Please Read the Instructions First

Check your pages. There are 17 pages in this exam.
You are responsible for making sure that you have all the pages.
This examination is worth 130 points.
Write your name, ID#, and Lab. Section on your scantron.

Multiple Choice Questions

1. Indicate your answers on the scantron sheet using a number 2 or a test scoring pencil. Press heavily, don’t stray out of the margins, and completely erase any changed answers.

2. If you think that a multiple choice question is ambiguous or confusing, use the “gripe sheet” at the end of the examination to explain the problem.

3. There are 45 multiple choice questions worth 2 points each.

Fill-in Questions

1. Use pen only (no grade corrections for pencil).

2. Write only one answer per question. You can elaborate on an answer, but you will not be given any credit if you write two different answers to the question.

3. Spelling rules: ½ credit for 2–3 letters wrong or transposed. No points will be given if the misspelling alters the meaning of the word.

4. There are 14 fill-in questions worth 40 points in total.
Choose the one best answer:

1. All sea stars
   a. are carnivores
   b. have five arms
   c. have pedicellariae
   d. have suckers on their tube feet
   e. **live in marine environments**

2. Echinoderms are _____________ and they all possess _____________.
   a. deuterostomes; pedicellariae
   b. deuterostomes; tube feet with suckers
   c. **deuterostomes; a water vascular system**
   d. protostomes; tube feet
   e. protostomes; a water vascular system

3. Sea urchins are in the Class _______________ and they are _________________.
   a. Asteroidea; penta–radially symmetrical
   b. Crinoidea; filter–feeders
   c. Crustacea; in possession of a calcium carbonate exoskeleton
   d. **Echinoidea; herbivores**
   e. Holothuroidea; bilaterally symmetrical

4. In a video seen in class, what did David Attenborough pick up out of a dried–up water hole?
   a. a dead coelacanth
   b. **a hunk of hard sediment with a live lungfish inside**
   c. a large, fossilized fecal pellet from an extinct mammal
   d. a lizard fossil
   e. a fossilized tooth from a dinosaur

5. Comparisons of radial forms of adult sea urchins to the larvae and adults of descendant species such as heart urchins, sand dollars, and sea cucumbers, indicates that the last three groups exhibit
   a. pentamerous unilateral symmetry
   b. primary asymmetry
   c. primary radial symmetry
   d. **secondary bilateral symmetry**
   e. secondary radial symmetry

6. Which of the following is **NOT** a characteristic of chordates
   a. notochord
   b. pharyngeal gill slits
   c. postanal tail
   d. **ventral nerve cord**
   e. All of the above are characteristics of chordates
7. A tunicate where several zooids share a common exit pore would be classified as
   a. a cephalochordate
   b. common
   c. competitive
   d. compound
   e. confusing

8. Larvaceans are
   a. an early stage in insect metamorphosis
   b. another name for the tadpole stage in frogs
   c. pelagic and members of the gelatinous zooplankton
   d. primitive vertebrates
   e. sessile and adults look like the larvae

9. Which of the following statements is TRUE?
   a. All chordates are vertebrates.
   b. All invertebrates are in the subphylum Invertebrata.
   c. All invertebrates are members of the phylum Chordata.
   d. All tunicates are vertebrates.
   e. Both invertebrates and vertebrates are in the phylum Chordata.

10. Jawless fishes include
    a. cartilaginous fishes and lobe–finned fishes
    b. flatfishes and lungfishes
    c. hagfishes, lampreys, and lungfishes
    d. lobe–finned fishes and ray–finned fishes
    e. members of the Superclass Agnatha

11. Amniotic eggs are only found in
    a. amphibians, reptiles, birds, and mammals
    b. fishes, birds, and mammals
    c. mammals
    d. reptiles, birds, and mammals
    e. none of the above

12. The correct sequence for the location of the origin and evolution of fishes is
    a. freshwater – marine – freshwater
    b. marine – freshwater
    c. marine – freshwater – marine
    d. terrestrial – freshwater
    e. terrestrial – marine
13. From a cladistic viewpoint, why should birds be demoted from Class Aves to an Order within Class Reptilia?
   a. scales are modified feathers
   b. wings of insects are homologous to the wings of birds
   c. birds and reptiles are parapatric
   d. birds have all the characteristics of reptiles, but are simply specialized for flight
   e. birds and reptiles are endothermic

14. Based on simple lungfish morphology, we think lungs evolved by
   a. an increase in the size and complexity of pockets in the digestive tract
   b. development and internalization of gills
   c. expansion of nasal passages
   d. outpocketing of the inner ear sinuses
   e. vascularization of the fish’s mantle cavity

15. The frequency of the T allele in a population is 0.7. There are only two alleles at this locus and T is dominant. What will the frequency of homozygous recessive individuals be if the population is in Hardy–Weinberg equilibrium?
   a. 0.09
   b. 0.42
   c. 0.49
   d. 0.90
   e. None of the above

16. A population of California poppies (a plant) grew to an average height of 5 cm during the growing season of 1995. During the growing season of 1996, they grew to an average height of 9 cm. What is most likely to have happened between the two years?
   a. evolution
   b. phenotypic change
   c. herbivory
   d. adaptation
   e. stabilizing selection
17. Which of the lines in the graph above represents maximum heritability of height?

   a. A
   b. B
   c. C
   d. D
   e. E

18. A population of mice exists in the Bay Area. A huge earthquake along the San Andreas Fault produces a 100 mile long crack that fills with water and bisects the population. The two parts of the population are now

   a. allopatric
   b. geographically isolated
   c. reproductively isolated
   d. spatially isolated
   e. all of the above

19. Which of the following names for singular and plural scientific classifications is correct?

   a. genus, genuses
   b. phylum, phylums
   c. species, species
   d. taxon, taxons

20. Which of the following structures are **NOT** homologous?

   a. bat wing – human arm
   b. front flipper of a whale – arm of a frog
   c. pectoral fin of a coelacanth – front limb of a lizard
   d. scales of a reptile – feathers of a bird
   e. All of the above are homologous
21. Red deer stags (males) compete with other males for females to add to their harem. While two stags are fighting there is a high risk of

a. injury
b. “sneaky fuckers” stealing matings
c. genetic drift
d. both a and b
e. all of the above

22. An evolutionary change in the timing of development of characteristics from ancestor to descendant would be a definition of

a. gastrulation
b. heterochrony
c. juvenilization
d. polyploidy
e. stasis

23. Which were the first organisms to evolve flight?

a. bats
b. birds
c. insects
d. pterosaurs
e. trilobites

24. The diagram shown above is an example of

a. heterozygote inviability
b. hypermorphosis
c. neoteny
d. parsimony
e. progenesis
25. Which of the theories of multicellular origin is most widely accepted and why?

a. cellular aggregation because we know that organisms are genetic patchworks and their cells have different genetic make-ups
b. **colonial theory because the first metazoans were colonial protozoans or choanoflagellates that could have given rise to sponges**
c. syncytial theory because the first metazoan was likely a triploblastic organism and diploblasts evolved later
d. All three theories are equally plausible because my instructor said so

26. What is most likely responsible for bioluminescence in the ocean

a. a toxin found in red tides
b. apicomplexans
c. **dinoflagellates**
d. trypanosomes
e. *Volvox*

27. Malaria is caused by

a. a parasite
b. an apicomplexan
c. *Plasmodium*
d. drinking water with fecal contamination
e. **a, b, and c**

28. Annelids and Arthropods are similar in that they both have

a. a reduced coelom
b. an open circulatory system
c. **external segmentation**
d. septa between segments
e. tagmatization

29. One indication that molluscs and annelids share a common ancestor is the presence of __________ in both groups.

a. a closed circulatory system
b. a **trochophore larva**
c. collagen
d. metamericism
e. monoecious and dioecious forms

30. Echinoderms and Chordates

a. are radially symmetrical
b. are protostomes
c. display spiral cleavage
d. **have a blastopore that becomes the anus**
e. have the same larval stage
31. After a male spider mates with a female, the best strategy that would improve his fitness would be to
   a. approach the female and stroke her often
   b. eat the female’s eggs and mate with her again
   c. keep rival males out of the web
   d. lure prey into the web for both of them to eat together
   e. tear off his pedipalps and hang them in the web

32. Which of the following is **NOT** a matching calcified structure in the corresponding taxon?
   a. CaCO₃ spicules in Porifera
   b. calcareous tube in Polychaeta
   c. shell in Polyplacophora
   d. skeleton in coral polyps of Anthozoa
   e. skull in Chondrichthyes

33. The slits in the chordate pharynx probably evolved as what type of structure?
   a. digestive
   b. filter–feeding
   c. locomotory
   d. respiratory
   e. sensory

34. While at a restaurant at Fisherman’s Wharf in San Francisco, you order soup. You ask your server what is in it and you are told the soup contains clams, oysters, squid, shrimp, and one fish. How many different **Classes** have been used in this soup?
   a. 1
   b. 2
   c. 3
   d. 4
   e. 5

35. Which of the following would be a good example of a lineage with lots of extinctions?
   a. heavily shelled cephalopods
   b. trilobites
   c. sessile echinoderms with long, heavy stalks
   d. b and c
   e. **a, b, and c**

36. In seahorses and poison arrow frogs, males take care of the eggs. In poison arrow frogs, males can only care for eggs from a few females, and females fight with other females for access to males. In seahorses, female and male animals are the same size and females do not fight with each other for access to males. This is best explained by the fact that
   a. each female seahorse keeps a herd of males to take care of the young
   b. male seahorses defend territories and rear young
   c. male seahorses eat most of their eggs so they really aren’t that busy
   d. male seahorses rear the eggs from hundreds of females at once
   e. **seahorses are monogamous**
37. Modern lungfishes
   a. are capable of breathing methane
   b. do not have a swimbladder
   c. evolved from reptiles
   d. have lungs and no gills
   e. make an amniotic egg

38. Bilaterally symmetrical echinoderms
   a. are visible at the larval stage
   b. can be found in adult forms of Asteroidea
   c. can be found in adult forms of Holothuroidea
   d. a and c
   e. a, b, and c

39. The name of the chewing mouth parts in scorpions is
   a. chelicerae
   b. chelipeds
   c. claws
   d. pedipalps
   e. uniramous

40. One advantage to an organism undergoing holometabolous metamorphosis is
   a. each life stage is resistant to parasitoids
   b. mating can occur at any stage
   c. of all the life stages, only one is susceptible to predation
   d. the calcareous endoskeleton of the pupa protects the developing animal inside
   e. the different life stages feed in different habitats

41. Cicadas are insects (locusts) in the genus *Cicada* that emerge from the ground after many years of a resting phase. One species emerges every 13 years while another species emerges every 17 years. Which mechanism best explains the inability of these two species to reproduce and create fertile offspring?
   a. pre–zygotic and behavioral isolation
   b. pre–zygotic and ecological isolation
   c. pre–zygotic and temporal isolation
   d. post–zygotic and hybrid inviability
   e. post–zygotic and hybrid sterility

42. Shell collectors enjoy the diversity of representatives of the Class Gastropoda. The wealth of specimens available is a result of
   a. anagenesis
   b. cladogenesis
   c. homogenesis
   d. spermatogenesis
   e. stabilizing selection
43. A population of fish (Species A) lives in a lake that has been isolated from other bodies of water for the last 20,000 years. Species A has a typical fish life history: individuals hatch at a small size, mature at a larger body size, and then continue to grow as sexually mature adults. A game manager releases another, predatory species (species B) into the lake. Species B prefers to eat large members of species A. In this situation

a. directional selection would favor earlier maturity in species A
b. directional selection would favor later maturity in species A
c. stabilizing selection would favor reduced growth rates in species A
d. stabilizing selection would favor reduced variation in body size in species A
e. b and d

44. Cnidarians may be solitary or colonial and the colonies can be sessile or pelagic. These morphological features are similar to those of members of the

a. Subphylum Cephalochordata
b. Subphylum Chelicerata
c. Subphylum Crustacea
d. Subphylum Urochordata
e. Subphylum Vertebrata

45. Which of the taxa below contain ectoparasitic species?

a. Cestoda and Trematoda
b. Chelicerata and Insecta
c. Hirudinea and Monogenea
d. b and c
e. All of the above

Fill–in questions:

46. From what structure(s) did the jaws of fishes evolve? (1 pt)

   gill arches
   (½ pt for pharyngeal gill slits, gill slits, pharyngeal gills, gills, pharyngeal pouches)
47. A marine fish has an internal concentration of 300 mOsm and swims in ocean water with a concentration of 1000 mOsm. Make a sketch of the solute concentrations inside and outside the fish and describe how water would naturally move into or out of the fish. (1 pt)

Sketch shows low internal concentration inside fish and high external concentration in surrounding seawater

How does the marine fish counteract this natural flow of water? (1 pt)

Any of the following are correct answers:
1. reduce the size of the kidney and excrete very little isosmotic urine
2. drink seawater to replace lost water. This brings in more ions.
3. excrete the extra ions from the seawater they drink, plus the ones that are leaking in anyway. Excrete the ions across the gills. Cells in the gills take ions out of the blood.

48. If humans are chordates, where are our pharyngeal gill slits and postanal tails? (2 pts)

They are present in the embryo (fetus).
[Since this question is worded in a very general way, acceptable answers would also include what these structures have become (i.e., gill slits became upper and lower jaws, inner ear, thymus gland, etc.; postanal tail became coccyx).]

49. Describe an anti–predator behavior in sea cucumbers including the advantages and disadvantages to both the predator and prey. (2 pts)

When threatened, sea cucumbers can eviscerate. The predator consumes the intestines while the sea cucumber crawls away to safety to regenerate a new gut. Similarly, sea cucumbers can also expel organs of Cuvier that are sticky and can entangle predators.
50. Fill in the following table that describes reproductive differences between males and females. (6 pts)

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Male</th>
<th>Female</th>
</tr>
</thead>
<tbody>
<tr>
<td>Relative Size of Gamete(s)</td>
<td>small</td>
<td>large</td>
</tr>
<tr>
<td>Relative Number of Gametes (few, many, or same)</td>
<td>many</td>
<td>few</td>
</tr>
<tr>
<td>Nourishment given (no or yes)</td>
<td>no</td>
<td>yes</td>
</tr>
<tr>
<td>Potential Number of Reproductions per Year (few, many, or same)</td>
<td>many</td>
<td>few</td>
</tr>
<tr>
<td>Degree of Choosiness in Mate Selection (very choosy or rarely choosy)</td>
<td>rarely choosy</td>
<td>very choosy</td>
</tr>
<tr>
<td>Total Investment (small, large, or equal)</td>
<td>small</td>
<td>large</td>
</tr>
</tbody>
</table>
51. For the cladogram below, fill in the appropriate taxa for A and B, and definitive characteristics for each number. Use words other than “protostome” and “deuterostome”.

(4 pts)

A. **Echinodermata**

B. **Chordata**

1. coelom arises by enterocoely

2. blastopore becomes anus

3. water vascular system

4. secondarily pentaradial symmetry

5-6. dorsal tubular nerve cord

    - notochord
    - pharyngeal gill slits
    - postanal tail

52. From a tunicate tadpole larva, how might a large, free-swimming, filter-feeding chordate have evolved? (4 pts)

**A tadpole larval stage increased in size by neoteny, was able to swim and filter-feed, and delayed its metamorphosis to the sessile stage. Eventually metamorphosis was eliminated.**
53. In wild radishes, two alleles (Y and y) at a single locus control the expression of flower color. Individuals carrying the Y allele always produce yellow flowers. In every year from 1987 through 1997, you observe that a large population of wild radish plants consists of 64% yellow–flowered individuals and 36% white–flowered individuals. Assuming that in 1997, this population was in Hardy–Weinberg equilibrium, what is the frequency of the yellow–flowered allele in the population? Show all your work to receive full credit.

\[
\begin{align*}
YY \text{ or } Yy &= 0.64 \\
yy &= 0.36 \\
q(y) &= \sqrt{0.36} = 0.6 \\
p(Y) &= 1 - 0.6 = 0.4
\end{align*}
\]

frequency of yellow–flowered allele 0.4 or 40%

54. What is the name of the substance made by the body of bivalves, larvaceans, sea squirts, and some brittle stars that is often associated with filter–feeding? (1 pt)

mucus

55. Arrange the following events in chronological order (2 pts – all or nothing and you can have one letter in the wrong position to still get full credit)

a. arthropods evolve flight
b. dinosaurs go extinct
c. eukaryotes appear
d. the Burgess Shale fauna were alive
e. the first mammals appeared
f. vertebrates arrive on land

c, d, f, a, e, b
56. On the horizontal lines of the cladogram above, place the letters below to indicate the first occurrence of each of the following: (6 pts)

A. jaws
B. amniotic egg
C. tetrapod
57. On the cladogram on the previous page, draw a **box** around all members of the phylum Chordata *including* all relevant ancestral taxa. (2 pts)

[see previous page for answer]

58. On the cladogram on the previous page, **circle** the monophyletic Class Reptilia as recognized by cladists. Be sure to also **include** the relevant ancestral taxa. (2 pts)

[see previous page for answer]

59. List two **solutions** to the problems of reproducing sexually in dry, terrestrial environments. (2 pts)

- internal fertilization
- amniotic egg
- cocoon of mucus for developing embryos (earthworms)
Gripe Sheet

Instructions:

1. Put your name at the top of the page.

2. If you think that a question is ambiguous or confusing, indicate the question number, the answer you gave, and the reason that you gave this answer.

<table>
<thead>
<tr>
<th>Question #</th>
<th>Answer you gave</th>
<th>Gripe</th>
</tr>
</thead>
</table>