Name: _____

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

1. In the history of life on earth, the first multicellular organisms 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 the evolutionary timeline presented in class, which of the following made its evolutionary appearance after paramecia and before porifera?

   ① chordates (amphioxus)

   ② colonial algae (*volvox*)

   ③ insects (cockroach)

   ④ cnidaria (jellyfish)

   ⑤ roundworms (*C. elegans*)

3. In paramecia, mechanical stimulation of the posterior end of the cell activates mechanosensory _____-channels, leading to _____ of the cell's membrane potential, which in turn produces faster forward swimming.

① Ca^{2+}, depolarization	⑤ K^+, depolarization
② Ca^{2+}, hyperpolarization	⑥ K^+, hyperpolarization
③ Cl^- depolarization	⑦ Na^+, depolarization
④ Cl^- hyperpolarization	⑧ Na^+, hyperpolarization
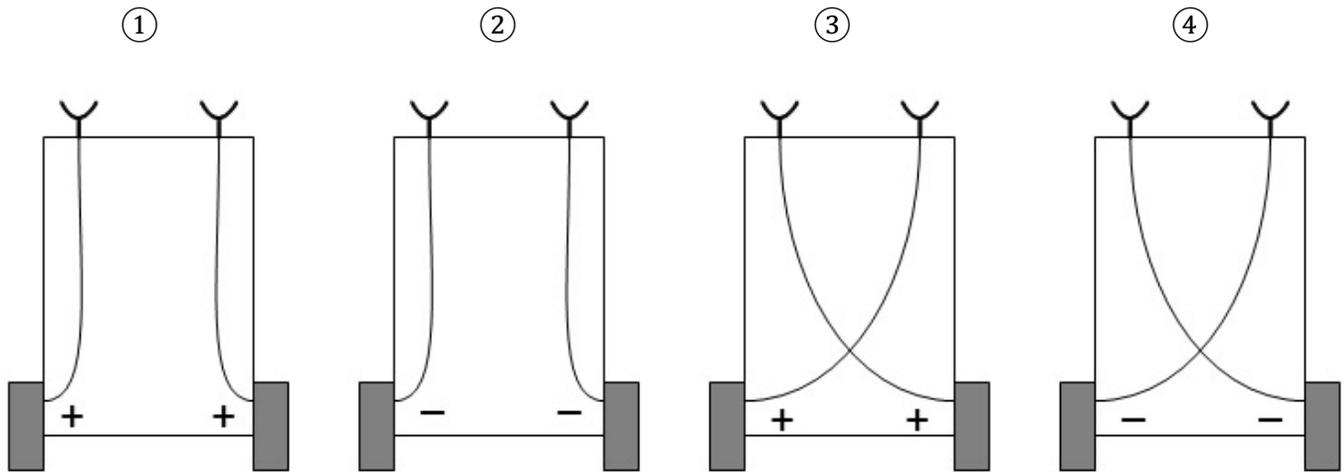
4. Which one of the four Braitenberg vehicles above moves faster in brighter parts of the environment and turns away from light sources as it approaches them?

   ① ② ③ ④

5. Based on multiple foraging trips to different types of flowers, a honeybee develops a preference for pink flowers because they tend to provide more nectar. According to Dusenbery, the color of the flower is a(n) _____ influence and the nectar is a(n) _____ influence. The odor of the flower would likely be a(n) _____ influence.

   ① causal, causal, causal   ⑤ informational, causal, causal
   ② causal, causal, informational   ⑥ informational, causal, informational
   ③ causal. informational, causal   ⑦ informational, informational, causal
   ④ causal, informational, informational   ⑧ informational, informational, informational

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

| 7. ⑤ | ```
let a = 0.1;
let b = random(0.5);
let c = snsL + snsR;
let d = snsL - snsR;
this.speed = b;
this.heading += a * d;
``` |
| --- | --- |
| 8. ① | ```
let a = random(0.2);
let b = 0.1;
let c = snsL + snsR;
let d = snsL - snsR;
if (c < this.previous_val) {
   this.heading +=  a - b;
} else {
   this.heading += random(0.2) - 0.1;
}
this.speed = c;
this.previous_val = c;
``` |

9. The behavioral response of *E. coli* to the onset of a step increase 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 solute sensing mechanisms (e.g., detection of dissolved particle):

    ① touch, smell, vision
    ② balance, hearing, touch
    ③ taste, smell, vision
    ④ pheromones, neurotransmitters, vision
    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 located in the nerve ring near the head and with processes that extend down the length of the body is most likely a:

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

4

13. What's the approximate number of neurons in the *C. elegans* nervous system?

    ① 100

    ② 300

    ③ 1000

    ④ 5000

    ⑤ 100,000

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' cauliflower without seeing any fruit (apples and/or bananas); the output should be zero in all other circumstances.

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

    ① $w_A = -1, w_B = -1, w_C = 2, \theta = 0.5$

    ② $w_A = -1, w_B = -1, w_C = -2, \theta = 0.0$

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

    ④ $w_A = -2, w_B = -2, w_C = 2, \theta = 1.5$

15. In *C. elegans* area-restricted search behavior, neuromodulation changes the probability for high-angle turns. How long does this neuromodulatory influence typically last?

① milliseconds

② seconds

③ minutes

④ hours

⑤ days

16. Of the organisms discussed in class, porifera (sponges) were the first multicellular organisms to exhibit distinct cell types and cellular division of labor.

    ① TRUE   ②FALSE

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

    ① climate instablity

    ② predator-prey arms race

    ③ appearance of nervous systems
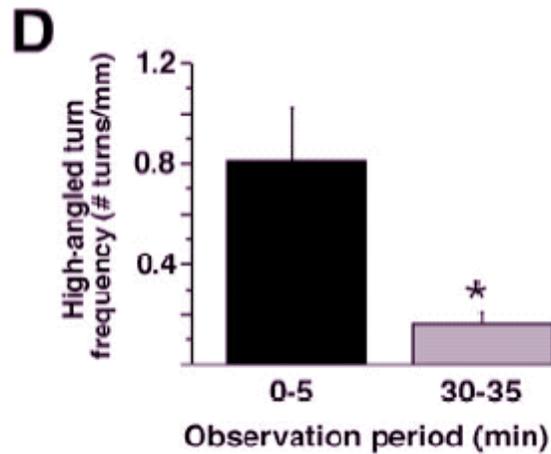
    ④ increasing atmospheric oxygen levels

18. Which of the following is NOT associated with the area-restricted search behavior of ferrets?

    ①   simultaneous comparison of left/right sensor strength (tropotaxis)

    ②   tighter turns (smaller search area) when oil drops are closer together

    ③   learning from experience

    ④   increased turning behavior following first encounter with an oil drop

19. In Beer's artificial insect model, a pacemaker neuron associated with the *right middle leg* <u>sends</u> inhibitory connections to how many other pacemaker neurons?

    ①   1

    ②   2

    ③   3

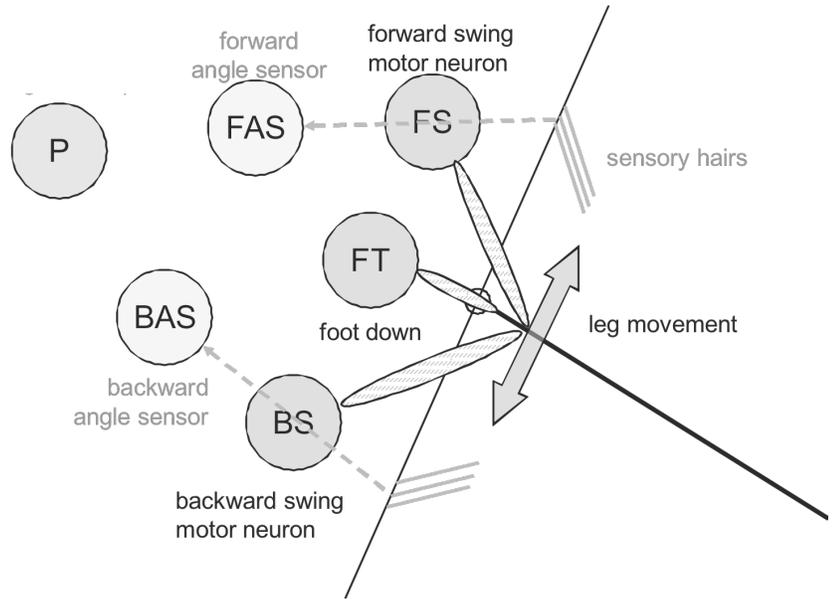   ④   4

    ⑤   5

    ⑥   6

20. Below is a graph showing high-angled turns per millimeter of path length (#turns/mm) for *C. elegans* in a standard area-restricted search (ARS) experiment after the worm has been transferred to an observation plate. Which of the following statements is TRUE?

① The worm covers more total distance (mm) in the 0-5 observation period than in the 30-35 period.

② Dopamine levels are higher during the 0-5 observation period than during the 30-35 period.

③ The worm was exposed to food just before the 30-35 observation period.

④ Mechanosensory dopamine neurons receive more sensory stimulation during the 0-5 observation period than during the 30-35 period.

⑤ Chemosensory neurons receive more sensory stimulation during the 30-35 period.

21. In the leg-control circuit shown below, the forward angle sensor (FAS) is activated when the leg contacts the forward sensory hairs (indicated by dashed line). The FAS neuron would be expected to make INHIBITORY connections with which of the following neurons?

① FS

② FT

③ BS
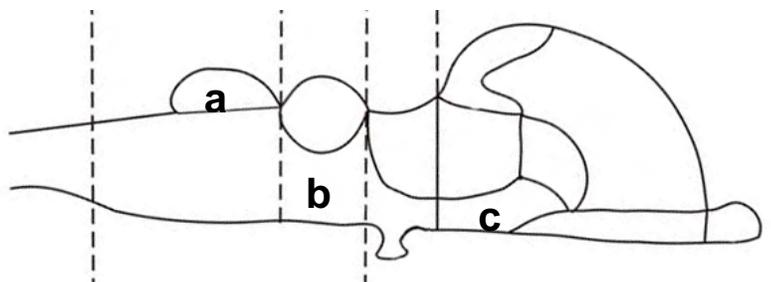
④ both FS and FT

⑤ both FT and BS

⑥ none of the above

22. Which vertebrate brain structure is primarily associated with selection and initiation of motor actions?

① thalamus

② hypothalamus

③ hindbrain

④ spinal cord

⑤ basal ganglia

23. In the generalized diagram of the vertebrate brain shown here, 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

24.   Performing bilateral lesions of the *thalamo-tectal pathway* in the toad generally causes the animal to strike at both 'worm' and 'anti-worm' stimuli.

⟨1⟩ TRUE   ⟨2⟩ FALSE

25. While reaching in to get a pizza out of the oven, you touch the hot metal rack. Your withdrawal reflex is primarily mediated by circuitry in the

① amygdala

② basal ganglia

③ cerebral cortex

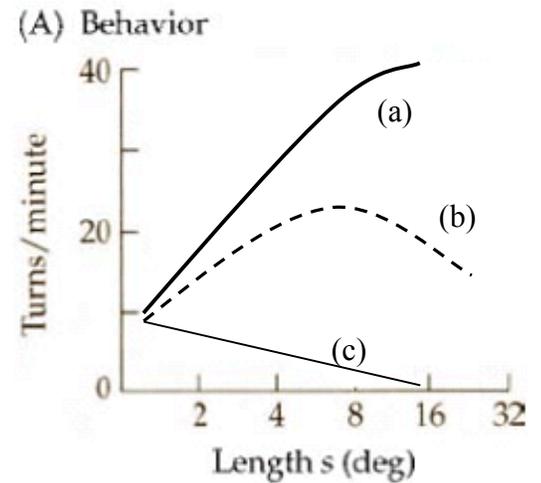④ hindbrain

⑤ midbrain

⑥ spinal cord

⑦ thalamus

26. 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, o, 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

27. Consider using a genetic algorithm to evolve the string "To be, or not to be…" from a population of random strings. If you set the crossover and mutation rates to zero, and use a tournament-style selection process (like in the HW assignment) what will generally happen to the "best fitness" and "mean fitness" over the first several generations?

① both will stay almost constant

② both will increase

③ best fitness will increase and mean fitness will stay relatively constant

④ mean fitness will increase and best fitness will remain relatively constant

28. 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 (a):

(A) Behavior

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).

29. Consider a pure integrate-and-fire neuron (with no leak term) that receives a constant current injection. Which of the following manipulations would increase 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

30. Consider evolving a gene string to control a Braitenberg vehicle using the following encoding:
   mtrL =gene[0] + gene[1] * snsL + gene[2] * snsR
   mtrR = gene[3] + gene[4] * snsL + gene[5] * snsR
   Which of the following gene arrays would implement the "Love" behavior?
   ① [3, 9, 0, 3, 0, 9]
   ② [3,-9,0, 3, 0, -9]
   ③ [-3, 0, 9, -3, 9, 0]
   ④ [3, 0, -9, 3,-9, 0]

10

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	VERSION B
```let action = "none";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";}if (detectDirt) { action = "clean_carpet";}do_behavior(action);```	```let action = "none";if (batteryIsDead) { action = "annoying_beep";} else if (atCharger) { action = "recharge_battery";} else if (batteryIsLow) { action = "taxis_to_charger";} else if (detectFamilyMember) { action = "say_hello";} else if (detectHuman) { action = "use_stun_gun";} 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

<center>END OF EXAM</center>