By 8 weeks, about 2 months, all major organs are in place in at least a rudimentary form; this is why drugs early in pregnancy are so important to avoid – many cause birth defects; baby is a little over 1” long (below right)
Fetal Period

Duration: Weeks 9 to 38 after conception (or until birth).

Major fetal events: Organs grow in size and complexity.

20-week fetus

Nine months, shown in mother’s womb (uterus)
Fetal growth and development

- Is dependent on adequate transfer of nutrient and oxygen across the placenta, by itself is dependent on adequate maternal nutrition and placental perfusion.

- Fetal hormones have an important role in fetal development they affect the metabolic rate, growth of tissues and maturation of individual organs.

For example:
- IGFs co-ordinate a precise and orderly increase in growth through late gestation.

- Insulin and thyroxin are required through late gestation to ensure appropriate growth in normal and adverse nutritional circumstances (fetal hyperinsulinemia as in DM result in macrosomia due excessive fat deposition, while in growth restricted fetuses fetal insulin levels are low)
Lack in thyroid hormone produces deficiency in skeletal and cerebral maturation (cretinism), also there is delayed surfactant production.

Cortisol has a limited role in stimulating growth, but it is essential in:

1-lung compliance and surfactant release, which ensure that spontaneous breathing can occur at birth.

2-in the fetal liver, it induces beta receptor and glycogen deposition to maintain a glucose supply to the neonate after delivery.

3-in the gut it is responsible for villus proliferation and induction of digestive enzymes, which enable the neonate to switch to enteral feeding after birth.
The average birth weight is about 3.5 kg at the end of normal pregnancy.

1/3 of the eventual birth weight is reached by 28 wk, ½ by 31 wk, 2/3 by 34 wk.

Each baby has its own optimal growth potential, which is predictable from physiological characteristics known at the beginning of pregnancy; those factors are:
- Pre-pregnancy weight and maternal booking weight (increasing with maternal weight).
- Maternal height (increasing with maternal height).
- Maternal age and parity increased with mother >para2.
- Ethnic group (low in South Asian and Afro-Caribbean).
- Fetal sex (male >female).
- Paternal height.
Maternal smoking affect the birth weight significantly adversely, it is consistent and dose dependent.

Growth restricted fetuses are those who have failed to achieve their growth potential, they have significantly higher perinatal mortality and morbidity rate.

Growth restricted fetuses/infants are more likely suffer from:
- intrauterine hypoxia/asphyxia.
- stillborn.
- hypoxic ischaemic encephalopathy (sezure).
- multi organ failure.
- neonatal hypothermia, hypoglycaemia, infection and necrotizing enterocolitis.
- cerebral palsy.
- in adulthood they are at greater risk of hypertension, IHD, NIDDM.
Cardiovascular system (fetal circulation)
Special Structures in Fetal Circulation

- **Placenta** – Where gas exchange takes place during fetal life

- **Umbilical Arteries** – Carry deoxygenated blood from the fetus to placenta

- **Umbilical Vein** – Brings oxygenated blood coming from the placenta to the fetus

- **Foramen Ovale** – Connects the left and right atrium. It pushes blood from the right atrium to the left atrium.

- **Ductus Venosus** - Carry oxygenated blood from umbilical vein to inferior vena cava, bypassing fetal liver

- **Ductus Arteriosus** - Carry oxygenated blood from pulmonary artery to aorta, bypassing fetal lungs.
Is quite different from that of the adult by the follows:

1- oxygenation occurs in the placenta not in the lung.
2- the right and left ventricles work in parallel rather than in series.
3- the heart, brain and the upper body receive blood from the left ventricle, while the placenta and lower body receive blood from both right and left ventricles.

There are modifications in fetal vascularity that ensure that the best, oxygenated blood from the placenta is delivered to the fetal brain, these are:

1- the ductus venosus that shunts blood away from the liver.
2- the foramen ovale, shunts blood from right to left atrium.
3- the ductus arteriosus that shunts blood from the pulmonary artery to the aorta.
Oxygenated blood from the placenta returns to the fetus through the umbilical vein, which is divided into two main branches:

1- One supply the portal vein in the liver.
2- another narrow vessel called ductus venosus which joins the inferior vena cava as it enters the right atrium.

50% of oxygenated blood will pass to the portal system and 50% will pass to the ductus venosus.

The ductus is a narrow vessel and a high blood velocities are generated within it.

The streaming of ductus venosus blood, together with a membranous valve in the right atrium (the crista dividens), prevents mixing of the well-oxygenated blood from the ductus venosus with the desaturated blood of the inferior vena cava.
The ductus venosus stream passes across the right atrium through a physiological defect in the atrial septum (foramen ovale) to the left atrium, then the blood will pass to the left ventricle through the mitral valve and hence to the aorta.

50% of the left ventricle blood goes to the head and upper extremities, the remainder passes down to the aorta to mix with blood of reduced oxygen saturation from right ventricle.

Blood from inferior vena cava and superior vena cava is directed across the tricuspid valve to the right ventricle.

Only a small portion of RT ventricle blood passes to the lungs as they are not functional.

Most of the Rt ventricle blood is directed through a narrow vessel (ductus arteiosus) into the descending aorta below the origin of head and neck vessels from the aortic arch.
(c) Scheme of fetal circulation
- The desaturated blood from the RT ventricle passes down the aorta to enter the umbilical arterial circulation and hence to the placenta.

- Prior to birth, the ductus remains patent due to production of the prostaglandin E2 and prostacyclin which act as local vasodilator, so administration of cyclo-oxygenase inhibitor will lead to premature closure of the ductus.

- At birth, the cessation of umbilical blood flow causes cessation of flow in the ductus venosus, a fall in the right atrium pressure and closure of the foramen ovale.

- Ventilation of the lungs opens the pulmonary circulation, with rapid fall in pulmonary vascular resistance.

- The ductus arteriosus closes functionally within a few days of birth.
Persistent fetal circulation:

- Occurs when there is delayed closure of the ductus arteriosus after birth because the pulmonary vascular resistance fails to fall despite adequate breathing.

- Results in left to right shunting of blood from the aorta through the ductus arteriosus to the lung.

- The baby remains cyanosed and can suffer from life threatening hypoxia.

- This is mostly occur in the premature infants.

- Result in congestion in the pulmonary circulation and reduction in the blood flow to the gastrointestinal tract and brain, that lead to necrotizing enterocolitis and intraventricular haemorrhage.
**Before birth**

- **Ductus arteriosus**
- **Foramen ovale**

**Immediately after birth**

- **Ductus arteriosus** constricts, allowing all blood leaving the right ventricle to travel to the lungs via the pulmonary arteries.

- **Foramen ovale** closes, leaving a small depression called the **fossa ovalis**. This isolates deoxygenated and oxygenated blood within the heart.

**Before birth**

- **Inferior vena cava**
- **Ductus venosus**
- **Portal vein**

**After birth**

- **Blood arrives via umbilical vein**

- **Ductus venosus** degenerates and becomes the **ligamentum venosum**.

- The **inferior vena cava** now carries only deoxygenated blood back to the heart.

- **Umbilical arteries**

- **Umbilical ligaments**
Respiratory system (lung)

- By 20 wk gestation full differentiation of capillary and canalicular elements of the fetal lung is apparent, but alveoli develop after 24wk.

- Fetal breathing movements occur in utero especially during rapid eye movement.

- Adequate amniotic fluid volume is necessary for lung maturation.

- The fetal lung is filled with fluid, the production of this fluid starts from early gestation and ends in the early stages of labour.

- At birth the production of this fluid must cease and the fluid present is absorbed, adrenaline play a major role in this process.