Although few people have ever seen one, glaciers are in many ways as important to our future on this planet as the seas we sail and the air we breathe. For if the world's climate were to cool substantially, as it has in the past, the glaciers of Antarctica and Greenland would greatly expand, lowering sea levels with disastrous consequences. On the other hand, if these ice caps should melt further, and thus raise the level of the sea, the destruction of coastal areas throughout the world would be severe.

But if glaciers pose a threat to man, they also offer unique and prodigal gifts. Consider: Most of the world's great river systems, from the Amazon to the Ganges, the Rhone to the Columbia, originate in glaciers. About 3/4 of all the fresh water in the world - some seven million cubic miles - is stored in the form of glacial ice. Scientists estimate that this reserve is equivalent to about 60 years' rainfall over the entire globe.

How are glaciers born? Simply put, glaciers form whenever winter snowfall exceeds summer melt. The excess accumulates, and is gradually transformed into ice. The first change is from snowflakes to minute ice crystals called "meve" or "firn". As storm follows storm, and the snowfall accumulates, the delicately wrought crystals are compacted and recrystallized into nearly spherical granules of solid ice. With each year's accumulation of snow, the ice mass grows, becoming tougher and harder all the time.

What makes this rock-like glacial mass flow? Glaciologists debate several theories, but generally agree that at a thickness of 100 to 150
feet the ice undergoes a further transformation. The crystalline ice, under heavy pressure deep within a glacier becomes a quasi-plastic substance and, initiated by the force of gravity, starts to flow. Nobody really knows, however, where this happens or at what temperature. Tunneling into the ice in Greenland, scientists found the glacier solidly frozen to the ground—yet in motion from one to 30 feet above the ground.

Whatever the precise mechanism, most glaciers move only an inch or two, or maybe a foot or two per day (some do not move at all). But some record breakers have shown astonishing speeds. In 1966 a pilot flying over Mt. Steele in Yukon Territory spotted a spectacular glacier that galloped two feet per hour—nearly 50 feet a day! Pushing ahead in great pulsating surges, the river of ice, 22 miles long and over a mile wide, sheared through everything in its path including the stagnant ice of previous advance.

Over the centuries, glaciers have dramatically changed the face of the Earth. Scouring with tremendous erosive power, they helped scoop out the Great Lakes of North America and Norway's fiords, chiseled the mighty Matterhorn and helped dig the breath-taking valleys of the Rocky Mountains.

How do glaciers sculpt these masterpieces? As they advance, they literally quarry rock and soil from the sides and floor of the valleys through which they move—everything from finely ground stones to boulders as big as a house. Shoved along by the ice, this glacial debris abrades and rasps away the underlying bedrock, widening and deepening the trough.

During the last great advance of the Ice Age, which reached a maximum 18,000 years ago, ice sheets covered nearly 30 per cent of the Earth’s land. Of these only two remnants exist today—in Greenland and Antarctica—and they account for about 97 per cent of the world’s glaciers. Antarctica covers
some 5.5 million square miles, an area larger than Europe. The entire continent is covered with a mantle of ice, pierced in many places by mountain ranges as high as the Alps, while in places the ice sheet is up to 12,000 feet thick.

The world's second largest ice cap, with 708,000 square miles, is in Greenland. From the forbidding Greenland plateau, huge icebergs "calve" into the open ocean to travel hundreds of miles. One such iceberg, moving out into the Atlantic on the night of April 14, 1912, sank the "unsinkable" Titanic.

The rest of the world's glaciers, important but tiny by comparison with Greenland and Antarctica, are located in North and South America, Europe, Asia, Africa, and New Zealand. In all, about ten percent of the land surface is presently covered by glaciers.

Modern glacial research stems from the curiosity of a Swiss scientist, Louis Agassiz, who set out a century ago to measure the precise movement of glaciers high in the European Alps. Today an entire army of glaciologists is probing the world's glaciers, studying, among other things, the causes of advance and retreat, the flow mechanism and the probability and timing of a new ice age.

The Antarctic is a major theater for this glacial study. There, scientists found nearly a dozen nations, using an imposing array of new tools and techniques, are making extensive surveys and investigations. In 1969 a team of scientists and engineers drilled more than 7,000 feet into the ice sheet at Byrd Station in western Antarctica. Their specially designed rotary drill brought up a continuous core, four inches in diameter, which provided a clear profile of polar history — and an exciting look into the Earth's past.
By analyzing the oxygen in ice formed 25,000 to 100,000 years ago, for instance, scientists were able to study the composition of the Earth's atmosphere back to that early time. In ice 10,000 to 14,000 years old, the scientists found layers of volcanic ash, possibly deposited by an ancient, major cataclysm. At approximately 850 feet, they recovered ice that had fallen as snow at the time of Christ, and in the topmost layers they identified ice contaminated with radio-active fallout from our Atomic Age. The drillers discovered water at the bottom of their 7,100 foot hole-in-the-ice, indicating melting from pressure, assisted by the heat of the Earth itself.

Why are scientists so interested in the Antarctic glacier? "The Antarctic ice cap," says the U. S. National Science Foundation, which sponsored the drilling, "has a powerful influence on the world's weather. Any significant change in this great freshwater reservoir would affect man's environment by causing changes in sea level, rainfall, river flow and lake levels."

"In fact," says William O. Field, noted glaciologist of the American Geographical Society, "with about 90 percent of the world's ice, Antarctica is a super refrigeration system. Should the ice cap wholly melt, the level of the oceans might rise as much as 200 feet, flooding the present coastal regions and engulfing the world's great port cities."

What caused the last Ice Age? Scientists don't agree. All they are sure of is that several million years ago, the earth began to grow cold. One after another, four mammoth ice sheets invaded the Northern Hemisphere. In Europe the ice piled more than 8,000 feet high on the Scandinavian Peninsula. Pushing south, it covered northern England and Germany, and, to the east, penetrated almost to Moscow. In North America the ice spread out until it covered more than half the continent, mile-deep, as far south as the Ohio and Missouri river valleys. The last ice began to retreat
rapidly here about 13,000 years ago, and the melting raised the oceans 400 feet or so to their present level.

Scientists vigorously debate several hypotheses on what brought about this climatic pendulum. According to the "solar-radiation" theory, variations in the amount of energy radiated by the Sun produce climatic changes on Earth. Thus, during periods of less intense solar radiation, the Earth could be cooled sufficiently to trigger an ice age.

Closely linked with radiation is a second theory which holds that unexplained changes in the composition of the Earth's atmosphere - increased cloud cover, for example - might black out some of the Sun's radiation, and so lower the Earth's temperature. A similar effect could be produced by air pollution, volcanic dust and, possibly, concentrations of meteoric debris or other matter in space between us and the Sun. Whatever the reason, the whole subject is profoundly complex, with enough variables to defy a computer, and it will be a long time before man unravels the true story.

Meanwhile, where do we stand now? Are the world's glaciers melting sufficiently to raise the sea level and submerge our great coastal cities? Or is the Earth cooling and heading for another ice age?

"Very probably we are now in the middle or perhaps toward the end of an interglacial period lasting thousands of years." says Richard P. Goldthwait, founder of the Institute of Polar Studies in the United States. "The Earth has swung back and forth between ice ages and interglacial periods for a million or two years, and we can expect it to continue. But don't worry about the return of an ice age soon."
All the facts associated with the formation of a river and the uniting of streams into a river system may be observed in a road-way after a shower. The drops of water collect into small rills which unite with others to form larger rills, and a number of these unite and form a main stream which carries the water down the embankment. Each tiny stream wears its channel in the soft earth, and the raindrops that flow in one are separated from those flowing in another by a little ridge or a gentle slope whose crest forms a watershed in the miniature landscape. However, large a river may be, it had been formed in a manner similar to that of the little stream flowing down the embankment. The only difference is that in case of the river we deal with larger facts.

A river usually has its beginning far up in the mountains or hills, with a little spring or a melting glacier for its source. As it flows on, other streams join it and it continues to increase in volume. The river wears for itself a channel which is lower than the surrounding country. The bottom of the channel is known as the bed of the stream, and the sides are the banks. The right bank of a river is that on the right hand of the observer when he is facing downstream. A river and all its tributaries constitute a river system. The area drained by a river system is known as the river basin.

The basin of the Mississippi River, for instance, includes that portion of the United States drained by that river and its tributaries. The volume of a river depends upon the area of its basin and the amount of rainfall. Heights of land which separate rivers and river systems are known as divides.
The course of a river is divided into three parts - the upper, the middle and the lower course. These parts are seldom of equal length, and each is marked by distinctive characteristics. In the upper course the slope of the channel is steep and the current swift. The channel has been worn down rapidly and the banks have steep slope, sometimes being nearly perpendicular. The water carries quantities of sand and gravel and sometimes rocks of considerable weight, which are borne swiftly along by the current, constantly wearing away the bed of the stream. The swiftness of the current enables it to remove most of the obstacles in its course, and the channel is free from small curves. The channels of the tributaries are usually worn down to the level of the main channel, forming ravines.

The river enters upon its middle course when it leaves the mountainous or hilly region in which it rises, and enters the lower lands where the slope is more gentle. The current is not swift enough to carry the heavy material that it has brought down to this point, and this is deposited on the bottom of the channel. For this reason the beginning of the middle course of many rivers is marked by gravel beds. Since the channel is worn more slowly the slope of the banks is more gentle and the valley is broader. The current has lost much of its velocity and it cannot remove obstacles; therefore it must flow around them, and so the middle course is characterized by numerous curves, some of which may take the river miles out of the general direction of its flow. The middle course of the Mississippi affords an excellent illustration of this fact. Again, obstructions in the middle of the channel collect deposits of silt until finally they reach the surface and form islands. Islands in the upper part of the stream, on the other hand, consist of rocks which the current has been unable to wear away.
The lower course of a river differs but little from the middle course. The current is slower, and the continuous deposit of silt raises the bed of the stream. Frequent overflowing of the low banks forms vast flood plains which, when drained, make productive farms. In case of the Mississippi this process of raising the river bed has continued until the river is higher than the surrounding country, and disastrous floods follow a break in the banks.