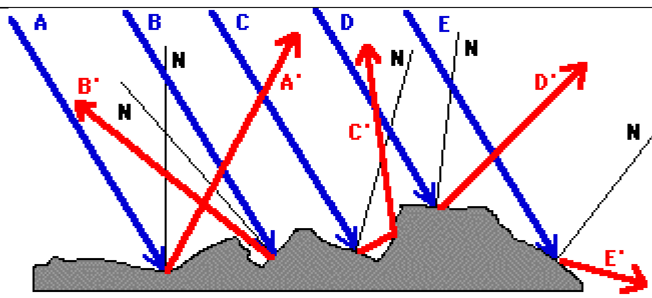
REMOTE SENSING

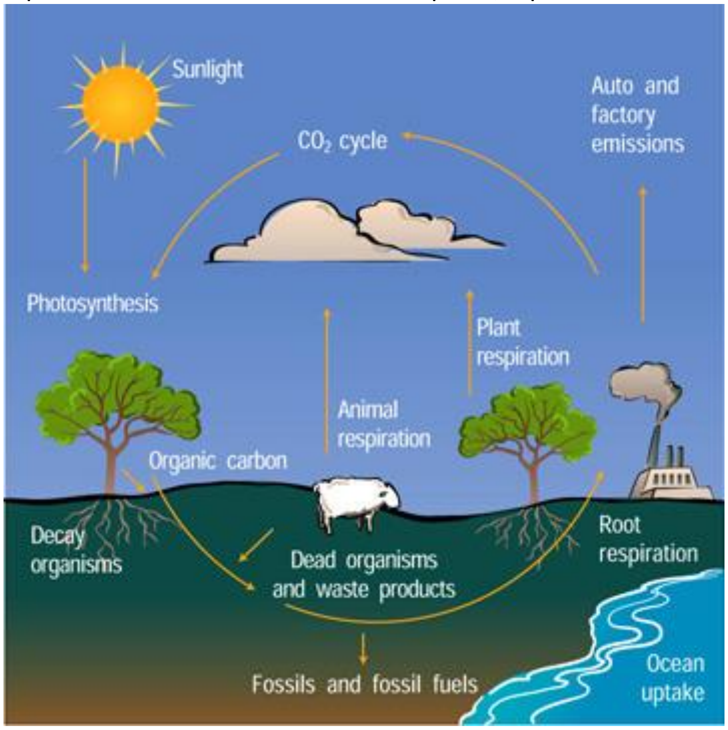
CAPTAINS' TRYOUTS KEY (TOTAL: 160 points)

#	Points	Answer
1	2	Radar map, precipitation map, Doppler radar map, Weather Radar, Weather Surveillance Radar
2	2	Pulse Doppler technology (do not accept Doppler)
3	5	Combines pulse radars and continuous radars (1), using pulse timing techniques to determine distance/range (2) and the Doppler effect of the returning signal to detect velocity (2)
4	3	Motion (1.5) and Intensity (1.5) of precipitation
5	2	Canadian Rockies
6	2	From west to east
7	2	Diffuse; specular
8	2	D
9	4	 For each type of reflection, each individual ray follows the law of reflection (1). However, the roughness of the material means that each individual ray meets a surface which has a different orientation (2). The normal line at the point of incidence is different for different rays. Subsequently, when the individual rays reflect off the rough surface according to the law of reflection, they scatter in different directions (1). The result is that the rays of light are incident upon the surface in a concentrated bundle and are diffused upon reflection. The diagram above depicts this principle.
10	5	Meteorology: Mie scattering occurs when the particle size is the same as the wavelength, thus allowing detection of pollen, dust, smoke Oncology: angle-resolved low-coherence interferometry has been used to see if cellular nuclei match cancerous or normal cellular nuclei. Materials Science: used to design metamaterials by allowing better design and combination of different types of particles detected by Mie scattering Particle Sizing: can detect cavities in materials and types of particles present; for example, oil in polluted water Microbiology: has been used to study structure of microbes and parasites 2.5 points for each correct explanation
11	2	A
12	2	C
13	2	C
14	11	Visible light is from 380 to 760 nm (using 400 to 700 nm is acceptable as well). (1)

		$$380\ nm: c = \lambda v \Rightarrow 3.00 * 10^8 = 3.9 * 10^{-7} * \nu$$ $$\nu = 7.69 * 10^{14} Hz\ (or\ s^{-1})$$ $$400\ nm: c = \lambda v \Rightarrow 3.00 * 10^8 = 4.0 * 10^{-7} * \nu$$ $$\nu = 7.50 * 10^{14} Hz\ (or\ s^{-1})$$ 2 points for correct calculation of frequency of lower bound (1 point for correct numerical answer with 3 sig figs, 1 point for unit) $$700\ nm: c = \lambda v \Rightarrow 3.00 * 10^8 = 7.0 * 10^{-7} * \nu$$ $$\nu = 4.29 * 10^{14} Hz\ (or\ s^{-1})$$ $$760\ nm: c = \lambda v \Rightarrow 3.00 * 10^8 = 7.6 * 10^{-7} * \nu$$ $$\nu = 3.95 * 10^{14} Hz\ (or\ s^{-1})$$ 2 points for correct calculation of frequency of upper bound (1 point for correct numerical answer with 3 sig figs, 1 point for unit) 1 point for correct formula of speed of energy=wavelength x frequency $$E = h\nu \Rightarrow E = 6.626 * 10^{-34} Js * \nu$$ $$380\ nm: \nu = 5.10 * 10^{-19} J$$ $$400\ nm: \nu = 4.97 * 10^{-19} J$$ $$700\ nm: \nu = 2.84 * 10^{-19} J$$ $$760\ nm: \nu = 2.62 * 10^{-19} J$$ 2 points for correct calculation of lower bound energy (1 point for correct numerical answer with 3 sig figs, 1 point for unit) 2 points for correct calculation of higher bound energy (1 point for correct numerical answer with 3 sig figs, 1 point for unit) 1 point for correct formula of energy=Planck's constant x frequency Choose to carry over or not carry over mistakes – just be consistent throughout grading
15	6	Use Wien's Law: Need temperature in Kelvin $$T = 3293°C + 273.15 = 3566\ K$$ $$\lambda_{max} = \frac{b}{T} = \frac{2.897 * 10^{-3}\ \mathrm{m * K}}{3356\ K} = 8.632 * 10^{-7} m = 863.2\ nm$$ This is near-infrared radiation 1 point for Kelvin conversion 1 point for correct formula 1 point for correct numerical answer with 4 sig figs 1 point for correct unit 1 point for near 1 point for infrared radiation
16	14	The energy intercepted by the sun= $$E_{intercepted} = K_s * \pi {R_E}^2 = 1361 \frac{W}{m^2} * \pi * (6371000)^2 = 173.5 * 10^{15} W$$ 1 point for correct formula 1 point for plugging in numbers correctly 1 point for correct numerical answer with 4 significant figures 1 point for units Because of surface albedo, the Earth reflects away some of the energy intercepted from the sun. The energy absorbed (P) is the energy intercepted * (1-albedo): P=E_{int}=*(1-a) 1 point for this formula/explanation. Further, the energy emitted by the earth is given by Stefan-Boltzmann's law as

		$E_{emitted} = \sigma T^4 * 4\pi {R_E}^2$ 1 point for use of Stefan-Boltzmann's law Because Stefan-Boltzmann's gives energy ONLY as emitted per unit area, we must multiply by the surface area of the earth (although it cancels out in the next step). Solving the above equation for temperature, we get: $E_{emitted} = \sigma T^4 * 4\pi {R_E}^2 \Rightarrow T = \sqrt[4]{\frac{P}{\sigma 4\pi {R_E}^2}} = \sqrt[4]{\frac{K_S * \pi {R_E}^2 * (1 - albedo)}{4\sigma * \pi {R_E}^2}} = \sqrt[4]{\frac{K_S * (1 - albedo)}{4\sigma}}$ 3 points for solving the E emitted equation for temperature (Working this equation out without using the surface area of the earth works just as well). Law of Conservation of Energy tells us the P(in)=P(out); that is, the energy emitted as a function of Stefan-Boltzmann's law is equal to the energy absorbed. (2 points for application of conservation of energy) $T = \sqrt[4]{\frac{1361 \frac{W}{m^2} * (1 - 0.31)}{4 * 5.67 * 10^{-8}}} = 253.7\ K$ 2 points for correct numerical temperature with 4 significant figures with correct units 1 point for getting all parts of the problem correct
17	3	Diameter at breast height is closely correlated to height (1) and crown width (1), which can be measured directly by LiDAR (1).
18	5	One emitted laser pulse can encounter multiple reflection surfaces and separate into many returns (2). The first returned laser pulse is the most significant return and will be associated with the highest feature in the landscape like a treetop or the top of a building. The first return can also represent the ground, in which case only one return will be detected by the LiDAR system (1). Multiple returns are capable of detecting the elevations of several objects within the laser footprint of an outgoing laser pulse. The intermediate returns, in general, are used for vegetation structure, and the last return for bare-earth terrain models (1). The last return will not always be from a ground return, but is generally near-ground vegetation or terrain (1).
19	4	1.065 micrometers=1065 nm (1) Near (1) infrared radiation
20	4	Green leaves scatter strongly in the near infrared, ensuring a relatively strong signal over vegetation (2) atmospheric transmittance is high at these wavelengths, ensuring minimal loss of signal from scattering and absorption in any intervening atmosphere (2).
21	2	NVDI (1), Normalized Vegetation Difference Index (1)
22	2	+1 (1) and -1 (1)
23	4	red=0.15 and NIR=0.44 NDVI=(NIR-Red)/(NIR+Red)=0.49 1 for correct formula 1 for plugging in correctly 1 for correct numerical answer with 2 sig figs Indicates that this piece of leaf is pretty healthy vegetation as its NDVI value is between 0 and 1. (1)

24	3	Red results from non-biological factors (1) because it is unlikely that in a single leaf there are that many variations in photosynthesis. It is far more likely that the red is a result of surface angle or sunlight.
25	1	Advanced Very High Resolution Radiometer
26	1	Geographic Information System
27	1	Heat Capacity Mapping Mission
28	1	Advanced Microwave Scanning Radiometer - Earth Observing System
29	1	Radio Detection and Ranging
30	1	Systeme Probatoire d'Observation del la Terre
31	1	Synthetic Aperture Radar
32	1	Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observations
33	1	Tropical Rainfall Measuring Mission
34	1	Earth Observing System
35	1	Clouds and the Earth's Radiant Energy System
36	5	AMSR-2 (1) on JAXA's GCOM-W1 spacecraft (1) AMSR-E on NASA's EOS Aqua spacecraft (1) AMSR (1) on JAXA's ADEOS-II spacecraft (1)
37	4	AMSR-E's calibration system has a cold mirror (1) that provides a clear view of deep space (a known temperature of 2.7 K) and a hot reference load (1) that acts as a blackbody emitter; its temperature is measured by eight precision thermistors. After launch, large thermal gradients due to solar heating developed within the hot load, making it difficult to determine from the thermistor readings the average effective temperature, or the temperature the radiometer sees. The hot load temperature is not uniform or constant, and empirical calibration methods must be employed (2).
38	2	Arctic Sea Ice
39	2	Global warming is happening and the ice is melting.
40	3	Much of the ice at the edge of the maximum ice boundary is seasonal ice that quickly melts in the summer when the weather is warmer.
41	3	Each band is a different frequency AMSR-E detects remote sensing data at and combine each band to form the final data set.
42	2	Multispectral (1) because it has 6 bands, and >1, <10 is considered multispectral (1)
43	3	Sea Surface Temperature Atmospheric Water Vapor Surface Wind Speed Low Frequency Surface Wind Speed High Frequency Time Cloud Liquid Water Rain Rate
44	4	CALIPSO (1) and CLOUD-SAT (1) by taking cross sections of the atmosphere (2)
45	3	Data points from the systems can be used as initial trajectory points for a model of volcanic ash travel.
46	2	Chlorophyll concentrations
47	2	MODIS
48	4	The chlorophyll concentration is a measure of the productivity in a region (1). With more chlorophyll, there is more GPP (1.5). Combined with measurements of carbon levels across the ocean at that point, the NPP can be calculated (1.5).
49	2	An iceberg

50	15	1 point for each term in the correct place, 1 point for each correctly named sink/source:  Sinks: fossils and fossil fuels, ocean uptake, atmosphere Sources: animal respiration, plant respiration, root respiration, auto/factory emissions, decaying organisms