The theory of ecological succession was first developed in 1898 by Henry Chandler Cowles, a University of Chicago graduate student. He proposed the theory in his Ph.D. thesis, which was based on fieldwork he had undertaken in the Indiana Dunes, a region of beaches, sand dunes, bogs, and woods along the south shore of Lake Michigan. Cowles's thesis, which described the phenomenon of plant succession as one travels from the beach inland, was published in a scientific periodical and established him as the first professional American ecologist. According to the thesis, the relative ages of the different plant communities are a function of distance from the lakeshore.

The Indiana Dunes

Today the Indiana Dunes area is protected as the Indiana Dunes State Park and the Indiana Dunes National Lakeshore. Take an imaginary visit to the area. Set up camp under the cottonwood and pine trees along the back of a large dune. Then climb to the top of the dune where you can view Lake Michigan and see the Chicago skyline in the distance. Walk back through the campground beneath oak and hickory trees to the trailheads from which you can hike through the maple and beech forest.

Along the way, a marker will point you to a trail to the beach. Take this trail over the top of another dune and walk through dunes grass on your way to the sandy lakeshore. Lake Michigan was formed when glaciers retreated at the end of the Ice Age about 10,000 years ago, leaving meltwater, sand, clay, and gravel. Winds picked up sand grains from the beach and blew them inland, creating the dunes. This process continues today.

Analyze and Conclude

Respond to each question and statement.

1. **Summarize** What did Henry Cowles propose in his Ph.D. thesis?

2. **Explain** How did the Indiana Dunes form?
3. Systematize  The water level of Lake Michigan was once 18 m higher than it is today, and an original beach level can be identified about 72 km southwest of today's western shore. As the lake receded, land was exposed and small ponds were left behind where there were depressions in the land. The table below describes four ponds.

<table>
<thead>
<tr>
<th>Pond A</th>
<th>Pond B</th>
<th>Pond C</th>
<th>Pond D</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cattails, bullrushes, and water lilies grow in the pond. Larvae and insects serve as food for fish, crawfish, frogs, and turtles. Decayed plants and animals form a medium-sized layer of humus over the bottom of the pond.</td>
<td>Plankton growth in the water is rich enough to support animals that entered the pond when it was connected to the lake. Fish make nests on the sandy bottom.</td>
<td>A thin layer of humus covers the bottom of the pond. Branching green algae cover the humus. Fish that build nests on the bare bottom have been replaced by those that lay their eggs on the algae.</td>
<td>The pond is filled with vegetation, and there are no longer any areas of open water. The humus layer has reached the top of the pond in most places. The pond is filled with grasses, and the water evaporates during the summer months.</td>
</tr>
</tbody>
</table>

Place the letters of the ponds in order of succession (1 = youngest; 4 = oldest).

(1) __________________ (2) __________________ (3) __________________ (4) __________________

4. Apply  One of the reasons succession occurs is that many species change the environment in which they live in ways that make it more favorable for others. Give an example of how this happens in a dune, woodland, or pond ecosystem.

5. Suggest  Dunes grass has rootlike rhizomes that form a webbed underground network. Describe two ways in which dunes grass might change a sand dune.

6. Analyze  A man living on the lakeshore feared that the blowing, shifting sand eventually would cover his house. To prevent this from happening, the man researched the area and learned that jack pine trees grew on the tall dunes that did not move. He planted young jack pines on the sand hills close to his house, but his plan did not work. The jack pines died within a month. Why did the jack pines die?

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