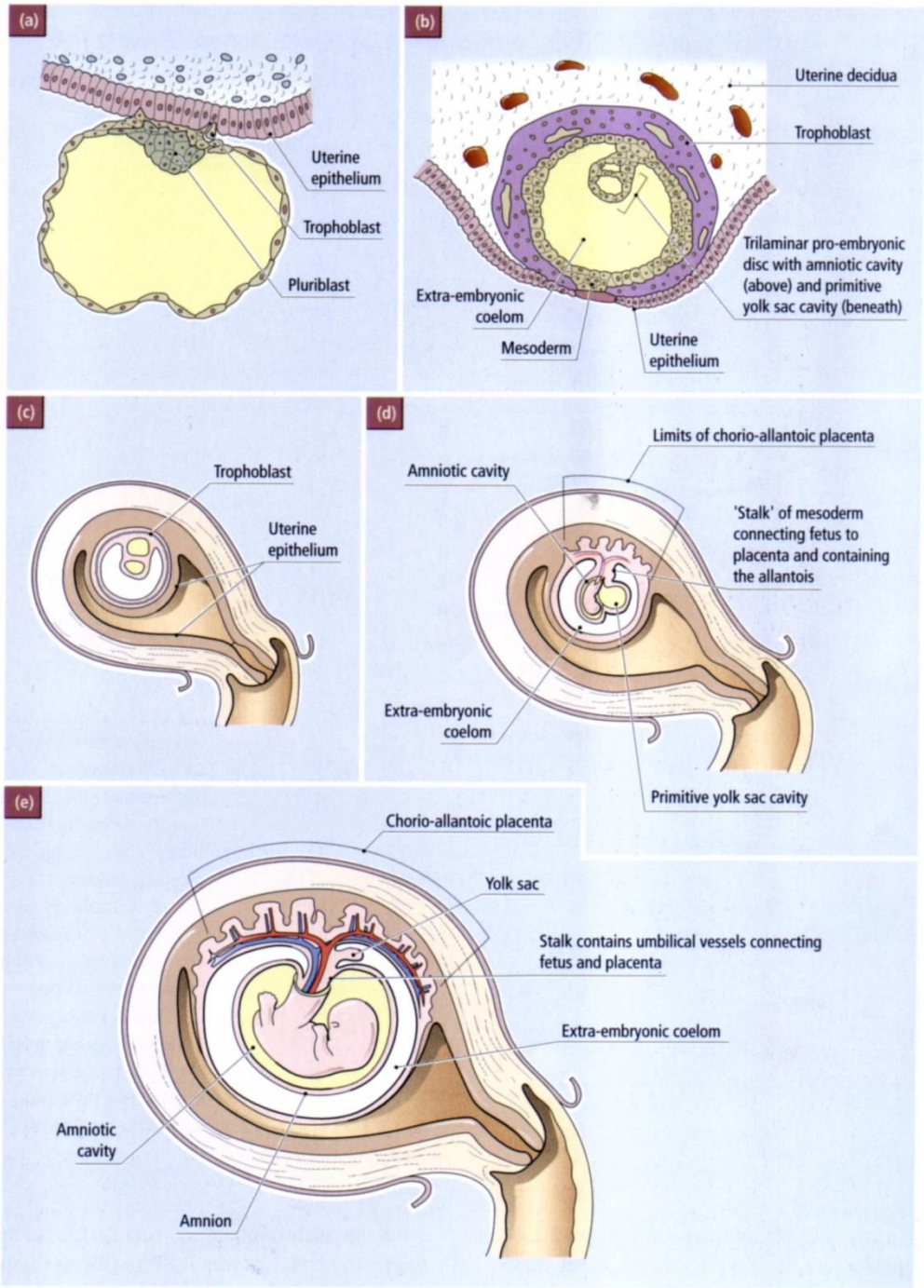
Embryology - 2

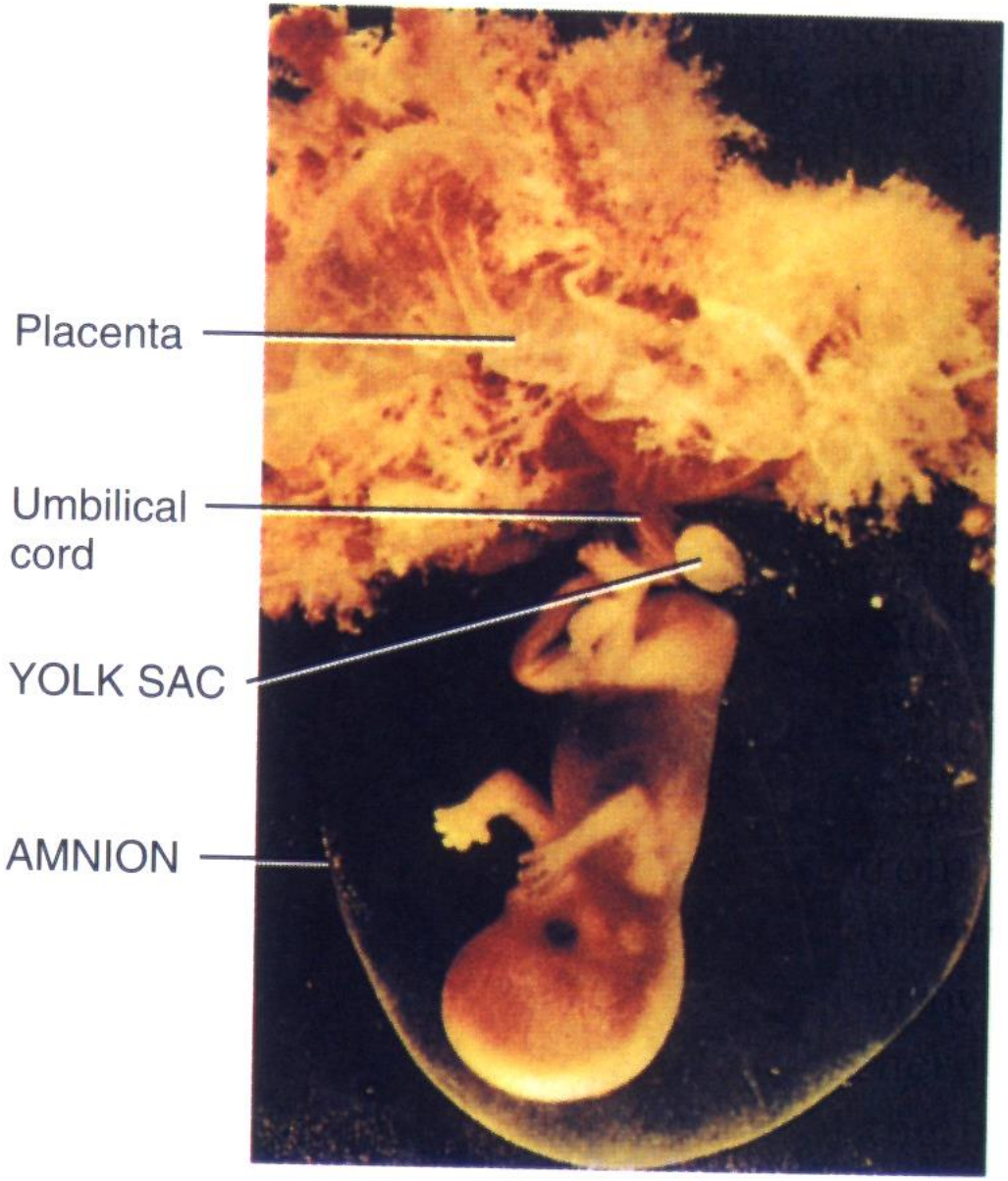
WSO

The University of Hong Kong

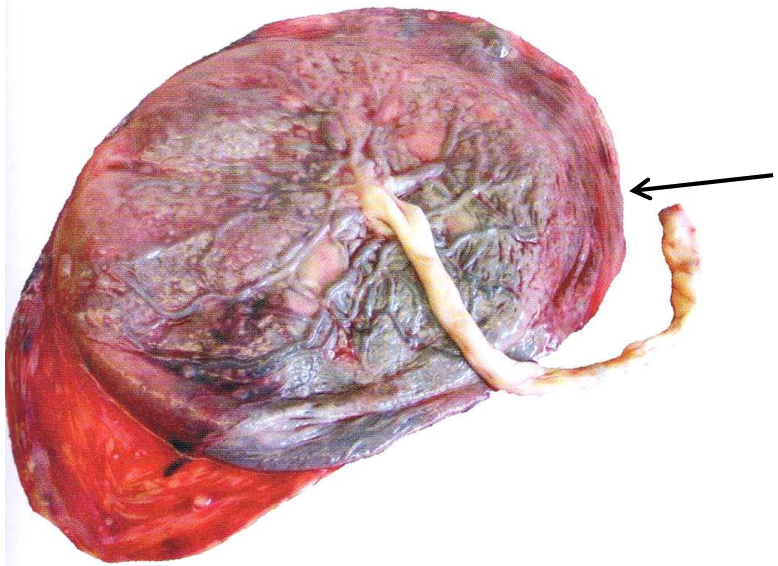
Objectives:

- Describe the development and function of placenta.
- Describe the formation of twins
- Describe factors contributing to congenital malformations.
- List the common prenatal diagnostic tools.


(a)
Uterine epithelium
Trophoblast
Pluriblast
(b)
Uterine decidua
Trophoblast
Trilaminar pro-embryonic disc with amniotic cavity (above) and primitive yolk sac cavity (beneath)
Extra-embryonic coelom
Mesoderm
Uterine epithelium
(c)
Trophoblast
Uterine epithelium
(d)
Limits of chorio-allantoic placenta
Amniotic cavity
'Stalk' of mesoderm connecting fetus to placenta and containing the allantois
Extra-embryonic coelom
Primitive yolk sac cavity
(e)
Chorio-allantoic placenta
Yolk sac
Stalk contains umbilical vessels connecting fetus and placenta
Extra-embryonic coelom
Amniotic cavity
Amnion

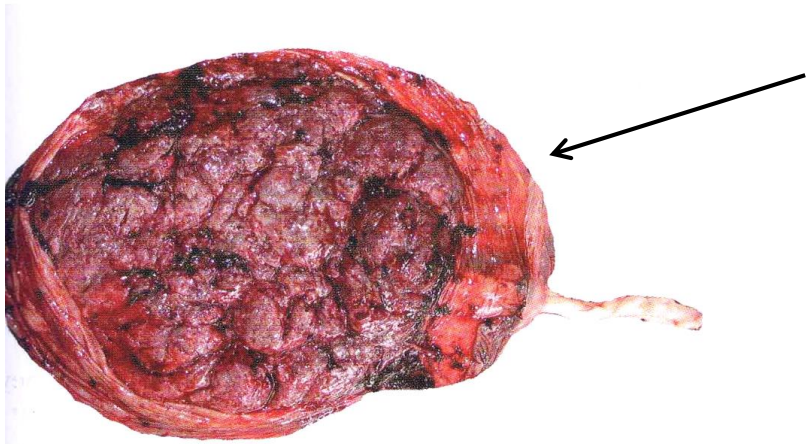


(b) Ten-week fetus



Placenta and umbilical cord.

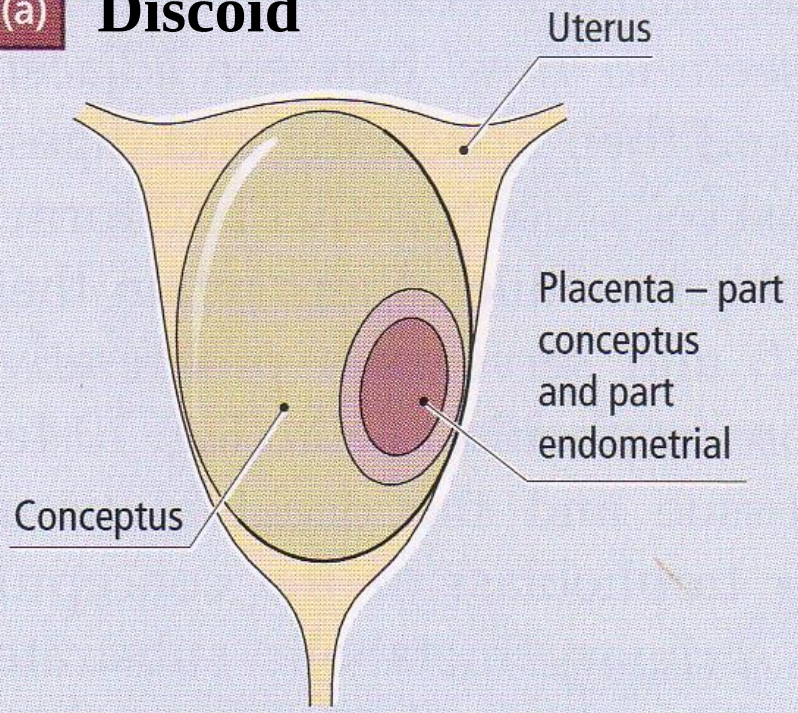
The fetal side showing blood vessels and umbilical cord; the amniotic sac is attached to the lower right margin.



The maternal (uterine) side has a rougher appearance.

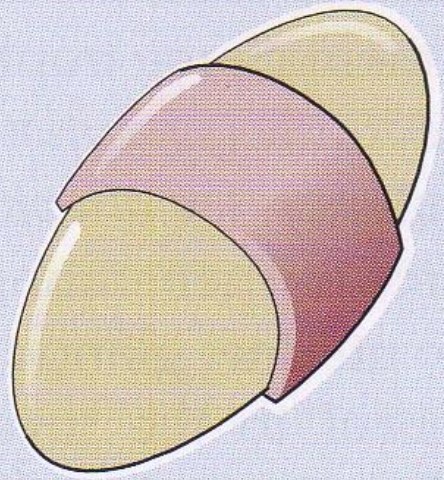
Question: *How many arteries and veins are found in the umbilical cord?*

(a) **Discoid**



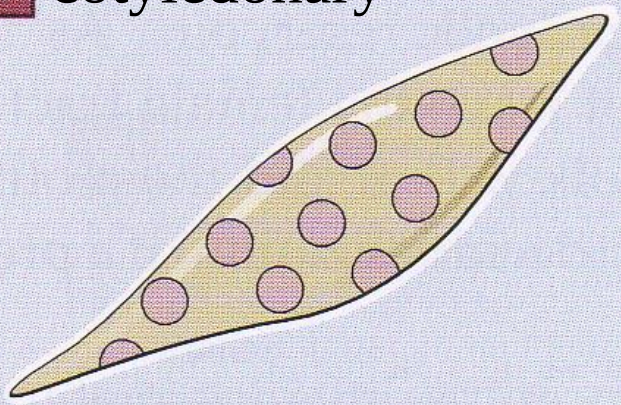
e.g. human, mouse, rat, rabbit, bat

(b) Zonary



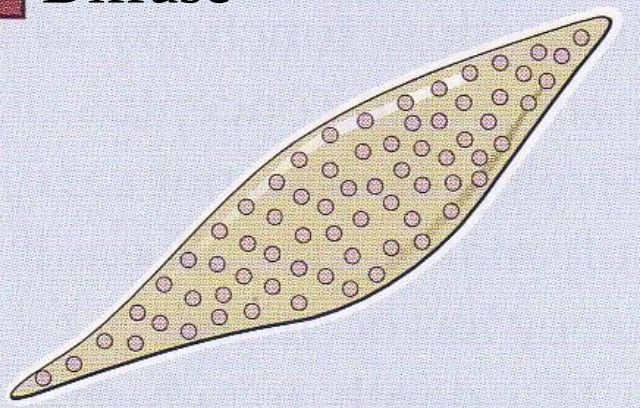
e.g. cat, dog,

(c) cotyledonary

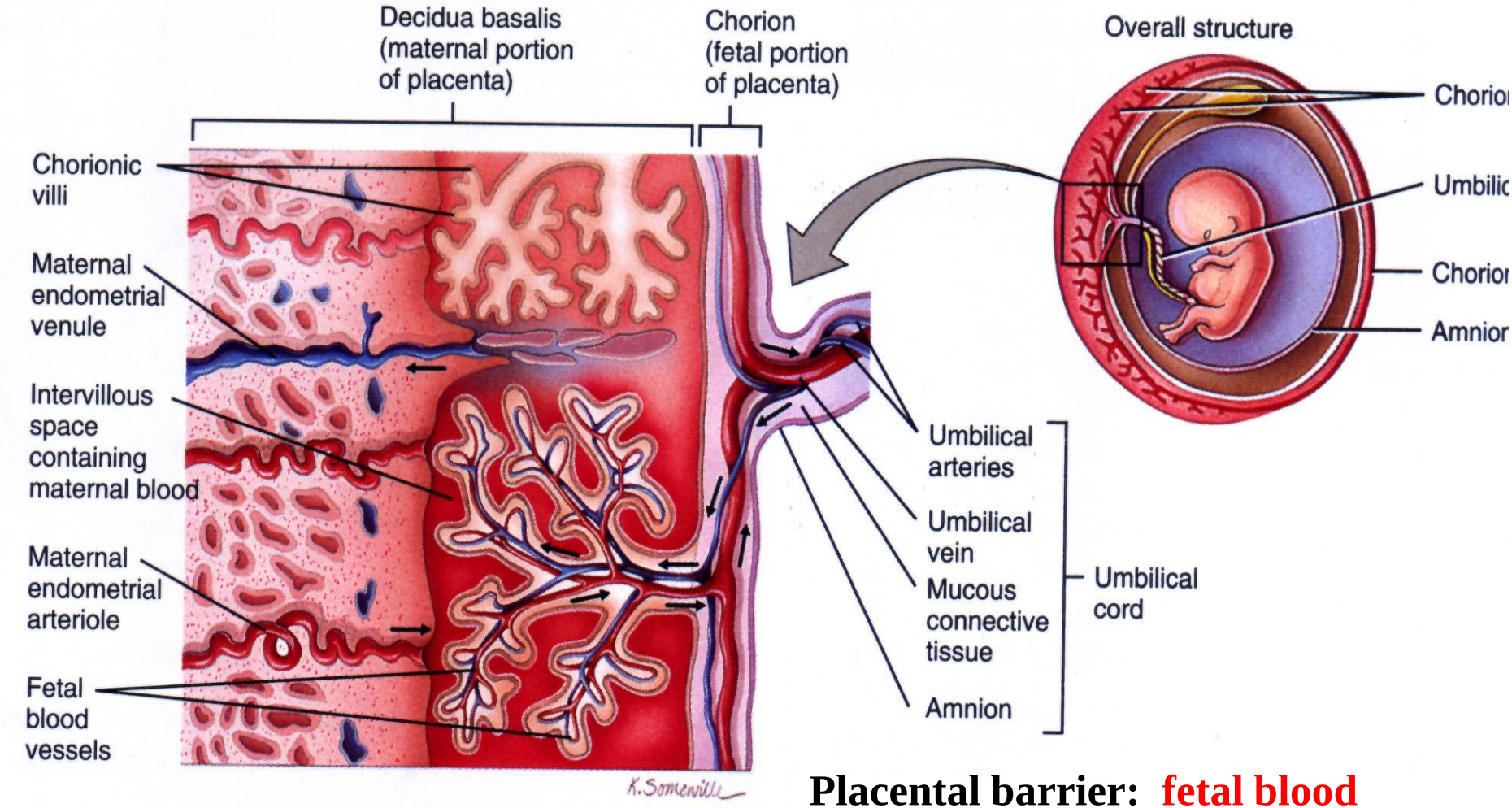


e.g. cow, sheep, mink, seal, elephant

(d) Diffuse



e.g. horse, pig, camel, whale, dolphin



(a) Details of placenta and umbilical cord

Placental barrier: **fetal blood**

Fetal endothelium

Fetal connective tissue

Cytotrophoblast

Syncytiotrophoblast

Maternal blood

Functions of the Placenta:

- Placental metabolism: Particularly during early pregnancy, synthesizes glycogen, cholesterol and fatty acids that serve as sources of nutrients and energy.
- Placental transport.
- Endocrine secretion: using precursor derived from the fetus and/the mother, the syncytiotrophoblast synthesizes various hormones.

Waste Products

carbon dioxide
urea, uric acid
bilirubin

Other Substances

R.B.C. antigens

via umbilical arteries

via umbilical vein

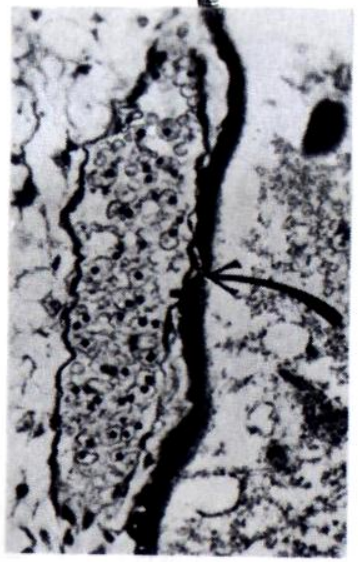
fetal capillary

intervillous space

via endometrial veins

endometrial spiral arteries

placental membrane



mother's lungs and kidneys

Nutrients

oxygen
water
carbohydrates
amino acids
lipids
electrolytes

Other Substances

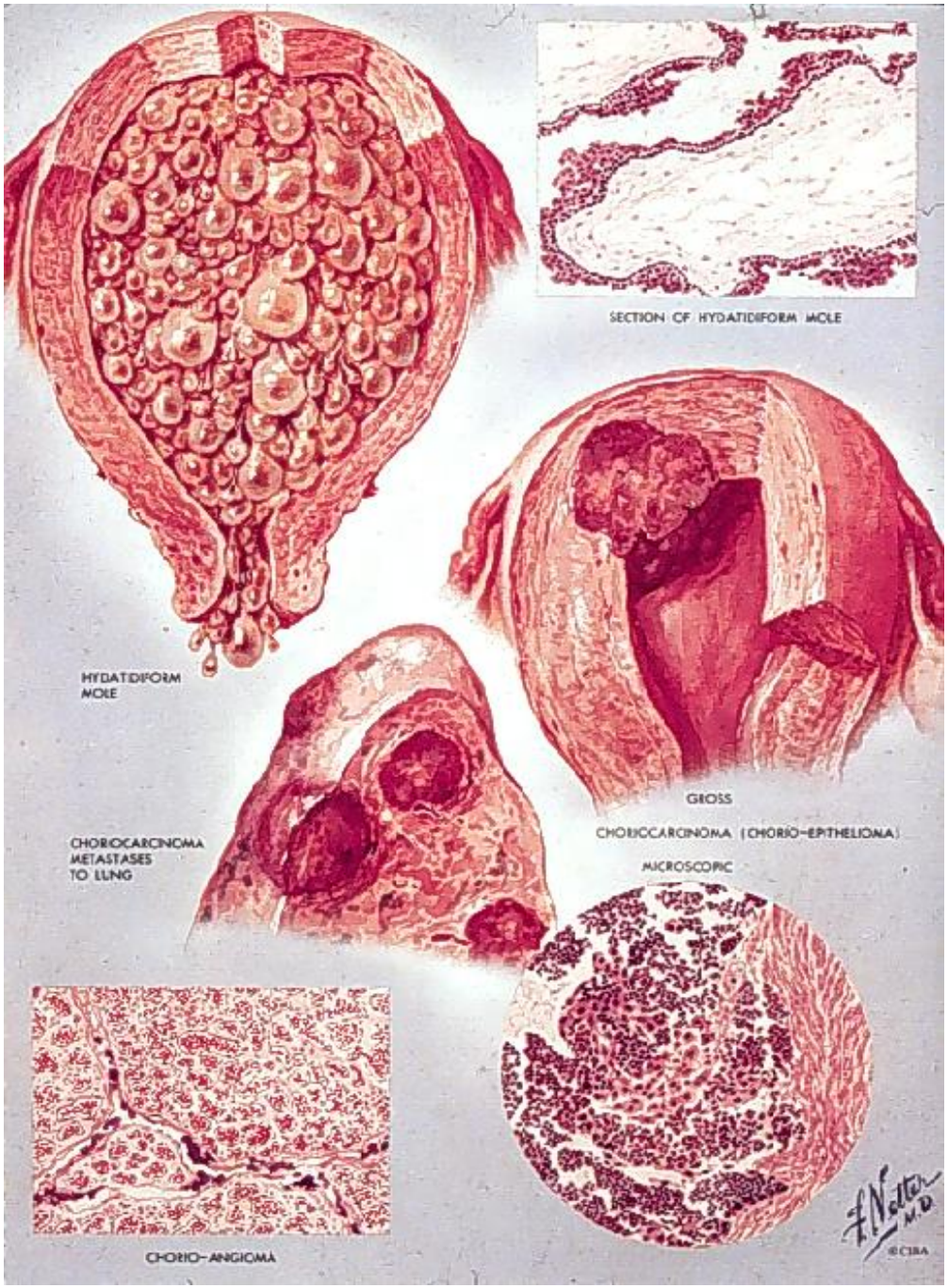
antibodies, IgG & vitamins

Harmful Substances

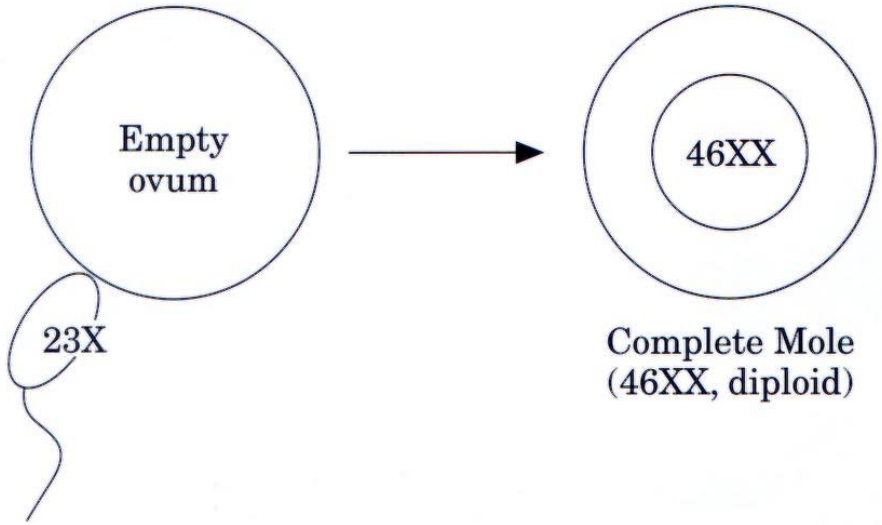
drugs, poisons & carbon monoxide
viruses: rubella, cytomegalovirus
strontium-90
Toxoplasma gondii

Nontransferable Substances

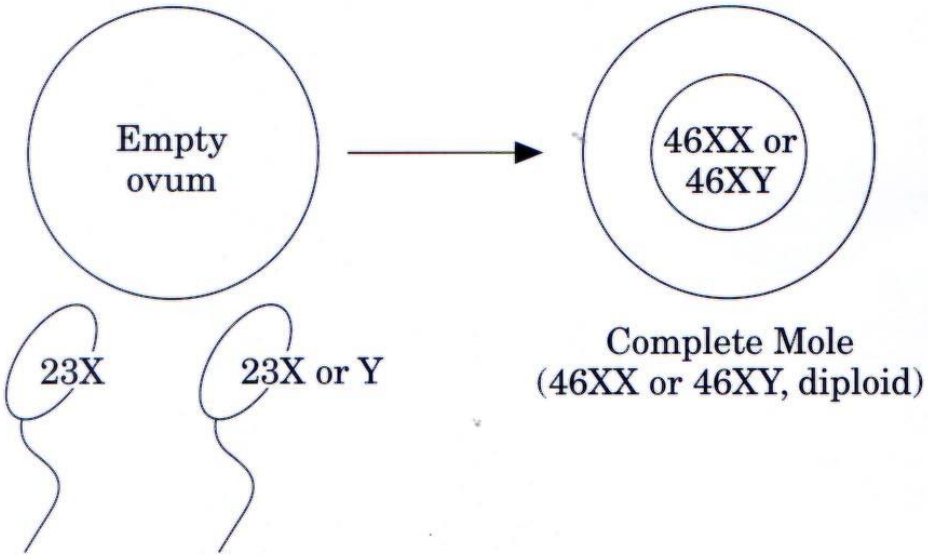
bacteria, heparin
transferrin, IgS & IgM



Hydatidiform moles contain either solely (complete moles) or an excess (in partial moles) of paternal contribution to the genome.

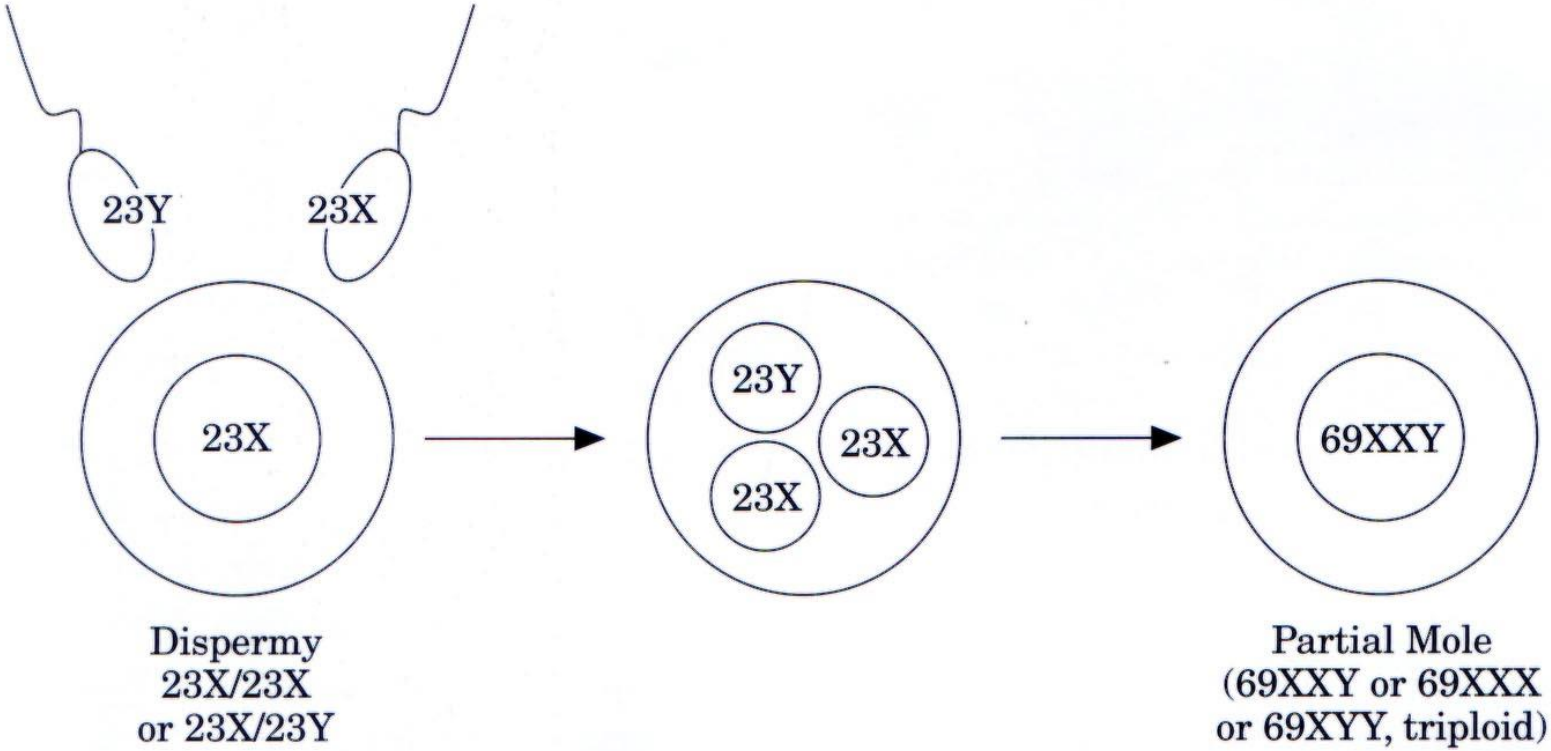


(i) A single sperm fertilizes an empty ovum, with duplication of the 23X haploid set of chromosomes, giving rise to a homozygous diploid complete mole.



(ii) Two sperms with two independent haploid sets of chromosomes fertilize an empty ovum, producing a dispermic complete mole with either 46XX or 46XY karyotype.

(a) Complete hydatidiform mole

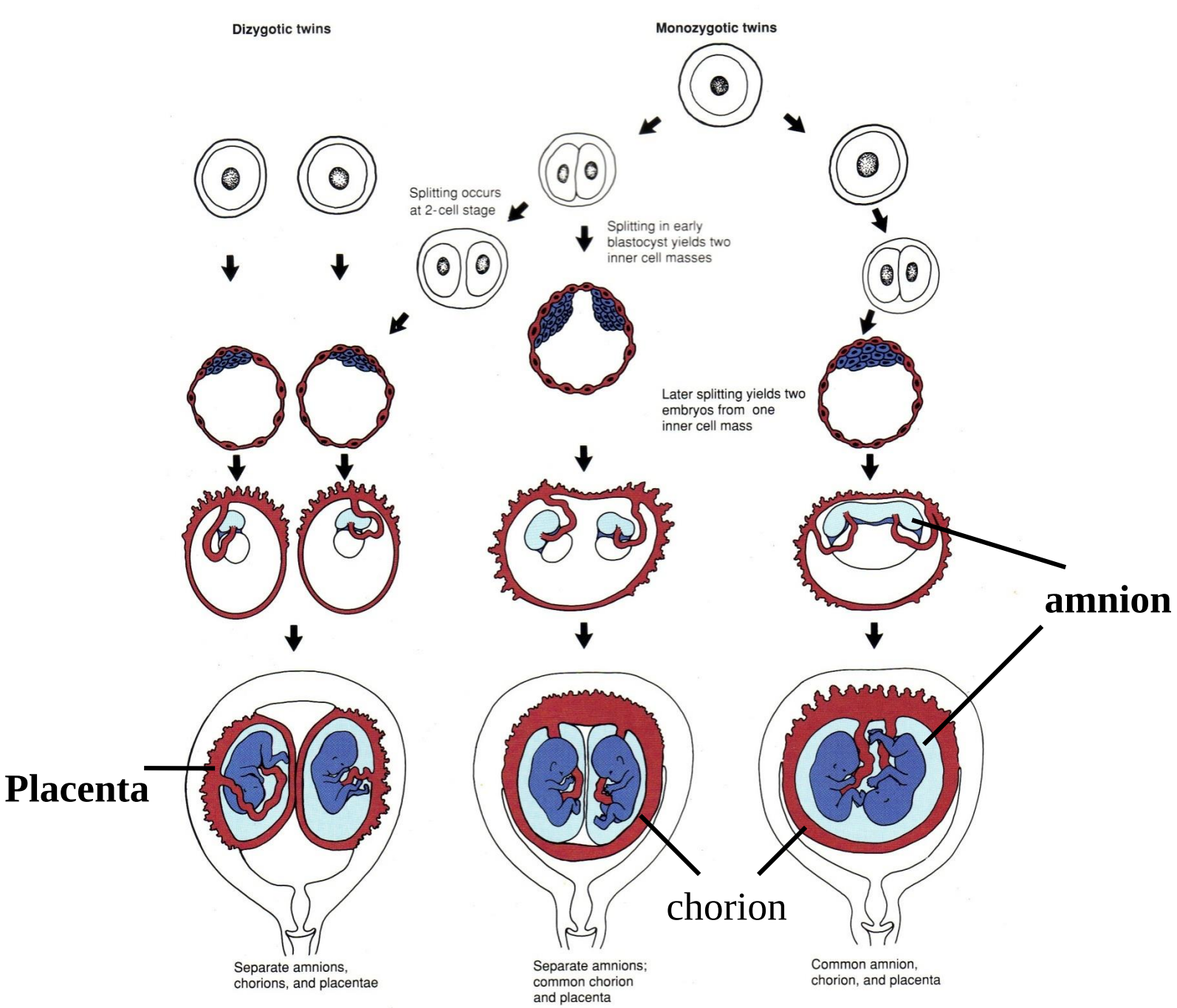


Fertilization of a normal 23X haploid ovum by two sperms, producing a triploid partial mole with either 69XXY, 69XXX or 69XYY karyotype.

(b) Partial hydatidiform mole

Twinning

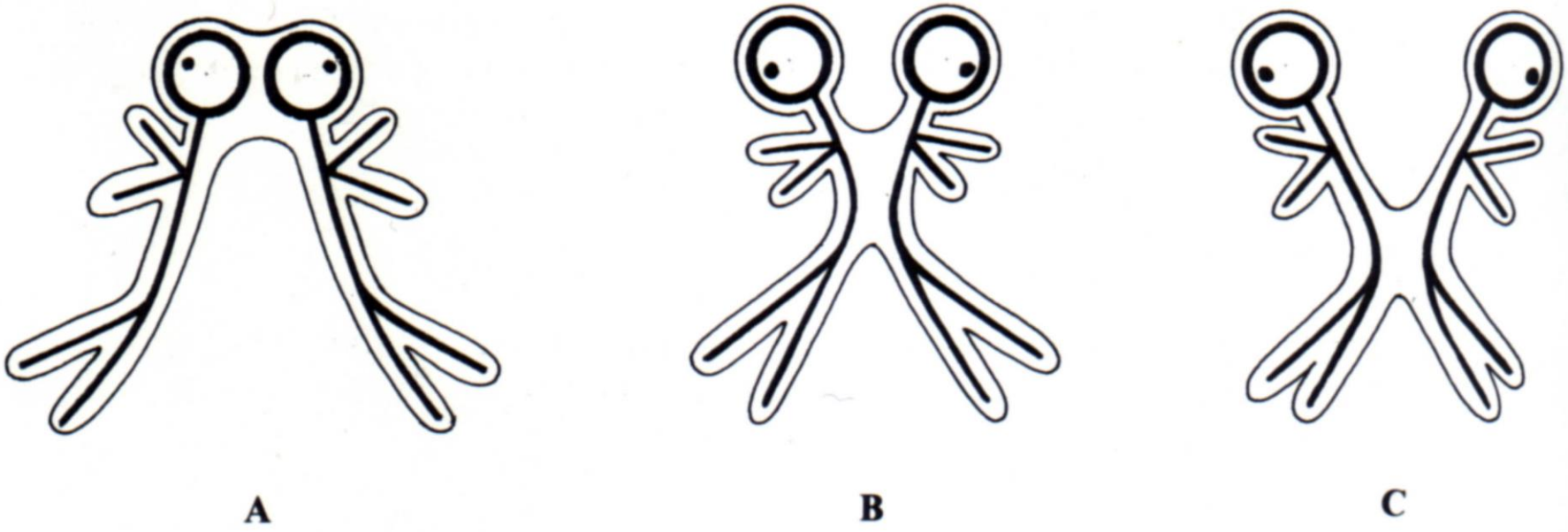
- The incidence of twinning is about 1 in 85 pregnancies
- Twins are of two kinds: monovular or identical and biovular or fraternal.
- Types of monovular twins:
  - Dichorial, diamniotic twins
  - Monochorial diamniotic twins
  - Monochorial, monoamniotic twins.
- Abnormalities – conjoint twins


Dizygotic twins
Monozygotic twins
Splitting occurs at 2-cell stage
Splitting in early blastocyst yields two inner cell masses
Later splitting yields two embryos from one inner cell mass
Placenta
amnion
chorion
Separate amnions, chorions, and placentae
Separate amnions; common chorion and placenta
Common amnion, chorion, and placenta

A **B** **C**

FIG. 7-2. Results of duplication of primitive streak: **A**, duplication of rostral end; **B**, duplication of rostral half; **C**, rostral and caudal duplication.

FIG. 7-3. Results of incomplete duplication of germ layers: **A**, rostrally; **B**, centrally; **C**, caudally.



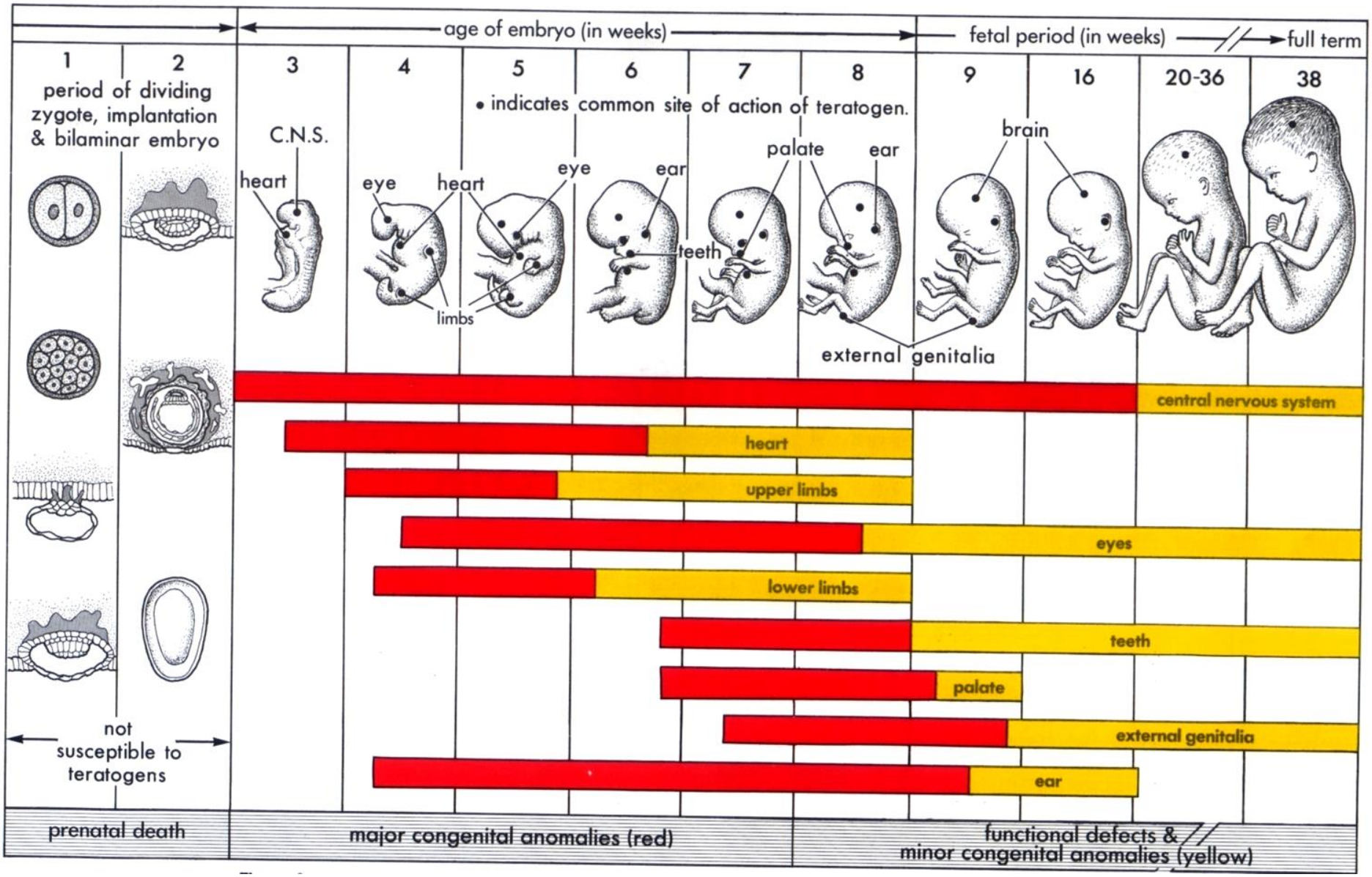
craniopagus

thoracopagus

pygopagus

Frequency of types of placentae and fetal membranes in monzygotic (MZ) and dizygotic (DZ) twins

Zygosity	Single chorion		Two chorions	
	Single amnion	Two amnions	Fused placenta	Two placentae
MZ	Uncommon	65%	25%	10%
DZ	--	--	40%	60%


age of embryo (in weeks)
fetal period (in weeks)
full term
1
2
3
4
5
6
7
8
9
16
20-36
38
period of dividing zygote, implantation & bilaminar embryo
• indicates common site of action of teratogen.
C.N.S.
heart
eye
heart
eye
ear
palate
ear
brain
teeth
limbs
external genitalia
central nervous system
heart
upper limbs
eyes
lower limbs
teeth
palate
external genitalia
ear
not susceptible to teratogens
prenatal death
major congenital anomalies (red)
functional defects & minor congenital anomalies (yellow)

Mechanisms of chromosomal anomalies:

- **Nondisjunction** – failure of homologous pair to separate into anaphase. Meiosis I is usually affected resulting in

Monosomy e.g. XO or Turner's syndrome.

Trisomy e.g. Trisomy 21 or Down's syndrome

Trisomy 17-18 or Edward's syndrome

Trisomy 13-15 or Patau's syndrome.

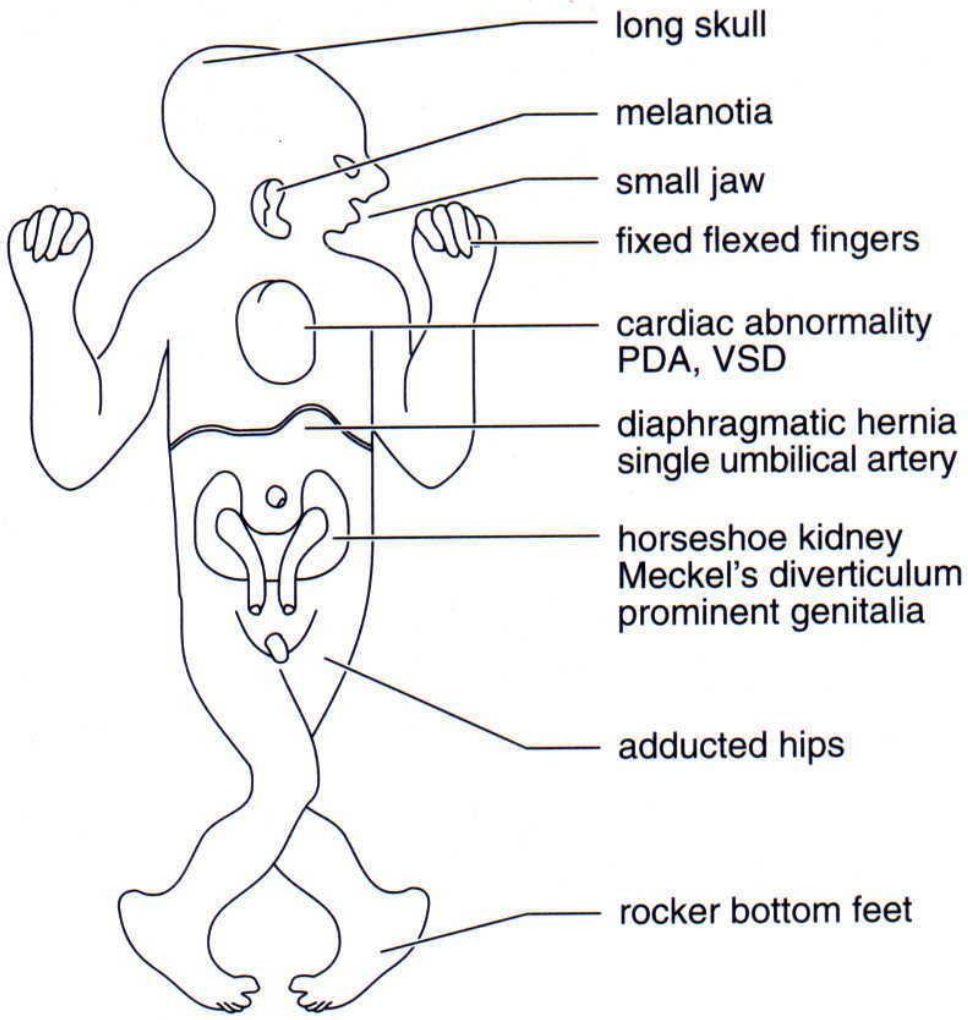


FIGURE 6 Edward's syndrome: abnormalities in trisomy 17–18.

FIGURE 7 Edward's syndrome: flexed fingers cannot be extended (child, 18 months).

FIGURE 8 Edward's syndrome: "rocker bottom" feet in a neonate.

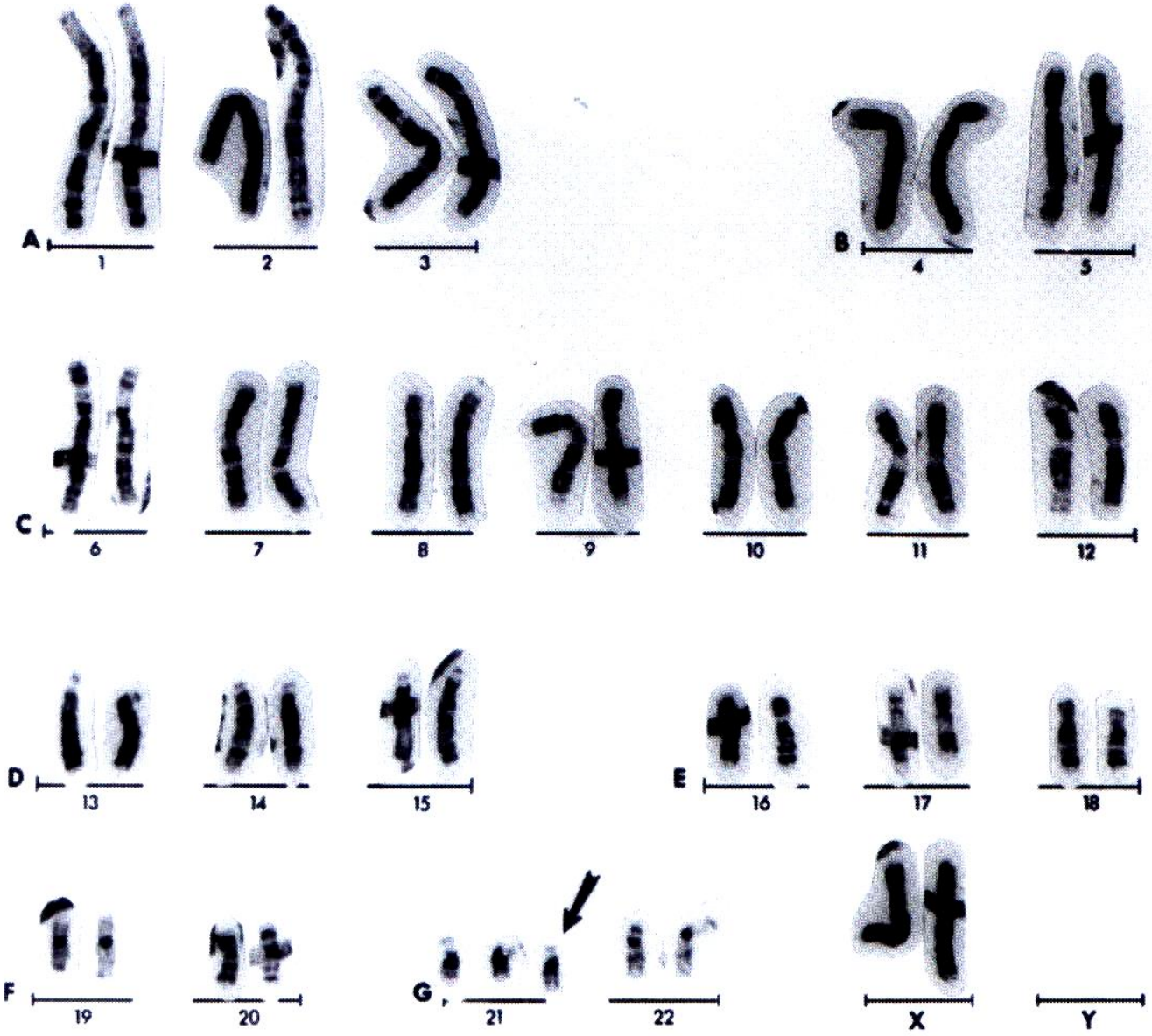


Figure 1.7 Karyotype of trisomy 21 (*arrow*), Down syndrome.

FIGURE 2 Down's syndrome: characteristic facies.

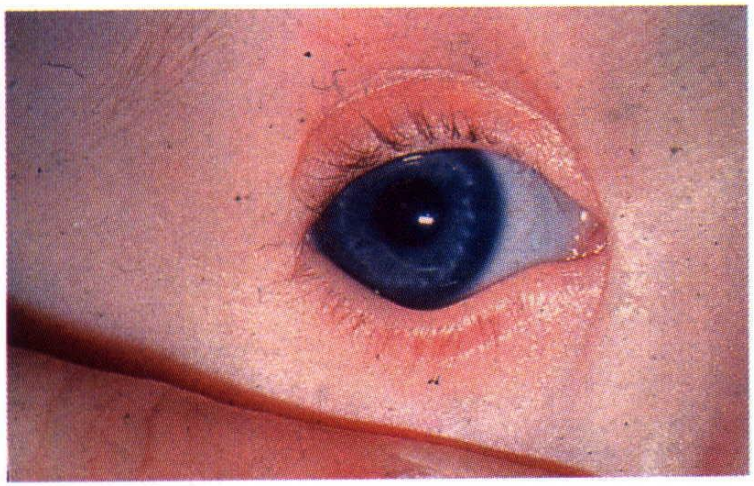


FIGURE 3 Down's syndrome: notched eyelids and epicanthic fold.

FIGURE 4 Down's syndrome: characteristic palmar "simian" crease.

FIGURE 5 Down's syndrome: transverse crease in the sole of the foot, with separation of the hallux.

Indications for Prenatal Diagnosis:

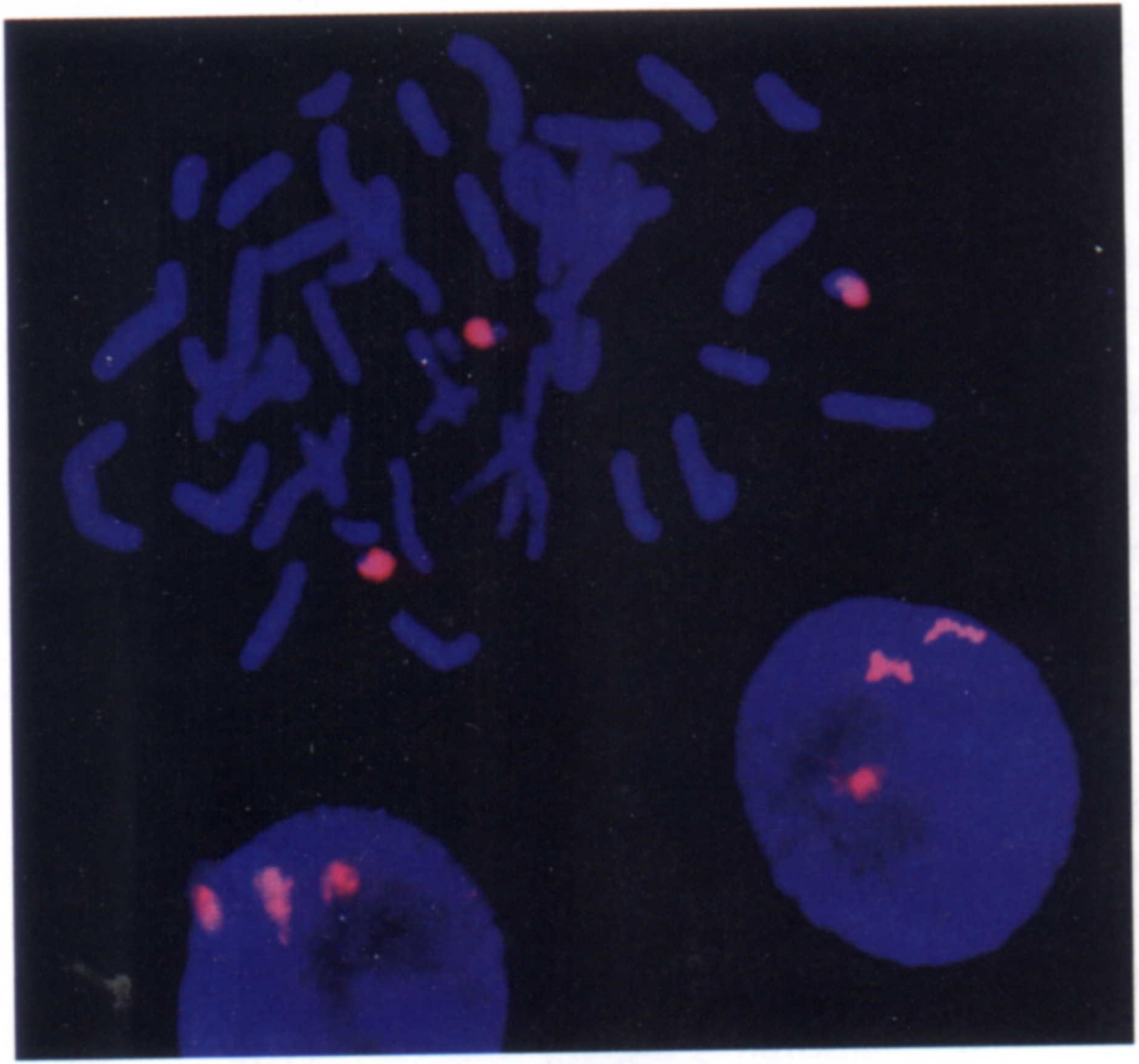
- Maternal age of >35
- Previous child with a *de novo* chromosomal abnormality (recurrent risk 1%)
- Presence of a structural chromosomal abnormality
- Family history of some genetic defect: known neural tube defect (risk 2-5%), other type (risk 1% higher)
- X-linked disorders

Incidence of Down syndrome in newborn infants

Maternal age (years)	Incidence
20-24	1:1400
25-29	1:1100
30-34	1:700
35	1:350
37	1:225
41	1:140
43	1:50
45+	1:25

Prenatal Genetics Diagnosis (PGD) of Apneuploidy:

- Ploidy assessment using a number of autosomal and sex chromosomal probes.
- Trisomy detection probes for X, Y, 13,16, 18 and 21 chromosomes has been used.
- False negative can be due to lose of part of chromosomes during processing, multi-nucleated blastomeres or mosaicism in blastocysts.



Trisomy shown by FISH

Human Teratogens and Congenital Anomalies -1

Drugs as Teratogens

- Cigarette smoking
- Caffeine
- Alcohol – Fetal alcohol syndrome in chronic alcoholic mother will induce pre- and post-natal growth deficiency, metal retardation.
- Androgens and progesterone – masculiniz-ation of external genitalia.
- Diethylstilbesterol is a recognized teratogen – causes congenital abnormal uterus and vagina.

Human Teratogens and Congenital Anomalies -2

- Anticoagulants – except heparin cross placental membrane; causes hypoplasia of nasal cartilage and epiphysis; CNS defects.
- Anticonvulsants
- Antineoplastic agents - cytotoxic agents such as busulphan; aminopterin.
- Tranquilizers
- Thyroid drugs

Human Teratogens and Congenital Anomalies -3

Environmental agents

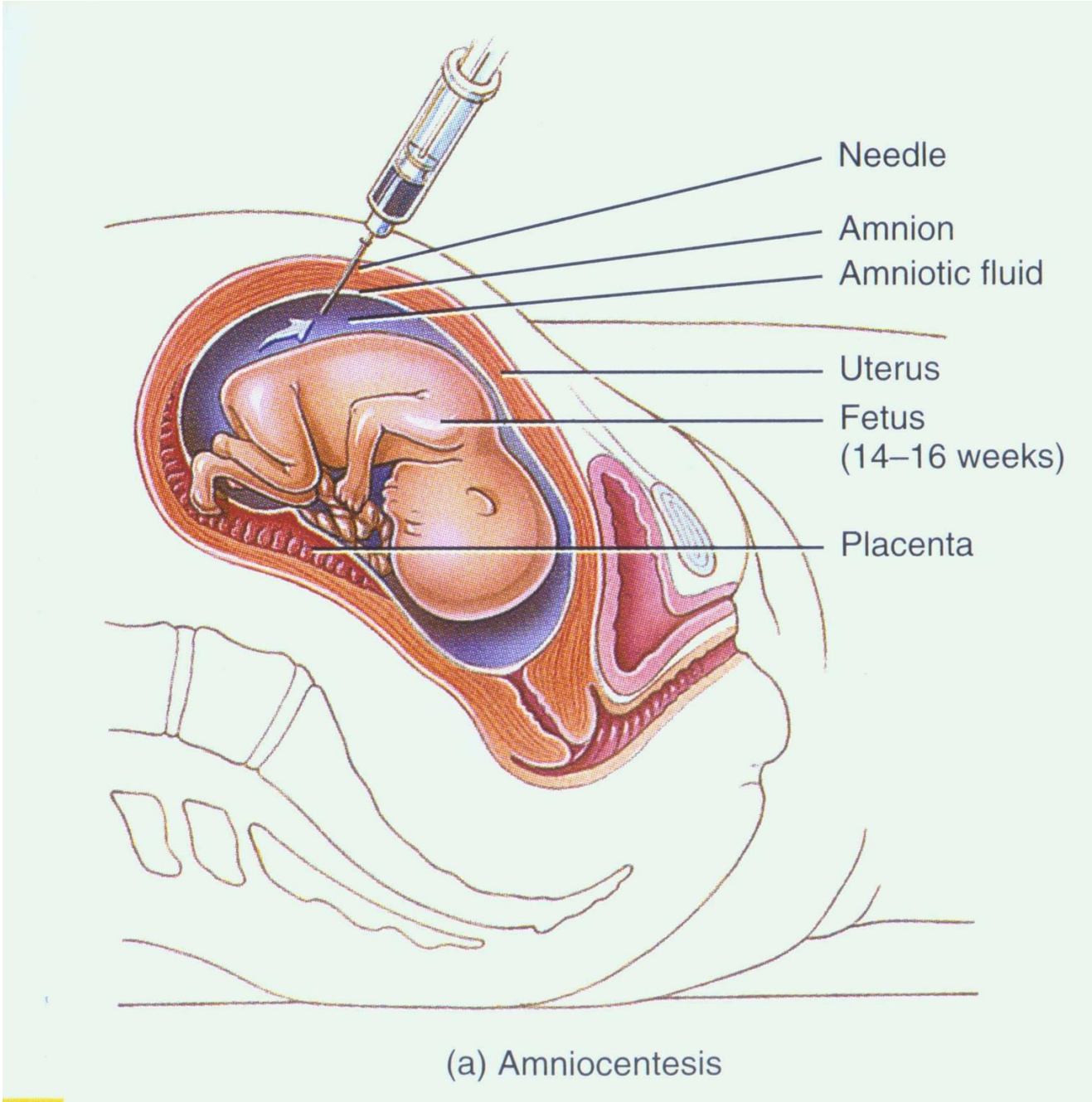
- Organic Mercury (Minamata disease); Lead (growth retardation)
- Infectious agents – Rubella ; HIV; Herpes simplex virus
- Radiation
- Mechanical factors

Ultrasonography

- Chorionic sac and its contents can be visualized during the embryonic and fetal period by using ultrasound techniques.
- Placental and fetal size, multiple births and abnormal presentations can also be determined.
- Ultrasound scans can accurately measure the *biparietal diameter* of fetal skull, male and female genitalia, and nasal bone.

Amniocentesis:

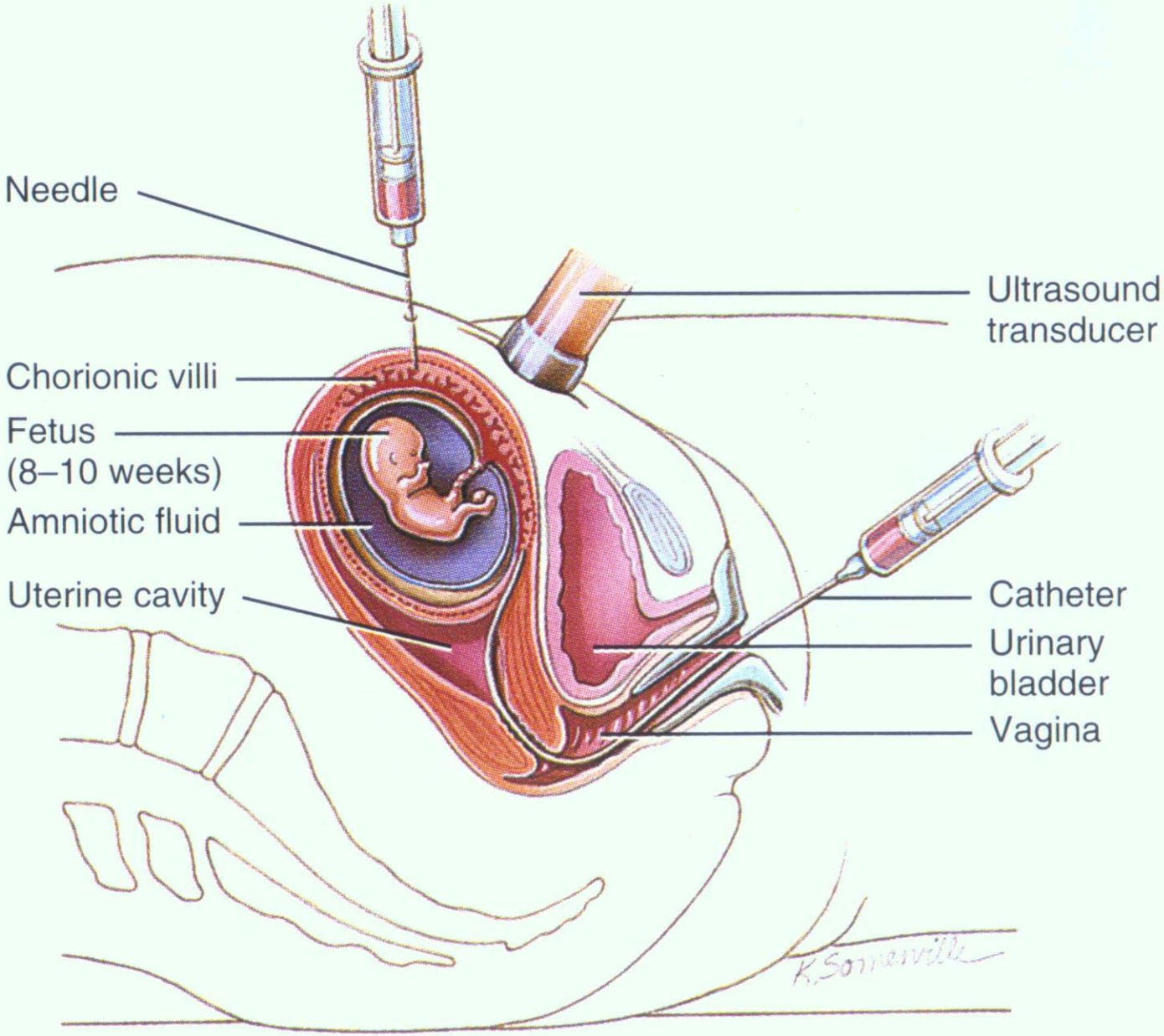
- Procedure of removing amniotic fluid by syringe at gestational age of 16 to 18.
- Fetal cells can be cultured for karyotyping and amniotic fluid assayed for AFP.
- Risk of procedure to induce abortion is about 1 in 200.
- Maternal infection is a rare complication.



(a) Amniocentesis

Chorionic villi sampling:

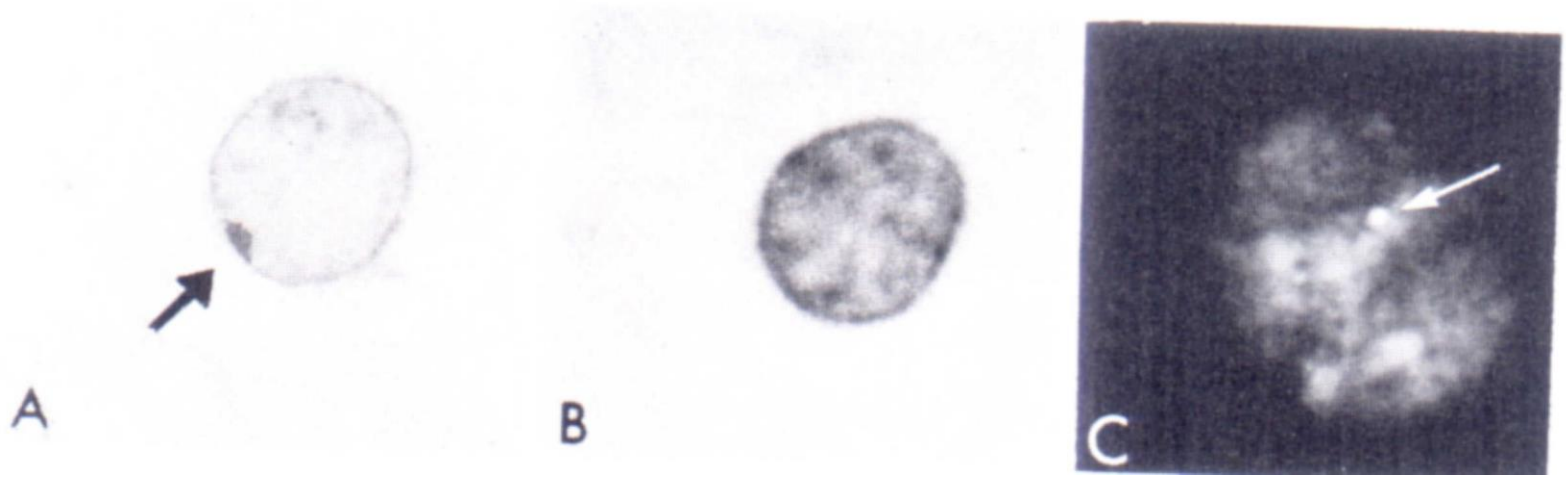
- Fetal tissue for analysis through aspiration from the villous area transcervically guided by ultrasound.
- Performed from gestational age of 9 to 12 weeks – more actively dividing cells.
- Useful for detection of chromosomal abnormalities, inborn errors of metabolism and X-linked disorders.
- Rate of fetal loss is about 1%.



(b) Chorionic villi sampling (CVS)

Detection Methods:

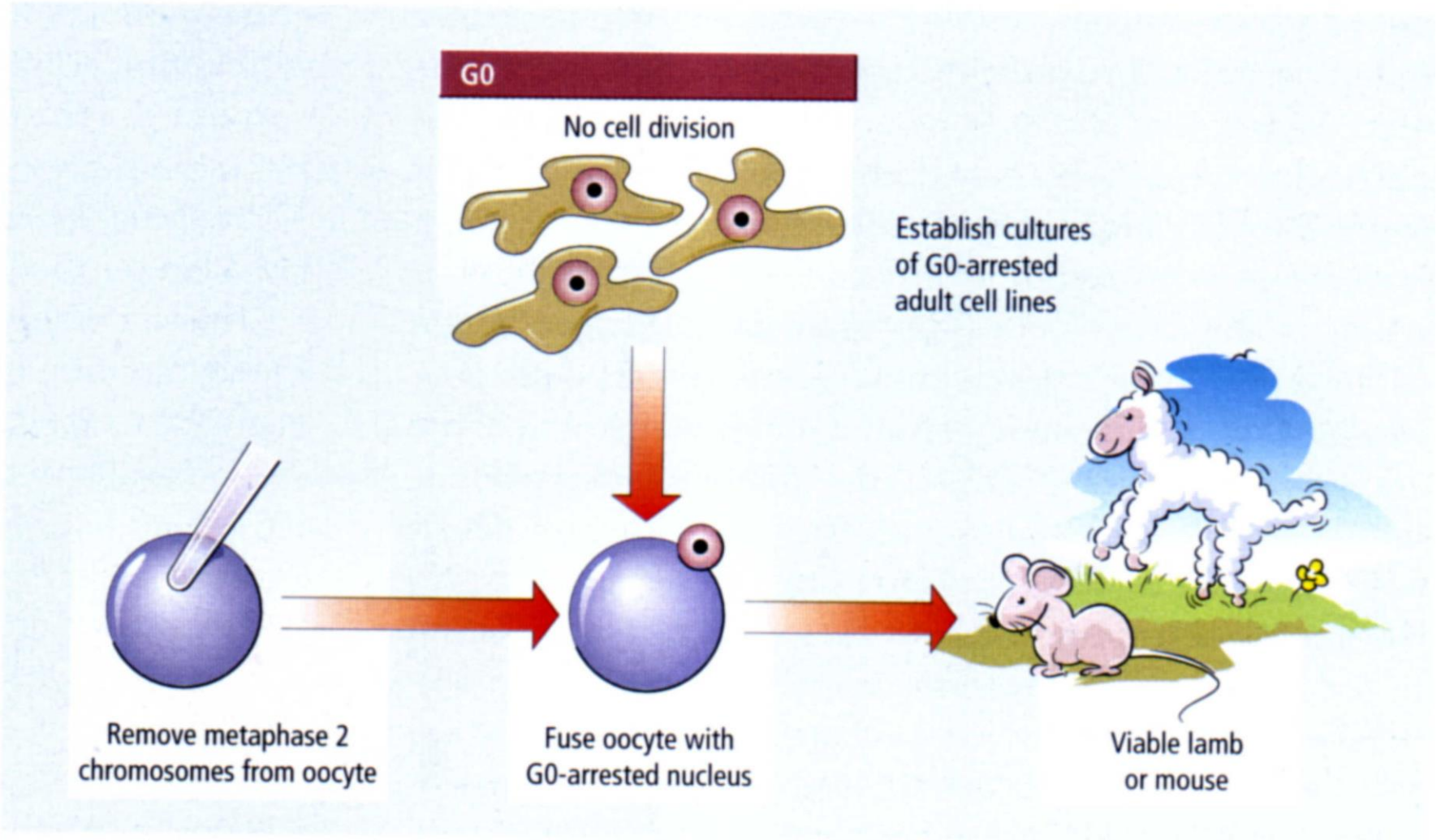
- Karyotyping
- Chromosomal banding/painting
- DNA sequencing
- mRNA detection
- Fetal DNA chip - microarray based comparative genomic hybridization (array CGH) technology
- Protein e.g. alpha fetoprotein AFP in neural tube defect; low lecithin-spigomyelin ratio in lung abnormalities.



Chromatin-positive cell

Chromatin-negative cell

Y-chromatin positive (FISH)



Schematic summary of the procedure for cloning sheep/mice.

The individual so produced shares all the nuclear chromosomes with the donor nucleus.

Question: In what way does this cloned offspring differ from the oocyte donor?