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What do you see here?

Using an analysis of the Hertzsprung-Russell diagram in astronomy to create a survey of disciplinary discernment.

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Overview

Astronomy is special

History of HR diagram

Potential problems for learning

Research project

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Astronomy

Astronomy is a special kind of science

No experiments

Can only observe

Time scales and distances are difficult to comprehend **Eriksson *et al.* (2014a)**

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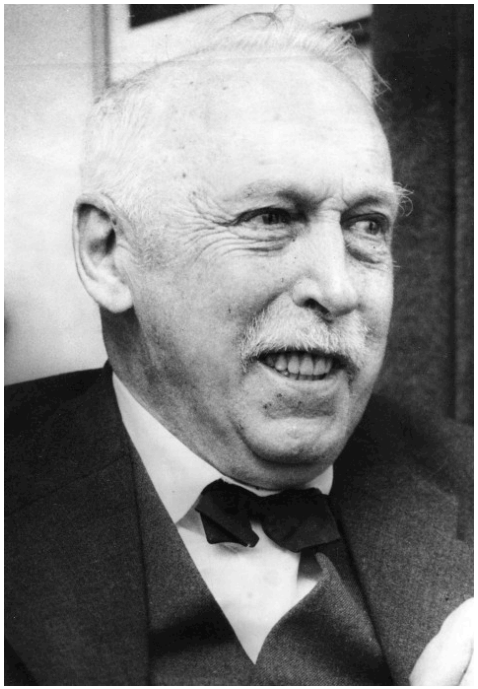
The Hertzsprung Russell Diagram



Ejnar Hertzsprung
1863-1967

Henry Norris Russell
1877-1957

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The HR diagram

Analysis of the disciplinary affordances of Hertzsprung-Russell (HR) diagram.

This is a semiotic resource used in astronomy that can be used to plot all known stars

Stars are formed, develop and evolve.

The position of a star on the HR diagram tells us its evolutionary stage and its final ”fate”

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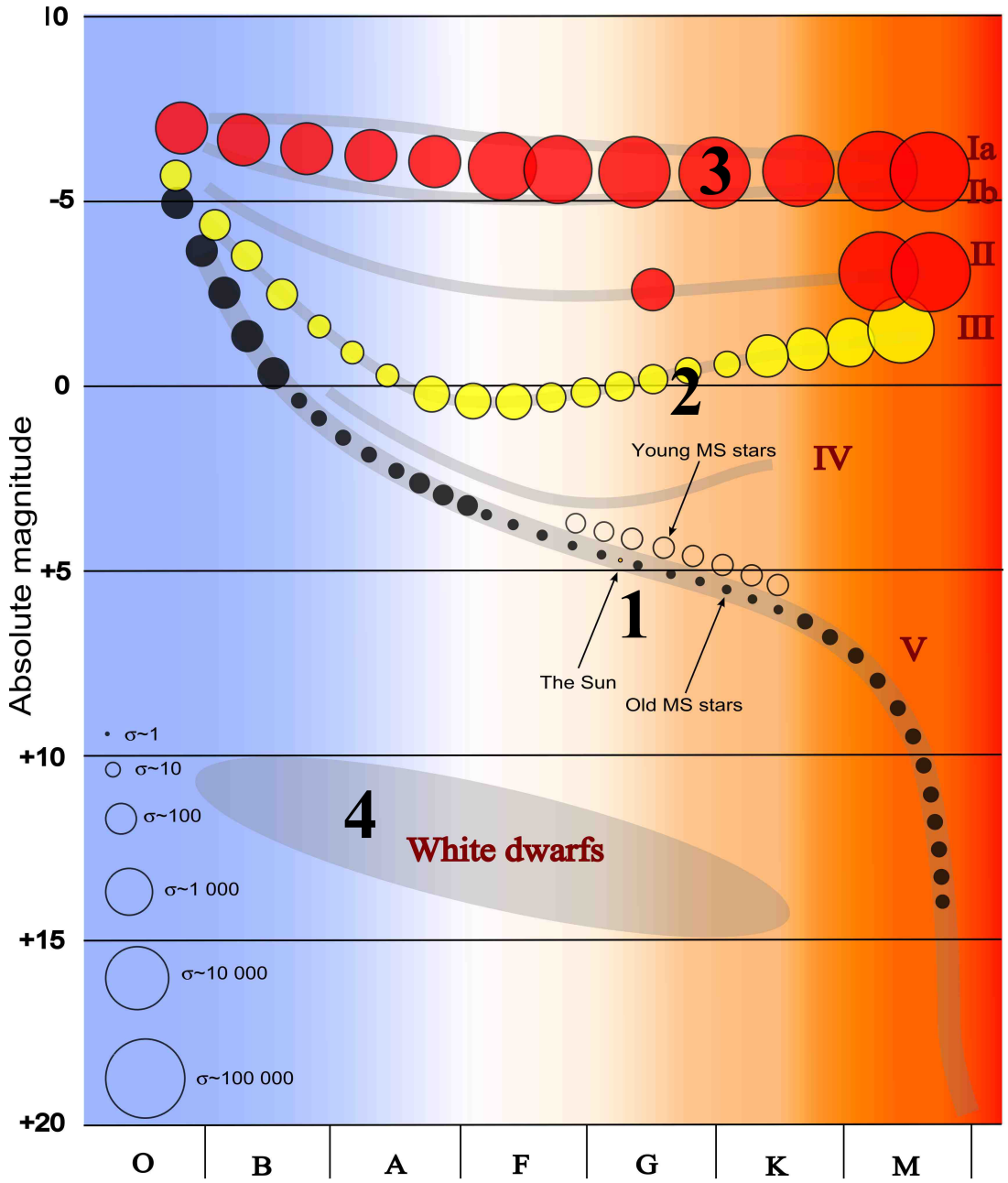
The HR diagram

What is an HR diagram?

A plot of how bright stars are against their surface temperature.

Major advance in understanding the ”lives of stars”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Young MS stars
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What do students experience?

- Complicated ’graph’
- Impossible to immediately interpret
- The disciplinary affordances are hidden

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Disciplinary affordance

Fredlund *et al.* (2012) suggest the term disciplinary affordance for semiotic resources

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Disciplinary affordance

Definition:

The potential of a given semiotic resource to provide access to disciplinary knowledge

Fredlund *et al.* (2012:658)

Deals with individual semiotic resources

Focuses on the *discipline's interpretation* of the *resource* rather than the learner's experience

Airey *et al.* (2014)

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Disciplinary learning

- Interested in learning…
- Students need the diagram to be *unpacked* or *reverse-rankshifted* for them Fredlund (2014)
- Students' experience of the HR diagram needs to move towards the disciplinary interpretation
- Need to start to discern the disciplinary affordances of the diagram.

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What are the disciplinary affordances?

Why does the diagram look like it does?

Need a little history lesson…

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Annie Jump Cannon

Born: 1863, Died: 1941

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Annie Jump Cannon

Astronomer from Harvard
Catalogued nearly 400 000 stars
Discovered 300 variable stars
First woman to gain a honorary doctorate from Oxford

Worked for at Harvard for 40 years but only received tenure two years before retirement.

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Annie Jump Cannon

Oh Be A Fine Girl Kiss Me

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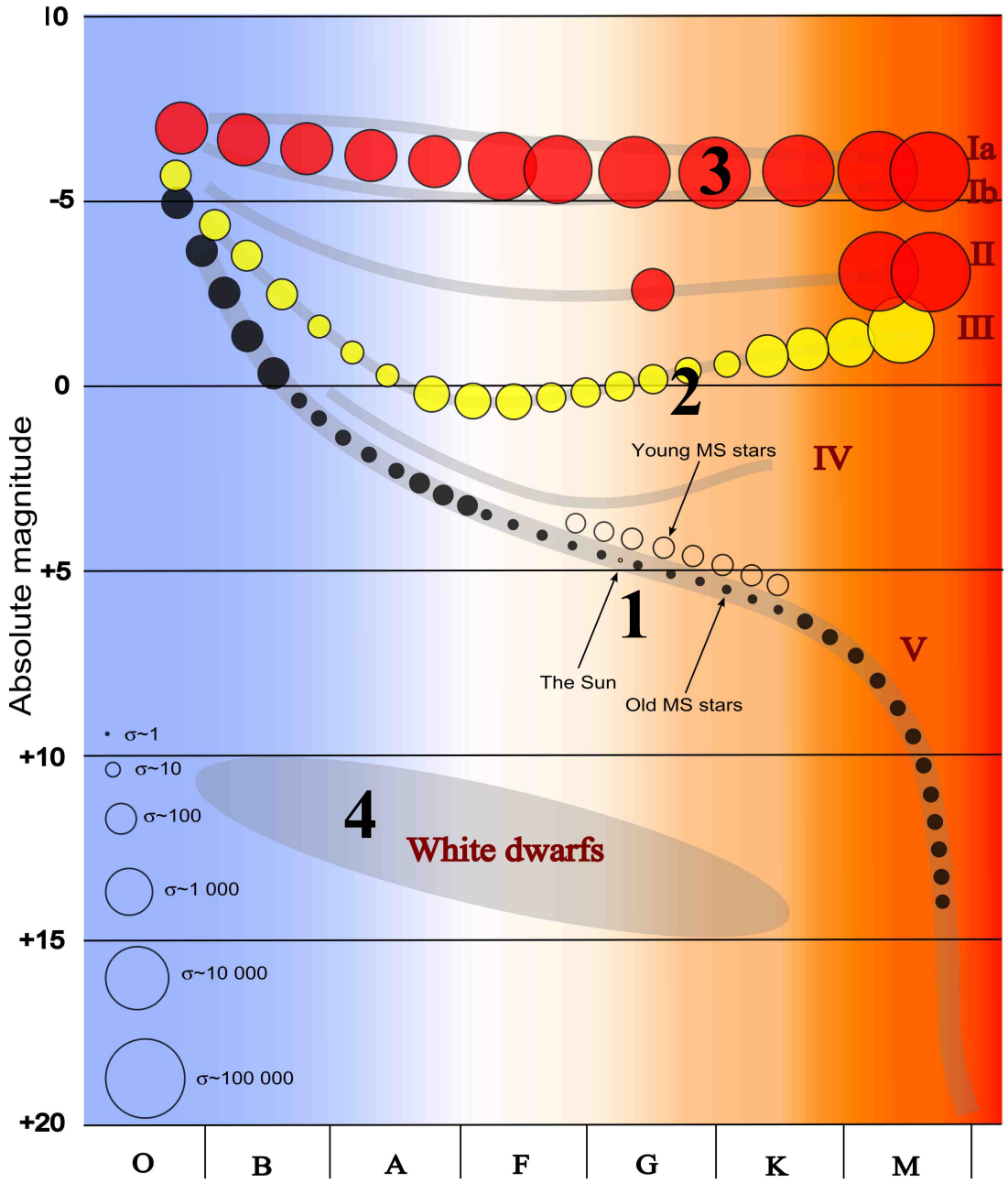
Annie Jump Cannon

Oh Be A Fine Girl Kiss Me

O B A F G K M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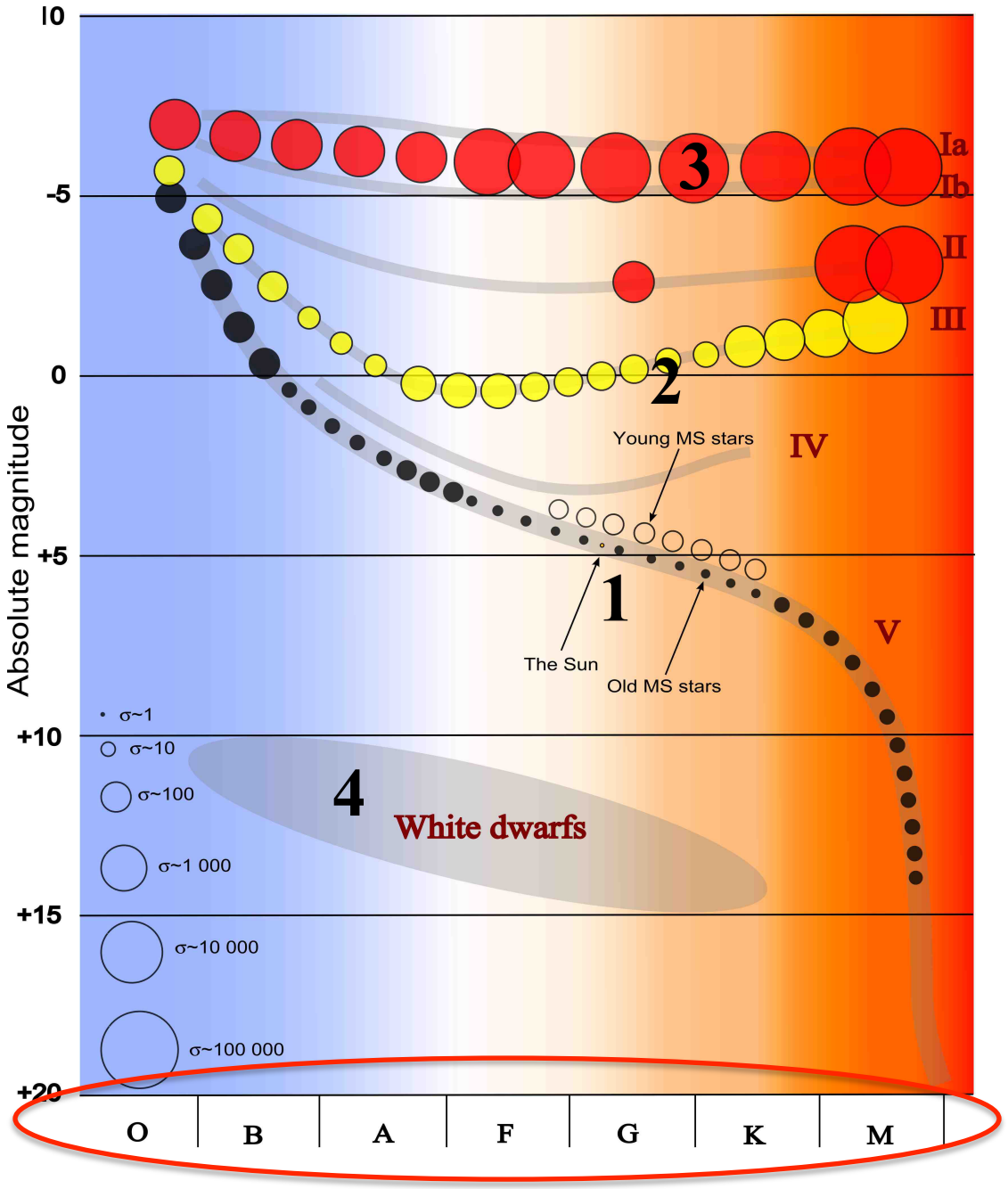
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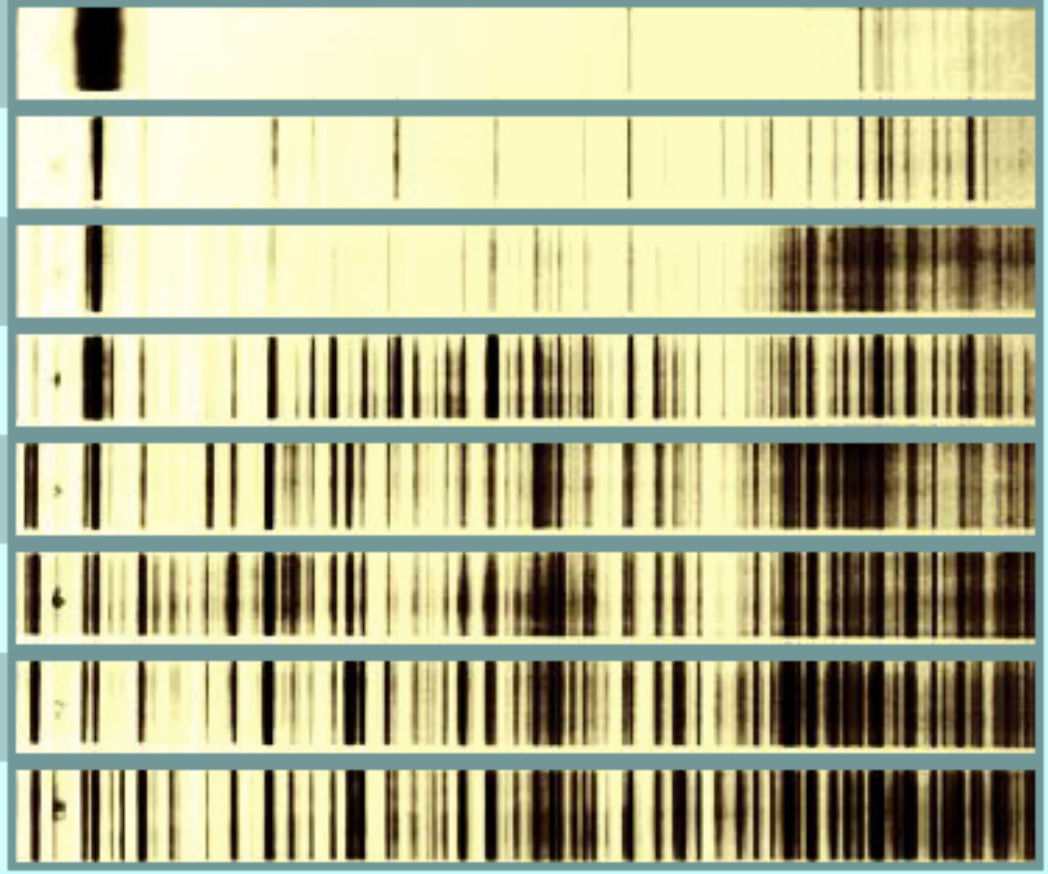
Spectra

Stars Representative of Different Spectral Classes

star	temp.	class
Sirius	10,000K	A1-V
Deneb	8,000K	A2-I
Procyon	7,000K	F5-IV
Algenib	6,500K	F5-I
Sun	5,700K	G2-V
Arcturus	4,500K	K2-III
Aldebaran	4,000K	K5-III
Betelgeuse	3,000K	M2-I



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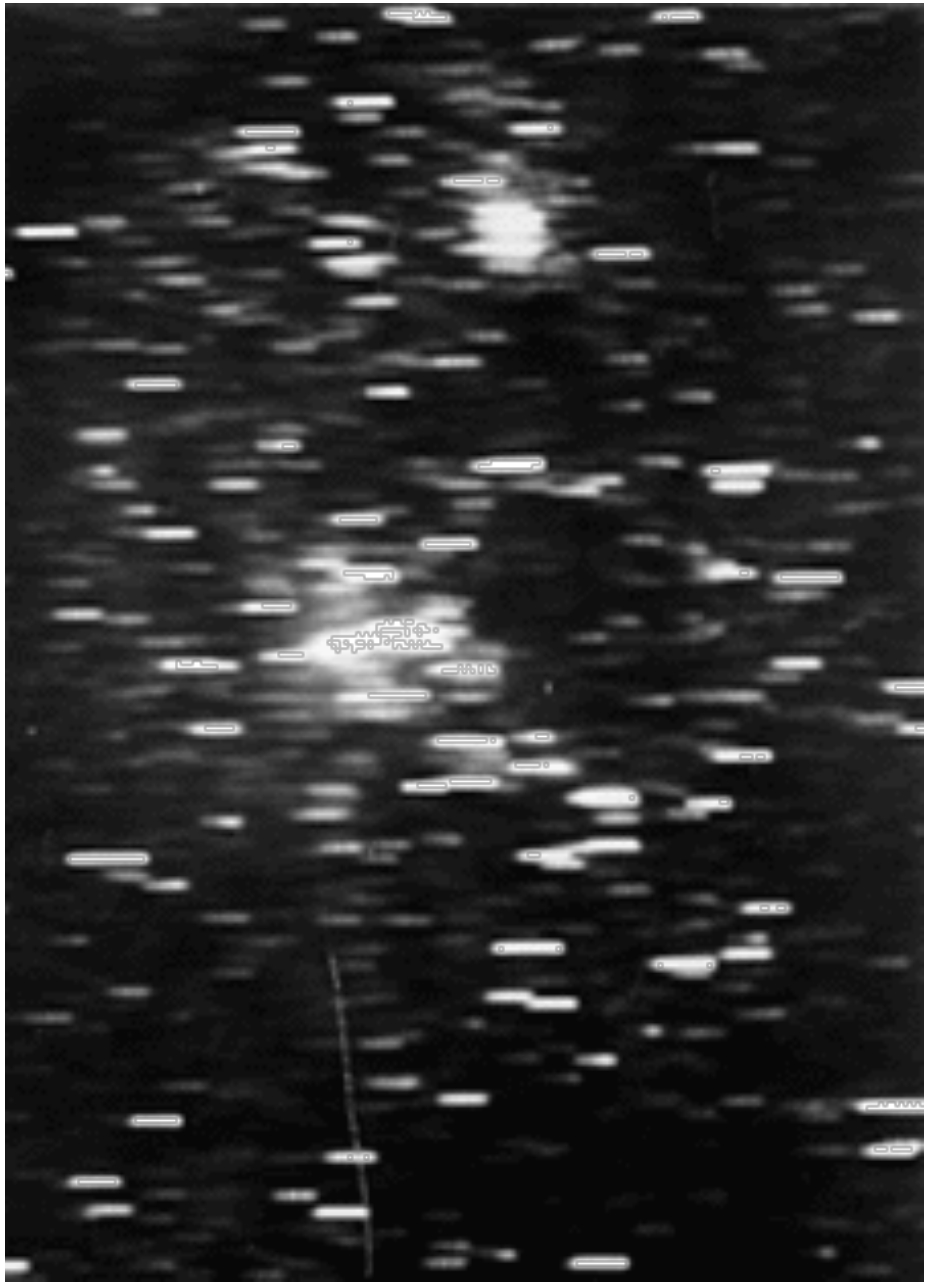

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Reordering the horizontal axis

The black and white photographs of the spectra of stars were originally labelled alphabetically from A-Q

Cannon realised that these essentially arbitary categories could be rationalized and re-ordered to make more sense from an astrophysical point of view

The original 17 alphabetical categories became seven ordered O B A F G K M

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New meaning for the horizontal axis

Discoveries in physics later showed that this ordering on the horizontal axis of the HR diagram was related to the surface temperature of stars.

Blue occurs at higher temperatures, while red occurs at lower, cooler, temperatures.

When our everyday lives when we think of colour we think of *reflected light*

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New meaning for the horizontal axis

Surface temperature of stars decreases we as move through Cannon's classification from O to M

Right on the HR diagram means colder

This means the HR diagram has a doubly counter-intuitive horizontal axis

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New meaning for the horizontal axis

Opposite to the cultural associations attributed to colors, in which "red" is "hot", and "blue" is "cold”.

In astronomy blue is *very* hot

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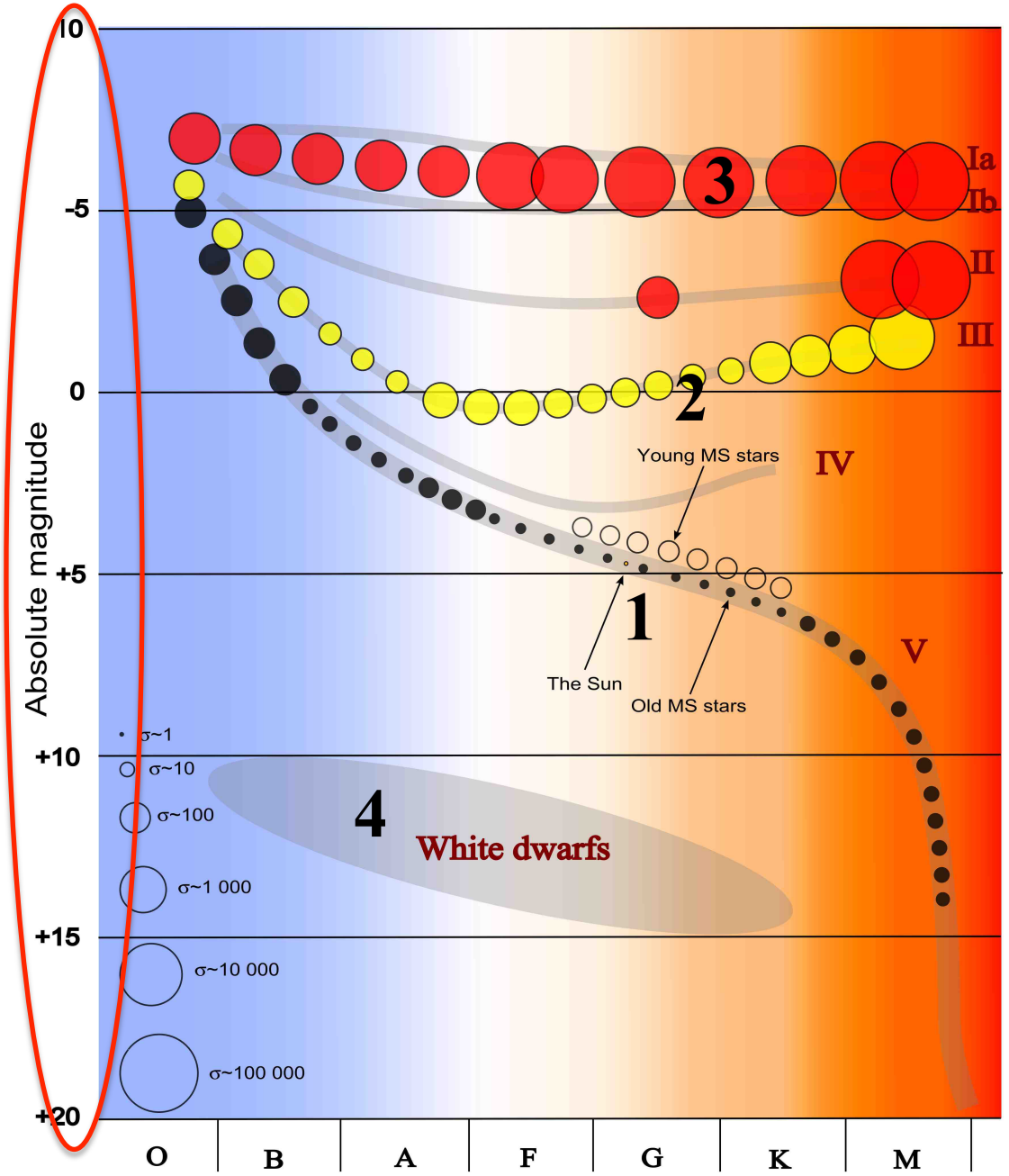
Counter-intuitive

Culturally we expect red to be hot and blue to be cold

We also expect graphs to move from lower quantities on the left to higher quantities on the right.

So history leaves us with essentially random labelling OBAFGKM of a counter-intuitive temperature scale

What about the vertical axis ?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Brightness

The vertical axis on the HR diagram is linked to how bright a star is—its *Apparent magnitude*

Apparent magnitude

Hipparchos (≈150 B.C.)

Six levels:

Brightest: magnitude 1

Faintest: magnitude 6

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Brightness

Stars are at different distances from us.

Astronomers want a brightness value that is comparable.

Absolute magnitude: how bright a star would be at a standard distance.

(10 parsec about 31000000000000 km)

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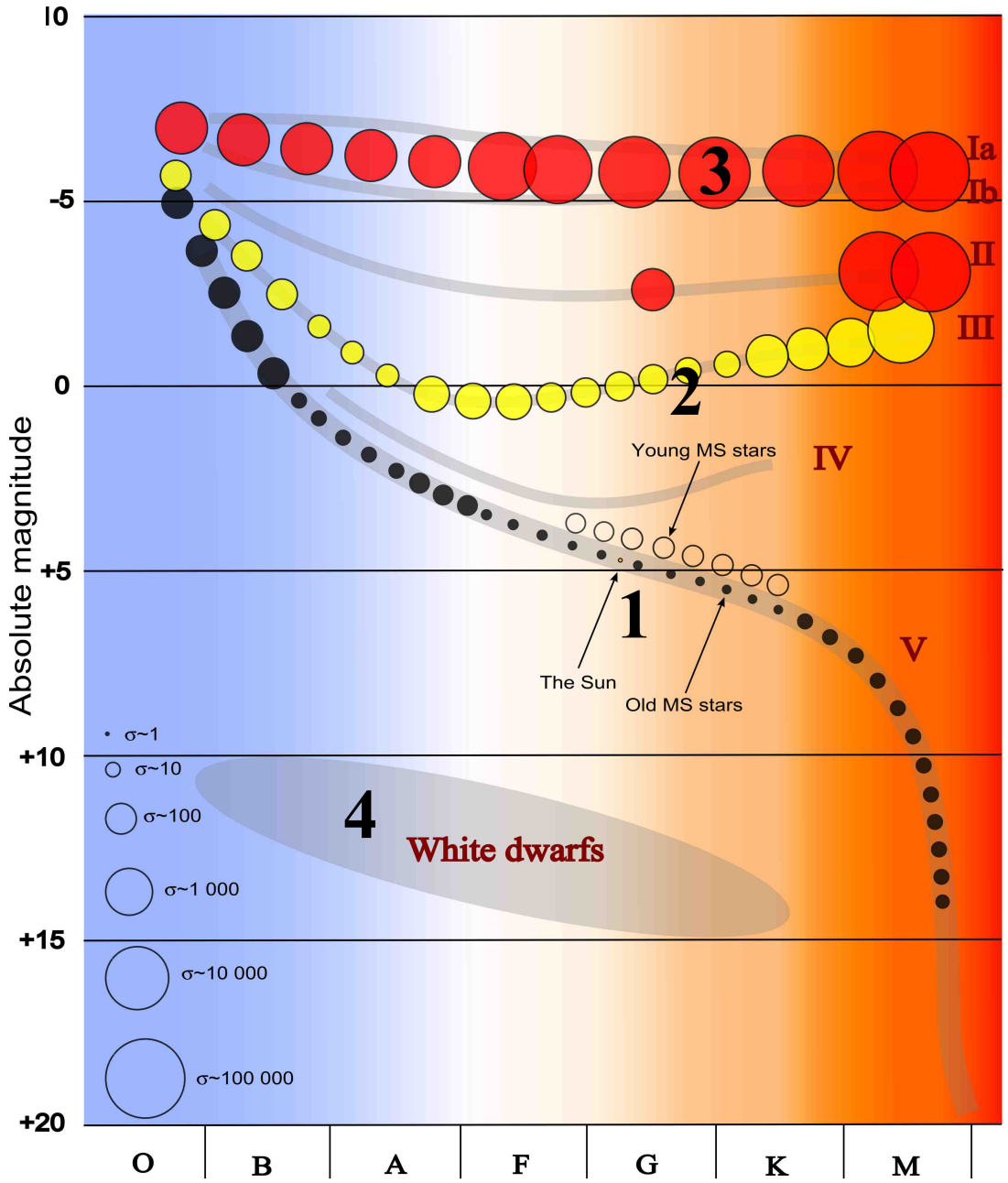
The lives of stars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The lives of stars

One further counter intuitive element.

The anthropomorphic idea of the lives of stars.

When people die they get cold-right?

But when stars ‘die’ they have a hotter surface temperature than when they are on the ‘main sequence’

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The study

Interested in how students experience the HR diagram

Online study

Students shown the diagram and asked questions about it.

Do the historical ‘remnants’ and the counterintuitive aspects of the diagram cause barriers to student learning?

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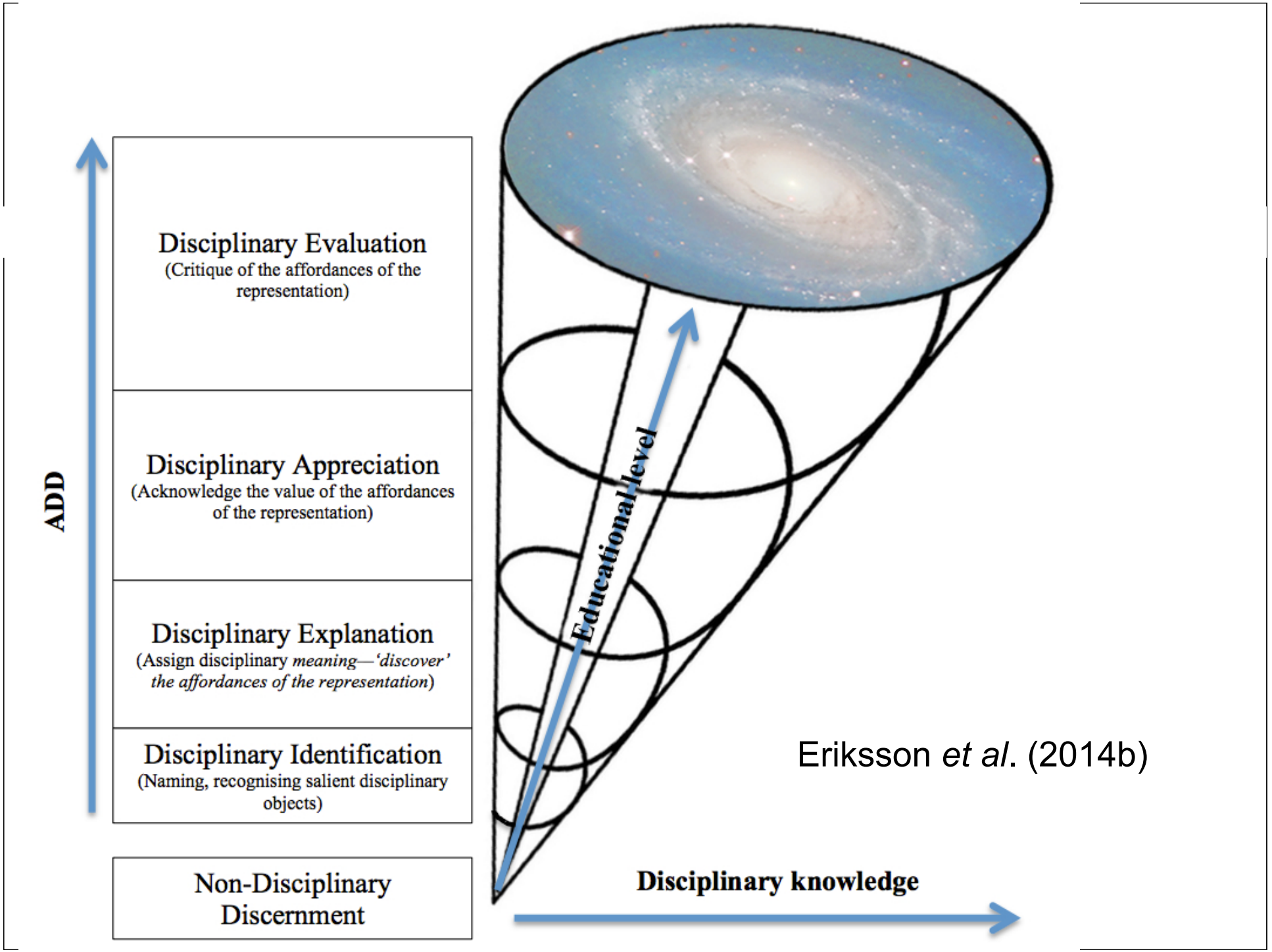
Use the concept of disciplinary discernment to analyse our data…



Eriksson *et al*. (2014b)

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Thank you for listening!

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