NOTESKARTS | PREMIUM STUDY NOTES

BP812ET — DIETARY SUPPLEMENTS & NUTRACEUTICALS

UNIT — I | Complete Theory Notes |

B.Pharm 8th Semester · PCI / AKTU Syllabus · Exam-Ready + MCQs + Question Bank

UNIT-I | LEARNING OBJECTIVES

After studying this unit, the student will be able to:

- LO-1: Define and differentiate Functional Foods, Nutraceuticals, and Dietary Supplements with examples.
- LO-2: Classify Nutraceuticals based on chemical nature, origin, and mechanism of action.
- LO-3: Explain the role of Nutraceuticals in prevention and management of major lifestyle diseases including obesity, diabetes, cancer, CVD, hypertension, osteoarthritis, and stress.
- LO-4: Discuss Public Health Nutrition, Maternal & Child Nutrition, and Nutrition in Ageing.
- LO-5: Describe Nutrition Education strategies used at the community level in India.
- LO-6: Identify the source, marker compounds, chemical nature, medicinal uses, and health benefits of Spirulina, Soybean, Ginseng, Garlic, Broccoli, Gingko, and Flaxseeds.

FUNDAMENTAL DEFINITIONS

Functional Foods

Functional foods are **conventional foods consumed as part of the normal diet** that, beyond basic nutritional functions, **demonstrate physiological benefits** and/or reduce the risk of chronic disease. The term was coined in Japan in the 1980s under the FOSHU (Foods for Specified Health Use) programme — the world's first regulatory system for functional foods.

Definition	Functional Foods — Foods that, by virtue of physiologically active components, provide health benefits beyond basic nutrition. (Goldberg, 1994; Roberfroid, 2002)

⚠ Exam Trick	Functional food = conventional food + extra health benefit. It is NOT a drug. Examiners love asking: 'Is fortified milk a functional food?' Answer: YES.

Nutraceuticals

The term **'Nutraceutical'** was coined by **Dr. Stephen DeFelice** in 1989 from a combination of 'Nutrition' + 'Pharmaceutical'. It refers to **any substance considered a food (or part of a food) that provides medical or health benefits, including the prevention and treatment of disease.**

WHO Definition	A nutraceutical is a food or part of a food that provides medical or health benefits, including the prevention and/or treatment of a disease.

Examples: Fish oil capsules, Coenzyme Q10, Lycopene, Phytosterols, Probiotics, Glucosamine, Omega-3 fatty acids.

Dietary Supplements

As defined by the **Dietary Supplement Health and Education Act (DSHEA), 1994 — USA**: A dietary supplement is a product taken **by mouth** that contains a 'dietary ingredient' intended to supplement the diet. Dietary ingredients include: vitamins, minerals, herbs/botanicals, amino acids, enzymes, organ tissues, metabolites, concentrates, and extracts.

DSHEA 1994	A dietary supplement is a product (other than tobacco) intended to supplement the diet that contains one or more dietary ingredients — a vitamin, mineral, herb or other botanical, amino acid, or a dietary substance to supplement the diet by increasing total dietary intake.

Comparison Table — Three Concepts

Parameter	Functional Food	Nutraceutical	Dietary Supplement
Form	Conventional food	Food OR isolated component	Pill/capsule/powder/liquid
Example	Fortified milk, Oatmeal	Lycopene, Omega-3, Ginseng extract	Vitamin C tablet, Fish oil capsule
Intake route	Oral (as food)	Oral (food or supplement)	Oral (non-food form)
Regulatory status (India)	FSSAI	FSSAI / Drugs Act	Drugs & Cosmetics Act
Primary purpose	Nutrition + health benefit	Health / disease prevention	Supplement diet deficiency
Coined by / year	Japan (FOSHU), 1980s	DeFelice, 1989	DSHEA, USA, 1994

⚠ Exam Trick The difference between Nutraceutical vs Dietary Supplement: Nutraceuticals CAN be foods in normal form; Dietary Supplements are ALWAYS non-food form (tablets, capsules, powder). This 1-mark question trips most students.

CLASSIFICATION OF NUTRACEUTICALS

Nutraceuticals are classified by **multiple criteria**. You must know ALL classification schemes for the exam.

Based on Chemical Nature / Source

Category	Examples	Mechanism
Polyphenols / Flavonoids	Quercetin, Resveratrol, Catechins (green tea), Genistein (soy)	Antioxidant, anti-inflammatory
Carotenoids	Lycopene, Beta-carotene, Lutein, Zeaxanthin	Antioxidant, anticancer, eye health
Glucosinolates	Sulforaphane (broccoli), Indole-3-carbinol	Anticancer, enzyme induction
Omega-3 Fatty Acids	EPA, DHA (fish oil), ALA (flaxseed)	Cardioprotective, anti-inflammatory
Phytosterols	Beta-sitosterol, Campesterol	Reduce LDL cholesterol
Probiotics	Lactobacillus, Bifidobacterium	Gut health, immune modulation
Prebiotics	Inulin, FOS (fructooligosaccharides)	Feed beneficial gut bacteria
Vitamins & Minerals	Vitamin C, E, D, Selenium, Zinc	Antioxidant, immune support
Proteins / Peptides	Whey protein, Casein peptides	Muscle building, antihypertensive
Terpenoids	Ginkgolides (Gingko), Ginsenosides (Ginseng)	Neuroprotective, adaptogenic
Organosulfur Compounds	Allicin (Garlic), Diallyl disulfide	Antimicrobial, cardioprotective

Based on Origin

Origin	Examples
Plant-derived (Phytonutraceuticals)	Soybean, Garlic, Broccoli, Flaxseed, Ginseng, Gingko, Spirulina
Animal-derived	Fish oil (omega-3), Glucosamine (shellfish), Collagen (bovine/porcine)
Microbial-derived	Probiotics (Lactobacillus, Bifidobacterium), Coenzyme Q10
Marine-derived	Spirulina (cyanobacteria), Omega-3 EPA/DHA, Astaxanthin
Mineral-based	Calcium, Magnesium, Selenium, Zinc supplements

Based on Mechanism of Action

Mechanism	Examples	Disease Target
Antioxidant	Vitamin C, E, Lycopene, Resveratrol	Cancer, CVD, ageing
Anti-inflammatory	Omega-3, Curcumin, Ginger	Arthritis, CVD, IBD
Immunomodulatory	Zinc, Vitamin D, Beta-glucan	Infections, autoimmunity
Cardioprotective	Omega-3, Phytosterols, Garlic	Hypertension, dyslipidemia
Adaptogenic	Ginseng, Ashwagandha	Stress, fatigue
Prebiotic/Probiotic	Inulin, Lactobacillus	Gut health, immunity
Anticancer	Sulforaphane, Genistein, Lycopene	Breast, prostate, colon cancer
Neuroprotective	Ginkgolides, DHA, Curcumin	Alzheimer's, dementia

★ Point Classification by mechanism is the most asked in 10-mark questions. Learn ALL 8 mechanisms with examples.

NUTRACEUTICALS IN DISEASE PREVENTION & MANAGEMENT

Weight Control / Obesity

Obesity is defined as BMI ≥ 30 kg/m². Nutraceuticals help by **increasing satiety, enhancing thermogenesis, inhibiting lipogenesis, and promoting lipolysis.**

Nutraceutical	Mechanism	Source
Green Tea Catechins (EGCG)	Thermogenesis ↑, fatty acid oxidation ↑	Green tea
Conjugated Linoleic Acid (CLA)	Reduces body fat, increases lean mass	Dairy, meat
Glucomannan	Increases satiety, slows gastric emptying	Konjac plant
Psyllium husk	Soluble fiber → reduces appetite	Isabgol (Plantago ovata)
Chromium picolinate	Improves insulin sensitivity, reduces cravings	Broccoli, nuts
5-HTP (5-Hydroxytryptophan)	Increases serotonin → reduces appetite	Griffonia seed

Diabetes Mellitus

Type 2 Diabetes (T2DM) is characterized by **insulin resistance + relative insulin deficiency**. Nutraceuticals target: glucose absorption, insulin secretion, insulin sensitivity, and oxidative stress.

Nutraceutical	Action	Marker Compound
Fenugreek (Methi)	Slows glucose absorption, stimulates insulin	4-Hydroxyisoleucine, soluble fiber
Bitter Gourd (Karela)	Insulin-like action, increases GLUT4	Charantin, Polypeptide-P
Cinnamon	Improves insulin receptor sensitivity	Cinnamaldehyde, Methylhydroxychalcone
Chromium	Enhances insulin receptor signaling	Chromium ion (Cr3+)
Alpha-lipoic acid	Antioxidant, improves glucose uptake	Lipoic acid (thioctic acid)
Berberine	Activates AMPK pathway (like Metformin)	Berberine (alkaloid)
Ginseng	Reduces post-prandial glucose	Ginsenosides
Flaxseed	Improves glycemic control via fiber + lignans	Secoisolariciresinol diglucoside (SDG)

Clinical Berberine activates the same AMPK pathway as Metformin — this is a HIGH-YIELD clinical comparison. Berberine = 'Natural Metformin'.

Cancer Prevention

Nutraceuticals prevent cancer by: **(a) Antioxidant protection**, (b) Phase II enzyme induction, (c) Apoptosis promotion, (d) Angiogenesis inhibition, (e) Hormone modulation.

Nutraceutical	Target Cancer	Active Compound	Mechanism
Broccoli	Colon, breast, prostate	Sulforaphane	Phase II enzyme ↑, NF-κB ↓
Soybean	Breast, prostate	Genistein (isoflavone)	Phytoestrogen, tyrosine kinase ↓
Garlic	Stomach, colon	Allicin, DADS	Apoptosis ↑, detox ↑
Tomato (Lycopene)	Prostate	Lycopene	Antioxidant, cell cycle arrest
Green Tea	Breast, colon, lung	EGCG	Angiogenesis ↓, apoptosis ↑
Turmeric	Multiple	Curcumin	NF-κB ↓, apoptosis ↑
Flaxseed	Breast, prostate	SDG (Lignan)	Antioestrogenic effect

Cardiovascular Disease (CVD) / Heart Disease

CVD risk factors: dyslipidemia, hypertension, oxidative stress, inflammation, platelet aggregation. Nutraceuticals target each.

Nutraceutical	Mechanism	Effect on Lipids
Omega-3 (EPA/DHA)	Reduces TG synthesis, anti-platelet	TG ↓↓, LDL slightly ↓, HDL ↑
Phytosterols	Block cholesterol absorption in gut	LDL ↓ 10–15%
Garlic	Inhibits HMG-CoA reductase, anti-platelet	LDL ↓, platelet aggregation ↓
Red Yeast Rice	Contains Monacolin K (like lovastatin)	Total cholesterol ↓, LDL ↓
Soluble fiber (Psyllium, Beta-glucan)	Bile acid sequestrant → LDL ↓	LDL ↓
Resveratrol (Grape, wine)	Antioxidant, eNOS activation	Vasodilation, atherosclerosis ↓
CoQ10	Antioxidant, mitochondrial support	Protects heart muscle

Stress & Anxiety

Adaptogenic nutraceuticals help the body **adapt to physical, chemical, and biological stress** by normalizing physiological processes and supporting the HPA (Hypothalamic-Pituitary-Adrenal) axis.

Nutraceutical	Active Compound	Effect
Ginseng (Panax)	Ginsenosides (Rb1, Rg1)	HPA axis regulation, cortisol ↓, mental clarity ↑
Ashwagandha	Withanolides	Cortisol ↓, anxiety ↓, stamina ↑
Valerian Root	Valerenic acid	GABA-A receptor modulation, sleep quality ↑
L-Theanine (Green tea)	L-Theanine (amino acid)	Alpha brain waves ↑, calming without sedation
Magnesium	Mg2+ ion	NMDA receptor antagonism, reduces anxiety
Omega-3 DHA	DHA	Reduces cortisol response, neuroinflammation ↓

Osteoarthritis

Osteoarthritis (OA) involves cartilage degradation and joint inflammation. Nutraceuticals work by **rebuilding cartilage, reducing inflammation, and inhibiting matrix metalloproteinases (MMPs).**

Nutraceutical	Mechanism	Evidence Level
Glucosamine sulphate	Chondroprotection, GAG synthesis ↑	Strong (Grade A)
Chondroitin sulphate	Inhibits cartilage-degrading enzymes	Strong (Grade A)
Collagen hydrolysate	Stimulates collagen II synthesis in cartilage	Moderate
Omega-3 fatty acids	PGE2 ↓, TNF-alpha ↓, inflammation ↓	Moderate
Curcumin (Turmeric)	COX-2 ↓, NF-κB ↓, IL-6 ↓	Moderate (well studied)
Avocado Soybean Unsaponifiables (ASU)	Inhibit IL-1β, TGF-β stimulation	Moderate
Boswellia	BLTA enzyme inhibition, leukotrienes ↓	Moderate

> **⚠ Exam Trick** For OA: Glucosamine + Chondroitin is the standard nutraceutical combination. Always mention these two together in exam answers.

Hypertension

Nutraceuticals lower BP by: vasodilation (NO ↑), ACE inhibition, diuretic effect, and reduction of oxidative stress.

Nutraceutical	Mechanism	BP Reduction
Garlic (Allicin)	H2S production → vasodilation, ACE inhibition	~8/5 mmHg
Omega-3 EPA/DHA	eNOS activation, prostaglandin E3 ↑	~4/2 mmHg
CoQ10	Antioxidant, reduces peripheral resistance	~17/10 mmHg
Potassium (banana, etc.)	Na+ excretion ↑, vasodilation	~4/2 mmHg
Magnesium	Ca2+ antagonism, smooth muscle relaxation	~3–4 mmHg
Beetroot (Nitrate)	Converted to NO → vasodilation	~4–10 mmHg
Hibiscus tea	ACE inhibition, diuretic effect	~7/3 mmHg

> **★ Point** Remember: Garlic, Omega-3, and CoQ10 are the top 3 nutraceuticals for hypertension. Garlic's mechanism = Allicin → H2S → vasodilation.

PUBLIC HEALTH NUTRITION

Concept of Public Health Nutrition

Public Health Nutrition (PHN) is **the science and art of preventing disease, prolonging life, and promoting health through organized community efforts using nutrition**. It applies nutritional science at the **population level**, not just individuals.

Component	Elements in Indian Context
Goals	Reduce malnutrition, prevent micronutrient deficiencies, combat obesity/NCD
Major Programs	POSHAN Abhiyaan (2018), Mid-Day Meal Scheme, ICDS, NFSA 2013
Indicators	BMI, stunting, wasting, anemia prevalence, calorie/protein intake
Approaches	Dietary diversification, food fortification, supplementation, nutrition education
Deficiencies (India)	Iron (anemia), Vitamin A (night blindness), Iodine (goitre), Vitamin D, Zinc

Maternal Nutrition

Adequate maternal nutrition is critical for **fetal growth, neural tube development, and reducing maternal mortality**. nutritional requirements during pregnancy:

Nutrient	RDA (Pregnancy)	Deficiency Effect	Source
Folic Acid	400–600 mcg/day	Neural tube defects (spina bifida)	Green leafy veg, fortified cereals
Iron	27 mg/day	Maternal anemia, IUGR, premature delivery	Meat, spinach, lentils
Calcium	1000–1200 mg/day	Maternal bone loss, poor fetal bone dev	Milk, dairy, sesame
Iodine	220 mcg/day	Cretinism, hypothyroidism in baby	Iodized salt, seafood
Vitamin D	600 IU/day	Rickets in newborn, poor bone mass	Sunlight, fortified milk
Omega-3 DHA	200 mg/day	Poor fetal brain & eye development	Fish, flaxseed
Zinc	11 mg/day	Growth retardation, immune impairment	Nuts, seeds, meat

Child Nutrition

The **1000-day window (conception to 2 years)** is the most critical period. Under-nutrition during this period causes **irreversible stunting, cognitive impairment, and immune deficiency**.

- Exclusive breastfeeding for first 6 months — WHO recommendation.
- Colostrum — first milk, rich in IgA, lactoferrin, and growth factors — must not be discarded.
- Complementary feeding from 6 months onwards (Daal, Khichdi, mashed fruits).
- Severe Acute Malnutrition (SAM): MUAC < 11.5 cm; Moderate Acute Malnutrition (MAM): MUAC 11.5–12.5 cm.
- Vitamin A supplementation (6 monthly doses) — reduces child mortality by 23–34%.
- Iron & Folic Acid (IFA) supplementation — ICDS programme covers 6 months to 5 years.

Nutrition and Ageing

Ageing is associated with **reduced caloric need, decreased absorption, increased protein requirement, and higher micronutrient needs**. concerns:

Age-related Change	Nutritional Implication	Nutraceutical Approach
Sarcopenia (muscle loss)	↑ Protein need (1.2–1.6 g/kg/day)	Whey protein, leucine, creatine
Osteoporosis	↑ Calcium + Vitamin D need	Calcium carbonate, Vitamin D3
Reduced gastric acid	Poor B12 & Iron absorption	B12 supplement, Iron chelate
Oxidative stress ↑	↑ Antioxidant need	Vitamin C, E, CoQ10, Resveratrol
Immune decline (immunosenescence)	↑ Zinc, Selenium, Vitamin D need	Zinc, Selenium, Vitamin D3
Cognitive decline	DHA, Choline, B vitamins need ↑	Fish oil, Gingko, Phosphatidylserine
Constipation	↑ Fiber and water intake	Psyllium, inulin, probiotics

Clinical In geriatric patients, Vitamin B12 deficiency is common due to reduced intrinsic factor + gastric acid. Supplement with sublingual or injectable B12 rather than oral tablets.

Nutrition Education in the Community

Nutrition education is **any combination of educational strategies, accompanied by environmental supports, designed to facilitate voluntary adoption of food choices and other food- and nutrition-related behaviors** conducive to health and well-being. (FAO definition)

Strategy	Description	Indian Example
Individual counselling	1-to-1 dietary advice	PHC nutritionist counselling
Group education	Antenatal classes, village meetings	ASHA worker meetings

Strategy	Description	Indian Example
Mass media	TV, radio, social media campaigns	Poshan Maah (Sep every year)
Food demonstrations	Cooking nutritious food using local foods	Anganwadi centres
School nutrition programs	Mid-Day Meal, nutrition gardens	Rajya Poshan Mission
SBCC approach	Social Behaviour Change Communication	POSHAN Abhiyaan IEC

- Organizations: ICMR (Indian Council of Medical Research), NIN (National Institute of Nutrition, Hyderabad), FSSAI, WHO India.
- NIN publishes the Dietary Guidelines for Indians (DGI) — revised periodically.
- My Plate for the Day (ICMR-NIN 2024) — updated balanced diet visual.

NUTRACEUTICAL PROFILE CARDS — SOURCE, MARKER COMPOUNDS & HEALTH BENEFITS

The following 7 nutraceuticals are **directly mentioned in the PCI syllabus** — learn each one completely. Examiners ask: Source, Marker compound, Chemical nature, Medicinal uses. All must be memorized.

Spirulina

SPIRULINA	
Marker Compound	Phycocyanin (blue pigment) + C-Phycocyanin
Chemical Nature	Biliprotein (phycocyanobilin chromophore) + essential amino acids (all 9), Gamma-Linolenic Acid (GLA)
Medicinal Uses	Nutritional supplement in malnutrition; antioxidant, anti-inflammatory, immunomodulatory, hypolipidemic, anti-diabetic, anti-viral

- Scientific name: Arthrospira platensis (earlier Spirulina platensis)
- Classification: Cyanobacterium (blue-green algae) — NOT a true algae, it's a prokaryote.
- Source: Freshwater lakes; commercially cultivated in India (Gujarat, Rajasthan), USA, China.

- Protein content: 60–70% dry weight — highest natural protein source. Contains ALL essential amino acids.
- Contains: Phycocyanin (blue), Chlorophyll (green), Carotenoids (beta-carotene, zeaxanthin, lutein), GLA, Vitamin B12.
- Medicinal uses: Anemia (iron + B12 content), malnutrition, immune booster, cholesterol reduction, anti-diabetic, HIV support, detoxification (heavy metal chelation).

⚠ Exam Trick

Most asked: 'Is Spirulina a plant or algae?' — It is a PROKARYOTE (cyanobacterium), NOT a plant or true algae. Also: Spirulina is the RICHEST NATURAL SOURCE of Vitamin B12 — important for vegans.

Soybean

SOYBEAN	
Marker Compound	Isoflavones: Genistein & Daidzein
Chemical Nature	Phytoestrogens — Isoflavones (polyphenolic, plant-derived estrogen-like compounds). Also: Saponins, Phytosterols, Omega-3 ALA
Medicinal Uses	Menopausal symptoms relief, cancer prevention (breast/prostate), cardioprotection, osteoporosis prevention, diabetes management

- Scientific name: Glycine max (Family: Fabaceae / Leguminosae).
- Source: Soybean seeds — native to East Asia; major producers: USA, Brazil, India.
- Isoflavones: Genistein (5,7,4'-trihydroxyisoflavone) + Daidzein + Glycitein — act as SERM (Selective Estrogen Receptor Modulators).
- Complete plant protein: Contains all essential amino acids (PDCAAS score = 1.0 — same as whey).
- Genistein mechanism: Inhibits tyrosine kinase (anticancer), inhibits angiogenesis, phytoestrogenic action in bone.
- Uses: Menopausal hot flushes (reduces frequency by 25–30%), osteoporosis, CVD, Type 2 diabetes, cancer chemoprevention.
- Products: Tofu, tempeh, soy milk, miso, soy isoflavone tablets.

Clinical

Genistein competes with estrogen at ER-beta receptors. It has PROTECTIVE effect against breast cancer despite being estrogenic — because ER-beta activation inhibits ER-alpha-mediated proliferation. High-yield for pharmacology integration!

Ginseng (Panax ginseng)

GINSENG

Marker Compound	Ginsenosides (also called Panaxosides) — specifically Rb1, Rc, Rd (sedative/calming) and Rg1, Re, Rf (stimulating)
Chemical Nature	Triterpene saponins — dammarane-type (protopanaxadiol and protopanaxatriol series) and oleanane-type
Medicinal Uses	Adaptogen (stress), cognitive enhancement, immune modulation, anti-fatigue, sexual function, anti-diabetic, cardioprotective

- Scientific name: Panax ginseng (Korean/Asian Ginseng); Panax quinquefolius (American Ginseng)
- Family: Araliaceae | Root (fleshy tap root) is the medicinal part.
- 'Panax' = Greek for 'all-heal' (pan = all, akos = cure) — ginseng is the ultimate adaptogen.
- Ginsenoside classification: Group 1 (Rb1, Rb2, Rc, Rd) — CNS depressant; Group 2 (Rg1, Rg2, Rf) — CNS stimulant. Both groups are active!
- Adaptogenic mechanism: Modulates HPA axis and SAM (Sympatho-Adrenal Medullary) axis, reduces cortisol.
- Anti-diabetic: Ginsenosides enhance insulin secretion, improve GLUT4 translocation, reduce post-prandial glucose.
- Immune: Activates NK cells, macrophages, T and B lymphocytes.
- Cognitive: Improves acetylcholine neurotransmission, antioxidant in brain, used in Alzheimer's prevention.

⚠ Exam Trick Ginseng has DUAL (opposite) acting ginsenosides — Rb1 series = sedating; Rg1 series = stimulating. This paradox is a favorite MCQ trap.

Garlic (Allium sativum)

□ GARLIC	
Marker Compound	Allicin (diallyl thiosulfinate) — PRIMARY marker compound; also: Ajoene, Alliin, DADS (Diallyl Disulfide), DATS (Diallyl Trisulfide)
Chemical Nature	Organosulfur compounds — Allicin: diallyl thiosulfinate [CH2=CH-CH2-S(=O)-S-CH2-CH=CH2]. Thiosulfinates, Vinyldithiins, Ajoene
Medicinal Uses	Antimicrobial, antihypertensive, hypolipidemic, anticancer, antioxidant, anti-platelet, antifungal, immunomodulatory

- Scientific name: Allium sativum | Family: Liliaceae (or Alliaceae) | Part used: Bulb (cloves).
- Alliin (S-allyl-L-cysteine sulfoxide) is the precursor — ODOURLESS.
- Allicin is formed when garlic is CRUSHED/CHOPPED → enzyme alliinase converts Alliin to ALLICIN (odorous).
- ALLICIN is UNSTABLE — breaks down to DADS, DATS, Ajoene (all biologically active).
- Antimicrobial: Allicin inhibits bacterial enzymes (cysteine proteinases, thiol-containing enzymes). Effective vs MRSA!
- Cardioprotective: LDL ↓, TG ↓, platelet aggregation ↓, BP ↓ (via H2S production from organosulfur compounds).
- Anticancer: DADS/DATS induce apoptosis, inhibit cell cycle progression, upregulate Phase II enzymes (GST).
- Commercial forms: Aged Garlic Extract (AGE) — standardized for S-Allyl Cysteine (SAC) content.

⚠ Exam Trick	chain: Alliin --[alliinase]-→ Allicin --[heat/oxidation]-→ DADS/DATS/Ajoene. Without crushing, alliin and alliinase are in SEPARATE cell compartments — no allicin formed! Explain this in exam answers.

Broccoli (Brassica oleracea var. italica)

□ BROCCOLI	
Marker Compound	Sulforaphane — PRIMARY marker compound; Indole-3-Carbinol (I3C), Glucoraphanin (glucosinolate precursor)
Chemical Nature	Sulforaphane: isothiocyanate [CH3-SO-CH2CH2CH2-N=C=S]; Glucosinolates (S-containing glycosides). I3C: Indole alkaloid
Medicinal Uses	Anticancer (colon, breast, prostate), antioxidant, anti-inflammatory, detoxification, anti-diabetic, cardioprotective

- Family: Brassicaceae (Cruciferous vegetables). Part used: Flower head, leaves.
- Glucoraphanin (glucosinolate) → crushed/chewed → SULFORAPHANE via enzyme MYROSINASE.
- Sulforaphane is an NRF2 ACTIVATOR: induces Phase II detoxification enzymes (Glutathione S-Transferase, NQO1, HO-1).
- NF-κB inhibition by sulforaphane → anti-inflammatory, pro-apoptotic effect.
- I3C (Indole-3-Carbinol) → DIM (Diindolylmethane) in stomach → antioestrogenic → breast cancer prevention.
- Contains: Vitamin C (high), Vitamin K, folate, fiber, calcium, potassium, beta-carotene, lutein.
- Broccoli sprouts contain 20–50x MORE sulforaphane than mature broccoli — pharmacologically more potent.

Clinical H. pylori eradication: Sulforaphane from broccoli sprouts has shown clinical efficacy against Helicobacter pylori. This is a highly topical area in nutraceutical oncology.

Gingko (Ginkgo biloba)

GINGKO BILOBA	
Marker Compound	Ginkgolides (A, B, C, J, M) and Bilobalide — PRIMARY; Flavonoids (Quercetin glycosides, Kaempferol glycosides)
Chemical Nature	Ginkgolides: diterpene lactones (cage-shaped polycyclic structure). Bilobalide: sesquiterpene lactone. Flavonoids: polyphenols
Medicinal Uses	Cognitive enhancement, dementia/Alzheimer's, peripheral arterial disease, tinnitus, macular degeneration, antioxidant, anxiety

- Scientific name: Ginkgo biloba | Family: Ginkgoaceae | 'Living fossil' — unchanged for 200 million years!
- Part used: Dried GREEN leaves (standardized extract EGb 761® — 24% flavonol glycosides + 6% terpene lactones).
- Ginkgolide B: Potent PAF (Platelet Activating Factor) ANTAGONIST — inhibits platelet aggregation.
- Mechanism in dementia: Vasodilation (NO ↑), blood viscosity ↓, antioxidant, mitochondrial function ↑, beta-amyloid inhibition.
- Tinnitus: Improves cochlear circulation via vasodilation and PAF antagonism.
- Peripheral arterial disease (PAD): Increases walking distance in claudication.
- Drug interaction WARNING: Gingko + Warfarin/Aspirin = BLEEDING RISK (anti-platelet effect additive).
- Standardized extract used in EGb 761 — global standard for Gingko products.

⚠ Exam Trick Ginkgolide B is the ONLY natural PAF antagonist known! This is a HIGH-YIELD fact. Also: Gingko is contraindicated before surgery (anti-platelet). Always mention the interaction with blood thinners.

Flaxseeds (Linum usitatissimum)

FLAXSEEDS	
Marker Compound	Secoisolariciresinol Diglucoside (SDG) — PRIMARY lignan marker; Alpha-Linolenic Acid (ALA) — Omega-3; Mucilage (soluble fiber)

Chemical Nature	SDG: Phenylpropanoid (plant lignan, converted to mammalian lignans enterolactone + enterodiol by gut bacteria). ALA: polyunsaturated fatty acid (18:3 omega-3, n-3)
Medicinal Uses	Cardiovascular protection, breast/prostate cancer prevention, menopausal symptoms, diabetes, constipation, anti-inflammatory

- Scientific name: Linum usitatissimum | Family: Linaceae | Common name: Alsi / Tisi (Hindi).
- Part used: Seeds (whole or ground) and seed oil (linseed oil).
- RICHEST PLANT SOURCE of: (1) Omega-3 ALA, (2) Lignans (SDG), (3) Mucilaginous fiber.
- SDG → gut bacteria → Enterolactone + Enterodiol (mammalian lignans) → phytoestrogenic + antiandrogenic effect.
- ALA → partial conversion to EPA and DHA in body (conversion rate: ~5–15% to EPA, <1% to DHA).
- Fiber fraction (mucilage): Lowers cholesterol (bile acid sequestrant), improves glycemic control, relieves constipation.
- Cancer prevention: SDG lignans are antioestrogenic in ER+ breast cancer; antiandrogenic in prostate cancer.
- Menopausal symptoms: SDG reduces hot flushes (like soy isoflavones) — safe alternative to HRT.
- Ground flaxseeds preferred over whole seeds (better absorption), or cold-pressed flaxseed oil.

⚠ Exam Trick Flaxseed has BOTH omega-3 (ALA) AND lignans (SDG). In exam: differentiate — ALA = lipid component; SDG = phenolic lignan. Many students confuse these two marker compounds.

Master Comparison Table — All 7 Nutraceuticals

Nutraceutical	Botanical Family	Part Used	Primary Marker	Chemical Class	Top Indication
Spirulina	Cyanobacteria (prokaryote)	Whole organism	Phycocyanin	Biliprotein	Malnutrition, anemia
Soybean	Fabaceae	Seeds	Genistein	Isoflavone (phytoestrogen)	Menopause, cancer
Ginseng	Araliaceae	Root	Ginsenosides (Rb1, Rg1)	Triterpene saponins	Stress, cognition
Garlic	Liliaceae	Bulb/Cloves	Allicin	Organosulfur (thiosulfinate)	CVD, antimicrobial
Broccoli	Brassicaceae	Flower head	Sulforaphane	Isothiocyanate	Cancer prevention

Nutraceutical	Botanical Family	Part Used	Primary Marker	Chemical Class	Top Indication
Gingko	Ginkgoaceae	Dried leaves	Ginkgolide B	Diterpene lactone	Dementia, tinnitus
Flaxseeds	Linaceae	Seeds	SDG (lignan) + ALA	Phenylpropanoid + PUFA	CVD, cancer, menopause

DEFINITIONS — 18 TERMS

Nutraceutical	A food or food component that provides medical or health benefits including the prevention and treatment of disease. (DeFelice, 1989)
Functional Food	Conventional food that provides health benefits beyond basic nutrition due to physiologically active components.
Dietary Supplement	Product taken by mouth containing dietary ingredients (vitamins, minerals, herbs, amino acids) intended to supplement the diet. (DSHEA, 1994)
Phytonutrients	Bioactive compounds derived from plants with health-promoting properties (e.g., polyphenols, glucosinolates, carotenoids).
Adaptogen	A natural substance that helps the body non-specifically resist stressors (physical, biological, chemical) — e.g., Ginseng, Ashwagandha.
Phytoestrogen	Plant-derived compounds that have estrogen-like activity. Examples: Genistein (soy), SDG (flaxseed), Coumestrol.
Isothiocyanate	Organosulfur compounds (R-N=C=S) found in cruciferous vegetables; sulforaphane is the most studied for anticancer activity.
Ginsenoside	Triterpene saponins unique to Panax species — the active principles of Ginseng; classified into Rb and Rg series.
Allicin	Diallyl thiosulfinate — the primary bioactive organosulfur compound in garlic, formed when garlic is crushed.

Lignan	Polyphenolic compounds found in plants (SDG in flaxseed); converted by gut bacteria to mammalian lignans (enterolactone, enterodiol).
Ginkgolide	Diterpene lactones from Ginkgo biloba with unique cage-shaped structure; Ginkgolide B is a PAF antagonist.
PAF Antagonist	Platelet Activating Factor antagonist — inhibits platelet aggregation and inflammation. Ginkgolide B is the most potent natural PAF antagonist.
NRF2 Pathway	Nuclear factor erythroid 2-related factor 2 — transcription factor activated by sulforaphane, inducing Phase II detox enzymes.
Phycocyanin	Blue biliprotein pigment in Spirulina; potent antioxidant and anti-inflammatory agent, also the primary marker compound of Spirulina.
Myrosinase	Enzyme in cruciferous vegetables (Brassica) that converts glucosinolates to biologically active isothiocyanates (e.g., sulforaphane) upon crushing.
PDCAAS	Protein Digestibility Corrected Amino Acid Score — measures protein quality. Soy protein = 1.0 (equal to whey protein).
Glucosinolate	Sulfur-containing secondary metabolites in cruciferous vegetables; precursors of isothiocyanates and indoles upon enzymatic hydrolysis.
Sarcopenia	Age-related progressive loss of skeletal muscle mass and strength — mitigated by protein nutraceuticals (whey, leucine, creatine).

QUESTION BANK — 2 MARK QUESTIONS (with Model Answers)

Q. Q1. Define Nutraceutical. Give two examples.

Ans: A nutraceutical (DeFelice, 1989) is any food or part of a food that provides medical or health benefits, including the prevention and treatment of disease. Examples: (1) Fish oil (Omega-3 fatty acids) — cardioprotective; (2) Ginseng extract (Ginsenosides) — adaptogenic and anti-stress.

Q. Q2. What is the marker compound of Garlic and how is Allicin formed?

Ans: The primary marker compound of Garlic (Allium sativum) is ALLICIN (diallyl thiosulfinate). Allicin is formed enzymatically: When garlic cloves are CRUSHED or CHOPPED, the enzyme ALLIINASE (released from ruptured cells) converts the substrate ALLIIN (S-allyl-L-cysteine sulfoxide) to ALLICIN. Allicin is responsible for the characteristic pungent odour and most of garlic's biological activity.

Q. Q3. Name the chemical class of Ginsenosides and their two major series.

Ans: Ginsenosides (also called Panaxosides) are TRITERPENE SAPONINS, classified into: (1) Protopanaxadiol series (Rb1, Rb2, Rc, Rd) — produce CNS depressant/sedative effects; (2) Protopanaxatriol series (Rg1, Rg2, Re, Rf) — produce CNS stimulant effects. Both series together contribute to the adaptogenic profile of Ginseng.

Q. Q4. What is Sulforaphane? State its chemical class and source.

Ans: Sulforaphane is the primary marker compound of Broccoli (Brassica oleracea). Chemical class: ISOTHIOCYANATE (organosulfur compound; R-N=C=S). Formation: The precursor glucosinolate GLUCORAPHANIN is converted to Sulforaphane by the enzyme MYROSINASE when broccoli is chewed or crushed. Sulforaphane is a potent NRF2 activator and induces Phase II detoxification enzymes — anticancer mechanism.

Q. Q5. What is Spirulina? Why is it important for vegans?

Ans: Spirulina is a CYANOBACTERIUM (blue-green alga; technically a prokaryote, not a true plant). Scientific name: Arthrospira platensis. It is important for vegans because it is one of the RICHEST NATURAL SOURCES of Vitamin B12 (which is otherwise found mainly in animal foods), and contains 60–70% complete protein (all essential amino acids). Its blue pigment PHYCOCYANIN is the primary marker compound.

Q. Q6. State the role of SDG in Flaxseeds.

Ans: SDG (Secoisolariciresinol Diglucoside) is the primary LIGNAN (phenylpropanoid) marker compound of Flaxseeds (Linum usitatissimum). SDG is converted by intestinal bacteria to mammalian lignans — ENTEROLACTONE and ENTERODIOL — which have PHYTOESTROGENIC and ANTIANDROGENIC activity. SDG is responsible for: (1) Prevention of hormone-dependent cancers (breast, prostate); (2) Relief from menopausal symptoms; (3) Cardioprotection and glycemic control.

Q. Q7. What is the PAF antagonist present in Gingko? Mention its significance.

Ans: GINKGOLIDE B (a diterpene lactone) is the potent PAF (Platelet Activating Factor) ANTAGONIST present in Ginkgo biloba leaves. Significance: It is the ONLY known naturally occurring PAF antagonist. PAF is involved in platelet aggregation, inflammation, and bronchoconstriction. By inhibiting PAF, Ginkgolide B (1) reduces platelet aggregation (prevents thrombosis), (2) improves peripheral circulation (useful in tinnitus, PAD, dementia).

Q. Q8. Differentiate between Functional Food and Dietary Supplement.

Ans: Functional Food: A conventional food consumed as part of normal diet that provides health benefits beyond basic nutrition (e.g., fortified milk, oats). It exists in regular food form. Dietary Supplement: A product taken by mouth in non-food form (tablet, capsule, powder) containing dietary ingredients (vitamins, minerals, herbs). (DSHEA definition). difference: Functional food = regular food; Dietary supplement = non-food dosage form.

QUESTION BANK — 5 MARK QUESTIONS

Q1. Classify Nutraceuticals with examples. (5 marks)

Q2. Write a note on the role of Nutraceuticals in Cancer Prevention. (5 marks)

Q3. Write a note on Maternal Nutrition and Child Nutrition. (5 marks)

Q4. Write the source, marker compounds, chemical nature, and medicinal uses of Ginseng. (5 marks)

Q5. Explain the role of Nutraceuticals in management of Hypertension and Cardiovascular Disease. (5 marks)

QUESTION BANK — 10 MARK QUESTIONS

Q1. Define Nutraceuticals. Classify them. Explain the role of Nutraceuticals in prevention of Diabetes, Cancer, and CVD with specific examples. (10 marks)

Q2. Write a detailed note on the following nutraceuticals — Source, Marker compounds, Chemical nature, and Health benefits of: (a) Spirulina (b) Garlic (c) Gingko biloba. (10 marks)

Q3. Write a comprehensive note on Public Health Nutrition in India, covering Maternal Nutrition, Child Nutrition, Nutrition in Ageing, and Community Nutrition Education. (10 marks)

PREVIOUS-YEAR STYLE QUESTIONS (Likely Exam Questions)

#	Question	Marks	Section Ref
1	Define Nutraceuticals and Dietary Supplements. How do they differ from Functional Foods? Give examples of each.	5	Section 1
2	Write a note on the classification of Nutraceuticals based on (a) chemical nature and (b) mechanism of action.	10	Section 2
3	Write the source, marker compound, chemical nature, medicinal uses, and health benefits of any THREE of the following: Spirulina, Ginseng, Garlic, Broccoli, Flaxseeds.	10	Section 5
4	Explain the role of nutraceuticals in the management of Diabetes Mellitus and Osteoarthritis.	5	Section 3
5	Write a note on: (a) Maternal and Child Nutrition (b) Nutrition in Ageing (c) Nutrition Education in the Community	10	Section 4

TOP 15 MCQs — WITH ANSWERS & EXPLANATIONS

Q1. The term 'Nutraceutical' was coined by:

(A) Stephen DeFelice
(B) Linus Pauling
(C) WHO
(D) FSSAI

✓ Correct: (A) Stephen DeFelice

Explanation: Dr. Stephen DeFelice coined the term 'Nutraceutical' in 1989 by combining 'Nutrition' and 'Pharmaceutical'. This is a definitive 1-mark fact — must memorize.

Q2. The primary marker compound of Spirulina is:

(A) Allicin
(B) Phycocyanin
(C) Ginsenoside Rb1
(D) Sulforaphane

✓ Correct: (B) Phycocyanin

Explanation: Phycocyanin is the blue biliprotein pigment and primary marker compound of Spirulina (Arthrospira platensis). It is a powerful antioxidant and is responsible for Spirulina's characteristic blue-green colour.

Q3. Allicin in garlic is formed from its precursor by the enzyme:

(A) Myrosinase
(B) Alliinase
(C) Linamarase
(D) Glucosidase

✓ Correct: (B) Alliinase

Explanation: Alliinase is the enzyme that converts ALLIIN to ALLICIN when garlic is crushed or chopped. Myrosinase is the enzyme in Broccoli that converts glucoraphanin to sulforaphane — don't confuse these two!

Q4. Ginkgolide B is known as a potent:

(A) ACE inhibitor
(B) PAF antagonist
(C) HMG-CoA reductase inhibitor
(D) COX-2 inhibitor

✓ Correct: (B) PAF antagonist

Explanation: Ginkgolide B from Ginkgo biloba is the ONLY known natural PAF (Platelet Activating Factor) antagonist. PAF is involved in platelet aggregation, inflammation, and bronchoconstriction. This is one of the most frequently asked MCQs on Gingko.

Q5. Which nutraceutical is called 'Natural Metformin' due to its AMPK activation?

(A) Curcumin
(B) Genistein

(C) Berberine
(D) Resveratrol

✓ **Correct: (C) Berberine**

Explanation: Berberine (an isoquinoline alkaloid from Berberis plants) activates the AMPK pathway — the same pathway targeted by Metformin — making it effective in Type 2 Diabetes management. This is a high-yield clinical nutraceutical correlation.

Q6. Sulforaphane exerts its anticancer effect primarily by:

(A) Inhibiting HMG-CoA reductase
(B) Activating NRF2 pathway and inducing Phase II enzymes
(C) Blocking estrogen receptors
(D) Inhibiting platelet aggregation

✓ **Correct: (B) Activating NRF2 pathway and inducing Phase II enzymes**

Explanation: Sulforaphane from Broccoli activates the NRF2 transcription factor, which induces Phase II detoxification enzymes (GST, NQO1, HO-1), inactivates carcinogens, and reduces NF-κB driven inflammation. This is the core mechanism for its anticancer activity.

Q7. SDG (Secoisolariciresinol Diglucoside) is the primary lignan found in:

(A) Ginseng
(B) Broccoli
(C) Flaxseeds
(D) Spirulina

✓ **Correct: (C) Flaxseeds**

Explanation: SDG is the primary marker compound (phenylpropanoid lignan) of Flaxseeds (Linum usitatissimum). It is converted by gut bacteria to mammalian lignans (enterolactone + enterodiol), which have phytoestrogenic and anticancer properties.

Q8. Ginsenosides in Ginseng are chemically classified as:

(A) Flavonoids
(B) Triterpene saponins
(C) Organosulfur compounds
(D) Isothiocyanates

✓ **Correct: (B) Triterpene saponins**

Explanation: Ginsenosides (Panaxosides) are triterpene saponins unique to Panax species. They are of dammarane-type (protopanaxadiol — Rb series; protopanaxatriol — Rg series) and oleanane-type. Triterpene saponin = chemical classification answer.

Q9. Which isoflavone in Soybean acts as a tyrosine kinase inhibitor with anticancer properties?

(A) Daidzein
(B) Formononetin
(C) Genistein
(D) Coumestrol

✓ **Correct: (C) Genistein**

Explanation: Genistein (5,7,4'-trihydroxyisoflavone) is the primary active isoflavone in Soybean with documented tyrosine kinase inhibitory activity. It also inhibits angiogenesis (VEGF ↓) and is a SERM (Selective Estrogen Receptor Modulator) — used in breast and prostate cancer chemoprevention.

Q10. The 1000-day window in child nutrition refers to the period from:

(A) Birth to 3 years
(B) Conception to 2 years
(C) Birth to 2 years
(D) 6 months to 3 years

✓ Correct: (B) Conception to 2 years

Explanation: The '1000-day window' spans from conception to the child's second birthday (~1000 days). This critical window determines lifelong health outcomes including brain development, immune function, and risk of chronic diseases. Undernutrition during this period causes IRREVERSIBLE consequences.

Q11. Spirulina is scientifically classified as:

(A) Eukaryotic green algae
(B) Prokaryotic cyanobacterium
(C) Basidiomycete fungus
(D) Dinoflagellate

✓ Correct: (B) Prokaryotic cyanobacterium

Explanation: Spirulina (Arthrospira platensis) is a PROKARYOTE — a cyanobacterium (blue-green alga). It LACKS a membrane-bound nucleus, unlike true (eukaryotic) algae. This is the most common trick question on Spirulina in MCQs.

Q12. The recommended first-line nutraceutical combination for Osteoarthritis is:

(A) Omega-3 + Curcumin
(B) Glucosamine sulphate + Chondroitin sulphate
(C) CoQ10 + Resveratrol
(D) Berberine + Chromium

✓ Correct: (B) Glucosamine sulphate + Chondroitin sulphate

Explanation: Glucosamine sulphate + Chondroitin sulphate is the standard evidence-based nutraceutical combination for Osteoarthritis (Grade A evidence). Glucosamine provides building blocks for GAG synthesis; Chondroitin inhibits cartilage-degrading enzymes (MMPs). Used together for synergistic chondroprotective effect.

Q13. Which enzyme converts glucoraphanin to sulforaphane in Broccoli?

(A) Alliinase
(B) Myrosinase
(C) Beta-glucuronidase
(D) Phospholipase A2

✓ Correct: (B) Myrosinase

Explanation: MYROSINASE (thioglucoside glucohydrolase) is the enzyme in cruciferous vegetables that converts glucosinolates (glucoraphanin) to biologically active isothiocyanates

(sulforaphane). Myrosinase is released when plant tissue is disrupted (chewed/chopped). Alliinase is specific to Allium/Garlic — don't confuse!

Q14. The standardized extract of Ginkgo biloba (EGb 761) is standardized to contain:

(A) 24% flavonol glycosides + 6% terpene lactones
(B) 6% flavonol glycosides + 24% terpene lactones
(C) 12% flavonol glycosides + 12% terpene lactones
(D) 18% flavonol glycosides + 8% terpene lactones

✓ Correct: (A) 24% flavonol glycosides + 6% terpene lactones

Explanation: EGb 761 (standardized Ginkgo biloba extract) contains 24% FLAVONOL GLYCOSIDES (quercetin, kaempferol, isorhamnetin glycosides) + 6% TERPENE LACTONES (ginkgolides + bilobalide). This standardization ratio is a direct exam-ready fact.

Q15. The primary mechanism by which Garlic reduces blood pressure is:

(A) ACE inhibition
(B) Hydrogen sulfide (H2S) production causing vasodilation
(C) Beta-1 receptor blockade
(D) Aldosterone antagonism

✓ Correct: (B) Hydrogen sulfide (H2S) production causing vasodilation

Explanation: Organosulfur compounds in garlic (allicin, DADS, DATS) are enzymatically converted to H2S (hydrogen sulfide) by erythrocytes in the blood. H2S is a gasotransmitter that causes smooth muscle relaxation → vasodilation → reduction in peripheral resistance → BP reduction. ACE inhibition is secondary. H2S production is the PRIMARY mechanism.