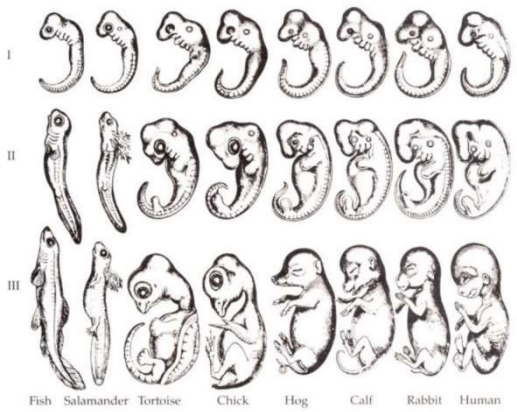
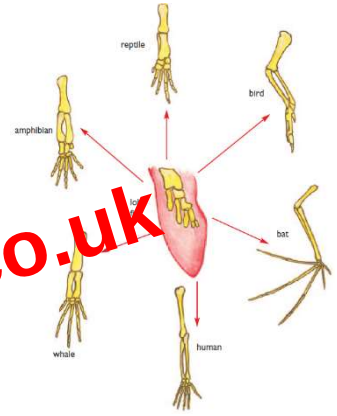
- Haeckel's embryos are a famous illustration comparing the early stages of various animals. However, they are over-exaggerated.



– Comparative Anatomy:

- Comparative anatomy is the study of the differences and similarities in structure between different organisms.
- The structures they have in common are evidence of similar inherited characteristics from a common ancestor.
- *E.g.* Pentadactyl Limb
  - ➢ The pentadactyl limb is a 5-digit limb
  - ➢ It is a structure of bones that is found in many vertebrates
  - ➢ It is believed that this limb was inherited from an aquatic ancestor – lobe-finned fish



- *E.g.* Xylem
  - ➢ Xylem is found in almost all plants. This suggests a common ancestor
  - ➢ Ferns, conifers and angiosperms all have vascular tissue, including xylem
- Analogous structures are organs that differ greatly in their basic plan and are thought to have started off being very different and then to have evolved independently to become similar, because they were selected to be used for a similar purpose.

– Biochemistry:

- All organisms share the same basic biochemistry. They all:
  - ➢ Consist primarily of organic compounds
  - ➢ Share a common genetic code of DNA or RNA
  - ➢ Rely on enzymes to control chemical reactions
  - ➢ Share the same cell membrane structure
  - ➢ Rely on cellular respiration to make energy for cell processes (except chemosynthetic bacteria)
- Similarities in the base-pairing of DNA strands have been analysed to show evolutionary links between organisms
- The amino-acid sequence of certain proteins found in many organisms (such as haemoglobin and cytochrome-c) has been analysed across a range of organisms, and similarities provides evidence for evolution in general
- Techniques such as assessing compatibility of blood, amino acid sequencing and DNA hybridisation help identify evolutionary relationships.
- DNA Hybridisation
  - o Two strands of DNA from different species are separated using heat
  - o The single strands from each species are mixed with other species

3. Chromosomal structure provides the key to inheritance.

Students Learn to:	*Notes*
– *Outline the roles of Sutton and Boveri in identifying the importance of chromosomes*	– **Walter Sutton** – He was an American geneticist who studied meiosis of cells of grasshoppers – In 1902, he proposed the Chromosomal Theory of Inheritance – Suggested Mendel's inheritance "factors" are carried on chromosomes – Formulated theory after observing meiosis in grasshopper testicles – *Sutton's observations revealed that:* ➢ **Chromosomes** occur in distinct **pairs** as distinct entities, visible during meiosis in grasshopper cells. o One chromosome of each pair is paternal and the other maternal (today termed **homologous pairs**). o These chromosomes in each pair have the same size and shape. ➢ During meiosis, the chromosome number of a cell is **halved**. o The chromosomes in each pair separate. o Each gamete receives one chromosome from each pair. ➢ Fertilisation restores the full number of chromosomes in the zygote. • *Sutton concluded that:* ➢ Chromosomes arrange themselves independently along the middle of the cell just before it divides. ➢ Chromosomes are **units involved in inheritance**. Sutton believed several "Mendelian factors" must be present in one chromosome. ➢ If two characteristics are on the same chromosome (linked genes) they will move together rather than separately according to Mendel's law of independent assortment. – **Theodor Boveri:** • A German zoologist • Showed that chromosomes were transferred from one generation to the next in cell division • Suggested that chromosomes might be the means of inheritance • Noticed that there are many more characteristics that chromosomes, and hypothesised that each chromosome contains many "factors" • Argued that chromosomes could exchange factors with each other during meiosis (crossing over) • He carried out experiments on sea urchin eggs between 1896 and 1904. He studied the behaviour of the cell nucleus and chromosomes during meiosis and after fertilisation. • *Boveri's experiments showed that:* ➢ The nucleus of the egg and sperm each contribute the same amount of chromosomes to the zygote, thus connecting chromosomes and heredity. ➢ When a normal egg and sperm fused, the resulting offspring showed characteristics of both parents. ➢ If the nucleus of only one parent was present, the larvae resembled that parent, but showed abnormalities. o When an egg with its nucleus removed was fertilised with a sperm, the resulting sea urchin larvae showed characteristics similar the male parent. However, they were smaller, had only half the normal number of chromosomes and showed some abnormalities. • *Boveri deduced that:* ➢ A complete set of chromosomes (in pairs) is required for normal development. ➢ The inheritance "factors" are found on chromosomes within the nucleus – chromosomes are the carriers of heredity. ➢ There are more hereditary "factors" than chromosomes and so there must be many factors (today known as genes) on one chromosome.

– *Explain the relationship between the structure and behaviour of chromosomes during meiosis and the inheritance of genes.*

Inheritance of genes	Structure and behaviour of chromosomes
Factors (genes) responsible for heredity occur in pairs.	Chromosomes occur in pairs in body cells.
During meiosis one of each of these factors passes into the gametes.	Alleles for a particular characteristic are located on each member of a homologous pair, which segregate during meiosis.
Only one of each pair of genes is present in each gamete; the number of genes in gametes is half that of body cells. Only one allele is present for what used to be a pair.	The number of chromosomes going into each sperm and ovum at the end of meiosis is half the number found in somatic cells.
Four haploid cells are formed in meiosis.	Meiosis involves two divisions, hence forming four daughter cells. They are haploid because chromatids separate in the second stage.
Genes may change position during meiosis, leading to increased variation: recombinant types can be produced.	Crossing over may occur when two chromosomes swap chromatid parts.

– *Explain the role of gamete formation and sexual reproduction in variability of offspring.*

– *The events that create variation in sexual reproduction are:*

- RANDOM SEGREGATION: During meiosis, genes on different chromosomes sort independently. They can line up in the middle of the cell in many different ways. This produces many gene combinations, which are different from the parents
- CROSSING OVER: Crossing over of genetic material during meiosis results in the exchange of genes between chromosome pairs. The combinations of alleles of the gametes will vary across cells and differ from the parent
- RANDOM FERTILISATION: When the male and the female mate, the two different gametes randomly fuse. Many different combinations are possible, and this causes variation.

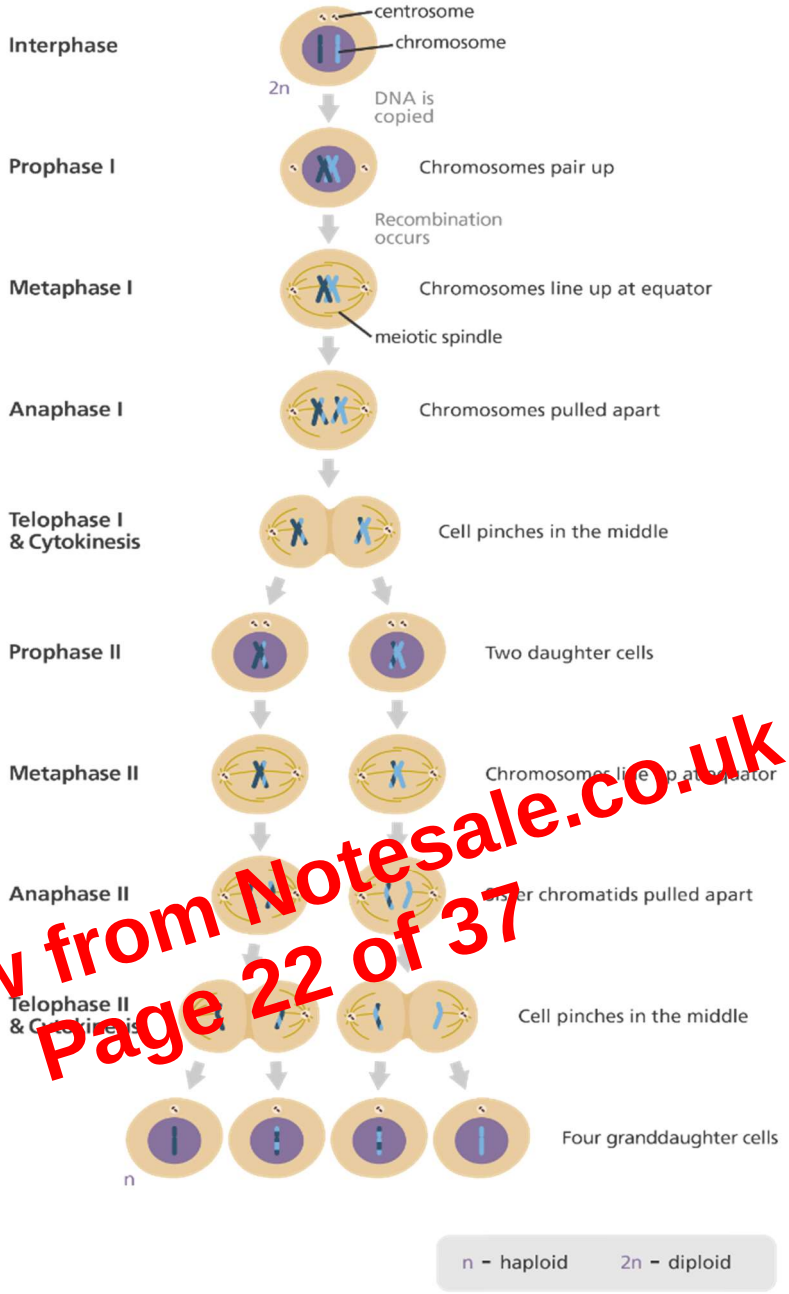
– *Describe the inheritance of sex-linked genes, and alleles that exhibit co-dominance and explain why these do not produce simple Mendelian ratios.*

– Sex linkage:

- SEX is a genetically determined characteristic
- Every cell in the human body contains 23 pairs of chromosomes 22 pairs of autosomes (general traits within the body) and 1 pair of sex chromosomes (the 23rd pair)
- Sex chromosomes may differ from each other in size and shape
- For females, both the sex chromosomes are the same. This combination is called XX. Females have two X chromosomes, and the chromosomes are homozygous
- For males, the sex chromosomes are different. The combination is XY. The Y chromosome is shorter than the X chromosome.
- Because the Y chromosome is much shorter than the X chromosome, some characteristics are only coded for by the X chromosome
- This is a special case of inheritance of characteristic.
- Most sex-linked characteristics are recessive
  - Take, eg, haemophilia. "H" is the dominant, normal allele; "h" is the recessive, haemophiliac allele.
  - Females:
    - A normal female's genotype – X^HX^H
    - A carrier female has the genotype - X^HX^h
    - A haemophiliac female has the genotype – X^hX^h
  - Males:
    - A normal male - X^HY
    - A haemophiliac male - X^hY
- As you can see for the example, males only have to inherit a single gene to have the characteristic.
- A single recessive gene has the same phenotypic effect as a single dominant gene
- This is why some sex-linked characteristics are much more common in males than females.

– Sex Determination

- The offspring of most animals have an equal chance of being male or female

Students:	*Notes*
• *Process information from secondary sources to construct a model that demonstrates meiosis and the processes of crossing over, segregation of chromosomes and the production of haploid gametes.*	
• *Solve problems involving co-dominance and sex linkage.*	
• *Identify data sources and perform a first-hand investigation to demonstrate*	Aim: To investigate the effect of environment on phenotype Hypothesis: The plant which receives no water will look different to that which receives less water Equipment: Geraniums, soil, water, scissors, tissue

- Summary:

Changed gene → no enzyme → no reaction → no vitamin

  - Beadle and Tatum concluded that different genes are involved in making different enzymes that catalyse different reactions in a cell.
  - This lead to the:

One gene → one enzyme hypothesis

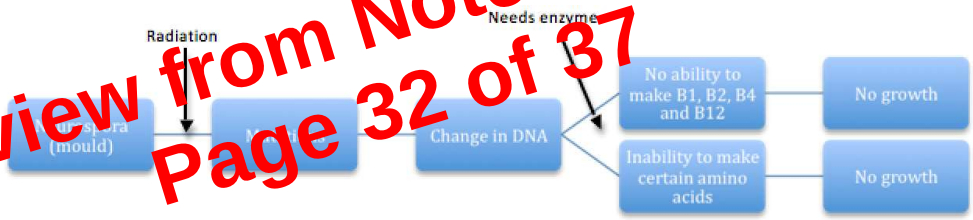
  - Because enzymes are not the only proteins made by cells, this was later changed to the:

One gene → one protein hypothesis

  - Because it was later discovered that some proteins are made by joining 2 or more polypeptides, each of which has its own gene, this was further modified to the:

One gene → one polypeptide hypothesis

- Eg haemoglobin is made from 2 different polypeptides, haemoglobin 'a' and haemoglobin 'b', each having their own gene



– *Process information to construct a flow chart that shows that changes in DNA sequences can result in changes in cell activity.*

– *Process and analyse information from secondary sources to explain a modern*

Golden Staph:

- The use of antibiotics is a selective pressure.
- Bacteria resistant to antibiotics survive and reproduce quickly.
- For example, **Staphylococcus aureus (golden staph)** have developed to be resistant to most modern antibiotics, due to overuse of antibiotics.
- The new strain of the golden staph is called the MRSA – methicillin (type of penicillin) resistant staphylococcus aureus
- This means that resistant bacteria are entering our food.

- Most bacteria contain small, circular pieces of DNA called plasmids
- Plasmids can be used as vectors or carriers to transfer transgenes into bacteria

– <u>Reasons For Using These Processes:</u>
  - These processes enable scientists to combine the qualities of different organisms
  - Transgenic species are being developed to:
    - Increase the resistance of plants or animals to diseases, pests or extreme environmental conditions
    - For medicines and vaccines and to study human diseases
    - To improve productivity of crops, pastures and animals
    - To improve the quality of food and efficiency of food processing

– <u>Examples of the Use of Transgenic Species:</u>
  - BT CROPS: BT is a bacterium that naturally produces chemicals that kills many insects. The chemicals are specific to many pests and do not kill other insects. Genetically modified crops have had the gene of BT pesticide inserted into them. They produce their own BT chemicals, and no longer need to be sprayed
  - COLD STRAWBERRIES: A gene from a type of salmon that allows it to survive cold temperatures has been isolated, and inserted into a strain of strawberry. This strawberry can survive and grow in cold temperatures.
  - BACTERIAL INSULIN: Diabetics previously obtained their insulin from animals, esp. pigs. The gene for insulin production, taken from the human pancreas, was placed in to the DNA of a bacterium. This now provides mass production of insulin.

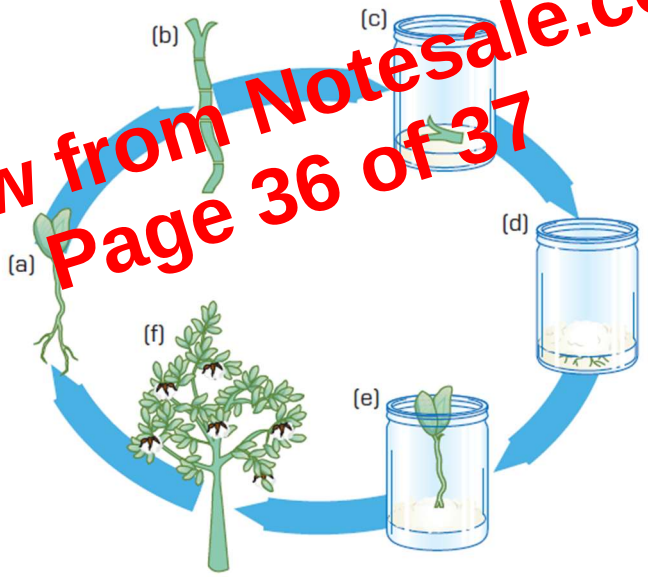


Figure 5.11 Tissue culture of Bt cotton:
(a) normal cotton seedling;
(b) fragmented seedling infected with Bt genes;
(c) fragment grown into a callus;
(d) callus cells in liquid medium with hormones becomes an embryo;
(e) cotton seedling develops from embryo;
(f) transgenic mature plant

– <u>Ethical Issues of Transgenesis:</u>
  - These technologies help treat diseases and increase food production
  - Should we be tampering with nature in this way?
  - Is it right to change living organisms for commercial gain?
  - Transgenesis disrupts evolutionary relationships between organisms
  - If a transgenic species was released into the natural environment, it could outcompete the natural organisms
  - Health-risks and side effects with eating GM foods.