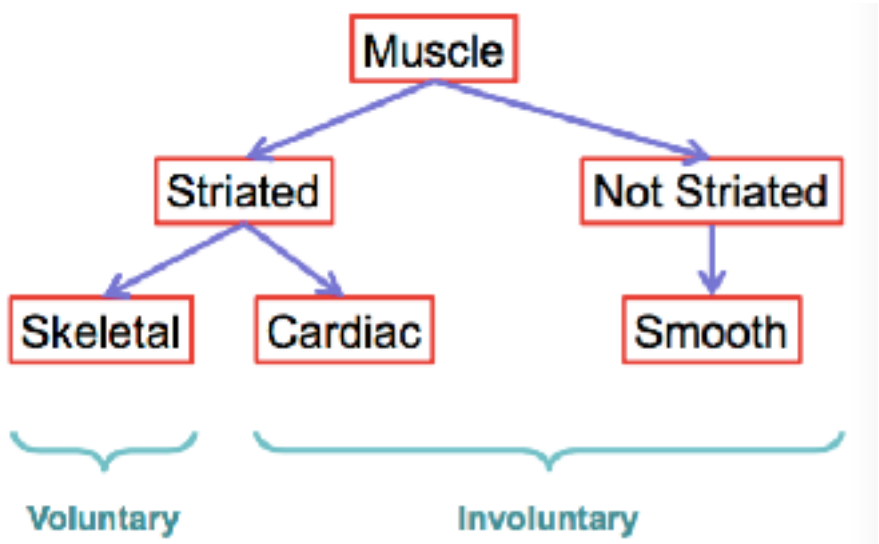

Contraction

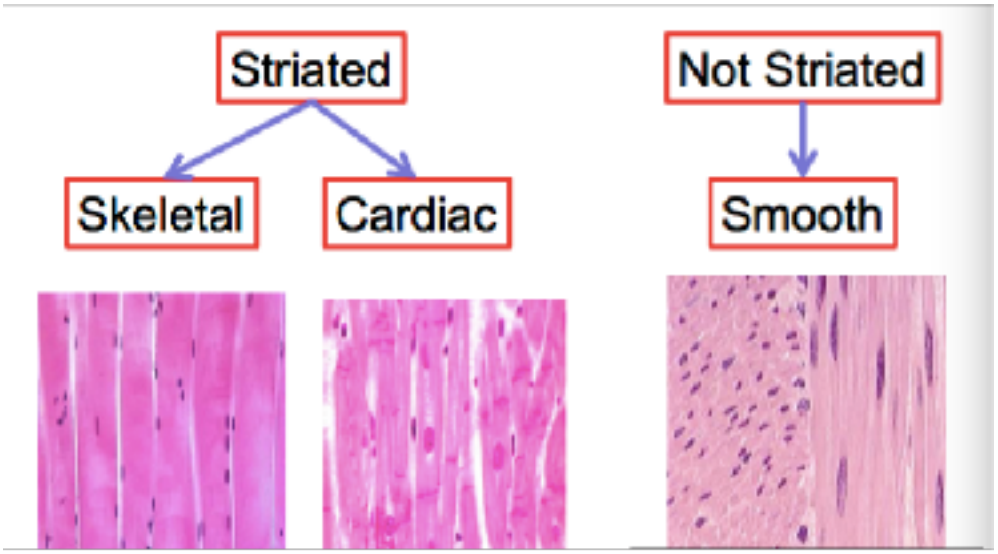
- movement of specialised intracellular structures - cause shortening of muscle cells
- groups of cells work together to produce force & movement
- muscle cells arranged in parallel so contract. produces force in single direction

3 types of muscle

- classified based on appearance & contractile cells made of



- under light microscope
- skeletal muscle cells running longitudinal

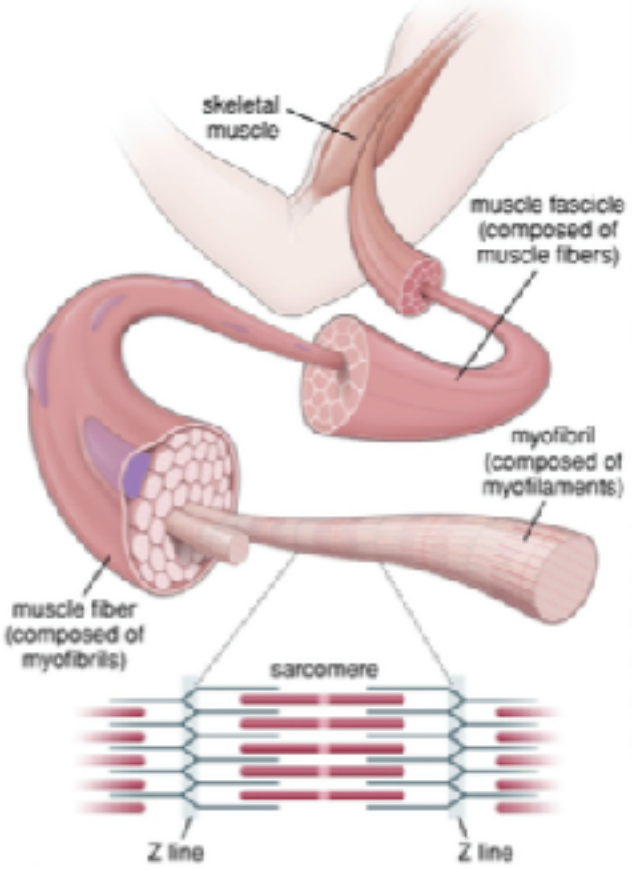


Muscle cell terminology

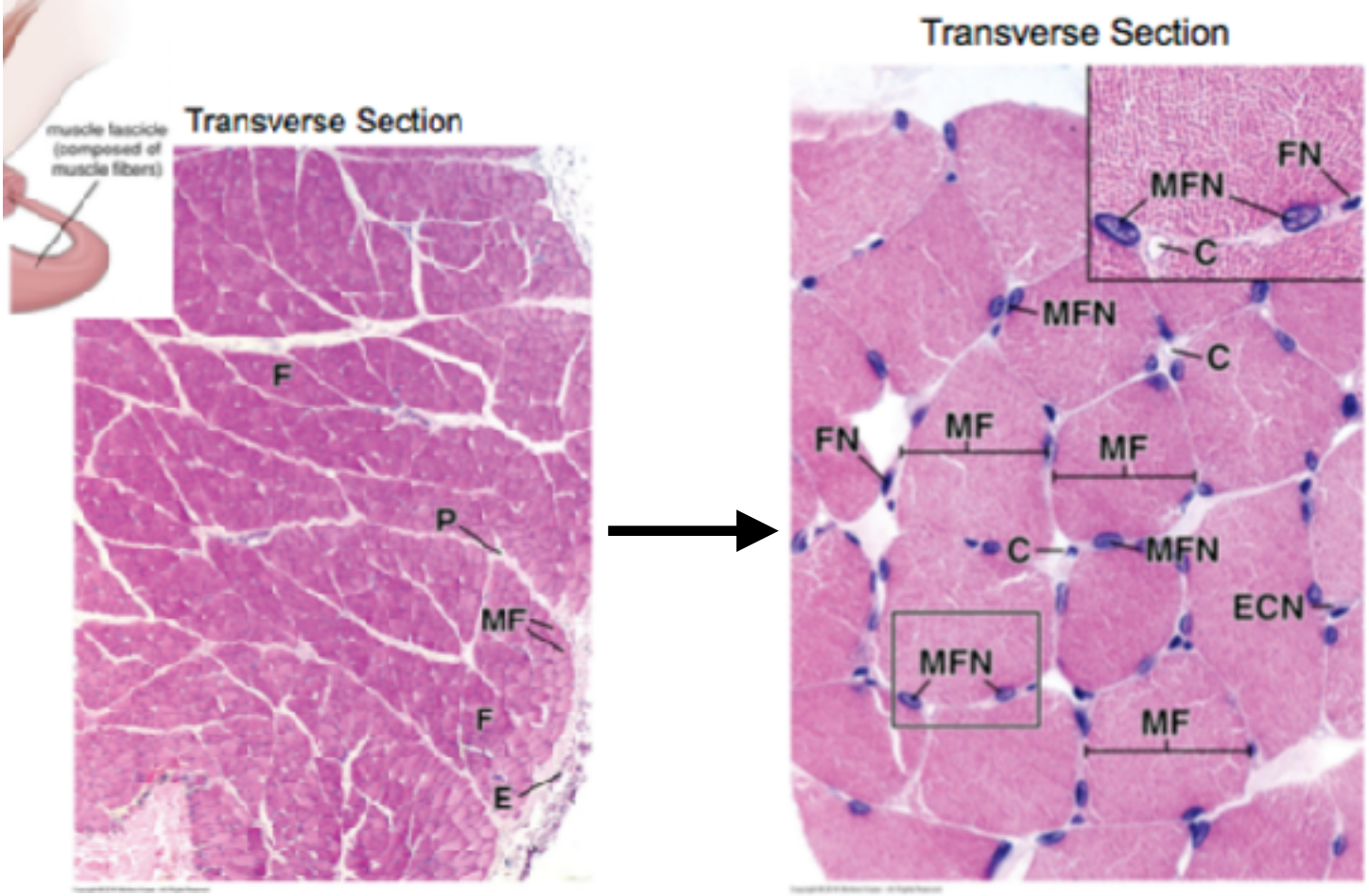
- sarcolemma = plasma membrane
- sarcoplasm = cytoplasm
- sarcoplasmic reticulum (SR) = specialised sER

Skeletal muscle

- usually attached to bone - effective movement of skeleton
- voluntary control
- skeletal muscle within other organs e.g. oesophagus, diaphragm
- made up of “fascicles” held together by connective tissue
    - at end of muscle, connective tissue continues as a tendon & attaches to bone
    - *fascicles* bundles of striated muscle fibres/ cells
- *multinucleate syncytium*
    - fusion of indi. muscle cells during development to make large, single cell with multiple nuclei
- muscle fibres entirely composed of *myofibrils* in continuous network
    - nuclei sit at periphery
- myofibrils extend entire length of skeletal muscle
    - made up of *myofilaments*
    - actual contractile elements of skeletal muscle = *actin & myosin*
    - arranged into highly specialised structures - *sarcomeres* allowing contraction



“muscle made of *fascicles* surrounded by connective tissue - fascicles made up of multiple muscle cells surrounded by connective tissue & muscle cells filed up with *myofibrils* which are made of *myofilaments*”



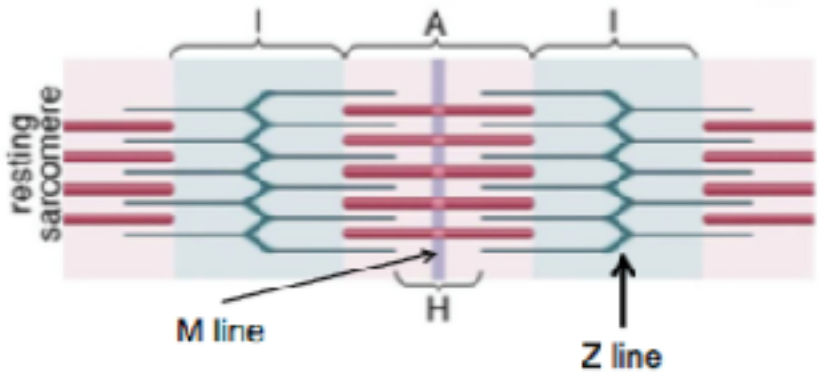
Why is muscle striated?

- striations caused by highly organised arrangement of myofilaments (within myofibrils) into sarcomeres
- sarcomeres in adjacent myofibrils are aligned with each other, allowing for striated pattern = straight line across whole cell
- A (dark) & I (light) bands sarcomeres are primary cause of striations
- sarcomeres joined end-end = myofibril

Sarcomeres

- functional unit of muscle
- arrangement of molecules in sarcomere allows for muscle contraction
- 2 main components:
    - thin filaments = actin
    - thick = myosin = myofilaments
- every sarcomere shortens during muscle contraction but actin & myosin remain same length

organisation of sarcomere



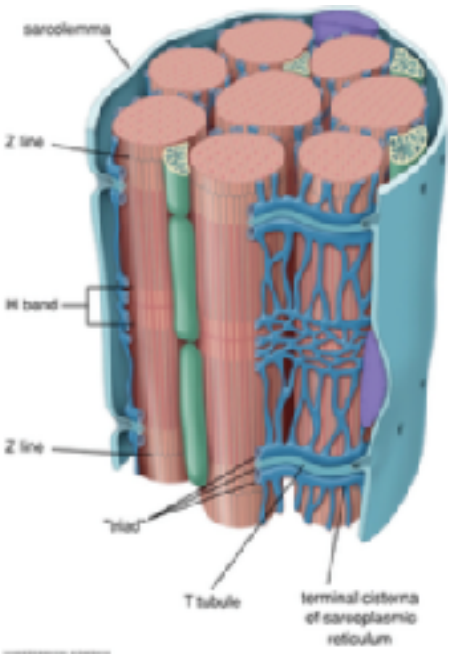
- **A band:** region of myosin filaments, don't change during contraction (dark)
- **i band:** region between 2 sarcomeres containing actin only. Incorporates Z lines (which shorten during contract) therefore also shortens during muscle contract (light)
- **Z line:** band where actin attach to each other - point of connection of adjacent sarcomeres
- **M line:** myosin filaments attach to each other - in centre of sarcomere
- **H band:** region containing myosin filaments online - shorted during contraction

Muscle contraction

- during contract, the thin filaments slide over thick filaments & move towards M line
- brings Z lines closer together, causing shortening of sarcomere (therefore myofibril)
- I band & H band become shorter during contraction

Sarcoplasmic reticulum

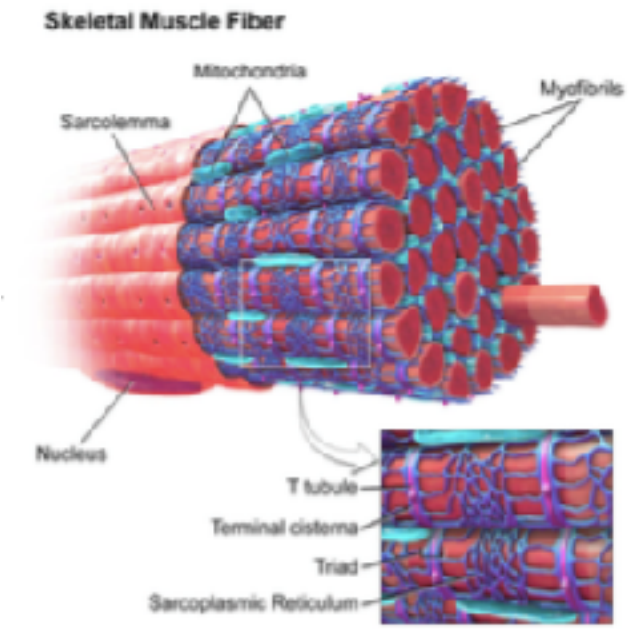
- within muscle fibres - myofibrils surrounded by highly developed see called *SR*
- SR highlight organised tubular network around myofibrils
- Ca stored in SR
- myofibrils surrounded by mitochondria & glycogen deposits
- 2 transverse tubules (T-tubules) penetrate inside of muscle cell causing contraction through all muscle
    - T tubules run along A-I band junc.
    - SR forms tubules that run adjacent to T-tube called *terminal cisternae*



- each T-tubule associated with 2 terminals cisternae = *triad*

Initiation of contraction

- contraction of sarcomere caused by Ca ions
- release of Ca from SR triggered by nerves = muscle contract
- motor neurons meet muscle at neuromuscular junction
- action potentials pass from nerve into sarcolemma
- action potential passes along sarcolemma & into t-tubules
    - depolarises T-tubules triggering Ca release from SR = muscle contract



Cardiac muscle

- contractile component of heart
- called “myocardium”
- involuntary straited muscle
- cardiac muscle cells = *cardiomyocytes*
- cardiac muscle fibres = *myocardial fibres*

Cardiac muscle fibres

- made up of collections of branching fibres in network
- cardiac muscle ells join together to make these fibres

Cardiac muscle cells

- not multinucleate syncytium - made of indi. cells joined end-to-end
- contain same type of myofilaments
- arranged in sarcomeres = striations
- Nuclei of CM cells located in centre of cell - indi. myofibrils must seperate to pass around
- CM cells may attach to 2+ neighbouring cells through intercalated disks = branching fibres
- is a *functional syncytium*
    - because fibre structure allows rapid coordinated contraction along ints entire length

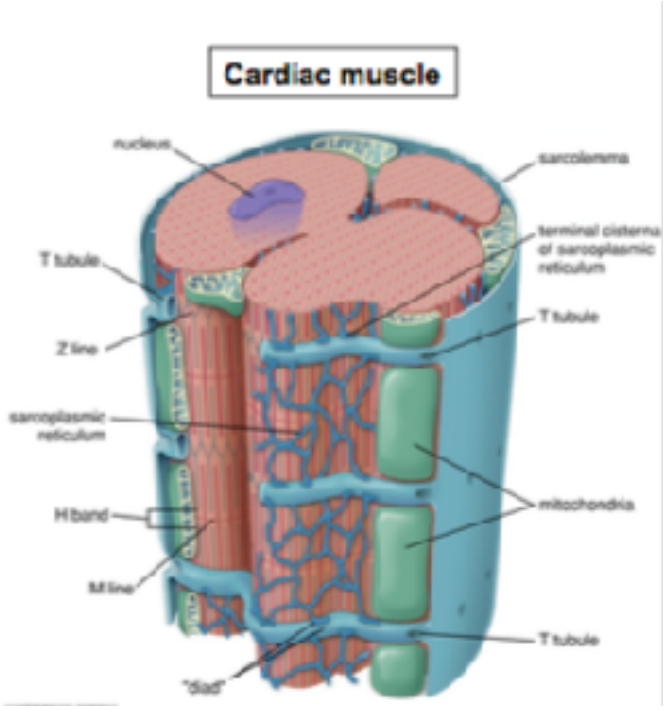
- achieved through *intercalated disks*

intercalated disks

- disks represent highlight specialised junctions attaching CM cells together (between all CM cells)
- 3 components
    - **Fascia adherens**
        - cause of dense staining, physically attaches cells at ends to form fibre, functionally similar to adherent junction in epithelia
    - **Macula adherens**
        - desmosomes, physical attachment, reinforce fascia adherent, prevent cells from pulling apart, found bit ends & sides of CM cells
    - **Gap junctions**
        - provide ion continuity between cells allowing coordinated contraction = functional syncytium

Supporting structures

- inside next to each myofibril are numerous large mito & glycogen stores for energy = reliability (e.g. heart)
- mitochondria use glycogen sores to produce ATP via *oxidative phosphorylation* = efficient
- sk M = 1-2% mito, CM = 35% mito



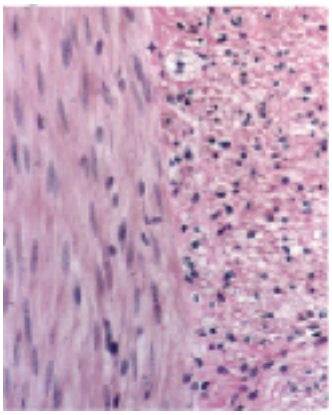
Sarcoplasmic reticulum

- not as highly organised as in skeletal
- SR forms relatively sparse network in CM
- SR does not form tubule-shaped terminal cisternae
    - small endfoot-type terminal cisternae = *diad*
    - 1 tubule per sarcomere but MUCH larger
- T-tubule at teach **Z-line**

Contraction

- Caused by Ca = Ca release from tubes causing Ca releasing from SR

- contraction of sarcomeres = myofilaments sliding
- contraction initiated **spontaneously**
- specialised *pacemaker cells* create & control heartbeat
- signals pass from cell-cell through gap junctions on intercalated disk = coordinated contraction



Smooth Muscle

•not straited

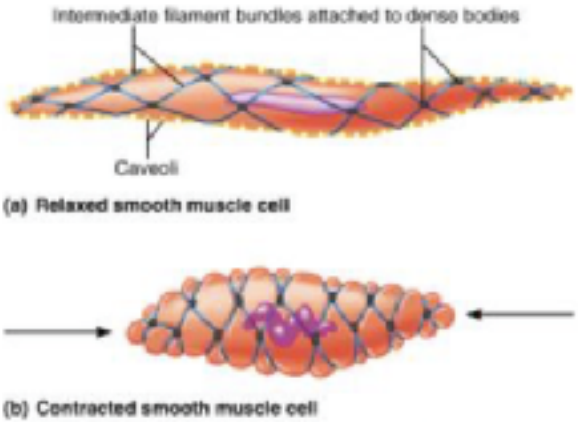
•involuntary contraction

•made of bundles/sheets of smooth muscle cells (SMCs)

•found in walls of organs (e.g. stomach, intestine, uterus and walls blood vessels)

Smooth muscle cells

- **fusiform-shaped** - differ in size depending on location
- connected together by gap junctions allowing coordinated contraction
- central elongated nuclei
- no sarcomeres = no striations
- majority of cytoplasm filled with thin filaments (actin)
- myosin filaments scattered throughout cytoplasm
- contraction of SMCs causes shortening of cell



Smooth muscle contraction

- caused by range of stimuli (involuntary)
    - mechanical (stretching)
    - electoral (autonomic nervous system)
    - chemical (hormones)
- contraction caused by Ca
- no T-tubules but still have SR

- smooth muscle specialised for slow, prolonged contraction
    - can contract without fatigue
- can contract in wave-fashion = peristaltic movements within organs
    - narrowing/shortening of objects through lumen of organs
- can contract whole smooth muscle at once to produce extrusive movements e.g. urinary bladder & uterus = closing of lumen = urination