FILE NO. 10

Research
and
Discovery on:

the Sanctuary
and
Human Physiology
(Functions)

METHOD NO. 10

THE SANCTUARY AND HUMAN PHYSIOLOGY (FUNCTIONS)

SUGGESTED METHOD:

- Read all the quotes carefully and appreciate the principle presented in the charts and commentaries: the human body was created to be an holy temple in the Lord, an habitation of God through the Spirit.
- View the animated study of Human Anatomy & Physiology: The Eleven Systems.

FILE NO. 10

FILE NO. 10
THE SANCTUARY AND HUMAN PHYSIOLOGY (FUNCTIONS)

IT IS WRITTEN:
"(Ye) are built upon the foundation of the apostles and prophets. Jesus Christ himself being the chief cornerstone; in whom all the building fitly framed together groweth unto an holy temple in the Lord. In whom ye also are builded together for an habitation of God through the Spirit." Ephesians 2:20-22.

THE BIBLE COMPANIONS:
"Another lesson the tabernacle, through its service of sacrifice, was to teach, was the lesson of pardon of sin, and power through the Savior for obedience unto life.

Through Christ was to be fulfilled the purpose of which the tabernacle was a symbol - that glorious building... In all, God desired His people to read His purpose for the human soul. It was the same purpose long afterward set forth by the apostle Paul, speaking by the Holy Spirit: "Know ye not that ye are the temple of God, and that the Spirit of God dwelleth in you? If any man defiles the temple of God, him shall God destroy; for the temple of God is holy, which temple ye are."
1 Corinthiens 3:16, 17...

Thus in labor and in giving they were taught to co-operate with God and with one another. And they were to co-operate also in the preparation of the spiritual building - God's temple in the soul." Education, p. 36, 37.

"The mind controls the whole man. All our actions, good or bad, have their source in the mind. It is the mind that worships God and allies us to heavenly beings. All the physical organs are the servants of the mind, and the nerves are the messengers that transmit its orders to every part of the body, guiding the motions of the living machinery...The harmonious action of all the parts - brain, bone, and muscle - is necessary to the full and healthful development of the entire human organism." Mind, character and personality, p. 396.

"But if there was a sin above another which called for the destruction of the race by the flood, it was the base crime of amalgamation of man and beast which defaced the image of God and caused confusion everywhere.... Every species of animal which God created was preserved in the ark. The confused species which God did not create, which were the result of amalgamation, were destroyed by the flood. Since the flood, there has been amalgamation of man and beast, as may be seen in the almost endless varieties of species of animals, and in certain races of men."
Spirit of Prophecy, page 69 and 78.

Photo of mouse growing a "human ear" - a shape made of cartilage

FILE 10 - Appendix of Studies

STUDY: Cloning and Amalgamation of Animals and Human Beings
(See File 10 p. 8-59)

STUDY: Animated study of Anatomy and Physiology of the Body
(See File 10 p. 60-94)

REFERENCES:

It is written, the Bible, Genesis 49

The Cross and its Shadow, N.S. Haskell

Principles of Anatomy and Physiology, Harper Collins Publ. - 1990
Human Anatomy and Physiology, 5th Ed, Wm.C. Brown Publ. - 1990

Appendix

ALLEGORY BETWEEN THE PHYSIOLOGY OF SANCTUARY, THE 12 TRIBES OF ISRAEL AND THE 11 SYSTEMS OF THE BODY

THE SANCTUARY & THE 12 TRIBES:	THE BIBLE VERSES:	THE 11 SYSTEMS OF THE BODY:
1. Reuben	Genesis 49:3, 4	Circulatory
2. Simeon	Genesis 49:5-7	Respiratory
3. Levi (Priesthood)*	Genesis 49:5-7	Breath of Life**
4. Judah (Progenitor of Messiah)**	Genesis 49:8-12	Nervous
5. Zebulun	Genesis 49:13	Lymphatic
6. Issachar	Genesis 49:14	Skelatal
7. Dan	Genesis 49:19	Muscular
8. Gad	Genesis 49:19	Urinary
9. Asher	Genesis 49: 20	Endocrine
10. Naphtali	Genesis 49: 21	Integumentary
11. Joseph***	Genesis 49: 22-26	Reproduction
12. Benjamin	Genesis 49: 22	Digestive

The 3 Tribes representing the Birthright:

Because Reuben did not control his passions and slept with his father Jacob's concubine, he lost his birthright – as his uncle Esau did because of appetite – the birthright inheritance went to:

*The Tribe of Levi which received the Priesthood and replaced the firstborn because of the idolatry at the Golden Calf (Exodus 32 – Numbers 4). However, they did not received a piece of land as an inheritance. Instead, they were given the cities of refuge. They were the Breath of Israel – just like the Breath of Life is not related to any body system because it

encompasses them all: without the Breath of Life from our Creator, the body would be a dead corpse.

**The Tribe of Judah which received to be the Progenitor of Messiah.

*** The Tribe of Joseph which received the Double Portion of the Early and the Latter Rain (Doctrines – Precious and Present Truth) of the Holy Spirit.

According to Galatians 4:4-7, in the fullness of time, Christ came on the earth, lived, died and was resurrected, and restored the birthright of the Firstborn so we can be sons and daughters of God and heirs with Him. Glory to His Most Holy Name.

FILE NO. 10

CLONING: WONDER OR ABOMINATION

INTRODUCTION

This research on the cell and cloning combines excerpts and adaptation of the book "The Genetic Revolution" written by Patrick Dixon, MD., and the whole concept of the Brain Nerves as presented by Numbers 1317.

PURPOSE

To prove without a shadow of a doubt that the Creator of man and every living things, is the perfect **Genetic Engineer**. Any attempt to imitate or clone His magnificent work is a base crime of the worst kind.

WARNING

Could it be that the history of this century's holocausts is repeated under our very eyes but under more sophisticated appellations: GENETIC ENGINEERING, CLONING, FETAL TRANSPLANTS, SCIENTIFIC RESEARCH, FOOD ENGINEERING.

We would do well to remember Hitler "pure blond race" and dwell on these dramatic words written under inspiration:

"But if there was a sin above another which called for the destruction of the race by the flood, it was the base crime of amalgamation of man and beast which defaced the image of God and caused confusion everywhere.... Every species of animal which God created was preserved in the ark. The confused species which God did not create, which were the result of amalgamation, were destroyed by the flood. Since the flood, there has been amalgamation of man and beast, as may be seen in the almost endless varieties of species of animals, and in certain races of men." Spirit of Prophecy, Volume 1 page 69 and 78.

"The brain nerves that connect with the whole system are the only medium through which heaven communicates with man and affects his inmost life." Education p. 209.

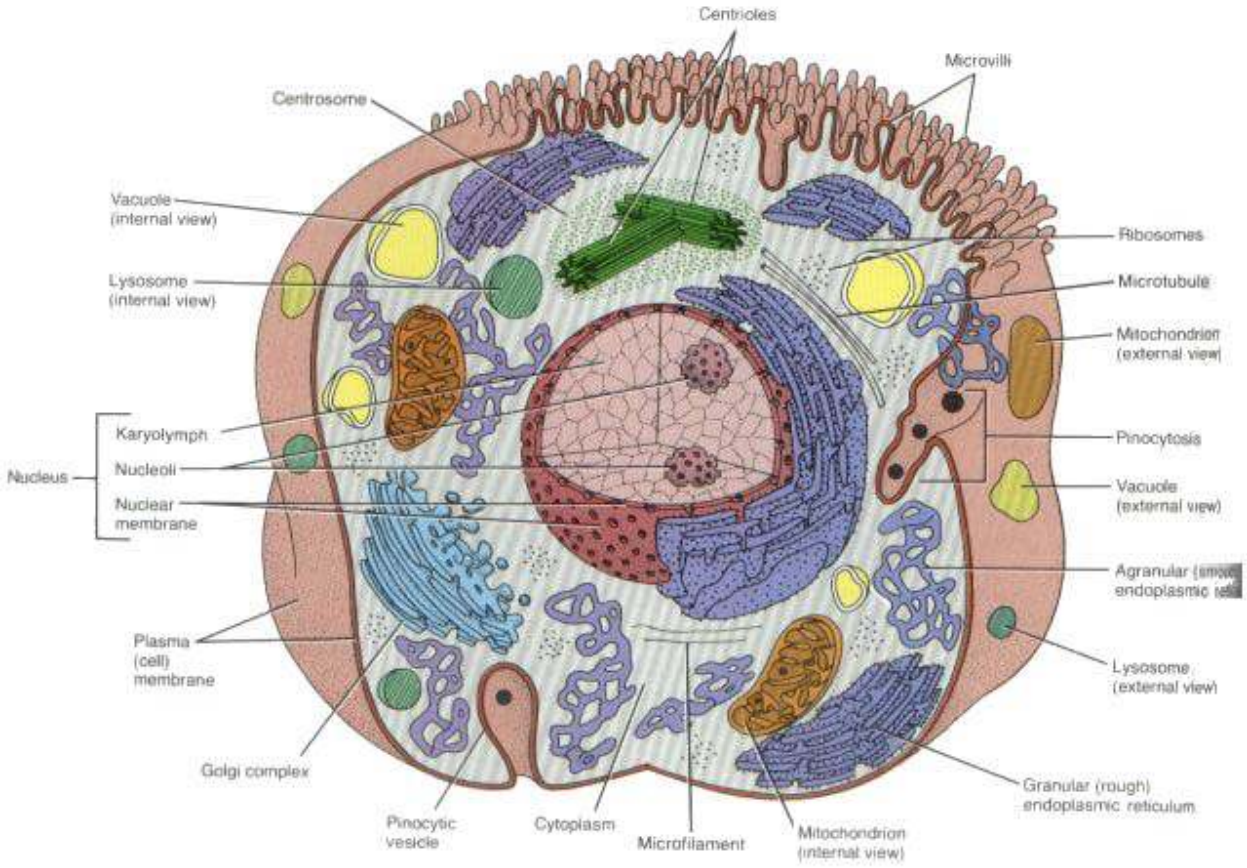
IN THE BEGINNING

LAST "FIXED" GENETIC CODE

From the most ancient times, generations have come and gone: individuals have formed relationships, married, conceived and brought up children

quite literally in the image of themselves. Out of this experience of oneness (however transient) has come with conception a unique historical event: a fusion of their two lives and individuality to form a brand new mix of them both as a new child is born. Yet for the generation born this year, or next, it could be the end of the line.

The generation being born now may well be the last to have a "fixed" genetic code, inherited universally in a conventional way. As we will begin to see, there may be few alive in 30 years time who have not had the genetic code of at least some of their cells reprogrammed away from what they naturally inherited. For some, they will acquire genetic changes which will outlast their own lives because they will be passed on to their children, their grandchildren and their great grandchildren. Subsequent generations will have to judge whether this is a blessing or a biological curse.



PART 1
THE BOOK OF LIFE

The quite extraordinary thing about the code of life is that it is so constant: the smallest most primitive living organism to the largest has a book of life written in exactly the same language and structured in an identical way. For

evolutionists this comes as no surprise, neither does it to those who believe the Genesis account as truth and that when God spoke the language of creation he spoke in the language of life, or genetic code.

This mystery of life itself is about to be broken, in the test tube of the laboratory and in the brain of the desktop microcomputer. It is happening right now in front of our eyes yet few have seen it happening or understood the consequences. What about the consequences, and how we respond to them?

For centuries, people have dreamed of being able to alter themselves, or each other or of being able to produce "clones". More recently parents have thought not only of choosing the sex of their children but also of being able to influence the development of their children to produce high intelligence, attractive personality, healthy constitution, athletic body, musical ability and maybe even an obedient nature!

Farmers have dreamed of low fat cows, non-bruised tomatoes, cold-resistant bananas, corn which comes up year after year without seeding and other strange creations.

Parents of children with inherited diseases such as cystic fibrosis, where the lung problems are a result of faulty genetic code have dreamed of a day when doctors might be able to program the faulty gene back.

Those with AIDS have dreamed of a cure for HIV infection, reversing the damage done to cells by the virus called HIV, which programs white cells to produce more viruses instead of fighting infection.

To say that all these things are already possible would be a gross exaggeration. However, as we will see, the machinery and knowledge is already here and the experience will be before long. But before we look at what is happening now we need to see the "genetic revolution" in an historical context.

PART 2
THE THIRST FOR KNOWLEDGE

Man's greatest discoveries have often happened by accident or curiosity. Great social change has often followed useful ones. It was by accident that ancient man found metal in the fire after heating earth, and glass after heating sand. The first steam engines in 1698 led to a massive demand for coal and the rapid industrialization of England. Life would never be the same again.

Then came the discovery of electricity in 1820 and the means of storing it in a battery in 1836, together with the means of generating it using magnets and massive coils of wire turning at high speed by 1850, with industrial power generation by 1880.

The petrol engine invented in 1885 also had a massive impact which continues today. Radio transmission started in 1901 as yet another curious experiment before leading to television broadcasts in 1936 and today's satellite technology.

Often the work of the inventor is hijacked by urgent need; the second world war accelerated work on penicillin, aircraft engines and rockets, radar and of course, nuclear energy.

The continued arms race in the cold war of the 50's and 60's together with the American space program goal to walk on the moon led to a massive search for ways to reduce weight of electronic equipment. Bulky glass valves using technology dating from earlier this century used a lot of heat, took time to warm up, were unreliable, and heavy. A rocket full of glass was unlikely to go far.

THE SILICON CHIP

Laboratory discoveries of silicon's remarkable ability to allow electricity to flow well at times and badly at others, produced a replacement for valves. The age of the transistor dawned. By the 1960s transistor radios were proudly displayed in every High Street. Their main distinguishing feature printed boldly on the box was the number of transistors they contained.

Thirty years ago, scientists found ways to produce larger sheets of silicon onto which could be built not two or three but millions of transistors, each vastly smaller than a pinhead. A computer occupying a room 200 feet by

100 feet and with its own generator could now be compressed into a metal box the size of a briefcase, running on batteries.

In 1980, people were predicting that by 1990 every person in the West would own things containing these "silicon chips": in cars, washing machines, radios, electric mixers or calculators to name but a few. In 1980, this looked a little far-fetched. By 1988, it was already a reality. By the mid 1980s, most shops had converted to electronic cash registers, most banks were using electronic cash dispensers and it had become impossible to buy a transistor television, except in a junk shop.

Most of these discoveries were made by inventive, curious people interested in solving puzzles and finding out more about the world we live in. Most of these people were already searching for a particular answer to a particular problem. Few realized at the time how big an impact their own discoveries would have. As we will see, the same has been true of genetic engineering.

FASTER AND FASTER

Every ten years, our total scientific knowledge is doubling: we knew twice as much about the world in 1950 than in 1940, four times as much by 1960, 8 times as much by 1970, 16 times as much by 1980 and by 1990, we knew over 30 times as much scientifically as 50 years previously. By now, count on 60 to 100 times as much as we did then.

The pace of discovery is increasing so fast that human brains cannot understand it all. We are already beginning to see major problems with equipment we make such as computers because there is not one brain in the world capable of understanding the whole machine. When unexpected things happen, it can be extremely difficult to understand why, and how to solve the problem.

Even if no new progress is made in computer design, it will probably take programmers at least another 10 years from now to get to grips with what these early 1990's machines are really capable of. At the top end, scientists are making huge advances every month in making faster, more powerful electronic brains while at the bottom end, we are struggling to keep the electronic brains we now have busy for more than one per cent of their working lives.

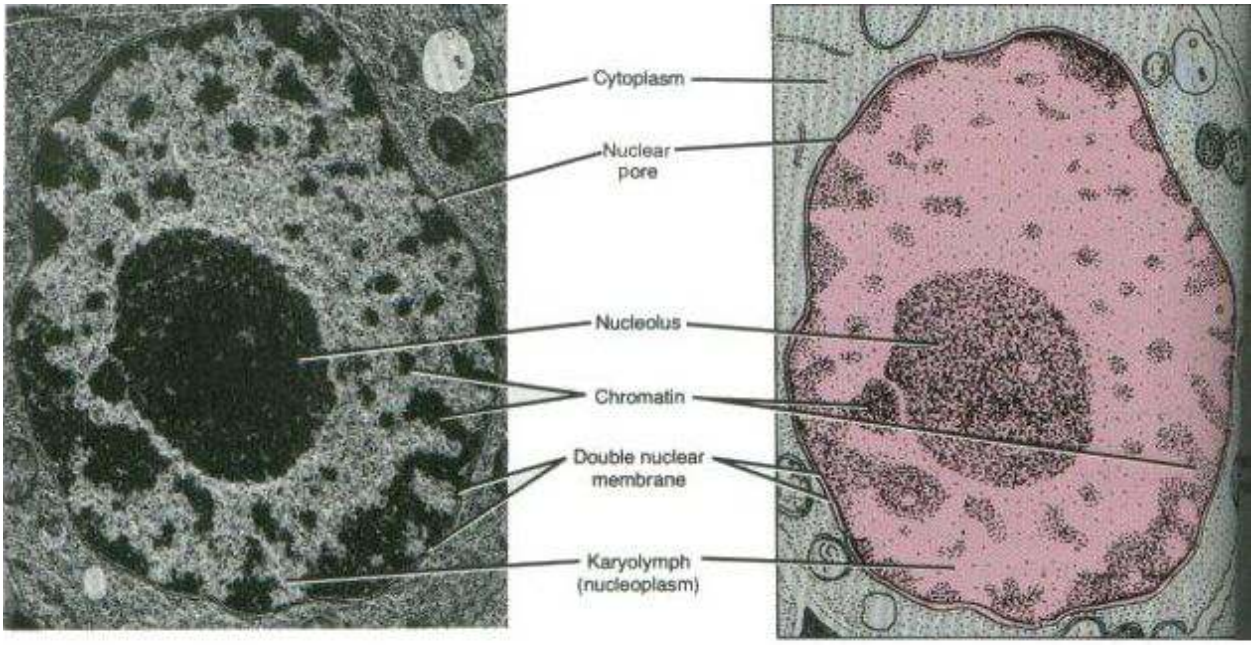
Such is the pace of change in computers that the model bought today is guaranteed to be prehistoric within 6 years. Because it can take up to a hundred man or woman years of labor to produce a good program say for accounting all new machines have to be able to run old programs. Bigger and bigger brains are running systems designed originally for tiny, slow electronic brains over 10 years ago and are working less and less efficiently.

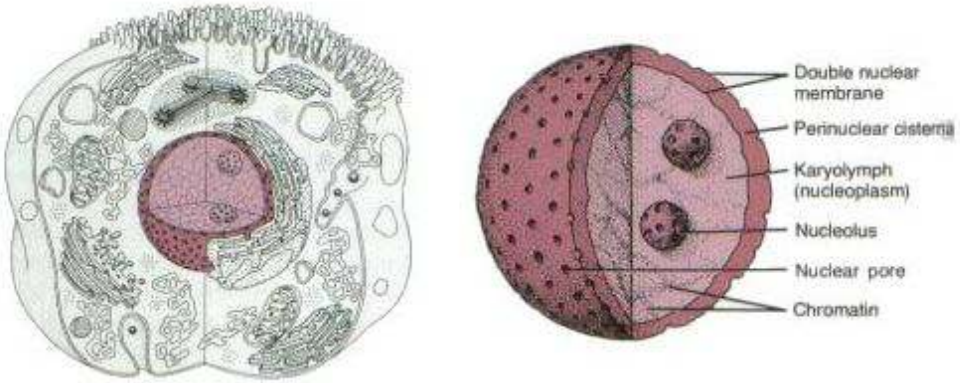
These points are emphasized because unless we understand what is happening in electronic programming now, we will not fully understand the impact of genetic programming in the future, where, once again, the tools and equipment available is developing enormously faster than our thinking about how to use them. However there is one big difference: computers may make people redundant in many jobs but they do not alter life itself. Genetic engineering on the other hand by definition alters the very substance on which life is based.

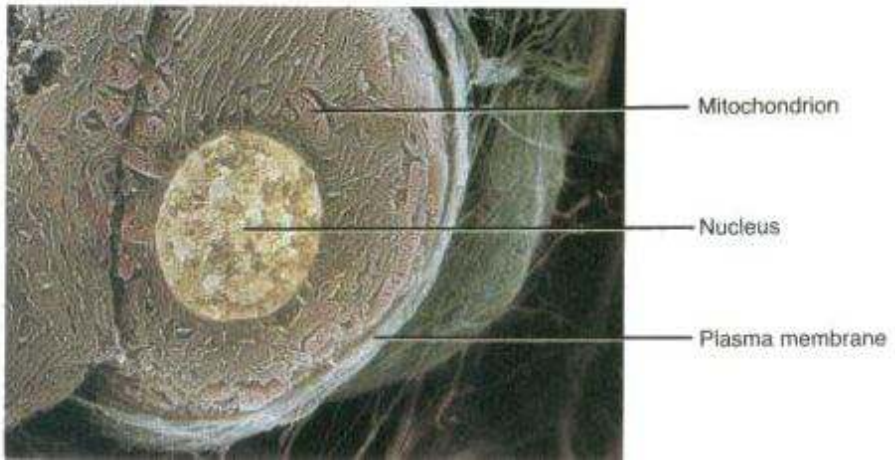
THE NEW INDUSTRIAL REVOLUTION

So, into this new computerized age, we now add the age of the gene, with greater potential to help than the microchip, and possibly (if the technology is used unwisely for peaceful or military purposes) the power to harm of a dozen nuclear reactors or atomic bombs.

The Bio-revolution is being developed under exactly the same pressures as the computer revolution or any other of the major discoveries this century: it is driven by curiosity, together with commercial interest built on urgent human need. So what are the human needs? It is also built on the discoveries of the past, in particular the progress in computer technology.


Cytoplasm
Nuclear pore
Nucleolus
Chromatin
Double nuclear membrane
Karyolymph (nucleoplasm)


Double nuclear membrane
Perinuclear cisterna
Karyolymph (nucleoplasm)
Nucleolus
Nuclear pore
Chromatin


Mitochondrion
Nucleus
Plasma membrane

PART 3
PLEASURE TODAY; NIGHTMARE TOMORROW

In this new millennium, we are faced with a series of nightmares that are so hellish that most of us manage to avoid thinking about them. Global warming is one among others such as:

1. Energy Shortage:

One-third affluent world will largely have burnt out all the main sources of oil and gas in this generation. Coal will remain but will be scarce and expensive. How are we going to keep warm or powered up in tomorrow's world?

The world population is growing faster than ever and that many two-thirds world cities are mushrooming chaotically in size and problems. The great majority of the world's growing population live in towns or cities. A new wave of industrialization must follow to improve standards of living and provide jobs for the millions.

2. Materials shortage:

Industry uses power, iron ore, aluminum, plastics from oil, stone, wood, gold, silver, diamonds. The resources will run out faster. Scarcer resources carried further at greater cost will create further hyper-inflation in many countries, and possibly bankruptcy for some of the most vulnerable..

3. Oxygen Shortage:

Then there is the problem of food - or rather also the problem of oxygen. Global warming happens when the carbon dioxide we breathe out, also released by burning fuels, rises in the atmosphere, trapping the heat of the sun. Carbon dioxide rises as oxygen falls.

Plants and trees breathe in carbon dioxide and when in sunlight they use it to build fiber or wood, releasing precious oxygen back into the atmosphere. Trees are cut down for fuel in some countries like Africa for example. Without fuel, you cannot boil water or cook meals. Trees are also cut down for building materials. In South America, trees are cut down to grow food. We need to realize that most of the UK was cleared of ancient woodlands in a short time: for burning, for building houses or ships or furniture and to make suitable land for sowing crops.

If the pressure on land is too great to permit vast forests as giant "lungs" breathing out oxygen, then how will tomorrow's world be supplied with oxygen? We used to think plankton in the oceans produced much of the world's oxygen. We now know not much is produced this way. If it were, the ocean-beds would be covered with a layer some meters thick of black carbon deposits from remains of dead plant matter. Ocean-beds are relatively clear except near the coast from rivers.

4. Massive Epidemics:
There is another historic fact which tends to follow a higher density of people - especially where population or cities have grown fast: epidemics of disease or plagues.

By the mid 1980s, there was hardly a country in the world not admitting it had been hit by new worldwide plague, spreading faster than scientists had the techniques to monitor it. Known as the silent killer, it had the capacity to destroy countries for some 10 to 20 years before the devastating effects were fully seen: the disease AIDS which is a result of infection by a virus called HIV for up to 20 years prior to obvious disease and subsequent death.

This virus has already infected 10 million worldwide. The death toll from AIDS has already exceeded double that from the Vietnam War, with a total of almost a million infected and likely to need care in the future. In Africa, a silent holocaust has already taken place among the young, with a million deaths already of which a great number have been children or babies infected through the womb. In some areas one adult in three is already infected. At least one country is giving reliable test survey figures showing infection levels as high as one adult in eight throughout the entire population, including the most inaccessible rural areas.

AIDS is a late twentieth century problem: it is mainly a heterosexually spread disease worldwide (over 70% of total world infections currently, expected to rise soon to 80% of total). The rapid spread of HIV is part of a massive global epidemic of a number of other sexually transmitted diseases, related to an increase in the number of sexual partners per average adult in the course of a lifetime. This has been accompanied also by a huge increase in mobility as the petrol engine and low-cost of jet

transport have enabled millions to move from town to town or from continent to continent each year.

Syphilis was also known as a plague in previous centuries: until the 1940s, there was no cure; it killed after 10 to 20 years, it was spread sexually and children were infected at birth.

These are just a few of the problems we will be confronted with. Progress measured by the microchip, the petrol engine, the discovery of antibiotics, burning earth to make steel, burning coal to make power - none of these society changing discoveries bring any answers. In fact, these discoveries have simply added to the growing problems of increasing consumption of resources, and increasing population as general health rises and child mortality falls.

Please do not misunderstand: we should not for a moment say that we should wind back the clock. We should not express regret for any of these previous discoveries; on the contrary, we experience their benefits every day.

But we are seeing an unprecedented series of local and global problems which will ultimately affect life on this planet as we know it. The result is a new massive surge of resources, time, money and organization into the new revolution that, it is believed, could hold the keys to some solutions, and maybe also open the doors to new unimaginable disasters.

So what can the genetic engineer possibly hope to contribute towards such a world as we face tomorrow? It is believed that re-designed organisms could offer us new ways to convert scarce sources of energy including coal and industrial wastes to substances we can use to make recyclable plastics. New organisms could provide new food sources, while new ultra efficient plants and trees could be part of the world lungs of the future. Finally altered microbes could offer complete cures for diseases such as AIDS and malaria.

PART 4
THE RULE OF LIFE

From the most ancient times a rule of life has been seen to be true: insects breed insects, birds breed birds, cows breed cows and humans breed humans. If you take acorns from an oak tree and plant them the result is

more oak trees. Creatures and plants remain true to type, faithfully passing on their characteristics from generation to generation. Where there are slight variations, for example in skin pigmentation or in the coloring of flowers, then these too can usually be traced down the generations. The basis of life has been remarkably stable considering its complexity.

The basis of this inheritance was not understood however. An understanding of how organisms are built out of cells only emerged with the invention of the first light microscope by Robert Boyle in the eighteenth century. It was many decades later before we began to understand how the cell works. Most of the structures in a cell could only be seen with the high power of the electron microscope. However, for many centuries experiments were already taking place with cross-breeding, the earliest technique of genetic engineering.

AN AUSTRIAN MONK

In order to understand the mechanism of inheritance, we need to start in an Austrian monastery around 1760, in the potting sheds of a gardener called George Mendel. This monk was curious to know what would happen if he took pollen from one type of plant and used it to fertilize another. Would the pollen be accepted? Would it succeed in fertilizing the plant? If it did, would seed result which would germinate? Finally, when it germinated, what kind of plant would grow?

For thousands of years previously such attempts had been made with animals. For instance, in the time of Jesus, it was common to allow a horse to mate with a donkey: the result was a cross-fertilized egg which went on to develop into a rather strange-looking creature at birth. The creature had some of the best characteristics of both parents and was known as a mule. This new species had one important drawback: you could not breed from it because it was always sterile.

Hundreds of others examples could be given over previous centuries of selective breeding - indeed Jacob in the Old Testament seemed to know what he was doing in selectively breeding white and black sheep to produce a herd entirely colored as he wanted, at a time when sheep ownership was being determined solely by coloring of their woolen coats.

The process of inheritance has been well understood by families who observe - say -grandpa's orange hair through to a grandchild or other

family likeness. However, the mechanism has only relatively recently been fully understood. Why was it that dark hair parents could occasionally produce a fair-haired child?

CROSS-FERTILIZATION

Mendel was interested in all this. Moreover the monastery stood to gain from improved strains of cereal plants. Mendel found that when he cross-fertilized closely related plants with obvious differences, he got neither a mix nor equal numbers of a each type. Instead he found a curious pattern. After a while he found he could predict in advance not only what variations he would see, but also how many of them. He realized that in each seed there was a lot more information stored than would ever be used to form the new plant.

Some of this information it seemed was hidden away in many plants and only expressed when cross-fertilization took place. It seemed like each plant had its own strong and weak features. Weak features only came to the surface under certain circumstances. These strong features have become known as "dominant" while those which tend to be hidden away are called "recessive".

This same information and understanding is used daily in dozens of genetic engineering laboratories all over the world. When he cross-fertilized tall and short varieties of the same plants he found he always landed up with seeds that produced plants in a fixed ratio of three tall to one short. From this he proposed a theory which was to revolutionize our thinking about breeding.

He came to the conclusion that each plant must have two sets of instructions for each part of its structure. Therefore each plant had two set of instructions for height. However if the plant had a mixture, then the tall one was always dominant.

You can see how this works in figures below. When sperms or eggs are made - or their equivalent in plants - the original cells divide into two, with only half the full set of instructions needed for life in each half. So parents with a mixture of tall and short instructions in their cells will produce sperm or eggs with either one or the other.

Fertilization happens when pollen and ova meet, (or sperm and eggs in animals). When this happens, the new composite cell has a complete set of

instructions and is able to start forming a new plant. Clearly four types of plants could result: one type where both pollen and ova have provided tall instructions, another where both are short, and two where there is a mix. Three of these out of four will be tall. The only plant type that will turn out short will be the one where both sets of instructions are short, because both parent plants passed on the recessive gene.

FIGURE 1

Mother	Father	(T: TALL; S: SHORT)
T S	T S	
Both these plants have a tall gene in the pair so both are tall.		

FIGURE 2

1	Mother	Father
	T	T
	A tall plant	
2	Mother	Father
	T	S
	A tall plant	
3	Mother	Father
	S	T
	A tall plant	
4	Mother	Father
	S	S
	A short plant	

So in his classic experiment: two tall plants cross-fertilized produced short plants one time in four. Interestingly, if short plants are only fertilized by other short plants then you can see that no more tall plants will ever be produced. A new strain will have been created.

Simple methods like this have been widely used by gardeners and horticulturists for over a hundred years: selective breeding from plants showing the characteristics you want to encourage. The development of pedigree dogs is an ancient art which has worked on the same principle: only allowing dogs to mate that have the right characteristics.

Incidentally you can see straight away a major problem: if you go on inter-breeding from just one small group, then more and more recessive genes may emerge. Some may have hidden dangers for the animal. Take dogs again as an example: in the wild they breed widely producing a group of fairly even appearance. If bad traits emerge, they tend to be eliminated because these dogs do not survive long enough to breed or because the recessive traits are covered up by dominant genes from others in the group. However in domestic breeding, the dominant genes are being deliberately trimmed out. The result is a beautiful breed but one which may be susceptible to a high rate of blindness, tumors or hip problems for example. There are many inherited disorders in humans that can arise in a similar way.

HEMOPHILIA AND HUMAN INHERITANCE

Take hemophilia for example: hemophilia is a disease where blood does not clot properly so people can in severe cases bleed to death. In the last century hemophilia was known as the Royal Disease because it was so common in the Royal Family. The reason for this was of selective breeding. The gene causing the problem is recessive and emerged when members of the European Royal Families continually inter-married.

The result was a "pedigree" with the same kind of problems as in over-bred animals. There is then a biological basis for the Biblical injunction against close relatives marrying. Cross-fertilization is needed to keep us all healthy.

In those with hemophilia the substance which is missing is called Factor 8 - a substance which is found in normal blood and which is one component of the clotting mechanism. Factor 8 can be extracted from blood donated for blood transfusion, although the process is complicated and expensive. If someone with hemophilia is bleeding uncontrollably from a cut an injection of Factor 8 stops it very well.

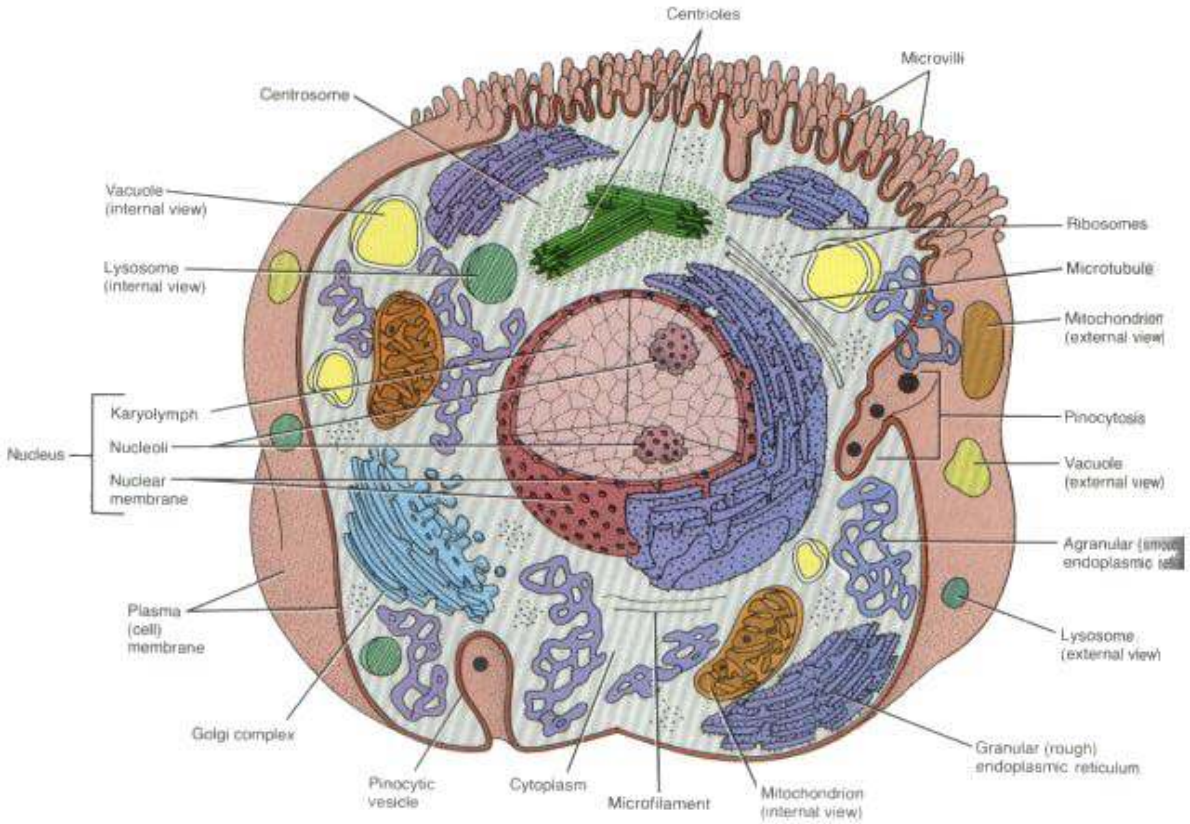
PART 5
GENES AND CHROMOSOMES

All the genes or sets of instructions in a human are contained in just 46 chromosomes, each of which exists as one of 23 pairs. Chromosomes can be seen under the microscope and most look quite similar. However, there is an obvious difference between men and women: women have a pair of chromosomes shaped like two Xs while men have one X chromosome and another shaped like a Y. The Y is dominant so a single Y produces a boy and suppresses a single X. The hemophilia defect is on the X chromosome so women never get the disease although they can be carriers, with their second normal X chromosome dominating over the abnormal one.

GENES AND CELLS FACTORIES

So now we understand what genes are and how they are inherited we can begin to see where scientists can start to make changes and how scientists can make artificial chromosomes (strings of genes). There is one further thing we need to understand. While every human cell (except red blood cells and sperm or eggs) contains a full set of chromosomes with all the genes for the whole person, each cell only uses a minute fraction of the information.

One of the greatest puzzles in medicine is how a kidney cell knows it is a kidney cell and not a piece of skin for example. The chromosomes are the same. The genes are the same. The full genetic code is the same. We need first to understand how a cell works: each cell in the body has a similar structure. Incidentally you will find an almost identical structure in the cells of every living creature. Cells are tiny. Around a million will just about cover a square measuring one centimeter by one centimeter. Each of these cells is basically a chemical factory with three parts: a brain (nucleus), cell fluid (cytoplasm) and a cell wall to keep it all together.



1. Cell Wall

All cells are like tiny balloons or bags. The bag itself is made of a special membrane which functions like the wall of a fortified city: it keeps things in and others out. There are gates in the wall which open or close at various times to take in food or dispose of manufactured goods.

There are also pumps in the wall which push substances in or out. These pumps are like air conditioning units in an office building. They keep the internal environment constant, whatever is happening outside. The water inside may need to be kept saltier for example, or there may even be a need for an electrical charge to be stored inside the cell like a tiny battery. This means that when the cell wall gates are suddenly opened, a current can flow: this is how nerve cells conduct electrical impulses.

If cell walls are exposed to various chemicals, they become leaky, not only allowing unusual substances out but also allowing all kinds of things to drift inside the cell from the surrounding fluid. This is very important for the genetic engineer. A favorite trick is to place cells in a liquid containing fragments of genetic code and make the cells leaky so they can move inside.

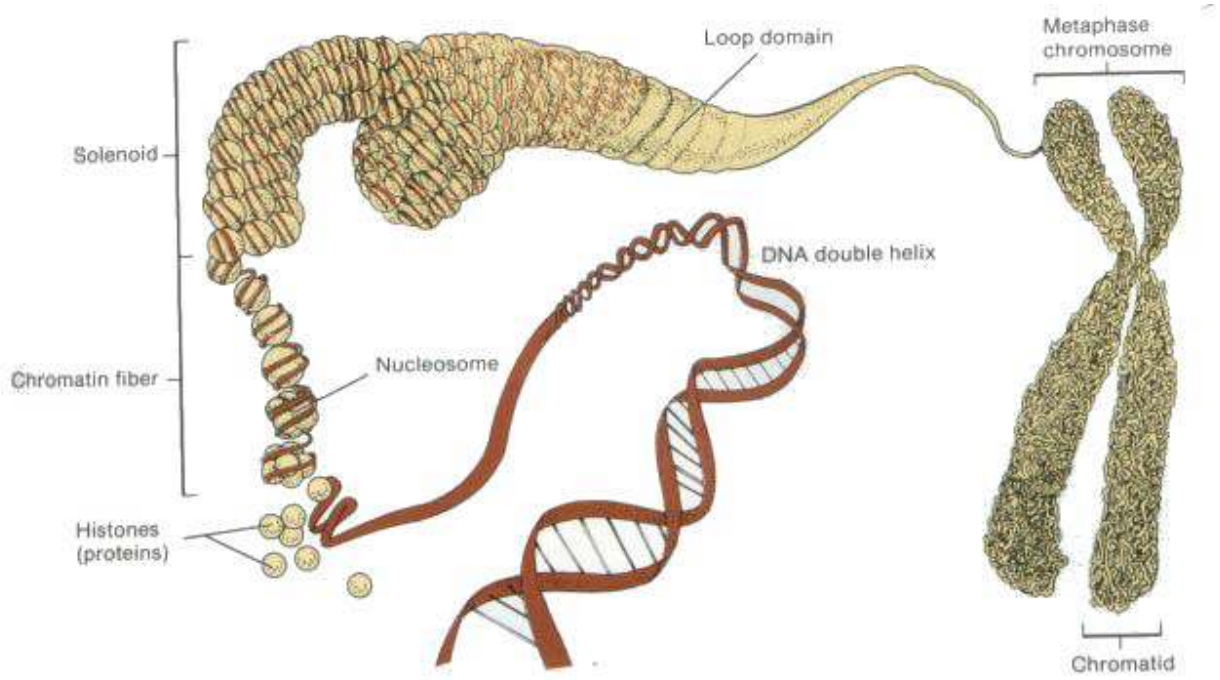
2. Nucleus
Inside the cell there is a bag within a bag. This second bag is much smaller but has a similar function. This bag keeps all the chromosomes together inside the cell. Every instruction the cell needs is in the nucleus. The nucleus is the equivalent of the cell brain, or the controller of a factory.

3. Cytoplasm
Outside the nucleus, the rest of the cell is far from empty: the space is stuffed full of a maze of tubing, called endoplasmic reticulum, as well as factory assembly units called ribosomes and power supply units called mitochondria.

Since chromosomes and their genes never leave the cell nucleus, how do the ribosome units know what to make and when? There is a special communication system which takes messages from the inside of the nucleus to the ribosome's assembly lines. It works on the same principle as a fax machine or a photocopier and courier service. These very same principles are used by genetic engineers all the time to copy instructions. But first we need to understand a little more about how a chromosome stores it's vital information.

HOW CHROMOSOMES STORE INFORMATION
If you take a chromosome apart into its tens of thousands of genes and take each gene apart one by one, you will find each one is made up of a long string of building blocks or molecules. There are around 300,000,000 building blocks used in every human cell. These special strings of them are called nucleic acids, because they are chemically slightly acidic and they are used in the nucleus of a cell. The nucleic acids themselves are called DNA (or deoxyribonucleic acid). DNA is built up of only four different building blocks known as bases.

These form a four letter "alphabet" formed from the different shapes of the four structures: Adenine, Thymine, Guanine and Cytosine, or A,T,G and C for short. Assembled DNA consists of two strands that look a little like the model railway track in our home. Each rail is a long string of the four bases in a special language sequence - ATGCCTA for example. These chemicals operate in reverse pairs so that if - say - A is one side of the track, T is always on the other; G always pairs with C and the other way round is also true. The pairs are joined together like the sleepers of a railway track.



BUILDING BLOCKS OR BASES FORMING NUCLEIC ACID (DNA)

There is one other curiosity: when the double track is formed, it has a natural coil to it so it circles round and round like a spring. This spring shape is called a double helix. This coiled structure was first discovered by James Watts and Francis Crick who won a Nobel Prize for it in the 1950s.The 3,000,000,000 pairs of basis are held in groups of 100,000 genes or packets of instructions.

THE LANGUAGE OF LIFE

When a gene is dismantled, you can write out the order of bases as a code or language - even with punctuation marks. Typing out the full language from all your own genes would fill more than a whole book of 100 of pages. In fact, the lists of instructions are extremely long and detailed - probably enough to fill the entire Encyclopedia Britannica. There is a lot of information which is repeated twice and many pages which are "spare" filled with a jumble of words and phrases not being used currently at all.

Each cell in your body contains the full encyclopedia but only uses a few pages. All the other genes are "turned off" or deactivated. To put it another way, the other volumes of the encyclopedia are in the bookshelf unopened.

One feature of cancer cells is that the wrong volume of the encyclopedia is open and the wrong genes are active, sending "correct" but inappropriate instructions to cells to grow and usually to become less specialized.

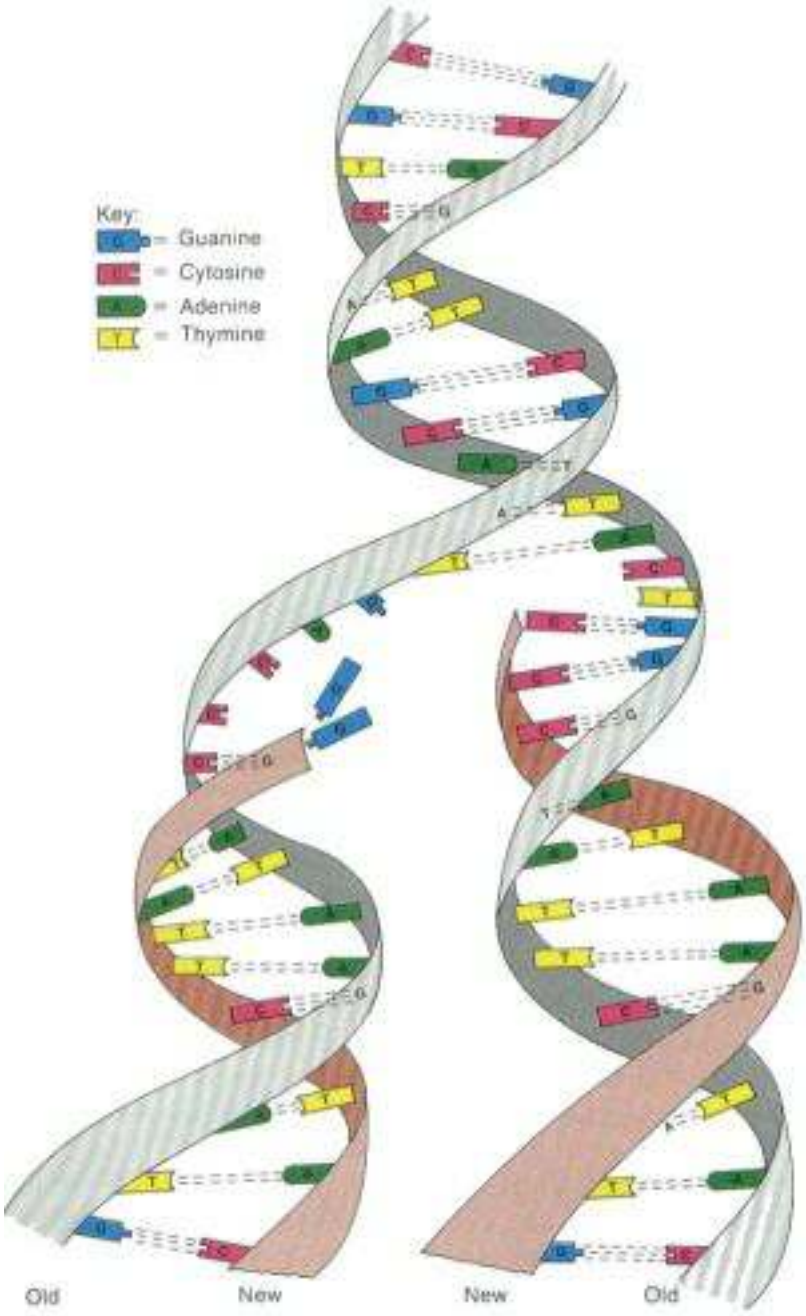
MESSENGERS OF LIFE

So how exactly are these instructions sent? The cell uses a second form of genetic code called RNA (or ribonucleic acid) to make a precise copy of just one strip of code. The RNA is written also in a four letter code, the only difference being that it uses Uracil or U instead of Thymine or T. Once this messenger RNA has been printed off the DNA using it as a template, it passes through the wall of the nucleus and is carried through the cytoplasm until it finds a ribosome factory. And then the real action begins.

Every structure in the human body is built out of twenty different building blocks called amino acids. Each is the equivalent of as differently shaped piece of lego. The body finds it very difficult to make them which is why we need protein in our diet from meat or plant sources. In the small intestine (mostly in the duodenum and jejunum), proteins are broken down and the amino acids are then absorbed.

There is almost no limit to the shapes that can be built with these amino acids, with a parallel being how many different models can be built with twenty thousand lego bricks of twenty different shapes. The only difference with proteins is that as with DNA they are assembled piece by piece in a long string. However once the string becomes longer, or is completed, the string starts to bend and kink, with curves and straight sections appearing in different places according to which different building blocks are where.

As the folding up continues, building blocks which were in the center of the long string can suddenly find that they are almost touching building blocks near the beginning or the end. Some building blocks tend to pull towards each other as if magnetized, and these "magnets" tend to "glue" the structure together and give it stability. A drawing would look just like a coiled piece of string. This is very misleading because the reality is more that of a string of sausage tangled up and pressed down into a soft round ball.



HOW 20 AMINO ACIDS IN A STRING FORM STRUCTURES

The coiling is seen only in two dimensions. In real life the coiling also happens towards and away from you in three dimensions. Many such shapes can be seen in Science Museum where they display some of the original models built by scientists to try and work out the structure of proteins.

The ribosome reads the four letter language of the messenger RNA in three letter words. Each of the three letter words is the cells own name for one of the twenty amino acids. The ribosome starts at the beginning of the RNA sequence and reads it triplet by triplet, and as it does so, the factory increases the length of the amino acid chain block by block.

As the chain begins to emerge, it starts to fold up into its correct shape.

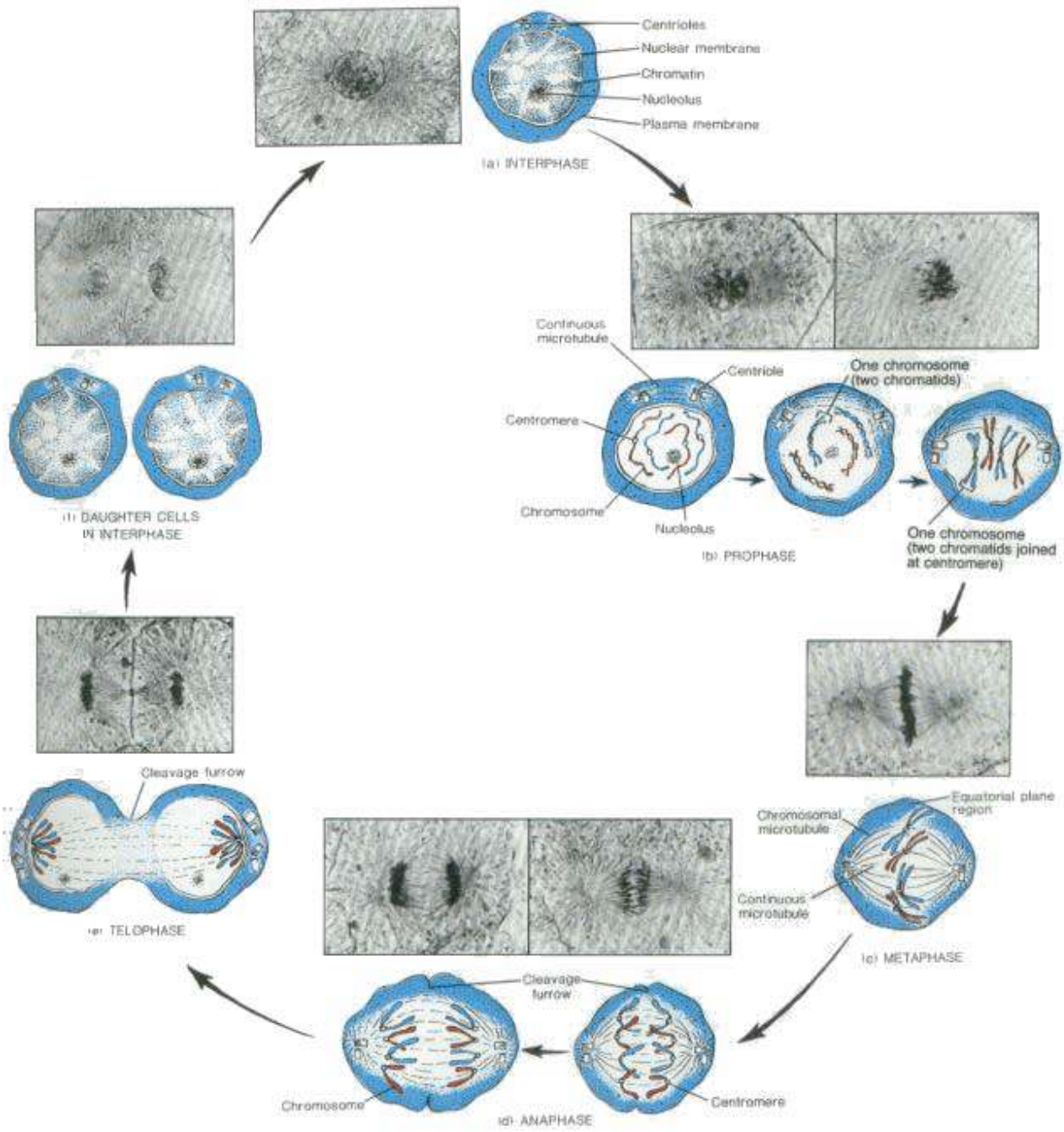
Here the triplet being read is UUU which you see from the cell dictionary, is the code for an amino acid known by human chemists as phenylalanine. The assembly process is entirely automated. There are 61 different transporters or "fork-lift trucks", each of which exactly fits only one of the 61 combinations of three bases used in the cell dictionary. You see that like human language, the cell sometimes has several words that mean the same thing. These are used interchangeably. As soon as the forklift truck latches onto the RNA, an enzyme automatically joins the amino acid to the growing chain and disconnects it from the truck. The process moves along the RNA to the next RNA and repeats until it meets the UAA, UAG or UGA words which are cell language for "stop".

PROTEINS, FATS AND SUGARS

Some very complicated structures are formed from several different protein chains: Insulin for example is formed from two, and antibodies which are immensely important to the genetic engineer in medicine are formed from four.

Structures formed from sugars and fats cannot be programmed directly by the nucleus as ribosome can only handle amino acids. To make these other things the nucleus tells the ribosome to produce particular proteins which are themselves part of a new production line. These special proteins are called "enzymes" and they repeatedly carry out simple joining up or splitting of identical units in identical ways.

Having looked around inside a living cell and caught a glimpse of the huge range of activities going on, we can begin to understand why it is so attractive an idea to be able to control a cell for ourselves, and take over these amazing ribosome assembly lines for our own purposes. We can also begin to understand how we could do it. After all, all we have to do is get the right message to a ribosome by fixing the nucleus exactly how we want it to work.



DIVIDING CELLS - DUPLICATING GENES

There is one other thing we must understand before we can go any further in moving from a single cell under our control to a massive chemical production factory using billions of these cells: how do cells divide, and how do they keep their genetic code the same each time?

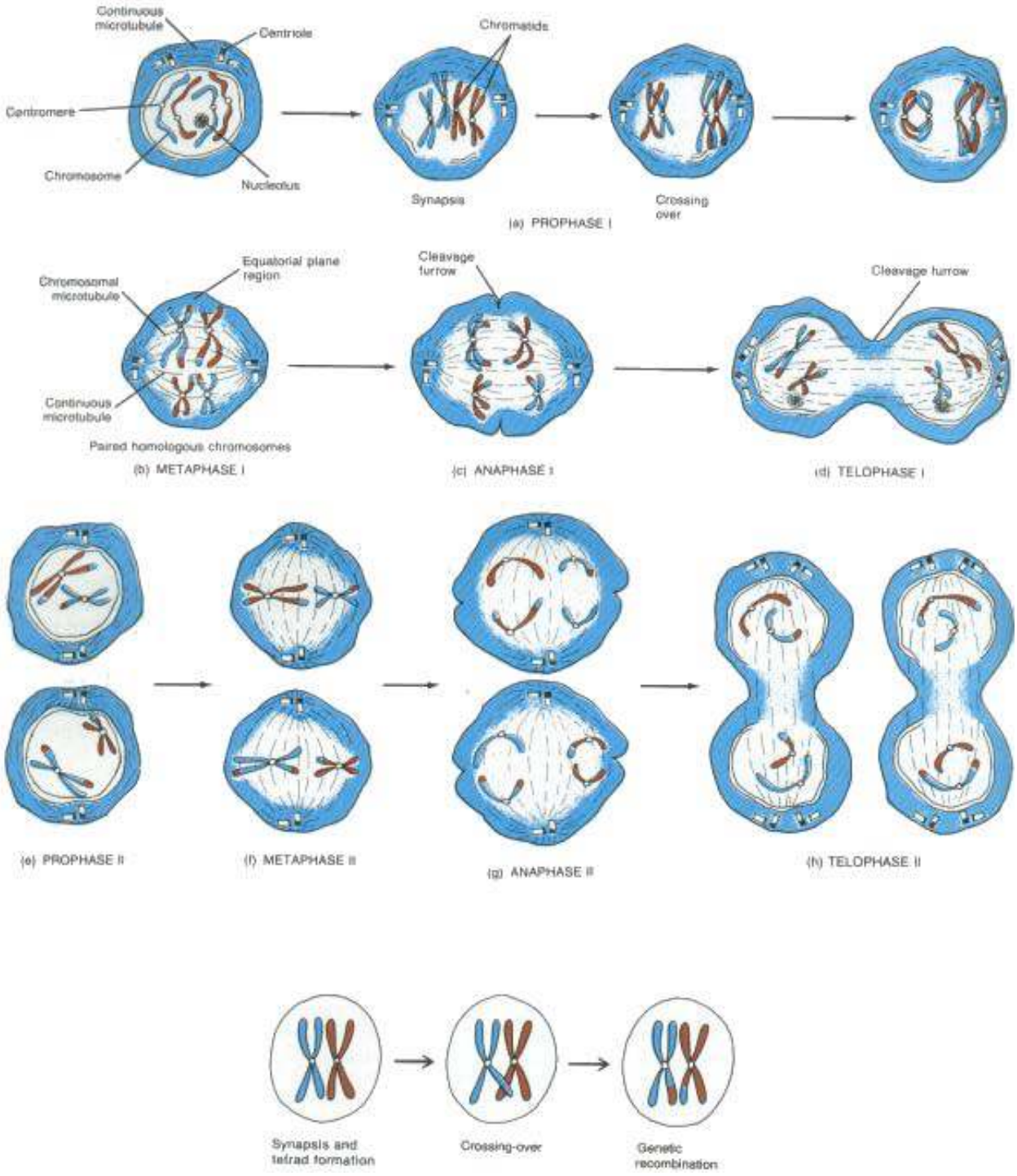
The process is similar to what happens when messenger RNA is formed from DNA. The coiled structure of the DNA first has to straighten out. Next it is unzipped by an enzyme running from top to bottom. All the natural joins are broken.

HOW DNA IS UNZIPPED TO ALLOW THE CELL TO DIVIDE

As the DNA unzips, loose bases in the liquid of the nucleus get attracted to their opposite numbers and the result is two new double strands, each identical to the one before. The cell is very vulnerable to interference at this stage and mistakes can happen in the copying process. If they do occur the result is a mutation although the effects may be so slight as to be unnoticeable. Many mutations are lethal to the cell and the cell dies or gets stuck mid-division. Other mutations may trigger off unwanted effects, for instance damaging that part of the genetic code that enables the cell to understand where it is in the body from interpreting chemicals released by it's neighbors. The result is that cells go on dividing to form benign tumors if the growth is slow and localized, or cancers if the growth is faster with cells breaking of to grow elsewhere.

Cancer chemotherapy hits cells at this vulnerable stage of chromosome duplication, by jamming the dividing mechanism. This can be done by giving someone a slightly altered base as a medicine. The base is used to build new DNA but the process halts when an incorrectly shaped building block is used.

Radiotherapy also attacks dividing cells - this time by firing atomic particles at high speed, from a radioactive source, into a mass of dividing cells. The atomic particles knock out bases from the growing sequence, damaging the cell so it cannot divide properly and dies. The same treatment can of course increase the risks of cancer developing in normal cells, but rather less so.



REORGANIZING THE BODY

So now we understand how cells work and divide, how is it that cells turn out so differently in the body if all start off with the same genetic code?

Usually, cells in the body become specialized before birth: This process is called differentiation. For example, a nerve cell will always be a nerve cell. In other words, the destiny of each cell is determined in the womb. Cells influence each other by complex signals which are often using chemicals so that cells landing up in a certain position in a developing embryo are influenced in the way they develop. These chemical signals lock away huge sections of genetic code permanently; not only does information come out of the nucleus in the form of messenger RNA, but also the part of the genetic code copied in RNA is influenced by messages from the outside of the cell.

It is essential to remember here the difference between "somatic cells" which are fixed for a lifetime in one place or at one job, with a complete set of genes, and "germ" cells (sperm and eggs) which have half of each unzipped chromosome without duplication. Germ cells therefore have 23 half chromosomes and cannot divide until the other halves are provided at fertilization.

The genetic engineer has two choices: he can alter somatic cells so, for example liver cells in a diabetic start to produce Insulin, or he can alter germ cells so that every cell in the new embryo is reprogrammed. These changes will be passed on from generation to generation for ever or until further reprogramming is done. Laboratories all over the world are already trying out a wide range of such experiments on animals. Many scientists accept that with current rates of progress it will only be a matter of time before human germ cells are being reprogrammed routinely. This raises huge ethical problems.

However before we go to all the bother of altering genetic code, how about simply copying it to produce an identical clone or perfect twin; this technology is already widely used in animal breeding, so could it be done with humans?

PART 6
PLAYING GOD
CLONING ANIMALS IS A ROUTINE

A science fiction nightmare has been giving people the power to create carbon copies or identical twins of themselves. The technology is already here and so are growing concerns about its use. It is in fact far easier to just copy all the genetic code of a cell than it is to rewrite it. Even easier

than copying is to get the body to do the copying for you. Since all cells in the body except red blood cells and germ cells have an identical nucleus containing all the individuals genes, we have an unlimited source of complete chromosome set we can use. Even simpler, we could transplant the entire nucleus from one cell into another using a microfine glass. For many years, we have been able to clone animals including pigs, sheep, rabbits, cows and chickens. In fact we seem able to clone just about any mammal we have turned out energies to cloning.

To produce a clone, we need to be able to get hold of a complete set of chromosomes and put them into an egg and see what happens. A frog's egg is easy to do this on because the nucleus, seen as a black dot, in unfertilized eggs in fresh frogs pawn is so large. As we have seen, the nucleus removed contains only a half set of chromosomes of course and would not give instructions to divide until the half is provided by a sperm at fertilization.

CLONING TECHNIQUES

However, with somewhat greater difficulty, we can borrow a complete set of chromosomes by taking a whole nucleus out of a skin cell. The skin nucleus is very small and the procedure is not easy. If we now inject the skin nucleus into an egg (nuclear transplantation) then a remarkable transformation happens: the nucleus wakes up to the fact that it is no longer in a determined cell, and pulls all the volumes of the encyclopedia off the shelf at once. The nucleus instructs the cell to divide and divide again repeatedly until the call of the cell starts to influence itself with each cell touching other cells beginning to fix its role for the future according to its position.

Interestingly, if you want to save all the fuss and bother, you can make yourself a cheap cloning system by separating individual cells off before the big ball develops. If you do, each single cell taken away will carry on as if it is the only cell in the world and will go on dividing like a brand new fertilized egg. This technique is called: blastomere separation.

Robbing early dividing groups of cells to produce clones has worked well recently for a variety of animals, especially cows and sheep. Why bother to mate a magnificent prize cow with a bull which will add extra genes you may not want? Why not just clone the freak high output high meat yield cow and insert these egg-like dividing cells into dozens of other cows to act as

surrogate mothers for the clones? Why not indeed? Farmers have felt there are so many good reasons in favor that cloning is now set to become a standard breeding technique.

The days of prize bulls or stallions mating or even donating sperm may be numbered. Any animal can in theory be cloned this way. Obviously, it takes a lot of skill to detach healthy dividing cells after fertilization and insert them into wombs at the right time and there is a limit to the number of clones you can make for each fertilized egg. We used to be able to work this method only up to the eight cell stage in mammals, but the limit is growing all the time. The reason is that until the developing ball of cells has properly implanted, each time the cells divide, they tend to get smaller, with less food reserves remaining in each. Taking one call out of the ball to form a new ball is going to result in a smaller second ball of cells and a weakened embryo which may not be viable. Many of the techniques being used here - for example invitro fertilization and embryo replacement, have been routine in infertility clinics and in farming for a number of years.

WHAT ABOUT CLONING HUMANS?

So what are the practicalities of cloning humans? A scientist claiming he has already cloned a human embryo, found his embryos were dying very early - it is suspected that he was using animals as surrogates and the surrogates were rejecting human embryos.

So is there a market for human clones? Deliberately laying aside any ethical considerations for the moment, the question is important at every level of genetic engineering. If there is a market then it will happen somewhere. Legislation, as we will see, may not protect unless it is effective and global. If there is no market it may still happen, but probably on a more experimental scale limited only by the conscience of the experimenter.

Unfortunately, global experience in war and peace shows us that such vast cultural and individual differences exist in world view and personal ethics between individuals and nations that it is inevitable that somewhere at some time scientists will pursue what is physically possible. To some extent such exploration will be for its own sake but no doubt driven by whatever are their own moral, philosophical, religious or political persuasions.

The market for human clones could be huge - especially if they can be frozen (and they can) and only produced some years after the death of the clone donor.

PART 7
A CHILD WITH BUILT IN GUARANTEES

After all - and that is being deliberately provocative - if couples can opt for a donated egg and sperm from parents with known characteristics to be inserted into the mother's womb, why not cut out the uncertainties and go for a child with a set of guarantees?
guaranteed intelligence,
guaranteed free from genetic diseases,
guaranteed abilities in other areas.

You could even have a photograph showing what the child would look like aged 2 and 6 years old. The only thing that would not be guaranteed would be the right environment for the child so that his or her genetic potential could flourish best. However, we could also describe a guaranteed environment as one which has tended to produce excellent results with this set of genes in the past.

Dictators in the past wishing to guarantee the survival of some aspect of their own personality have only been able to resort to conceiving a large number of children. Cloning could be very appealing - possibly "irresistibly" tempting to a dictator wanting a son and heir worthy of his destiny. For someone possessed with a sense of his own self, it could indeed be a fascinating adventure to watch himself grow up again in a different situation.

Let us argue for the sake of exposing the controversy that it is in fact no different from having a child who seems to have naturally inherited vastly from one parent: "He is the spitting image of his father".

WHAT IS SO UNNATURAL ABOUT TWINS?

Here is another thought: would you be able to spot a clone if you met one? The answer is probably not unless you are a member of the same family and have access to the photograph album. It should be pointed out here that identical twins of course have a totally identical, genetic code and are clones of each other.

Triplets are also natural clones. In our example of adult cloning, the only thing that makes it unnatural is that the identical embryos are not born at the same time but possibly fifteen, twenty or even fifty years apart. The other difference is that they would be born with different parents - or apparently so.

It could be argued that since environment does have such a huge influence on development, the only identical-ness would be in appearance at each stage compared to old photographs of the clone donor. In fact, due to age differences, donor and clone will probably never even look identical. Even if they are similar in age and look and sound the same one might ask what is so unnatural anyway about twins? Natural clones exist therefore in virtually every family tree.

Unless we understand the ways these issues are likely to be presented then we will be wholly unprepared to meet the issues of tomorrow's world - a world approaching faster than we ever realized. Genetic engineers are swift to point out technical difficulties but in fact they are no different from the difficulties of cloning any other mammal. However the ethical difficulties are vast.

PART 8
NEW PARTS FOR OLD BODIES

These is another more hideous (yet also potentially lifesaving) aspect of cloning: using a clone to manufacture a new organ. Earlier we saw that cells in an embryo quickly sense their position in the body and become more and more specialized. In theory it should be possible to take a semi-specialized cell developed from a fertilized egg and treat it in the laboratory so that it reacts to form, say, a perfect replacement kidney. A simpler approach already being used in medicine is to collect aborted fetus in a bucket in an operating room and then surgically remove various organs and tissues for transplanting into people who need them. Needless to say the practice, although common, has not been widely publicized.

WHY IS THERE A DEMAND FOR FETAL OR CLONE TRANSPLANTS?

Spare part surgery only works if spares are available, and if spare parts work after replacement. Unfortunately for many who die each year of kidney, heart or other organ failure, not only are spares often not available but they also often fail to work.

Spares are often unavailable because tissues or organs need ideally to be moved instantaneously from one living body into another. The nearest we get to this is the living donor: a parent who donates a kidney to a child for example. In these cases, two surgical teams operate at the same time on donor and recipient in adjacent operating rooms.

In many cases, where an organ could be donated, death has occurred with loss of circulation and accumulation of poisonous substances before tissues can be removed. In the case of donated corneas or skin grafts the timing is not critical Corneas survive body death for a number of hours.

Their need of food and oxygen is low and transplants are relatively straightforward. Kidneys however work extremely hard at all times in the body, purifying the blood. Kidney cells are damaged permanently in half an hour unless the kidney is rapidly chilled after removal by storage in an ice box. Kidney donors tend therefore to be accident victims where massive brain destruction has occurred, the person is effectively deceased but the heart, lungs and kidneys are all still functioning, with machines artificially maintaining the body in the twilight zone between life and full death. Kidney donation is therefore accompanied by a temptation to turn off a life-support machine. The numbers of kidneys available fell dramatically recently after a series of television program which caused great public uncertainties about whether or not such accident victims were truly dead. Fears that pressures to transplant could over-ride a small chance of recovery led to many relatives refusing to give permission and to large numbers of people tearing up their kidney donor cards. There is still an acute shortage.

However, even if sufficient organs are available, there is often a further major limitation of spare part surgery: compatibility of tissues between donor and recipient.

As we have seen, each person's set of genes is a quite unique combination of tens of thousands of individual messages. Just as each person's facial features are different, so also are the surface features of each cell in the body. The area where we are most familiar with this is that of blood group: there are several main blood groupings, each of which is incompatible with the others. For this reason blood type of both donor and recipient are always checked before transfusion. However, even if you are the same blood group as me, and were to donate to me a kidney, my body would almost certainly regard it as a foreign germ and try to destroy it. Very

occasionally, you find two people whose cell features are so similar that a transplant would be accepted well. Finding these matches between all organ donors and people needing them is therefore extremely complicated and explains why organs are often flown great distances to find the person with the best "match". It also explains why commercial pressures have resulted in buying and selling kidneys, and in paying non-relatives to donate them. Genetic engineering is contributing to our understanding of these cell differences and how to overcome them.

Badly matching organs usually fail rapidly although some help can be given by giving high doses of steroid and other treatments to try and persuade the body's defenses from attacking the transplant so vigorously.

So spare parts are often not available and often do not work as well as we would like after a transplantation. Having said this, we are seeing great improvements with more sophisticated treatment after transplantation and a great many alive today owe their survival to organ donation. The two which perhaps do best are kidneys where kidney failure itself poisons the body's defenses so transplant rejection is often less and cornea transplants where the body's defenses seem to tolerate new eye coatings very well.

SPARE PART PRODUCTION USING NEW TECHNOLOGY

Having decided there could be a big market in self-grown replacement organs, how would it be done?

First we have to look at what has already been carried out in animals or using animals. In 1984 there was a huge outcry when a surgeon in Southern California removed the beating heart from a baboon and transplanted it into a baby known as "Baby Fae". For reason which are obvious from what we have just seen, the heart was rejected and the baby died. However we are now seeing similar experiments in reverse: organs removed from late human fetus that have just been aborted, and inserted into animals.

These experiments are being carried out in Palo Alto Mexico by a company called Systemix backed by a $10 million investment. They are using mice bred without any natural immune system to fight either infection or transplants from humans. They are kept in a strictly germ free environment. Then they receive human tissue - for example thymus, lymph node or liver cells. With these transplants the mouse develops a human style immune

system. The mouse can then be infected with the AIDS virus (HIV) or with other viruses which also fail to grow well other than in humans. The mice can then be used to test potentially hazardous new treatments. These humanized mice are big business but may be flawed because mice still do not produce disease like we do.

Incidentally, there is another more serious problem: trying to infect mice with HIV could lead to a mutation producing an even more dangerous version of HIV. This could happen if mouse viruses combined in some way with HIV. It has even been suggested by some scientists that such inter-species virus experiments could conceivably have led to the emergence of HIV in the first place. Although the evidence appears to be stacked against this alarming suggestion, the fact that it can even be made shows some of the problems that can emerge. Experimental viruses have combined unexpectedly with each other in animals in the past, becoming more dangerous as the new strain emerged.

FETAL TRANSPLANTS FOR HUMANS

We can reverse this method to treat humans: how about taking organs or tissue from animal fetus and transferring them into humans? Such transplants will be as surely rejected as the monkey heart in the earlier example. But what about removing tissue from an aborted human fetus and using that instead? Such an idea is abhorrent to most of the population but is it being done?

For several years now tissue from aborted fetus has been used to treat patients with "severe combined immuno-deficiency disease". Unlike AIDS this is an inherited condition affecting all the immune system rather than just one part. The tissues transplanted are pieces of liver and parts of the bone marrow. In another related disease called the Di George syndrome, the tissue transplanted is from the Thymus gland. Other types of immuno-deficiency, disorders of red blood cell production and disorders of metabolism can also be treated in this way.

Interestingly, although the fetal tissue is completely incompatible and would normally have been rejected - no matching takes place between fetal donor and recipient - these transplants seem to work. Other uses are likely to be made of fetal transplants in the future. Over the last ten years a number of experiments have been carried out in animals using fetal tissue transplants to cure brain damage. Such experiments are an extension of nerve tissue

transplants that have been studied for around 100 years. If these latest experiments prove successful then we can expect to see fetal brain or spinal cord transplants in humans. The hope would be to try and overcome a big problem in damaged human brains. Unlike the situation in the developing embryo, once a baby is born the nerve cells seem to stop dividing and their response to injury is unlike other parts of the body. By using primitive brain cells we might be able to allow a certain amount of repair of the brain to take place.

PART 9
SO WHAT ABOUT THE FUTURE?

Let's take the case of a dying prize winning musician. He needs a kidney and none is available. He gives a blood sample and is told to come back in about eight to ten months' time for a transplant. He pays a very large sum for the privilege. The transplant is entirely successful. The only complication is that it takes quite a while to get going fully.

Without realizing it, he has just paid a private clinic for a cloned kidney. A nucleus was taken from a white blood cell in the sample he gave, and it was then inserted into a human egg, which in turn was implanted into a surrogate mother's womb. After nine months, a cloned baby was removed by Cesarean section. Shortly after birth one kidney was removed and inserted into the professor. The baby was adopted 24 hours later by doting new parents believing that the child had been born naturally but with a defective kidney that had now been removed.

Fact or fiction? As we have seen the cloning technology is all there. The demand is certainly there. For the present there are two blocks: the first is obtaining a surrogate mother. However that is becoming easier in the West if the right story is told and is difficult to prevent commercially in the two-thirds world. A mother could be offered the equivalent of ten years wages by an agent. The second larger block is that a newborn baby kidney is much too small and immature to help a full-grown adult much. However, other tissues might do rather better, in particular bone marrow and other rapidly dividing organs such as skin to cover grossly disfiguring burns for example.

Perhaps having at least formed a complete baby kidney we will in the future be able to accelerate its growth in the laboratory using new growth hormones while connecting it to an artificial blood supply.

The skin example is an interesting one because we are able in this case to clone skin directly from skin cells - without having to create a whole new human being. Skin cells can be stimulated to grow and divide. They can be tricked into thinking that they are on the edge of the wound. In the laboratory large sheets of skin can be grown quite rapidly from just a few sample pieces of skin. These can then be returned to the donor. We are also able to clone cells successfully from bone marrow as a routine part of medical treatment in those with leukemia.

PART 10
FARMING IS A HIGH RISK BUSINESS

The genetic engineer is already making huge changes to the way farmers are growing food. Farming has never been riskier or more competitive than today. In many countries food production is artificially stimulated or destroyed by large fluctuations in market prices. Some of these fluctuations are natural due to variations in crop yields from year to year for example. Others are due to systematic rigging of the markets through governments guaranteeing minimum prices. These steps were designed to prevent the boom and bust effect from year to year and to guarantee regular farming income. However they have led to situations where at a time of mass starvation in Africa, farmers are paid to produce more non-transportable food than we need (milk, butter, beef). European and American farmers are now to be paid instead not to farm their land - maybe to plant trees instead.

Dumping subsidized food onto the world market - during famine, dumping free food can become disguised or re-labeled as "aid" - also has massive effects on small two-thirds world farmers who can find the value of their produce disappear overnight.

For a Western farmer high yield for low cost is always the key factor: more crops per acre, lower seed cost, lower wastage from disease, greater resistance to frost, heat and drought, quicker ripening time, and less need for fertilizers or pesticides.

A difference of five to ten percent in yield makes all the difference between catastrophic loss and a reasonable return.

So what can the genetic engineer offer the farmer? Large manufacturers of pesticides, fertilizers and seed suppliers might look at it all another way.

What could the genetic engineers of a rival company come up with that might damage sales?

Four huge areas lie waiting for the farmer of cereal crops:
1. better seed - greater yield
2. lower need for pesticides
3. lower need for fertilizers
4. biological warfare against pests

In fact the last two could be dealt with by getting the genetic code right in the first place. At least 27 of the world's largest chemical companies are attempting to change the genetic code of cereals to produce a new product they can sell. As long ago as 1985 a company in the US successfully took out a patent on one of the first newly "invented" cereals: this was to protect the creation of a new type of maize with high loads of a substance called tryptophan.

LOWER NEED OF FERTILIZERS

Taking the issue of fertilizers first: there are some bacteria which take nitrogen out of the atmosphere - it is the major gas we breathe - and turn it into nitrates which are the chemicals plants use to grow, because they are needed to form amino acids, used as building blocks in making proteins. Nitrates are artificially applied in fertilizers. Some plants such as carrots and turnips have self-fertilizing factories in nodules attached to their roots. They create homes for these special bacteria who produce nitrates just where they are needed, at the roots of the plants. These plants tend to leave more nitrates in the soil at the end of the year than there were at the beginning. So much so in fact that before the widespread use of fertilizers farmers would often sow one of these types of plants into each field roughly every third year to restore the exhausted soil.

The farmer's dream would be to take genetic code for these roots and add them to the genetic code of cereals. Attempts are currently under way to do this. If successful, the turnover of many large chemical companies would be damaged overnight which is why so many are locked in a genetic-engineering race, expecting to switch production from chemical fertilizers to genetically engineered products soon.

A further dream would be to grow crops containing their own fungicides and pesticides - substances made inside the cells of each plant instead of being

absorbed artificially through spraying. Clearly these substances would need to be non-toxic to humans or at least not find their way through the sap into the harvested seed. The dream is becoming reality with viruses already modified to infect and transform plants giving them insect and disease resistance and weed-killer (herbicide) tolerance. Such steps also could have alarming implications for pesticide manufacturers.

INSECTICIDES AND PESTICIDES

It is interesting that one company (Calgene) is now marketing a new genetically engineered seed which gives resistance to damage from a powerful applied weed-killer - it just happens to be specific protection to the weed-killer produced by the same company. Pesticides or insecticides themselves can also be produced by genetic engineering - programming bacteria to produce them. This approach guarantees sale of expensive super-seed and own-brand chemicals. Work is continuing on cotton, tomatoes, rape seed, potatoes and sugar beet.

At first, "green" consumers may be misled into thinking that new crops grown without pesticides or fertilizers are more ecologically sound. However they may soon be wondering what the side effects are of eating vegetables or other crops programmed to fill themselves with home-made poisons.

At the moment there is no legislation to protect consumers from such crops. If the substances are produced within a plant then the plant is deemed as safe and as wholesome as it's original ancestor. Nor does there have to be any indication in the shop. Safety testing is being carried out but in almost every country of the world there is no regulatory authority for genetically created foods.

You have probably already eaten your first genetically engineered food without even knowing it - after all it is hardly something shops want to shout about, and manufacturers are keeping a very low profile for the same reasons. It could be the quickest way to kill sales by causing anxiety in shoppers in our supermarkets.

PART 11

RAPID PRODUCTION OF NEW SEEDS

Genetic engineering also allows us to produce new strains of seed more quickly. Usually a single cross-bred cereal plant has to be bred from seed

through several generations over several years to produce enough seed to sell and be able to produce more.

Incidentally there are huge commercial advantages in selling genetically engineered seed with all advantages but producing sterile seed. In other words the farmer having lost the need to buy pesticides and fertilizers now has to buy new seed at inflated prices each year where previously he would have kept some of the harvest back for next year's sowing.

Here is the simple answer to raising millions of seeds from just one genetically engineered plant in just twelve months: plant cloning. Hundreds or even thousands of identical growing plants from just one original. The result is fields ready for harvesting by summer, to produce a massive crop of commercial seed for sale. Plant cloning is of course a well established practice. A type of plant cloning is taking cuttings and transplanting them. This has been a standard procedure commercially for decades.

GERM WARFARE PROTECTS PLANTS

Progress is also being made in designing new plants which are virus-resistant. Another option for the farmer is to use germ warfare against insects which eat his crops. Research is going on to develop insect viruses which can either be sprayed onto crops or which will be released into the sap by plant cells. In one experiment, a new insect virus was developed which when injected into silkworm larvae caused an overdose of a particular insect hormone to be produced by the silkworm.

The new virus was 20% more lethal than the original. Other types of laboratory made viruses have also been developed recently by using genetic code for poisons produced by bacteria and inserting it into viruses. The end result was the same as in silkworms, with the insect larvae infected beginning to produce minute doses of the insecticide themselves in their own body cells.

However this has more implications for human safety. Do we want to eat genetically engineered plant viruses with our fresh salad? If we turn from cereals to vegetables we find genetic engineers have already left their mark. Unlike cereals which have a long shelf life when dried, vegetables quickly decay due to their high water content.

NEW FRUITS AND VEGETABLES

Many vegetables are also soft and susceptible to bruising especially if ripe. Farmers are faced with a stark choice: either harvest unripe crop and hope it softens in the supermarket, or harvest it ripe - heavier and better quality- but with a risk of severe damage by the time it reaches the wholesalers.

The tomato is a high value vegetable (some would say it is a fruit) that has been studied carefully by genetic engineers. Small adjustments have been made to produce a "non-bruising" tomato. It looks good, survives travel well but some say it's taste is strange or inferior. Recent advertisements in Sunday newspapers in the UK were promoting a genetically engineered strain of tomato bush, guaranteed to grow without support in any soil, producing huge tomatoes up to 12-15 inches in circumference.

Horticulture Research International is a British company making big strides forward in this area. In 1986 the company bred a new apple called "Fiesta". They are now working on genetic markers which will tell them when the new genes for pest and disease resistance have successfully "taken". They are still at the stage of having to plant trees and watching an orchard develop over a number of years. The company has also produced a new type of mushroom with better storage qualities and double the shelf life after harvest. The Company was funded by the Government but this has stopped now that commercially viable products are resulting. The government now expects industry to provide all the investment.

There are some foods that we will never see in the West unless genetic engineering provides some answers. Only visitors to Africa know what bananas are supposed to taste like. Supermarket bananas have been picked very early when they are small and have a low sugar content. Locally picked ripe bananas taste like supermarket ones mashed up with brown demerara sugar.

There are other kinds of bananas in Africa that do not even survive air-travel well. These will never be eaten in quantity abroad - without a genetic refit. The strawberry is another obvious target for genetic changes as a high value for weight food. The farmer is faced either with going for good taste but lower yield, or high yield with poor flavor and all the same problems about ripeness and bruising.

PART 12
FASTER GROWING ANIMALS

Genetic engineering has much to offer farmers looking for higher animal yields - of meat or milk for example. There does not need to be a change in the genetic code of the animal itself: we can use genetically engineered bacteria to produce hormones to drive the bodies of animals as hard as they can go for maximum profit. This is a similar approach to using insulin as a genetically engineered medicine in humans. One example of such an application has resulted from the discovery of the genetic code for growth hormone in chickens. This could soon be used to produce larger chickens faster. Other experiments on chickens are using viruses to program germ cells, with the aim of producing chicks which hatch out with a built in resistance to chicken viral disease.

The company Monsanto has just applied to the European Commission for a license to use a genetically engineered drug on cows called bovine somatotrophin .This artificially stimulates extra milk production producing the same yield with 30% fewer cattle. The Commission has approved the drug use but the Council for Veterinary medicinal Products has not reached a verdict. In the meantime a ban was applied in the European Community until the end of 1991 while it considered a whole range of similar biotechnology products.

However despite the great debates, milk from cows treated with genetically produced bovine growth hormone has been drunk by the British public since 1986 - from ten test farms. Although some farmers are opposed to this farming method because they fear bankruptcy if the price of milk falls as a result, environmentalists also question the need for it when Europe already overproduces milk. As we saw earlier, farmers are already being encouraged with financial incentives to take land out of farm production because it is cheaper than caring for butter mountains.

In early 1991 the British Veterinary Product Committee recommended that the British government should refuse a license to the two companies wanting to market the drug. The grounds for objection where not risks to humans or the environment, but concern for the welfare of the over-stimulated animals .However other scientists in the US also query human safety - small amounts of an insulin-like substance seem to be secreted into the milk of treated cows. Some are also concerned about a possible

new milk allergy in humans as a result. The hormone does increase the incidence of udder infection (mastitis) and the treatment involves giving cows painful injections.

In November 1990 new evidence was emerging of other problems, possibly including increased miscarriages in pregnant cows being treated. These new findings have led the US Food and Drugs Administration (FDA) to say that the drug was unlikely to be licensed for use in the US "for some time".

With a ban already announced by German Parliament, the strength of the "caution" lobby is growing. Meanwhile in the US alone, four companies hope to market the drug and have already spent hundreds of millions of dollars in research and development. We can also use genetic engineering to produce vaccines against animal diseases such as foot and mouth disease.

NEW "SUPER-ANIMALS"

However as we have already seen, the biggest stakes of all are in genetically engineered farm animals or "super animals". We have already seen how the sex of embryos can be determined using genetic techniques, and how a whole new herd can be created in months by cloning. But how about genetically altering the first animal before we begin?

In 1987 a scientific paper said that "within the foreseeable future it will be possible to add foreign genes to the genetic composition of animals in order to transfer disease resistance, rapid growth, fertility and efficient use of foodstuffs to their offspring." Patent protection has been available on newly created animals as well as plants under US law since a historic decision by the US supreme court in 1987. The test case involved polypoid oysters. In fact the first gene transfers in mammals happened in mice over 26 years ago in 1976.

Food fads come and go. Doctors are still unable to agree about the relationship between high levels of animal fat in the diet and heart disease. What seems likely is that a small proportion of the population is sensitive to the damaging effect of animal fats while for the rest of us the advice is probably irrelevant. We can probably detect who needs to be on low fat diets through family history of heart disease or strokes, by testing blood cholesterol levels - and in the future by inspecting the genetic code because such sensitivity seems to be inherited.

NEW PIGS

However the public perception of the dangers in eating animal fats is now firmly rooted and the demand for low fat meat is therefore growing. In 1987 a new kind of "trans-genic" pig was created for the first time with lower than normal body fat. Fertilized eggs from pigs were injected with a strip of genetic code formed from two fragments, one from a human with the instructions to produce human growth hormone, and the other from a mouse with instructions to activate the gene. The technology for injecting a single microscopic cell has been well established for many years. The middle of a hollow piece of glass tubing is heated in a flame while pulling at both ends. As the glass softens the two ends suddenly shoot apart. The middle becomes thinner and smaller until finally it is hundreds of times thinner than a human hair and snaps .It is fascinating to watch it happen. You are left with two pieces of glass tubing which taper off at one end to microscopic size. The tubing is then attached to a microscope with special controls so it can be precisely positioned in an individual cell.

Once injected the injected cells were returned to the womb to develop. Out of 341 pigs that resulted, 31 were reprogrammed. They developed as a new species containing pig, mouse and human genetic code. The human growth hormone production in the animals lowered body fat, and stimulated mammary development (milk production). Moreover, the new species gave birth to identical offspring five out of six times.

NEW SHEEP

The same experiments were also repeated using fertilized eggs from sheep with less success - only three of 111 lambs born were a new creation. However, as long as you can reproduce from the new stock, you only need to have a one in a thousand success rate or less to make the effort worthwhile. After all, how much will a company pay for the first of a new super-breed of cow, likely to become a new world class breed?

NEW COWS

Other methods of reprogramming fertilized eggs include infecting them with genetically engineered virus. This is fast becoming a standard technique. The demand is also rising for skimmed milk. What do you do with all the cream when you cannot sell it as cream or as butter?

The udders of cows have been particular targets for the genetic engineer: here is a massive chemical factory producing very large amounts of complex proteins. We can either try to adjust the composition and flavor of the milk in some way, or program the udders to manufacture completely new substances which we can later extract from the milk to use as medicines. Such milk would be unlikely to be suitable for drinking, even after extraction of the medicine.

Mothers are also being increasingly driven again to old fashioned breast feeding of their babies as more and more evidence grows of the long term damage to some through early feeding on cow's milk - even in modified powder form.

A first immediate challenge has been to reprogram the udders of a cow by inserting the human genes a mother's breast cells use to make the special formula for human breast milk. This has been done in cow embryos and the reprogrammed cows are now growing up fast. We can expect to see human breast milk substitute bottled direct from cows in the near future.

The next problem is to alter the metabolism of animals so they grow more flesh faster and less bone or fat. This is just an extension of selective breeding which as we have seen is centuries old. A genetic engineering company called Granada Genetics in Texas said recently that: "The concept of producing large numbers of genetically identical embryos, frozen, sexed, screened for economic traits and produced inexpensively from slaughterhouse by-products is within our grasp....all...have already been demonstrated. What will happen to protein production when commercial cow herds can be made up of one or two female clone lines mated to bulls of the same clone? The obvious answer predictability of performance to a magnitude never before achieved in agriculture".

Rapid progress is being made. It is even possible that we may see new animals emerging although one suspects consumer pressure will mean they will still be called by familiar names to avoid anxieties being raised. Would you buy geep meat at 40p a pound less than lamb - combined goat and sheep?

NEW FISH

New species of fish are also being made. Rainbow trout have been reprogrammed by taking fertilized eggs and adding a second copy of the

gene for Rainbow trout growth hormone attached to a mouse gene designed to activate it artificially. In 1990, of 3,104 eggs treated in this way, 25% - 783 - hatched out of which 4% were of the new species. Of 180 hatching, 35 survived as adult fish. Two were of the new species (trans-genic).The new species gave rise also to offspring with the same genetic characteristics.

The list of transformed creatures is huge - even rabbits have been changed. Once a trans-genic animal has been made, very large numbers of others can be created by cloning, well established as we have seen for duplicating sheep and cattle embryos. These are produced by separating cells at the earliest stage after fertilization. However nuclear transplantation will open the way for cloning on a much larger scale.

The Department of Meat and Animal Science at Wisconsin University in the US published a paper in 1990 which said:

"Efficient in vitro systems for maturing oocytes and capacitating spermatozoa, for fertilizing and developing the embryos have resulted in commercial...production of embryos. Cloning of embryos by nuclear transfer has been accomplished for sheep, cattle, pigs, and rabbits, with nuclear material sullied by embryos as late as the 120 cell stage in sheep. Embryos have been re-cloned....Research is needed .....so that the number of clones may be increased to thousands or millions.

"Trans-genic embryos or offspring have been produced for mice, rats, rabbits, chickens, fish, sheep, pigs and cattle. ...badly needed efforts to map the genome of domestic animals. "These and other new technologies promise to change livestock breeding drastically over the next decade"

FOOD FROM MICROBES

The trouble with animals is that they are inefficient: almost everything a cow eats is turned into heat keeping warm, energy in moving around, and cells for tissues wearing out such as gut lining shed into cow dung, or skin and hair. Some of the rest is excreted as dung although cows are much more efficient than horses which excrete huge amounts of undigested cellulose in food.

If people could eat grass, straw, hay or protein from bacteria or yeast , our food bills would be much lower. However even plants are not always as

efficient as you might think in trapping solar energy and using the power to make proteins, sugars or fiber.

Basically all we eat is solar powered directly or indirectly. The solar energy is stored, converted or transferred in one way or another. How about using another form of stored energy to fuel human beings with good food for us to burn inside our bodies?

Bacteria already exist which eat oil and grow to produce protein which we could use as food. What about bacteria that burn hydrogen to produce energy? Nuclear power or hydroelectric power can be used to make electricity. Electricity can be used to turn water into oxygen and hydrogen - the same chemical reaction that happens when car batteries are recharged. Hydrogen can be fed to bacteria which use it as fuel to grow. Here then is a potential way of producing food from nuclear power.

Because energy itself is at a premium, we will always find our best results will come from new plants producing most of our dietary needs from sunlight and soil rather than through bacteria directly or through the unnecessary wasteful intermediary of a farm animal.

In the meantime yeast are also being genetically engineered as future food sources. When the world's oil supplies have nearly run out - less than a generation away - there will be a huge drive to produce low cost alternatives to petrol for cars. One well proven alternative is ethanol or alcohol. New ways are being tried to program Ecoli bacteria to produce ethanol.

Having considered some of the range of ways genetic engineering is having an impact on what we eat, we now need to look at the most important areas of all: genetic engineering for maximum health, using genes in medicine.

NEW MEDICINES FOR A NEW WORLD

Genetic engineering is beginning to revolutionize medical and surgical practice. However as soon as we put genetic engineering and medicine together we need to make a big distinction between techniques designed simply to selectively identify and abort fetus simply on the basis of their genetic problems (e.g. Downs babies) and techniques designed to produce cures or treatments for conditions.

Although much embryo research has been labeled as assisting in the prevention of many inherited diseases we have to be honest with ourselves and say that this is only being achieved by mothers consenting to abortions if doctors suspect that the developing child may have an inherited disease. This is "prevention by elimination" or "birth denial" rather than prevention through counseling, education, treatment or cure.

Our understanding of human genetic code means that a vastly increased range of predictions can be made about what an embryo will turn out to be like. In the past such genetic tests were confined to gross problems like Downs Syndrome, where an entire chromosome has been added to the basic number of 46.The defect is obvious with simple observation down the microscope using special techniques. Incidentally, taking a sample from a developing fetus is not without its hazards. The rate of spontaneous miscarriage following the procedure can be as high as one in ten. It is a procedure to be considered very carefully - whatever your position on abortion - especially where the mother is in her late thirties or early forties and the couple have taken some years to conceive. In this situation it is a particular tragedy to discover after a doctor-induced miscarriage that the baby developing was completely normal. It may be the only pregnancy the woman will ever have.

Incidentally, one wonder about this conflict between the rights of the mother to have a healthy child, and the right of a child with medical problems to be born - whatever the religious or philosophical persuasions of the parents.

A large number of other genes are being pinpointed. For example the gene causing neurofibromatosis which at its most extreme form produced the Elephant man. A milder form affects one in 3000 of all babies born. The gene causes symptoms ranging from brown patches on the skin ("cafe au lait") to multiple benign tumors arising from the sheaths of nerves.

Another example is breast cancer which kills 15,000 women a year as the commonest cancer in women, and between five and ten out of a hundred of all cases are inherited. Women with a mother and a sister with breast cancer have more than eight times the risk of developing it themselves. Women with relatives who developed breast cancer after the menopause have only slightly increased risk. The Human Genetics Resources Laboratory in Hertfordshire believes it has located two faulty genes on

chromosome 17 - a chromosome already highlighted as suspect by American researchers. Researchers are very close of finding genetic markers so that high risk of breast cancer can be detected in the womb or after birth. Examples of such medically important genes are increasing almost every week. A recent addition to the list as we saw in an earlier chapter has been the discovery of the fragile X gene which causes mental handicap.

Although there are a large number of genetic diseases where the problem is entirely a result of faulty genetic code, it is also emerging that the commonest killers of all: heart disease and other similar problems, also have a genetic component. Doctors have known this for a great many years which is why family history is so important. Doctors in hospital will always ask if your parents are still alive and if not, what they died from. An example is heart disease: a man who's grandfather and father all died before the age of 60 from heart attacks is at high risk for developing diseased coronary arteries. The genetic engineer should be able to help us confirm who in the general population is likely to become ill from particular diseases.

For the last ten years we have recognized that if 10,000 adults eat a diet high in animal fats - especially cholesterol - then the number with heart disease is likely to rise. The huge marketing campaigns by margarine manufacturers have been built on this fact. However what is becoming clear is that for the great majority of the population, fat intake is probably almost irrelevant compared to a minority who have a genetic problem which means animal fats in their diet tend to produce damaging changes in the body.

Genetic cures or treatments are a massively growing area and fall into several groups:

1. Programming bacteria, fungi or mammalian cells to produce missing hormones or other substances including complex chemicals. This has been recognized as an area of major importance for many years.
2. Growing white cells (soldier cells used to fight infection) to harvest special "monoclonal antibodies" to attack things like cancers. This is a form of human cloning.
3. Growing skin, bone marrow or other cells as a form of cloning.
4. Producing vaccines.

5. Reprogramming human cells - for example to cure HIV infection and AIDS.
6. Reprogramming genes in an embryo to cure genetic diseases.

CONCLUSION
HOW TO RESPOND

Now we have seen what the new technology can do and what it is likely to be able to do in the future we are now in a position to consider urgently some of the issues involved.

There are two main questions we need to apply to each area of genetic engineering and to each technique used. Firstly is it safe, and secondly is it right? Having done this and decided what regulations are necessary we need to see them introduced in every country of the world, otherwise scientists and factories will simply relocate and set up elsewhere.

Is it safe?

There is a real danger of an instant response to the possible dangers of genetic engineering based on emotion and fear rather than reason. The first thing that is obvious is that there are a number of aspects of genetic engineering which are merely direct extensions of long established practice. Cross-breeding and propagating plants using cuttings are but two examples.

However as we have seen there are a large number of new areas where massive strides forward are being made with very little control particularly in the areas of food production, environmental release of altered species, viral contamination and spread, and biological warfare research.

Public needs to be informed

Most people have little idea of what is really going on. Even when reports appear, they can be confusing to the non-expert and be hard even for scientists in unrelated specialties to understand.

The truth may not be told

Almost the only sources of information about the new technology from the very people who have the most to loose from regulations, not just in limits on research, but also because an increasing number of genetic engineers have large commercial interests in the application of their technology,

particularly in the US. It is inevitable that risks will be played down, that accidents will be kept very quiet and experiments likely to trouble the public conscience will continue to be done quietly, without necessarily publishing results.

Lessons from the food industry

The food industry is an example where there is great consumer sensitivity - especially in the West with an increasing emphasis on "natural" foods. An example was the huge consumer reaction seen recently over the proposed introduction of food irradiation. The technique involves blasting pre-packaged foods with a large dose of radiation using X-rays. The doses used are enough to kill any bacteria so the food inside the sealed packet becomes effectively sterile. At first there were natural anxieties about whether any surviving organisms might be likely to mutate into a more dangerous form. That fear has been largely laid to rest by extensive tests which show these germs cannot survive the process. The next fear was that the treatment would be used to sterilize decaying or contaminated food which would then be sold in supermarkets having been passed as safe.

Public fear leads to caution

However the biggest problem has been that people are afraid of radiation following such things as the contamination of Welsh sheep by the Chenobyl nuclear disaster in the Soviet Union. Radiation to the public means one thing: contamination with invisible particles which can be absorbed into the body and which can cause cancer in the future, for which there may be no cure.

Irradiation of food is probably completely safe, and would probably have been in wide use by now if food manufacturers had been able to introduce the technique without any publicity. Instead, after big media coverage, manufacturers were forced to indicate on the labeling if radiation was used. The regulation killed the process stone dead as far as many suppliers were concerned.

Unless there is a regulation, you and I will discover we have been buying genetically engineered foods after we have eaten them rather than before. Who wants to advertise the fact and risk a massive loss in sales?

So what response should there be?
Firstly we have to be realistic: although I am very doubtful about the ability of any single government or group of governments to control this technology effectively - even if they agree to do so, and how to do it - nevertheless I think it is important to think through what should happen, and highlight the biggest problems.

a) Food production safety
1) The government should set up a licensing authority to approve genetically engineered foods for human consumption, including those derived from plants and animals. The license should cover not only where germ cells have been reprogrammed but also where the organism contains a subgroup of infected cells. Particular attention needs to be paid to the possibility of introducing substances into the human diet on a large scale which could turn out to have cancer inducing, fetus damaging or other toxic effects. Genetically engineered foods should therefore be subject to a rigorous chemical analysis to determine what new or unfamiliar compounds may now be contained in the food. The amount of analysis needed will depend on the degree of reprogramming.

2) Genetically engineered foods should be labeled clearly as such so that consumers can make a choice.

b) Environmental release of new organisms
The government should introduce strict regulation of the environmental release of new organisms. In some countries such controls already been in existence for some time, albeit as part of a voluntary code of practice. These controls should apply especially to micro-organisms, to plants, fish, birds and animals which could survive quite easily if they escaped from a contained area on a farm. Controls do not need to be so strict with conventional farm livestock although such stock should be indelibly marked in such a way as to make their origin and nature instantly recognizable. Breeding of fish in a confined pond with no water outlet from it might be a borderline area.

c) Viral contamination controls
Viral spread outside the laboratory as a result of genetic research is a serious possibility - whether spread of plasmids, of plant viruses, of animal viruses or of viruses infecting humans. In the absence of effective anti-viral cures we have to recognize the great vulnerability humans have to a

second plague like AIDS, but this time maybe of an even worse nature, spread - say - by respiratory droplets rather than by sexual intercourse or through the blood, and killing people in weeks or months rather than years.

We need to acknowledge that many countries of the world do now have all the resources to make by laboratory accident even more dangerous viruses than HIV.

All procedures involving the reprogramming or reassembling of viruses should therefore be strictly controlled. In particular there should be some kind of licensing authority for experiments where animals or plants are being infected by synthetic viruses. Less controls are needed for test-tube infections except where infected cells are replaced in plants or animals. It should be recognized that there is already evidence that genetically engineered viruses given to animals have the potential to mix uncontrollably with other viruses already present with unpredictable and possibly disastrous effects.

d) Ban on biological warfare research

There should be an immediate world ban on developing biological weapons of any kind. All biological weapons stations owned by the military or by secret services in different countries should be closed and their supplies destroyed.

e) World monitoring of code of practice

At the moment it is too easy for those wishing to avoid any controls to move the base of their operations from one country to another. There needs to be a global consistency in the regulations applied from country to country. The World Health Organization might be the appropriate vehicle to do this.

2) Is it right?

Having considered some urgent issues relating to safety of this new technology we now need to turn to the more subjective area and look at where some of the most difficult **ethical issues** are. Broadly speaking they seem to fall into two groups:

- those concerned with the development of humans from egg to embryo to birth
- and those concerned with the radical changing of species.

Each of us has a view of the world which will color our response to these issues. However it is helpful first to establish a few common principles that

a large number of people would probably accept. The first principle is an aesthetic dislike of creating the grossly unnatural, or monsters. In the traveling fairs of some countries, for a small charge you can enter a tent and see some of the strange wonders of the world: animals with two heads stuffed in a glass box, or a baby with two heads and four arms. The Elephant man of the last century was not a loved or popular public figure. Going to the zoo to see cages full of animals mutated beyond all recognition is hardly likely to be a money spinner for the owners.

What is a human being?
The second principle is a strong sense of what a human is - we recognize other human beings instinctively without necessarily being able to analyze all the reasons why. Our whole civilization rests on social interaction and respect between individuals and groups of other people.

Therefore a language speaking chimpanzee with reasoning powers, will, personality and artistic ability, is likely to be disturbing to most - especially if the chimpanzee talks fluently, with a large vocabulary, dresses in human clothes and adopts human mannerisms.

When it is realized that the cause of this genius is that the human genetic code for the brain's development was programmed into the developing embryo there may well be some who begin to wonder if the creature is not in fact more human than animal. After all, many owners of pets have similar feelings of identity with their dogs or cats for example.

There is a natural curiosity about such possibilities but a revulsion against having to live with the consequences on a daily basis.

FINAL WARNING AND CONCERN:
"The brain nerves that connect with the whole system are the only medium through which heaven communicates with man and affects his inmost life." Education p. 209.

"But if there was a sin above another which called for the destruction of the race by the flood, it was the base crime of amalgamation of man and beast which defaced the image of God and caused confusion everywhere.... Every species of animal which God created was preserved in the ark. The confused species which God did not create, which were the result of amalgamation, were destroyed by the flood.

Since the flood, there has been amalgamation of man and beast, as may be seen in the almost endless varieties of species of animals, and in certain races of men." Spirit of Prophecy, Volume 1 page 69 ,78.

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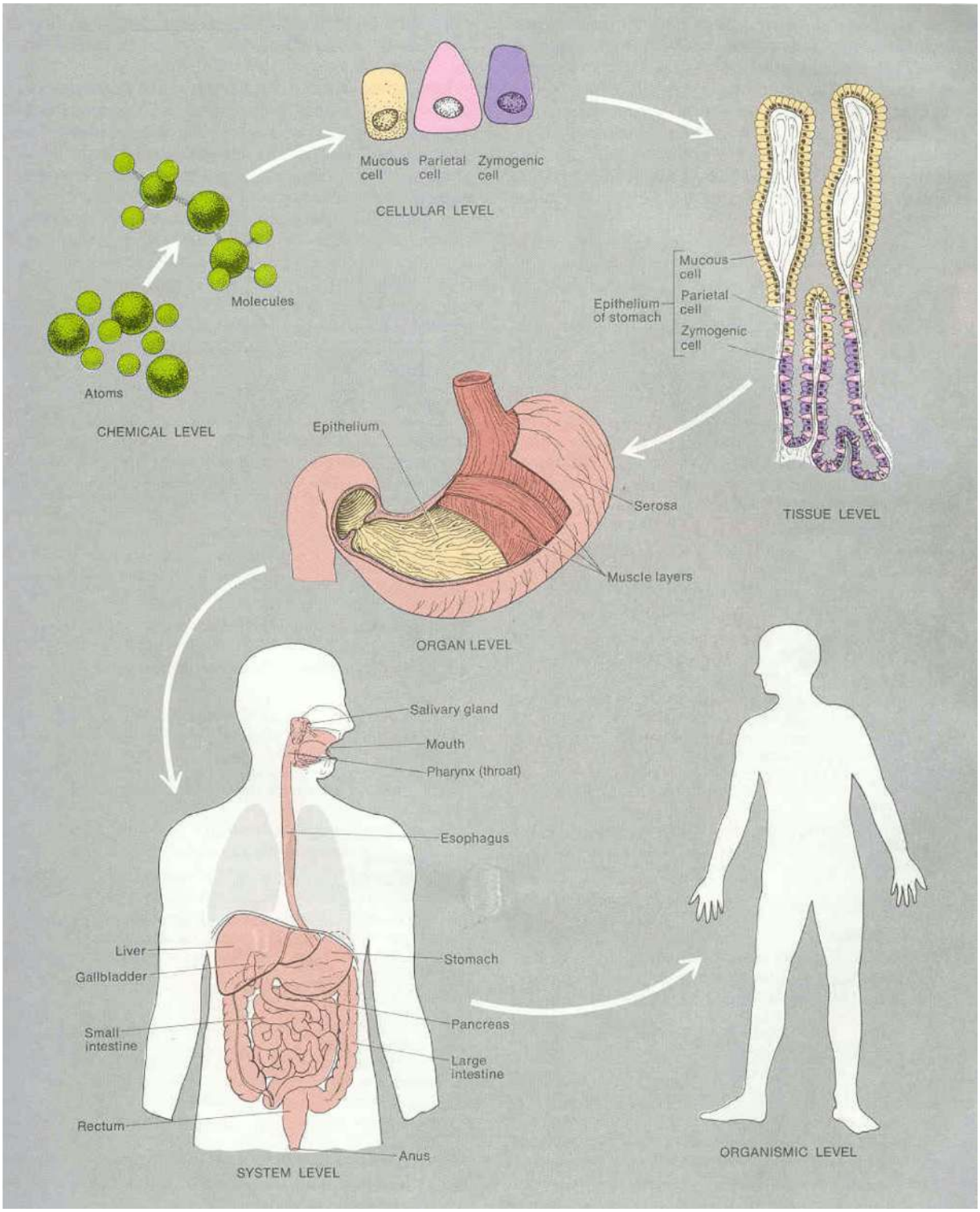

Mucous cell
Parietal cell
Zymogenic cell
CELLULAR LEVEL
Molecules
Atoms
CHEMICAL LEVEL
Epithelium of stomach
Mucous cell
Parietal cell
Zymogenic cell
TISSUE LEVEL
Epithelium
Serosa
Muscle layers
ORGAN LEVEL
Salivary gland
Mouth
Pharynx (throat)
Esophagus
Liver
Gallbladder
Stomach
Small intestine
Pancreas
Large intestine
Rectum
Anus
SYSTEM LEVEL
ORGANISMIC LEVEL

11 Systems of the Human Body

PRINCIPAL SYSTEMS OF HUMAN BODY, REPRESENTATIVE ORGANS, AND FUNCTIONS

1. Integumentary
Definition: The skin and structures derived from it, such as hair, nails, and sweat and oil glands.
Function: Helps regulate body temperature, protects the body, eliminates wastes, synthesizes vitamin D, and receives certain stimuli such as temperature, pressure, and pain.

2. Skeletal
Definition: All the bones of the body, their associated cartilages, and the joints of the body.
Function: Supports and protects the body, provides leverage, houses cells that produce blood cells, and stores minerals.

3. Muscular
Definition: Specifically refers to skeletal muscle tissue; other muscle tissues include visceral and cardiac.
Function: Participates in bringing about movement, maintains posture, and produces heat.

4. Nervous
Definition: Brain, spinal cord, nerves, and sense organs, such as the eye and ear.
Function: Regulates body activities through nerve impulses.

5. Endocrine
Definition: All glands that produce hormones.
Function: Regulates body activities through hormones transported by the cardiovascular system.

6. Cardiovascular
Definition: Blood, heart, and blood vessels.
Function: Distributes oxygen and nutrients to cells, carries carbon dioxide and wastes from cells, maintains the acid–base balance of the body, protects against disease, prevents hemorrhage by forming blood clots, and helps regulate body temperature.

7. Lymphatic
Definition: Lymph, lymphatic vessels, and structures or organs containing lymphatic tissue (large numbers of white blood cells called lymphocytes), such as the spleen, thymus gland, lymph nodes, and tonsils.
Function: Returns proteins and plasma to the cardiovascular system, transports fats from the gastrointestinal tract to the cardiovascular system, filters body fluid, produces white blood cells, and protects against disease.

8. Respiratory
Definition: The lungs and a series of associated passageways leading into and out of them.
Function: Supplies oxygen, eliminates carbon dioxide, and helps regulate the acid–base balance of the body.

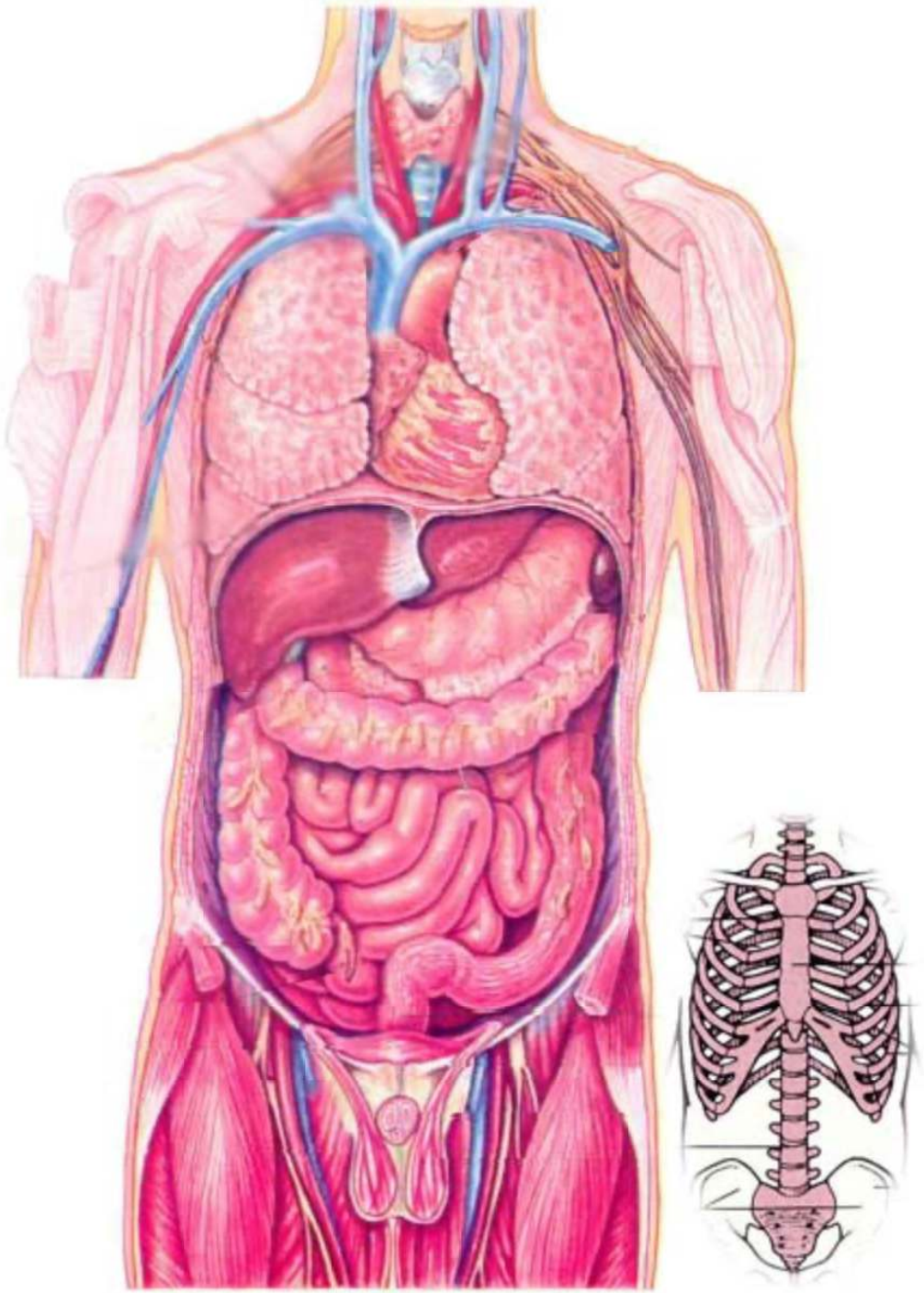
9. Digestive
Definition: A long tube called the gastrointestinal (GI) tract and associated organs such as the salivary glands, liver, gallbladder, and pancreas.
Function: Performs the physical and chemical breakdown and absorption of food for use by cells and eliminates solid and other wastes.

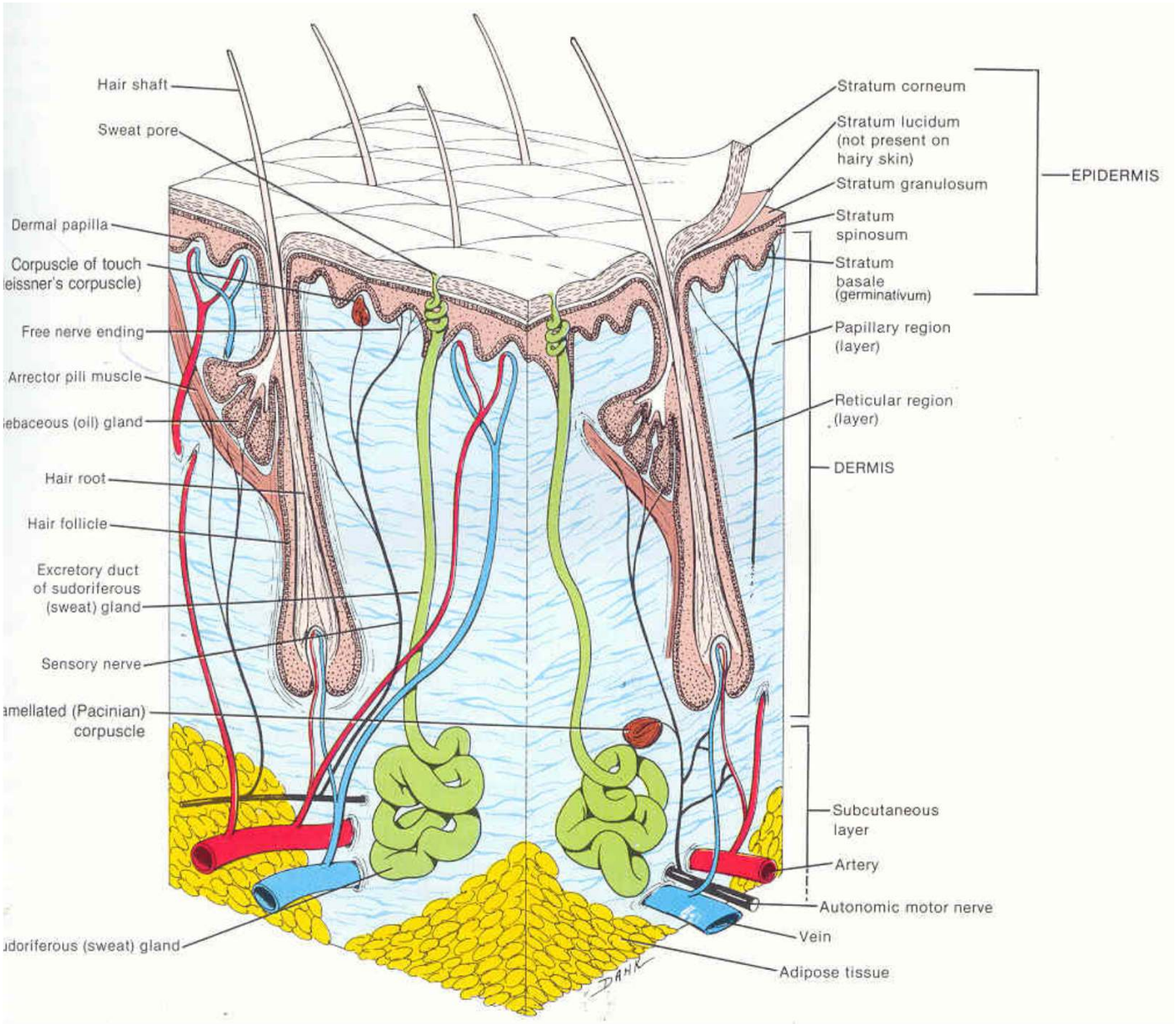
10. Urinary
Definition: Organs that produce, collect, and eliminate urine.
Function: Regulates the chemical composition of blood, eliminates wastes, regulates fluid and electrolyte balance and volume, and helps maintain the acid–base balance of the body.

11. Reproductive
Definition: Organs (testes and ovaries) that produce reproductive cells (sperm and ova) and other organs that transport and store reproductive cells.
Function: Reproduces the organism.

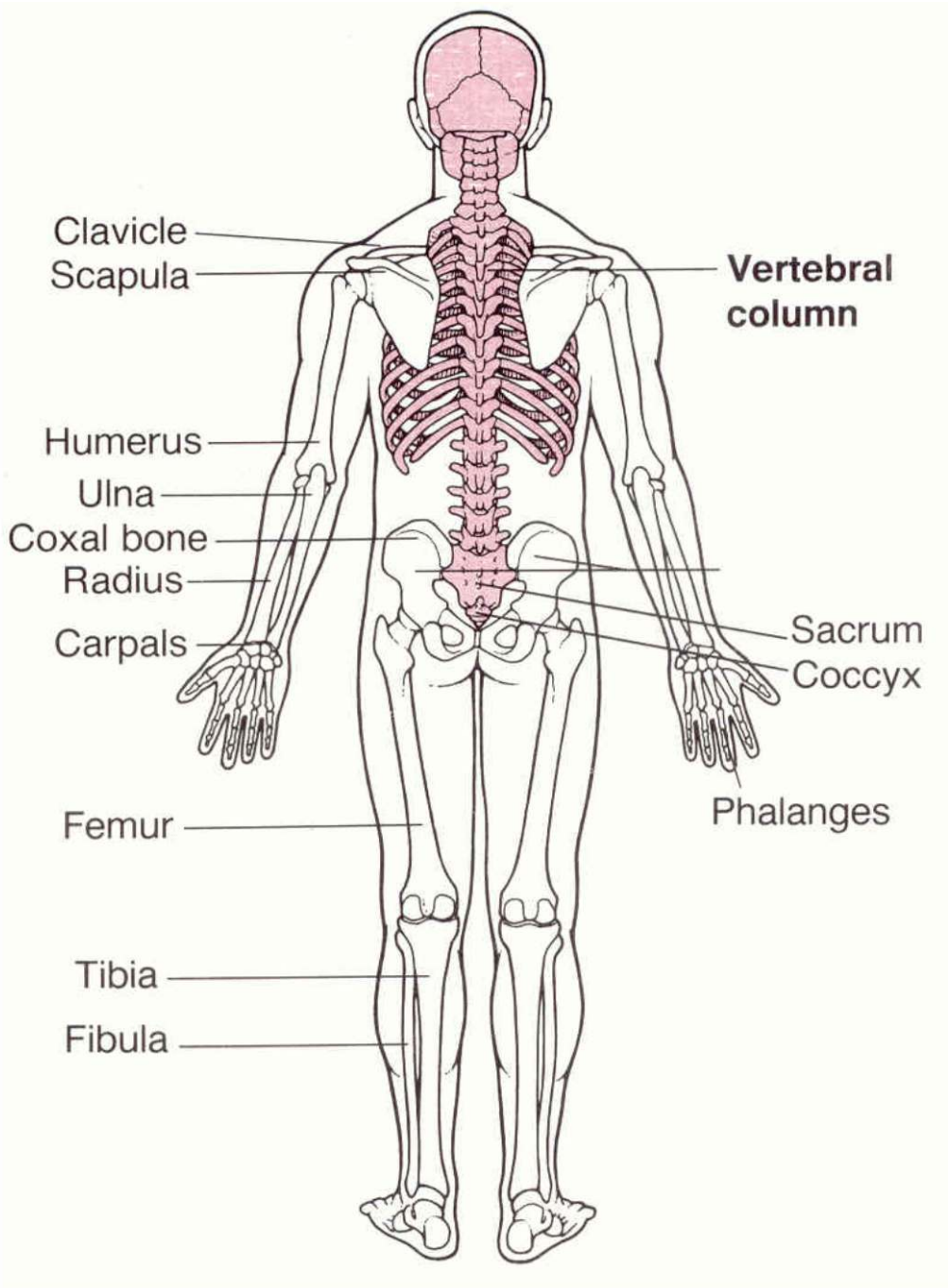
Levels of structural organization that compose the human body.

Anatomy and Physiology
The Eleven Systems

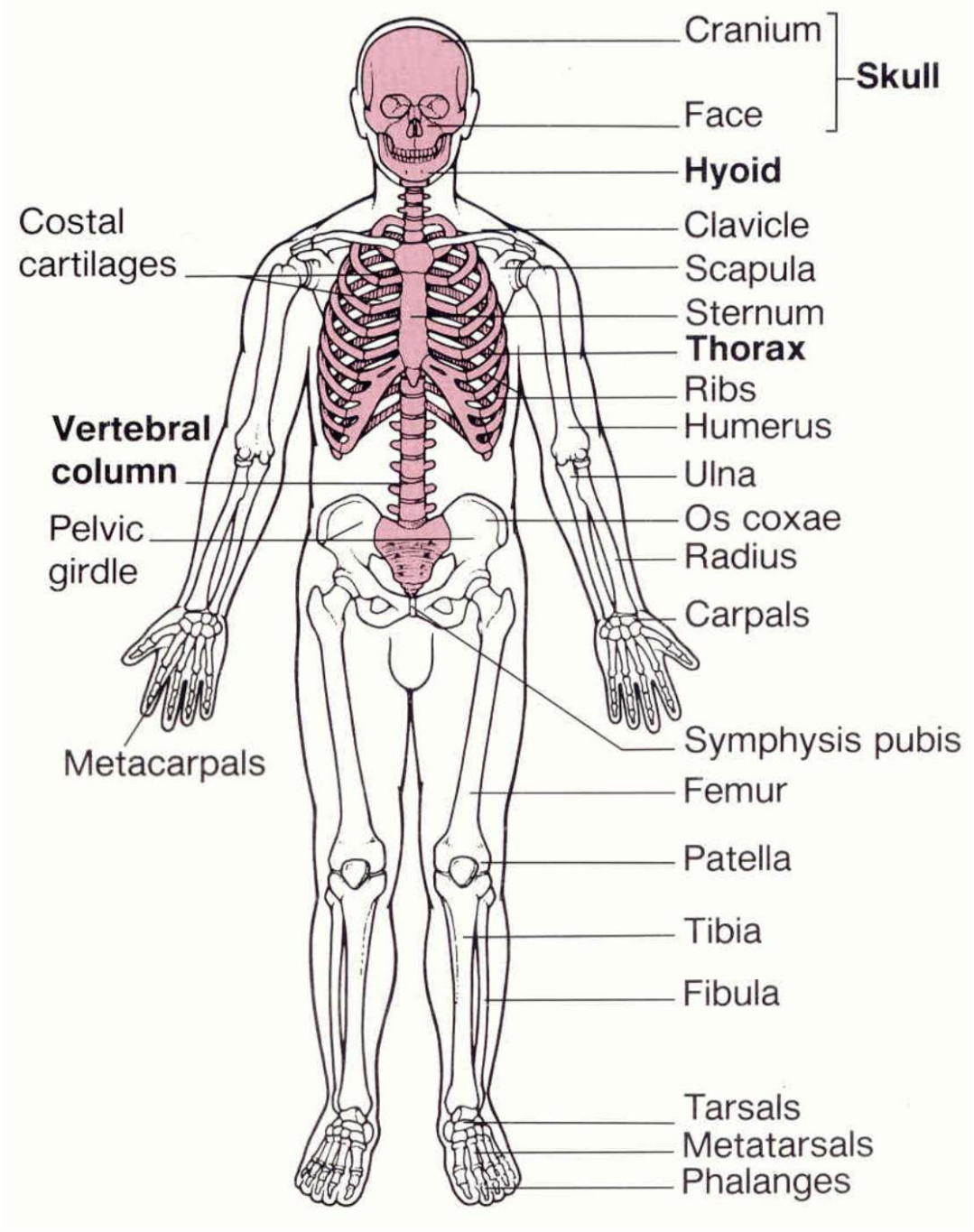




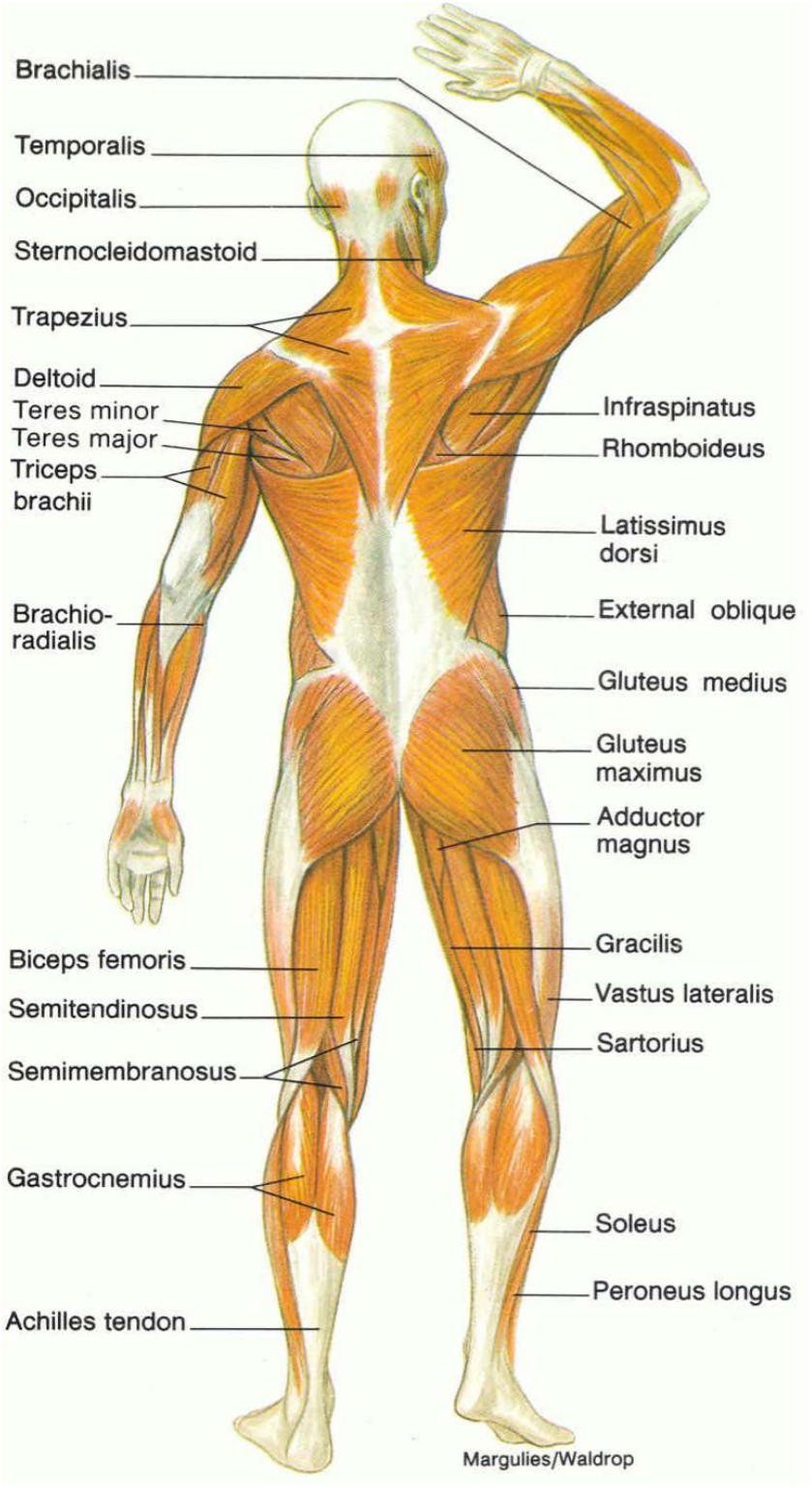
1. Integumentary System (Skin)



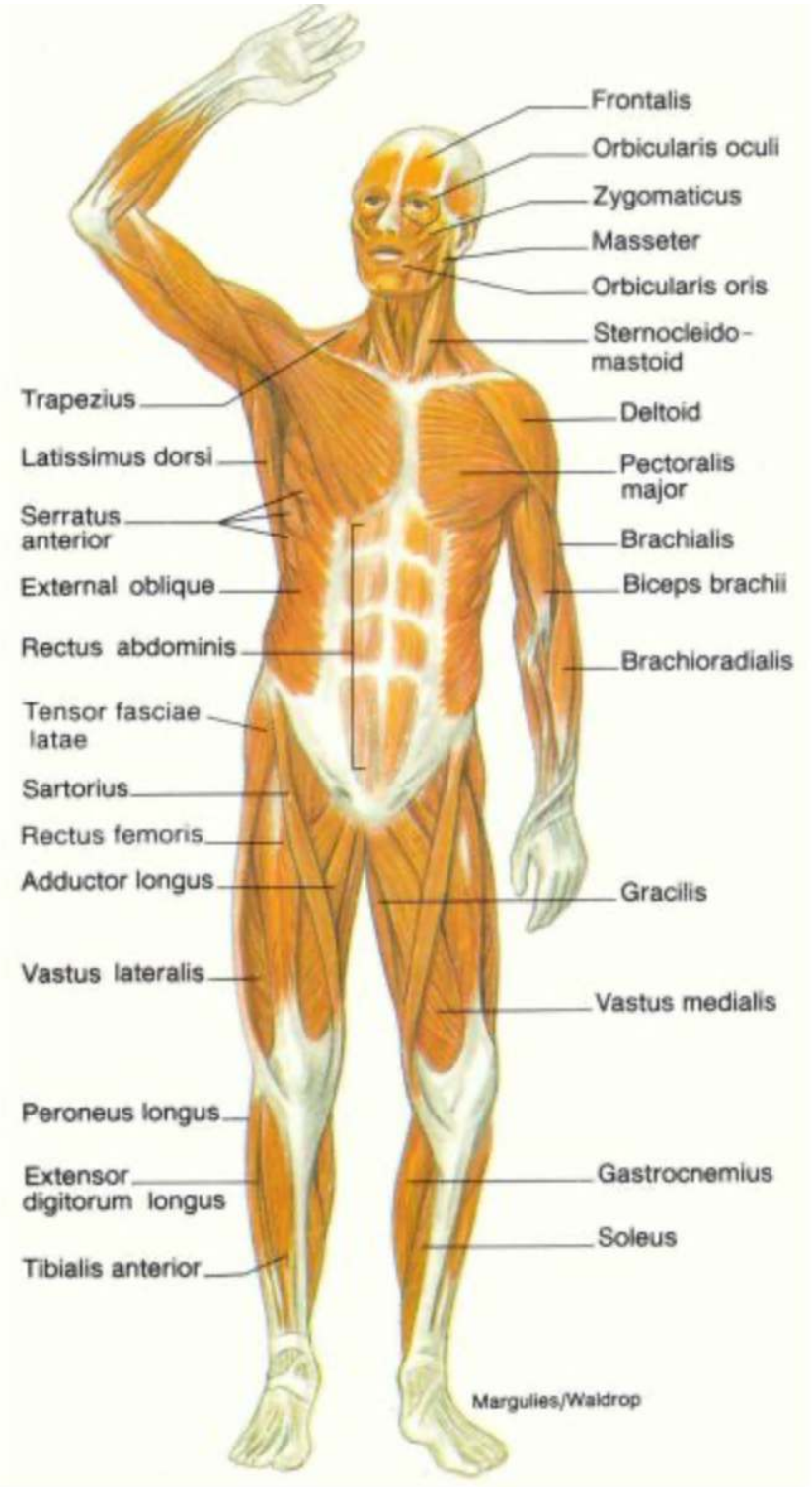
2a. Skeletal System



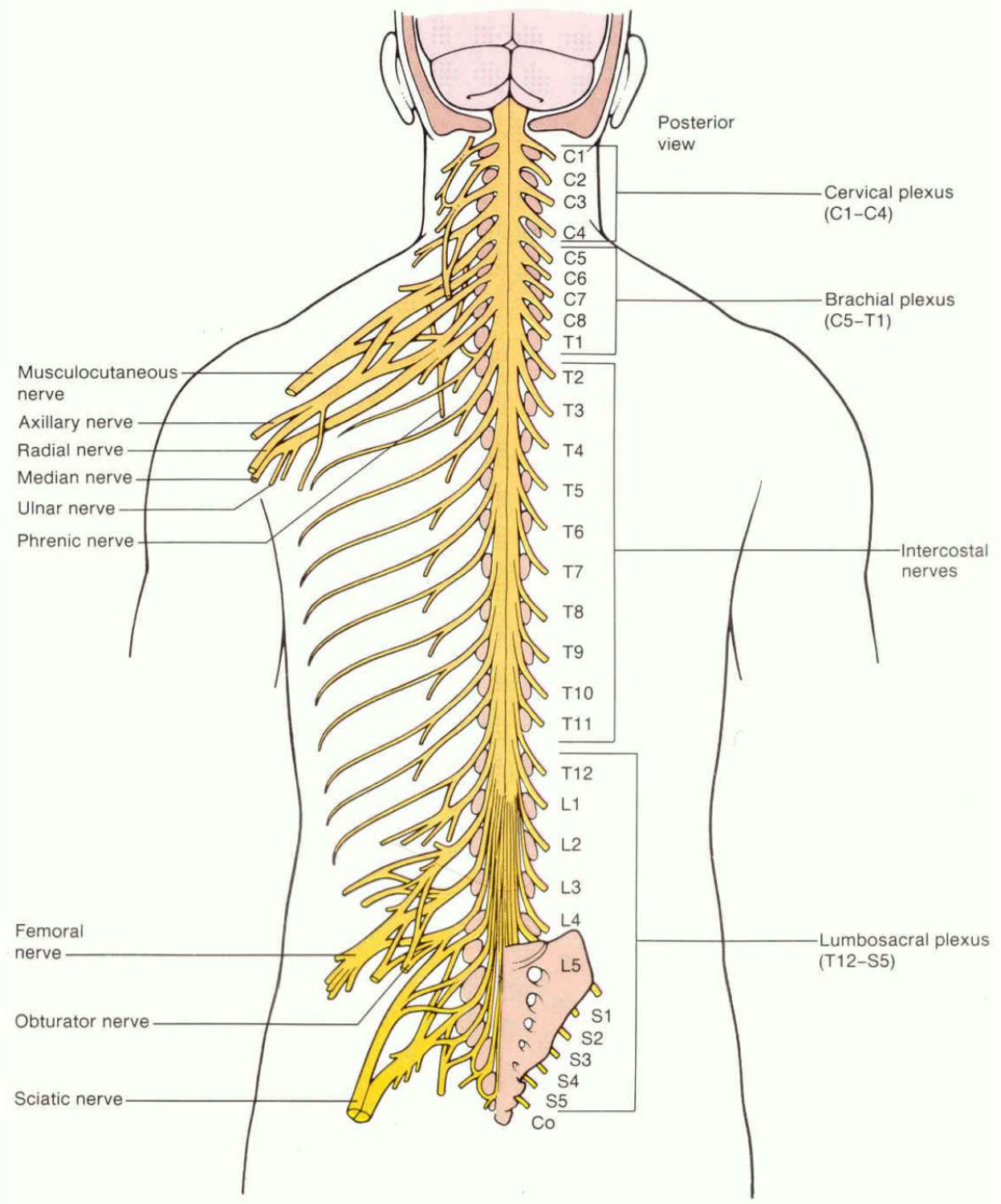
2b. Skeletal System



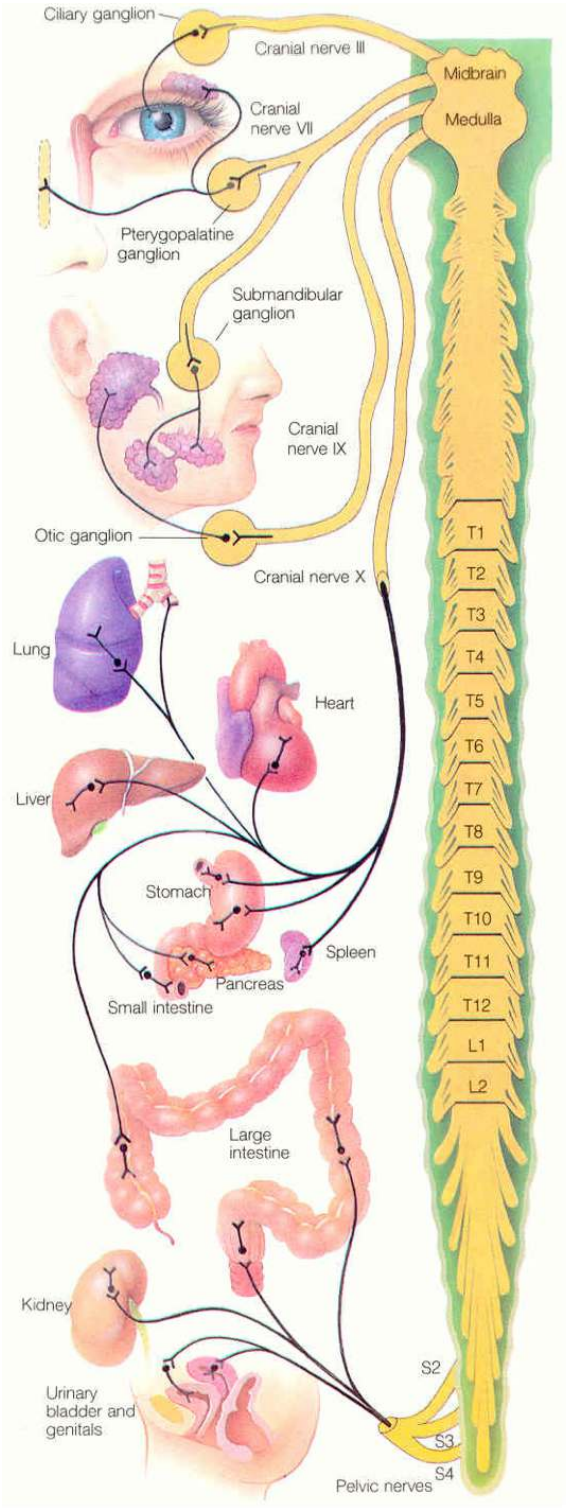
3a. Muscular System



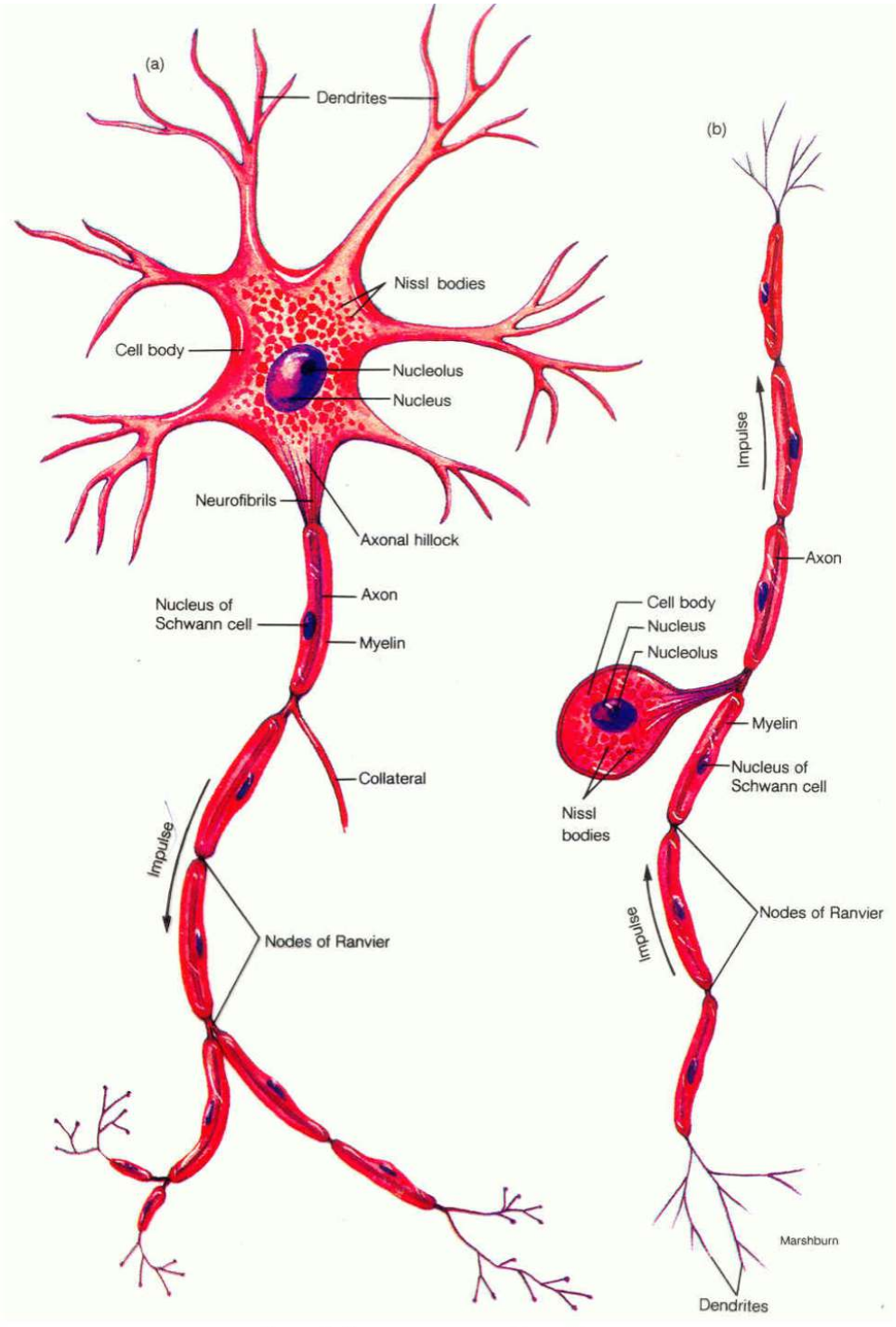
3b. Muscular System



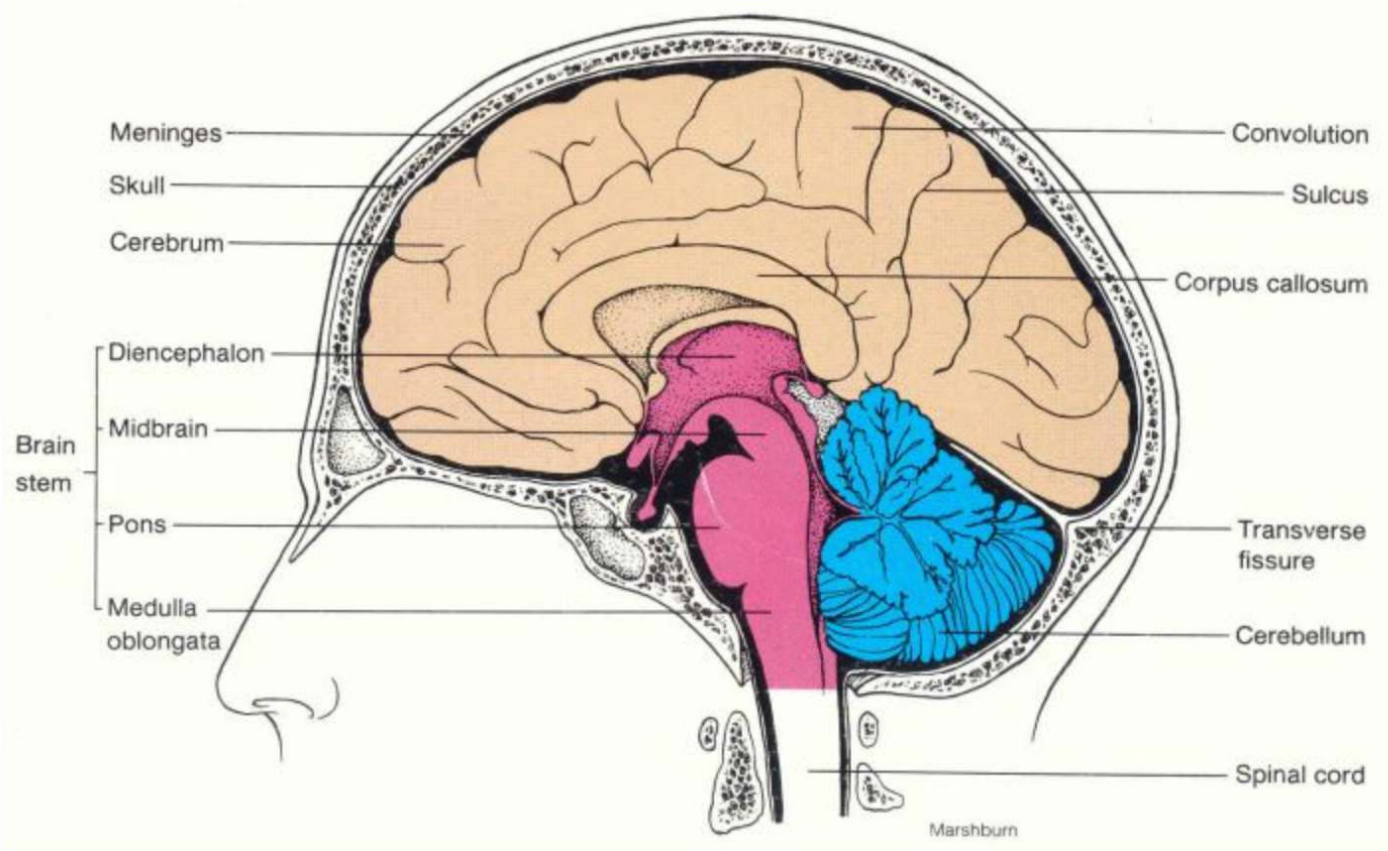
4a. Nervous System



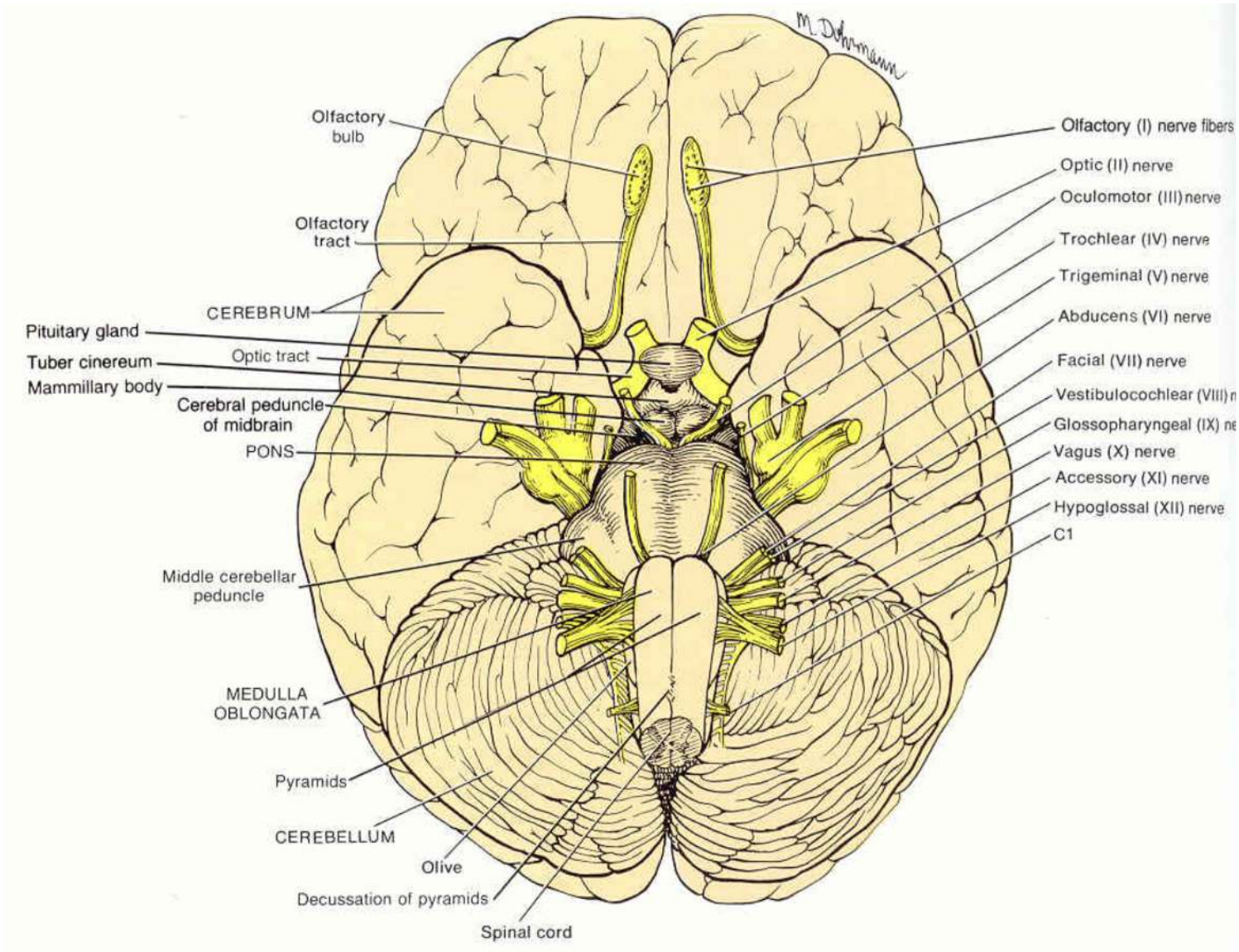
4b. Nervous System



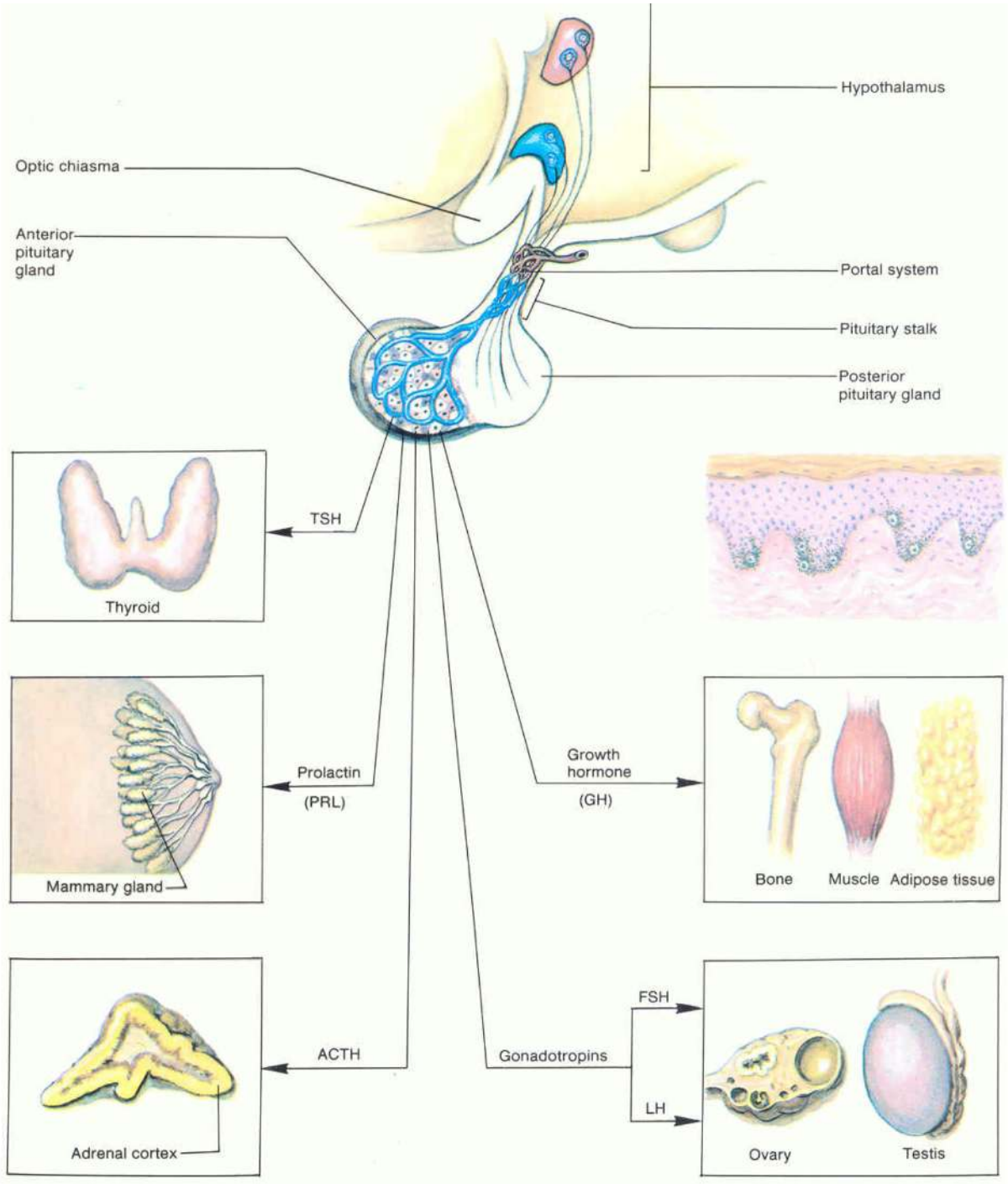
4c. Nervous System



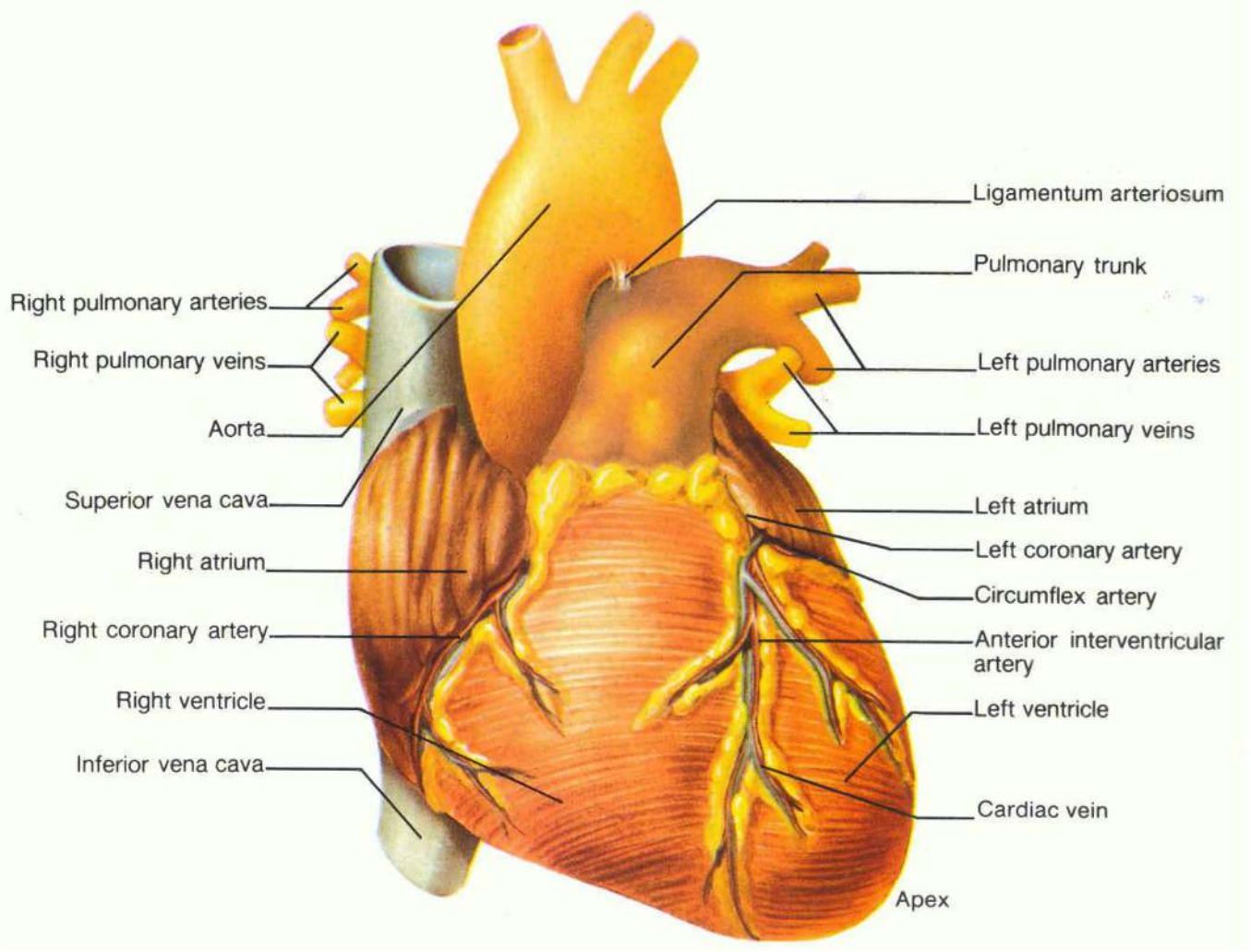
4d. Nervous System



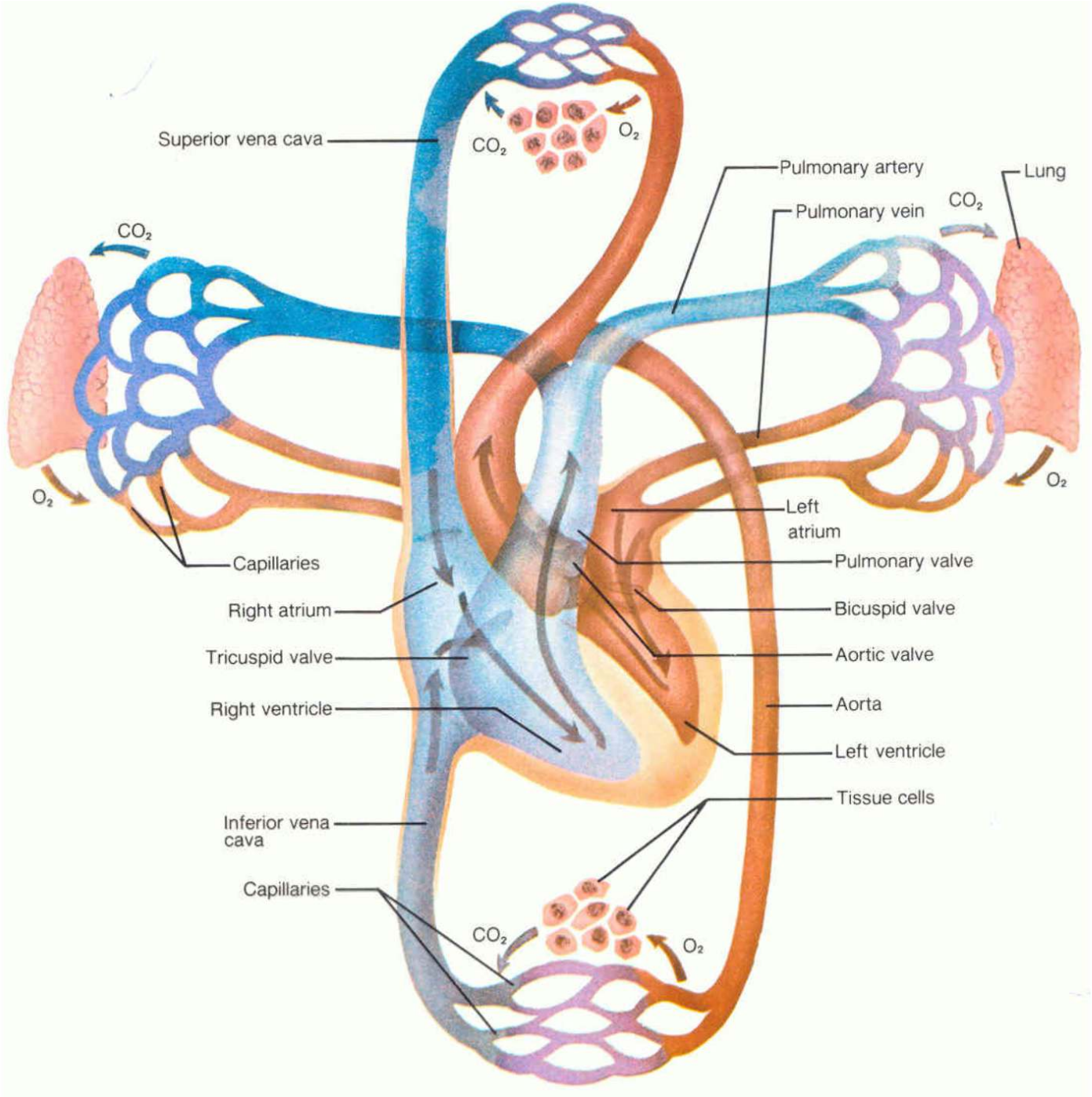
4e. Nervous System



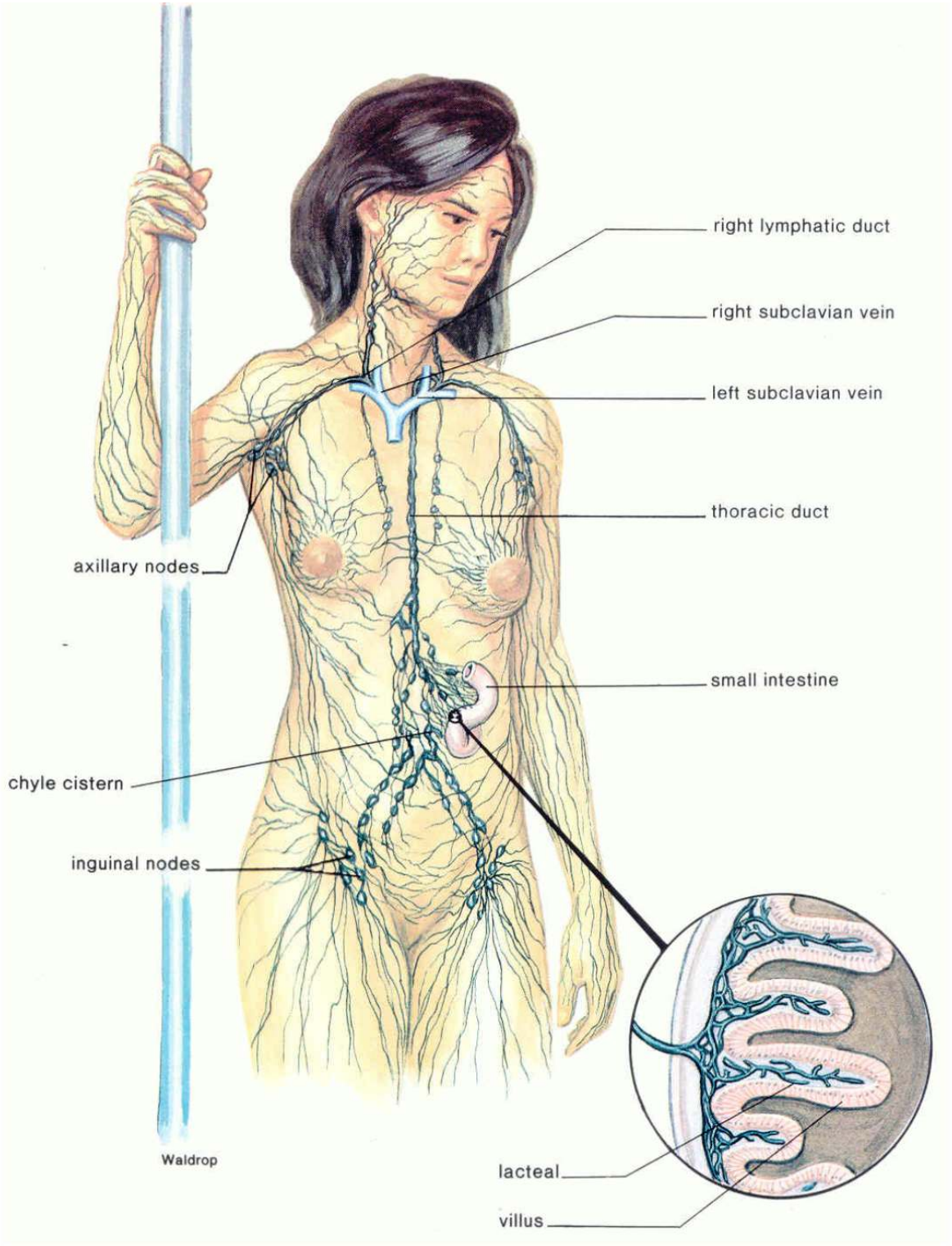
5. Endocrine System



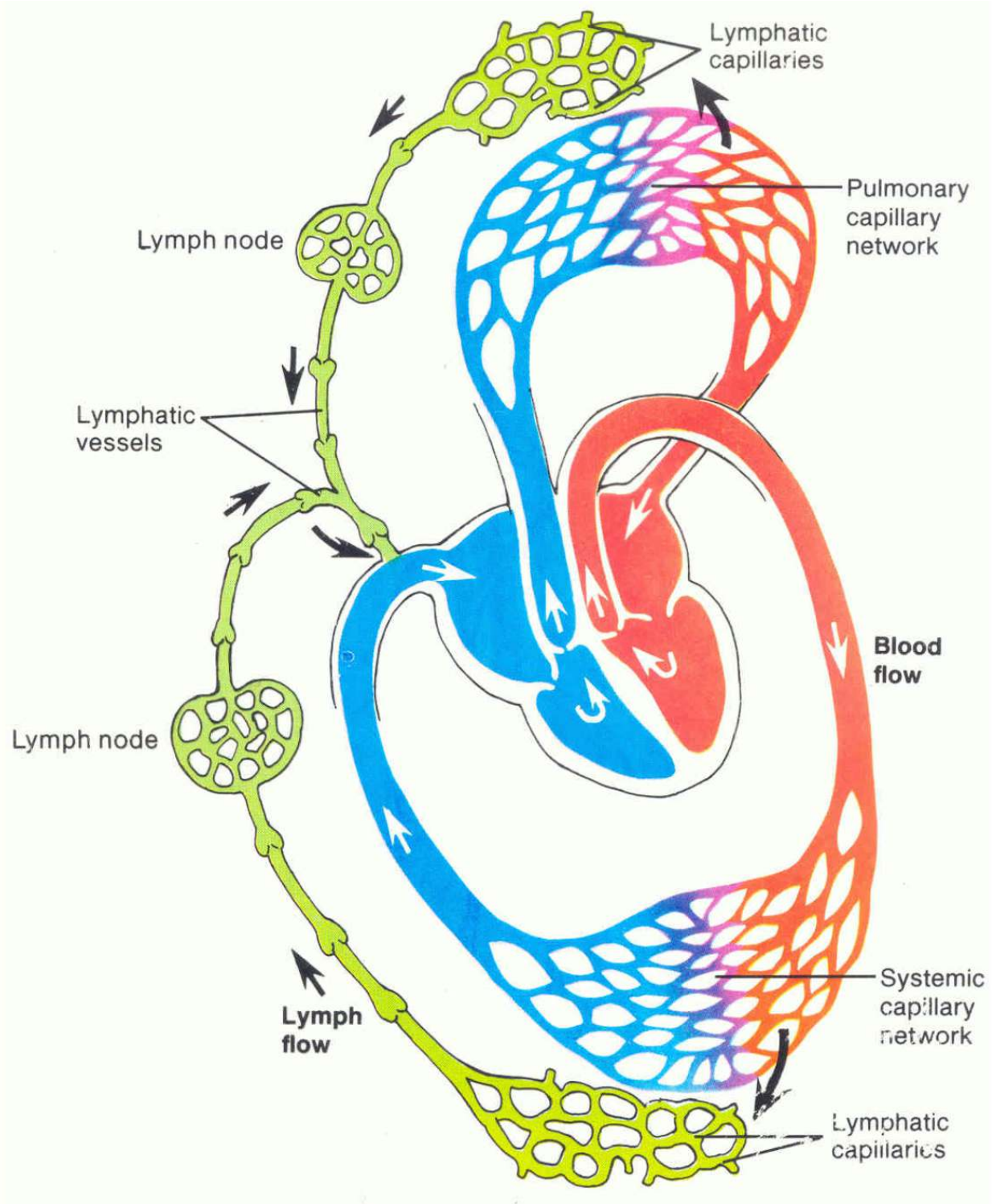
6a. Cardiovascular System



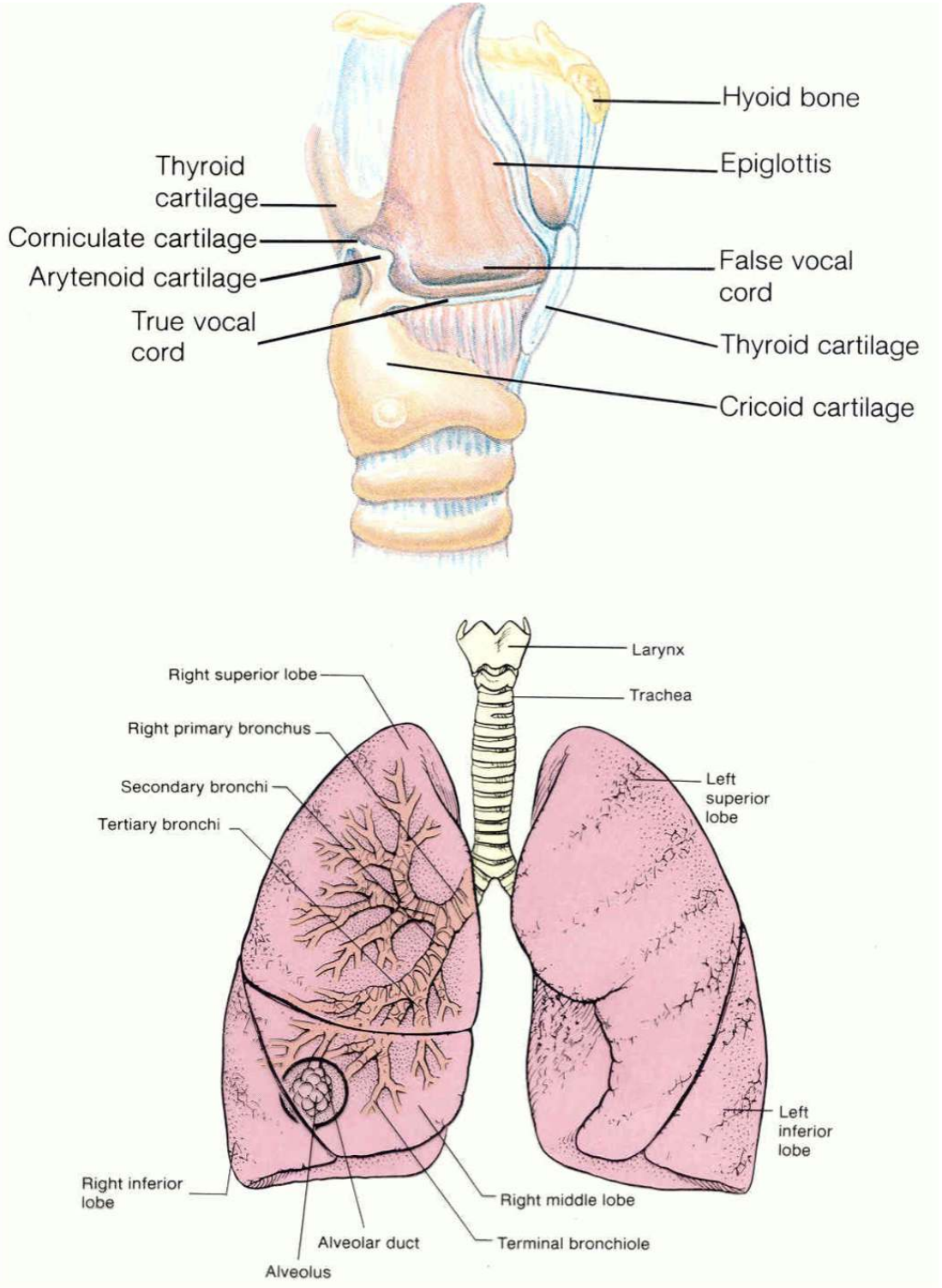
6b. Cardiovascular System

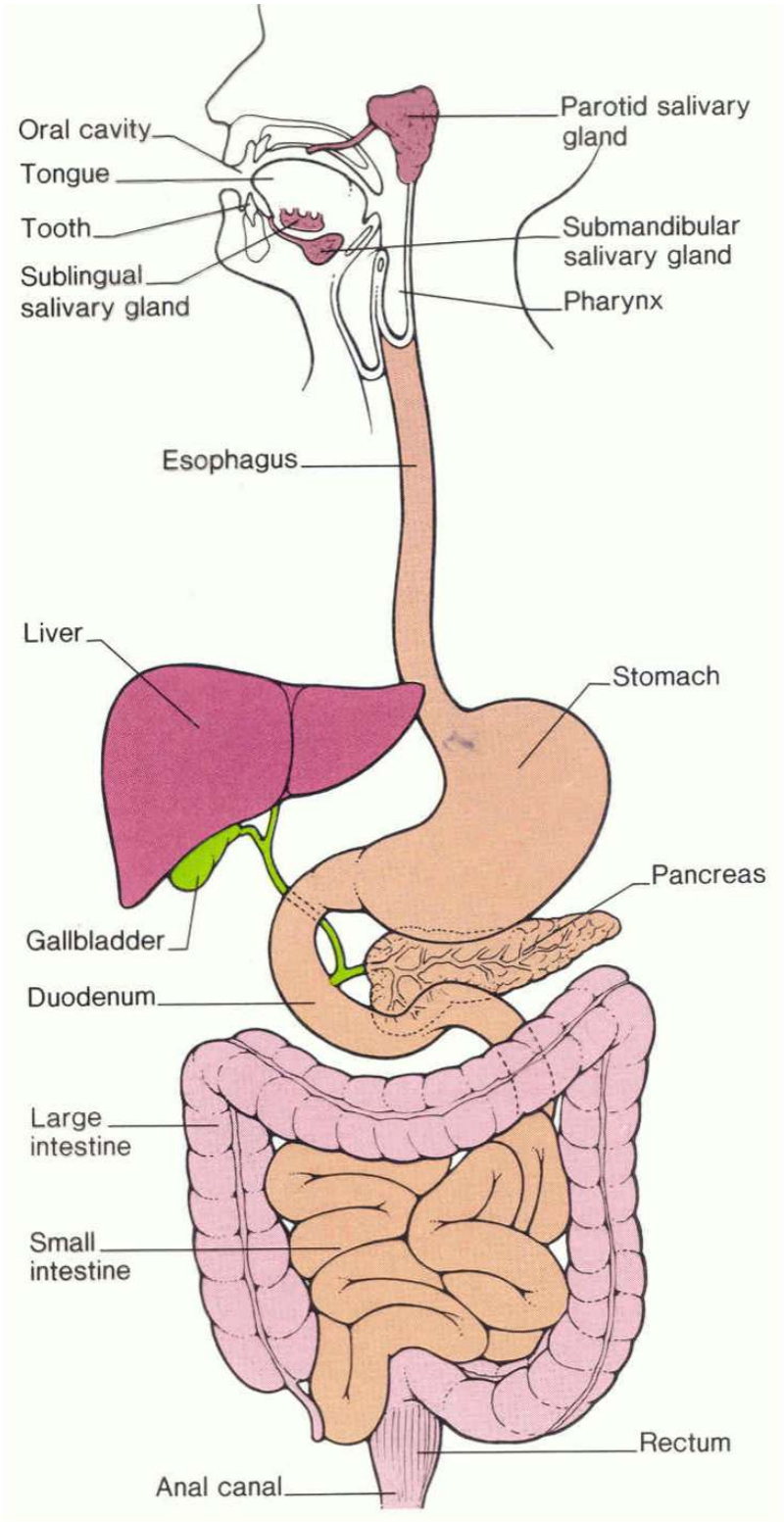


7a. Lymphatic System

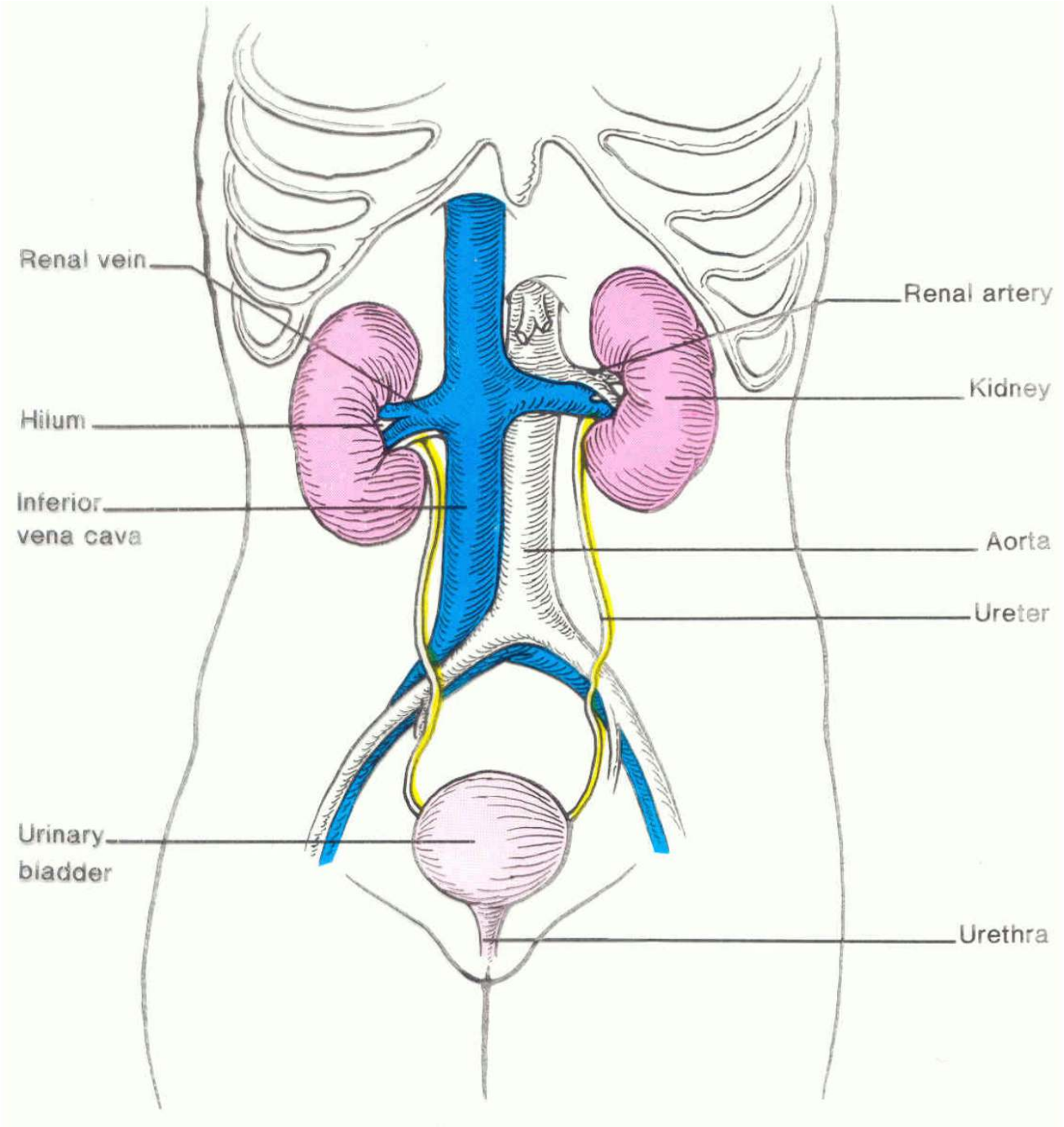


7b. Lymphatic System

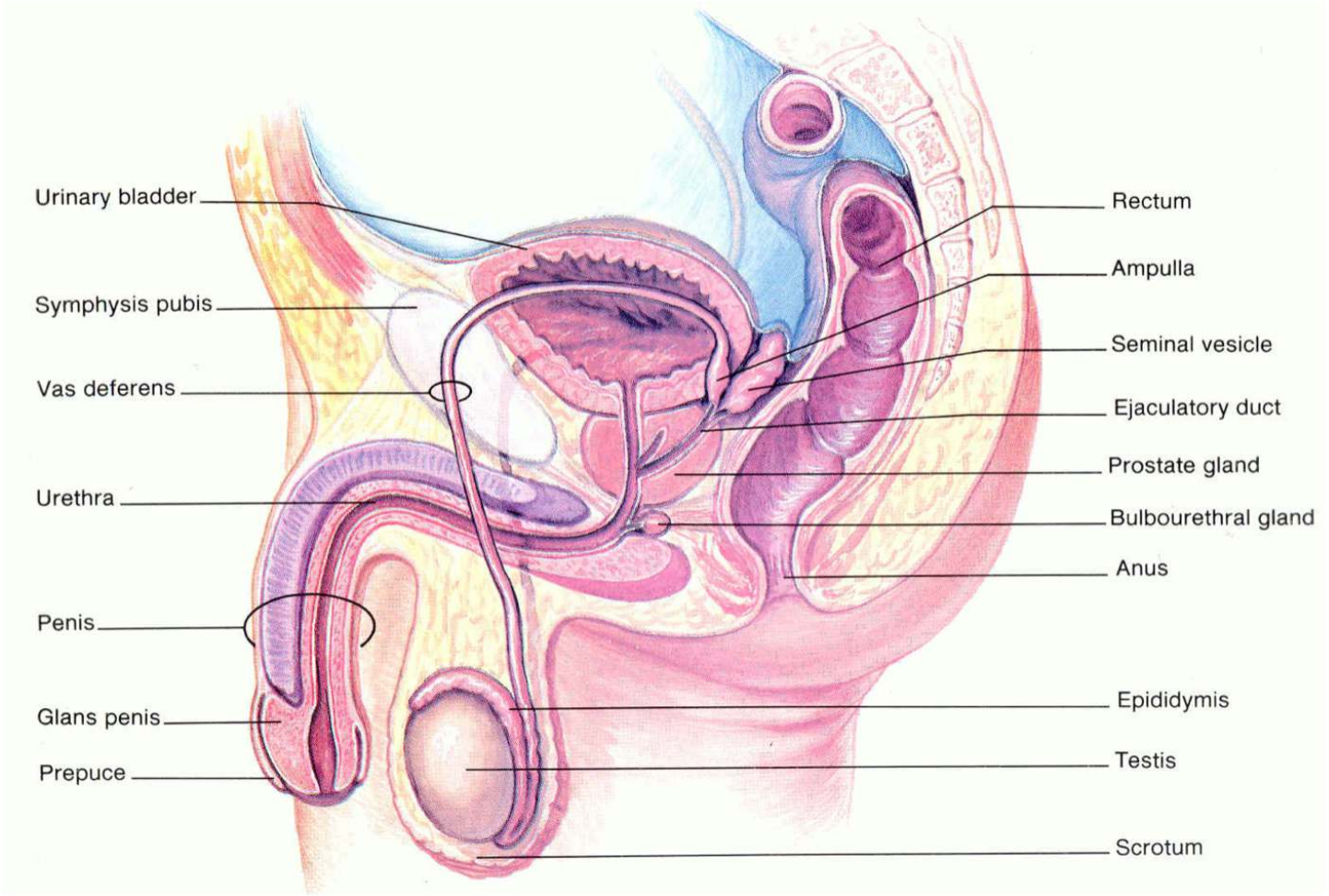

Hyoid bone
Epiglottis
Thyroid cartilage
Corniculate cartilage
Arytenoid cartilage
False vocal cord
True vocal cord
Thyroid cartilage
Cricoid cartilage
Larynx
Trachea
Right superior lobe
Right primary bronchus
Secondary bronchi
Tertiary bronchi
Left superior lobe
Left inferior lobe
Right inferior lobe
Right middle lobe
Alveolar duct
Terminal bronchiole
Alveolus



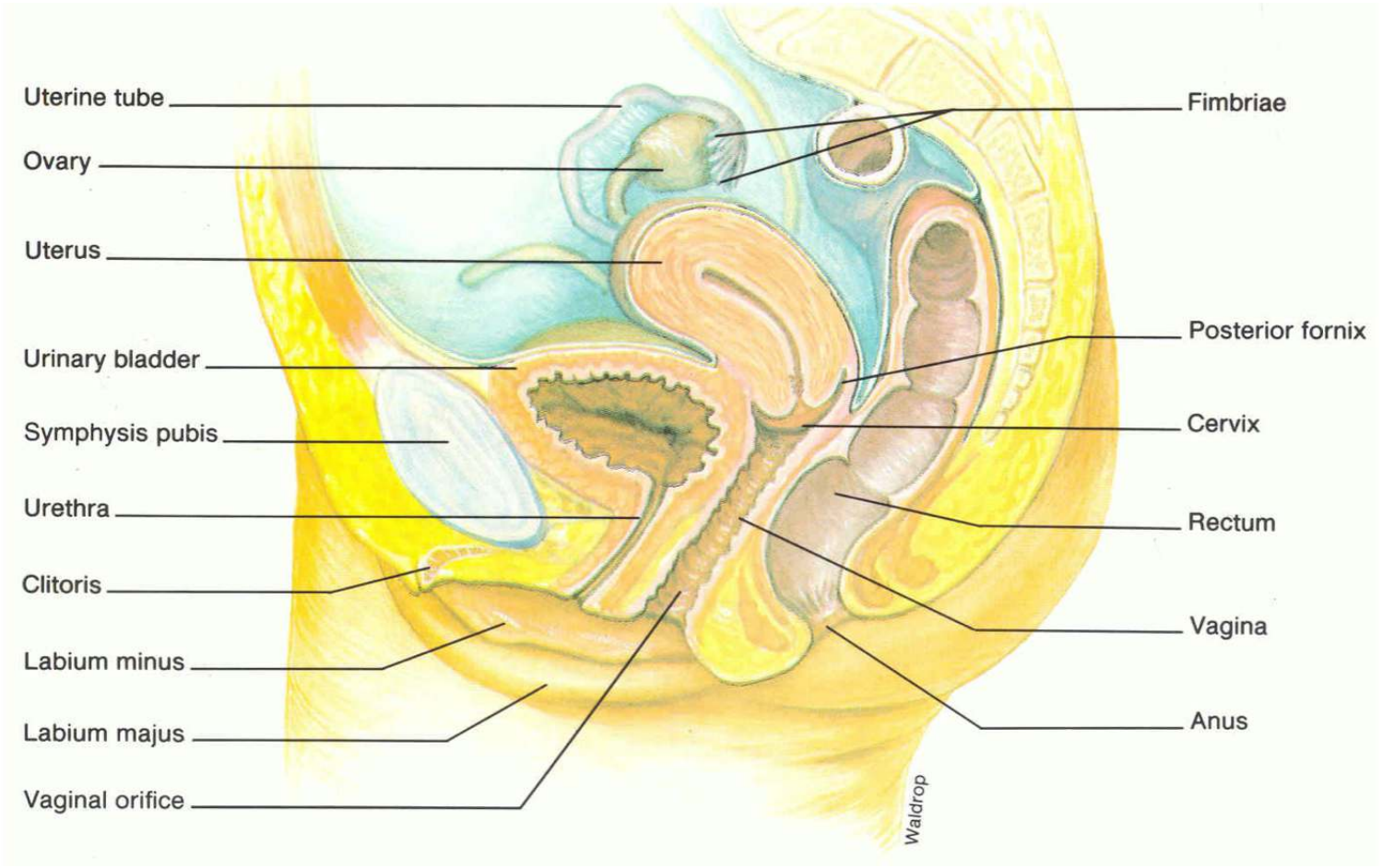
9. Digestive System



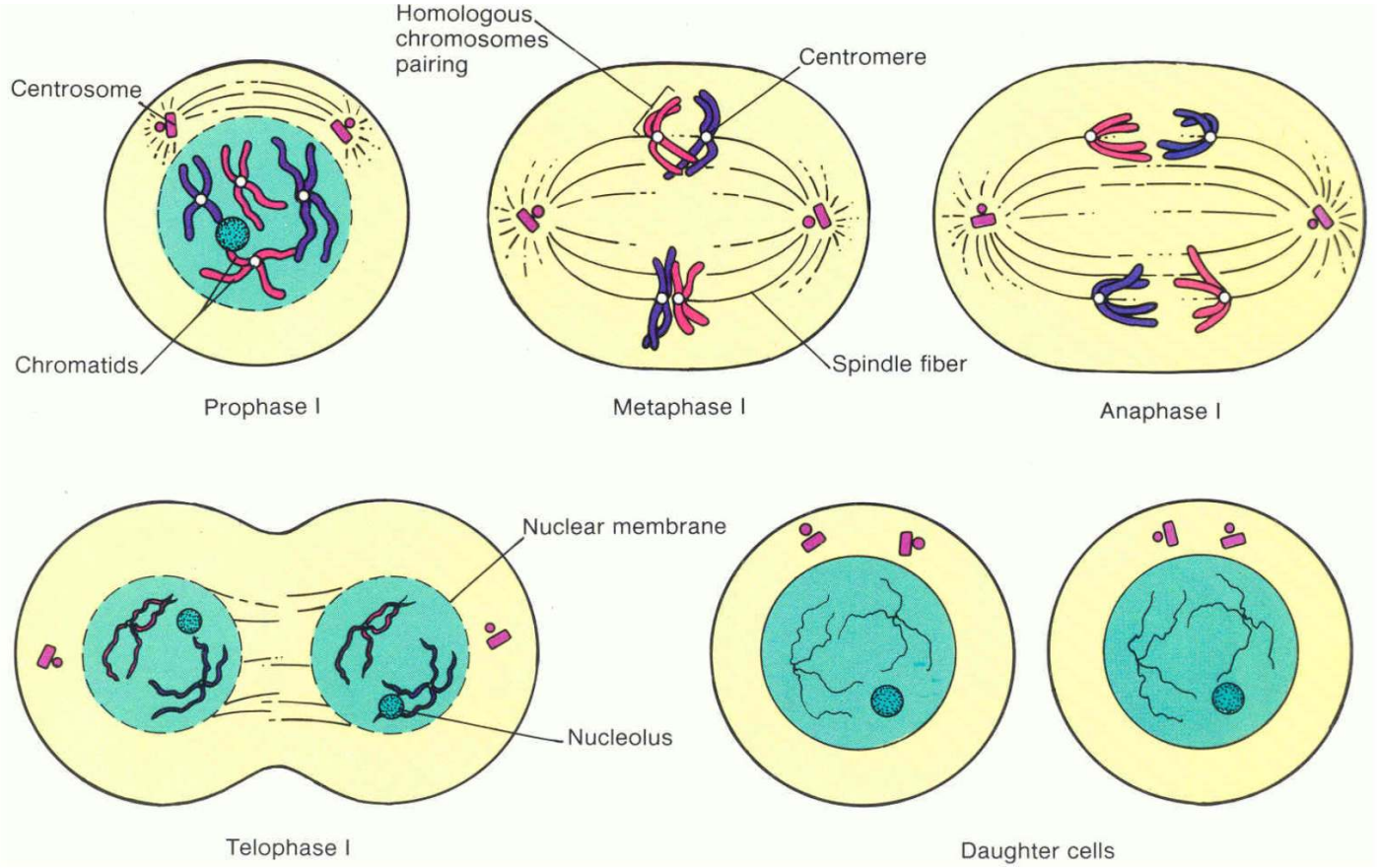
10. Urinary System



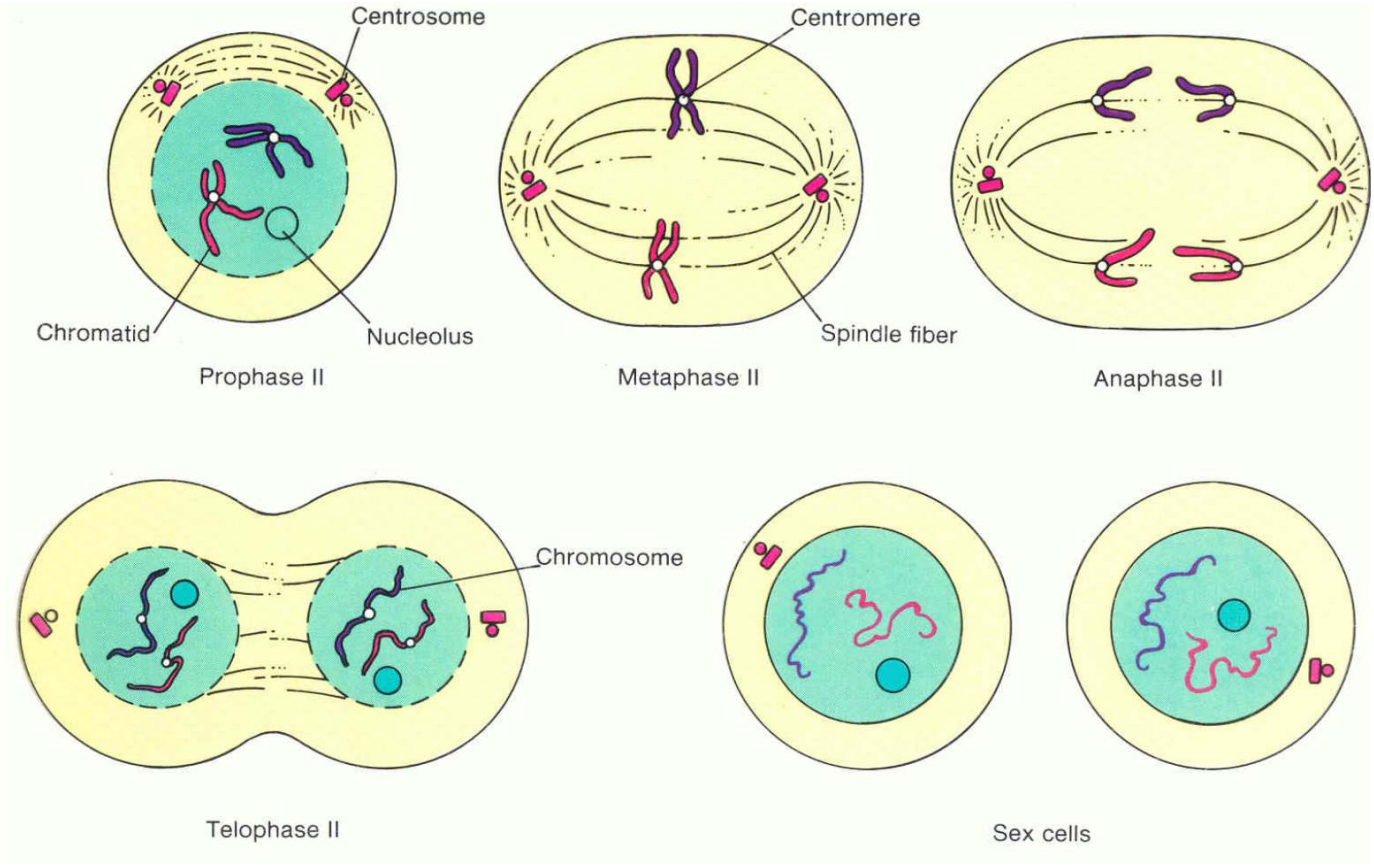
11a. Male Reproductive System



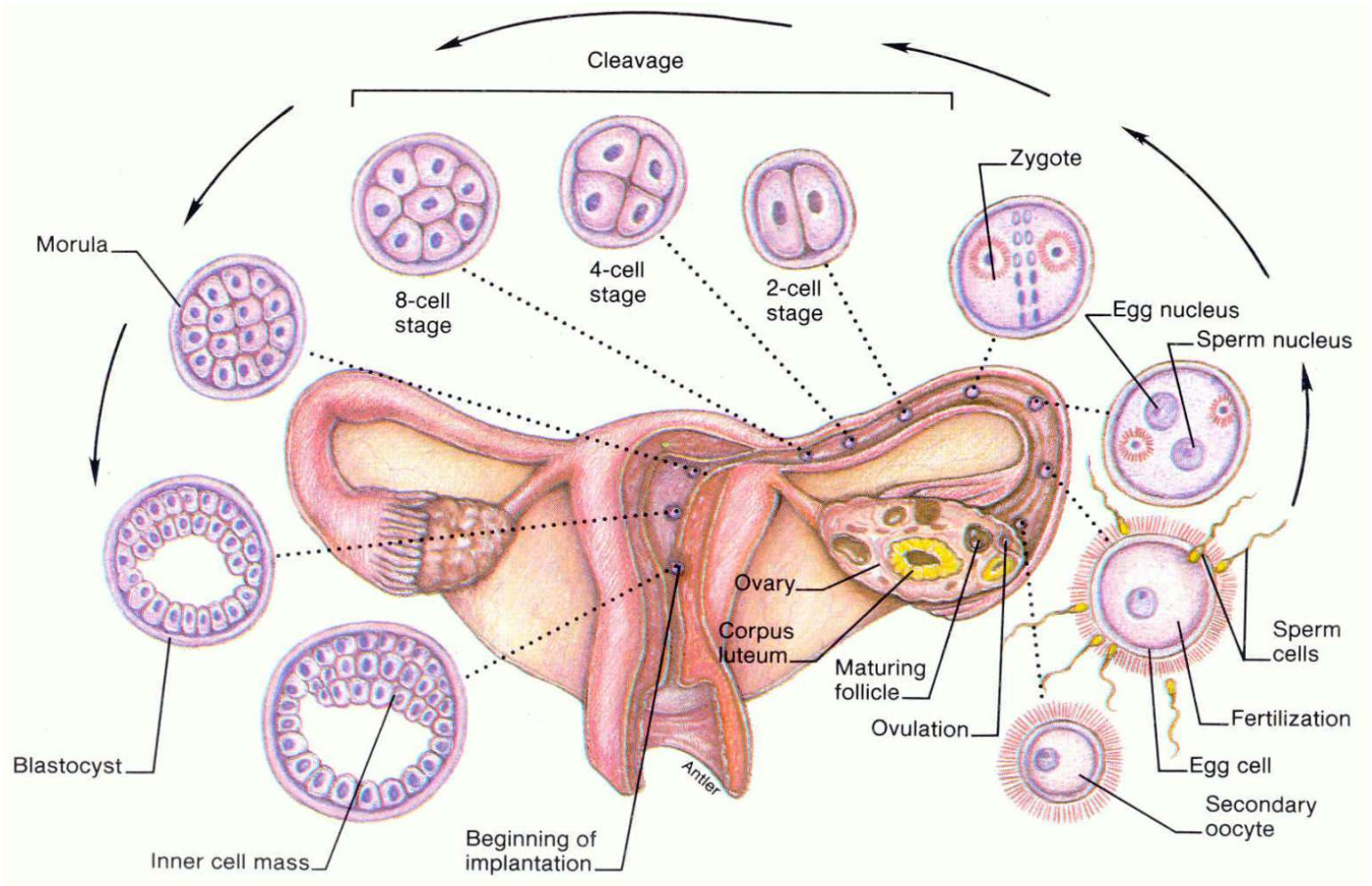
11b. Female Reproductive System



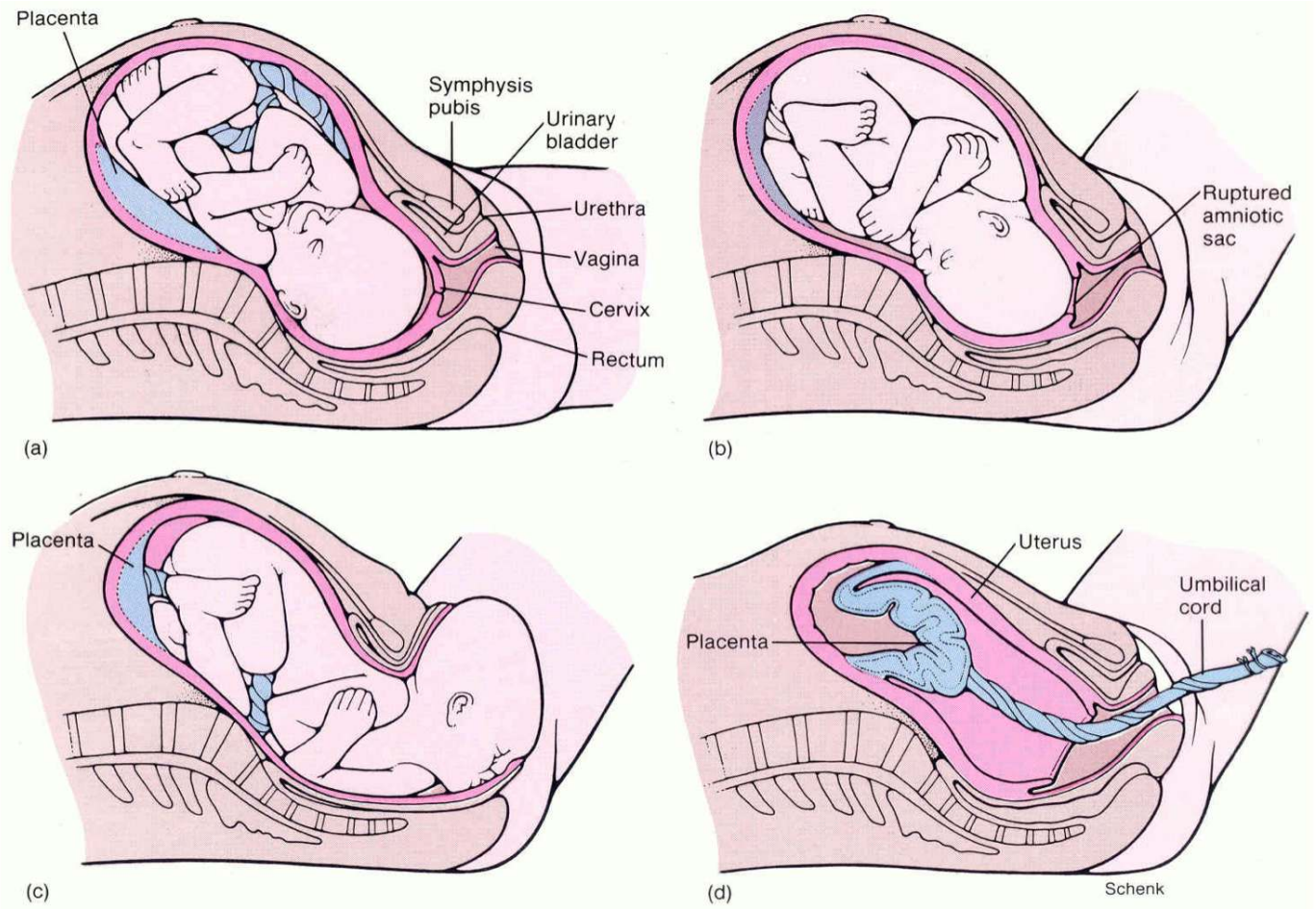
11c. Reproductive System - First Meiotic Division



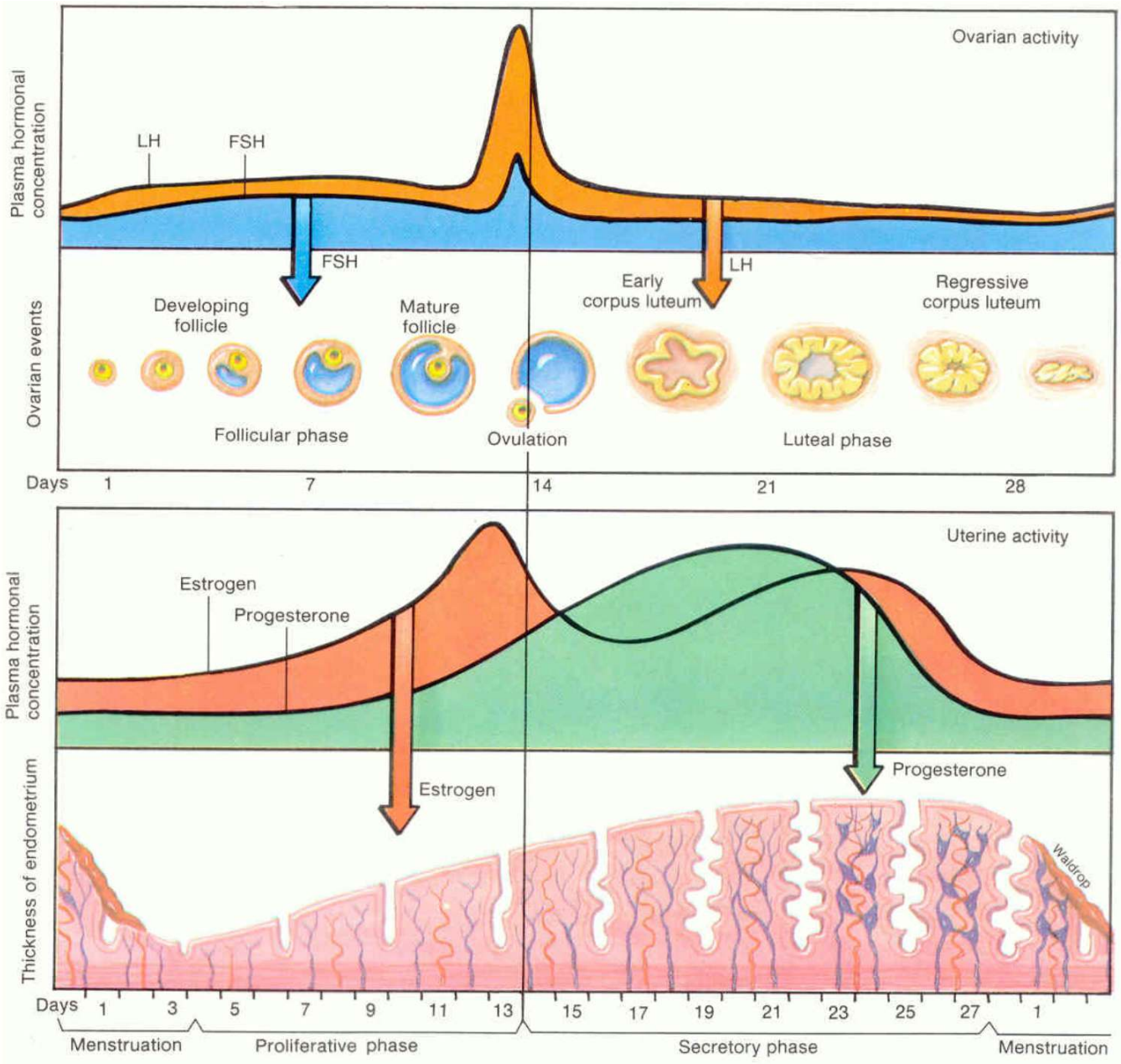
11d. Reproductive System - Second Meiotic Division



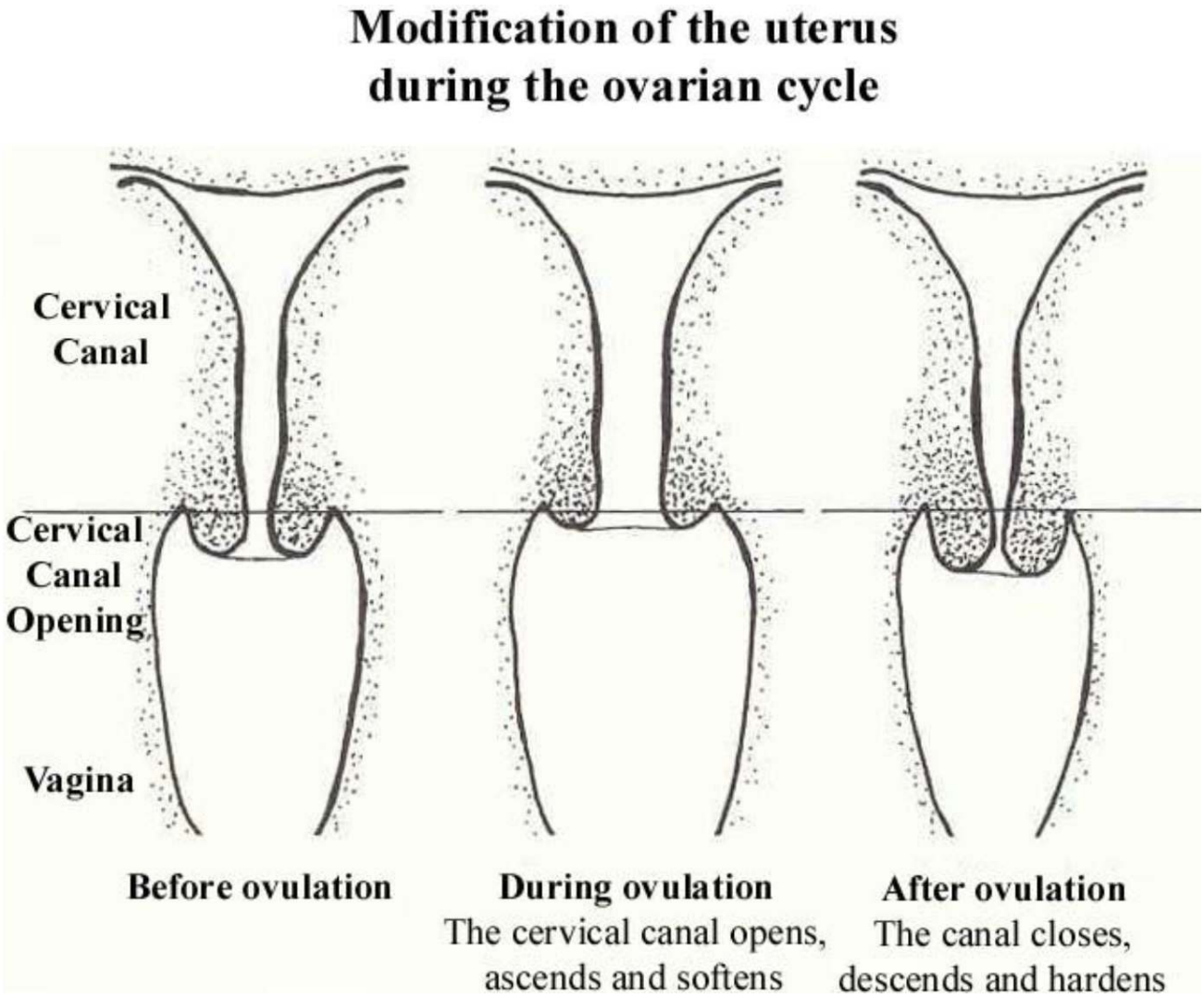
11e. Reproductive System - Human Embryonic Development



11f. Reproductive System - Birth Process



11g. Reproductive System - Menstrual Cycle



11h. Reproductive System - Uterus During Ovarian Cycle

THE OVARIAN CYCLE HAS FOUR PHASES:

"The duration of the menstrual cycle ranges from 24 to 35 days. For this report, we shall assume an average duration of 28 days. Events occurring during the menstrual cycle may be divided into four phases:

1. menstrual phase
2. preovulatory phase
3. ovulatory phase
4. postovulatory phase

1. **The menstrual phase**, also called menstruation or the menses, is the periodic discharge of 25 to 65 ml of blood, tissue fluid, mucus, and epithelial cells. It is caused by a sudden reduction in estrogens and progesterone and lasts for approximately the first 5 days of the cycle. The first day of the ovarian cycle is designated as the first day of menstruation. The discharge is associated with endometrial changes in which the stratum functionalis layer degenerates and patchy areas of bleeding develop. Small areas of stratum functionalis detach one at a time (total detachment would result in hemorrhage) the uterine glands discharge their contents and collapse, and tissue fluid is discharged. The menstrual flow passes from the uterine cavity to the cervix and through the vagina to the exterior. Generally, the flow terminates by the fifth day of the cycle. At this time the entire stratum functionalis has been shed, and the endometrium is very thin because only the stratum basalis remains.

During the menstrual phase, the ovarian cycle is also in operation. Ovarian follicles, called primary follicles, begin their development. At birth, each ovary contains about 200,000 such follicles, each consisting of a primary oocyte (potential ovum) surrounded by a single flattened layer of epithelial (follicular) cells.

2. **The preovulatory phase**, the second phase of the menstrual cycle, is the time between menstruation and ovulation. This phase of the menstrual cycle is more variable length than the other phases. It lasts from days 6 to 13 in a 28-day cycle.

During the preovulatory phase, one of the secondary follicles in the ovary matures into a vesicular ovarian (Graafian) follicle or mature follicle, a follicle ready for ovulation. This follicle produces a bulge on the surface of the ovary. During the maturation process, the follicle increases its estrogen production. Early in the preovulatory phase, FSH is the dominant hormone

of the anterior pituitary, but close to the time of ovulation, it is secreted in increasing quantities. Moreover, small amounts of progesterone may be produced by the vesicular ovarian (Graafian) follicle a day or two before ovuation.

3. **Ovulation**, the rupture of the vesicular ovarian (Graafian) follicle with release of the secondary oocyte into the pelvic cavity, usually occurs on day 14 in a 28-day cycle. During ovulation, the secondary oocyte remains surrounded by its zona pellucida and a covering of follicle cells directly around it. These cells are referred to as the corona radiata. It generally takes 10 to 14 days for a primary follicle to develop into a vesicular ovarian (Graafian) follicle, and it is during this time that the developing ovum completes reduction division (meiosis 1) and reaches metaphase of equatorial division (meiosis II). The developing ovum is in this stage when it is discharged during ovulation. The fimbriae of the uterine tubes drape over the ovaries and become active near the time of ovulation. Movements of the fimbriae and ciliary action create currents in the peritoneal serous fluid that carry the secondary oocyte into the uterine tube.

Just prior to ovulation, the high level of estrogens that developed during the preovulatory phase exert a positive feedback directly on both LH and GnRH. LH release increases sharply because of the direct effect of estrogens on the anterior pituitary and also because of the increase in secretion of GnRH by the hypothalamus. This causes the anterior pituitary to release a surge of LH. Without this surge of LH, ovulation will not occur. (An over-the-counter home test that detects the LH surge associated with ovulation is now available. The test predicts ovulation a day in advance.) FSH also increases at this time, but riot as dramatically as LH because FSH is stimulated only by the increase in GnRH. Following ovulation, the vesicular ovarian (Graafian) follicle collapses, and blood within it forms a clot called the corpus hemorrhagicum. The clot is eventually absorbed by the remaining follicular cells. In time, the follicular cells enlarge, change character, and form the corpus luteum, or yellow body, under the influence of LH, which also stimulates the corpus luteum to secrete estrogens and progesterone.

CLINICAL APPLICATION: SIGNS OF OVULATION

One sign of ovulation involves basal temperature (body temperature at rest). When menstruation ceases, the temperature is taken immediately upon awakening each morning and marked on a chart. An increase in

temperature, usually between 0.4 to 0.6°F, typically occurs about 14 days after the start of the last menstrual cycle and is due to increasing levels of progesterone. The 24 hours following this rise in temperature is the period immediately following ovulation and is generally considered the best time to become pregnant. The accuracy of the determination depends on many factors including individual variations, the accuracy of the temperature readings, and any factor other than the ovarian cycle that might affect body temperature.

Another sign of ovulation is the amount and consistency of cervical mucus. Secretion of cervical mucus is regulated by estrogens and progesterone. At midcycle, near the time of ovulation, increasing levels of estrogens cause secretory cells of the cervix to produce large amounts of cervical mucus.

About a day or two before ovulation, the quantity of mucus frequently begins to decrease and usually disappears a few days after ovulation. More important, as ovulation approaches, the mucus becomes clear, stretchy (it may stretch from 2.54 to 15.24 cm, that is, 1 to 6 inches), and slippery and causes feelings of lubrication, slipperiness, or wetness on the outer lips (labia majora) of the external genitals. This is the more fertile type of mucus and indicates the time of greatest fertility. Around the day of ovulation, cervical mucus becomes nonstretchy, tacky, thicker, and more opaque and then disappears by a few days after ovulation. This less fertile mucus is produced in response to the influence of progesterone.

The cervix also exhibits signs of ovulation. The external os opens, the cervix rises, and the cervix becomes softer. There is also abundant cervical mucus.

Some females also experience a pain in the area of one or both ovaries around the time of ovulation. Such pain is called mittelschmerz (MIT-el-shmarts), meaning "pain in the middle," and may last for several hours to a day or two.

4. **The postovulatory phase** of the menstrual cycle is the most constant in duration and lasts from days 15 to 28 in a 28-day cycle. It represents the time between ovulation and the onset of the next menses. Following ovulation, LH secretion stimulates the development of the corpus luteum. The corpus luteum then secretes increasing quantities of estrogens and progesterone. Progesterone is responsible for preparing the endometrium

to receive a fertilized ovum. Preparatory activities include secretory activity of the endometrial glands that causes them to appear tortuously coiled, vascularization of the superficial endometrium, thickening of the endometrium, glycogen storage, and an increase in the amount of tissue fluid. These preparatory changes are maximal about one week after ovulation, and they correspond to the anticipated arrival of the fertilized ovum. During the latter post-ovulatory phase, FSH secretion again gradually increases and LH secretion decreases. The functionally dominant ovarian hormone during this phase is progesterone. The relation of progesterone to prostaglandins is causing painful menstruation.

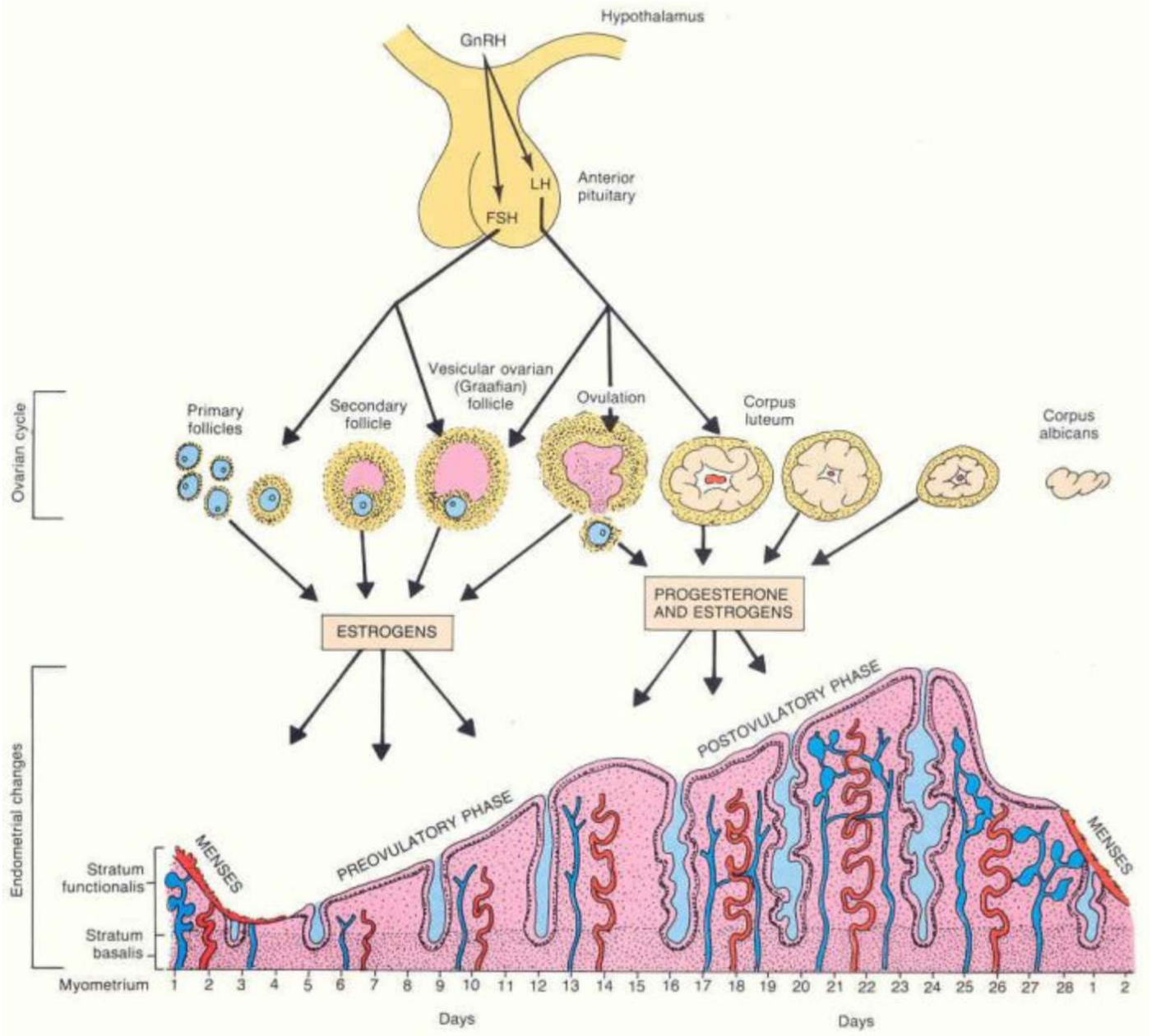
If fertilization and implantation do not occur, the rising levels of progesterone and estrogens from the corpus luteum inhibit GnRH and LH secretion. As a result, the corpus luteum degenerates and becomes the corpus albicans, or white body. The decreased secretion of progesterone and estrogens by the degenerating corpus luteum then initiates another menstrual period. In addition, the decreased levels of progesterone and estrogens in the blood bring about a new output of the anterior pituitary hormones especially FSH in response to an increased output of GnRH by the hypothalamus. Thus, a new ovarian cycle is initiated. If, however, fertilization and implantation do occur corpus luteum maintained until the placenta takes its hormone-producing functions. During this time, corpus luteum secretes estrogens and progesterone. corpus luteum is maintained by human chorionic re-ON-ik) gonadotropin (hCG), a hormone prodl by the developing placenta. Presence of hCG is an indication that a female is pregnant The placenta itself secretes estrogens to support pregnancy and progesterone to support pregnancy and breast development for lactation. Once the placenta begin secretion, the role of the corpus luteum becomes minor.

Menarche and Menopause
The menstrual cycle normally occurs once each month from menarche (me-NAR-ke), the first menses to menopause (mens = monthly; pausa = to stop), last menses. The advent of menopause is signaled by the climacteric (kli-MAK-ter-ik) -menstrual cycles become less frequent. The climacteric, which typically begin between ages 40 and 50, results from the failure of the ovaries to respond to the stimulation of gonafotropic hormones from the anterior pituitary." Principles of Anatomy and physiology, Harper Collins Publisher, p. 901-904.

Note:
"The rising and descending of the cervix is different for each woman. For some women, it is very slow and may take a few days, for others, it may take only a few hours. It explains why some women can get pregnant easily while for others it is more difficult. Once the cervix has risen and comes down again, conception is impossible, no matter how long or irregular is the cycle. Once the cervix descends, the woman is infertile for fourteen days until her next menstruation. With this knowledge, a woman may decide when she wants children and how many she wants, without the use of other anti-contraceptive method.

According to David M. Rorwik and Landrum B. Shettles, M.D. Ph.D., in their book entitled 'Your baby's sex: now you can choose', a girl is conceived between the end of the menstruation and the ovulation, while a boy is conceived on the day of the ovulation and the next day."

Les Cinq Dimensions de la Sexuality Feminine, Daniele Starenkyj, p. 45, 46. (graphe p. 46.), Orion Publications, To order: 819-848-2888.


Hypothalamus
GnRH
LH
FSH
Anterior pituitary
Ovarian cycle
Primary follicles
Secondary follicle
Vesicular ovarian (Graafian) follicle
Ovulation
Corpus luteum
Corpus albicans
ESTROGENS
PROGESTERONE AND ESTROGENS
Endometrial changes
MENSES
PREOVULATORY PHASE
POSTOVULATORY PHASE
MENSES
Stratum functionalis
Stratum basalis
Myometrium
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 1 2
Days
Days