vocal development, MAN neurons don't accumulate the male hormone testosterone very effectively. Toward the end of development, however, when the MAN region appears no longer needed for song learning, its nerve cells are full of testosterone.

"We see this as a very intriguing finding," says Bottjer. One possibility is that testosterone "causes certain neural circuits to become hardwired in the brain. And once those circuits are wired in, they seem to lose their capacity for forming new kinds of behavior." In particular, she posits that the increase of testosterone directs the MAN to send certain signals to another section of the brain, which permanently stores the bird's songs.

Another approach to learning about bird songs is to monitor the singing behavior of birds in the field. In the February The Condor and in upcoming issues of Animal Behavior, Stephen I. Rothstein at the University of California at Santa Barbara and Robert C. Fleischer at the University of Hawaii in Honolulu report on the "flight whistles" — songs that flying male birds use to communicate with males and females over long distances — of brown-headed cowbirds in the eastern Sierra Nevada.

The researchers found that groups of cowbirds separated by several kilometers have very distinct flight-whistle dialects. For example, the flight whistle of one group near Mammoth Lake in California contains three syllables, or continuous sounds, while a group to the south has a flight whistle made up of four syllables, three of which are identical to the whistle of its northern neighbors. Rothstein says there are dozens, if not hundreds, of dialects within a 300-kilometer band.

"Even though these flight-whistle dialects are only now being described," he says, "we feel that they're one of the most clear-cut examples of dialects in songbirds." Unlike other kinds of songs, flight whistles are simple and short, so researchers have little difficulty identifying different dialects.

"The big question in dialects, about which there's been a lot of controversy, is how they are maintained — what is making all the birds within one population converge to one type of vocalization," says Rothstein. He and Fleischer propose a new theory called "honest convergence," in which female cowbirds judge the suitability of a male caller by its whistle; males who do not know the proper dialect are either newcomers or yearlings, who are too young to mate.

Rothstein thinks the honest convergence theory is better than the three existing hypotheses because it is the only one that adequately explains how a large population of birds can maintain one dialect while still having a large amount of gene flow and exchange between dialect groups. *— S. Weisburd*

Energy for life among the waves

The thunderous crash of a large wave breaking on an ocean beach is a vivid reminder of the sizable amount of energy that such a wave dissipates. Although marine plants and animals can't harness this energy directly, it now appears that wave energy probably contributes in a variety of ways toward enhancing the productivity and diversity of organisms that live on wave-beaten shores between low and high tide.

"The intertidal zones of rocky weather coasts receive far more energy from the waves than from the sun," say Egbert G. Leigh Jr. of the Smithsonian Tropical Research Institute in Balboa, Panama, Robert T. Paine of the University of Washington in Seattle, and their colleagues. This abundant wave energy allows marine organisms in places such as the coast of Washington state "to maintain exceptionally high productivity," the researchers say. Their report appears in this month's Proceedings of the National Academy of Sciences.

The researchers base their conclusion on a detailed study of the quantity and type of organisms, such as algae, sea palms and mussels, produced at several exposed and sheltered sites around Tatoosh Island, off Washington state. They discovered that two species of algae that grow only on wave-beaten shores are the most productive algae at Tatoosh. Beds of these algae often produce twice the dry weight of organic matter generated by an equal area of rain forest. Even more surprising was the finding that some intertidal mussel beds are as fruitful (also measured as dry weight) as any plant community on earth.

"Animals and plants shouldn't be equally productive," says Paine. "This is a rather remarkable phenomenon that's not easily addressed without asking questions about the kinetic energy impinging on the shore."

The researchers list several possible reasons for the presence of lush, diverse plant and animal communities in turbulent water. They suggest that on exposed shores, the stirring action of breaking waves increases the capacity of resident algae to collect nutrients and use sunlight. Waves also protect intertidal inhabitants by knocking away their enemies or by preventing potential predators and grazers from feeding. Even devastating winter storms help by clearing away patches of old material to allow fresh, vigorous growth.

Wave energy, says Paine, "is an important contributor to the overall richness of this type of environment." Similar effects can be seen along other wave-battered shores or on the margins of coral reefs where waves pound hardest. *— I. Peterson*

Bound for the crown of Neptune

A decade ago, when Voyager 1 and 2 took off from Florida's Cape Canaveral, the official mission plan called only for both probes to fly close to Jupiter and Saturn. There was hope that Voyager 2 would then go on to Uranus in 1986, but the craft would have to survive more than twice as long to do so, and speculation about its lasting yet another three and a half years to reach Neptune produced even more cautious prognoses.

The Uranus encounter in 1986 was a ringing success, however, and the long-lived vehicle is looking ready and able for Neptune. So it was not concerns about the probe's longevity that prompted engineers last week to fire Voyager 2's rocket engine for a slight increase in speed hastening its Neptune arrival by 12 hours, on Aug. 24, 1989.

The reason was to improve the reception of the craft's radio messages from what is now the solar system's most distant known planet. It is a matter of getting to Neptune when the earth is turned as to allow the signals to be picked up from Australia, where one of the antennas of NASA's Deep Space Network has been electronically arrayed with the big dish of the Parkes Radio Astronomy Observatory, about 200 miles away. The result will be a larger, more sensitive antenna.

And when the Neptune "flyby" passes 3,100 miles from the cloud tops, Voyager 2 will be going about 16 times closer than it went to Uranus, 20 times closer than it went to Saturn and 55 times closer than Voyager 1's visit to Jupiter.

Voyager 2's trajectory past Neptune has been dubbed the "polar crown," approaching from the south, swooping up through the plane of the planet's equator and then bending back down over the North Pole on a path that will carry the probe about 25,000 miles from Neptune's big moon, Triton. One official called the maneuver the Neptune encounter's "holy grail."

But the quest for the grail has involved trying to be as sure as possible that it will not risk Voyager's life by sending the probe through material from the planet's rings, which have been detected only as incomplete "ring arcs" in earth-based occultation studies. Another concern has been possible danger from Neptunian trapped radiation belts, concern that prompted a special meeting of Voyager scientists on Jan. 16 to see if they felt that the polar crown would be a safe route. The group reached a favorable consensus after evaluating the possibility of hazardous radiation on the basis of last year's experience with Uranus. *— J. Eberhart*