(1) LIFE FINDS A WAY? (3 pts each)

Last summer's Jurassic World movie (featuring Chris Pratt, pictured above center) was a sequel to the 1993 Movie Jurassic Park. In that first movie the character of Ian Malcolm (pictured above on the right) is nervous about the idea of a park for dinosaurs and doesn't believe that the various safeguards put in place will be effective. He claims that:

"If there is one thing the history of evolution has taught us, it's that life will not be contained. Life breaks free. It expands to new territories, it crashes through barriers, painfully, maybe even dangerously, but, uh, well, there it is!....I'm simply saying that, uh, life finds a way."

Arguments can be made both for and against this viewpoint that life always "finds a way". Use information from class to make two arguments, one for and one against this very strong statement by Dr. Malcolm. Note: don't just give your opinion, use actual data or reasoning based on concepts or data from class.

(a) For (i.e., life [always] finds a way):

(b) Against (i.e., life doesn't [always] find a way):
(2) GEOLOGIC RECORD. (4 pts). Carbon dating is often used on old campfire sites to date the age of the fire. The initial ratio of \(^{14}\text{C}\) to \(^{12}\text{C}\) in the ash will be the same as the atmospheric ratio (wood formed from trees photosynthesizing using this atmosphere acquire this ratio). Radioactive decay of \(^{14}\text{C}\) into \(^{14}\text{N}\) changes this ratio over time because the half-life of this decay process is approximately 5,700 years. If the \(^{14}\text{C}\) in the atmosphere was initially present in amounts of "one part per trillion" when the campsite was made, what would the concentration of \(^{14}\text{C}\) be after 22,800 years? Express your answer in "____ parts per trillion" or "____th of a part per trillion". (Note: "parts per X" where "X" is millions, billions, trillions, etc. is a standard descriptor for very low concentrations).

(3) ARTIFICIAL SELECTION. (3 pts. each). Consider the following hypothetical selective breeding program for faster horses. In a base population of 20 horses the average (mean) time required to run 1.25 miles (the length of the Kentucky Derby) was measured to be 130 seconds. From these horses the fastest 10 were chosen for breeding (their average time was 127 seconds). They produced 17 offspring and the average time to run 1.25 miles for these horses was 128 seconds.

(a) Based on this data what is your estimate of the heritability of running speed for the population of horses used?

\[ h^2 = \underline{\text{______}} \]

Actual data for the winning times in the Kentucky Derby are shown to the right. As you can see, the speed increased early on (1900-1940), but has remaining fairly constant and without improvement more recently despite the continued efforts of horse breeders to produce faster horses.

(b) Using your knowledge of the evolutionary process and what leads to responses to selection, describe why breeders have been unable to produce faster horses more recently using the same selective breeding methods that worked earlier.
(4) HISTORY OF SCIENCE. FILL IN THE BLANKS (1 pt. each).

The first influential attempt to organize and systematically structure biodiversity was made by ________________ who conceptualized living organisms as holding positions on a ladder of quality or complexity. He was a student of the Greek philosopher __________ who had previously described living organisms as degenerate or corrupted versions of the true versions or ________________ created by a supernatural creator. Much later, Carl ________________ cataloged all known living animals and plants and in doing so created binomial nomenclature.

The idea of a static world was generally held until the 19th century when fossils and other types of evidence convinced scientists that biological and geological change had occurred over time. Two geologists were very influential in thinking about this change. The geologist ________________ argued that slow gradual change over time (i.e., the same thing we see today) could account for the patterns in the geological record whereas ________________ argued that catastrophes and saltational changes were evident.

Biologists soon proposed their own models for change over time, with ________________ arguing that species evolved up the biological ladder to keep up with environmental change while new species were constantly created at the bottom. This initial idea proved false, but set the stage for ________________ and ________________ to propose a model in which natural selection acting on individuals in populations led to the changes seen.

This model faced a huge challenge when particulate inheritance was demonstrated because the small gradual changes described seemed incompatible with the large changes that genetic ________________ seemed to cause. These ideas were reconciled later by the work of ________________, Wright and Haldane who showed that genetics and evolution were compatible if most traits were produced by a large number of genes with small effect.

Other influential scientists later brought these results into related fields, widening their impact; Ernst Mayr used these population genetics ideas to gain insight into ________________ and G.G. Simpson used these population genetics ideas to gain insight into ________________. More recently, the pair of researchers ________________, and ________________ developed the neutral and nearly neutral theories of molecular evolution using sophisticated mathematical models.
(5) PHYLOGNETIC RELATIONSHIPS. (3 pts. each).

In the boxes below provide the phylogenies for the following sets of taxa:

<table>
<thead>
<tr>
<th>Animalia</th>
<th>Annelida</th>
</tr>
</thead>
<tbody>
<tr>
<td>Archaea</td>
<td>Chordata</td>
</tr>
<tr>
<td>Eubacteria</td>
<td>Cnidaria</td>
</tr>
<tr>
<td>Plants</td>
<td>Mollusca</td>
</tr>
<tr>
<td>Fungi</td>
<td>Nematoda</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Birds</th>
<th>Bats</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crocodiles</td>
<td>Humans</td>
</tr>
<tr>
<td>Frogs</td>
<td>Rats</td>
</tr>
<tr>
<td>Pigs</td>
<td>Platypus</td>
</tr>
<tr>
<td>Salamanders</td>
<td>Snakes</td>
</tr>
</tbody>
</table>
(6) EVOLUTION AND GEOGRAPHY. (3 pts). The geographic distributions of modern living organisms support an evolutionary model of biodiversity. Describe the logic of the geographic distribution line of evidence for evolution. Don't just define the terms, describe the logic and argument.

(7) FOSSILS. (3 pts each). Fossils were first recognized to represent the remains of living creatures in the 1800s. When this occurred they quickly provided three distinct and important pieces of evidence of both evolutionary change and continuity over time (this is how this was described in the lectures and note that I am not talking about radioactive dating which became available in the 1900s). What were these three things that fossils showed that contributed to the quick acceptance of evolutionary change by scientists of the 1800s?

1. Fossils showed ...

2. Fossils showed ...

3. Fossils showed ...
FOR THE REMAINING QUESTIONS USE YOUR SCANTRON FORM,
► MULTIPLE CHOICE: (3 pts each).

(1) Which of the following was not described as a line of circumstantial evidence for self-replicating RNA polymers as the precursor to life as we know it?
(A) ATP and GTP, which is used by cells for energy storage is chemically similar to RNA.
(B) RNA is resistant to degradation in aqueous solutions.
(C) RNA is used for translation in all modern living cells.
(D) RNA can catalyze the breaking of phosphoester bonds.
(E) RNA can catalyze the forming of phosphoester bonds.

(2) Which of the following events occurred least recently?
(A) 65 million years ago
(B) Extinction of the dinosaurs
(C) First marsupial mammals
(D) First placental mammals

(3) Which of the following events occurred most recently?
(A) 2 billion years ago
(B) 3 billion years ago
(C) The end of the Hadean eon
(D) The end of the Proterozoic eon

(4) Which of the following events occurred most recently?
(A) Cambrian period
(B) Cretaceous period
(C) Jurassic period
(D) Permian period

(5) Which of the following pairs of events occurred approximately the same time?
(A) Extinction of ediacaran fauna & origin of eukaryotes.
(B) Extinction of dinosaurs & origin of mammals.
(C) Origin of amphibians & origin of vascular plants.
(D) Origin of bacteria & origin of land plants.
(E) Origin of birds & origin of flowering plants.

Use the 5 phylogenetic trees shown here for the next two questions. The shade of the circles for each extant taxon indicates the morphology of the trait in question.

(6) Which of the 5 phylogenetic trees shown above is the MOST parsimonious?

(7) Which of the 5 phylogenetic trees shown above is the LEAST parsimonious?
The following 4 questions are about the video you were required to watch for this exam.

(8) Which of the following occurs toward the beginning of the episode?
(A) The host describes human diversity while at a Diwali celebration.
(B) The host describes the domestication of dogs while at a campfire.
(C) The host describes the extinction of dinosaurs while at a fossil dig site.
(D) The host tells Darwin’s biography while at Down House.
(E) The host travels to the Galapagos to show where Darwin saw iguanas.

(9) Using cartoons, the episode examines natural selection in which of the following taxa?
(A) Aerobic and anaerobic bacteria.
(B) Dull and brightly colored birds.
(C) Fast and slow antelopes.
(D) Tall and short trees.
(E) White and brown bears.

(10) About halfway through the video the evolution of a particular trait was examined by describing the changes in the trait and showing what advantages each slight change would have provided over time? What trait was this?
(A) The camera lens eye of vertebrates.
(B) The skeletal system of vertebrates.
(C) The shapes of teeth in predators.
(D) The wings of birds.
(E) The spines of cacti.

(11) Which of the following occurs toward the end of the episode?
(A) The ship of the imagination travels back in time to watch the extinction of the dinosaurs.
(B) The ship of the imagination travels back in time to watch the first bird take flight.
(C) The ship of the imagination travels through space and time to watch the big bang.
(D) The ship of the imagination travels through space to Saturn’s moon.
(E) The ship of the imagination shrinks to show how white blood cells resemble ancient bacteria.

► TRUE/FALSE questions: (1 point each, 12 pts total). For these questions, mark "A" for TRUE, "B" for FALSE

(12) The actinopterygii include flounder, sharks, and salmon.
(13) The arthropods include crabs, ants, and bees.
(14) The echinoderms include urchins, sea cucumbers, and sea fans.
(15) The marsupials include opossums, wombats, and kangaroos.
(16) The marsupials include Tasmanian devils, koala bears, and black bears.
(17) The molluscs include scallops, slugs, and oysters.
(18) The molluscs include squid, chitons, and barnacles.
(19) The order artiodactyla includes antelope, zebra, and warthogs.
(20) The order carnivora includes weasels, lions, and dogs.
(21) The order cetacea includes porpoises, blue whales, and sperm whales.
(22) The order rodentia includes rats, mice, and rabbits.
(23) The primates include chimpanzees, gibbons, and lemurs.