ENERGY BALANCE,REQUIREMENT AND NUTRITIONAL STATUS DURING METABOLIC STRESS

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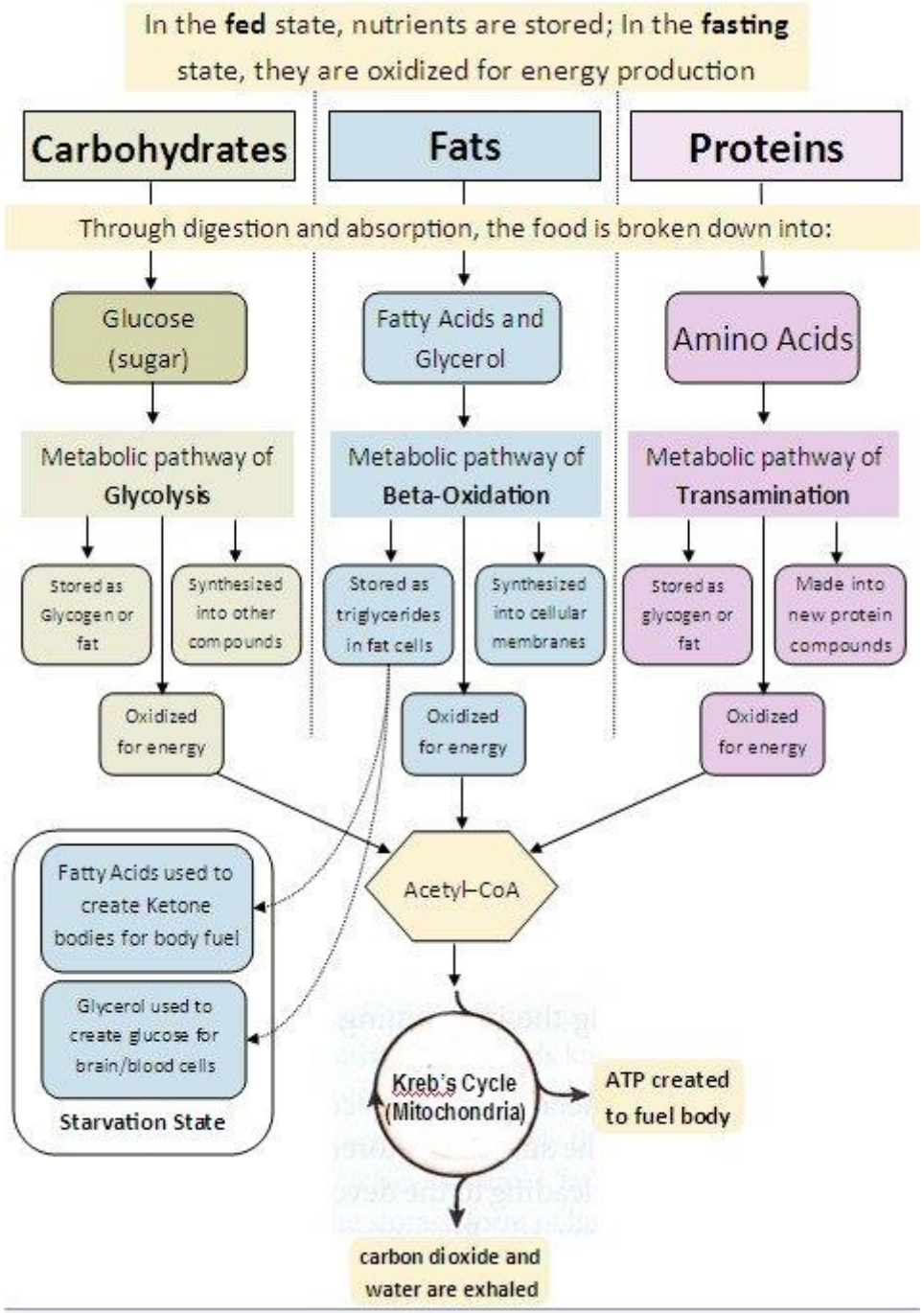
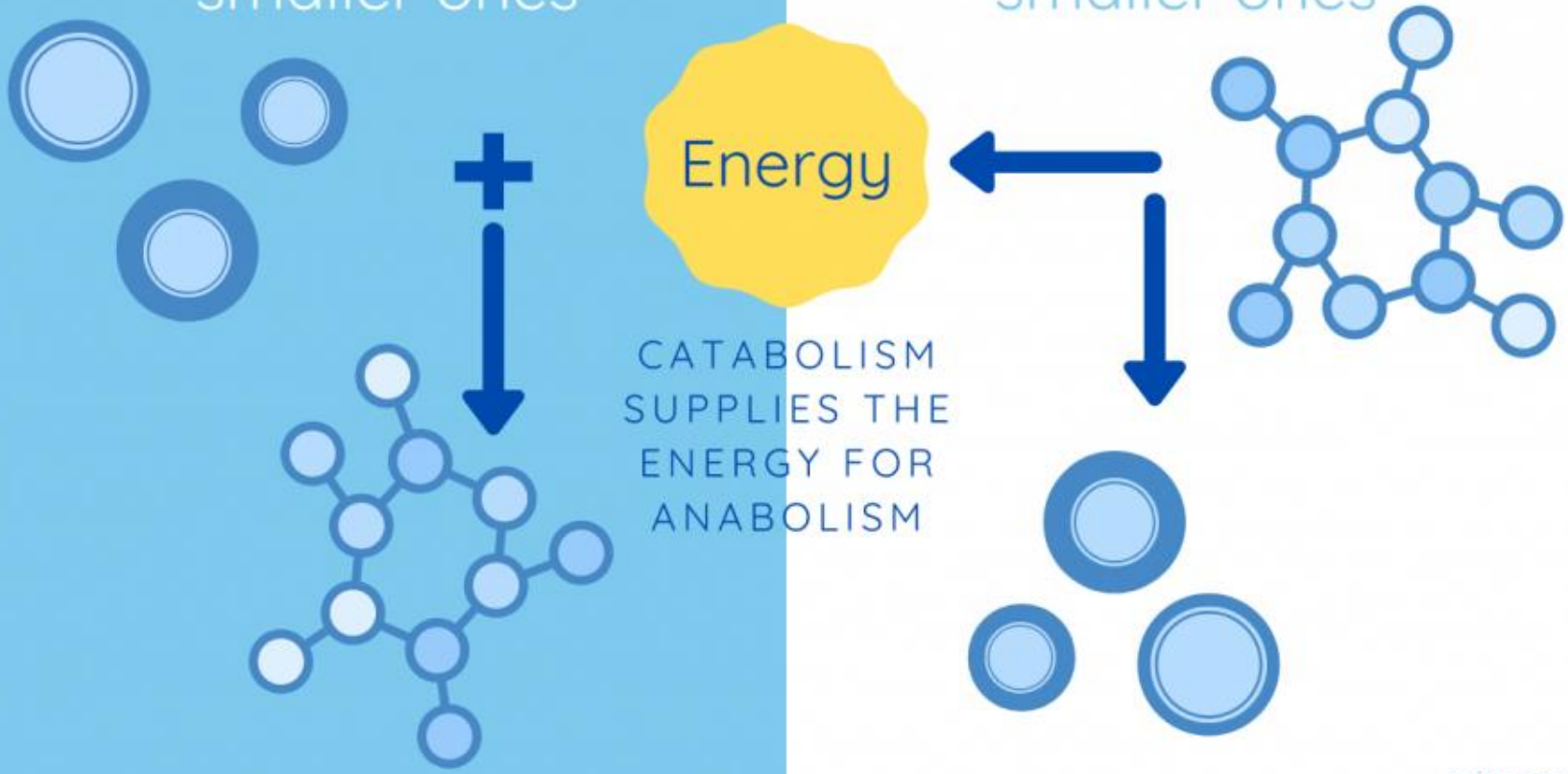
Updated 2023


In the fed state, nutrients are stored; In the fasting state, they are oxidized for energy production
Carbohydrates
Fats
Proteins
Through digestion and absorption, the food is broken down into:
Glucose (sugar)
Fatty Acids and Glycerol
Amino Acids
Metabolic pathway of Glycolysis
Metabolic pathway of Beta-Oxidation
Metabolic pathway of Transamination
Stored as Glycogen or fat
Synthesized into other compounds
Stored as triglycerides in fat cells
Synthesized into cellular membranes
Stored as glycogen or fat
Made into new protein compounds
Oxidized for energy
Oxidized for energy
Oxidized for energy
Fatty Acids used to create Ketone bodies for body fuel
Glycerol used to create glucose for brain/blood cells
Starvation State
Acetyl-CoA
Kreb's Cycle (Mitochondria)
ATP created to fuel body
carbon dioxide and water are exhaled

Anabolism and Catabolism

Set of metabolic pathways that synthesize larger molecules from smaller ones

Set of metabolic pathways that break larger molecules into smaller ones



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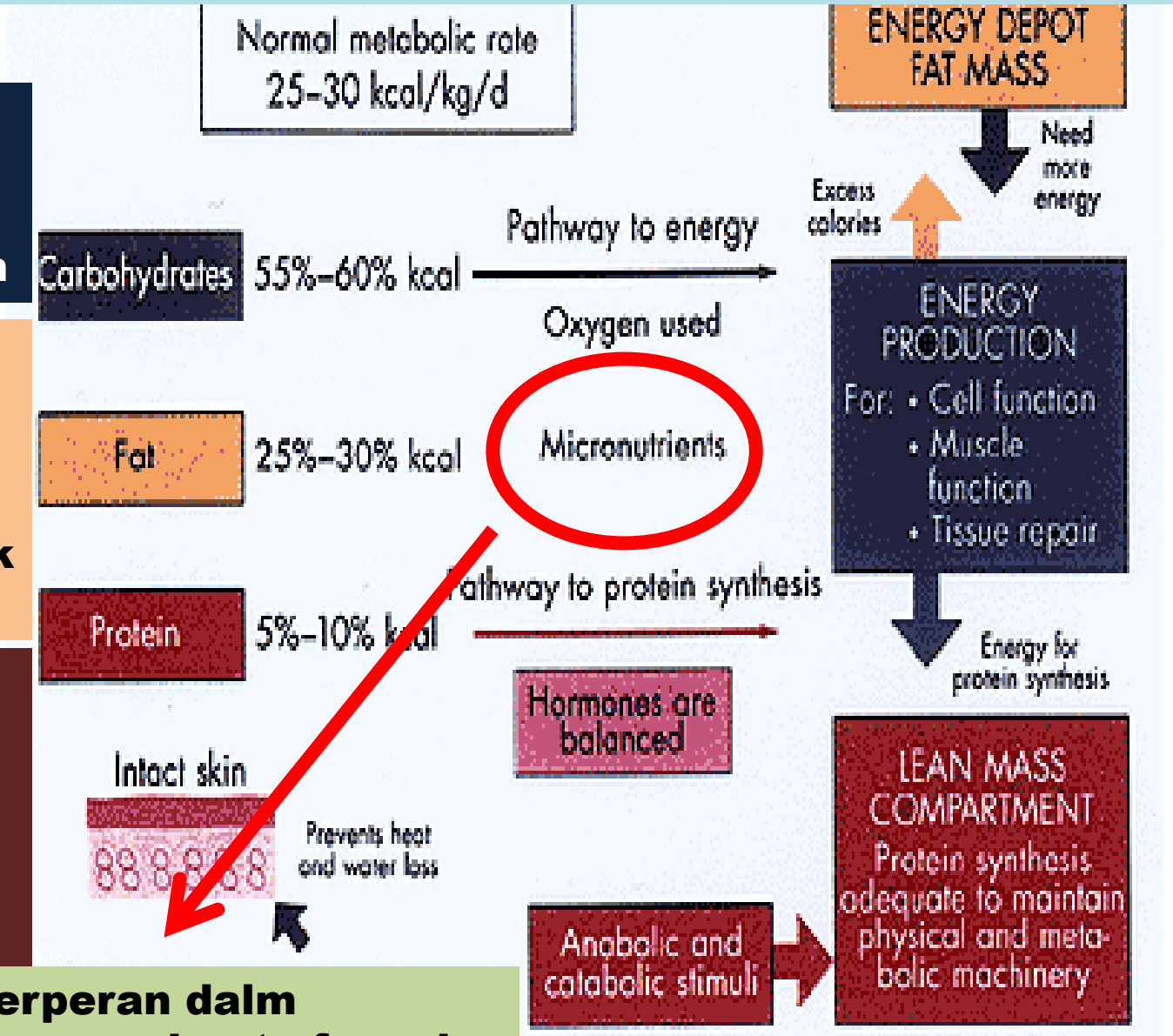
SISTEM METABOLISME NUTRISI MAKRO DAN MIKRO SERTA PERANANNYA DLM KONDISI NORMAL

Karbohidrat: sumber energi utama bagi metabolisme tubuh

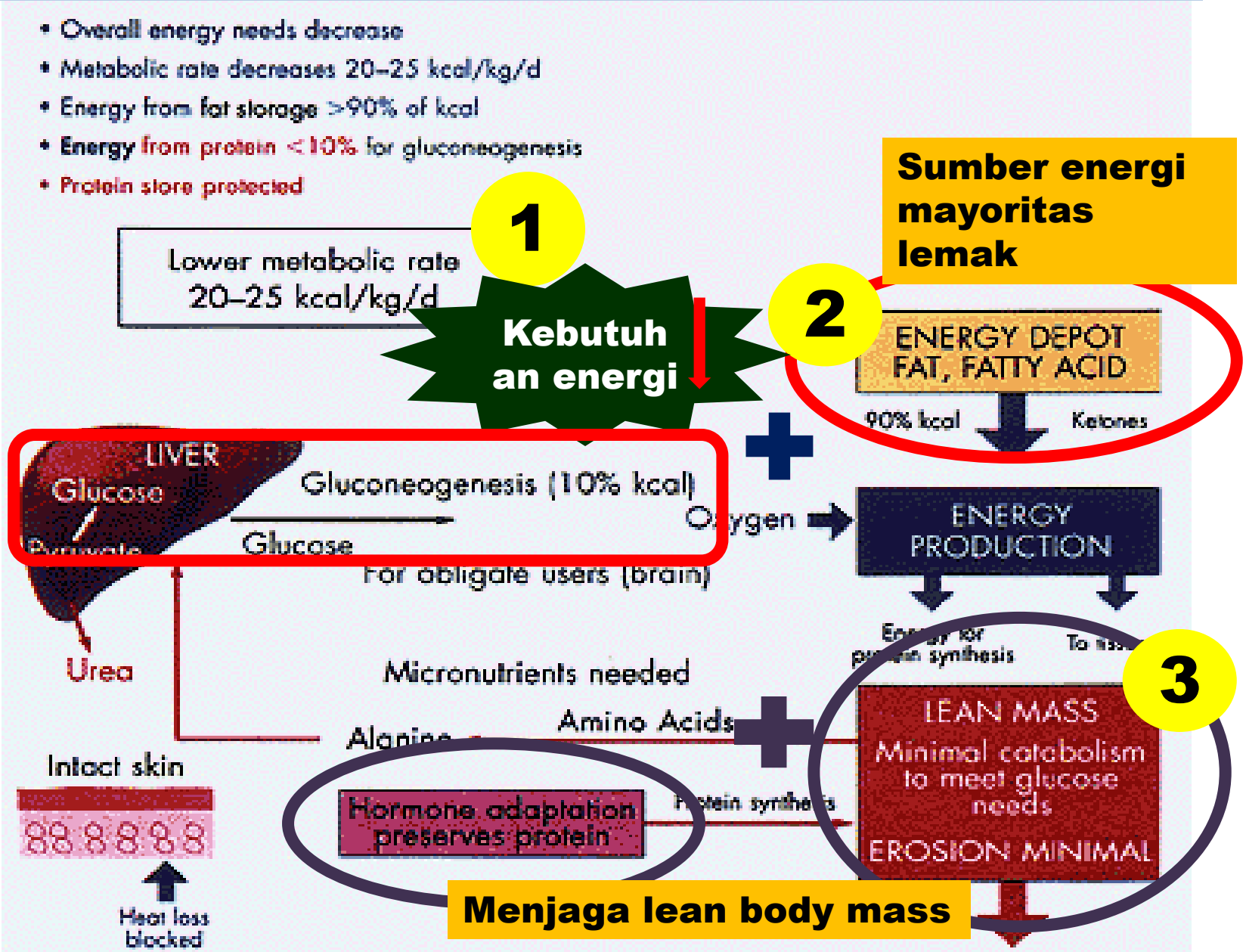
Lemak: cadangan energi terbesar, bhn pembentuk hormon, carrier vitamin larut lemak (ADEK)

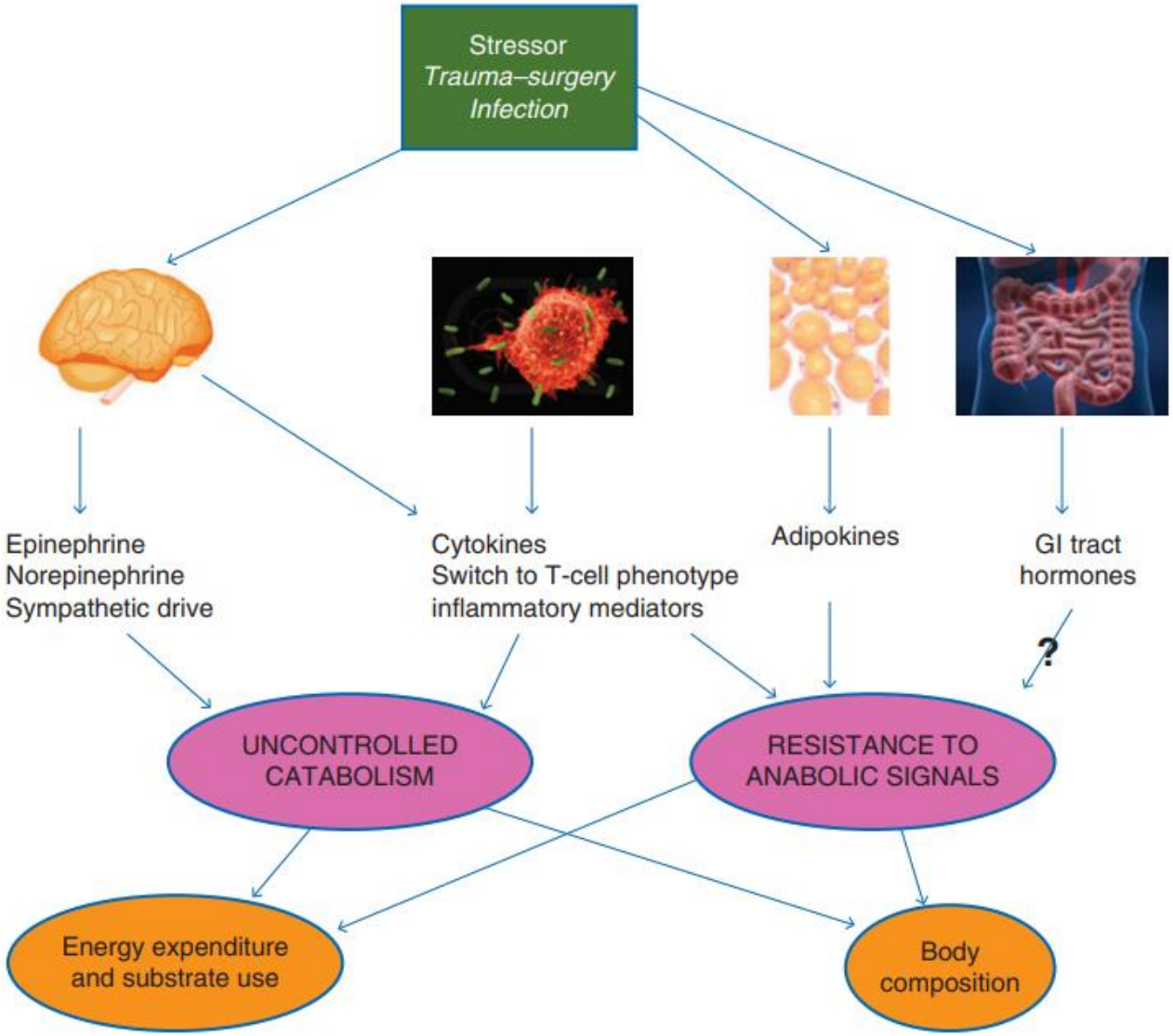
Protein: pembtk otot & protein visceral, spt albumin, RBP, sistem imun; penyusun gen dll

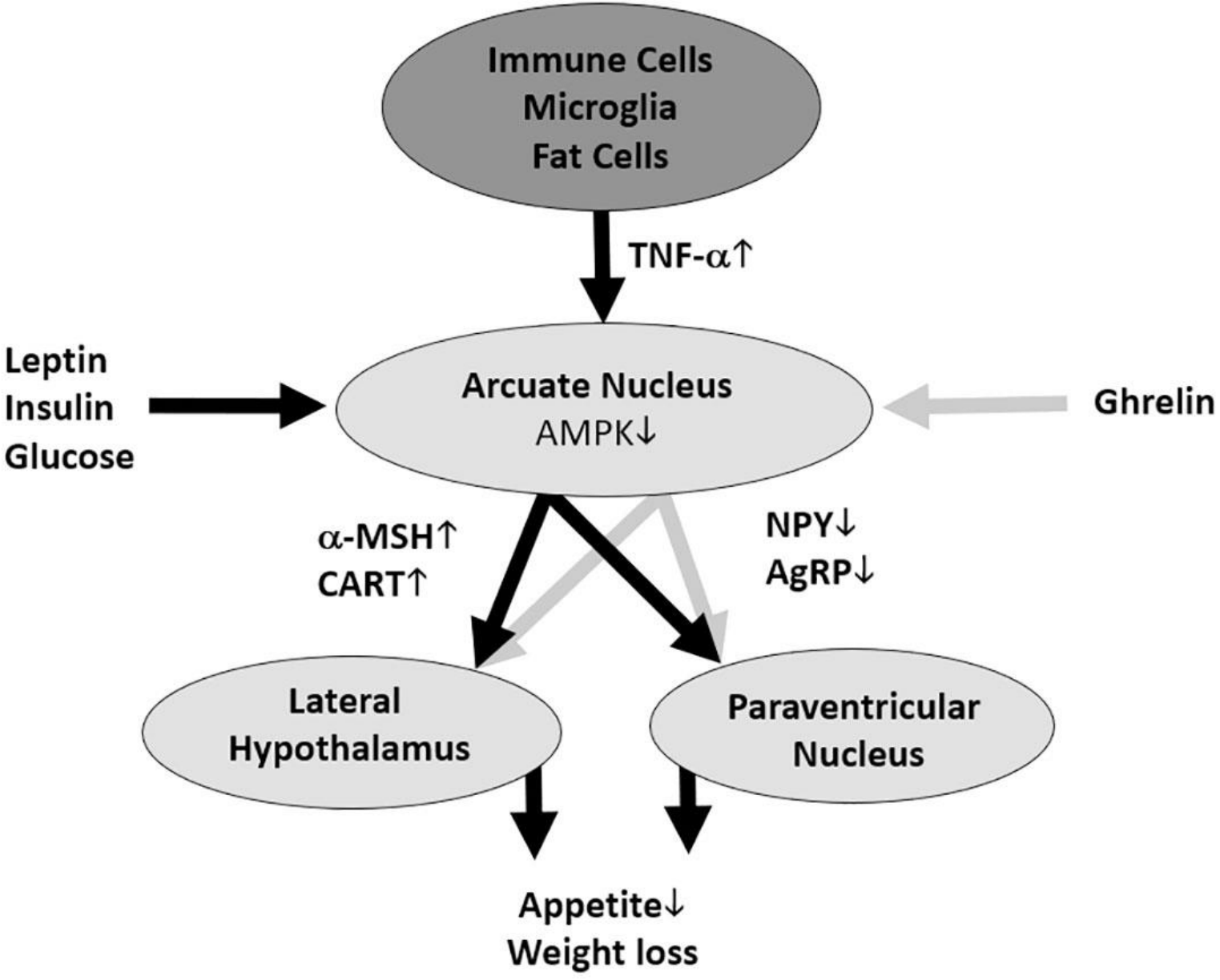
Vitamin & mineral, berperan dalm pepenyusun enzim dan membantu fungsi metabolisme zat makro



RESPONSE METABOLISME DALAM KEADAAN STARVASI JANGKA PENDEK TANPA DISERTAI STRESS/TRAUMA

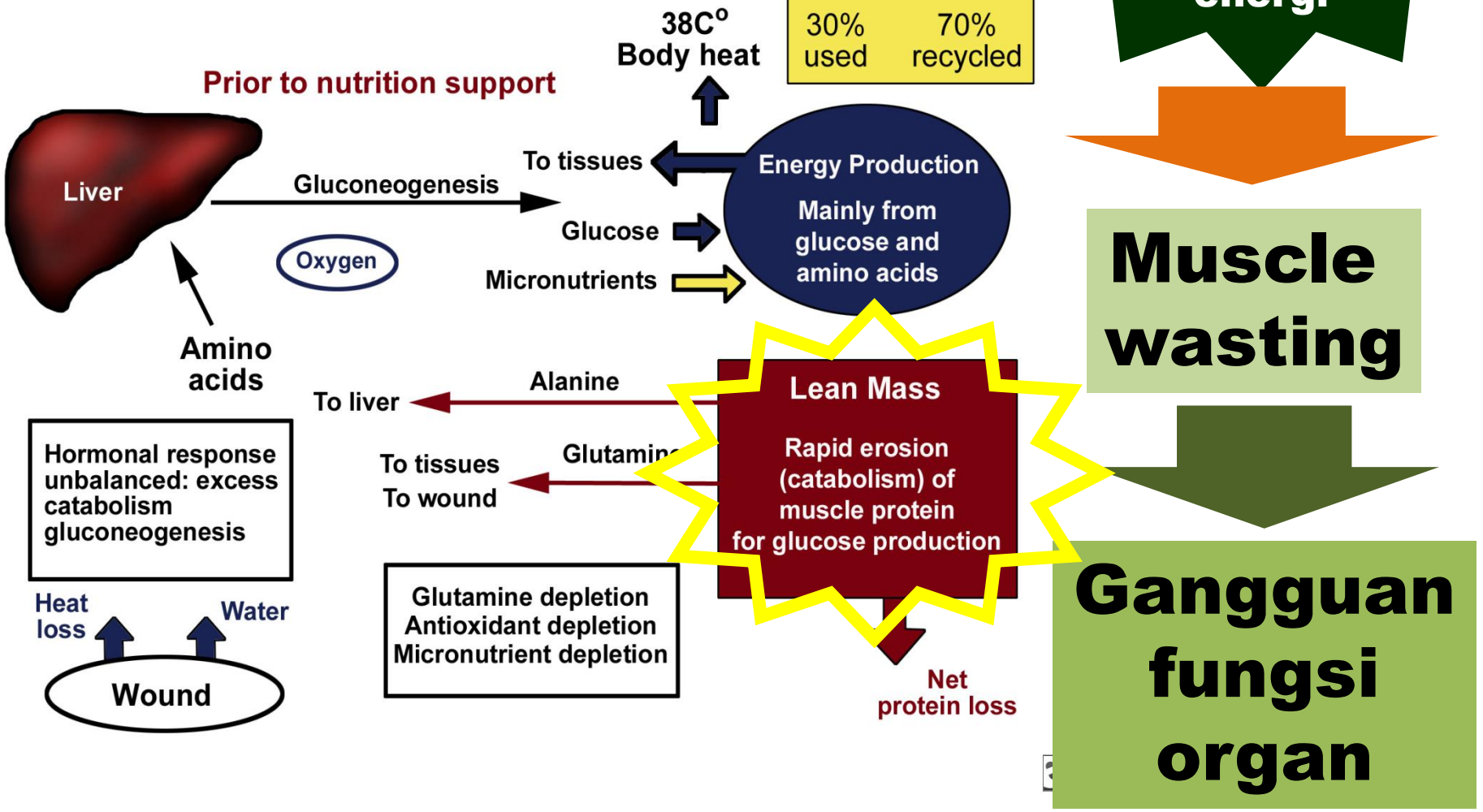


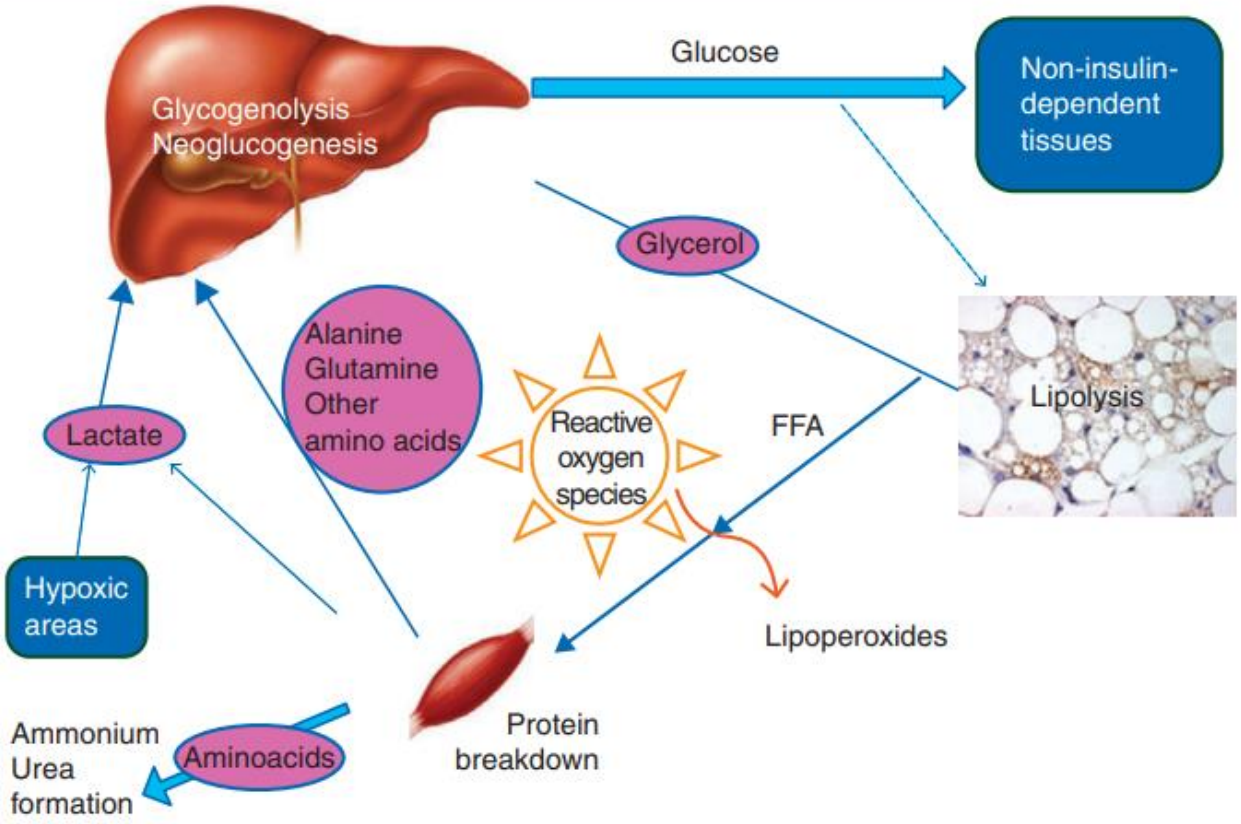

Stressor
Trauma–surgery
Infection
Epinephrine
Norepinephrine
Sympathetic drive
Cytokines
Switch to T-cell phenotype
inflammatory mediators
Adipokines
GI tract
hormones
?
UNCONTROLLED
CATABOLISM
RESISTANCE TO
ANABOLIC SIGNALS
Energy expenditure
and substrate use
Body
composition

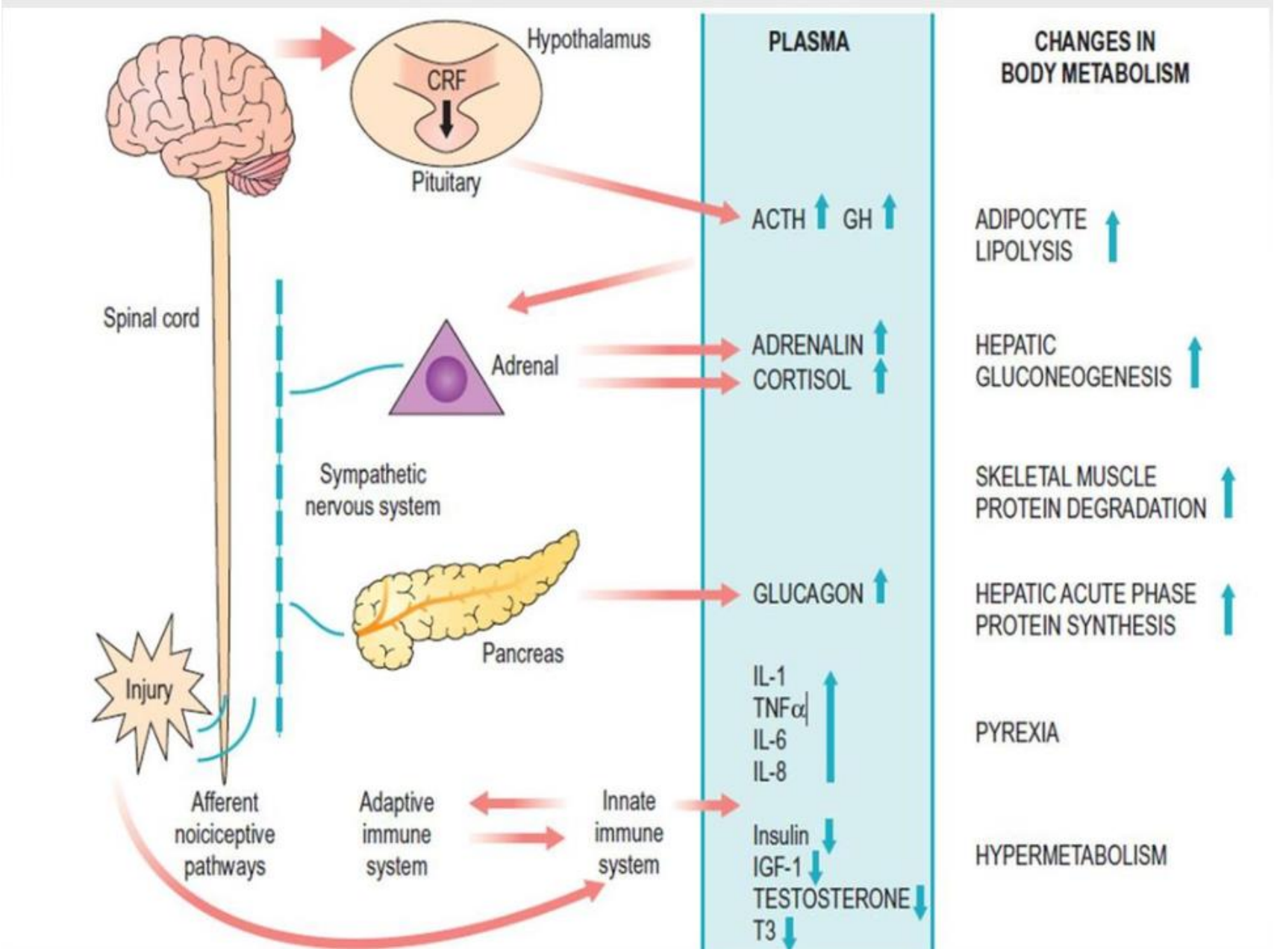

Immune Cells
Microglia
Fat Cells
TNF-α↑
Leptin
Insulin
Glucose
Arcuate Nucleus
AMPK↓
Ghrelin
α-MSH↑
CART↑
NPY↓
AgRP↓
Lateral
Hypothalamus
Paraventricular
Nucleus
Appetite↓
Weight loss

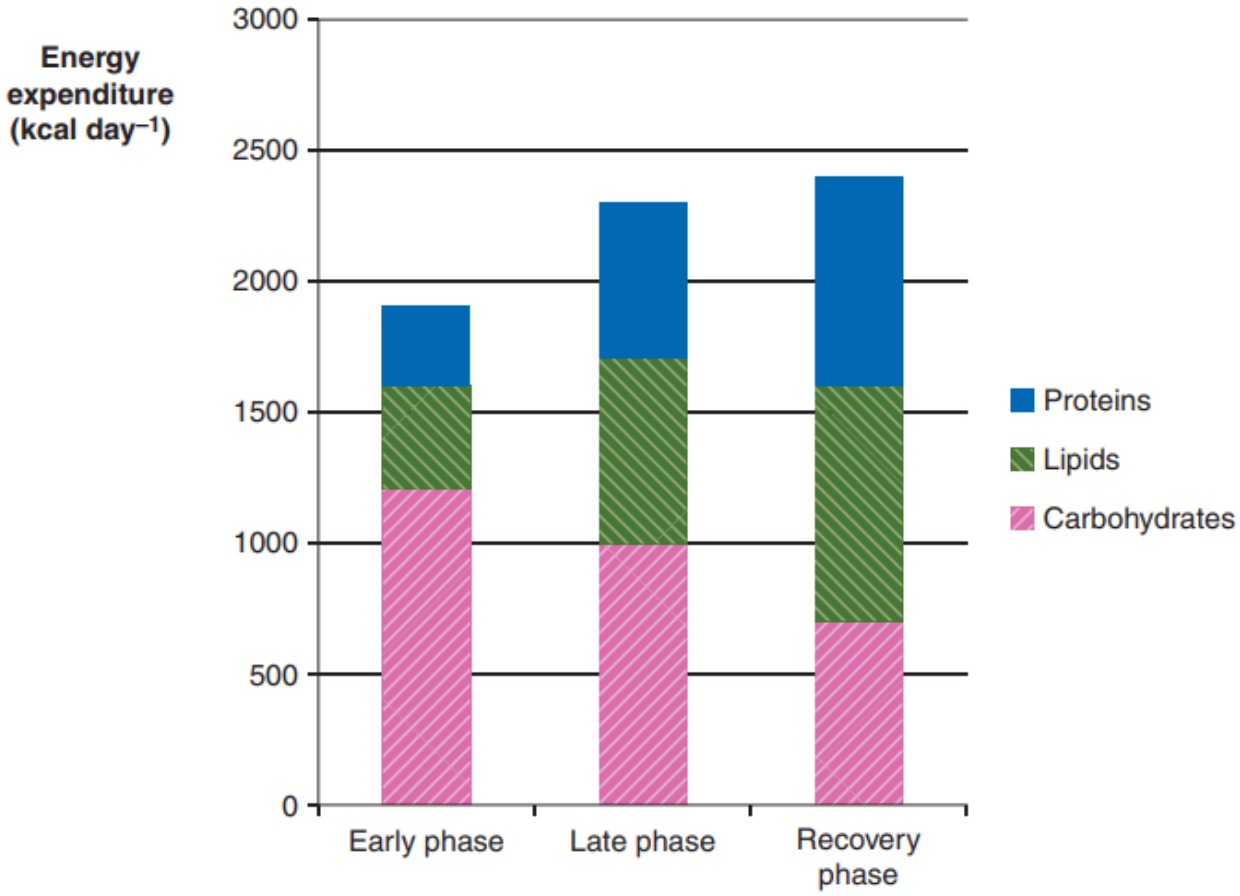
Catabolic Insult-Induced Protein-Energy Malnutrition (Protein and Energy Production Abnormal)

- No adaptive responses activated
- Increase metabolic rate 35-40 kcal/kg/d
- Increase glucose production in excess of need
- Increase use of protein for fuel (glucose)
- Inefficient use of fat for energy




Glycogenolysis
Neoglucogenesis
Glucose
Non-insulin-dependent tissues
Glycerol
Alanine
Glutamine
Other
amino acids
Lactate
Reactive oxygen species
FFA
Lipolysis
Hypoxic areas
Lipoperoxides
Ammonium
Urea
formation
Aminoacids
Protein breakdown

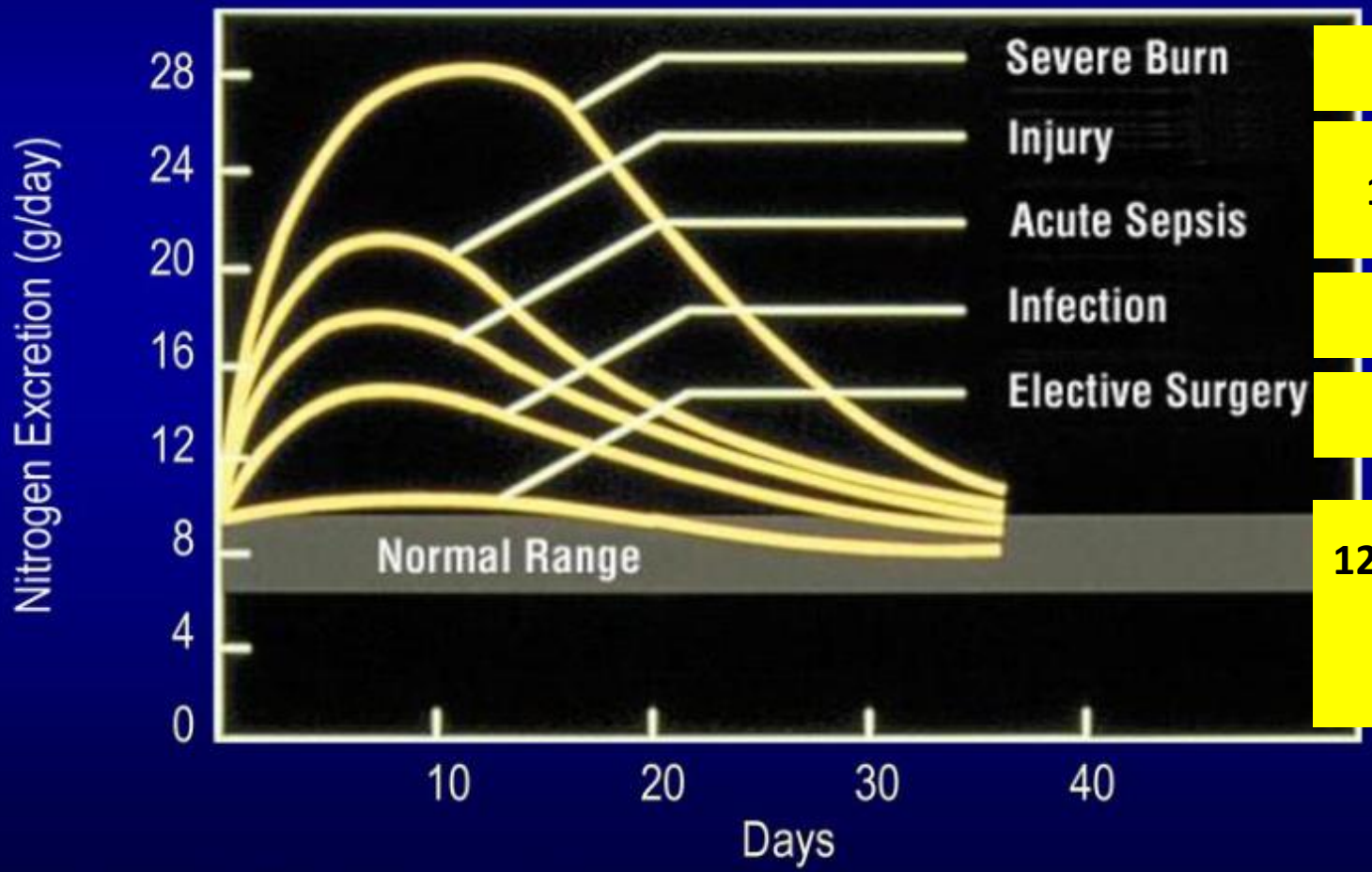

Hypothalamus
CRF
Pituitary
PLASMA
CHANGES IN BODY METABOLISM
ACTH
GH
ADIPOCYTE LIPOLYSIS
Spinal cord
Adrenal
ADRENALIN
CORTISOL
HEPATIC GLUCONEOGENESIS
Sympathetic nervous system
SKELETAL MUSCLE PROTEIN DEGRADATION
GLUCAGON
HEPATIC ACUTE PHASE PROTEIN SYNTHESIS
Pancreas
Injury
IL-1
TNFα
IL-6
IL-8
PYREXIA
Afferent noiciceptive pathways
Adaptive immune system
Innate immune system
Insulin
IGF-1
TESTOSTERONE
T3
HYPERMETABOLISM


Energy expenditure (kcal day⁻¹)
3000
2500
2000
1500
1000
500
0
Early phase
Late phase
Recovery phase
Proteins
Lipids
Carbohydrates

Key catabolic elements of flow phase

- Hypermetabolism
- Alterations in skeletal muscle protein
- Alterations in Liver proteins
- Insulin resistance

Metabolic Response to Trauma



PROTEIN LOSSESS
175 g/day
100 – 130 g/day
60 – 90 g/day
30 – 60 g/day
12 – 18 g/day ≈1 kg muscle ≈2 – 3 nitrogen

Long CL, et al. *JPEN* 1979;3:452-456

MENGHITUNG PROTEIN CATABOLIC RATE

- Lakukan pemeriksaan kadar urinary urea nitrogren (UUN) dengan mengumpulkan urin 24 jam pasien
- Hitung besarnya UUN total dengan menggunakan rumus:

$$\textbf{UUN total} = \frac{(\text{kadar UUN 24 jam}) \times (\text{volume urin 24 jam})}{100}$$

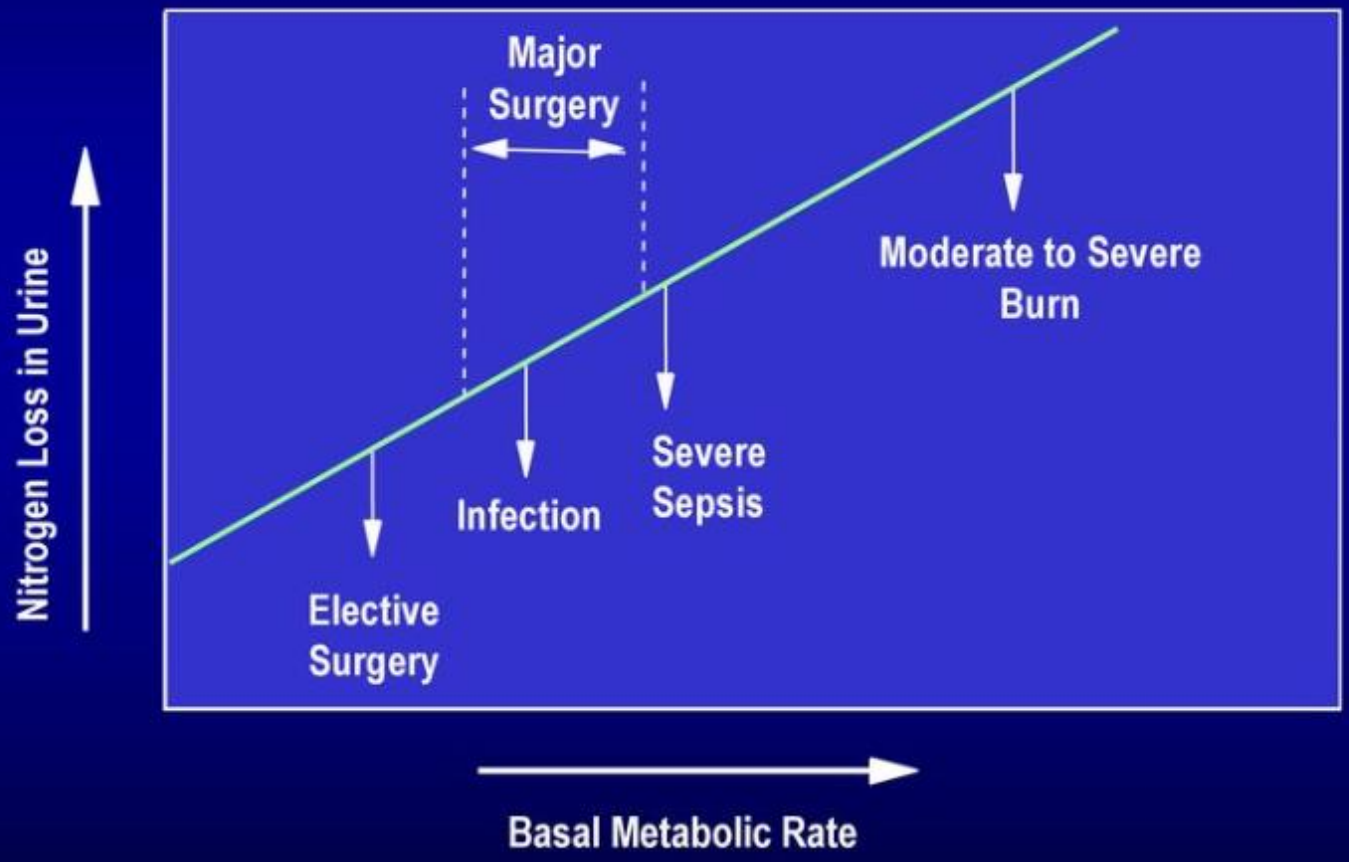
Type equation here.

- Hitung besarnya asupan nitrogen berdasarkan asupan protein pasien sesuai data recall 24 jam dengan membagi asupan protein dengan konstanta 6,25
- Hitung besarnya keseimbangan nitrogen dengan menggunakan rumus berikut:

$$\Delta N = (\text{asupan nitrogen total}) - (\text{UUN total} + 4)$$

6,25

Severity of Trauma: Effects on Nitrogen Losses and Metabolic Rate



Adapted from Long CL, et al. JPEN 1979;3:452-456

Energy calculation :

Indirect calorimetry, Ireton Jor… …fflin- St Jeor

Harris benedict equation:

♀ = 655 + (9,6 x Wt) + (1,8 x … 4,7 x A)
♂ = 66 + (13,8 x Wt) + (5 x H… 8 x A)

To be multiplied with:
- Physical activity factor (outpatient)
- Activity Factor and stress factor (inpatient)

Based on BMI:

Energy requirements (kcal/kg/day)		
BMI (kg/m^2)	Critically ill (BMR)	Other (RMR+TEF+TEA)
< 15		
20		
≥ 30		15 – 20

For practical use:
RULE OF THUMB: 25 – 30 kkal/kgBW

- Use Harris Benedict if energy estimation < 1200 kcal/day
- For BMI ≥ 30 : do not exceed 2000 kcal/day

RULE OF THUMBS – PERKENI 2015

- **Status gizi**: lebih/obese: - 20 – 30%| kurang: + 20 – 30%
- **Jenis kelamin**: Perempuan: 25 kkal/BBI | laki-laki 30 kkal
- **Usia**: 40 – 59 : - 5% | 60 – 69: - 10% | ≥ 70: 20%
- **Aktifitas fisik**: sangat ringan/RMR: + 10%| ringan: 20%| sedang: 30% | berat: 40% | sangat berat: 50%
- **Stress metabolic**: + 10 -30% tergantung derajat stess
- Jumlah energi minimal: 1000 – 1200 kkal/hari

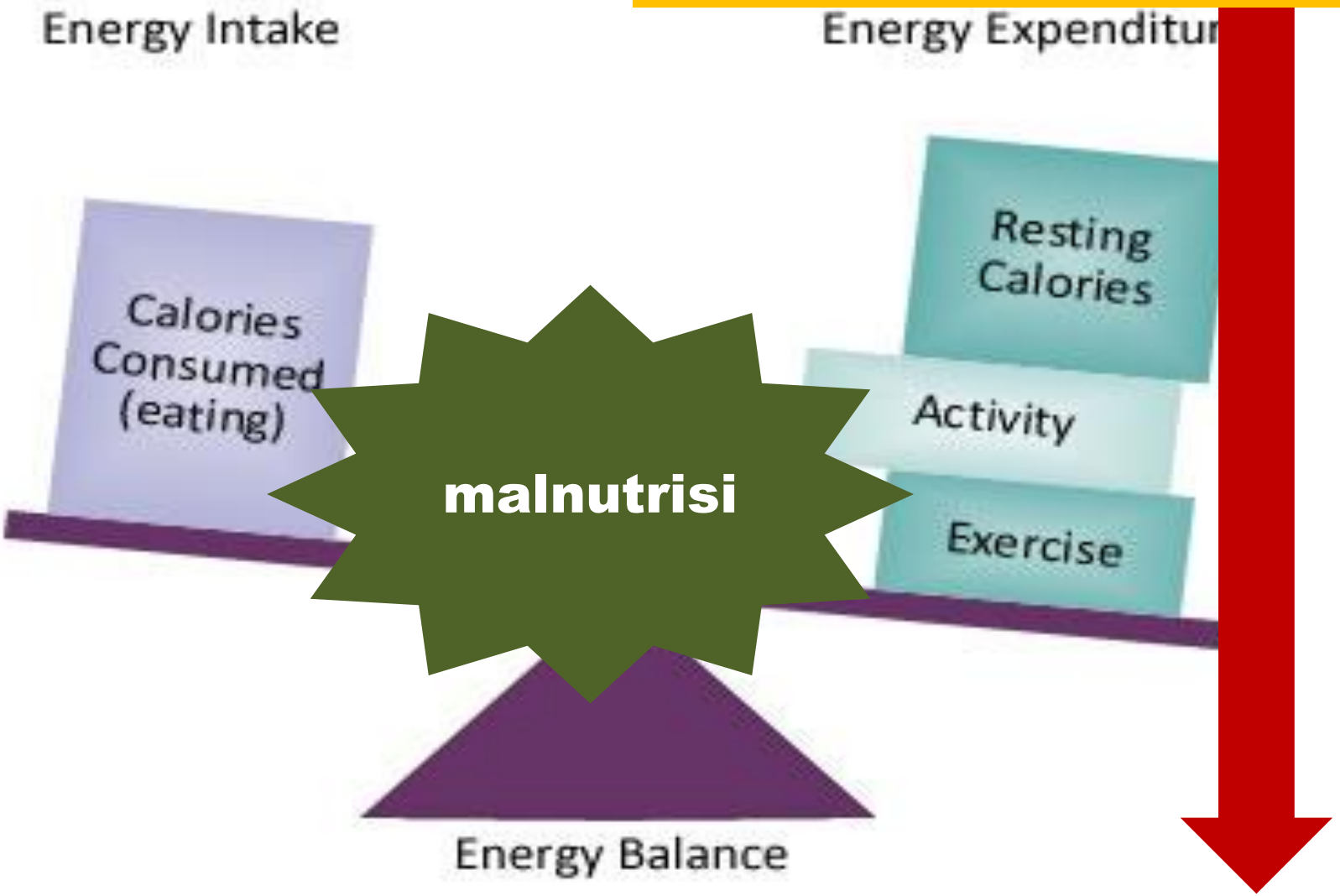
REFERENSI LAIN

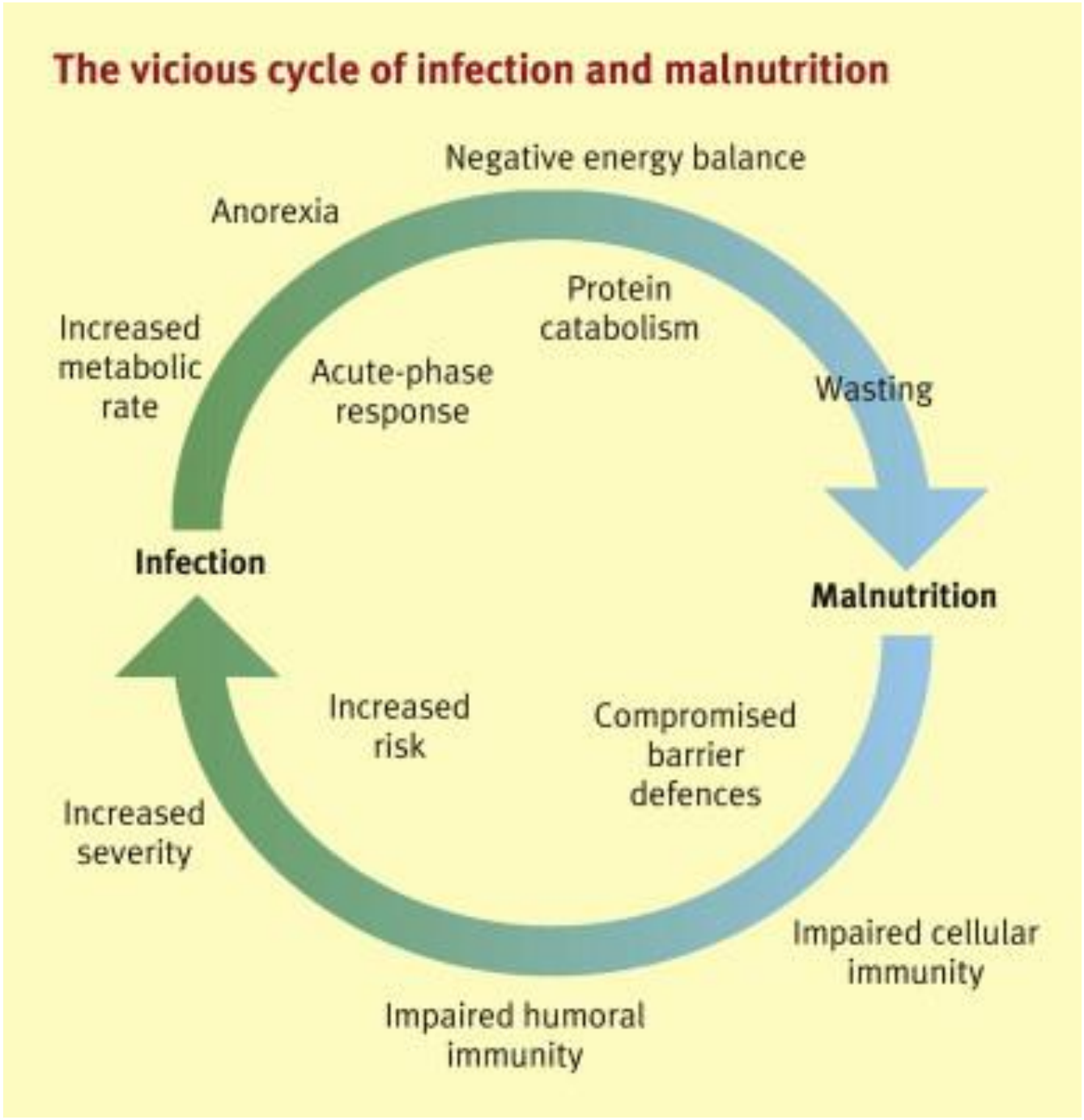
- Normal: 25 – 30 kkal/BB
- Stress:
  - Ringan: 30 – 35 kkal/BB
  - Sedang – berat: 35 – 45/BB

Physical Activity	Sex	
	♂	♀
Very light	1,3	1,3
Light	1,65	1,55
Moderate	1,76	1,70
Active	2,10	2,00

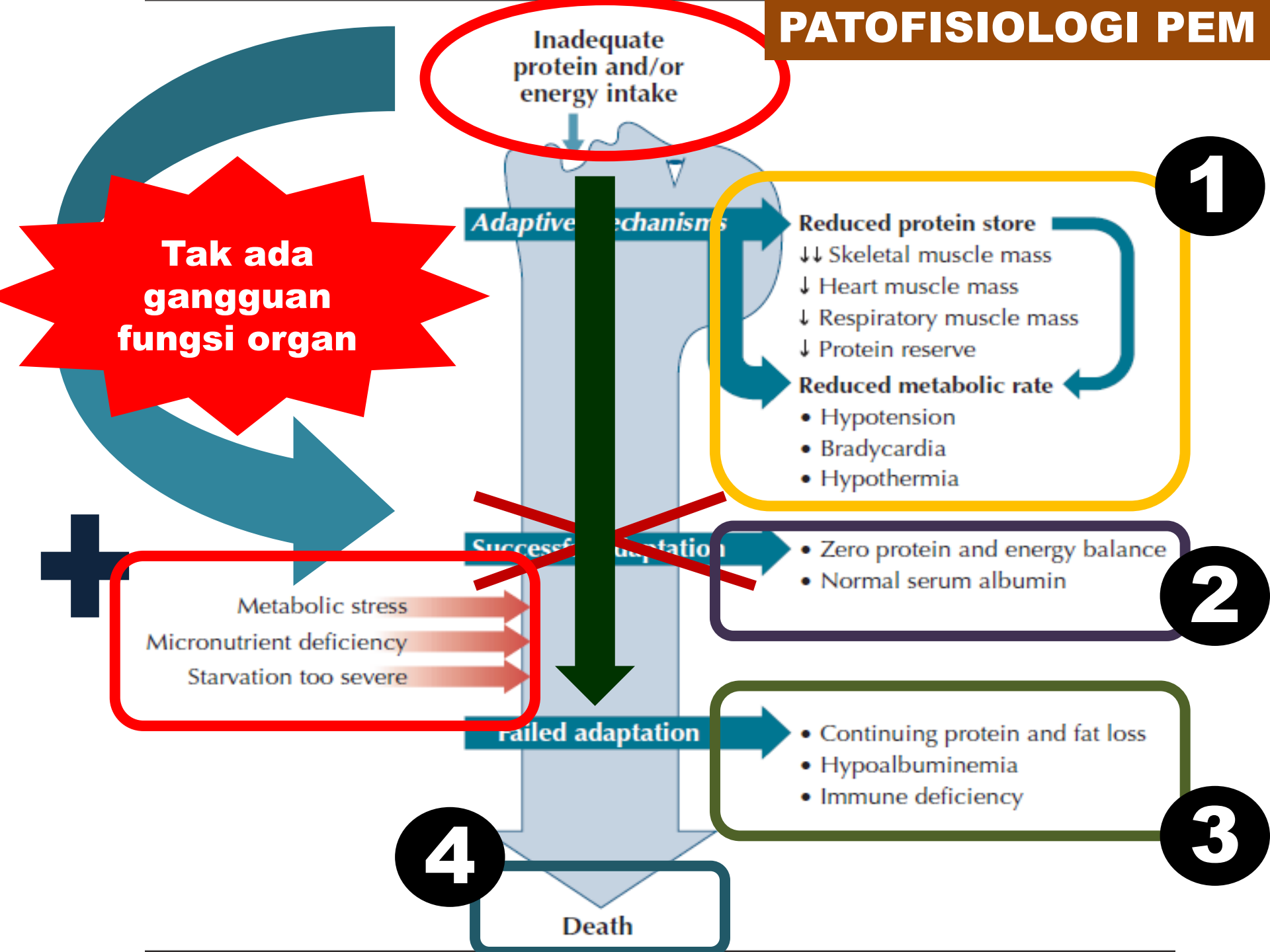
Activity Factor		Stress Factor			
Confined to bed	1,2	Burn ≤ 20% BSA 20 – 40% BSA > 40%	 1,5 1,8 1,8 – 2,0	Surgery Minor Major	 1,1 1,2
Ambulatory	1,3	Infections Mild Moderate Severe	 1,2 1,4 1,8	Trauma Skeletal Blunt Close Head Injury	 1,2 1,35 1,4
		Starvation	0,85		

Pemakaian energi lebih besar daripada asupan energi




The vicious cycle of infection and malnutrition
Negative energy balance
Anorexia
Protein catabolism
Increased metabolic rate
Acute-phase response
Wasting
Infection
Malnutrition
Increased risk
Compromised barrier defences
Increased severity
Impaired cellular immunity
Impaired humoral immunity

PATOFISIOLOGI PEM

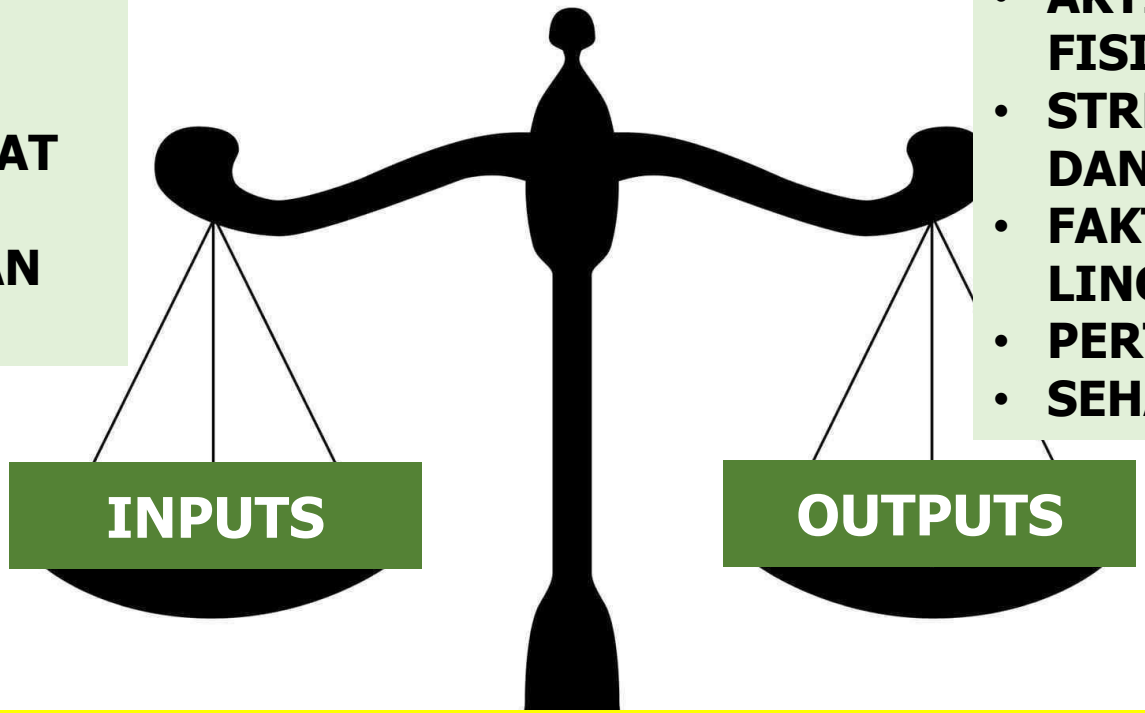


Asupan energi lebih besar dari pada yang digunakan

GIZI UNTUK SISTEM IMUN

Apa itu gizi optimal?

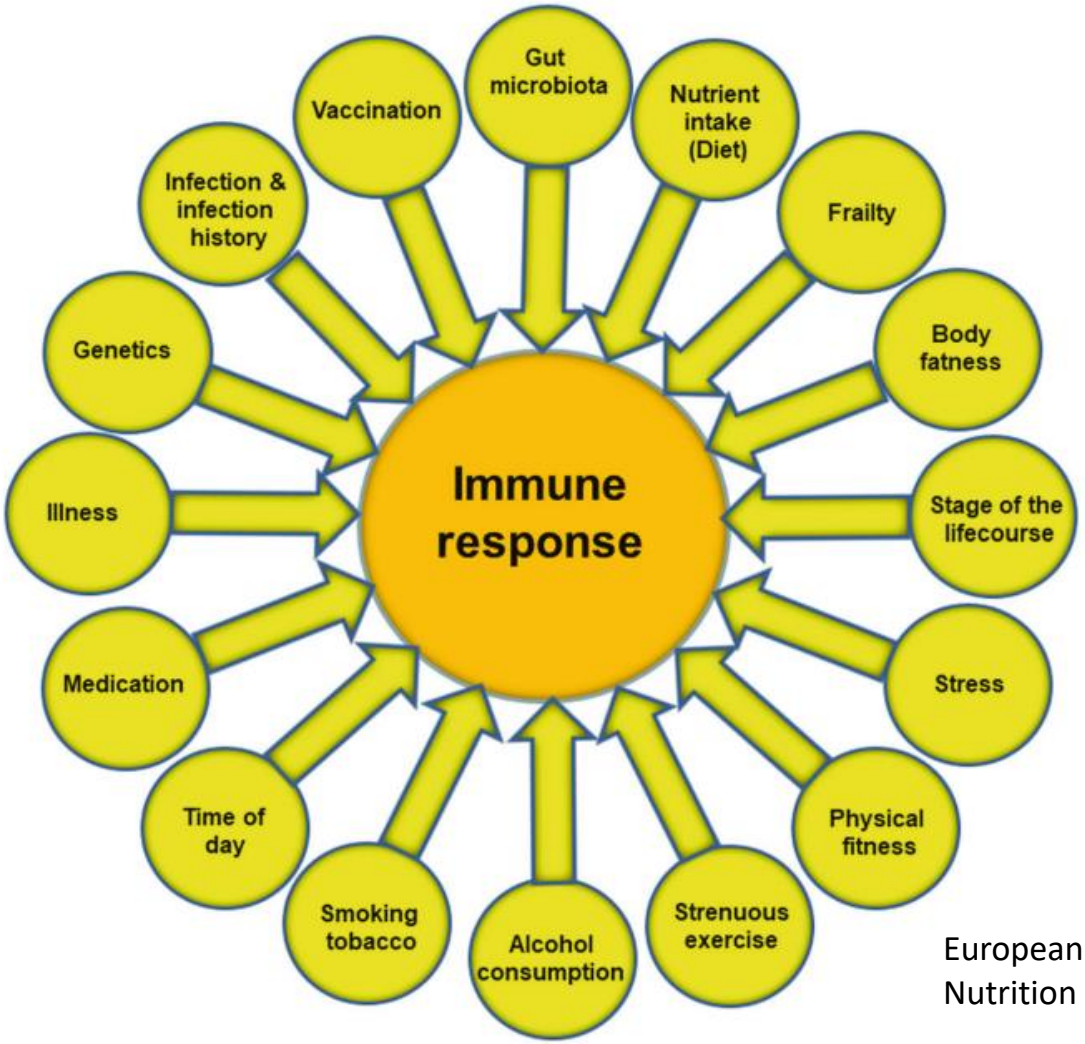
- ASUPAN ADEKUAT
- KUALITAS ZAT GIZI BAIK
- PENCERNAAN BAIK



- AKTIFITAS FISIK ADEKUAT
- STRESS FISIK DAN PSIKIS
- FAKTOR LINGKUNGAN
- PERTUMBUHAN
- SEHAT/SAKIT

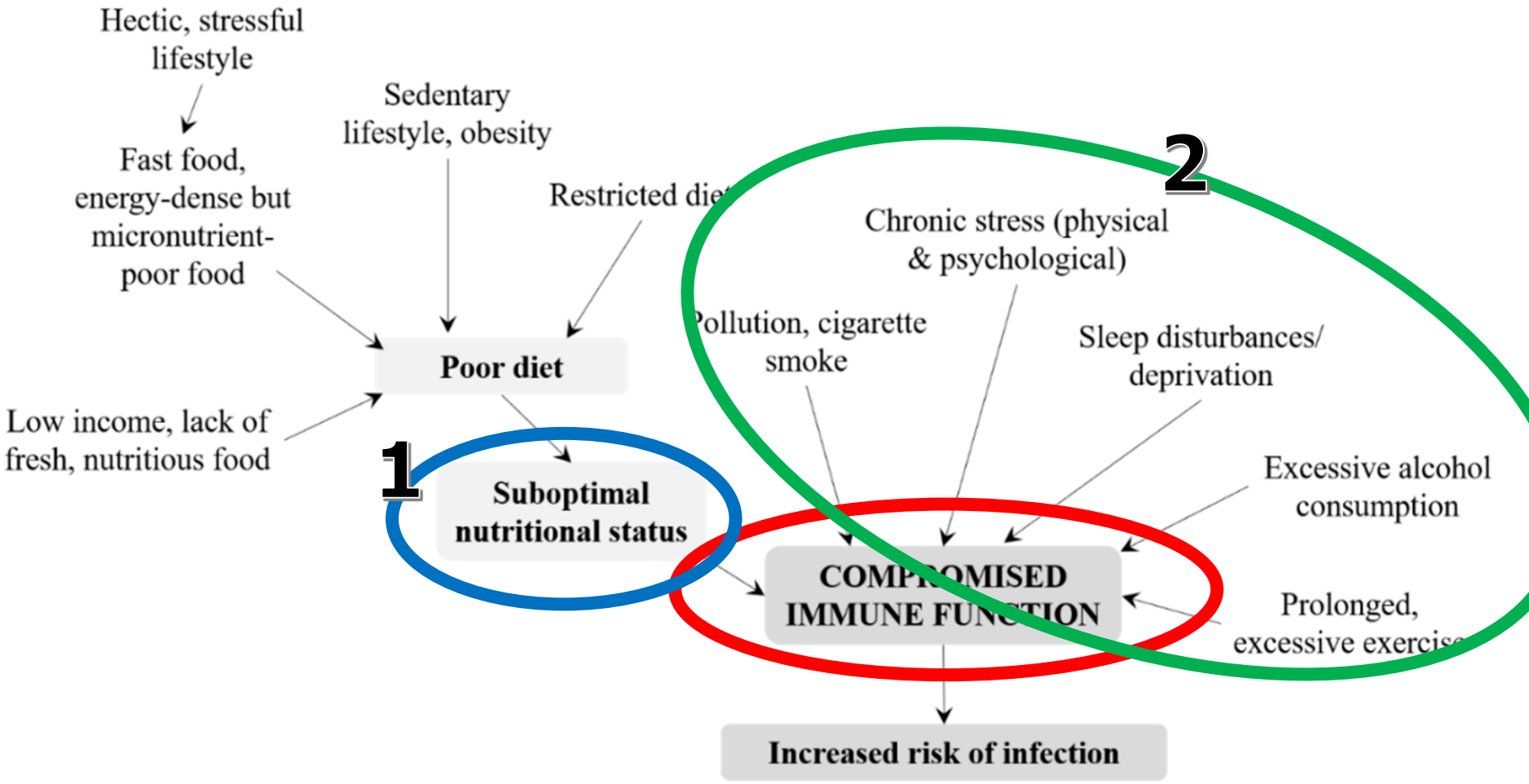
Seimbang antara asupan dan kebutuhan

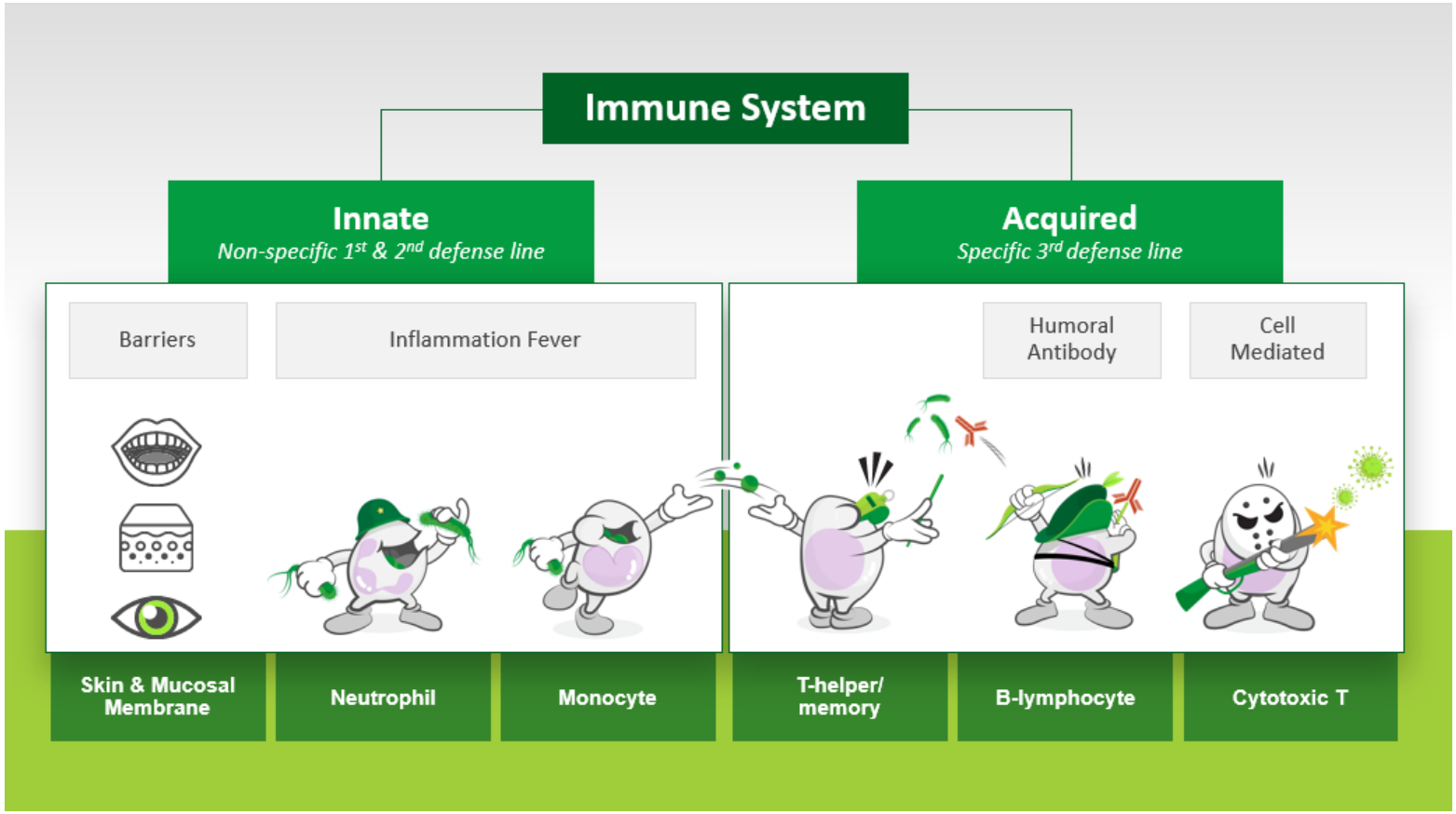
STATUS GIZI NORMAL

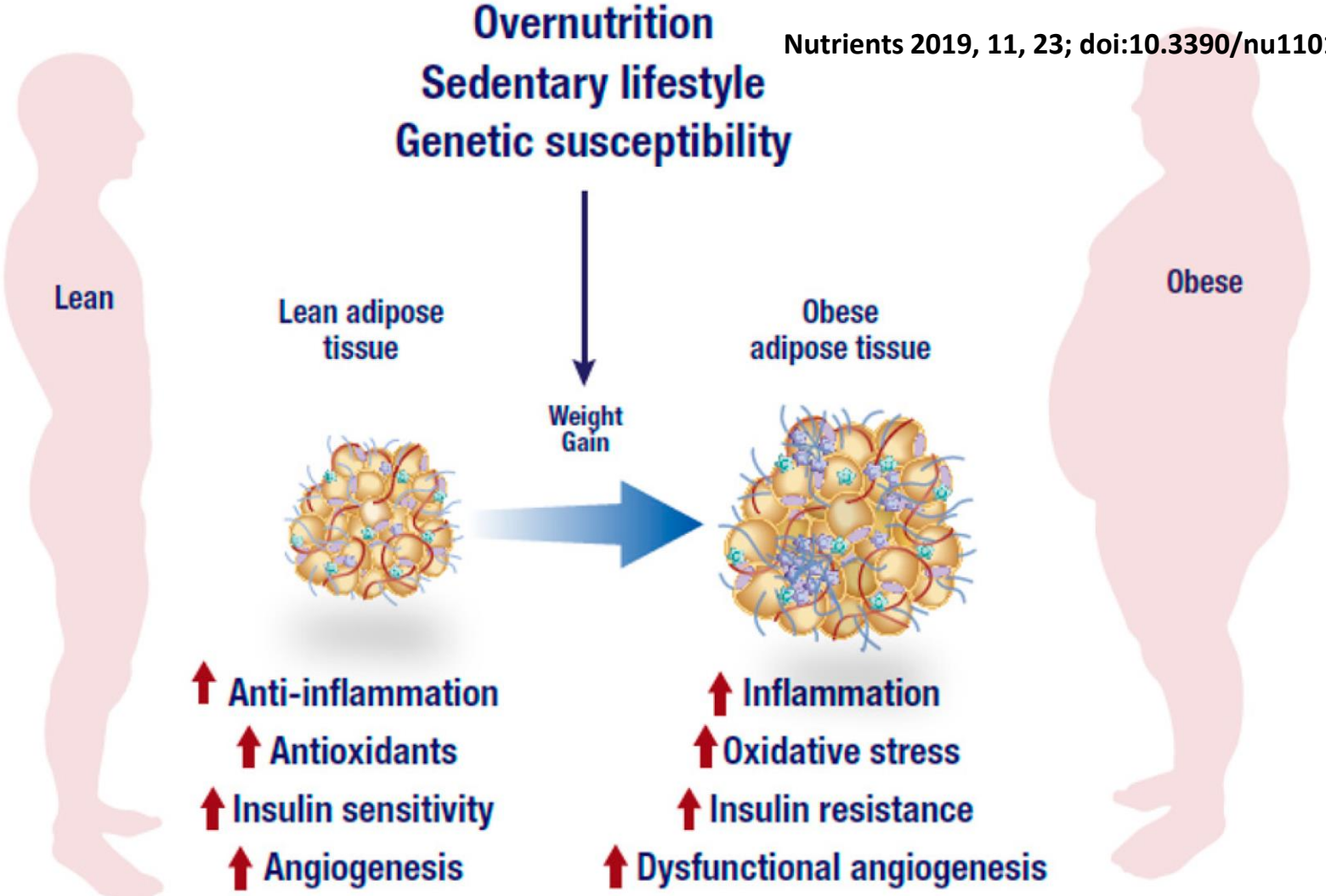


European Journal of Clinical Nutrition (2021) 75:1309–1318

Apa yang akan mempengaruhi status kekebalan tubuh?

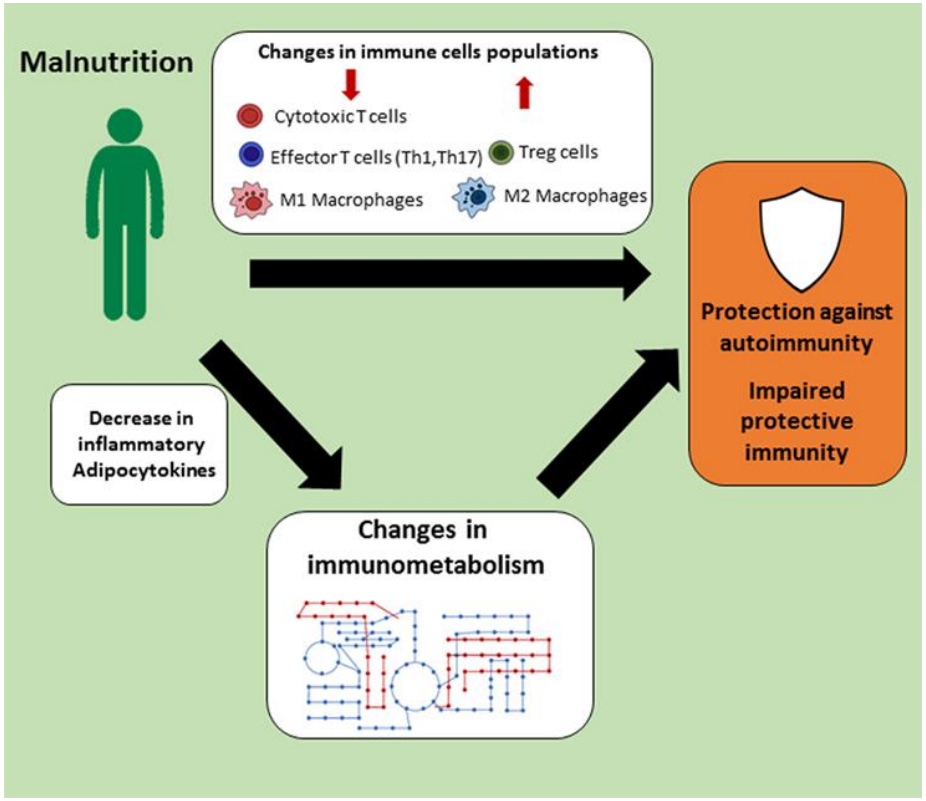

Hectic, stressful lifestyle
Fast food, energy-dense but micronutrient-poor food
Sedentary lifestyle, obesity
Restricted diet
Low income, lack of fresh, nutritious food
Poor diet
1
Suboptimal nutritional status
2
Chronic stress (physical & psychological)
Pollution, cigarette smoke
Sleep disturbances/ deprivation
Excessive alcohol consumption
Prolonged, excessive exercise
COMPROMISED IMMUNE FUNCTION
Increased risk of infection

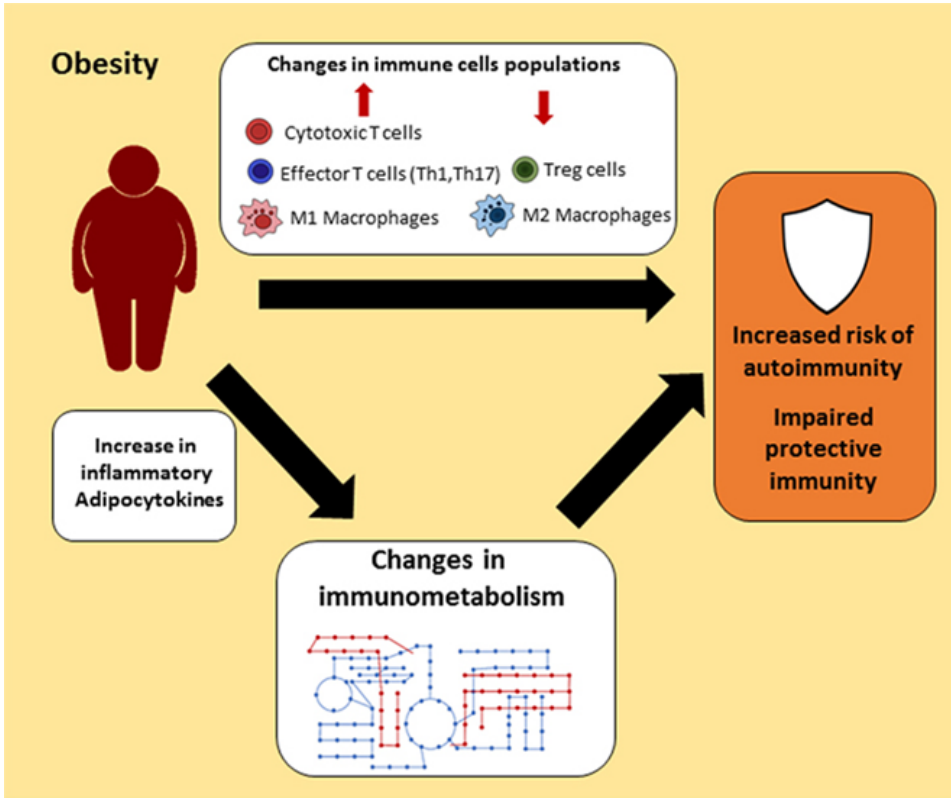

Immune System
Innate
Non-specific 1st & 2nd defense line
Acquired
Specific 3rd defense line
Barriers
Inflammation Fever
Humoral Antibody
Cell Mediated
Skin & Mucosal Membrane
Neutrophil
Monocyte
T-helper/ memory
B-lymphocyte
Cytotoxic T



Nutrients 2019, 11, 23; doi:10.3390/nu11010023

Kurus atau gemuk? Mana yang lebih baik?


Malnutrition
Changes in immune cells populations
Cytotoxic T cells
Effector T cells (Th1,Th17)
Treg cells
M1 Macrophages
M2 Macrophages
Protection against autoimmunity
Impaired protective immunity
Decrease in inflammatory Adipocytokines
Changes in immunometabolism


Obesity
Changes in immune cells populations
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Increased risk of autoimmunity
Impaired protective immunity
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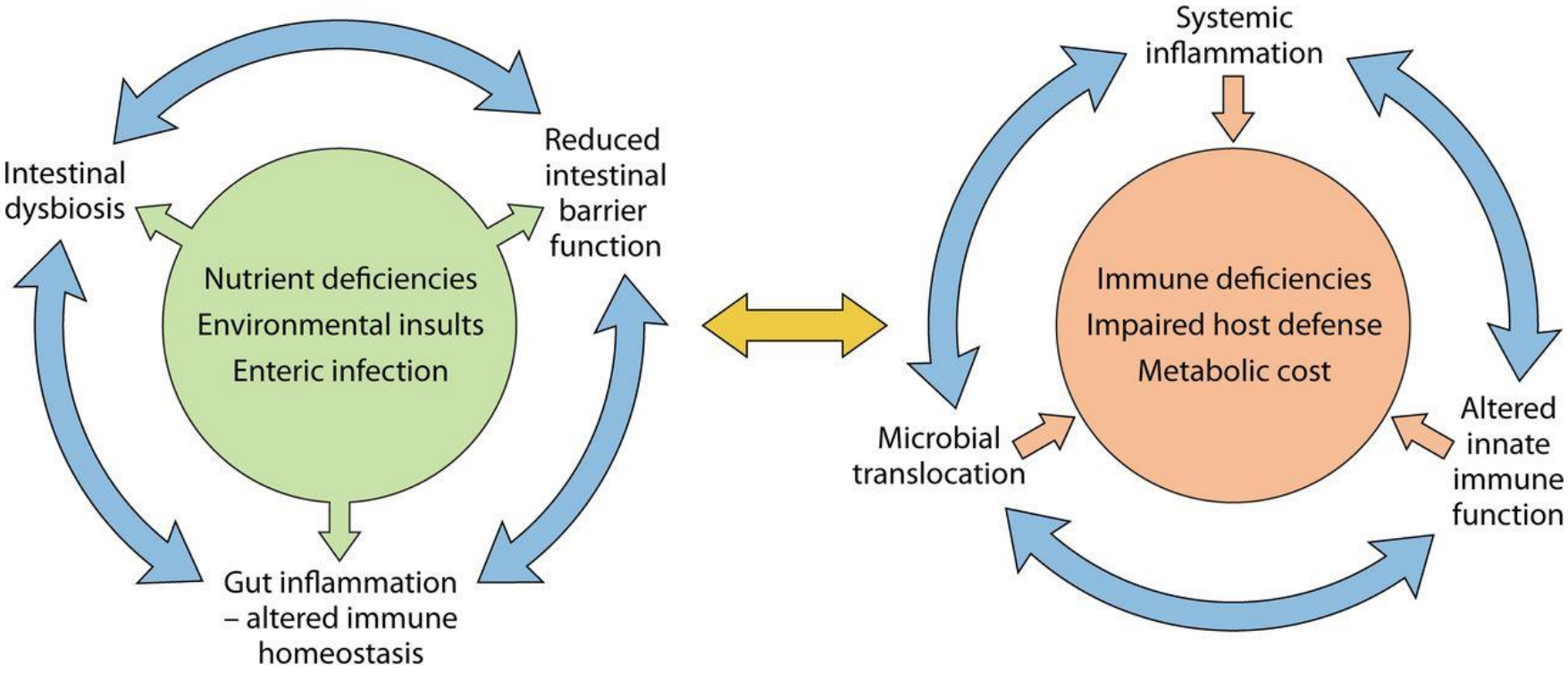
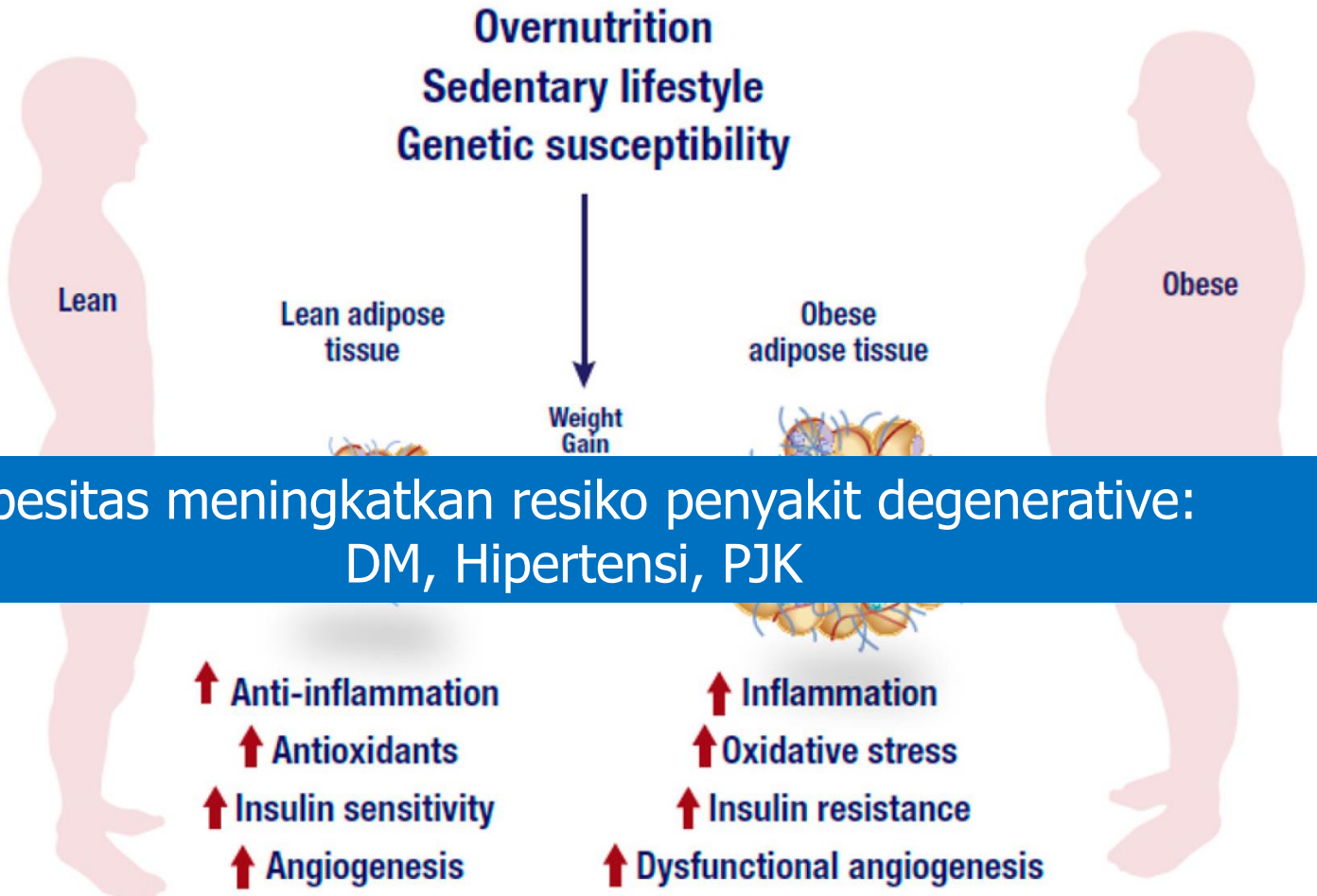

Intestinal dysbiosis
Reduced intestinal barrier function
Nutrient deficiencies
Environmental insults
Enteric infection
Gut inflammation – altered immune homeostasis
Systemic inflammation
Immune deficiencies
Impaired host defense
Metabolic cost
Microbial translocation
Altered innate immune function



Obesitas meningkatkan resiko penyakit degenerative:
DM, Hipertensi, PJK

nutrients

MDPI

Concept Paper

The Metabolic Concept of Meal Sequence vs. Satiety: Glycemic and Oxidative Responses with Reference to Inflammation Risk, Protective Principles and Mediterranean Diet

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Received: 23 July 2019; Accepted: 17 September 2019; Published: 5 October 2019

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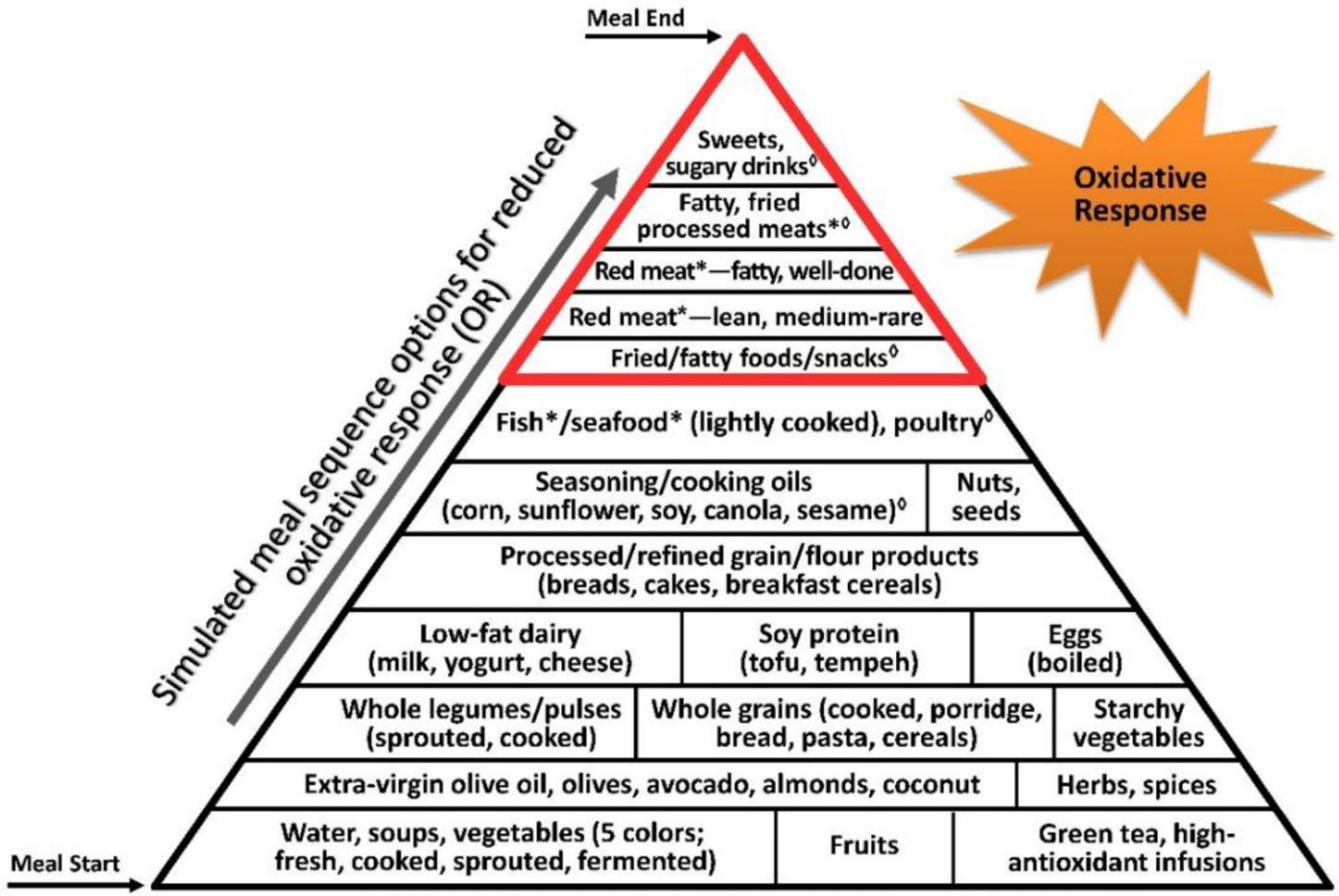
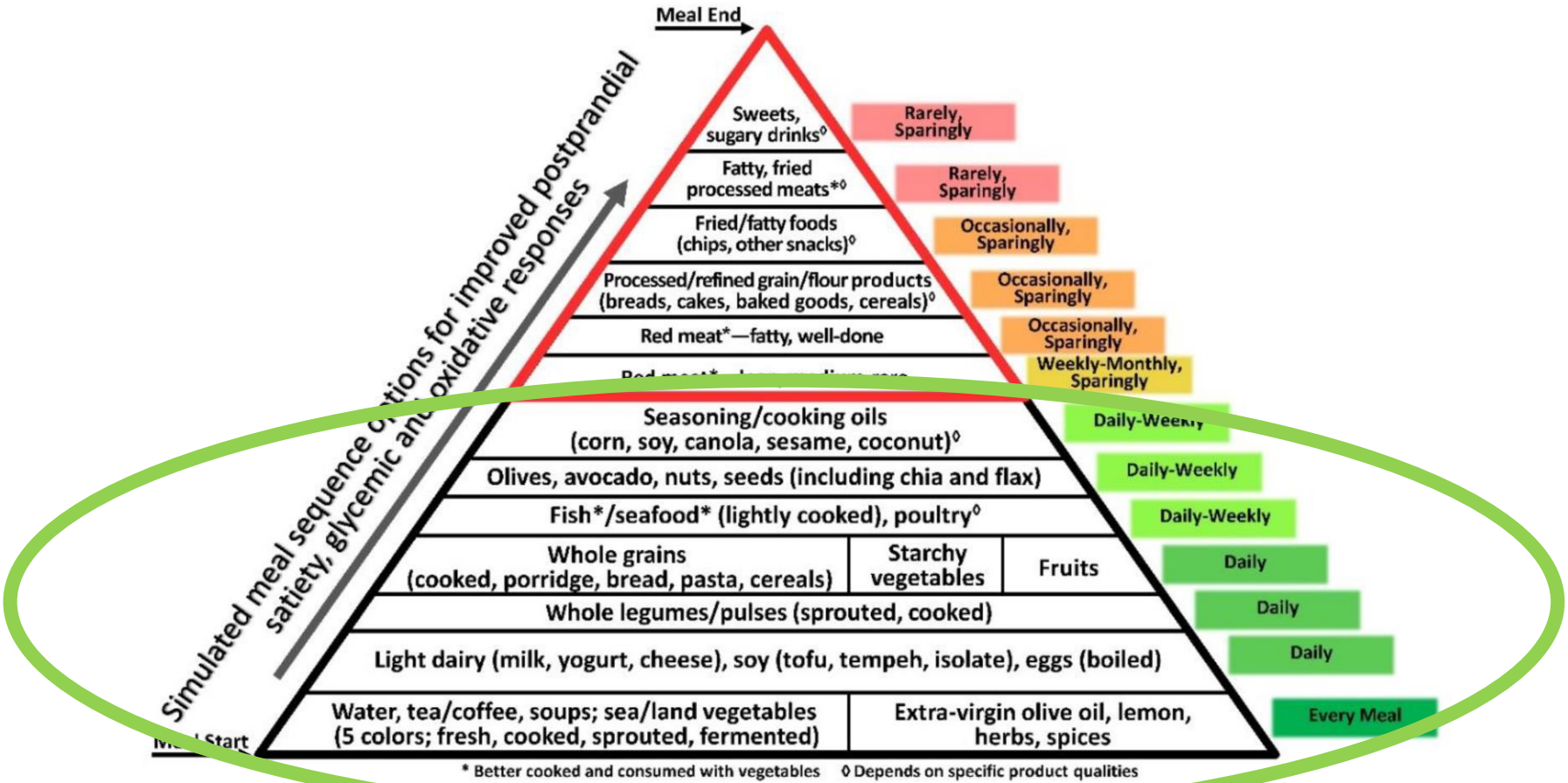


The advised simulated meal sequence may further suggest decreasing portions and exclusions, especially of foods towards the upper levels (inside the red triangle).



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Nutrients 2019, 11(10), 2373

Five colour food

Phytochemical Contained in 5 Colors of Fruits and Vegetables

Purple	grapes, eggplant, blueberry, purple sweet potato anthoxanthins, resveratrol Effect – antioxidant effect, suppression and detoxification of carcinogens
Red	tomato, watermelon, strawberry, cherry Lycopene Effect – suppresses prostate cancer, lung cancer
Green	broccoli, spinach, avocado, green grapes, kale Lutein, sulforaphane Effect – prevents cancer formation and development
Yellow, Orange	orange, tangerine, carrot, pumpkin flavonoid Effect – prevents recurrence of breast cancer
White	garlic, onion, mushroom allicin, quercetin Effect – powerful anti-bacterial effect, prevents stomach cancer

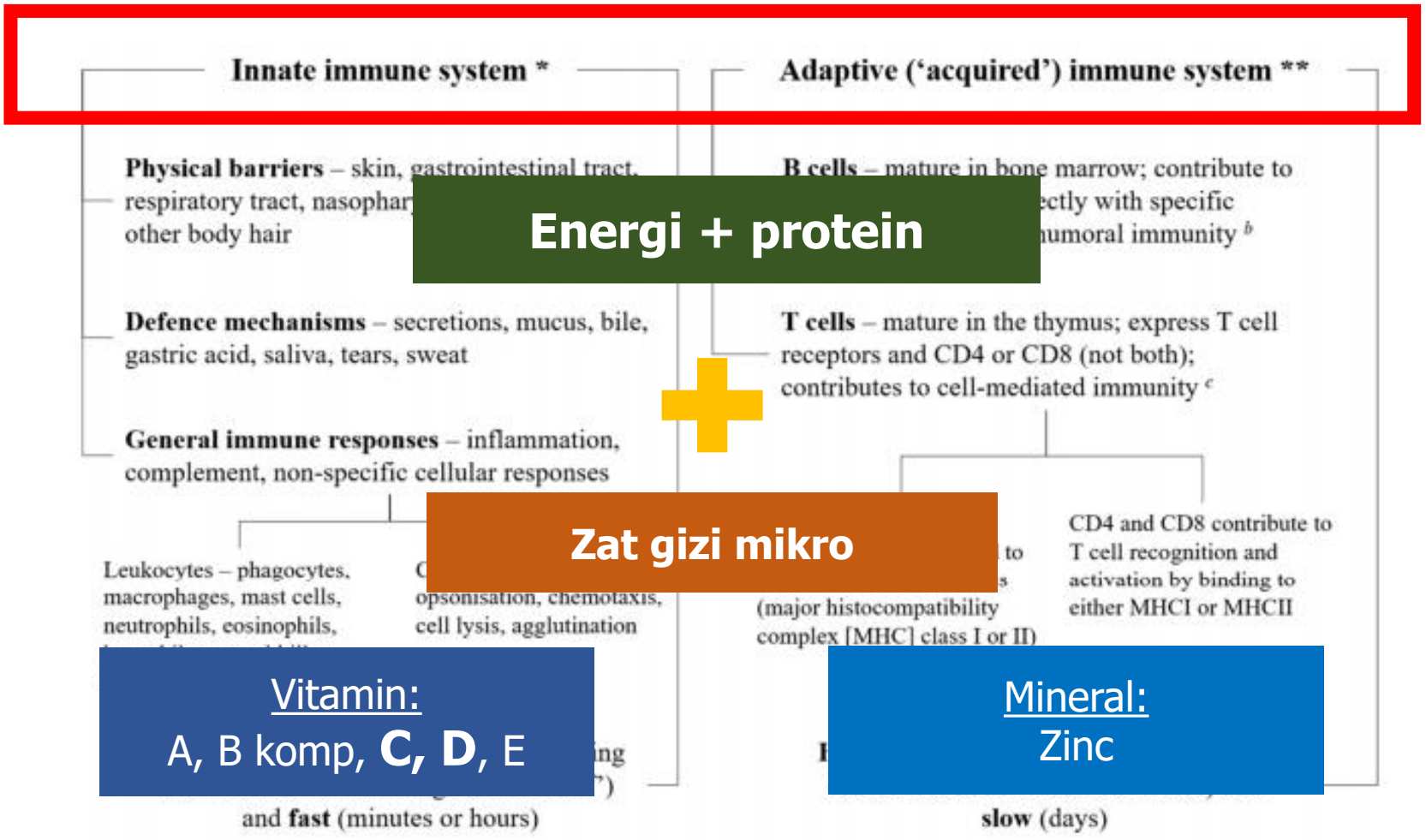
Innate immune system *
Adaptive ('acquired') immune system **
Physical barriers – skin, gastrointestinal tract, respiratory tract, nasophar other body hair
B cells – mature in bone marrow; contribute to ectly with specific umoral immunity b
Defence mechanisms – secretions, mucus, bile, gastric acid, saliva, tears, sweat
T cells – mature in the thymus; express T cell receptors and CD4 or CD8 (not both); contributes to cell-mediated immunity c
General immune responses – inflammation, complement, non-specific cellular responses
Leukocytes – phagocytes, macrophages, mast cells, neutrophils, eosinophils,
opsonisation, chemotaxis, cell lysis, agglutination
CD4 and CD8 contribute to T cell recognition and activation by binding to either MHCI or MHCII
(major histocompatibility complex [MHC] class I or II)
and fast (minutes or hours)
slow (days)
Energi + protein
Zat gizi mikro
Vitamin:
A, B komp, C, D, E
Mineral:
Zinc

Table 1. Recommended intakes of selected nutrients to support optimal immune function.

Nutrient	Rationale	Recommendation
Vitamins and trace elements	These micronutrients play important roles in supporting the cells and tissues of the immune system. Deficiencies or suboptimal status in these micronutrients negatively affect immune function and can decrease resistance to infections.	A multivitamin and trace element supplement that supplies the nutrient requirements (e.g., 100% US RDA for age and gender) [78] for vitamins and trace elements including vitamins A, B_6, B_{12}, C, D, E, and folate, and trace elements including zinc, iron, selenium, magnesium and copper. This is in addition to the consumption of a well-balanced diet.
Vitamin C	Doses of ≥200 mg/day provide saturating levels in the blood, and support reduction in the risk, severity and duration of upper and lower respiratory tract infections. Requirements for vitamin C increase during infection.	Daily intake of at least 200 mg/day for healthy individuals. In individuals who are sick, 1–2 g/day is recommended.
Vitamin D	Daily supplementation of vitamin D reduces the risk of acute respiratory tract infections.	Daily intake of 2000 IU/day (50 µg/day).
Zinc	Marginal zinc deficiency can impact immunity. Those deficient in zinc, particularly children, are prone to increased diarrheal and respiratory morbidity.	Daily intake in the range of 8–11 mg/day.
Omega-3 fatty acids (EPA + DHA)	Omega-3 fatty acids support an effective immune system, including by helping to resolve inflammation.	Daily intake of 250 mg/day of EPA + DHA.

Nutrients 2020, 12, 1181; doi:10.3390/nu12041181

Table 1 Summary of the effects of various micronutrients on different aspects of immunity.

Micronutrient	Role in barrier function	Role in cellular aspects of innate immunity	Role in T-cell mediated immunity	Role in B-cell mediated immunity
Vitamin A	Promotes differentiation of epithelial tissue; promotes gut homing of B- and T cells; promotes intestinal immunoglobulin A^+ cells; promotes epithelial integrity	Regulates number and function of NK cells; supports phagocytic and oxidative burst activity of macrophages	Regulates development and differentiation of Th1 and Th2 cells; promotes conversion of naive T cells to regulatory T cells; regulates IL-2, IFN-γ and TNF production	Supports function of B cells; required for immunoglobulin A production
Vitamin B6	Promotes gut homing of T cells	Supports NK-cell activity	Promotes T-cell differentiation, proliferation and function, especially Th1 cells; regulates (promotes) IL-2 production	Supports antibody production
Vitamin B9 (Folate)	Survival factor for regulatory T cells in the small intestine	Supports NK-cell activity	Promotes proliferation of T cells and the Th1-cell response	Supports antibody production
Vitamin B12	Important co-factor for gut microbiota	Supports NK-cell activity	Promotes T-cell differentiation, proliferation and function, especially cytotoxic T cells; controls ratio of T-helper to cytotoxic T cells	Required for antibody production
Vitamin C	Promotes collagen synthesis; promotes keratinocyte differentiation; protects against oxidative damage; promotes wound healing; promotes complement	Supports function of neutrophils, monocytes and macrophages including phagocytosis; supports NK-cell activity	Promotes production, differentiation and proliferation of T cells especially cytotoxic T cells; regulates IFN-γ production	Promotes antibody production
Vitamin D	Promotes production of antimicrobial proteins (cathelicidin, β-defensin); promotes gut tight junctions (via E-cadherin, connexion 43); promotes homing of T cells to the skin	Promotes differentiation of monocytes to macrophages; promotes macrophage phagocytosis and oxidative burst	Promotes antigen processing but can inhibit antigen presentation; can inhibit T-cell proliferation, Th1-cell function and cytotoxic T-cell function; Promotes the development of regulatory T cells; inhibits differentiation and maturation of dendritic cells; regulates IFN-γ production	Can decrease antibody production
Vitamin E	Protects against oxidative damage	Supports NK-cell activity	Promotes interaction between dendritic cells and T cells; promotes T-cell proliferation and function, especially Th1 cells; regulates (promotes) IL-2 production	Supports antibody production
Zinc	Maintains integrity of the skin and mucosal membranes; promotes complement activity	Supports monocyte and macrophage phagocytosis; supports NK-cell activity	Promotes Th1-cell response; Promotes proliferation of cytotoxic T cells; promotes development of regulatory T cells; regulates (promotes) IL-2 and IFN-γ production; reduces development of Th9 and Th17 cells	Supports antibody production particularly immunoglobulin G
Copper		Promotes neutrophil, monocyte and macrophage phagocytosis; supports NK-cell activity	Regulates differentiation and proliferation of T cells; regulates (promotes) IL-2 production	
Iron	Essential for growth and differentiation of epithelial tissue	Promotes bacterial killing by neutrophils; regulates balance of M1 and M2 macrophages; supports NK-cell activity	Regulates differentiation and proliferation of T cells; regulates IFN-γ production	
Selenium		Supports NK-cell activity	Regulates differentiation and proliferation of T cells; regulates (promotes) IFN-γ production	Supports antibody production

IFN Interferon, *IL* interleukin, *NK* natural killer, *Th* T-helper, *TNF* tumour necrosis factor.

Tips to Support your Immune System

MAINTAIN A BALANCED DIET

Lean protein, healthy carbs and omega-3 fatty acids

WASH YOUR HANDS

Wash with soap for 40 seconds*. Make sure to get to palms, backs of hands, under fingernails and wrists.

GET ADEQUATE REST

Aim for ~7 hours per night to allow your body to recover from stress and exercise

EXERCISE

Daily moderate activity (30 min/day) can help boost your immune system

HYDRATE

Drink 4 to 6 cups of water daily

*https://www.who.int/gpsc/5may/Hand_Hygiene_Why_How_and_When_Brochure.pdf

Take home message

1. Kekebalan tubuh sangat dipengaruhi oleh status gizi. Gizi lebih dan gizi kurang mempengaruhi kekebalan tubuh
2. Trigger eksternal akan menyebakan kekebalan tubuh bekerja ekstra → immune compromised
3. Keadaan tubuh yang terus menerus mendapatkan trigger (internal dan eksternal) akan menyebabkan tubuh rentan sakit
4. Bahan baku utama kekebalan tubuh asupan gizi makro dan mikro adekuat dengan focus pada antioksidan
5. Tidak diperlukan suplemen dalam dosis tinggi sepanjang zat gizi tersedia secara adekuat dan berkesinambungan setiap hari


TERIMA KASIH