GENERAL SCIENCE

Unborn Guinea-Pigs Now Aid Study of Disease Resistance

Animals Before Birth Grow Less Susceptible to Infection; All React in Same Way as Their Parents

GUINEA-PIGS do not even wait to be born, now, before they go to work in the laboratory, as the living instruments of scientists in their unceasing search for the causes of human ills and means for their prevention and cure. At the University of Ohio a group of bacteriologists have been using unborn guinea-pigs and rabbits to gain better knowledge of how germs attack and how living cells and tissue defend. At the meeting of the National Academy of Sciences, their leaders, Drs. Oram C. Woolpert and N. Paul Hudson, described their research and outlined some of the preliminary results.

By a relatively simple surgical procedure, performed under anesthesia, the Ohio biologists introduced the causal organisms of tuberculosis, infantile paralysis, cowpox, and several other human diseases into unborn guinea-pigs and rabbits at various stages of development. After a number of days or weeks, they brought them into the world by means of cesarean operation, and studied the results.

Dr. Woolpert summed these up briefly, as answers to six questions:

Six Questions

(1) Are unborn animals generally susceptible to infection? "Yes. We have found that the effects of inoculation can be uniformly related to the specific infectious organism employed and that they are usually proportional to the concentration of the inoculum. In all instances the fetuses have proved as susceptible as adults of the same species and in many instances they have appeared definitely more susceptible." The only exception found was in the resistance of unborn rabbits and guinea-pigs to the virus of infantile paralysis; but this may be explained by the resistance shown by the adult animals as well.

(2) Why are unborn animals often more susceptible? To this question Dr. Woolpert did not make a categorical answer, but suggested, first, the considerably lower number of phagocytes or germ-killing cells in the blood of unborn and very young animals, second, the known susceptibility of all young and rapidly-growing tissues, and finally, the lack of any stimulus to build up resistance, such as is furnished to adult animals by the constant insidious attacks which they must as constantly throw off.

(3) Are younger fetuses more susceptible than older ones? "Certain of our experiments . . . lend support to the view that the more immature the fetus, the more susceptible it is. It is unlikely that any tissue is entirely without resistance to infection, but we suspect that resistance is minimal in the youngest embryos and that during fetal growth the potentialities of resistance gradually increase."

Same Reaction

(4) Are the reactions of unborn animals to infection attacks different in kind from those of the adult? They do not seem to be. Tubercles appeared in guinea-pig fetuses inoculated with tubercle bacilli, and in other ways the unborn animals reacted along the same patterns as their parents, the differences being quantitative rather than qualitative.

(5) What relationship is there between immunity in the mother and in her unborn young? "This probably depends very largely on the species of animal considered, as well as the fetal age. In certain animals, e.g., man and rodents, the placental tissue barrier between maternal and fetal circulations is more tenuous than in others, e.g. herbivora and carnivora. Also, as the placenta matures it becomes more permeable; thus the younger the embryo the more effectively it is isolated from maternal influences. Another reason thus presents itself for inferring that younger fetuses should prove more susceptible than older ones."

(6) Are bacteria and disease viruses changed in any way by having lived in fetal tissues? "The infectious agents which we used were not greatly modified by transfer through series of fetal animals, though there are minor exceptions to this statement."

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PHYSIOLOGY

Hearts Are Efficient; Stomachs Are Not

HEARTS are efficient machines. In fuel economy they are twice as efficient as modern steam or gasoline engines. A healthy mammalian heart can convert 20 per cent of the energy latent in its supply of food fuel into useful work. The best fuel efficiency of a steam engine is 10 or 11 per cent; under ordinary working conditions steam engines usually function at about 5 or 6 per cent. A good internal combustion engine realizes a fuel efficiency theoretically about as high as that of the heart—20 per cent or even better—but under usual working conditions its actual output also drops to about half its theoretical possibilities. But the good sound heart still keeps on pumping away at 20 per cent fuel efficiency.

The high mechanical efficiency of the heart was discussed by Prof. Maurice B. Visscher, of the University of Minnesota Medical School, before the National Academy of Sciences.

Prof. Visscher was able to isolate living hearts of laboratory animals in such a way that he could measure the oxygen going in and the carbon dioxide coming out. This gave him data on which the fuel consumption of the heart could be calculated.

Among other things, he discovered that in one type of failing heart, the effort was made to keep constant the amount of blood pumped by dilating more and more, thereby greatly reducing the mechanical efficiency. Doses of the standard heart remedy, digitalis, corrected this tendency by "tightening up" the heart muscle fibers as they grew slack. A heart undergoing this type of failure could suffer a loss of efficiency to a point as low as one per cent, as compared with the 20 per cent efficiency of the normal healthy heart.

Not Good Factories

The stomach and pancreas are not particularly efficient chemical factories, Prof. Martin E. Hanke of the University of Chicago informed the academicians. As measured by the amount of energy intake, the stomach is only about ten per cent efficient in producing hydrochloric acid used in digestion, and the pancreas has about the same rating in its production of pancreatic juice.

Thermostat Under Brain

There is a thermostat under the brain, that regulates body temperature. Experiments on monkeys demonstrating its existence were described to the Academy by Dr. S. W. Ranson of Northwestern University Medical School.

The temperature-regulating mechanism is in the hypothalamus, a group of structures on the under side of the brain, running back toward the base of the spinal cord; it includes, among other things, the pituitary gland, now famous as the "boss gland" of the body.

Cats and monkeys in which the hypothalamic region had been injured were used in the experiments. Those in which the injury was toward the front part of the region would heat up rapidly if placed in warm incubators, running temperatures as high as 103 to 105 degrees, without sweating. They seemed, however, to be able to bring their body warmth up if they were subjected to subnormal outside temperatures. However, when the injury was located toward the rear of the hypothalamus, the animals could not compensate for cold, and data thus far accumulated seem to indicate that they are also unable to protect themselves against heating. They have become in effect cold-blooded animals, like reptiles and fish.

Juvenile Sex Hormones

Grafting salamander tadpoles together to form artificial Siamese twins has proved the existence of juvenile sex hormones quite different from those of adulthood, Prof. Emil Witschi of the University of Iowa declared. When immature salamanders of opposite sex were thus grafted together, the ovaries of the female were first practically suppressed by the secretions introduced into her blood stream by the male. Later, male-like secondary sex characters appeared on her body, induced by the maturing male's adult glandular secretions.

"Grappling Bridge"

A typical four-legged animal, like a horse, is structurally a combination of bridge, steam shovel or dredge, and automobile, in the evolutionary analogy presented at the Academy's principal evening lecture by Prof. William K. Gregory of the American Museum of Natural History. The legs are the piers, the backbone a sort of cantilever arch, the neck is a crane, ending in the grab bucket of the mouth. Prof. Gregory coined the descriptive phrase, "self-moving grappling-bridge," to cover the whole situation.

As for man, he is physically a quadruped turned up on end. "A comparison of the skeleton of *Homo sapiens* with those of his nearest subhuman relatives shows that he has longer legs and shorter arms and that his cranium has become greatly inflated," Prof. Gregory said.

Surgical Mistake

Cutting a nerve to put the adrenal glands out of action, in cases of high blood pressure, is a major surgical mistake, Dr. J. M. Rogoff of the University of Chicago indicated. It does reduce the pressure, but it induces Addison's disease, a much worse ailment, which kills the patient off much more quickly.

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ASTRONOMY

"Nervous System" Guides Eye of a Telescope

WHILE biologists were discussing the mechanisms of life before the National Academy of Sciences, an almost-living electrical mechanism was being described by the two astronomers who are its creators, Drs. A. E. Whitford and G. E. Kron of the Washburn Observatory, University of Wisconsin.

Their device is designed to perform one of the most precise, exacting, and wearisome tasks that at present burdens some of the most skilled eyes, nerves, and fingers in the world—keeping great telescopes trained with split-hair's-breadth exactness on a star during the long hours required to make an astronomical photograph. At present, astronomers must sit by their instruments as a gunner sits by his cannon, keeping the sighting crossed hairs undeviatingly on the same tiny spot of light, while all the rolling world sleeps about them.

But with the automatic guider now under test in the Wisconsin observatory, all this precise and tedious labor is delegated to a photoelectric cell. The astronomer picks up a star that is to serve as guide. Its light is divided into two beams by a reflecting knife edge, and the two beams are made to shine alternately on the light-sensitive surface of the cell. If the star is not perfectly centered on the knife edge one beam will be brighter than the other and there will be a flickering intensity. Suitably amplified, this flicker controls a motor which makes the proper correction to center the star on the knife edge and reduce the flicker to zero.

Naturally, such an electromechanical system is almost unimaginably delicate and has offered its share of troubles. Said Dr. Whitford:

"The principal difficulty is the extremely small amount of light available to actuate the mechanism, so that the feeble impulse from a star must be amplified as much as a billion billion times (10 to the 18th power, or 1,000,000,000,000,000,000). This amplification is so great that the graininess of electricity is a serious limitation, that is, the original photoelectric current is not a steady stream but a procession of irregularly spaced electrons. The use of the new Zworykin electron multiplier has made it possible to extend the working limit somewhat beyond that attainable by conventional methods of amplification. The control is exercised entirely through electron tubes, without mechanical relays.

"The instrument is still in the experimental stage, but successful preliminary tests have been made on the 60-inch telescope of the Mount Wilson Observatory using stars down to the eighth magnitude. Artificial errors were introduced into the driving mechanism of the telescope, but the guider continuously corrected them and produced satisfactory star images."

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BIOLOGY

Biology and Engineering Attack Basic Food Problem

BIOLOGY and engineering have united both points of view and methods of attack, for efforts toward the eventual solution of the world's basic food problem—the problem of chlorophyll.

Chlorophyll is the green stuff in plant cells that captures the energy of sunlight and uses it to tie water and carbon dioxide together to form sugars and starches. It is a large-moleculed, complex substance, related chemically to the red hemoglobin of our own blood. Not very much is known, as yet, of how it works, or of how it is formed in the growing plant.

These and related problems are under attack in many laboratories. Among the most notable of research teams that have tackled chlorophyll is the group working at Antioch College, Ohio, on the Kettering Foun- (*Turn to page* 350)