Life and Health Science

Xingyi MA

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Course Information

Wechat Group

Textbook FYI

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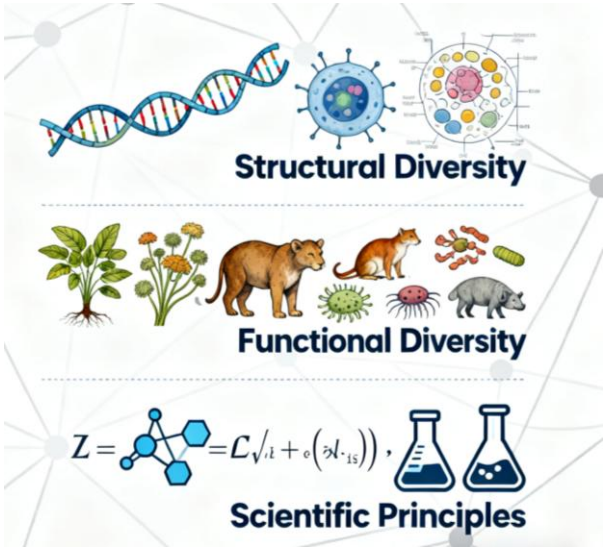
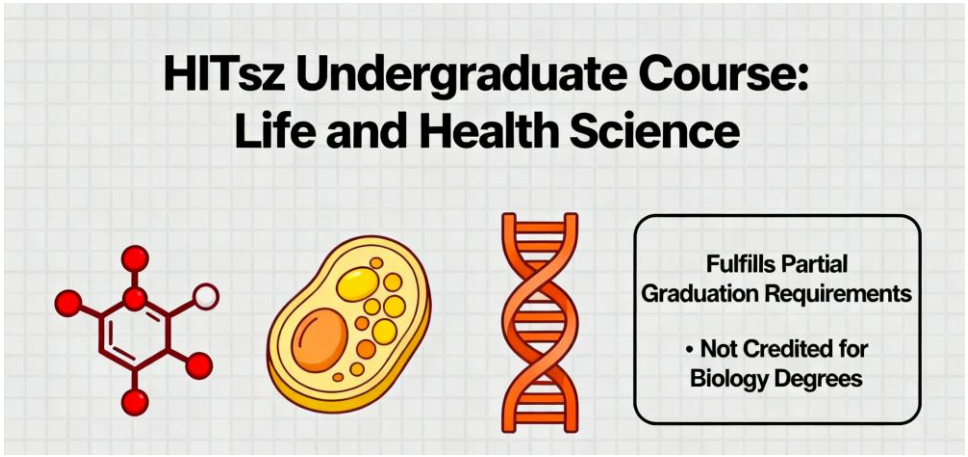
Course Description

- LHS provides the non-science major a strong and diverse background necessary to **understand the structural and functional diversity of organisms while providing students with basic scientific and biological principles.**
- **Topics include basic and biological chemistry, cell structure and processes, and DNA and genetic basics.** This course partially fulfills the undergraduate graduation requirements of HITsz. It may not be credited toward a biology degree.





Course Description

- **It is important for all of us to have a good working knowledge of life, biology, health for day-to-day life.**

Increasingly, biology-related topics are appearing in newspapers, magazines, on SNS, and in politics.

Over the course of your life you will make important decisions regarding LHS issues, such as voting for politicians with specific stances; and influencing your community to take a stance on various issues and policies:

Should we produce and eat genetically modified organisms?

Should we allow some amount of stem cell use or cloning?

Further, the decisions you make for your own life, such as those that are health and medicine related, are all based on an underlying understanding of LHS.

- **LHS affects every aspect of our daily lives whether we are immediately aware of it or not.**

Should we produce and eat genetically modified organisms?

- The question of whether to produce and eat GMOs has no absolute "yes" or "no" answer, as it depends on a balanced assessment of their benefits, risks, and regulatory safeguards.
- **1. Core Reasons Supporting GMO Production and Consumption**
- **Addressing global food security**: GMOs can be engineered to resist pests, droughts, or saline-alkali soils, significantly increasing crop yields. This helps alleviate food shortages in regions with harsh natural conditions or large populations.
- **Reducing resource consumption and environmental impact**: Pest-resistant GMOs (e.g., Bt cotton) reduce the need for chemical pesticides, lowering pollution to soil and water and protecting non-target organisms like bees.
- **Enhancing nutritional value**: Some GMOs are modified to enrich nutrients, such as "golden rice" fortified with beta-carotene (which converts to vitamin A), helping combat vitamin A deficiency in developing countries.
- **2. Key Concerns About GMO Production and Consumption**
- **Potential long-term ecological risks**: There is uncertainty about whether GMO genes (e.g., herbicide-resistant genes) could spread to wild relatives through cross-pollination, leading to the emergence of "super weeds" and disrupting local ecosystems.
- **Uncertainty about long-term human health impacts**: While most short-term studies confirm the safety of approved GMOs, some argue that long-term effects (e.g., potential allergenicity or impacts on gut microbiota) require more prolonged observation and research.
- **Ethical and economic issues**: Large biotech companies may control GMO seed patents, leading to higher costs for farmers and reduced diversity in traditional crop varieties. Additionally, some groups oppose GMOs on ethical grounds, such as "interfering with natural genetic laws."
- **3. Critical Premise: Strict Regulation and Scientific Evaluation**
- The safety of GMOs largely depends on rigorous pre-market assessment and post-market monitoring:
- **Mandatory safety evaluation**: Approved GMOs must undergo strict testing for toxicity, allergenicity, and environmental impact (e.g., assessments by the U.S. FDA, European Food Safety Authority, or China's Ministry of Agriculture and Rural Affairs).
- **Clear labeling systems**: Many countries (e.g., the EU, China) require mandatory labeling of GMO-containing foods, allowing consumers to make informed choices based on their preferences.

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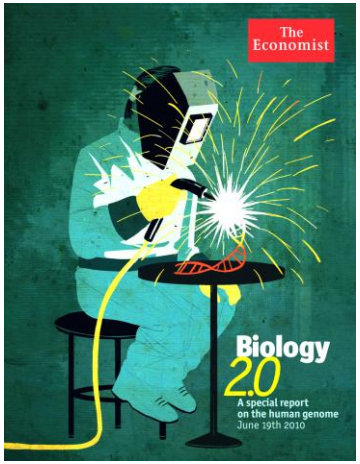
Course Objectives *(with Syllabus)*

1) To examine the nature of science, the scientific method, & hypothesis testing
2) To examine cell diversity, structure, & function
3) To examine basic chemical principles, the nature of organic molecules, & the function of chemicals within cells
4) To examine the role of energy in maintaining life & learn how cells acquire & use energy
5) To examine the structure & function of DNA especially as it pertains to protein synthesis
6) To examine the principles of inheritance (genetics) & explore patterns of inheritance in humans
7) To examine the principles & regulation of cell division, & the consequences of malfunctions in the regulation of cell division (e.g. cancer)
8) To examine aspects of LHS & biotechnology, and discuss the role that biotechnology plays in our world, including an exploration of the ethics & consequences of emerging technologies
9) To examine the typical cases developed with LHS

Learning Outcomes

- should show competency in each objective listed above.
- should be able to demonstrate understanding of basic principles of biology, have a conversational knowledge of the principles behind breaking news in LHS, and understand metabolism, physiology, and genetics sufficient to make wise decisions regarding health and nutrition.
- should also have an improved ability to think critically and to make informed decisions as a member of society.



How Obtain?

- **Consistent attendance is required**; accumulating >3 absences will result in a final grade of "Fail".
- **Engage in thoughtful reflection (40%)**: independently complete *quizzes* or *reports* and submit it within one week following the assignment's release.
- **One-time closed-book examination (60%)**: dedicate yourself to thorough revision to attain outstanding results in the final examination.

Etiquette: Be respectful and professional when interacting with the professor and other students by email or in the Wechat Group. Inappropriate comments will result in a **0** (if made in a graded forum) and may result in a student's removal from the course.

All forms of academic dishonesty are extremely serious offenses. Note that YOU are responsible for knowing what counts as academic dishonesty- ignorance is not an excuse. Any student caught in an act of academic dishonesty will automatically receive a **0** on the relevant assignment and will likely be given a failing grade ("F") for the entire course. In accord with the University Regulations, students will also be reported to the office of academic affairs.

Special Needs: I am committed to making educational opportunities available to all students. If you have special needs, please contact me at the beginning of the semester. If you have special needs to be addressed (e.g. medical conditions, etc.), please let me know so that we can work together to figure out how you can best succeed in this course.

Report 1

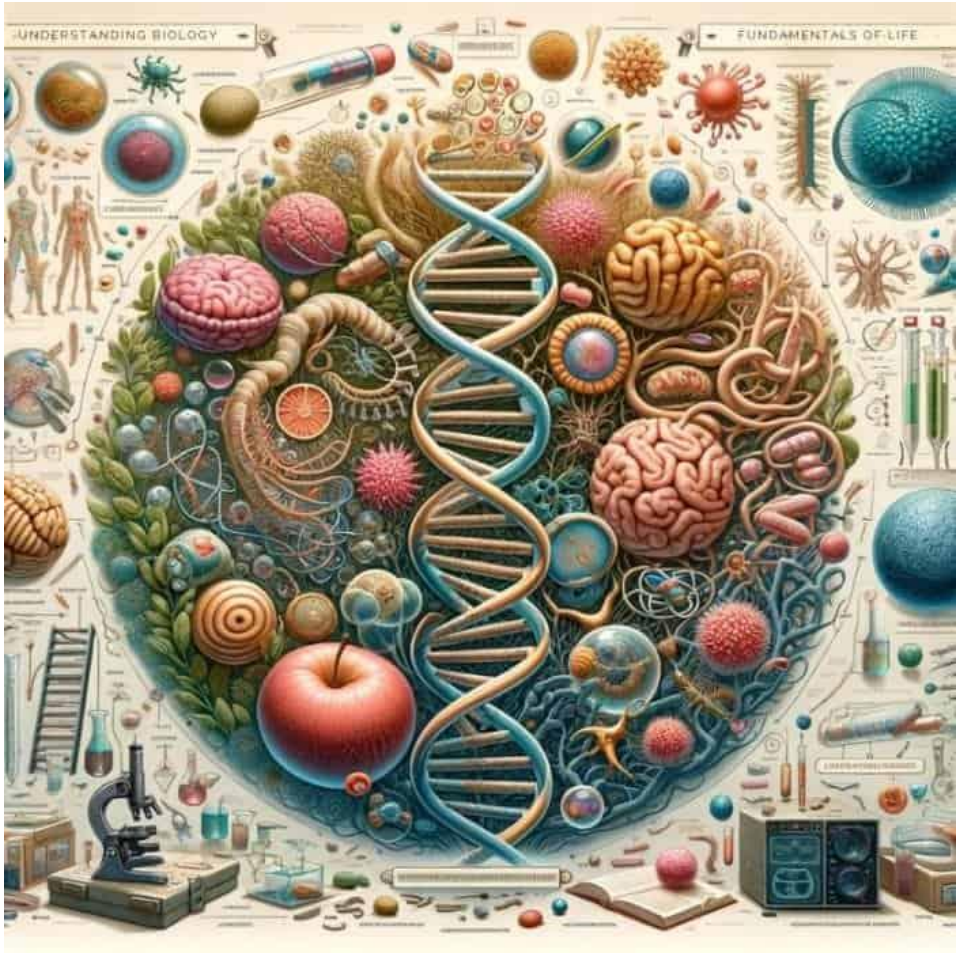
Report 1: Should we allow some amount of stem cell use or cloning?

Requirements：

- ✓ **1~2 pages in length use A4 paper,;**
- ✓ **content must include both a diagram and text;**
- ✓ **Submission deadline: Nov 13, 2025;**
- ✓ **You can handwrite, draw, or use Office Word. The final document will be converted to PDF and sent by email.**
- ✓ **Email subject: *Your Student ID* – Report 1.**
- ✓ **Email: LifeHealthScience@yeah.net**

If AI use is detected, the assignment will receive a score of 0.

Importance of LHS?



Importance of Biology | Top 25 Reasons Biology Matters! (bioexplorer.net)

Importance of LHS?

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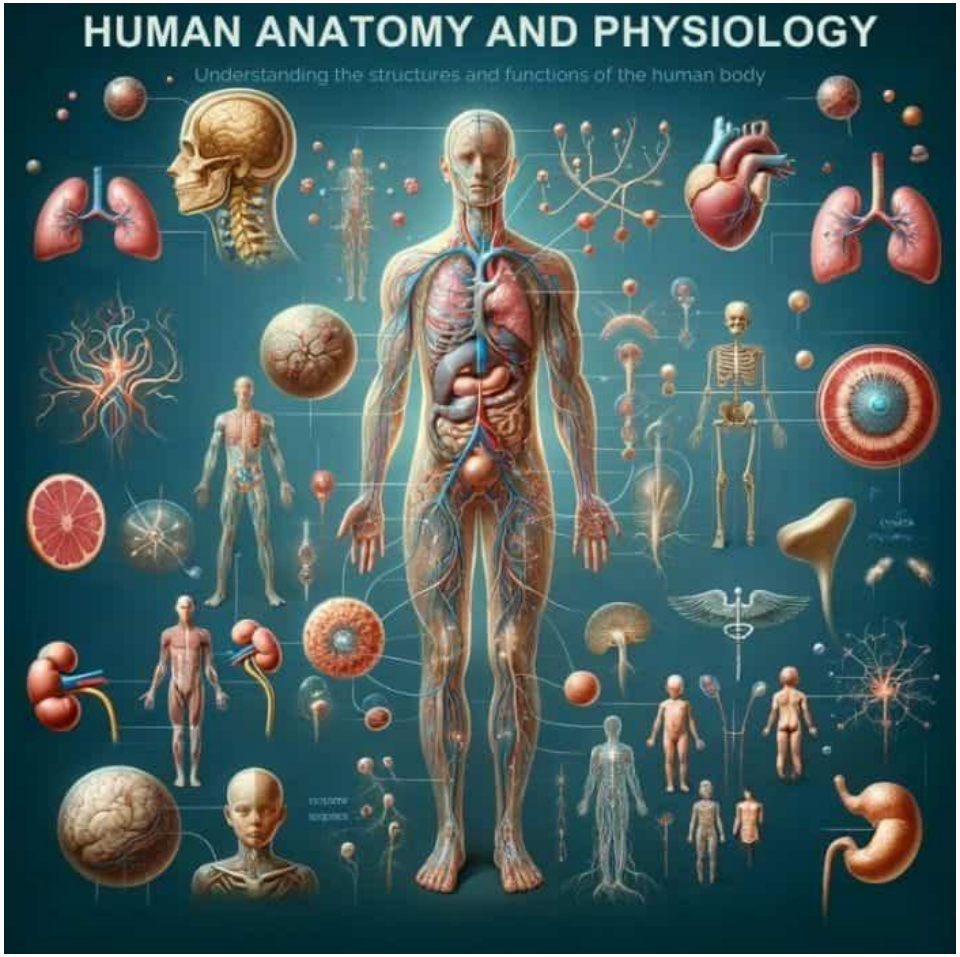

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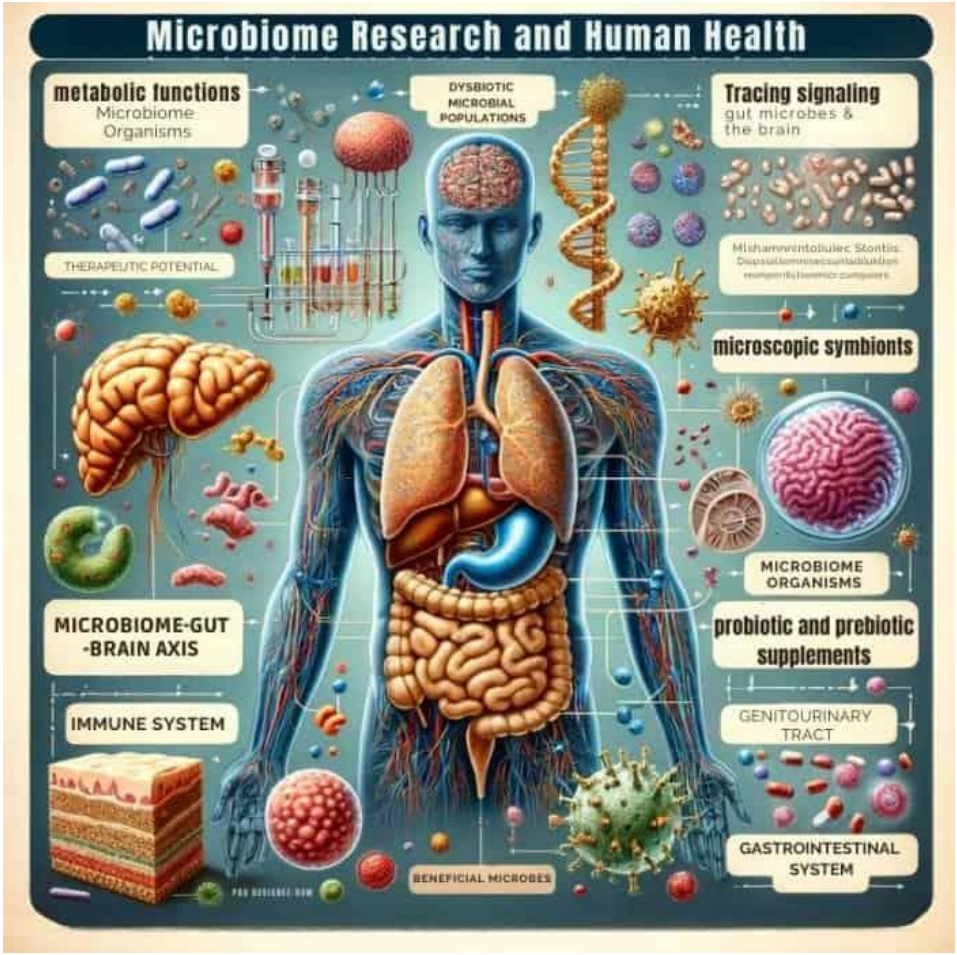

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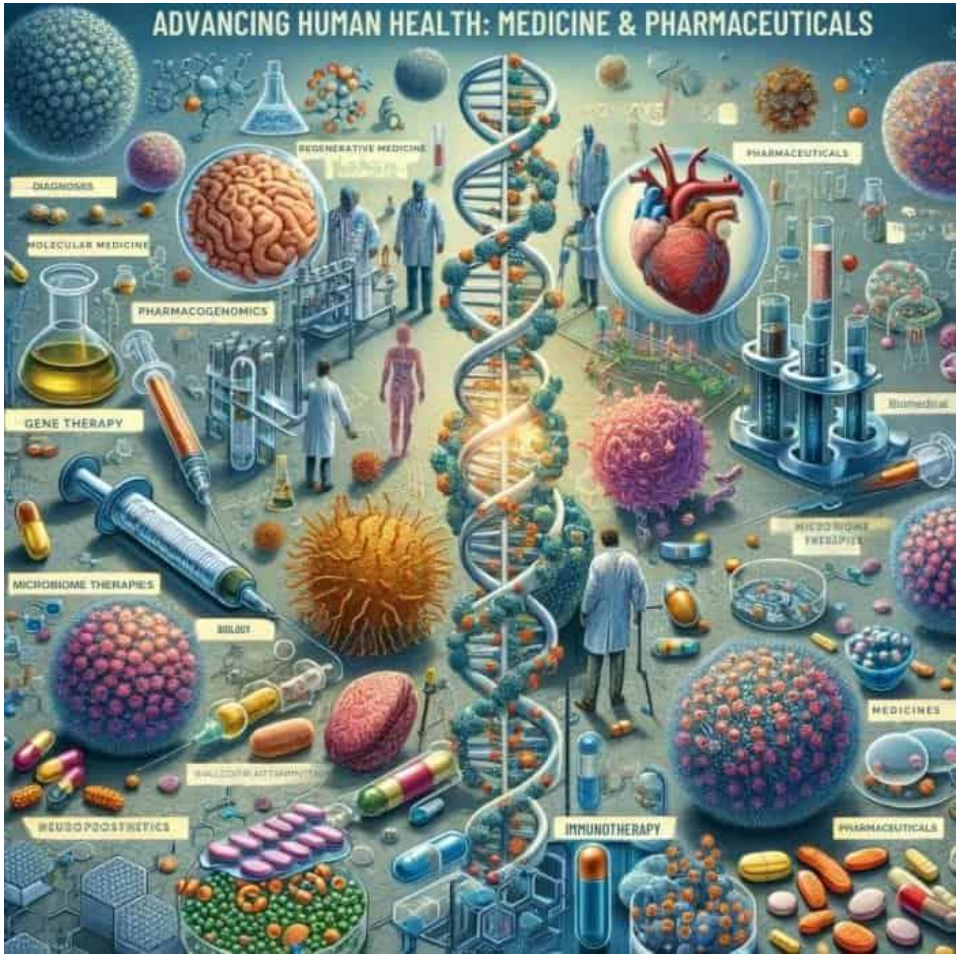

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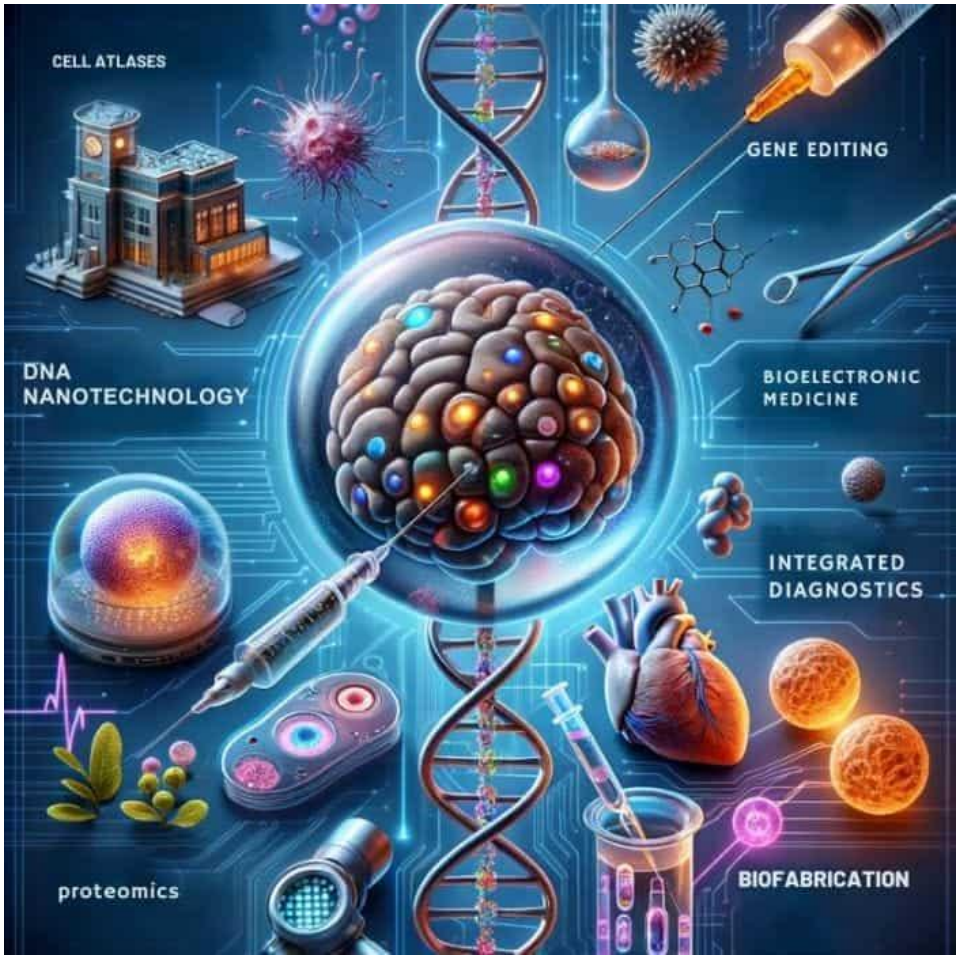
Importance of LHS?

Advanced Medical Research:
Regenerative and Personalized Medicine



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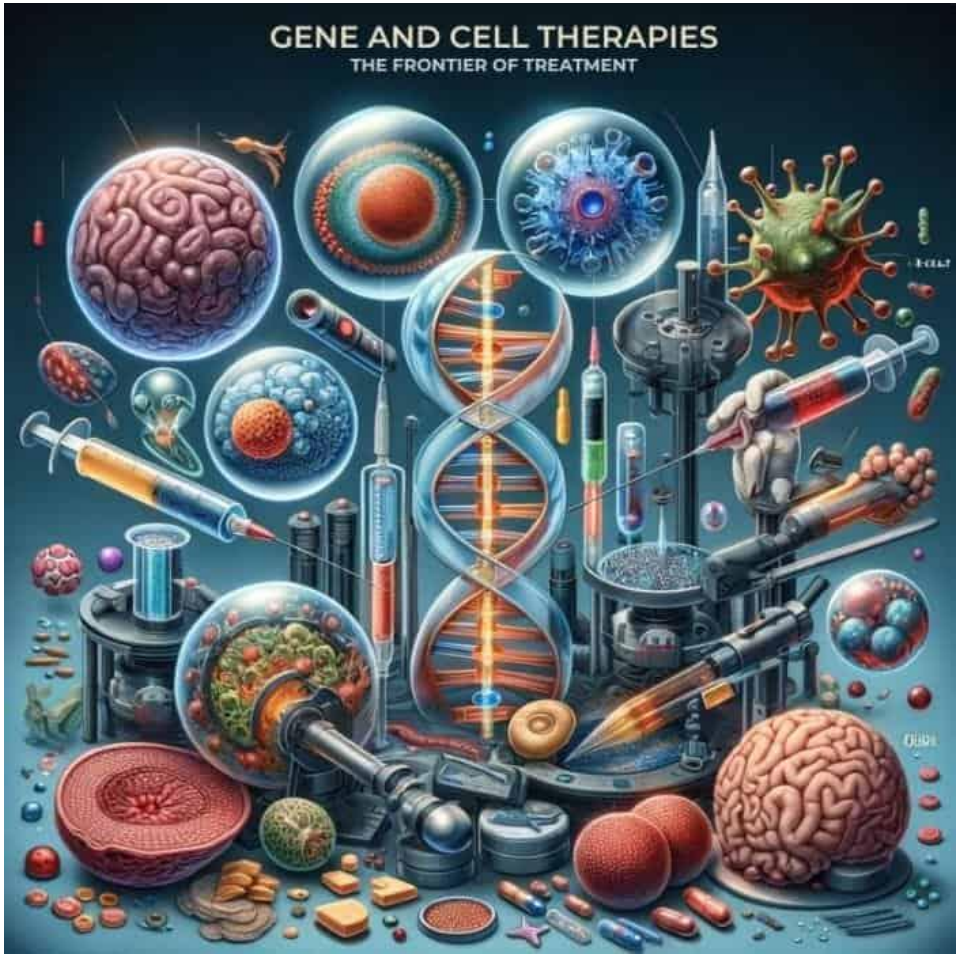

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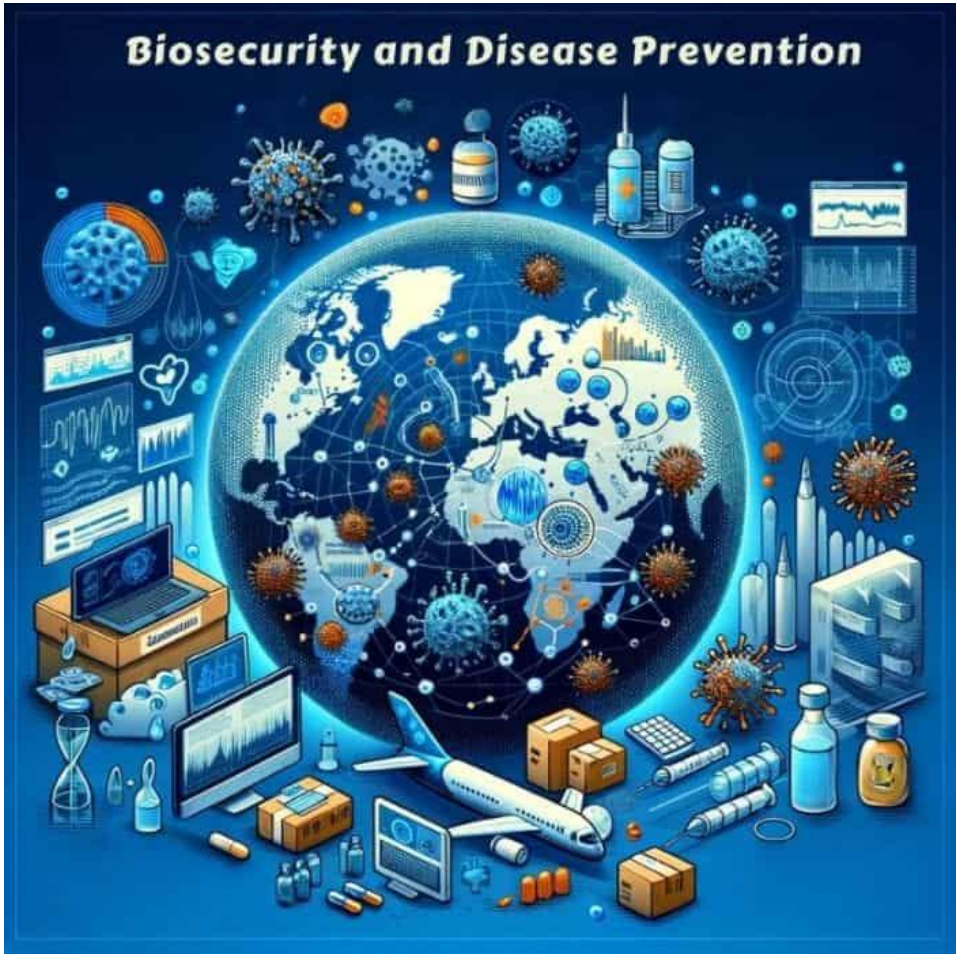

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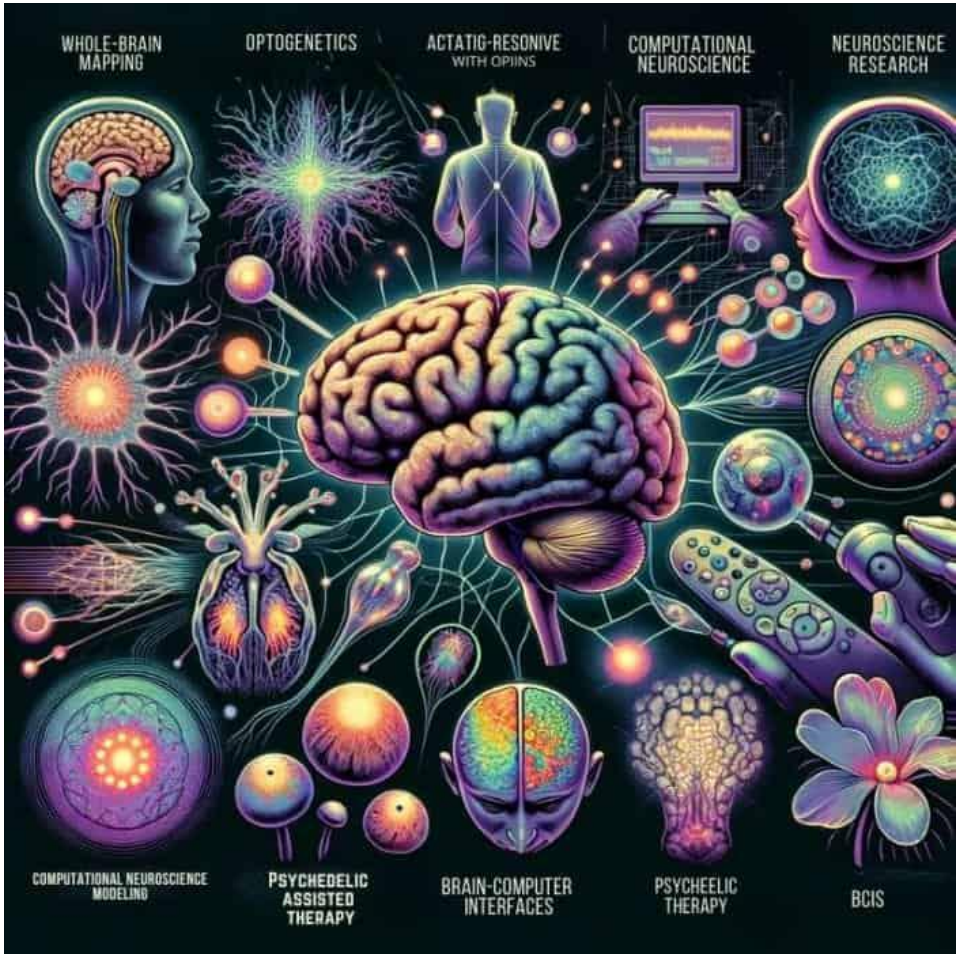
Importance of LHS?

Neurobiology and Cognitive Sciences



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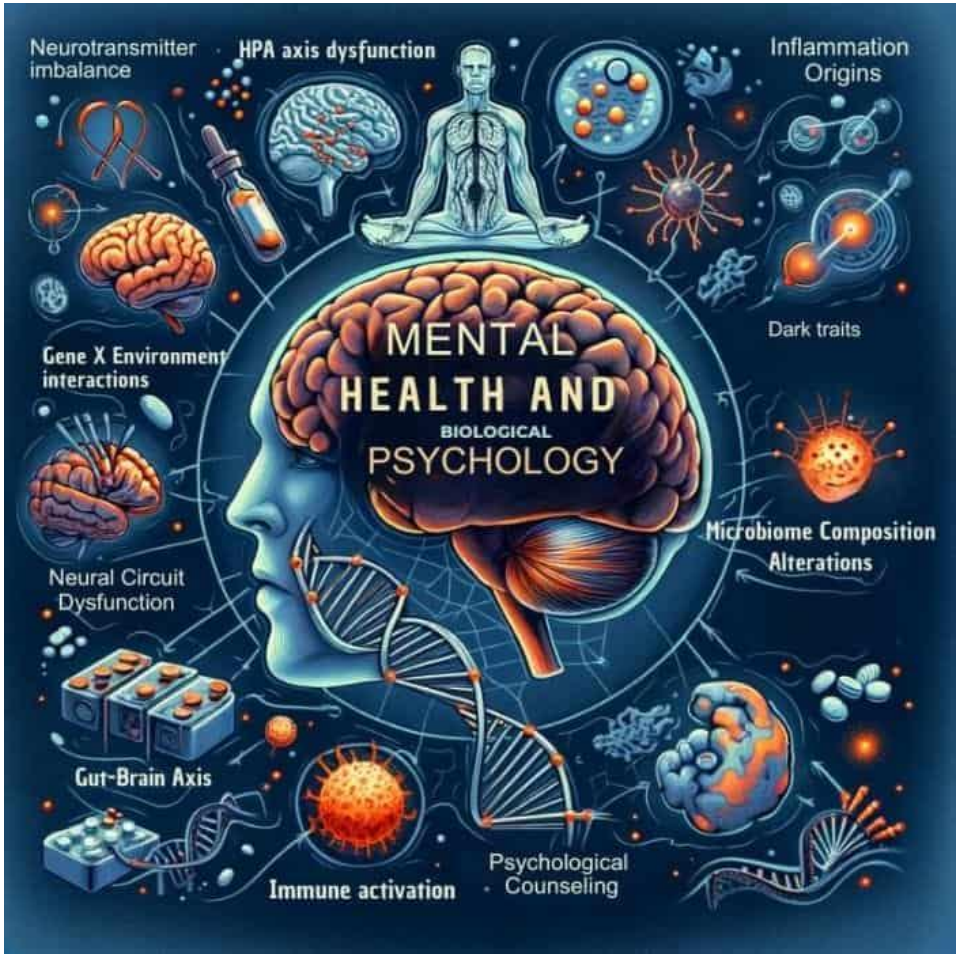

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Botany and New Food Source Exploration

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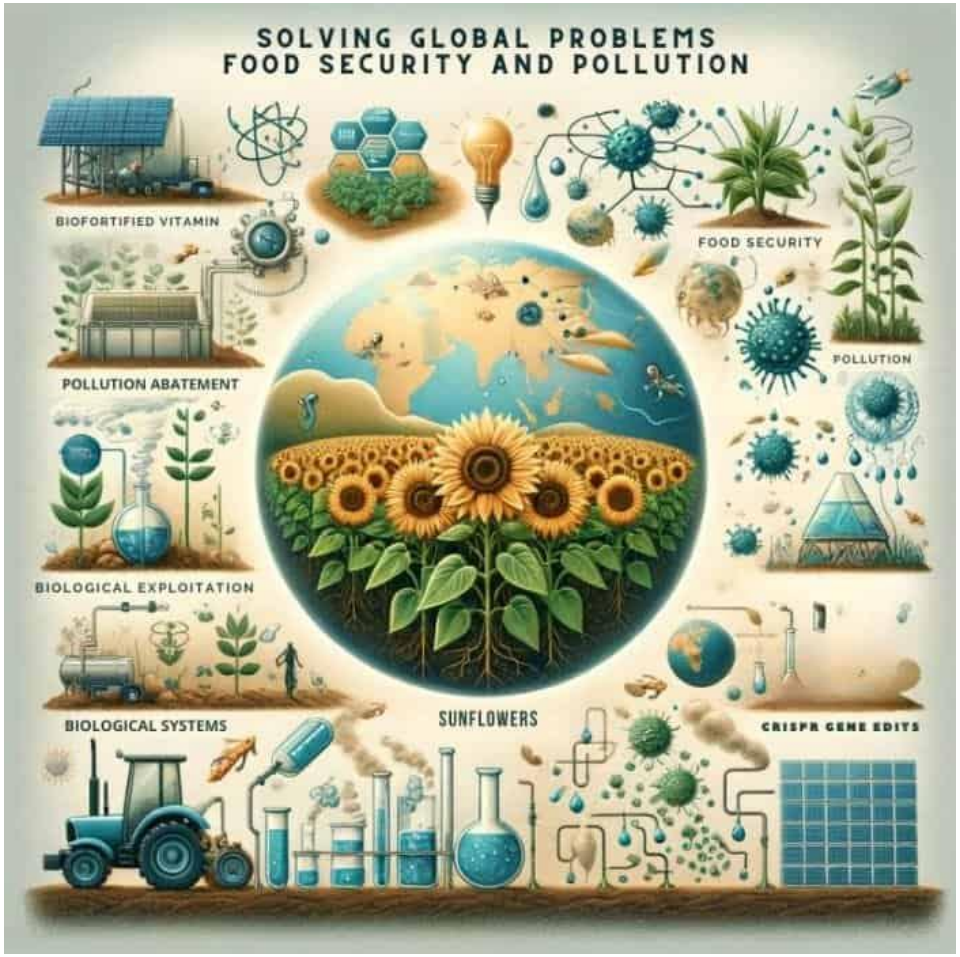

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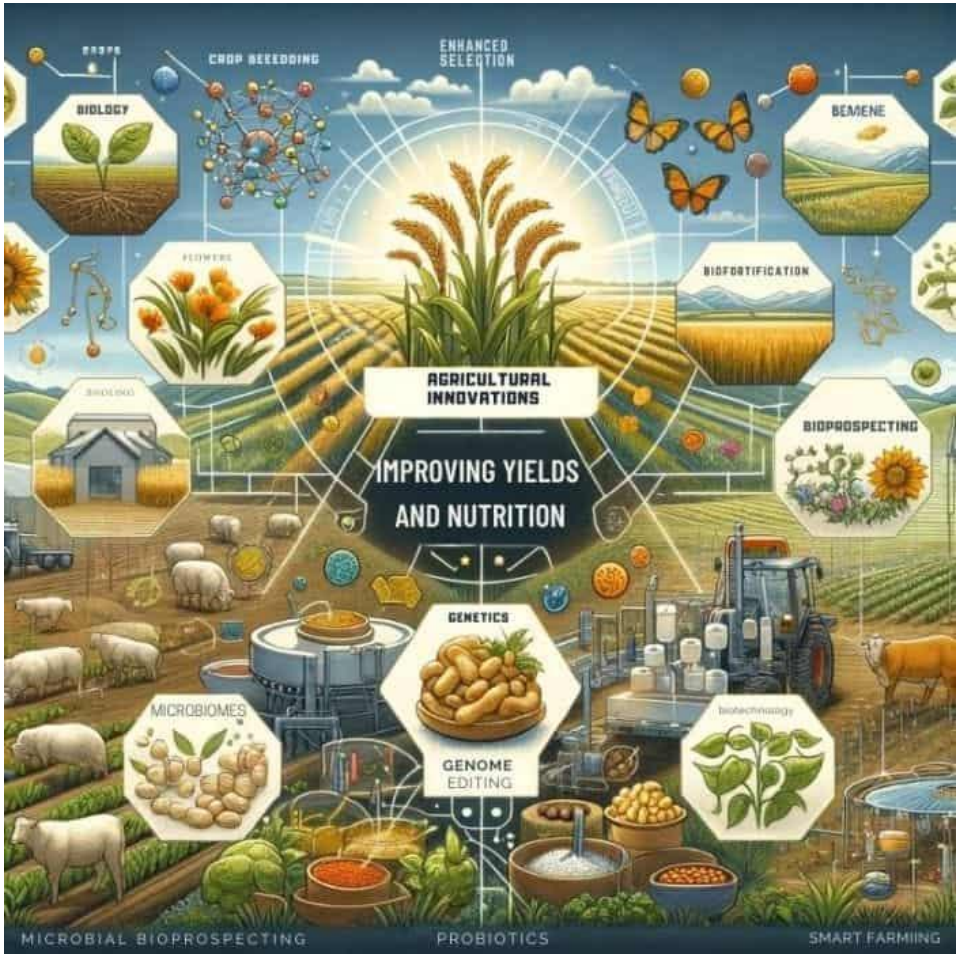

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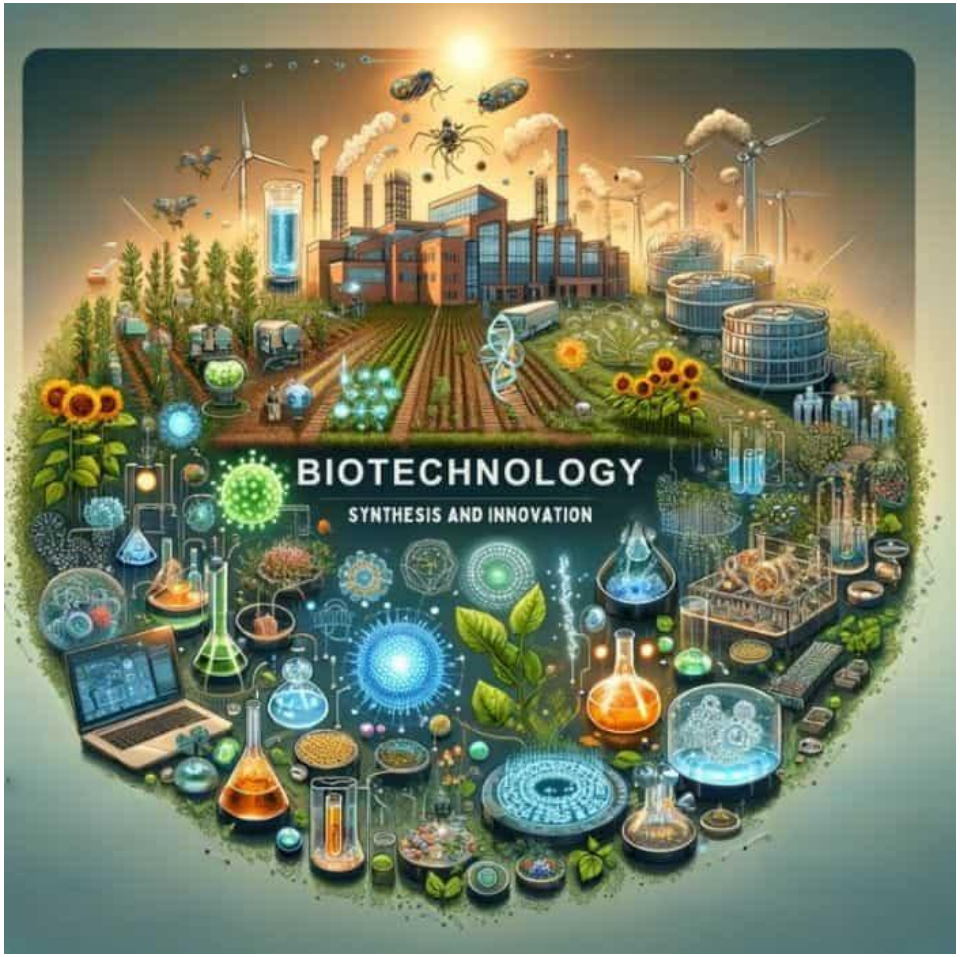

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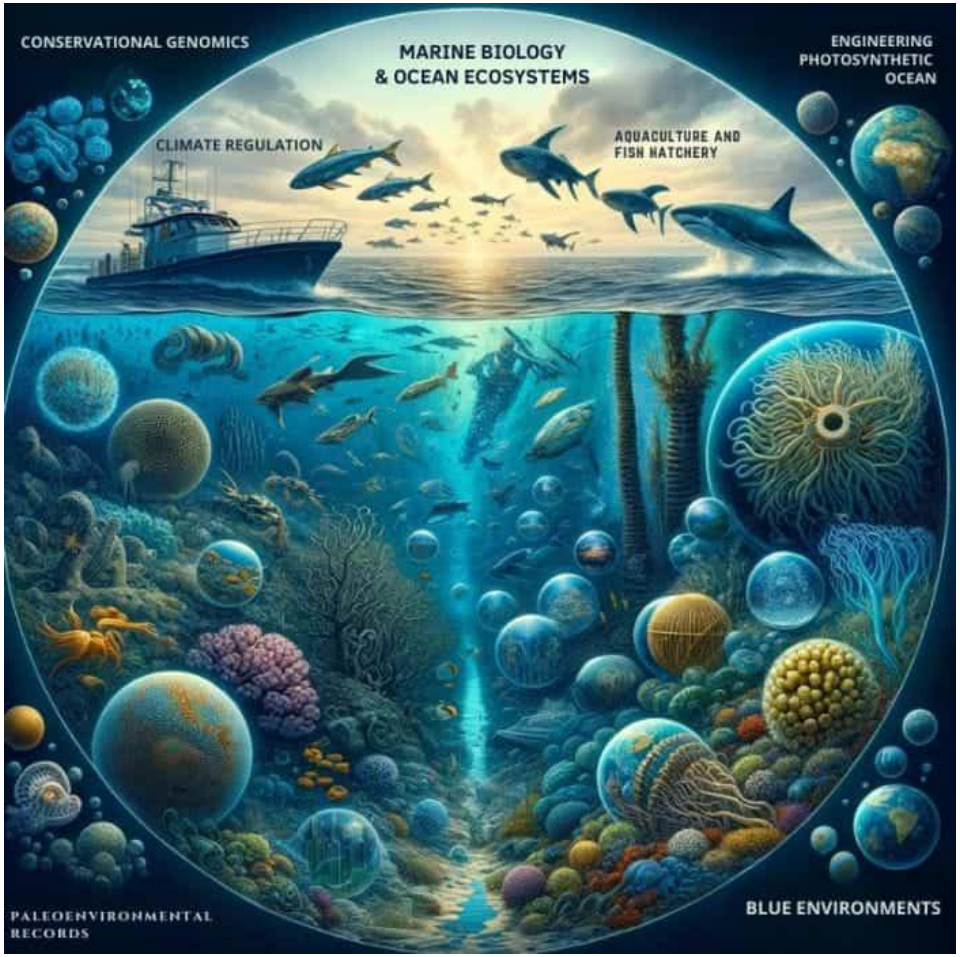

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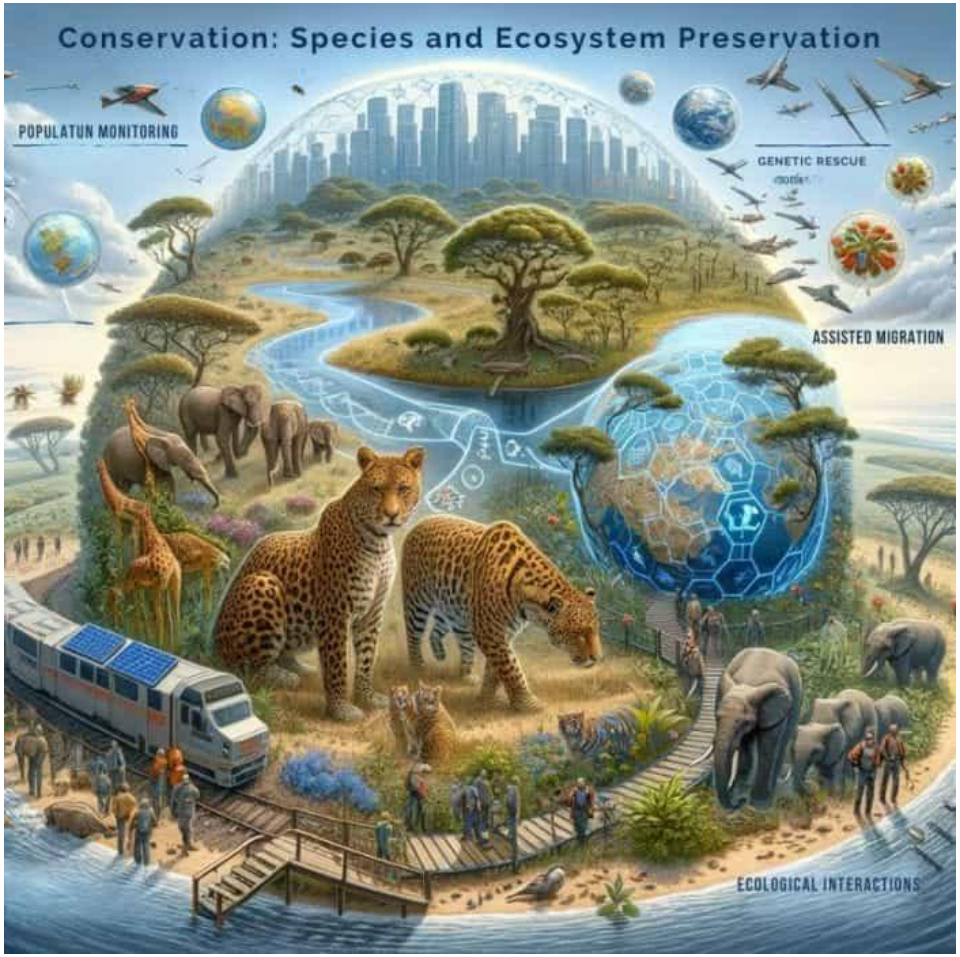

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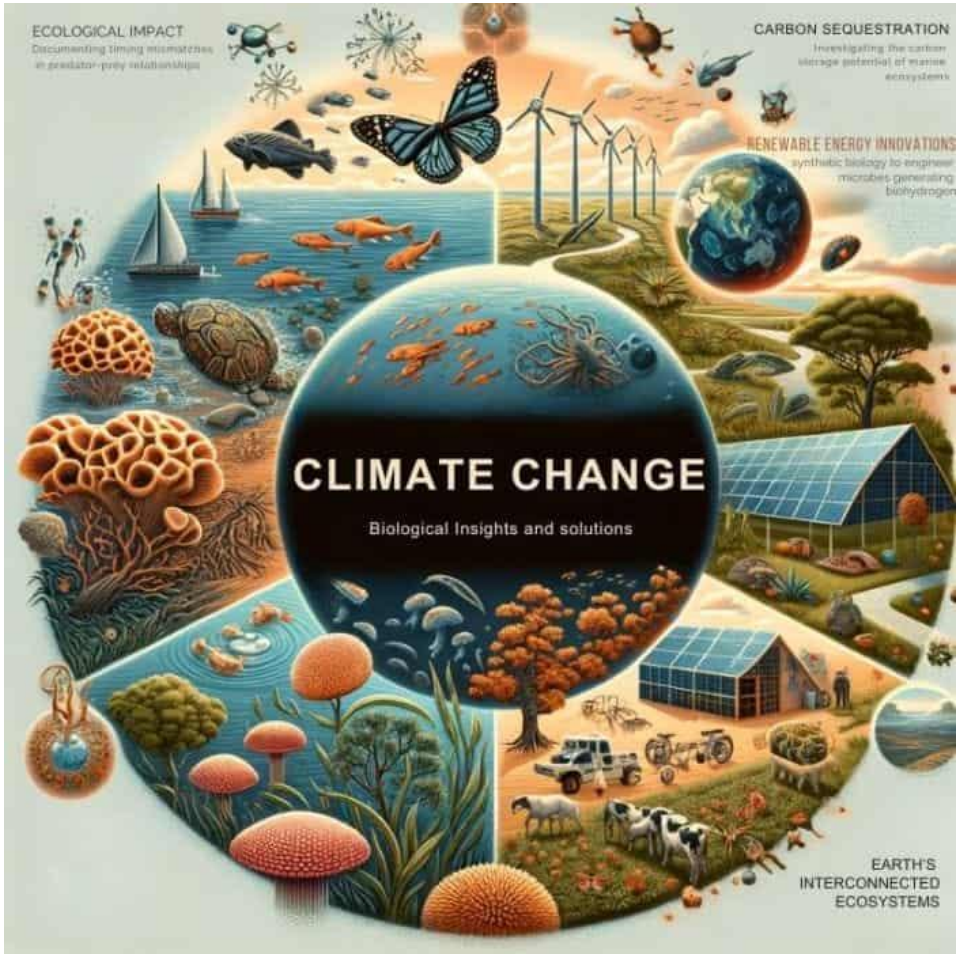

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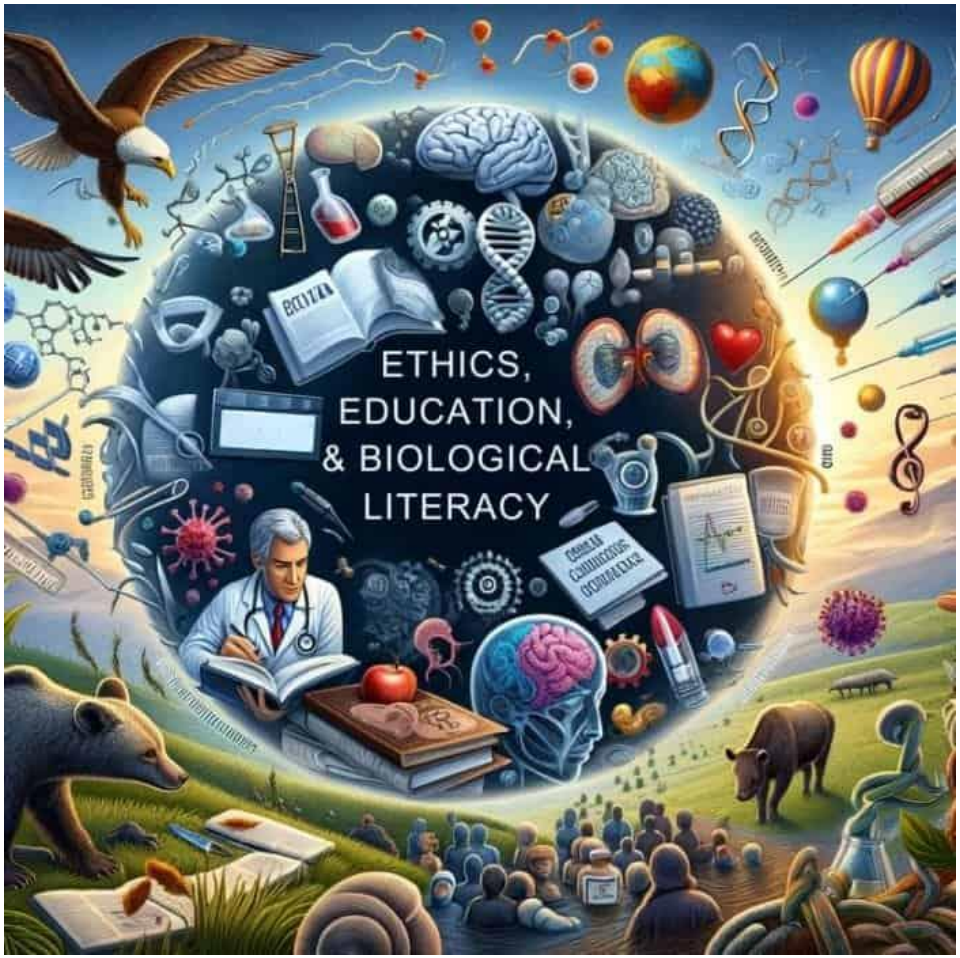

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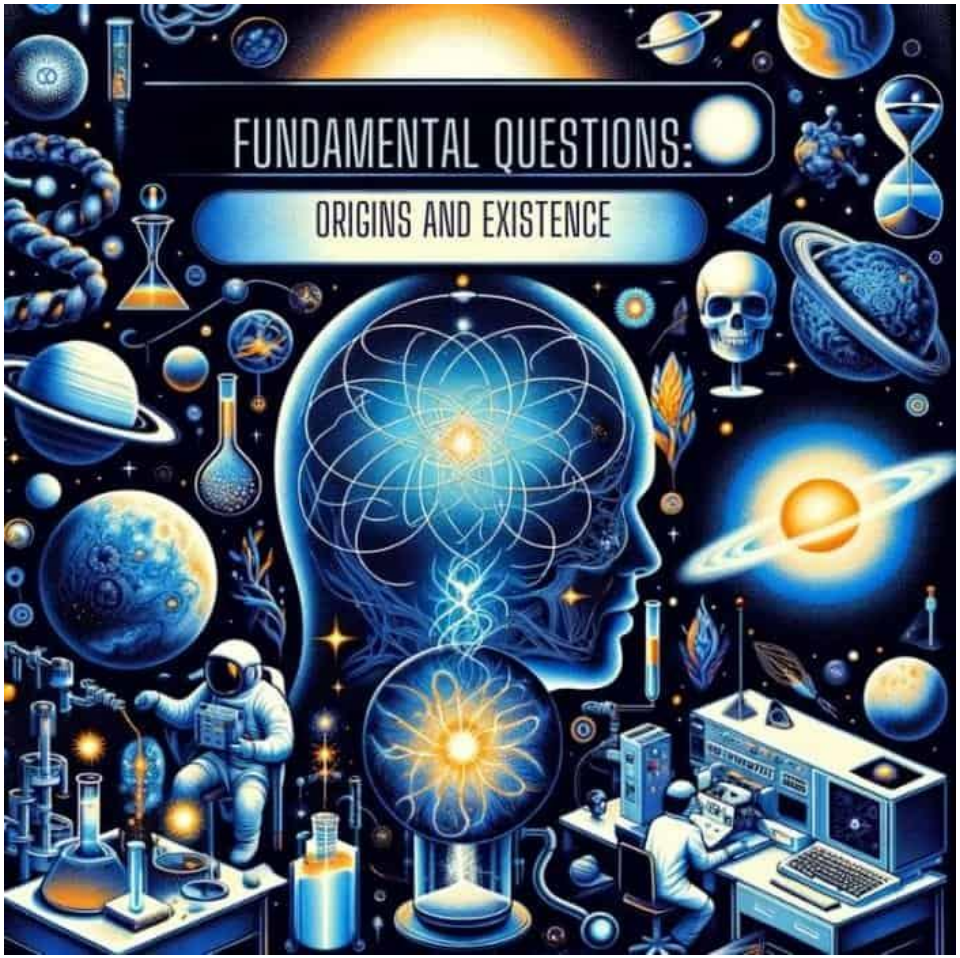

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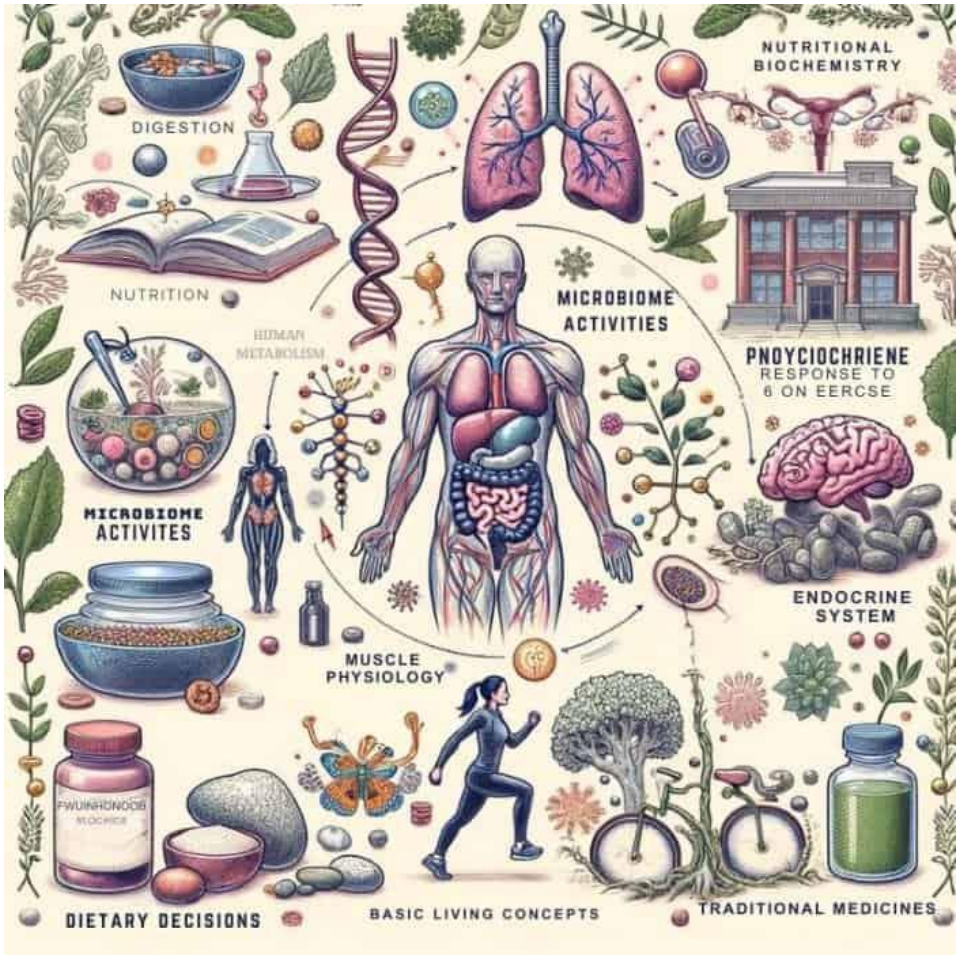
Importance of LHS?

Basic Living Concepts and Lifestyle Applications



Importance of Biology | Top 25 Reasons Biology Matters! (bioexplorer.net)

Chapter 1: The Scientific Study of Life

- What is science & how do we “do” science?
- What is biology & what makes a thing “living?”

Corresponds with OpenStax Biology 2e Chapter 1

What is science & how do we "do" science?

- **Science** = an intellectual activity involving observation, description, experimentation, & explanation of the *natural world*
  - The natural world is the *objective* & *measurable* world around us
    - Science is NOT just a collection of facts, it's something you *do*
    - Science can NOT answer questions about immeasurable things
      - e.g. religion, morals, ethics, values, art, etc.

- **Being a scientist is like being a detective**
  - instead of answering questions about crimes
  - you answer questions about the natural world

- *Does the radiation from cell phones cause brain tumors?*
- *Does vitamin C reduce the likelihood of getting a cold?*
- *Does "blood doping" really improve athletic performance?*
- *Are indoor tanning salons safer than tanning outdoors?*
- *What dose of alcohol is lethal for a human?*
- *Which parent determines a baby's sex?*
- *Does aspirin help with fevers?*
- *Do probiotics actually improve gut?*

photo by Mike Mozart

Question	Core Conclusion	1-Sentence Key Note	Visual Cue Reminder
Does cell phone radiation cause brain tumors?	**No conclusive evidence supports this.**	**Emits low-energy non-ionizing radiation; large studies find no link to brain tumors.**	📱 + ❌ (no risk link)
Does vitamin C reduce cold likelihood?	**No (for most healthy people).**	**Fails to prevent colds generally, but may shorten symptoms by 1–2 days in some cases.**	🥤 + ⏳ (shortens duration)
Does "blood doping" improve athletic performance?	**Yes, but illegal & dangerous.**	**Boosts oxygen to muscles for endurance, but risks blood clots, heart attacks, or organ failure.**	🏃 + ⚠️ (illegal warning)
Are indoor tanning salons safer than outdoor tanning?	**No—often more dangerous.**	**Emits 2–5x more UVA than midday sun; use before 35 raises melanoma risk by 75%.**	🌞 + 🚫 (avoid indicator)
What alcohol dose is lethal for humans?	**Typically ≥0.4% blood alcohol concentration (BAC).**	**A 60kg adult reaches ~0.4% BAC with 20–25 standard drinks in 2–3 hours (causes organ failure).**	🍷 + ☠️ (lethal dose note)
Which parent determines a baby's sex?	**The father's chromosome**	**Mothers pass only X chromosomes; fathers pass X (XX = female) or Y (XY = male) chromosomes.**	👶 + 🧬 (sex chromosome clue)
Does aspirin help with fevers?	**Yes, but strict usage limits apply.**	**Reduces fever via prostaglandin inhibition, but banned for kids under 12 (risk of Reye's syndrome).**	💊 + 👶 (no kids warning)
Do probiotics improve gut health?	**Depends (strain, individual, goal).**	**Helps with antibiotic-associated diarrhea/IBS, but no benefit for healthy gut microbiomes.**	🦠 + ✅ (conditional benefit)

- A good detective acts carefully, going step by step to gather evidence, looking for patterns & relying on logic, evidence, & objectivity – they don't rely on a hunch or subjective biases
  - *some bad detectives do, which leads to the wrongful arrest & imprisonment of innocent people*

A good scientist does the same, following the **scientific method** to form a logical hypothesis & collect data/evidence in an *objective* way

figure from OpenStax Biology 2e

Scientific Method

A logical **hypothesis**

= a tentative explanation for observations

-must be testable

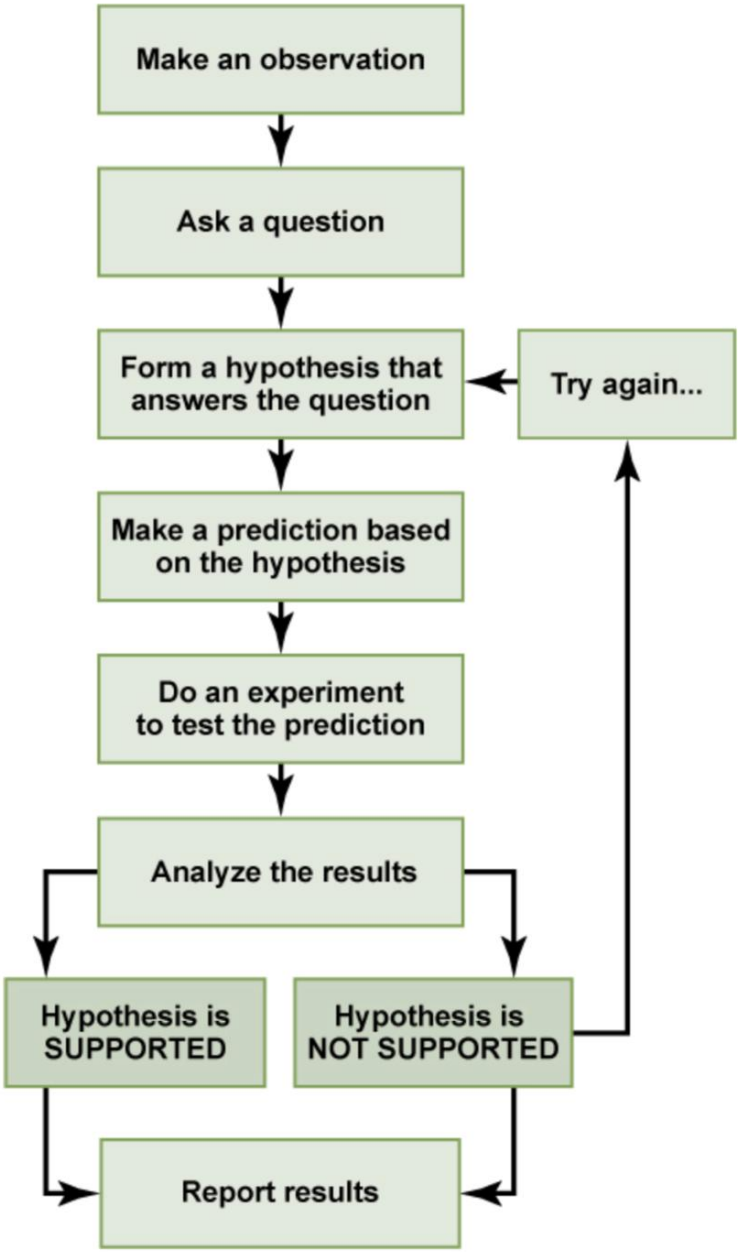


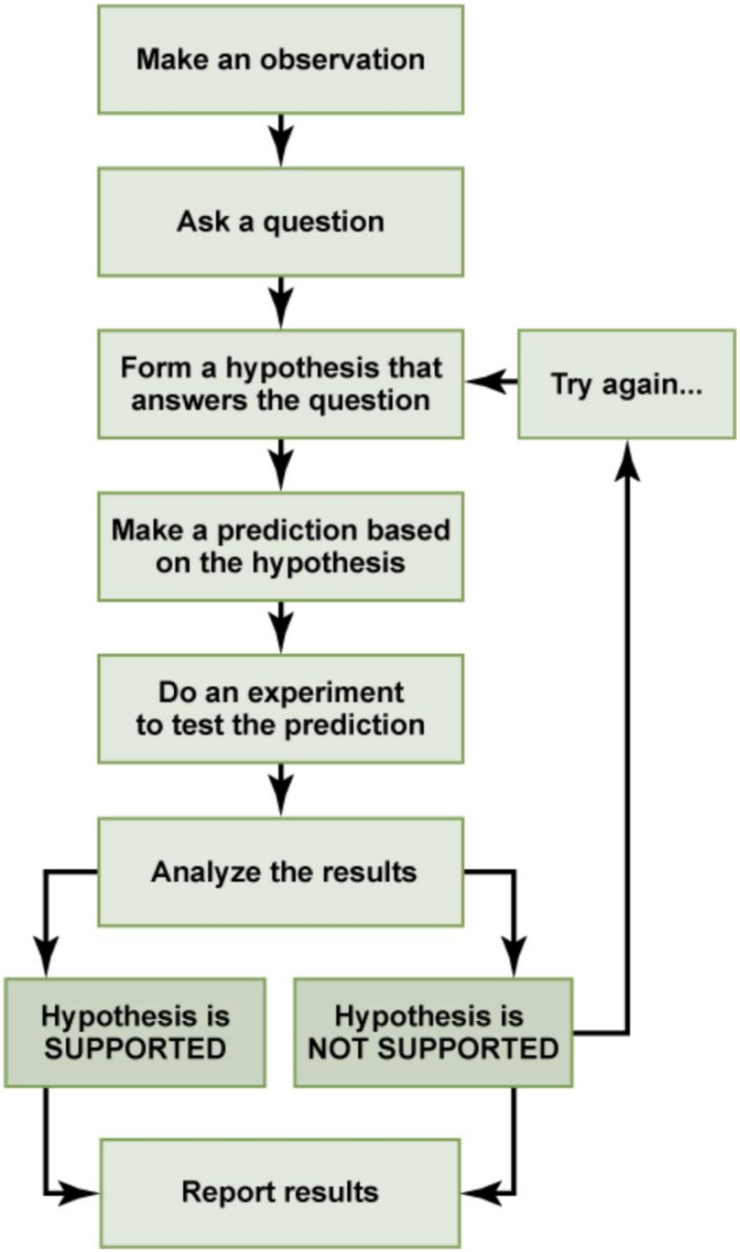
figure from OpenStax Biology 2e

Scientific Method

A **prediction** based on the hypothesis

= if / then statement

If *my hypothesis is true,*
then _____*will happen*



Scientific Method

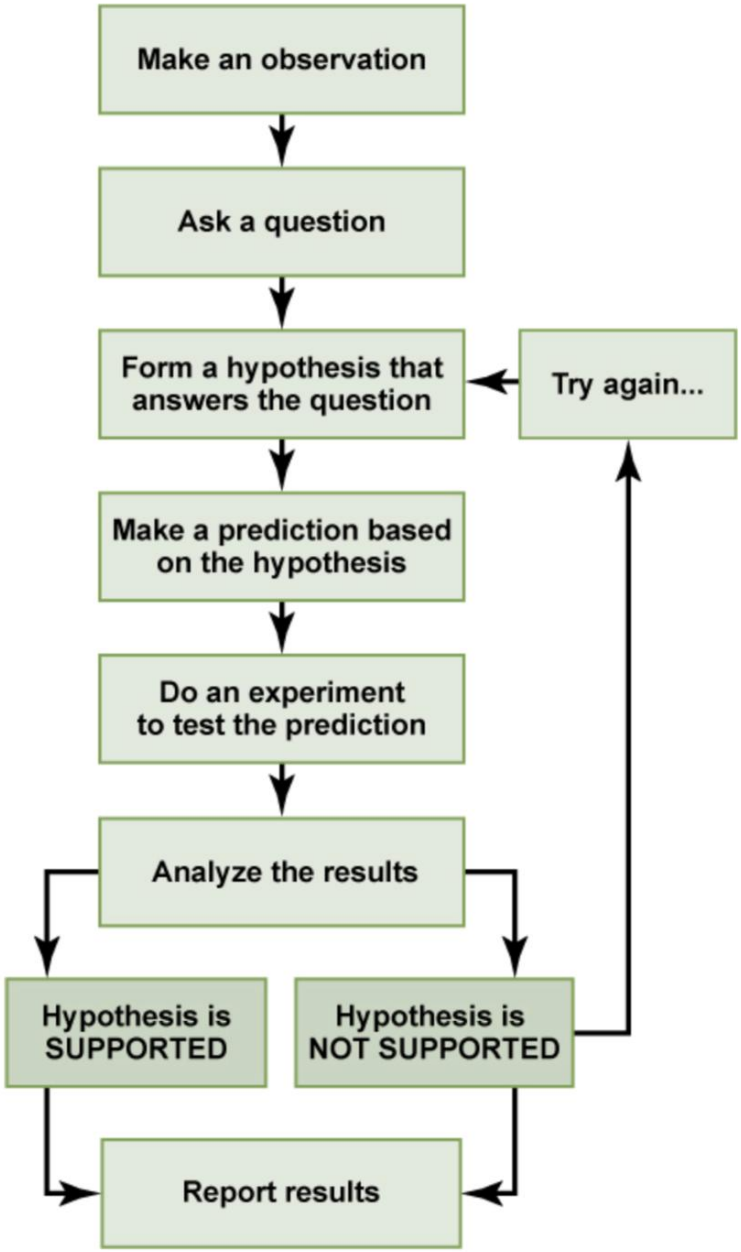
- **Hypothesis & prediction examples:**
  - **Suppose you hypothesized that your car won't start because the battery is dead**
    - **Hypothesis: My car won't start because the battery is dead.**
    - **Prediction: If my hypothesis is correct, then**
      - ✓ *my car will start if I put in a new battery.*
      - ✓ *a different car won't start if I put my battery in it.*

figure from OpenStax Biology 2e

Scientific Method

- An **experiment** or **observation** that allows you to collect data

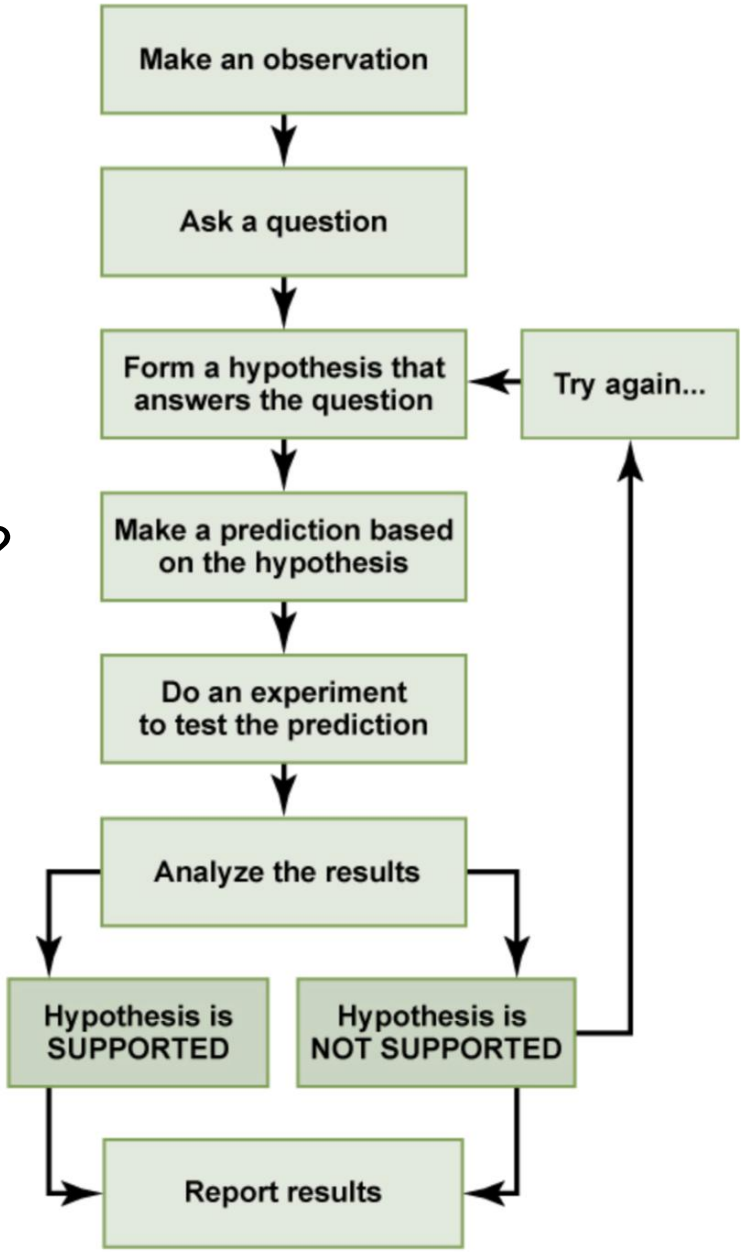
  -More on setting up experiments soon



Scientific Method

- Drawing a **conclusion**

  Is your hypothesis supported or not?



Scientific Method

- **Scientific method in action:**
  - Hypothesis: My car won't start because the battery is dead.
  - Prediction: If my hypothesis is correct, then my car *will* start if I put in a new battery.
  - Experiment: Put in a new battery & try to start car.
  - Conclusion:
    - If the car starts – hypothesis supported
    - If the car does not start – hypothesis rejected, come up with new hypothesis
      - e.g. My car won't start because it is out of gas.

Scientific Method

observation	My toaster doesn't toast my bread.
question	Why doesn't my toaster work?
hypothesis	There is something wrong with the electrical outlet.
prediction	If something is wrong with the outlet, then my coffeemaker also won't work when plugged into it.
experiment	I plug my coffee maker into the outlet
result	My coffeemaker works.

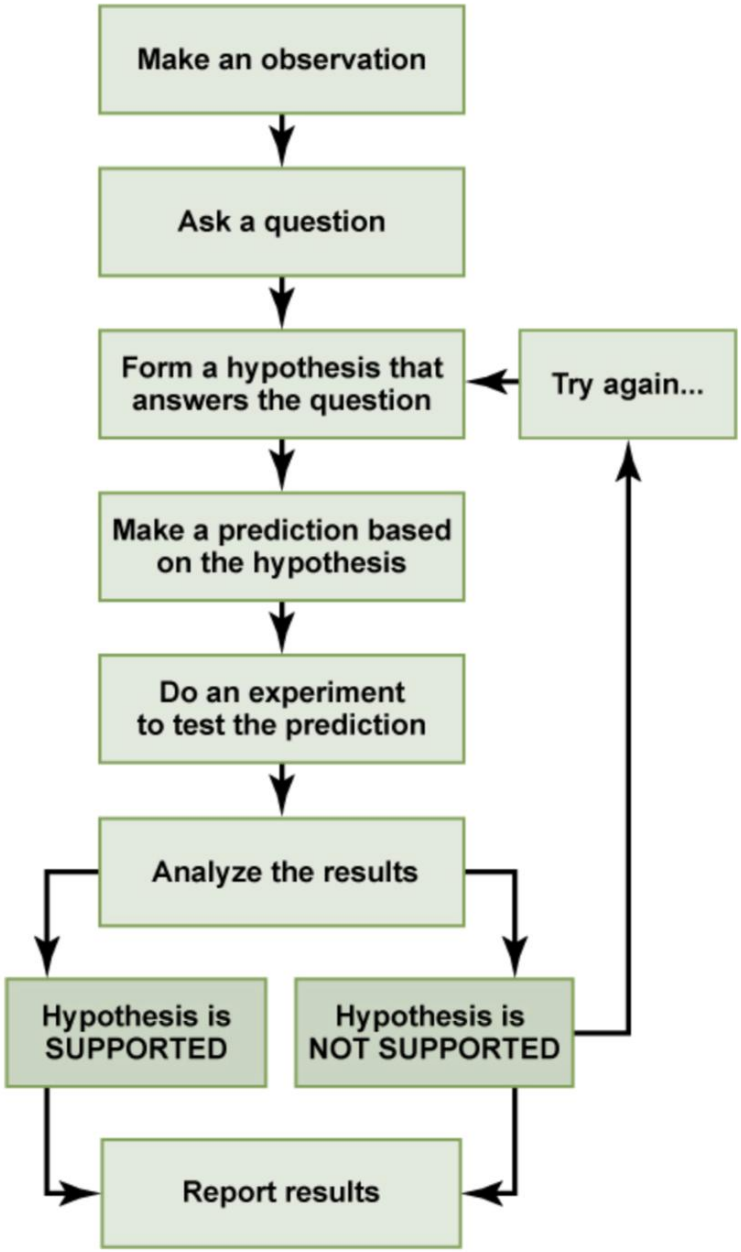
Is your hypothesis supported or not here?

- What is **peer review**?

- Before publishing/reporting results, other scientists evaluate the validity of the methods, data, & conclusions

  If they are not appropriate & well done, the conclusions will not be accepted or published

  Not all journals require peer review these days, which makes it difficult for non-scientists to know what results to trust



How do we set up a good experiment?

- We must test only ONE **variable** at a time
  - variable = changeable characteristics of an experiment
    - testing more than one at a time = **confounds**

- We use **controls** to keep all variables (except one) the same between experimental groups
  - this prevents confounds

Take note of:

- *the experimental group vs. the "control" group*
- *the ONE variable being tested*
- *the many variables that are "controlled" for & thus eliminated as confounds*

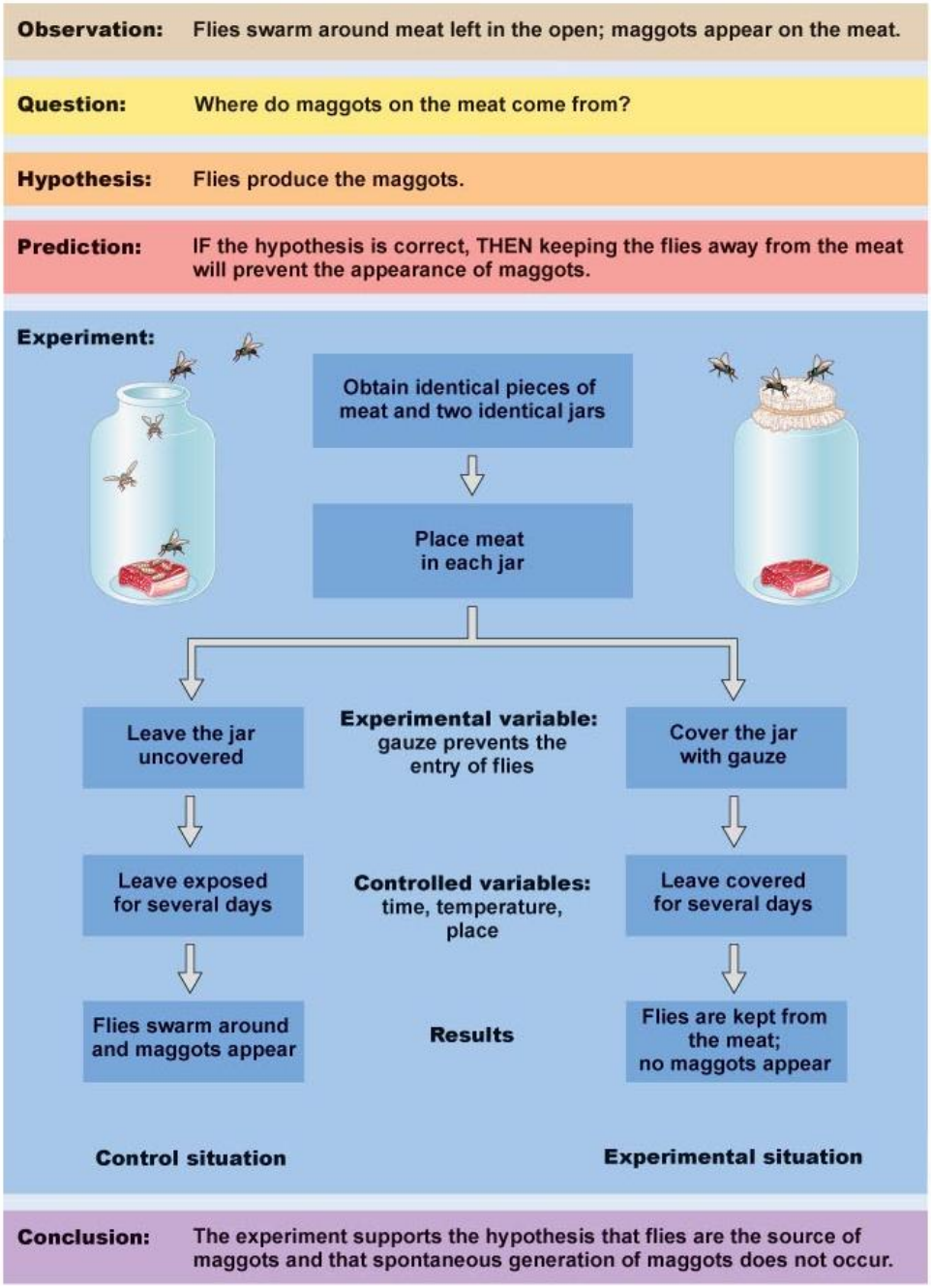


Figure from Biology: Life on Earth

The Experiment of Malte Andersson

- *Again note the controls & variables*

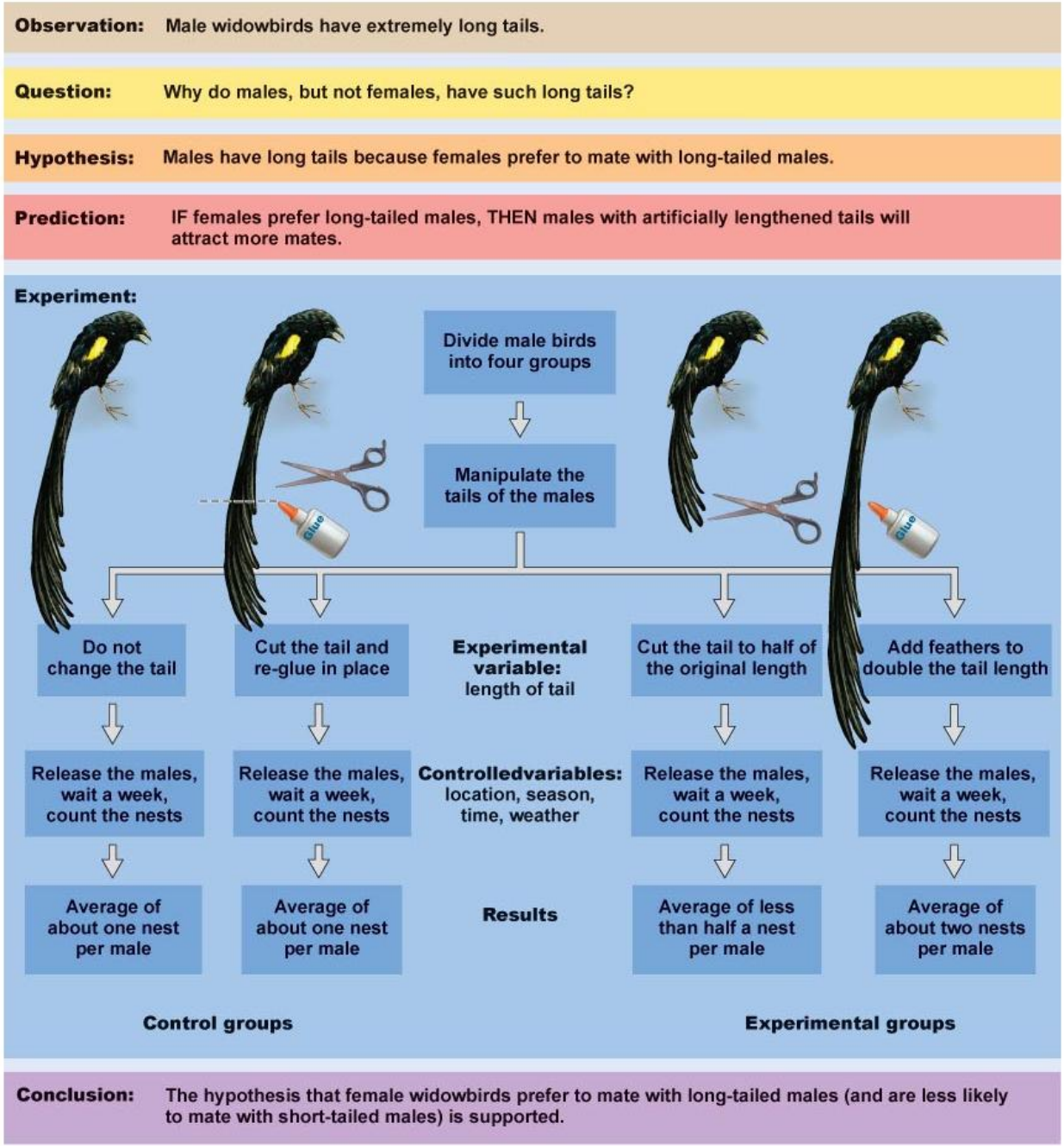


Figure from Biology: Life on Earth

Generally, during setting up an experiment, we should keep in mind 2 principles. Please briefly explain them.

作答

- The scientific method in action with controls:

OBSERVATION

Consuming echinacea seems to reduce the intensity or duration of symptoms of the common cold.

HYPOTHESIS

Echinacea reduces the duration of the common cold.

Echinacea

https://vibaike.com/226635/

Figures of this section from What is Life? A Guide to Biology
Copyright: W. H. Freeman

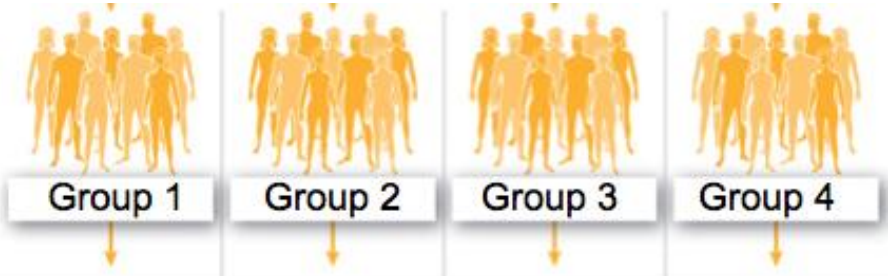
PREDICTION

If echinacea reduces the duration and the severity of symptoms of the common cold, then:

	Individuals that take echinacea	Individuals that don't take echinacea
FREQUENCY OF COLD SYMPTOMS	LOWER	HIGHER
DURATION OF COLD SYMPTOMS	SHORTER	LONGER

EXPERIMENT

Researchers randomly divided 437 volunteers into **four** groups to test the effect of echinacea on the common cold.

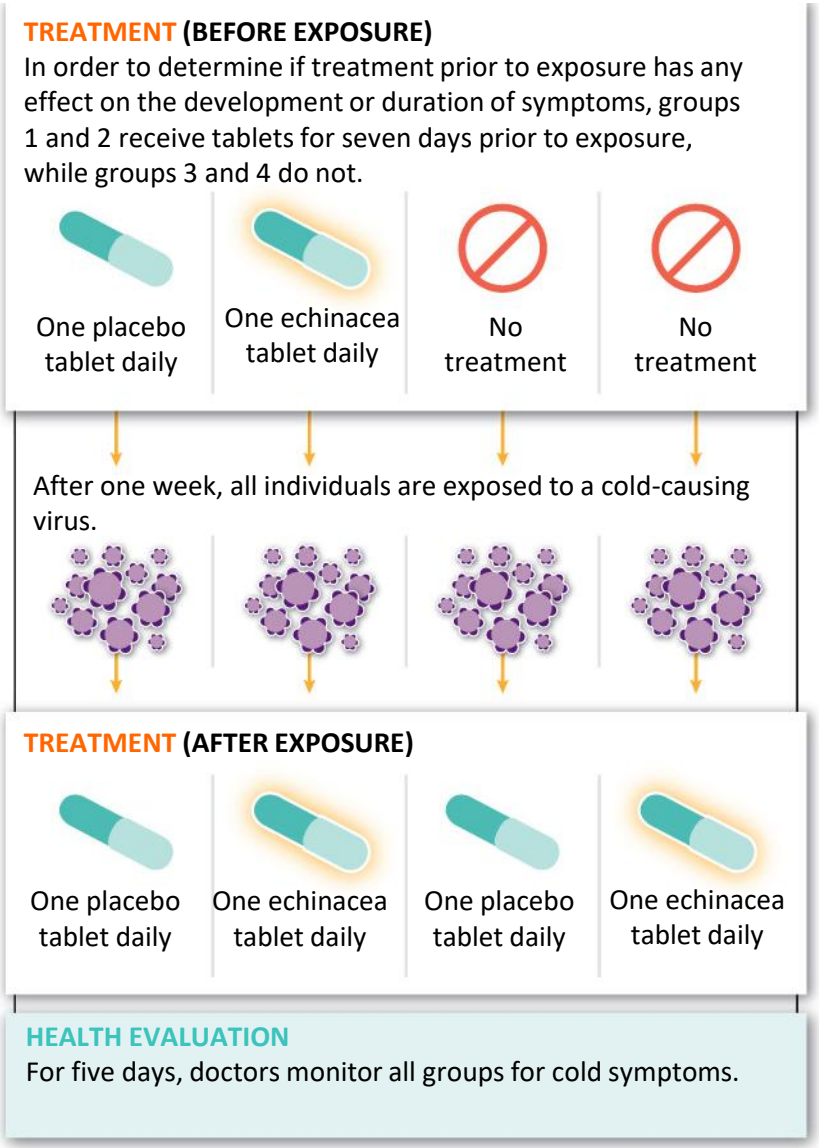


EXPERIMENT

Placebo = a fake pill or substance, no active ingredient

Take note of:

- *each group and its purpose in the study*
- *the variable being tested (echinacea)*
- *the many variables that are "controlled" for and thus eliminated as confounds*
  - *e.g. time, placebo pill, same virus, etc.*



RESULTS

GROUP	TREATMENT	COLD SYMPTOMS PRESENT?	DURATION OF COLD SYMPTOMS (DAYS)
Group 1	Placebo **before** and **after** exposure to cold virus	✓	✓ ✓ ✓ 1 2 3 4 5
Group 2	Echinacea **before** and **after** exposure to cold virus	✓	✓ ✓ ✓ 1 2 3 4 5
Group 3	Placebo **after** exposure to cold virus	✓	✓ ✓ ✓ 1 2 3 4 5
Group 4	Echinacea **after** exposure to cold virus	✓	✓ ✓ ✓ 1 2 3 4 5

CONCLUSIONS

- Individuals from all four groups are equally likely to develop a cold.
- Cold symptoms lasted for the same amount of time in all groups.
- Echinacea had no effect on the duration or severity of the cold.

FURTHER EXPERIMENTATION

Alter the **amount** of echinacea given to subjects *(threshold value)* or the **length of time** subjects receive the echinacea treatment

- In science, **repeatability** is essential
  - Once is not enough: experiments must be repeated several times for their conclusions to be valid & widely accepted
    - this is because larger, better controlled follow-up studies may undermine earlier conclusions

A small study in 2005 suggested an epilepsy drug might cure AIDS, getting people very excited → But a huge study was done & published in 2008, showing that it did not actually work

2008 study: https://pubmed.ncbi.nlm.nih.gov/18525257/

  - On the next slide, you'll see two studies published only a few months apart – one suggested there is a correlation between brain structure & using marijuana, while the other suggested there is no correlation

Proc Natl Acad Sci U S A. 2014 Nov 25;111(47):16913-8. doi: 10.1073/pnas.1415297111. Epub 2014 Nov 10.

Long-term effects of marijuana use on the brain.

Filbey FM[1], Aslan S[2], Calhoun VD[3], Spence JS[4], Damaraju E[5], Caprihan A[5], Segall J[5].

Author information

http://www.ncbi.nlm.nih.gov/pubmed/25385625

Abstract

Questions surrounding the effects of chronic marijuana use on brain structure continue to increase. To date, however, findings remain inconclusive. In this comprehensive study that aimed to characterize brain alterations associated with chronic marijuana use, we measured gray matter (GM) volume via structural MRI across the whole brain by using voxel-based morphology, synchrony among abnormal GM regions during resting state via functional connectivity MRI, and white matter integrity (i.e., structural connectivity) between the abnormal GM regions via diffusion tensor imaging in 48 marijuana users and 62 age- and sex-matched nonusing controls. The results showed that compared with controls, marijuana users had significantly less bilateral orbitofrontal gyri volume, higher functional connectivity in the orbitofrontal cortex (OFC) network, and higher structural connectivity in tracts that innervate the OFC (forceps minor) as measured by fractional anisotropy (FA). Increased OFC functional connectivity in marijuana users was associated with earlier age of onset. Lastly, a quadratic trend was observed suggesting that the FA of the forceps minor tract initially increased following regular marijuana use but decreased with protracted regular use. This pattern may indicate differential effects of initial and chronic marijuana use that may reflect complex neuroadaptive processes in response to marijuana use. Despite the observed age of onset effects, longitudinal studies are needed to determine causality of these effects.

J Neurosci. 2015 Jan 28;35(4):1505-12. doi: 10.1523/JNEUROSCI.2946-14.2015.

Daily marijuana use is not associated with brain morphometric measures in adolescents or adults.

Weiland BJ[1], Thayer RE[2], Depue BE[3], Sabbineni A[2], Bryan AD[2], Hutchison KE[2].

Author information

http://www.ncbi.nlm.nih.gov/pubmed/25632127

Abstract

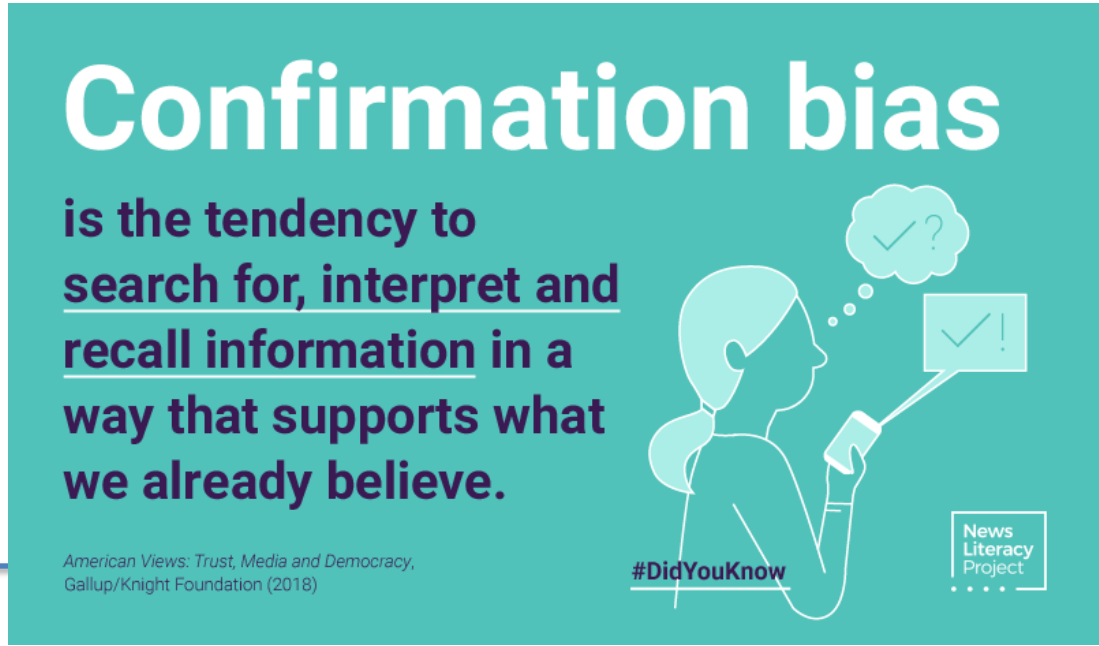
Recent research has suggested that marijuana use is associated with volumetric and shape differences in subcortical structures, including the nucleus accumbens and amygdala, in a dose-dependent fashion. Replication of such results in well controlled studies is essential to clarify the effects of marijuana. To that end, this retrospective study examined brain morphology in a sample of adult daily marijuana users (n = 29) versus nonusers (n = 29) and a sample of adolescent daily users (n = 50) versus nonusers (n = 50). Groups were matched on a critical confounding variable, alcohol use, to a far greater degree than in previously published studies. We acquired high-resolution MRI scans, and investigated group differences in gray matter using voxel-based morphometry, surface-based morphometry, and shape analysis in structures suggested to be associated with marijuana use, as follows: the nucleus accumbens, amygdala, hippocampus, and cerebellum. No statistically significant differences were found between daily users and nonusers on volume or shape in the regions of interest. Effect sizes suggest that the failure to find differences was not due to a lack of statistical power, but rather was due to the lack of even a modest effect. In sum, the results indicate that, when carefully controlling for alcohol use, gender, age, and other variables, there is no association between marijuana use and standard volumetric or shape measurements of subcortical structures.

Things to Avoid

– **Bias** – all people, including scientists, have biases, which can be subconscious (we don't realize them), so avoiding them is a challenge

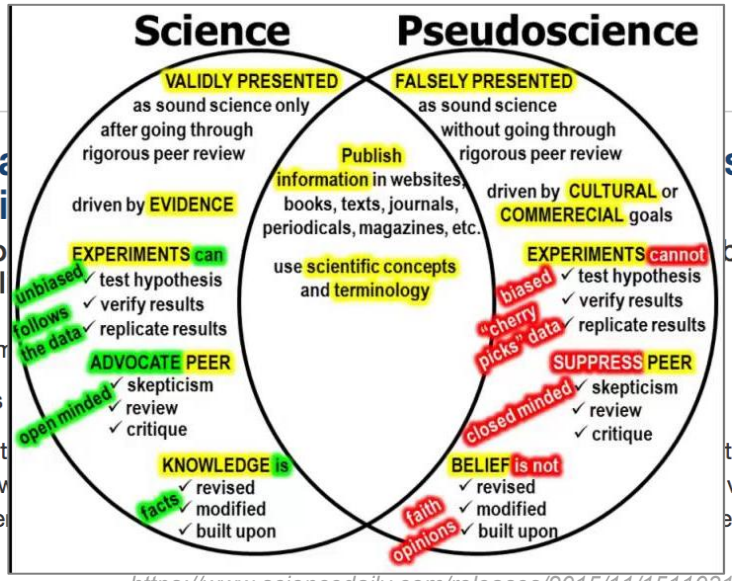
e.g. most journals hide author names during the peer review process because female authors are less likely to have papers accepted when the reviewers know they're female (even though most reviewers believe they are not sexist)

e.g. I once knew a student that would re-measure something when it didn't fit his hypothesis, but only measure once when it did



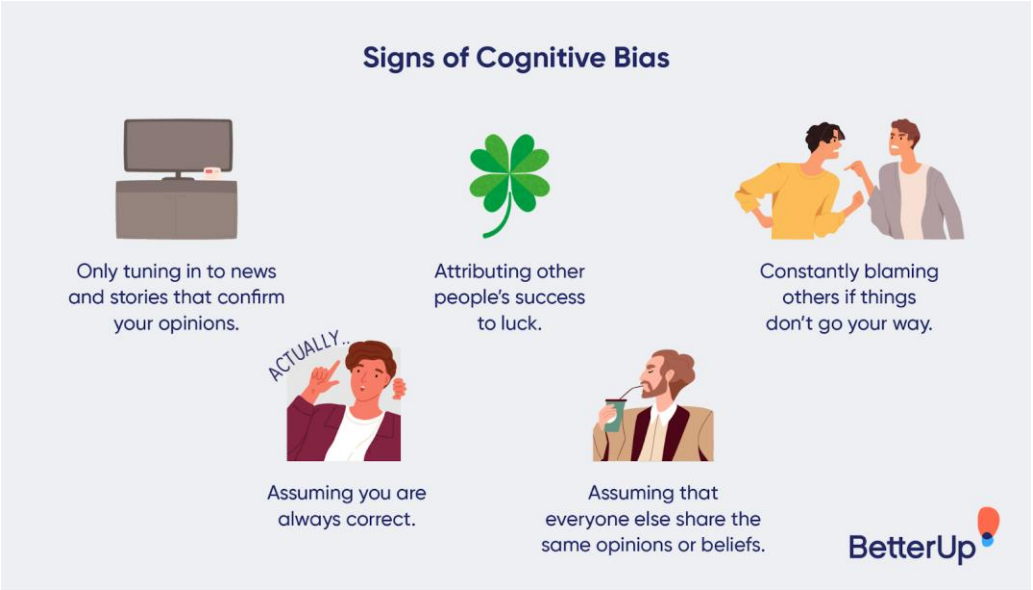
Things to Avoid

- **Pseudoscience** = practices that claim to be factual but incompatible with the scientific method



https://www.sciencedaily.com/releases/2015/11/151103134800.htm
SCIENCE vs. PSEUDOSCIENCE [youtube.com]

- **Cognitive bias** = a mental shortcut that influences our thinking and decision-making, leading us to process information in a selective and subjective manner, often resulting in inaccurate or irrational judgments.



https://www.betterup.com/blog/cognitive-bias

Things to Avoid

The truth: Airborne does not reduce how often you get sick or how long you are sick

– **People that want your money**

- Example 1: for 15+ years Airborne stated it boosts your immune system, based on a “rigorous clinical study”
- A class-action lawsuit revealed there was no study ever done – it was completely made-up!
- They had to remove the false claim but sales haven’t dropped yet consumers aren’t aware

photo by Mike Mozart

Things to Avoid

- **People that want your money example 2:**
  - In 1998 Andrew Wakefield published data that MMR vaccines (measles, mumps, rubella) caused autism
    - it was found later that he made up the results completely – the results were fake!
  - Why would he fake the data?
    - Wakefield had patented a new vaccine & wanted people to buy his instead
    - parents of children with autism payed him for the research so they could sue the vaccine company

by Brian Deer

Sunday February 22 2004, 12.00am GMT, The Times

Revealed: MMR research scandal

FULL details are disclosed today of the four-month Sunday Times investigation that has uncovered a medical scandal at the heart of the worldwide scare over MMR.

Andrew Wakefield, the doctor who champions the alleged link between measles, mumps and rubella vaccine and autism in young children, stands discredited for misleading his medical colleagues and The Lancet, the professional journal that published his findings.

The investigation has found that when he warned parents to avoid MMR, and published research claiming a link with autism, he did not disclose he was being funded through solicitors seeking evidence to use against vaccine manufacturers.

https://www.thetimes.co.uk/article/revealed-mmr-research-scandal-7ncfntn8mjq

Photo by Bladość

OpenClipArt from j4p4n

- Wakefield's paper was fully retracted, he lost his medical license, & lost his appointments to medical organizations

- However: the results of his paper are still evident today – some parents now decide NOT to vaccinate their children based on these fears

  – Many diseases were once eradicated, but in the last few years they have made a comeback due to low vaccination rates

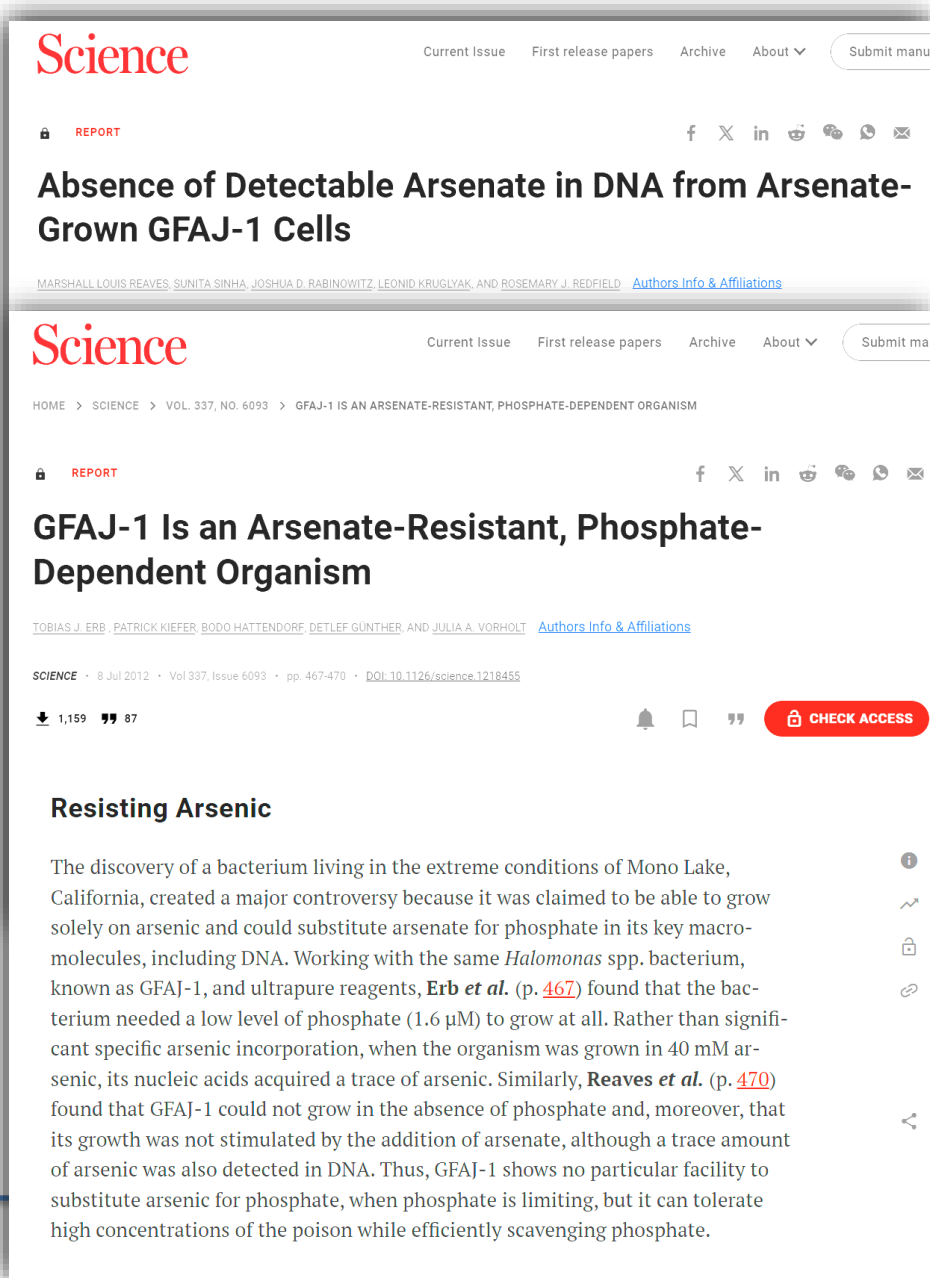
    e.g. measles, mumps, rubella, whooping cough: most can be fatal or cause birth defects

LHS is IMPORTANT!

Things to Avoid

- **Sensationalism** = reporters may be trying to alarm you to get you to click on their articles, or they may have good intentions but not enough knowledge to accurate report the findings

We will learn chemistry of life ^^



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REPORT

Absence of Detectable Arsenate in DNA from Arsenate-Grown GFAJ-1 Cells

MARSHALL LOUIS REAVES, SUNITA SINHA, JOSHUA D. RABINOWITZ, LEONID KRUGLYAK, AND ROSEMARY J. REDFIELD Authors Info & Affiliations

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HOME > SCIENCE > VOL. 337, NO. 6093 > GFAJ-1 IS AN ARSENATE-RESISTANT, PHOSPHATE-DEPENDENT ORGANISM

REPORT

GFAJ-1 Is an Arsenate-Resistant, Phosphate-Dependent Organism

TOBIAS J. ERB , PATRICK KIEFER, BODO HATTENDORF, DETLEF GÜNTHER, AND JULIA A. VORHOLT Authors Info & Affiliations

SCIENCE • 8 Jul 2012 • Vol 337, Issue 6093 • pp. 467-470 • DOI: 10.1126/science.1218455

1,159 87 CHECK ACCESS

Resisting Arsenic

The discovery of a bacterium living in the extreme conditions of Mono Lake, California, created a major controversy because it was claimed to be able to grow solely on arsenic and could substitute arsenate for phosphate in its key macromolecules, including DNA. Working with the same *Halomonas* spp. bacterium, known as GFAJ-1, and ultrapure reagents, **Erb *et al.*** (p. 467) found that the bacterium needed a low level of phosphate (1.6 μM) to grow at all. Rather than significant specific arsenic incorporation, when the organism was grown in 40 mM arsenic, its nucleic acids acquired a trace of arsenic. Similarly, **Reaves *et al.*** (p. 470) found that GFAJ-1 could not grow in the absence of phosphate and, moreover, that its growth was not stimulated by the addition of arsenate, although a trace amount of arsenic was also detected in DNA. Thus, GFAJ-1 shows no particular facility to substitute arsenic for phosphate, when phosphate is limiting, but it can tolerate high concentrations of the poison while efficiently scavenging phosphate.

Things to Avoid

- **Getting hung up on a unique study**: if a few small studies show one thing, but the vast majority of studies show something else, go with the majority
  - Repeatability is vital in science because a number of things can occur in a study that can throw off the results or give inaccurate data

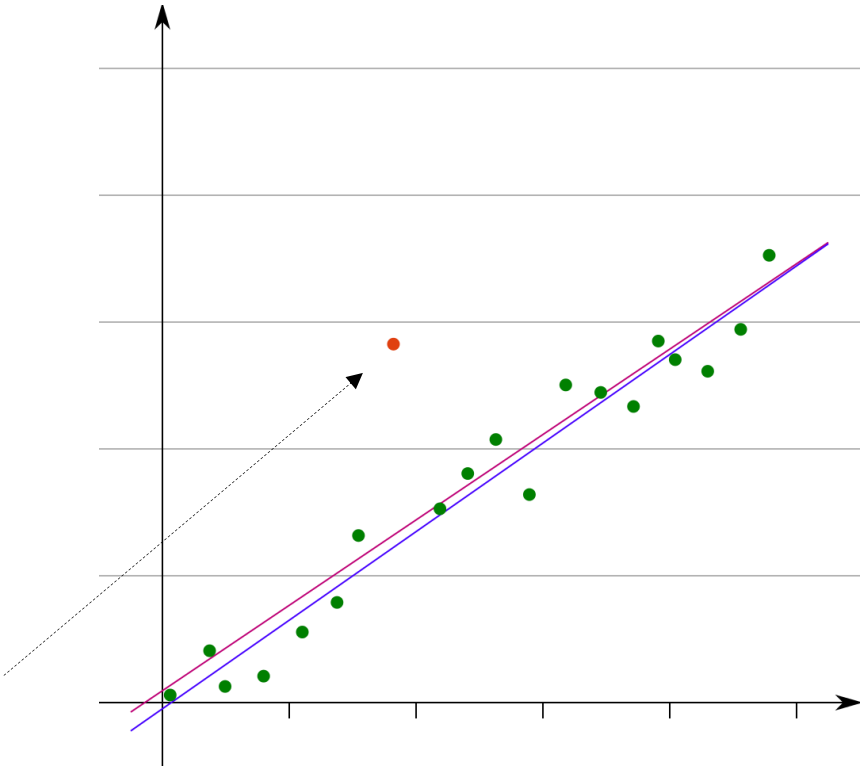


Figure: https://commons.wikimedia.org/wiki/File:Outlier_statistics.svg

Chapter 1: The Scientific Study of Life

- What is science & how do we “do” science?
- What is biology & what makes a thing “living?”

Corresponds with OpenStax Biology 2e Chapter 1

What is LHS & what makes a thing "living?"

LHS = the scientific study of living things for health

- How do we know if a thing is living?
  - Can't define life by it's parts: we can put proteins, fats, DNA, etc. in a test tube but it's not alive
  - Instead of a definition, scientists agree some characteristics of life: need all to be a living thing

Characteristic of Life

- A characteristic of life: **living things are organized**
  - *Covered in chapters 2, 3, 4, & 5*
  - At the smallest scale, living things are made up of **atoms**
  - Atoms make up **molecules**, which make up **cells**, which make up living things
  - From trees to bacteria to humans, we are all organized in the same way

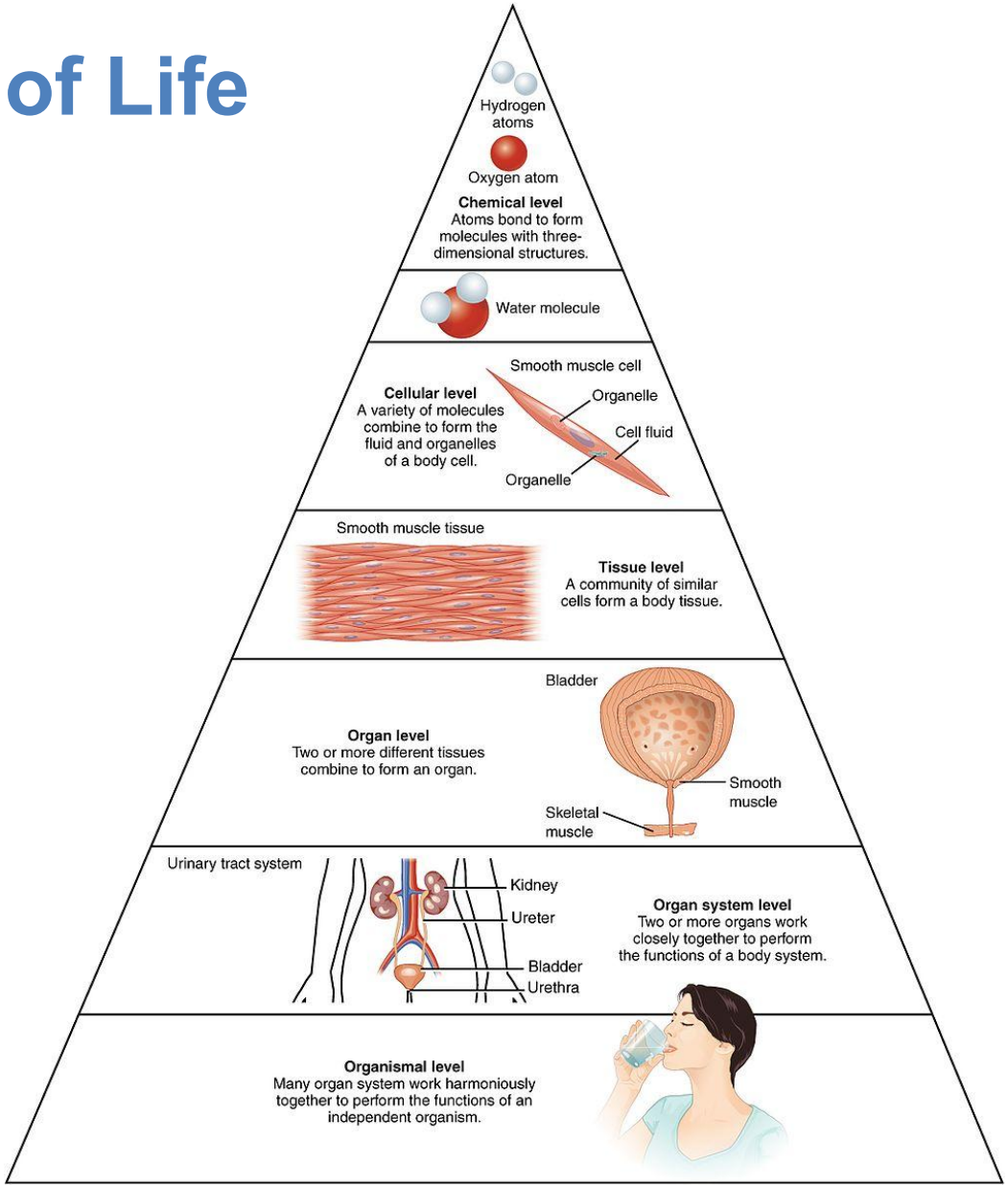


Figure from OpenStax Anatomy and Physiology

Characteristic of Life

- A characteristic of life: **living things require energy & nutrients**
  - *Covered in chapters 3 & 6*
  - Energy comes the sun or from consuming other organisms
  - Nutrients come from the nonliving environment or from consuming living organisms

Dark green lines represent the movement of nutrients, and dashed lines represent the movement of energy. As you can see, nutrients remain within the system while energy enters via photosynthesis and leaves primarily as heat energy.

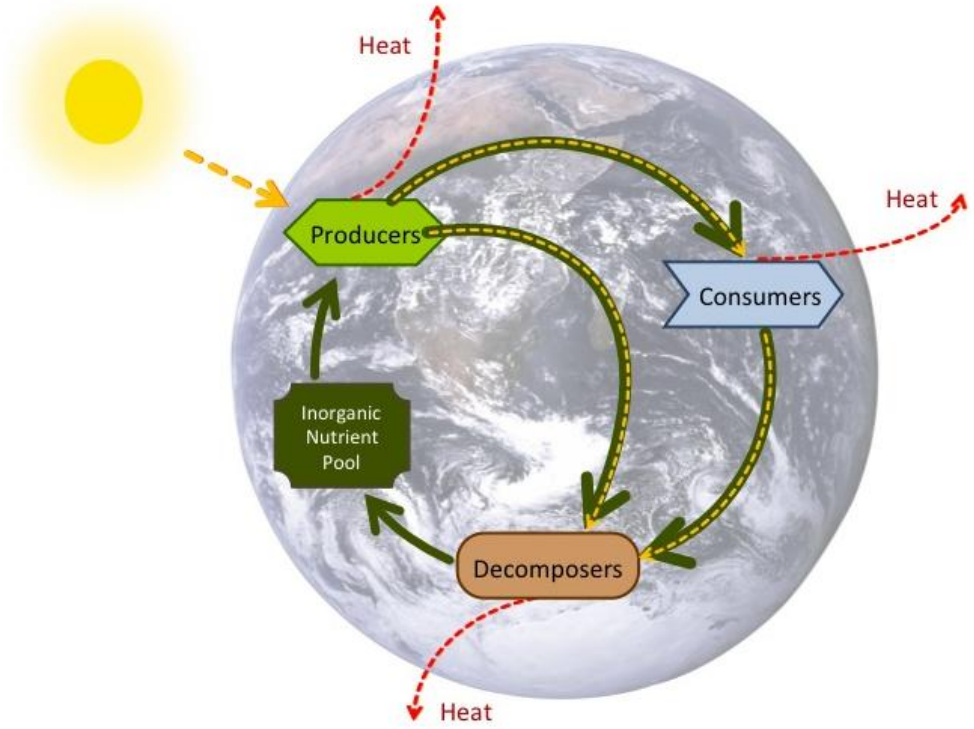
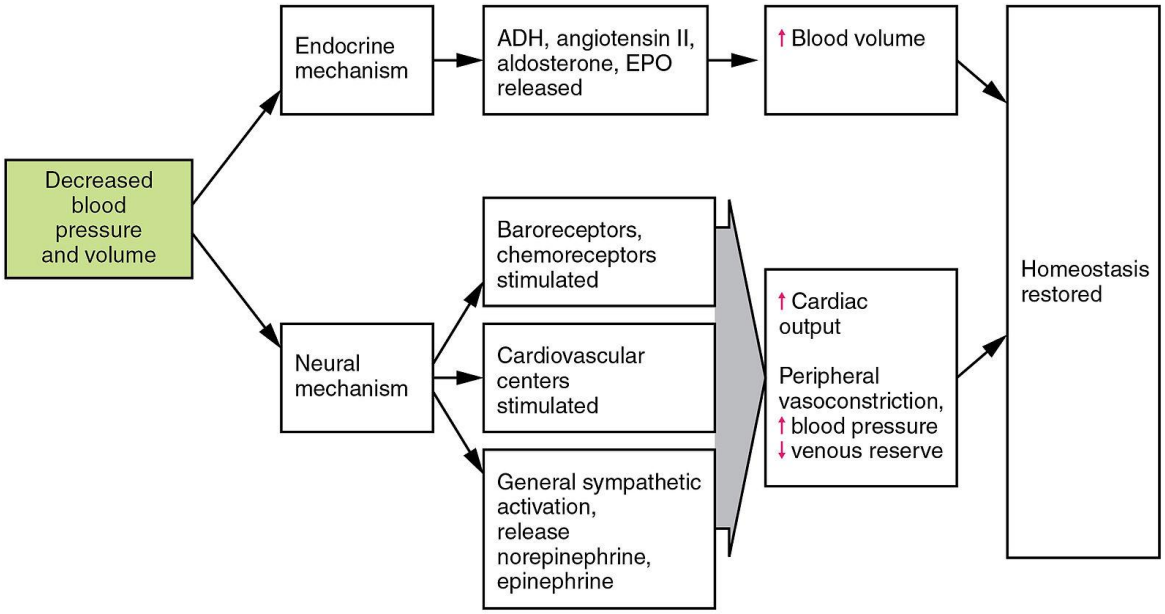


Figure from OpenStax Principles of Biology

Characteristic of Life

- A characteristic of life**: living things maintain homeostasis**
  - *This theme is covered in almost every chapter*
  - **Homeostasis** = process by which an organism regulates their body, maintaining *equilibrium (*internal constancy) even as the surrounding environment changes
    - e.g. temperature, blood pressure, pH



Life = Negentropy

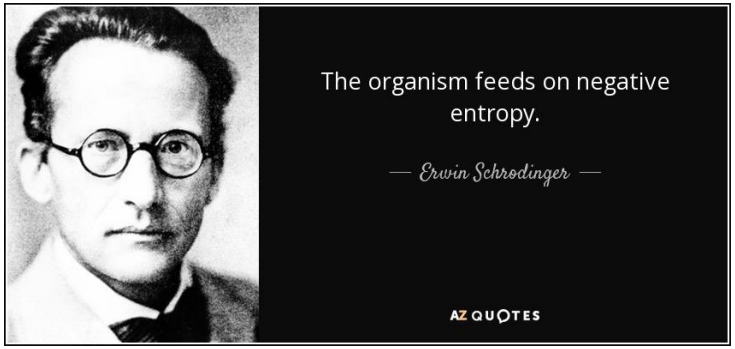


Figure from OpenStax Anatomy and Physiology

Characteristic of Life

- A characteristic of life: **living things grow & develop**
  - *Covered in chapters 7 & 8*
  - DNA guides the development & expression of our traits
  - We grow from a cell

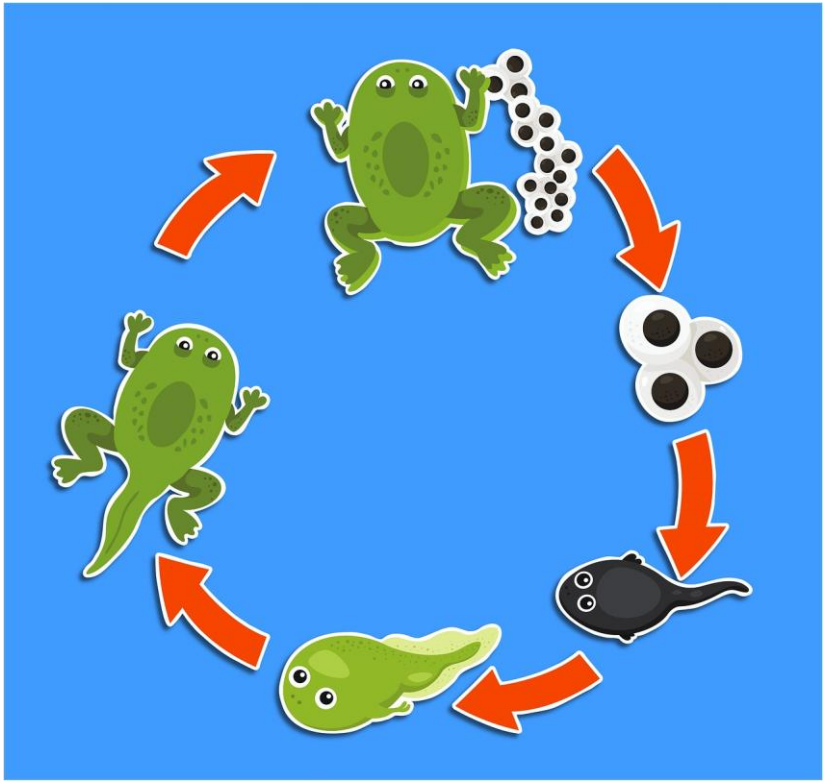


Figure from Pixabay

Characteristic of Life

- A characteristic of life: **living things reproduce**
  - *Covered in chapters 9, 10, & 12*
  - Reproduction is the transmission of DNA from generation to generation
    - this must happen at a species level, not necessarily at the individual level (i.e. you don't have to individually reproduce to be alive, but at least some members of your species must)

Figure: https://www.maxpixel.net/Horns-Baby-Mom-Animal-Buffalo-Grass-Fauna-5476131
Figure: https://stocksnap.io/photo/black-family-SEHHFDFUBR

Characteristic of Life

- A characteristic of life: **living things evolve**
  - **Evolution** = change in genetic make-up of a population over multiple generations
    - does not occur in individuals, but instead takes time over many generations

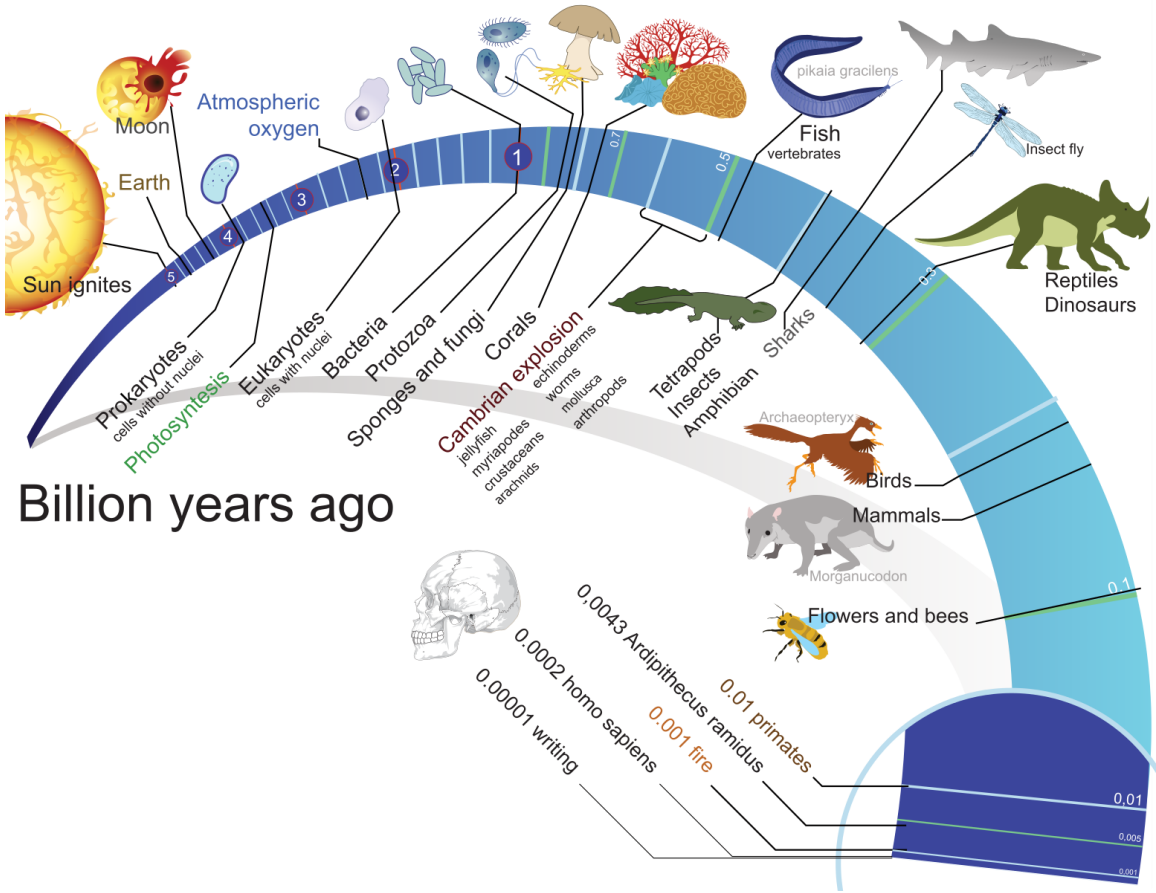


Figure https://commons.wikimedia.org/wiki/File:Timeline_evolution_of_life.svg

Characteristics of Life

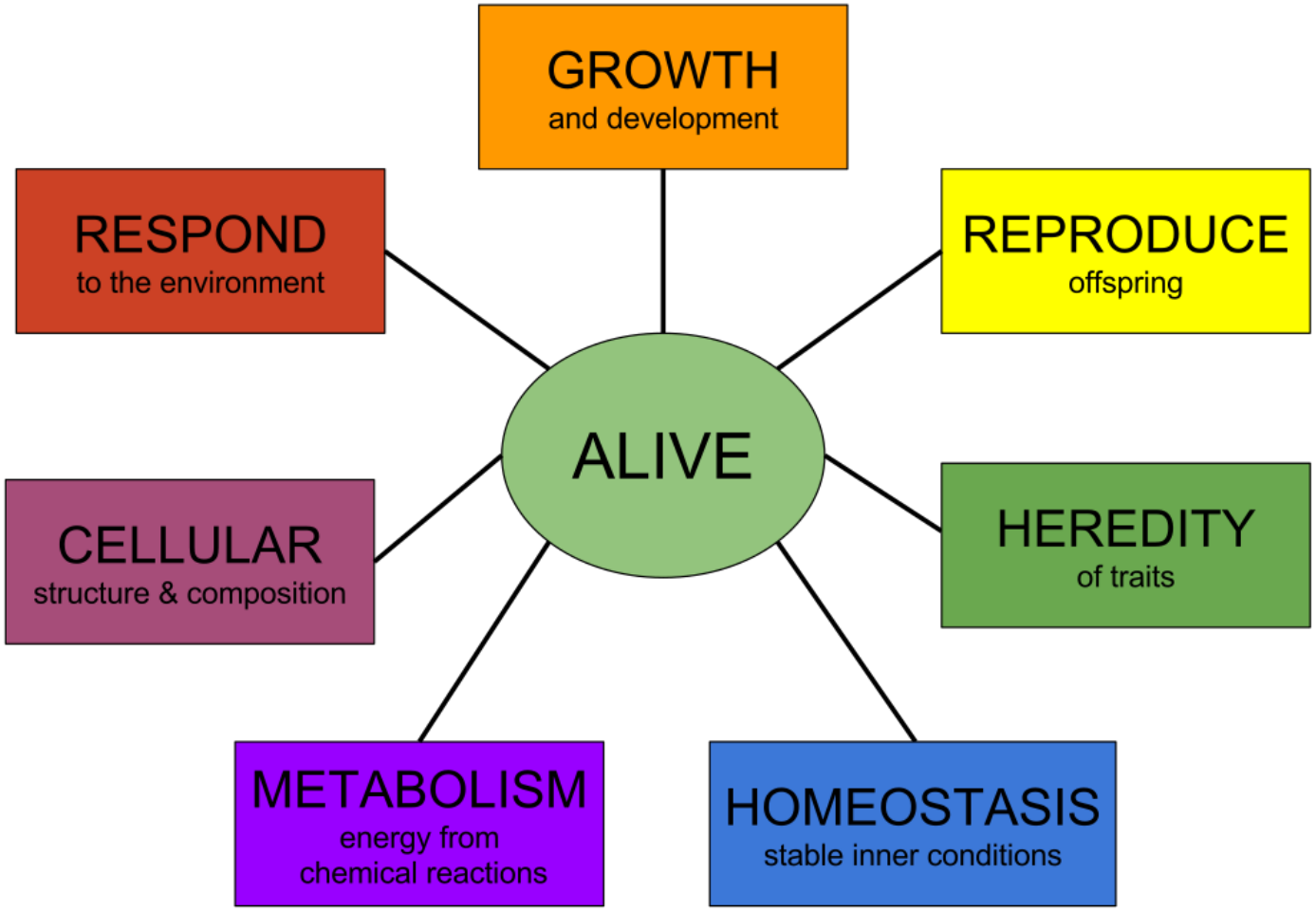


Figure: http://commons.wikimedia.org/wiki/User:Earthdirt