Chapter 2

Foundations of Development – Genetics and Prenatal Development

Overview

This chapter explores early biological effects on development. Introductory genetic theory is discussed together with examples applicable to human development. Genetic effects on variables such as intelligence are examined in the context of behavioural genetics. Prenatal development is explored in terms of biological processes and developmental milestones. The effects of negative environmental influences, such as drugs and disease, on prenatal development are also discussed. The chapter concludes with a discussion of birth and the health of a newborn. Essentially, this chapter takes the child from fertilisation to infancy.

Learning objectives

2.1 Describe the basic principles of genetic transmission of normal and abnormal human attributes

2.2 Discuss disorders associated with chromosomal abnormalities

2.3 Discuss the ways in which psychologists employ behaviour genetics to distinguish between inherited and experiential factors in development

2.4 Outline the time course of prenatal development

2.5 Identify the principles governing the action of environmental agents that may cause harm to the developing embryo/foetus

2.6 Assess evidence of prenatal learning

2.7 Identify the adverse effects on infant survival and healthy development of prematurity/low birth weight

2.8 Conduct a research exercise examining the difference between related and unrelated pairs of children on a number of behavioural characteristics.

Stop and review

A dominant gene determines the presence of facial dimples. Jane's father has dimples but neither Jane's mother nor her sister has them. What are the odds that Jane has facial dimples? (Page 44)

Jane's father has dimples and the 'dimples gene' is dominant. Therefore, he has either two copies of the dimples gene or one copy of the dimples gene and one copy of the 'no dimples gene'. By contrast, Jane's mother does not have dimples. Therefore, she must have two copies of the 'no dimples gene' because this gene is recessive to the dimples gene.

Now, Jane's sister does not have dimples. Therefore, like her mother, she must have two copies of the no dimples gene. However, one of these must have come from her father. Consequently, her father must have at least one copy of the no dimples gene. Because, as discussed in the previous paragraph, Jane's father must also have a copy of the dimples gene, it can be concluded that he has one copy of the dimples gene and one copy of the no dimples gene.

The only way that Jane will have dimples is if she inherits the dimples gene from her father (as her mother does not have this gene). Because her father has one dimples gene and one no dimples gene (and the dimples gene is dominant), Jane has a 50 per cent chance of having dimples.

What would be the probability of a daughter being colour-blind if the father was colour-blind and the mother a carrier? (Page 45)

Let X refer to the X chromosome with the non-colour-blind gene and x refer to the X chromosome with the colour-blind gene. Let Y refer to the Y chromosome. As the father is colour-blind, he must have xY sex chromosomes. Because the mother is a carrier of colour-blindness, she must have xX sex chromosomes.

Now, the daughter must inherit x from her father (because inheriting Y would make her a male). She also inherits one of her mother's sex chromosomes and consequently she could be either xX or xx depending on whether she inherits her mother's x or her mother's X. If the daughter is xX then she is a colour-blindness carrier. If she is xx then she is colour-blind.

Therefore, there is a 50 per cent chance that the daughter would be colour-blind.

Given what you now know about the sex of individuals with different numbers of X and Y chromosomes, what is it that determines whether a person will be male or female? (Page 48)

We know that:

- Normally, males have XY chromosomes.
- Normally, females have XX chromosomes.

- Individuals with Turner's syndrome (XO) are female.
- Individuals with Poly-X syndrome (XXX) are female.
- Individuals with Klinefelter's syndrome (XXY or XXXY) are male.
- Individuals with XYY syndrome (XYY) are male.

The common feature in each of these is that an individual will be male if they have at least one Y chromosome and female if they do not have any Y chromosomes. It could also be noted that there are no OY individuals because the X chromosome contains important genetic information that is needed by both sexes in order to survive.

In what ways might the environments experienced by twins be more similar than for siblings of different ages? (Page 49)

Conceptually, there are two sets of factors that result in twins often experiencing more similar environments than differently aged siblings. The first set involves factors within the family and the second set involves factors outside the family.

Examples of the first include:

- Changes in parental income, wealth or status over time.
- Changes in parental values, personality or child-rearing approach over time.
- Birth order effects among siblings of different ages. While differently aged siblings have different birth orders, twins effectively have the same birth order.

Examples of the second include:

- Economic changes within society resulting in changes in the quality of services such as education and health.
- Political changes in society resulting in different values and expectations.
- Economic/political changes that affect the nature of the family (e.g. wartime conscription, women joining the workforce in greater numbers). This is also an example of how factors from the second set can have an indirect effect via factors from the first set.

Issues such as this mean that we need to be careful when interpreting heritability coefficients.

Given the background noises present in the womb (from the mother's digestive processes, blood flow, heartbeat, etc.), how clearly would the foetus be likely to hear the reading of *The Cat in the Hat*? (Page 60)

There is lot of ambient noise inside the womb. To get an idea of the mother's heartbeat, imagine carrying a metronome on your neck. The noise created by the mother's digestive system would be more sporadic – imagine that you attached a microphone to the outside of your stomach and

mounted the speakers on your shoulders. (Think how bad a burp would be…) Blood flow and general nervous system activity would provide continuous background noise (from almost every direction); these respectively have a low and high pitch.

Now with these and other noises, you would still be able to hear things but there would be a lot of distractions and frequently parts of words would 'clash' with all the other noise you would be hearing. You could, however, make out the rhythm of the speech because it would stand out from all the background noise and this is why Dr Seuss was an inspired choice for DeCasper and Spence's (1986) study (given Dr Seuss's strong rhythms). You could also, to some extent, make out the 'melody' of words because the different syllables have different pitch (e.g. 'Dog in the Fog' has more emphasis on lower pitch sounds than 'Cat in the Hat').

At this point you might think, 'Well, I think that, even with all those noises, I could probably make out quite a few words.' Quite possibly you could (although it wouldn't be easy). However, you also need to remember that the infant is surrounded by fluid, which tends to have a 'muffling' effect on sound and to affect high-pitch noises more than low-pitch noises making word differentiation more difficult.

Critical thinking

Imagine that you are a school counsellor to whom a concerned teacher has referred a child with very poor reading and spelling but with good number skills. The child's mother reports that it is not something that can be fixed as 'dyslexia runs in her family' and therefore 'must be genetic'. What evidence is there for a genetic basis for dyslexia? What other factors could be contributing to this familial problem? How would you design a study to test the inheritance of such a characteristic? (Page 61)

Possible Responses

What evidence is there for a genetic basis for dyslexia?

- Francks, C., MacPhie, I. L., Monaco, A. P. (2002). The genetic basis of dyslexia. *Lancet Neurology*, *1*(8), 483–490.
- Novel discovery of 'DCDC2' gene associated with dyslexia. *Science Daily* (28 October 2005).

What other factors could be contributing to this familial problem?

- Samuelsson, S. & Ingvar, L. (2003). Impact of environmental factors on components of reading and dyslexia. *Annals of Dyslexia*, *53*(1), 201–217.
- *Home environmental factors*: SES, early print exposure, being read to, attitudes of parents, expectations of family, birth order, etc.
- *School conditions*: Class size, teacher competence, match between

techniques and student learning style and needs, expectations of race and social class, availability of suitable materials, and diagnostic and remedial support.

How would you design a study to test the inheritance of such a characteristic?

- Compare family trees of students diagnosed as dyslexic to see patterns and prevalence.
- Control for factors such as opportunity to learn, SES, etc.

Critical thinking for group discussion

1. Based on your knowledge of X-linked inheritance, explain why males are more likely to be miscarried than females. (LO 2.1, 2.2)

Miscarriages are often a 'natural' way of eliminating embryos that fail to develop appropriately. One of the primary causes of this failure is genetic abnormality. However, as discussed below, male embryos are more likely to be genetically malformed than female embryos, meaning that they are more likely to be miscarried.

Females have two X chromosomes while males have one X chromosome and one Y chromosome. However, while the Y chromosome contains very little genetic information beyond 'male' information, the X chromosome contains extra genes that can affect the development of both males and females.

Now, one way that a fatal genetic abnormality can arise is via inheritance of a recessive gene (this gene can't be dominant because this would make it impossible for individuals with this gene to reproduce). Consequently, if this gene is on an X chromosome then a female must have two copies of the gene to have the genetic abnormality (and be miscarried).

However, a male only needs to have one copy of this gene because he only inherits one X chromosome. Thus, if a mother is a carrier of this recessive gene, the chance that a male has this genetic abnormality is 50 per cent because that is the chance that the mother will pass the gene on to him. However, the chance that a female will have the disorder is 0 per cent (although there is a 50 per cent chance she will become a carrier) because she must have received one copy of the matching dominant gene from her father (he would have been miscarried if he carried the recessive gene).

Consequently, males are more likely to be miscarried because male embryos are more likely to inherit a sex-linked genetic abnormality that results in failed prenatal development.

2. Why is it difficult to interpret the results of studies of resemblance in intelligence between relatives of differing degrees of genetic similarity? (LO 2.3)

Studies comparing the correlations of intelligence scores among relatives

with differing degrees of genetic similarity are sometimes used to estimate the heritability of intelligence. For instance, if the intelligence scores of identical twins were much more highly correlated than the intelligence scores of fraternal twins then this would be taken as evidence for intelligence being strongly heritable.

Three major problems with this approach are:

- People who are genetically similar tend to pick similar environments. Perhaps the higher correlation is from identical twins having more similar attitudes to education than the fraternal twins as a result of sharing more 'personality genes'.
- People tend to treat very similar individuals, such as identical twins, more similarly than less similar individuals. For instance, teachers might place more similar expectations on identical twins than fraternal twins.
- When comparing siblings of different ages, there are greater environmental differences than when comparing siblings with the same age. With time, the economic, social and political factors, both within families and society at large, change.

In general, the main problems with this approach are that it tends to view the environment as static rather than dynamic and fails to adequately account for the interaction of genetic and environmental influences.

3. What is a 'sensitive period'? Discuss the concept in relation to the effects of teratogenic agents. (LO 2.4, 2.5)

A sensitive period is a period in which the development of a body part, cognitive skill, etc. is particularly sensitive to environmental influences. In many cases, the sensitivity is to a particular environmental influence (or set of influences).

A good example of sensitive periods can be found in the way that teratogenic agents affect prenatal development. The effects that teratogenic agents may have on development are dependent on when the embryo/foetus comes into contact with them. One example is the possible effects of teratogenic agents on ears and hearing.

In the case of ears and hearing, exposure to teratogenic agents before week 4 does not seem to pose a significant risk to the child's hearing. However, from about week 4 to about week 9, exposure to teratogenic agents sometimes results in deafness and/or malformed ears. This period is thus a highly sensitive period for hearing development.

It should be noted that after this there is a minor sensitive period for hearing development until about week 20 where, although not as sensitive as during weeks 4–9, exposure to teratogenic agents can lead to ear damage. It should also be noted that sensitive periods for one type of development can overlap with sensitive periods for another type of development. Week 5 of prenatal development, for instance, is a sensitive period for several different anatomical structures.

4. What is foetal alcohol syndrome? How many alcoholic drinks are 'safe' for an expectant mother? Outline the case against drinking during pregnancy. (LO 2.4, 2.5, 2.7)

Foetal alcohol syndrome (FAS) is a collection of abnormalities found in children whose mothers were heavy drinkers during pregnancy. FAS can manifest as a combination of physical abnormalities (e.g. microcephaly or small head), behavioural abnormalities (e.g. excessive irritability) and cognitive deficits (e.g. low intelligence).

FAS is not the only condition than can result from alcoholic consumption during pregnancy – many other minor physical and behavioural abnormalities are possible. Even one drink per day during early pregnancy has been shown to be associated with abnormality. This does not mean that one drink per day *will* produce these abnormalities but a mother cannot be sure that they will not. Consequently, the only completely 'safe' level of alcohol consumption during pregnancy is zero.

It should be noted that the more drinks one has, the worse the outcome is likely to be. If a mother averages five drinks a day or more, there is a 30 per cent chance that her baby will have FAS and the odds are even higher for other, minor abnormalities. It should also be noted that binge drinking (as opposed to consistent daily alcohol consumption) has also been associated with abnormalities and does not appear to be 'an improvement' on consistent drinking.

5. Does any of the evidence of foetal learning indicate that it plays an important role in later development? (LO 2.6)

The study of foetal learning is quite difficult, not only in what can be reliably transmitted to the foetus, but also the responses that can be obtained from the foetus. Heart rate is the only available measure of foetal learning, which limits what can be studied. Many studies have utilised this and have supported the existence of prenatal learning. However, although many research studies have utilised different in-utero experiences to try to prove the persistence of learning following birth, many researchers still are not convinced that foetal learning is indicative of later development. The majority of studies that examine whether prenatal learning is remembered postnatally have found support, but only for what was specifically learned in the womb. For example, DeCasper and Spence (1986) found that babies who were read *The Cat in the Hat* prenatally showed preference for it postnatally. However, it is not known whether infants who learned this story inside the womb developed better later in life.

Practical exercise

Practical exercise A

Students visit parents and ask them to rate their children in terms of several behavioural characteristics. Each student gathers data from two children.

Half the students gather data on two siblings while half the students gather data from two children of the same age and sex but from different families. The hypothesis is that siblings will be more similar than the unrelated children.

Instructor's notes

The purpose of this task is for students to understand some of the practical issues involved in developmental research. While this applies primarily to research attempting to discover genetic effects, it also applies to developmental research in general.

A good place to begin the discussion is simply to make sure that students understand the results of the *t* test (though hopefully, as psychology students, they would have had some experience here). Assuming that the test is statistically significant, the test merely means that the mothers of the siblings rated their children more similarly than the two mothers of the unrelated children rated their children.

If the point isn't brought up by a student, it might be wise to emphasise that the finding that the ratings of the unrelated children are more different than the ratings of the siblings is not evidence that the siblings actually *are* more different (although they might be). Have students explore the potential methodological problems with mothers rating their children. This can be expanded into a general discussion of psychological measurement techniques if desired.

After this, this study can be viewed in a behavioural genetics context. Make sure that students understand that both environmental and genetic effects can explain the results. (Genetic effects can explain them because the siblings are more genetically similar than the unrelated children. Environmental effects can explain them because the siblings have a more common environment – i.e. shared family – than the unrelated children.) One way to do this might be to divide the class into small groups and have half of the groups work out the genetic explanation and the other half work out the environmental explanation. Alternatively, each group could work out both.

This would be an excellent launching point into a detailed discussion of behavioural genetics methodologies. Students could discuss the pros and cons of twin studies, adoption studies and the like.

Practical exercise B

If there are problems with accessing data from parents about children, this exercise can be used as an alternative to the above.

In Week One, students can decide on a common talent (such as maths or music or art) and a common element of temperament (irritability, temper, placidity, etc.) that all students will record, OR teams of students can be formed to explore different talents and temperaments. This data will be used in Week Two.

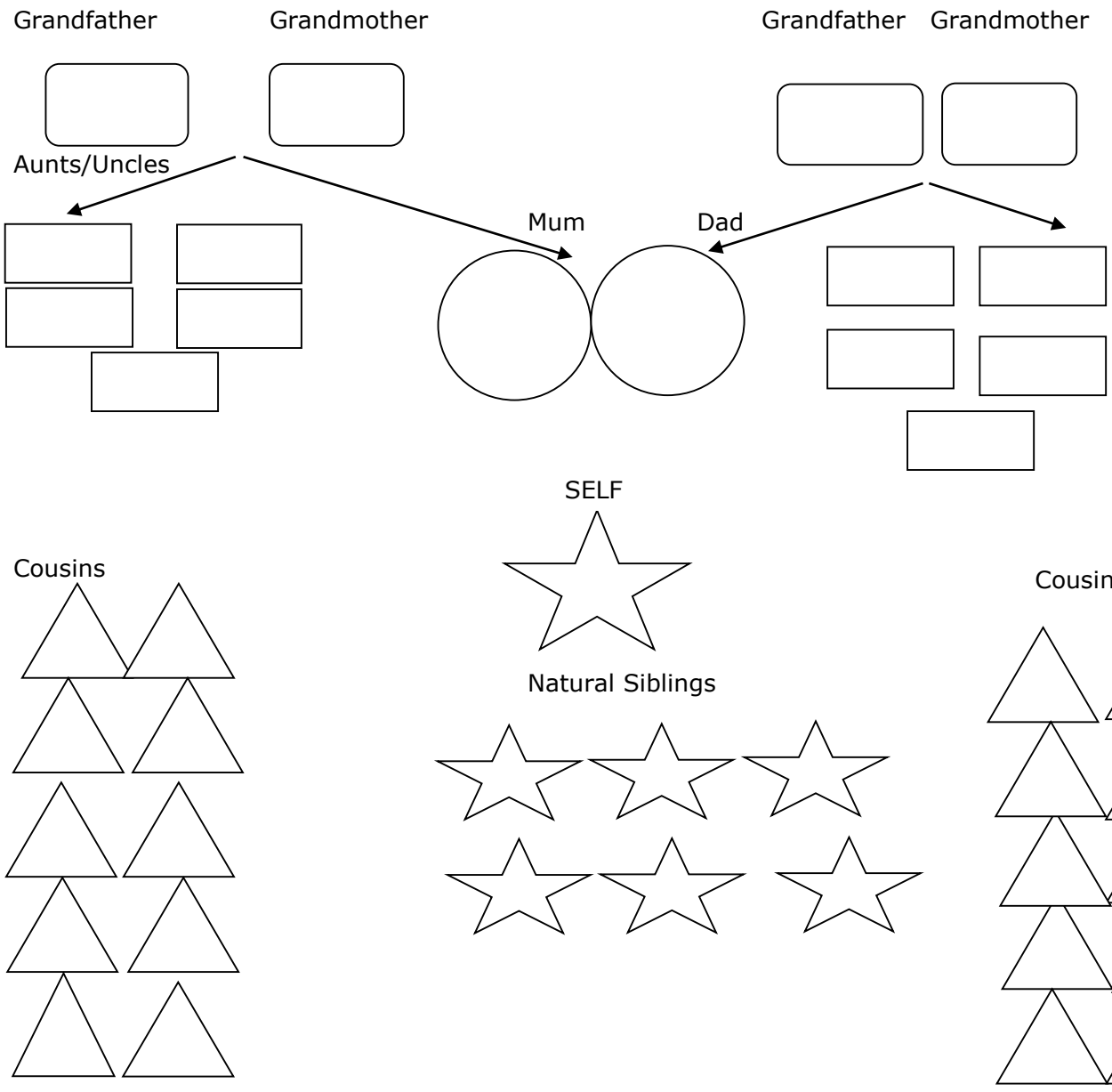
Students collect ratings of the trait/talent for members of their known family. Naturally, this will vary by family size, etc.

Students can examine the strength of the trait/talent as it appears through the generations and, if different groups elect to do different traits/talents, suggestions can be made about the degree to which heredity seems to play a role in the transmission of the different variables.

Where traits are not apparent where they would be expected, or where traits appear 'out of the blue', students should explore the possibility of environment as a moderating variable in the expression of the characteristic.

TALENT OR TEMPERAMENT _____

Place rating (0–5) in the appropriate space



Step Brothers and Sisters A. B. C. D.	Adopted Siblings A. B. C. D.

Tutorial suggestions

In-class debate

Select one of the issues below OR divide the class so that two different debates run during the session.

Set up debating teams. Each team should take a side on one of the following positions relative to the information below.

ISSUE ONE

It may be possible in the not-too-distant future to genetically design children to the point where we can determine not only their physical attributes but also their mental and emotional characteristics.

Team A. Limitations on the application of genetic engineering of children for the good of society and the human gene pool should be legislated.

Team B. No limitations should be legislated, as the application of genetic engineering will benefit not only individuals but society at large.

Some issues that might be pursued by the debaters are:

- Is it better to be good at 'everything' or is it better to have some hills and valleys in one's profile?
- Can a society work effectively if there are no people to fill the less intellectual roles in society?
- What happens when the market for one type of intelligence, such as maths, goes into decline?
- Should some people be designed as leaders and some as followers? What are the implications of designing everyone to become a 'leader'? Is this a genetic trait?

ISSUE TWO

Breastfeeding has been associated with psychological development, cognitive ability and decreased risks of:

- physiological reflux
- juvenile diabetes
- inflammatory bowel disease
- some childhood cancers
- coeliac disease
- obesity
- ear infections
- urinary tract infection
- bacterial meningitis
- Sudden Infant Death syndrome
- severe respiratory illness

Team A. Welfare payments made by the Australian government to mothers should be adjusted according to their willingness to breastfeed their babies.

Team B. Welfare payments made by the Australian government should not be tied to willingness to breastfeed babies due to the variety of physical, social, economic and psychological factors that may disadvantage a mother who does not comply.

Structure

Teams should be of equal numbers within the tutorial group with each group being comprised of 4–5 members.

All members of the team bring suggestions for the team's arguments to the tutorial based on readings and references related to genetic possibilities as well as ideas about the results of engineering.

Each team works collaboratively for 15 minutes to prepare its argument.

Speakers for each team are randomly selected to present the case prepared, as randomness of selection encourages greater participation during the planning.

Each team has 4 minutes in which to present its case.

Each element is rated on a 5-point scale

TEAM	Clear links to genetics	Consistent links to genetics	Consistent use of readings/research	Logical and well-sequenced arguments	TOTAL
1					
2					
3					
4					
5					
6					
7					
8					

OHP 1: Quick Think Question – Dimples

Mum

No Dimples

dd

Dad

Dimples

DD or Dd

Sister

dd

Jane

Dd

OHP 2: Quick Think Question – Colour-blindness

Xx Xy

OUTCOME

or

Xx Xx

Normal Colour-blind