Montogue

Quiz Bl107

Basic Entomology

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PROBLEMS

Problem 1

Associate the following insect species with the pertaining definition.

A. *Xenopsylla cheopis*
B. *Simulium neavei*
C. *Pediculus humanus corporis*
D. *Triatoma infestans*
E. *Aedes aegypti*
F. *Glossina fuscipes*
G. *Culex quinquefasciatus*

1.( ) This insect, shown below, serves as a vector for dengue and yellow fever, two common viral infections, and is said to be the most widespread mosquito species.

2.( ) This is the name of a species of sandfly, or tsetse fly, known for being the vector of arboviral, bacterial (*Bartonella*), and protozoal (*Leishmania*) human diseases.

3.( ) This black fly species is an important vector of onchocerciasis (or “river blindness”) in Central Africa, and occurs in lakes where it is attached to the gills of crabs.

4.( ) This is an example of flea, a holometabolous, blood-sucking insect that serves as vector for rickettsial (murine typhus) and bacterial (*Yersinia* plague organisms) pathogens.

5.( ) This is an example of lice. It is a wingless, hemimetabolous insect that stays attached to human clothes. It has been implied as a vector of louse-borne typhus and louse-borne relapsing fever.

6.( ) This species of mosquito is the one of the many vectors of *Wuchereria bancrofti*, the nematode that causes lymphatic filariasis; the insect serves as an intermediate host for this helminth parasite by harboring the larval stages.

7.( ) This species of blood-sucking bug carries *Trypanosoma cruzi*, the protozoan that causes Chagas disease. Since this insect establishes itself in the crevices of wattle and daub house walls, use of masonry in construction is a simple way to deter its propagation.

▶ Problem 2

Regarding insect biology, true or false?

1.( ) That the existence of complete metamorphosis constitutes an evolutionary disadvantage for insects can be attested by the relatively low number of species that feature this characteristic in their life cycles. Indeed, insect species with complete metamorphosis are outnumbered by insect species that do not exhibit complete metamorphosis by a ratio of nearly ten to one.

2.( ) Insects belong to the Arthropoda phylum and possess most of the features associated with this taxonomic rank, including presence of a chitinous exoskeleton and jointed appendages.

3.( ) The fossil record outlines the evolution of insects. Whereas arthropods such as crustaceans date back to the Cambrian period, the first terrestrial hexapods arose fairly recently, specifically in the Carboniferous.

4.( ) Most adult insects have two pairs of wings, but some feature no wings at all, as in the case of all species in the Apterygota subclass and some in the Pterygota subclass, including fleas, lice, and worker ants.

5.( ) In insects, blood (hemolymph) vessels are generally less well-developed than in other arthropods, but nonetheless remain essential to processes such as the distribution of nutrients and hormones, gas transport, and defense/repair mechanisms.

6.( ) The muscles of insects, similarly to those of vertebrates, can be either smooth or striated. Smooth muscle is concentrated in the heart, while striated muscle occurs in the remaining regions of the body, including, for instance, the digestive system and the wings.

7.( ) Insects are poikilothermic.

8.( ) The antennae are freely mobile segmented appendages articulated with the head in front of or between the eyes. The antennae of insects are sensory organs, well provided with olfactory and tactile receptors. They differ appreciably between species and, within the same species, are often sexually dimorphic.

9.( ) Insects perceive vibration by subcuticular mechanoreceptors known as chordotonal organs. All adult insects have a special chordotonal organ, called Johnston's organ, lying within the pedicel, the second antennal segment. Its main function is to sense movements of the antennal flagellum relative to the rest of the body, as in the detection of flight speed by air movement.

10.( ) The most common method of sound production in insects is stridulation, in which one specialized body part, the *scraper*, is rubbed against another, the *file*. Many moths are able to produce ultrasound, often by dint of a file and scraper set located on the wings, legs, or genitalia. These sounds are exclusively used for sexual courtship and bear no relation with, say, defense against predators.

11.( ) Most adult insects and some nymphs have dorsal ocelli in addition to compound eyes. Larval holometabolous insects do not possess ocelli.

12.( ) Insect chemoreceptors are in fact sensilla with one or more pores. Sensilla can be defined as uniporous (with one pore) or multiporous (with several pores). Suppose a typical moth has 15,000 sensilla in each antenna. Of these sencilla, 8000 are multiporous with 1000 pores each, 6000 are multiporous with 1800 pores each, and the remaining sencilla are multiporous with 2500 pores each. The pores are all 10 – 15 nm in diameter. We can surmise that this moth has a total number of pores greater than 43 million.

13.( ) Pheromones are signaling semiochemicals used by many animals, including insects. One pheromone of particular importance in insect communication is *N*,*N*-diethyl-3-methylbenzamide, or DEET, which is used by female mosquitoes and flies to attract potential mating partners.

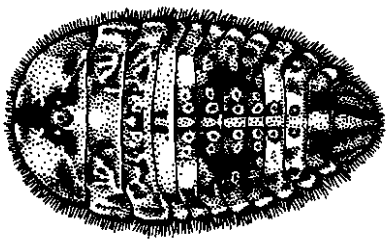
14.( ) An insect's brain, ventral connectives, ventral ganglia, and large nerves are protected from direct contact with the hemolymph by a selectively permeable barrier, the *hemolymph-CNS barrier*. The barrier consists of an outer

layer of epidermal cells known as the *neurolemma* and an inner cellular layer, the *perineurium*, made up of various types of glial cells.

15.( ) Insect flight can be brought about by synchronous or asynchronous flight muscles. Examples of insects that fly with synchronous flight muscles include butterflies, grasshoppers, flies, and wasps.

16.( ) Some insects sustain their flight movement by a clap and fling wing motion, in which the wings clap together at the end of each upstroke and fling apart at the beginning of each downstroke. It has been shown that insects that have a clap and fling wing motion have more muscle mass-specific lift than insects that do not use a clap and fling wing maneuver.

17.( ) Aquatic insects possess different adaptations depending on whether they inhabit lotic (flowing) or lentic (standing) waters. One common anatomical feature of lentic hexapods is a dorsoventrally flattened shape, as in the case of the water penny larva illustrated below.



18.( ) The diverse order Coleoptera encompasses all beetles, of which there are many aquatic species. Some are exclusively aquatic as both larvae and adults, and an additional few are predominantly aquatic as both larvae and adults. There is at least one family of beetles wherein larvae are terrestrial and adults are aquatic.

▶ Problem 3

Regarding the identification of Anophelinae and Culicinae mosquitoes, which of the following is *false*?

A) In both genera, eggs are laid singly and possess floats.
B) Anophelinae larvae do not have a siphon, while Culicinae larvae have a short or long siphon.
C) Adults (both sexes) of Anophelinae rest at an angle to any surface, while adults (both sexes) of Culicinae rest with body more or less parallel to the surface.
D) Adult females of Anophelinae have palps as long as the proboscis, while adult females of Culicinae have palps much shorter than the proboscis.

▶ Problem 4

Regarding further aspects of insect biology, true or false?

1.( ) The proboscis of mosquitoes is generally long and projects conspicuously forward. Although male mosquitos have a proboscis, the maxillae and mandibles are usually reduced in size or the mandibles are absent; consequently, male mosquitoes cannot bite.

2.( ) It is said that the mosquito *Anopheles gambiae*, shown below, is anthropophagic, endophagic, and endophilic with respect to its biting habits. This means that the mosquito in question feeds on human blood (anthropophagic), rests inside houses during blood digestion and development of the eggs (endophagic), and frequently enters houses to search for a host (endophilic).

3.( ) Most mosquitoes mate shortly after emergence from the pupa. Sperm from a male enter the spermotheca of a female, and this usually serves to fertilize all eggs laid during her lifetime; thus only one mating and insemination per female is required. With a few exceptions, a female mosquito

must bite a host and take a blood-meal to obtain the necessary nutrients for the development of her eggs. This life cycle behavior, which occurs in most mosquitoes, is known as *autogenous* development.

4.( ) Tiny phloem-feeding aphids, ectoparasites equivalent to the blood-sucking lice of mammals, usually have a minor impact on the health of targeted plants, but heavy infestations of aphids, leafhoppers and various piercing-sucking bugs may precipitate death of the plant. These insects share a ectoparasitic relationship known as *myrmecochory*, in reference to myrmecophytes, a kind of plant that is preyed upon by parasitic ants.

5.( ) Lepidoptera, the taxa that includes butterflies and moths, are often anthophilous. A typical flower that attracts butterflies has no showy coloration and a strongly unpleasant smell (to humans, at least).

6.( ) Bees are regarded as the most important group of insect pollinators. However, not all species of bee are pollinators; for example, the so-called stingless bees, or meliponines, have no ecological role in pollination.

7.( ) In Hymenopteran societies, caste distribution is determined by diet. The food supplied by workers to the bee destined to be the queen, or "royal jelly," differs from worker food in having high sugar content and being composed predominantly of mandibular gland products, including pantothenic acid.

8.( ) In Hymenopteran societies, drones develop from unfertilized eggs, do not work, and are fed by workers until they leave the hive to attempt mating with a queen.

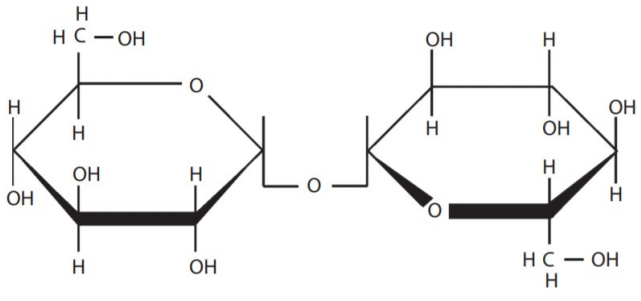
9.( ) In the formation of a new society, a mass of bees known as a *prime swarm* leaves the original hive and accumulates in a potential site, such as a tree branch. Meanwhile, in the old nest, the first new female reproductive to emerge destroys the other queen cells. If two emerge at the same time, they fight to the death, using their venomous stings, so that only one remains as queen. This reproductive female then attracts a single drone using pheromones and goes on a mating (nuptial) flight with it; the queen is then endowed with a lifetime's supply of sperm, which will prove crucial in furnishing worker bees for the new society. The drone chosen remains active and guards the queen for the remainder of its life cycle.

▶ Problem 5

Regarding aspects of insect molecular biology and biochemistry, true or false?

1.( ) The main pigments in insects, much like in vertebrates, are melanins, pigments that confer a black, brown, yellow or red coloration to many insect species. Melanins are insoluble, irregular polymers derived from glycine.

2.( ) The two most common carbohydrate-store reserves of insects are the sugar trehalose and the polysaccharide glycogen. Trehalose is a disaccharide and a nonreducing sugar; its structure is as illustrated below.



3.( ) In addition to trehalose and polysaccharide, insects may also rely on other molecules to impel energy-intensive tasks such as flight. For example, it has been verified that the amino acid proline is a major metabolic fuel for the tsetse fly and some species of beetle.

4.( ) Cuticular proteins are exclusively synthesized by epidermal cells, as indicated by the fact that these proteins cannot be detected in the hemolymph.

5.( ) The cuticle of insects is endowed with extensive hydrogen bonding of adjacent chains of chitin, an unbranched polymer, which confers it a great degree of hardness. In some species, the cuticle is made harder still by the occurrence of *resilin*, a structural protein found in specialized compartments of some arthropods.

6.( ) The signal for initiating sclerotization of the expanded cuticle after ecdysis is release of the neurohormone bursicon from the central nervous system. Bursicon has a pronounced influence on the activities of epidermal cells; indeed, absence of bursicon results in the failure of endocuticle deposition, as well as lack of melanin production and sclerotization of the cuticle.

7.( ) One of the first stages of the sclerotization process at the molecular level is the hydroxylation of tyrosine to 3,4-dihydroxyphenylalanine (DOPA), which by decarboxylation is transformed to dopamine, a compound of central importance for both sclerotization and melanin formation. Dopamine can be *N*-acylated to either *N*-acetyldopamine (NADA) or *N*-β-alanyldopamine (NBAD), but, in most insect species, only NADA can serve as a precursor in the sclerotization process.

8.( ) Other important cuticular catechols are *N*-acetylnorepinephrine (NANE) and *N*-β-alanylnorepinephrine (NBANE), which occur both in a free form and as *o*-glucosides in hemolymph and integument of several insects. There is evidence that NANE is an important sclerotization precursor.

9.( ) Chitin metabolism in insects, much like in other arthropods, is subjected to hormonal regulation. Interestingly, however, this conjecture has been challenged by experiments with *Manduca sexta* precluded from receiving hormonal signals from the brain by a ligature below the second thoracic segment. Injection of 20-hydroecdsysone (20HE) into these ligated abdomens produced no increase in transcripts for chitinase, one of the main enzymes in insect chitin metabolism.

10.( ) The peritrophic matrix (PM) is a chitin and glycoprotein layer that lines the midgut of insects. It is normally divided into two types, Type I and Type II. Type I PM is formed by the midgut epithelium, whereas Type II is formed by the cardia, a specialized tissue at the anterior midgut. Type I PM is more organized and mainly occurs in primitive orders such as Dermaptera and Isoptera.

11.( ) Prothoraciotropic hormone (PTTH) is so named because it targets prothoracic gland cells, stimulating the secretion of ecdysone or related ecdysteroids. Only one form of PTTH has been registered to date; it is a relatively small peptide of 4.4 kDa molecular mass, also known as *bombyxin* because it was isolated from the *B. mori* moth.

12.( ) After being stimulated by PTTH, the prothoracic glands sequester cholesterol from the circulating hemolymph and convert it into ecdysone or a closely related ecdysteroid. Insects cannot synthesize cholesterol; it must be supplied from their diet.

13.( ) Juvenile hormones (JH) are a class of sesquiterpenoid hormones secreted by the corpora allata. The main JH variant is JH III, which has been found to be the principal – and sometimes only – form of the hormone in many insects. However, JH III is found only in trace amounts, if at all, in Diptera.

14.( ) Arylphorins are a class of non-structural proteins with high content of aromatic amino acids and some lipid. Research has shown that these proteins can be synthesized by multiple insect tissues.

15.( ) Arylphorins are also known as hexamerins, so named because they typically consist of six equal size subunits. One remarkable trait of these proteins is that they are specific to diapause, that is, they are mainly produced by insects just before or during entering a period of dormancy. Insects that synthesize hexamerins necessarily diapause at some point in their life cycles.

SOLUTIONS

P.1 ➡ *Solution*

The correct associations are listed below.

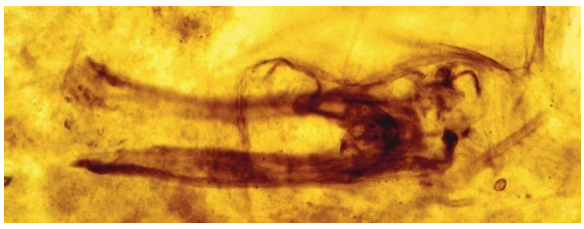
Insect Species	*Definition*
A	*4*
B	*3*
C	*5*
D	*7*
E	*1*
F	*2*
G	*6*

P.2 ➡ *Solution*

1. False. In actuality, it is the number of insects with complete metamorphosis that easily outstrips that of insects without this form of development. Complete metamorphosis has enabled insects such as beetles, moths and flies to conquer demanding terrestrial habitats that insects without a complete life cycle could not.

2. True. Traits that insects share with other arthropods also include an excretory system based on Malpighian tubules (instead of nephridia, which occur in the Annelides) and a fairly well-defined division of the body into head, thorax, and abdomen.

3. False. The oldest insect fossil on record is *Rhyniognatha hirsti* (shown below) and dates from the early Devonian, the period that precedes the Carboniferous. It is true, nonetheless, that the insect fossil record from the Carboniferous is much more numerous.



4. True. The Apterygota subclass was specifically conceived to accommodate wingless, primitive insects such as silverfish. The Pterygota subclass, while used to encompass winged species, also includes species that have lost their wings over the course of evolution, including fleas, lice, worker ants, and termites.

5. False. Blood vessels indeed play a role in the distribution of some nutrients and hormones and defense/repair mechanisms, but they rarely carry respiratory pigments and have no participation in gas exchange. Gas exchange in terrestrial insects is mediated by the tracheal system, which functions altogether independently from the circulation.

6. False. Insects only have striated muscles. The muscles that line the digestive system, the rapidly contracting synchronous muscles of the wings, and the heart muscles are, in fact, all striated in nature.

7. True. All insects are poikilothermic, i.e., they lack the means to maintain a constant body temperature that is independent from their surroundings (homeothermy). The temperature of an insect can be regulated relatively to the surroundings by using external heat (ectothermy) or by physiological mechanisms (endothermy).

8. True. Dimorphism in antennae ranges from microscopic morphological details observable only via scanning electron microscopy to clear distinctions in anatomy, such as the plumose antennae of some male mosquitoes.

9. True. Johnston's organ is a mass of radially arranged mechanoreceptors that respond to vibrations of the flagellum. This structure also occurs in some larvae.

10. False. The ultrasonic songs of moths are primarily used for sexual communication, particularly mate attraction and courtship. However, some

tiger moths (Arctiidae) can produce ultrasound using metathoracic tymbals and hear the ultrasound produced by bats. The high-frequency clicking sounds produced by some arctiids cause bats to veer away from attack, and have the following (non-exclusive) roles: interference with bat sonar systems; aural mimicry to delude the predator about presence of a prey item; and warning of distastefulness (aposematism).

11. True. The only visual organs of larval holometabolous insects are the so-called stemmata, also known as larval ocelli; this latter term, however, is misleading, as it leads to confusion with the dorsal ocelli from which they are functionally and often structurally distinct.

12. False. The pore diameter is The number of pores in one antenna is $8000 \times 1000 + 6000 \times 1800 + 1000 \times 2500 = 21.3$ million, and the total number of pores is determined to be $21.3 \times 2 = 42.6$ million. The pore diameters are junk information. This number is fairly close to the number of pores of the silkworm moth, *Bombyx mori*, which has been estimated at 45 million.

13. False. DEET is in fact a common component of insect repellents. Mosquitoes avoid surfaces impregnated with the chemical after detecting it with specific olfactory receptor neurons in short trichoid sensilla on their antennae. The presence of DEET induces avoidance in sugar-seeking female and male mosquitoes, and deters females from landing when in search of a blood meal.

14. False. The statement errs by stating that the neurolemma consists of epidermal cells; this structure, also known as *neural lemma* or *neural lamella*, is acellular and consists of fibrils of collagen-like material embedded in a matrix of glycosaminoglycans.

15. False. Butterflies and grasshoppers indeed have synchronous flight muscles, but flies and wasps are endowed with asynchronous flight muscles. Synchronous flight muscles are so named because each muscle contraction is produced as a response to the action potential that initiated it, whereas with asynchronous flight muscles individual contractions are not synchronized with individual nerve action potentials; instead, a number of contractive oscillations follow each action potential, and a wing-beat occurs in response to each oscillation. This enables the wings to beat multiple times in response to a single action potential and ultimately leads to the unusually high wing-beat frequency of some flies and wasps. A single nerve impulse can result in approximately 50 cycles of the wing, and frequencies as high as 1000 cycles per second have been reported in some midges.

16. True. Indeed, it has been reported that insects that have a clap and fling wing motion have as much as 25% more muscle mass-specific lift than insects that do not use a clap and fling maneuver. A group of investigators showed that the damselfly, *C. splendens*, which uses a clap and fling maneuver, gets 44% more muscle mass-specific lift than the dragonfly, *S. sanguineum*, which does not employ this flight mechanism.

17. False. A dorsoventrally flattened shape confers superior hydrodynamics in the often intense currents of lotic waters. With the exception of wave action at the shore of larger bodies of water, the effects of water movement cause little or no difficulty for aquatic insects that live in lentic environments.

18. True. The family Dryopidae includes beetles that inhabit terrestrial habitats as larvae and aquatic habitats as adults.

P.3 ➡ *Solution*

The following table provides a comparison of the two genera.

	Anopheles	*Culicinae*
Eggs	→ Eggs are boat-shaped → Eggs are laid singly, possess floats → Eggs are preferably laid on clean water	→ Eggs are cigar-shaped → Eggs are laid singly or in egg rafts or masses
Larvae	→ Larvae never have a siphon → Larvae lie parallel to the water surface	→ Larvae have a short or long siphon → Larvae subtend an angle from water surface

	→ Larvae have abdominal palmate hairs and tergal plates	→ No palmate hairs or tergal plates
Pupae	→ Usually green in color → Breathing trumpets short and broad apically → Short peg-like spines on abdominal segments 2 – 7 or 3 – 7	→ Usually colorless → Breathing trumpets short or long, opening not broad → No spines on abdominal segments 2 – 7
Adults (both sexes)	→ Rest at an angle to any surface → In most species dark and pale scales on wing veins arranged in distinct 'blocks'	→ Rest with body more or less parallel to the surface → Scales on wing veins not arranged in 'blocks'; scales frequently all brown or blackish, or a mixture of pale and dark scales scattered on veins
Adult females	→ Palps about as long as proboscis	→ Palps much shorter than proboscis
Adult males	→ Palps about as long as proboscis and swollen at ends	→ Palps about as long as proboscis but never swollen at ends; palps may be hairy distally

♦ The correct answer is **A**.

P.4 ➡ *Solution*

1. True. When a female mosquito bites a host, the labella, at the tip of the fleshy labium, are placed on the skin and the labium, which cannot pierce the skin, curves backwards. This allows the paired mandibles, paired maxillae, labrum and hypopharynx to penetrate the host's skin. The biting process is often accompanied by the release of saliva from a pair of trilobed salivary glands. The saliva contains antihaemostatic enzymes that produce haematomas on the skin and facilitate the uptake of blood; further, the saliva contains anticoagulants to prevent blood from clotting and obstructing the mouthparts as it is sucked up, and anaesthetic substances that help reduce the pain inflicted by the mosquito's bite, thereby inhibiting the host's defensive reactions.

2. False. The only problem with this statement is that the definitions of *endophagic* and *endophilic* have been swapped; in actuality, an *endophagic* insect routinely enters houses to feed, while an *endophilic* insect typically inhabits closeted spaces. The definitions offered by these terms are gross generalizations, as a mosquito that feeds indoors could very well regularly attack hosts in an open setting (i.e., be *exophagic*) or establish itself outdoors (i.e., be *exophilic*).

3. False. The statement actually provides a definition of *anautogeneous* development. In autogenous development, the female requires no prior blood-meal before producing a batch of eggs.

4. False. Myrmecochory is actually a mutualistic ecological relation between myrmecophytes and ants. Myrmecophytes provide food and shelter to ants, which in turn act as ferocious body guards, bitting and stinging other insects and vertebrates that attempt to harm the plant. The ants also aid in pollination and seed dispersal.

5. False. "Anthophilous" is the term used to define flower-frequenting insects. Butterfly-pollinated flowers usually possess vivid coloration (usually red, yellow, or blue), open at night (diurnal anthesis), and emanate a sweet smell.

6. False. Meliponines are just as active pollinating agents as honey bees. Crops such as avocado, blueberry and strawberry all benefit from their pollination, and their short flight distances ensure that they remain within the crop area.

7. True. Indeed, royal jelly consists of a high load of sugars and mandibular gland products, including pantothenic acid and biopterin. Royal jelly also contains a protein, termed *royalactin*, that participates in the differentiation of honey-bee larvae into queens. A societal organization in

which development is dictated by diet, as in the case of honey bees and other Hymenoptera, is aptly called *trophogenic*.

8. True. Drones indeed develop from unfertilized eggs (arrhenotokous parthenogenesis), are sustained by workers, and eventually leave the hive to attempt mating with a queen.

9. False. The statement errs twice, firstly by mentioning that the nuptial flight involves a single drone – depending on the species, the queen actually mates with many drones, often 10 to 15, in succession – and secondly by implying that the drones remain active after the mating ritual – in the process, the males have their genitalia detached from the abdomen and ultimately die.

P.5 ➡ *Solution*

1. False. Melanin is actually derived from tyrosine, which, like glycine, is one of the 20 common amino acids.

2. True. Trehalose is the principal storage sugar of insects, and from 200 mg to as much as 1.5 g per 100 mL hemolymph occur in the circulation of various insect species. Trehalose is a disaccharide (*α-D*-glucopyranosyl-*α-D*-glucopyranoside) with the two glucose units linked *α*-1,1.

3. True. Indeed, the amino acid proline has been implied as a metabolic fuel for the tsetse fly, adults of the Colorado potato beetle (*Leptinotarsa decemlineata*), and some beetles in the families Scarabaeidae and Cerambycidae. In the South African long-horned beetle, *Phryneta spinator*, about 50% of the carbohydrates and 40% of the proline in the hemolymph were metabolized to support 5 min of flight, and alanine increased. This latter effect is expected because of the transamination reaction in which the amino group from glutamic acid is transferred to pyruvic acid, creating alanine and *α*-ketoglutarate.

4. False. In actuality, researchers have verified the existence of cuticular proteins in the circulation, prompting them to look for other sites of protein synthesis. The most comprehensive studies on epidermal cells handling proteins from external sources were carried out in *Calpodes*, and revealed the existence of four classes of exported proteins: the C class, the B class, the BD class, and the T class. The latter was identified for proteins transported into cuticle but not synthesized by the epidermis.

5. False. While it is true that resilin occurs in some compartments of a varied number of arthropods, the statement errs by saying that this protein enhances the hardness of cuticle. In actuality, resilin is an elastomeric, highly resilient protein, which exhibits a rubber-like behavior when subjected to mechanical stress. Elongation to break of resilin can be as high as 400%, and its stiffness (as represented by Young's modulus) is no greater than 0.7 MPa.

6. True. This is an excerpt from *Insect Molecular Biology and Biochemistry*. Bursicon is produced by neurosecretory cells in the brain and stored in the corpora cardiaca. The molecular structure of bursicon is a heterodimer of two cysteine knot protein subunits. This hormone has been implicated on a number of processes in insects soon after ecdysis, including, for instance, expansion of wings in the final stages of metamorphosis in *D. melanogaster*.

7. False. Both NADA and NBAD can be enzymatically oxidized to the corresponding *o*-quinones and thence proceed in the sequence of reactions for sclerotization. It is true, however, that in the cuticle of some insects, such as the locusts *Schistocerca gregaria* and *Locusta migratoria*, the sclerotization process seems to be exclusively brought about by the reaction of NADA, as no *β*-alanine has been obtained from their acid hydrolysates.

8. True. NANE, and possibly NBANE, may function as sclerotization precursors. When radioactively labeled NANE was injected into newly ecdysed locusts, a significant fraction of the radioactivity was incorporated into the cuticle, and hydrolysis was needed to release the activity. Acid hydrolysis of cuticle from locusts injected with labeled norepinephrine resulted in the release of both labeled norepinephrine and artenerone, whereas little

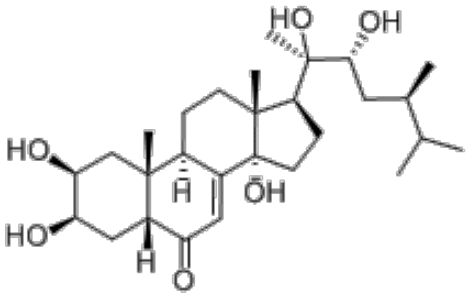
radioactivity was present in the neutral ketocatechol fraction. This is in contrast to parallel experiments where labeled dopamine was injected into locusts and nearly all the radioactivity was recovered as neutral ketocatechols, indicating that the cuticular enzymes can catalyze the incorporation of norepinephrine and NANE into the cuticular matrix, but not as efficiently and not by the same route as incorporation of dopamine and NADA.

9. False. In the experiment in question, cited on *Insect Molecular Biology and Biochemistry*, injection of 20HE into the ligated abdomens actually resulted in a sharp and rapid increase in transcripts for chitinase, corroborating the hypothesis that at least some pathways of chitin metabolism are under hormonal control. This is not to say that every insect hormone has a role in the process in question; for example, in one experiment application of juvenile hormone on *Manduca sexta* produced no inductive effect on chitinase transcript levels. Muthukrishnan et al. caution that there is little evidence to support the idea that hormones play a direct role in chitin synthesis.

10. False. The last sentence of the statement actually defines Type II PM. In Type I peritrophic matrix, delamination of successive concentric lamellae occurs along the length of the midgut; this type of PM is encountered in Coleoptera, Dictyoptera, Ephemeroptera, Hymenoptera, Odonata, Orthoptera, Phasmida, larval Lepidoptera, and adult hematophagous Diptera. Type II PM, in turn, is more organized and consists of one to three laminated layers; it is mainly found in primitive orders such as Dermaptera and Isoptera, but also occurs on Embiodea, some Lepidoptera, and the larvae of Diptera.

11. False. In addition to bombyxin, researchers have isolated a second peptide that induces the prothoracic glands to produce ecdysteroid hormone; this peptide has a molecular mass of 30 kDa and is correspondingly named 30 K PTTH. It is noteworthy, however, that use of the same nomenclature to define the two hormones may be misleading, as it has been verified that their structures are notably dissimilar. Another finding that renders the statement false is that electrophoresis of bombyxin has revealed the existence of three distinct species of this hormone, labeled PTTH-I, PTTH-II and PTTH-III.

12. True. Cholesterol must be obtained by diet. There is some molecular diversity in the structure of molting hormones; one reason for this is the fact that some insects are plant feeders (phytophagous), and for that reason consume sterols with 28 or 29 carbons rather than 27 in the case of cholesterol. Ordinarily, phytophagous insects dealkylate plant sterols to cholesterol. Some, however, do not dealkylate cholesterol but rather synthesize a C-28 or C-29 ecdysoid hormone; makisterone A or 20-hydroxy-24-α-methyl ecdysone (shown below) is the principal molting hormone of honeybees, and radiolabeled tracers have shown that they synthesize it from *campesterol*, a plant steroid with 28 carbons and a C-24 methyl group in the α-configuration.



13. False. The statement would have been correct had the term "Diptera" been replaced with "Lepidoptera"; the JH III form of juvenile hormone is rare among moths and butterflies, although other variants of the hormone, especially JH I and JH II, can be found abundantly in parts of their life cycles.

14. True. Arylphorins, first identified from hemolymph, have been of special interest since one group of investigators in the 1980s verified that, although calliphorin (the arylphorin from *Calliphora*) was found in cuticle, it actually seemed to come from hemolymph because labeled calliphorin injected into the hemolymph appeared in the cuticle. Nonetheless, further research furnished evidence that the epidermis is also capable of synthesizing arylphorins, as one group of researchers detected arylphorin mRNA in the epidermis of *Manduca*. Thus, while the possibility remains that some arylphorin

is transported from hemolymph to cuticle, it need not be, for the epidermis itself is often also capable of synthesizing this protein. This exemplifies the finding that more than one tissue is capable of synthesizing the same protein. Whether the synthesis processes are mediated by the same genes remains unknown.

15. False. Some insects in fact synthesize hexamerins, but never diapause. In these species, hexamerins are synthesized by the fat body and released into the hemolymph. Generally, they are resequestered by fat body cells and stored until used in building new tissues, generally during pupation and formation of adult tissues. In nondiapausing insects, they usually do not persist in the body for long because they are used in metamorphosis and growth of new tissues. They do persist at high concentrations in the hemolymph of diapausing insects, presumably because diapausing insects are not building new tissues. They disappear soon after diapause ends, probably again being used as a source of amino acids for tissue construction in renewed development.

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