



University of  
**Leicester**

CETL · Centre for Excellence in  
Teaching and Learning

# GENIE GUIDES

## CALCULATION AND COMMUNICATION OF GENETIC RISK for Non-Geneticists



[www.le.ac.uk/genetics/genie/index.html](http://www.le.ac.uk/genetics/genie/index.html)

Study guide prepared 2008-2009  
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## Aims:

The main aim of this study guide is to help prepare health care personnel who are confident and capable of explaining genetic risk to patients and relatives in an understandable and meaningful manner, within the limitations of their own genetic expertise.

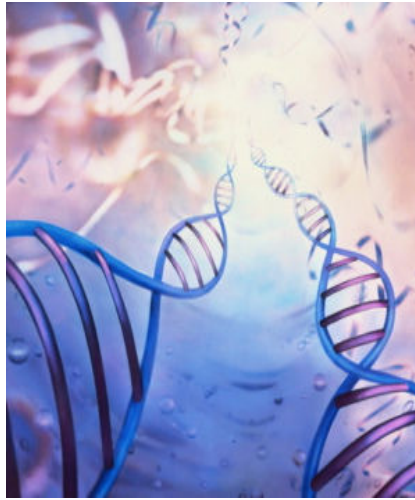
**It is NOT the aim of this study guide to qualify individuals as specialist genetic counsellors.**



Adapted from the work of P.Lowe (ccl)  
<http://www.flickr.com/photos/utacnyc/3524755021/>

**NOR is it the aim to reinvent the wheel!**

Throughout the study guide recommendations and links will be given to other freely available relevant educational sources, in addition to original material!



<http://farm4.static.flickr.com/3393/35888215307bfl1d14d34.jpg> by "Public 15" (ccl)

## The Target Audience:

- Qualified and trainee registrars (non genetic specialist)
- Qualified and trainee General practitioners with an interest in genetics
- Qualified nurses as preparation for work in Genetic risk assessment triage teams
- Other graduates interested in the communication of genetic risk

## Learning Objectives:

Four things you should feel confident in doing after working through this study guide are:

- **Working with pedigree charts**
  - Draw a chart for a given family history
  - Identify simple patterns of genetic inheritance
- **Discussing genetic risk**
  - Calculate simple risk
  - Be aware of elevated genetic risk due to: Ethnic origin & Consanguinity
  - Explain the interaction of behaviour, genetics and environment
- **Appreciation that understanding genetic risk can be difficult**
- **Utilizing different approaches to explain the same genetic risk**
- **Explaining the results obtained from commonly used online risk calculation aids.**

These objectives, are derived from published required basic genetic competencies.  
[http://www.nchpeg.org/core/Core\\_Comps\\_English\\_2007.pdf](http://www.nchpeg.org/core/Core_Comps_English_2007.pdf)

## Sources:

Rather than reinvent the wheel this guide seeks to act instead as a hub at the centre of a wheel, from which extended information can be reached. For this reason, in addition to original material, external sources of information have been quoted and utilised extensively and, where possible, hyperlinks provided. The two main sources utilised are:

- The Virtual Genetic Education Centre (VGEC) at the Centre of Excellence for Teaching and Learning (CETL) Genetic Education Networking for Innovation and Excellence (GENIE) in the Department of Genetics University of Leicester <http://www.le.ac.uk/ge/genie/vgec/index.html>
- The NHS National Genetics Education and Development Centre (NGEDC) <http://www.geneticseducation.nhs.uk/>

both of these are excellent resources and it is highly recommended that any interested reader explores them fully. In addition other valuable sources, suitable for further study, have also been referred to throughout the text.

## Acknowledgements:

- Valuable feedback and suggestions from Prof. Annette Cashmore (Director of GENIE), Dr Julian Barwell (Consultant Clinical Geneticist and member of GENIE), and to members of the Leicester Clinical Genetics Counselling Team are gratefully acknowledged.
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- Finally, accepting me as a visiting fellow to their institution the CETL:GENIE, Dept Genetics, University of Leicester, have been a supportive and welcoming host for my sabbatical, allowing me full access to all their facilities and providing me with the benefits of their expertise.

## Orientation to Layout:

The introduction presents reasons why busy healthcare professionals, who are not genetic specialists should spend time increasing their knowledge of genetics and the communication of genetic risk.

**The material in this study guide is organised into five independent sections which can be accessed in any order according to the knowledge and needs of the reader.**

The **three sections** dealing with risk calculation, perception and communication of risk and the public understanding of genetics, each contain a theoretical summary, and suggested practice exercises.

At the back of the guide there are **two sections** which provide an opportunity to revise the basics of communication and genetics. Each of these sections comprises a brief summary of the topic and links and references to where further information can be found.

Although emphasis will be made throughout on genetic risk, the section on how individuals perceive risk and methods of risk communication should also prove useful as a guide to how to communicate risk in other healthcare situations.

## Contents

<b>Introduction-----</b>	<b>4</b>
<b>The calculation of genetic risk: -----</b>	<b>8</b>
The “Anatomy” of a Pedigree Chart-----	8
How to draw a pedigree chart-----	9
Tools for drawing -----	10
Why the ability to analyse Pedigree chart is useful to your professional practice-----	10
How to deduce simple patterns of inheritance from pedigree charts; a step by step guide-----	11
Other factors effecting pedigree chart patterns-----	16
HOW to get from the pedigree chart to an estimate of genetic risk-----	17
Quick explanation of Probability-----	19
Calculating the probability of a given genotype-----	20
Online risk calculators-----	23
Consanguinity and Ethnicity-----	24
<b>How individuals perceive risk, and methods to communicate risk -----</b>	<b>27</b>
Practical suggestions to aid patient understanding-----	29
Problems that may occur while communicating risk and help to avoid them!-----	29
A selection of tools for explaining risk-----	31
<b>Public understanding of genetics -----</b>	<b>35</b>
“Bad Blood” and other misconceptions-----	35
Communicating about Genetics: examples of common misconceptions and the confusion behind them -----	36
<b>Overview of Basic Communication: with links ---</b>	<b>40</b>
<b>Overview of Basic Genetics : with links-----</b>	<b>44</b>
<b>Index-----</b>	<b>48</b>

## What are the challenges of communicating genetic risk to patients?

When non genetic specialists are communicating genetic risks to patients they are attempting to transfer information which may be slightly outside their main specialist area and with which they may not themselves feel completely confident.

In addition the patient who is receiving or seeking the information may also find both the concept of risk and the topic of inheritance and genetics difficult to understand, and finally the health professional needs to be fully aware of the how the patient perceives inheritance, genetics, and risk!



## Introduction

With the completion of the human genome project and advances in the understanding of the molecular aetiology of more and more diseases there is an increase in the number of resulting clinical applications and a corresponding increase in the amount of information now available in the public domain (Hall et al 2004).

With the increasing number of tests and anticipated public demand to be tested, it is probable that much of the initial explanations and testing in future will occur at the primary healthcare level (Julian-Reynier et al 2008, Emery and Hayflick 2001). To meet these challenges it is essential that all members of the primary health team, have a knowledge of genetics relevant to their scope of practice.

A source of more clinical scenarios requiring the understanding and communication of genetics is “Telling Stories” from the NHS Genetics Education Centre.

Each story has a selection of resources including selected quotes from the story illustrating the patients experience, and suggested activities, which you would need to perform in that clinical setting. The following sections of this study guide present opportunities for revision and practice of these individual skills.

Some of the stories in the resource “Telling Stories” relate incidences of poor communication between the practitioner and the patient. Communication is of course, in compliance with the curriculum revisions following publication of “Tomorrows Doctor” (GMC 2002), part of most, if not all, medical school and health science courses.

Health care professionals are expected to reach at least basic levels of genetic competency; published guidelines include those from the NHS Genetics Team (2003), the NHS National Genetics Education and Development Centre (2007), The European Society of Human Genetics (Coviello and Skirton 2008) and USA based National Coalition for Health Professional Education in Genetics (2007).



<http://images.wellcome.ac.uk/>

**Why should health professionals, whose speciality is not genetics, need to know even more genetics?!**

- Reflect on your experiences with patients presenting with genetic conditions or problems?
- Read through “Telling Stories”  
<http://www.geneticseducation.nhs.uk/tellingstories/>  
Think about how you would have responded
- Reflect on your level of confidence to deal with similar activities as those suggested in your daily practice.

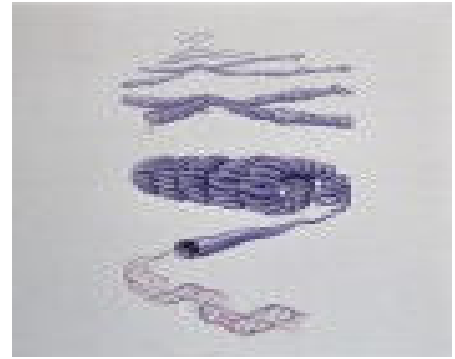
It is now the norm for basic genetics and patterns of inheritance to be part of every health professional educational course. However for those healthcare professionals who are not genetic specialists, and who are therefore not dealing with genetic problems on a daily basis, it is easy for all they have learned about genetics lectures to recede back into the mists of time!

If you recognise yourself to be in this category please take the opportunity to revise basic genetics in order to facilitate understanding of the sections dealing with the calculations and communication of genetic risk!

All health care professionals have almost certainly had, as part of their basic training, at least some instruction in communication and genetics. However the communication of genetic risk presents a compound challenge not found in most other healthcare communication scenarios and the abilities of understanding genetics, and communication may not be sufficient skills on their own.

There are several studies which have documented low levels of confidence in dealing with genetics in primary care, particularly the genetics of common diseases and the risk of occurrence (Qureshi et al 2005), and achieving good communication of genetic topics (Cooley 2008). Studies from Australia, Turkey and Europe, and (Metcalf et al 2002, Tomatir et al 2007, Calefato et al 2008) all identified similar concerns.

With modern mass media and communications all of us, health professionals and patients alike, are subjected to an almost continuous stream of daily activities and exposures which have been found to subject us to an increased health risk, and this can easily lead to information overload (Paling 2003). This may make the significance of a health risk presented by a health care professional difficult to appreciate (it becomes just one more risk in a sea of risks). Since both genetics and risk are potentially difficult concepts for the patient, especially when they are already under stress, special care has to be taken to ensure that a patient has correctly understood the information that is presented to them.



<http://images.wellcome.ac.uk/>

**The “basics” for genetics includes familiarity with how the code in DNA results in physical characteristics in the individual (the phenotype), and how these characteristics are inherited.**

🌐 Try some of the activities in “Overview of Basic Communication” page 44 and “Overview of Basic Genetics” page 48 to test your knowledge of the “basics”

**It is important that risk communication is done effectively, miscommunication not only stops the patient from making the best decision for them but may even lead them to making a decision that they will later consider to be the wrong one. (Fischhoff et al 1993).**

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## Notes:

## The Calculation of Genetic Risk :

An accurate, and as detailed as possible, family history is essential in producing a good pedigree chart. The pedigree chart, in addition to being a graphical summary of the patient's family history gives insight into the pattern of inheritance to any of the trait / phenotype / medical condition presented by the patient.

The classical symbols of the circle for female and the square for male family members and the drawing of a simple nuclear family are probably familiar to you all. However to deal with more complex situations ( eg cases of sperm or ovum donation, adoption etc) and in order to include as much clinical data about individuals as possible on the pedigree chart a system of standardized human pedigree nomenclature has been proposed (Bennett et al 1995) and is widely used,

### The “Anatomy” of a Pedigree Chart

This simplified pedigree chart uses standard nomenclature.

- The Roman Numerals (I-III) identify three generations.
- The male and female in line (I) therefore are the grand-parents of all the individuals in line (III).
- The male and female in line (I) have three children, two daughters (who are both affected with the genetic condition being investigated) and one unaffected son.
- The **proband** (the individual whose genetic condition is being enquired about) is identified with an asterisk \*

In each row each individual has an ID number and individuals can be identified by referring to their generation number and their ID number. The **proband** can be identified as **III3** in the above example the proband is an unborn child. The individual who comes asking for genetic advice is known as the **consultand** and this is not necessarily the proband. In the pedigree chart presented the **consultands** were the parents (II1, II2) of the unborn child wanting to know the probability that the child would be affected.

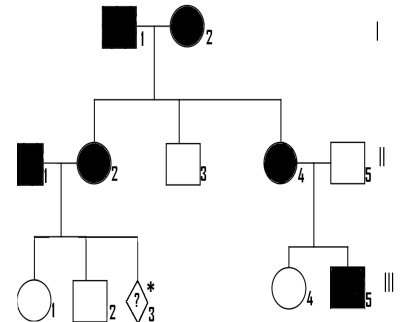
#### The relationship connections:

Relationship connections are represented by horizontal and vertical lines.

The **vertical individual lines** of siblings are connected with horizontal lines (**sibship lines**) by convention the eldest sibling is to the left and the youngest to the right. A **vertical parental line** connects the horizontal sibship line to the parents. There is a **horizontal relationship line** between the parents.



<http://images.wellcome.ac.uk/>



#### Basic Pedigree Chart

##### Symbols:

- Phenotypically normal female
- Affected female
- Phenotypically normal male
- Affected male
- ◇ ? Individual of unknown phenotype and sex
- \* Proband

# How to draw a pedigree chart:

## General Guidelines :

- Record the date the pedigree is being taken and who is drawing it.
- A4 paper, landscape orientation is convenient
- Use standard nomenclature as agreed in your institution or as in Bennett et al (1995)
- Start towards the centre in the lower third of the paper (to give room for both sides of the family!) and leave plenty of space between individuals
- First draw the proband, then siblings, parents and grandparents.
- A horizontal sibship line connects the vertical individual lines of siblings, with the eldest to the left and the youngest to the right
- A vertical parental line connects the horizontal sibship line to the parents. There is a horizontal relationship line between the parents.
- Branches of the family are added later
- Partners are added as applicable.
- Always ask about adoption.
- Stillbirths, spontaneous abortions and pregnancies must be noted (and twins)
- Name, date of birth and relevant medical history are added, including, if known, cause of death.

A useful summary of the process can be accessed at the following link:

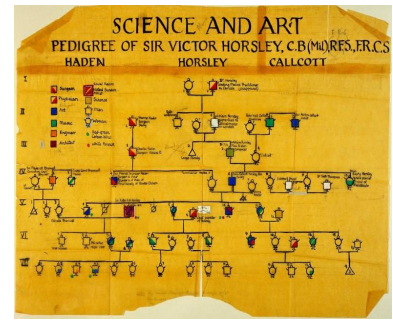
[http://www.geneticseducation.nhs.uk/family\\_history/Family\\_History\\_Series.pdf](http://www.geneticseducation.nhs.uk/family_history/Family_History_Series.pdf)

The NHS genetics education site also has an animated set of power-point slides of pedigree chart drawing.

[http://www.geneticseducation.nhs.uk/family\\_history/Taking\\_and\\_Drawing\\_a\\_Family\\_History.ppt](http://www.geneticseducation.nhs.uk/family_history/Taking_and_Drawing_a_Family_History.ppt)

To be effective clinical tools pedigree charts need to be accurate and as complete as possible.

- **Take time outside the clinical setting to gain proficiency in this skill; it takes a lot practice to achieve an accurate, complete, and tidy pedigree chart during the clinical interview!**



<http://images.wellcome.ac.uk/>

## Suggested Practice Activities:

- Make a pedigree chart of your own extended family
- Draw out the pedigree charts of your colleagues during “mock” clinical interview sessions. Then read it back to them to check your accuracy!
- The NHS genetics education site has a collection of resources for non genetic health specialists which can be used for pedigree chart drawing practice.  
[http://www.geneticseducation.nhs.uk/teaching/non\\_genetics\\_speciality.asp?id=119](http://www.geneticseducation.nhs.uk/teaching/non_genetics_speciality.asp?id=119)

## Tools for drawing:

With practice tidy, accurate and informative pedigree charts can be drawn by hand. However if tidier drawings are required (for example when preparing reports, or teaching materials) or electronic storage is required there alternatives:

Including templates of the basic shapes to assist drawing, such as the template available from the NHS Genetic Education Unit.

### Computer Drawing Programs.

Commercial software packages,  
for example that produced by Cyrillics  
<http://www.cyrillicsoftware.com/>

Open source software  
For example "Madeline"  
<http://eyegene.ophthy.med.umich.edu/madeline/aboutwebservice.php>

The American National Institute of Health has even produced a simplified pedigree drawing programs to encourage patients to keep their own medical history  
<https://familyhistory.hhs.gov/fhh-web/home.action>

### Why the ability to analyse pedigree charts is useful to your professional practice:

Basic familiarity with the patterns will help

- Support other clinical findings when a genetic condition is suspected (for simple cases)
- Answer patients questions about how the condition was inherited .
- Identify other at risk members of the family
- Identify situations where referral to a genetics specialist is required
- Confirm the information obtained by the patient from the genetic specialist has been understood, prior to discussing further management.



Henk ter Heide ccl  
<http://www.flickr.com/photos/99343243@N00/1809414241/in/photostream/>

### Two Sample pedigrees

<http://www.cyrillicsoftware.com/products/cy3screenshot.htm>

<http://eyegene.ophthy.med.umich.edu/madeline/webservice.php>

**A finished chart is more than a method of recording family medical history graphically, although this in itself is useful. The completed chart can be used to review the distribution of disease/condition in the family and make deductions about the possible patterns of inheritance.**

## How to deduce simple patterns of inheritance from pedigree charts : A step-by-step guide

For conditions that are under the control of a single gene there is usually a predictable pattern of inheritance, autosomal recessive, autosomal dominant and x-linked recessive each having distinctive characteristics. Knowledge of the pattern of inheritance can be used to identify who is at risk and probability of re occurrence.

**1.Examine an Overview** of the complete chart for any of the following pattern characteristics which indicate which is the most likely of these three types of inheritance.

### **Autosomal Recessive:**

Approximately equal numbers of males and females effected  
Two unaffected parents may have an affected child

### **Autosomal Dominant**

Approximately equal numbers of males and females effected  
Affected child must have at least one affected parent  
Two affected parents may have an unaffected child

### **X-linked Recessive**

More males than females effected  
Most affected males have unaffected parents  
No male to male transmission

**2. Conclude:** Which of these patterns is the probable mode of transmission

**3. Verify** which of the three types of inheritance could account for the pattern observed in the pedigree and which could not.


### **Reminder of Basics:**

With the exception of genes on the X chromosome in males, there are two copies (two alleles) of each gene, one maternal one paternal. For single gene disorders, dominant alleles are represented with a capital letter, and recessive alleles by a lower case letter.

**Autosomal recessive** the condition is carried on the **r allele**, an individual with the **condition must be homozygous recessive (rr)**

**Autosomal dominant** the condition is carried on the **R allele**, an individual with the **normal phenotype must be homozygous recessive (rr)**

**X-linked recessive :** the condition is on the **X<sup>r</sup> allele** **males with the condition have the genotype X<sup>r</sup>Y**, females with the condition must have the genotype **X<sup>r</sup>X<sup>r</sup>**

 **See “Over View of Basic Genetics” page 44 for more details**

### Worked Examples:

Consider which mode of inheritance is accountable for each of the examples of pedigree charts (A, B, and C)

#### Key (for pedigree charts A,B and C)

- Phenotypically normal female
- Affected female
- Phenotypically normal male
- Affected male
- ◇? Individual of unknown phenotype and sex
- \* Proband
- R Dominant allele
- r Recessive allele



<http://images.wellcome.ac.uk/>

#### i) Pedigree Chart (A)

##### Overview:

Equal numbers of males and females with the condition  
Parents with the condition may have unaffected children

##### Conclusion:

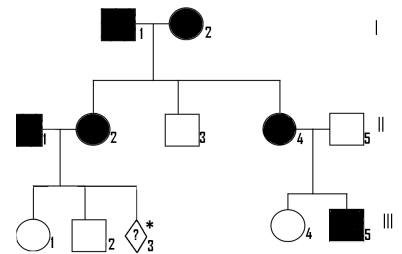
The probable mode of transmission is **autosomal dominant**

##### Verification:

**IF** the condition is **autosomal dominant** III1, and III2 are normal and therefore must have the genotype rr, one r allele from each of their parents II1 and II2, who since they have the condition must both be heterozygous (Rr).  
II2 having received R from one parent and r from the other.

(The remaining genotypes can be completed in a similar fashion resulting in the verification that autosomal dominant is the probable form of inheritance for this pedigree)

#### Chart A :





**However** the possibility of other types of inheritance also fitting the observed pattern should also be tested.

**IF** the condition is **autosomal recessive**

I1 and I2 both have the condition and so would both have to be rr.

In which case **ALL** their children would be rr and affected (since neither of the parents would have a R for them to inherit)

**HOWEVER**

Their children are **NOT AFFECTED**

and therefore for do not have the genotype rr

Therefore autosomal recessive is not the probable form of inheritance for this pedigree

**IF** the condition is **X-linked recessive**

I1 is affected and would have to have the genotype  $X^r Y$

I2 is also affected and would have the genotype  $X^r X^r$

In which case **ALL** their children would be effected (since neither of the parents would have a  $X^R$  for them to inherit)

**HOWEVER**

Their son (II3) is **NOT AFFECTED** and therefore for does not have the genotype  $X^r Y$

In addition there should also be in total more males than females and there are not.

Therefore it can be concluded that X linked recessive is not the probable form of inheritance for this pedigree

### **Test your understanding with these interactive revision exercises**

- i) Testing knowledge of pedigree chart symbols drag the labels to the appropriate symbols
- ii) Matching narrative to pedigree chart:
- iii) Identifying warning signals in pedigree for each of the cases identify the probable mode of inheritance.

 **Suggested Activity:**

Visit the site

<http://pa.nchpeg.org/>

which has some useful

additional resources,

including a genetics primer and

genetics testing,

(accessible by following the

tabs at the top of the page).

<http://pa.nchpeg.org/flash/exercises/pedmatch.html>

<http://pa.nchpeg.org/flash/exercises/pednarr.html>

<http://pa.nchpeg.org/flash/exercises/redflags.html>

## ii) Pedigree Chart (B)

### Overview:

Equal numbers of males and females with the condition  
Parents without the condition may have affected children

### Conclusion:

The probable mode of transmission is **autosomal recessive**

### Verification:

**IF** the condition is **autosomal recessive**,

II1 is affected as is II2, and therefore must have the genotype rr.

II2 inherited one r allele from each of her parents I1 and I2.

I1 and I2 are both unaffected,

and therefore must both be heterozygous (Rr).

(The remaining genotypes can be completed in a similar fashion resulting in the verification that autosomal recessive is the probable form of inheritance .

### HOWEVER

the possibility of autosomal dominant and X-linked recessive also fitting the observed pattern should also be tested.

**IF** the condition is **autosomal dominant**

I1 and I2, who are unaffected, would both have the genotype rr

and **NONE** of their children would be **AFFECTED**

since neither parent has an R allele for them to inherit

**HOWEVER** their daughters II2 and II4 are **BOTH AFFECTED**

Therefore autosomal dominant is not the probable form of inheritance for this pedigree

**IF** the condition is **X-linked recessive**

II2, being an affected female, would have an  $X^r X^r$  genotype.

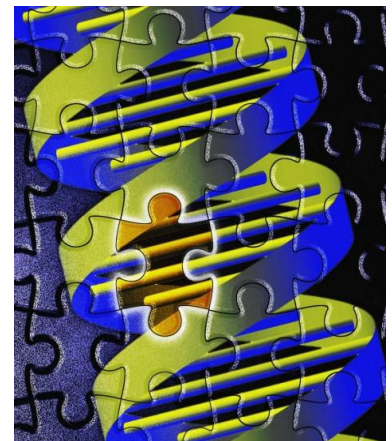
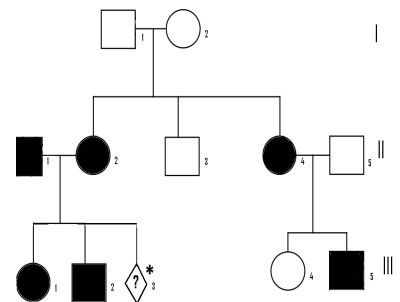
For II2 to have this genotype she would have had to inherit a copy of  $X^r$  from **BOTH** her parents, in which case her father would be  $X^r Y$  and **AFFECTED**,

**but he is not!**

In addition there would be expected to be, in total, more males than females and there are not.

Therefore X linked recessive is not the probable form of inheritance for this pedigree

Chart B:



<http://images.wellcome.ac.uk/>

### iii) Pedigree Chart C

#### Overview:

Only males have the condition. Maternal grandfather and a grandson are affected. No male to male transmission. Unaffected parents may have affected sons.

#### Conclusion:

The probable mode of transmission is **X linked recessive**

#### Verification:

**IF** the condition is **X linked recessive**

I1 is **AFFECTED** and will therefore have the genotype  $X^r Y$ .

**BOTH** his daughters will inherit this  $X^r$  and will be carriers  $X^r X^R$

II1 is unaffected and therefore has

the genotype  $X^R Y$

III3 inherits the Y chromosome from his father and the  $X^r$  from his mother and is therefore **AFFECTED**

II4 is a carrier  $X^r X^R$  II5 is unaffected  $X^R Y$ .

Their son III5 is **UNAFFECTED** and therefore has the genotype  $X^R Y$ .

(He inherited Y from his father and  $X^R$  from his mother)

verification that **X linked recessive** is the probable form of inheritance for this pedigree

#### HOWEVER

the possibility of autosomal dominant and autosomal recessive fitting the observed pattern should also be tested.

**IF** the condition is **autosomal dominant**

III3 is affected and therefore has at least one R allele.

This R would must have been inherited from one of his parents

**BUT BOTH** his parents are **UNAFFECTED** and would be rr

Therefore autosomal dominant is not the probable form of inheritance for this pedigree

**IF** the condition is **autosomal recessive**

I1 is affected and would have the genotype rr

Since I2 is **UNAFFECTED** she must have at least one copy of R

It is therefore possible for their children to be Rr, and therefore **UNAFFECTED**.

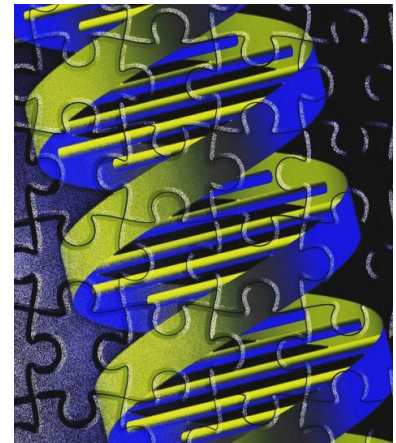
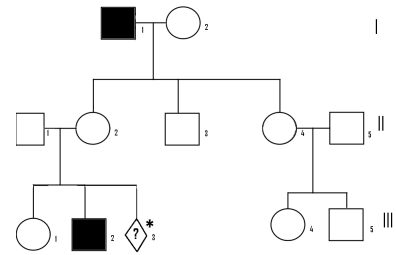
III2 is **AFFECTED** and therefore would have the genotype rr.

The r alleles were inherited from his mother and father who, since they are

**UNAFFECTED** would be heterozygous carriers (Rr).

Therefore it can be concluded that **autosomal recessive** is **ALSO** a possible form of inheritance for this pedigree

Chart C:



<http://images.wellcome.ac.uk/>

## Other factors effecting pedigree chart pattern

As can be seen from pedigree C, even in cases of single gene conditions definite identification of the mode of inheritance from the chart alone is not always possible. There are other factors that can affect the pattern observed in the family pedigree chart. Knowledge of these will help the non geneticist identify complex situations which may require referral, and also enable them to explain such complex patterns to patients, if required, after they have seen the genetics specialist. Not all affected individuals may be shown in the pedigree; factors which may cause this include:

### Late onset conditions:

Individuals may be reported as being non-affected when in fact they just have not yet developed the symptoms. Such an individual in the pedigree chart may appear to be unaffected when they actually are! Bayesian analysis, which takes prior events into account may be used to calculate risk in such a situation. In the case of a late onset condition the age at which individuals in the family developed symptoms and the present ages of any possibly affected but as yet non symptomatic individuals would be significant.

### In utero death:

Foetuses with a particular genotype may die in utero, as occurs in the X-linked dominant condition incontinentia pigmenti. In this condition affected males die in utero and only affected females occur in the pedigree, therefore altering the observed pattern in the pedigree chart.

<http://ghr.nlm.nih.gov/condition=incontinentiapigmenti>

Other factors which can complicate the analysis of the pedigree chart include:

### Anticipation:

In conditions that show anticipation the onset of symptoms tends to get earlier and more severe as it is passed to future generations. So the great grandfather may have only developed very mild symptoms late in his adult life yet his great grandson is severely affected at an early age.

It is possible in such a situation that the occurrence in earlier generations has gone unrecorded and that the severely affected child is thought to be exhibiting the effects of a *denovo* mutation, whereas in fact there is already an established family history with the associated risk to other members of the family.

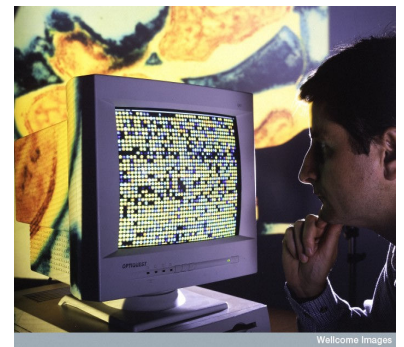
## Online resources

1) Examples of complications to pedigree patterns can be found in Molecular genetics 2 (Strachen and Read 1999)

These are available online at <http://www.ncbi.nlm.nih.gov/books/bv.fcgi?rid=hmg.figgrp.248>

Explanations are given at <http://www.ncbi.nlm.nih.gov/books/bv.fcgi?rid=hmg.section.286>

Additional information can be accessed from the links at the left hand side of the same web page.



<http://images.wellcome.ac.uk/>

Examples of conditions that exhibit anticipation include myotonic dystrophy and fragile-X syndrome. Explanation of the genetics of anticipation can be found at <http://ghr.nlm.nih.gov/handbook/inheritance/anticipation>

### **Reduced Penetration:**

Results in not all individuals who have the mutated gene being symptomatic, and not all individuals developing the condition at the same age. An example of genes with variable penetrance are those associated with familial breast cancer BRCA1 and BRCA2.

Differences in degree of penetration are probably caused by interactions between BRCA1 and BRCA2 with environmental factors, as well as with other genes in the individuals genotype which may have a modifying effect. It is these modifying factors which are combined with the genetic information in online risk calculator programs. (see page 23)

### **Variation in Gene expression or expressivity:**

Refers to the situation where individuals who have the same mutated form of the gene have very different degree of symptoms, and it is difficult to predict who will be severely affected and who will not be.

An example of such variation in expression is found in the FBN1 gene associated with Marfan syndrome, where manifestations in individuals vary from having no debilitating affects (apart from characteristic features and stature) to life threatening abnormalities.

<http://ghr.nlm.nih.gov/handbook/inheritance/penetranceexpressivity>

Professionals who do not have a specialization in genetics would normally refer cases with complicated pedigrees to the genetics counselling service. Although some non geneticists may develop considerable expertise, especially in those areas which present themselves frequently in their clinical practice .

For example:

Professionals serving a population with a high incidence of thalassaemia and sickle cell anaemia will be more familiar and build up a certain expertise with the genetics of these conditions compared to those who serve a population where thalassaemia and sickle cell anaemia are rare

### **Reduced penetration and variation in gene expression**

These can both also obscure the pattern of inheritance demonstrated by the pedigree chart.

Normally, in conditions exhibiting a simple Mendelian pattern of inheritance for dominant diseases homozygous dominant and heterozygous individuals will exhibit the condition whereas and homozygous recessive individuals will not.

i.e. If you have the gene you will have the condition, this is 100% penetration.

## HOW to get from the pedigree chart to an estimate of genetic risk

### Risk Calculation from knowledge of the mode of inheritance

Knowing the mode of inheritance and examining the probands location in the family pedigree chart, and the phenotypes of his relatives, it is possible to calculate the probability of the individual being:

Homozygous recessive (e.g.  $rr$  or  $X^rX^r$ ),

Heterozygous (e.g.  $Rr$ , or  $X^rX^R$ )

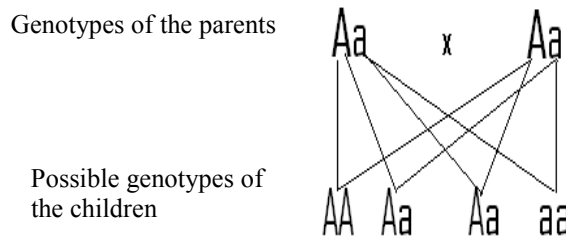
Homozygous dominant ( $RR$  or  $X^RX^R$ )

and therefore (dependent on the mode of inheritance) if the individual will be affected or not affected.

For single gene disorders, it is possible to calculate the probability of inheriting the condition.

Two pictorial methods for illustrating the possible genotypes of children which might be produced by parents of known genotype are

#### Genetic tree diagram Or Mating Diagram



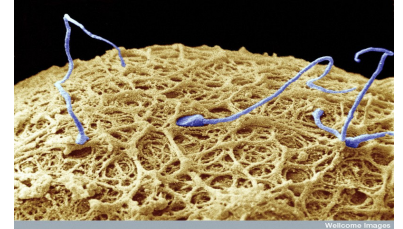
**Punnett Square :** where the possible gametes of the parents are shown at the top and down the side, and the resulting possible genotypes of the children are inside the grid

	A	a
A	AA	Aa
a	Aa	aa

#### Basics:

Each individual has two copies (two alleles) of each gene in their somatic cells; each egg or sperm getting one of the two alleles in each pair.

**(Except sex linked genes in males).**



<http://images.wellcome.ac.uk/>

If both parents are

heterozygous ( $Aa \times Aa$ )

**The father produces sperm** with allele (a)

and sperm with allele (A).

**The mother has ova** with

allele (A) and ova with allele (a)

**If a sperm with allele (A)** fertilised an egg with allele (a)

the baby would be **Aa**

**If a sperm with allele (A)**

fertilised an egg with allele (A) the baby would be **AA**

**If a sperm with allele (a)**

fertilised an egg with allele (A) the baby would be **Aa**

**If a sperm with allele (a)**

fertilised an egg with allele (a) the baby would be **aa**



Both styles of diagram can be found in health literature. The inheritance tree has the possible disadvantages of being prone to errors when sketched rapidly, and resembles the layout seen in pedigree charts (parents on one line joined to children on a lower line), which could be confusing to the patient, and a source of potential misunderstanding. Punnett squares will therefore be the format of choice in this guide.

**Pedigree charts record the existing family health history**  
**Punnett squares/tree diagrams predict the probability of an individual having a particular genotype**

### Quick explanation of Probability:

If an event is absolutely certain to happen, eg the probability of an individual dying eventually, the event is said to have a probability of 1.

If an event is absolutely certain not to happen, eg the probability of the page (or screen) you are reading turning into pure gold within the next 5 minutes!, the event is said to have a probability of 0.

All probabilities therefore have values between 0 and 1. Probabilities are sometimes referred to in terms of percentage chance a probability of 0 being 0% chance and a probability of 1 being 100% chance

#### Calculations with probabilities:

If a coin is flipped it will either land with the head side up or the tail side up, these are the two possibilities.

There is therefore a 0.5 probability of a tail ( 50% chance)

And a 0.5 probability of a head (50% chance)

Providing that events are independent

(i.e. none effects the probability of any of the others happening) the probability of two or more independent events happening ALL happening is the **PRODUCT** of the individual events

This is known as **the product law of probability**

So if the probability of the first event is P1 and the probability of the second even is P2 and the probability of the third event is P3 the probability of ALL THREE events happening according to **the Product Law of Probability** is

**P1 x P2 x P3**

If there are more than one ways of independent events happening then the probabilities are added this is **the Addition Law of Probability**

**P1 + P2 + P3**

Read this about punnett squares and inheritance trees  
[http://anthro.palomar.edu/mendel/mendel\\_2.htm](http://anthro.palomar.edu/mendel/mendel_2.htm)  
 Then try this practice quiz  
<http://anthro.palomar.edu/mendel/quizzes/mendqui2.htm>



### Examples:

What is the probability (P) when flipping a coin of getting tail, tail, head

#### IN THAT ORDER

P1 of getting “tail”(T) is 0.5

P2 of getting “tail”(T) is 0.5

P3 of getting “head”(H) is 0.5

Therefore the probability of tail, tail, head (PTTH)

**in that order** is

$P1 \times P2 \times P3 = 0.5 \times 0.5 \times 0.5 = 0.125$  or 12.5% chance

The probability of getting two tails and a head **in ANY order**  
 $P TTH + PTHT + PHTT = 0.125 + 0.125 + 0.125 = 0.375$  or 37.5% chance

## Calculating the probability of a given genotype:

### 1) Where both parents are known heterozygotes. $Aa \times Aa$

To produce a baby with AA

both the sperm AND the egg must contain the (A) allele

so the probability of this occurring is the probability of the egg having (A) multiplied by the probability of the sperm having (A)

$$0.5 \times 0.5 = 0.25 \text{ probability or 25\% chance.}$$

A similar calculation results in a

0.25 probability that the babies genotype is aa.

Calculating the probability that the baby has a genotype of Aa however is slightly different

because there are **TWO WAYS** that a baby can have a Aa genotype

So the probability of the baby having this genotype is therefore the **SUM** of the **TWO** probabilities

The probability of the sperm having (A) and the egg having (a) =  $0.5 \times 0.5 = 0.25$

The probability of the sperm having (a) and the egg having (A) =  $0.5 \times 0.5 = 0.25$

**BOTH** of these will result in a baby with genotype Aa

So the probability of the baby having the genotype Aa =  $0.25 + 0.25 = 0.5$

Or 50% chance.

i) For this same mother and father ( $Aa \times Aa$ ). What is the probability if they only have two children that they will both be affected?

P first child aa x P second child aa

$$0.25 \times 0.25 = 0.0625 \text{ or 6.25\% chance}$$

ii) What is the probability if they only have two children that they will both be unaffected

P first child AA or aa x P second child AA or aa

$$(0.25+0.5) \times (0.25+0.5) = 0.5625 \text{ probability}$$

or 56.25% chance

iii) What is the probability of them having a second affected child after they have already had one affected child

P child aa = 0.25 probability or 25% chance

### Theory:

By convention the alleles in the eggs of the mother are placed at the top of the square and the alleles in the father's sperm are placed down the side.

$Aa \times Aa$

	A	a
A	AA	Aa
a	Aa	aa

Like in the coin toss there are two options,  
the egg contains either an (A) allele or an (a) allele.

So the probability for either event is 0.5. Similarly for the sperm the probability a sperm has an (A) allele is a 0.5 and the probability of it having an (a) allele is also 0.5.

Whether the first child is affected or not

**HAS NO EFFECT**

each pregnancy is an independent event

**PROBABILITY HAS NO MEMORY**

If their first child was unaffected there would still be a 0.25 probability of the second child being affected.

**2) If the same mother and father (Aa x Aa) have a baby that is UNAFFECTED what is the probability of this baby being a carrier ?**

**The baby has already been born and is known to be unaffected !**

**The probability of this baby being aa is therefore 0**

The probability of the baby being AA or Aa is 1.0 (100%)

These are shaded light green in the Punnett Square

There is therefore a **2/3 probability that the baby will be a carrier**

	A	a
A	AA	Aa
a	Aa	aa

**IF the baby is affected it is aa**

**IF the baby is unaffected it is AA or Aa**

**3) When one parent has a recessive disease, and is therefore homozygous recessive, and the other (unrelated parent) has no family history, What is the possibility that their baby will have a child with the condition?**

If the disease occurs in the population with an incidence frequency of  $1/X$  then the approximate incidence frequency of carriers (Nn) is equal to  $2\sqrt{1/X}$ . So if the recessive disease in this question has a frequency of  $1/400$  the frequency of carriers (Nn) equals 1 in 10.

**The combined probability** of the baby being affected is the product of

P1 (the first passing on the allele n) = 1.0

P2 (the second parent being a carrier) =  $1/10$

P3 (that both would pass on the allele n) =  $1/2$

$P1 \times P2 \times P3$  = combined probability

Which equals a probability 0.05 or  $1/20$  or 5% that the baby will be affected.

	N	n
n	Nn	nn
n	Nn	nn

**IF the other parent was a carrier the probability of the baby being nn is a  $1/2$ .**

**4) Diseases without a clear Mendelian pattern of inheritance**

These also rely on tabulated empirical risks to predict the risk of recurrence, available in standard texts.

E.g. isolated cleft palate (Crocetti et al 2004) pages 103-104.

<http://books.google.com/books?id=I3Kh1cNJxyUC&pg=PA104&lpg=PA104&dq=#v=onepage&q=&f=false> )

Reoccurrence of isolated cleft palate:

If **both parents** are unaffected and they already have one affected child

**probability of another affected child is 0.035**

if they have two affected children

**the probability of having a third affected child is raised to 0.13**

If **one parent** is affected and they already have one affected child probability of

**another affected child is 0.1**

if they have two affected children the probability of

**having a third affected child is raised to 0.24.**

### Theory:

Tables of risk can be found in most standard paediatric texts

Values of risk vary according to factors such as the number of affected relatives and the degree of their relationship to the proband, and, for some conditions, the severity of the condition in the affected individuals

### 5) Where the risk associated with predicted Mendelian inheritance (the prior probability) is modified with other factors to produce a different final relative probability

With late onset autosomal dominant conditions the older an individual's relatives become without developing symptoms the lower the probability that individual carrying the gene, these can be calculated using Bayes theorem.

For example: If two women both have a 0.5 probability of inheriting a X-linked recessive gene from their carrier mothers; if one of them already has an unaffected son then she has a lower probability of being a carrier than the other woman who has yet to have any children.

Details of the calculation can be found at the following link:

<http://www.uic.edu/classes/bms/bms655/lesson7.html#Counseling>

Although such complex cases would normally be referred to the Genetic Counselling Clinic awareness about what Bayes theorem is and how and when it is applied will help:

- in the decision making process of when to refer cases
- understanding of how online calculators of health risk function,
- in explanations to patients when they have received genetic risk information where Bayes theorem has been utilised

### 6) Age related risks:

Down's syndrome: Tables of incidence are also used to estimate an individual's risk.

A woman's individual risk of having a baby with Down's syndrome increases with age.

BUT, since most pregnancies are in women under 30 years of age, up to half of Down syndrome babies are born to mothers in this age group.

**For younger mothers even though the individual risk of having a baby with Down's syndrome is lower, the actual number of babies born/conceived is higher!**

A table showing how the risk of having a baby with Down's syndrome increases with the mother's age can be found at The Leeds Antenatal Screening Site

<http://www.leeds.ac.uk/las/Index.htm> by selecting the tab "Down's screening"

Risks range from 1 in 1529 at 20 years of age to 1 in 28 at 45 years of age.

### Theory:

Applications of Bayes theorem also permit allowances to be calculated for the sensitivity of genetic testing (false positives and false negatives) (Ogino et al 2007)

### Practice questions:

1) The GENIE website has a set of 15 questions available online and as a printable pdf file. Each of the questions is presented with a discussion of its relevant clinical relevance, the key learning points it is designed to meet and a model answer.

<http://www.le.ac.uk/ge/genie/vgec/hp/genesdisease.html>

2) Set of multiple choice probability questions from the website of Medical Genetics by Ian D Young (2006)

<http://www.oup.com/uk/orc/bin/9780198564942/resources/risk/quiz/>

## Online risk calculators

Calculations of modifying estimated risk can be very complex but many online calculators of clinical risk exist which can estimate final relative probability of developing the condition. The majority of medical conditions, which are not caused by physical trauma, are controlled by a combination of factors. These include: environmental mutagens (e.g. radiation or chemical exposure, etc.), life style factors (e.g. smoking, obesity etc.), and the genetics of the patient (or the infective agent (e.g. bacteria or virus)).

The calculators therefore typically ask questions about the individuals environmental exposures, life style (behaviour), and personal and family medical history (which adds information about the genetics); and produce the combined expected risk based on the responses. Many clinical risk tools exist which allow the effect of a wide range of genetic, environmental, and behavioural factors to be considered. In addition to aiding the practitioner these tools could also be recommended to computer literate patients to help motivate them to adopt beneficial life style changes. Four examples follow, but there are others!

### Heart disease

The American heart association have an online tool that estimates the individuals 10 year risk of heart disease taking into account genetic and environmental factors [https://www.americanheart.org/gglRisk/locale/en\\_US/index.html?gtype=health](https://www.americanheart.org/gglRisk/locale/en_US/index.html?gtype=health) Visit this location, and enter different data sets and see how the total risk varies.

In addition to risk estimation about heart disease many other online risk calculators exist that estimate the risk of cancer. Risk factors for developing cancer, like heart disease, also involve environmental, behavioural, and genetic factors. The majority of cancers are not familial (inherited), but in so far as all cancers involve changes in cellular regulation, which is ultimately controlled by genes, all cancers can be said to be genetic.

### Non-familial colorectal cancer.

The site [www.cancer.gov/colorectalcanccerrisk/](http://www.cancer.gov/colorectalcanccerrisk/) presents a series of questions, related to gender, ethnicity, age, behavioural, genetic, and environmental variables.

The scientific rationale for posing for each question can be read by selecting the (?) icon at the end of each question, and is a useful source of information both to the practitioner and for the computer literate patient.

Using the above risk calculation tool investigate how different genetic, environmental and behavioural factors affect the risk of developing colorectal cancer.



CCL John Sullivan

<http://www.pdphoto.org/Copyright.php?lid=2>

- Suggestions for different data sets:
  - Two obese individuals with low levels of exercise one a smoker and the other a non smoker.
  - Two non-smokers but one with normal BMI and the other morbidly obese.

- Suggestions for different data sets:
  - Compare the result of the risk calculation one person with normal BMI and one in the morbidly obese range. (All other factors should be the same)
  - Keep all values mid range investigate the effect of first age, then sex, family history
  - Very good diet and exercise can be compared with very poor diet etc

### Familial Breast Cancer:

Boadicea (Breast and Ovarian Analysis of Disease Incidence and Carrier Estimation Algorithm) from the University of Cambridge UK.

Use of Boadicea is now recommended in the UK NICE guidelines for cases of familial breast cancer

<http://www.nice.org.uk/nicemedia/pdf/CG41fullguidance.pdf>

Details on the use of Boadicea with screen shots are available at

[http://www.srl.cam.ac.uk/genepi/boadicea/boadicea\\_bwa.html](http://www.srl.cam.ac.uk/genepi/boadicea/boadicea_bwa.html)

It is possible to register and download this program following instructions on the home page

[http://www.srl.cam.ac.uk/genepi/boadicea/boadicea\\_home.html](http://www.srl.cam.ac.uk/genepi/boadicea/boadicea_home.html)

### OPERA:

This online risk assessment tool for breast and ovarian cancer is designed for use by members of the public.

<http://www.cancerbackup.org.uk/Aboutcancer/Genetics/GeneticBreastOvarianCancerRiskAssessmentTool>

Be aware of it (your patients might!)

A useful feature of the site is that it provides simple explanations of why particular questions are being asked.

The site as a whole is also a source of useful links for patient education.

## Consanguinity & Ethnicity:

### Consanguinity:

Consanguinity effects genetic risk, The risk of a severe congenital abnormality in a baby of non related parents with no history of such abnormalities is approximately 2%, The estimated additional risk to babies from cousin-cousin relationships is approximately 3% making 5% in total. Bennet et al 2002 present a summary.

<http://www.springerlink.com/content/uxwm5qr18j5lgrdt/fulltext.pdf> . Many institutions produce information sheets on consanguinity which present useful additional information. Links to examples of these from the Australian centre for genetics education, and Guys and St Thomas hospital (NHS) are given here.



### Activity:

Create a series of pedigrees varying the sex, age of onset, degrees of relationships of affected individuals, etc and note how this alters the risk to the proband.



### Activity:

Practice Questions.

Cancer Pedigree charts

[http://ocw.mit.edu/NR/rdonlyres/Biology/7-012Fall-2004/A9061713-DE7B-4B21-B3AC-](http://ocw.mit.edu/NR/rdonlyres/Biology/7-012Fall-2004/A9061713-DE7B-4B21-B3AC-1CD6FC2B11EE/0/can3a.pdf)

[1CD6FC2B11EE/0/can3a.pdf](http://ocw.mit.edu/NR/rdonlyres/Biology/7-012Fall-2004/A9061713-DE7B-4B21-B3AC-1CD6FC2B11EE/0/can3a.pdf)

MIT Biology Department



<http://images.wellcome.ac.uk/>



The Australian centre for genetics education

<http://www.genetics.com.au/pdf/factsheets/fs16.pdf>



Guys and St Thomas hospital (NHS)

<http://www.guysandstthomas.com/resources/patientinfo/genetics/genetics/Consanguinity.pdf>



## Ethnicity:

Ethnicity may also influence genetic risk. Ethnicity and genetics, due to historical events during the eugenics movement (page 35), is potentially a controversial and ethical minefield, and consequently may be an emotive topic to some. However, at least certain genetic conditions have been observed to occur at different rates of incidence (and therefore have different rates of occurrence) in different ethnic groups.

The two probable mechanisms for this are:

**a) Genetic:** Geographically or culturally isolated groups develop and maintain ethnic identity. Members in these communities tend to “marry from among themselves”. Population geneticists would refer to this as “inbreeding” however this term has emotive connotations to the lay public (see page 36) and its use should be avoided! The result after generations of “marrying among themselves” is that individuals in an inbreeding community share certain genes at a higher incidence than occurs in an outbreeding population.

Examples of this include: Incidence of conditions such as Tay-Sachs (1 in 30 carrier frequency in the Ashkenazi Jewish population compared to 1 in 300 in other populations (Roe and Shur 2007). Raised incidence is not only seen in the Ashkenazi Jewish population, for example, there are carrier frequencies of between 1 to 192 and 1 to 52 in Americans with an Irish ancestry (Roe and Shur 2007), Spinal Muscular Atrophy (SMA) varies in carrier frequencies from 1 in 25 in Germany to 1 in 63 in China (Smith et al 2007).

**b) Behavioural and Environmental** The majority of medical conditions are controlled by a combination of environmental, life style factors and genetics (see page 23). Ethnic groups often also have distinctive life styles, and may be exposed to either different mutagens, or increased exposure to a specific mutagen when compared to other population groups.

For example: Obesity (a life style factor) has been demonstrated to increase the risk of colorectal cancer (Moghaddam et al 2007), and high level consumption of traditionally salted fish (increased exposure to mutagens (possibly N-nitrosodimethylamine)) has been related to increased levels of nasopharyngeal carcinoma incidence in China, Tunisia and Alaska (IARC 1993).



Read more about common diseases in the Ashkenazi Jewish population at <http://www.jewishvirtuallibrary.org/jsource/Health/genetics.html>

Reflect on the results obtained from extreme variation in diet in the estimations of risk obtained from the online risk calculators, and which categories the following ethnic diets would fall into:

- Indian
- Japanese
- Mediterranean

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**VOL 56** (p. 41)  
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## How individuals perceive risk and methods to communicate risk

The purpose of risk communication on matters related to health is to help the patient make informed decisions. There are a variety of circumstances where a patient might need to make such a decision.

These include choosing

- between two or more treatment options
- to give consent for a procedure or not
- to have a baby even though there is known risk of congenital abnormality

Factors affecting the communication of risk are quite complex. Patients decision making is based of their perception of the risk rather than the actual statistical risk alone (O'Doherty and Suthers 2007). Generally, for a decision to be made the patient needs to know the nature of the possible negative out-come (how serious or debilitating is it) and the probability of it occurring. For some health conditions how to limit the probability of a negative outcome is also relevant, eg life style changes (loss of weight, quitting smoking) to lower the risk of heart attacks (Weinstein 1999). The nature of the consequences of a negative outcome must be appreciated and considered together with the risk of it occurring. Generally if the negative outcome is minor or treatable then the patient may find a relatively high level of risk acceptable, whereas the risk of a more serious debilitating condition for which there is no treatment would be rejected at this same level.

However, communication of risk, and in particular genetic risk, is not a simple clinical transfer of information, it is frequently laden with problems. Etchegary and Perrier (2007) report on evidence to show how difficult the process of effective genetic risk communication can be, and how, even after counselling, individuals may still fail to have an accurate understanding of their genetic risk.



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### For example

The consequences of the negative out come (eg a baby effected with an inherited genetic disorder) should be understood by the patient in terms of the nature and probability of the symptoms which would be present in the baby and the baby's long-term care needs and prognosis.

Although they may wish to understand, even in simplified terms, the aetiology of the condition (what would cause our baby to be sick?), this knowledge is not essential to reach a decision about the risk.

Etchegary and Perrier (2007) use the heuristic-systematic model of information processing to describe the process of risk communication. The model describes the heuristic approach whereby information is processed superficially and often quickly and the systematic approach where there is deeper consideration of the information received. The systematic approach requires more effort and thought and normally takes longer.

Results from the study by Kahlor et al (2003) show that while these two approaches are not mutually exclusive within the decision making process there is normally a tendency by the patient to favour one approach over the other. The systematic approach is used when the risk being considered is of high importance to the individual and when that individual appreciates that it is their decision to take. Conversely the heuristic approach is taken if the risk is of low personal interest to the patient and when they judge the information being presented is “beyond them” and they can't see the benefit of processing further. Some individuals when faced with a decision to make in a high risk situation will “switch off” and deal with the information heuristically, possibly trying to transfer the responsibility for taking the decision to the health care professional. This observed “switching off” is described by McAllister (2003) as a lack of engagement and defined in the paper as being “the degree of cognitive and emotional involvement” when faced with the information about their increased risk and is probably a defensive coping mechanism. Another motive which may influence some patients is the desire to give the “right” or “socially accepted” answer; once they have identified what they think they are expected to say they stop processing any further information. Systematic processing, where the patient is actively involved in processing the information, results in better understanding by the patients of the information and risks presented and consequently a more valid decision making process (Natter and Berry 2004).

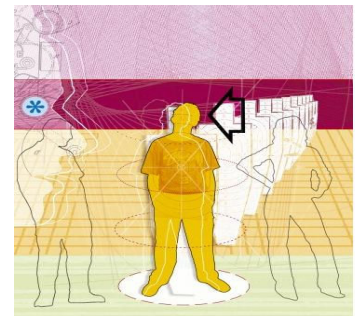
Of course there are other factors that influence an individual's behaviour even after they have understood the risk factors. Their decision may be influenced by their emotional feelings, personal beliefs, social pressures, and financial issues (Weinstein 1999). Misconceptions of the process of genetic inheritance may exist which interfere with the processing of the reception and processing of the risk information being explained to them. For example, previously held beliefs based on their observations of their family

such as **“in our family only the females are affected”**  
or **“I am sure to get the same as my father because I look so much like him”**

Misconceptions such as these are related to the individuals understanding of inheritance and genetics they are discussed further in that section (page35).

🌐 **Reflect on how patients in your own clinical experience have reacted to risk information.**

🌐 **The behaviours described are so common that they are frequently parodied in modern hospital sit-coms. Watch some episodes and identify which real-life reactions the interaction in the drama is based upon.**



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**However the understanding the magnitude of the risk and consequences of a negative outcome are probably the major elements that effect the decision reached.**

## Problems that may occur while communicating risk and help to avoid them!:

### Avoid Qualitative Expressions:

Qualitative expressions of risk such as, large, negligible, and small mean different things to different people. If the doctor and the patient do not share the same interpretation of the terms used, this can lead to miscommunication, and erroneous decisions may be reached by the patient as a consequence (Sedgwick and Hall 2003).

The following activity, described by Sedgwick and Hall 2003) demonstrates the potential problems of using qualitative descriptions:

A group of colleagues working in the same with the same group of patients

- make a list of events and conditions experienced by their patients, for which they were commonly required to give risk estimates (E.g. probability of Down's syndrome in the unborn baby, probability of developing breast cancer etc.)
- add to this list numerical values
- and finally add a qualitative description of this risk (e.g. Unlikely, occasionally, probably etc.).
- then the lists are compared.

If this exercise is undertaken there is frequently a wide range of divergence.

This exercise illustrates the extent to which caution must be taken in using qualitative terms, because if such divergence of understanding is found among practitioners it can be expected that patients' understanding will be equally, or even more diverse.

- **Repeat this exercise among your colleagues to raise awareness of how variable the understanding of qualitative expressions can be.**

### Practical suggestions to facilitate systematic risk processing by the patient (derived from Etchegary and Perrier (2007)):

- Give enough time
- Emphasise that any decision is theirs to make.
- Acknowledge that there are many things to consider.
- Numerical information presented both in figures and pictorially
- Avoid ambiguous terms (usually, possibly etc)
- Make sure the information is pitched at the correct level for the patient
- Ensuring they have understood what has been said
- Personalize the information (eg your baby, your future family etc).

## Be Aware of Framing Effects:

Framing also has been shown to affect patients' decision making (Sedgwick and Hall 2003).

Framing, in layman's terms can be considered "the spin" that is put on a story or prediction.

For example consider the following two statements:

"Since you both carry the gene for this genetic condition there is a 25% risk each time you are pregnant that your baby will have the disease", compared with

"Both of you carry the gene but are healthy so there is a 75% chance, that's 3 out of 4, that any baby you have will also be healthy".

Basically the information is the same but the "spin" or frame is obviously different (negative in the first case and positive in the second case).

The practitioner should pay attention to and be aware of how the information they present is phrased. It is possible for a practitioner to subconsciously bias the facts presented by framing them in an exclusively positive or negative manner to reflect their own opinions as to what decision the consultand should make.

Be aware of your own beliefs and opinions about the situation and try not let these frame your presentation of the facts which could result in you, unintentionally or otherwise, imposing "what you would do" on the patient.

## Make sure you are aware of the patient's degree of understanding of genetics and any misconceptions they may have

Misconceptions about genetics and inheritance, such as those described on page 36, may interfere with the understanding of genetic risk (page 29). By being aware of the patient's knowledge and preconceptions gives you the opportunity to correct misconceptions and aid their understanding of the risk.

## Avoid emotive words

Due to historical negative connotations, misconceptions or misuse in the popular media certain words relating to genetics and inheritance may provoke an emotive response, blocking effective communication. Be aware of these words, see page 36 for examples, and try, where ever possible, to use alternatives.

## Exercises in Framing

- Prepare each of the scenarios used for the calculations (page 19-20) as both negatively framed and positively framed explanations to the patients. Role-play each of these, taking turns with a colleague, and/or record the conversation. Reflect on the difference that framing made to the message.



<http://www.flickr.com/photos/tojosan/1582834566>

- If you already communicate risk to patients as part of your clinical practice, reflect on your present approach to explaining risk. How do you frame your explanations? Is your present practice imposing your opinion on the patient, or does it help them reach an independent decision



## Avoid Stereotyping:

If the patient feels they are being patronised and/or stereotyped it is also likely to provoke an emotive response and block effective communication.

Conscious or subconscious stereotyping by the health care professional may result in them jumping to conclusions about the patient's capability to understand and/or the type of decisions they will make. In a worst-case scenario this could lead to a patient not having everything fully explained to them, or even not being offered a full range of options because of the assumption that

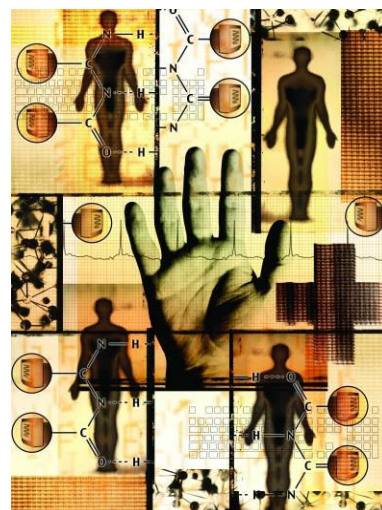
"individuals from that group/community never except such and such an option".

### Do not assume:

- That well-educated individuals will automatically have good knowledge, or that poorly educated individuals will know nothing (they may have taken great efforts to learn about "their particular problem").
- That lack of knowledge reflects low intelligence.
- That a patient's ethnic/cultural/social group dictates what decisions they will make. (E.g. deciding to terminate a pregnancy). Take every case individually and, while being sensitive to how the subject is raised, explain all options to all patients

### Do be aware of :

- common stereotypes, some of which might apply to patient groups in your practice, and be vigilant that you yourself are not, even subconsciously, applying these stereotypes to your patients.



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## Make sure tools you use to help explain are helping and not causing more confusion!

There is no one method of explaining risk that will work for all people in all situations, be prepared to use a selection of different approaches if necessary. Some people understand pictures better than numbers, others prefer verbal comparisons. By having at your disposal a variety of ways of explaining risk, some verbal, others numerical or graphical, it is possible to choose the method of delivery of the information that is most meaningful to the patient. In addition, it is possible, and may be preferable, to present the information using more than one method (Dolan and Iadarola 2008).

### Activity

- Using cases you have read earlier (or write your own!) prepare tools to help you explain the risk involved
- Practice using these tools in "mock consultations" with colleagues, friends, and neighbours!

## Selection of tools for explaining risk

The following are all approaches which have been adopted to explain risk. There is almost certainly no perfect approach suitable for use for all individuals and for all situations. The approach will vary according to what and to whom, the information being presented. It is useful to have as many tools as possible available.

### Numerical:

The numbers should be presented as a ratio or percentage (see probability page 18) However numbers are easily forgotten or, remembered incorrectly which is probably worse. For example a 1 in 4 possibility of an affected baby (each pregnancy) for a couple who are carriers of a particular autosomal recessive disease (page 20-21) can be remembered as a four-fold possibility or in the case where they already have 1 affected child that the next 4 will be unaffected.

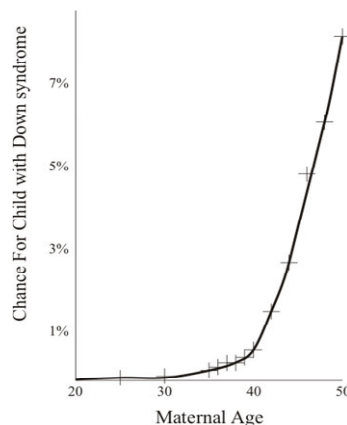
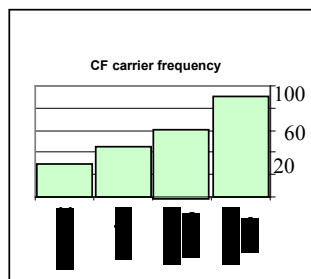
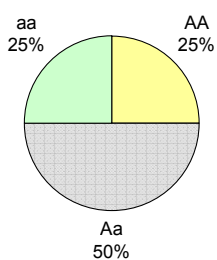
Consideration should be given to writing down the numbers for the patient, or preparing a post consultation written summary, or having suitably highlighted patient information sheets available. Numbers are probably best used in combination with some type diagram (graphical, scalar, or pictorial).

If the parents are both carriers of an autosomal recessive disease what is the probability of their unborn baby having the disease (being aa) ?

	A	a
A	AA	Aa
a	Aa	aa

The probability of the baby having the disease can be given as:  
1 in 4 or 1:3 or  $P = 0.25$   
or 25%

### Graphical: Examples of graphs



[http://commons.wikimedia.org/wiki/File:Maternal\\_Age\\_Effect.png](http://commons.wikimedia.org/wiki/File:Maternal_Age_Effect.png)

The punnett square above is itself a graphical representation of probability. Graphical images come in many forms, which to use depends largely on what you need to show.

**However, it is important that you fully understand how any graph you use was compiled and how to explain the information on your graph before you face the patient!**

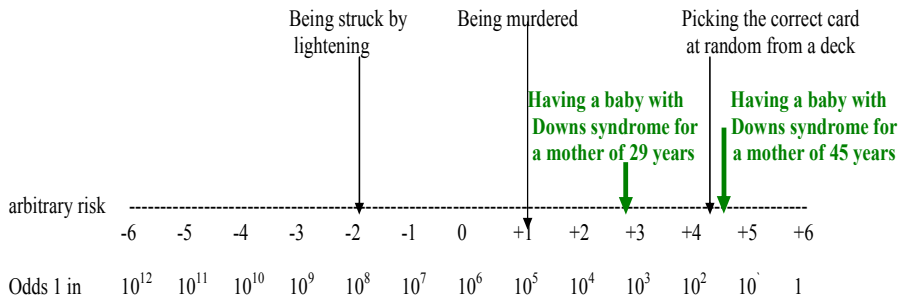
## Scales:

Scales could be considered as a distinct category of graphical representation.

Risks are presented on a scale in order to allow comparison, to see the risk within context. An example of this is the “The Paling Perspective Scale” In “Up to your armpits in alligators”(1997) Paling describes it as a “A Richter scale for risks”, and summarises his approach in an article in the BMJ (Paling 2003)

<http://www.bmj.com/cgi/reprint/327/7417/745>

Paling suggests setting up a scale from +6 (absolutely certain) to -6 (almost impossible) placing along this scale risks which are familiar and then comparing the risk to be explained with these.



Read about John Paling's approach  
<http://www.johnpaling.com/perspective.html>

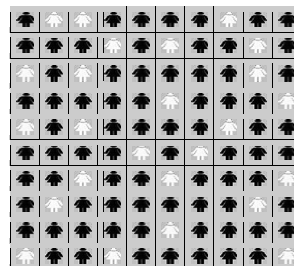
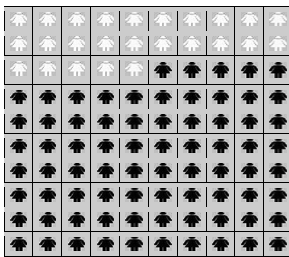


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These two grids **BOTH** represent a probability of 0.25 (25%)

## Pictorial:

Choice of which to use again depends on purpose



The left hand grid of black and white figures is ordered by rows, the right hand grid shows the same number of figures but at random.

Both presentations are valid, the block presentation conveys the probability of the event most clearly but the scattered presentation helps the understanding of randomness (Ancker et al 2006).

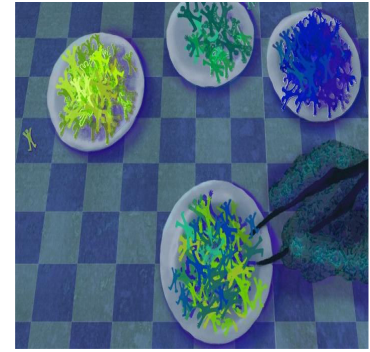
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## Public understanding of genetics & explaining genetic and inherited conditions to patients

Confirming the patient's understanding and opinions is an important part of medical communication during clinical consultation.

It is absolutely vital in the communication of genetics, since this is a topic of which patients may have pre-conceived ideas (not necessarily correct) and firmly held opinions. An awareness of some of the misconceptions about genetics amongst the lay population will help the health-care professional in this process.



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### “Bad Blood” and other Misconceptions:

While some patients may have an excellent grasp of their genetic condition (either due to educational background or individual research) this is not the case for all. Recent research by Dillard et al (2008) studying the communication of genetic risk information about cystic fibrosis documents the variation of information held by parents both in terms of quantity and quality.

It is still not uncommon, especially in members of the older generation, for genetic disease to be considered to be “something bad that is passed through the blood” and, in many communities, to be known to have the resulting “tainted” blood is considered a source of stigma (Frazier, 2006.). These negative messages, found not infrequently in the communal understanding of genetic disease, are to some extent the legacy of the propaganda messages propagated by the eugenics movements in the first half of the last century. The eugenics movements no longer exist, but the perceived stigma of having an undesirable trait, genetic disease, or “tainted blood” lives on.

Some perfectly accurate and scientifically correct genetic terms can present an entirely different message to some members of the lay population. It is important to be aware that this may occur and to know which genetic terms are likely to cause misunderstandings and an emotive response in your patient population:

#### Links to Eugenics:

<http://www.intute.ac.uk/healthandlifesciences/cgi-bin/browse.pl?gateway=medhist&id=96182>

(A collection of links about the history of eugenics in Europe, the USA and Australia)

**Examples** of such terms, together with possible lay understanding, include:

- **Mutation:** An alteration in a gene,
- **Normal/abnormal :** Affected or not affected by the condition
- **Inbreeding:** A situation that exists when a population choose partners from among themselves, for many generations, rather than from outside the population, often due to geographical or cultural isolation. The result of inbreeding is an increase in homozygosity.
- **Carrier:** An individual who is heterozygous for an autosomal recessive gene and who therefore does not have the condition but may pass it to their children
- After years of sci-fi films mutant equates for many to being abnormal and monstrous
- Similar to mutation: abnormal has the implication of being an abomination
- Inbreeding is equated by some to being the same as incest. Isolated communities are likely to be particularly sensitive to such suggestions.
- Confusion with “carrier” of a viral or bacterial disease (such as AIDS or Tuberculosis) result in some thinking that genetic disorders such as cystic fibrosis are infective and may be caught by contact with carriers.

### Communicating about Genetics: examples of common misconceptions and the confusion behind them

Genetic inheritance therefore, can be an emotive subject, and must be communicated with particular care. This is to ensure the welfare of the patients and provide informed freedom of choice. It should also aim, if possible to reduce any perceived stigma (Khoury et al 2000). A recent document presenting guidance on the communication of genetics in the primary care setting is that prepared by C.Cooley (2008) from the NHS Nation Genetics Education Development Centre (NHS-NGEDC).

Ineffective communication can result in misconceptions about genetics, inheritance, and the condition being discussed. Patients previously accessing inaccurate sources of information, or, even failing to comprehend accurate information correctly can result in them believing as documented fact something that is not true! If such pre-held misconceptions are not addressed they may hinder the accurate systematic processing of information by the patient, and may cause them to reach an erroneous decision.

- Would the above terms evoke a negative response from patients in your practice?
- Are there other terms which are “best avoided” ?  
Make a list, with acceptable alternatives!



It is important therefore that the health care professional is aware of the misconceptions held by some members of the lay public. Awareness of commonly held perceptions will help the practitioner recognise when a patient is holding such a belief. Since misconceptions may interfere with the patients understanding and processing the information presented correctly, it will be necessary for the practitioner to design tactful, non confrontational, methods of challenging and correcting the misconception

**“One of the most important skills in communication  
is remembering that  
it is not what we say that is important,  
but what the patient hears and understands”**

[www.geneticseducation.nhs.uk/learning/downloads/Communicating\\_genetics\\_within\\_primary\\_care.pdf](http://www.geneticseducation.nhs.uk/learning/downloads/Communicating_genetics_within_primary_care.pdf)

### **Examples of Common Misconceptions :**

This list represents a selection of misconceptions about genetics the examples are fictitious but are representative of misconceptions that occur. The extent and nature of misconceptions will vary from community to community and within communities from individuals to individuals.

Some common misconceptions about inheritance include:

- If you have a certain mutation, then you will definitely get the associated disease.  
  
I.E. They are assuming that the disease is dominant and has 100% penetrance.
- “My father has heart problems and I have red hair like him so guess I will get heart problems too”  
  
I.E. Looking like a relative means you are at risk of the same conditions they have.

Read the publication from the NHS-NGEDC  
[www.geneticseducation.nhs.uk/learning/downloads/Communicating\\_genetics\\_within\\_primary\\_care.pdf](http://www.geneticseducation.nhs.uk/learning/downloads/Communicating_genetics_within_primary_care.pdf)



<http://images.wellcome.ac.uk/>

Watch this slideshow on the extent of genetic knowledge among first year college students. It makes interesting viewing:

<http://www.slideshare.net/BLestz/genetic-misconceptions-presentation>

- Familial breast cancer can only be inherited from your mothers side of the family

**I.E.** “Female” conditions come from the female side of the family (and male conditions from the male side).

- “Diabetes only affects the men in our family so I don’t think I will get it”.

**I.E.** If the condition (by chance) has only appeared in one sex in a family then members of the opposite sex are “safe”.

- “I was told there was a 1 in 4 risk so since my first baby was sick I should be OK with the next baby”

**I.E.** Misunderstands that the 1in4 probability applies to **EACH PREGNANCY.**

- “I have heart problems just like my dad, they persuaded him to have bypass surgery and he died on the table. Now its me, but I am not going for the surgery, or it will be just like with dad.”

Or

“ My sister was diagnosed with breast cancer 5 years ago, when she was the same age as me, and she’s fine now. I think the cancer that we have is the easier to treat kind, so I should be OK too.”

**IE** Considers that having a close relative who had the same condition means that they will automatically share the same fate.

- “I was told I had inherited this bad breast cancer gene from my mum. Mum died young but they didn’t know as much then about anti-oxidants and healthy eating, so I’m going to make sure that I eat all of the right stuff”

**IE** that diet can change or negate the gene they have inherited.



<http://images.wellcome.ac.uk/>

### Activity:

- List misconceptions which you have met in your own community.
- Survey those of your friends and family who have had no or limited scientific and/or medical training about their comprehension of genetics. (Include both younger and older individuals)
- If you work in a multi ethnic community ask your colleagues who belong to communities other than your own to repeat the above exercise

- “My mother and two of my aunts died young from breast cancer, and I know mothers grandma had it too. Breast cancer seems to skip a generation in our family, so I should be OK, but I am really worried that my baby daughter will grow up and get it.”

**IE** They are assuming 100% penetrance, if it is there it must “show”, and if it did not “show” then it was absent. Hence the “skipping generations” theory, and the conclusion that they are not at risk but their daughter is.

Research into the lay persons understanding about genetics and inheritance has revealed that understanding the topic of “How genetic material is inherited” and in particular what exactly is the link between DNA, genes, and chromosomes, often poses a particular problem. This difficulty has been observed in a range of different population groups, including:

- 14-16 year old secondary school students from West Yorkshire (Lewis and Robinson 2000)
- 40 – 49 year olds from Scotland, with no family history of genetic disease. (Emslie et al 2003)
- British Pakistani users of Genetics services (Shaw and Hurst 2008)
- Older adults belonging to different ethnic groups, 53-92 years of age, from Texas (USA) (Frazier et al 2006)

Unfortunately it is not sufficient to just ask a patient a question such as, “are you familiar with genes and how they are inherited?”

Since, according to the findings of Lanie et al (2004), patients may appear to be familiar with genetic terminology claiming to understand, and yet do not realise that their understanding of the topic is based on misconceptions.

Care must be taken when attempting to correct patients apparent misconceptions because these adoption of a “misconception” may be a coping mechanism to distance themselves from the condition, or to minimise their own personal risk. In this situation it may be necessary, depending on the practitioners own expertise, to obtain specialist help from the mental health team

Completion of the suggested activity should provide you with an overview of common misconceptions among the patients in your practice, and the process of reflection should prepare you to meet these challenges should they arise!

● Reflect on the results of the last activity paying particular attention to:

● What effect each misconception might have on the individual’s understanding and decision making.

● How necessary do you think it is to pursue the correction of the misunderstanding?

● How might you approach correcting the misunderstanding?

● Is the “misconception” being used as a coping mechanism?

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## Overview of Basic Communication

Communication is an essential skill for all healthcare professionals (Travaline et al 2005). The exact structure of the undergraduate tuition of communication skills varies from institution to institution. However a useful and widely accepted framework is that based on the Kalamazoo Consensus Statement (Makoul 2001(a)) The Kalamazoo Consensus Statement results identified seven basic components essential for effective patient doctor communication.

Kalamazoo, and similar guide lines, result from a process of consensus and therefore tend to be a simplified generalisation of the main elements of clinical communication.

It is recognised that because they are general in nature, these guidelines may need to be modified or expanded according to the nature of the specific clinical communication task required (Veldhuijzen et al 2007).

### Seven Basic Elements during the Clinical Interview

- 🌐 The greeting; establishing the relationship
- 🌐 Initiating the discussion
- 🌐 Collecting information
- 🌐 Ascertaining patients understanding and opinions
- 🌐 Communication of information
- 🌐 Discussion of the problems and agreement on the chosen plan of action
- 🌐 Closure of the discussion

The communication of genetic risk, in addition to the basic guidelines outlined above, also requires:

- 🌐 A confidence on the part of the healthcare worker in their understanding of the basic genetics relevant to the clinical problem.
- 🌐 An appreciation of when the genetic complexity is such that they need to refer the patient to a genetic specialist.
- 🌐 An understanding of how patients perceive and deal with risk.
- 🌐 An appreciation of a patients understanding of and feelings about genes and inheritance.



<http://images.wellcome.ac.uk/>

### Communication Skills Review Activities

A useful online review of medical communication skills can be found at

<http://learning.bmj.com/learning/search-result.html?moduleId=6057021>

This module “Communication skills – an up to date guide”, written by the Australian GP Kathryn Robertson, is part of the British Medical Journal Series of continuing medical education – “Just in time”.

- 🌐 The module also includes eight multiple choice questions for self assessment. The quiz is corrected online, and reasons for wrong and correct answers given. Access is free, although it does require registration

The Kalamazoo Consensus statement has formed the basis of several patient satisfaction questionnaires. Reading studies such as that of Baumann et al (2008) which analysed the results from such questionnaires will help provide insight into the patient perspective of the health care professional to patient communication process.

A novel approach to introducing patient communication into health care practice is discussed in Wong et al (2009). The research paper proposed that watching medical soap operas on television could help residents and students understand and improve their communication skills. The programmes selected by Wong et al were from the first season of “House” and “Greys Anatomy”.

The research, using selected segments dealing with particularly difficult or sensitive issues, indicated an improvement in the residents’ understanding of evidence-based communication models such as the Kalamazoo model, and confidence in applying it to their clinical practice. In addition the residents also showed significant improvement in their understanding of the seven basic communication competencies, and reported a significant increase in their confidence in dealing with difficult scenarios similar to those portrayed.

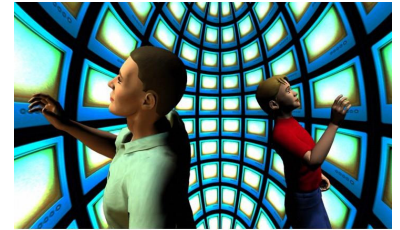
This paper is available in full as an open access resource at  
BMC Medical Education: <http://www.biomedcentral.com/1472-6920/9/9>

The Kalamazoo guidelines have also been used as the basis of clinical communication assessment tools (Makoul 2001(b), ACGME 2005, Rider et al 2006) in addition to patient feedback assessment studies of their healthcare professionals communication skills (Baumann et al 2008, Davies et al 2009).

The keeping of a reflective diary of your communication activities is a useful exercise not only for those just starting their professional lives, but even for more senior members since it helps give insight into, and facilitates awareness of, the relative strengths and weaknesses in ones own performance as a communicator.

Review these, or similar, studies, and consider the clinical communication scenario from the perspective of the patient

Using the methods suggested in Wong et al (2009) try analysing the medical communication in your favourite medical soap opera!



<http://images.wellcome.ac.uk/>

Use the assessment described in these papers to perform a self-assessment of your own practice. Keep a reflective diary, record and comment on your observations of on your own practice, with reference to the basic communication guidelines.



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## Overview of Basic Genetics:

The following links are to the GENIE Virtual Genetics Education Centre (VGEC)

<http://www.le.ac.uk/ge/genie/vgec/index.html>

On each page of the VGEC are links which can be selected to access more resources

### A) DNA, Genes, and Chromosomes

<http://www.le.ac.uk/ge/genie/vgec/he/dna.html>

DNA:

Deoxyribonucleic acid : A molecule made of nucleotides arranged in a double helix.

GENE:

A sequence of nucleotides that codes for a protein, together with the necessary control sequences that code for a product.

The pattern of genes is the genotype which produces the phenotype of heritable traits. DNA is packed into chromosomes by means of structural proteins.

KARYOTYPE:

The set of chromosomes of an individual. The normal human karyotype comprises of 46 chromosomes (44 autosomes and 2 sex chromosomes).

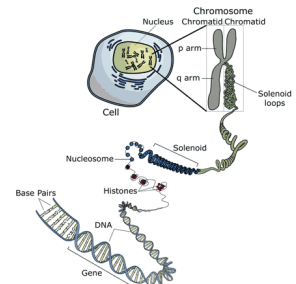


Image adapted from: National Human Genome Research Institute.

### B) Gene Expression and Regulation

<http://www.le.ac.uk/ge/genie/vgec/he/expression.html>

All nucleated somatic cells contain a complete copy of DNA organized into chromosomes. Genes are sections of DNA which code for a product and therefore (through a process of transcription and translation) all cells have the information to code for all body products.

However not all cells produce all products, there are methods of **regulating gene expression**, methods of “turning genes on and off”, so that products are only produced when needed.

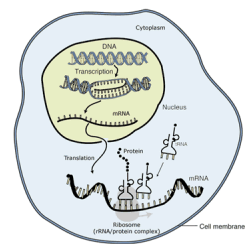


Image adapted from: National Human Genome Research Institute.

## C) Cell Cycle, Mitosis and Meiosis

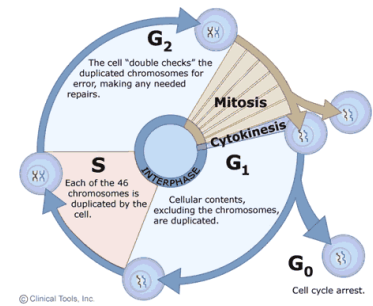
<http://www.le.ac.uk/ge/genie/vgec/he/cellcycle.html>

**CELL CYCLE:** The sequence of events that occur in mitotically dividing cells, and which is regulated by a large number of steps controlled by genes.

**MITOSIS:** Cell division which occurs during growth and repair of somatic cells.

Each division produces two genetically identical diploid cells. Normal human diploid cells have 23 pairs of chromosomes (46).

**MEIOSIS:** Cell division which occurs during the formation of gametes. The gametes produced by meiosis are haploid, ie they have half the number of chromosomes of normal somatic cells (23 chromosomes)

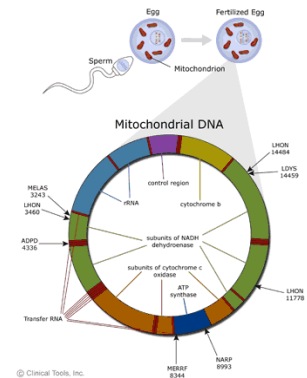


## D) Patterns of Inheritance

<http://www.le.ac.uk/ge/genie/vgec/hp/inheritintro.html>

Different patterns of inheritance include:

Mendelian monogenic, polygenic, multifactorial and mitochondrial.



## E) Population Genetics

<http://www.le.ac.uk/ge/genie/vgec/he/population.html>

The study of genetic variation in a population.

Using population genetics it is possible to estimate carrier incidence of recessive disorders and used to predict individual risk.

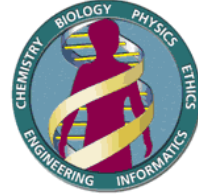


## F) The Human Genome

<http://www.le.ac.uk/ge/genie/vgec/he/genomics.html>

The complete copy of DNA of a human being is the human genome.  
The purpose of the Human Genome Project was to sequence the entire human genome.

The logo of the Human Genome Project



© U.S. Department of Energy Human Genome Program: <http://www.ornl.gov/hgmis/home.shtml>

## G) Cancer Genetics

Cancer occurs when the normal genetic control of cell growth no longer functions correctly. Therefore all cancers can be considered genetic, even though only a few types are inherited. The following links describe some of the mechanisms involved:

<http://archive.student.bmj.com/issues/05/02/education/52.php>

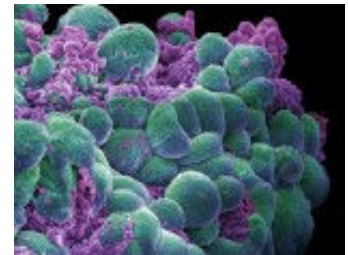
Beginner's guide to genetics-cancer genetics

<http://www.nature.com/scitable/topicpage/Tumor-Suppressor-TS-Genes-and-the-Two-887>

<http://www.cancer.gov/cancertopics/understandingcancer>

<http://www.cancer.gov/cancertopics/understandingcancer/cancer>

<http://www.cancer.gov/cancertopics/understandingcancer/cancergenomics>



<http://images.wellcome.ac.uk/>

## H) Links to some additional sources of genetic information

### NHS UK:

- Excellent resource about genetic screening, and genetic communication from the NHS and the UK National Screening Committee which contains both reading material and workbooks.  
[http://cpd.screening.nhs.uk/choicestoolbox/web\\_nsc.html](http://cpd.screening.nhs.uk/choicestoolbox/web_nsc.html) .The link after the introduction asks for registration, however since this no longer appears to be possible, in order to progress through the content cancel the register screen and choose the pdf files you wish to read
- A glossary of common terms is available at [http://www.geneticseducation.nhs.uk/learning/list\\_term.asp](http://www.geneticseducation.nhs.uk/learning/list_term.asp) and common genetic conditions available at [http://www.geneticseducation.nhs.uk/learning/list\\_conditions.asp?id=42](http://www.geneticseducation.nhs.uk/learning/list_conditions.asp?id=42)
- Professional Education for Genetic Assessment and Screening a good source of basic information  
<http://www.pegasus.nhs.uk/index.php>

### USA:

- A comprehensive but simple explanation of genetics is available at Genetics Home Reference (<http://ghr.nlm.nih.gov/>) from NIH USA including an interactive “Jeopardy” type quiz <http://ghr.nlm.nih.gov/download/GHRChallenge.pdf>
- <http://www.geneticalliance.org/>  
Genetic screening and testing in addition to basic genetics  
[http://www.geneticalliance.org/ksc\\_assets/pdfs/manual\\_all2.pdf](http://www.geneticalliance.org/ksc_assets/pdfs/manual_all2.pdf)  
A source of stories about patient experiences can be found at:  
[http://www.geneticalliance.org/ksc\\_assets/publications/genetic\\_testing\\_stories\\_march09.pdf](http://www.geneticalliance.org/ksc_assets/publications/genetic_testing_stories_march09.pdf)  
Some of which express patient dissatisfaction, a good source of topics for discussion!

### Australia:

- [http://www.genetichealthvic.net.au/Documents/PDF/GeneticsFile/The\\_Genetics\\_File\\_PartA.pdf](http://www.genetichealthvic.net.au/Documents/PDF/GeneticsFile/The_Genetics_File_PartA.pdf)  
Good review of basic genetics and how to talk about genetics to patients. Includes a glossary of terms and useful appendices including use of symbols and communication skills. Produced by The State of Victoria Genetics Health Service, Australia  
<http://www.genetichealthvic.net.au/sections/HealthProf/?docid=68143607-65bf-4ef3-b172-9a9300ff2a97> also contains other useful genetic links.
- “Genetics in Family Medicine: The Australian Handbook for General Practitioners”  
[http://www.nhmrc.gov.au/your\\_health/egenetics/practitioners/gems.htm](http://www.nhmrc.gov.au/your_health/egenetics/practitioners/gems.htm)  
Section 17 from this guide “Genetics in practice” is a very good chapter about genetics communication and basic genetics [http://www.nhmrc.gov.au/your\\_health/egenetics/practitioners/\\_files/gems/Sections/17%20-%20Genetics%20in%20practice%20WEB.pdf](http://www.nhmrc.gov.au/your_health/egenetics/practitioners/_files/gems/Sections/17%20-%20Genetics%20in%20practice%20WEB.pdf)

## Indexes

### Online Extra Readings:

	Page
<b>General:</b>	
Consanguinity-----	24
Diseases in Ashkenazi	
Jewish populations -----	25
Eugenics-----	34
Genetic anticipation, penetrance, and expressivity---	17
Genetic Communication in Primary practice-----	36
Genetics for non-geneticists----	9
Genetics for physicians- assistants-----	12
 <b>Calculation of Genetic Risk:</b>	
Complications to pedigree	
Patterns-----	16
Bayes theorem calculation ----	22
Punnett Squares-----	19
 <b>Perception of Risk:</b>	
Paling perspective scale-----	33

### Exercises:

	Page
<b>Calculation of Genetic Risk:</b>	
Pedigree charts-----	9,13
Punnett Squares-----	19
Genetic Risk-----	22
Online Calculators-----	23-25
 <b>Perception of Risk:</b>	
Common reactions to risk----	28
Framing-----	30
Qualitative terms-----	29
Tools to explain risk-----	31
 <b>Public Understanding Of Genetics:</b>	
Emotive terms-----	36
Genetic misconceptions---	37-39
 <b>Overview of Basic Communication:</b>	
Communication skills-----	42
Communication papers-----	42
Sit-Com Communication-----	42
Reflective diary-----	42

### Additional Basic Theory Notes:

	Page
<b>General:</b>	
Alleles and fertilization-----	18
What is basic Genetics-----	5
 Genotype nomenclature-----	11



## Summary of suggestions to help facilitate effective genetic communication:

### Before meeting the patients ensure you:

- Can make an accurate and informative pedigree chart
- That you are sure of the necessary genetic facts and feel confident in explaining them to the patient in a non-directive manner
- Can calculate, or understand the calculations, of any relevant risk information
- Are aware of any common misconceptions or worries about genetic diseases prevalent where you practice, and have considered how to challenge these if required
- Have a range of tools and techniques available to explain genetic information and risk to the patient, and feel confident in their use
- Have taken the opportunity to practice all of the above on friends and colleagues!

### Arrangements for the consultation

- Have a safe quiet environment
- Ensure adequate time

### Points to remember during the consultation

- Explain any necessary terms simply
- Avoid emotive words
- Ask what concerns them most
- Inform them about the specialist genetics units (if they have not already been to them)
- Establish what they already know and try to identify any major misconceptions they may hold
- Acknowledge that lots of new info not always easy to assimilate and may want another meeting
- Check what they have understood
- Give opportunity for follow up talks
- Give information about reliable sources of information
- Provide contact with reliable support groups



## GENIE

(Genetics Education Networking for Innovation and Excellence) is a Centre for Excellence in Teaching and Learning (**CETL**) based within the Department of Genetics , University of Leicester.

**GENIE** builds on existing expertise and synergy between world-class science and genetics education in the Department of Genetics at the **University of Leicester**.

**GENIE** are leading the development of innovative approaches and are establishing a network of institutions engaged in teaching genetics, promoting the sharing of resources and experience; including the compilation of , the Virtual Genetics Education Centre, an internationally accessible database for these resources.



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