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Chapter 02: Basic Electrophysiology
Aehlert: ECGs Made Easy, 7th Edition

MULTIPLE CHOICE

1. In most patients, the sinoatrial (SA) and atrioventricular (AV) nodes are supplied by the _____ coronary artery.
   a. right
   b. left main
   c. circumflex
   d. left anterior descending

   ANS: A
   The SA node receives its blood supply from the SA node artery that runs lengthwise through the center of the node. The SA node artery originates from the right coronary artery in about 60% of people. The AV node is supplied by the right coronary artery in 85% to 90% of the population. In the remainder, the circumflex artery provides the blood supply.

   OBJ: Describe the location, function, and, when appropriate, the intrinsic rate of the following structures: sinoatrial node, atrioventricular bundle, and Purkinje fibers.

2. The intrinsic rate of the atrioventricular (AV) bundle is _____ beats/min.
   a. 20 to 40
   b. 40 to 60
   c. 60 to 80
   d. 80 to 100

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   ANS: B
   The AV bundle has pacemaker cells capable of firing at a rate of 40 to 60 beats/min.

   OBJ: Describe the location, function, and, when appropriate, the intrinsic rate of the following structures: sinoatrial node, atrioventricular bundle, and Purkinje fibers.

3. How do you determine whether the atrial rhythm on an ECG tracing is regular or irregular?
   a. Compare QT intervals.
   b. Compare PR intervals.
   c. Compare R to R intervals.
   d. Compare P to P intervals.

   ANS: D
   To evaluate the regularity of the atrial rhythm on a rhythm strip, the interval between two consecutive P waves is measured. The distance between succeeding P-P intervals is measured and compared. If the atrial rhythm is regular, the P-P intervals will measure the same.

   OBJ: Describe a systematic approach to the analysis and interpretation of cardiac dysrhythmias.

4. _____ is the ability of cardiac pacemaker cells to spontaneously initiate an electrical impulse without being stimulated from another source, such as a nerve.

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a. Excitability
b. Conductivity
c. Automaticity
d. Contractility

ANS: C
The ability of cardiac pacemaker cells to create an electrical impulse without being stimulated from another source is called *automaticity*. Excitability is the heart muscles' ability to respond to impulse or stimulus. Conductivity is the ability of the cardiac cells to receive and transmit an electrical impulse. Contractility is the contraction of the heart muscle which produces the heartbeat.

OBJ: Describe the primary characteristics of cardiac cells.

5. In the heart's conduction system, the _____ receive(s) an electrical impulse from the bundle of His and relay(s) it to the Purkinje fibers in the ventricular myocardium.
a. atrioventricular (AV) node
b. atria
c. sinoatrial (SA) node
d. right and left bundle branches

ANS: D
The right and left bundle branches divide into smaller and smaller branches and then into a special network of fibers called the *Purkinje fibers*. These fibers spread from the interventricular septum into the papillary muscles. They continue downward to the apex of the heart, composing an elaborate web that penetrates about one third of the way into the ventricular muscle mass. The fibers then become continuous with the muscle cells of the right and left ventricles.

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OBJ: Describe the location, function, and, when appropriate, the intrinsic rate of the following structures: sinoatrial node, atrioventricular bundle, and Purkinje fibers.

6. In the heart's conduction system, the _____ receive(s) an electrical impulse from the right and left bundle branches and relay(s) it to the ventricular myocardium.
a. AV node
b. SA node
c. Purkinje fibers
d. atrial pacemaker cells

ANS: C
The right bundle branch innervates the right ventricle. The left bundle branch spreads the electrical impulse to the interventricular septum and left ventricle.

OBJ: Describe the location, function, and, when appropriate, the intrinsic rate of the following structures: sinoatrial node, atrioventricular bundle, and Purkinje fibers.

7. What does the QRS complex represent?
a. Atrial depolarization
b. Ventricular contraction
c. Ventricular repolarization
d. Ventricular depolarization

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ANS: D
When the ventricles are stimulated, a QRS complex is recorded on the ECG. Thus, the QRS complex represents ventricular depolarization. Atrial depolarization is initiated by the SA node on the wall of the right atrium, which is symbolized by the P wave that shows on the EKG. Ventricular contraction happens when the cardiac muscles contract within the ventricles, although this contraction is represented by the QRS on the EKG, the most specific answer related to electricity in the heart (and not heart muscle) is ventricular depolarization. Ventricle repolarization represents the relaxation and journey back to isoelectric baseline, which can include ST segment and T wave.

OBJ: Define and describe the significance of each of the following as they relate to cardiac electrical activity: P wave, QRS complex, T wave, U wave, PR segment, TP segment, ST segment, PR interval, QRS duration, and QT interval.

8. The normal pacemaker of the heart is the _____ node, which is found in the _____ atrium, and has an intrinsic firing rate of _____ beats/min.
   a. sinoatrial; left; 40 to 60
   b. sinoatrial; right; 60 to 100
   c. atrioventricular; left; 20 to 40
   d. atrioventricular; right; 100 to 180

ANS: B
The sinoatrial (SA) node is normally the primary pacemaker of the heart because it has the fastest firing rate of all of the heart's normal pacemaker sites (60 to 100 beats/min). The SA node is located in the upper posterior part of the right atrium where the superior vena cava and the right atrium meet.

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OBJ: Describe the location, function, and, when appropriate, the intrinsic rate of the following structures: sinoatrial node, atrioventricular bundle, and Purkinje fibers.

9. On an ECG, what is the first negative deflection seen after the P wave?
   a. Q wave
   b. R wave
   c. S wave
   d. T wave

ANS: A
A QRS complex normally follows each P wave. The QRS complex begins as a downward deflection—the Q wave. A Q wave is always a negative waveform.

OBJ: Define and describe the significance of each of the following as they relate to cardiac electrical activity: P wave, QRS complex, T wave, U wave, PR segment, TP segment, ST segment, PR interval, QRS duration, and QT interval.

10. Lead II records the difference in electrical potential between the _____ leg and _____ arm.
    a. left; left
    b. left; right
    c. right; left
    d. right; right

ANS: B

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Lead II records the difference in electrical potential between the left leg and right arm electrodes. The positive electrode is placed on the left leg and the negative electrode is placed on the right arm. Lead II views the inferior surface of the left ventricle.

OBJ: Describe correct anatomic placement of the standard limb leads, the augmented leads, and the chest leads.

11. Leads II, III, and aVF view the _____ surface of the left ventricle.
    a. anterior
    b. inferior
    c. septal
    d. lateral

    ANS: B
    Leads II, III, and aVF view the inferior surface of the left ventricle.

    OBJ: Relate the cardiac surfaces or areas represented by the ECG leads.

12. The period during the cardiac cycle when cells cannot respond to a stimulus, no matter how strong, is called the _____ period.
    a. depolarized
    b. supranormal
    c. relative refractory
    d. absolute refractory

    ANS: D
    During the absolute refractory period, the cell will not respond to further stimulation. This means that the myocardial working cells cannot contract and the cells of the electrical conduction system cannot conduct an electrical impulse—no matter how strong the stimulus. As a result, tetanic (sustained) contractions cannot be provoked in cardiac muscle. On the ECG, the absolute refractory period corresponds with the onset of the QRS complex to the peak of the T wave. Depolarized is the electrical activity coming back to a baseline level, to the isoelectric line. Supranormal is the electrical potential of the cell. Relative refractory is when the cell requires a stronger than normal stimulus to produce a contraction.

    OBJ: Define the absolute, effective, relative refractory, and supranormal periods and their location in the cardiac cycle.

13. Leads I, aVL, V_5, and V_6 view the _____ surface of the left ventricle.
    a. anterior
    b. septal
    c. inferior
    d. lateral

    ANS: D
    Leads I, aVL, V_5, and V_6 view the lateral surface of the left ventricle.

    OBJ: Relate the cardiac surfaces or areas represented by the ECG leads.

14. The absolute refractory period begins with the onset of the _____ and terminates _____.
    a. P wave; with the end of the QRS complex

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b. QRS complex; at approximately the apex of the T wave
c. QRS complex; with the end of the T wave
d. P wave; with the beginning of the QRS complex

ANS: B
On the ECG, the absolute refractory period corresponds with the onset of the QRS complex to the peak of the T wave.

OBJ: Define the absolute, effective, relative refractory, and supranormal periods and their location in the cardiac cycle.

15. The QT interval is measured from the beginning of the _____.
a. QRS complex to the end of the T wave
b. P wave to the end of the QRS complex
c. QRS complex to the beginning of the T wave
d. P wave to the beginning of the QRS complex

ANS: A
The QT interval is measured from the beginning of the QRS complex to the end of the T wave. In the absence of a Q wave, the QT interval is measured from the beginning of the R wave to the end of the T wave. The term *QT interval* is used regardless of whether the QRS complex begins with a Q or R wave.

OBJ: Define and describe the significance of each of the following as they relate to cardiac electrical activity: P wave, QRS complex, T wave, U wave, PR segment, TP segment, ST segment, PR interval, QRS duration, and QT interval.

16. In an adult, the normal duration of the QRS complex is _____.
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a. 0.12 to 0.20 second
b. 0.10 second or less
c. 0.04 to 0.14 second
d. 0.20 second or less

ANS: B
The normal duration of the QRS complex is 0.10 second or less.

OBJ: Define and describe the significance of each of the following as they relate to cardiac electrical activity: P wave, QRS complex, T wave, U wave, PR segment, TP segment, ST segment, PR interval, QRS duration, and QT interval.

17. The intrinsic rate of the Purkinje fibers is _____ beats/min.
a. 20 to 40
b. 40 to 60
c. 60 to 100
d. 100 to 180

ANS: A
The Purkinje fibers have pacemaker cells capable of firing at a rate of 20 to 40 beats/min.

OBJ: Describe the location, function, and, when appropriate, the intrinsic rate of the following structures: sinoatrial node, atrioventricular bundle, and Purkinje fibers.

18. The intrinsic rate of the SA node is _____ beats/min.

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a. 40 to 60
b. 60 to 100
c. 100 to 180
d. 200 to 260

ANS: B
The intrinsic rate of the SA node is 60 to 100 beats/min.

OBJ: Describe the location, function, and, when appropriate, the intrinsic rate of the following structures: sinoatrial node, atrioventricular bundle, and Purkinje fibers.

19. On the ECG, the T wave represents _____.
a. atrial contraction
b. atrial repolarization
c. ventricular contraction
d. ventricular repolarization

ANS: D
Ventricular repolarization is represented on the ECG by the T wave.

OBJ: Define and describe the significance of each of the following as they relate to cardiac electrical activity: P wave, QRS complex, T wave, U wave, PR segment, TP segment, ST segment, PR interval, QRS duration, and QT interval.

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20. On the ECG, the time necessary for the spread of an electrical impulse through the AV node, bundle of His, right and left bundle branches, and the Purkinje fibers is reflected by the _____.
a. TP segment
b. PR segment
c. QT interval
d. QRS duration

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ANS: B
The PR segment is the horizontal line between the end of the P wave and the beginning of the QRS complex. It is part of the PR interval and represents activation of the AV node, the bundle of His, the bundle branches, and the Purkinje fibers.

OBJ: Define and describe the significance of each of the following as they relate to cardiac electrical activity: P wave, QRS complex, T wave, U wave, PR segment, TP segment, ST segment, PR interval, QRS duration, and QT interval.

21. The portion of the ECG tracing between the QRS complex and the T wave is called the ____.
a. PR segment
b. ST segment
c. TP segment
d. QT interval

ANS: B
The portion of the ECG tracing between the QRS complex and the T wave is the ST segment.

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OBJ: Define and describe the significance of each of the following as they relate to cardiac electrical activity: P wave, QRS complex, T wave, U wave, PR segment, TP segment, ST segment, PR interval, QRS duration, and QT interval.

22. Which of the following is the first positive deflection seen on the ECG after the P wave?
    a. Q wave
    b. R wave
    c. S wave
    d. T wave

    ANS: B
    If the QRS complex consists entirely of a positive waveform, it is called an *R wave*. If the complex consists entirely of a negative waveform, it is called a *QS wave*.

    OBJ: Define and describe the significance of each of the following as they relate to cardiac electrical activity: P wave, QRS complex, T wave, U wave, PR segment, TP segment, ST segment, PR interval, QRS duration, and QT interval.

23. _____ cells are working cells of the heart that contain contractile filaments and form the muscular layer of the atrial walls and the thicker muscular layer of the ventricular walls.
    a. Pacemaker
    b. Myocardial
    c. Specialized
    d. Electrical

    ANS: B
    Myocardial cells (working or mechanical cells) contain contractile filaments. When these cells are electrically stimulated, the contractile filaments slide together, and the myocardial cell contracts.

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    OBJ: Describe the two basic types of cardiac cells in the heart, where they are found, and their function.

24. When the cardiac muscle cell is stimulated, the cell is said to _____.
    a. polarize
    b. recover
    c. depolarize
    d. repolarize

    ANS: C
    The movement of charged particles across a cell membrane causing the inside of the cell to become positive is called *depolarization*. Depolarization must take place before the heart can mechanically contract and pump blood.

    OBJ: Define the terms membrane potential, threshold potential, action potential, polarization, depolarization, and repolarization.

25. On the ECG, the P wave represents atrial _____ and the QRS complex represents ventricular _____.
    a. depolarization; depolarization
    b. repolarization; repolarization
    c. repolarization; depolarization

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d. depolarization; repolarization

ANS: A
On the ECG, the P wave represents atrial depolarization and the QRS complex represents ventricular depolarization.

OBJ: Define and describe the significance of each of the following as they relate to cardiac electrical activity: P wave, QRS complex, T wave, U wave, PR segment, TP segment, ST segment, PR interval, QRS duration, and QT interval.

26. _____ is a term used to describe the period of recovery that cells need after being discharged before they are able to respond to a stimulus.
a. Irritability
b. Conductivity
c. Polarization
d. Refractoriness

ANS: D
Refractoriness is a term used to describe the period of recovery that cells need after being discharged before they are able to respond to a stimulus. In the heart, the refractory period is longer than the contraction itself.

OBJ: Define the absolute, effective, relative refractory, and supranormal periods and their location in the cardiac cycle.

27. Tall, peaked T waves observed on the ECG are most commonly seen in patients with _____.
a. hypokalemia
b. hyperkalemia
c. hyponatremia
d. hypernatremia

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ANS: B
Tall, pointed (peaked) T waves are commonly seen in hyperkalemia.

OBJ: Define and describe the significance of each of the following as they relate to cardiac electrical activity: P wave, QRS complex, T wave, U wave, PR segment, TP segment, ST segment, PR interval, QRS duration, and QT interval.

28. Which part of the conduction system receives an impulse from the bundle of His and relays it to the Purkinje fibers?
a. SA node
b. AV node
c. Right and left atria
d. Right and left bundle branches

ANS: D
The right and left bundle branches receive an impulse from the bundle of His and relay it to the Purkinje fibers. The conduction system begins with the SA node, travels to the AV node, bundle of His, bundle branches then Purkinje fibers.

OBJ: Describe the normal sequence of electrical conduction through the heart.

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29. Which of the following correctly reflects examples of ectopic (latent) pacemakers?
    a. The SA node and AV junction
    b. The AV junction and Purkinje fibers
    c. The SA node and right bundle branch
    d. The AV junction and left bundle branch

    ANS: B
    Ectopic pacemakers have to do with the section of electricity between the atria and ventricles, which is between the AV junction and ventricles. The SA node and AV junction are both within the atria. The SA node and right bundle branch is too large of a section, but also too specific when talking about just right bundle branch, it would need to be both right and left. AV junction and left bundle branch is too large and the ectopic pacemaker does not extend down to the left bundle branch.

    OBJ: Describe the location, function, and, when appropriate, the intrinsic rate of the following structures: sinoatrial node, atrioventricular bundle, and Purkinje fibers.

30. The PR interval is considered prolonged if it is more than _____ seconds in duration.
    a. 0.06
    b. 0.12
    c. 0.18
    d. 0.20

    ANS: D
    A PR interval is considered *short* if it is less than 0.12 second and *long* if it is more than 0.20 second.

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    OBJ: Define and describe the significance of each of the following as they relate to cardiac electrical activity: P wave, QRS complex, T wave, U wave, PR segment, TP segment, ST segment, PR interval, QRS duration, and QT interval.

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COMPLETION

1. _____ is the ability of cardiac cells to spontaneously initiate an electrical impulse without being stimulated from another source.

   ANS: Automaticity

   OBJ: Describe the primary characteristics of cardiac cells.

2. An ECG lead that has a positive and negative electrode is called a(n) _____ lead.

   ANS: bipolar

   OBJ: Describe correct anatomic placement of the standard limb leads, the augmented leads, and the chest leads.

3. A line between waveforms is called a(n) _____.

   ANS: segment

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OBJ: Define and describe the significance of each of the following as they relate to cardiac electrical activity: P wave, QRS complex, T wave, U wave, PR segment, TP segment, ST segment, PR interval, QRS duration, and QT interval.

4. The cells of the heart that contain contractile filaments are called _____ cells.

ANS: myocardial

OBJ: Describe the two basic types of cardiac cells in the heart, where they are found, and their function.

5. Name the first positive deflection seen after the P wave on the ECG. _____

ANS: R wave

OBJ: Define and describe the significance of each of the following as they relate to cardiac electrical activity: P wave, QRS complex, T wave, U wave, PR segment, TP segment, ST segment, PR interval, QRS duration, and QT interval.

MATCHING

Match each item to the correct description below.

a. Ventricular
b. Atrial
c. Repolarization
d. Augmented
e. Reciprocal changes
f. Indicative changes
g. Reentry
h. Ectopic
i. Positive
j. Amplitude
k. Voltmeter
l. Electrolyte

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1. ECG changes observed in leads opposite the affected area of the heart; also called *mirror image changes.*
2. The QRS complex represents _____ depolarization.
3. Each electrode placed in a "V" position is a(n) _____ electrode.
4. Element or compound that breaks into charged particles (ions) when melted or dissolved in water or another solvent.
5. An ECG machine is a sophisticated _____.
6. ECG changes observed in leads that look directly at the affected area of the heart.
7. The T wave represents ventricular _____.
8. The *a* in aVR, aVL, and aVF.
9. Impulse(s) originating from a source other than the SA node.
10. The spread of an impulse through tissue already stimulated by that same impulse.
11. Height (voltage) of a waveform on the ECG.

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12. The P wave represents _____ depolarization.

1. ANS: E
2. ANS: A
3. ANS: I
4. ANS: L
5. ANS: K
6. ANS: F
7. ANS: C
8. ANS: D
9. ANS: H
10. ANS: G
11. ANS: J
12. ANS: B

TRUE/FALSE

1. A conduction problem above the level of the bundle branches will largely affect the P wave and PR interval.

   ANS: T
   Delays in impulse conduction through the atria, AV node, or AV bundle can result in prolongation (greater than 0.20 second) of the PRI. Conditions causing such disturbances may be inflammatory, circulatory, nervous, endocrine, or pharmacologic in origin. The P wave associated with a prolonged PRI may be normal or abnormal.

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   OBJ: Define and describe the significance of each of the following as they relate to cardiac electrical activity: P wave, QRS complex, T wave, U wave, PR segment, TP segment, ST segment, PR interval, QRS duration, and QT interval.

2. The period of time during the cardiac cycle when cells cannot respond to a stimulus, no matter how strong, is the relative refractory period.

   ANS: F
   During the absolute refractory period, the cell will not respond to further stimulation. This means that the myocardial working cells cannot contract and the cells of the electrical conduction system cannot conduct an electrical impulse, no matter how strong the stimulus.

   OBJ: Define the absolute, effective, relative refractory, and supranormal periods and their location in the cardiac cycle.

3. Depolarization is the same as contraction.

   ANS: F
   Depolarization is *not* the same as contraction. Depolarization (an electrical event) is expected to result in contraction (a mechanical event). It is possible to see organized electrical activity on the cardiac monitor, yet evaluation of the patient reveals no palpable pulse. This clinical situation is called pulseless electrical activity (PEA).

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OBJ: Define the terms membrane potential, threshold potential, action potential, polarization, depolarization, and repolarization.

4. In most ECG leads, a normal Q wave is less than 0.04 second in duration and less than one third the amplitude of the R wave in that lead.

   ANS: T
   With the exception of leads III and aVR, a normal Q wave in the limb leads is less than 0.04 second (one small box) in duration and less than one third the height of the R wave in that lead. An abnormal (pathologic) Q wave is more than 0.04 second in duration or more than one third the height of the following R wave in that lead. Myocardial infarction is one possible cause of abnormal Q waves.

   OBJ: Define and describe the significance of each of the following as they relate to cardiac electrical activity: P wave, QRS complex, T wave, U wave, PR segment, TP segment, ST segment, PR interval, QRS duration, and QT interval.

5. The point where the QRS complex and the ST segment meet is called the *ST junction* or *J-point*.

   ANS: T
   There are different points within the EKG that have specific identifying parts. The J-point is located where the QRS and ST segment meet.

   OBJ: Define and describe the significance of each of the following as they relate to cardiac electrical activity: P wave, QRS complex, T wave, U wave, PR segment, TP segment, ST segment, PR interval, QRS duration, and QT interval.

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6. If the wave of depolarization (electrical impulse) moves toward the positive electrode, the waveform recorded on ECG graph paper will be upright (positive deflection).

   ANS: T
   Waveforms are named alphabetically, beginning with P, QRS, T, and occasionally U. When electrical activity is not detected, a straight line is recorded. This line is called the **baseline** or **isoelectric line**. If the wave of depolarization (i.e., the electrical impulse) moves toward the positive electrode, the waveform recorded on ECG graph paper will be upright (i.e., a positive deflection). If the wave of depolarization moves away from the positive electrode, the waveform recorded will be inverted (i.e., a downward or negative deflection).

   OBJ: Define the terms membrane potential, threshold potential, action potential, polarization, depolarization, and repolarization.

7. In the limb leads, the ST segment is normally isoelectric, or less than 1 mm above or below the isoelectric line.

   ANS: T
   The normal ST segment begins at the isoelectric line, extends from the end of the S wave, and curves gradually upward to the beginning of the T wave. In the limb leads, the normal ST segment is isoelectric (flat) but may normally be slightly elevated or depressed (usually by less than 1 mm).

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OBJ: Define and describe the significance of each of the following as they relate to cardiac electrical activity: P wave, QRS complex, T wave, U wave, PR segment, TP segment, ST segment, PR interval, QRS duration, and QT interval.

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