Application Syllabus

Genetically Modified Organisms – Summary

Learning Outcomes:

- Explain the significance of genetic engineering in improving the quality and yield of crop plants and animals in solving the demand for food in the world.
- Disuss the ethical and social implications of genetically modified organisms.

Animals

Transgenic Atlantic Salmon

- By A/F Protein (Waltham, MA)
- Fish raised in ocean pens
- Tremendous growth potential
- Heightened feed conversion efficiency.
- Chinook salmon growth hormone, coupled with ocean pout promoter, carried by transgenic Atlantic salmon, now produced all year round by both liver and pituitary gland (latter ceases production in winter).
- 2-3% of fry express the gene
- ~75% of them will express the GH protein
- Grow 3 – 6 times faster

Pigs

- Meat that's rich in omega-3 fatty acids.
- Normal pigs rich in unhealthy omega-6 fatty acids (this is not removed)
- *fat-1* gene first transferred from C. elegans to pig fetal cells.
- 8% omega-3 fatty acids vs 1% in normal pigs

Milk

- Human factor IX (blood clotting factor)
- Tissue plasminogen activator (dissolves blood clots)
- (above are produced in milk of transgenic animals)

Bovine Somatotrophin (BST)

- Somatotrophins → growth hormones
    - normally secreted by pituitary gland
- Increases efficiency of animal feed conversion
- Gene obtained from cows, engineered into *Escheria coli*, then transferred back
- Bovine somatotrophin injected into lactating cows

- Small doses every 1-2 weeks
- Milk production increased by 25% (around 5L)
- 10-15% increase in weight of beef cattle
- BUT cows more likely to contract mastitis (bacterial infection of udder)
- Prolonged used show to weaken cows by depleting the immune system (increased susceptibility to disease).
- Approved by US FDA in 1993
- Banned in EU
- Marketed as POSILAC in USA by Monsanto

Procine Somatotrophin (PST)

- May improve human health
- Lower farmer's cost of production
- Improves feed efficiency in pigs by 15-20%
- Reduces fat deposition → leaner cuts of pork

Diagnostic Tests

- Biotech-based diagnostic tests via use of monoclonal antibodies
- High specificity → more accurate diagnosis
- Faster treatment
- E.g. Brucellosis in cattle (causes spontaneous abortions in cows, and can spread to humans)

Vaccines

- Antigens are now produced by non-pathogenic bacteria and yeast for use as vaccines
- Mass production reduces cost
- Need to inactivate vaccine material (making the live virus harmless) is eliminated as it is synthesized separately from the pathogen
- E.g. conventional foot and mouth vaccines made by weakening the virus that causes the disease. Vaccines sometimes revert to the virulent state, and cause outbreaks (Europe). Foot and mouth vaccine made with biotechnology cannot cause the disease as disease causing genes have been removed.

Disease-Resistant Livestock

- Some breeds naturally/genetically resistant (e.g. cows resistant to mastitis)
- Influenza-resistant pigs (by scientists)

- But a very limited number of genes are currently known to be responsible for resistance to diseases in animals

Plants

Disease resistant plants

- *Agrobacterium* has been used to produce tomato and tobacco plants with increased resistance to the tobacco mosaic virus
- *Agrobacterium* used to improve resistance to many fungal and bacterial diseases
- Codes for substance toxic to pathogen or enzyme that blocks essential metabolic pathway
- Protoplast fusion (resistance to some major viral disease transferred this way from a wild variety to commercial high yield potato plants)
- Plant cloning/engineering
- E.g. Papaya ringspot virus (PSRV) resistant papaya (Hawaii)

Insect Resistant Plants

- CASE STUDY 1
    - Bt Corn, Bt Tomato (IMPORTANT)
    - More effective way is to destroy the insect pest using the bacterium *Bacillus thurigiensis* which produces spores with Bt toxin
    - Spores ingested by caterpillar, fly or mosquito larvae, and toxin is broken down by the digestive enzymes into toxic proteins
    - Only certain organisms susceptible (hence specific)
    - *Bacillus thurigiensis* does not survive well in natural environment → Bt gene then isolated and transferred to the plants, giving them permanent protection
    - Bt maize and Bt cotton (Yieldgard and Bollgard respectively) and Bt tomato now available (by Monsanto)
    - KNOW DISADVANTAGES OF PESTICIDES (common sense)
- CASE STUDY 2
    - Produce inhibitors to essential enzymes in the insect
    - Plant proteases inhibitors have been shown to be effective general pesticides
    - E.g. Cowpea trypsin inhibitor successfully transferred into tobacco by *A. tumifaciens* that produces an inhibitor to trypsin
    - Insects that ingest this starve to death

Herbicide Resitant Plants

- RoundUp Ready Soybean
- RoundUp is a glyphosate-based herbicide used since the 1970s. It is not specific inhibits EPSP sythase that prevents the manufacture of certain amino acids and the plant dies. Is commonly sprayed before planting of crop seeds to kill weeds.
- Difficulty comes when crops are already grown
- Resistance gene isolated from Agrobaterium species strain CP4 that codes for CP4EPSP which was then introduced into soybean plants
- RoundUp herbicide spraying now more effective

Improved Nutritional Quality

- Case 1 Met-producing lupines
    - Humans cannot produce all essential amino acids
    - Rest from diet
    - Corn can't produce lysine
    - Legumes can't produce methionine
    - Lupines (a legume) which produces methionine successful produced and is used as a feed for chickens.
- Case 2 Golden rice
    - Especially important in developing countries
    - Transgenic rice is rich in beta-carotene, precursor to Vitamin A
    - Vitamin A deficiency leads to blindness and disease susceptibility
    - Rice is poor in micronutrients and vitamins
    - Genes for enzymes that convert a natural compound in rice into beta-carotene introduced into rice plants. Two of these genes are from the daffodil and another from the bacterium Erwinia. Transformed *Agrobacterium* then used to infect rice embryos in tissue culture. Resulting rice plants then crossed with local rice to ensure that they are adapted to local conditions.

Flavr-Savr

- Developed by Calgene which is now under Monsanto
- Delayed ripening
- Ripen on the vine longer to maintain firmer skin thus producing a fuller flavoured tomato
- Has antisense gene of enzyme **polygalacturonase** (PG)

- Prevents translation of mRNA transcript (ds mRNA produced) that codes for PG which in turn hydrolyses the middle lamella into shorter soluble fragments.
- Duplex RNA then quickly degraded by ribonucleases in the cell
- Quick notes about this production process:
    - Ti plasmid
    - A tumifaciens
    - Tissue culture
    - Kanamycin selectable marker

For other examples, refer to bio notes.

Ethical issues are common sense, refer to bio notes if need be.