Physiology of labour

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Labour

Labour is a process by which the products of conception are expelled by the mother within the last few hours of pregnancy

Normal labour is when a full term fetus presenting as vertex is expelled by maternal efforts unaided within a period of 24 hours

Phases of parturition(labour)

- Phase 1 – Quiescent phase
- Phase 2 – Activation phase
- Phase 3 – Stimulation phase
- Phase 4 – Involution phase

Phase 1 - Quiescent phase

- Starts even prior to implantation and continues till onset of activation phase which begins 6 – 8 weeks before labour
- Quiescence of myometrium is essential for retaining pregnancy inside uterus
- Uterine smooth muscle is unresponsive to natural stimuli

- Cervix softens due to changes in matrix components and changes in collagen
- Mediators involved are progesterone, relaxin, prostaglandin I_2 , nitric oxide

Phase 2 - Activation phase

- Begins 6 – 8 weeks before term and ends with onset of regular uterine contractions
- Changes in myometrium and cervix occur, which are preparatory to uterine contractions and cervical dilatation
- Regulated by fetal hypothalamo-pituitary-adrenal axis, maternal hypothalamo-pituitary axis and placental endocrine and paracrine factors

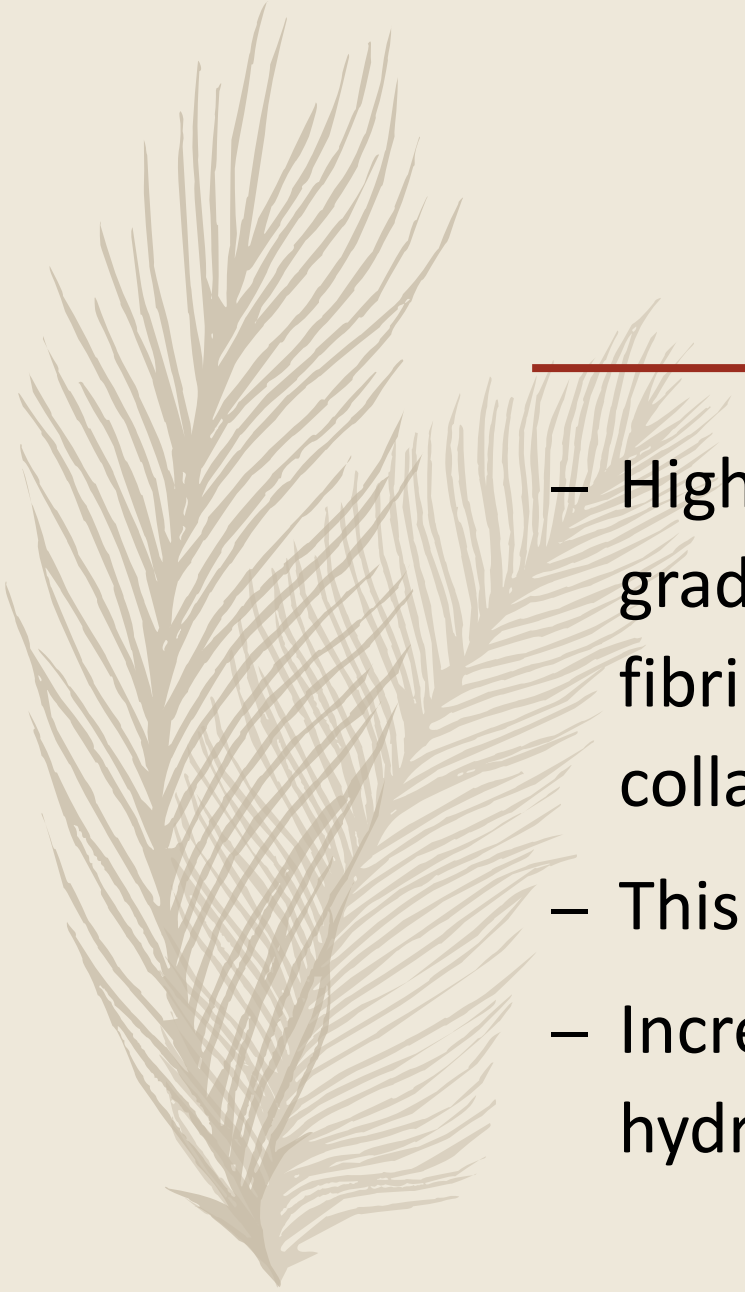
Changes in myometrium

- Increase in uterine responsiveness and uterine contractility is characteristic
- Increase in expression of contraction associated proteins like oxytocin receptors, prostaglandin receptors and connexin 43

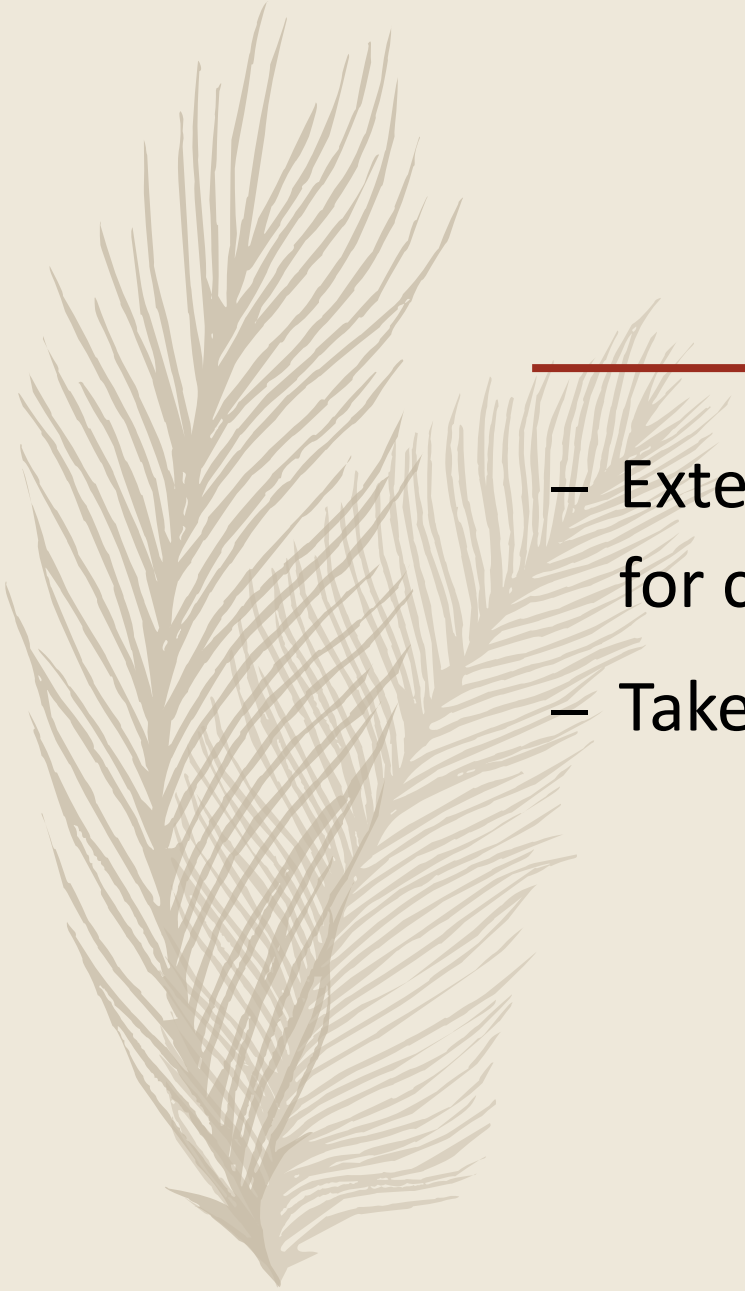
- Connexin 43 is a gap junction protein which is increased because of increase in area of gap junctions in myometrium
- Increase in gap junction permits electrical synchrony and allows effective coordination of uterine contractions

Changes in cervix

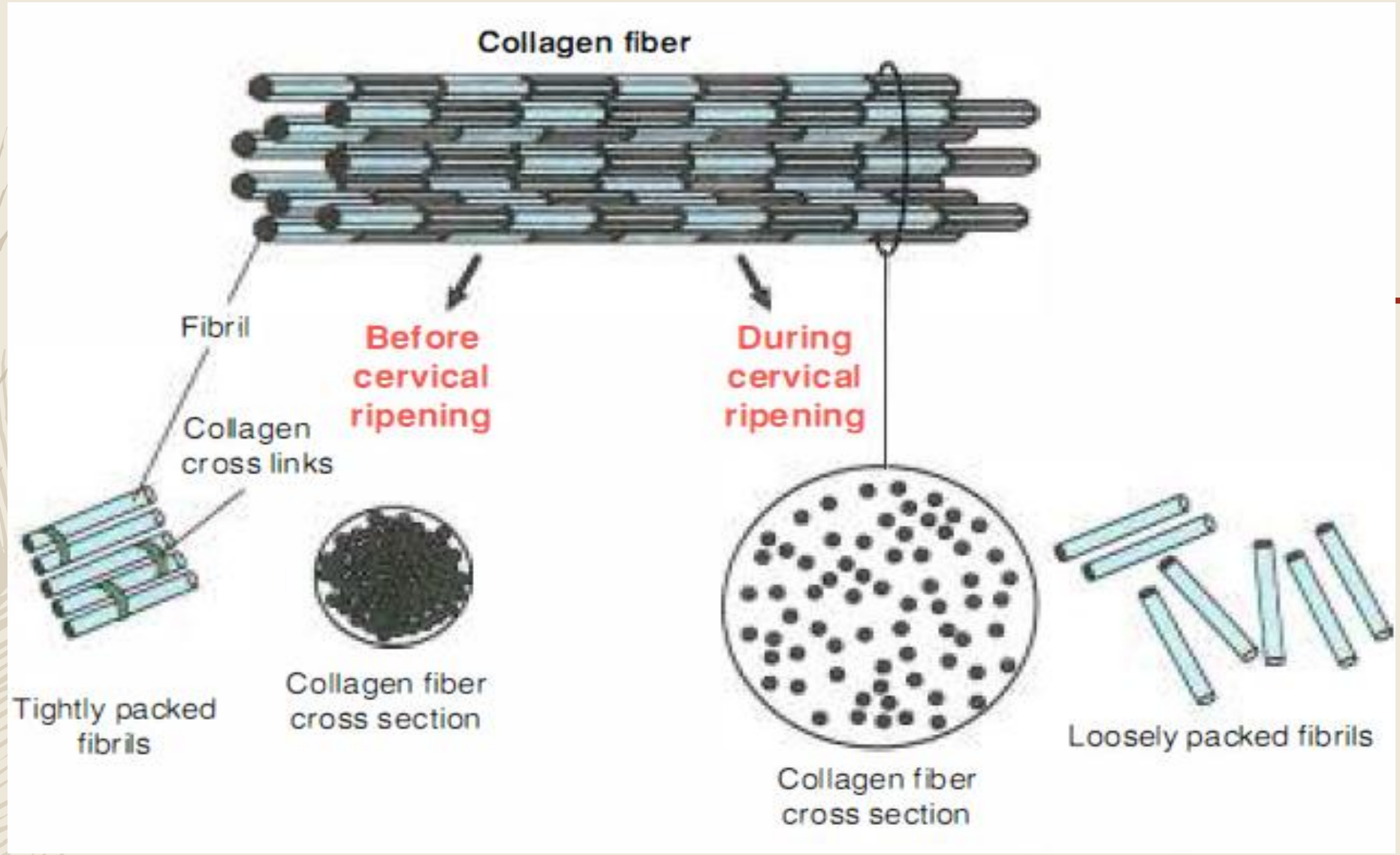
- Alteration in collagen structure and relative concentrations of matrix metalloproteases , glycosaminoglycans and proteoglycans
- Inflammatory cell infiltration leading to increase in inflammatory cytokines mainly Interleukin 8



- Higher turnover of collagen during pregnancy allows gradual replacement of mature cross linked collagen fibrils with poorly cross linked fibrils which yield greater collagen disorganization
- This helps to achieve cervical remodeling
- Increase in hyaluronic acid increase viscoelasticity, hydration and matrix disorganisation



- Extensive remodeling of cervix occurs- cervical ripening for cervix to efface and dilate with uterine contractions
- Takes place 2 weeks to few days before labour


Collagen fiber
Fibril
Before cervical ripening
During cervical ripening
Collagen cross links
Tightly packed fibrils
Collagen fiber cross section
Collagen fiber cross section
Loosely packed fibrils

- The falling forward of uterus with head sinking into pelvis resulting in “lightening” due to relief of pressure exerted by gravid uterus on diaphragm and therefore on lungs and heart
- Gradual shortening of cervical canal
- False labour pain – temporary, irregular pain felt over abdomen, do not progress, not associated with contraction of uterus or dilatation of cervix

Parturition cascade

- Series of events at term beginning with removal of factors ensuring uterine quiescence and activation of factors promoting uterine contractions occurring in phase 2 of labour
- Is a complex phenomenon involving fetus, mother and placenta

Role of fetus in parturition cascade

- Activation of fetal hypothalamic-pituitary-adrenal axis occurs
- Increase in hypothalamic corticotropin releasing hormone stimulates fetal pituitary to secrete ACTH
- This stimulates fetal adrenal gland to secrete DHEAS (dehydroepiandrosterone sulphate) which is converted to oestradiol by placenta

- Some DHEAS undergo 16 hydroxylation in fetal liver to 16OH DHEAS which is converted to oestriol by placenta
- Placental oestrogens act on uterus and stimulate production of PGF2α and increase oxytocin receptors, PG receptors and gap junctions
- Fetal adrenals also secrete cortisol which stimulate synthesis and release of placental CRH

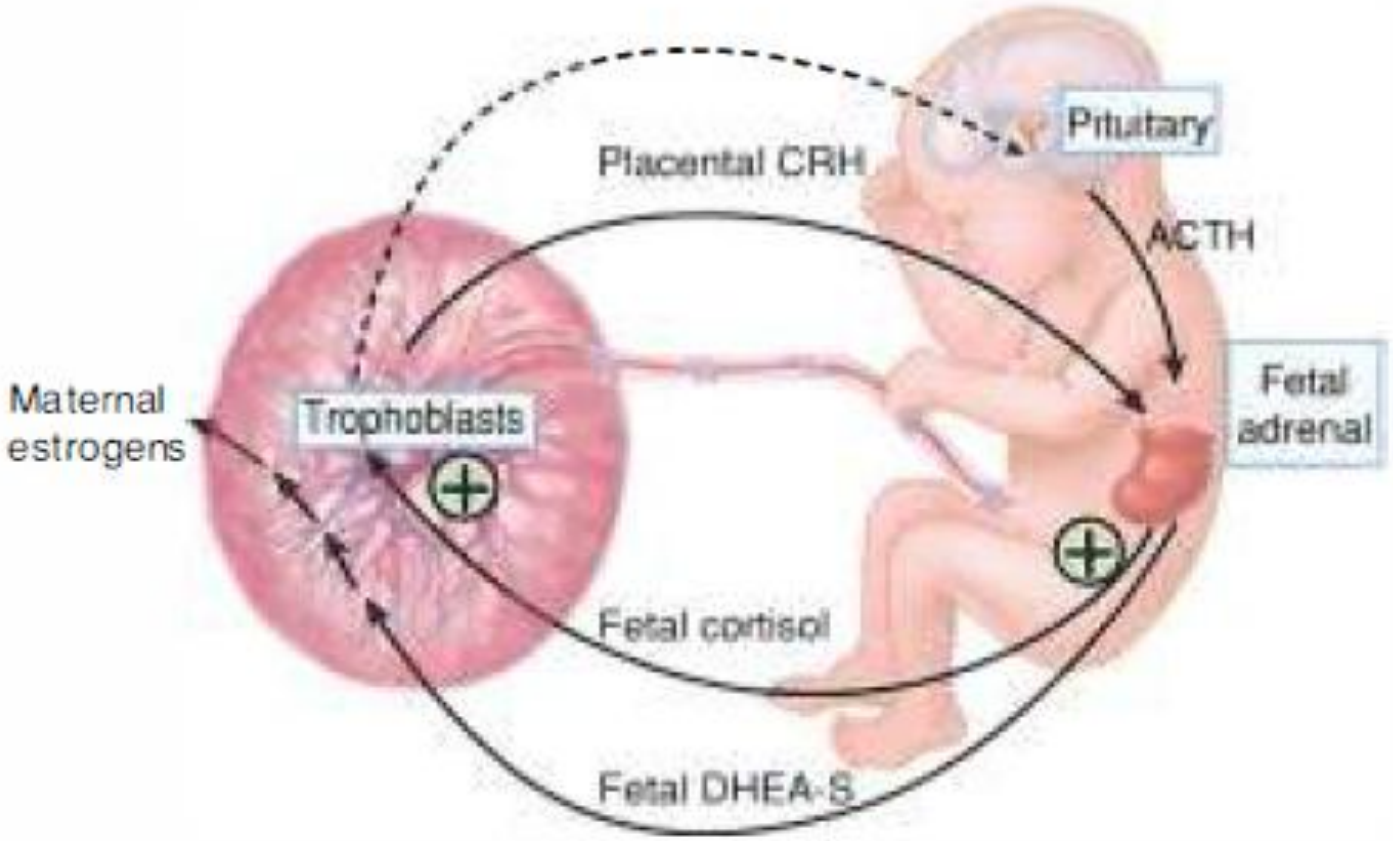
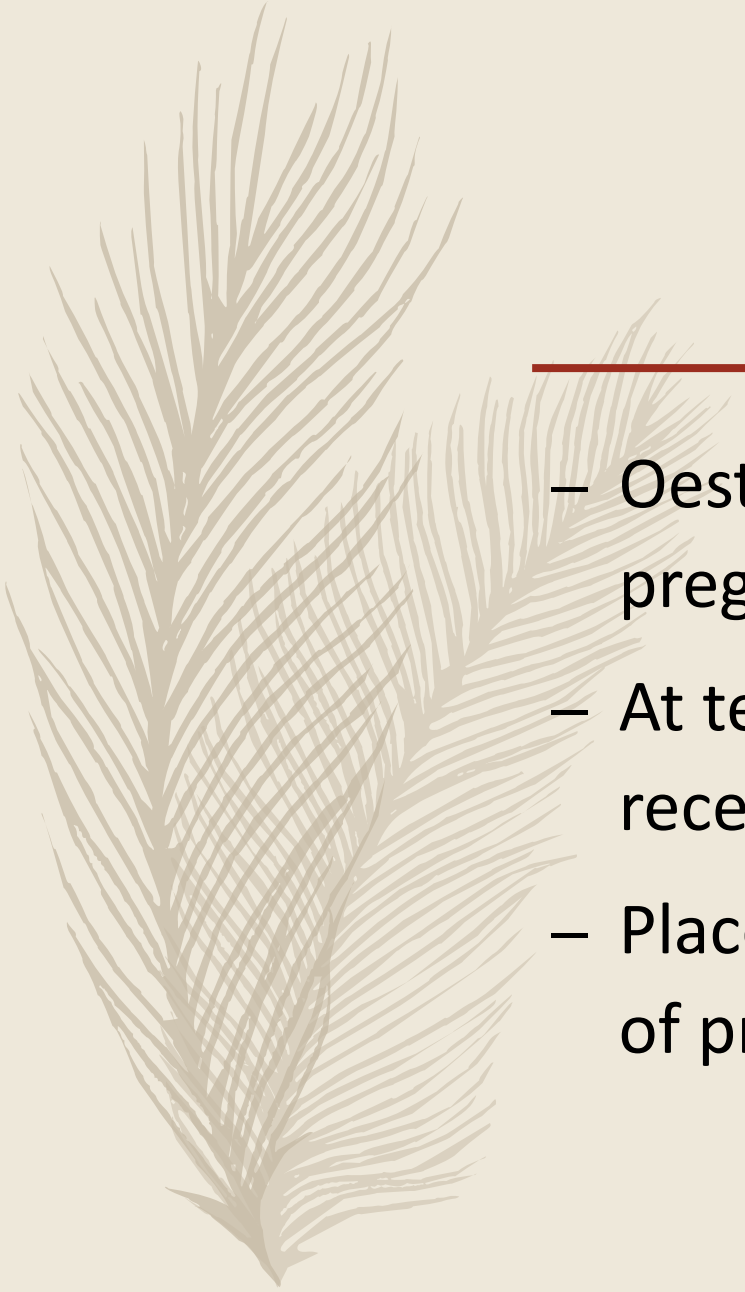


FIGURE 21-10 The placental–fetal adrenal endocrine cascade. In late gestation, placental corticotropin-releasing hormone (CRH) stimulates fetal adrenal production of dehydroepiandrosterone sulfate (DHEA-S) and cortisol. The latter stimulates production of placental CRH, which leads to a feed-forward cascade that enhances adrenal steroid hormone production. ACTH = adrenocorticotropic hormone.

Role of placenta in parturition

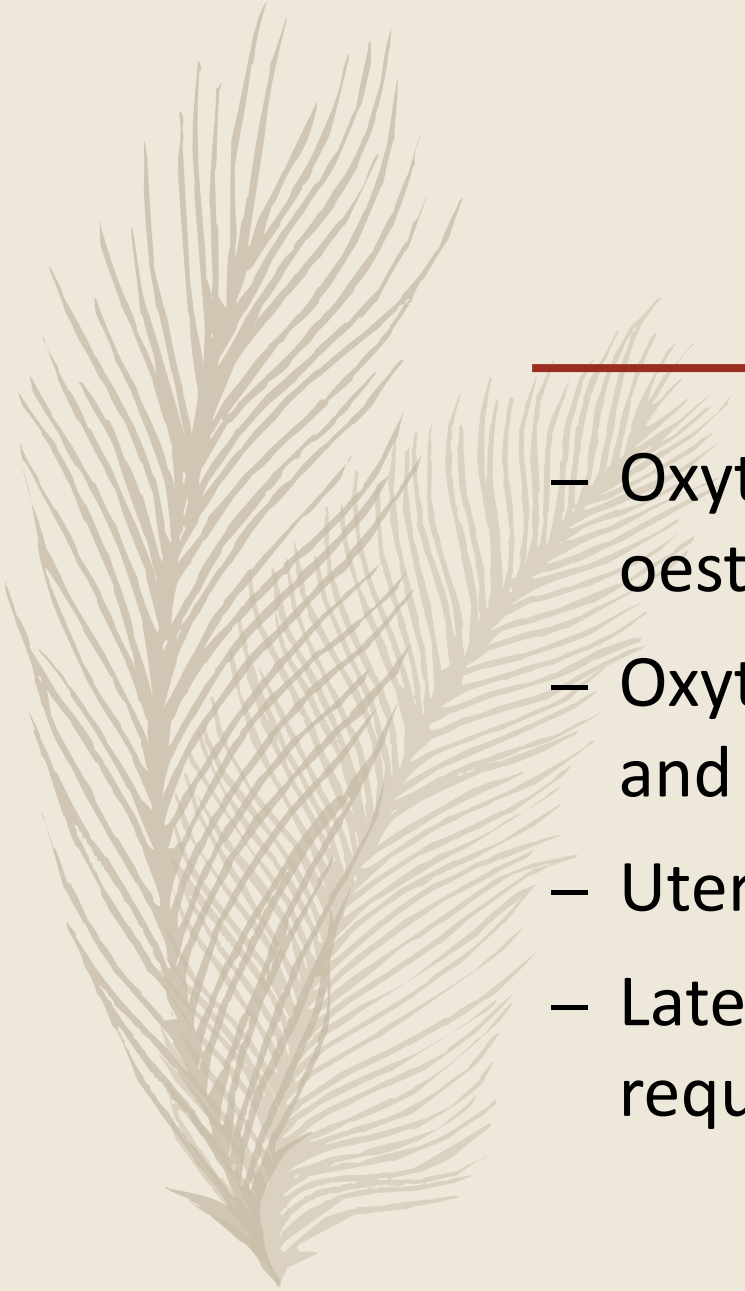
- Placenta secretes oestrogen, progesterone and CRH
- Human placenta lacks 17αhydroxylase. So conversion of progesterone to oestrogen does not occur
- Oestrogen binds to oestrogen receptors and stimulate production of contraction associated proteins, thus stimulating uterine contractions



- Oestrogen receptors are suppressed through out pregnancy by progesterone
- At term, changes in relative expression of progesterone receptors lead to functional withdrawal of progesterone
- Placental CRH acts on decidua and stimulates production of prostaglandins stimulating uterine contractions

Role of mother in parturition cascade

- Maternal oxytocin secreted by pituitary along with prostaglandins secreted by decidua and fetal membranes play a role in parturition
- No rise in oxytocin level during pregnancy
- Progressive increase in myometrial sensitivity to oxytocin due to marked increase in oxytocin receptors



- Oxytocin receptors increase towards term in response to oestogen produced by placenta
- Oxytocin induces prostaglandin production in decidua and fetal membranes
- Uterine sensitivity to oxytocin is gestational age related
- Later the gestational age, less the dose of oxytocin required to induce uterine contractions

- PGF2α causes uterine contractions
- PGE2 plays a role in cervical ripening
- Prostaglandins also increase oxytocin receptors in myometrium
- Fetal membranes and decidua contains phospholipase and cyclooxygenase enzymes

- They are activated by local inflammatory reaction, trauma, stretch, oestrogen and progesterone
- Arachidonic acid released from phospholipids of cell membranes are converted to prostaglandins
- Prostaglandins bind to myometrial PG receptors and exert their effects

Mechanical factors

- Uterine distension due to growing fetus and resultant stretching of myometrial fibres play a role in initiation of labour

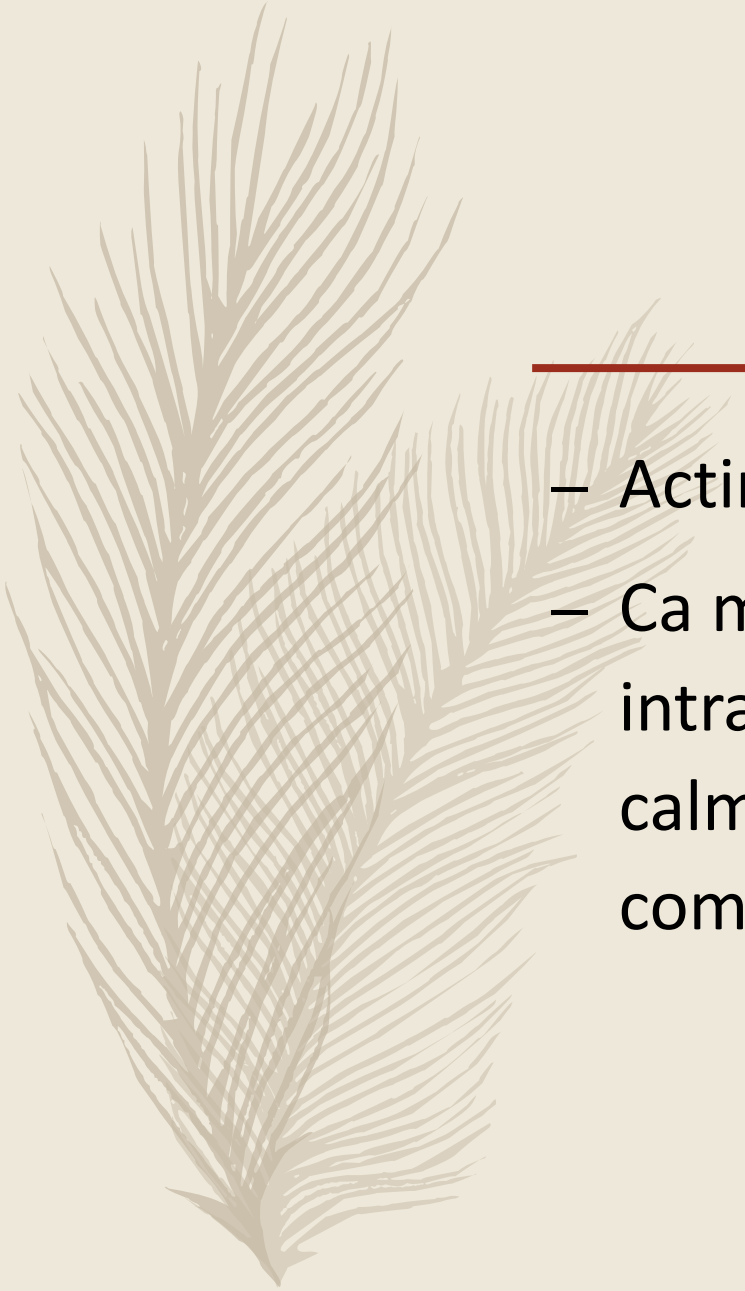
Myometrial contraction

- Uterine myometrium is poorly innervated
- Contraction and relaxation are mediated by hormones and locally produced paracrine factors such as PG in myometrium
- There are myometrial surface receptors located on cell surface

- Hormones and prostaglandins exert their effect by binding to receptors
- Receptors are upregulated or downregulated by hormones mainly oestrogen and progesterone
- At term, receptors for oxytocin and PGF2α are upregulated by oestrogen

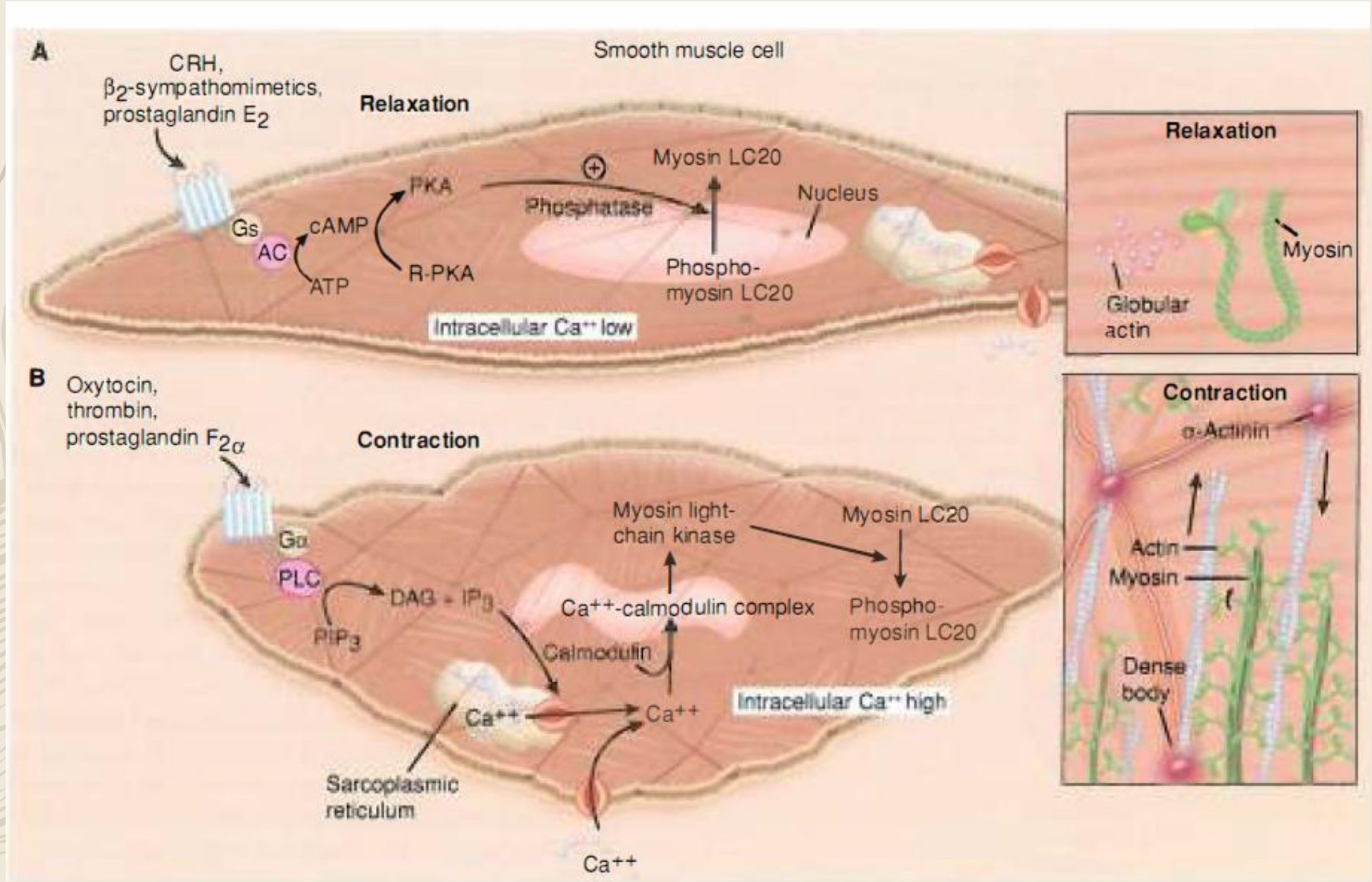
At cellular level, myometrial contraction involves,

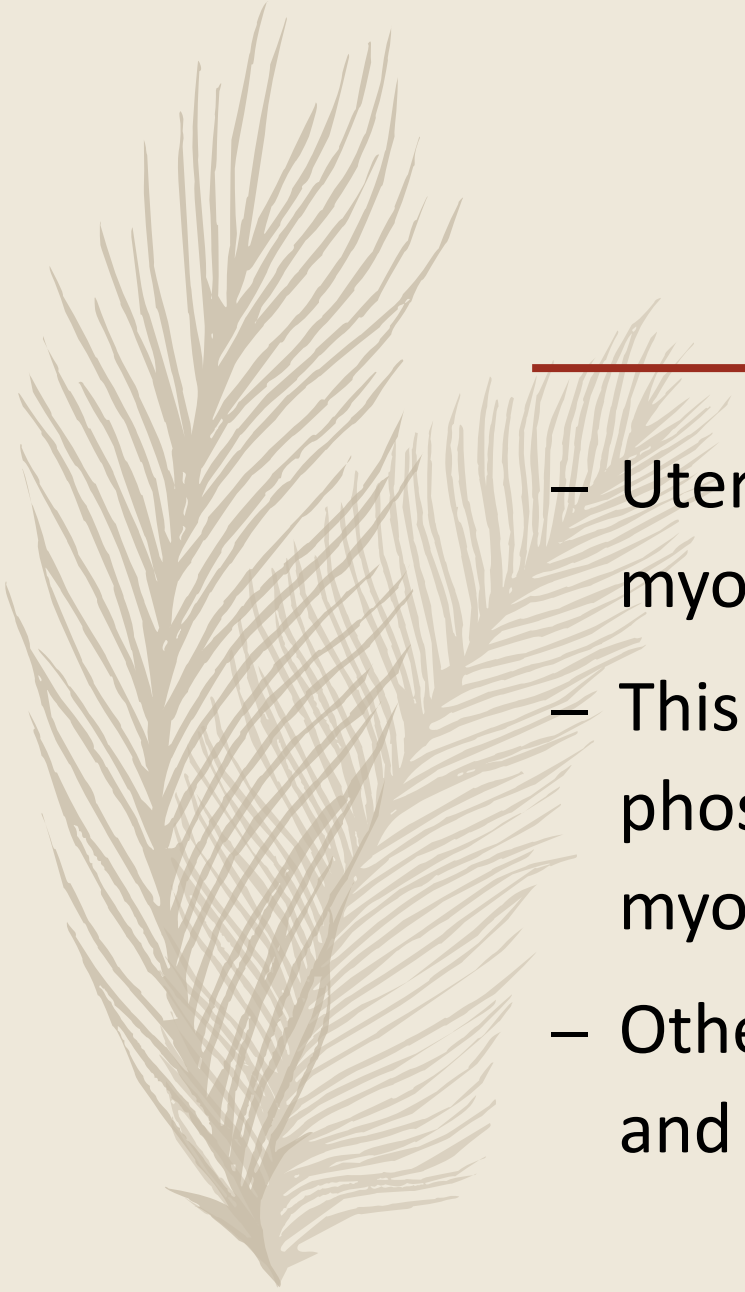
- Interaction between muscle proteins actin and myosin
- Interaction between myometrial cells



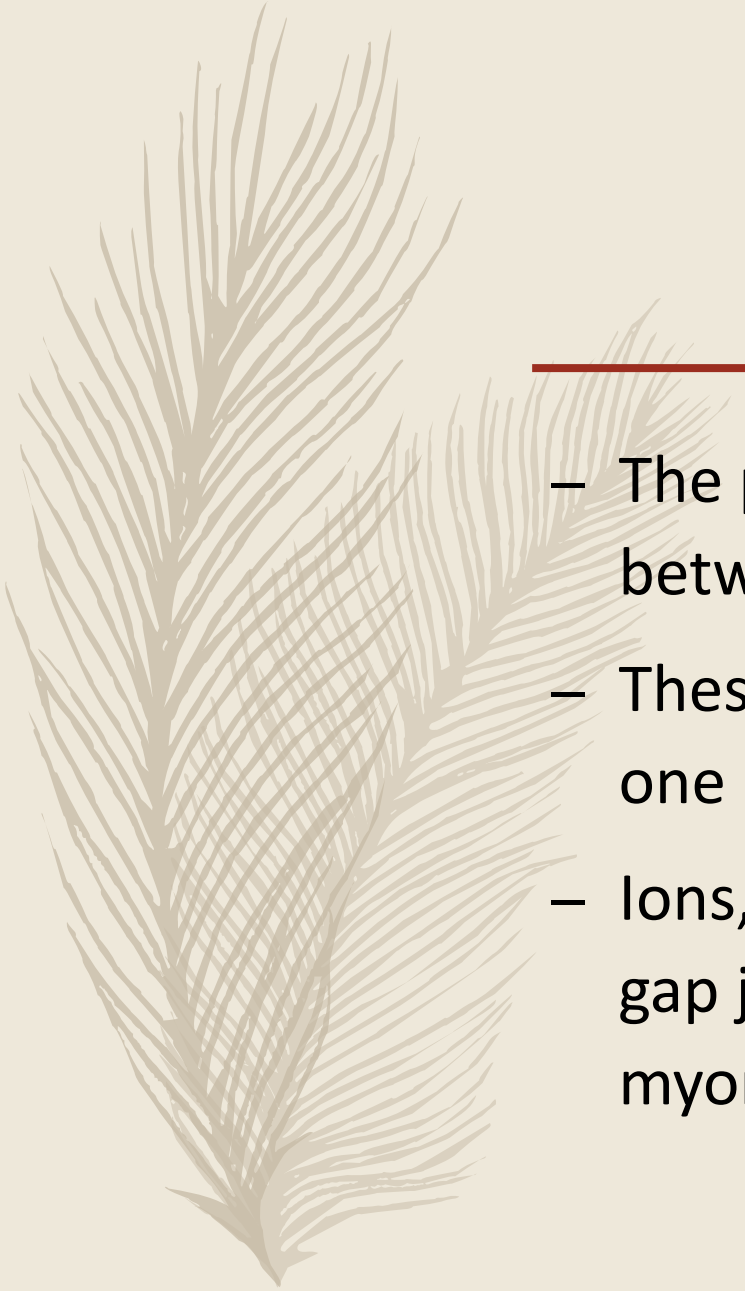
- Actin myosin interaction is calcium dependent
- Ca moves from extracellular compartment to intracellular compartment and combines with calmodulin, a carrier protein to form calcium calmodulin complex

- This activates the enzyme myosin light chain kinase which catalyses phosphorylation of myosin
- This leads to myosin actin interaction and activation of ATP resulting in myometrial contraction

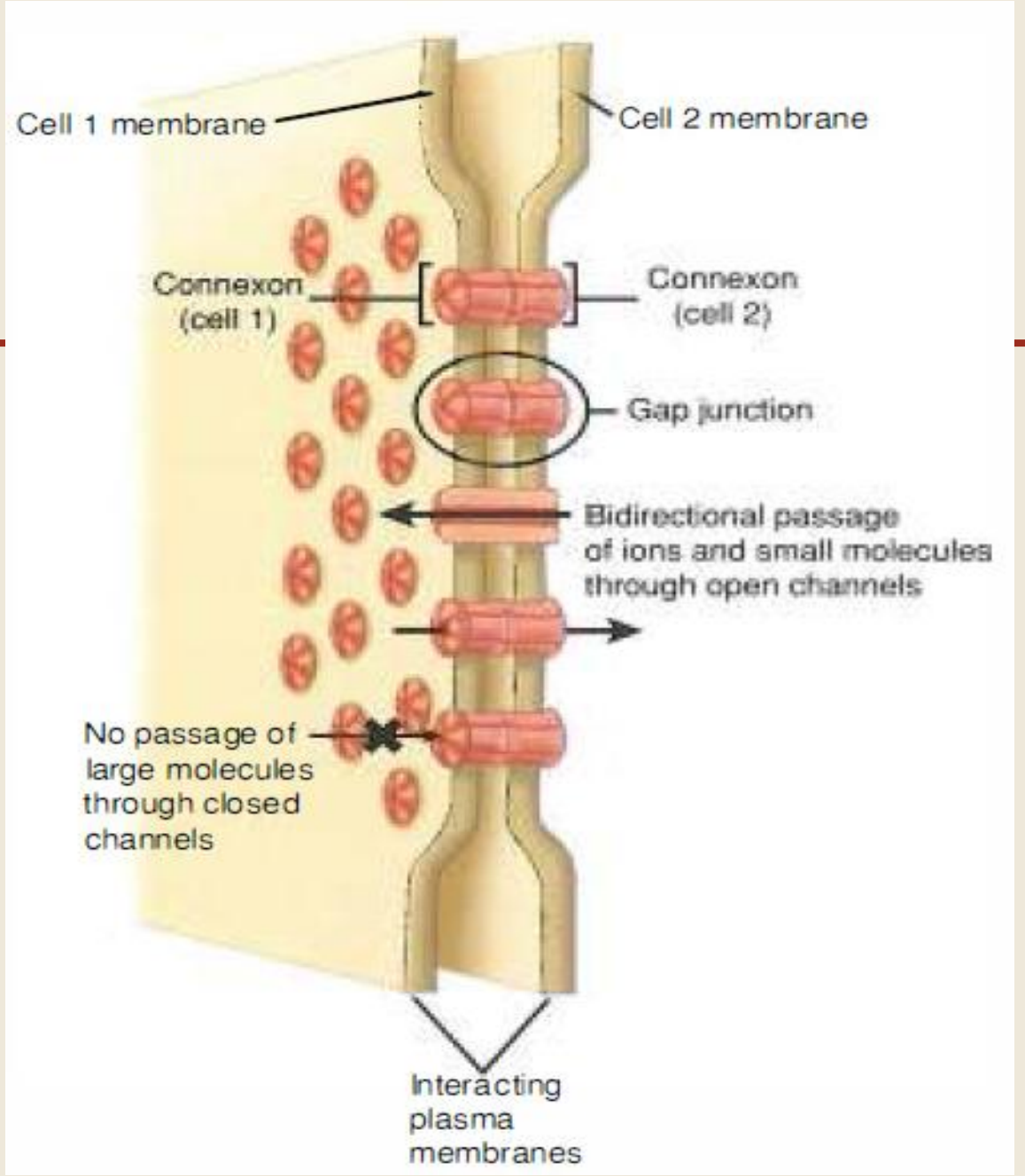

A
Smooth muscle cell
CRH,
β2-sympathomimetics,
prostaglandin E2
Relaxation
Gs
AC
cAMP
ATP
PKA
R-PKA
Phosphatase
Myosin LC20
Phospho-
myosin LC20
Nucleus
Intracellular Ca++ low
Relaxation
Myosin
Globular
actin
B
Oxytocin,
thrombin,
prostaglandin F2α
Contraction
Gα
PLC
PIP3
DAG + IP3
Myosin light-
chain kinase
Myosin LC20
Ca++-calmodulin complex
Phospho-
myosin LC20
Calmodulin
Ca++
Ca++
Intracellular Ca++ high
Sarcoplasmic
reticulum
Ca++
Contraction
α-Actinin
Actin
Myosin
Dense
body



- Uterine relaxation is maintained by factors that increase myocyte cAMP levels
- This activates protein kinase A to promote phosphodiesterase activity with dephosphorylation of myosin light chains
- Other processes serve to maintain actin in globular form and prevent fibril formation necessary for contraction



- The passage of signals causing contraction and relaxation, between myometrial cells is through gap junctions
- These are channels formed by proteins, the most important one in labour is connexin 43
- Ions, electric impulses and metabolites pass through these gap junctions to cause synchronized contraction of myometrium


Cell 1 membrane
Cell 2 membrane
Connexon (cell 1)
Connexon (cell 2)
Gap junction
Bidirectional passage of ions and small molecules through open channels
No passage of large molecules through closed channels
Interacting plasma membranes

Phase 3 - Stimulation phase

- Active uterine contractions, cervical dilatation and descent of fetus, followed by expulsion of fetus and placenta
- This phase is divided into 3 stages

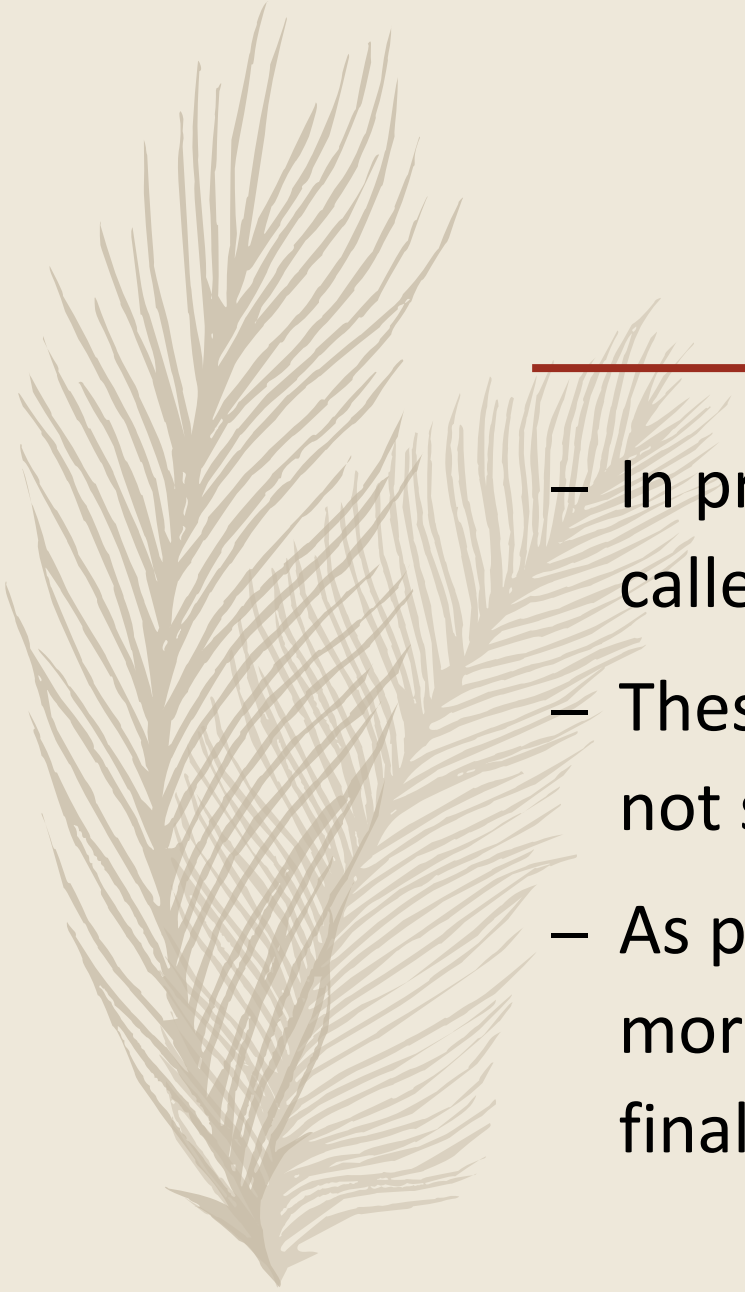
First stage

Onset of labour pains till full dilatation of cervix

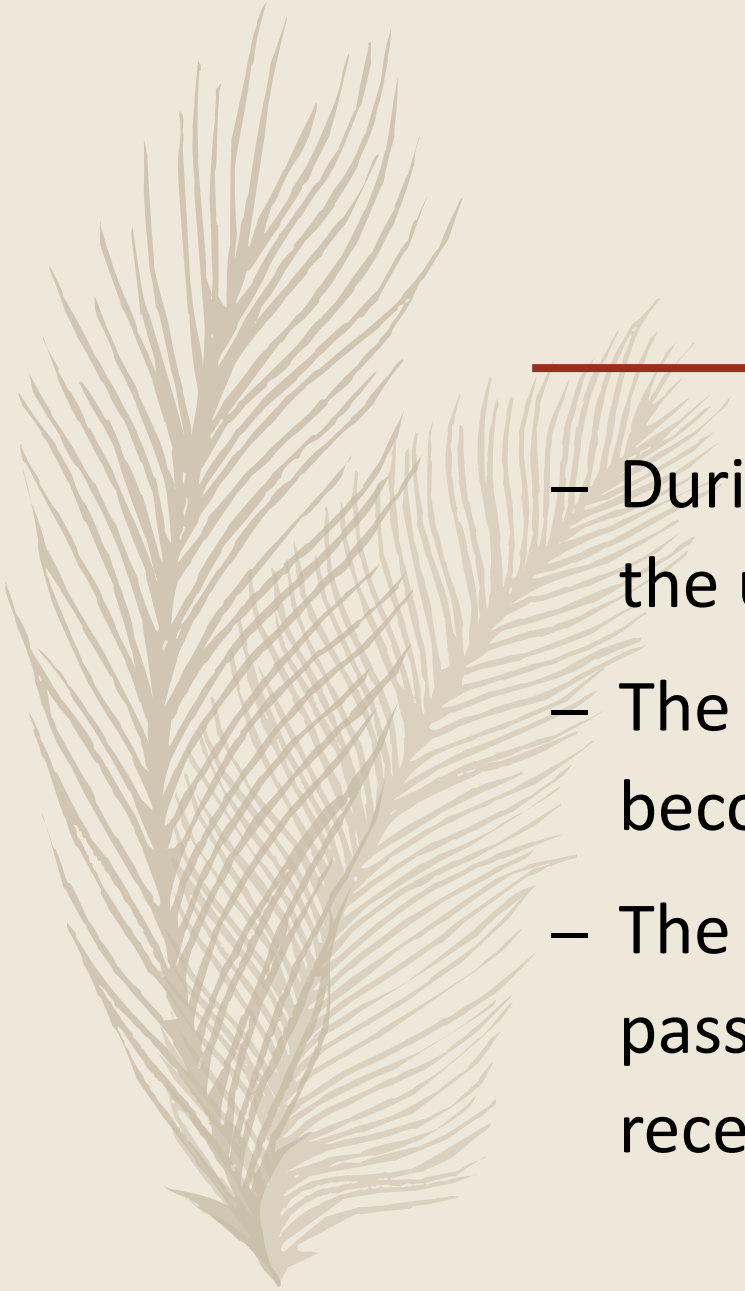
- True labour pains
- Mucosanguinous discharge or show
- Dilatation of cervical canal
- Fixation of head at brim and progressive descent
- Rupture of membranes

Uterine contractions

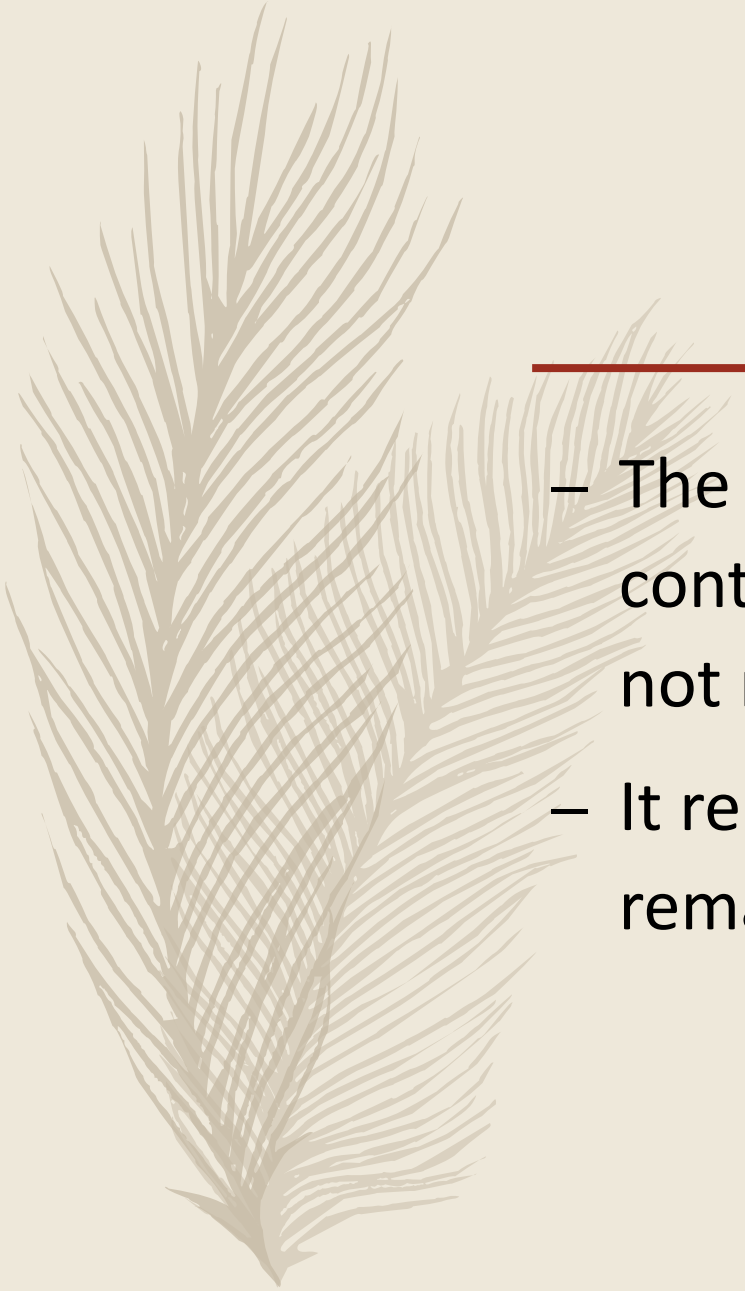
- Contractions occur at regular intervals, gradually become more frequent, occurring every few minutes lasting for 45 seconds
- Each contraction gradually increases in intensity, reaching a peak and then diminishes in intensity
- At first the pain is over the sacrum but later radiates to lower abdomen and even to legs



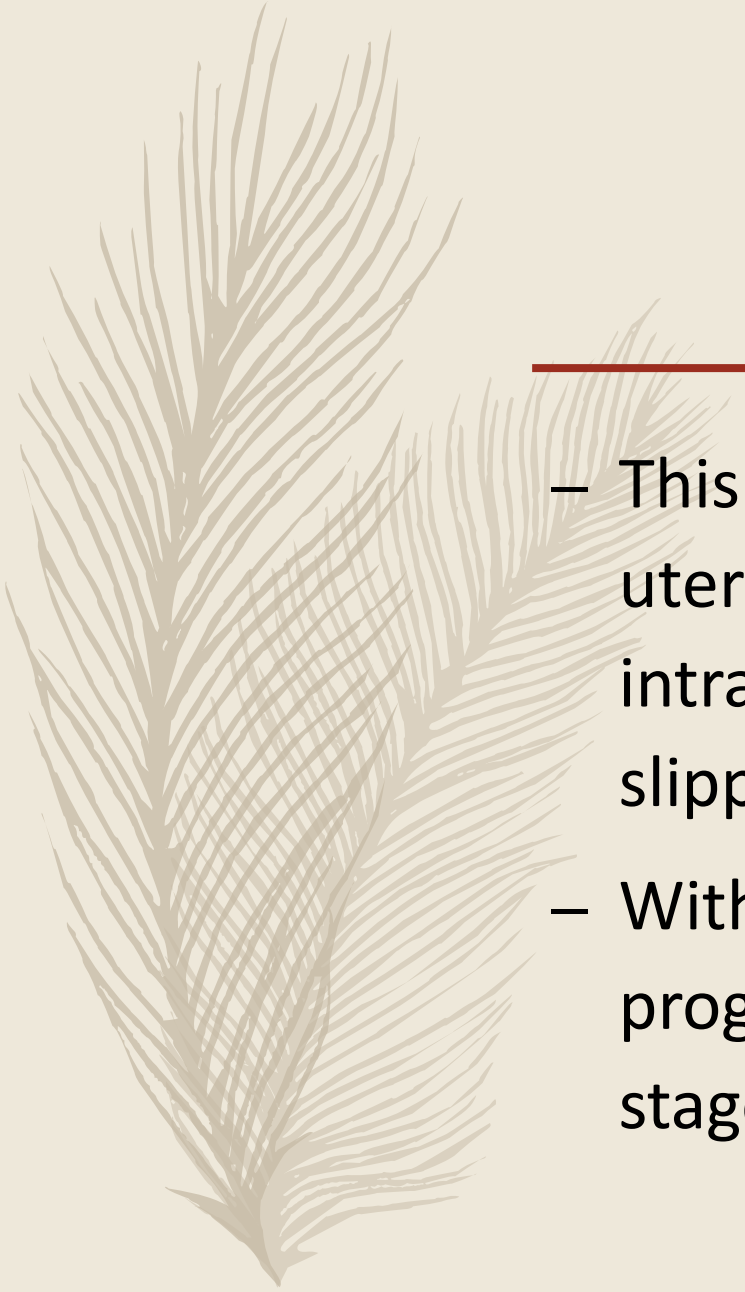
- In pregnancy, uterus shows intermittent contractions called Braxton Hick’s contraction in earlier weeks
- These contractions are irregular in time and force and do not show any coordination or diminishing gradient
- As pregnancy advances, these contractions become more frequent and regular and occasionally painful and finally convert themselves to labour pains at term



- During labour under the influence of uterine contraction, the uterus gets differentiated into 2 distinct portions
- The upper segment is thicker and more active and becomes progressively thicker as labour advances
- The lower portion ie. the lower segment with cervix is passive and becomes thinner and stretched out to receive the descending fetus



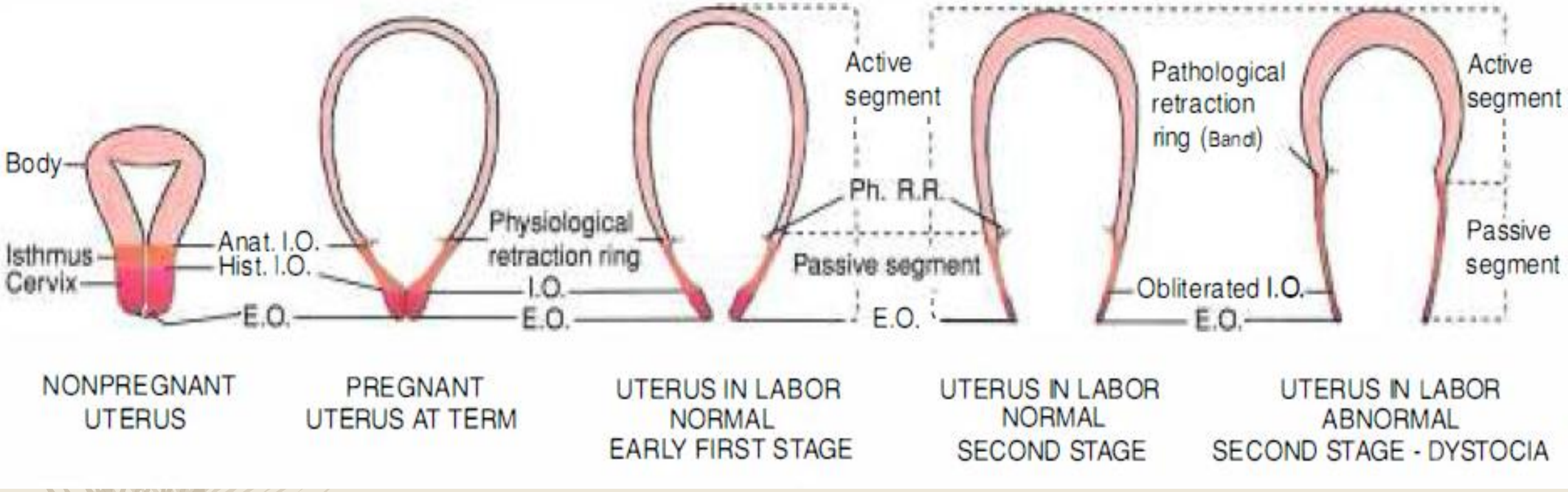
- The musculature of upper segment undergoes a type of contraction in which the muscle after contraction does not relax to get back to its original length.
- It remains fixed at a shorter length, the tension remaining the same as before contraction



- This ability of musculature to retract maintains the uterine musculature to be in firm contact with the intrauterine contents and helps to prevent fetus from slipping back
- With each contraction the upper segment becomes progressively thickened throughout the first and second stages of labour and more so after the birth of the baby

- The lower segment relaxes, its fibres become stretched with each contraction of upper segment, after which they do not return to their previous length
- It remains relatively fixed at a larger length
- The lengthening of muscle fibres lead to thinning of lower uterine segment

- The junction of upper and lower segment is characterised by a ring of circular muscle fibres – physiologic retraction ring
- This ring becomes more prominent in obstructed labour and is called the pathologic retraction ring (Bandl’s ring)


Body
Isthmus
Cervix
Anat. I.O.
Hist. I.O.
E.O.
Physiological retraction ring
I.O.
E.O.
Active segment
Ph. R.R.
Passive segment
E.O.
Pathological retraction ring (Bandl)
Obliterated I.O.
E.O.
Active segment
Passive segment
NONPREGNANT UTERUS
PREGNANT UTERUS AT TERM
UTERUS IN LABOR NORMAL EARLY FIRST STAGE
UTERUS IN LABOR NORMAL SECOND STAGE
UTERUS IN LABOR ABNORMAL SECOND STAGE - DYSTOCIA

Labour contraction at term is characterized by

- Retraction of upper segment
- Stretching and relaxation of lower segment
- Fundal dominance
- Diminishing gradient of activity from fundus through body to the lower uterine segment

Lower segment

- Lower segment is formed from the isthmus portion of non pregnant uterus between the anatomical internal os and histological internal os – former being higher
- This area grows and stretches during pregnancy
- Lower segment is formed by the retraction of upper segment, which pulls out and thins out the tissue intervening between itself and fixed cervix

- The thinning of lower segment in labour is due to outward and downward thrust of descending fetus
- Upper margin of lower segment is at the level of upper border of symphysis pubis in late pregnancy
- It is indicated roughly by the line of close attachment of uterovesical fold of peritoneum

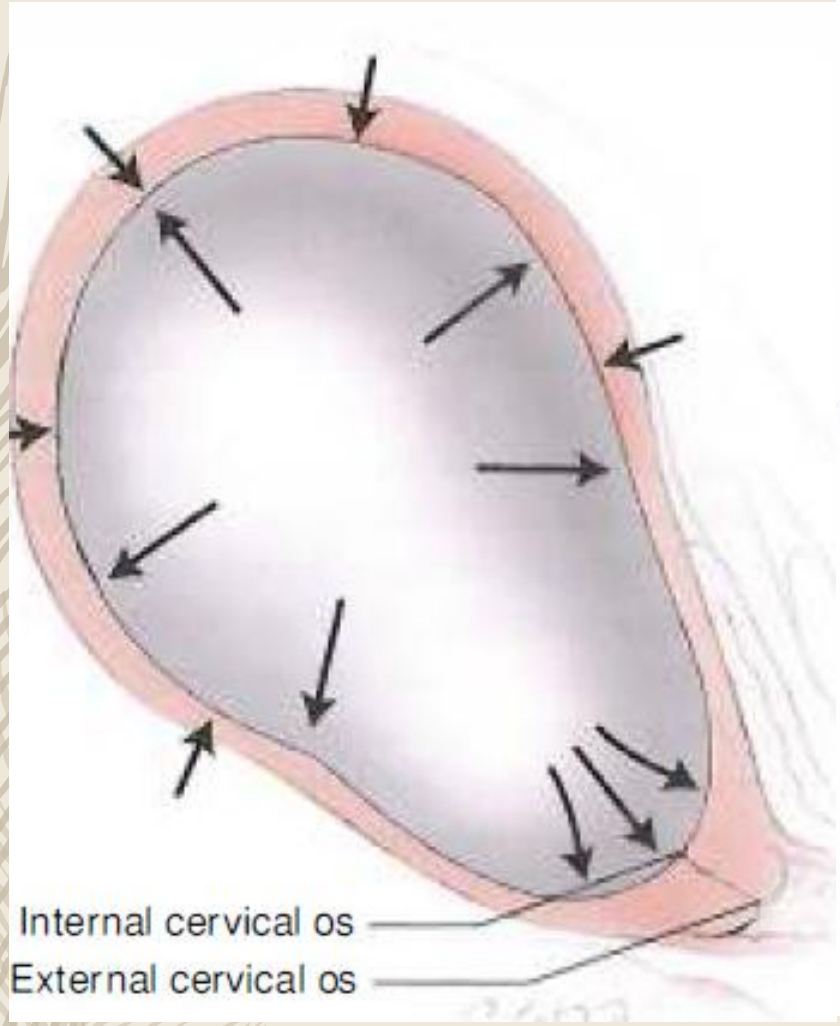
Mucosanguinous discharge

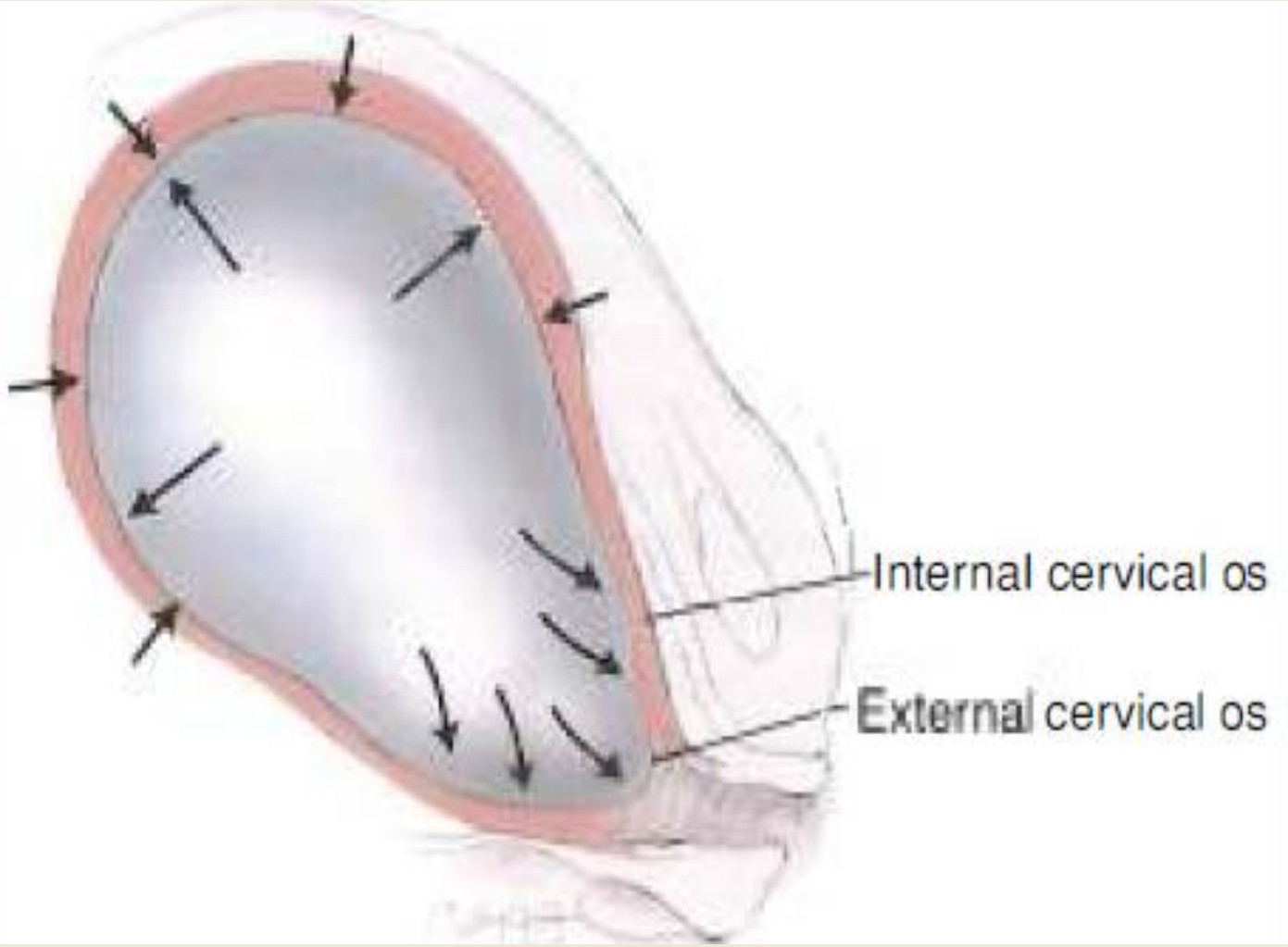
- Just before the onset of labour a small amount of red tinged mucous may be passed called show
- It is plug of cervical mucous mixed with blood

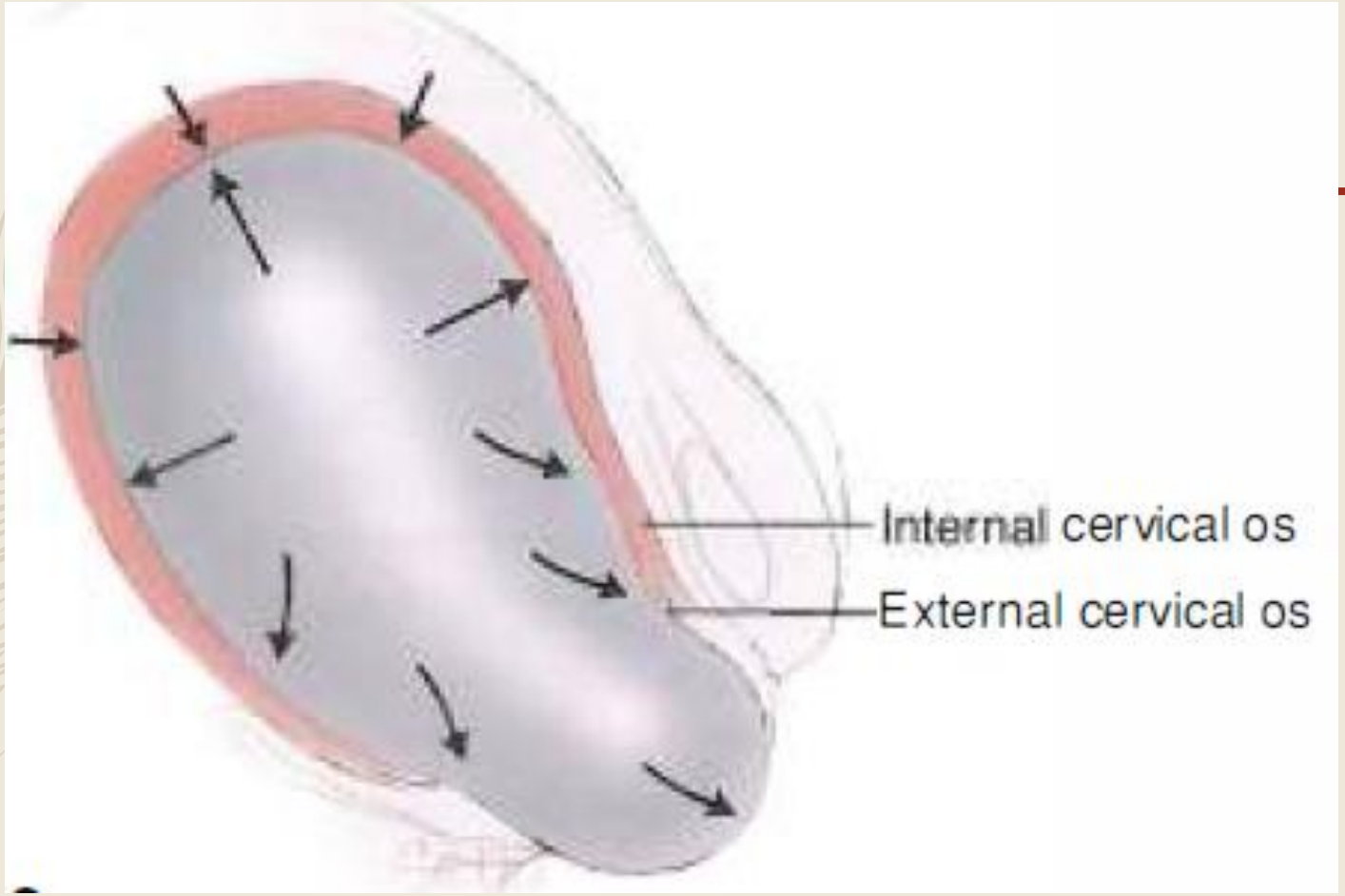
Cervical dilatation

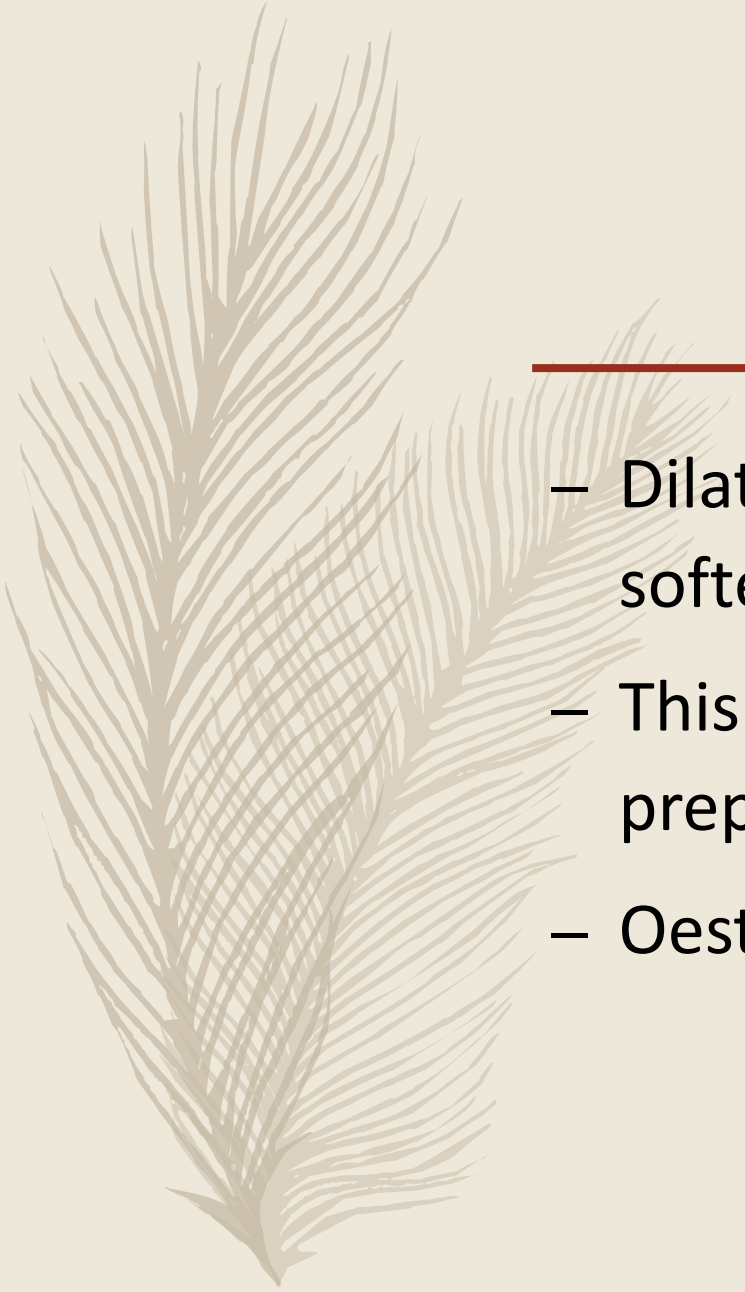
- Contracting and retracting upper segment lifts up and thins out the lower segment
- Pulls the cervix over the advancing presenting part without significantly altering the level of external os
- Well fitting presenting part favours good uterine contractions and smooth dilatation of cervix

- Uterine contractions cause pressure on the membranes
- Hydrostatic action of amniotic sac dilates the cervical canal
- After rupture of membranes, the pressure exerted by presenting part on cervix induces reflex uterine contractions which are more powerful


Internal cervical os
External cervical os

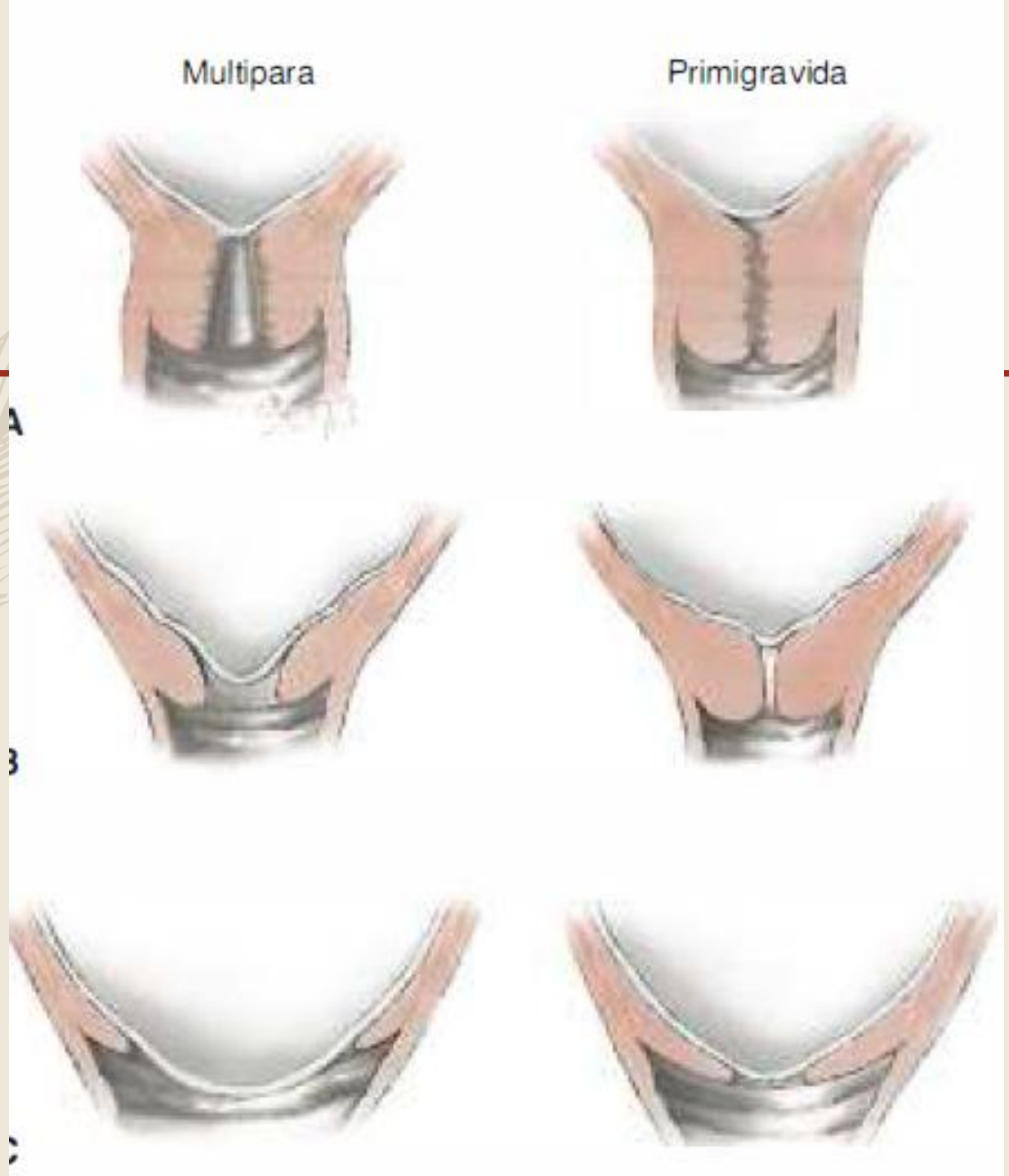

Internal cervical os
External cervical os

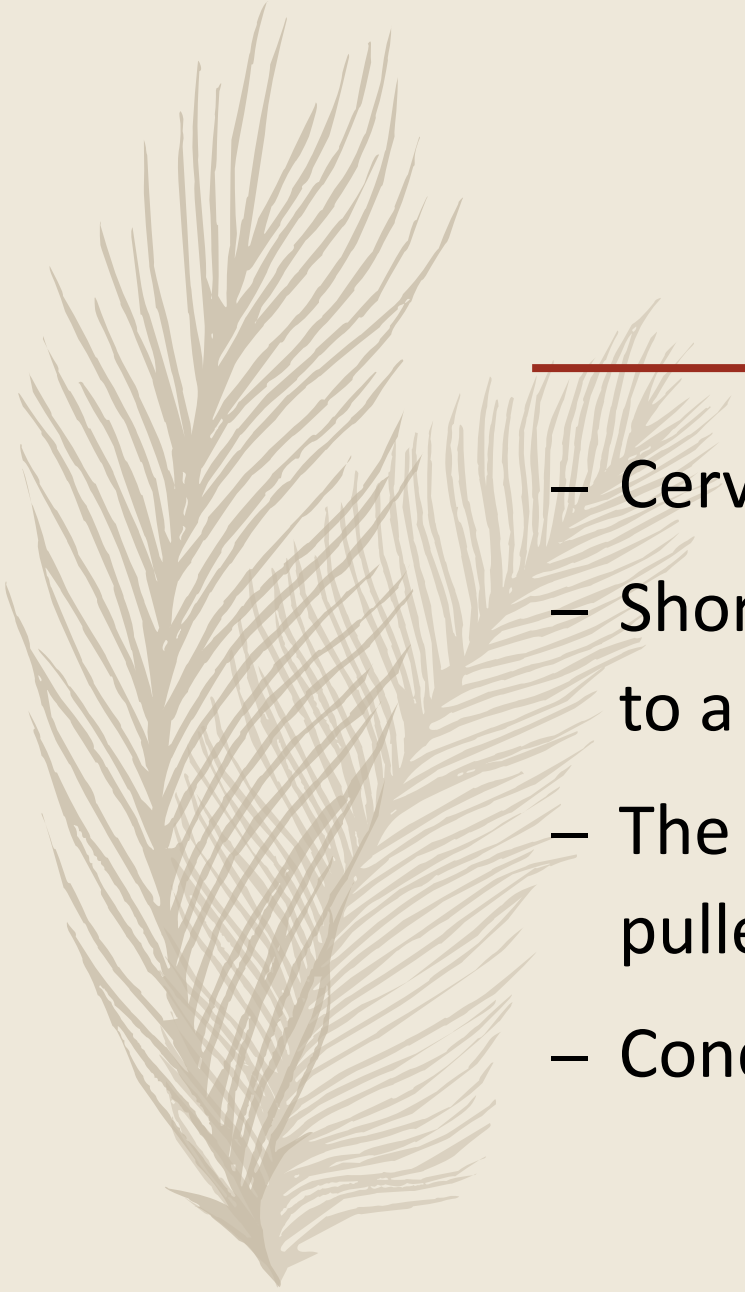

Internal cervical os
External cervical os



- Dilatation of cervix also depends on its own capacity to soften and stretch
- This depends on intrinsic development and on its preparation during pregnancy
- Oestrogen, progesterone and prostaglandins play a role

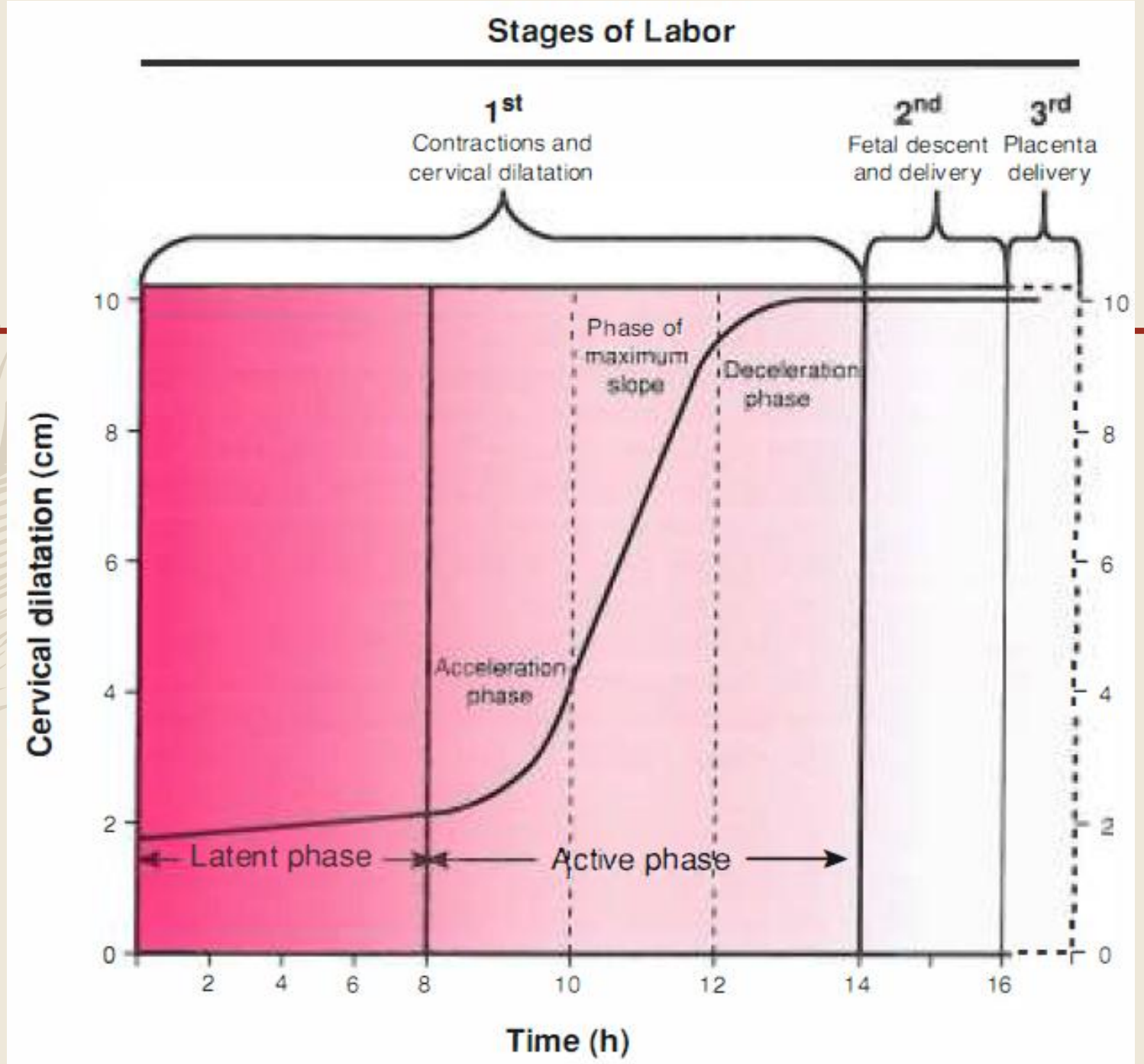
- In primi, the whole cervical canal is closed, both internal and external os
- The dilatation occurs progressively from above downwards, internal os dilating first, then the cervical canal and last the external os
- In multi, external os is patulous
- Dilatation of internal os brings about simultaneous dilatation of whole cervical canal


Multipara
Primigravida
A
B
C



- Cervical effacement is obliteration or taking up of cervix
- Shortening of cervical canal from a length of about 3 cm to a mere circular orifice with paper thin edges
- The muscular fibres at the region of internal os are pulled upward or taken up into the lower segment
- Condition of external os remains temporarily unchanged

- Friedman explained that the cervical dilatation during labour when plotted against time takes the shape of sigmoid curve
- Cervical dilatation is divided into latent phase and active phase
- Active phase is subdivided into acceleration phase, phase of maximum slope and deceleration phase


Stages of Labor
1st
Contractions and cervical dilatation
2nd
Fetal descent and delivery
3rd
Placenta delivery
Phase of maximum slope
Deceleration phase
Acceleration phase
Latent phase
Active phase
Cervical dilatation (cm)
Time (h)
0
2
4
6
8
10
12
14
16

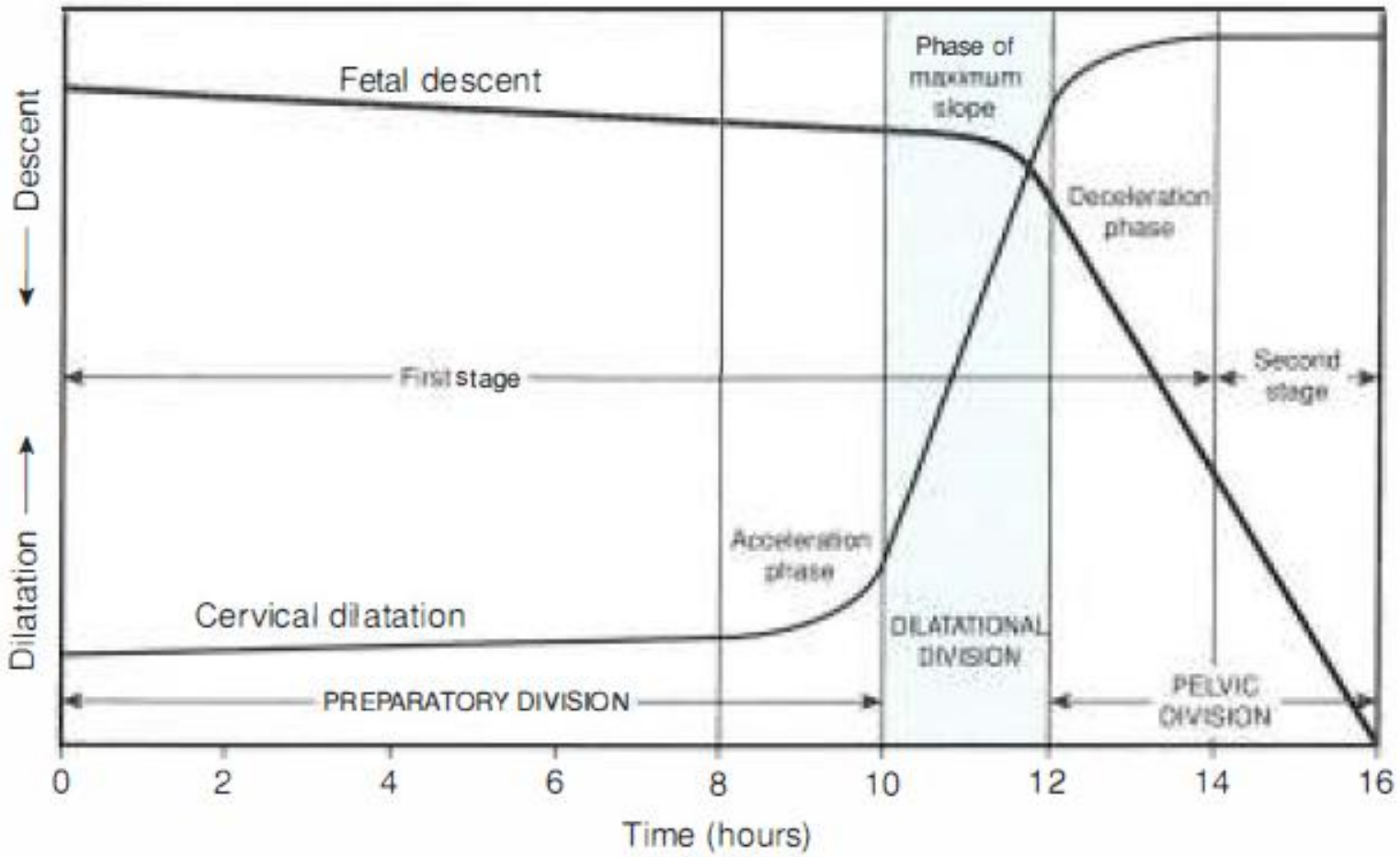


FIGURE 21-15 Labor course divided on the basis of expected evolution of the dilatation and descent curves into three functional divisions. The preparatory division includes the latent and acceleration phases. The dilatational division is the phase of maximum slope of dilatation. The pelvic division encompasses both the deceleration phase and the second stage, which is concurrent with the phase of maximum slope of fetal descent. (Redrawm from Friedman EA: Labor: Clinical Evaluation and Management, 2nd ed. New York, Appleton-Century-Crofts, 1978.)

Fetal descent

- In nullipara, engagement of fetal head occurs before the onset of labour
- Active descent occurs during the phase of maximum slope of cervical dilatation and continues till head reaches the perineum

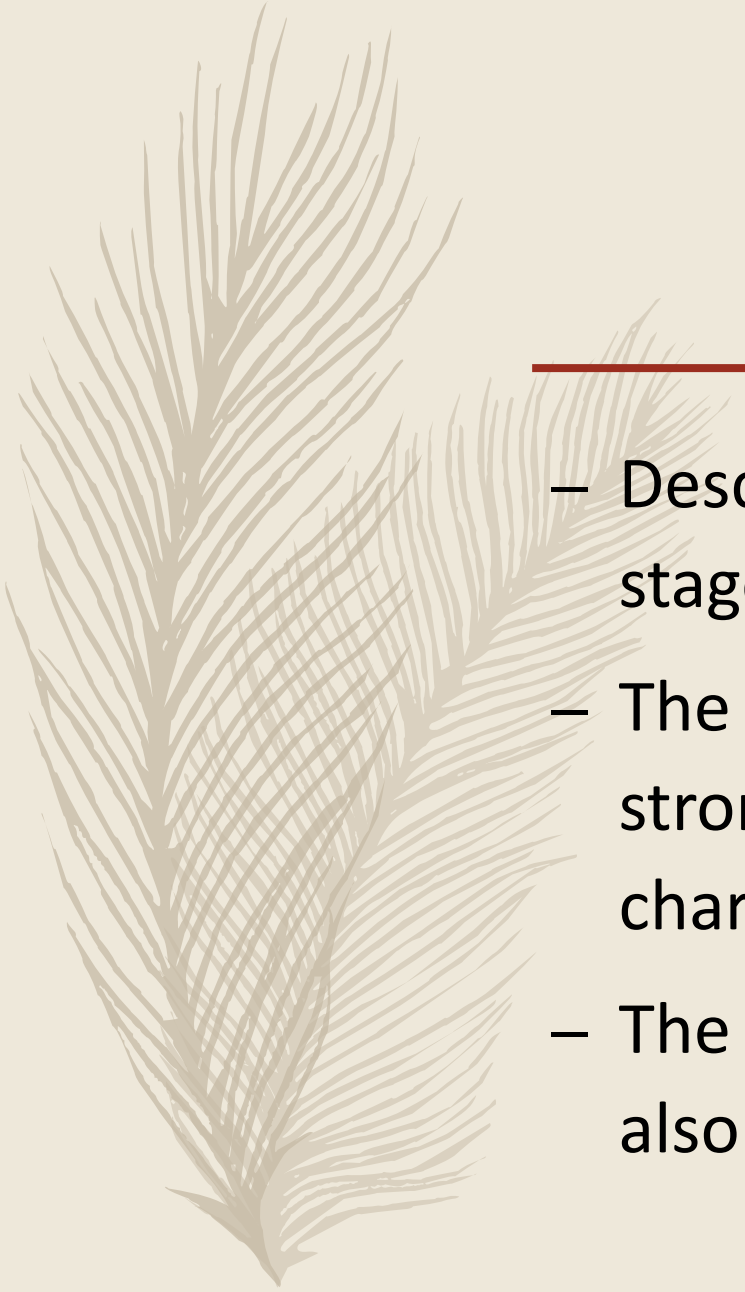
Rupture of membranes

- Spontaneous rupture of membranes occur usually during the active phase of labour
- Rupture is evident by sudden gush of fluid

Second stage

Starts with full dilatation of cervix and ends with delivery of fetus

- Descent of fetus
- Bearing down pains
- Crowning of head
- Expulsion of fetus



- Descent of head occurs in the late first stage and second stage of labour
- The nature of uterine contractions change, they get stronger in the second stage and are of a bearing down character
- The voluntary muscles – the accessory muscles of labour also contract and exert their influence

- The diaphragm and abdominal muscles begin to act and the fetus is pushed through the dilated cervical canal
- Vagina relaxes and dilates to receive it
- When perineum is reached it is stretched so that it begins to bulge with every uterine contraction
- When the presenting part is fixed under symphysis pubis crowning of head occurs

- Head passes through the outlet by a series of uterine contractions, helped by involuntary straining efforts on the part of the patient due to action of accessory muscles of labour
- After the expulsion of head, rest of the baby is born

Second stage of labour is divided into 2 phases

- Pelvic phase
- Perineal phase

Pelvic phase –

- Full dilatation of cervix to the time when the head reaches the pelvic floor
- Rapid descent of head occurs
- End of phase is marked by bearing down pains

Perineal phase

- Beginning of bearing down pains to delivery of fetus
- If this phase is prolonged, fetal hypoxia and damage to pelvic floor muscles and fascia can occur

Third stage

Expulsion of fetus to complete expulsion of placenta

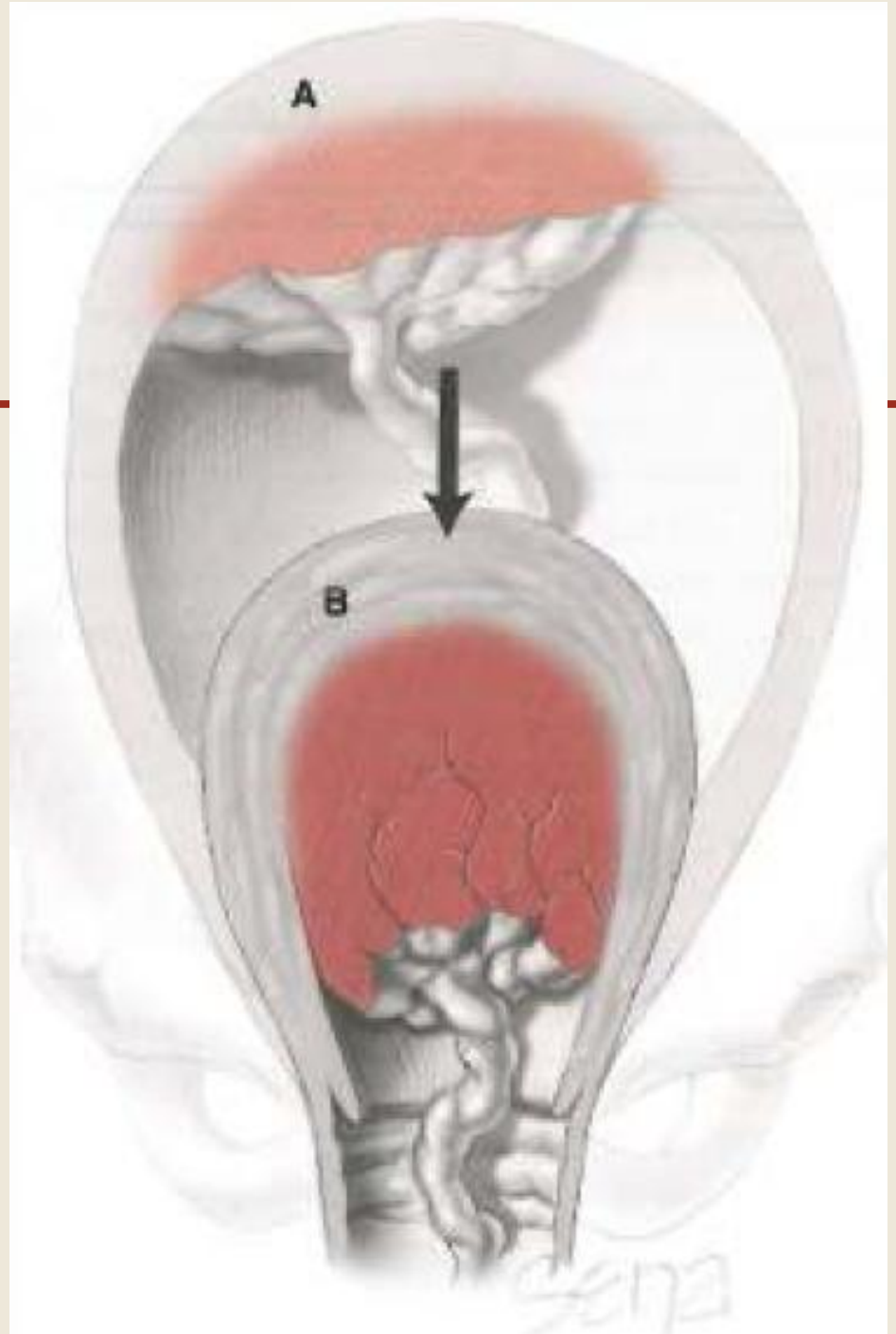
- Characteristic uterine contraction
- Separation of placenta
- Expulsion of placenta
- Control of haemorrhage
- Permanent contraction and retraction of uterus

Uterine contraction

- After expulsion of fetus uterus will be almost at the level of umbilicus and is firm and hard
- Rhythmic contractions occur
- Sometimes patient feels pain

Separation of placenta

- Shrinkage of placental site and forcing down of whole placental mass by uterine contraction cause separation of placenta
- 2 methods of placental separation
    1. Duncan’s method
    2. Schultze method



Shrinkage of placental site after delivery of fetus

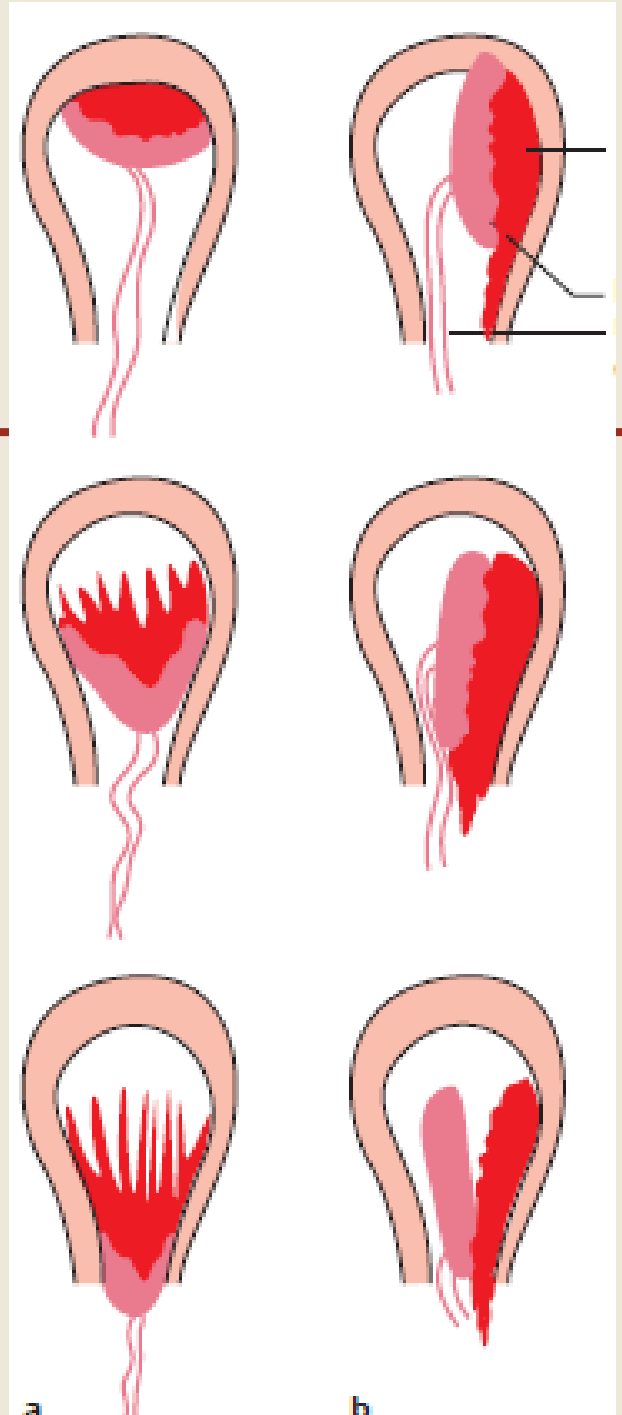
Duncan’s method

- The placenta may be folded on itself
- The long axis of placenta corresponds to the long axis of uterus
- The margin that presents at the cervix or vagina is the lower margin

Schultze method

- Placenta may separate in the centre
- A retroplacental haematoma is formed which with each contraction of uterus forces more of placenta to separate
- Separated placenta presents at the vaginal outlet with the centre of fetal surface with attached cord like an inverted umbrella

Schultze method of placental separation



Duncan’s method of placental separation

Expulsion of placenta

- Occurs within few minutes after birth of fetus
- Uterus will be tonically contracted so that the placenta separates

Control of haemorrhage

- Contraction and retraction of uterus constricting the vessels passing through the uterine wall to the placental site
- Occlusion of torn vessels themselves
- Formation of blood clots which favour closure of lumen of vessels

Phase 4 - Involution phase

- Described as puerperium
- Involution of uterus and cervix
- Responsiveness of endometrium to ovarian hormones

- Uterus and cervix return to their normal state and integrity
- Changes take place over a period of 4- 6 weeks
- Local inflammatory processes resolve, production of glycosaminoglycans and proteoglycans ceases, changes in collagen and other tissues of cervix regress

- Uterine involution is aided by oxytocin that is released in response to suckling
- The endometrium becomes slowly responsive to the cyclical hormone production by the ovary
- Maternal hypothalamo- pituitary- ovarian axis starts functioning again in normal cyclical fashion once lactation ceases

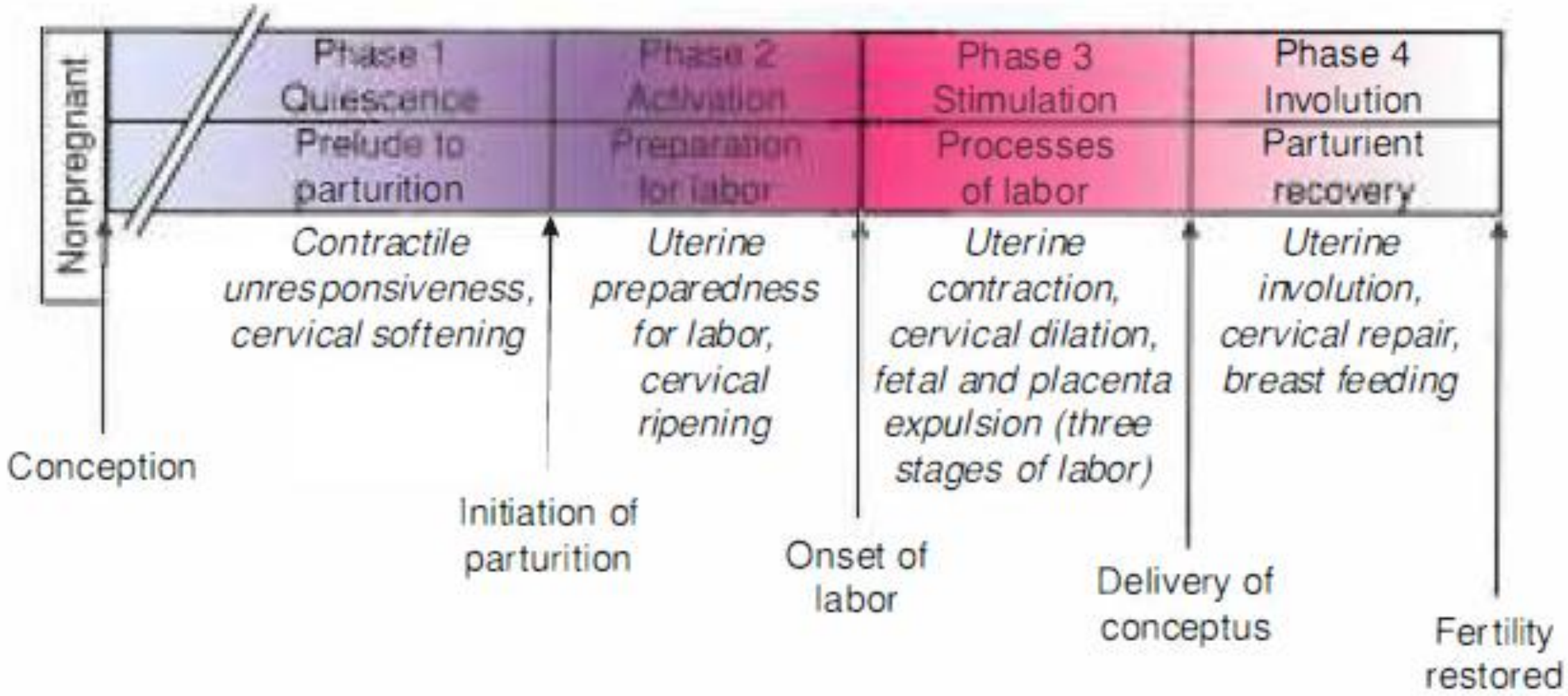


FIGURE 21-3 The phases of parturition.

Clinical applications

Physiological function	Application
Progesterone causes uterine quiescence	Used to prevent preterm labour
PGF2α causes uterine contractions	Used to stimulate uterine contractions
	First and second trimester pregnancy termination
	Prevent and control PPH
	Antagonists used as tocolytics
PGF2α released by fetal membranes	Sweeping of cervix for labour induction
PGE2 causes cervical softening	Used in cervical ripening
Oxytocin causes uterine contractions	Used for induction and acceleration of labour
Calcium essential for myometrial contraction	Calcium channel blockers used as tocolytic
Magnesium competes with calcium	Magnesium sulphate used as tocolytic

THANK YOU