per se—even though the only direct connection between the chicken and human populations was table scraps fed to the chickens. However, since the settlers brought little with them except their special living habits and customs, the problem could be the way they processed their food. Perhaps, the researchers reasoned, it was the result of a special recipe. They were right.

"It's called pickling, and it's a dish with chopped willow leaves, sweet potatoes chopped fine, sesame seeds, turnip greens, and maybe some spices," Miller said. "I'm not clear on this, but it seems the only processing they do is to boil the food for a while." The vegetables stay in large earthen pots for as long as six months, eventually developing a fungus.

The preparation of the dish makes it highly suspect. But there were nitrosamines in the food as well (a type of molecule that has recently been implicated in stomach cancer in the United States). A recent article in THE CHINESE MEDICAL JOURNAL said tests showed that a combination of the nitrosamines and the mold produced precancerous cells in chickens.

Chinese party members are working to upgrade water quality and improve food-drying techniques to quell molds—and are discouraging "pickle" eating. But they do not expect the rate of esophageal cancer to decline in the near future; like many other tumors, it can have a latency as long as 30 years. But by manipulating the chickens' diet, they hope to erase gullet cancer by trial and error soon, signalling an end to carcinogenic exposure and foretelling a time when human generations will be unafflicted.

Miller and other cancer researchers in this country are closely monitoring the Chinese progress, albeit informally, and are running further tests to determine the pickled foods' mutagenic properties. "Even though the United States has no cancer exactly like the Chinese strain, the opportunity they [the Chinese] have to isolate a natural cause of cancer may very well help us better understand the neoplastic process." □

Electricity and natural healing

The chemistry of the human body and the effects of chemical compounds on the body have been explored, but what of the electricity naturally present in the body and the effect of electrical currents applied externally to the body?

Insights into this largely unexplored area have surfaced in recent years. For instance, certain cells and tissues are electrical conductors (SN: 9/11/71, p.179); electric fields weaker than electroencephalogram readings may be intrinsic to the brain and may regulate nerve firing, which is both a chemical and electrical event (SN: 7/17/76, p. 41); and externally applied electrical currents can regenerate amphibian limbs, help heal human fractures and ulcers and even partially regenerate mammalian limbs (SN: 5/4/74, p. 287).

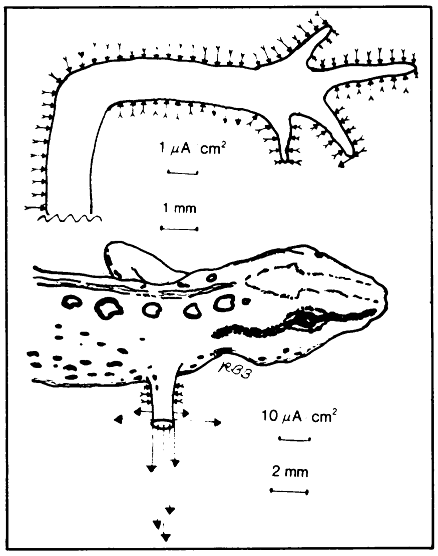
Now research reported in the October PROCEEDINGS OF THE NATIONAL ACADEMY OF SCIENCES shows that limb regeneration occurring naturally among amphibians is driven by electrical currents present in the animals' skin. These experiments also suggest that skin-driven electrical currents might promote natural healing or limb regeneration among vertebrates, including humans.

Recently, Richard B. Borgens, Joseph W. Vanable Jr. and Lionel F. Jaffe of Purdue University showed that, in the process of regenerating amphibians' limbs with external electrical currents, current must be pulled out of the stump in order to induce regeneration. Inward current actually induces degeneration. This suggested that electrical current present in amphibians' limbs might be involved in natural regeneration.

The researchers have now attempted to determine whether normally regenerating amphibian stumps generate

A

B



Borgens, Vanable, Jaffe/NAS

More current leaves stump than limbs.

ample-sized currents after amputation. (Research reported in 1941 had suggested that they do; two subsequent papers reported conflicting results.) They anesthetized red-spotted newts, then amputated the right forelimbs of the animals. Once the forelimbs started to regenerate, the biologists measured current entering or leaving the stumps. They did so with a newly available, ultrasensitive vibrating probe. The probe was also used to measure currents leaving or entering newts' intact forelimbs.

Specifically, they measured for current around intact forelimbs and found that current entered at almost all locations, but left regularly only at the base of the first digit and occasionally only at the fingertips (Fig. A). In contrast, far larger currents (50 times larger) were found to leave the recently amputated stumps than left the intact forelimbs, and current entering the stumps was much less than that entering intact forelimbs (Fig. B). Thus it appeared that large currents do escape from naturally regenerating amphibian limbs and might very well be the drive behind the regeneration. Borgens, Vanable and Jaffe also found that the peak current densities coming off stumps one week after amputation were very high, but that they dropped dramatically as the stumps showed development of new limbs.

With the role of electrical currents in limb regeneration fairly well established, the biologists began to search for the source of the currents. First they removed the motor and sensory nerves from newt limbs and amputated only some of the limbs. The denervated stumps generated larger currents than did the denervated intact limbs, suggesting that the regenerating currents were nerve independent. Next the researchers ran tests to see whether the regenerating currents were sodium dependent. When they increased the sodium concentration in the solution surrounding the newt stumps, current leaving the stumps always rose. When they lowered the sodium concentration, current leaving the stumps always declined. Thus, limb regeneration appeared to depend on sodium input. But where might the currents arise? The biologists thought they might come from the skin covering the stumps. Three different chemicals were used to keep sodium from entering the stumps. All three agents drastically reduced current escaping from the stumps, showing that the sodium-driven currents do arise in skin over the stumps.

But how could sodium-driven currents in the skin over a stump actually bring about regeneration of that stump? Recent cell research advances, the investigators believe, suggest an answer. The advances show that drops in current across a cell membrane can move certain molecules in the membrane. Sodium passing through the membranes of skin cells over a stump, the scientists believe, might well alter large molecules in the membranes of these cells as well as in the membranes of nerves penetrating the skin, thus promoting wound healing and limb regeneration.

All these experiments, the researchers conclude, present a good case for the role of electrical currents in natural amphibian limb regeneration. But the experiments raise an even more provocative question. Might there be skin-driven electrical currents that promote healing or even regeneration in other vertebrates, including humans? Yes, the investigators reply, pointing out that as far back as 1860 and 1910 there were reports of large currents leaving injured human skin.

"Our new results encourage reinvestigation of these old findings," Borgens, Vanable and Jaffe say, challenging fellow biologists. □