Table 3. Background fluxes.

Diffuse x-ray (1 to 10Å)
7.9 count cm^{-2} sec^{-1} $steradian^{-1}$
9×10^{-8} erg cm^{-2} sec^{-1} $steradian^{-1}$ (synchroton $\alpha = 1$)
Integral of radio galaxies (100 to 10^4 mc sec^{-1})
1.5×10^{-9} erg cm^{-2} sec^{-1} $steradian^{-1}$
Ratio of x-ray flux to radio flux
60

With the synchrotron hypothesis, however, it became necessary to explain how the billion-volt electrons, needed to produce the radio emission, were accelerated and to account for the total energy contained in electrons and magnetic fields. Because the synchrotron process is inefficient, the total energy content must be in excess of 10^{60} erg, and perhaps as great as 10^{62} erg.

In the thermonuclear burning of stars, the efficiency of conversion of mass to energy is of the order of 1 percent, and the burning of 1 sun produces about 10^{52} erg. It would, therefore, take the nuclear conversion of 10^{10} suns, or the entire mass of a medium-sized galaxy, to produce the energy content of Cyg A. Attempts to explain the energy in terms of gravitational collapse of a superstar have thus far failed. The present x-ray observation, which indicates that x-ray emission is more than an order of magnitude greater than radio plus optical emission, correspondingly increases the difficulty of explaining the total content of radio galaxies.

M-87 (Virgo A) is an elliptical galaxy, one of the brightest in the Virgo cluster, at a distance of 11 megaparsecs. It is about 5 minutes of arc in angular size, and the brightness is highly concentrated toward the center. Its total mass may be about 10^{12} solar masses, 10 times the mass of our galaxy. A luminous jet, 20 seconds long (about 1000 parsecs) bursts from its center, and its light is highly polarized. It provided Shklovsky (*5*) with the first evidence for the role of synchrotron radiation in radio galaxies. The radio power of M-87 is about 1000 times weaker than that of Cyg A, but it ranks immediately behind Cyg A and Cen A in flux received at the earth.

The detection of x-rays from the direction of Cas A provides evidence for a second supernova x-ray source in addition to the previously identified Crab Nebula. Cas A is believed to be a Type II supernova, whereas the Crab is Type I. It is estimated from the expansion velocity that the supernova explosion took place in the year 1702, ± 14. Taking the distance to Cas A as 3.4 kiloparsecs, its x-ray power is about equal to that of the Crab.

Several weaker sources were discovered in the April 1965 survey, and it is clear that many more are indicated by signals near the 2-σ background level. A modest increase in sensitivity and resolution should suffice to reveal these sources clearly. The great majority of x-ray sources are still unidentified with optical or radio objects, and the identifications proposed here for Cyg A, Cas A, and M-87 should be accepted with some caution because of the 1.5-deg uncertainty in positions. However, the circumstantial evidence for these identifications is strong. In the history of radio astronomy, Cyg A was the first discrete source detected; the Crab was the first radio source identified with an optical object; and M-87 was the first radio source identified with an optical galaxy. Cas A is the brightest radio source in the sky. It seems more than fortuitous that the first x-ray sources that can be associated with radio sources, within the present uncertainty of the observations, should fit four of the most spectacular radio sources. At the same time, the large number of x-ray sources that do not fit radio supernova remnants or radio galaxies implies the existence of a new type of celestial object observable only in the x-ray spectrum.

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Polymorphism in Pleistocene Land Snails

Abstract. *Under suitable conditions the colors and patterns of the shells of land snails may be preserved for thousands of years. In a late Pleistocene population of* Limicolaria martensiana *all the major color forms that occur in modern living snails may be distinguished, and the basic polymorphism is at least 8,000 to 10,000 year old.*

Under favorable conditions the colors and patterns of the shells of land snails may be preserved for thousands of years. When the species is polymorphic for shell color and pattern it may be possible to establish how long the polymorphism has persisted and if any evolutionary changes have occurred.

The African land snail, genus *Limicolaria* (Achatinidae), contains a number of species that exhibit conspicuous polymorphism in shell color and pattern. In Uganda one species, *L. martensiana* (*1*), forms well-defined populations, each with a characteristic frequency of the polymorphic forms: Adjacent populations separated by no more than a few meters may differ significantly in the frequency of the forms, provided there is sufficient ecological isolation between them (*2*). The polymorphism, which involves the presence or complete or partial absence of dark streaking and the presence or absence of pigment in the columella, may be detected in late Pleistocene shells. In an earlier report (*3*) the frequencies of streaked and unstreaked fossils were given; these fossils, which are not particularly well-preserved with regard to color and pattern, were obtained from the Kichwamba escarpment and from Equator Road in the Western Rift of Uganda, in areas covered by ash from the Katwe volcanic explosions, estimated to have occurred 8,000 to 10,000 years ago (*4*).

A new fossil site has now been found in Western Uganda; here the colors of the shells are much better preserved and the polymorphic forms can be recognized with greater accuracy. The new site is on Kabazimu Island in northern Lake Edward in the Western Rift. The shells have been washed by floods into a paleosol which is overlaid by a varying thickness (20 to 300 cm) of volcanic ash deposited

Table 1. Frequency of color forms (percent) in a fossil population of *Limicolaria martensiana*, and a comparison with living populations. Streaked and pallids 1 to 3 have been figured and described (*2*). Broken-streaked resembles streaked, but throughout the length of the shell there is a pallid band breaking up the streaks. The ground color of the shells of living snails varies from pale yellow to deep orange and the streaks (where present) are dark brown. The ground color of fossil snails is white and the dark brown markings are faded to pale brown. Kayanja is 11 km from Kabazimu Island, Ishasha Road 16 km, and Rwenshama 30 km. *N*, number.

Color form	Fossil	Living		
	Kabazimu Island (N= 1277)	Kayanja (N= 2840)	Ishasha Road (N= 882)	Rwenshama (N= 841)
Streaked	61.0	54.6	40.6	33.7
Broken-streaked	5.2	8.9	4.2	9.8
Pallid 1	3.9	24.0	7.0	1.9
Pallid 2	28.3	11.9	43.2	37.3
Pallid 3	1.6	0.6	5.0	17.3

from the Katwe explosions. The shells are therefore of the same age as those described from Kichwamba and Equator Road (*3*). They are in large concentrations in the paleosol, and a sample of 1277 was collected and classified into color forms (Table 1).

All the major color forms known from *L. martensiana* occur in the Kabazimu Island fossils and, as in most living populations, the streaked form is the most frequent. Twenty-four living populations of *L. martensiana* were sampled from the same general area of the Western Rift (there are no living snails on Kabazimu Island itself), but only three of these populations resemble the fossil one in the presence of all major color forms, and, in particular, in the presence of broken-streaked, which is an exceedingly local form throughout the range of *L. martensiana* in Uganda. As shown in Table 1, there are differences in the frequencies of the forms between those of Kabazimu Island and the three living populations, and also among the three living populations themselves. Such differences are a feature of polymorphism in *L. martensiana*, and because of them it is not possible to demonstrate evolutionary changes on the basis of past and present frequencies. On the other hand the Kabazimu Island fossils show that five forms of *L. martensiana* are at least 8,000 to 10,000 years old; the fossils do not contain forms that no longer exist. Evolutionary trends in the past 8,000 to 10,000 years have undoubtedly been in repeated adjustment of the frequencies of the forms to local conditions with occasional extermination or spread of a form into a new population and with periods of relative stability.

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References and Notes

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Analysis of Complex Vascular Systems in Plants: Optical Shuttle Method

Abstract. *The "optical shuttle" is an improved method of photographing with a motion-picture camera, one by one, sequential sections mounted on separate slides. The optical output from two microscopes is combined so that the images can be focused on a single film plane. Slides are photographed alternately through the microscopes. Simultaneous viewing of two successive sections in the microscopes enables initial precise alignment of images. Complex anatomical structures can thus be analyzed with relative ease.*

Recently we have shown that, by photographing with a motion-picture camera, frame by frame, subsequently cut surfaces or serial microtome sections of palm stems, it is possible to analyze a vascular system of far greater complexity than is possible with serial sections alone or with serial photographic records. The method has been used to analyze in quantitative detail the course of vascular bundles in the stem of a small palm, *Rhapis excelsa* (Thunb.) Henry (*1*).

The original apparatus (Fig. 1) incorporates a drawing tube (camera lucida) into the microscope-camera system (*2*). An outline sketch of the section, on a fixed piece of paper, serves to orient in turn a number of succeeding sections in the sequential series so that a fixed point successively occupies the same position in each frame of the film. New drawings have to be made at intervals as alignment gradually deteriorates. Drawings, which include coordinates of photographed positions at regular intervals, are filed as useful references, but essentially all information is "stored" in the film and "retrieved" later by projecting the film in a photo-data analyzer. Films run at 16 to 24 frames per second and can be used to demonstrate essential features to large audiences (*3*); their application in teaching is obvious.

The most critical operation is precise alignment of each succeeding section in the microscope. If each section is mounted on a separate microslide, as is easy with freehand sections of large woody objects cut on a sliding microtome, alignment at the film plane can be accomplished with an "optical shuttle" system. Light output of the two microscopes used is combined by means of a discussion tube in an inverted position (Fig. 2). In its intended use the discussion tube is mounted above a single microscope and divides the optical output so that two observers can simultaneously view and discuss a microscopic preparation. In the inverted position special adapters are necessary so that the male-male and female-female fittings can be joined (*4*).

Successive sections are photographed alternately through each microscope. After selection and photography of one slide by way of one microscope (the other has its light source cut off simply by interposition of a piece of card below the condenser), the next section on the stage of the second microscope is aligned by superimposing its image over that of the first, both images being viewed through the binocular eyepiece. This section in turn, after being photographed, is used to align the third slide in the series, and so on.

Alignment of images may appear to be difficult during the first trials, but with some practice one learns to work quickly. Relative light intensities in the two microscopes can be varied with one of the condenser diaphragms as an aid to the alignment. Photography