

How is phosphorylase b converted into phosphorylase a?
addition of a phosphate to a serine residue
dimerization, which forms the active site pocket
cleavage of 10 amino acids from the *N*-terminal end of the protein
All of the above.
None of the above.

Why is the T state of glycogen phosphorylase less active?
The adjacent amino acids are not phosphorylated and thus the catalysis cannot be carried out.
The active site is partially blocked.
ATP cannot be bound by the T state.
All of the above.
None of the above.

What physiological conditions render phosphorylase b less active?
high ATP, high AMP, and glucose 6-phosphate levels
high ATP and low calcium ion levels
high ATP and high glucose 6-phosphate levels
All of the above.
None of the above.

What is the function of liver glycogen degradation?
for glucose export to other tissues when glucose levels are low
to maintain glucose levels after a large meal
to provide for the large energy needs of the liver
All of the above.
None of the above.

Phosphorylase kinase is regulated by:
calcium ions.
cAMP activated PKA (Protein Kinase A).
glycogen levels.
A, B, and C.
A and B.

Two critical hormones that signal for glycogen breakdown are:
A) insulin and epinephrine.
B) glucagon and epinephrine.
glucagon and insulin.
D) All of the above.
E) None of the above.

Muscle phosphorylase is mostly inactive when:
A) the enzyme is in the b state.
B) in the R state.
bound to AMP.
D) All of the above.
E) None of the above.

What is required to remove branches in glycogen?
a debranching enzyme
a transferase enzyme
a glycosidase enzyme
A and C.
All of the above.

Which liver enzyme is deficient in Hers disease?
A) phosphorylase
B) transferase
glucosidase
D) phosphoglucomutase.
E) None of the above.

Inhibition of muscle glycogen phosphorylase by glucose 6-phosphate is an example of what kind of inhibition?
allosteric heterotrophic activation
allosteric homotrophic inhibition
feedback inhibition
feedforward inhibition
mixed inhibition

Why does it make sense that muscle cells are not responsive to glucagon, but both types of cells are responsive to epinephrine?
Glucagon in liver signals the need for glycogen synthesis.
Phosphorylase b in muscle transitions to the T state in the presence of epinephrine so that control is independent of liver phosphorylase b.
Epinephrine stimulates the transferase enzyme so that glycogen is more readily available in highly active muscles.
Formation of lactate in muscle cells is released into the blood where it is taken up by the liver for gluconeogenesis.
The function of epinephrine is to maintain a nearly constant concentration of glucose in the blood during periods of relaxation.

You are taking your new puppy for a walk and a vicious-looking dog comes rushing out from an unfenced yard. You pick up your puppy and take off down the road. What is the most likely form of the phosphorlase in muscle?
phosphorlyase a, R state, not phosphorylated
phosphorylase a, R state, phosphorylated
phosphorlyase a, T state, phosphorylated
phosphorylase b, R state, phosphorylated
phosphorylase b, T state, phosphorylated

You are on a long car trip and stop to fill up on gas and sugary snacks. Once back on the road, what is the most likely form of phosphorlyase in the liver?
phosphorlyase a, R state, not phosphorylated
phosphorylase a, R state, phosphorylated
phosphorlyase a, T state phosphorylated
phosphorylase b, R state, phosphorylated
phosphorylase b, T state, phosphorylated

Short-Answer Questions

What are some of the advantages of having glycogen as a readily available glucose source?

What are the three steps in glycogen degradation?

Why is the formation of glucose-1-phosphate advantageous?

Why can’t the glucose 1-phosphate diffuse out of the cell?

Why does the liver possess a specific enzyme that can cleave glucose 6-phosphate to form glucose and orthophosphate?

Draw a structure showing the most common linkage between glucose units found in glycogen.

Why must glycogen control be manifested differently in muscle and liver?

How does epinephrine stimulate glycogen breakdown in muscle? (Describe the series of events.)

What path in addition to the cAMP-induced signal transduction is used in the liver to stimulate glycogen breakdown by epinephrine?

Both phosphorylase a and b exist in equilibrium between R and T states. Which are the most active and least active combinations?

What are the two regulatory controls for phosphorylase kinase?

Your puppy has grown into a dog that needs lots of exercise so you take her out everyday for a long, slow bike ride. Which type of muscle fiber are you using and what state is glycogen in?

Chapter 25 Glycogen Synthesis

Matching Questions
Use the following to answer questions 1-10:

Choose the correct answer from the list below. Not all of the answers will be used.
UDP-glucose
non-reducing
synthesis
glucose
glycogenin
von Gierke disease
glycogen synthase
UTP-glucose
protein phosphatase 1 (PP1)
PPi
glycogen phosphate
McArdle disease

Synthesis of glycogen starts with the phosphate group transfer from UTP to ____________.

_____________ This is the activated form of glucose that is required for glycogen synthesis.

Hydrolysis of _________ drives the formation of UDP-glucose.

_____________ Glucosyl units are added to this end or terminal of glycogen.

_____________ is the key regulatory enzyme in glycogen synthesis.

Glycogen ____________is inhibited by phosphorylase kinase.

____________ dissociates from phosphorylase a in the T state.

____________is the storage disease that results in cramps with light exercise.

____________ This protein serves as the primer used by glycogen synthase.

____________is the glycogen storage disease where the defective enzyme is glucose 6-phosphatase.

Fill-in-the-Blank Questions

_____ acts as a “high-energy handle” for biosynthetic reactions including glycogen synthesis.

The reaction catalyzed by _____ transfers UDP-glucose to the hydroxyl of an existing glycogen core.

_____ is the protein that can self-glycosylate with up to 10–20 glucose units

In general, phosphorylated forms of glycogen synthase lead to _____ levels of glycogen.

There is a high _____-to-insulin ratio in diabetes.

Glycogen synthase catalyzes the transfer of a glucose residue from UDP-glucose to one of the _____ ends of glycogen.

The glycogen branching enzyme moves a block of _____ (or so) glucose residues to form a branch point at least four residues from a pre-existing branch.

Glycogen synthase is converted into the active form by the action of _____.

The complete oxidation of a glucose residue from glycogen produces _____ ATP.

Insulin stimulates glycogen synthase by inactivating _____.

Multiple-Choice Questions

The activated glucose donor of glycogen synthesis is:
A) glucose 1-phosphate.
B) glucose.
ATP.
D) UTP.
E) None of the above.

At the center of a glycogen molecule is:
A) glucose.
B) glygogenin.
UDP-glucose.
D) glycogen synthase.
E) glycogen phosphorylase.

What enzyme(s) is (are) required to synthesize α-1,4-glycosidic bonds in glycogen?
A) glycogen synthase
B) UDP-glucose phosphorylase
branching enzyme
D) A and B
E) B and C

Glycogenin:
A) consists of dimmer proteins.
B) self assembles 10-20 glycosyl units.
is the primer for glycogen synthase.
D) B and C
E) All of the above.

The _______________ creates a 1,6-glycosidic link.
A) branching enzyme
B) glucose transferase
glycogen isomerase
D) glycogen synthase
E) None of the above.

The enzyme that begins the kinase cascade activating glycogen degradation is:
A) glycogen synthase
B) phosphorylase kinase
PKC
D) PKA
E) tyrosine kinase

Which is the true glucose level sensor in the cell?
A) insulin
B) phosphorylase a
glucagon
D) glycogen synthase
E) protein phosphatase I

An incorrect, tight binding of PP1 to glycogen synthase would result in
A) a hyperactive glycogen synthase.
B) hyper-glycogen levels.
increased in insulin action
D) high blood glucose.
E) activated glycogen synthase.

After exercise, muscle cell glycogen metabolism is regulated by:
A) insulin.
B) phosphorylase a
glucagon
D) glycogen synthase
E) protein phosphatase 1

___________ results from a loss or inactive insulin receptors
A) Hypoglycemia
B) Hyperinsulinemia
Type I diabetes
D) Type II diabetes.
E) None of the above.

Which of the following occur after a carbohydrate-rich meal?
Blood-glucose levels increase leading to glycogen storage in the liver.
Blood-glucose levels increase leading to glycogen storage in the muscle.
Glycogen storage in the muscle shuts down.
All of the above.
None of the above.

Type I diabetes leads to ___________ in the liver.
A) increased glucose transport
B) increased glycogen synthesis
decrease in fructose 2,6-phosphate
D) decrease in gluconeogenesis
E) All of the above.

ATP is known as the energy currency of the cell; however, ATP is not used directly in any of the enzymatic reactions in glycogen synthesis. How then does ATP provide energy currency for glycogen synthesis?
ATP is used to regenerate GTP in the cGMP cascade.
ATP is used by the diphosphokinase to regenerate UTP.
Dietary glucose is phosphorylated to glucose 1-phosphateby hexokinase.
The branching enzyme requires the hydrolysis of ATP.
An activated glucosyl unit of ADP-glucose is transferred to the hydroxyl group at c-4 of a terminal residue within a chain of glycogen.

Why would you expect the amount of glycogen in type I glycogen-storage disease (von Gierke disease) to be increased?
Glycogen phosphatase is activated by increases in glucose 6-phosphate.
Glucose 6-phosphatase is the final step in glycogenolysis. Thus, glucose 6-phosphate, the first metabolite in glycogen synthesis, remains high.
Epinephrine inhibition of glycogen synthesis is defective.
cAMP inhibition of glycogen synthesis is defective.
The R form of glycogen synthase is stabilized permanently.

Glycogen metabolism is regulated, up to a point, by a cyclic AMP cascade. At what point do glycogen synthesis pathways diverge from glycogen degradation pathways?
Phosphorylase kinase converts phosphorylase *b* to phosphorylase *a* and glycogen synthase *a* to glycogen synthase *b*.
Protein kinase A leads to the activation of glycogen degradation, and also the inhibition of glycogen synthase by conversion from *a* to *b*.
Phosphorylase kinase converts phosphorylase *a* to phosphorylase *b* and glycogen synthase *a* to glycogen synthase *b*.
Protein kinase A leads to the activation of glycogen degradation, and also the inhibition of glycogen synthase by conversion from b to a.
Cyclic AMP converts inactive PKA to active PKA, causing the inactivation of phosphorylase kinase.

Predict the major consequence of the loss of the gene that encodes the glycogen-targeting subunit of protein phosphatase 1.
Protein kinase A would not be inhibited from phosphorylating PP1.
Glycogen synthase *a* will be fixed in the T form.
Phosphorylase kinase will be activated only in the presence of cAMP.
Glucose 6-phosphatase will display reduced activity.
Loss of this gene would prevent association of the catalytic subunit of PP1 from its substrate.

Short-Answer Questions

Draw the substrates and products for glycogen synthesis and indicate where insulin and glucagon coordinate both pathways.

Using thermodynamic terms, describe the mechanism by which UDP-glucose is formed.

How are new glucosyl units added to a growing glycogen molecule?

Type I diabetes is often called fasting in the sea of plenty. Explain?

Explain the conversion between both a and b, R and T forms of phosphorylase.

There is a rare disease where a critical serine in muscle glycogenin is mutated to alanine, which results in what biochemical outcome?

Insulin binds to its receptor and causes what protein to be activated in the cytoplasm? Explain

how the liver responds to muscle challenges during insulin dependent diabetes. Explain why

patients with McArdle's disease do not accumulate lactate during light exercise? Give the

reaction catalyzed by UDP-glucose pyrophosphorylase.

669 The reaction, glucose-1-phosphate + UTP $\rightleftharpoons$ UDP-glucose + PPi, is readily reversible. Explain how the formation of UDP-glucose from glucose-1-phosphate and UTP is essentially reversible.

How does insulin stimulate glycogen synthesis?

What did Carl and Gerty Cori discover about the cause of von Gierke disease? Briefly explain how this information helps to explain the symptoms of the disease.

How does insulin act on glycogen synthesis?

Chapter 26 The Pentose Phosphate Pathway

Matching Questions

Use the following to answer questions 1-10:

Choose the correct answer from the list below. Not all of the answers will be used.

non-oxidative phase
oxidative phase
transketolase
glucose 6-phosphate
reducing equivalents
f)lactonase
transaldolase
glutathione reductase
glycolysis
NADH
fructose-6-phosphate
NADPH
glucose

____________ is a substrate for the pentose phosphate pathway.

____________ is the key source of biosynthetic reducing equivalents.

____________ The second phase of the pentose phosphate pathway.

____________ Excess carbons of the pentose phosphate pathway are shunted to this other metabolic pathway.

____________ and transketolase are the enzymes that link glycolysis and the pentose phosphate pathway.

____________ Ribulose 5-phosphate is the product of this phase.

_____________ results in a C3 and a C7 carbohydrate from two C5 carbohydrate precursors.

_____________ Two molecules of this product are formed in Phase II of the pentose phosphate pathway.

_____________ A deficiency of glucose 6-phosphate can cause hemolytic anemia. This is due to a loss in activity in this enzyme in red blood cells.

_____________ 6-phosphogluconate is the product of this reaction.

Fill-in-the-Blank Questions

The two key components required for growth are _____ and biochemical reducing power.

_____ is the committed step of the pentose phosphate pathway.

Hemolytic anemia is a result of an increase in reactive oxygen species. The manifestation of the disease is actually caused by a defect in_____.

_____ is converted to xylulose-5-phosphate by the enzyme phosphopentose epimerase.

Isomers with multiple asymmetric centers differing in only one asymmetric center are_____.

The enzyme transketolase transfers a _____ -carbon fragment from a ketose to an aldose.

_____ is the enzynme that catalyzes the hydrolysis of the ester linkage of the lactone resulting in the ring opening.

The oxidative phase of the pentose phosphate pathway produces _____, which is required for lipid biosynthesis.

NADPH is required by the liver and adipose for synthesis of _____.

Hemolytic anemia is caused by a deficiency of the enzyme _____.

Multiple-Choice Questions

ATP is called the energy currency. The currency of biosynthetic reducing power is A) NADPH. B) NADH. C) AMP. D) ADP. E) None of the above.

The pentose phosphate pathway

A) is stimulated by NADH.
B) is stimulated by NADPH.
operates primarily in non-dividing cells.
D) is contained within the mitochondria of adipose cells.
E) None of the above.

The sugar(s) that is (are) converted into ribulose 5-phosphate by a single enzymatic step is (are):

A) ribose 5-phosphate.
B) xyulose 5-phosphate.
erythrose 4-phosphate.
D) A and B
E) B and C

_____ oxidizes the C3 hydroxyl to a ketone.

A) Lactonase
B) Glucose 6-phosphate dehydrogenase
Transaldolase
D) Transketolase
E) 6-phosphogluconate dehydrogenase

Which biosynthetic pathway requires NADPH?

A) cholesterol
B) fatty acid
nucleotide
D) All of the above.
E) None of the above.

In mode two, _____

A) the needs for NADPH and ribose 5-phosphate are balanced.
B) much more NADPH than ribose 5-phosphate is required.
more ribose 5-phosphate than NADPH is required.
D) NADPH and CO_2 are required.
E) NAD^+ is needed in excess.

The purpose of the pentose phosphate pathway is to:
A) generate ATP.
B) generate NADPH.
synthesize five-carbon sugars.
D) A and B
E) B and C

Reduced glutathione maintains red blood cell structure by:
A) protecting against falciparum malaria.
B) maintaining hemoglobin structure.
preventing Heinz body formation.
D) A and C
E) B and C

Which of the following reactions is NOT part of the pentose phosphate pathway?
A) $C_5 + C_5 \underset{}{\overset{Transketolase}{\rightleftharpoons}} C_3 + C_7$
B) $C_4 + C_5 \underset{}{\overset{Transketolase}{\rightleftharpoons}} C_3 + C_6$
$C_3 + C_7 \underset{}{\overset{Transaldolase}{\rightleftharpoons}} C_6 + C_4$
D) $C_5 + C_6 \underset{}{\overset{Transketolase}{\rightleftharpoons}} C_2 + C_9$
All of the above.

What is the net reaction of the transketolase and transaldolase steps?
A) $3C_5 \rightleftharpoons 2C_6 + C_3$
B) $2C_5 \rightleftharpoons C_6 + C_4$
$3C_5 \rightleftharpoons C_6 + 3C_3$
D) $2C_5 \rightleftharpoons 2C_4 + C_2$
E) None of the above.

Glucose-6-phosphate dehydrogenase is inhibited by low levels of:
NADPH.
$NADP^+$.
ribose-5-phosphate.
A and C
B and C

In the non-oxidative stage of the pentose phosphate pathway, intermediates of ______________ are produced.
the citric acid cycle
glycolysis
glycogen degradation
A and C
B and C

Section 26.3 in the text highlights several conditions due to a deficiency in glucose 6-phosphate dehydrogenase. All of these conditions include anemia as a symptom. Why?
The oxidized form of glutathione is the substance that normally eliminates peroxides and is depleted in the absence of NADPH.
Peroxides cause damage to red blood cells because there is no NADPH being produced.
Red blood cells with diminished glucose 6-phosphate dehydrogenase activity have an overactive response to oxidative stress.
Reactive oxygen species formation is enhanced by reduced glutathione leading to cell membrane disruption.
There is an abundance of NADPH in red blood cells due to the loss of mitochondria.

Under what conditions might the pentose phosphate pathway produce large amounts of NADPH without significant net production of ribose-5-phosphate?
Synthesis of fatty acids in the liver.
Pyruvate is synthesized to generate ATP.
Cells are rapidly dividing.
A and C
B and C

NADPH is required for which of the following detoxification reactions or enzymes?
cytochrome P450 monooxygenase
reduction of glutathione$_{(ox)}$.
deamination of serine
A and B
All of the above.

The link between the pentose phosphate pathway and glycolysis is well documented. How does this link facilitate the growth of rapidly dividing cancer cells?
Rapidly dividing cells switch to anaerobic glycolysis to meet their $NADP^+$ needs.
Glycolytic intermediates are rapidly depleted due to the increased demand for ATP to synthesize cellular structures leading to decreased production of ribose 5-phosphate.
Accumulated glycolytic intermediates are used by the pentose phosphate pathway to synthesize ribose 5-phosphate.
Lactonase is allosterically activated by the increase in glycolytic intermediates.
6-Phosphogluconate dehydrogenase switches to NADH formation to speed up ribose 5-phosphate synthesis.

The following reaction summarizes the formation of ribose 5-phosphate when the cell requires ribose for biosynthesis, but does not require NADPH. Identify the enzyme that catalyzes the reaction that requires ATP.

$$5 \text{ glucose 6-phosphate} + \text{ATP} \rightarrow 6 \text{ ribose 5-phosphate} + \text{ADP}$$

lactonase
glutathione reductase
aldolase
phosphofructokinase
6-phosphogluconate dehydrogenase

If C-1 of ribose 5-phosphate is labeled with radioactive ^{14}C , where would this label be after the following reaction?

xylulose 5-phosphate + ribose 5-phosphate ↔
glyceraldehyde 3-phosphate + sedoheptulose 7-phosphate

C-1 of glyceraldehyde 3-phosphate
C-3 of glyceraldehyde 3-phosphate
C-1 of sedoheptulose 7-phosphate
C-2 of sedoheptulose 7-phosphate
C-3 of sedoheptulose 7-phosphate

Short-Answer Questions

What enzyme controls the pentose phosphate pathway?

What is the common feature of the mechanism of the metabolic oxidations of 6-phosphogluconate and isocitrate?

How is the pentose phosphate pathway regulated?

Several physiological modes are possible for the metabolic need for NADPH, ribose 5-phosphate, and ATP. In one scenario, such as found in adipose tissue, much more NADPH is required than ribose 5-phosphate. How is this maintained?

How can a deficiency of glucose 6-phosphate confer a physiological advantage?

Using structures, give the oxidative phase of the pentose phosphate pathway.

In the non-oxidative phase of the pentose phosphate pathway, two reactions are catalyzed by transketolase. What are the substrates and products of these reactions?

What is a primary difference between the oxidation of glucose to CO_2 by glycolysis and the citric acid cycle vs. by the pentose phosphate pathway?

How does NADPH protect red blood cells from hemolysis?

What are the reactions in the oxidative phase of the pentose phosphate pathway?

In Mode 4 of the pentose phosphate pathway, pyruvate is the final product. What does this mode provide for the cell?

Chapter 27Fatty Acid Degradation

Matching Questions

Use the following to answer questions 1–10:

Choose the correct answer from the list below. Not all of the answers will be used.

pyrophosphate
106 ATP
pyruvate dehydrogenase
β oxidation
glucagon
glycolysis
30 ATP
cobalamin
β hydroxybutyrate
hormone-sensitive lipase
oxaloacetate
adipose
acyl CoA dehydrogenase

722 Triacylglycerols are stored in ____________ cells in animals.

The approximate energy yield from complete oxidation of palmitate is ____________.

The molecule ____________stimulates lipolysis when energy reserves are low.

The enzyme ____________ is activated by hormones and is responsible for the first hydrolysis of triacylglycerol.

The transfer of an acyl group to coenzyme A is driven by the hydrolysis of ____________.

The pathway by which an acyl CoA is degraded to acetyl CoA is ____________.

Another name for vitamin B_{12} is ____________.

The availability of the metabolite ____________ determines whether acetyl CoA, made from fatty acids, can enter the citric acid cycle.

The compound ____________ is considered one of the "ketone bodies."

Increases in acetyl CoA during starvation inhibit the enzyme ____________.

Fill-in-the-Blank Questions

In eukaryotes, the degradation of fatty acids occurs in the _____.

The first step of β oxidation is a(n) _____-linked oxidation of the fatty acyl chain.

Glucagon and _____ stimulate the breakdown of triacylglycerols by activation of a hormone-sensitive lipase.

β oxidation of odd-numbered fatty acids produces acetyl CoA and _____.

The final step of each round of oxidation of fatty acids is the _____ cleavage to yield acetyl CoA.

_____ from fatty acid oxidation may enter glycolysis after phosphorylation and oxidation.

Acetoacetate spontaneously decarboxylates to form _____.

The brain uses _____ instead of glucose for its source of ATP production during long-term fasting.

Acetoacetate and _____are referred to as ketone bodies and are a major fuel source for muscle tissue.

Untreated, chronic ketone body production will_____blood pH levels.

Multiple-Choice Questions

Fatty acids are the building blocks of
cholesterol.
phospholipids.
glycolipids.
B and C.
A, B, and C.

Enzymes that digest the triacylglycerols into free fatty acids and monoacylglycerol are called
hydrases.
glyases.
lipases.
All of the above.
None of the above.

The hormone __________ induces lipolysis, whereas the hormone __________ inhibits the process.
epinephrine; adrenocorticotropic hormone
glucagon; insulin
insulin; norepinephrine
glucagon; epinephrine
epinephrine; glucagon

The enzyme acyl CoA synthetase catalyzes
lipolysis to release free glyceraldehyde.
ATP-dependent reduction prior to activation.
ATP-dependent activation of fatty acids using CoA.
All of the above.
None of the above.

Coenzyme(s) involved in the degradation of saturated fatty acyl CoA include(s)
FAD.
NAD^+.
TPP.
A and B.
A, B, and C.

The β oxidation of myristyl-CoA (14:0) yields
7 acetyl CoA + 7 $FADH_2$ + 7 NADH + 7 H^+.
6 acetyl CoA + 7 $FADH_2$ + 7 NADH + 7 H^+.
7 acetyl CoA + 6 $FADH_2$ + 6 NADH + 6 H^+.
7 acetyl CoA + 7 FAD + 7 NAD^+.
14 acetyl CoA + 12 $FADH_2$ + 12 NADH + 12 H^+.

How many rounds of β oxidation would be required for a 16-carbon fatty acyl chain to be degraded to acetyl CoA?
16
8
7
15
None of the above.

In the conversion of propionyl CoA to succinyl CoA, what type of reaction does the cobalamin-containing enzyme catalyze?
intramolecular rearrangements
methylations
reduction of ribonucleotides to deoxyribonucleotides
A and C
A, B, and C

Odd-numbered unsaturated fatty acids are metabolized by which of the following enzymes?
propionyl CoA carboxylase
2,4-dienoyl reductase
enoyl-CoA isomerase
All of the above.
None of the above.

Which organs or tissues prefer to use ketone bodies such as acetoacetate as a fuel energy source instead of glucose?
the heart muscle
the renal cortex
the brain
A and B
A, B, and C

Triacylglycerol stored in adipose tissue is used by the liver and other tissues for
glycerol for pyruvate and glucose in liver.
ATP production via the citric acid cycle in muscle.
conversion to acetyl CoA and ketone bodies during starvation for the brain.
All of the above.
None of the above.
Ans: D Section: 27.1

What does muscle weakness and cramping affecting skeletal muscle, heart, and kidney likely indicate?
carnitine excess in the diet
loss of hormone-sensitive lipase activity
malfunctioning or deficient carnitine translocase
ketone-body production
All of the above.

Three rounds of fatty acid oxidation result in
two acetyl CoA molecules.
three acetyl CoA molecules.
the synthesis of palmitate.
the formation of enoyl CoA.
the complete oxidation of palmitate B.

The activation of fatty acids for degradation takes place in two steps. What is the intermediate formed and why is activation necessary for β oxidation to occur?
Acyl adenlyate; the cAMP formed by this reaction activates protein kinase A.
Acyl adenlyate; only the activated form of the fatty acid can react with coenzyme A.
Propionate; only the activated form of the fatty acid can react with coenzyme A.
Acyl carnitine; the cAMP formed by this reaction activates protein kinase A.
Acyl carnitine: this intermediate is needed to fuel the carnitine cycle.

Exercising first thing in the morning without eating mobilizes lipid stores for fuel. All of the below are involved in this mobilization, EXCEPT
glucagon binds 7TM receptors that activate adenylate cyclase.
perilipin is phosphorylated.
cAMP stimulates protein kinase A.
hormone-sensitive lipase completes the mobilization of fatty acids with the production of a free fatty acid and glycerol.
hormone-sensitive lipase is phosphorylated.

What is the role of acetoacetate in lipid metabolism in addition to providing energy when blood glucose is low?
Acetoacetate is used to synthesize glucose when glucose stores are low.
Acetoacetate can be readily converted to oxaloacetate, a precursor for the amino acid aspartate.
Acetoacetate has a pK_a near 7.4 and so it can act as a blood buffer when glucose is low.
Acetoacetate can be converted to lactate and so it can provide energy in the same way that is done under anaerobic glycoliysis.
The liver lacks CoA transferase and so it releases acetoacetate into the blood for us by other tissues.

How does the formation of acetyl CoA by β oxidation not only provide energy for cellular respiration, but also spare glucose?
As acetyl CoA levels increase during lipid metabolism, D-3-hydroxybutyrate is reduced to pyruvate for gluconeogenesis.
Acetyl CoA provides carbon for the formation of oxaloacetate, which in turn can be decarboxylated to form pyruvate.
Acetyl can be converted to acetoacetate and from there to lactate for anaerobic metabolism.
Acetyl CoA derived from fatty acids inhibits pyruvate dehydrogenase, the enzyme that converts pyruvate into acetyl CoA.
Acetyl CoA derived from fatty acids activates pyruvate carboxylase stimulating gluconeogenesis.

Every biochemistry student knows that most naturally occurring unsaturated fatty acids are “cis” fatty acids. Why then do so many fat-containing foods come with the notation “Contains no trans fats”?
Vegetable oils contain polyunsaturated fatty acids prone to oxidation, which then convert them to trans fats.
Olive oils, normally healthy oils, are converted to trans fat when cooked at high temperatures. Thus, olive oils are used only at low temperatures.
Vegetable oils are often hydrogenated to form trans unsaturated fatty acids to preserve shelf life.

Oils that contain an odd number of carbon atoms are particularly susceptible to oxidation to trans fats. Thus, no odd numbered carbon fatty acids are used in these foods.
Oils that contain an odd number of carbon atoms are particularly susceptible to reduction to trans fats. Thus, no odd number carbon fatty acids are used in these foods.

Short-Answer Questions

How and where are fatty acids stored?

What are the repeated steps of fatty acid degradation?

Briefly outline the steps in fatty acid degradation.

Why is the anhydrous nature of triacylglycerols important in energy efficiency?

What three stages are required to utilize the energy stores in adipocytes?

What is the fate of glycerol released during lipolysis?

How is pyrophosphate formation an important theme in biochemistry?

Calculate the amount of ATP generated from the total oxidation of an activated fatty acid with an acyl chain of 16 carbons.

How are unsaturated fatty acids degraded?

In odd-numbered fatty acid chains, how is the final three-carbon piece, propionyl CoA, utilized?

What pathological conditions can arise from a large increase in blood levels of ketone bodies in diabetics?

Explain why animals cannot convert fatty acids to glucose.

What organelle contains the enzymes for β oxidation and how does the fatty acid enter this organelle?

Chapter 28Fatty Acid Synthesis

Matching Questions

Use the following to answer questions 1–10:

Choose the correct answer from the list below. Not all of the answers will be used.

malonyl CoA
three
four
C_{16}-acyl ACP
cytosol
glycolysis
acetyl CoA
β-hydroxybutyrate
acetyl CoA carboylase
AMP-activated protein kinase
oxaloacetate
malic
citrate

772 Fatty acid synthesis takes place in ________________ stages.

773 Fatty acid synthesis primarily takes place in the cellular location ________________.

The reaction utilizing $NADP^+$ and malate uses the ________________ enzyme.

________________ is the product of the committed step in fatty acid synthesis.

The committed step in fatty acid synthesis is inactivated by the regulatory enzyme ________________.

Thioesterase determines the acyl-chain length by cleaving ________________.

The date rape drug GHB is an isomer of ________________.

The availability of the metabolite ________________ determines whether acetyl CoA, made from fatty acids, can enter the citric acid cycle.

________________ is the key regulator of fatty acid metabolism.

The molecule ________________ is the form in which acetyl groups are carried across the mitochondrial membrane from the matrix to the cytoplasm.

Fill-in-the-Blank Questions

Activation of acetyl CoA results in the production of _____.

Citrate serves as a signal for a high-energy state as it stimulates _____ .

A biotin-deficient diet may lead to an increase of cytosolic _____.

The major product of mammalian fatty acid synthesis is _____.

The synthesis of fatty acids takes place in the _____of the cell.

The coenzyme required for fatty acid synthesis is _____.

The committed step of fatty acid synthesis is the formation of _____.

Acetyl CoA is transferred from the mitochondria to the cytoplasm in the form of _____.

Double bonds are introduced into fatty acids in the _____compartment of the cell.

Prostaglandins and thromboxanes are synthesized from _____, a 20-carbon fatty acid.

Multiple-Choice Questions

Which of the following is an essential fatty acid?
palmitate
palmitoleate
linoleate
oleate
All of the above.

The reaction that catalyzes the addition of an activated two-carbon compound with an activated three-carbon compound is
malonyl transacylase.
β-ketoacyl synthase.
β-ketoacyl ACP reductase.
acetyl transacylase.
enoyl ACP reductase.

The carrier of an acyl chain through the synthetic protein complex is
ACP.
a serum albumin.
acetyl coenzyme A.
a biotin-activated complex.
None of the above.

Acetylation of serine on prostaglandin synthase leads to the reduction of which lipid mediator?
prostacyclin
thromboxane
prostaglandins
All of the above.
None of the above.

The function of the enzyme acyl CoA synthetase is
lipolysis to release free glyceraldehyde.
ATP-dependent reduction of acetyl-CoA prior to activation.
ATP-dependent activation of fatty acids using CoA.
All of the above.
None of the above.

Increasing the activity of adenylate kinase results in the activation of which enzyme?
acetyl CoA carboxylase
cAMP-dependent kinase
PKC
AMP-activated protein kinase
citrate synthase

Which compound inhibits the entry of fatty acyl CoA into the mitochondria as a function of the cell being in the high-energy state?
malonyl CoA
carnitine acyltransferase
inhibition of acetyl CoA carboxylase
All of the above.
None of the above.

Chronic ethanol ingestion alters carbohydrate metabolism and leads to a fatty liver due to an increase in which of the following?
NADH
NADPH
ATP
AMP
None of the above.

Insulin leads to
an activation of fatty acid synthesis.
an inhibition of fatty acid synthesis.
a phosphorylation of proteins.
a decrease of protein phosphatase hydrolysis of fatty acid synthesis enzymes.
a decrease in pyruvate transport into mitochondria.

What enzyme catalyzes the committed step in fatty acid synthesis?
enoyl reductase
acetyl CoA carboxylase
transacylase reductase
3-hydroxyacyl dehydratase
None of the above.

Enzymes from which of the following pathways are utilized for fatty acid synthesis?
glycolysis
the citric acid cycle
the pentose phosphate pathway
All of the above.
None of the above.

Acetyl carboxylaseis is regulated globally by
allosteric inhibitors and activators.
phosphorylation and dephosphorylation.
zymogen activation.
the binding of cAMP.
None of the above.

How are fatty acids larger than the 16 carbons formed?
by elongation reactions catalyzed by enzymes on the endoplasmic reticulum
by 1-carbon additions at the mitochondrial membrane
by elongation reactions catalyzed by enzymes in the peroxisomes
All of the above.
None of the above.

Aspirin binds and blocks which of the following enzymes, thus explaining its multiple effects?
phospholipase A_2
prostacyclin synthase
diaceylglycerol lipase
thromboxane synthase
prostaglandin synthase

How are the consumption of eating corn oil and prostaglandin synthesis related?
Prostaglandins are synthesized from membrane proteins originally derived from corn oil.
ω-six fatty acids found in corn oil inhibit thromboxane synthase, shifting synthesis to prostaglandins.
Corn oil contains linoleate, required for arachidonate synthesis.
ω-three fatty acids found in corn oil inhibit thromboxane synthase, shifting synthesis to prostaglandins.
Prostaglandidn synthesis and corn oil are not related.

How does the cell ensure that fats are not synthesized when the energy charge of the cell is low?
Acetyl CoA carboxylase 1 is switched off by phosphorylation.
AMP-activated protein kinase is activated by AMP.
Acetyl CoA carboxylase 1 exists as inactive dimers unless citrate and ATP levels are high.
Polymerization of active acetyl CoA carboxylase I is facilitated by the protein MIG12.
All of the above.

Fatty acid synthesis is regulated by hormone depending on feeding vs. fasting and recent exercise vs. no recent exercise. Which hormones are active and what is their mechanism of action of the(se) hormone(s) after exercise and a meal?
Insulin stimulates fatty acid synthesis by activating acetyl CoA carboxylase 1.
Insulin stimulates the mobilization of fatty acids for β oxidation.
Epinephrine stimulates the mobilization of fatty acids and stimulates their accumulation as triacylglycerols.
Glucagon activates the carboxylase by enhancing the phosphorylation of AMPK.
Epinephrine stimulates AMPK, preventing the phosphorylation of acetyl CoA carboxylase 1.

What are the conditions that lead to a “beer gut” due to the excess consumption of alcohol?
NADH produced from the metabolism of ethanol stimulates the citric acid cycle for glucose-derived acetyl CoA.
Excess ethanol metabolism leads to an accumulation of NADH that inhibits fatty acid metabolism.
NADH stimulates citric acid cycle enzymes that stimulates glucose-derived acetyl CoA metabolism.
NADH inhibits ketone body formation, stimulating glucose rather than fatty acid metabolism.
The processing of acetate in the liver becomes inefficient leading to a pH imbalance in liver cells, reducing enzyme efficiency in general.

Short-Answer Questions

What are the four physiological roles for fatty acids?

What are the similarities between fatty acid synthesis and degradation?

Describe the chemistry for fatty acid synthesis at the stage when a two-carbon molecule reacts with a three-carbon molecule to give a four-carbon molecule and a 1-carbon molecule.

What is citrate’s role in fatty acid synthesis?

NADPH-reducing equivalents important for the biosynthesis of fatty acids come from several sources. Explain.

How is the structure of fatty acid degradation enzymes different from that of synthesis enzymes?

Describe the regulation of fatty acid synthesis by AMP and citrate.

Where are the enzymes for fatty acid elongation and desaturation in eukaryotes?

Why are linoleate (18:2) and linolenate (18:3) considered essential fatty acids in mammals?

Describe the allosteric stimulatory effect of citrate on acetyl CoA carboxylase.

In fatty acid synthesis, what is the compound X in the following metabolic conversion?

$$CH_3(CH_2)_2\overset{\overset{O}{\|}}{C}CH_2\overset{\overset{O}{\|}}{C}\text{—}SACP \longrightarrow \mathbf{X}$$

Explain this statement: “Fats burn in the flame of carbohydrates.”

Chapter 29Lipid Synthesis

Matching Questions

Use the following to answer questions 1–10:

Choose the correct answer from the list below. Not all of the answers will be used.

liver
receptor-mediated endocytosis
phosphatidyl ethanolamine
muscle
lipoprotein particles
dihydroxyacetone phosphate
vitamin D
pregnenolone
glycocholate
acetyl CoA
vitamin A
sphingomyelin

In mammals, the ________________ is the major site of triacylglycerol synthesis.

The reduction of the metabolite ________________ supplies glycerol 3-phosphate for acylglycerol synthesis.

The membrane component ________________ is produced from the activated precursor CDP-diacylglycerol.

________________ is a component of the myelin sheath.

All of the carbons in cholesterol are derived from the metabolite ________________.

________________ is the process by which LDL enters the cell.

Cholesterol and triacylglycerols are transported in body fluids in the form of ________________.

________________ is the vitamin that is a derivative of cholesterol.

________________ is the primary bile salt.

________________ is the derivative of cholesterol that is the precursor of the steroid hormones.

Fill-in-the-Blank Questions

In mammalian cells, phosphatidate is synthesized in the outer mitochondrial membrane and the _____.

A(n) ____ is composed of a fatty acid linked to sphingosine via an amide bond.

In the biosynthesis of phosphatidates, the fatty acyl group attached to the C-2 position is usually _____.

_____ is a nine-carbon sugar that is a component of the gangliosides.

In the biosynthesis of sphingomyelin, the terminal hydroxyl group of ceramide is substituted with ______.

In membrane-lipid biosynthesis, the nucleotide _____ is used to activate the components of the reaction.

The synthesis of _____ is the committed step in cholesterol biosynthesis.

_____ is the 30-carbon (triterpene) precursor of cholesterol.

_____ is the major carrier of cholesterol esters in the blood.

Vitamin D_3 is converted into _____, which is an active hormone that functions as a transcription factor.

Multiple-Choice Questions

Which of the following is the common precursor for both the phosphatidyl inositols and triacylglycerols?
diacylglycerol
inosinic acid
phosphatidate
CDP-diacylglycerol
None of the above.

Phosphatidate is formed from
glycerol 3-phosphate and two fatty acyl CoAs.
glycerol and two free fatty acids.
pyruvate and triacylglycerol.
glycerol and two fatty acyl CoAs.
None of the above.

In a ganglioside, what links the oligosaccharide to the hydroxyl of the ceramide?
stearic acid
glucose
choline
sialic acid
None of the above.

The highest concentration of sphingolipids is found in the
central nervous system.
lymph system.
serum.
All of the above.
None of the above.

The starting materials necessary to synthesize sphingosine are
palmitoyl CoA and serine.
acetyl CoA and glycine.
palmitoyl CoA and aspartate.
acetyl CoA and glutamine.
None of the above.

Which of the following is(are) major component(s) of low-density lipoproteins?
phospholipid
apoprotein B-100
cholesteryl ester
All of the above.
None of the above.

Respiratory distress syndrome is caused by a failure in the biosynthetic pathway of
sphingosine.
gangliosides.
dipalmitoylphosphatidylcholine.
cholesterol.
bile salts.

Tay Sachs disease is caused by an inability to degrade
sphingosine.
gangliosides.
dipalmitoylphosphatidylcholine.
ceramide.
None of the above.

HMG CoA is synthesized from acetyl CoA and
oxaloacetate.
acetoacetyl CoA.
acetyl CoA.
farnesyl pyrophosphate.
mevalonate.

Feedback regulation of cholesterol synthesis is mainly controlled at the step catalyzed by the enzyme
3-hydroxy-3-methylglutaryl (HMG) CoA reductase.
geranyl transferase.
HMG transferase.
farnesyl reductase.
None of the above.

The role of lipoprotein particles is to
solubilize hydrophobic lipids.
aid in clot formation.
contain cell-targeting signals.
A and B.
A and C.

The major carrier(s) of dietary fat from the intestine is(are)

VLDL.
chylomicrons.
HDL.
LDL.
IDL.

The LDL receptors on the plasma membrane are localized in *coated pits* that contain the receptors of which of the following proteins?

clathrin
lipoprotein A
adrenodoxin
HMG-CoA reductase
sterol regulatory element binding protein (SREBP)

Which of the following combines with cholic acid to form a major bile salt?

ATP
glycine
glycerol
A and B
A, B, and C

Hydroxylation of cholesterol by cytochrome P450 requires

NADPH.
activated O_2.
PLP.
A and B.
A and C.

In previous chapters, biosynthetic pathways were commonly regulated by phosphorylation/ dephosphorylation mechanisms. Which of the following mechanisms for steroid biosynthesis uses an alternative method?

The sterol regulatory element binding protein (SREBP) migrates to the nucleus and binds the sterol regulatory element (SRE) stimulating transcription.
The SREBP is cleaved from the endoplasmic reticulum membrane rendering it inactive; thus, it no longer blocks steroid synthesis.
CTP reacts with acetoacetate to provide an activated substrate to start cholesterol synthesis.
CTP reacts with acetate to provide an activated substrate to start cholesterol synthesis.
CTP is required to provide the phosphate for the conversion of mevalonate to 5-phosphomevalonate unlike other pathways that use ATP.

Your grandfather has been told he has high cholesterol and has been given one of the statins to bring it down. He asks you if you can think of any reason that he should not double the dose so that it will reduce blood cholesterol faster. What do you tell him?

Yes, statins block the reabsorption of bile, effectively blocking the absorption of cholesterol.

Yes, statins decrease the amount of LDL receptors on the surface of intestinal mucosal cells, thereby decreasing cholesterol uptake into the blood.

Yes, statins increase the amount of LDL receptors on the surface of blood vessels increasing the internalization of cholesterol into cells and clearing the blood.

No, at high levels, statins have a stimulatory effect on HMG-CoA reductase rather than inhibitory effect.

No, some cholesterol synthesis is essential. Cholesterol is essential for proper functioning of cell membranes and for precursors for bile salts and steroid hormones.

A friend, who is struggling with weight gain, reads about a new miracle supplement that blocks the formation of phosphatidate, the precursor for triacylglycerols. Would taking this supplement work as a weight reduction scheme?

Yes, many weight loss drugs target enzyme catalyzed reactions that occur early in this biosynthetic pathway.

Yes, decreases in phosphatidate leads to activation of key β-oxidation enzymes, which drives lipid metabolism over glucose metabolism.

Yes, decrease in phosphatidate leads to increases in cellular glycerol 3-phosphate, which stimulates glycolytic enzymes.

No, because this would also block formation of phospholipids and cell membrane integrity would be impacted.

No, triacylglycerol synthesis takes place in the mitochondria and it is unlikely that there is a transporter for the supplement in the inner membrane.

You are prone to sunburn, but you doctor tells you not to apply your sunscreen until you have been outside for five minutes. Why?

Sunscreen blocks UV radiation necessary for cholesterol synthesis in the skin where it is converted to vitamin D.

Sunlight is necessary for the conversion of cholesterol to vitamin D, a hormone necessary for bone health.

Skin pigmentation, as occurs when you get a light tan, blocks UV radiation and reduces the incidence of skin cancers.

Vitamin D in the skin blocks UV radiation, but only for a short period of time; thus, it is a natural sun block.

Sunlight promotes HDL mobilization and a clearing of cholesterol in the blood.

If you were considering designing a drug to regulate blood pressure, which of the following families of steroids would you target?

androgens

estrogens

glucocorticoids

mineralocorticoids

progestogens

Short-Answer Questions

What are the causes and symptoms of familial hypercholesterolemia?

How is methionine metabolism related to the synthesis of phosphatidyl choline?

What is the role of CTP in the synthesis of a phospholipid?

Why is phosphatidyl serine considered a class of molecules, and not one type?

What is phosphatidyl choline? How is it synthesized in mammals?

How are gangliosides synthesized?

What are the three stages of cholesterol synthesis?

What is the role of phosphatidyl choline in the synthesis of sphingomyelin?

Describe the various ways that 3-hydroxy-3-methylglutaryl CoA reductase is regulated, including both gene expression and enzyme regulation.

List the types of lipoprotein particles and give the primary physiological role of the lipoprotein.

How do blood levels of lipoproteins serve diagnostic purposes?

What are the steps in LDL uptake into cells?

What are some of the medical strategies to control cholesterol levels at an appropriate level?

What are bile salts?

The first step in vitamin D synthesis is unusual. What is it?

Chapter 30Amino Acid Degradation and the Urea Cycle

Matching Questions

Use the following to answer questions 1–10:

Choose the correct answer from the list below. Not all of the answers will be used.

hyperammonemia
aminotransferase
methionine
S-adenosylmethionine
glutamate dehydrogenase
oxaloacetate
biopterin
glutamate
hippurate
urea
dehydratase
dioxygenases
ammonia disorder

877 The molecule _______________ undergoes oxidative deamination to an ammonium ion.

Serine and threonine are deaminated by the enzyme _______________.

The ______________ enzymes transfer an α-amino group from amino acids to α-ketoglutarate.

The _______________ enzyme catalyzes an oxidative deamination and can utilize either NAD^+ or $NADP^+$.

_______________is caused by defects in the urea cycle, which lead to an elevated level of ammonia in blood.

The molecule _______________ is formed from excess NH_4^+ by ureotelic organisms.

The product _______________ results when aspartate is transaminated with α-ketoglutarate.

The methyl group donor _______________ is the product of the first step of methionine degradation.

The class of enzymes that cleaves most aromatic rings in biological systems is _____________.

The cofactor required by phenylalanine hydroxylase is _______________.

Fill-in-the-Blank Questions

_____ is the prosthetic group used in deaminations by dehydratases.

Oxidative deamination of glutamate results in free ammonium ions and _____.

In adults, the urea cycle produces sufficient quantities of _____ so that it is not considered an essential amino acid.

The hydrolysis of arginine by arginase produces ornithine and _____.

Nitrogen is transported from muscle to liver in the form of _____ or _____.

The urea cycle is linked to gluconeogenesis via formation of _____, a precursor of glucose synthesis.

Serine dehydratase catalyzes the conversion of serine into NH_{4+} and _____.

In the degradation of amino acids, the amino nitrogens can eventually become the amino group of _____.

In the first step of the urea cycle, CO_2 and NH_4^+ are converted into _____.

The genetic deficiency of the enzyme _____ results in a condition referred to as phenylketonuria.

Multiple-Choice Questions

Surplus amino acids are
stored in proteasomes.
stored in protein scaffolds.
used as metabolic fuel.
All of the above.
None of the above.

Which of the following is an allosteric activator of mammalian carbamoyl phosphate synthetase?
α-ketoglutarate
N-acetylaspartate
N-acetylglutamate
glutamine
None of the above.

Which of the following amino acids is glucogenic?
asparagine
methionine
valine
lysine
A, B, and C.

In the urea cycle, the second nitrogen of urea enters the cycle in the form of which of the following metabolites?
alanine
glutamine
ornithine
aspartate
arginine

The urea cycle is
a system for protein degradation and turnover.
responsible for nitrogen fixing.
responsible for the filtering of nitrogen by the kidney.
a system involved in transporting nitrogen from muscle to the liver.
None of the above.

Which amino acids can be directly deaminated to produce NH_{4^+}?
serine and threonine
serine, asparagine, and threonine
proline and threonine
serine and valine
None of the above.

In the urea cycle, free NH_{4^+} is coupled with carboxyphosphate to form
uretic phosphate.
pyruvate.
carbamic acid.
All of the above.
None of the above

Which amino acid is a metabolite in the urea cycle, but is not used as a building block of proteins?
ornithine
citrulline
glutamate
A and B.
A, B, and C.

In the urea cycle, the carbon skeleton of aspartate is preserved as
succinate.
fumarate.
urea.
All of the above.
None of the above.

Which of the following amino acids is/are ketogenic?
asparagine
methionine
valine
lysine
A, B, and C.

Ammoniotelic organisms excrete excess nitrogen as
N_2H_8.
NH_4^+.
urea.
All of the above.
None of the above.

Uricotelic organisms release nitrogen as
NH_4^+.
arginine.
uric acid.
All of the above.
None of the above.

Ketogenic amino acids are degraded to which of the following metabolites?
pyruvate
acetyl CoA
acetoacetate
All of the above.
B and C.

Which amino acids supply carbons for eventual entry into metabolism as succinyl CoA?
methionine, valine, leucine
methionine, isoleucine, valine
isoleucine, valine, leucine
All of the above.
None of the above.

Which amino acid is converted to tyrosine in the degradative pathway?

phenylalanine
tryptophan
methionine
A and B.
A, B, and C.

Three enzymes of the urea cycle require ATP, but when counting high-transfer-potential phosphoryl groups spent, the number is four. Explain this apparent discrepancy.

Carbamoyl phosphate synthetase is regulated allosterically by ATP, so the phosphorylation / dephosphorylation reactions utilize twice the ATP.
The urea cycle starts in the mitochondrial matrix and ends in the cytoplasm. ATP is required for the translocation of citrulline across the mitochondrial matrix.
Ornithine transcarbamoylase is regulated allosterically by ATP, so the phosphorylation / dephosphorylation reactions utilize twice the ATP.
Argininosuccinate synthetase is driven by the cleavage of ATP into AMP and pyrophosphate and by the subsequent hydrolysis of pyrophosphate.
Glutamine synthetase is driven by the cleavage of ATP into AMP and pyrophosphate and by the subsequent hydrolysis of pyrophosphate.

Individuals with phenylketonuria can ameliorate the symptoms by consuming a diet low in phenylalanine. Would the same strategy (a diet low in one amino acid) work for individuals with citrullinemia?

Yes, citrullinema is due to a deficiency of α-Aminoadipic semialdehyde dehydrogenase, which is usually benign.
Yes, citrullinema is due to an inability to degrade lysine. A diet low in lysine would work.
No, citrullinema is due to a deficiency of argininosuccinase, an enzyme that all amino acids ultimately utilize for nitrogen disposal.
No, citrullinema is due to an inability to transport citrulline out of the mitochondrial matrix, eventually shutting down the citric acid cycle.
No, citrullinema is due to the inability of ornithine to be carried into the mitochondrial matrix with the concomitant loss of the ability to dispose of nitrogen.

As shown in Chapter 28, excess alcohol consumption not only makes you overweight, it can also lead to ammonia poisoning. How is alcohol metabolism linked to increased levels of blood ammonia?

Excess alcohol consumption can cause liver damage, the primary site of urea formation. Loss of liver function can lead to increases of ammonia in the blood.
Excess alcohol consumption can cause a buildup of acetaldehyde, a reactive species that short circuits the urea cycle at the formation of cambamoyl phosphate.
Excess alcohol consumption makes the liver more acidic, driving the equilibrium from ammonium ion to free ammonia.
Alcohol acts as an allosteric inhibitor of carbamoyl phosphate reducing the rate of ammonium ion removal.
Excess alcohol facilitates the formation of an abortive complex for glutamate dehydrogenase.

Metabolic pathways are said to be variations on a theme. Which of the following would accurately illustrate this statement?

All amino groups in amino acids enter the urea cycle through glutamate.
Defects in the urea cycle lead to increased transamination reactions in muscle.
Cleavages of aromatic rings in amino acids are catalyzed by oxygenases.
The carbon skeletons of amino acids are metabolized by the citric acid cycle and the pentose phosphate pathway.
Like monosaccharides, amino acids are oxidized by NADH.

You are studying a species of ground squirrel that hibernates and you want to determine if nitrogen is salvaged in the same way it is salvaged in bears. You feed the ground squirrels a stable isotope of nitrogen-labeled food. Where would you look for the labeled nitrogen during hibernation?

in ammonia released into the hibernating den
in $NH_4{+}$ in the blood of the ground squirrel
in proteins in the bacteria in the intestine of the ground squirrel
in urea in liver mitochondria of the ground squirrel
in $NH_4{+}$ in in liver mitochondria of the ground squirrel

Short-Answer Questions

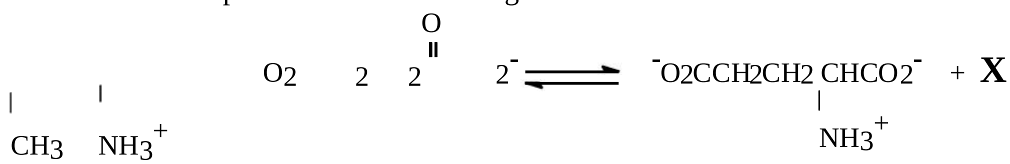
In addition to increased fatty acid accumulation in the liver, excess consumption of ethanol can also induce two further stages of liver damage. What are they?

Why are more uricotelic organisms found in the desert than in the tropics?

Draw the urea cycle and indicate which component is in which compartment of the cell.

Why do you think that weight lifters take large amounts of branched-chain amino acids?

What is the structure of compound X in the following metabolic reaction?



Describe the glucose-alanine cycle and its significance in amino acid metabolism.

How is the urea cycle linked to the citric acid cycle?

Write the net equation of the urea cycle and indicate whether energy is produced or consumed by the cycle.

What type of damage occurs if there is a defect in the urea cycle?

What is the basic strategy by which proteins are degraded?

Which amino acids can be converted to pyruvate by a single enzyme-catalyzed reaction?

What general feature is involved in the degradation of aromatic amino acids?

Biopterin is a complicated coenzyme required for the conversion of phenylalanine to tyrosine. Why is biopterin not considered a vitamin?

What is the cause of PKU? Give the structure of the abnormal metabolite that accumulates from which this condition gets its name.

Chapter 31Amino Acid Synthesis

Matching Questions

Use the following to answer questions 1–10:

Choose the correct answer from the list below. Not all of the answers will be used.

atmospheric nitrogen (N_2)
3-phosphoglycerate
cumulative
nitrogen fixation
B_{12} histidine
tetrahydrofolate
committed
pyridoxal phosphate
enzyme multiplicity
MoFe cofactor
ammonia (NH_3)

_______________ is the original nitrogen source for the nitrogen found in amino acids.

The process of converting N_2 to NH_3 is called _______________.

_______________ is the site of nitrogen fixation by nitrogenase enzymes.

The precursor for serine, cysteine, and glycine amino acid biosynthesis is _______________.

A versatile carrier of one-carbon units is _______________.

Methylcobalamine is derived from vitamin _______________.

7. _______________ is a cofactor for transamination reactions.

The final product pathway that inhibits an enzyme that catalyzes its production typically takes place at the _______________ step.

Glutamine synthesis is inhibited by _______________ feedback inhibition.

Isozymes, or multiple enzymes with the same identical catalytic properties but with different regulation, are an example of _______________.

Fill-in-the-Blank Questions

Only a few prokaryotes, such as _____, are able convert N_2 to ammonia.

_____ ATP molecules are hydrolyzed for each N_2 reduced.

The α-amino group found in most amino acids comes from _____ through a transamination reaction.

Glutamine synthase adds NH_3 to _____ to make glutamine.

Glutamate is the precursor for the amino acids glutamine, proline, and _____.

Methyl, methylene, and _____ units can be carried by tetrahydrofolate.

Homocysteine is an intermediate in the synthesis of cysteine and _____.

The enzyme _____ is regulated by cumulative feedback inhibition.

The binding of serine to 3-phosphoglycerate dehydrogenase induces a _____ in V_{max}.

Metabolic pathways that have alternate products are often regulated by _____ and _____.

Multiple-Choice Questions

Amino acid synthesis is generally regulated by
turnover.
diet.
feedback and allosteric enzyme regulation.
A and B.
A, B, and C.

Organisms capable of carrying out reduction of atmospheric nitrogen include
some bacteria and archaea.
higher eukaryotic organisms, such as mammals.
all plants.
All of the above.
None of the above.

The electrons for the reduction of molecular nitrogen are donated by
proteins.
NADPH.
ferredoxin.
None of the above.
All of the above.

The carbon skeletons for amino acids are intermediates found in
glycolysis.
the citric acid cycle.
the pentose phosphate pathway.
All of the above.
None of the above.

Essential amino acids differ from nonessential amino acids in that
nonessential amino acids are synthesized in simple reactions compared to many for most essential amino acids.
essential amino acids are generally synthesized directly from citric acid cycle intermediates, but nonessential amino acids are not.
microorganisms and animals cannot synthesize essential amino acids but plants can.
animals cannot synthesize essential amino acids because they have lost the ability to carry out transamination reactions.
None of the above.

S-adenosylmethionine carries which groups?
methyl
CO_2
ammonia
None of the above.
All of the above.

This amino acid, in high levels, is correlated with the damage of cells lining the blood vessels.
serine
cysteine
S-adenosylmethionine
citrulline
homocysteine

Essential amino acids are synthesized by:
microorganisms.
humans.
plants.
A and B.
A and C.

Which amino acid is added to indole to form tryptophan?
glutamine
serine
tyrosine
All of the above.
None of the above.

Erythrose 4-phosphate is a precursor to the amino acids
tryptophan, tyrosine, and phenylalanine.
tryptophan and phenylalanine.
tyrosine and phenylalanine.
tryptophan, tyrosine, phenylalanine, and serine.
None of the above.

Through what process might feedback inhibition processes have evolved?
duplication of genes encoding catalytic domains
evolution of homologous subunits in the enzyme catalyzing the committed step
linking specific regulator domains to catalytic domains
linking of multiple regulatory domains
All of the above.

An example of a reaction controlled by enzyme multiplicity is
phosphorylation of asparagine by aspartokinases.
phosphorylation of aspartate by aspartokinases.
phosphorylation of glutamine by glutamine synthetase.
All of the above.
None of the above.

Which gaseous plant hormone is involved in triggering ripening?
melanin
epinephrine
ethylene
A and B.
A and C.

The activated methyl cycle involves the production and use of
glutamine.
glycine.
heterocysteine.
homocysteine.
methanol.

The rates of synthesis of amino acid metabolic pathways often depends on the
committed step.
allosteric regulation.
feedback inhibition.
All of the above.
None of the above.

The making of carbon-carbon bonds requires energy. How does the activated methyl cycle provide energy for methyl group transfer to a wide variety of acceptors?
The side-chain methylene group of serine is transferred to tetrahydrofolate, a carrier of one-carbon units.
The fully oxidized one-carbon unit, CO_2, is carried by biotin.
The most reduced form of one-carbon groups carried by tetrahydrofolate is the methyl group.
Transmethylation reactions are carried out by pyricoxal phosphate-dependent methyltransferases.
The methyl group of methionine is activated by the transfer of an adenosyl group to the sulfur atom of methionine.

Increased synthesis of which of the following amino acids might affect DNA production?
histidine and tryptophan
aspartate and glutamate
threonine and methionine
cysteine and glycine
valine and leucine

Insufficient amounts of this amino acid would not only inhibit protein synthesis, but also phostidylcholine and phostidylethanolamine.
glutamine
histidine
phenylalanine
methionine
alanine

In Chapter 22, we learned that ferredoxin is a strong reductant in the ferredoxin-NADP$^+$ reductase. Where else is ferredoxin's reducing power required?
glutamine synthetase
reductase (Fe protein)
nitrogenase (MoFe protein)
glutamate dehydrogenase
aspartate transaminase

Enzymes that catalyze the same reaction but are regulated differently is a strategy known as
sequential feedback inhibition.
end-product inhibition.
substrate-limited inhibition.
enzyme multiplicity.
cumulative feedback inhibition.

Short-Answer Questions

What is significant about many of the intermediates in amino acid biosynthesis?

What determines the range of one-carbon units carried by tetrahydrofolate?

Describe the process and proteins involved in nitrogen fixation.

44. What is the MoFeco factor?

What is a major difference between the amino acid biosynthetic capacity of prokaryotic organisms and humans?

What do *S*-adenosylmethionine and fruit ripening have in common?

Draw homocysteine.

Describe the regulation of the enzyme threonine deaminase.

What is enzyme multiplicity?

What is the advantage of the cumulative enzymatic regulation of glutamine synthetase activity?

What would be the result of a pathway such as that shown in Figure 31.12 if only one enzyme catalyzed the first reaction? What if there was inhibition only by X and not by Y?

Describe the effect of cumulative inhibition.

Chapter 32Nucleotide Metabolism

Matching Questions

Use the following to answer questions 1–10:

Choose the correct answer from the list below. Not all of the answers will be used.

de novo
xanthylate
riboflavin
amino acids
UTP
N_5, N_{10}-methylenetetrahydrofolate
nucleotide
gout
nucleoside
ATP
urate
salvage

Purines and pyrimidines are derived from __________________.

Assembly of a compound from simpler molecules is known as a(n) ________________ pathway.

Assembly of a compound from phophoribosylpyrophosphate (PRPP) and a base is known as a(n) __________________ pathway.

A purine or pyrimidine base linked to a sugar is a(n) __________________.

A purine or pyrimidine base linked to a sugar and to a phosphate ester is a(n) __________________.

CTP is formed by the amination of __________________.

7. The intermediate between inosinate and guanylate is __________________.

The methyl donor to make TMP is _________________.

High levels of urate cause the disease _________________.

The final product of purine degradation is _________________.

Fill-in-the-Blank Questions

DNA is built from _____.

Scaffolds for the ring systems in nucleotides are from the amino acids glycine and _____.

In _____ biosynthesis the base is assembled first and then attached to ribose.

Hypoxanthine-guanine phosphoribosyltransferase catalyzes the formation of guanylate and _____.

Fluorouracil acts as an analog of _____.

Dihydrofolate reductase is an excellent target for anticancer drugs because it is critical in the synthesis of _____.

The conversion of ribonucleotides to deoxyribonucleotides is catalyzed by _____.

The committed step in purine nucleotide biosynthesis is the conversion of _____ to 5-phosphoribosyl-1-amine.

_____ disease is caused by a genetic mutation resulting in the absence of hypoxanthine-guanine phosphoribosyltransferase.

Some individuals with a deficiency in the enzyme adenosine deaminase exhibit _____.

Multiple-Choice Questions

The source(s) of NH_2 groups in the synthesis of nucleotides is(are)
aspartate.
glutamine.
glycine.
A and B.
A, B, and C.

Both de novo and salvage paths are used in the synthesis of
ribonucleotides.
deoxyribonucleotides.
dideoxyribonucleotides.
All of the above.
None of the above.

TMP is made from
dTMP.
dUMP.
CTP.
ATP.
None of the above.

In de novo synthesis, the pyrimidine ring is assembled using
bicarbonate.
aspartate.
glutamine.
A and B.
A, B, and C.

How many ATP molecules are necessary to make carbamoyl phosphate by carbamoyl phosphate synthetase (CPS)?
1
4
2
3
None of the above.

Which enzyme carries out this reaction: XDP + YTP ↔ XTP + YDP?
nucleoside triphosphate kinase
nucleoside diphosphate kinase
nucleoside diphosphate phosphorylase
nucleoside triphosphate phosphorylase
None of the above.

The synthesis of CTP from UTP requires UTP and
glutamine and ATP.
glycine and ATP.
glutamine, ATP, and NADH.
All of the above.
None of the above.

Which enzyme(s) catalyze(s) the first step in de novo nucleotide biosynthesis?
aspartate transcarbamylase nucleoside
monophosphate kinase glutamine
phosphoribosyl amidotransferase A and B.
A and C.

The displacing nucleophile in pyrimidine synthesis is typically
ammonia or an amino group.
a metal ion.
coenzyme A.
All of the above.
None of the above.

Inosinate can be converted to
AMP.
GMP.
UMP.
A or B.
A, B, or C.

The ultimate reductant in synthesis of deoxyribonucleotides is
$FADH_2$.
NADH.
NADPH.
quinone.
None of the above.

Which amino acid side chain in thymidylate synthase activates the ring of dUMP, making C-5 a good nucleophile?
cysteine
aspartate
glutamine
tyrosine
serine

Tetrahydrofolate is generated from dihydrofolate by dihydrofolate reductase and uses the reductant

$FADH_2$.
NADH.
NADPH.
riboflavin.
None of the above.

The competitive inhibitor(s) of dihydrofolate reductase is(are)

aminopterin.
methotrexate.
fluorouracil.
A and B.
B and C.

Allopurinol is used to treat gout and is an inhibitor of the enzyme(s)

xanthine oxidase.
xanthine hydrolase.
hypoxanthine-guanine phosphoribosyltransferase.
All of the above.
None of the above.

Sulfa drugs are analogs of *p*-aminobenzoate, a compound necessary for N_{10}-formyltetrahydrofolate. How do these drugs act on bacterial infections and why are humans not susceptible?

N_{10}-formyltetrahydrofolate is a ferredoxin analog and a potent inhibitor of ribonucleotide reductase in bacteria but not humans.
N_{10}-formyltetrahydrofolate is a ferredoxin analog and a potent inhibitor of ribonucleotide reductase, but humans consume sufficient quantities of ferredoxin in their diet to saturate the reductase.
N_{10}-formyltetrahydrofolate is an NADPH analog and a potent inhibitor of ribonucleotide reductase in bacteria but not humans.
N_{10}-formyltetrahydrofolate twice transfers a formyl group during de novo synthesis of the purine ring. Bacteria dihydrofolate reductase is blocked by sulfa drugs, whereas the human enzyme is not.
N_{10}-formyltetrahydrofolate twice transfers a formyl group during de novo synthesis of the purine ring. Bacteria synthesize their own folate, whereas humans get theirs from eating green plants.

What intermediate in pyrimidine synthesis will accumulate if a strain of bacteria is lacking in aspartate?

orotidylate
orotate
dihydroorotate
5-phosphoribosyl-1-amine
carbamoyl phosphate

Pyrimidine biosynthesis is allowed to take place in the presence of [$_{15}N$]aspartate. What position would be labeled in the newly synthesized nucleotides?

N_3 in IMP
N_7 in IMP
N_9 in Imp
N_1 in UTP
N_3 in UTP

Human beings contain two different carbamoyl phosphate synthetase enzymes. If you wanted to study the enzyme inhibition for the enzyme specific for nucleotide synthesis, which of the following analogs would you choose?

analog for bicarbonate
analog for carboxyphosphate
analog for carbamic acid
analog for NH_3
analog for glutamine

How is the purine nucleotide cycle linked to the citric acid cycle?

The purine nucleotide cycle serves as an anapleurotic reaction for the formation of oxaloacetate.
The purine nucleotide cycle serves as an anapleurotic reaction for the formation of fumarate.
The purine nucleotide cycle serves as an anapleurotic reaction for the formation of pyruvate.
The condensation of IMP with glutamate generates adenylosuccinate, which is hydrolyzed to form succinate.
The condensation of IMP with glutamine generates adenylosuccinate, which is hydrolyzed to form succinate.

Short-Answer Questions

Why is nucleotide synthesis an important pathway for medical intervention? What types of disease could be treated using this information?

Given the function of nucleotides, would you expect their synthesis to be simple or complex and diverse?

Describe the reaction by which carbamoyl phosphate synthetase acquires an ammonia to make carbamoyl phosphate.

What is the advantage of channeling intermediates by carbamoyl phosphate synthetase?

What reaction actually forms the six-member ring found in pyrimidines?

How is pyrimidine biosynthesis regulated?

Why do purine salvage pathways save the cell energy?

What is a general theme in purine ring synthesis, in terms of reaction logic and mechanism?

How is the reciprocal use of nucleotides useful in purine synthesis?

What is the disadvantage of methotrexate as a therapeutic agent?

How is ATCase, a key enzyme in pyrimidine biosynthesis, inhibited?

Which vitamin supplement is taken during the first trimester of pregnancy to prevent the birth defect known as spina bifida?

What are advantages of high urate levels?

Chapter 33The Structure of Informational Macromolecules: DNA and RNA

Matching Questions

Use the following to answer questions 1–10:

Choose the correct answer from the list below. Not all of the answers will be used.

supercoiling
DNA
5′→3′
circular
stem loop
B-DNA
retroviruses
exon
Erwin Chargaff
histones
RNA
Rosalind Franklin
A-DNA
3′→5′

The stable genetic information passed on from one generation to the next is _______________.

________________ A transient copy of genetic information.

The scientist who provided data for Watson and Crick's model of DNA is _______________.

The _____________ form is more accessible for interactions with proteins.

The axis of a double helix can be twisted by a mechanism called _______________.

DNA can exist in both linear and _______________ forms.

________________ Form of DNA that exists under dehydrating conditions.

The base sequence, as written by convention, is in the ________________ direction.

________________ is the simple motif of RNA structure.

H2A, H2B, H3, and H4 are all major classes of ________________.

Fill-in-the-Blank Questions

A nitrogen containing an aromatic base attached to a ribose is a _____.

5′ dAMP refers to _____.

The distribution of parental atoms in newly synthesized DNA is called _____ replication.

There are approximately _____ bases per turn of a B-DNA double helix.

The _____ effect stabilizes the structure of DNA, resulting in more polar surfaces being exposed to the aqueous media.

The nature of replication was determined using DNA labeled with nitrogen isotopes and _____.

The nucleoside that is composed of a D-ribose linked to a cytosine base is called _____.

_____ is a left-handed double helix.

Unwinding of naturally occurring plasmid, circular DNA results in _____.

Proteins that bind to DNA are rich the amino acids _____and _____.

Multiple-Choice Questions

The difference in RNA bases compared to DNA bases is
RNA contains A instead of T.
RNA contains U instead of G.
RNA contains U instead of T.
RNA contains A instead of U.
None of the above.

How does a nucleotide differ from a nucleoside?
Nucleosides are found in DNA, whereas nucleotides are found in RNA.
Purines are only found in nucleotides.
Nucleosides contain only deoxyribose sugars.
A nucleotide is a nucleoside with a phosphate ester linked to the sugar.
None of the above.

Replication takes place in which manner?
conservative
random
semiconservative
N-linked
None of the above.

How many different sequence possibilities are there for a DNA polymer that is 10 bases long?
262,13232
320
32,000
1,048,576
100,000

The shorthand notation pApCpG denotes that
a phosphate is attached to the 5′ of the adenosine nucleotide unit.
a phosphate is attached to the 3′ of the guanine nucleotide unit.
the cytosine nucleotide has a free hydroxyl group.
A and C.
All of the above.

The feature(s) of DNA deduced by Watson and Crick include
two antiparallel polynucleotide chains coiled in a helix around a common axis.
that the pyrimidine and purine bases lie on the inside of the helix.
that the bases are nearly perpendicular to the axis.
All of the above.
None of the above.

The chemical forces that contribute to the stability of the DNA due to the base stacking present in the DNA helix are
hydrogen bonds.
van der Waals interactions.
disulfide bonds.
C and B.
None of the above.

What is the approximate error rate in DNA replication?
1×10^{-8}
1×10^{-6}
1×10^{-15}
1×10^{-10}
None of the above.

The form of DNA that is the narrowest but having the longest pitch per turn of helix is the
A form.
B form.
C form.
Z form.
None of the above.

The temperature at which half of the DNA helical structure is lost is called the
denaturation temperature.
T_m.
annealing temperature.
dehybridization temperaure.
replication temperature.

After two generations of replication in the Meselson and Stahl experiment, what was the composition of the two bands?
One band was all ^{14}N and one ba nd was all ^{15}N.
One band was all ^{14}N and one band was half ^{14}N and half ^{15}N.
One band was all ^{15}N and one band was half ^{14}N and half ^{15}N.
One band was all ^{14}N and one band was one quarter ^{14}N and three quarters ^{15}N.
One band was all ^{15}N and one band was one quarter ^{14}N and three quarters ^{15}N.

The process of rehybridizing melted DNA is called
denaturation.
T_m.
annealing.
dehybridization.
replication.

Unwinding prior to ligation results in
relaxed DNA.
a wider major groove.
negative supercoiling.
positive supercoiling.
None of the above.

The anticancer drug cisplatin disrupts
histone binding to DNA.
supercoiling of DNA.
chromatin–DNA binding.
replication and transcription.
None of the above.

RNA
is oxygenated on the 2′ of ribose.
can form non-Watson–Crick base pairings.
uses metals to stabilize folding.
may form triplet base pairings.
All of the above.

The mole-fraction composition of one of the strands of a double-helical DNA molecule is [T] = 0.22 and [C] = 0.28. What can you say about [A], [G], [T], and [C] of the complementary strand?
[A] = 0.22, [G] = 0.28, [T] = 0.50 – [C], [C] = 0.50 – [T]
[A] = 0.22, [G] = 0.28, [T] = 0.28, [C] = 0.22
[A] = 0.22, [G] = 0.28, [T] = 0.22, [C] = 0.28
[A] = 0.50 – [G], [G] = 0.50 – [A], [T] = 0.22, [C] = 0.28
Not enough information is given to determine these concentrations.

You perform melting experiments on double stranded DNA, starting at low salt concentrations (~0.2 M NaCl) and then increasing the salt concentration to about 0.6 M NaCl. How does salt concentration affect the melting temperature of the DNA?
Salt at these low concentrations have no effect on T_m.
Increasing salt causes a decrease in T_m due to the stabilizing actions of the salt.
Increasing salt causes an increase in T_m due to the destabilizing actions of the salt.
Increasing salt causes a decrease in T_m due to the destabilizing actions of the salt.
Increasing salt causes an increase in T_m due to the stabilizing actions of the salt.

What makes DNA so much more stable than RNA in the presence of a basic solution?
The negative charge on the phosphate repels the negative charged base.
Histones block access to all but a few nucleotides that act as linkers.
The 2′-H in DNA is not reactive, whereas the 2′OH of RNA is under basic conditions.
DNA precipitates in basic solutions making it unreactive.
RNA forms elaborate structures that are susceptible to alkaline digestion.

Which of the following explain why RNA forms unique structures not found in DNA?
RNA can wrap around itself to form supercoiled structures but not DNA.
RNA contains hydrogen-bond donors and acceptors that are not normal participants in Watson-Crick base pairs.
Histones can direct the folding of RNA into unique structures, as it does with DNA.
The uracil base in RNA allows for additional hydrogen bonding to stabilize unique structures.
Unique structures in RNA are due to mismatches because there is no proofreading in RNA synthesis.

The mole-fraction composition of a strand of a RNA molecule is [U] = 0.19 and [C] = 0.33. What can you say about the [A] and [G] of this RNA?
[A] = 0.19, [G] = 0.33
[A] = 0.33, [G] = 0.19
[A] + [G} = 0.52
[A] + [G} = 0.48
There is not enough information to determine these concentrations.

Short-Answer Questions

Draw two nucleotides in DNA, showing the linkage between the sugars.

What advantage do phosphodiesters have compared to other esters?

Describe the DNA helix proposed by Watson and Crick.

Draw the hydrogen-bonded base pairs of A to T and show why A does not hydrogen bond to C.

Briefly describe the Meselson and Stahl experiment that indicated that DNA replication is semiconservative.

Describe the structure of chromatin.

What are topoisomers of DNA?

What role does a nucleosome play in DNA structure?

Why is there a major and a minor groove in DNA?

Compare and contrast the three forms of DNA with respect to handedness and hydration state.

Describe, in simple terms, the hallmarks of DNA structure.

Chapter 34DNA Replication

Matching Questions

Use the following to answer questions 1–10:

Choose the correct answer from the list below. Not all of the answers will be used.

helicases
Type I
Type II
G-rich strand
telomeres
topoisomerases
DNA polymerase
A-DNA
trombone-slide model
template
Holliday
Okazaki

_______________ catalyzes the addition of deoxyribonucleotides to DNA.

The _______________ describes the lengthening of the loop formed by the lagging strand during replication.

The strands of DNA must be relaxed or unwound for replication by _______________.

The type of topoisomerase that does not require ATP is _______________.

The type of topoisomerase that can introduce supercoils is _______________.

DNA can serve as a(n) _______________ to direct synthesis of the complementary strand of DNA or RNA.

988 The small DNA synthesized on the lagging strand are called _______________ fragments.

Proteins that use ATP hydrolysis to separate the DNA during replication are called ________________.

The ends of chromosomes are called _______________.

A(n) ________________ is critical in the formation of a telomere.

Fill-in-the-Blank Questions

Elongation of the DNA strand proceeds in the _____ direction.

The dimeric β2 subunit of DNA polymerase III acts as a(n) ____.

Type _____ topoisomerase introduces negative supercoils in DNA, while type _____topoisomerase relaxes supercoil structures.

The primer for DNA synthesis is an RNA molecule formed by the enzyme _____.

The DNA strand that is replicated continuously is known as the _____ strand.

Proofreading by DNA polymerase increases accuracy by a factor of _____ times.

During DNA replication, the RNA primer pieces are removed by _____.

The accuracy for DNA polymerase depends on the proper formation of a _____.

1000 In eukaryotes, each origin of replication represents a replication unit, or _____.

1001 In *E. coli*, dnaA protein binds to the _____.

Multiple-Choice Questions

1002 The observed error rate in DNA replication is
1 per 10_6 nucleotides.
1 per 10_4 nucleotides.
1 per 10_8 nucleotides.
1 per 10_{15} nucleotides.
None of the above.

1003 What do DNA polymerases require for replication to begin?
supercoiled DNA
single-stranded template DNA
a primer strand to elongate
All of the above.
None of the above.

1004 Polymerase I has which of the following?
a 3′ → 5′ exonuclease site
a 5′ → 3′ exonuclease site
C locus binding site
A and B.
A, B, and C.

1005 The Klenow fragment
has primase activity.
is an *E. coli* DNA polymerase fragment.
has exonuclease activity.
A and B
B and C

1006 What is DNA gyrase?
a bacterial topoisomerase II
a bacterial topoisomerase I
a bacterial helicase
All of the above.
None of the above.

1007 Replication moves from the
5′ → 3′ direction.
3′ → 5′ direction.
5′ → 5′ direction.
3′ → 3′ direction.
None of the above.

1008 What is true about *E. coli* DNA polymerases?
There are five structural classes.
All have finger and thumb domains that wrap around the DNA.
All catalyze the same reaction, which requires metal cofactors.
B and C
A, B, and C

1009 How is replication specificity dictated?
Watson-Crick hydrogen bonding must occur.
Enzyme interactions with the DNA act as a “ruler” to determine whether the properly spaced base pair has been formed.
The bond is broken and reformed to ensure its accurate placement at each base pair.
A and B
A, B, and C

1010 What function does helicase perform during replication?
It stabilizes the negative charge of the transition state.
It utilizes ATP to power strand separation.
It adds negative supercoils to DNA.
A and C
None of the above.

1011 How can the leading and lagging strands be synthesized in a coordinated fashion?
Specific enzymes control the size of the DNA opening.
Lagging-strand binding proteins inhibit leading-strand replication if the strands become disproportionate in size.
Polymerase III is a dimeric holoenzyme, and the looped lagging strand allows the enzyme to proceed in the same direction with each strand.
All of the above.
None of the above.

1012 The free end of the eukaryotic chromosome is thought to form a unique DNA structure that allows for complete replication. This structure involves a G-rich repeating sequence and forms a
replication fork.
large duplex loop.
supercoiled loop.
displacement loop
None of the above.

1013 The term processivity
indicates the error rate for a polymerase.
is the deletion of one or more bases in the DNA.
is specifically the speed of replication.
is the ability to catalyze many reactions without releasing substrate.
A, B, and C

1014 The ends of the eukaryotic chromosomes are called
pyrimidine caps.
telomeres.
G-rich ends.
replicon ends.
None of the above.

1015 DNA clamps
are composed of β2 subunits.
form a ring around the front of the fork of DNA.
allow the polymerase to move along the DNA molecule without falling off.
All of the above.
None of the above.

1016 Replication of telomers involves
an RNA-dependent DNA polymerase.
GC capping.
looping of the DNA ends.
helicase-dependent ATP melting of the strands.
None of the above.

1017 How would a mutation that reduced uracil formation affect DNA replication?
The effect would be negligible because uracil is found in RNA not DNA.
The effect would be minimal because UTP is formed from the emanation of CTP.
Uracil could be synthesized by a salvage pathway and so the effect would be minimal.
DNA synthesis depends on dCTP formed by nucleotide reductase of dUTP.
DNA synthesis depends on the synthesis of a short strand of RNA primer, thus DNA synthesis would be negatively impacted.

1018 What is it about the structure of nucleotides that requires 5′ to 3′ elongation of DNA?
Okazaki fragments use the hydrolysis of the pyrophosphate bonds to drive 5’ to 3’ DNA synthesis.
Okazaki fragments are not sterically hindered by a 2′-OH found in ribonucleotides, making 5′ to 3′ synthesis possible on both strands.
The hydrolysis of the triphosphate on the 5′-OH drives elongation, dictating a 5′ to 3′ direction for DNA synthesis.
The triphosphate on the 5′-OH undergoes a nucleophilic attack by the Mg^{2+} in DNA polymerase.
The direction of polymerization is determined by primase, not the nucleotide structure.

1019 If it could be targeted directly to cancer cells, would dideoxy-ATP (ddATP) make a good cancer drug?

No, because ddATP would promote the unwinding of supercoiled DNA and promote DNA synthesis.

No, because ddATP would promote Okazaki fragment formation due to loss of steric hindrance.

Yes, because ddATP has a lower K_m for DNA polymerase and acts as a competitive inhibitor for dATP.

Yes, because ddATP has no 3′OH and so synthesis stops when it is incorporated into DNA.

Yes, because ddATP acts as an analog of dGTP and causes mismatch and mutations.

1020 If you were to subject *E. coli* circular DNA to gel electrophoresis in the absence (lane 1) and presence (lane 2) of topoisomerase I, what would you expect to find?

Both lanes would look the same because the DNA is still the same size, with only a small portion uncoiled.

Lane 1 would run farther than lane 2 due to a smaller charge/density ratio of the DNA in lane 1.

Lane 1 would run farther than lane 2 due to relaxed and therefore slower moving DNA in lane 2.

Lane 2 would run farther than lane 1 due to a smaller charge/density ratio of the DNA in lane 1.

Lane 2 would run farther than lane 1 due to relaxed and therefore slower moving DNA in lane 1.

1021 The mode of DNA replication termed the *trombone model* describes a mechanism whereby the loop lengthens and shortens like the slide on a trombone. Specifically, what loop is being described?

The loop refers to the clamp of the DNA polymerase.

The loop is the strand of RNA synthesized by the primase.

The loop refers to the unwinding of the DNA by topoisomerase I.

The loop is made by the leading strand as it completes replication.

The loop is formed by the 3′ to 5′ lagging strand on the DNA template.

Short-Answer Questions

1022 Why are enzymes, other than DNA polymerase, required for replication?

1023 What is the difference between Type I and Type II topoisomerase with respect to the thermodynamics of the reactions catalyzed?

1024 How are breaks sealed in discontinuous DNA formed during replication?

1025 What are the minimal requirements for DNA replication?

1026 What is a processive polymerase enzyme versus a distributive polymerase enzyme?

1027 How is the processivity of DNA polymerase III accomplished?

1028 How are single-stranded regions of DNA maintained?

1029 How does the trombone-slide mechanism work to coordinate replication?

1030 Write the chemical reaction for the addition of the dNTP to a DNA strand at the 3′ end.

1031 Why is DNA gyrase the target for several different antibiotics?

Chapter 35DNA Repair and Recombination

Matching Questions

Use the following to answer questions 1–10:

Choose the correct answer from the list below. Not all of the answers will be used.

uracil
DNA ligase
Huntington disease
Ames
xeroderma pigmentosum
tumor-suppressor genes
trinucleotide repeats
skin carcinoma
mutagen
direct repair
indirect repair
photolyase

1032 _______________ is(are) often found to cause alternative structures in DNA replication.

1033 A(n) _______________ chemically changes the nature of a base in DNA.

1034 _______________ is(are) typically involved in DNA repair.

1035 _______________ is(are) involved in joining DNA molecules together.

1036 _______________ is(are) caused by expanded trinucleotide repeats.

1037 _______________ is the process for correcting for base-pair mismatches without excising bases.

1038 The enzyme that uses light energy to form an excited state to cleave the dimer into individual bases is _______________.

1039 _______________ is an enzyme that cleaves a glycosidic bond to release a damaged base.

1040 _______________ is a rare skin disease caused by the inability to correct for UV damage to skin DNA.

1041 An assay used to determine carcinogenic potential is the _______________ test.

Fill-in-the-Blank Questions

1042 Proteins that contain a string of glutamines are likely to be involved in _____ disease.

1043 *E. coli* DNA polymerase III removes mismatched nucleotides from the _____.

1044 Hydroxyl radicals cause DNA damage by _____.

1045 _____ is the enzyme that converts polycyclic aromatic hydrocarbons into a reactive epoxide that alkylates the N-7 of guanine.

1046 Light-driven DNA damage results in _____.

1047 Replication errors are often corrected by proofreading and _____.

1048 A photoreactivating enzyme is called _____.

1049 X-rays cause damage to DNA by inducing _____.

1050 The human genetic skin disease that is caused by a mutation in components of the human nucleotide-excision-repair pathway is called _____.

1051 _____ are intermediates in recombination pathways composed of four polynucleotide chains in a cross-like structure.

Multiple-Choice Questions

1052 Damage to DNA may result in
cell death.
cell transformation.
changes in inherited sequences.
blockage of DNA replication.
All of the above.

1053 _________________ is an ATPase needed for DNA repair by recombination.
Polymerase III
RecA
RecB
RAD51
None of the above.

1054 The three-strand structure involved in strand invasion is
the D-loop.
recombinase DNA.
an RNA triplet.
non-Watson–Crick pairing.
RecA

1055 The process whereby two daughter molecules of DNA are formed by the exchange of genetic material between two parent molecules is known as
chemical modification.
recombination.
alkylation.
dimerization.
None of the above.

1056 In *E. coli*, mismatch repair involves
recognition of mismatched pair by MutS.
removal of a mismatched nucleotide by DNA polymerase III.
cleavage of the backbone by MutH.
A and C
A, B, and C

1057 Huntington disease is caused by
pyrimidine dimers.
trinucleotide expansion.
suppressor mutants.
All of the above.
None of the above.

1058 Aflatoxin B_1 is an example of a(n)
intercalating chemical.
alkylating agent.
base analog.
All of the above.
None of the above.

1059 Photolyase functions to
repair pyrimidine dimers.
remove damaged bases.
ligate single-strand breaks.
All of the above.
None of the above.

1060 An important feature of the Ames test is:
the inclusion of mammalian liver enzymes.
a linear response curve.
that the bacteria used are unable to grow in the absence of arginine.
A and B
A, B, and C

1061 Exposure to aflatoxin B_1 can lead to
the expansion of repeats of three nucleotides.
DNA damage by alkylation.
the defective repair of DNA.
the recombination of DNA.
None of the above.

1062 Why does the deamination of cytosine to uracil not cause a problem in the next round of DNA replication?
Although uracil cannot form the third hydrogen bond to guanine, it is recognized by DNA polymerase as a mismatch and the error is corrected on the next round of replication.
The AP endonuclease nicks the backbone and removes the uracil and replaces it with another cytosine.
The repair machinery recognizes uracil in DNA as a mistake and replaces it with cytosine.
The uracil undergoes spontaneous depurination and is replaced with a cytosine.
Deamination of cytosine rarely occurs within the coding region and so causes few mutations.

1063 There are 1080 depurination repair events required per cell per hour and the human genome contains about 6×10^9 base pairs. What is the spontaneous rate of depurination?
1.08×10^{-8} depurinations per purine per minute
1.8×10^{-7} depurninations per purine per minute
4.8×10^{-9} depurinations per purine per minute
2×10^{-9} depurinations per purine per minute
3×10^{-9} depurinations per purine per minute

1064 The Ames test is a simple and sensitive test for detecting chemical mutagens. What characteristic of the strain of *Salmonella* used in the Ames test makes them appropriate for "detecting chemical mutagens"?
A high proportion of the *Salmonella* reverse the original mutation.
The addition of the chemical mutagen allows reversal of a mutation for DNA synthesis. The addition of the chemical mutagen allows reversal of a mutation for histidine synthesis.
Reversal of the original mutation requires liver homogenates; thus, no spontaneous reversals.
This strain of bacteria is susceptible to very low levels of mutagens and amplifies very small signals.

1065 If you are not genetically predisposed to *xeroderma pigmentosum*, is it okay to go ahead and get a summer suntan?

Yes, especially in children, where vitamin D formation is critical of bone growth.
Yes, the incidence of *xeroderma pigmentosa* is extremely rare and the mutation rate in the affected genes is low.
No, defects can arise through UV entering the eyes, which is not protected by sunscreen.
No, defects in DNA-repair systems increase with multiple exposures to mutagens.
No, the defective gene in *xeroderma pigmentosa* is highly susceptible to UV-mutation and can be acquired later in life.

1066 If you could look at individual strands of DNA and you saw a Holliday junction, what would that tell you?

A region of DNA that contains a thymidine dimer is undergoing repair.
DNA repair of a double stranded break is occurring via a recombination mechanism.
DNA with a point mutation is undergoing base-excision repair.
DNA with a point mutation is undergoing nucleotide-excision repair.
Mutagenic reversal is occurring, as seen in the Ames Test.

Short-Answer Questions

1067 Describe the difficulties in dealing with halts in DNA replication.

1068 What is DNA adduct and how is it formed?

1069 How are breaks in DNA sealed that were formed during nucleotide-excision repair?

1070 Deamination of adenine causes what kind of mutations in DNA?

1071 What are the enzymes needed for base-excision repair?

1072 Tumor-suppressor genes have a dominant negative genetic trait. What does this mean?

1073 Describe the Ames test.

1074 Describe the consequences of incorrect DNA replication or DNA damage.

1075 Name the types of DNA repair, categorized in groups.

1076 Why is thymine used in DNA instead of uracil?

1077 To what does the phrase “recombination of genetic material” refer?

1078 What role does the protein RAD51 play in recombination?

1079 Give examples of types of damage to DNA that have led to the development of a variety of DNA-repair systems.

1080 How do double-strand breaks occur during replication?

1081 How is recombination used as a biochemical tool?

Chapter 36 RNA Synthesis and Regulation in Prokaryotes

Matching Questions

Use the following to answer questions 1–10:

Choose the correct answer from the list below. Not all of the answers will be used.

divalent cation
primer
stem loop
operon
consensus
amanitin
transcription
translation
repressor
transcription bubble
catabolite repression
promoters

_______________ A group of genes that are closely related and are produced as a single mRNA.

RNA synthesis (tRNA, mRNA, and rRNA) is called _______________.

_______________ is a required cofactor for RNA polymerase.

DNA sequences that direct RNA polymerase to the initiation site are called _______________.

Unlike DNA synthesis, RNA synthesis does not require a(n) _______________.

The region of RNA synthesis containing the DNA, RNA, and enzymes is called the _______________.

7. _______________ Sequences deduced from the analysis of many related DNA sequences.

The expression of galactosidase requires the induction of an operon by removal of a(n) _______________.

The RNA structure that often signals termination of transcription is the _______________.

An increase in cellular metabolism that inhibits expression of the genes for that metabolism is a process known as _______________.

Fill-in-the-Blank Questions

RNA polymerases read the template strand in the _____ direction.

Promoter sites in *E. coli* are located _____ and _____nucleotides upstream of the start site.

The _____ sequence is determined by an alignment of DNA base sequences used to deduce a recurring pattern or motif.

The coding strand has the _____ sequence as the RNA transcript (except that it has T instead of U).

The first step of transcription depends on the _____ subunit.

The RNA polymerase can unwind approximately _____ bases, or about 1.6 turns of B-DNA.

The rate of RNA synthesis in *E. coli* is approximately _____ nucleotides per second.

The Rho protein terminates transcription by acting as a _____.

Many antibiotics, such as rifampicin, function by blocking _____.

Adding lactose to *E. coli* culture results in _____ of expression of the *lac* operon.

Multiple-Choice Questions

Functions of RNA polymerase include
searching for promoter sites.
unwinding short stretches of DNA.
detecting termination signals.
A and C
A, B, and C

RNA polymerase requires which of the following for initiation?
DNA primer
RNA primer
supercoiled DNA
nicked DNA
None of the above.

The structure of DNA must be in which complex for transcription to occur?
the closed promoter complex
the biphasic promoter complex
the open promoter complex
All of the above.
None of the above.

The major RNA types include
messenger RNA
template RNA
ribase RNA
All of the above.
None of the above.

The Pribnow box
is found +10 base pairs from the start site of an operon.
is found −10 base pairs from the end site.
is the site where promotors bind.
serves to regulate translation.
None of the above.

The protein that binds DNA sequences and helps RNA polymerases initiate transcription is
α.
β.
δ.
β'.
σ.

In transcription, the 3′-hydroxyl group

attacks the α-phosphorous group on an incoming nucleotide.
binds to a Mg^{2+} in the active site.
binds to the 5′ ribose.
attacks the 5′ hydrogen of the incoming nucleotide.
None of the above.

Which subunit of *E. coli* RNA polymerase binds DNA and takes part in catalysis?

α
β
δ
β′
σ

Structural diversity of tRNA molecules is caused by

folding patterns.
methylation of the ribose.
poly(A) tailing.
All of the above.
None of the above.

In *E. coli*, what other protein(s) is(are) synthesized when β-galactosidase is synthesized?

σ_{70} of RNA polymerase
RNA helicase
ribonuclease III
galactoside permease
All of the above.

An RNA mutation improves the error rate slightly at the expense of a slightly slow transcription speed. Is this a significant improvement?

No, because transcription takes place at a rate nearly 50 times that needed by most cells.
No, because an error in mRNA affects only one molecule and the error does not become part of the permanent genome,
Yes, because fewer errors in transcription give bacteria, who turnover rapidly, a survival advantage.
Yes, because bacteria turnover rapidly, and so protein synthesis runs a maximum capacity.
Yes, because the transcription bubble is stable only at slow transcription rates.

What would happen if regions of DNA encoding the CAP were deleted?
Bacterial growth would be inhibited because β-galctosidase would remain low even when glucose levels are low.
This condition would effectively drive lipid production due to excess glucose metabolism.
On a molecular level, the *lac* repressor would stay bound to the operon preventing transcription.
This would activate the catabolite repression mechanism in the presence of glucose.
The bacteria would switch to glycogen metabolism.

If you were to target a mutation in RNA polymerase to inhibit bacterial growth, which subunit would you target and why?
σ-subunit because it binds to DNA.
α-subunit because it takes part in promoter recognition.
α-subunit because it binds to DNA.
β-subunit because it is required to restore denatured polymerase.
β-subunit because it takes part in all stages of catalysis.

Would it be possible to predict the complete sequence of a tRNA molecule knowing the DNA sequence that encodes for it?
Yes, tRNA is transcribed in the same process as mRNA.
Yes, tRNA forms short sequences of Watson-Crick base pairing.
Yes, primer sequences are regulated the same for all types of RNA.
No, tRNA is modified enzymatically after transcription.
No, tRNA is not translated, and so sequence data is unavailable.

What parallels are there between the *lac* operon and a gene for an allosteric enzyme?
Both respond to cAMP cascades.
Both contain both regulatory regions and structural genes.
Transcription of both requires the formation of a hairpin loop.
Both are sensitive to actinomycin D inhibition.
Transcription of the regulator gene requires binding of the inducer to the promoter.

Short-Answer Questions

Name the three stages of RNA synthesis.

How do promoters differ in efficiency?

38. What is the significance of the σ subunit?

How does RNA polymerase find the proper binding site?

What is the theory about how palindromic RNA polymerase transcription termination signals function?

What is a common feature of both protein-dependent and protein-independent termination signals in transcription?

How does the antibiotic rifamycin function mechanistically?

A σ subunit that is mutated such that the protein binds tightly to DNA with a 10-times-higher affinity than wild-type sequences will likely have what effect?

Describe how RNA is modified.

How does the addition of lactose to *E. coli* induce the expression of proteins important for lactose metabolism?

A mutation in the 3′ end of mRNA leads to an increase in AT-rich regions. What is the likely outcome of this change?

What are the DNA components of a regulatory system?

How is the expression of the *lac* operon inhibited by the *lac* repressor?

What is the social interaction known as quorum sensing and how does it change gene expression?

50. What are riboswitches and how do they control gene expression?

Chapter 37Gene Expression in Eukaryotes

Matching Questions

Use the following to answer questions 1–10:

Choose the correct answer from the list below. Not all of the answers will be used.

enhancers
bromodomain
regulated
chromatin-remodeling engine
ligand
coactivators
agonists
histone acetylase
citrate
TATA box
histone deacetylase
zinc finger

A(n) _______________ is a region of a protein that regulates transcription by interacting with the acetylated lysine of histones.

_______________ is a complex that can shift the position of nucleosomes along a DNA strand.

The molecule _______________ shuttles acetyl groups into the nucleus for use by histone-modifying enzymes.

Molecules that bind to a receptor and trigger a signaling pathway are called _______________.

5. _______________ is a DNA-binding domain involving eight cysteine residues.

Binding sites in DNA for specific regulatory proteins are called _______________.

Proteins that act in a coordinated manner with hormone receptors to mediate gene expression are called _______________.

The enzyme that removes the acetyl group for a lysine of a histone is called _______________.

_______________ is a general term for molecules that bind to receptors.

In eukaryotes, transcription is initiated by the binding of the transcription factor to the _______________.

Fill-in-the-Blank Questions

The nuclear membrane is important in gene expression because it separates the process of _____ from that of _____.

_____ genes are continuously expressed rather than regulated.

Eukaryotic RNA polymerases differ in their sensitivity to the mushroom toxin _____.

RNA polymerase I is located in the _____.

The carboxyl-terminal domain of RNA polymerase II is phosphorylated on _____ residues.

The repeating unit formed by the DNA wrapping around the histone core is called a(n) _____.

_____ receptors differ from cell surface receptors in that they are soluble cytoplasmic proteins.

Nuclear hormone receptors bind to specific DNA sites known as _________________.

When a steroid hormone receptor binds ligand, it does not change the binding of a receptor to DNA but to the _____.

A molecule that binds to a nuclear hormone receptor but does not trigger a response is called a(n) _____.

Multiple-Choice Questions

Differential gene expression is caused by
control of translation.
control of mRNA processing.
control of transcription.
control of replication.
None of the above.

When phosphorylated, the carboxyl-terminal domain of RNA polymerase II
is insensitive to α-amanitin.
enhances transcription.
recruits other factors.
A and C.
B and C.

What do many DNA binding proteins contain that is involved in chromatin remodeling?
a helix-turn-helix motif
an acetyl–lysine binding domain
a zinc-finger motif
All of the above.
None of the above.

In eukaryotes, DNA-binding proteins bind to DNA by which of the following DNA-binding structures?
the zinc-finger domain
the cAMP binding
closed loops called lariats
A and B
A, B, and C

A common selective estrogen receptor modulator used in breast cancer therapy is
tamoxifen.
α-amanitin.
acetyl–lysine binding protein (ALBP).
All of the above.
None of the above.

Pluripotent cells
are stem cells.
can develop into any adult cell.
can develop into any fetal cell.
All of the above.
None of the above.

The interaction of many different protein factors to stimulate or repress transcription is called
combinatorial control.
synergy.
the hypomethylation effect.
All of the above.
None of the above.

Enhancer sites are often located
near the poly(A) tail site.
within introns.
at a distance from the transcription start site.
All of the above.
None of the above.

Molecules that bind to a receptor and trigger signaling pathways are called
antagonists.
agonists.
IRE-binding proteins.
promoters.
None of the above.

How do coactivators mediate expression?
by blocking RNA polymerase binding
by loosening the histone complex formation
by inhibiting intron splicing
A and B
B and C

A key reaction in gene repression is the deacetylation of which amino acids in histones?
serine
threonine
arginine
lysine
All of the above.

A deletion in which of the following would most likely inhibit cell specific protein synthesis?
enhancer sequence
promoter sequence
initiator element
downstream core element
–35 region

Like so many other proteins, the carboxy-terminal domain of RNA polymerase II undergoes what type of activation to transition from initiation to elongation?
dephosphorylation
phosphorylation
binding of a steroid hormone receptor
binding of a G-protein
acetylation

Why would an inhibitor of RNA polymerase II not cause rapid cell death even if every molecule of RNA polymerase II was inhibited?
Phosphorylation protects RNA polymerase II from inhibitor binding.
As long as TFIID can bind, then RNA polymerase II can stay bound and continue to transcribe proteins.
There would still be many functional mRNAs and viable proteins to continue cellular functions.
TBP binding to the TATA box protects degradation of RNA polymerase II.
Downstream core promoter elements initiate RNA polymerase activation.

Why is the action of nuclear receptors so different from G-protein-coupled receptors?
G-protein-coupled receptors act on cytosolic proteins, not nuclear proteins.
Nuclear receptors activate transcription factors via methylation reactions, not phosphorylations.
G-protein-coupled receptors activate or inhibit enzymes, not transcription.
Nuclear receptors bind steroids, which can cross the cellular membrane; thus, specificity of action resides in the cytoplasm.
G-protein-coupled receptors bind carbohydrate moieties, whereas nuclear receptors bind prostaglandin hormones.

What steroid-hormone receptors make good targets for drugs?
Anabolic steroids stimulate the expression of genes that enhance the development of lean muscle mass.
Raloxifene blocks estrogen-mediated pathways needed for cancer growth.
Tamoxifen is used in the treatment and prevention of breast cancer.
Estradiol triggers signaling pathways and is said to have agonist properties.
All of the above.

Short-Answer Questions

What additional complexities exist between gene expression in eukaryotes but not in prokaryotes?

Why must gene regulation be more complicated in eukaryotic cells when compared to prokaryotic cells?

Briefly describe the path of a steroid hormone in gene regulation.

How does a coactivator function in gene expression?

Why are steroid hormone receptors excellent drug therapy targets?

How does binding of thyroid hormone to its nuclear hormone receptor promote transcription?

By what mechanism does histone acetylation prepare the DNA for transcription?

What is the role of a mediator in transcription?

45. Which two characteristics differentiate promoters from enhancers?

What are the steps in modifying gene expression by hormones such as estrogen?

What benefit does combinatorial control give to multicellular organisms?

What are induced pluripotent stem cells?

What are the three most common *cis*-acting elements for genes transcribed by RNA polymerase II?

Explain why different RNA polymerases transcribe specific genes and only those genes.

Chapter 38RNA Processing in Eukaryotes

Matching Questions

Use the following to answer questions 1–10:

Choose the correct answer from the list below. Not all of the answers will be used.

poly(A) tail
methylation
alternative splicing
spliceosome
U2 and U6
U4, U5, and U6
spliced
translation
RNA editing
GU
ribozyme
RNA polymerase I
ATP

mRNA precursors may be spliced by ______________ complexes.

Nearly all mRNA precursors in higher eukaryotes are _______________.

_______________ is an elongated sequence that stabilizes RNA.

_______________ transcription gives rise to three ribosomal components.

_______________ is a common rRNA modification.

Introns to be spliced start with this sequence of _______________.

_______________ These small nuclear RNAs form the catalytic center of the spliceosome.

A change, other than splicing, made to the base sequence of RNA following transcription is called _______________.

_______________ is a mechanism of splicing that allows diversity in the proteins generated from a particular gene.

An RNA molecule that is catalytic is called a(n) _______________.

Fill-in-the-Blank Questions

At least ____ % of all genetic diseases are caused by mutations that affect RNA splicing.

The small subunit of ribosomal RNA is _____ S.

Recognition of the 5′ splice site by _____ is the first step in splicing.

Diversity in proteins is due to _____ of the same gene.

Improper splicing that leads to improper hemoglobin synthesis may cause the disease known as _____.

The enzyme _____ transcribes a single precursor that encodes for the 18S rRNA, the 28S rRNA, and the 5.8S rRNA.

RNA self-splicing demonstrates the role of RNA as a(n) _____.

The immediate product of RNA polymerase II is often referred to as _____.

Self-splicing by RNA requires a _____ cofactor.

Multiple-Choice Questions

The percentage of diseases caused by mutations that affect mRNA splicing is
2.
15.
20.
30.
None of the above.

Noncoding regions of RNA are called
nonsense RNA.
empty RNA.
intron RNA.
exon RNA.
precursor RNA.

RNA polymerase III is responsible for the transcription of
18S rRNA.
28S rRNA.
tRNA.
mRNA.
A and B.

mRNA is transcribed by
RNA polymerase I.
RNA polymerase II.
RNA polymerase III.
All of the above.
None of the above.

RNA polymerase I transcribes the genes for
mRNA precursors.
18S, 5.8S, and 28S rRNA.
most tRNA.
All of the above.
None of the above.

Which of the following modifications are made to eukaryotic tRNA transcripts?
modification of base and ribose moieties
removal of the 3′ trailer
cleavage of the 5′ leader by RNase P
CCA is added
All of the above.

______________ is used to form cap 0 of mRNA.
S-adenosylmethionine
Cysteine
Biotin
Methanol
Dimethyl-RNA methylase

The polypyrimadine tract
is found at the 3′ end of an intron.
is a consensus sequence.
contains a stretch of 10 pyrimidines.
All of the above.
None of the above.

Diseases caused by mutations in pre-mRNA or in the splicing factors include
Burkett lymphoma.
thalassemia.
retinitis pigmentosa.
A and C.
A, B, and C.

Proteins that possess alternative splicing products include
antibodies.
hemoglobin β.
apolipoprotein.
A and C.
B and C.

The function of guanosine in self-splicing is
to provide energy.
as an attacking group.
as a necessary base for RNA editing.
All of the above.
None of the above.

The carboxy-terminal domain (CTD) of RNA polymerase II undergoes reversible phosphorylation during transcription. In that phosphorylation events tend to be a signal, what does this phosphorylation event signal?
Dephosphorylation signals recruiting of proteins to catalyze polyadenylation.
Phosphorylation signals recognition of the “stop” codon.
Dephosphorylation signals recruiting of spliceosome proteins.
Phosphorylation signals the transition from transcription initiation to elongation.
Dephosphorylation activates the catalytic function of ribozymes.

Why might a single base pair mutation in eukaryotic mRNA be less serious than one in prokaryotic mRNA?
If the mutation occurs in the intron, it will not affect the gene product.
If the mutation occurs in a transcript with alternative splicing but not in the splice site, only one gene product may be affected.
If the mutation occurs 3’ of the start site, it will not affect the gene product.
A and B
A, B, and C

A mutation in an enzyme that catalyzes a transesterification reaction would inhibit which of the following events?
mRNA termination
polyadenylation
mRNA splicing
5′ capping
chain initiation

You read an article in a popular magazine about a unicellular plant that has DNA with catalytic activity. Knowing that RNA can have catalytic activity, would you believe this article?

Yes, DNA could easily be attacked by a guanosine cofactor.
Yes, but only DNA not associated with proteins that would constrain the formation of DNA loop structures.
Yes, all that is required is a 3’OH to attack the 3’splice site.
No, uracil of RNA is required in the catalytic site.
No, DNA is constrained by its double helix structure and could not fold into a catalytic structure.

Because RNA polymerase II has no proofreading function, it may provide a mechanism for generating diversity. Explain?

Small nucleolar ribonucleoproteins direct modification to form pseudouridine bases.
RNA can be altered after transcription by RNA editing.
Proofreading would slow down transcription, preventing cells to respond rapidly to changing cellular demands.
The 5′ leader sequence is removed prior to translation. The synthesis of this extra length of transcript is thermodynamically unsound.
Several 5′ caps are added to mRNA, which shifts the reading frame, depending on the cap.

Short-Answer Questions

How is the mature 3′ end of mRNA formed?

Loss of a 3′ polyadenylation is likely to cause what?

Explain the modifications of tRNA.

What role do small nucleolar ribonucleoproteins (snoRNPs) play in RNA processing?

How are introns detected for splicing?

41. What is the catalytic chemistry of mRNA splicing?

Two proteins, X and Y, are highly homologous with many identical domains. However, protein Y has two cassettes of amino acid sequences that are not found in X. Explain.

What is the function of the 5′ cap on mRNA transcripts?

Guanosine cofactor is used in what mechanism?

Distinguish between the 5′-mRNA caps designated cap 0, cap 1, and cap 2.

Approximately how many mRNA transcripts in higher eukaryotes undergo processing?

What is the role of GTP in self-splicing?

What is present in the spliceosome complex?

Draw the mechanism of lariat formation in a splicing pathway.

What are the two types of splicing categories?

Chapter 39The Genetic Code

Matching Questions

Use the following to answer questions 1–10:

Choose the correct answer from the list below. Not all of the answers will be used.

CCA 3′
polysome
PP_i hydrolysis
transcription
translation
phosphorylated
pG
two
wobble
three
charged tRNA
30S
20S

1082 The term applied to the process of protein synthesis is _______________.

1083 The amino acid is attached to the tRNA molecule at _______________.

1084 Another name for an amino acid ester of tRNA is _______________.

1085 _______________ is a group of ribosomes bound to a single mRNA.

1086 The _______________ hypothesis explains why some tRNA molecules can bind to more than one codon.

1087 The 5′ end of tRNA is _______________.

1088 An I in the first position of the anticodon indicates that _______________ codons can be read by that tRNA.

1089 The small subunit of the ribosome is ______________ _.

1090 In prokaryotic gene expression, _______________ and translation are closely coupled in time and space.

1091 Hydrolysis of _______________ drives the charging of tRNA with amino acids.

Fill-in-the-Blank Questions

1092 The error frequency of protein synthesis is approximately ____.

1093 Class I aminoacyl-tRNA synthetases acylate the _____ or 3′ hydroxyl group of the terminal adenosine of tRNA.

1094 The 3′ CCA terminal region of tRNA contains the _____.

1095 Precision of tRNA–mRNA recognition takes place at the first _____ base pairs of the codon.

1096 The activation of a tRNA involves the formation of an _____ intermediate.

1097 Aminoacyl-tRNA synthetases contain both an activation site and an _____ site.

1098 A genetic code, which reads 5′CCCACUGUA3′, codes for _____ amino acid sequence?

1099 The genetic code is _____, in that some amino acids are coded for by more than one codon.

1100 Proteins constitute only _____ of the mass of ribosomes.

1101 The synthesis of _____ is the crucial step in protein synthesis.

Multiple-Choice Questions

1102 Protein synthesis takes place on
lysozomes.
nuclear pores.
vacuoles.
ribosomes
None of the above.

1103 The ribosome is thought to be
an example of a catalyst that has survived from the RNA world.
unique to eukaryotes.
a ribozyme.
A and C.
A, B, and C.

1104 The rate of translation in *E. coli* is ________ amino acids per second.
5
20
40
120
None of the above.

1105 What are some of the features common to tRNA molecules?
Each is a single chain with between 73 and 93 ribonucleotides.
They contain many unusual bases.
About half the nucleotides in tRNA are base-paired.
They usually have a pG at the 5′ terminal.
All of the above.

1106 The actual three-dimensional structure of tRNA is a(n)
L-shape.
cloverleaf.
twisted triple helix.
All of the above.
None of the above.

1107 In preparation for attachment to the tRNA, amino acids are activated by
methylation.
adenylation.
dimethylation. All
of the above. None
of the above.

1108 Which of the following components of the tRNA is/are important for the binding specificity of the tRNA synthetase?
acceptor stem
anticodon loop
TΨC loop
A and B.
A, B, and C.

1109 Which amino acid has only one codon triplet?
phenylalanine
alanine
methionine
aspartate
None of the above.

1110 The start signal for most organisms is
ATG.
AUG.
AAA.
UAA.
AGG.

1111 Accuracy during translation occurs because of
codon degeneracy.
wobble at the third site.
tRNA specificity in binding the mRNA.
aminoacyl tRNA charging.
the structure of mRNA and the stability of that molecule.

1112 Abundant amino acids in proteins have the most codons and the least abundant amino acids have the fewest. Why might this provide a selective advantage?

Degeneracy decreases the likelihood that a substitution for a base will change the encoded amino acid.
Degeneracy prevents variation in base composition and therefore proofreading is not necessary.
Early organisms had overlapping DNA and under those conditions, each amino acid was coded by the same number of codons.
Thermodynamically, less energy is expended by the cell in making abundant amino acids.
Redundancy allows for base modifications without affecting protein structure and function.

1113 Which of the following can occur in bacteria but not eukaryotes?

RNA can be translated in both 5′→3′ and 3′ → 5′ directions.
Eukaryotic mRNA is read without punctuation, whereas splicing can occur in bacteria.
The bacterial genetic code is overlapping.
Translation can start before transcription is completed.
In bacteria, there is only one tRNA for each amino acid.

1114 Where in a tRNA molecule would you expect that a mutation would not cause a problem in protein synthesis?

the anticodon loop due to the wobble hypothesis
the CCA terminus because this is where the amino acid binds and it is the amino acid that determines specificity
the 5′ phosphorylation site because any purine would suffice.
The TψC loop is not recognized by the synthetase.
All of these would cause problems because tRNA recognition is important for high-fidelity protein synthesis.

1115 Consider the overall reaction an activated tRNA molecule.

Amino acid + ATP + tRNA aminoacyl-tRNA + AMP + PPi

If the ATP was labeled with ^{32}P in the α-position, where would the label end up?

aminoacyl-Trna
AMP
AMP and PPi
PPi
the next tRNA in the sequence

1116 In which component of the ribosome would a mutation have the greatest impact and why?

RNA, because protein synthesis requires that the RNA be folded into complex structures to ensure proper orientation of amino acids.
RNA, because the RNA is thought to provide the catalytic activity.
Protein, because the protein is thought to provide the catalytic activity.
Protein, because the recognition sites are primarily protein.
Carbohydrate, because the recognition sites are primarily protein.

Short-Answer Questions

1117 What is the amino acid error rate in protein synthesis? Is this rate logical in evolutionary terms of function?

1118 What is significant about yeast alanyl-tRNA?

1119 Explain why some bases in RNA cannot be involved in base pairs.

1120 Where is the attachment site and where is the anticodon loop with respect to the nucleotide sequence and with respect to the L-shaped structure of tRNA?

1121 How much energy is used to attach the amino acid to the tRNA?

1122 How is a high level of fidelity maintained in attaching the amino acids to the tRNA structure?

1123 How does the size of an amino acid influence accurate attachment of the amino acid to the tRNA in aminoacyl-tRNA synthetase reactions?

1124 What is significant about the direction of transcription and translation?

1125 Describe the subunits of *E. coli* ribosomes.

1126 Why is it important that transcription and translation are tightly coupled?

Using structures of the base pairs, show how the presence of inosine at the 5′ position of the anticodon can recognize three different codons.

What is the theory about how palindromic RNA polymerase transcription termination signals function?

What is meant by the statement “Degeneracy minimizes the deleterious effects of mutation”?

Give an example of how the treatment of diabetes has benefited from the near universality of the genetic code.

What role does the ribosomal RNA play in the 70S ribosome structure?

Chapter 40The Mechanism of Protein Synthesis

Matching Questions

Use the following to answer questions 1–10:

Choose the correct answer from the list below. Not all of the answers will be used.

initiation factors
ATP
ricin
one
Shine-Dalgarno
elongation factor Tu
polysome
two
kanamycin
release factor
N-formylmethionine
signal sequence
GTP

1127 The sequence that interacts with a complementary sequence on the 3′ end of the 16S rRNA is ______________.

1128 _______________ include(s) IF1, IF2, and IF3 in prokaryotes.

1129 _______________ is the first amino acid in bacteria and typically is chemically modified.

1130 EF-G translocase proteins use the energy of _______________ hydrolysis.

1131 _______________ inhibits the interaction between tRNA and 16S rRNA.

1132 The biomolecule _______________ delivers the aminoacyl-tRNA to the “A site” in *E. coli*.

1133 The _______________ proteins recognize UAA, UAG, and UGA codons.

1134 _______________ is a sequence of 9–12 hydrophobic amino acid residues, sometimes containing positively charged amino acids.

1135 How many release factors do eukaryotes have?

1136 The protein _______________ is toxic because it hydrolyzes a critical adenine base from the 28S RNA molecule of eukaryotes.

Fill-in-the-Blank Questions

1137 In a ribosome, A stands for _____ and P stands for _____.

1138 mRNA that codes for more than one protein is considered _____.

1139 The first amino acid in bacterial proteins is _____.

1140 After the peptide bond forms, the mRNA and tRNA are _____, or moved, a distance of one codon.

1141 GTP binds to the _____ protein in the translocation mechanism.

1142 Release factors function by allowing _____ to attack the ester linkage between tRNA and amino acid.

1143 Proteins are synthesized in the _____ direction.

1144 In *E. coli*, the signal sequence that properly aligns the initiation codon in the P site is called the _____ sequence.

1145 Initiation, elongation, and termination all require factors that are members of the _____ family.

1146 The signal sequence that marks a protein for translocation across the endoplasmic reticulum membrane is located near the _____ end of the protein.

Multiple-Choice Questions

1147 Eukaryotic mRNA is
linear.
circular.
modified only at the ribose.
discontinuously translated.
None of the above.

1148 In vanishing white matter disease, nerve cells disappear due to
phagocytosis of living cells.
an autoimmune result of mutations in mRNA.
mutation in release factors.
mutations in initiation factor 2.
mutations in the tRNA charging mechanism.

1149 Chloramphenicol acts by
binding to the peptidase cell-wall enzyme.
inhibiting peptidyl transferase activity.
inhibiting protein synthesis.
binding to fMET tRNA.
changing the shape of the mRNA.

1150 Ricin is made from castor beans and is a strong toxin, which
removes an adenine from 28S rRNA.
glycosylates tRNA.
inhibits protein synthesis initiation.
blocks the A binding site.
coats the mRNA.

1151 Which of the following is required for the initiation of protein synthesis in prokaryotes?
mRNA
the 30S subunit
fMet-$tRNA_f$
GTP
All of the above.

1152 What is the order of the tRNA binding sites on the 70S ribosome with respect to the 5′ → 3′ direction of the mRNA?
E P A
P A E
A E P
P E A
E A P

1153 What is the direction of translation of mRNA?
bidirectional
5′→3′
3′→5′
All of the above.
None of the above.

1154 Signals that define the beginning and end of protein synthesis are contained in
rRNA.
tRNA.
mRNA.
the ribosome.
protein.

1155 Which of the following *E. coli* proteins is responsible for translocation of the mRNA as a result of a conformation change due to the hydrolysis of GTP?
RRF
EF-Tu
EF-G Shine–
Delgarno
None of the above.

1156 What factor(s) is (are) necessary for the correct placement of the mRNA and initiating tRNA on the ribosome?

IF1
IF2
IF3
A and B.
A, B, and C.

1157 Eukaryotic and prokaryotic translation differs primarily in which step?

initiation
elongation
termination
All of the above.
None of the above.

1158 What is the mechanism of action of the A fragment of diphtheria toxin?

binding the 60S subunit
cleaving tRNA
the chemical modification of EF2
All of the above.
None of the above.

1159 An error in the synthesis of an RNA molecule or a protein molecule will not be passed on to subsequent generations. Suggest a reason why there is a proofreading mechanism in protein synthesis but not RNA synthesis?

Protein proofreading occurs during protein folding events; thus, the rate of protein synthesis is not reduced.
Protein proofreading occurs during post-translational splicing of proteins (such as insulin); thus, the rate of protein synthesis is not reduced.
Protein synthesis takes place at a much slower rate than RNA synthesis; thus, giving time for improper codon-anticodon binding destabilization.
The mischarging of some tRNAs is corrected by the hydrolytic action of aminoacyl-tRNA synthetase; thus, mistakes are prevented.
Some tRNAs are proofread in the E site triggering hydrolytic action of peptidyl transferase; thus, mistakes are corrected as they are made.

1160 What would happen if you introduced a substitution of two of the Gs for two Cs in the Shine-Dalgarno sequence?

Weak base-pairing between the mRNA and the 3′ end of the 16S rRNA could terminate initiation.

Weak base-pairing between the 5′ end of the tRNA and the 18S rRNA could cause the insertion of the wrong amino acid.

Weak base-pairing between the codon and the anticodon sequences could cause the insertion of the wrong amino acid.

The Shine-Dalgarno sequence allows for the proper pairing of each amino acid with its tRNA, which would lead to an incorrect protein sequence.

The 16S and 18S ribosomal subunits would not be bound tightly enough and early chain termination would occur.

1161 Suppose you added 20 amino acids, each carrying a $_{14}$C label to as protein synthesis system with only one mRNA present. After one minute you purify the newly synthesized protein and then cleave it through several rounds first with an aminopeptidase and then a carboxypeptidase. The majority of the radioactive label is in the carboxypeptidase digest. What does this tell you?

tRNA molecules are not bound to amino acids until the mRNA binds to the 16S ribosomal site.

The newly synthesized protein is not labeled because it is screened by the 18S rRNA.

Protein synthesis occurs relative to the 3′ to 5′ direction of the mRNA.

Protein synthesis occurs in the amino-terminal to carboxy-terminal direction.

Carboxypeptidase has a much higher k_{cat} than aminopeptidase.

1162 Even if the protein synthesis machinery in the ribosomes is flawless, could there be other pitfalls in the formation of a biologically active protein? Why?

Yes, a defect in the signal-recognition particle fails to recognize the termination signal.

Yes, a defect in the signal-recognition particle fails to recognize the signal sequence.

Yes, The splicing mechanism of the 18S rRNA is defective so proteins do not get spliced properly.

No, proper protein folding is driven by hydrophobic interactions.

No, protein tertiary structure is determined by the primary structure.

1163 What explains the remarkable toxicity of diphtheria toxin?

Initiation is inhibited causing misreading of the mRNA.

Binding to the 30S subunit inhibits the binding of aminoacyl-tRNAs.

EF2’s capacity to carry out the translocation of the growing polypeptide chain is blocked.

Causes premature chain termination by acting as an analog of aminoacyl-tRNA.

Binding to the 50S ribosomal subunit inhibits peptidyl transferase.

Short-Answer Questions

1164 What is the final destination of proteins directed to the secretory pathway?

1165 Can a protein fully translated and released from a ribosome enter the mitochondria or ER lumen?

1166 What is the function of RF1?

1167 What is an iron response element?

1168 What proteins are involved in the circularization of eukaryotic mRNA?

1169 Describe RNAi.

1170 Describe the subunits of *E. coli* ribosomes.

1171 What are the names for the tRNA binding sites on the ribosome?

1172 What is the role of the translocon in protein synthesis?

1173 What role does the amino acid itself play in the accurate placement of the charged tRNA at the codon?

1174 What is the first step in the elongation cycle?

1175 Give the chemical mechanism that is involved in the peptide bond formation as catalyzed by peptidyl transferase on the 23S sRNA.

Section: 40.2; Figure 40.7

1176 How does puromycin inhibit protein synthesis?

Chapter 41Recombinant DNA Techniques

Matching Questions

Use the following to answer questions 1–10:

Choose the correct answer from the list below. Not all of the answers will be used.

ligase
restriction enzymes
DNA microarray
expression
Sanger
footprint
vector
E. coli
cDNA
reverse trancriptase
fluorescent
polymerase chain reaction

1177 _______________ are enzymes that split DNA at specific base-pair sequences.

1178 _______________ A collection of DNA sequences representing all of the mRNA expressed in a particular cell type.

1179 DNA sequencing by controlled termination of replication is called the ______________ method.

1180 Instead of radioactivity, current DNA sequencing commonly uses _______________ base analogues.

1181 The enzyme that joins two DNA molecules is _______________.

1182 DNA sequences are amplified by the _______________.

1183 A plasmid is an example of a common _______________.

1184 _______________is a method for analyzing the expression of thousands of genes.

1185 _______________is the enzyme used to create DNA from RNA.

1186 The type of vector used for synthesis of protein is _______________.

Fill-in-the-Blank Questions

1187 The enzyme that catalyzes the formation of a phosphodiester linkage at a break in a DNA strand is _____.

1188 _____ cleave DNA at sites with inverted repeat sequences referred to as palindromic sequences.

1189 Complementary, single-strand overhangs that are produced by some restriction endonucleases are referred to as _____.

1190 The Sanger technique for sequencing DNA involves the use of _____nucleotide analogs that terminate chain elongation.

1191 The technique in which DNA fragments are separated by electrophoresis and identified using a radiolabeled probe is called _____.

1192 PCR is the abbreviation for _____, which is an in vitro technique used to make multiple copies of a DNA molecule.

1193 Bacterial plasmid DNA and bacteriophage DNA are commonly used _____ to introduce foreign DNA into a bacterium.

1194 The enzyme _____ can be used to add nucleotides to the 3′ end of DNA.

1195 Complementary DNA (cDNA) is formed by the action of reverse transcriptase on _____.

1196 DNA fragments can be visualized in polyacrylamide-gel electrophoresis by staining with _____, which binds to double-stranded DNA and fluoresces an intense orange when irradiated by UV light.

Multiple-Choice Questions

1197 The biological role of restriction enzymes in bacteria is to
repair DNA.
induce DNA crossover.
cleave foreign DNA.
All of the above.
None of the above.

1198 Which of the following DNA sequences contains a 4–8 base palindromic site? (Note: Only one strand is shown.)
CAGTCC
GCATCC
CGATTAGC
GAGAGAGA
GCATATGC

1199 What do Southern, Northern, and Western blots detect, respectively?
DNA, RNA, and protein
DNA, protein, and RNA
RNA, DNA, and protein
protein, DNA, and RNA
RNA, protein, and DNA

1200 The specificity or stringency of a PCR reaction can be controlled by altering the reaction
volume.
target sequence.
temperature and salt concentration.
All of the above.
None of the above.

1201 Reagents necessary for sequencing by chain termination include:
template DNA, deoxyribonucleoside triphosphates (dNTPs), primer, dideoxynucleotide analogs, DNA polymerase, and radioactive probe.
template DNA, dNTPs, primer, dideoxynucleotide analogs, and DNA polymerase.
template DNA, dNTPs, primer, dideoxynucleotide analogs, and RNA polymerase.
All of the above.
None of the above.

1202 Plasmids used in recombinant DNA technology typically
possess a gene for antibiotic resistance.
replicate independently of the host genome.
are circular double-stranded molecules.
All of the above.
A and B.

1203 For identification of a gene, against which strand of DNA must the probe complement?
either strand
both strands
only the coding strand
only the template strand
None of the above.

1204 Reverse transcriptase is normally found in
plants.
retrovirus.
mitochondria.
All of the above.
None of the above.

1205 The probe used to isolate a gene from a genomic library is often
the ligand that binds to the protein.
its promoter region.
a portion of the mRNA of the gene.
All of the above.
None of the above.

1206 A technique used to identify RNA after gel electrophoresis and which employs ssDNA in the detection process is
none of the below.
the Southwestern blot.
the Western blot.
the Southern blot.
the Northern blot.

1207 Which of the following would more likely yield a more optimal oligonucleotide probe, one with tryptophan and methionine or one with serine and leucine?

It is impossible to predict the optimal nucleotide sequence, which is why poly-U nucleotides are generally used.

The amino acids coded by codons, where all three positions can be the same nucleotide, generate the optimal oligonucleotide; therefore, serine and leucine.

The amino acids coded by codons, where the first two positions are the same, generate the optimal oligonucleotide; therefore, serine and leucine.

The amino acids with the least number of codons would not provide enough variation for all necessary oligonucleotides; therefore, leucine and serine.

The amino acids with the least number of codons would require the fewest number of nucleotide probes; therefore, tryptophan and methionine.

1208 In the controlled termination method of DNA sequencing, in what direction do you read the nucleotide sequence and why?

Reading the gel from the top to the bottom gives the sequence in the 5′ to 3′ direction; shorter fragments that were terminated early in polymerization move faster down the gel.

Reading the gel from the top to the bottom gives the sequence in the 5′ to 3′ direction; longer fragments that were terminated early in polymerization move faster down the gel.

Reading the gel from the bottom to the top gives the sequence in the 5′ to 3′ direction; shorter fragments that were terminated early in polymerization move faster down the gel.

Reading the gel from the bottom to the top gives the sequence in the 5′ to 3′ direction; longer fragments that were terminated later in polymerization move faster down the gel.

Reading the gel from the bottom to the top gives the sequence in the 3′ to 5′ direction; shorter fragments that were terminated early in polymerization move faster down the gel.

1209 Controlling stringency may be the most important parameter in PCR. If you want to check a gene from two distantly related species, for example, humans vs. zooplankton, what kinds of stringency measures would you take?

Start PCR annealing temperatures high to see if there are similar sequences.

Lower PCR annealing temperatures slowly if no product is formed.

Adjust salt concentrations to achieve maximum ionic strength.

Synthesize primers corresponding to the ends of the gene.

All of the above.

1210 How does the genome differ from the transcriptome?

The genome is all of the genes in the DNA of a species, whereas the transcriptome is only those that are unique to an individual.

The genome is all of the genes in the DNA of a cell, whereas the transcriptome is only those that are expression within a specific tissue.

The genome is the genes that encode for proteins in a cell, whereas the transcriptome is only those proteins that are needed for steady-state levels of a particular cell.

The transcriptome is all genes that can be transcribed by a cell, whereas the genome is the complete DNA sequence of the cell.

The genome does not contain untranslated regions of the DNA but the transcriptome include all transcribed regions of the DNA.

1211 What technique has become a valuable tool in forensics and legal medicine?
PCR
pyrosequencing
ion semiconductor sequencing
controlled termination of replication
genomic library screening

Short-Answer Questions

1212 A number of tools are critical to gene exploration. Name at least four.

1213 Design a potential DNA-restriction enzyme site. Show both strands.

1214 How can DNA fragments of various sizes be separated?

1215 What is a DNA probe?

1216 What is the basis of the Sanger method?

1217 Explain the basis of the polymerase chain reaction.

1218 Describe two ways PCR can be used in medical diagnosis.

1219 Briefly outline the steps necessary to create a recombinant DNA molecule.

1220 How is a single gene of interest identified on a plate containing many different library clones?

1221 Briefly outline how a cDNA library is made.

1222 How is gene disruption used to determine the function of a gene?

1223 What is a transcriptome?

1224 Why are monoclonal antibodies more useful than polyclonal antibodies?

1225 How does quantitative PCR differ from nonquantitative PCR?

1226 Describe the technique called a DNA microarray.