I. Joints or articulations link bones together for movement and protection. They allow for motion and create the structural integrity necessary to support weight and protect vital internal organs.

II. Joints can be structurally classified as fibrous, cartilaginous, or synovial.
   a. Fibrous joints lack a joint cavity and the bones are linked by dense regular connective tissue.
   b. Cartilaginous joints lack a joint cavity and the bones are linked by intervening cartilage.
   c. Synovial joints have a fluid-filled joint cavity enclosed by a connective tissue capsule and the bones are adjoined by ligaments.

III. Joints can be classified functionally as immovable joints, slightly movable joints, and freely movable joints. There is a fundamental trade-off between mobility and structural strength.

IV. An example of a fibrous immovable joint is a suture. Sutures are only found in the skull. The edges of the articulating bone interlock, giving these joints tremendous strength – but no mobility.

V. A synchondrosis is a cartilaginous immovable joint. The costochondral joints between the ribs and the costal cartilage are examples.

VI. A syndesmosis is a fibrous slightly movable joint between the radius and the ulna and the tibia and the fibula. In these joints, the bones are linked by a sheet of dense CT known as an interosseous membrane. Rotational movements are permitted at these joints.

VII. An example of a cartilaginous slightly movable joint is a symphysis. Symphyses are found in the joints between vertebrae and in the joint between the left and right pubic bones in the pelvis. In symphyses, articular cartilage covers the joint surfaces and there is a pad of fibrocartilage between the joint surfaces. Symphyses are very stable and only allow a small degree of motion.

VIII. Freely movable joints are synovial and are numerous in the body. The knee, shoulder, and elbow joints are examples. Synovial joints have several characteristics: articular cartilage, joint cavity, articular capsule, synovial fluid, reinforcing ligaments, and abundant nerves and blood vessels.
   a. Articular cartilage covers the ends of the adjoining bones. It is hyaline cartilage and provides cushioning between the bone surfaces.
   b. The joint cavity is the space between the articulating bones. It is enclosed by the articular capsule and contains synovial fluid.
   c. The articular capsule is a double layered membrane that is continuous with the periostea of the articulating bones and surrounds the entire joint and unites the bones. The outer layer is the fibrous capsule which is composed of dense irregular connective tissue. The fibrous capsule helps to hold the 2 bones together. The inner layer is the synovial membrane which is composed of areolar connective tissue with abundant fibroblasts and macrophages. The synovial membrane produces the lubricating and shock absorbing synovial fluid. The synovial membrane is rather vascular and its blood vessels are the source of the synovial fluid.
   d. Ligaments are bands of dense regular connective tissue that strengthen synovial joints.
   e. Synovial joints are vascular (to produce the synovial fluid and nourish the joint structures) and innervated by nerves for pain perception and sensation of limb positions (proprioception).
   f. Synovial joints are also stabilized by tendons which are ropy bands of dense regular CT linking skeletal muscle to bone.
   g. Most synovial joints have associated bursae. A bursa is a fibrous sac containing synovial fluid and lined by a synovial membrane. Bursae alleviate friction and are often between bones, ligaments, tendons, muscles, and the skin. An elongated bursa (called a tendon sheath) wraps around tendons that are subject to excessive friction (e.g. within the wrist and ankle).
h. A synovial joint can be classified based on the number of planes within which it is capable of movement. The joint may be uniaxial, biaxial, or triaxial, if it allows movement in 1, 2, or 3 planes respectively.

i. There are 6 basic types of synovial joints: plane joints, hinge joints, pivot joints, condyloid joints, saddle joints, and ball-and-socket joints.

j. Plane joints involve a pair of flat articulating surfaces. They are uniaxial and the least mobile synovial joints. Gliding movements occur at these joints. The intertarsal and intercarpal joints are examples.

k. Hinge joints involve a bony cylinder nestled within a bony trough. The elbow joint (between the trochlea of the humerus and trochlear notch of the ulna), the knee joint, and the interphalangeal joints of the fingers and toes are all examples. Hinge joints are uniaxial joints that allow flexion and extension.

l. Pivot joints involve a bony head that can rotate within a bony or ligamentous ring. The joint between the first 2 cervical vertebrae (the atlantoaxial joint) as well as the proximal radioulnar joint are examples. Pivot joints allow rotation.

m. Condyloid joints involve an oval bony projection resting in an oval bony depression. Condyloid joints are biaxial joints. The metacarpophalangeal joints 2-5 are examples.

n. Saddle joints involve 2 adjoining saddle-shaped projections. The carpometacarpal joints of the thumbs are examples.

o. Ball-and-socket joints involve a spherical bony projection joining a cup-like depression. All angular movements are allowed. The shoulder and hip joints are examples.

IX. Synovial joints allow 3 basic types of movement: gliding, angular movement, and rotation.

a. Gliding movements occur when flat bone surfaces slide upon one another. These movements occur at the intercarpal joints, intertarsal joints, and the intervertebral joints.

b. Angular movements change the angle that exists between 2 bones. Common angular movements include: flexion, extension, hyperextension, abduction, and adduction.

c. Flexion is a bending motion occurring in the sagittal plane. It decreases the angle of a joint.

d. Extension is the reverse of flexion. It occurs in the sagittal plane and increases the joint angle. Excessive extension beyond normal anatomical position is hyperextension.

e. Abduction is the movement of a limb away from the midline of the body in the frontal plane.

f. Adduction is the opposite of abduction. Note that \( ab \) means away while \( ad \) means towards.

g. Rotation turns a bone along its long axis. It occurs in at the atlo-occipital joint in the familiar “no” motion. At the hip and shoulder joints, lateral rotation (external rotation) turns the anterior surface of the femur/humerus laterally, while medial rotation (internal rotation) turns the anterior surface of the femur/humerus medially.

h. Pronation is the medial rotation of the forearm so that the palm faces posteriorly or inferiorly. The radius and ulna form an X during this motion.

i. Supination is the returning rotation of the forearm so that the palm is once again anterior or superior facing.