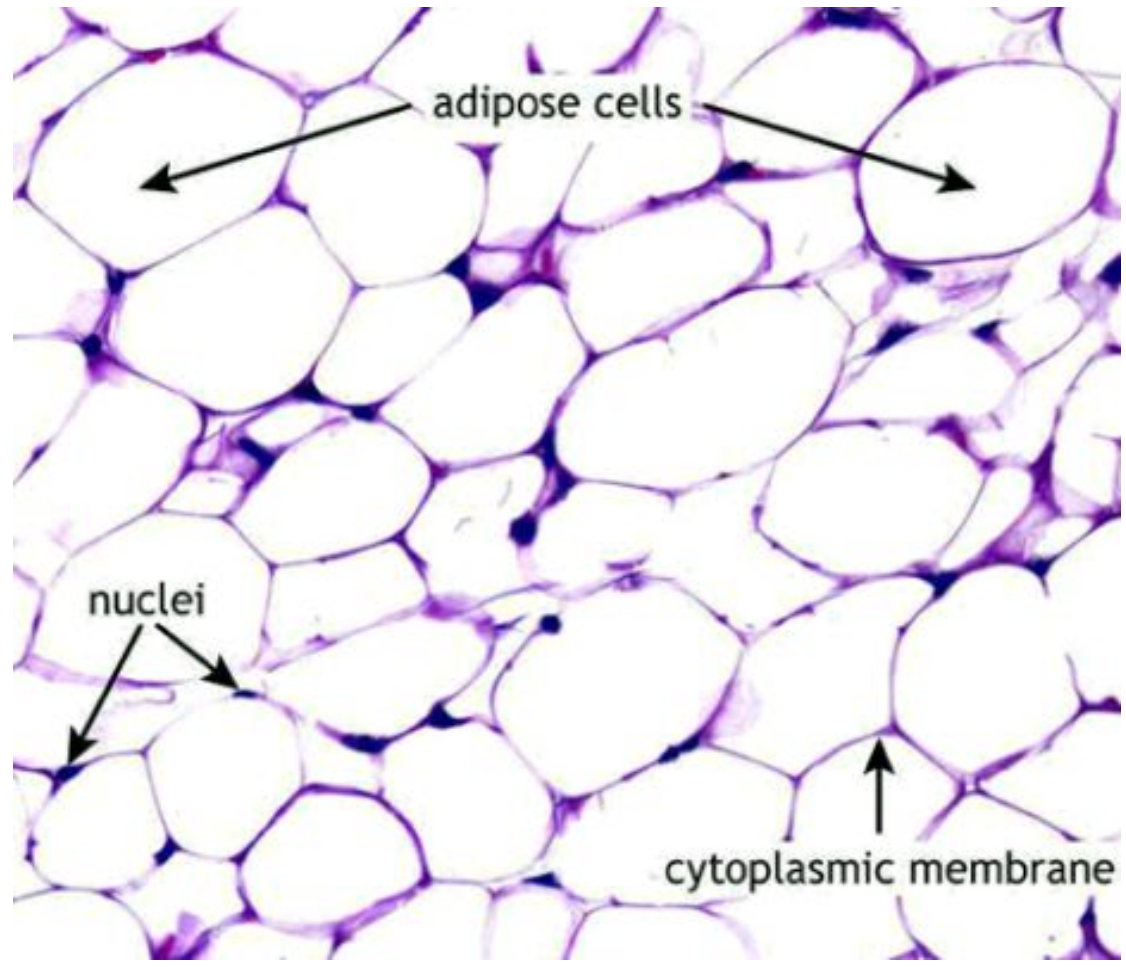
Adipose Connective Tissue

6th lecture
November 26, 2015

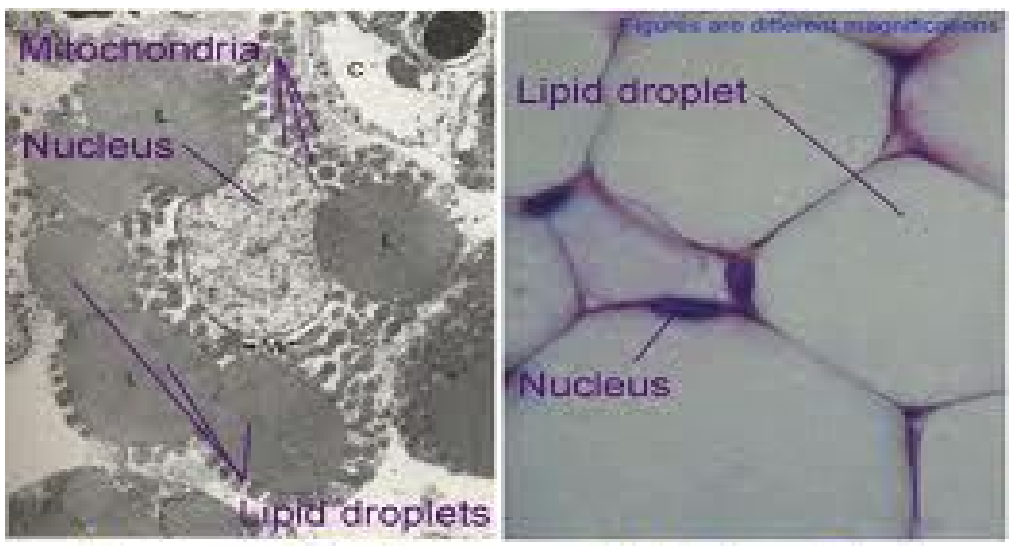
What is the Adipose Tissue?

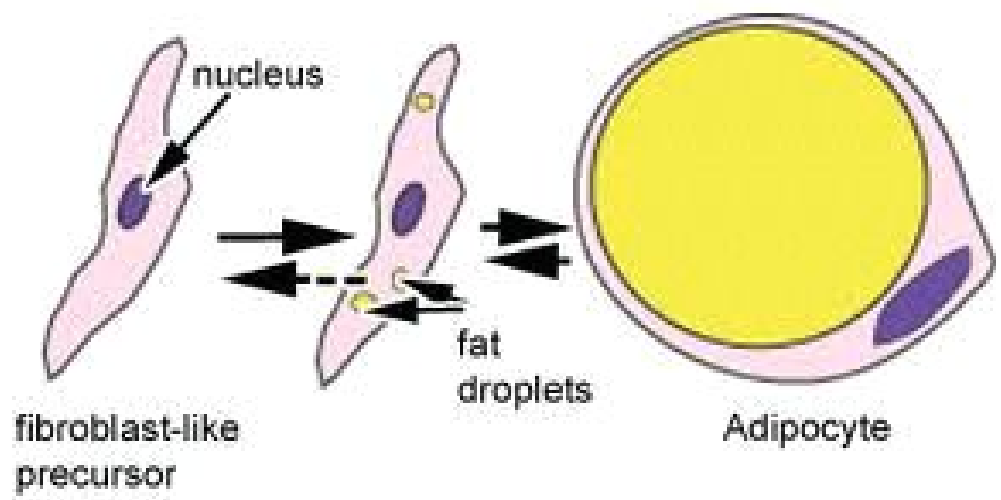
- Is a complex organ that regulates and coordinates energy homeostasis
- Composed of
  - Adipocytes
  - Fibroblasts and fibroblastic pre-adipocytic cells
  - Endothelial cells
  - Nerves
  - Immune cells



What is the Adipose Tissue?

- Originally thought to just be an energy storage
- It is an organ
- Composed of White Adipose Tissue (WAT) and Brown Adipose Tissue (BAT)
- Both types of cells differentiates form mesenchymal stem cells - Adipogenesis





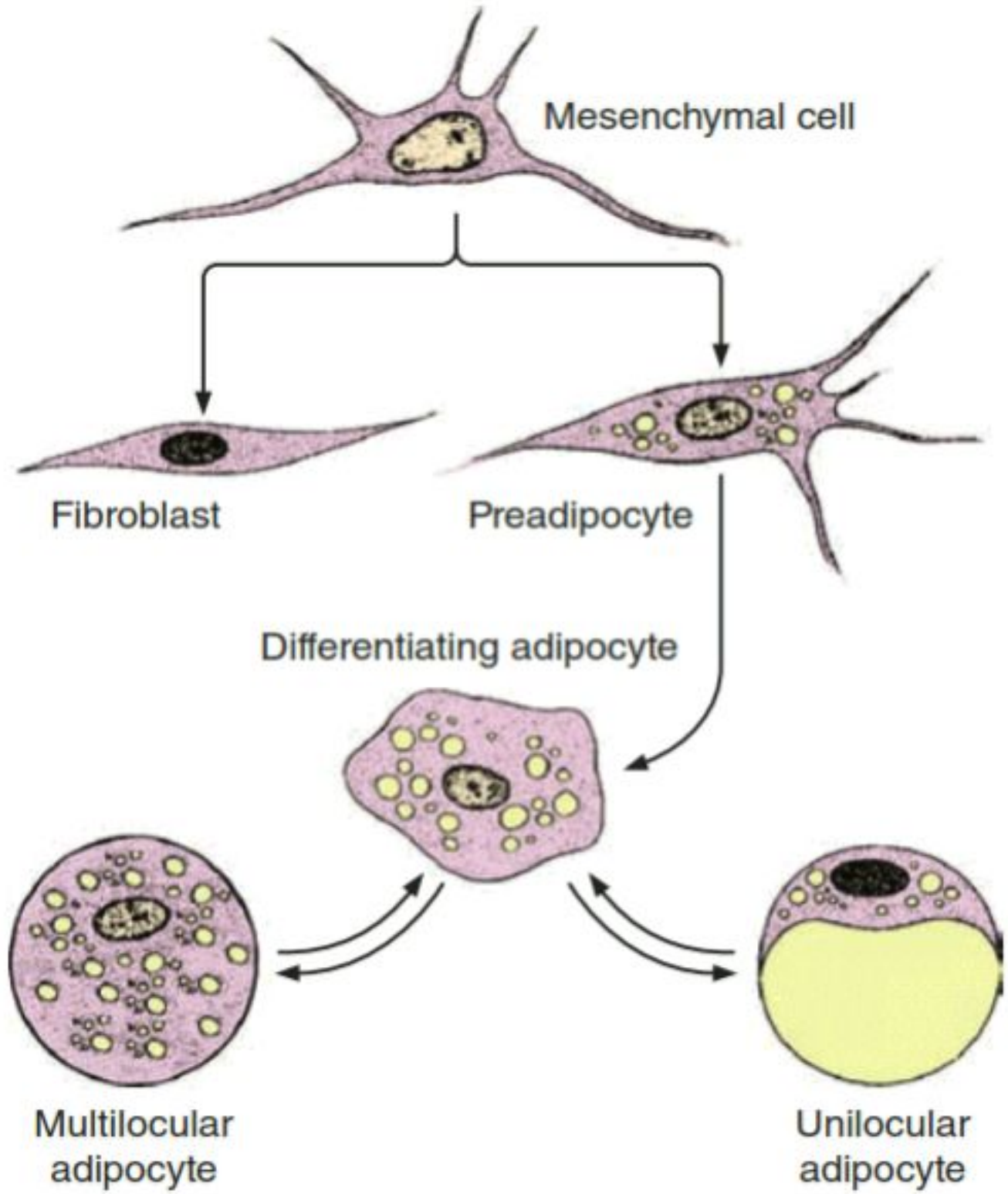
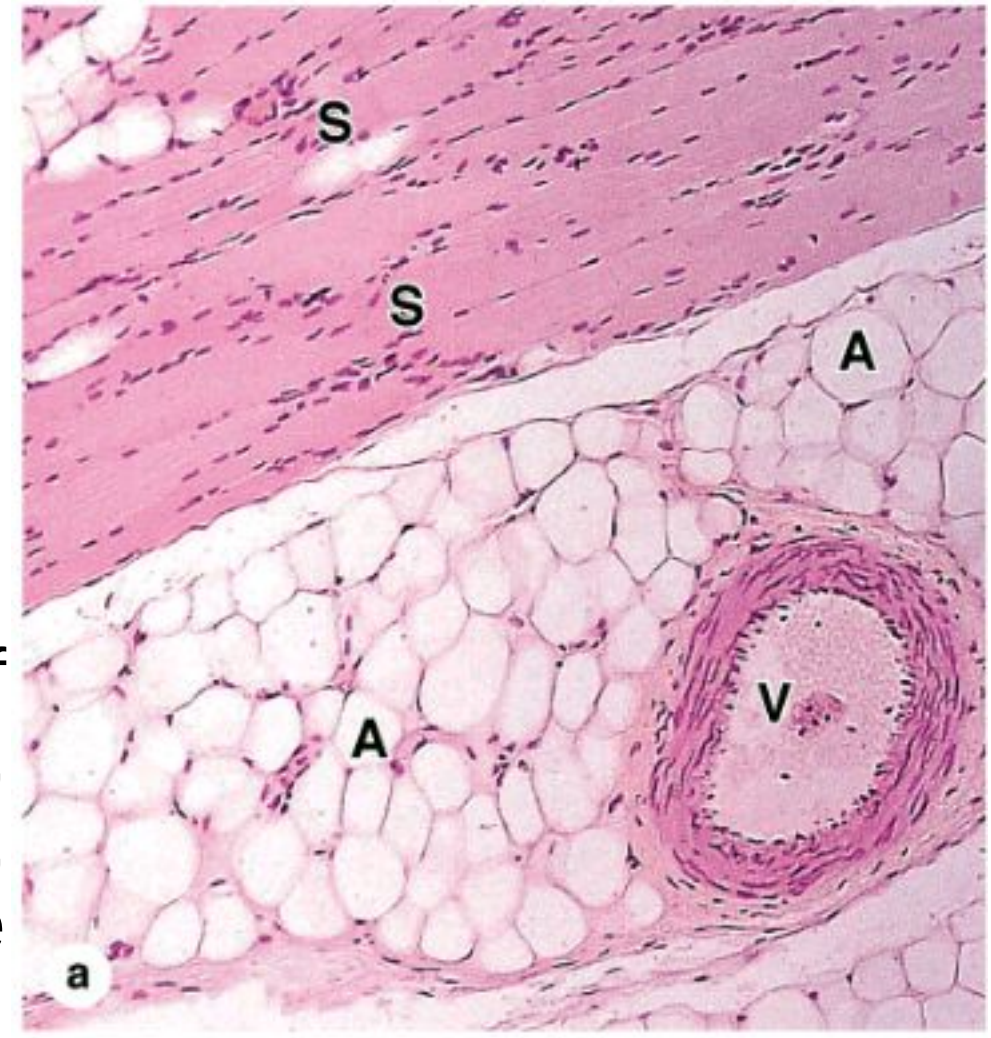


Figure 1: development of white and brown fat cell

Adipose connective tissue:
is located throughout the body, adipose tissue normally represents 15%-20% of the body weight in men, somewhat more in women about 20%-25%.

With a growing worldwide epidemic of obesity and its associated health problems, including diabetes and heart disease, adipocytes and adipose tissue now constitute a major area of medical research.



In this photomicrograph adipocytes (A) are seen in the connective tissue associated with a blood vessel (V) in striated muscle (S). X100. H&E.

The main functions of adipose connective tissue are as following:

1. These cells release hormones and various other important substances, and adipose tissue is now recognized as an important endocrine tissue.

2. Adipose tissue conducts heat poorly and helps thermally insulate the body.

3. Adipose tissue also fills up spaces between other tissues and helps cushion and keep some organs in place.

4. Subcutaneous layers of adipose tissue help shape the body surface, where pad-like deposits act as shock absorbers, chiefly in the soles and palms.

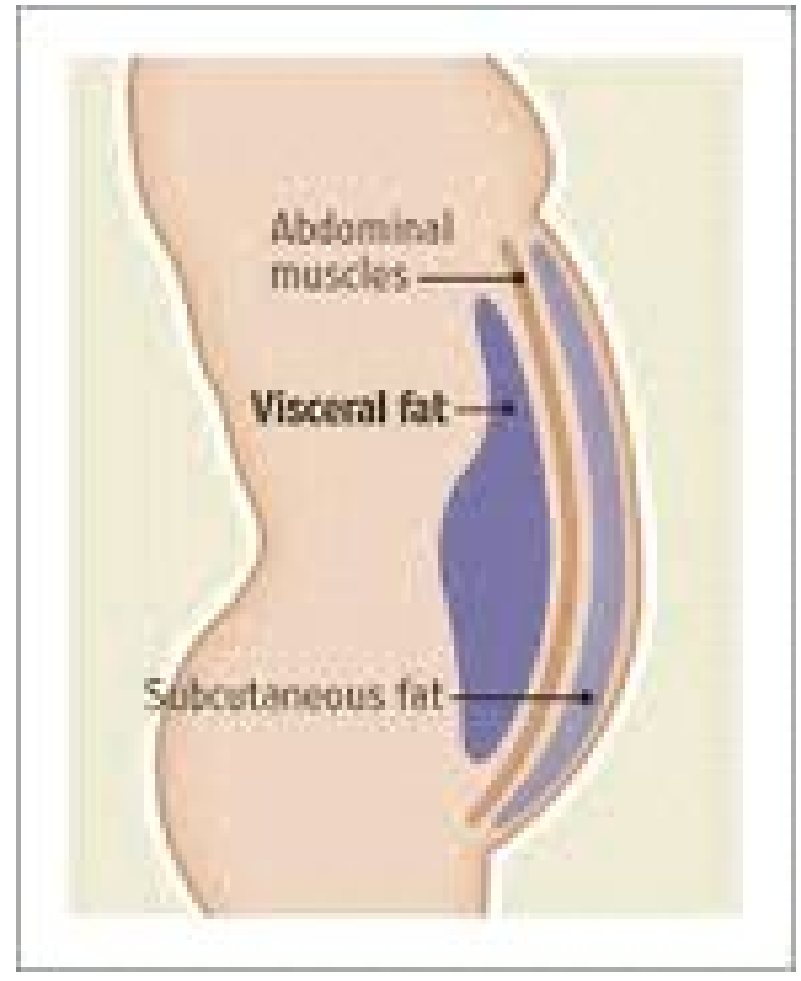
White Adipose Tissue

- It is the main type of adipose tissue and can be found in subcutaneous regions, surrounding visceral organs and in the face

- Contains large unilocular lipid droplets

- Differs between subcutaneous and visceral

- It is an active endocrine organ that regulates
  - Insulin sensitivity and lipid metabolism



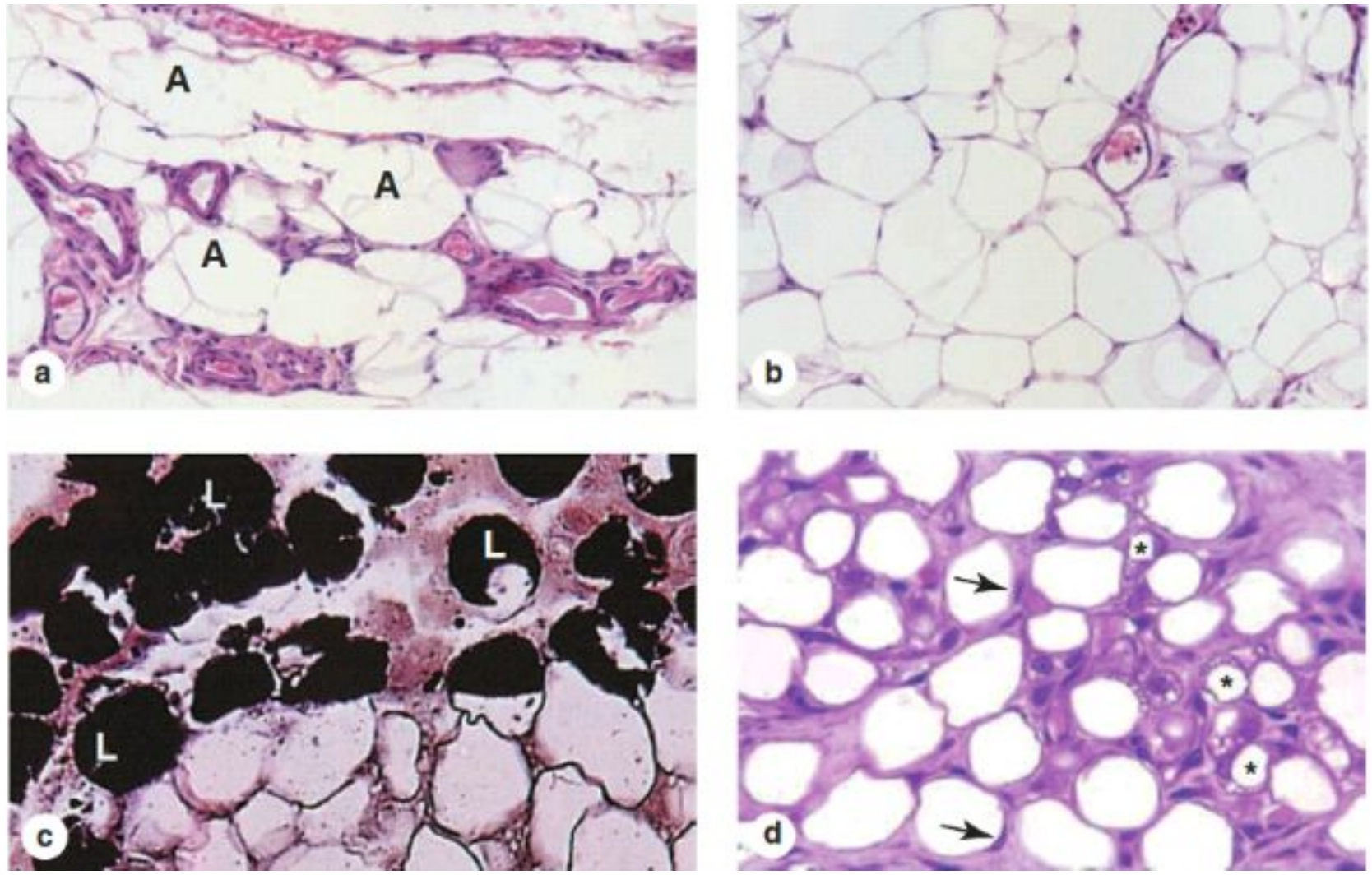


Figure 2: White or unilocular adipose tissue is commonly seen in sections of many human organs. (a) Large white adipocytes (A) are seen in the connective tissue associated with small blood vessels. X100. H&E. (b) Large (empty) adipocytes predominate in this typical white adipose tissue, which shows only a small portion of microvasculature. X100. H&E. (c) Tissue was fixed here with osmium tetroxide, which preserves lipid (L) and stains it black. Many adipocytes in this slide retain at least part of their large lipid droplets. X440. (d) The specimen here was from a young mammal, and the adipocytes marked with asterisks are not yet unilocular, having many small lipid droplets in their cytoplasm, which indicates that their differentiation is not yet complete. The eccentric nuclei of unilocular cells are indicated by arrowheads. X200.

Storage & Mobilization of Lipids

Triglycerides stored by cells of white adipose tissue can be derived from dietary fats brought to adipocytes as circulating chylomicrons, from triglycerides synthesized in the liver and transported as very-low-density lipoproteins (VLDLs), and by the local synthesis of free fatty acids and glycerol from glucose. Chylomicrons (Gr. *chylos*, juice + *micros*, small) are small particles of variable size, up to 1200 nm in diameter, formed Triglycerides are transported by blood and lymph from the intestine and liver in lipoprotein complexes known as chylomicrons (Chylo) and VLDLs. In the capillary endothelial cells of adipose tissue, these complexes are partly broken down by lipoprotein lipase, releasing free fatty acids and glycerol. The free fatty acids diffuse from the capillary into the adipocyte, where they are esterified to glycerol phosphate, forming triglycerides that are stored in the lipid droplet until needed. Norepinephrine from nerve endings stimulates the cyclic AMP (cAMP) system, which activates hormone-sensitive lipase to hydrolyze the stored triglycerides to free fatty acids and glycerol. These substances diffuse into the capillary, where the fatty acids bind albumin for transport throughout the body for use as an energy source.

Mobilization of Triglycerides Stored in Adipose Tissue

Low levels of glucose in the blood trigger the mobilization of triglycerides through the action of epinephrine and glucagon.
cAMP pathway activate hormone sensitive lipase to cause hydrolysis of triglycerides into glycerol and FFA.

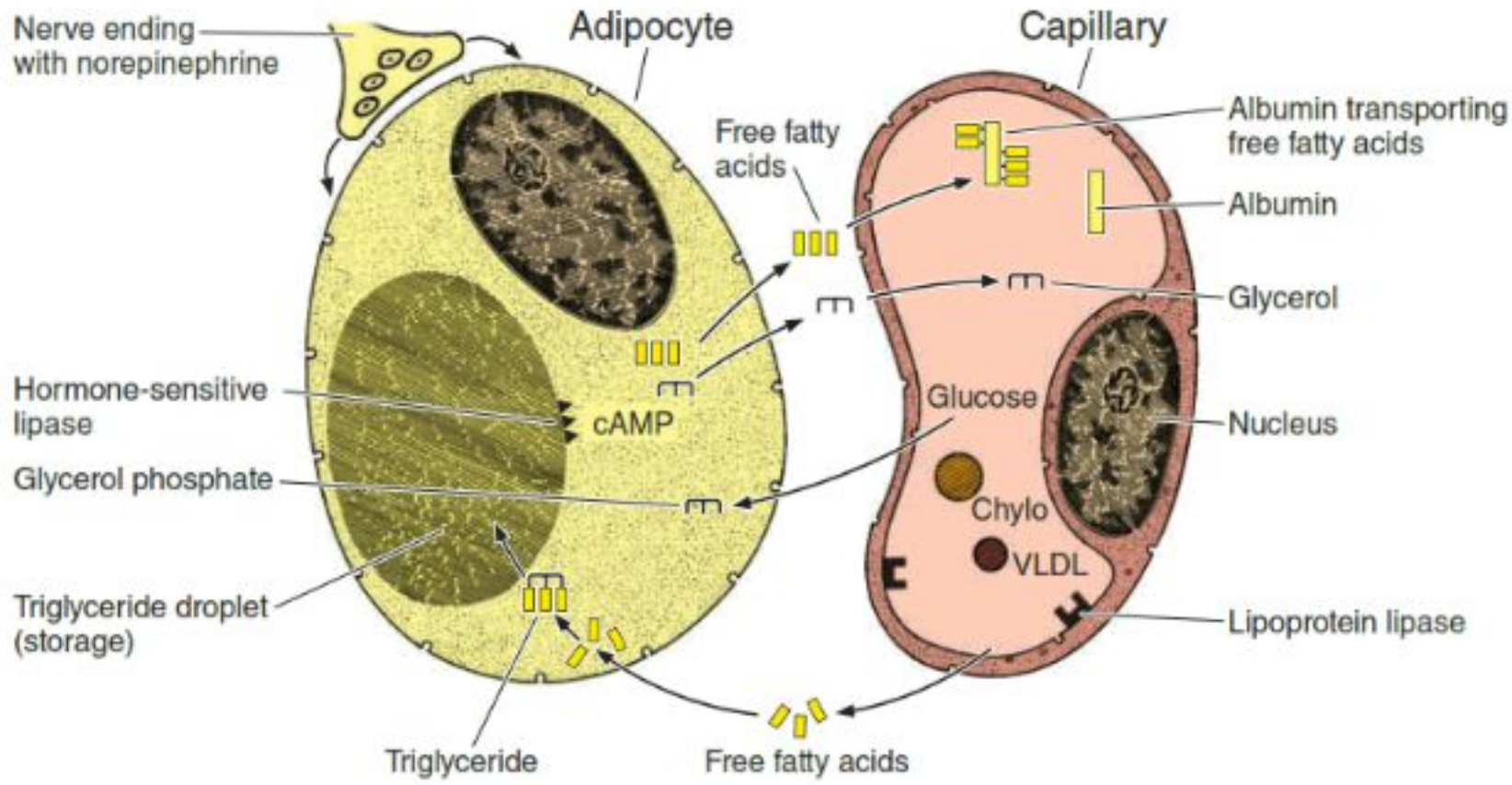


Figure 3: lipid storage and mobilization from adipocyte

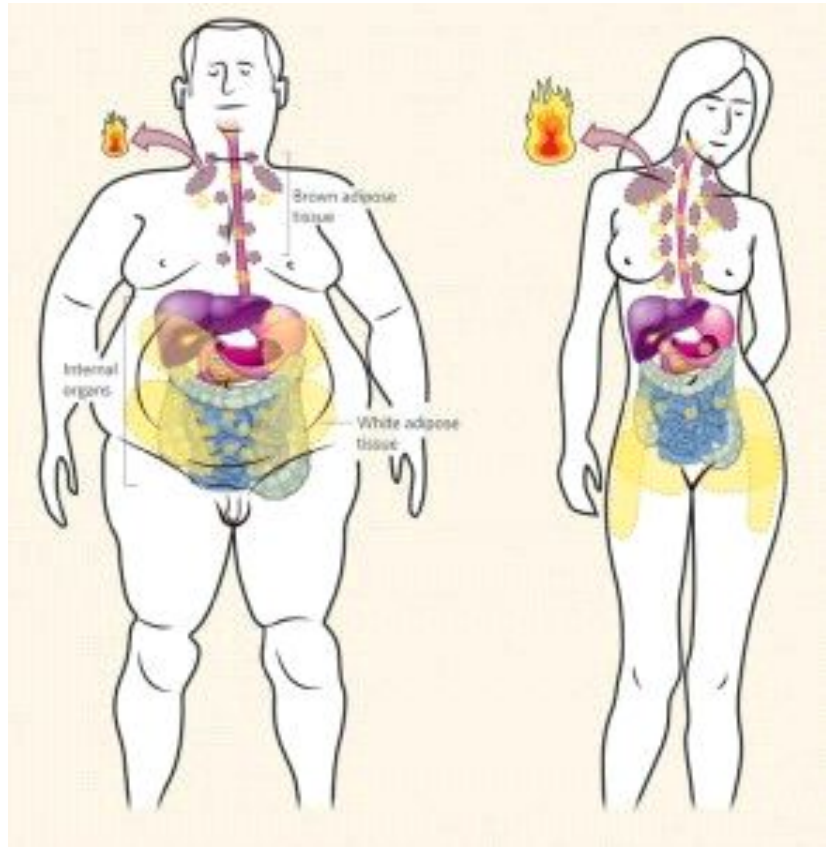
MEDICAL APPLICATION

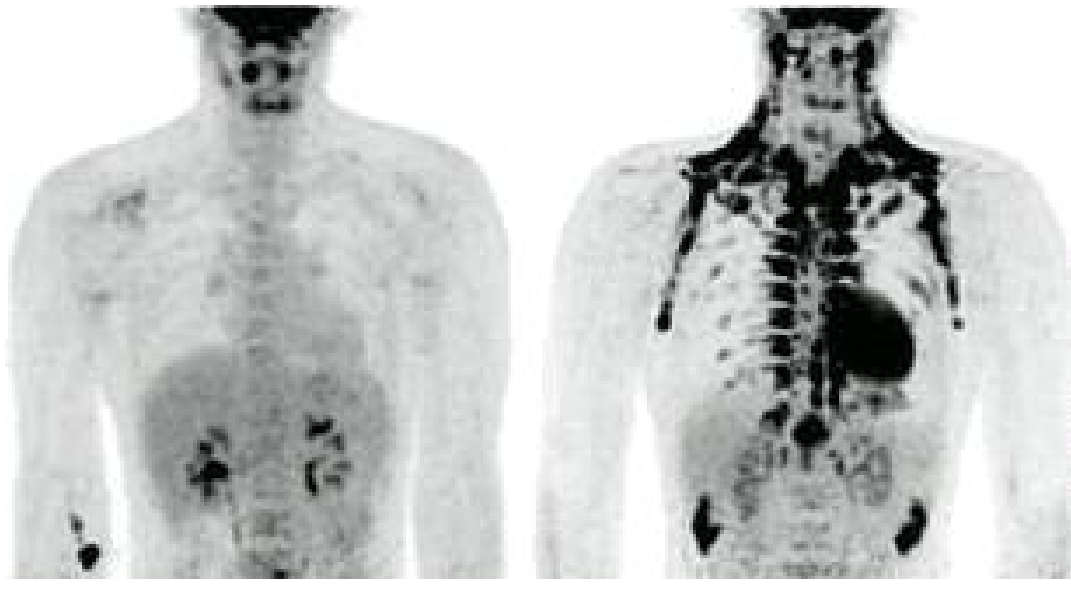
With its increased amounts of white adipose tissue, obesity is characterized by a state of chronic mild inflammation. Cytokines and other factors released from visceral fat are being investigated for links to the inflammation-related disorders associated with obesity such as diabetes and heart disease.

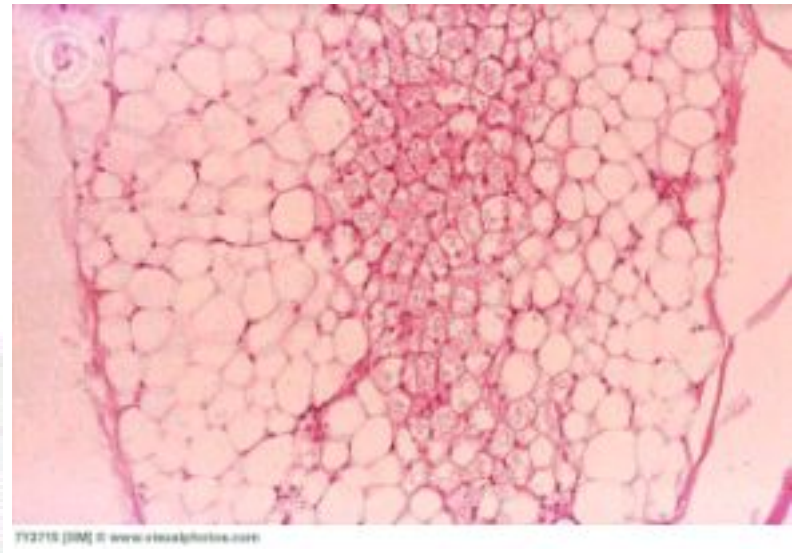
Brown Adipose Tissue

- Mainly participates in Thermogenesis
- Located in separate pockets in the paravertebral, supraclavicular and periadrenal regions

- Histologically different from WAT
  - Multiloculated adipocytes
  - Large number of mitochondria (brown colour)







Brown adipose tissue

- contains cells with multiple lipid droplets interspersed among abundant mitochondria, which give these cells a darker appearance.
- Both types of adipose tissue have a rich blood supply.
- In humans the amount of brown fat is maximal relative to body weight at birth, when thermogenesis is most needed and partially disappears by apoptosis and involution during childhood.
- In adults the amount and activity of brown fat are higher in slim individuals.
- The number of brown adipocytes increases during cold adaptation in adults, usually appearing as clusters of multilocular cells in white adipose tissue. Besides stimulating thermogenic activity, autonomic nerves also promote brown adipocyte differentiation and prevent apoptosis in mature brown fat cells.
- These cells each contain primarily one large lipid droplet (they are unilocular), causing the nucleus and remaining cytoplasm to be pushed against the plasmalemma. Brown Adipose Tissue Brown fat comprises up to 5% of the newborn body weight but smaller amounts in adults. Adipocytes of this tissue are typically smaller than those of white fat and contain primarily many small lipid droplets (they are multilocular) in cytoplasm containing many mitochondria and a central nucleus.

Function of Brown Adipocytes

The main function of the multilocular adipose cells is

- to produce heat by thermogenesis.

As In white fat, the neurotransmitter activates the hormone-sensitive lipase of adipocytes, promoting hydrolysis of triglycerides to fatty acids and glycerol. However, unlike the process in white fat, liberated fatty acids of multilocular adipocytes are not released but are quickly metabolized, with a consequent increase in oxygen consumption and heat production. This raises the temperature

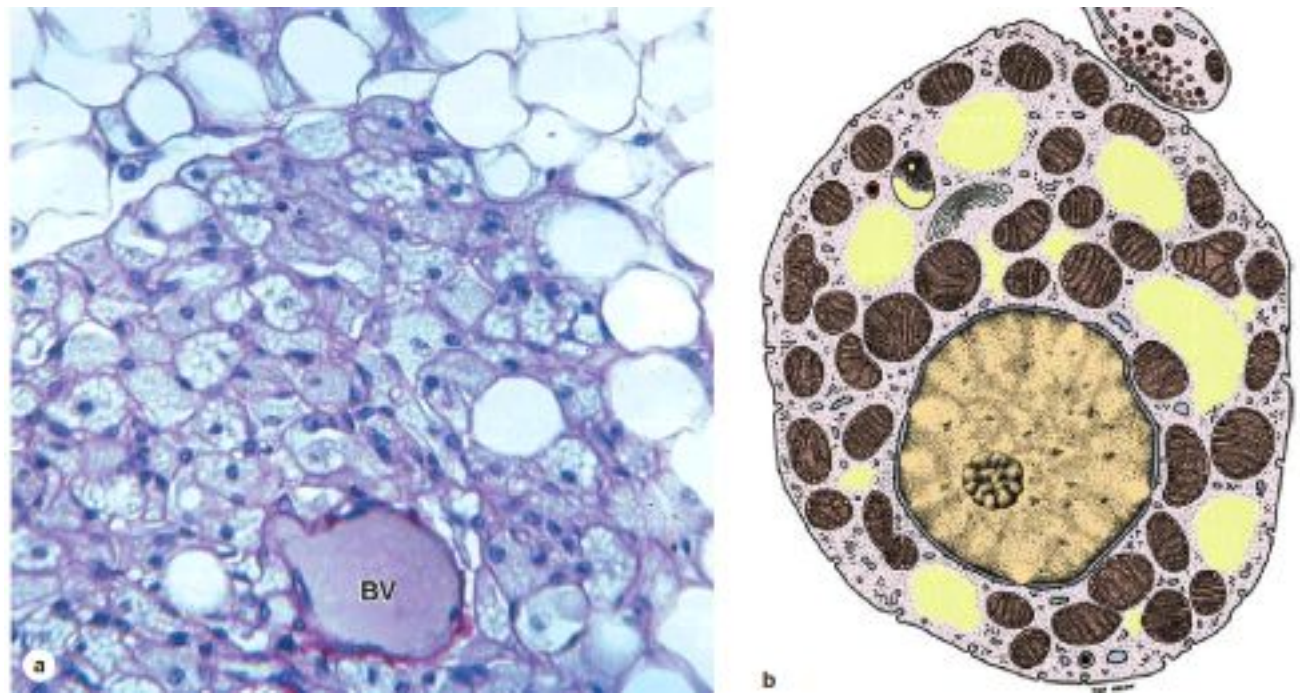


Figure 4: (a) Brown adipose tissue is shown here around a small blood vessel (BV) and adjacent white adipose tissue at the top of the photo. Brown adipocytes are slightly smaller and characteristically contain many small lipid droplets and central spherical nuclei. If the lipid has been dissolved from the cells, as shown here, the many mitochondria among the lipid spaces are reserved and can be easily distinguished. X200. PT. (b) A diagram of a single multilocular adipocyte showing the central nucleus, numerous small lipid droplets (yellow), and many mitochondria.

MEDICAL APPLICATION

Unilocular adipocytes can generate very common benign tumors called lipomas. Malignant adipocyte- derived tumors (liposarcomas) are infrequent in humans.