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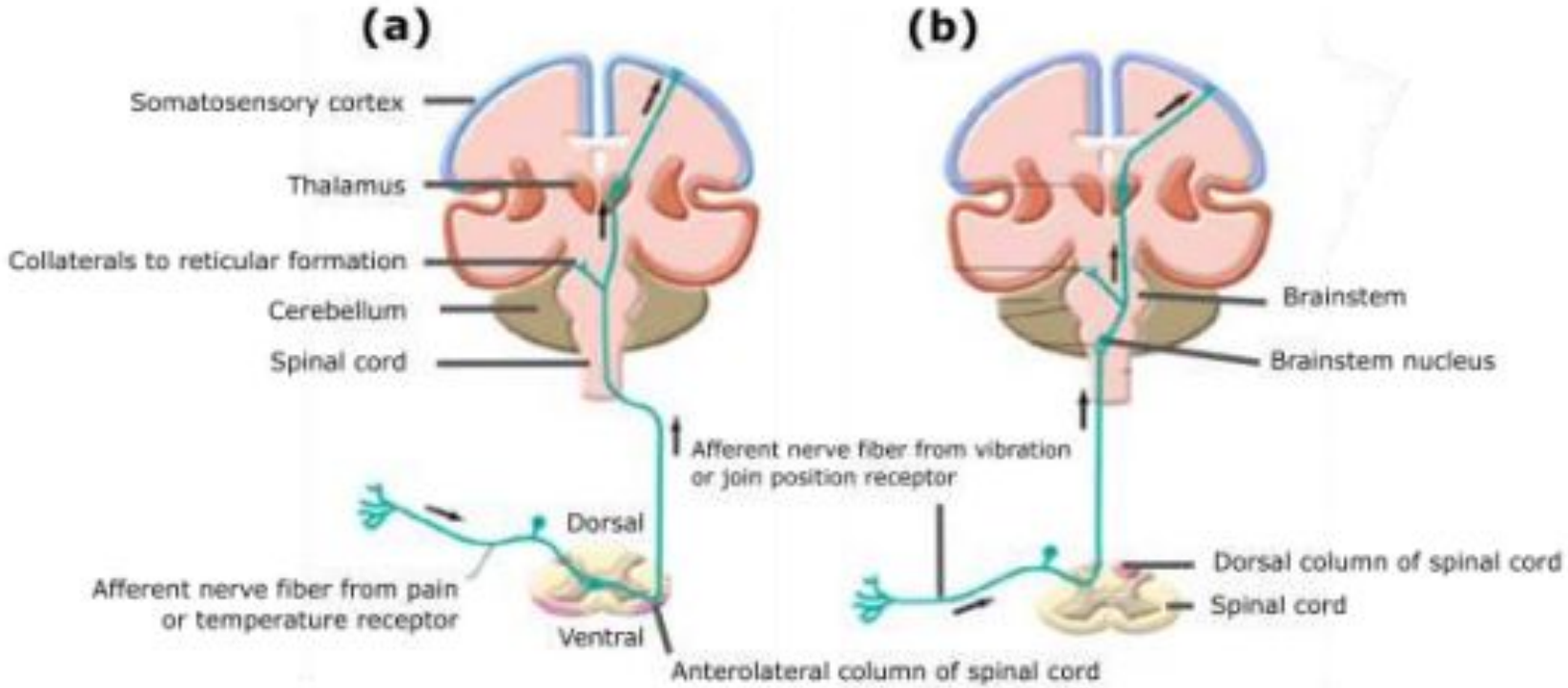
IBO 2018 discussion

Q. 16 – Pain Transmission

In figure a, the pain and temperature sensory pathway is depicted. The first-order neuron enters the spinal cord and forms a synapse with the second-order neuron, which its axon ends in the thalamus. The third-order neuron transmits the information to the brain cortex. Figure b shows the vibration and proprioception (joint position) sensory pathway. The axon terminals of the first-order neurons are located in the brain stem and form synapses with second-order neuron, which crosses the midline and their axons end in the thalamus. finally, the sensory information is conducted to the cortex via the third-order neurons.

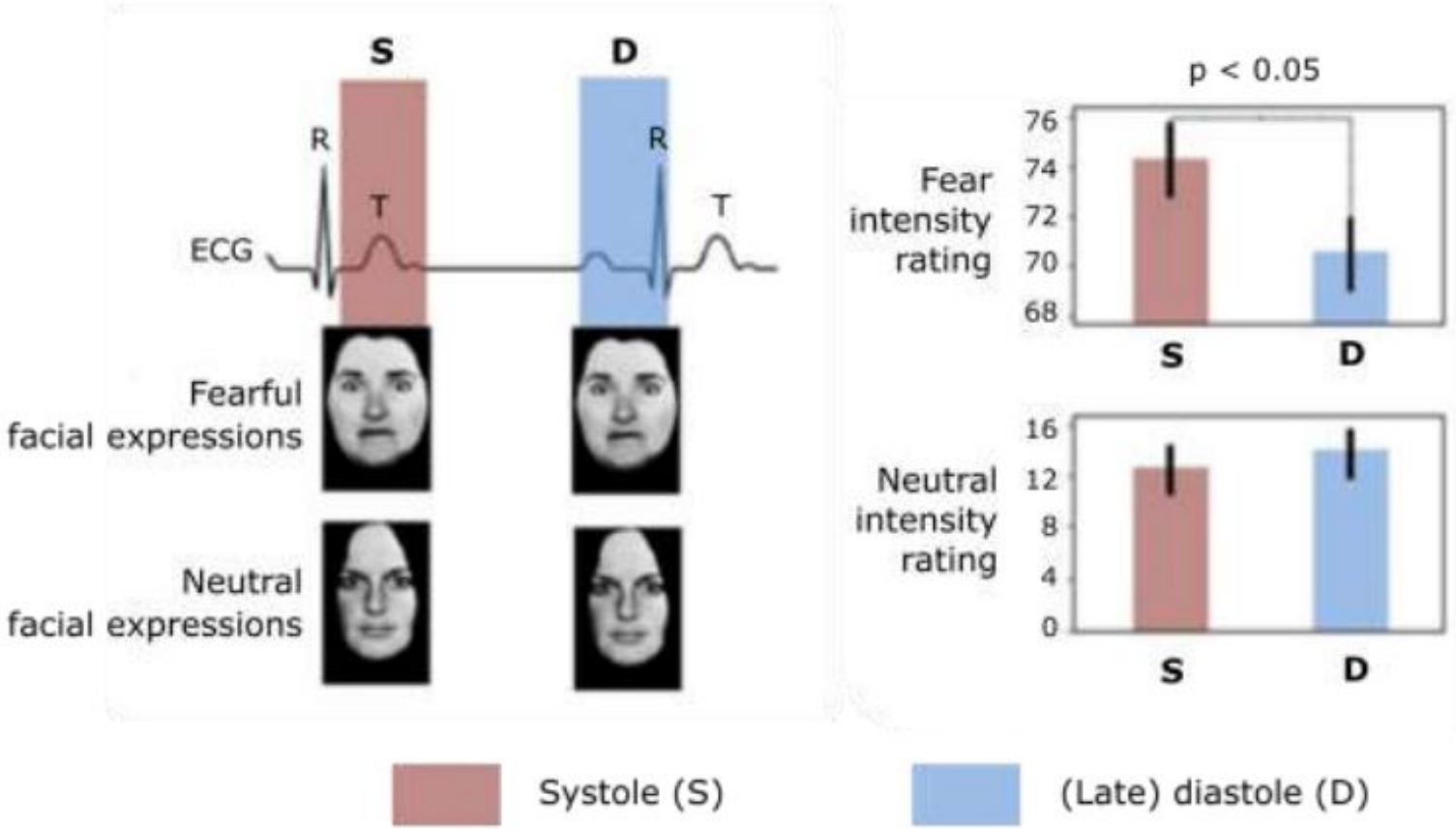
Following a spinal injury, the right ventral and left dorsal sides of the white matter in thoracolumbar spinal cord are damaged.

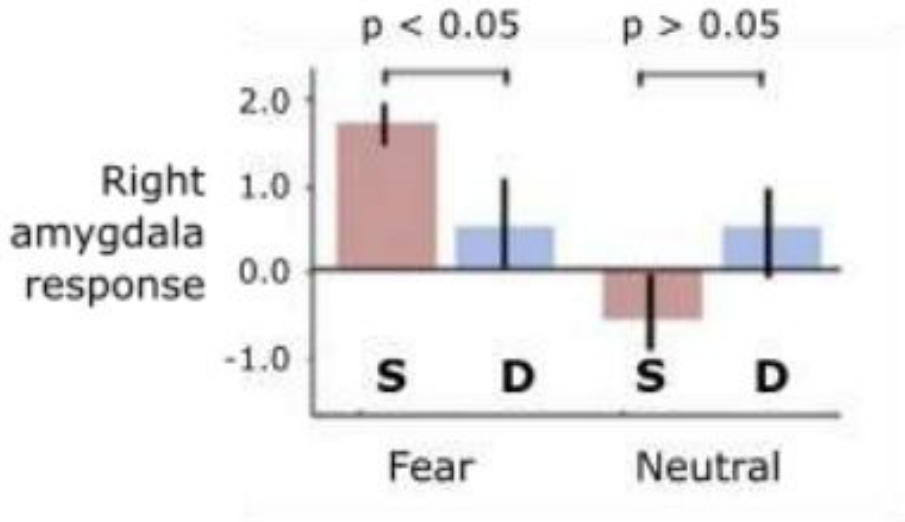


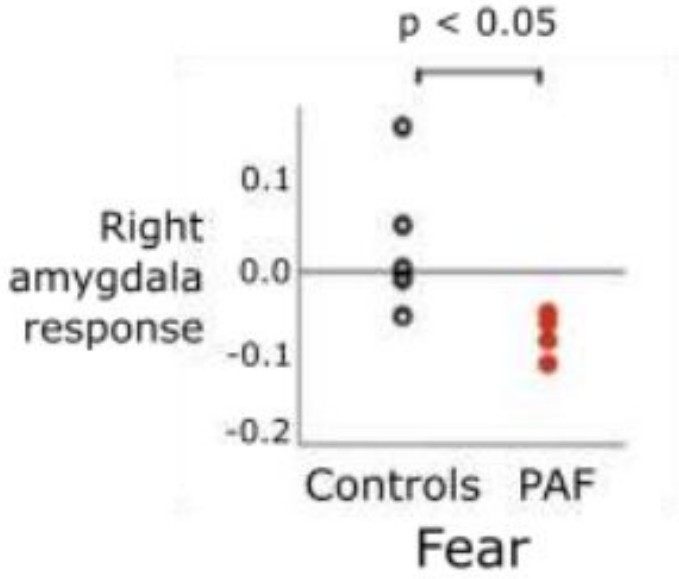
		True	False
A.	The patient has impaired temperature sensation in right hand.	☐	☐
B.	The patient has impaired vibration sensation in left leg.	☐	☐
C.	The patient has impaired joint position sensation in left leg and temperature sensation in right leg.	☐	☐
D.	The patient has impaired pain sensation in left leg.	☐	☐

Q. 17 – Cardiac Response to Emotional States

Perception of the emotional stimuli is a reciprocal process between the brain and the heart. In an experimental task, pictures depicting facial expressions were quickly and sequentially presented to the subjects at different phases of the cardiac cycle. Participants then rated the emotional intensity of the faces in a scale of 0 to 100. Given the role of the amygdala in the process of fear, the amygdala response was measured in normal individuals and subjects with pure autonomic failure (PAF) at the time of presenting facial expression images (using the fMRI method). The results of the study are as follows. (Consider $p < 0.05$ indicates significant difference between groups).



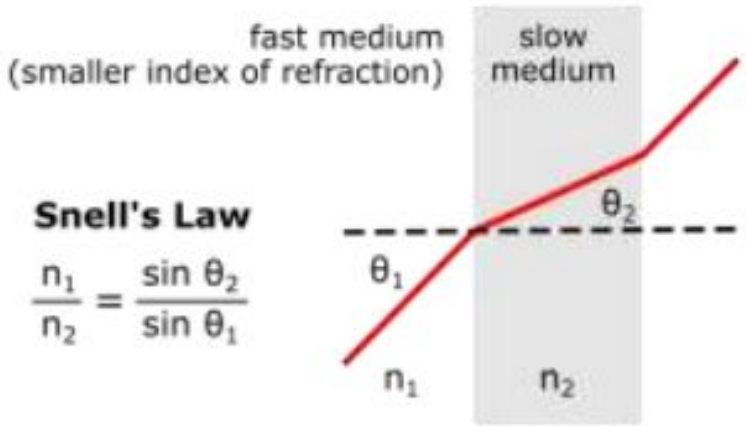


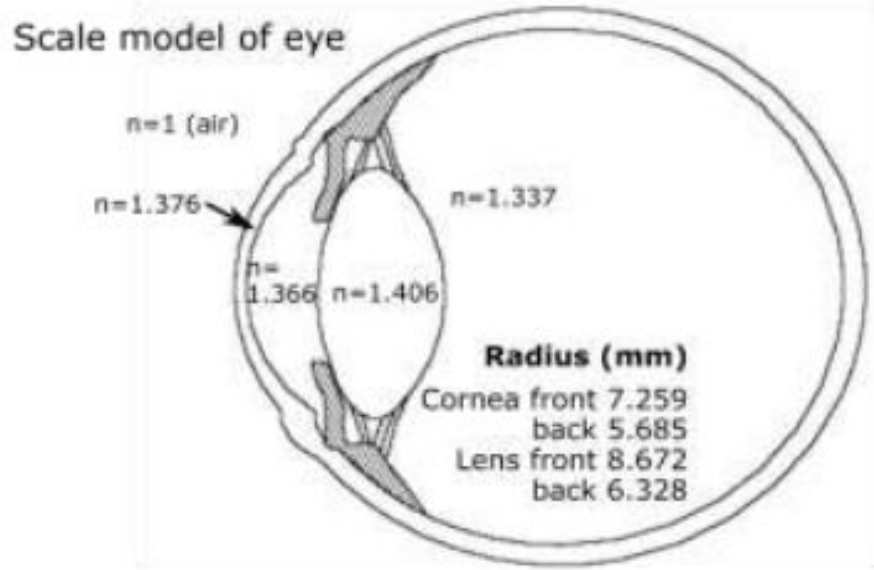


		True	False
A.	Perception of the fear face in the systolic phase is higher than the diastole phase.	☐	☐
B.	The difference between systolic and diastolic response of the amygdala to neutral face images is the opposite of facial expressions of fear.	☐	☐
C.	Increasing the arterial baroreceptors sensitivity in the carotid and aorta may cause a significant reduction in the perception of the fear.	☐	☐
D.	Increased blood flow to amygdala in the systolic phase compare to the diastole phase *cannot* explain the results of this study.	☐	☐

Q. 18 – Light Refraction

When a light beam enters another medium in an oblique angle, its direction will change. This phenomenon is called light refraction. The amount of this change in beam direction can be calculated by Snell's law, where "*n*" is the refraction index.





This phenomenon is also the principle of conversion and diversion of beams in lenses. Power of a lens can be calculated by the following formula. Optical power of a lens demonstrates the degree of convergence or divergence of the light beam.

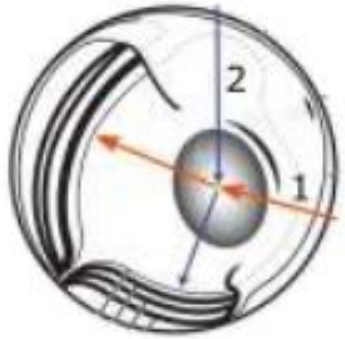
(*D*: Power of lens, *r*: radius of curvature)

$$D = (n_1 - n_2)/r$$

The figure below shows the eye structure of *Anableps sp.* which can simultaneously see objects in both aquatic and terrestrial scenes.

(a)

(b)



(c)

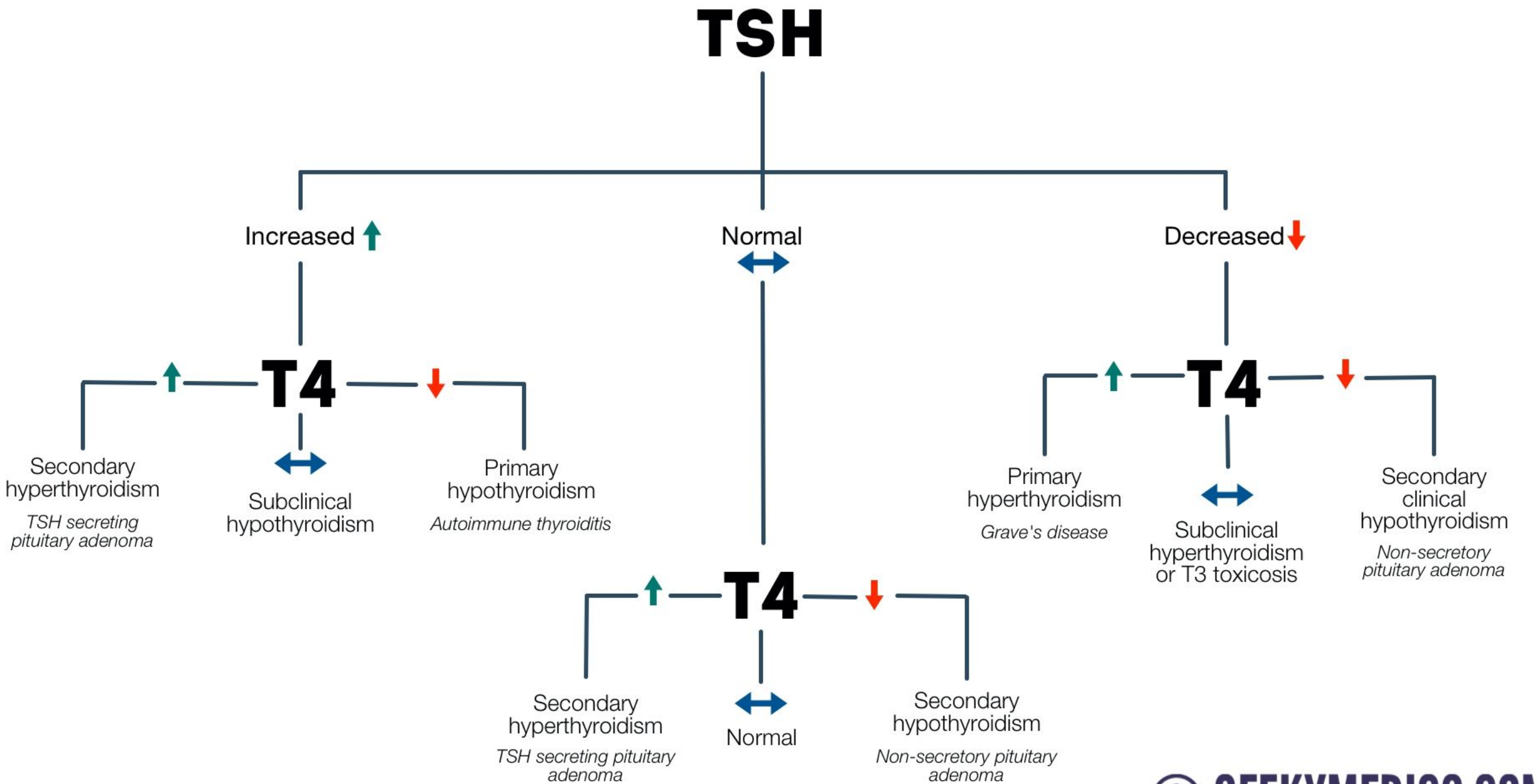
A) *Anableps* sp. B) Eye of *Anablebs* sp. C) Schematic diagram of *Anableps*. sp. eye

		True	False
A.	The largest refraction index belongs to the lens.	☐	☐
B.	The largest amount of refraction belongs to the lens.	☐	☐
C.	The light beam would be more divergent when passing through the aqueous humour than the cornea.	☐	☐
D.	Considering the different diameters of the lens of *Anableps* fish, light ray 1 and 2 belong to terrestrial and aquatic spaces, respectively.	☐	☐

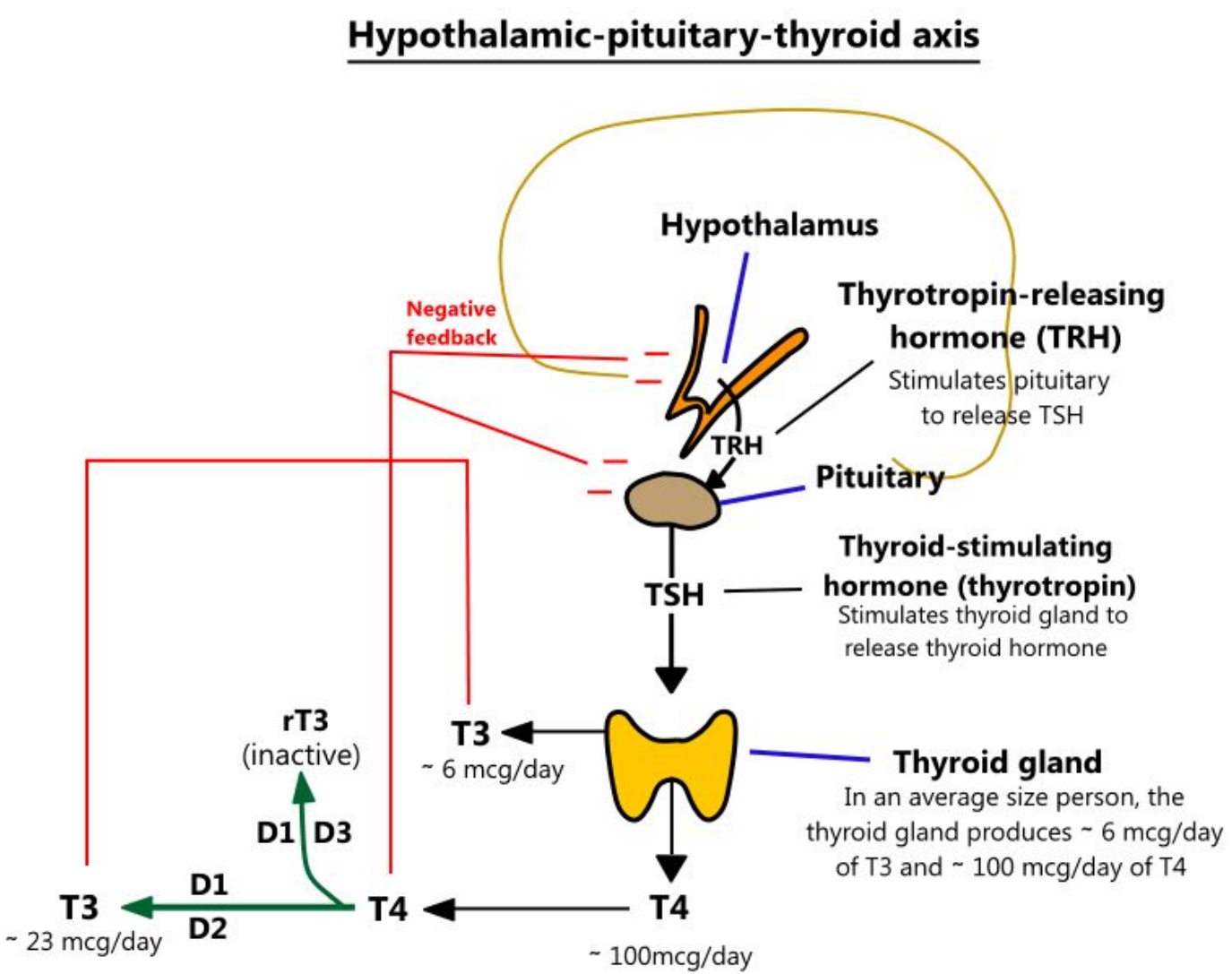
Q. 19 – Thyroid Hormone Transport

Thyroid hormones are transported in blood by proteins. The TBG (thyroid hormone binding globulin) is the main thyroid hormone transporting protein. Many factors affect TBG concentration such as oestrogen and OCP (oral contraceptive pill), etc. OCP increases TBG concentration. T3RU (T3 resin uptake) assay is a method of quantification of unbound TBG in the blood. It indirectly measures the capacity of patients TBG to bind radioactive labelled T3. The less patients thyroid hormone level is the more radioactive labelled T3 will bound to TBG. Thus, since radioactive T3 is only detectable in unbound form, the T3RU assay result will be lower.

		True	False
A.	In primary hypothyroidism, the thyroid function test would be like below: TSH increased T4 decreased T3RU decreased	☐	☐
B.	A person who uses OCP and is euthyroid (normal functioning of thyroid) the thyroid function test would be like below: TSH normal T4 decreased T3RU decreased	☐	☐
C.	In primary hyperthyroidism the thyroid function test would be like below: TSH increased T4 Increased T3RU increased	☐	☐
D.	In secondary hypothyroidism (pituitary dysfunction) the thyroid function test would be like below: TSH decreased T4 decreased T3RU decreased	☐	☐
E.	In tertiary hypothyroidism (hypothalamic dysfunction) the thyroid function test would be like below: TSH normal T4 decreased T3RU decreased	☐	☐



Q19



Peripheral tissue

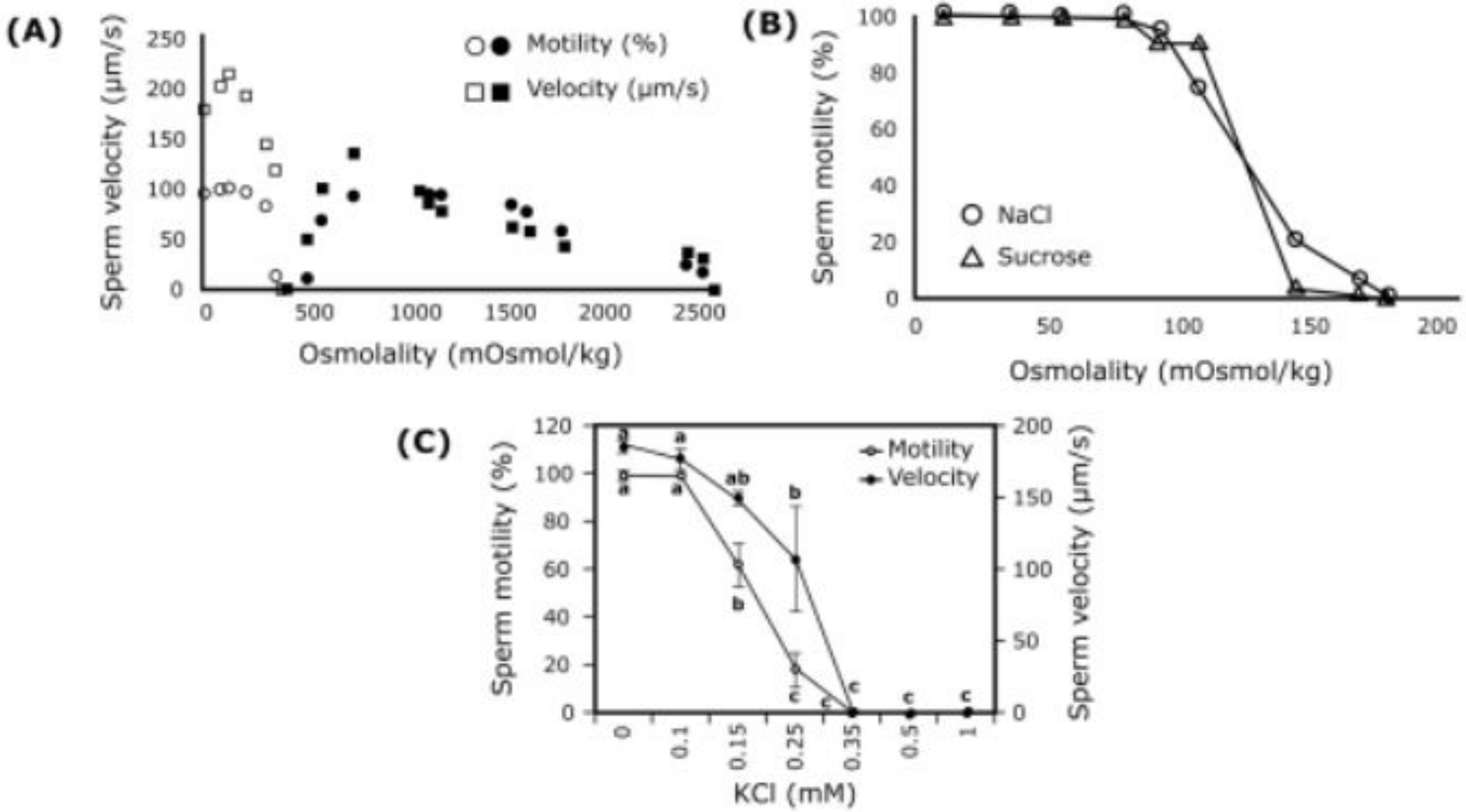
- In the liver, kidney, brain, and skeletal muscle, T4 is converted to T3 by the iodothyronine deiodinase enzymes (D1,D2,D3)
- D1/D2 convert T4 to active T3
- D1/D3 convert T4 to inactive rT3

T4 = thyroxine
T3 = triiodothyronine
rT3 = reverse T3
D = deiodinase enzymes (D1, D2, D3)

Q. 20 – Sperm Motility

Spermatozoa motility is essential for the fertilization of an oocyte. In most animals, including fish, spermatozoa are immotile in the male reproductive organ (testis or sperm duct). Spermatozoa motility is triggered after being ejaculated into the female reproductive tract (in animals with internal fertilization) or after it is released into the aquatic environment (in animals with external fertilization). Ionic composition and osmolality of freshwater, seawater, and seminal plasma of pike (*Esox lucius*), sturgeon (*Acipenser ruthenus*), and cod (*Gadus morhua*) are shown in the table. Pike and sturgeon spawn in freshwater, and cod spawns in seawater.

	Freshwater	Seawater	Pike	Sturgeon	Cod
Sodium Na^+ (mM)	0.26	469	75	20	197
Chloride Cl^- (mM)	0.22	546	112	6	179
Potassium K^+ (mM)	0.07	10	82	1	6
Calcium Ca^{2+} (mM)	0.38	10	2	0.2	3
Osmolality (mOsmol/kg)	<1–5	1000	302	51	385


(A)
Sperm velocity (µm/s)
250
200
150
100
50
0
0
500
1000
1500
2000
2500
Osmolality (mOsmol/kg)
Motility (%)
Velocity (µm/s)
(B)
Sperm motility (%)
100
80
60
40
20
0
0
50
100
150
200
Osmolality (mOsmol/kg)
NaCl
Sucrose
(C)
Sperm motility (%)
120
100
80
60
40
20
0
Sperm velocity (µm/s)
200
150
100
50
0
Motility
Velocity
0
0.1
0.15
0.25
0.35
0.5
1
KCl (mM)

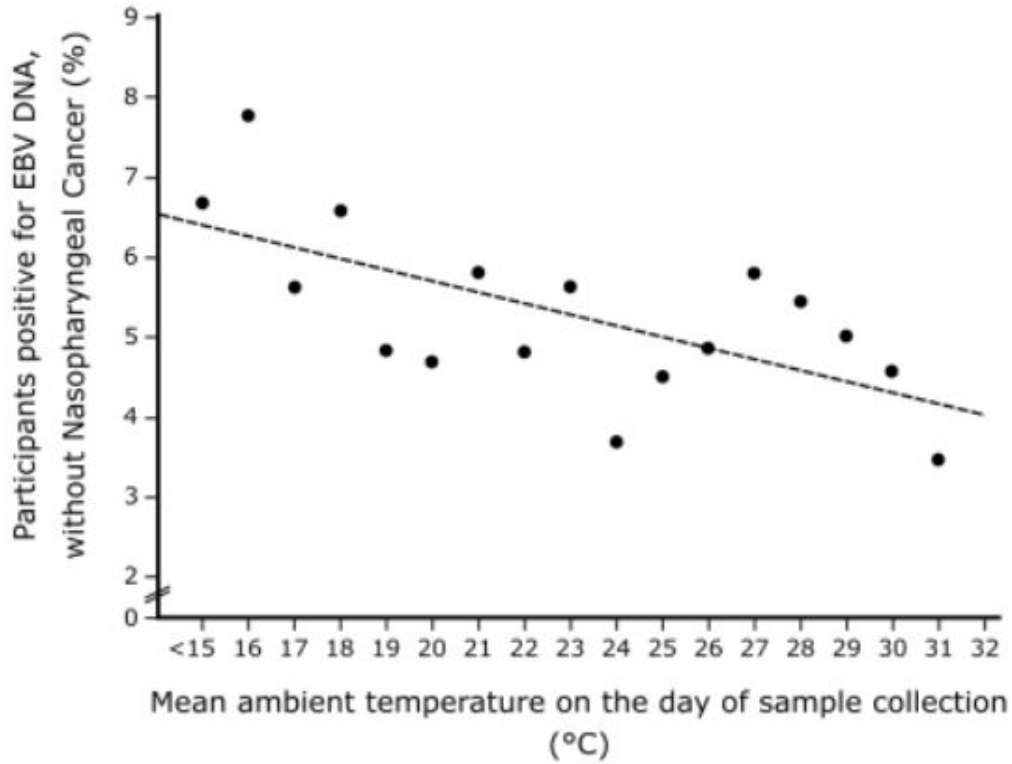
A) Effect of osmolality on sperm motility initiation in pike (open markers) and cod (filled markers). NaCl and Sucrose were used to make activation medium for pike sperm. NaCl and artificial sea salt were used to make activation medium for cod sperm.
B) Effect of osmolality on sperm motility initiation in sturgeon. NaCl and Sucrose were used to make activation medium for sturgeon sperm.
C) Effect of potassium ions (K^+) on sperm motility initiation and sperm velocity in sturgeon. KCl (mM) was added into activation medium made by NaCl or sucrose with osomolality 40 mOsmol/kg.

		True	False
A.	Sperm motility in pike and cod become triggered in a hypo-osmotic and hyper-osmotic environment, respectively.	☐	☐
B.	Under physiological condition, osmolality is the main factor that inhibits sperm motility initiation in sturgeon.	☐	☐
C.	Sperm motility in sturgeon become triggered after discharged into a hypo-osmotic environment with lower K^+ ions.	☐	☐
D.	Environmental osmolality is a key signal to trigger sperm motility initiation after release from reproductive system into aquatic environment in marine fish	☐	☐

Q. 21 – Epstein-Barr Virus Screen

Nasopharyngeal carcinoma is closely associated with the Epstein–Barr virus (EBV) infection. In a recent prospective study involving more than 20,000 participants, detection of EBV DNA in plasma was shown to be useful in screening for nasopharyngeal carcinoma. However, 5.4% of participants without nasopharyngeal carcinoma had detectable EBV DNA in plasma at recruitment. Figure below shows the effect of ambient temperature on test results.

- Sensitivity refers to the test's ability to correctly detect affected patients who do have the condition. It is calculated as: number of affected patients with positive tests/total number of affected individuals studied.
- Specificity relates to the test's ability to correctly identified those without disease. It is calculated as: number of healthy individuals with negative tests/total number of healthy individuals studied.



		True	False
A.	Based on Figure above, performing the test in warmer places will increase the specificity.	☐	☐
B.	When a test becomes more sensitive, the specificity of the test will increase.	☐	☐
C.	A 100% specific test will be 100% sensitive.	☐	☐
D.	To rule out a disease, it is better to use a test with high sensitivity instead of a test with high specificity.	☐	☐

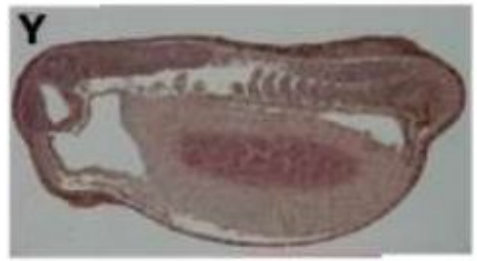
Q21

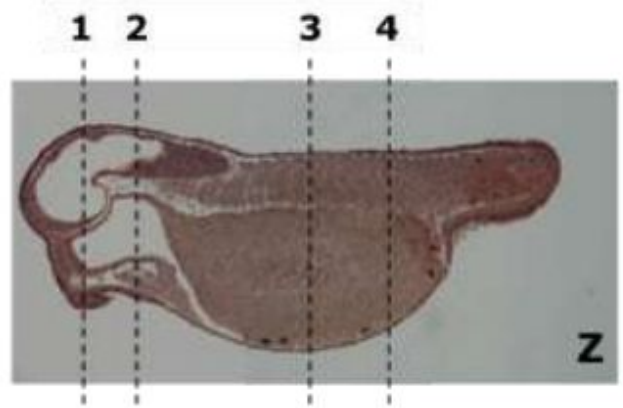
	Disorder	No Disorder
Positive Test Result	True Positive (TP)	False Positive (FP)
Negative Test Result	False Negative (FN)	True Negative (TN)

Sensitivity = TP/(TP+FN)
Specificity = TN/(TN+FP)
PPV = TP/(TP+FP)
NPV = TN/(FN+TN)

Q. 22 – Frog Embryo Morphology

Figures X, Y and Z show the sagittal sections (the plane which divides body into left and right parts) of a frog embryo from the surface to the depth, respectively. Figures a–d are cross sections of the same embryo shown in Figure Z.

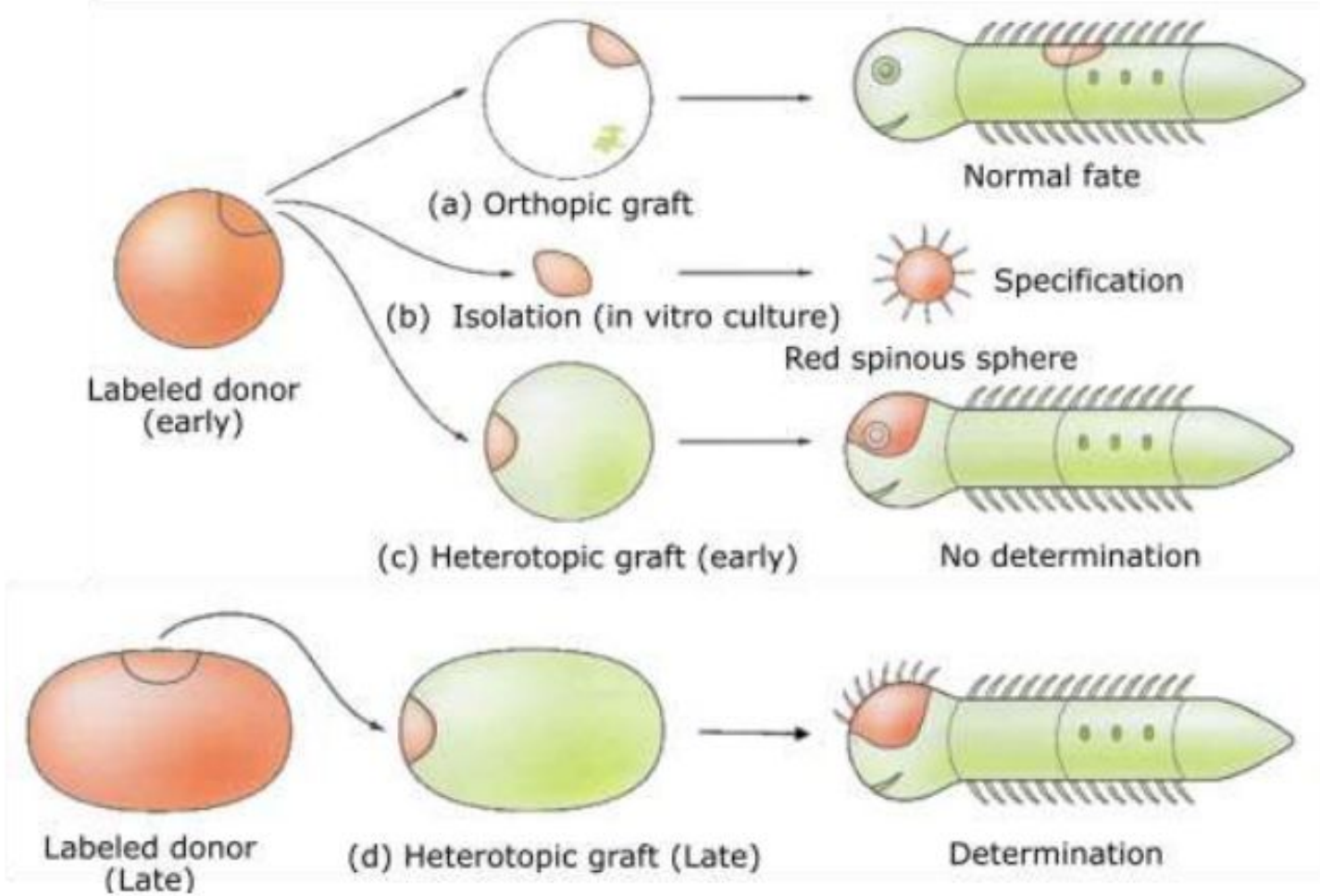




	True	False
A. Figure “a” is the cross section from region “1 “.	☐	☐
B. Figure “b” is the cross section from region “3 “.	☐	☐
C. Figure “c” is the cross section from region “4 “.	☐	☐
D. Figure “d” is the cross section from region “2 “.	☐	☐

Q. 23 – Heterotopic Grafting

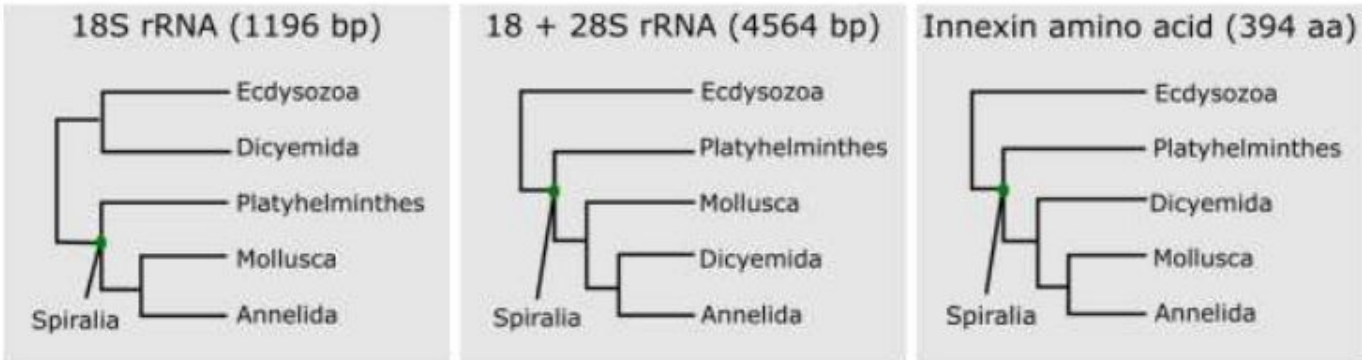
The early embryonic cells pass through two stages of differentiation: specification and determination.



		True	False
A.	These data supports that the fate of the determined cell is not reversible.	☐	☐
B.	The cell that is specified loses its other differentiation potentials	☐	☐
C.	If the graft is removed at the late stage and cultured in isolation, it will give rise to the red spinous sphere (shown in the picture)	☐	☐
D.	If the graft is removed at the late stage and cultured in the presence of the eye inducing factors, the eye-like structure will be developed.	☐	☐

Q. 25 – Phylogenetic Position of Dicyemids

In 1876, Van Beneden, found a group of microscopic ciliated wormlike organisms that inhabited the renal sacs of cephalopods, mainly octopuses and cuttlefishes and named them as Dicyemids. Biologists have been fascinated because of their highly-simplified body organization and complex life cycles of asexual (under normal condition producing vermiform larva in host kidney) and sexual (under crowded condition producing infusoriform larva excreted in host urine). These ciliated animals are composed of approximately 20-30 (or 40) cells arranged in two layers, and they lack coeloms, circulatory systems, and other differentiated tissues and their embryos employ spiral cleavage. Due to their simple body plans, it can be considered as intermediates between the Protozoa and the Metazoa.

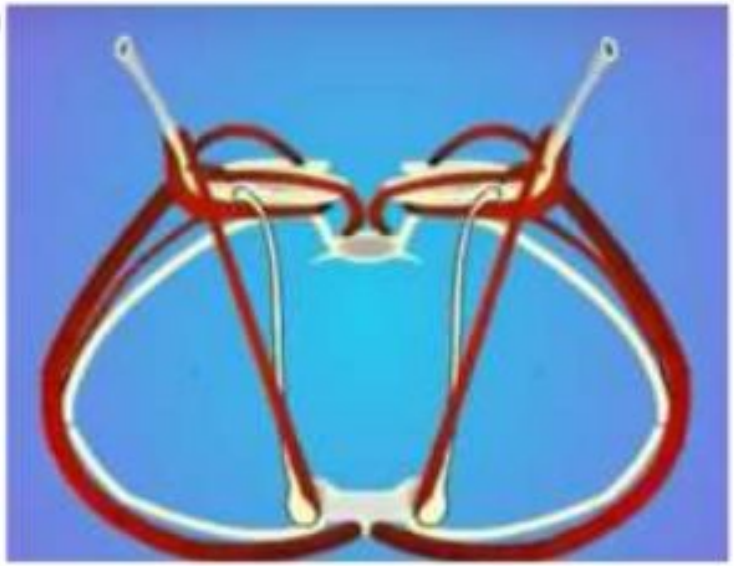


The phylogenetic position of dicyemids suggested by previous phylogenetic studies remains controversial.

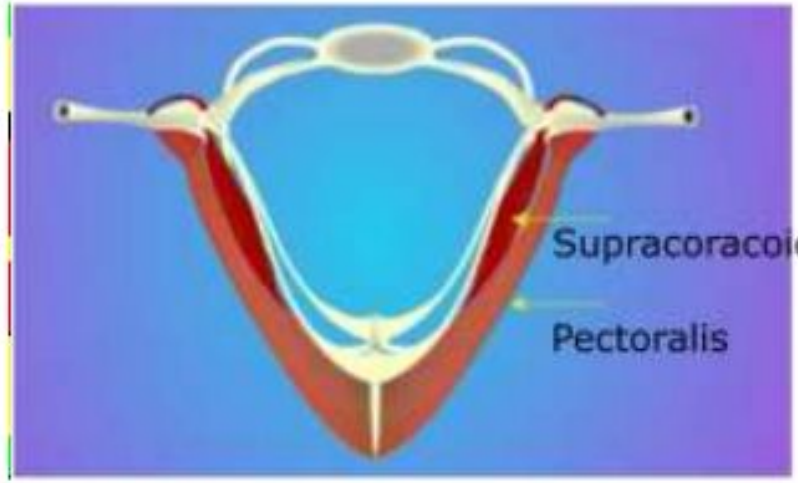
		True	False
A.	Based on the above explanations, infusiform larva is a mean of dispersal for these animals.	☐	☐
B.	Based on the above molecular data, these animals are missing link between Metazoa and protozoa.	☐	☐
C.	Based on the data, these described animals faced a regression evolution during its evolutionary history.	☐	☐
D.	Based on the given data, it is more likely that Dicyemida is more closely related to Mollusca than to Ecdysozoa.	☐	☐

The figures 1-4 illustrate the schematic cross-sectional anatomy of bones and flying muscles of a bird and a bat.

(1)

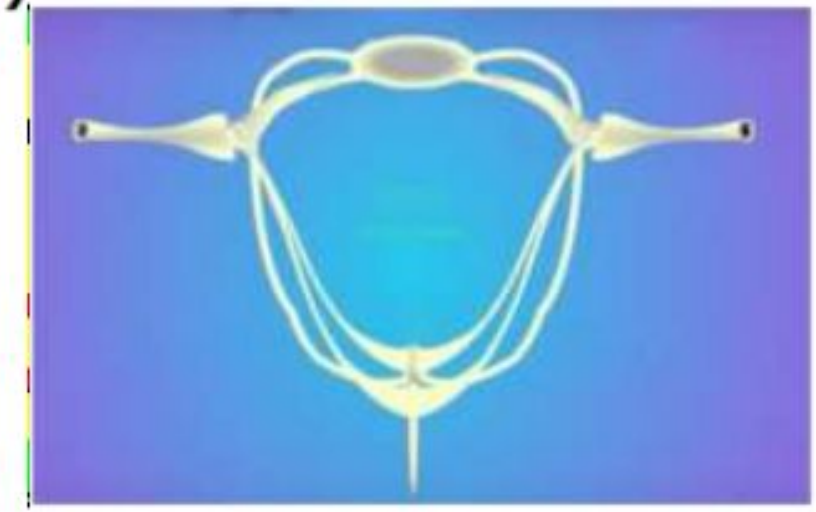


(3)



(2)

(4)



		True	False
A.	Figure 1 and 2 are the bat structures.	☐	☐
B.	The animal of figure 1 and 2 has seven cervical vertebrae.	☐	☐
C.	In figure 1 and 2 the only mobile joint, which is involved in wing's flapping is scapula-humoral.	☐	☐
D.	The muscle supracoracoideus in figure 3, is responsible for downstroke movement in flapping cycle.	☐	☐

The principle of magnetic resonance imaging (MRI) is based on the fact that the nuclei of certain elements align with the magnetic force when placed in a strong magnetic field. At the field strengths currently used in medical imaging, hydrogen nuclei (protons) in water molecules and lipids are responsible for producing anatomical images.

If a radiofrequency pulse at the resonant frequency of hydrogen is applied, a proportion of the protons change alignment, flipping through a present angle, and rotate in phase with one another. Following this radiofrequency pulse, the protons realign (relax), they induce a signal which, although very weak, can be detected and localized by copper coils placed around the patient. An image representing the distribution of the hydrogen protons can be built up.

The strength of the signal depends not only on proton density but also on two relaxation times, T1 and T2; T1 depends on the time the protons take to return to the axis of magnetic field, and T2 depends on the time the protons take to dephase. A T1-weighted image is one in which the contrast between tissues is due mainly to their T1 relaxation properties, while in a T2-weighted image the contrast is due to the T2 relaxation properties.

T1-weighted image: Fat signal intensity > Water signal intensity

T2-weighted image: Fat signal intensity < water signal intensity

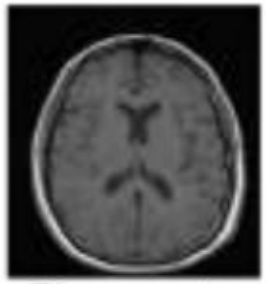


Figure 1:
axial image
of brain

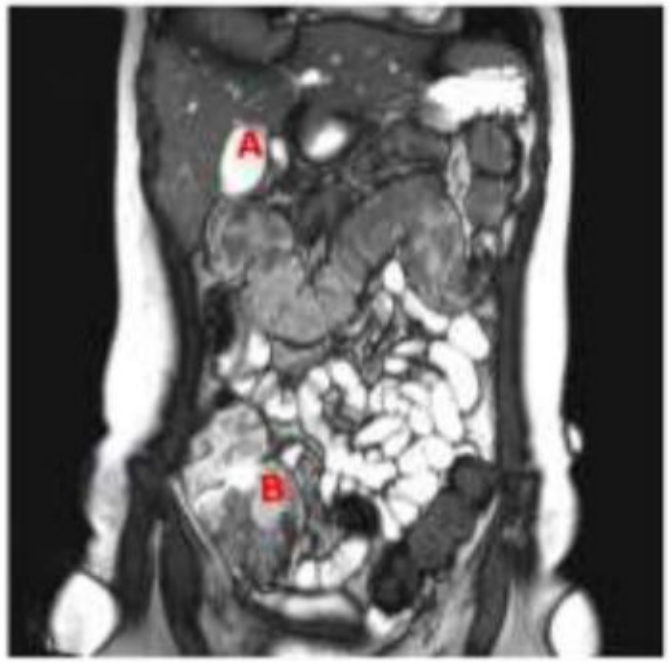


Figure 2:
Coronal T2-weighted
image of abdomen

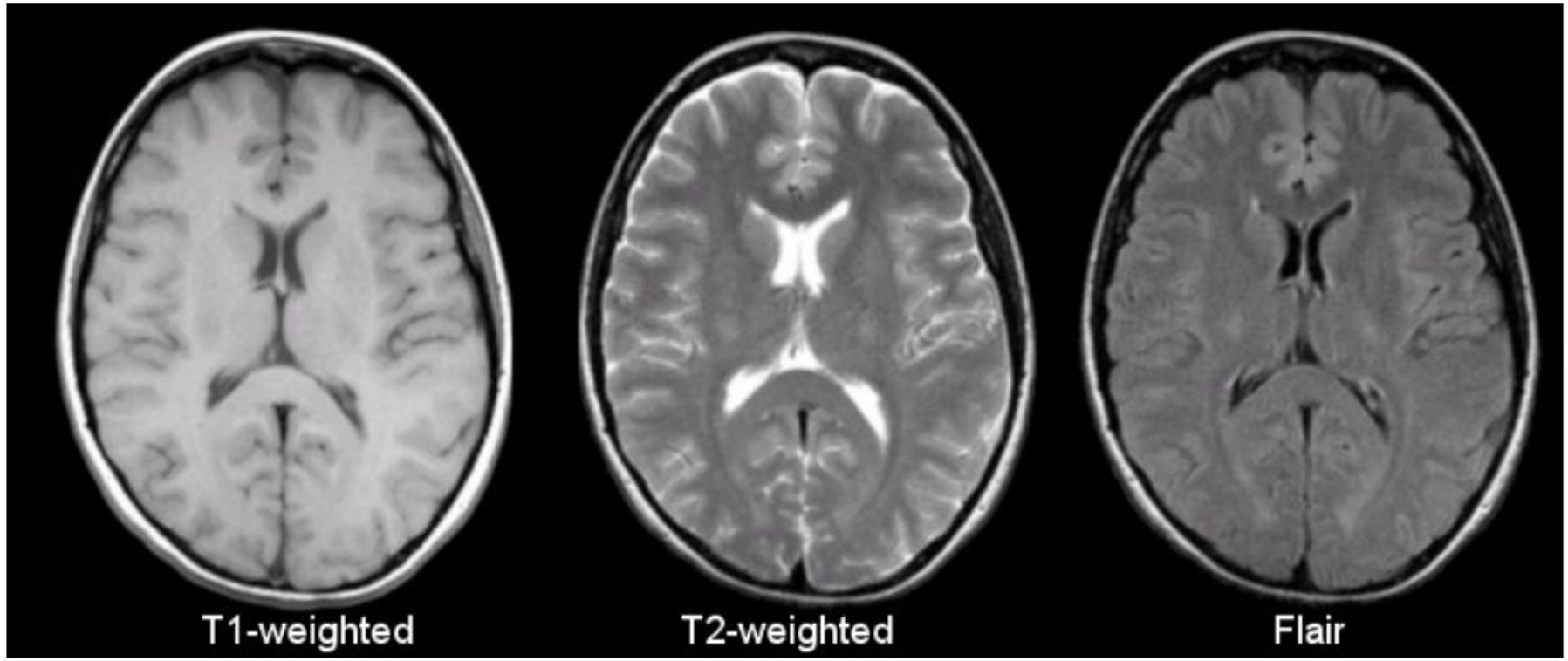
A. The figure 1 must be T1-weighted image due to higher signal intensity of white matter than grey matter.

B. If there is inflammation in a tissue the inflamed area would be of higher intensity in T2-weighted due to the resulting oedema.

C. the major secretions of the organ in figure 2 which is marked as **A**, are amylase and lipase.

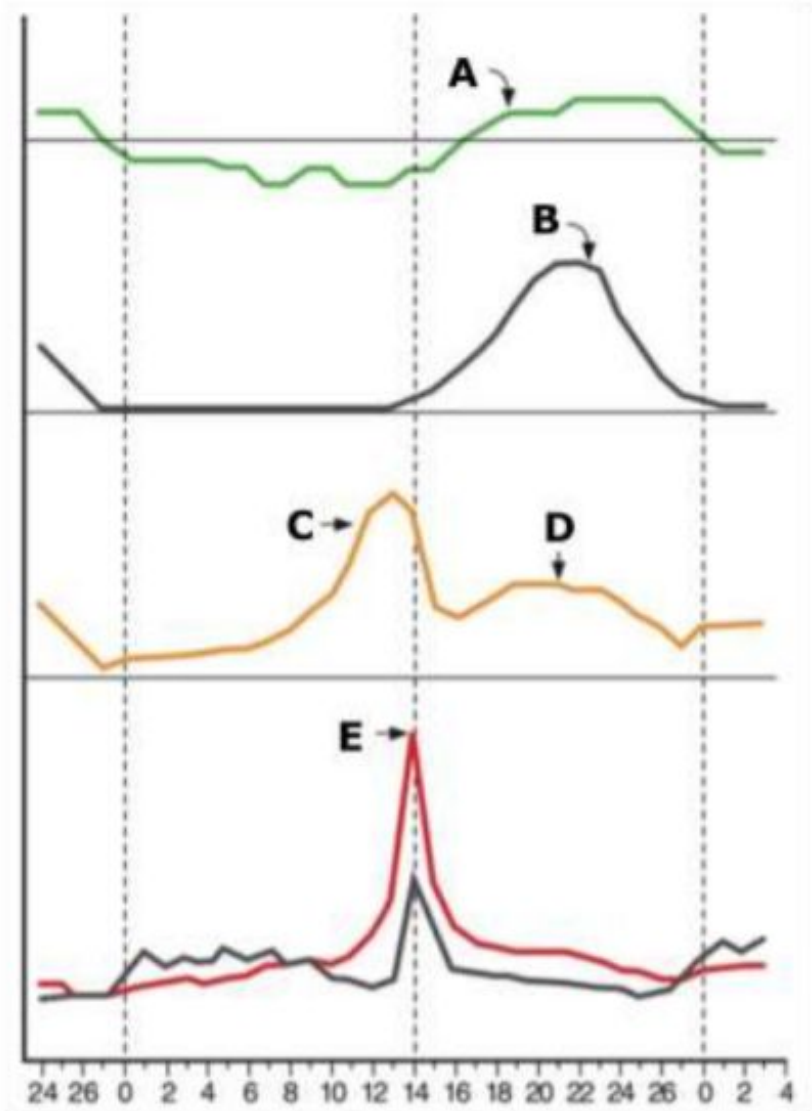
D. In figure 2 the part **B** is shorter in herbivores than carnivore mammals.

Comparison of T1 vs. T2 vs. Flair (Brain)



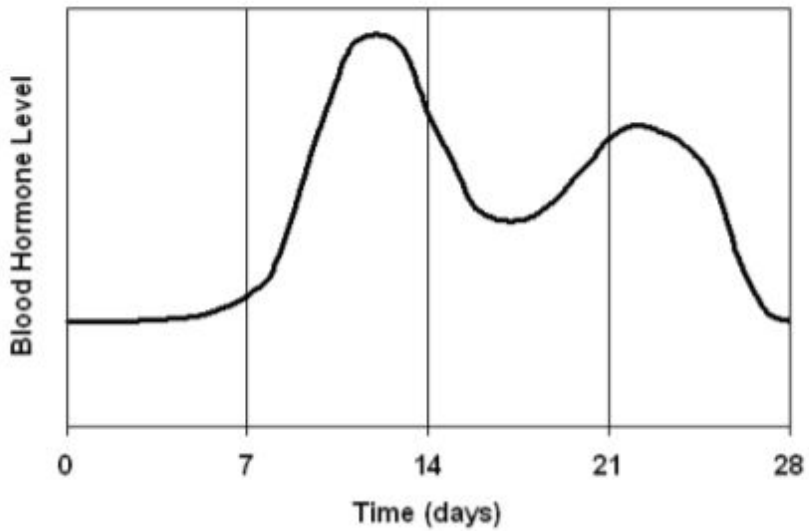
Tissue	T1-Weighted	T2-Weighted	Flair
CSF	Dark	Bright	Dark
White Matter	Light	Dark Gray	Dark Gray
Cortex	Gray	Light Gray	Light Gray
Fat (within bone marrow)	Bright	Light	Light
Inflammation (infection, demyelination)	Dark	Bright	Bright

The menstrual cycle is the regular natural change that occurs in the female reproductive system. In the ovary, where oogenesis take place, each cycle can be divided into three phases consisting of the follicular phase, ovulation and luteal phase. The menstrual cycle is controlled by hormones of hypothalamus-pituitary-ovary axis. The figure shows alternations in body temperature and hormonal changes during the menstrual cycle.



		True	False
A.	The increase shown at point A is caused by the effect of oestrogen on the anterior pituitary.	☐	☐
B.	Curve B shows changes in progesterone level during menstrual cycle.	☐	☐
C.	The source of the increase in concentrations indicated at point C and D are granulosa cells and corpus luteum, respectively.	☐	☐
D.	Substance E is secreted by follicular cells.	☐	☐
E.	The cause of the sudden increase shown at point E is positive feedback of oestrogen on the anterior pituitary and absence of progesterone.	☐	☐

27. Menstruation cycle involves several hormones. One of the hormones in the menstruation cycle has a fluctuation pattern as shown below :



Indicate if each of the following statements is true or false

A. The first peak in the hormone level triggers ovulation.
B. The physiological effect of the hormone is instantly mediated by cell surface receptors.
C. The peaks result from hormones produced by the oocytes.
D. If implantation occurs, plasma concentration of the hormone is maintained at high level.

Q. 22 – Coombs Test

There are two clinical tests to detect some antibodies against erythrocytes (RBCs), direct coombs test and indirect coombs test.

During the direct coombs test a blood sample is taken from a person. RBCs are washed (removing the patient's own plasma) and then incubated with anti-human globulin, which attaches to all IgG antibodies. Coombs test is positive if agglutination reaction occurs.

In the indirect coombs test, serum is extracted from the blood sample taken from the person. Then, the serum gets incubated with RBCs of known antigenicity and is washed. Finally, anti-human globulin is added. If agglutination occurs, the indirect coombs test is positive.

		True	False
A.	Direct coombs test will be positive only if autoantibodies are present.	☐	☐
B.	If the result of indirect coombs test using serum of patient 1 and RBCs of patient 2 is positive, so we can use the patient 2 as a blood donor for patient 1.	☐	☐
C.	Anti-human globulin specifically binds to the variable part of human antibodies.	☐	☐
D.	In a positive indirect coombs test, antigen-antibody reaction happens *in vivo*.	☐	☐

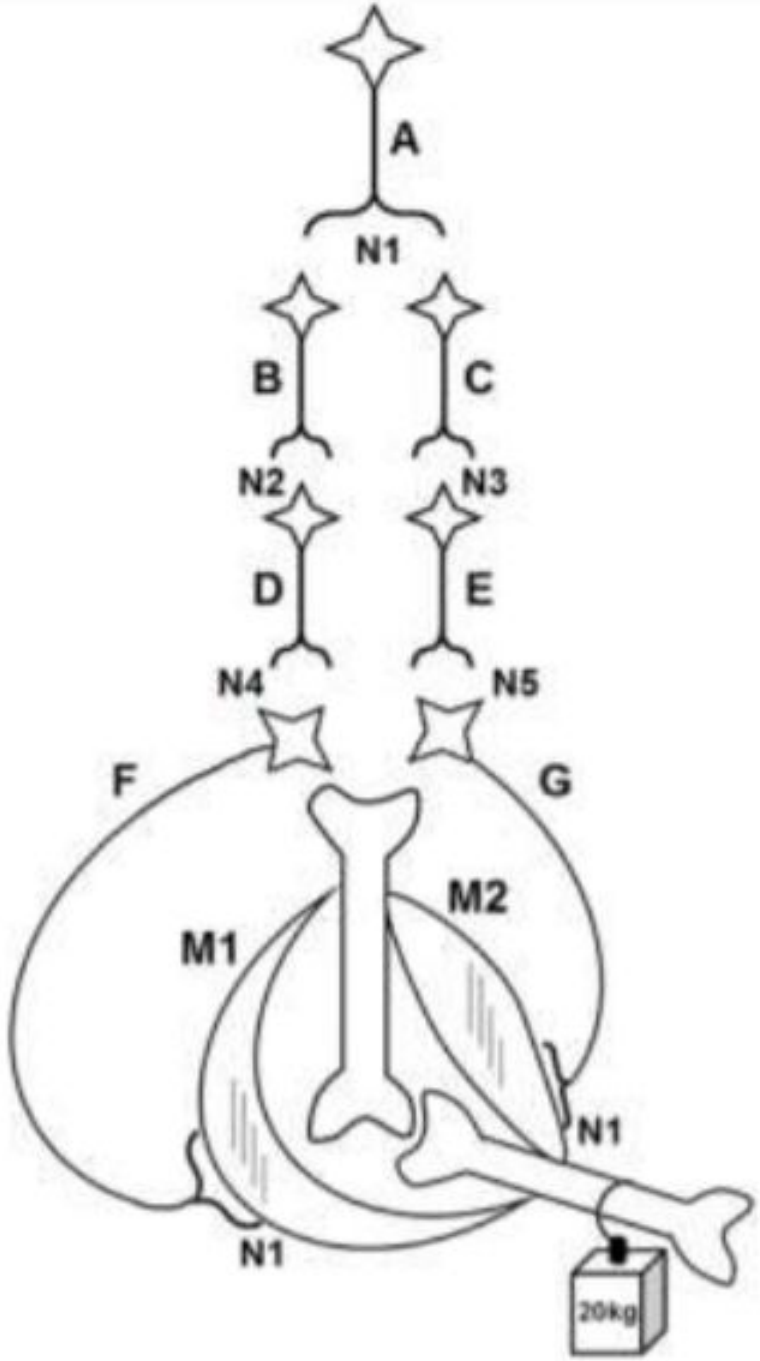
Q. 23 – Neural Network

The diagram below illustrates a neural pathway and the features of the associated neurotransmitters are described in the table.

Ions concentrations inside and outside of the cells are same as their physiological normal values in body and inhibition of an inhibitory neuron results in the stimulation of postsynaptic neuron.

"+" Symbol in table indicate the activation of the ion channels which increases the ion permeability across the membrane.

Neurotransmitter	Cl- Permeability	Na+ Permeability	K+ Permeability
N1		+	
N2	+		
N3			+
N4	+		
N5		+	



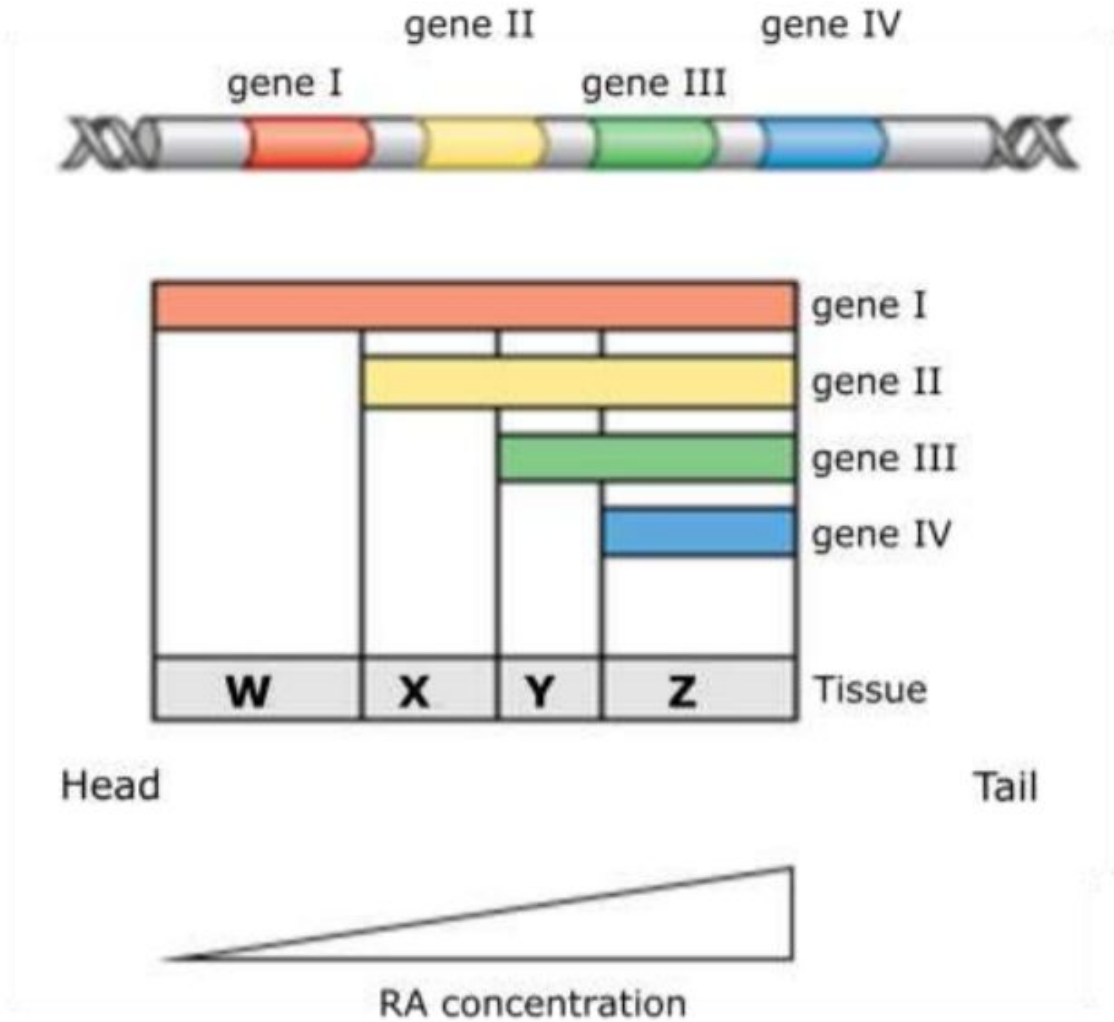
A. The function of N1 neurotransmitter is same as acetylcholine.

B. Neuron G is not depolarized and neuron F is stimulated so muscle M1 contracts.

C. Neuron G gets depolarized as a result of Na ions influx.

D. Neuron F gets depolarized as a result of Cl ions efflux.

Neural tube in the vertebrate embryos, lies the anterior-posterior (AP) axis and creates a variety of structures. There is a large body of evidence showing that AP patterning of the vertebrate embryos is controlled by *HOX* genes. Spatial and temporal expression patterns of *HOX* genes are controlled by factors usually present as gradients in the AP axis of embryos. One of these gradients is generated by retinoic acid (RA), a derivative of vitamin A, with a maximum concentration in the posterior region of the embryos (Figure below).



A. Overuse of vitamin A by pregnant women may cause abnormalities in the embryos.

B. In an embryo that has been affected by excessive amounts of RA in the early stages of embryogenesis, the forebrain may not form.

C. Loss of function of a *HOX* gene in the embryo may have the same effect as an excessive amount of RA.

D. In an embryo whose expression of RA nuclear receptors has been downregulated, the midbrain may develop similar to the forebrain.

In snail, the direction of cleavage, and therefore the snail shell coiling, is controlled by a single gene, in which the right-coiling allele, D, is dominant to the left-coiling allele, d. Below table shows the results of a set of mating experiment.

	Genotype	Phenotype
DD♀ x dd♂ →	Dd	All right-coiling
DD♂ x dd♀ →	Dd	All left-coiling
Dd x Dd →	1DD:2Dd:1dd	All right-coiling

		True	False
A.	The direction of cleavage is determined by the genotype of the developing snail.	☐	☐
B.	If the egg cytoplasm of a recessive homozygous right-coiling mother is injected into the eggs of the "dd" mother, the resulting embryos coil to the left.	☐	☐
C.	Injection of the egg cytoplasm from a heterozygous left-coiling mother into the eggs of the right coiling heterozygous mother, does not affect the right-coiling in the embryos.	☐	☐
D.	"DD" or "Dd" mothers place a coiling determinant factor inside the egg cytoplasm.	☐	☐

Electrocardiography is a method to study the electrical activity of the heart (ECG). In addition to P, QRS and T waves, there are segments and intervals which are defined to show a specific period of time in a cardiac cycle. A variety of different factors like concentration of electrolytes, drugs and temperature could have an effect on waves and intervals of ECG. A group of researchers have studied the effect of body temperature on QT and RR interval in electrocardiogram of beagle dogs. The result of their study is demonstrated in the figures.

Note that RR interval is the time between two consecutive R waves and QT interval is the exact time before start of Q wave till the end of the next T wave.

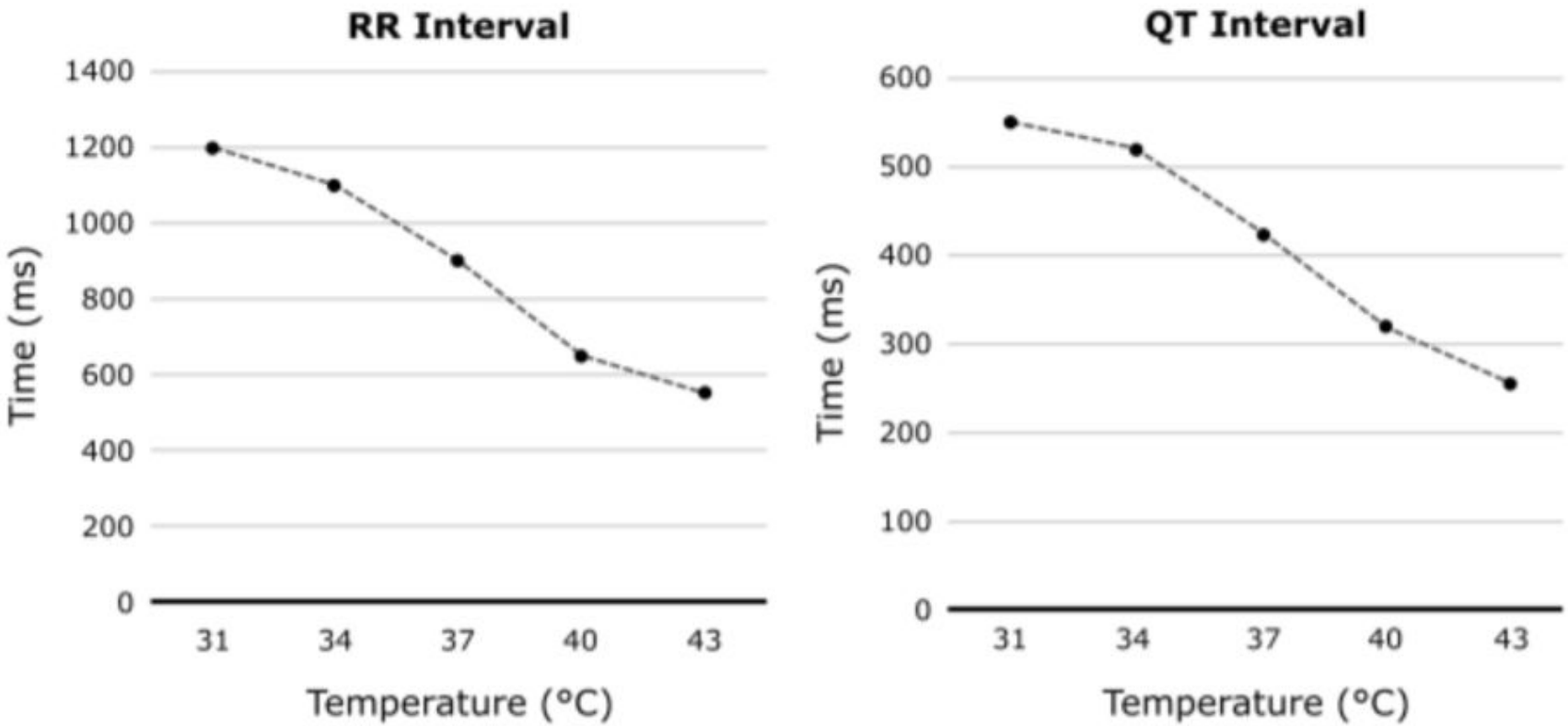
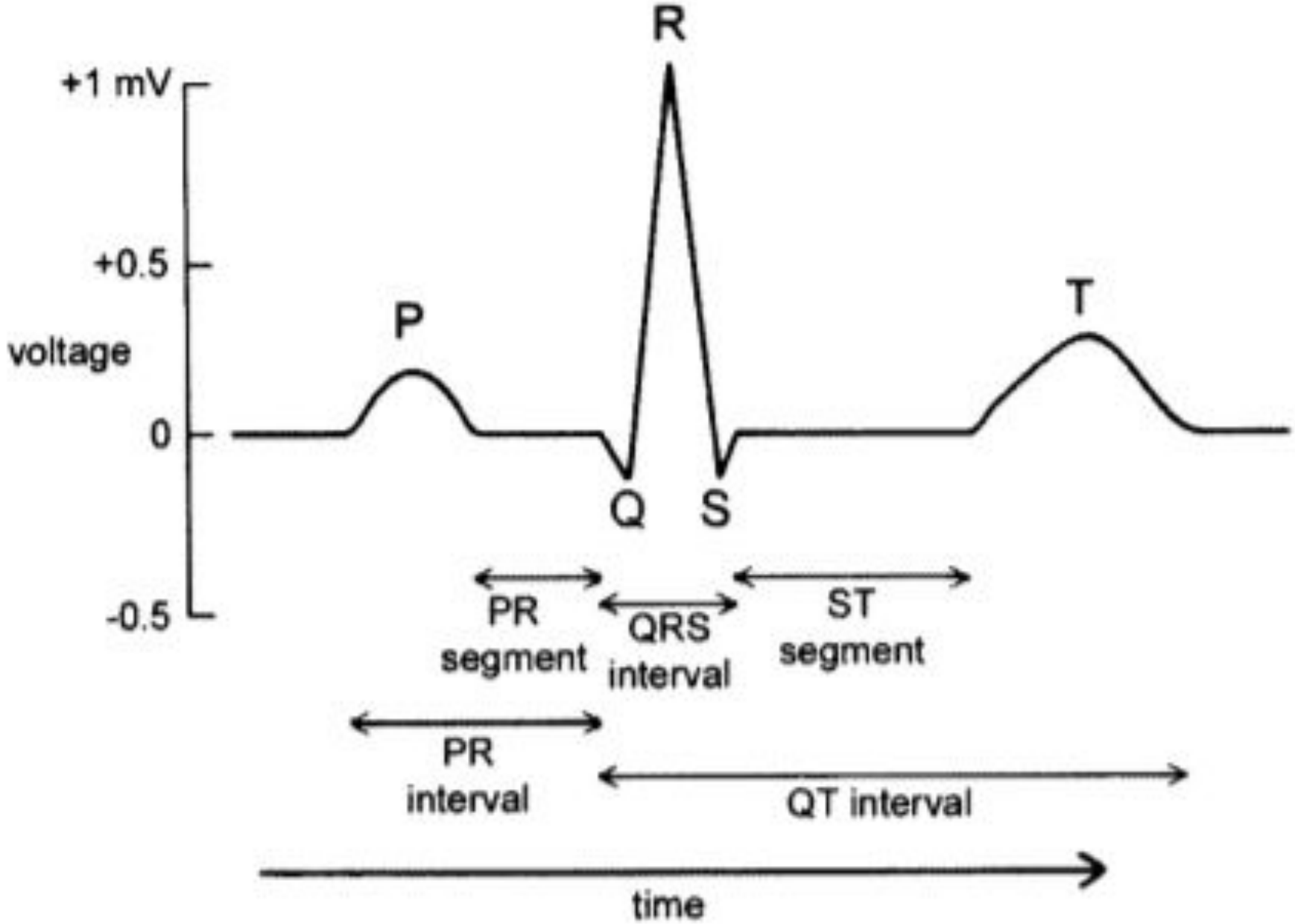


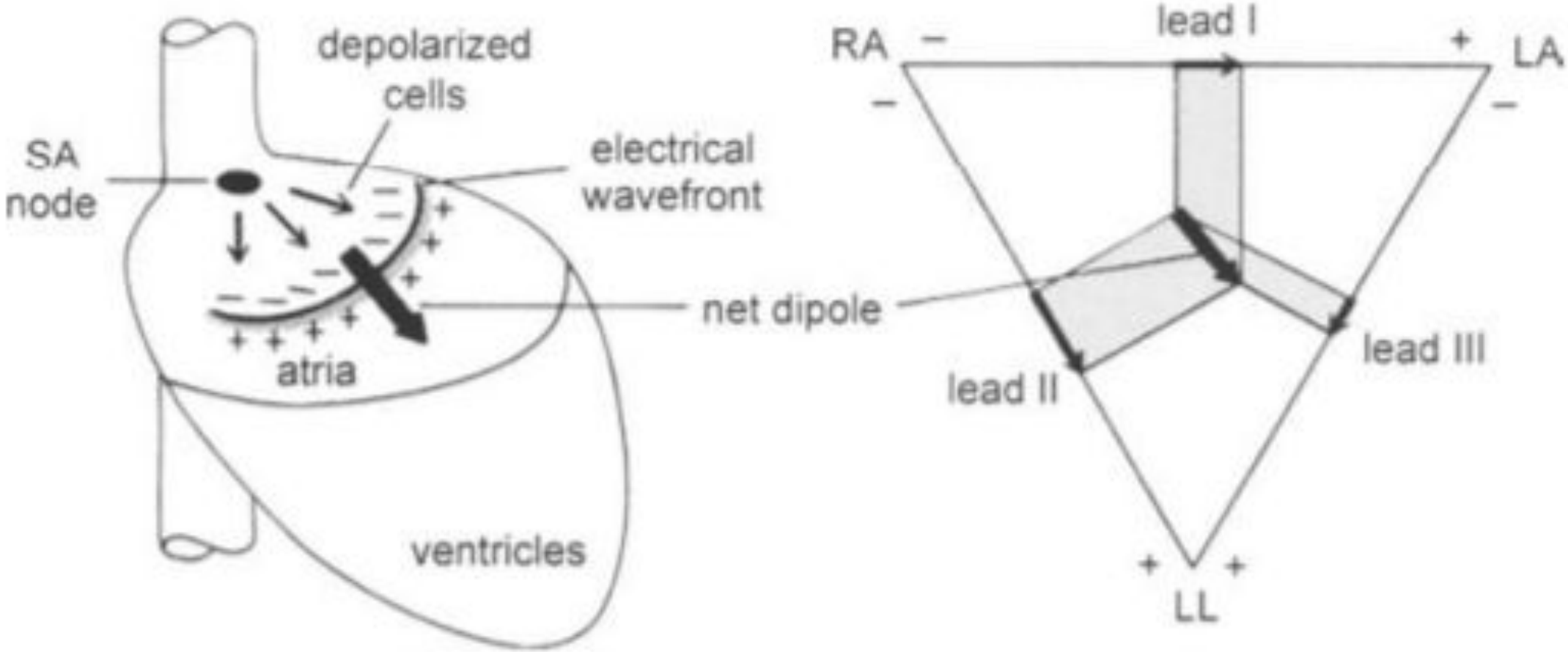
Figure *(left)* Relation between RR Interval and body temperature. *(right)* Relation between QT Interval and body temperature.

Given that QT interval gets shorten by the shortening of the RR interval, a formula (given below) has been approved to calculate a corrected QT interval (QTc) to allow the comparison of QT interval over time at different heart rates.

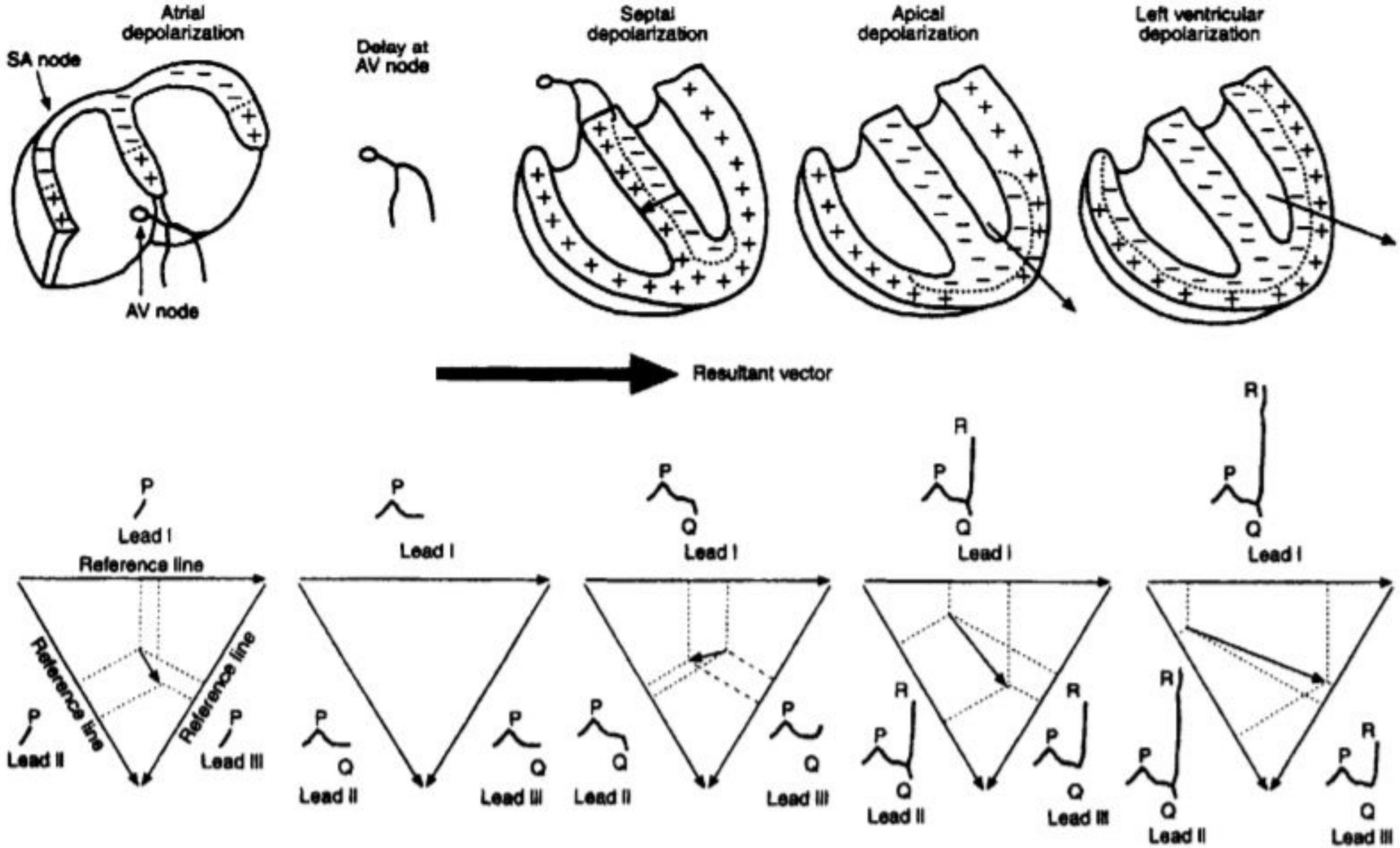
Hodges formula: $QTC = QT + 1.75\ (\text{heart rate} - 60)$

		True	False
A.	Body temperature does not have any effect on heart rate.	☐	☐
B.	Independent of changes of heart rate, QT interval is shortened by rise of body temperature.	☐	☐
C.	Hypocalcaemia will shorten the QTc interval.	☐	☐
D.	In higher body temperature, end diastolic volume of ventricles is increased.	☐	☐

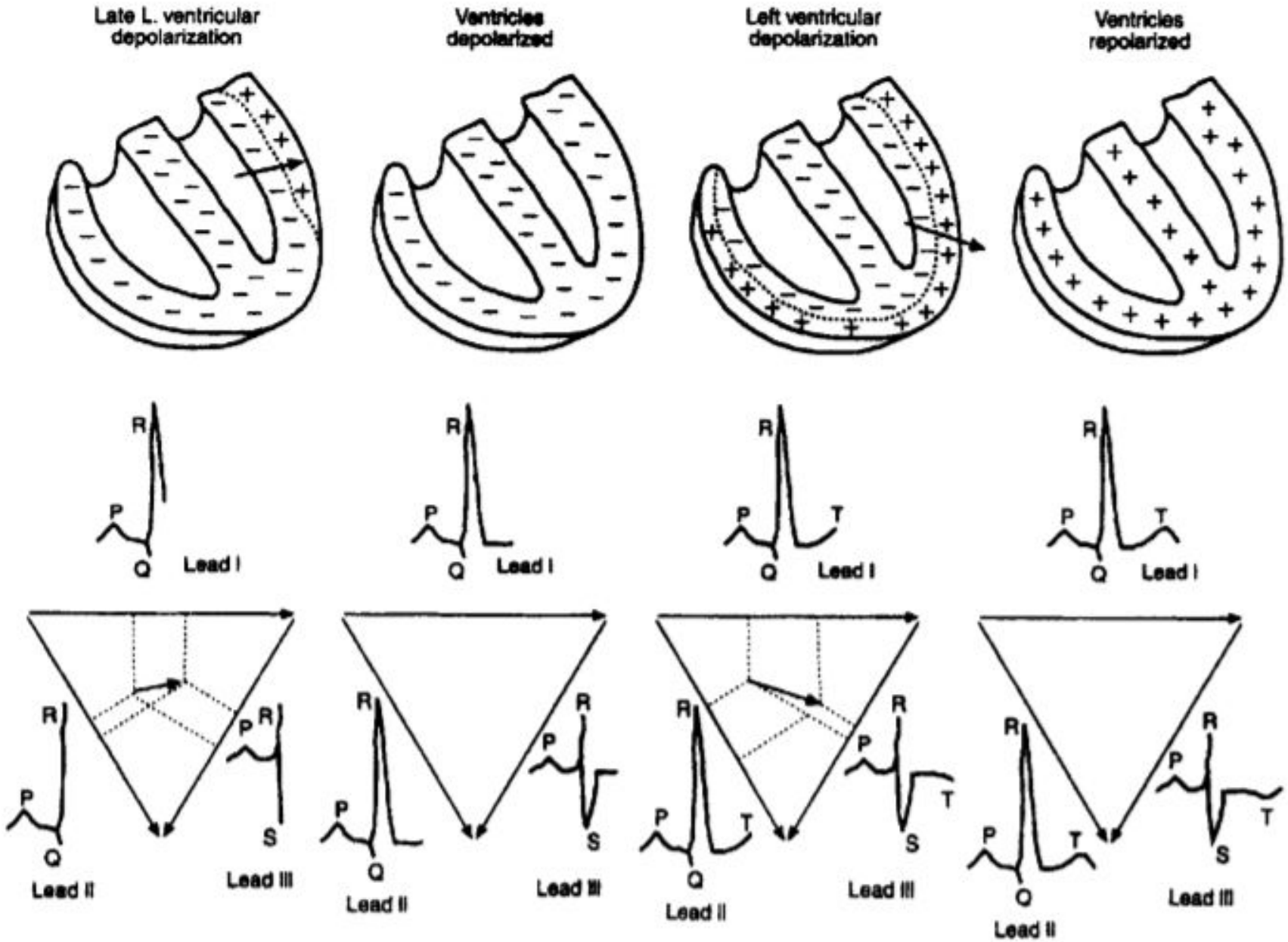

R
+1 mV
+0.5
voltage
P
T
0
Q
S
-0.5
PR
segment
QRS
interval
ST
segment
PR
interval
QT interval
time

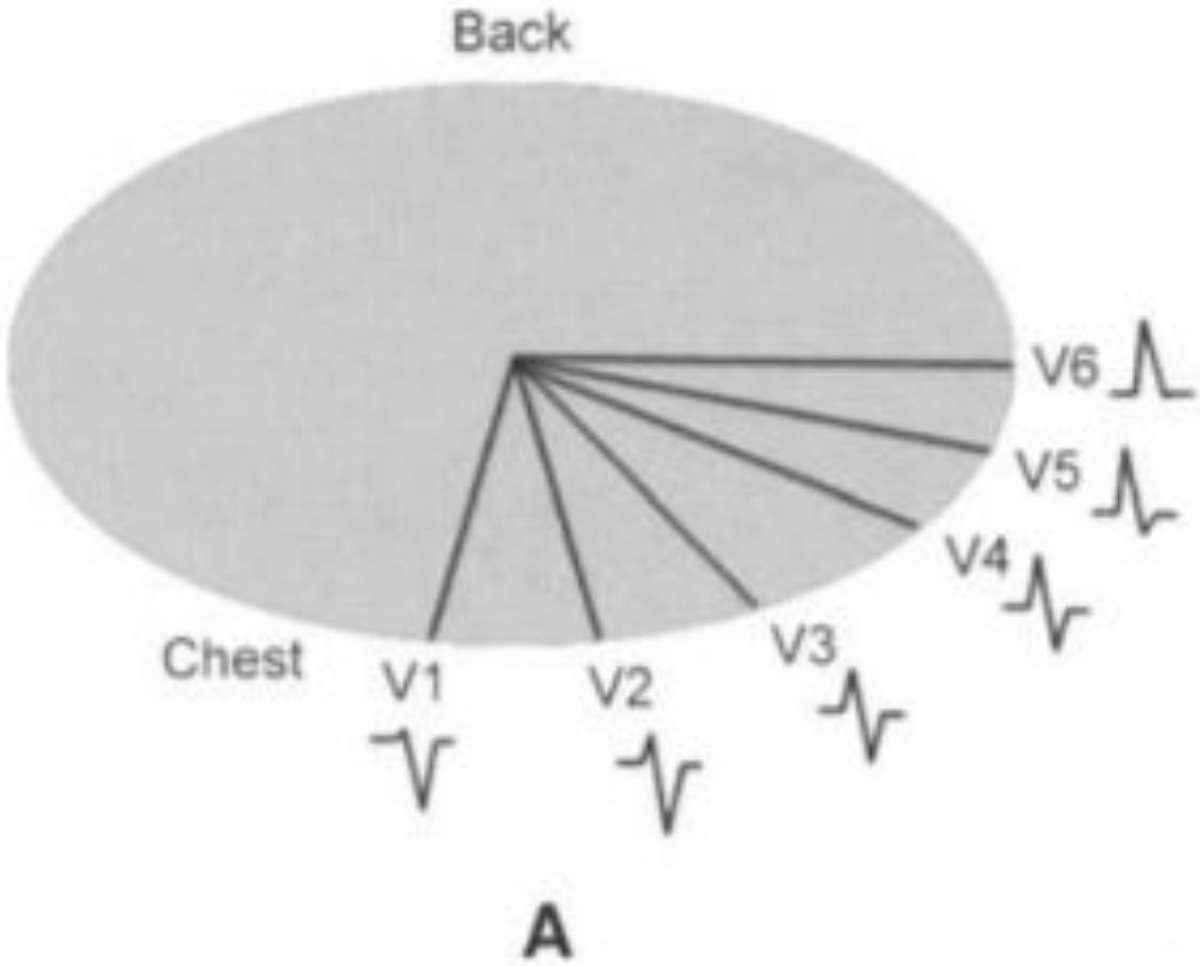

depolarized cells
SA node
electrical wavefront
net dipole
atria
ventricles
RA
lead I
LA
lead II
lead III
LL

Progression of depolarization

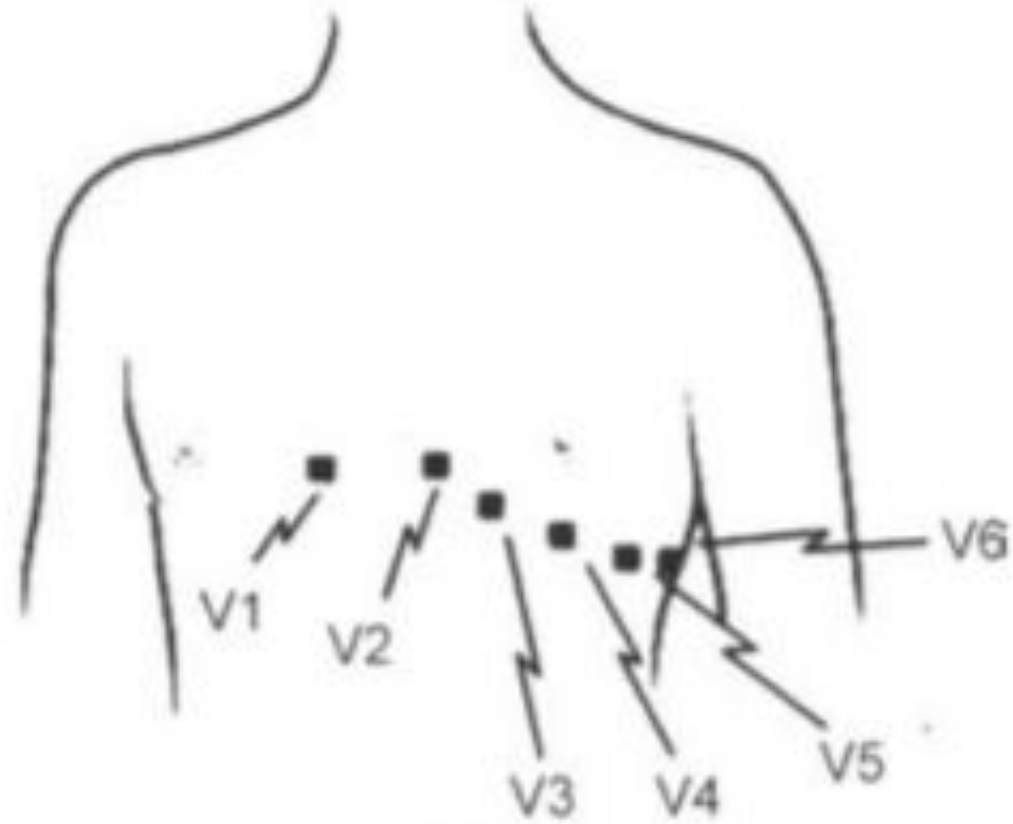


End of depolarization and repolarization

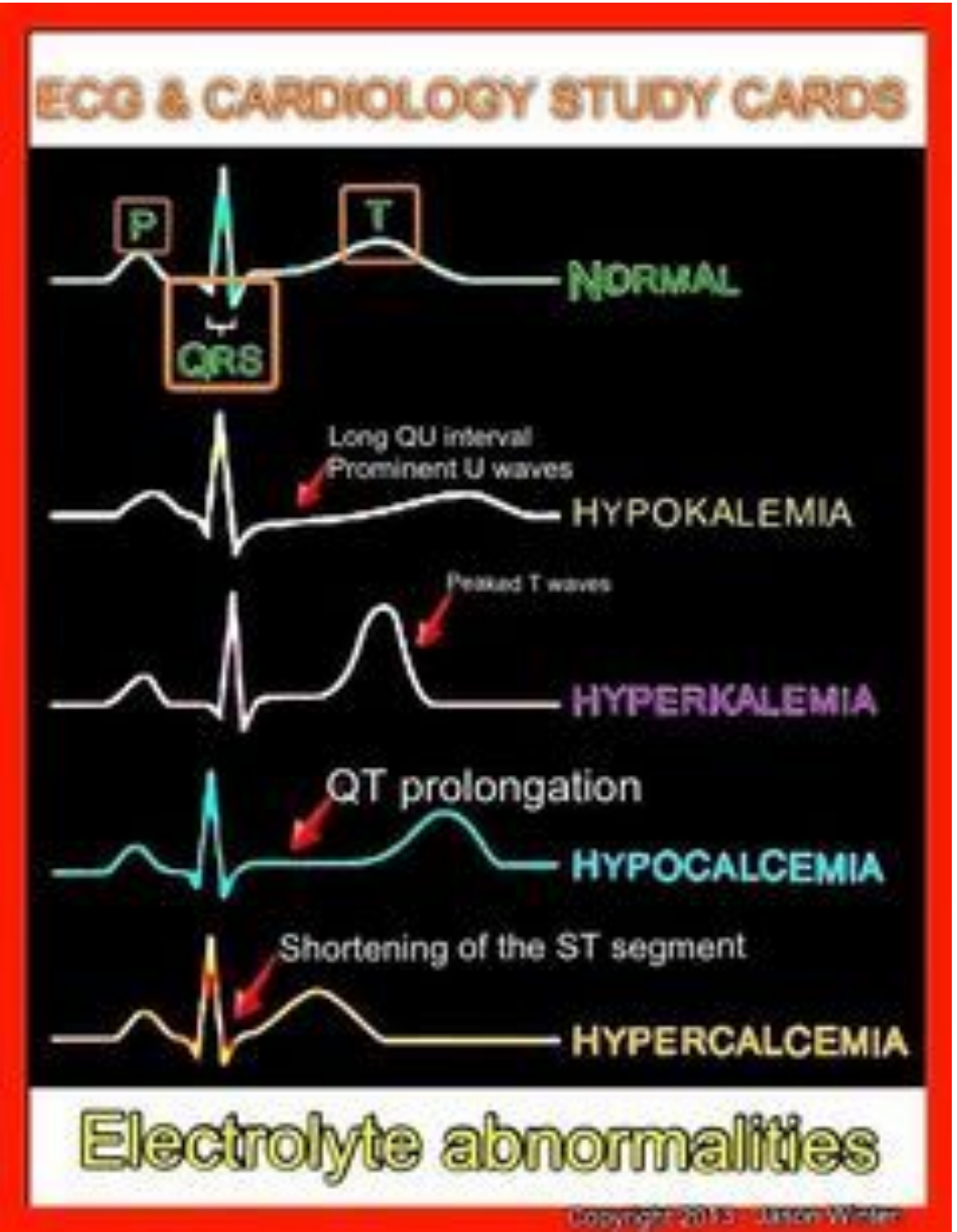


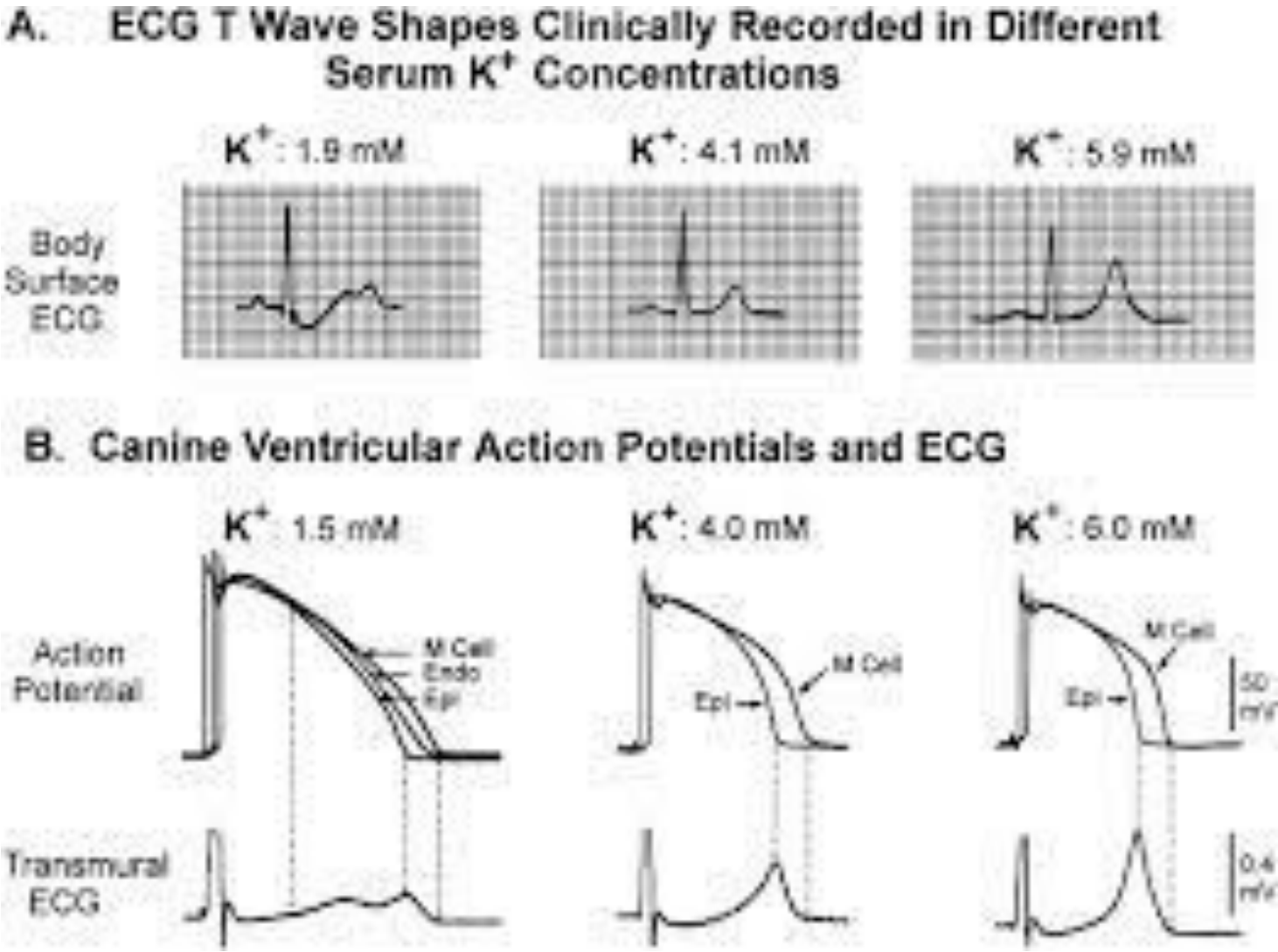


A



B


ECG & CARDIOLOGY STUDY CARDS
P
T
QRS
NORMAL
Long QU interval
Prominent U waves
HYPOKALEMIA
Peaked T waves
HYPERKALEMIA
QT prolongation
HYPOCALCEMIA
Shortening of the ST segment
HYPERCALCEMIA
Electrolyte abnormalities
Copyright 2013 - Jason Winter


A. ECG T Wave Shapes Clinically Recorded in Different Serum K+ Concentrations
K+: 1.9 mM
K+: 4.1 mM
K+: 5.9 mM
Body Surface ECG
B. Canine Ventricular Action Potentials and ECG
K+ 1.5 mM
K+: 4.0 mM
K+: 6.0 mM
Action Potential
M Cell
Endo
Epi
Transmural ECG

1. What portion of the ECG would change if there is a delay in the conduction between the SA node and the AV node?

2. 2. Will the ECG change when heart rate increases?

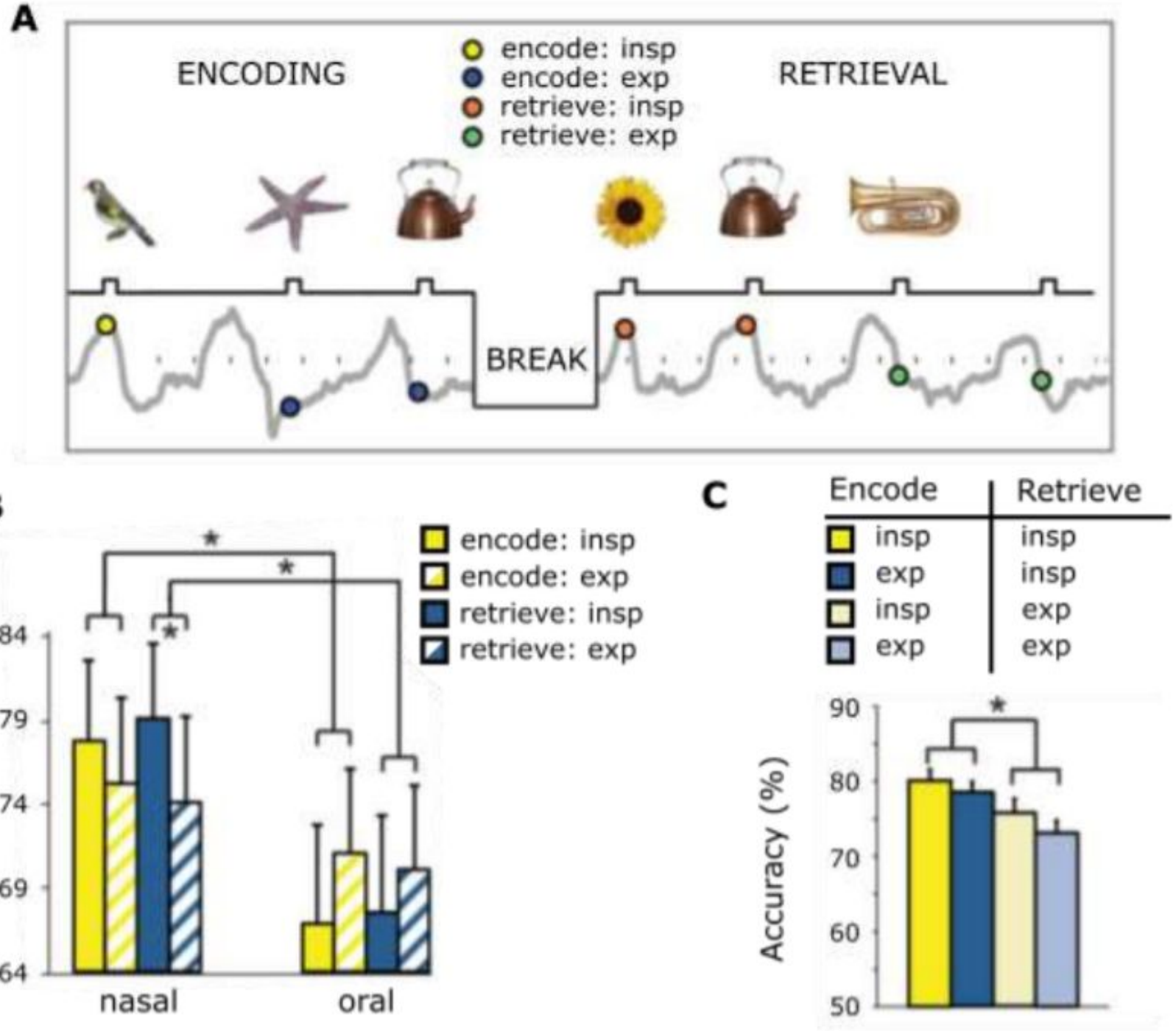
In a recognition memory task, subjects (human being) viewed a series of different visual objects that occurred at different times within the breathing cycle. The interval between displaying images was 3–6 seconds. After a 20 min break, subjects were presented with the old pictures from the encoding session plus an equal number of new pictures; and the subjects pressed the "Yes" button if they had previously viewed the object's image, and pressed the "No" button if the image was new. Subjects' memory performance was examined in the episodes of inspiration and expiration, and in mouth breathing and nasal breathing (In figures "*" means $p < 0.05$ which indicates significant difference between groups).

A. The inspiration and expiration phase does not affect memory performance during oral breathing.

B. Memory function during nasal breathing is significantly more accurate than during oral breathing.

C. Regardless of the respiratory phase in which the image is encoded, if the object's images are depicted in the inspiration phase during the retrieval, memory performance is significantly greater.

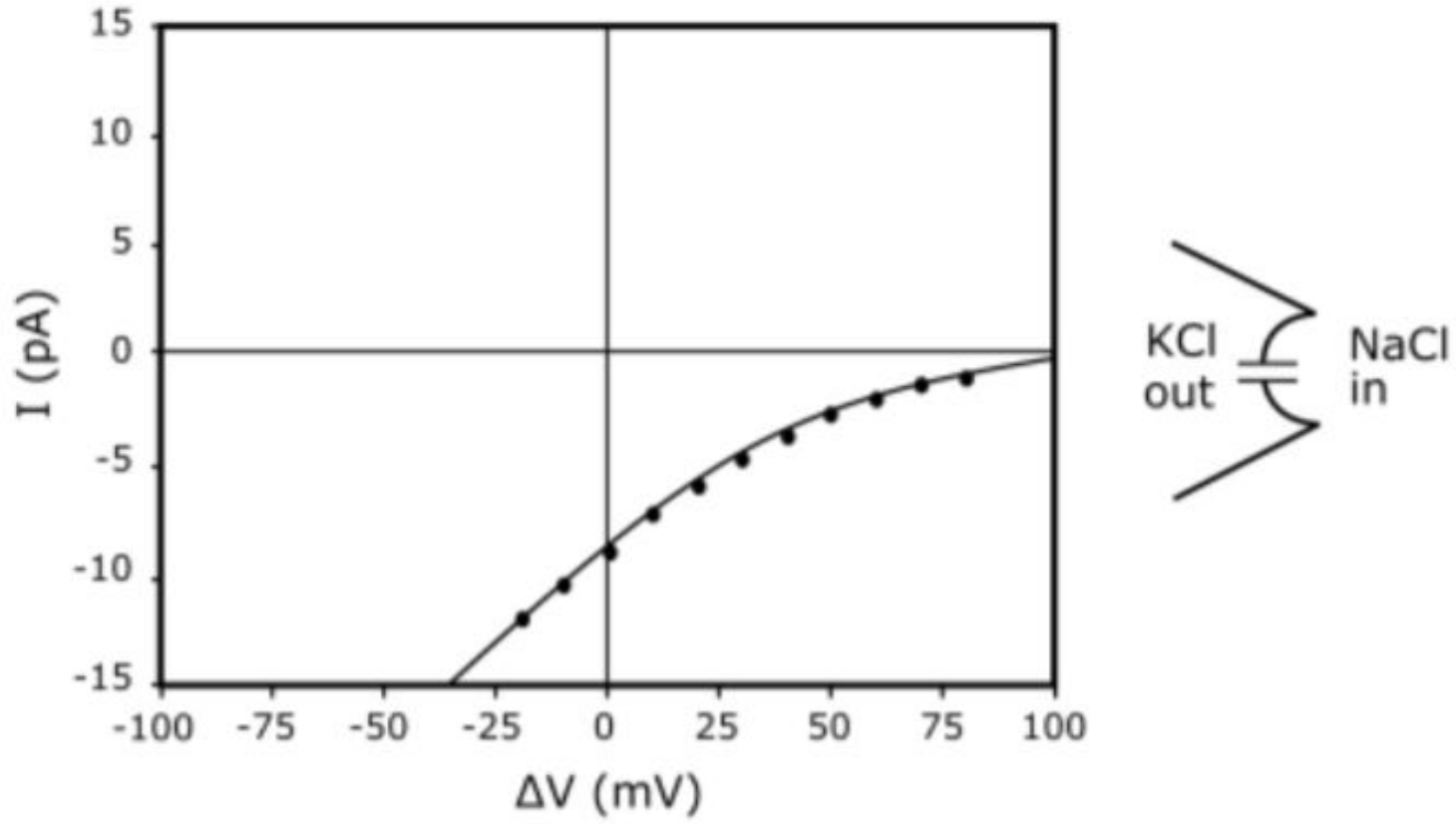
D. In breathing through the nose, unlike encoding, the accuracy of retrieval in the inspiration phase is significantly higher than in the expiration phase.


A
ENCODING
encode: insp
encode: exp
retrieve: insp
retrieve: exp
RETRIEVAL
BREAK
B
encode: insp
encode: exp
retrieve: insp
retrieve: exp
Accuracy (%)
84
79
74
69
64
nasal
oral
C
Encode
Retrieve
insp
insp
exp
insp
insp
exp
exp
exp
Accuracy (%)
90
80
70
60
50

A researcher used a patch clamp technique to record the current of only a cation channel (single channel recording). The pipette contains 150 mM of KCl surrounded by a bath solution containing 150 mM of NaCl, and measures the channel current by clamping the voltage in different values. Current-Voltage curve (I-V curve) is shown in the following figure. $\Delta V = V_{interior} - V_{exterior}$.

A negative current value (i.e., inward current) can reflect either the movement of positive ions (cations) into the cell or negative ions (anions) out of the cell.

A positive current value (i.e., outward current) can reflect either the movement of positive ions (cations) out of the cell or negative ions (anions) into the cell.



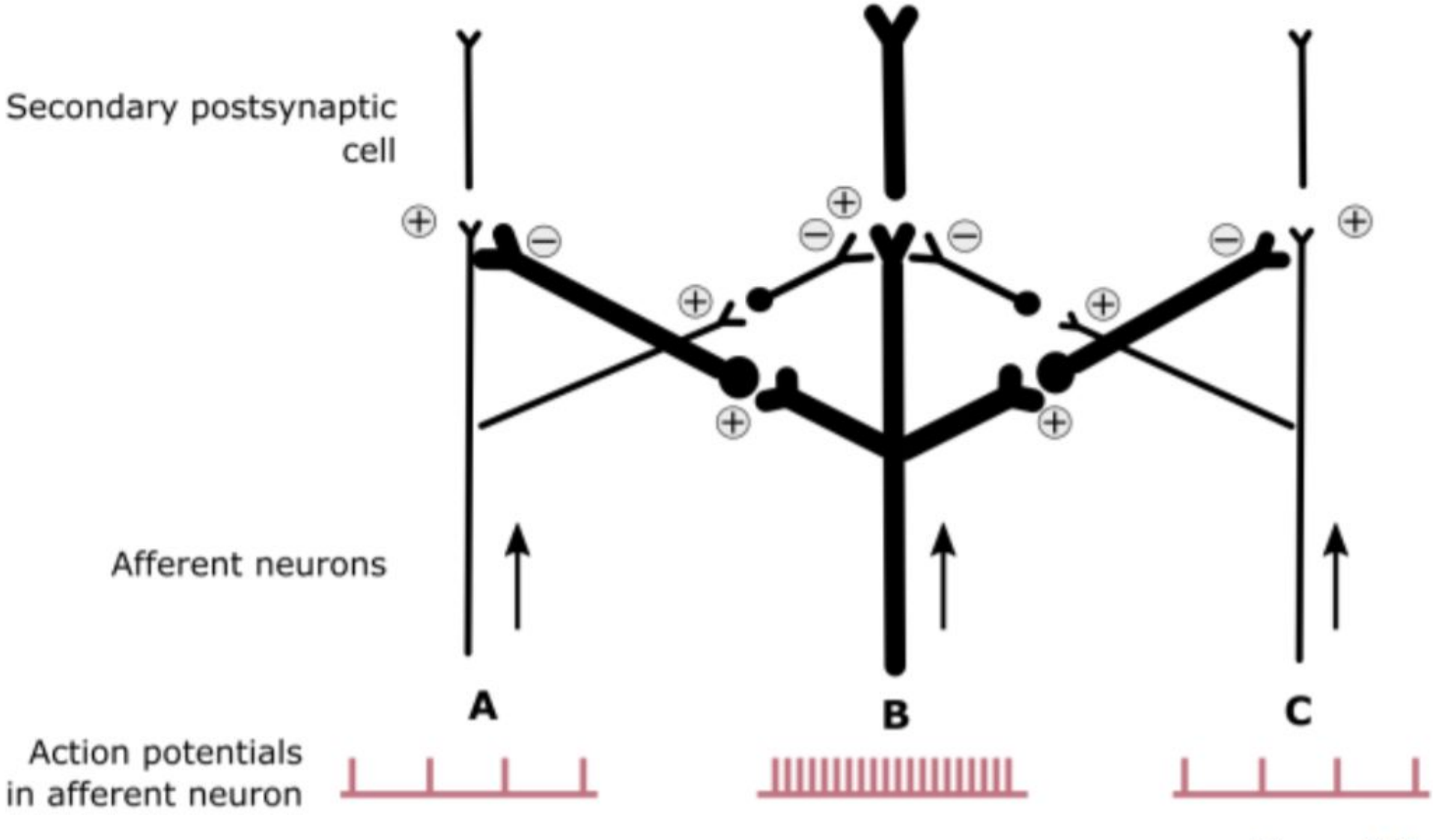
A. This channel is not selective, and both K^+ and Na^+ ions pass through this channel.

B. The Na^+ current decreases with increasing voltage.

C. The K^+ current increases with increasing voltage.

D. The resistance of the channel to negative voltages is less than positive voltages.

As it is shown in the figure, the sensory neurons can modify the function of adjacent sensory pathway. This inhibitory effect is conducted via intermediate neurons at their synapse with second-order neurons. The width of neurons is correlated with their activity.



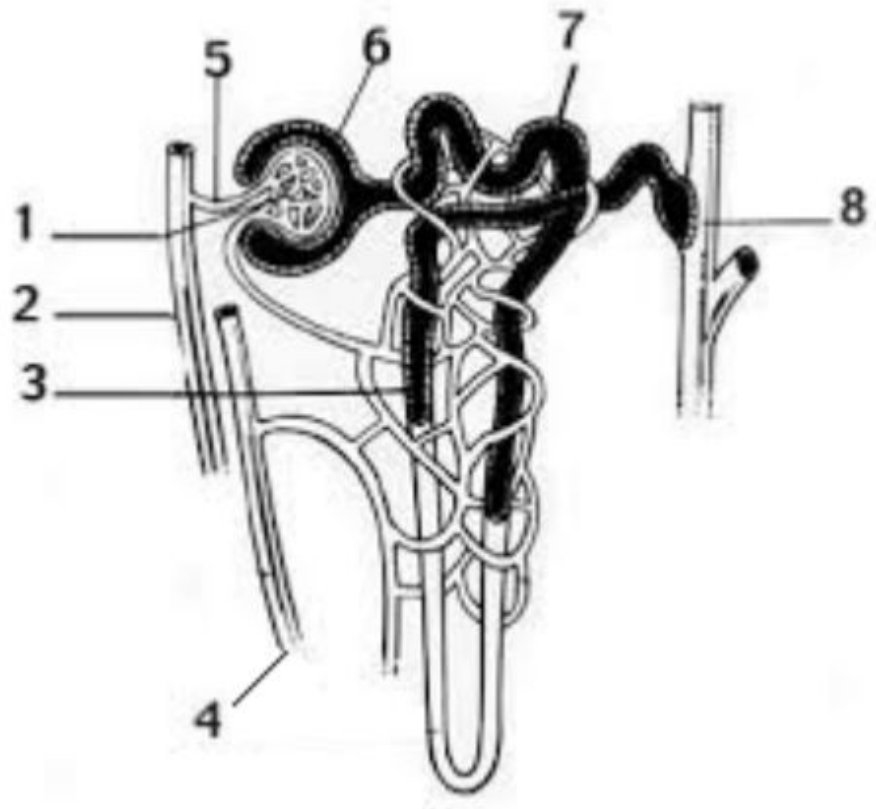
A. The firing rate of all second-order neurons is higher than to first-order neurons.

B. The highest relative changes between second and first-order neurons will happen in Path B.

C. The difference between the firing rate of second order neurons in A and B pathways will be higher than the difference between firing rate of the first order neuron in these pathways.

D. This mechanism may help to localize the sensory stimulus more accurately.

22. The process of urine formation takes place in the nephron.



Indicate if each of the following statements is true or false.

A. Transport from 5 to 6 in the figure, is dependent on blood pressure.
B. The most important process in the structure labelled 7 in the figure is ATP-dependent directly or indirectly.
C. The concentration of HCO_3^- is higher in structure 2 than in 4.
D. The water reabsorption in the structure labeled 8 is driven by a concentration gradient.

Summary of Factors Affecting GFR

Factor	Effect
Vasoconstriction (↑ Sympathetic stimulation)	
Afferent arteriole	↓ GFR
Efferent arteriole	↑ GFR
Vasodilation (↓ Sympathetic stimulation)	
Afferent arteriole	↑ GFR
Efferent arteriole	↓ GFR
Increased capillary hydrostatic pressure	↑ GFR
Increased colloid osmotic pressure	↓ GFR
Increased capsular hydrostatic pressure	↓ GFR

29. X-linked agammaglobulinemia (AGG) disease occurs mostly in boys. X-linked agammaglobulinemia patients have a non-functional bruton tyrosine kinase (BTK), a protein essential for the development and maturation of B cells. The concentrations of several immunoglobulins of a 5-year old boy with AGG were compared with standard normal conditions. .

	Patient values mg mL^{-1}	Standard values mg mL^{-1}
IgG	0.80	6-15
IgA	0	0.50-1.25
IgM	0.10	0.75-1.50
IgE	0	0.005

Indicate if each of the following statements is true or false.

AGG boys:

A. have larger tonsils and spleens than normal children.

B. are more vulnerable to infection by pathogens through the gastrointestinal tract.

C. do not show evidence of this condition in the first six months of life.

D. will not experience allergy to pollen.

25. A 15-year-old boy was diagnosed as a case of Duchenne muscular dystrophy (DMD) and presented with progressive proximal weakness of the lower limbs starting at 4 years old followed by involvement of the upper limbs. In DMD, there is a mutation in dystrophin gene leading to the absence of the corresponding protein. Dystrophin is a molecular 'shock absorber' in the sarcolemma and has a major structural role in muscle as it links the internal cytoskeleton to the extracellular matrix.

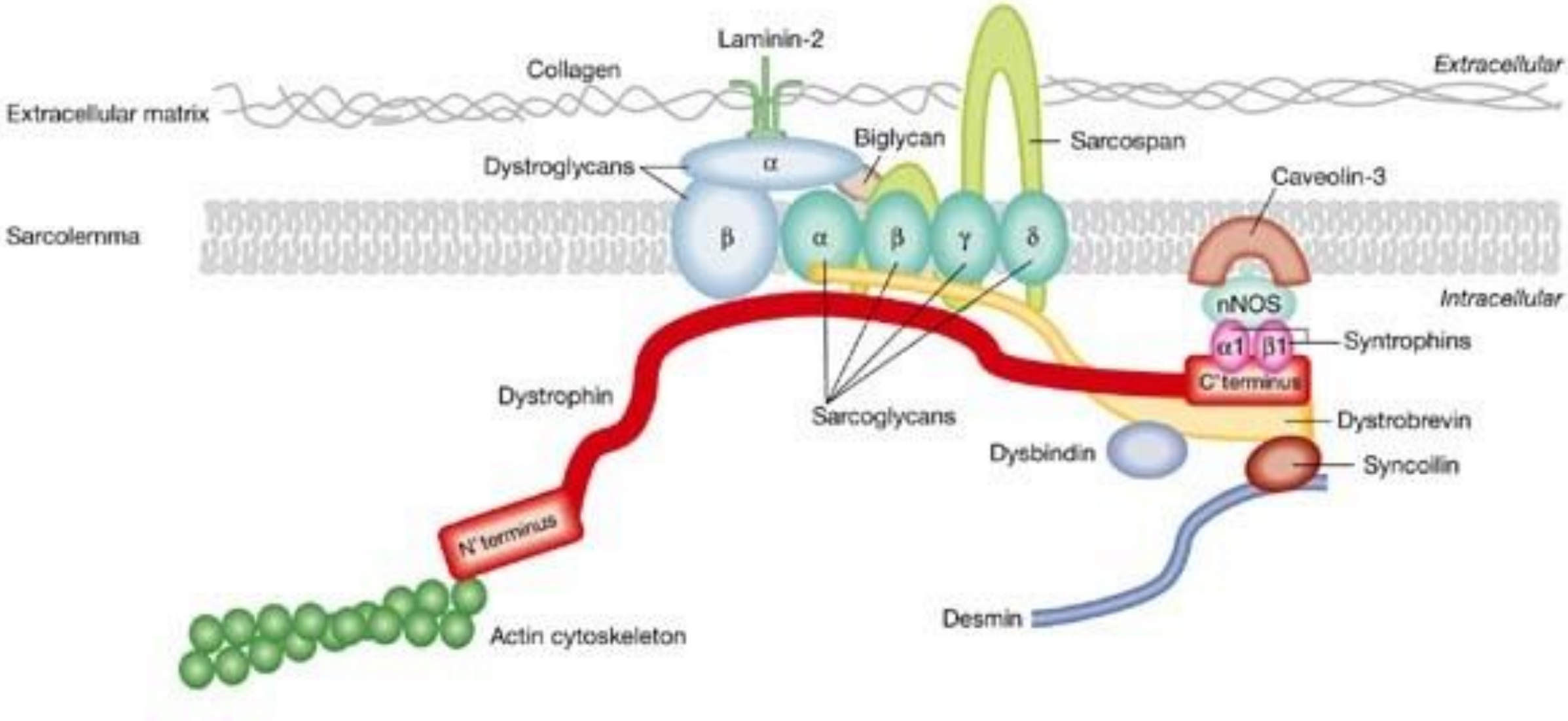
Indicate if each of the following statements is true or false.

A. Increased levels of creatine kinase and other muscle-specific proteins in the blood plasm are used to diagnose the DMD

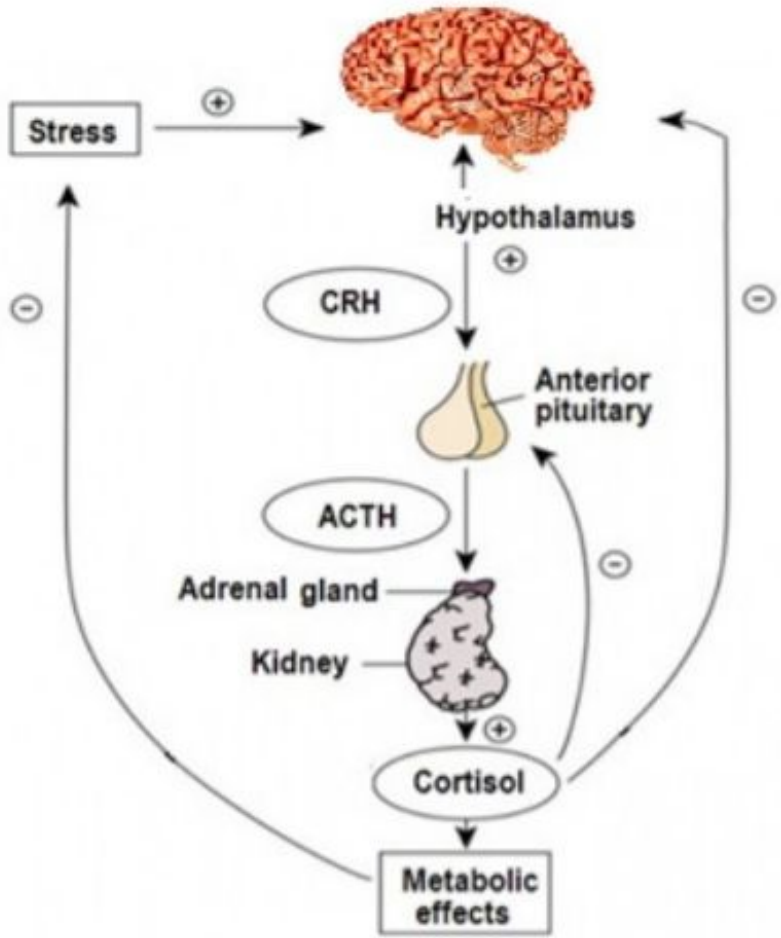
B. ATP cannot bind to myosin heads in the muscle of DMD.

C. Motor neurons can initiate contraction in muscle fiber of DMD.

D. The maximal contractile force of skeletal muscles is significantly reduced in DMD.


Laminin-2
Collagen
Extracellular matrix
Extracellular
Biglycan
Sarcospan
Dystroglycans
α
Caveolin-3
Sarcolemma
β
α
β
γ
δ
nNOS
Intracellular
α1
β1
Syntrophins
C terminus
Dystrophin
Sarcoglycans
Dystrobrevin
Dysbindin
Syncoilin
N terminus
Desmin
Actin cytoskeleton

22. The diagram outlines the feedback mechanisms regulating secretion of stress hormones in the human body.



Levels of hormones involved in stress responses can be abnormal in a large number of clinical states

Indicate if each of the following statements is true or false.

	CRH	ACTH	Cortisol	Cause
A.	High	High	High	Long term stress
B.	High	High	Low	Chronic adrenal insufficiency (Addisons' disease)
C.	Low	Low	High	Adrenal hyperfunction (Chusing's disease)
D.	Normal	Normal	High	During long-term treatment with cortisol