

تعداد سوالات: تستی: ۲۸ تشریحی: —

زمان آزمون: تستی: ۹۰ تشریحی: — دقیقه

آزمون نمره منفی دارد ○ ندارد ●

نام درس: زبان تخصصی

رشته تحصیلی/گد درس: علوم جانوری (۱۱۲۱۳۸)

منبع: —

مجاز است.

استفاده از: —

گد سری سؤال: یک (۱)

پیامبر اعظم (ص): روزه سیر آتش جهنم است.

*Read the text and answer questions:*

A)

A principal task of the biochemist. Is to understand how a cell regulates its myriad reaction sequences and, in so doing, controls its internal environment. In Chapter 11 we discussed the properties of individual enzymes and control mechanisms that affect their activity. Here we consider specific reaction sequences, or pathways; the relationship between each pathway and cellular architecture; the biological importance of each pathway; control mechanisms that regulate flux, or intracellular reaction rate; and experimental methods used to investigate metabolism, a simplified view of the processes we shall consider, illustrates two important principles: (1) Metabolism can be subdivided into two major categories-catabolism, those processes related to degradation of complex substances, and anabolism, those processes concerned primarily with the synthesis of complex organic molecules. (2) Both catabolic and anabolic pathways occur in three stages of complexity-stage 1, the interconversion of polymers and complex lipids with monomeric intermediates; stage 2, the interconversion of monomeric sugars, amino acids, and lipids with still simpler organic compounds; and stage 3, the ultimate degradation to, or synthesis from, inorganic compounds, including  $\text{CO}_2$ ,  $\text{H}_2\text{O}$ , and  $\text{NH}_3$ . As we proceed through this chapter, we shall add detail to this figure, introducing you thereby to each major metabolic process and identifying the functions of each.

1. Catabolism means...

- a. Degradation of complex substance      b. synthesis of complex substance  
c. Catabolism      d. b, c

2. Metabolism subdivided into ..... Stage

- a. 2      b. 4      c. 3      d. 5

3. Interconversion of monomeric sugars to simple organic compound is occurs in stage .....

- a. 1      b. 2      c. 3      d. 5

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B)

Most organisms derive both the raw materials and the energy for biosynthesis from organic fuel molecules such as glucose. The central pathways involve the oxidation of fuel molecules and the synthesis of small biomolecules from the resulting fragments; these pathways are found in all aerobic organisms. But a fundamental distinction among these organisms lies in the source of their fuel molecules. Autotrophs (from Greek, "self-feeding") synthesize glucose and all of their other organic compounds from inorganic carbon, supplied as  $\text{CO}_2$ . In contrast, heterotrophs ("feeding on others") can synthesize their organic metabolites only from other organic compounds, which they must therefore consume. A primary difference between plants and animals is that plants are autotrophs and animals are heterotrophs. With the exception of rare insect eating plants, such as the Venus flytrap, green plants obtain all of their organic carbon through photosynthetic fixation of carbon dioxide. Animals feed on plants or other animals and synthesize their metabolites by transforming the organic molecules they consume. Microorganisms exhibit a wide range of biosynthetic capabilities and sources of metabolic energy.

4. Green plants fixed..... to obtain their organic carbon?

- a.  $\text{CO}_2$       b. glucose      c. inorganic carbon      d.  $\text{H}_2\text{O}$

5. Heterototrophs synthesize organic metabolites from.....

- a. Inorganic compound      b. organic compound      c.  $\text{NH}_3$       d. lipids

C.

Recall from our discussion, that metabolism can be subdivided into three stages of complexity of the metabolites involved. The first pathway that we present in detail (in Chapter 13) is glycolysis, a stage 2 pathway for degradation of carbohydrates, in either aerobic or anaerobic cells. The major input to glycolysis is glucose, usually derived from either energy storage polysaccharides or dietary carbohydrates. This pathway leads to pyruvate, a three-carbon keto acid. Anaerobic organisms

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گد سری سؤال: یک (۱)

reduce pyruvate to a variety of products for example, ethanol and carbon dioxide. These processes are called *fermentations*. In oxidative metabolism (respiration) the major fate of pyruvate is its oxidation to a metabolically activated two-carbon fragment, acetyl-coenzyme A, or acetyl-CoA. The two carbons in the acetyl group then undergo oxidation in the citric acid cycle. In aerobic organisms the citric acid cycle, presented in Chapter 14, is the principal stage 3 pathway. This cyclic pathway accepts simple carbon compounds, derived not only from carbohydrate but also from lipid or protein, and oxidizes them to  $\text{CO}_2$ . Using the freeway analogy again, we will see that numerous on-ramps from the highways and byways of stage 1 and stage 2 metabolism lead to the citric acid cycle. In fact, all catabolic pathways converge at this point.

Oxidative reactions of the citric acid cycle generate reduced electron carriers whose reoxidation drives ATP biosynthesis, primarily through processes in the mitochondrial respiratory chain-electron transport and oxidative phosphorylation, the mitochondrial membrane uses oxidative energy to maintain a transmembrane gradient of hydrogen ion concentration, and discharge of this osmotic energy is coupled to the synthesis of ATP from ADP.

6. Glycolysis occurs in ..... cell?

- a. aerobic      b. anaerobic      c. bacteria      d. a,b

7. In oxidative metabolism pyruvate is oxidized to...

- a.  $\text{H}_2\text{O}$       b. ethanol      c.  $\text{CO}_2$       d. acetyl coA

8. In cyclic pathway simple carbon oxidize to .....

- a. Ethanol      b.  $\text{CO}_2$       c. acetyl CoA      d.  $\text{NH}_3$

9. Reoxidation of reduced electron carrier drives.....?

- a. chain electron transport activate      b. oxidative phosphorylation reaction  
c. citric acid cycle activate      d. ATP biosynthesis

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منبع: —

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گد سری سؤال: یک (۱)

10. Mitochondrial membrane uses energy to maintain of .....

- a. Respiratory chain                      b. reduced electron carrier  
c. hydrogen ion                              d. acetyl group

D.

Biosynthetic and degradative pathways are rarely, if ever, simple reversals of one another, even though they often begin and end with the same metabolites. The existence of separate pathways is important for two reasons. First, to proceed in a particular direction, a pathway must be exergonic in that direction. If a pathway is strongly exergonic, then reversal of that pathway is just as strongly endergonic under the same conditions.

Second and equally important is the need to control the flow of metabolites in relation to the bioenergetic status of a cell. When ATP levels are high, there is less need for carbon to be oxidized in the citric acid cycle. At such times the cell can store carbon as fats and carbohydrates, so fatty acid synthesis, gluconeogenesis, and related pathways come into play. When ATP levels are low, the cell must mobilize stored carbon to generate substrates for the citric acid cycle, so carbohydrate and fat breakdown must occur. Using separate pathways for the biosynthetic and degradative processes is crucial for control, so conditions that activate one pathway tend to inhibit the opposed pathway and vice versa.

11. When ATP levels are high in the cell, which pathway is occurred?

- a. gluconeogenesis                      b. fatty acid syntheses                      c. glycolysis                      d. a,b

E)

Biological oxidations, however, are far more complex processes than combustion. When wood is burned, all of the energy is released as heat; useful work cannot be performed, except through the action of a device such as a steam engine. In biological oxidations, by contrast, oxidation reactions occur without a large increase in temperature and with capture of some of the free energy as

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زمان آزمون: تستی: ۹۰ تشریحی: — دقیقه

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گد سری سؤال: یک (۱)

chemical energy. This energy capture occurs largely through the synthesis of ATP, and the hydrolysis of ATP can be coupled to many processes to provide energy for biological work. In catabolism of glucose, about 40% of the released energy is used to drive the synthesis of ATP from ADP and Pi.

Unlike the oxidation of glucose by oxygen shown in the previous equation, most biological oxidations do not involve direct transfer of electrons from a reduced substrate to oxygen. Rather, a series of coupled oxidation-reduction reactions occurs, with the electrons passed to intermediate electron carriers such as  $\text{NAD}^+$  and finally transferred to oxygen. The reaction sequence is called the electron transport chain, or respiratory chain, and oxygen is called the terminal electron acceptor. Because the potential energy stored in the organic substrate is released in small increments, it is easier to control oxidation and capture some of the energy as it is released—small energy transfers waste less energy than a single large transfer does. This situation is somewhat analogous to the generation of hydroelectric power, in which a series of small dams on a river generates more electricity than a single large dam, even though the total distance through which the water drops is the same in both cases.

12. In biological oxidation, some of energy captured as

- a. Large increase in temperature      b. chemical energy  
c. small increase in temperature      d. a, b

13. Electrons transferred from intermediate electron carrier to.....

- a. ADP      b.  $\text{O}_2$       c.  $\text{NAD}^+$       d. ATP

تعداد سوالات: تستی: ۲۸ تشریحی: —

زمان آزمون: تستی: ۹۰ تشریحی: — دقیقه

آزمون نمره منفی دارد ○ ندارد ⊗

نام درس: زبان تخصصی

رشته تحصیلی/گد درس: علوم جانوری (۱۱۲۱۳۸)

منبع: —

مجاز است.

استفاده از: —

گد سری سؤال: یک (۱)

F)

If metabolic energy comes primarily from oxidative reactions, it follows that the more highly reduced a substrate, the higher its potential for generating biological energy. We can use a calorimeter to measure the heat output (enthalpy) from oxidation of fat, carbohydrate, or protein. The combustion of fat provides more heat energy than the combustion of an equivalent amount of carbohydrate. In other words, fat has a higher caloric content than carbohydrate. For illustration, compare the oxidation of glucose with the oxidation of a typical saturated fatty acid, palmitic acid:



Converting calories (the units of nutrition) to joules (the units of biochemistry), we see that the oxidation of glucose yields 15.64 kJ/g, and the oxidation of palmitic acid yields 38.90 kJ/g. The carbons in fat are in general more highly reduced than those in carbohydrate; thus, they contain more protons and electrons to combine with oxygen on the path to  $\text{CO}_2$  than do the carbons in sugar. We can see this by counting oxygen atoms. Glucose has more oxygens per carbon than does palmitic acid; each carbon in glucose is linked to at least one oxygen atom.

We can also tell that glucose is the more highly oxidized substance, because its oxidation produces more moles of  $\text{CO}_2$  per mole of  $\text{O}_2$  consumed during oxidation, a ratio called the respiratory quotient, or RQ. The above equations show RQ for glucose to be 1.0 ( $6\text{CO}_2/6\text{O}_2$ ), whereas that for palmitic acid is 0.70 ( $16\text{CO}_2/23\text{O}_2$ ). In general, the lower the RQ for a substrate, the more oxygen consumed per carbon oxidized and the greater the potential per mole of substrate for generating ATP.

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زمان آزمون: تستی: ۹۰ تشریحی: — دقیقه  
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نام درس: زبان تخصصی  
رشته تحصیلی/گد درس: علوم جانوری (۱۱۲۱۳۸)

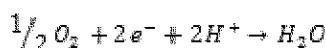
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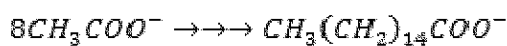
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گد سری سؤال: یک (۱)

Another way to express the degree of substrate oxidation is to say that more reducing equivalents are derived from oxidation of fat than from oxidation of carbohydrate. A reducing equivalent can be defined as 1 mole of hydrogen atoms (one proton and one electron per H atom). For example, two reducing equivalents are used in the reduction of one-half mole of oxygen to water:



Whereas the breakdown of complex organic compounds yields both energy and reducing equivalents, the biosynthesis of such compounds utilizes both. For example, we know that both carbons of acetate are used for fatty acid biosynthesis:



Acetate

palmitate

Fifteen of the 16 carbon atoms of palmitate are highly reduced, 14 at the methylene level and 1 at the methyl level. Therefore, many reducing equivalents are required to complete this biosynthesis.

14. RQ for palmitic acid is ..... than glucose

- a. Higher                      b. lower                      c. equal                      d. none

15. 15 Carbon of palmitic acid are at the....

- a. ethylene                      b. methyl                      c. Methylene                      d. ethyl

16. A reducing equivalent defined as.....?

- a. 1 mole of oxygen atoms                      b. 1 mole of hydrogen atoms  
c. Measure heat release                      d. b,c

17. How many reducing equivalents are used for reduction of oxygen to water?

- a. 1                      b. 4                      c. 2                      d. 3

تعداد سوالات: تستی: ۲۸ تشریحی: —  
زمان آزمون: تستی: ۹۰ تشریحی: — دقیقه  
آزمون نمره منفی دارد ○ ندارد ⊗

نام درس: زبان تخصصی  
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منبع: —

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استفاده از: —

گد سری سوال: یک (۱)

G)

Compartmentation can also result from weak interactions among enzymes that do not remain complexed when they are isolated. For example, conversion of glucose to pyruvate by glycolysis is catalyzed by enzymes that interact quite weakly in solution. However, there is evidence that these enzymes interact within the cytosol, forming a supramolecular structure that facilitates the multistep glycolytic pathway. The concept of intracellular interactions among readily solubilized enzymes developed as scientists began to realize that the cytosol is much more highly structured than was formerly thought. High-resolution electron micrographs of mammalian cytosol reveal the outlines of an organized structure that has been termed the cytomatrix. It is likely that such structures form as a result of the extremely high concentrations of proteins inside cells, which decrease the concentration of water and drive weakly interacting proteins to associate. It has been proposed that soluble enzymes are bound within the cell to the structural elements of the cytomatrix.

Whether highly structured or loosely associated, multienzyme complexes allow for efficient control of reaction pathways. Enzyme complexes restrict diffusion of intermediates, thereby keeping the average concentrations of intermediates low (but their local concentrations high, at enzyme catalytic sites). This complexing reduces *transient time*, the average time needed for a molecule to traverse a pathway. Thus, the flux through a pathway can change quickly in response to a change in the concentration of the first substrate for that pathway.

18. Soluble enzymes in cell bound to .....

- |  |   |
|--|---|
| a. structural elements of mitochondria       | b. structural elements of cytomatrix      |
| c. structural elements of cytoplasm membrane | d. structural elements of plasma membrane |

19. Efficient control of reaction pathway is happened by

- |                   |             |                |                   |
|-------------------|-------------|----------------|-------------------|
| a. soluble enzyme | b. reactant | c. multienzyme | d. multisubstrate |
|-------------------|-------------|----------------|-------------------|



تعداد سوالات: تستی: ۲۸ تشریحی: —

نام درس: زبان تخصصی

زمان آزمون: تستی: ۹۰ تشریحی: — دقیقه

رشته تحصیلی/گد درس: علوم جانوری (۱۱۲۱۳۸)

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گد سری سوال: یک (۱)

H)

Glycolysis is an ancient metabolic pathway that was probably used by the earliest known bacteria. some 3.5 billion years ago. Because that time was about 1 billion years before the earliest known photosynthetic organisms began contributing  $O_2$  to the earth's atmosphere) glycolysis had to function initially under completely anaerobic conditions-with no net change in the oxidation state as substrates are converted to products. However (note in Figure 13.2 that the conversion of glucose to pyruvate) which does oxidize the carbons of glucose involves the concomitant reduction of 2 moles of  $NAD^+$  to NADH. For the pathway to operate anaerobically, NADH must be reoxidized to  $NAD^+$  by transferring its electrons to an electron acceptor so that a steady state is maintained. Some microorganisms growing anaerobically can generate additional energy by transferring the electrons to inorganic substances such as sulfate ion or nitrate ion) and some microorganisms reduce organic substrates. Most straightforward is the route used by lactic acid bacteria, which simply use NADH to reduce pyruvate to lactate) via the enzyme lactate dehydrogenase. This reaction occurs when milk sours.

20. Oxidation of carbons of glucose is involved the reduction of

- a. 1 mole NADH      b. 1 mole  $NAD^+$       c. 2 moles NADH      d. 2 moles  $NAD^+$

21. NADH must reoxidized to

- a.  $O_2$       b. pyruvate      c.  $NAD^+$       d. a,c

K)

In the energy generation phase (reactions 6 through 10), the triose phosphates undergo further activation to yield two compounds containing energy-rich phosphate bonds-first 1,3-bisphosphoglycerate and then phosphoenolpyruvate. Recall from (page 75) that each of these compounds has a higher potential of hydrolysis than ATP; they can be considered as super-high-energy compounds. During the energy generation phase, each of these compounds transfers its high

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گد سری سوال: یک (۱)

energy phosphate to ADP, yielding ATP. This process is called substrate-level phosphorylation the transfer of a phosphoryl group from a super-high-energy compound to ADP, yielding ATP. Substrate-level phosphorylation is distinguished from oxidative phosphorylation, the synthesis of ATP driven by electron transport, and photophosphorylation, the utilization of photosynthetic light energy to drive ATP synthesis.

Because 2 moles of triose phosphate are metabolized per mole of glucose, the yield from the two substrate-level phosphorylations of glycolysis is 4 moles of ATP per mole of glucose. Subtracting the 2 moles of ATP invested in the first phase (reactions 1-5), we see a net gain of two ATP molecules synthesized per molecule of glucose converted to pyruvate).

22. Which of the following is super high energy molecule?

- a. 1,3- biphosphoglycerate, pyruvate      b. phosphoenolpyruvate, pyruvate  
c. 1,3- biphosphoglycerate, phosphoenolpyruvate      d. pyruvate, ATP

23. How many moles of ATP synthesized in phosphorylation of glucose ?

- a. 2      b. 38      c. 6      d. 4

L)

The enzyme requires  $Mg^{2+}$  and K, Even though the reaction involves the endergonic synthesis of ATP, the overall reaction is strongly exergonic because, as noted in Chapter 3, the spontaneous tautomerization of the product, enolpyruvate, to the highly favored keto form provides a strong thermodynamic drive in the forward direction.

The pyruvate kinase reaction is another site for metabolic regulation. In vertebrate liver the enzyme, a tetramer of  $M_r$  (molecular weight) about 250,000, is allosterically inhibited at high ATP concentrations and activated by fructose-1,6-bisphosphate. The synthesis of the liver enzyme is under dietary control; intracellular activity may increase as much as 10-fold from increased enzyme synthesis, or induction, as a result of high carbohydrate ingestion. Whatever the genetic regulatory

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آزمون نمره منفی دارد ○ ندارد ⊗

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مجاز است.

استفاده از: —

گد سری سؤال: یک (۱)

mechanisms involved, this induction may contribute to the efficacy of "carbohydrate loading:" the practice of eating a great deal of carbohydrate before an athletic event requiring great endurance, such as a marathon run. Augmented pyruvate kinase levels increase the rate at which energy can be generated by glycolysis.

Pyruvate kinase activity in the liver is also regulated by phosphorylation and dephosphorylation of the enzyme protein. The dephosphorylated form is far more active than the phosphorylated form. Phosphorylation, which is under hormonal control, diverts phosphoenolpyruvate to gluconeogenesis (see Chapter 16) when fatty acid oxidation and the citric acid cycle are already operating at rates sufficient to meet the energy needs of the cell. By contrast, virtually all of the phosphoenolpyruvate produced in muscle is converted to pyruvate.

Human genetic deficiencies of erythrocyte pyruvate kinase have been studied. Accumulation of phosphoenolpyruvate leads to excessive levels in blood of other glycolytic intermediates. Of major clinical importance is the accumulation of 2,3bisphosphoglycerate, which was introduced in Chapter 7 as an allosteric inhibitor of oxygen binding to hemoglobin. This accumulation leads to impaired oxygen uptake in the lungs and impaired transport through the bloodstream to tissues.

24. Pyruvate kinase in liver is regulated by ..... enzyme.

- a. Fatty acids      b. phosphorylation      c. dephosphorylation      d. b,c

25. Pyruvate kinase is activated by

- a. Fructose 1,6 bisphosphate      b. high ATP level  
c. low ATP level      d. phosphoenolpyruvate

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منبع: —

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استفاده از: —

گد سری سؤال: یک (۱)

M)

The recognition that glycolysis is controlled primarily by the activity of phosphofructokinase developed largely from a discovery made over a century ago by Louis Pasteur: When anaerobic yeast cultures metabolizing glucose were exposed to air, the rate of glucose utilization decreased dramatically. It became clear that this phenomenon, the Pasteur effect, involves the inhibition of glycolysis by oxygen. This effect makes biological sense, because far more energy is derived from complete oxidation of glucose than from glycolysis alone. What is the mechanism of this effect if oxygen is not an active participant in glycolysis? The needed insight came from analyses of the intracellular contents of glycolytic intermediates in aerobic and anaerobic cells. These analyses required techniques for the rapid interruption of metabolism and extraction of metabolites. One such technique is freeze-clamping, in which tissue is rapidly compressed between metal plates cooled to liquid nitrogen temperatures. The solid tissue can then be powdered and extracted for analysis.

Experiments of this type revealed that when oxygen is introduced to anaerobic cells, the levels of all the glycolytic intermediates from fructose-1,6-bisphosphate onward decrease, while all of the earlier intermediates accumulate at higher levels. This finding is consistent with the idea that the metabolic flux through phosphofructokinase is specifically decreased in the presence of O<sub>2</sub>.

26. According to Pasteur effect, glycolysis controlled by.

- a. Phosphofructokinase      b. oxygen      c. glucose      d. CO<sub>2</sub>

27. In presence of O<sub>2</sub> metabolic flux through phosphofructokinase is.....

- a. increased      b. accumulate      c. decreased      d. a,b

N)

Reaction 9, catalyzed by enolase, generates phosphoenolpyruvate (PEP), another super-high-energy compound. PEP participates in the second substrate-level phosphorylation of glycolysis. The reaction involves a simple dehydration, or α,β-elimination, and the overall free energy change is small. However, the effect is to increase enormously the free energy of hydrolysis of the phosphate bond-

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نام درس: زبان تخصصی

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گد سری سؤال: یک (۱)

from -15.6 kJ/mol for 2-phosphoglycerate to -61.9 kJ/mol for phosphoenolpyruvate. Carbon 2 of phosphoenolpyruvate is "locked into" the unfavored enol configuration and, as discussed in Chapter 3, the great thermodynamic instability of enolpyruvate is chiefly responsible for the large negative free energy of hydrolysis of phosphoenolpyruvate.

28. PEP generates by ..... enzyme.

- a. Pyruvate kinase      b. enolase      c. phosphoenolpyruvate      d. A,c

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