MCB/BIOP/NEUR 419
MIDTERM (32 pts total)
Spring 2017

Name: _____

(*Provide the best response to each question. 32 questions, 1 point per question*)

1. In the history of life on earth, the first vertebrates appeared about how many years ago:

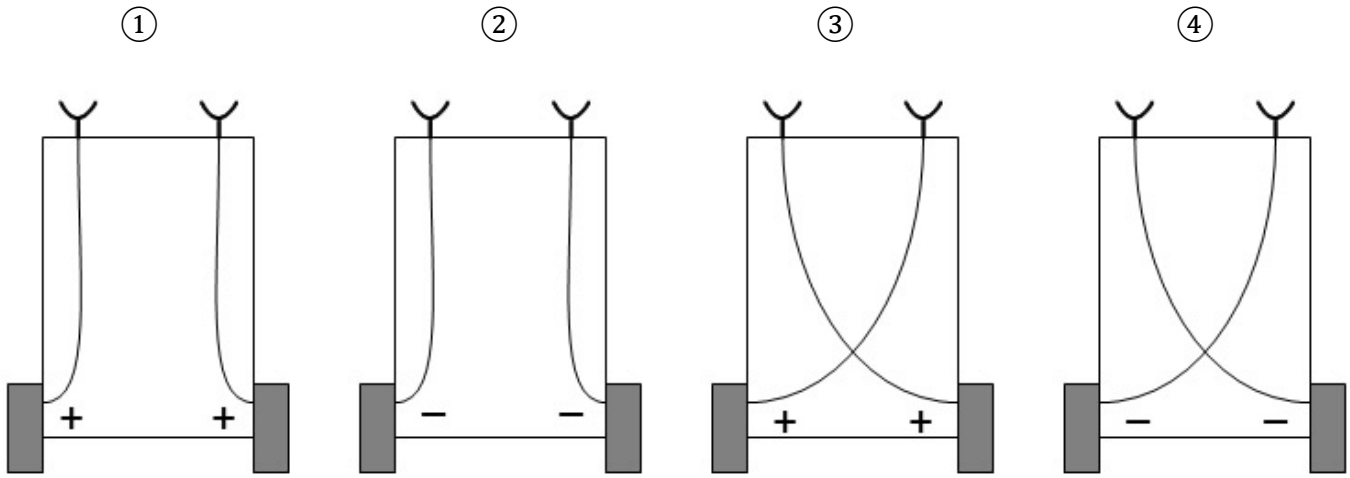
① 14 billion	⑥ 500 million
② 4.5 billion	⑦ 200 million
③ 3.5 billion	⑧ 100 million
④ 2 billion	⑨ 0.6 million
⑤ 1 billion	⑩ 0.1 million

2. Considering these organisms as representatives of their respective phyla, what is the correct order of evolutionary appearance, from earliest to most recent?

① amphioxus, cnidaria, *C. elegans*, porifera, *Volvox*
② paramecium, *Volvox*, cnidaria, *C. elegans*, amphioxus
③ bacteria, paramecium, *C. elegans*, *Volvox*, amphioxus
④ bacteria, paramecium, *C. elegans*, amphioxus, porifera
⑤ amphioxus, cnidaria, paramecium, porifera, *C. elegans*

3. In paramecia, high levels of internal Ca^{++} indicate that an obstacle collision has just occurred. This relationship is most closely associated with the _____ aspect of the information processing system.

① hedonic
② pragmatic
③ semantic
④ syntactic



4. Which one of the Braitenberg vehicles above implements the "Coward" behavior?

   ① ② ③ ④

5. Which one of the four Braitenberg vehicles above moves slower in brighter parts of the environment and turns away from light sources as it approaches them?

   ① ② ③ ④

6. Which of the following organisms uses a form of intracellular signaling for movement coordination that is most similar to the rapid electrical signaling that takes place between different parts of an individual neuron?

   ① *E. coli*
   ② cyanobacteria
   ③ paramecia
   ④ Volvox

7-8. Consider a Bot controller with left/right sensors as input and speed/heading as output. Heading angle increases toward the right. Indicate whether the (possibly poorly coded) control algorithms below could best be described as a form of:

① orthokinesis
② simple klinokinesis
③ adaptive klinokinesis
④ positive taxis
⑤ negative taxis

[Note: the Bot class includes instance variables: snsL, snsR, previous_val, speed, heading]

7. ② simple klinokinesis	`var a = random(-1, 1);`
	`var c = snsL + snsR;`
	`var d = snsL - snsR;`
	`this.previous_val = c;`
	`var turn_angle = a * (c + d);`
	`if (c < this.previous_val) {`
	`  turn_angle = random(TWO_PI);`
	`}`
	`this.speed = 1 - a;`
	`this.heading += turn_angle;`

8. ③ adaptive klinokinesis	`var a = random(-1, 1);`
	`var c = snsL + snsR;`
	`var d = snsL - snsR;`
	`var turn_angle = 0.0;`
	`if (c < this.previous_val) {`
	`  turn_angle = random(TWO_PI);`
	`}`
	`this.previous_val = c;`
	`this.speed = abs(a) + 0.5;`
	`this.heading += turn_angle;`

9. The behavioral response of *E. coli* to the onset of a step decrease in external concentration of a chemical attractant would be a transient decrease in tumble probability.

① TRUE
② FALSE

10. According to a hypothesis discussed in class, different sensory modalities may have their evolutionary origins either in solute or solvent sensing mechanisms of single-celled organisms. Which of the following are thought to have arisen from solvent sensing (e.g., osmotic pressure sensing):

① touch, smell, vision
② balance, hearing, touch
③ taste, smell, vision
④ hormones, pheromones, neurotransmitters
⑤ proprioception, touch, vision

11. Sowbugs (also called pillbugs, woodlice, roly-polies) are often found under rocks, boards and other damp places. In dry areas, sowbugs generally increase their level of locomotor activity; once they find a damp spot, they tend to slow down and become almost motionless. This behavior is best described as a type of:

① klinokinesis
② klinotaxis
③ orthokinesis
④ orthotaxis
⑤ tropotaxis

12. In *C. elegans*, a neuron with its cell body and neurite processes all confined to the nerve ring near the head is most likely a:

① sensory neuron
② primary (sensory) interneuron
③ secondary (pre-motor) interneuron
④ motor neuron

13. The table to the right lists some nematode sensory neurons. Which of these is important for helping juvenile root-knot nematodes stay at the proper soil depth to find plant roots?

① AFD
② ASE
③ ASJ
④ ASK
⑤ ADF
⑥ ASE, ASK and ADF

AFD	Thermotaxis
ASE	Chemotaxis (Na+, Cl-, cAMP, biotin, lysine)
ASG	Chemotaxis (Na+, Cl-, cAMP, biotin, lysine) Dauer formaiton
ASI	Chemotaxis (Na+, Cl-, cAMP, biotin, lysine) Dauer formation
ASJ	Recovery from dauer, dauer formation
ASK	Chemotaxis (lysine)
ADF	Chemotaxis (Na+, Cl-, cAMP, biotin)

14. A threshold-logic unit has three inputs *A, B* and *C*. Each input value can be 0 (FALSE) or 1 (TRUE). The output of the unit is 1 if the weighted sum of the inputs exceeds a threshold value θ, and is 0 otherwise.

Let A, B and C stand for Apples, Bananas and Cauliflower. As part of a feeding circuit, we want the output of the threshold-logic unit to be 1 whenever it 'sees' fruit (apples and/or bananas) without any vegetables (cauliflower).

Which of the following is a valid set of weight and threshold values to achieve the desired response?

① $w_A = 1, w_B = 1, w_C = -1, \theta = 0.5$
② $w_A = 1, w_B = 1, w_C = -1, \theta = 1.5$
③ $w_A = 2, w_B = 2, w_C = -4, \theta = 1.0$
④ $w_A = 2, w_B = 2, w_C = -1, \theta = 1.5$

15. Of the organisms discussed in class, cnidaria (anemones, jellyfish) were the first multicellular organisms to evolve primitive nerve nets.

① TRUE ②FALSE

16. Which of the following is NOT associated with the Cambrian explosion?

① emergence of cellular division of labor
② climate instability
③ predator-prey arms race
④ emergence of axons for long distance communication

17. Which of the following is NOT associated with the area-restricted search behavior of ferrets that was discussed in class?

① modulation of turning behavior during foraging (klinokinesis)
② tighter turns (smaller search area) when oil drops are closer together
③ mechanosensory stimulation of dopamine-releasing neurons
④ increased turning behavior following first encounter with an oil drop
⑤ learning from experience

18. In an area-restricted search experiment, *C elegans* is sequentially exposed to three different experimental culture plates (#1-#3). Plates #1 and #3 are empty and culture plate #2 is covered with *E. coli*. The worm spends 30 minutes on each plate and is rinsed off between transfers. The frequency of high-angle turns would be significantly greater:

① during minute 29 on plate #1 than during minute 29 on plate #2
② during minute 15 on plate #2 than during minute 29 on plate #3
③ during minute 1 on plate #3 than during minute 29 on plate #1
④ both ① and ②
⑤ both ① and ③
⑥ both ② and ③
⑦ all cases, ①, ② and ③

19. In the proposed model of the cellular mechanisms underlying area-restricted search behavior in *C. elegans*, dopamine acts as a neuromodulator to enhance glutamate signaling onto pre-motor neurons that control high-angled turning behavior.

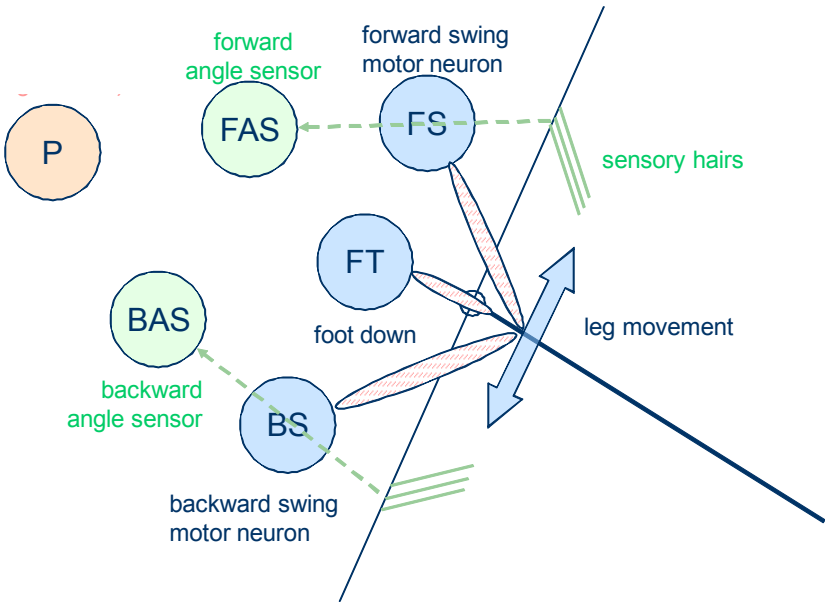
① TRUE ②FALSE

20. In Beer's artificial insect model, a pacemaker neuron associated with the *right rear leg* sends inhibitory connections to how many other pacemaker neurons?

① 1
② 2
③ 3
④ 4
⑤ 5
⑥ 6

21. In Beer's artificial insect model, the pacemaker neuron (P) initiates a forward swing. Neuron P would thus be expected to make synaptic connections to neurons FS, FT and BS with the following signs:

① FS(+), FT(+), BS(−)
② FS(+), FT(−), BS(+)
③ FS(+), FT(−), BS(−)
④ FS(−), FT(+), BS(+)
⑤ FS(−), FT(+), BS(−)
⑥ FS(−), FT(−), BS(+)



22. Responses to species-specific threat stimuli are primarily associated with which two regions of the vertebrate brain::

① hippocampus and septum
② medulla and cerebellum
③ hindbrain and spinal cord
④ midbrain and hypothalamus
⑤ cortex and amygdala

23. The output structures of the basal ganglia primarily exert an inhibitory influence on motor areas. Action selection is thought to occur by removing inhibition from motor areas that control specific actions.

① TRUE ②FALSE

24. While having dinner at a quiet restaurant, a waiter accidentally drops a tray of dishes behind you, making you flinch in your chair. This startle response to an unexpected loud noise is primarily mediated by circuitry in the

① amygdala
② basal ganglia
③ cerebral cortex
④ hindbrain
⑤ midbrain
⑥ spinal cord
⑦ thalamus

25. Performing bilateral lesions of the *retino-tectal pathway* in the toad generally enhances the toad's preference for striking at 'anti-worm' stimuli, relative to 'worm-like' stimuli.

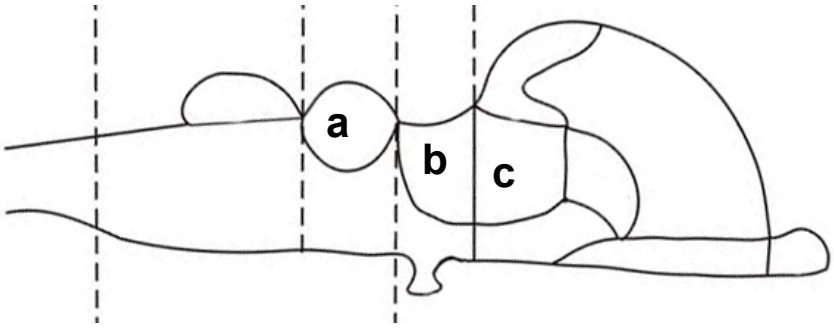
① TRUE ②FALSE

26. In the lamprey model of visuomotor integration, which neural connections are responsible for preventing the lamprey from striking at a location that is halfway in between two nearby prey items located on the same side of the lamprey?

① crossed connections from retina to visuomotor centers
② crossed connections from visuomotor centers to reticulospinal neurons
③ inhibitory connections from GPi to STN
④ inhibitory connections from GPi to visuomotor centers
⑤ lateral inhibition between neurons in the response layer of visuomotor centers

27. Prey capture in the toad involves several possible actions: approach (a), orient (o), fixate(f), snap (s). A toad is observed to generate the following sequence of actions: o, a, o, a, f, s, a, f, s, resulting in successful capture of a moving prey. What can we infer about the relative positioning of the prey immediately following the first 'snap'?

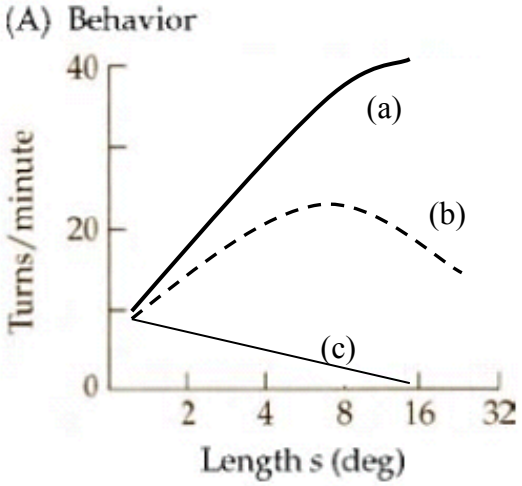
① the prey moved further away from the toad
② the prey moved closer to the toad
③ the prey moved into the lateral visual field of the toad
④ the prey moved into the binocular fixation area of the toad



28. In the generalized diagram of the vertebrate brain shown above, the structures labeled a, b, c correspond to which brain regions, respectively:

① cerebellum, tectum, thalamus
② cerebellum, thalamus, striatum
③ cerebellum, tegmentum, amygdala
④ tectum, hypothalamus, amygdala
⑤ tectum, thalamus, striatum
⑥ thalamus, tectum, striatum

29. The graph to the right shows a toad's behavioral response (turns per minute) in response to several different stimuli. The visual stimulus corresponding to curve (b):



① is stationary.
② is moving in a direction parallel to its long axis.
③ is moving perpendicular to its long axis.
④ has an aspect ratio of 1:1 (i.e. square-shaped).

30. Consider a pure integrate-and-fire neuron (with no leak term) that receives a constant current injection. Which of the following manipulations would decrease the output spike rate?

① increasing the input current
② decreasing the input current
③ increasing the threshold
④ decreasing the threshold
⑤ both ① and ③
⑥ both ① and ④
⑦ both ② and ③
⑧ both ② and ④

Consider the following code for a home robot that can detect fire, humans, recognize family members (who are also humans), vacuum the carpet, and recharge its own batteries. The programming team has produced two questionable versions of the action-selection code. The bot's actual behavior is generated by calling the `do_behavior` method, which accepts a String variable as input.

VERSION A

```
var action = "none";
if (detectDirt) {
  action = "clean_carpet";}
if (batteryIsLow) {
  action = "taxis_to_charger";}
if (atCharger) {
  action = "recharge_battery";}
if (batteryIsDead) {
  action = "annoying_beep";}
if (nearFire) {
  action = "extinguish_fire";}
if (detectFire) {
  action = "taxis_to_fire";}
if (detectHuman) {
  action = "use_stun_gun";}
if (detectFamilyMember) {
  action = "say_hello";}

do_behavior(action);
```

VERSION B

```
var action = "none";
if (batteryIsDead) {
  action = "annoying_beep";
} else if (atCharger) {
  action = "recharge_battery";
} else if (batteryIsLow) {
  action = "taxis_to_charger";
} else if (detectHuman) {
  action = "use_stun_gun";
} else if (detectFamilyMember) {
  action = "say_hello";
} else if (nearFire) {
  action = "extinguish_fire";
} else if (detectFire) {
  action = "taxis_to_fire";
} else if (detectDirt) {
  action = "clean_carpet";
} else {
  action = "chase_cat";
}
do_behavior(action);
```

31. Which version is likely to use the 'stun gun' on a family member?

① A
② B
③ both A and B
④ neither

32. Which version will continue to vacuum a dirty carpet while the house is on fire?

① A
② B
③ both A and B
④ neither

END OF EXAM