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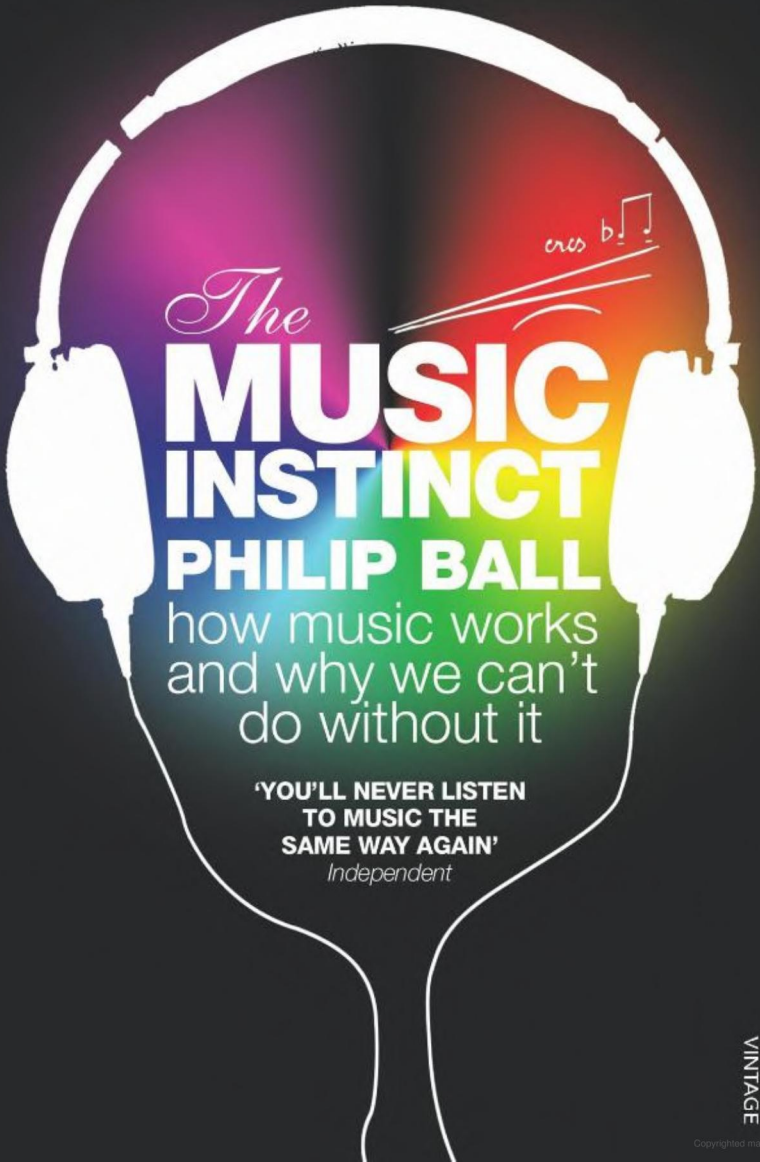

The MUSIC INSTINCT

PHILIP BALL

how music works and why we can't do without it

'YOU'LL NEVER LISTEN TO MUSIC THE SAME WAY AGAIN'
Independent

VINTAGE

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The Music Instinct

How Music Works and Why We Can't Do Without It

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Contents

Preface

'Must the majority be made "unmusical" so that a few may become more "musical"?' This question, in John Blacking's seminal 1973 book *How Musical Is Man?*, apparently sums up the status of music in Western culture: it is composed by a tiny minority and performed by a slightly larger one, and these are the people we call 'musicians'. But Blacking points to the contradiction inherent in the way that music is at the same time utterly pervasive in this culture: at supermarkets and airports, in movies and on television (every programme must have its theme tune), at important ceremonies, and now, on the private, portable soundscapes that snake ubiquitously from pocket to ear. '"My" society', says Blacking, 'claims that only a limited number of people are musical, yet it behaves as if all people possessed the basic capacity without which no musical tradition can exist – the capacity to listen to and distinguish patterns of sound.' He implies that this assumption goes still further: 'his' society presupposes shared ground in the way those patterns will be interpreted, understood, responded to.

And of course these assumptions are justified: we *do* have this capacity to hear music, and to develop a cultural consensus about how to respond to it. Yet we have, in the West at least, decided that these mental faculties are so commonplace that they are hardly worth noting, let alone celebrating or designating as 'musical' attributes. Blacking's experiences among African cultures in which music-making was far less rigidly apportioned between 'producers' and 'consumers' – where, indeed, those categories were sometimes meaningless – helped him to appreciate the oddness of this situation. Personally, I suspect that it might in any event be easy to overplay that schism, which, to the extent that it exists at all, may prove to be partly a transient aspect of

the emergence of mass media. Before music could be recorded and broadcast, people made it themselves. And now it is increasingly easy and cheap to make and broadcast it yourself, huge numbers are doing so. Yet we still tend to ascribe primacy of musicality to the 'production' mode. In this book I hope to show why the 'capacity to listen to and distinguish patterns of sound', which we nearly all possess, is the essence of musicality. The book is about how this capacity arises. And I want to suggest that, while hearing great music played by great performers is an incomparable pleasure, this is not the only way to get enjoyment and satisfaction from music.

Because the question of how music does what it does is so phenomenally complicated and elusive, one could easily construct an illusion of cleverness by pointing out flaws in the answers offered so far. I hope it will be clear that this is not my intention. Everyone has strong opinions on these matters, and thank goodness for that. In a subject of this nature, ideas and views that differ from one's own should not be targets for demolition, but whetstones for sharpening one's own thoughts. And since it is likely that everyone will find something with which to disagree in this book, I hope that readers will feel the same way.

For helpful advice and discussion, providing material, and for general support or even just good intentions, I am grateful to Aniruddh Patel, Stefan Koelsch, Jason Warren, Isabelle Peretz, Glenn Schellenberg, Oliver Sacks and David Huron. I am once again much indebted to my agent Clare Alexander for her encouragement, insight and incomparable combination of experience, diplomacy and resolve. I am thankful to be in the safe and supportive editorial hands of Will Sulkin and Jörg Hensgen at Bodley Head. And I cherish the music that Julia and Mei Lan bring into our home.

I should like to dedicate this book to everyone with whom I have made music.

Philip Ball
London
November 2009

Author's Note

To listen to the musical examples illustrated in this book, please visit www.bodleyhead.co.uk/musicinstinct

1

Prelude

The Harmonious Universe

An Introduction

Fourteen billion miles away from Earth, Johann Sebastian Bach's music is heading towards new listeners. An alien civilization encountering the *Voyager 1* or *2* spacecraft, launched in 1977 and now drifting beyond our solar system, will discover a golden gramophone record on which they can listen to Glenn Gould playing the Prelude and Fugue in C from the second book of *The Well-Tempered Clavier*.

You couldn't fit much on a long-playing record in 1977, but there was no room for a more extensive record collection – the main mission of the spacecraft was to photograph and study the planets, not to serve as an interstellar mobile music library. All the same, offering extraterrestrials this glimpse of Bach's masterwork while denying them the rest of it seems almost an act of cruelty. On the other hand, one scientist feared that including Bach's entire *oeuvre* might come across as an act of cosmic boasting.

Recipients of the *Voyager* golden record will also be able to listen to the music of Mozart, Stravinsky and Beethoven, as well as Indonesian gamelan, songs of Solomon Islanders and Navajo Native Americans, and, delightfully, Blind Willie Johnson performing 'Dark Was the Night, Cold Was the Ground'. (They are denied the Beatles; apparently EMI couldn't see how to maintain copyright on other worlds.)

What are we thinking of, sending music to the stars? Why should we assume that intelligent life forms that may have no human attributes, perhaps not even a sense of hearing, could comprehend what

happens if – following the pictorial instructions included with the discs – you spin the *Voyager* golden records and put the needle in the groove?

That question is, in a sense, what this book is all about. Why is the succession of sounds that we call music comprehensible? What do we mean when we say that we do (or don't) 'understand' it? Why does it seem to us to have meaning, as well as aesthetic and emotional content? And can we assume, as the *Voyager* scientists have done implicitly, that these aspects of music are communicable to others outside our own culture, or even our own species? *Is* music universal?

A glib argument for the universality of music would say that it is at root mathematical, as Pythagoras proposed in the sixth century BC, so that any advanced civilization could 'decode' it from the vibrations excited in a stylus. But that is far too simplistic. Music is not a natural phenomenon but a human construct. Despite claims to the contrary, no other species is known to create or respond to music as such. Music is ubiquitous in human culture. We know of societies without writing, and even without visual art – but none, it seems, lack some form of music.

But unlike the case of language, there is no generally agreed reason why that should be so. The evidence suggests it is an inevitable product of intelligence coupled to hearing, but if so, we lack an explanation for why this is.

It is deeply puzzling why these complex mixtures of acoustic frequencies and amplitudes make any sense to us, let alone why they move us to joy and tears. But little by little, that is becoming a less mysterious question. When we listen to music, even casually, our brains are working awfully hard, performing clever feats of filtering, ordering and prediction, automatically and unconsciously. No, music is not simply a kind of mathematics. It is the most remarkable blend of art and science, logic and emotion, physics and psychology, known to us. In this book I will explore what we do and don't know about how music works its magic.

Confectionery for the mind?

'Music is auditory cheesecake, an exquisite confection crafted to tickle

the sensitive spots of at least six of our mental faculties,' claimed cognitive scientist Steven Pinker in his 1997 book *How the Mind Works*. He went on:

> Compared with language, vision, social reasoning, and physical know-how, music could vanish from our species and the rest of our lifestyle would be virtually unchanged. Music appears to be a pure pleasure technology, a cocktail of recreational drugs that we ingest through the ear to stimulate a mass of pleasure circuits at once.

These claims provoked predictable outrage. Imagine it, comparing Bach's B minor Mass to the Ecstasy pills of club culture! And by suggesting that music *could* vanish from our species, Pinker seemed to some to be implying that he wouldn't much mind if it did. So Pinker's remarks were interpreted as a challenge to prove that music has a fundamental evolutionary value, that it has somehow helped us to survive as a species, that we are genetically predisposed to be music-makers and music-lovers. It seemed as though the very dignity and value of music itself was at stake.

Pinker responded to all of this with understandable weariness. No one was suggesting, he said, that music could only be taken seriously as an art form if it could be shown to be somehow evolutionarily beneficial. There are plenty of aspects of human culture that clearly did not arise as adaptive behaviour and yet which are deeply important components of our lives. Literacy is one: an evolutionary psychologist who argues that writing is obviously adaptive because it preserves vital information in a way that can be reliably passed on to our offspring is making a hopeless case, because writing is simply too recent an innovation to have any dedicated genetic component. We can read and write because we have the requisite intrinsic skills – vision and pattern recognition, language, dexterity – and not because we have literacy genes.

Joseph Carroll, professor of English at the University of Missouri-St Louis, has offered a more substantial reply to Pinker. 'Art, music and literature are not merely the products of cognitive fluidity,' he says. 'They are important means by which we cultivate and regulate the complex cognitive machinery on which our more highly developed functions depend.' These arts aren't at all like stimulation of the taste buds – they embody emotions and ideas:

> They are forms of communication, and what they communicate are the qualities of experience. Someone deprived of such experience would have artificially imposed on him a deficiency similar to that which is imposed on autistic children through an innate neurological defect . . . a child deprived of all experience with art and literature would still have innate capacities for social interaction, but these capacities would remain brutishly latent. The architecture of his or her own inner life and that of other people would remain dully obscure. In the place of meaningful pattern in the organization of emotions and the structure of human needs and purposes, such a child would perhaps scarcely rise above the level of reactive impulse.

This is the classical argument of the ennobling nature of art, which goes back to Plato. The problem is that it is awfully difficult to prove. Carroll cites the example of the Smallweeds in Dickens' *Bleak House*, who 'discarded all amusements, discountenanced all storybooks, fairy tales, fictions, and fables, and banished all levities whatsoever'. The Smallweed children are, as a result, 'complete little men and women [who] have been observed to bear a likeness to old monkeys with something depressing on their minds'. But that is all so much literary invention; and more to the point, the absence of art in the lives of the Smallweed children is obviously a symptom of their general lack of love and nurture, not a cause of it. Do we have any real evidence that being deprived of music would impoverish our spirit and diminish our humanity?

In this book I suggest why, even though there is something to be said for both Pinker's and Carroll's positions, they both miss the point. While it is possible in principle to disprove Pinker's thesis (and while, as we'll see, there are already reasons to suspect that it is indeed wrong), it is a mistake to think that this would somehow establish the fundamental value of music. Neither do we need to show that Carroll is right – that exclusion of music leads to a brutish nature – to prove that we can't go without it. After all, the reverse is not true: beastliness and a finely honed musical aesthetic may coexist, as personified by Anthony Burgess' Alex in *A Clockwork Orange*, not to mention Hitler's notorious love of Wagner. It is misguided to think that music enriches us in the mechanical manner of a nutrient. The fact is that

it is meaningless to imagine a culture that has no music, because music is an inevitable product of human intelligence, regardless of whether or not that arrives as a genetic inheritance. The human mind quite naturally possesses the mental apparatus for musicality, and it will make use of these tools whether we consciously will it or not. Music isn't something we as a species do by choice – it is ingrained in our auditory, cognitive and motor functions, and is implicit in the way we construct our sonic landscape. Even if Pinker is correct (as he may be) that music serves no adaptive purpose, *you could not eliminate it from our cultures without changing our brains.* Boethius seemed to understand this in the early sixth century AD: music, he said, 'is so naturally united with us that we cannot be free from it even if we so desired'.

For that very reason, Pinker is also wrong to suggest that music is simply hedonistic. (Besides, however much cheesecake or recreational drugs we consume, we do not thereby exercise our intellect or our humanity – quite the reverse, one might say.) Here is the surprising thing: *music does not have to be enjoyed.* That sounds terrible, but it is a fact. I don't mean simply that everyone does not enjoy every possible sort of music; that's obviously true. I mean that we don't just listen to music for pleasure. In some cultures that doesn't seem to be the primary function, and it has been debated whether an aesthetic response to music is at all universal. Of course, there are also many reasons for eating other than hunger – but it is far from clear that the main reason for music is enjoyment in the same way that the main reason for eating is survival.

Happily, though, on the whole we *do* enjoy music, and one of the major themes of this book is to find out why. But the pleasure may well be a consequence, not a cause, of music-making. Pinker's 'auditory cheesecake' is itself a side effect of our urge to find music in our auditory environment, although in fact the image of a guzzling diner is absurdly inappropriate to span the range from an indigenous tribesperson singing a ritual chant to a composer of the hard avant-garde plotting out his mathematical music in the 1970s. We have a music instinct as much as a language instinct. It might be genetically hard-wired, or it might not. Either way, we can't suppress it, let alone meaningfully talk of taking it away.

What's more, it no longer makes much sense to reduce this instinct to some primitive urging on the savannah, any more than it makes

sense to 'explain' the minutiae of courtship, personal grooming, extra-marital affairs, romantic fiction and *Othello* on our urge to reproduce. Cultures elaborate basic instincts out of all recognition or proportion, even inverting what one might presume to be their biological origin (if such a thing exists). Does it really make any sense to apply Pinker's phrase, or indeed Carroll's argument, to John Cage's *4'33"*, or to Motörhead playing 'Overkill' at a volume close to the pain threshold?

Whose music?

Although my survey ranges across cultures, much of it will draw on Western music. This is only in part because it is the music with which I am (and probably most readers will be) most familiar. More importantly, it is the best-studied system of highly developed 'art music', and so provides the richest source so far of information about how music is processed. Yet by exploring non-Western music, I hope not only to avoid the common error (many composers have made it) of asserting universal relevance to culturally specific concepts, but also to bring to light those aspects of music that *do* seem to have some cross-cultural validity. I shall look in particular at some highly developed and sophisticated non-Western forms of music, such as Indian classical music and Indonesian gamelan.* I will also show that 'more sophisticated' does not by any means imply 'better', and that art music is no more highly developed in some respects than traditional or folk music. Indeed, I will not on the whole be attempting to make judgements about music in an artistic or aesthetic sense, although we will find some clear, objective indications of why certain types of music seem to be more satisfying and enriching than others. I hope this book might encourage you, as researching it encouraged me, to listen again to music that you previously dismissed as too boring, too complicated, too dry, too slushy, or just plain incomprehensible. I doubt that there is a single one of us whose musical horizons could not be broadened with a little more understanding of what the music is doing and why.

* In a recent study of the 'complexity' of musical styles, gamelan scored highest: an emphatic reminder that we should not associate the geographic ubiquity of Western music with superiority.

Music is not a luxury

The fact that we humans are bound to be musical come what may could be taken as advocacy for a laissez-faire attitude to music education. And it's true that children who don't venture near an instrument and never have a music lesson at school are as likely as anyone else to end up plugged into their iPods. But to neglect music education is to stunt development and to deny opportunity. If we don't teach our children to cook, they won't starve, but we can't expect them to take much delight in food, or to be able to discover how to distinguish good fare from bad. Music is the same. And no one needs to be taught *what* to cook, but only *how*.

Whether or not Joseph Carroll is right to assert that deprivation of music makes us lumpen brutes, there is no question that the provision of music enriches in countless ways. One of the most remarkable illustrations of that is the National System of Youth and Children's Orchestras of Venezuela (commonly known simply as El Sistema), which has offered music tuition to around 250,000 impoverished Venezuelan children. Its 200 youth orchestras have provided a haven from crime and drugs for young people in the barrios, and the flagship Simón Bolívar Youth Orchestra plays with a passion and musicality that is the envy of more 'developed' nations. In part, the social benefits of El Sistema no doubt stem from the mere fact that it supplies some degree of structure and security in lives that had precious little before – perhaps football or literacy schemes would have similar effects. But it seems hard to doubt that the music itself, generally taken from the European classical repertoire, has instilled a focus, curiosity and optimism in the young Venezuelan players. In contrast, music education in the West is often seen as elitist and irrelevant, a drudge that promises little in the way of either satisfaction or inspiration. At best, it is something that children do if they have the spare time and resources.

Yet music ought to be a central and indispensable facet of a rounded education. For one thing, we will see that it is a gymnasium for the mind. No other activity seems to use so many parts of the brain at once, nor to promote their integration (the tiresome, cod-psychological classification of people as 'left brain' or 'right brain' is demolished

where music is concerned). The spurious 'Mozart Effect' aside (see Chapter 9), it is clearly established that music education has a positive effect on general intellect. It is also a potentially socializing activity, and one that most young people are interested in, often passionately. And sensitive music teaching (as opposed to hothousing of little virtuosos) will bring out one of music's most valuable attributes, which is the nurturing and education of emotion.

The case for musical education should not rest on its 'improving' qualities, however, even if these are real. The fact is that music no less than literacy gives access to endless wonders. To cultivate those avenues is to facilitate life-enhancing experience.

But what usually happens instead? Children stop singing and dancing, they get embarrassed about their piano lessons (if they're lucky enough to be offered them) and frustrated that they don't sound like the stars on MTV. As adults, they deny that they possess having any musicality (despite the extraordinary skills needed to listen to and appreciate just about any music), they jokingly attribute to themselves the rare clinical condition of tone-deafness. They probably do not know that there are cultures in the world where to say 'I'm not musical' would be meaningless, akin to saying 'I'm not alive'.

This book is about that too.

2

Overture
Why We Sing

What is music and where does it come from?

Hadn't I better explain what I am talking about, when I am talking about music? That would seem a sensible preliminary, but I am going to decline it. Just why I do so should become clear when I begin to explore shortly the different forms that music takes in different cultures, but let me say right away that there is no meaningful definition of music that doesn't exclude some or other aspect of it. The most notorious counter-example to most definitions is John Cage's silent opus *4'33"* (a work that is more accurately described as specifying that the performer play no notes). Some might, with reason, argue that this is not music but a conceptual artwork* – but that risks straying towards arid semantics. Such eccentricities aside, one definition of music that seeks to acknowledge its cultural and historical diversity, proposed by musicologist Ian Cross, runs as follows:

> Musics can be defined as those temporally patterned human activities, individual and social, that involve the production and perception of sound and have no evident and immediate efficacy or fixed consensual reference.

And of course you can at once choose your own favourite nitpick – for example, that this includes a person idly scuffing his shoes at the street corner. 'Evident and immediate efficacy' in particular raises enormous questions. But perhaps most significantly, you need only

* Philosopher Stephen Davies does just that in an illuminating and dogma-free discussion, while concluding that 'we should acknowledge the originality and importance of Cage's contribution to our understanding of music and of the philosophy of the arts'. *4'33"*, he says, 'challenges the boundary between noise and music', but 'is likely to include more of the former'.

start listening to Sam Cooke or Ravel to sense that straining for a definition of music is a vapid exercise that tells us nothing important about what it is or why we listen.

Such definitions tend to consider music as an acoustic phenomenon, with the result that they seek distinctions between musical and non-musical sound. 'Organized sound' isn't a bad working description of music, so long as you recognize that this definition would make no sense to some cultures, and that it excludes some types of music and includes sounds not generally considered to be music.* Yet whatever you think of the twentieth-century Western avant-garde, it served as a reminder that this sort of exercise in definition is futile. Music can be made from mistuned radio sets, from the incidental noises of a concert hall, from the hum of machinery. No one says you have to like it.

There's a good argument that music is better defined in sociological and cultural than in acoustic terms. It's a thing we do. It is universal only in the sense that every culture seems to have it. But about what music is, and what purpose it serves, we can make no other generalizations.

Some cultures make music by banging on drums, blocks, pieces of metal: they value rhythm (and perhaps timbre) above melody. In others, the main instrument is the human voice; in others, music is inseparable from dance. In some cultures, music is reserved for special occasions; in others, people create a more or less continual musical soundtrack to their lives. Some reserve a term like 'music' only for a subset of the apparently musical things they do. Some analyse music in obsessive detail; others are puzzled by any need to discuss it. Perhaps most significantly, there is no reason to suppose that all musics should share any particular trait in common – that music has universal features. As semiologist Jean Molino has put it, 'Nothing guarantees that all forms of human music contain a nucleus of common properties that would be invariant since the origination of music.'

*There's a good case for saying that a viable definition of music doesn't have to be all-inclusive, but should simply apply to the central instances of the art. Of course, that in itself provokes questions; but I sympathize with the idea that we need feel no great obligation to encompass extreme experiments in our definitions.

Music in the world

One of the strongest objections to Steven Pinker's characterization of music as 'auditory cheesecake' is its ethnocentricity: it implies that all people listen to music simply because they like to do so. That is probably not true even in Western culture, where a type of music might for example serve as a badge of affiliation to a subculture, or proclaim a regime's military might. And music may serve very specific social functions that do not obviously demand (and perhaps do not involve) aesthetic judgements. For the Kaluli people of Papua New Guinea, music allows communion with the dead. The music of the Venda people in South Africa helps to define social relations.

And music is not merely structured sound. The word for 'music' in the language of the Igbo people of Nigeria is synonymous with 'dance', and in Lesotho there is no distinction between dance and song. In parts of sub-Saharan Africa, music without a steady rhythm, to which one cannot therefore dance, is not considered music at all, but instead a form of lamentation.

Ethnomusicologists have documented an abundance of social functions for music: it expresses emotion, induces pleasure, accompanies dance, validates rituals and institutions, promotes social stability. The last of these is not merely a matter of 'bringing people together' – music can serve as a socially sanctioned outlet for negative or controversial behaviours too. In some African cultures, the 'protest song' is tolerated as a form of political dissent that could not be voiced in speech or text. And in Bali, musicians and dancers may enact socially disruptive emotions such as rage so as to discharge them publicly in a way that serves the community. In Senegal, the low-caste *griots* of the Wolof people play music to and dance for the nobles in an emotional way. The *griots* are considered expressive and excitable, the nobles cool and detached. These musical performances enable both groups to maintain the stereotypes, which may have nothing to do with the true nature of the individuals. The music stands proxy for the emotions of the nobles, to ward against apathy, without them having to break their mask and actually display such attributes.

Music can be a vehicle for communication, sometimes with exqui-

site precision. The 'talking drums' of African cultures are legendary, and may be used to convey quite specific information in intricate codes almost like Morse, which seem to be tied to the pitch structure of African tonal languages. Villagers might burst into laughter during a xylophone performance as the musician uses his instrument to make a joke about a particular member of the tribe. Everyone gets it – except, sometimes, the butt.

The music of the Sirionó Indians of Bolivia, meanwhile, seems extremely simple: each song is a short phrase containing just a handful of closely spaced pitches. The function of this music seems to be entertainment rather than ritual, but in some ways that objective works on a far deeper level than it does in the West. Each member of a tribe has a 'signature' tune that forms the basis of all he sings, and these songs are voiced in the morning and evening almost as a kind of conversation, a way of saying 'here I am again'. Here's a musical culture of which composer Paul Hindemith would surely have approved when he wrote that 'Music that has nothing else as its purpose should neither be written nor be used.'

In many of these cases, music serves a symbolic purpose. It has been tacitly agreed in advance what the 'meaning' of the music is, and no one is too bothered about judging how 'well' the music meets that goal – the mere fact of the performance guarantees it. Yet whether such a purpose involves any element of pleasure is a difficult question. It has sometimes been claimed that some cultures show no aesthetic response to music, but other ethnomusicologists consider this a prejudiced view: the absence of critics, fanzines and discussion groups doesn't mean the listeners don't assess and enjoy what they hear. Such disagreements may themselves be a consequence of imposing alien categories on the musical experience. It has been claimed that composers among the Basongye people of the Congo have no explicit intention of creating music that others will admire, partly because there is nothing to be judged: they deem music to be an intrinsic good, not something that might be 'good' or 'bad'. Some ethnologists say that art criticism in general has no place in African tribal culture, since it is taken for granted that what we call art is a positive activity that meets essential needs. Meanwhile, David McAllester, a pioneer in the study of music in pre-Columbian American societies, suggests that aesthetic judgements in Native Americans are

commonly tied to function: people like particular songs because they are associated with enjoyable ceremonies. (He says that some people in these cultures also express preferences for songs that are more easily learnt.)

The Canadian ethnomusicologist Colin McPhee claimed in 1935 that Balinese music is utilitarian, 'not to be listened to in itself' and containing no emotion. Rather, he said, it is simply, like flowers or incense, a necessary component of ceremony, as though someone had said 'We need three hours of music here' in the same way that they might specify the necessary dimensions of the meeting hall. Anthropologist Margaret Mead later argued that this did not mean listeners derive no enjoyment from the performance, but she suggested that this pleasure came from the performance aspects itself – from 'the way in which music is played rather than the music'. No one would, in that sense, be saying 'Oh, I love this song'. Yet these responses may have been the result of the Western observers' distance from Balinese culture; certainly, modern listeners to gamelan seem to derive aesthetic satisfaction from it. The ethnomusicologist Marc Benamou cautions that aesthetic and emotional judgements about music can be tricky to compare across cultures: Javanese people don't necessarily recognize the same categories of musical affect (happy/sad, say) as those in the West.

In any event, the Basongye people consider music to be inseparable from good feelings – they say they make music in order to be happy, or to express that happiness: 'When you are content, you sing.' But that's a more complex statement than it sounds; it is as if the emotion defines music rather than stimulates it, for music is not something that can be made in anger: 'When you are angry, you shout.' What's more, any notion that Basongye music is thereby a spontaneous outburst of pure joy is complicated by the claim of one tribesman that 'When one shouts, he is not thinking; when he sings, he is thinking.' All this suggests that Basongye music has a subtle and sophisticated social function that can't easily be described by analogies with the West.

The Basongye readily admit that music can be utilitarian too: another reason for making it, they say, is to be paid. In some cultures it is a tradable commodity, a form of wealth. In New Guinea, tribal people might sell dances from village to village, bundled up with new

forms of clothing and some bits and pieces of magic. The Navajo Native Americans can own songs and sell them to others. And this, at least, is hardly unfamiliar in the West.

Neither is the sacred aspect of music and song. A further reason for making music, say the Basongye, is that God (whom they call Efile Mukulu) tells them to do so. The Yirkalla aborigines of Arnhem Land in Australia hear sacred song words in the babbling of babies. To them, songs are never composed but only discovered: all songs exist already. Where music is used for ritual purposes, a concern with accuracy may become almost obsessive, for a ceremony that is conducted incorrectly loses its power. If a single error is made in the song accompanying a Navajo ritual, the whole thing has to be started again – a standard that even the most exacting of Western concert performers hardly feels a need to uphold.

The purely functional roles of music are also evident in its association with healing. The ancient Egyptians regarded music as 'physic for the soul', and the Hebrews used it to treat physical and mental disturbance – an early form of music therapy. The Greek philosopher Thales is said to have used music to cure a 'plague' of anxiety suffered by the Spartans. According to Plutarch, Thales' songs dispelled the affliction with concord and harmony, in an echo of the magical healing powers attributed to the music Orpheus sang while playing his lyre. That myth is also reflected in the Bible:

> Now the Spirit of the Lord had departed from Saul, and an evil spirit from the Lord tormented him . . . Whenever the spirit of God came upon Saul, David would take up his harp and play. Then relief would come to Saul; he would feel better, and the evil spirit would leave him.

In antiquity and the Middle Ages, music was deemed (at least by the intelligentsia) to have a primarily moral rather than an aesthetic, much less a hedonistic, purpose. It was performed not for enjoyment but to guide the soul. For Plato and Aristotle, this made music a tool that could either promote social harmony or, if improperly used, discord. (It's no coincidence that those are both musical terms.) For the early Christian writer Boethius in the sixth century, music was to be judged 'by means of reason and the senses', not by the heart, and this made it the province of the philosopher rather than the artist. None of this

is to deny that these classical listeners took pleasure from music, but that pleasure was supposed to be a means, not an end. No wonder St Augustine worried that people listening to religious singing might be 'more moved by the singing than by what is sung'. Philosopher Roger Scruton argues that music still has the capacity to provide moral education:

> Through melody, harmony, and rhythm, we enter a world where others exist besides the self, a world that is full of feeling but also ordered, disciplined but free. That is why music is a character-forming force.

In this view, music has as part of its function an educative and socializing value, and I have some sympathy with that.*

Faced with all this diversity, ethnomusicologists have long tended to avoid any quest for universals in the forms and categories of music. Yet there do seem to be some overlaps and parallels between traditions. African music, for example, can be crudely divided into two types, divided by a boundary that lies along the southern edge of the Sahara. To the north, the music is primarily vocal and monophonic, supported by a drone or rhythmic accompaniment. There is a lot of improvisation and ornamentation of the vocal line, often using microtones. In sub-Saharan Africa, in contrast, music is usually performed in groups, being polyphonic and often harmonized and making use of complex, multilayered rhythmic patterns. And the modes of singing are quite different: full-throated in the south, nasal in the north. The musicologist Alan Lomax argued that these distinctions reflect cultural attitudes towards cooperation, sex, hierarchy and class, and that the two styles are in fact representative of twin progenitors of all musical traditions. He proposed that a form based on (mostly male) improvised solos, with free rhythm and complex, highly ornamented melodies, sprung up in eastern Siberia, while sub-Saharan Africa gave birth to a 'feminized', many-voiced, rhythmically regular style. From these twin roots Lomax claimed to discern the branching of ten families of musical styles throughout the world. Although few

* I have less sympathy for Scruton's suggestion that both music and morals are on the decline – see p.335.

ethnomusicologists now accept this idea, the basic traits that Lomax identifies can indeed be recognized in the musics of many disparate cultures.

The science of music cognition is starting to make the question of universals respectable again. Perhaps this is because it has tended to break down music into the simplest structural elements, such as pitch and tone and rhythm, the perception and organization of which would seem to be an essential part of any listener's ability to transform sound into music regardless of the function that it serves. This approach can only get so far, however, because even the issue of what we perceive is not simply a matter of auditory acoustics: just as emotional, social and cultural factors may promote selective hearing of language, so they impinge on music. A Western listener can hear just about any music on the radio and make some kind of assessment of it without knowing anything about the composer, performer, period or context of the music. This would be an alien notion to some preliterate societies such as the Basongye or the Flathead Native Americans, for whom a response to, and even a recognition of, music depends on context, on the reason why it is being played and heard. To ask, as music psychologists routinely do of their test subjects, how one feels about particular intervals or rhythms has no meaning for these people – those are not, to them, questions about music at all.

That's one reason why studies in music cognition have focused almost entirely on the music of large and generally industrialized cultures: it is not only logistically difficult but also potentially ambiguous to test the perception of and response to music among tribal societies. Highly developed musical traditions usually have a rather explicit set of rules for composition, performance and analysis – to put it in coldly scientific terms, we have a better view of what the relevant variables are. But given this lacuna, we have to wonder whether a cognitive science of music can really say anything universal about it as a human activity. Jean Molino doubts that there is much we can learn about the question of *why* we make music by studying the 'great' music of the European classical *oeuvre* – he asserts that music used for ritual and dance (even disco), as well as poetry, is more relevant to that question.

This is not to say that cognitive studies based on the Western

tradition – which means most of those discussed in this book – need be hopelessly parochial. We'll see that there is no reason to think, for example, that Western scales and musical structures are somehow processed with mental apparatus uniquely designed for that purpose, any more than the English language has dedicated modules that could not be used for other languages. And by asking how Western listeners cope in cognitive terms with non-Western music, we can gain insight into the general mechanisms the human brain uses to organize sound. Besides, the Western musical tradition, while having no claim to primacy, is unquestionably one of the most sophisticated in the world, and worth exploring in its own right.

In fact, music cognitive studies are helping to dismantle the old prejudices of ethnomusicology. While even much of the early work in this field had the virtue of challenging centuries of presumed Western musical supremacy,* it nevertheless tended to assert an exceptionalism of the sort voiced by one of the founders of the field, Bruno Nettl, who in 1956 defined ethnomusicology as 'the science that deals with the music of peoples outside of Western civilization'. A modern definition characterizes it instead as 'the study of social and cultural aspects of music and dance in local and global contexts', which rightly implies that Western music is as much a part of the subject as any other form. (Popular culture has yet to catch up, which is why we have the absurd genre category of 'world music', where the world is one in which a West is curiously absent.) As they probe deeper into such questions as how music is linked to emotion, researchers have become struck by how important it is to turn the ethnomusicologist's lens on their own culture. For according to music psychologist John Sloboda, 'It is a curious paradox that we probably know . . . more about the different purposes for which music is used within certain non-Western societies than we do about how it is used in Western consumer societies.'

* It is a relief to be free of the culture that enabled the early philosopher of music Eduard Hanslick to state in 1891 that South Sea Islanders 'rattle with wooden staves and pieces of metal to the accompaniment of fearful howlings', producing 'no music at all'.

In reawakening interest in universals, music psychology is also revitalizing an old question that ethnomusicologists have skirted with understandable caution. Once you start to ask how our brains make sense of music, you can't avoid the issue of *why* they are able to do so. And that summons forth the mystery behind any survey of how music is used in different cultures today: how and why did music arise in the first place?

The first musicians

In 1866 the Linguistic Society of Paris decided it had heard enough dogmatic bickering and vapid speculation about the origins of language, and decided to ban from its meetings any papers on the topic.

If you survey modern discussions about the origins of music – not just a parallel question but most probably a related one – you might have to concede that the Linguistic Society of Paris knew what it was doing. As seems to be the case with any academic enquiry, the stridency with which points of view are asserted seems to bear an inverse relation to the quantity and quality of supporting evidence. And about the origins of music, we have almost no evidence whatsoever.

Music in human culture is certainly very ancient. Several flutes made of bone have been found from the Stone Age – that's to say, the Palaeolithic period, deep into the last ice age. The oldest candidate known so far is carved from the bone of a young cave bear and dates to around 44,000 years ago. It was found in 1995 in Slovenia, and has two holes with the suggestion of a third, and perhaps another on the opposite side. When blown at one end and fingered, it will produce a diverse range of pitches.

It's possible that this object isn't an instrument, but a bone punctured by the sharp teeth of some carnivore which gnawed it later. But the holes appear to be carefully made, with no cracking at the edges, and it would be rather surprising if they had been formed in just these places without shattering the bone or presenting too much of a mouthful for any chewer. Besides, there is no doubt that bone flutes *were* made in the Stone Age. Several unambiguous examples have been

unearthed in the Swabian Jura in Germany dating from around 40,000 years ago, including one more or less complete and rather elegant flute made from a bird bone (Figure 2.1). These instruments show that humans had already by this time rather thoroughly integrated music into their everyday lives.

Yet why should our ancestors have wanted or needed music, especially during an ice age when merely surviving from one day to the next was hard enough?

Charles Darwin offered one of the earliest speculations about why humans first made music. He couldn't ignore the puzzle it seemed to pose for evolutionary explanations of human behaviour, and in his *Descent of Man* (1877) he wrote:

> As neither the enjoyment nor the capacity of producing musical notes are faculties of the least direct use to man in reference to his ordinary habits of life, they must be ranked amongst the most mysterious with which he is endowed. They are present, though in a very rude and as it appears almost latent condition, in men of all races, even the most savage.

In other words, Darwin viewed music-making as an evolved behaviour without obvious adaptive value. He was, however, familiar with other apparently useless adaptations, and he believed his evolutionary theory could explain them. He argued that music had nothing to do with *natural* selection ('survival of the fittest'), but could be

Figure 2.1 A bone flute discovered by Nicholas Conrad of the University of Tübingen and his co-workers in 2008, during excavations at Hohle Fels Cave in the Swabian Jura. It is thought to be about 40,000 years old. (Image: H. Jensen/University of Tübingen.)

accounted for by his parallel notion of *sexual* selection, in which organisms gain a reproductive advantage not by living longer but by having more success at mating. He considered the music of our ancestors to be a form of exhibitionist display or prowess akin to the mating 'songs' and 'dances' of some animals. This hypothesis can accommodate the fact that music is not just of no 'direct use' but is seemingly anti-adaptive: it takes time to learn an instrument and to sit around playing it, which early humans or hominids might be expected to have spent more productively in hunting and gathering. The effort pays off, however, if the musician's skill makes him more attractive. (We can, for these purposes, assume a 'him', since these sexual displays are, in animals, the preserve of the male.) Why, though, should an ability to make music be deemed sexy? One possible answer is that it displays coordination, determination, good hearing, and perhaps stamina (some cultures engage in very lengthy musical ritual), all of which are arguably features that a female might wish to find in her offspring. In this view, music is like the peacock's tail: an elaborate display that is useless, and indeed a hindrance, in itself but which sends out a signal of 'good genes'. The pioneering American behavioural neurologist Norman Geschwind believed that musical ability is a genuine predictor of male reproductive prowess, because (he argued) both are promoted by high levels of foetal testosterone. Although this hypothesis was developed before we knew much about the links between brain anatomy and musicality (there's still much we don't know, as you'll see), it is sometimes still asserted today in support of Darwin's sexual-selection origin of music.

And indeed this idea isn't without merit. But its modern adherents too often mistake the accumulation of ad hoc arguments for the collection of scientific evidence.* One researcher points out, for instance,

*One argument adduced by psychologists Vanessa Sluming and John Manning has at least the virtue of being amusing: they found in 2000 that, averaged over eleven concerts of classical music, there were significantly more women in the seats nearer the (predominantly male) orchestras than in the back rows – a genteel form, they implied, of the female hysteria that greeted the Beatles in concert. Sluming and Manning admitted that the hypothesis might, however, need to take into account how many of these women were pre-menopausal. I suspect they may have found this information hard to acquire at classical recitals.

that just about all complex, varied and interesting sounds produced by other animals are made for the purposes of courtship, so why not humans? This would seem equally to argue that every phrase we utter has the aim of attracting a mate, which I rather doubt was true even of Casanova. In any event, the claim is not even true as stated: monkeys and apes don't appear to use calls for sexual purposes. And 'primitive' songs are by no means the tribal equivalents of 'Let's Spend the Night Together': those of the Australian Aborigines, for example, express the singer's feelings as a member of the community.

If music really did stem from sexual selection, we might reasonably expect that musicians will have more children (or children who survive better). Do they? We have no idea, and no one seems too concerned to find out. Even more regrettably, supporters of the sexual-selection hypothesis seem to find it extraordinarily difficult to refrain from drawing a facile analogy with the libidinal excesses of rock stars – which is why I suggest we view this as the 'Hendrix theory' of music's origins. Yes, Jimi Hendrix had plenty of sexual conquests (though he sired few children) before his untimely death (thereby, in evolutionary terms, making the dangerous drugs and drink a price potentially worth paying) – but if there's one thing worse than theorizing by anecdote, it is theorizing by celebrity anecdote. For every such case, there is a counter-example. We don't know much about the sexual adventures of troubadours, but most Western music in the Middle Ages was practised by (supposedly) celibate monks. In some African societies, musicians are regarded as lazy and unreliable – poor marriage prospects, in other words. (Some seem to find those characteristics in themselves aphrodisiac, but *chacun à son goût* is no evolutionary theory either.)

Besides, if music is an adaptation via sexual selection, we might expect it to be developed to different degrees in men and women. There's no evidence that it is (even though there may be slight differences in how music is processed in the brain – see p. 249). We know of no other example of sexual selection that is manifested the same way in both sexes. This doesn't mean that music *can't* be unique in that respect, but it does warrant some scepticism about the idea.

There's no lack of alternative hypotheses for the origin of music. One key question is whether human music has any connection to the 'songs' that some animals, from birds to whales, produce. Some people

might be happy to call these 'songs' music simply because they sound a bit like it; and it hardly seems important to dissuade them, provided we accept that birdsong does not become music merely because Olivier Messiaen transcribed it as such (and because countless earlier composers, including Beethoven, mimicked it acoustically in their compositions). But as will become increasingly clear, music is not just a series of pitches, and neither is it a sound designed to impart information. One could, in theory, encode any message in music, merely by assigning notes to letters. If you know the code, the Bible could be communicated that way. But it wouldn't be the Bible rendered in 'music', because it would be musically empty.

Most animal sound is of this encoding type: the sounds have designated meanings, serving as warning signals or mating calls or summonses to the young. What is striking and suggestive about bird and whale songs is that they are not obviously like this: they aren't mere screams or whoops, but consist of phrases with distinct pitch and rhythm patterns, which are permutated to produce complex sound signals sometimes many minutes or even hours long. It seems clear that these sequences don't in themselves encode semantic information: songbirds don't mean one thing when they repeat a phrase twice, and another with three repeats. In this sense, no animal makes lexically meaningful combinations of sound – sentences, if you like, which derive a new meaning from the combined meanings of the component parts.

This challenges any notion that animal song is like human language – but what about human music? As we'll see, the questions of whether music may have either a grammar or any semantic meaning are hotly contested, but neither has yet been shown to be an essential characteristic of music. Songbirds, which comprise nearly half of all known bird species, tend to create their songs by the shuffling and combination of short phrases. In this way they can create a huge repertoire – sometimes hundreds of songs, each one apparently remembered and repeatable – from a small inventory of basic fragments. Yet the songs don't each have a distinct meaning; rather, it seems that the aim is merely to create sensory diversity, to produce a 'new' song that will capture the attention of potential mates through novelty. (In an echo of Darwin's sexual-selection hypothesis, the females of some of the songbird species with the most complex songs, such as sedge warblers and starlings, may choose males with the most elaborate songs.) This

finally 'pure' instrumental music. 'Music and language have just too many important similarities for these to be chance occurrences alone,' claims Brown. He believes that a musilanguage could have served as a launching stage for both music and language if it contained three essential features: lexical tone (the use of pitch to convey semantic meaning), combinatorial formation of small phrases, and expressive phrasing principles, which add emphasis and connote emotion (for example, fast tempos to convey happiness, and slow to convey sadness).

A remnant of such musilanguage might be perceived in the so-called Auchmartin and Enermartin of some Ecuadorian tribes, which are forms of song-speech used respectively by strangers meeting on a jungle path and by groups of men to promote courage before battle. More generally, perhaps relics of musilanguage survive in tonal languages, and in the way songs and rhythmic poems are often used in preliterate cultures to encode important knowledge. Here the musicality aids memory: it's generally much easier to memorize poetry than text, and we typically find song lyrics easier to recall when we sing rather than say them. (We'll look later at some of the possible neurological reasons for this.)

A curious variant of the 'musical communication' hypothesis was put forward by the Hungarian-Dutch psychologist Géza Révész, a friend of Béla Bartók, who pointed out that a song-like voice has acoustic features that allow it to carry over greater distances than a speech-like voice. You might say that this makes the earliest music a kind of yodel – if you like, the 'Lonely Goatherd' theory of music's origins.

One of the most obvious features of music the world over is that it tends to be a group activity. Even when performed by a select few, music commonly happens in places and contexts in which it creates social cohesion, for example in religion and ritual or in dance and communal singing. One of the clearest descriptions of this role was given by the English social anthropologist Alfred Radcliffe-Brown in his study of dance among people of the Andaman Islands in the Bay of Bengal:

> The dance produces a condition in which the unity, harmony and concord of the community are at a maximum, and in which they are

> intensely felt by every member. It is to produce this condition, I would maintain, that is the primary social function of the dance . . . For the dance affords an opportunity for the direct action of the community upon the individual, and we have seen that it exercises in the individual those sentiments by which the social harmony is maintained.

This function has led some to suspect that we shouldn't be searching for music's origins in the benefits it might confer on individuals, but rather, in how it is advantageous to an entire society or culture (and thus *indirectly* the individual). This is, you might say, the 'New Seekers theory' of music's origins: 'I'd like to teach the world to sing'. The music psychologist Juan Roederer puts it a little more soberly:

> The role of music in superstitions or sexual rites, religion, ideological proselytism, and military arousal clearly demonstrates the value of music as a means of establishing behavioural coherency in masses of people. In the distant past this would indeed have had an important survival value, as an increasingly complex human environment demanded coherent, collective actions on the part of groups of human society.

The notion of 'group selection' as an evolutionary force, whereby behaviours are selected because they benefit a group, has had a controversial history, and remains so today. The question of how much advantage you get from helping those only distantly related to you, or not related at all but nonetheless sharing common goals, is a very subtle one. All the same, the theory that music's adaptive value lay in the way it brought communities together and promoted social cohesion enjoys wide support.* A 'social' element is found in primate calls, which seem to help members of a group locate one another. And music in tribal societies often has communal functions: for example, it's said that Venda tribespeople can tell from a song what the singer is doing. The men of the Mekranoti tribe of Amazon Indians devote several hours a day to group singing, especially very

* There is in fact nothing necessarily incompatible with an origin of music in social cohesion and one in sexual selection, for individuals that take the lead in social music-making gain status.

early in the morning. Everyone is expected to attend these communal sessions, in which the singing possibly keeps the groggy men awake so that they can be alert to attacks from enemy tribes. That would certainly give music-making a survival value – and indeed, it would be odd to devote this much time to an activity that did not have some adaptive benefit.

Rhythmic sounds provide a great vehicle for synchronization and coordination of activity – witness (say the theory's advocates) the ubiquity of 'work songs'. And even when nothing tangibly 'useful' comes of group participation in music, it promotes a lasting sense of togetherness. Again, contemporary parallels offer themselves with treacherous alacrity: look at the way adolescent subcultures establish their identity through allegiance and shared listening to specific modes of music. Japanese researcher Hajime Fukui has found that people have lower testosterone levels when listening to their favourite music, which he interprets as an indication of music's socializing function, promoting sexual self-control and lowering aggression. Those notions seem squarely contradicted by rave parties and mosh pits, of course, but it's questionable whether we can deduce much about music's origins from the antics of Western teenagers. More importantly, Fukui's findings fail to tell us whether changes in listeners' testosterone levels are prompted by music as such or by the fact that they are hearing their favourite kind.

Rather more convincingly, the almost universal use of music in communal ritual might be understood on the basis that its ability to arouse emotion and teeter on the brink of meaning, without any such meaning ever becoming apparent at the semantic level (and we'll look at that contentious claim later), seems to recommend it for expressing or representing numinous concepts. Stravinsky seems to have shared this view, saying that 'the profound meaning of music and its essential aim . . . is to promote a communion, a union of man with his fellow man and with the Supreme Being'.

Sexual display, group bonding, transmission of information: it all sounds rather, well, male. Another hypothesis aims to relocate the musical impulse in the maternal, by pointing out that infants are much more receptive to speech when conveyed in the singsong tones dubbed 'motherese', and that mothers of all cultures use this instinctively. (So do fathers and siblings, although an infant's exposure to

this kind of communication would usually come mostly from the mother.) And babies seem to come equipped with the mental apparatus for discerning simple musical attributes: they can discriminate from the time of birth between upward and downward musical contours, and within two months they can detect a change in pitch of just a semitone.

If better mother-child communication – not just semantic but emotional – leads to better-adjusted and more cognitively able adults who do well in the world, then there is a potential selective advantage to a predisposition to musicality.* But one can also interpret at least some features of motherese in purely linguistic terms: it facilitates language learning by helping to emphasize contrasts between different vowels and consonants, for instance. And the descending pitch contours that characterize lullabies throughout the world are also found in speech typically used to soothe a child.

Furthermore, it's not easy to explain how traits shaped by one-on-one infant interactions find their way into adult social ritual. Musicologist Ellen Dissanayake suggests that the music-like sensitivities and competencies developed in the mother-infant interaction 'were found by evolving human groups to be emotionally affecting and functionally effective when used and when further shaped and elaborated in culturally created ceremonial rituals where they served a similar purpose – to attune or synchronize, emotionally conjoin, and enculturate the participants'. That seems something of a leap of faith, and surely invites the question of why often (although by no means universally) it is men who have traditionally engaged in the production of music. Even less comfortable is the suggestion that an origin of music in infanthood explains why (Western) popular songs use childish words such as 'baby' to express sentiment, an idea that tempts me to call this the 'Ronettes theory' of music's origins: 'Be My Baby'.

Might it be that to ask 'what is the origin of music?' is simply to ask the wrong question? Some palaeontologists and archaeologists consider that the transition from our ape-like ancestors to humans

*Some Freudian psychologists, such as Heinz Kohut, have stood this argument on its head, suggesting that music is therefore a form of infantile regression, albeit one that has been made socially and aesthetically acceptable.

– what they call hominization – involved the appearance of such a rich complex of traits, such as language, arithmetic, logic, society and self-consciousness, in such a short time that it makes little sense to consider them independent of one another. Either they are all part of the same basic phenomenon, or the emergence of one made all the others inevitable. In a similar vein, Jean Molino argues that, as there seems to be no universal definition of music, we can't reasonably say that something called music emerged in evolution, but only that certain human capacities and tendencies appeared which have gradually found expression in what we now consider types of music.

Pinker redux

To almost all of this theorizing about origins, one can only say: yes, it sounds plausible. You could be right there. Maybe it's unfair to point out (as one nonetheless must) that all these ideas are more or less impossible to prove. After all, no one has access to a Palaeolithic society. But it's unfortunately rather rare to hear hypotheses about music's origins asserted with anything less than firm conviction, and rather common (as I've hinted) to find them supported by cherry-picking from the vast and diverse ways in which music is made and used throughout the world – or worse still, by anecdotes from Western popular culture, in which music has surely become a more artificial, abstracted, and fashion-bound medium than in any other culture.

More troubling still is the sense that these speculations are being offered in desperate determination to prove that music has been hard-wired into our brains by evolution – to show, in other words, that Steven Pinker is wrong to portray music as a kind of aesthetic parasite. One can't help feeling that an evolutionary role for music is often seen as the only way it can be afforded its true dignity. Even worse is the implication that if we understand where music came from, we will understand what it is about. Whether or not Pinker is right about why we have music, he is right to say that the debate should not become a surrogate for arguing over the *value* of music. When evolutionary biology becomes the arbiter of artistic worth, we are in big trouble.

3

Staccato
The Atoms of Music

What are musical notes and how do we decide which to use?

'Organized sound' might strike you as a pretty neat definition of music. But the phrase was coined by the French-born avant-garde composer Edgar Varèse, who wrote music in the early twentieth century that many of his contemporaries would not have accepted as 'music' at all. And Varèse wasn't seeking a catchy general definition that could be applied to anything from Monteverdi to Leadbelly; rather, he used the description to *distinguish* his bold sonic explorations from conventional music. His compositions called for howling sirens, the ghostly electronic wail of the theremin, and electronically taped ambient noises: rumbling, scraping, jangling, honking and the churning of machines. He gave these works pseudoscientific names: *Intégrales*, *Ionisation*, *Density 21.5*. 'I decided', he said, 'to call my music "organized sound" and myself, not a musician, but a "worker in rhythms, frequencies and intensities".' If *that* was meant to apply to Mozart too, it would seem to make him something like a cross between a laboratory technician and an industrial labourer.

But Varèse didn't regard himself as an iconoclast. He traced his heritage to music's ancient practices, and professed admiration for the music of the Gothic Middle Ages. This seems appropriate in many ways, for the composers and musical scholars of antiquity shared his view of music as a kind of technical crafting of sound. Unlike the nineteenth-century Romantics, they would have had no problem with a discussion of music in terms of acoustic frequencies and intensities.

I suspect many people share the romantic sense that music is a product of numinous inspiration, and are apt to feel disheartened, even appalled, when it is fragmented and seemingly reduced to a

matter of mere acoustics, of the physics and biology of sound and audition. If that seems at first to be the business of this chapter, I hope you will soon see that it isn't really so. But I don't intend to apologise for a digression into the mathematics, physics and physiology of acoustic science by justifying it as an unavoidable introduction to the raw materials of music. It is much more interesting than that.

I will admit, however, that while dissection is as necessary in musicology as it is in biology, it is likewise apt to leave us contemplating a pile of lifeless parts. A better metaphor than the anatomical is the geographical: music is a journey through musical space, a process that unfolds in time and the effect of which depends on how clearly we can see where we are and how well we recall where we have come from. Only the vista ahead is obscure to us; but our sense of journey depends implicitly on our anticipation of what it might contain. And just as a journey is not made from trees and rocks and sky, music is not a series of acoustic facts; in fact, it is *not acoustic at all*. I can't emphasize this enough. It is fine to call music 'organized sound', so long as we recognize that this organization is not solely determined by the composer or performer: it emerges from a collaboration in which the listener too plays an active part.

Nonetheless, this chapter is not merely about the cold facts of the 'sound' that Varèse sought, in his idiosyncratic way, to organize. It is about how nature and culture interact to produce the diverse palettes of notes that most traditions draw on in creating their sonic art. There is very little that is preordained in this palette – contrary to common belief, it is not determined by nature. We are free to choose the notes of music, and that's what makes the choices interesting. They crystallized in Western music into the notes of the modern piano, which repeat in octave cycles with twelve notes each. Not everyone accedes to that arrangement. The maverick American composer Harry Partch (1901–74), searching for a system better adapted to the nuances of the human voice, devised a microtonal scale of 43 pitch steps per octave (he also experimented with 29-, 37- and 41-note scales). The music Partch wrote was played on special instruments that he designed and built himself, bearing exotic names such as the chromelodeon, the bloboy and the zymo-xyl. It sounds frighteningly experimental, but Partch's music is actually not as formidable or jarring as one might

expect, especially if you've had any exposure to gamelan and South East Asian percussion orchestras.

The point is not necessarily *which* notes we choose, but the fact that we choose them at all. Painters understand that notion. They have in principle an infinite range of colours at their disposal, especially in modern times with the chromatic explosion of synthetic chemistry. And yet painters don't use all the colours at once, and indeed many have used a remarkably restrictive selection. Mondrian limited himself mostly to the three primaries red, yellow and blue to fill his black-ruled grids, and Kasimir Malevich worked with similar self-imposed restrictions. For Yves Klein, one colour was enough; Franz Kline's art was typically black on white. There was nothing new in this: the Impressionists rejected tertiary colours, and the Greeks and Romans tended to use just red, yellow, black and white. Why? It's impossible to generalize, but both in antiquity and modernity it seems likely that the limited palette aided clarity and comprehensibility, and helped to focus attention on the components that mattered: shape and form. That is perhaps even more true in music, because the notes carry a heavy cognitive burden. To make sense of music, we need to be able to see how they are *related* – which are the most important, say, and which are peripheral. We need to understand them not just as stepping stones in musical space, but as a family group with a hierarchy of roles.

Making waves

Most of the music in the world is made from notes. And to a good approximation, we hear each note as a *pitch* with a specific acoustic frequency. Notes sounded in succession create a *melody*, while notes sounded simultaneously produce *harmony*. The subjective quality of the note – crudely, what instrument it sounds like – is its *timbre*. The duration and timing of notes, meanwhile, define the *rhythm* of music. With these ingredients, musicians compile 'global' structures: songs and symphonies, jingles and operas, compositions that typically belong to a certain form, style and genre.

Most music is experienced as vibrations in air. That's to say, some object is struck, plucked or blown, or driven by oscillating electro-

magnetic fields, so that it vibrates at specific frequencies. These motions then induce sympathetic vibrations in the surrounding air that radiate away from the source like ripples in water. Unlike waves on the sea surface, the vibrations of air are not undulations in height; they are changes in the air's density. At the 'peaks' of sound waves, the air is compressed to greater density than it would be in a soundless space; at the 'troughs', the air is less dense (rarefied) (Figure 3.1). The same is true of acoustic waves passing through other substances, such as water or wood: the vibrations are waves of material density. Earpieces attached to portable electronic devices sit in contact with the tissues of the ear and transmit vibrations to them directly.

The perceived pitch of a sound becomes higher as the frequency of the acoustic vibrations increases. A frequency of 440 vibrations per second – the 'concert pitch' to which Western pitched instruments are conventionally tuned – corresponds to the A note above middle C. Scientists use units of hertz (Hz) to denote the number of vibrations per second: concert A has a frequency of 440 Hz. We can hear frequencies down to 20 Hz, below which we feel rather than hear them. Frequencies just below the lower threshold of hearing are called

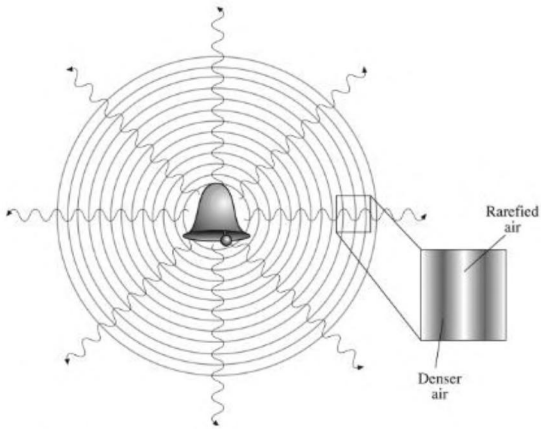

Figure 3.1 Sound waves in air are waves of greater or lesser air density.

infrasound, and are produced by some natural processes such as surf, earthquakes and storms. They seem to stimulate strange psychological responses, particularly feelings of unease, revulsion, anxiety and awe, and have been credited with inducing 'supernatural' experiences. Infrasound has been used for its unsettling effect in some contemporary music, for example in the soundtrack to the French shocker movie *Irréversible*. As a way of using music to induce emotion, that somehow seems like cheating.

The upper frequency limit of human hearing is typically about 20,000 Hz, but tends to be lower in older people because our ear's sound sensor cells stiffen with age. Higher frequencies than this (ultrasound) are inaudible to humans, but are detected by many other animals: bats use them for echolocation. Between these extremes, human hearing typically spans a gamut of about ten octaves. On the 88-note piano, the lowest A growls at 27.5 Hz, and the top C is a shrill 4,186 Hz. We find it harder to make out a single well-defined pitch for notes at either extreme of the piano than for those in the middle – which is why most music is played there, and of course why it is the middle of the keyboard at all. The human male speaking voice has a typical frequency of around 110 Hz, and the female voice an octave higher, 220 Hz; so when men and women sing together 'in unison', they are actually singing in octave harmony.

How we hear

Converting acoustic vibrations in the air to a nerve signal that is sent off for processing in the brain is the job of the cochlea, a spiral chamber of bone in the inner ear that looks like a tiny snail shell (Figure 3.2). Housed within it is a long membrane sheet called the basilar membrane, covered with sound-sensitive 'hair cells', so called because of the little tuft-like protrusions that poke above their surface. These cells are like mechanical switches: when the 'hairs' are set waving by acoustic vibrations in the fluid that fills the cochlea, the movement pulls open tiny pores in the cell walls, letting in electrically charged metal atoms from salt in the surrounding fluid that change the electrical state of the cell. This

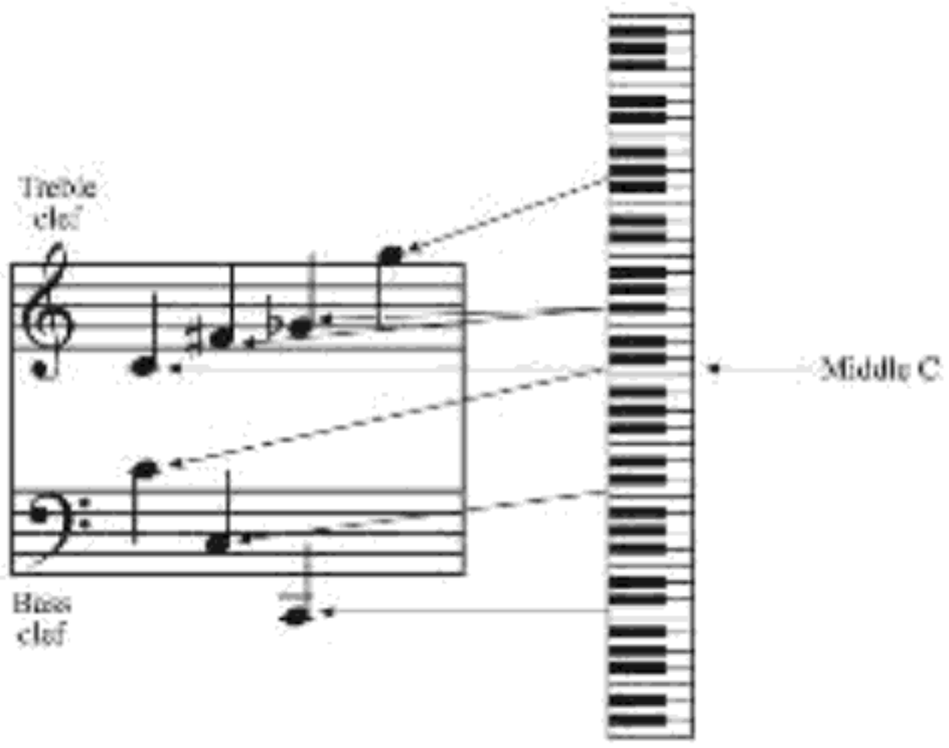

Figure 3.3 The musical clefs and staves. Notes higher on the stave indicate notes 'higher' on the piano. Every note either sits on a stave line or between them.

ornate 'clef' signs that appear at the start of the stave – the baroque treble clef on the upper stave, the coiled bass clef on the lower – are merely symbols to tell you where the correspondence between stave lines and piano keys is anchored. The treble clef looks a little like a fancy 'g', and its lower body circles the stave line corresponding to the note G above middle C. The bass clef is a stylized F, and its two dots straddle the stave line corresponding to the F below middle C (Figure 3.3). Other types of clef are sometimes used that define different 'origins' on the staves, but we needn't be concerned with them.

What about the black notes on the piano? These are indicated by so-called accidentals – the sharp and flat signs ♯ and ♭ – next to a note of a particular pitch, indicating that this note should be played either on the black note above (sharp) or below (flat). There is some redundancy in this system, because it means that the black notes have more than one 'identity'. That above F, for example, is simultaneously F♯ and G♭ (Figure 3.3). And for white notes that do not have a black note immediately adjacent in a certain direction, a sharp or a flat becomes another white note: B♯, for instance, is the same as C. We will see shortly where this notation for accidentals came from, and also how the 'multiple identities' of the various notes have a complex history and a subtle role to play in how we conceptualize music.

The notes go in a repeating cycle as they ascend. Rising from concert A, for example, we find the white notes B, C, D, E, F, G – and then A again. This second A is an octave above the first: eight notes higher as we rise up the musical scale. We'll see below precisely what that means. Each particular note can be given a unique label by numbering those in each octave, starting from the lowest A on

the piano keyboard (A0). This makes middle C equivalent to C4, and concert pitch A4.

The blobs denoting notes take on different appearances in a musical score (Figure 3.4) – sometimes filled in (♩), sometimes empty (𝅗𝅥), some with wavy tails attached, some linked by bars or accompanied by dots or so on. These markings indicate the note's duration: whether they last a whole beat, or several beats, or a fraction of a beat. And there are other objects arrayed on the staves. Some (such as 𝄽 and 𝄾) denote *rests*, which are beats or fractions of a beat during which no notes sound. Arching lines might designate *ties*, which show that a note is to be prolonged over both of the note durations at each end; or they might tell the musician about patterns of phrasing, meaning how notes are to be articulated in groups.

There are rhythmic codes here too. The numbers at the start of a stave are the *time signature*, which indicates how many notes of a particular duration should appear in each of the *bars* denoted by vertical lines. In essence, they tell us whether we count the rhythm (more properly, the *metre* – see Chapter 7) in groups of two, three, four or more beats. Music scores are littered with other signs too, indicating such matters as dynamics (where to get louder or softer), accents, trills and so forth. This isn't the place for a comprehensive account of what music notation means; Figure 3.4 shows the main symbols that will suffice to understand most of the musical extracts I quote. To keep matters simple, I have generally stripped them down to their bare essentials rather than following the composers' scores rigorously. I hope that will not trouble purists.

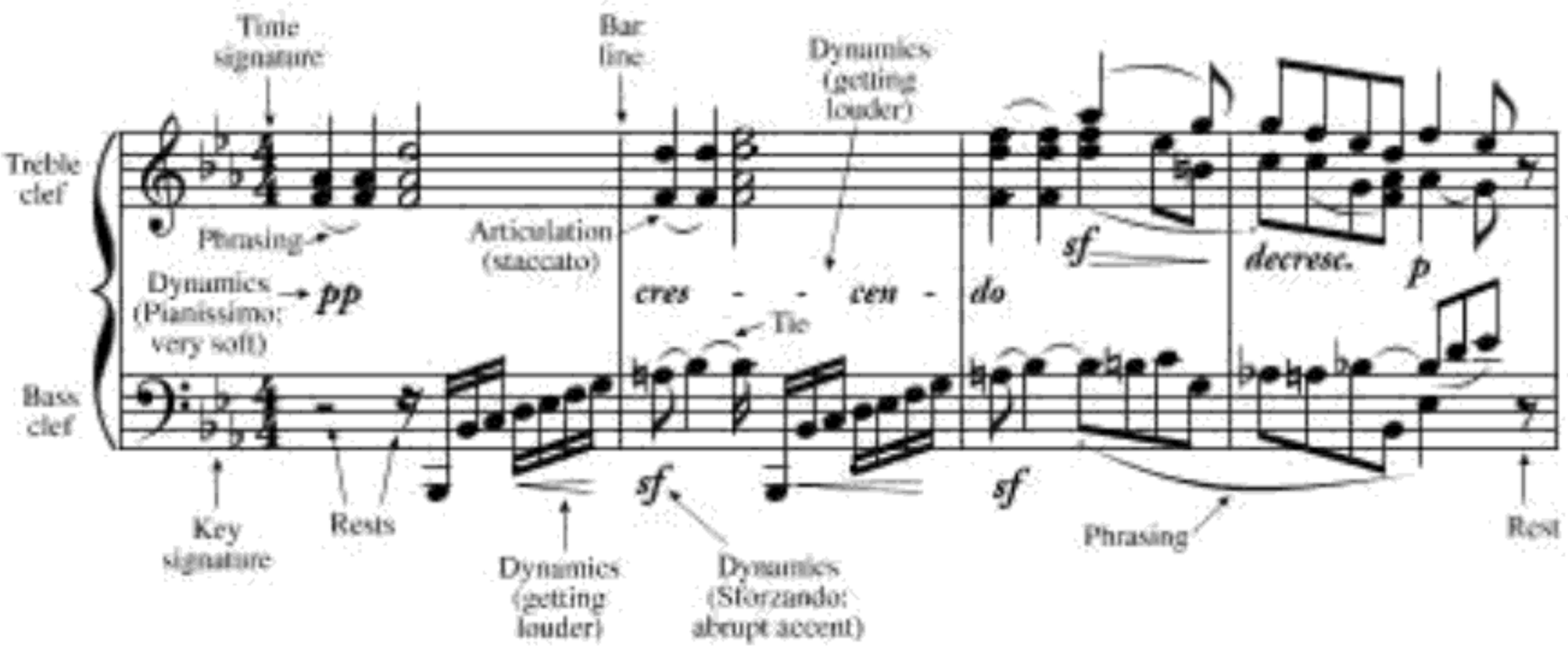

Figure 3.4 Basic elements of written music.

Arranging the sonic staircase

In principle, the relationship between the pitch and acoustic frequency of a musical note seems simple: the higher the frequency, the higher the pitch. But a striking aspect of music in nearly every culture is that its notes are *discrete*. There are an infinite number of pitches within the frequency range audible to humans, since the difference between two frequencies can be made as small as you like. Although there comes a point at which we can no longer distinguish between two very closely spaced tones, just as there are limits to the resolution with which we can discriminate objects visually, there are consequently very many 'notes' that we could arrange into music. Why do we use only a subset of them, and how is that subset selected?

Nature seems to have imposed a basic division of this continuous pitch scale: the octave. If you play any note on the piano and then play the same note an octave higher, you will hear it as a 'higher version' of the original note. This is so commonplace that it seems barely remarkable. Anyone who has ever picked out a simple melody on a piano with tentative prods of a finger will have discovered that the same melody can be played, with the same pattern of key strokes, an octave higher or lower. The octave is itself enshrined on the piano in the shape and arrangement of the keys: novice pianists learn to recognize the L shape of Cs and Fs, and the cyclic clustering of two and three black notes.

But octave equivalence is deeply strange. It is a perceptual experience unique to music: there is no analogous repeat pattern in visual perception, or in taste.* In what way is middle C 'like' the C above

* It is often remarked that the two extremes of the visible spectrum of light – red and violet – match up, so that the spectrum seems to come full circle. There is no obvious reason why this should be so: the frequencies of light corresponding to the two colours are unrelated. The circularity of colour space is, however, a genuine perceptual phenomenon, which has been tremendously useful to colour theorists in permitting them to construct closed 'colour wheels' for purposes of classification. It is an artificial construction, however: the 'colour' just as visible light turns into infrared does not really look identical to the colour as violet becomes ultraviolet. And in any case, there is no repetitive cyclicity here as there is in pitch perception – colour has, at best, only 'one octave'. Nonetheless, a semi-mystical conviction that colour and sound must be related wave-determined phenomena was what led Isaac Newton to postulate seven divisions of the rainbow, by analogy to the seven notes of the musical scale. This arbitrary Newtonian scheme of colour categories is still taught as objective fact today.

or below it – what quality remains unchanged? Most people would say 'they sound the same' – but what does that mean? Clearly they are not the same. Perhaps one might say that the two notes sound good or pleasing together, but that only generates more questions.

Pythagoras is attributed with the discovery of how octave pitches are related to one another. The apocryphal story has it that the Greek philosopher once walked into a blacksmiths' forge where notes rang out as the smiths' hammers struck their anvils, and he noticed that there was a mathematical relationship between the relative pitches and the size (the masses) of the anvils that produced them. When he went on to investigate the sounds made by plucking taut wires or strings, Pythagoras is said to have found that tones which sound harmonious together, such as octaves, have simple ratios of their frequencies. The octave is the simplest of all: a note an octave above another has double the frequency of the first. This is equivalent to saying that the higher note has *half* the wavelength of the lower.

We can visualize the relationship in terms of the lengths of the plucked string. If you halve the length of the vibrating string by putting your finger on its midpoint, you double the frequency and generate a note an octave higher. This is easily done on a guitar: the fret that produces an octave higher than the open string is located exactly halfway between the contacts of the string at the head and the bridge (Figure 3.5*a*).

The next higher octave has a frequency that is doubled again, making it $2 \times 2 = 4$ times that of the original note. The frequency of A6, say, is $4 \times 440 = 1{,}760$ Hz. You will get such a double-octave jump on a guitar string by pressing down three-quarters of the way along the string and plucking the upper quarter. And so it goes on: each successive octave entails another doubling of the original frequency.

Just about every musical system that we know of is based on a division of pitch space into octaves: it seems to be a fundamental characteristic of human pitch perception. We'll see later the likely reason why.

But what about the notes in between the octaves? Again, legend credits Pythagoras with an explanation for how these are chosen in Western scales, although in fact this knowledge was surely older. If

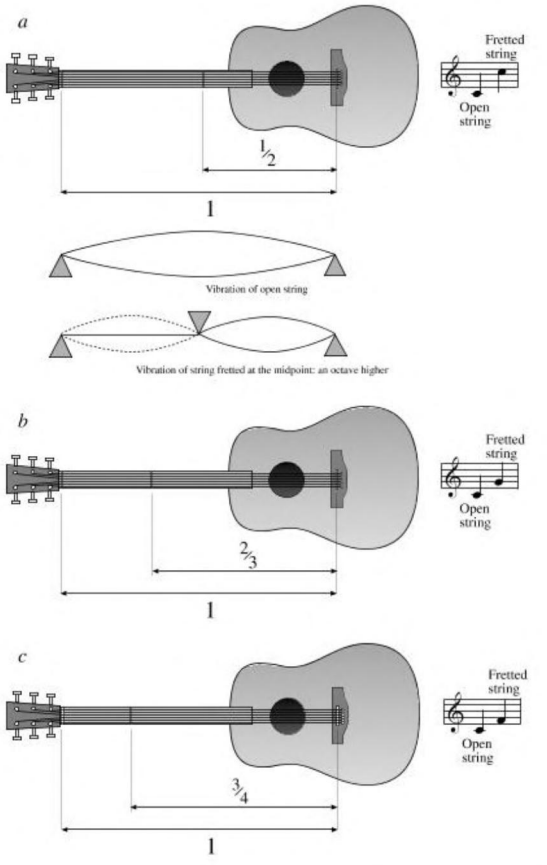

Figure 3.5 An octave can be produced on a plucked string by fretting it halfway along its length (*a*). The two notes have wavelengths in the ratio 2:1, and frequencies in the ratio 1:2. Fretting a third of the way along produces a note a perfect fifth above the open string (*b*), and fretting a quarter of the way along produces a perfect fourth (*c*).

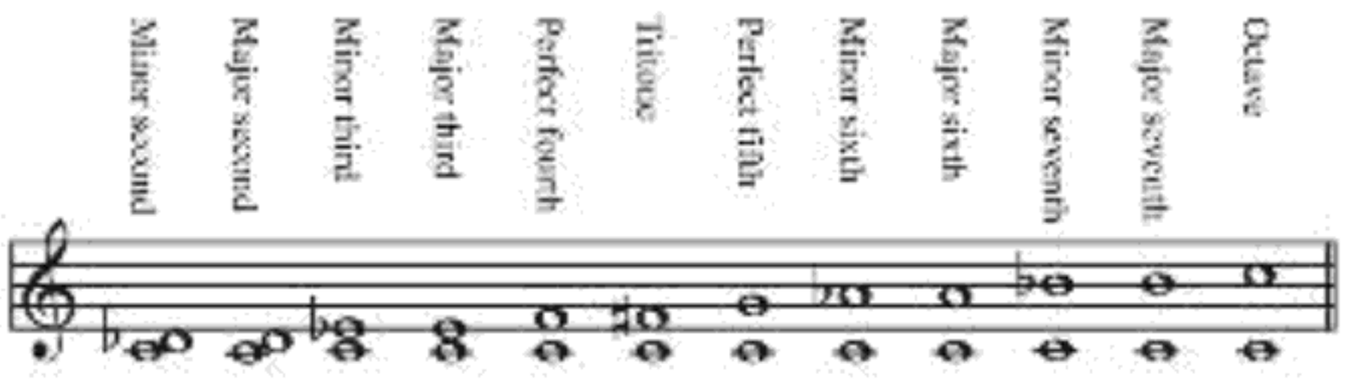

Figure 3.7 The intervals of the diatonic scales.

for example, is an octave plus a second, or nine scale degrees, and is called a (major) ninth. Arguably one could denote this step as **1→9**; but the **9** here is also the second note of the scale starting an octave higher, and so is more commonly written as **2'**, the prime denoting the start of a new octave. The octave interval is, in this notation, **1→1'**.

Any specific interval always spans a set number of semitone steps between the lower and upper notes: a major third corresponds to four semitone steps, a minor third to three, say.

So it is all really just a matter of counting. Where things get a little complex is that intervals aren't always defined with reference to the tonic note of the key in which they appear. Consider the interval E to G, say. This is a minor third: G is four semitones above E, and is also the third note of the E minor scale. But this doesn't mean that the E→G step is somehow confined to music in E minor. It is also a step between the **3** and **5** of the C major scale, for example, and between the **7** and **2'** of F major.

Thus an interval of a fifth separates pitches whose frequencies are in the ratio of 3:2. Having decided that this interval is pleasing to the ear, the followers of Pythagoras deduced from this a general principle: pitches whose frequencies are related by simple ratios sound 'good', which is to say, they are considered consonant. (The real relationship between 'consonance' and what we perceive is more complex, as we'll see.) For the consonant perfect fourth – C to F, say – the pitches are in the frequency ratio 4:3 (Figure 3.5*c*). The frequency of F is four-thirds that of the C below it.

These three simple frequency ratios – 2:1, 3:2 and 4:3 – give us three notes related to the original one: an octave, a perfect fifth and a fourth above, or **1'**, **5** and **4**. In the key of C, these are C', G and F. And so we have the beginnings of a scale, a set of notes that seem to fit together harmoniously and which we can arrange into music. One

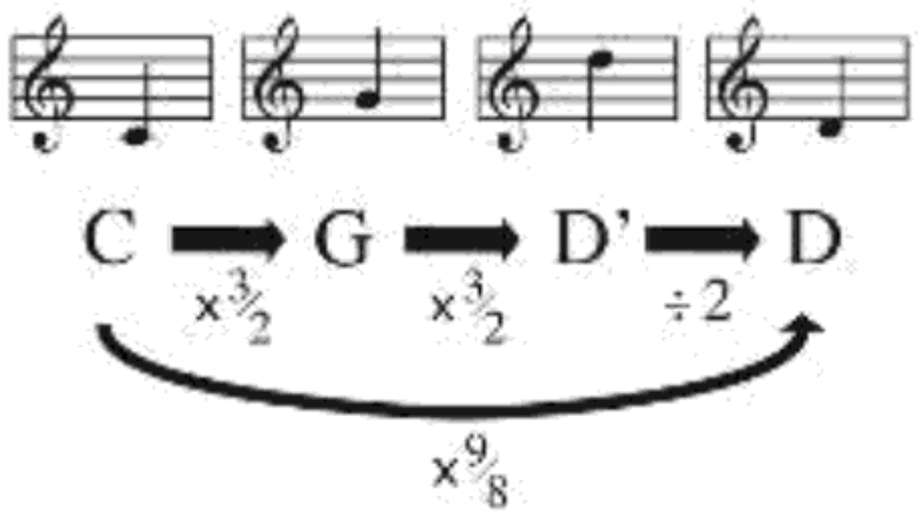

Figure 3.8 Getting from C to D in steps of fifths and octaves. The resulting frequency ratio is 9/8.

might then explore the notes that follow from other simple ratios, such as 5:4 and 6:5. We'll come to that shortly. But it isn't how the Greeks proceeded. They recognized that just these three intervals alone can provide a basis for generating other scale notes, because one can apply the same mathematical transformations on the 'new' notes **5** and ***4***. For clarity, let's stay with the specific versions of these notes in C – that is, G and F. We can raise G by a perfect fifth by increasing its frequency in the ratio 3:2 (multiplying by 3/2). Relative to the original C, this new note has a frequency greater by a factor 3/2 × 3/2, or 9/4, and it corresponds to the note D'. Now if we fold this new note back into the octave span C→C' by dropping it an octave (halving its frequency), we find that we have a note 9/8 times the frequency of the tonic C, corresponding to the D above (Figure 3.8).

We can get to this D another way from just steps of fourths and fifths: by stepping up a perfect fifth to G, and then down a perfect fourth. I won't go through the maths, but that too brings us to a note with a frequency 9/8 that of the tonic. Consistency! So we have a scale C, D, F, G, C'. But there are big gaps between D and F, and between G and C'. We can fill them by taking step sizes equal to that between C and D, or between F and G, which are both frequency increments of 9/8. Applying this to D gives us an E with a frequency ratio 81/64 that of C, and applying it to G gives us an A at 27/16 the frequency of C. A further such step up from A gives B, with a ratio of 243/128. An equivalent way of getting these extra notes is simply to raise the tonic progressively in steps of a fifth – from C to G, G to D', D' to A', A' to E" and E" to B" (Figure 3.9) – and then to fold these notes back into the original octave span.

And there is our major scale. Closer inspection reveals that it has a curious, uneven pattern of pitch steps. The first two degrees, **1→2** and **2→3** are as wide as the steps **4→5** and **5→6**, and all are equal to frequency increments of 9/8. But the steps **3→4** and **7→1'** (E to F and B to C', say)

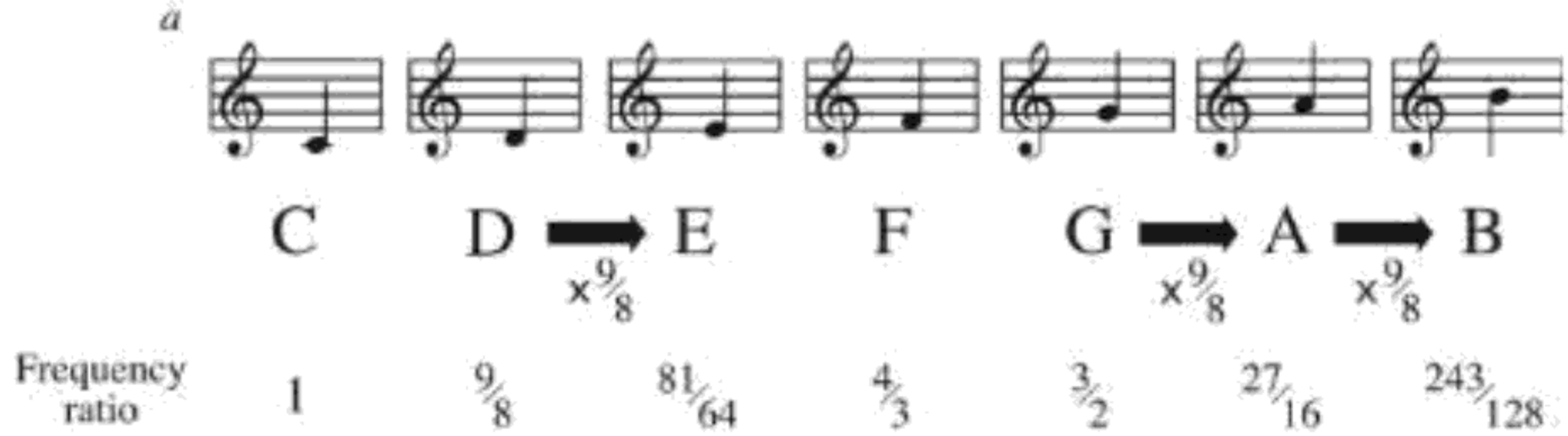

Figure 3.9 The other notes in the major scale can be 'filled in' by using the same whole-tone step of a 9/8 frequency increment (*a*). Equivalently, all the notes can be obtained through a repeated upwards step of a fifth (or downward to reach F), followed by 'folding' the notes back into a single octave span (*b*). The result is the Pythagorean tuning.

are smaller, equal to a factor 256/243. On the modern piano keyboard, these two types of step are the whole tone and semitone respectively.

The scale formed this way is called a Pythagorean scale. It seems to stem from a mathematically attractive way of iterating the harmonious interval of a perfect fifth – a kind of hierarchy of the simple 3/2 ratio. In fact, it turns out that all the note frequencies can be related to that of the tonic by factors of 3 and 2: the ratios for *3* and 7, say, are $3^4/2^6$: 1 and $3^5/2^7$: 1. So even if the maths ends up a little hair-raising, there is a sound, logical basis to it all, derived from simple proportion. To the Pythagoreans, for whom proportion and number constituted the fundamental ingredients of the universe, this seemed to place music on a solid mathematical footing, suggesting that music was itself a branch of maths with a structure that was embedded in nature.

Keys and tonics

The term 'tonal music' has come to be almost synonymous for many Western music-lovers with music that 'has a tune' – music you can hum in the street. Why this is so, and to what extent it is true, is