PES UNIVERSITY

ENVIRONMENTAL STUDIES AND LIFE SCIENCES

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GREEN ENERGY- BIOHYDROGEN

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GREEN ENERGY

- Green energy is energy that can be produced using a method, and from a source, that causes no harm to the natural environment.
- The terms ‘green energy’ and ‘renewable energy’ are often used interchangeably, but there is one essential (and sometimes confusing) difference between them. While most green energy sources are also renewable, not all renewable energy sources are considered entirely green.

https://knnindia.co.in/news/newsdetails/state/

GREEN ENERGY

- Renewable energy comes from sources that are constantly and naturally renewed (hence the name), such as wind power and solar power. Renewable energy is also often called sustainable energy.
- A renewable energy source may not be considered ‘green’ if, for example, some carbon emissions are associated with the processes used to generate the energy – such as the building of infrastructure.

GREEN ENERGY

- Clean energy is energy that, when used, creates little or no greenhouse gas emissions.
- As with renewable energy, some types of clean energy may not always be considered entirely green.

✔ Clean energy = clean air

✔ Green energy = no harm to the environment

✔ Renewable energy = sources that replenish naturally, such as the sun and the wind

GREEN ENERGY

- Due to the local nature of energy production through sources like solar and wind power, the energy infrastructure is more flexible and less dependent on centralized sources that can lead to disruption as well as being less resilient to weather related climate change.
- Green energy also represents a low-cost solution for the energy needs of many parts of the world. This will only improve as costs continue to fall, further increasing the accessibility of green energy, especially in the developing world.

GREEN ENERGY

- There are plenty of examples of green energy in use today, from energy production through to thermal heating for buildings, off-highway and transport. Many industries are investigating green solutions and here are a few examples:
- **Heating and Cooling in Buildings:** Green energy solutions are being used for buildings ranging from large office blocks to people's homes. These include solar water heaters, biomass fuelled boilers and direct heat from geothermal, as well as cooling systems powered by renewable sources.

- **Industrial Processes:** Renewable heat for industrial processes can be run using biomass or renewable electricity. Hydrogen is now a large provider of renewable energy for the cement, iron, steel and chemical industries.
- **Transport:** Sustainable biofuels and renewable electricity are growing in use for transportation across multiple industry sectors. Automotive is an obvious example as electrification advances to replace fossil fuels, but aerospace and construction are other areas that are actively investigating electrification.

GREEN ENERGY

- Can It Replace Fossil Fuels?
- Green energy has the capacity to replace fossil fuels in the future; however, it may require varied production from different means to achieve this. Geothermal, for example, is particularly effective in places where this resource is easy to tap into, while wind energy or solar power may be better suited to other geographic locations.
- We are still some years away from this happening, but the fact remains that this is necessary to reduce climate change, improve the environment and move to a more sustainable future.

BIOHYDROGEN

- **Biohydrogen: the next green alternative fuel**
- Hydrogen has a high energy content (120-142.9 MJ/kg); it is a clean energy carrier and can replace fossil fuels.
- Hydrogen is already a fuel of choice for space programs; it guarantees environmental quality and mitigates climate change. However, the presently used commercial methods for its production are not environmentally friendly; they require a major energy input and entail high costs.

BIOHYDROGEN

- Biohydrogen production offers an environmentally friendly alternative. It makes good use of organic wastes and requires less energy input (ambient temperature and atmospheric pressure) compared to thermochemical and electrolysis processes.
- *Biohydrogen is hydrogen gas produced through biological processes, such as fermentation and biophotolysis, using microorganisms to convert biomass into fuel.*

BIOHYDROGEN

- Microorganisms
- In the field of biohydrogen research, researchers use well-characterized and composite microorganisms; they have made significant efforts to enhance hydrogen production by using co-culture systems (‘consortia’).
- A consortium is a highly diverse and complex community of microbes, capable of performing complex tasks in cooperation.

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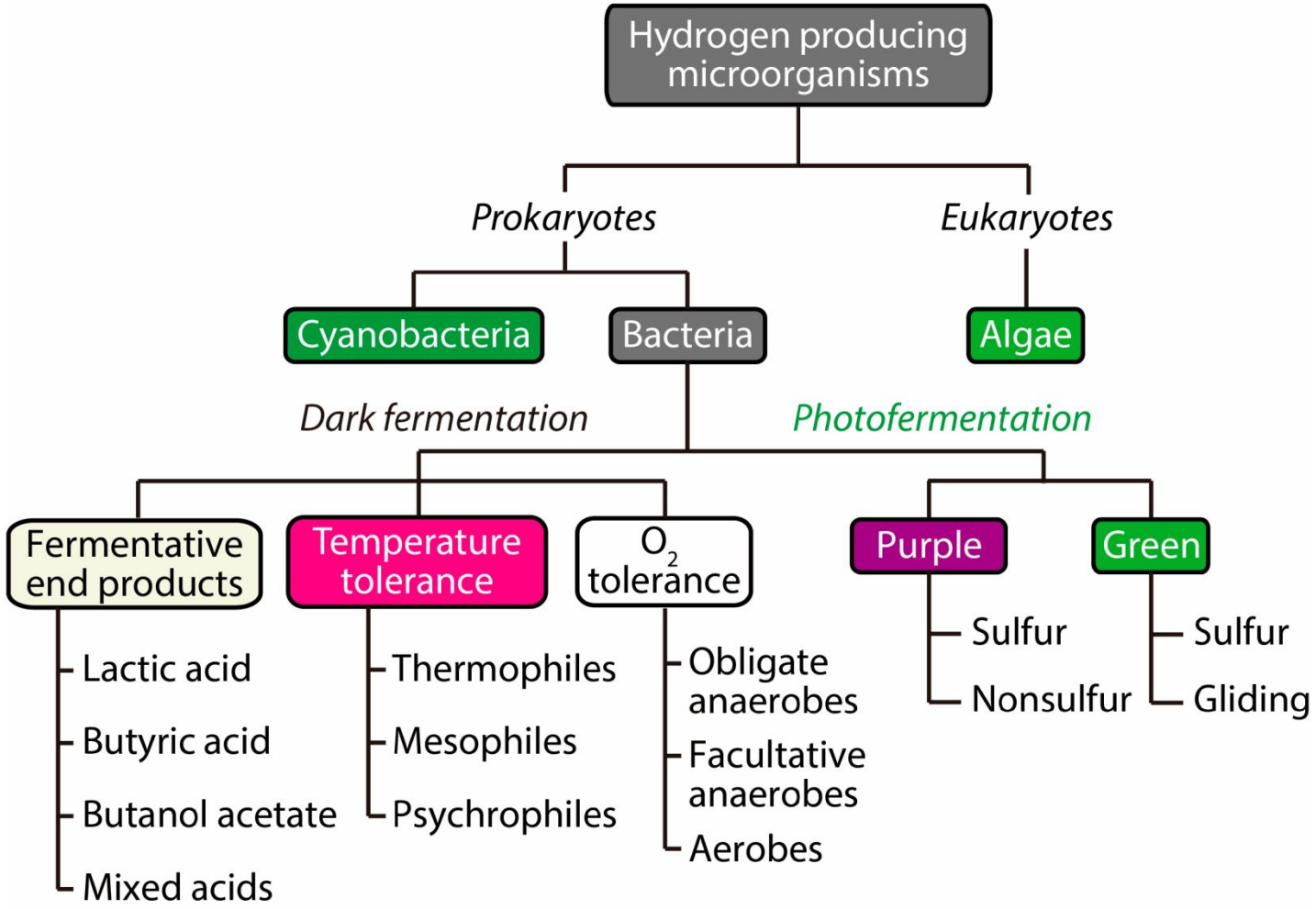
BIOHYDROGEN



https://www.mdpi.com/1422-0067/16/4/8266

BIOHYDROGEN

- With single microorganism, process efficiency is limited and hydrogen production is low.
- The co-culture system works in harmony, ensuring stability of the process; it has a better performance by performing complex functions, such as substrate hydrolysis, simultaneous substrate consumption, exchange of metabolites, working on a variety of substrates through co-existence.

BIOHYDROGEN

- In comparison to mono-culture, co-culture offers synergistic effects with higher yield, decreased fermentation time and higher biohydrogen production. Microbiologists and engineers have exploited the microbial communities to engineer synthetic consortia for biohydrogen production.
- The selection of microflora from various sources is a difficult task, due to the co-existence of hydrogen consuming bacteria.
- Dark-fermentative (in absence of light) bacteria are fast growing and produce volatile acids at a faster rate.

BIOHYDROGEN

- On the contrary, photo-fermentative (in presence of light) bacteria that process the acids to biohydrogen are slow growing, which causes an imbalance in the utilization rate of volatile acids, limiting hydrogen production.
- These issues can be eliminated by incorporating two different microorganisms, capable of dividing the tasks and working in tandem for increased yield.

BIOHYDROGEN

- Even better yields result from a two-phase system that avoids process termination, using a multi-layer photo-bioreactor for efficient light utilization, repeated fed-batch culture to reduce run time and improved bioreactor design to overcome hydrogen gas-hold up issues.

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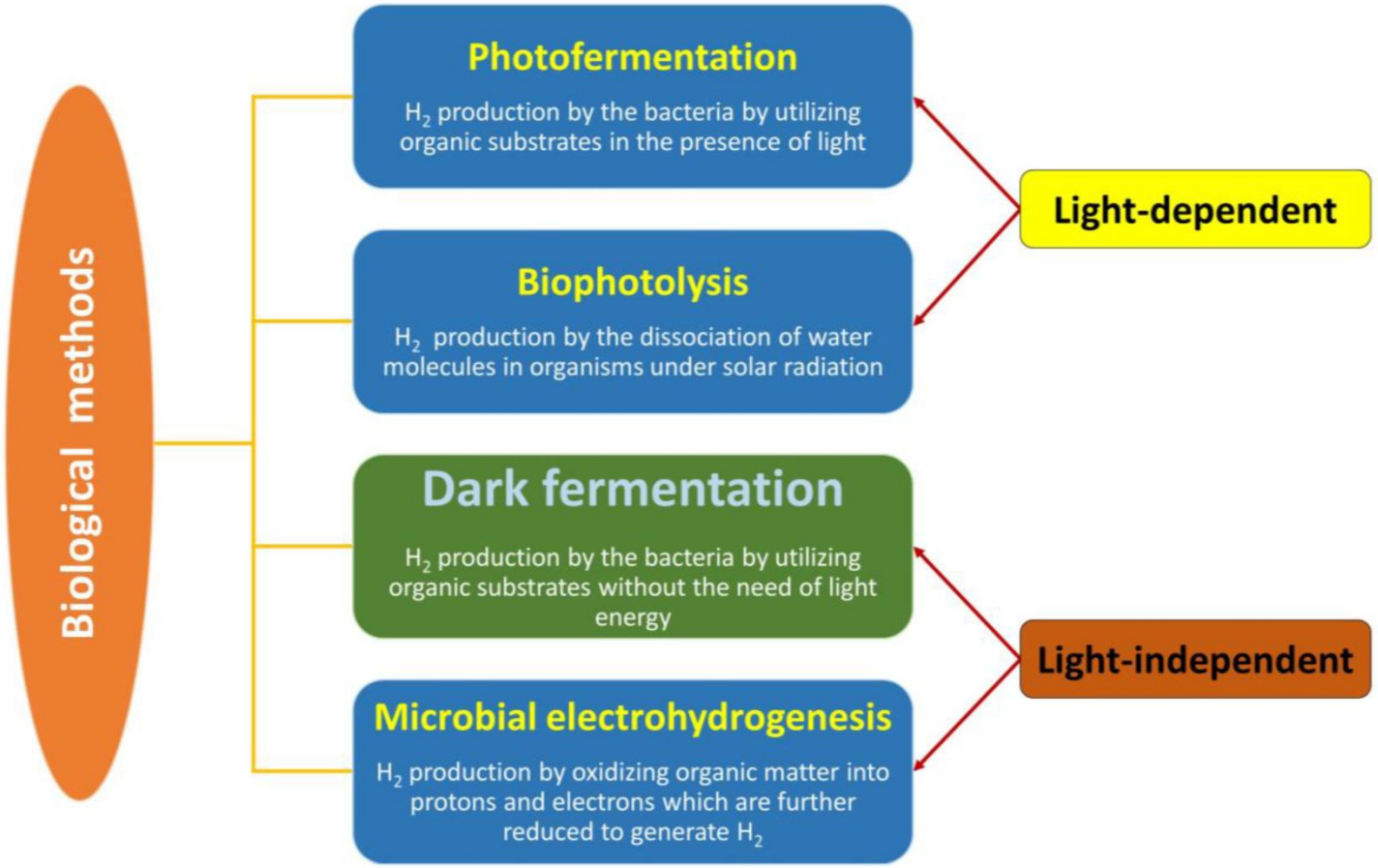

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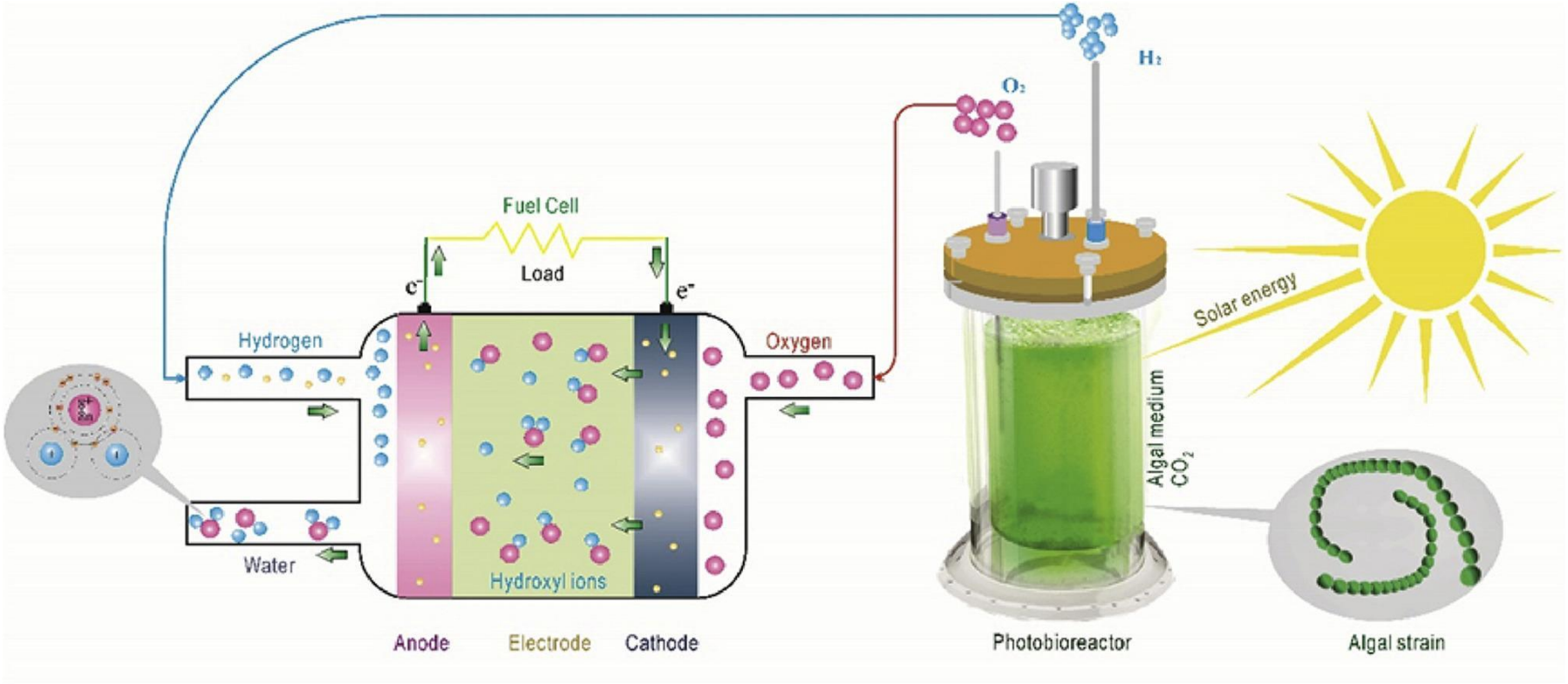
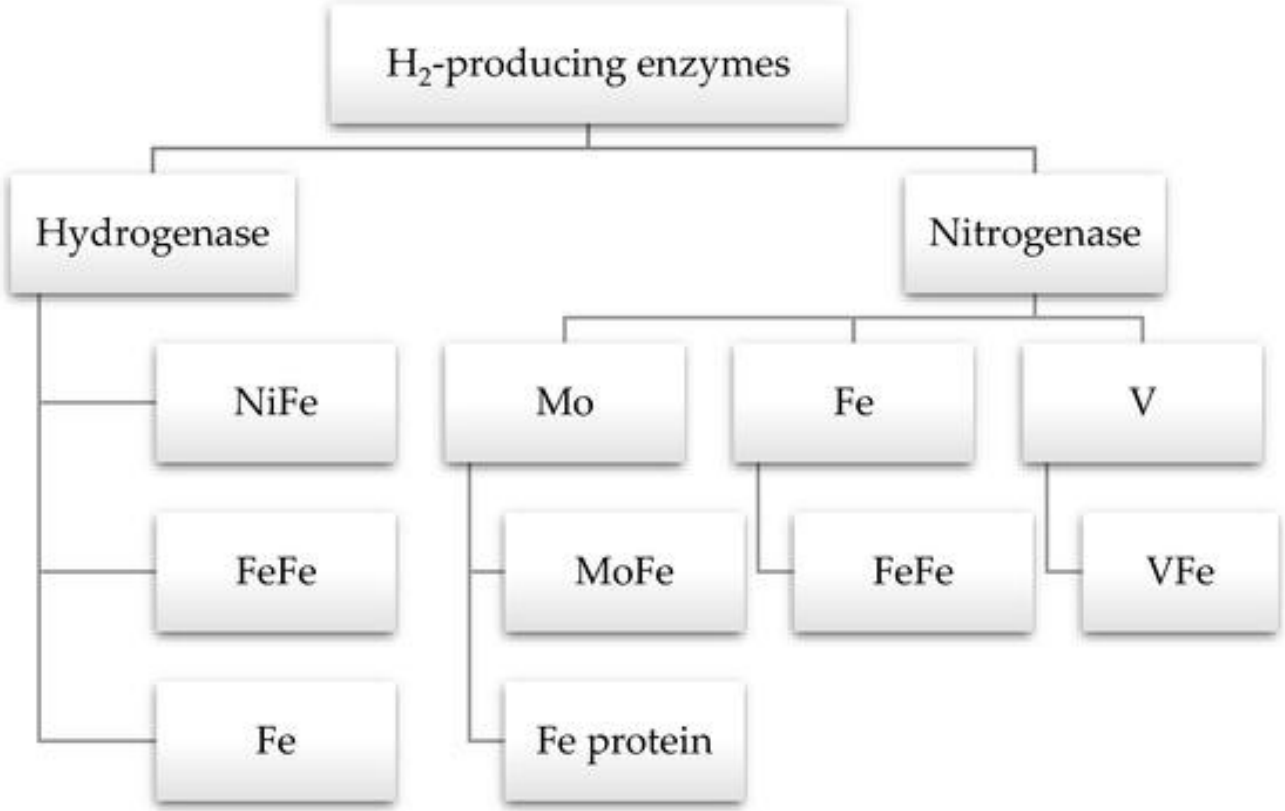


https://www.sciencedirect.com/science/article/abs/pii/S0360319919302241

Enzymes involved in hydrogen production



https://www.mdpi.com/1996-1073/15/20/7783

BIOHYDROGEN

- Biohydrogen from waste streams
- In recent years, biohydrogen production advances with improvements in the co-culture system, replacement of costly substrates with utilization of organic wastes (lignocellulosic and food wastes etc.) and industrial wastes (crude glycerol, apple pomace, eggshells etc.).
- The crude glycerol produced from the biodiesel industry as a by-product has proven to be an excellent source for biohydrogen production.

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- A novel approach of the co-culture system was adapted by the Integrated Project ‘HYVOLUTION’, funded under the EU Framework. This provides the highest biohydrogen production efficiency for small-scale industries.
- The economically viable process for hydrogen production, a combined co-culture system was scaled-up from lab-scale to 100,000 L using a distillery effluent.

https://www.biobasedpress.eu/2019/01/biohydrogen-the-next-green-alternative-fuel/

BIOHYDROGEN

- This sustainable way of effluent treatment producing biohydrogen, produced 21.38 kg of hydrogen in less than 40 h. In order to maximize the economic value, it has been proposed to blend 5-15% hydrogen into the existing natural gas pipelines.

One of the main applications of biohydrogen will be in (public) transport.

BIOHYDROGEN

- Biohydrogen can be used to produce electricity and heat by powering fuel cells or internal combustion engines.
- It can also be used in small, decentralized power systems for homes or communities
- It is considered a versatile fuel for future transportation needs.
- As a zero-carbon fuel, it can help significantly reduce greenhouse gas emissions and carbon footprints, which is beneficial for industrial processes.

THANK YOU

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