are caused by loss of some of the synMuv B chromatin regulators (*5*, *7*, *8*). Notably, although LIN-53 is a member of the synMuv B group, some experiments (*8*) suggest that it is not among the synMuv B proteins whose loss causes a strong soma-to-germ transformation. Figuring out which chromatin regulators limit competence to respond to lineage-regulating factors, and in which cell types (see the figure), is an important future direction for research.

Tursun *et al*. give a big boost to cellular reprogramming efforts. Each cell type of the body might be governed by a unique set of transcription and chromatin-regulating factors. A detailed understanding of these would allow for precise and directed manipulation, potentially enabling the creation of any cell type from any other. Although there are some examples of reprogramming cultured mammalian cells from one cell type to another, investigators are far from having complete control over the process (*9*–*12*). Studies such as this can reveal fundamental aspects of the processes that keep cell types distinct, and reveal important targets for regenerative medicine approaches that seek to step over barriers between cell types.

References

1. B. Tursun, T. Patel, P. Kratsios, O. Hobert, *Science* **311**, 304 (2010); 10.1126/science.1199082.
2. O. Uchida *et al*., *Development* **130**, 1215 (2003).
3. S. Sarin, C. Antonio, B. Tursun, *Development* **136**, 2933 (2009).
4. D. S. Fay, J. Yochem, *Dev. Biol.* **306**, 1 (2007).
5. S. Strome, R. Lehmann, *Science* **316**, 392 (2007).
6. R. Ciosk *et al*., *Science* **311**, 851 (2006).
7. Y. Unhavaithaya *et al*., *Cell* **111**, 991 (2002).
8. D. Wang *et al*., *Nature* **436**, 593 (2005).
9. K. Takahashi, S. Yamanaka, *Cell* **126**, 663 (2006).
10. Q. Zhou, D. A. Melton, *Cell Stem Cell* **3**, 382 (2008).
11. T. Graf, T. Enver, *Nature* **462**, 587 (2009).
12. B. Feng, J. H. Ng, J. C. Heng, H. H. Ng, *Cell Stem Cell* **4**, 301 (2009).

10.1126/science.1201288

ASTRONOMY

Disclosing Identities in Diffuse Interstellar Bands

The linear isomer of C_3H_2 has been proposed as the source of broad absorption bands in diffuse interstellar clouds, but it is still being debated.

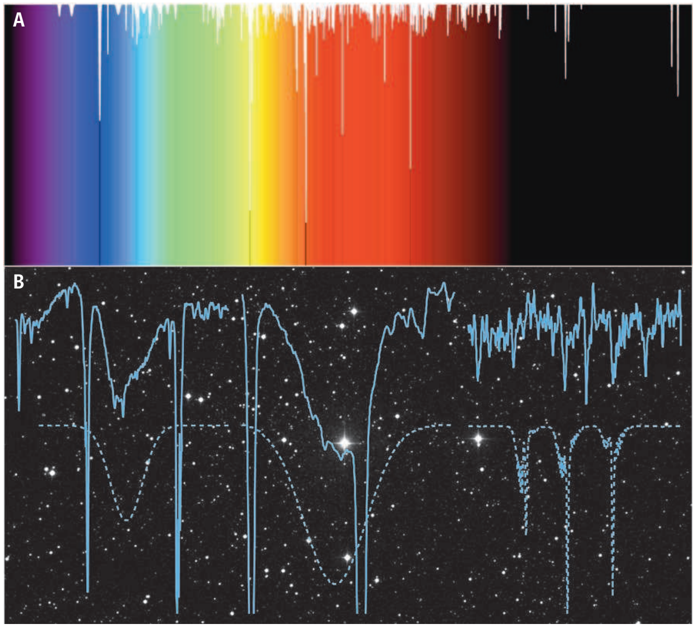
Takeshi Oka[1] and Benjamin J. McCall[2]

Just as detectives use fingerprints to pin down criminals, astronomers use spectra to identify molecules in interstellar space. Astronomical spectroscopy, especially spectroscopy of molecular ions, is developing rapidly. Numerous interstellar negative ions, the very high abundance of H_3^+ in the Galactic center, and the extremely strong far-infrared absorptions of OH^+, H_2O^+, H_2Cl^+, and CH^+ have all been discovered during the last few years (*1*). In contrast to these rapid developments in the discovery of new molecular spectra, whose sharp features can be thought of as clean fingerprints, there exists a group of several hundred intriguing broad optical spectra (see the figure, panel A) called the diffuse interstellar bands (DIBs). These blurry fingerprints have defied attempts by many astronomers, physicists, and chemists to understand them for many decades. Maier *et al*. (*2*) now have a suspect in custody as the molecule responsible for DIBs—the linear carbene molecule, *l*-C_3H_2—but more evidence will be needed to get a conviction.

The strongest DIB, at the wavelength of 4430 Å, was initially observed by Annie Jump Cannon, the first astronomer to classify stars systematically by spectroscopy, sometime between 1911 and 1919 (*3*–*5*). The carriers of DIBs are molecules, not atoms or solid grains, and they are not in the stars but are in huge diffuse clouds between the stars and us. More than that is not known with certainty. It is difficult to hunt criminals by using blurry fingerprints. In comparison, radio detections of molecules are clear-cut because their fingerprints (rotational spectra) are extremely sharp. Milestone discoveries of molecules, like H_2O, H_2CO, CO, HCO^+, and HC_5N, were initially claimed by detecting one spectral line, and there have not been any mistakes.

Numerous hypotheses, many from eminent spectroscopists and astronomers, have been proposed to explain DIBs, and most of these hypotheses look far-fetched in hindsight. The chemist Bill Klemperer once said that "there is no better way to lose a scientific reputation than to speculate on the carrier for the diffuse bands" (*6*). During the past 10 years, candidates have included C_7^-, $C_3H_2^-$, $C_{10}H_8^+$, and HC_4H^+, proposed on the bases of their laboratory spectra. However, they have not been accepted because their fingerprints were not a good enough match to DIBs. There have been many more proposals not based on laboratory spectra, but these are more speculative, and akin to naming a suspect based on circumstantial evidence.

Maier *et al*.'s proposal that two DIBs at 4881 Å and 5450 Å are caused by *l*-C_3H_2 has stirred



The basis of blurry fingerprints. (**A**) Diffuse interstellar bands (DIBs) are broad visible spectral features caused by molecules in interstellar matter absorbing starlight. (**B**) The star HD 183143 at the center of this starfield in the constellation Sagitta is used to measure DIBs. The solid curves show DIBs for the wavelength ranges from 4812 to 4956 Å, 5431 to 5472 Å, and 6144 to 6176 Å. The simulations of Maier *et al*. based on their laboratory data for *l*-C_3H_2 are shown as dashed lines.

CREDIT: PALOMAR OPTICAL SKY SURVEY

---

[1] Department of Chemistry, University of Chicago, Chicago, IL 60637, USA. [2] Department of Chemistry, University of Illinois, Urbana, IL 61801, USA. E-mail: t-oka@uchicago.edu; bjmccall@illinois.edu

Published by AAAS

great interest within the astronomy community. Maier is a leader in the field of laboratory spectroscopic astrophysics and, using a variety of newly developed techniques, has been amazingly productive in discovering new visible and ultraviolet spectra of carbon-containing unstable molecules, which are likely carriers of DIBs (only the almost collision-free environment of interstellar space allows such molecules to exist in abundance there; in the lab, they are difficult to prepare). This particular candidate molecule had already been observed by radio emission in dense interstellar clouds (~100 times denser than diffuse clouds where DIBs are observed) nearly 20 years ago (*7*). Cyclic C_3H_2 has been observed in diffuse clouds (*8*), so the presence of *l*-C_3H_2 may not be surprising. Related molecules such as C_2, C_2H, and C_3 have also been seen in diffuse clouds, and such a simple molecule is more appealing than very complicated molecules whose spectra are difficult to obtain in the laboratory.

Maier's group had previously recorded sharp fingerprints of *l*-C_3H_2 in the laboratory in the 6150 to 6330 Å region, which correspond to this molecule's lowest-energy electronic transition (*9*, *10*). The major breakthrough in the present work was the proof that two much broader bands at 4881 and 5450 Å are also caused by a higher electronic transition of *l*-C_3H_2. The broad spectral lines of a simple molecule like *l*-C_3H_2 appear to be the result of the extremely short lifetime (~3×10^{-13} s) of the second electronic excited state. This interpretation follows from the uncertainty principle—a shorter transition time corresponds to higher uncertainty in energy and hence a broader spectral line.

The match of the two broad bands to DIBs seems reasonable, but with such "blurry fingerprints," it does not constitute proof beyond a reasonable doubt. In panel B of the figure, the interstellar spectra (solid curves) and simulations from laboratory data (dashed curves) are shown, with the 4881 Å DIB at left, and the 5450 Å DIB at center. Maier *et al.* also searched for the sharp transitions of *l*-C_3H_2 in the 6150 to 6330 Å region; the match with their spectra of interstellar clouds is promising, but not entirely convincing (panel B of the figure, lower right). Unfortunately, different stars were used in the searches for the broad and sharp bands, so it remains to be seen whether all of the supposed *l*-C_3H_2 transitions appear in a single diffuse cloud, and whether the intensities of all these transitions have a constant ratio in all clouds (as they should if they are caused by the same molecule).

Another aspect of the work by Maier *et al.* that is difficult to accept is the apparently high abundance of *l*-C_3H_2 toward the star HD 183143 (center of panel B of the figure). This line of sight, which has been famous in the DIB community since the pioneering work of Herbig (*11*), is remarkable in that it contains very few carbon-chain molecules, such as C_2 (*12*) or C_3 (*13*). In this respect, HD 183143 is an extreme case; its polar opposite is the star HD 204827, which has by far the highest C_3 and C_2 column densities of all sightlines so far studied and led to the discovery by our co-workers and ourselves of a group of DIBs called "C_2 DIBs" whose intensities correlate well with the C_2 column densities (*12*). These two sightlines have also served as contrasting prototypes for detailed compilations of the DIBs (*14*, *15*). If Maier's claim about *l*-C_3H_2 is correct, this molecule must be more than two orders of magnitude more abundant than C_2 and C_3 in HD 183143. Although the chemical mechanism for producing hydrocarbon molecules in diffuse clouds is not well understood, it is hard to imagine such a tremendous discrepancy in the abundance of C_3 and *l*-C_3H_2.

At present, we conclude that there is insufficient evidence to "convict" *l*-C_3H_2 as a carrier of the DIBs. Searches for both the sharp and broad *l*-C_3H_2 bands in a number of diffuse clouds could establish whether the sharp bands are a perfect match, and whether the broad bands have a constant intensity ratio in different clouds. It may also be possible to search for *l*-C_3H_2 in diffuse clouds through its pure-rotational transitions (*16*); however, a direct comparison of absorption in the optical and the radio spectrum would require a background source that is bright at both wavelengths.

References and Notes

1. Those developments were hotly debated at a recent symposium, "Spectroscopy of molecular ions in the laboratory and in (extraterrestrial) space," held in Kos, Greece, 3 to 6 October 2010; http://fermi.uchicago.edu/~smiles/.
2. J. P. Maier *et al.*, *Astrophys. J.* **726**, 41 (2011).
3. G. H. Herbig, *Astrophys. J.* **196**, 129 (1975).
4. A. D. Code, *Publ. Astron. Soc. Pac.* **70**, 407 (1958).
5. G. E. Bromage, *Q. J. R. Astron. Soc* **28**, 295 (1987).
6. E. Herbst, *Annu. Rev. Phys. Chem.* **46**, 27 (1995).
7. J. Cernicharo *et al.*, *Astrophys. J.* **368**, L39 (1991).
8. R. Lucas, H. S. Liszt, *Astron. Astrophys.* **358**, 1069 (2000).
9. P. Birza, A. Chirakolava, M. Araki, P. Kolek, J. P. Maier, *J. Mol. Spectrosc.* **229**, 276 (2005).
10. E. Achkasova, M. Araki, A. Denisov, J. P. Maier, *J. Mol. Spectrosc.* **237**, 70 (2006).
11. G. H. Herbig, *Z. Astrophys.* **64**, 512 (1966).
12. J. A. Thorburn *et al.*, *Astrophys. J.* **584**, 339 (2003).
13. T. Oka *et al.*, *Astrophys. J.* **582**, 823 (2003).
14. L. M. Hobbs *et al.*, *Astrophys. J.* **680**, 1256 (2008).
15. L. M. Hobbs *et al.*, *Astrophys. J.* **705**, 32 (2009).
16. J. Cernicharo, P. Cox, D. Fossé, R. Güsten, *Astron. Astrophys.* **351**, 341 (1999).

17. We thank L. M. Hobbs, P. Sonnentrucker, D. E. Welty, and D. G. York for helpful discussions.

10.1126/science.1200144

MICROBIOLOGY

Another Microbial Pathway for Acetate Assimilation

Scott A. Ensign

In a salt-loving Archaeon, a patchwork of enzymes creates a variation of the glyoxylate cycle.

Countless students in introductory biochemistry classes have heard the adage "fats burn in the flame of carbohydrates." It refers to the inability of vertebrates to convert acetyl coenzyme A (acetyl-CoA), an important metabolic molecule, into intermediate compounds that replenish carbon in the citric acid cycle and enable the synthesis of glucose. In contrast, plants and certain bacteria, fungi, and invertebrates have solved this barrier to "anabolism from acetate" by using a variation of the citric acid cycle. This variation is called the glyoxylate cycle, and it allows acetyl-CoA to be used as a replenishing source for carbon in the synthesis of glucose and other important reactions (*1*). However, a number of acetate-using microorganisms lack one of the signature enzymes involved in the glyoxylate cycle, isocitrate lyase, demonstrating that other pathway(s) for acetate assimilation must exist (*2*–*4*). In 2007, fully 50 years after the discovery of the glyoxylate cycle, investigators revealed the first complete details of one of these alternate pathways (*5*). Now, on page 334 of this issue, Khomyakova *et al.* (*6*) describe yet another acetate-assimilation pathway. It is in a salt-loving (halophilic) microorganism belonging to the Archaea, and incorporates

---

Department of Chemistry and Biochemistry, Utah State University, Logan, UT 84322–0300, USA. E-mail: ensigns@cc.usu.edu

Published by AAAS