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United States Medical Licensing Examination Step 1

QUESTION 834
A 68-year-old postmenopausal female with a history of osteoprosis and essential hypertension is placed on the thiazide diuretic chlorothiazide, which has a beneficial action toward both conditions. Which letter in below figure depicts the tubular location of epithelial cells containing a / cotransport

Na^+

protein inhibited by thiazide diuretics?

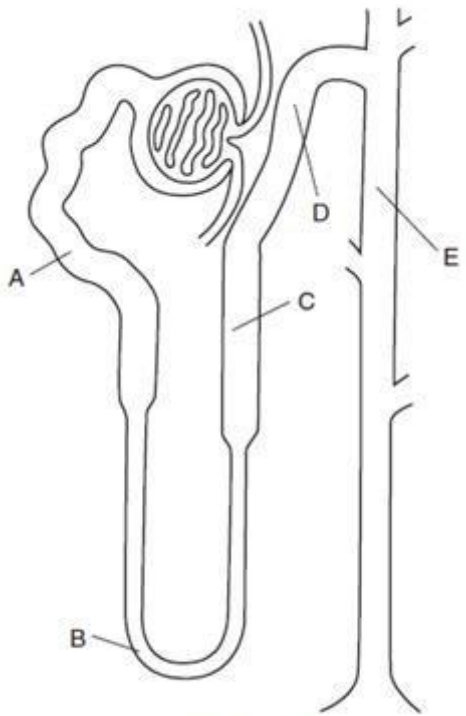

FIG. 2-25

A. A
B. B
C. C
D. D
E. E

Answer: D
Section: Physiology
Explanation

Explanation:
The epithelial cells of the early portion of the distal tubule contain a / cotransporter that is

Na^+

inhibited by thiazide diuretics which promote a diuresis and a natriuresis, and which secondarily, promote increased renal reabsorption of filtered calcium. Choices A and B denote the proximal and thin loop of Henle segments, respectively; which do not have the properties of the early distal tubular segment. Likewise, choices C and E denote the thick ascending loop of Henle and the collecting duct, which also do not have the same properties as the early distal tubular segment.

QUESTION 835
Worldwide, one of the most common parasitic infections is schistosomiasis. Assume a complete blood cell count is performed in a patient with this condition. Which of the following blood cells would most likely be present in elevated amounts?

A. eosinophils
B. erythrocytes
C. monocytes
D. neutrophils
E. platelets

Answer: A
Section: Physiology
Explanation

Explanation:
Eosinophils normally constitute about 2% of all blood leukocytes. These cells are phagocytic and exhibit chemotaxis. Their primary role is in fighting parasitic infection. In schistosomiasis the eosinophil attaches to the immature parasite and, by releasing various cytotoxic compounds, is able to kill the parasite. Erythrocytes (choice B) are the most numerous blood cells. They are not leukocytes, but function in blood gas transport. Erythrocyte number would not be increased in schistosomiasis. Monocytes (choice C) are leukocytes found in the blood. They are immature cells which migrate to the tissues, where they mature into macrophages. These cells are very active in phagocytosis and play a prominent role in the inflammatory response. They are not, however, particularly important in parasitic infections. Neutrophils (choice D) are another type of leukocyte that, though essential to combat bacterial infections, are not particularly sensitive to parasitic challenge. Platelets (choice E) are not leukocytes. The platelet is a cell fragment that functions in hemostasis.

QUESTION 836
After total thyroidectomy as a result of a car accident, a 47-year-old woman is positive for Trousseau sign. It is manifested as carpopedal spasm occurring after an inflated blood pressure cuff is held above systolic blood pressure for a few minutes. Which of the following would best describe her postoperative condition when compared to preoperative?

A. decreased deep tendon reflexes
B. higher serum calcitonin levels
C. lower serum calcium levels
D. lower serum phosphate levels

E. shorter Q-T interval of her ECG

Answer: C
Section: Physiology
Explanation

Explanation:
A positive Trousseau sign indicates increased neuromuscular irritability, which is caused by low serum calcium levels. Apositive Trousseau sign or a positive Chvostek sign (spasms of facial muscles) can often diagnose hypocalcemia before other gross manifestations develop. Serum calcium is regulated by parathyroid hormone produced by the parathyroid glands. During the woman's accident, the glands, or their vasculature, were most likely damaged enough so that they could not be saved during the total thyroidectomy. If total thyroidectomy occurs as a consequence of thyroid cancer, damage to all four parathyroid glands would be considered an operative mishap. A consequence of hypocalcemia is hyperreflexia and not hyporeflexia (choice A). Calcitonin is secreted by parafollicular or "C" cells in the thyroid gland. Since no other cells of the body make this hormone, serum calcitonin levels do not rise (choice B), but instead go to zero postoperative. Low serum phosphate levels (choice D) typically signify secondary hyperparathyroidism or low dietary phosphate intake. In the current case, high or unchanged serum phosphate would be expected. The Q-T interval of the ECG represents the time for both ventricular depolarization and repolarization to occur. It therefore roughly estimates the duration of an average ventricular action potential. Hypocalcemia leads to a long Q-T interval, not a short Q-T as in choice E. In severe cases, this can lead to arrhythmias, hypotension, and heart failure.

QUESTION 837
A 60-year-old woman is admitted to the hospital with a fever and severe diarrhea for the last 24 hours. Cultures of blood, cerebrospinal fluid, urine, and stool are all negative for pathogens. The profile of gut hormones reveals elevated levels of VIP. An analogue of which of the following would most likely lower her VIP levels?

A. erythromycin
B. histamine
C. motilin
D. somatostatin
E. trypsin

Answer: D
Section: Physiology
Explanation

Explanation:
VIP is a neurotransmitter in the brain and in the parasympathetic nerves of the digestive tract. It also acts as a hormone. VIP has a secretin-like effect on the pancreas. It increases the volume of water and bicarbonate output and affects GI blood flow and motility. All this contributes to severe secretory diarrhea in the case of VIP overproduction. Somatostatin is the best choice because it has a broad range of inhibitory effects, inhibiting GI secretions, slowing GI motility, and reducing splanchnic blood flow. An analogue of somatostatin, called octreotide, was found useful for treatment of syndromes related with VIP overproduction. Octreotide has a longer half-life than physiologic somatostatin. Erythromycin (choice A) is known to have antibiotic

features. This is not the best choice, since no pathogens were found. Histamine (choice B) is a physiologic stimulant of gastric hydrochloric acid secretion, potentiating the effects of acetylcholine and gastrin. Motilin (choice C) stimulates gastric motility, which is contraindicated for diarrhea. Trypsin (choice E) is a protease released by pancreatic cells, breaking peptide bonds as well as converting many other proteolytic enzymes to their active form. All of the negative choices will not affect, and in fact may even worsen the VIPrelated symptoms.

QUESTION 838
Malignant hyperthermia is a relatively rare genetic disorder, found in approximately one in 10,000 individuals. Affected individuals can exhibit a life-threatening response to inhalation anesthetics, which entails elevated core body temperature, skeletal muscle rigidity, and elevated blood carbon dioxide levels. Based on these observed symptoms, which of the following is most likely present in malignant hyperthermia?

A. decreased release of acetylcholine at the neuromuscular junction
B. increased activation of myosin light chain kinase
C. increased activation of skeletal muscle potassium channels
D. increased activation of the calcium release channels of the sarcoplasmic reticulum
E. inhibition of skeletal muscle sodium channels

Answer: D
Section: Physiology
Explanation

Explanation:
Malignant hyperthermia is caused by a mutation to the calcium release channel of the skeletal muscle sarcoplasmic reticulum (the socalled ryanodine receptor). Increased calcium release into the myoplasm causes strong, sustained skeletal muscle contraction. This causes excessive ATP hydrolysis, increased metabolic activity to replenish ATP levels, heat generation, and carbon dioxide production. Decreased acetylcholine release would decrease muscle contraction (choice A). Myosin light chain kinase is involved in contractile activation in smooth muscle (choice B). Activation of K channels would hyperpolarize muscle fibers and tend to decrease susceptibility to contractile activation (choice C). Inhibition of sodium channels would diminish the ability of skeletal muscle to generate action potentials and thus decrease excitability (choice E).

QUESTION 839
Below figure shows the conversions of cholesterol into the hormones C and D within follicular cells of the ovary (large arrows) and the regulation of these processes (small arrows) by pituitary hormones (A, B, E), when binding to their receptors on the cell surfaces (dark squares). Which of the letters in the figure best represents the hormone the concentration of which in serum changes in the following way?

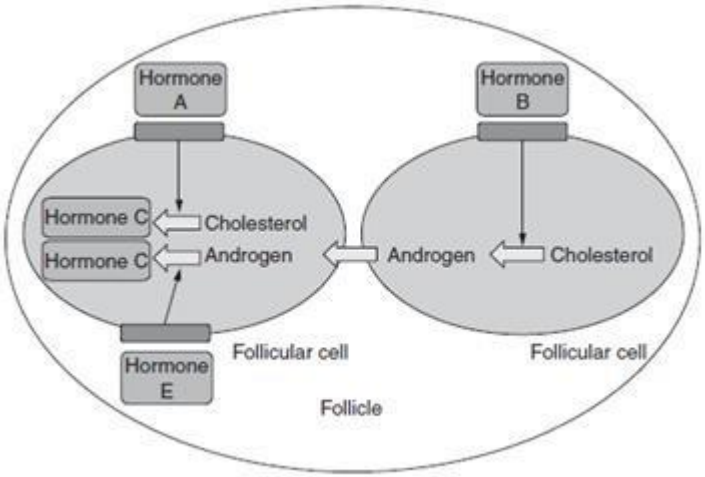

FIG. 2-26

A. A
B. B
C. C
D. D
E. E

Answer: D
Section: Physiology
Explanation

Explanation:
It represents the estrogen estradiol, which is produced from androgen by granulosa cells of the ovaries and released into the capillaries. A woman's estradiol serum concentration roughly reflects the activities of her ovaries. Estradiol levels rise during the follicular phase of the menstrual cycle (days 0 13). They reach peak levels shortly before ovulation on day 1314, and drop back during the luteal phase (days 1428). They reach menstrual/follicular levels at the end of the luteal phase unless there is a pregnancy. After menopause, the ovaries atrophy and estradiol levels become very low. During reproductive cycles, androgens are the main substrate for estrogen synthesis in the granulosa cells. The androgen-estrogen conversion is under the influence of FSH (choice E). FSH concentrations are high after menopause compared to their premenopausal concentrations. The source of androgens is theca cells. They produce it from cholesterol under the influence of LH (choice B). LH concentrations, like FSH, are high postmenopausal. Both, FSH and LH levels are used as a diagnostic tool to determine menopause. Granulosa cells also produce progesterone (choice C) from cholesterol. Progesterone serum levels are low during follicular phase of the menstrual cycle and high during the luteal phase of the menstrual cycle. The transition of cholesterol to progesterone is under the influence of LH (choice A).

QUESTION 840

During a marathon attempt a runner collapses and is admitted with severe acute dehydration. Which of the following is most likely to occur in this patient?

A. decreased baroreceptor firing rate
B. decreased plasma osmolarity
C. high renal water excretion
D. low plasma ADH levels
E. low water permeability of collecting duct tubular cells

Answer: A
Section: Physiology
Explanation

Explanation:
Acute dehydration results in decreased plasma volume, cardiac output, and arterial pressure, which leads to a lower firing rate of the baroreceptors. Plasma osmolarity increases (choice B) because more water than salt is lost in sweat. The increase in plasma osmolarity leads to increased ADH secretion (choice D). High plasma ADH levels cause increased water permeability of collecting duct cells (choice E). Therefore, more water is reabsorbed by the kidneys and renal water excretion is low (choice C).

QUESTION 841
When glucose is chronically elevated in poorly controlled diabetes mellitus, nonenzymatic glycosylation of various proteins occurs. The change of which of the following substances is most commonly monitored as indicator for the efficiency of blood glucose control?

A. hemoglobin A1c (HbA1c)
B. lipoprotein A.
C. modified albumin
D. myoinositol
E. sorbitol

Answer: A
Section: Physiology
Explanation

Explanation:
The hallmark of poorly controlled diabetes mellitus is elevated blood glucose, which causes unphysiological glycosylation of proteins. An important long-term measure of blood glucose control in patients with diabetes mellitus is to monitor the modification of hemoglobin A to form glycated hemoglobins. HbA1c is the major subfraction, and determination of HbA1c is usually achieved by ion- exchange or gel electrophoresis. The level of glycated hemoglobins in the blood is directly related to the average blood glucose levels over the life span of the hemoglobin in the circulation. Since the half- life of red blood cells is about 120 days, a single determination of glycated hemoglobin reflects the average blood glucose level during the preceding 812

weeks. Lipoprotein A. (choice B) is a lipoprotein particle implicated in atherosclerosis and thrombosis. Albumin (choice C) is the most abundant plasma protein, but is not significantly affected by glycosylation. Myoinositol (choice D) is a signaling molecule the decrease in response of which to elevated sorbitol has been suggested as a complication of diabetes. Sorbitol (choice E) is another sugar derivative, unrelated to HbA1c that is believed important in causing other diabetic complications such as cataracts and peripheral neuropathy.

QUESTION 842
Apatient on intensive care is ventilated with a frequency of 12 per minute and a tidal volume of 0.6 L. His arterial pH increases to >7.5. What is the most reasonable action to correct this respiratory alkalosis?

A. decrease dead space
B. decrease tidal volume
C. increase minute ventilation
D. increase oxygen fraction
E. use positive end-expiratory pressure (PEEP)

Answer: B
Section: Physiology
Explanation

Explanation:
Respiratory alkalosis is due to hyperventilation, which lowers . Decreasing tidal volume will

CO_2

reduce alveolar ventilation and correct the respiratory alkalosis. Assuming a dead space of 150 mL, alveolar ventilation in this patient is 450 mL × 12/ min = 5400 mL/min. If the tidal volume were decreased from 600 to 300 mL and the frequency increased from 12 to 24 per minute, then the alveolar ventilation would decrease to 150 × 24/min = 3600 mL/min even though the minute ventilation (12 × 600 mL/min = 24 × 300 mL/min) remains unchanged. The fraction of (choice D) in the respiratory

O_2

air does not affect respiratory volumes or frequencies in a mechanically ventilated patient. Increasing minute ventilation (choice C) or decreasing dead space (choice A) would increase alveolar ventilation and worsen respiratory alkalosis. PEEP (choice E) is positive pressure applied during the expiratory phase to prevent the collapse of alveoli and to increase FRC of the lungs. It is used primarily to improve arterial oxygenation in severely hypoxic patients.

QUESTION 843
Below figure illustrates the extracellular and intracellular volumeosmolarity status of a patient (broken lines) and that of a normal subject (solid lines) for comparison. This patient most likely suffers from which of the following conditions?

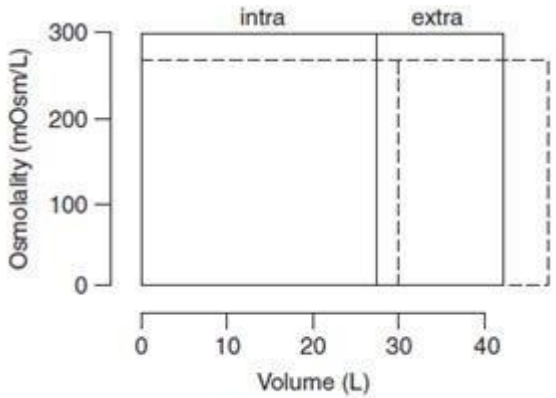

FIG. 2-19

A. adrenal insufficiency
B. chronic vomiting
C. iatrogenic fluid overload with 0.9% NaCl
D. iatrogenic fluid overload with hypertonic solution
E. syndrome of inappropriate hypersecretion of antidiuretic hormone (SIADH)

Answer: E
Section: Physiology
Explanation

Explanation:
This patient has increased extra- and intracellular volumes and a decreased osmolarity. SIADH results in inappropriately low water permeability of the renal collecting duct tubular cells and inappropriate water retention. As a result, patients with SIADH often present with hypotonic overhydration. Adrenal insufficiency (lack of aldosterone) (choice A) and chronic vomiting (choice B) lead to dehydration. Fluid overload with isotonic NaCl (choice C) results in volume expansion without change in osmolarity. Fluid overload with hypertonic solution (choice D) results in volume expansion with increased osmolarity.

QUESTION 844
Gamma-aminobutyric acid (GABA) is an amino acid that functions as a neurotransmitter in the central nervous system. GABA typically causes increased chloride conductance and functions as an inhibitory transmitter. Assume that the equilibrium potential for chloride (ECl-) in a particular cell is -80 mV and that application of GABA inhibits the cell without any change in resting membrane potential. What is the resting membrane potential of the cell?

A. +80 mV
B. 0 mV

C. -70 mV
D. -80 mV
E. -90 mV

Answer: D
Section: Physiology
Explanation

Explanation:
This problem addresses two issues: (1) the mechanism of action of inhibitory neurotransmitters and (2) the relationship of equilibrium potential and membrane potential. First, an inhibitory neurotransmitter acts by increasing conductance of an ion the equilibrium potential of which is either equal to or more negative than the cell resting membrane potential. If the equilibrium potential of the ion is more negative than the resting membrane potential, increasing the conductance of that ion will hyperpolarize the membrane--will generate an inhibitory postsynaptic potential (IPSP). Second, if the equilibrium potential of the ion is equal to resting membrane potential, increasing the conductance of that ion will "clamp" the membrane potential more tightly at its resting level--this will make the cell less excitable. In this problem, the membrane potential must equal -80 mV D.. If, and only if, the resting membrane potential equals the equilibrium potential for an ion, will an increase in the conductance to that ion not cause a change in membrane potential.

QUESTION 845
The striped area in below figure indicates a red light on the receptive fields of a red on-center, green off-center surround retina ganglion cell. How will the light spot be perceived?

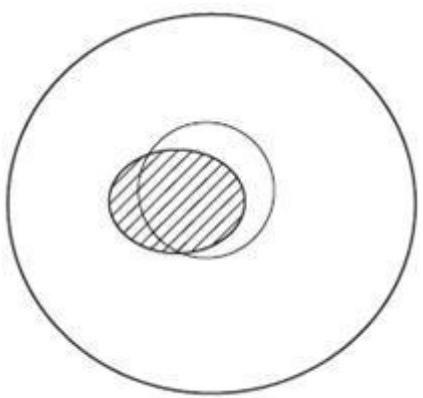

FIG. 2-20

A. brown (red + green)
B. green
C. no color

D. red
E. reddish green

Answer: D
Section: Physiology
Explanation

Explanation:
A light spot exclusively hitting the center would be perceived as deep red. Some of the light hits the inhibitory surround area. In this area, light is processed coming from cones that are best excited by green light (middle wavelength) and inhibited by red light (long wavelength). In the below figure the on-response dominates the off-response so that the perceived light is different from deep red, but not green (choice B). At the retina ganglion level, the trichromate signals from the cones are transferred into the neuronal stage of color processing, the opponent color stage. The cone photoreceptors are linked together to form opposing color pairs, in this case red versus green. Activation of one member of the pair inhibits the activity in the other so that a color pair cannot be seen at the same location. We cannot experience reddish green (choice E). Physiological color image formation differs from the physical process of coloring a piece of paper with a red and green pencil (choice A), one on top of the other, called subtractive color mixture. It starts with the presence of all colors of light and then dyes subtract some of the reflected light so that adding more dyes results in a darker image such as brown. For physiological color mixing, the presence of all colors is perceived as white, the absence as black (choice C).

QUESTION 846
Creatinine clearance is often used to evaluate glomerular function. Which of the curves in below figure best represents the relationship between plasma creatinine concentration and creatinine clearance in a normal healthy person?

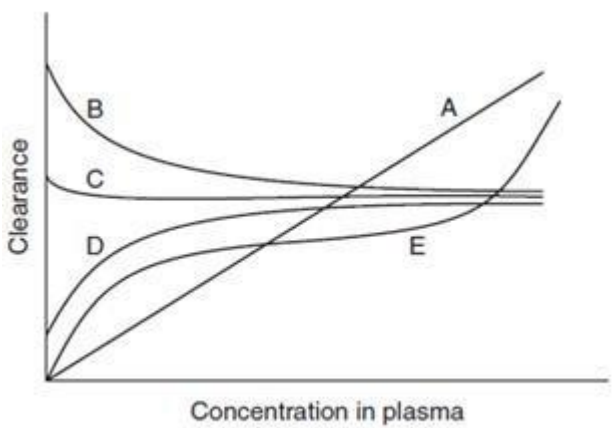

FIG. 2-21

A. A
B. B

C. C
D. D
E. E

Answer: C
Section: Physiology
Explanation

Explanation:
Creatinine clearance is independent of plasma creatinine concentration; otherwise, creatinine would not be a useful measure of GFR. Clearance is defined as the amount of plasma that delivered the excreted substance, and for a substance that is neither actively secreted nor reabsorbed by the kidneys; its clearance equals the amount of plasma filtered through the glomerular membrane. All creatinine contained in that amount of plasma is excreted by the kidney, no matter what the concentration of creatinine in that plasma volume was. Because in the normal person a small amount of creatinine is secreted by the renal tubules, clearance at low plasma concentrations is slightly higher than at elevated plasma concentration (slight initial upward bend of curve). Curve Adescribes the relationship between creatinine plasma concentration and renal excretion of creatinine. Note that excretion and clearance are not synonymous. Curves B and D describe the clearance of a substance that is secreted and filtered, or filtered and reabsorbed, respectively. At large plasma concentration, the active transporters become saturated and the clearance of these substances approaches the creatinine clearance. Curve E depicts an improbable event with relatively increased clearance at both low and high concentrations of a substance, although there is an independent linear clearance at intermediate substance concentrations.

QUESTION 847
The patient is a 43-year-old male. He is anemic, with a hemoglobin level of 12.2 g/dL (normal is 15.5 g/dL). The erythrocytes are microcytic (MCV = 70 fL, with normal MCV = 80100 fL). Which of the following would most likely be present in this patient?

A. acute bleeding
B. folate deficiency
C. iron deficiency
D. vitamin deficiency
E. vitamin K deficiency

Answer: C
Section: Physiology
Explanation

Explanation:
Microcytic anemia can often be associated with defective hemoglobin synthesis. In the case of iron deficiency, heme synthesis is impaired due to the lack of iron. Acute bleeding (choice A) is normally associated with erythrocytes of normal size, since the anemia is due to simple loss of blood, with plasma expansion to maintain total volume. Both vitamin and folate (choices B and D) are

B_{12}

required for DNA synthesis. Due to the extremely active cell division required to sustain the erythrocyte pool, impaired DNA synthesis first normally manifests as a lack of erythrocyte production. Anemia due to vitamin B12 or folate deficiency is macrocytic. Vitamin K (choice E) is required for synthesis of several clotting factors. Lack of vitamin K often presents as a problem with coagulation.

QUESTION 848
Which of the following statements concerning total body energy storage is correct?

A. Most of the body's energy store is held as carbohydrate.
B. Most of the body's energy store is held as lipid.
C. Most of the body's energy store is held as plasma glucose.
D. Most of the body's energy store is held as protein.
E. Total body's energy storage approximately equals resting metabolic rate.

Answer: B
Section: Physiology
Explanation

Explanation:
Lipid is the most concentrated form of energy storage, holding 9.4 kcal/g. For a typical 70 kg human over 130,000 kcal is typically stored as fat. Storage of energy as available protein (choice D) is about 20,000 kcal, while storage as carbohydrate (choice A) is about 3,000 kcal. Though blood glucose (choice C) is critically important, in particular as a source of energy for the brain, blood glucose does not provide a significant fraction of total body energy storage. While total body energy stores typically exceed 150,000 kcal, resting metabolic rate (depending on age and body mass) is about 2100 kcal/day (choice E).

QUESTION 849
During a brain surgery, during which the patient remained conscious, a part of the DC/ML (dorsal column, medial lemniscal) system was exposed and stimulated. Which of the following sensations might the patient most likely experience?

A. a feeling as if his fingers are warming up
B. a feeling as if something were touching his index finger
C. a tingling sensation
D. mild pain but he is unable to explain exactly where it hurts

Answer: B
Section: Physiology
Explanation

Explanation:
The dorsal column-medial lemniscus (DC/ML) system is the sensory pathway that transmits conscious proprioceptive information with fine gradations such as a fine touch on the index finger to the cerebral cortex. The brain interprets any signals coming along the "labeled lines," the nerves that carry messages from the sensory organ to the cortex, as being information about a particular sense. Hence, activation of certain neurons in the somatic sensory system can cause a sensation as if it originated from mechanical pressure on the finger (choice E). Thermal sensations (choice A), tingling (choice C), and crude undetermined pain (choice D) are sensory modalities that are processed in the spinothalamic or anterolateral system.

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