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A Review On: Industrial Biotechnology

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ABSTRACT : Biotechnology (BT) is a rapidly growing branch of science which deals with the technical application of living systems or organisms to produce products for human welfare such as health care, agriculture, food production and processing, veterinary, and environment Advancement in the field of biotechnology has opened a vast global market. The Indian biotechnology arena is promising for advance and pioneering growth with its immense growth potential which could play a significant role toward India's contribution to global industrial biotechnology. Today, India is one of the fastest-growing trillion-dollar economies in the world and the fifth largest overall, with a GDP (gross domestic product) of \$2.94 trillion. Biotechnology (BT) and information technology (IT) are the key drivers contributing to this growth which constitutes approximately 5% of the country's total annual GDP. Indian biotechnology growth is fueled by bio-pharmaceutical, bio-industrial, bio-services, bio-agricultural, and bioinformatics, and among them, the bio-industrial area is one of the most promising and advanced. New approaches which Indian industrial biotechnology is exploring, include harnessing microorganisms for the production of value-added bioactive ingredients such as industrial enzymes, organic acids, bulk chemicals, and single-cell proteins, which have played a predominant role in the overall development of biotechnology after bio-pharmaceuticals. The above factors made India one of the world's top 12 destinations for biotechnology. In this article, we review the status of the biotechnological industry and its future perspective in context to the Indian market and its role in global economy

KEY WORDS: Enzyme Production , Biofuels , Biotechnology ,Bioremediation , Fermentation Biotechnology .

Introduction :

Biotechnology (BT) is a rapidly growing branch of science which deals with the technical application of living systems or organisms to produce products for human welfare such as health care, agriculture, food production and processing, veterinary, and environment. (1) The term “ biotechnology ” was coined by a Hungarian engineer Karl Ereky, in 1919, to refer to the science and methods that permit products to be produced from raw materials with the aid of living organisms(4).The implications of biotechnology includes, breeding of plants for raising and stabilizing yields by improving their ability to confront various pests, insects and other possible threats, to fight various conditions like drought and counter diseases that could attack and cold and soil acidity, biotechnology is also being applied for nutritional enhancement of various foods (5,6,7).

Industrial biotechnology helps to utilize the potential of biotechnology by providing a global platform which strengthens the economy in a greater capacity. From recombinant protein production for medical purposes to the waste management at the industrial level, it provides opportunity to the growth of the various sectors aiding to the economy [1,8,9].Industrial biotechnology which is also known as white biotechnology started with the intentional use of the fermentation process using microorganisms such as bacteria, fungi, as well as eukaryotic cells to produce products at the industrial level [Figure 1].(1)

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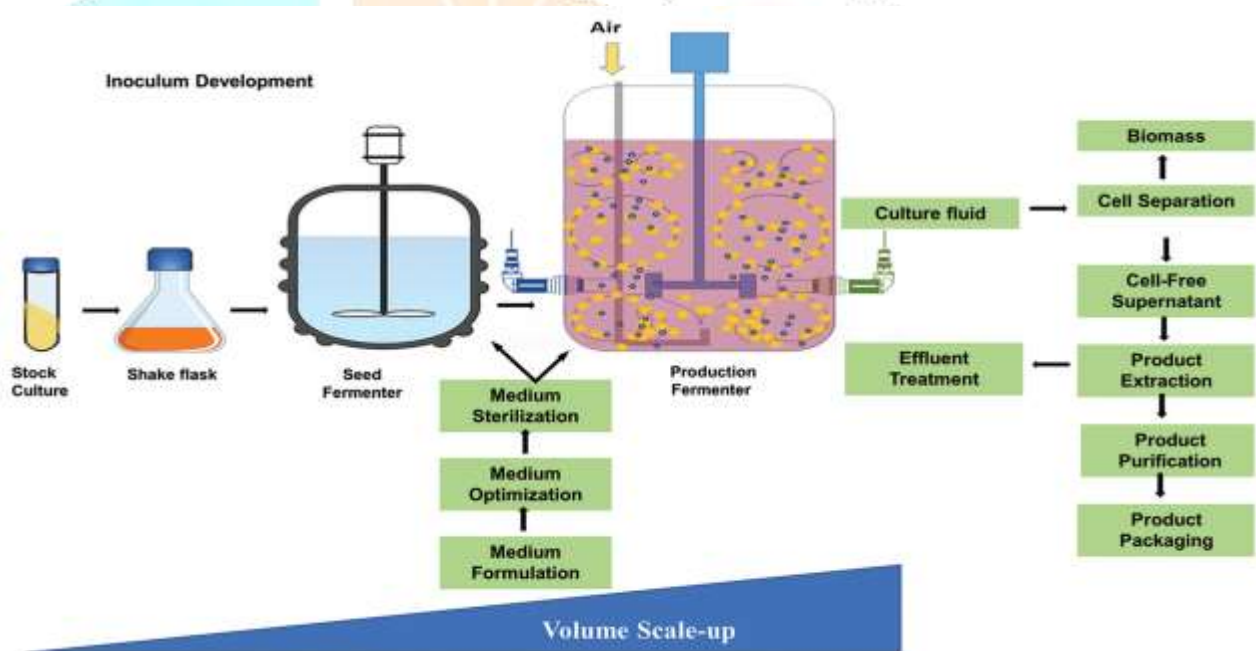


Fig : 1 Schematic representation of fermentation process.

. Since then, fermentation biotechnology is being widely used at the industrial level in the field of bio-agriculture, probiotics, brewing, biofuel, food, nutraceuticals, and enzyme production to shift the market paradigm from traditional chemical based to more eco-friendly, sustainable, and innovative market. Biotechnology uses minimum resources than the traditional processes to produce high-value industrial goods [22]. . Biotechnological processing uses enzymes and microorganisms or plant/animal cells to make products in a wide range of industrial sectors including chemicals, pharmaceuticals, food & feed, detergents, pulp & paper, textiles, energy, materials and polymers. Some of the historical developments in industrial biotechnology are given in Fig. 1. Man has already benefited from biotech for a long time, but with the advancement of new technologies and a much deeper understanding of cell metabolism and material sciences, many new opportunities have been identified and others are continuing to emerge.[23].

❖ EXAMPLE OF BIOTECHNOLOGY INDUSTRY USING AI TECHNIQUE

Another organization concentrated on overseeing clinical preliminary information is Precision Medicine Group. The organization's Precision for Medicine business as of late gained Quartz Bio, an AI stage that breaks down natural and clinical information streams to extricate information and bits of knowledge to quicken medicate advancement [3]. This process is only from time to time succeeding, proposes Cliff Culver, senior VP of Precision Medicine Groups.

1.1. Industrial Fermentation Biotechnology :

Fermentation biotechnology is a sustainable and rapidly growing field with an expectation to reach \$205,465 million by 2023 [6], deals with reduced energy consumption, greenhouse gas emission, and recyclable waste generation for the production of value-chemicals(12).

Industrial biotechnology is a multidisciplinary technology and includes the integrated application of discipline such as biochemistry, microbiology, molecular genetics and process technology to develop useful processes and products, based on microbial, animal or plant cells, their organelles or enzymes as biocatalysts(14).

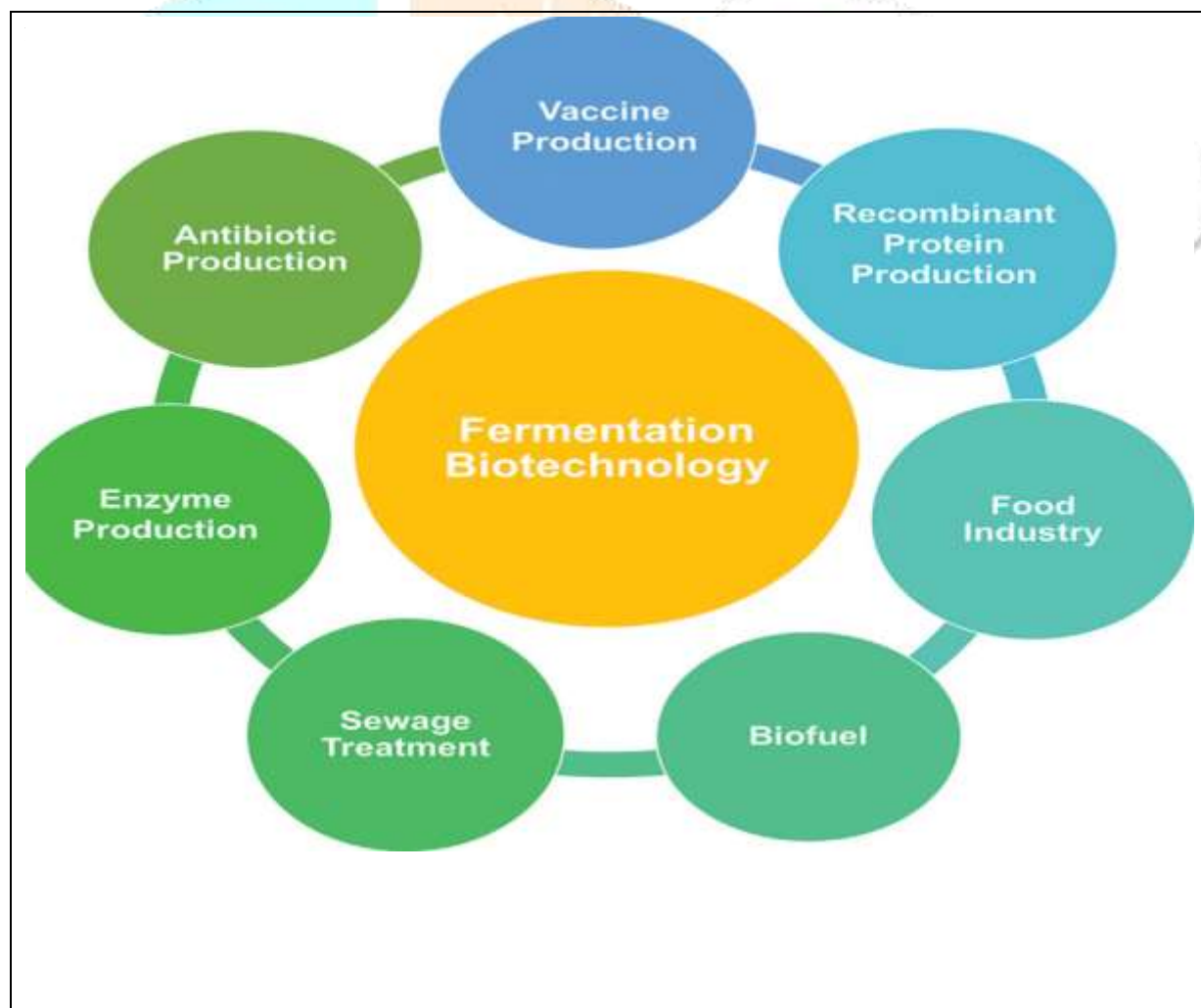


Fig : 2 Scope of Fermentation Biotechnology

1.1.2. Biofuel industry :

Fermentation technology has changed the fate of biofuel industry making it more efficient and economical.(12). Bioethanol is one of the major producers of biofuel industry. The fact that it is originated from sustainable sources such as grass and feedstock makes it an affordable and effective renewable resource that can cut both cost and pollution, making it a cleaner and greener alternative. The United States, Brazil, and some of the European countries have used this technique to become the more efficient producer of low price ethanol fuel (biofuel) by fermenting corn and sweetgrass [8]. Fermentation can also produce hydrogen gas using *Clostridium pasteurianum* which converts glucose to butyrate, acetate, carbon dioxide, and hydrogen gas (1). Since India has a vast area of agricultural land, the by-product produced from harvesting of the crops could be used for their conservation into biofuel by fermentation technology. Furthermore, substantial research and advancements in metabolic engineering have the potential to switch from fossil fuel to biofuel and lead the way to next-generation biofuels which would foster this industry in creating annual employment and job opportunities as well as making the planet greener.(1).

1.1.3. Food industry :

Fermentation has been used in food preservation and for increasing nutrient value since ancient times. It has been used for producing cheese, bread, wine, curd, syrups, etc., which has been utilized by various industries and large-scale production of these has come into practice in the food industry. The probiotic enzymes and lactic acid in fermented food increase the Vitamins B and C and enhance folic acid, riboflavin, niacin, thiamin and biotin, etc., making them more accessible for absorption [1,7]. Table 1 lists the metabolites produced by microbes during fermentation process which are used exclusively in food industry.(1).Table .1.

Primary metabolites	Microrganism	Industrial application	Reference
Vitamins	Streptomyces SP; Rhizosphere	Food supplement	[31]
Amino acids	E.coli, C.glutamicum	Flavor enhancer,Nutraceutical, Food technology.	[32]
Ethanol	Saccharomyces Cerevisiae, Lactobacillus Acidophilus, Wickerhamomyces Anomalous (CDBT7).	Active ingredient in alcoholic beverages.	[33,34]
Nucleotide	Corynebactrium, Bacillus,E.coli	Flavor enhancer and production of riboflavin	[35]

1.1.4. Enzyme production :

By the help of various microorganisms such as yeast and bacteria, fermentation can produce several enzymes which can be further used in many enzyme-dependent industries such as wine brewing, cheese making, and baking. The two main methods to produce enzymes are submerged fermentation and solid-state fermentation. In submerged fermentation, the product is produced in a liquid medium and in solid-state medium, the product is produced on a solid substrate by immobilizing microorganisms on various scaffolds [16]. . With time, advanced biotechnological techniques and more sophisticated fermenters have brought enzymes with novel properties on the table such as enzymes from thermo-tolerant organisms and marine organisms various sensitive enzymes utilizing genetic engineering tools.fig



fig:-3 process of enzyme production and isolation

1.2. Biotechnology of Antibiotics Production :

The discovery of antibiotics has crucially changed the health-care management from simple wound management to post-surgical care. Since, the first antibiotic penicillin was discovered by Alexander Fleming in 1928, they have been the reason for saving lives of billions. If it was not for the availability of antibiotics, the mortality rate after World War II would have unimaginably been many folds higher [16], because before its discovery, even small wounds resulted in amputation or life-threatening conditions[17]. Globally, the use of antimicrobial agents save almost 3 million lives annually and this might still be under-represented data. Even in developed and hygienically more advanced countries such as the USA, use of antibiotics saves 200,000 lives every year [18,19].

1.2.1. semi synthetic :

This is the most common and applicable form of the second-generation antibiotics where both microbial fermentation method and synthetic chemistry are applied. One of the best examples is ampicillin which was developed by adding an amino (NH₂) group to the R group of penicillin. Similarly, by adding two methoxy groups to the phenyl group of penicillin, methicillin is produced which is potent against penicillin-resistant bacteria [23]. This method of antibiotic production [Figure 4] has tremendous room for innovation and research, where new synthetic groups could be designed, tested, and screened for better potency, less toxicity, and more environment friendly.[1].

1.2.3. Synthetic :

Some of the antibiotics, especially that of the third generation, are produced entirely synthetically such as quinolones (nalidixic acid), carbapenems, and oxazolidinones [23]. There is a greater scope for designing and producing this class of antibiotics in India. It could require multidisciplinary collaboration for designing, formulating, synthesizing, screening, and testing the antibiotics. Further, it could be scaled up for industrial grade production in collaboration with industries.[25].

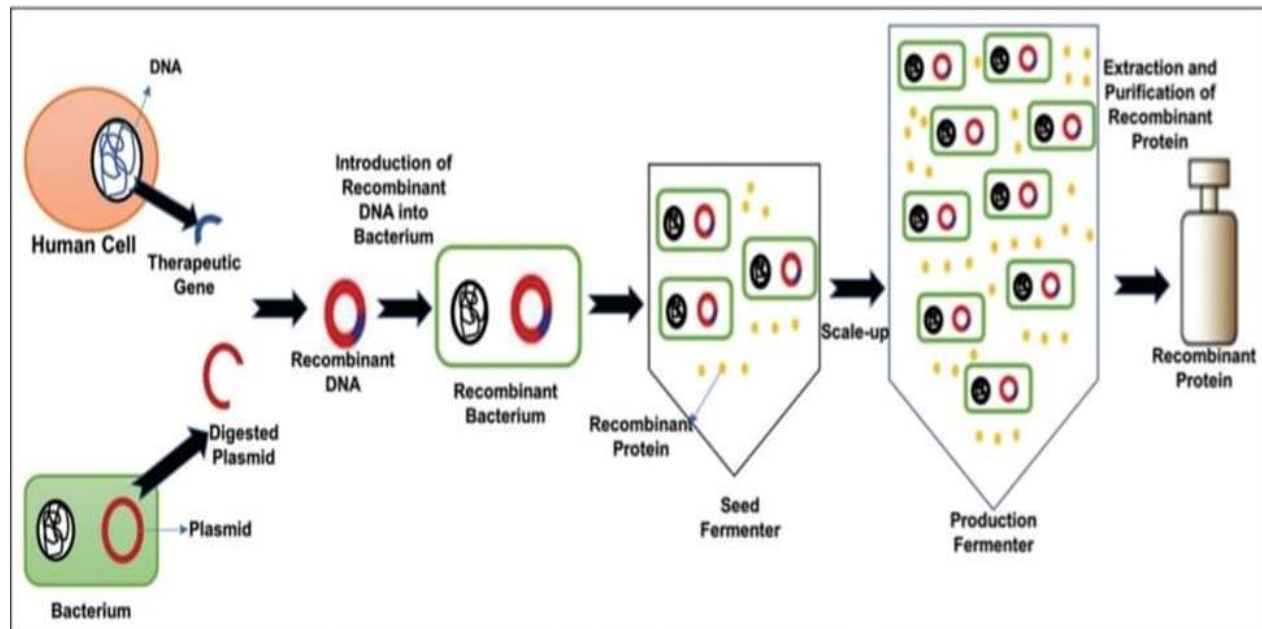


Fig : 4 Schematic representation of recombinant protein production .

1.3. Medical Biotechnology

Medical biotechnology utilizes living cells for the advancement of human wellbeing by delivering medications and anti-toxins. It additionally includes the investigation of DNA and hereditarily controls the cells to build the creation of significant and gainful qualities. Artificial Intelligence consciousness and Machine Learning are widely utilized in sedate revelation. AI helps in finding little particles that could give remedial advantages subject to realized objective structures [5]. AI is generally utilized in diagnosing maladies as it utilizes the genuine outcome to improve the analytic tests i.e., the more demonstrative tests that are run, the more exact outcomes can be accomplished. Artificial Intelligence is likewise helping in lessening the radiation treatment arranging process bringing about sparing time and improving patient consideration. Another region where Artificial Intelligence and Machine Learning are ending up being promising incorporate improving the EHRs with proof based drugs and Zamnova .T (2019) Eleyon Publishers Page 8-10 clinical choice emotionally supportive networks. Aside from the previously mentioned applications, these innovations are broadly utilized in quality altering, radiology, customized medication, medicine the executives, and so forth.

1.4.. Biotechnology of Bioremediation :

In situ and ex situ. The in situ bioremediation process treats the contaminated groundwater or soil in the location where it is found. Phytoremediation, bioventing, bioleaching, bio-slurping, biostimulation, and bioaugmentation are inThe term bioremediation technology stands for the technology which uses microbes and biological products for neutralizing, detoxifying, and degrading environmental waste. The waste could be either natural or human generated. The very first commercial use of bioremediation was in control of the sun oil pipeline spill in Pennsylvania, USA. The growing population worldwide is creating a huge burden of

waste in nature. Bioremediation is a cost-effective sustainable process that works using certain microorganisms which utilize the contaminants such as oil, pesticide, and solvents as the source of food and energy and converts them into water and harmless gases like CO₂. Bioremediation involves oxidoreductase reactions, where either an electron acceptor adds to oxidize reduced pollutants or an electron donor is added to reduce oxidized pollutants. The extent of biodegradation by the microorganisms depends on several factors such as (i) system selected specific treatment, (ii) initial concentration and toxicity of contaminant, and (iii) biodegradable property of soil. [37]. There are two main types of bioremediations : situ types of bioremediation methods. Whereas, the ex situ process requires pumping of groundwater or the excavation of contaminated soil before it can be treated. Composting, controlled solid-phase treatment, and slurry-phase biological treatment are examples of ex situ bioremediation. Other criteria for the categorization of bioremediation are on the basis of application and technology [Table 4] .[29 ,30].

Bioremediation technology	Properties	Reference
Biostimulation	Stimulation of indigenous microbial populations in soil or groundwater which can be performed either in situ or ex situ	[36,37]
Land farming	Solid –phase treatment system for contaminated soils ; may be performed in situ or in constructed soil treatment cell ; cost efficient	[36,38,39]
Composting	Aerobic,thermophilic treatment process ;can be performed using statics piles ;low cost but extended treatment time .	[36]
Bioreactors	Biodegradation in cotainer or reactor . It is use to treat several liquid wastes or slurries repid degradation kinetics but relatively high capital and operational cost .	[36,39]
Biofilters	Use of microbial striping columns to treat air emissions or odours for volatile compounds	[36,40]

1.4. Agriculture Biotechnology :

Agriculture biotechnology grows hereditarily changed plants to build crop yields or acquaint new qualities with the current plants. It includes customary plant rearing, tissue culture, micro propagation, sub-atomic reproducing, and hereditary designing of plants [21]. Biotechnology firms are presently utilizing Artificial Intelligence and Machine Learning strategies to create and program independent robots that handle significant agrarian assignments like collecting crops at an a lot quicker pace than people. PC Vision and Deep Learning calculations are utilized to process and examine the information caught by the automatons. These are mainly helpful for checking harvest and soil wellbeing. AI calculations help in following and foreseeing different ecological changes like the climate changes that sway the harvest yield.[20].

Renewable raw materials for the industrial :

Renewable raw materials are essentially based on the use of “biomass”, the sum of all substances that the living world is made of. Renewable raw materials thus have a biological origin. Its fundamental basis is the plant growth and production, which is fuelled by the photosynthesis process, and possibly via the intermediate step of animal production results in a large variety of available biomass. The total annual biomass production on our planet is estimated at 170 billion tons and consists of roughly 75% carbohydrates (sugars), 20% lignins and 5% of other substances such as oils and fats, proteins, terpenes, alkaloids, etc. [27]. Of this biomass production, 6 billion tons (3.5%) are presently being used for human needs, distributed as: – 3.7 billion tons (62%) for human food use, possibly via animal breeding as an intermediate step; – 2 billion tons of wood (33%) for energy use, paper and construction needs; – 300 million tons (5%) to meet the human needs for technical (non food) raw materials (clothing, detergents, chemicals,..). The rest of biomass production is used in the natural ecosystems (feed for wild animals), is lost when biomass is obtained for humans (especially by burning) or is lost as a result of the natural mineralization processes. The renewable raw materials discussed here are almost all provided by agriculture and forestry.[14].

Products from industrial biotechnology ;

General :

A vast range of useful products can be produced by industrial biotechnology. These fall within the categories of fine chemicals, pharmaceuticals, food additives and supplements, colourants, vitamins, pesticides, bio-plastics, solvents, bio-plastics, bulk chemicals and biofuels. These products range from very cheap bulk chemicals (e.g., ethanol: 38 million ton/year at 400 B/ton) to extremely expensive fine chemicals (e.g., vitamin B12: a few ton/year at 25 000 B/kg). Whereas industrial biotechnology is already well established in the production of fine chemicals and pharmaceuticals, also bulk chemicals, biofuels and bio-plastics are now increasingly produced by industrial biotechnology [41,42].

Vitamins :

Vitamins are important fine chemicals that are produced in relatively large quantities. Whereas a number of vitamins can be prepared only via biotechnology such as vitamin B12, an extremely complicated compound, other more simple vitamins can be produced by either a chemical route or a biotechnological route and quite often by a combination of both. The synthesis of vitamin B2 (riboflavin, 4000 tons/year) is a good example of this. The conventional process consisted of the synthesis of the building block D-ribose by fermentation with *Bacillus* bacteria, followed by a sequence of chemical reactions to obtain riboflavin.

Plastics or bio-plastics :

Recently, numerous plastics have been commercialised on a large scale, in which industrial biotechnology has a significant part in their synthesis. The production process typically consists of an intelligent combination of conventional chemical polymer technology and industrial biotechnology. Industrial biotechnology usually participates in the synthesis of monomer building blocks of these plastics. These monomer building blocks are then converted to plastics by means of conventional (chemical) polymerisation technology.

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