



Module 12 Part 7: Vision in the aged

COURSE CODE: C-11702/O

Systemic diseases of old age



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As Benjamin Franklin famously said "...nothing can be said to be certain except death and taxes." Although some people do seem to avoid paying taxes, and the average life expectancy has risen dramatically during the last century (Figure 1), death will eventually come to us all. The average Briton can, at present, expect to live to an age of 78.7 years, with women living around five years longer than men. Obviously, life expectancy varies enormously throughout the world (from 84.2 years in Macau to only 32.2 years in Swaziland)¹.

The mortality rate for those over 75 years old in the UK has fallen sharply from 137 deaths per thousand per year in 1911-1915 to 83 deaths per thousand in 2006-2007². Thus, the proportion of elderly people has increased significantly in the last century and they are the fastest growing age group in the UK. The number of people aged 80 years or over has increased from around 1.6 million in 1981 to 2.8 million in 2007², currently accounting for 4.5% of the population. Not surprisingly therefore, the prevalence of age-related disease has increased and is likely to continue to do so.

It is to some extent possible to differentiate 'normal' changes that are an inevitable part of the ageing process, from the 'diseases' that are associated with old age. However, the dividing line between the two is not always clear. For example, the brains of all people lose neurons, possess larger ventricles and develop deposits of amyloid protein as they age. In dementias, such as Alzheimer's disease, these changes are greatly accentuated.

Ageing can perhaps best be seen as a gradual deterioration in bodily function onto which are superimposed periods of more rapid decline due to disease.

'Normal' biological changes with age

The oldest authenticated person died in 1997 in her 123rd year, whilst the oldest person alive today is 115 years old. Even if both heart disease and malignant neoplasia (cancer), the two leading causes of death in the West (Table 1), were eradicated, humans are unlikely to live far beyond 100-110 years due to the general deterioration in the body's systems with time.

The precise causes of such normal ageing are unclear, but the following are probably contributory factors; genetically programmed cessation of mitosis, damage to the body's deoxyribonucleic acid (DNA), breakdown in the accuracy of protein synthesis, changes in neuroendocrine function, decline in immune function, and an increase in cellular free radical injury. Whatever the causes, ageing is

Cause of death	%
Heart disease	26.6
Malignant neoplasms (cancer)	22.8
Cerebrovascular disease (stroke)	5.9
Chronic lower respiratory disease	5.3
Accidents	4.8
Diabetes	3.1
Alzheimer's disease	2.9
Influenza and pneumonia	2.6
Kidney disease	1.8
Septicemia	1.4

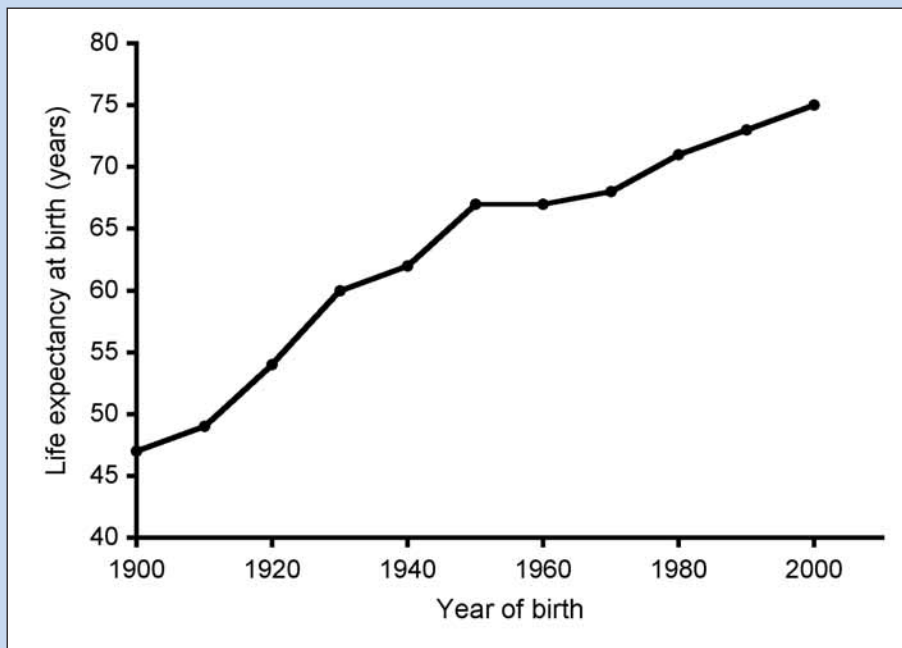
➔ Table 1

The major causes of death in the U.S. in 2005 (data from <http://www.cdc.gov/nchs/fastats/deaths.htm>)

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➔ **Figure 1**

Average life expectancy at birth in the U.S. 1900-2005 (data from [http://www.cdc.gov/nchs/data/08.pdf#026](http://www.cdc.gov/nchs/data/hus/08.pdf#026))

accompanied by some characteristic changes in biological function.

The death of cells, a decreased ability of cells to reproduce, changes in overall cellular morphology, and alterations in the structure and function of organelles, occur to some extent in all tissues as we age. Cell loss is especially apparent in amitotic tissues, such as central nervous system (CNS) neurons and cardiac muscle. In the eye, such simple cellular changes with age are apparent in the corneal endothelium. At birth, the relatively dense endothelial cells form a regular hexagonal lattice. With age, their density decreases and cells become larger and less regular in size and outline as they migrate to fill in the spaces left by neighbouring cells that have died and not been replaced (Figure 2). Another example of simple cell loss is the gradual atrophy of skeletal muscle after the age of 25 years (which is often replaced by fat, a process termed sarcopenia). The gradual decline of pupil diameter with age (senile miosis) may also, in part, be caused by wasting of the (smooth) iris dilator muscle. The accumulation of lipofuscin in the cells of the liver, kidney, nerve tissue and heart muscle,

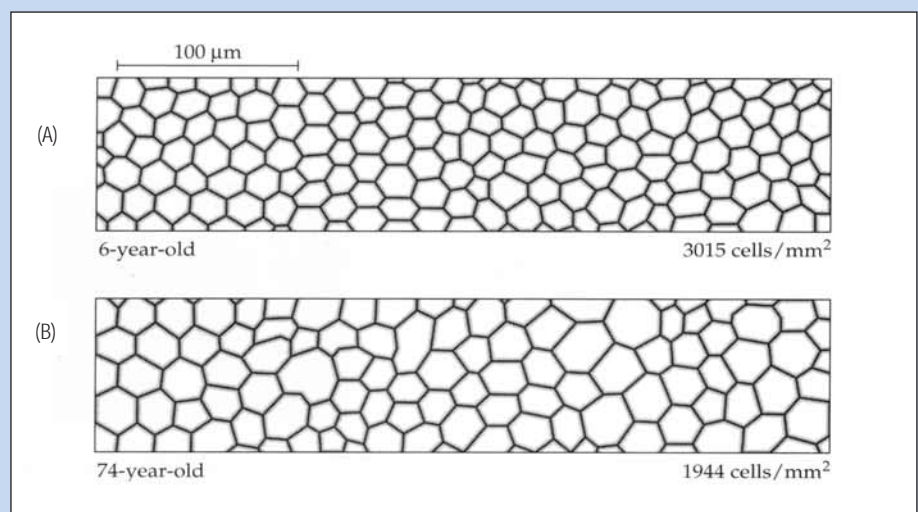
as well as the retinal pigment epithelium, is another sign of cellular ageing.

A common feature of ageing is the accumulation of advanced glycation end products (AGEs) which are important in diseases such as Alzheimer's and diabetes, and are also central to aspects of the normal ageing process. AGEs cause cross-linking

between proteins such as collagen which accounts, in part, for the age-related sclerosis of blood vessels. In the lens, cross-linking between crystallins is associated with cataract.

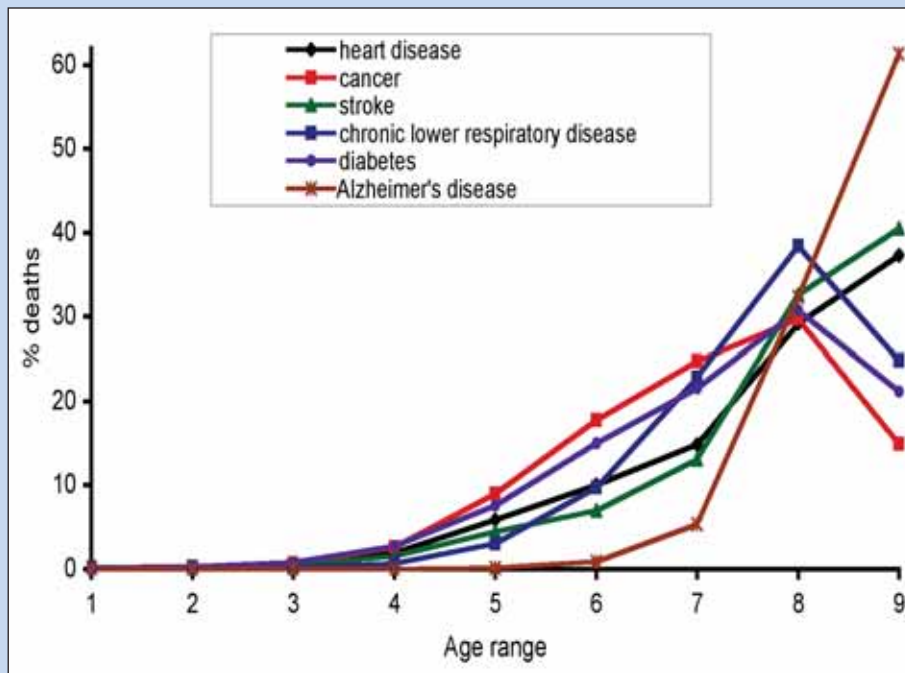
DNA also becomes progressively damaged as we age, due mainly to a failure of the body's DNA repair mechanisms. For example, the ends of chromosomes are made up of a sequence of bases called telomeres, that help protect the chromosome, especially when it divides during mitosis. Each time a cell divides, a chromosome loses around 30-200 base pairs from its ends, primarily because the enzymes involved in DNA duplication cannot continue their function all the way to the end of a strand of DNA. Without telomeres, useful DNA would be lost during each cell division. Telomeres get shorter with age and when telomeres get too short, the cell can no longer divide and dies. This shortening is thought to be key to the process of ageing in general, and cancer specifically.

Connective tissue changes are responsible for some of the most obvious signs of human ageing. Alterations in elastic and collagenous fibers, due in part to the formation of AGEs, lead to a loss of elasticity, for example, wrinkles. The enzymes that destroy collagen may also be upregulated with age which results, for



➔ **Figure 2**

Morphology of corneal endothelial cells viewed with a specular microscope in subjects aged (A) 6 and (B) 74 years old. The cells decrease in number, become larger and less regular in outline in old age (from Oyster, C.W. *The human eye; structure and function*. Sinauer Associates)



➔ **Figure 3**

The age distribution of the six most common disease-related causes of death in the U.S. in 2005. Data are shown for different age groups and expressed as a percentage of deaths due to that disease occurring in a particular age group. Age range: **1** – less than 15 years of age; **2** – aged 15-24; **3** – aged 25-34; **4** – aged 35-44; **5** – aged 45-54; **6** – aged 55-64; **7** – aged 65-74; **8** – aged 75-84; **9** – aged 85 or over. Accidental deaths are not shown, although they are the fifth most common cause of death, as they are not dependant on age (data from <http://www.cdc.gov/nchs/fastats/deaths.htm>)

example, in ptosis. Changes in cartilage between articulating bones with age result in osteoarthritis (which affects 80-85% of people over 70) and loss of bone causes the collapse of vertebrae. This explains why older people are often stooped and shorter.

Age is also associated with multisensory deterioration. The decline in visual function is well known to optometrists. Other senses, however, are also affected. Semicircular canal function, for example, deteriorates with age, leading to problems with balance. Hearing also becomes impaired (presbycusis) and the number of chemosensory cells involved in both smell and taste declines over time. Pain, pressure and temperature sensitivity also become progressively impaired with age, as does proprioceptive function. A loss of cutaneous sensitivity may, for example, explain the well-documented decrease in corneal sensitivity with age³.

Critically, immune function declines with age making the elderly more

susceptible to disease. The thymus gland, essential for the formation of T-lymphocytes, for example, begins to atrophy in early life. Elderly people are therefore much more prone to infection, probably explaining why pneumonia is such a common cause of death in elderly people (Figure 3). The high incidence of cancer in old age (Figure 3) may also be related, at least in part, to the immune system's inability to destroy cancerous cells. Some auto-immune diseases, such as giant cell arteritis⁴, are also more common in elderly people.

Systemic diseases of old age

Systemic diseases also affect the eye and an optometrist is often the first to detect such changes. Although not all systemic age-related disease results in death, an indication of the relative importance of such diseases is given by the frequency they are cited as the cause of mortality. Thus, 50% of all

deaths in the West have just two causes; cardiac disease and cancer (Table 1). Comparatively, other diseases are of much less importance.

All of the leading ten causes of death, with the exception of accidents, increase as a function of age (Figure 3). In this article, we will concentrate on the diseases most likely to impact on visual function; the various manifestations of cardiovascular disease, cancer and diabetes.

Cardiovascular disease

Blood vessel disease

Arteries are normally elastic, which enables them to dilate during cardiac systole (which prevents extreme rises in blood pressure) and recoil during diastole (which facilitates the movement of blood). Arteriosclerosis, which is a group of diseases characterised by a loss of arterial elasticity, will therefore generally result in increased blood pressure. It is common in old age (senile arteriosclerosis) and is characterised by the degeneration of smooth muscle in the artery's tunica media, the cross-linking of collagen and elastin, thickening of the blood vessel wall and deposition of calcium salts. It also occurs as a complication of diabetes.

The most important form of arteriosclerosis is atheroma (atherosclerosis), which is most commonly triggered by an injury to the smooth endothelial lining of the tunica interna of an artery. Causes of such injury include; carbon monoxide from smoking, hypertension or viral infection. The damaged endothelial cells release chemotactic factors which lead to the accumulation of low density lipoproteins (LDLs) from the plasma which become oxidised. LDLs deliver cholesterol to tissues. Macrophages ingest the oxidised lipids, forming 'foam cells' which cause the formation of a fatty 'yellow streak' in the vessel's tunica interna. Subsequently, smooth muscle cells migrate from the tunica media into the tunica interna, where they proliferate and secrete collagenous and elastic connective tissue. This mass of abnormal tissue in the vessel wall, known as an atherosclerotic 'plaque',

also contains a number of other substances such as calcium deposits as well as the white blood cells characteristic of inflammatory responses. Eventually, the plaque may become so large that the cells in the tunica media no longer get enough oxygen from the blood to sustain them and consequently die, to be replaced by fibrous scar tissue. The end result is that the size of the artery's lumen is decreased by a large immobile plaque (Figure 4).

In a large artery, an atherosclerotic plaque may have little affect by itself. However, it might completely block a smaller vessel. More commonly, a plaque will lead to disturbed blood flow, causing a thrombosis, which is a blood clot (thrombus) in an unbroken vessel, potentially blocking the artery. Vessels can also become blocked by embolisms, which are foreign bodies, such as a piece of plaque or part of a thrombus, which become dislodged

and circulate in the cardiovascular system until they lodge in a smaller vessel. Finally, blood vessel walls may become weakened, often, but not exclusively, by an atheromatous plaque, leading to the formation of a sac-like protrusion of the vessel wall (Figure 5). As the walls of such aneurysms are relatively thin, they can rupture, resulting in haemorrhaging, or they can become the site of a thrombosis. Thus, the end result of most blood vessel disease is that the vessel either becomes blocked or breaks. Consequently, the part of the body being supplied by the vessel does not receive a sufficient supply of oxygen (ischaemia), resulting in tissue necrosis. Such cell death is known as infarction and the dead area of tissue is termed an infarct.

Sometimes the blockage is not permanent and hence does not result in infarction. An example of such a transient ischaemic attack (TIA) is

amaurosis fugax (fleeting darkness) in which, for example, a thrombosis which formed on an atherosclerotic plaque in the carotid artery might become dislodged, travel into the ophthalmic artery and eventually lodge in the central retinal artery, leading to a painless loss of vision in the affected eye. However, if the blockage is resolved within a few minutes, no retinal tissue dies and vision returns. TIAs in the brain cause short-lived symptoms similar to those of a stroke and are a warning that a full stroke may occur in the future.

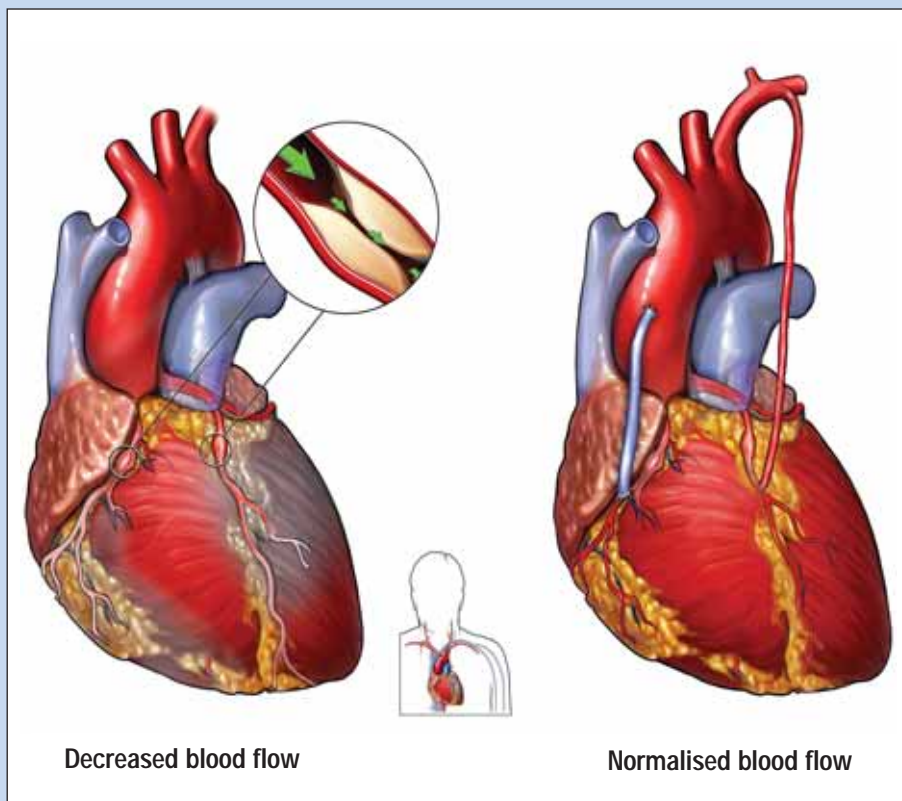
Cerebrovascular disease

The brain receives oxygenated blood both from the internal carotids anteriorly and the vertebral arteries, which join forming a single basilar artery, posteriorly. At the base of the brain these two supplies merge forming the circle of Willis, from which pairs of anterior, middle and posterior arteries originate, roughly supplying the front, middle and back of the brain respectively (Figure 6). An interruption in the blood supply in any cerebral vessel leading to tissue infarction is termed a cerebrovascular accident (CVA), commonly referred to as a stroke. However, it is not the random occurrence implied by the word 'accident', but the predictable result of events often occurring many years previously.

CNS neurons are particularly susceptible to infarction as, unlike some tissue, there is little functional reserve and they require an almost continual supply of oxygen to survive. Furthermore, unlike most cells they are amitotic and thus do not get replaced once they die. Stroke is therefore the third most common cause of death in the western world (Table 1).

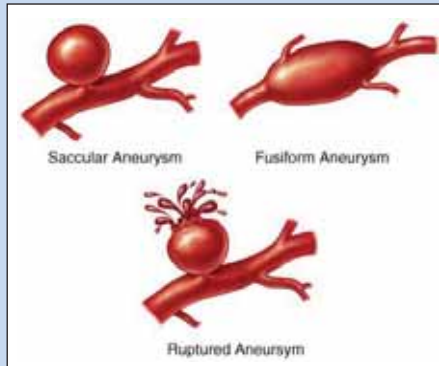
Strokes can be either haemorrhagic, caused for instance by a bursting aneurysm (accounting for 20% of all strokes) or they can be occlusive, possibly resulting from a thrombosis on an atheromatous plaque.

The consequences of a stroke obviously depend on which vessel is disrupted and therefore the area of the brain affected. Common signs are muscle weakness and difficulties with



➔ Figure 4

On the left is a schematic illustration of a coronary artery narrowed by an atherosclerotic plaque, resulting in the cardiac muscle receiving insufficient oxygen, potentially causing ischaemic heart disease. As illustrated on the right, such a blockage can be bypassed in order to restore normal blood flow to the heart (courtesy of photolibary.com)



➔ **Figure 5**

Two forms of aneurysm. These are prone to haemorrhage, resulting in 'stroke' if this occurs in the cerebral vasculature (courtesy of Internet Encyclopaedia of Science)

speech. Since one third of the cerebral cortex is involved in processing visual information, stroke often results in visual impairment. A disruption of the posterior cerebral artery, for example, might affect most of the striate cortex resulting in contralateral hemianopia (although macular vision may be spared as the posterior occipital cortex, which receives input from foveal photoreceptors, has a secondary supply arising from the middle cerebral artery). If the infarct is in the pre-striate cortex, the defect is more specific, such as achromatopsia if V4 is affected, or akinetopsia (inability to see motion) if the defect is in V5/MT.

Not all cerebrovascular disease involves infarction. Aneurysms, especially in the circle of Willis, are common and can compress surrounding tissue. Such aneurysms occur in all age groups, but increase in frequency with age, being most prevalent in people aged 50 to 60 years. An aneurysm of the carotid artery in the cavernous sinus, for example, can have multiple visual consequences affecting the neighbouring 3rd, 4th, 5th and 6th cranial nerves. A rupture of such an aneurysm results in a cavernous sinus fistula, which forces arterial blood back down the venous drainage system of the eye causing conjunctival congestion and chemosis and sometimes pulsatile exophthalmos.

An inflammation of the cranial arteries (cranial arteritis or giant cell

arteritis), which is characterised by the fragmentation of the tunica interna and the presence of giant multinucleate phagocytic cells, can cause profound visual loss when it affects the ophthalmic artery. Principally, the vascular supply to the optic nerve head by the posterior ciliary arteries is disrupted leading to optic neuropathy. It is one of the few ocular emergencies and is rarely observed in individuals under 65 years of age.

Heart disease

There are many forms of cardiac disease, for example, myocarditis (an inflammation of the heart muscle), pericarditis (an inflammation of the 'sac' containing the heart), infective endocarditis (inflammation of smooth lining of the heart), defects of the valve (resulting in either stenosis or regurgitation), or disturbances to the heart's excitatory and conductive muscle system (resulting in cardiac arrhythmias or heart block). However, by far the most significant is ischaemic heart disease (IHD).

In total 95% of the blood ejected from the heart into the aorta supplies the body with oxygen – 5% however, leaves the aorta soon after the semilunar valves, and enters the right and left coronary arteries, which supply blood to the heart muscle itself (Figure 4). The first few centimetres of these vessels are particularly susceptible to atheromatous plaque formation, resulting in cardiac muscle receiving insufficient oxygen to perform properly and thus the body does not receive a sufficient circulation.

The least severe consequence of IHD is angina pectoris, which is caused by a short term inadequacy of the blood supply to the heart, usually in times of increased demand. Symptoms, which are principally radiating chest pain, can often be alleviated by rest and vasodilator drugs and there is no long term damage to the heart as no tissue dies. Angina currently affects over one million people in the UK, is more common in men than women, and the incidence increases with age.

If the coronary circulation is interrupted for a longer period of time,

heart muscle dies. Such myocardial infarction (commonly referred to as a 'heart attack') is particularly serious as the heart, by definition, cannot stop functioning if life is to be maintained. Also, like CNS neurons, cardiac muscle is amitotic. The seriousness of the infarction, usually caused by a thrombosis on an atherosclerotic plaque in the coronary circulation, depends on the location of the blockage and hence the size and location of the dead tissue. An infarction of the left ventricle is the most serious as this distributes blood around the body, while a minor atrial infarct may be less serious.

Hypertension

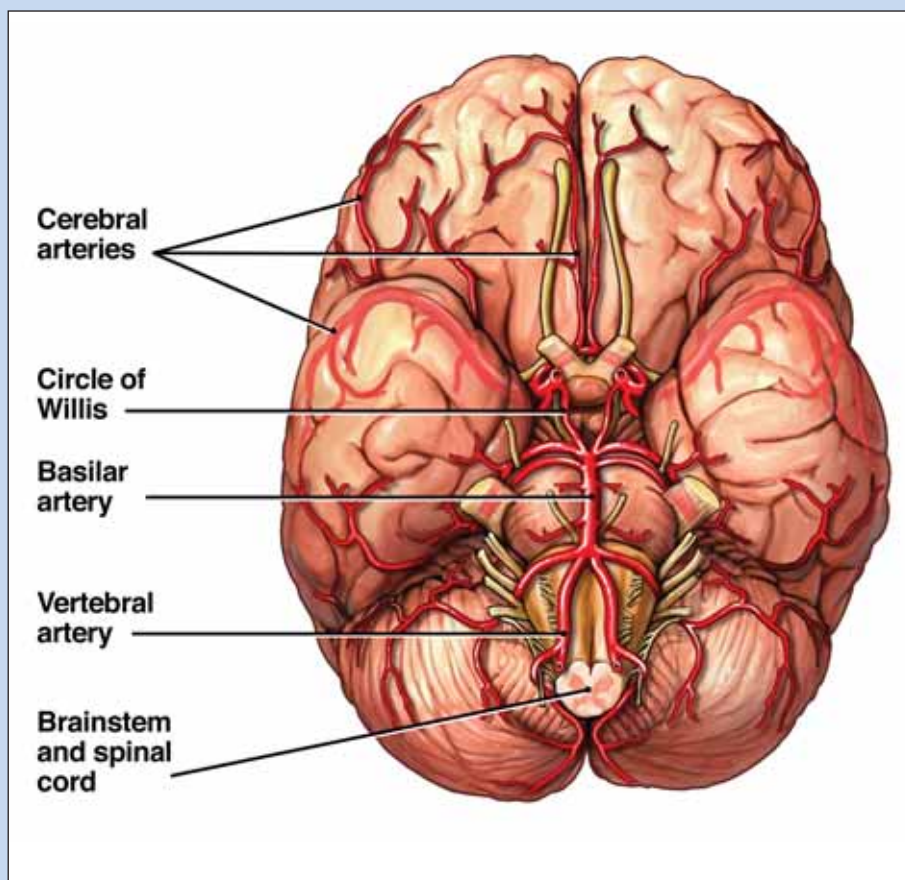
Hypertension is a prolonged period of abnormally high blood pressure and although it is not directly one of the top ten causes of death, it contributes to two diseases that are – heart attack and stroke. Furthermore, the incidence of hypertension increases dramatically with age.

Most cases of hypertension (defined by the World Health Organisation (WHO) as a systolic pressure >160mmHg and/or a diastolic >95mmHg) has no known cause and is termed 'primary' (also known as 'essential' or 'idiopathic'), whilst about 10% is 'secondary' to other known (mainly renal) diseases. In most instances, the speed of onset is gradual ('benign') and patients can be symptomless for years. If the increase is very rapid ('malignant'), death can occur soon after onset if not treated. Papilloedema is characteristic of malignant hypertension.

Unchecked hypertension can result in damage to the kidney, but most importantly is often the first event in atheromatous plaque formation, causing damage to the arterial wall. In the eye, hypertension can lead to hypertensive retinopathy, branch retinal vein occlusion and anterior ischaemic optic neuropathy.

Kidney disease (and hypertension)

The kidney in the young has a considerable functional reserve and is much less sensitive to damage than the heart or brain. Nevertheless, its



➔ **Figure 6**

Illustration of the brain and brain stem with normal arteries and cranial nerves, inferior view. Shown are the vertebral, basilar, and the cerebral arteries; the circle of Willis; the olfactory, trigeminal, and optic nerves; the optic chiasm; and other cranial nerves (courtesy of photolibary.com)

function is commonly impaired in the elderly and only about 3% of the elderly have normal kidney histology. Glomerular filtration rate declines with age and by 70 years, it is only about half that of middle-aged adults.

The kidney receives around 25% of the heart's output of oxygenated blood and is involved in controlling blood pressure both in the short-term by the release of renin, and in the long-term by controlling the body's fluid levels (pressure diuresis). Glomeruli are easily damaged by hypertension and, as they are not replaced, blood pressure cannot be controlled adequately. This can be the start of a vicious circle as kidney damage will result in blood pressure rising further, which will cause further kidney damage ultimately resulting in renal failure. Even in the absence of hypertension, the number of glomeruli decreases with age, and those

that remain become abnormal. Not surprisingly, kidney disease is a frequent cause of death (Table 1).

Cancer

Neoplasia is an abnormality in cellular differentiation, maturation and control of growth, which results in a mass of abnormal tissue (tumour). Neoplasms can be either benign or malignant (although the dividing line is not as clear as this implies). Benign tumours; tend to stay at their site of origin, are surrounded by a fibrotic capsule and are therefore smooth, grow slowly, are composed of cells resembling normal tissue and tend to be less dangerous. Malignant tumours, on the other hand; invade other tissue (metastasis), are not encapsulated and are therefore usually irregular, grow rapidly, do not resemble normal tissue and are often fatal if not treated. Only

malignant neoplasms are known as cancer.

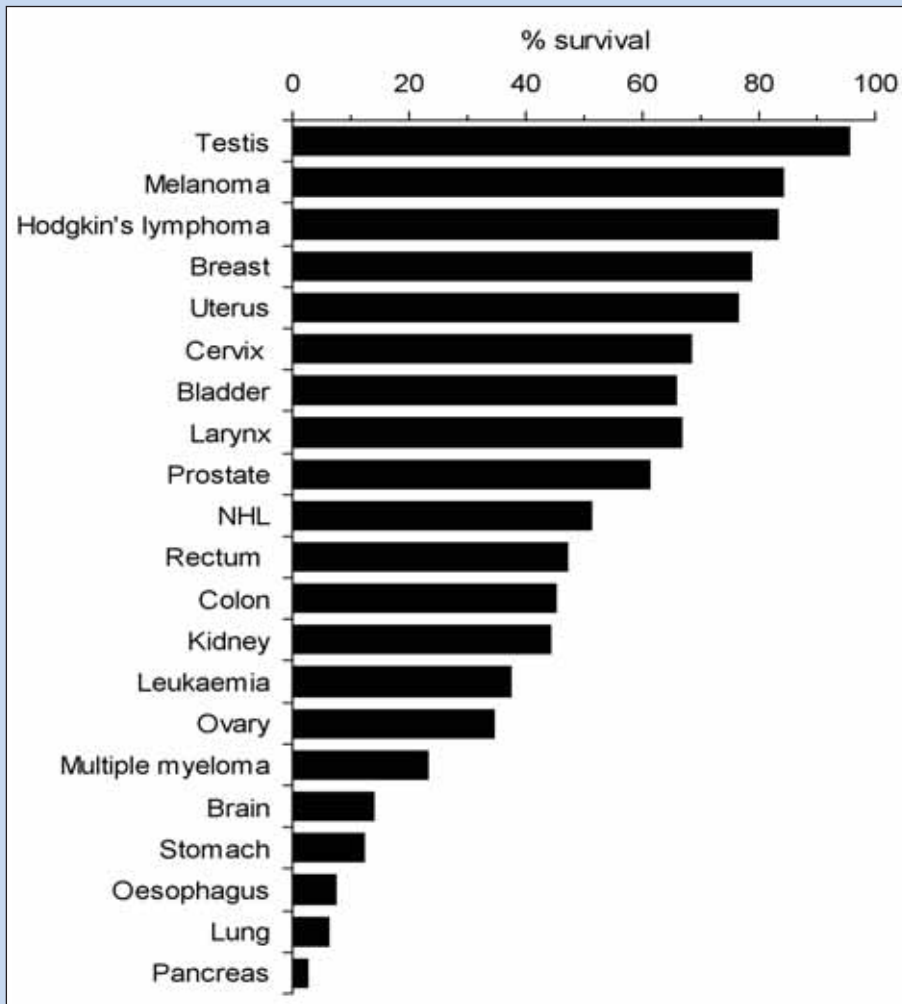
Normal cell growth is promoted by proto-oncogenes, which code for things like growth factors and their receptors, and can mutate into tumour-causing oncogenes. Conversely, normal cell growth is inhibited by tumour suppressor genes and tumours can also result from their malfunction.

Thus, neoplasia results from a breakdown in the normal balance of two classes of gene that have opposite effects on cell growth. These genes can be affected by inherited genetic triggers, spontaneous mutations, or the effects of external agents such as viruses or chemicals. Such effects can be augmented by defective DNA repair mechanisms and an impaired immune system, both of which are common in the elderly.

The risk of developing cancer doubles every five years after the age of 25 and half of all cancers become clinically evident in people over 70 years old (Figure 3). Worldwide, the number of deaths due to cancer may double in the next 50 years, largely due to an increase in the number of elderly people.

Egyptian embalmers were probably the first to notice that one way of classifying tumours is by their site of origin. An alternative is to refer to them by the type of cell they originate from. Therefore, adenomas and adenocarcinomas are benign and malignant growths of glandular cells respectively, while lipomas and lipocarcinomas arise from fatty tissue.

Both the incidence of a particular form of cancer and the efficacy of its treatment (Figure 7) determine the number of deaths caused by it (Figure 8). Thus, skin cancer is by far the most common neoplasm in the U.S. (over 500,000 cases a year) but as it is relatively easily treated, most people survive (Figure 7) and the number of deaths is relatively few (Figure 8). The prognosis for different types of cancer varies widely and while the outcome of testicular cancer and malignant melanoma is usually favourable, the survival rate for pancreatic cancer, for example, is very low (Figure 7).



➔ **Figure 7**

Estimates of various forms of cancer based on survival probabilities observed during 2000-2001 in England and Wales (data from Cancer Research UK <http://info.cancerresearchuk.org/cancerstats/survival/latestrates/> June 2009)

Optometrists are obviously primarily interested in tumours in the eye and the areas of the brain that impact on vision. The most common type of primary intraocular cancer in adults is melanoma. In the eye, melanocytes, and hence melanomas, occur in the uvea (choroid, ciliary body and iris), whilst extraocular melanomas can be found in the conjunctiva and skin. Uveal melanomas affect about one person in every 2,500 whereas conjunctival melanomas are much rarer, affecting only one person in every 125,000.

Intracranial tumours can occur in any part of the visual pathway as well as in areas of the brain involved with visual reflexes. Only around 2% of neoplasms are intracranial and 65% of

these arise from neuroglia (gliomas). A further 10% are pituitary adenomas, and thus can impact the ventral surface of the central chiasm causing characteristic bitemporal visual field losses (ganglion cells from the nasal retina are affected). Acoustic neuromas, which account for 6-10% of intracranial tumours, affect the 7th cranial nerve and hence prevent eye closure, requiring life long management of dry eye⁵.

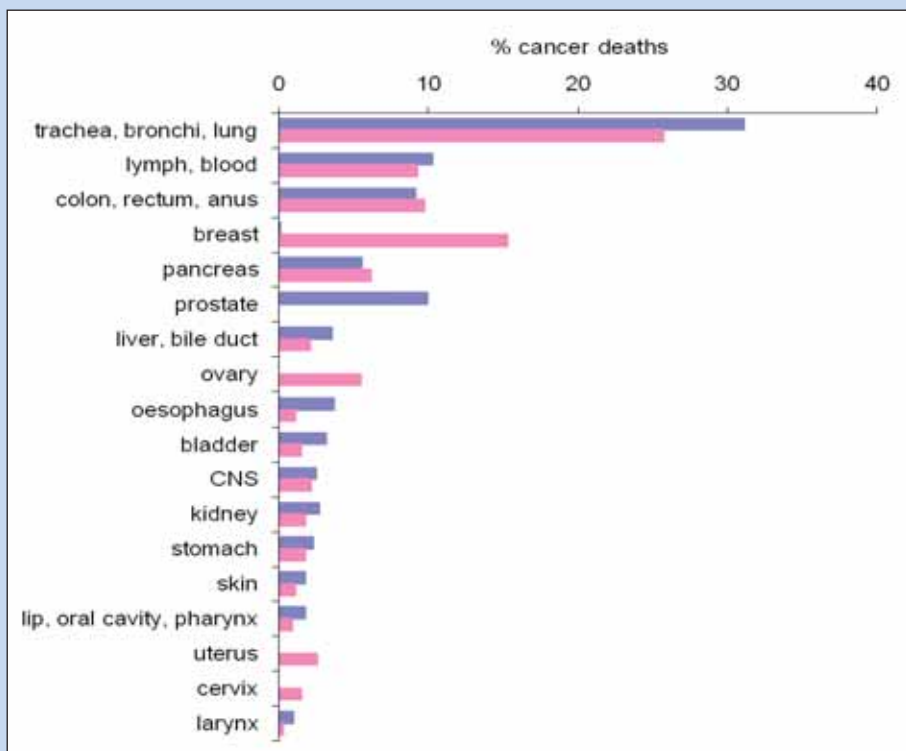
Diabetes

The end product of digestion is mainly glucose, which is converted by the body into energy in the form of adenosine triphosphate (ATP). Since we eat sporadically, yet blood glucose levels have to be maintained at a more

or less constant level, we have to store glucose immediately after a meal and gradually release it between meals. This is principally achieved by converting glucose into long chain glycogen (glycogenesis) and storing it in the liver. If storage in the liver is at capacity, the same process can also occur in muscle. Some glucose is also converted into glycerol, which is a constituent of fat. Between meals, the glycogen is converted back to glucose (glycogenolysis). Glucose can also be derived from the breakdown of muscle and fat (gluconeogenesis). Two enzymes secreted by the pancreas help regulate glucose levels; (i) insulin is secreted by the β cells of the Islets of Langerhans immediately after a meal and promotes the storage of glucose and (ii) glucagon is released between meals by the α cells facilitating glucose release.

Diabetes (derived from the Greek meaning 'running through') is characterised by the production of large quantities of urine. There are two basic forms of the disease. The rarer form, diabetes insipidus, results from either a decreased release of antidiuretic hormone (ADH) by the posterior pituitary or an insensitivity of the kidney to ADH. Since ADH serves to concentrate the urine by promoting water retention, its reduction results in excessive urination which does not contain large amounts of glucose. Diabetes mellitus (mellitus meaning 'honey' in Latin), on the other hand, is characterised by the production of large amounts of urine that smells (and tastes!) sweet.

Diabetes mellitus can be of two types. Type 1 (also known as insulin dependent, or juvenile onset) is caused by a complete loss of pancreatic β cells (due to a number of factors, for example, genetic susceptibility, autoimmune attack, retroviruses) resulting in a lack of insulin and consequently an inability to store glucose, causing high blood sugar levels (hyperglycaemia). As a result, glucose is excreted in the urine which leads to water being retained in the urine by osmosis. It is easily treated with insulin. Type 1 diabetes



➔ **Figure 8**

Proportion of total cancer deaths caused by various types of malignant neoplasms in the U.S. in 2005 in both males (blue) and females (pink) (data from <http://www.cdc.gov/nchs/fastats/deaths.htm>)

is usually diagnosed in people under 20 years old and therefore cannot be considered a disease of old age.

Type 2 (also known as insulin independent, or maturity onset) diabetes, is by far the most common type of diabetes mellitus (accounting for over 90% of all cases) and is almost exclusive to older people. Sufferers are at increased risk of stroke and heart disease and their life expectancy is decreased by 5-10 years compared to the general public. In Type 2 diabetes mellitus, insulin levels are often near normal, but after a meal, blood glucose levels remain high due to a decrease in the number of functional insulin receptors on cells. It can initially be controlled by diet and exercise (which increase sensitivity to insulin), although many patients eventually also require insulin as β cell function also declines.

The hyperglycaemia resulting from diabetes causes the formation of AGEs leading to characteristic changes in blood vessels including a diffuse thickening of the basement membrane.

This results in diabetic retinopathy, which is characterised by haemorrhages and exudates, and ultimately neovascularisation. As a consequence, it is the leading cause of new cases of blindness among adults aged 20-74 years in the Western world. Diabetes also accelerates the formation of cataract. Many of the non-ocular complications of diabetes such as heart disease, stroke, end-stage renal disease and nervous system damage, also involve AGEs.

Risk factors for the development of diabetes include family history, obesity, inactivity, high blood pressure, and one recent study even suggested a woman's breast size at 20 years may help predict the likelihood of getting diabetes in middle age⁶!

Why do we age?

This article has tried to answer the question 'how we age', which is quite a different question to 'why we age'. Since evolution has solved the seemingly far greater problem of developing an organism in the first

place, it would seem a relatively small step to enable an animal to live and reproduce forever⁷. There are, however, two broad categories of explanation as to why no animal is immortal. Firstly, tissues might simply accumulate too much unavoidable damage that cannot be repaired during an animal's life. Thus, animals have reached the limit of what is biologically possible. An alternative way of looking at this is in terms of evolution. Evolution will only eliminate a trait if it affects the ability of an individual to raise offspring successfully. Thus, mutations occurring early in life will be selected against, whilst those occurring after an individual has successfully reproduced will be subject to much weaker selection pressure⁷. Ageing might therefore be regarded as the accumulation of deleterious mutations that occur after the age of successful reproduction and child rearing. Furthermore, some genes that may be beneficial early in life could have deleterious effects in old age (antagonistic pleiotropy)^{7,8}.

Although the age structure of prehistoric societies is still a matter of debate^{7,9}, it seems possible that a few individuals may have survived beyond 60 years. However, due to disease, predators and accidents, the majority of people in Palaeolithic times died long before this, possibly most not living much beyond 30-40 years of age. Modern humans only survive for significantly longer as recent advances in sanitation and medicine have to a large extent insulated them from evolutionary pressures. Currently, we therefore live far longer than our bodies are adapted to survive, explaining the widespread occurrence of disease in old age.

About the author

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References

See www.optometry.co.uk/references



Module questions

Course code: c-11702/0

Please note, there is only one correct answer. Enter online or by the form provided

An answer return form is included in this issue. It should be completed and returned to CET initiatives (C-11702/0) OT, Ten Alps plc, 9 Savoy Street, London WC2E 7HR by August 5 2009

- Which one of the following tissues are usually replaced during a person's lifetime?
 - CNS neurons
 - corneal endothelial cells
 - corneal epithelial cells
 - cardiac muscle
- Which one of the following does not occur during ageing?
 - lipofuscin accumulates in cardiac muscle
 - advanced glycation end products cause the cross-linking of collagenous fibres
 - collagen destroying enzymes in the eyelid are upregulated
 - the iris sphincter muscle hypertrophies
- The first event during atheromatous plaque formation is usually:
 - damage to the endothelium of the tunica intima
 - release of chemical signals from thrombocytes
 - deposition of cholesterol
 - proliferation of smooth muscle
- What is a thrombosis?
 - the blockage of a blood vessel by a circulating piece of debris
 - the death of tissue due to lack of oxygen
 - a formation of a blood clot in an unbroken vessel
 - a sac-like protrusion from a blood vessel wall
- Aneurysms:
 - are never involved in stroke
 - can be the site of a thrombosis
 - are a circulating piece of debris
 - are rare in the circle of Willis
- Despite complete blockage of the posterior cerebral artery, some vision may be maintained. Such 'macular sparing' is the result of a secondary blood supply from:
 - the vertebral artery
 - the cavernous sinus
 - the internal carotid
 - the middle cerebral artery
- Intracavernous carotid aneurysms:
 - compress the vagus nerve
 - compromise the optic nerve
 - can result in ptosis
 - never affect the lateral rectus
- A benign tumour of glandular tissue is usually known as:
 - an adenoma
 - a glioma
 - an osteoma
 - a lipoma
- Pituitary tumours usually affect:
 - ganglion cells coming from the nasal retina
 - ganglion cells coming from the superior temporal retina
 - ganglion cells coming from the macula region
 - fibres of the optic tract
- Insulin:
 - stimulates glycogenesis
 - raises levels of blood glucose
 - promotes breakdown of proteins
 - stimulates gluconeogenesis
- In Type 1 diabetes mellitus:
 - ADH levels are compromised
 - glucose in the urine results in water retention by the kidney through osmosis
 - pancreatic α cells are lost
 - diagnosis is usually made in people under 20 years of age
- Myocardial infarction:
 - has the most severe consequences if the left atrium is affected
 - is often the result of atheroma in a coronary artery
 - risk is independent of age
 - is always associated with malignant hypertension

Please complete online by midnight on August 5 2009 - You will be unable to submit exams after this date - answers to the module will be published on www.optometry.co.uk

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