Rangeland Plant Ecophysiology **Name_____ [1 point]**
EXAM 1, REWM 3500, Fall 2011

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

1) The correct units for expressing quantities of **photosynthetic photon flux density** are:

a) µmols photons m^{-2} s^{-1}
b) mols photons $gram^{-1}$ s^{-1}
c) W m^{-2}
b) grams photons s^{-1}
e) None of the above are correct

2) The correct units for expressing quantities of **photosynthetic irradiance** are:

a) Watts s^{-1}
b) Joules s^{-1}
c) Joules m^{-2} s^{-1}
b) Joules m^{-2}
e) Watts $Joule^{-1}$

3) The correct units for expressing **quantum yield of photosynthesis** are:

a) Watts m^{-2}
b) mols CO_2 gained / mols photons absorbed
c) mols CO_2 gained m^{-2} s^{-1}
b) mols CO_2 gained / mols H_2O lossed
e) mols photons absorbed / mols CO_2 gained

4) In early research on photosynthesis this individual verified that uptake of minerals from soil by a willow tree was not responsible for the majority of plant mass gain during growth:

a) Joseph Priestly
b) Jan Ingenhausz
c) Frederic Clementz
d) Alexander von Humbolt
e) John Babtista von Helmont

5) Photosynthetically active radiation (PAR) refers to:

a) light within the infra-red portion of the spectrum only
b) light within the green portion of the visible spectrum only
c) light within the blue portion of the visible spectrum only
d) light within the red portion of the visible spectrum only
e) light within the ultra-violet portion of the spectrum only
f) none of the above are correct

6) The most accurate definition of an **isotope** is:

a) atoms of an element that radioactively decay
b) atoms of an element that do not radioactively decay
c) atoms with the same number of neutrons, but different numbers of protons
d) all atoms with an even number of protons and neutrons
e) atoms with the same number of protons, but different numbers of neutrons
f) none of the above are correct

7) A **photoautotroph** is an organism that:

a) obtains energy through the uptake and chemical oxidation of organic compounds present in its surrounding environment
b) obtains energy through the uptake and chemical oxidation of inorganic compounds present in its surrounding environment
c) obtains energy through the conversion of heat to chemical energy
d) obtains energy through the conversion of light energy to chemical energy
e) none of the above are correct

8) Stress response in plants, as defined in lecture, refers to:

a) the reduction in the rate of an essential process due to the imposition of a stress factor
b) the ability to adjust to stress through morphological changes
c) the ability to adjust to stress through physiological changes
d) the increase in the rate of an essential process due to physiological or morphological changes
e) none of the above are correct

9) Stress tolerance refers to:

a) the capacity to endure and maintain the rate of an essential process in the face of stress
b) the capacity to escape the stress factor in space or time
c) the inability to adjust morphologically to a stress factor
d) the capacity to either avoid or tolerate a stress factor
e) none of the above are correct

10) Chronic photoinhibition is best defined as:

a) the change in light absorbance due to changes in leaf angle
b) the reduction of maximum photosynthetic rate resulting from damage by excess light energy
c) the movements of chloroplasts inside of plant cells to maximize light absorbance for photosynthesis
d) the adjustment of pigment composition to dissipate excess light energy as heat
e) the temporary change in chlorophyll content to maximize light capture

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

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

12) 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) PGA and Rubisco
b) RuBP and PGA
c) ATP and O_2
d) PGA and PEP
e) PEP and RuBP
f) none of the above

13) 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

14) Blackmun's "law of multiple limiting factors" 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

15) The term **acclimation** 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) tendency to maintain constant internal conditions and process rates in the face of varying external conditions
d) evolutionary response that results from genetic changes in populations leading to morphological or physiological compensation for the decline in performance caused by stress
e) none of the above

16) The term **adaptation** 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) tendency to maintain constant internal conditions and process rates in the face of varying external conditions
d) evolutionary response that results from genetic changes in populations leading to morphological or physiological compensation for the decline in performance caused by stress
e) none of the above

17) The correct expression of Beer's Law applied to the decay of PPFD as light passes through plant canopies is (where I_o = PPFD at top of canopy; I = PPFD 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) $I = I_o\log_{10}{}^{-KL}$

18) Using the correct expression of Beer's Law above, what is the PPFD at the bottom of a forest canopy if I_o = 500, K = 0.3, and L = 3.5.

a) 175
b) 17.5
c) 1429
d) 0
e) 142.9

19) 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; g = leaf stomatal conductance)

a) $E = (e_i - e_a) / g$
b) $g = (e_i - e_a) \times E$
c) $g = (e_a - E) / ei$
d) $E = (e_i - e_a) \times g$
e) $E = (e_a - e_i) / g$

20) The correct expression of Planck's relationship used to determine the energy content in Joules (J) of a photon of light is (where ***e*** = energy of the photon in joules; ***h*** = Planck's constant [6.63×10^{-34} J s^{-1}]; ***c*** = the speed of light [3×10^{17} nm s^{-1}]; and **λ** = wavelength in nm):

a) $e = h\lambda/c$
b) $e = c\lambda/h$
c) $e = h\lambda c$
d) $e = h^{-\lambda c}$
e) $e = hc/\lambda$

21) Using the correct expression of Planck's relationship above, what is the energy of a single photon of light at a wavelength of 400 nm?

a) 7.96×10^{-14} J
b) 1.81×10^{53} J
c) 4.97×10^{-19} J
d) 8.84×10^{-49} J
e) 7.96×10^{-19} J

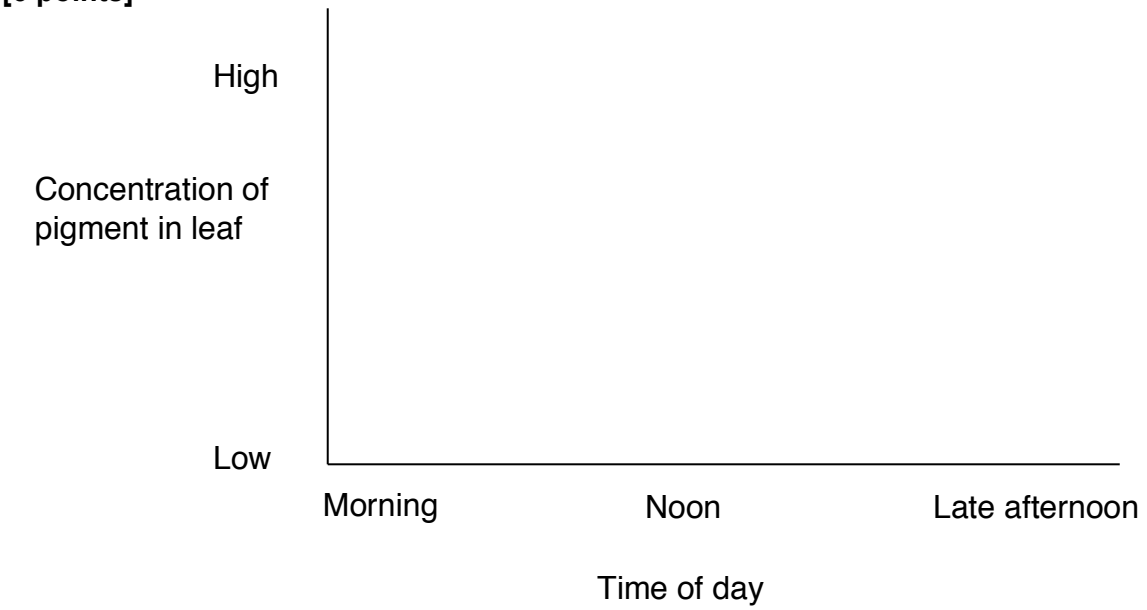
Provide concise answers to the following.

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

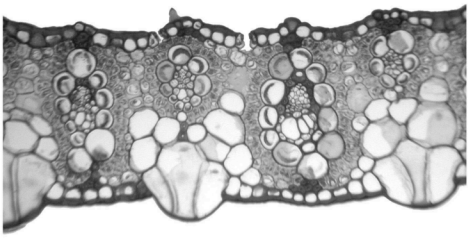
23) In the table below, draw an **up** or **down arrow** in each box to show the relative difference in biochemical and structural traits associated with "**shade" and "sun" acclimated leaves**.
[7 points]

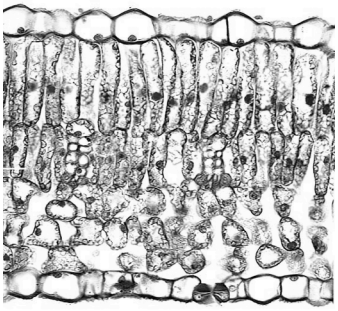
	shade	**sun**
Structural		
Thickness of spongy parenchyma layer		
Thickness of palisade parenchyma layer		
Total leaf thickness		
Density of grana stacks in chloroplasts		
Functional		
Maximum photosynthetic rate		
Light compensation point		
Dark respiration rate		
Biochemical		
Leaf nitrogen concentration		
Leaf protein content		
Concentration of Xanthophylls		

24) Draw two curves on the graph below showing the expected daily change in Xanthophyll pigment concentration in a leaf. One curve should show the changes in Violaxanthin concentration (label this "Violaxanthin"), and the second curve should show the changes in Zeaxanthin concentration (label this "Zeaxanthin"). Assume that irradiance levels are low in the morning, reach maximum values at noon, and then decline again to low values in late afternoon.
[6 points]

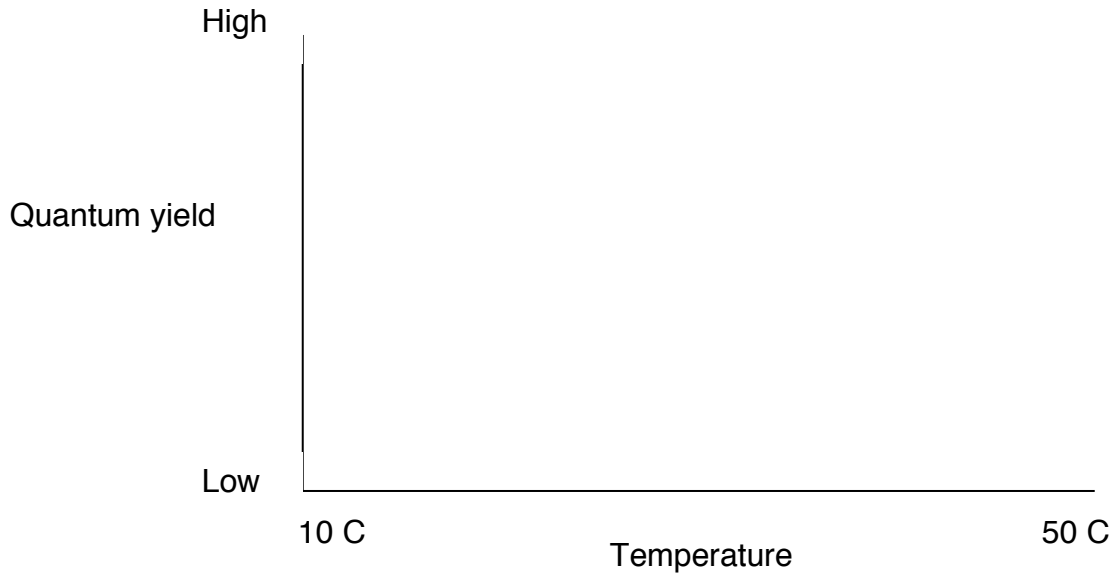


25) The two pictures below show leaf cellular anatomy in cross section. First, identify which picture belongs to a plant with "**C4 Kranz anatomy**" and which has the typical a "**C3 anatomy**." Second, for the C4 leaf, identify clearly the **bundle sheath** and **mesophyll** cell types using two separate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

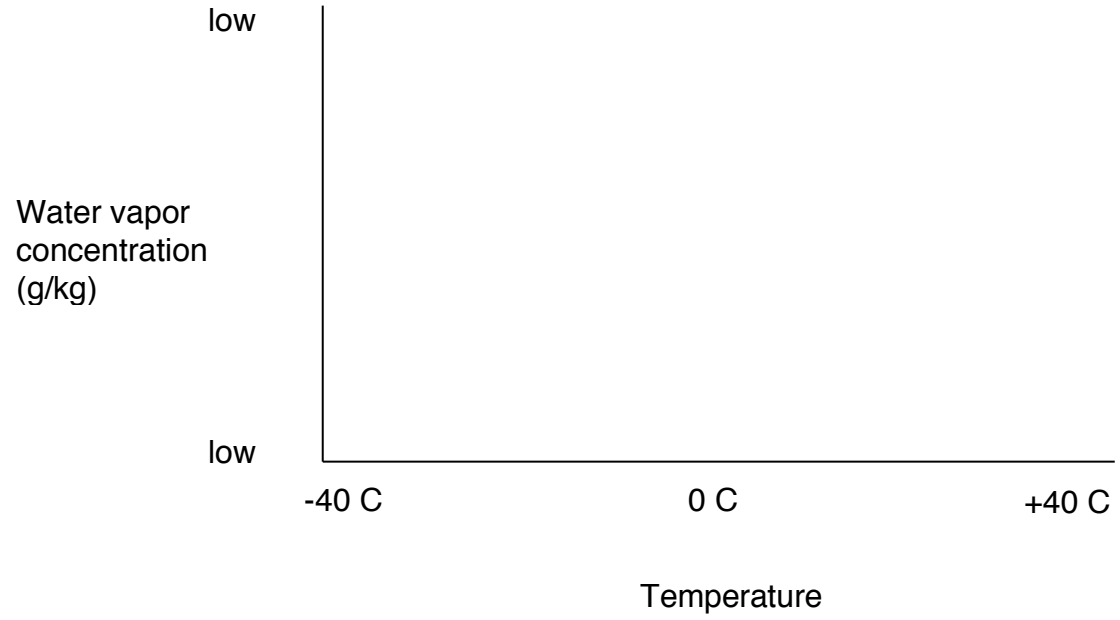




26) Draw three lines on the graph below representing the quantum yield (mols CO_2 assimilated per mol of photons absorbed by leaf) responses of a hypothetical **C3** and **C4** plant in relation to leaf temperature. The first line should represent the response curve for a **C3 plant** in **normal air** (21% oxygen; O_2). Label this line "**C3 21% O_2**". The second line should represent the response of a **C3 plant** in **low oxygen air** (2% O_2). Label this line "**C3 2% O_2**". The final line should represent a **C4 plant** in **normal air**. Label this line "**C4**".
[9 points]



27) On the graph below, draw a single, curved line showing the relationship between saturated water vapor concentration (g/kg) in air as a function of rising temperature. **[3 points]**



28) 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. You must explain this in terms of the relationship you have shown on the above graph in #28. **[8 points]**

29) 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. **[10 points]**