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1. (25 points) Freshwater ecosystems occupy less than 1% of the earth's surface but deliver goods and services of enormous global value. An estimated 12% of all animal species live in freshwater ecosystems, and most other species depend in some way on freshwater ecosystems for their survival. Compared with domestic and industrial water uses, agriculture has a disproportionate impact on water flow, water quality, and alteration of freshwater habitats. About 70% of all water withdrawals are for agriculture, but more than half the water entering irrigation distribution systems never makes it to the crops because of leakage and evaporation. As population grows, we will become even more dependent on irrigation for our food supplies. This places extraordinary stress on freshwater systems particularly in arid and semi-arid regions.

2. (25 points) The increasing worldwide contamination of freshwater systems with thousands of industrial and natural chemical compounds is one of the key environmental problems facing humanity. Although most of these compounds are present at low concentrations, many of them raise considerable toxicological concerns, particularly when present as components of complex mixtures. First, tools to assess the impact of these pollutants on aquatic life and human health must be further developed and refined. Second, cost-effective and appropriate remediation and water-treatment technologies must be explored and implemented. Third, usage and disposal strategies, coupled with the search for environmentally more benign products and processes, should aim to minimize introduction of critical pollutants into the aquatic environment.

見背面

3. (25 points) Hyaluronic acid is an anionic, nonsulfated glycosaminoglycan distributed widely throughout connective, epithelial, and neural tissues. It is unique among glycosaminoglycans in that it is nonsulfated, forms in the plasma membrane instead of the Golgi, and can be very large, with its molecular weight often reaching the millions. One of the chief components of the extracellular matrix, hyaluronan contributes significantly to cell proliferation and migration, and may also be involved in the progression of some malignant tumors. The average 70 kg (154 lb) person has roughly 15 grams of hyaluronan in the body, one-third of which is turned over (degraded and synthesized) every day. Hyaluronic acid is also a component of the group A streptococcal extracellular capsule, and is believed to play a role in virulence.

4. (25 points) In 2013, 175 million hectares of genetically modified (GM) plants were cultivated, mostly in the United States, Brazil, Argentina, India and Canada. The majority of these plants are engineered to express one or more novel proteins, providing specific agronomic traits such as insect resistance or herbicide tolerance. GM plants intended for market release can also be designed to induce silencing of target genes *in planta* or in insect pests through RNA interference (RNAi), which is an emerging technology that offers new opportunities for the generation of new traits in GM plants. RNAi involves small RNAs that bind to messenger RNA (mRNA) with sequence homology and leads to the silencing of target gene expression by cleavage of the mRNA via an enzyme complex. RNAi-based GM plants express either a double-stranded RNA (dsRNA), which is subsequently cleaved into a pool of active siRNA molecules that can interact with different parts of the target mRNA, or an artificial miRNA precursor, which is cleaved to a mature and active miRNA.

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