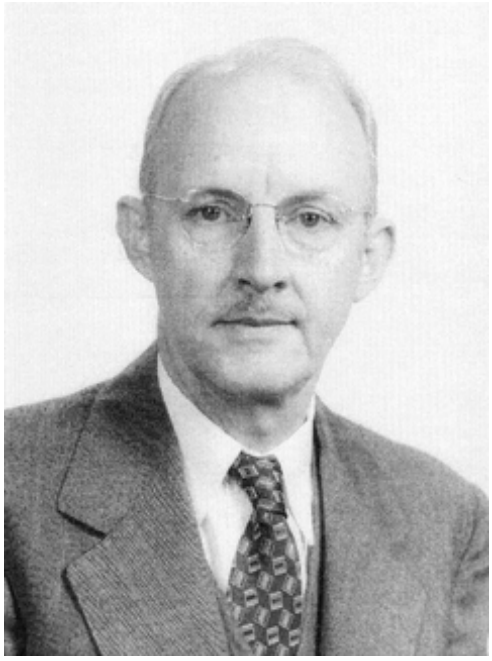

Robert Kyle Burns

July 26, 1896 — June 26, 1982

By James Murray

ROBERT KYLE BURNS was born in Hillsboro, West Virginia, on July 26, 1896, and died in Bridgewater, Virginia, on June 26, 1982. His long and productive scientific career was devoted to understanding the processes of sexual differentiation in vertebrates. He pioneered the experimental manipulation of sex hormones in order to establish their roles in sex determination and differentiation.

Although both his parents were Virginians, Burns' boyhood was spent in West Virginia, where his father was a blacksmith and mechanic, charged with keeping the mill of a local lumber company in running order. In 1906 the elder Burns was killed in an accident with a horse and buggy, and the rest of the family moved back to Virginia. Burns completed his high school studies in the public schools of Culpepper, Virginia. As the family then found itself in straitened circumstances, there was some question whether the young Burns would be able to continue his education beyond high school. Fortunately, his uncle, who lived in Bridgewater, Virginia, persuaded his mother to move there so that Burns could attend Bridgewater College as a day student, thereby reducing the expense. Thus began an association with the college that was to last a lifetime.

Burns had not intended to become a scientist. In both high school and college he was fascinated by history, and by the time he was a senior at Bridgewater he had completed his major in that subject. But, as so often happens, a stimulating teacher was responsible for changing the direction of his life. He enrolled in a course in general biology taught by Dr. Frank J. Wright, and as a direct result he began to think of a career as a professional biologist. A strange link in this chain of circumstances is that Wright was not himself primarily a biologist. He was a geologist who happened to be filling a gap in the curriculum, there having been no biology taught at Bridgewater before then.

Bridgewater must have recognized Burns' developing talent for biology since he was kept on after graduation as an instructor in biology. The First World War interrupted his career with a year and a half of military service as a private in the U.S. Marine Corps, no doubt giving him time to consider his future plans. In the end the pull of biology was irresistible, and he entered graduate school at Yale University in 1920 with a laboratory assistantship, receiving his Ph.D. degree in 1924.

These were exciting times to be starting work in developmental biology. Not long before, F. R. Lillie had created a sensation by successfully explaining the occurrence of freemartins in cattle. A freemartin is a genetically female individual that has the external genitalia and mammary glands of a female. However, its internal organs are intersexual, and it is always sterile. The gonads are rudimentary but show some testis-like characters. The freemartin is invariably the twin of an animal of opposite sex, and the two share a network of the placental blood vessels. Deducing that a bloodborne factor from the male must be altering the development of the female, Lillie elaborated his theory that hormones are responsible for sexual differentiation among vertebrates.

Since at that time the hormone theory rested only on observation, the stage was set for testing it experimentally. Burns began

trying to recreate the conditions that would produce the freemartin state. He chose to work with amphibians, more directly accessible to manipulation than mammals. By joining two embryos in parabiosis he was able to provide the first experimental evidence that hormones can alter the course of sexual development. Parabiotic pairs of embryos establish a common circulation before there is any sexual differentiation of the gonads, thereby exposing the gonads of pairs of opposite sex to a common hormonal environment. Although the earliest experiments gave variable results (1925), Burns demonstrated that it was possible to alter the female gonad in such pairs to an intersexual condition. Burns also pioneered the technique of transplanting gonads from younger larvae into older ones. In this case, if the younger gonad is of opposite sex to the host, it becomes intersexual (1928). A further set of experiments with salamanders of different species and sizes showed that parabiotic pairs tend to develop the sex of the larger species (1935).

During this period steady progress was being made in the isolation and characterization of the mammalian sex hormones, and Burns was not slow to apply to his work the results of these advances. He first used extracts of the mammalian hypophysis (1931,2; 1934) and then crystalline androgens and estrogens (1938,1; 1939,1) to test their effects on developing salamander larvae.

During this time Burns also turned his attention to the same kinds of questions in mammals, in which experiments designed by others to alter sexual differentiation had proved to be disappointing. Burns reasoned that the problem probably lay in the difficulty of intervening early enough in development. He therefore decided to work with the American opossum (*Didelphis marsupialis*) because of its very short gestation period (twelve and one-half to thirteen days) and the accessibility of the developing young in the maternal pouch.

Burns achieved immediate success in altering the development of the secondary sexual characters of both males and females. In 1939 he showed that the injection of female hormone into male pouch young caused them to retain the Müllerian ducts and to develop typical derivatives such as the oviduct, uterine tube, and vaginal canal. The prostate was suppressed and the genital tubercle reduced. On the other hand, treating female young with male hormone tended to inhibit development of the vaginal segment of the female reproductive tract and to cause the genital tubercle to develop into a penis (1939,1,3; 1942). These results were still disappointing, however, since they were not successful in stimulating the production of germ cells of the opposite sex in the developing gonads. It was therefore still possible to argue that the known hormones were not those responsible for normal development.

The key to the problem was discovered by Burns in a series of experiments in which males from one litter treated with estradiol in very low doses developed testes with a cortical zone similar to the cortex of developing ovaries. This litter appeared to have been born at stage 34 instead of the usual stage 35 and was therefore about twelve hours premature. Following up this result, Burns began to work with litters of the earliest possible stage and with very small doses of hormone. The results fully justified his hypothesis that the reason for the earlier failures was that treatments could not be begun early enough. He was able to produce genetic males in which the testes produced a persistent germinal epithelium, a well-developed cortex, primordial follicles, and growing oöcytes (1955,1). Thus he was able to establish the adequacy of the hormonal theory of sex determination as a general mechanism for vertebrates. For this work he was elected to the National Academy of Sciences in 1955.

In addition to being a gifted experimental scientist, Burns was a keen student of natural history. During his work on the effects of sex hormones in the opossum, he spent several spring seasons at the University of Florida's Conservation Reserve near Welaka, Florida. There he seized the opportunity to collect original data on food, movement, breeding season, gestation period, numbers of young born and reared, pouch life, and even the folklore of these animals (1956,1; 1957).

Burns not only was able to present his experimental results in a clear and lucid series of papers, but he also had a gift for writing succinct reviews, placing his work in the larger context of the field. His final paper (1961), on the role of hormones in the determination of sex, represents the state of the art at the culmination of his career.

Burns began teaching with an instructorship in zoology at the University of Cincinnati in 1924 and was promoted to assistant professor a year later. In 1928 he moved to the University of Rochester, first as assistant professor of anatomy (1928-30) and then as associate professor (1930-40). Much of his active research career was spent at the Carnegie Institution of Washington's Department of Embryology in Baltimore (1940-62). He also held an honorary professorship of zoology at Johns Hopkins University (1945-62).

On his retirement from the Carnegie Institution, Burns returned to his alma mater, Bridgewater College. He began teaching there in 1962 and continued until his second retirement in 1968, except for a short stint in 1965 as visiting professor of biology at the University of California, Santa Barbara.

During much of his active career Burns spent his summers at the Mountain Lake Biological Station of the University of Virginia, where I first met him and learned to appreciate his quick mind and generous nature. He began his work there with research in the summer of 1940 and taught courses in experimental embryology for several summers.

Burns took an active interest in the development of the Mountain Lake Station. He built a cottage for use during his lifetime, with reversion to the station at his death. Around it he planted an extensive wildflower garden that served not only as an aesthetic attraction but also as a botanical garden for teaching plant taxonomy and ecology. In 1966 he financed the construction of a lake at the station. With characteristic modesty he refused to let us announce his gift. Each year he spent many hours developing, maintaining, and signposting the trail network surrounding the station, a contribution to the station community that has benefited generations of students and researchers.

When he finally became unable to move to the station in the summer, Burns lived quietly in Bridgewater until his death in 1982.

In death as in life he preserved his modest bearing, directing that there should be no public notice of his death and no memorial service.

Burns was married to Emily Lucile Moore on June 21, 1924. There are three children from the marriage, Robert Kyle Burns, Jr., William Moore Burns, and John McLauren Burns.

IN THE PREPARATION OF this memoir I received generous help from John M. Burns, curator of lepidoptera at the National Museum of Natural History, and Harry G. M. Jopson, professor emeritus of Bridgewater College. I also was able to use an incomplete autobiographical account of Burns's early life and the files of the Mountain Lake Biological Station.

SELECTED BIBLIOGRAPHY

1925

The sex of parabiotic twins in Amphibia. *J. Exp. Zool.* 42:31-89.

1928

The transplantation of larval gonads in urodele amphibians. *Anat. Rec.* 39:177-91.

1930

The process of sex transformation in parabiotic Amblystoma. I. Transformation from female to male. *J. Exp. Zool.* 55:123-69.

1931

The process of sex transformation in parabiotic Amblystoma. II. Transformation from male to female. *J. Exp. Zool.* 60:339-87.

With A. Buyse. The effects of extracts of the mammalian hypophysis upon immature salamanders. *Anat. Rec.* 51:155-85.

1932

With A. Buyse. Effects of hypophysectomy on the reproductive system of salamanders. *Anat. Rec.* 51:333-59.

1933

With A. Buyse. The induction of precocious maturity in the reproductive tract of recently metamorphosed female salamanders, by an extract of the mammalian hypophysis. *Anat. Rec.* 58:37-53.

1934

With A. Buyse. The effect of an extract of the mammalian hypophysis upon the reproductive system of immature male salamanders after metamorphosis. *J. Exp. Zool.* 67:115-35.

1935

The process of sex transformation in parabiotic Amblystoma. III. Conversion of testis to ovary in heteroplastic pairs of A. tigrinum and A. punctatum. *Anat. Rec.* 63:101-29.

1938

The effects of crystalline sex hormones on sex differentiation in Amblystoma. I. Estrone. *Anat. Rec.* 71:447-67.

Hormonal control of sex differentiation. *Am. Nat.* 72:207-27.

1939

The effects of crystalline sex hormones on sex differentiation in Amblystoma. II. Testosterone propionate. *Anat. Rec.* 73:73-93.

The differentiation of sex in the opossum (*Didelphis virginiana*) and its modification by the male hormone testosterone propionate. *J. Morphol.* 65:79-119.

Sex differentiation during the early pouch stages of the opossum (*Didelphis virginiana*) and a comparison of the anatomical changes induced by the male and female sex hormones. *J. Morphol.* 65:497-547.

1941

The origin of the rete apparatus in the opossum. *Science* 94:142-44.

1942

Hormones and experimental modification of sex in the opossum. *Biol. Symp.* 9:125-46.

1945

Bisexual differentiation of the sex ducts in opossums as a result of treatment with androgen. *J. Exp. Zool.* 100:119-40.

1949

Hormones and the differentiation of sex. *Surv. Biol. Prog.* 1:233-66.

1950

Sex transformation in the opossum: Some new results and a retrospect. *Arch. Anat. Microsc. Morphol. Exp.* 39:467-81.

1955

Experimental reversal of sex in the gonads of the opossum *Didelphis virginiana*. *Proc. Natl. Acad. Sci. USA* 41:669-76.

Urogenital system. In *Analysis of Development,* eds. B. H. Willier, P. A. Weiss, and V. Hamburger, pp. 462-91. Philadelphia: W. B. Saunders.

1956

With L. M. Burns. Vie et reproduction de l'opossum américain *Didelphis marsupialis virginiana* Kerr. *Bull. Soc. Zool. Fr.* 81:230-46.

Transformation du testicule embryonnaire de l'opossum en ovotestis ou en "ovaire" sous l'action de l'hormone femelle, le dipropionate d'oestradiol. *Arch. Anat. Microsc. Morphol. Exp.* 45:173-202.

1957

With L. M. Burns. Observations on the breeding of the American opossum in Florida. *Rev.*

Suisse Zool. 64:595-605.

1961

Role of hormones in the differentiation of sex. In *Sex and Internal Secretions*, 3rd ed., ed. W. C. Young, pp. 76-158. Baltimore: Williams and Wilkins.