ASTR 380: Life in the Universe

Professor Cole Miller

Outline

- Major questions and aim of class
- Overview of syllabus
- What is life?
- First look at the Drake equation
- Some things that may or may not be necessary to life everywhere
- Pre-test to determine background

Major Questions

- Are we alone?
- What are the conditions for life?
- How did life develop on Earth?
- How are we searching for life elsewhere?

Syllabus

- Class webpage: www.astro.umd.edu/~miller/teaching/astr380f09
- Textbook: “Life in the Universe” by Bennett and Shostak
- My contact info: (301) 405-1037, miller at astro.umd.edu
- Class meets TuTh 9:30-10:45

Course Grading

- Homework 25%
  Assigned every two weeks
- Midterm exam 30%
  Tuesday, October 13, 9:30, in class
- Final exam 40%
  December 15, 8-10 AM, in CSS 2400
  Cumulative
- Participation 5% (questions, responses)

About Participation

- This is an exciting topic, and many of the answers are unknown
- Class discussion will therefore play a major role
- I will often ask for your *opinions* on questions for which we do not have a definite answer. Your questions are important as well.
- Exchanges will improve class

Letter Grades

I will guarantee that you will receive no worse than the following letter grades for a given percentage of available points:

90%-100%	A
80%-90%	B
70%-80%	C
60%-70%	D

Your grade might be better than this, depending on class performance.

There will be no extra credit in this class.

Late and Make-Up Policy

- All HW due promptly at beginning of class.
- All excuses must be valid and documented in writing, in advance if possible.
- No credit beyond Tuesday after HW is due (solutions handed out then).
- If cannot make scheduled exam time, tell me in advance and we will arrange an earlier time.

Yes, Right at Beginning!

- If you turn in HW after class has started (i.e., after I've started speaking), it is late and will be docked points
- Why? Late arrivals disrupt class, so we want to discourage it!

Academic Integrity

- All work must be in your own words, period! Copying from our textbook, other books, websites, other students, etc. is an offense.
- If you must quote, put source in quotes and give attribution: As Carl Sagan said, "billions and billions" (source: Cosmos)
- Quoting with attribution is not an offense, but it will result in a lower grade; I want your thoughts, not that of a book!
- Best bet: don't look at sources when writing.

Laptop Policy

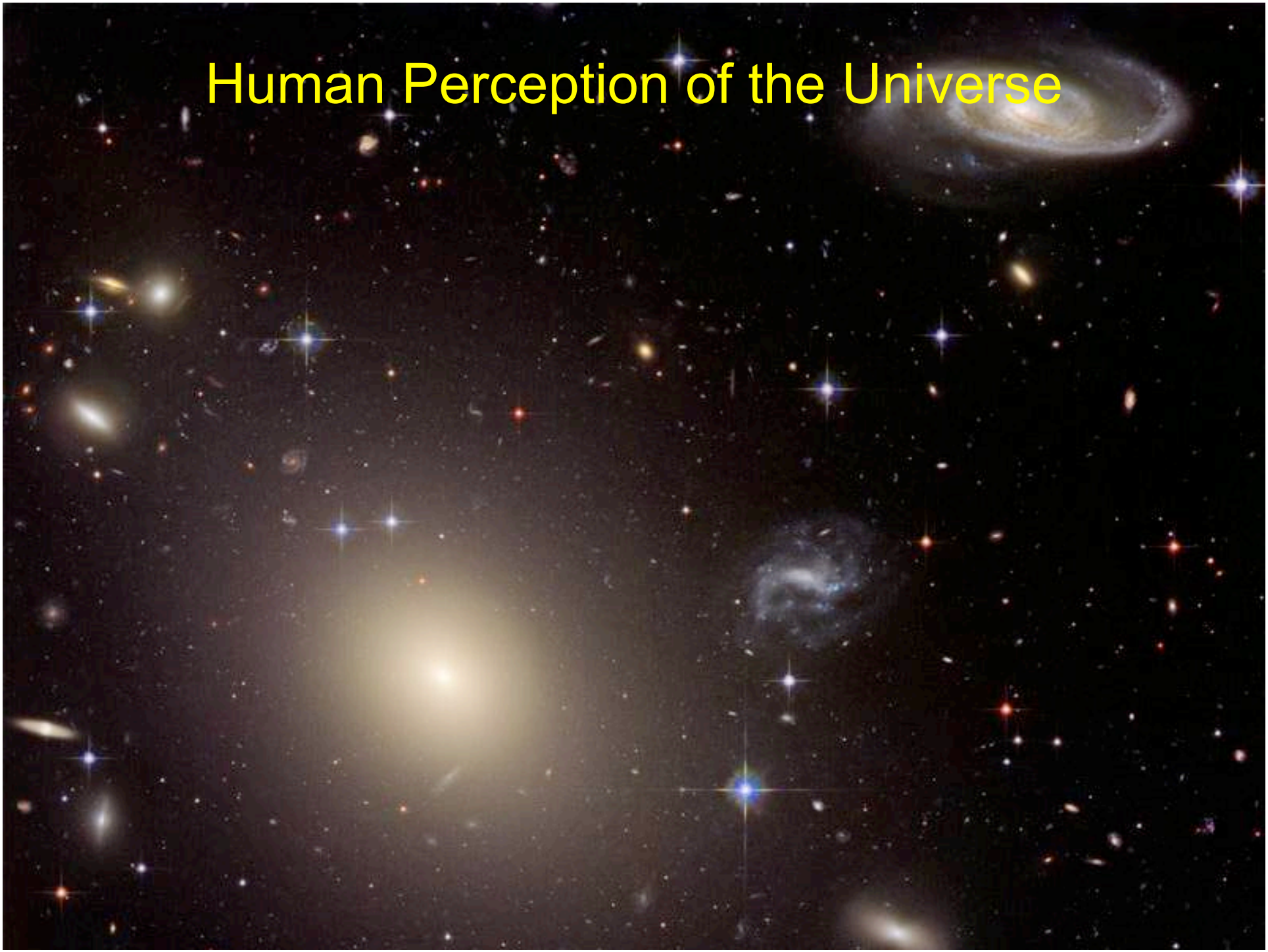
- In principle, laptops can allow you to take notes faster and access the class website
- In practice, more likely to be used for non-class purposes :)
- Therefore, if you bring a laptop, you must:
  Sit in the far back row
  Turn the sound off (no headphones)
- This will reduce distractions. Thanks!

Opinions Encouraged!

- Some aspects of this course are well known
  Basics of astronomy, physics, chem, bio
- But many others are not
  Conditions for life, number of civilizations
- I encourage you to suggest your own opinions during class!
  Looking for robust discussions
- Will often have short debates during class

So that you know...

- Biological evolution has been the driver of life on Earth, and it is simple and general enough to do so anywhere.
  The fact of evolution has been established.
- As a result, we will have several classes on evolution, as well as HW and exam Qs.
- If for some reason you are offended by evolution, you should not be in this class.


Human Perception of the Universe

Our place in the Universe

Our understanding of the Universe

Our perception of where life can exist

People have always sought to understand their place in the Universe.

This understanding has always been in the context and the capability of the civilization of the time.

The ancient Greeks developed a tradition of trying to understand the Universe with reason and systematic logic, and mathematics.

- Size of the Sun
- Size of the Moon
- Size of the Earth
- Earth is round
- Distance to the Sun
- the concept of planets
- Earth-centered Universe
- Sun-centered Universe

Re-creation of Library at Alexandria

Aristarchus: 3rd Century BC

How Big is the Earth?

- This question, and similar ones, are factors in whether we think there are many, or few, possibilities for life
- Eratosthenes: geometric measurement

http://remacle.org/bloodwolf/erudits/eratosthene/eratosthenes.jpg

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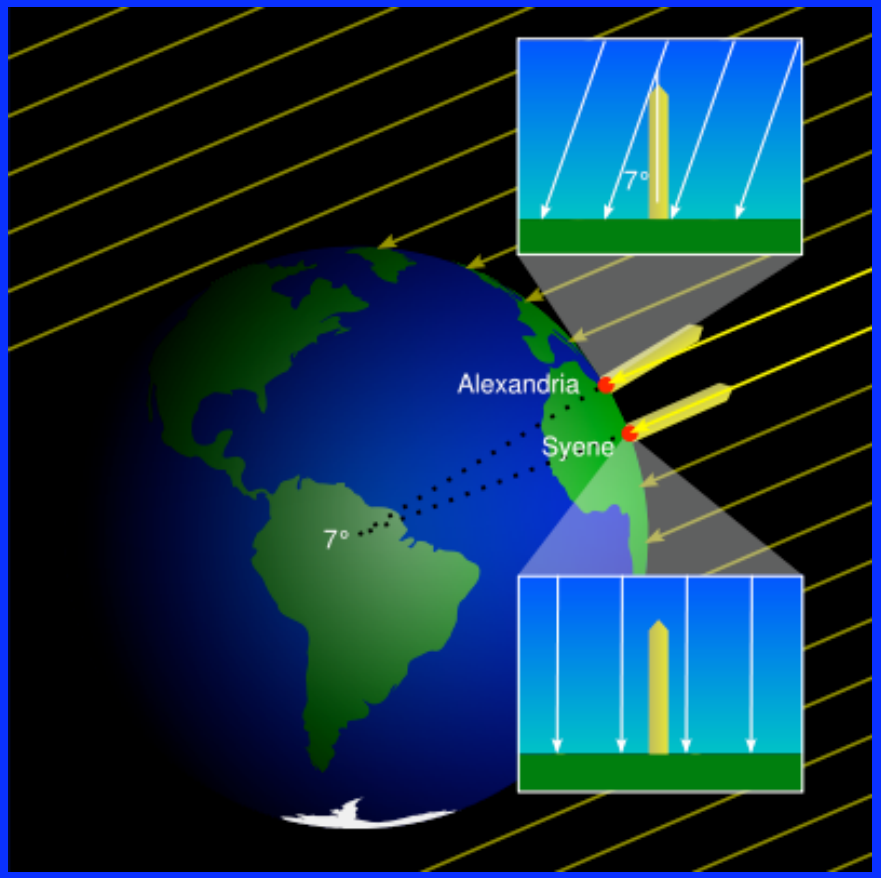


http://scienceblogs.com/startswithabang/upload/2009/06/carnival_of_space_108_solstice/400px-Eratosthenes.bjb.svg.png

Extent of the Universe

- We now think that the universe is vastly larger than the Greeks thought
- What are some of the factors that lead us to this conclusion?

Modern Science: A way of looking at the Universe

Observations/experimentation is the base – empirical facts

Organize the data around a topic and a question

Devise a hypothesis which is testable – reason and logic

Test the hypothesis against existing data

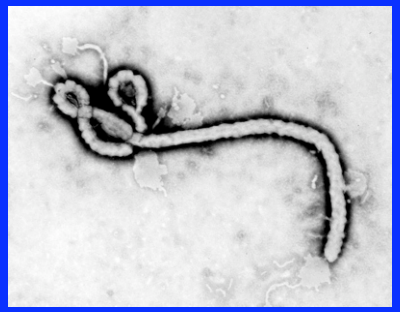
Make a prediction or devise an experiment – test ideas

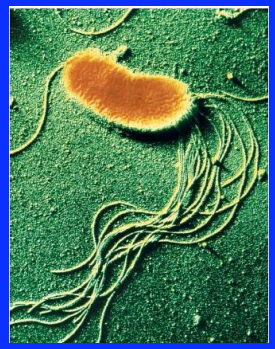
Perform experiments/observations to test the hypothesis

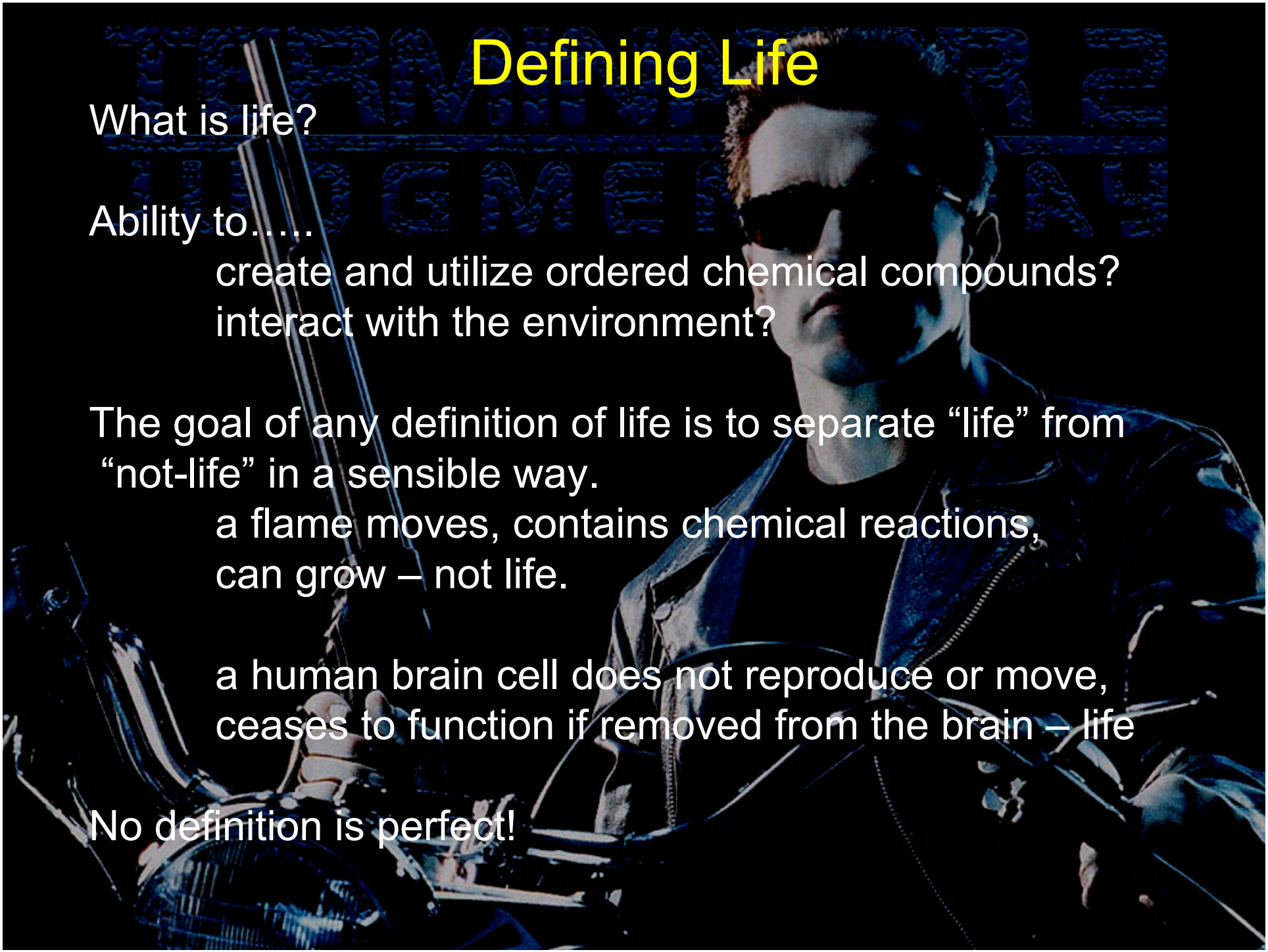
Use all information to create a new hypothesis or refine the original hypothesis – build sequentially the body of knowledge

Example: What is Life?

- Which is alive?
  - A rock
  - A snowflake
  - Clay
  - A virus
  - A bacterium
  - A fly
  - A person







Defining Life

What is life?

Ability to…..

create and utilize ordered chemical compounds?
interact with the environment?

The goal of any definition of life is to separate “life” from “not-life” in a sensible way.

a flame moves, contains chemical reactions, can grow – not life.

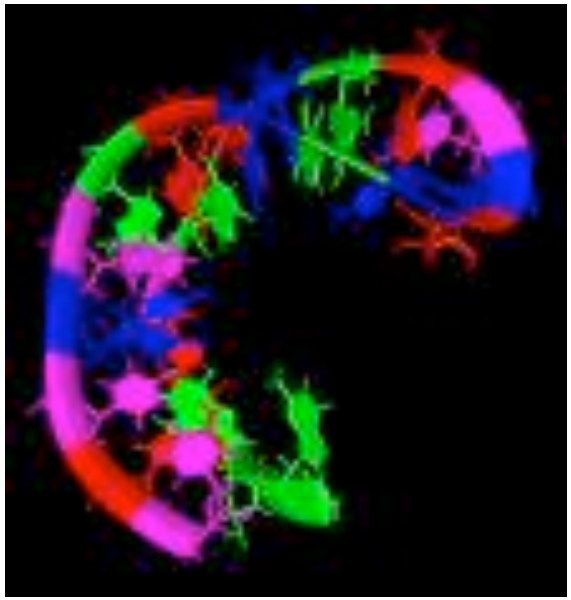
a human brain cell does not reproduce or move, ceases to function if removed from the brain – life

No definition is perfect!

Defining Life

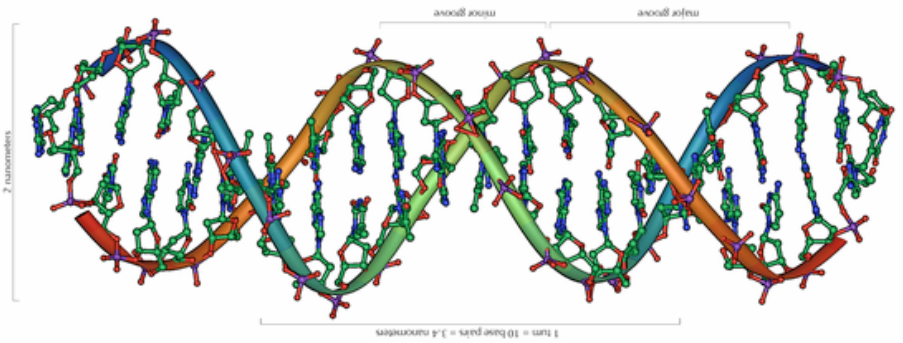
Key Properties of Biological Life

- order
- growth and development
- energy utilization
- response to environment
- reproduction
- evolutionary adaptation



All life creates chemical order within its boundaries. The organism uses energy to create specific complex molecules – proteins, fats, RNA, DNA – which are central to its existence.

More about this later in the course...



A Difficulty to Remember

- We only know of life on this planet
- Our inclination is to look for similar conditions
- But is this reasonable?

ASTR 380
The Drake Equation

Drake Equation:

$$N = N^* \times f_p \times n_e \times f_l \times f_i \times f_c \times f_s$$

where:

N is the number of civilizations in our galaxy for us to talk to today.
*N** is the number of stars in our galaxy
f_p is the fraction of those stars that have planets
n_e is the number of planets that can support life per star that has planets
f_l is the fraction of the above that actually develop life
f_i is the fraction of the above that develop intelligent life
f_c is the fraction of civilizations that develop interstellar communication
f_s is the fraction of time such civilizations release detectable signals into space.

What are your guesses for the factors?

Summary

- Life can be difficult to define
- There are arguments about what is necessary for life
- Many stars and galaxies, but not clear what fraction of them host life
- Our course will explore many aspects of these questions