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RESEARCH IN LABORATORY ASTROPHYSICS WITH UNDERGRADUATES: 11 YEAR REPORT[1]

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Abstract

A briet description is given of the white-dwarf, cool main-sequence, and other stages of a small-college undergraduate research program. Four observations are given relevant to the administration and value of such a program. A fifth observation is submitted to the effect that government funding of small-college research should continue in view of the "mopping-up" function which it is suited to fulfill.

The reader may be aware of the currently accepted picture of stellar evolution. In a nutshell this is it: The cool supergiant stage forms first. As time passes it becomes a hot main-sequence star. Then it progresses "down" the main sequence, becoming cooler. Finally it jumps rather discontinuously to the white dwarf stage.

The physics department of SMC has carried on a research program in spectroscopy for eleven years. Two distinct phases are past, and a third is in formation. Results startlingly suggest the reverse of the hypothetical stellar history. During the white-hot dwarf stage home-made equipment was developed on which very crude measurements were made on the simplest of arcs to obtain relative atomic oscillartor strengths whose precision was something like ±40%. Figure 1 shows the optical bench input to our home-made Paschen spectrograph, including slit, chopper, lens, water-cooled titanium arc, and (phased in with mirror) standard lamp. Figure 2 shows the focal curve of the Paschen spectrograph, along which a scanning photocell was driven by a clock motor. Figure 3 shows the adjacent room again, but this time the readout equipment can be seen. All material was obtained from surplus supplies.

For the white-hot dwarf stage there was eager proposal-writing, and funding in 4-figure amounts during that half of the period which was in the space age. The total period covered in this stage was 1956-1960. The work was done by myself and interested students, who were occasionally paid.

For the cool main-sequence stage modern scientific apparatus was available yielding medium precision results concerning light from an interesting, but as yet untamed, excitation source — the seeded plasmajet. A variety of techniques have been used, and in some cases improved upon, for spectroscopic plasma diagnostics on an absolute number basis. For instance, electron number densities in the 10^{16} cm^{-3} region, as a function of radius, have been found using three totally different diagnostic techniques, and the curves differ by a factor of two, at most. Figure 4 shows the Ebert spectrograph and associated equipment, for much of which we express thanks to the National Science Foundation. The plasmajet is at the source position. Figure 5 shows the plasmajet seeding glassware which allows aspirating interesting metals, such as manganese, in liquid solution, into the inert carrier gas. The cool main sequence stage was funded in 5-figure amounts at comfortable 3-year intervals. The total period covered by this stage was 1961 to the present. The work was done by three staff members (two of whom were present for part of the period only), by a MS candidate from Vanderbilt University, and by many students, several of whom were on assistantships.

A hotter main-sequence stage is now contemplated. The cool super-giant stage is viewed as an infinitely remote, and possibly undesirable, eventuality.

My first observation concerns the undergraduate majors in this regime. The generation of great enthusiasm during the construction or installation of scientific apparatus is common. Maintenance of interest during extensive data collection is more difficult, but can be achieved by rotation of tasks. Retention of loyalty during prolonged data reduction is almost impossible except for the justifiable challenge of digesting the results into a form suitable for presentation at a society (or section) meeting, or for publication. But, in the cool-main-sequence stage, where we are now, I postulate that it is not wise to try to do more than one of these and it is suicidal to do all three at once. This observation, or postulate, leads to the second point.

My second observation is that a small department cannot carry on a significant cool main-sequence research program concurrent with any other major effort, such as management of a radio station, or extensive recruiting at secondary schools. The small department cannot carry on more than one significant research program.

The second observation implies a third one. If a small department has the choice of hiring a person with a doctoral degree or one with a master's degree of otherwise equal qualifications, it is occasionally possible that the one with the master's degree should be selected. A person with a doctorate is characteristically more independent in his research interests and would be much more likely to insist upon adding another research program than to participate enthusiastically in an existing program.

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[1] Paper C9, American Association of Physics Teachers, January 30, 1967, New York City.

Our fourth observation concerns the investment of staff time necessary to carry on an active research effort. Approximate tallies have been made on occasions during the first two stages. During the white-hot dwarf stage, it was found that the number of staff clock hours (planning ahead, explanations, and checking) was equal to the number of student clock hours. During the cool main-sequence stage, the time steadily decreased to approximately 75% of the number of student clock hours.

My fifth observation concerns the present national debate on research support for projects in small colleges. On the one hand, it has been widely felt that as far as news-making research is concerned, small colleges do not exist. Their work is simply too slow; it takes them too long, even at best, to execute the research. The conclusion is sometimes drawn that the only function of research in small departments it to train students as if they were in a particularly advanced laboratory course. It is inferred that any support should come from agencies, or sections of agencies, entirely concerned with science education. On the other hand, work done by small staffs can be of quality and precision. The results can be of value to science by mopping-up behind the lines rather than by making news-making advances. As far as mopping-up is concerned, I postulate that a small department can do it cheaper than can a large research center. It follows that, in my opinion, research support for such work should not be relegated as if it were a mere educational experience.

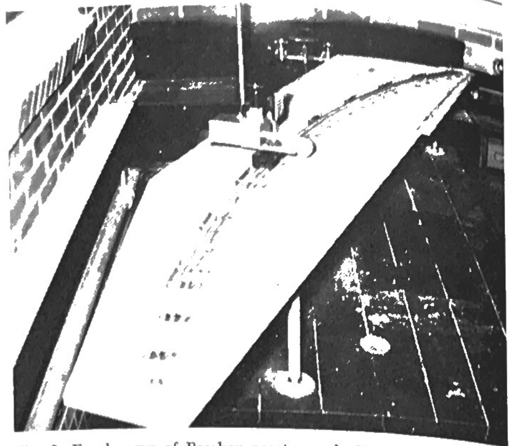

Fig. 2. Focal curve of Paschen spectrograph. The exit slit, photomultiplier, and preamplifier are mounted on a model railroad car chassis.

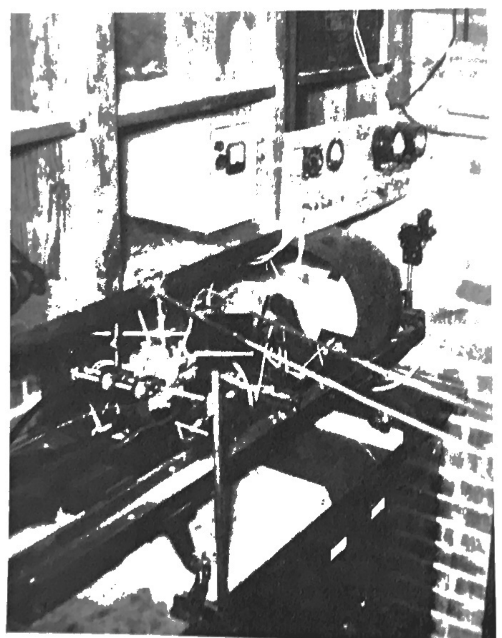

Fig. 1. Input optical bench for Paschen spectrograph, entrance slit of which is against brick wall.

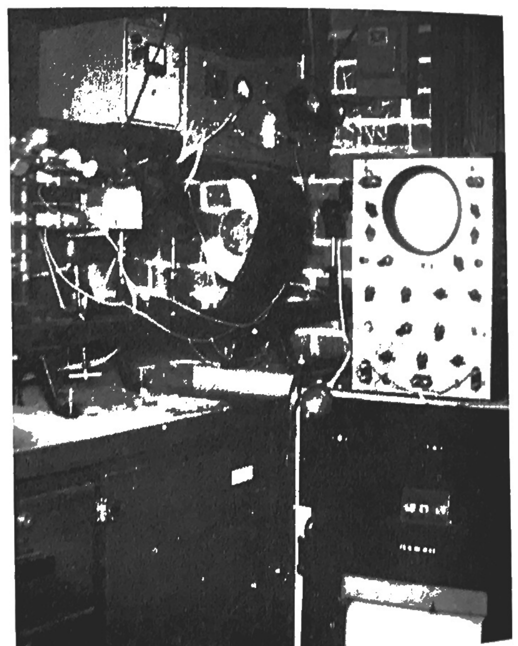

Fig. 3. War-surplus recorder to plot ratio of signals from scanning photomultiplier (Fig. 2) and from stationary photomultiplier monitoring source light output. With the equipment seen in Figs. 1 to 3, measurements of oscillator strengths of iron and titanium were made.

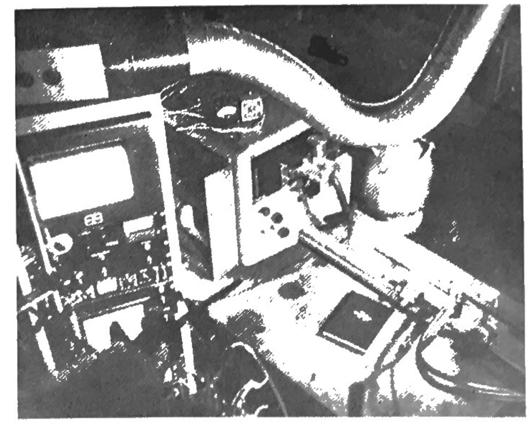

Fig 4. Ebert spectrograph on which undergraduates have measured oscillator strengths of manganese and have studied plasma produced by the plasmajet at lower right.

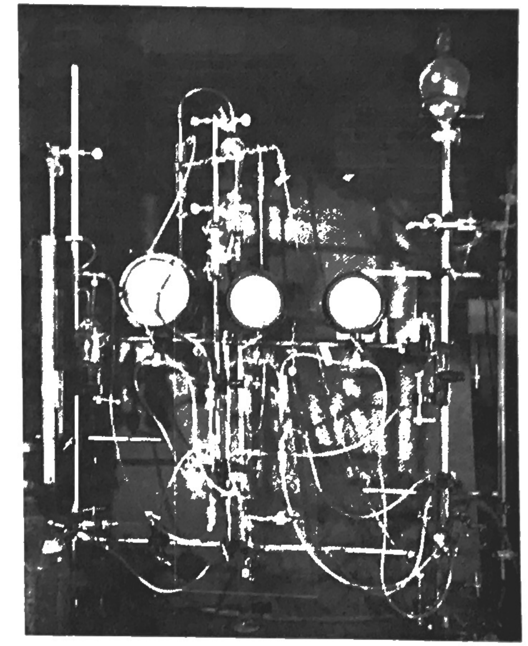

Fig. 5. Seeding system to aspirate solutions into carrier gas of the plasmajet. This system was built by an undergraduate physics student.

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PROCOTYLA FLUVIATILIS, A WHITE PLANARIAN FROM WESTERN TENNESSEE

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Abstract

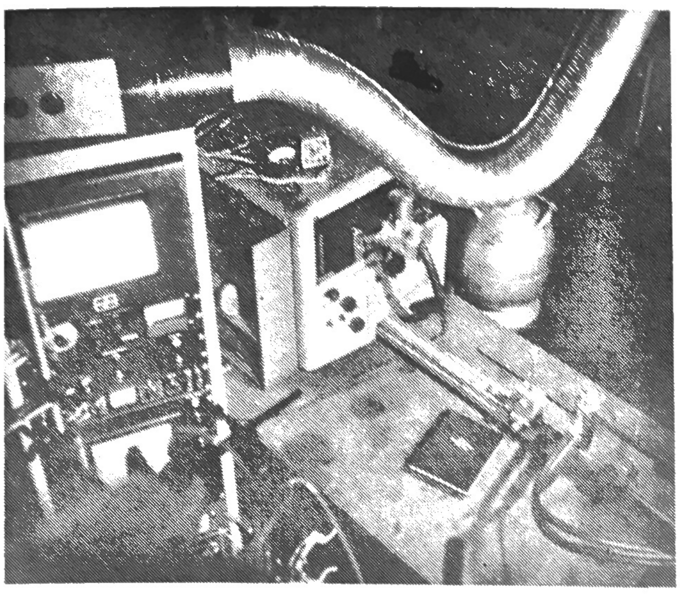
The occurrence of *Procotyla fluviatilis* (Platyhelminthes, Turbellaria, Dendrocoelidae) in western Tennessee is reported for the first time. Salient morphological features of the species and some aspects of its locale and ecology are described. A listing of other freshwater planarians collected from western Tennessee is given.

The literature contains few accounts of freshwater planarians (Turbellaria, Tricladida, Paludicola) from western Tennessee. Bolen (1938) reported three species of the family Planariidae from the Reelfoot Lake region: *Cura foremani* (Girard) 1852 *(Curtisia foremanii* =), *Dugesia tigrina* (Girard) 1850 *(Euplanaria tigrina* =), and *Phagocata gracilis gracilis* (Haldeman) 1840 *(Phagocata gracilis* =). Horne and Darlington (1967) investigated digestion in specimens of *P. g. gracilis* collected from springs in Shelby Forest, north of Memphis. I have collected or received planarians of all these species from western Tennessee and have identified *Procotyla fluviatilis* Leidy (1857), a species of the family Dendrocoelidae heretofore unreported from this area (Table 1). The morphology, taxonomy and distribution of *Procotyla fluviatilis* were described by Hyman (1928, 1959) and Kenk (1944), neither of whom reported the species from Tennessee.

Table I

Collections of Planarians from Western Tennessee

Species	*Collection Sites*
Cura foremani	Carroll County, Everett's Spring
	McNairy County, Coon Creek



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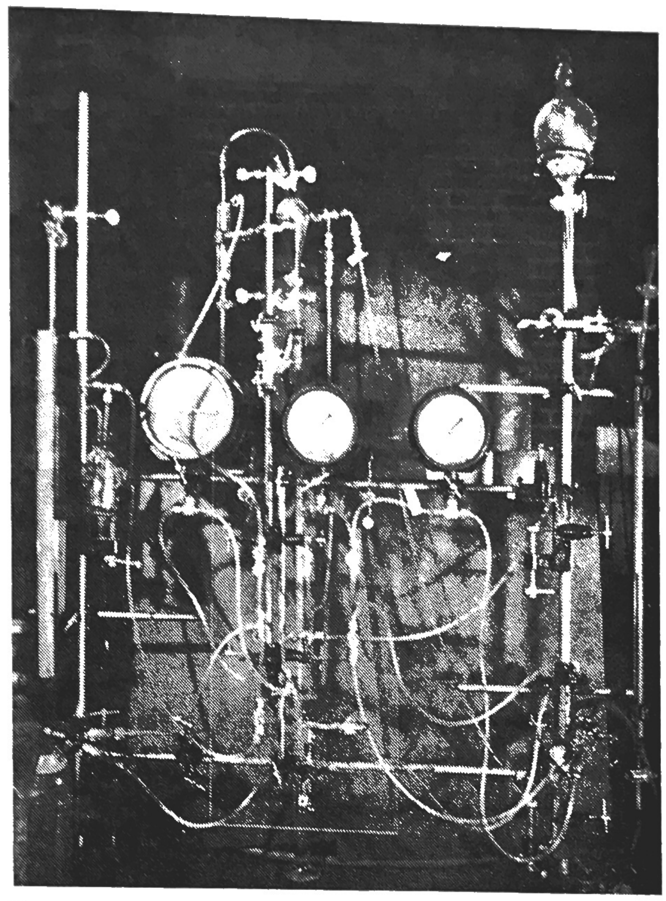

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ABSTRACT

The occurrence of *Procotyla fluviatilis* (Platyhelminthes, Turbellaria, Dendrocoelidae) in western Tennessee is reported for the first time. Salient morphological features of the species and some aspects of its locale and ecology are described. A listing of other freshwater planarians collected from western Tennessee is given.

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Species	Collection Sites
Dugesia tigrina	Benton County, Tenn. River (Ky. Lake)
	Carroll County, Clear Lake
	Carroll County, Everett's Lake
	Henry County, Big Sandy River (Ky. Lake)
	Lake County, Reelfoot Lake
Phagocata gracilis gracilis	Decatur County, near Scott's Hill
	Weakley County, spring off state road 22
Procotyla fluviatilis	Carroll County, Everett's Spring

One of my collections of *Procotyla fluviatilis* consisted of 17 specimens that ranged from 5 to 15 mm in length when fully expanded. They were milky white with the digestive tract variably pigmented. A distinct adhesive organ was observed at the anterior end of each specimen except on the shortest individual. Supernumerary eyes were present in 4 planarians and all but the shortest and another specimen clearly exhibited the region of the penial bulb posterior to the pharynx (Fig. 1). Four of the larger specimens were fixed in Zenker's fluid and serial sagittal sections were stained with Mallory's triple stain in order to obtain positive identification. The chief diagnostic characteristics of the species were confirmed: large penial bulb composed of longitudinal muscle fibers; mucous core in the lumen of the penial bulb; and weak elongated penial papilla (Fig. 2).

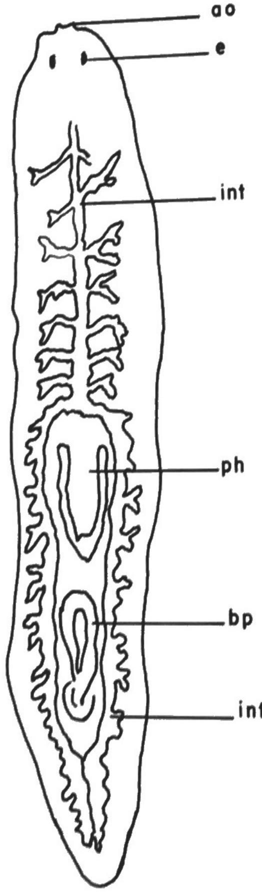

Fig. 1. Specimen of *Procotyla fluviatilis* drawn with bioscope from a whole mount stained with Mayer's carmalum. ao, adhesive organ; bp, penial bulb; e, eye; int, intestine; ph, pharynx.

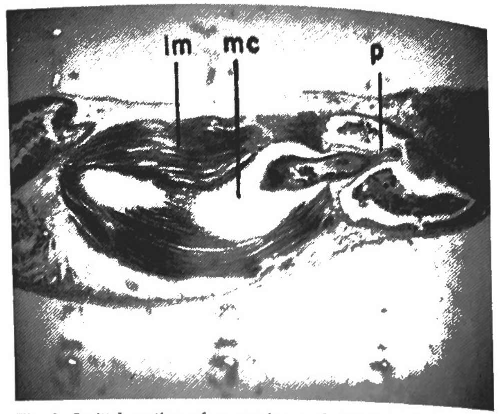

Fig. 2. Sagittal section of a specimen of *Procotyla fluviatilis*. lm, longitudinal muscle fibers of penial bulb; mc, mucous core of penial bulb; p, penial papilla.

All collections were made from a relatively large population of *Procotyla fluviatilis* in Everett's Spring. The locality is a small seepage spring situated in a ravine adjacent to Everett's Lake on the east side of state road 22 about 0.7 mi. from McKenzie, south of the junction of state road 22 and U. S. highway 79. The spring-fed area is boggy and heavily shaded. The water is shallow (3 to 4 inches deep) and filled with decomposing leaves, bark and tree branches, many of which have numerous planarians on the undersurface. The substrate is composed of sand and silt. On 17 May 1967 water temperature varied from 14C to 16C and pH was 5.4 as tested with a Helige comparator. Individuals of *Procotyla fluviatilis* seem most abundant near the spring source. About 50 ft. from the source *Cura foremani* occurs in association with *P. fluviatilis* on the same leaf or branch. Capsules, or cocoons, of *Procotyla fluviatilis* were found adhering to the undersurface of leaves and bark. The capsules were spherical, each about 1 mm in diameter, reddish brown and without markings or stalks (capsules of *C. foremani* are stalked). Several capsules were held in the laboratory at 10C for several days but none ruptured to produce juveniles.

Specimens of *Procotyla fluviatilis* in the laboratory were fed living isopods (*Asellus*) and amphipods (*Crangonyx*) from Everett's Spring. The planarians usually attacked these crustaceans with surprising speed and adeptness. Each worm used its anterior end to contact the crustacean, wrapped its body around the prey and commenced to suck the soft parts of its victim with the pharynx. Many planarian species, *e.g.*, *C. foremani* and *P. g. gracilis*, feed readily upon liver and other vertebrate organs which they apparently sense with chemoreceptors of the auricular sense organs (Hyman 1951). My specimens of *Procotyla fluviatilis* were insensitive to the usual fare, although they were starved previously. They apparently have a poor chemical sense for diffusing food juices but require a mechanical vibratory stimulus such as that produced by a swimming amphipod. Dr. Roman Kenk of the Smithsonian Institution once demonstrated to me the quickness with which a specimen of *Procotyla fluviatilis* seizes a dissecting needle that is being tapped rapidly on its point in proximity to a worm.

Acknowledgments

Mr. Stanley Stuart of Bethel College prepared the whole mount from which Fig. 1 was drawn, and Mr. R. H. Boyd of Preiser Scientific Company photographed the sagittal section from which Fig. 2 was printed.

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A REDESCRIPTION OF SPHAERIROSTRIS TERES (WESTRUMB, 1821) (ACANTHOCEPHALA) FROM CROWS OF EGYPT[1,2]

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Acanthocephala were collected from crows, *Corvus corax* and *Corvus corone*, in Egypt by parasitologists of the United States Naval Medical Research Unit No. 3 under the direction of Dr. Robert E. Kuntz. They have been identified as *Sphaerirostris teres* (Westrumb 1821). Golvan (1956) redescribed this species and listed the following species as synonyms: *Echinorhynchus picae* Rudolphi, 1819; *E. teres* Westrumb, 1821; *E. hepaticus* Molin, 1858 and 1861; *E. lobianchii* Monticelli, 1887; and *Sphaerirostris picae* Dollfus, 1953. The present study, which is based on measurements of approximately 160 specimens, extends the range of measurements and contributes additional morphological details to previous descriptions of this species. The following description of specimens from Egypt is based on stained whole mounts; all measurements are given in millimeters, except when stated otherwise.

Sphaerirostris teres (Westrumb, 1821)

Male (Fig. 1): body length 12.9 (5-18); maximum body width 1.8 (1.0-3.2). Proboscis length 0.63 (0.52-0.81); maximum width 0.38 (0.31-0.47). Proboscis hooks (Fig. 2) in 32 (26-36) longitudinal rows; number of hooks per row 12 (11-15). The anterior 5 hooks have posteriorly directed roots; the 6th hook has both a posterior root and a small anteriorly directed manubrium; the next 3 to 6 hooks have anteriorly directed manubria; the last 2 to 4 spines have no roots or manubria. Length of longest hook 34μ (28-44μ). Proboscis sheath length 1.12 (0.78-2.06); width 0.32 (0.26-0.48). Lemnisci length 2.38 (1.15-3.64); width 0.18 (0.09-0.39). Testes located anteriorly in tandem; anterior testis length 1.47 (0.63-2.08); width 0.69 (0.39-0.99); posterior testis length 1.43 (0.61-2.21); width 0.72 (0.42-0.99). Four elongate cement glands; length 4.4 (2.0-7.0); width 0.12 (0.09-0.39).

Female: Body length 14.6 (7-20); maximum body width 2.3 (1.0-3.0). Proboscis length 0.69 (0.42-0.98); maximum width 0.41 (0.21-0.51). Proboscis hooks in 32 (24-36) longitudinal rows; number of hooks per row 12 (11-16). Arrangement of hooks with roots and manubria same as for male. Length of longest hook 37μ (28-47μ). Proboscis sheath length 1.18 (0.96-1.40); width 0.36 (0.15-0.52). Lemnisci length 2.93 (2.50-3.90); width 0.21 (0.10-0.49). Eggs (Fig. 2d) elliptical and enclosed in 2 membranes, length 50μ (32-63μ); width 22μ (18-26μ).

Hosts: *Corvus corax* (raven) and *Corvus corone* (hooded crow)

1. From a thesis submitted to the Graduate Council of the University of Tennessee in partial fulfillment of the requirements for the degree of Master of Science.

2. Supported in part with aid provided by Contract ONR (NR 103-690/N0014-66-C0094) between the Office of Naval Research and the Southwest Foundation for Research and Education.