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PG Entrance Examination

AIIMS

May 2017
Nov 2016

With Explanatory Answers

Includes colored question paper with all images

Rituraj Upadhyay

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11. Countercurrent mechanism is not seen in:

a. Kidney
b. Testes
c. Eye
d. Intestine

Ans. c. Eye *Ref: Ganong 24/e p687,419*

Principles and Practice of Endo. and Metabolism by KL Becker p957

A countercurrent mechanism system is a system that expends energy to create a concentration gradient. It is a system in which the inflow runs parallel to, counter to, and in close proximity to the outflow for some distance.

It is found widely in nature and especially in mammalian organs. For example, it can refer to the process that is underlying the process of urine concentration, that is, the production of hyperosmotic urine by the mammalian kidney.

Testis

- The spermatic arteries to the testes are tortuous, and blood in them runs parallel but in the opposite direction to blood in the pampiniform plexus of spermatic veins.
- This anatomic arrangement may permit countercurrent exchange of heat and testosterone.
- Spermatogenesis requires a temperature considerably lower than that of the interior of the body. The testes are normally maintained at a temperature of about 32°C. They are kept cool by air circulating around the scrotum and probably by heat exchange in a countercurrent fashion between the spermatic arteries and veins.

Kidney

- Countercurrent exchange for concentration of urine is a passive process; it depends on movement of water and could not maintain the osmotic gradient along the pyramids if the process of counter-current multiplication in the loops of Henle were to cease.
- It is worth noting that there is a very large osmotic gradient in the loop of Henle and, in the presence of vasopressin, in the collecting ducts.
- It is the countercurrent system that makes this gradient possible by spreading it along a system of tubules 1 cm or more in length, rather than across a single layer of cells that is only a few micrometers thick.
- There are other examples of the operation of countercurrent exchangers in animals. One is the heat exchange between the arteries and venae comitantes of the limbs. To a minor degree in humans, but

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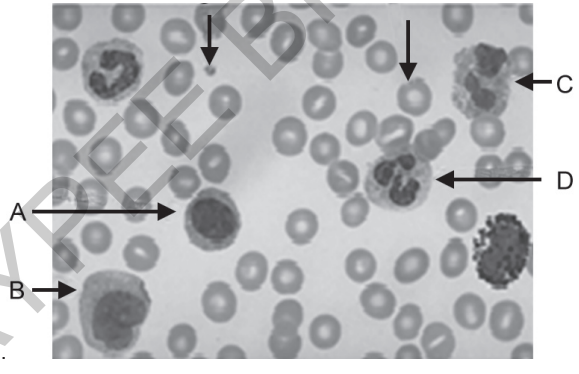
to a major degree in mammals living in cold water, heat is transferred from the arterial blood flowing into the limbs to the adjacent veins draining blood back into the body, making the tips of the limbs cold while conserving body heat.

Gut

- Countercurrent blood flow is seen in the intestinal villi where oxygen directly diffuses from arterioles to vein.
- The idea that a countercurrent system operates in the villus was based initially on observations on the vascular morphology of mammalian villi. The villus contains a central arterial vessel surrounded by a dense capillary network and neighboring venous vessels.
- The hairpin arrangement of the arterial and venous vessels, resembling the renal microvasculature, could produce a "countercurrent" flow system in which blood flow occurs in opposite directions.

12. In this Leishman's stained blood smear, identify the cell which is raised markedly in worm infestations.



a. C
b. B
c. D
d. A

Ans. a. C *Ref: Guyton 11/e p436*

Eosinophils

- The eosinophils normally constitute about 2 per cent of all the blood leukocytes.
- Eosinophils are weak phagocytes, and they exhibit chemotaxis.

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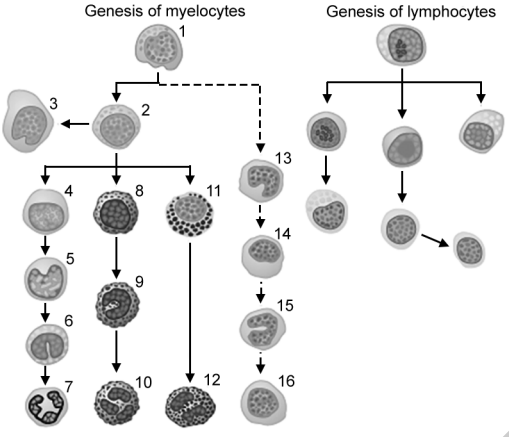

Genesis of white blood cells. The different cell of the myelocyte series are 1, myeloblast; 2, promyelocyte; 3, megakaryocyte; 4, neutrophil myelocyte; 5, young neutrophil metamuelocyte; 6, "band" neutrophil metamyelocyte; 7, polymorphonuclear neutrophil; 8,eosinophil myelocyte; 9,eosinophil metamyelocyte; 10, polymorphonuclear eosinophil; 11,basophil myelocyte; 12, poly-morphonuclear basophil; 13–16, stages of monocyte formation.

- **Eosinophils are often produced in large numbers in people with parasitic infections, and they migrate in large numbers into tissues diseased by parasites.**
- Although most parasites are too large to be phagocytized by eosinophils or any other phagocytic cells, eosinophils attach themselves to the parasites by way of special surface molecules and release substances that kill many of the parasites.
- Eosinophils attach themselves to the juvenile forms of the parasite and kill many of them. They do so in several ways:
  (1) by releasing hydrolytic enzymes from their granules,which are modified lysosomes; (2) probably by also releasing highly reactive forms of oxygen that are especially lethal to parasites; and (3) by releasing from the granules a highly larvicidal polypeptide called *major basic protein*.
- Eosinophils also have a special propensity to collect in tissues in which allergic reactions occur, such as in the peribronchial tissues of the lungs in people with asthma and in the skin after allergic skin reactions.
- The mast cells and basophils release an *eosinophil chemotactic factor* that causes eosinophils to migrate toward the inflamed allergic tissue.
- The eosinophils are believed to detoxify some of the inflammation-inducing substances released by the mast cells and basophils and probably also to phagocytize and destroy allergen-antibody complexes, thus preventing excess spread of the local inflammatory process.

13. The following image shows cell count in different squares of a Neubauer's chamber after charging with 20 times diluted blood. What is the total leukocyte count?

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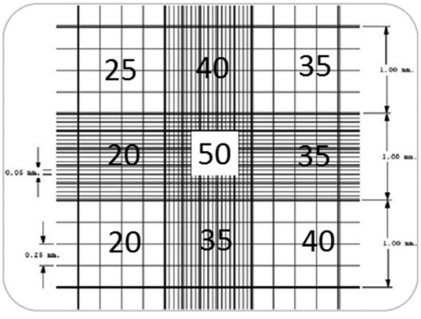

a. 6000 per cu mm
b. 2400 per cu mm
c. 3000 per cu mm
d. 14200 per cu mm

Ans. a. 6000 per cu mm

Ref: Textbook of Practical Physiology by GK Pal 2/e p57

If you remember the volume factor (2.5) in WBC count, simply multiply the total cell number(n) with it and the dilution to get the final cell count.

Otherwise,

Volume of one square = (1 × 1 × 0.1) cu mm = 0.1 cu mm
Cells counted in 4 corner squares = n = (25 + 35 + 40 + 20) = 120
Total Volume of 4 squares = 4 x 0.1 = 0.4 cu mm
So, 0.4 cu mm contains 120 cells
1 cu mm = 120/0.4 = 300 /dL
Dilution factor = 20
WBC Count = 300 × 20 = 6000 cells/dL

A hemocytometer is a square chamber carved into a piece of thick glass that has a specific depth

- Neubauer chamber's counting grid is 3 mm × 3 mm in size.
- The grid has 9 square subdivisions of width 1 mm.
- In case of blood cell counting, the squares placed at the corners are used for white cell counting. Since their concentration is lower than red blood cells a larger area is required to perform the cell count.
- The central square is used for platelets and red cells. This big square is split in 25 squares of width 0.2 mm (200 μm). Each one of the 25 central squares is subdivided in 16 small squares. Therefore, the central square is made of 400 small squares.
- For TLC, count the total number of WBCs in the four corner squares under low-power objective.
- To avoid counting the same cells again, count the white cells present in the square and those present on its left and lower lines. WBCs are identified as clear, nucleated and refractile bodies.

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Dilution Obtained

The volume of the bulb is 10 (11-1 = 10). The stem of the pipette (from the tip of the pipette to mark 1) contains diluting fluid that does not take part in the dilution. Dilution (mixing of blood with diluting fluid) occurs only in the bulb. Thus 10 volumes of diluted blood (in the bulb) contain 0.5 volume of blood and 9.5 volumes of diluting fluid giving a dilution of 0.5 in 10. Thus, the dilution obtained is 1 in 20, or 20 times.

Calculation

Area of 4 WBC squares = $4 \times 1 = 4\ mm^2$
Volume of 4 WBC squares = $4 \times 1/10 = 4/10\ mm^3$
Dilution factor = 1:20
Cells in $4/10\ mm^3$ volume of diluted blood = n
Therefore, cells in $1\ mm^3$ volume of diluted blood = $n \times 10/4$
Therefore, cells in $1\ mm^3$ volume of undiluted blood = $n \times 10/4 \times 20 = n \times 50$

14. In the following electron micrograph of the sarcomere, correctly identify the area labeled as "E".



a. A-band
b. I-band
c. M-band
d. H-zone

Ans. b. I-band *Ref: Ganong 24/e p99*

The area marked as "E" is the lighter and Isotropic band, called as I-band. It contains a dark, Z-line at its center.

A: A-band
B: Actin filaments
C: Sarcomere width
D: H-zone

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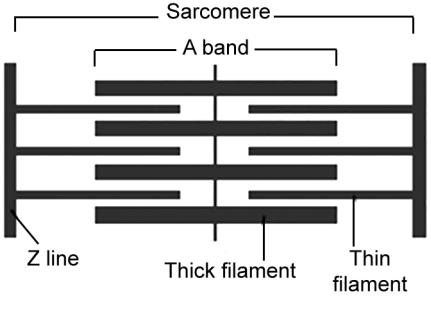
Striations in Skeletal Muscles

- Differences in the refractive indexes of the various parts of the muscle fiber are responsible for the characteristic cross-striations seen in skeletal muscle when viewed under the microscope.
- The light I band is divided by the dark Z line, and the dark A band has the lighter H band in its center.
- A transverse M line is seen in the middle of the H band, and this line plus the narrow light areas on either side of it are sometimes called the pseudo-H zone.
- The area between two adjacent Z lines is called a **sarcomere.**
- The thick filaments, which are about twice the diameter of the thin filaments, are made up of myosin; the thin filaments are made up of actin, tropomyosin, and troponin.
- The thick filaments are lined up to form the A bands, whereas the array of thin filaments extends out of the A band and into the less dense staining I bands. The lighter H bands in the center of the A bands are the regions where, when the muscle is relaxed, the thin filaments do not overlap the thick filaments. The Z lines allow for anchoring of the thin filaments.
- Some additional structural proteins that are important in skeletal muscle function include **actinin, titin,** and **desmin.**
- Actinin binds actin to the Z lines.
- Titin, the largest known protein (with a molecular mass near 3,000,000 Da), connects the Z lines to the M lines and provides scaffolding for the sarcomere. It contains two kinds of folded domains that provide muscle with its elasticity. At first when the muscle is stretched there is relatively little resistance as the domains unfold, but with further stretch there is a rapid increase in resistance that protects the structure of the sarcomere.
- Desmin adds structure to the Z lines in part by binding the Z lines to the plasma membrane.



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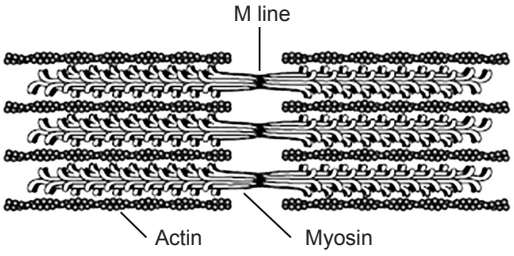

15. Which of the following is not true about the salivary gland output in Sjögren's syndrome?

a. Increase in sodium concentration
b. Increase in phosphate concentration
c. Decreased output of salivary glands < 0.5 ml/min
d. Increase in IgA concentration

Ans. b. Increase in phosphate concentration

Ref: Harrison's 18/e Chap 324, Ganong p456

Concentration of Sodium and IgA increases in Sjögren's syndrome due to decrease in the serous component of saliva (ductal secretions are unaltered). Phosphate concentration is more or less the same as it is secreted by the gland itself rather then duct.

Chemical Constitution of Saliva

- Saliva is produced by three pairs of salivary glands (the **parotid, submandibular,** and **sublingual glands**) that drain into the oral cavity.
- It has a number of organic constituents that serve to initiate digestion (particularly of starch, mediated by amylase) and which also protect the oral cavity from bacteria (such as immunoglobulin A and lysozyme).
- Saliva also serves to lubricate the food bolus (aided by mucins).
- The composition of the saliva is then modified as it flows from the acini out into ducts that eventually coalesce and deliver the saliva into the mouth. Na^+ and Cl^- are extracted and K^+ and bicarbonate are added.
- Because the ducts are relatively impermeable to water, the loss of NaCl renders the saliva hypotonic, particularly at low secretion rates. As the rate of secretion increases, there is less time for NaCl to be extracted and the tonicity of the saliva rises, but it always stays somewhat hypotonic with respect to plasma.

Sjögren's syndrome is a chronic, slowly progressive autoimmune disease characterized by lymphocytic infiltration of the exocrine glands resulting in xerostomia and dry eyes. Approximately one-third of patients present with systemic manifestations.

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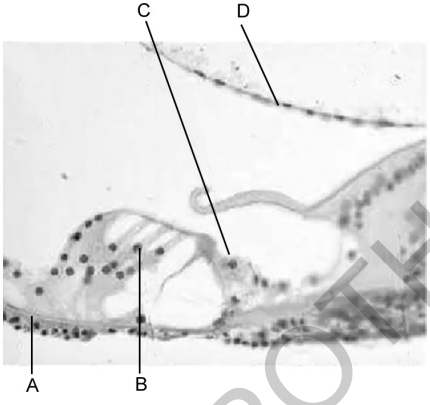
Unstimulated whole salivary flow <1.5 mL in 15 min in Sjögren's syndrome.

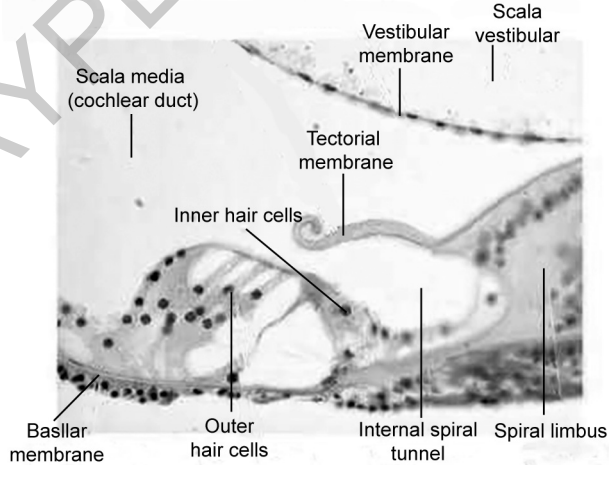
16. Where do the peripheral processes of spiral ganglion end?



a. C
b. D
c. B
d. A

Ans. a. C *Ref: Ganong p206-207*

The cell bodies of the sensory neurons that arborize around the bases of the hair cells, are located in the spiral ganglion. **90-95% of these sensory neurons innervate the inner hair cells**, only 5-10% innervate the more numerous outer hair cells.



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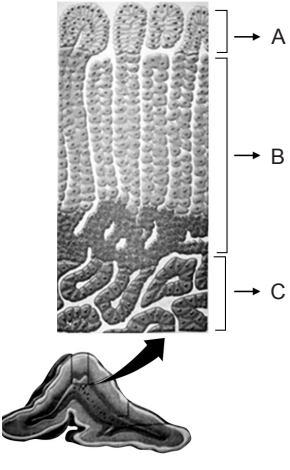
Organ of Corti

- The **organ of Corti** on the basilar membrane extends from the apex to the base of the cochlea and thus has a spiral shape.
- It contains the highly specialized auditory receptors (hair cells) whose processes pierce the tough, membrane like **reticular lamina** that is supported by the **pillar cells** or **rods of Corti**.
- The hair cells are arranged in four rows: Three rows of **outer hair cells** lateral to the tunnel formed by the rods of Corti, and one row of **inner hair cells** medial to the tunnel.
- There are 20,000 outer hair cells and 3500 inner hair cells in each human cochlea.
- Covering the rows of hair cells is a thin, viscous, but elastic **tectorial membrane** in which the tips of the hairs of the outer but not the inner hair cells are embedded.
- The cell bodies of the sensory neurons that arborize around the bases of the hair cells are located in the **spiral ganglion** within the **modiolus,** the bony core around which the cochlea is wound.
- Ninety to 95% of these sensory neurons innervate the inner hair cells; only 5–10% innervates the more numerous outer hair cells, and each sensory neuron innervates several outer hair cells.
- **By contrast, most of the efferent fibers in the auditory nerve terminate on the outer rather than inner hair cells.**
- The axons of the afferent neurons that innervate the hair cells form the **auditory (cochlear) division** of the eighth cranial nerve.

17. In the following sections of the adrenal gland, what hormone is secreted by the region marked as "A"?



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a. Aldosterone
b. Cortisol
c. Testosterone
d. Epinephrine

Ans. a. Aldosterone *Ref: Ganong p355*

A: Zona Glomerulosa - secretes Aldosterone
B: Zona Fasciculata - secretes Corticosteroids mainly
C: Zona Reticularis - secretes Sex Steroids mainly
Mnemonic: GFR from out to in
Adrenal Medulla secretes Epinephrine and norepinephrine.

In adult mammals, the adrenal cortex is divided into three zones.

- The outer **zona glomerulosa** is made up of whorls of cells that are continuous with the columns of cells that form the **zona fasciculata.** These columns are separated by venous sinuses.
- The inner portion of the zona fasciculata merges into the **zona reticularis,** where the cell columns become interlaced in a network.
- The zona glomerulosa makes up 15% of the mass of the adrenal gland; the zona fasciculata, 50%; and the zona reticularis, 7%.
- The adrenocortical cells contain abundant lipid, especially in the outer portion of the zona fasciculata.
- All three cortical zones secrete **corticosterone,** but the active enzymatic mechanism for **aldosterone biosynthesis is limited to the zona glomerulosa**, whereas the enzymatic mechanisms for forming cortisol and sex hormones are found in the two inner zones.
- Furthermore, subspecialization occurs within the inner two zones, with the zona fasciculata secreting mostly glucocorticoids and the zona reticularis secreting mainly sex hormones.

18. Endo-cochlear potential is:

a. +45 mV
b. –45mV
c. –60mV
d. +85 mV

Ans. d. +85 mV *Ref: Guyton 11/e p656*

The **endocochlear potential** is the positive voltage of 80-100 mV seen in the cochlear endolymphatic spaces.

- Within the cochlea the EP varies in the magnitude all along its length.
- The scala media is filled with a fluid called *endolymph,* in contradistinction to the *perilymph* present in the scala vestibuli and scala tympani.
- The scala vestibuli and scala tympani communicate directly with the subarachnoid space around the brain, so that the perilymph is almost identical with cerebrospinal fluid.
- Conversely, the endolymph that fills the scala media is an entirely different fluid secreted by the *stria vascularis,* a highly vascular area on the outer wall of the scala media.

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- Endolymph contains a high concentration of potassium and a low concentration of sodium, which is exactly opposite to the contents of perilymph.
- An electrical potential of about +80 millivolts exists all the time between endolymph and perilymph, with positivity inside the scala media and negativity outside.
- This is called the *endocochlear potential*, and it is generated by continual secretion of positive potassium ions into the scala media by the stria vascularis.
- When a sound is presented, the endocochlear potential changes either positive or negative in the endolymph, depending on the stimulus.
- The change in the potential is called the summating potential.
- With the movement of the basilar membrane, a shear force is created and a small potential is generated due to a **difference in potential between the endolymph (scala media- +80 mV) and the perilymph (vestibular and tympanic ducts- –70 mV).**
- EP is highest in the basal turn of the Cochlea and decreases in the magnitude towards the apex. EP is highly dependent on the metabolism and ionic transport.
- An acoustic stimulus produces a simultaneous change in conductance at the membrane of the receptor cell.
- Because there is a steep gradient (150 mV, changes in membrane conductance are accompanied by rapid influx and efflux of ions which in turn produce the receptor potential. This is known as the **Battery Hypothesis**.
- The receptor potential for each hair cell causes a release of neurotransmitter at its basal pole, which elicits excitation of the afferent nerve fibers.
- The importance of the endocochlear potential is that the top of the hair cells project through the reticular lamina and are bathed by the endolymph of the scala media, whereas perilymph bathes the lower bodies of the hair cells.
- Furthermore, the hair cells have a negative intracellular potential of –70 millivolts with respect to the perilymph but –150 millivolts with respect to the endolymph at their upper surfaces where the hairs project through the reticular lamina and into the endolymph.
- It is believed that this high electrical potential at the tips of the stereocilia sensitizes the cell an extra amount, thereby increasing its ability to respond to the slightest sound.

19. Rapid source of energy by resynthesizing ATP for exercising muscles is:

a. Glycolysis
b. Glycogenolysis
c. TCA cycle
d. Phosphocreatine

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Ans. d. Phosphocreatine *Ref: Guyton 13/e p1087; Ganong 24/e p106*

Phosphocreatine can easily provide enough energy to reconstitute the high-energy bond of ATP. Furthermore, most muscle cells have two to four times as much creatine phosphate as ATP.

- $ATP + H_2O \rightarrow ADP + H_3PO_4 + 7.3$ kcal
- Phosphorylcreatine + ADP $\rightleftarrows$ Creatine + ATP
- Glucose + 2 ATP (or glycogen + 1 ATP)
$$\xrightarrow{\text{Anaerobic}} 2 \text{ Lactic acid} + 4 \text{ ATP}$$
- Glucose + 2 ATP (or glycogen + 1 ATP)
$$\xrightarrow{\text{Oxygen}} 6\ CO_2 + 6\ H_2O + 40 \text{ ATP}$$
- FFA $\xrightarrow{\text{Oxygen}} CO_2 + H_2O + ATP$

Phosphorylcreatine

- ATP is resynthesized from ADP by the addition of a phosphate group. Some of the energy for this endothermic reaction is supplied by the breakdown of glucose to CO_2 and H_2O, but there also exists in muscle another **energy-rich phosphate compound that can supply this energy for short periods**.
- This compound is **phosphorylcreatine,** which is hydrolyzed to creatine and phosphate groups with the release of considerable energy
- At rest, some ATP in the mitochondria transfers its phosphate to creatine, so that a phosphorylcreatine store is built up.
- During exercise, the phosphorylcreatine is hydrolyzed at the junction between the myosin heads and actin, forming ATP from ADP and thus permitting contraction to continue.

Carbohydrate and Lipid Breakdown

- At rest and during light exercise, muscles utilize lipids in the form of free fatty acids as their energy source. As the intensity of exercise increases, lipids alone cannot supply energy fast enough and so use of carbohydrate becomes the predominant component in the muscle fuel mixture.
- **Thus, during exercise, much of the energy for phosphorylcreatine and ATP resynthesis comes from the breakdown of glucose to CO_2 and H_2O.**
- Another source of intracellular glucose, and consequently of pyruvate is glycogen.
- When adequate O_2 is present, pyruvate enters the citric acid cycle and is metabolized— through this cycle and the so-called respiratory

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enzyme pathway—to CO_2 and H_2O. This process is called **aerobic glycolysis.** The metabolism of glucose or glycogen to CO_2 and H_2O forms large quantities of ATP from ADP.

- If O_2 supplies are insufficient, the pyruvate formed from glucose does not enter the tricarboxylic acid cycle but is reduced to lactate. This process of **anaerobic glycolysis** is associated with the net production of much smaller quantities of energy-rich phosphate bonds, but it does not require the presence of O_2.

20. Change in sex hormone binding globulin will most affect levels of which of these hormones?

a. Testosterone
b. Estrogen
c. Progesterone
d. DHEA

Ans. a. Testosterone *Ref: Ganong 24/e p424*

Sex hormone binding globulin is a glycoprotein which binds sex steroids with high affinity as: DHT>T>>Estrone/estradiol

Because of the higher affinity of SHBG for DHT and T, compared to E, variation in SHBG has profound effects on the levels of androgens.

Steroid	% Free	% Bound to		
		CBG	GBG	Albumin
Testosterone	2	0	65	33
Androstenedione	7	0	8	85
Estradiol	2	0	38	60
Progesterone	2	18	0	80
Cortisol	4	90	0	6

CBG, corticosteroid-binding globulin; GBG, gonadal steroid-binding globulin

- Catecholamine and most peptide hormones are soluble in plasma and are transported as such. In contrast steroid hormones are hydrophobic and are mostly bound to large proteins called **steroid binding proteins** (SBP), which are synthesized in the liver. As a result, only small amounts of the free hormone are dissolved in the plasma.
- Specifically, **sex hormone-binding globulin** (SHBG) is a glycoprotein that binds to the sex hormones, testosterone and 17β-estradiol.
- Progesterone, cortisol, and other corticosteroids are bound by transcortin.
- The SBP-hormone complex and the free hormone are in equilibrium in the plasma, and only the free hormone is able to diffuse across cell membranes.
- SBP have three main functions:
  - They increase the solubility of lipid based hormones in the blood.

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