Sawa University

Biochemistry I

Biochemistry And Metabolism In Illness And Recovery

Sawa University — جامعـــــة ســـــــاوة الاهلية

College of health and medical techniques — كليـــــة التقنيـــات الصحيـة والطبيـة

Department of Medical Laboratories — قسم تقنيات المختبرات الطبية

Stage : 2nd — المرحلـــــــــــــة : الثانية

الجانب النظري محاضرة رقم 2 و 3

Theoretical Lecture No. 2 and 3

تدريسي المادة : .م.د. عبدالرحمن يسر خليفه

Topics

- **Biochemistry and Metabolism in Illness and Recovery:**
  - **Subtopics:**
    - **Obesity**
    - **Stress**
    - **Exercise**
    - **Recovery**

Metabolic Changes During Illness:

– When a person becomes ill, profound changes occur in the body's biochemical reactions. These changes meet the body's increased **energy needs** and **fight off disease**. During **acute** or **chronic illness**, the body's energy consumption rises to support **the immune system** and **repair damaged tissues**.

- **Increased Gluconeogenesis**: During illness, the liver increases **gluconeogenesis** to provide more **glucose** for **immune** and **muscle cells**, which require extra energy.
- **Protein Breakdown**: When sufficient **carbohydrates** or **fats** are unavailable, the body starts breaking down stored **proteins** in **muscles** to obtain amino acids, **leading to muscle loss**.
- **Role of Cytokines and ROS**: **Immune cells** release **cytokines** like **Interleukin 6** (**IL-6**) and **Tumor necrosis factor-α** (**TNF-α**) that stimulate the inflammatory response. However, the production of **reactive oxygen species** (**ROS**) can cause cellular damage if not properly controlled.

 These metabolic changes help the body survive during illness, but they can have negative effects if prolonged.

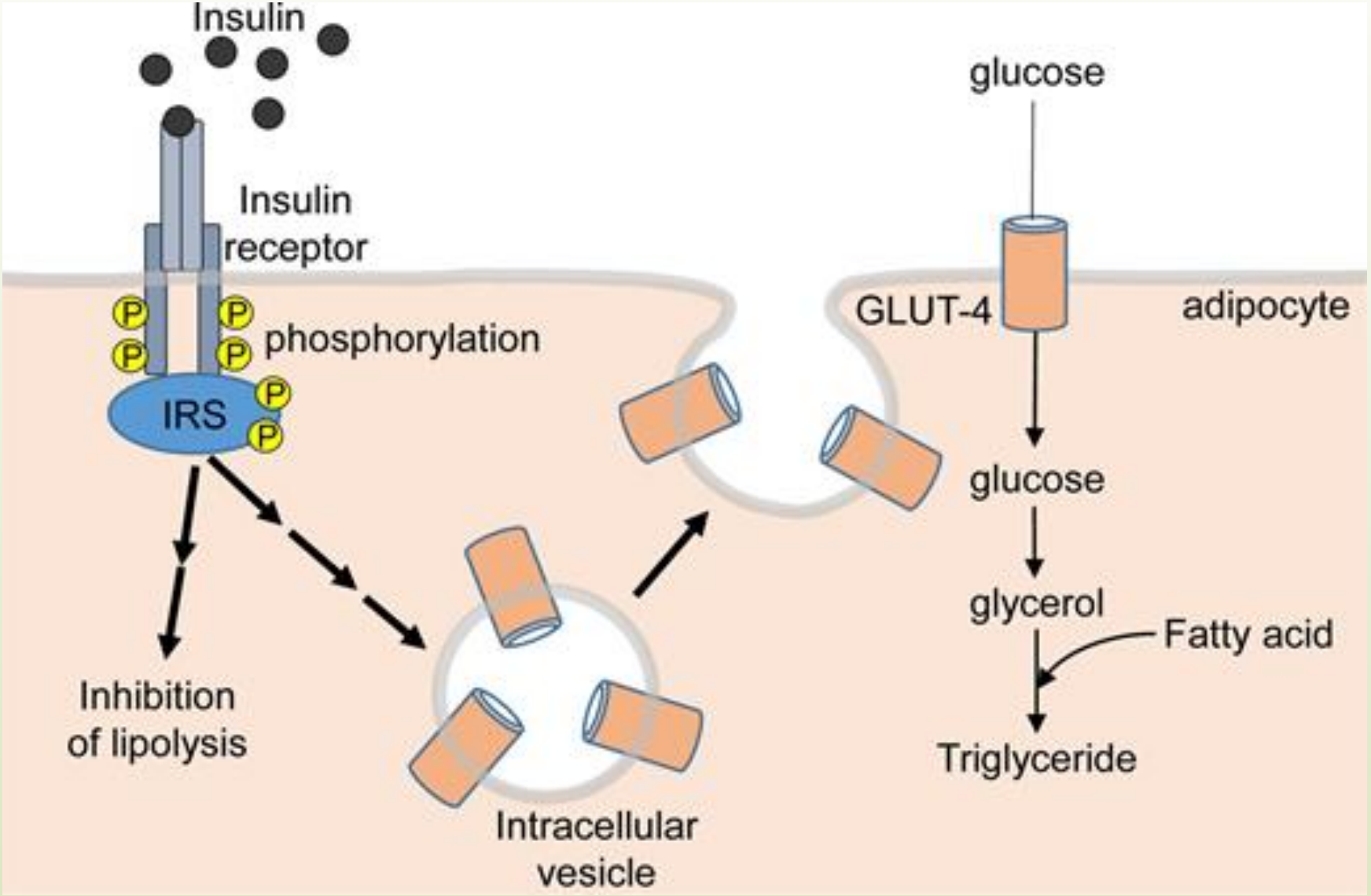
Obesity and Metabolic Dysfunction

Biochemistry of Obesity

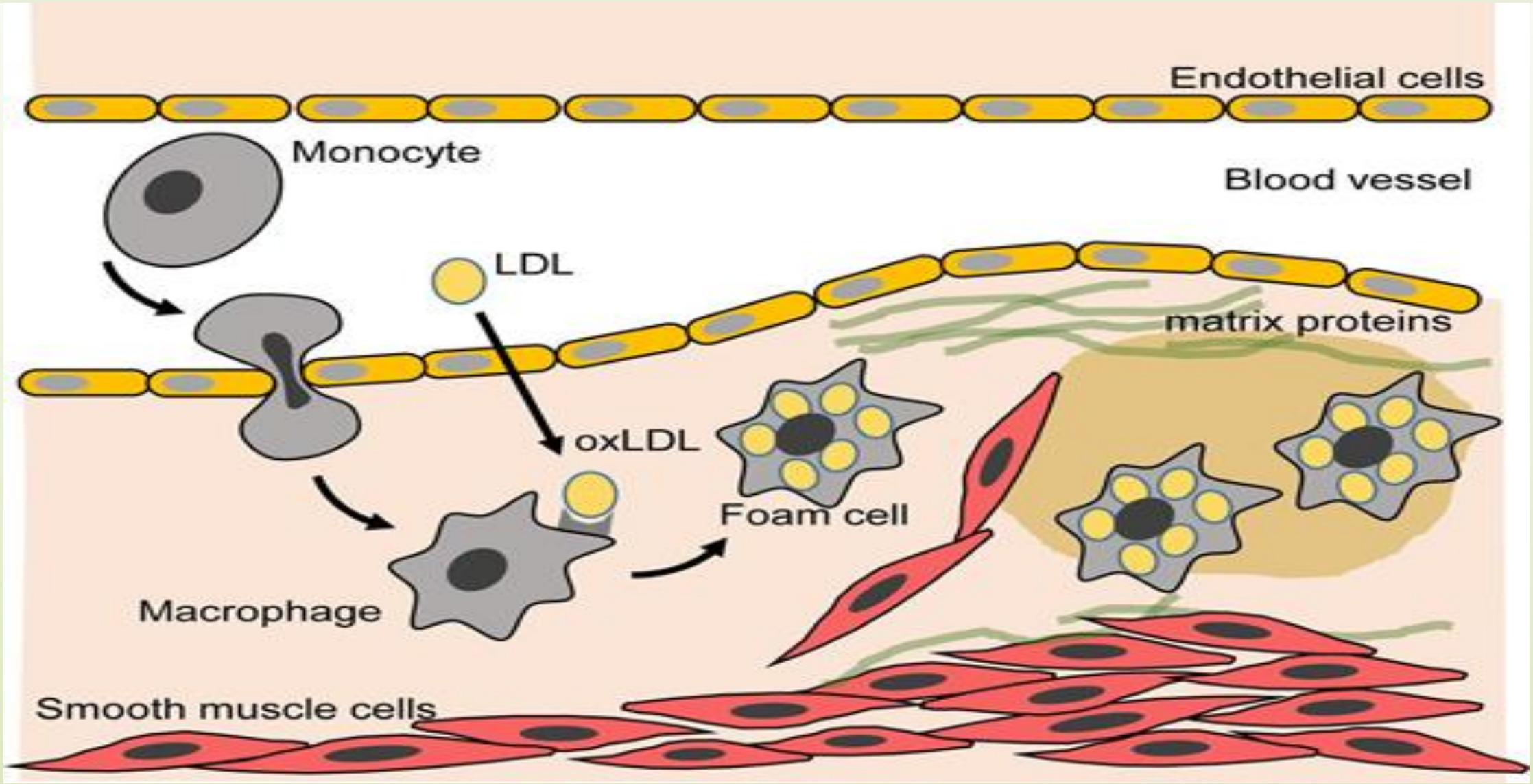
Obesity is a metabolic disorder caused by excessive fat accumulation. Excess fat affects many vital systems in the body and leads to metabolic imbalances.

✔ **Adipocyte Secretion**: Adipocytes (fat cells) secrete chemical signals like **leptin**, which regulates appetite, and **adiponectin**, which enhances **insulin sensitivity**. In **obesity**, there is a disruption in these signals, leading to issues like **increased appetite** and **reduced fat metabolism**.

✔ **Insulin Resistance**: Insulin resistance is one of the major metabolic issues in **obesity**. Enlarged fat cells increase **chronic inflammation** and **reduce insulin sensitivity**, making glucose transport into cells less efficient.


Insulin
Insulin receptor
phosphorylation
IRS
Inhibition of lipolysis
Intracellular vesicle
glucose
GLUT-4
adipocyte
glucose
glycerol
Fatty acid
Triglyceride

✔ **Blood Lipids**: High levels of **triglycerides** and **low-density lipoprotein (LDL)** increase the risk of heart disease. These fats accumulate in artery walls, leading to **atherosclerosis** and narrowing of blood vessels.



Stress and Biochemical Impact

❖ Biochemistry of Stress Response

Stress significantly affects the body's biochemistry through its impact on the **hypothalamic-pituitary-adrenal (HPA) axis**. When the body is under stress, stress hormones such as **cortisol** are released.

- **Increased Glycogenolysis**: **Cortisol** promotes the breakdown of **glycogen** stored in the liver into **glucose**, raising blood sugar levels to provide immediate energy to cells.
- **Oxidative Stress**: Stress leads to increased production of **reactive oxygen species (ROS)**, causing cellular damage by affecting **DNA**, **proteins**, and **lipids**. This **accelerates aging** and **increases the risk of chronic diseases**.
- **Chronic Inflammation**: Prolonged stress causes a long-term inflammatory response, which raises **the risk of heart disease, diabetes**, and **certain cancers.**

Note: Chronic psychological stress has detrimental effects on overall health as it disrupts metabolic balance and increases cellular damage.

Exercise and Metabolic Adaptation

❑ Impact of Exercise on Metabolism

Exercise is an effective way to improve metabolic functions in the body. Exercise impacts both aerobic and anaerobic metabolism and plays a key role in regulating **insulin sensitivity** and **reducing stored fat**.

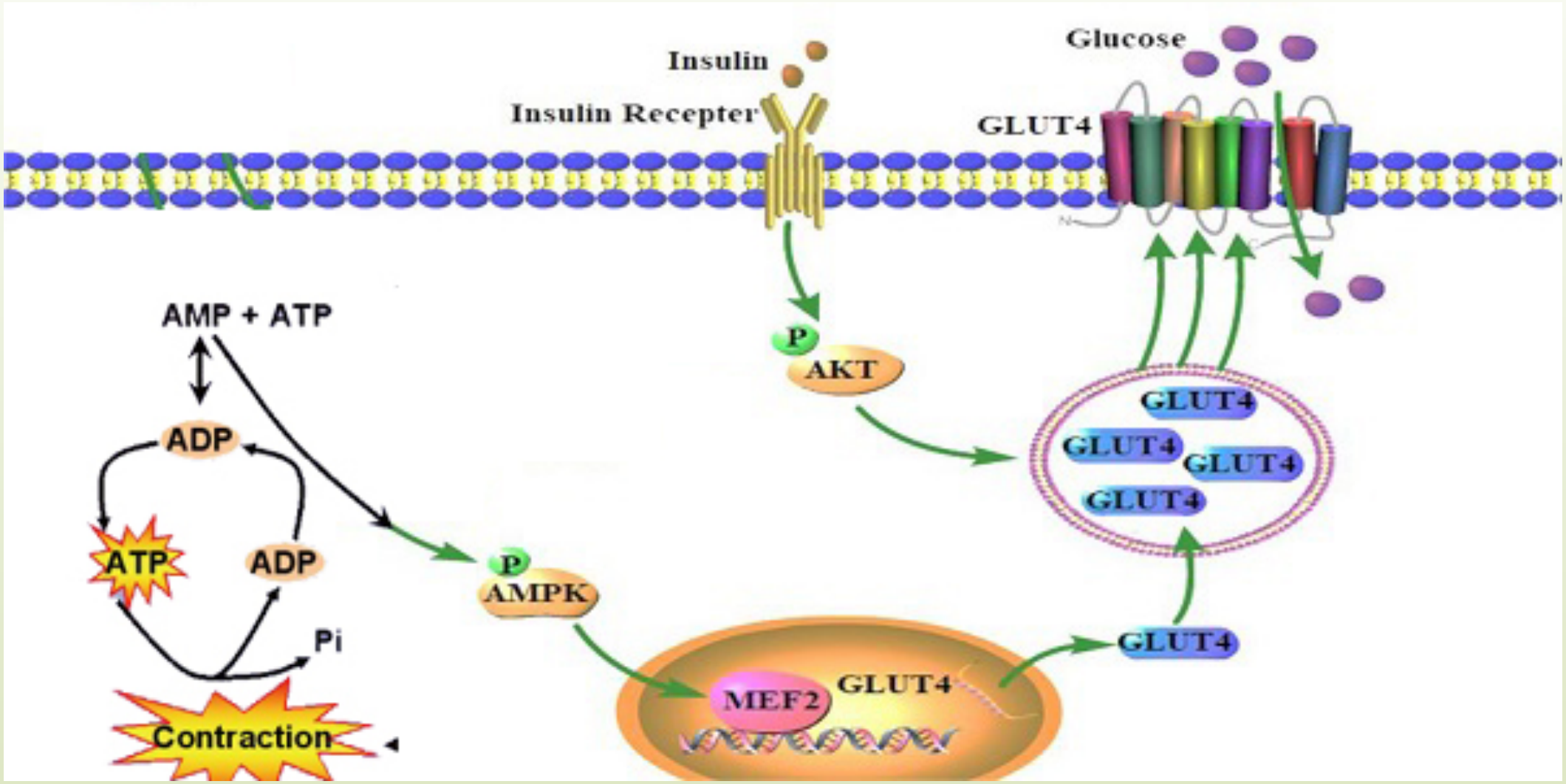
— **Insulin Sensitivity**: Regular exercise increases the body's ability to use insulin more effectively, lowering blood glucose levels and protecting against **insulin resistance**.

1) Exercise-Induced Improvements in Insulin Sensitivity:-

- **Muscle Contractions and Glucose Uptake**: During exercise, muscle contractions stimulate the translocation of **glucose transporter type 4 (GLUT4)** to the cell membrane of skeletal muscles, independently of **insulin**. This process increases glucose uptake into the muscles via:
  - **Muscle contraction** activates **AMPK (adenosine monophosphate-activated protein kinase)**.
  - **AMPK** increases the movement of **GLUT4 vesicles** to the cell membrane, facilitating glucose entry into the cells.

  After exercise, **muscle insulin sensitivity** is significantly increased, making muscles

- The effect of increased **insulin sensitivity** persists for several hours to days after exercise. **Muscle cells** become more responsive to insulin's effects, meaning the body requires **less insulin** to maintain normal blood glucose levels.
- This improves blood sugar regulation and reduces the risk of developing **insulin resistance**.



- **Increased Glycogen Storage**: After exercise, glucose storage in muscles as glycogen increases, improving insulin sensitivity and promoting efficient glucose usage.

2) Exercise and Insulin Resistance (Long-Term Benefits)

- **Effect of Exercise on Insulin Resistance in Adipose Tissue:**
  - Exercise helps reduce **visceral fat**, the fat closely associated with increased **insulin resistance**.
  - By reducing body fat, exercise improves the responsiveness of body cells to insulin, thereby lowering the chances of developing **insulin resistance**.
- **Anti-Inflammatory Effects:**
  - Exercise decreases levels of **inflammatory cytokines** such as **TNF-α** and **IL-6**, which are linked to **insulin resistance**.
  - The reduction in these inflammatory markers enhances cellular **insulin signaling**, further improving **insulin sensitivity**.

Recovery and Long-Term Health

❑ Recovery and Biochemical Balance

During recovery from illness, the body restores metabolic balance after being under stress. The recovery process should include proper nutrition, stress management, and regular physical activity.

- ✔ **Restoring Metabolic Balance**: After illness, the body returns to a normal state by reducing gluconeogenesis and increasing the synthesis of proteins that help rebuild muscles and repair damaged tissues.
- ✔ **Proper Nutrition**: Proteins and carbohydrates are essential to support recovery by providing the amino acids and energy needed for tissue repair and cell regeneration.
- ✔ **Stress Management**: Strategies like physical exercise and relaxation techniques such as meditation help the body recover faster and restore biochemical balance.
- ✔ **Regular Physical Activity**: Plays a crucial role in improving long-term body functions by preventing obesity, enhancing insulin sensitivity, and promoting overall health.

Any questions?