

Designing Controlled Experiments

- · Experiments must be designed to test
 - the effect of one variable by testing control groups and experimental groups in a way that cancels the effects of unwanted variables

Limitations of Science

- Science cannot address supernatural phenomena because hypotheses must be testable and falsifiable and experimental results must be repeatable
- Do supernatural phenomena influence biological systems ?

Theories in Science

- · A scientific theory
 - is broad in scope
 - generates new hypotheses
 - is supported by a large body of evidence
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The Phenomenon we call Life

- · We recognize life
 - by what living things do (changing / action)
- Biologists explore life from the microscopic to the global scale
- The study of life extends from the microscope scale of molecules and cells to the global scale of the entire living planet

Induction in Discovery Science

In inductive reasoning scientists derive generalizations based on a large number of specific observations

Deduction: The "If...then" Logic of Hypothesis-Based Science

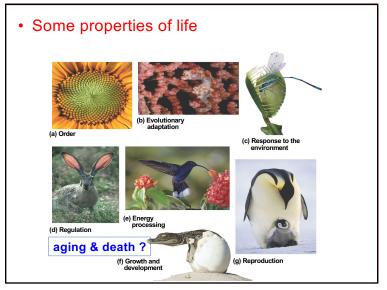
- In deductive reasoning, the logic flows from the general to the specific
- If a hypothesis is correct, then we can expect a particular outcome

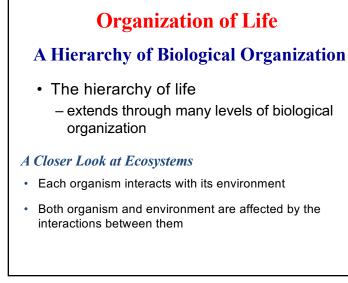
A Closer Look at Hypotheses in Scientific Inquiry

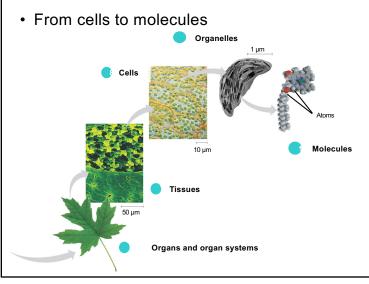
- · A scientific hypothesis must have two important qualities
 - It must be testable
 - It must be falsifiable

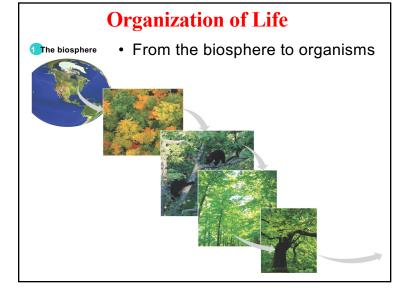
The Myth of the Scientific Method

- The scientific method is an idealized process of inquiry
- Very few scientific inquiries adhere to the "textbook" scientific method
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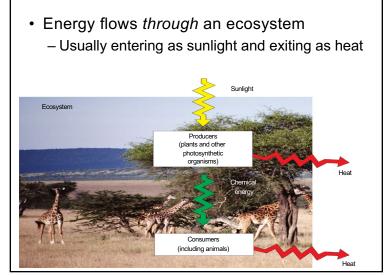
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Ecosystem Dynamics

- · The dynamics of any ecosystem include two major processes
 - Cycling of nutrients, in which materials acquired by plants eventually return to the soil
 - The flow of energy from sunlight to producers to consumers

Energy Conversion

- Activities of life require organisms to perform work, which depends on an energy source
- The exchange of energy between an organism and its surroundings often involves the transformation of one form of energy to another



The Theory of Evolution

- 1. Cosmic Evolution Big Bang, origin of time, space, material
- 2. Chemical Evolution all elements derive from H₂ (hydrogen)
- 3. Evolution of the stars stars die, but never anyone has seen the birth of a star

4. Organic evolution – origin of life (a stone became human being)

5. Macro evolution – change from one species to another (nobody has ever observed it)

6. Micro evolution - variation within a species (no doubt about it)

1.) - 5.) are 'theories' -- we only observe/d 6.)

Science is about observations – but we never really observed evolution yet – it is a theory using 'time' as the most important parameter ! The secret is 'time' !

The Origin and Study of Life

• The evolutionary view of life

came into sharp focus in 1859 when Charles Darwin published On the Origin of Species by Natural Selection

Life is composed of 1 materialistic component only. No independent 'Information' compone No independent lively component.

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The 1st Law of Thermodynamics:

It is in no way possible, either by mechanical, thermal, chemical, or other devices, to obtain perpetual motion, i.e. it is impossible to construct an engine which will work in a cycle and produce continuous work, or kinetic energy, from nothing.

The energy of an isolated system is constant. (cannot be destroyed nor be created – but how this world then evolved ?

The Origin of Life - Big bang (BB): all material concentrated in one dot, then it exploded ... a very crowded spot ! Then it cooled down by long rain, ...

in other words: BB says: nothing exploded and here we are. We all came from a dot and the dot (energy in this dot) came from nothing.

Uni verse (cosmos) = 1 spoken sentence = we live in a single spoken sentence

Which theory fits best with our scientific observations (not with our assumptions that we may make based on our observations) ?

The 2nd Law of Thermodynamics:

Everything tends toward **disorder** – that is in clear agreement with our observations.

via aging to dust ..., however ---> in contrast:

Evolution: higher order/systems appeared: We developed from $atoms/H_2$ to organic molecules to RNA to cell, bacteria, fish, monkey and then into human being!?

Evolution: the earth is an open system – it works if you add energy and overcome the 2nd law of thermodynamic – *however*. 1) the universe is a closed system

2) adding energy is destructive without a force mechanism that controls it (Pearl Harbor, Hiroshima, sun on your house roof, car, skin, etc

3) Only chlorophyll can use the energy of the sun - a plant cell (the biological system that makes photosynthesis) is extremely complex – thus, adding energy is not bringing order – you need to use the energy properly (solar cells).

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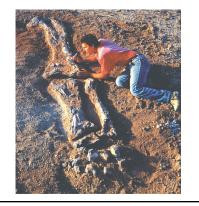


Biologists explore life across its great diversity of species



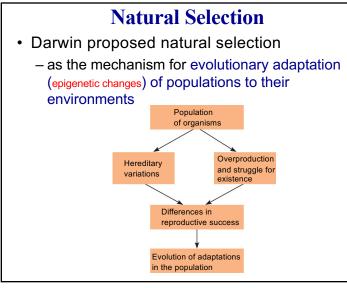
'Evolution' accounts for life's unity & diversity

- the history of life
 - is a saga of a changing earth <u>'billions' of years old (?)</u>

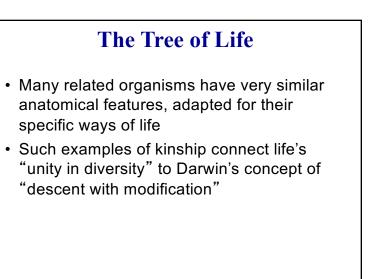


- The Origin of Species articulated two main points
 - Descent with modification
 - Natural selection





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- Natural selection is the evolutionary process that occurs
 - when a population's heritable variations are exposed to environmental factors that favor the reproductive success of some individuals over others



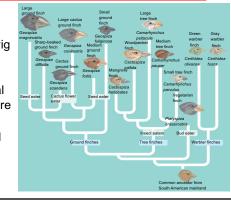
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Darwin proposed a hypothesis that natural selection

 could enable an ancestral species to "split" into two or more descendant species, resulting in a "tree of life"

Comparative Biology – Morphology vs Genomics etc.

- Each species is on twig of a branching tree of life extending back in time through ancestral species more and more remote
- All of life is connected through its long evolutionary history



Grouping Species: The Basic Idea

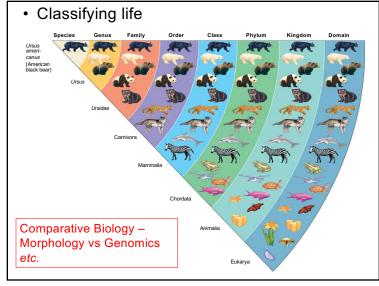
Taxonomy

- Is the branch of biology that names and classifies species according to a system of broader groups
- the conception, naming, and classification of organism groups.

Taxonomy (from Ancient Greek: τάξις taxis, "arrangement," and -voµíα nomia, "method") is the science of defining groups of biological organisms on the basis of shared characteristics and giving names to those groups. Organisms are grouped together into taxa (singular: taxon) and given a taxonomic rank; groups of a given rank can be aggregated to form a super group of higher rank and thus create a taxonomic hierarchy. The Swedish botanist Carolus Linnaeus is regarded as the father of taxonomy, as he developed a system known as Linnaean classification for categorization of organisms and binomial nomenclature for naming organisms. With the advent of such fields of study as phylogenetics, cladistics, and systematics, the Linnaean system has progressed to a system of modern biological classification based on the evolutionary relationships between

organisms. Check: http://en.wikipedia.org/wiki/Taxonomy (biology)

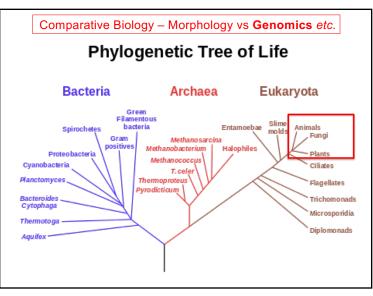
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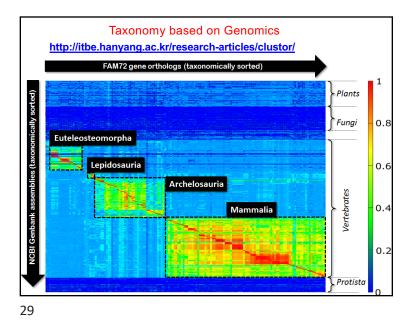


Phylogeny

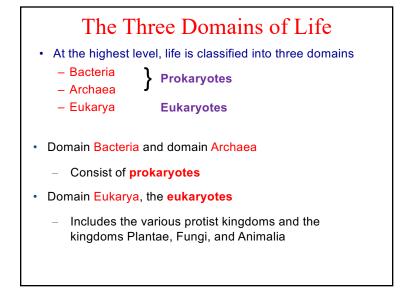
plural phy·log·e·nies: the evolutionary history of a kind of organism: the evolution of a genetically related group of organisms as distinguished from the development of the individual organism

Phylogenetics / faɪloʊdʒəˈnɛtɪks, -lə-/ (Greek: φυλή, φῦλον - phylé, phylon = tribe, clan, race + γενετικός - genetikós = origin, source, birth) – in biology – is the study of the evolutionary history and relationships among individuals or groups of organisms (e.g. species, or populations). These relationships are discovered through phylogenetic inference methods that evaluate observed heritable traits, such as DNA sequences or morphology under a model of evolution of these traits. The result of these analyses is a phylogeny (also known as a phylogenetic tree) - a hypothesis about the history of evolutionary relationships. The tips of a phylogenetic tree can be living organisms or fossils. Phylogenetic analyses have become central to understanding biodiversity. evolution, ecology, and genomes, Taxonomy is the classification, identification and naming of organisms. It is usually richly informed by phylogenetics, but remains a methodologically and logically distinct discipline. The degree to which taxonomies depend on phylogenies (or classification depends on evolutionary development) differs depending on the school of taxonomy: phenetics ignores phylogeny altogether, trying to represent the similarity between organisms instead; cladistics (phylogenetic systematics) tries to reproduce phylogeny in its classification without loss of information; evolutionary taxonomy tries to find a compromise between them. https://en.wikipedia.org/wiki/Phylogenetics

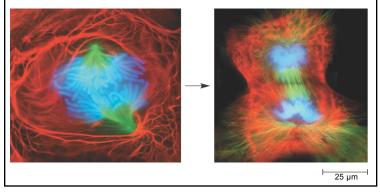


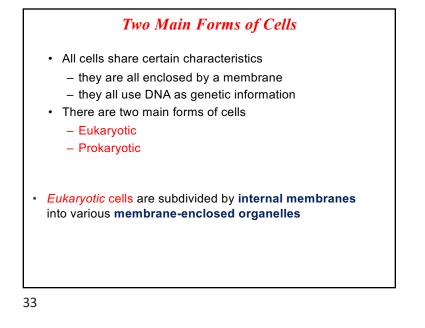


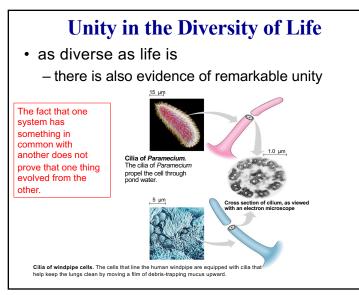
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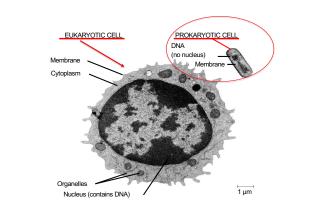
• The **Cell** is the lowest level of organization that can perform *all* activities required for **Life**

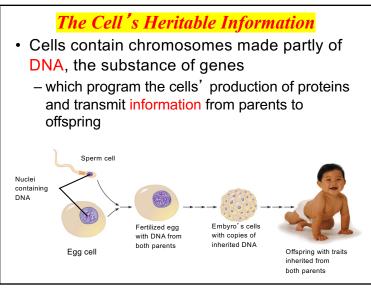


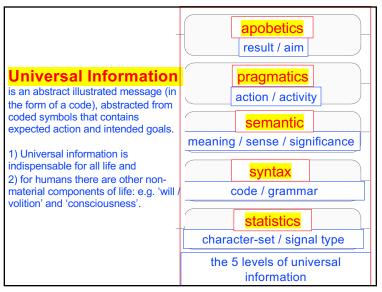


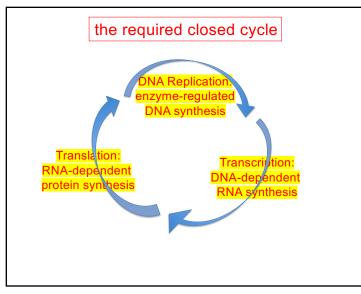


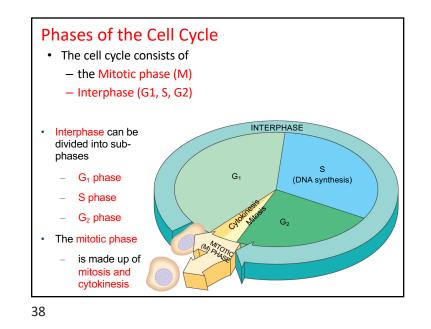
• Prokaryotic cells lack the kinds of membraneenclosed organelles found in Eukaryotic cells EUKARYOTIC CELL PROKARYOTIC CELL DNA (no nucleus) Membrane

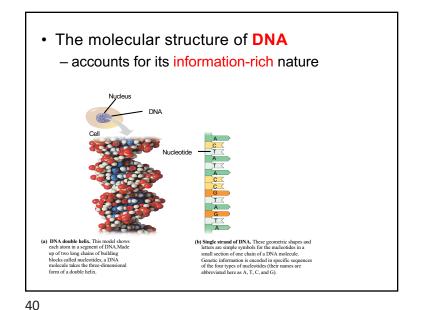












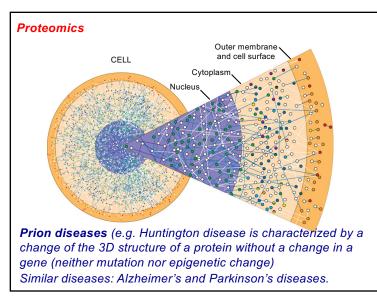
Genomics

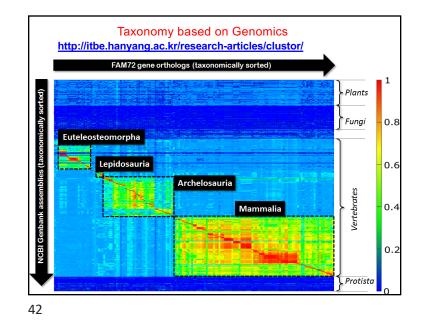
• The study of DNA structure, an example of reductionism has led to further study of heredity, such as the Human Genome Project



Diseases: Alzheimer's disease; Parkinson's disease: gene mutations

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Systems Biology – Regenerative Medicine

- Systems biology seeks to create models of the dynamic behavior of whole biological systems
- With such models scientists will be able to predict how a change in one part of a system will affect the rest of the system (bottom ---> up approach)
- · Systems biology
 - Is now taking hold in the study of life at the cellular and molecular levels
 - Includes three key research developments: highthroughput technology, bioinformatics, and interdisciplinary research teams

A single change (e.g. mutation) in a gene (or protein) may induce a change in a protein function and thus affect the entire biological system (organism) !

- Biological systems are much more than the sum of their parts
- A system is a combination of components that form a more complex organization

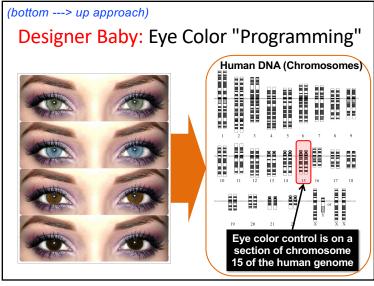
The Emergent Properties of Systems

• Due to increasing complexity new properties emerge with each step upward in the hierarchy of biological order

The Power and Limitations of Reductionism

 Reductionism involves reducing complex systems to simpler components that are more manageable to study

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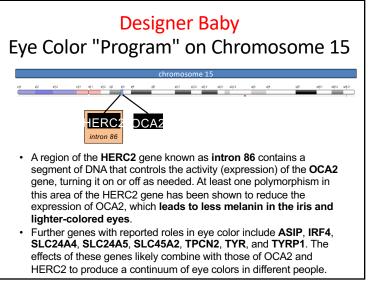
Systems Biology – Regenerative Medicine

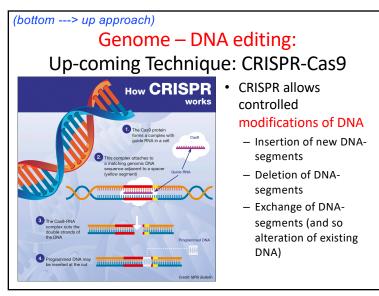
Example: Genome editing: Designer Baby (bio system)

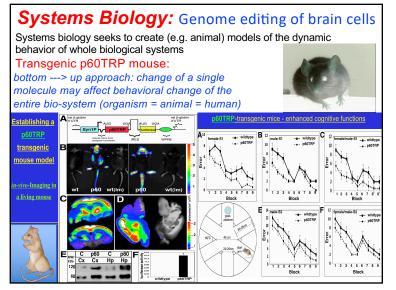
• Definition (Wikipedia):

A designer baby is a human embryo that has been genetically modified, usually following guidelines set by the parent or



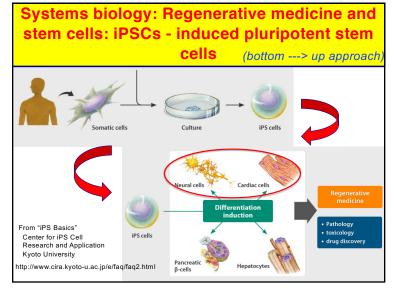


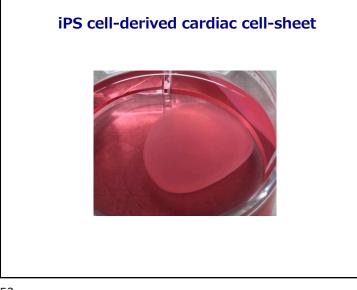


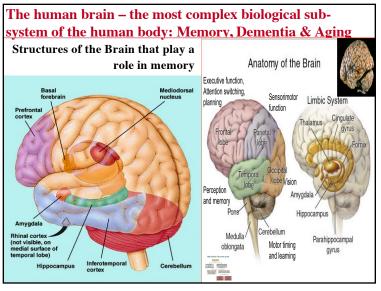


CRISPR-Cas9

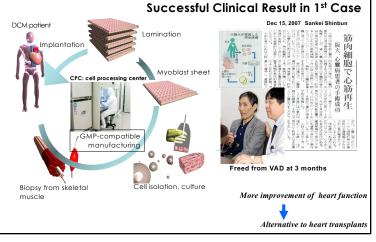
- First proposed in 2013
- Technique gets continuously improved and is on the verge of maturity for large scale laboratory usage.
 - CRISPR related gene editing might be a revolution like the WEB or Mobile Phones and could change our world significantly within the next 20 years.

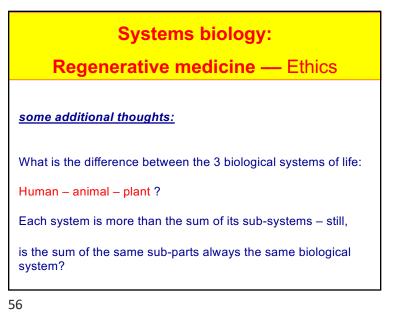






Regeneration therapy using myoblast sheet for the treatment of dilated type cardiomyopathy





Or, in other words:

What is the difference between the 3 biological systems of life: or, between/among:

Human – animal (monkey, fish) – plant – ... – table – stone, ... ?

	Have /	don't have
Human		
Animal		
Plant		
Table		
Stone		

A few challenging questions?

Why did we not observe yet a tree that is older than about 4000 years ?
Why is oil still under pressure beneath the earth surface after so many years ?
Why are there so many trees going vertically through many layers that are supposed to be 100 000y or more different in age ?
If the spin of the earth around itself is slowing down (about 33s added since 1970), how could the dinosaurs stay on earth so many years ago ?
The earth is losing the moon – many years ago the tides would have taken away Korea
In the beginning was material that concentrated to a dot and after high spinning exploded to become the universe – but - where this material/dot/energy came from ?
Where did the energy come from ?
Where did the energy come from ?
Conservation of spinning moment: if big bang started as a spinning dot – all pieces should have the same spin – however, the Venus, Uranus and probably Pluto rotate backwards compared to other 6 planets including the earth.
8 out of 91 rotate backwards. Jupiter, Saturn and Neptun have moons orbiting in both

directions! Even some entire galaxies spin backwards.

----> why it is so ---> to show us the Big Bang theory doesn't work out?

Has 'modern science' really provided convincing evidence that evolution exists?