vide a way of determining the accelerating field experienced by the jets.

Observation of the γ-rays from SS 433 has apparently allowed us to observe the occurrence of some of the fusion processes normally occurring only in the stellar interior. These same data might also provide extremely detailed information about some of the properties of that stellar system. Whether the existing data are good enough for such inferences or not, this one experiment certainly gives strong impetus for further high-spectral-resolution γ-ray astronomy experiments, both to refine our understanding of SS 433 and to search for other stellar objects from which similarly detailed information could be obtained. Systems from which γ-rays of well-defined energies might be emitted would certainly include objects known to have both jets and x-ray emission, such as the quasar 3C273, the peculiar galaxy M87, and the galactic x-ray source G109.1-1.0.

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19 March 1984; accepted 16 May 1984

A New Ribosome Structure

Abstract. *Ribosomes derived from the sulfur-dependent archaebacteria are structurally distinct from those types found in ribosomes from eubacteria, eukaryotes, and other archaebacteria. All four ribosome types share a common structural core, but each type also has additional independent structural features. In the smaller subunit derived from sulfur-dependent archaebacteria ("eocytes"), lobes, similar to those found at the base of the eukaryotic small subunits, and an archaebacterial bill, similar to those found on the smaller subunit of archaebacteria and eukaryotes, are present. On the larger subunit from sulfur-dependent archaebacteria, an eocytic lobe, eocytic gap, and eocytic bulge are present. These features, with the exception of the eocytic gap, are found in a slightly modified form on eukaryotic large subunits. These novel ribosomal properties are in general consistent with other molecular biological properties peculiar to these organisms.*

In recent years, our understanding of the diversity of the fundamental molecular processes found in living organisms has expanded. Numerous data collected on fundamental cellular properties of diverse organisms seem to fall into a few patterns (*1*). In particular, ribosomes from organisms within the eubacterial, archaebacterial, and eukaryotic lineages each have different three-dimensional structures (*2*). We now report an unusual fourth type of ribosomal structure found in the sulfur-dependent archaebacteria ("eocytes") (*3*) that thrive in thermal springs at temperatures above 90°C (*4*, *5*).

Small ribosomal-subunits from five representative sulfur-dependent archaebacteria (eocytes) (Fig. 1A) were compared to ribosomal subunits from eubacteria, other archaebacteria, and eukaryotes (Fig. 1B). The four types are interpreted in diagrams at the bottom of Fig. 1. The "asymmetric projection" of the small subunit is shown to facilitate comparisons. This is the same projection that has been used to analyze the three-dimensional structures of archaebacterial, eukaryotic, and eubacterial small subunits (2).

Large subunits from five representative sulfur-dependent archaebacteria (Fig. 1C) were compared to ribosomal subunits from eubacteria, other archaebacteria, and eukaryotes (Fig. 1D). The large subunits are shown in a projection that is useful for comparative purposes, the "quasisymmetric" projection (*6*). Identification of this projection of the eocytic large subunits was determined by reference to the eubacterial structure. Beneath both galleries (Fig. 1, E and F, respectively) are composite diagrams that illustrate the features of all four types of small and large subunits.

The small subunits of sulfur-dependent archaebacteria contain a feature not found in ribosomes of other bacteria. Lobes are present at the base of their small subunits so that their structure is intermediate between that of the archaebacterial and the eukaryotic small subunits. The lack of "eukaryotic lobes" in small subunits of eubacteria and other archaebacteria has been described (2). These sulfur-dependent bacterial ribosomes are the only bacterial ribosomes known to have these "eukaryotic" structures. Like the ribosomes of archaebacteria and eukaryotes, the small subunits of sulfur-dependent archaebacteria have the archaebacterial bill (*2*).

Large subunits from sulfur-dependent archaebacteria (Fig. 1C) can be recognized by an indentation, the "eocytic gap." This feature gives these ribosomes their characteristic shape by separating a region of density at the bottom of the subunit, the "eocytic lobe," from a second region on the side of the subunit, the "eocytic bulge." For example, they can be compared with the large subunit from the archaebacterium *Halobacterium cutirubrum* (central panel, Fig. 1D). In both the other archaebacteria and in eubacteria the lobe and bulge are absent, or nearly so. In the eukaryotic large subunit, both the lobe and the bulge are present, and the gap between them is filled. The "eocytic lobe and bulge" are present in the large ribosomal subunits of both the sulfur-dependent archaebacteria and eukaryotes (Fig. 1D), but the gap occurs only in ribosomes of the sulfur-dependent archaebacteria.

In many molecular properties, the sulfur-dependent archaebacteria resemble eukaryotes. Their DNA-dependent RNA polymerases are composed of protein subunits with molecular weights and immunological properties that resemble those of eukaryotic polymerase A(I) more closely than the patterns found in the halobacteria, methanogens, and eubacteria (*7*). Introns similar to those found in eukaryotic transfer RNA (tRNA) genes, have been found in tRNA genes in the sulfur-dependent bacteria *Sulfolobus* (*8*), whereas none has yet been found in other bacteria. The sec-

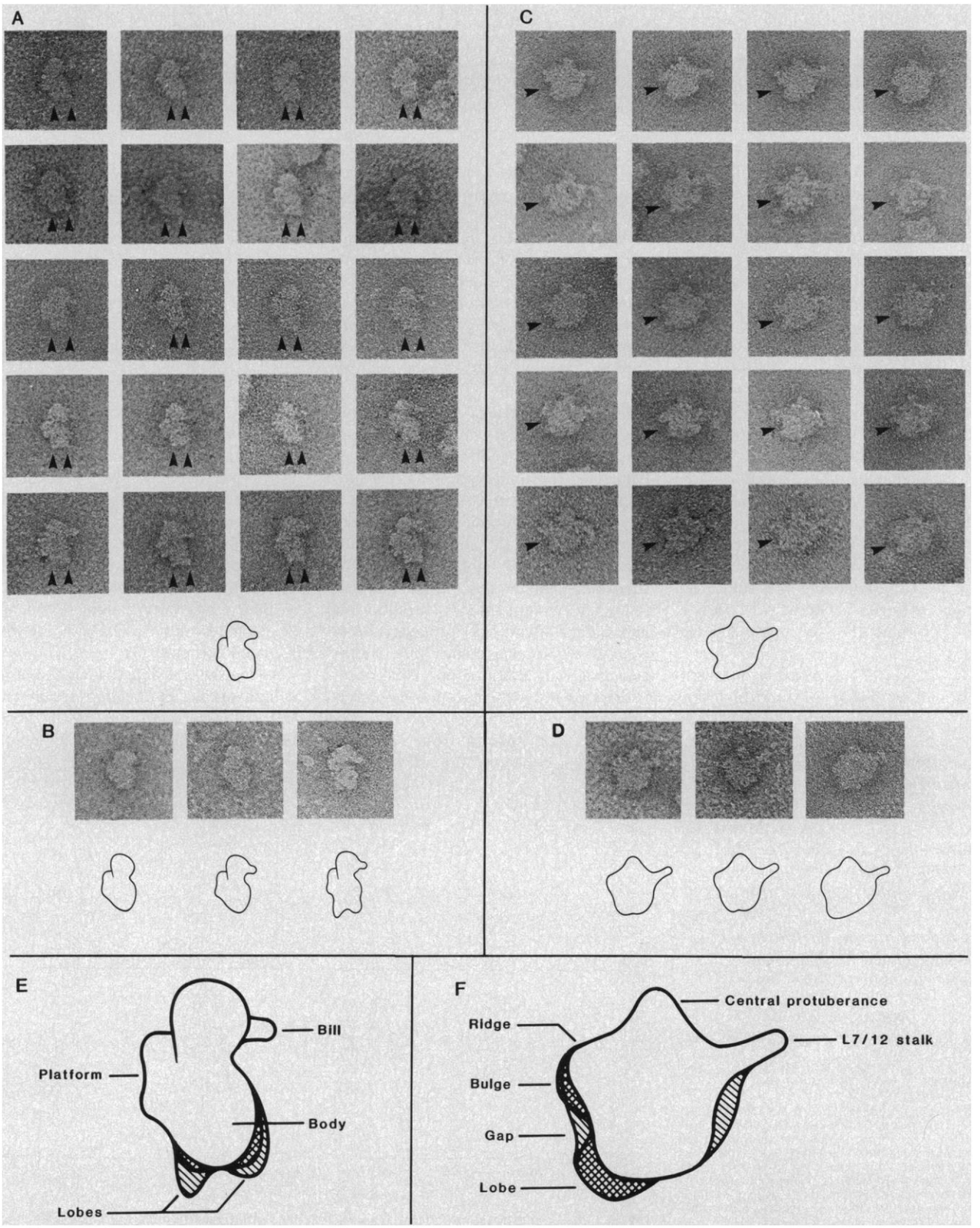

Fig. 1. Electron micrographs of the ribosomes of sulfur-dependent archaebacteria and of the three other ribosomal types. The taxa shown in each row of (A) and (C) from top to bottom, respectively, are *Thermoproteus tenax*, *Sulfolobus acidocaldarius*, *Desulfurococcus mucosus*, *Thermococcus celer*, and *Thermofilum pendens*. Small subunits are shown in (A) and large subunits are shown in (C). These are followed, just below (A) and (C), by a schematic diagram. A comparison of the three other ribosomal types is shown in (B) (small subunits) and (D) (large subunits). These comparative organisms are, from left to right, *Synechocystis 6701*, a cyanobacterium (eubacteria); *Halobacterium cutirubrum*, an extreme halophile (archaebacteria); and *Saccharomyces cerevisiae*, a yeast (eukaryote) (×260,000). Summaries of the structural features found in the four ribosomal types are shown in (E) (small subunits) and (F) (large subunits). Features found in ribosomes from sulfur-dependent archaebacteria (but absent in other bacteria) are indicated by diagonal (lower left to upper right) striping. Features found in eukaryotic ribosomes (but not in eubacterial, methanogenic, or halobacterial ribosomes) are indicated by diagonal (lower right to upper left) striping. The ribosomes and ribosomal subunits were prepared as described (*2*), except that ribosomal subunits from sulfur-dependent bacteria were resuspended in 200 m*M* NH_4Cl, 5 m*M* tris-HCl (*p*H 7.6), and 10 m*M* $MgCl_2$.

ondary structures of 5S ribosomal RNA (rRNA) from *Sulfolobus*, and to a lesser degree from *Thermoplasma*, while related to the eukaryotic 5S pattern, differ more from those of eubacteria, halobacteria, and methanogens than do even eukaryotic 5S rRNA (*9*). The initiator tRNA's of sulfur-dependent bacteria also show this pattern; for example, the sequence of the initiator tRNA of *Halococcus* more closely resembles those of eubacteria than of eukaryotes while the sequence of *Sulfolobus* initiator tRNA is closest to that of *Saccharomyces*, and that of *Thermoplasma* is intermediate (*10*). Significant amounts of long polyadenylated sequences are found in *Sulfolobus* RNA and are similar to those in eukaryotic messenger RNA's (mRNA), whereas much lower amounts (30 times less) are found in eubacteria (*11*).

Only a small number of sulfur-dependent archaebacteria have been isolated so far; however, both anaerobic and aerobic taxa are known. Many of them are capable of a novel anaerobic, purely chemolithoautotrophic metabolism utilizing H_2, CO_2, and elemental sulfur as a terminal electron acceptor (*12*). Hence, they prominently occupy unusual niches.

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2 April 1984; accepted 28 May 1984

Far Red Bioluminescence from Two Deep-Sea Fishes

Abstract. *Spectral measurements of red bioluminescence were obtained from the deep-sea stomiatoid fishes* Aristostomias scintillans *(Gilbert) and* Malacosteus niger *(Ayres). Red luminescence from suborbital light organs extends to the near infrared, with peak emission at approximately 705 nanometers in the far red. These fishes also have postorbital light organs that emit blue luminescence with maxima between 470 and 480 nanometers. The red bioluminescence may be due to an energy transfer system and wavelength-selective filtering.*

Emission spectra of luminescent marine organisms generally occur in the blue and green spectral regions (*1, 2*). However, red luminescent flashes have been observed, but never measured, in the deep-sea stomiatoid fishes *Aristostomias scintillans* (*3*) and *Pachystomias* spp. (*4*). The red light originates from suborbital light organs, which fluoresce red in ultraviolet light (*5*). The suborbital light organs of another stomiatoid, *Malacosteus niger*, also contain red-fluorescent material, although no visual observations of red luminescence have been reported for this species. We now present emission spectra from suborbital light organs of *Aristostomias scintillans* and *Malacosteus niger*.

Spectra were recorded at sea on freshly trawled specimens with the use of a computer-controlled, intensified optical multichannel analyzer (OMA). Operation, collection optics, calibration, and correction and data analysis procedures for this system have been described (*1, 6*). Specimens were caught by opening-closing midwater trawls with thermally insulated cod ends (*7*).

No light was visible from the suborbital light organs of the first specimen of *Aristostomias scintillans*. When norepinephrine ($10^{-4}M$) was applied topically

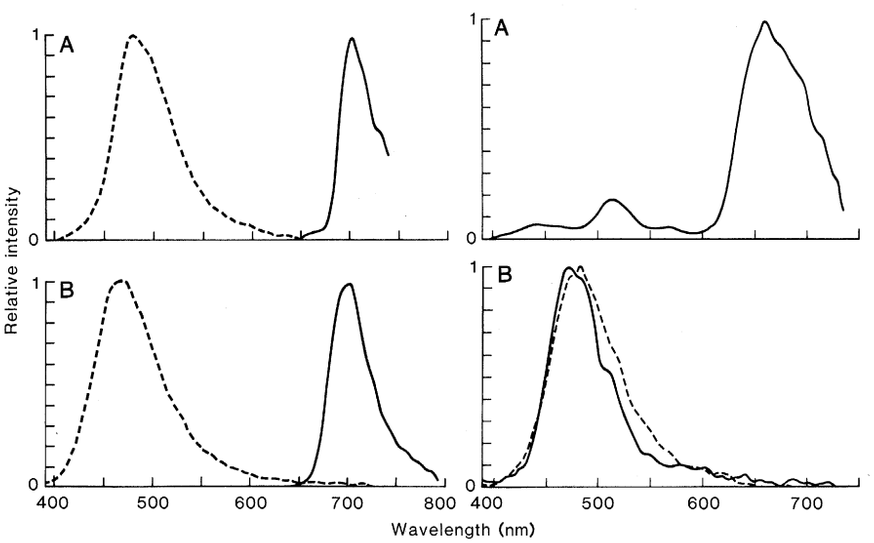

Fig. 1 (left). (A) Emission spectra from a specimen of *Aristostomias scintillans*, fiber-optic input. Each curve represents standardized relative intensity with respect to wavelength. (- - -) Postorbital light organ: λ_{max}, 479 nm; FWHM, 67 nm; signal to noise ratio, 82. (——) Suborbital light organ: λ_{max}, 703 nm; FWHM, 47 nm; signal to noise ratio, 39. The spectrum ends at 750 nm, the long wavelength polychromator limit used for this specimen. (B) Emission spectra from *Malacosteus niger*, double lens collecting optics. (- - -) Postorbital light organ: λ_{max}, 469 nm; FWHM, 77 nm; signal to noise ratio, 87. (——) Suborbital light organ: λ_{max}, 702 nm; FWHM, 49 nm; signal to noise ratio, 94. Fig. 2 (right). Emission spectra measured from *Malacosteus niger*, double lens optics. (A) Suborbital light organ after superficial tissue was removed and organ was cut open: λ_{max}, 660 nm; FWHM, 76 nm; signal to noise ratio, 86. (B) Postorbital light organ. (——) Before isolation: λ_{max}, 471 nm; FWHM, 65 nm; signal to noise ratio, 44. (- - -) After isolation: λ_{max}, 483 nm; FWHM, 74 nm; signal to noise ratio, 34.