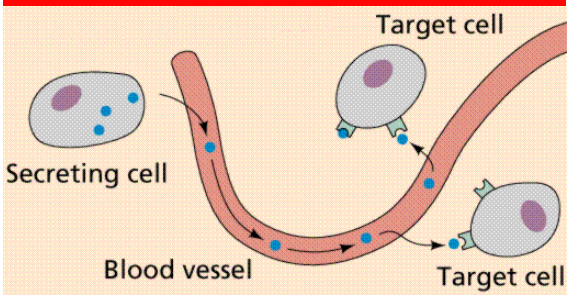
Human Physiology
6.6- Hormones, Homeostasis, and Reproduction

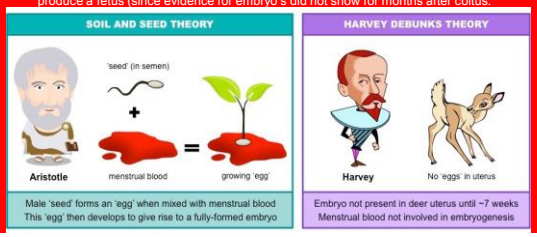
Essential idea:

- Hormones are used when signals need to be widely distributed.



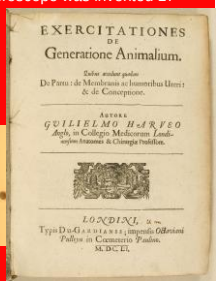
Applications and Skills

- Application: William Harvey's investigation of sexual reproduction in deer.
  - Believed Aristotle's "Seed and Soil" theory.
  - Male seed forms an egg when mixed with menstrual blood.
  - Dissected female deer during breeding season to seed development of embryo.
  - Did not see development of an embryo immediately after breeding.
  - Argued that Aristotle's theory was false and that coitus (sexual intercourse) does not produce a fetus (since evidence for embryo's did not show for months after coitus.



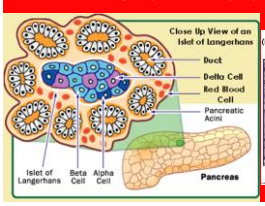
Nature of science:

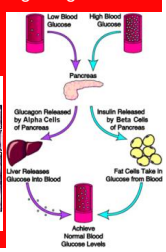
- Developments in scientific research follow improvements in apparatus
  - William Harvey was hampered in his observational research into reproduction by lack of equipment. The microscope was invented 17 years after his death. (1.8)
    - Could not see fusion of gametes or embryo development.
    - Unfortunately deer embryos remain small for a longer period of time.
    - He published his book *Exercitationes de Generatione Animalium* in 1651.



Understandings

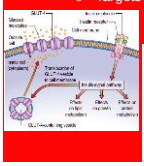
- Insulin and glucagon are secreted by β and α cells of the pancreas respectively to control blood glucose concentration.
  - Blood glucose set point is 5 mmol L^{-1}
  - Deviations from set point trigger pancreas response.
  - Islet of Langerhans cells secrete insulin and glucagon
    - Insulin produced by *beta* cells
    - Glucagon produced by *alpha* cells

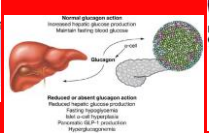


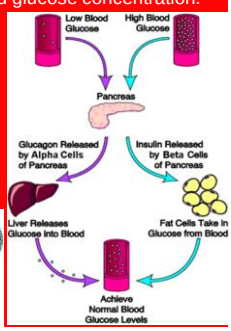


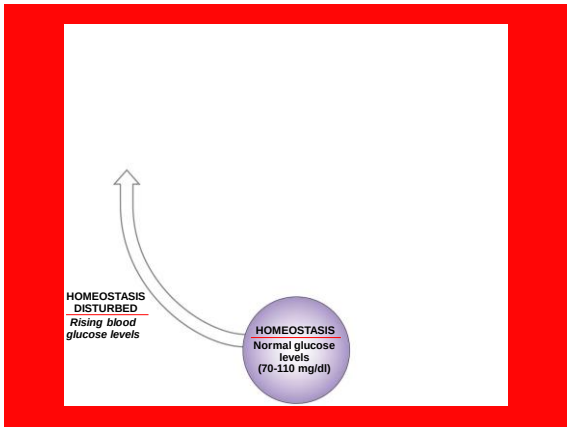
Understandings

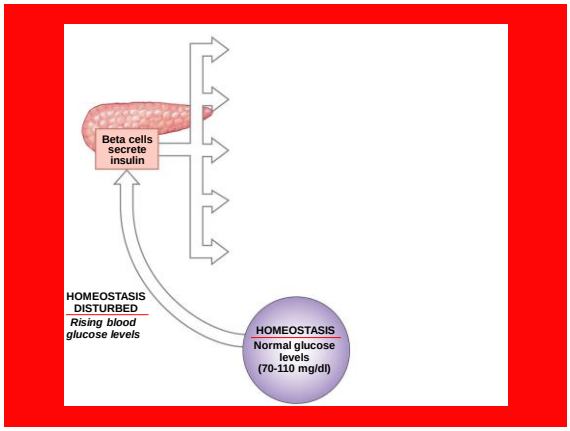
- Insulin and glucagon are secreted by β and α cells of the pancreas respectively to control blood glucose concentration.
  - Insulin
    - Lowers blood glucose
    - Increases glucose uptake, storage, and use by target cells
    - Targets liver, muscle, fat cells
  - Glucagon
    - Raises blood glucose concentration
    - Increases *glycogen* breakdown and glucose synthesis
    - Targets liver cells








HOMEOSTASIS DISTURBED
Rising blood glucose levels
HOMEOSTASIS
Normal glucose levels (70-110 mg/dl)


Beta cells secrete insulin
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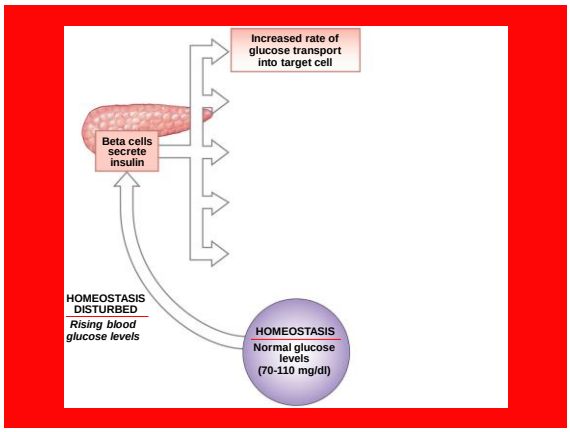
Rising blood glucose levels
HOMEOSTASIS
Normal glucose levels (70-110 mg/dl)


Increased rate of glucose transport into target cell
Beta cells secrete insulin
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Rising blood glucose levels
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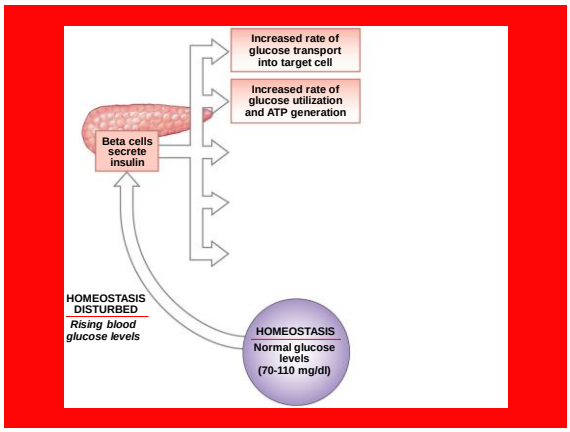
Increased rate of glucose transport into target cell
Increased rate of glucose utilization and ATP generation
Beta cells secrete insulin
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Rising blood glucose levels
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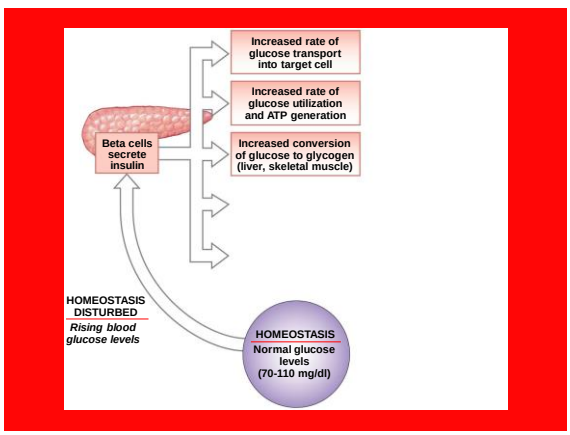
Normal glucose levels (70-110 mg/dl)


Increased rate of glucose transport into target cell
Increased rate of glucose utilization and ATP generation
Beta cells secrete insulin
Increased conversion of glucose to glycogen (liver, skeletal muscle)
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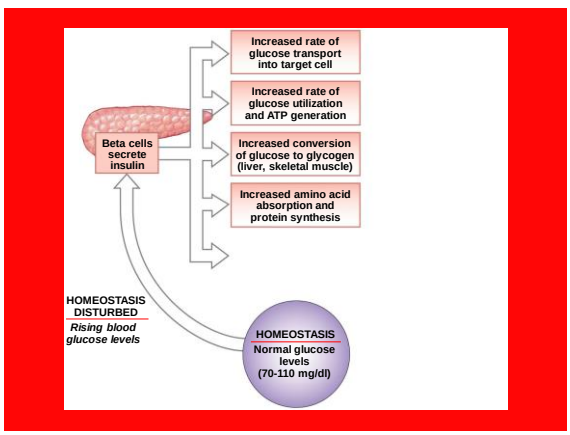
Increased rate of glucose transport into target cell
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Beta cells secrete insulin
Increased conversion of glucose to glycogen (liver, skeletal muscle)
Increased amino acid absorption and protein synthesis
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Rising blood glucose levels
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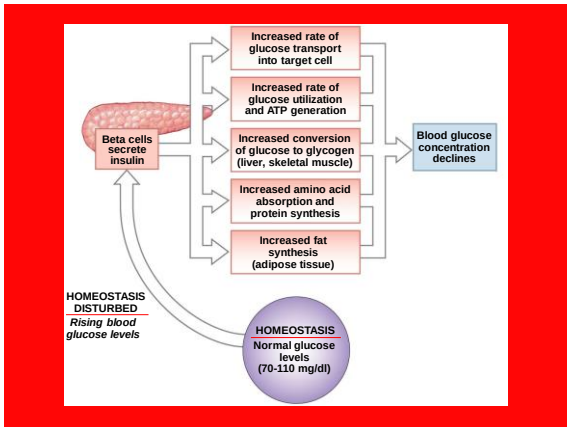
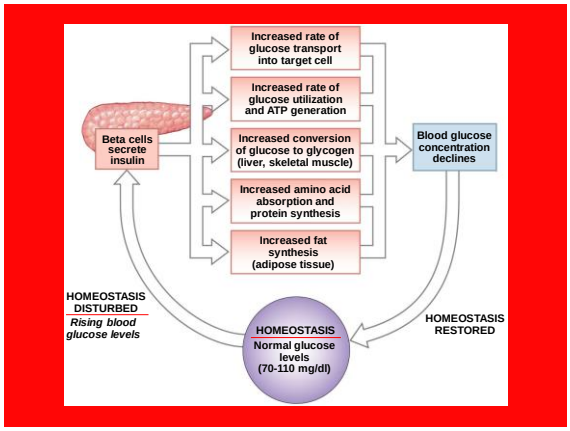

Increased rate of glucose transport into target cell
Increased rate of glucose utilization and ATP generation
Increased conversion of glucose to glycogen (liver, skeletal muscle)
Increased amino acid absorption and protein synthesis
Increased fat synthesis (adipose tissue)
Beta cells secrete insulin
Blood glucose concentration declines
HOMEOSTASIS DISTURBED
Rising blood glucose levels
HOMEOSTASIS
Normal glucose levels (70-110 mg/dl)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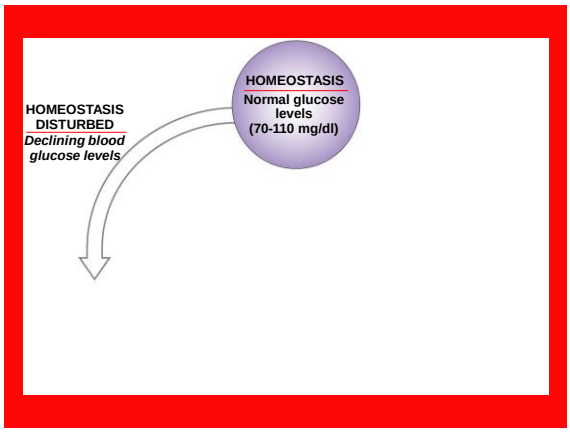
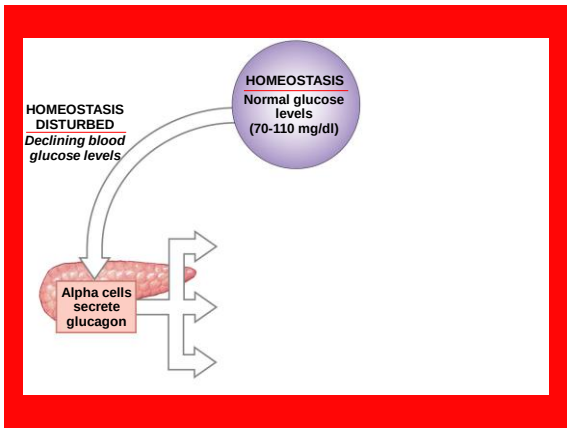
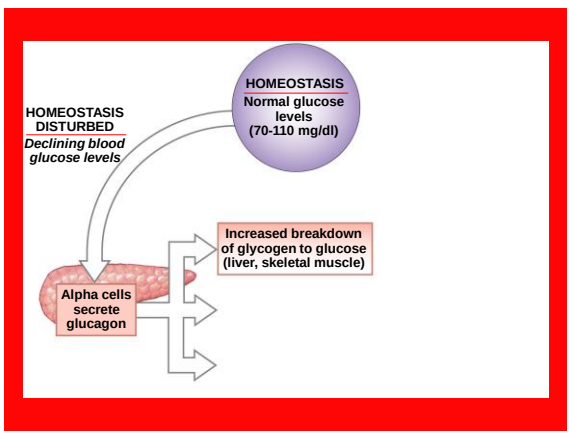
Increased fat synthesis (adipose tissue)
Beta cells secrete insulin
Blood glucose concentration declines
HOMEOSTASIS DISTURBED
Rising blood glucose levels
HOMEOSTASIS
Normal glucose levels (70-110 mg/dl)
HOMEOSTASIS RESTORED


HOMEOSTASIS
Normal glucose levels (70-110 mg/dl)
HOMEOSTASIS DISTURBED
Declining blood glucose levels


HOMEOSTASIS
Normal glucose levels (70-110 mg/dl)
HOMEOSTASIS DISTURBED
Declining blood glucose levels
Alpha cells secrete glucagon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Normal glucose levels (70-110 mg/dl)
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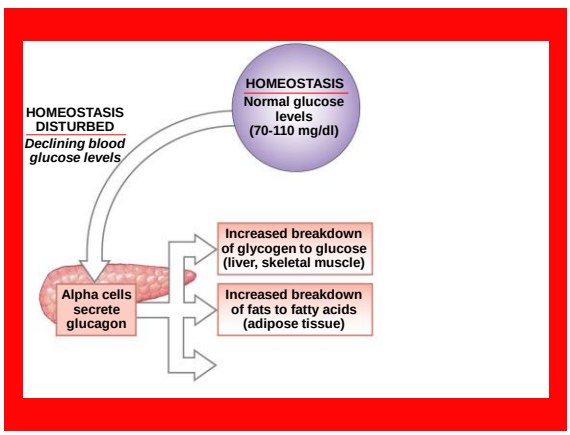
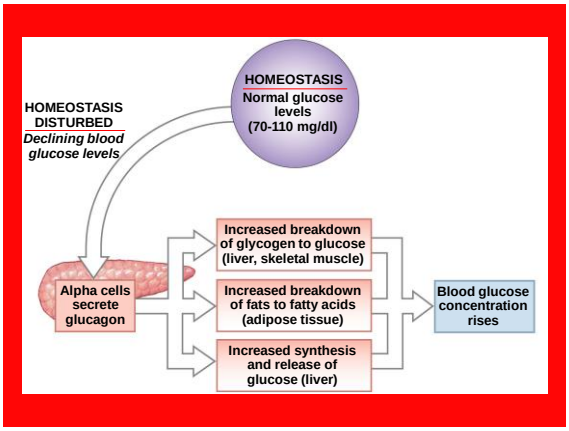
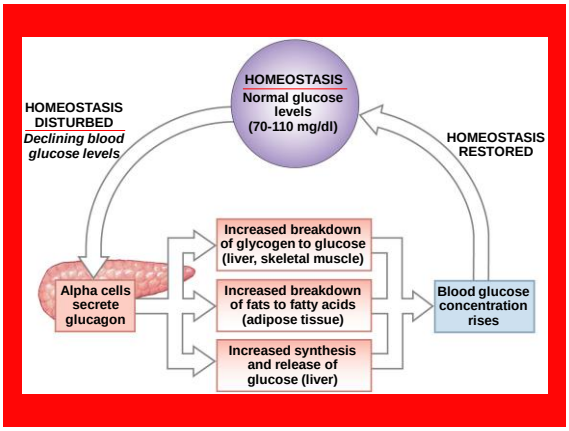
Declining blood glucose levels
Increased breakdown of glycogen to glucose (liver, skeletal muscle)
Alpha cells secrete glucagon

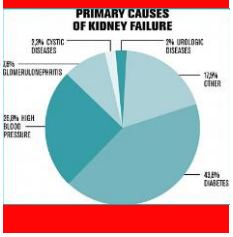

HOMEOSTASIS
Normal glucose levels (70-110 mg/dl)
HOMEOSTASIS DISTURBED
Declining blood glucose levels
Increased breakdown of glycogen to glucose (liver, skeletal muscle)
Increased breakdown of fats to fatty acids (adipose tissue)
Alpha cells secrete glucagon





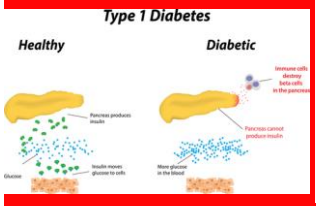
Applications and Skills

- Application: Causes and treatment of Type I and Type II diabetes.
  - Elevated blood glucose levels (fasting 100-125 mg/dL)
    - Damages tissues (particularly proteins)
    - Increases urine output (dehydration)



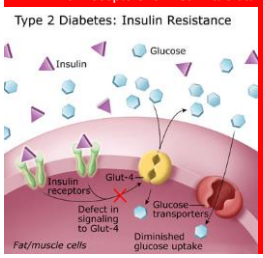
Applications and Skills

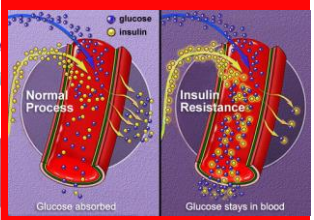
- Application: Causes and treatment of Type I and Type II diabetes.
  - Type I
    - Develops in childhood
    - Beta cells attacked by immune system (autoimmune disease)
    - Inability to produce insulin



Applications and Skills

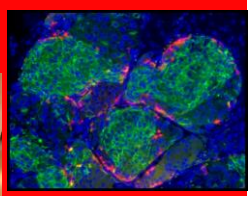
- Application: Causes and treatment of Type I and Type II diabetes.
  - Type II
    - Late onset (was rare for those under 50)
    - Receptors for insulin are damaged





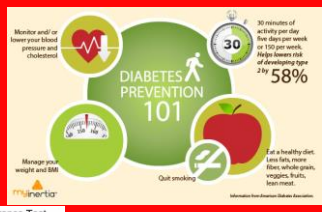
Applications and Skills

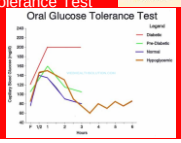
- Application: Causes and treatment of Type I and Type II diabetes.
  - Treatments
    - Type I
      - Insulin injections
      - Insulin pump
      - Stem cell replacement of beta cells
      - Genetic engineering of stomach and intestinal cells



Applications and Skills

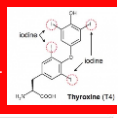
- Application: Causes and treatment of Type I and Type II diabetes.
  - Treatments
    - Type II
      - Adjust diet
      - Small meals at more frequent intervals
      - Strenuous exercise and weight loss
      - High fiber diet to slow digestion
  - Glucose Tolerance Test (DBQ 331)

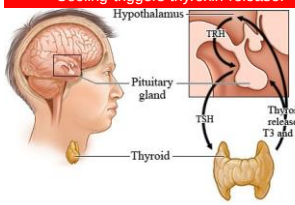


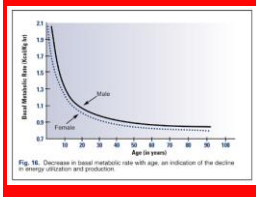


Understandings

- Thyroxin is secreted by the thyroid gland to regulate the metabolic rate and help control body temperature.
  - Secreted by the thyroid gland.
  - Thyroxin contains 4 iodine atoms.
  - Regulates metabolic rate of almost all cells.
  - Most active tissue (liver, muscle, brain) affected the most.
  - Cooling triggers thyroxin release.

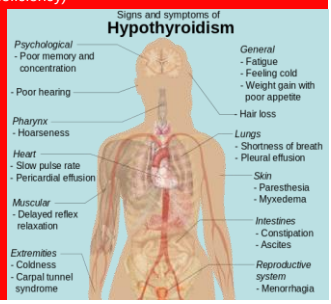






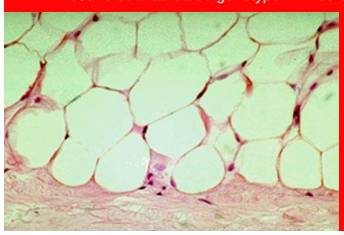
Understandings

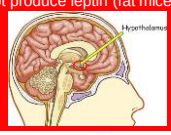
- Thyroxin is secreted by the thyroid gland to regulate the metabolic rate and help control body temperature.
  - Hypothyroidism (thyroxin deficiency)
    - Lack of energy
    - Forgetfulness and depression
    - Weight gain (although feel a loss of appetite)
    - Feeling cold
    - Constipation due to slowing of peristalsis
    - Impaired brain development in children



Understandings

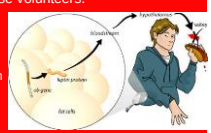
- Leptin is secreted by cells in adipose tissue and acts on the hypothalamus of the brain to inhibit appetite.
  - Levels of adipose tissue control release.
  - Target is the hypothalamus.
  - Inhibits appetite and therefore food intake.
  - Discovered that *ob/ob* genotype in mice cannot produce leptin (fat mice)

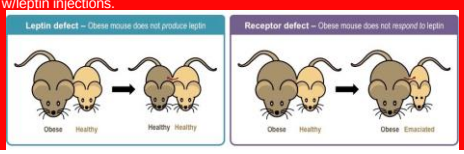




Applications and Skills

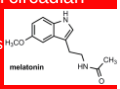
- Application: Testing of leptin on patients with clinical obesity and reasons for the failure to control the disease.
  - Amgen biotech tested leptin injections on 73 obese volunteers.
  - Leptin injections vs placebo.
    - Induced skin irritation and swelling
    - Only 47 patients finished the trials.
    - Unlike obese mice, obese humans have high leptin concentrations.
    - Receptors are resistant and appetite is not suppressed.
  - Obesity caused by insufficient leptin synthesis have shown some success w/leptin injections.

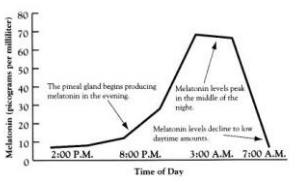


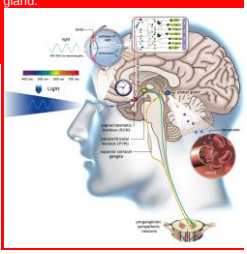


Understandings

- Melatonin is secreted by the pineal gland to control circadian rhythms.
  - 24 hour cycle (circadian rhythm) is established in humans
    - Retina detects 460-480 wavelegnths.
    - Superchiasmatic nuclei (SCN) of hypothalamous set rhythm.
    - Control release of melatonin from the pineal gland.
    - Levels of melatonin:
      - High: Drowsiness, peaks in evening, low body temperature, decreases urine production
      - Low: Wakefulness.





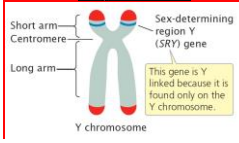


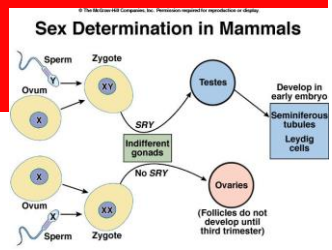
Applications and Skills

- Application: Causes of jet lag and use of melatonin to alleviate it.
  - Difficulty remaining awake during daytime, and difficulty falling asleep at night.
  - Fatigue, irritability, headaches and indigestion.
  - Melatonin taken orally at bedtime can reduce jet lag symptoms.

Understandings

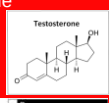
- A gene on the Y chromosome causes embryonic gonads to develop as testes and secrete testosterone.
  - SRY gene on male Y chromosome.
  - Codes for testes determining factor (TDF)
  - TDF binds to DNA, stimulating genes that cause testis development.

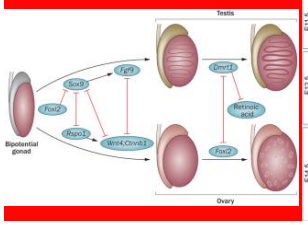


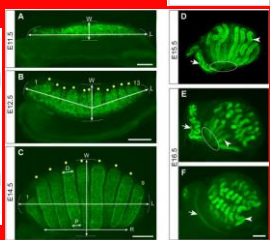


Understandings

- Testosterone causes pre-natal development of male genitalia and both sperm production and development of male secondary sexual characteristics during puberty.
  - Testes develop within 8 weeks of pregnancy.
  - Secrete testosterone until week 15.
  - Increased production at puberty.

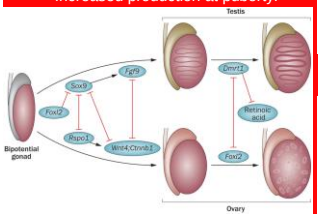


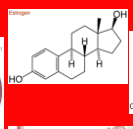


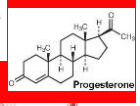


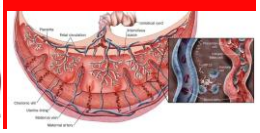
Understandings

- Estrogen and progesterone cause pre-natal development of female reproductive organs and female secondary sexual characteristics during puberty.
  - No SRY gene expression develops ovaries.
  - Estrogen and progesterone are always present (from mom and placenta).
  - Increased production at puberty.



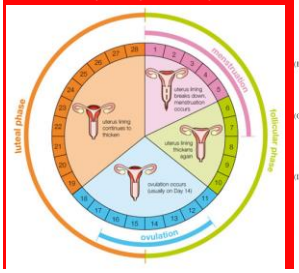


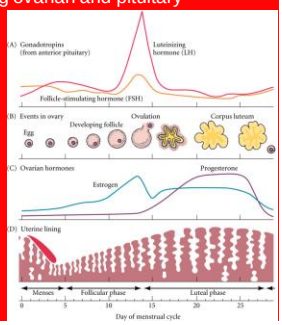




Understandings

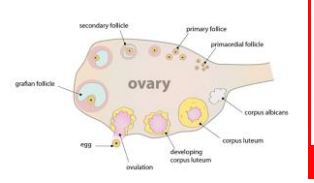
- The menstrual cycle is controlled by negative and positive feedback mechanisms involving ovarian and pituitary hormones.
  - From puberty to menopause.

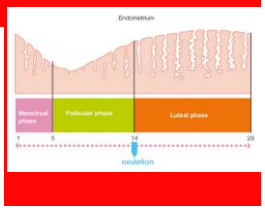




Understandings

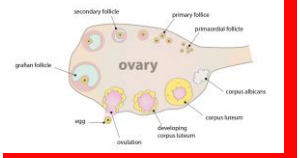
- The menstrual cycle is controlled by negative and positive feedback mechanisms involving ovarian and pituitary hormones.
  - Follicular Phase (1st HALF)
    - In each follicle an egg develops.
    - Endometriun (lining of uterus) thickens.
    - Most developed follicle breaks open. (others degenerate)
    - Egg travels down oviduct.

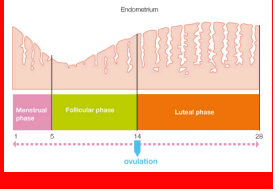




Understandings

- The menstrual cycle is controlled by negative and positive feedback mechanisms involving ovarian and pituitary hormones.
  - Luteal Phase (2nd HALF)
    - Wall of follicle that released egg becomes the corpus luteum.
    - Endometrium continues to develop for implantation.
    - No fertilization results in corpus luteum and endometrium breaking down.





Applications and Skills

- Application: The use in IVF of drugs to suspend the normal secretion of hormones, followed by the use of artificial doses of hormones to induce superovulation and establish a pregnancy.
  - *In vivo* is within body.
  - *In vitro* is outside the body.
  - First stage (down-regulation)
    - Drug reduces FSH and LH.
    - This stops estrogen and progesterone production.
    - Suspends menstrual cycle.
  - Intramuscular injections of FSH and LH for 10 days.
  - Higher concentration than normal, leads to more follicles developing (superovulation).
  - At 18 mm follicles are stimulated with HCG (normally from embryo).
  - Eggs are washed out of the follicle.
  - They are mixed with sperm at 37ºC in a petri dish.
  - 48 hour embryo is implanted in uterus.

Applications and Skills

- Skill: Annotate diagrams of the male and female reproductive system to show names of structures and their functions. (pg 336)

Male:
- Testis
- Scrotum
- Epididymis
- Sperm duct
- Seminal vesicle
- Prostate gland
- Urethra
- Penis

Female:
- Ovary
- Oviduct
- Uterus
- Cervix
- Vagina
- Vulva