Biological Systems of Animals Second Edition – Answers

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1. Red blood cell. They deliver oxygen to cells around the body.
2. White blood cell. They are part of the body's immune system. There are a number of different types of white blood cell.
3.

a Tricuspid valve (or right AV valve)

b Right atrium

c Vena cava

d Aorta

e Pulmonary artery

f Right ventricle

4.

Artery	**Vein**
Takes blood away from the heart	Carries blood towards the heart
Blood in an artery is at high pressure	Blood in a vein is at low pressure
Have thick muscular walls with a narrow lumen	Have thin muscular walls with a wider lumen

5. The discussion should include four of the following five points:

Single circulatory system	**Double circulatory system**
Blood passes through the heart once during a complete cycle	Blood passes through the heart twice during a complete cycle
The heart has two chambers – an atrium and a ventricle	The heart has four chambers – two atriums and two ventricles
The heart only receives deoxygenated blood	The heart receives both deoxygenated and oxygenated blood
Lower blood pressure	Higher blood pressure
Present in fish	Present in mammals and birds

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1. The respiratory system is the way in which an animal supplies oxygen to, and removes carbon dioxide from, all cells in the body.
2. The discussion should include four of the following points:

Mammalian respiratory system	**Bird respiratory system**
Air travels into the lung and then back the way it came.	Air travels in one direction through the lung (unidirectional).
Gas exchange takes place at alveoli, which are tiny spheres which are in contact with	Gas exchange takes place at parabronchi, which are tiny tubes in contact with blood

blood capillaries. Alveoli are 'dead ends' for inhaled air –the air must be returned back through the lung.	capillaries. These tubes are open at both ends which allows air to constantly flow through them during inhalation and exhalation.
Oxygen is passed into the blood capillaries during inhalation, and carbon dioxide is passed into the lung during exhalation.	Oxygen and carbon dioxide are constantly exchanged between the lung and blood capillaries, during both inhalation and exhalation.
Uses a diaphragm muscle to inflate and deflate the lungs, which causes air to be inhaled and exhaled respectively.	No diaphragm, so their lungs do not inflate. Instead, they use air sacs to draw air through the lungs during inhalation and exhalation.
Takes one inhalation-exhalation cycle for air to travel through the system	Takes two inhalation-exhalation cycles for air to travel through the system.
Able to extract less oxygen from air than birds.	Able to extract more oxygen from air than mammals.

3. A – bronchioles
   B – alveoli
4. The function of alveoli is to facilitate gas exchange, allowing oxygen to travel into the blood capillaries and allowing carbon dioxide to be removed from the blood capillaries.
5. The discussion should include four of the following points:

Mammalian respiratory system	**Invertebrate respiratory system**
Air enters through the mouth and nose.	Air enters the body through openings on the surface called spiracles.
Air travels through the windpipe (trachea) and into the lungs.	Air travels through a system of tubes in the body which also called trachea – but they are quite different from the mammalian trachea.
The lungs are the respiratory organ.	There is no respiratory organ in many invertebrates, although some do have a book lung.
Oxygen is transported through the respiratory system to the circulatory system; the circulatory system then ensures oxygen reaches all the cells in the body.	The trachea transport air directly to cells in the body.
Gas exchange takes place at alveoli.	Gas exchange takes place at location of each cell.
Uses a diaphragm muscle to inflate and deflate the lungs, which causes air to be inhaled and exhaled.	No diaphragm, and there is no inhalation and exhalation. However, the flow of air through the trachea can be controlled by some invertebrates by using muscles in their body.

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1. The ovaries are responsible for the production of eggs (ovum) and the production of oestrogen and progesterone.
2. Female: a) Ovaries b) Uterus c) Cervix d) Vulva
   Male: a) Prostate gland b) Testes c) Vas deferens

3. a) Adaptations might include examples of oviparous animals, ovoviviparous animals, marsupials or egg-laying mammals. b) Answer will depend on the specific example but all the adaptations are to maximise the likelihood that the parents' genetic material is successfully passed on. In general terms this is a balance between having as many offspring as possible, ensuring that the offspring make it through to a reproductive age, and minimising the risks and energy requirements of pregnancy and birth. There are a number of different solutions to this problem.
   Oviparous animals –the embryos derive their nutrients from the egg, which is less energy-intensive than in viviparous animals, and therefore provides far less strain on the mother. In addition, because the eggs provide an independent habitat once they leave the mother's body, the parents can have little to do with their offspring once they hatch (with the exception of birds). Both of these factors mean these animals can spend more time finding new mates rather than looking after offspring, so they can give birth to more offspring over their lifetime. However, the lack of parental involvement means individual offspring are less likely to survive e.g. due to predators.
   Ovoviviparous animals – the embryos derive their nutrients from the egg, but hatch inside the mother's body and give birth to live offspring. This is less energy-intensive and demanding on the mother than for viviparous animals, but is more energy-intensive and demanding than in oviparous animals. The live offspring are more fully developed than in oviparous animals, meaning they are more likely to survive – but the increase demands of this method means fewer offspring are born over the mother's lifetime.
   Egg-laying mammals – these combine some advantages of oviparous animals (less energy-intensive) with some advantages of viviparous animals (long period of parental care after hatching, including milk production, to make survival more likely).
   Marsupials – the short period of development in the uterus before birth is less energy-intensive than for viviparous animals. The period of development in the pouch means that offspring are protected and more likely to survive than in oviparous animals. However, newly-born marsupials are far less developed than viviparous animals and they are therefore less likely to survive than in viviparous animals.

4. This simplified model gives an indication of the general features; the most important thing to note is that Oestrogen is dominant in the pro-oestrous and oestrous phases, whilst progesterone is dominant in the metoestrous and dioestrous phases.

	Oestrogen	**Progesterone**	**FSH**	**LH**
Pro-oestrous	High	Lowest	High	High
Oestrous	Highest	Low	Highest	Highest
Metoestrous	Low	Highest	Lowest	Lowest
Dioestrous	Lowest	High	Low	Low

5. In the gestation phase in placental mammals:
   - the embryo and placenta form from the implanted blastocyst
   - all major body systems are formed during the embryo stage
   - once all systems are formed, the embryo becomes a foetus
   - the foetal stage is when all the bodily systems fully develop until they can provide independence from the mother
   - the placenta provides all the nutrients required by the embryo/foetus as it grows
   - as the foetus continues to grow the mother's uterus expands and moves, pushing other organs out of the way, so that the mother is visibly pregnant.

- the end of the gestation period is when the mother is ready to give birth.

6.

Fertilisation

Fertilisation is much the same in both.

Copulation

The copulation stage is almost the same in both, except that marsupials have three vaginas, and sperm travels through the outer two, which are connected to two separate uteruses.

Implantation

This stage is much the same in both. Marsupials are able to prevent a blastocyst from implanting, temporarily delaying pregnancy, which is known as embryonic diapause. However, some placental mammals can also do this.

Gestation

- A much more basic placenta develops in a marsupial compared to a placental mammal.
- The embryonic phase in marsupials is shorter than in placental mammals
- A marsupial foetus is far less developed when it is ready to be born, compared to a placental mammal.
- The gestation phase overall is much, much shorter in marsupials than placental mammals.

Parturition

- The birth process itself is similar in both.
- The new-born of most mammals are fairly well-developed at birth and capable of living relatively independently. In marsupials, the new-born are very underdeveloped and cannot survive independently – they must remain in the pouch to continue to grow and develop.
- Some development that takes places in the uterus for placental mammals takes place in the pouch for marsupials.
- Both marsupials and placental mammals provide milk to their new-born.

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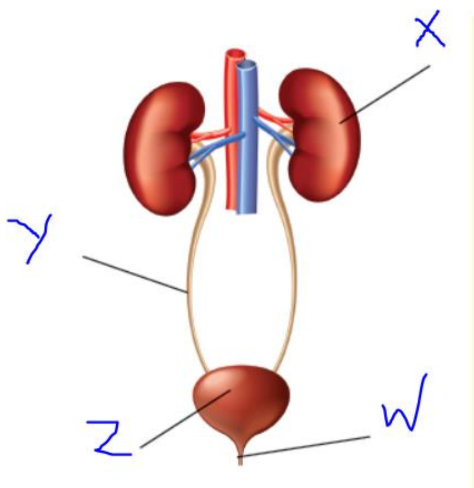
1.



X – kidney

Y – ureter

Z – bladder

W - urethra

2.

- The kidney has two main functions: to filter substances out of the blood using a process called ultrafiltration, and to reabsorb the correct quantities of substances back into the blood, in a process called reabsorption. The main substances that are removed are salts, water and urea, which together make up urine. Through this process, the kidneys play an important role in the homeostasis of water and salts.
- The ureter passes urine from the kidneys to the bladder.
- The bladder collects urine until it can be expelled from the body.
- The urethra is an opening (orifice) through which urine leaves the body.

3. a) Ammonia is the toxin which the excretory system needs to remove from the body. b) In mammals such as dogs it does this through a chemical reaction which uses ammonia molecules to create a substance called urea, which is relatively non-toxic. In birds such as parrots, ammonia molecules are used to produces uric acid, which is even less toxic than urea. In fish such as trout, ammonia can be removed directly via the gills because ammonia will dissolve in water (although its kidneys also still remove some ammonia as urea.)
4. Mice or rats.
5. The function of the bladder is to hold urine temporarily and expel it at regular intervals. The bladder can stretch and is structured with folds. This allows the bladder to expand in order to hold urine temporarily. There are muscles in the neck of the bladder, which keep the urine in place until they are instructed to relax. Stretch receptors in the bladder send signals to the brain when the bladder is full, and then the brain sends signals to the muscles to relax. This causes the bladder to expel urine. In this way the muscles control the bladder and allow it to empty at regular intervals.

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1.
    a. scapula
    b. humerus
    c. ulna
    d. carpals
    e. phalanges
    f. metatarsals
    g. fibula
2. Three from:
    - To protect important organs
    - To provide a rigid structure for other body tissue
    - To provide a way for the body to move, in conjunction with the muscular system
    - As a store of essential minerals
    - Through bone marrow, a production site for components of the blood - red blood cells, white blood cells and platelets.

3. To protect important organs (e.g. the brain and spinal cord, the heart, the lungs) and as a central axis from which the appendicular skeleton can attach to.
4. Tendons attach muscles to bones. Ligaments attach bones to each other.
5. Three from the following, or any other relevant answers:
    - Facilitates the act of chewing, which itself supports the energy requirements of endotherms (warm blooded animals)
    - The arrangement of limbs under the body allows for a more upright stance and more efficient movement – including a much better running technique
    - This in turn led to muscular developments which allowed for faster running and higher jumping
    - A shorter tail aids balance and allows for the more upright stance.
    - The lack of a lower rib cage allows for extended foetal development in the uterus, which has led to more complex species.
    - The diaphragm muscle, through the act of breathing, provides a way to get more oxygen into the body, which allows for greater physical exertion than reptiles are capable of. (Though birds are capable of even greater exertion but do not have a diaphragm).
6. Horses are cursorial animals, i.e. running animals. Their main adaptations include:
    - The development of hooves, which means a horse is walking on its 'tiptoes'. This allows the leg to extend to its full length. The hoof of a horse is made of only one weight-bearing phalange.
    - The forelegs and hindlegs are long, to allow for a greater stride length. Part of the extension of the legs is due to relatively longer metatarsals and metacarpals.
    - The radius and ulna are fused together for most of their length, to provide stability and prevent twisting of the leg due to the large muscle forces that act on it.
    - There is no clavicle, which allows for greater mobility and rotation of the shoulders, which leads to a greater stride length. This necessitates extra muscles to attach the scapula to the torso.

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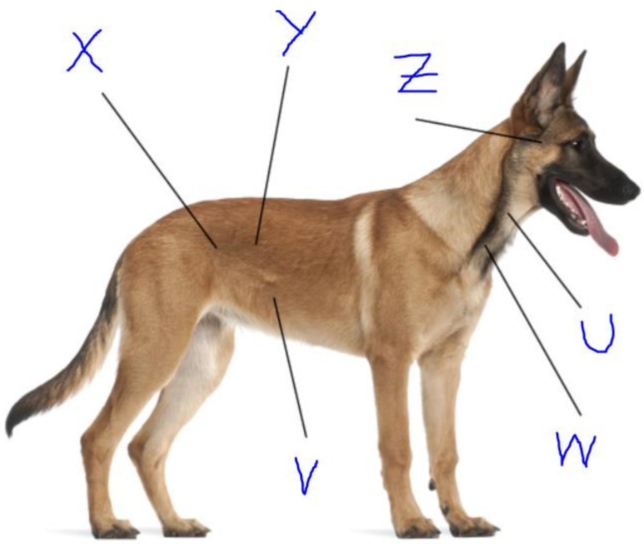
1.



U – para-thyroid gland

V - pancreas
W – thyroid gland
X – ovaries
Y – adrenal gland
Z – pineal gland

2.
- The pancreas measures the amount of glucose (sugar) in the blood.
- Alpha cells are activated when glucose levels are too low, and beta cells are activated when glucose levels are too high.
- Alpha cells cause the hormone glucagon to be released, which causes glycogen in the liver to be released. This raises the level of glucose in the blood, in response to the previously low blood sugar levels.
- Beta cells cause the hormone insulin to be released, which causes glucose to either be absorbed into the body's cells or to be transformed into glycogen which is stored in the liver. This lowers the level of glucose in the blood, in response to the previously high blood sugar levels

Both responses return blood sugar levels to a normal range and hence ensure homeostasis.

3. Four from: adrenocorticotropic hormone, thyroid-stimulating hormone, FSH (follicle stimulating hormone), LH (luteinising hormone), prolactin, growth hormone, anti-diuretic hormone, oxytocin.
4. Hormones are chemicals which are released into the bloodstream by endocrine glands and travel around the body. They allow organs to be controlled remotely. They can do this because each organ has special receptors on cells on their surface. The receptors are proteins that can only bind to specific hormones. When the correct hormone binds with a receptor, the hormones cause other cells within the organ to change their behaviour, which causes the organ itself to change its behaviour. However, if a hormone does not bind to a receptor, then nothing further happens.
5. The adrenal glands are responsible for producing adrenaline, cortisol and aldosterone.
   - Adrenaline is responsible for the 'fight or flight' response, priming the body to prepare for imminent exertion. It acts on most parts of the body, such as causing the heart and breathing rate to increase.
   - Cortisol helps to provide the body with energy because it aids the production of glucose from non-carbohydrate sources. It also helps inhibit the action of insulin, preventing glucose levels from decreasing. This is a useful response when the body faces a stressful situation.
   - Aldosterone regulates the balance of salts in the body by instructing the liver to reabsorb different amounts of each type of salt.

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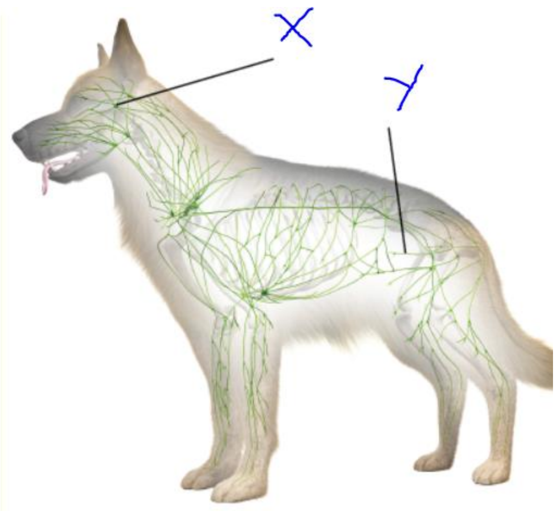
1.



X - Lymph gland/node
Y - Lymph vessel

2. Two from:
    - Drain fluid from tissues – by collecting excess blood that has been supplied to tissues. This is possible because the lymphatic system, unlike the circulatory system, is not a closed loop.
    - Aid in fat digestion – through lymphatic capillaries called lacteals which are part of the intestines and which can absorb fats. The fats are eventually transported into the bloodstream.
    - Transport of material around the body – lymph in the lymphatic system moves around the body until it eventually drains into the bloodstream. This distributes allows necessary substances to reach all parts of the body, and can also remove waste material via the bloodstream and kidneys. The lymphatic system transports dead cells, pathogens, T-lymphocytes, B-lymphocytes, other white blood cells, and fat.
    - As part of the immune system – the lymphatic system helps distribute white blood cells, along with the circulatory system. Lymph glands are sites where pathogens are trapped and where white blood cells gather, particularly lymphocytes. T-lymphocytes (T-cells) also mature in a lymphatic organ called the thymus.
3. Any four of these differences:

Circulatory system	**Lymphatic system**
Closed loop	Open loop
Circulating fluid is called blood, which is red in colour	Circulating fluid is called lymph, which is colourless
Uses a pump (the heart) to move blood around the system	No pump – relies on gravity, muscles and one-way valves to ensure lymph travels around the system
Blood circulates quickly around the system	Lymph circulates slowly around the system
Role is to provide oxygen to, and extract carbon dioxide from, all cells in the body	Multiple roles: to drain excess fluid from tissues, to transport material around the body, as part of the immune system, and to aid in the digestion of fat.

1. Any four of these differences:

2.

T-lymphocytes	B- lymphocytes
Part of the adaptive immune system	Part of the adaptive immune system
Form in bone marrow but mature in the thymus	Form and mature in bone marrow
Gather in lymph glands	Gather in lymph glands
Can respond to pathogens that have invaded cells	Can respond to pathogens circulating in lymph
Kill pathogens using special chemicals which destroy the cells that have been invaded	Kill pathogens by producing antibodies which attach to the pathogen and disable it.

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1. Animals that rely on their environment to maintain their body temperature, e.g., a lizard.
2. They are less suited to cold environments.
3. They can live in colder environments than ectotherms, and can continue operating across a wider range of daily temperatures.
4.
    - The hypothalamus is able to continually measure the internal temperature of the dog as well as it's skin temperature.
    - When this temperature measurement is too high, the hypothalamus sends signals that the dog needs to cool down.
    - This causes the dog to stop moving, to pant (which evaporates moisture from their mouth and tongue), and for blood vessels near any exposed skin surface to dilate so warm blood can be cooled. It also causes the dog to seek out somewhere cool or out of the sun.
    - When the hypothalamus temperature measurement is too low the hypothalamus sends signals that the dog needs to warm up.
    - This causes the dog to move around, the dog's hairs to stand on end (a bit like goosebumps in humans) so it can trap some air which acts as an insulator, to shiver or tremble in order to generate muscle heat, to curl up in a ball to conserve heat, and to constrict blood vessels near any exposed skin so that warm blood does not cool down and keeps internal organs warm instead.

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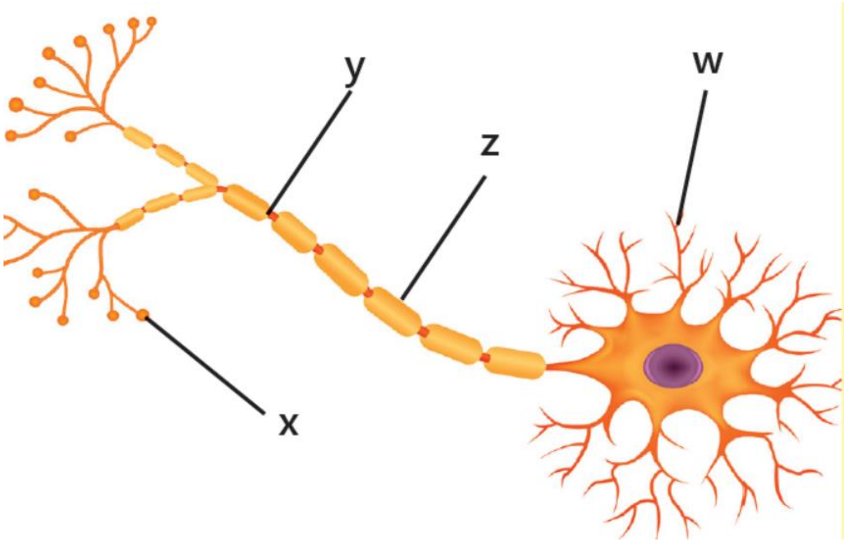
1.

a. cerebral cortex
b. thalamus
c. medulla
d. cerebellum

2. Neurons receive electrical and chemical signals, and transmit them to other neurons. They do this by transmitting electrical signals to their axon terminals which stimulate the release of neurotransmitters from synaptic vessicles. The neurotransmitters travel across the

synaptic cleft and are received by neuroreceptors in the dendrites of the receiving neuron. This allows signals to travel through the brain and nervous system.

3. The medulla, the cerebellum and the pons.
4. As soon as the lion sees, hears and smells the piece of meat, sensory neurons pass information through the central nervous system to the brain. They travel through the pons, on to the reticular formation, and to the thalamus. The thalamus sends this information on to the cerebral cortex so the information can be processed and understood by the animal. At the same time the limbic system is engaged, as the lion has an emotional response to presence of food. This response may be linked to memories associated with hunting, as well as the pleasure associated with food; the hypothalamus also senses the level of hunger. The hypothalamus begins to secrete hormones that stimulates the rest of the endocrine system, to prepare the lion for hunting and for eating and digestion.
   After processing the sensory information it has received, the cerebral cortex makes a plan to move towards the meat and eat it. The instructions to move are passed back through the thalamus, through the reticular formation and coordinated by the cerebellum, which is responsible for balance and coordination.
   During and after eating the medulla is responsible for all of the autonomic processes associated with digestion – for instance, the muscle movements to move food through the intestines.
   Once the plan to move towards and eat the meat has been executed, the intestines and stomach create hormones to indicate that they are full. The hypothalamus receives this information and sends signals to the cerebral cortex, which ultimately sends more signals back through the thalamus, reticular formation and to the cerebellum, in order for the animal to stop eating and walk away from the meat. Along with the role of the medulla, the hypothalamus continues to secrete hormones to control the endocrine system, in order that food can be digested.
5. Motor neurons carry signals away from the central nervous system and cause a response, either to move muscles or to cause glands to produce hormones.
6. Sensory neurons.
7. The autonomic nervous system needs to respond to the environment around it in order for the animal to survive. The two systems work in opposition to each other, and allow an animal to make the best use of its resources to make it more likely to survive, according to the circumstances. it finds itself in. The sympathetic nervous system allows an animal to use its energy resources to prepare for sudden exertion whilst the parasympathetic nervous system allows an animal conserve energy and obtain more energy from food. An animal with only a sympathetic nervous system would burn through its energy supplies and collapse; and an animal with only a parasympathetic nervous system would probably be killed by a predator, or rival or lose out in competition for food.
8.



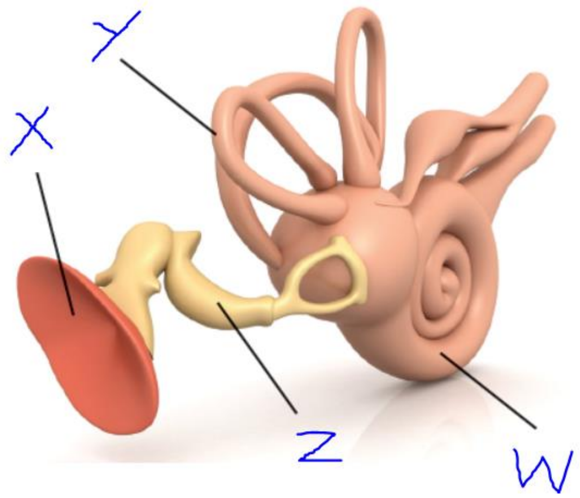
X – axon terminals
Y – node of Ranvier
Z – Schwann cell
W - dendrite

Page 84-5

1.
    a. lens
    b. choroid
    c. fovea
    d. optic disc
    e. iris
2. Three from:
    - They have more rods than cones, as colour vision is less important than sensitivity to light
    - They have a tapetum lucidum, a structure behind the retina which reflects light back into the eye, to make sure that any light that has not been sensed by the retina is not lost. Reflecting it back into the eye gives it another chance to fall on a rod or cone cell, and thus be sensed.
    - They have large pupils, to let in as much light as possible at night.
    - They have slit pupils so that the eye is not damaged in daylight conditions. They also have a multifocal lens, which works in combination with the slit pupil, to ensure all frequencies of light are in focus.
3. The choroid contains blood vessels which are responsible for transporting nutrients to, and removing waste products from, the retina.
4. As the eagle scans the ground the medial and lateral rectus muscles move the eye left and right. Light first hits the cornea and is bent. It then enters the pupil. The iris surrounding the pupil changes size according to how much light is entering the eye; this mechanism is controlled by the autonomic nervous system. Light then hits the lens, which bends it a little more in order that it focuses on the retina at the back of the eye. As the prey is far away, the ciliary body muscles relax in order make the lens thinner and ensure a sharp focus. This change in shape is controlled by the autonomic nervous system. The retina is made up of

light-sensitive cells called rod and cones and the fovea is densely packed with cones. When light hits these cells in the retina they become stimulated and send signals to the optic nerve. The optic nerve transports these signals through the optic disc and on to the brain, where the images are processed and made sense of by the eagle.

5.



W – Cochlea
X – Tympanic membrane
Y – Semi-circular canals
Z - Incus

6. The organ of Corti senses vibrations of the membrane in the cochlea and sends these signals through the cochlea nerve and on to the brain for interpretation. It sends different signals for different parts of the membrane. Different parts of the membrane correspond to different frequencies (pitches) of sound.
7.
    - A rabbit has evolved large pinna, to help pass the correct frequencies of sound in the most efficient way through to the middle ear. (The pinna also evolved to aid with maintaining body temperature, which is essential for an endotherm such as a rabbit.) Most lizards, which are ectotherms, do not have any pinna, or have pinna that are much reduced.
    - A rabbit has three bones in the middle ear – the malleus, the incus and the stapes (known collectively as the ossicles). A lizard only has one of those bones, the stapes, which connects the tympanic membrane to the cochlea.
    - The rabbit's cochlea, like all mammals, is curled up in the shape of a shell. A lizard has a cochlear duct, which is a straight tube. The difference in shape means that the rabbit can hear higher frequencies of sound than a lizard.
8.
    a. turbinates
    b. olfactory nerve
    c. olfactory bulb
9. The olfactory bulb is able to process signals sent through the olfactory nerve. It can sort signals into different categories before sending them on to the brain for further processing. This is in contrast to other senses, where the nerves are connected directly to the brain.
10. There is no simple answer – but consider some of the following points:

- Smell evolved as way to sense the presence of food, and as a way to avoid dangerous or toxic substances.
- Dogs evolved from wolves, and they came to rely heavily on smell as the primary way to hunt prey and find food. Environment and lifestyle always dictate evolutionary changes, and this would have been the reason why their sense of smell developed – only wolves with a good sense of smell would survive and pass on their genes to the next generation.
- Whilst smell was still important for early humans and their ancestors, they could use other senses such as vision to locate food. Their environment and lifestyle meant they did not have to rely as heavily on their sense of smell, which meant those with a poor sense of smell were more likely to survive and pass on their genes. This meant there was less need for the sense of smell to evolve over time.
- Wolves also formed complex social structures and found that they could use smell to communicate through scents. Again, it was an evolutionary disadvantage to not be able to communicate well within social groups, so the sense of smell continued to evolve to accommodate this.
- Early humans and their ancestors developed other ways to communicate, primarily language, which again meant that a poor sense of smell did not hinder the ability to communicate in social groups. This meant that the sense of smell did not need to evolve in the same way.

11.
- Sound waves hit the pinna and are directed down the auditory meatus.
- They reach the tympanic membrane, causing it to vibrate.
- This causes the malleus, incus and stapes to vibrate in turn. The vibrations of the stapes are much larger than those of the tympanic membrane.
- The stapes causes the membrane covering the oval window, attached to the cochlea, to vibrate.
- This, in turn, vibrates the fluid in the cochlea.
- The fluid vibrations cause different sections of the membrane in the centre of the cochlea to vibrate. The vibration of different sections corresponds to different frequencies of sound.
- The hair-like projections of the organ of Corti are stimulated by the movement of the different parts of the membrane. When stimulated, they send signals to the cochlear nerve.
- Signals from the cochlear nerve are sent to the brain for processing; the brain is able to classify the different signals as corresponding to different sound frequencies which the dear hears.

12. The palate separates the nasal passages from the mouth. This allows mammals to breathe whilst eating, which facilitates chewing.
13. The sense of taste is linked to evolutionary dietary trends. Cats have no dietary need for sugars and therefore their taste buds cannot taste sweet things. Meanwhile, as hunters, cats have a relatively consistent diet and know the source of their food. They also use other senses to locate food sources and solely don't rely on their sense of taste. All of these factors mean that cats do not need a large number of taste buds.
    A catfish, in contrast, spends its time searching for food at the bottom of rivers. Its sense of taste is the main sense it uses for locating food because the water can be so murky that they

can't see anything. Most catfish are omnivores, eating animal matter or plant material, which extends the tastes that they need to be able to sense. All kinds of material lies at the bottom of a river bed but often in small quantities, so they need a very sensitive gustatory system to find this food. To maximise their likelihood of finding food they have also developed taste buds all over their body. A catfish completely relies on its sense of taste to prevent it from starving to death. All of this together means that they have a vast number of taste buds and incredibly sensitive gustatory system – far more developed than a cat's.

14. The sense of smell detects chemicals that easily evaporate, so they are suspended in air. The sense of tase detects chemicals that easily dissolve in liquids. (Note: Jacobson's organ also detects chemicals that dissolve in liquids; however, it detects very specific chemicals that come from potential mates, predators and prey – these are chemicals that the animal cannot sense using its gustatory system).
15. Two from:
    - mechanoreceptors, which detect gentle touches or changes in pressure
    - thermoreceptors, which detect absolute temperatures and changes in temperature
    - nociceptors, which detect any physical or thermal interactions which are likely to cause damage and send signals which are interpreted as pain
16. Main points include:

Horse	**Great apes (e.g. gorilla, chimpanzee, orangutan)**
Almost entirely covered in hair, which is less sensitive to fine touch. This also means a horse has many root hair plexus skin receptors.	Has hairless (glaborous) skin on the hands, face and chest, which is more sensitive to fine touch than hair-covered skin.
Hooves are not very sensitive to touch	Hands and feet have a large number of skin receptors; this allows for the high levels of dexterity seen in such primates
Uses whiskers to help explore the environment.	Small whiskers present but they play a small role in the overall sense of touch
Both have mechanoreceptors, thermoreceptors and nociceptors	

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1. a) and b) Any from:
    - lateral line – present in fish, consists of a series of openings in the skin connected to a canal into which hair-like structures, called neuromasts, project. These structures move with the water in the canal, and their movement generates signals which are sent to the nervous system and brain. In this way a lateral line allows a fish to sense currents and movements in the water in which it swims.
    - vibrissae – a special type of hair whose only function is to provide sensory information. Animals sense any movement in their vibrissae, caused when they come into contact with objects or other animals. A common example of vibrissae are whiskers.
    - platypus bill – this soft and flexible structure is filled with tens of thousands of mechanoreceptors, a type of skin receptor. It allows the platypus to hunt and navigate without using any other sense s.
    - the nose of a star-nosed mole – this organ is also packed with mechanoreceptors, which gives this species of mole an incredibly detailed tactile sense.

2. The bat emits very high-pitched screams which are too high for humans to hear. This is called ultrasound. Ultrasound spreads out from the bat and is reflected by surrounding objects, including potential prey. Some of these reflections (or echoes) reach the bat, whose ears are specially adapted to hear them. The bat can compare its original scream with the reflections, to build up a picture of its surroundings, including the prey. The bat continually emits ultrasound and listens to its reflections, which allows it to sense that its prey is moving. In this way the bat can adjust its own position whilst flying until it catches its prey.
3. Jacobson's organ is a secondary part of the olfactory system. It allows animals to sense chemicals that are not airborne but which are instead dissolved in a liquid – specifically pheromones of potential mates and scents of potential prey, predators or mates. Some animals display the flehmen response when attempting to expose their Jacobson's organ to pheromones or scents.
4. Sharks use a range of senses when hunting:
    - Hearing: sharks have a good sense of hearing for lower frequency sounds; wounded potential prey often emits sounds in these frequencies.
    - Vibration: hearing and vibration sensing are strongly linked in water because sound is a vibration of water molecules. However, sharks, along with other fish, also have a lateral line specifically to sense water vibrations. They use it to navigate and also to sense the presence and movement of potential prey.
    - Eyesight: sharks' eyes have many more rods than cones, which allows them to detect contrast, shadows and movements. This allows them to see the movement of prey that is nearby. However, they rely on other senses to detect prey that is further away. They have a tapetum lucidum to help maximise the amount of light available – this is useful underwater where light conditions can be low.
    - Smell: sharks have an excellent sense of smell, and can detect small amounts of blood from potential prey, diluted in water, from hundreds of metres away.
    - Electroreception: the ampullae of Lorenzini is a specialist organ which detects small electrical currents in water, created by other living organisms, including prey. Sharks use this sense to help detect prey that is very near but hidden from sight – for instance, fish hiding in the sand at the bottom of the sea.
    - Touch: sharks use their sense of touch to investigate objects, and will often bump into potential prey before biting them, so they can understand their size and shape, and whether the prey is suitable or not.
    - Taste: the sense of taste does not help sharks find food but can help them reject anything they have hunted which is in fact unsuitable to eat.