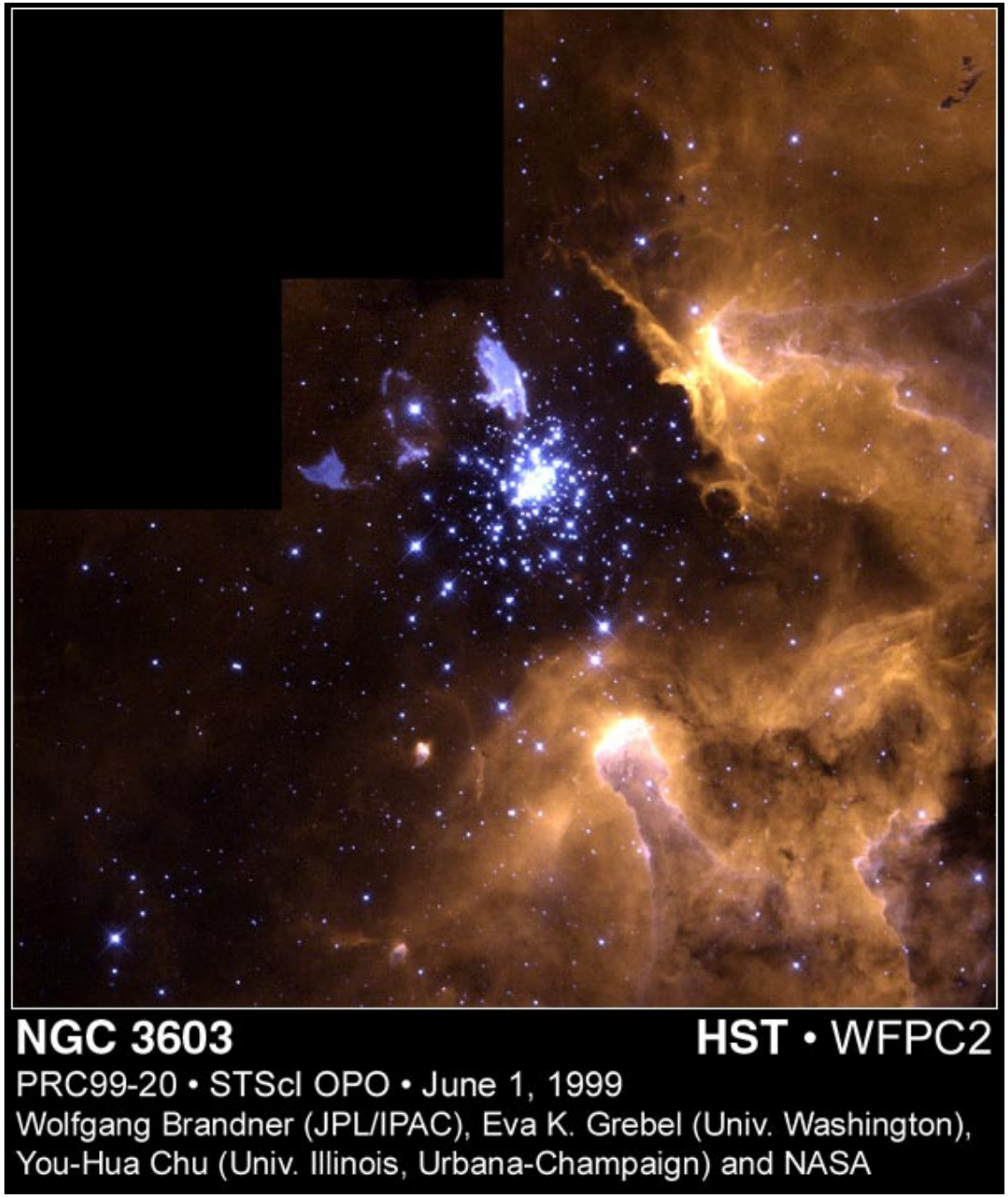
Recycling in the Universe

Alyssa A. Goodman

Department of Astronomy
Harvard University



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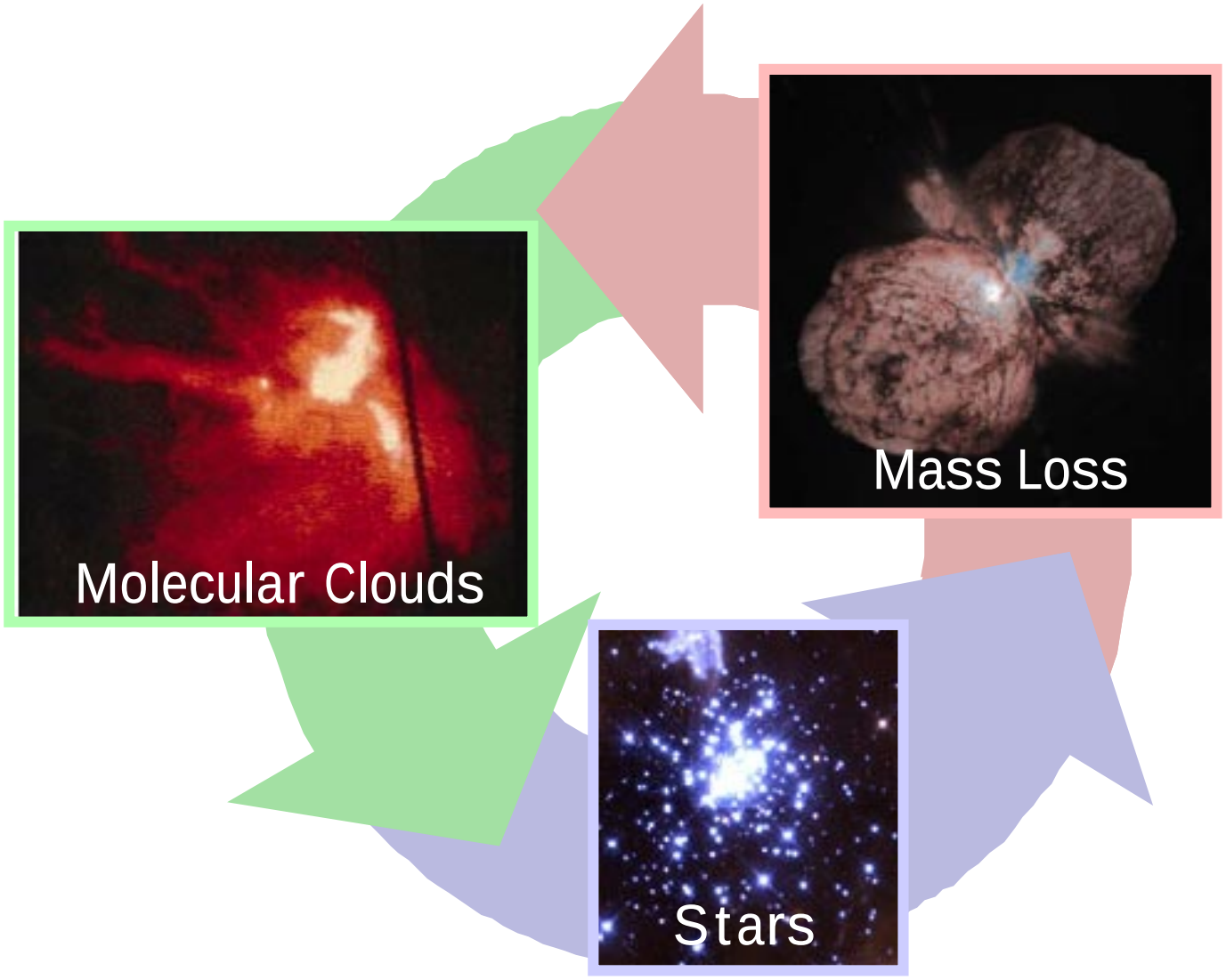
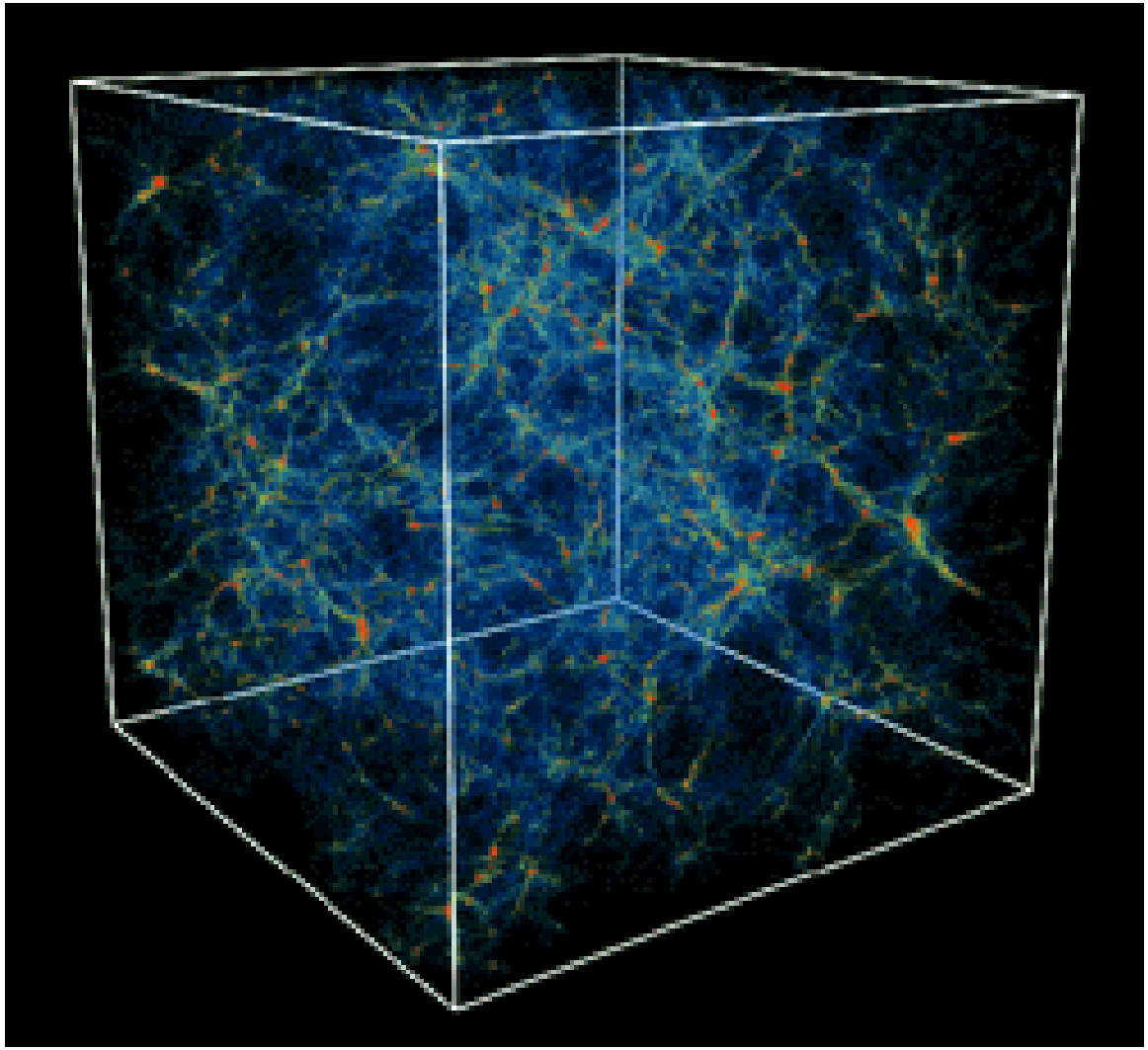
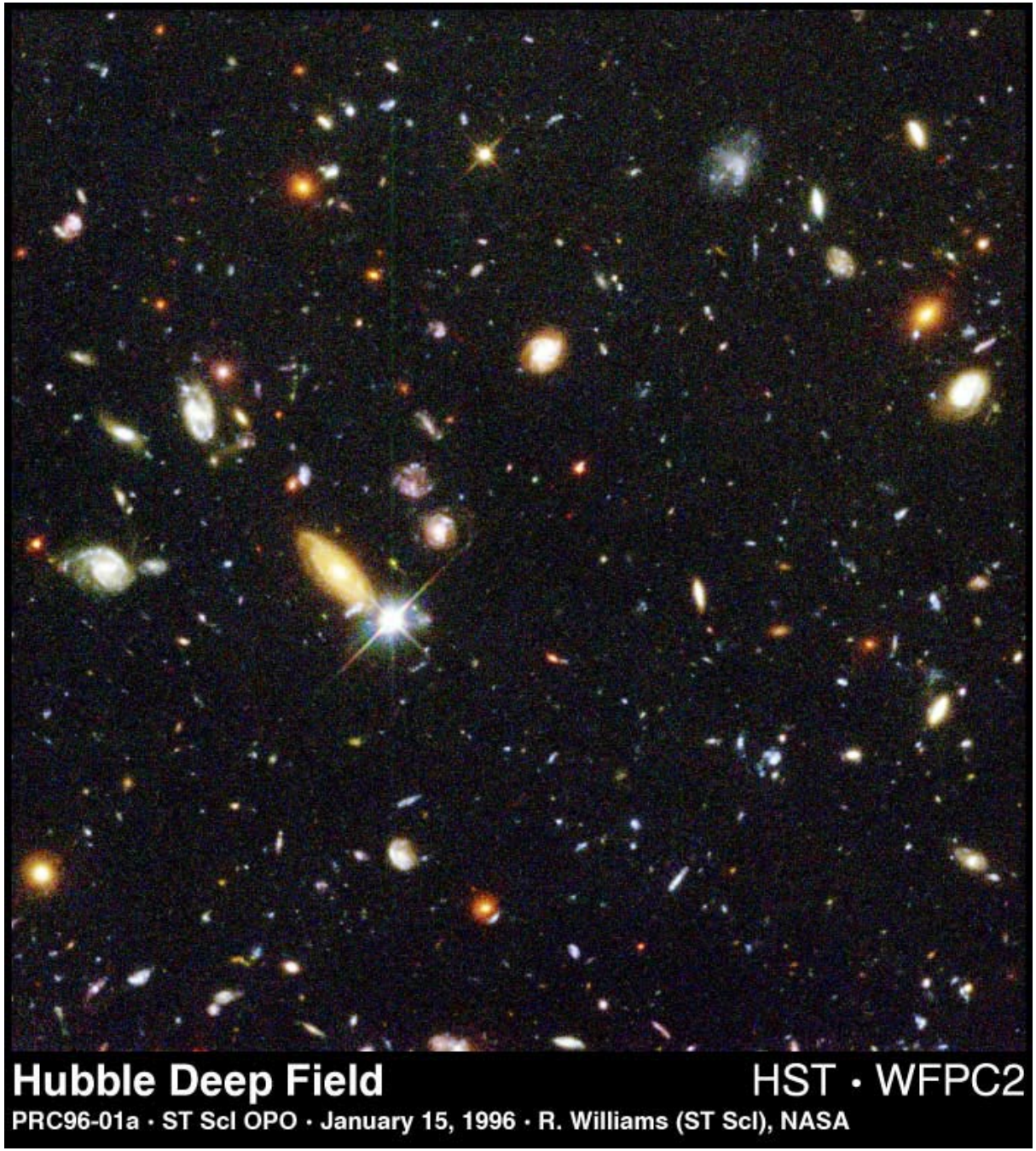


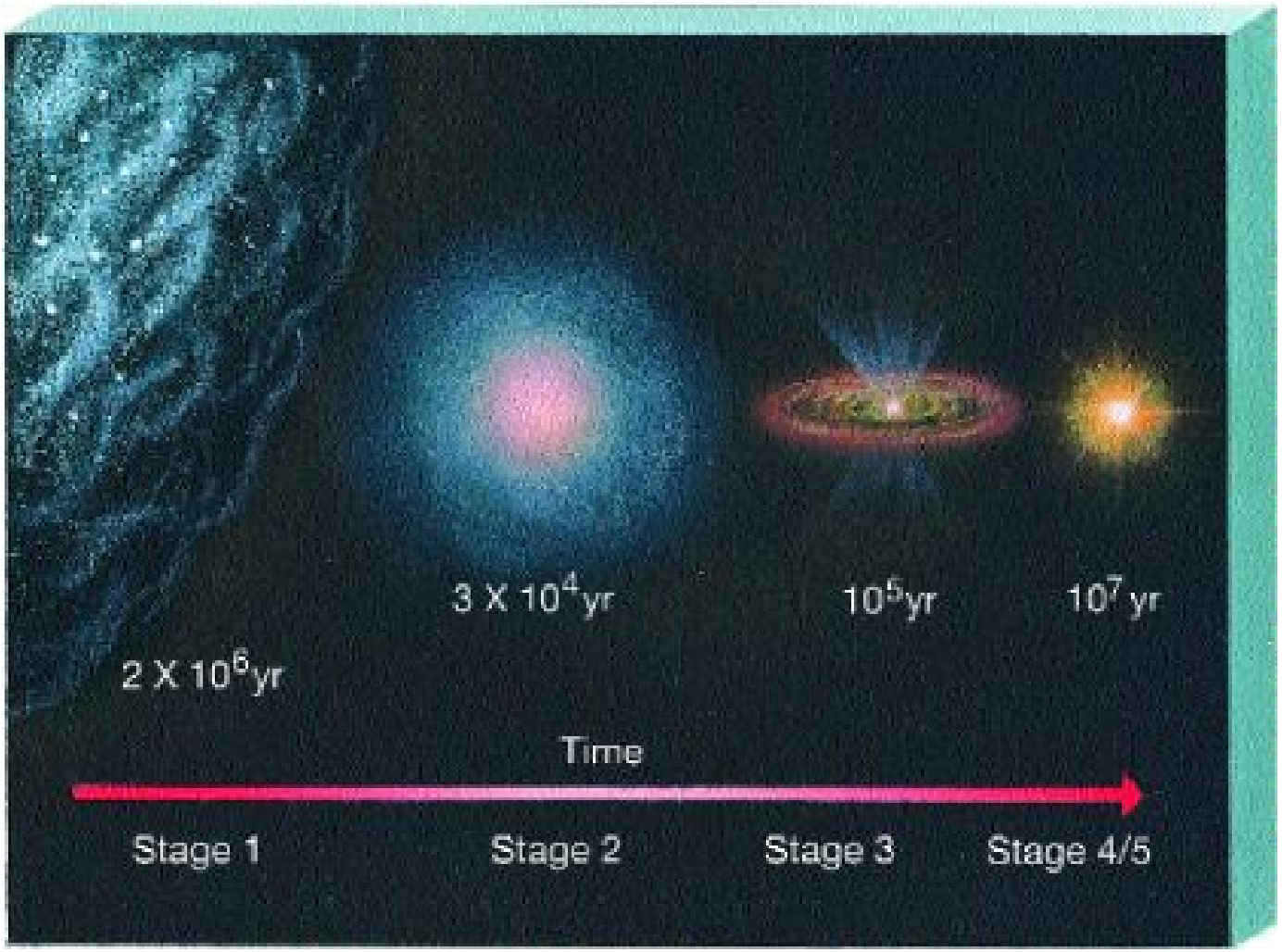
Fluctuations about 300,000 years after the Big Bang led to "Structure Formation"



Pretty young galaxies

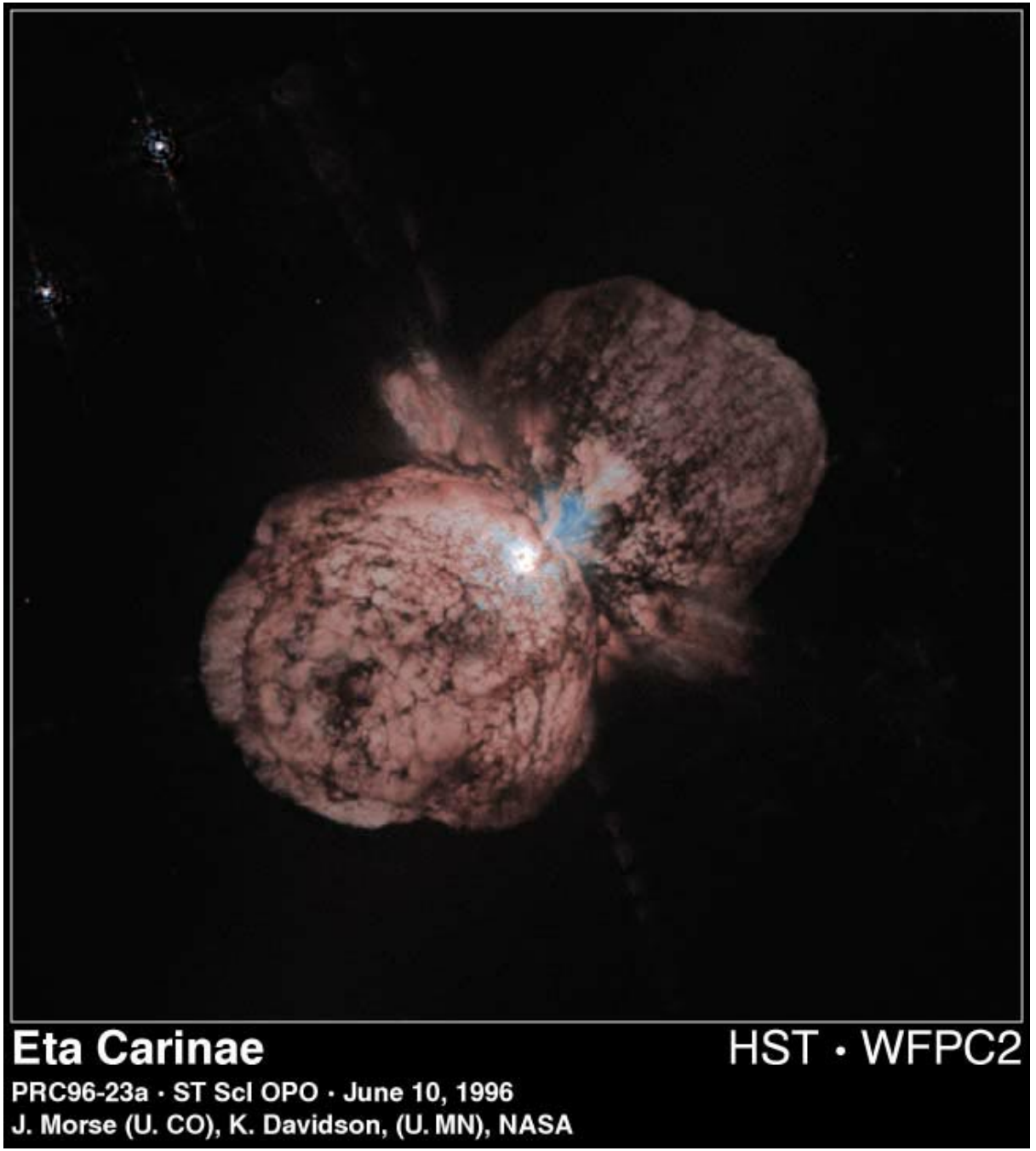


"Star Formation"



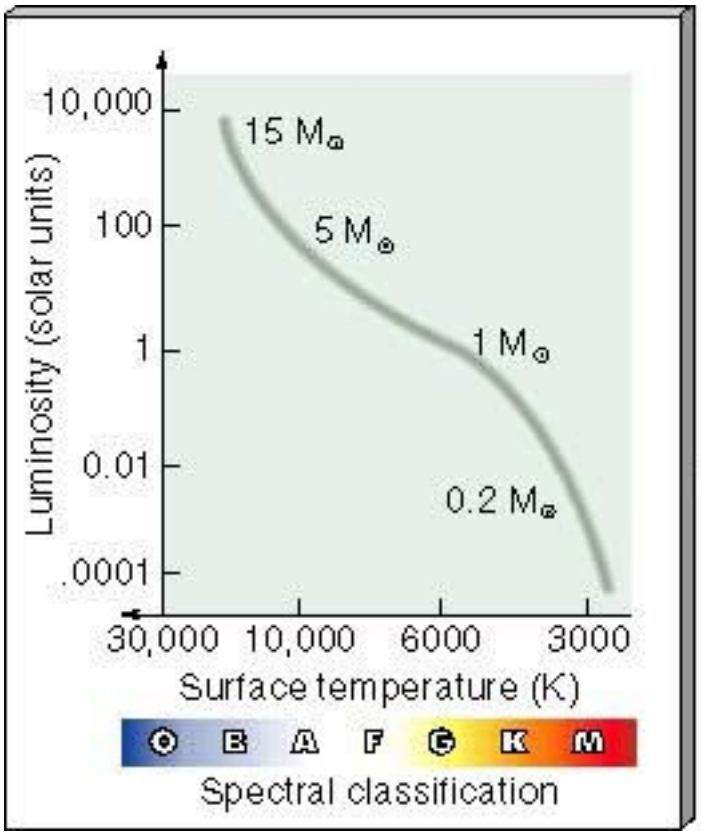
Star "Death": Interstellar Recycling Plants

Mass=100 x Sun

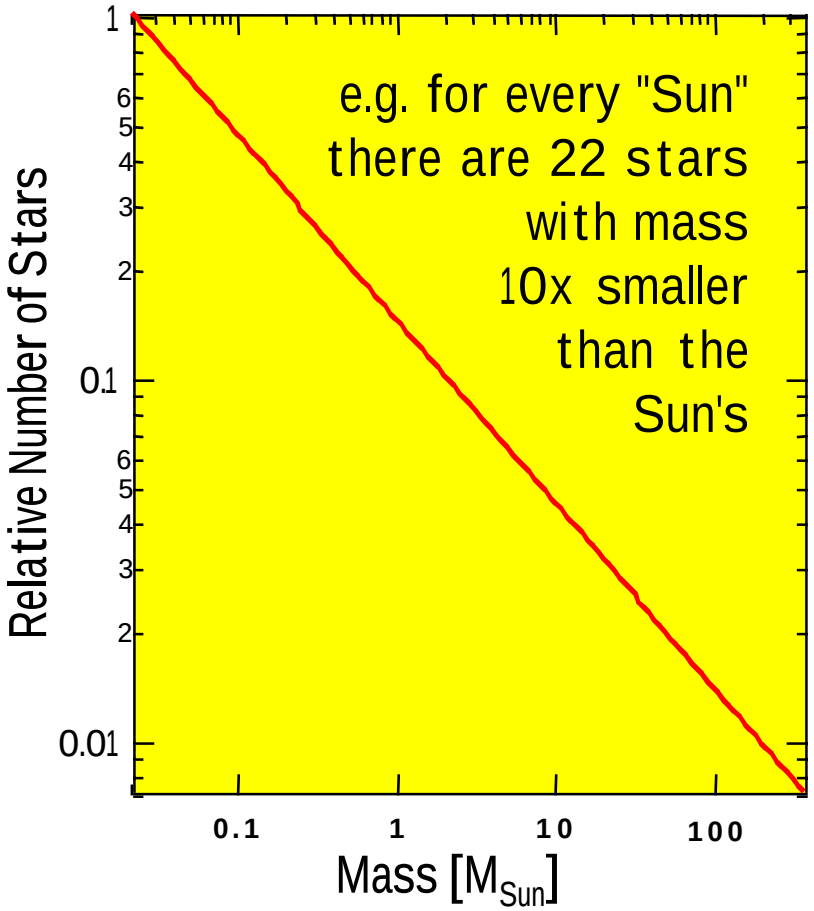


Distribution of Recycling Plants

The Hertzprung-Russell Diagram

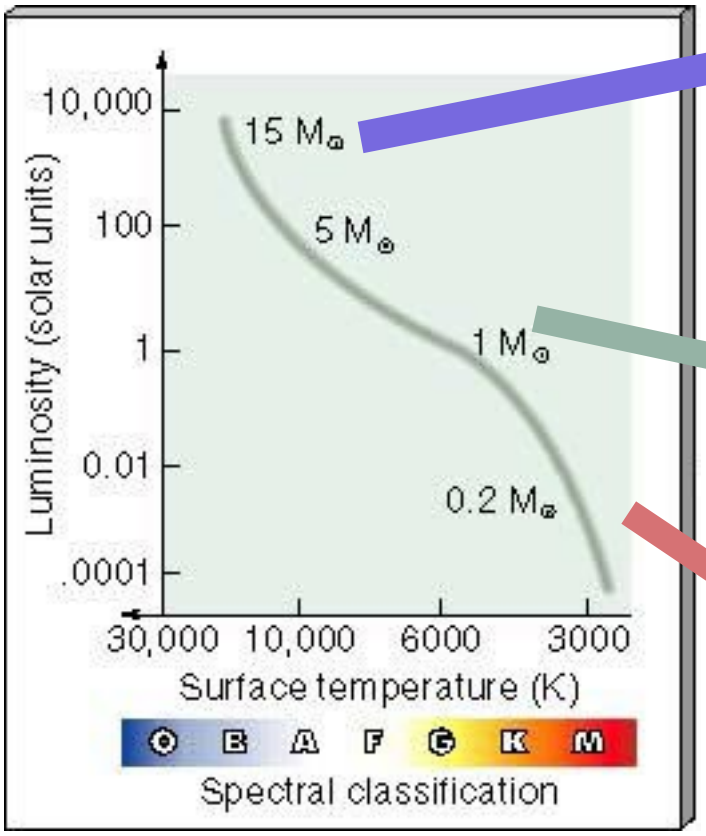


The "Initial Mass Function" (IMF)



Output of Recycling Plants

The Hertzprung-Russell Diagram

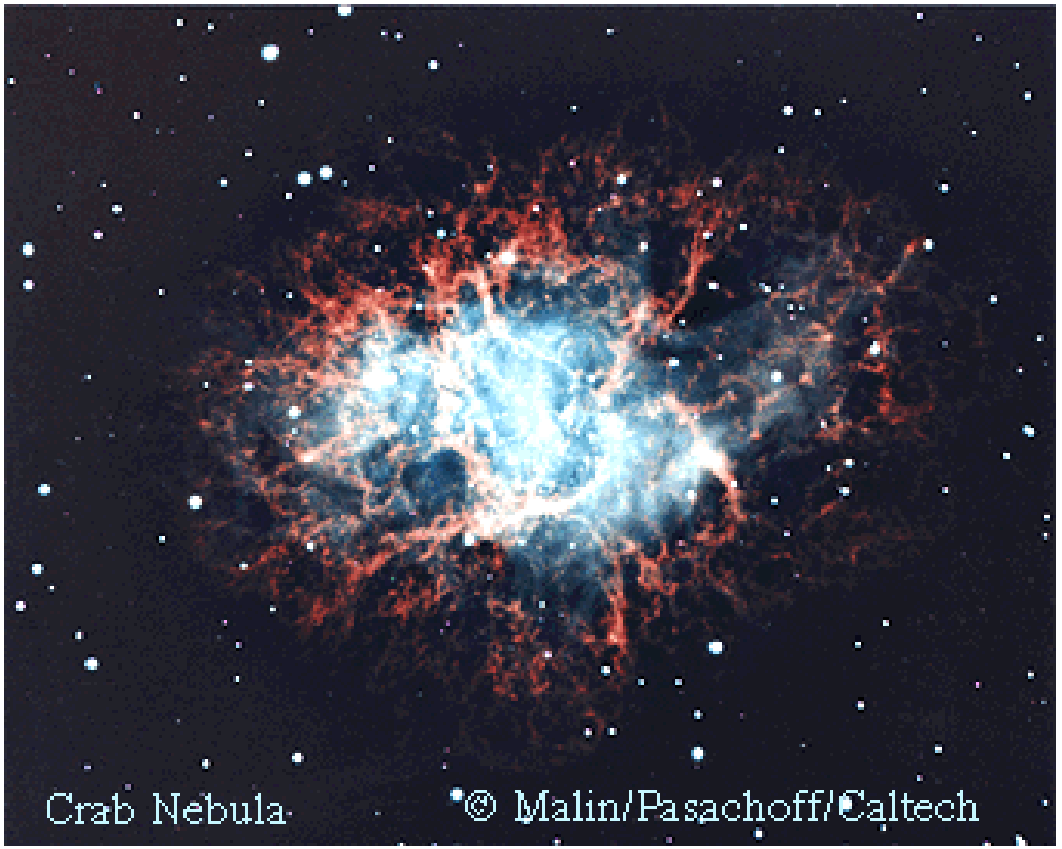


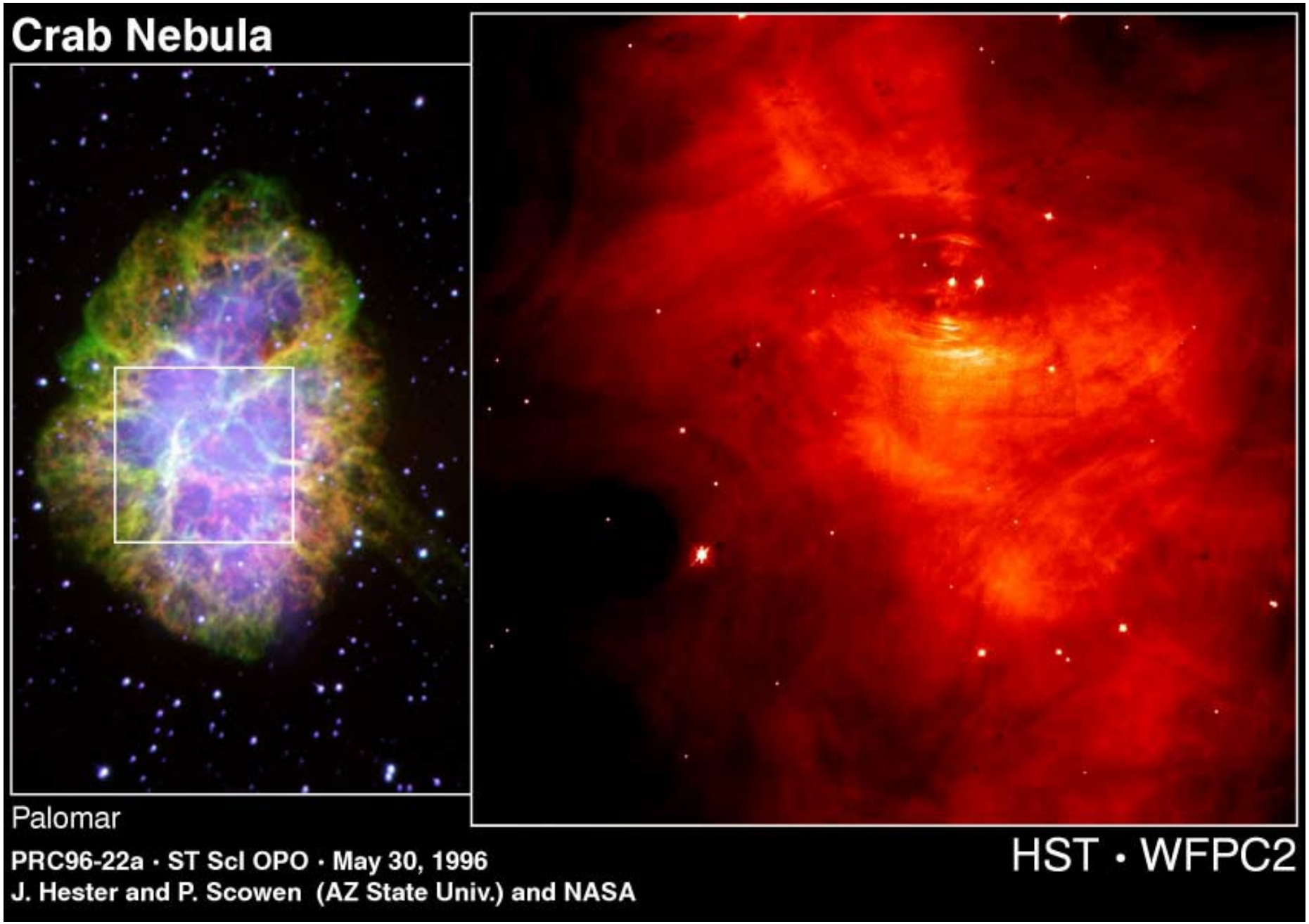
Supernova, then neutron star/pulsar or black hole → Spectacular contribution, and collection. Explosion injects, and "sweeps up" interstellar material.

Red giant then white dwarf → Good recyclables. Red-giant wind main dust injection in ISM.

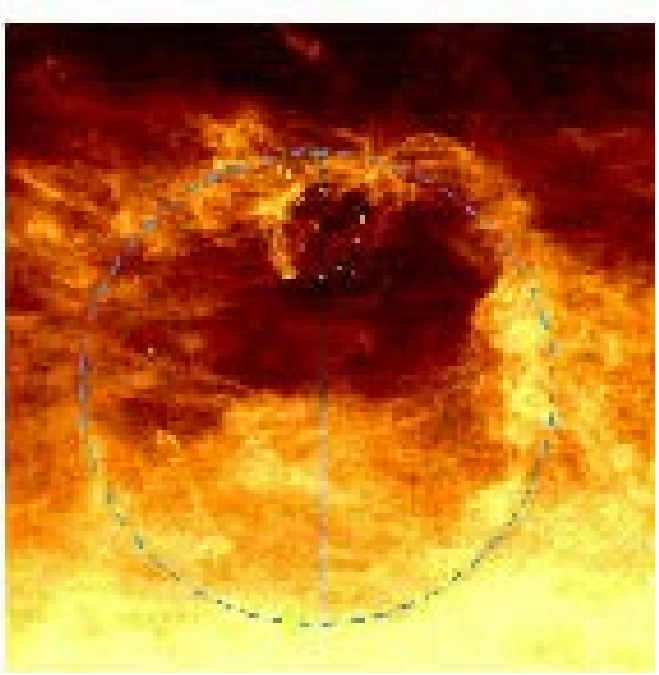
Long-lived brown dwarfs → "Styrofoam"

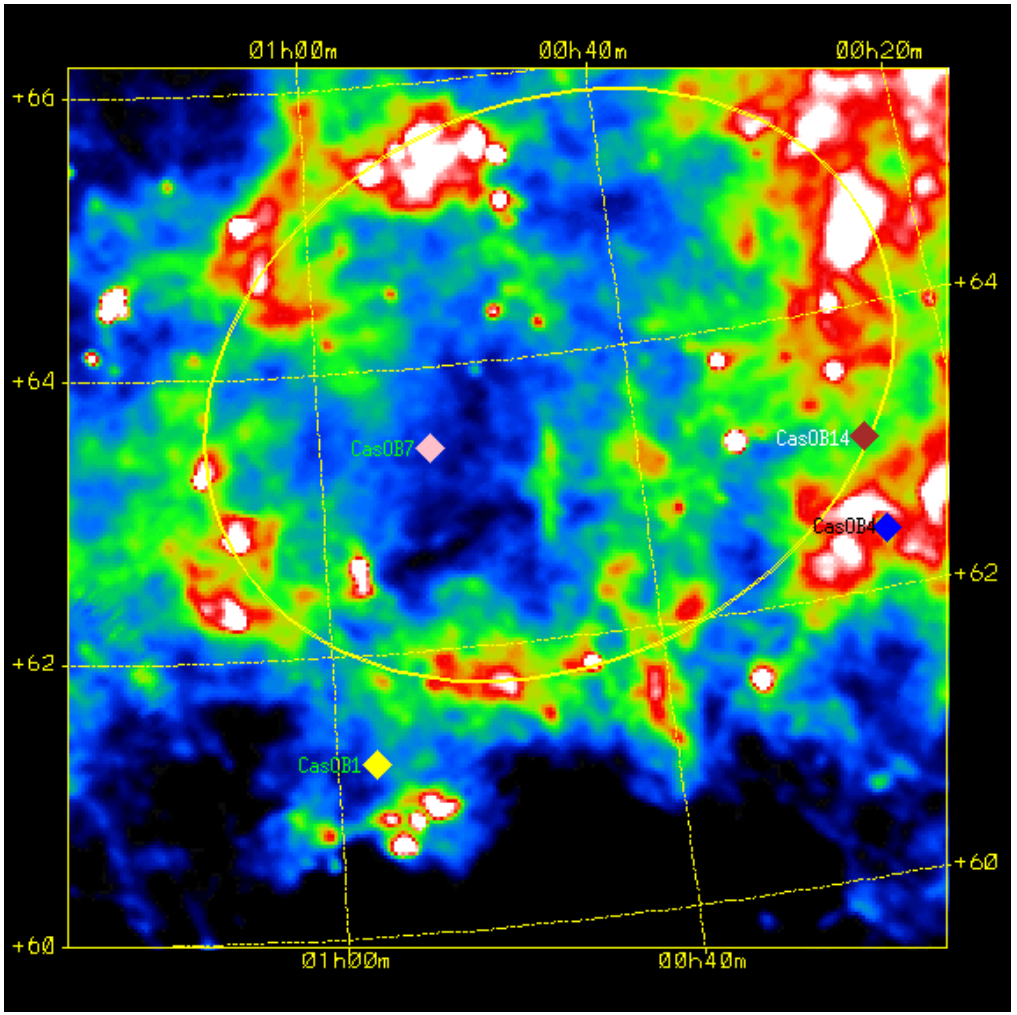
A "Supernova" Recycling Plant



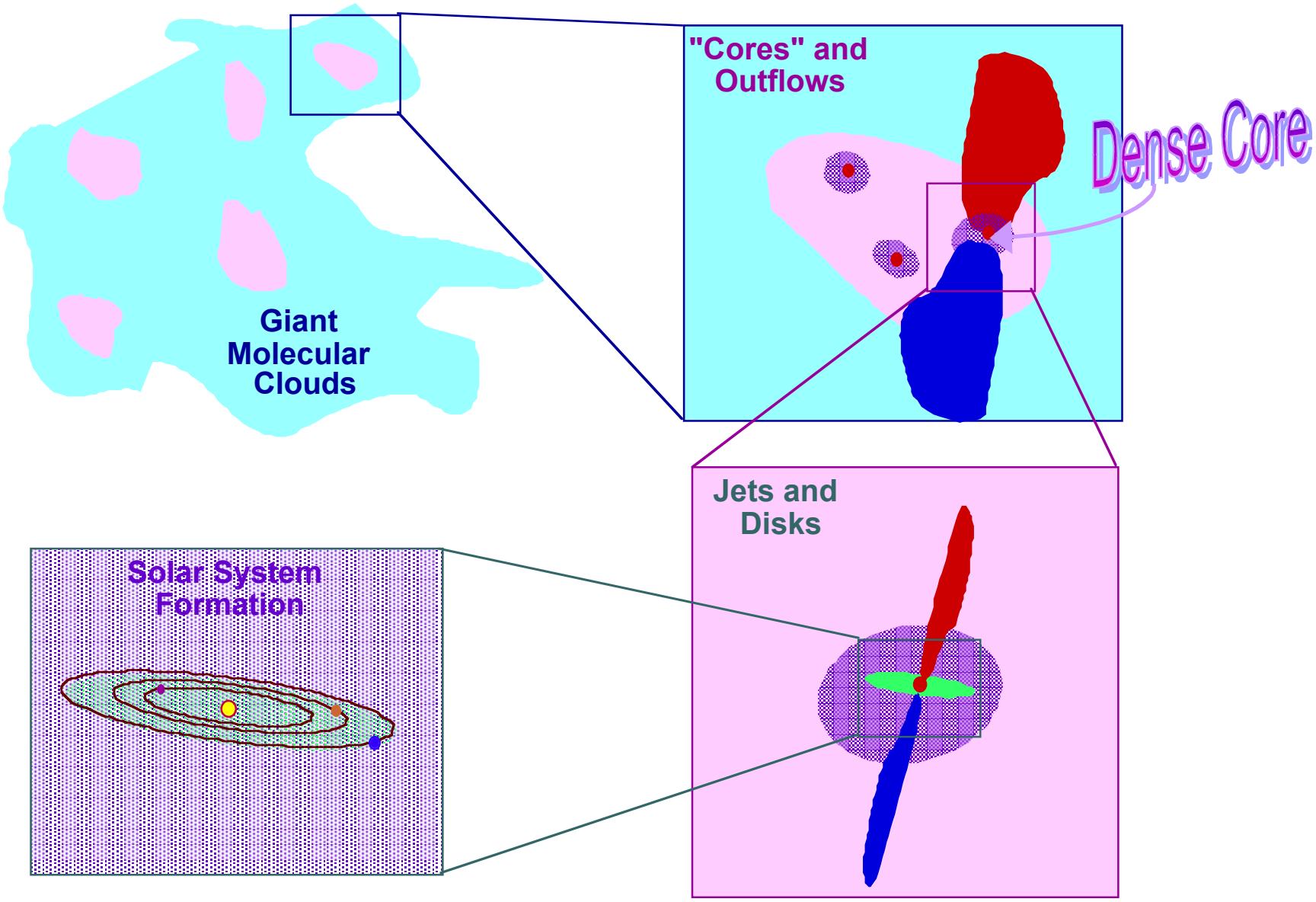

Crab Nebula
Palomar
PRC96-22a · ST ScI OPO · May 30, 1996
J. Hester and P. Scowen (AZ State Univ.) and NASA
HST · WFPC2

Swept-up Gas:The Next Generation

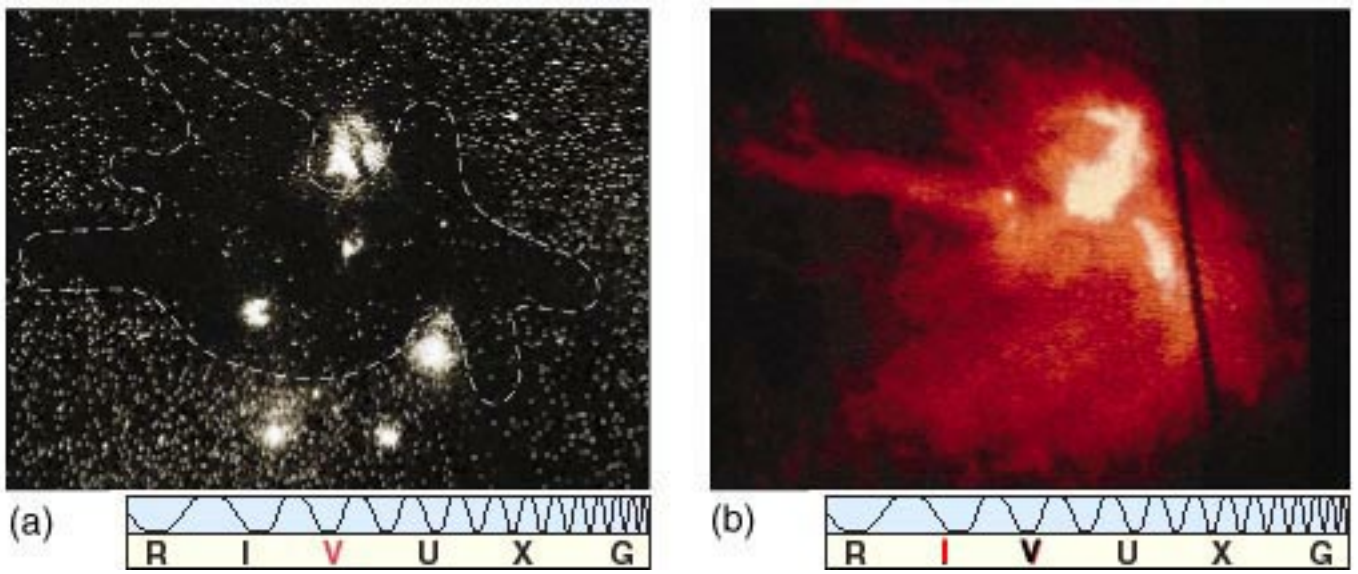


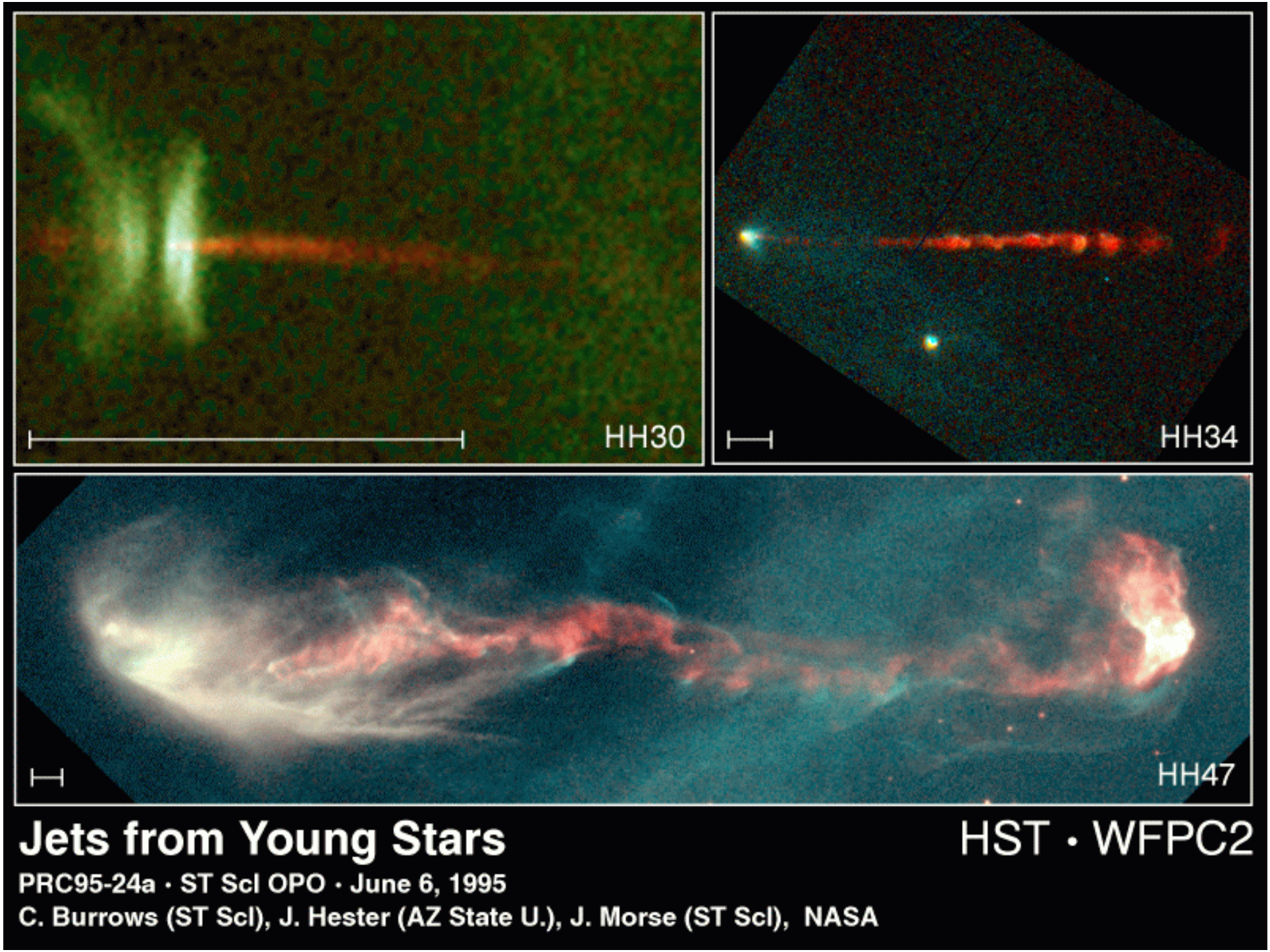


“Star and Planet Formation”

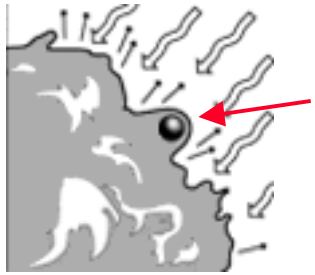


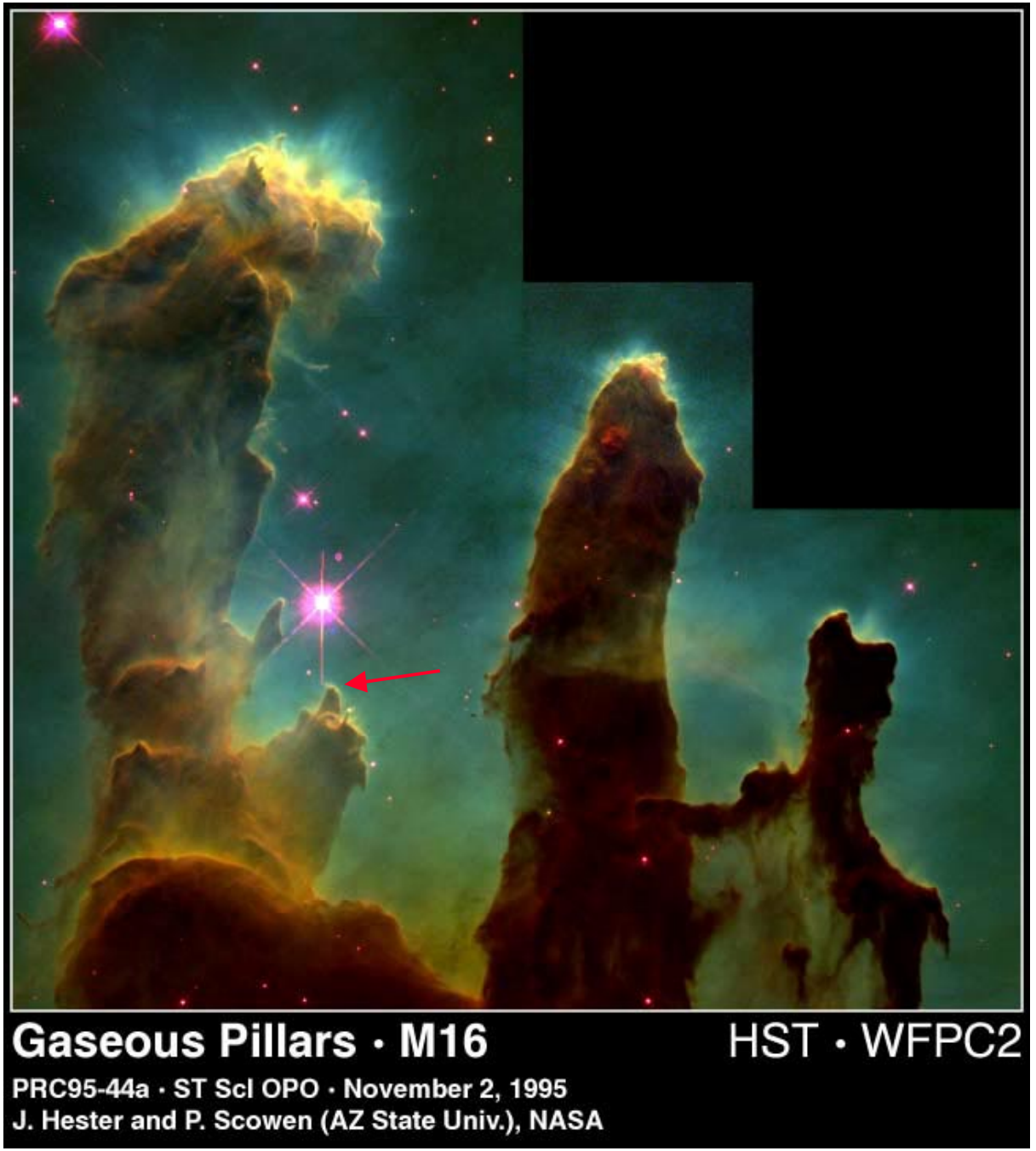
"Dark" Clouds



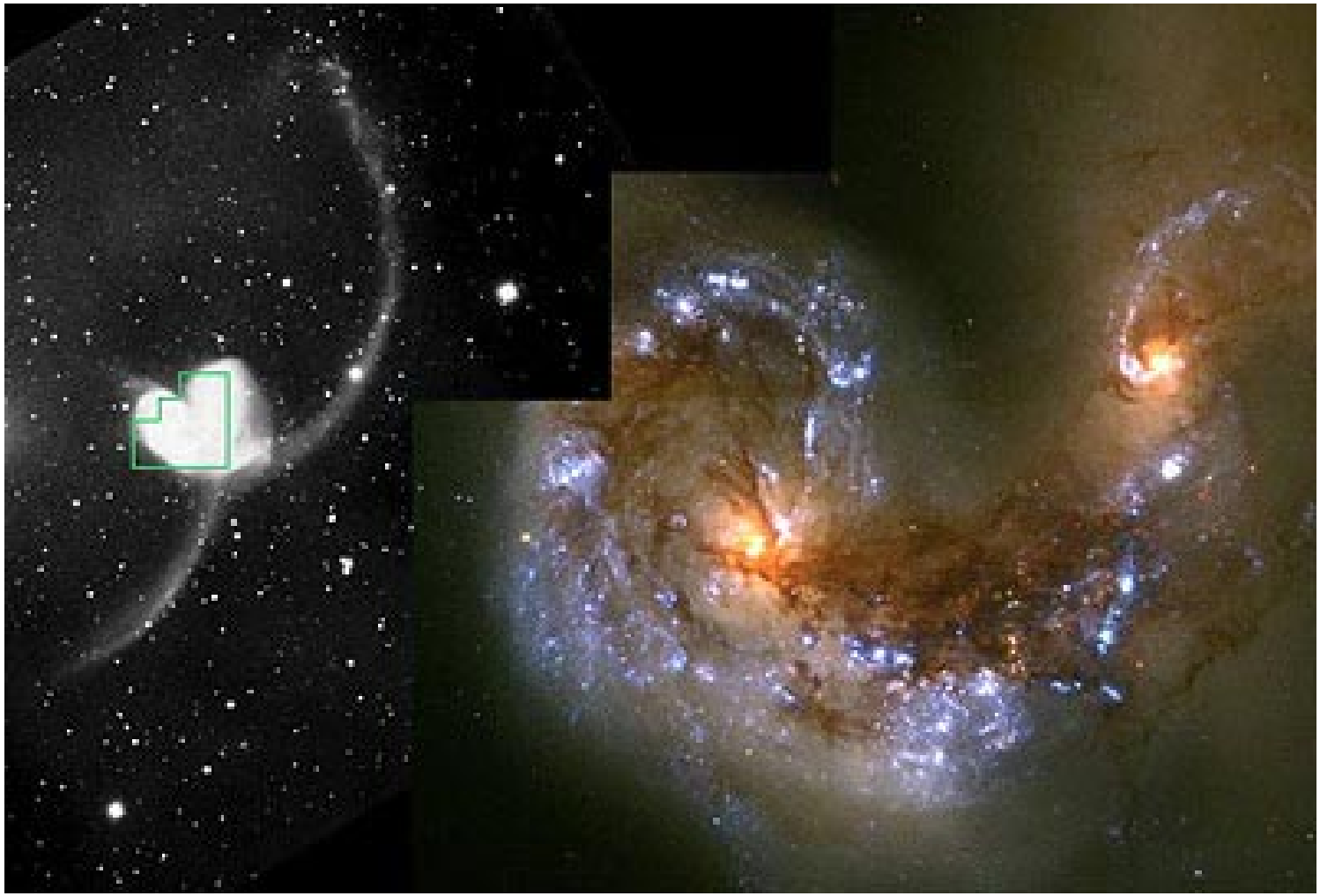

HH30
HH34
HH47
Jets from Young Stars
HST • WFPC2
PRC95-24a · ST ScI OPO · June 6, 1995
C. Burrows (ST ScI), J. Hester (AZ State U.), J. Morse (ST ScI), NASA

(Unusual?) Stellar Nursery in the Eagle Nebula





Star Formation Caused by A Galaxy Collision (a.k.a. igniting the trash)



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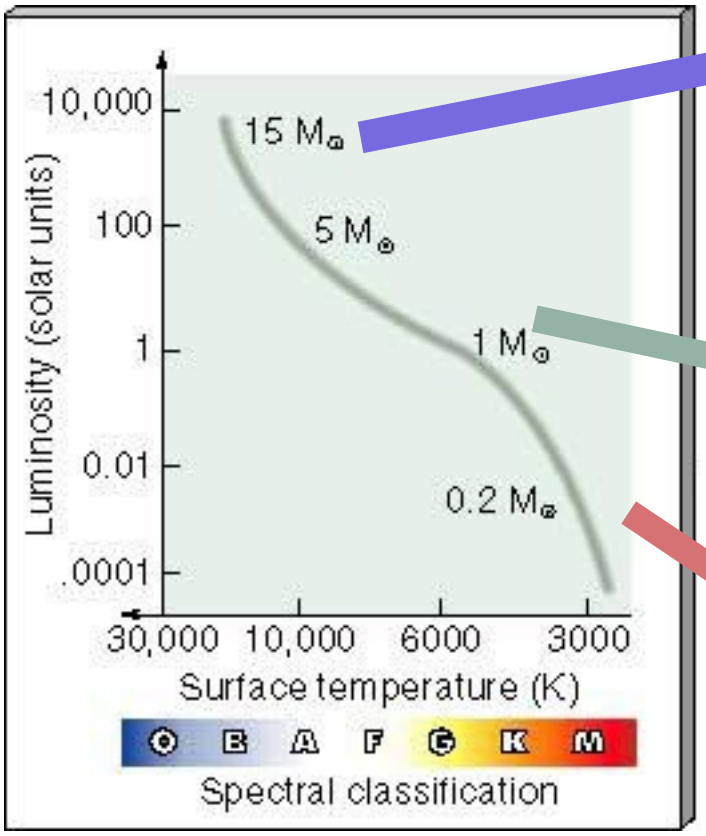

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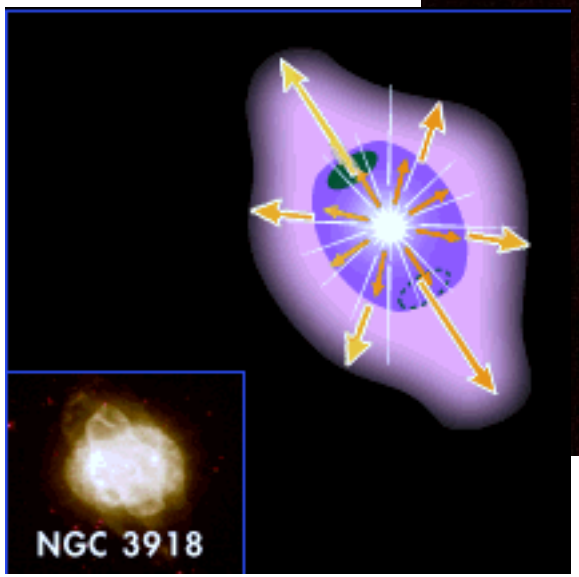
"Excess Gas?"

Post-red-giant planetary nebula



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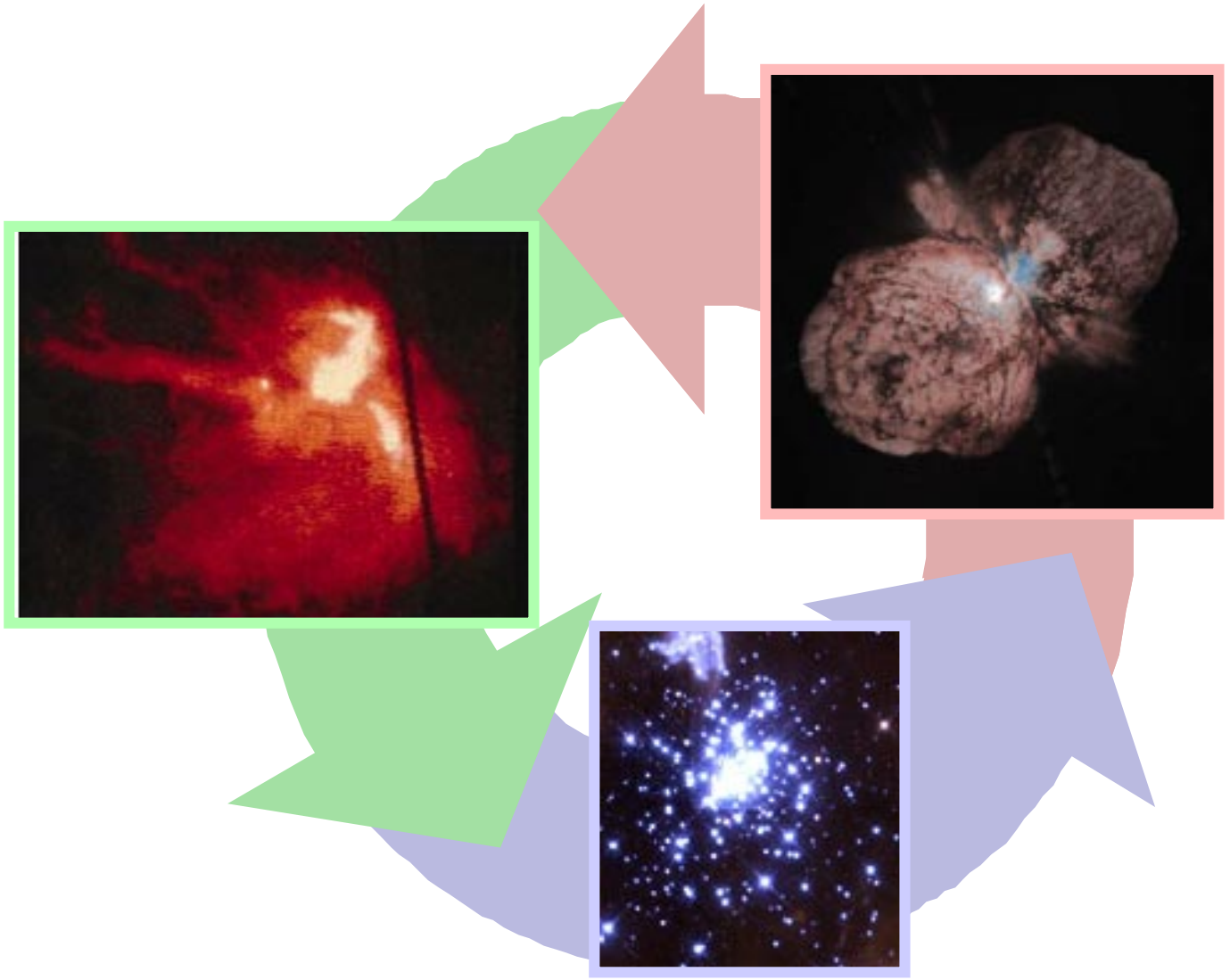
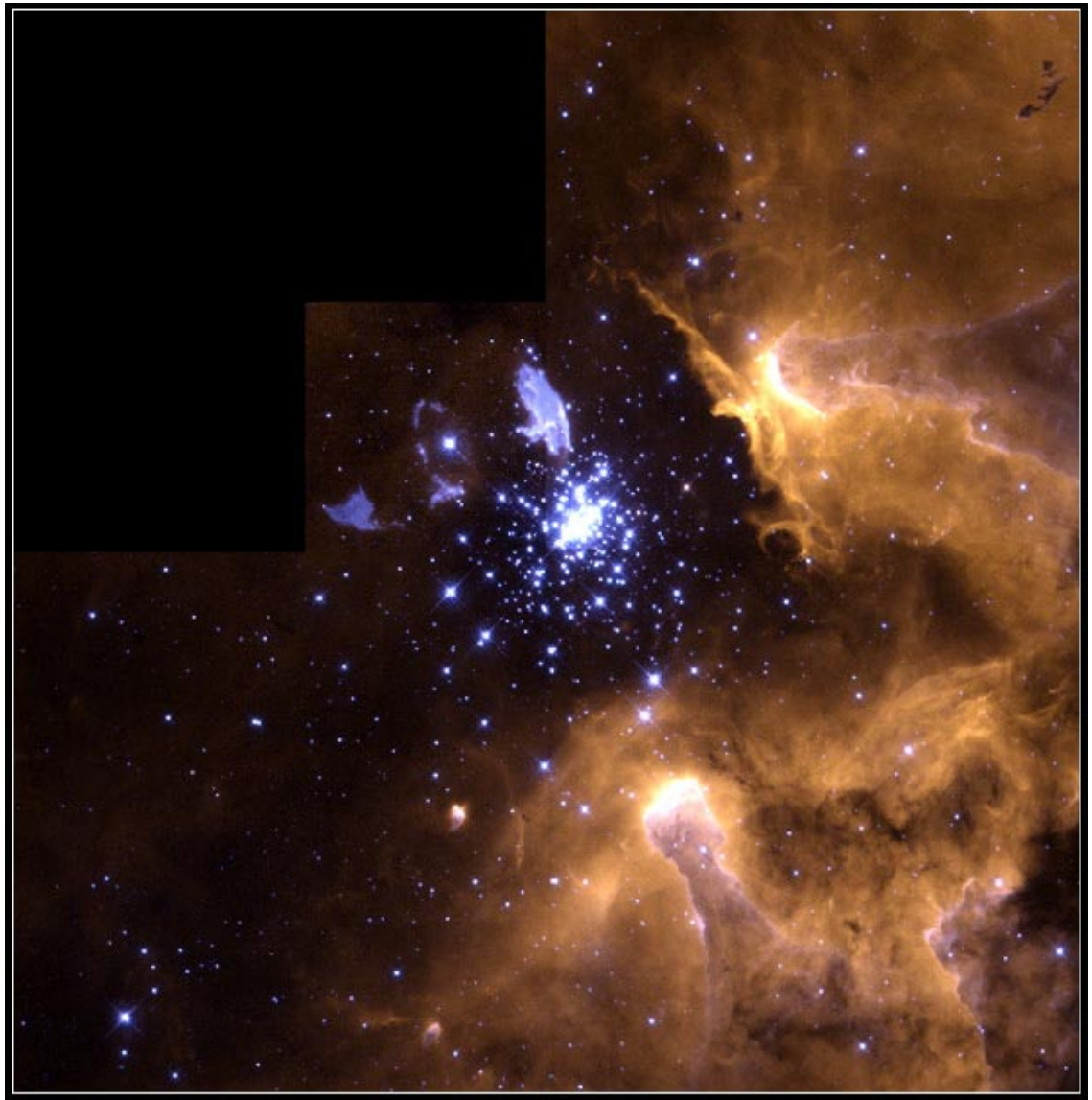


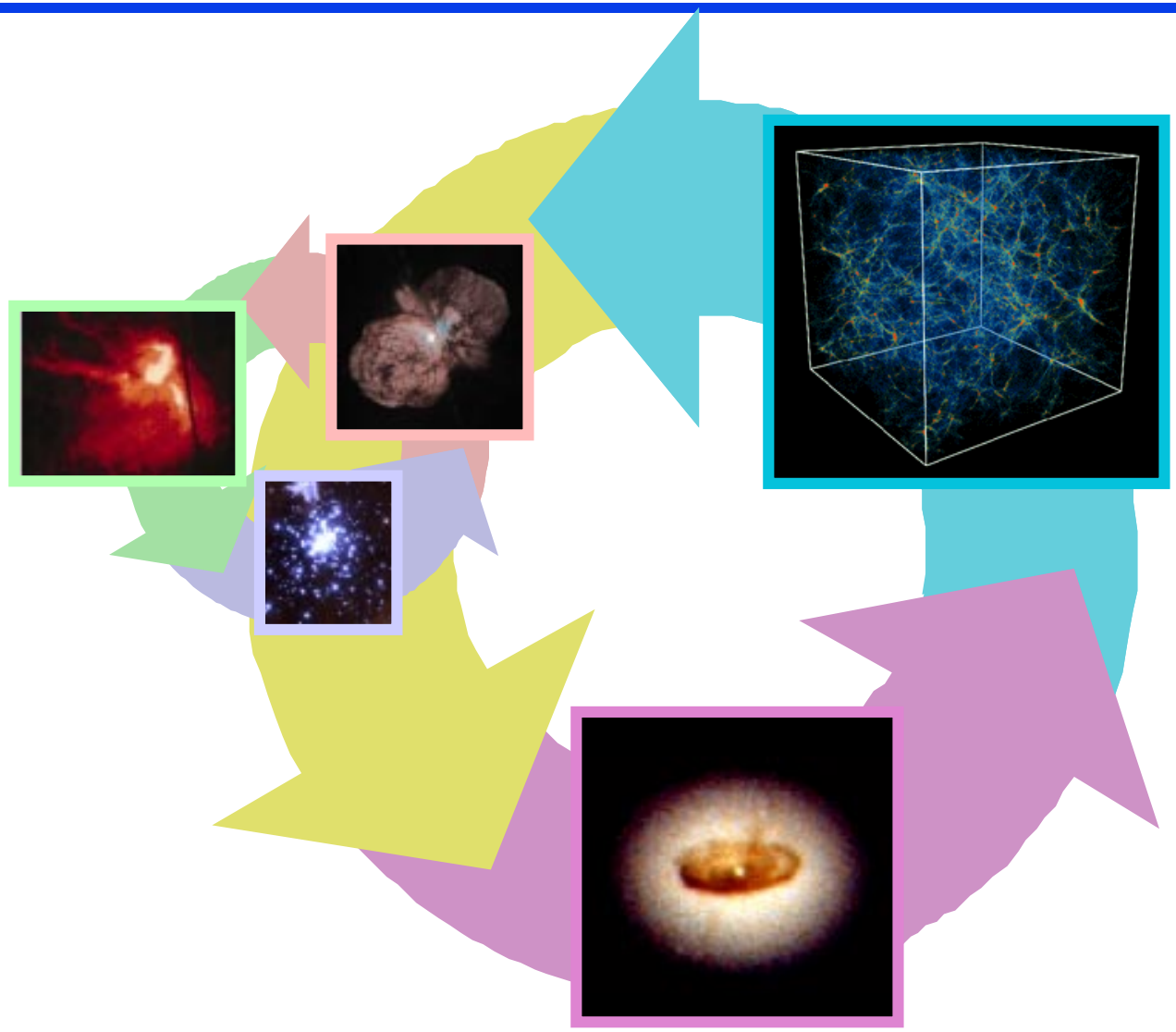


NGC 3603 **HST** • WFPC2

PRC99-20 • STScI OPO • June 1, 1999

Wolfgang Brandner (JPL/IPAC), Eva K. Grebel (Univ. Washington), You-Hua Chu (Univ. Illinois, Urbana-Champaign) and NASA

Recycling in the Universe(?)



Thanks to the MMO!

For more information, or an
on-line version of this talk, visit:

cfa-www.harvard.edu/~agoodman