1. **A -** Organism that use light energy, primarily in the form of sunlight, undergo photosynthesis. These organisms are said to be autotrophic. Heterotrophic organisms have to consume other organisms to obtain their energy, i.e. humans and other animals. Chemotrophic organisms can make their own food, but do so using chemical compounds not light energy.

2. **B -** In cellular respiration, organisms use energy from glucose to make ATP. The steps of cellular respiration include: glycolysis, the Krebs cycle, and the electron transport chain. In order for the cell to produce the maximum amount of ATP from one glucose molecule, oxygen must be present. When oxygen is absent, the cell undergoes fermentation to regenerate NAD+ and produces 2 ATP from glycolysis. This is deemed an anaerobic process and yields less ATP than if oxygen were present to perform the aerobic processes of the Krebs cycle and the electron transport chain.

3. **D -** In cellular respiration, organisms use energy from glucose to make ATP. The steps of cellular respiration include: glycolysis, the Krebs cycle, and the electron transport chain. In order for the cell to produce the maximum amount of ATP from one glucose molecule, oxygen must be present. This is because oxygen is the “final electron” acceptor, and combines with the electrons on the electron transport chain and nearby hydrogen to form water. This stops the process of cellular respiration, and terminates the pumping of hydrogen across the mitochondrial inner membrane.

4. **C -** In the reaction, the components in the original mixture are still present, with the addition of glucose. Glucose is a monomer of carbohydrate. Glycogen is a polymer of glucose and is how animals store excess sugar that is not currently needed by the cells. Since glucose appears in the mixture, the enzyme therefore must be catalyzing (breaking down) the glycogen in the mixture.

5. **E -** Fungi are eukaryotic organisms and as such would have organelles like the mitochondria for cellular respiration, lysosomes for the digestion of cellular waste, ribosomes for protein synthesis, and the golgi bodies for protein modifications. Fungi are not photosynthetic and therefore would lack chloroplasts within their cells.

6. **C -** The key to understanding this question is to know the chemical name for H_2O_2, which is peroxide. Peroxisomes are specialized organelles that serve to cleanse the cell of peroxide, which can be toxic in high levels. Lysosomes are specialized organelles that detoxify the cell and digest cellular waste, but not peroxide.

7. **C -** Mitosis is the process of cell division where the parent cell is essentially cloned to produce two identical cells, with the same number of chromosomes as the parent cell. For humans, mitosis yields two genetically identical cells each with 46 chromosomes. It is in meiosis that the cells produced are genetically different and have half the amount of chromosomes (haploid) in comparison to the parent cell.

8. **D -** Glucose is the monomer or building block of carbohydrates. Organisms store their excess sugar in the form of large carbohydrate structures called polymers or polysaccharides. Starch and cellulose are how plants store their excess sugars and glycogen is how animals store excess sugar. All three compounds are therefore polymers or chains of glucose molecules.

9. **B -** In eukaryotic cells, the cellular structures are said to be membrane bound. Centrioles are essential for cell division and generate the spindle fibers that are used to attach to the chromosomes to pull them apart during metaphase (of both mitosis and meiosis). Centrioles do not have a membrane structure.

10. **C -** The steps of cellular respiration include: glycolysis, Krebs cycle, and the electron transport chain. Glycolysis does not require the presence of oxygen and is therefore an anaerobic process. When oxygen is not present, the cell undergoes fermentation to regenerate NAD+ to continue glycolysis. As a byproduct, lactic acid is produced (by animal cells) or alcohol is produce (by bacterial cells). Since the question refers to muscle cells, this indicates the cell is an animal cell in which lactic acid would be produced, following the equation: (glucose) $C_6H_{12}O_6 \rightarrow 2\ C_3H_6O_3$ (lactic acid).

11. **E -** The movement of water through a selectively permeable membrane is called osmosis. The movement of particles across a selectively permeable membrane from high concentration to low concentration is referred to as diffusion. The question details the movement of water through a membrane using a carrier protein embedded in the cell membrane. This is called facilitated diffusion as the channel is helping the water molecules cross the membrane. The protein serves as a channel and when open, the water molecules will move from an area of high water concentration to an area of low water concentration and this process does not require energy.

12. **A -** Biosynthetic reactions are a special form of a synthesis reaction. In synthesis reactions, reactants combine to form a one product, following the convention: $A + B \rightarrow AB$. In this case, entropy or the amount of disorder decreases as two elements are combining to form one compound therefore becoming more organized. When a reaction becomes more organized, this is a decrease in entropy (or disorder).

13. **D -** The smallest organelle in the cell is the ribosome. Ribosomes can be free floating in the cytoplasm or can be attached to the Endoplasmic Reticulum, forming the Rough Endoplasmic Reticulum. The mitochondria and chloroplasts are relatively large and contain their own DNA and have a double membrane structure. The nucleus is also larger than the ribosome as it contains the nuclear envelope, DNA, and the nucleolus. The Golgi body is a large flattened network that is essential in modifying and packaging proteins.

14. **E -** The action potential of a nerve impulse travels faster on a myelinated axon, by "jumping" between unmyelinated segments called Nodes of Ranvier. This

conduction process is called saltatory conduction, whereby the impulse is able to jump from node to node, as opposed to having to travel down the entire axon.

15. **A -** The respiratory system is controlled by the brain examining the pH and levels of CO_2 in the blood. High levels of CO_2 in the blood would cause the blood to become too acidic. CO_2 travels in the blood in the form of dissolved bicarbonate in the blood plasma. When CO_2 levels in the blood become too high, this triggers breathing and the intake of oxygen. This would involve exhaling out CO_2 and inhaling in O_2.

16. **C -** A motor unit is able to contract and therefore contains one muscle nerve and all the muscle fibers attached to it. Often motor units work together to contract an entire muscle. The motor nerve in a motor unit would receive signals from the Central Nervous System to contract or relax and would then work in tandem with the muscle fibers attached to the nerve to contract or relax the muscle fibers.

17. **E -** The heartbeat is controlled by electrical impulses that are generated by the SA or sinoatrial node. This is a complex that is housed in the upper region of the right atrium and is composed of a bundle of neurons. The SA node is deemed to be "self-polarizing" and can initiate its own action potentials to control and propel the heart to beat.

18. **B -** Filtration is the process where blood is forced out of the capillaries into the glomerulus and Bowman's capsule. The nephron then goes through several processes to recollect (also known as absorption) ions, water, or salt back into the blood or adds additional waste (also known as secretion) to the tubules to eventually be urinated out. Filtration is the least selective of the processes that take place in the nephron.

19. **A -** Adding potassium iodide to the blood would most affect the thyroid. The thyroid produces a hormone that regulates cellular metabolism. This hormone is called T_3 and T_4. These hormones cannot be synthesized without the presence of iodine. With more iodine in the blood from the addition of potassium iodide, more iodine is present to help generate more T_3 and T_4, thereby increasing the amount of thyroid hormones produced, in turn affecting the cellular metabolism of the body. The kidneys may be slightly affected as more salt would be retained, since salt levels would decrease and more potassium would be secreted into the urine, however, this would not be a significant change to what the kidney already does. The parathyroid produces parathyroid hormone, which is essential in regulating blood calcium levels which would remain unaffected by the introduction of potassium iodide.

20. **E -** The pituitary gland produces most of the body's hormones. The pituitary gland is separated into the anterior and posterior portions, with each region producing its own hormones. The posterior pituitary stores oxytocin and antidiuretic hormone (ADH), whereas the anterior pituitary produces adrenocorticotropic hormone (ACTH), follicle stimulating hormone (FSH), luteinizing hormone (LH), thyroid stimulating

hormone (TSH), prolactin (PRL), growth hormone (GH).

21. **D -** Blood clotting occurs when platelets and fibrin networks aggregate to the injured site. Prothrombin undergoes a conformational change to produce thrombin. Thrombin then cleaves fibrinogen to form soluble fibrin, which can then travel to the site to help to stop bleeding by forming a thrombus or blood clot.

22. **B -** Chordates have three main physical characteristics:
- *Pharyngeal pouches*- this serves to connect the throat with the neck and is used as gills in some animals.
- *Notochord*-rod-like structure that serves to protect and support the soft spinal cord. In some chordates this structure is the precursor to the vertebral column, in other chordates it remains as a cartilaginous structure.
- *Dorsal tubular nerve cord*-this is a bundle of nerves that is located on the dorsal side (back side) of the chordate, connecting the brain with the organs and appendages.

23. **E -** The question indicates that the organism lives in a marine environment. This eliminates annelida (segmented worms). Though segmented worms do need to be near water for moisture, they do not as a general rule live in marine environments. Likewise, all chordates do not necessarily live in marine environments, though fish do, birds (who are also in the chordate) phylum do not. Next, the question refers to the organism as having spiny skin. This eliminates cnidaria. cnidaria include polyps and jellyfish, both of which do not have spiny skin. Between porifera (sponges) and echinodermata (like the starfish), only the echinodermata have radial symmetry. porifera are considered to be asymmetric.

24. **E -** Primitive vertebrates are said to be deuterostomes, meaning the first opening in the gastrula called the blastopore differentiates to become the anus. This advanced characteristic is also shared with the echinodermata. The other organisms listed are protostomes, whereby the first opening in the blastopore differentiates to form the mouth. Based off of embryological development, the primitive vertebrates are closely related to the echinodermata.

25. **D -** Monera including bacteria are prokaryotes, which lack a nucleus and membrane bound organelles. The other kingdoms (Plantae, Animalia, Fungi, and Protista) are all eukaryotes that have a defined membrane-bound nucleus and organelles. Though most bacteria are autotrophic so too are plants, therefore not making this a distinguishing factor. Likewise, some protists are unicellular similar to bacteria and some bacteria, fungi and protists can also be macro and microscopic.

26. **A -** When DNA is transcribed into RNA the following pairings occur: A→ U (note: in RNA there is no Thymine), T→ A, G → C, C → G. Therefore, if the DNA sequence is GGCATTAGG this would be transcribed to form CCGUAAUCC.

27. **E -** If the parent's genotype is AaBbcc, according to the law of segregation, each of the alleles can separate and be passed on to the offspring. Likewise, in accordance

with the Law of Independent Assortment, these separated alleles can combine with other alleles to form new combinations of alleles that can be passed on to the offspring. Therefore the parent could pass on an "A" or an "a", a "B" or a "b", and only a "c" (since there is only one type of c allele in the parent's genotype). The different combinations that result are: ABc, Abc, aBc, and abc.

28. **B -** Organisms that are diploid have two copies of each chromosome. For example, human body cells are diploid containing 23 pairs of chromosomes, with one chromosome being inherited from each parent. For a given locus or location on a gene, there are at most two types of alleles, which could either be recessive and dominant. One pair of chromosomes often carries two alleles, either two recessive alleles (homozygous recessive), two dominant alleles (homozygous dominant), or one dominant and one recessive allele (heterozygous). This is "usually" true as some traits may involve multiple alleles, more than just a dominant and a recessive, as is the case with blood groups. Likewise, the alleles that code for the same gene are located in identical areas on homologous (related chromosomes). A single chromatid only contains one copy of an allele.

29. **D -** If the parents are Ggss and ggSs, the different combinations of alleles that can be passed on to the offspring have to be determined. The parent with the genotype Ggss can contribute Gs and gs to its offspring, whereas the parent with the genotype ggSs can contribute gS and gs to its offspring. Doing the following punnett square gives the possible genotypes of the offspring.

	Gs	gs
gS	GgSs	ggSs
gs	Ggss	ggss

The following phenotypes are present:

1 GgSs – Green Short
1 Ggss – Green Long
1 ggSs – Striped Short
1 ggss – Striped Long

Which are all in a 1:1:1:1 phenotypic and genotypic ratio.

30. **C -** Sexual reproduction is the process whereby two organisms exchange genetic information (often through the fertilization of an egg by a sperm) to produce an offspring that is genetically different from the two parents. However, asexual reproduction is the process where a parent cell divides to produce a genetically identical offspring cell. Sexual reproduction and asexual reproduction often produce offspring that are viable and are able to reproduce in subsequent generations. Natural selection is based on the environment, not the mode of reproduction of the organisms in the environment.

31. **C -** Some traits are carried on the X chromosome and often affect male offspring more than female offspring. Females may appear phenotypically normal but can be carriers of a X-linked trait since females have two X chromosomes and most X-linked traits are recessive, requiring a female to have both recessive alleles, one on each X chromosome, in order for her to have the trait. For this question the male has normal vision and would be represented with the genotype: X^RY. The female parent is a carrier, but has normal vision and would be represented with the genotype: X^RX^r. The following Punnett square results:

	X^R	X^r
X^R	X^RX^R	X^RX^r
Y	X^RY	X^rY

For female offspring, there is a 100% chance of normal vision as both females have at least one dominant allele. 50% of the females would be carriers.

For the male offspring, there is a 50% chance of color blindness and a 50% chance of normal vision.

32. **C -** In humans there are 23 pairs of chromosomes. The pairs result from one chromosome being inherited from the mother and one chromosome being inherited from the father. Homologous chromosomes are identical and shape and size but are not identical in their genetic information. Instead they carry information for the same traits though this information may differ. For example, eye color is located on chromosome 15 and one parent may have the alleles for blue eye color, whereas another parent may have the alleles for brown eye color. The combination of these alleles from each parent will influence the child's eye color. Chromosomes do not pair together or synapse during mitosis, this is done during meiosis with the formation of gametes or sex cells that have to have half of the genetic information and must contain only 23 chromosomes not 46 chromosomes.

33. **A -** Embryonic induction involves the differentiation of cells based on the activity of nearby cells. Induction factors are released as a cell differentiates and this causes other cells in that area to also differentiate to form parts of the growing embryo. An unfertilized egg is able to develop through a process called parthenogenesis, not through induction. Likewise cellular induction does not involve the transfer of genes or genetic information. Recessive genes are expressed if two recessive alleles are present, with each recessive allele being inherited from each parent, not only from the mother.

34. **B -** Following fertilization, the zygote undergoes successive rounds of mitosis to form the morula, which is a dense ball of cells. This ball of cells has to begin to hollow out to make room for internal structures to begin to develop. The hollowing out of the morula, now called a blastula begins when the archenteron forms which is the precursor to the intestinal system or gut of the growing embryo. After the archenteron is formed, the blastula, now hollowed forms the gastrula, which then

gives rise to the germ layers and cell induction occurs to further differentiate the embryo's cells into the embryo's physical structures and organs.

35. **A -**There are three germ layers in the human embryo, the endoderm, ectoderm, and mesoderm. The endoderm forms the intestinal tract, the bladder and the lungs. The mesoderm forms the blood, bones, the heart, connective tissue and parts of the eye. The ectoderm forms the central nervous system (including the brain), the hair, and the epidermis. The brain is part of the central nervous system and is therefore derived from the ectoderm germ layer.

36. **A -** Cleavage following fertilization can be either holoblastic or meroblastic. In holoblastic cleavage, the entire cell divides and continue to divides to form the blastula. In meroblastic cleavage, only the non-yolk region divides, as is what occurs in birds. The amount and location of the yolk will dictate which type of cleavage occurs. Generally holoblastic cleavage is faster than meroblastic cleavage, therefore the amount and location of the yolk can also affect the rate at which cleavage occurs. The thickness of the zona pellucida, which is the membrane surrounding an unfertilized egg, would only affect the rate of fertilization. A thicker zona pellucida would make fertilization harder, as sperm would have to get through this denser region to fertilize the egg.

37. **D -** As a pond changes from an aquatic environment with less animal and plant diversity, to a terrestrial environment with more biodiversity, this process is called ecological succession. A similar process also occurs after a natural disaster like a volcano covers a terrestrial environment and the community must rebuild the vegetation and animal life. Though one may think of desertification as a feasible answer option since the pond is in essence "drying" out to form a terrestrial environment, desertification would result in less biodiversity and the question implies that the terrestrial community formed is more diverse than the organisms that were present in the initial pond.

38. **B -** Speciation is the process by which different species are formed from a common ancestor. New species arise due to: natural selection, mutations, and geographical or reproductive barriers. If a population is separated geographically by a mountain range or body of water, the organisms will evolve to fit their separate environments and over time they may begin to look and behave like two different species.

39. **B -** A conditioned response is a learned response to a stimulus. For example, if a bell is rung and then a dog is feed. Then eventually when the dog hears a bell, they will expect to be fed and may begin to salivate (as was done in the Pavlov's dog experiment). The question discusses a behavioral response that is shared by all organisms, which implies that it is innate to that species. A reflex is an innate response, but it is not necessarily as a result of being exposed to the same stimulus each time. Likewise, taxis is the movement toward or away from a stimulus as opposed to a specific behavioral response to a stimulus. A fixed action pattern is a behavioral response to the same stimulus. For example, a waterfowl will roll an egg

or an egg-shaped object toward its nest as an instinctive behavior to reclaim a lost egg that may have rolled from its nest. This is a hard-wired behavior that is not taught to the waterfowl, but comes as instinct as a way to preserve their young and is observed around any oval-shaped object.

40. **D -** How often an allele appears in a population is the allele frequency. For example, in a sample population the allele k may appear in 45% of all organisms, whereas the allele K may appear in 55% of all organisms. The allele frequency can be affected by the movement of organisms into and out of the population (immigration and emigration), natural selection, mutations, and random changes to the frequency of alleles through genetic drift. Random interbreeding should not change the frequency of alleles if all mating organisms have an equal chance of reproducing and passing on their alleles to their offspring. With nonrandom mating, some organisms are preferred over others and have more opportunities to pass on their alleles and this would over time change the allele frequency of the population.

