Rangeland Plant Ecophysiology **Name**_____
EXAM 1, REWM 3500, Fall 2009

Multiple choice. Circle the letter corresponding to the single most correct answer for each of the following. **[2 points each]**

1) The field of plant physiological ecology expanded after World War II because:

a) the National Science Foundation was formed in the late 1940's to support scientific research
b) the enhancement of the nation's transportation systems (highways) provided access to remote areas for study
c) technological advancements in electronics, computing, etc. stemming from WWII provided new ways of conducting ecophysiological measurements
d) returning veterans had the technical skills necessary to pursue scientific careers
e) all of the above

2) This individual observed in the 18th century that air inside a glass jar "spoiled" by a burning candle could be "restored" only in the presence of light and only by the green portions of plants:

a) Joseph Priestly
b) Jan Ingenhausz
c) Frederic Clementz
d) Alexander von Humbolt
e) John Babtista von Helmont
f) none of the above are correct

3) This individual during the early 19th century documented plant distributions in Central and South America and was a key player in the development of the field of plant geography:

a) Joseph Priestly
b) Jan Ingenhausz
c) Frederic Clementz
d) Alexander von Humbolt
e) John Babtista von Helmont
f) none of the above are correct

4) This individual is considered one of the founders of the field of Rangeland Management in North America:

a) Joseph Priestly
b) Jan Ingenhausz
c) Frederic Clementz
d) Alexander von Humbolt
e) John Babtista von Helmont
f) none of the above are correct

5) The "products" derived from photochemical conversion, the so called "light reactions," that are then used in photosynthetic carbon reduction and regeneration in the Calvin cycle are:

a) ATP and NADPH
b) RuBP and PGA
c) ATP and O_2
d) PGA and PEP
e) PEP and RuBP

6) The correct expression of Beer's Law applied to the decay of irradiance through plant canopies is: (where I_o = irradiance at top of canopy; I = irradiance at bottom of canopy; K = extinction coefficient; L = leaf area index)

a) $I = Ke^{-IoL}$
b) $I_o = Ie^{-KL}$
c) $I = I_oe^{-KL}$
d) $I = I_oe^{KL}$
e) None of the above are correct

7) The correct expression of Fick's Law applied to transpiration rates of leaves in plants is: (E = transpiration rate; ei = leaf internal water vapor concentration ; ea = ambient air water vapor concentration; r = leaf resistance; g = leaf conductance)

a) E = (ei – ea) / g
b) E = (ei – ea) x r
c) E = (ea – ei) / r
d) E = (ei – ea) x g
e) E = (ea – ei) / g

8) The following is used to quantify the irradiance from a direct light source incident on a flat leaf as a function of the leaf angle relative to the light beam:

a) Plank's constant
b) Fick's law
c) Lambert's cosine law
b) Beer's law
e) the speed of light

9) The following is needed to convert photosynthetic irradiance (W m^{-2}) to photosynthetic photon flux density (µmol m^{-2} s^{-1}):

a) atmospheric pressure
b) the average wavelength of light between 400 and 700 nm
c) the average wavelength of light across the entire spectrum of solar radiation
b) atmospheric CO_2 concentration
e) temperature

10) Water use efficiency is defined as:

a) the amount of CO_2 uptake by photosynthesis divided by the amount of water transpired
b) the amount of water transpired divided by temperature
c) the amount of CO_2 uptake by photosynthesis divided by amount of light absorbed
b) the amount of water transpired divided by the amount of CO_2 uptake by photosynthesis
e) none of the above are correct

11) Quantum yield of photosynthesis is expressed as:

a) the amount of CO_2 uptake by photosynthesis divided by the amount of water transpired
b) the amount of photons absorbed divided by the amount of H_2O lost
c) the amount of water transpired divided by the amount of CO_2 uptake by photosynthesis
b) the amount of CO_2 uptake divided by the amount of light absorbed
e) none of the above are correct

12) Liebig's "law of the minimum" generally states that:

a) too much of any single resource is damaging to a plant
b) if one limiting resource is absent the plant fails to grow or dies
c) plant growth is co-limited by more than a single resource
d) plants can trade one resource for another to survive
e) none of the above are correct
f) all of the above are correct

13) The term <u>acclimation</u> refers to:

a) random genetic alterations in a plant induced by a stress
b) morphological or physiological differences between individuals in a population due to differences in microenvironmental conditions
c) evolutionary response resulting from genetic changes in populations leading to compensation for effects of stress
d) morphological or physiological adjustments by an individual plant to compensate for effects of stress
e) none of the above

14) The term <u>adaptation</u> refers to:

a) random genetic alterations in a plant induced by a stress
b) morphological or physiological differences between individuals in a population due to differences in microenvironmental conditions
c) evolutionary response resulting from genetic changes in populations leading to compensation for effects of stress
d) morphological or physiological adjustments by an individual plant to compensate for effects of stress
e) none of the above

15) Radiant energy has important direct and indirect effects on plants, including effects on:

a) germination
b) induction of flowering
c) bud dormancy
b) photosynthesis rate
e) transpiration rate
f) all of the above
g) none of the above

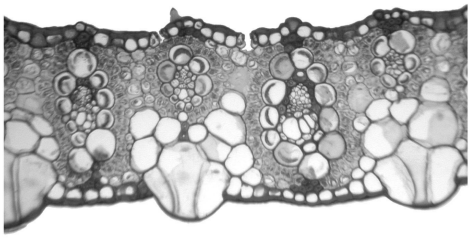
16) Isotopes are:

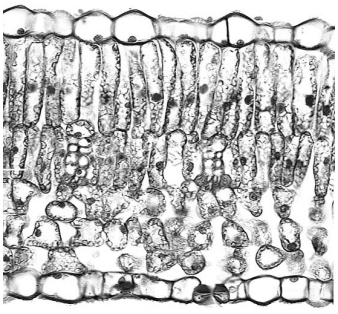
a) atoms of an element that radioactively decay into atoms of another element
b) atoms of the same element that differ in the number of protons
c) atoms of the same element that differ in the number of electrons
b) atoms of the same element that differ in the number of neutrons
e) atoms of an element that do not radioactively decay into atoms of another element

---

Provide concise answers to the following.

17) The two pictures below show leaf cellular anatomy in cross section. First, identify which picture belongs to a plant with "**C4 Kranz anatomy**" and which has the typical a "**C3 anatomy**." Second, for the C4 leaf, identify clearly using two separate lines and labels the **bundle sheath** and **mesophyll** cell types. For the C3 leaf, identify clearly using two separate lines and labels the **palisade parenchyma** and **spongy parenchyma** regions of the leaf. **[6 points]**



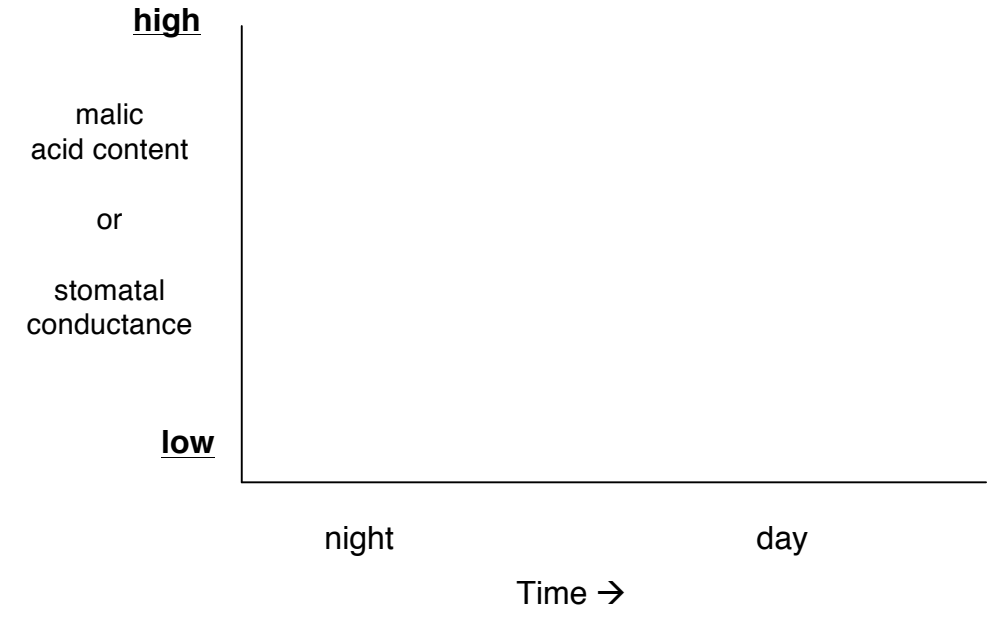


18) Earth's atmospheric CO_2 concentration is predicted to rise from 385 ppm at present to approximately 600 ppm by the end of the current century. **First**, describe how quantum yield of photosynthesis in grasses possessing the C3 and C4 photosynthetic pathways will likely change as a result of the rising CO_2, assuming that no other environmental changes occur. **Second**, provide a mechanistic explanation for your prediction. **Third**, based on these responses, predict how the latitudinal distribution and dominance of C3 and C4 grasses of the North American prairies will shift in response to this global atmospheric change. **[6 points]**

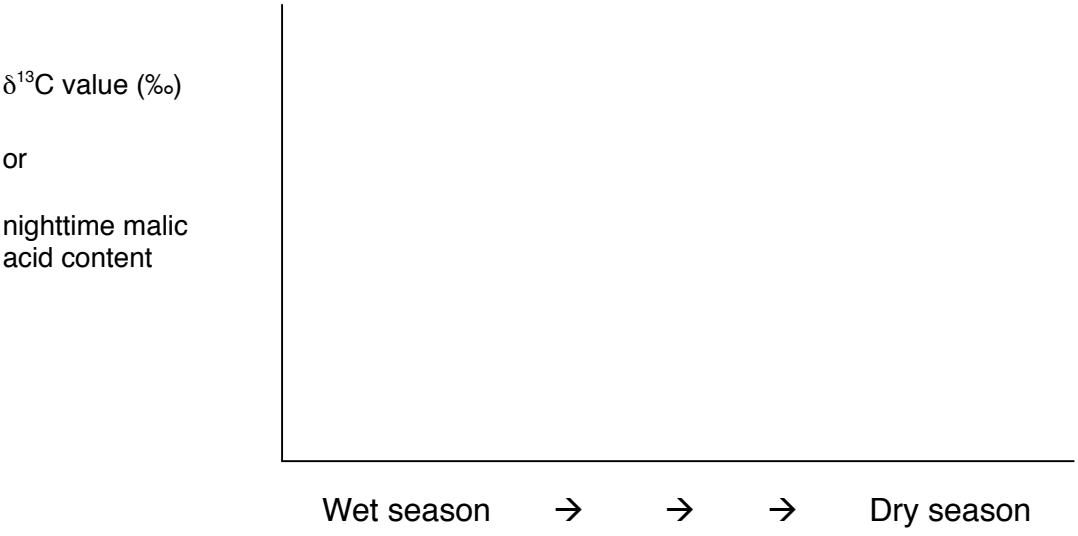
19) Consider again the quantum yield responses for C3 and C4 grasses. Suppose growing season temperature rises by several degrees Celsius in the North American prairies over the next 100 years as is predicted by climate change models. How would you expect the distribution of C3 and C4 grasses to shift across a latitudinal gradient (north-south gradient) in these prairies under this scenario, assuming there were no other environmental changes? Assume all other aspects of the environment remain unchanged. Provide a mechanistic explanation for your prediction. **[6 points]**

20) CAM photosynthesis is thought to be an adaptation to drought. Why? What advantage do plants with CAM photosynthesis have over plants possessing the C3 and C4 photosynthetic pathways? What is the mechanistic basis for this advantage. **[6 points]**

21) CAM cycling and CAM idling are two variations on normal CAM photosynthesis. Draw curves on the graph below depicting the daily change (from nighttime through daytime periods) in tissue malic acid content AND stomatal conductance for plants expressing CAM cycling AND CAM idling. Clearly label the curves "**CAM cycling – stomatal conductance**", "**CAM idling – stomatal conductance**" , "**CAM cycling – malic acid**" and "**CAM idling – malic acid**". You should have a total of four separate curves drawn. **[6 points]**



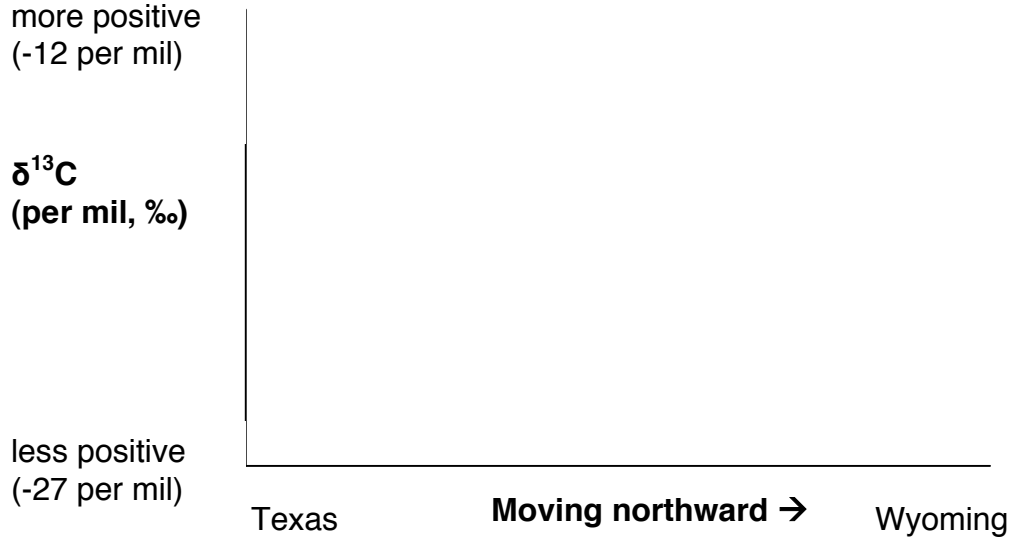
22) Draw two lines on the graph below depicting the predicted response of a facultative CAM plant to the seasonal drying of its environment. One line (solid line) should depict the shift in the $\delta^{13}C$ value of leaves successively produced from the wet season through the dry season. The second line (dashed line) should depict the nighttime malic acid concentration in photosynthetic tissues over the same period. In each case on the y-axis, up is a more positive value for $\delta^{13}C$ and higher concentration for malic acid content. **[6 points]**



23) Contrast **holism** and **reductionism** in ecology. Which of the two perspectives is adopted by plant physiological ecologists? **[8 points]**

24) Using the conceptual analogy of "filters" that was discussed in class, explain why only a small proportion of the world's 270,000 vascular plant species occur within a particular region. **[8 points]**

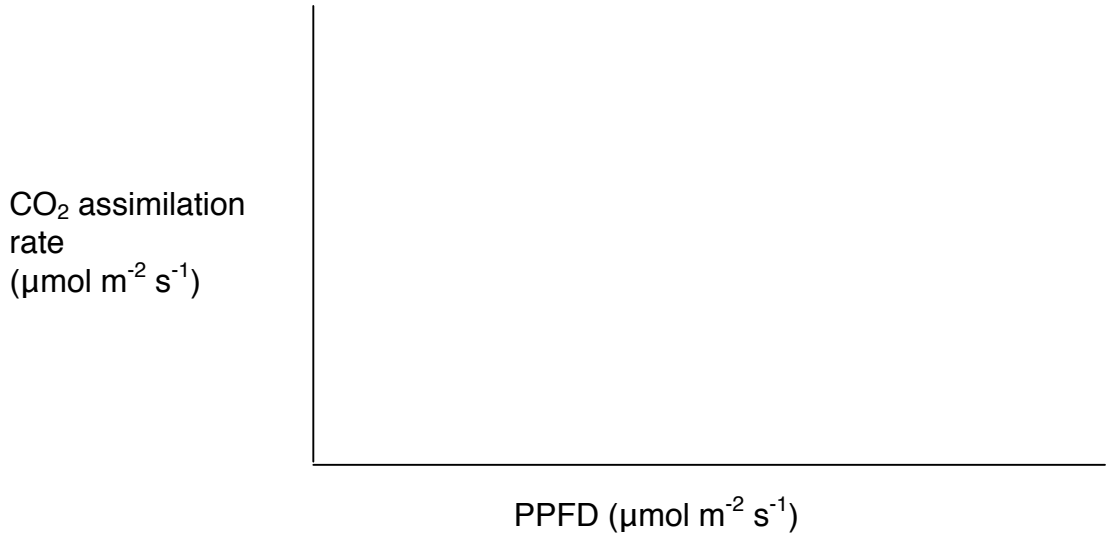
25) On the graph below, draw a line representing the expected value of the carbon isotope ratio ($\delta^{13}C$) of bone protein in bison feeding this year on native prairie grasses across North America from south Texas to Wyoming. In the space below the graph, explain why you might expect this pattern. **[6 points]**



26) For each leaf biochemical, physiological or anatomical property listed below, state whether the quantity of that property would be "higher" or "lower" in the shade-acclimated leaf compared to the sun-acclimated leaf from question #8. **[4 points]**

	"higher" or "lower"
leaf nitrogen content [N]	
leaf protein content	
leaf thickness	
specific leaf area (m^2/g)	
chlorophyll a to chlorophyll b ratio	

27) Draw two lines on the graph below representing light response curves of photosynthesis. The first line should represent that for a **shade-acclimated leaf**. Use a **solid (——) line** for this shade curve. The second line should represent the light response curve of photosynthesis for a **sun-acclimated leaf** on this tree. Use a **dashed (- - - -) line** for the sun curve. On the curve for the sun-acclimated leaf, identify the dark respiration rate (R_d), the light compensation point (**LCP**), and the maximum rate of photosynthesis (A_{max}). **[6 points]**



BONUS: Some aquatic plants (e.g., *Isoetes*) have evolved the CAM photosynthetic pathway? What might be the advantage of CAM in an aquatic habitat? **[2 points]**