AP® Biology
2003 Sample Student Responses

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2. Regulatory (control) mechanisms in organisms are necessary for survival. Choose **THREE** of the following examples and explain how each is **regulated**.

(i) Flowering in plants – phytochrome, long-night, short-night, P_r P_{FR}, possible flowering hormone

(ii) Water balance in plants

(iii) Water balance in terrestrial vertebrates - ADH, aldosterone, cognitive responses, panting

(iv) Body temperature in terrestrial vertebrates - panting, extremities, movement, sweating

(2) (i) Plants flower in response to photoperiod. Photoperiod is the length of day and night. Plants maintain an internal clock to monitor the circadian rhythms of day and night. The mechanism for this internal (or endogenous) clock will continue even in the absence of external clues, but it is 'reset' by external clues.

Flowering plants' recognition of photoperiod relies on phytochromes. ~~The~~ Phytochromes are modified proteins with a core and at least two isomeric forms. When phytochromes are exposed to red light the phytochrome shifts to a position denoted as P_{fr}. When far-red light from the visible spectrum strikes the phytochrome, it shifts to P_r. During the night, P_r accumulates. This is due to a variety of factors including: P_r is produced initially by plants, P_{fr} is unstable, and, in some plants P_{fr} is actively ~~is~~ manipulated. When sunlight returns with daylight, though, P_r is rapidly converted to P_{fr} until they reach equilibrium. This tells the plant when day has come and 'resets' the clock.

Night length is central to flowering. Some plants require night to be a certain length or longer. Other plants require that night be a certain length or less. In either case, phytochromes measure the photoperiod.

When conditions are ~~not~~ met for flowering, it is hypothesized (and ~~experiments~~ experimentally suggested that ~~a~~ ~~there~~ a hormone is released to signal flowering.

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(2)(iii) Water balance in terrestrial vertebrates is controlled by a variety of means. Hormones are one central mechanism. In humans Antidiuretic hormone (vasopressin) is secreted by the posterior pituitary gland and causes the collecting duct of the nephron to become more permeable to water, Urine is concentrated more as a result. Aldosterone, from the adrenal cortex, retains salt and water by affecting the collecting duct similarly.
Terrestrial vertebrates can also use cognitive responses. When sensory neurons detect a decline in water balance, the vertebrate will experience thirst and seek water, in many cases.
A final means of control is the means of disposing of nitrogenous wastes, in a sense. By using uric acid (a ~~solid~~ ~~dot~~ paste or solid) rather than dissolved urea or ammonia, animals may conserve water.

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(2)(iv) Body temperature may be regulated through movement. If a vertebrate becomes too cold, it may move to generate heat internally. It might also use a cognitive response and burrow or put on a coat. Body temperature is also controlled through blood flow. Vasodilation would increase blood flow at the surface, and thereby aid cooling. Blood flow might be increased (as in a rabbit's ears) in an extremity where heat loss is likely. This would help cool the animal.

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(2)(iv) cont. Another regulatory mechanism is sweating. By secreting fluid onto the surface, it evaporates. Evaporation requires energy, and some of this energy is heat from the body. This lost heat will aid cooling. The same principle is used when animals pant. Here the evaporation is in the mouth and respiratory system.

All of these means are mechanisms for regulating body temperature changes detected by the nervous system.

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   (i) Flowering in plants

   (ii) Water balance in plants

   (iii) Water balance in terrestrial vertebrates

   (iv) Body temperature in terrestrial vertebrates

iv: Body temperature in terrestrial vertebrates is controlled by many different actions. When body temperature is too cold the organism may have contractions of skeletal muscle to increase blood flow and warm the body otherwise known as shivering. Also, the organism's hair may stand on end causing gooseb umps. When this occurs the hair forms a net-like structure to help trap heat in.* When the organism is ~~cold~~ warm the blood vessels enlarge and rise closer to the skin. This allows for heat to escape easier. Also the organism may sweat to cool off. The ~~sweat~~ perspiration on the skin will absorb heat while being evaporated cooling the body temperature.

*The blood vessels will constrict and move farther away from the skin.

iii: water balance in terrestrial vertebrates is maintained through reabsorption and hormones. When the body has too much water, the kidneys allow the water to flow through them without reabsorbing

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the unnecessary water. When the organism is dehydrated or lacking water, the kidneys will reabsorb more water than usual with the help of hormones. These hormones are antidieretic hormone (ADH) and aldosterone. ADH helps reabsorb water by causing the body to realize it needs it. Aldosterone helps reabsorb water by causing the kidneys to reabsorb more sodium which in turn reabsorbs water along with it. and doesn't allow as much water to filter through the body.

ii: water balance in plants is maintained by the stomates. The stomates are openings in the bottoms of leaves that allow for the exchange of gases as well as water. The stomates are regulated by guard cells. When water needs to be kept in the plant, the guard cells expand, causing the stomate to close. When there is too much water in the plant, the guard cells become flacid and allow water to pass easily out of the leaves.

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i. Flowering in plants requires careful control mechanisms. Photoperiodism is the greatest control on flowering. To flower certain plants require specific amounts of light. A plant that requires a little amount of light is a short-day plant and vice versa for a long day plant. Scientists actually have determined that it is not the day length but the night length that matters. So short day plants actually require more than a given amount of darkness before they flower and long day plants require less than a given amount of darkness. Phytochromes are the means by which a plant detects light. Phytochromes are particularly sensitive to red(R) and far-red (FR) light. If red light interrupts the night of a plant then the plant will not flower. However if FR light interrupts the night period of a plant then it will flower. This dependence on light to flower is known as photoperiodism. The biological clock of a plant also determines it's flowering. Many plants flower seasonally because of the night length. Some also flower according to their circadian rhythms which is a daily biological clock.

ii. The stomata in plants control waterbalance. Stomata are pores in the undersides of leaves through which gas exchange takes place. The water which begins in the ground is conveyed up the tree through the roots and xylem. The vascular bundles in leaves that branch from the xylem carry the water to the cells in the leaf. If there is a lot of water available then the guard cells, which are two cells surrounding the stomata, swell because the

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water has filled their central vacuoles and increased their turgor pressure. Turgor pressure is the pressure of the cytoplasm and central vacuole on the cell wall of the cell. With the guard cells tense the stomata is open allowing water to escape. If there is not enough water then the turgor pressure in the guard cells is low and they are flaccid. The flaccid guard cells collapse, thus closing the stomata and preventing water from escaping. CAM plants have evolved an interesting adaptation to ~~keep~~ handling water loss. They close their stomata during the day and open them at night so as to prevent excessive dissication or water loss.

iii. Water balance in terestrial vertebrates is controled by the nephrons which are located in the kidneys. Renal arteries bring blood to the kidneys where concentrations of various substances in the blood are regulated. In the glomerulus, blood pressure forces small organic matter into the bowman's capsule. The capsule then passes everything through a long tube until it finally reaches the ureter and eventually bladder. If there is too much water in the blood then urea is released into the nephron tube. Water then attempts to diffuse into the tube to dilute the water. This diffused water is carried away to the ureter. Otherwise if there is not enough water in the blood - less urea is released so less water diffuses.

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(i) Angiosperms (flowering plants) have the greatest survival rate of all plants on land. Regulatory mechanisms for survival in flowering plants include flowers, seeds, and pollination. The bright, colorful, ~~s~~scented flowers of angiosperms attract birds and insects, ~~allowing them to~~ ~~spread~~. Pollen sticks to these organisms and carries the male gametophyte to other flowers, allowing them to pollinate the other flowers. Seeds are also carried by animals to other locations and allow flowers to ~~spread~~. ~~Seed~~ Fruit, which are mature ovary of flowers, contain seeds which are eaten by animals, and carried through the digestive system safely because of the protective seed coat. Wind also carries pollen grains to other sites for reproduction. This type of Reproduction in flowering plants is an important control mechanism to prevent inbreeding, maintain ~~separation~~ mating, and increase survival.

(iii) Terrestrial vertebrates maintain water balance because of ~~scales (in reptiles),~~ skin (epidermis) in mammals, and urine. ~~Reptiles~~ The epidermis of mammals provides a layer of skin that allows certain materials in and also prevents dessication (drying out). Panting, in animals like dogs, also maintains water balance. ~~Similarly, sweat~~

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Animals that live in dry, arid regions like the desert have long loop of Henle in their kidneys, to provide for more water reabsorbtion as wastes pass through the kidneys. The urine excreted is usually very undiluted and these animals do not urinate often. There are large amounts of salt and waste in their urine, but not water. Urea may also be released.

(iv) In cold climates, blood may not flow to the extremities of vertebrates in order to warm the body by concentrating blood flow. In the heat, panting and sweating provides a way for the body to cool down. Sweat contains salt and urea and allows the body to release wastes without releasing water, thereby keeping the body cool.

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