General synarthrology

I. Types of joints
II. Types of synarthroses
III. Diarthroses
a) Obligatory elements
b) Auxilliary elements
c) Characteristics of the diarthroses elements
d) Movements of joints
e) Classification of joints
f) Functional characteristics of joints
IV. Amortizing factors of the human body
V. Specific features of the joints of the trunk and limbs
V. Development of the joints
VI. Methods of examination of the joints

Author: PhD, professor Tamara Hacina

General synarthrology

1. **JOINTS, or places where the bones come together, permit the bones to move without damaging each other.**

2. **Joints are responsible for keeping bones far enough apart so they do not rub against each other as they move. At the same time, joints hold the bones in place.**

There are 360 joints in the human body. There are 86 skull joints, 6 throat joints, 66 thorax joints and 76 in the spine and pelvis.

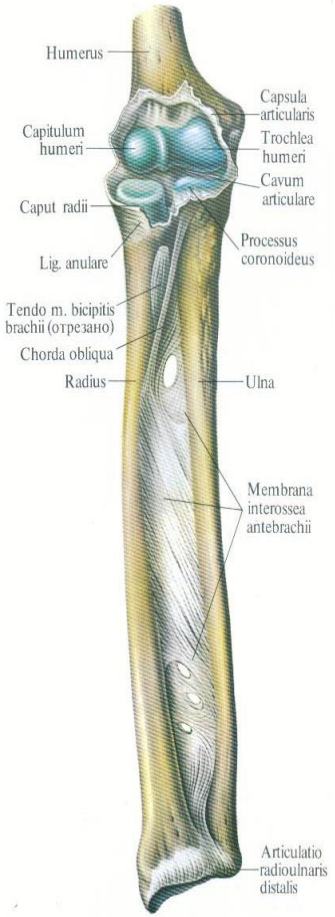
Also there are 32 in each upper limb and 31 in each lower limb.

Types of bone joints

I.Contiguous articulations

=

Synarthroses



II. Transitional form

=

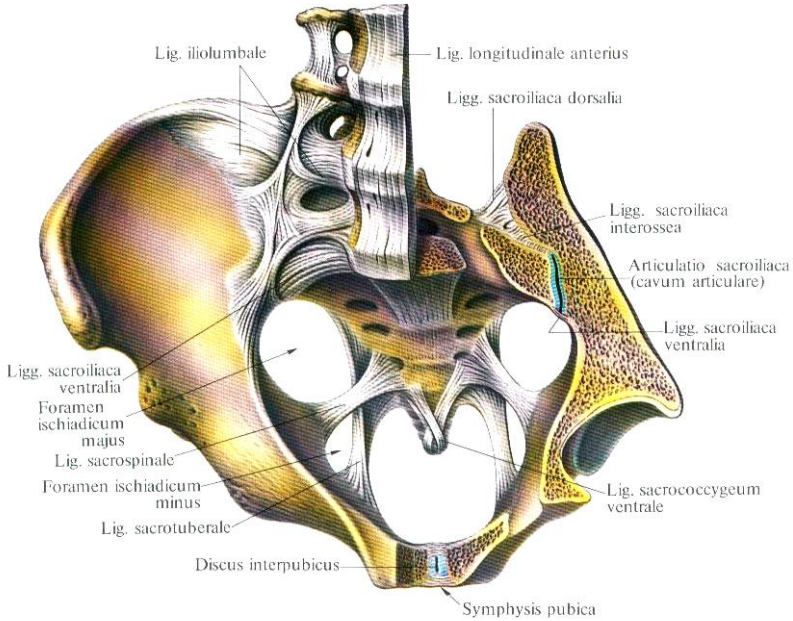
Symphyses

=

Hemiarthroses

=

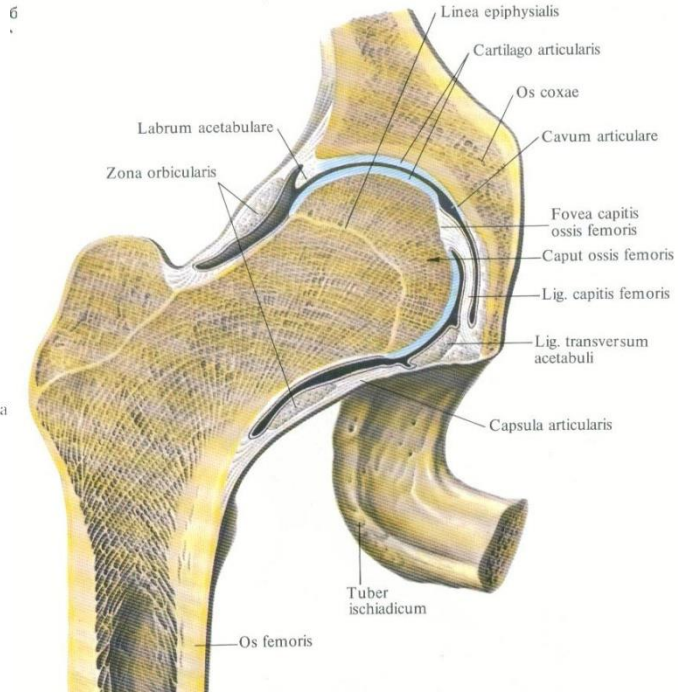
Half-joints



III. Interrupted articulations

=

Diarthroses



Types of synarthroses

I. ***Syndesmoses*** ***/by means of soft connective tissue/***

****ligaments*** /c/t between the bones forms fibrous bundles/:

synelastoses /composed of elastic c/t/

synfibroses /-- of collagen fibers/

****membranes*** /c/t fills a large space between the bones/

****fontanells*** /wide remnants of the primary connective

tissue between the skull bones/

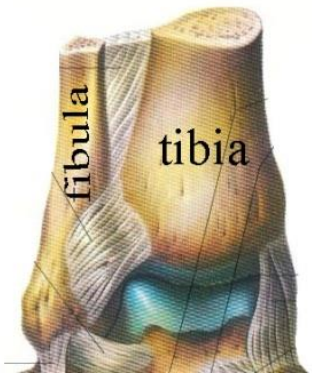
serrate

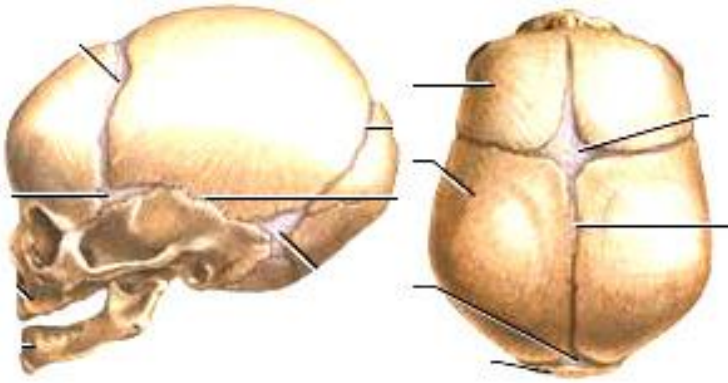
****sutures*** squamous

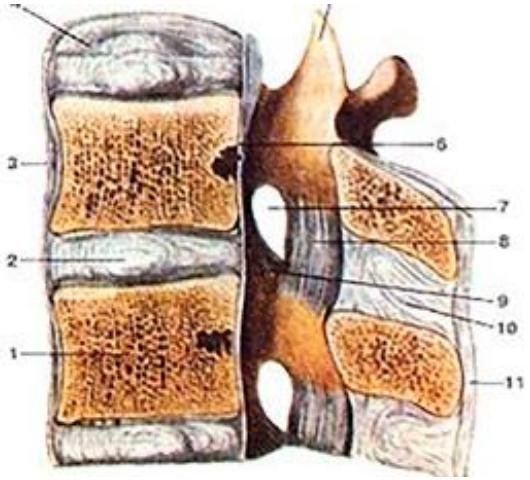
plane = flat

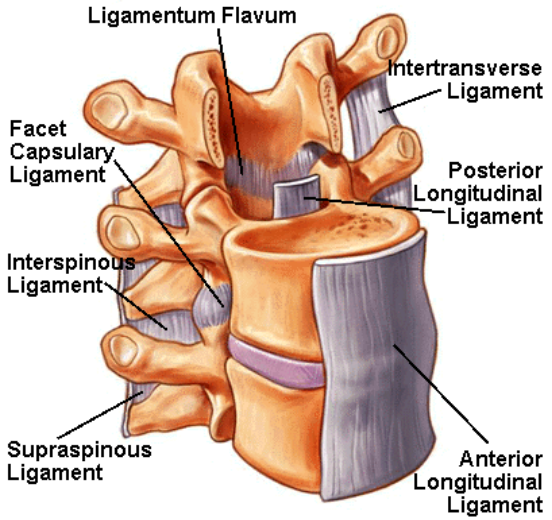
****gomphoses*** /connection of the tooth tc walls

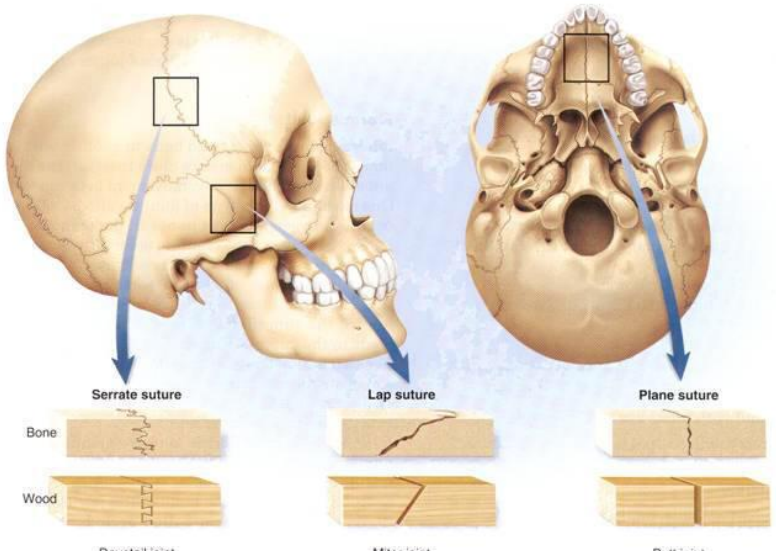
of the sockets by collagen fibers/

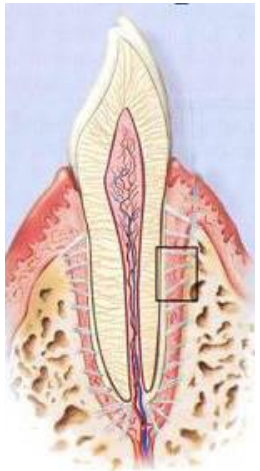












Types of synarthroses

II. Synchondroses ***/by means of cartilage/***

a) according to the duration of their existence:

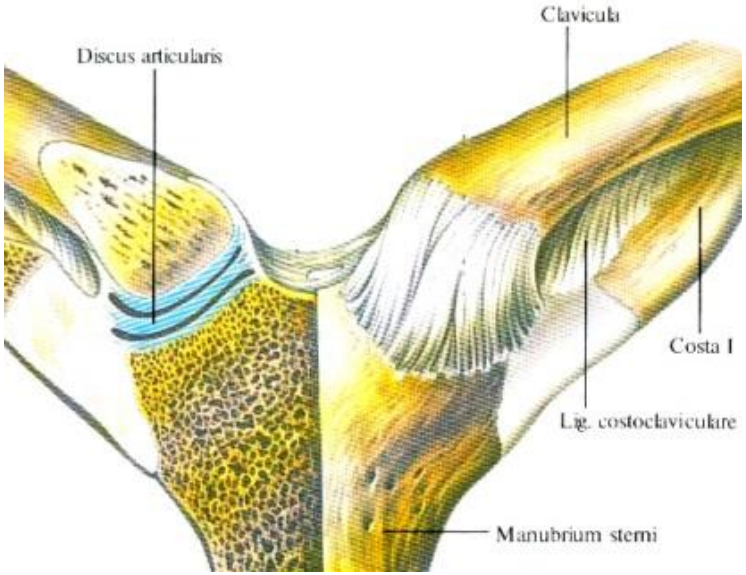
- temporary
- permanent

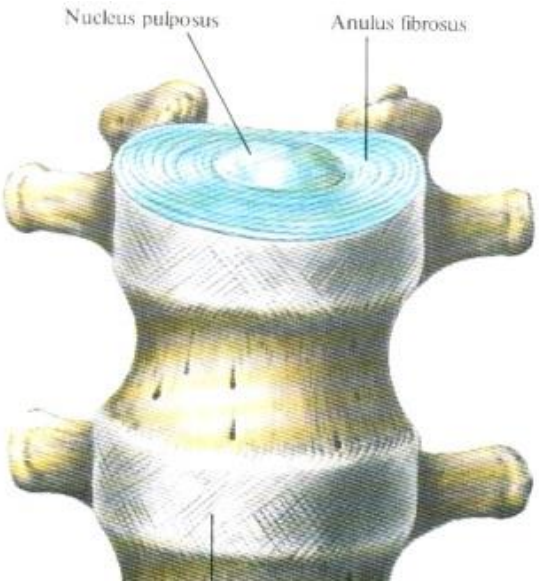
b) according to type of cartilaginous tissue:

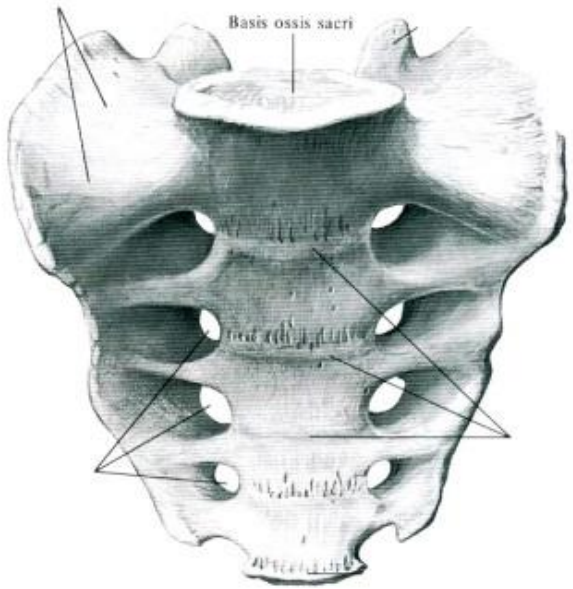
- hyalinic
- fibrous

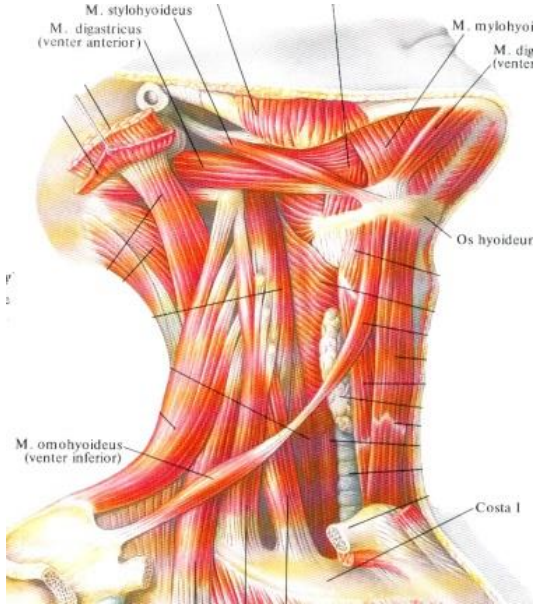
III. Synostoses /by means of bony tissue/

IV. Synsarcoses /by means of the muscles/





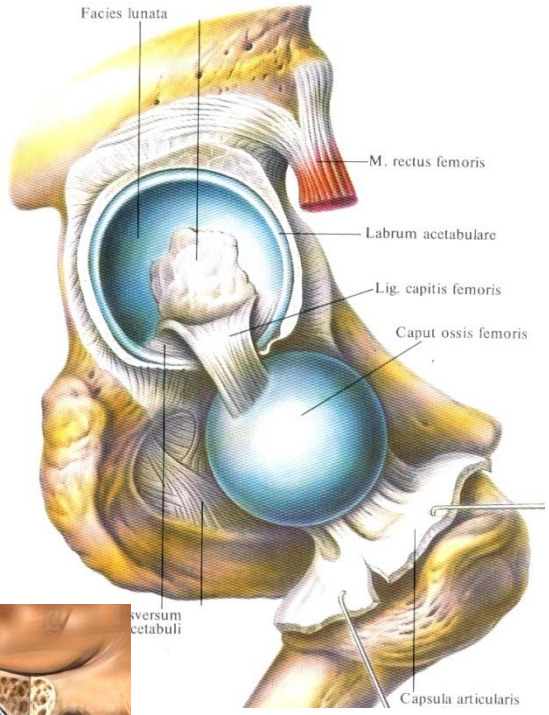




Interrupted articulations =Diarthroses

Obligatory elements

1) congruent articular surfaces
2) articular capsule
3) articular cavity



Auxiliary apparatus

1)Ligaments

*Intracapsular

*Capsular

*Extracapsular

2) Intraarticular cartilages

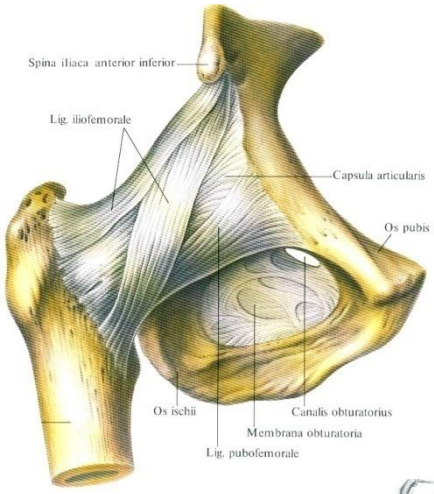
*Discs

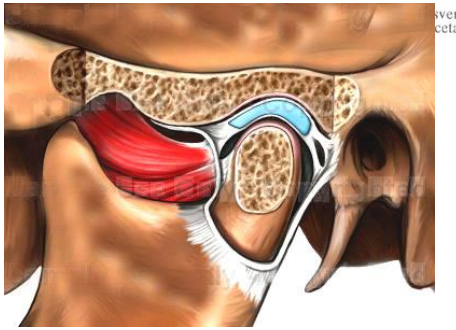
*Menisci

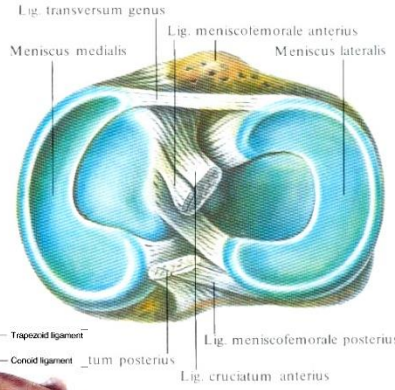
*Cartilaginous rims /labrum/

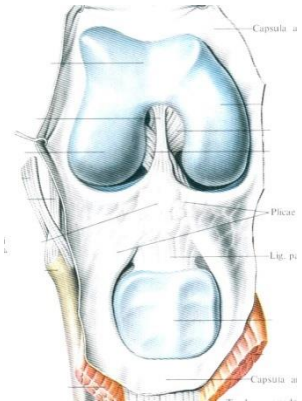
3) sesamoid bones

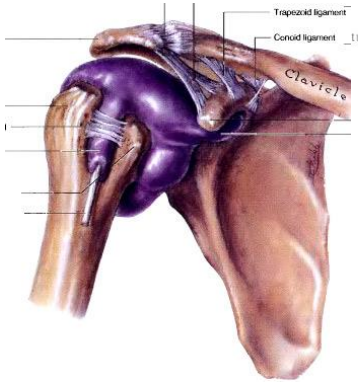
4) synovial vagines and bursae











MORE OFTEN THE <u>DIARTHROSIS</u> IS A FREELY MOVABLE JOINT.

Obligatory elements of the diarthroses

1) articular surfaces: **are covered by articular hyaline less frequently fibrous cartilage;**

2) articular capsule:

*** it encloses the joint cavity hermetically;**

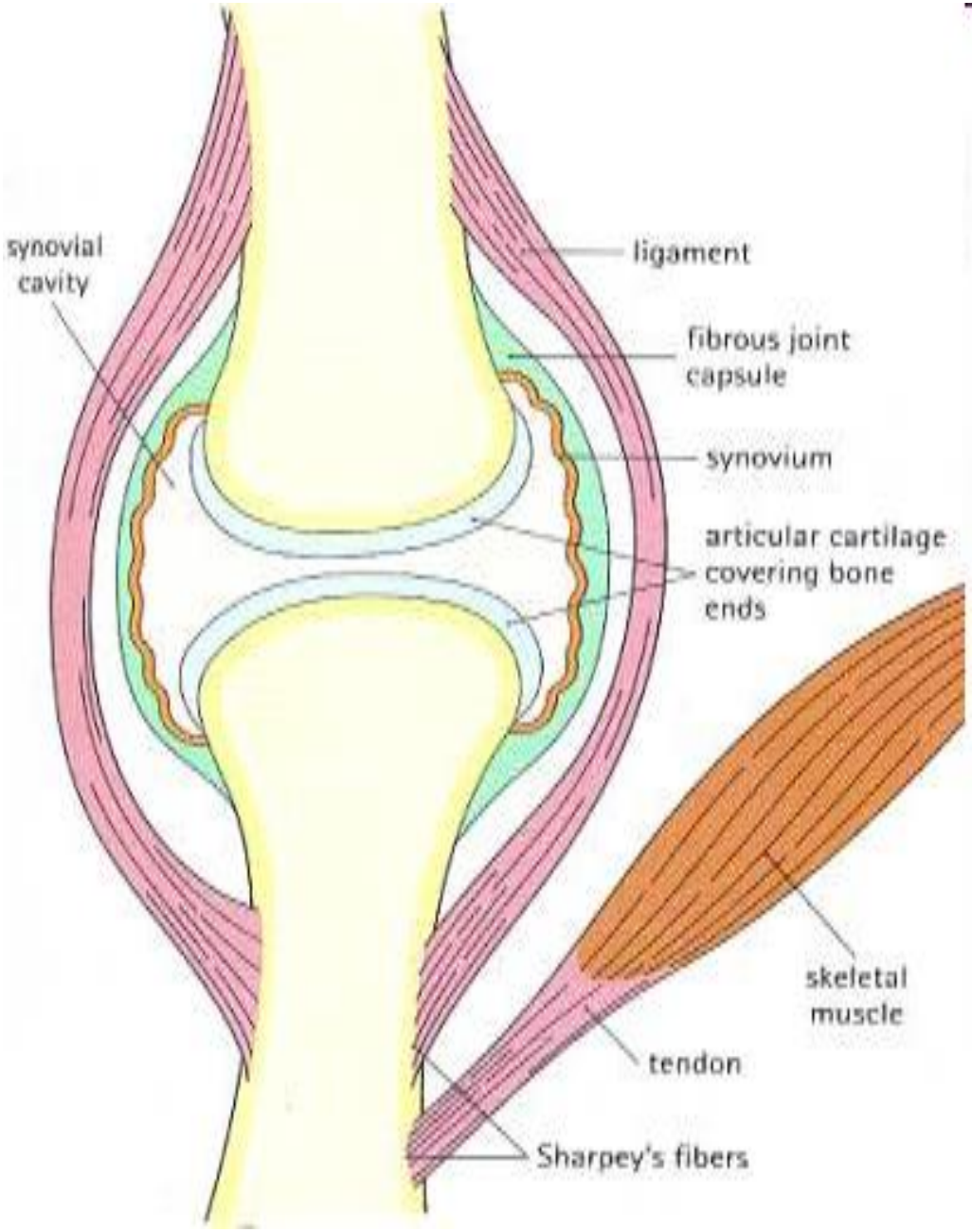
*** is attached to the articulating bones along the margin of the articular surfaces or at some distance from them;**

*** consists of an *outer fibrous membrane* and an *inner synovial membrane:***
-secrets a sticky, clear *synovial fluid* into the cavity of the joint /synovia/;

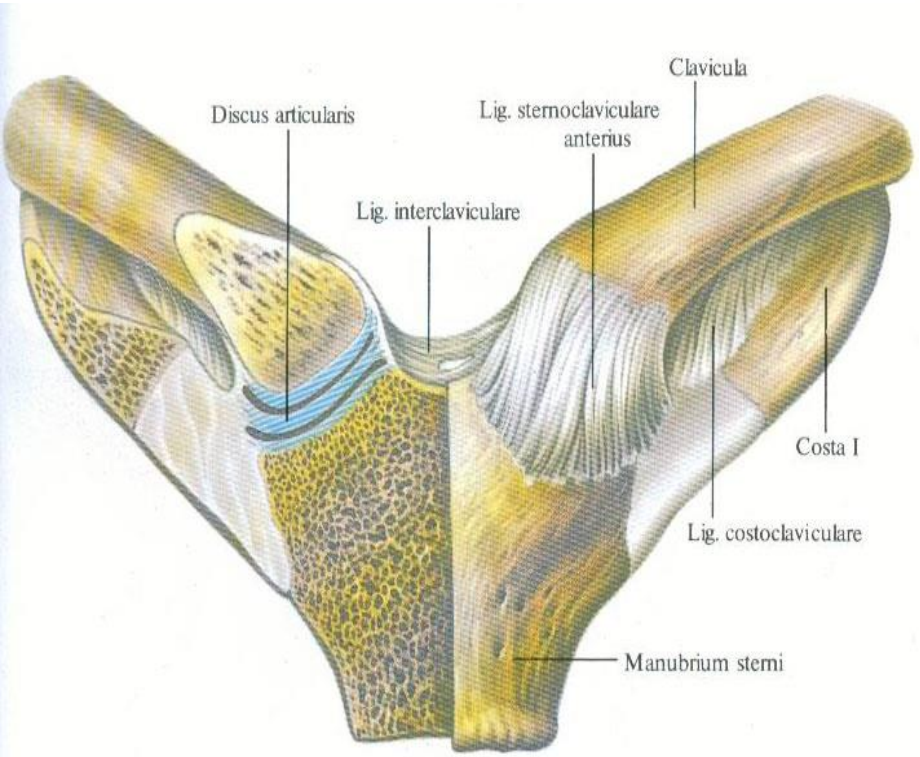
3) joint cavity:

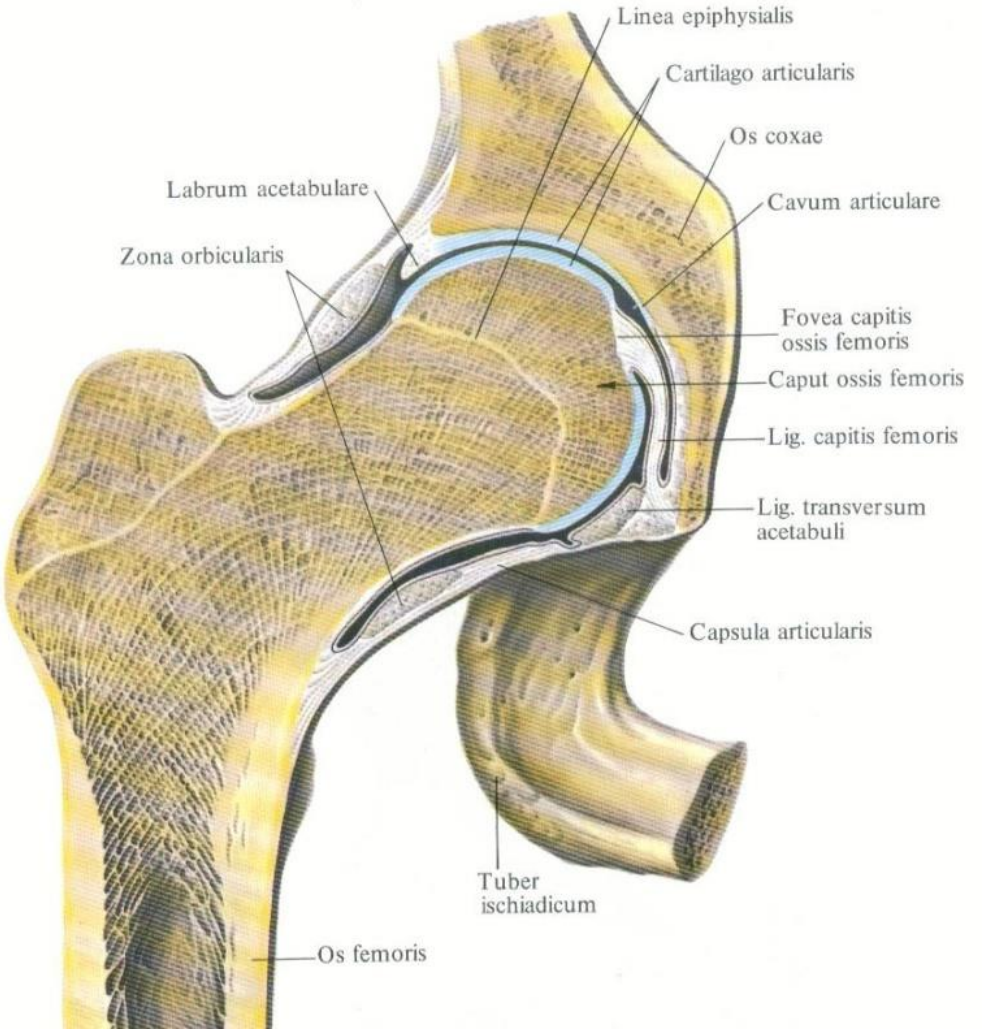
*** it is a closed, air-tight slit bounded by the articular surfaces and the synovial membrane**
•under normal conditions it contains synovial fluid.

!!! the pressure between the articular surfaces is negative /below that of the atmospheric/

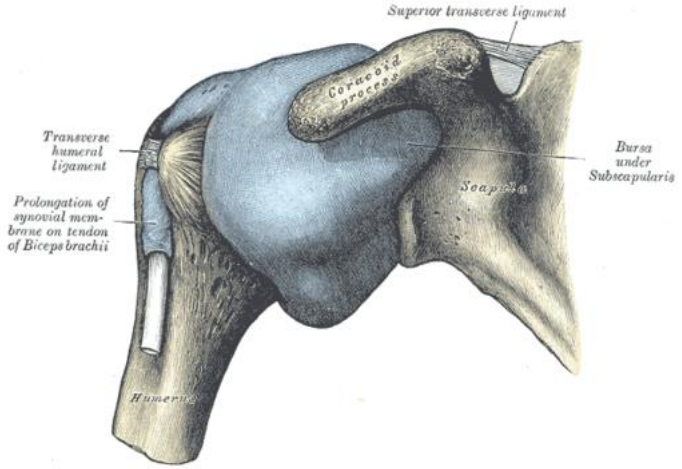


Articular capsule: its attachment to the articulating bones along the margin of the articular surfaces or at some distance from them



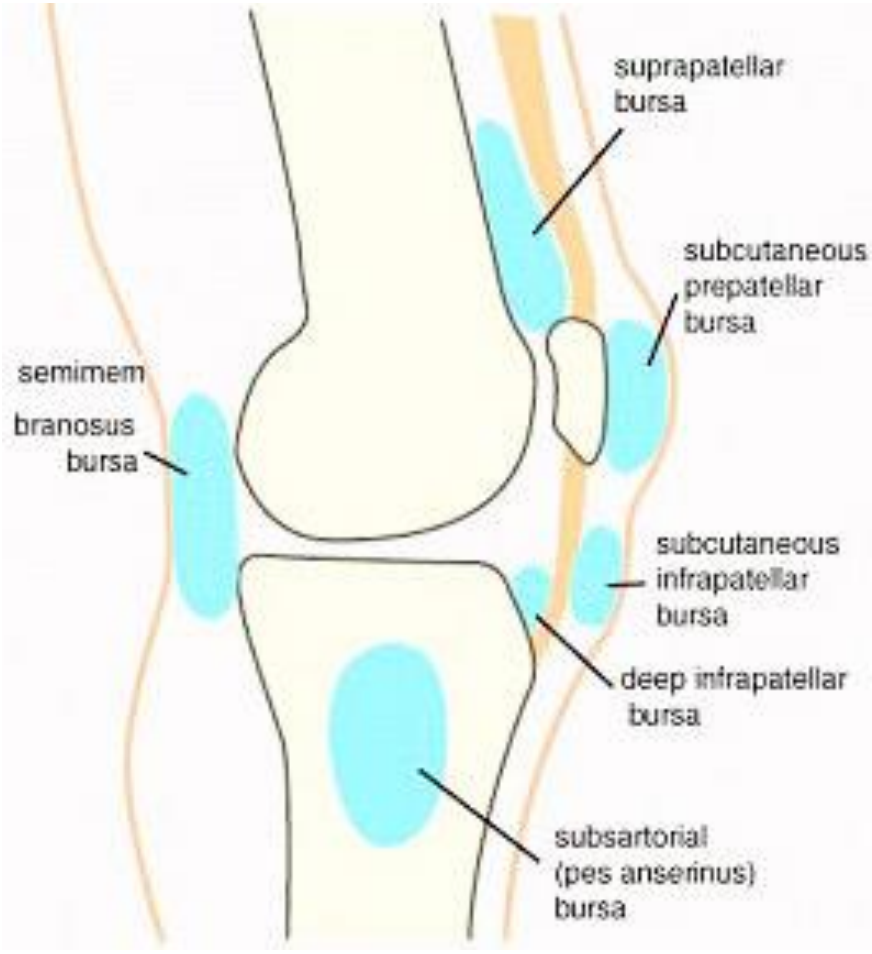


Synovial bursae

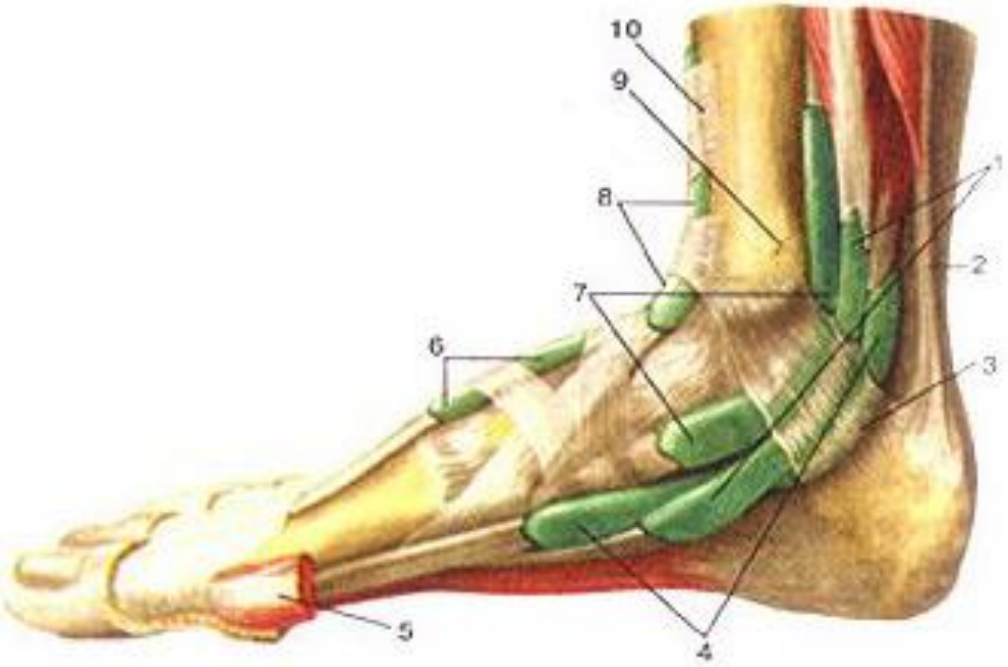


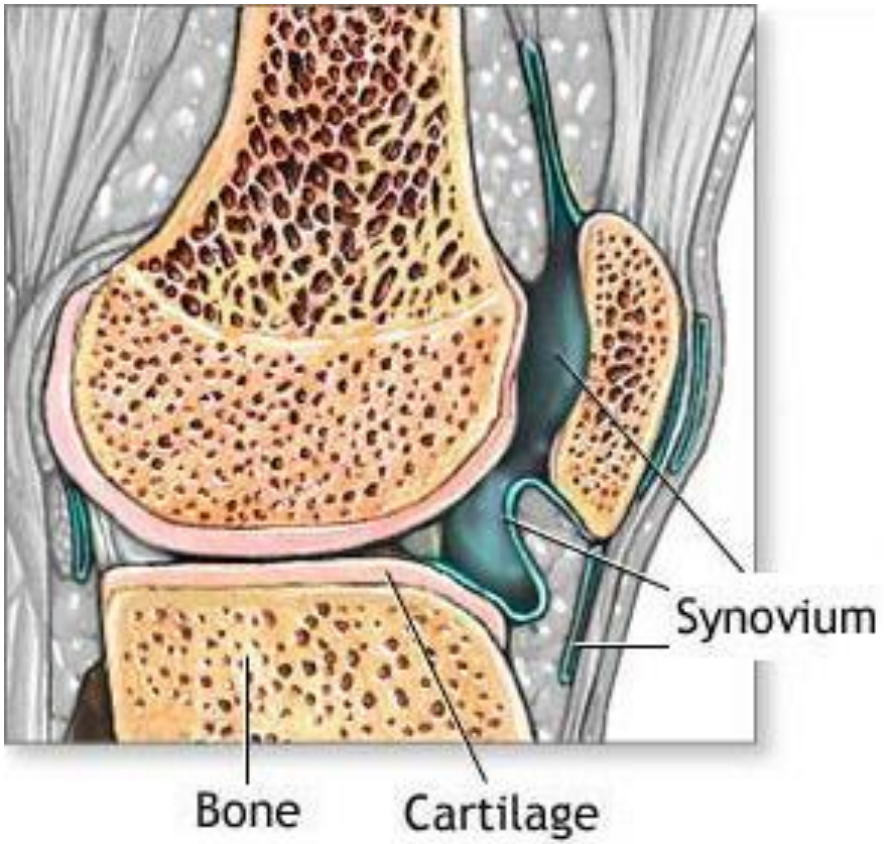
- **in some places synovial membrane forms large and small *synovial folds*, which protrude into the joint cavity, some of these folds contain a large amount of fat growing into them from outside as a result of which fatty pads forms;**
- **saccular protrusions or evertions of the synovial membrane form sometimes the *synovial bursa*, which are found around the tendons or under muscles located close to the joint, are filled with synovia and reduce the friction**

A **bursa** (plural **bursae**) is a small fluid-filled sac lined by synovial membrane. It provides a cushion between bones and tendons and/or muscles around a joint. This helps to reduce friction between the bones and allows free movement. Bursae are filled with synovial fluid .



Role of the auxiliary apparatus





Synovial vagines and bursae – an enclosed cavity filled with an oily substance which facilitates the movement of one ligament or tendon over another or over a bone.

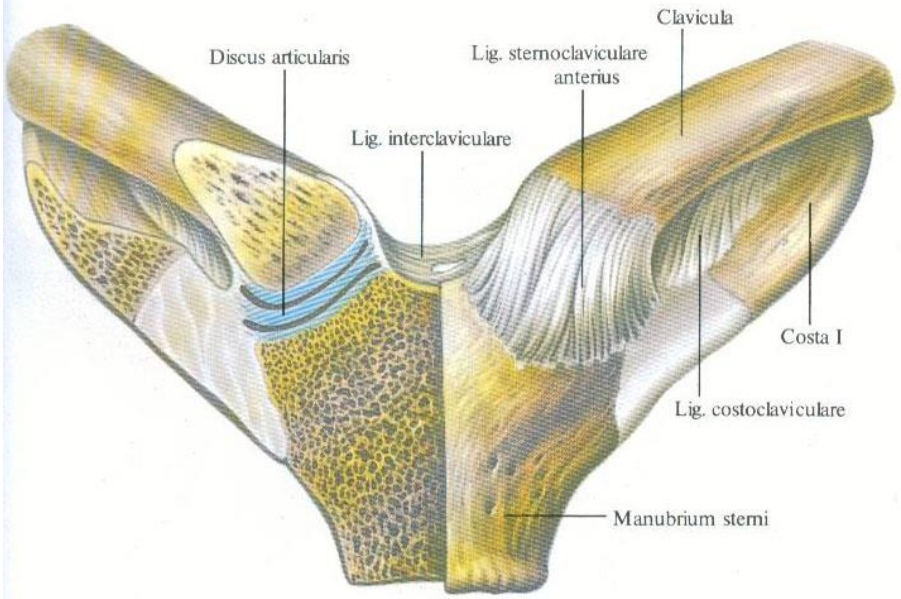
Role of the auxiliary apparatus

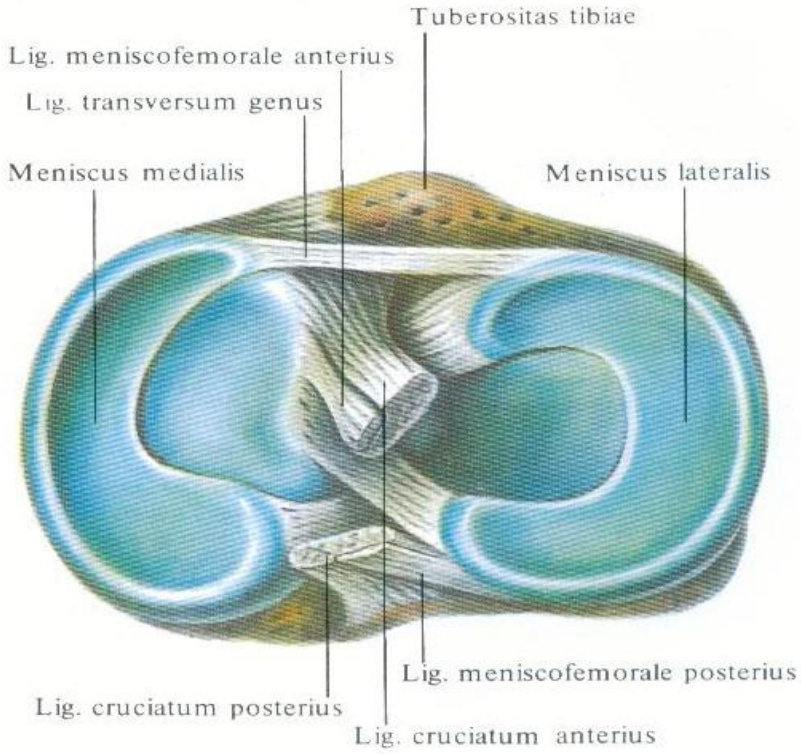
Intraarticular cartilages

* **serve to level out incongruent articular surfaces;**

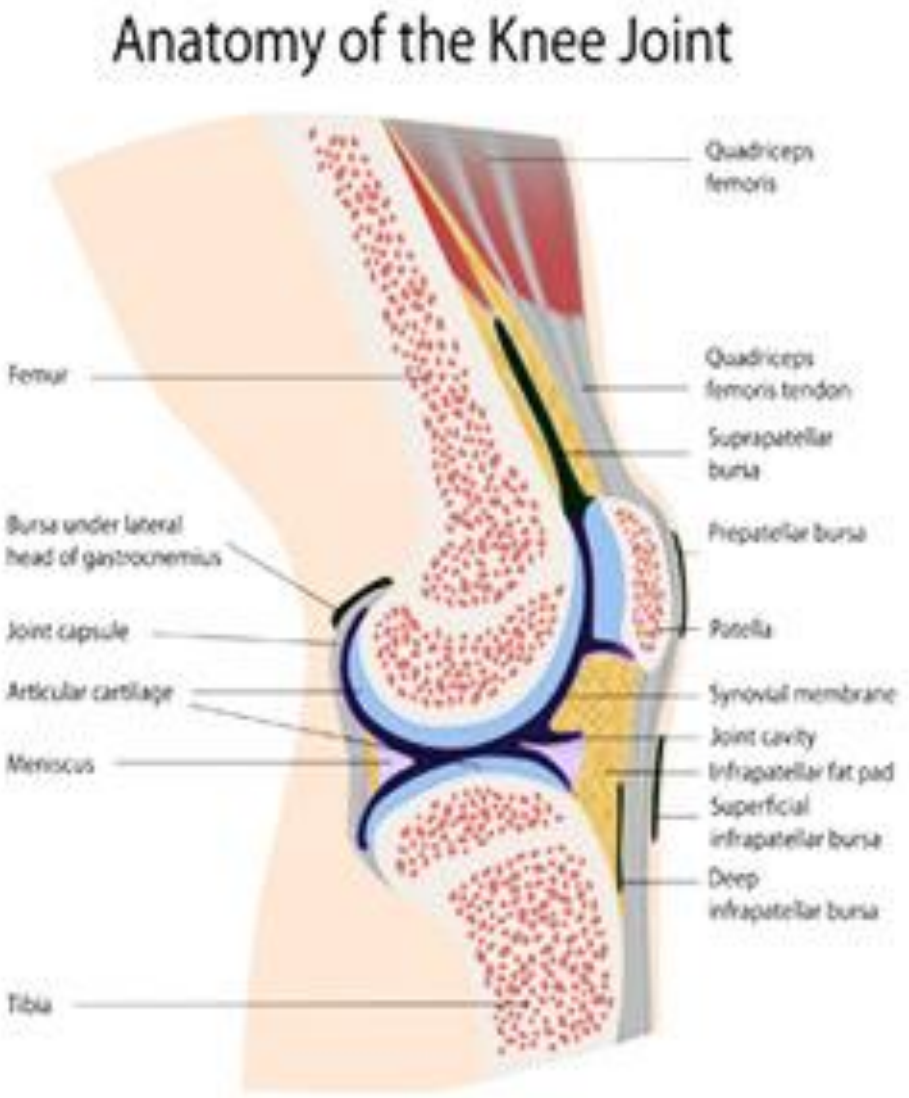
* **form new functional demands, as a response to complicated and increased static and dynamic load;**

* **posses strength and elasticity: resists jolts and facilitate movements at the joints.**





Role of the auxiliary apparatus



Ligaments and muscles with the sesamoid bones

***constitute the auxiliary strengthening apparatus of the joint.**

Characteristics of the diarthroses elements

I. The Protection Structures

1.The fibrous membrane of the capsule

It is very resistant and little flexible sleeve, a prolongation of the periosteum.

It ensures the mechanical protection of the joint.

2. The synovial membrane of the capsule

It is well irrigated and rich in histiocyste cells - it is a part of the mononuclear phagocyte system.

It ensures the protection of the joint against germs and upkeeps the articulatory tissues.

II. Structures of pressure amortization

These are structures with the essential role of reducing, amortizing and dispensing the pressure that is exerted in the joint.

1.The cartilage

It is hyaline cartilage that protects the articular surfaces against attrition.

Its extention is directly related to the amplitude of the movement.

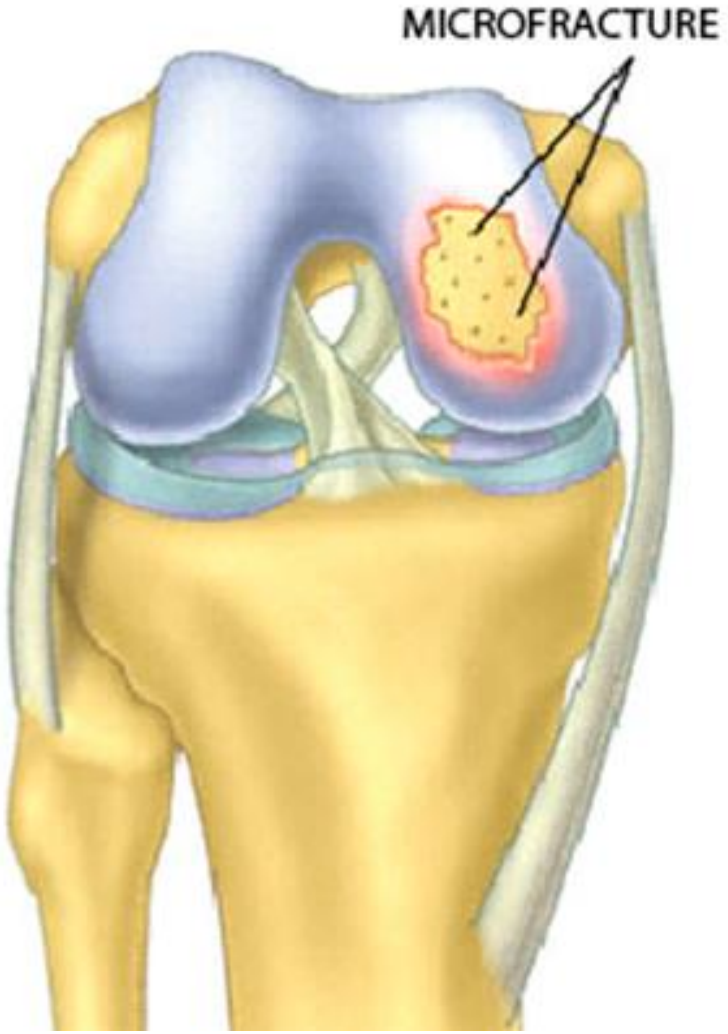
Its thickness is proportionally related with the pressure exerted on a surface unit.

It is deformable in all directions and may loose 15% of its thickness under pressure.

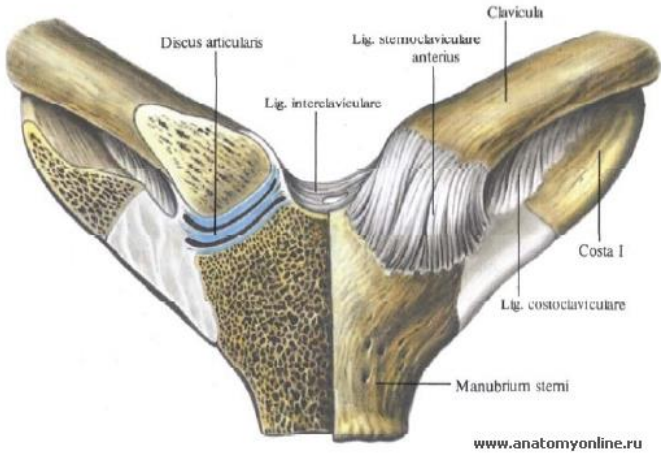
2. Synovia

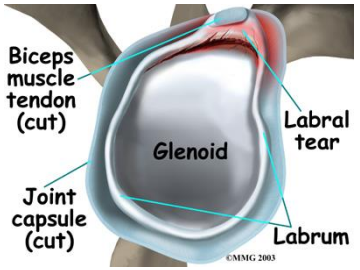
Its viscosity varies according to the pressures it bears, and decreases with the movement speed. The rise in pressure will cause its jellifying.

Characteristics of the diarthroses elements



III. Adaptive structures of the articular surfaces



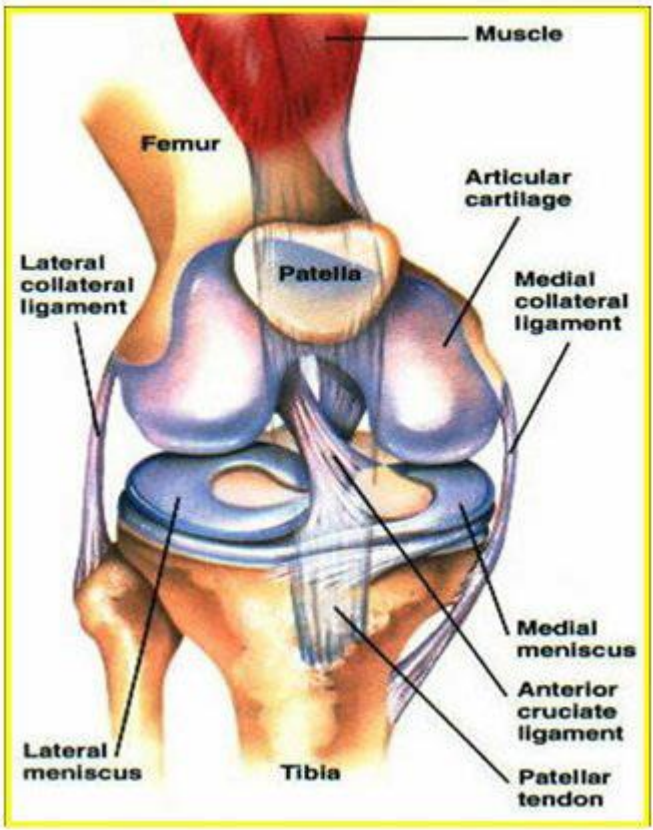


The fibro-cartilages insure the congruence of the articular contact surfaces. They consist of:

1. ***The labrum*** **or the articular brow is a marginal ring, triangular in section. It has one free side and two adherent sides, one to the articular capsule, the other to the articular surface.**

2. *The meniscus* is a marginal ring with 2 free sides and one adherent to the articular capsule.

3. *The discus* is an intraarticular septum , which adheres to the articular capsule through its peripheral side. It subdivides the articular cavity.



V. Sliding structures

They facilitate the sliding of the articular surfaces, either directly or indirectly.

1.The articular cartilage

Due to its very smooth surface, the articular cartilage diminishes the articular friction quotient.

2.The Synovia

It plays the role of a lubricant of the cartilage.

3.The labrum, the meniscus and the discus - help the stretching of the synovia during movement.

IV. Supporting structures

They prevent articular dislocations.

Their elongation or breaking results in strains.

1.The fibrous membrane of the articular capsules

is most important means of linking.

2.The ligaments

They are fibrous bands that links components of a joint.

There are:

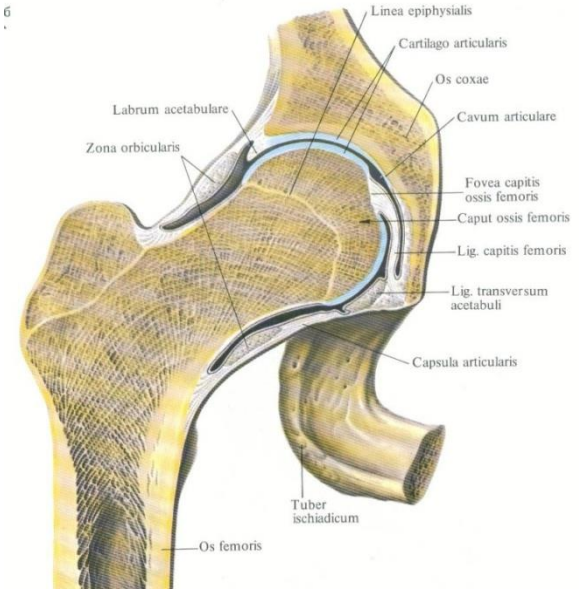
Capsular ligaments – thickening of the fibrous membrane if the capsule. E.g.: Gleno-humeral tendons. Between these tendons there are weak points, which form favorable places for sprains.

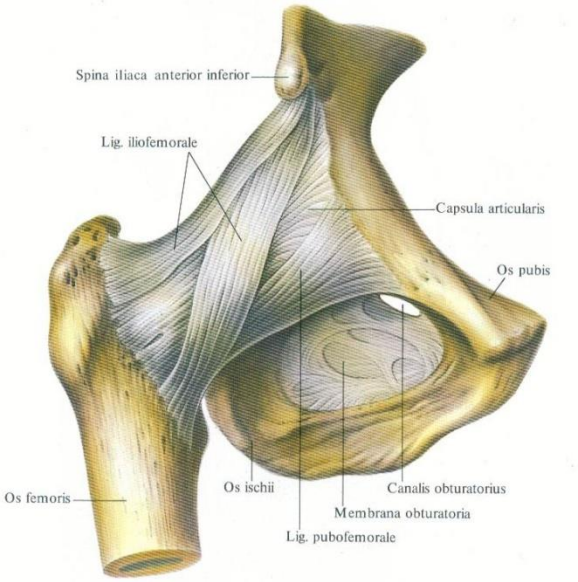
Extracapsular ligaments –are autonomous formations, independent of the articular capsule and placed outside the articular capsule.

Intracapsular ligaments –placed inside the articular cavity.They are surrounded by an articular sleeve. E.g.: the tendon of the femoral head.

***3.The periarticular muscular tendons* –also play a very important and supporting role.**

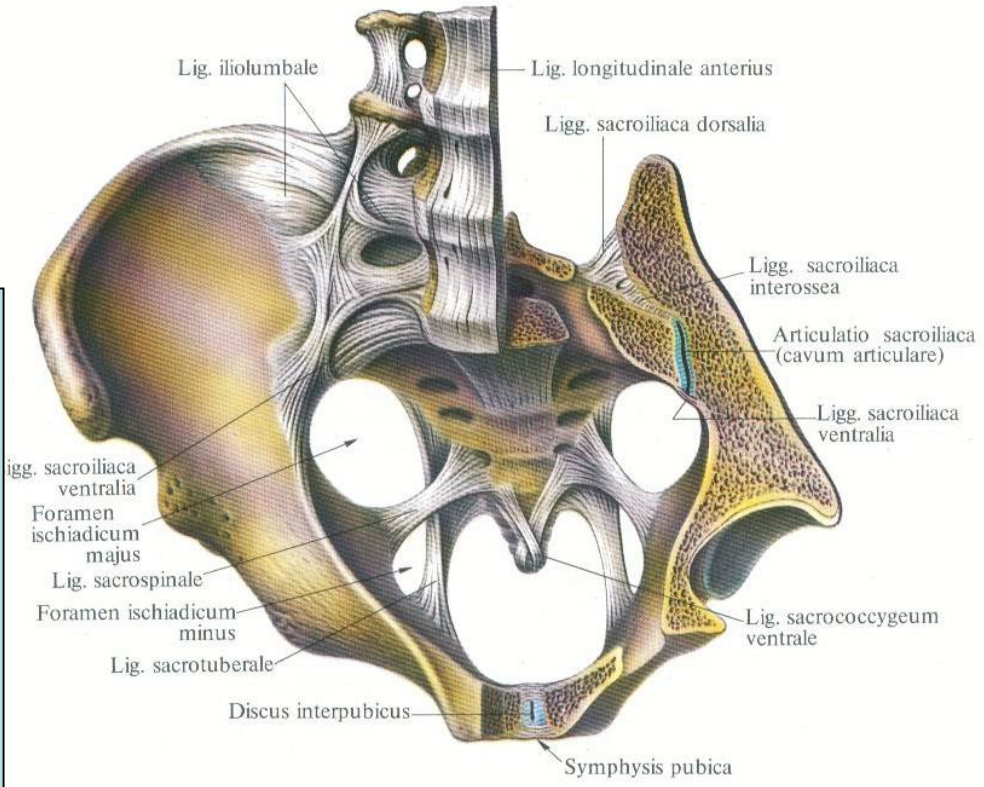
The atrophy of the supporting structures favors relapsing sprains.

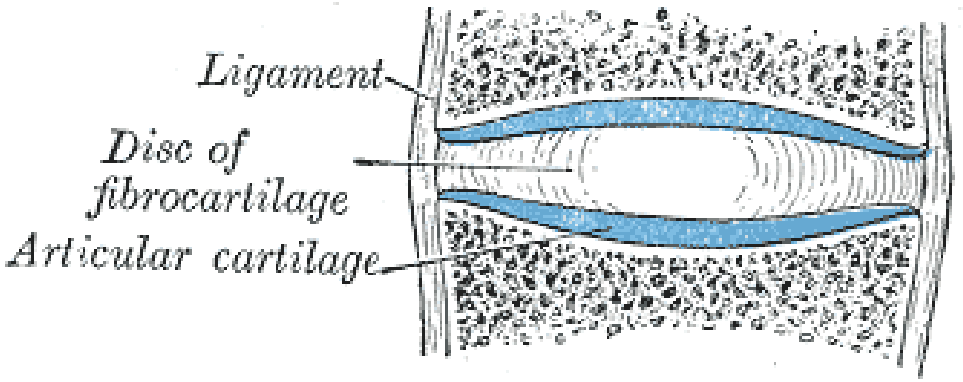




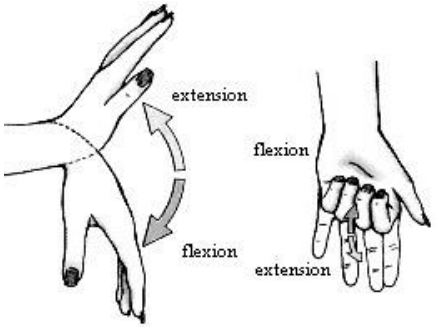
Symphyses
= hemiarthroses

- A narrow gap forms in the centre of a synchondrosis.
- It is a transitional form between the synarthroses and diarthroses
- Symphysis may form as the result of reverse transition from interrupted to contiguous articulation due to reduction of joints.





Movements of the joints



1) Movements on the frontal transverse axis:

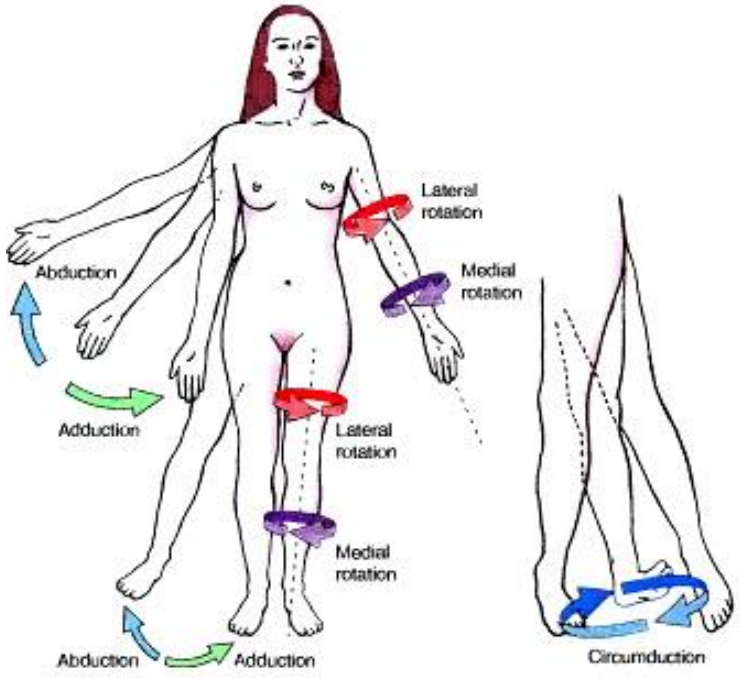
flexion **– it is a reduction of the angle formed by the articulating bones;**

extension **– increase of this angle**

2) Movements on the saggital axis:

adduction **– drowning towards the median plane,**

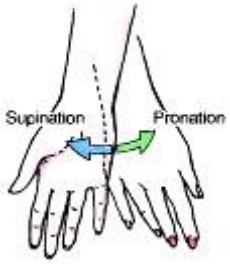
abduction **– drowning away from it**



3) Movements on the vertical axis:

rotation - ***pronation*** **– rotation inward;**

supination **– rotation outward**

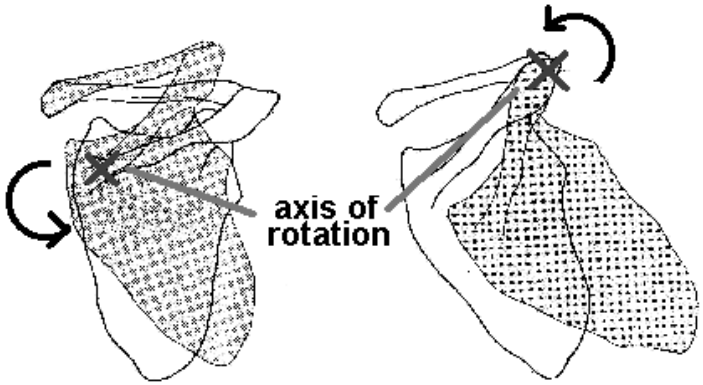


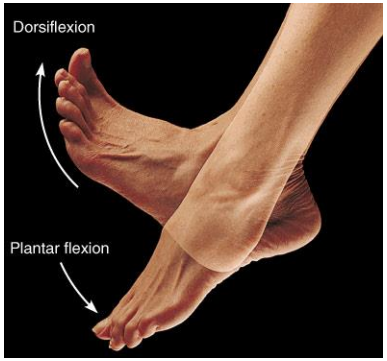
4) Movements in a circular manner, *circumduction,* by changing from one axis to another with one end of the bone describing a circle and the whole bone describing the figure of a cone.

Special movements

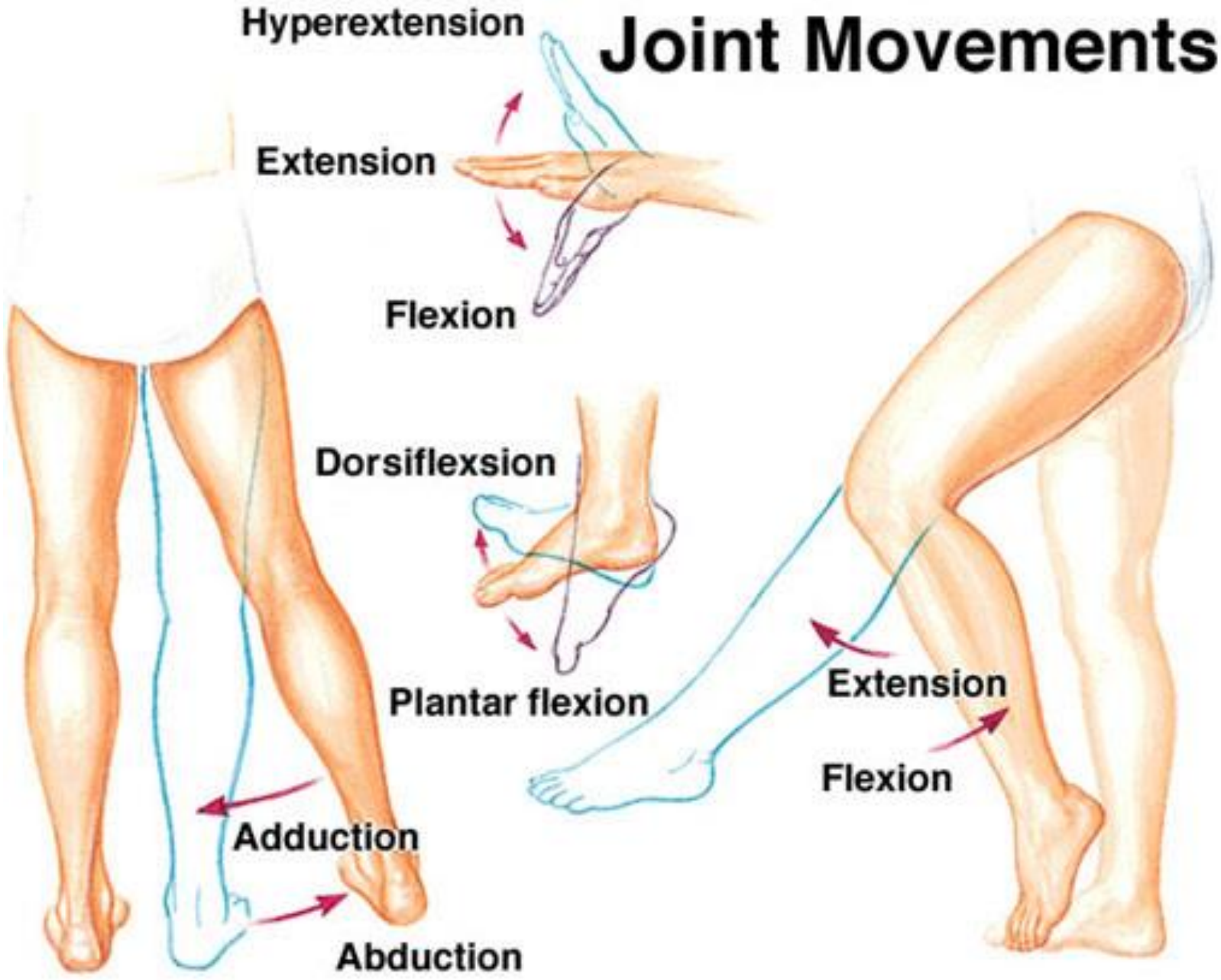
Some movements apply only to particular body parts.

- **Pronation & supination - rotation of the hand between the palm-down and palm-up positions.**
- **Opposition - movement to touch the thumb to the fingers; opposite is reposition.**
- **Dorsiflexion - extension of the foot at the ankle.**
- **Plantarflexion - flexion of the foot as in pointing the toes.**
- **Eversion - lateral or outward rotation of the foot.**
- **Inversion - medial or inward rotation of the foot.**
- **Elevation and depression - with respect to the shoulders or mandible.**
- **Protraction and retraction of the jaw.**
- **Rotation and lateral flexion of the head.**

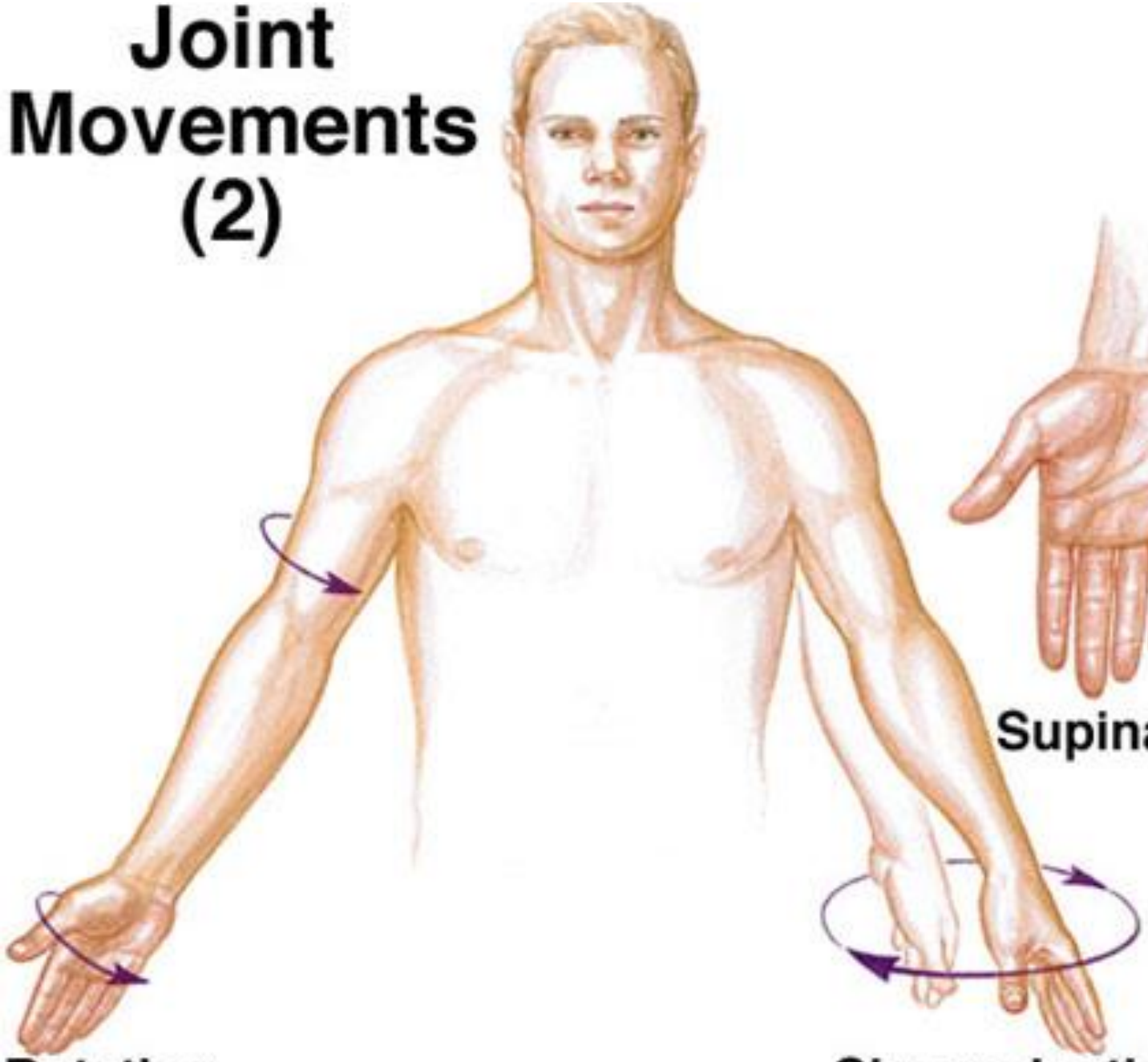




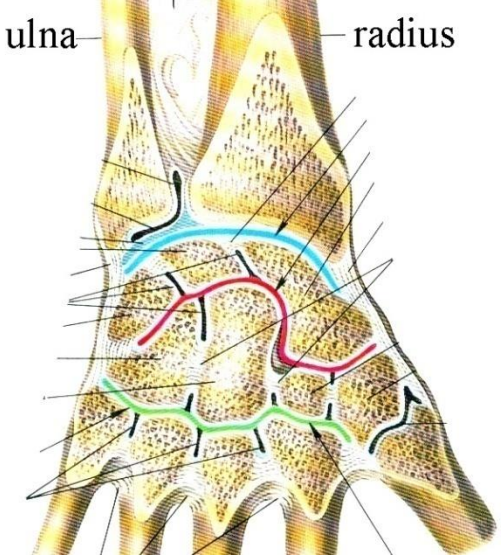
Joint Movements (1)



Joint Movements (2)

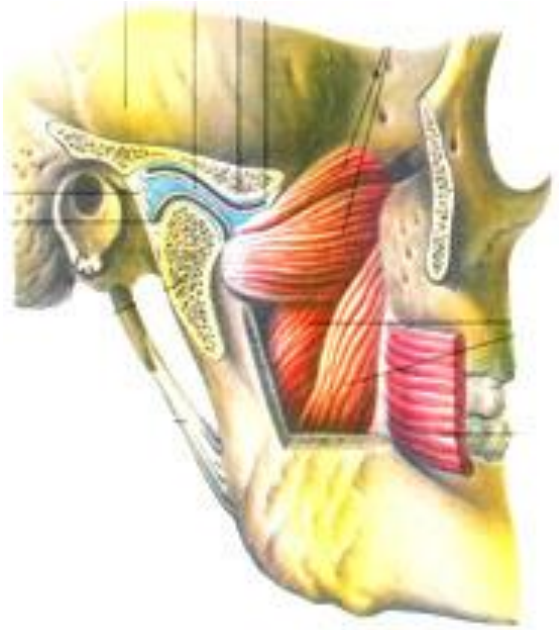


Classifications of diarthroses



I. Classification according to the number of articular surfaces

1. **Simple** /only 2 articular surfaces/
2. **Compound** /more than 2 /



II. Classification according to their structure

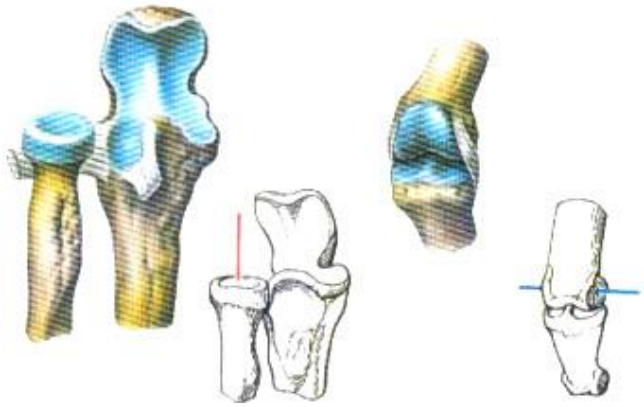
1. **Complex** /have intraarticular cartilage separating the joint into 2 parts/
2. **Combined** /2 or more isolated joints functioning together/

Biomechanical classification of the diarthroses according to the function and shape

Uniaxial

***Pivot = trochoid = cylindrical**

*** Hinge /screw/**

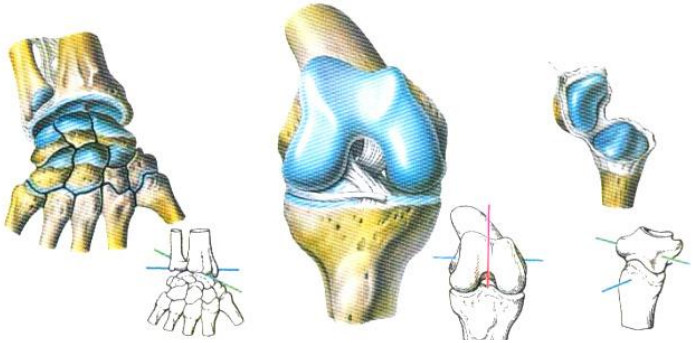


Biaxial

*** Elipsoid**

*** Condyloid**

*** Saddle**



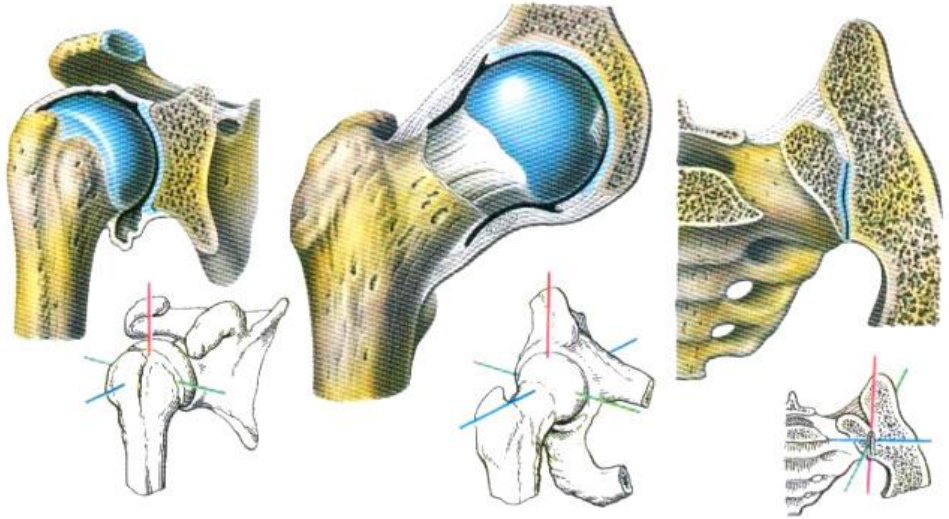
Multiaxial

*** Ball-and socket**

*** Cotyloid**

*** Plane**

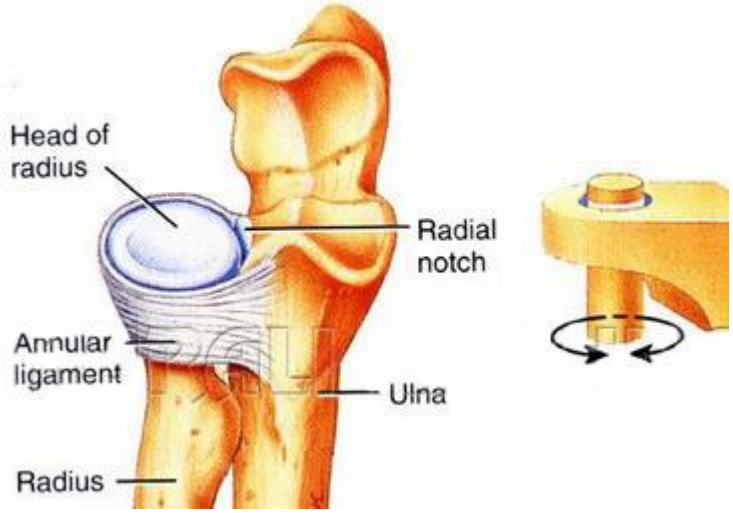
/amphiarthroses – unmobile joints/

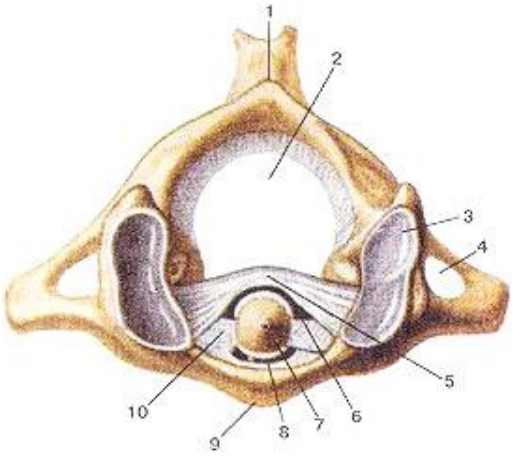


UNIAXIAL JOINTS

A. PIVOT JOINT = TROCHOID = CYLINDRICAL

- Permits rotation of one bone around another.
The elbow enables your hand to turn over.
It also allows you to turn your head from side to side.



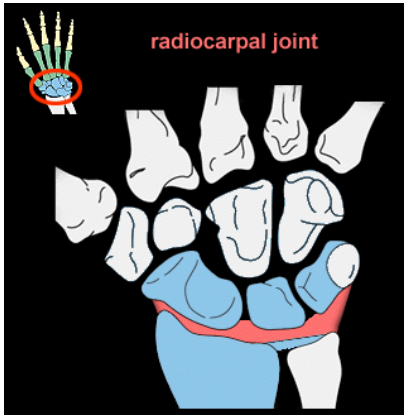


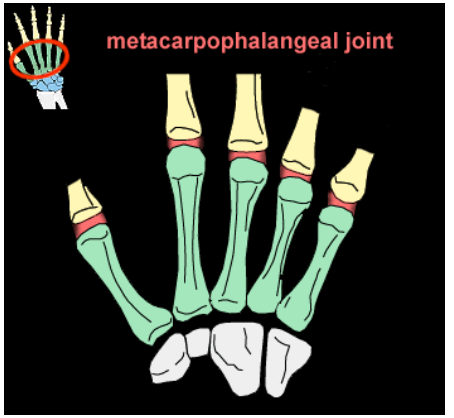
B. HINGED JOINT = SCREW

- Permits a back-and-forth motion.
The elbow allows you to move your forearm forward and backward.

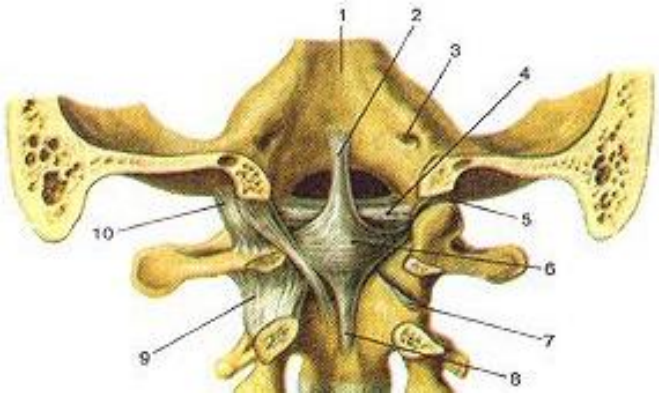
BIAXIAL JOINTS

C. ELLIPSOID JOINT - Allows movement in two directions. The radiocarpal joint, joints that connect phalanges of the fingers with the metacarpals and phalanges of the toes with the soles of feetmetatarsals are examples.

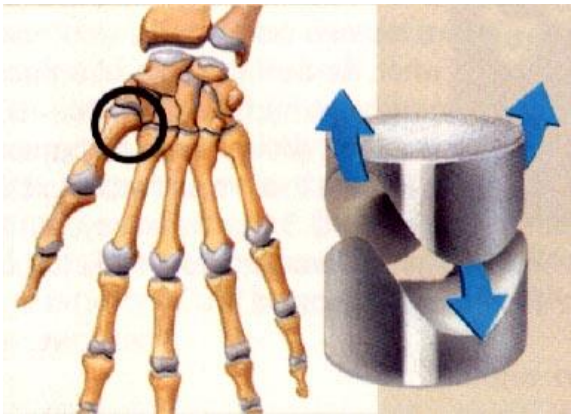




D. CONDYLOID JOINT - The condyloid joint is distinguished from the other kinds of synovial joints by the distinctive oval shape of the bones involved. Both the articular surface of the bone inserting into the joint — a surface known as a condyle — and the cavity receiving the bone are elliptical in shape.



E. SADDLE JOINT = SELLAR - the opposing surfaces are reciprocally concave-convex. Permits movement in two planes. This type of joint is found at the base of the thumb.



MULTIAXIAL JOINTS

F. BALL AND SOCKET JOINT - Permits circular movement - the widest range of movement. The shoulder joint, which enables to move the arm up, down, forward and backward, as well as to rotate it in a complete circle.

G. COTYLOID JOINT - A freely moving joint in which a sphere on the head of one bone fits into a rounded cavity in the other bone.

H. PLANE = GLIDING JOINT - Permits a sliding motion of one bone over another. Found at the ends of the collarbones, between wrist bones, and between anklebones.

CLASSIFICATION OF JOINTS BASED ON THE AMOUNT OF MOVEMENT POSSIBLE

A. Synostoses, many synchondroses, sutures are IMMOVABLE JOINTS; THEY ARE OFTEN CALLED FIXED JOINTS, AND ALLOW NO MOVEMENT BETWEEN BONES. These joints are interlocked and held together by connective tissue, or they are fused together. The places where the bones of the SKULL meet (SUTURE) are examples of immovable joints.

B. Plane joints are SLIGHTLY MOVABLE JOINTS. These joints permit a small amount of movement. The joints between the two bones of the leg (TIBIA and FIBULA) and the joints of the vertebrae are examples of slightly movable joints.

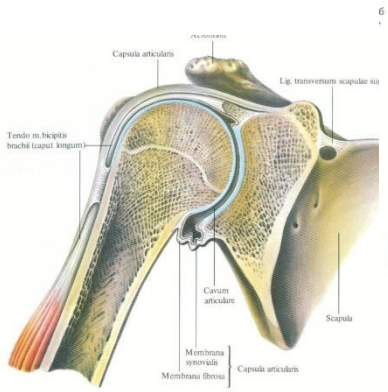
C. Diarthroses (except those plane) are FREELY MOVABLE JOINT. Most of the joints of the body are freely movable.

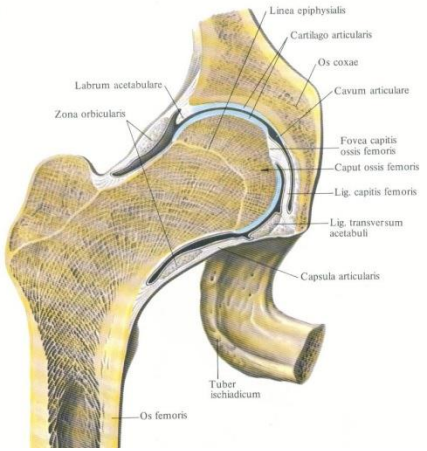
Factors maintaining contact of the articular surfaces

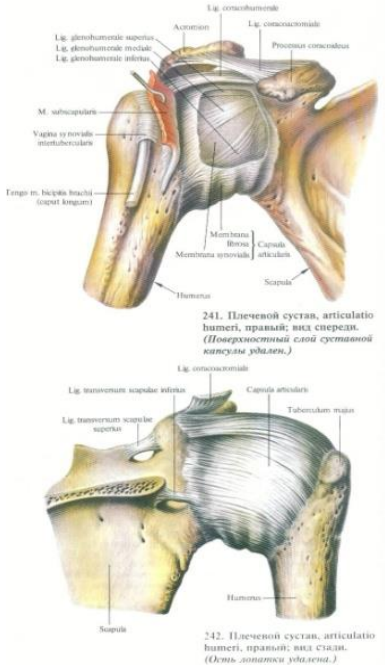
1) **Extension of the articular capsule**
2) **Muscular tonus**
3) **Power of the molecular attraction of the synovial fluid**
4) **Atmospheric pressure**

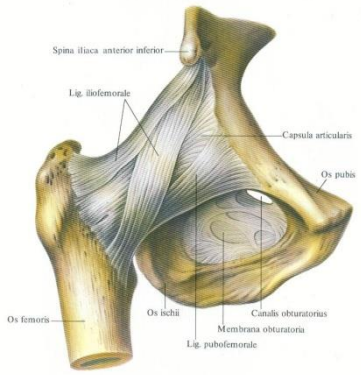
Factors determining the range of diarthrosis movements

1) **Shape of the articular surfaces**
2) **Degree of articular surfaces congruence**
3) **Degree of the extension of the articular capsule**
4) **Peculiarities of the structure and insertion of articular capsule**
5) **Localization of the muscles to the bones**
4) **Presence of the auxiliary apparatus of the joint: cartilaginous discs and ligaments**
5) **Size difference of the articular surfaces**
6) **Muscular tonus**







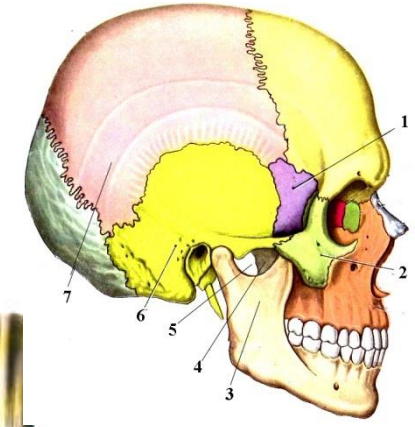


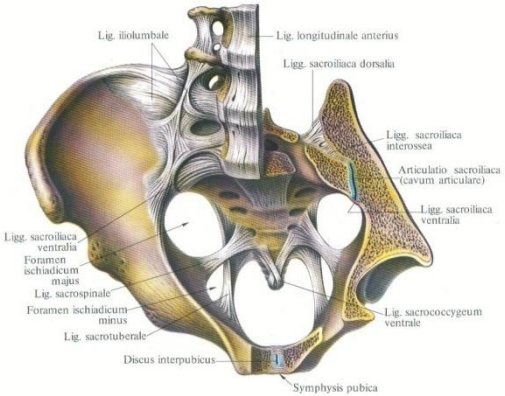
Age-related changes in joints:

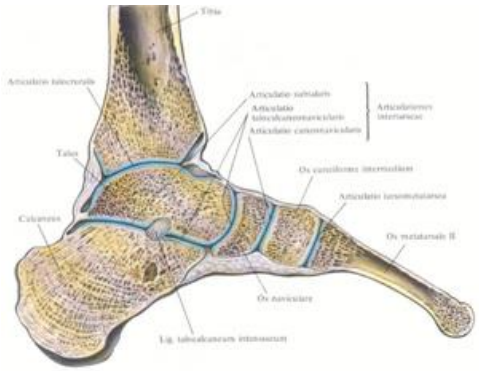
- Joint movement becomes stiffer and less flexible because the amount of lubricating fluid inside of joints decreases and the cartilage becomes thinner.
- Ligaments also tend to shorten and lose some flexibility, making joints feel stiff.
- Many of these age-related changes to joints are caused by lack of exercise.
- Movement of the joint, and the associated ‘stress’ of movement, helps keep the fluid moving.
- Being inactive causes the cartilage to shrink and stiffen, reducing joint mobility.

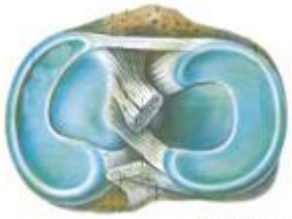
Amortizing factors of the human body

1) Curvatures of the vertebral column
2) Intervertebral discs
3) Plantar arches
4) Pelvic ring
5) Articular cartilages
6) Articular discs and meniscs
6) Synovial articular fluid
7) Interosseal membranes
8) Sutures









Variability of joints of different regions of the body

Joints of the vertebral column

The human vertebral column contains all types of joints, e.g.:
1)Syndesmoses:
a)*synfibroses* - ligaments between the transverse and spinous processes;
b)*synelastoses* - ligaments between the vertebral arches;
2)Synchondroses - between the bodies of a series of vertebrae;
3)Synostoses - between the sacral vertebrae, coccygeal vertebrae;
4)Hemiarthroses - between the bodies of some vertebrae;
5)Diarthroses - between the articular processes.

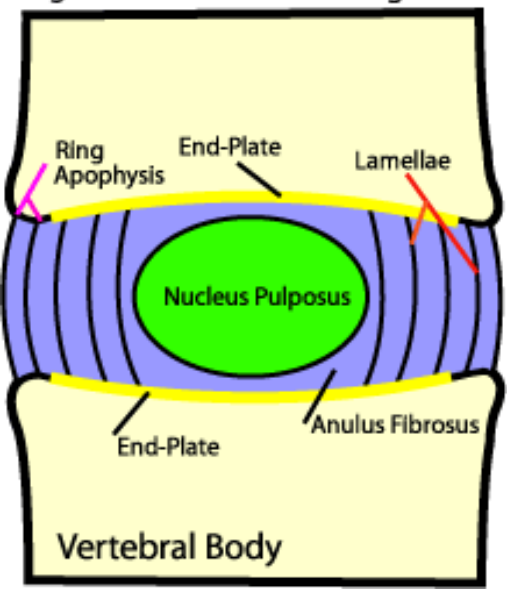
Joints of the shoulder girdle

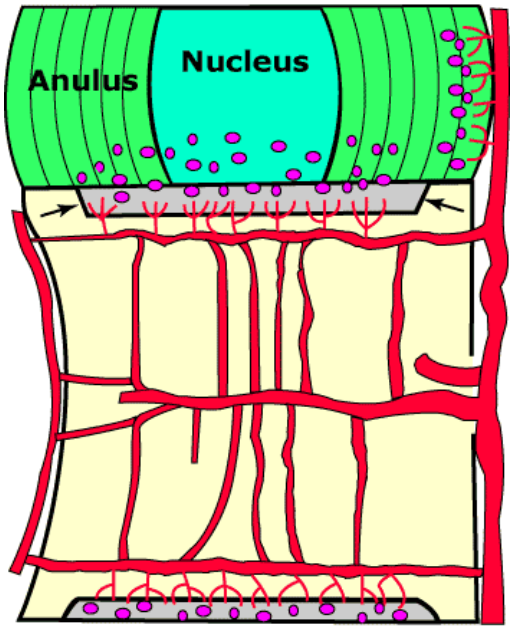
- **Diarthroses (sterno-clavicular, acromioclavicular, shoulder joint)**
- **Synsarcoses (between the scapula and the trunk) – allows rotation of the scapula**

Joints of the pelvic girdle

- **Amphiarthroses (plane diarthrosis with limited movement**
- **Symphysis (pubic)**
- **Synchondrosis and synostosis (at the region of the acetabulum)**

Figure #2 The 'Motion Segment'





The vertebrae are support for the body's frame, keeping it standing upright. It connects the head to the rest of the body.

There are *23 discs* in the human spine: 6 in the cervical region, 12 in the thoracic region, and 5 in the lumbar region.

The disc is made up of three basic structures: the *nucleus pulposus*, the *annulus fibrosus* and the *vertebral end-plates*.

***Discs are avascular* and rely on the diffusion of nutrients; oxygen, glucose and substrates; to enable fibroblasts and chondrocytes to continue synthesis of the tissue.**

The low oxygen concentration, due to reliance on anaerobic metabolism, means that the *discs operate in a slightly acidic environment with the optimum PH being between 6.8 and 7.1.*

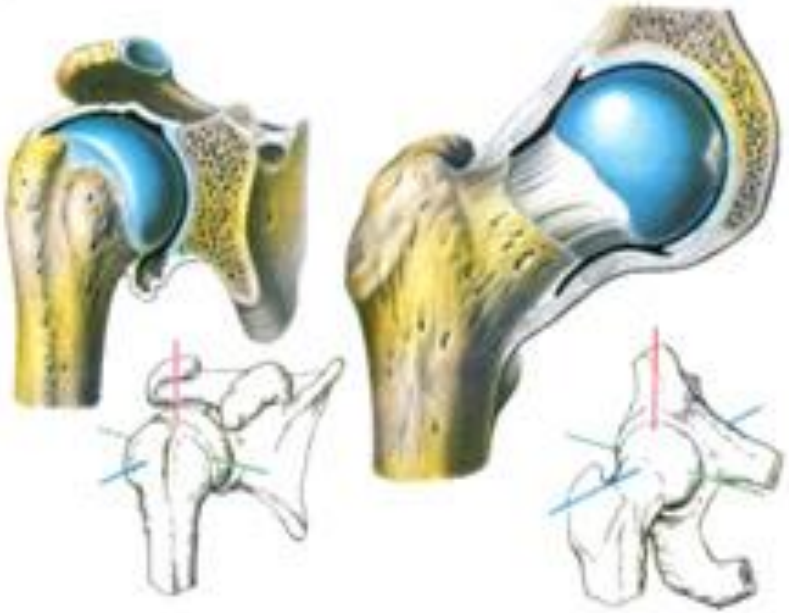
There is a steep decline in performance when the PH drops below 6.8 (becoming more acidic).

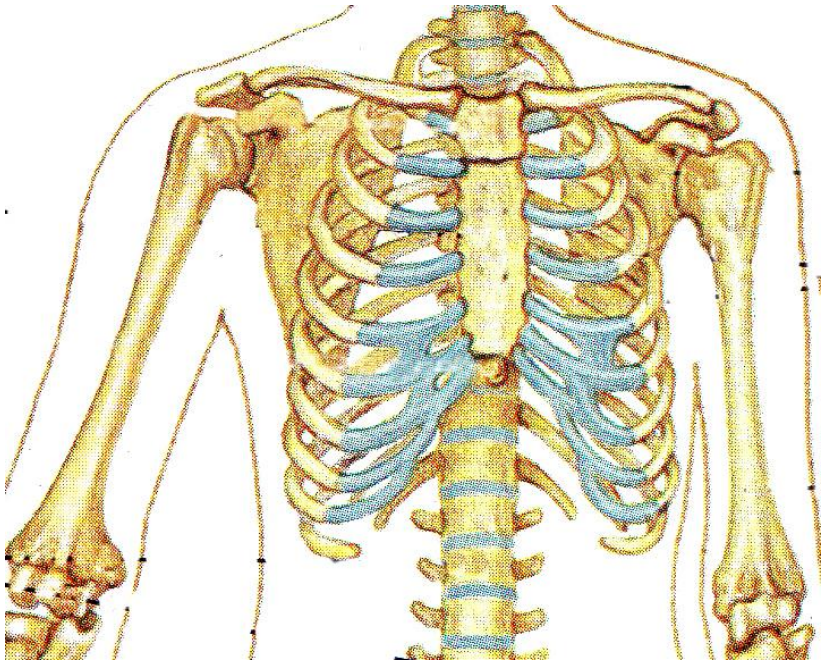
This is an important factor to take into account when considering the health of a disc.

As an example, *smoking raises the acidity of blood and smoking has been noted to be a risk factor in disc prolapses*.

Peculiarities of the bone joints of the upper and lower limbs

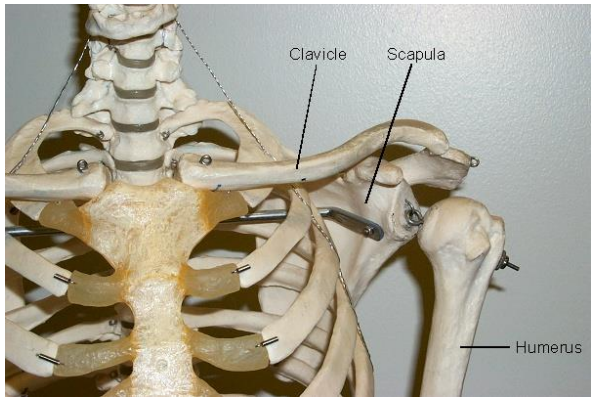
1) Shape of the articular surfaces
2) Structure and fixation of the articular capsule
3) Bones of the free upper limb are placed far from the trunk due to the clavicle
4) Auxiliary apparatus of the joints of lower limb is richer than that of the upper limb





Specific features of the shoulder and pelvic girdles

***In accordance with different functions of the upper and lower limbs, the structure of the shoulder girdle and pelvic girdle the same are different.**



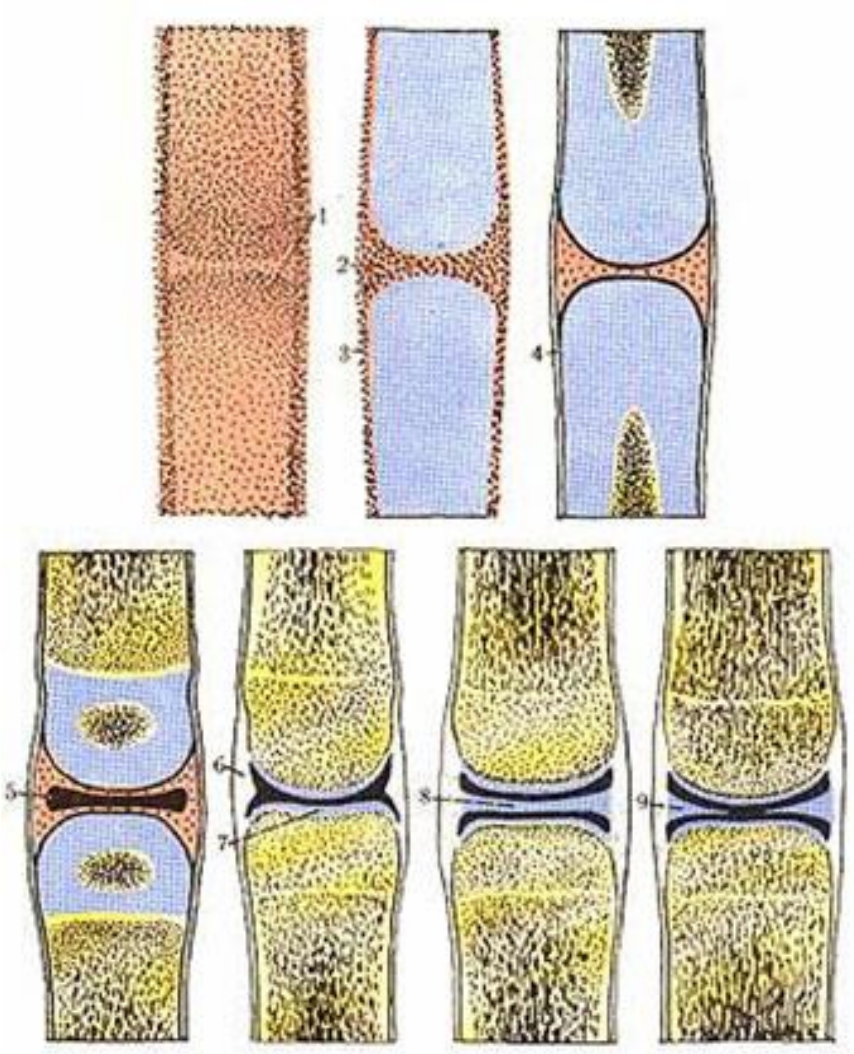
***The shoulder girdle consists of four bones: the paired scapulae and clavicles.**

- **Its right and left parts *are united only anteriorly* by joints between the clavicles and sternum**
- **It allows freedom of the movements of the upper limb.**

***The bones of the pelvic girdle joining *form closed circle*. It is necessary to provide function of the support.**

Organogenesis of the joints

- **All the joints are derived from the *mesenchyme*.**
- **The mesenchyme is transformed into fibrous tissue or into cartilaginous tissue.**
- **These two types of tissue are progressively invaded by osseous tissue.**
- **The temporary mesenchymal inter-zones are transformed and generate three types of joints: *fibrous, cartilaginous and synovial.***



Modalities for examination of the skeleton

1. Direct observation techniques
2. X-rays examination
- Fluoroscopy
- Computerized axial tomography
- X-ray tomography
3. Magnetic resonance imaging (MRI)
4. Skeletal Scintigraphy

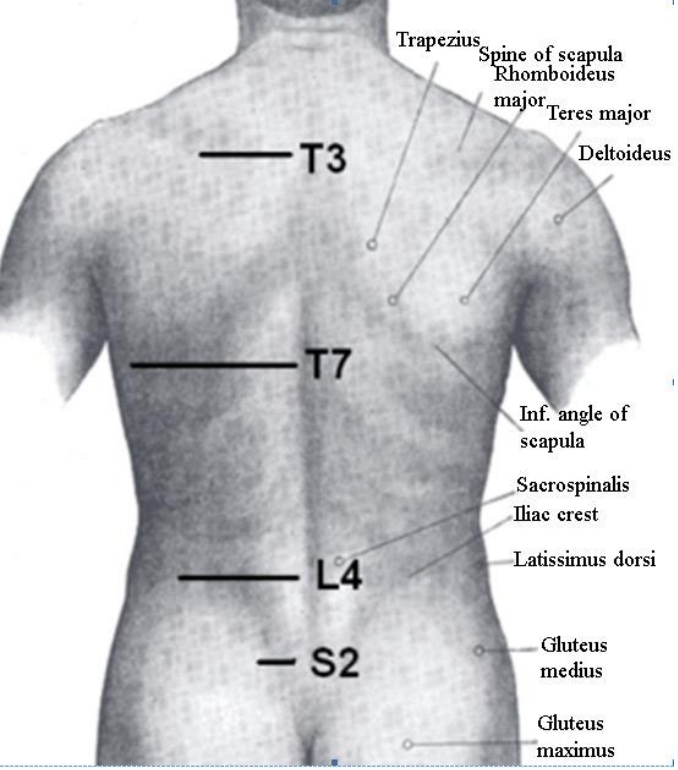
Direct observation techniques

-Visual inspection

- Measuring (morphometrics)

-Palpation - tactual exploration (a method of examination in which the examiner feels the size or shape or firmness or location of something (of body parts when the examiner is a health professional)

-Percussion - the act of tapping or striking the surface of the body in order to learn the condition of the parts beneath by the sound emitted or the sensation imparted to the fingers.



Visual inspection of the vertebral column:

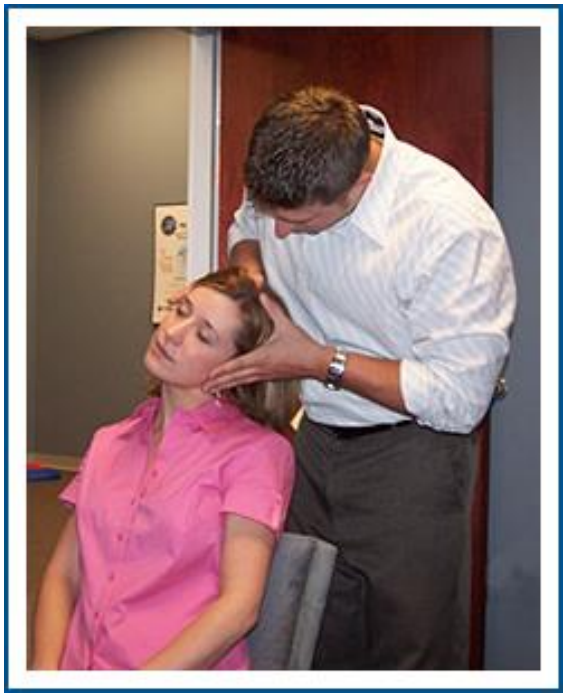
the curvatures of the vertebral column, spinous process of the C7, spinous processes of the Th and L vertebrae /median groove/, sacral region

Visual inspection of the thoracic cage:

respiratory motions,
jugular notch,
anterior surface of the sternum,
sternal angle,
xyphoid process.

Palpation

Examination by pressing on the surface of the body to feel the organs or tissues underneath.



Palpation of the thoracic cage:

jugular notch /on the median line/,
anterior surface of the sternum,
sternal angle + the second rib,
xyphoid process
the III– XII ribs /by 2 fingers (index and middle finger) put at the intercostal spaces/.

Palpation of the upper limb:

clavicle,
acromion and scapular spine,
epicondyles of the humerus /in the normal conditions are located on the same line/,
styloid process of the radial bone – at the lateral border of the radiocarpal joint,
head + styloid process of the ulnar bone – at the medial border of the radiocarpal joint,
proeminences of the pisiform bone and tuberosity of the scaphoid bone /at the palmar surface of the hand, medial and lateral parts of the carpus/
phalanges.

Palpation of the lower limb:

iliac crest,
anterosuperior and anteroinferior iliac spines,
greater trochanter,
head of the fibula,
anterior surface and borders of the patella,
epicondyles of the femor,
anteromedial surface of the tibia,
medial and lateral malleoli,
tuberosity of the calcaneus
phalanges.

Methods of examination of the skeleton

• **X-ray technology is the best known diagnostic procedure in medicine.**

•Various application-specific and organ-specific methods have become standard practice, in particular radiography (generation of two-dimensional static images),

fluoroscopy (fluoroscopy during an extended period of time to observe dynamic processes, e.g. during gastrointestinal examinations or surgical interventions).

SHORT HISTORY

•Wilhelm Conrad Röntgen, Professor of Physics in Wurzburg, Bavaria, accidentally discovered X-rays in November 1895 while studying cathode rays in a low pressure gas discharge tube.

•Alone in his laboratory on a Friday evening, he placed his hand in the path of the invisible rays which he was investigating, and saw an image of the bones on the screen beyond. Later, using a photographic plate instead of a screen, he made the first X-ray photograph — of his wife's hand, her wedding ring clearly visible.

•This was a highly significant breakthrough in the history of medicine.

•The X-ray microscope were invented in the 1950s.

An X-ray picture (radiograph), taken by Wilhelm Röntgen in 1896

Body tissues and other substances are classified according to the degree to which they allow the passage of x-rays (*radiolucency*) or absorb x-rays (*radiopacity*).

•As X-rays pass through the body, <u>different tissues absorb different amounts of the X-rays</u>:

- the bones are dense and absorb X-rays well;

- the soft tissues, such as your skin, fat, muscles and organs, allow more X-rays to pass through them;

a) the result is that bones appear white on the X-ray;

b) other tissues appear in varying shades of gray;

- structures containing air, such as your lungs, appear dark.

- **The X-ray image is black and white.**

- **Dense structures that block the passage of the X-ray beam through the body, such as the bones, appear white on the image.**

- **Softer body tissues, such as the skin and muscles, allow the X-ray beams to pass through them and appear darker.**

Photographs made with X rays are known as radiographs or skiagraphs.

Fluoroscopy is based on the same techniques, with the photographic plate replaced by a fluorescent screen;

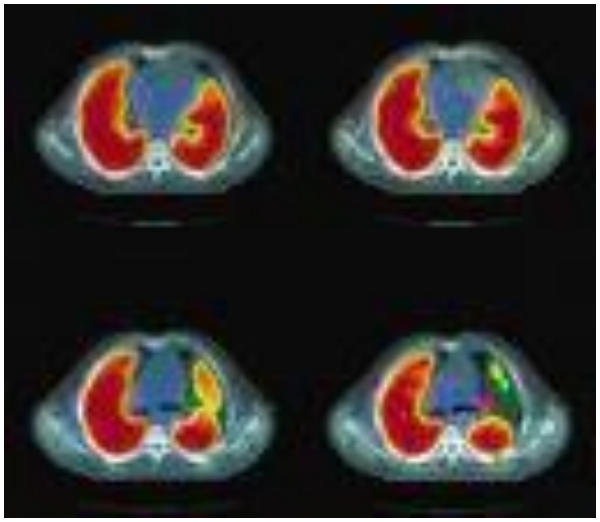
its advantages over radiography in time and cost are balanced by some loss in sharpness of the image.

X rays are also used with computers in CAT (computerized axial tomography) scans to produce cross-sectional images of the inside of the body.

CAT, also known as CAT or CT, scans images of your body in slices showing the structures in that area.

A computer is used to provide clear, sharp images. CT is used to detect and define the characterization of various disease processes in the body.

•**X-ray tomography is a further technique used to define deep internal structures more clearly.**



•**In 'linear tomography' the X-ray tube, emitting a beam of X-rays, moves in a straight line while the X-ray film moves in the opposite direction. In this way most structures are blurred by the movement but the image is focussed at a particular plane, so giving greatly improved definition.**

•**More complicated variations include circular and multidirectional tomography, producing even sharper images. This type of tomography was widely used in the past to define bones, kidneys, or the inner ear, but has now largely been supplanted by *computed tomography***

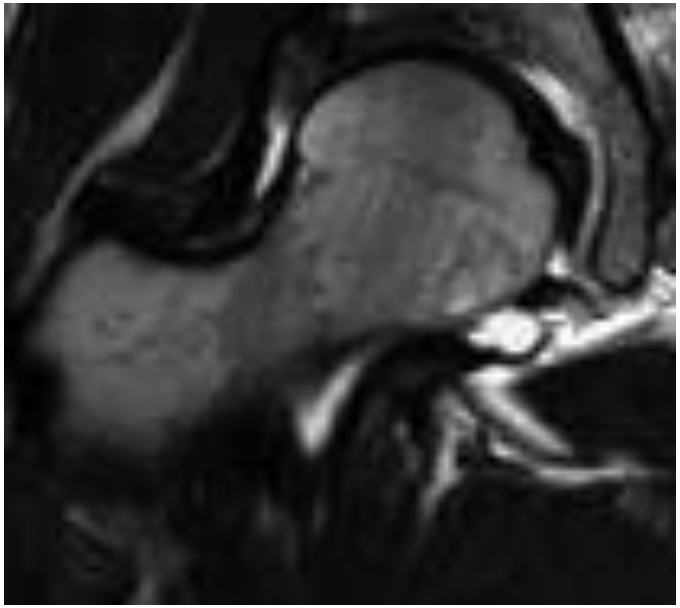
Arthrograms

A local anaesthetic is given to numb the skin.

A thin needle is inserted into the joint space and an x-ray dye, air and more local anaesthetic are injected.

A series of x-ray are then taken of the joint.

Patient may be aware of some discomfort in the joint for a day or two after the examination.



Disadvantages

- **X-rays involve exposure to radiation, which has a cumulative damaging effect. Those done during pregnancy can result in birth defects.**

- **Plain X-rays often do not provide adequate details about internal organs, blood vessels, and other soft-tissue structures.**

- **Intravenous contrast agents may make patients sick, although this reaction passes quickly.**

- **One of the dangers in the use of X rays is that they can destroy living tissue and can cause severe skin burns on human flesh exposed for too long a time.**

- This destructive power is used in X-ray therapy to destroy diseased cells.

Skeletal Scintigraphy

• Some materials such as sodium iodide (NaI) can "convert" an X-ray photon to a visible photon; an electronic detector can be built by adding a photomultiplier.

• These detectors are called "scintillators", filmscreens or "scintillation counters". The main advantage of using these is that an adequate image can be obtained while subjecting the patient to a much lower dose of X-rays.

• Bone scintigraphy is an important modality for examination of skeletal pathology.

The main indications of skeletal scintigraphy are detection of:

fractures

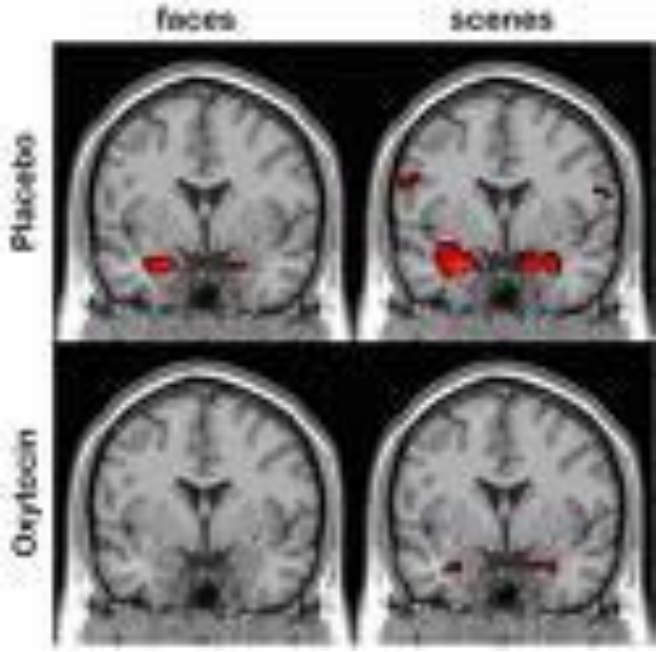
osteomyelitis

bone neoplasms

-benign

-malignant

- **Other imaging techniques that do not use x rays include magnetic resonance imaging (MRI), ultrasonography, and radionucleotide imaging.**



•Magnetic resonance imaging is the full name for an MRI. An MRI is based on a strong magnetic field that utilizes the magnet to stimulate the nerve cells in the body to create an image. MRI is a diagnostic study that produces images without the need for radiation

•Computed tomography or CT scan works on the same principles as fixed plate x rays, only with a CT scan, an x ray tube rotates around the individual, taking hundreds of images that are then compiled by a computer to produce a two-dimensional cross section of the body. Although many images are taken to produce a CT scan, the total dose of radiation the individual is exposed to is low..

END