and power ATP synthesis. Finally, during stage 4, the ATP and NADPH gener- ated in the earlier stages are used to drive CO_2 fixation and carbohydrate synthe- sis. CO_2 fixation occurs in the stroma and carbohydrate (sucrose) synthesis occursin the cytosol.

18. Chlorophyll *a* is present in both reaction centers and antenna. Additionally, antennas contain either chlorophyll *b* (vascular plants) or carotenoids (plants andphotosynthetic bacteria). Antennas capture light energy and transmit it to the reaction center, where the primary reactions of photosynthesis occur. The pri- mary evidence that these pigments are involved in photosynthesis is that
the absorption spectrum of these pigments is similar to the action spectra of pho-tosynthesis.

19. Photosynthesis in green and purple bacteria does not generate oxygen because these bacteria have only one photosystem, which cannot produce oxygen. Theseorganisms still utilize photosynthesis to produce ATP by utilizing cyclic electronflow to produce a pmf (but no oxygen or reduced coenzymes), which can be uti-lized by F_0F_1 complexes. Alternatively, this photosystem can exhibit linear, non- cyclic electron flow, which will generate both a pmf and NADH. For linear elec-tron flow, hydrogen gas (H_2) or hydrogen sulfide (H_2S) rather than H_2O donateselectrons, so no oxygen is formed.

20. PSI is driven by light of 700 nm or less and its primary function is to transfer electrons to the final electron acceptor, $NADP^+$. PSII is driven by light of 680 nm or less, and its primary function is to split water to yield electrons, as well as pro-tons and oxygen. During linear electron flow, electrons move as follows: PSII (water split to produce electrons) → plastoquinone (Q) → cytochrome *bf* complex → Plastocyanin → PSI → $NADP^+$. The energy stored as NADPH is used to fix CO_2 and ultimately synthesize carbohydrates.

21. The Calvin cycle reactions are inactivated in the dark to conserve ATP for the synthesis of other cell molecules. The mechanism of inactivation depends on theenzyme; examples include pH-dependent and Mg^{2+}-dependent enzyme regula- tion, as well as reversible reduction-oxidation of disulfide bonds within certain Calvin cycle enzymes.

22. Rubisco (ribulose 1,5-bisphosphate carboxylase) is a large enzyme present in the stromal space of the chloroplast. Rubisco is the enzyme responsible for adding (fixing) inorganic carbon in the form of CO_2 to the five-carbon sugar ribulose 1,5 bisphosphate, which is rapidly cleaved into two molecules of 3-phosphoglyceratethat can be converted into starch and sugars.