Tracing the origin of elements with NuPyCEE

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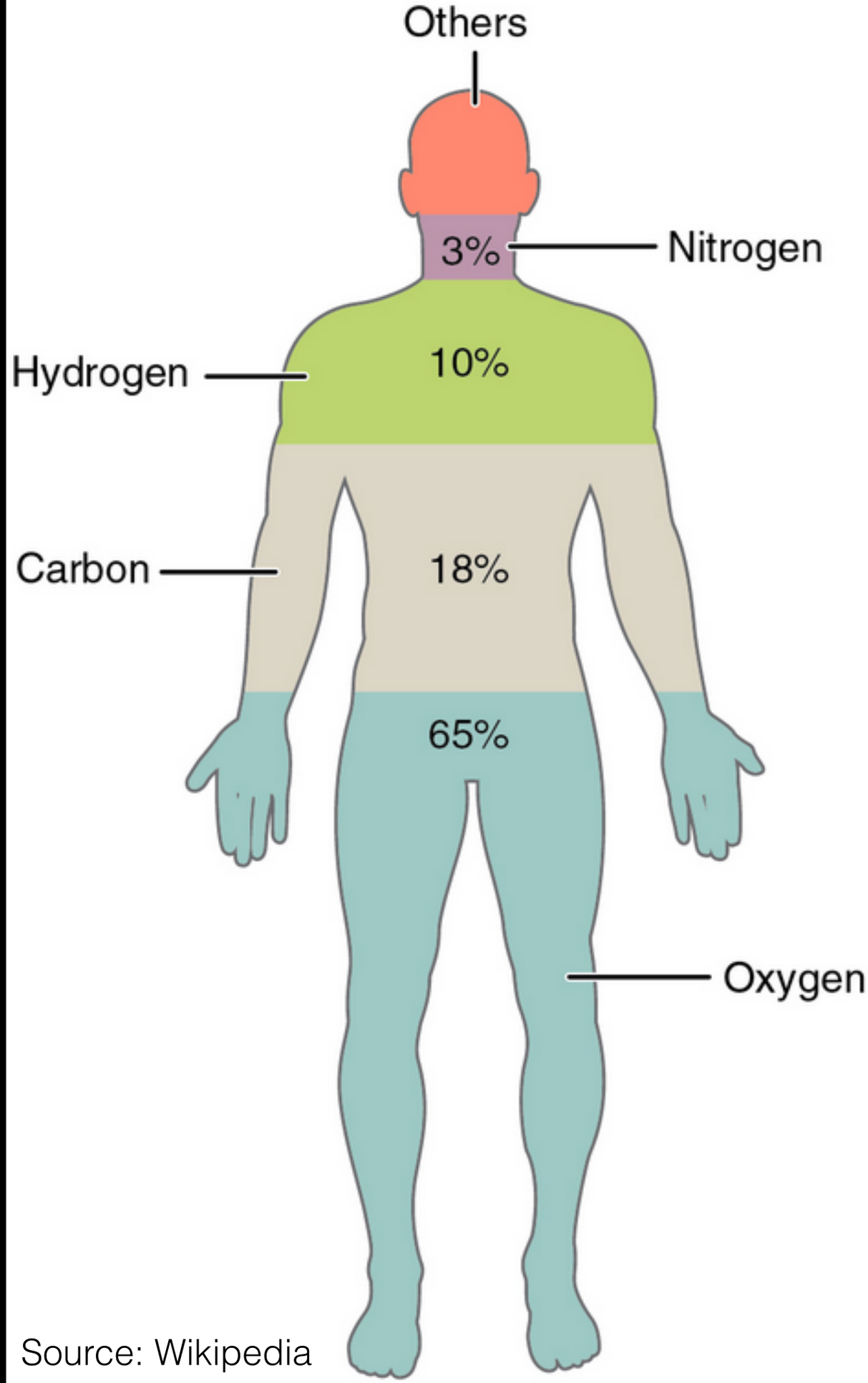
Orion Nebula, Source: NASA's Hubble Space Telescope

Recipe for a human

- ✳65% Oxygen
- ✳18% Carbon
- ✳10% Hydrogen
- ✳3% Nitrogen
- ✳Others

Where do all elements come from?



Source: Wikipedia

Element enrichment in stars

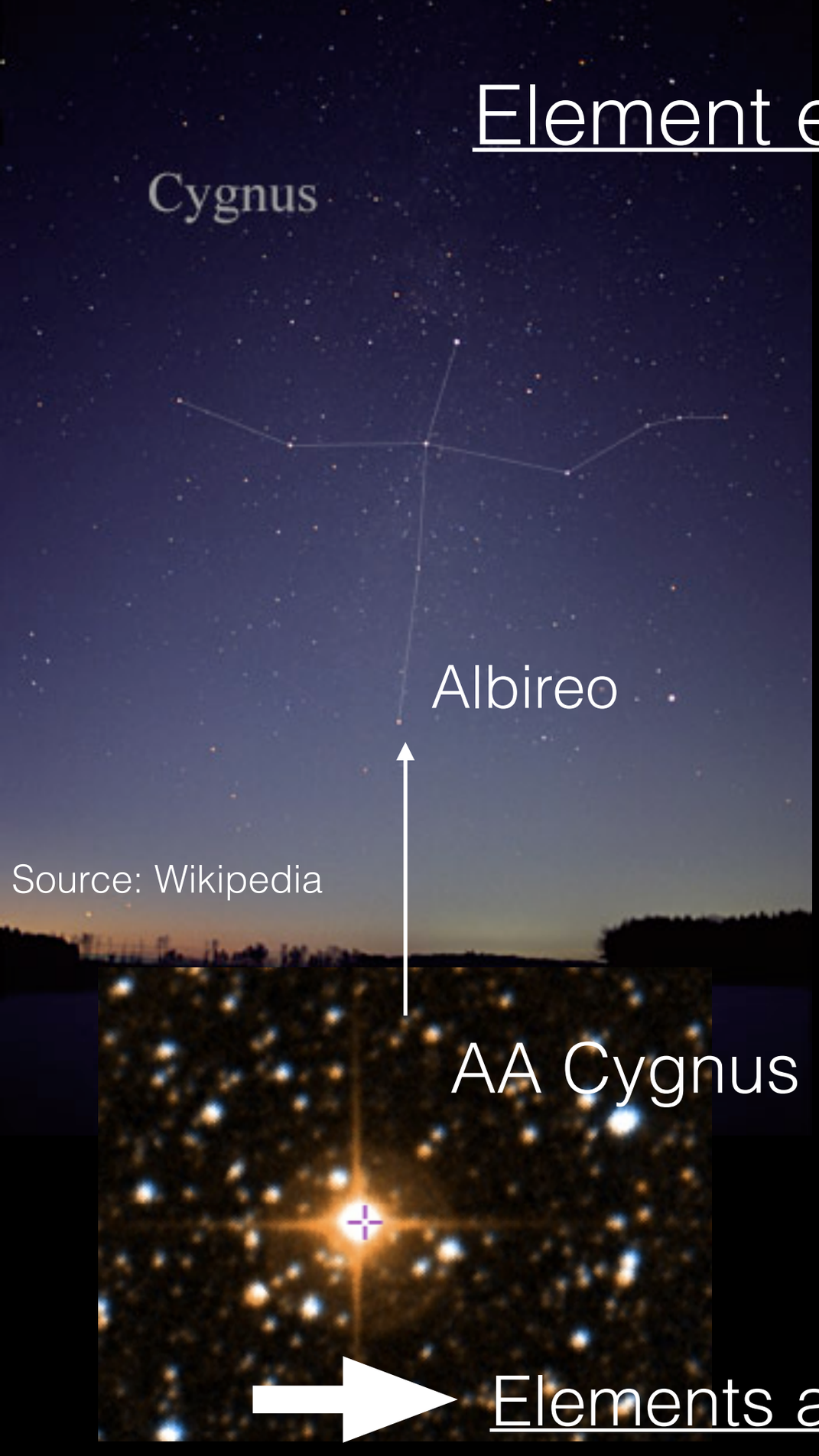
HD19445

Methuselah star (HD 140283)

Sources: http://simbad.u-strasbg.fr/simbad

Ca and Fe in different amounts observed in stars above (Camberlain & Aller 1951)

Element enrichment in stars



- No stable isotopes of Tc
- BUT: Observed in various amounts in stars such as AA Cygnus and R Cygnus (Merrill 1952)

Sources: http://simbad.u-strasbg.fr/simbad

Elements are produced in stars!

Andromeda galaxy

800.000.000.000 stars

Element production in billions of stars over billions of years.

How are the synthesized elements ejected?

Source: NASA

Element enrichment through powerful stellar winds and explosions

Crab Nebula

Source: Wikipedia

Cassiopeia A

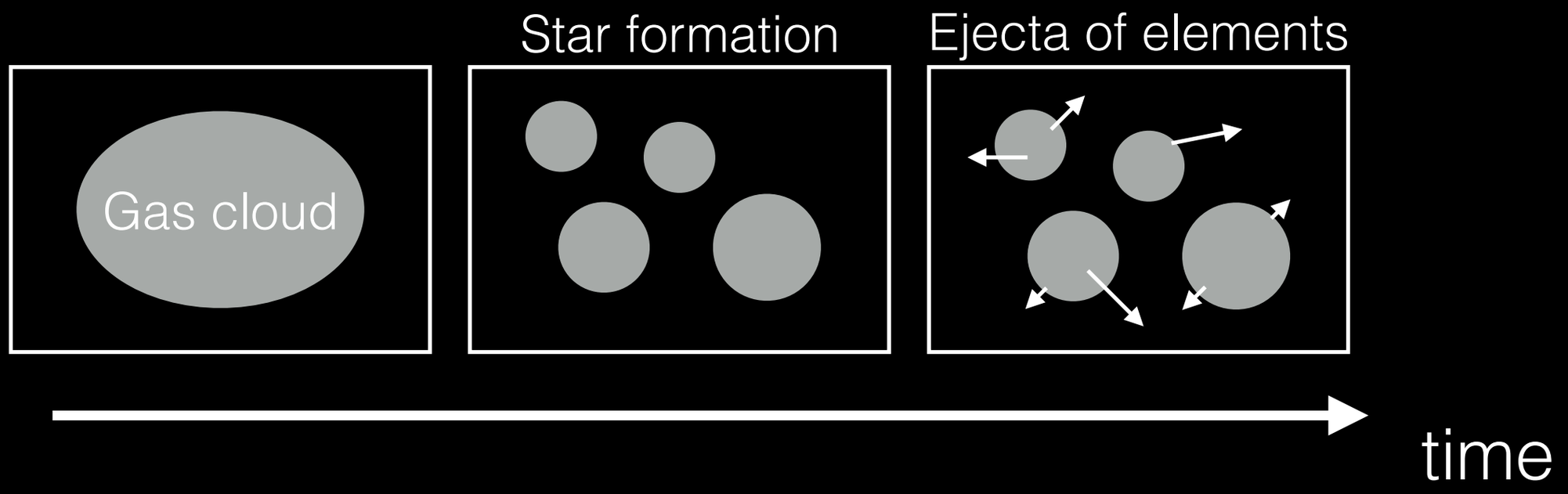
Cats Eye

Hourglass Nebula

Sources: Wikipedia

A generation of stars formed under the same conditions and initial composition:

Simple stellar population (SSP)



SYGMA: Fold stellar yields (ejecta) into simple stellar populations

Basic input for SYGMA

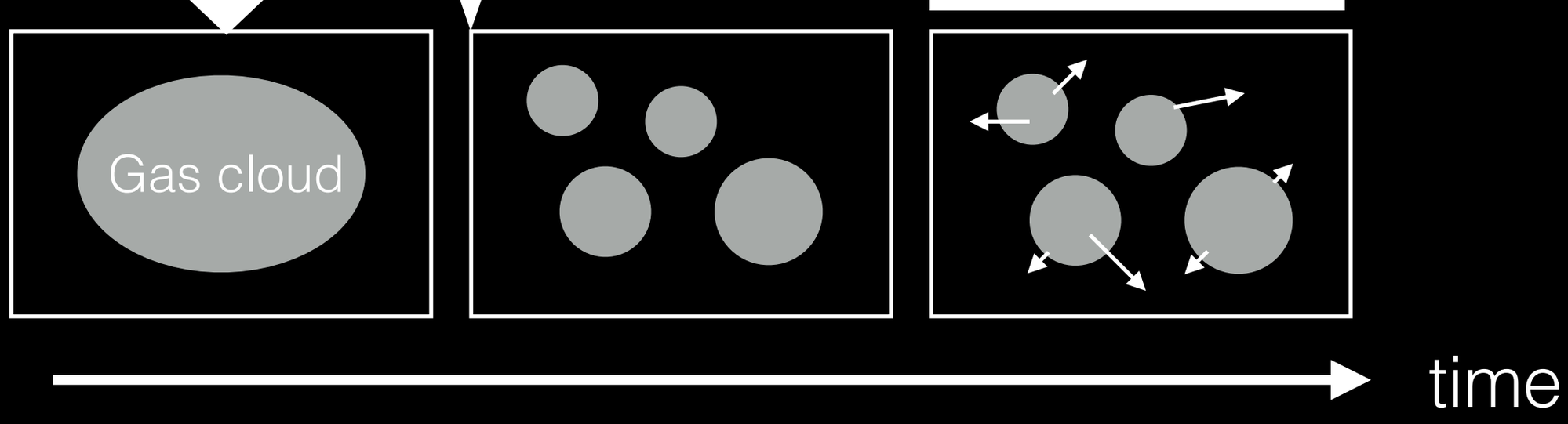
input from stellar models

SSP assumptions

- Total mass
- Initial metallicity

- IMF type
- IMF range
- SNIa modeling
- …..

Stellar yields of
- Low-mass stars
- Massive stars
- Supernova
- …..



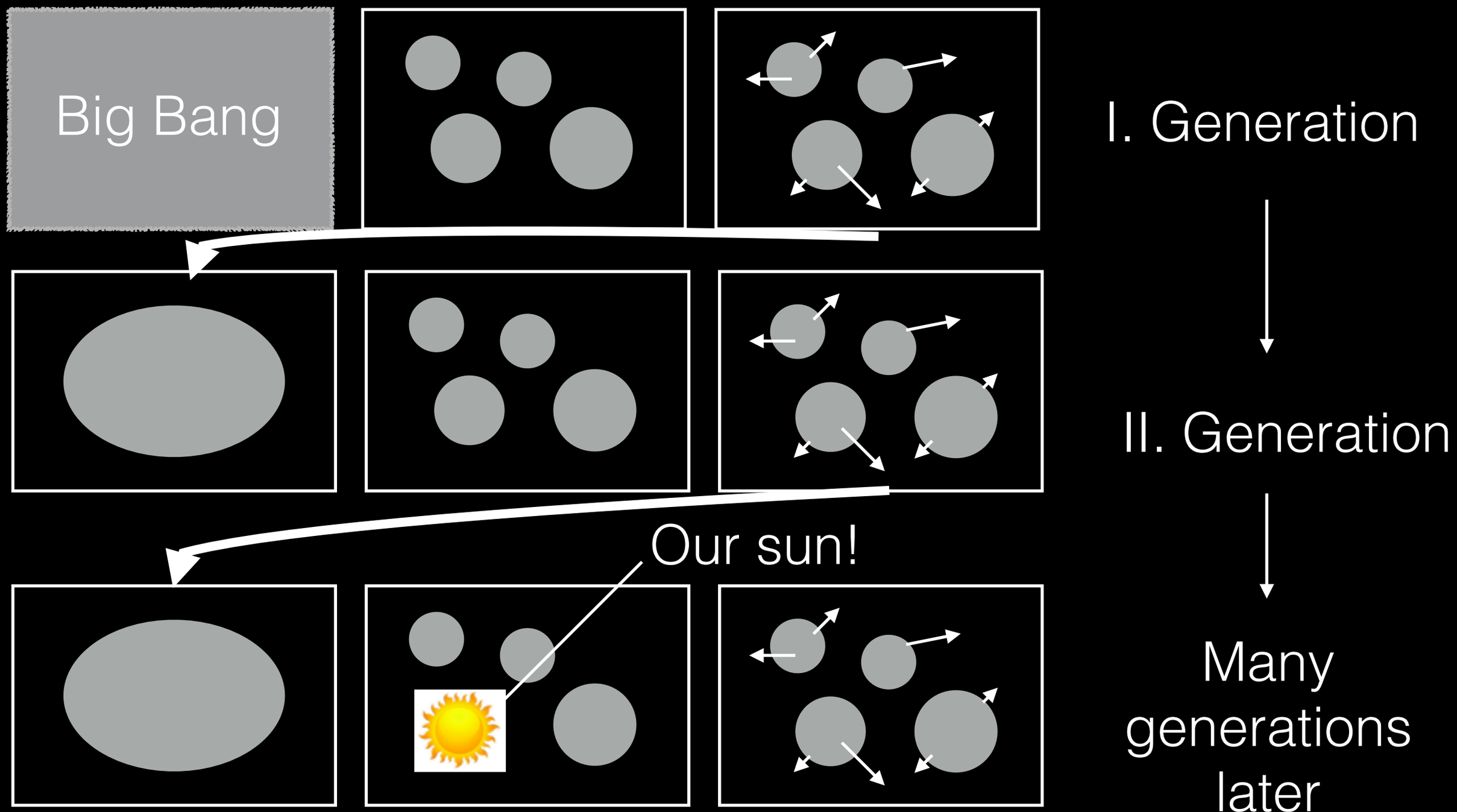
SYGMA output:

Total ejecta of elements and isotopes over time

+ other quantities such as total luminosity

Multiple generations of stars

OMEGA: Chemical evolution of galaxies



Metals (elements beyond He)
recycled in the next generation of stars.

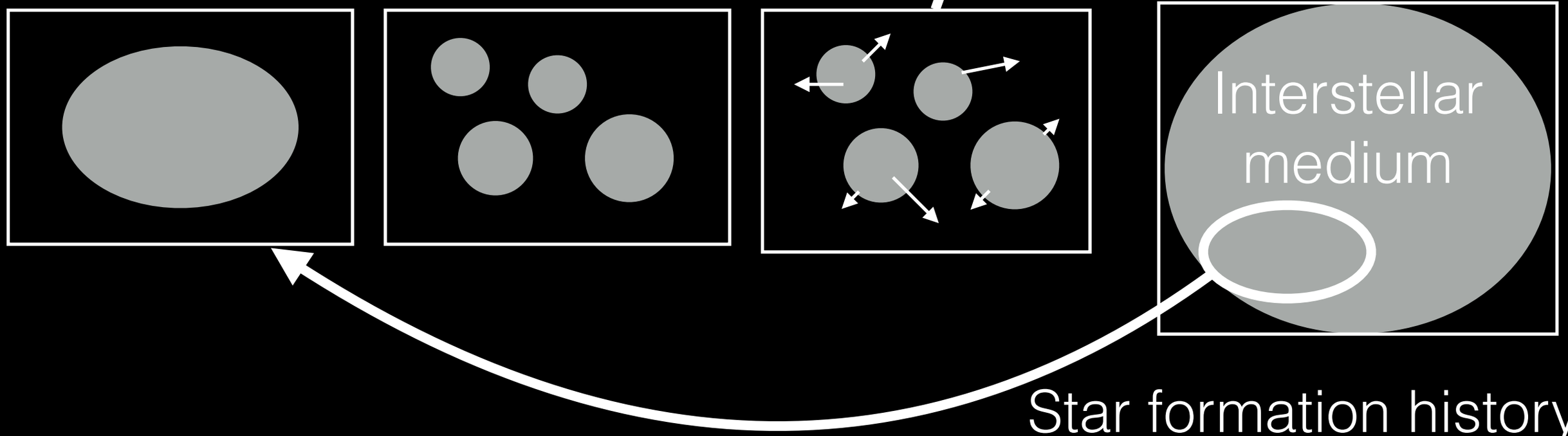
Basic input for OMEGA

OMEGA input

Inflows Outflows

OMEGA input

SSP assumptions



Star formation history

OMEGA input

OMEGA output:

Total ejecta of elements and isotopes over time

+ other quantities such as metallicity-distribution function

Applications with SYGMA

- SSP ejecta for galactic modeling applications including dark matter + baryonic content
- Probe the impact of nuclear physics and model assumptions on chemical evolution

Applications with OMEGA

- Reproduce observed abundance trends of disk and halo stars of the Milky Way
- Analyze the interplay of various nucleosynthesis source on the overall element production

Overview GettingStarted Modules Teaching Documentation Installation

Website with code: http://nugrid.github.io/NuPyCEE

NuPyCEE
NuGrid Python Chemical Evolution Environment
A NEW GENERATION python galaxy framework