CLAMS

Claim 1. A biological and chemical ~~process~~ method for the capture and conversion of carbon dioxide ~~and/or other sources of inorganic carbon,~~ into ~~biomass~~organic compounds, comprising:

introducing ~~a feedstock into an environment suitable for maintaining chemoautotrophic organisms and/or chemoautotrophic cell extracts, and the carbon contained in the feedstock comprises~~ carbon dioxide gas, either alone and/or dissolved in a mixture or solution further comprising carbonate ion~~,~~ and/or bicarbonate ion, into an environment suitable for maintaining chemoautotrophic organisms and/or chemoautotrophic cell extracts~~or inorganic carbon contained in a solid phase~~; and fixing the carbon dioxide and/or inorganic carbon~~contained in the feedstock~~ into organic compounds within the environment via at least one chemosynthetic carbon fixing reaction utilizing ~~one or more~~ chemoautotrophic microorganisms ~~selected from the group consisting of~~comprising a *Ralstonia sp.*~~, an *Alcaligenes sp.*, and a *Hydrogenomonas sp.*~~;

wherein where the chemosynthetic carbon fixing reaction is driven by chemical and/or electrochemical energy provided by electron donors and electron acceptors that have been generated chemically and/or electrochemically and/or are introduced into the environment from at least one source external to the environment, and wherein the ~~concentrations of the~~ electron donor comprises hydrogen generated through an electrolysis method selected from the group comprising photon exchange membrane electrolysis, liquid electrolyte electrolysis, high pressure electrolysis, and high pressure electrolysis of steam and ~~,~~ said electron acceptors, comprises carbon dioxide ~~nitrogen,~~ and/or oxygen ~~phosphorous are maintained at levels for maximum chemoautotrophic growth~~;

wherein the environment suitable for maintaining chemoautotrophic organisms and/or chemoautotroph cell extracts is maintained using continuous influx and removal of nutrient medium and/or biomass, in substantially steady state where the cell population and environmental parameters are targeted at a substantially constant suitable or optimal level over time; and

wherein biomass is produced by the at least one chemosynthetic reaction, and wherein the biomass is separated from the environment and is processed into a product comprising an animal feed, a fertilizer, a soil additive, a soil stabilizer, a carbon source for large scale

fermentations, ~~and/or~~ a nutrient source for the growth of other microbes or organisms; and/or as a source of pharmaceutical, medicinal or nutritional substances.

Claim 2. ~~The process according to claim 1, wherein the animal feed product is a feed for cattle, sheep, chickens, pigs, and/or fish.~~

~~3. The process according to claim 1, wherein said biomass and/or biochemicals are processed into a carbon source for a large scale fermentation and/or a nutrient source for the growth of other microbes or organisms, wherein said large scale fermentation and/or said other microbes or organisms produce one or more of: commercial enzymes, antibiotics, amino acids, vitamins, and bioplastics.~~

~~4. The process according to claim 1, wherein said biomass and/or biochemicals are processed into a nutrient source for the growth of fish~~.

~~5. The process according to claim 1, wherein molecular hydrogen acts as an electron donor.~~

~~6. The process according to claim 5, wherein said hydrogen is generated through electrolysis of water and/or thermochemical splitting of water.~~

~~7. The process according to claim 6, wherein said electrolysis of water comprises at least one of: Proton Exchange Membranes (PEM); a liquid electrolyte; high-pressure electrolysis; and high temperature electrolysis of steam (HTES).~~

~~8. The process according to claim 7, wherein said electrolyte comprises potassium hydroxide.~~

~~9. The process according to claim 6, wherein said thermochemical splitting of water comprises at least one of: iron oxide cycle; cerium(IV) oxide-cerium(III) oxide cycle; zinc – zinc oxide cycle; sulfur-iodine cycle; copper-chlorine cycle; calcium-bromine-iron cycle; and hybrid sulfur cycle.~~

~~10. The process according to claim 5, wherein said hydrogen is generated through one or more of: electrolysis of hydrogen sulfide; thermochemical splitting of hydrogen sulfide; and the half-cell reduction of H^+ to H_2 accompanied by the half-cell oxidization of electron sources comprising ferrous iron (Fe^{2+}) oxidized to ferric iron (Fe^{3+} and/or the oxidation of sulfur compounds, wherein the oxidized iron or sulfur is recycled to back to a reduced state through additional chemical reactions with minerals comprising at least one of a metal sulfide, hydrogen sulfide, and a hydrocarbon.~~

~~11. The process according to claim 5, wherein said hydrogen is generated through an electrochemical or thermochemical process known to produce hydrogen with low- or no- carbon dioxide emissions, comprising at least one of: carbon capture and sequestration enabled methane reforming; carbon capture and sequestration enabled coal gasification; the Kvaerner process; a process that generates a carbon-black product; and carbon capture and sequestration enabled gasification or pyrolysis of biomass.~~

~~12. The process according to claim 1, wherein said electron donors and/or electron acceptors are generated or recycled using renewable, alternative, or conventional sources of power that are low in greenhouse gas emissions, and wherein said sources of power comprise at least one of: photovoltaic, solar thermal, wind, hydroelectric, nuclear, geothermal, enhanced geothermal, ocean thermal, ocean wave, and tidal power sources.~~

~~13. The process according to claim 1, wherein said electron donor comprises one or more of: ammonia; ammonium; carbon monoxide; dithionite; elemental sulfur; a hydrocarbon; hydrogen; a sulfide; a sulfite; a thionate; a thionite; a transition metal and/or its sulfide; an oxide; a chalcogenide; a halide; a hydroside; an oxyhydroxide; a phosphate; a sulfate; a carbonate; and a conduction or valence band electron in a solid state electrode material.~~

~~14. The process according to claim 1, wherein said electron donor is generated within or recycled to the environment through non- or low-carbon dioxide emitting chemical reactions with hydrocarbons, comprising one or more of: thermochemical reduction of sulfate reaction (TSR); the Muller-Kuhne reaction for the production of hydrogen sulfide or reduced sulfur; and methane reforming-like reactions utilizing metal oxides in place of water, wherein the metal oxides comprise one or more of: iron oxide, calcium oxide, and magnesium oxide, and wherein the hydrocarbon is reacted to form solid carbonate with little or no emission of carbon dioxide gas along with hydrogen electron donor product.~~

~~15. The process according to claim 1, wherein said electron acceptor comprises one or more of: carbon dioxide; oxygen; a nitrite; a nitrate; a transition metal ion; a sulfate; and a valence or conduction band hole in a solid state electrode material.~~

~~16. The process~~ A method according to claim 1, wherein the fixing step is followed by one or more process steps in which organic and/or inorganic ~~unused nutrients and/or process water left after removal of chemoautotrophic cell mass and/or~~ chemical ~~co-~~products of chemosynthesis are separated from a ~~and/or waste products or contaminants of the~~ process stream produced during the fixing step and processed to form products in a form suitable for storage, shipping, and sale ~~are recycled back into a reactor system in which the chemosynthetic carbon fixing reaction is performed to support further chemosynthesis~~.

Claim 3. A method according to any preceding claim, wherein said electron donors and/or electron acceptors are generated or recycled using renewable, alternative, or conventional sources of power that are low in greenhouse gas emissions, and wherein said sources of power are selected from at least one of: photovoltaic, solar thermal, wind power, hydroelectric, nuclear, geothermal, enhanced geothermal, ocean thermal, ocean wave, tidal power sources and carbon capture and sequestration enabled gasification or pyrolysis of coal or biomass.

~~17. The process according to claim 1, wherein said at least one chemosynthetic carbon fixing reaction is performed by chemoautotrophic microorganisms that have been improved, optimized or engineered for the fixation of carbon dioxide and/or other forms of inorganic carbon and the production of organic compounds.~~

~~18. The process according to claim 1, wherein said electron donor is generated from pollutants or waste products selected from one or more of: process gas; tail gas; enhanced oil recovery vent gas; biogas; acid mine drainage; landfill leachate; landfill gas; geothermal gas; geothermal sludge or brine; metal contaminants; gangue; tailings; sulfides; disulfides; mercaptans selected from one or more of methyl mercaptan, dimethyl mercaptan, and ethyl mercaptan; carbonyl sulfide; carbon disulfide; alkanesulfonates dialkyl sulfides; thiosulfate; thiofurans; thiocyanates; isothiocyanates; thioureas; thiols; thiophenols; thioethers; thiophene, dibenzothiophene; tetrathionate; dithioite; thionate; dialkyl disulfides; sulfones; sulfoxides; sulfolanes; sulfonic acid; dimethylsulfoniopropionate; sulfonic esters; hydrogen sulfide; sulfate esters; organic sulfur; and sour gases.~~

~~19. The process according to claim 5, wherein delivery of reducing equivalents from the electron donor to the chemoautotrophic microorganisms for the chemosynthetic reaction during the fixing step is kinetically and/or thermodynamically enhanced by one or more of: introduction of hydrogen storage materials into the environment in the form of a solid support media for microbial growth that facilitates bringing absorbed or adsorbed hydrogen electron donors into close proximity with the chemoautotrophic organisms; introduction of electron mediators comprising one or more of: cytochromes, formate methyl viologen, NAD^+/NADH, neutral red (NR), and quinones to help transfer reducing power from a poorly soluble electron donor comprising H_2 gas or electrons in solid state electrode materials into chemoautotrophic culture media in the environment; and introduction of electrode materials in the form of a solid growth support media directly into the environment to facilitate bringing solid state electrons into close proximity with the chemoautotrophic microorganisms.~~

~~20. The process according to claim 1, wherein said environment comprises a bioreactor, and wherein said microorganisms are maintained in a culture medium in said bioreactor.~~

~~21. The process according to claim 20, wherein said bioreactor is formed at least in part by a microbial culture apparatus selected from: an airlift reactor; a biological scrubber column; a bubble column; a continuous stirred tank reactor; a counter-current, upflow, expanded-bed reactor; a digestor for a sewage and/or waste water treatment or bioremediation system; one or more filters; a fluidized bed reactor; a gas lift fermenter; an immobilized cell reactor; a membrane biofilm reactor; a mine shaft; a Pachuca tank; a packed bed reactor; a plug-flow reactor; a static mixer; a tank; a trickle bed reactor; a vat; and/or a vertical shaft bioreactor.~~

Claim ~~22~~4. ~~The~~ A ~~process~~ method according to any preceding claim ~~1~~, further comprising ~~prior to the fixing step, a step of~~ reacting carbon dioxide with minerals to form a carbonate or bicarbonate product~~, which is then used in the fixing step~~.

Claim 5. A method according to any preceding claim, wherein carbon dioxide is introduced in the introducing step, and wherein the carbon dioxide is dissolved in aqueous solution.

Claim 6. A method according to any preceding claim, wherein molecular hydrogen acts as an electron donor and wherein hydrogen concentrations in air between 4 to 74.5% are avoided.

Claim 7. A method according to any preceding claim, whereby a culture broth is continuously removed from the environment suitable for maintaining chemoautotrophic organisms and flowed through membrane filters to separate the cell mass from the broth.

Claim 8. A method according to any preceding claim, wherein the biomass produced by the at least one chemosynthetic reaction is centrifuged and then dried with evaporation, and where the biomass produced is collected from dryers.

Claim 9. A method according to claim 7 or 8, where remaining water and nutrients separated from the biomass are pumped back into the environment suitable for maintaining chemoautotrophic organisms.

~~23. The process according to claim 1, comprising fixing the carbon dioxide and/or inorganic carbon into the organic compounds via at least one chemosynthetic carbon fixing reaction within a reactor system, wherein the electron donor utilized in the chemosynthetic carbon fixing reaction is produced via a non-biological process in the reactor system.~~

~~24. The process according to claim 1, wherein the environment suitable for maintaining chemoautotrophic organisms and/or chemoautotroph cell extracts is maintained using continuous influx and removal of nutrient medium and/or biomass.~~

~~25. The process according to claim 1, wherein the chemosynthetic carbon fixing reaction is aerobic.~~