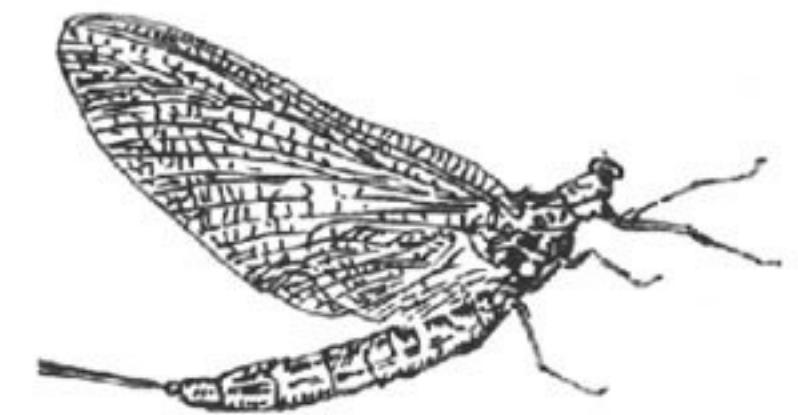

Galaxy Morphology

25.04.29

Mayflies

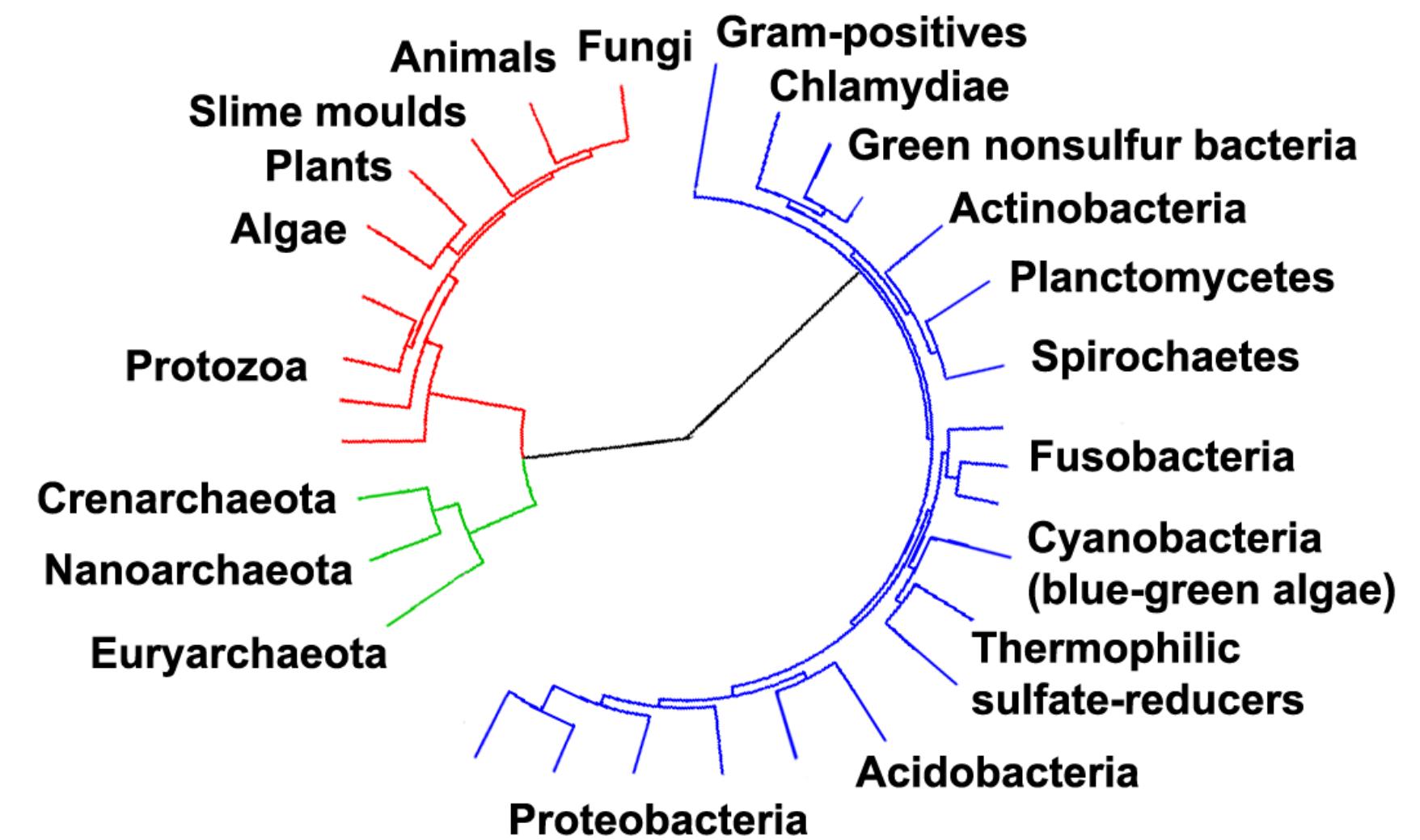
“Compared to a star, we are like mayflies, fleeting ephemeral creatures who live out their whole lives in the course of a single day. From the point of view of a mayfly, human beings are stolid, boring, almost entirely immovable, offering hardly a hint that they ever do anything. From the point of view of a star, a human being is a tiny flash, one of billions of brief lives flickering tenuously on the surface of a strangely cold, anomalously solid, exotically remote sphere of silicate and iron.”

-Carl Sagan 『Cosmos』(1980)



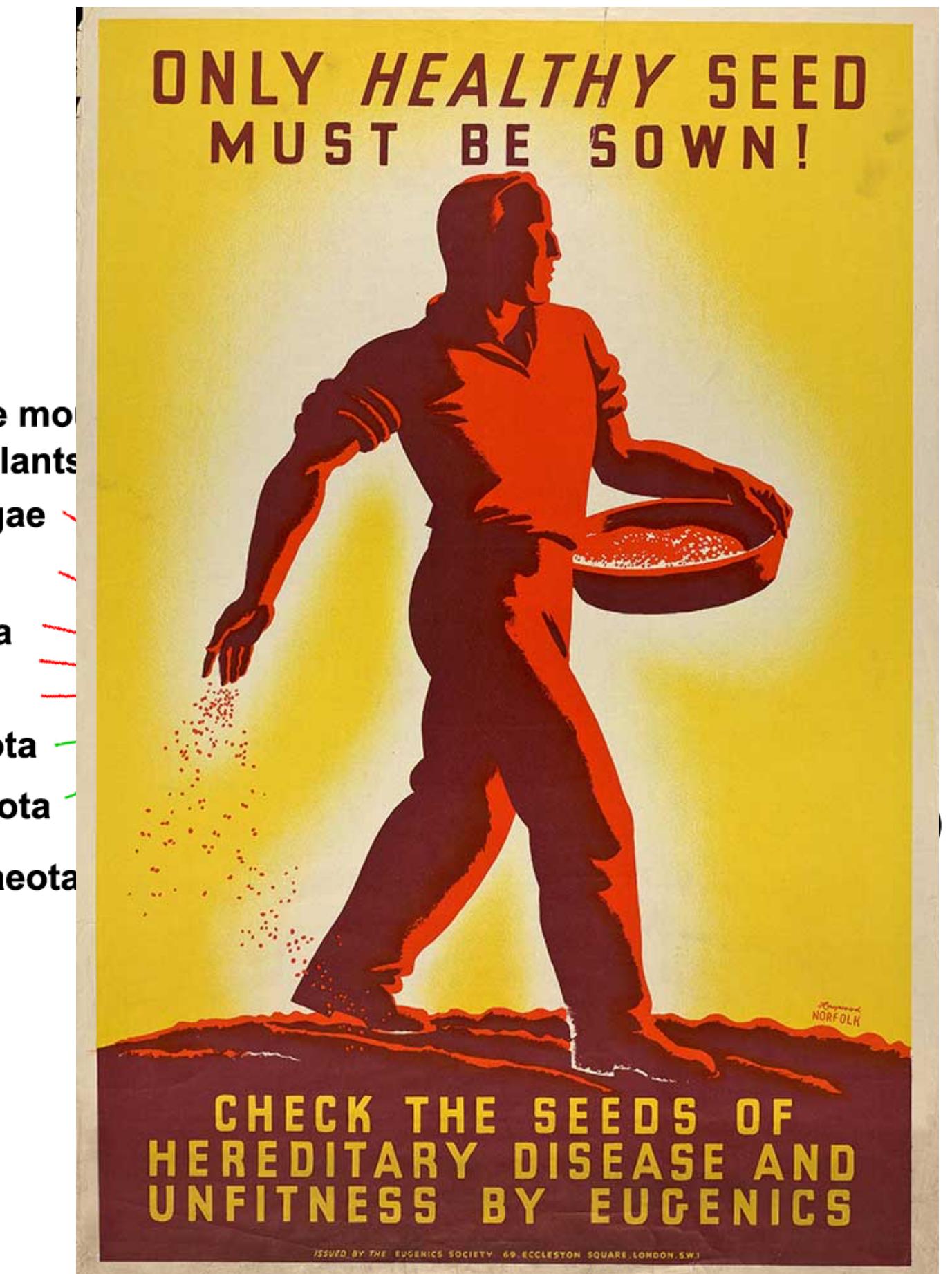
Classification

- **Classification** is one of the basic scientific approaches.
- Classification helps us understand the objects



Classification

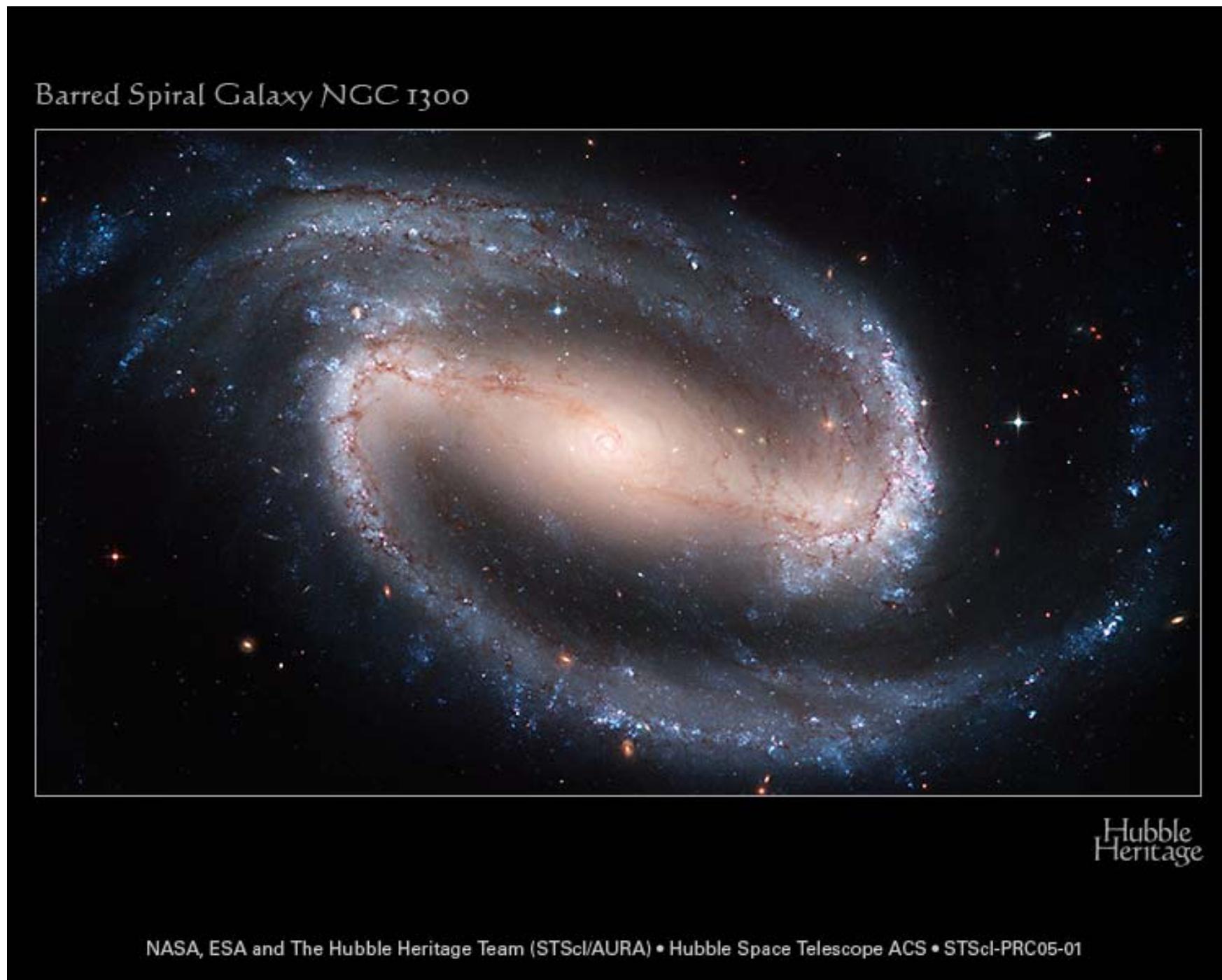
- **Classification** is one of the basic scientific approaches.
- Classification helps us understand the objects
- Classification requires **criteria**
- **And, we must always be prepared to criticize the criteria**



Classification - Galaxy

- Like ‘mayflies seeing human beings’, we cannot witness the growth (or evolution) of galaxies
 - (Except for AGN, we can observe their variability)
- However, we can observe **a number of galaxies**, then **classify** them to research.
 - How can we classify the galaxies?

What do you see?



NGC 1300

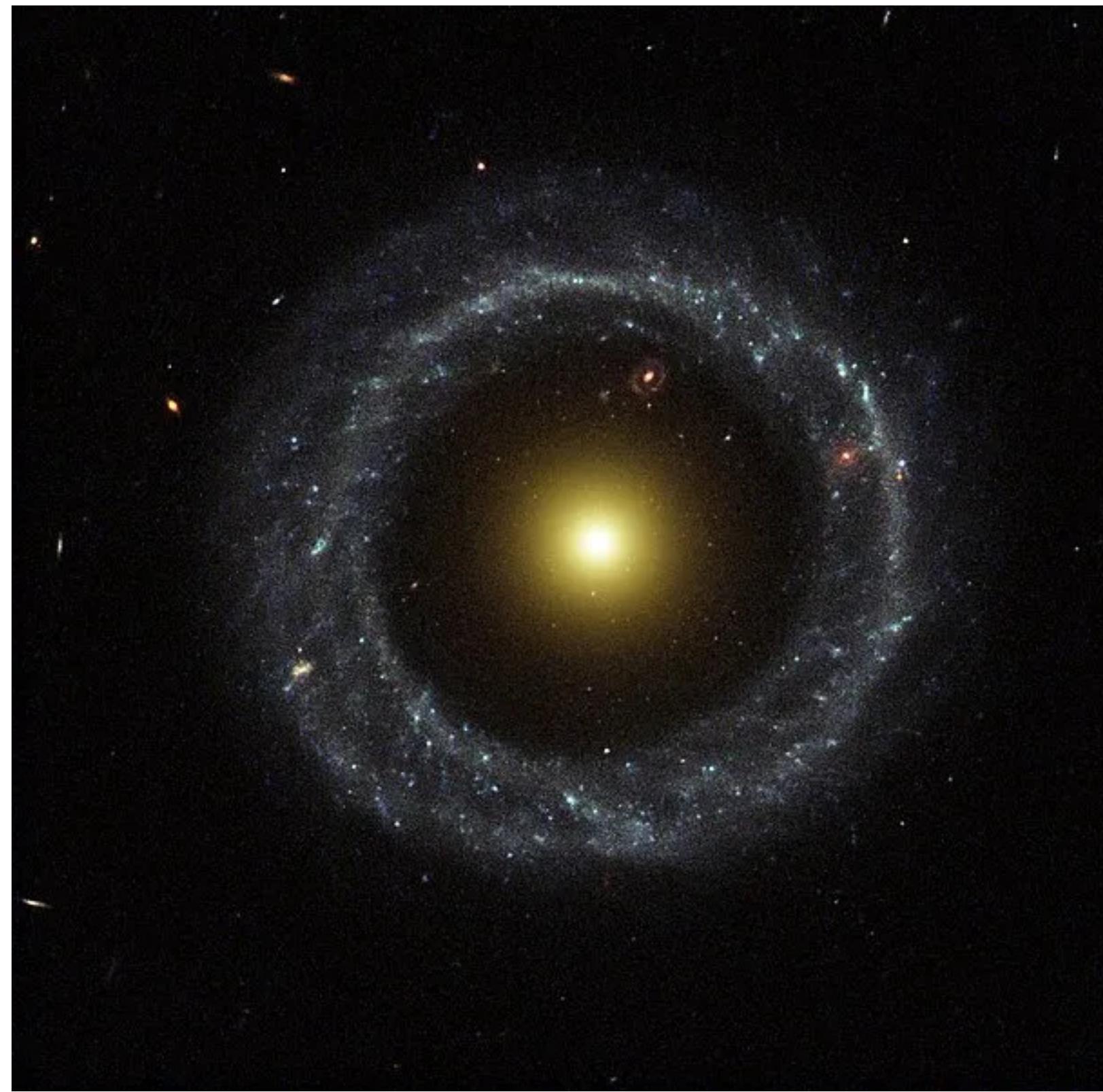


M61

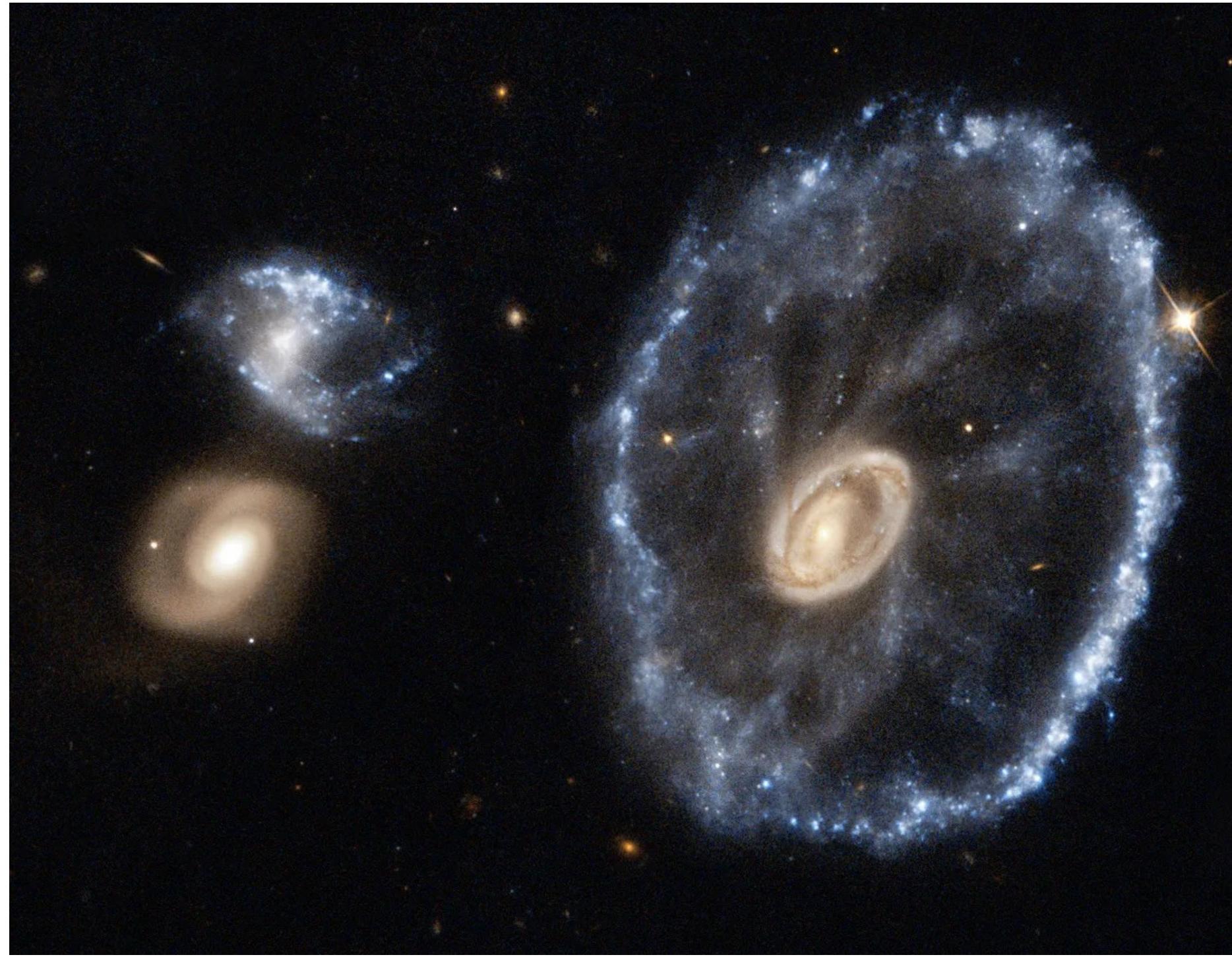


NGC 1132

What do you see?



Hoag's object (PGC54559)



Cartwheel galaxy (PGC2248)

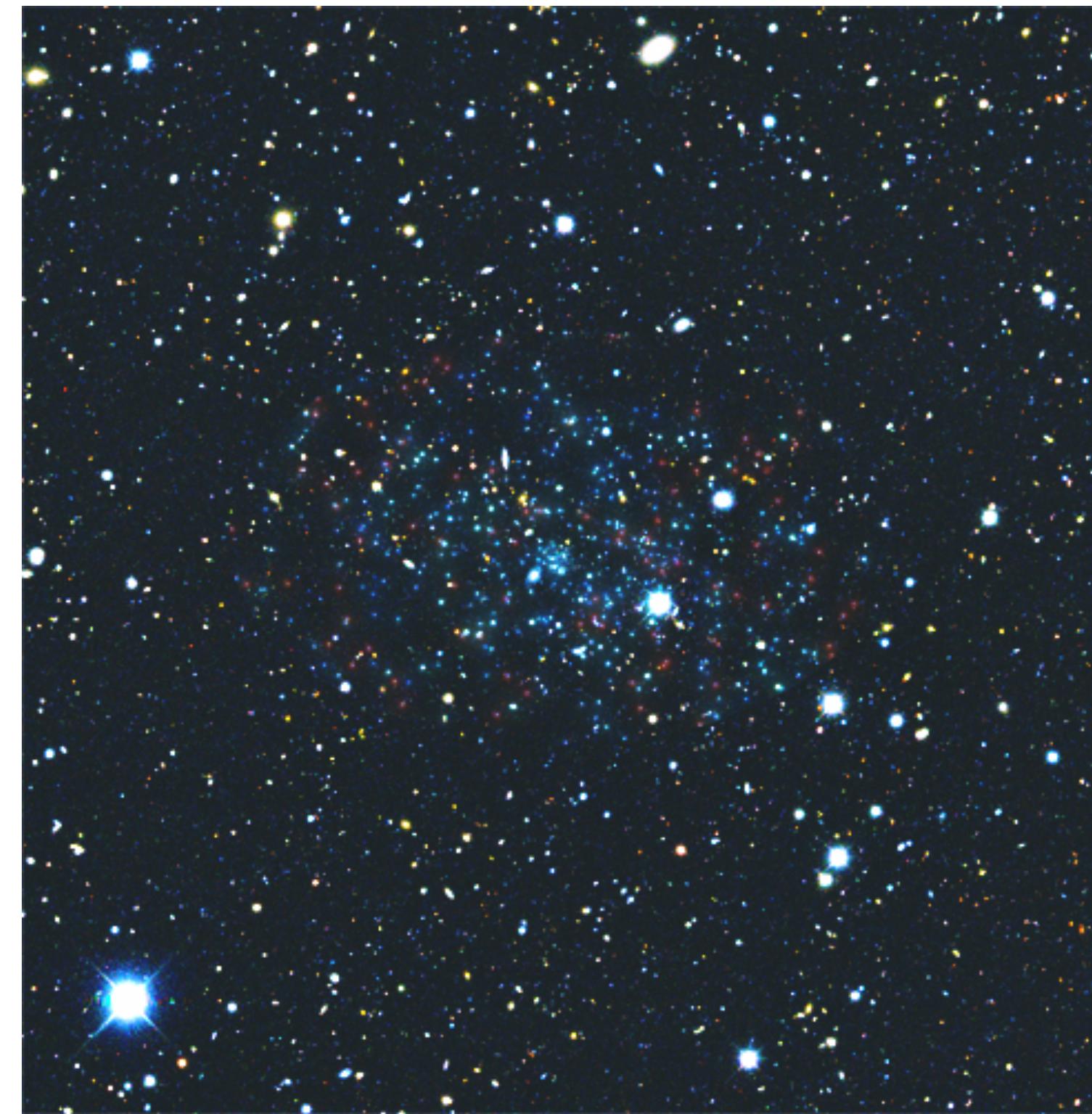


NGC 474

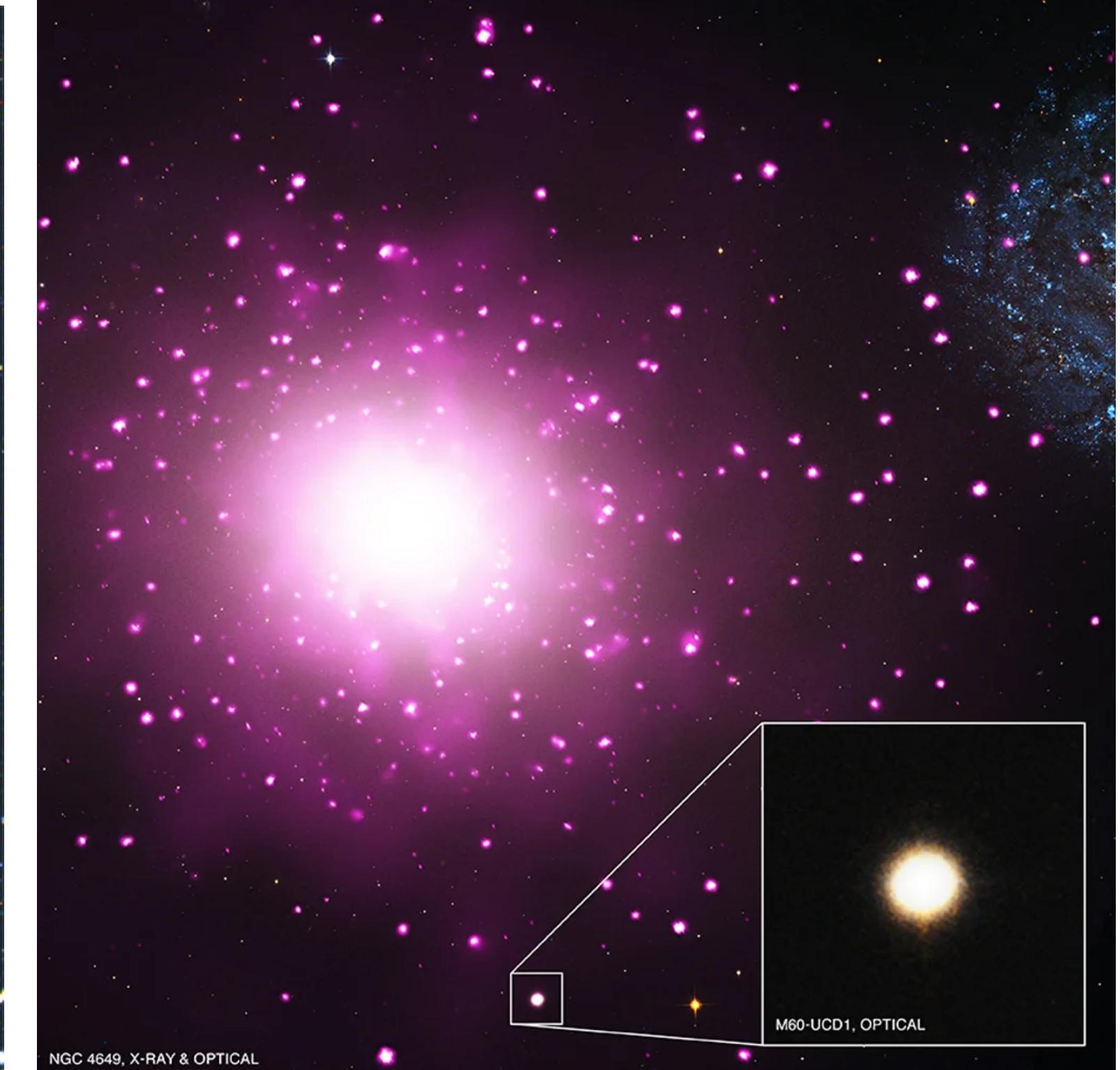
What do you see?



Cigar galaxy (M82)



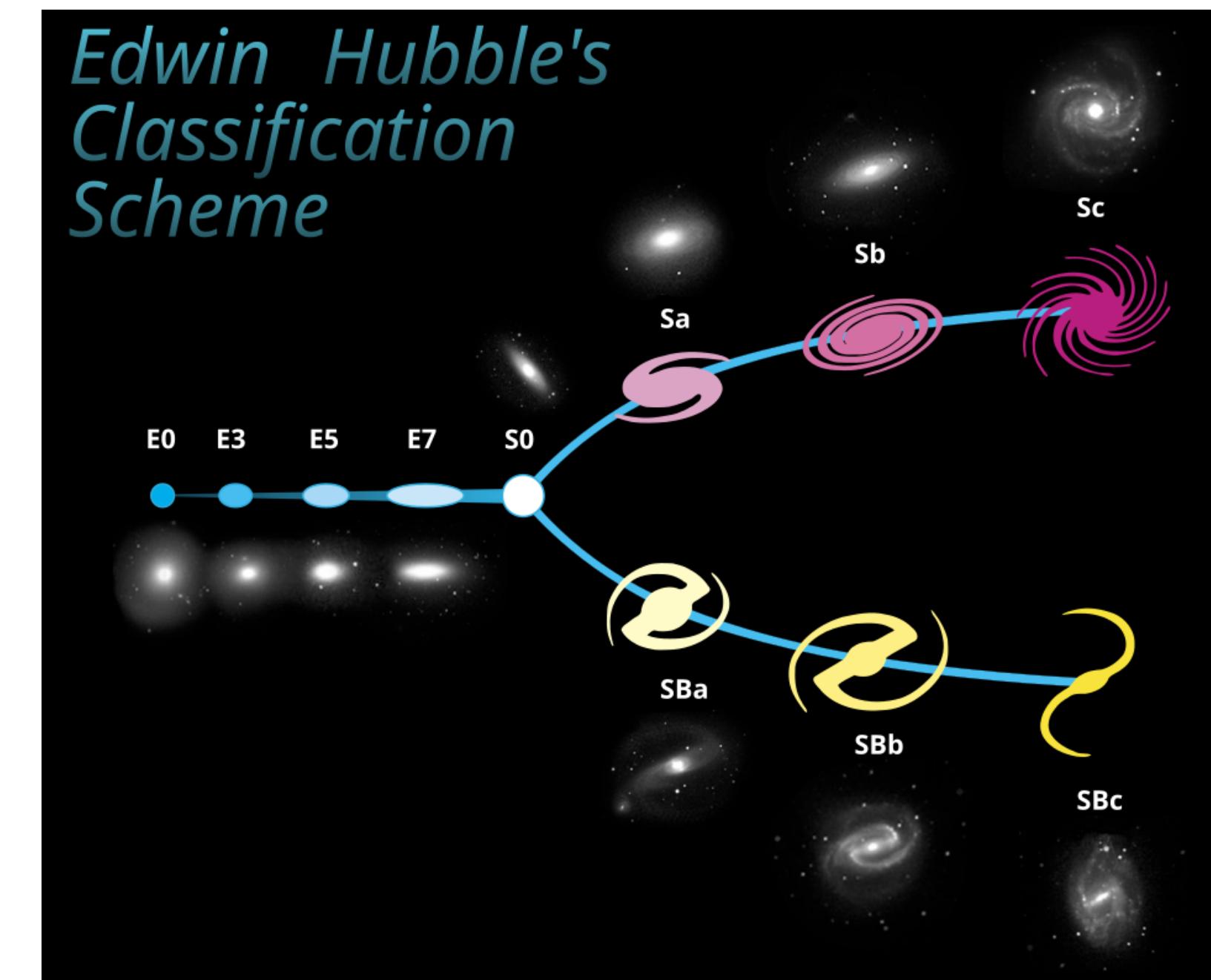
Eridanus II Ultra Faint Dwarf



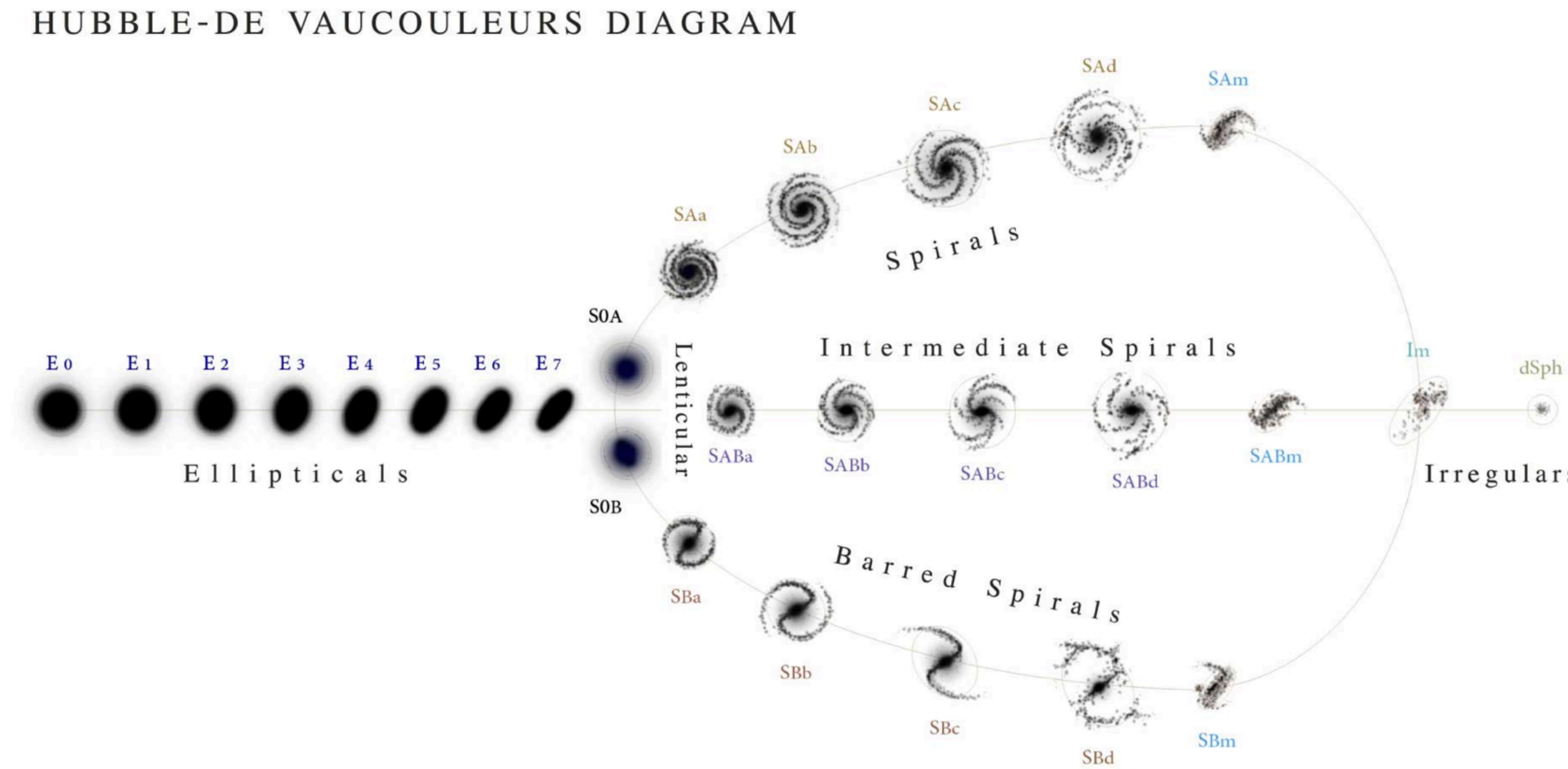
M60-UCD1

Hubble Sequence

- Ellipticity, Bar existence, Curvature of spiral arms
- Hubble assumed that spiral galaxies 'grow' out of elliptical forms
- He named that the elliptical galaxies as Early type galaxy (ETG) and spiral galaxies as Late type galaxy (LTG)
- As far as we know, that sequence does not represent the true story.



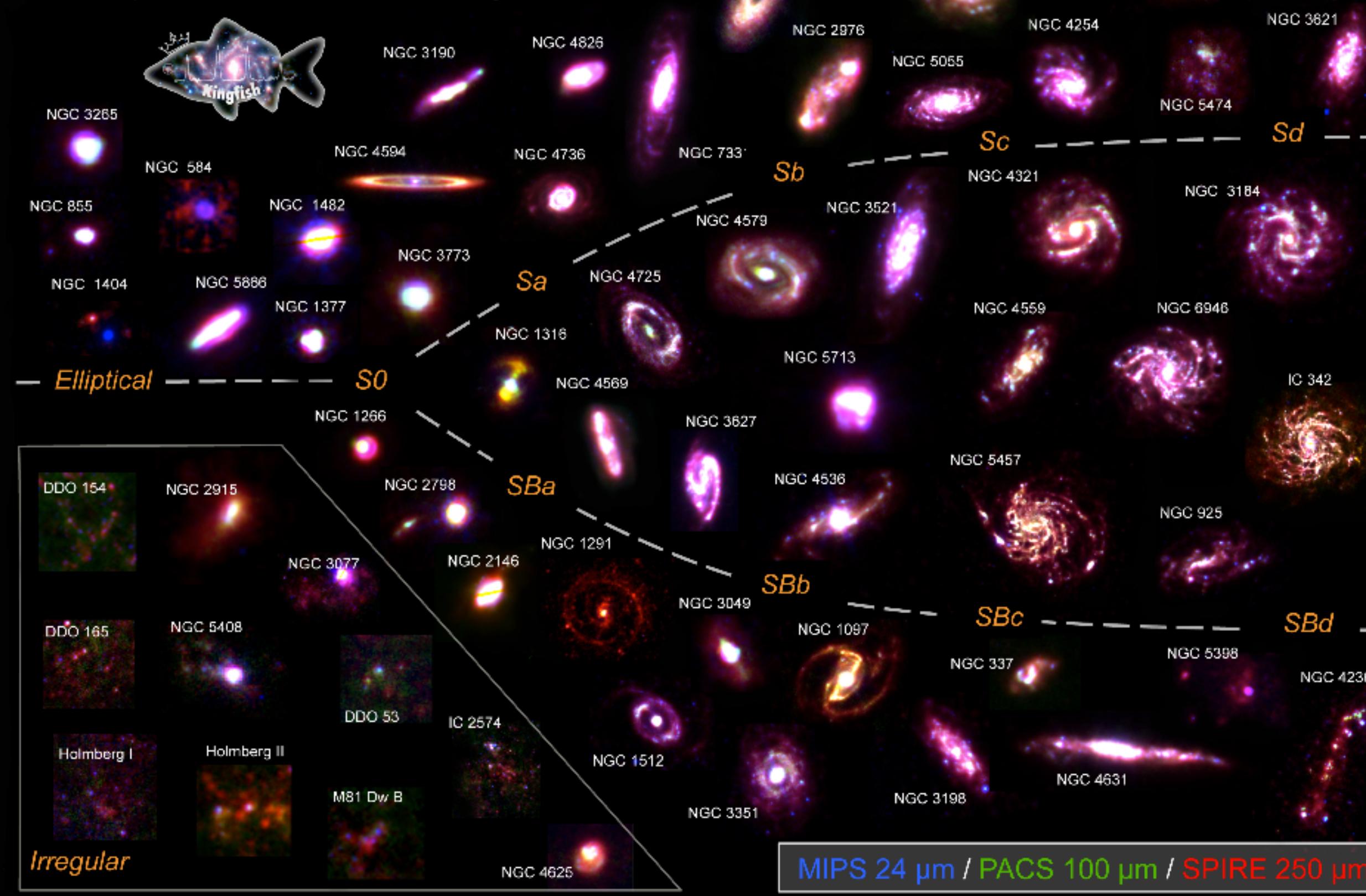
De Vaucouleurs system



Hubble Tuning Fork

Kingfish (Key Insights on Nearby Galaxies:
a Far-Infrared Survey with Herschel)

<http://www.ast.cam.ac.uk/research/kingfish>

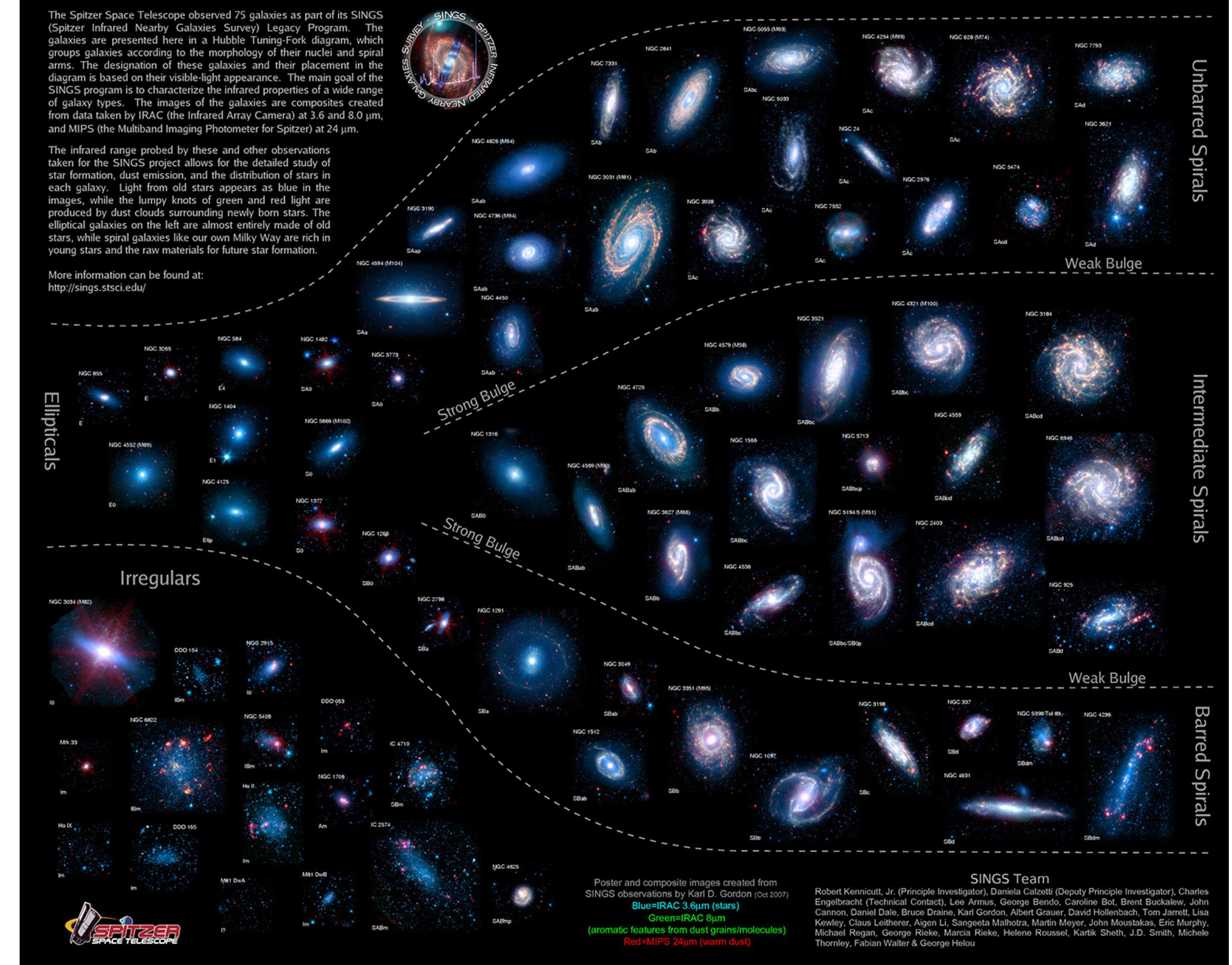


The Spitzer Infrared Nearby Galaxies Survey (SINGS) Hubble Tuning-Fork

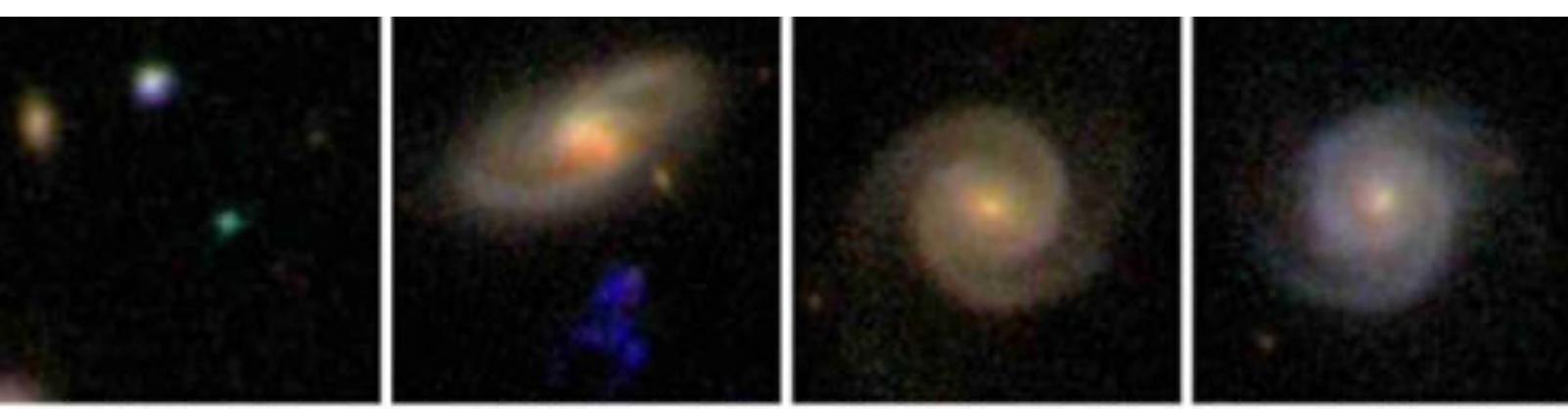
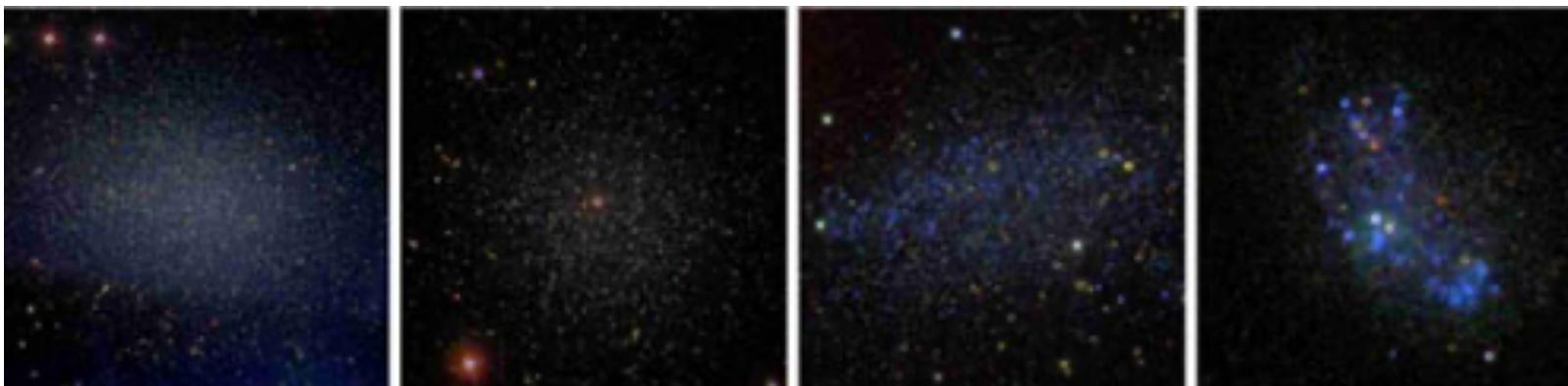
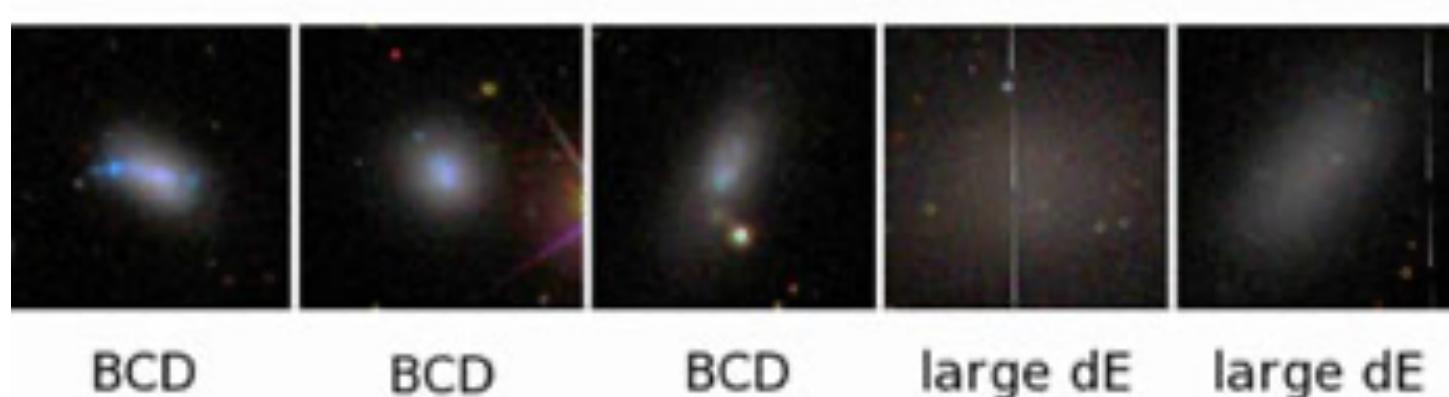
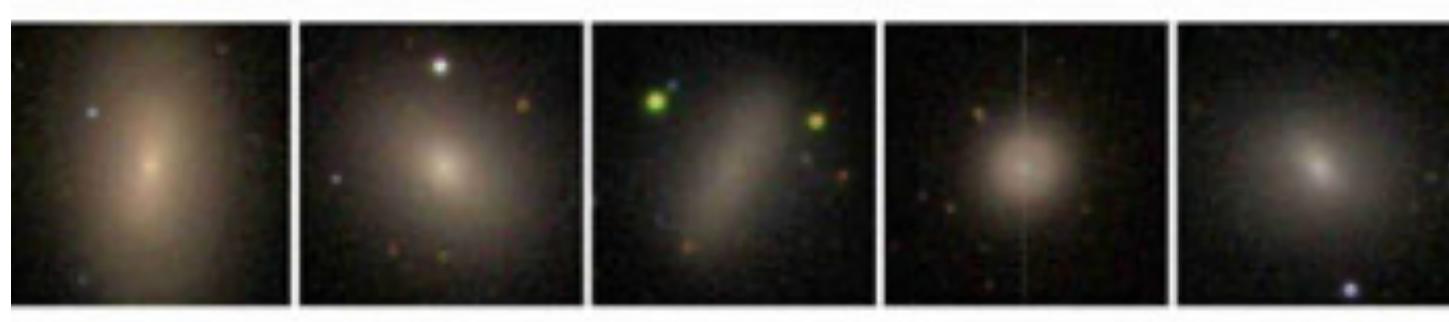
The Spitzer Space Telescope observed 75 galaxies as part of its SINGS (Spitzer Infrared Nearby Galaxies Survey) Legacy Program. The galaxies are presented here in a Hubble Tuning-Fork diagram, which groups galaxies according to the morphology of their nuclei and spiral arms. The designation of these galaxies and their placement in the diagram is based on their visible-light appearance. The main goal of the SINGS program is to characterize the infrared properties of a wide range of galaxy types. The images of the galaxies are composites created from data taken by IRAC (the Infrared Array Camera) at 3.6 and 8.0 μm , and MIPS (the Multiband Imaging Photometer for Spitzer) at 24 μm .

The infrared range probed by these and other observations taken for the SINGS project allows for the detailed study of star formation, dust emission, and the distribution of stars in each galaxy. Light from old stars appears as blue in the images, while the lumpy knots of green and red light are produced by dust clouds surrounding newly born stars. The elliptical galaxies on the left are almost entirely made of old stars, while spiral galaxies like our own Milky Way are rich in young stars and the raw materials for future star formation.

More information can be found at:
<http://sings.stsci.edu/>



Dwarf galaxies

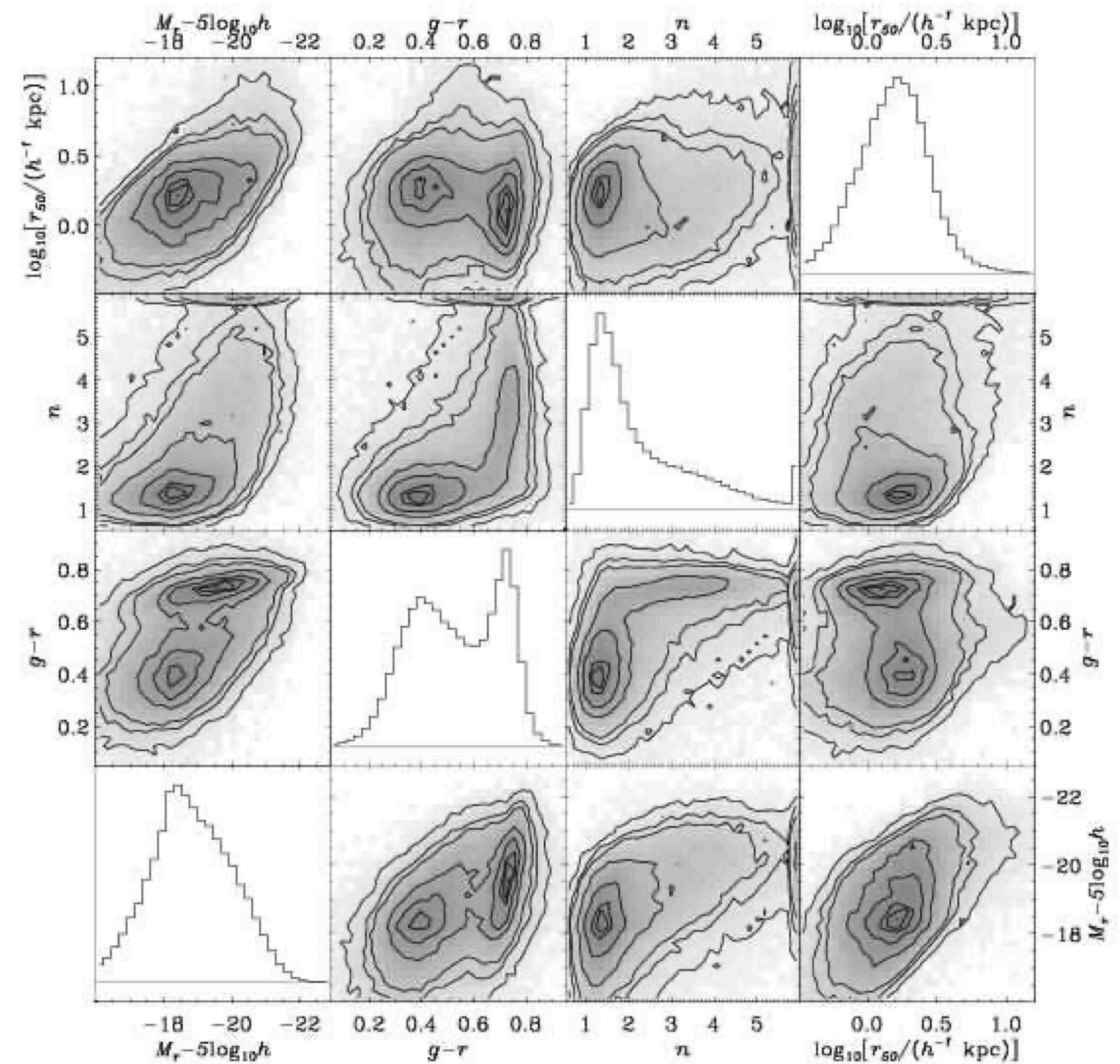


Intermediate and high mass
regime ($M_\star > 10^{9.5} M_\odot$)

Dwarf regime
($M_\star < 10^{9.5} M_\odot$)

Alternatives

- Color
- Size
- Service index
- Star Forming Rate
- Dn4000
- Rotational velocity vs Velocity dispersion
- **Pros & Cons?**

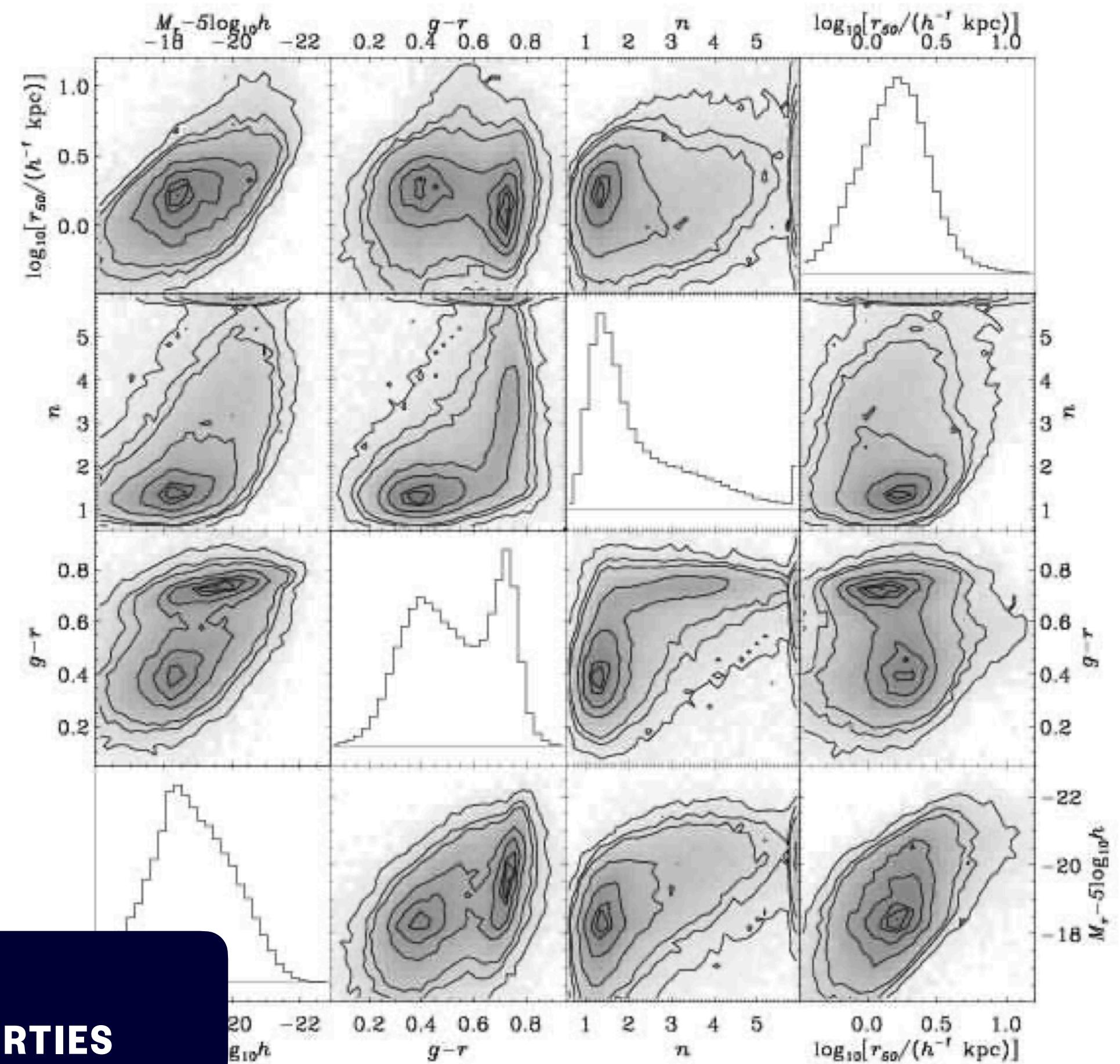


Blanton & Moustakas (2009)

Alternatives

- Color
- Size
- Service index
- Star Forming Rate
- Dn4000
- Rotational velocity vs Velocity dispersion
- Pros & Cons?

ALTERNATIVE: FAST AND EXTENDABLE
BUT WE NEED MASSIVE CATALOGS WITH VARIOUS PROPERTIES



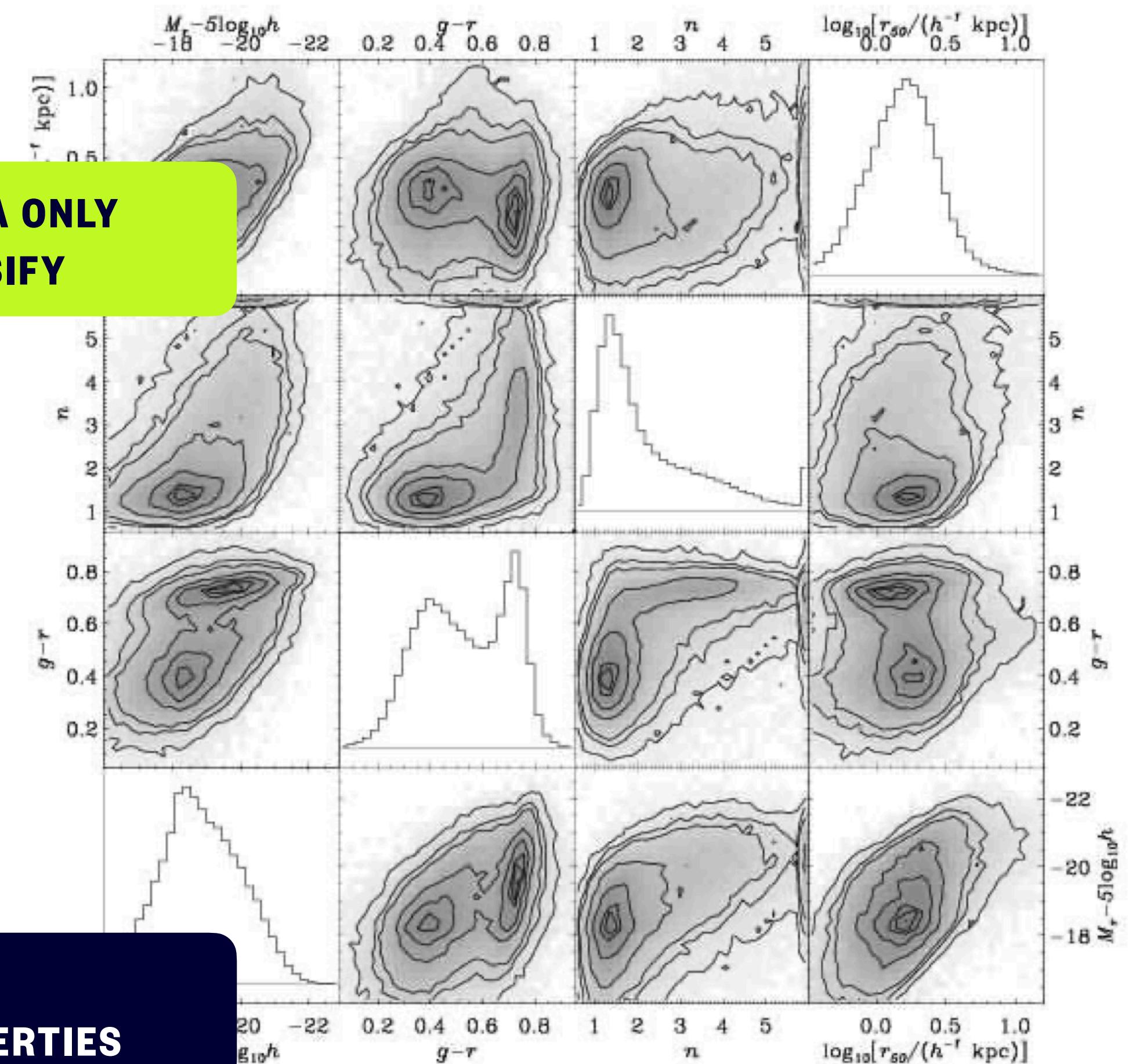
Blanton & Moustakas (2009)

Alternatives

- Color
- Size
- Service index
- Star Forming Rate
- Dn4000
- Rotational velocity vs Velocity dispersion
- Pros & Cons?

MORPHOLOGY: INTUITIVE, WE NEED PHOTOMETRIC DATA ONLY
BUT MORPHOLOGY IS NOT EASY TO QUANTIFY, CLASSIFY

ALTERNATIVE: FAST AND EXTENDABLE
BUT WE NEED MASSIVE CATALOGS WITH VARIOUS PROPERTIES



Blanton & Moustakas (2009)

Machine Learning

- Morphology classification consumes amount of time
- Currently, astronomers try to apply machine learning to classify galactic morphology.
- We need some ‘training sets’ for machine learning

Citizen science (Galaxy Zoo)

The screenshot shows the Galaxy Zoo website homepage. At the top left is the logo "Galaxy Zoo" with a dropdown arrow. At the top right are language settings showing "Language English". Below the header is a blue banner with text about new images from the CEERS survey taken by JWST, and a note about Euclid Challenge. The main background is a dark, star-filled image of a galaxy. Centered text reads "Few have witnessed what you're about to see". At the bottom are two buttons: "Learn more" and "Get started".

Language English

Galaxy Zoo

ABOUT CLASSIFY TALK COLLECT

10th March 2025: We are live with [new images](#) from the CEERS survey, taken by JWST!
Thanks to your classifications our Euclid Challenge is starring in the [ESA press release for Euclid](#) - well done!

Few have witnessed what you're
about to see

Learn more Get started

Citizen science (시민과 함께 과학.kr)

The screenshot shows the homepage of the Citizen science website. The background features a dark, circular graphic resembling a galaxy or solar system. At the top, there is a navigation bar with links for '프로젝트 소개' (Project Introduction), '온하분류하기' (Classify Onha), '시민과 함께 과학' (Citizen Science), and '모두의 은하 연구소' (Everyone's Galaxy Observatory). A 'Join' button is also present. The main content area includes a 'Mission Galaxy' section with a 'Classify Onha' button. To the right, there is a 'TOP BOARD' section showing rankings for '로메' (Lrome), 'Orrey', and '허선' (Husun) with their respective counts: 29712 Galaxy, 4027 Galaxy, and 4025 Galaxy. Below this is a '참여자 수' (Number of Participants) section showing '1,070 Crew'. Further down is a '분류된 은하 수' (Number of Classified Galaxies) section showing '106,785 Galaxy' with a progress bar indicating '3.382% Cleared'. The bottom of the page features directional markers for North (N), Northeast (NE), East (E), Southeast (SE), and South (S).

프로젝트 소개 온하분류하기 시민과 함께 과학 모두의 은하 연구소 Join

Mission Galaxy

모두의 은하 연구소

온하분류하기

TOP BOARD

위치	온하 수	변경 기호
1 로메	29712 Galaxy	-
2 Orrey	4027 Galaxy	▲
3 허선	4025 Galaxy	▼

참여자 수
1,070 Crew

분류된 은하 수
106,785 Galaxy
3.382% Cleared

N NE E SE S

SEUNGWU YOO

HW

참가증명서

- <https://xn--vb0ba14lo8zo8hr12a6ca.kr/project/galaxy/>

유승우

시민연구원

- **Classify the morphology of at least 100 galaxies**

시민과 함께 과학은 모두의 은하 연구소에서

2024.09.17.-2024.09.20 동안

100개의 은하 이미지를 식별하는데

참여한 공로를 인정하여 이 증서를 드립니다.

- Submit your certificate until the end of the semester

2024.09.20

- **No report is required**

OPEN KIAS 센터장 박창범 박 창 범

시민과 함께 과학 Mission Galaxy 과제지도단장 황호성 황 호 성

SEUNGWU YOO

Reference

- Carl Sagan - Cosmos
- <https://ned.ipac.caltech.edu/level5/Sept11/Buta/Buta15.html>
- <https://arxiv.org/pdf/0908.3017>
- <https://www.zooniverse.org/projects/zookeeper/galaxy-zoo>