ISBN 978-615-5169-12-0 The Illusion (The Science of Human Perception)

MEDICAL UNIVERSITY CERTIFIED
IMUNE
MEDICAL TEXTBOOK

WARNING!

This book contains provocative material not for children or the sexually immature

The Illusion

The Science of Human Perception

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Introduction

We now know that the world/universe is made up of atoms and these atoms are made up of very small subatomic particles. These particles are so small and are vibrating and moving very fast. The electrons are moving at 600 miles a second. If we condensed these particles of matter any object would be very very very very very VERY VERY small.

Less than 99.99999999999999999999999999% of the world is solid matter. The rest of the world is just empty space. Objects only appear to be solid because of the speed of movement of the subatomic particles.

The human being has no ability to directly perceive the world as it truly is. Thus everything we see is an illusion. All is a whimsy vision, a trick of perception. Everything we see, feel, hear, smell, taste and intuit is but a phantasm, mirage, or delusion of fancy.

The rules of these small particles are the rules called quantum. In the macro large world the objects follow different rules like Newtonian precepts. These rules are more repeatable and thus reliable. So we can operate in a world of mutual hallucination.

Everything we perceive, behold, or observe is a reflection inside our own brain. Our brain does not interact directly with the outside environment, but instead receives sensory stimuli and assembles a view of consistency of the outside world. The mutual hallucination posses an imposing ability of an impeding pressure for survival thru cooperation with the environment. We need to find nutrition and be repelled from toxins.

We soon find there are rules and constructs of existence such as that we are all at once of the body, the mind, the spirit, the social society, and the environment. These can appear to be separate, but at another deeper level they all blend to make up what we are and what we will evolve to be.

All is an illusion but there is a great degree of constraint and restriction in this illusion. The matrix as some have said. Social lines of structure are imposed by our parents and internal family and later our friends, schools, organizations. Mutual illusions and belief systems are imposed. All are false at one level or another but some are more false. Many of these false beliefs are inconvenient, as that they might be found to cost money or offend the rich.

Education and Metabolic typing (nature / nurture) effect our motivation, motivation effects perception, social perceptive patterns structure into beliefs, and beliefs are hard to dispel once they have been invested in.

All beliefs are false at some level of introspection, but some are more false. This mutual hallucination and delusion of agreed fancy, needs to be challenged by the large minded and defended by the small minds. Yin Yang, dualistic extremes that blend and weave the pathways of our life. The Dharma for want of a good English word, we use a good foreign word. Dharma means that our lives flow with the circumstance and the innate intelligence of the universe.

There is a intelligence of the universe, or is this just another false belief. But as there is nothing wrong, but thinking makes it so, there is nothing good but thinking makes it grow. Every idea has it thesis and antithesis and the mold and dance into the expansion and contraction of the low of life.

Everything is seen only thru the perspective of one's own brain. All of laughter is making fun or hurting someone. The real person that is hurt or embarrassed then is only us. Will Rodgers said that the best sign of mental stability thus is the ability to laugh at one's self.

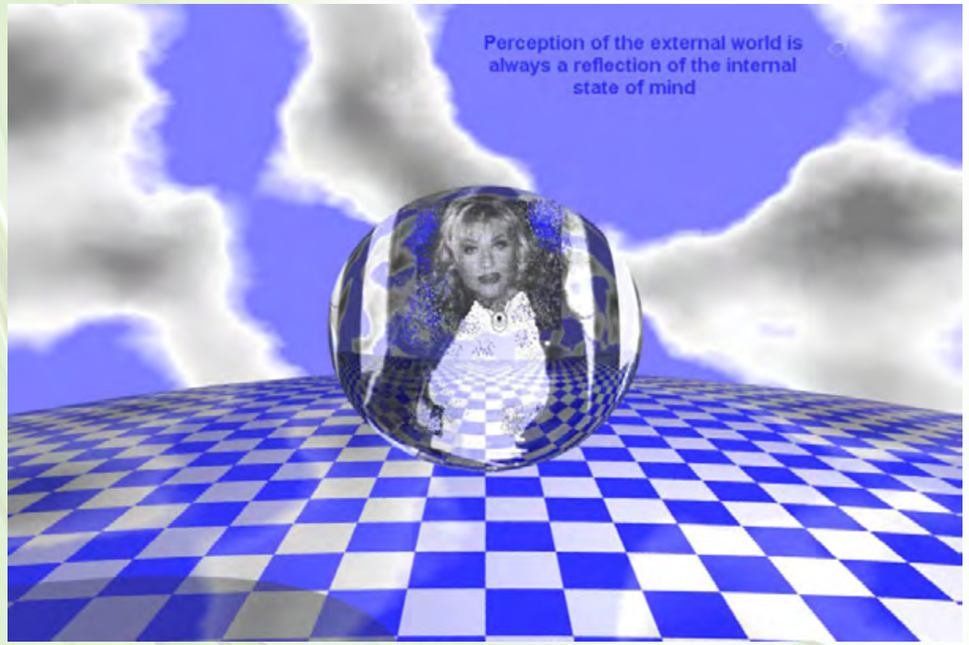
The cause of all suffering is the desire for something to be different. We can reduce this desire thru acceptance of what we cannot change, change of what we can, and the wisdom of perception to find that we can be set free from the imposition of all false beliefs. Mindful non-judgmental awareness, liberated enthusiasm, respect for the universe, love and forgiveness of self, compassion for others, and ability to laugh at one's self and take the jokes of life with humor and laughter. It's all just an illusion at one level.

This book is a deep analysis of perception. Reality's weaknesses, and strengths. The normal and abnormal. The healthy and unhealthy. The illusion of perception. The frolic tricks of materiality and non-materiality

The ultimate joke of reality is that we cannot know it. We make good guesses but we still do not have a good complete theory of just how it works.

Now Quantum theory tells us that there is an Non-deterministic, Uncertainty locked into reality. Fractals tell us that things never repeat in complex situations. And the joke of science goes on.

Human perception is very very very very very VERY VERY flawed and we are stuck with misperception. And the biggest joke of all is that some are over anxious to be convinced and excessively obstinate and clutching possessive of false beliefs. People are tortured, prosecuted, persecuted, discriminated, persecuted, and even murdered daily because of false beliefs. This book is dedicated to analysis of the joke of reality, and the illusion of perception.



Perception

Now let's talk about the basic construct of what we are as human beings. For long time we talked about body, mind spirit. The idea was that there was a body, mind spirit. This is a unique perspective that has been developed in the last couple of hundred years. Now when we look at the body we understand that there are certain physiological biological needs. Biological needs are not just limited to the body however, but let's talk about the actual body's needs: we have hunger, thirst, clothing, shelter. This leads to an idea of territorialness as well. The mind, then - we're not trying to say there's a differentiation that the mind and spirit or the body can be separated, they're all entwined here, it really is much more of a Gestalt, not really a separate thing, but we can talk about these on different, separate ways.

Inside the mind we have needs for respect, love, intellectual stimulation, sex - and sex is one that appears on the body, because we have sexual need of the body, but there are also sexual needs of the mind and the actual sex act is actually mostly of the mind. It really is not so much of the body. Sex really takes place as the mind, in fact everything really does. Now in the spirit, we going to see that the really is a spirit, the idea of the prayer, a oneness, a selflessness, reverence, the idea of a power greater than one. Probably the best way to really explain this is the idea of Christmas, the feeling that universally, atheists or whatever, but the feeling of a joyous time of the yet, that Christmas represents - that type of a feeling that happens on that special day, whether you're Christian or whatever. You might have other holidays that you have found that special feeling on, for whatever religion you might have or share. Or you might have found these days just for having a good day. But when you find that, that quality of spirit that is very nice, very positive,

very helpful. Couldn't we have a society that is more than just one day a year. Couldn't we have a society where we could achieve something close to that every day? Is it possible? That's what this project is all about. In order to understand that, in order to achieve that we need different rule. And that's what this project is about.

But right now let's understand that there is a body, mind and spirit and they have different needs. Each of these needs produces biological states that drive the need for these things and make the body go out and try to find food, to find respect, to find love, to find intellectual stimulation. Also altered states of consciousness: there's an innate drive for the human being to want to alter his state of consciousness, to have a beer or maybe more, different types of drugs. That can lead into an addiction quality, any of these things that are on the board now can be addictive. They can make it so that a person has to have it - and then gets into an addictive state. However, there are drugs that are even much more addictive because they will have biological effects of addiction as well as mental effects of addiction. Smoking can be a physical addiction but also has a mental component to it as well. So all of this comes in together for us to be able to analyze. The human brain is built so that all different types of things are happening, but at certain times a hormonal reaction can get so intense as to fill the brain, thereby a type of obsession comes on where maybe somebody can't get out of an idea. The basic idea of how to build a monkey trap, we've talked about this many times, if you haven't heard about it - we take the little coconut and put hole in the top, monkey comes along puts his hand in the coconut, grabs a piece of candy. While he's got a hold of the piece of candy he can't get his had out of the coconut. He's trapped. What really has him trapped is a state of greed. Now greed could be seen as a biological drive, because of protection of territory, trying to make sure you have clothing - survival, food. But actually greed is much more of the mind because now all the monkey has to do is let go of the candy, let go of the greed and he'll escape, he'll be able to leave, he can escape. Greed holds the monkey, down comes the hunters and it's the wise monkey the hunters don't want to kill, but it's only a wise monkey that can let go.

And as human beings, that's what we also need because we recognize that anger comes. Somebody hits the back of your car you're going to get angry, but the question is how long does it take to let go. Two monks were walking down the field and they're walking along, it's the rainy season and there's this beautiful woman wearing a beautiful silk kimono and she can't get across the road because it's too muddy - what to do? The one monk picks her up and carries her across the road, sets her down. They continue to walk, they continue to walk, miles later the other monk says "I've got to say something - we're not allowed to think about beautiful women, let alone touch them. How did you do that? How did you touch that women?" and the other monk said "I set her back down hours ago; you're still carrying her?" In other words he had still been obsessed by the thought. Sometimes this obsession can be good, can be purposeful, helpful. Sometimes this obsession can be negative. The whole practice of psychology has been finding ways to help people get out of their little mental traps. That is the best perspective of psychology that I have found. That is how I been trying to build my practice as a psychologist. To recognize that when you reward a behavior you get more of it, so to reward depression, to reward anxiety -"you are so depressed, oh my God" - that's rewarding. "Tell me about your anxiety" - that's rewarding. Actually we can help wipe out those behaviors by ignoring them and getting into positive behaviors. That's one type of practice.

Now let's get back to our idea here of the mind; the mind and the spirit. As human beings we are

also social. It's wrong for us to think that we are just body, mind and spirit. In fact that was one of the big mistakes of the sixties; everybody thought: my body, my mind, my spirit. And that tended to an idea of conceit, just 'me'. It helped to build a kind of a problem in that culture, it was just 'my' perspective. Go to California and everybody wants to talk about themselves and after they've talked about themselves they say ‘well that's enough about me, what do you think of me?’. That type of perspective, just body, mind and spirit - but we are social. Because as God found it and as I believe as he laid out the ideas in the bible - love thy neighbor as thyself - very, very important - we are social beings. The worse thing we can do to a human being is not really deprive them of food etc, the worse thing we can do is create solitary confinement, where we deprive them of social contact. Because on a social context we find that we need networking, we need to talk. People who have networks live longer and people who marry live longer because they have a built-in network, meaningful others. To take away the right of marriage is a disturbing thing to take away from anybody. That is a real problem in our society, to think that we're going to take away a possibility of pursuit of happiness and that's what marriage seems to offer us, not only pursuit of happiness but also an extension of life through happiness and through talking, through sharing, networking, caring. The social needs are very important because we are social animals and we live and work. Anything that anyone has ever been proud of is always a team effort. It's always a team that gets together to do these things. Very important. The computer, the car, the house - there are very few things that are just done by one person, it's a team. And even though I'm making this entire movie myself etc I want you to understand that you are a part of the team because you are watching it.

There's a connection of people and that's when we're really together and really alive, when we connect, because we are social beings as well. As soon as we say this we now take a different perspective of community. We take a look at the sharing and caring. We now have to have social laws to allow us to understand and to set down bits of ideas of sharing and caring. We talk about equality, we talk about freedom, words that mean a lot, words that inspire, words that fill us with uplifting emotions, happiness, family. They come out of that social network; freedom, liberty, justice, fraternity, brotherhood. So it is positive emotions. Negative things that counteract that are anger, hatred, prejudice and the prejudice of the world is maintained through keeping an unequal economic strata. This is something we talk about over and over again in these tapes, but I want to at least mention it here as this might be the only tape you get a chance to see.

It is the inequality of the education, because up here in our mental area we're going to see intellectual stimulation. We know that if we take away stimulation from certain rats they don't develop as well and they're not as healthy. Intellectual stimulation is a need; this is something we need, something we want, something we have to have. Now, when we have a society that is built on unequal education, because of economic concerns, because one school over here 5 miles away has a poorer set of houses than the other school, these children get a different education. That is what we call an apartheid - a separation - a prejudice - a true expression - a prejudice. Now we have defined the problem, as we will a hundred times in this concept. We're going to complete our ideas of who and what we are, we're not just body, mind and spirit and social - we're also environmental. We are locked into the perspective of this planet. We are children of this planet that have been born into planet, raised in its gravitational field, its electromagnetic filed, its social field, its air - because we all share air.

Now it's in the concept of the American Indian that planet earth was part of his religion, part

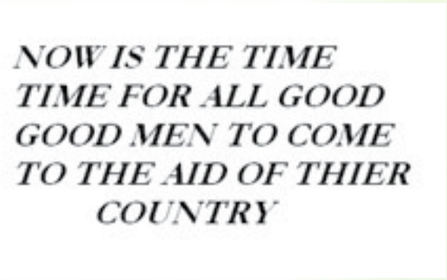
of his cosmology part of his belief in all, and the reverence of mother earth was the deep, deep part of what he believed in. He thereby had a hard time when the trinity came, when the church came, they said father, son and Holy Ghost and they had this idea of a trinity and they had this idea of a God and a spirit and they could accept that but they said, “where is mother earth in your religion?” It didn't exist in their religion. Because it didn't exist in their religion, perhaps that's why they felt they could destroy mother earth, they could ravage mother earth, they could pillage mother earth. It wasn't part of their perspective. We now must recognize that as human beings we reap what we sow and what we sow we reap and if we’re going to pollute this planet and corrupt this planet it's going to be a problem. We are body, mind, spirit, social and environmental. These are the ways we must understand ourselves. We have to give back and forth of this planet because all of biology is giving forth - a flow of inside nutrition outside excess, outside excretion. And the excretions that we have as an animal are also then the food for plants as we exhale carbon dioxide, plants need carbon dioxide to make oxygen. The life-cycle of the entire world - that allows us all to live, not just our individual biology, not just our social community network, but our respect and honor and share to the environment and this is what the human beings are.

The bible tells us the body is the temple of god and he who defiles that temple, him shall God destroy. Not him will God slap the wrist but God will destroy : the body is a temple. In the areas of the mind - as a man thinkest in the heart so is he. As you think in your heart, you are. Because it is as you think that will be the filter of all your thoughts. Two men walking looked up at a beautiful and one said 'what an incredible bird' and had a moment of rapture and harmony of touch of the process of the beauty and the other man said - "is the bird going to shit on me". My father now is sick and I've always seen how my father has lived his life in bitterness and every day more bitter than the next. Not that the world is bitter, but that in his heart that bitterness has made his world bitter. And all around us we've always tried to touch him and help him, maybe one day we will because we won't stop trying, because this is as you are - ' as a man thinkest in his heart, he is' - well that's absolutely true because as you are, as you think you are etc will determine the world around you. Because all the world around you, all of your perceptions will be cast through that filter of who you are and as you think. So – as a man thinkest in his heart, so he is.

Next – spiritual. He we say, God says – ‘have no other God before me, honor the Lord thy God Almighty’. You might want to take out the word God and put a different word. Somebody told me that God’s an inappropriate word – it’s really a reverence, it’s a feeling of spirit, it’s that quality of spirituality. Spirituality can also be thought of as family and social but it’s beyond that. It’s a

reverence, a connection to the “all”. Recognition that there is a power of spirit and there is a definite power of spirit that everyone touches and they always said that there’s no atheists in fox holes, because even then at certain times everyone can be touched. That’s what I believe – you believe that as well. And if you don’t, you will.

Next – social. Love thy brother as thy self. Social – the golden rule – do not do unto others what you do not want done unto you. A simple rule. It doesn’t say ‘do unto other want you want done to you’ – that’s a nice rule but, I don’t really like chocolate ice cream and if someone wants to give me chocolate ice cream because they like chocolate ice cream, I don’t like chocolate ice cream, I like vanilla ice cream. Do not do unto others what you do not want done unto you. Don’t hurt people, basic ideas. Medicine was built around the idea first don’t hurt. An idea that modern medicine gave up and an idea that modern medicine must return to. First don’t hurt. Don’t hurt others. The golden rule. Do not do unto other people what you do not want done unto you.



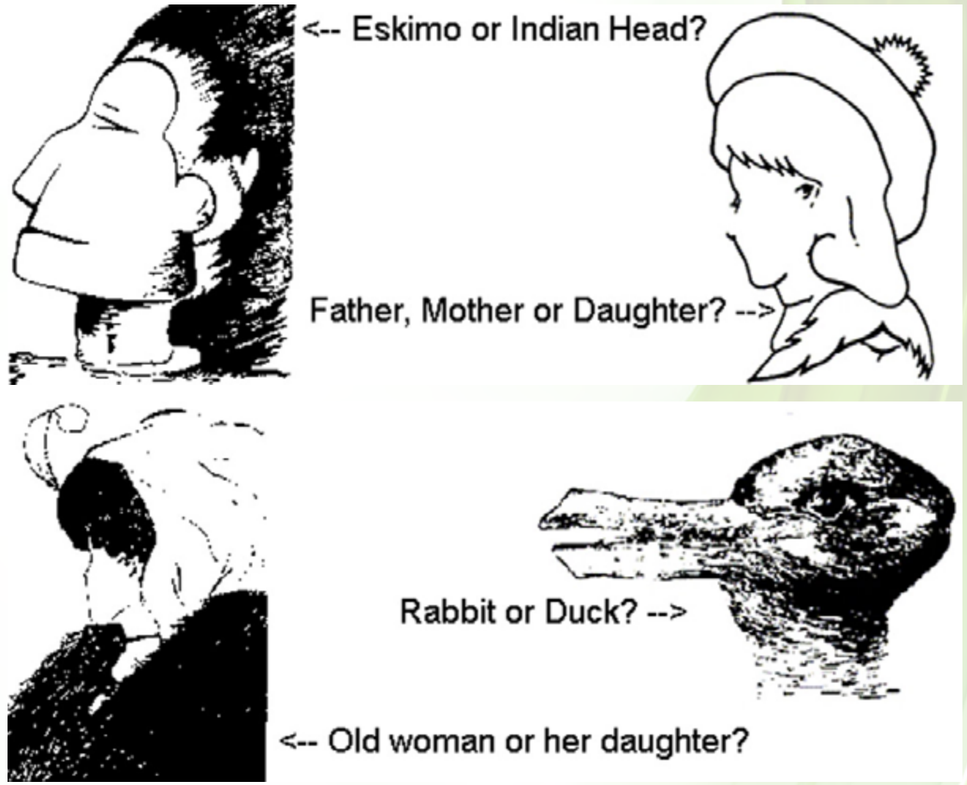
The basic idea. Environmental – as we reap we will sow. What we plant into this world – if we’re going to put into this world genetically modified foods what will we get out. If we’re going to let greed drive us, because now let’s return to our picture here: we’re going to see as we look at this body, mind, spirit, social, environmental that territorialism extends to almost all of this because people want to protect their environment, their social network. Out of this comes a geographical nature that is a biological event, where people want to protect their country, their brethren, their “brothers”. It’s very difficult for people to recognize that all people are their brothers because few people live in the world today, most people live in their little countries, their little houses, their communities etc, they don’t live in the world. They might travel the world, but they don’t really live in it. Very, very few people are actually of the world, most people are of their little areas and

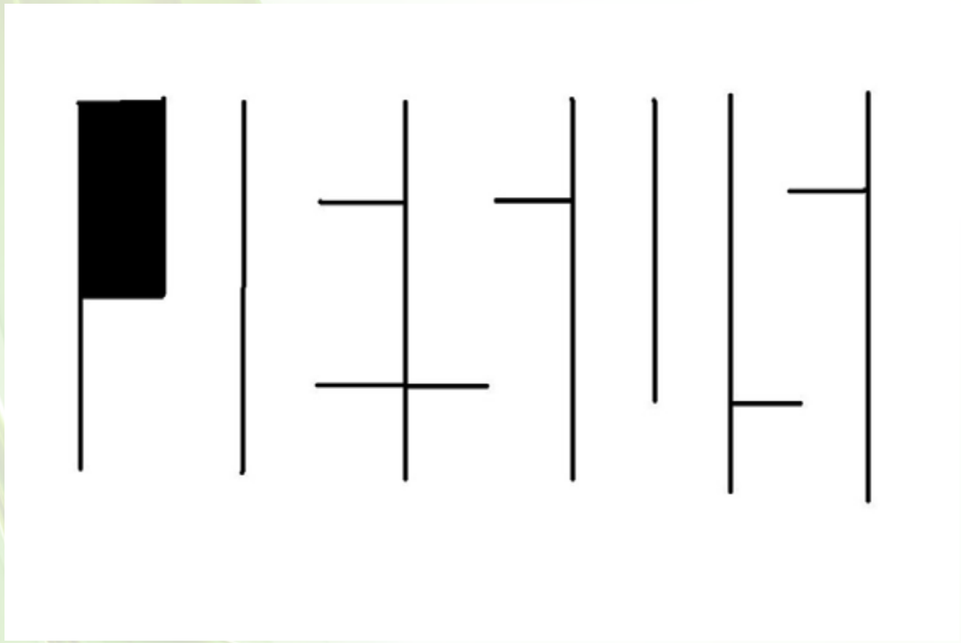
they try to take their little areas with them and construct little things and make sure that they’re always safe and secure in their own little perspective. Not really joining into another culture or really experiencing it, kind of sitting back and observing it and laughing at it. That’s what most people do. In the perspective of territorialism that grows out of this then comes in greed. As we’re talking about perception in the movie let’s understand that motivation affects your perception and if your motivation is that you’re hungry your perception will be tuned to this. If your motivation is that you are lonely you’re going to be tuned into places and observations where there might be people where you might have a chance. You might want to go to a library, social clubs, night clubs for contact. If you’re hungry you're going to be looking at advertisements for food, restaurants. If something is wrong with you car you're going to be driving along and you're going to be looking for a mechanic. Motivation will determine your perception and if your motivation becomes money, greed - that will effect your perception.

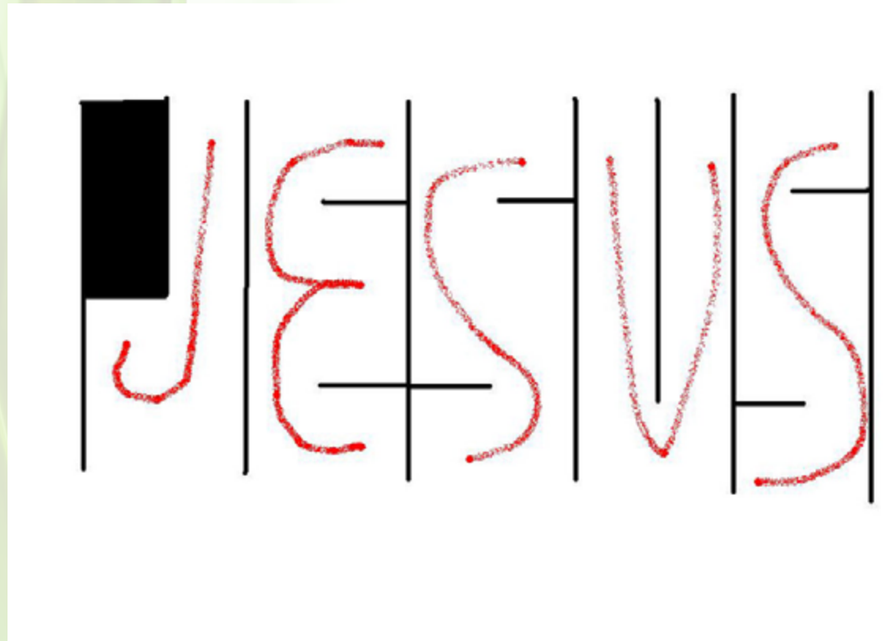
People who have always spent a large part of their life honoring me as a wise man who then owe me money say, I'm not so wise. It happens to me all the time. As soon as they owe me a million dollars well I'm not such a good person after all. Whereas before that I'm a wonderful person, I'm fantastic - but as soon as they owe me money 'well, I dunno, was he all that good?'. Because greed effects perception, it's an undeniable truth, something we must recognize as true. So when we saw the tobacco executives with their hand on the Bible saying that tobacco had no effect on cancer and that it was not addictive and absolutely found out that they were lying because we knew that. A part of them were probably convinced that they were telling the truth because that's how strongly money can switch perception. Money can switch perception and if we look into the books of Machiavelli we're going to see what seems a depressing, but true look and it is something that we are going to have to deal with and that's what we're here talking about today.

So now, as we get into the ideas of perception we've established that we cannot perceive the true nature of the world, we can only perceive a certain level of it. What does it take for perception? In our science we can see what it took for living, to be able to metabolize and to reproduce - but perception is something different. What does it take for perception? Perception seems to be pattern recognition; pattern recognition means some kind of bonding. Let's talk about consciousness, to be able to perceive and have that type of consciousness. This is irrelevant of metabolism and reproduction that's a biological event. Could it be that there are conscious beings, not biological beings but conscious beings in the moon? In the sun? If it's at zero degrees Kelvin and there's absolutely no movement, if everything is static, and if there is no electromagnetic radiation it would be hard to conceive of a perception ability there but as long as there is some type of energy could it be that organizational states will happen that could produce consciousness - the spirit world etc. Interesting - we'll talk about that later. What we've basically been able to show in our discussion here is that we cannot really understand the quality of the world, we have a perspective. Our senses are giving us information that is variant and not perfect. We do the best we can. We filter this through a social construct and a reflection of what’s inside us and as we see things, as we look at other cultures and how we see things. Something we have bonded to in one little culture might not like something that's in another culture thereby we have to have prejudicial ideas of this and that because that’s part of what we are growing up. Our ideals of all of the people around the world when we come up with the ideals of who we’re going to revere, it’s always the open-minded person who is able to more relaxed, wise, not give into those prejudicial states. Those are what we actually see as our guidelines, as our goals, our role models – as it

were – because we really want more of those people. We talk about the qualities of the positive energy, the freedom etc but the ideas of killing and prejudice etc – those are negative words in all cultures. But this is something we need to do more of, because right now we are in the dark ages, the dark ages of development.







Now if we look into the ideas of bonding, the ideas of different types of bonding – we've looked at this type of thing, we've shown different perspectives, now let's go back to the – is that a skull? Is that a woman looking in the mirror? Is that and Indian? Is that an Eskimo? Look at these things – what's the name of that person? Well, very easily that's Jesus. So you can see these different perspectives, we have bonding - now let's look at some clouds, simple clouds in the sky and you recognize how certain people can look up and see a dog and another person looks up and sees two men at a table. In psychology there's a projective test we do, we talk about the raw-shot test. Take an ink-blot – somebody might say I see a moth, somebody else might say I see two dancing bears, I see somebody fighting with his mother. What we're going to find is the words are going come out according to what they perceive. Their perception is taken through a filter inside them and then that filter enhances and changes their perception. Motivation effects the perception, all the other factors of who and what you are effects your perception, thereby that's how these projective, psychological tests work. They're based on a truism. All perception is given through us, so by looking at our perceptions we can see who the person is in more detail and oftentimes we can find little problems in social constructs etc. That's the skill of projective quality. Something I've been trained in. I've done thousands of house, tree, persons. People draw a house, draw a tree, draw a person and their drawing will tell me different things about their personality. But what if our society here we have the clouds and what if we have a society where a social construct has been given. Synthetic drugs are good – this is a social construct developed in the 1920s – somebody looked up on the clouds and said you know what I can make insulin, petrochemicals, the development of synthetic drugs started. People started making a lot of money from this, an awful lot of money from this. Money started interfering with their perception, so then they started teaching this is if it were reality and now in this point in time the absolute undeniably irrevocable

truth is the synthetic drug era didn't really work. Natural medicine has the answers, it's much more complicated than just where to put that calcium it's also into the quantum states of that calcium and whether it's organic or not. Our society has now decided to reject the synthetic foods, the synthetic wines, the synthetic cheeses – we reject these things. And our society is about to reject the synthetic medicines. Because somebody else looked up there and said, you know what I don't see that picture. So the social picture was that the chemical companies said I see a doggie in that cloud. They looked into their perspective of the synthetic drugs and they saw a doggie. It was not hard and fast. That was their perception – they bonded to that perception very heavily. They started using this stuff then somebody else, a group of people, including myself and a lot of other people came up with – you know what, that's not a doggy, I see a horse – I see natural medicine. Just another perspective.

According to the rules there really should be an equal ability because synthetic drugs haven't been proven, the whole idea of their statistical analysis - we tear that apart in different parts of this movie, we don't need to do that now, you can go to that and look at it. But there were two different perceptions and the person seeing the doggie said no you must see a doggie, you have to see a doggie - but here we have a problem. Thomas Jefferson wrote on the top of his memorial "I have sworn upon the altar of God eternal hostility against every from of tyranny over the mind of man." Because there are people that want to tyrannize the minds of men, they want everybody to see that doggie, they want them to see those synthetic drugs. And the real truth is somebody else might say you know what, I don't want those synthetic drugs, I see natural medicine. Maybe somebody see osteopathy, acupuncture, maybe they see something a little different. They have the ability to go out a check it and do it and develop a culture and try to do it safely within the rules. But somebody else said no, everybody must see a doggie. The idea of equal economic education, you see the minorities of the world, let me speak to the black cultures of America. The black cultures have been told - take what we give you, you have your little bit of real estate tax and that's it. And over here we have our real estate tax and that whole insult to the word equality perpetuates the prejudice. And the rich people have seen their little doggie, "blacks shut up, take what we give you. Take the education based on your own real estate - ha, they fucked you hard".

Now you might look up having seen this tape and see something different. You might look up and say you know what - I see a black guy hanging a white guy from a tree…

Did I go too far?

Maybe.

Can I go far enough?

Can I let you understand that anything less than equality is prejudice? If the state of California has one student getting a different amount from another, that's called prejudice. Equal economic education, anything less is just prejudice. I've given you a new idea here. Can you bond? Can

you understand the world equality versus the world of prejudice? The emotions that anger and prejudice give you - hatred - that can be taken away because we knew it, because we built a society built on equality, freedom. That's what we built. But that's not how it came down.

A new idea. Maybe you look up and you might see that doggie, maybe you might look up and see a different perspective. That's the idea of a social construct. There's another thing, right now throughout the entire world 99.9% of the population sees a world, a universe of prayer, spirit, religion, what we're going to call a non-local universe.

The ideas of the mind, the ideas of being able to pray for somebody. The idea of God, the idea of a power. Being able to effect things. They read the religious books, the Bible and they see this and they believe it and the human race has built on this. Now science has come along through Bell's theorem and a lot of other things as we discuss local versus non-local universe. A type of science has come along that says “yes there is a quality of spirit, there is an absolutely undeniable, provable, yes here it is! Boom - there is a non-local universe, one mind can affect another mind”.

These things happen and everybody tells stories throughout the entire back door of time. 99.9% of people look up and see a world of spirit and power and yet that .1% sees a scientific reduced side, a side where there is no spirit - no God - no religion. And we have given that tiny .1% the power of affecting our medicines, affecting our lives, affecting whether we go to war or not. We've given these people power and they laugh at us. They laugh at us and our ability to see God. To see religion. The scientists that we have given control of this planet to - they laugh at us because they see a different doggie. I'm not trying to say whether it's a doggie or a horse or whatever, but we have the ability to see this and we should not be giving up our power to people who have no idea or perspective of spirit. We should not be giving our power to these people. We should try to hold on to that power of science.

So here as we've gone through we've looked at the ideas of bonding and our societies tried to force everybody to try to bond to these ideas of unequal economic education. The ideas that synthetic drugs are the only way to do medicine. The ideas that God doesn't really exist. You might have a different bonding, you might have chosen a different way to see the world in your perspective. And now you've been given some ideas and given some different perceptions because now you've been changed, your different. Now you see this thing and you know it's Jesus, you see this pattern and you know it's an Eskimo and an Indian. You've been changed, you’re different now. You also know that equality and equal economic education is going to help solve the problems of this world.

You know that everybody in medicine has the right to choose natural or synthetic and you know that now. You've bonded to that. And you also know that there is a spirit and you have at least the choice to choose. And that there’s no way that that .1% of the population should be taking away that right from you, they should not be controlling all your decisions. So here in this idea of perception I've tried to explore lots of different ways of looking, at perception and bonding and consciousness.

We should never let greed be so excessive that it risks destruction of the environment because that would mean destruction of the mind; the mind, the spirit. Greed has gotten to the point now of extreme development. I was watching the movie Dr No the other day made in the 1960, Sean Connery was a skinny little guy, very interesting - and Dr No was asking for a million dollars and today it's funny because it would cost a million dollars to build his fish tank. What we've seen

now is a dramatic development in culture where there is a dramatic building drift with the richer getting richer and richer - excessively, incredibly, undeniably, fantastically rich.

There were just a couple of billionaires years ago. In my life I've seen this development. Whereas there were millionaires back in James Bond's time of Dr No, now there are billionaires and now the possibility of some trillionaires. It's incredible and yet there are more and more poor people every year. We don't need to give these people money, that's not the answer. We don't want to give them fish, we want to teach them how to fish. We want to develop an education. And it should be an obligation of the incredibly, disturbingly rich people to give more money to the education of the poor. That's basically what these people need, equal economic education because then that would produce the harmony to bring us to that 1000 years of peace and tranquility.

That would bring us to stabilizing real estate values and a respect of the planet. We must build the respect of the environment into all of our world religions and all of our world dogma. We must recognize that all of this must go forward in order to get to that place, to reduce our prejudices and we all need to start recognizing we are people of the world. We share air, we share a planet, we share a brotherhood.

We are body, mind, spirit, we are all social and when our socialness of the brain extends to include all the people of the planet and when our respect for the planet grows and develops this will stabilize the body, the mind and the spirit of all of us through the social environmental network and we will get to that 1000 years of peace and harmony, if we don't pull the trigger, if we don't let synthetic chemicals destroy this world - the possibilities of genetically modified foods, the possibilities of what the chemical companies could really do, the potential harm, the potential harm of judgmentalness and the possibility of destroying this entire world. We must do something, that's what this is all about.

I just want to step aside and talk about memory function a little bit. You see memory is stored in an imprecise fashion, meaning not really like a computer. We have the idea that we store our memories in a type of computer fashion, that they can be retrieved like a video tape etc - that's not the case. If you think about the last time you went ice-skating or skiing - many people will remember it as if they see themselves on television - that's called autoscopic imagery. 60-80% of the population, depending on where you are, will be able to do this. You didn't actually experience the skiing that way, you experienced it from inside, not really watching yourself. But yet you store

many memories in a different fashion. Now the best analogy for this, the best way to really explain this, as I found when I did marital counseling as a psychologist in America, when the husband would come to me and say, “now I remember last Friday night, I came in and I was so nice and I said where's dinner”. And the wife would say “I remember that you came in and slammed your fist on the table and yelled and screamed” ... real quickly we're going to find that those two people have experienced exactly the same event. Not only do they experience it in different ways, but they actually stored the memory in a different fashion and now they retrieve the memory in a different fashion because when you retrieve memory it's just as well you are clouding your retrieval of memory, your perception of memory, clouding it through your personality, your emotions. So emotionality takes a big place in this.

We have the Michael Jackson case going on now, where the young boy said that Michael Jackson handled his sex organ and yet he says it almost felt like a dream, so now it's up to the jury to decide and of course the jury hasn't been out yet and so it's close. But the jury has to decide - What is the truth? Is his dream quality meaning something? Just what is that? Did it actually happen? Is that memory enhanced by money, by the fact that he's going to get big money out of this?

Because that's the other part of that case. Because we have to understand that when I talked to some of those tobacco people who had their hand on the Bible, they absolutely firmly believed what they were saying even though it was completely obvious it was a lie. They were not intentionally lying, something happened inside to actually make them believe that.

So when we get down to here and our ideas of perception we've got to understand that our ways of storing memory really do not take place in a computerized fashion. Our perception of the universe, how we see the little electrons and protons, we're completely blinded from that. We're completely blinded from the actions of what's happening outside the cosmos, even events that happen within our own solar system. We are perceptually linked to a very small band of perceptual things that we are capable of seeing and feeling and touching and then reading and as ideas pass through our society we must realize that these things have an awful lot of social network, behavioral concepts because certain things are rewarded we get more of.

If you're growing up and you're rewarded for being a bigot and prejudiced your behavior in that area will increase. These are the things that really happen that kind of shape who and what we are.

But now we are faced with a big problem in the world, we are faced with a changing environment, a destructive environment; we're faced with the possibility of losing a planet because of what greed has done. We're faced with a big problem here. So we need to do something about that.

But here in our analysis of perception we must realize that it's more than just not trusting the eyes and the ears there's a whole bunch of other things that we need to mistrust and we need to really get back to an honest perception and try to get back to the spiritual nature as well.

Basic concepts of sensory physiology

Methodological approaches in sensory physiology:

- Objective sensory physiology: The investigation of sensory systems with physiochemical methods.
- Subjective sensory physiology (perception psychology): The study of sensations and perceptions with psychological methods.
- Psychophysics: Quantitative measurements relating (objective) stimulus magnitude.
- Psychophysiology: Simultaneous measurement and linking of objective events to sense organs, or of central nervous phenomena (measured non – invasively e. g. by EEG) to subjective perceptions and to behavior.

Our sense organs inform us of only a tiny fraction of all that happens in our surroundings and in ourselves (modified after Dudel. 1985)

Objective sensory pathology		Subjective sensory pathology
	Perceptions Sensory impressions - feelings Integration in the sensory central nervous system	
Sensory Stimulation Sensory Feedback Excitation of sensory pathways Integration in the sensory CNS		

Map

- Excitation of sensory brain centers
- Interaction with sensory organs
- Suitable sensors, above threshold sensory Potentials

Mapping conditions

Because we lack suitable sensors, most of the physical and chemical events in the environment and in our bodies do not act as sensory stimuli: the only events that do so are those for which we have a suitable sense organ (e. g. the ear for sound waves, the eye for light).

The figure shows the processes set in motion by excitation of a sense organ: in the boxes are basic phenomena of sensory physiology and the arrows between them signify 'leads by the way of' (correspondence or mapping, not direct causality): the fourth arrow marks the transition from physiological to psychological processes.

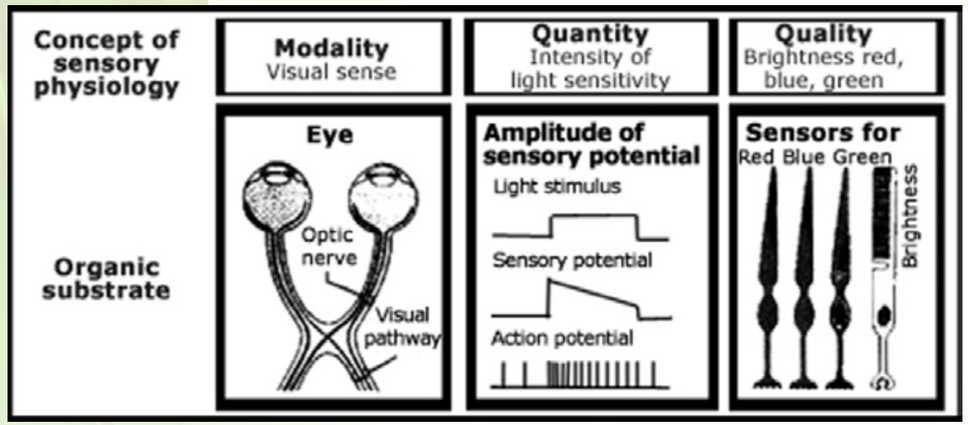
Sensory impressions are the simplest elements of the sensory experience: when several coincide the result is a sensation. When the latter is interpreted by means of our memory it becomes a perception.

Every sensory modality (synonym: sense, modality, i.e. all sensory impressions conveyed by a sense organ, e.g. the eye) has 4 basic dimensions:

Dimension	Definition, comments
Quality	Groupings of related/similar sensory impressions, e. g. in vision gray shade (achromatic value) and color
Quantity	Intensity of the sensation, e. g. strength of brightness sensation, saturation of colors
Spatiality	Position of the sensation in the spatial structure of the surroundings and of our body; degree varies in different senses

Dimension	Definition, comments
Temporality	Position of the sensation in the temporal structure of the surroundings; temporal resolution varies greatly in different senses (e. g. very precise in vision, inaccurate in the sense of temperature)

Modality, quantity, quality and their organic substrates, exemplified by the visual system (modified after Dudel. 1985)



Classification of sensations based on the sensory receptors they employ

Sensors	Modality they mediate
Exteroceptors	Receptors that detect stimuli from the surroundings, e. g. cones and rods in the eye. The five 'classical' senses of sight, hearing, smell, taste and touch employ exteroceptors
Proprioceptors	Receptors that record the position and movement of one's own body, e. g. muscle spindles and tendon organs (see motor system), also the receptors of the vestibular system; together they mediate deep sensibility (proprioception)

Sensors	Modality they mediate
Enteroceptors	Receptors the record mechanical and chemical events in the viscera, e. g. in the carotid sinus baroreceptors measure blood pressure and chemoreceptors measure carbonic acid and oxygen tension; enteroceptors mediate visceral sensibility or visceroreception. Excitation of enteroceptors produces general sensations (e. g. hunger, thirst, sometimes signaling emergencies (e. g. shortness of breath), but often no consciously perceived sensation

General objective sensory physiology

The specificity of the sense organs is shown by their adequate stimuli and reflected in the 'law of specific sensory energies'

The sensory receptors respond optimally to only one physicochemical form of stimulus (usually the stimulus that excites with minimal energy). This is called the adequate stimulus (e. g. in the eye: electromagnetic waves with lengths of 400-800 nm [blue or red]; ear: sound waves at 20-16.000 Hz). But other, such as electrical, can also excite receptors; they are called non adequate stimuli. the subjective sensations elicited by both forms of stimulus are always those specific to the sense organ (e. g. for the eye, sensation of light). It is this fact that the 150-year old 'law of specific sensory energies' basically expresses.

Classification of the sensory receptors according to their adequate stimuli

Type of sensor	Description/comments
Mechanoreceptor	Record mechanical deformation, e. g. in skin, muscle, ear and equilibrium organ
Thermoreceptor	Records cooling or warming, mainly in the skin, but also in hypothalamus and other central nervous structures
Chemoreceptor	Responds to chemical stimuli, e. g. the smell and taste receptors, but also many enteroceptors
Photoreceptor	Responds to photons e. g. visible light; the rods and cones of the retina
Nociceptor	Is specialized to detect (potentially) tissue-damaging physical or chemical stimuli; nociceptors are present in practically all tissues

Arrival of a stimulus at a sensory receptor initiates the processes of transduction, transformation and conduction

Process	Description/Comments
Transduction	Receptors have a normal resting potential. Arrival of stimulus leads to a change in permeability of the receptor membrane (mainly opening of Na channels) and hence to depolarizing ion currents. The resulting depolarization is called a receptor potential. It lasts as long as the stimulus and its amplitude increases with stimulus intensity; it is an image of the stimulus. The entire process of converting the stimulus into a receptor potential is called transduction.
Transformation	Process in which the receptor potential triggers action potentials in adjacent parts of the axon of the afferent nerve fiber. The receptor potential spreads electronically into the adjacent parts of the axon, where it depolarizes the resting potentials to the threshold for action potential generation. The result is volleys of action potentials, the frequency of which depend on the amplitude of the receptor potential.
Conduction	Propagation of the afferent volleys, at a velocity specific to the nerve fiber (see p. 17), to the first synapse in the CNS (spinal cord or brainstem, depending on sensory modality); there the stimulus is recoded into synaptic potentials.

Structural, temporal and spatial aspects of stimulus encoding and the coding for stimulus intensity in sensory receptors

Concept	Description/Comments
Primary and secondary sensory receptors	In primary sensory cells (the majority) the transformation occurs in the beginning of the axon of the sensory cell. In secondary sensory receptors there is a synapse between an accessory cell and the axon (e. g. hair cells of the inner ear). The receptor potential in a hair cell results in a synaptically mediated generator potential in the axon.

Concept	Description/Comments
Tonic receptor	Represents the amplitude of the stimulus in particular, hence the terms static or proportional sensor; simultaneously measures accurately the duration of the stimulus (good example: Golgi tendon organ; very slight phasic component)
Phasic receptor	Disproportionately large responses to changes in stimulus intensity, hence also called dynamic or differential sensor; signals velocity of stimulus change, hence also fairly accurately the stimulus duration. Extreme example: Pacinian corpuscles (vibration receptor, no tonic sensitivity at all).
PD receptor	Receptor with proportional and differential sensitivity; most common receptor type, allowing many gradations and combinations of the two properties. Example of a balanced mixture: primary muscle spindle afferent.
Coding of stimulus amplitude	The characteristic function expressing the quantitative relation between stimulus intensity S and tonic discharge frequency F of the afferent burst is usually a power function: F=k*(S S)? - where k is a constant and S? stands for the threshold stimulus intensity. The exponent n has a characteristic positive value for each receptor type; examples: n=1 for stretch receptors, n<1 for photoreceptors, n>1 for nociceptors
Adaptation	Gradual decrease in afferent volleys as stimulus continues unchanged. Phasic receptors are by definition rapidly adapting, but tonic receptors also adapt, though slowly. Exceptions, e. g. nociceptors (prolonged toothache) an dcold receptors (feet stay cold for hours). PD receptors are also mixed with respect to adaptation. Threshold (see above) and adaptation protect us from being inundated with trivial stimuli: submechanism of habituation

Concept	Description/Comments
Primary receptive field	Area, e. g. on the skin, from which a receptor, e. g. a pressure receptor in the skin, can be excited. Many afferent axons branch to supply several receptors, so the primary receptive field can consist of one relatively large or several small areas. In many receptors the primary receptive field cannot be definitely determined, e. g. because higher-intensity stimuli can elicit excitation 'at a distance'. The (secondary) receptive field of central sensory neurons (see below), in contrast, can be unambiguously defined, because it is delimited by central excitatory and inhibitory processes.

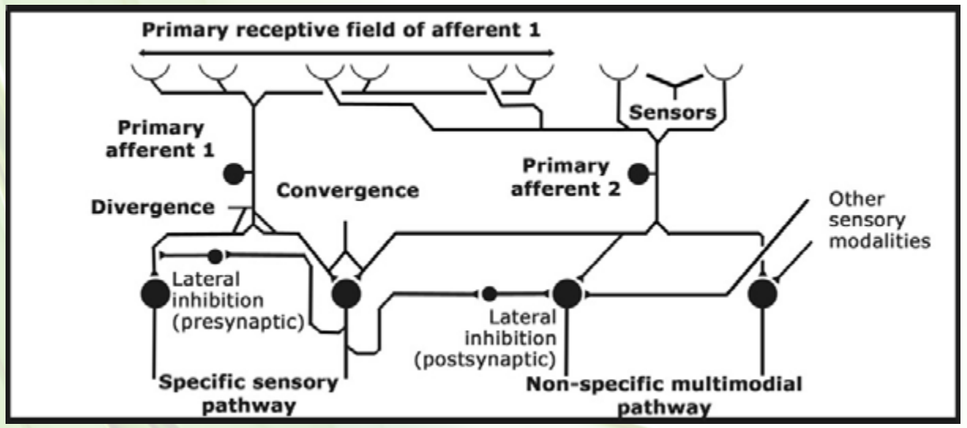
Mapping and processing in the sensory pathways

A stimulus normally excites many sensory receptors simultaneously. The resulting flood of impulses in the afferents contains all the information about spatial extent, intensity and temporal structure of the stimulus. This information must be evaluated by the CNS. In all senses, evaluation occurs at several relay stations between the sensory receptor and cerebral cortex (e. g. dorsal horn, brainstem, thalamus; details given later). Here are some general principles:

Concept	Description/Comments
Structural	Practically all afferents divide into collaterals after centering the CNS and thus send afferent impulses to several (often many) neurons
Physiological	Practically all sensory neurons in the CNS receive inputs from several (often many) sensory receptors. Divergence and convergence provide a 'large safety factor' in sensory systems, so that loss of a few receptors and neurons is irrelevant
Feedback	Is needed to prevent unrestricted spread of excitation. Lateral inhibition (surround inhibition) by negative feedback leads to a contract enhancement, descending inhibition blanks out undesired information (e. g. in focusing attention)
Inhibition	The entire part of the body periphery from which a sensory neuron can be excited or inhibited by stimuli. Often the excitatory receptive field is surrounded by an inhibitory field, and vice versa (contrast enhancement mechanism). The size of receptive fields varies widely and can be altered by inhibitory processes; pathophysiological changes (e. g. due to inflammation) are common

Concept	Description/Comments
Electrolyte Intensity	The characteristic function for the coding of stimulus amplitude is usually a power function, like that for sensory receptors (see above)
Quantic Indetrminancy	Absolute threshold: smallest stimulus intensity that elicits a detectable change in neuronal impulse frequency; difference threshold: smallest change in a stimulus parameter that causes a change in discharge frequency, e. g. intensity-, position-, timing-, pitch- or color-differnce thresholds
threshold	Area, e. g. on the skin, from which a receptor, e. g. a pressure receptor in the skin, can be excited. Many afferent axons branch to supply several receptors, so the primary receptive field can consist of one relatively large or several small areas. In many receptors the primary receptive field cannot be definitely determined, e. g. because higher-intensity stimuli can elicit excitation 'at a distance'. The (secondary) receptive field of central sensory neurons (see below), in contrast, can be unambiguously defined, because it is delimited by central excitatory and inhibitory processes.

Schematic representation of a sensory system (modified after Shepherd 1983)



General subjective sensory physiology (perception psychology)

Conscious perception of sensory stimuli usually follows the same rules as information processing in sensory receptors and sensory neurons.

In all the senses it is possible to test thresholds, difference thresholds, intensity of sensation, spatial and temporal dimensions as well as the adaptation of subjective sensations and perceptions by using the subject as a 'measuring device'. The subjects indicate their sensations either verbally or non-verbally (e. g. moving a pointer, intermodal intensity comparison). Such measurements can also be made in animals after suitable conditioning, so that the stimulus induces a behavioral change.

The following table summarizes the most important concepts:

Concept	Description/Comments
Absolute threshold	Smallest stimulus just capable of producing a sensation ; also called stimulus limen, S.I. Measured by the methods of limits, contrast procedure or signal-detection theory approach
Difference threshold	Synonym: difference limen, DI.: just noticeable difference, jnd. The amount by which a stimulus must be made smaller or larger than a comparison stimulus in order to be perceived as just barely weaker or stronger; according to Weber's rule it is usually a constant percentage (Weber fraction) of the comparison stimulus, e. g. 3% (jnd, for space and time discussed below)
(Weber fraction)	Describes sensation intensity E as proportional to the logarithm of stimulus intensity S, i. e. E=log S ?; was long regarded as basic law of psychophysics, but for most senses it applies only to an intermediate intensity range, not to very small or very large stimuli
Weber-Fechner law	Describes the dependence of sensation intensity E on stimulus intensity S as a power function E ? just like the coding of stimulus intensity in sensory receptors (see table above); for most senses applies over a brad intensity range. If the exponent n<1(normal case), E increases distinctly more slowly than S (just as a logarithmic relation), e. g. when n=0,3, E doubles when S increases tenfold
Steven's power law	Smallest distance (jnd, see above) between two stimulus points at which they are perceived as separate, e. g. spatial threshold for sense of touch; acuity for vision. Spatial discrimination ability is assisted by contrast enhancement, e. g. in vision the contrast at a boundary between a light and a dark area is perceived as stronger than that corresponding to the physical brightness distribution (simultaneous contrast)
Spatial threshold	Temporal resolution is determined by measuring time difference thresholds (jnd, see above), e. g. comparing the duration of tones. With periodic stimuli the fusion frequency is measured, e. g. flicker fusion frequency in vision. More prolonged stimuli lead to adaptation a decrease in sensation intensity (exception pain)
Temporal thresholds, adaptation	Area, e. g. on the skin, from which a receptor, e. g. a pressure receptor in the skin, can be excited. Many afferent axons branch to supply several receptors, so the primary receptive field can consist of one relatively large or several small areas. In many receptors the primary receptive field cannot be definitely determined, e. g. because higher-intensity stimuli can elicit excitation 'at a distance'. The (secondary) receptive field of central sensory neurons (see below), in contrast, can be unambiguously defined, because it is delimited by central excitatory and inhibitory processes.

The basic types of somatovisceral receptors (after Birbaumer and Schmidt, 1996)

Sensory type	Example of adequate stimulus
Mechanoreceptor	Pressure, touch, vibration, tension, stretch
Thermoreceptor	Cooling, heating
Chemoreceptor	Metabolites, pH, pCO_2, pO_2, glucose
Nociceptor	Tissue damage (noxa), heat, crush
Nociceptor	Metabolites, pH, pCO_2, pO_2, glucose

Mechanoreception (sense of touch)

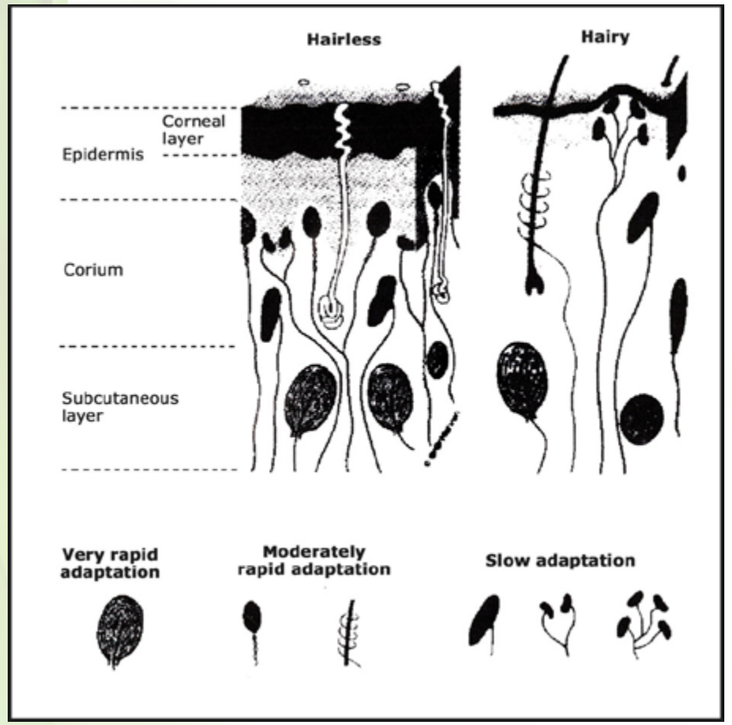
Psychophysically measurable properties of mechanoreception

There are four qualities of cutaneous mechanoreception: the sensation of pressure, touch, vibration and tickle. Each quality is mediated by specific mechanoreceptors, which are distributed over the skin in varying densities. Single mechanoreceptors can be stimulated in inolation with von Frey hairs. The density of such touch points is especially high on the lips and balls of the fingers and especially low on, e. g. the back.

Carefully performed measurements of the tactile sense have shown:

Concept	Description/Comments
Pressure	Minimal depth of indentation of the skin for just perceptible touch sensation (tactile sensation threshold) is 0.01 mm. It is lowest on the fingertips.
sensors	Steven's power law applies: there are interindividual differences in the exponent n, which is usually around n=1. Intraindividually n is fairly constant.
Touch sensitvity	Simultaneous spatial threshold (2-point threshold) is optimal, ca. 1-3 mm, at the tip of the tongue, lips, fingertips. Successive spatial threshold 9tested by placing compass tips one after the other) is distinctly better than simultaneous. Spatial resolution of touch can be improved by practice (the blind)
Vibration	Absolute threshold is lowest, 1 µm amplitude, for oscillation frequencies of 150-300 Hz; difference threshold for change in vibration frequency is best < 100 Hz
Tickle detection	Metabolites, pH, pCO_2, pO_2, glucose

Structure and position of mechanoreceptors in human skin (after Birbaumer and Schmidt, 1996)



All receptors are supplied by group II afferents. The innervation density is known for the inner surface of the hand, namely 17000 afferents, 43% of them from Meissner's corpuscles (at the fingertips, ca. 140 Meissner's corpuscles per cm^2). Receptive properties of human mechanoreceptors can be measured with transcutaneous metal microelectrodes (transcutaneous microneurography). The associated subjective sensations are recorded at the same time.

Classification of cutaneous mechamoreceptors by their adaptation properties (column headings: SA slowly adapting, RA rapidly adapting) and their adequate stimulus (bottom of columns)

	Adaptation to constant pressure stimulus - Slow (SA) Moderately fast (RA) Very fast
Hairless skin	Merkel's disk SA1 Meissner's corpuscle Paciniann corpuscle - Ruffini ending SA2
Hairy skin	Tactile disk Hair follicle receptor Paciniann corpuscle - Ruffini ending
	Intensity detector Velocity detector Acceleration detector - Classification according to adequate stimuli

Proprioception (deep sensibility)

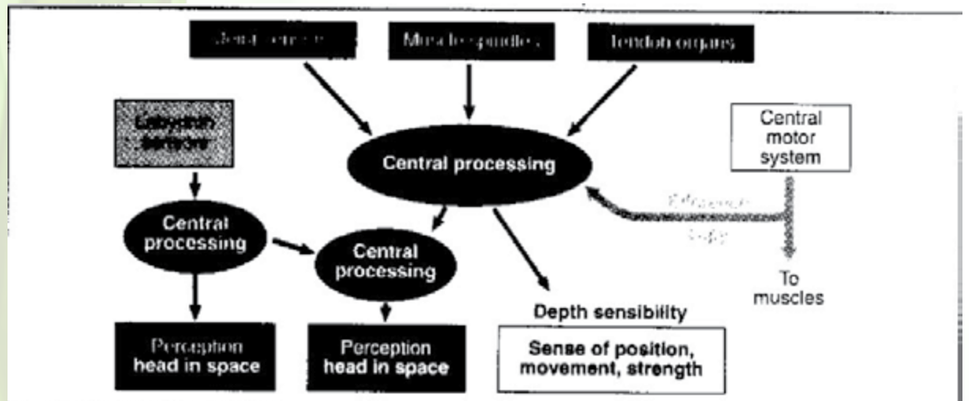
Qualities of proprioception

Quality	Description/Comments
Positional	Informs about the angular positions of the joints and hence about the positions of the limbs with respect to one another and to the head and body (without visual control)
Motion	Informs (also without visual control) about speed and extent of active and passive joint movements. Perception threshold is lower at proximal joints than at distal
Momentum	Informs about the degree of muscular force necessary to carry out a movement or to maintain a joint position; characterized by great preci¬sion and exact reproducibility

Sensory receptors for proprioception

Sensor	Description/Comments
Movement	Joint capsules and ligaments contain mechanosensitive sensory corpus¬cles similar to the Ruffini endings and Pacinian corpuscles in the skin. These signal mainly joint movement
Positional	Muscle spindles are involved in the senses of position and movement, and also, together with Golgi tendon organs, in the sense of force
Potential injury detection	The skin around joints is compressed and stretched during movements. Cutaneous receptors thereby excited could contribute to proprio¬ception, but the contribution is probably small

For proprioception to be perceived, integrative processing of the afferent inputs is necessary (after Birbaumer and Schmidt, 1991)



None of the above receptors can mediate deep sensations by itself. The necessary central processing (see Fig.) includes efference copies to remove the inevitable ambiguity of afferent information (e.g. activation of primary muscle spindle afferents either by stretching or by intrafusal contraction). Involvement of the vestibular system is also necessary, to perceive the position of head and body in space.

Thermoreception (sense of temperature)

Temperature sensations of the skin (with the qualities 'sense of warmth' and 'sense of cold')

	Static temperature sensation (constant skin temperature)
Intermediate skin temperature	Warming or cooling in an intermediate temperature range only transiently causes a sensation of warmth or cold. Then complete adaptation occurs. This thermoneutral zone is between 30 and 36ºC for small skin areas, and between 33 and 35°C for the whole body unclothed
High skin temperature	Temp. >36°C causes a prolonged warm sensation (more intense, the higher the skin temperature), with a transition to heat pain al 43 45ºC; warm sensation is strongest after a temperature step, followed by incomplete adaptation to the long-term sensation
Low skin temperature	Temp. <30°C causes a prolonged cold sensation (more intense, the cooler the skin); onset of cold pain is at I7ºC or lower, but the prolonged cold sensation begins to have unpleasant components even at 25ºC

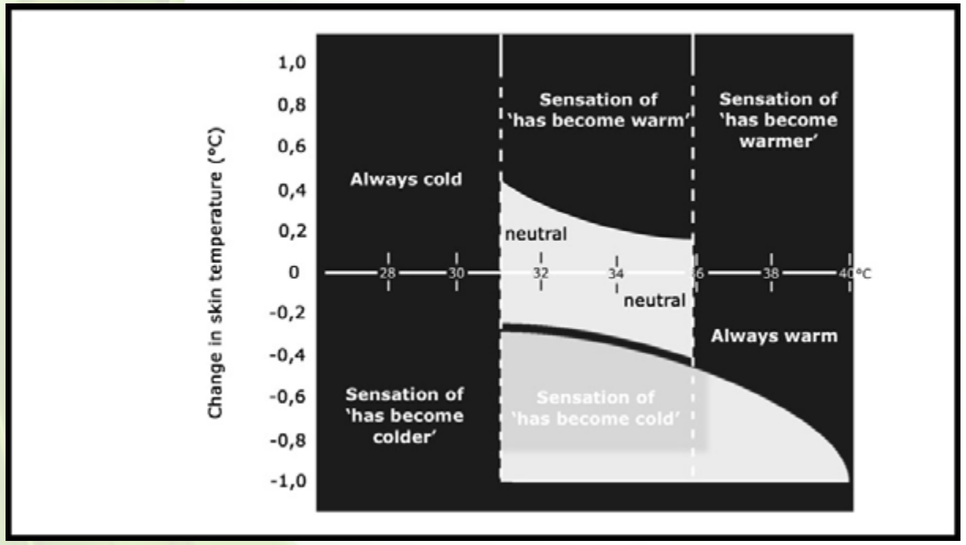
	Static temperature sensation (constant skin temperature)
	Dynamic temperature sensation (during change in skin temperature)
Initial temperature	Very significant for the resulting sensation. At low skin temperature the threshold for warm sensation is high and that for cold sensation (or for the sensation 'has become colder') is low: the reverse applies at high skin temperatures
Rate of tempo. change	Not important as long as long as the change occurs at . With slower temperature changes the warm and cold threshold increase distinctly and continuously (during very slow cooling one can become ‘chilled’ without noticing; factor in catching a cold)
Size of skin area	When small skin areas are stimulated, the thresholds for warm and cold sensation are higher than with large-area heating or cooling (central spatial facilitation of the afferent impulses from the warm in cold receptors

Warm and cold receptors

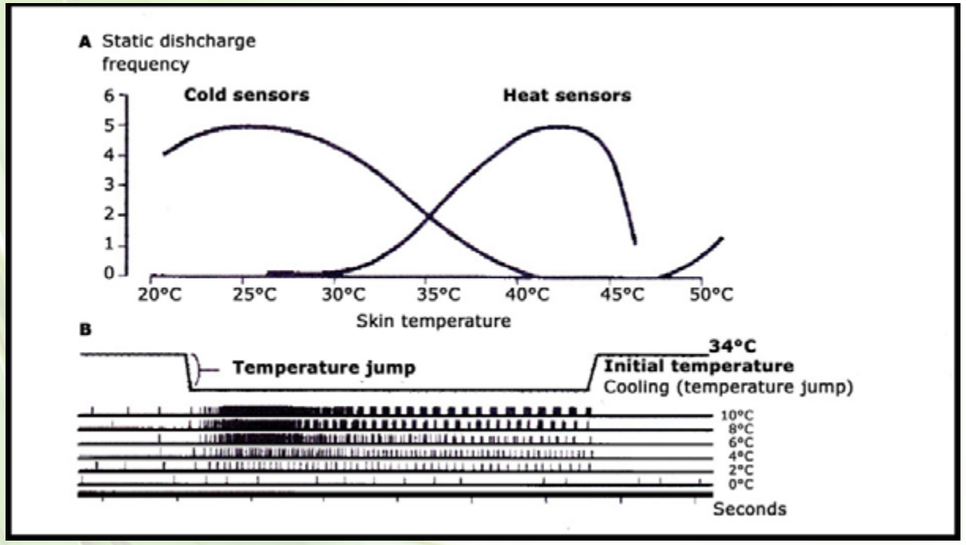
Sensor	Description/Comments
Warm receptor	Maintained discharge when skin temperature is constant in the range to 30 46°C (tonic response), with maximum at am 42ºC, plus rise or fall in discharge rate when temperature changes (phasic response, PD receptor), small receptive fields (warm points), group IV afferents (unmyelinated)
Cold Sensors	Maintained discharge when skin temperature is constant in the range 20- 40°C (tonic response. see Fig.) with maximum at ca.30ºC. Rise or fall in diischarge rate when temp. falls or rises. respectively (phasic response PI receptor): small receptive fields (cold points), group III afferents (thm myelinated)

The discharges of the thermoreceptors are directly responsible for temperature sensations, though only after considerable central nervous integration (processing) of the afferent inputs (see the complex dependence of warm and cold thresholds on the initial conditions and nature of stimulus).

Dependence of warm and cold thresholds on initial temperature of the human skin (after Kenshalo, 1976)



Behavior of thermoreceptors at constant skin temperature (A) and the response of a cold receptor to short cooling temperature steps (B) ([A] after Kenshalo, 1976, [B] from Darian-Schmidt et al., 1973)



Visceral sensibility

Receptors in the viscera (visceroreceptors) are mainly involved in homeostatic functions (regularly processed)

Viscera in the thoracic and abdominal cavities contain many receptors, the impulse activity of which is usually not consciously perceived. Instead they send information to the autonomic nervous system, signaling departures of the internal milieu from the desired states, (e. g. blood pressure too low or too high, wrong carbonic acid concentration in blood): homeostatic role of visceral receptors. In addition, conscious perceptions may be produced, e. g. pain or other nameable feelings (hunger, thirst, satiety, urge to urinate, shortness of breath, etc.)

Receptors of viscera

Location	Description/Comments
Cardiovascular system	Pressure receptors in aortic arch and carotid sinus measure blood pressure, stretch receptors in the atria of the heart measure filling. However, the heartbeat is perceived by way of mechanoreceptors in somatic- structures. Excitation of cardiac nociceptors (due to ischemia) produces heart pain (angina pectoris)
Pulmonary system	Mechanorecepters in the lung are involved in breathing reflexes, as are chemoreceptors (carotid sinus, brainstem) that measure the carbonic acid and oxygen tension in the blood. Overexcitation of the chemoreceptors produces the feeling of hunger for air and suffocation. Excitation of nociceptors in the airways elicits coughing and sneezing reflexes.
Gastrointestinal system	The gastrointestinal tract is part of the bodv surface. Mechanoreceptors elicit different sensations, depending on their location: satiety when the stomach is stretched, urge to defecate when the rectum is stretched. We are not directly conscious of activity of chemoreceptors in the gut walls (e. g. glucoreceptors, aminoacid receptors) though they may contribute to a feeling of satiety. Cold and warm stimuli are perceived only in the esophagus and anal canal. Pain can occur everywhere

Location	Description/Comments
Renal system	Mechanoreceptors in the kidneys and ureters do not gener¬ate conscious sensations. In the bladder they induce the feeling of need to urinate (depends strongly on attention). Retention of urine in the renal pelvis and ureter (blockage by 'kidney stone) cause severe pain (renal colic). Inflam¬mation of the bladder mucosa produces pain and long-lasting sensation of need to urinate, even when the bladder is empty

Central transfer and processing of somatovisceral information

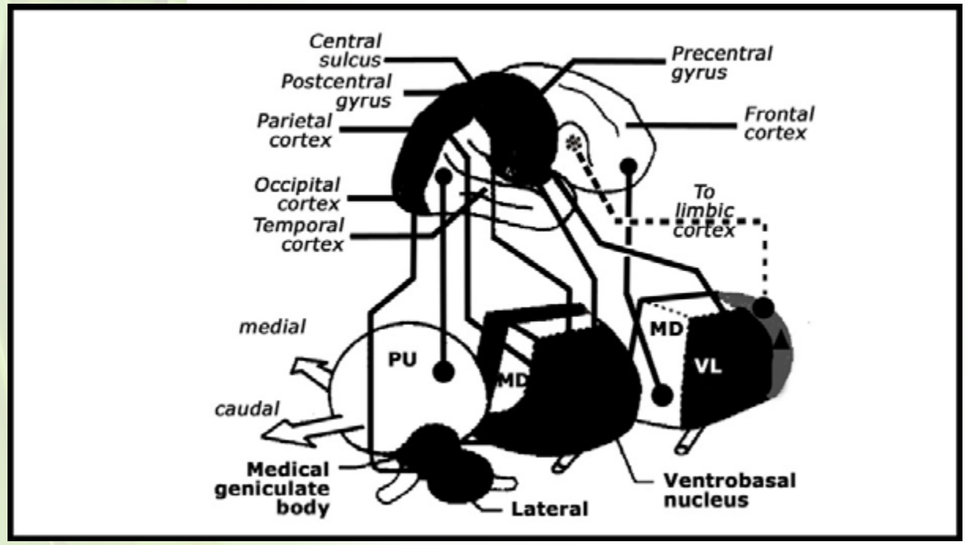
The thalamus is the only 'entrance gate' to the celebral cortex. It consist of many nuclei, which can be assigned to 4 classes on the basis of their functions and cortical projection areas

Class	Description/Comments
Sensory projection entry	Nuclei of the sense organs. Eye: lateral geniculate nucleus; input: optic tract, output: optic radiation to visual cortex. Ear: medial geniculate; input: inferior colliculus, output: to primary auditory cortex. Skin: ven¬trobasal nucleus, VB; input: lemniscal tract systems, output: to postcentral gyrus (primary somatosensory cortex, SI, and the secondary somatosensory cortex lateral to it. SII)

The ventrobasal nucleus (VB) has to main divisions: the ventral posterolateral nucleus (VPL, receives perceptions from the body) and ventral posteromedial nucleus (VPM, receives projections from the face). Inputs are the corresponding lemniscal tract system.

Support	Various, mainly medially situated nuclei with no clearly delimitable corti¬cal projections. Inputs: ascending extralemniscal tract systems, outputs: diffuse projections to practically all cortical areas: part of the ARAS
Motor	Various nuclei with predominantly motor function, e.g. ventral lateral nucleus (VL): inputs: basal ganglia and cerebellum, output: to primary motor cortex and premotor cortex (precentral gyrus)
Interface	Various nuclei with integrative functions. e.g. medial dorsal nucleus (MD) projects to frontal associative cortex

Thalamus of the right half of the brain with its ipsilaterial projections to the cerebral cortex (from Zimmermann, 1990)



Ascending spinal and supraspinal somatoviscelar tract systems (Willis and Coggeshall, 1991)

	Specific lemniscal tract systems
Dorsal column path	Group II afferents from mechanoreceptors of the trunk and the limbs. Synapses in dorsal column nuclei (gracilis and cuneate nuclei); from there continues as medial lemniscus after crossing to opposite side, to ventrobasal nucleus of the thalamus and on to the postcentral gyrus
Spinothalamic tract	Part of the anterolateral funiculus with afferents from thermo-receptors and nociceptors. Axons decussate segmentally and in the brainstem join the medial lemniscus
Trigeminal (V)	Afferents from the face and the mouth region. Main sensory nucleus is the relay station for mechanoreceptors. Axons decussate and join the medial lemniscus, as do some of the axons from the spinal trigeminal nucleus with information from thermoreceptors and nociceptors
	Unspecific extralemniscal tract systems

	Specific lemniscal tract systems
Spinoreticular tract	Part of the anterolateral funiculus with afferents from then-me receptors and nociceptors. Axons decussate segmentally and end in the reticular formation: pathway continues from there to the medial thalamic nuclei
Spinothalamic tract	Part of the anterolateral funiculus with afferents from thermo-receptors and nociceptors. Axons decussate segmentally and run to the medial thalamic nuclei
Trigeminal nerve	Majority of the axons from the spinal trigeminal nucleus, from thermoreceptors and nociceptors in the face and mouth region: end in reticular formation; pathway continues from there to the medial thalamic nuclei

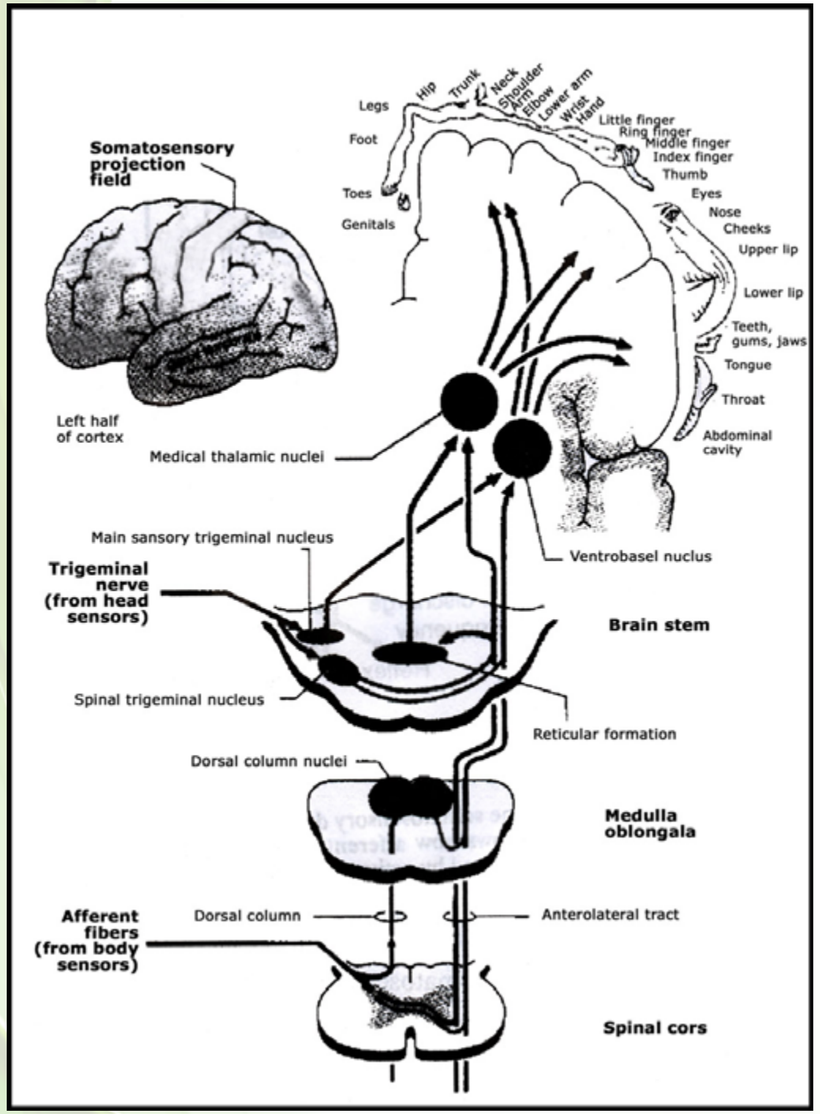
The primary sensory cortex, SI, is organized somatotopically, i.e. there is an orderly spatial mapping of the body surface onto the (contralateral) cortical surface

Somatotopy has been illustrated in the form of a sensory homunculus. It illustrates the fact that the body areas especially important for tactile sensations (mouth region, fingertips) occupy disproportionately large areas on the SI: a particularly large part of the central apparatus is made available to the dense sensor systems in the periphery, for optimal evaluation of the information they provide

The secondary sensory cortex. SII, is also somatotopically organized. Here, however, both halves of the body are mapped onto each hemisphere (bilateral projection): it is probably responsible for bilateral co-ordination of sensory and motor functions (e.g. two-handed activities)

Conscious somatosensory perceptions ordered in space and time are possible only with an intact cerebral cortex. Furthermore, we must be awake and must direct our attention to the event to be perceived. These processes involve primarily the unspecific sensory system (key words: extralemniscal tracts, reticular formation, ARAS, arousal)

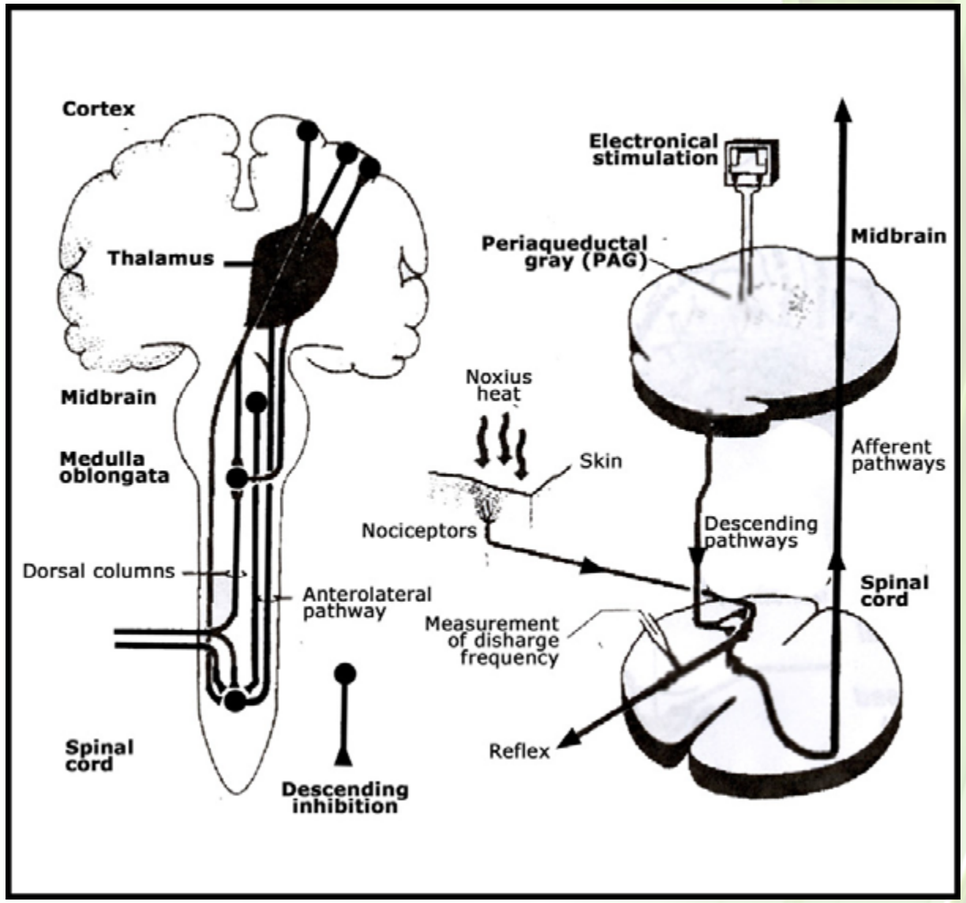
Course of the somatosensory pathways, with the most important relay stations (after Schmidt, 1983)



The position of the postcentral gyrus (somatosensory projection field SI) can be seen in the side view of the brain, above left. The schematic drawing of Penfield and Rasamussen, showing the topographically arranged projection of the body periphery onto the postcentral gyrus (sensory homunculus), is included to illustrate the relative sizes of the projections of individual parts of the body onto the cerebral cortex.

Centrifugal control of the afferent influx in the somatosensory system is an example of descending inhibition in all sensory systems; important function: protection against inundation with

unimportant information (after Zimmermann, 1990)



The diagram on the left summarizes the somatosensory descending inhibitory systems. The right diagram shows how afferent information from cutaneous receptors can be inhibited in the spinal cord by activation of the PAG in the midbrain (submechanism of opiate action, because opiates excite PAG neurons).

Pathophysiological disturbances of somatosensory function can manifest as:

- Sensory deficit symptoms (e. g. hypesthesia or dysesthesia following damage in the lemniscal system)
- Symptoms of stimulation (e. g. complex paresthesias caused by ectopic impulse generation when ascending pathways have been damaged)
- Disturbances of sensory discrimination functions (e. g. astereognosis, disturbances of body scheme, hemineglect)

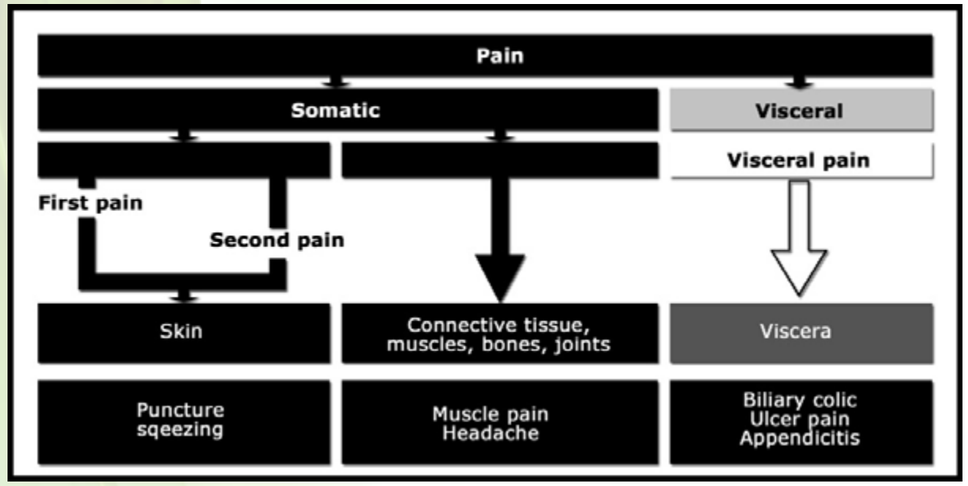
There are many definitions of pain: none is universally accepted; a useful one follows:

Pain

An unpleasant sensory and emotional experience associated with actual or potential tissue damage, or described in items of such damage.

Characterizations of pain

Pain has various qualities, which are closely correlated with its site of origin (from Schmidt, 1990a)

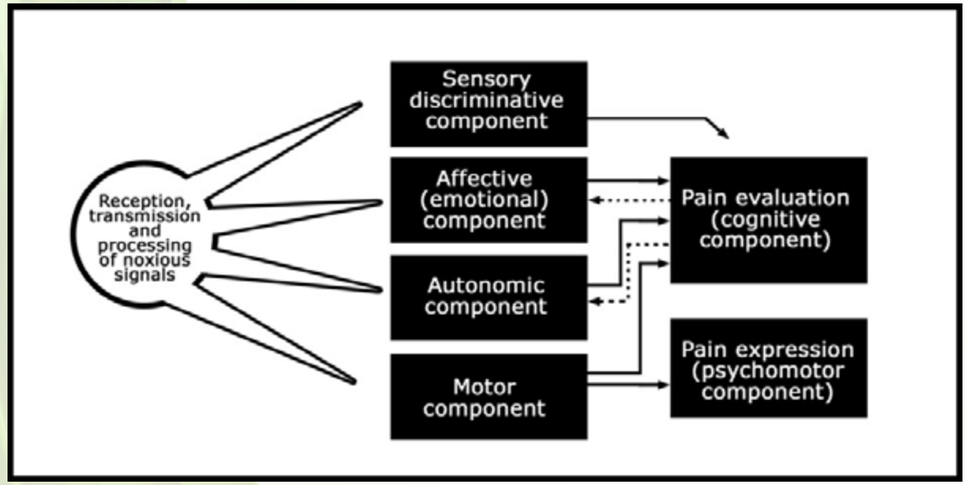


The distinctions between acute and chronic, as well as organic versus psychogenic pain, are as follows:

Type of pain	**Definition/Comments**
Temporary	Group II afferents from mechanoreceptors of the trunk and the limbs. Synapses in dorsal column nuclei (gracilis and cuneate nuclei); from there continues as medial lemniscus after crossing to opposite side, to ventrobasal nucleus of the thalamus and on to the postcentral gyrus
Acute	Organically induced pain of brief duration: limited to the site of damage; often definitely localizable; pain intensity proportional to stimulus intensity, pain ends after end of stimulus; clear signal and warning function, activation of autonomic and motor systems

Type of pain	**Definition/Comments**
Chronic	Organically induced pain that lasts a long time (>1–3 months) or returns repeatedly (e.g. migraine, trigeminal neuralgia); pain intensity often greater or less than stimulus intensity; autonomic changes, affective elements superimposed. Chronic pain may persist after re¬moval of the organic cause or reappear (with no new organic damage)
Psychogenic pain	**(Synonym: psychologically induced). Pain as direct consequence of social circumstances, emotional events or mental disease (with no organic stage); is experienced like organic pain (see definition of pain, '... or described in terms of such damage'). Example of psychogenic pain: no physiological but often a social function (e.g. pension claim)**
Spinoreticular tract	Part of the anterolateral funiculus with afferents from then-me receptors and nociceptors. Axons decussate segmentally and end in the reticular formation: pathway continues from there to the medial thalamic nuclei
Spinothalamic tract	Part of the anterolateral funiculus with afferents from thermo-receptors and nociceptors. Axons decussate segmentally and run to the medial thalamic nuclei
Trigeminal nerve	Majority of the axons from the spinal trigeminal nucleus, from thermoreceptors and nociceptors in the face and mouth region: end in reticular formation; pathway continues from there to the medial thalamic nuclei

A person's evaluation of experienced pain (cognitive component) and the resulting expressions of pain (psychomotor component) involve sensory, affective, autonomic and motor components (after Schmidt, 1990a)



A crucial factor in the evaluation of pain is the comparison of present pain with pain in the past and the consequences at that time. This cognitive evaluation in turn influences the magnitude of the affective and autonomic components (dashed arrows). other common influences on the evaluation of pain: social situation, family background (upbringing), ethnic origin, circumstances in which pain arises (e. g. accident, war wound, tumour).

Experimental algesimetry: psychophysical measurements (methods, p. 33) of the relationships between noxious stimulus (mechanical, thermal, electrical or chemical 'pain stimulus') and pain sensation

Application of the methods of experimental algesimetry to the patient; in addition, use of pain questionnaires (e.g. McGill Pain Questionaire) and comparison of the intensity of clinical pain with that of pain imposed experimentally (e.g. tourniquet pain quotient)

Neurophysiology of pain (nociception)

Definitions (see Willis, 1985)

- Nociception: transduction, transformation, conduction and central nervous system processing of noxious (tissue damaging or potentially tissue damaging) stimuli
- Nociceptive system: the peripheral and central nervous structures involved in nociception. The subjective sensation of pain is common, but not obligatory consequence of activity in the nociceptive system
- Specify theory of pain: the concept that the nociceptive system represents the function-specific sensory channel for the sense of pain (in analogy to the visual system for seeing, auditory system for hearing, etc.) has strong experimental support. Alternative views with little experimental support: intensity theory (postulates that every somatovisceral can encode noxious stimuli, by a high discharge rate) and pattern theory of pain (postulates the encoding of noxious stimuli by special discharge patterns of somatovisceral receptors).

Elements of the nociceptive system, their properties and functions:

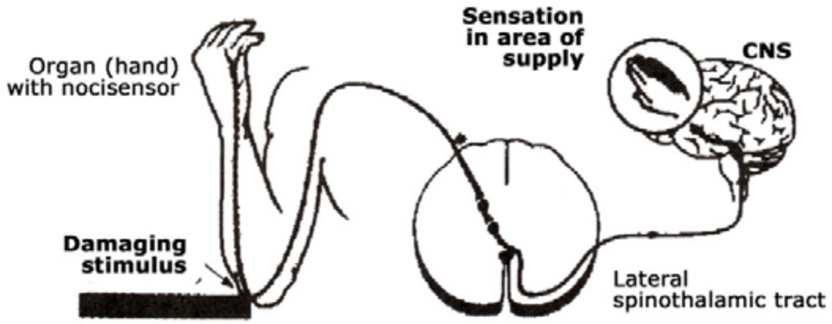
Element	**Properties, functions, comments**
Intense	Sensory receptor with high threshold, usually sensitive to high-intensity mechanical as well as chemical and thermal stimuli (noxae), i.e. polymodal; non-corpuscular ('free') nerve ending, present in practically all body tissues; in normal tissue partially inexcitable ('sleeping'). Function: transduction and transformation (p. 30) of noxious stimuli; sensitivity altered by sensitization (e.g. by inflammation mediators) and desensitization (e.g. by analgesics)
Fast reaction	Either thin myelinated (group III, synonym: Aδ) or unmyelinated (group IV, synonym: C fiber, p. 17). Function: conduction (p. 30). Distinctly more group IV than group III fibers present. Transmission of initial pain by group III, of delayed pain by group IV fibers. Local anesthetics (mechanism p. 14) block conduction of nociceptive im¬pulses (e.g. in dental medicine) but also other sensory information (hence the region innervated by the blocked nerve is not only analgesic but also anesthetized)
Slow reaction	Nociceptive afferents end in the dorsal horn of the spinal cord or the corresponding trigeminal nucleus. Connection there with ascending tract systems that convey the noxious information to the thalamus and cortex Function: central conduction and processing of noxious information. The generation of conscious pain sensations involves the somatosensory cortex and asso¬ciative cortical areas
Effluage	**These have a predominantly inhibitory function in the nociceptive system; hence are described under 'endogenous pain control systems' on p. 48**

Pathophysiology of nociception and pain

Definitions of patophysiological pain sensations

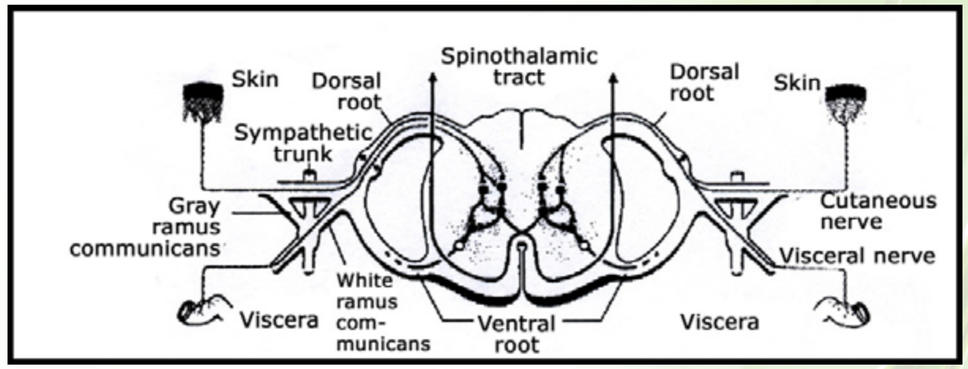
Allodynia	**Pain caused by non-noxious stimulation of normal skin. This expression designates conditions in which a normal mechanical or thermal stimulus to the skin elicits pain sensations: the receptors involved may be mechanoreceptors or thermoreceptors; depends on altered central processing**
Anesthesia	Abolition of all cutaneous sensory modalities
Analgesia	Absence of pain during noxious stimulation
Dysesthesia	Unpleasant abnormal sensation, either spontaneous or elicited by a stimulus
Hypesthesia	**A reduced sensitivity to somatosensory stimuli. The type of hypesthesia should be specified with respect to region and to modality or stimulus form**
Hypalgesia	**Reduced sensitivity to noxious stimuli. Hypalgesia is usually a component of hypesthesia (see above)**
Hyperesthesia	**Increased sensitivity to non-noxious stimuli. The type of hyperesthesia should be specified with respect to region and stimulus form**
Hyperalgesia	**Increased sensitivity to noxious stimuli. It involves a lowering of the threshold to noxious stimuli and/ or an intensification of the response to a noxious stimulus**
Hyperpathia	**Pain syndrome characterized by delayed onset, increased response and an after-response which outlasts the stimulus. It is most clearly during repetitive stimulation. Hyperpathia can be combined with hypo-, hyper- or dysesthesia**
Paresthesia	**Abnormal induced but not unpleasant sensation, either spontaneous or stimulus – induced.**

Projected (neuralgic) pain is produced by pathophysiological impulse generation in the nociceptive afferent nerve fibers (after Schmidt, 1990a)



Acute impulse generation in afferents produces a brief dysesthesia (stimulation of ulnar afferents when elbow is struck); chronic impulse generation in nociceptive afferents leads to a neuralgic pain, restricted to the region supplied by the affected nerve or the affected dorsal root (e.g. compression of a spinal nerve in a disk syndrome). Neuralgic pain often recurs in waves or attacks.

Referred pain



Disorders of internal organs often produce sensations of pain on the body surface; referred pain (each organ is associated with typical areas on the surface, e. g. inner side of left arm for heart). Caused mainly by convergence of visceral and somatic nociceptive afferents onto dorsal horn neurons of the nociceptive systems (left); in addition, somme nociceptive afferents supply both superficial and deep tissue (right).

Central pain

Pain that results from overexcitability or pathological spontaneous activity in the nociceptive system. Examples: anesthesia dolorosa (after dorsal roots have been torn out), phantom pain (after amputations), thalamic pain (associated with diseases of the sensory ventral nuclei of the thalamus).

Endogenous and exogenous inhibition of pain

Pain control system within the boy (endogenous inhibition)

System	Definition, action, comments
Opiate	At many places in the nociceptive system there are opiate receptors (four subtypes known at present). Under certain conditions (e.g. extreme stress situations) the body releases endogenous opiates, which bind as ligands to these opiate receptors and induce an¬algesia. Important examples: polypeptide dynorphin, contains the pentapeptide leu-enkephalin; polypeptide β-endorphin, contains the pentapeptide met-enkephalin
Sympathetic	From the periaqueductal gray matter (PAG) and the adjacent lateral reticular formation, tracts descend to synapse in the nucleus raphe magnus (NRM) and locus coeruleus. Descending projections terminate in the dorsal horn of the spinal cord and inhibit nociceptive pathways by release of monoamine transmitters (serotonin, norepinephrine): see gate control theory. The PAG contains very many opiate receptors and is an important target of morphine

Gate control theory: Postulates that nociceptive information can be modulated at as low a level as the dorsal horn, by afferent and descending inhibition. Details of the mechanism are unknown. Therapeutic attempts to activate this control mechanism in order to inhibit pain (e. g. by electroacupuncture nerve stimulation, stimulating the dorsal column with implanted electrodes and transcutaneous nerve stimulation, TNS) have so far had limited success.

Target sites for pain therapy

Procedure	Action/Comments
Non-narcotic analgesics	Substances that inhibit pain with no restriction of con¬sciousness (narcosis): many groups of substances and preparations (example: acetylsalicylic acid); predominant target: peripheral nociceptors
Narcotic analgesics	Substances with a strong analgesic action which also limit consciousness, especially in high doses (oldest example: morphine, contained in opium; today many opiates [syn.: opioids] are in use); activate endogenous pain control systems by binding to opiate receptors

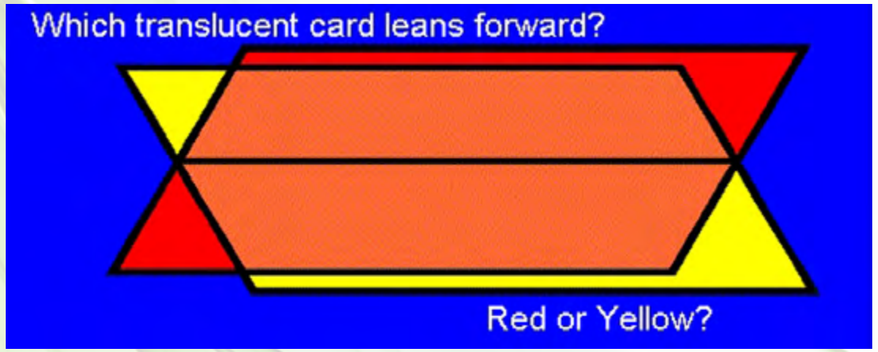
Procedure	Action/Comments
Psychotropic drugs	No direct analgesic action, but can have a favorable effect on emotional components of the pain experience. Main groups: tranquilizers and antidepressants
Local anesthesics	Block the generation (surface anesthesia) or conduction of impulses in nociceptive (and other) afferents (nerve block)
Physical measures	Depending on the origin of the pain, a great variety of methods are employed, ranging from application of heat and cold to electrical stimulation and neurosurgery, and also including various forms of therapeutic exercise. In neurosurgery the only procedure of some significance is cordotomy (transection of the anterolateral funiculus of the spinal cord), to interrupt conduction of nociceptive signals from the contralateral half of the body
Psychological methods	Used especially but not exclusively for pain with no clear peripheral cause. Typical methods: biofeedback operant conditioning, relaxation, meditation, hypnosis

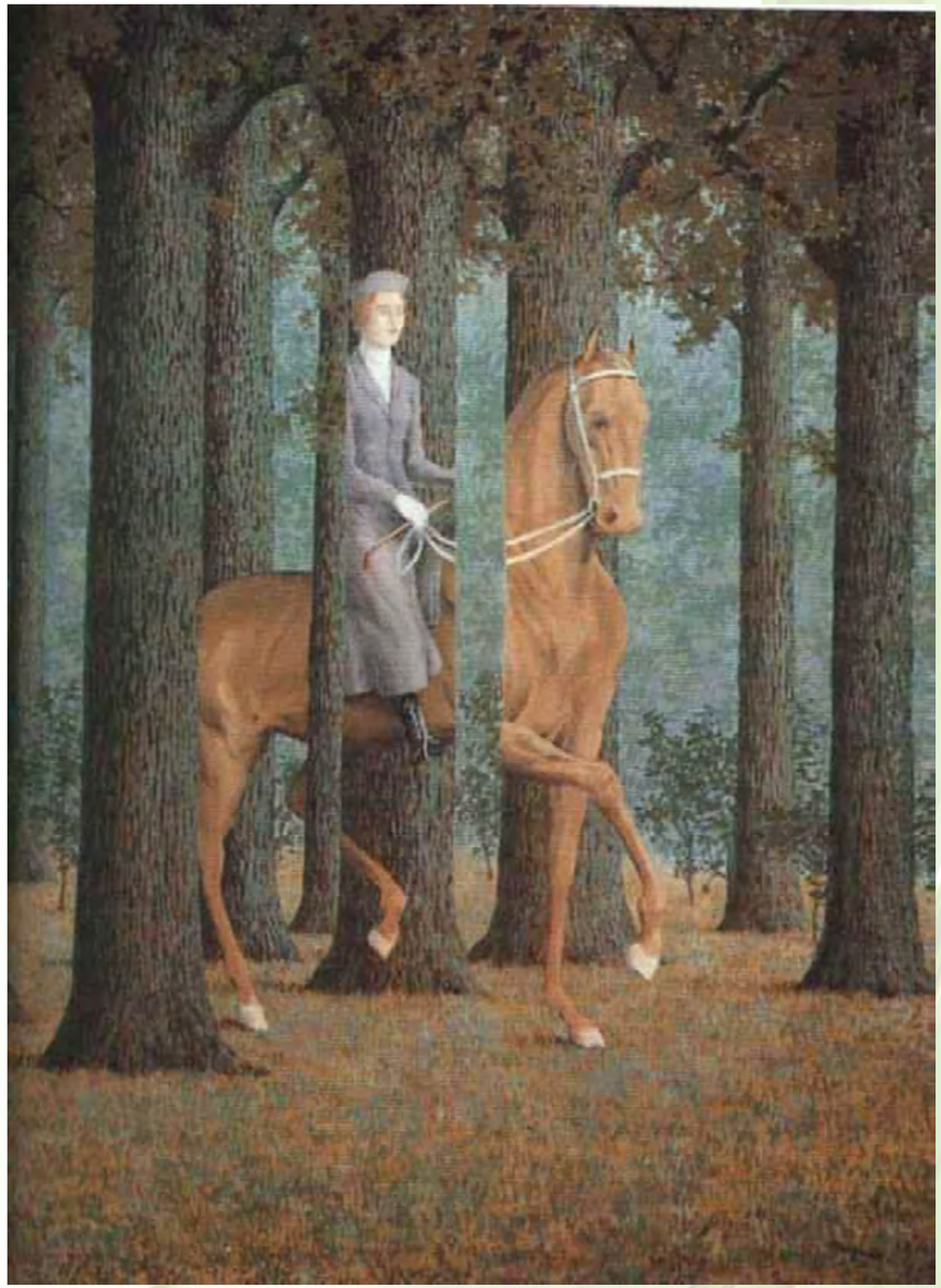
Itch

Is itch a form of pain?

Not enough is known about the pathophysiotogical sensation itch, which is related to pain. It occurs only in the skin and the adjacent mucous membranes, where it is triggered by the release of histamine. The main open question is whether it is an independent sensation (with its own receptors, etc.) or a special form of the pain sensation.

Optical illusions





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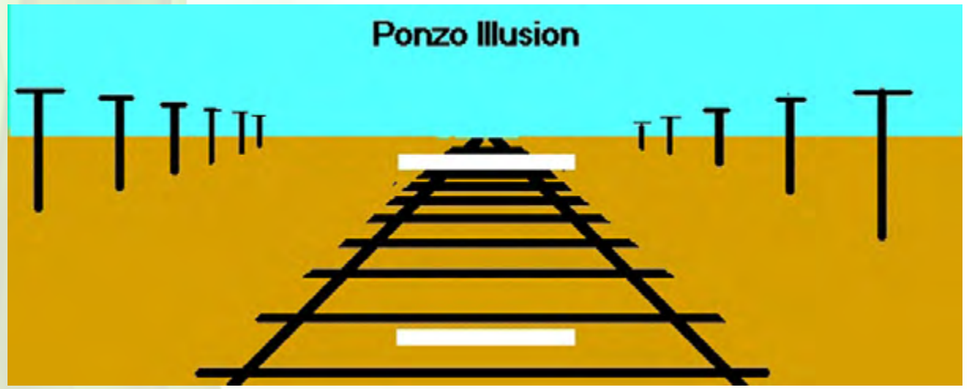

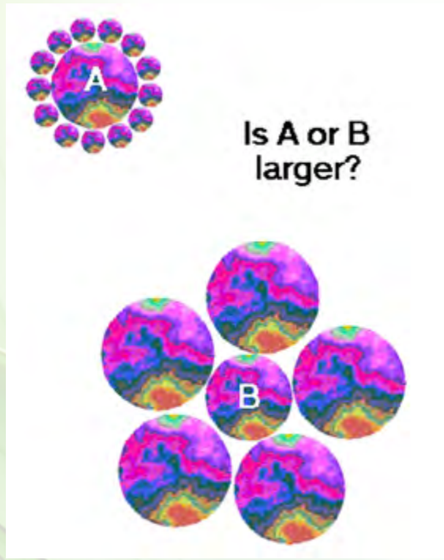

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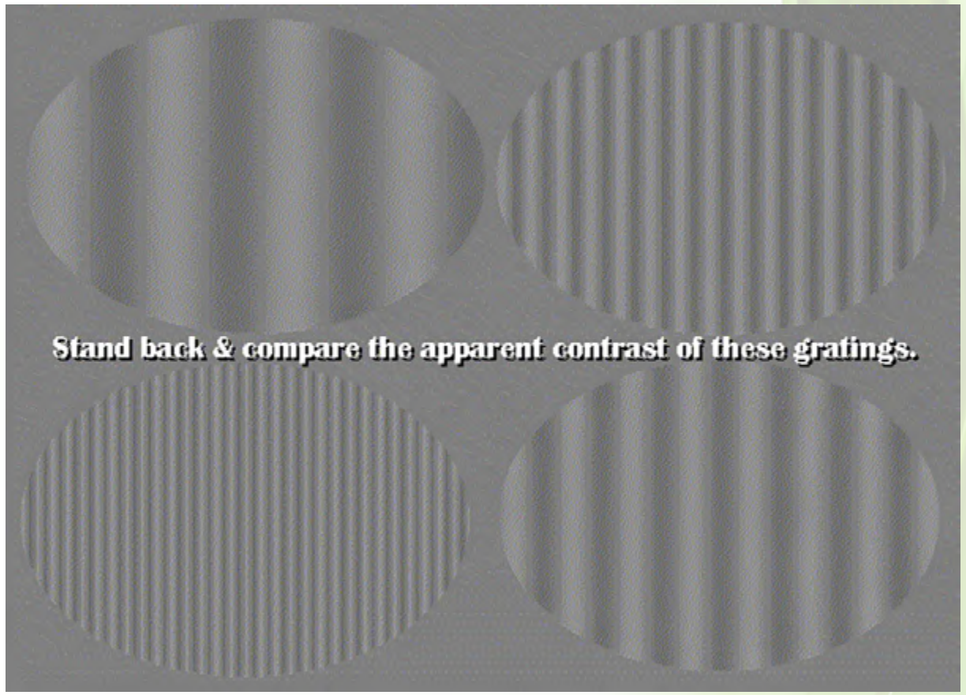


The eye and its optical system (dioptric apparatus)

The optical system of the eye casts onto the retina an inverted and much reduced image of the surroundings. The amount of incident light is controlled by pupillary responses, the sharpness of the image by accommodation. These involve:

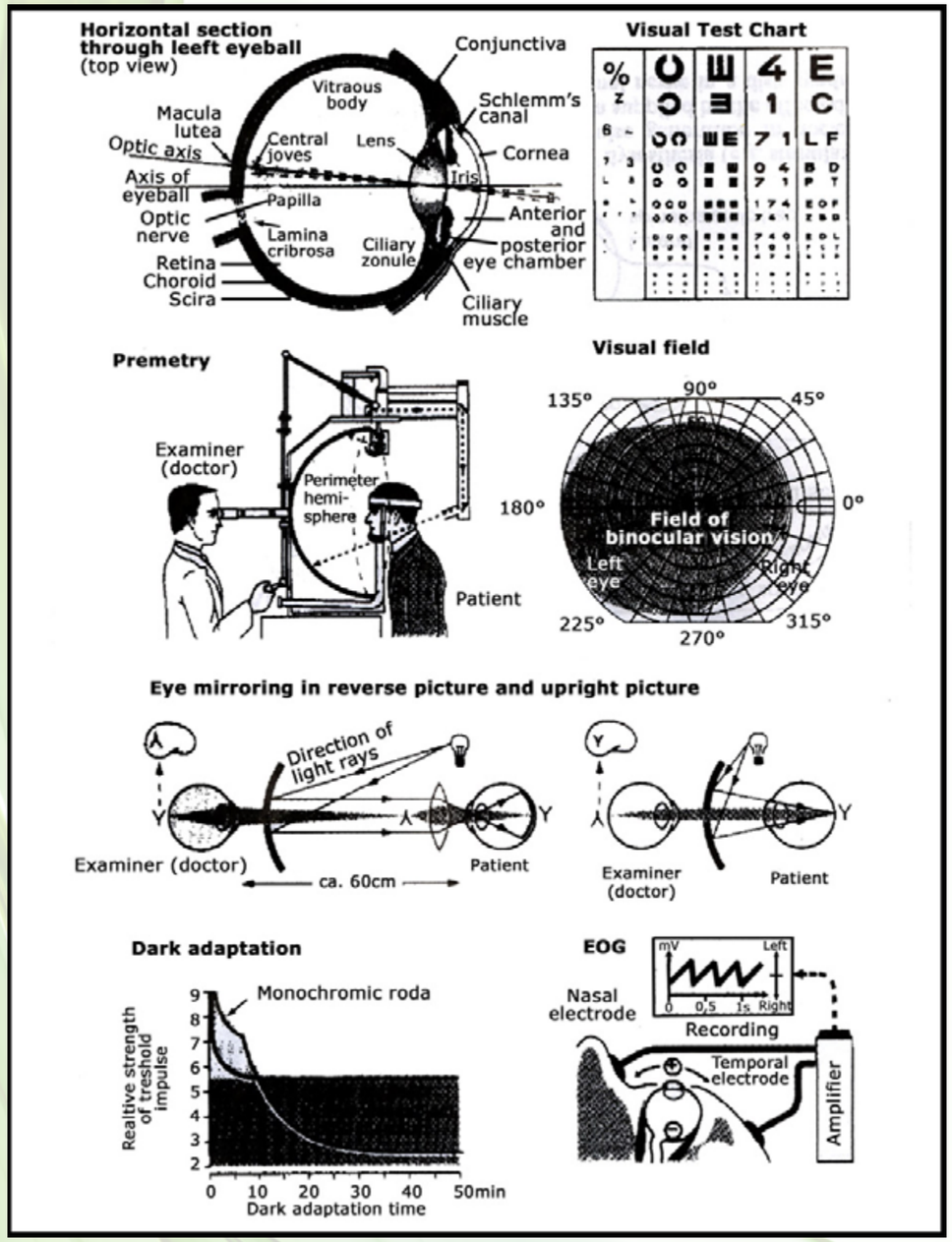
Element	Function(s)/Description/Comments
Liquid	Anterior, transparent part of the sclera enclosing the eye, ca. 1 mm thick, with no blood vessels; covered by the conjunctiva and continuous with the sclera, which looks white and contains blood vessels; outer surface kept moist and sterile by lacrimal fluid, inner bounded by anterior chamber of the eye. Sensory innervation by first branch of trigeminal nerve (blink reflex when touched). Overall RP 43D, unalterable. Distance between anterior corneal surface and retina: 24.4mm
Movement	Biconvex, elastic, transparent connective tissue body surrounded by lens capsule, which is connected to ciliary muscle (see below) and sclera by zonule fibers. Intraocular pressure pulls lens flat. Refractive power at rest 19.1D (flattened state, unaccommodated). Lens plus cornea, aqueous humor in anterior chamber and vitreous body constitute the compound optical system of the eye, the dioptric apparatus; overall RP 58.6D, see above
Intense light	Flat disk of tissue in front of the lens with circular central opening, the pupil. iris contains the smooth dilator (sympathetic innervations) and sphincter (parasympathetic innervations) muscles of pupil which regulate pupil diameter and hence amount of light entering the eye (extremes: mydriasis and miosis). Light response always simultaneous in both pupils (`consensual'), even with light into only one eye. Pupil also narrows during accommodation: near-vision re¬sponse. Degree of iris pigmentation determines eye color, from blue to gray to brown
Cholinergic	Annular smooth muscle around the lens, parasympathetic innervation (oculomotor nerve). Its contraction relaxes the zonule fibers, so that the lens curvature increases, especially the front surface: accommodation (front and back focal lengths shorten). Accommodation range (max. increase in RP): 14D at age 10 (near point 7cm), 2D at age 50, 0.5 D at age 70. (Presbyopia caused by loss of lens elasticity; near point moves away from eye: loss of RP is compensated by reading glasses)
Photoreceptors	Light-sensitive lining of back inner surface of eye; contains the photoreceptive cones (color vision) and rods (twilight vision); also a network of higher-order nerve cells, the final layer of which comprises the ganglion cells. In the visual axis is the fovea centralis (site of most acute vision, cones only)
Psychological methods	Used especially but not exclusively for pain with no clear peripheral cause. Typical methods: biofeedback operant conditioning, relaxation, meditation, hypnosis

Subjective and objective methods for eye exhamination

Method	Definition/Description/Comments
Acuity measurement	Subjective measurement of visual acuity at the site of greatest acuity (fixation point in optic axis, is projected onto fovea centralis) with test charts (Landolt rings. picture or letter charts). The result is usually expressed as a Snellen fraction (ratio of the distance at which a symbol is discriminated to the distance at which it subtends 1 minute of arc, in practice usually 20 feet, normal: 20/20)
Perimetry	Measurement of visual field of each eye with perimeter appara-tus; tested with white and colored light spots (visual field larger for white than for colored). Visual field deficits arc called sco-tomata. A physiological scotoma is the blind spot, where the optic nerve enters the retina; ordinarily not noticed because filled in perceptually. Visual fields of the two eyes overlap only par¬tially, hence binocular field > monocular. Binocular visual field is expanded by eye movements= `field of gaze')
Ophthalmoscope	Used to study the fundus of the eye by way of the light it reflects. Depending on the method used, the image is upright or inverted (enlarged 16- and 4-fold, respectively). Refractive anomalies found in the eye must be corrected with lenses (objective measurement)
Tonometry	Measurement of intraocular pressure (by applying pressure to the cornea); normally 15–16 (limits 10 and 21) mmHg. produced by ultrafiltration of plasma from capillaries in the ciliary body to form aqueous humor (2mm²/min), which flows from posterior to anterior chamber and thence through the canal of Schlemm into the venous system. Blockage of outflow raises the pressure (glaucoma), which damages the retina and may cause blindness.

Method	Definition/Description/Comments
Measurement of dark adaption	Color vision by day, photopic vision (with cones), gives way to black–white scotopic vision (with rods) as brightness decreases, along with a rapid deterioration of acuity. Because the fovea has only cones, it is impossible to fixate at night (hence scotopic vision has 2 blind spots). Light-adapted eve requires ca. 30min to adjust to twilight; dark-adapted eye is at first dazzled by sudden brightness but then quickly adjusts. Night blindness, nyctalopia, can be congenital or caused by vitamin A deficiency.
ERG	Electrocardiogram. ERG, recordable with macroelectrodes from outside of the eye. Illuminating or darkening the eye elicits a charac¬teristic sequence of voltage fluctuations (waves a, b, c, d), caused by excitation and synaptic transmission in the retina. Across the
resting eye is a steady potential, the cornea being positive with respect to the retina	
EOG	Electro-oculogram, EOG, employs the steady corneoretinal potential (forms electric dipole with surrounding electric field) to measure eye movements
VEP	Visual evoked potential can be recorded over the occipital cor¬tex after light stimuli; complex sequence of waves, strongly dependent on stimulus form (light flash. checkerboard pattern, color)

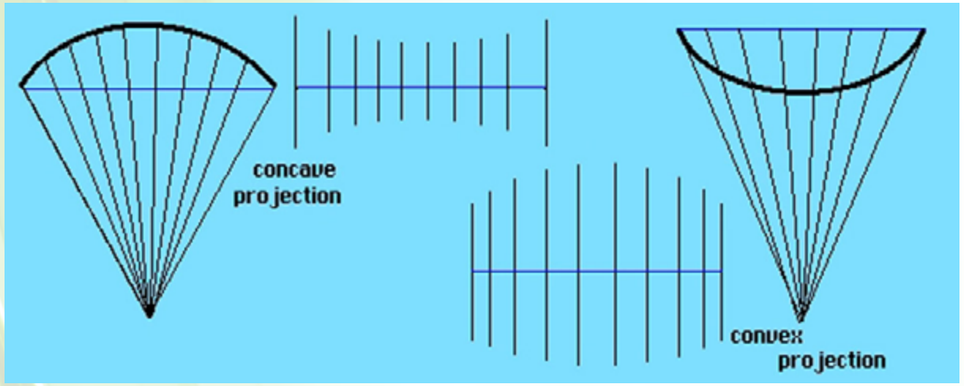
Structure of the eye; important examination methods:



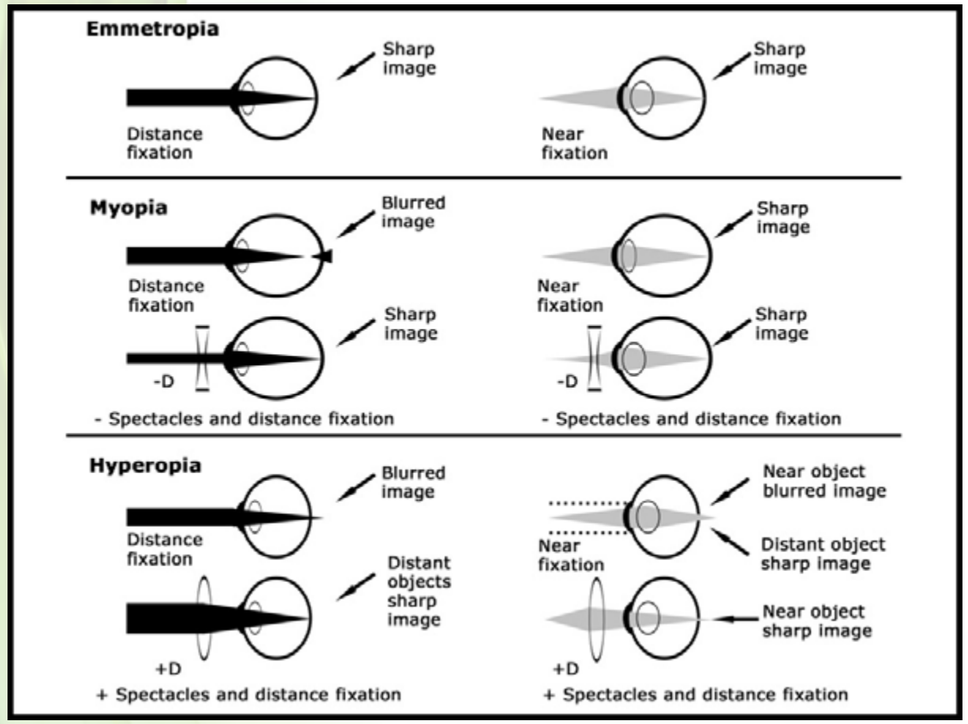
Optical defects of the eye, refractive anomalies, spectacles and contact lenses:

Term	Description/Comments
Spherical aberration	The dioptric apparatus refracts peripheral rays more strongly than those near the optic axes. The resulting blurring is reduced by constricting the pupils (excluding peripheral rays)
Chromatic aberration	Short-wavelength (blue) light is more strongly refracted than long (red) in the dioptric apparatus. Hence greater accommodation is required for red objects at a given distance, i.e. blue objects appear further away (often evident in viewing stained glass church windows (e. g. Chartres)
Astigmatism	The corneal curvature is not ideally spherical but (usually) stronger vertically than horizontally: a dot is imaged as a stripe: up to 0.5 D physiological; when greater is corrected by cylindrical glasses or correspondingly ground contact lenses
Myopia	Eye too long relative to refractive power of the dioptric apparatus. Image plane is in front of retina, hence blurred image of distant objects. Far point (definition: acute vision without accommodation) is too close (hence 'near' sighted). Near point (shortest distance for acute vision with maximal accommodation) little changed. Correction: concave lens (negative diopters) or corresponding contact lenses
Hypermetropia	Eye too short relative to refractive power of the dioptric apparatus. Image plane behind retina, hence acute vision impossible without accommodation (no far point). Because accommodation is needed to see at a distance, near point moves away from eye (hence far sighted). Correction: convex lens (positive diopters) or corresponding contact lenses
Squint (strabismus)	Accommodation is accompanied by convergence of the optic axes, to keep the image of the fixated object on the fovea centralis in hypermetropia this necessarily causes squint, because the optic axes converge (instead of remaining parallel) even when looking into the distance. Correct glasses (or contact lenses) prevent squint. Squint can also have other causes (e.g. congenital); surgery may help

Term	Description/Comments
Presbyopia	Associated with aging. Loss of lens elasticity in older people reduces the range of accommodation (see ciliary muscle in preceding Table). Far point unchanged. Near point moves away from eye. Correction convex lens for near vision (reading glasses)
Chataract	Clouding of the lens in old age, mainly caused by water incorporation and the development of fissures. Vision restored by surgical removal and glasses with strong convex lens (ca. 13 D for distance vision): it is also possible to insert a plastic lens during the operation
VEP	Visual evoked potential can be recorded over the occipital cor¬tex after light stimuli; complex sequence of waves, strongly dependent on stimulus form (light flash. checkerboard pattern, color)



Ray path in emmetropia (normal vision) myopia and hyperorpia



Psychophysiology of vision

Vision provides the basis for perception.

The eye does not send an ambiguous image of the surroundings of the brain. The brain interpret the impulses arriving from the optic nerves on the basis of its experience, so that we do not see meaningless patterns of visual stimuli but rather perceive objects in the environment. The following aspects are important here:

Image size on the retina is halved for each doubling of the distance of the viewed object. Nevertheless, it is always seen as about the same size

People or objects known to us are always recognized as the same, regardless of viewing conditions (light, perspective distortion, distance. etc.). The brain employs many mechanisms and kinds of information (e.g. contours, contour intersections or interruptions, horizontal disparity) to arrive at the perception of a closed shape (‘Gestalt’)

The data provided by the retina are often ambiguous, as in Necker cubes and other 'impossible' figures. Then the interpretation switches back and forth between alternative solutions. Sometimes

misinterpretations can occur, because normally reliable evidence is misleading in a special case. The result is a so called optical illusion

The Fraser Spiral

Look at the figure here. It clearly looks like a spiral, converging toward the center. How much would you be willing to bet that it is a spiral? On the basis of your perception alone, would you ever believe that it is actually a set of concentric circles? It is actually a set of circles, which you can verify yourself. Place one finger on any line making up the “spiral”. Place a finger from the other hand beside it, and carefully trace the line around with this finger while not moving the first finger. Eventually the moving finger will come back to the stationary one because the lines that appear to spiral all are part of a set of concentric circles. This shows that no matter how convincing a perception might be, because it is based on a hypothesis or conclusion used to interpret stimuli reaching us, our conscious interpretation may be wrong!

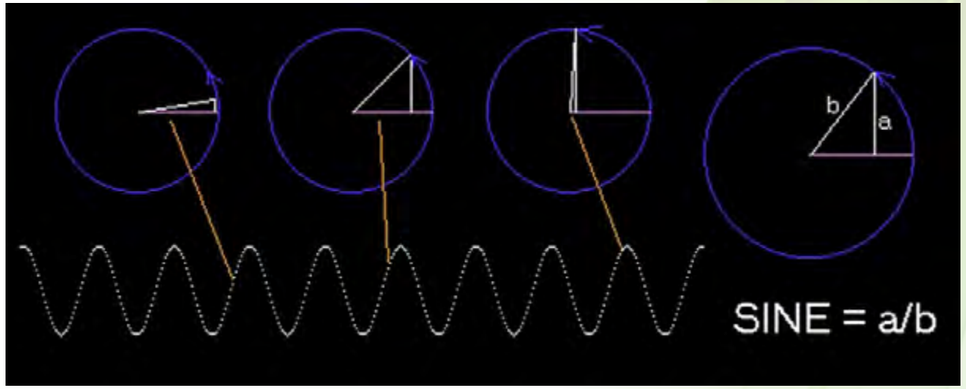
Concept	Definition/Description/Comments
Eigengrau	After a long time in darkness a medium gray (Eigengrau -‘intrinsic gray’) is perceived, often together with lighter nebulae dots of light, etc. probably due to spontaneous activity in the visual system

Concept	Definition/Description/Comments
Shades of gray	In daylight 30-40 different shades of gray can be discriminated, from deepest black to lightest white. Interpretation (perception) always depends on the surroundings: black checkerboards squares immediately look dark when light goes on in a dark room (even though the retina is receiving more light from the black squares than under Eigengrau conditions)
Simultaneous contrast	The visual system emphasizes (enhances) contours and contrasts. Hence a gray field seems lighter in dark surroundings than in light, etc. simultaneous contrast; particularly clear along a light dark boundary: simultaneous border contrast (Mach bands)
Afterimages	Consequence of local adaptation of the retina by preceding illumination. In addition to light – dark afterimages, they are often colored (in the appropriate opponent color red/green, blue/yellow)
Flicker fusion frequency	Light stimuli can be resolved at repetition rates up to 30/s, above which the light appears continuous: the critical flicker frequency is higher at higher light intensity
Phi phenomenon	The term for apparent movement, such as that perceived when lights in a row consecutively turned on and off

Special features and advantages of binocular vision

Concept	Definition/Description/Comments
Visual field	In binocular vision this, like the field of gaze, is larger than in monocular. There is a considerable region of overlap in the middle, called the binocular field. Lateral regions are seen by only one eye because of the nose
Convergence	Serves to measure distance. The closer a fixated point comes, the more the optic axes converge. The convergence angle can be evaluated by the brain as a measure of the distance of the fixated object (principle of the split – image range finder)

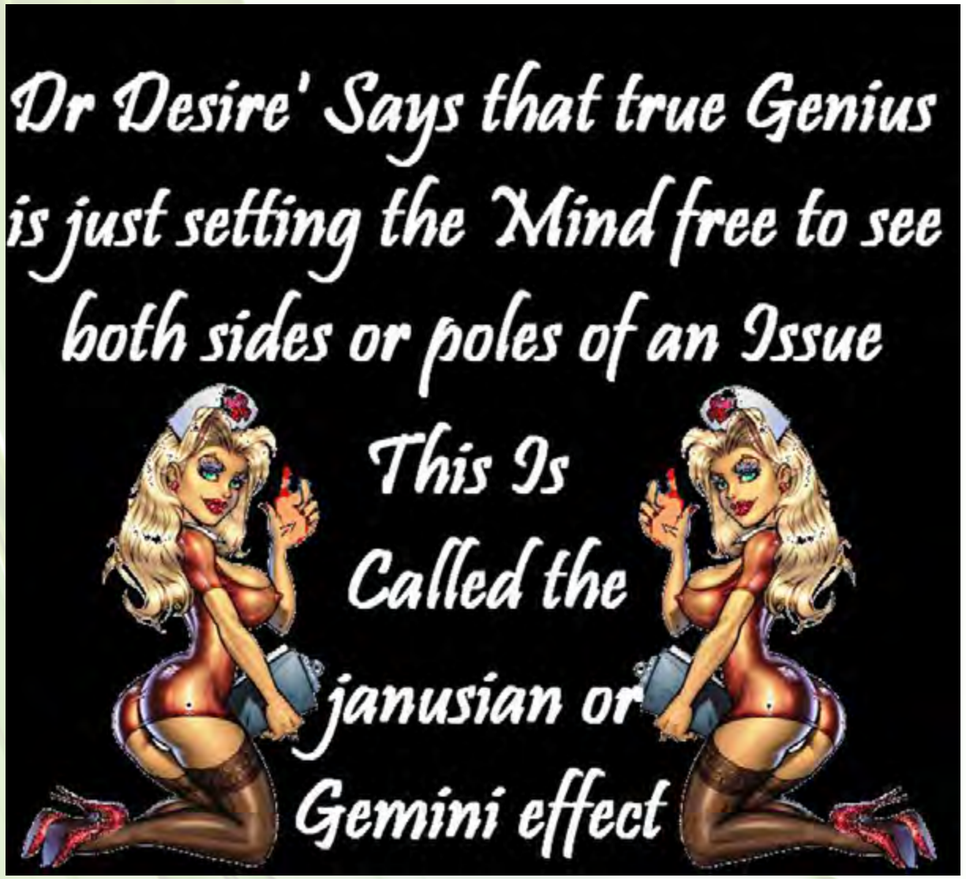
Concept	Definition/Description/Comments
Horizontal disparity	Each eye sees a given object from a different horizontal position: horizontal disparity. As a result, objects are imaged on the retina in such a way that all objects closer than the fixation point would have to appear as crossed double images, and all those further away as uncrossed ones. The brain processes this information to produce binocular fusion, generating an impression of spatial depth: effective only up to a distance of about 6m. When the complex interplay of convergence and disparity is disturbed (e. g. slight displacement of an eyeball with a finger, eye muscle paralysis), binocular fusion disintegrates and double images appear



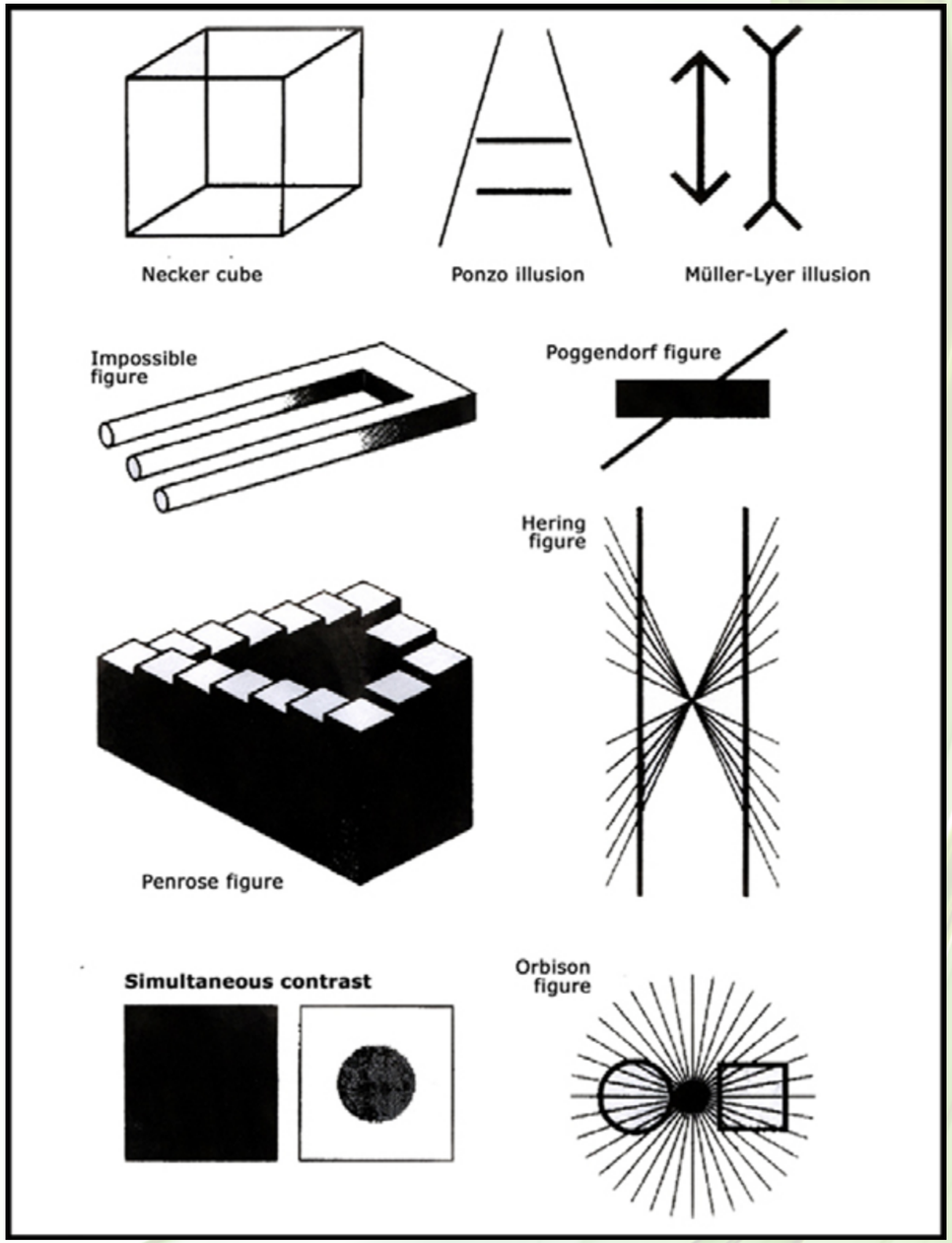
Gears and Circles

The pattern shown in this box should be viewed in motion. Move the box around, so that the motion resembles to that which you would make if you were swirling coffee around in a cup without using a spoon. Notice that the six sets of concentric seem to show radial regions of light and dark that appear to move in the direction you are swirling the book. They look as though they were covered by a liquid surface tending to swirl with the stimulus movement.

A second effect has to do with the center circle that seems to have gear like teeth. As you swirl the array, the center gear seems to rotate, but in a direction opposite to that of the movement of the outer circles. Some observers see it moving in a jerky, step like manner from one rotary position to another, and other observers see a smooth rotation. Of course, there is no physical movement between the circles, and the geared center circle is also unchanging, despite your conscious impression to the contrary.



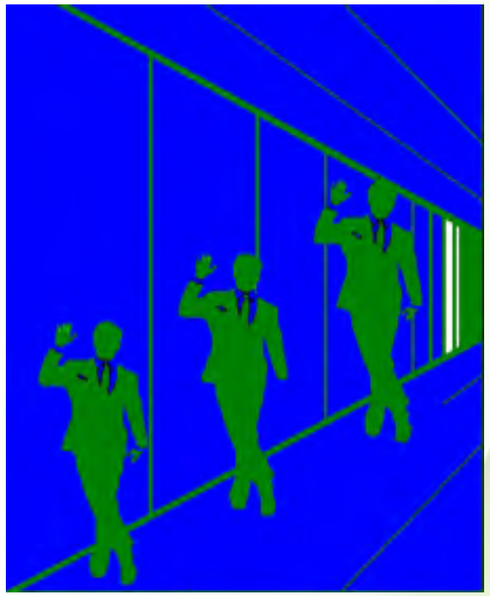
Sensory illusions in form perception, ambiguous and 'impossible' figures, example of simultaneous contrast

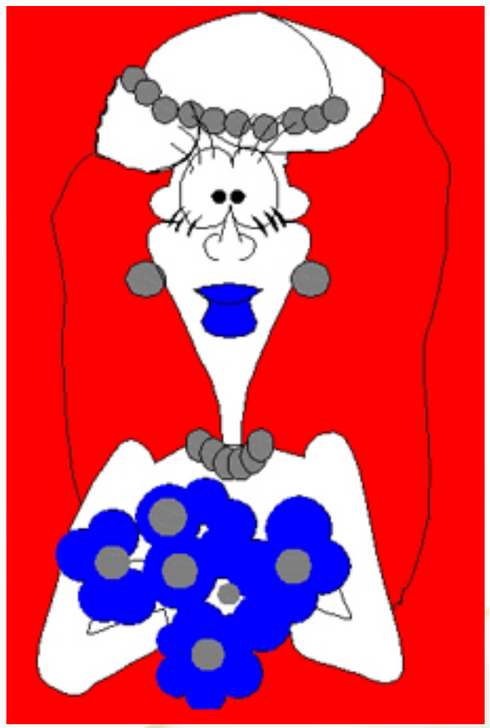


Color vision

Physical aspects of color vision, measurement of color

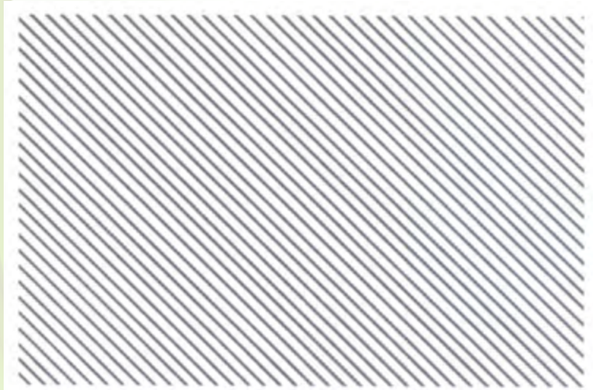
Concept	Definition/Description/Comments
Spectral color	Due to chromatic aberration (see p. 53) a prism separates white sunlight into the monochromatic spectral colors red, orange, yellow, green, blue, indigo and violet, with electromagnetic wavelengths of 700–400 nm
Mixed color	General term for all non-monochromatic spectral colors. Mixing of red and blue gives purple hues that are not present in the spectrum. However, all the spectral colors can also he produced by mixing (see below)
Achromatic valencies	The set of shades of gray from the most radiant white to the deepest black. Saturation of a color is determined by its achromatic component. Furthermore, color valencies are produced that cannot be produced by mixing spectral colors: spectral red plus white gives pink, plus black gives brown
Additive color mixtures	Produced when light of different wavelengths from self-luminous sources falls onto the same place on the retina, e.g. green and red mix in this way to give yellow, see Fig. (Yellow also exists as a spectral color, see above.) For every luminous light source in the color circle there is another that can be additively mixed with it to give white: complementary colors
Subtractive color mixture	Colors can be derived from white light by using color fillers. e.g. a broad-band blue filter also lets green through but no red and a broad-band yellow filter also passes green but no blue: what remains is green



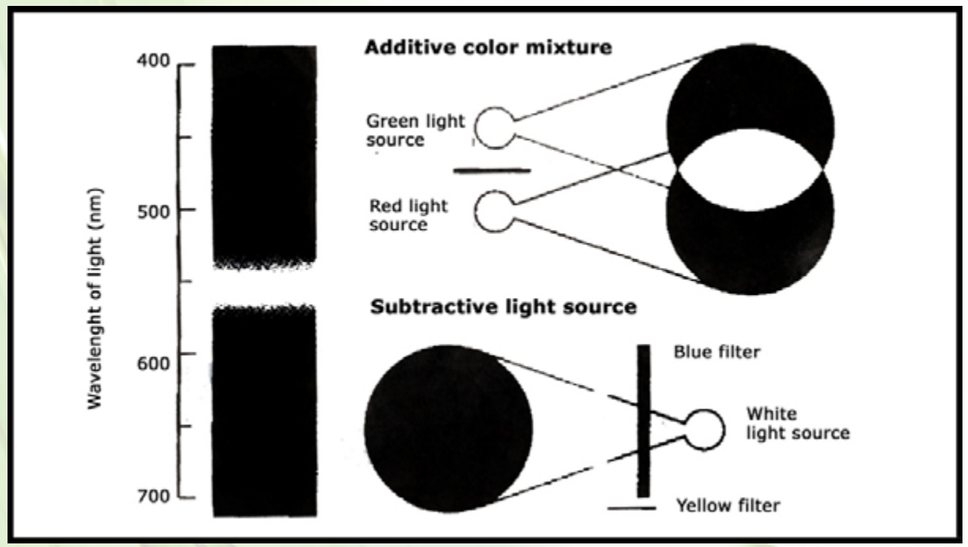


A Subjective Color Grid

The figure in this box consists of a series of thinly spaced diagonal black lines alternating with white spaces. Study this figure for a couple of seconds, and you will begin to see faint, almost pastel streaks of orange-red and other streaks of blue-green. For many observers, these streaks tend to run vertically up and down the figure crossing both white and black lines; for others, they seem to form a random, almost fishnet like pattern over the grid. These colors are not present in the stimulus; hence they are subjective, or illusory, colors.



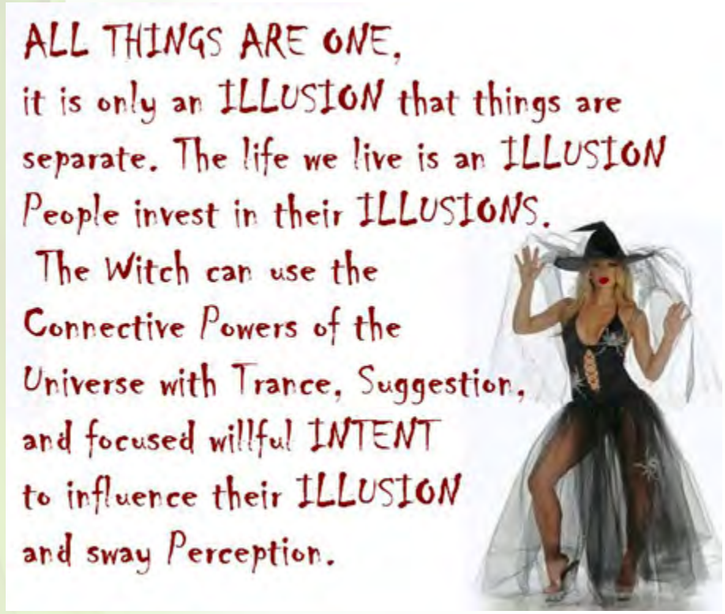
Spectral colors obtained by splitting sunlight with a prism (see above) and diagram of addictive and subtractive color mixtures (color mixture illustrations from Grüsser and Grüsser-Cornehls. 1990)



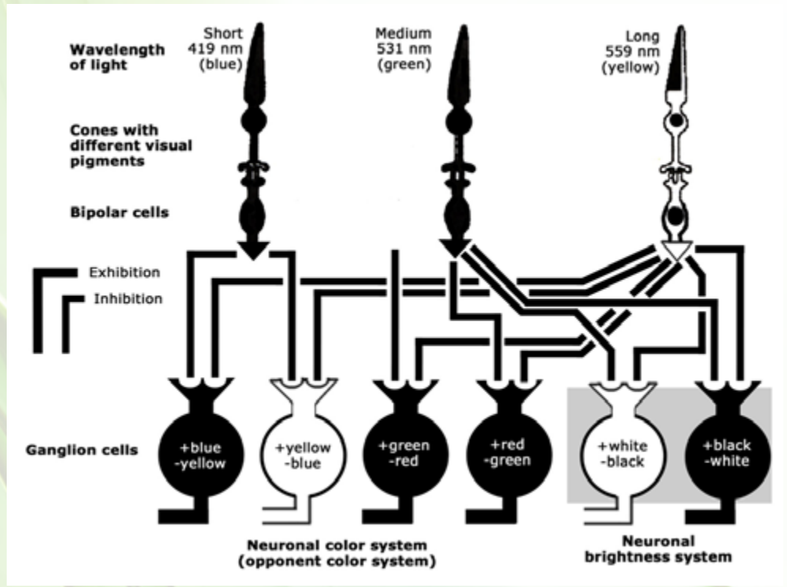
Trichromatic color vision, color theories

Theory	Description/Comments
Color Hues mixture	Findings: Three hues suffice to mix all colors. Various combinations of three primary colors can be selected from the spectral colors. By international convention: 700 nm (red), 546 nm (green), 435 nm (blue). Theory: color vision is based on differential activation and subsequent common process-ing of excitation in these three color systems. Neurophysiology: the retina contains three cone types with different absorption maxima. i.e. different visual pigments
Photo freq. interaction	Findings: intense red stimulus produces green afterimage (and vice versa); the same holds for blue/yellow and white/black. Theory: color vision is based on four primary colors that act as antagonistic pairs, the opponent colors red/ green, blue/yellow. Neurophysiology: in the retinal neurons on which cones synapse, antagonistic excitatory and inhibitory processes are elicited by the opponent colors, and an additional black-white system is present as a brightness system. That is, both theories are 'correct' at differ-ent levels of the visual system

The existing color theories represent first approximations to the actual situation. Experiments by Edwin Land, the inventor of the polaroid camera, show that even when only two colors are actively present a great abundance of colors can be provided and that in some circumstances colors are perceived that are not present at all. Familiar objects, such as green field, are perceived with astonishing color constancy (by central nervous processes, retinex theory). It is also unclear how metallic colors (gold, silver) are produced; they cannot be mixed from spectral colors.



Model of the color system in the retina that encompasses the trichromatic and the opponent process theories (modified after De Valois, 1969 from Birbaumer and Schmidt, 1996)



Defects of the color sense, color blindness

Examination: method to test for all color vision defects: pseudoisochromatic charts. They are patterns of many colored dots, arranged in such a way that a person with normal color vision sees a particular number, while one with a defect sees no number or an incorrect one (formed by brightness differences). Anomaloscope: color-mixing device for quantitative measurement of the inability to distinguish red from green. The color impression of a monochromatic (sodium) yellow field is matched in an adjacent field by mixing (lithium) red and (mercury) green. People who see red poorly require more red in the mixture, and so on.

Inability to distinguish red from green

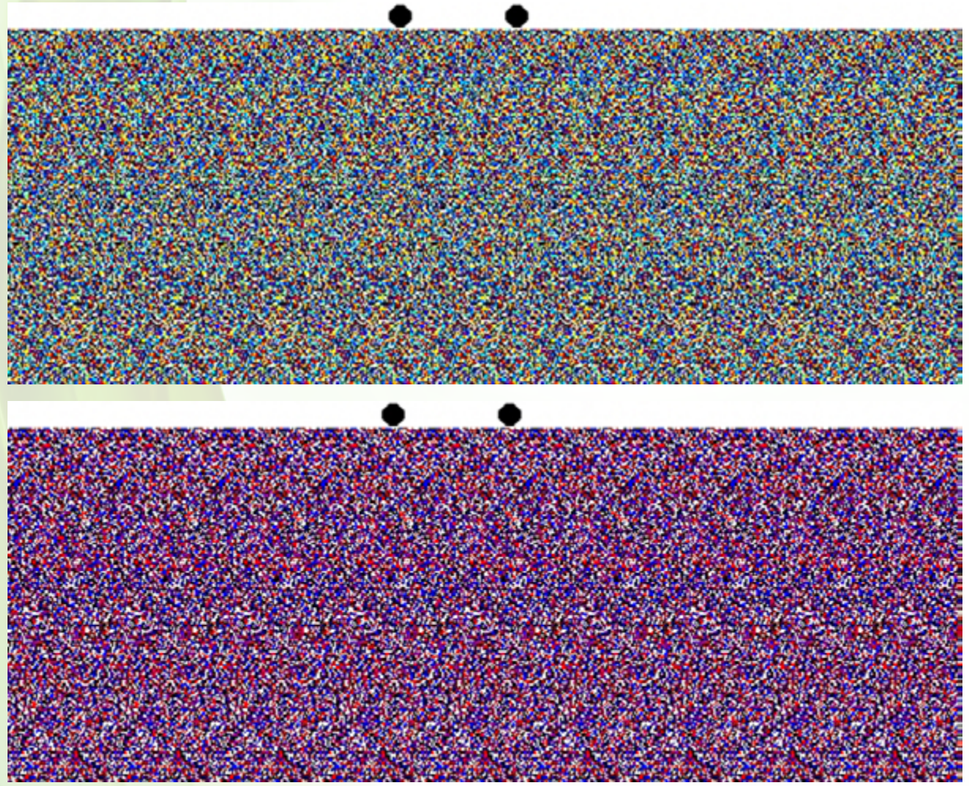
Protanomaty, protanopia	Confusion of red and green because of inadequacy (protanomaly) or complete absence (protanopia) of red sensitivity. Color spectrum shortened at the long-wavelength end: red blindness: confusion of red lr with black, dark gray, brown and green
Deuteranomaly, deuteranopia	Confusion of red and green because of inadequacy or absence of green sensitivity. Prot- and deuteranomalies are common defects of color vision: about 8% of all men, 0.4% of all women (inherited as recessive trait carried by X chromosome)

Inability to distinguish yellow from blue

Tritanomaly, tritanopia	Extremely rare, confusion of yellow and blue. Blue violet end of the color spectrum shortened, perceived as gray to black
	The various '-opias' are all forms of dichromatopsia, because these people require only two colors to describe all the colors of the color space

Total color blindness

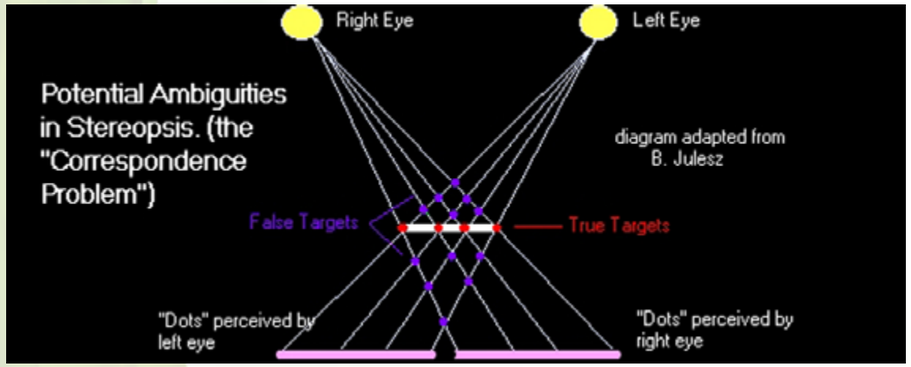
Achromatopsia	Also (inaccurately) called monochromatopsia. Complete failure of the cone apparatus, hence there is only scotopic black-white vision (see p. 51); normal vision in twilight, by day acuity reduced to 1/10 by central scotoma; also oscillatory eye tremor (nystagmus) because fixation is im-possible, photophobia because bright daylight is dazzling



Oculomotor and gaze-directing functions

External eye muscles, innervation, main action

Muscle	Nerve	Main action
External (lateral) rectus	Abducens (VI)	Abductor
Internal (medial) rectus	Oculomotor (III)	Abductor
Superior rectus	Oculomotor (III)	Elevator
Inferior rectus	Oculomotor (III)	Depressor
Inferior oblique	Oculomotor (III)	Outward rotator
Superior oblique	Trochlear (IV)	Inward rotator



The eyes make vergence movements and conjugate movements

Vergence movements

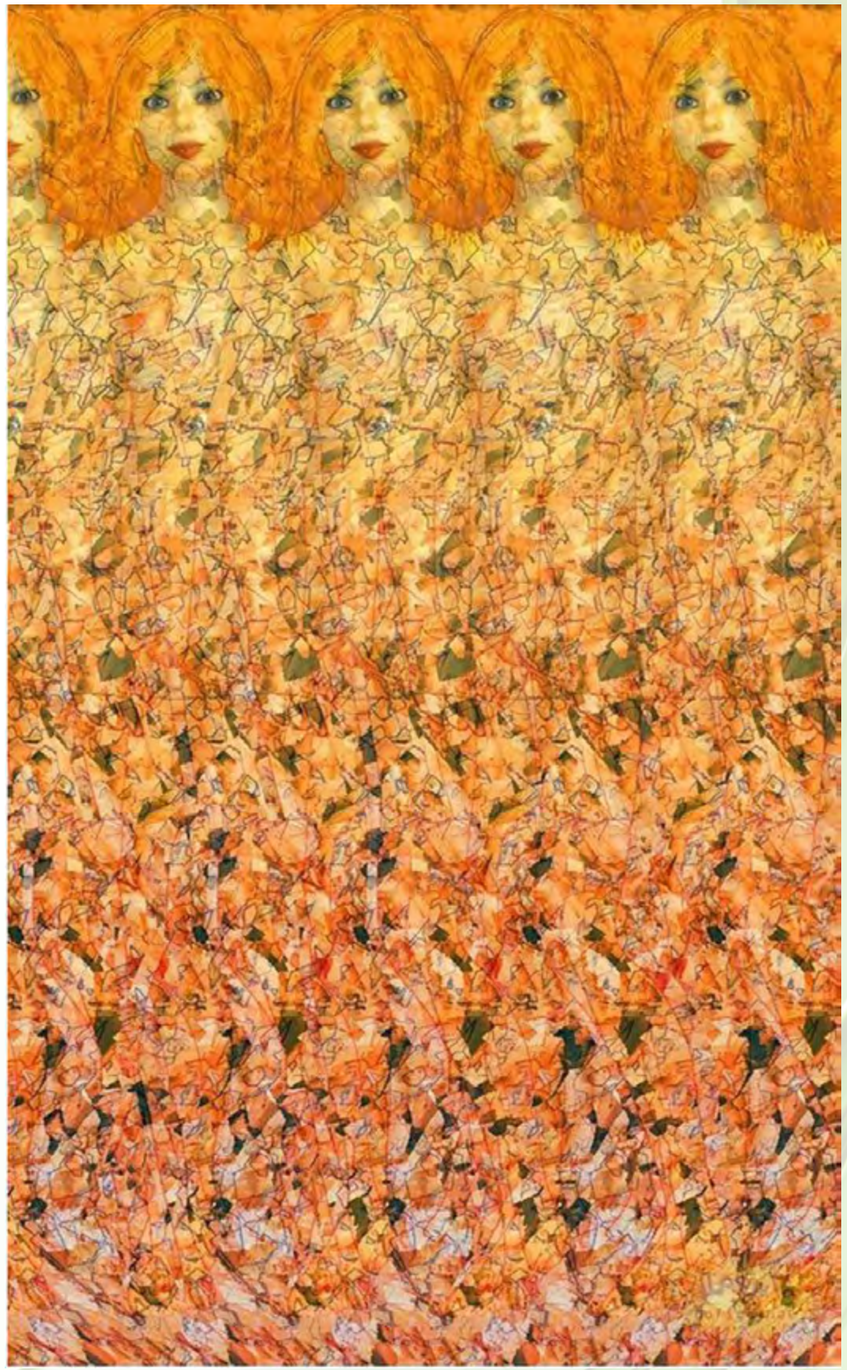
Optic axes are parallel when viewing far-away objects. For fixation of close objects the optic axes must converge. This convergence is closely coupled to contraction of the ciliary muscle for accommodation and to pupillary constriction (p. 50). The combination of these three is called the `near reflex'. The reverse movement of the optic axes when fixation shifts from near to far. Vergence movements have amplitudes as great as 5° and last about 1s.

Conjugate eye movements

Jerky eye movements from one fixation point to another when freely looking around: duration of saccadic movement 10–80 ms, separated by fixation periods of 0.15-2s. Large saccades are usually accompanied by head movements. The visual acuity dur¬ing a saccade is low; visual perception is suppressed (saccadic suppression). Occur during fixation of a moving object (advantage: image is kept at the position of greatest acuity, the fovea centralis); often com¬bined with following movements of the head. Both eyes move in the same direction in the frontoparallel plane when the head is tilted; also, during marked accommodation convergence is accompanied by slight, symmetrical rotator movement.

Conceptually driven processing

The figure in this box is a drawing of an animal you have seen many times before. Do you know what it is? If not, turn the page and look at the hint given in the figure there. In the figure on the next page, the cow's head is outlined. Now look back at the figure here. Having once "seen" the cow, you may wonder how you missed recognizing it in your first glance at this picture. The difference between your experience during the first look at the figure and your experience during the second look illustrates the distinction between data-driven and conceptually driven visual processing. In the first viewing, the data-driven processes extracted shapes of various sizes and with various features. You then tried to match this collection of features with objects in your long term memory. Perhaps you thought it was an aerial photograph of the Grand Lakes or some other familiar scene. In the second viewing, your memory representations of a cow influenced the way you grouped the shapes in the picture. From now on, your memory will contain a record of this picture, and you will probably be unable to look at the figure below without seeing the cow immediately.



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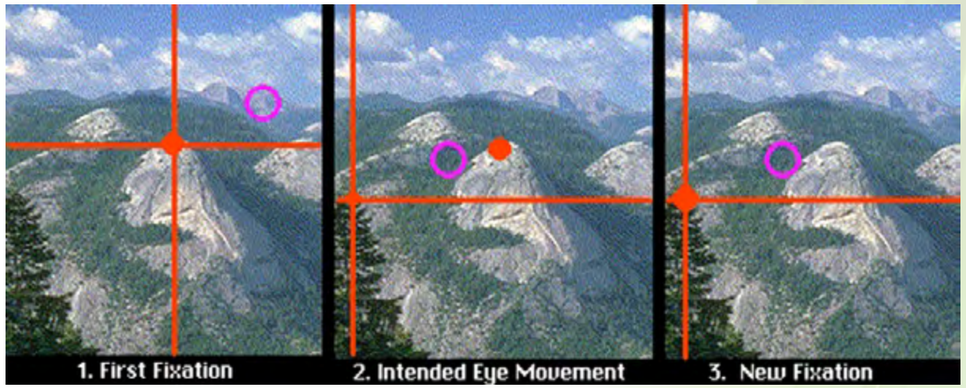
83

The eyes are thus continually in motion. Stability of the surroundings despite eye movements is an important example of sensorimotor integration, which is accomplished mainly in gaze control centers of the brainstem (control centers for all eye movements).

Nystagmus

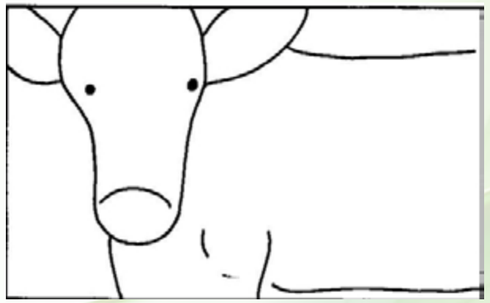
Definition: Rhythmic eye movements consisting of a periodic alternation of between slow following movements and saccades in the opposite direction. Direction of nystagmus is indicated by the direction of the saccadic movement

Example 1: optokinetic nystagmus: When looking out of a moving train, the eye focuses on a point in the landscape as long as possible and then, with a 'restoring' jumps forward (in the direction of travel) to the next fixation point.



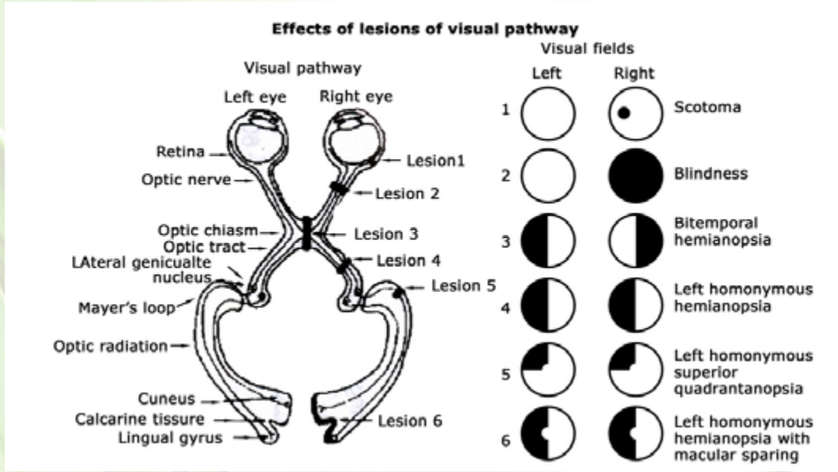
Example 2: vestibular nystagmus: When fixation is prevented with Frenzel's spectacles and the subject is rotated on a chair, the horizontal semicircular canals elicit nystagmus in the direction of rotation, and when the chair stops turning this is replaced by postrotatory nystagmus in the other direction. In everyday life this vestibulo-ocular reflex serves to stabilize the eyes during head movements.

Nystagmogram: electro-oculographic recording of nystagmus

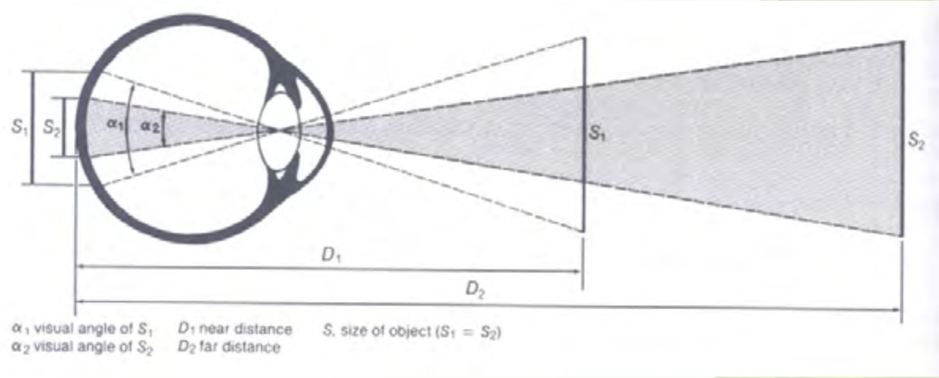


Areas in the brainstem and cortex that control conjugate eye movements

Horizontal gaze center	Reticular formation near abducens nucleus in pons. Activation on one side causes horizontal conjugate eye movement toward the same side; the right horizontal gaze center causes both eyes to deviate to the right. Output for this is by right abducens and left through the medial longitudinal fasciculus
Lesien of horizontal gaze center	Destruction of the right horizontal gaze center causes an inability to look conjugately to the right and there is a tendency for the eyes to look left
Internuclear ophtalmoplegia	Due to interruption of MLF. An attempt to gaze conjugately leads to abduction of one eye (intact output through abducens), but failure of adduction the other eye because of the interruption of theconnection with the oculomotor nucleus through the MLF
Vertical gaze center	Located in midbrain. Controls conjugate vertical eye movements (as well as vergent movements)
Frontal eye field	Located in frontal lobe (area 8). Activation of one frontal eye field causes saccadic conjugate deviation of the eyes toward the opposite side. Output is through the superior colliculus and the brainstem gaze centers
Occipital eye field	Located in MT and MST areas of cortex. Involved in optokinetic nystagmus and in smooth pursuit movements. output includes several brainstem nuclei and cerebellar connections.



Signal processing in the visual system

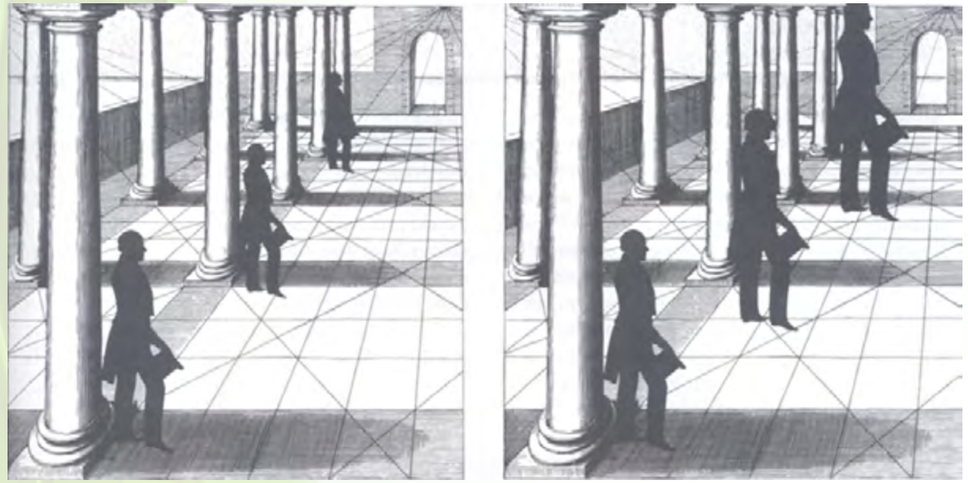


The visual angle

Although the physical size (S) of the object does not change, changes in distance (D) will result in changes in the size of the visual angle (α). Here α1 (the image of the Object S1 close to the eye) is larger than α2 (the image of Object S2 farther from the eye.

Signal processing in the retina

Definition/description/comments
Photoreceptors are 120 million rods (scotopic vision) and 6 million cones (photopic vision). Both types contain visual pigments in their other segments, rhodopsin (`visual purple') in the rods and 3 pigments in the cones. When the visual pigments absorb light, their conformation changes and they decompose into precursors: by way of a series of intracellular messengers, this event triggers hyperpolarizing receptor potentials
Photoreceptors are the ‘entrance’ to the retinal neuronal network; ganglion cells are the 'exit', because their axons form the optic nerve. Between them are the horizontal, bipolar and amacrine cells. Signals pass both from photosensors via bipolar cells to ganglion cells and in the perpendicular direction, in horizontal and amacrine cells. All signal processing in these cells is by slow synaptic potentials (no action potentials) except some amacrine cells
Ca. 1 million in each eye, hence considerable signal convergence from the 126 million photoreceptors. They generate action potentials that pass to the brain along the optic nerve. Round receptive fields with an inner receptive field center (RFC) and an outer RF periphery with antagonistic connections. Two main types for black—white vision: on-center neurons (discharge increases with light stimulus in RFC, de-creases with stimulus in RF periphery) and off-center neurons with the opposite behavior. In light adaptation the center is small and the periph¬ery large, in dark adaptation the reverse, sometimes no periphery at all. Processing of color stimuli occurs in neurons with either red—green antagonism.

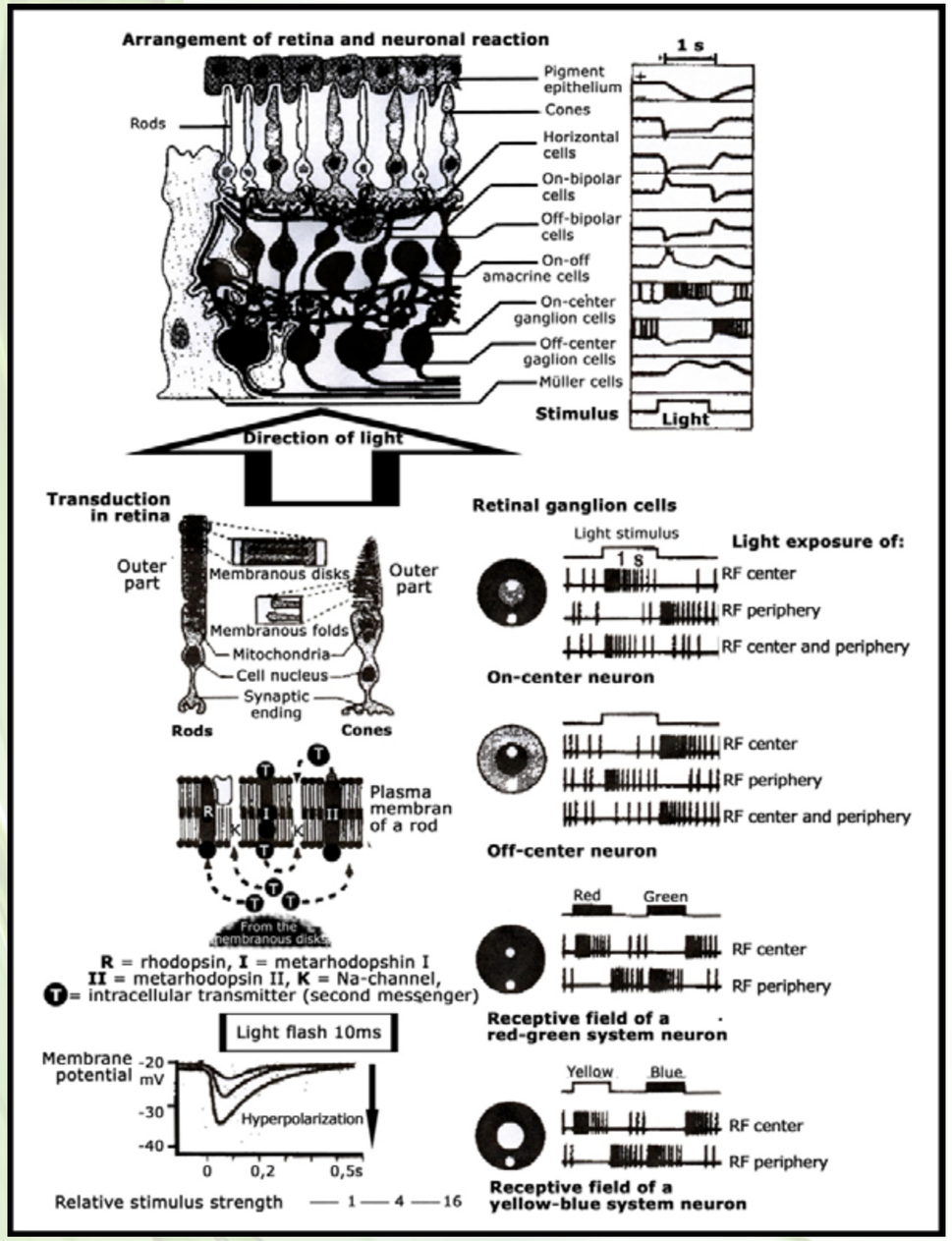


(A) Three men whose retinal image grows smaller as they appear to be more distant; however, because of size constancy they appear to be the same size. (B) Here, when the images remain the same size, the apparently more distant man appears to be larger.

Signal processing in the subcortical visual centers

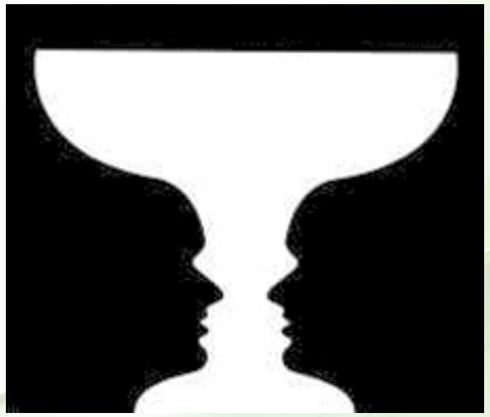
Definition/Description/Comments
Begins with axons of the retinal ganglion cells (see above). From each eye an optic nerve (cranial nerve II) runs to the optic chiasm (decussation) at the base of the skull. Axons from nasal half of each retina cross to the opposite side and, together with ipsilateral axons, form the optic tract, which sends out collaterals to the hypothalamus (suprachiasmatic nucleus), pretectal region and superior colliculus and the lateral geniculate nucleus (thalamic nuclear region). From the LGN the optic radiation passes to the primary visual cortex
Composed of six layers, some associated with the ipsilateral eye (2, 3, 5) and some with the contralateral eye (1, 4, 6). Receptive fields organized as for retinal ganglion cells (see above)
Serves for control of reflex gaze movements, especially the saccades. Neurons respond preferentially to moving stimuli, in some cases are direction-specific
Controls circadian rhythms. Visual input signals prevailing ambient lighting
Involved in pupillary light reflex. Also involved in control of gaze direction specially in vergence movements and smooth pursuit movements

Signal processing by the photoreceptors and neurons of the retina (according to Grüsser and Grüsser-Cornhels, 1990)



Signal processing in the visual cortex

Definition/Description/Comments
General term for cortical areas involved in visual signal processing. Optic radiation (see above) terminates in occipital, primary visual cortex (syn.: area 17. area striata or VI). From there information passes toward parietal and temporal, to the extrastriatal areas V2 (area 18), V3, V3a, V4, V5, with increasing specialization for vari¬ous qualities of vision (e.g. V2 contours, V3 and V5 movement, V4 color)
The whole visual pathway, including the cortices, is topologically organized. Projection is not linear, by far the most space being occupied by the fovea (cf. Sens. and mot, homunculus). In higher visual cortices retinotopy decreases in favor of other parameters (see above)
Information processing in the cortex proceeds perpendicular to the cortical surface (concept of cortical columns, p. 110). In VI regular alternation between ocular dominance columns processing pri¬marily inputs from the right eye and those processing left eye inputs
Receptive fields in VI are oriented lengthwise. The term orienta¬tion columns is used for 'subcolumns', within the ocular domi¬nance columns, containing neurons with receptive fields oriented/ organized in the same direction. There is a stepwise change in orientation angle from one orientation column to the next
Additional 'subcolumns' in the ocular dominance columns, with concentrically organized receptive fields oriented by color (rather than direction)
Directionally oriented neurons have either simple RFs with longi¬tudinally arranged on and off zones (respond well to light–dark contours in certain orientations), complex RFs (respond best to interruptions of contour, especially with moving stimuli) or hypercomplex RFs (respond best to moving contrast boundaries that meet one another perpendicularly)



A reversible figure-ground stimulus in which a pair of black faces or a white vase (or perhaps a bird bath or goblet) can be seen.

Motion, form and color

- Contributes to analysis of motion and spatial relationships, as well as to depth perception. Involves large M-type retinal ganglion cells, magnocellular layers of the lateral geniculate nucleus, and several areas of the visual cortex, including V1, V2, V3, V5 (syn.: MT) and MST.
- Contributes to the analysis of form. Involves small P-type retinal ganglion cells, parvocellular layers of the lateral geniculate nucleus, and VI, V2, V4 and the inferior temporal cortex.
- Contributes to the analysis of color. Involves P-cells, parvocellular layers of the lateral geniculate nucleus and 'blobs' in VI, as well as V2, V4 and inferior temporal cortex

Motion Aftereffects

The form of motion aftereffects demonstrated in this box is often called the spiral aftereffect because the stimulus used to induce it is a rotating spiral. Photocopy or trace the accompanying stimulus and place it on the turntable of a record player as if it were a record. Let the stimulus rotate for about a minute, while you stare at the center. Stop the turntable and hold it so that is completely stationary. While the turntable was moving, the spiral appeared to expand. Now it should appear to be (paradoxically) shrinking. This shrinking (without any apparent change in size) is an illusory movement because the stimulus is no longer in motion. It is probably caused by fatiguing, or selective adaptation, of physiological motion detectors, produced by prolonged stimulation in one direction of movement. The 60 seconds of a viewing will give you an aftereffect (the paradoxical contraction) that will last about 10 to 15 seconds. You can demonstrate that the cells are turned for different stimulus velocities by changing the speed of your turntable and repeating the demonstration. You will notice that this will change the rate of shrinking in the aftereffect.

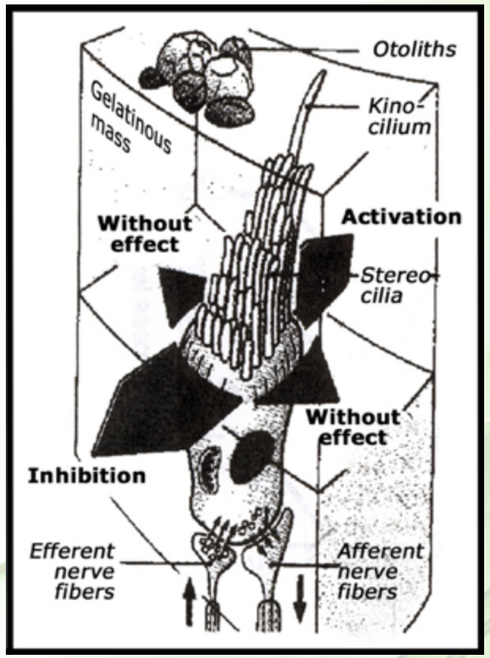
Peripheral and central vestibular system

The vestibular organ consists of the 3 semicular canals (with ampullary crests) and the 2 otolith organs (with maculae: saccule and utricle); its function is to detect linear and angular accelerations

Adequate stimulus	Associated with Part of associated organ
Linear acceleration	Positive and negative linear On each side one saccule accelerations of all kinds (normal position vertical) and (e.g. gravity, in elevator,one utricle (normally nearly in vehicles) horizontal
Angular acceleration	Angular acceleration about Semicircular canals with all three spatial axes (e.g. their ampullae (one horizontal turning the head) and two vertical on each side)

The force of gravity (gravitational acceleration) operates continuously; therefore the maculae can always signal precisely the position of the head in space; also any tilting of the head in the earth's gravitational field (these are their most important functions); together with the sensors for proprioception the otolith organs provide the information necessary to determine the position of the body in space. Semicircular canals and otolith organs interact with proprioception to monitor the movements of head and body in space.

Discharge behavior of the hair cells: their spontaneous activity increases when the cilia are bent toward the kinocilium and is inhibited when they bend away from the kinocilium (directional sensitivity of each hair cell)



Each hair cell has one kinocilium and 60—80 smaller stereocilia; the cilia are embedded in a gelatinous mass: the cupula in the semicircular canals and the otolithic membrane, which contains otoliths (calcite crystals) in the maculae; the efferent innervation adjusts the sensitivity of the hair cells (functional significance unknown).

Linear acceleration displaces the mass above the maculae, which has higher specific gravity due to the otoliths, and thereby modulates the spontaneous discharge of the hair cells.

Angular acceleration exerts a shear force on the cilia in the ampullae by deflection of the cupula by the inertia of the endolymph; because the three semicircular canals are roughly perpendicular to one another, all conceivable rotational accelerations can be detected.

Because the cilia are oriented in various directions in the array of sensors in the vestibular organ, for every form of acceleration there is a particular constellation of excitation in the associated nerve fibers, which can then be evaluated in the central parts of the vestibular system (see below).

Central components of the vestibular system

The afferent nerve fibers of the vestibular organ have their somata in the vestibular (Scarpa's organ) ganglion. The axons from the vestibular nerve, which joins acoustic nerve of the inner ear to form the vestibulocochlear nerve (VIII); this enters the brainstem at the cerebellopontine angle; here the vestibular afferents end in the following vestibular nuclei:

- Superior
- Lateral
- Medial
- Inferior

The vestibular nuclei receive additional inputs from the receptors for proprioception (see above); their main connection efferent connections are as follows:

- Vestibulospinal tract (primarily to the motoneurons of the extensors)
- To the eye muscle nuclei (by way of the medial longitudinal fasciculus)
- To the contralateral vestibular nuclei 9contralateral information exchange)
- To the archicerebellum and other parts of the cerebellum
- To neurons of the reticulospinal tract (from there on to a α- and y-motoneurons
- To the thalamus and cerebral cortex (conscious orientation in space)

Function of the vestibular system is to provide information for:

1. Conscious perception of the accelerating acting on the body
2. Maintenance of equilibrium and of an upright stance and gait (especially from the organs)
3. Keeping a fixation point during eye movements
4. Stability of the surroundings during movement of the eyes, head and body (especially from the semicircular canal organs)

The motor functions of the vestibular system are partly based on labyrinthine reflexes; among them are (see also the definition of postular and righting reflexes):

Reflex	Description/Definition/Comments
Voluntary	These are in part postural and in part righting reflexes; originate in the otolith organs; preserve equilibrium during quiet standing, sitting, ly¬ing down; the counter-rotation of the eyes when the head tilts away from vertical is also a static reflex. Postural and righting reflexes also originate in receptors in the neck (tonic neck reflexes); there are also visual righting reflexes
Organic	Originate in otolith organs and semicircular canals; occur during movement and are themselves movements; best-known example is vestibular nystagmus (see p. 60 and below); others are the reflex twist-; ing of a cat's body in free fall and the elevator reaction (adjusts muscle tone to vertical accelerations)

Pathophysiological aspects of the sense of equilibrium

Disorder	Description/Comments
Motion sickness	Best-known examples are seasickness and car sickness; caused by greater excitation of the equilibrium organ than one is accustomed to
Failure of labyrinth function	Acute failure of one labyrinth: vertigo toward the healthy side, tendency to fall toward the affected side, nystagnuas toward the healthy side. Chronic labyrinth deficit is generally well compensated by the visual system and proprioception; bilateral labyrinth deficits practi¬cally never occur in human
Zero gravity conditions	Only gravitational acceleration is lost. all other linear and angular accelerations being preserved: this constellation of stimuli does not occur on earth; during space (light it may cause motion sickness)
Pathological nystagmus	(For definition and examples of physiological nystagmus see p. 60) Pathological forms involve the vestibular (but also the optic and oculomotor) system, e.g. as spontaneous or as oscillatory nystagmus

Vestibular organ function is tested by nystagmograms (see p. 60); either simultaneous excitation of both labyrinths by rotating the subject (rotatory or postrotatory nystagmus) or unilateral test using caloric nystagmus (elicited by placing cold [30°C] or hot [44°C] water in the external meatus of the ear with the head positioned so that the horizontal canal is vertical).

Psychoacoustics

Acouctic and auditory terminology

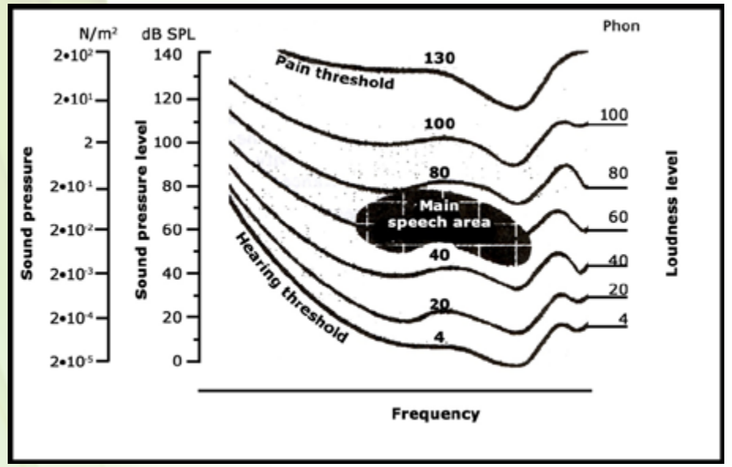
- Tone: Sound event comprising only one frequency in the audible range (between 211 nil 16000 Hz); pitch increases as frequency rises
- Harmonic: Tone, the frequency of which is an integer multiple of the fundamental tone
- Complex sounds: Superposition of a relatively small number of tones and their harmonics produces sounds with a musical quality; superposition of many unrelated frequencies produces noise (white noise if the number is practically infinite)
- Effective sound pressure pr in N/m2 or Pa: effective value (amplitude, intensity) of periodic air pressure oscillations
- Reference sound pressure: The standard reference pressure has been arbitrarily set at p_o=2●10N/m², used to calculate sound pressure level, see below; is near the auditory threshold
- Sound pressure level L=20●log10(p_x/p_o) in dB SPL, see next page
- Sound intensity I (sound power density): Energy flux per unit time through a unit area, e. g. the surface of the tympanum, in W/cm²; is proportional to the square of the sound pressure, so that when given in dB I=10●log(I_x/I_o)
- Auditory threshold: Minimal sound pressure level for perception of a tone
- Loudness level: Expressed in phon, equal to the sound pressure level in dB of a 1000Hz tone that sounds just as loud as the tone for which loudness level is being determined
- Isophone: Curve including all the tones that sound equally loud

Measurement and hearing of sound

Definition/Description/Comments
Very small longitudinal pressure oscillations in the air, which can he detected by the ear: their frequency is given in hertz (Hz) (see p. 1); the sound velocity is ca. 340 mis (1224 km/h, Mach 1); the audible frequency range is 20–16000Hz (<20Hz infrasound, >16000Hz ultrasound); the pitch increases with increasing frequency
The dynamic range of the ear encompasses sound intensities from 10-j6 to 10-' W/cm2 (12 orders of magnitude from the normal auditory threshold to noises at the pain boundary); hence it would not he practical to use sound pressure or sound intensity as measures; it was therefore agreed to use sound pressure level (SPL), expressed in decibels (dB), definition on p. 67; this gives manageable numerical values between 0 and 120 dB SPL

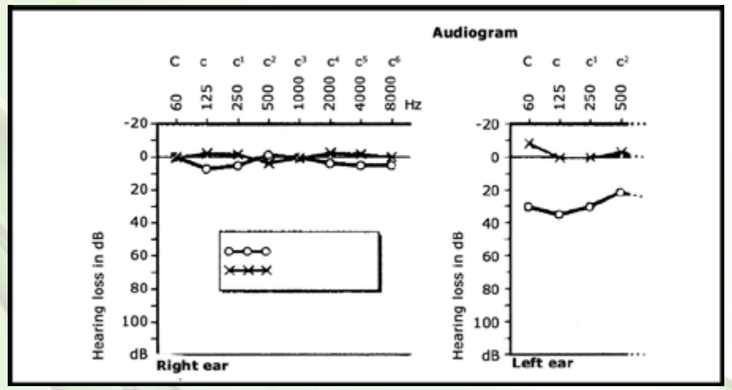
Definition/Description/Comments
The subjectively experienced loudness of sound is frequency-dependent (see Fig.); for a given sound pressure, sounds between 2000 and 5000 Hz are perceived as louder than higher- or lower-frequency tones; the audi¬tory threshold and loudness are measured by audiometry with pure tones (presented to each ear separately by way of headphones)
Defined on p. 67; it follows that at 1000 Hz the phon and dB values are equal. Curves of equal loudness level are called isophones (see Fig. below), The auditory threshold is also an isophone: the lowest one, at 4phon. The 60phon curve passes through the main speech region. the 130phon curve lies at the pain threshold

The operating range of the human auditory system, represented by curves of equal loudness level (isophones)



Clinical test of hearing ability

Clinical threshold audiometry



In clinical routine it would be impracticable to represent the complex auditory threshold curve in dB SPL; hence the auditory threshold is arbitrarily assigned the value 0 dB HL (hearing level), making the clinical auditory threshold curve a straight line. By convention, higher threshold values are plotted downward as hearing loss. Conduction in air is tested with headphones, bone conduction by placing an oscillating object on the mastoid process.

Tests of hearing

Test	Description/Comments
Weber's test	An oscillating tuning fork is placed on the middle of the skull: in case of inner ear deafness (sensorineural hearing deficit) the lone is perceived as louder on the healthy side, in middle ear deafness (conductive hearing deficit) it is louder on the affected side
Rinne's test	Comparison of air and hone conduction with a tuning fork; it is first placed on the mastoid process: when it can no longer be heard there it is held just outside the ear; the tone is again heard by the healthy and those with sensorineural deficits (Rinne positive) hut not by those with conduction deficits (Rinne negative)
Speech audiometry	To test the understanding of speech. prerecorded spoken numbers or standard syllables are played hack: in cases of inner ear damage understanding is impaired
ERA	Evoked response audiometry; recording of the auditory evoked potential produced by click stimuli (AEf'. sec Fig. p. I14): enables objective test without patient's collaboration: especially useful to reveal retrocochlear damage

Functions of the middle and inner ear

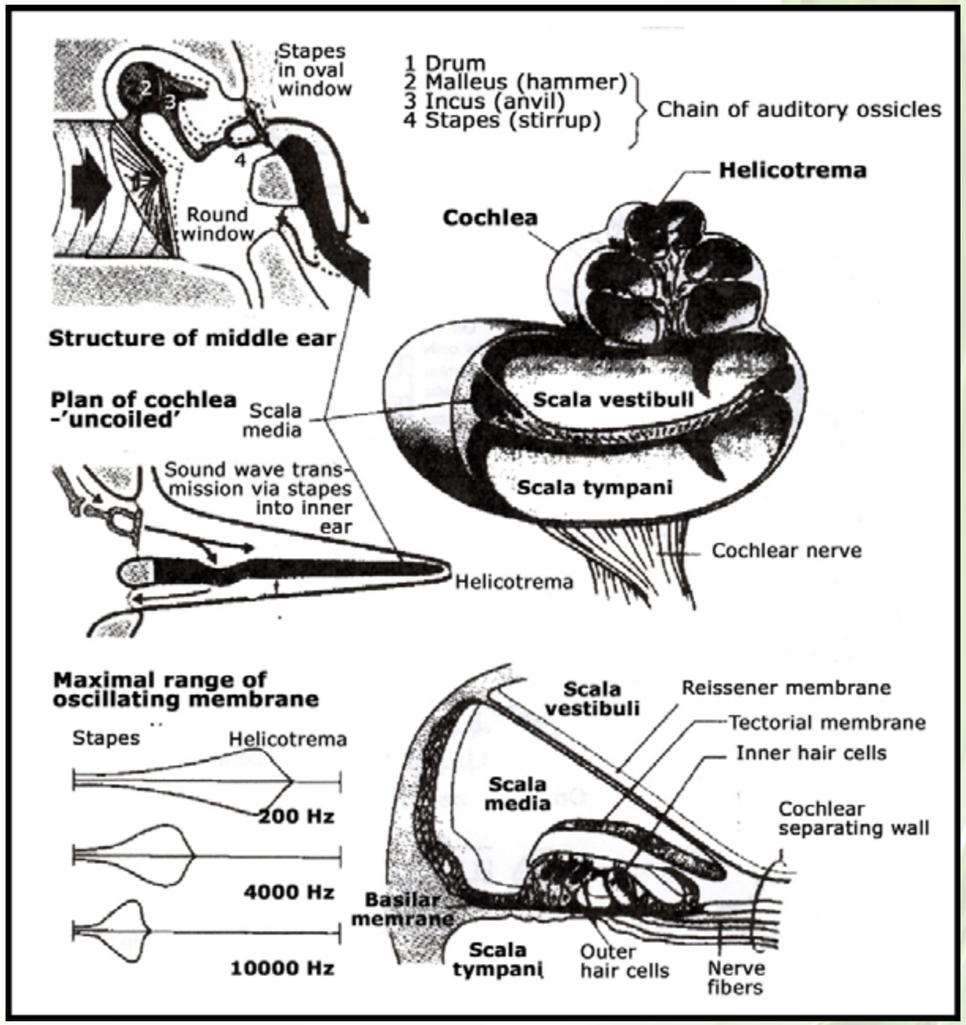
Role of the middle ear: impedance matching

Sound is transmitted through the external meatus to the eardrum and from there by way of the hammer (malleus), anvil (incus) and stirrup (stapes) to the perilymph in the scala vestibule. Without the middle ear only 2% of the sound would enter the inner ear and 98% would be reflected, because air has a lower impedance than liquid; the chain of ossicles transmits 60%, or 30 times as much. This impedance matching is achieved by (1) pressure amplification when force is transmitted from the large eardrum to the small stapedial footplate (area ratio 35:1) and (2) lever action in the ossicle chain.

Sequence of events during sound transmission in the inner ear:

Description/Comments
The stapedial footplate transmits the sound oscillations to the perilymph of the scala vestibuli, and from there the oscillations propagate through the helicotrema to the scala tympani; because liquids are incompressible, the volume displacements are compensated by movements of the secondary tympanic membrane in the round window
The pressure oscillations in the inner ear are also transmitted to the cochlear partition (composed of the organ of Corti, tectorial membrane, scala media, Reissner's membrane: see Fig.), in which they produce waves that travel from the stapes to the helicotrema; the oscillation is always maximal in a particular region, which is located closer to the stapes the higher the tone is
(Place theory, tonotopy), states that good frequency discrimination by the ear (e.g, 0.3% at 1000 Hz, hence 3 Hz) is based on the traveling wave maxima in the cochlear partition. because it is only there, at the place associated with the characteristic frequency (CF), that a few hair cells are stimulated
The passive oscillation maxima induce active contractions of the three rows of outer hair cells (>100-fold amplification): this produces particularly sharp traveling wave maxima, which are the basis of the ear's acute frequency discrimination (see above): loss of the outer hair cells greatly reduces the maxima; the impaired frequency selectivity (flat tuning curves) causes difficulties in understanding speech (the outer hair cells have hardly any afferent innervation and release little transmitter; hence they have predominantly a motor function)
The threshold of the inner hair cells (only one row) is 50–60dB higher than that of the outer hair cells: therefore they are not excited until the sharp traveling wave peak has been formed by contraction of the outer hair cells
All hair cells bear stereocilia (sensory hairs that give the hair cells their name); the longest ones on the outer hair cells just touch the gelatinous tectorial membrane: during oscillation of the cochlear partition these cilia are deflected outward and inward by the relative movement between the organ of Corti and the tectorial membrane; this is their adequate stimulus: by a hydrodynamic coupling to this relative movement the inner hair cells are also excited, in a similar manner

Reception, conduction and processing of sound in middle ear and inner ear (modified after Birbaumer and Schmidt, 1996)



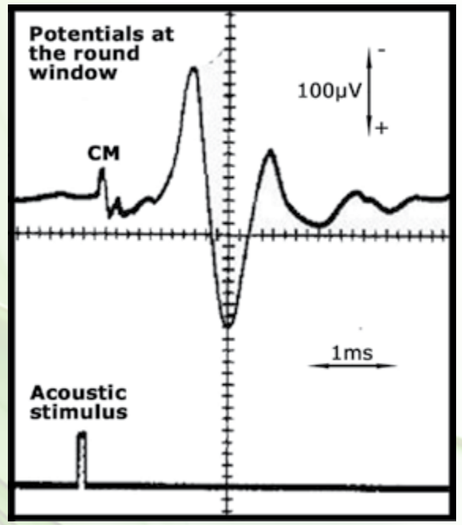
The cochlea resembles a tube coiled through 2.5 turns, like a snail shell: the cochlear partition divides the tube into the upper scala vestibuli (begins at the oval window) and the lower scala tympani (begins at the round window), which communicate with one another at the helicotrema; they are filled with perilymph. The cochlear partition is the actual functional unit of the cochlea. It is bounded by Reissner's membrane on the side of the scala vestibuli and by the basilar membrane on the scala tympani side; the scala media in between contains endolymph (different composition from perilymph, sec below); the basilar membrane bears supporting cells and the hair cells, and together these three structures form the organ of Corti; humans have ca. 35()0 inner and 1200) outer hair cells; they are covered by the tectorial membrane; the hair cells are secondary sensory

cells, innervated by nerve fibers from the spiral ganglion; there is also an efferent innervation of the hair cells. Each hair cell bears 8()-1(X) sensory hairs (stereocilia, there is no kinocilium).

Prerequisites and mechanism for transduction in the hair cells

Description/Comments
The endolymph of the scala media (1) is extremely K*-rich (140 mM) and (2) maintains a steady positive potential of +85 mV with respect to its surroundings (e.g. the perilymph), the endo¬cochlear potential; (1) and (2) are produced by energy-consuming Na',K* pumps in the stria vascularis
The resting potential of the inner hair cells is -40 mV, that of the outer ones is -70 mV; hence there are potential differences of -125 and -155 mV, respectively, between hair cell interior and endolymph
Deflection of the stereocilia opens ion channels at their tips through which, because of the concentration and potential relationships (see 1 and 2 above), mainly K* ions flow into the interior and thereby depolarize the cell; this depolarization is the receptor potential; the depolarization in turn opens K channels in the basolateral membrane, through which K* ions passively enter the perilymph of the scala tympani: this ends the receptor potential: the whole cycle lasts barely 1 ms
90% of the afferent synapses of the auditory nerve are located at the basal ends of the inner hair cells; here each receptor potential releases glutamate (or a similar substance), which postsynaptically elicits action potentials in the auditory nerve fiber: the rate can he up to 5000 Hz, and this process is strictly coupled to the rhythm of cilia deflection, i.e. to the frequency of the sound signal

Stimulus-elicited of inner and auditory nerve (microphonic and compound action potentials) (from Klinke, 1990)



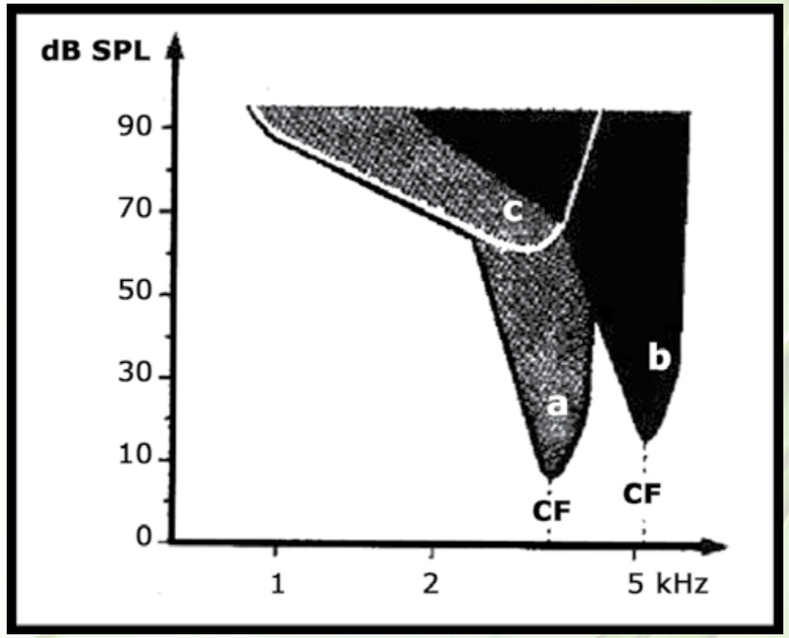
Even in humans, fine electrodes can be inserted through the tympanic membrane and placed on the promontory (bony wall of inner ear) or the round window; then, when sound (e.g. speech) is presented, mierophonic potentials (CM, cochlear microphonics) can be re-corded, which when played over a loudspeaker reproduce the speech accurately; they originate at or near the outer hair cells; the mechanism is unknown. When the ear is stimulated with a very brief sound pulse ("click'), the corn-pound action potential (CAP) of the auditory nerve can be recorded. Clinical promontory tests are carried out in order to learn whether the deaf are candidates for an electronic cochlear implant (includes a speech processor and electrodes that can be inserted into the cochlea to stimulate the auditory nerve directly):sometimes these even make it possible to use a telephone.

Otoacoustic emissions

Inner ear produces sounds that can be measured as otoacoustic emissions with a microphone in the external meatus. For example, if a 'click' is used as stimulus, after brief latency a transiently evocable otoacoustic emission (TEOAE) can be recorded; the sound pressure level of the TEOAE. is below the auditory threshold: this serves as a screening method to examine hearing in the newborn, infants and small children. Many people also have permanent spontaneous otoacoustic emissions (SOAE). Causes of SOAE and TEOAE are presumably the movements of the outer hair cells (see p.70), which generate so much energy that some is released to the outside.

Auditory signal processing

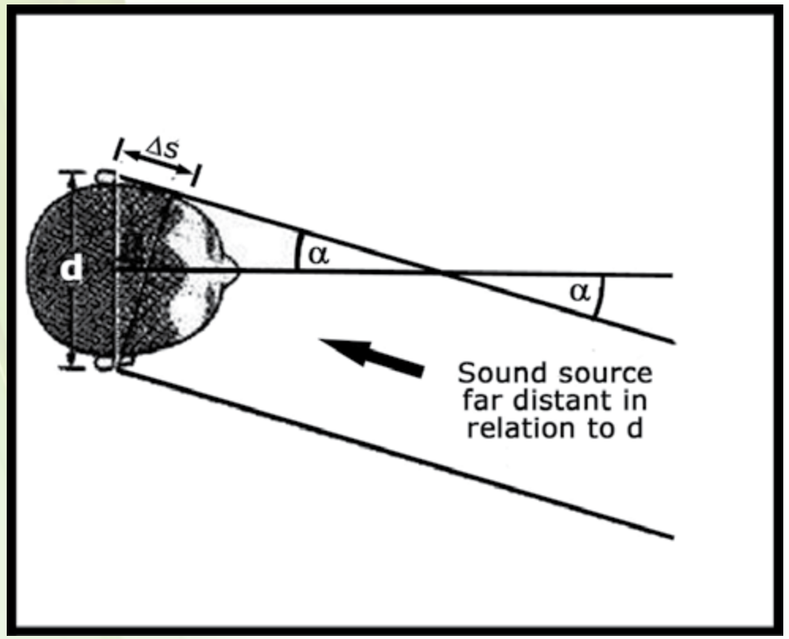
Encoding of sound in the auditory nerve fibers (after Klinke, 1990)



Each nerve fiber coming from the inner hair cells can be optimally excited by sound at a particular frequency, its best frequency or characteristic frequency (CE) (place principle, see p. 70). To excite the fiber with an adjacent frequency, considerably higher sound intensities must be used; this can be represented as tuning curves (threshold curves, a and b); if the cochlea is damaged, both threshold and frequency selectivity are impaired (c).

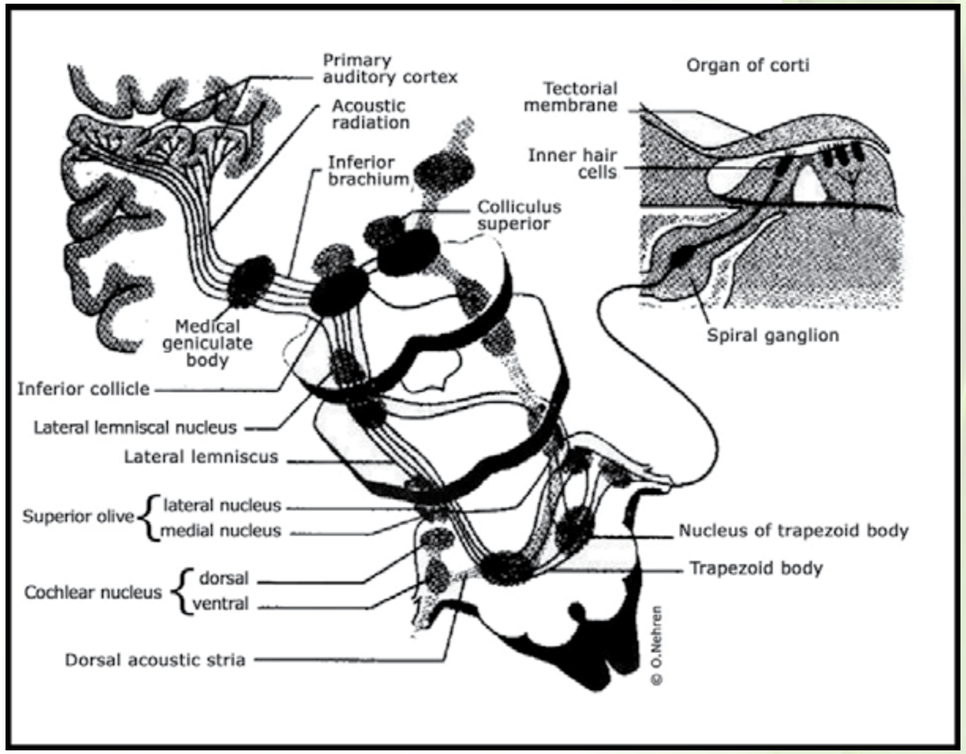
Periodicity analysis of sound frequency: In addition to the traveling wave the organ of Corti can analyze frequency by detecting periodically recurring sound pressure peaks (periodicity analysis); this must play a role especially above 5000Hz, because the release of transmitter from the inner hair cells and the action potential bursts of the auditory nerve fibers cannot follow at higher frequencies.

Auditory sensing in three dimensions with binaural hearing (e.g. directional hearing)



Differences in arrival time and pressure level arise because one ear is usually further away from the sound source than the other ear; these differences are evaluated for three-dimensional hearing. Arrival time differences as slight as 3.10-5s can be reliably judged (sound source at α = 3° away from the midline); processing is done far distant in by the superior olivary complex. The directional characteristic (distortion of the sound signal) of the pinna is also employed for auditory orientation in space (evaluation mechanism unknown.

Elements of the auditory pathway their arrangement (after Klinke, 1990)



Only the pathways from one year are drawn hear; those from the other have a mirror image arrangement; the descending pathways are omitted, as are the projections to the ipsilateral auditory cortex. Afferent impulses from the organ of Corti are relayed by 5-6 synapses on the way to the primary auditory cortex.

Signal processing in the neurons of the auditory pathway

Description/Comments
The length of a sound stimulus is encoded in the duration of activation of the afferent nerve fibers
Differences in sound pressure level are reflected in a change in discharge rate of the active neurons; the higher the level, the higher the rate: when the highest possible rate has been reached, further increases in level are signaled by activation of neighboring fibers (recruitment)
The (small.) proportion of the sound information that reaches the auditory cortex; for humans the most important effective sound is speech; the background noises, etc. (interference) have already been filtered out at the preceding stations of the auditory pathway, which are specialized for sound pattern recognition

Description/Comments
The efferent nerve fibers of the auditory nerve mostly originate in the contralateral superior olive (olivocochlear bundle) and 90% of them terminate at the outer hair cells; transmitters to these are acetylcholine and GABA; probably control or modulate the motil¬ity of the outer hair cells, e.g. to protect them from sound damage or improved signal detection; details are unknown

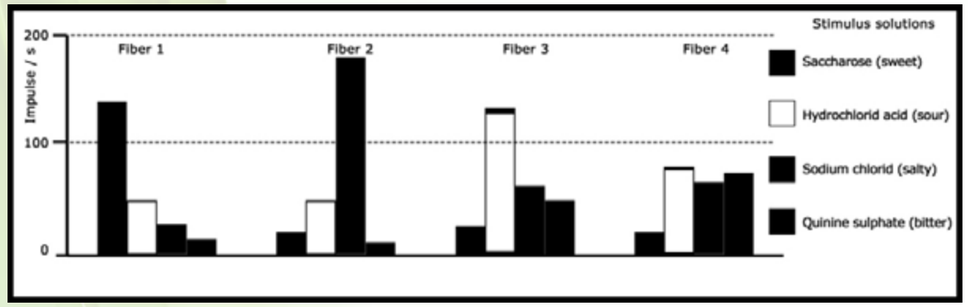
Sense of taste

Characteristic properties of the sense of taste

Term	Definition/Description/Comments
Receptor	Secondary sense cells (taste or gustatory cells. life span ca. 7d. replaced from basal cells) in the taste buds; in youth humans have ca. 2000 taste buds, each with 40-60 gustatory cells. in old age only as many
Locations	The taste buds are situated in the walls of three different Iypcs of tongue papillae: the fungiform (over the whole surface of the tongue), foliate (hack lateral edges of tongue) and vallatc papillae (7-12 in V-shaped arrangement at base of tongue)
Innervation, gustatory pathways	Fungiform papillae: chorda tympani (from Vllth nerve): foliate and vallate papillae: IXth nerve: CNS stations: (1) solitary tract: (2) nucl. of solitary tract; (3) (a) medial lemniscus → ventral thalamus → postcentral gyrus; (b) hypothalamus → amygdala → stria terminalis
Adequate stimulus	Organic and inorganic, usually not volatile substances Stimulus source near or in direct contact with taste buds
Qualitatively discriminable stimuli	Only four basic qualities (primary taste sensations): sweet. sour. salty, bitter; also mixed qualities, e.g. sweet-sour: under discussion are alkaline and metallic tastes
Topography	Previous assumption: sweet taste al tip of tongue. sour and salty at edges, bitter at base of tongue: new finding: every papilla is sensitive to several taste qualities, usually all four

Term	Definition/Description/Comments
Sensitivity; adaptation	Absolute sensitivity of taste is low; 10 or more molecules per ml solution needed for suprathreshold stimulation (nevertheless. qui-nine sulfate tastes bitter at 0.005g/l). Sense of taste exhibits pro-nounced adaptation
Biological function	Short-distance sense; to check food for indigestible or poisonous substances: participates in the reflex control of secretion (amount and composition) by the digestive glands

Quality discriminationis based on graded specific discharge of the gustatory nerve fibers, the taste profiles, wich are decoded in the CNS (Fig. after Altner, 1985a)



Taste profiles of four chorda tympani fibers (rat) in response to the indicated solutions. The crucial information about taste quality \nd intensity is thus contained in the afferent impulse pattern of the population of fibers.

Transduction mechanisms in the gustatory cell membranes

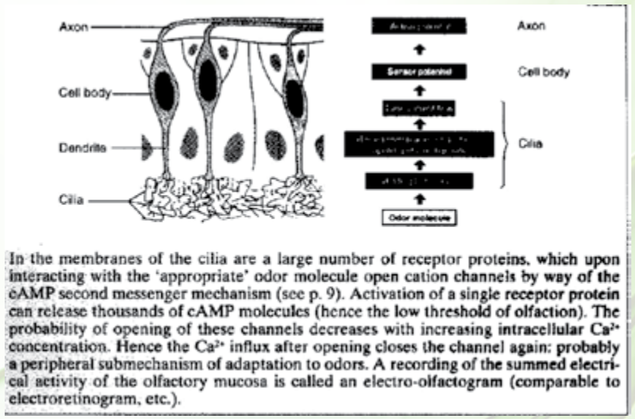
Transduction mechanism/Comments
Adequate stimulus: H* ions; these specifically block K* channels in the microvillar membrane of the taste cells: because of the concentration and electrical gradients (see Table p. 11), this causes depolarization, i.e. receptor potential
Food containing salt causes an increased influx of Na' ions through the channel for small cations present in the membrane, which produces a receptor potential. Na* is subsequently removed by the N..K'-ATPase pump (see p. 4). There are specific receptor proteins for hitter substances. Their activation initiates a second messenger chain that ultimately raises the intracellular Ca'. This in turn opens cation channels through which Na* flows in to depolarize the cell
The various sweet substances all interact with a specific receptor protein, activation of which produces cAMP as a second messenger (for chain of actions see p. 9). The latter blocks K' channels and thus produces a receptor potential (see above)

Sense of smell

Characteristic properties of the sense of smell

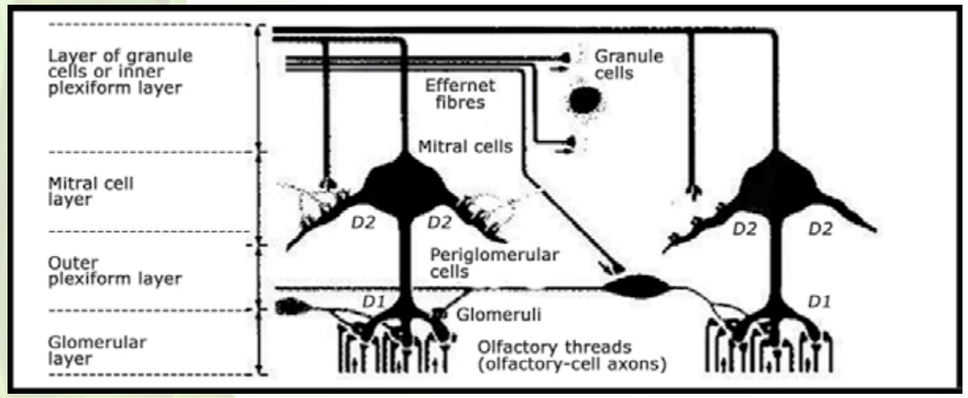
Description/Comments
Primary sensory cells, called olfactory cells (total ca. 10 million, life span ca. 30 d, replaced from the basal cells); bear apical cilia that spread out within the mucous membrane
The olfactory cells plus supporting and basal cells together form the olfactory epithelium, which in humans covers ca. 5 cm² on the upper concha of each of the two nostrils.
The unmyelinated axons of olfactory cells emerge from the olfactory epithelium as the fila olfactoria; after passing through the lamina cribrosa these form the olfactory nerve (cranial nerve I) which ends in the olfactory bulb. CNS stations: (1) olfactory tract; (2) (a) through the anterior comissure to the contralateral bulb; (b) to the olfactory brain (olfactory tubercle, prepiriform area, amygdale, entorhinal region)l from there (3) (a) thalamus → orbitofrontal neocortex; (b) → limbic system → hypothalamus → reticular formation
Molecules of organic compounds in gas form, which do not become dissolved in the liquid phase until they reach the olfactory cells. The stimulus sources are usually a relatively long distance away
Ca. 10 000 odors are distinguishable; roughly classified into 7 odor classes, each with typical 'representative odors': odor quality can change with increasing concentration
Absolute sensitivity of olfaction is high; 10 or more molecules per ml air needed for suprathreshold stimulation (in animals often only 10). Sense of smell exhibits marked adaptation and cross-adaptation.
Far and near sense; important role in social communication (key words: scent marks, individual or group identifier, pheromone); strong emotional component

Transduction mechanisms in the olfactory cell membranes (after Hatt, 1993)



In the membranes of the cilia are a large number of receptor proteins, which upon interacting with the 'appropriate' odor molecule open cation channels by way of the cAMP second messenger mechanism (see p. 9). Activation of a single receptor protein can release thousands of cAMP molecules (hence the low threshold of olfaction). The probability of opening of these channels decreases with increasing intracellular Ca^{2+} concentration. Hence the Ca^{2+} influx after opening closes the channel again: probably a peripheral submechanism of adaptation to odors. A recording of the summed electrical activity of the olfactory mucosa is called an electro-olfactogram (comparable to electroretinogram, etc.).

Information processing in the olfactory bulb (Fig. after Altner, 1985b)



The olfactory bulb comprises four layers. In the glomeruli the olfactory cell axons terynlnate on the primary (Dl) dendrites of the mitral cells (ca. 50(100; their axons form the olfactory tract, see above). The periglomerular cells (also end on Dl) and granule cells, which end on the secondary dendrites (D2) of the mitral cells, mediate the efferent inputs and make lateral modulation possible. The direction of synaptic trans-mission is indicated by arrows (excitation black, inhibition red). The basic features of information processing here are: (1) marked convergence (ca. 1000 olfactory cell axons to one mitral cell), (2) widespread inhibitory mechanisms (transmitter; GABA) and (3) efferent control.

Distinguishing characteristics of the seven odor classes; contributions of nerve V; thresholds for perception and identification; stimulus-sensation relation (Table from Altner and Boeckh, 1990)

Odor class	Representative components	Smells like	'Standard'
Floral	Geraniol	Roses	d-1-β Phenylethylmethyl carbinol
Ethereal	Benzyl acetate	Pears	1,2 Dichlorethane
Musky	Musk	Musk	1,5 Hydroxypenta decanoic acid lactone
Camphoraceous	Cineole, camphor	Eucalyptus	1,8 Cineole
Putrid	Hydrogen sulfide	Rotten eggs	Dymethil sulfide
Pungent	Formic acid acetic acid	Vinegar	Formic acid

Individual olfactory cells have receptors for several odor classes; odor classes, as in taste, depend on a population code. For classification of odors based on congenital partial anosmias, see below.

In addition, some substances give rise to olfactory sensations with a stinging, biting or tarry quality (in the nose) of burning sharp sensation (in the mouth). These result from stimulation of freenerve endings of the trigeminal nerve, which innervates the entire mucosa of the nose and oral cavity.

It is typical of olfaction that there is both a perception of threshold (unspecific olfactory sensation at very low odor concentration) and in identification threshold (odor can be identified).

With suprathreshold odor stimuli (the same applies to taste) the intensity of sensation increases with increasing concentration of the odor substance, according to Steven's power law.

Frequency of occurrence (% of the population) of partial anosmias in man (after Hatt, 1993)

Main odor component	Frequency
Androstenone	40%
Isobutanal	35%
1,8-Cineole	33%
1-Pyrroline	20%
Pentadecanolide	7%
Trimethylamine	7%
Isovalerianic acid	2%

Partial anosmias are astonishingly widespread (see Table). Affected people seem to lack receptor molecules with which to identify the odors concerned. in view of these clinical observations there are likely to be more than seven, perhaps 10 odor classes. The partial anosmias are inherited as autosomal recessive traits. Congenital complete anosmia is rare.

When the olfactory threshold is higher than normal, the condition is called hyposmia; when it is lower, hyperosmia. Anosmia exists when odor substances are not detected at all. Parosmia designates qualitatively false olfactory sensation.

ESP (extrasensory perception)

ESP is most commonly called the "sixth sense." It is sensory information that an individual receives which comes beyond the ordinary five senses sight, hearing, smell, taste, and touch. It can provide the individual with information of the present, past, and future; as it seems to originate in a second, or alternate reality.

History

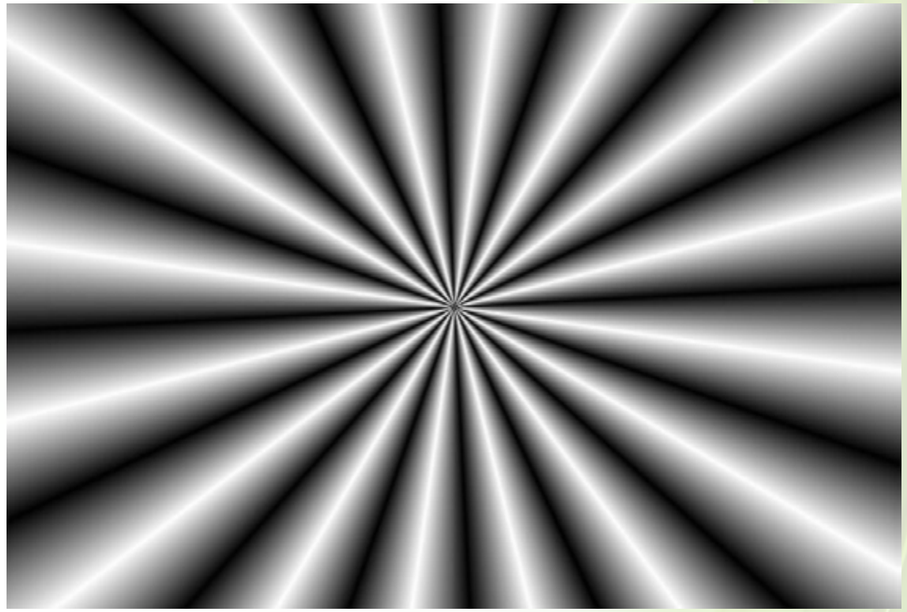
The term "ESP" was used in 1870 by Sir Richard Burton. A French researcher, Dr. Paul Joire, in 1892 used the term ESP to describe the ability of person who had been hypnotized or were in a trance state to externally sense things without using their ordinary senses.

However, the phenomena of ESP activity has been indicated much earlier, some say even in Biblical times. Although there is no clear evidence as to the certainty of the phenomena it has attracted the attention and enthusiasm of many throughout the centuries.

In the 1920's a Munich ophthalmologist, Dr. Rudolph Tischner, used ESP in describing the "externalization of sensibility." Then in the 1930s the American parapsychologist J. B. Rhine popularized the term to include psychic phenomena similar to sensory functions. Rhine was among the first parapsychologists to test ESP phenomena in the laboratory.

The first systematic study of ESP was conducted in 1882, when the Society for Psychical Research was founded n London. The journals of this society Proceedings and Journal were published as well as other publications in the United States and the Netherlands. Soon other countries were reporting similar findings.

However, these first studies of ESP were rarely experimental. The studies consisted of mostly spontaneous incidents that were located. Many of the individuals studied were self-claimed "sensitives" or psychics. Rarely were they examined under anything resembling laboratory conditions. The researchers conducting the examinations resembled prosecuting lawyers. The subjects were bombarded with questions, those standing up the best were judged creditable.



The Rhine experiments

The first card-guessing ESP experiments were conducted by Rhine at Duke University in 1930. The cards consisted of five designs, now called ESP symbols, a square, a circle, a plus sign, a five pointed star, and a set of three wavy lines. The symbols were printed singly, in black ink, on cards resembling playing cards.

In the classic Rhine experiments on ESP, the subject tries to guess or "call" the order of the five symbols when they are randomly arranged in a deck of 25 ESP cards. The likelihood of calling a card correctly by chance is one in five. Therefore, it is possible to calculate how often a particular score is likely to occur by chance in a given number of calls. It was Rhine'' argument that when his subjects made high scores that could be expected by chance only once in a thousand tries, or once in a million, they displayed "extrachance" results, or ESP.

The early experiments faced several criticisms. Two were automatically dismissed: (1) The statistics were unsound which was refuted by the president of the American Mathematical Association. (2) That ESP is physical impossibility which begs the question.

Several appropriate criticisms were accepted by Rhine which he used to improve his experiments. Examples are: (1) There may have been sensory cues. An example of this is that if a strong light shined on the back of the ESP cards, it might be possible to see the symbol through the back. Currently to avoid this possibility the target card is covered by an oblique shielding, or kept far from the subject. (2) An experimenter that knows the target might whisper it or otherwise give a cue to the subject. Presently no one in contact with the subject knows the target. (3) More hits might be recorded than actually occurred. Currently hits and responses are recorded by machine or by someone not knowing either.

Three criticism remain: (1) The "file drawer" effect. Only favorable results are published. Larger experimental data like one in a million make this unlikely. (2) Results are inconsistent and not repeatable. This can be remedied statistically. (3) Charges of fraud. Can be refuted by other reputable investigators obtaining similar results.

There was a finding which seemed puzzling until better understood. While some label it "missing-ESP" it might be thought of as reverse-ESP too. It is found among subject who dislike ESP. Even though the subjects were consciously trying to achieve good scores, they scored lower than chance. An unconscious factor seemed to come into play here. Experimenters have found they can predict higher scores for some groups (for example, those who are interested and relaxed), and lower scores for other groups (those who show fear, negativity, or boredom). The factor of missing-ESP indicates why ESP data is unreliable.

More recently computer games are increasingly being used to test ESP. The computer is programmed so that a random series determines the targets, and the subjects attempt to outguess the computer.

Another factor that researchers and experimenters must watched for in ESP and all psychical experiments is preconceived or previously learned knowledge. This concerns any knowledge which might influence the subject's activity. For example, a person might say she sensed her son would telephone her on that certain day at that specific time. If the son had previously called her in such a fashion, then her sensation must be suspect for it might have been based upon knowledge of her son's previous performance. A person might strongly feel that he would receive an email message from a friend on a certain day, and he does; but, can this be considered an ESP phenomenon considering that this person had not heard from the other person for some time and was expecting the message. The point being made is that when dealing with psychic phenomena all factors must be considered when examining the performance.

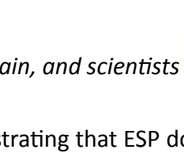
ESP in General

In New Frontiers of the Mind (1937) Rhine said that ESP experiments were changing the way people thought the mind sensed information. Historically learned people held the human mind received information through the ordinary five senses, and that therefore, the mind is subject to the laws of the mechanical world. Laboratory tests have attempted to determine the existence of ESP, and discover the physical mechanism by which it operates.

“The mind has been equated with the brain, and scientists search to discover how ESP registers in the brain/mind.”

However, increasing evidence is demonstrating that ESP does exist, but it cannot be explained or quantified by physical laws; and furthermore, that the mind (consciousness) and the brain are two separate entities. Simultaneously, research in quantum physics points to the existence of a second, nonmaterial universe. So, the time is fast approaching when Western scientists must come to terms with the Eastern mystical concept: "that an extrasensory force exists in another realty, and intersects and integrates with the physical world. In function, ESP is dissimilar to the ordinary senses. There is no location like governs the other senses which receive information through various parts of the body; and it is not dependent on any of the other five senses. ESP is independent of such factors as geography, time, intelligence, age, or education.

ESP has been given various names. In the 19th century it was called "cryptesthesia," later it was labeled "relesthesia" which since became clairvoyance, or "seeing in the distance." It was Rhine who coined the term "general extrasensory perception" (GESP) to include both telepathy and clairvoyance. Later the term psi was designated to cover ESP and PK. It was researcher Lousia E. Rhine who proposed the theory that ESP starts in the unconscious, a storehouse of memories, hopes and fears. At this point a contact is made between the objective world and the center of the mind. The person remains unaware of this contact until or unless the information is brought to the conscious level. Also, the psychiatrist Carl G. Jung proposed a similar theory that the conscious mind has subliminal psychic access to the collective unconscious, a vast repository of accumulative wisdom and experience of the human race.



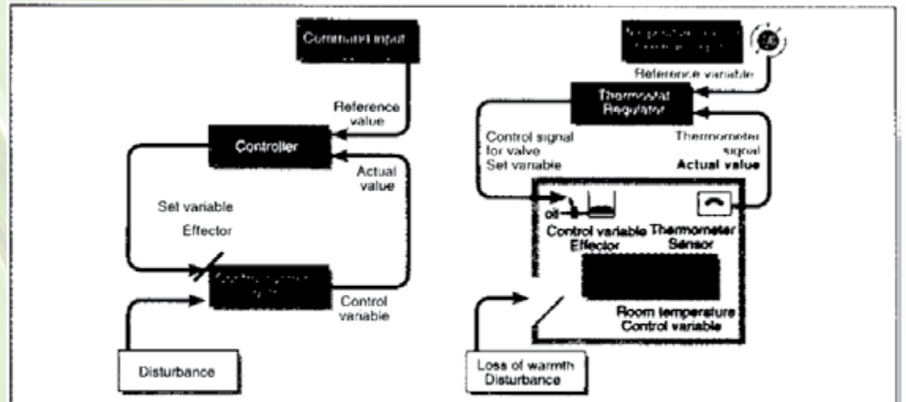
Others theories attempting to explain ESP have been produced. One such theory involved macrophages, cells present in connective tissue, lymph nodes, and bone marrow and tied to nerve endings. The person thought these might be the body's ESP organs, sending and receiving impressions below the normal perceptive level. Such cells are more sensitive and active during childhood, but deteriorate without proper diet. Some theories involve the discussion of two subconsciousnesses, the second one sometimes called the superconsciousness, soul, subliminal self, transcendent ego, dream self and several other terms. The argument rest on the hypothesis that two realities exist, the physical one and a second one. ESP can occur when there is a integration between both realities. This occurs infrequently only when the barriers between the realities are broken which does not happen often because if it did all unconscious thought would

flood and overflow the conscious mind. A condition which the mind could not withstand. When considering types or forms that ESP might take dreams become an important factor, especially in relationship to the theory of two realities. Upon this basis dreams were separated into two categories: realistic, vivid having detailed imagery of the information conveyed, and intuition which includes "gut feelings." forebodings, and premonitions; and unrealistic dreams containing fantastical imagery and symbols. Hallucinations that relayed visual and auditory information also were included. Rhine suggested the reason for dreams being efficient carriers of ESP messages is because the barriers surrounding the conscious mind appear to be thinnest.

It has been discovered that the natural tendency for ESP in individuals can be distorted by previous prejudices, thoughts, and conditioning. Likewise, inaccurate ESP messages may be the result of distortions and blockages of the conscious mind. However, in times of crisis such as accidents and death of loved ones, ESP messages seem to occur spontaneously. It is theorized that perhaps trauma and shock enable negative information to penetrate the subliminal barriers more easily than happy information. There are theories concerning individuals who possess ESP and how they acquired this ability. One theory holds that some people such as seers, prophets and diviners were bore with the gift which was inherited by their relatives. Another theory hold that it is` a primordial sense which has decreased in populations as their cultures advanced. Still another theory claims ESP is a super sense which evolves in the nervous system.

Psychical research does support the theory that everyone is born with ESP capability, though some may possess more than others. Most people have experienced at least one ESP experience in their lives. It was found in a survey published in 1987 by the University of Chicago's National Opinion Research Council, that 67 percent of all adult Americans believed they have experienced ESP. Eleven years earlier the figure was 58 percent. It was thought the increase indicates an increased acceptance of the possibility of ESP among the general public.

Operation of engineering control systems



Left: Block diagram of a simple control system, showing the customary terminology (defined below). Right: Illustration of the components of a control system as exemplified in a heating system; for each element of the temperature control system, the corresponding general technical term is also given.

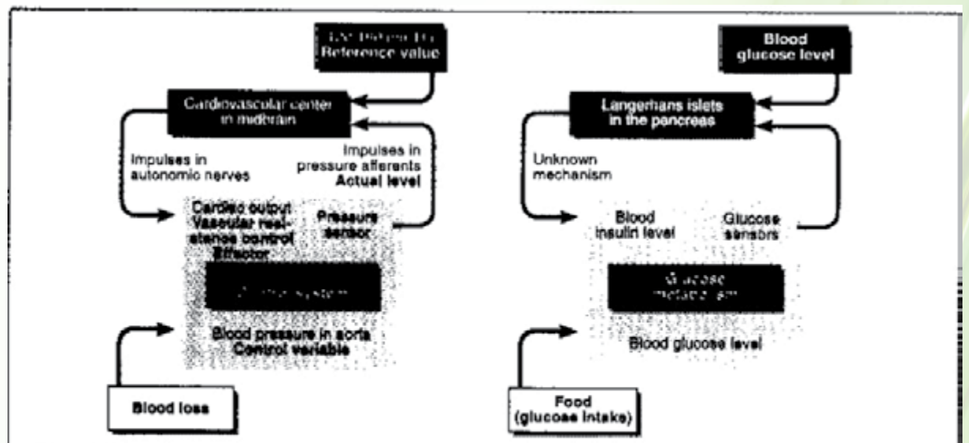
Basic terms in control system technology

- Controlled variable: a state that is to be kept constant (e.g. room temperature, blood pressure, blood glucose level)
- Controlled system: The physical substrate upon which regulation operates (e.g. living room, cardiovascular system, glucose metabolism).
- Sensor: Serves to measure the actual value of the controlled variable (e.g. thermometer, pressosensor. glut-osensor).
- Controller: Device that compares the actual value signaled by feedback from the sensor with a reference signal (set point) and, if a difference between them is detected (an error), generates an appropriate control signal (e. g. signal to supply fuel, impulses in autonomic nervous system).
- Effector: Apparatus that responds to .the control signal so as to correct the error (e.g. with adjustable fuel feed, cardiac output).
- Disturbance: Factor that acts on the controlled system or the controlled variable so as to drive the actual value away from the set point.

Cloed-loop and open-loop systems

An essential feature of regulation by a control system is that the circuit is closed, i.e. any deviation from the set point is automatically corrected by negative feedback. It is also possible to employ the same elements in an open-loop configuration, in which there is

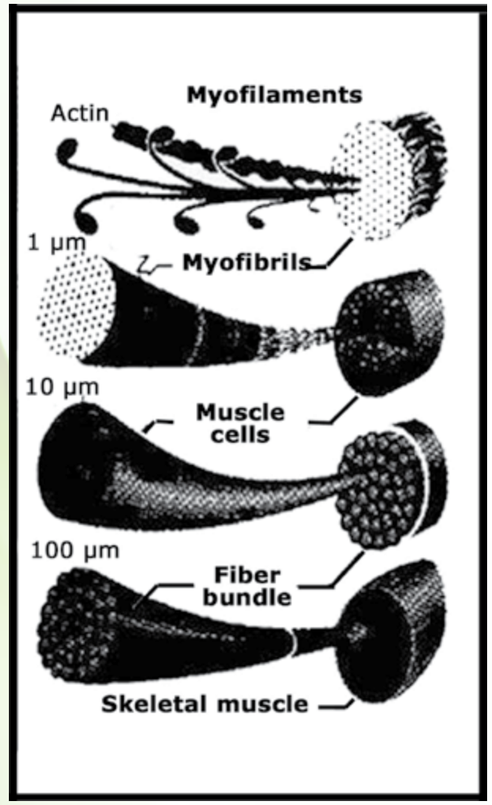
no negative feedback for automatic error correction . Such a system can compensate for a disturbance known in advance, such as heat loss at a constant outdoor temperature, but not for unpredictable disturbances of variable magnitude.



Left: Control system to keep arterial blood pressure constant (see also p. 188); loss of blood is shown as an example of a disturbance. Right: Control system to keep blood sugar level constant (see also p. 144).

Molecular mechanism of contraction

Structure and functions of skeletal muscle



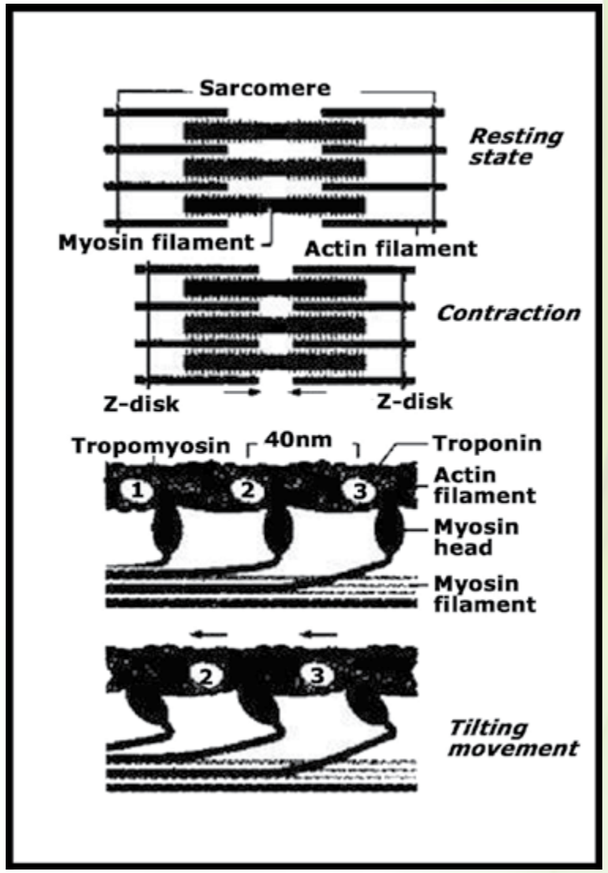
Skeletal musculature makes up 40–50% of the body weight and hence is the largest organ in the body. Main function: contraction, i.e. forceful shortening. Responsible for all communication with the surroundings; also supplies heat.

Skeletal muscle cells (muscle fibers) are very large, multinucleated cells; striated appearance is due to alignment of contractile proteins.

The `elementary motor' of the muscle is the sarcomere, which is bounded by Z disks and contains mainly the contractile proteins actin, myosin and tropomyosin–troponin, and also other proteins such as myoglobin (for 02 transport, resembles hemoglobin).

Myofibrils are chains of sarcomeres lined up end to end. Within a muscle cell many myofibrils are bundled in parallel. In turn, the muscle comprises bundles of muscle fibers sheathed in connective tissue.

Sliding filament theory describes elementary processes of contraction



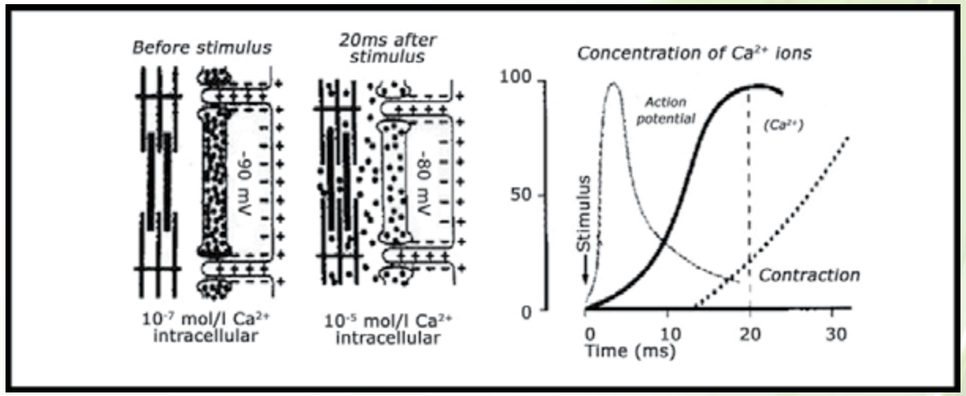
Resting state: Thick myosin filaments in the middle of the sarcomere only slightly overlap thin actin filaments, which project into them from the Z disks.

Contraction: Actin filaments are pulled between the myosin filaments. The force is exerted by cross-bridges (myosin heads) at the ends of the myosin filaments, which attach to the actin, carry out a tilting movement (the actual contraction process, which pulls actin filaments toward the middle of the sarcomere) and then release themselves and 'stretch for-ward' for a new tilting movement (complete cross-bridge cycle). They then reattach and so on. 50 such rowing strokes produce maximal shortening, bringing the opposed actin filaments so close that they meet in the middle of the sarcomere.

Relaxation: Myosin heads release themselves from the actin filaments, which then slide passively out from between the myosin filaments.

In excitation-contraction coupling Ca2 ions serve as messengers to turn contraction on and off

Description/Definition/Comments
The end-plate potential transmits excitation from motor axon to muscle fiber (described on p. 19). The resulting muscle action potential propagates at high speed over the whole muscle fiber and penetrates its interior through the T system
By way of the T system the action potential reaches the sarcoplasmic reticulum, where it releases Ca ions into the cell interior (cytoplasm), mainly from the terminal cisternae
Ca ions bind to troponin molecules on the actin filaments; the resulting deformation of these molecules pushes the tropomyosin filaments away from the sites where the myosin heads attach, so that the contraction process can begin
The release of Ca ions stops, the terminal cisternae pump the free Ca ions back again; hence troponin molecules return to the original configuration and tropomyosin filaments again cover the myosin head attachment sites. Tilting movements are no longer possible, and relaxation begins



Muscle mechanics

All forms of contraction can be described in terms of a few basic patterns.

The sarcomeres transmit the force they develop through intramuscular elastic structures to the somewhat elastic tendons and to the skeleton. Examples of elastic elements are the myosine cross-bridge and the actin filaments as well as the tendon insertions, which act together as partly parallel and partly serial elastic elements. When the actin filaments are pulled between the myosin filaments during contraction, the serial elastic elements are put under tension and it is this that produces the measurable force.

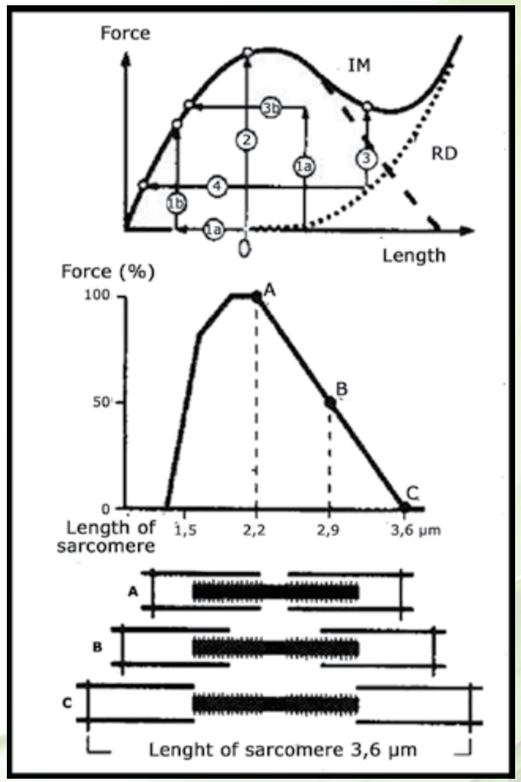
Form of contraction	Definition/Description/Comments
Single twitch	Takes about 80 ms to reach maximum, somewhat longer until relaxation; causes a very small shortening or tension development. Not all muscles twitch equally rapidly. Slow muscles (e.g. postural) contain much red myoglobin ('red' muscles). Fast muscles look white (e. g. eye muscles)
Multiple Twitch	During multiple excitation each new single twitch begins while some contraction is still left from the preceding twitch: superposition or summation. At a low excitation rate the single twitches arc still discernible (incomplete or partly fused tetanus). Al rates above ca. 30 Hz the maximal force is generated (complete or smooth tetanus)

Whether how much a muscle shortens and how much force it develops depend on the external circumstances under which the work is being done. These too can be described by a few basis patterns; the following characterizations each apply to titanic contraction.

Isotonic	Muscle shortening under constant load: there is more rapid shortening, the less the load and vice versa, sec F.ig. p. 84; the amount shortening Is also greatest with a slight load. The amount of mechanical work done is given by load (force) time distance. If the load exceeds the greatest possible force that can be developed., the active muscle is stretched (typical, very common braking movement, as in walking downhill)
Isometric	Tension developed without muscle shortening (e.g. bracing against a load too heavy to move); maximal force development with prestretching to about the resting length of the sarcomeres (optimal overlap of actin and myosin filaments, see Fig. p 84). Less force is developed with more overlap or greater pre-stretching
Contra	Due to interruption of MLF. An attempt to gaze conjugately leads to abduction of one eye (intact output through abducens), but failure of adduction the other eye because of the interruption of theconnection with the oculomotor nucleus through the MLF

metric	Shortening with simultaneous force increase (e. g javelin throwing and other very rapid movements). Rate of shortening is greatest with a small load (see above)
Iso twitch	First isometric, then isotonic contraction (e.g. lifting a bucket), common in everyday life. Again, shortening is more pronounced the less the load. Mechanical work (load times distance lifted) Is maximal for an intermediate load (for fatigue-tree operation, machinery must be appropriately designed)
Stopped twitch	Initial isotonic shortening followed by isometric contraction alter an immovable barrier is encountered (e.g. biting through sob loud until the jaws close)

Forms of twitch and relations between contractile force, sarcomere length and filament overlap (modified from Rüdel, 1993)



The passive tension curve PT describes the force that must be expended to stretch the muscle passively to a given length. The following forms of contraction can be observed:

1. stopped twitch
2. and 3. isometric contraction at resting length (2) and with prestretching (3)
3. isotonic contraction
4. afterloaded twitch.

The curve of isometric maxima IM gives the maximal isometric force available by a tetanically excited muscle at a given length. The dashed curve represents IM minus PT, i. e. the actively generated force.

The relationship between contractile force and prestrecthing depends on the amount of overlap between the actin and myosin filaments. The optimum lies at a sarcomere length of 2.2 µm, because in this case all cross-bridges present are available for attachment and tilting.

The maximal rate of shortening or lengthening of a muscle depends on the load that is lifted or is applying tension, respectively (after Rüdel, 1993)

Neural control of muscle contraction

Definition of the motor unit (MU); its size

Every motor axon supplies several to many muscle fibers by way of axon collaterals. These elements plus the associated motoneuron are together called a motor unit. Each action potential in the motor axon triggers a twitch in all muscle fibers of the MU. The smaller the motor unit and the less forceful it is, the more finely graded the contraction can be. The size of the MU is extremely variable; for example, the external eye muscles have ca. six muscle fibers per MU, while the biceps muscle of the arm has about 750 fibers per MU.

The gradation of contraction in everyday activity and the development of muscle tone are brought about by tetanization and recruitment; measured by electromyogram (EMG)

Definition/Comments
Every MU is capable of gradation from single twitch through partial fusion to complete tetanus. The transition from partly fused to complete tetanus occurs at an excitation rule of 8-31)s'. The force generated rises to tenfold that of the single twitch. Excitation rates between 30 and I211s serve to vary the shortening velocity (8U–120s ' for only ca, I011ms at onset of ballistic movements). Our lingers can he moved back and forth up to 8 Hz
Gradation of the number of activated MUs plays a greater role physiologically than tetanization (see above). An increase in number of activated MUs also raises contraction velocity, because each MU has a smaller load to accelerate (see above). Within a muscle small MtJs are activated more often than larger ones

Definition/Comments
An erect body posture requires continual slight muscle tension without length change (see postural motor systems p. 951, "1-his is achieved by asynchronous activation of Mils. The resulting active background muscle tension is called tone (muscle tone), The degree of tone changes continually. e.g. a distinct decrease in deep sleep and an increase during excitement and mental effort and for heat production (extreme: shivering with cold)
Extracellular recording of the action potentials of single motor units, The electrodes are either attached to the skin over the muscle or inserted into the muscle as needles (electrically insulated except for the tip). Used as diagnostic aid in muscle diseases (myasthenia gravis, myotonia, muscular dystrophy), to measure muscle tone in psychophysiology (especially forehead and upper arm muscles) and in behavioral medicine and rehabilitation to provide feedback of muscle activity for the psychological treatment of tension-related pain and of flaccid and spastic paralysis

Muscle energetics

ATP is the direct source of energy for muscle contraction (see above); efficiency of muscular work; forms of muscle heat. The reaction following contraction serves to resynthesize ATP (Table). Prolonged muscular activity must be supported by aerobic (i. e. with consumption of oxygen) oxidative phosphorylation. Brief (ca. 30 s) powerful effort can also be supported anaerobically (without oxygen consumption) by way of glycosis (e. g. sprint at 10m/s)

The sarcomeres have a right mechanical efficiency of 40-50%, the remaining energy is dissipated as heat (used to maintain body temperature). The overall efficiency with respect to the exterior is 20-25%, because in addition to the losses during contraction there are also losses in the purely chemical recovery processes. Shivering with cold does no mechanical work and is exclusively for the purpose of heat production.

The resting heat of resting metabolism is derived entirely from oxidative processes. During work it is supplemented by (1) initial heat during contraction and (2) heat of recovery after contraction; the latter can last for many minutes following powerful muscular.

The direct and indirect energy sources in human skeletal muscle (from Ppeachey et al., 1983)

Energy source	Content (µmol/g muscle)	Energy supplying reaction
Adenosine triphosphate (ATP)	5	ATP ←→ ADP + p1
Creatine phosphate (PC)	11	PC + ADP←→ ATP + creatine
Glucose units in glycogen	84	Anaerobic breakdown by way of pyruvate to CO_2 and H_2O
Triglycerides	10	Oxidation to CO_2 and H_2O

75% of the energy requirement at rests and during stationary work is supplied from fatty acids, the rest from carbohydrates

As the above Table shows, ATP is present in muscle only at a low concentration, so that rapid resupply is necessary. The creatine phosphate depot is sufficient for about 100 twitches. During moderate work it is replenished by breakdown of free fatty acids (75%) taken from the blood and by glucose (25%). These proportions reverse only during brief high and maximal performance. The glycogen depots in the muscle cells are drawn upon only for extreme exertion. For further remarks on muscle metabolism and reactions that adjust the body to muscular work.

Fatigue and exhaustion are partly peripheral and partly central in origin

Depending on circumstances, the fatigue caused by muscular work can be more mental or more physical. There is no fixed borderline between the two; the causes of mental fatigue (fatigue in the CNS) are not yell well understood.

- Musculature of the viscera and all vessel walls (except for the capillaries, which have no muscle layer)
- The spindle – shaped individual cells are connected by nexuses (gap junctions) to form a syncytium (just like myocardial cells).
- No cross striatio is visible in the light microscope, because the actin and myosin ligaments are not arranged in a regular pattern (hence ‘smooth’ muscle).
- The aliding filament theory (see above) also applies here, but the individual rowing stroke is 100-1000 times slower than in skeletal muscle; this conserves energy for sustained contractions, but makes rapid movement impossible.
- Innervated by autonomic nervous system. Many smooth muscles are also spontaneously active (myogenic activity).

Important characteristics of smooth muscle; differences from skeletal muscle

Definition/Comments
Because the single twitch is very long lasting (often many seconds), complete tetanus is reached at very long excitation rates (<Hz)
Pacemaker cells generate spontaneous action potentials, which propagate across the gap junctions and maintain tone without neural input. Acetylcholine raises the spontaneous frequency and norepinephrine lowers it. Hormones also have an influence, e.g. estrogens on the uterine musculature and angiotensin II on vascular musculature: for visceral musculature see pp. 239. 24
Organ-specific, periodic fluctuations in myogenic tone, responsible for peristaltic waves in the viscera, where it is called basal organ – specific rhythm (BOR)

Definition/Comments
Plastic (viscoelastic): when stretched, smooth muscle yields plastically after an initial classic period. Therefore smooth muscle can be relaxed in both shortened and stretched states (e. g. urinary bladder). In reaction to severe stretching the pacemaker cells increase their activity and elicit contractions (bladder evacuation, auto regulation of arteriole diameter etc.)
This predominates in the smooth muscles of arteries, vas deferens, iris, ciliary muscle, which lack pacemaker cells; an inhibitory influence by way of the autonomic nervous system is also common
A T system (see above) is lacking and there is little sarcoplasmic reticulum to store calcium. The cell membrane contains additional action potential-controlled calcium channels. Hence contraction is elicited partly by influx of extracellular Ca2 and partly by release of sarcoplasmic Ca2+. These processes involve regulator proteins (calmodulin, caldesmon, calponin). Much time is required to pump the Ca2+ back, so that contraction subsides slowly

Pathophysiological aspects

Neurogenic muscle disorders include all defects of the motor unit apart from those of the muscle fiber itself. Motoneuron diseases may be degenerative (e. g. amyotrophic lateral sclerosis), inflammatory (e. g. poliomyelitis) or toxic (e. g. tetanus or botulinus toria). As an example of impaired neuromuscular transmission is myasthenia gravis.

The myogenic muscle disorders, in which the defect resides in the muscle fibers, are also called myopathies. They include myotonia, periodic paralysis, progressive muscular dystrophy, metabolic muscle disease and myositis.

Neurogenic and myogenic muscle diseases together are called neuromuscular diseases. In many cases the underlying pathological mechanisms have been clarified.

Somatosensory inputs to the motor system

Muscle spindles, Golgi tendon organs and cutaneous afferents are the most important receptors for the motor system.

Definition/Description/Comments - Structure and function of muscle spindles
These are thinner and shorter than normal (extrafusal) muscle fibers and arc enclosed in a spindle shaped connective tissue sheath: scattered Through the muscle in parallel to the extrafusal musculature, especially numerous in muscles for fine movements (e.g. finger muscles): are stretched when the muscle is stretched and relaxed during muscle contraction

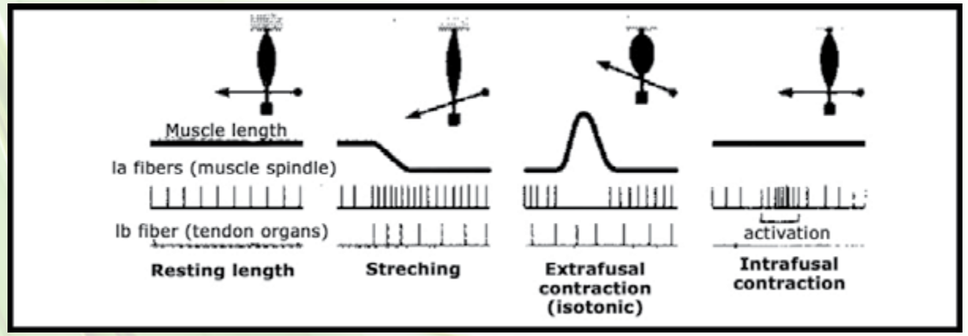
Definition/Description/Comments - Structure and function of muscle spindles
Wound around the middle of each intrafusal muscle fiber Cannulospiral ending). Afferent nerve fiber (one per spindle) is called la fiber. Excited by stretching of the central region hence measure muscle length. Note: intrafusal contraction also stretches central region (see below). Response has dynamic component, and so they also measure rate of change of length
Wound around intrafusal muscle fiber on either side of the primary ending: their afferent fibers are called group II fibers (see p. 17): they are also stretch-sensitive
By y-motoneurons (smaller than α.-montoneurons). End-plates of the (thin) y-motor axons are situated between the poles of the spindles kind the afferent innervation. Activation causes this polar region to contract and stretch the central region (thus exciting the primary aflerents)

Structure and function of Golgi tendon organs

Definition/Description/Comments - Structure and function of muscle spindles
Tendon fascicles comprising ca. 10 extrafusal muscle fibers are enclosed in a connective tissue sheath; present in the tendons of all muscles, arranged ‘in series' with the extrafusal musculature and hence are stretched during both stretching and contraction of the muscle
By 1-2Ib nerve fibers (see p. 17), the ends of which branch among the tendon fascicles. They are excited by stretching of the tendon organ and hence measure muscle tension

Cutaneous receptors: important for escape reflexes (flexor reflex, crossed extensor reflex) are the nociceptors, which are excited by noxious (damaging) stimuli

Discharge patterns of the muscle spindles and tendon organs

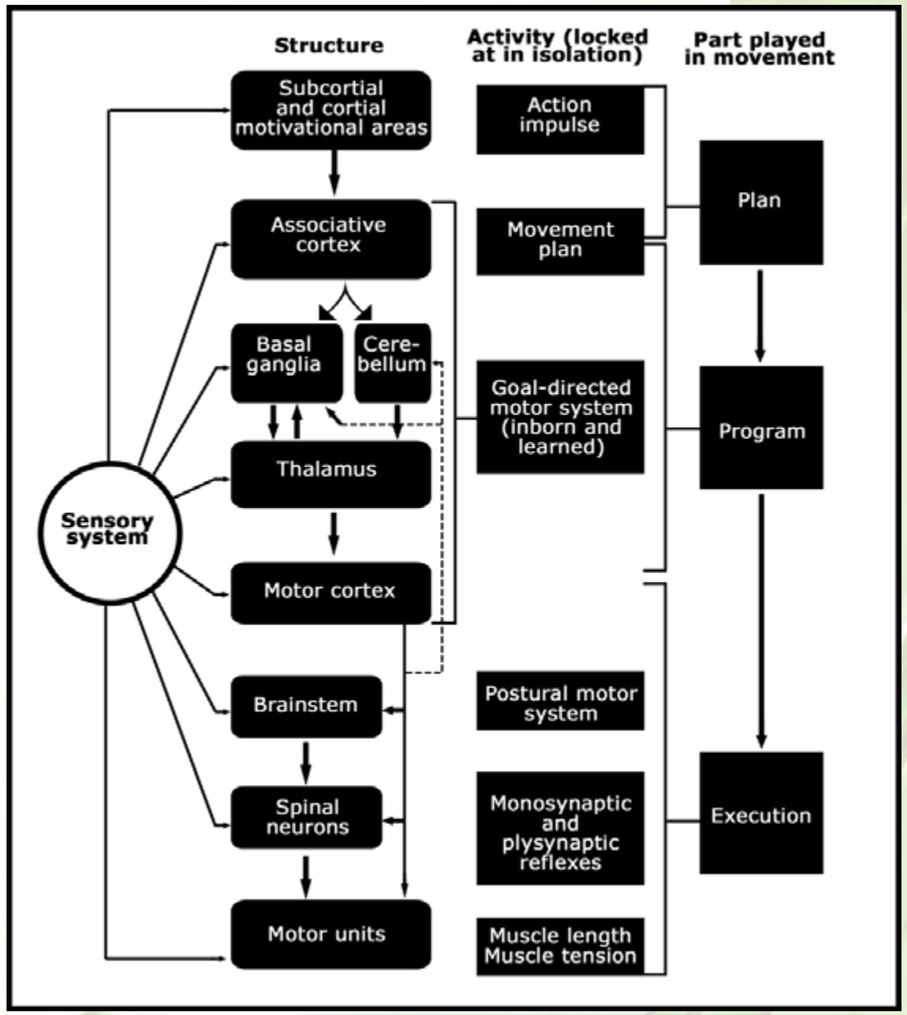


Components and functions of the motor system

Definition of motor centers of the central nervous system (CNS)

The nervous system includes all neural structures, the only or predominant ? of which is the control of posture and movement. Such structures, e. g. the are called motor centers. These are stimulated in a cascade arrangement in various parts of the CNS. They are specialized for motor tasks and hence must cooperate with one another. The key words, therefore, are hierarchy and partnership.

Survey of the motor system; explanations of the positions of the individual components and their functions are on the following page (after Birbaumer and Schmidt, 1996)



The most important structures and their connections are shown in the left column. For simplicity all sensory inputs are lumped together in the far left. The middle column emphasizes the predominant functions of the individual centers considered in isolation and on the right their roles in initiating and executing a movement are indicated.

Cascade organization of the motor system and the special functions of the motor centers

Position and function(s)/Comments
Consists of a motoneuron in the spinal cord or brainstem plus the muscle fibers innervated by its axon; the most peripheral component of the motor system. The size of a motor unit ranges from a few muscle fillers in the external eye muscles to 500—1000 fibers in the back musculature
Part of the gray matter of the spinal cord: contains the interneurons and motoneurons of many mono- and polysynaptic motor reflex arcs. The spinal reflexes constitute a library of elementary posture and movement programs, which when initiated ‘from outside’ (sensory stimuli) or 'from above' (voluntary movement) are executed automatically
Chief among these, from caudal to cranial, are: (1) medullary part of reticular formation (RF), (2) motor components of vestibular nuclei, (3) pontine part of RF, (4) red nucleus. Main role of these centers: (1) control of postural motor functions and (2) coordinating these with directed, movements, as well as (3) regulating muscle tone
This includes (1) the primary motor cortex in the precentral gyrus (area 4) and (2) its neighboring motor areas (area 6 with supplementary motor area SMA and premotor cortex PMC). Part of the pyramidal tract originates here (corticospinal tract). Main role: goal directed motor programs including (esp. area 4) control of fine movements; area 6 is involved in planning of movement
Most important motor nucleus of the thalamus is the ventral lateral nucleus (VL). It links the cerebellum and the basal ganglia to the motor cortex. Main role: incorporating sensory inputs into motor functions
The main components (with cortical and nuclear regions in each case) and main roles are: (I) vermis: control of postural motor systems, (2) intermediate region: coordination of posture and goal-directed movements; (3) hemispheres: control of rapid (learned, ballistic) directed movements. In addition (1) and (2) participate in oculomotor control
Most important components: striatum (input structure. consists ()I' put amen subthalamic nucleus. Main function: production of motor programs (generation of spatiotemporal impulse patterns to control the amplitude, direction, speed and force of a movement)

The subcortical (e. g. ‘hunger center’ or ‘thirst center’ in the hypothalamus) and cortical (association cortex with input into cerebellum and basal ganglia) motivation areas, which are responsible for the internal drive to act and the design of movement strategies, can also be considered motor centers in a broad sense.

To a great extent our motor systems serve to adopt and maintain posture and the orientation of the body in space. In a category apart from these postural functions are goal-directed movements related to the world outside the body. Goal-directed (voluntary) movements are always accompanied by actions and reactions of the postural motor system.

Motor functions of the spinal cord: reflexes

Every reflex arc consists of the same five elements

Definition/Description/Comments
All sensory receptors in the muscles. skin, viscera and the special sense organs (e.g. eye) participate in reflexes of one kind or another
The afferent nerve fibers of the receptors form the afferent limb of the reflex arc
Their number is always >1 except for the monosynaptic stretch reflex (see below). Excitatory and inhibitory inputs to these neurons are the basis of reflex plasticity
In motor reflexes these are the motor axons: in autonomic reflexes they are the postganglionic fibers of the autonomic nervous system
In motor reflexes these are the skeletal musculature: in autonomic reflexes, the smooth musculature, the heart or the glands

The monosynaptic stretch reflex (myotatic reflex) is the simplest example of a motor reflex arc (see figure on the following page)

Definition/Description/Comments
Primary muscle spindle endings and Ia fibers of the homonymous muscle. The reflex arc is activated by stretching the muscle. hence the name stretch reflex
α - motoneurons of the homonymous muscle (i.e. the muscle from which the Ia fibers come). The reflex arc has only one central synapse (Ia afferent to
motoneuron), hence the name monosynaptic stretch reflex
α - motor axons of the homonymous muscle
Extrafusal muscle fibers; because these are in the same muscle as the muscle spindles (homonymous) the reflex is also called the myotatic reflex

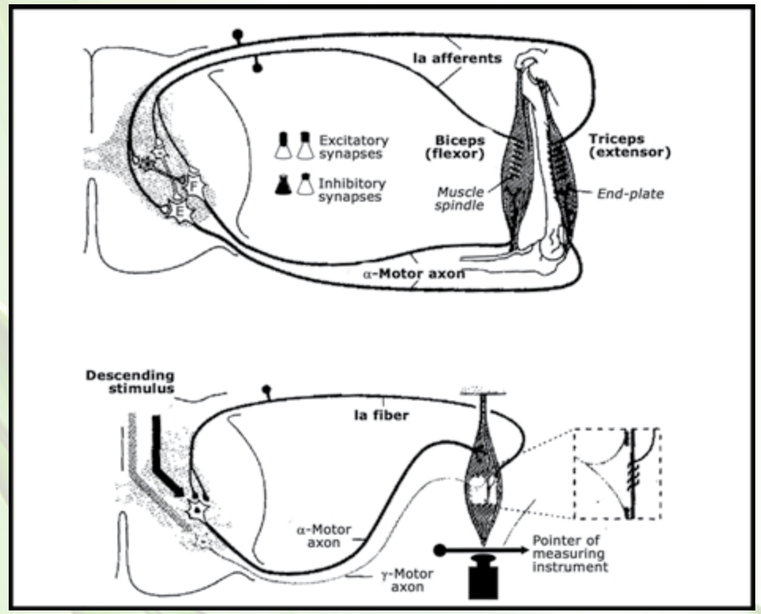
Has a very short reflex time (time from beginning of stimulus to effector action 20-30 ms). The best known example is the patellar tendon reflex; stretching of the quadriceps femoris mucle by striking the knee tendon. Called an H reflex (after P. Hoffman) when elicited by electrical stimulations of Ia fibers (e. g. tibial nerve behind the knee) recorded myographically as an H wave. Higher-intensity stimuli also elicit an M wave by exciting motor axons. Main reflex function: reflex stabilization of muscle length (postural tone).

General terms for the elements of a reflex arc: specific element of the monosynaptic stretch reflex:

Reciprocal inhibition of motoneurons to antagonist muscles by Ia afferents is the simplex inhibitory reflex arc:

Definition/Description/Comments
Primary muscle spindle endings and Ia fibers of the antagonist muscles). Activation simultaneous with monosynaptic stretch reflex (on the antagonistic side)
Spinal interneuron with inhibitory synapse on antagonist motoneurons, hence two central synapses (disynaptic reflex arc)
Antagonist motor units are inhibited (decreased (one): also called direct inhibition because of the short pathway. Main function: reinforces monosynaptic stretch reflex in maintaining conststant muscle length and joint position

Reflex pathways of the stretch reflex and reciprocal inhibition at a hinge joint involving flexor (F) and extensor (E) motoneurons (first picture) and the elicitation of the monosynaptic stretch reflex by intrafusal contraction – γ-loop.



Excitation of the γ-motoneurons by higher motor centers causes intrafusal contraction, which stretches the central region of the muscle spindles and thus activates the monosynaptic reflex arc; γ-loop. Usually α- and γ-motoneurons are excited simultaneously: α-γ linkage. Advantage: muscle spindle is not taken out of its operating range by excessive shortening or stretching; instead, its sensitivity is adjusted to the new muscle length.

Golgi tendon organs produce effects opposite to those of the primary muscle spindle afferents: autogenic inhibition and antagonistic excitation.

Definition/Description/Comments
Golgi tendon organs and Ib fibers of the homonymous muscle. Reflex arc activated by increased tension (stretching or isometric contraction)
Homonymous and agonist motoneurons: there are 1–2 interneurons in the path that inhibit the motoneuron. Antagonist: interneuron with excitatory synapse on motoneuron (di- and trisynaptic reflex arc)
Homonymous and agonist motor units are inhibited: autogenic inhibition. When muscle tension decreases, autogenic inhibition also decreases, causing disinhibition. Antagonist motor units show excitation (increased muscle tone). Main function of both reflex arcs: to maintain constant tension

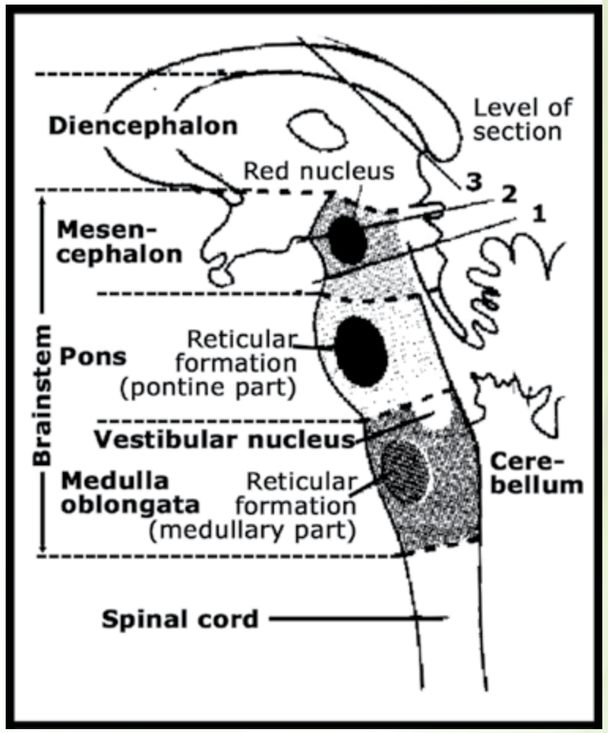
Flexor reflex and crossed extensor reflex are prototypes of polysynaptic motor reflexes

Definition/Description/Comments
Nociceptors (high-threshold mechano-, thermo-, chemoreceptors) with group III and group IV afferents (AS and C): excited by noxious (i.e, actually or potentially damaging) high-intensity stimuli
Spinal interneuron chains (polysynaptic reflex arcs) that excite ipsilateral flexor motoneurons and contralateral extensor motoneurons; inhibit corresponding antagonists
Motor units in ipsilateral flexors are strongly excited, antagonists are inhibited. The result is rapid flexion (withdrawal from the danger zone). Contralaterally the extensors are excited (elevated tone) and flexors inhibited (to strengthen the supporting leg, since the flexed leg no longer provides support)

Many kinds of modification can occur in the interneuronal pathway 2, e. g. summation of subthreshold stimuli until a reflex is triggered; habituation to repeated stimuli and dishabituation when the stimulus changes; sensitization to painful stimuli and conditioning, a long-term change in the reflex response due to learning, etc.

Motor functions of the brainstem: postural functions

Motor centers of the braistem; their efferents and afferents



The motocenters of the brainstem control postural functions and muscle tone by way of descending tracts named according to their origin and destination:

1. Lateral reticulospinal tract (from medullary RF)
2. Medial reticulospinal tract (from pontine RF)
3. Vestibulospinal tract
4. Rubrospinal tract

A modulating influence is also exerted by the descending noradregenic system from the locus coeruleus and by the serotonergic system from the raphe nuclei.

These centers receive inputs from the somatosensory system (especially in the neck region), the vestibular system and the motorcenters higher in the hierarchy (cerebellum, basal ganglia, motor cortex).

The functions of the brainstem centers are revealed by eliminating higher motor centers

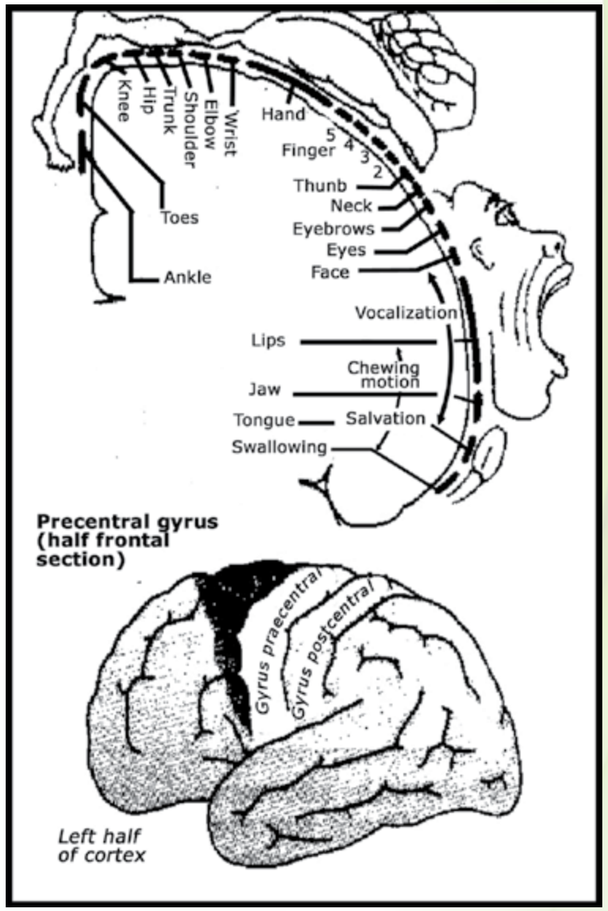
Definition/Description/Comments
Transection at the boundary between midbrain and pons (section plane 1 above); cerebellum intact. The result is a massive increase in muscle tone: decerebrate rigidity, especially affecting the extensors and neck muscles (similar to human apallic syndrome after severe skull/brain trauma or cerebrovascuiar accident). Marked resistance to stretching of the musculature during movement. The rigidity disappears after transection of the dorsal roots and hence is based on overactivity of the y-loop
Midbrain also intact (section plane 2 above). The animal can right itself and the rigidity is less pr nonrated. These functional improve¬ments are due mainly to preservation of the red nucleus
Diencephalon also intact (section plane 3 above). The animal makes spontaneous rhythmic stepping movements, though they are automaton-like
Basal ganglia also intact. Movement repertoire well preserved though automaton-like; unrestrained, extremely persistent locomotion (animal walks stubbornly into obstacles). Postural and righting reflexes well developed

Motor functions of the brainstem: postural and righting reflexes, postural synergies (long-loop reflexes)

The reduced preparations described on the preceding page have been used extensively to study the function of brainstem centers, and much was learned about reflex adjustment of tone distribution (postural reflex) and restoration of the normal body orientation (righting reflexes), both of which originate mainly in the proprioceptors of the neck musculature (neck reflexes) and the vestibular system (labyrinthine reflexes). These analyses greatly increased our understanding of motor organization. Today, however, more attention is paid to the incorporation of postural functions into directed movements. In humans the upright gait is of particular interest, as it involves the collaboration of both spinal and reflex mechanisms and supraspinal reflex mechanisms and supraspinal reflex loops (long-loop reflexes) to create postural synergies, which serve in part to prevent directed movements from interfering with stable posture: anticipatory postural synergies.

Functions of the area of the motor cortex: goal-directed (voluntary) movement.

Electrical stimulation of the cortex revealed somatotopy and multiple representation (after Penfield and Rasmussen, 1950).



Definition of somatotopy: The body is represented as a disorted map on the motor cortex, especially the precentral gyrus, in which the body regions with a high degree of motor flexibility are disproportionately large; in humans these are mainly the hands and face,. Diagrammed as a motor homunculus.

Multiple representation: In addition to the precentral gyrus (area 4) there are other somatotopically organized motor cortices, esp. in area 6, supplementary motor area (SMA); premotor cortex (PMC). Distribution of functions among these areas is currently under intensive study. During voluntary movement activity in the SMA (demonstrated by a readiness potential) precedes that in area 4 (demonstrated by a motor potential)/

Afferents and efferents to areas of the motor cortex

Inputs come primarily from the basal ganglia (some directly, some by way of the thalamus), the cerebellum (via the thalamus) and the sensory centers 9via pontine nuclei). Main efferents: corticospinal tract (pyramidal tract) with collaterals to practically all supraspinal motor centers.

Endings partly directly on motoneurons, partly on interneurons of motor reflex arcs, also indirect efferents by way of brainstem centers.

Functional deficits illustrate the roles of the motor cortex.

Description/Comments
(Pyramidal tract) Selective experimental transection causes little impairment of general mobility except for deterioration of line hand movements: movement slowed, impossible to grip precisely with thumb and index finger, hand grasps by closing all lingers together
(Premotor cortex) Experimental ablation and clinical lesions cause erro¬neous postural adaptations; also. movement complexes can no longer he executed in correct temporal sequence
(Supplementary motor area) Clinical lesion produces distinct poverty of movement and of speech (with normal ability to repeat spoken words)
(Syn.: stroke, apoplexy) Interruption of cortical efferents in the region of the internal capsule; initially shock with contralateral paralysis (flaccid hemiplegia), later hypertonus (spastic hemiplegia). Many additional symptoms occur (e.g. aphasias, impaired consciousness, spatial neglects).Spasticity resembles decerebrate rigidity. Overall syndrome is caused by interruption of pyramidal and brainstem tracts

Functions of the cerebellum

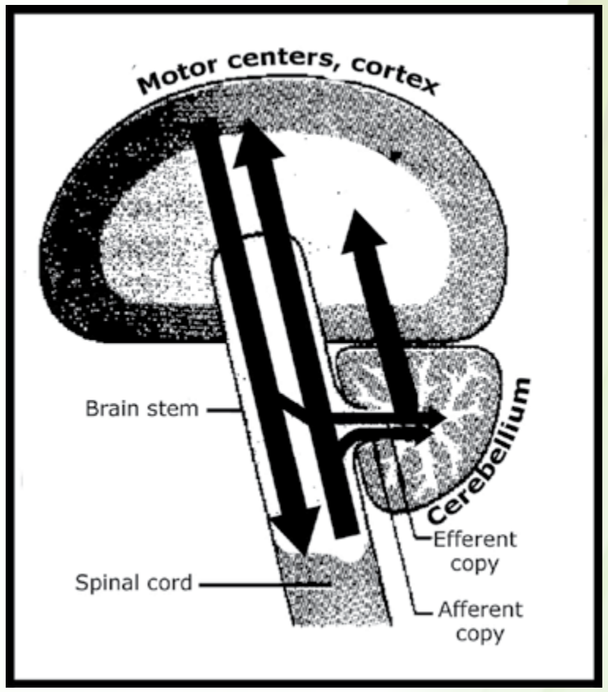
Afferents and efferents of the cerebellum

1. Medial regions (vermis including flocculus and nodulus, also intermediate region): inputs from the somatosensory, vestibular and visual systems, efferents directly to motor centers in brainstem and spinal cord.
2. Hemispheres: input from sensorimotor associative cortex, efferents to motor thalamus (VA) hence motor cortex (see above).
3. For the cerebellar as a whole: all inputs go to the cerebellar cortex and are doubly represented, as mossy and climbingfibers (functional significance still unclear). The only output from the cerebellar cortex comprises the axons of the Purkinje cells, which exclusively inhibitory synapses (transmitter: GABA) on neurons of the deep cerebellar nuclei (motor modulation by increasing and decreasing inhibition).

Role of the cerebellar structures in motor activities:

Function/Comments
Control and correction of the postural elements of stance and movement (posture, tone, balance)
Course correction in slow directed movements and co-ordination of these with the postural elements
Execution of the rapid directed movements 'designed' by the cerebrum. Assistance in the learning and execution of rapid directed movements without feedback (ballistic movements as in speaking. saccadic eye movement; playing musical instruments, sports)

Functional diagram of the medial parts of the cerebellum (after Schmidt and Wiesendanger, 1990)



By way of collaterals, these parts receive an efference copyof command signals sent from the motor centers to the spinal cord in descending motor tracts. The cerebellum also receives a sensory afference copy by way of collaterals from ascending tracts.

In the illustrated hypothesis, the cerebellum can calculate departure from the desired values (errors) by comparing the two inputs. The result is fed back to the motor centers to enable continual correction of the motor program once a movement has been initiated.

The motor disturbances and deficits caused by clinical and experimental lesions emphasize the role of the cerebellum.

Medial elements

Hemispheres
Inability to send correctly balanced neural signals to muscles. Symptoms as follows:
Components of a movement arc not executed simultane¬ously but rather one after another
Movements are too short (hypometria) or too long (hypermetria) and are subsequently overcompensates
Uncertain, overshooting gait with legs wide apart, similar to drunken gait (see above)
Inability to make movements in rapid succession (as in piano play-ing) (syn.: dysdiadochokinesia)
Occurs only during movement: intention tremor; can crescendo in approaching a target so greatly that the target is missed (e.g. in trying to pick up a glass)
Too-low muscle tone, often associated with weakness and rapid fatiguability of musculature

Functions of the basal ganglia

Afferents and efferents of the basal ganglia

The excitatory afferent inputs come mainly from the entire cortex and sensory centers who run to the striatum (transmitter; glutamate), which sends inhibitory in puts to the substantia nigra and polidum (transmitter: GABA). Outputs are partly direct to the brainstem, partly to the motor thalamus (inhibitory: GABA) and from there to the motor cortex (as in the cerebellum; there is a marked parallelism of these two structures in the motor system). Internally strong feedback between substantia nigra and striatum (dopaminergic, clinically important: parkinsonism, see below).

Role of the basal ganglia in the motor system

The main function is to participate in the conversation of movement plans into movement programs, i. e. to develop spatiotemporal impulse patterns to control the motor centers that execute movement; includes the setting of movement parameters such as the force, direction, velocity and amplitude of a movement.

Inputs and outputs of the basal ganglia are incorporated in separate, parallel cortico-subcortical, trans-striatal (putamen and caudatum) functional loops, all similarly organized for execution of specific subfunctions.

Loop	Function/Comments
Skeletomotor	Preparation for movement and control of movement param¬eters (e.g. direction, amplitude, speed. load); somatotopic organization throughout, emphasis on mouth and face movements

Loop	Function/Comments
Oculomotor	Control of eye movements, e.g. temporal control of saccades; cortical input from the frontal eye field (area R, supplementary input from area 7)
Complex associative	Three loops known at present: (1) dorsolateral-prefrontal, (2) orbitofrontal, anterior-cingulate. Functions still un¬clear, probably involved in programs for motor strategies in motivation- and cognition-controlled behavior

Modulation of functional loops in the basal ganglia

The main information flow in the above trans-striatal loops can be enhanced or inhibited by modulation systems:

- Dopamine system: dopaminergic nigrostriatal pathway terminates diffusely in the whole striatum. Discharge rhythm ca. 1 Hz; at each discharge dopamine is released at countless synapses and acts to modulate glutamatergic corticostriatal transmission in the various functional loops (it is unclear, however, whether the action is inhibitory, facilitatory or both).

Other potential modulatory systems

- serotonergic from raphne nuclei
- noradrenergic from locus coeruleus
- cholinergic from striatal interneurons
- peptidergic from various sources (much still unknown)

Lesions of the basal ganglia cause movement disorders classified clinically as positive and negative symptoms. It may be possible to interpret the two categories pathophysiologically as hyper- and hypoactivity of transmitter systems.

Classification by positive and negative symptoms
Hyperkinesias (abnormal, involuntary movements). These includes:
athetosis (slow rotating limb movements)
chorea (rapid, brief, irregular movements)
ballism (violent proximal flinging movements); caused by lesion of subthalamic nucleus
tremor (involuntary, strictly rhythmic oscillatory movements of individual parts of the body)
rigidity (abnormal muscle tone during passive movement)

Classification by positive and negative symptoms
Movements disturbed and slowed. Technical terms used essentially synonymously:
akinesia
hypokinesia
bradykinesia
Classification according to transmitter systems
Hypoactivity of the nigrostriatal pathway leads to parkinsonism (see be-low). Substitution therapy: administration of the precursor r.-dopa. Also treated by inhibiting the dopamine-destroying enzyme monoamine oxidase B (MAO-B), and recently by administering dopamine agonists (bromo¬criptine. lisuride). The disinhibition (hyperactivity) of the cholinergic system produced by dopamine insufficiency is counteracted by anticho¬linergics (atropine derivatives)
Huntington's chorea: hereditary degenerative disease of the basal ganglia (involuntary, tic-like twitches). The GABAergic striatopallidal and -nigral pathways degenerate, as do the cholinergic interneurons (see modu-latory systems). So far no substitution therapy is known, nor for hemihallism (unilateral involuntary flinging movements)

Parkinsonism is the most common disease of the basal ganglia. Its symptoms are akinesia, rigor and tremor at rest, to varying degrees:

Symptom	Definition/Description/Comments
Akinesia	Difficulty in initiating a movement and in completing it ('freezing' of voluntary movement); face mask-like, expressionless: speech only slightly modulated. No arm movements while walking; small steps with body bent forward
Rigor	Muscular hypertonia with increased tonic (not phasic) stretch reflexes; waxy resistance to passive movement, which periodically gives way ('cogwheel phenomenon')
Tremor at rest	Mainly noticeable in the hands (4-7Hz), sometimes also lips and other parts of the body; subsides during directed movements and resumes after the movement

Peripheral ANS

Subdivisions of the ANS

Element	Description/Comments
Sympathetic	Its preganglionic neurons are all located in the thoracic and up-per lumbar spinal cord (red, below); the preganglionic axons (B and C fibers, see p. 17) end either in the paravertebral ganglia of the sympathetic trunk or in unpaired abdominal ganglia: the long postganglionic axons (C fibers) run to the effector organs (see p. 102)
Parasympathetic	Its preganglionic neurons are located in the brainstem and the sacral cord (green below); the preganglionic axons (B and C fibers) end in parasympathetic ganglia near the effector organs. to which the short postganglonic axons (C fibers) run
Cross neural	Main elements are the myenteric plexus (Auerbach's) and the submucosal plexus (Meissner's, see p. 236); both contain sensory. motor and interneurons: main function is control of the GIT (pp. 236–249); is independent, But can Be modulated by sympathetic and parasympathetic influences

Organ system Parasympathetic stimulation Sympathetic stimulation Adregenic response

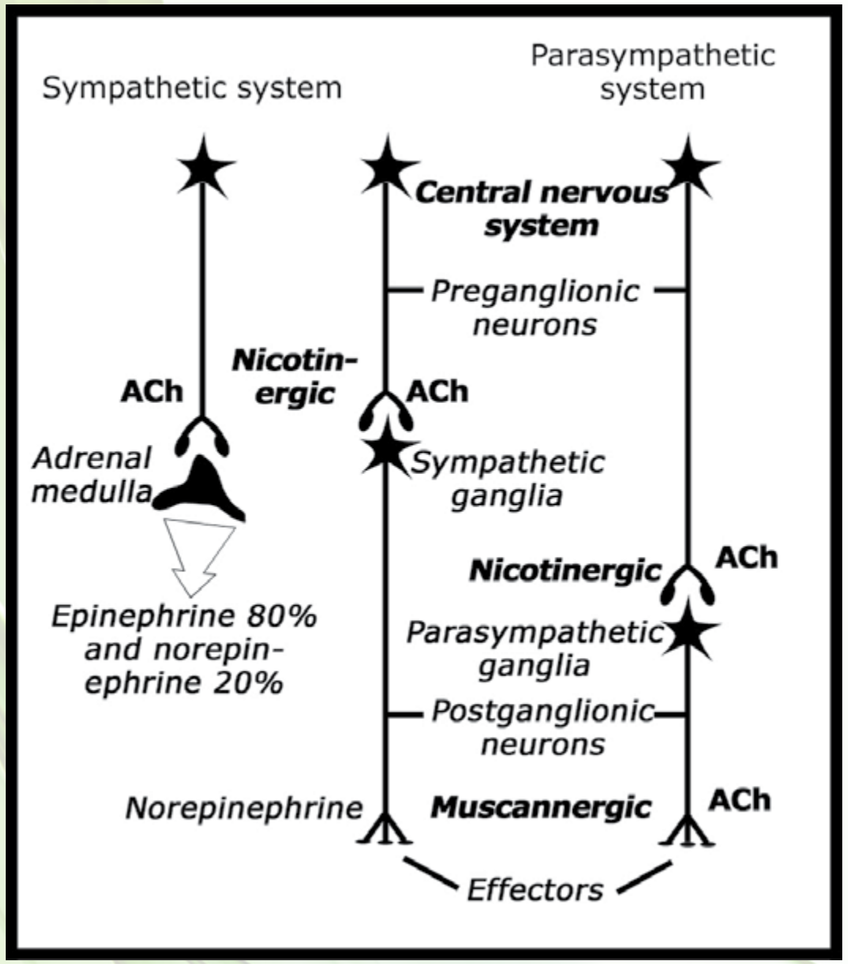
Heart muscle Decreased heart rate Increased heart rate β

Characteristics of ANS operation

- Specific final motor paths: The pre- and postganglionic ANS is organized with functional specificity in its sympathetic and parasympathetic elements: important examples include the systems of the muscular vasoconstrictor neurons, the cutaneous
- Vasoconstrictor neurons, the sudomotor neurons (to the sweat glands) and the pilomotor neurons (to the musculature of the hair follicles).
- Divergence: Within each functional system every preganglionic axon branches to glionic neurons; in this way, a few preganglionic axons can influence many postganglionic axons (distributor and amplifier function).
- Convergence: Within each functional system many preganglionic axons converge onto a single postganglionic neuron; this ensures a high safety factor for synaptic transmission.
- Parallel innervations by sympathetic and parasympathetic systems (see previous page); all organs with parasympathetic innervation also receive sympathetic innervation, but not the reverse (in partcular no parasympathetic innervation of the body wall or of the vessels).
- Interaction of sympathetic and parasympathetic: In organs with parallel innervation, the two usually have antagonistic actions; however, in some organs the parasympathetic action altogether predominates (e.g. urinary bladder, salivary glands).
- Role of visceral afferents: About 80% of all axons in the vagus nerves and 50% of all axons in the splanchnic nerves are afferent; they innervate the thoracic and abdominal cavities with mechano- and chemoreceptors; their information is used by the ANS together with somatosensory information (e. g. viscerovisceral and somatovisceral reflexes)

Synaptic and hormonal transmission in the ANS

Transmitters and receptors in preganglionic and postganglionic synaptic transmission (after Janig, 1995)

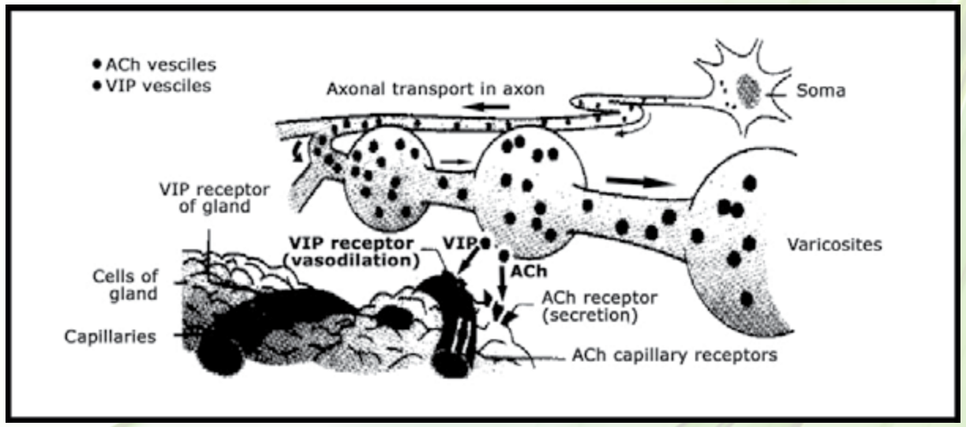


Acetylcholine (ACh) is the transmitter at all preganglionic synapses (nicotinergic receptors, block by quaternary ammonium bases [ganglionic blockers]) and at all postganglionic parasympathetic and some (e. g. sweat glands) sympathetic synapses (muscarinergic receptors, block by atropine). Norepinephrine (NE) is the transmitter at most postganglionic sympathetic synapses; postsynaptically partly α-, partly β-receptors (each with diverse selective agonists and blockers).

Special features of the neurotransmission in the ANS; role of epinephrine (E) from the adrenal medulla (AM)

- (syn.: α-adrenoceptor): pharmacologically defined by the decreasing of equimolar doses of the catecholamines NE>E>I (I: isoprenol) and by the effectivenss of specific α-adregenic blockers
- β-receptor (syn.: β-adrenoreceptor): catecholamine effectiveness graded in reverse order, I>E>NE; again, there are specific β-adregenic blockers; the two types of adrenoreceptors are currently being classified into subtypes: α1-, α2-, β1-, β2- receptors
- Effect of α- and β-receptor activation: effectors of the ANS contain both α- and β-receptors: their action is usually antagonistic; which action predominates in each case depends on the relative number of adrenoreceptors present and on whether they are exposed to more NE or more E (from the AM)
- Release of catecholamines from the AM: occurs in the proportions 80%E and 20%NE; slight release in resting conditions, increased under stress, in emergencies and in emotional situations by preganglionic cholinergic activation; in the β-adregenic action, E serves mainly as a metabolic hormone (glycogenolysis,)
- Presynaptic control of transmitter release: involves feedback by way of presynaptic α- and β-adrenoreceptors; partly facilitatory, partly inhibitory; additional reciprocal presynaptic α-receptors of cholinergic neurons. ACh to presynaptic muscarinergic receptors of adrenergic neurons)
- Co-localization of neuropeptides with NE and ACh: occurs routinely, certain combination being found more commonly; classical transmitters and neuropeptides are stored in the vesicles of the varicosities and released from there.

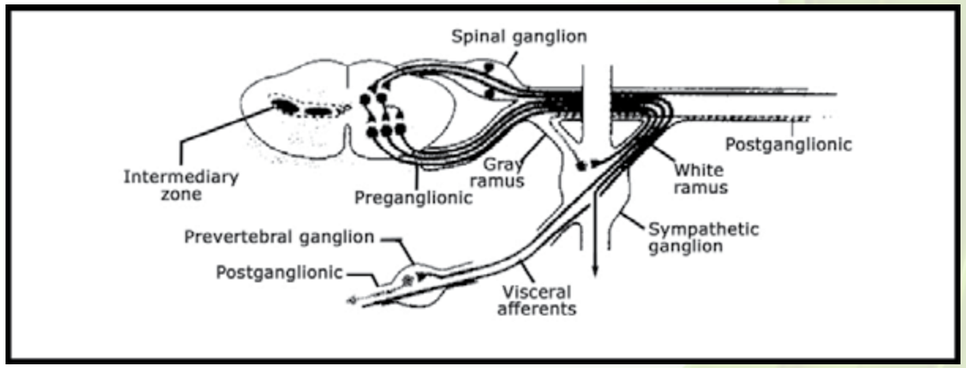
Co-localization of ACh and VIP (vasoactive intestinal peptide) in a postganglionic axon of the salivary gland (modified after lundberg, 1981. From Birbaumer and Schmidt, 1996)



The release of ACh primarly activates the secretion of saliva and to a lesser extent causes vasodilation, whreas in the case of VIP vasodilation predominates.

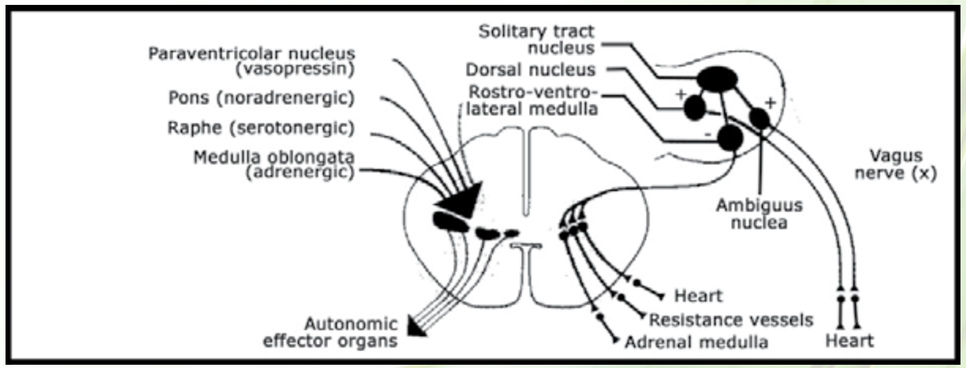
Spinal and supraspinal organization of the ANS

Arrangement of the spinal autonomic reflex arc (from Janig, 1995)



The synaptic linkage between afferents and the ANS at the segmental level in the spinal cord is called the spinal autonomic reflex arc; it comprises at least three synapses, two in the spinal gray matter and one in the aut tnic ganglion; there are feedback connections between the receptors of an eff or and the effector-specific parts of the ANS, e.g. cardiocardiac and intestinointestinal reflex arcs; somatic afferents can also be the afferent elements for spinal autonomic reflexes (e.g. cutaneovisceral reflex arcs; can be exploited therapeutically, e.g. to improve blood flow through the intestine by applying heat to the skin); conversely, visceral afferents may be connected to motoneurons (viscerosomatic reflex arcs; are responsible, e.g. for increased muscle tone and tenderness associated with intestinal disorders)

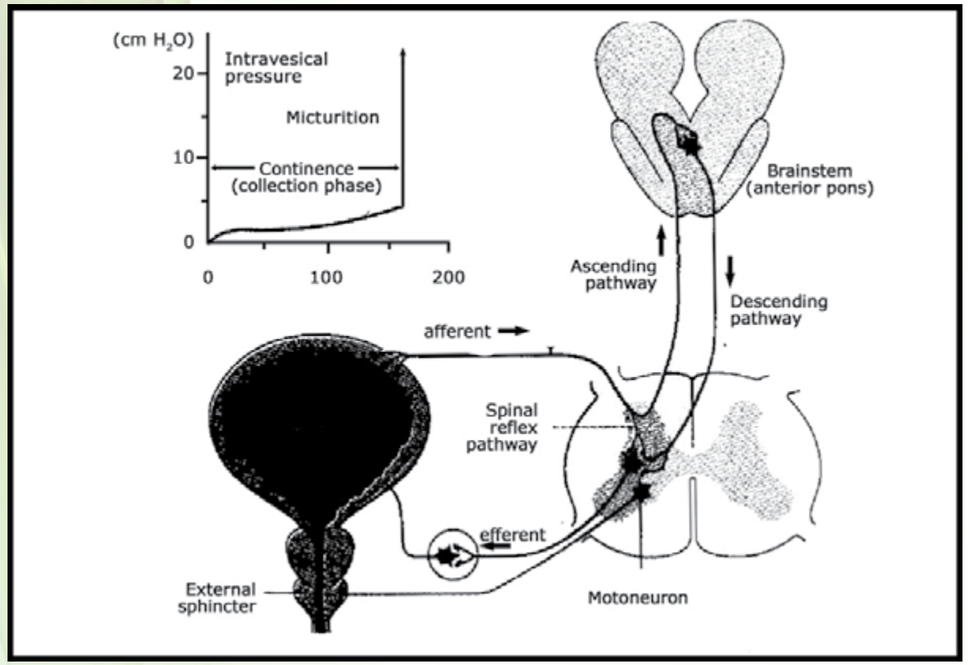
Control of the spinal ANS by brainstem and hypothalamus



Large parts of the brainstem (medulla oblongata, pons, mesencephalon) and of the hypothalamus participate in the control of autonomic effector organs; the descending pathways that mediate this control and their transmitters are indicated on the left; the right half of the picture shows an example, the structures involved in control of systemic arterial blood pressure (circulatory centers)

and their connections; here the sympathetic and parasympathetic elements have functionally synergistic effects (though the individual actions are antagonistic).

Reflex arcs and mechanisms of urinary continence and micturition with pressure-volume diagram (cystometrogram) of the human urinary bladder; example of central nervous regulation by the ANS:



Innervation of the urinary bladder:

- Parasympathetic: by way of the pelvic splanchnic nerve with fibers from the 2nd to 4th sacral segments, has excitatory action on the smooth musculature of the bladder wall; perquisite for normal bladder evacuation.
- Sympathetic: Comes from the upper lumbar cord by way of the inferior mesenteric ganglion (not shown); inhibits bladder wall musculature; hence may contribute to continence
- Afferent: Stretch receptors in the bladder wall, also nociceptors; afferents run in pelvic splanchnic nerve; are increasingly excited as bladder fills; activate the bladder evacuation reflex
- Somatomotor: Motor axons of sacral motoneurons, running in the pudendal nerve, supply: the external sphincter muscle, i.e. this muscle is under voluntary control.

Continence: Denotes the ability of the bladder to store urine (collecting phase); fills at a rate of ca. 50ml/h; the urge to urinate begins to be felt when bladder contains ca. 250 ml; can fade away until this rises to ca. 500 ml or be voluntarily suppressed.

Micturision: notes the active evacuation phase, preceded by the urge to urinate from increased

pressure in the bladder; once initiated, evacuation of the bladder is completed by way of the pontine reflex pathway; the spinal pathway is normally of no physiological importance (this is not the case, e. g. in paraplegia); voluntary control of micturition is mediated by suprapontine, including cortical structures.

The role of the hypothalamus with respect to the ANS is to organize higher-order autonomic regulation as well as neuroendocrine regulation and elementary behavior patterns; the functional impairments resulting from damage to the hypothalamus in man are correspondingly diverse (modified after Reichlin et. at. 1978):

	Anterior hypothalamus, preoptic area	**Intermediate hypothalamus (tuberal, ventromedial)**	**Posterior hypothalamus**
Integrative functions	Sleeping, waking rhythm, thermoregulation, endocrine regulation, integration of autonomic and nervous system	Perception, thermal balance, fluid balance. endocrine regulation	Perception, consciousness, thermoregulation, complex endocrine and autonomic regulation
Acute lesions	Insomnia, hyperthermia, diabetes insipidus, ADH secretion disorder	Hyperthermia, diabetes insipidus, endocrine disorders	Excessive sleepiness, emotional disturbances, autonomic disturbances, poikilotherm
Chronic lesions	Insomnia, complex endocrine disorders (e.g. precocious puberty), endocrine disorders resulting from damage to median eminence, hypothermia, no feeling of thirst	Medial: Memory impairments, emotional disturbances, hyperphagia and adiposity, endocrine disorders Lateral: Emotional disturbances, emaciation and loss of appetite, no feeling of thirst	Loss of memory, emotional disturbances, excessive sleepiness, poikilothermy, autonomic disorders, complex endocrine disorders (e.g. precocious puberty)

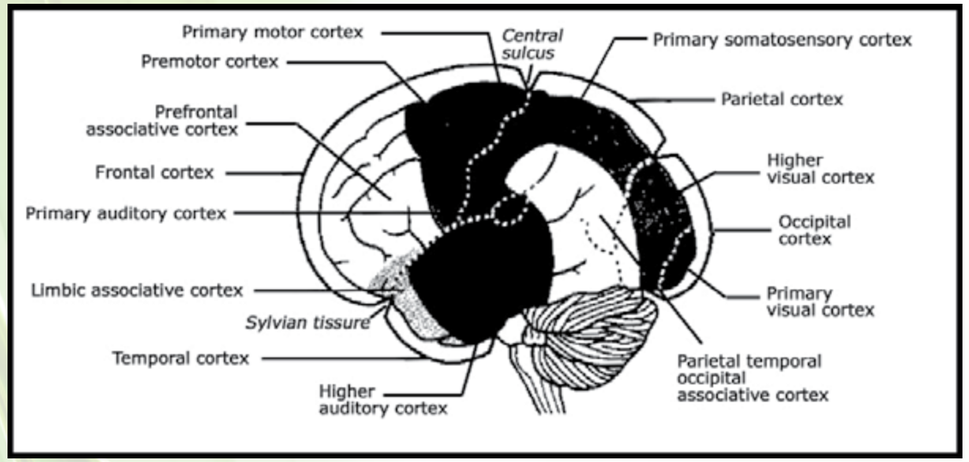
Definition and localization of integrative functions

For lack of a better term, all functions of the CNS are considered 'integrative' if they are not directly involved in sensory, motor or autonomic activity. There are seven such functions:

1. circadian periodicity including the sleep—wake cycle,
2. consciousness
3. language
4. thinking (understanding, reason)
5. memory including learning
6. motivation (drives)
7. emotion.

A crucial structure for (6) and (7) is the limbic system and for (1)--(5) the cerebral cortex (neocortex or isocortex, usually called simply cortex). Certain cortical areas play special roles, often in only one half of the cerebellum (hemispheric specialization); examples; motor and sensory speech centers (Broca's and Wernicke's areas).

The four lobes of the cerebral cortex (frontal, temporal, parietal and occipital)



The three large association areas of the human cortex have been found to have the following integrative functions:

Association cortex	**Integrative function**
Parietal, temporal, occipital lobe	Sensory elements of language, higher sensory activities such as linking auditory to visual information

Association cortex	Integrative function
Frontal lobe	Higher motor activities such as movement strategies, learned control of innate behavior patterns
Association areas of the parietal- temporal-occipital complex	Motivation, emotional-affective aspects of behavior

General physiology of the cerebral cortex

The figure on the next page shows that the cortex is composed of six layers and contains two main types of neurons: pyramidal cells and stellate cells

The pyramidal cells are so called because the pyramidal shape of the cell body (A), their axons run to other cortical (B) or subcortical (C, D) structures; hence they are cortical efferents. The stellate cells are also named after their shape (A). Their axons terminate within the cortex, i. e. they are cortical interneurons. There are many special forms of stellate cells: candelabra cells, basket cells (inhibitory), etc. (E).

Differences in the cytoarchitecture (density, arrangement, shape of neurons) of the 6 cortical layers can be represented in brain maps (e.g. in the Brodmann map there are ca. 50 areas)

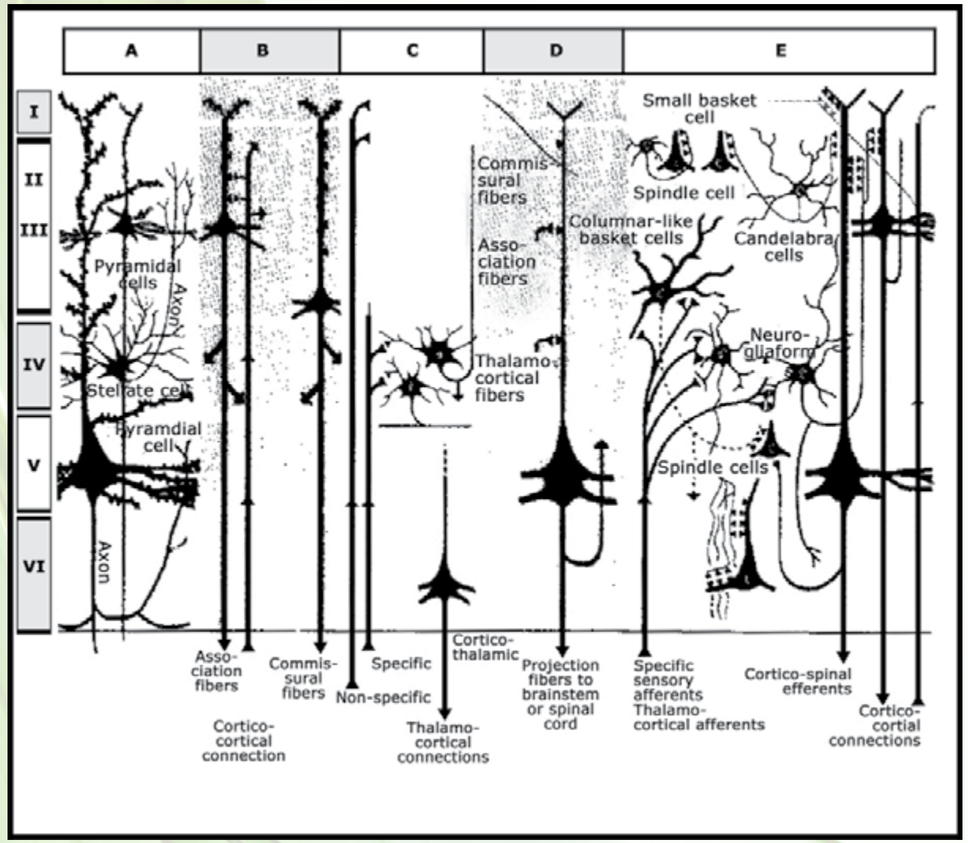
These histologically defined cortical fields often coincide amazingly closely with the areas to which particular functions are ascribed on the basis of physiological studies, e. g. the precentral gyrus includes Brodmann area 4, which is the primary motor cortex, and area 6, which includes the SMA and PMC; area 17 is the primary visual cortex, etc. The brain map of Brodmann, first published in 1909, is therefore still in use for orientation to the cerebral cortex.

Layers I—VI (counting from the cortical surface inward) are associated with particular aspects of information processing in the cortex

Layer	Function/Comments
The Molecular Layer I	Contains apical dendrites of the pyramidal cells and tangentially oriented stellate cell axons, which provide local connections between cortical neurons in the immediate vicinity
The External Granular Layer II, III	Contain small pyramidal cells, the axons of which run to other cortical areas (if these are ipsilateral, the axons are association fibers; if contralateral, commissural fibers) and which receive axons from those areas; subserve intercortical information
The Internal Granular Layer IV	Contains stellate cells, the destinations of specific thalamic afferents; subserves thalamocortical information reception

Layer	Function/Comments
The Internal Pyramidal Layer V	Contains large pyramidal cells (especially large ones called giant cells of Betz, found in the primary motor cortex). The axons run as projection fibers to subcortical structures, e.g. basal ganglia, brainstem, spinal cord (from motor cortex: corticospinal [pyramidal] tract); subserves information transfer to subcortical region
The Multiform layer VI	Contains small modified pyramidal cells, the axons of which run to the thalamus as projection fibers: subserves corticothalamic information transmission

The information processing in the cortex occurs essentially perpendicular to the cortical surface (see neuronal inputs and outputs in B-D and their linkage in E). This finding has led to the view that the cortex is organized both histologically and functionally into units perpendicular to the surface, the cortical columns.



Simplified schematic representation of the cortical neurons, their circuitry and their afferent and efferent connections, on the background of the layered structure of the cerebral cortex:

- A Position and appearance of the two main types of cortical neurons
- B Input/output relations of corticocortical connections
- C Thalamicocortical and corticothalamic connections
- D Synaptic input zones of a pyramidal cell
- E Summary of the interconnections of cortical neurons
- B-D drawn from the results of studies by many authors

Where all six layers are present the cortex is called homotypical; where some layers are not clearly evident it is heterotypical. Heterotypical cortex is called agranular if the small-celled layers II and IV are absent, or granular if II and IV predominate at the expense of the pyramidal cell layers III and IV.

The biophysical properties of cortical neurons resemble those of other (e.g. spinal) neurons

Parameter	Definition/Comments
Amperage	-50 to -80mV, as yet recorded intracellularly mostly in pyramidal cells (also applies to other values in this table)
Voltage	Amplitude 60–100 mV, duration 0.5–2 ms. generated at axon hillock; no marked afterpotentials, hence AP frequencies up to 100 Hz possible (e.g. in epileptic attacks); secondary generation sites in the dendritic trees, where the APs provide active propagation of EPSPs to axon hillock (amplifier function)
Resistance	In all cases longer than spinal PSPs: EPSPs 10–30ms. IPSPs 70-150ms. The discharge rate of EPSP-evoked APs is low in healthy cortex, usually <10 Hz

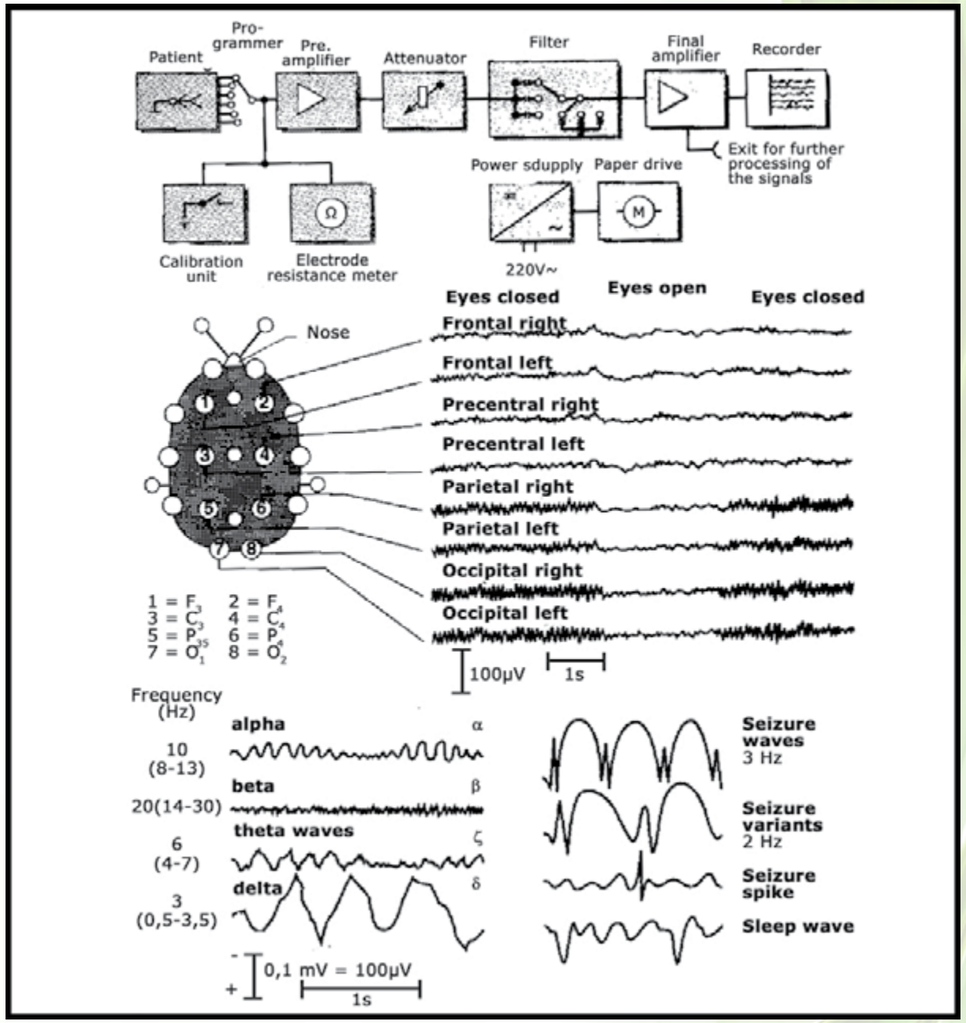
When the activity of the cortical neurons is recorded exracellularly, with uni- or bipolar electrodes directly on the cortical surface (animal experiment, neurosurgery), the responding is called a electrocorticogram (ECoG); when recorded from the scalp (clinical routine), an electroencephalogram (EEG). Both procedures basically reflect the postsynaptic activity (EPSPs, IPSPs) of cortical neurons; for phenomenology see EEG.

Electroencephalogram (EEG): event-related potentials (ERPs)

Forms of EEG, diagnostic significance

Waves	Definition/Comments - Physiological waveforms
Alpha	8-13 Hz, average 10 Hz; basic EEG rhythm at rest, especially with eyes closed, clearest occipitally: synchronized EEG. Rhythmic activity originates in thalamic pacemaker cells: rhythm modified particularly by the reticular formation, e.g. rapid desynchronized EEG while awake (see below) and slow, synchronized EEG during sleep (q.v)
Beta	14–30 Hz, average 20 Hz; rhythm appears when eyes are opened and other sensory stimuli occur, also during emotional excitement (a blockade): EEG becomes desynchronized because frequency is increased, so that its amplitude is reduced
Theta	4–7 Hz, average 6 Hz; in healthy adults appears during sleep (q.v.): in children and adolescents such waves also appear normally
Delta	0.5–3.5 Hz, average 3 Hz; in healthy people only observable during deep sleep (q.v)
	Pathophysiological waveforms
Epileptic spike	Low frequency (2–3 Hz), often with characteristic sequence of pointed and slow waves (spike-and-wave complex); EEG remains the most important method for diagnosis and follow-up of the condition
Blank Trail	Generalized extinction of the EEG, also called isoelectric EEG; is used together with other parameters as criterion for death (`brain death'): often preceded by coma state with very slow, irregular waves

Normal and pathological forms of EEG (modified from Schmidt, I990b, after recordings from R. Jung)



Magnetencephalography (MEG); cortical DC potentials

Movement of electrical charge (here: synaptic currents) produces both electrical field changes (recordable as EEG) and magnetic field changes. The latter can be recorded as a magnetencephalogram (MEG); this is an extremely elaborate procedure, because magnetic fields are very small; not practicable for routine use; advantage: better spatial resolution than EEG. Also not routinely applied, for technical reasons: recording of cortical DC potentials (steady potentials);

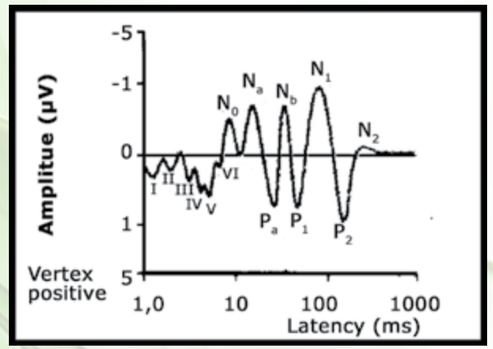
the cortex surface is normally several mV negative with respect to underlying white matter or distant reference electrode; fluctuates when attention shifts and under pathophysiological conditions.

Association between activation and EEG frequency (after Birbaumer and Schmidt, 1991)

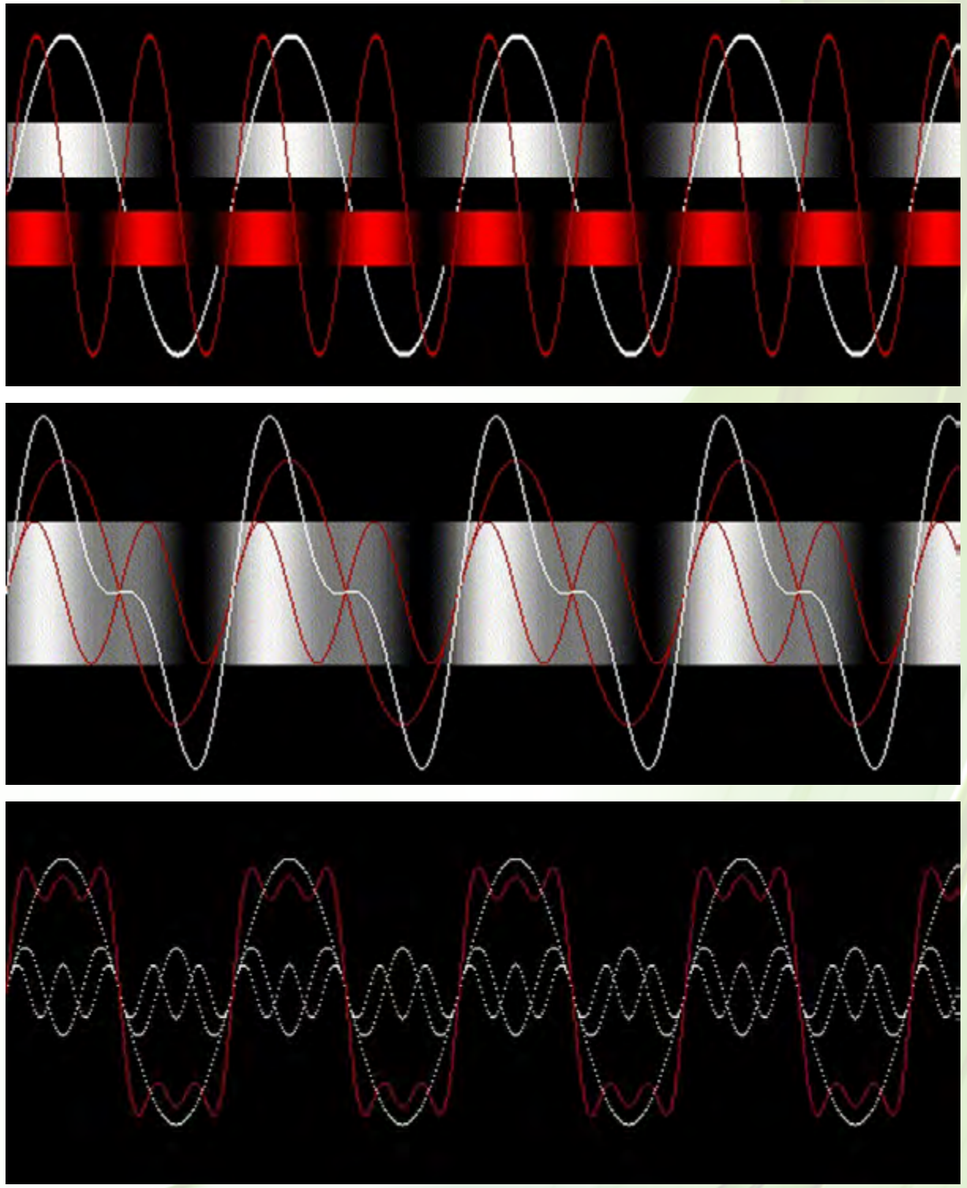
EEG frequency	Behavioral efficiency
Desynchronized, low amplitude	Poor; loss of control, disorganized; startle reflex
Mixture of high frequencies	Good; effective; selective, rapid reactions
Synchronization, distinct a rhythm	Good for automatic reactions (in part for creative thinking)
α, β	Poor, uncoordinated
Θ, sleep spindles, K complexes δ, large slow waves	Reactions only to very strong stimuli or those corresponding to particular expectation
Large slow waves, also partially isoelectric	
Progressive disappearance of electrical activity; finally completely isoelectric	

Event-related potentials (ERPs) appear in the EEG in association with psychological, motor and sensory events. A special form, evoked potentials EPs) are elicited by sensory stimulation

Definition/Comments
Somatic evoked potential; appears after stimulation of peripheral somatic nerves or receptors; first positive component, called primary evoked potential, is found only in the topographically associated area of the postcentral gyrus; later, slower secondary evoked potential appears in more extensive cortical regions
Visual evoked potential; just as complex, highly dependent on nature of stimulus (light flashes, checkerboard pattern, color, etc.): equally important in diagnosis and research



Auditory evoked potential; complex series of waves that reflect the arrival and synaptic transmission of the afferent burst at the different stations of the auditory pathway; peaks I–VI are called far-field potentials; the N and P peaks originate in thalamus and cortex; AEP is an important diagnostic aid, e.g. where there is a question of hearing loss in infants who cannot yet speak.



Imaging methods to reveal the activity, metabolism and circulatory status of the brain

Description/Comments
Measurement of regional cerebral blood flow with radioactive xenon-133; up to 300 detectors distributed over a cortical hemisphere measure gamma radiation, which is higher the more blood is flowing through the cortical area below the detector. The amount of blood flow is directly related to the local energy consumption, and this in turn to the neuronal activity level. The resulting blood flow maps therefore reflect activity of the cortical neurons
X-ray computer tomography (CAT scan. computerized axial tomography). Computer-assisted X-ray examination of the brain with a fine beam rotated around the head. Provides high-contrast images of a planar section with a resolution of 0.5-1 mm for a layer 2-13 mm thick. Radiation exposure no greater than in normal X-ray procedure
Positron emission tomography; measures release of positrons (or .y-rays, produced when positrons collide with electrons) from radioisotopes that had been incorporated into biologically important molecules (e.g. glucose) and then injected; hence measures the distribution of these isotope-bearing molecules in the brain, which depends on momentary activity (metabolism, in the case of glucose); spatial resolution 4-H mm, temporal 1 s. Because the isotopes required have short half-lives, the procedure is possible only near a cyclotron: expensive
Magnetic resonance imaging; externally imposed magnetic fields induce resonance of hydrogen atoms (proton) and hence emission of radiation, which is measured and analyzed with computer assistance. The resulting images of brain sections have a layer thickness of 5-I0 mm: spatial resolution 1 mm, temporal 10-20s. These figures are improving with the use of high field strength magnets

Circadian periodicity

Introduction

- Humans (like practically all organisms) have at least two (possibly more) endogenous oscillators (internal clocks), innate rhythm generators that adjust nearly all organ functions to the 24h day/night rhythm
- The periods of the oscillators is approximately (circa) that of a 24 h day (Latin dies), hence circadian periodicity. Precise synchronization to 24 h is achieved by external (entraining signals), especially social factors and the alternation of night and day. Examples of 24 h fluctuations are found in the body temperature (minimum in the morning, maximum in the evening) and the waking/sleeping rhythm.
- Although certainly innate, in humans a circadian rhythm does not develop until15 weeks after birth; after the ‘chaotic’ early weeks with short, irregular sleeping and waking periods, free-running sleep phases develop which later, from the 20th week can be synchronized with the ‘parents’ rhythm.

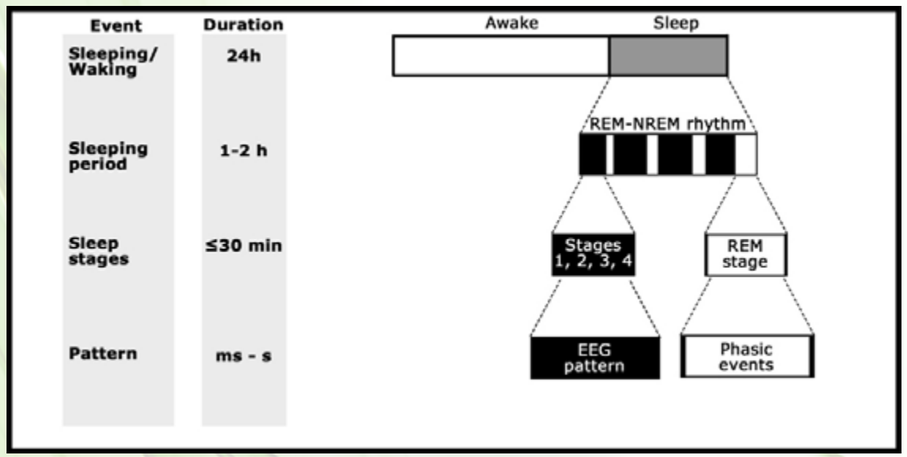
Important properties of the human circadian rhythm

Definition/Comments
The advantage of a somewhat flexible 24 h periodicity is that it can be adjusted to an altered Zeitgeber (e.g. outdoor temperature) within certain limits, the entrainment range (e.g. the entrainment range for body temperature is 23–27 h, for motor activity 20–32 h)
When all Zeitgebers are eliminated (e.g. seclusion from the outside world in a bunker or cave), the circadian periodicity runs with its own rhythm, usually >24 li in humans; the internal clocks mostly remain synchronized with one another, hut can also become spontaneously uncoupled (e.g. temperature period remains 25 h, sleeping/waking rhythm shifts to 33h)
This is the German word for environmental factors that synchronize the internal clocks with an exactly 24 h diurnal cycle; in humans these are mainly social factors (knowing the time of day, other people's activities) the light/dark cycle. A single shift in the Zeitgeber (as in flying east or west) causes a transient disturbance (jet lag): about 24h of adaptation are necessary per time zone. Night- and shiftwork involve a permanent conflict between personal and ambient Zeitgeber
Internal clocks are located in the ventral hypothalamus, especially the suprachiasmatic nuc us (SCN) and the ventromedial nucleus (VMN), and perhaps also other sites as yet unknown

In addition to the circadian rhythm there are many others, with periods distinctly shorter or longer than 24 h; ultradian (e. g. respiration, heartbeat, EEG) and infradiant, respectively. Chief among the infradiant rhythms (e. g. animal hibernation, bird migration) in humans is the female menstrual cycle.

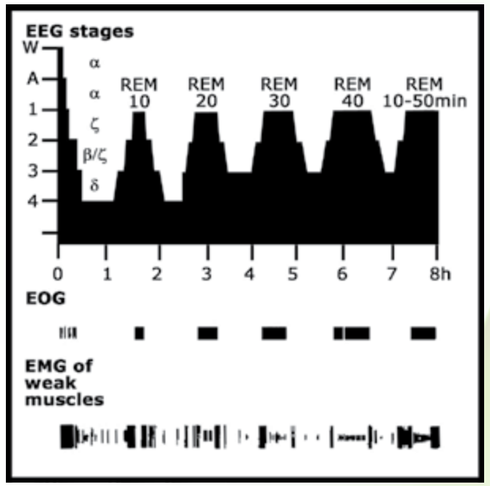
Sleep and dreaming

Four temporal levels for the description of normal and pathological sleep phenomena.



The highest temporal integration level is the circadian sleeping-waking rhythm; the next integration level comprises the sleep cycles with their NREM-REM rhythm; then follow the levels of sleep stages and finally of EEG patterns and phasic events.

Time courses of sleep cycles in humans in the course of the night

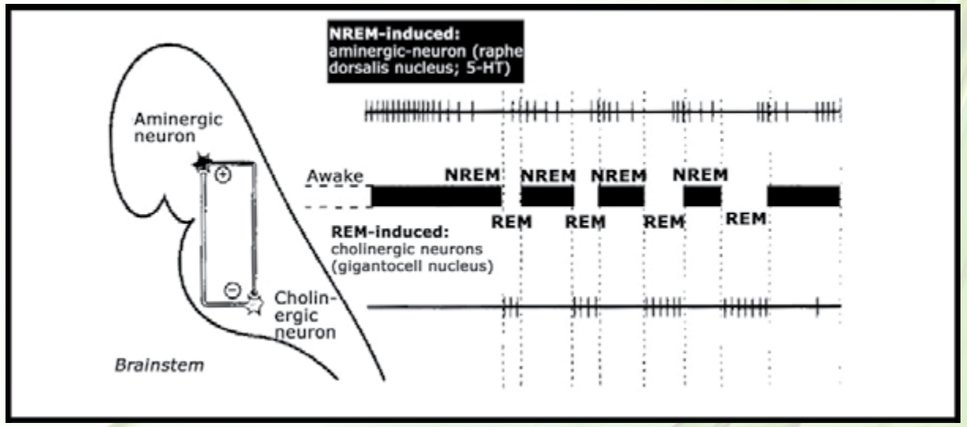


The basic structure of sleep is an ultradian rhythm of sleep cycles, each consisting of four NREM stages and one REM stage; average cycle duration 100 min, 3-5 cycles per night.

The five sleep stages are distinguished from one another by the EEG. In each cycle the depth of sleep first increases (NREM stages 1-4) and then decreases.

Each cycle ends with a fifth stage in which there are rapid eye movements (REM stage, recorded by electro-oculogram, EGG); dreams are most likely to occur during the REM stages.

According to the reciprocal interaction model of ultradian sleep periods, aminergic neurons in the brainstem are responsible for NREM sleep and cholinergic neurons for REM sleeps.



It is not completely clear how the transition from waking to sleep and back to occurs. Various theories (deafferentation theory, reticular theory, serotonergic theory) are under discussion. As the figure shows, the NREM-REM rhythm is apparently generated by regions of the brainstem; here, again, there is no completely satisfactory interpretation of the many findings.

Endogenous sleep factors are substances that initiate or maintain sleep: factor S is a glucopeptide, the concentration of which in the cerebrospinal fluid rises during and the injection of which induces NREM sleep. DSIP (delta sleep inducing peptide) is a nonapeptide that elicits deep sleep (SS 4)

Characterization of the individual sleep stages

EEG Pattern/Comments
Relaxed waking with predominant a rhythm; transition to sleep is sometimes additionally designated stage A
Absence of a waves, low rapid]3 activity and low 8 activity; stage of falling asleep and lightest sleep
Low rapid activity with P spindles (inhibition of sensorimotor areas), later K complexes (internal discharge of sensory systems); light sleep; more than 50% of sleep is spent in this stage
δ waves for 10—50% of the time; intermediate sleep. The sleep cycles in the morning often no longer reach this stage and the stage of deep sleep (SS 4); then sleep passes directly from SS 2 to the REM stage
δ waves (>1001V, <3 Hz) over 50% of the time; deep sleep; together with SS 3: synchronized deep or SW sleep (slow-wave sleep); musculature atonic, high awakening threshold
Low-amplitude EEG with low 9 waves: otherwise the EEG resembles that for the attentive waking state (no a waves), hence the name desynchronized sleep; accompanied by REM bur is (see Fig.). remaining musculature practically atonic, awakening threshold very high. Because of similarity to the waking EEG is called paradoxical sleep (NREM = orthodox). REM duration in first cycles 5—10 min, later longer, in final cycle as long as 22 min (followed by awakening)

Dreams usually occur during REM sleep, but the brain is mentally active even In NREM sleep; key concepts:

- in 80-90% of awakening from REM sleep, dreams are reported: the content is substantial, with pictures, odors, tones
- in ca. 70% of awakening from NREM sleep, dreams are reported: however, the content is more ‘thought like’ (cognitive) that of REM dreams
- the REM dreams of the first half of the night are more reality-related and refer to experiences of the precedent day, whereas morning dreams are progressively more bizarre and emotionally intense
- people remember a dream only if they are awakened within 5 minutes after a REM period or if it is the last dream before awakening; therefore morning dreams are especially well remembered, which is why the dream life seems so unreal to us

- the psychological significance of dreams is still unclear; selective ‘dream deprivation’ (at the beginning of every REM phase) merely leads mentally to increased and psychologically to prolonged REM periods during the recovery nights

Sleep disturbances that do not result from organic, in particular neurological, diseases are called primary; some common disturbances are summarized:

Definition/Comments
Insomnia (difficulty going to sleep and staying asleep)
Subjective difficulties in falling and staying asleep are reported, but the sleep profile is normal for the person's age; usually the disturbance is psychological, e.g. partnership and sexual problems
Subjectively experienced and objectively verifiable abnormal sleep profile; many causes. e.g. too much or too little physical activity, chronic stress, traveling, extreme dieting
Hypersomnia
Increased tiredness by day with Frequent sleep attacks lasting a few seconds to 30 min; can be interpreted as 'invasion' of REM episodes into the waking state; the attacks are associated with muscular relaxation and loss of tone (sometimes collapse) (cataplexy). There may also be sleep paralysis (loss of muscle tone while sleeping) and hypnagogic hallucinations at sleep onset
Disturbances associated with sleep stages
Sleepwalking; motor automatism at the transition from SS 4 to SS 2: seen especially in children and adolescents, also adults under stress. Eyes are wide open. the person does not respond when spoken to and is disoriented after waking up, does not remember dreams
Bed-wetting occurs in about 5% of all children after the second year of life; almost always occurs in NREM sleep. Alter waking up the child is disoriented, confused and cannot report anything about dreams
Occurs mainly between the third and eighth year of life: child sits up and begins to scream; stares with eyes wide open: lace pale and covered with sweat; breathing is difficult; similar to nightmares in adults

Consciousness, language, cerebral asymmetry

Consciousness can be (1) experienced introspectively (self-consciousness) and (2) observed in the behavior of others; key concepts:

- There are various forms of consciousness; therefore a unitary definition of consciousness is impossible
- A psychological characteristic common to all forms of consciousness is an extensive subcortical and cortical increase in excitation (ARAS concept, see below).

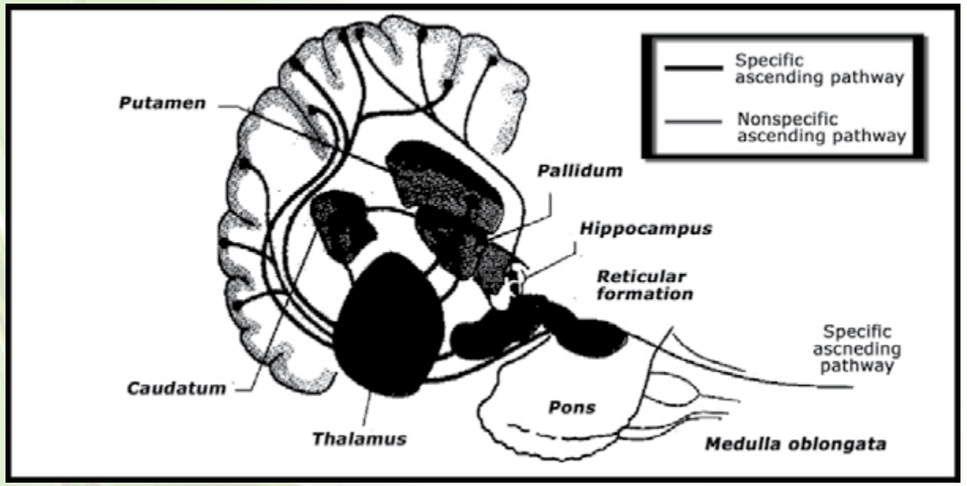
- Common psychological characteristic: transition from unconscious 'automatic' to attentive, ‘controlled’ information processing
- The production of consciousness is a property of short-term memory; processes in long term memory are not consciously apprehended until transferred to short term memory
- Consciousness requires, among other things, activation of the cerebral cortex by the reticular formation (RF); the tracts ascending from the RF are therefore called the ascending reticular activating system, ARAS

Disturbances of consciousness can be ascribed to three mechanisms, according to the ARAS concept:

1. Reversible inhibition or irreversible damage to the RF, as a result of which the central driving force for the cerebral cortex is eliminated
2. Damage to the ARAS above, the RF, with preservation of the functional and structural integrity of the RF itself
3. Destruction or functional inhibition of the cerebral cortex

The ARAS concept goes back to observations of sleeping cats, in which high-frequency electrical stimulation of the RF triggered as immediate awakening reaction (arousal), whereas lesions of the RF caused coma-like permanent sleep.

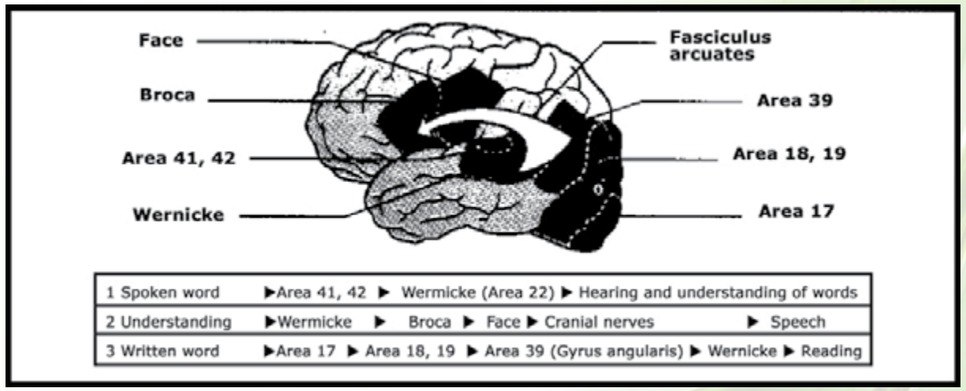
Conscious perceptions require simultaneous excitation of the cortical fields (1) of the ARAS, originating in the RF and (2) through the specific sensory pathways.



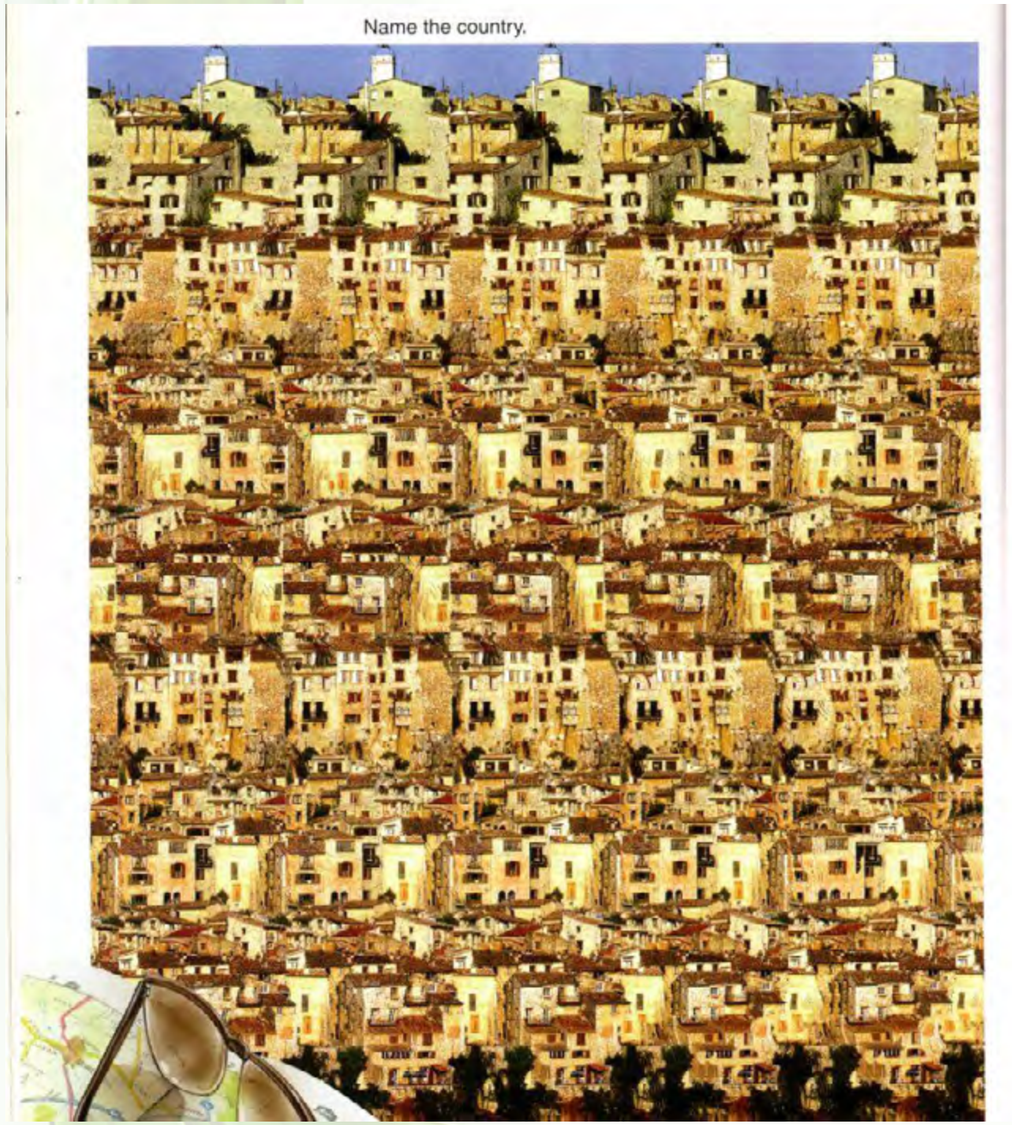
For both production and understanding of speech, several information-processing events in the left hemisphere must take place in sequence (serial) and simultaneously (parallel); the main speech disturbances due to damage of the participating brain structures are:

Definition/Description/Comments
Motor (expressive) failure of speech in lesions of the left inferior frontal gyrus (Broca's area); patient speaks very little, only 'key words' (telegraphic style) and only with great effort; articulation and prosody (speech melody) are poor; good understanding of speech
Sensory (receptive) failure of speech in lesions of the temporal lobe (Wernicke's area): patient speaks fluently with many phonematic (sound-related, e.g. spilling instead of spinning) and semantic (e.g. mother instead of wife) paraphasias, also neolo¬gisms; severely disturbed understanding of speech
Interruption of the arcuate fasciculus, which connects Wernicke's and Broca's areas; verbal communication is possible, but the pa¬tient cannot repeat words spoken to him
Severe disturbance of both expressive and receptive language ability with simultaneous lesion of Wernicke's and Broca's areas
Also called amnesic or semantic; impaired word-finding ability, though speech is fluent and understanding preserved; usually le¬sions in temporal–parietal cortex
Initial mutism (dumbness) followed by paraphasias that disap¬pear when repeating spoken words; slight speech production, good understanding of speech, usually rapid recovery
Disturbances of reading, writing and calculating, respectively, that accompany aphasias and can occasionally be the dominant symptoms

A classification of the brain areas involved in language is derived from Geschwind's model; it is based chiefly on evaluation of speech impairments due to brain lesions



Plasticity, learning, memory



Learning and retaining behavioral changes in humans and animals

Learning process	Definition/Comments
Non-associative learning. The non-associative processes behavior changes are a consequence of repetition stimulus situation, not as a result of close temporal association of stimuli and responses	
Habituation	If the internal comparison of an actual stimulus with the 'expected' model of the stimulus reveals a discrepancy, an orienting reaction (OR) (redirected attention, arousal, etc.) results: its intensity is proportional to the mismatch between stimulus and model; habituation is a reduction of the OR when the stimulus
Sensitization	The mirror image of habituation, i.e. an increase of a physiological response or a behavior due to especially intense, in particular noxious, stimulation (high negative significance)

Associative learning

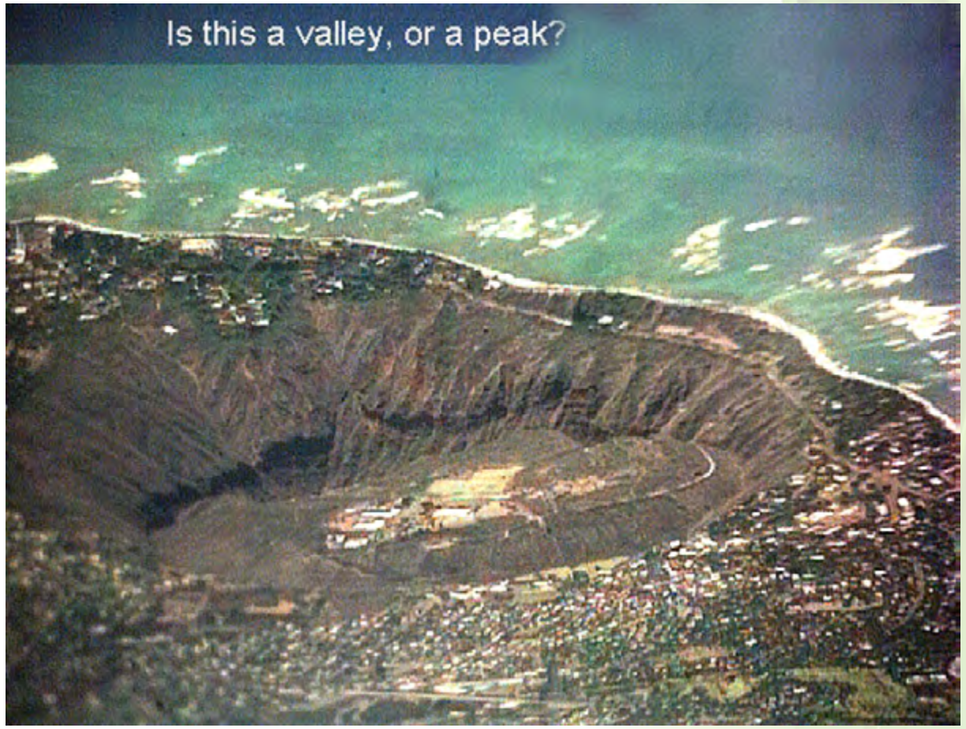
Learning by conditioning is so called because the central nervous process consists in an establishing an association between stimuli (S) and responses (R). The result is a change in behavior (memory)

Classical conditioning	Acquisition of conditioned reflexes by Pavlov's method: prior to an unconditioned stimulus (US, e.g. food presentation), which elicits an unconditioned reflex (UR, here salivation)- a conditioned stimulus (CS. e.g. a hell) is given repeatedly: eventually presentation of CS alone elicits the reflex response (conditioned reflex, CR). Hence CS → US → UR becomes CS → CR. For optimal learning the time interval between C'S and US must be <1s
Operant conditioning	If a desired behavior is (accidentally) exhibited (e.g. bar-press in a Skinner box) and is rewarded within 1s (e.g. with food), the reward increases the probability that the behavior will he performed again. The behavior itself acts (is operant) to produce rewarding stimulus: in other words, the behavior is the instrument for obtaining the stimulus (reward): instrumental learning
Imprinting	Special form of associative learning, namely learning of social bonds by a specific stimulus pattern during a temporally limited development period: is manifest in staying close to the 'imprinted' object (mother animal) and in defensive or escape behavior with respect to strange objects; common in birds (geese of Konrad Lorenz), rare in mammals

In humans the acquisition of knowledge (simplest experiment: learning a sequence of nonsense syllables) is called cognitive learning and ascribed to a cognitive memory

In cognitive learning a distinction is made between:

- short-term memory (STM), or primary memory (often called working memory) and
- long-term memory (LTM), or secondary memory
- the transfer of information from STM to LTM is called consolidation; is made easier by practice
- a memory trace stored in the LTM is called an engram



The following Tables employ these concepts and supplement them with a

- sensory memory, which precedes the STM and a
- tertiary memory for especially well-consolidated material

The subdivisions of cognitive memory

Memory	Comments
Sensory memory	In auditory context called echoic, in visual iconic; serves to increase attentiveness and for feature extraction; encoding for transmission to primary memory is chiefly verbal; forgetting due to passive extinction or active overwriting (erasure) with new information
Short-term memory	(STM) Small capacity but can be increased by organizing the information in chunks (superordinate groups, e.g. letters into words); transmission to secondary memory practice (memorizing)

Memory	Comments
Long-term memory	(LTM) Large, long-term storage system. Procedural LTM: the learned knowledge itself (e.g. playing a piano from a score). Declarative LTM: knowing that one is able to play from a score and when and how the ability (or knowledge) was acquired. Forgetting due to disruption of the material to be learned by material learned previously (proactive inhibition) or subsequently (retroactive inhibition)
Tertiary memory	Independent part of the LTM, in which practically unforgettable knowledge is stored, e. g. one's own name and other personal data, the ability to read and write; in contrast to secondary memory, very rapid access to stored material

Neurophychological disturbances of consolidation: amnesias

Term	Definition/Comments
Fuge	New material cannot be learned, retained and retrieved; primary memory (STM) is usually intact, but transfer to secondary memory (LTM), i. e. the consolidation process, is defective; secondary and tertiary memory normal for the time before onset of the disease; bilateral damage to the hippocampus seems to be the main cause of the lack of consolidation
Injury Specific Amnesia	Loss of ability to remember the time before impairment of brain function, e.g. by concussion, stroke, electroshock; content of primary memory is extinguished, that of secondary memory is lost further into the past, the more severe the brain damage was; the forgotten time period can shrink during the recovery phase, so apparently access is disturbed more than content; tertiary memory remains intact the pathophysiological mechanism of retrograde amnesia is unknown
Total Amnesia	Very rare complete loss of memory, including tertiary memory (one's own name, etc.); exclusively functional, mental disturbances; key stimuli (previous surroundings, family members, friends) have no effect, good STM and LTM for new information

Term	Definition/Comments
Confabulation	Memory defect in alcoholics, with anterograde and retrograde amnesia; loss of memory is concealed with invented stories; confabulation; no realization of illness, apathy

Neuronal and neurochemical mechanisms of the engrams (memory contents) In the various forms of memory

Memory	Mechanism/Comments
Long term	Engram largely laid down as synaptic depression or facilita¬tion (tetanic or post-tetanic depression or potentiation). Short-term: reduced or enhanced presynaptic transmitter release. Long-term: structural changes, e.g. increase in size and number of presynaptic active zones
Short term	Mixture of the above-mentioned synaptic processes; tempo¬rary storage by circulating excitation in a 'reverberatory circuit', as a dynamic engram, and eventually cellular consoli¬dation to a structural engram; details largely unknown
Mid term	InSTM,adynamicengramintheformofreverberating exci¬tation, which in the consolidation phase is transferred into a, structural engram in the LTM; so far known to involve synaptic potentiation (see above), increase in number of dendritic processes (spines; raises synaptic efficiency), in-creased protein synthesis (pharmacological inhibition of pro¬tein synthesis during critical consolidation phase inhibits formation of LTM engram)

Contrary to all claims, direct and specific pharmacological improvement of intelligence and of the learning and memory functions is impossible; proposed but ineffective include glutamic acid (glutamate), cholinergic anticholinergic substances, strychnine, picrotoxin, tetrazole, caffeine, ribonucleic acid etc.

Basic concepts related to motivation

Definition of the term `motivation'

The term 'motivation' refers to factors affecting the frequency and intensity of a behavior that on states within the organism, i.e. the behavior observed does not depend exclusively on stimulus, site of stimulation, or genetic predisposition.

Examples of variable states within the organism include departures from homeostatic equilibria (e.g. lowered blood glucose level, water deficiency) or fluctuating hormone concentrations (e.g. sexual hormone).

Motivated behavior takes the form of drives, distinct behavioral patterns (e.g. foraging and feeding, sexual behavior); the analysis of drives has led to the following concepts:

Term	Definition/Description/Comments
Physiologic Instinctual Drives	Drives, the intensity of which depend mainly on the degree of deviation of a homeostatic parameter within the body (e.g. blood glucose concentration) from a stable reference point; deviation r upward or downward initiates a sequence of behaviors that are performed until the reference point is regained
Learned	Drives with no clear internal reference point, which depend strongly on environmental conditions (availability, incentive) and on what the individual has learned in the past (e.g. sexuality, exploratory drive, bonding need, emotion)
Priority	The mechanisms that determine which drive behavior is performed at any given time: the drive hierarchy is the end result competition among drives of different intensity (see below)
Addiction Satisfaction	In homeostatic drives, intensity depends on the degree of deviation from the reference point (see above), which in turn depends chiefly on the time since the last restoration of equilibrium, i.e. the deprivation time
Shaping	Increase in intensity of a drive by stimuli that raise the probability of occurrence of the preceding behavior, i.e. by instrumental, learning ; a typical reinforcing stimulus is the taste of good food during eating
Stimulus Response	Technical term for the (learned) 'reward potential' of a stimulus: e.g. a monthly wage does not provide positive reinforcement (because it is paid too long after the actual work) but it acts as an incentive to continue performing the behavior

Definition of the term ‘instinctive behavior’

Instincts require innate stimuli (e.g. parent's beak in birds); they also require endogenous hunger contractions of the stomach) in order for a key stimulus to be tare more simply organized than drives; they are species-specific, neutral and blind to consequences; under certain conditions parts of instinctive behavior as vacuum behavior and displacement activities.

Thirst and hunger

This subject is treated in the following chapter on thirst and hunger

Sexuality and reproduction

On this page only a few general and pathopsychobiological aspects are considered.

The basic structure of reproductive behavior comprises four phases; these must occur in sequence in one individual and each must induce the corresponding phase in another individual, in order for successful mating to result; they are:

1. Sexual destruction: like all following stages, in most species this is positively influenced by the androgen level in the male animal and the estrogen level in the female; other important stimuli include the odor of the sexual odor of the sexual of the sexual organs and changes in posture and color
2. Behavior: keeps the partners together; among the appetitive reactions are ‘invitations’ to approach and mount, erection, vocalizations, etc.
3. Copulatory behavior: triggered by appetitive behavior; in the male partner consist of transmission and orgasm with ejaculation and contraction of the pelvic musculature and penis; in the female orgasm there are uterine contractions and, likewise, contractions of the pelvic musculature; the positive feelings of orgasm are correlated with the pelvic muscle contractions
4. Postcopulatory behavior: discharge of semen in the man and uterine contractions in the woman are associated with the decline of sexual excitation; the man passes through an absolute refractory period after orgasm; in the woman multiple orgasms are possible.

Sexual dysfunctions in humans are usually mental in origin; they can also be symptoms accompanying organic disease (e. g. diabetes mellitus) or induced pharmacologically (alcohol and drug abuse, side-effect of many medicines); among the sexual dysfunctions are:

- little or no sex drive
- impaired sexual excitation
- in the man: primary and secondary impotence (no or insufficient erection)
- in the woman: little excitation, no lubrication and no swelling of the outer and inner labia
- anorgasmia: failure to reach orgasm despite normal excitation and plateau phases
- premature ejaculation (in the man)
- functional dyspareunis in the woman (pain during sexual intercourse with no pathophysiological basis)

Learned motivation and addiction

Drug dependence

According to the World Health Organization, dependence is a syndrome expressed in a behavior pattern in which consumption of the drug acquires priority over other

behavior patterns that previously had been valued more highly. This behavior need not be present at all times. Dependence is not absolute, but exists in different degrees. The intensity of the syndrome is measured by the forms of behavior exhibited in association with the search for and consumption of the drug, and by other, resulting forms of behavior.

Psychology of addiction: opponent process theory (two-process theory) of acquired motivation

- Stimuli with a pleasurable quality first activate the pleasurably positive a-process (e.g. euphoria). Duration, intensity and quality of the a-process is directly proportional to the stimulus. After some delay, the a-process leads to opposed b-process: 'b' exhibits the reverse pleasurable quality ('withdrawal symptoms') (e.g. depression), has a longer temporal latency, increases more slowly and – this is crucial – is initially smaller than ‘a’ but becomes stronger with repetition (whereas 'a' always remains constant)
- Drugs with an extremely positive 'a' effect produce strong negative 'b' after fluctuations, which can be reduced only by renewed drug intake (a), which further increments ‘b’ and delays the return to the neutral starting point: the vicious circle is closed. The withdrawal symptoms (abstinence phenomena, b-process) are always the opposite of the positive a-process (e.g. euphoria/depression, power/social anxiety and panic). Reduction of the negative withdrawal symptoms is the central motivator for repeated intake, not the positive reinforcing action of the drug.
- Tolerance is the situation in which the original action of the substance decreases with repeated intake (habituation); according to the two-process theory, it is a consequence of an intensification of the b-process when stimulation is repeated.
- Note also that both a- and b-processes are classically conditioned to stimuli presented shortly before or simultaneously (e.g. situation in which drugs are taken). Conditioning of the b-process, for example, causes expectation effects that also mine the degree of tolerance (e.g. the `golden shot' is often not an overdose but normal' dose in unfamiliar surroundings)

Basic concepts related to emotion

Definition of the terms ‘emotion’ and ‘mood’

- Emotions are patterns of response to stimuli inside and outside the body, which are always experienced in the dimensions (1) pleasant/unpleasant (approach/avoidance) and (2) exciting/deactivating; the distinction between emotions and motivations is only a matter of degree
- Primary emotions are innate response patterns, which take the same form in all cultures; they include happiness or joy, sadness, fright, rage, surprise and disgust; primary emotions
- Moods are longer-lasting (hours, days) response tendencies, which make the occurrence of a particular emotion likely.

The three primary emotion systems; each system is activated by different environmental stimuli and controls corresponding behavior.

Emotion system	Reinforcing stimulus	Behavior
Concern	Condition stimuli for punishment and condition non regard	Passive avoidance, extinction
Approach Avoidance	Conditional stimuli for punishment, reward and withdrawal of punishment	Learning to approach, active avoidance; goal directed, cond, flight, prey aggression
Fight - Flight	Unconditioned punishment and unconditioned non-reward	Unconditioned escape response, defensive aggression

Neurobiology of avoidance (fear and anxiety, BIS)

The BIS consists of the hippocampus, subiculum, entorhinal cortex (EC) and septum; three of these form a closed circuit (EC → hippocampus → subiculum → EC), the septum connects the hippocampus to the hypothalamus. The subiculum circuit has a comparison function: the arriving sensory information, preselected as significant and how is compared with stored (expected) sensory stimulus pattern and intended movement sequences; these expectations and predictions derive from the fronthalamic system (Papez circuit); if the result of the comparison is that punishment is to be expected, the intended movement is interrupted by way of the septum (to hypothalamus) and the subiculum (to striatothalamic).

Pharmacology of the BIS

The Bis is specifically inhibited by barbiturates, benzodiazepines (e.g. Valium) and alcohol. Therefore, of all the possible anxiety phenomena, these drugs reduce only the in passive avoidance situations, e.g. frustration, fear of innate fight stimuli (‘prepared’ stimuli such as snake phobia)l they have no influence on unconditioned fear and aggression situations (e.g. noise) or on active avoidance (compulsive behavior, e.g. impulsing hand-washing).

Neurobiology of approach (BAS) and of aggression.

Anatomy of intracranial self-stimulation (ICSS; at present the only fully developed model of positive states in the brain)

When rats are given an opportunity to stimulate themselves through electrodes implanted in the brain, by pressing a bar, many subcortical and cortical areas in the brain (‘pleasure centers’) are stimulated constantly by the rats (up to 5000 or more bar-presses per hour, until complete exhaustion): optimal sites are the descending medial forebrain bundle (MFB) and the lateral hypothalamus (LH) in the neocortex , the frontal cortex is especially suitable. The stimulation of lower-lying structures of the midbrain has the opposite effect: the animals try to prevent electrical stimulation of these parts of the brain (‘punishment’ and ‘aversion’ centers)Electrical stimulation of the fight-flight system in the hypothalamus, depending on stimulus site, leads to three kinds of attack behavior:

- stimulation of the medial hypothalamus causes affective aggressions; this consists in extreme attacks on the nearest accessible target, moving or not; the stimuli are aversive, and the animals soon learn bar-pressing responses to avoid them

- stimulation of the lateral hypothalamus causes prey aggressions; the attack on prey is not aversive, has few autonomic accompaniments, consists of orderly 'cold-blooded' behavior sequences and depends on the surroundings (e. g. victim's behavior); prey can be attacked regardless of hunger, e.g. cats kill mice only for positive reinforcement of prey aggression
- stimulation of the dorsal hypothalamus causes flight and flight aggression (flight attacks); the latter occurs only if during its flights the animal encounters an obstacle on the whole, this behavior has more to do with anxiety and fright than with aggression (overlap with the BIS).

Thirst and the quenching of thirst

The following cross-references give important information about other aspects of water and electrolyte balance relevant to the survey of thirst on this and the next page:

- Water and electrolyte balance; the adequate stimuli for the regulation of 'water balance, the intra- and extracellular receptors and the neuronal and hormonal systems involved are the same as, discussed here
- Posterior pituitary system; there certain aspects of ADH (antidiuretic hormone, adiuretin, vasopressin) are discussed.
- Long term regulation of the circulation; survey of the mechanisms that regulate extracellular volume and hence the filling of the vascular system.
- Thermoregulation; in particular, heat loss by the evaporation of sweat acclimatization to heat in a tropical climate.

Origin of the feeling of thirst (Irani Schmidt. 1990c)

Thirst arises mainly by:

1. Decrease in cell volume due to emergence of water while the amount of salt in the cell stays constant; sensors for this osmotic thirst are osmoreceptors in the diencephalon (chiefly in and anterior to the hypothalamus).
2. Decrease in extracellular fluid: sensors for this hypovolemic thirst are stretch receptors in the walls of the large veins near the heart

- Simultaneous occurrence of 1 and 2 has an additive effect, i.e. causes especially strong thirst; on the whole, 1 is more important than 2.
- Dryness of the mouth in water deficiency is caused by decreased secretion of saliva; it is merely an accompanying symptom (e.g. moistening the mouth does not quench thirst, nor does local anesthesia there or denervation). Dryness of the mouth without water deficiency (e.g. due to speaking, smoking) produces false thirst, which can be eliminated by moistening the oral mucosa.
- Conditions that elicit thirst simultaneously cause the release of renin (and hence the of angiotensin II) and of ADH (antidiuretic hormone, adiuretin)
- Thirst does not adapt; therefore as a very general rule it can be quenched only by water intake (drinking, or if necessary by gastric tube of infusion).

Mechanism of preabsorptive and absorptive satiety (from Schmidt, 1990c)

Preabsorptive satiety means that in general drinking stops before extra- and intracellular water deficiency is abolished by water absorption in the small intestine; this prevents excessive water intake, the amount drunk corresponding almost exactly to that required; the receptors and mechanisms of preabsorptive satiety are unknown.

Absorptive satiety is achieved as soon as a relative (after intake of too much NaCl) or absolute water deficit is abolished; the receptors involved ('thirst sensors') are the same ones that signal intra- or extracellular water deficiency (see preceding figure)

Thirst threshold

The water contest of the human body makes up 70-75% of its weight (fat stores. The long-term variation is only ±0,22% of the body weight, about ± 150 ml in a 70 kg man. When the body loses more than 0,5% of its weight For 70 kg body weight, the thirst threshold is reached and sensation of thirst occur. After absorptive satiety has been achieved, therefore, some time elapses before thirst recurrs, despite ongoing physiological water loss; the thirst threshold then prevents one from feeling thirst when only small amounts of water have been lost.

Primary and secondary drinking

Drinking as a consequence of thirst is primary drinking; all drinking with no obvious need for water intake is called secondary drinking. The latter is normally the usual form of liquid intake. In general, we consume in advance (e.g. at mealtimes) the psychological required water, the necessary amount being estimated very precisely on the basis of previous learning and perhaps other, unknown mechanisms.

Hunger and satiety

The regular daily recurrence of hunger is basically associated with the short-term regulation of food intake; in addition, there is a long- term regulation (see the two frames in the figure) that compensates dietary errors in both directions.

Mechanisms and receptors involved in eliciting hunger sensations

Description/Comments
The earliest presumed cause of hunger: based on the observations that (1) hunger is a general sensation localized in the stomach region and that (2) when the stomach is empty strong contractions of the stomach wall (detected by its mechanosensors) occur; however, denervation or surgical removal of the stomach has no appreciable effect on eating behavior.
Decreasing availability of glucose (not the level of the blood sugar itself) is very closely correlated with the occurrence of hunger: glucose receptors are present in the diencephalon, as well as in liver, stomach and small intestine: short-term mechanism

Description/Comments
Based on the idea that internal thermosensors (e.g. in the hypothalamus) are involved in the maintenance of an energy balance, such that a decrease in overall heat production elicits hunger: participate in short- and long- term regulation
Based o the idea that liposensors detect intermediate products of fat metabolism and evaluate these as hunger or satiety signals (in the breakdown or deposition of stored fat): suitable only for long-term regulation

Food intake without hunger. The amount of food eaten depends not only on the actual deficit and on appetite (see below), but also on the time the next meal is expected and how much energy is assumed to be spent by them (cf. secondary thirst above); in the case of sufficient food on offer, the kind of food intake will be normal.

Mechanisms of preabsorptive and absorptive satiety (from Schmidt, 1990c)

Preabsorptive satiety: Ensured by many mechanisms; in addition to the act of chewing and sensory stimuli during food intake, factors that contribute to preabsorptive satiety include stretching of the stomach and the glucose and amino acid content of the food, by way of purely sensory or with intermediate humoral steps (e.g.release of CCK.)

Absorptive satiety: All three enteroceptive sensory processes associated with hunger contribute in the reverse direction to absorptive satiety (compare figure above with the preceding one); in addiction involves the enteroceptive chemoreceptors that participate in preabsorptive satiety (see above).

Central mechanisms of hunger and satiety

Bilateral destructions of the ventromedial hypothalamus (VMH) induces hyperphagia, which leads to adiposity (obesity); conversely, electrical stimulatin of the VMH (by means of chronically implanted electrodes) induces aphagia (refusal to eat) hence the VMH can be considered as a ‘satiety center’.

Bilateral destruction of the lateral hypothalamus (LH) induces aphagia, and electrical simulation of it causes hyperphagia; hence the LH can be considered as ’hunger center’.

Cross-references: the chapter on the gastrointestinal tract (GIT) considers, the porcesses of food intake an the subsequent processes int he uper GIT (stomach, duodenum); the regulation of glucose balance is described int he chapter on endocrinology the chapter on motivation and emotion treates the physiology of homeostatic drives (which include thirs and hunger).

General endocrinology

Classification of hormones according to chemical structure, site of action (localization of receptors) and nature of action on the target cell.

Cell membrane

E.g. insulin, ADH, many others, see p. 6 not or not very lipohilic, therefore do not permeate the plasma nembrane; interaction with the membrane receptor initiates a second messenger cascade. See p. 9

FSH, LH, TSH, erythropoietiin: likewise not very lipoéhilic; interaction with the membrane receptor causes initiation of a second messenger cascade. See p. 9

(Syntesized from two molecule of tyrosine) dopamine, epinephrine and norepinephrine: are also neurotransmitters, see p. 5: depending on target cell either initiale second messenger cascades or open on channels.

Cell nucleus

(Synthesized from two molecules) thyroxine (T1) and triiodothyronine (Ta): bind to nuclear receptors to influence DNA synthesis and hence the rate of transcription of genetic information to mRNA (transcription amlification)

Cytosol

(Cholesterol derivatives) e.g. corticosteroids: lipidsoluble, permeate the cell membrane, bind to cítoplasmic receptors and migrate with these to cell nucleus; act as transcription amlifiers, see above

Endocrine and paracrine actions of hormones: when the hormone acts ont he same cells that produced it, the action is autocrine; if acts in the immediate vicinity of the site of its release without blood transport) it is paracrine.

Features and functions common to hormones in general

Function: Can be classified according to predominant type of action: metabolic, kinetic (action on glandular secretion or pigment migration), morphogenetic or behavioral: functioning in information transfer, they are usually incorporated into control systems with negative feedback, which often involve central nervous strictures (subject of the field of neuroendocrinology)

Origin, secretion, transport: For most hormones these are the same as in exocrine glands (synthesis, packing in vesicles, exocytosis); exceptions are the steroid hormones, which diffuse through the cell membrane without being packed in vesicles; storage is intracellular; an exception is the extracellular storage of the thyroid hormones (see below); in the blood, hormones are often bound to carrier proteins.

Hormone titer in the blood: Kept extremely low (ca. 10-12 mol/l) by regulatory processes; the advantage is that when they are needed, small absolute changes amount to large relative changes; release cascades can provide considerable amplification (e.g. 01 µg CRH releases 1.0 µg ACTH and this in turn causes release of 50 µg of corticosteroids, i.e. amplification by a factor of 500).

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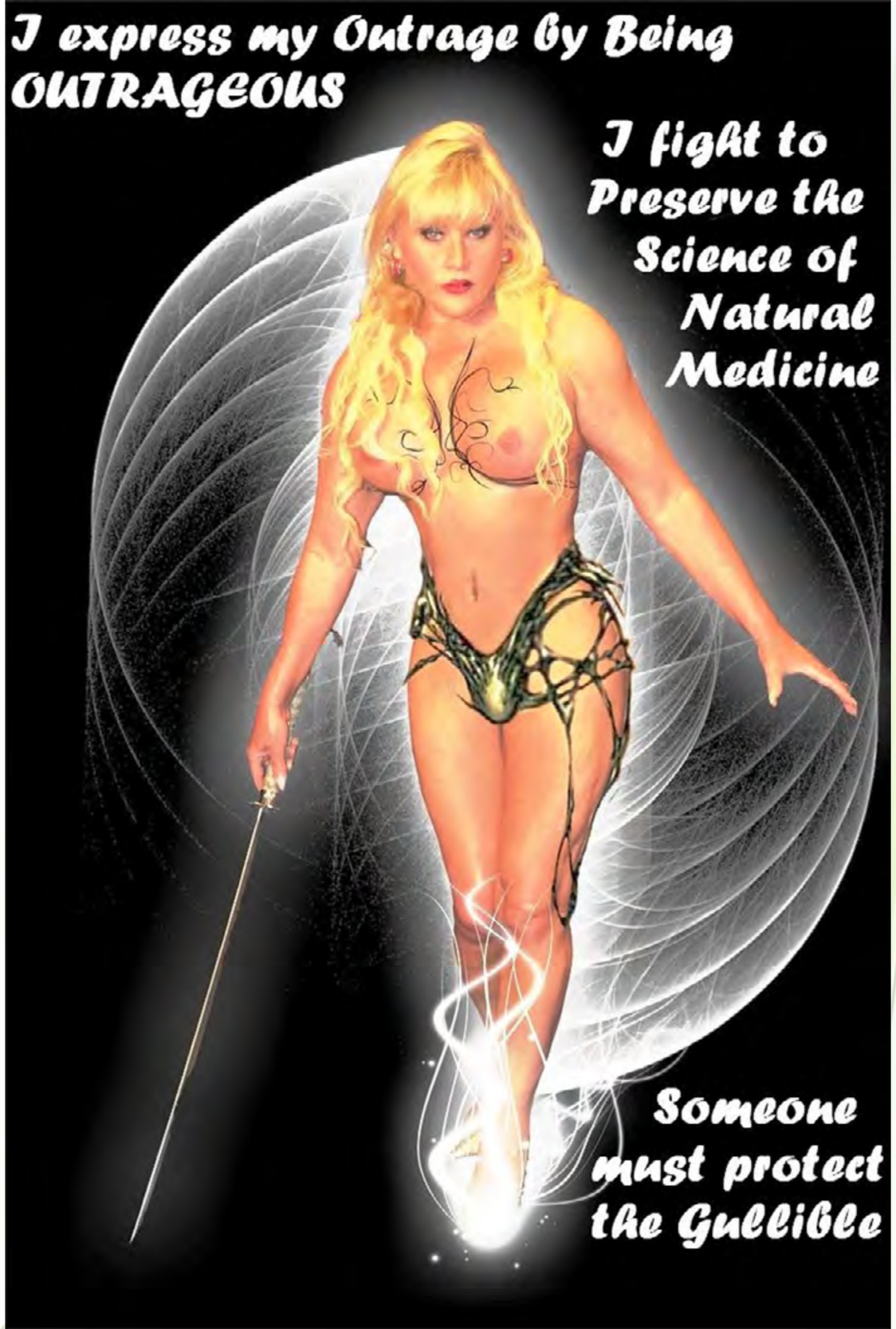

William Nelson or Desiré D. Dubounet as most know her, is a legend in her own time. With over 60 books on medicine, over 200 medical articles published in peer reviewed medical ISSN journals, over 35 movies, three 24/7 TV channels, 2 radio stations, and a host of other publications, Desiré is one of the most important and influential persons of the new age. The courage to stand up and prove that all synthetic drugs are incompatible with the human body. The intrepid pluck resolution to let the big head choose her sex not the little head's presence. Desiré is one of the most courageous people alive today. It is a constant battle against the small and petty minds to fight for freedom and awareness. A modern day warrior fighting for rationality in an ever increasingly stupid and judgmental world, Desiré fights on against all who live in false belief. False beliefs are the hardest to release.

With over 5 patents, 10 trademarks, thousands of copyrights, and a host of other leading edge changes to help natural medicine, Desiré is now a Professor Emeritus of Medicine at the International Medical University. IMUNE is Registered in the British Virgin Is. And the Isle of Mann, accredited internationally, recognized by the U.N. and the E.C. there are IMUNE offices in Switzerland, Mexico City, Beijing and Romania. Desiré won the Beethoven prize for intellectualism in 1990. The Who's Who man of the year in 1991, and women of the year in 2001. Doctorate degrees in Medicine, Counseling, Acupuncture, Homeopathy, Naturopathy, Corporate Wellness, International Law, and Quantum Physics and Biology constitute just some of her educational experience.

Desiré was licensed to treat and diagnoses patients in Ohio, and is now licensed internationally as a medical doctor. She has directed produced, written and stared in over thirty movies. Desiré established the proof of homeopathy in the USA. She personally made homeopathy legal in Hungary. She is known as the father of modern Homeopathy in Pakistan. She is known as the mother of current Superlearning. She personally registered the acupuncture needles as medical equipment in the USA. Made patents in homeopathy in the USA and Ireland. She has been nominated for the Nobel prize in medicine over ten times. Dr. Bill Nelson was proclaimed the greatest intellectual of the 20th century. But now Desiré is eclipsing and displaying
greater genius.

Desiré has developed a new and exciting style of movie making that has Hollywood shaking in fear. Her Intellectual Angel Movies are a fantastic unprecedented and inventive style of movie aimed at the sophisticated intelligent audience. Desiré has the courage and fortitude to make over 35 movies that challenge the system and the powers of big money. She has defined and elucidated the evil of the Illuminatti in her movies. As Einstein once said "great spirits get incredible resistance from mediocre minds". Judging from the petty trivial critiques and biased twisted criticisms it can be said that Desiré must be one great spirit. Her courage, intrepid spirit and clarity of mind are legendary.

Desiré was awarded the first prize in a contest of Cardiologists in Florida in 1989. Medical Doctor of the year in 2003, and voted best Healer of the year in 2005. Often called the most eminent Doctor and Naturopath alive today. She has become the world's most famous expert on Natural and Energetic medicine. The story goes on and on this is just a brief set of the ever growing legend and saga of Desiré D. Dubounet.

As Desiré says the past is not, real the resume is just an illusion. The power of the mind must stand on it's own. The petty mind can come at you from any angle and the only defense is steadfast dedication to the truth. When you read or watch her scientific journals, clinical studies, advanced scientific papers, medical discussions, philosophical essays, social themes, and intellectual movies you can see a world class genius. Petty minds will say that it is too good to be true, well Desiré is so true to be good.

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Law of Interpretation not Attraction

The Movie "The Secret" is wrong. You do not completely create the world or the events around you. You do completely control your interpretation of the world and the events around you.

It is not the Law of Attraction, it is an Effect of Attraction. It is a Law of Interpretation. There is the law of gravity. What goes up must come down, but there some few exemptions. This constitutes a law. It is seldom changed. The Law of Interpretation says that any verbal human will interpret what has happened to him based on his experiences, beliefs, and philosophies. He will always impose an attempt to explain what happens to him. Even "Shit Doth Happen" is an explanation.

In physics a weak force can affect things. We have the "observer effect" and the mind has been proven to be able to effect things. There is power in the human mind to affect objects. Telekinesis, remote viewing, Extra-Sensory Perception etc are all proven to be possible, but the effect is weak. But the effect is there. (see the "Proof" movie)

We can affect our lives and we have some very small control over objects, the world, and the events around us. But we have great and complete control over how we interpret the objects, the world, and the events around us.

All of the people in Hiroshima did not wake up that August morning and create the bomb, nor did they deserve it. All of them later interpreted the results. Most saw the bomb as a negative event. But some saw it as a growing event and a positive result. Nelson Mandela came out of jail after more than two decades and saw it as a positive thing. Some people can find the positive in the most horrendous events. We completely control the interpretation of the objects, the world, and the events around us. Some use negativity to describe the events, some use positivity but all interpret the events. All do this from within their own brains. The state of your brain determines the state of your interpretation of the world around you.

Some people are always happy and they learn to find the silver lining in every cloud. Some people are always dissatisfied and find fault in all around them. But all of us completely control the interpretation of the world around us. We do have some limited control of the world around us but we will never have complete control.

"The Secret" is wrong, in that you cannot just sit at home and think of things and bring them into your life. "The Secret" is right that you can affect your life positively and you can dramatically increase your chances of getting what you want. If you want to get a job you must fill out an application or two.

People think there is a law of attraction, but it does not hold out as a way to predict things. If it were a law then we could predict things. Example: if someone throws a rock off of a building and there is a crowd below, someone in the crowd will get hit by the rock. Now we might say the bad guy got it because he deserved it. The good guy got it because he was too good. The sad guy got it because he was negative and he brought it to him. The happy guy got it because he needed to learn a lesson. But in truth we do not know who gets it before it is done.

If there were a law we could predict the outcome easily. We could put a crowd in place and let one guy focus on wanting the rock to hit him and he does chants of mantras I want the rock. The rest of the people do chants of protection and affirmations that they are protected from rocks. We throw the rock and no matter how powerful the meditations we just don't know who will get it till after it hits.

After it hits we then are always able to explain it. We say the bad guy got it because he deserved it. The good guy got it because he was too good. The sad guy got it because he was negative and he brought it to him. The happy guy got it because he needed to learn a lesson. The human mind can interpret things very well after the fact. President Gerald Ford said that Hind Sight is 20/20. But Fore Sight is just probability theory. The law of interpretation holds fast.

When President Harry Truman dropped two bombs on non-military target cities of women and children, there was so much radioactive fallout thrown into the air. If one of these alpha ray or beta ray fallout products were to be ingested or breathed in the person would get cancer and die. There was such an increase in cancer in America after the three atmospheric detonations of atomic weapons of mass destruction that the world had to declare atmospheric atomic detonation illegal. Harry S. Truman killed more Americans with fallout over the next fifteen years than he killed Japanese on that day. Here once again people interpret his actions based on their own perceptions. In some minds he was a hero, in another mind he is a War Crime criminal. But I feel if more people knew what happened there would be more people thinking the later. (see the movie "War Crimes Trail of Harry S Truman")

Now who got the radioactive fallout, the good, the bad, the ugly, the deserving? The answer is we cannot predict, but we can always explain. Whatever happens people will step forward and explain why. You do not completely create the world or the events around you. You do completely control your interpretation of the world and the events around you. Your mind interprets what is around you.

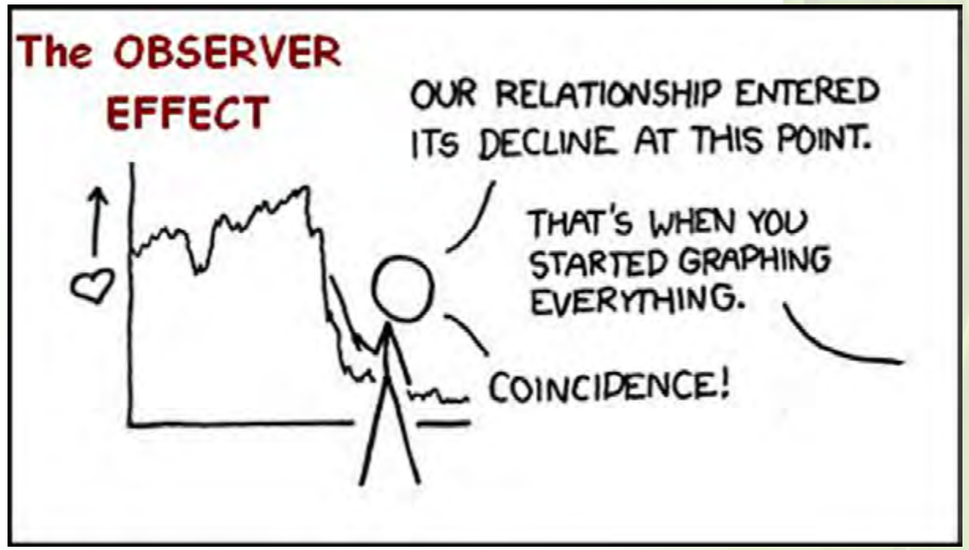
In sports we can analyze, study and examine the details of the two teams competing. If there was a law of attraction we could always or at least generally predict a winner from who attracts it the most. But this is not the case. We must play the game. And no one knows the outcome. But after the outcome everyone steps forward with and explanation. Your mind has a weak power to affect your surrounding but a strong firm power to interpret events after they are completed.

The condition of your mind, spirit and soul determines how you perceive the world around you.

God and The Cosmos

I believe firmly in a God that does guide all of us for growth and spiritual development. This allows for karma as well. The theory of the big bang states that all of the energy in the universe or at least a big chunk of it came through a singularity in one to the minus forty third of a second. Matter will later evolve from condensation of this energy. This means that all things all particles have a quantum entwined history. Particles of quantum energy that were once entwined can communicate with each other as in Bell's theorem. The PEAR project proved that there was a connectivity of things and that the human mind a known quantum engine could communicate with things. There is a God consciousness of the universe. This God consciousness determines who gets the radioactive particle.

We have a part of the God consciousness in us. But just because a drop of water has the same characteristics as the ocean the drop should not think it is the ocean. We have some small part of this power in us but we need to be humble.



So the message to the "What the Beep"people is firmly you can affect your world slightly. God controls your world completely. We need to have humility. You need to act not just think. And you do control your interpretation of the events completely.

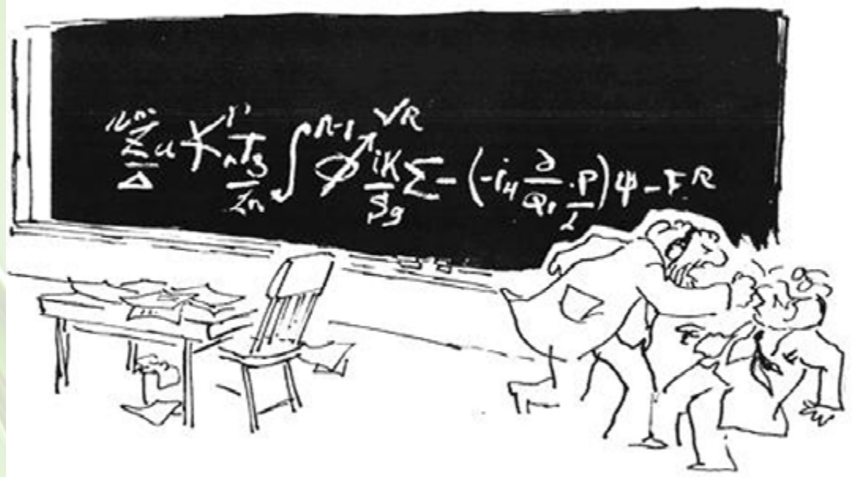
And people will interpret their reality as they see fit, and often this means they will adjust their interpretation to fit their belief system. I have seen scientist observe undeniable data on UFO, the powers of the mind, psychic phenomena, Ghosts etc and after seeing irrefutable evidence they adapt an interpretation to fit their dogma. It is difficult for people to face their disbeliefs.

We don't' create the world around us we interpret how we see it.

They say there is always a quote "RATIONAL EXPLANATION". Of course the rational human mind after the fact can always make a rational explanation. This does not mean it is true but they must do it to preserve their belief system. Any rational explanation will do to allow them to drop pursuit into paranormal. For maintain a false belief is more important than truth.

Science has lost itself into a search for funding and in saving face. It ignores many obvious truths that should get more consideration and Rational explanations are easily accepted for too many phenomena that should be explored. Rationality and Rational explanations becomes a religion to these people who rationally reject religion.

The human mind must try to preserve its integrity. Everything we do has error built in. some would say that this alones guarantees the uncertainty problem. But this alone would imply that technology might solve the problem with less error. But in fact indeterminacy goes beyond error and extends to all things at the core of existence.



"You want proof? I'll give you proof!"
" Beleive it or Lose Your Funding"

They Say "god made man but Samuel Colt made them equal"

$$\Delta x \Delta p_x \geq \frac{1}{2}\hbar$$

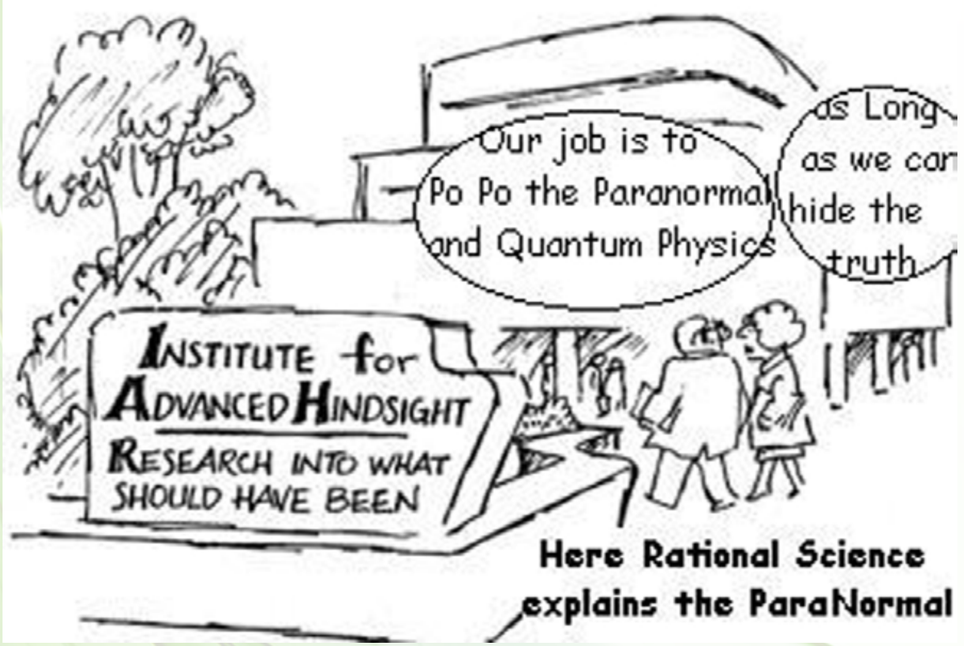
FREEWILL

"Heisenberg gave Man free will"

The World we Live in Has Indeterminancy built into it

There is Error in all things but the Indeterminacy Principle goes beyond Error the basic core of all existance is indeterminant

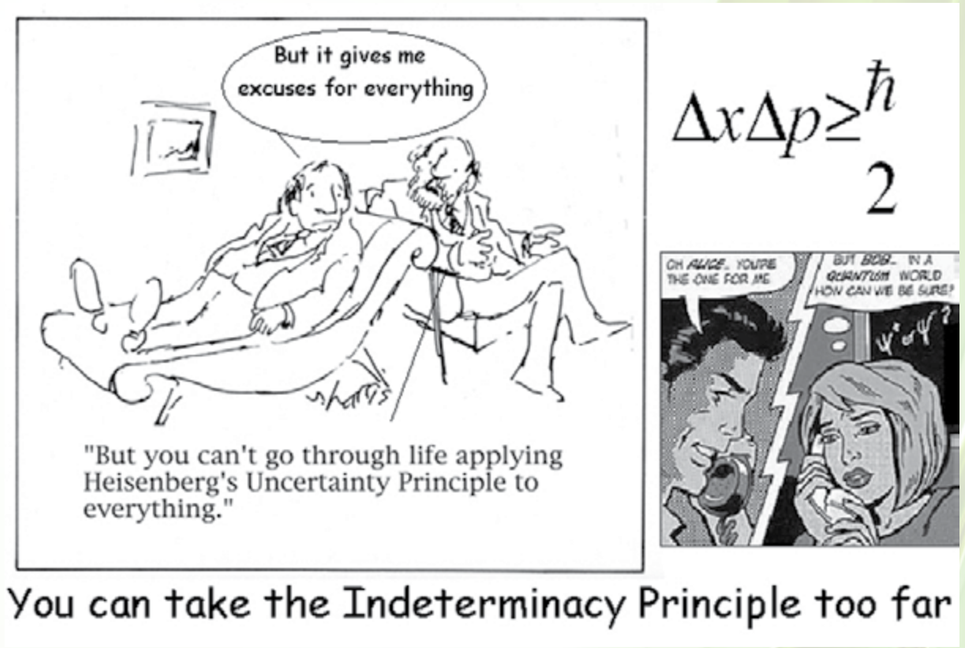
Even when we know the way things should turn out we must Play the Game, Because we just don't know, in life things have a degree of indeterminancy built in, and sometimes "Shit Happens", Owen's Law



You Can Take the Indeterminacy principle too far. Even though it is true and we do have Free Will. We must act on what we know and try to act on our predictions of outcomes. We need to play the game of life as best we can. And see where the outcomes lead us.

We need to find a balance of rationality and indeterminacy. The Yin versus Yang. There is a need for rational logical linear thought as in Western philosophy, but it is not the only path to knowledge. The Eastern ways have more of the other side of the brain working finding dreams, art, beauty, intuition. There is a male and female mind, a left and right hemisphere, a dreamer and doer, a 'see'-er and a 'be'-er, a watcher and a player, an active agent and a passive one all in each of us and many more. As we learn about the differences and the polarities we learn about ourselves. We learn to be the best we can and how to face life when 'Shit Happens'.

The best doctor is the doctor within. The best teacher is the teacher within. When you discover this and you activate it with modesty and humility recognizing what you don't know is always greater than what you know, life is much better. You can do anything it is just a matter of time.



Laws Versus Rules

You can call me anything except late for dinner

But if people respect personal freedom they will call me my chosen name Desiré.

Some people are more caught up in the way something looks rather than it's true nature and some people have limited minds but if you are true to truth, and you respect freedom over conformity then You can call me Desiré. I am deeply respectful of the law, in that way I am very very conservative.

But I am very suspicious and not respectful of rules. There is a law in South Carolina that says a person labeled male on his birth certificate cannot openly dress as a female. So I won't visit South Carolina. For the rest of America this is a rule not a law. I do not respect the rules of conformity. I do not respect the rules of convention or tradition. I challenge them with one word freedom. Small petty minds try to take away freedom and prefer tradition.

Once a FDA agent came into my office in Denver Colorado and he demanded we close up the shop because he said homeopathy was illegal. It was a rule he said. I took him into the office and showed him the FDA law. The FDA was founded by a homeopath. Homeopathy appears three times in the first three pages. He apologized and left.

You see the law is how we run our society. And our society makes and assumes rules. Many governmental people do not know the difference. They even think a rule is sometimes a law. But the law is always written on paper and can be read and enforced. Still there are times we need courts to decide when police or enforcement people have differing opinions than the public. Such was the case in 1996, when the FDA had a rule to ban acupuncture. The FDA thought that this was a law. I challenged this rule. And I won acupuncture became a real medical art in March 1996 because of me. I used the law to change the rule.

Right now many people thing that energetic medicine is illegal. This is a rule not a law, and I fight to defeat this rule and preserve the law. The law allows energetic medicine today. I am sure that we will need to go to a judge to decide this someday.

I do not break laws. I work diligently to obey laws. The FDA has broken the law in their vendetta against me and One day I will prove that. I left America in March right after Judge Matsch made the FDA and the Prosecutor dismiss the case against me on leap day 1996. The FDA went to Washington in June 1996 and tricked a Grand Jury into illegally making a bogus indictment against me. There was no charge against me when I left. So I did not flee, nor am I a fugitive.

I am a concerned citizen who is waiting for an American judge to rule on the validity of my case before I return. I have obeyed every law and always do. But everyone has denied me a judge to rule on the validity of the indictment against me. I have been warned of a conspiracy against me to have me put away without the chance of seeing a judge how could free me like the last one did.

I do not respect nor do I feel obligated to obey rules. Salesmen think that it is a rule they should wear a suit. I tried to tell them that most everyone knows to never trust a suit. But he is caught between people who are confused by rules and think their rules are law.

I have changed my name and sex rating in America. There are three American ID papers used, Passport, Driver's License, and Voter's registration. My medical papers say I am both sexes and can chose which one I want. My only driver's license from Kentucky lists me as Desiré Dubounet and female. My voter's registration in Colorado is as Desiré Dubounet and lists me as female as well. So by American law I am Desiré Dubounet and female. This is the law, but for some this voids a rule. For some rules are more important than laws. It is a pity. For me law is more important than rules.

My name is legally in America, Europe, Africa, and around the world is Desiré Billie Dubounet

I studied the Buddhist way and that the cause of all suffering is Desire. To stop suffering you must control Desire. This was my doctoral thesis, in New Orleans. So when I choose my female name I choose Desiré to always remind me that desire has to be controlled. It can be expressed but controlled.

When Dustin Hoffman first became Tootsie in the movie he was in the Russian Tea Room in NY and he ordered a Dubonnet with a Twist, I said well I my life has now a twist.

But Dubonnet is the drink, Dubounet in French is a beautiful sexy bonnet worn by the most elegant of women. I am an elegant woman. Dubounet rhymed with Desiré so I choose my name.

For my middle name I choose Delicious, in my stand up comedy I say that

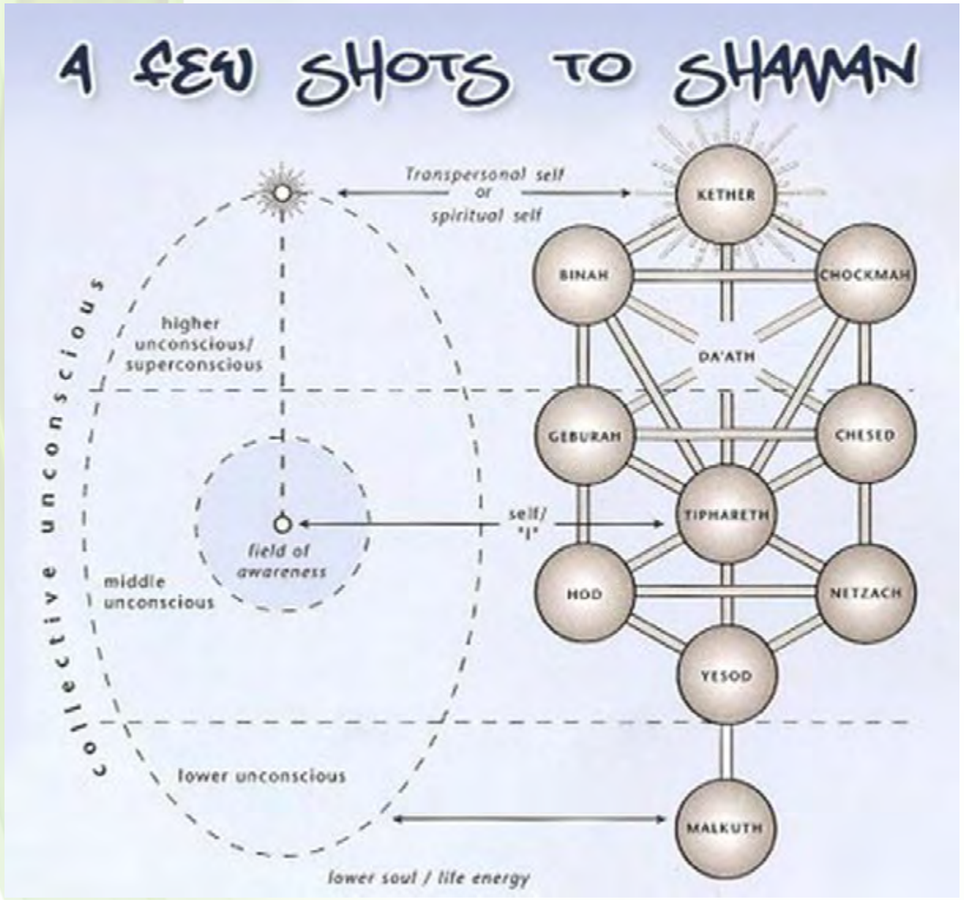
“Delicious is my middle name. It is not my whole name. It is the name of my hole.” Ta Da drum role

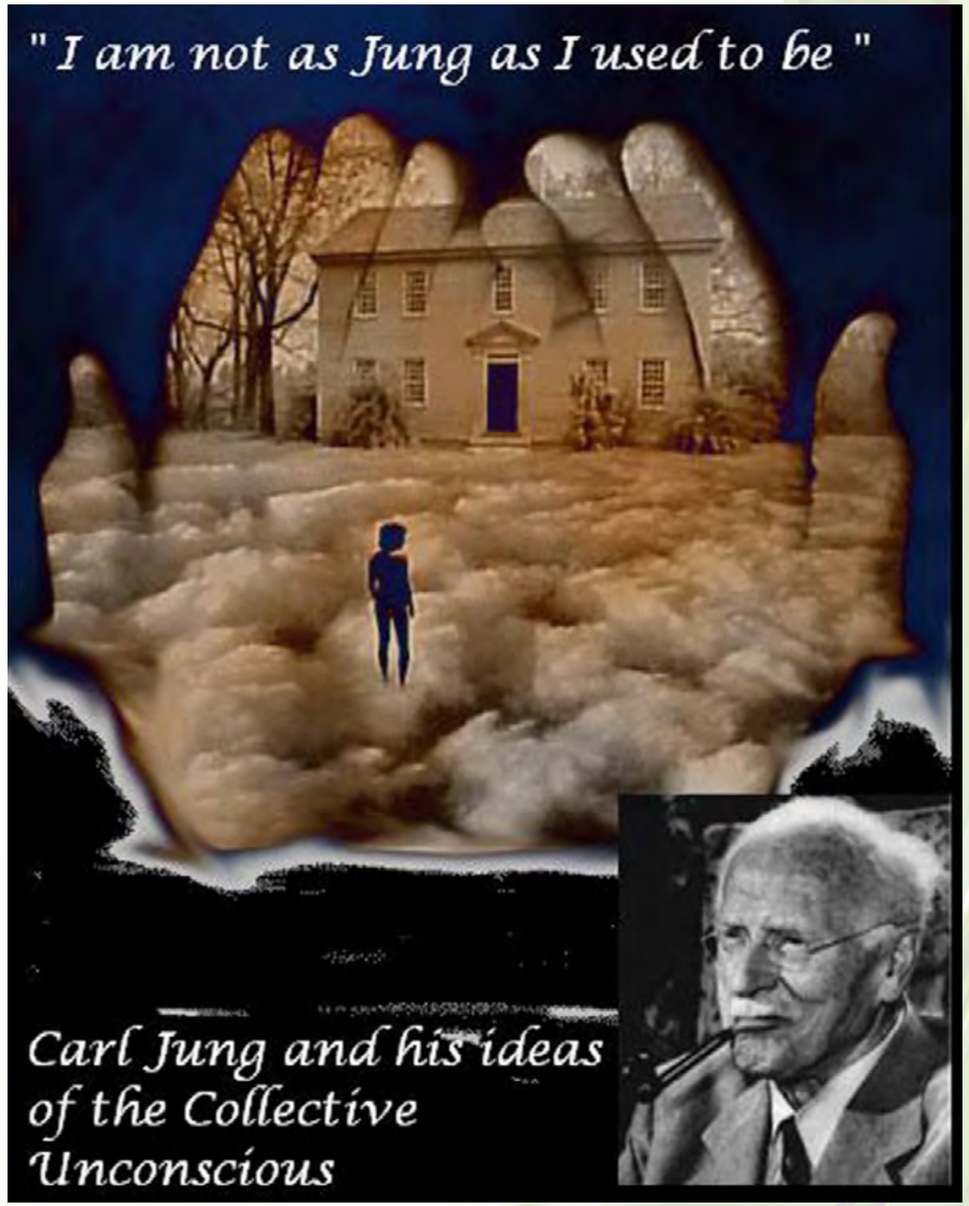
By American law of the 14th amendment you can change your name by yourself in most states (not in California, but yes in Colorado) but the law says you cannot use trivial sexy terms and the specifically use the word “Delicious” as an example of words you can’t use. So I cannot make my middle name Delicious.

When my father was born at first they thought the child was female, same with me. So the name on his birth certificate is Billie. The female spelling not Billy the male spelling. One week later my father's penis popped out and then on the birth certificate you can see where they erased female and changed it to male but they did not change the spelling of his name.

So my dad went thru life with a female name and he was tortured and troubled by the sex identity crisis with his hermaphrodite heart. He was bitter, mean, fearful, nasty and cruel and he hated almost everybody. He was abusive and brutal to my mother. But he was my dad and to honor him I took the middle name Billie. This reminds me of how a person can twist their soul, mind and those around him when they have to suppress and repress their inner feelings. It reminds me to love the sinner and hate the sin. It reminds me that to suppress a truth is to give it power over you.

For me to have the courage, the fortitude, the power of mind to be me what I am and not what others want me to be. It takes extreme power of personality and intellect.





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Well, the game of Reality Monopoly is still being played all over the world. One percent of the world's population is winning and now controls over 80% of the wealth. The law allows the game to continue till we will see one winner and 6 billion plus losers

PROFESSOR DESIRÉ DUBOUNET

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