B2 – Kidneys

2016 Q1 – the correct answer is D: 3 is the renal vein, as this is the filtered blood obtained from the kidneys. During filtration, urea is removed from the blood, and the renal vein carries blood towards the heart. Hence, it has the ***lowest concentration of urea*****. 5 is the ureter** which contains the ***highest concentration of urea.*** This is as, the filtrate contains urea which is filtered by the kidney to be excreted by the body.

2015 – Q13 – the correct answer is D: The question is asking **the mass of substance** in urine. The mass of the substance on a hot and cold day is the **same**, yet the concentration differs dependent on the **water content** in urine, not the mass of substance (urea, ions, toxins etc.). On a hot day, more water is reabsorbed, whereas less water is reabsorbed on a cold day. The mass content remains the same – only the water content differs

2014 – Q13 – the correct answer is B: The water content in the blood is detected by the brain, which controls how much ADH is released by the pituitary gland. When the water content is too low, **the pituitary gland releases more ADH**. This causes an **influx in water reabsorption by the kidneys,** hence a high volume of water passes into the blood.

B3 – Genetic Engineering

2016 – Q5 - the correct answer is B: W – Chromosome, which is shown by its characteristic 'X' shape during metaphase. **X – restriction enzyme**, as restriction enzymes are used to cut out a portion of DNA from the donor organism. **Y – restriction enzyme**, as the plasmid (shown by its circular structure) has to be cut up using the same restriction enzymes as used to cut the donor DNA, as they leave the same sticky ends. **Z – ligase.** This enzyme seals up and joins together the sticky ends of the plasmid – donor DNA - gene complex.

2014 – Q9 – the correct answer is D: The insulin gene can be cut out, using restriction enzymes, and inserted into a plasmid (which contains bacterial DNA). Through the asexual reproduction of such genetically engineered bacteria, large

quantities of insulin produced from the reproducing bacteria can be used to treat human diabetes.

2013 – Q13 – the correct answer is C: The fluorescent protein is **not** required to genetically engineer bacterial cells to produce fluorescent protein from jellyfish. The **gene** for fluorescent protein production is required to be inserted in the plasmids of bacterial cells for fluorescent protein production. Genes code for a particular sequence of amino acids, which in turn codes for a particular protein. Options A,B and D are all required: a ligase enzyme **seals** and joins the sticky ends of the plasmid and inserted fluorescent protein gene, a plasmid carries bacterial DNA in which the fluorescent protein gene is inserted (the viral vector can transport the fluorescent protein gene to the bacterial DNA of bacterial cells – this mechanism is used by viruses to invade host cells). Restriction enzymes are needed to cut the fluorescent protein gene and the recipient plasmid. The recipient plasmid must have **complementary** sticky ends to the restriction site of the fluorescent protein gene, hence the same restriction enzymes are used.

2009 – Q5 – the correct answer is E: Cloning produces another organism, which is genetically identical to its parent organism – it contains the same genetic material. Clones do not always show identical features at maturity, as the genes may be expressed differently as characteristics, dependent upon various transcription factors that dictate gene expression. Multiple births (I.e. twins, triplets etc.), are not always members of a clone. This is as, non-identical twins/triplets etc. can occur due to the release of multiple eggs at ovulation, which are subsequently fertilised by multiple sperms. The genetic material of the sperms and eggs differ from each other, due to genetic recombination (crossing over) in meiosis. Hence, they can express different characteristics. Members of a clone cannot be produced through a mutation; if this occurred, then their genetic material would differ immensely, and so they would be genetically non-identical – **not** members of a clone.

B4 – Digestion

2016 Q9 – the correct answer is F: These statements all apply to protease. Protease works in **optimally acidic conditions.** The lower the pH, the greater the acidity of the solution. The **hydrochloric (HCl) acid** in the stomach ranges from pH 1.5 – 3.5 for protease to catalyse the breakdown of proteins. Protease digests **proteins** into **amino acids**. Protease, like all digestive enzymes, have an optimum temperature of 37°C.

2014 Q9 - the correct answer is B: Emulsification **increases overall surface area** as it breaks down a large lipid droplet into many smaller droplets. However, the **individual** droplet surface area is **reduced**. Hence, Statement 1 is correct. Bile **is alkaline** and **neutralises** the acid material released from the stomach into the small intestine. Alkalinity **increases** pH, rather than pH reduction. Hence, statement 2 is incorrect. Lipase is **not** present in human bile, hence statement 3 is incorrect.

2013 Q5 - the correct answer is F: The question asks for a **decrease** in pH, which corresponds to an **increase** in **acidity** of the mixture. Protease digests proteins into amino **acids,** lipase digests fats into glycerol and **fatty acids,** and carbohydrase digests starch into sugars. The action of protease and lipase will subsequently lead to an **increase** in acidity, as they produce **acids -** amino acids and fatty acids. Sugars are of **neutral** pH, and so the action of carbohydrase will be **ineffective** in reducing pH.

B5 – Respiration and Breathing

2016 Q13 – the correct answer is B: Glucose is involved in **both** aerobic and anaerobic respiration. **Carbon dioxide** and water are products of aerobic respiration, whereas **lactic acid** is a product of aerobic respiration. Hence, Statements 1 and 3 are incorrect, as they don't apply to both respiratory processes; glucose is **required** for both processes to occur.

2015 Q5 – the correct answer is A: Anaerobic respiration occurs in the **absence** of oxygen – when **insufficient** oxygen is available for aerobic respiration to occur. Hence, glucose is broken down to **lactic acid**; **no** carbon dioxide **nor** water is produced.

2012 Q5 – the correct answer is B: Nicotine affects the **brain** as it creates a dependency for tobacco inhalation via smoking - addiction. It releases glucose from the liver, adrenaline from adrenal glands and various neurotransmitters in the brain, increasing the sensitivity of the brain's reward system to rewarding stimuli.

Bronchitis: inflammation of the bronchi (airways) in the lungs. It can cause coughing, wheezing, shortness of breath etc., as the inflammation restricts air flow into the lungs, making it harder to breathe. The walls of the bronchi produce mucus to trap particles (in the case of smoking, this is tobacco smoke), leading to inflammation.
Emphysema: Due to frequent infection, **phagocytes** are attracted to the lungs where they release **elastase** - an enzyme which breaks down the **elastin** in the alveolar walls, to enable them to reach the surface where the bacteria are. Without adequate elastin, the alveoli cannot stretch, so they recoil and burst. This causes large air spaces, reducing the surface area for gaseous exchange, causing rapid breathing. Alveolar air sacs break down and fuse together, leading to severe breathing difficulties.
Carbon Monoxide: Carbon monoxide is released in tobacco smoke, and enters the blood vessels. Red blood cells have a **higher affinity** to carbon monoxide, in comparison with oxygen. Hence, more red blood cells bind **irreversibly** to carbon monoxide, rather than oxygen. Respiration cannot occur sufficiently for metabolic processes to occur, hence breathing becomes very short and rapid. Carbon monoxide poisoning is **very critical** as this **directly affects respiration.**

2011 Q13 – the correct answer is E: When blood enters an active muscle first, it is **oxygen rich (high oxygen concentration)**, as it has been supplied with oxygen via alveolar gaseous exchange in the lungs. There, the carbon dioxide diffuses **out** of the lungs, hence the concentration of carbon dioxide is very low in this **oxygenated blood.** Gaseous exchange between capillaries and cells occurs via **diffusion.** Oxygen diffuses across the cell membrane of the cells **down** a concentration gradient from the blood. Carbon dioxide diffuses **down** a concentration gradient, from the cells to the blood. Oxygen concentration in active muscles is **very low**, as oxygen is being supplied for respiration, to generate energy in contraction. Carbon dioxide concentration **increases**, as the respiring muscle cells release carbon dioxide as a by product.

2009 Q13 – the correct answer is B: If oxygen concentration in the blood becomes very low, all other processes, apart from B, are unaffected. This is as, processes A and C are gaseous exchange – if the blood oxygen concentration is low, oxygen can pass from the alveoli to the blood, down a concentration gradient. Similarly, the concentration of carbon dioxide in the blood will be high, due to the previous usage of oxygen in respiration to produce carbon dioxide, thus carbon dioxide also passes out of the blood, into the alveoli, down a concentration gradient. Water from the blood plasma passes into the muscle cells and nephron via **osmosis,** which does **not** require oxygen. Urea passes from the blood plasma into the nephron via

diffusion, which does **not** require oxygen either. Only process B is affected. This is as, glucose enters the villi, from the lumen, via the glucose-sodium **co-transport mechanism – facilitated diffusion.** Here, glucose passes into the epithelial cells on the villi lining due to the presence of sodium ions. The sodium-potassium pump on the cell membrane of the epithelial cell bordering the capillary in the villi, **actively transports sodium ions against** their concentration gradient, out of the epithelial cells (and couples the transport of potassium ions into the cell). This causes a **low concentration** of **sodium ions**, promoting the entry of sodium ions, which couple with glucose, into the epithelial cell via the lumen. Due to a **constant** concentration gradient established by the **active transport** of sodium ions, glucose continuously moves out of the epithelial cells, into the villi capillaries. Active transport **requires** oxygen. If there is insufficient oxygen, the active transport of sodium cannot occur, hence sodium accumulates in the cell, **stopping** the concentration gradient of glucose and sodium **into** the cell.

2009 Q21 – the correct answer is D: The blood in the capillaries is **deoxygenated**, with **high carbon dioxide concentration.** This is as, oxygen is used by the cells for respiration, which produces carbon dioxide, which passes into the blood capillaries. This **high concentration** of carbon dioxide reaches the alveolus. Due to the air in the alveolus having a **higher concentration** of **oxygen**, relative to the capillaries, oxygen passes down a concentration gradient from the alveolus to the capillaries. The reverse occurs for carbon dioxide, as the blood capillaries has a greater carbon dioxide concentration, relative to the air in the alveolus. Hence, carbon dioxide moves out of the capillaries, into the alveolus, to be exhaled.

B6 – Inheritance

2016 Q17 – the correct answer is G: All 4 Statements are correct. A mutation leads to a change in the base sequence of amino acids, which in turn leads to a change in the structure of the protein that is produced. Each triplet of bases codes for one amino acid. The order of bases determines the sequence of amino acids, thus dictating which protein is coded for. A mutation can occur through: substitution (in a base is substituted by another base) , deletion (a base is not added to the sequence) and addition (an extra base is added in the sequence) of bases. These all include the possibilities of either a functional/non functional protein being coded for, depending upon which base is deleted/added/substituted. Hence, both Statements 3

and 4 are correct, as **enzymes** are **proteins** (including protease), and the mutation can have a negative, positive or no effect on the non functional protein (the protease enzyme may not perform its role, but it may lead to other consequences, or it may not affect cellular activity at all). Statements 1 and 2 are correct, as the change of protease structure may cause it to bind more **tightly** to protein substrates, or **loosely**; hence, this determines the efficiency of the protease.

2016 Q25 – the correct answer is H: This question asks for the **maximum** number of **heterozygous** mice.
We don't know whether the characteristic Grey is dominant, or whether White is dominant. Hence, grey mice are either dominant or recessive, and the same applies for White mice.

Type	Grey or White?	Genotype
Dominant	Unknown	CC or Cc
Recessive	Unknown	cc

To get the smallest number of heterozygous mice, we can assume that all dominant mice are heterozygous dominant (Cc), not homozygous dominant (CC).

All of the recessive mice are homozygous recessive (cc), as you cannot get heterozygous recessive.

There are 12 grey mice, and 4 white mice. Hence, it seems sensible to make the white colour recessive as the recessive mice are homozygous. We want to **maximise** heterozygous. Hence, at maximum, there are **12 heterozygous mice.**

2015 Q9 – the correct answer is D: As the offspring of the first breeding experiment are all black, and it is known that Mouse 1 is **homozygous**, the white mouse has to be **homozygous recessive** for the white colour to be expressed. The offspring are all **heterozygous dominant black, Cc.**

	C	**C**
c	Cc	Cc
c	Cc	Cc

First breeding experiment

	C	**C**
C	CC	CC

c	Cc	Cc

Second breeding experiment
When Mouse 1 (CC) is bred with Mouse 2 (Cc), the offspring produced are all **black** as they all have the dominant C. Half (50%) of the offspring are heterozygous dominant (Cc) and 50% are homozygous dominant (CC). Hence, there are 2 genotypes in the population of offspring: homozygous and heterozygous.

2015 Q25 – the correct answer is G: A fruit fly will be male if X: A = 0.5:1 and female if X: A = 1: 1. Here, the determination of sex is **clearly stated** by the X:A ratio. Although the Y chromosome contains **genes** for sperm production, the determination of sex is **only** controlled by the X:A ratio. The genes for sperm production can be activated or be dormant, **depending** on the X:A ratio. Hence, the presence of a Y chromosome has **no effect** on sex determination.
XAA – 1X:2A (1:2 ratio), 0.5:1 = 1:2 hence **male**
XYAA – 1:2 ratio (no effect of Y) = **male**
XXAA – 2X:2X (2:2 ratio) = **female**
XXYAA – 2:2 ratio (no effect of Y) = **female**
XXYYAA – 2:2 ratio (no effect of 2Y either) = **female**

2014 Q25 – the correct answer is E: In order to have the condition, the woman must have 2 copies of the recessive allele, as stated in the question. In order to inherit 2 copies, she must have inherited a recessive copy from each of her parents. As neither of them have the disorder, they must be heterozygous, hence A is true. Her parents must have inherited a recessive allele each from their parents (the woman's grandparents) so they could all be carriers (D), one of each set of grandparents could be a carrier (C) or they may have the condition (B). In order for the woman to develop a condition that requires two copies of the recessive allele, however, the DNA mutation in one gamete is not sufficient. DNA in the gametes from both parents would have had to mutate if neither of them possessed the recessive allele to start with. Therefore E cannot be true.

2013 Q25 – the correct answer is C: Let's define the recessive allele as t, and dominant allele as T. From the question: tt - tail; Tt –no tail; TT – die before birth. In order to find the population of Manx cats **without tails,** a genetic cross is needed. Any offspring with TT should be **excluded** in calculations, as they do not contribute to the outcome of a tail, due to pre-birth death.

With Tail X Without Tail

	t	t
T	Tt	Tt
t	tt	tt

Without Tail X Without Tail

	T	t
T	TT	Tt
t	Tt	tt

From the first genetic cross, there are 50% heterozygous dominant, hence without a tail, and 50% homozygous recessive – with a tail.
The second genetic cross requires **essential care!** The genotypes are: TT, Tt, Tt, tt. Here, the TT must be **discarded.** Hence, the sampling of heterozygous (no tail) has to occur from a population of the **three** genotypes: Tt, Tt and tt. This is 2/3, corresponding to 67% of the population.

2012 Q21 – the correct answer is D: Statement 1 is too vague, as it doesn't specify whether the offspring die within the womb or after birth. If the offspring die within the womb, the alleles of the offspring cannot be known, to deduce it to be dominant. However, if there is a method of knowing these alleles, they are to be excluded. If the offspring die after birth, due to dominant alleles, this ratio is still included as it is **post-birth death.** Due to this ambiguity, it cannot be Statement 1. The ratio 3:0 could be obtained, if there are a small number of offspring produced (i.e. only 3 offspring produced, with all 3 phenotypes). This can be the case, as we are not given the number of offspring. As ratios can be amplified, i.e. 3:1 = 6:2 etc, it may be due to a matter of **chance**, that a population of offspring repeatedly express one phenotype; fertilisation is a **random** process, hence the outcome is only **probabilistic.**

2012 Q25 – the correct answer is E: For a recessive condition to be expressed, the individual must contain **2 recessive alleles.** The question asks for the **minimum number** of **heterozygous individuals** required for a recessive condition to be expressed.
Let D = dominant, d = recessive

For U to **only** be recessive: The parents (S and T) both are required to be Dd and Dd.

	D	**d**
D	DD	Dd
d	Dd	**dd**

As we require the minimum heterozygous number, the parents of S produce 1 heterozygous dominant (Dd) and one homozygous dominant R (DD). Hence, P and R have to be: DD and Dd for this to occur, with either P or R having either genotypes.

	D	**d**
D	DD	Dd
D	DD	Dd

Hence, the parents of U: S and T are **both** Dd, and either P or R (U's grandparents) are Dd. Therefore, the minimum number of heterozygous for this situation is: **3**.

For R **and** U to **only** be recessive: We have already established that for U to be recessive, S, T and either P or Q are heterozygous. For R to be recessive too, we need to eliminate the homozygous dominant, and replace it with heterozygous dominant. Hence, both P **and** Q are Dd (heterozygous dominant), as with the case of S and T.

	D	**d**
D	DD	Dd
d	Dd	**dd**

The parents of U: S and T are both Dd, and the parents of R are both Dd, totaling **4 heterozygous dominant** alleles.

2011 Q17 – the correct answer is D: Statement 1 is correct – the condition is dominant – as the question states that the genetic condition is caused by the **presence of at least one allele.** This eliminates recessive alleles, as they can **only** be expressed if there are more than 1 recessive alleles. Dominant alleles can be expressed if they are single or multiple as alleles. As the condition is dominant, it could be possible that the sperm from T (no genders are specified) carriers the allele, which may have been inherited by U through the random process of fertilisation. Statement 3 does **not** contradict with Statement 2, as it suggests that S is female (**egg**). A mutation can cause a change in the base sequence, resulting in changes within the allele. The previously non-functional allele, may now code for the condition, after the mutation.

2010 Q17 – the correct answer is E: This question can be worked through methodically. Let dominant allele = G, recessive allele = g.

P and Q are **carriers** of a **recessive allele.** Hence, they both have the alleles: Gg and Gg

Their offspring are:

	G	**g**
G	G G	Gg
g	Gg	gg

The ratios are: 1 (GG): 2 (Gg): 1 (gg)

To deduce which of S, T, U are more likely to be carriers (Gg) we must use the further information: **Only** individuals R and X have the condition.

For X to have the condition, alleles of X: **gg**

U and V **cannot** either be carriers (Gg) or homozygous dominant (GG), as this means that X is either a carrier or completely unaffected:

	G	**g**
G	G G	Gg
g	G G	Gg

Hence, both U and V **must** be carriers. As the question asks for U – the percentage likelihood is 100%. The ratio of offspring is 1:2:1, with 2 (Gg). We have already found 1 Gg (U).

Individual R is affected, hence its alleles are: **gg**

For W to be unaffected, it needs to have the alleles: GG or Gg

With R being gg, S needs to be **either** Gg **or** GG.

	G	**G**
g	Gg	Gg
g	Gg	Gg

	G	**g**
g	Gg	gg
g	Gg	gg

With S being GG, W has 100% likelihood of being a carrier, whereas with Gg, W has 50% likelihood of being a carrier. As S can either be Gg or GG, it has a **50% likelihood** of being a carrier.

Now, as S and U are carriers, we have found 1 Gg (U) and 0.5 Gg (S). As the question asks for the **likelihood of carriers** it is plausible to assume that T **also** has a **50% chance of being a carrier,** fulfilling the 1:2:1 ratio – 1 Gg (U), 0.5 Gg (S),).5 Gg (T).

2009 Q1 – the correct answer is C: Let dominant allele = P, recessive allele = p. A: homozygous dominant = **PP**; B: homozygous recessive = **pp**

	P	**P**
p	Pp	Pp
p	Pp	Pp

C and D are **100%** heterozygous dominant. For F homozygous recessive:

i) E is homozygous recessive:

E alleles = pp

	P	**p**
p	PP	pp
p	Pp	pp

Ratio = 1 (PP) : 1 (pp)

Hence, there is a **50% probability** that F is homozygous recessive

ii) E heterozygous:

E alleles = Pp

	P	**p**
P	PP	Pp
p	Pp	pp

Ratio = 1 (PP) : 2 (Pp) : 1 (pp) – 1+2+1=4. pp = ¼

Hence, there is a **25% probability** that F is homozygous recessive

2009 Q9 – the correct answer is D: Statement D is **incorrect**. Statement A is **correct**, as the risk increases by 0.5 (1.0 → 1.5 and 4.0 → 4.5) in **both** types of alcohol intake. Statement B is **correct**, as there is a positive correlation of increase between the variables of **number of mutant alleles present** and **risk value**; as the number of mutant alleles present **increases**, so does the risk. Statement C is **correct**, as the figures for heavy drinking **significantly increase** the risk from being in the range of 1-1.8, to 4-6 which is an increase greater than fourfold. Statement E is correct, as the difference between the risk values with 1 and 2 alleles is 1.5 for heavy drinkers (6 – 4.5 = 1.5), whereas it is only 0.3 (1.8 – 1.5) for light drinkers.

Statement D is **incorrect,** as the presence of at least one mutant allele is **not** the main factor for an increase in risk – this contradicts Statement C, which has proven that heavy drinking is the main factor which increases risk.

B7 – Cell Division

2016 Q21 – the correct answer is A: Statement 1 and 4 are correct, as they involve **division.** Mitosis is the process of cell division, whereby 2 daughter cells are produced which have the same number of chromosomes, hence are genetically identical. Asexual reproduction produces **genetically identical** offspring, through mitosis (i.e. bacterial reproduction). Stem cells also produce **genetically identical** stem cells through mitosis. Be careful – mitosis **makes** new cells for growth, repair and replacement (i.e. cell replacement in humans, or reproduction in microorganisms). Statement 2 is **incorrect** as it mentions **growth** of a cell – mitosis produces cells for growth of a **tissue**, which is composed of **many cells.** Statement 3 is **incorrect** too, as a tissue is **repaired** through the production of cells by mitosis – **not** the cell itself.

2014 Q5 – the correct answer is D: DNA synthesis **doubles** the DNA content in the cell, so the content will increase from 1 to 2 arbitrary units, which is M. The DNA **separates** within the cell. However, the total content is still 2, hence this is N or J. The cell divides in **half**, which **halves** the DNA content per cell back to 1, which is K.

2013 Q17 – the correct answer is A: Statements 2 and 4 are **incorrect.** Statement 2 mentions fertilisation, whereas cloning **does not** involve this process; mitotic divisions occur to produce the new organism. Statement 2 mentions the implantation of stem cells; be careful with this, as it says 'may not differentiate properly.' Problems in differentiation may occur, however, the preceding use of 'implanted stem cells' is incorrect. Only the **embryo** is implanted into the womb of a surrogate mother, which contain stem cells. Stem cells **alone cannot** produce a live organism, as they are differentiated into specialised cells. Statements 1,3 and 5 are correct: there may be problems in division and development when the foreign nucleus is transferred to an enucleated egg – this issue of compatibility is stated in Statement 5 too. The implantation of the embryo into the surrogate mother can fail due to the **rejection** of the foreign embryo, as the foreign antigens on the surface of the embryonic cells can stimulate an immune response to destroy the embryo.

2011 Q5 – the correct answer is F: Statements 3,4 and 5 are fully correct – they are facts to be learned for cell division - Mitosis produces diploid cells (with a full set of chromosomes), whereas meiosis produces haploid cells (with half the number of a full set of chromosomes), and mitosis produces 2 daughter cells. Statements 1 and 2 are **incorrect**, as they are mixed up. The correction is: Mitosis results in the production of genetically identical cells, and meiosis results in variation within the species (due to genetic recombination and crossing over).

2010 Q21 – the correct answer is B: Statements 1,2 and 3 are fully correct - they are facts to be learned for cell division – Meiosis only occurs in reproductive organs, as the reproductive cells are fertilised to create a full set of chromosomes for the new embryo. Mitosis can result in the formation of clones, as clones are **genetically identical**. Asexual reproduction occurs through **mitosis,** not meiosis, as **genetically identical** organisms are produced. Statements 3 and 4 are incorrect; they should be swapped around to correct the statements: Mitosis results in 2 nuclei; Meiosis results in 4 nuclei.

B8 – Neuroscience

2015 Q1 – the correct answer is E: The brain does **not** take part in the autonomic nervous system. The response to touching a hot plate, gives an involuntary and reflex response. The brain is not involved in such responses, as they are unconscious and involuntary. The electrical impulse is passed onto the relay neurone, after the sensory neurone, across a synapse.

2013 Q9 – the correct **answer is F:** Sensory neurones have one long dendrite which receives impulses from receptor cells, and one short axon which takes the impulse to the CNS. This is the longest neurone. Relay neurones have many short dendrites which receive the impulses from sensory neurones, and many short axons which take the impulse to motor neurones. This is the shortest neurone. Motor neurones have many short dendrites which receive the impulses from the relay neurones in the CNS, and one long axon which takes the impulse to the effector muscle or gland.

2012 Q9 – the correct answer is A: Only Statements 1 and 2 are correct. A reflex action would **not** occur, as neurons (which are used in the reflex arc to give a

response) cannot detect the stimulus. As the stimulus is not detected, an electrical impulse cannot travel to other neurons, through synapses, to give an appropriate reflex response. However, if the stimulus is seen (i.e. fire), despite not experiencing it, one can withdraw one's limbs from it. Statements 3 and 4 are **incorrect**. This is as, the stimulus can't even be interpreted as pain, as the neurons which can cause pain detection, are not functioning. Without the sensation, action cannot be taken. Statement 4 is contradictory – pain is interpreted by the brain, hence the brain's involvement is key in detection. The patient is only aware of pain after the brain interpretation.

2010 Q13 – the correct answer is F: Only statements 4 and 5 are correct. An impulse (action potential) at the pre-synaptic terminal causes depolarisation, leading to the release of neurotransmitter molecules in the vesicles to be released in the synaptic cleft. The transmitters diffuse across the cleft and bind to receptors on the post-synaptic neurone, and binding to the post-synaptic receptors triggers depolarisation in the post-synaptic neurone, hence a new impulse is generated. Statement 1 is incorrect – neurotransmitters are enclosed in vesicles in the **presynaptic membrane** at the end of the axon terminal, **not** receptors. Statement 2 is incorrect, as neurotransmitters **diffuse** across the synapse, **not** osmosis. Neurotransmitters are stimulated by the **depolarisation** of the **presynaptic membrane**, causing a signal to be transmitted across the synapse, **not** after signal transmission.

B9 – Homeostasis

2013 Q1 – the correct answer is H: All statements are correct. Both nervous and hormonal systems maintain a **constant internal environment,** hence they are homeostatic processes. Nervous systems use neurotransmitter chemicals in synapses, whereas hormonal systems use hormones as chemical messengers in the blood. Nervous responses are either voluntary (use the brain) or involuntary (do not use the brain), whereas hormonal responses are always involuntary, but are activated through detection in the brain.

2014 Q21 – the correct answer is G: Statement 1 is not true. In the opening paragraph, it is stated that oxygen supply is essential for neurons in the brain to function for more than 5 – 10 seconds. Hence, anaerobic respiration cannot be used for prolonged periods of time. Statement 2 is true because a by-product of aerobic respiration is heat so as respiration occurs, the body will have to work to counteract

the corresponding increase in temperature. Statement 3 is true - too much insulin will lower body glucose levels and this could prevent sufficient respiration from occurring, resulting in a lack of energy and therefore brain function. Statement 4 is true because carbon dioxide is produced during aerobic respiration.

2012 Q1 – the correct answer is F: All 4 Statements are correct. To **maintain a constant internal environment,** a rise and reduction in internal and external conditions can be counteracted by hormones, to restore the original balanced state. Although it may seem that external conditions should not be included in the answer, external conditions are not specified here – they can apply to external stimuli, which can be cause nervous responses, action of chemicals on the body (restricted to the skin), which can be counteracted by hormones etc.

2012 Q17 – the correct answer is C: Statements 1 and 4 are correct. ADH is a **hormone,** hence it travels through the bloodstream. A reduction in ADH causes less volume of water reabsorbed by the kidneys; if ADH successively decreases, there is a successive decrease in the volume of water reabsorbed, thus leading to dehydration. Statement 2 and 3 are both incorrect – there is a **negative correlation** between dilute urine production and level of ADH. This is as, a greater release of ADH causes **more** water reabsorption in the blood, leading to more **concentrated urine.** Less release of ADH causes **less** water reabsorption, leading to more **dilute urine.**

2011 Q1 – the correct answer is F: Carbohydrase does not fit into anything. **Adrenal** glands release **adrenaline** which can **increase heartbeat rate. Ovaries** produce **oestrogen,** leading to **female secondary characteristics. Testes** produce **testosterone** which lead to **male secondary characteristics. Pituitary** glands produce **Antidiuretic hormone (ADH)**, which **regulates water level in the blood. Pancreas** produces **insulin,** which **regulates blood glucose level.** All these glands, hormones and functions are related to the hormonal homeostatic response. Carbohydrase is an **enzyme,** which is involved in digestion, and so does **not** fit into homeostatic processes.

2011 Q25 – the correct answer is D: If the homeostatic system is **less responsive,** the time taken to respond doesn't change; however, the **frequency** of response changes. In order to change the frequency, the raised level would have to be higher, hence 2 is raised. This is as, this would steepen the graph from both sides (1 and 3), and in order for a response to occur, a new higher threshold is set.

2010 Q1 – the correct answer is E: Temperature change is detected by the thermoregulatory centre in the **hypothalamus**. The thermoregulatory centre activates a response, in which: the arterioles **dilate,** hair erector muscles **relax** – be careful, the capillaries themselves **do not move.** However, **dilation** of the arterioles **supplying blood** to the **skin capillaries,** causes more warm blood to flow near the surface of the skin, hence heat is lost by radiation.

2010 Q25 – the correct answer is E: Only Statements 2,3 and 5 are correct. Statement 1 and 2 are incorrect – the nervous system uses neurotransmitter chemicals at synapses, to continue an electrical impulse across another neurone. Both hormonal and nervous systems activate specified targets i.e. the nervous system activates an effector (muscle in a reflex response), hormonal system stimulates an organ/tissue/localised area for a particular function (ADH controlling reabsorption of water in kidneys). Parts of the hormonal system may be controlled by the nervous system, as effectors can be glands (i.e. thermoreceptors on the skin detect temperature changes, and a nervous impulse is carried to the thermoregulatory centre)

2009 Q25 – the correct answer is F: Statement 1 is incorrect – **insulin regulates blood glucose level, not** water content. ADH regulates water content of the body. Statement 2 is incorrect - Homeostasis is **not only** dependent on hormones – the nervous system can influence the release of hormones, such as the release of hormones noradrenaline and acetylcholine at the SAN to regulate heart rate, when detected by chemical and pressure changes in the blood flowing through the medulla oblongata in the brain, via the parasympathetic (decreases heart rate) and sympathetic (increases heart rate) nervous systems. Statements 3,4 and 5 are all correct. The pancreas produces insulin to control glucose content of the blood. Both nervous and hormonal systems are involved in homeostasis (which contradicts Statement 2), and thermoreceptors on the skin can help to control body temperature.

B10 – Carbon Cycle

2015 Q17 – the correct answer is H: Firstly, digestive enzymes are used in Process 2. This is when plants animals eat plants, and so digestive enzymes break down long chains of carbon compounds into their smaller organic forms (fatty acids, glycerol, amino acids, glucose etc), to be assimilated in the body as fat, muscle etc. When animals die, they are decomposed by saprobiotic decomposers, which are microorganisms that release digestive enzymes. These enzymes catalyse the breakdown of organic compounds that have been ingested by the animals, thus releasing carbon containing compounds into the soil. Respiratory enzymes are **only**

used in Process 4, which is respiration. Saprobiotic decomposers respire **aerobically** as they assimilate the products of digestion**,** thus releasing carbon dioxide into the atmosphere.

B11 – Cell Structure

2015 Q21 – the correct answer is A: Statements 1 and 4 are correct. Statement 2 is incorrect, as although aerobic bacteria (prokaryotic cells) would possess a cell wall, human white blood cells do not have a cell wall. Statement 3 is incorrect, as although a human white blood cell would contain a nucleus, prokaryotic cells do not have a nucleus – their DNA is chromosomal, with no true nucleus, commonly circular as a plasmid. Both their DNA are double helixes, and both eukaryotic and prokaryotic cells possess a cell membrane.

2015 Q21 – the correct answer is E: An adult liver cell would contain sex chromosomes, as these determine the gender of the organism, and form the full set of chromosomes; hence, they are present in every cell (apart from sex cells which have either chromosome). Be careful – Statement 1 is **correct** – a gene for amylase is definitely present within an adult liver cell, as all genes are to be contained within a full set of chromosomes. However, the gene is **not expressed** in this cell, as amylase production is not required in the liver. Statement 3 is **incorrect** – starch granules are **not** present in liver cells, as they are too big to pass the cell membrane. Starch granules are present in chloroplasts of plant cells.

2011 Q21 – the correct answer is D: It may be hard to grasp what the question is asking, as 'nuclear DNA' is very vague here. It is referring to the **chromosomal arms/double helix** of the DNA. As an egg cell is haploid, it contains half the number of nuclear DNA relative to a normal body cell, hence its quantity is '1', as DNA is in a single helical structure. In comparison, the quantity of nuclear DNA of a nerve cell is '2', as it contains DNA as a double helix, with double the quantity of nuclear DNA relative to gametes. An **enucleated** egg cell, in which **enucleated** refers to a cell that has **no nucleus,** will have 0 nuclear DNA.

B12 – Heart

2014 Q1 – the correct answer is C: Statement 1 is **incorrect** - **deoxygenated blood** flows through the **right side** of the heart. Statement 2 is **incorrect** because blood **from** the **vena cava** enters the atrium. Statement 3 is **incorrect** because the pulmonary artery is one of the few arteries that carries deoxygenated blood.

Statement 4 is **correct** because there are valves in the base of the aorta to prevent the backflow of blood into the ventricle, when the ventricle relaxes.

B14 – Natural Selection

2012 Q13 – the correct answer is E: Statement 1 is **correct** – this is as, the distance between the circumference of the antibiotic and the circumference of region S, which can be defined as the region in which there are no bacterial colonies, is the same in both antibiotics. Hence, both antibiotics are equally as effective, if they restrict an equal amount of growth. Statement 2 is **incorrect** and too vague – it is unknown whether antibiotic resistance has spread across the population, as the same antibiotic, in different strengths, produces the same results. From observation, it only seems that the bacteria are resistant to antibiotic P, however, the assumption of resistance would be incorrect, as the antibiotics are the same – their strengths only differs. Statement 3 is **correct** – S may represent the maximum distance the antibiotic has diffused out of the disc, hence restricting bacterial growth up to a certain point in the plate.

2011 Q9 – the correct answer is C: Statements 1,2,3 and 5 are correct. Statement 4 is **incorrect** – it is too definitive; the use of **only** cannot validate that statement, as individuals with advantageous adaptations are more likely to survive adulthood (as given with Statement 3), and so are **more likely** to breed due to their survival. However, there are other factors i.e. competition in breeding, hence survival advantages are **not** definitive of breeding. Statement 1 is correct – individuals within a species show variation due to genetic recombination and crossing over at meiosis, the random process of fertilisation and mating with individuals that have different alleles to one's own. Statement 2 is correct – individuals within a species compete with each other for resources etc. due to the instinct of survival. Statement 5 is correct - Alleles for advantageous adaptations are more likely to be inherited, as those individuals survive, and so are more likely to breed, hence passing their adaptations to their offspring.

2010 Q9 – the correct answer is B: During the process of evolution, natural selection will favour individuals with an advantageous allele. This is as, those with advantageous alleles outcompete individuals without advantages alleles, as they are more likely to survive, hence are more likely to breed successfully. Due to reproductive success, they are more likely to pass on their alleles to the next generation.

2009 Q17 – the correct answer is F: All Statements 1,2,3 and 4 are correct. Statements 1 and 2 - Competition can occur between individuals of the same species (intraspecific competition) and between individuals of different species (interspecific competition). Statements 3 and 4 - Selection of advantageous alleles, which are favoured by the environment, can lead to evolution of a species, as they are passed onto successive generations. However, if a species does not possess any advantageous alleles to suit the changes in the environment, the individuals cannot survive to breed successfully, hence their alleles are not passed onto any offspring, leading to extinction.